A

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"CRACK DETECTION IN BEAM THROUGH VIBRATION ANALYSIS"

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This is to certify that

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Have carried out the project on “TITLE OF PROJECT**”** under my guidance in partial fulfillment of the requirement for the degree of Bachelor of Technology in Mechanical Engineering of Bharati Vidyapeeth (Deemed to be University), Pune during the academic year 2019-2020. To the best of my knowledge and belief this work has not been submitted elsewhere for the award of any other degree.

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ABSTRACT

The presence of a crack is hazardous problem in the performance of many structures and it affects many of the vibration parameters like Natural frequency and mode shapes. Crack in a structure changes the dynamic behaviour of the structure and by examining this change, crack size and location can be identified. Current research has focused on using different modal parameters like natural frequency, mode shape and damping to detect crack in beams. This work concentrates on the parameters like Deflection of a beam, Bending moment and behaviour of stresses.

In this work, simulation is carried out by using FFT Analyser to find the relation between the change in natural frequencies and mode shapes for the cracked and uncracked beam. ANN is used to determine crack depth and location along with the directions of propagation and Natural frequencies and relative mode shapes difference as input parameters to calculate the variation and the vibration parameters. The output from ANN controller is relative crack depth and relative crack location. Results from numerical analysis are compared with the Experimental results and they have good resemblance to the results predicted by the ANN controller. It is an iterative process to reach to the final solution. By using this, same results are found and related with the results of ANN. And finally the results are compared to find the most appropriate approach amongst the two methods.

Keywords:

- Vibrational Analysis
- Ensure safety of equipment
- Prevent any disaster due to damage caused by cracks

1.INTRODUCTION

1.1 Background

Damage detection by using crack analysis in a mechanical or civil structure has been a topic of research for last few decades. For every new researcher, a new method or change in modal parameters is a way to carry out the detection procedure of a crack. Damage is a result of crack and crack changes stiffness of a structure. Due to change in stiffness dynamic response of a system changes. The dynamic properties of a structure can be determined by Finite Element Method , or by experimental modal analysis. Dynamic characteristics of cracked and uncracked beams are very different. Because of this,faults in materials can be detected, especially in beams. Crack formation due to cycling loads tends to fatigue of the structure and forms discontinuities in the crystal structure of a beam. When a structure suffers from crack, its dynamic properties change. To be specific,crack can cause reduction in stiffness , with a significant reduction in natural frequencies, and increase in modal damping, and a change in the mode shapes. Cracks in vibrating components can initiate miserable failures. Therefore, there is a need to understand the dynamics of cracked structures. When a structure suffers from damage, its dynamic properties can change. Specifically, crack damage can cause a stiffness reduction, with an intrinsic reduction in natural frequencies, an increase in modal damping, and a change in the mode shapesFrom such changes, the crack position and magnitude can be identified. Since the reduction in natural frequencies can be easily observed . In the work by Kam and Lee, the finite elements method has been used to determine the crack locations and magnitudes for a cantilever beam with one crack. Natural frequency of the beam has also been determined and verified experimentally. For the beam with one crack and pinned at the two ends, mathematical expressions were derived to examine the effect of the crack to the natural frequency of beams.

1.2 Problem Definition

The presence of a crack is hazardous problem in the performance of many structures and it affects many of the vibration parameters like Natural frequency and mode shapes. Crack in a structure changes the dynamic behaviour of the structure and by examining this change, crack size and location can be identified.

2. Literature Review

2.1 Literature survey

2.1.1 Crack detection in cantilever beam by vibration techniques:

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.

OBJECTIVE: Objective of this study is to establish a method for detecting the location and depth of a crack in beams using experimental vibration data. The scope of present work is kept limited to case cantilever beam with single crack. The method has been considered only for normal edge crack.

Proposed method is based on measurement of natural frequencies is presented for detection of the location and size of a crack in a stepped cantilever beam. The crack is represented as a rotational spring and the method involves obtaining plots of its stiffness with crack location for any three natural modes through the characteristic equation. The point of intersection of the three curves gives the crack location. The crack size is then computed using the standard relation between stiffness and crack size. When a crack develops in a component, it leads to a reduction in the stiffness and an increase in its damping. This, in turn, gives rise to a reduction of natural frequencies and a change in the mode shapes. A vibration based method of crack detection utilizes any one of the above as the key parameter. For the beam, the first three natural frequencies are measured. Using one of the frequencies and assuming a particular value for e, the non-dimension stiffness K is computed from equation. Since physically there is only one crack, the position at which the three curves intersect gives the crack location. The crack size is then obtained using the relationship between stiffness K and crack size a. The accuracy of the method is illustrated by a case study involving a two-step beam. The method predicts the location of crack quite accurately. The error in prediction of the location is always less than about 3%. The crack size is also predicted accurately, the error is again less than 4.5%.

CONCLUSION: Vibration measurement based technique for non destructively assessing the integrity of structure has certain advantages over the common NDTs, like online conditioning, monitoring ete. It is tedious and time consuming job lot apply common NDTs to large structures like long pipelines, rail tracks, aircraft structures, engineering components, ctc An analytical method, which provides the theoretical basis for crack detection using three natural frequencies of cracked and cracked beam, has been developed for application to uniform beams. Thecrack is modeled as a torsional spring and is placed at the root of the crack. With this type of modeling the crack location can be predicted accurately. In deriving these theories fow important assumptions are made like, the structural member is assumed to behave linearly, the structural properties are assumed to be a time invariant. The error in prediction of crack location and crack size is up to 4%. The proposed method is confirmed by comparing it with results of FEM results The proposed method is found to be simple and accurate[1].

2.1.2 A signal-processing-based approach for damage detection of steel structures

This study reports the results of an analytical, experimental and a numerical study (proof of concept study) on a proposed method for extracting the pseudo-free-vibration response of a structure using ambient vibration, usually of a random nature, as a source of excitation to detect any change in the dynamic properties of a structure that may be caused by damage. The structural response contains not only a random component but also a component reflecting the dynamic properties of the structure, comparable to the free vibration for a given initial condition. Structural response to the arbitrary excitation is recorded by one or several accelerometers with a desired data-collection frequency and resolution. The free-vibration response of the structure is then extracted from this data by removing the random component of the response by the method proposed in this study. The features of the free-vibration response of the structure extracted by a suitable method, namely Fast Fourier Transform (FFT) in this study, can be used for change detection. Possible change of the pattern of these features is dominantly linked to the change in dynamic properties of the system, caused by possible damage. To show the applicability of the concept, besides an analytical verification using Newmark's linear acceleration method, two steel portal frames with different flexural stiffness were made in the steel workshop of the structural laboratory for an experimental study. These structures were also numerically modeled using a finite element software. A wireless accelerometer with a sampling frequency rate of 2046 Hz was affixed on the top of the physical structure, at the same location where the acceleration was recorded for the corresponding numerical model. The physical structure was excited manually by an arbitrary hit and the response of the structure to this excitation, in terms of the acceleration on the top of the structure, was recorded. The pseudo-free-vibration response was extracted and transferred into frequency domain using FFT. The frequency with the largest magnitude which is the fundamental frequency of the structure was traced. This was repeated for several independent excitations and the fundamental frequencies were observed to be the same, showing that the process can correctly identify the natural frequencies of the structure. Similarly, the numerical model was excited and for several base excitation cases, the fundamental frequencies were found to be the same. Considering the acceptable accuracy of the results from the two numerical models in simulating the response of their corresponding physical models, additional numerical models were analyzed to show the consistency and applicability of the proposed method for a range of flexural stiffness and damping ratio. The results confirm that the proposed method can precisely extract the pseudo-free-vibration response of the structures and detect the structural frequencies regardless of the excitation. The fundamental frequency is tied to the stiffness and a larger stiffness leads to a higher frequency, as expected, regardless of the simulated ambient excitation[2].

2.1.3 An Analytical Method for Crack Detection of Beams with Uncertain Boundary Conditions by a Concentrated Test Mass

The aim of this study is to introduce a method for crack detection and simultaneously assessing boundary conditions in beams. This study suggests a method based on the effect of a concentrated test mass on the natural frequency that is defined as a stationary mass, which can be located in different positions of the beam and cannot be separated from the beam. Timoshenko beam theory is used to calculate the frequencies. In this method, a beam with the desired number of cracks is modeled. The beam is divided into separated parts at crack section which are joined together by elastic weightless torsion springs, to avoid non-linearity effects, it is assumed that the crack is always open. At the first step, equations for a cracked beam are extracted by considering the spring boundary conditions. Then, to verify the equations, numerical finite element model is used. In this way, a new method is also applied to model the torsion springs in supports and it is shown that suggested model is acceptable. Eventually, the obtained responses are evaluated and the sources of errors are identified. To correct the existing errors, a modifying function is suggested. Finally, the inverse problem is solved[3].

2.1.4 An approximate technique for damage identification in beams using shifts in natural frequencies

The objective of this work is to use natural frequencies for the localization and quantification of cracks in beams. First, to study the effect of the crack on natural frequencies, a finite element model of Euler–Bernoulli is presented. Concerning the damaged element, the stiffness matrix is calculated by the theory of fracture mechanics, by inverting the flexibility matrix. Then, in order to detect damage, we are going to show that the shape given by the change in the natural frequencies is as function of the damage position only. Thus, the crack is located by the correlation between the shape of the measured frequencies and those obtained by the finite elements, where the position that gives the calculated shape which is the most similar to the measured one, indicates the crack position. After the localization, an inverse method will be applied to quantify the damage. Finally, an experimental application is presented to show the real applicability of the method, in which the crack is introduced by using an Electrical Discharge Machining. The results confirm the applicability of the method for the localization and the quantification of cracks[4].

2.1.5 Detection of crack location and crack depth in leaf spring by using fuzzy logic technique

The objective of this work is to find the crack location and crack depth in leaf spring of an army jeep. The spring is subjected to heavy jerks and vibration during the military operation. Therefore it is necessary to find the crack in a leaf spring. Crack in a leaf spring introduces local flexibility that would affect the vibration response of the leaf spring. Main problem is to detect existence of a crack together with its location and depth in the leaf spring .We used a natural frequency a basic criteria for crack detection. Analytical calculations are done to find out natural frequency of leaf spring by using Euler's beam theory.Ansys 16.0 is used to find out natural frequency along with experimentation on FFT analyzer. Now, 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[5].

2.1.6 Crack Detection in Structural Beams by using Curvature Mode Shapes

The location of crack is determined by the sudden changes in the spatial variation of the transformed response. The results in the simulation mode and experiments show that HHT appears to be a more effective tool for the analysis. The location and depth corresponding to any peak on this curve becomes a possible notch location and depth. The identification procedure presented in this study is believed to provide a useful tool for detection of medium size crack in a cantilever and simply supported beam applications. Vibration data obtained from the perturbed system is processed for mode shapes which are converted into mode shape curvatures and subsequently fed to the wavelet transform. It is observed that the decomposition of the spatial signal into wavelet details can identify the damage position in beam like structure by showing relatively larger peaks at the position of damage.Damage is considered as localized reduction in structural stiffness. From the numerical simulations, it is observed that the absolute changes in modal curvature are localized in the region of damage and hence can be used to detect damage in a structure.A new scheme of damage detection and localization is presented by implementing frequency response functions (FRFs) of damaged structure only.Model for free vibration analysis of a beam with an open edge crack has been presented. Variations of natural frequencies due to crack at various locations and with varying crack depths have been implemented. Cantilevered beam model is investigated numerically by use of finite element method. Slope and curvature of displacement mode shapes differences were calculated using a central difference approximation. Changes in the mode shape characteristics are good indicator of damage location and severity, and hence can be used to detect damage in a structure. Illustrating significant refinements concerning the use of wavelets, when these latter are used in the guise of continuous wavelet transforms (CWT) for identifying damage on transversally vibrating structural components. The estimated mode shapes of the beam are analyzed by the one-dimensional continuous wavelet transform. The formulation of the two dimensional continuous wavelet transform for plate damage detection is presented. The spatial wavelet based approach can provide an alternative to classical approaches in damage detection because it is not necessary that detecting damage from variation in natural frequencies and structure stiffness relative to an undamaged structure. The damage reduces the stiffness of the structure and increases its damping value, at the same time it will decrease the natural frequency and the corresponding mode shape changes. The present thesis work aims at detecting the cracks of a propped cantilever beam and to study the effects of cracks in its dynamic characteristics. The curvature response function, function of crack location and size, are approximated by means of polynomial surface fitting. The numerical data obtained is meshed using B-spline. The algorithm based on curvature, Wavelet Transform and surface fitting technique is proposed for damage detection. An experimental program was undertaken to test the feasibility to detect the occurrence of structural damage using a modified mode shape difference technique. Modal analysis was performed to extract the frequencies and mode shapes. The method shows a good potential in detection of occurrence and location of damage. A technique for structure damage detection based on spatial wavelet analysis by using only needs the spatially distributed signals (e.g. the displacements or mode shapes) of the rectangular plate after damage.

The premise of the technique is that damage in a structure will cause structural response perturbations at damage sites. Such local perturbations, although they may not be apparent from the measured total response data are often discernible from component wavelets.

In this paper, the curvature damage detection technique was investigated both experimentally and numerically on an example of the cantilever beam with damage in the form of the notch of depth 10%, 20% and 30% of the beam height. The analysis was performed on the first eight mode shapes. Results of the research on the effectiveness of the damage detection technique applied to higher vibration modes lead to the following conclusions: For the established curvature function, if the mode is higher, the value of the curvature modulus is also higher, what indicates that higher modes are more sensitive to the presence of the defect. For the established mode shape, it contains a large number of zero values, what facilitates damage identification. In this case, strong non-zero values are observed only in places where the damage occurs[6].

2.1.7 Vibration analysis of simply supported beam with varying crack depth and location by using ansys

Cracks in the beam create changes in geometrical properties so it becomes complex to study the effect of cracks in the beam. The crack modelling has been very important aspect. The analysis has been done using finite element method. FEM software package ANSYS 17.2 has been used. Cracked beam has been modelled and free vibration analysis has been performed considering geometric and material non linearity. The crack is considered to be an open edge Crack with 1mm width on the top surface of the beam has been modelled. It is assumed that crack have uniform depth across the width of the beam. For modelling of cracked beam the process is same as un cracked beam except while doing geometry an open transverse single crack of 1mm width is taken at the top surface of the beam. Here the cracks are developed at locations of 0.50L of the beam(where L is the length of the beam) with varying crack depth of4mm, 8mm, 12mm, 16mm, 20mm & 24mm of the beam. A total of 6 models are analysed and some of the models are shown in fig. The modal values i.e. natural frequency for 1st mode, 2nd mode , 3rd mode and its corresponding mode shape values each model are found out.

Conclusion: The vibration analysis of a structure holds a lot of significance in its designing and performance over a period of time. Detailed analytical investigations of the effect of crack on the first three modes of vibrating simply supported beam have been presented in this paper. The vibration behavior of the beam is shown to be very sensitive to the crack location, crack depth and mode number. It has been observed that natural frequency change subsequently due to presence of crack depending upon location and size of crack. In case of cracks the frequencies of vibration decreases with increase of relative crack depth and crack location. The results obtained are accurate and expected to be useful to other researchers for comparison. The study in this work is necessary for a correct and thorough understanding of the vibration analysis of a simply supported single crack beam[7].

2.1.8 Crack Detection and Quantification in Beams Using Wavelets

A new method has been proposed to detect the location and also to quantify the crack using the deflection response of the damaged beams alone. The deflection is measured at a particular point for various locations of a concentrated load on the beam. This static deflection profile is used as the input signal for wavelet (Symlet) analysis. Due to variation in deflection at some points, compared to their adjacent points, peaks are seen in the wavelet coefficient (WC) plot. These peak points are identified as damage points along the length of the beam. The peaks can also be seen at sensor point and supports. These can be eliminated by performing wavelet analysis for the deflection profile measured at another point. In a real damaged structure, it is very difficult to measure deflection at several points, as a large amount of instrumentation needs to be installed to measure the response. This practical difficulty can be avoided by minimizing the number of measuring points in the field as explained in the present work. A parametric study has been carried out by varying the damage, location of damage, intensity of load, flexural rigidity, and length of the beam. It has been observed that the WCs change with variations in damage, location of damage, intensity of load, flexural rigidity, and length of the beam. A generalized curve has been proposed to quantify the damage in a fixed beam by taking envelop of all maximum WCs of the deflection response measured at damage points.

The main advantage of the continuous wavelet transform (CWT) is its ability to provide information simultaneously in time and scale with adaptive windows. An application of wavelet theory in the spatial domain crack identification of structures was proposed by Liew and Wang (1998). The wavelet in the spatial domain is calculated based on finite difference solutions of a mathematical representation of the structure in question. The crack location is indicated by a peak in the variations of the WCs along the length of the beam. Wang and Deng (1999) proposed that the wavelet transform be directly applied to spatially distributed structural response signals, such as surface profile, displacement, strain, or acceleration measurements. The CWT of the fundamental mode shape and its Lipschitz exponent was used to detect the damage location and extent in a beam by Hong et al. (2002), Gentile and Messina (2003), Douka et al. (2003), and Chang and Chen (2003). The key point of this method is to check on the spatially distributed response signals that can pick up damage information. A classical measurement system, for example, an impulse hammer technique is only able to measure mode shapes at a few discrete points of a transversely vibrating beam. Therefore, new sensors or measuring techniques are needed to pick up the perturbations caused by the presence of a crack[8].

2.1.9 Multiple crack detection in beams from the difference in curvature mode shapes

The presence of crack in a structure tends to modify its modal parameters (natural frequencies and mode shapes). The fact can be used inversely to predict the crack parameters (crack depth and its location) from measurement of the changes in the modal parameters, once a functional relationship between them has been established. The machine components like turbine blade can be treated as a cantilever beam and a shaft as a simply supported beam. Vibration analysis of cantilever beam and simply supported beam can be extended successfully to develop online crack detection methodology in turbine blades and shafts. In the present work, finite element analysis of a cantilever and simply supported beams for flexural vibrations has been considered by including two transverse open U-notches. The modal analysis has been carried out on cantilever and simply supported beams with two U-notches and observed the influence of one U-notch on the other for natural frequencies and mode shapes. This has been done by carrying out parametric studies using ANSYS software to evaluate the natural frequencies and their corresponding mode shapes for different notch parameters (depths and locations) of the cantilever and simply supported beams FEM model. Later, by using a central difference approximation, curvature mode shapes were then calculated from the displacement mode shapes. The location and depth corresponding to any peak on this curve becomes a possible notch location and depth. The identification procedure presented in this study is believed to provide a useful tool for detection of medium size crack in a cantilever and simply supported beam applications[9].

Below is the abstract of some more literatures:-

SR. NO.	Name of author	Aim	Experimental Method	Analytical Methods	Software methods	Software used
1	M.S. Mhaske, S.N. Shelke. (IERJ)	Detection of Depth and Location of Crack in a Beam by Vibration Measurement and its Comparative Validation in ANN and GA	FFT analyser	1)ANN(Artificial neural network) 2)GA (Genetic Algorithm)		Keel is a software tool of MATLAB which is used for GA method. GMDH shell software is used for ANN method
2	Nitesh A. Meshram, Prof. Vaibhav S. Pawar. (IRJET)	Analysis of Crack Detection of A Cantilever Beam using Finite Element Analysis		Euler-Bernoulli beam equation for a constant rectangular cross-section beam and Hermitian shape functions	FINITE ELEMENT ANALYSIS	ANSYS software is used for FEA experimental method.

3	Mangesh Dilip Ratolikar, M Chandra Sekhar Reddy, T Ravi Theja, Chintapatla Siddhartha. (IOSR-JMCE)	Crack Detection for Various Loading Conditions in Beam Using Hilbert – Huang Transform	SCADA is used in experimental method.	Hilbert-Huang Transform (HHT) form which empirical mode decomposition (EMD) method is used.	FINITE ELEMENT ANALYSIS	MATLAB software is used for FEA. LMS test lab software for experimental analysis.
4	Priyadarshini Subhasmita. (IRJET)	Vibration analysis of simply supported beam with varying crack depth and location using ANSYS	Euler-Bernoulli beam equation		FINITE ELEMENT ANALYSIS	ANSYS software is used for FEA experimental method.
5	Hui Long, YilunLiu, Changzheng Huang,Weihui Wu, and Zhaojun Li	Modelling a Cracked Beam Structure Using the Finite Element Displacement Method	The cantilever beam vibration testing apparatus was produced by Donghua Testing Company with DHVTC in China.	Finite Element Displacement Method(FEDA)		MATLAB software is used for FEDA.
6.	Mr. Vaibhav B. More, Mr. Aditya D. Wakchaure, Mr. Durgaraj P. Nikam, Mr.Kushal B. Patil4 Mr. Tushar T. Kapade, Mrs.Rajashree B. More	Detection of Crack Location and Crack Depth in Leaf Spring by using Fuzzy Logic Technique.	Frequencies are provided as input to Fuzzy logic to obtained relative crack location and depth.	Euler’s beam theory	Finite Element Analysis	ANSYS

7.	E.Ekinovic	An approximate technique for damage identification in beams using shifts in natural frequencies.	The beam is modeled using solid elements in software I-DEAS Master Modeler 9.	The appropriate regression relations can be found by trial-and-error for any type of the real beam .		I-DEAS Master Modeler 9
8.	P.K. Umesha, R. Ravichandran. K. Sivasubramanian	Crack Detection and Quantification in Beams Using Wavelets	Static deflection profile is used as the input signal for wavelet (Symlet) analysis.	The wavelet analysis has been carried out on the static deflection profile obtained by measuring deflection at a particular point by changing the locations of loads.	Computation of crack depth ratio	MATLAB
9.	Kaustubha V. Bhinge, P. G. Karajagi, Swapnil S.Kulkarni	Crack Detection In Cantilever Beam by Vibration Techniques	Equation of Motion for the Euler-Bernoulli Beam	The catachrestic equation obtained from the vibration analysis of Eluer-Bernoulli beam is manipulated to give the relationship between the stiffness & location of crack	Finite Element Analysis	ANSYS

10.	Gollangi Raju, L. Ramesh	Crack Detection in Structural Beams by using Curvature Mode Shapes	The location of crack is determined by the sudden changes in the spatial variation of the transformed response	Change in slope at each node can be calculated by using central difference approximations	Modal Analysis	ANSYS
11.	K. Ravi Prakash babu, B. Raghu Kumar, K.L. Narayana and K. Mallikarjuna Rao	Multiple crack Detection in beams from the differences in curvature mode shape	-	Finite element analysis of beam with u notches	ANSYS software analysis of beam by eigen value	ANSYS
12.	'Daming Chen, yongfeng xu, W. D. Zhu	Non Model Based Multiple damage identification of beam by a continuously scanning laser doppler vibrometer system	CSLDV is used for the velocity response of beam under scan line and spatially dense operating deflection shapes ODS is used on width and depth of three damage are varied from 3mm to 9mm increment of 3mm and thickness reduction 15% to 5% and decrement of 5%.	-	-	-
13	Fatemeh Mottaghain, Ali Alijani, A. F. Darvizeh	Extended finite Element Method for statics and vibration analysis on cracked bars and beam	-	XEFM equation of cracked bars and beams was formed by FEM equation and Gauss integration points	-	-

14.	Mustapha Dahak, Noureddine Touat, Tarak Benkedjouh	Crack detection through the change in the normalize frequency shape	The crack is introduced through electrical discharge machining for the applicability of the method for the localization and the quantification of cracks	A FEM finite element model of Euler-Bernoulli is presented change in frequency is given by crack	-	MATLAB
15.	Amin Moghadam	A signal processing-based approach for damage of steel structures	Accelerometer with desired data collection frequency and resolution on a structure Fast Fourier Transform (FFT) is used for change detection	Newmark's Linear acceleration method two steel portal frames with different flexural stiffness	-	-

.2.2 Objectives

- To detect the location of a crack in beams using experimental vibration data.
- To detect the depth of a crack in beams using experimental vibration data.
- To prevent any disaster due to damage caused by cracks.
- To ensure safety of equipment.

3. FABRICATION OF EXPERIMENTAL SETUP

3.1 Overview

Setup mainly consist of the beam arrangement components

The components are as follows:-

1.Table

2.Clamps

3.Beams

4. Impact Hammer

5. FFT Analyzer

3.1.1. Table

A Table in the setup is the base of the setup on which the all the components of the experiment are mounted, At which the two clamps are mounted the fixed clamps is fixed by the simple holes on the table while the adjustable clamp is mounted through the slotted holes on the table by which the clamp is adjusted.

The Impact hammer works thought the motor, the motor is also mounted on the table through which the vibration is produced. The wooden table is as shown below.

Fig.3.1 Table

3.1.2. Clamps

The clamps are the object made up of Iron in the shape of I , There are couple of clamps used to hold the beams which is vibrated through the impact hammer so the clamps are rigid, one of the clamp is fixed at one end and the other clamp is adjustable which allows to use the beams of different lengths.

The beams are made up of iron, a single clamp is made up of three-square plates of size 6cm*6cm and hollow square shaped rod of length 30cm, two of the plates are welded at the either end of the rod and one plate is to fix the beam through the nut bolt.

Fig.3.2 clamps

3.1.3. Beams

The beams are the most important component of the setup on which the experiment is based on the beams are fixed on the clamps and vibrated through the impact hammer the vibration gives the mode shapes to the beam, there are total 6 beams of two different materials 3 of Mild steel and Aluminum each, length of each beam is 50cm, one of the beam of each material is raw, one of the beam of each material has a crack on it in the middle of it i.e. 25cm, one of the beam of each material has a crack on it at the distance of 37.5 cm or 12.5 cm from its end. Which will help in studying the change in frequency of the material on different position of crack.

Fig.3.3 M.S. and Aluminum beam

3.1.4. Impact hammer

The impact hammer is designed in a way that the rotational motion can be converted into reciprocal motion and hence it can transmit equal amount of force at equal interval of time so that a fixed amount of frequency can be obtained, the motor provides the rotational motion at an fixed rpm, the kinematic link at the offset distance is provided at the output of the motor the offset distance depends upon the output required of the impact at the other end of the motor there is an hammer attached to it which provides the impact on the beam through which the vibration is produced at the constant frequency, the motor is fixed on the base i.e. table.

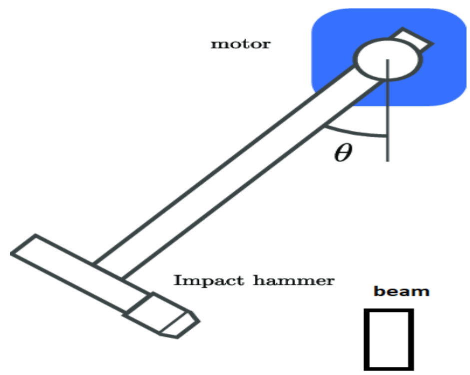

Fig.3.4 Impact hammer

3.1.5.FFT analyzer

A **spectrum analyser** measures the magnitude of an input signal versus frequency within the full frequency range of the instrument. The primary use is to measure the power of the spectrum of known and unknown signals. The input signal that most common spectrum analysers measure is electrical; however, spectral compositions of other signals, such as acoustic pressure waves and optical light waves, can be considered through the use of an appropriate transducer. Spectrum analysers for other types of signals also exist, such as optical spectrum analysers which use direct optical techniques such as a monochromator to make measurements.

By analysing the spectra of electrical signals, dominant frequency power, distortion, harmonics, bandwidth, and other spectral components of a signal can be observed that are not easily detectable time domain waveforms. These parameters are useful in the characterization of electronic devices, such as wireless transmitters.

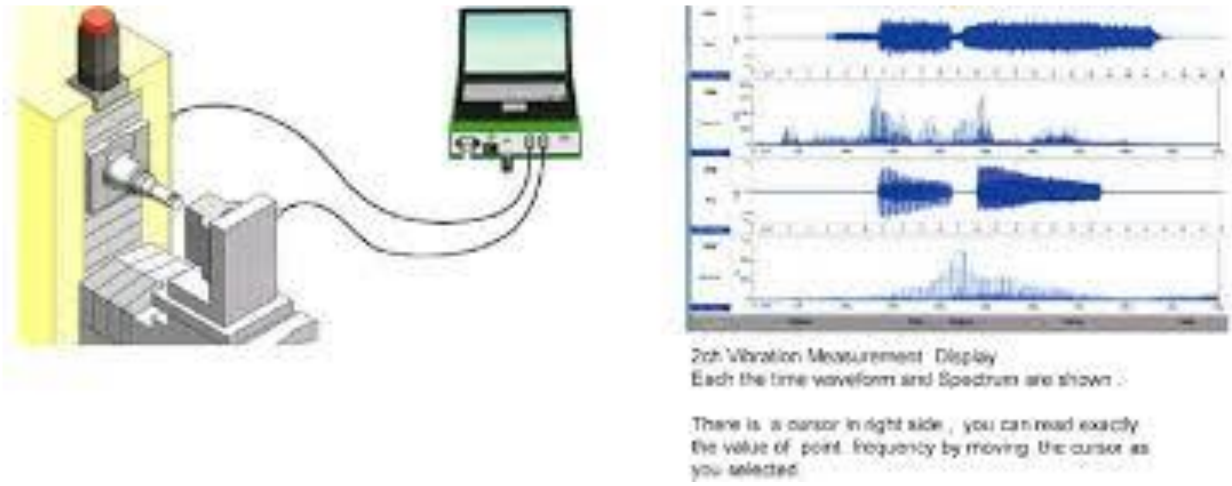

Fig.3.5 FFT analyzer

4. Preliminary Experimentation

4.1 Plan of experimentation

When damage or crack occurs in a beam, it modifies the vibration characteristics of uncracked beam, such as natural frequencies, mode shape, and modal damping ratios. The characteristics of the uncracked beams are often referred to as initial values in crack detection, which can be identified with modal tests. In comparison with the initial values, any deviation of the structural parameters measured during the service life reflects possible damage and may be used to identify the severity and location of crack. Among various parameters, the natural frequency has been widely used as a representive parameter of damage occurring in a beam. since it can be simply identified from modal tests with sufficient accuracy. If crack occurs in a structure, degradation of stiffness values takes place and the natural frequencies of the structure gets reduced. The instruments used for experimental analysis i.e., measurement of natural frequencies are Fast Fourier Transform (FFT) analyzer, accelerometer, impact hammer and related accessories. The piezoelectric, miniature type unidirectional accelerometer is used to capture the frequency response functions. The accelerometer is mounted on the beam using mounting clips. The accelerometer is mounted near the crack to capture the correct signal. The impact hammer is used to excite the beam whose frequency response function has to be captured. For every test, the location of impact of impact hammer is kept constant. The beam is tapped gently with the impact hammer. The experiments are performed on mild steel cantilever beam having single crack and one without crack .Depth and location of a crack is varied along the dimensions of the beam

4.2Calculations and Results

4.2.1Calculations.

The properties of mild steel are

- Young’s modulus (E) 2.0 e11 N/m2
- density (ρ) 7950 N/m3
- Poisson’s ratio 0.3
- the cross sectional area is 0.4 x 0.1 m
- L = 0.25m

Crack depth is represented in terms of (a/h) ratio

- a = depth of crack
- h = height of beam

And crack location is represented in terms of (e) where e is ratio of location of crack at distance L1 from the support to the length of the beam L. The FFT Analyzer is a tool developed for vibration measurement. It uses impulse execution & either frequency domain analysis or time domain analysis to give the model Parameter from the response measurement in real time. The variable parameters considered for the experimentation are

- depth of a crack &
- location of a crack from fixed end of a beam.

5 COST ESTIMATION

5.1 Cost of each component used

Table below shows the total cost analysis of the project stage-II.

Sr. no.	ENTITY	QUANTITY	COST PER UNIT	TOTAL COST
1	Table	1	1100/-	1100/-
2	Aluminium Beam	3	500/-	1500/-
3	Mildsteel Beam	3	350/-	1050/-
4	Clamp	2	600/-	1200/-
5	Impact Hammer	1	-	7800/-
6	FFT Analyser	-	-	-
7	Machining	-	-	2000/-
8	Miscellaneous	-	-	1000/-
9	Total	-	-	15350/-

6. CONCLUSION

6.1 Expected outcome:

The vibration behavior of the beams is very sensitive to the crack location, crack depth and mode number. A simple method for predicting the location and depth of the crack based on changes in the natural frequencies of the beam is also presented, and discussed. This procedure becomes feasible due to the fact that under robust test and measurement conditions, the measured parameters of frequencies are unique values, which will remain the same (within a tolerance level), wherever similar beams are tested and responses measured. The experimental identification of crack location and crack depth is very close to the actual crack size and location on the corresponding test specimen. It was learnt while simulating the results that normalized slope mode shapes yield quick and accurate results when compared to the displacement mode shapes and the same has been implemented in this thesis. Natural frequencies calculated by the proposed model agree quite well with the experimental data.

6.2 Gantt Chart:

Activity	January	February	March
Literature Survey			
Design and fabrication			
Market Survey			
Purchase of materials			
Project Execution			

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