Study and Observation of Cracks in Beams Using Vibrational Analysis

Detection of Location of Cracks

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***Abstract*: The identification of cracks in flexible structures and their components is an important factor in judging in creating their care and retirement. Failure to identify damage has various implications. Early identification of errors in engineering structure during their service time is a major challenge for us. Although dynamic-based error diagnoses have been developed in the past and have a large amount of literature, there are still many problems that avoid making use of them. Cracks in the vibration system can lead to sudden and completely impossible recovery from it. This causes changes in the body parts of the structure and thus the dynamic response also varies. The depth of the crack and its location from the fixation are the main parameters of the vibration analysis. It is very important to know the changes in these building parameters in order to achieve its reliability, efficiency and safety and to study the effect of parameters on the natural frequency of the beams. In this paper, the effect of fracture parameters (relative location of fracture and depth of fracture, and tendon fracture) is examined.**

***Index Terms*: Vibrational Analysis, Beams, Simply supported Beam, Fixed Beam, and Natural Frequencies.**

I. INTRODUCTION

Vibration is a time-dependent migration a particles or particle system in relation to position of equality. Natural frequency is one of the most important parameters associated with structural vibration is. Each building has its own natural frequency of a series of different modes that control their flexibility behavior. All structures that have a certain weight and having elasticity is said to vibrate. When these amplitude of vibration exceeds the allowable limit, structure failure occurs. For avoiding such failures, one should know operating frequency of various materials along with it boundary conditions such as simply supported, suspension or if we are having cantilever conditions. Presence of cracks in the member of the structure, such as the RC beam, causes a variety in stiffness, its size depends on the location, the tendency and depth of cracks. Studying the changes in the reaction parameters of the structure were used in assessment of structural integrity, performance and safety. A cracking of inflexible or even flexible structures can lead to sudden failure if they are not known at first. Modal parameters, example, modal frequencies, mode nodes are the functions of building structures such as the strength and size of the building. Therefore, the diversity of building structures will create variety of modal structures. The main purpose of this paper is to read the variation of modal parameters (natural frequency and shape mode) of the RC rod such as depth and cracking the tendency which varies by performing free vibration analysis.

II. THEORETICAL BACKGROUND

The frequencies of a cracked structure system can be obtained through many of the civil structural testing methods. When any two natural frequencies of a cracked simply supported ferroconcrete beam are obtained from measurements, the situation, inclination and therefore the depth of the crack can then be determined.

TYPES OF VIBRATION

The vibrations can be categorized as follows

- **Free and forced vibration:** If the system, after internal disturbances,is left to shake on itself, then vibration is known as free vibration. Here there are not any external forces working on the system. If the system is under external force then the resulting vibration is known as forced vibration. If the frequency of external forces corresponds to one of the natural frequency of the system, resonance happens and the system goes through a very dangerous process of oscillations
- **Damped and Undamped vibration**: When energy is not scattered in friction or other resistance at the time oscillation, vibration is called undamped vibration. If any energy is lost during this way, it's called damped vibration. Consideration ofdamping becomes important because of analysis of vibratory system near resonance.
- **Linear and non linear vibration**: If all is basic parts of the vibration system, eg.-spring, the mass and the damper-behave linearly then the resulting vibration is known as line vibration. If any of the basic components behave indirectly, vibration is called indirect vibration.

Cracks

Fragmentation of a building member introduces space fluctuations that may affect the vibration response of structure.
This property can be used for discovery of the presence of a splits together in its place, inclination and the thickness of the structure member. Presence of cracks of a building member changes location compliance that may affect the vibration response under external loads.

Based on geometry, cracks are classified as follows:

(1) Cross-sectional cracks: These are cracks perpendicular to the beam axis. They are too common and very disastrous as they lower the cross part as by weakening the beam. They Present a local flexibility in beam intensity due to concentration of the strain energy on the immediate area or crack tip.

(2) Length cracks: These are parallel cracks to the axis of the beam. They are rare but very striking danger if the tensile load is applied at the ninety degree to the point of cracking i.e. perpendicular to the axis of the beam.

(3) Open cracks: Cracks remain open. They are best called "notches". Open cracks are easy to make in the laboratory area too And many experimental tasks focus on this type of cracking.

(4) Breathing cracks: These cracks opens where the affected part of the material is acted by pulling forces ie tensile stress and closes when the pressure is reversed. The segment is strongly influenced under pressure situation. Crack breathing causes non-linearity in the vibrating behavior of beam. Cracks for "transverse breath" are straight forward visual correlation and multidisciplinary research efforts are focused on this.

(5) Slant cracks: These are angular cracks to the axis of the beam.

(6) Surface: These are open cracks on the face. These are usually found by dye-entry or visual inspection.

(7) Underground cracks: Constructed cracks inside the surface and not over the surface is called underground cracks. Special strategies such as ultrasonic, magnetic particle etc. is required in order to see.

III. LITERATURE REVIEW

Before proceeding on the study, it is often useful to restudy the works carried out by others previously. A number of journals and papers which comprises with the vibrational analysis and fault detections in beams have been referred to and are expressed below briefly.

Previous works on it

O. S. Salavu (1997), discussed the utilization of natural frequency as a diagnostic parameter in structural assessment procedures using vibration monitoring. The relationships between frequency changes and structural damage are discussed here. Various methods proposed for detection of damage using natural frequencies are reviewed. Factors which lesser the successful application of vibration monitoring to wreck detection and structural assessment also are being discussed.

Keichi inoue , Masaro kikoochi , Maeaaiki uedaa , and Taakeakii koshiikava (2004), analysed the vibration problem of Ferro concrete beam members including bond-slip of the reinforcements. During this paper, virtual work was used to derive equations which supported the finite element method. For the free vibration analysis the effect of bond-slip on the characteristics of the vibration relys on the varied bond moduli assumed, whereas, for sinusoidal dynamic study, the effect of bond-slip on the response relys on the different bond moduli assumed, also as, the bond-slip damping and period of the input.

N. Puvarodom and K. Charroenponng (2004), presented a study on dynamic testing and numerical studys of a 6-storey Reinforced Concrete building to develop more understanding and add surplus informative data for the problem in this area. The effect of masonry walls , base flexibility on natural frequencies, damping ratios along mode shapes were studied through ambient vibration measurements in conjunction with numerical modelling. The rise in natural frequencies of the building with the quantity of partition masonry wall are analysed.

Tayphun Dede, Yousuf Aywaz and Yaprakk I O ¨ zdemir (2010), done the materially non-linear free vibration study of a beam by using the FEM. Here, two approaches are used. In the1st approach, the material matrices of concretes and reinforcements are constructed separately, then superimposed to get the element stiffness matrix. In the other approach, the reinforcement is uniformly distributed throughout the beam. Thus, the beam is modelled as single composite element with increase in the modulus of elasticity of concrete considering the reinforcement ratio. It Is thenafter concluded that the approaches and the model which are considered in this study can be used in the materially nonlinear free vibrational study of ferro concrete beams and the effects of the change in the stiffness matrix from initial to yield on the non linear frequency parameters of the beam are always larger than those of the differece from yield to failure

Gavali A I and Sanjay C. Kumavat (2011), have made vibrational study of beam. It was found that the frequencies of vibration of cracked beams reduced with rise in crack depth for the crack at any particular location due to reduction of stiffness. The result of crack is more pronounced near the fixed end than that at the far free end. The first natural frequency of free vibration reduces with rise in the number of cracks. The natural frequency reduces with rise in relative crack depth.

V. Shrinivas,C. Antony Jayasehar , K. Ramnujaneyulu , Saptarishi Sasmal (2012), did an experimental investigation on result of damage on vibration characteristics of a ferro concrete beam. The Forced vibration testing of a ferro concrete beam has abeen administered using an electrodynamic shaker under sweep sine and distinct loadings to spot the changes in vibrational properties under different damaged conditions. Along side the dynamic characteristics, the static behaviour of the beam during applying of the load is also obtained to compute the damage state. Two different cases ,i.e, during formation of crack and after yielding of main reinforcement of the beam are examined..The dynamic properties (frequencies and mode shapes) was computed from the FRF matrices supporting the responses measured through accelerometers. It is found that the damage results in the changes in flexural rigidity of the beam which is clearly observed by the changet in natural frequency at different stages of damage.

Prathmesh M. Jagdale, Dr. M. A. Chakrawarty (2013), gave a model for free of charge vibrational analysis of a beam with an open edge crack. Fluctuations of natural frequencies due to crack at different locations and with varying crack depths have been examined. When the crack positions are fixed , the natural frequencies of a cracked beams are inversely proportional to the crack depth. It has been seen that the change in frequencies is not only a function of the crack depth, and location of crack, but also of the mode number.

Sayidi abdul karim, Haemouine abdul majid and Abdulatif megnounif (2014), examined the effect of crack depth and area of presence on modal properties of the beam. Whenever the location of the crack increased from the clamped end of the beam, natural frequencies of the beam and the amplitude of higher frequency vibration also rised, but the amplitude of lesser frequency vibration reduced. It was seen that as the depth of the crack reduces, the amplitude of vibration also rised at higher frequencies while the natural frequencies reduced as expected.

AliAhmed (2014),had done the modelling of a ferro concrete beam provided to sudden vibration. In this study, 30 analysis had been executed changing many properties, like damping, stress stiffness recovery, damage property-strain, displacement relations and friction coefficients,to decide the simplest performing FE model.

Malay Kilala, Professor Samar Ch. Mandal, Professor Susenjeett Sarkar in 2014 ,has worked on the theoretical study of transverse vibration of a fixed beam & examines the mode shape frequency .In this paper, a model for free vibrational analysis of a beam with an open edge crack is presented. Fluctuations in natural frequencies due to crack at various locations and depth and with varying crack depths are examined. Natural frequency fluctuates surprisingly when crack is on the point where amplitude of vibration is in maximum. It is also seen that natural frequency of the cracked beam reduces with increment of crack distance and crack depth due to reduction in stiffness. Therefore it appears that the change in frequencies isn't just a function of crack depth and crack location but is also of the mode number.

Neha S. Badiger (2014), administered the four point bending analysis using ferro concrete beam. The results of the beam with respect to density of mesh , use of the steel cushions for supporting and loading points, effect of the shear reinforcement on flexure behaviour, impact of the tension or compression reinforcement on according response of the beam are studied. It is seen that by fluctuating the tension in steel, the initial cracking behavior of beam is unaffected. But it has more impactful within the post cracking stage of the beam. The ultimate capacity of the beam might be varied by changing the steel percentage. By removal of steel plate at support and loading point,the stress concentration takes place. The beam which is without having steel plate show more number of cracks than beam with steel plate. For more precise analysis, steel cushion has to be included in the modelling.

Mr. Gade Ganesh G, Professor Mhaski M. S (2015), completed the vibrational analysis of a cantilevered cracked beam using various technique. It was observed that the changes in natural frequencies are an important parameter that determines crack size and crack location respectively.

Preethi Dharanya.Y, Dr. Shrinivasa.V, Dr. Anand.N (2015), made an investigation for the possibility of using non-linear vibrational property to find damage in ferrro concrete beams under simply supported & free conditions. Modelling of ferro concrete beam was conducted using Ansys12.1 software and simulations results were produced for linear, nonlinear, model analysis and transient dynamic analysis.The dynamic properties (frequencies and mode shapes) have been computed from the FRF matrices and supported the responses calculated through accelerometers. It had been seen that the damage makes the changes in flexural rigidity of the beam ,clearly observed by the change in natural frequency at different levels of cracks in beams . From testing of vibration, it is seen that there is a fall in frequency of 10–15% in the first 3 modes from normal to cracking and failure point scenario of the beam. It was also seen that there's clear change in natural frequencies with the rise in damage level.

Arjun Menon & Glory Joseph (2015), examined the dynamics of transverse non propagating open cracks in composite beams. After using the models of the cantilevered cracked composite beam, the effect of depth of a crack or fault in a cracked composite beam on stress condition, the changes of the natural frequencies of the cracked composite beam as function of the angle of fibres, the result on cracks due to harmonic loads,results of boundary conditions are obtained. Parmod Kumar, S. Bhadauri (2015), explains the detection and forecast of cracks in beams.In this paper a review is done on the predictions and detection of crack in structures. Many methods of crack study are explained in the paper. A.I. Devkar, S.D. Kaatekar (2015), computed natural frequencies and mode shapes by using FEA Software ANSYS 11. A simple elastic and simply supported beam with crack at the multiple locations and crack depth is taken for the analysis of modal . The frequency of the beam when the fault is in the middle is lesser than the frequency with faults near the end point & the natural frequency of beam reduces with rise in crack depth due to reducing of beam stiffness at any point of crack in beam. Ms. P. P. Gangoorde, R.S.Pavar (2016),completed the vibrational analysis of cracked simply supported beam with free excitation at the base. The result of non-linearity's on the natural frequency & mode shapes of cracked simply supported beam is computed by theoretical, numerical and experimental kind of methods. Numerical authentication of vibrational analysis of a cracked simply supported beam having non linear parameters and computation of natural frequency & mode shapes with ANSYS software for free vibrations are made.

IV. CONCLUSION

This paper went with the multiple numbers of papers and research journals that is found helpful and useful for studying out the work on vibrational analysis. A brief and compact review of the given literatures reflects that the natural frequency fluctuates substantially due to the presence of cracks and faults depending upon the length, depth and inclination of cracks and faults. Many non-destructive methods for crack detection is already in use worldwide.However this vibration based method is comparatively fast and inexpensive for crack/damage/fault identification, as it is quick adequate and reliable.

V. ACKNOWLEDGMENT

This work would not have been possible without the support of many people. Many thanks to Head of Department , Civil Engineering, Prof. Rajeev Chandak, who read out this thesis and helped me create a sense of understanding. And thanks to all my college members for providing me proper guidance and support.

I thank the Jabalpur Engineering College for providing me a proper environment and grooming my capabilities to complete this project. And lastly, I thank my family and many friends for life who endured this difficult process with me, always supporting me and lovingly.

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