Vibration Analysis of Cracked Beams Using the Finite Element Analysis.

Ganesh Swami[1], **Prof. Ananthrama A**[2], **Prof. Yogesh Ingulkar**[3].

[1]P.G. Student, M.E. Mechanical Engineering, Dhole Patil College of Engg. Pune.
[2]Professor, M.E. Mechanical Engineering, Dhole Patil College of Engg. Pune.
[3]HOD, M.E. Mechanical Engineering, Dhole Patil College of Engg. Pune.

Abstract: Generally in vibrating component sudden generated crack can initiate catastrophic failures. The occurrence of cracks changes the physical characteristics and appears of a structure which in turn alter its dynamic response characteristics. Therefore there is need to understand what is effect of cracked structures. Number of crack, Crack depth and location are the main parameters for the vibration analysis. So it becomes necessary to monitor the changes in the response parameters of the structure to access structural integrity, performance and safety. To examine the effect of the crack to the natural frequency of beams observed. Crack hinders the optimum performance of a machine. The 3D model of cracked beam was drawn with the help of CATIA V5 software. The experimental testing was carried on FFT analyzer. The analysis was carried out with the help of ANSYS 19.2 software. The comparative analysis was carried out for new results. After making the comparative analysis result and conclusion was drawn.

Keywords: Crack, Vibration, FEA, ANSYS.

I. INTRODUCTION

It is needed that structures should safely work throughout its service life. But, damages initiate a breakdown period on the structures. Cracks in a structure may be hazardous due to static or dynamic loadings, so that crack detection plays an important role for structural health monitoring applications. Beam kind structures square measure being unremarkably utilized in steel construction and machinery industries. In the literature, several studies deal with the structural safety of beams, especially, crack detection by structural health monitoring. Studies based on structural health monitoring for crack detection deal with change in natural frequencies and mode shapes of the beam. The most common structural defect is the existence of a crack. Cracks are present in structures due to various reasons. The presence of a crack could not only cause a locally variation in the stiffness but it could affect the mechanical behavior of the entire structure to a considerable extent. Cracks may be caused by fatigue under service conditions as a result of the limited fatigue strength. They may also occur due to mechanical defects. Another group of cracks square measure initiated throughout the producing processes. Generally they are small in sizes. Such small cracks are known to propagate due to fluctuating stress conditions. If these propagating cracks stay unobserved and reach their essential size, then a sudden structural failure may occur. Hence it is possible to use natural frequency measurements to detect cracks. In the present investigation a number of literatures published so far have been surveyed, reviewed and analyzed. Most of researchers studied the impact of single crack on the dynamics of structures. However in actual practice structural members such as beams are highly susceptible to transverse cross-sectional cracks due to fatigue. Therefore to attempt this been created to analyze the dynamic behavior of basic structures with crack.

II. LITERATURE REVIEW

Marjan Djidrov [1] damages and therefore cannot to be guaranteed definite fault free operational mode and successful exploitation. In this paper, vibration analysis and frequency response analysis of cantilever beam with guaranteed electricity electrical device area unit bestowed by exploitation finite element method in finite element analysis software ANSYS. Cantilever beam vibration response area unit analyzed and numerical results of unimpaired beam model area unit compared to totally different eventualities of harm presence in structure, by location and depth of single transversal crack. Technique relies on the thought, if a crack appears in mechanical structure, this can be recognized as changes in the physical properties, which leads to cause changes in the modal properties of the structure.

Prathamesh M. Jagdale et al. [2] The Development of cracks may affect in the physical properties of a structure which introduces flexibility, and thus reducing the stiffness of the structure with an inherent reduction in modal natural frequencies. Consequently it results in the modification within the dynamic response of the beam. In this paper, A model for free vibration analysis of a beam with an open edge crack has been studied. Variations of natural frequencies because of crack at numerous locations and with variable crack depths are studied. Most of the members of engineering structures operate below loading conditions, which may cause damages or cracks in overstressed zones. The presence of cracks in an exceedingly support, such as a beam, causes local variations in stiffness, the magnitude of which mainly depends on the location and depth of the cracks.

Abhijit Naik [3]The objective of this paper is to update its readers the various vibration based Crack/damage diagnosis techniques bestowed by numerous researchers for a cracked structures. These study use "finite component analysis techniques, together with experimental results, to detect damage in a fibre reinforced composites, laminated composites and non composite structures for its vibration analysis. Damage in structure changes its dynamic characteristics. It ends up in reduction of natural frequencies and changes in mode shapes, stiffness of the beam. An analysis of these changes makes it possible to determine the position and depth of cracks.

Priyanka P. Gangurde [4] Vibration refers to mechanical oscillations about an equilibrium point. The oscillations is also periodic like the motion of a apparatus or random like the movement of a tire on a gravel road. A crack in an exceedingly support introduces native flexibility that will have an effect on vibration response of the structure. It is used to detect existence of a crack together its location and depth in the structural member. The presence of a crack in an exceedingly support alters the native compliance that will have an effect on the vibration response below external masses. However, once the displacements area unit massive, linear beam theory fails to accurately describe the dynamic characteristics of the system. These massive displacements cause geometric and different nonlinearities to be important. The nonlinearities couple the modes of vibration and can lead to modal interactions where energy is transferred between modes

Gade Ganesh G [5] This paper discusses the crack detection of cantilever beam using the various vibration based Crack/damage diagnosis techniques presented by various researchers for cracked structures. These study use "Mathematical analysis, finite component analysis techniques, at the side of experimental results, to detect damage in a cantilever beam for its vibration analysis. Damage in structure alters its dynamic characteristics. It results in minimization of natural frequencies and changes in mode shapes, stiffness of the beam. An analysis of these changes makes it possible to determine the location and depth of cracks.

K. B. Waghuld et al. [6] Vibration analysis of a beam is an important and peculiar subject of study in mechanical engineering. Many developments are disbursed so as to undertake to quantify the consequences made by dynamic loading. Examples of structures wherever it's notably vital to contemplate dynamic loading effects area unit the development of tall buildings, long bridges under wind-loading conditions and buildings in earthquake zones, etc. Dynamic structures subjected to periodic masses compose a awfully vital a part of industrial machineries. One of the major problems in these machineries is the fatigue and the cracks initiated by the fatigue. These cracks are the most important cause of accidents and failures in industrial machinery. Presence of the cracks may cause vibration in the system. Thus associate correct and comprehensive investigation concerning vibration of cracked dynamic structures appears to be necessary. On the base of these investigations the cracks can be identified well in advance and appropriate measures can be taken to prevent more damage to the system due to the high vibration level. Typical things wherever it's necessary to contemplate a lot of exactly the response made by dynamic loading area unit vibrations because of instrumentation or machinery, snatch loading of cranes, impulsive load produced by blasts, earthquakes or explosions. So it's vital to check the dynamic nature of structures.

III. OBJECTIVE

- Vibration Analysis of Cracked Cantilever beam.Natural Frequency of beam according to various parameters.
- Experimental determination of the natural frequency of Cracked beam with and without crack.
- Determination of the natural frequency of Cracked beam with and without crack by using FEA.
- Determination of effect cracks on natural frequency of Cracked beam.
- Vibration Analysis of Cracked Cantilever beam.
- Natural Frequency of beam according to various parameters.

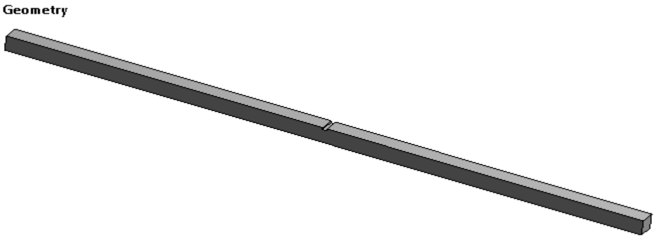
IV. METHODOLOGY

Using the knowledge from literature review, we can know how the CAD model is to be prepared. The conditions required for applying various constraints and how the loads are applied is briefed about in the technical papers referred.

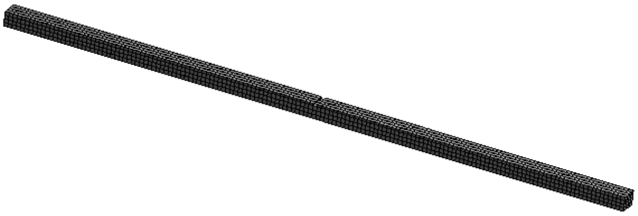
1. CAD Model Generation
   - Getting input data on dimensions cantilever lever beam
   - Creating 3D model in CATIA.
2. Determination of loads
   - Determination of different loads and boundary condition acting on the component by studying various ref papers, and different resources available
3. Testing and Analysis
   - Meshing the CAD model and applying the boundary conditions.
   - Solve for the solution of meshed model using ANSYS.
4. Fabrication, Experimental validation and Result
   - Fabrication of specimen
   - Suitable experimentation
5. Validation of result by comparing with software results.

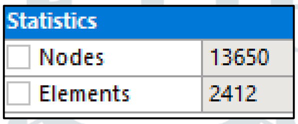
V. MODEL ANALYSIS OF BEAM

- **Geometry**



- **Mesh**

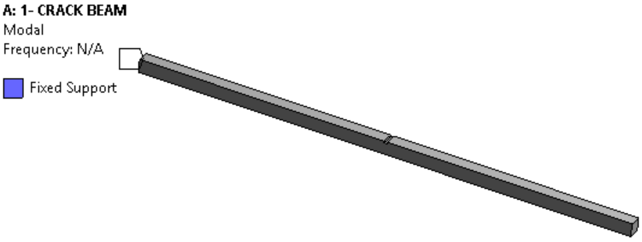


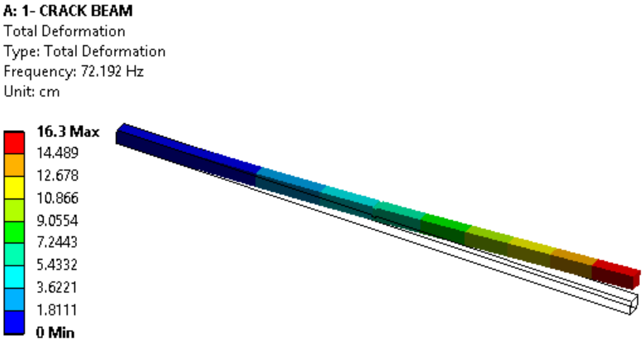


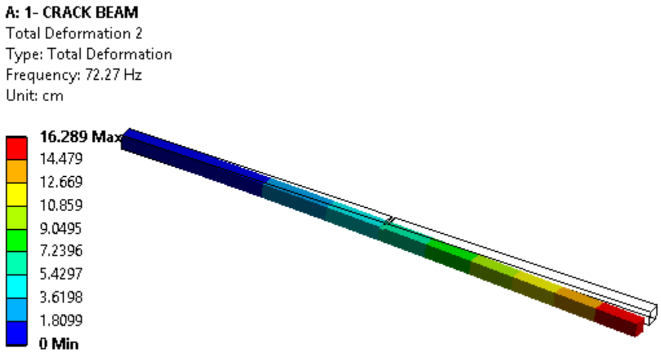
Statistics	
☐ Nodes	13650
☐ Elements	2412

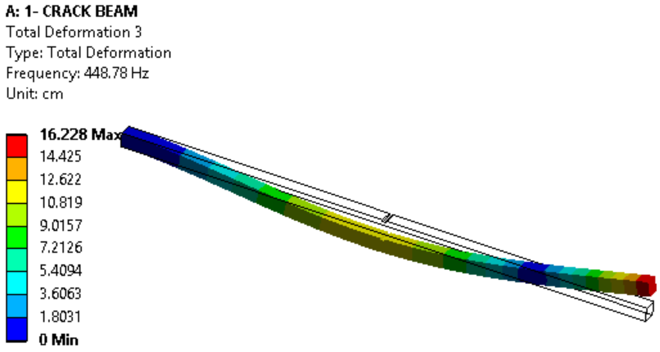
Figure1. Meshing of beam with single crack

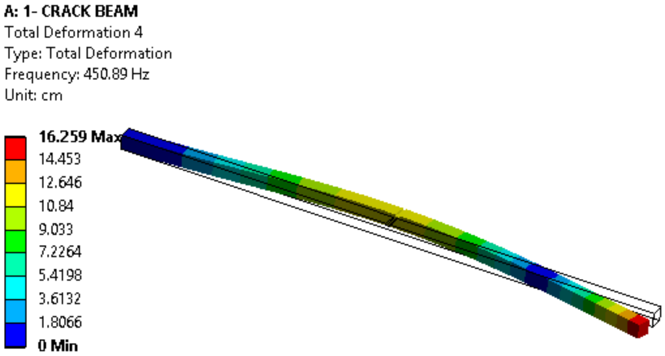
- **Boundary condition**

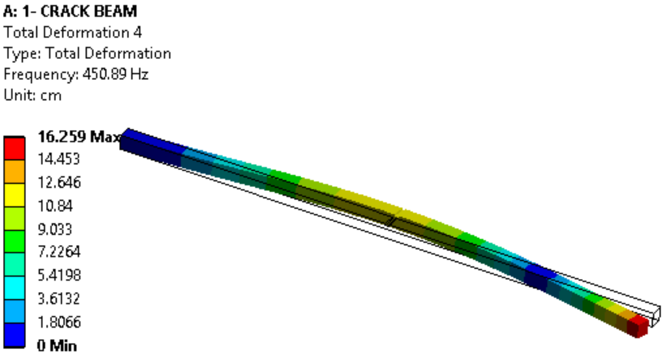


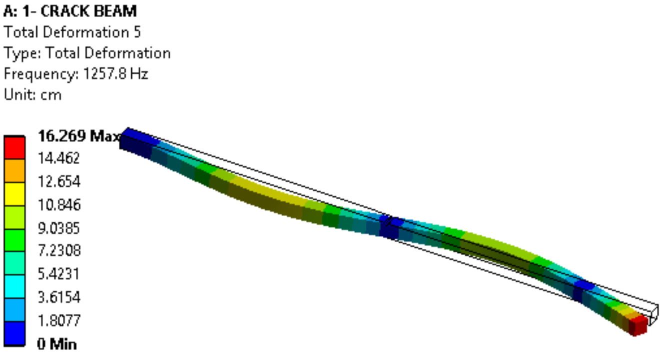


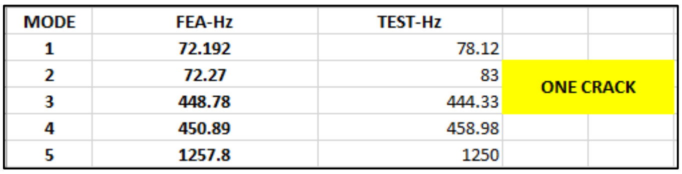




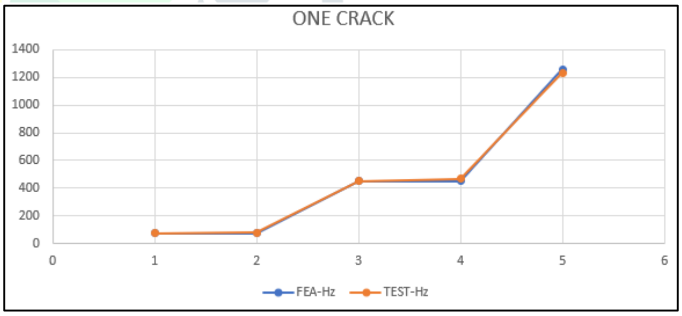




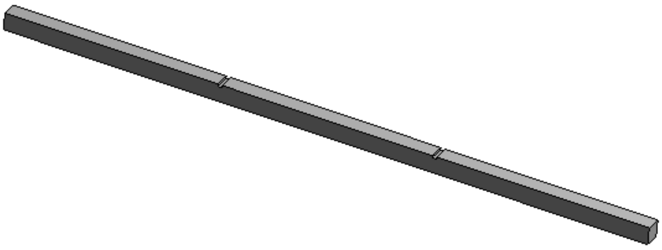


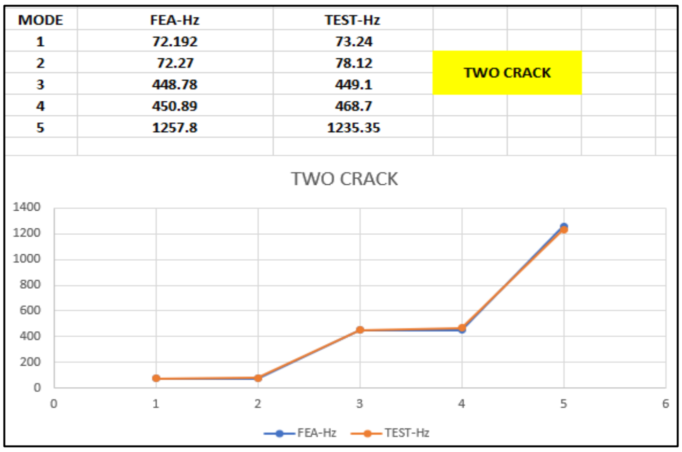


MODE	FEA-Hz	TEST-Hz	
1	72.192	78.12	
2	72.27	83	ONE CRACK
3	448.78	444.33	
4	450.89	458.98	
5	1257.8	1250	



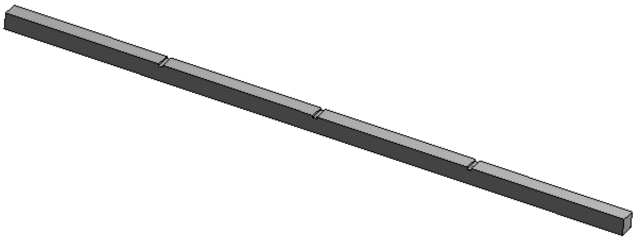
A. Model analysis of beam with two crack

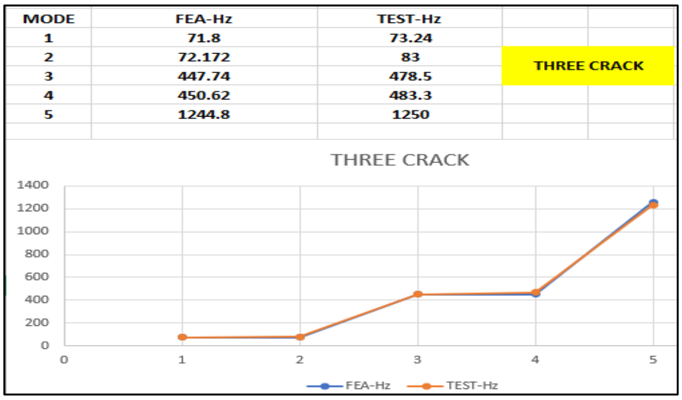




MODE	FEA-Hz	TEST-Hz	
1	72.192	73.24	
2	72.27	78.12	TWO CRACK
3	448.78	449.1	
4	450.89	468.7	
5	1257.8	1235.35	

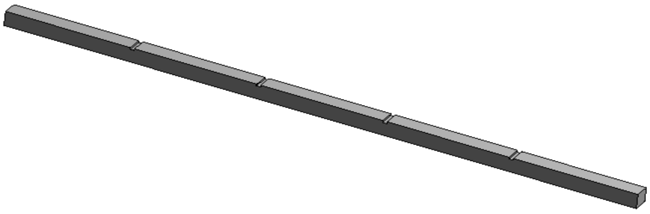
B. Model analysis of beam with three crack

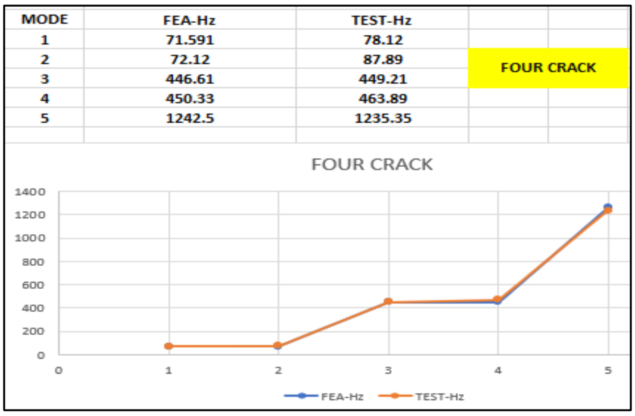




MODE	FEA-Hz	TEST-Hz		
1	71.8	73.24		
2	72.172	83	THREE CRACK	
3	447.74	478.5		
4	450.62	483.3		
5	1244.8	1250		

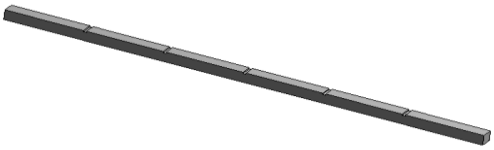
C. Model analysis of beam with four crack

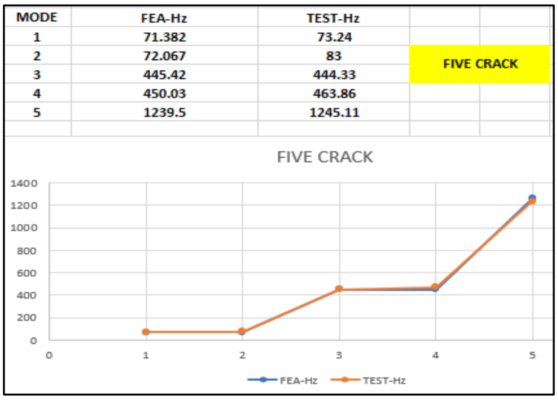




MODE	FEA-Hz	TEST-Hz		
1	71.591	78.12		
2	72.12	87.89	FOUR CRACK	
3	446.61	449.21		
4	450.33	463.89		
5	1242.5	1235.35		

D. Model analysis of beam with five crack

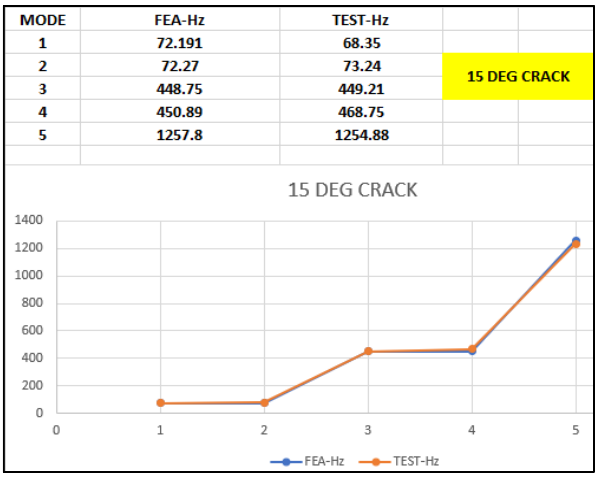




MODE	FEA-Hz	TEST-Hz	
1	71.382	73.24	
2	72.067	83	FIVE CRACK
3	445.42	444.33	
4	450.03	463.86	
5	1239.5	1245.11	

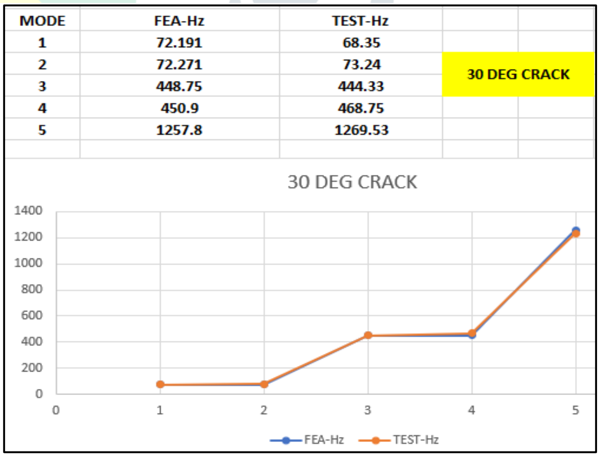
VI. ANGLE ORIENTED CRACKS

1. 15 DEGREE



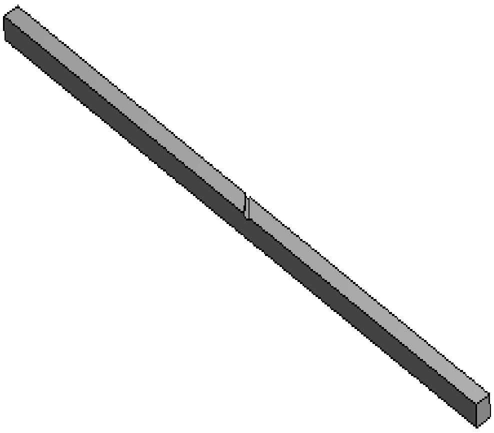
MODE	FEA-Hz	TEST-Hz	
1	72.191	68.35	
2	72.27	73.24	15 DEG CRACK
3	448.75	449.21	
4	450.89	468.75	
5	1257.8	1254.88	

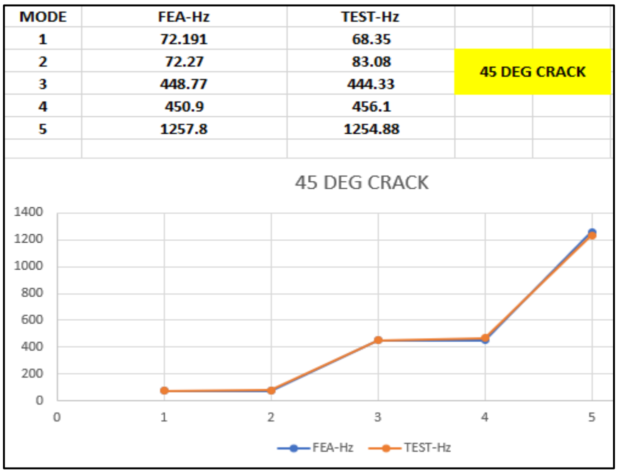
2. 30 DEGREE



MODE	FEA-Hz	TEST-Hz	
1	72.191	68.35	
2	72.271	73.24	30 DEG CRACK
3	448.75	444.33	
4	450.9	468.75	
5	1257.8	1269.53	

3. 45 DEGREE

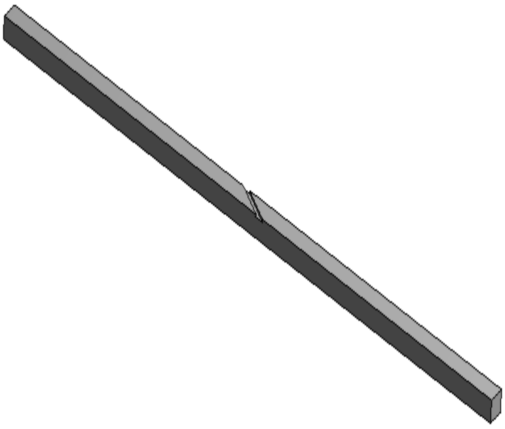


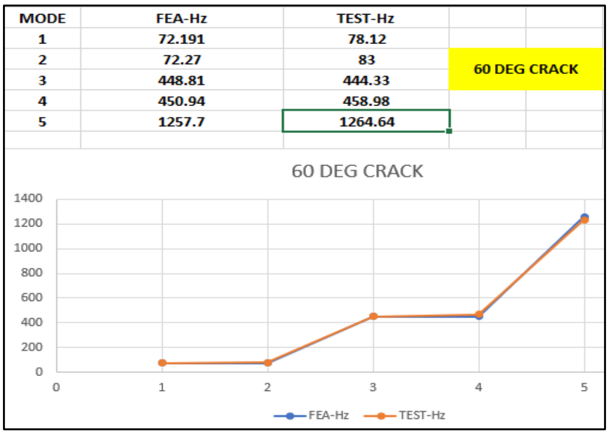


MODE	FEA-Hz	TEST-Hz
1	72.191	68.35
2	72.27	83.08
3	448.77	444.33
4	450.9	456.1
5	1257.8	1254.88

45 DEG CRACK

4. 60 DEGREE:





MODE	FEA-Hz	TEST-Hz
1	72.191	78.12
2	72.27	83
3	448.81	444.33
4	450.94	458.98
5	1257.7	1264.64

60 DEG CRACK

VII. FFT ANALYSIS

FFT is one main property in any sequence being used in general. To find this property of FFT for any given sequence, many transforms are being used. The major issues to be noticed in finding this property are the time and memory management. Two different algorithms are written for calculating FFT and Autocorrelation of any given sequence. Comparison is done between the two algorithms with respect to the memory and time managements and the better one is pointed. Comparison is between the two algorithms written, considering the time and memory as the only main constraints. Time taken by the two transforms in finding the fundamental frequency is taken. At the same time the memory consumed while using the two algorithms is also checked. Based on these aspects it is decided which algorithm is to be used for better results.

Figure 2: Experimental setup of FFT

Figure 3: Experimental setup of FFT

VIII. CONCLUSION

1. Model Frequency from FEA and FFT analyzer are in good relationship.
2. Shiftiness changes as crack generate in beam.
3. It has been observed that the changes in natural frequencies are the important parameter that determine crack size and crack location respectively.
4. In case of cracks the frequencies of vibration of cracked beams decrease with increase of crack depth for crack at any particular location due to reduction of stiffness.

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