



## Experimental and Numerical Analysis of Cracked Cantilever Beam

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**Abstract:** Beams are extensively utilized in various engineering application fields, like machinery, aerospace, automobile and else. Crack in the vibrant structure can lead to premature failure if it is not identified in early stages. The failure rate increases as the crack growth increases due to the structure becoming weaker. Therefore, crack identification and type is a key issue. The existence of crack which influences the performance of structure also because of the vibration parameter such as; natural frequencies, mode shapes, stiffness and modal damping. Our current investigation is to model a rectangular and angular edge crack in a cantilever beam and analyze the model using a finite element package, as well as an experimental approach. A finite element model has been developed to analyze the variation of modal parameters according to the location, size and angle of crack in the cantilever beam. The proposed method is predicated on measured frequencies and mode shapes of the beam.

**Index Terms -** cracked beam, rectangular crack, angular crack, crack location, crack depth, FEA, natural frequency.

### I. INTRODUCTION

Commonly utilized in steel construction and machinery industries, automobile, aerospace health monitoring and therefore the analysis of injury within the sort of crack in beam structures poses an important mean. Since long efforts are on their thanks to find a best solution for crack detection in beam structures during this regard many approaches have thus far been taken place. When a structure suffers from damages, its dynamic properties can change with time. Crack damage results in decrease stiffness also with an inherent reduction in natural frequency and increase in modal damping. The work gives a feasible relationship between the modal natural frequency and thus the crack depth at different location. The free vibration analysis has frequently become a subject of the many studies therefore attention is concentrated on it only. Crack localization and sizing during a beam from the free and mode response measurements method. Beam theory is employed for modeling transverse vibrations. Finite Element Method is employed for the free and generated vibration analysis of the cracked beam and open transverse crack is chosen for the crack model. Repetition begins in nature. Estimates of crack depth ratio and repetition estimate crack location and crack depth up to the desired convergence has been reached for both. In the commonest terms, damage is often defined as changes appearing during a system which will affect its current or future performance. From this definition of injury once can see that damage isn't meaningful without a comparison between two different states of the system, one among which is assumed to represent the initial state, and thus the opposite the damaged state. The definition of injury also can be limited to changes to the fabric and geometric properties of the system, including changes to the boundary conditions and system connectivity, which adversely affect the present or future performance of that system. The basic premise in modal analysis based damage detection is that damage will significantly change the stiffness, mass, or energy dissipation properties of a system, which successively, modifies the measured dynamic response of the system. The most challenging aspects of modal analysis based damage detection are that damage is typically a local phenomenon and may not significantly influence the lower-frequency response of the structure that is normally measured during Fast Fourier Transform analyzer tests.

### II. LITERATURE REVIEW

Sadettin Orhan et.al [3] had investigated the beam with a transverse edge crack is fixed at one end, free at opposite end and it has a uniform structure with a constant rectangular cross-section. The Euler-Bernoulli beam model was assumed. The crack is assumed to be an open crack. Nitesh A. Meshram et. Al [4] describes FEA of a cracked beam and analyzes the relation between the modal natural frequencies with crack depth, modal natural frequency with crack location. The material of beam is taken as aluminum. The free bending vibration of an Euler-Bernoulli beam is solved by the governing equation of motion. Ali A. Al-Saffar et. al [5] Studied the variations of depth, shapes and location of the crack on the natural frequency of cantilever circular shaft. The natural frequency of cracked and un-cracked cantilever aluminum shaft was measured experimentally. Issam Abu-Mahfouz [6] had investigated the application of the fuzzy clustering method using experimentally obtained vibration response data to predict the location of cracks in a cantilever beam. Signal processing techniques like Fast Hartley Transform (FHT) and Fast Fourier Transform (FFT) are used as features to for edge-detection using clustering with applications in infrastructure monitoring. Jinhee Lee et. Al [7] presented a method to detect a crack in a beam. The crack modeled as a mass less rotational spring. The inverse problem was solved repetitive for the crack location and therefore the crack size by the Newton-Raphson

method. The forces were derived from fracture mechanics expressions because the inverse of the compliance matrix is calculated using stress intensity factors and strain energy release rate expressions. Some of the paper explains different types of crack such as rectangular, angular crack. In angular type of crack there are different angles, Studied the variations of depth, shapes and location of the crack on the natural frequency of cantilever rectangular beam. The natural frequency of cracked and un-cracked cantilever aluminum shaft was measured experimentally. They find out the three finite element models using ANSYS. They are comparing the experimental and numerical results.

### III. PROBLEM STATEMENT

To identify the variation of shape, size and location of crack on the natural frequency of aluminum cantilever rectangular beam by numerical analysis and experimentally.

#### 3.1 Aim of project

The main aim of project is to understand the effect of crack shape, crack location and crack depth and natural frequency of cantilever beam using experimentation and numerical approach.

#### 3.2 Objectives of dissertation

1. To create finite element analysis model of cracked cantilever beam.
2. To create the experimental set up for to measure the natural frequency of cracked cantilever beam.
3. Finite element analysis model result validation by experiment through FFT analyzer.
4. Study the effect of crack size and location on natural frequencies.
5. To compare the experimental and numerical result.

### IV. EXPERIMENTAL SET UP

To measure the frequencies of the cracked cantilever beam, the accelerometer was utilized to obtain the response of the beam. Impact hammer was employed to excite the beam and an amplifier was used to amplify the accelerometer signal and send it, the output signal, to an oscilloscope. The experimental rig diagram is shown in Figure. 1. Crack position and crack depth are show in table 1.

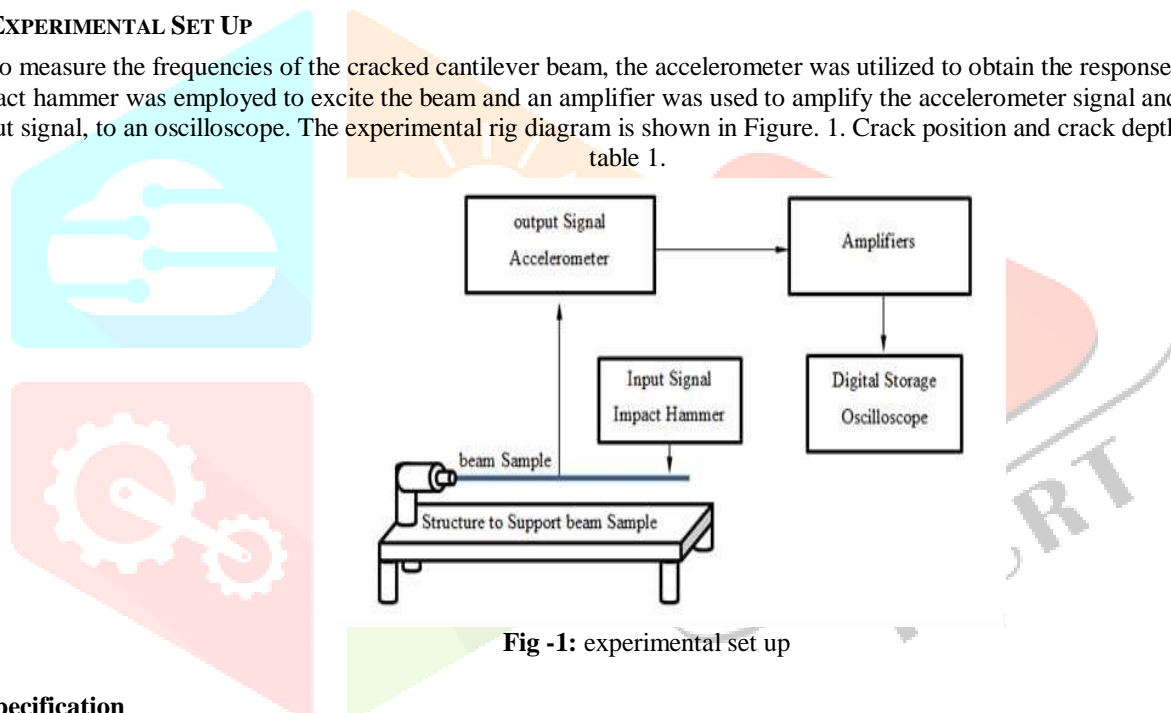


Fig -1: experimental set up

#### 4.1. Specification

Material of beam – Aluminum

Length – 300mm

Density of material –  $2700\text{kg/m}^3$

Cross section of beam –  $40 \times 30 \text{ mm}^2$

Young's modulus – 70 Gpa

Poisson ratio – 0.3

### V. FINITE ELEMENT ANALYSIS

The finite element analysis carried out using ANSYS finite element program for modal analysis of the rectangular and angular crack of cantilever beam to determine the natural frequencies and mode shape. In fig shows meshed model of beam.

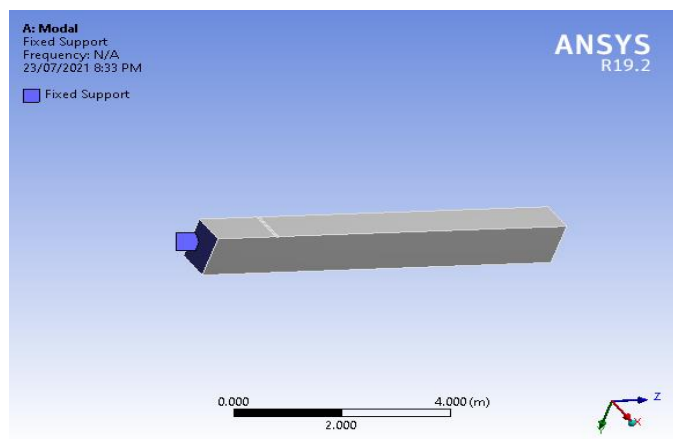


Fig -2: cantilever beam rectangular crack in ansys nature

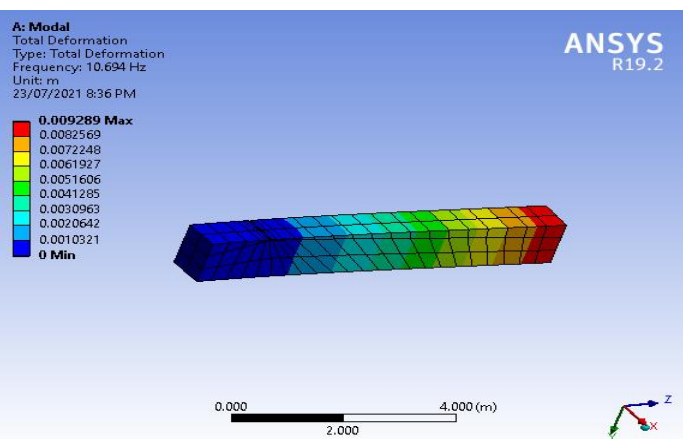


Fig -5: Second mode deformation of beam with crack at 50mm and depth 0.5mm

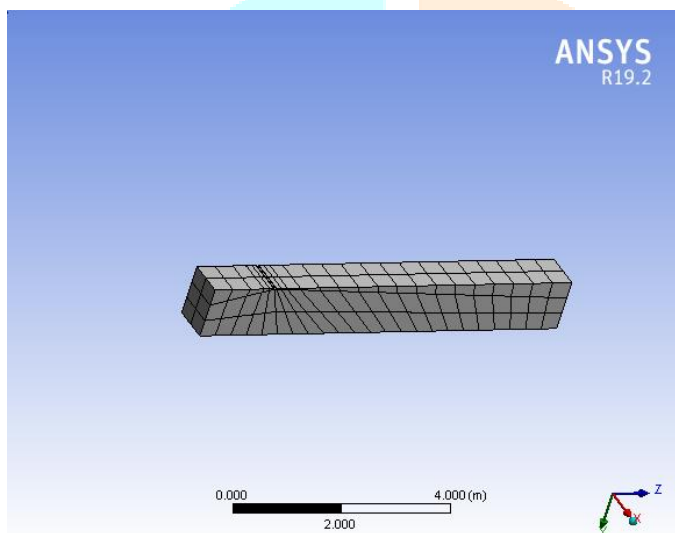


Fig -3: cantilever beam rectangular crack meshing

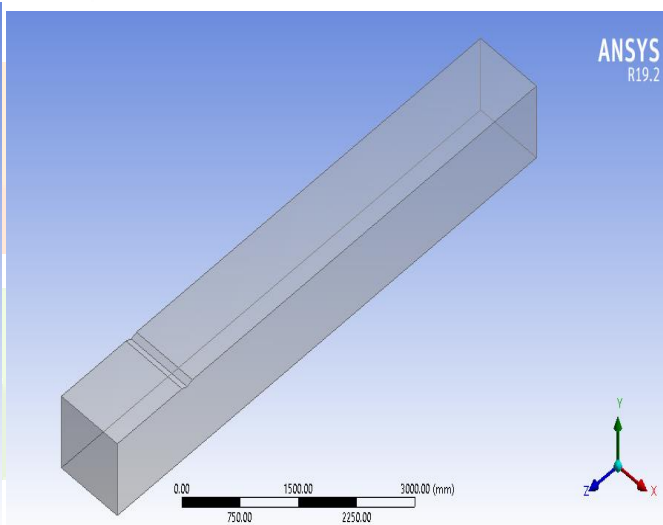


Fig -4: cantilever beam triangular crack in ansys nature

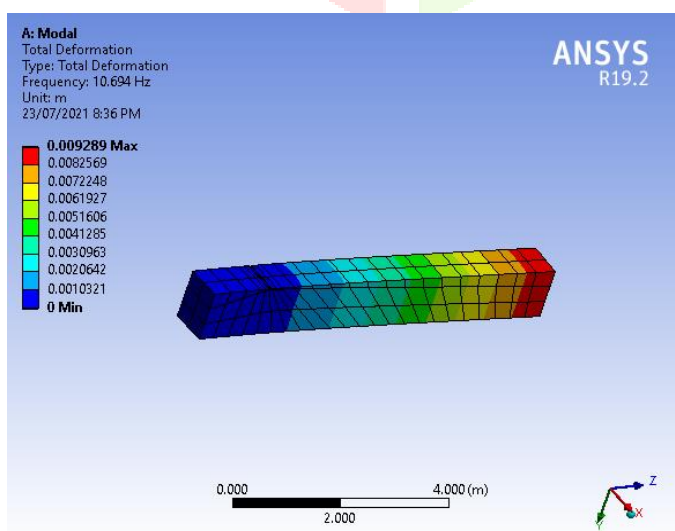


Fig -4: First mode deformation of beam with crack at 50mm and depth 0.5mm

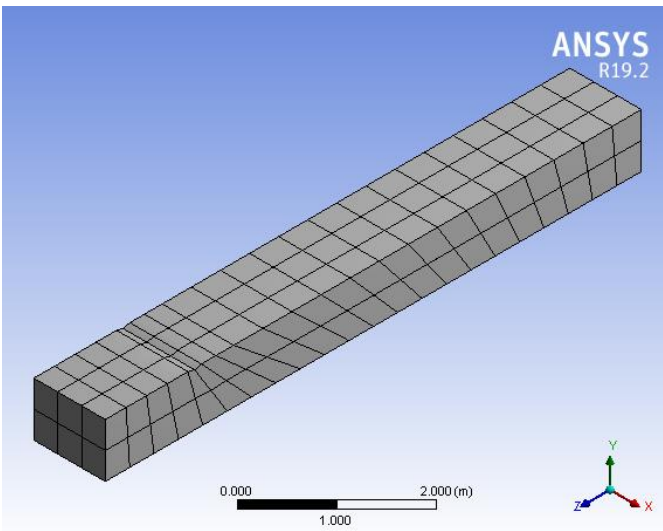


Fig -7: cantilever beam triangular crack meshing

### IV. RESULTS AND DISCUSSION

The comparison between experimental and numerical first mode of frequency when crack depth increase for different crack position. In first model first mode of frequency crack depth is increases then frequency is decreases. In second model first mode of frequency increases when the angle is rise. When the mode number increases the natural frequencies increase. As shown in chart 1 rectangular crack natural frequencies highly decreases, as compared to triangular crack. In triangular crack angle is rises then natural frequencies is also increases. In experimental model triangular crack 40 degree and experimental values are slightly close.

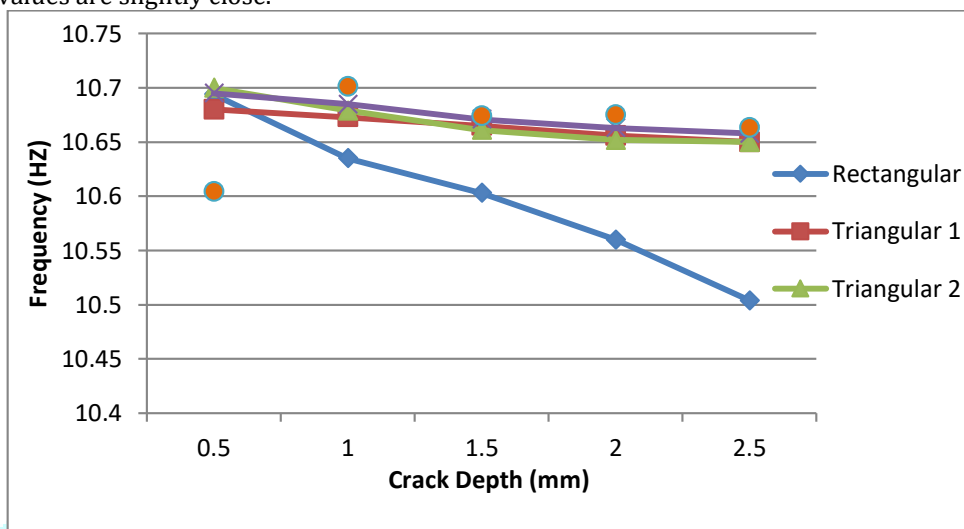


Chart -1: First mode of frequency against depth of crack, position of crack is 15 cm.

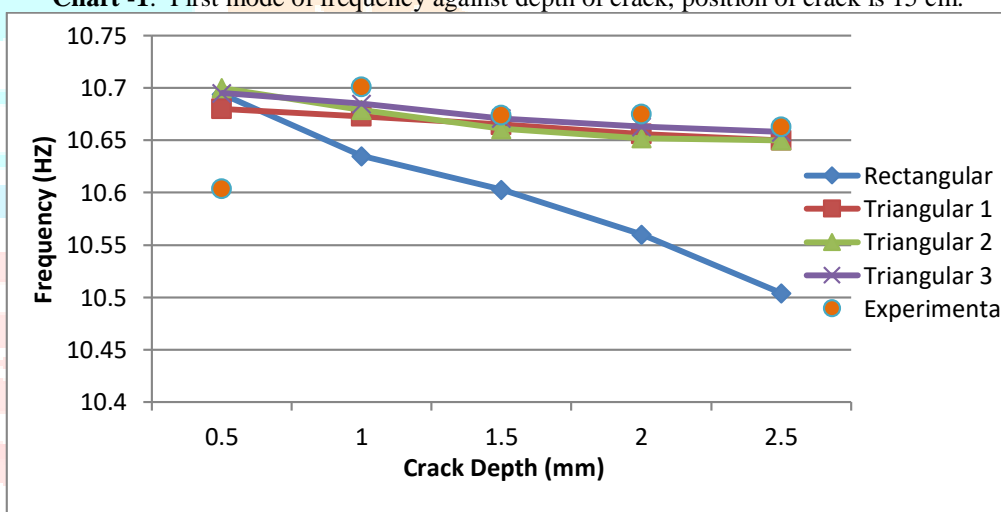


Chart -2: First mode of frequency against depth of crack, position of crack is 5 cm.

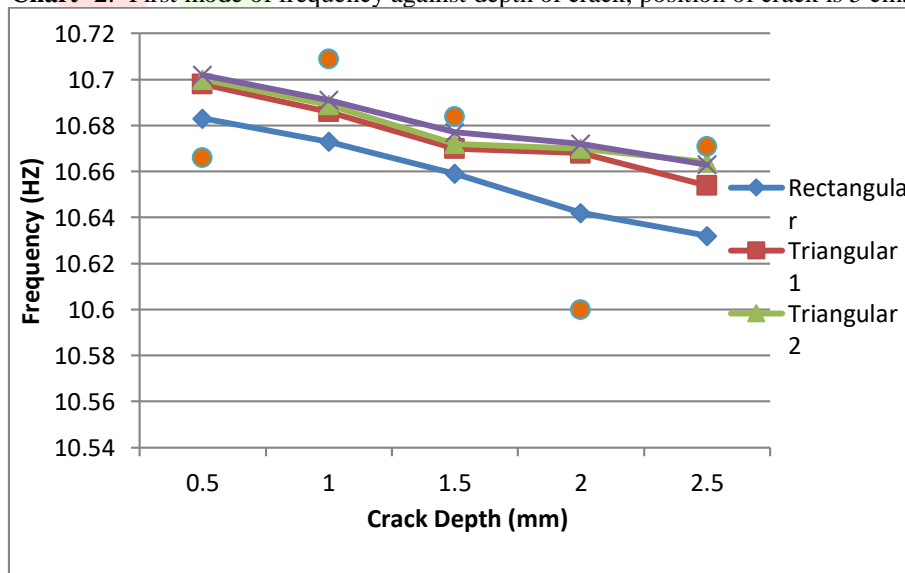


Chart -3: First mode of frequency against depth of crack, position of crack is 10 cm.

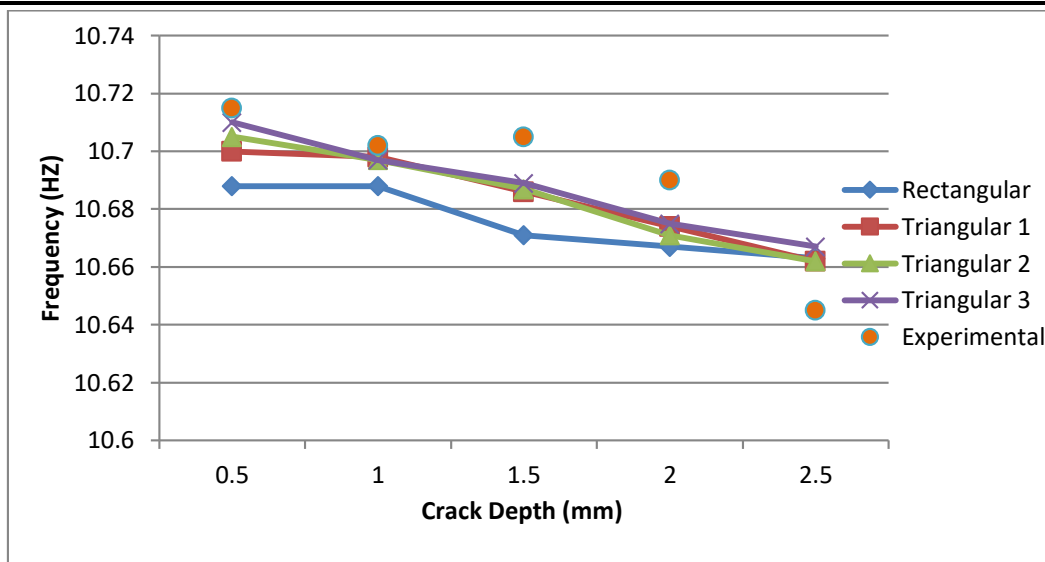


Chart -4: First mode of frequency against depth of crack, position of crack is 20 cm

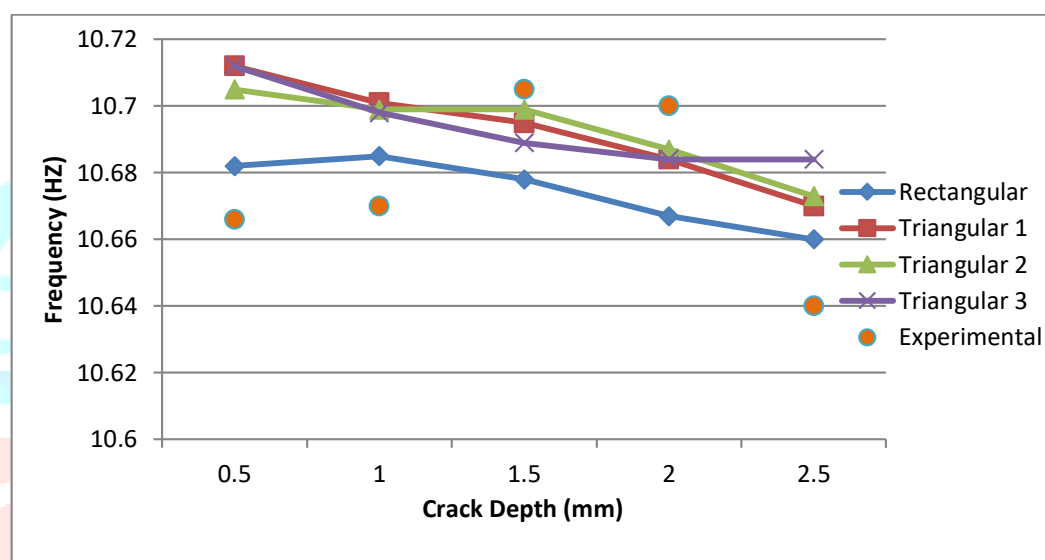


Chart -5: First mode of frequency against depth of crack, position of crack is 20 cm

**I. CONCLUSION**

II. The frequencies of cracked beam depend on the crack depth, when the crack depth increases the frequency decreases for the same mode number. When the mode number increases, the crack depth effects on the natural frequencies increase. In other word, the variation rate of natural frequencies increases when the mode number increases at the same crack depth. The frequencies of cantilever beam depend on the crack position, the first, second and third mode frequencies decreases when the crack lies close to the fixed end for the large crack depth. For the small crack depth, there is no effect of crack position on the first and second modes of frequencies. Finally, the triangular 3 model is suitable for crack simulation in shaft and the effect of crack angle (45 degree) is sharply appearing in this model.

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