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Comparison of Different Finite Element Method on Cracked Cantilever Beam Modal Analysis

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Abstract: Finite Element Analysis or Simulation software have been used widely in the world of engineering. Can different party transfer or share information with different software? In this study, a software comparison is being conducted. The study is on studying the presence of crack in a cantilever beam. The previous study uses ABAQUS as Finite Element Analysis software. For this study, ANSYS will be used for Finite Element Analysis software. Any structure with a crack is vulnerable to failure, depending on the mode of vibration. Failure is caused by the superposition of the frequency of the periodic force acting on the structure and the natural frequency of the structure. It is critical to determine natural frequency to be aware of resonance caused by periodic load. The natural frequency and mode shapes of transverse vibration for both un-cracked and cracked cantilever beams were extracted in this modal analysis study for the first three modes. For cracked beams, various crack depths, crack opening and crack locations are analyzed. In this study, it was discovered that the presence of a crack reduces natural frequency. The amount of reduction varies depending on the location, depth, and size of the crack opening. After the data has been extracted for ANSYS, it will be compared with the data obtained from previous studies which uses ABAQUS. It is found that the despite of a slight percentage discrepancy, both data collected share the same trend.

Keywords: Finite Element Analysis, Software, Comparison, Cantilever Beam, ANSYS

1. Introduction

In this fast-paced world, information transfer is happening in almost in an instant. There are many methods to transfer information. This is the same for analysis because there a many analyses software that are being used and has its own perks and features. It is important to ensure that analyzed data that is to be shared and transfer between two parties that uses different software for analysis to have a low percentage of discrepancies of the data collected and analyzed.

The objective of this study is to compare the data obtained from two finite element analysis software which is the ABAQUS software ANSYS software. The study will revolve

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around the study of effect of crack in cantilever beam. Previous study has conducted the analysis by using ABAQUS and this study will use the same parameter as previous study. With the same parameter, the analysis will be done by using ANSYS.

In addition to that, sustainability is a crucial practice that need to be develop. Now most studies conduct analysis by using finite element analysis software to study the behaviors on specific topics. Compared to experimental study, due to the advance element analysis software, it enables more in-depth analysis compared to that of experimental and reduces a lot in cost and material used.

2. Methodology

This section covers the research strategy, research technique, research methodology, data collection methods, research process, and data analysis. The study is carried out by gathering information from internet articles and other studies completed in the literature review to obtain the study's information and data, then determining all the parameters that are required and simulating using ANSYS, and finally collecting and analyzing all the data from the simulation.

The model of cantilever beam is done in ANSYS design modeler with the dimension of 3m x 0.25 m x 0.25m. The variables that are applied to the cantilever beam is the distance of crack from wall (0.5m, 1.0m, 1.5m, 2.0m, 2.5m), depth of crack (0.050m, 0.075m, 0.100m, 0.125m, 0.150m) and crack opening size (0.002m, 0.004m, 0.01m).

The cantilever beam will be under Mode 1, Mode 2 and Mode 3. Next, meshing will be done to the cantilever beam model with meshing size 0.3m. Then, the frequency data will be extracted first with an uncracked cantilever beam as a datum. Then, the variables will apply, and frequency data will be extracted for Mode 1, Mode 2 and Mode 3 that is applied on cantilever beam.

3. Results and Discussion

The results and discussion section presents data and analysis of the study. To recap the objectives of this study, it is to compare the data from two different software which is ABAQUS and ANSYS. As well as the effect of presence of crack in a cantilever beam.

3.1 Results

Table 1 shows a very small difference in the percentage of discrepancies for uncracked cantilever beams. The range of percentage discrepancies for all three modes is 0.31 percent to 0.33 percent. The graphs in Figure 3.3 clearly show a very slight difference between the results obtained from ABAQUS and ANSYS.

Table 1 Frequency of Uncracked Cantilever beam

Uncracked						
Mode	**1**	**Percentage Discrepancy %**	**2**	**Percentage Discrepancy %**	**3**	**Percentage Discrepancy %**
Previous	18.622	0.33	114.35	0.31	310.64	0.33
Finding	18.561		113.99		309.63	

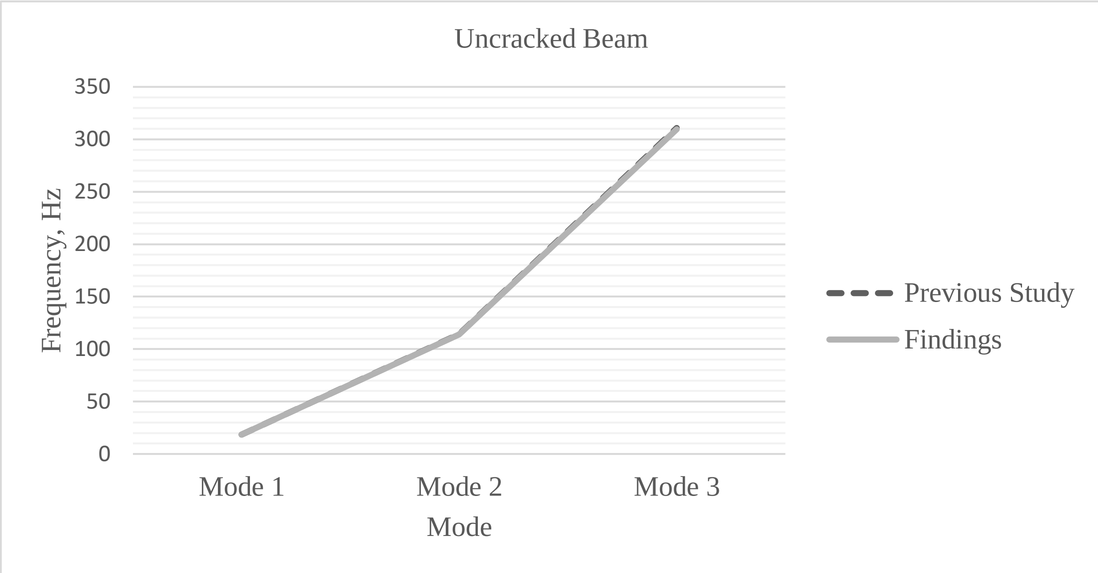

Figure 1 Graph of Frequency, Hz against Mode

Table 2 Frequency at Different Crack Opening

	Variable (Crack Opening)	Mode 1	Percentage Discrepancy %	Mode 2	Percentage Discrepancy %	Mode 3	Percentage Discrepancy %
Previous	0.002 m	17.917	1.06	99.513	2.42	310.080	0.28
Finding		17.727		97.105		309.200	
Previous	0.004 m	17.918	1.07	99.542	2.44	310.080	0.28
Finding		17.727		97.110		309.200	
Previous	0.01 m	17.919	1.16	99.587	2.69	310.080	0.29
Finding		17.711		96.906		309.180	

From Table 2, the percentage of difference from the uncracked cantilever beam increases for different crack openings. According to a previous study that used the software ABAQUS, the frequency of Mode 1 and Mode 2 crack openings increases as crack opening size increases. In terms of Mode 3, the frequency appears to be constant and stable as crack opening increases. The frequency for Mode 1 and Mode 2 can be seen decreasing as crack opening size increases in the finding that uses the software ANSYS. In Mode 3, the frequency appears to decrease slightly as crack opening increases.

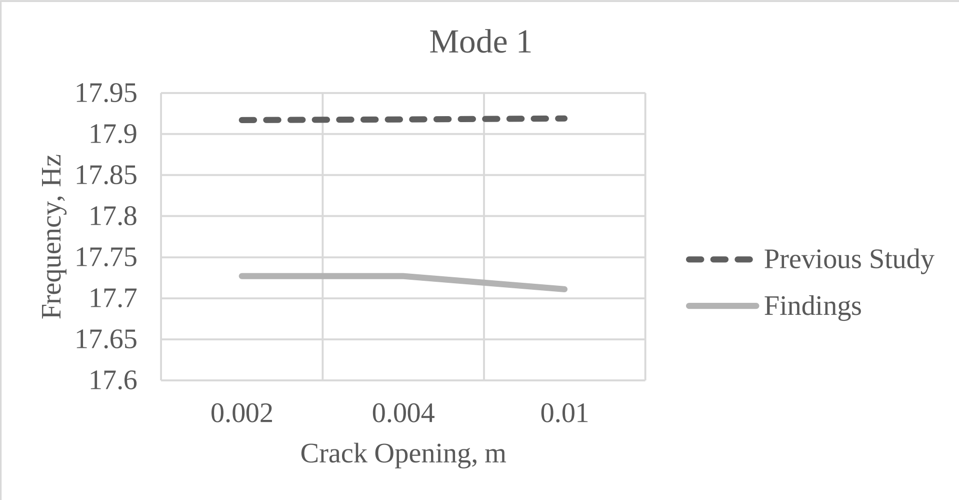

Figure 2 Graph of Frequency, Hz against Crack Opening, m for Mode 1

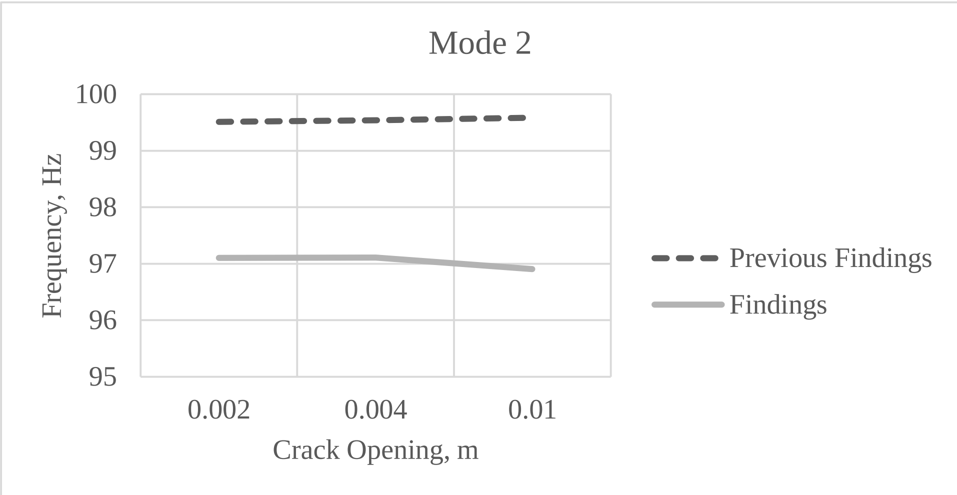

Figure 3 Graph of Frequency, Hz against Crack Opening, m for Mode 2

The percentage discrepancy range for Mode 1 is 1.06 percent to 1.17 percent. The percentage discrepancy range for Mode 2 is 2.42 percent to 2.69 percent. An increase in the difference between Modes 1 and 2. However, the percentage difference between Mode 3 and Mode 1 and Mode 2 is very small. For Mode 3, the percentage discrepancy ranges from 0.28 to 0.29 percent.

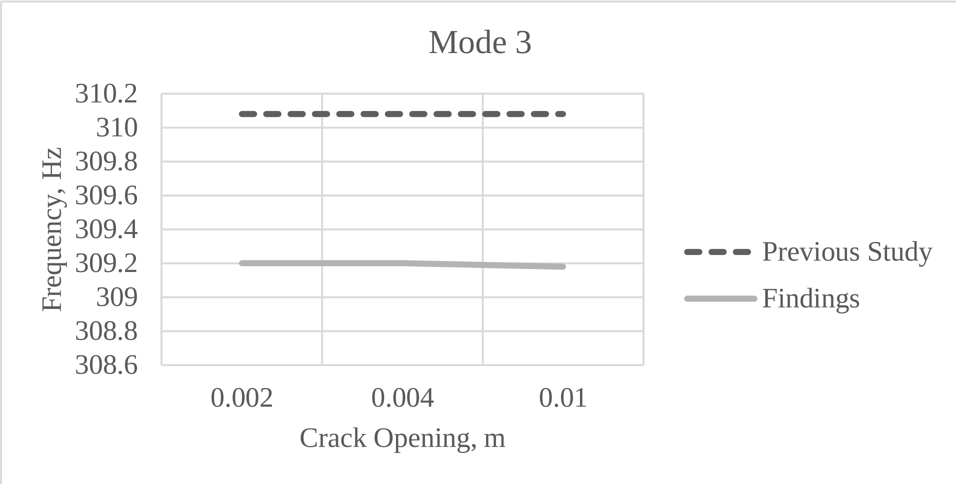

Figure 4 Graph of Frequency, Hz against Crack Opening, m for Mode 3

Table 3 Frequency at Different Crack Location

	Variable (Crack Location)	**Mode 1**	**Percentage Discrepancy %**	**Mode 2**	**Percentage Discrepancy %**	**Mode 3**	**Percentage Discrepancy %**
Previous	0.500 m	15.686	3.12	112.980	0.43	305.750	0.59
Finding		15.196		112.490		303.940	
Previous	1.000 m	16.936	1.90	108.770	1.01	280.810	1.72
Finding		16.615		107.670		275.990	
Previous	1.500 m	17.917	1.06	99.513	2.41	310.080	0.28
Finding		17.727		97.110		309.200	
Previous	2.000 m	18.437	0.45	102.650	2.12	274.090	1.87
Finding		18.354		100.470		268.970	
Previous	2.500 m	18.600	0.28	112.280	0.64	285.660	1.99
Finding		18.548		111.560		279.970	

The percentage discrepancy in frequency in Mode 1 decreases as the crack location increases from 0.5m to 2.5m. The percentage of discrepancies for Mode 1 ranges from 3.12 percent to 0.28 percent.

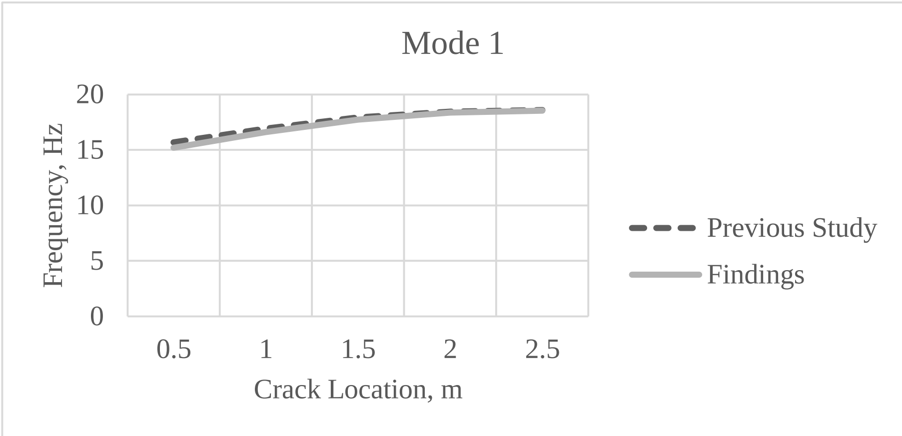

Figure 5 Graph of Frequency, Hz against Crack Location, m for Mode 1

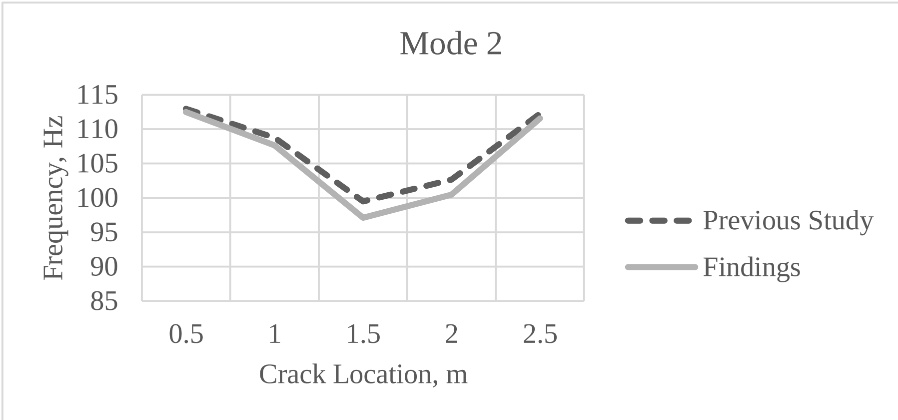

Figure 6 Graph of Frequency, Hz against Crack Location, m for Mode 2

The percentage discrepancy for Mode 2 is the highest at 1.5 m crack location, which is 2.41 percent. However, the percentage of discrepancy at crack locations of 0.5m and 2.5m is very small, at 0.43 percent and 0.64 percent, respectively.

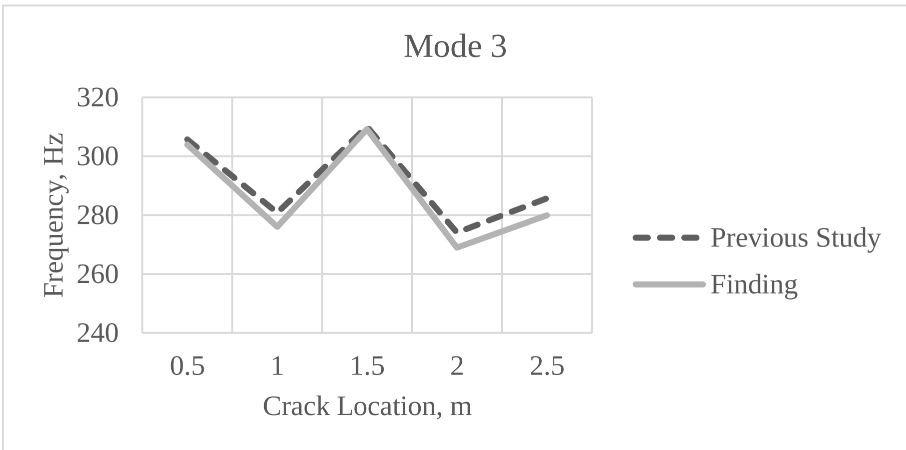

Figure 7 Graph of Frequency, Hz against Crack Location, m for Mode 3

The smallest percentage of discrepancy is shown at Mode 3, which is 0.28 percent at crack location 1.5m. The percentage discrepancy is greatest at 2.5m crack locations, which is 1.99 percent.

Table 4 Frequency at Different Crack Depth

	Variable (Crack Depth)	Mode 1	Percentage Discrepancy %	Mode 2	Percentage Discrepancy %	Mode 3	Percentage Discrepancy %
Previous	0.050 m	18.200	0.19	112.750	0.12	302.360	0.20
Finding		18.166		112.610		301.750	
Previous	0.075 m	17.733	0.82	110.680	0.00	293.740	0.83
Finding		17.588		110.680		291.290	
Previous	0.100 m	16.936	1.90	107.670	0.00	280.810	1.72
Finding		16.615		107.670		275.990	
Previous	0.125 m	15.471	3.25	103.160	0.00	261.180	2.18
Finding		14.968		103.160		255.480	
Previous	0.150 m	13.210	7.37	99.175	2.04	238.640	2.69
Finding		12.236		97.155		232.230	

Table 4 shows how different depths at the same crack location and crack opening affect frequency. At Mode 1, it can be seen that at crack depth 0.15m, the highest frequency of all variables is 7.37 percent. As the depth of the cracked cantilever beam increases, so does the percentage discrepancy.

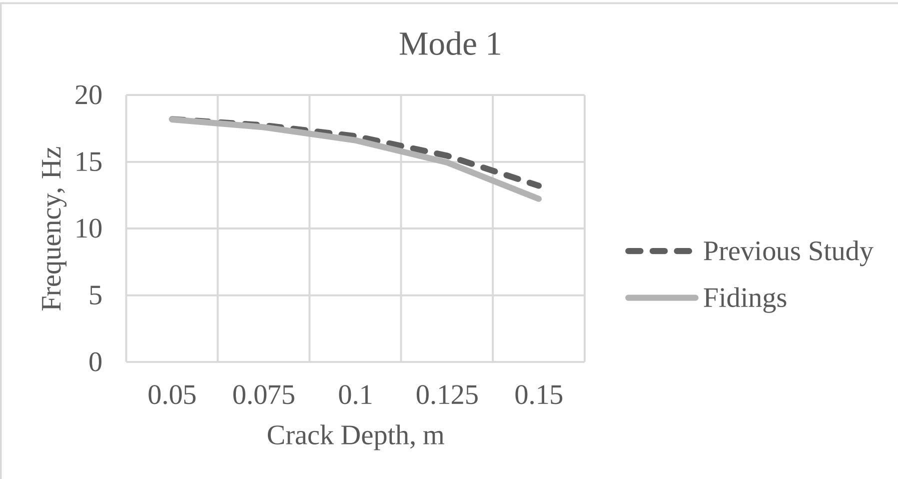

Figure 8 Graph of Frequency, Hz against Crack Depth, m for Mode 1

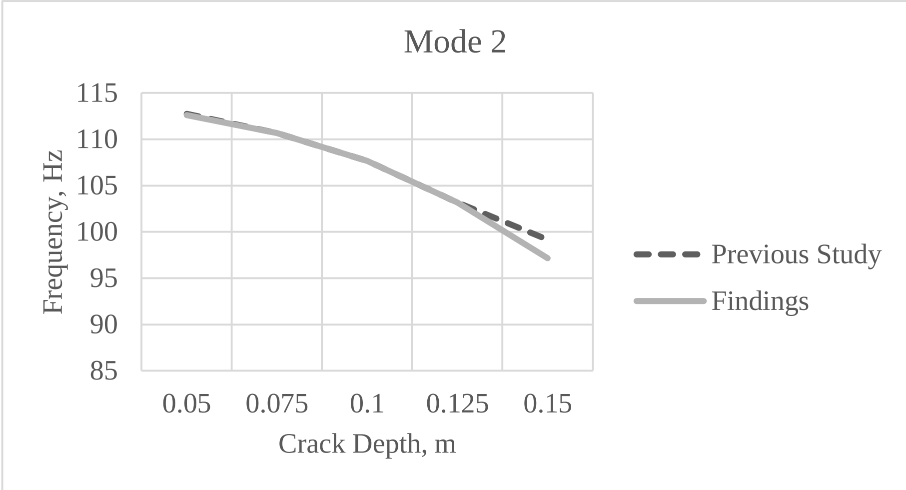

Figure 9 Graph of Frequency, Hz against Crack Depth, m for Mode 2

The data obtained in mode 2 are more interesting, with 0% discrepancies at crack depths of 0.075m, 0.1m, and 0.125m. However, the percentage of discrepancies at crack depths of 0.05m and 0.15m is 0.12 percent and 2.04 percent, respectively.

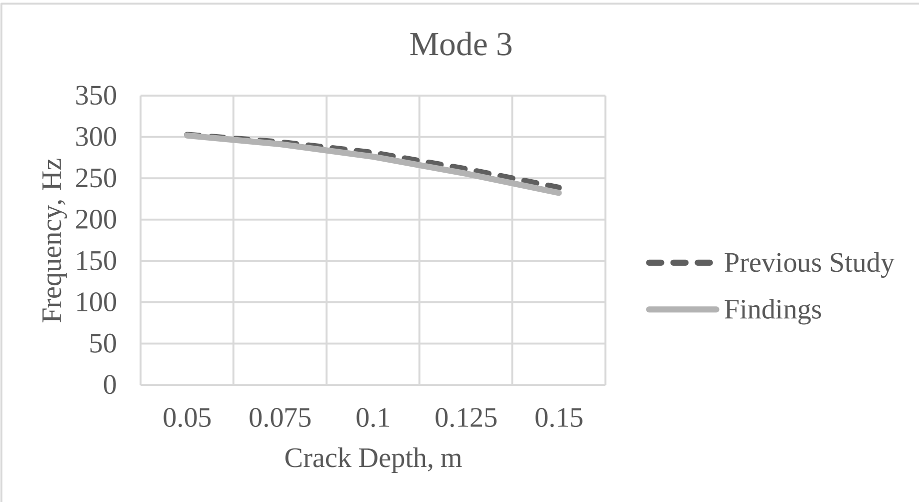

Figure 10 Graph of Frequency, Hz against Crack Depth, m for Mode 3

Mode 3 appears to follow the same trend as Mode 1 in that the percentage of discrepancies increases as crack depth increases, from 0.20 percent to 2.69 percent.

4. Conclusion

In conclusion the highest percentage of discrepancy of results obtain between ABAQUS and ANSYS is 7.37 %. This is where the variable is the depth of cracked at Mode 1. The least percentage of discrepancy is as low as 0%. In other words, they yield the exact same result. This is as well where the variable is depth of cracked for Mode 2. Despite the percentage discrepancies between previous study and current study which is ABAQUS and ANSYS respectively, they share the same trend for all the variables that are set for the Cantilever Beam. Natural frequency reduces due to the presence of cracks. The amount of reduction depends on the location and size of the cracks. For a certain crack location, the natural frequency of a cracked beam is inversely proportional to the crack depth. For a certain crack depth, change in natural frequency is less as the crack position moves away from the fixed end. Effect of crack opening size on frequency becomes significant as crack opening size decreases. Effect of crack is not same for all mode of vibrations

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