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Analyze the Effects of Cracks on Natural Frequency and Trends of Deformation on Cantilever Beam by ANSYS

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Abstract: *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 type structures are being commonly used in steel construction and machinery industries. 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 are initiated during the manufacturing processes. Generally they are small in sizes. Such small cracks are known to propagate due to fluctuating stress conditions. If these propagating cracks remain undetected and reach their critical size, then a sudden structural failure may occur. The cracks present in the structure interrupt the continuity of the assembly in most of the engineering structures like beam, columns in which geometrical properties can also be altered. Cracks caused due to fatigue stresses or stress concentration reduces the natural frequency and change mode of vibration due to local flexibility induced by the crack. All these effects due to concentrated cracks have been exclusively discussed in this work. A crack is modeled by describing the variation of the stiffness matrix of the member in the vicinity of a crack. The presence of a crack in a structural member introduces a local compliance that affects its response to varying loads. The change in dynamic characteristics can be measured and lead to identification of structural alteration, which at the end finally might lead to the detection of a structural flaw.*
So it becomes very important to monitor the changes in the response parameters of the structure to access structural integrity, performance and safety, and to examine the effect of the crack to the natural frequency of beams.
Keywords*: Natural frequency, cracked beams, Ansys, Deformation of cracked beam cantilever beam*

1. Introduction

1.1 Preamble

Present chapter tells about the overview of cracks, and objectives of the research work and chapterisation of the thesis, the details of which are presented in upcoming sections.

1.2 Overview of Cracks

The presences of cracks change the physical characteristics of a structure, which in turn alter its dynamic response characteristics. Cracks in vibrating component can initiate catastrophic failures. Crack depth and location are the main parameters for the vibration analysis. So it becomes very important to monitor the changes in the response parameters of the structure to access structural integrity, performance and safety, and to examine the effect of the crack to the natural frequency of beams.
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 type structures are being commonly used in steel construction and machinery industries. 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 are initiated during the manufacturing processes. Generally, they are small in sizes. Such small cracks are known to propagate due to fluctuating stress conditions. If these propagating cracks remain undetected and reach their critical size, then a sudden structural failure may occur. The cracks present in the structure interrupt the continuity of the assembly in most of the engineering structures like beam, columns in which geometrical properties can also be altered. Cracks caused due to fatigue stresses or stress concentration reduces the natural frequency and change mode of vibration due to local flexibility induced by the crack. All these effects due to concentrated cracks have been exclusively discussed in this literature. A crack is modeled by describing the variation of the stiffness matrix of the member in the vicinity of a crack. The presence of a crack in a structural member introduces a local compliance that affects its response to varying loads. The change in dynamic characteristics can be measured and lead to identification of structural alteration, which at the end finally might lead to the detection of a structural flaw.

Considering above mentioned facts, present research work is devoted to investigations of a concrete cracked beam. For this purpose a simulation approach is being utilized under which cracked beam models of different dimensions and different crack locations are analyzed for natural frequencies and deformations at six different modes of vibration. The material used for the this purpose was M20 concrete and the software used was ANSYS 14.0.

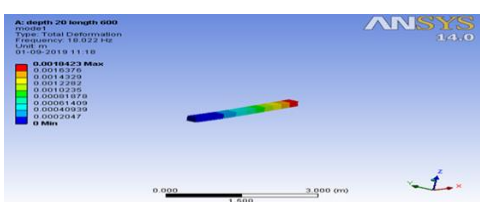
1.3 Objectives of the Research

Following are the objectives of present research work.

1. To analyze the trend of natural frequencies in cracked beams; and

2. To analyze the trend of deformations in cracked beams.

2. Results and Discussion



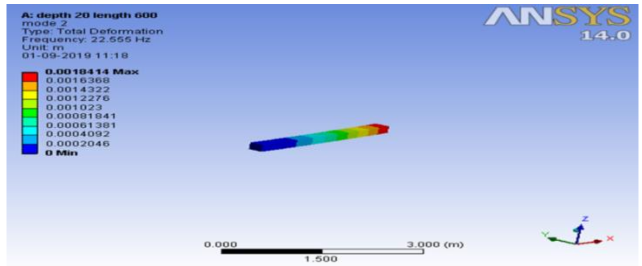


Fig. 1 Results of modal analysis for beam length 600 mm and depth 20 mm.

Table 1 Summary of Results for beam length 600 mm and depth of 20 mm

S. No	Mode number	Frequency (Hz)	Maximum deformation (mm)
1.	First	18.022	0.0010423
2.	Second	22.555	0.0018414
3.	Third	111.31	0.0018392
4.	Forth	137.3	0.001836
5.	Fifth	234.06	0.0022604
6.	sixth	301.94	0.0018334

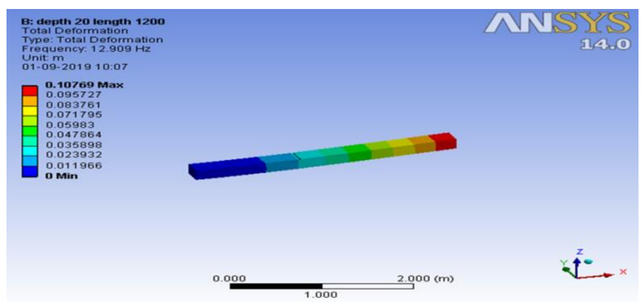


Fig. 2 Mode shapes for beam length 1200 mm and depth of 20 mm

Table 2 Summary of Results for beam length 1200 mm and depth of 20 mm

S. No	Mode number	Frequency (Hz)	Maximum deformation (mm)
1.	First	12.909	0.10769
2.	Second	16.129	0.10758
3.	Third	79.296	0.10707
4.	Forth	98.163	0.10716
5.	Fifth	175.97	0.13213
6.	sixth	216.1	0.1078

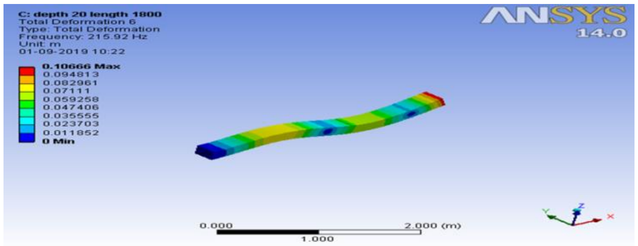


Fig.3 Mode shapes for beam length 1800 mm and depth of 20 mm

Table 3 Summary of Results for beam length 1200 mm and depth of 20 mm

S. No	Mode number	Frequency (Hz)	Maximum deformation (mm)
1.	First	12.934	0.1077
2.	Second	16.141	0.10759
3.	Third	79.187	0.10753
4.	Forth	98.113	0.10731
5.	Fifth	176.01	0.13224
6.	sixth	215.92	0.10666

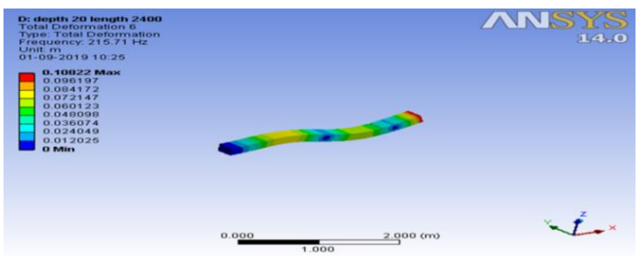


Fig. 4 Mode shapes for beam length 2400 mm and depth of 20 mm

Table 4 Summary of Results for beam length 2400 mm and depth of 20 mm

S. No	Mode number	Frequency (Hz)	Maximum deformation (mm)
1.	First	12.944	0.10767
2.	Second	16.148	0.1076
3.	Third	79.494	0.10775
4.	Forth	98.228	0.1074
5.	Fifth	176.13	0.13228
6.	Sixth	215.71	0.10822

3 Conclusion, Limitations and Future Scope of the Research

Present research work was focused on modal analysis of a concrete cantilever with cracks at different locations from the fixed end, during which maximum nodal frequencies and total deformations were investigated. Following are the conclusions drawn from the research work:

1. Natural frequency decreases with increase in span and notch depth; and
2. During the research work, focus was made on only two properties; and
3. Total deformation increases with increase in length of span and notch depth.

Following points represent limitations of the research work.

1. The research work focuses only on concrete beam of cantilever type; and
2. The research work is based on a set of notch depth values and spans.

Following points represent future scope of the research work.

1. A detailed research work consisting of a detailed set of beams may be started;
2. A detailed research on different types of beam materials may be initiated; and
3. A detailed research focusing on a broader set of properties can be initiated.

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