Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 6, Issue 2; April-June, 2019, pp. 62-64

http://www.krishisanskriti.org/Publication.html

Damage Detection of Frame Structures using Classical Method

Dr. Akil Ahmed[1], Mohd Moeed Akhtar[2] and Alhamd Farqaleet[3]

[1]Department of Civil Engineering, Jamia Millia Islamia
[2]PG Student, Department of Civil Engineering, Jamia Millia Islamia
[3]Research Scholar, Department of Civil Engineering, Jamia Millia Islamia
E-mail: [1]aahmed@jmi.ac.in, [2]moeed.jamia@gmail.com, [3]alhamd9lf@gmail.com

Abstract—*Damage detection of engineering structures and systems is an emerging research area that has drawn much attention to the engineers and researchers. Damage creates changes in stiffness, mass and damping of the structure, which in turn, results in changing mode shape and frequency - dynamic characteristics of the structure. In this paper, curvature mode shape method and natural frequency are used to detect damages in structures using SAP2000.*

Keywords*: damage detection, structural health monitoring, curvature mode shape, frequency, frame.*

1. INTRODUCTION

Damage detection in mechanical and civil structures is important for taking appropriate measures for repairing. This is a multidisciplinary research area and has drawn much interest from researchers of various fields [1 - 2]. Damage is often observed in civil engineering structures during their service life [2 - 5]. Damage is induced either through sheer deterioration over time or owing to excessive structural loads such as winds, earthquakes, or traffic. So the improvement of public safety and maintainability of new and existing structures is necessary [6 - 8].

Aircraft crashes, catastrophic failures in important structures happen due to improper structural health monitoring of structures. The detection of damages and its location and quantification is required for taking appropriate measures to avoid failures. Detecting, locating and quantifying the damage in the structures is a challenge for scientific community [3]. Different sensing techniques may be used to robustly and accurately detect, locate, and quantify the damages in structures [9 - 10].

2. METHODOLOGY

The following methodology has been adopted for getting curvature mode shape and frequency of the frame [11]:

a. A frame structure is modelled in SAP2000.

b. Acquisition of modal parameter from SAP2000

c. Mode shape curvature graph plot

d. By recording the sudden change in the mode shape curvature graph we will predict the location of damage.

e. Comparison between damaged and undamaged frequencies

Properties of materials used for modelling in SAP 2000:

Concrete: M30

Steel: Fe500

Size of beam: 500 mm x 300 mm

Size of column: 500 mm x 500 mm

Length of beam: 6 m

Height of column: 3.5m

E_{STEEL}=2.1 x 10^5 MPA

Damaged induced: 15 %

Size of damaged beam at the damaged location: 425 mm x 300 mm

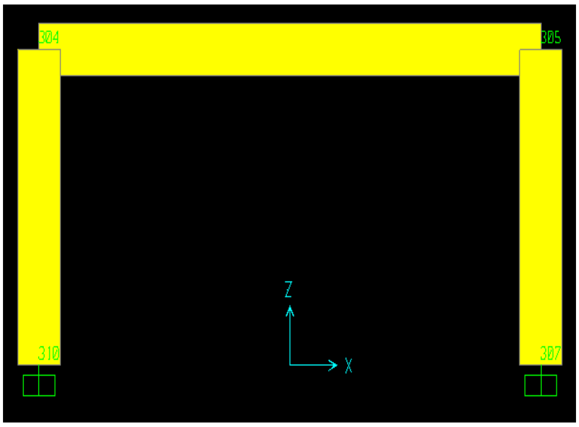

Figure 1: Undamaged frame

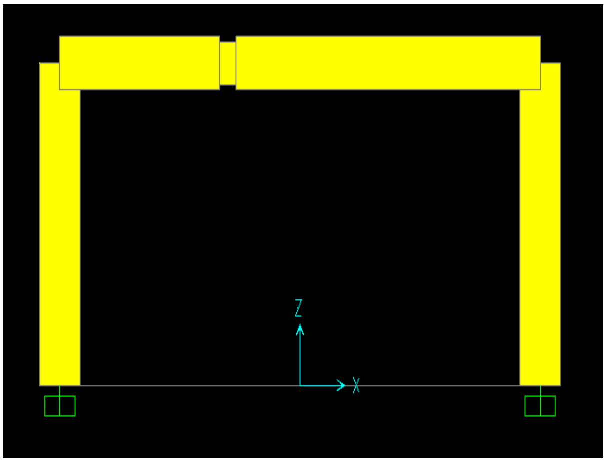

Figure 2: Damaged frame

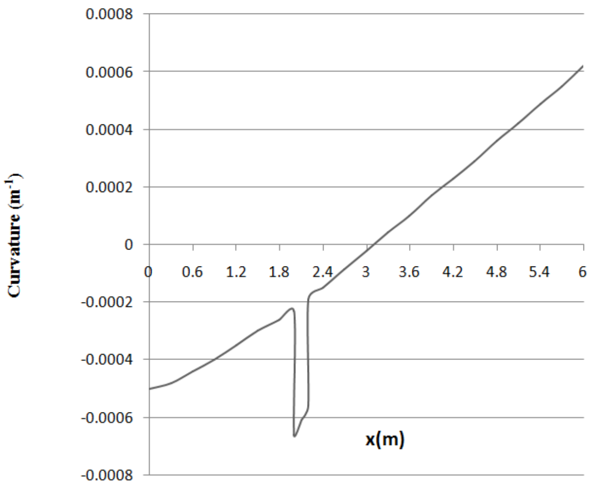

Figure 3: Curvature mode shape plot

3. RESULTS AND DISCUSSIONS

Mode shapes of an undamaged and of the corresponding damaged structure are identified and is numerically evaluated by a central difference approximation [7] (Table 1 and Figure 3). The natural frequency obtained for different modes of vibration of the damaged and undamaged frame from the analysis are presented here (Table 2 and Figure 4).

Table 1: Curvature mode shape

Distance (m)	Curvature (m^{-1})
0	-0.0005
0.3	-0.00048
0.6	-0.00044
0.9	-0.00040
1.2	-0.00035
1.5	-0.00030
1.8	-0.00026
2.0	-0.00023
2.0	-0.00066
2.1	-0.00061
2.2	-0.00056
2.2	-0.00019
2.4	-0.00015
2.7	-0.000085
3.0	0.000022
3.3	0.000042
3.6	0.00010
3.9	0.00017
4.2	0.00023
4.5	0.00026
4.8	0.00036
5.1	0.00042
5.4	0.00049
5.7	0.00055
6.0	0.00062

Table 2: Comparison of the natural frequency between damaged and undamaged frame of different modes

Damaged	Undamaged
6.6087	6.6996
10.859	11.078
14.035	17.061
26.569	20.391
29.318	31.734
58.412	160.67
76.271	165.86
82.318	188.56
85.535	325.91
96.875	336.38
107.77	468.32
129.6	1058.5

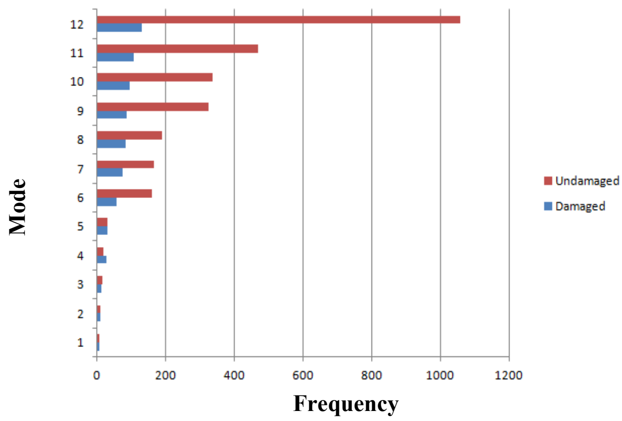

Figure 4: Natural frequency of different modes

4. CONCLUSION

Mode shape curvature method shows that the damage in a frame structure occurs at 2 m from the left showing the damage location. Mode shape curvature method is good to detect the damages when the variation in the curvature is high. Sometimes variation in curvature is so small that discontinuity cannot be judged, so mode shape curvature method proves to be a good tool to detecting damages under higher modes.

Frequency does not tell us exact location of damage but it shows the damaged frequency that decreases as compared to undamaged frequency because of stiffness of damage structure decreases.

REFERENCES

[1] Waldemar J. Rakowski (2017) “Wavelet approach to damage detection of mechanical systems” 7th International Conference on Engineering, Project, and production management. doi:10.1016/j.proeng.2017. 03.162

[2] Duk Jin Joo (2012), “Damage Detection and System Identification using a Wavelet Energy Based Approach”

[3] R.P.C. Sampaio, N. M. M. Maia and J.M.M. Silva (1999), “Damage detection using the frequency response function curvature method” https://doi.org/10.1006/jsvi.1999.2340

[4] Yusuke Mizuno; Evan Monroig; and Yozo Fujino (2008), “Wavelet decomposition-based approach for fast damage detection of civil structures”

[5] C M Hasrizam and Noor Fawazi (2017), “Damage identification based on curvature mode shape using cubic polynomial regression and chebyshev filters”

[6] X Liu, N. A. J. Lieven, P. J. Escamilla Ambrosio (2009), “Frequency response function shape-based methods for Structural damage localisation”

[7] B K Raghu Prasad, N Lakshmanan, K Muthumani and N Gopalakrishnan (2006) “Enhancement of damage indicators in wavelet and curvature analysis”

[8] Lin, T. K., S. L. Hung, And C. S. Huang (2012), "Detection of Damage Location Using A Novel Substructure-Based Frequency Response Function Approach With A Wireless Sensing System" International Journal of Structural Stability and Dynamics

[9] Li, Xuan, Ya Hui Wang, Lei Jiang, and Fan Fang Tang (2015) "Research on the Damage Identification of Weld Metal Cracking of Metal Structure Based on PVDF", Applied Mechanics and Materials

[10] Esfandiari, A. (2009), "Structural model updating using frequency response function and quasi-linear sensitivity equation" Journal of Sound and Vibration

[11] SAP2000, CSI, Berkeley, California, U.S.