16th INTERNATIONAL CONFERENCE
Dynamical Systems – Theory and Applications
December 6-9, 2021, On-line

Localization of changes in stiffness in numerical models of beams using additional masses

ARTUR BOROWIEC[1*]

1. Rzeszów University of Technology, Rzeszów, Poland [0000-0002-9475-3251]
* Presenting Author

Abstract: The paper presents the possibilities of developing a damage localization method that is not based on a reference model. The work presents examples of stiffness changes localization in numerical models of beam based on changes in natural frequency in combination with the Laplacian differential operator. The changes were caused by two additional masses moving on the nodes of the cantilever beam model.

Keywords: damage localization, eigenfrequencies, Laplacian differential operator

1. Introduction

Damage detection using modal analysis has been developed in civil engineering since the 1970s. Most modal diagnostics is based on changes in the natural frequency or the mode of natural vibrations. Most of the methods are based on a reference model for which the values of the dynamic parameters of an undamaged structure are known. In the work [1], for the location of the damage, a comparison of vibration curves with the use of a differential operator was used. Currently, methods without a reference model are also used [2]. In the article [3] was taking into account an additional parameter (mass, support), which made it possible to locate damage by analysing changes in the natural frequency with respect to its position.

The paper proposes the use of the Laplacian differential operator to evaluate the change in dynamic parameters caused by two masses in order to determine the position of stiffness changes in the beam model.

2. Results and Discussion

The numerical model of the considered cantilever beam (Fig.1) was built in the Matlab environment with FEM libraries from the Calfem package.

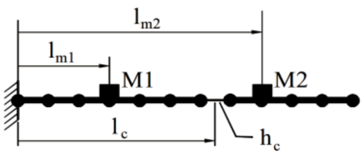

Fig. 1. Numerical model.

The simple model was constructed of 24 elements and contained of 25 nodes. During the analyzes, the eigenfrequencies ω_i were calculated for the selected locations of stiffness changes (l_c) and for the selected range of stiffness changes (h_c) with the masses (M1, M2) added at the nodes (l_{m1}, l_{m2}).

Department of Structural Mechanics, ul. Poznańska 2, 35-959 Rzeszów, artur.borowiec@prz.edu.pl

The obtained results include changes in the eigenfrequencies ω_i performed using discrete Laplacian approximation:

$$L\left(\omega_{l_{m1},l_{m2}}\right) = \frac{\omega_{l_{m1}+1,l_{m2}} - 2\omega_{l_{m1},l_{m2}} + \omega_{l_{m1}-1,l_{m2}}}{d_{l_{m1}}^2} + \frac{\omega_{l_{m1},l_{m2}+1} - 2\omega_{l_{m1},l_{m2}} + \omega_{l_{m1},l_{m2}-1}}{d_{l_{m2}}^2} \quad (1)$$

The results on Fig. 2a shows changes in second eigenfrequency ω_2 with stiffness reduction (40%) of the 14th element. The most significant changes of L(ω_2) were observed near location of stiffness changes (Fig. 2b).

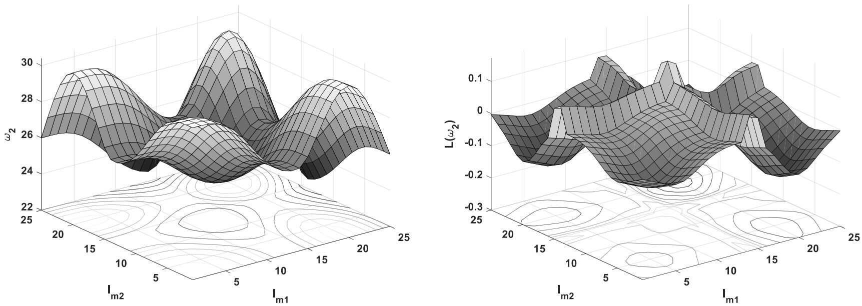

Fig. 2. Localization of change in stiffness in the 14th element: a) ω_2; b) L(ω_2).

3. Concluding Remarks

The main advantage of the presented approach is the possibility of stiffness changes localization without a reference model using two addition masses. The use of Laplacian operator improved the ability to identify the position of changes in stiffness.

References

[1] PANDEY A, BISWAS M, SAMMAN M: Damage detection from changes in curvature mode shapes. *Journal of Sound and Vibration* 1991, **145**:321-332.

[2] ZHONG S, OYADIJI O, DING K: Response-only method for damage detection of beam-like structures using high accuracy frequencies with auxiliary mass spatial probing, *Journal of Sound and Vibration* 2008, **311**(3-5):1075-1099.

[3] DEMS K, MRÓZ Z: Identification of damage in beam and plate structures using parameter-dependent frequency changes, *Engineering Computations* 2001, **18**(1/2):96-120.