Localization and quantification of damage by frequency based methods : Numerical and Experimental applications on bending vibration beams

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Abstract

The sudden growth of damages can cause catastrophic failure of structures or mechanisms that lead to unplanned shutdowns of machines and production lines. If damage remains undetected and reaches a critical size, sudden collapses and failures can happen. To overcome these problems, it is essential to detect these damages before they reach their critical state. The presence of damages can alter the structure which reduces the bending stiffness and modify the modal parameters and the natural frequencies. One of the most suitable monitoring methods to define the presence of damage and assess the structure is vibration based structure health monitoring (VBSHM). The objective of the work is localization and quantification of damages with the consideration of eigenfrequencies of healthy and unknown structures. Different frequency-based approaches (Frequency shift coefficient (FSC), Normalized natural frequency (NNF), Frequency error function (ϵ) and Least frequency change ratio (LFCR)) are presented. To achieve these goals, numerical finite element models (2D and 3D FE models) are performed and correlated to obtain a damage library for the cantilever beam structure[1]. Based on several indicators (or cost functions), Young's modulus of 2D and 3D models are iteratively updated to closely match the frequencies of an experimental beam. These approaches also illustrate the localization and quantification of rectangular geometry damage by vibration measurements on cantilever beams, which is related to an equivalent bending stiffness reduction by the use of frequency shift coefficient[2]. Many damage cases are tested, where the damage was located through the different parts along the beam: near the embeddedness, at the middle, and at the end of the beam. The effect of severity of the damage is considered. The quantification is classified between FE models by changing the location and depth of the damage. Finally, results are validated experimentally through the identification of different damage cases.

Keywords— Finite element models, natural frequency, stiffness reduction, modal analysis, young modulus updating, frequency shift coefficient.

References

[1] Serra, R., Lopez, L., and Gautier, G. 2016., Tentative of Damage Estimation for different damage scenarios on cantilever beam using Numerical Library, *In Proceedings of the 23th International Congress on Sound and Vibration*, Athens, Greece, (pp. 10-14).

[2] Silva, J.M.M. and Gomes, A.J.M.A. 1994., Crack Identification of Simple Structural Elements Through the use of Natural Frequency Variations: The Inverse Problem, *In Proceedings of the 12th International Modal Analysis Conference*, (1728–1735).