UNIVERSITI TEKNOLOGI MARA

AN APPROACH TO ENHANCE THE STRUCTURAL OPERATIONAL DEFLECTION SHAPE UNDER RANDOM AMBIENT EXCITATION THROUGH MODE SHAPE EXPANSION

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PhD

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Over the years, numerous system identification techniques for vibration analyses have been evolved, proposed and successfully tested, and implemented for a wide range of vibrating structures application. Although these techniques have been established, performed, and tested successfully by many researchers, they fell short of addressing crucial issues explicitly related to large structures with huge numbers of Degrees of Freedom (DOFs). In practice, measured responses will display better results using large numbers of measurement points. Consequently, this requires a complicated procedure to obtain a better response and accuracy of results with the increasing number of points on the structure. However, practically this is not possible since it needs a more robust data/signal processing equipment system with many transducers to be placed at all DOFs of a structure, especially on a large complex structure. For this reason, the main objective of this study is to predict the response at unmeasured locations and subsequently enhance the deflection of the structures at more DOFs using a limited number of sensors. This study utilizes a modified Local Correspondence Principal (LCP) to smooth and expand the mode shapes data and obtain much better and greater information from measured responses. The implementation of this study involves systematic methodology; (i) Operational Modal Analysis (OMA) as an experimental method – The experimental data were collected and processed in order to decompose the signal into modal components using different algorithms to obtain reliable experimental modal data (ii) Finite Element (FE) as numerical technique – FE model was developed, and normal modes results were obtained. (iii) An expansion approach was applied by a linear combination of both OMA and FE mode shapes data using the modified LCP method (iv) A new algorithm that includes the selection matrix and rotation matrix were used to obtain the estimated experimental mode shape at higher DOFs. Using these results, the structural Operational Deflection Shape (ODS) was enhanced as 'full-blown animation'. A test case for a crack aluminium beam was considered since it comprises both visible and invisible disturbances. This case study is important to show the modified LCP method's applicability in improving the results, although it was modelled without the presence of the crack in the FE. Modal data from both OMA and FE results show a good correlation since the MAC values for all modes are approximately equal to 1. Excellent quality of smoothed and expansion mode shapes was obtained as shown by the optimum number of FE modes with better MAC values. The results and findings show that the enhanced ODS from measured data were completely estimated and developed. It shows the ability to predict the response of the whole structure without being restricted by the number of points of measurements taken. This new approach has the benefit over traditional methods by reducing equipment cost and measurement time with less complexity in the procedure while maintaining the accuracy. It provides the fundamental platform for theoretical expression and algorithm to smooth and expand the experimental modes and subsequently enhance the ODS to higher DOFs.

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