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Structural response reconstruction with transmissibility concept in frequency domain

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ABSTRACT

This paper presents a method for structural response reconstruction in the full structure or in a substructure, using the generalized transmissibility concept in frequency domain. The response reconstruction is based on transforming the measured responses into responses at other selected locations with the transmissibility matrix. The use of transmissibility concept in a substructure for response reconstruction is introduced by taking the interface forces at the interface degrees-of-freedom as input excitations. The First-Order-Hold input approximation is used in the forward response calculation to improve the accuracy of the dynamic response analysis. Numerical studies on a seven-storey plane frame structure are conducted to investigate the accuracy and efficiency of the proposed method and the effects of influencing parameters, such as the system sampling duration, sampling rate, sensor numbers and measurement noise are studied. Accurate reconstruction is achieved in all studies when there is significant vibration in the measured responses.

1. Introduction

An important issue in the application of system identification technique for monitoring of the structures is the availability of the identification approaches with only a limited number of measured responses. Due to the cost related to data acquisition and analysis, or to practical reasons such as the inaccessibility of locations for measurement, responses are usually obtained only in a few locations, which are much smaller than the total degrees-of-freedom (DOFs) of the structure. In the case of structural monitoring and damage detection, responses are required at known critical areas of the structure. However situations may exist, in which the desired locations are not accessible for measurement during the operation of the structure. It has been found that in the estimation of dynamic characteristics of a structure, the lack of measured responses can lead to non-uniqueness of results with divergence in the identification [1,2].

Kammer [3] proposed a method for estimating the response of a structure during its operation at locations that are inaccessible for measurement using sensors. The prediction is based on measuring response at other locations on the structure and transforming it into the response at the desired locations using a transformation matrix, which is computed using the system Markov parameters determined from a vibration test. The predicted responses are good even with noise in the measurements. In Ref. [4], the time domain response, response quantity (including internal forces, moments or shears), and intensity in beams can be reconstructed, using wave decomposition technique. The wave decomposition approach enables sensors to be optimally spaced, reducing sensitivity to noise and an incorrect calibration. Ma et al. [5]

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