UNIVERSITI TEKNOLOGI MARA

INDIRECT SCHEME FOR ESTIMATING ROTATIONAL FREQUENCY RESPONSE FUNCTION AND IMPROVING FREQUENCY-BASED SUBSTRUCTURE COUPLING

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ABSTRACT

The frequency-based substructuring (FBS) method, which is widely used in the vibration and acoustics industries, offers the attractive advantage of combining both theoretical and experimental frequency response functions (FRFs) to derive the dynamics of assembled structures. One of the biggest challenges in the FBS method is rotational frequency response functions (FRFs), which account for 75% of the coupling matrix. Rotational FRFs are essential for the success of the FBS method, but they are very difficult to determine experimentally. In this study, a validated scheme for estimating the rotational FRFs for the FBS method is proposed. The scheme was developed based on the integration of model updating, mode expansion and the FRF synthesis method into the FBS method for analysis of an assembled structure. An approximated and simplified (ASFE) model was developed and used in the scheme to overcome the difficulties encountered in constructing and analysing a FE model of a complex assembled structure. The geometry of the ASFE model was approximated and simplified, but still capable of representing the EMA mode shapes for the purpose of mode expansion. The applicability and capability of the proposed scheme was demonstrated in a case study to determine the FRFs of an assembly consisting of a beam substructure (FE model) and an irregular plate substructure (ASFE model). The ASFE model was expanded using the updated ASFE model to obtain the unmeasured rotational FRFs. The accuracy of the rotational FRFs of the expanded ASFE model was evaluated using experimental rotational FRFs measured with Kistler's direct piezoelectric rotational accelerometer. The rotational FRFs of the expanded ASFE model agreed well with the EMA FRFs. The frequency-based substructuring method was successfully applied by coupling the FRFs of the FE model of the beam and the expanded ASFE model of the irregular plate with the proposed scheme. The comparison of the results between the coupled FRFs of the expanded ASFE model and the EMA showed that the proposed scheme was highly capable of accurately predicting the dynamic behaviour of the assembled structure. Moreover, the coupled FRF calculated with the proposed scheme was compared with the widely used EMPC approach for FBS. It was found that the proposed scheme resulted in a less noisy and more accurate pattern of FRF compared to its EMA counterparts. This indicates that the proposed scheme has the potential to significantly reduce the heavy dependence of the FBS method on the experimental rotational FRF data, which is very difficult to determine experimentally. In addition, the proposed scheme can help speed up decisions in product manufacturing or to improve the performance of products, which will have a positive impact on the industry.

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