Propagation of uncertainties on physical subsystem measurements in dynamic substructuring

Giuseppe Abbiati*, Catherine Whyte*, Bozidar Stojadinovic*, Oreste S. Bursi†, Luca Caracoglia˜, Vincenzo La Salandra†

* Department of Civil, Environmental and Geomatic Engineering (D-BAUG), IBK, ETH Zurich
Stefano-Franscini-Platz 5, 8093 Zürich, Switzerland
e-mail: abbiati@ibk.baug.ethz.ch, whyte@ibk.baug.ethz.ch, stojadinovic@ibk.baug.ethz.ch

† Department of Civil, Environmental and Mechanical Engineering, University of Trento
Via Mesiano 77, 38123, Trento, Italy
e-mail: oreste.bursi@unitn.it

˜ Department of Civil and Environmental Engineering, Northeastern University,
360 Huntington Avenue, Boston, Massachusetts, 02115 USA
e-mail: lucac@coe.neu.edu

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ABSTRACT

Experimental dynamic substructuring plays a significant role in the field of structural dynamics. It allows for simulating the dynamic response of structural systems, which are too large or complex to be tested as a whole, by combining Numerical and Physical Substructures (NSs and PSs). Three substructuring methods are considered in this paper: i) Frequency Based Substructuring (FBS) techniques [1], that typically operate offline and rely on the concept of transfer function; Impulse Based Substructuring (IBS) methods [2] which have been recently proposed for time domain, they also operate offline and gather information about PSs through related impulse response functions-; iii) Hybrid Simulation (HS) that is an online technique where force feedbacks from both NSs and PSs enter in a time integration loop that determines the global system displacement response for each time step [3].

All three techniques require measurements on PSs, which involve uncertainties, i.e. systematic and random errors. Systematic errors result from a bias in the experimental design, such that repeated measurements are always too high or low. Random errors result from random influences on the measurement environment and round off errors in the A/D conversion, and can be quantified through repeated measurements. This paper focuses on the propagation of such uncertainties, and particularly, how they may magnify in the dynamic substructuring assembly process depending on the choice of coupling algorithms. A comprehensive set of state-of-art coupling methods, FBS, IBS and HS, are compared and both bias and variance of the assembled system response is chosen as a measure to determine the robustness of each coupling algorithm. First, theoretical performances are derived using purely numerical examples. Then, the same comparative study is extended to a three degree-of-freedom linear experimental benchmark system PS.

REFERENCES

[1] Rixen, D. J., & van der Valk, P. L. (2013). An impulse based substructuring approach for impact analysis and load case simulations. Journal of Sound and Vibration, 332(26), 7174-7190.

[2] Voormeeren, S. N., De Klerk, D., & Rixen, D. J. (2010). Uncertainty quantification in experimental frequency based substructuring. Mechanical Systems and Signal Processing, 24(1), 106-118.

[3] Bursi, O.S., (2008) "Computational techniques for simulation of monolithic and heterogeneous structural dynamic systems", in Modern Testing Techniques for Structural Systems Dynamics and Control , Edited by O. S. Bursi and D. J. Wagg, CISM-Springer, Wien New York.