VIBRATIONS OF PLATES WITH SPATIALLY-EXTENDED RANDOM EXCITATION - APPLICATION TO TURBULENCE-INDUCED VIBRATIONS

Jacques Cuenca^{1,•}, Marcin Kurowski^{1,2}, Bart Peeters¹

 ¹ LMS International, Interleuvenlaan 68, B-3001 Leuven, Belgium
² Institute of Fluid-Flow Machinery, Polish Academy of Sciences, Fiszera 14 st., 80-231 Gdańsk, Poland
[•] jacques.cuenca@lmsintl.com

Key words: Vibrations of plates, Mid-frequencies, Uncertainty, Random excitation, Turbulent excitation.

Vibration uncertainty plays a major role in the dynamic behaviour of structures, especially in the mid- and high-frequency ranges. Such uncertainty can arise as a consequence of the uncertainty in the properties of the structure, such as the geometry, the material properties or the boundary conditions, and also from the uncertainty in the source mechanism. Common examples include defective contact areas between two structural components and turbulent flow in the vicinity of a structure.

This paper provides a method for computing the vibration response and its probability distribution for a plate subjected to random excitation over an extended area. The methodology relies on the image source method, which consists in representing successive wave reflections in a structure by means of a series of mirror sources. The spatial nature of such representation makes it appropriate for computing the response of finite structures in the mid- and high-frequency ranges.

The image source method [1, 2] provides the Green's function between two points of the structure. The response to a spatially-extended excitation is obtained by taking advantage of the reciprocity of the Green's function [3, 4]. The source is described using a statistical model of a spatially-extended random excitation, consisting in a superposition of random fields with different spatial scales. This allows to study of the uncertainty in the vibration response in connection with the statistical properties of the source, such as the spatial cross-correlation and the probability distribution. An application example will be given for a polygonal panel excited by a turbulent flow. The wall pressure is obtained using an unsteady time-domain computational fluid dynamic simulation and used as the vibration input in the image source method. The statistical properties of the wall pressure are

extracted and the relation with the probability distribution of the vibration response is discussed.

Fig. 1 shows a preliminary example of the influence of the spatial cross-correlation of the source on the probability distribution of the vibrations of a polygonal panel.



Figure 1: Vibration response of a polygonal panel with a random excitation over an area. Top: spatial cross-correlation; bottom: displacement response. Left: low spatial cross-correlation; right: high spatial cross-correlation. The units are arbitrary.

REFERENCES

- J. Cuenca, F. Gautier, and L. Simon. Harmonic Green's functions for flexural waves in semi-infinite plates with arbitrary boundary conditions and high-frequency approximation for convex polygonal plates. *Journal of Sound and Vibration*, 331(6):1426–1440, 2012.
- [2] J. Cuenca, F. Gautier, and L. Simon. The image source method for calculating the vibrations of simply supported convex polygonal plates. *Journal of Sound and Vibration*, 322(4-5):1048–1069, 2009.
- [3] P.M. Morse and H. Feshbach. Methods of Theoretical Physics. McGraw-Hill, New York, 1953.
- [4] J. Cuenca. Computing the vibrations of polygonal panels under distributed random excitation using the image source method. In 5th European Conference for Aeronautics and Space Sciences (EUCASS), Munich, 1-5 July 2013 2013.