DYNAMIC MODELLING OF BEAM-PLATE SYSTEMS IN THE MID-FREQUENCY REGION

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This project developed and compared approaches that can deal with built-up structures in the mid-frequency range. This frequency range is where neither a low frequency deterministic method nor a high frequency statistical method might be amenable. For structures such as automotive vehicles, ships and aircraft, this region corresponds to an important part of perceived sound spectrum, and it is necessary to develop practical methods to predict the response in this region.

Previous work had been limited to simple applications, for example, a one-dimensional system or a single beam coupled to a plate. Two principal configurations considered were a fully framed rectangular plate and a rectangular plate with two beams on opposite parallel edges. While the beams are relatively stiff, the plate is more flexible. Such systems are typical components in industrial applications and it is important to identify their dynamic behaviour at the mid and high frequencies.

The analytical models considered are based on a wave method, proposed by Grice and Pinnington. The beam is assumed infinitely stiff to torsion and thus the plate edge at a junction is sliding. This method starts from free wavenumbers of subsystems and uses an approximate impedance for the plate in determining the coupled beam wavenumbers. It is reasonable as long as the beam is much stiffer than the plate. This approximate wave method is enhanced by introducing Muller's method to solve for the wavenumbers.

The model is extended from a single-beam-plate system, to a plate with two parallel beams which is modelled using a symmetric-antisymmetric wave model, and a plate surrounded by four beams which is modelled using a plate-decoupled wave model. The modelling techniques for the two systems are different, although

a similar wave approach is used. Because the wave methods provide an approximate response, a Fourier technique and a modal method based on simplified boundary conditions are also considered for comparison. These provide exact responses for the two-beam-plate and four-beam-plate systems respectively for the particular boundary conditions. The wave method can be applied more generally and is computationally more efficient but involves approximations that are not always justified. For example, mobilities show some discrepancy when the coupled beam wavenumbers found from the travelling wave have a high rate of decay.

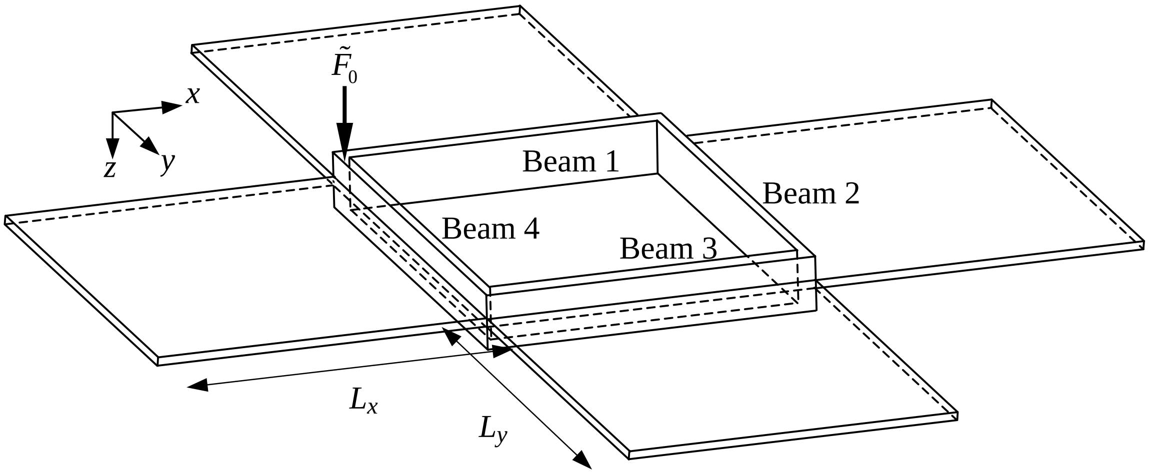

Figure 1. Configuration of the coupled structure for the use of the wave method.

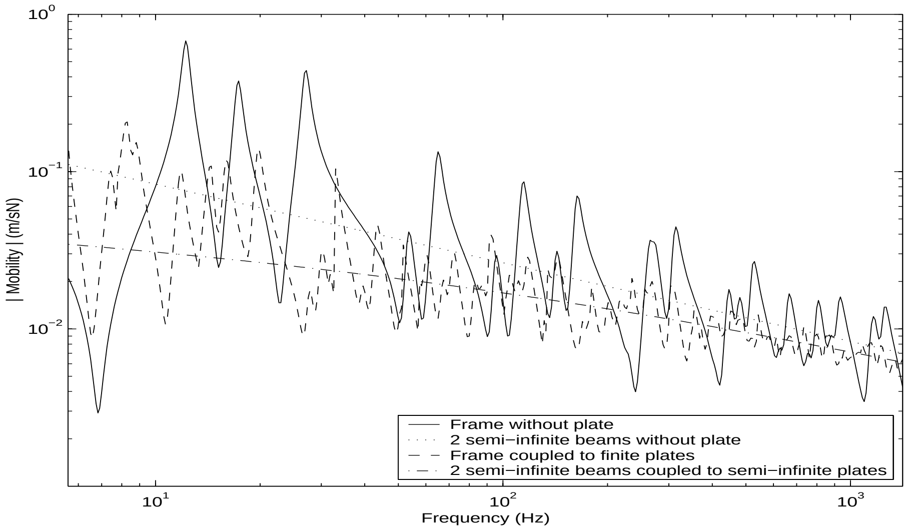

Figure 2. Point mobility comparison of the plate-coupled structure as in the above figure and the structure consisting of only four beams (based on the wave method, excitation at $x = 0$).

An experimental study was performed to verify the analytical models. Comparisons based on power and subsystem energy ratios show that the wave models replicate well the experimental results at mid and high frequencies. Also, the modal and Fourier models show good agreement at these frequencies, which justifies their use of simplified boundary conditions. A wavenumber correlation technique has been used to verify experimentally that the wavenumbers in the plate follow those of the beam in the direction parallel to the beam.

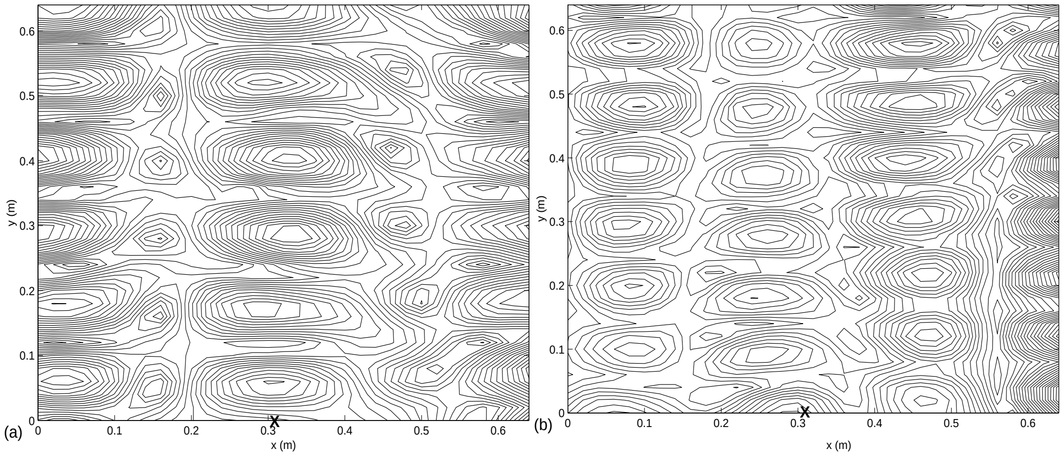

Figure 3. Contour of mobility amplitudes (a) at 172 Hz (b) at 283 Hz of a two-beam coupled showing the influence of the long wavelength in the beam (x direction) and the short wavelength in the plate (in the y direction). The symbol ✖ on the *x* axis indicates the excitation point.

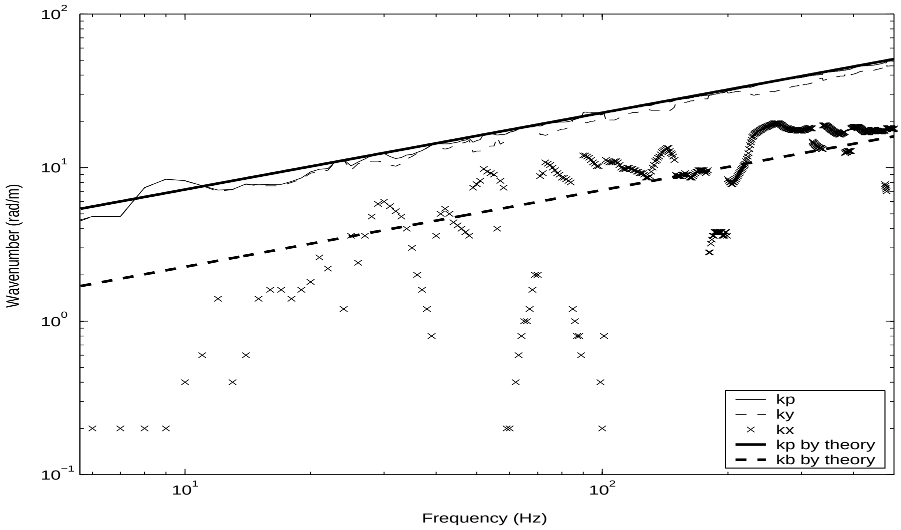

Figure 4. Wavenumber comparison of the two-beam-plate showing the wavenumber in the coupled plate is approximately the plate wavenumber in a direction normal to the beam. In the beam direction the beam wavenumber dominates.