A Finite Element Structural-Acoustic Model of Coupled Membranes

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Finite Element (FE) analysis of problems involving structural-acoustic coupling is an active field of research [2]. Several conferences and special issues of journals have been devoted to the topic of computational structural-acoustics in recent years (see, for example, the special issue [3] and the review paper by Everstine [1]).

In this paper, a simple model displaying structural-acoustic behavior is considered. The model comprises of two parallel infinitely-long flat membranes lying on elastic foundations and the acoustic medium separating them is considered. The structural-acoustic coupling manifests itself in that a vibrational excitation of one of the membranes triggers vibrations in the other.

Using the $(\mathbf{u}, p)$ formulation [4], the governing equations are stated for the general case, which is three dimensional and time dependent. Following the the reduction to a two-dimensional time harmonic problem, the associated finite element formulation is constructed. The model is then analyzed numerically and its vibrational properties are investigated using standard modal analysis techniques. The influence of the acoustic coupling can be observed from the difference between the modal properties of the uncoupled and coupled membranes. The coupling between the two membranes, which is characterized by the transmissibility, is seen to be growing as the density of the coupling fluid increase.

The proposed model is especially simple, being two-dimensional and involving a small number of parameters, but at the same time it brings to light some important features associated with structural-acoustic coupling. Therefore it may serve as a benchmark for evaluating structural-acoustic numerical schemes and as an educational tool for studying structural-acoustic coupling in a simple context.

References

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