11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

MODAL BASED REDUCTION OF STRUCTURAL-ACOUSTIC PROBLEMS USING XFEM

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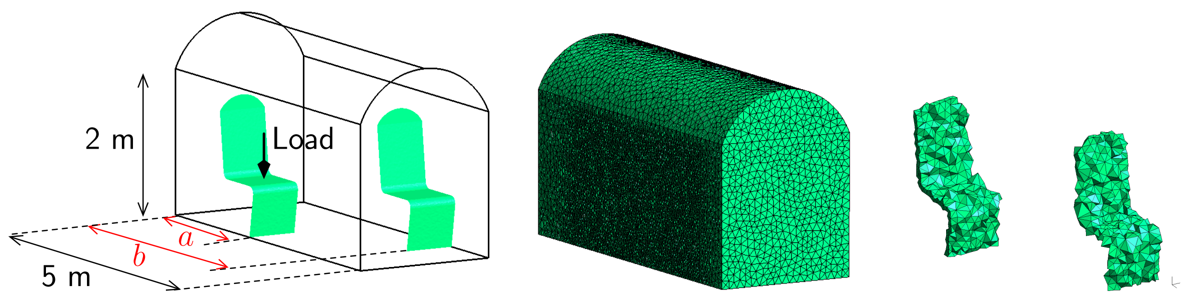
Key words: *XFEM, structural-acoustics, reduced basis.*

Noise reduction for passengers comfort in transport industry is now an important constraint to be taken into account during the design process. This leads to the study of several configurations of the structures inside a given acoustic cavity (optimization, uncertainty, reliability study ...). The classical finite element method needs an interface conforming mesh for each studied configuration which may become time consuming. The aim of this work is to be able to efficiently analyze different configurations of structures immersed in the acoustic domain and their influence on the noise level in the cavity. The embedded structures, such as seats in a plane cabin, are assumed to have no thickness in the acoustic domain. The thin flexible structures, discretized using shell elements, are immersed arbitrarily within the acoustic mesh allowing to always use the same acoustic mesh. This makes the parametric study easier since it does not involve a meshing process anymore.

The first idea is to use XFEM in order to take into account the structure influences in the acoustic compressible fluid domain by enriching the pressure by a Heaviside function [1]. The finite element discretization of the whole fluid-structure coupled problem leads to a linear system in the frequency domain. In this system, the only matrices needed to be recomputed when the structures are placed arbitrarily in the fluid, are those corresponding to the enrichment and the one corresponding to the coupling between the fluid enrichment and the structures.

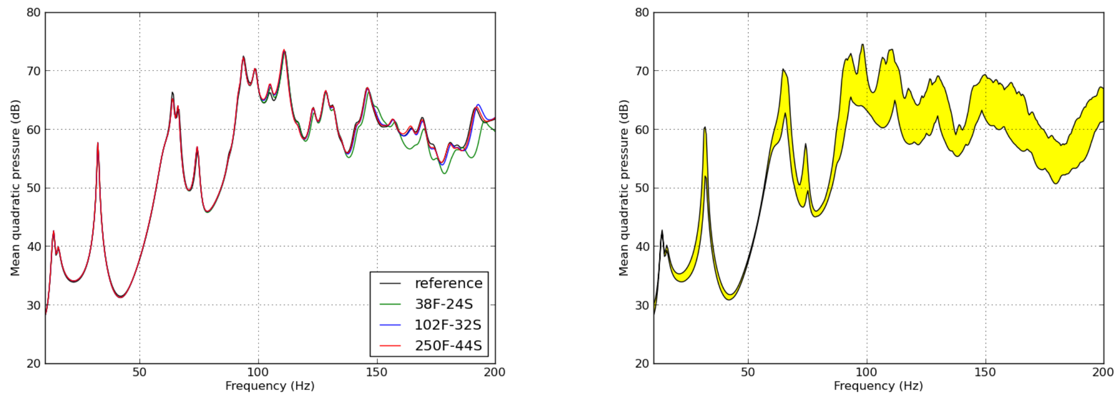
The second idea is to build reduced basis. The structure basis is composed of its eigenmodes whereas a component mode synthesis with a fixed interface is used to build the fluid basis. The interface degrees of freedom are thus the enriched nodes of the XFEM while the internal domain corresponds to the acoustic cavity with no structure inside. The method is implemented for flexible shell structures embedded in a 3D fluid.

The proposed application is made of two identical shell structures immersed in an acoustic cavity and localized by a and b, as described on figure 1(a). An harmonic load is applied



(a) Geometry (b) Fluid mesh (c) Enriched fluid mesh

Figure 1: Two immersed shell structures in an acoustic cavity



(a) Convergence of the basis (b) Envelope curves of the influence of a and b

Figure 2: Mean quadratic pressure in the cavity versus frequency

on one structure. The fluid mesh is shown on figure 1(b). For a given set of parameters (a, b), the fluid enriched elements are shown on figure 1(c). A convergence study (Fig. 2(a)) is realized for one configuration (a=2 m, b=4 m) in terms of number of modes in the fluid basis (F) and structure modes (S): basis 38F-24S has its highest frequency equal to about 200 Hz, while it is 300 Hz and 400 Hz for basis 102F-32S and 250F-44S respectively. The last basis gives accurate results: the number of degrees of freedom falls from about 40000 (no reduction) to 1100 (with reduction) while the computational time is divided by almost 10, which is a significant saving of time. The method enables to quickly perform an influence study of the (a, b) parameters on the acoustic response of the cavity ($2 < a < 3$ m and $3 < b < 4$ m). The envelope curves of all possible positions are plotted on figure 2(b).

REFERENCES

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