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IMPROVED APPROXIMATION FOR EXTERNAL ACOUSTIC-STRUCTURE INTERACTION VIA COMBINED RETARDED AND ADVANCED POTENTIAL, Part II: VALIDATION

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ABSTRACT

An external acoustic model interacting with flexible structures derived in the companion paper[1] is evaluated for its model fidelity employing a spherical shell and an infinite cylinder for which analytical series expansion solutions exist. The model parameters introduced in the present model are tailored to match with dominant poles of acoustic - structure interaction equations, which has provided the present authors to construct a discrete parameter matrix. Thus, the present model can be implemented for general interaction surfaces by using discrete boundary element models. Comparisons of the solutions of the present parameterized model with those of the classical Doubly Asymptotic Approximate(DAA) models[2] and available exact solutions[3,4] show that the present model offers improved accuracy, especially for early time responses.

PRESENT EXTERNAL ACOUSTIC-STRUCTURE INTERACTION EQUATION

The approximate external acoustic-structure interaction pressure model proposed in the companion paper, Part I[1] is recalled:

$$\mathbf{X}\overline{\mathbf{A}}\ddot{\mathbf{p}} + (1+\mathbf{X})c\mathbf{A}_1\dot{\mathbf{p}} + c^2\mathbf{B}_2\mathbf{p} \quad = \quad \rho c\mathbf{X}\overline{\mathbf{A}}\ddot{\mathbf{u}} + \rho c^2\mathbf{A}_1\dot{\mathbf{u}} \tag{1}$$

where $\mathbf{p}$ is the pressure on surface in normal direction, c is the speed of sound in acoustic fluid, ρ is the density of acoustic fluid and $\mathbf{X}$ is the weighting parameter that represents the weighting of the retarded potential and the advanced potential. Formulas for computing $\overline{\mathbf{A}}$, $\mathbf{A}_1$ and $\mathbf{B}_2$ are given in Part I[1].

As stated in Part I[1], the determination of the parametrized discrete matrix $\mathbf{C} = \mathbf{X}^{-1}$ is an important factor for the fidelity of the present approximate model, and presently we have arrived at the the following parameterized discrete matrix:

$$\mathbf{C} = \mathbf{B}_2\mathbf{N}^{-1} - \mathbf{I} + 2\mathbf{B}_1\mathbf{A}_1^{-1}, \quad \mathbf{N} = \mathbf{A}_1\overline{\mathbf{A}}^{-1}\mathbf{A}_1 \tag{2}$$

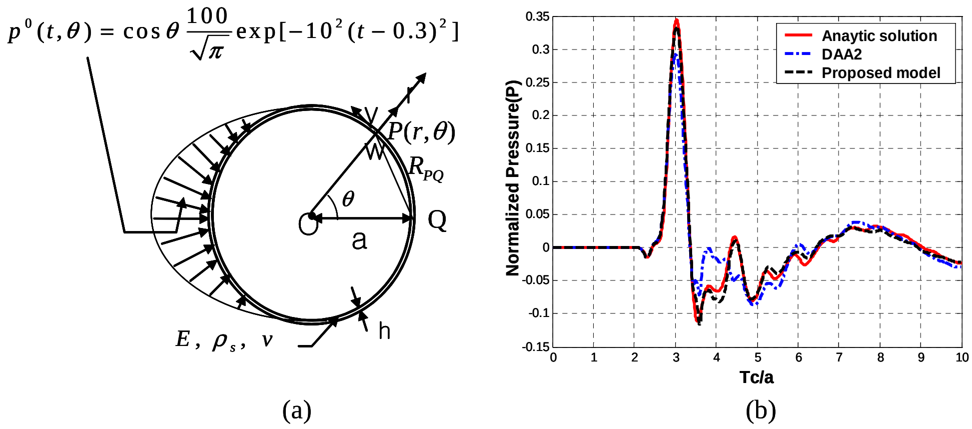

Figure 1: (a)A submerged spherical shell subjected to cosine-type impulse pressure (b)External pressure predicted by Hung's result, DAA_2 and present approximation at $\theta = 0^o$ and $r = 3a$

For the case of an elastic sphere, the present model is specialized to the following modal equation in terms of Legendre functions:

$$s^2\chi_n\overline{\mathbf{p}}_n + s(1+\chi_n)\overline{\mathbf{p}}_n + (1+n)\overline{\mathbf{p}}_n = s^2\chi_n\overline{\mathbf{u}}_n + s\overline{\mathbf{u}}_n \tag{3}$$

As with our predecessors, the availability of the exact solutions for an elastic sphere interacting with the external acoustic transient pressure fields and the performance of the above modal equation of the present model has played a key role in the construction of the weighting parametric matrix $\mathbf{X}$ or its inverse $\mathbf{C}$. This will be further detailed at the conference.

NUMERICAL EVALUATION

Figure 1 shows the external pressures at $(\theta = 0^o, r = 3a)$ obtained from analytic solution[2], the DAA_2[3] and the proposed approximation. The radiation pressures due to the vibrating wet spherical shell show that the proposed approximation yields more accurate response than by the DAA_2. Additional comparative results will be presented at the conference.

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