Scattering From Rough Poroelastic Surfaces Using COMSOL Multiphysics®

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Abstract

Accurate modeling of the acoustic scattering by the seafloor is of particular importance to many underwater acoustics problems, such as in the design and application of SONAR in shallow water environments. To achieve this end, much work has been done toward studying the effects of surface roughness and developing adequate models of the seabed sediment. Scattering effects are typically studied using analytic models based on approximations made to the Helmholtz integral formulation. Recently, the finite element method has been applied to problems of this type and has the benefit of converging to the exact solution of the Helmholtz integral. Concurrently, sediment models have evolved from simple fluid formulations to more robust models such as the poroelastic model developed by Biot and extended by Stoll. However, rarely is the combined problem addressed. This work looks at such a problem: modeling the interface scattering from one-dimensional rough poroelastic surfaces using COMSOL Multiphysics®.

The problem is studied using the Acoustics Module. The domain consists of two half-spaces: one of seawater and one of the sediment. The seawater is modeled as an acoustic medium and the sediment is modeled as a poroelastic material. These half-spaces are joined by a rough interface and the computational domain is surrounded by PMLs to enforce the Sommerfeld radiation condition, as shown in (Figure 1).

The incident wave is modeled as a Gaussian tapered plane wave to guard against edge effects and to allow study of shallow grazing angles. A far field calculation based on the Helmholtz/Kirchhoff integral is performed to determine the scattered pressure in the far field. The far field scattered pressure is then used to calculate the monostatic and bistatic scattering strengths.

Results are obtained for varying incident angles and frequencies and compared with those of other methods. It is found that the finite element results agree with lowest order perturbation theory and the Kirchhoff approximation in their respective regions of validity. An example of this agreement for backscattering is shown in (Figure 2).

The finite element method is found to be an effective way to assess the validity of the approximate methods more commonly used. Comparisons between finite element models and results from these methods allow one to determine the conditions for which these methods work.

The finite element method is also found to be useful in addressing problems that are outside the range of validity of other methods. In the future, these numerical results will be compared to experimental data; this comparison will go a long way toward determining whether or not poroelastic sediment models properly capture the physical properties of the seabed. [Work supported by the Office of Naval Research, Ocean Acoustics Program].

Figures used in the abstract

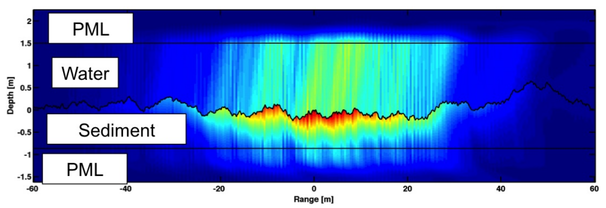

Figure 1: Sample computational domain.

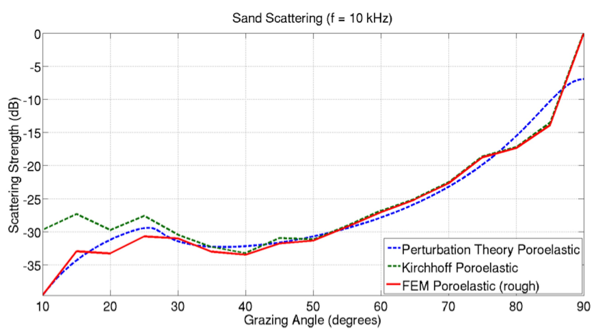

Figure 2: Comparison of FEM results with approximate methods.