Modeling the Acoustic Scattering From Objects Buried in Porous Sediment Using COMSOL Multiphysics® Software

A. Bonomo[1], M. Isakson[1]

[1]Applied Research Laboratories, The University of Texas at Austin, Austin, TX, USA

Abstract

Recently, there has been much effort made toward the development of automatic target recognition algorithms for the detection, identification, and removal of underwater unexploded ordnances (UXOs). Many of these algorithms require extensive knowledge of the structural acoustic response of the target and its physical interaction with the ocean environment. For the cases of targets in sandy sediments, the physical models used to train these algorithms often assume the sediment behaves as an acoustic fluid. Previous work has shown that these fluid models, which neglect shear wave propagation and poroelastic effects, may not properly predict the acoustic interaction with sandy sediments, as has been shown with past comparisons between predicted and measured bottom loss and backscattering strength. Nevertheless, the use of fluid sand models persist due to their relative ease of calculation, especially for oblique insonification. It is the goal of the present work to model the acoustic scattering of an object buried in a porous sediment using COMSOL Multiphysics® software.

The calculation of the acoustic scattering from a buried target excited by an obliquely incident plane wave would normally require a full 3D finite element simulation. However, if the problem geometry is axisymmetric, it is possible to use a modal superposition method to solve the problem using only 2D finite element simulations, instead. By default, COMSOL software allows the user to use this method if all objects in a given simulation can be modeled as an acoustic fluid. Implementation for fluid-structure interaction problems where all objects are either acoustic fluids or elastic solids is described by Zampolli et al. The work of Zampolli et al. is extended in the present work to allow for fluid, elastic, and poroelastic objects.

The problem geometry for an elastic shell buried in a porous sediment is shown in Figure 1. To allow for ease of implementation of the technique described above, all the elastic shell and poroelastic sediment are modeled using Weak Form PDE physics interfaces. The overlying water half-space is modeled using the Pressure Acoustics, Frequency Domain interface in the Acoustics Module. All physics coupling is done manually through the Weak Form PDE interfaces. The Sommerfeld condition is enforced using perfectly matched layers, which surround the computational domain and are implemented using the Pressure Acoustics, Frequency Domain physics interface. The incident field is modeled as a Gaussian tapered plane wave to guard against edge effects.

Figure 2 shows a comparison between the target strength of a steel shell buried in sand

measured by Simpson and coworkers at the Naval Research Laboratory and simulated using COMSOL Multiphysics. It is clear from the figure that modeling the sand as a poroelastic medium adds more complexity to the target strength predicted. Comparisons of this kind will allow researchers to determine whether the inclusion of poroelastic effects are the key to bringing model predictions in better agreement with experimental data.

Reference

M. Zampolli et al., "A computationally efficient finite element model with perfectly matched layers applied to scattering from axially symmetric objects," J. Acoust. Soc. Am. 122 (3), 1472-1485 (2007).

H. J. Simpson et al., "Laboratory measurements of sound scattering from a buried sphere above and below the critical angle," J. Acoust. Soc. Am. 113 (1), 39-42 (2003).

Figures used in the abstract

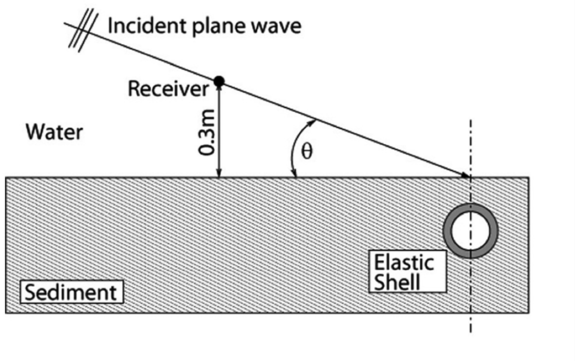

Figure 1: Model geometry.

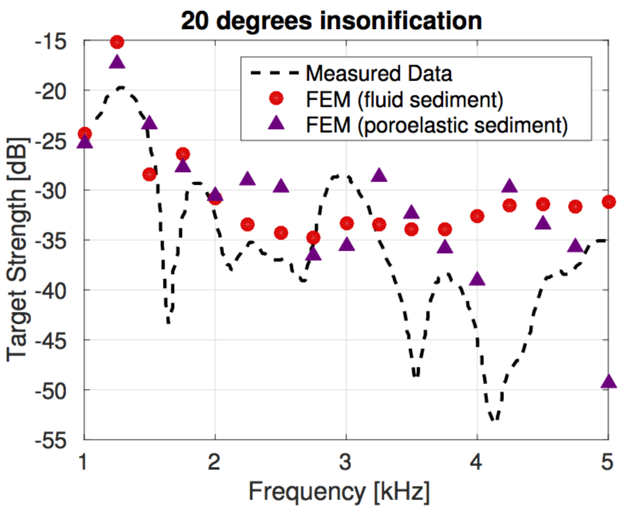

Figure 2: Model data comparison for target strength of an elastic shell buried in sand.