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Imaging and Characterizing the Waste Materials Inside an Underground Storage Tank Using Seismic Normal Modes

Dr. M. Nafi Toksöz
Massachusetts Institute of Technology
Building E34-440
42 Carleton St.
Cambridge, Massachusetts 02139
Phone: 617-253-7852
E-mail: nafi@ERL.MIT.EDU

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Research Objective

This work is directed toward finding a way to estimate the properties of wastes in tanks on the Hanford Reservation. Data acquisition work (Turpening et al., 1995) has shown that acoustic measurements can be made inside a Hanford tank. Although that data was collected in a cross-well geometry, other data acquisition methods are now of interest. In particular, it would be very useful if an estimate of the properties of the wastes could be made by lowering a single string of hydrophones into the one liquid observation well (LOW) that exists in every tank while activating a seismic source on the surface outside the tank.

Such an endeavor requires an understanding of the normal modes of oscillation of a Hanford tank when it contains various layers of wastes. The objective of this study to gain that understanding.

With advent of the cone penetrometer it is now possible to conduct acoustic cross-well measurements in a Hanford tank even though each tank has only one LOW. This in turn makes the study of normal modes even more important since these modes of oscillation constitute a major portion (along with tube waves) of the background noise in any cross-well data set. Knowing where the normal modes exist in the frequency domain, for example, will allow one to plan a data acquisition program that might avoid the especially strong modes.

Research Progress and Implications

The initial period of this study has focused on tanks containing non-rigid wastes, i.e. where only acoustic waves propagate in the waste materials. We have approached the problem both theoretically and by means of laboratory-sized scale models. The theoretical work has shown, and the lab measurements have confirmed what was expected, that the spatial complexity of the modes increases as frequency increases. The low frequency modes show a simple vertical distribution of pressure while the higher frequency modes (Figure 1) show a more complex distribution of pressure in the tank. In all of this work we assume that the tank is rigid

The implications of the work to date are twofold. First, the modes are rich in information, especially when the vertical array of hydrophones is not on the center line of the tank. Fortunately, that will be the case with many of the Hanford tanks. Second, it is clear that any future cross-well measurements in a tank should be made at high frequencies to avoid the strong fundamental modes. Again, this would be the normal action taken by any data acquisition specialist.

Planned Activities

Currently, we are treating the case of two liquid layers of waste, both theoretically and in the lab. In addition, we are including the standing waves in the sides of the steel tank. In the third year we will conduct a data acquisition program inside a Hanford tank to collect normal mode data. This will be performed in much the same manner as our successful work performed in 1994.

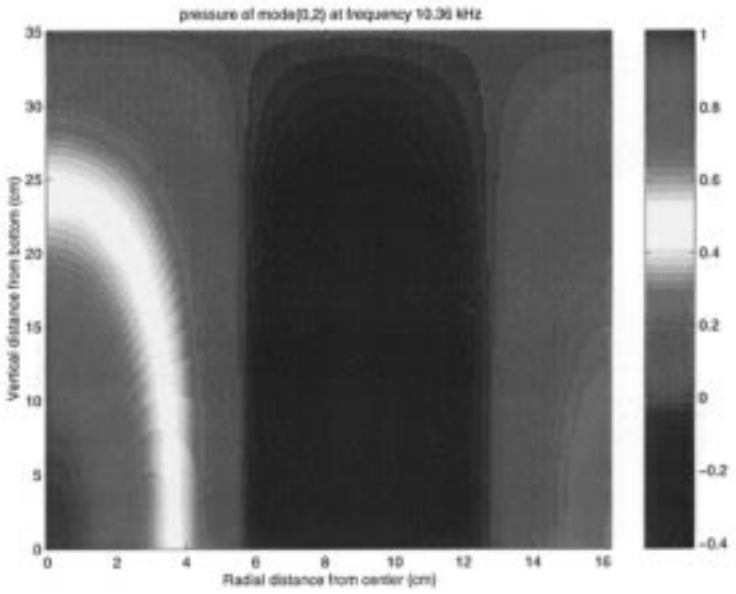

Figure 1. Display of the distribution of pressure in a vertical plane for one half of a tank. The source is on the center line of the tank half-way between the bottom and the surface of the liquid. This is a mode that would occur at approximately 138 Hz in a full-size Hanford tank. Reference: **Turpening, R., Z. Zhu, C. Caravana, J. Matarese, W. Turpening, 1995, *Acoustic imaging of underground storage tank wastes-A feasibility study*, Westinghouse Hanford Co., Richland, WA.**