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Acoustic Landmine Detection: Nonlinear Mesoscopic Elastic Flexural Vibrations of Dry and Wetted Sand

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Plastic land mines are difficult to detect using conventional metal landmine detection methods. In airborne acoustic landmine detection, subwoofers located above the ground excite the soil (gravel) which couples into structural vibration of the buried "target."The enhanced ground vibration can be measured remotely using a scanning laser Doppler vibrometer. Using nonlinear tuning curve results some false alarms due to soil inhomogeneous layering can be distinguished from the compliant vibration modes of the "top plate."An understanding of mesoscopic nonlinear elastic behavior of granular material in flexural vibration with the compliant top plate is modeled using the SPO apparatus. Experiments using a soil-plate-oscillator (SPO) involve a vertical cylindrical column of unconsolidated granular medium (masonry sand, glass spheres, uncooked brown rice, uncooked milled oats, or even "Toasty Oats"™ (dry cereal) that is supported by an air-backed thin circular elastic acrylic plate (4.5 inch diam and 1/8 inch thick) that is rigidly clamped between two thick-walled flanges. The soil column is driven from below 1) electrodynamically, using an AC coil & small rare earth magnet fastened on the plate's underside, on center, or 2) acoustically, using a small 2 inch diameter loud speaker (4 ohms) located below the plate. A small accelerometer attached to the magnet is used to measure the vibration. An optical displacement sensor can also be used. In nonlinear tuning curve experiments the resonant frequency decreases with increased amplitude –representing a softening in the nonlinear system. The backbone curve (peak acceleration vs. corresponding resonant frequency) exhibits mesoscopic NL elastic behavior that can be modeled by a bilinear hysteresis force vs. displacement curve. For fixed amplitude, the resonant frequency vs. the granular medium mass loading (over the plate) reaches a minimum and then increases with increased loading due to the granular medium's flexural stiffness –which overcomes the mass loading effects. For water loading, the frequency always decreases since there is no bending stiffness. Experimental results are compared for wetted vs. unwetted masonry sand.

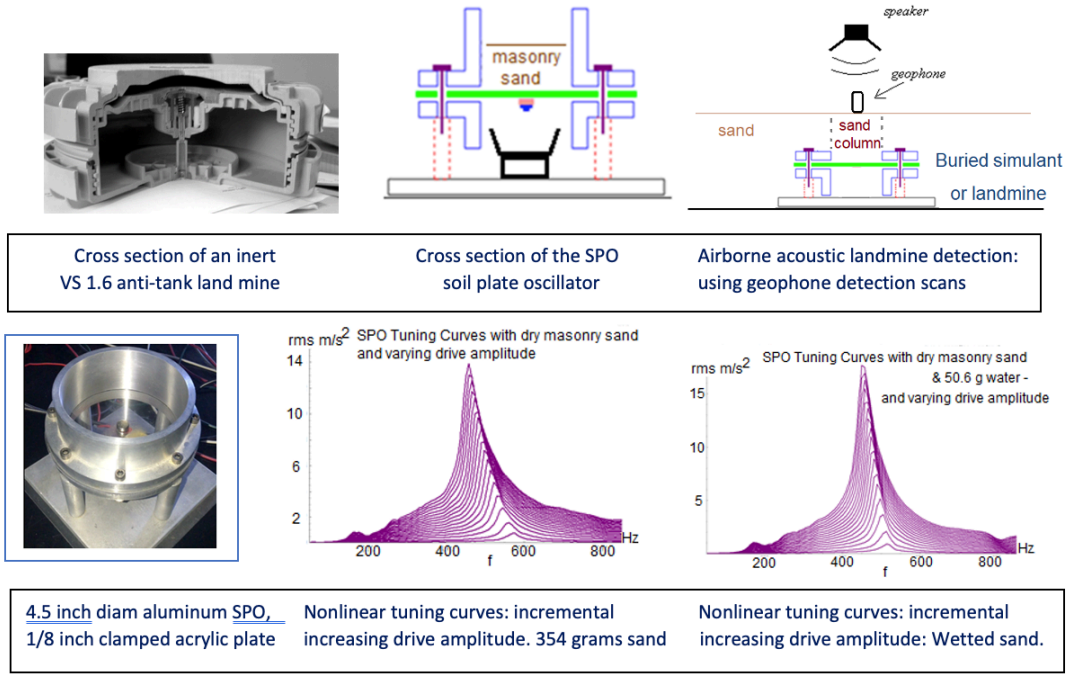

Figure 1:

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