Seafloor Interface Dynamics In Coastal Environments

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LONG-TERM GOAL

The goal of this research is to improve understanding of the dynamic pore water pressure gradients resulting from surface gravity (wind generated) waves in shallow-water, surficial sediments. This improved understanding of pore pressure gradients will, in turn, improve understanding of the resulting pore water flow and its impact on sediment transport, scour burial of objects resting on the seafloor, liquefaction of surficial sediments, and contaminant transport.

OBJECTIVES

The primary objective of this research is to identify and quantify all physical factors that can influence the magnitudes of the pore water pressures recorded by the Multi-Piezometer Array System (MPAS). This information will be used to establish a list of premises under which the MPAS data may be interpreted and to establish the accuracy of the MPAS as a scientific measurement system. The secondary objective is to provide the functional MPAS to Office of Naval Research (ONR) sponsored researchers for use in NATO mine burial research in nearshore water depths off the Netherlands.

APPROACH

The technical approach is to first examine the physical environment at the surface of the sea floor and mechanical behavior of the MPAS probes in that environment. Behavioral equations (mathematical representations of probe behavior) are then derived to represent interaction between the probe and the physical environment. From these equations, key parameters needed to fully describe the measured pore pressures are identified. In order to quantify the effect of these key parameters on the accuracy of the measured pore pressures, verification tests are conducted where MPAS measured pore pressures can be compared to reference pore pressures in a controlled environment. A testing matrix is established wherein the magnitudes of the key parameters are varied to the extent possible over their potential range and the deviations of the MPAS pore pressure measurements from the reference pore pressure measurements are evaluated and documented.

WORK COMPLETED

A complete analysis of the accuracies and errors inherent in the internal mechanics of the MPAS was completed, validated and published in the ASTM Geotechnical Testing Journal (see REFERENCE). MPAS performance data from nearshore and littoral zones, including data from the May 1997 NATO mine burial tests off the Netherlands, were analyzed and reported (see PUBLICATION).

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The refurbished and calibrated MPAS was deployed in the November 1997 NATO mine burial experiment off the Netherlands with shear keys added to each piezometer to improve resistance to lateral loading and increased mass to cause the piezometers to self-embed in response to scour of the surrounding surficial sediment. Diver observations of piezometer attitude suggest that the units remained embedded and upright during the experiment. Data from the November 1997 NATO experiment are being reduced and analyzed separate from this project by SeaProbe, Inc. The MPAS was refurbished upon return from the Netherlands. Of the original ten probes fabricated, seven are fully functional, with the losses due to internal corrosion and electronic component damage due to sea water leaks at seals. The MPAS with four complete probes, and minus its topside PC, was shipped to Texas A&M University (TAMU) (Dr. Glen Andersen) for added performance testing in a TAMU wave tank, with the first test of this series scheduled 26-31 October 1998. For the TAMU tests, a motion sensing package was assembled to be attached to one of the probe housings to gather data necessary for predicting the excess pore water pressure component self-generated by the probe motion. (The motion sensing package parts, assembly and use are funded by NRL's 6.2 Mine Burial Project).

RESULTS

Initial results from the field and laboratory tests suggest that the pore fluid pressures measured by the MPAS may not always represent the pore fluid pressure generated in the far-field seabed sediments (away from the influence of the MPAS probes). The measured pore pressures include a component being generated by the motion of the probes themselves in response to wave and current drag forces on the probe housings protruding above the seafloor. The wave tank tests scheduled for October 1998 will provide definitive data for validation of analytical models describing excess pore pressures self-generated by motion of the piezometer housings.

IMPACT/APPLICATIONS

The results from this research will have direct and significant impact on the work of scientists and engineers using the MPAS data, or data from another seabed pore water pressure probe with elements exposed to the water column, to infer basic behavioral mechanisms or to validate scientific models of seafloor-resting object scour burial, sediment transport contribution due to wind wave action, and contaminant transport due to sediment ventilation.

TRANSITIONS

The dynamic pore water pressure data sets obtained in this project will be used to validate, or improve, analytical models for predicting pore water pressure gradients generated by wind waves for the NRL 6.2 Mine Burial Processes Task Area. The validated models, in turn, will be used in that 6.2 project to better understand whether or not one can expect mine burial due to sediment scour, quicksand condition, and/or liquefaction in response to a given set of environmental conditions. Improvements in the mine burial models will eventually be transitioned into the Mine CounterMeasures (MCM) Environmental Decision Aids Library used in the field by MCM forces.

Another strong transition need is into environmental programs to follow ONR's Harbor Processes Program to make possible rational prediction of advection of contaminants from seabed sediments into the water column and into man's food chain. This is of import far beyond the Navy into the Corps of

Engineers' maintenance of navigable waterways and EPA concerns over the prediction of contaminant leaching from underwater deposits.

RELATED PROJECTS

Mine Burial Processes, NRL Task Area BE-35-02-27, Principal Investigator: Dr. Michael Richardson, NRL Code 7431.

REFERENCE

Andersen, G.R., Bennett, R.H., Barber, M.E., Todorovski, L. and Maynard, G.L. 1996: A Multi-Sensor Piezometer for Shallow Marine Sediments in Coastal Environments, American Society for Testing and Materials (ASTM) Geotechnical Testing Journal **19**:4, 373-383.

PUBLICATION

Andersen, G.R., Akguner, C. and Barber, M.E. 1998: NATO Mine Burial Study Phase I Report: Measurement and Interpretation of Pore Pressures in Shallow Marine Sediments Using a Multi-Piezometer Array System, NRL/CR/7401--98-0007, Naval Research Laboratory, Stennis Space Center, MS, 72 pp plus appendix.