Sediment Liquefaction Around an Object on the Seafloor

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LONG-TERM GOALS

The long-term goal of the project is to estimate the scale of liquefaction in seafloor and to predict the behavior of sinking heavy objects, *e.g.* mines in seafloor.

OBJECTIVES

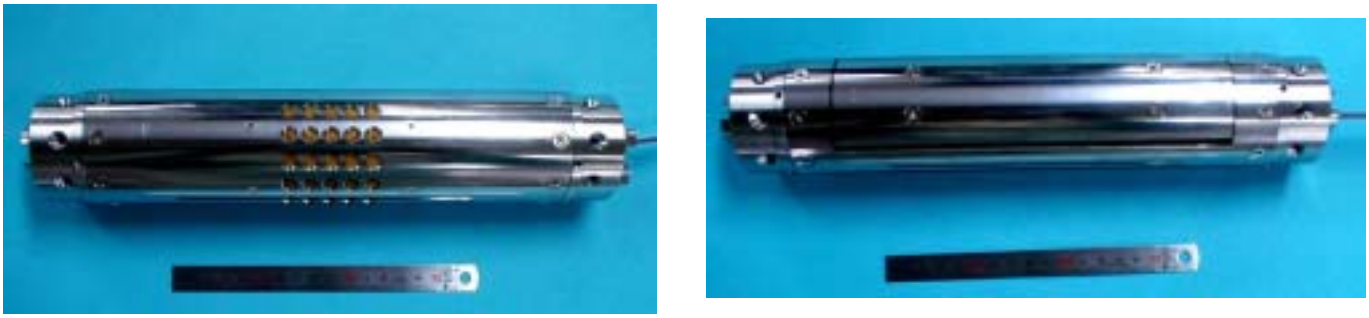
The distributions of earth pressure and pore pressure with depth below the surface of seafloor will be measured in order to identify the scale of liquefaction in seabed and estimate how deep heavy objects sink into seabed. The effective earth pressure and pore pressure fluctuations will be discussed by combining with the measured results on the velocities of shear waves in near surface sediment, water waves and currents under stormy weather.

APPROACH

Wave-induced liquefaction causes the sinking of heavy objects *e.g.* mines, concrete blocks and vessels. Maeno *et al.*(1996,1999) investigated the mechanism of wave-induced liquefaction and sediment transport by conducting field measurements on the wave-induced liquefaction of seabed deposit, the sea surface elevation, water wave and near shore current velocities, wind velocities and so on. The observed results indicated that a large steep wave induces the liquefaction in the surface layer of seabed. Outside surf zone the phase difference between wave pressure at seafloor surface and pore pressure inside seabed

causes liquidizing of seabed deposit. In surf zone, wave breaking plays an important role on wave-induced liquefaction. They also showed the thickness of liquefied layer reached up to three feet at the water depth of 6 to 7 meters with the wave height of 3 meters. If there were strong near-shore current, liquidized sediment is removed to another place. If not, the liquidized sediments accumulate at the same location. The sediment transport strongly correlates with both of liquefaction of seabed and near shore current. Each of large steep waves changes the elevation of seabed surface under large current condition. It is known that the wave breaking point changes with tide. The seabed is eroded during ebb and low tides and deposited during flood and high tides. The elevation of seabed surface fluctuates diurnally with large amplitude. So heavy objects repeat sinking into seabed or appearing on the seafloor due to tide, wave and current conditions. The repetition of erosion and accumulation may cause the sinking of such objects deeper into seabed.

The study will use the *in-situ* pressure transducers which Maeno and Yabe(2001) had developed and improved to operate in deep water. The probes will be customized to the project purpose. The effective earth pressure and pore pressure fluctuations will be measured and discussed by correlating with the velocities of shear waves and water waves and currents measured by Dr. Michael Richardson (NRL, Code 7341, Stennis Space Center) whom the PI works in collaboration with.



(a) Dynamic Pore Pressure Transducer ***(b) Effective Earth Pressure Transducer***

Figure 1 Schematic drawing of probe with effective earth pressure and dynamic pore pressure transducers.

WORK COMPLETED

Maeno, Yabe and Toyoko Elmes Co. Ltd. customized the effective earth pressure transducer and the dynamic pore pressure transducer to operate at the water depth of 10 meters under severe wave and current conditions as shown in Figure 1. The measuring probe will be assembled from two sets of effective earth pressure and pore pressure transducers to measure the profile of earth pressure and pore water pressure distributions below the mud line.

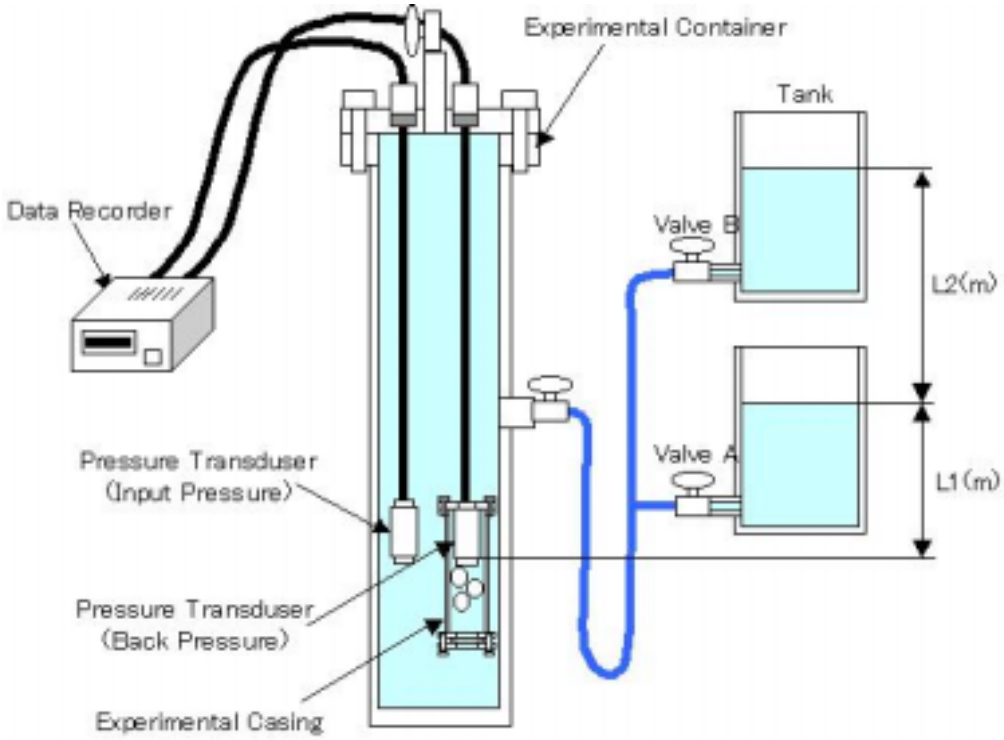


Figure 2 Experimental Container in which the Damping and the Phase Shift of Back Pressure from Input Pressure were examined for several samples to select the suitable filter.

RESULTS

The intrinsic performance of equipments was examined by using the experimental container as shown in Figure 2. The resonant frequency is 1386 Hz and 1640 Hz for only sensor and 429 Hz for sensor with load plate. These resonant frequencies are out of targeted frequency range of less than 10 Hz. In order to select a suitable filter for the effective earth pressure and pore pressure transducers the damping and the phase shift of output pressure (back pressure) from input pressure were examined. The

alumina-magnesium-glass complex was selected for the filter B which is expected to respond not to wave excitation but tide. The filter with diameter of 10 mm and entrapping of 6 cc air bubbles in the chamber will be reliable at the expected water depth of 10 m on the field measurement site.

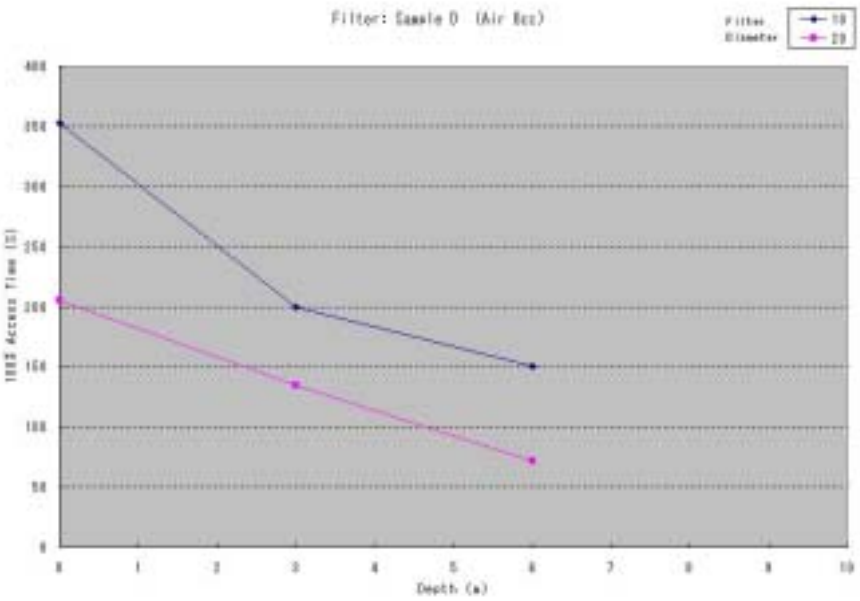


Figure 3 The Access Time of Back Pressure to100 % of Input Pressure Reduce with the Water Head (Depth of Water).

Since College of Science and Technology, Nihon University received the AWARDWEB notification on March 30th, 2002 and has not received funding at the present time, the order with Toyoko Elmes Co. Ltd. for equipments was delayed. So the preliminary field verification has not finished. After finishing the examination of the intrinsic performance of equipments PI will conduct the field verification of the performance of equipments. We will improve the equipments depending on its necessity.

IMPACT/APPLICATIONS

The sophisticated equipments customized in this study enable us to identify the scale of liquefied seafloor and the sinking depth of mine-like heavy objects. Since the mine burials strongly correlate with wave-induced liquefaction of seafloor sediment, the employment of these equipments toward the ONR Mine Burial Prediction (MBP) Program will bring fruitful results.

TRANSITIONS

The field measurement on effective earth pressure and pore pressure will provide excellent data especially on the wave-induced liquefaction around mine-like heavy objects. Consideration on such data with those provided by other PIs will bring us the reliable model to predict mine burial into seafloor.

RELATED PROJECTS

We are working in collaboration with Dr. Michael Richardson (NRL, Code 7341, Stennis Space Center) to correlate the wave-induced liquefaction of seafloor with the structure and the deformation of soil skeleton through the simultaneous field measurement of effective earth pressure, pore pressure and shear wave velocity. And we intend to collaborate with Prof. Horst Brandes (Department of Civil Engineering, University of Hawaii) to correlate the wave-induced liquefaction with the soil properties of seafloor, *e.g.* porosity, density and permeability.

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