

## **Field Observation of Wave induced Seabed Behavior for the estimation of geomaterial properties and the effect of permeable column method**

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### **ABSTRACT**

The response of seabed to sea wave loading was observed in New Ishikari Gulf Port, Hokkaido, Japan. We developed the observation rod, which is equipped with pore water pressure cells and earth pressure cells. Two observation rods were installed vertically near a sand groin located east side of the port; one of the two observation rods was surrounded by permeable columns installed vertically. The fluctuating pore water pressure and horizontal total earth pressure in the seabed were thus monitored at different levels of depth. The purpose of the field observation is to examine; (1) a method for estimating the response parameters of seabed to sea wave loading, (2) the effect of permeable column method for stabilizing seabed. The method of the observation is described and the observation results are analyzed to discuss the response behavior of the seabed.

**KEY WORDS:** *seabed response, sea wave loading, field observation, response parameters, permeable column method*

### **INTRODUCTION**

On and off shore structures and port and harbor facilities are occasionally damaged in stormy weather condition including attacks of typhoons. This type of damage is sometimes accelerated by the failure of seabed foundation induced by sea wave loading. For example Oka et al. (1995) investigated the severe damage to a breakwater built on a sandy seabed in Pomporoto Port, Hokkaido, Japan. The break water was settled down into the sand seabed by 1.4m, where the sand layer of about 4m in thickness was underlaid with thin clay layer and hard rock. Through a field geotechnical exploration and analytical examination of the damaged breakwater, it was found that the seabed was instabilized

by the sea wave loading, and the load bearing capacity reduced not enough for the weight of the breakwater. Fluctuating water pressure on the seafloor induces an uneven distribution of pore water pressure in the seabed, which generates hydraulic gradient and upward seepage force. The seepage force would lead to periodical reduction of effective stress and also in stiffness and strength.

The response of seabed to sea wave loading must be analyzed with the appropriate constitutive model and formulation of geomaterial as a multi-phase material: solid phase for soil particle structure, liquid phase for pore water and gas phase for pore air. The interaction of seabed with sea wave must be also taken into account appropriately with an appropriate modeling between the phases in seabed material. Madsen (1978) and Yamamoto (1978) have developed an analytical method for the harmonic changes in pore water pressures and effective stresses in sand seabed induced by sea wave loading, using Biot's equations for the poro-elastic solid as a binary-phase material; see Biot (1941). Their method is classified as a coupled analysis. Zen and Yamazaki (1991) measured the fluctuation of excess pore water pressure and effective stress in the seabed at a breaker zone in a real ocean environment. Asahara et al. (2007) and Miura and Asahara (2007) investigated intensively the appropriate modeling, formulation and dimensional conditions for the coupled analysis of seabed-structure-seabed system; exact solutions were derived, and numerical analysis method was developed.

The seabed response is strongly dependent on the permeability and compressibility of pore fluid as a function of the degree of saturation, as discussed by Asahara et al. (2007). Miura et al. (2001) investigated elastic waves which propagates through saturated soils with interactions between solid phase and liquid phase taken into account, and proposed a method for determining mechanical properties