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Behaviour of a Model Breakwater Element on a Sandy Seabed

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ABSTRACT

Breakwater elements are subject to wave and current forces that influence their stability, causing settlement and scour. An understanding of these processes is necessary for the optimum design of breakwaters. This paper reports the results of field measurements undertaken on a cylindrical, model breakwater element placed on a sandy seabed, along with numerical modelling that was used to analyse and interpret the data. Particular attention was paid to the possibility that the pore pressure response beneath the element was influenced by the presence of undissolved gas in the seabed.

INTRODUCTION

Breakwaters play an important role in coastal protection by reducing the severity of wave forces and controlling the movement of sediment. However, breakwaters are themselves subject to considerable wave and current forces and these influence their stability and effectiveness. In particular, erosion of the supporting bed and settlement of individual elements can affect the integrity of the structure as a whole. In order to achieve an improved understanding of the underlying processes, a programme of field measurement has been undertaken, using a 0.6-m-diameter cylinder as a model breakwater element. The cylinder was deployed on a sandy beach at low water, and measurements were made of total stress and pore water pressure during the subsequent submersion under the rising tide. This paper reports the results of these field measurements and compares them with a numerical simulation of this situation.

FIELD EXPERIMENT

A breakwater element has been simulated by a cylinder with a height and diameter of 0.6 m, using mild steel 2 mm in wall thickness. The approximate weight of the element was 229 kg, including the steel cylinder, logger box and lead weights, the latter being added so that the average density when full of water was 2100 kg/m^3. In its basic configuration, three 350-mbar and three 175-mbar pressure transducers were mounted on the base of the cylinder to measure, respectively, total stress and pore pressure at the seabed surface beneath the cylinder. Fig. 1 shows the arrangement of these transducers. One 350-mbar pressure transducer was mounted on the top surface to measure pressure variations caused by waves. All the transducers were connected to a 10-channel Datataker logger, in a waterproof box inside the cylinder. An acoustic altimeter on the outside of the cylinder measured distance to the bed on the seaward side. An Aquadopp current meter was mounted on the top of the cylinder to measure all 3 components of current in a control volume approximately half a metre above the cylinder and a similar distance seaward. The angle of tilt was recorded in 2 directions.

This deployment took place at Porthcawl, in South Wales. The seabed at the site is a medium-dense uniform sand. Table 1 provides information about the site and the conditions of the experiment.

The cylinder was placed upright on the beach near the low-water mark, and set to log, either continuously or in 10-min bursts, at a sampling frequency of 1 Hz in both cases. The measurements were made as the tide rose to a maximum water depth of about 4.6 m.

PREDICTION OF TOTAL STRESS

The horizontal wave force on the cylinder is acting in the separation regime and can thus be calculated using the Morison equation and the shallow water assumption that the water particle velocities do not vary significantly over the height of the truncated cylinder:

$$Q_H = 0.5\rho C_D D h(u\,|\,u\,|) + \rho C_M(\pi/4)D^2 h(\partial u/\partial t) \quad (1)$$

The parameters ρ, D, h and u in Eq. 1 are, respectively, the water density, the cylinder diameter and height, and the water particle velocity.

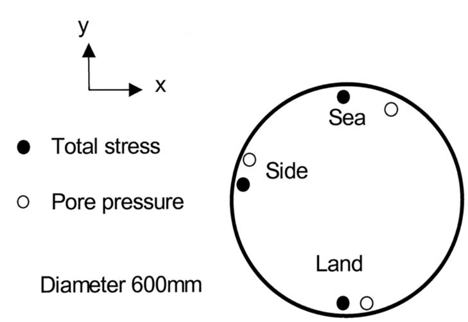

Fig. 1 Arrangement of transducers

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