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Experimental research on pore pressure attenuation in rubble mound breakwaters

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INTRODUCTION

When studying the structural response of rubble mound breakwaters to wave loading, the knowledge on pore pressures and related wave attenuation inside the porous structure is important as the pore pressures affect most responses, such as wave run-up, wave overtopping, reflection, transmission and hydraulic and geotechnical stability. Moreover, the pore pressure attenuation and wave damping in the core provide valuable information for the scaling of small scale hydraulic models.

Numerical wave flumes are being developed nowadays to analyse the structural responses of permeable rubble mound breakwaters. In order to validate the performance of the numerical flume, reliable pore pressure data are needed from prototype measurements or from physical model tests.

PORE PRESSURE MEASUREMENTS IN A SMALL SCALE MODEL

In this research, the pore pressure attenuation is analysed by performing pore pressure measurements at several locations within the body of a conventional breakwater, modelled at scale 1:30 in the wave flume of Ghent University (30x1.0x1.2m). The scale model tests have been designed to compare the pore pressure distribution and wave-structure interaction with numerical simulations of the same test setup. To model the porous flow resistance, the Forchheimer equation is used, which requires the knowledge of the shape factors corresponding to the porous material with specific properties, ie. porosity, mean diameter, grading, shape class. A review was carried out of the different factors which have been experimentally determined in permeameter flow tests by various researchers. Taking into consideration the target stone dimensions determined by the model scale 1:30, stone sample 'test 2' (5-25 mm) from the report of Burcharth and Christensen (1991) was selected as the core material. A single size stone fraction (25-40 mm) tested by Shih (1990) was selected as a filter layer. Care is taken that the flow conditions, determined by a specific range of the Reynolds number, correspond to the flow conditions occurring in the permeameter tests.

To measure the internal pore pressures, 24 pressure sensors were installed at different strategic positions inside the core of the breakwater and at the interface between armour and filter layer. The pressure transducers measure absolute pressures which enables a high-precision measurement.

RESULTS

The pressure drop through the armour and filter layer is represented by the dimensionless reference pressure, ie. the ratio between the dynamic pressure height oscillation $p_{0,s}/\rho g$, measured at the interface between filter layer and core, and the incident wave height H_s. The reference pressures from large-scale model tests (Oumeraci and Partenscky, 1990) and prototype measurements (Troch, 2000) showed a weak dependence on the wave steepness s_p and distance (y) of the pressure sensor under SWL, see Fig. 2a and 2b. For practical use, Burcharth et al. (1999) proposed a constant value for the reference pressure equal to 0.55, assuming a constant value along the interface between filter layer and core. Close to the SWL ($y/H_s<1$), the pressures are affected by turbulence and the proposed practical value is not valid.

The present tests (Fig. 2c) show a stronger correlation between the reference pressures and the wave steepness. In particular, the wave period appears to have a dominating influence on the reference pressure, rather than the wave height. If tests of equal wave steepness but different wave period are compared, a relatively large difference between reference pressures is observed, with the lowest reference pressures corresponding to the smallest wave period.

From Fig. 2c it is observed that the reference pressure exceeds the proposed value of 0.55, especially in the case of small values of wave steepness ($s_p<0.03$). A reference pressure larger than unity suggests that the reference pressure is highly influenced by wave run-up. A first preliminary comparison with results from numerical simulations using the same test setup confirms this hypothesis and suggests that scale effects play a significant role. The dissimilarity regarding air entrainment (turbulent flow dissipation) and the amplitude of viscous forces affects the energy dissipation through the armour and filter layer, leading to a significant difference in reference pressure for the different scale models.

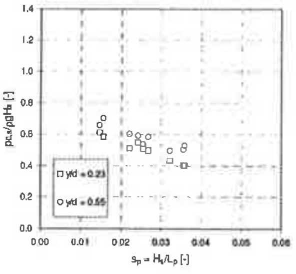

Fig. 2a: GWK data, Oumeraci.

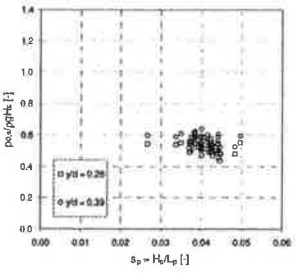

Fig. 2b: Zeebrugge data, Troch.

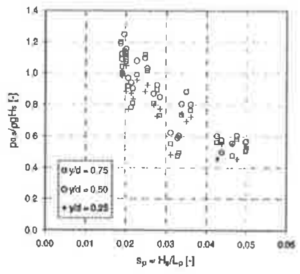

Fig. 2c: present tests.

The dynamic pressure height oscillation in the core decreases exponentially along the direction of wave propagation. The empirical formula for the damping coefficient (Burcharth et al., 1999) was validated with the present tests. However, from the tests it was observed that the damping factor shows a weak correlation with the incident wave height H_s. A linear regression analysis without H_s in the dimensionless predictor results in a better fitting of the damping coefficient. A reanalysis of the GWK data (Oumeraci et al., 1990) confirmed the obtained value of the regression coefficient. More details of the presented results will be provided in the paper.

REFERENCES

Burcharth H.F., Christensen C. (1991), On stationary and non-stationary porous flow in coarse granular materials. MAST G6-S report, Dept. of Civil Engineering, Aalborg University, Denmark.

Burcharth H.F., Liu Z., Troch P. (1999) Scaling of core material in rubble mound breakwater model tests. Proc. 5th COPEDEC, Cape Town, South Africa, pp. 1518-1528.

Oumeraci H., Partenscky H.W.,(1990) Wave-induced pore pressure in rubble mound breakwaters. Proc. of International Conference of Coastal Engineering, pp.1334-1347.

Troch P., (2000) Experimental study and numerical simulation of wave interaction with rubble mound breakwaters. PhD thesis, Dept. of Civil Engineering, Ghent University, Belgium.