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HYDRAULIC PERFORMANCE OF ELASTOMERIC BONDED PERMEABLE REVETMENTS AND SUBSOIL RESPONSE TO WAVE LOADS

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1 INTRODUCTION

Open revetments as compared to impermeable smooth revetments have the advantage of substantially reducing wave run-up, and thus the required crest level of the structure. Moreover, wave reflection which may affect sea bed stability (scour) and navigation is also reduced. Bonding the mineral aggregates (e.g. crushed stones), results in a revetment of much smaller thickness to resist the design wave loads. With these and further background considerations, Polyurethane (PU) has recently been introduced in coastal engineering to create a highly porous structure made of mineral aggregates with a durable and environmentally neutral bonding in a marine environment.

In order to improve the understanding of all relevant processes involved in the wave-structure-subsoil interaction and to come up with physically-based prediction formulae, large-scale model tests were performed in summer 2009 in the Large Wave Flume (GWK) of the Coastal Research Centre (FZK). The main objectives of these tests are to develop empirical/semi-empirical design formulae for wave reflection, wave run-up, pressure distribution on and beneath the revetment for impact and non-impact load as well as for pore pressure distribution in the subsoil. The paper will focus on the results related to the hydraulic performance (wave reflection, wave run-up and run-down), including the response of the revetment (flexural motions) and of the subsoil (pore pressure). The latter are needed for the analysis of the total failure experienced by an undesigned revetment alternative without mineral filter which will also be reported, including the implications for future design.

2 EXPERIMENTAL SET UP AND TESTING PROGRAM

As mentioned above, the experiments were performed in the Large Wave Flume (GWK), (l= 330m, d= 7m, w= 5m), mainly using irregular waves with significant wave height H_s up to 1.2m and peak periods T_p up to 8s (about 1000 waves/test). Regular wave tests with $H \leq 1.3$m and $T \leq 8$s were also performed (at least 100 waves/test). The water depth in the flume was varied from h=4.20m to h=3.40m. The wave conditions tested cover the full range of surf similarity parameters ξ to obtain plunging and surging breakers (impact and non-impact load).

As shown in Fig. 1, three Model Alternatives A, B and C with the same slope 1:3 and the same thickness (t_R = 0.15m) but with different thickness of the mineral filter layer (t_R= 0.0m; 0.10m and 0.20m) were tested.

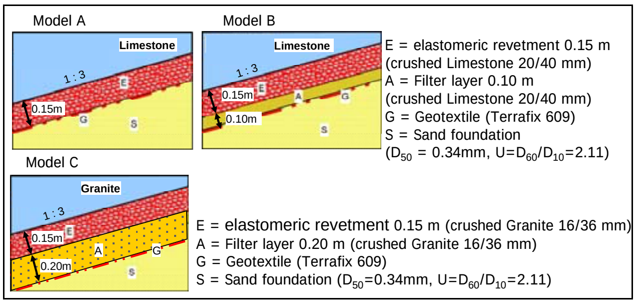

Fig. 1 Model Alternatives of Elastomeric Revetment Tested in GWK

A total of 86 measuring devices synchronized with two digital video cameras were used to record the waves in the far and near field, wave run-up and run-down, run-up layer thickness and velocity, pressures on and just beneath the revetment, pore pressure in the subsoil as well as motions of the revetment normal to the slope. The types and optimal locations of these devices were determined by a preparatory study, applying available empirical formulae and numerical modelling (Oumeraci et al, 2009a)

3 WAVE RELFECTION PERFORMANCE

Wave reflection from coastal structures may severely affect the stability of the structure by enhancing sea bed scour. It may also increase the erosion of the foreshore and of the neighbouring coastline. As depicted in Fig. 2, the reflection coefficients for irregular wave obtained from the irregular wave tests vary from $C_r = 0.25$ to $C_r = 0.75$ depending on the surf similarity ξ and range expectedly between those of smooth impermeable sloped structures and those of conventional rubble mound structures. Comparatively, the refection coefficients obtained from regular wave tests vary over a wider range (Oumeraci, 2009c).

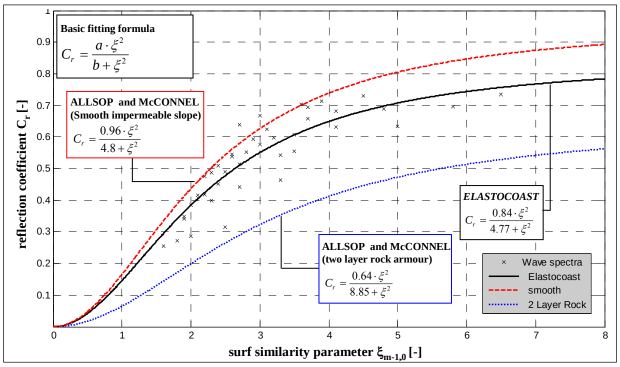

Fig. 2 Wave Reflection of Elastomeric Revetment for Irregular Waves

4 WAVE RUN-UP PERFORMANCE

Wave run-up R_u is particularly important in defining the design crest level, and thus the required height of the entire defence structure. Generally, the run-up level exceeded by 2% of the incident waves ($R_{u2\%}$) is used for design purpose. As shown from the results in Fig. 3 for irregular wave tests, about 25% smaller run-up heights than for smooth impermeable slopes are obtained in the upper ξ-range; i.e. lower design crest level would be required. However, the difference between the two model alternatives amounts only few percent and is thus within the uncertainty range of the measurement.

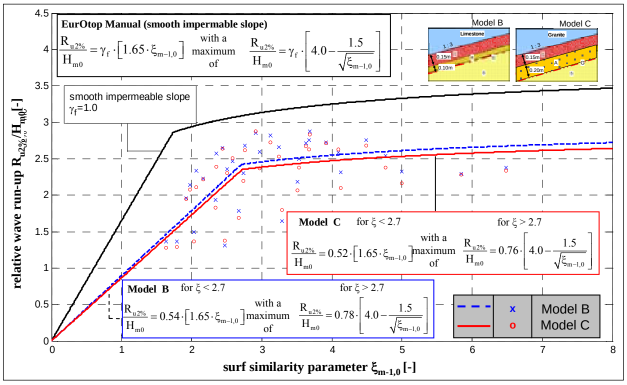

Fig. 3 Wave Run-up of Elastomeric Revetment for Irregular Waves

5 WAVE RUN-DOWN PERFORMANCE

Wave run-down R_d is particularly important in defining the required minimum depth beneath still water level (SWL) over which the revetment should be extended to avoid slope erosion. It is also important for the assessment of the stability of the revetment against uplift pressure (outside water level recedes faster than internal water table). As for wave run-up, the run-down exceeded by 2% for the incident waves ($R_{d2\%}$) is used for design purpose.

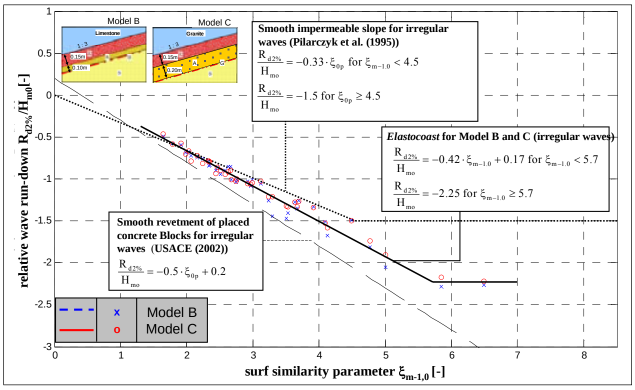

Fig. 4 Wave Run-down of Elastomeric Revetment for Irregular Waves

6 SUBSOIL RESPONSE AND REVETMENT FAILURE

Model Alternatives A and B, installed side by side in the wave flume and separated by a relatively thin wall with a height extending up to 0.76m above the slope surface and up to 1.8m beneath, were tested synchronously under the same wave conditions.

After the collapse of Model A (which was rather expected for more severe wave conditions), while Model B remained intact, Model C was installed to replace Model A (see Fig. 1). Both Models B and C remained undamaged over the entire testing program. The first results of the analysis of this failure, together with the results of the analysis of the response of the revetment (flexural motions) and the subsoil (pore pressures), which are to be finalized at the end of 2009 (Oumeraci et al, 2009c) reveals the vital importance of a deeper understanding of the hydrogeotechnical processes involved in the wave-structure-soil interaction, including reliable measurements and modelling. These processes and the failure mechanisms (video images synchronised with pre-pressure and revetment response) will be presented at the conference and in the final paper, including the implications for future design.

ACKNOWLEGEMENTS

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