REANALYSIS OF BREAKWATER STABILITY WITH STEEP FORESHORE

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INTRODUCTION

A steep foreshore may affect the stability of breakwaters and sea defences. Nonetheless, the foreshore slope is not explicitly addressed in common design formulae for breakwater armour layers.

The effect of foreshore slope on armour layer stability is twofold. Depth limited wave heights will be larger on a steep foreshore than on a gently sloping foreshore. Verhagen et al. (2006) indicated further that breakwaters with a steep foreshore will face larger damage even if the wave heights at the structure are not increased as compared to a gently sloping foreshore. They concluded that non-linear effects (i.e. wave asymmetry and peakedness), which are more prominent on a steep foreshore, will be responsible for the larger wave loads.

The findings of Verhagen et al. were based on different experimental studies including the hydraulic model test of Hovestad (2005). The experimental results of Hovestad have been reanalysed to substantiate these findings and to quantify the effect of foreshore slope on armour layer stability.

HYDRAULIC MODEL TESTS

Hydraulic model tests were conducted by Hovestad (2005) to determine the effect of foreshore slope on armour layer stability. A breakwater with 1:2 slopes was tested in a flume at Delft University of Technology. The armour layer was made of rock (rock size Dn50 = 1.57 cm, specific density 2780 kg/m3, layer thickness 6 cm). Two different fore shore slopes were tested, a gentle 1:30 slope and a steep 1:8 slope.

WAVE AND DAMAGE ANALYSIS

The incident wave heights at the toe of the foreshore slope (far-field) and at the structure (near-field) were reanalysed. The uncertainties of damage and wave height measurements were determined.

RESULTS

The stability tests with steep and gentle foreshore slope were conducted such that the incident wave heights were almost identical either in the far-field (at the toe of the foreshore) or in the near-field (at the structure).

Similar wave heights in the far-field will result in larger wave heights in the near-filed for a 1:8 foreshore. As expected the damage in case of a steep foreshore was significantly increased; damage numbers were in average about 65% larger, varying from 25% to 120% (see Figure 1).

Similar wave heights in the near-field resulted in slightly larger damage in case of a steep foreshore. In case of a 1:8 foreshore the damage numbers were in average about 20% larger, varying from 0% to 35% (Figure 2).

Hovestad observed more violent wave breaking on the 1:8 foreshore. The largest increase in damage (with 1:8 foreshore as compared to 1:30 foreshore) was observed at the transition from spilling to plunging breakers. A steep foreshore appears thus critical with respect to armour layer stability as it may affect breaker type and breaking point. Plunging breakers are more likely to occur on a steep foreshore and the breaking point is shifted closer to the structure. Both aspects will be addressed in the paper.

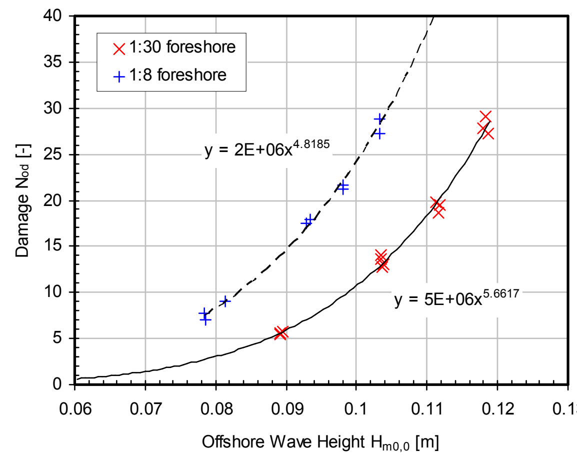

Figure 1: Damage on steep and gently sloping foreshore with similar wave conditions in the far-field

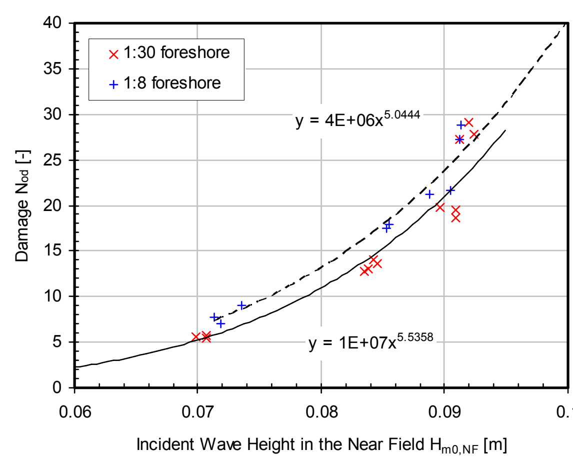

Figure 2: Damage on steep and gently sloping foreshore with similar wave conditions in the near-field

REFERENCES

Verhagen, Reedijk, Muttray (2006): The effect of foreshore slope on breakwater stability. Coastal Engineering, Proc. 30th Int. Conf., pp. 4828 – 4840.