PREDICTING THE RESHAPING OF TEMPORARILY EXPOSED BUNDS WITH XBEACH-G

Arjan Mol, DEME-group, mol.arjan@deme-group.com
Ton van der Plas, Bontrup Logistics, tvanderplas@bontrup.com
Robert McCall, Deltares, robert.mccall@deltares.nl
Merel Kroeders, DEME-group, kroeders.merel@deme-group.com

TEMOPORARILY EXPOSED BUNDS

During coastal construction works, damages often occur to temporary constructions consisting of fine and often wide graded rock material due to exposure to waves. Examples of vulnerable structures are the bunds that are constructed to serve as the core for a breakwater before placement of the filter and armour layers, or as temporary defense during reclamation works. Such structures – mostly built in bulk – are temporarily exposed to wave conditions, and will reshape depending on the duration of exposure and the prevailing hydraulic conditions. For the exposed breakwater core, it is important to have an idea on how much of the placed material will be moved outside the perimeter, and thus how much material needs to be rehandled before the cover layers can be constructed. For temporary defense works, it is important to know how much material needs to be placed initially in order to offer sufficient protection for a certain period. For both cases, an accurate prediction of the reshaping of such structures is necessary.

PREDICTION OF DAMAGE

There are no existing calculation methods available to predict the damage and reshaping of such bunds in an accurate way. Van der Plas et al. (2017) already compared results from physical model tests of reshaping bunds consisting of fine and very wide graded material to various calculation methods. Van der Plas et al. examined various bund layouts, both submerged and emerged for a number of different wave conditions. Although for emergent structures the design tool BREAKWAT which uses the Van der Meer relationships (1988) was found to provide reasonable estimates, for submerged and near-bed structures however no existing theory was found that could accurately describe the damage level development.

XBEACH-G

XBeach-G is a process-based numerical model that has been developed for the prediction of storm hydrodynamics and hydrology on gravel beaches (McCall et al., 2014) and to predict the morphodynamic response of gravel beaches to storms (McCall et al., 2015). The XBeach-G model has previously been validated for natural gravel coasts using field observations and data from a large-scale physical model experiment. The results show that XBeach-G is capable of reproducing the observed morphodynamic response, ranging from berm building to barrier rollover, of the barrier well in qualitative and quantitative sense. The current paper focusses on another application of this model. The model is applied to predict the stability and the reshaping of temporary exposed bunds consisting of relatively fine and wide graded material. The slope of such bunds ($\tan(\beta) \approx 0.65$) is generally much steeper than the gravel beaches considered by McCall (2015).

RESULTS

The model has been used to simulate the results of (various) physical scale model tests where a number of bund layouts have been subjected to various wave and water level conditions in a wave flume (van der Plas et al., 2017). The physical model tests were performed at INHA (Barcelona), with the primary objective to measure the stability of wide grade material (0-200mm) under wave attack (see Figure 1). The model scale was 1:10.

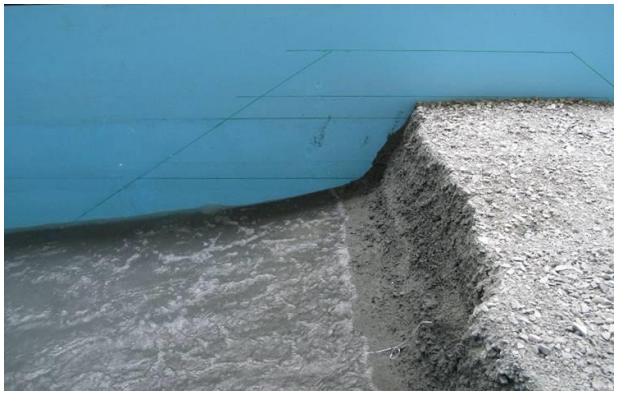

Figure 1 – Typical damage profile of emerged gravel bund from physical model test

Seven different cross sections have been tested, ranging from a near-bed type of structure to a fully emerged breakwater, all with a bund slope of 2:3. In this study, three of the cross sections have been modeled in XBeach-G (Table 1).

Layout	Crest width [m]	Freeboard [m]
B	30	-3
C	21	0
D	12	3

Table 1 – Characteristics of the modelled cross sections

During a test series, the wave conditions (4 in total) were increased stepwise without damage repair between runs, but damage was measured after each wave condition. In the XBeach-G simulations, the exact duration and sequence of wave conditions has been applied. The 4 wave conditions are indicated in Table 2.

Scenario	Hm0 [m]	Tp [s]
150	1.50	6.2
200	2.00	7.2
275	2.75	8.4
350	3.50	9.5

Table 2 – Applied wave conditions during tests

The XBeach-G model has been calibrated to the test results from the physical scale model by performing a large number of simulations where the 3 main calibration parameters have been varied, namely the sediment friction factor, the internal angle of repose and the boundary layer phase lag (cf. Masselink *et al.*, 2014). After calibration of the XBeach-G model, the results compare well with the measured damages from the physical model tests. For the three simulated layouts (B, C and D), the model results have been compared to the measured profile after the last wave condition 350 (see Figures 2 to 4, red represents XBeach-G result).

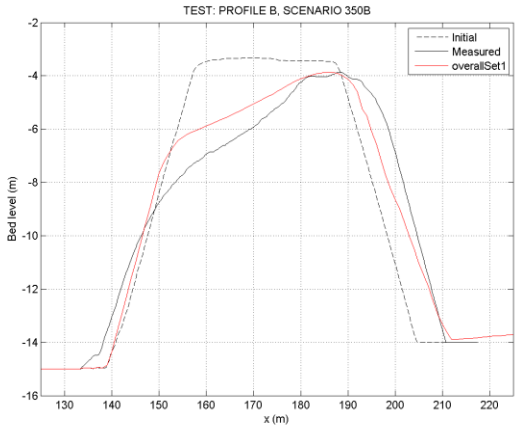

Figure 2 – Comparison of measured profile with XBeach-G result for layout B (submerged bund)

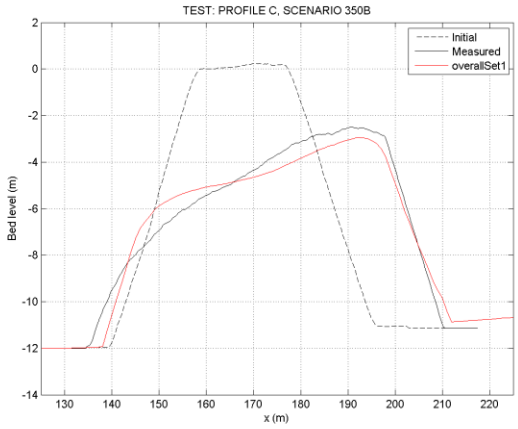

Figure 3 – Comparison of measured profile with XBeach-G result for layout C (crest level at still water level)

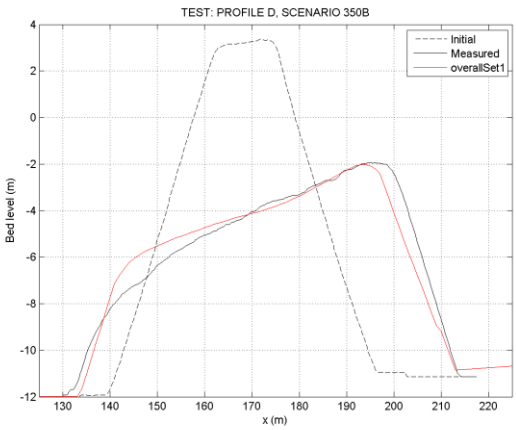

Figure 4 – Comparison of measured profile with XBeach-G result for layout D (emerged bund)

CONCLUSION

The reshaping of fine and wide graded temporary structures has been simulated using the process-based model XBeach-G. The results of the model compare well with measured reshaped profiles from physical model tests. XBeach-G appears to be a suitable tool to estimate the reshaping and the resulting volume losses of rock from temporary exposed structures.

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