A Laboratory Study of Overtopping and Breaching of Shingle Barrier Beaches

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INTRODUTION

Shingle and mixed sand / shingle beaches are widespread in many parts of the UK and Europe. These beaches are highly efficient and practical forms of coastal protection, however a shingle beach in common with any other type of beach, can suffer erosion and subsequent landward retreat of the shoreline. Consequently over a period of time a beach which was originally of satisfactory dimensions may be reduced to such an extent that it no longer constitutes an acceptable 'line of defence'. Anticipating this state is clearly important if shingle beaches are to be managed effectively, and landward structures are not to be damaged by flooding.

The classical dynamic equilibrium shingle beach profile has been described using the parametric model of Powell (1990). In theory, a dynamic equilibrium profile should develop for any given combination of wave conditions assuming that there is sufficient time and sediment available for the profile to form. This limitation means that the model is not valid for the prediction of overwashing and breaching of shingle barrier beaches. However it has been used to estimate profile performance in these circumstances (Buijs et al., 2005).

An empirical framework, based on extensive fieldwork and physical model data was developed to predict the threshold for breaching of shingle barrier beaches (Bradbury, 2000). The field and model data used to develop the model related only to the shingle barrier at Hurst Spit. Bradbury et al (2005) found that model did not work so well when applied to other sites and concluded that use of the model outside the valid predictive range would result in the under prediction of overwashing.

Further data was therefore required to test and extend the range of validity of the Bradbury model.

PHYSICAL MODEL TESTS

Physical model tests were performed in one of the wave basins at HR Wallingford at a scale of 1:15 to study the overwashing and breaching of shingle barrier beaches. The physical model consisted of 4 separate bays each 2m wide and 15m long, with the shingle beach represented by crushed coal according to the scaling adopted by Powell (1990). Bay 1 consisted of a lower sand layer and an upper coal layer with a prototype grain diameter of 16 mm. The sand layer was used to simulate the effect of an impermeable core on the threshold for breaching. Bay 2 contained sediment of the same size of as bay 1 so a direct comparison between a beach with and without an impermeable core could be made. Bay 3 & 4 much contained coarser sediment with a d_{50} of 42 mm and 53mm respectively. This allowed the effects of beach permeability on the threshold for failure of barrier beach to be observed.

One of the other main objectives of the study was to investigate the effect of the barrier width on the threshold for breaching. To do this three different crest widths were investigated (5m, 10m, & 15m prototype). Two different wave steepness were used (S=0.06, 0.01) to study the different effects of storm and swell waves. The geometry of the barrier also has a significant effect on the threshold for breaching and as a result two extra tests were made. The first was a barrier beach fronting an elevated hinterland and the second was a barrier with the same volume as a previous test but with an elevated free-board.

THRESHOLD FOR BREACHING

The dimensionless barrier inertia parameter (B_i) (Bradbury, 2000) has been used to estimate the threshold of breaching.

$$B_i = R_c B_a / H_s^3 \qquad (1)$$

Where R_c(m) is the barrier freeboard, B_a(m^2) is the cross-sectional area of the beach above still water level and H_s (m) is the significant wave height. The model is only valid in the range $0.015 < H_s/L_m < 0.032$. Figure 1 shows a comparison between the threshold curve (1) and the field and model data used to derive the curve combined with new physical model data. Being below the curve is meant to imply that breaching will occur. It is clear from the new physical model data that extrapolation of the empirical model is not valid and that the predictive curve needs to be modified. This empirical model only includes the effects of wave steepness and barrier cross-sectional area. Results from the physical model tests indicate that the sediment size and the barrier geometry have a significant effect on the threshold of failure. By combining the previous field and model data with the new physical model tests a new more widely applicable model to estimate the threshold for the breaching of shingle barrier beaches has been developed.

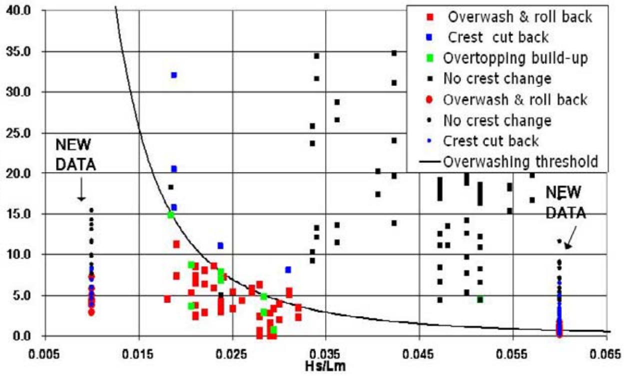

Figure 1: A comparison between the empirical approach of Bradbury (2000) and the combined field and model data.

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