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Assessing Artificial Longshore Bars By Numerical Model

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Introduction

It is known that under storm waves, beach will respond by eroding material from the beach face and the formation of longshore bar(s) in the vicinity of breaking point. This breakpoint bar is believed to have the effect of slowing down beach erosion by dissipating incoming wave energy and retarding offshore sediment transport. Recently, artificial bars are being proposed as beach protective measures based on this reasoning. However, these artificial bars, unlike natural longshore bars will not respond to changes of wave climate and water level. Therefore, their long term effectiveness and benefit are hard to assess.

Numerical computations are performed here to compare the response of profiles with artificial longshore bars to that with natural sandy longshore bars. These examples serve to illustrate the model's capability as an engineering tool for the design and assessment of artificial longshore bars as means of beach erosion protection.

Sediment transport model

The sediment transport formula contains two parts, bed load and suspended load. The bed load transport is based on an energetic approach driven by mean current and bottom wave orbital velocity. Owing to the asymmetric wave bottom orbital velocity in a wave cycle, this bed load transport by wave orbital velocity has a net onshore component. The suspended load transport which dominates in surfzone is built upon an undertow current. Here, the suspended sediment concentration is related to breaking wave energy dissipation and the transport velocity is the mean undertow current. This component is always directed offshore.

The total transport Q is the sum of bed and suspended loads as followings,

$$Q = q_b + q_s$$
$$q_b = A_{bc}(\tau_m - \tau_{cr})U_c/\rho g + A_{bw}(\tau_m - \tau_{cr})U_w/\rho g$$
$$q_s = A_s \tau_{turb} Q_u$$

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where ρ is the density of water, g is gravity coefficient, U_c is the integrated depth mean wave induced-current, U_w is the maximum orbital velocity at the bottom, $_uQ$ is the discharge by the undertow, τ_m is the maximum bottom shear stress generated by wave and current, τ_{turb} is the turbulent shear stress generated by waves and mean current, τ_{cr} is the critical shear stress under waves and mean current, A_{bc}, A_{bw}, and A_s calibrated coefficients. As simplified form, this model includes the slope effects and transition zone effects which are very important but often neglected in other approaches. By introducing additional cushioning effect in the water column, this model was shown to approach an equilibrium state.

Applications to Artificial Bars

The present model was applied to the case of fixed longshore structures such as submerged artificial longshore bars and the beach responses with artificial longshore bar under storm wave conditions were examined. It was assumed that the artificial bar is low and streamlined so that no wave reflection and energy dissipation other than the usual breaking and friction effects need to be considered. Under such simplification, the present model is applicable. The sediment conservation equation should be modified as bottom scouring will not go beyond the fixed bar. Therefore, for fixed bottom portion, the sediment conservation equation is modified as

$$\Delta h = 0, \qquad \text{if potential } q > \text{actual } q$$

$$\frac{\partial h}{\partial t} = \frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y}, \qquad \text{if potential } q = \text{actual } q$$

where potential q is the transport rate based on the movable bed, and actual q is for fixed bed.

The case used here is based on a 2-dimensional prototype profile typical to a Baltic coast. A storm condition of 2 m surge and waves of H=2 m, T=6sec, with normal incident wave angle is used as input to generate the configuration of a 2-D natural longshore bar after 20 hours run time. The question is how would this configuration respond to changing water levels and wave conditions if the bar is fixed in one case and movable in the other. Two different input conditions are used here for comparisons. The first one is to decrease the storm surge to 1 m but kept the same wave height at 2 m. The second one is to keep the same surge level at 2 m and increasing the wave height to 2.5 m. In the first case, the water level is reduced to 1 m storm surge but the wave height is kept the same. Now the bar is very near to the water level initially. The wave which has the same height as the high water case will now break further offshore and a bar will tend to form near the new breaking point. Initially, the cross-shore transport is zero over the bar as the material will only accumulate leeward of the bar. At the later time, material begins to by-pass the bar and moves offshore. Figure 1 shows the comparisons of profile change for a fixed bar and natural bar under a new condition. For the natural bar case, the initial bar will simply move seaward to its new stable location. For the fixed bar case the new breakpoint bar has to gather material from somewhere else which, in this case, from the foreshore area of the fixed bar, since enough sand is not transported over the bar as time goes, scouring will occur at the toe of the fixed bar. In the second case (Figure 2), when the wave height is increased while maintaining the same water level, the natural bar as well as the breaking point will move seaward requiring larger volume to reach a stable bar shape. If, on the other hand, the bar is fixed a second natural bar will be formed seaward of the fixed bar but welded to the fixed bar.

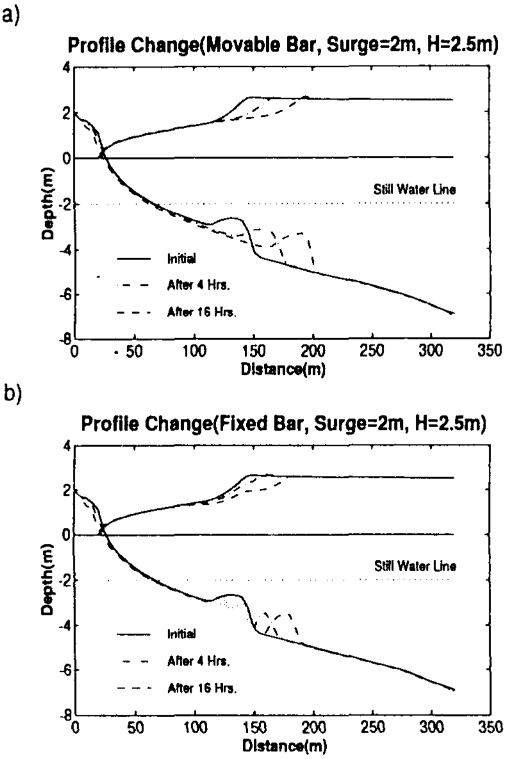

Figure 1 Profile Change for a)Movable Bar and b)Fixed Bar Case in 2 m Storm Surge and 2.5 m Wave Height.

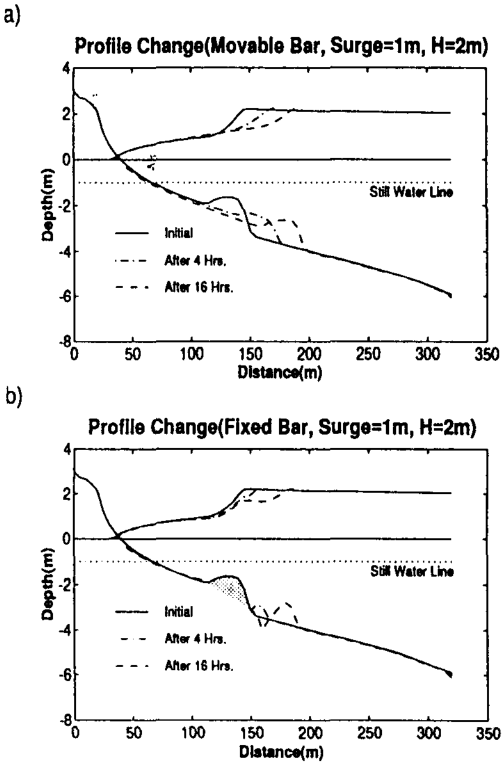

Figure 2 Profile Change for a)Movable Bar and b)Fixed Bar Case in 1 m Storm Surge and 2 m Wave Height.