PREDICTION OF CONSOLIDATED COHESIVE BOTTOM EROSION BY WAVE ACTION

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INTRODUCTION

A consolidated cohesive sediment layer exists below a layer of sand on some beaches along the Great Lakes (glacial till) and the Gulf of Mexico. The erosion process of consolidated cohesive sediment may be gradual but irreversible (no recovery) apart from sand and gravel released from the eroded consolidated cohesive sediment. The cohesive sediment erosion rate is increased by a thin mobile layer of sand and decreased by a thick sand layer. The complicated interactions of waves, sand and cohesive bottom are simplified and incorporated into an existing cross-shore numerical model.

SAND AND CLAY INTERACTION MODEL

The numerical model CSHORE (Kobayashi 2016) is extended to include the basic processes of cohesive sediment and cohesionless sediment interactions on the mixed clay and sand bottom under normally incident wave. The surface elevations of sand and clay are denoted as z_b and z_p, respectively (Figure 1). The sand layer thickness h_p is given by $h_p = (z_b - z_p)$. Initially, no sand is assumed to exist on the clay bottom ($z_b = z_p$ at $t = 0$). Sand released from the eroding clay bottom moves onshore and offshore by wave action. A dike erosion model is adjusted to predict the clay erosion depth using the clay resistance parameter R_c. A dimensionless function F is introduced to include the abrasive effect of a thin mobile sand layer and the protective effect of a thick sand layer. The mobility is represented by the sand movement probability P_b computed in CSHORE. An efficient numerical scheme is developed to predict both clay bottom erosion and sand layer thickness at each time step during the time marching computation.

COMPARISON WITH DATA AND APPLICATIONS

Skafel (1995) presented a small-scale laboratory flume experiment using intact till samples consisting of 21% sand and gravel, and 79% clay and silt. The laboratory data of hydrodynamic variables and erosion rates in two tests are compared with the extended CSHORE. The hydrodynamic variables are predicted within 20% errors. Figure 2 shows the comparison of the measured and computed erosion rates during 10 h. Sand released from the eroded clay bottom accumulates more near shoreline. The sand accumulation reduces the value of F and the clay erosion rate. The computation duration of two tests is increased to 100 h to assess longer-term erosion. The scale effect is estimated in two prototype tests based on Froude similitude with a length ratio of 1/4 (model/prototype) and the till characteristics are kept the same. The prototype 200-h simulations predict much larger till erosion near the shoreline. Sand volume budget is examined to ensure the conservation of sand volume including sand released from the eroded clay.

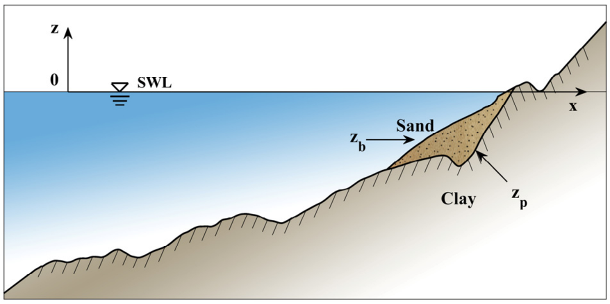

Figure 1 Definition sketch for sand surface elevation z_b and clay surface elevation z_p.

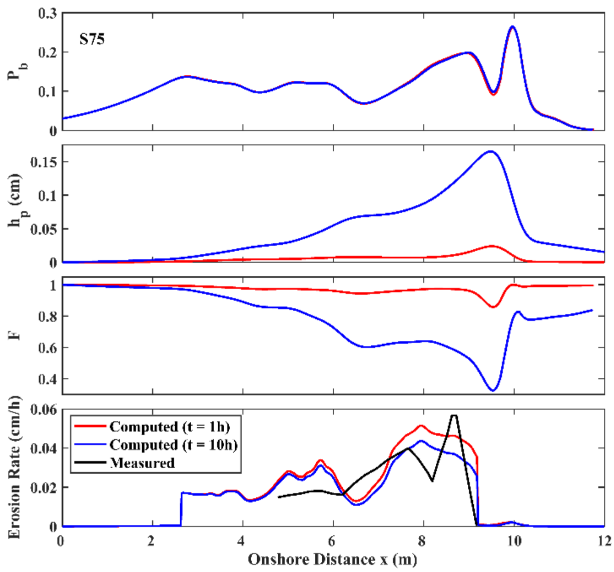

Figure 2 Computed (t = 1 h and 10 h) sand movement probability P_b, sand layer thickness h_p and abrasion and protection function F as well as measured and eroded computed erosion rates for S75 test.

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