BEACH AND STORM-TIDE PROTECTION ON THE COAST OF THE BALTIC SEA

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1 INTRODUCTION

The coastline of the southern Baltic Sea has been retreating due to the locally rising sea level. The rate of rise is estimated between 70 to 150 mm per century with diminishing trend. This has led to erosion, narrow beaches and wave-cut dunes and cliffs. In addition the coast is subject to storm-tides of the order of up to 2.5 m. Since much of the hinterland is low and flat these can have a devastating effect if the coastal defences are breached.

Extensive studies were carried out of the Fischland coast just east of Rostock, with the aim of devicing environmentally friendly beach and storm-tide protection (Dette, et al. 1999).

The shore parallel component of wave energy flux along the west coast of Fischland was found to vary substantially, and with it the shore parallel sediment transport potential. Over a stretch of 15 km the transport potential in net transport direction decreases from 68 900 m^3/year to 27 100 m^3/year. Since no local deposition is present, the difference must be directed offshore. Plots of seabed level changes from survey data showed low flat bed features moving offshore and a general deposition seaward of the 5 m depth contour. This depth corresponds approximately to the seaward limit of the active zone, the closure depth of numerical models. Erosion conditions prevailed in the active zone.

The slope of the active zone has been decreasing and that of the foreshore at water's edge increasing. At places the foreshore slope of fine sand beach is as steep as 1:10 or more, down to depth of ca. 2 m below MSL. Consequently, the conversion of the bulk of wave energy occurs on a very narrow surf zone, located on this slope, and the turbulence intensity and erosion potential per unit area are high. On such coastlines the underwater "equilibrium" profile has the form described approximately by $h = KA\ x^{0.3}$ rather than x to ⅔ rd power and the constant A, as in the Bruun-formula, is multiplied by K = 4 to 7 (Raudkivi, 1998, p. 387), wherein h is depth of water and x distance from water's edge.

2 RESULTS

The protection of shoreline and beach in the past has been with beach nourishment and use of premeable pile groynes, which slow down the shore-parallel velocity without blocking it (Raudkivi, 1996). However, along stretches of the shoreline, where the foreshore slope is very steep, it is difficult and expensive to establish a surf zone with an equilibrium profile of a non-eroding coast. For these locations a seaward support of the beach fill has been recommended, as shown schematically in Fig. 1. The performance of such a sill was investigated in the large wave flume in Hannover (Dette et al., 1997). There was no measurable loss of sand from the surf zone in 23 hours of wave action. In the Baltic Sea the sill could be constructed from coarse gravel, which is a by-product of dredging. The gravel ridge will stabilize on the seabed as shown by similar naturally occuring gravel ridges. The significant wave height at the Fischland coast for 96 % of time is $H_s \leq 1.5$ m. These waves break in 1.72 m of water, which could be taken as the seaward limit of the reestablished surf zone. Higher waves are associated with significantly raised water levels, which move the surf zone landward.

In order to protect dunes (cliff) against waves at raised water levels the usually dry beach should be wide enough to accomodate an equilibrium beach profile. For a 2½ m rise in water level, the water line on a fine sand beach would be moved about 95 m landward of that at MSL. The existing beach width to dunes is generally only a fraction of this.

The proposal for the protection of sand dune and provision of security against flooding during storm tides is illustrated in Fig. 2. The stonewall will intercept ca. 90 to 95 % of all storm-tides. The dune is protected by built-in geotextile membranes (Dette & Raudkivi, 1994). The membranes are covered with sand and planted. This cover has to be restored after an extreme event, at 15 or more year intervals on the average. The stonewall is usually buried in a reservoir from which the underwater profile is nourished by small frequently occurring storm events. This nourishment approximates to “continuous” nourishment, which has the least annual sand demand. The membrane protection has proved itself in Fiji and on the Insel Sylt in the North Sea.

3 REFERENCES

Dette, H.-H. And Raudkivi, A.J. Raudkivi (1994). Beach nourishment and dune protection. Proc. 24th Coastal Engineering Conf., Kobe, Vol. 2 1934-1945.

Dette, H.-H., Peters, K. And Newe, J. (1997). Large wave flume experiments 1996/97 in MAST III SAFE Project. Techn. Univ. Braunschweig, Leichtweiss-Institute, Reports Nos. 825 and 830.

Dette, H.-H., Raudkivi, A.J., Stelljes, K. and Bittner, R. (1999). Bewirtschaftung der Küste im Raum Fischland, Darss und Zingst. Techn. Univ. Braunschweig, Leichtweiss-Institute, Bericht Nr. 851.

Raudkivi, A.J. (1996). Permeable pile groins, ASCE J. Waterway, Port, Coastal and Ocean engineering, Vol. 122(6), 267-272.

Raudkivi, A.J. (1998). Loose Boundary Hydraulics, Balkema, Rotterdam.

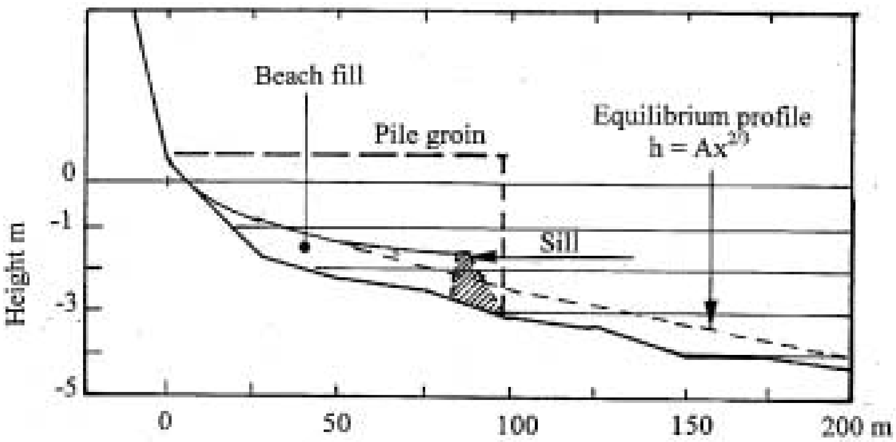

Fig.1: Seaward Support of Beach Fill (schematic)

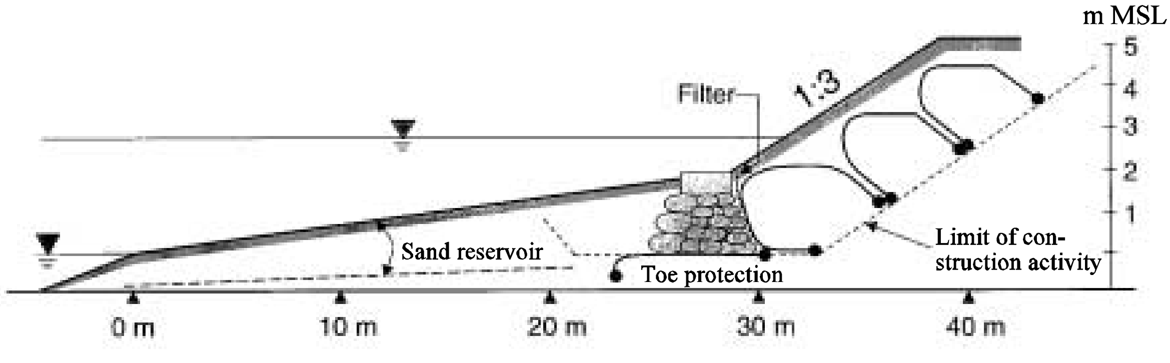

Fig.2: Arrangement of Dune and Storm Tide Protection (schematic)