Design and implementation of an erosion protection barrier for mercury-contaminated sediments at Tollare, Sweden

Andrew Petsonk[1], Jonas Jonsson[2], Fredrick Marelius[3]

[1]WSP Environmental, SE-121 88 Stockholm-Globen, Sweden
[2]WSP Civils, SE-121 88 Stockholm-Globen, Sweden
[3]Royal Institute of Technology, SE-100 44 Stockholm, Sweden

Phone: +46-(8)-688 60 00
E-mail: andrew.petsonk@wspgroup.se

Introduction: This paper describes the design and implementation process for construction of a barrier to protect mercury-contaminated sediments at Tollare, Sweden, from erosion by marine traffic.

The decommissioned Tollare paper mill site is a brown-field intended for redevelopment with residential housing. Marine sediments in the area contain cellulose fibers, a discharge residue from the mill. From 1941 until it closed in 1964, the mill used phenyl mercury to control bacterial and fungal growth in its various processes, thereby contaminating the fibrous sediments.

Geochemical and ecotoxicological studies demonstrated that conditions were similar to those found in other parts of the Stockholm archipelago [1]. It was also shown that the sediments did not pose significant risk to health or the environment [2], and that remediation of the sediments would not significantly improve conditions [2, 3]. However, due to the potential for propwash erosion of the sediments [6], the redevelopment project could not be implemented without some protective measures. It was therefore decided to construct an erosion protection barrier along the shoreline near the old factory location [3].

Methods: A geotechnical investigation of the sediments and underlying soils [7], as well as theoretical calculations about the erosive behavior of the sediments and of possible granular capping materials [6], showed that the sediments were very soft, had low shear strengths, were subject to large settlements, and were easily erodeable. They also discharged large quantities of gas due to anoxic decomposition of organic matter [1]. The initial design for the protective barrier therefore included a geonet covered by 20-30 cm crushed rock (grain size of 70-150 mm).

A first full-scale field test [4] showed the need for a revised design. The new design includes a woven geotextile fabric and two 5-10 cm thick layers of crushed rock (50-100 mm). The geotextile spreads out the load created by the rock layers. It also contains a 1 m square grid of impervious channels into which a brittle concrete ballast is pumped. This grid pulls the fabric in the squares taut, ensures that the geotextile follows the bottom contours, and helps contain the granular materials. Part of the fabric within the grid contains 3 cm x 3 cm squares of loosely woven and unwoven material, with loose threads crossing each other in several layers. The objective is to hinder transport of particulate through the geotextile while allowing the passage of gas.

The revised design was tested on both laboratory- and full-scale [5]. The latter test included intentional disturbance of the barrier by propwash from a boat with similar characteristics as that used for the theoretical calculations. The propeller was first run at low speed until the propwash velocity reached steady state. Thereafter the effect on the barrier was documented. The prop speed was subsequently increased stepwise up to the maximum velocity.

Results: Both field tests were documented mainly by scuba divers with video cameras. During the first test, a significant amount of sediment was pressed through the geonet prior to application of crushed rock. The barrier did allow discharge of gas, but installation caused much larger vertical and horizontal movement of sediments than expected.

The second field test gave much more satisfactory results. Only a small amount of very fine sediment passed through the geotextile, while the flow of gas was unimpeded. All of the barrier components remained in place and settlements were approximately as calculated. The erosion part of the test also demonstrated that the theoretical calculations were somewhat conservative, which indicated that the completed barrier should provide sufficient protection against propwash-driven erosion from vessels similar to that for which it was designed.

Discussion: Scour protection for soft, fine-grained low-density sediments with a small load-bearing capacity is difficult. Gas production adds an additional complication. A suitable barrier must be pervious to gas and impervious to particulate, as well as sufficiently light so as to not induce excessive settlement. This ruled out use of geonets and standard geotextile fabrics. The resulting design, with a tailor-made geotextile and a thin scour protection layer, is currently being implemented and is expected to provide the required level of protection.

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