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LARGE-SCALE PHYSICAL MODEL TESTS ON SAND-FILLED GEOTEXTILE TUBES AND CONTAINERS UNDER WAVE ATTACK

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1. Introduction

Sand-filled geotextile elements such as geotextile tubes or geotextile containers are considered more and more as a serious alternative material for coastal protection. There is a growing pressure to use alternatives to natural rock or concrete because of the high impact to the ecosystem and the landscape in consequence of mining these materials. Uncertainty with respect to the stability of geotextile elements under wave attack is one of the reasons why these systems are not applied widely. Therefore, large-scale physical model tests focusing on the stability of geotextile containers and tubes under wave attack have been performed in the Delta Flume of Deltares, which is among the largest flumes of the world.

Two research projects are reported in this paper. The first research project aims at the stability of geotextile containers under wave attack; the second research project focuses on the stability of geotextile tubes under wave attack. At both projects, irregular waves (JONSWAP spectrum) with a significant wave height up to H_s = 1.50 m and a wave steepness of s_{0p} = 0.03 were applied. The tests were repeated until failure occurred.

2. Experiments with geotextile containers

Two types of geotextile container cross-sections were tested. One cross-section where the crest was placed at sea level and one cross-section where the crest was at $0.75H_s$ below sea level were tested. In both cross-sections, the structure was placed on a 1:3 slope. The containers were filled with sand up to 45% of the theoretical maximum volume in the geotextile container. Before and after each test, the precise position of the containers was determined with the use of a profiler. To measure whether sand transport in the containers occurs, instruments were installed in the containers.

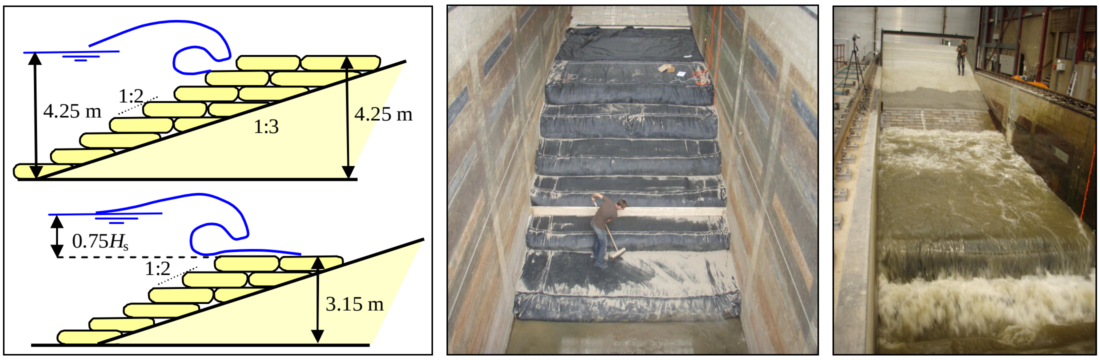

Figure 1. Schematized test set-up of geotextile containers; test set-up prior to test-run; test-run

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It is concluded that the stability of the geotextile containers is lower than the stability determined in other (smaller) scale model tests. This can be explained by the occurrence of a failure mechanism that did not occur in small-scale tests. It appeared that, besides sliding, the caterpillar mechanism of a container is a significant mechanism. This mechanism is caused by the internal migration of sand in the containers. This only occurs in large-scale tests because the migration of sand in the container is better modelled. Therefore, it is recommended to take the internal migration of sand into account since this will cause the caterpillar mechanism, which leads to a lower stability, just like in reality.

3. Experiments with geotextile tubes

Eight geometric variations of geotextile tubes were tested. The tubes were constructed in the flume by pumping a sand-water mixture into the tube, just like in reality. The variations include five individual tubes with different filling percentages and one individual tube with a bar placed at the landward side to simulate a trench. One test case consisted of two tubes placed behind each other and one test case was a so called 2-1 stack; two tubes placed behind each other with a third tube on top. Measurements that were taken were amongst others the movements of the tubes and sand migration within the tube. The internal sand movement in the tube was indicated by locally colouring the sand and determine the displacement of the coloured sand.

Figure 2. Schematized test set-up of geotextile tubes; filling of tubes (demonstration besides flume); test-run

In all test cases with individual tubes, the failure mechanism was sliding. Some migration of the sand within the tubes with a low filling percentage occurred, but significantly less than in the tests with containers. The test cases with two tubes placed behind each other failed due to landward sliding of the landward tube. Failure of the 2-1 stack occurred due to a seaward sliding mechanism of the top and seaward tube. Based on the results, a stability formula has been derived which includes the significant wave height (H_s), the height (D), width (B) and relative density (Δ) of the tube, a reduction parameter to include wave energy transmission (χ), the slope angle of the foundation of the geotextile tube (α) and the friction coefficient (f) between the geotextile tube and its foundation:

$$\frac{\chi H_s}{\Delta\sqrt{BD}\,(f\cos\alpha+\sin\alpha)} \leq 0.65 \qquad (1)$$

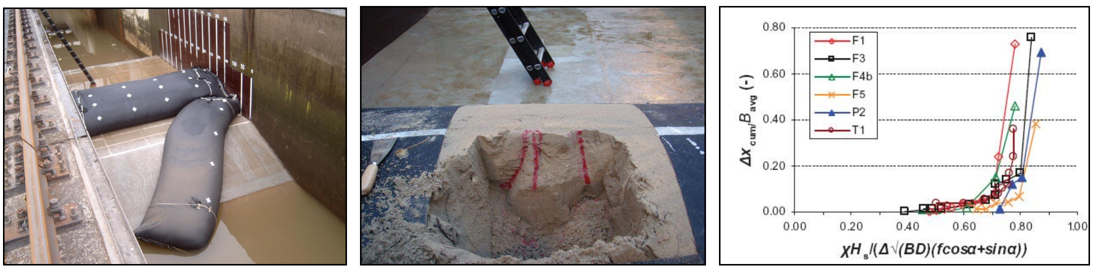

Figure 3. Failure of 2-1 stack; analyzing sand movement with colour injection; impression of results