

DESIGN AND LAYOUT OPTIMIZATION OF ROCK-FILLED MATTRESS SOLUTIONS FOR SCOUR PREVENTION BY MEANS OF SAND BED DEFORMATION TESTING UNDER MULTIPLE PROPELLER JET INDUCED FLOWS

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ABSTRACT

Propeller jets produced by large vessels generate high flow velocities near quay walls, jetties, and locks. To protect the stability of these structures a bed protection is typically recommended, otherwise the structures may collapse due to scour at the toe. Guidelines for the design of bed protection exists, but propeller-induced loads are far from fully understood and current design guidelines may not always result in optimal bed protection designs.

A joint research program was developed to reduce design-related uncertainty, potentially save construction materials, and reduce costs.

Therefore, the aim of the research is to better understand the loading on the harbor bed and its response to optimize the design of bed protection systems.

The bed protection solution tested are special rock-filled gabion mattresses, specifically designed for underwater applications, as a more environmentally friendly alternative bed protection system to mitigate scour near quay walls. This solution has the advantage of not requiring penetration of concrete/asphalt for stabilization since rocks are kept together in a wire cage (mattress), thus reducing the thickness of the protection and the impact on the environment.

This work summarizes the scale model tests performed to identify under which conditions the tested protection system is stable and effective under multiple bow thruster jet induced flows.

The research program first focused on the optimization of the rock-filled mattress bed protection layout. Failure mechanisms were identified during first series of tests after which they were mitigated by iteratively optimizing the design. The failure mechanisms that were encountered for the early-stage layouts were: Winnowing (outwash of sediment) along the interface between the bed protection and the quay wall, vortex attack induced by suction of the bow thruster inlet, uplift of the mattress by suction of the bow thruster inlet.

After the optimization phase, verification tests were performed on the final layout in which the above failure mechanisms have been mitigated. In the verification tests the layout was exposed to increasingly severe hydrodynamic conditions. In the most severe condition two bow thrusters were active at full power for the duration of one hour (prototype scale) and low under keel clearance to represent a realistic flow pattern generated by the maneuvering of large vessels.

The research described in this work focusses on

deformation tests, where the special rock-filled mattress solution, here used as bed protection, is investigated.

The flow patterns above the same solution were investigated by means of PIV measurements in a previous project.

The special rock-filled gabion mattresses were able to prevent large-scale erosion of the sediment bed material for all conditions tested including the most severe conditions. Some scour occurred along the interface of the quay wall and the bed protection, but the scour hole extents remained strictly limited and erosion rates decreased through the duration of the test.

Additionally, a test was performed without any bed protection to demonstrate the level of scour that can occur in these conditions. In this test the entire layer of sand between vessel and quay wall was washed away, highlighting the need of a bed protection system as the quay wall could otherwise be destabilized.

The research campaign led to the validation a novel interpretative model proposed for the design of special pre-filled gabion mattresses against jet propellers action, introducing new and more complete resistance parameters.