Modelling for Erosion Protection in Capping Design

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Background/Objectives. Capping is a method suitable for reducing transport of contaminants from sediments. External factors such as advection, bioturbation and erosion due to currents and ship traffic can degrade the cap. In particular, the seabed in harbors can be highly exposed to erosion from ships (prop wash) and from waves and other naturally generated water streams (ocean currents, tidal currents, rivers etc.). The Norwegian EPA has reviewed various capping projects from about 1990 and up to today (most of them located in Norway). The study demonstrates that cap damages due to erosion are mainly due to the caps lack of ability to withstand currents or prop wash. Herein, we describe a new method for quantification of cap design resilience to factors due to prop wash. Applying this method, we integrate collected measures as well as our experience from performed remediation projects to establish an erosion protection model. This model determines the properties of the masses that should be used in a cap layer in areas with polluted seabed in order to withstand prop wash loads.

Approach/Activities. Projects reviewed by the Norwegian EPA reveals that there is a different degree of detailing how the cap and erosion protection layer is composed in various capping projects. The degree of detail in describing the basis for the choice of cap design and material also differ strongly from project to project. The review report shows that external influences such as erosion have a significant impact on the cap's lifetime. Hence, it is necessary to reviewing the appropriateness of current practice design methods, as well as providing more detailed specification and evaluation of the different characteristics of the cap. Site-specific solutions is necessary.

In addition, design of the erosion layers in some cases poses challenges due to heavy boat traffic in shallow waters. Results of using initial capping design tools often implies significant erosion protection in relatively large areas. This has a major impact on the costs of such projects. However, the observed damage to a cap in the field often affects only a small area. It is therefore necessary to increase the knowledge of the effect of erosion and the accuracy of design tools in order for more cost-effective solutions.

To this end, we have developed a new model for calculating flow rate at sea bed and corresponding grain size D50 due to propeller-induced currents on the seabed, extending preliminary 1D models available at NGI. The new model combines analytical hydraulic jet functions describing the flow field, with different empirical erosion load functions such as those of Hjulstrøm, Maynord, and Shields. Moreover, the model takes into account three-dimensional effects such as the three-dimensional bathymetric variation, as well as the boats variable driving direction and travel speed. The model is implemented in Matlab. Results from the initial calculation and the model are compared with current measures in Oslo Harbour (Pipervika) and sediment samples in the actual traffic area.

Results/Lessons Learned. The comparisons between model results, the field measures and observations make the new model provide a significantly better basis for calculating erosion than initial calculations. Nevertheless, it is important to form an experience basis in using the model through capping projects. The initial method used to calculate erosion layer is used in already finalized remediation projects and results from monitoring of these projects can be used

to evaluate the robustness in the calculation. The erosion layer model will be used in a new project in Horten harbour, conducted in 2018-2019.