Offshore & Dredging Engineering

Technische Universiteit Delft

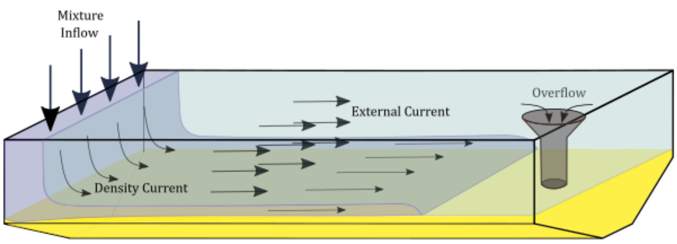
1-D modelling of the sedimentation process in the hopper

The total overflow losses during dredging activities determines the loading performance of Trailing Suction Hopper Dredgers. Therefore, predictions of the hopper sedimentation process in advance enables improvement of the effectiveness of the loading process and hence of the profitability of the TSHD. Previous models on the hopper sedimentation process include hopper volume averaged frameworks, one-dimensional vertical (1DV) and two-dimensional vertical along the hopper (2DV) models. However, these models do not include horizontal transport variation (1DV) and the variation of the cross-sectional hopper shape (1DV & 2DV).

The objective of this research was to develop a new sedimentation model to provide predictions of the overflow losses and the sandy-cargo distribution inside the hopper and to include variations of the cross-sectional shape of the hopper.

As a result the following research question was formulated:

Can a two-layered 1D horizontal numerical model within a cross-sectional framework provide valid predictions for the amount of overflow losses and longitudinal cargo distribution?



The model conceptualised in this thesis intends to provide a practical working tool that balances the need for inclusion of the related physical processes and computational time and complexity. The approach has therefore been to incorporate more physical processes than in 1DV models but do not meet the complexity of a 2DV model.

To this end, this thesis describes the development of a two-layered 1D cross-section averaged numerical model to predict the transport of sand. The model considers horizontal advection of water and sediment within a cross-section averaged framework that includes the geometrical variation of the hopper cross-section, see the figure above. Previous research shows that density currents plays a major role in the hopper sedimentation process. Therefore, the hydrodynamic model has been divided into two currents, an external driven free surface flow and a density driven internal flow. These hydrodynamic models has been dynamically coupled with the bed profile through erosion and deposition of sediment. Vertical transport between the two flows includes sediment settling, upward flow and entrainment effects.

Verification to idealised analytical solutions demonstrated that the hydrodynamic numerical models for the external and internal flow are mass, momentum and energy conservative. Furthermore the discretised models are robust and can deal with high and low (internal) Froude number flows and drying and flooding phenomena without the need of particular case specific numerical settings.

Laboratory experiments have been used for model calibration and an independent set of measurements for model validation. It is demonstrated that although a model of the external (barotropic) flow can predict the (overflow) losses well, the horizontal transport by turbidity currents has to be included to correctly predict longitudinal cargo distribution. This study demonstrates that the developed model predicts the amount of overflow losses and the longitudinal bed level elevation at a low user complexity level and requiring low computational time.

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Marine ingenuity

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