Testing water injection dredging for regular port maintenance

Alex Kirichek[1,2], Ronald Rutgers[3], Edwin Hupkes[3]

[1]Faculty of Civil Engineering and Geosciences, Department of Hydraulic Engineering, Phone: +31634401426
Delft University of Technology, 2628 CN Delft, the Netherlands
E-mail: alex.kirichek@deltares.nl

[2]Deltares, Boussinesqweg 1, 2629 HV Delft, the Netherlands

[3]Port of Rotterdam, Wilhelminakade 909, 3002 AP Rotterdam, The Netherlands

Introduction: As maintenance dredging of sediment deposits can be highly expensive and inefficient, port authorities seek for tailor-made solutions to reduce the costs and at the same time guarantee safe navigation in ports and waterways.
This work is focused on the water injection dredging (WID) that can be used as a tool for reallocation and conditioning of the deposited sediment. The efficiency of this dredging method has been recognized over the past 30 years. However, the successful application of the method can be only achieved by combining WID with the knowledge of the system where WID is applied. The knowledge on the sediment distribution after WID operations can be potentially a powerful tool that helps defining the timeframe for the next WID maintenance as a part of maintenance strategy.

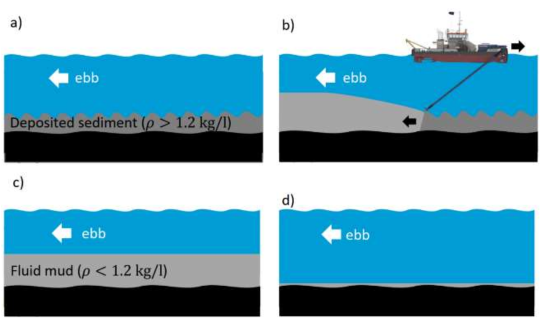

Fig. 1: Illustration of WID performed in a navigational channel during the ebb tide. a) Initial conditions for WID. b) Fluidization of deposited sediment during WID. c) WID-induced fluid mud layer. c) Final result after WID in case WID is conducted for sediment reallocation purposes in a high energy region.

Methods: WID was carried out in the Calandkanaal and in the Nijlhaven (the Port of Rotterdam) on a regular basis from May to November 2020. The results of WID operations have been systematically monitored by combination of in-situ tools and numerical models. The schematic representation on conducted WID within the scope of this work is shown in Fig.1.

Results: The water injection dredging has proven to be a relatively low-cost dredging method. In addition, the fluidized sediment is transported in the form of a density flow on the bed and is not distributed throughout the entire water column, thus WID is also characterized by a high level of environmental compatibility competing to traditional port maintenance dredging. Finally, the recent comparison of WID and TSHD showed that WID is more CO2 efficient than the regular TSHD maintenance [1]. All these aspects suggest that WID can be an attractive alternative to TSHD for port maintenance.

Discussion: The thickness of WID-induced fluid mud layer is often larger than the thickness of original mud layer resulting in a reduced draft for the incoming vessels. In this case, WID is combined with the nautical bottom approach defined by PIANC for navigation. According to PIANC [2], 'The nautical bottom is the level where physical characteristics of the bottom reach a critical limit beyond which contact with a ship's keel causes either damage or unacceptable effects on controllability and manoeuvrability'. The nautical bottom allows to use the fluid mud in estimates of under keel clearance (UKC) that the vessels can navigate in the port areas with no unacceptable effects on controllability and maneuvering of the vessels. If accepted by the port authorities, the nautical bottom approach is used worldwide for navigation through mud in ports and waterways with fluid mud layers [3].
The nautical bottom approach can be applied in WID areas in case WID-induced sediment plume stays in the port area by adapting either a density-based (1200 kg/m3) or yield stress-based (100 Pa) criterium for the nautical bottom. An additional 1.5-2 m of navigable depth can be used for navigation after adapting the nautical bottom approach after WID.

This study is funded by the Port of Rotterdam and carried out as a part of the research project PRISMA https://www.youtube.com/watch?v=LSbQhUJMBJw within the framework of the MUDNET academic network https://www.tudelft.nl/mudnet/

References: [1] Kirichek and Rutgers (2020) *Terra et Aqua* **160:16-26;** [2] PIANC (2014) *Harbour Approach Channels - Design Guidelines*; [3] Kirichek et al. (2018) *Terra et Aqua* **151: 6-18.**