Climate Change Impacts on the Sediment Structure in the Hamburg Port -Challenges and Opportunities: Use of Fluid Mud for Navigational Aspects-

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Introduction: For future strategies in water depth maintenance in the Port of Hamburg, determining the navigability limit (i.e., the nautical safe depth) is of major importance. For this purpose, a project "Nautical Depth" was set up at the Hamburg Port Authority (HPA), which is dedicated to deal with this issue. The aim is to measure a nautical safe depth under various boundary conditions and to identify limits for a safe passage of high concentrated soil suspensions [1].
Regarding the climate change aspect, the sediment structure in the port changed in the last 10 years driven by low precipitation and discharge rates in the catchment area of the river Elbe. These changing boundaries lead to a change of the bio-geochemical composition of the sediments and the amount of suspend matter concentration within the system. This also increase the sedimentation rates and dredging amounts within the port area [2].

Methods: To identify the processes and changes within the settling of suspended material in Hamburg, several research works were carried out within the MUDNET framework of the TU Delft [3] and further works at the TUHH. One main question in the project "Nautical Depth" is the investigation of boundary conditions until which sediment properties the safe sailing of bulkers, tankers, or ultra large container vessels (ULCV) within a fluid mud condition will be possible.
Therefore, the Institute for Fluid Dynamics and Ship Theory enhances existing CFD-models to represent and calculate the forces of fluid mud on the ship hull, rudder, and propeller properties to give the basics of the adaption of ship handling simulators regarding the maneuverability of vessels within fluid mud.
The CFD-models should be validated with hydraulic model tests within the ship handling water and wave basin of the BAW. For the tests within the hydraulic model, it is necessary that the used fluid mud (or its substitute) is represented by stable and only slow changing sediment properties during the time of investigation.

Results: Different investigations of existing fluid mud material and its substitutes were carried out and the production and availability for the BAW model basin was analyzed during a pre-investigation phase within the project "Nautical Depth" of HPA. E.g., Figure 1 gives an overview of the changing fluidic yield stress (FYS) of fluid mud (FM) from the Köhlfleet Hafen area in Hamburg over the time during the consolidation of the material under conditions within the model test hall.

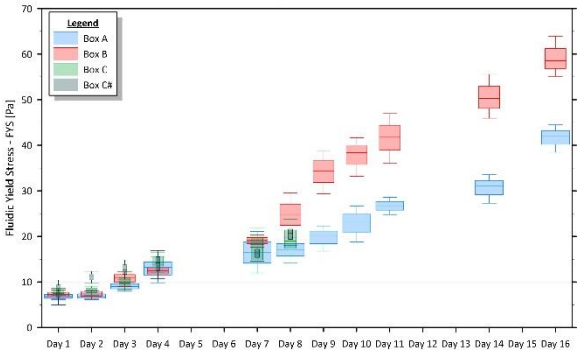

Fig. 1: Change of FYS during the consolidation within different big boxes (Box A: FM - without water overlay and undisturbed; Box B: FM with water overlay undisturbed; Box C and C#: FM without water overlay and disturbed and remixed after 7 days).

Discussion: The presentation will give an overview of the impacts of climate change on the sediment structure in the Port of Hamburg. It will show the challenges and consequences of the changed boundary conditions regarding the sediment management within the Elbe estuary. Furthermore, it will show the started investigations regarding the adaption of the nautical depth and will therefore also show their opportunities.

References: [1] Ohle & Schmekel (2019) Das Projekt „Nautische Tiefe" im Hamburger Hafen, Proceedings of the HTG-Kongress 2019; [2] Zander (2022) PhD thesis, TU Delft; [3] Shakeel (2022) PhD thesis, TU Delft.