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Publication date
2019

Citation (APA)
Shakeel, A., Zander, F., Gebert, J., Kirichek, A., & Chassagne, C. (2019). *Rheological characterization of fluid mud in ports and waterways*. Abstract from SedNet Conference 2019, Dubrovnik, Croatia.

Rheological characterization of fluid mud in ports and waterways

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Introduction: Fluid mud can be described as a mixture of water, organic matter and mainly cohesive mineral sediment. It is usually found in estuaries and in rivers with low-intensity currents as it is a fluid in a transient state that will densify over time unless favorable hydrodynamic conditions maintains it in its fluid-like state. Fluid mud has a yield strength that can develop over time to form a structured bed of considerably higher rigidity. The strength of mud can be measured by means of rheological methods.

The current definitions of fluid mud layers are based either on mineral concentration or on the density of the sediment. These definitions are ambiguous since the proposed critical parameters do not have a link to the strength developments in fluid mud, which are function of the changes in the fluid mud structure and composition over time. Based on our rheological investigations, we propose to use rheological properties for distinguishing the fluid mud layers from mud suspensions to be found above the fluid mud layers and consolidated mud layers to be found underneath. The development of shear strength in mud layers is important for ship navigation and surveying, maintenance of silted channels and erosion of rivers and channels with fluid mud layers [1], [2].

Currently, there are no protocols for measuring the rheological properties of fluid mud. The protocols have to be developed because fluid mud usually exhibits a thixotropic behavior (deformation, history and time dependence). Moreover, different rheological methods and geometries can be found in the literature. So far, it is not clear which geometry is optimal for the rheological measurements on mud.

Methods: Various laboratory protocols and equipment have been tested, and in particular tests have been carried out with a Couette rheometer that can perform oscillations, shear stress and shear rate controlled experiments. A number of natural mud samples from the Port of Hamburg and the Port of Rotterdam are used for testing.

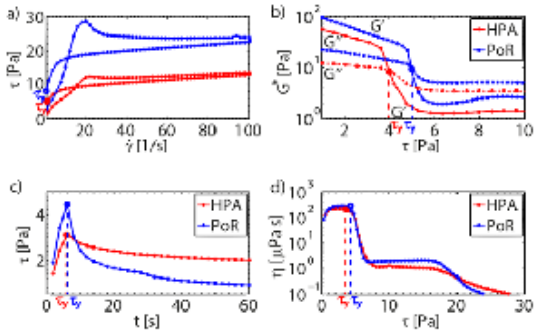

Fig. 1: Rheological methods for determining the yield stress τ_y of fluid mud at the Port of Rotterdam and the Hamburg Port Authority. a) Thixotropy of mud measured by controlled shear rate experiment. b) Amplitude sweep experiment. c) Stress grow experiment. d) Controlled stress sweep experiment.

There are several rheological methods that can be used to determine the yield stress of mud. We compared four methods of these methods in order to determine the yield stress of samples from the Hamburg Port Authority and the Port of Rotterdam. These methods [3] are controlled shear rate, amplitude sweep, stress grow, controlled stress sweep..

Results: The results are shown in Figure 1. It can be seen that the values of τ_y are consistent for all four methods. We are currently investigating the sensitivity of these methods as function of various states of mud (e.g. fluid mud, consolidated mud) in relation with their organic and mineral composition over time.

This study is funded by Hamburg Port Authority and carried out within the framework of the MUDNET academic network. www.MUDNET.eu

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