'Sailing through mud'
Results and consequences of field trials in the port of Delfzijl

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Introduction

The presence of a muddy sediment layer at the bottom of the tidal harbour of Delfzijl was the basis for an extensive study to establish the nautical depth. The muddy sediment layer in the 4km long entrance channel observed in the survey data was up to several meters thick and imposing a restriction to ship movements. The maximum draft of vessels in the entrance channel corresponded to 10%UKC above the high frequency echo-sounding (210kHz) reflections from the bottom of the entrance channel and harbour.

To establish the nautical depth Semaso (sister company of Wiertsema & Partners) together with Flanders Hydraulics Research investigated for Groningen Seaports the influence of the muddy sediment layer on the manoeuvrability of a vessel when sailing with a small and negative under keel clearance (sailing through mud) in the port of Delfzijl.

Fig.1 Aerial view of the entrance channel of the port of Delfzijl

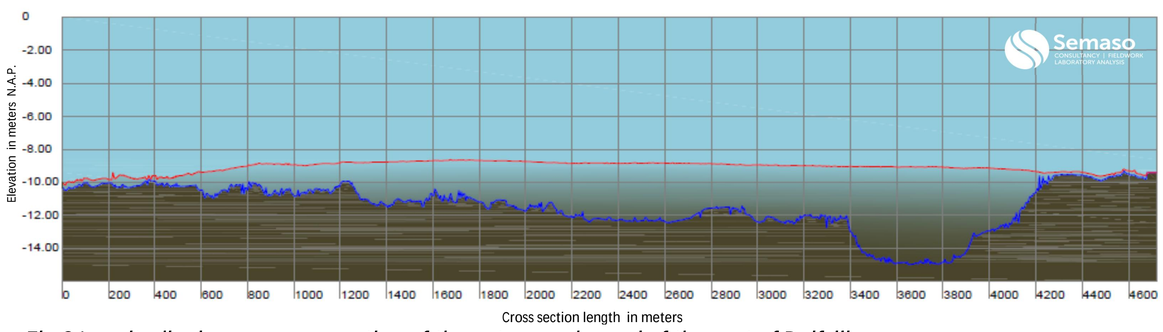

Fig.2 Longitudinal survey cross section of the entrance channel of the port of Delfzijl

Full Scale Field Test

Based on the feasibility study in the first phase of the project it was concluded that, based on the mud conditions at that time, it was realistic to implement the 'Keep Sediments Navigable' (short: KSN) method [1]. This was confirmed by manoeuvring simulations with experienced pilots in a 3D model of the port of Delfzijl, during which the thickness of the mud layer, the mud density and under keel clearance (UKC) were varied systematically [2].

To confirm the manoeuvrability of ships with negative under keel clearance (UKC) full scale field tests were carried out using a hopper dredger with the following characteristics; length 132 meter, width 23.6 meter, draft 7.4 meter and 2 propellers. During the tests, the vessel's behaviour (use of propeller, rudder, thruster and tugs including corresponding speeds and yaw velocities) was monitored and analysed in a similar manner as during the simulation runs in the 3D model [3].

Before the trials and after each run, the in-situ density profiles of the fluid mud were measured at pre-defined locations. Multi beam surveys were performed before and after the field tests.

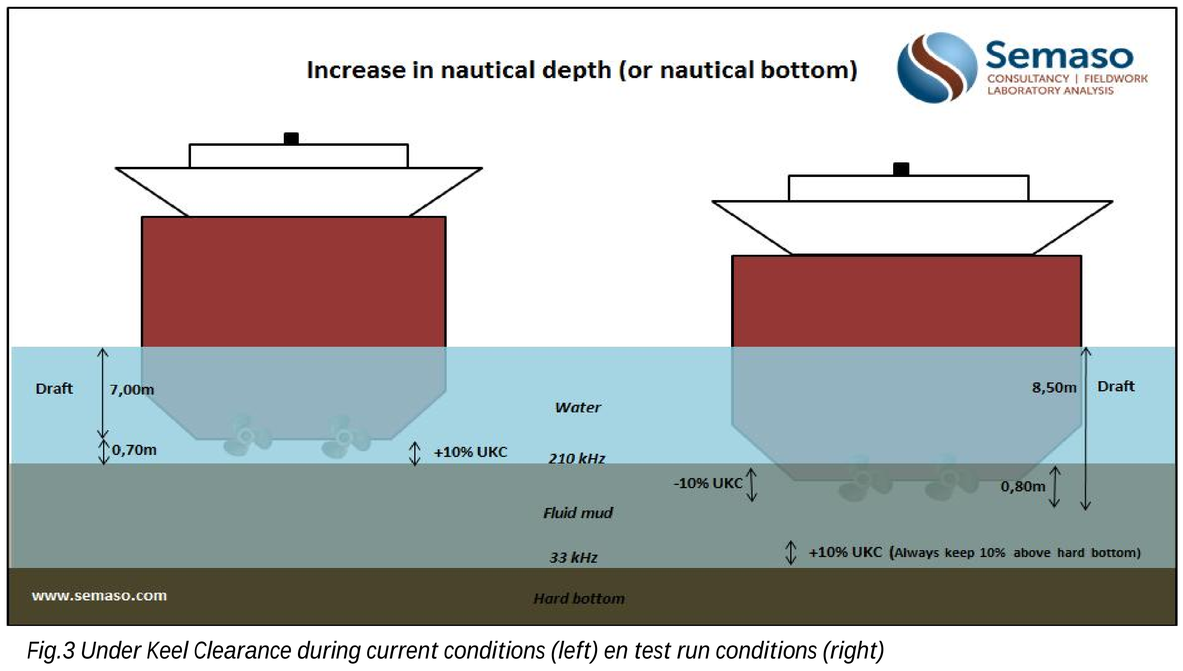

Fig.3 Under Keel Clearance during current conditions (left) en test run conditions (right)

Results

Summarizing it can be stated that based on the trial runs an UKC_{Net} between 0% and roughly +14% (up to 20%) has a significant influence on the vessel's behaviour, see figure 5. It should be noted that the current minimum operational UKC_{Gross} of +10% is already in the unfavourable range. Based on the trial runs, no significant reduced manoeuvrability was observed for an UKC between +10% and -5%..
From reference [4] it is known that the major impact of a relatively high UKC (10% - 20%) on the manoeuvrability and propulsion of the vessel is due to the hindered flow to the propeller and rudder. Especially in cases where sediment layers are present with a weak rheology, a sailing vessel generates an internal wave at the interface of sediment and water.
In a speed range of a vessel, corresponding to typical speeds in the entrance channel, a significant reduction of the clearance between the keel and the sediment water interface (see Figure 3) can be allowed in Delfzijl without jeopardizing safe shipping. The field trials with the hopper dredger confirm these findings.

The full scale field tests revealed important information regarding the relations between the UKC with respect to the mud-water interface, the mud layer thickness and the ship behaviour on both manoeuvrability and ship speed (figure 5). As the consecutive tests were carried out within a limited time frame, a disturbance of the mud layer (figure 4) could not be avoided. One additional test is to be carried out at negative UKC and an "undisturbed" mud layer to confirm the maximum nautical depth for the Port of Delfzijl in the entrance channel.

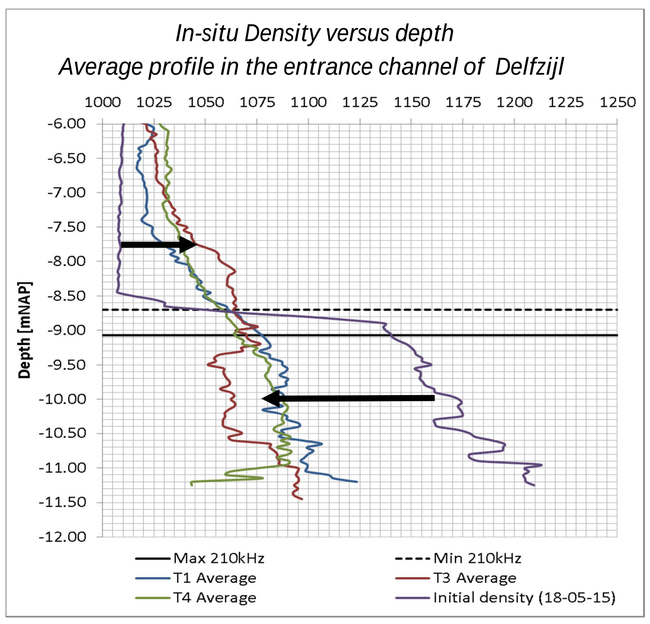

Fig.3 Average Insitu Density versus Depth for the Full scale field test

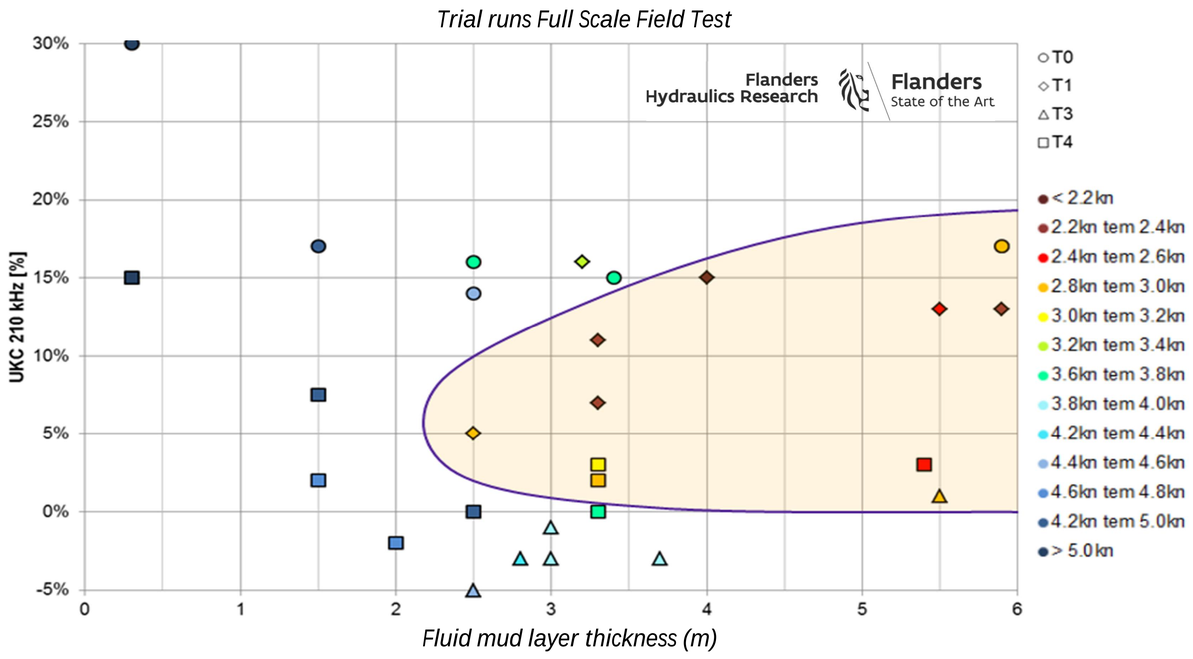

Fig.5 Summarizing graph of the evolution of the trail speed of the Geopotes 15 in function of the sediment layer and the under UKC in respect to top of the fluid mud layer [3].

Discussion

In the port of Delfzijl a minimum UKC of 10% with respect to the nautical depth is prescribed. Based on the field trials and the present experience of the pilots in the port of Delfzijl the nautical depth was altered. Before our investigation, the nautical depth was defined at the 210 kHz reflection of the single beam measurements. Since April 2016 the accessibility of vessels with a maximum length of 150 meters is based on a nautical depth corresponding to the 33 kHz reflection of the single beam measurements. This increases the tidal window for the port without a significant increase of the maintenance dredging requirements.

References:

[1] PIANC (2008), Minimising Harbour Siltation. PIANC REPORT N° 102, PIANC Secrétariat Général: Bruxelles, Belgium. ISBN 2-87223-169-2.
[2] Verwilligen et al (2014), Manoeuvrability in proximity of nautical bottom in the harbour of Delfzijl, 33rd PIANC World congress.
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[4] Delefortrie, G.; Vantorre, M. (2009). Prediction of the forces acting on container carriers in muddy navigation areas using a fluidization parameter. Journal of Marine Science and Technology, 14, 51-68.
[5] Groningen Seaports, New policy related to maximum draft in the outer harbour of Delfzijl, 1st of May 2017.

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