'Manoeuvring with negative UKC'
In-situ sediment measurements for field trial in the port of Delfzijl

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Introduction:

Sedimentation in the tidal port of Delfzijl implicates a restriction to the nautical accesibility of the port. In the 4km long entrance channel a sediment layer of several meters thick has been observed in the survey data (210kHz) single beam and sub bottom profiler.

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

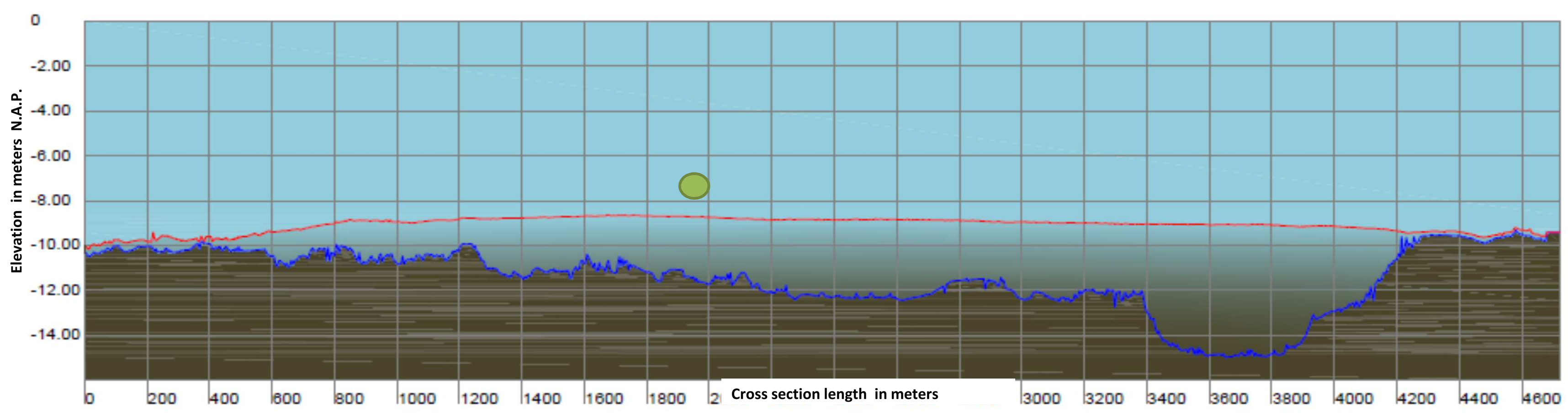

Fig.2 Longitudinal survey cross section of the entrance channel of the port of Delfzijl

Sustainable Port Management:

Wiertsema & Partners together with Flanders Hydraulics Research investigated by order of Groningen Seaports the influence on the manoeuvrability of a vessel when sailing with a small and negative under keel clearance in the port of Delfzijl by performing a full scale field test.

A recently performed simulator study (2012) showed that manoeuvring at smaller under keel clearances with respect to the high frequency echo-sounding than currently accepted (10%) is possible in the port of Delfzijl. A first full scale field test with 14% under keel clearance was performed in 2013. In order to validate the conclusions of the simulator study a second full scale field test was performed in May of 2015.

Full Scale Field Test:

The Full scale field test was performed with the Traling Suction Hopper Dredger 'Geopotes 15'. This vessel has a length of 132 meter and a width of 24 meter. The hopper was filled with water to have a maximum draught of 7,40 meter. In case of emergencies the bottom doors of the hopper could be openend to immediatly decrease the draught.

A tugboat was present during the test to assist the vessel in case of emergencies. Tug assistance was not needed during the full scale field test.

The second full scale field test was performed at the same location as the first full scale field test. In figure the route is indicated with the orange line. The approximate length of the route was 4.200 meters.

The test was executed during springtide. In total 4 different testruns were performed working from high tide towards low tide. Table 1 shows approximate Under Keel Clearance (UKC) during the testruns. The UKC is based on the 210 kHz singlebeam survey which roughly indicates the top of the fluid mud layer and is used by Groningen Seaports to determine the nautical depth of the port of Delfzijl.

The positions of the vessel, orientations relative to the ships centre and squat were monitored during the testruns.

Testrun	UKC (210kHz)
T0	14%
T1	2%
T2	-8%
T3	-4%

Tab. 1 Approximate UKC testruns

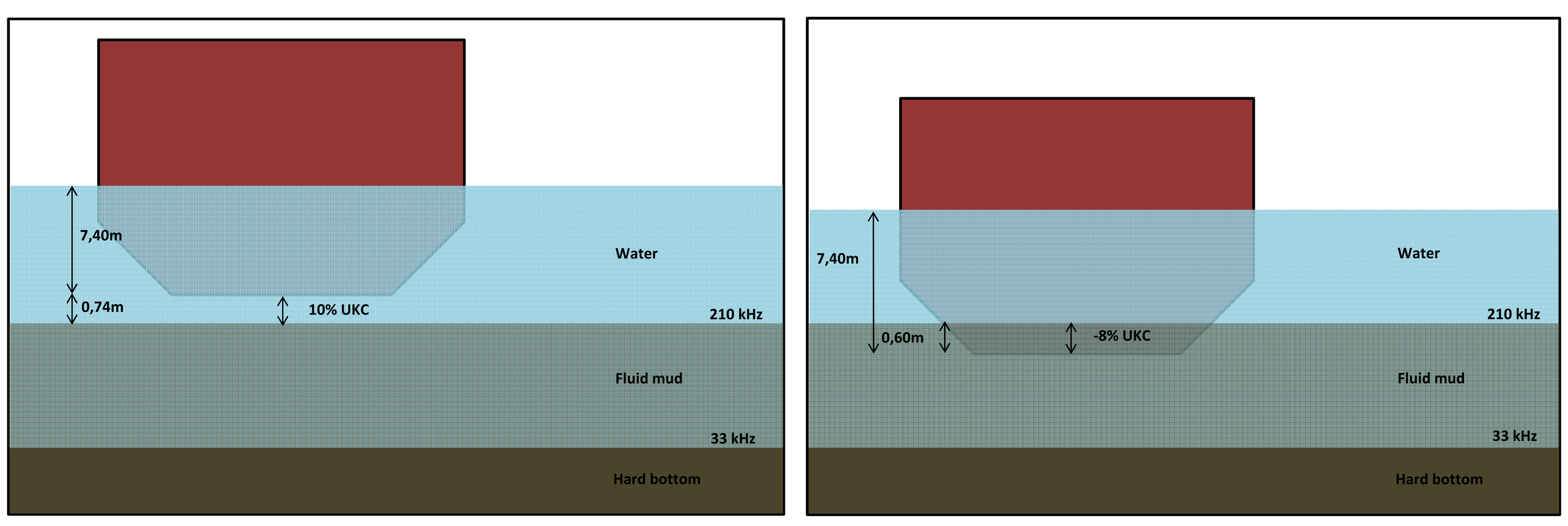

Fig.3 Under Keel Clearance during current conditions (left) en test run conditions (right)

Sediment in-situ characterization methods and results:

Several surveys (210 kHz) and in-situ measurements were performed to characterize the sediment layer before, during and after the field trial. The in-situ density profiles were measured with the SoniDens at different locations (Fig. 2). The device uses ultrasound to determine the density of the sediment. For validation of the in-situ density measurements and further characterization of the sediment, samples were taken using a recently in-house developed Sludge Sample and tested in our laboratory.

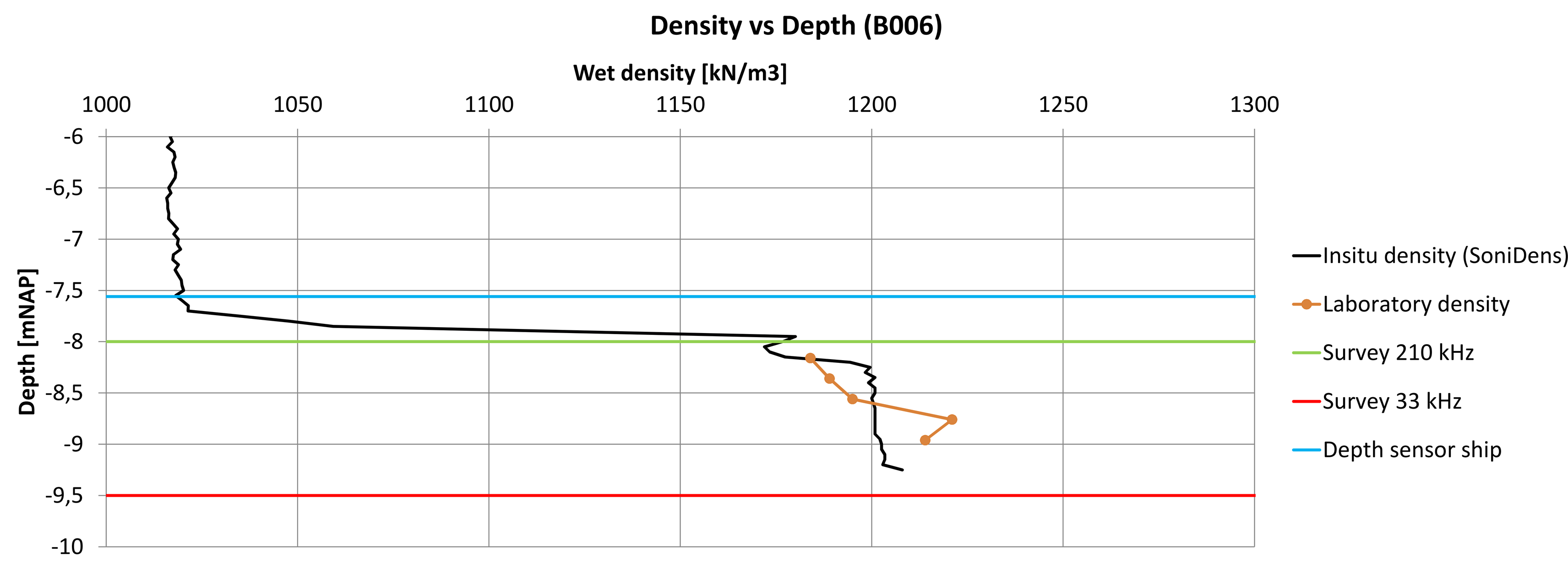

Fig.4 Density profiles with densities determined in the laboratory and with the SoniDens

Sediment laboratory characterization methods and results:

The rheological properties of the fluid mud were tested with a rheometer in the laboratory of Wiertsema & Partners in the Netherlands. The flow-point and dynamic viscosity were determined for the samples at different depths. Besides rheological properties the percentage of organic content (14%), chalk (2%), sand (64%of d.d.), silt (21%of d.d.) and clay (15%of d.d.) were also determined.

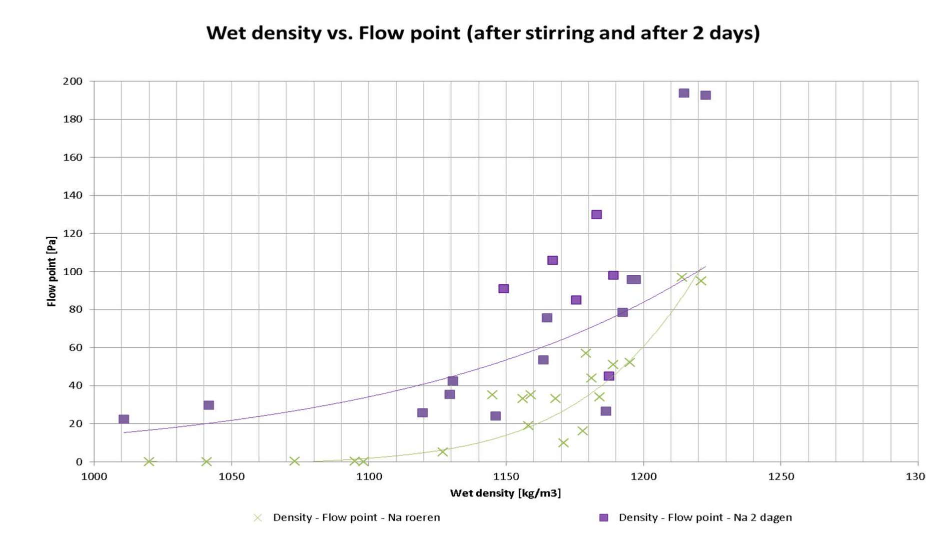

Fig.5 Wet density vs. Flow point (labtests)

Fig. 6 Stirred sediment behind vessel during tests

Fig.7 Sludge Sampler and SoniDens

Discussion:

By a full scale field test in the port of Delfzijl it was demonstrated that safe shipping was possible with a negative underkeel clearance.

To determine the nautical depth in shipping channels and ports , characterization of the sediment layers is essential. In situ measurements and laboratory tests before – during and after the field trial provides more insight in changes in characteristics of sediments as a result of sailing through mud.

The results of the in-situ measurements and laboratory tests will be used to validate the 3D model of the port of Delfzijl and to optimize the current dredging regime.

References:

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