Floating Breakwater Dimensioning

a hybrid modelling approach

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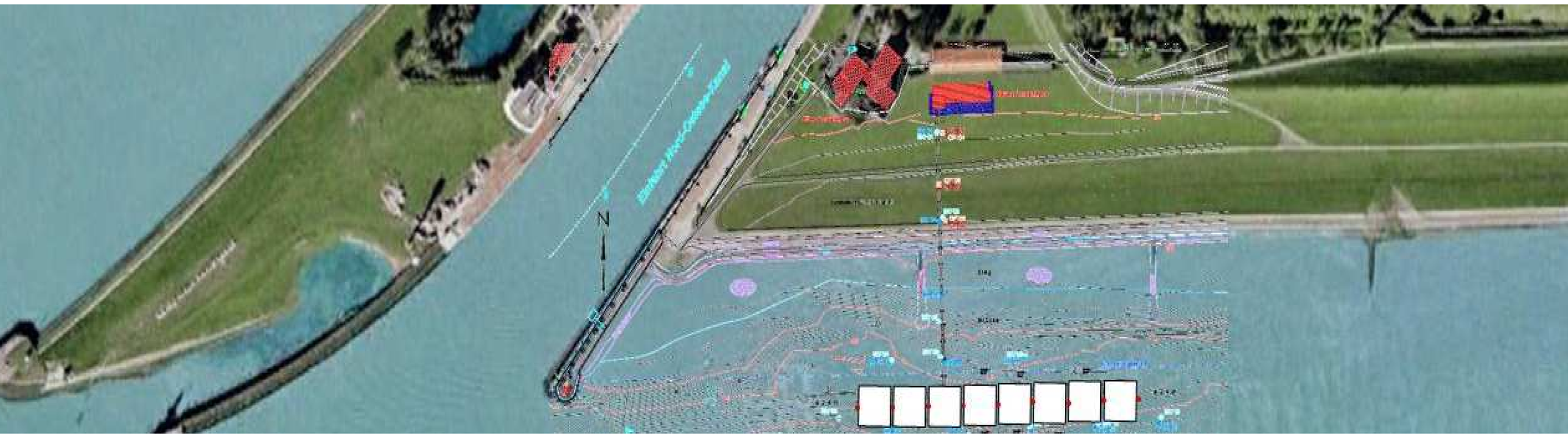


Introduction

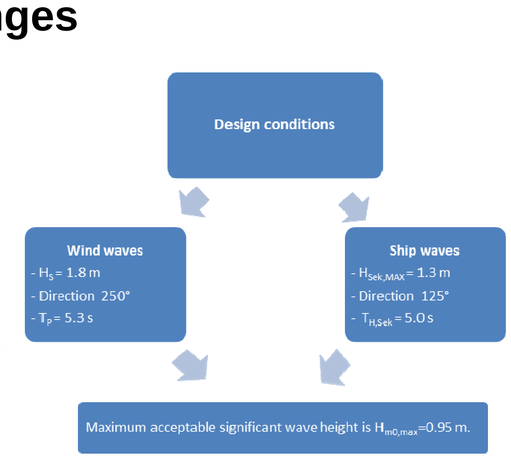
Within the redesign of the Kiel-Canal locks (NOK) new mooring places for the pilot boats have to be chosen. One of the options is a new pier for pilot ships at the northern bank of the Elbe River close to the Kiel-Canal (NOK). This place is influenced by strong currents and wind waves with a significant fetch length. Due to the large water depths and a desire to minimise influence on the sediment transport and to fulfil the requirements for a safe and unimpeded operation of the pilot ships, a floating breakwater was chosen as a possible wave protection system for the new pier.

The BAW, who is commissioned by the local water- and shipping administry (WSA Hamburg) for the conceptual planning, requested DHI to undertake numerical simulations and physical model tests in order to estimate the required dimensions and associated wave attenuation of the floating breakwater.

Design Conditions and Challenges

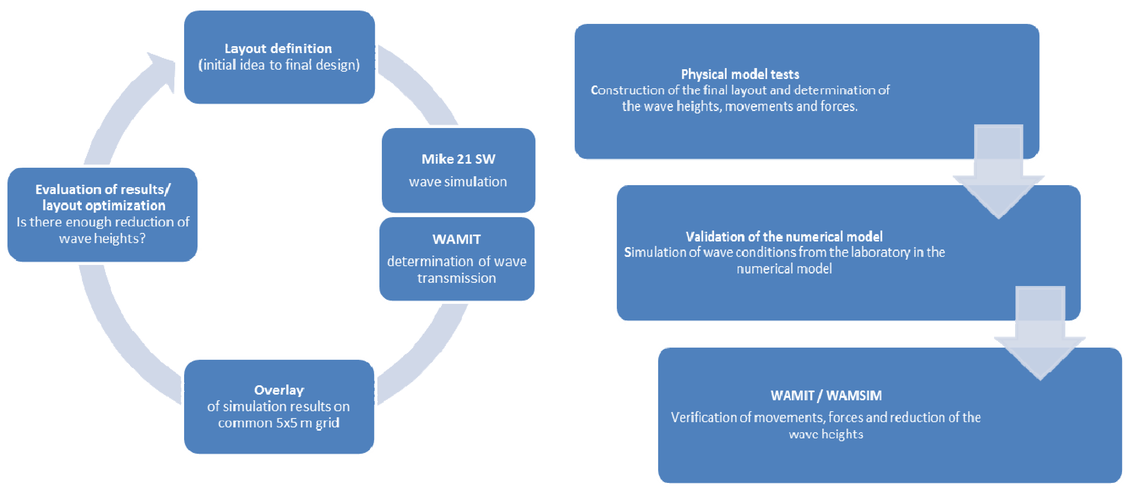
As specific challenge, the initial conditions can be accentuated: The water depths are large and wave periods are relatively long. Oblique wave attack restricts the damping effect.

Knowledge of the dimensioning and construction of floating breakwaters is available (see PIANC 1994), but rarely for oblique wave attack and long wave periods.



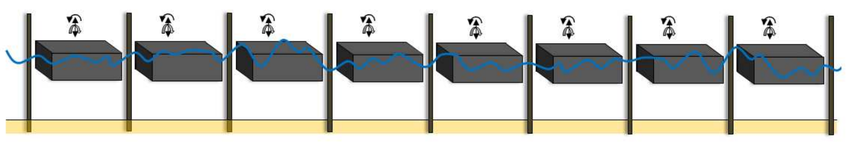
Methods

In consultation with BAW, DHI chose a hybrid approach to determine a suitable solution by undertaking the following tasks:



Results

An optimisation of the breakwater dimensions was made from a starting layout, this layout consisted a number of pontoons with a certain length and variable width and draft. Only movements within the vertical pane were allowed (heave, roll and pitch, see Figure).



Layout of the final breakwater design movement in the horizontal pane is fixed.

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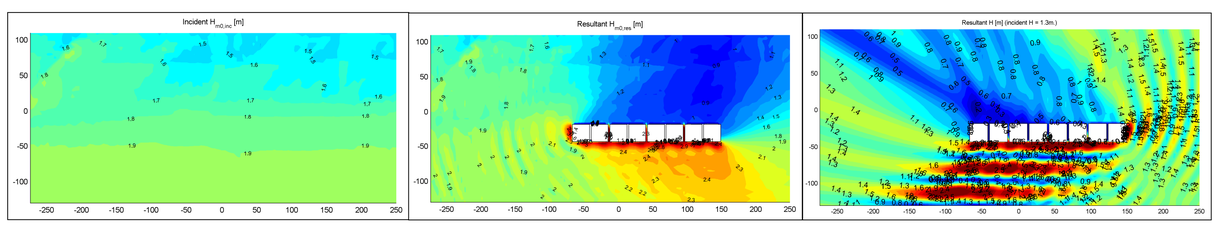
The numerical model showed that the required reduction of wave heights ($H_{m0,max}$=0.95 m) could be achieved for a wave breaker consisting of 25x25x5m pontoons.

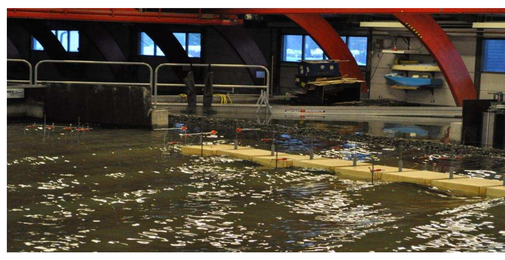


Incident wave field of wind waves (250°, H_S = 1.8 m, T_P = 5.3 s)

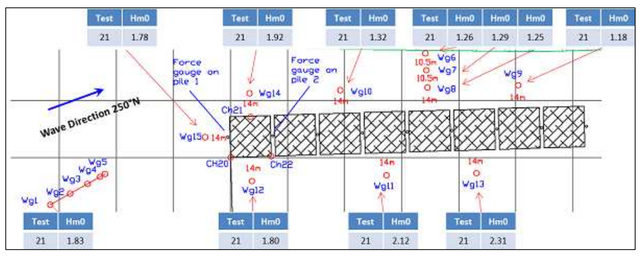
Resulting wave field for wind waves

Resulting wave field for ship waves (125°, $H_{Sek,max}$= 1.3 m, $T_{H,Sek}$ = 5.0)

It was found that wave attenuation within the physical model was smaller compared to the numerical approach.

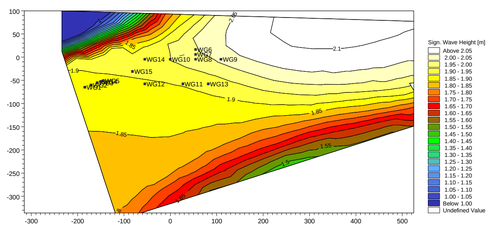


Physical model test for wind waves, draft 5 m

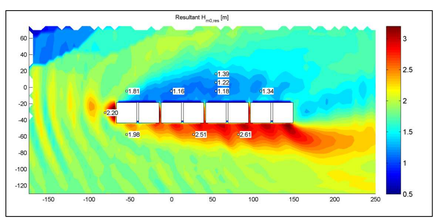


Calibrated wave field from physical model tests. Reflective boundaries c_{refl} = 0.4.

As reason for this difference reflected waves from the model boundary behind the wave breaker were identified. A validation of the numerical model simulating the wave attenuation using a calibrated wave field showed more consistent results.



Calibrated model test results for wind waves, draft 5 m



Wave heights from physical model tests for wind waves

Conclusions

The following conclusions could be drawn from the study:

- The required wave conditions behind the breakwater could be reached.
- A reduction of wave heights about 50% was achievable but the dimensions of the floating breakwater would result large and uneconomic for the given initial conditions and requirements.
- The accuracy of the numerical modelling approach was successfully verified by physical model tests.

References:
PIANC. Report of Working Group no. 13 - PTC II - Supplement to Bulletin N°85 (1994) Floating Breakwaters – A practical guide for design and construction.
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