WAVE SYSTEMS IN A TIDAL RIVER PORT INDUCED BY PASSING POSTPANMAX-SHIPS, PART I: SIMULATION OF WATER LEVEL VARIATIONS AND CURRENTS

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INTRODUCTION

Ship-induced waves and their loads on dikes, revetments and moored ships became a problem in tidal ports of the North Range and their access channels to open sea since POSTPANMAX-ships are operating.

Due to ship dimension and speed over ground (v_s>12 knts), induced water level variations and currents exceeded design values and caused intensive damage, especially on mooring systems, tows, smaller ships and pontoons.

Thus, intensive measurements of water level variations using pressure gauges, currents (by ship based Acoustic Doppler Current Profiler) and ship parameters (dimensions, draught, speed over ground, positions during passage) by AIS (Automated Identification System) were done during a six week campaign (Matheja & Schweter, 2007).

These measurements were the basis to setup a suite of models for hydrodynamics (2D) and mooring forces, coupled by water levels and currents.

Numerical simulation of the ship induced wave systems and currents during ship passage, necessary description of boundary conditions, accuracy of results and resulting input for the mooring model is described in this paper.

METHODOLOGY AND RESULTS

The 2D-hydrodynamic model MARINA 2D (smileconsult, 2006) was used to simulate incoming waves (Fig. 1) in the Elbe River and the adjacent port.

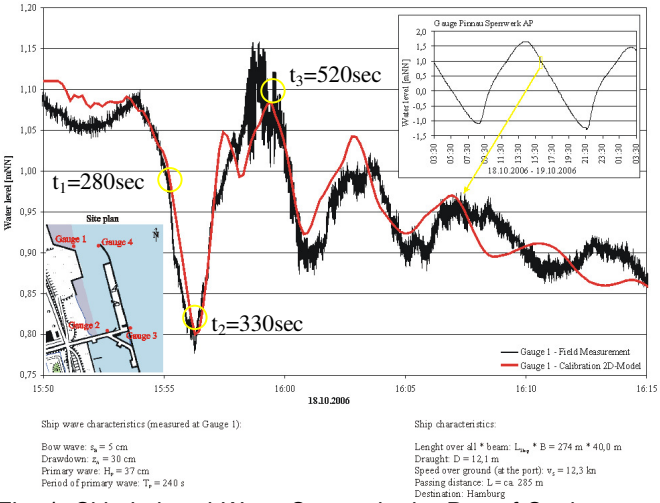

Fig. 1: Ship-Induced Wave System in the Port of Stade-Bützfleth

Tidal boundary conditions were generated at the upper and lower boundary from a regional 2D model.

Differences between simulated and measured water levels (Fig. 1) are below 5 cm in peak of the primary wave. The bow wave and the drawdown are calculated with an accuracy of 1.5 cm.

A comparison of current velocities (model results and depth averaged ADCP measurements) at time steps t_1 - t_3 (Fig. 1) shows a good agreement. Deviations are between +0.07 and -0.08 m/s for lower flow velocities and up to 0.40 m/s for higher velocities at t_3. At t_3 water level variations and turbulence (points a, b and c at t_3) near the entrance are higher. The turbulent part of the current goes up to 0.25 m/s (average of multiple ADCP courses near the west cay). Thus, accuracy of flow prediction is between 0.1 and 0.15 m/s in the areas with higher flow velocities.

Deviations of flow direction are up to 30 [°] for lower velocities and up to 15 [°] for higher velocities after the peak of the primary wave.

COUPLING OF MODELS

Time series of water levels were exported from the hydrodynamic model for approx. 3000 (depending on ship dimension and hull form) panel points on the hull of the ship as input for the mooring force model (ALKYON, 2007).

Flow velocities were averaged over the ship hull and exported as time series.

CONCLUSIONS

Numerical simulations have shown the capability to model wave systems and currents induced by a POSTPANMAX-ship passing a tidal river port.

Accuracy of model results is sufficient to give an input for the design of moorings, fenders and bollards. Results incorporate - in addition to classic design methods - dynamic effects from fast varying water levels and currents.

Numerical simulation of ship movements and mooring forces is described in another paper of this conference.

REFERENCES

ALKYON (2007): SHIP MOORINGS, User Manual, V6.15.

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Smileconsult GmbH (2006): MARINA 2D: User Guidelines and Reference Manual, Version 1.3