SIDE WALL AND SHALLOW WATER INFLUENCE ON POTENTIAL FLOW

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We want to compute the stationary flow of an incompressible, irrotational fluid around a laterally symmetric body in the center of a channel. Far upstream the fluid has the uniform velocity U opposite to the direction of the x-axis of our Cartesian xyz coordinate system with z pointing downward. The field differential equation is then Laplace's equation that holds everywhere in the fluid domain. Furthermore, for a unique solution of the potential and the a proiri unknown position of the free water surface, we state boundary conditions on all boundaries:

Neumann condition	Water does not penetrate the wetted hull surface
Kinematic condition	Water does not penetrate the water surface
Bottom condition	Water does not penetrate the water bottom
Side wall condition	Water does not penetrate the side walls
Dynamic condition	At the free surface there is atmospheric pressure
Radiation condition	Waves appear only in a sector behind the ship
Decay condition	Far away from the ship there is uniform flow

As the problem will be solved using a Rankine panel methods, we can only model part of the free surface. Waves created by the ship must then pass through the artificial boundary without being reflected and disturbing the solution at the ship (Open-boundary condition).

The Rankine panel methods solves iteratively the fully nonlinear free surface condition, *Jensen (1988)*. The nonlinear free surface condition is linearized about an arbitrary approximation. This linearized condition, the hull condition and the side wall condition are fulfilled in a collocation scheme. Staggered grids at the free surface enforce the radiation and open-boundary conditions. The shallow water effect is taking into account by using mirror images of the sources with the water bottom as plane of reflection. Free surface and side wall panels are desingularized by removing them a typical panel length from the collocation point. The problem without the effect of restricted water has been a standard problem at the workshops, e.g. *Jensen (1988)* and *Bertram (1989)*. However, for shallow water free surface problems using Rankine panel methods, the only references we are aware of are *Söding and Bertram (1989)*, *Bertram (1990)* and *Yasukawa (1989)*.

Computations for the river cargo-ship of Fig.1 are scheduled for February and will be compared with experimental results. Comparison will include changes in wave resistance and dynamic trim and sinkage due to shallow water and side walls as well as wave profiles. First trial computations for a parabolic hull (L=10m,B=2m,T=0.5m) show that the shallow water influence is already correctly incorporated. Wave resistance increased to 2.8 of the deep water value, sinkage to 6 times deep water value, for a depth Froude number $F_{nh} = 0.9$. The wave pattern, fig.2., shows that the primary wave system becomes dominant and the Kelvin angle gets wider as expected.

BERTRAM, V. (1989), *Nonlinear steady ship wave problem for a SWATH ship*, 4th WWWFB, Oystese

BERTRAM, V. (1990), *Stationary potential flow around ships*, 5th IMAEM-Congress, Athens

JENSEN, G. (1988), *Numerical solution of the nonlinear ship wave resistance problem*, 3rd WWWFB, Woods Hole

SÖDING, H. and BERTRAM, V. (1989), *Dynamic sinkage and trim of ships on shallow water*, 4th WWWFB, Oystese

YASUKAWA, H. (1989), *Calculation of free-surface flow around a ship in shallow water by Rankine source method*, 5th Int. Conf. on Num. Hydrodyn., Hiroshima

FIG.1: LINES PLAN OF RIVER CARGO-SHIP TO BE COMPUTED WITH SIDE-WALL EFFECTS

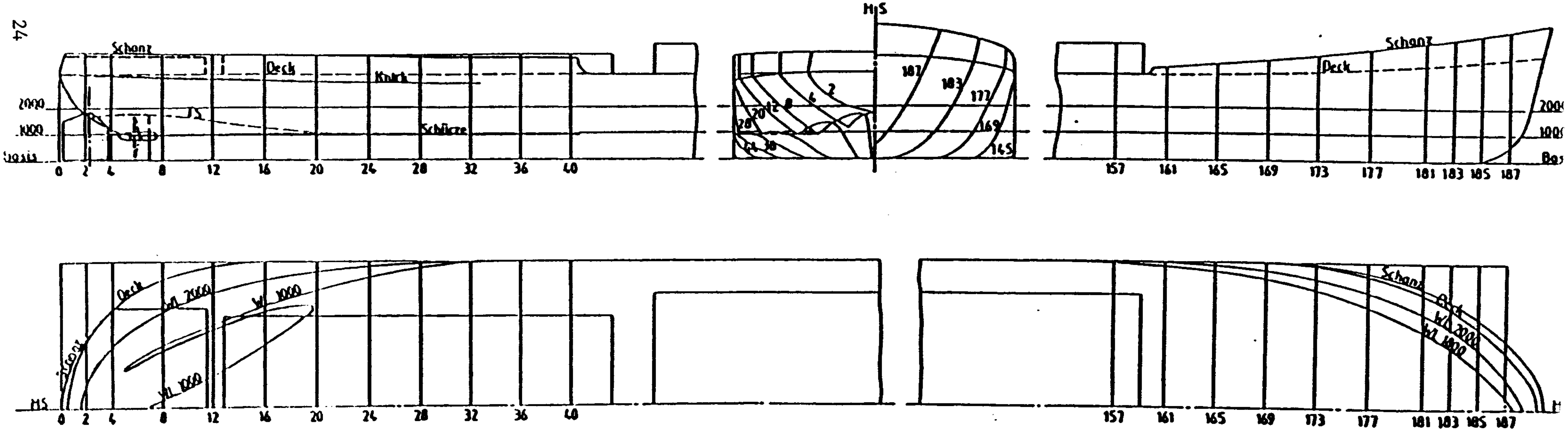
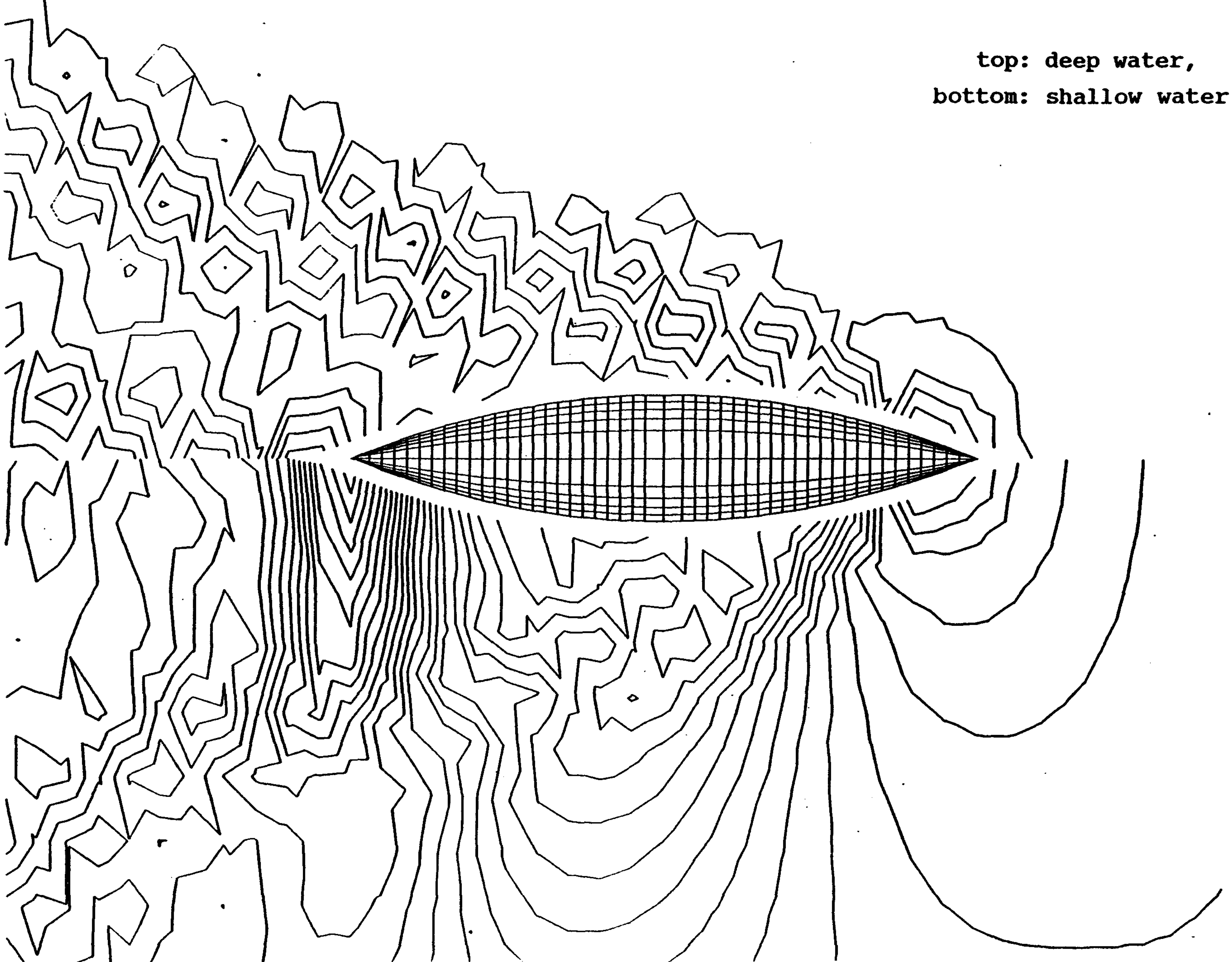


FIG.2: THE WAVE PATTERN CHANGES AS EXPECTED ON SHALLOW WATER

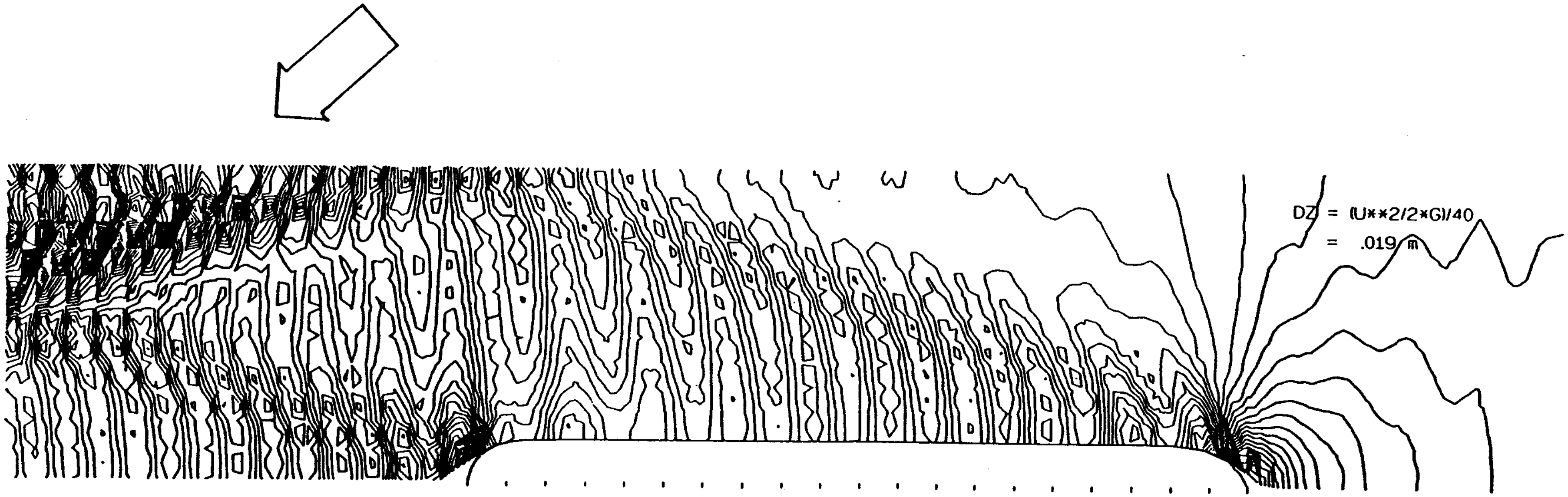


top: deep water, Fnh=0

bottom: shallow water, Fnh=0.9

THE WAVE PATTERN SHOWS A CLEAR REFLECTION AT THE SIDE-WALL

River Cargo Ship, Fn=0.12, Fnh = 0.55, canal width 81.6 m



Source: HSVA

DISCUSSION

MARTIN: Can you explain, with a little more detail, how you impose the radiation and open-boundary conditions? You mention staggered grids, but why do these work?!
BERTRAM & JENSEN: An extra row of collocation points at the upstream end of the grid and an extra row of source points at the downstream end. Ando and Nakatake applied our method to Hess & Smith panels and found similar results, i.e. no damping and no source strength oscillation at the downstream end. Paul Sclavounos and P.S. Jensen tried some explanations related to the topic. However, I don't know any satisfactory explanation, why exactly staggered grids work so well.

BECK: In the viewgraph for the submerged dipole, were the numerical and analytical results both for a linear free surface boundary condition?
BERTRAM & JENSEN: Yes.

MORI: I would like to remind you of Dr. Seto's recent work where he tried to provide some reasoning for the collocation method: M. Seto, "Some Considerations on the Basis of Rankine Source Methods and the Treatment of Open Boundaries in Steady Ship-Wave Problems," *Trans. of the West Japan Soc. of Naval Arch.*, No. 81, 1991.