TIME DOMAIN ANALYSIS OF SHIP MOTION AND WAVE LOADS BY BOUNDARY INTEGRAL EQUATIONS

A. Colagrossi*, G. Fotia¶, G. Graziani$^+$ and M. Landrini*

$\star$ INSEAN, The Italian Ship Model Basin, Roma, Italy

¶ CRS4, Area of Waves and Structures, Cagliari, Italy

$^+$ Dip. Meccanica e Aeronautica, Un. *La Sapienza*, Roma, Italy

Safety and comfort of marine vehicles require, since the design stage, a careful evaluation of the dynamic behavior of the vessel in rough sea. Traditionally, this is routinely accomplished through (expensive) model testing and numerically by some (extremely) successful simplified quasi-twodimensional models (the so-called *strip theory*, [1]). As a matter of fact, both the above approaches suffer severe limits (practical or theoretical) concerning the prediction of pressure distribution, which is a typical input data relevant for the structural analysis.

In this presentation, we like to discuss some aspects of a more general computational algorithm for the prediction of ship motion and loads induced by the interaction with wave systems. In particular, unlikely the more conventional models in frequency domain [2], we attack the problem by a time domain formulation. The purpose is twofold. First, within the framework of a linear analysis, the ship response function to a general wave excitation can be numerically determined by a transient test (i.e. the interaction with a wave pulse compact in time). In this way, a substantial saving of computational time with respect to the existing algorithms is achieved [3]. Second, a time domain modeling is intrinsically prone to deal with the fully nonlinear problem or, at least, to recover some nonlinear effects [4].

More specifically, the three-dimensional flow field around a ship advancing through waves is described by an inviscid flow model. The velocity potential is governed by the Laplace equation with time-dependent boundary conditions on free surface and moving rigid boundaries. Position and velocity of the latter are given by the coupled equations of ship motion. The differential problem is recast in terms of boundary integral equations for the velocity potential and for its Eulerian time derivative (used to evaluate the hydrodynamic loads). The integral equations are discretized by piecewise constant shape function and are numerically solved by a standard collocation method. Time stepping is achieved by a variable order Runge-Kutta algorithm.

In spite of its low-order in space, the resulting algorithm allows to handle easily non-structured grids with local refinement both on the free surface and on the body. This feature appeared to be essential for the applicability of the method to the complex geometries typical of practical ship hull forms.

An extensive validation activity has been performed by comparing the numerical results with experimental data, and will be summarized to discuss pros and limits of the current implementation of the code and to draw our more recent research and development activity.

References

[1] N. Salvesen, E.O. Tuck and O.M. Faltinsen (1970). "Ships motions and sealoads", SNAME Trans. 78.

[2] V. Bertram and M. Landrini (1999). "Rankine panel methods for seakeeping problems", 31^{st} WEGEMT School, CFD for Ship and Offshore design, Hamburg (Germany).

[3] A. Colagrossi, C. Lugni, M. Landrini and G. Graziani (2000) "Numerical and experimental transient tests for ship seakeeping", 10^{th} Int. Offshore and Polar Engineering Conf. (ISOPE2000), Seattle (USA).

[4] R.F. Beck and A.M. Reed (2000). "David Taylor Model Basin Modern Sea Keeping Computations", 23^{rd} Symposium on Naval Hydrodynamics, Paris (France).