On the Effect of Hull Girder Flexibility on the Vertical Wave Bending Moment for Ultra Large Container Vessels

Currently, a number of very large container ships are being built and more are on order, and some concerns have been expressed about the importance of the reduced hull girder stiffness to the wave-induced loads. The main concern is related to the fatigue life, but also a possible increase in the global hull girder loads as consequence of the increased hull flexibility must be considered. This is especially so as the rules of the classification societies do not explicitly account for the effect of hull flexibility on the global loads. In the present paper an analysis has been carried out for the 9,400 TEU container ship used as case-ship in the EU project TULCS (Tools for Ultra Large Container Ships). A non-linear time-domain strip theory is used for the hydrodynamic analysis of the vertical bending moment amidships in sagging and hogging conditions for a flexible and a rigid modelling of the ship. The theory takes into account non-linear radiation forces (memory effects) through the use of a set of higher order differential equations. The non-linear hydrostatic restoring forces and non-linear Froude-Krylov forces are determined accurately at the instantaneous position of the ship in the waves. Slamming forces are determined by a standard momentum formulation. The hull flexibility is modelled as a nonprismatic Timoshenko beam. Generally, good agreement with experimental results and more accurate numerical predictions has previously been obtained in a number of studies. The statistical analysis is done using the First Order Reliability Method (FORM) supplemented with Monte Carlo simulations. Furthermore, strip-theory calculations are compared to model tests in regular waves of different wave lengths using a segmented, flexible model of the case-ship and good agreement is obtained for the longest of the waves. For the shorter waves the agreement is less good. The discrepancy in the amplitudes of the bending moment can most probably be explained by an underestimation on the effect of momentum slamming in the strip-theory applied.