

Advanced backbone deployed to measure bending modes of ultra-large container vessels

MARIN carried out a series of model tests on behalf of the Marine Design and Research Institute of China (MARIC) to assess the flexural response of an ultra-large container ship (ULCS). A 10-segmented model was mounted on an advanced backbone to replicate the vertical and horizontal bending modes and tested in a range of wave conditions.

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The demand for cutting operational costs in the maritime industry has led to a substantial increase in containership size over the past 50 years. Operational costs are dominated by fuel costs, thus carrying more containers whilst burning the same amount of fuel, makes the operational costs per transported container decrease. This hopefully leads to a higher profit and better competitiveness.

Although ULCS do represent a substantial reduction in operational costs, the downside of these vessels – of nearly 400 m in length – is the impact of ship motions and slamming on the construction of the vessel. These ULCS need to withstand enormous forces acting on the hull, which are the result of slamming impacts on the bow and aft body, and these cause whipping and springing effects.

Model tests versus FEA and Class rules A containership of 400 m in length has huge cargo holds and a relatively weak construction. So to what extent do Class rules consider the fatigue and extreme loads and how well do they match the actual loads on the vessel? MARIN was asked to compare the model test results with Class rules and Finite Element computations carried out by MARIC.

10-segmented ship model Slamming impacts of high waves cause extreme loading on the hull, but even low wave impacts contribute to damage to the construction, so-called fatigue loading. The response of the hull structure on the wave frequency components is largely understood. However, there is a great deal of uncertainty surrounding the effect of springing and whipping on the lifetime

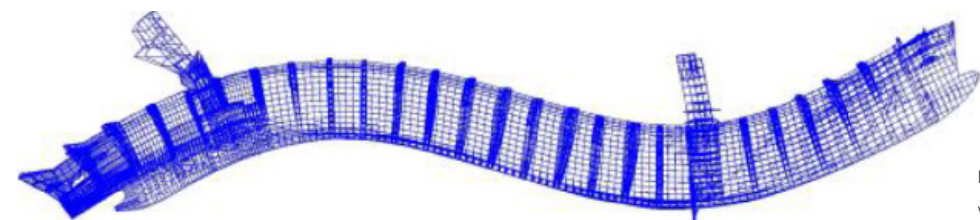


Figure 1: Shape of the 3-node vertical bending mode

Model tests in $H_s = 14.5$ m waves
Courtesy MARIC

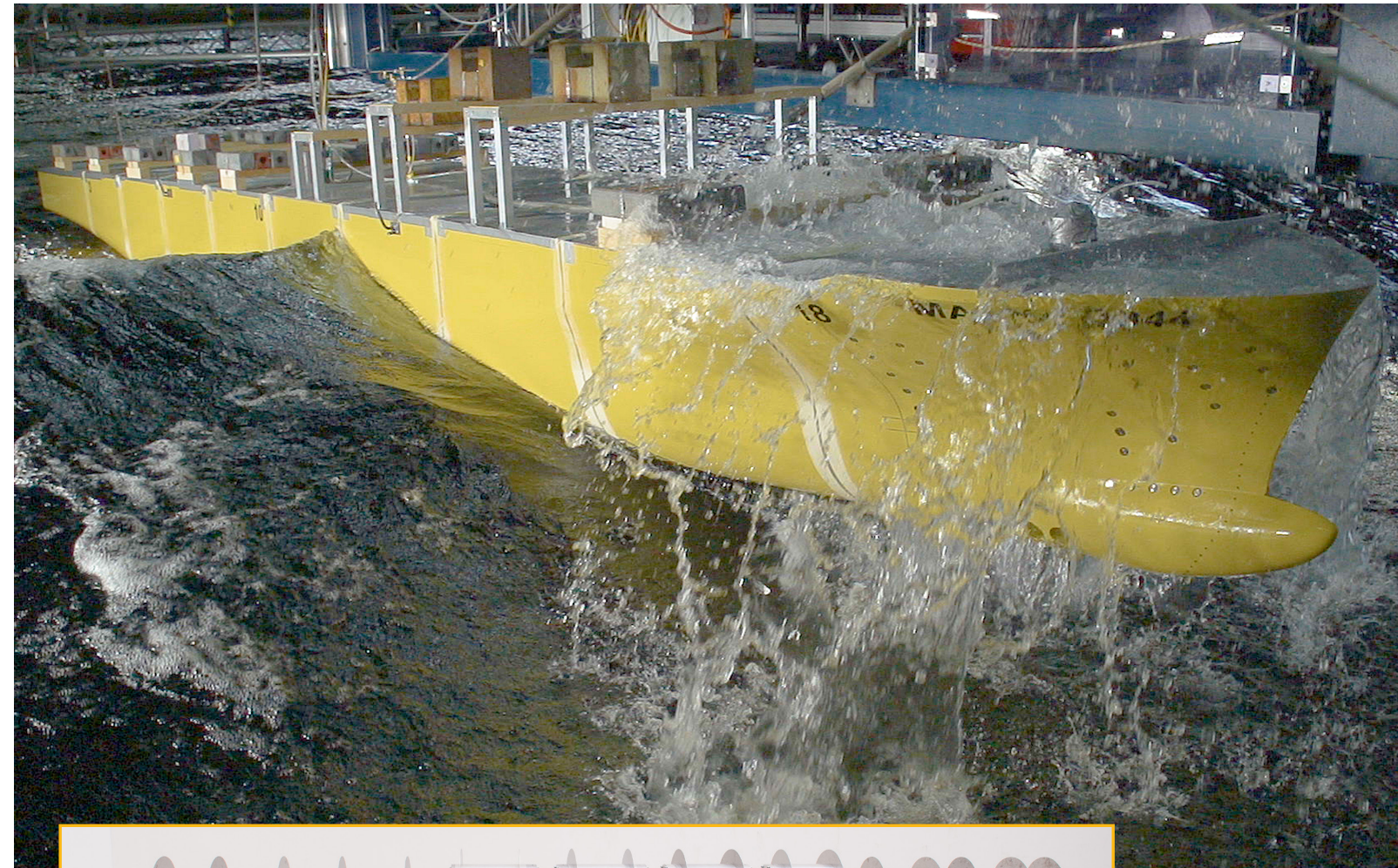


Figure 2: Design of advanced backbone

of the ship structure. This is particularly the case concerning slamming induced excitation of whipping and the non-linear excitation driving springing.

To get insight into the impacts on the hull and the structural response, a 10-segmented ship model of a containership was built, mounted on a backbone. This backbone (Figure 2) was used to model the vertical and horizontal bending moments of the containership. The model was tested in moderately low waves of 3 m up to waves with a height of 14.5 m. The tests showed the 2-, 3- and 4-node vertical bending, the 2- and 3-node horizontal bending moment, as well as the torsion moment. The 3-node vertical bending mode is illustrated in Figure 1.

Advanced backbone The shapes of frequencies of the global, flexural vibration modes were provided by MARIC and used to engineer the backbone. This advanced backbone is an aluminium pipe of which the diameter and wall thickness are chosen such that the modal parameters of the model match those of the ship. Because shear forces were to be measured accurately, a backbone from a combination of beam elements and link elements was manufactured. The link elements were made to control the stiffness of the backbone and to measure the forces and bending moments.

Importance of model tests Model tests in 14.5 m waves showed that the highest vertical bending moments are

about twice the magnitude of that of the horizontal bending moment. The measurements were consistent with the Finite Element computations with respect to the global loads. However, the highest local stresses were underestimated by the computations by some 15%, highlighting the importance of model tests.

The 10-segmented model mounted on the advanced backbone showed very good flexural responses and certainly these tests provide further insight. MARIN is now working on introducing this new way of engineering the backbone to future projects on flexural responses. ▢