ABSTRACT

Lloyd’s Register joined WILS II (Wave Induced Loads on Ships) Joint Industry Project. The aim of this JIP was to investigate the hydroelastic responses of on a large container ship and to provide reliable experimental data of the global loads acting on the ship. In this study Fluid Structure Interaction (FSI) models are used to investigate nonlinear wave actions and wave induced global loads acting on a 10,000 TEU class container ship. The results from the computational analyses have been correlated with those from model tests undertaken by MOERI (Maritime and Ocean Engineering Research Institute, Korea). Finally the global effects of springing and whipping acting on large container ships are discussed and commented upon.

KEY WORDS: Container ship; Wave induced dynamic response; Hydroelasticity; Fluid Structure Interaction; Springing; Whipping; Model test.

INTRODUCTION

The demand for larger container ships has increased dramatically in the last few years as world trade continues to grow and with the marine industry requirement for more energy efficient ships. Currently the largest of these ships have capacities of 14,000 TEU and designs of 18,000 TEU or more are currently being prepared. Due to the large deck openings of these ships springing and whipping phenomena can be critical for the design and operation of large container ships.

Springing of a ship is the continual hull girder vibration as a consequence of the waves exciting resonant hull girder frequencies. The flexing of the hull girder due to springing may continue for a significant period once initiated. Springing is an issue for ships which have low natural vibration frequencies of bending or torsion modes, typically when the lowest natural frequency is less than 3 rad/sec (≈ 0.5 Hz) and the ship operation speed is above 20 knots. This is the case for large container ships due to their high speed and open cross sections.

Whipping of a ship is the rapid flexing of the hull girder as a consequence of a wave impact on the hull. This usually results in high frequency cyclic oscillations of the hull girder which may result in increased vertical wave induced bending moments and shear forces compared to linear theory. High whipping responses are usually driven by bow flare impacts due to large bow flare angle and high speed or by bottom slamming. Occasionally stern counter slamming can lead to high whipping responses. The oscillations of the whipping responses usually decay rapidly after several wave periods due to damping effects. Whipping is primarily a strength issue. It is not a fatigue issue as the whipping induced vertical bending moment oscillations usually damp out quickly and hence the total number of whipping cycles in the ship’s life is small.

Ships that have hull girder natural frequencies close to the frequencies of the wave energy region are therefore potentially prone to springing. In addition springing may be excited after a wave impact as there is little damping resistance of the hull girder natural vibrations. Full scale measurements of the amidships vertical wave induced bending moment of an 8,100 TEU container ship are shown in Figures 1 and 2. A typical hull girder response due to bow slamming impact measured by a long base strain gauge is given in Figure 1. The hull girder natural frequency response has been extracted from the total response in Figure 1 and is shown in Figure 2. A whipping event is shown by the sudden amplitude increase at 418 seconds caused by the slamming impact, the initial high response decreases quite quickly due to hydrodynamic and structural damping effects. This time trace also shows a continuous springing hull girder vibration (Bakkers, 2009).

Recently the important contribution due to the global wave induced hull vibration on container ships has been investigated from several full scale measurements and model tests. Lloyd’s Register has participated in the WILS II JIP during the last two years. The aim of this project is to enhance our understanding with respect to the combined effects of fully nonlinear wave actions and wave induced loads on the global dynamic response of container ships. The main objectives of this JIP...