Springing Loads and Fatigue Assessment on Large Container Ships

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ABSTRACT

The methods for the determination of the springing response for inclusion in the fatigue assessment are presented. Fluid Structure Interaction (FSI) models are used to investigate nonlinear wave actions and wave induced global loads acting on large container ships. Time domain simulation techniques in critical wave frequencies are employed to investigate effects of springing on design bending moments of a large container ship based on the Lloyd’s Register 2014 Rule requirements for container ships that mandate springing fatigue analysis for large container ships. This study shows that the fatigue life is significantly reduced due to the inclusion of springing effects on a large container ship.

KEY WORDS: Nonlinear ship motion; hydroelasticity; Fluid Structure Interaction; springing; structural vibration; fatigue life; container ship.

INTRODUCTION

The demand for larger container ships has increased dramatically in the last decade as world trade continues to grow and with the marine industry requirements for more energy efficient ships. Currently the largest of these ships have capacities of 18,000 TEU and designs of 19,000 TEU or more are currently being prepared. Due to the slender hull form combined with high speed of these ships, springing and whipping phenomena can be critical for the design and operation of these large container ships with large deck openings. In this paper the springing phenomena are considered.

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 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. The magnitude of the springing moments (stresses) is usually low and hence springing is not normally a strength issue. However, the number of cycles is very large and this can make springing important with regard to the fatigue life of a structure (Lloyd's Register, 2014a).

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 8,500 TEU container ship are shown in Figure 1. A typical hull girder response due to bow slamming impact measured by a long base strain gauge is given in Figure 1. 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).

Fig. 1: A typical hull girder response due to bow slamming impact measured by a long base strain gauge

Fig. 2: Springing response testing of the WILS II container ship