REVISION OF THE INTACT STABILITY CODE

Review of MSC/Circ.707 – Parametric Roll in Head Seas

Submitted by Australia

SUMMARY

Executive summary: This document provides information on the outcomes of experimental work completed since the submission of SLF 49/INF.4

Action to be taken: Paragraph 2

Related document: SLF 49/INF.4

1 Further to the research described in the Australian submission SLF 49/INF.4, further experimental work has been carried out at the Australian Maritime College to provide improved understanding of parametric roll in head seas. The outcome of this work is outlined in the annex.

2 The Sub-Committee is invited to note the information provided and to take it into account in its consideration of this subject.

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ANNEX

Parametric Roll of Containerships in Head Seas
Addendum Report

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Executive Summary

This addendum supplements the report entitled ‘Parametric Roll of Containerships’ dated the 29th March 2006 (Thomas et al., 2006).

The original report outlined results from a series of model experiments, using a model of a containership, which were conducted in the Australian Maritime College’s towing tank. The aims of these experiments were to: validate the theoretical predictions for the inception of parametric roll using the Mathieu Equation; investigate the influence of wave height, wave length, vessel speed and GM on the inception of parametric roll; determine the influence of ship speed on roll damping.

The comparison between the theoretical and experimental results, of the threshold boundaries, was found to be good for a GM value of 0.69 m. However the comparison for a larger GM value of 1.1 m was poor. It was suggested that this was due to an increase in roll damping in waves, when compared with calm water, which was not accounted for in the theoretical predictions. In particular the natural roll period was significantly reduced as the GM was increased. This meant that a higher vessel speed was required for parametric roll to occur; but the increase in speed also led to an increase in roll damping.

Further tests have been conducted for a variety of GM values (1.1 m, 1.6 m and 2.1 m) where the natural roll period of the model has been maintained at more realistic values (25.8 s, 20.6 s and 17.9 s respectively) by changing the roll radius of gyration. For all the GM values tested reasonable agreement was found between the numerical predictions and experimental results, particularly at the higher \((\omega_e/\omega_0)^2\) boundary for parametric roll occurrence. However correlation was inferior for \((\omega_e/\omega_0)^2\) values less than 3.8; parametric roll did not occur in this region although the Mathieu Equation predicted that it would. In general the results suggest that the Mathieu Equation is an appropriate method for predicting the onset of parametric roll.

Scope of Work

The first aim of this work was to mathematically model the occurrence of parametric roll for a container vessel operating in head seas. This was done using the Mathieu Equation, as utilised successfully by a number of authors previously (Francescutto 2000, France et al. 2003). This allowed threshold boundaries to be predicted for the zone of instability where parametric roll may be expected to occur.

A series of model experiments was then conducted in the Australian Maritime College’s towing tank to investigate the influences of wave conditions, ship speed and GM on the parametric roll behaviour of this containership. The experiments were conducted on the *P&O Nedlloyd Hoorn* since this represents a typical containership.

Towing Tank Experiments

Details on the model, experimental configuration and test procedure can be found in the initial report ‘Parametric Roll of Containerships’ dated the 29th March 2006 (Thomas et al., 2006).

The tests were carried out in regular waves for a variety of wavelengths and wave heights, as shown in Table 1.
Table 1 – Summary of Test Conditions

<table>
<thead>
<tr>
<th>GM (full scale)</th>
<th>Natural Roll Period $T_\phi$ (full scale)</th>
<th>Wavelength Ratio $\lambda/L$</th>
<th>Wave Height (full scale)</th>
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<tbody>
<tr>
<td>1.1 m</td>
<td>25.8 s</td>
<td>0.8</td>
<td>3.0 m, 6.0 m &amp; 9.0 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>3.0 m, 6.0 m &amp; 9.0 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1</td>
<td>3.0 m, 6.0 m &amp; 9.0 m</td>
</tr>
<tr>
<td>1.6 m</td>
<td>20.6 s</td>
<td>0.8</td>
<td>6.0 m &amp; 9.0 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>3.0 m, 6.0 m &amp; 9.0 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1</td>
<td>3.0 m, 6.0 m &amp; 9.0 m</td>
</tr>
<tr>
<td>2.1 m</td>
<td>17.9 s</td>
<td>0.8</td>
<td>9.0 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>9.0 m</td>
</tr>
</tbody>
</table>

Results & Discussion

The roll angle time history for each run conducted in waves was examined and placed into one of two categories: parametric roll; no parametric roll, after the initial excitation the roll motion decayed.

The results for each test run were then plotted in conjunction with the theoretical threshold curves, for the various wavelength to ship length ratios ($\lambda/L$) investigated, see Figures 1 to 3.

Figure 1 – Threshold boundaries for parametric roll, comparison of experimental and theoretical results, $GM = 1.1$ m. Filled symbols indicate presence of parametric roll; empty indicate absence of parametric roll
For all the GM values tested reasonable agreement was found between the numerical predictions and experimental results, particularly at the higher \((\omega_e/\omega_p)^2\) boundary for parametric roll occurrence. However correlation was inferior for \((\omega_e/\omega_p)^2\) values less than 3.8; parametric roll did not occur in this region although the Mathieu Equation predicted that it would. In general the results suggest that the Mathieu Equation is an appropriate method for predicting the onset of parametric roll.
Figure 3 – Threshold boundaries for parametric roll, comparison of experimental and theoretical results, $GM = 2.1 \text{ m}$. Filled symbols indicate presence of parametric roll; empty indicate absence of parametric roll.

Acknowledgements

The Defence Science and Technology Organisation, Australia is gratefully acknowledged for permitting the use of their Crossbow IMU300CC sensor in the experimental program.

References


