DSCSD
Sept 2009

New Generation Intact Stability Criteria: Parametric rolling

by

N. Umeda ,

Y. Sogawa and I. Tsukamoto

(Osaka Univ., JAPAN)

DSCSD
Sept 2009

Introduction

- IMO is going to develop new generation intact stability criteria by 2012 for allowing the use of first-principle tools .
- These will cover
  - Harmonic resonance under dead ship condition,
  - Manoeuvring-related problems such a broaching-to,
  - Stability variation problems such as parametric rolling.
- It was agreed that the new criteria should consist of vulnerability criteria and performance-based criteria, i.e. direct stability assessment.

Ship Safety Research Initiative, Osaka University

Introduction

- The intersessional correspondence group on intact stability (ISCG) was established at SLF 51 (July 2008) and was instructed to collect draft criteria and sample calculation results from Member States and NGOs.
- Responding to the invitation, the delegation of Japan submitted its proposals with sample calculation results, which are based on its earlier submission to SLF 51 (SLF 51/4/3), to the ISCG.
- This paper describes the contents of its submission for wider discussion at this conference.

Parametric rolling

- For stability variation problems such as parametric rolling, simple analytical formulae for predicting the occurrence and the magnitude of parametric rolling in regular longitudinal waves were already established within the uncoupled roll model, e.g. ITTC formula (2005).
- These formulae seem to be suitable for the vulnerability criteria for this phenomenon but the mutual relationship with more rigorous models has not yet been established particularly in head waves.
- Thus, comparison results are reported in this paper.

PR: ITTC formulae

ITTC formula

- Uncoupled roll equation with linear damping in longitudinal waves.
- GM changes with time.
- Nonlinear restoring terms are approximated as cubic or quintic and does not depend on time.

Calculation here

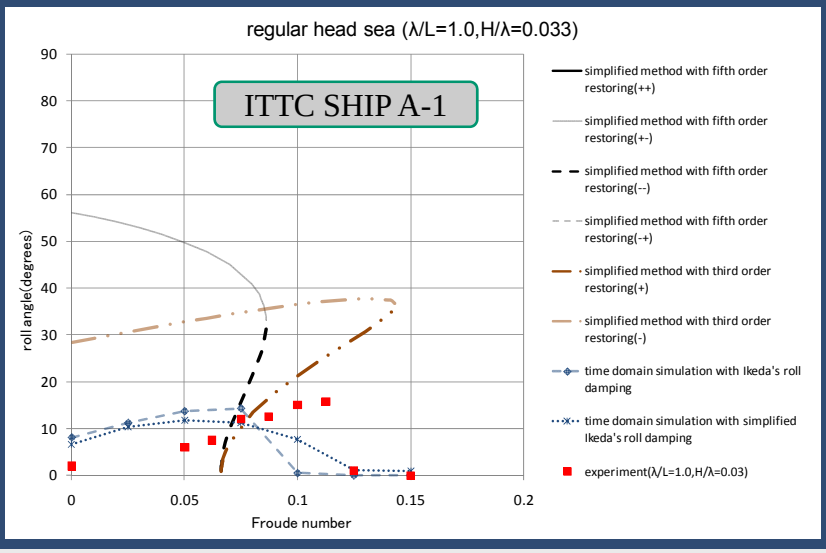
- GM variation : simplified formula or Froude-Krylov calculation with static balance in heave & pitch
- Roll damping: simplified version of Ikeda's semi-empirical formulae

PR: numerical simulation in the time domain

- Several numerical codes are available for this mode.
- In this work a numerical simulation code of uncoupled roll model (Hashimoto et al., 2007) is used with restoring arm variation where heave and pitch are implicitly taken into account.
- Here the restoring arm variation is estimated as the sum of the Froude-Krylov component using heave and pitch motion calculated by a strip theory, radiation and diffraction effects calculated by a strip theory for a heeled hull.

DSCSD
Sept 2009
9

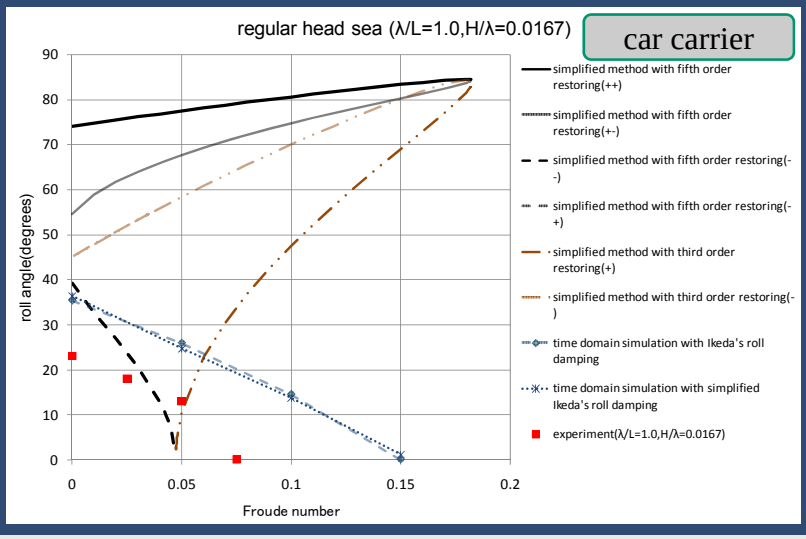
PR: sample calculation



Ship Safety Research Initiative, Osaka University

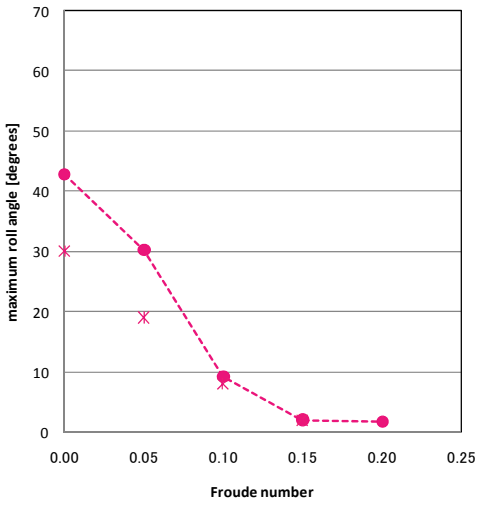
DSCSD
Sept 2009

PR: sample calculation



Ship Safety Research Initiative, Osaka University

PR: sample calculation



car carrier

in irregular head waves with the significant wave height of 5.31 m and the mean wave period of 9.76 seconds.

PR: draft direct assessment procedure

- Small GM ⟶ longer period ⟶ following waves
  ⟶ capsizing (total stability failure)
- Large GM ⟶ shorter period ⟶ head waves
  ⟶ cargo damage
  (partial stability failure)
- Quartering waves ⟶ GM variation becomes smaller
  Excitation does not contribute
- Therefore, a draft direct procedure could require calculation of probability of roll angle exceeding critical value for cargo damage or capsizing in the North Atlantic assuming the worst heading angle, i.e. following waves or head waves and the worst speed.

PR: draft direct assessment procedure

- The probability of roll angle exceeding critical value, ϕ_c, can be obtained as follows.
- Using a numerical simulation in time domain, the maximum roll angle within a specified duration under a stationary sea state, ϕ_{max}, is estimated as a function of the significant wave height and the mean wave period. Here it is necessary to repeat several numerical realisations for sufficiently long duration and its ensemble average should be used as the estimated value.

PR: raft direct assessment procedure

- Then, using the wave statistics of the North Atlantic, f, the probability of roll angle exceeding critical value for the time duration , p_i. is calculated as follows:

$$p_i = \int_0^\infty \int_0^\infty H(\phi_{\max}(H_{1/3}, T_{01}) - \phi_c) f(H_{1/3}, T_{01}) dH_{1/3} dT$$

where H(x)=1 when x 0 and H(x)=0 when x<0.

- Then we can calculate the number of container loss for one year or annual capsizing probability.

Concluding remarks

- Vulnerability criterion for parametric rolling is the future task.

ACKNOWLEDGEMENTS

- This work was supported by a Grant-in Aid for Scientific Research of the Japan Society for Promotion of Science (No. 18360415). It was partly carried out as a research activity of Stability Project of Japan Ship Technology Research Association in the fiscal year of 2008, funded by the Nippon Foundation.