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THE ROLE OF THE ITTC IN THE PHYSICAL MODELLING OF DAMAGED STABILITY IN WAVES

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SUMMARY

This report was prepared in response to a workshop on stability work relevant to the ITTC, to be held on September 18th, 1996. It describes IMD's proposals for the role of the ITTC in model testing damaged ships.

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The Role of the ITTC in the Physical Modelling of Damaged Stability In Waves

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Background

The recent tragedies related to RO-RO ferry capsize have prompted a flurry of activity around the world in the area of physical modelling of the capsize of flooded ships in waves (see bibliography). The techniques used for this work have all followed the path set by Bird & Browne (1973). The objectives of the model tests have been;

a) to understand the physical phenomena which limit survivability of ships after damage

b) to translate these physical phenomena into regulations

or more recently

c) to validate regulations after they have been proposed.

The latter of these three categories is the one which should be most worrying to the members of the ITTC. The IMO set up a Panel of Experts to review passenger ship safety after the sinking of the 'M. V. Estonia'. This panel recommended a procedure for model testing damaged ships as an alternative to prescriptive rules. The procedure was a genuine attempt to address the fact that simplistic approaches do not always address the specifics of a particular case, and the recommendations cannot be seriously criticized on the basis of the current state of the art. However, the ITTC must address the sensitivity of the results of experiments to the simplifications assumed for the convenience of the model testers.

Proposals for ITTC Activity in Physical Modelling of Damage Stability in Waves

So far, there are relatively few data sets for studying the damage stability of ships in waves, and with one exception, they have focused on RO-RO ferries. The tests have modelled a relatively small range of ship proportions, but there has been a lot of attention paid to the details of the design, such as the use of bulkheads to subdivide the car deck, and features such as external sponsons and air bags. Most experiments are reported in terms of limiting wave height for survivability, for a given residual freeboard, and a stability parameter. To date, the most popular choice has been the metacentric height of the flooded ship.

In some cases, results have been presented in non-dimensional form. Residual freeboard and significant waveheight have been combined into a single parameter and several proposals have been made for non-dimensional metacentric height;

Dand (1991)

$$\frac{10 \times GM_f \times B \times C_b}{T^2}$$

Spouge (1994)

$$\frac{D \times GM_f}{1.025 \times L \times B^3}$$

Vassalos (1996)

$$\frac{D \times GM_f}{T^2} \quad \text{or} \quad \frac{GM_f \times T \times C_b}{L \times B^2}$$

Where

GM_f is the flooded metacentric height, m

D is the displacement of the flooded ship, tonnes

B is the beam of the ship, m

C_b is the block coefficient of the flooded ship

L is the length of the ship, m

T is the draft of the flooded ship, m

However, as Vassalos et al (1996) point out, none of these parameters recognize the influence of the structural arrangement on stability. This leads to the suggestion (Vassalos et al, 1996) that other parameters such as maximum GZ lever are more important.

The work of the ITTC Stability Committee should include developing standard procedures for test programs and a set of variables that must be reported for the ship model and the wave parameters. These parameters should include the stability factors for the damaged model, the geometry of the hull and the compartments after flooding, the wave spectra and the parameters to be measured on the model. This will allow the maximum benefit to be derived from all experiments and also enable the results of the experiments to be used in the validation of numerical models of the process. A preliminary list variables is attached in Annex A.

The other major research item to be addressed is the sensitivity of the results to factors such as the permeability of the hull and the cargo deck. The flow of water onto the deck and around cargo (such as cars and trucks) during flooding is not well understood in a physical sense, and a series of experiments to observe the influence of cargo on the process is an essential step in convincing ship owners and regulators that the results of reduced scale experiments are valid. Schindler & Velschou (1994) carried out one set of tests with cargo on the vehicle deck and this showed that the waveheight required to capsize the ship was not significantly different from the empty deck case. However, the time to capsize, which is an important parameter for evacuating the damaged ship, was not reported. Similar arguments can be made for the permeability of under-deck spaces such as engine rooms.

Spouge (1985) proposed the concept of transient asymetrical flooding, or the concept of time dependent changes in ship stability during flooding, to account for the observed behaviour of the 'European Gateway' when she capsized. This theory has not been validated experimentally, since the all hulls used in the experiments to date did not study internal flooding from one compartment to another. It is important that the limits of classical hydrostatic assumptions are established.

Conclusion

In conclusion, I have tried to focus on issues related to carrying out experiments, and avoid issues related to the development of regulations or ship specific issues (such as the specific subdivision arrangements). It is the responsibility of the ITTC membership to provide accurate and reliable methods for testing damaged ships, which reflect the best scientific principles. ITTC members have done a good job in providing information to support the regulators, but now is the time to take stock of the progress in the field, and recommend procedures that will ensure we advance our understanding in this important area of ship stability research.

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ANNEX A

List of Variables to be Reported During Damage Stability Experiments

Hull Parameters

Intact (upright) hydrostatics (displacement, GM, draft, trim, depth to car deck)
Damaged hydrostatics (flooded displacement, flooded GM, GZ vs heel angle)
Residual freeboard in calm water
Volume of flooding and location
Midship section and car deck plan showing extent of damage
Location of any special features such as bulkheads, freeing ports or casings

Wave Parameters

Significant waveheight, peak period, energy spectrum,
Model orientation relative to wave direction

Experiment Parameters

Time histories (minimum sampling rate of 20Hz model scale)

Roll, heave, sway, pitch, surge and yaw
Waveheight close to location of model,
Water level on car deck (at a minimum of 10 locations),
Relative motion at damage location,
Model speed, relative to wave direction,
Time to capsize

ANNEX B

Presentation to ITTC Stability Workshop

Friday 20 September

Physical Modeling of Damaged Stability in Waves

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①

Background

- Model tests on damaged stability have been carried out to
  - » understand physics of problem
  - » translate physics into regulation
  - » validate regulations (or proposed regulations)

②

IMO Panel of Experts Proposal

- Fall out from Estonia disaster
- Model tests as an alternative to prescriptive rules
- Allows for physical representation of hull and special features (e. g. bulkheads)
- Current state of the art

③

Issues to be Addressed by Physical Modeling

- Sensitivity of parameters not understood
  - » small number of data sets
  - » small range of ship proportions
  - » choice of stability parameters
- Influence of vehicles on car deck
- Influence of transient effects during flooding

④

Role of ITTC in Modeling Damaged Stability

- Standardize on test methods and data presentation
  - » acceptance by user community
  - » easier comparison of experiment results
  - » easier integration with numerical models
- Address modeling of
  - » vehicles on car deck and permeability of spaces under bulkhead deck
  - » stability during flooding

⑤

Conclusions

- Experiment results must be to highest technical standard
- Address knowledge gaps through further research

⑥