The Specialist Committee on Stability in Waves

Committee Chairman: Dr. Naoya Umeda
Session Chairman: Dr. Ulderico Bulgarelli

1. DISCUSSIONS

1.1 Discussion to the 25th ITTC Stability in Wave Committee by Harukuni Taguchi, National Maritime Research Institute, Japan

From the fundamental dynamics of parametric rolling it has been clarified that the ratio between encounter period and natural rolling period is one of key factors for the occurrence of this phenomenon.

In irregular waves the ship speed fluctuates according to the sequence of encounter waves. Therefore the degree of fluctuation of encounter period differs from the one which is derived for constant speed assumption. In addition to this, the fluctuation of ship speed may affect the ship's roll damping, which is other key factor for the occurrence of parametric rolling, because it is speed dependent.

In this context, as France, et al. (2003) pointed out, the fluctuation of ship speed has some influence on the probability of parametric rolling in irregular waves.

Therefore, if a towed model is used, consideration should be given to the towing arrangement to ensure not to have an affect on the inevitable fluctuation of ship speed in irregular waves as far as possible. And the Committee's opinion that in order to take the full effect of the fluctuation of ship speed in waves into account, tests with a free-running model should be considered is quite reasonable.

This issue seems to be quite important for conducting parametric rolling experiment. Therefore it might be appropriate that this issue should also clearly be noted in the procedure 7.5-02-07-04.1 "Model Tests on Intact Stability".

1.2 Discussion to the 25th ITTC Stability in Wave Committee by Martin Renilson, Australian Maritime College, Australia

First I would like to thank the Committee for a very interesting and useful report. I think that the report has shown that assessment of ship stability, whether intact or in the damaged condition, is still in its infancy, and far from a routine task. I'm convinced that, in time, dynamic techniques will be required for all ship safety assessments and it's great that the ITTC is taking a lead in this.

Although there is a lot of discussion in the report about the progress that is being made in this field, both for intact and damaged conditions, the committee doesn't actually make any concrete conclusions as to when they expect performance based stability techniques to be able to be adopted on a routine basis. I wonder if they could comment on this?

I have a few comments on the report.

First, it is interesting that the committee refers to the forces caused by wind, particularly for vessels at zero speed. I'd like to add that in addition to the drifting direction, the wind will influence the drift velocity, and hence the encounter frequency. Although the committee are specifically referring to experiments, I'd like to point out that since the way that a vessel drifts can influence its motions, any code that purports to predict the motions of a ship with zero forward speed will need to first be able to predict the way that it drifts. This is often a lot harder than it seems!

The committee comments that comparative studies between free running and towed experiments for parametric rolling have shown acceptable agreement. Do they believe that there is enough data available to have confidence in this statement, or whether they are only indicating a trend at this stage, which still needs further verification?

I note that the committee does not appear to be confident about the current level of accuracy of numerical predictions of the motions of damaged vessels, and that it comments that 'the modelling of floodwater inside the damaged compartments is a challenge for all numerical methods'. It also concludes in the section on **Time to flood** that '… the prediction of flooding rates, especially for unventilated or partially ventilated compartments shows large variations.' Bearing in mind also the limited number of organizations that contributed to these benchmark studies, I wonder if they could comment on how they see this progressing? For example, what do they see as the timescale before the community can have confidence in the numerical predictions of damage vessel motions, such that this can be used for regulatory purposes? Should ITTC members be being encouraged to get more involved in this area? Does the committee feel that many members have expertise, but are not prepared to participate in the benchmark studies, or does it feel that this expertise does not presently exist in the ITTC community?

The required model length for damaged stability assessments, including time to sink, is an interesting issue. Various claims have been made as to the required minimum length. Is the committee aware if any serious studies that have been done on the influence of model length on damage stability investigations? Should this not be something that the ITTC should be encouraging, particularly as it is very unlikely to be able to get full scale data to compare the model test results with?

Bearing in mind all the variables involved in damage stability assessments (including the size and shape of the damage, the effect of short crested waves on water ingress *etc*) it is clear that this cannot be an exact science. Has the committee any comments on this, and would they agree that whole issue needs further fundamental investigation, as distinct from individual assessments?

The current ITTC recommended procedure for damage stability in waves define a survival limit of either an instantaneous roll angle of 30 degrees, or a three minute average roll angle of 20 degrees. Does the committee have any further information to confirm this definition, or otherwise? Would the committee agree that this is an important aspect, and that perhaps it needs further study?

I am interested in the US Navy dynamic stability criteria whereby a new vessel is required to have a 10% margin of stability over and above an existing vessel of the same type. It seems that if this continues to apply then what will happen is that US naval vessels will be required to have higher and higher standards of stability. As stability limits are very crucial to naval vessels, this could unfairly penalize new designs. Does the committee have any comments on this approach? Are there any indications that other navies are going to adopt this?

The committee refers to two major weaknesses of the US naval stability standards, but in addition there is the issue that it cannot

be applied to new ship types and/or those with new roles. Would the committee agree that to a certain extent this defeats the whole point of assessing stability from first principles, as if all that required is a comparison with similar vessels, then surely the standard statical approach is adequate?

Finally, the committee does not specially address the issues that are associated with the stability of high-speed craft in waves, such as deck-diving in following seas. Bearing in mind the increased number of high-speed craft, and the consequences of an accident with these craft, would the committee agree that this should addressed in future?

Again, I would like to thank the committee for a very interesting report.

1.3 Discussion to the 25th ITTC Stability in Wave Committee by Marcelo A. S. Neves, LabOceano, COPPE/UFRJ, Brazil

First of all, the Committee should be commended for the interesting report.

To open this discussion, a comment: I appreciated the consideration given to the nonlinear feature of head-sea parametric rolling, taken into account in the revised ITTC Recommended Procedures and Guidelines 7.5-02-07-04.1. In these Procedures it is clearly stated that it is desirable to carry out numerical simulations employing heave, roll and pitch coupled models. I would like to emphasize the importance of nonlinear coupling in the simulation of head seas PR. Particularly with respect to the possible appearance of specific forms of multistability and intermittency, which are dynamic characteristics not typical of simpler models.

Now, a question. Presently, a significant number of investigations are being undertaken on the control of PR in head-seas, in particular with the use of anti-rolling tanks or the application of rudder action. With respect to this type of experimental investigation, is the Committee considering the appropriateness of issuing specific proposals of regulations and/or guidelines regarding model tests with anti-roll tanks (and perhaps the use of rudder) in the context of parametric rolling control?

1.4 Discussion to the 25th ITTC Stability in Wave Committee by Sandy Day, University of Glasgow Strathclyde, UK

Thanks to committee for an interesting report. I have three questions:

1. Can the committee comment on why the effect of roll-damping on survival boundary appears small in the case presented, when it was found to be important in previous benchmark studies?

2. In section 4.2 the committee comment “roll-damping is still a current problem, both in prediction and model/ full-scale transfer” could the committee expound on what they see as the key problem?

3. Can the committee comment on the uncertainty in model test data for survival boundaries (given that the value quoted for the benchmark study is quoted as “close to but less than 300 m “without any indication uncertainty?

2 COMMITTEE REPLIES

2.1 Reply of the 25th ITTC Stability in Wave Committee to Harukuni Taguchi

The Committee would like to thank Dr Taguchi for his comments including the recommendation to the revised draft recommended procedure.

The Committee understands that Dr Taguchi supports the following statement in the committee’s report.

“A towed model was used in tests in irregular waves (Bulian, et al., 2004; Hashimoto, et al., 2007). However, even with the elastic mooring line towing arrangement it is difficult to

reproduce speed variation in irregular waves, which was noted to have some influence on the probability of parametric roll (France, et al., 2003). It is noted that comparative studies between free running and towed model experiments have shown acceptable agreement (SLF 49/5/7/Corr.1, 2006). However, in order to take into account the full effect of the vessels speed variation in waves, tests with a free-running model should be considered."

The Committee can further justify this statement based on simulation results, shown herein; demonstrating the effect of added resistance on parametric rolling in irregular head waves As Figure 1 (Umeda and Francescutto, 2008). Currently some time-domain numerical codes can predict the magnitude of parametric rolling in regular head waves within practical accuracy, if the wave steepness is not so large. In irregular head waves, however, even such numerical codes occasionally over-predict the amplitude of parametric roll. Other than the practical non-ergodicity of parametric roll, the effect of added resistance is one of the possible reasons for such deviations. While in regular waves the added resistance is constant with time, it slowly changes with time in irregular waves, as a slowly-varying drift force. This time-varying added resistance can disturb the initiation of parametric roll due to speed variation. As shown in Figure 1, this effect can be significant within a certain speed range. And it is noteworthy that the prediction without speed variation is conservative with respect to safety against parametric roll. Therefore, the towing experiment, which restricts speed variation, can be a very valuable way to assess the danger of parametric roll for a practical purpose. Independently, it is of importance for the validation/benchmarking of numerical simulation codes under controlled conditions.

Dr Taguchi also recommends that we clearly state such reason why free-running test is preferable in the draft revised procedure. The Committee appreciates his point but understands that a recommended procedure should principally contain only instructions and the explanations of procedures should be included in the technical committee report. (The 24th ITTC Quality System Group, 2005) Therefore, the Committee is of the opinion that the following statement in the draft revised procedure should be kept as it is.

"The model should preferably be unrestrained. When the model is towed, the towing point and the arrangement should be carefully selected to avoid undesirable effects on roll, pitch and yaw. The influence of any restraining system on ship behaviour should be examined and reported in detail".

References.

The 24th ITTC Quality Systems Group (chaired by G. Strasser), 2005, Final Report and Recommendation to the 24th ITTC, Proc. 24th ITTC, Univ. of Newcastle Upon Tyne, 2:313-321.

Umeda, N. and Francescutto, A. 2008, "Performance-Based Ship Operation", Proc. of the 2nd Int. Workshop on Risk-Based Approaches in Maritime Industry, Univ. of Strathclyde, pp 2.2.1-2.2.9.

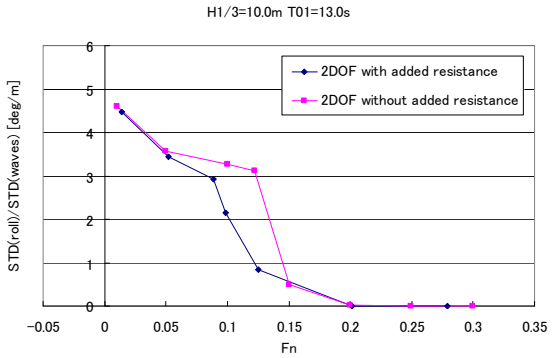

Figure 1 Effect of added resistance on parametric rolling in head waves in the light of numerical simulation in the time domain. (Umeda and Francescutto, 2008)

2.2 Reply of the 25th ITTC Stability in Wave Committee to Martin Renilson

The Committee would like to thank Prof. M. Renilson for his discussion.

Use of tools. First principle tools in some stability areas are almost ready to be applied to regulatory application. At least, model tests of damaged RoRo ships are already used in the framework of the Stockholm Agreement. This fact had been already noted in the previous report. It is true however that more research is required in most areas of dynamic stability. Even if the capabilities of current first principle tools are found to be sufficient, their application to regulatory purposes could require prohibitively large time, cost and human resources.

In case of intact stability assessment at IMO, it was agreed to supplement direct stability assessment with vulnerability criterion. This means that, if a ship complies with the vulnerability criteria, the direct stability assessment does not have to be applied to the ship. This allows the feasibility to use first principle tools for mandatory regulation. Detailed new intact stability criteria are now under development at IMO.

Wind. The Committee agrees with his comments on drifting effect on ship motion in waves. The point Prof. Renilson has raised was discussed in the 24th committee report, referring the work by Kuroda et al. (2003). However, the issues associated with wind go further than just the drift caused by wind. Moments caused by wind have a significant effect on the orientation of the vessel relative to the waves—we have seen the heading of a model with superstructure tested in open waters vary by 60˚ with variations in wind velocity.

In addition to drift due to wind, one also needs to include the wave induced drift and wave induced yaw moment. In the case of experiments allowing drift, it is necessary for a wind fan to trace the model by using carriage.

Parametric Rolling. Regarding the applicability of towing experiments for parametric rolling, the Committee would like to remark the following points. Methods of towing experiment can have many variations so that it is not easy to obtain generalised conclusions.

The Committee, however, found an acceptable agreement in regular waves between the towing test at Osaka University and the free-running model experiment at NRIFE. As explained in the reply to Dr Taguchi, the limitation of towing test exists in irregular head-sea cases due to time-varying speed as a consequence of changes in added resistance.

Numerical Prediction of Motions of Damaged Vessels. With respect to the motions of damaged ROPAX ships (Stockholm Agreement flooding scenarios) numerical prediction methods proved satisfactory in previously conducted ITTC benchmark studies, for which experimental data were made available (see also section **use of tools**).

When it comes, however, to the multi-compartment flooding problem, which is typical to cruise ships, there is very little data available against which such predictions can be validated. Looking at the problem in two parts: 1) the flooding process in the absence of waves, and 2) the motions of a flooded vessel; there is one good experiment with a simple body on part 1—the Helsinki University barge test discussed in our report, and virtually no data for problem 2. The best answer would be to have a good set of freely available experimental results for characteristic cruise ship designs against which computational tools can be validated.

- The time-scale for having validated tools for predicting motions of damaged cruise ships is difficult to predict, but it would seem that it will take at least 3 to 5 years.
- Expertise in damaged stability prediction is limited to very few organisations within the ITTC membership (or for that matter anywhere else in the hydrodynamics community.)
- Yes, ITTC members should be encouraged to become involved in the areas of motions of

cruise vessels and other ships in general—and sponsors should be encouraged to fund such research, as well as designers and experimental facilities to provide data for benchmarking.

In the absence of experimental data, it may be possible for several groups of researchers with computational tools to collaborate on making predictions for the same configurations until they can all predict similar results for the same cases—although this may be disturbed by commercial aspects.

Model Size for Damage Stability Assessment. The Stability in Waves Committee is unaware of any comprehensive studies concerning model size for damaged stability/motions tests. There have been very few damaged vessel motion experiments that are freely available, let alone any experiments available comparing model size. As well as the obvious issues with the construction of small models with multiple compartments there are several other issues. For models with unventilated or partially ventilated compartments, there will be significant scale effects, relating to model size, associated with the compressibility of the air in the compartments. Proportionately, the smaller the model, the stiffer the "spring" represented by the air, and the more difficult the analysis/computational modelling of these experiments.

•Yes, ITTC members should be encouraged to become involved in such studies—and sponsors should be encouraged to support such efforts.

Variables Associated with Damage Stability Assessment. We agree with the discusser that this is not an exact science. There is a need for fundamental studies, not just on hydrodynamics, but also on statistical methods for identifying the worst cases, environments, etc. The total number of damage cases and environments that might need to be examined by a brute-force approach could well be in the 10s of millions—a computational impossibility. This again reinforces the comment made at the beginning of this reply.

Survival Limits—30˚/20˚. These limits were not determined by the Stability in Waves Committee, but have been supplied by IMO and with no other more suitable available criteria these have been adopted.

US Navy Criteria—10%. The US Navy performance-based stability criteria are the first of this type that we are aware of. Thus, the intention was to be conservative in establishing the criteria, and this is the source of the 10-percent margin. The 10-percent margin is in the criteria to account for the uncertainties regarding the confidence in the current computational methods. As confidence in the application of the stability criteria and computational methods is gained, it is expected that arbitrary factors such as the 10-percent margin would be reduced or eliminated from the criteria. (It should be noted that IMO has stated a desire to have a performance-based stability criteria for commercial vessels but as yet none have been established.)

Weakness of US Navy Stability Criteria.

The use of "similar vessels" as a benchmark is not meant to apply to geometry or configuration, but rather to vessels with similar missions. The purpose of this constraint was to ensure that aircraft carriers are not used as the benchmark vessels for the design of minesweepers. Thus, this requirement should impose few true constraints on the process.

- The committee has heard of nothing to indicate that other navies are going to adopt a criterion similar to that employed by the US Navy.
- Within the Naval Stability Standards Working Group there is a desire to progress toward a performance based criteria for naval vessels, even for vessels that are more unconventional in design. This is due to the fact that it is difficult to know where the hydrostatic based criteria approach to stability places a design relative to the stability failure boundary.

High-Speed Vessels. Agreed, the committee has not specifically considered stability in waves for high-speed vessels. This is a consequence of tasking to the committee from the EC/AC for the 25th ITTC. For the 24th ITTC, the Committee did consider high-speed vessels. However, regarding high-speed craft issues, the current report mentions the model experiment of bow-diving by Matsuda et al in the literature survey. It is true that the IMO HSC Code allows us to use model experiments and numerical simulation for assessing stability and the 24th committee developed the guidelines for model experiments with high-speed RoRo vessels with bow-door damage, in response to a request from the IMO. Guidelines for many other experiments with high-speed craft have not yet been established. Thus, it is one of urgent tasks for the ITTC to review available techniques, if in existence, and then to develop recommended procedure as appropriate.

2.3 Reply of the 25th ITTC Stability in Wave Committee to Marcelo A. S. Neves

The Committee would like to thank Professor Neves for his comment supporting our model test procedure as well as his question on prevention devices for parametric roll.

The Committee agrees with the importance for establishing the procedure testing anti-roll tanks in model scale to mitigate parametric roll. Some model experiments using anti-rolling tanks for parametric roll (Umeda et al., 2008; Hashimoto and Umeda, 2008) were recently reported so that its procedure could be developed in the near future. The application of rudder action for mitigating parametric roll seems to require further investigation because significant parametric roll often occurs mainly at low forward speed but the rudder action is effective with higher forward speed.

References:

Umeda, N., H. Hashimoto, S. Minegaki and A. Matsuda, (2008) An Investigation of Different Methods for the Prevention of Parametric Rolling, Journal of Marine Science and Technology, Vol. 13, No. 1, 2008, pp. 13-26.
Hashimoto, H. and N. Umeda, (2008) Preventing Parametric Roll with Use of Anti-Rolling Tank for a Large Containership in Head and Following Waves, Proceedings of the 4th Asia-Pacific Workshop on Marine Hydrodynamics, Taipei, pp.73-78.

2.4 Reply of the 25th ITTC Stability in Wave Committee to Sandy Day

The Committee would like to thank Dr. Day for his three questions.

1. Regarding the effect of viscous roll damping on the estimated survival boundary of damaged RoPax ships, the presented study attempted to quantify the importance of semi-empirical estimation methods in employed numerical simulation methods, as this was found of importance in previously conducted studies. However, the limited available results of this study indicated that the sensitivity was in this benchmark case very small. This contradictory finding suggests that the problem is more complex and further research with focus on the accuracy of existing/employed semi-empirical methods and their appropriateness for the type of study vessels is necessary. This is specified as one of the tasks for the next Stability in Waves committee.

2. At the IMO, as parts of interim alternative procedures for its weather criterion, experimental guidelines for estimating roll damping coefficient including scale effect correction methods were published. However, it is desirable to standardise semi-empirical or theoretical prediction methods of roll damping are desirable for practical use. In addition, the scale effect cannot be taken

into account when we execute roll motion measurements of a ship model in waves because of complexity of the physical system to be investigated. This is also specified as one of the tasks for the next Stability in Waves committee.

3. Regarding the uncertainty for survival boundary in irregular waves, the Committee provides a formula for calculating confidence interval of estimated capsizing probability in Chapter 4 of the recommended procedure 7.5-02-07-0.4.1. This formula is applicable for both intact and damage cases.