FINALIZATION OF SECOND GENERATION INTACT STABILITY CRITERIA

Proposal for finalization of second generation intact stability criteria
Submitted by Japan

SUMMARY

Executive summary: This document contains a proposal for a feasible way forward for finalization of second-generation intact stability criteria for consideration by SDC 7

Strategic direction, if applicable: 2

Output: 2.6

Action to be taken: Paragraph 6

Related documents: SDC 5/6/13, SDC 5/15; SDC 6/5, SDC 6/5/1, SDC 6/INF.3 and MSC.1/Circ.1228

Background

1 The re-established Correspondence Group on Finalization of Second-generation Intact Stability Criteria worked in accordance with the terms of reference and submitted its report as document SDC 6/5. Said document includes the draft Interim guidelines for the specification of direct stability assessment (DSA), the draft Interim guidelines for the preparation of operational limitations and operational guidance (OL/OG) and the draft vulnerability criteria (levels 1 and 2) for each of the five stability failure modes as a package set out as annexes 1 to 3 to document SDC 6/5.

2 The development of the second generation intact stability criteria started at the SLF Sub-Committee in 2002, mainly with the following three objectives: First, to authorize sufficient intact stability of large cruise vessels which may not easily comply with the weather criterion. Second, facilitation for the use of state-of-the-art technologies such as time domain simulation tools as an alternative to prescriptive intact stability criteria. Third, prevention of a severe accident similar to that of a C11 class containership due to parametric rolling in head waves in 1998.
3 Regarding the matter of large cruise vessels, a practical solution is to allow the use of model experiments for the roll-back angles, the wind heeling moments and the extended wave steepness table for the application of the weather criterion, as set out in MSC.1/Circ.1200. Such approach has shown that the dead ship failure mode does not cause great concern. Numerical simulation tools may be used as an alternative whereby the newly developed package of the second generation intact stability criteria, including the direct stability assessment, definitely resolved the problem. Similarly, the new second generation intact stability criteria satisfactorily address the parametric rolling failure mode and thus their application is highly recommended.

4 Before the development of the second generation intact stability criteria, the operational guidance was developed in 1995 as MSC/Circ.707, and was superseded by MSC.1/Circ.1228. This guidance aimed at avoiding surf-riding, which could induce broaching, pure loss of stability and parametric rolling. The operational requirements for surf-riding in this guidance, which is based on the rigid background of nonlinear dynamics, are very effective and appear to have reduced accidents due to broaching. However, the guidance does not use the target ship data and the recommended operational speed has a wide range for well-designed ships. For parametric rolling, the operational requirements in MSC/Circ.707 are not sufficient to avoid serious accidents which may also be because the requirements are not based on target ship data. Thus, the operational measures for surf-riding and parametric rolling should be applied to actual ships as soon as possible.

Discussion

5 Japan submitted comments on document SDC 6/5 to the Correspondence Group and expressed concerns on the following three issues, as set out in annex 9 to document SDC 6/INF.3:

.1 relationship with existing weather criterion, which could prevent trial application of new criteria for the dead ship failure mode;

.2 missing guidance for a vessel with extended low weather deck for the pure loss of stability failure mode; and

.3 pending applicable range of the excessive acceleration failure mode.

6 During recent experiments for the validation of direct stability assessment tools for dead ship failure modes using a large cruise ship model, both synchronous rolling and parametric rolling were observed, as shown in figures 1 and 2. The model tests have also shown that synchronous rolling of only 12 degrees occurred, even under a severe wave height, whereby the long wave periods were almost outside the wave scatter table for the North Atlantic (see figure 1). However, as shown in figure 2, a larger roll amplitude can be observed in the region of parametric rolling. This roll amplitude suddenly emerges at a certain threshold in the wave height and then nonlinearly increases with the wave height. Thus, it can be concluded to be typical parametric rolling. This result suggests that this cruise ship is not vulnerable to stability failure under dead ship stability as it is now but, if the bilge keel size is reduced for minimizing the fuel consumption due to frictional resistance with the results of vulnerability criteria developed only for synchronous rolling, the danger due to parametric rolling in beam waves could occur. This indicates that vulnerability criteria should be reconsidered with parametric rolling in beam waves, which has a mechanism of roll restoring variation different from parametric rolling in longitudinal waves.
Figure 1 – Roll amplitude of a cruise ship model measured in regular beam waves having the different wave periods $T_w$ in the range for the synchronous resonance. The natural roll period of this ship, $\phi_n$, is 23.54 seconds in the relevant full scale. The wave height, $H_w$, is 10.5m in full scale regardless of the wave period.

Figure 2 – Roll amplitude of a cruise ship model measured in regular beam waves having the different wave heights. The wave periods $T_w$ is set as 9.42 seconds for a typical parametric roll resonance.

7 Difficulties exist in assessing ships that have low weather decks, which would result in water on the deck, for both pure loss stability and dead ship failure modes. Recent experiments using a typical chemical tanker model, which has a smaller freeboard, have shown that the ship fails to comply with the dead ship level 2 criterion in regular beam waves (figure 3). While the current draft level 2 criterion, as well as a linear seakeeping theory, assumes the effective wave slope coefficient not to be dependent on the wave steepness, the measured result shows that it is constant only for very small wave steepness but it suddenly decreases when the wave steepness is larger than 0.01. Just above this threshold of 0.01, instantaneous water level exceeds the weather deck edge as shown in figure 4. This means that the current level 2 dead ship failure criteria could be excessively conservative. This suggests that our understanding on the effect of water on deck on the ship having low weather deck is very limited not only for pure loss of stability but also for dead ship failure mode.
The sample calculation for the excessive acceleration failure mode, shown in document SDC 5/6/13, indicates that most of the ships were vulnerable at level 1 in ballast conditions. Hence, although the level 1 of vulnerability criteria should be sufficiently conservative, most of the ships are vulnerable to the excessive acceleration failure mode, which may require the use of new software for numerical calculations using offset data for almost all ships longer than 24 m applying level 2 criteria, contradicting the current criteria.

It is worth noting that during the discussion in the Correspondence Group, China reported inconsistencies between two levels in the vulnerability criteria for the excessive acceleration failure mode for ships having low weather deck and the United States and China expressed concerns on the vulnerability criteria for pure loss of stability failure modes. In addition, the United States, Finland and Germany proposed a way to rebuild the dead ship failure vulnerability criteria from the beginning although it would require additional sessions with new comprehensive sample calculations, which is beyond the terms of reference of the Correspondence Group established in SDC 5.
10  Bearing in mind that the Sub-Committee agreed that, if the complete package was not finalized by a drafting group at SDC 7, the work on this output should be considered "complete" and removed from the work programme of the Committee (paragraph 6.14 of document SDC 5/15). In this respect, Japan reviewed the problem of the five stability failure modes in order to find a way to address the issues under this agenda item.

11  The five stability failure modes were reviewed, identifying three major issues:

.1  problem which has not yet been solved through former works;

.2  investigating accidents (necessity of safety measure); and

.3  relation between this outputs and existing IMO instruments or guidance.

The brief descriptions of the results are set out in the annex to this document. Japan is of the view that pure loss of stability, dead ship and excessive acceleration failure modes have technical or legal difficulties which need to be solved. On the other hand, parametric rolling and surf-riding/broaching failure modes have no serious impact but criteria which address these failure modes are urgently needed, with a view to improve the intact stability of ships. In this respect, current state-of-the-art technology is almost ready to be applied in order to avoid future accidents arising from these two failure modes.

12  As mentioned in the introduction, the urgent need of new criteria exists for parametric rolling and surf-riding/broaching. Therefore, at least for these two failure modes, the new set of criteria should be tested as soon as possible. It is also important to allow for an alternative use of numerical simulation tools for the direct stability assessment. However, it should be underlined that unsuccessful outcomes of the application of direct stability assessment may not yield the expected results. Therefore, the use of this approach should start only with the failure modes that are sufficiently mature. In this respect it should be noted that numerical tools can be applied only to the failure modes that were well validated with model experiments relevant to that mode and the guidance should be structured to address each failure mode.

Proposal

13  Taking into consideration paragraphs 11 and 12 and annex to this document, the following changes to the existing output are proposed:

.1  parametric rolling and surf-riding/broaching should be assigned high priority at SDC 7 so as to finalize them for trail use; and

.2  accordingly, the other three failure modes should be categorized as low priority to be finalized at SDC 7, while further scientific research should be encouraged so as to provide technical evidence for new criteria, to be submitted under a new agenda item.

Action requested of the Sub-Committee

14  The Sub-Committee is invited to consider the proposal in paragraph 13 and take action, as appropriate.
ANNEX

CURRENT SITUATION OF THE FIVE STABILITY FAILURE MODES

(1) Serious problem which has not yet been solved.
(2) Relating accident (necessity of safety measure).
(3) Relation between this outputs and existing IMO instruments or guidance.

1 Pure loss of stability
   (1) The guidance for a vessel with extended low weather deck is not available.
   (2) Total or partial accidents of the RoPax and ro-ro ships in following waves were reported in Japan, New Zealand and Sweden and they were assumed to be caused by pure loss of stability in following waves.
   (3) The existing guidance in MSC.1/Circ.1228 already addressed pure loss of stability in following waves but without target ship data.

2 Parametric rolling
   (1) All undecided items identified at SDC 5 were resolved in the Correspondence Group.
   (2) Severe cargo loss accidents involving large container ships included a C11 class containership; large roll experiences of car carriers were frequently reported by the United States, Sweden and others. Thus there is an urgent need of new design and operational criteria.
   (3) The existing guidance in MSC.1/Circ.1228 already addressed parametric roll but without subject ship data.

3 Surf riding/broaching
   (1) No important aspect is missing in this respect in the three draft guidelines.
   (2) Many accidents including destroyers and small passenger ships were reported.
   (3) The existing guidance in MSC.1/Circ.1228 already addressed surf-riding but without subject ship data.

4 Dead ship stability
   (1) For vessels with low weather decks and very beamy ships, inconsistency between levels 1 and 2 of vulnerability criteria were reported. While both synchronous and parametric rolling in beam waves could exist, the current draft vulnerability criteria addresses only synchronous rolling.
   (2) No data of accident exists.
   (3) Addressed by the existing mandatory weather criterion (paragraph 2.3 of part A of International Code on Intact Stability, 2008). The draft intact stability criteria to be used as “trial” but they may cause some legal problem between existing criterion and new intact stability criteria for dead ship stability.

5 Excessive acceleration
   (1) The standard values were decided at the Correspondence Group; however, applicable range of vulnerability criteria using the ship principal dimensions is still undecided. Calculation by Japan have shown that a number of ships were vulnerable against level 1 assessment.
   (2) Several accidents of containerships including MV Chicago Express were reported but no report for other ship types.
   (3) No existing instruments or guidance addressed excessive acceleration.