JCSS

JCSS Workshop on Ship Collision Risk Assessment

14-15 January 2020, Kongens Lyngby, Denmark

Organizing committee: I.B. Kroon, A. Lentz and P. Terndrup Pedersen

Workshop conclusions

The workshop covered a number of different aspects of ship collision risk assessment, including frequency modelling, consequence modelling, codification in design standards and various applications and examples. A full list of the presentations is provided in the appendix.

The participants included representatives of academia and engineering consulting at equal proportions. As far as consequence modelling is concerned, the presenters came from both the structural engineering, offshore engineering and from the ship design world, which helped to get a more complete picture of recent developments on the force-energy relationships during collisions.

The concluding discussion on the second day of the workshop addressed a number of topics as summarised in the following:

Frequency modelling

A number of presentations dealt with tools for frequency modelling. Presentations [1], [4], [17], and [18] described the application of holistic models based on Fujii's approach (as known from O.D. Larsen's "green book[1]" and from AASHTO), and presentations [2], [3], [5], and [19] described fast track simulations with various degrees of detailed description of ship manoeuvring characteristics. A question was asked whether these holistic models should not be replaced by newer approaches after 50 years of use. One of the possible alternatives would be fast simulations, as presented during the workshop. Participants were generally positive towards this suggestion but had two reservations:

First, the human error would need to be accounted for in a much more comprehensive way in the fast simulation models.

Second, a lot more data analysis would be needed up front in order to parametrize this type of model appropriately. Here, it is a challenge that most accident databases simply are of insufficient quality, i.e. it is typically not possible to extract the nature of the human error that caused the accident from the data in a satisfactory way (or not at all). A possible workaround on this matter might be using flag state data rather than data from classification societies.

To the defence of the existing, holistic modelling (especially of the Fujii model) it was mentioned that namely the emergence of AIS data analysis has indeed meant an important step forward in terms of

[1] O.D. Larsen, Ship collision with bridges, The interaction between vessel traffic and bridge structures, IABSE, 1993

basic understanding of the underlying processes and according to parametrization. It is certainly a strength of holistic modelling that it does not narrow the perspective down to solely the most obvious scenarios. Rather, it accepts that ships can hit wherever ships can sail.

Another line of discussion was the importance of modelling post-aberrancy behaviour appropriately. There was a clear consensus that this is one of the main topics to address in the future regardless of what type of modelling – holistic Fujii/MacDuff or fast simulation – is applied. As for now, holistic approaches tell too little about the actual collision situation, i.e. how a ship strikes an obstacle, which is a challenge when designing structures against impact.

Consequence modelling

Comprehensive Non-Linear Finite Element Modelling (NLFEM) of ship-ship collisions were presented by [10] and [11] and impacts against offshore structures by [8]. These very detailed numerical analyses give insight into the many different crushing mechanisms involved in high-energy ship collisions.

Related to design of the floating bridges for the E39 road in Norway presentation [7] gave results on bridge-girder impact loads from ship containers and presentation [9] showed similar NLFEM results for ship impacts against pontoons and bridge girders from specific design ships. For the floating bridges, it is especially important to take into account the significant amount of energy, which is transferred into global vibrations of the very flexible bridge structures.

While having obvious strengths in terms of detailed understanding of ship-structure interaction, using NLFEM comes with a potential pitfall: Results are highly dependent on the specific geometry and stiffness of the involved ship. Thus, the selection of a representative set of possible ships is key to covering the event space in a comprehensive way and thereby achieving a robust estimate of the structural response.

Presentation [6] discussed numerical and experimental analyses leading to the design of protective structures around pylons.

Based on the presentation [12] the workshop reached an understanding that the existing Eurocode collision force equation for sea waterways is too conservative, as it is solely based on ice-class vessels. At the same time, there were concerns that the relatively low collision forces resulting from the AASHTO could become more critical nowadays, where engineers are willing and – thanks to computational power – also able to "squeeze" all conservatism out of the remaining parts of the model.

The so-called Heinrich factor (probability of actual failure, a structure being struck with a calculated collision force exceeding its capacity) was also the subject of discussions. There was a feeling that the present modelling, discussed by [13], – which is derived from the relative masses of two colliding ships rather than the situation of a ship hitting a fixed object – might, in fact, be better apt to describe collisions against floating structures. The question remains as how to address the "classical" case of a collision against a fixed structure such that proper account is taken of post-aberrancy behaviour including last-minute actions of the ship navigators and the effect of reserve strength of the bridge structure.

Other topics discussed included the importance of checking against local crushing forces and the forces arising during collisions between the ship superstructure (deckhouse, containers etc.) and an obstacle. In both cases, significant results have been presented for individual cases. However, there is a strong need for moving towards more generic models.

Present and future codes and standards

With the presentations [14]-[16] attention was paid to Eurocode 1991-1-7, which is currently under revision. The discussion touched both the (very limited) guidance on the frequency model and the perceived conservatism of the consequence model.

Most participants agreed that a simple "cookbook" approach is not the way forward as far as frequency modelling is concerned; however, there was an understanding that some more guidance would be needed – even if this just amounts to "writing down" whatever we can say right now about the general process to be followed.

In terms of consequence modelling, novel research [12] on non-ice-class vessels was seen as a relevant input to future code versions.

Claus Kunz, who is part of the Eurocode 1991-1-7 committee, also advised to consider the option of using the national annexes for introducing new code elements. These can then serve as an important inspiration for later versions of the Eurocode main text.

Appendix: List of presentations

Introduction (14 January)

1.	Jørgen Kampmann (COWI, Denmark):	*Development of ship collision risk modelling for the Great Belt since 1977*

Session 1: Frequency modelling (14 January)

2.	Axel Hörteborn (SSPA, Sweden):	*Ship simulator used in a ship-bridge collision analysis for a transparent risk assessment*
3.	Paul Redondo (Siport21, Spain):	*Frequency modelling by means of manoeuvre numerical models*
4.	Albrecht Lentz (COWI, Denmark):	*Basic frequency modelling concepts and recent developments*

Session 2: Consequence modelling I (14 January)

5.	Wojciech Misiag (Arcadis, Netherlands):	*Ship-moorings simulations*
6.	Henrik Gluver (COWI, Denmark):	*Risk-based design of external ship collision protection*
7.	Yanyan Sha (University of Stavanger, Norway):	*Ship collision loads on bridge superstructures*

Session 3: Consequence modelling II (14 January)

8.	Hagbart Skage Alsos (SINTEF, Norway):	*Evaluation of impacts offshore - some projects at SINTEF Ocean*
9.	Martin Storheim (Entail, Norway):	*Ship collision aspects on flexible floating bridges*
10.	Spyros Hirdaris (Aalto University, Finland):	*Recent lessons on structural crashworthiness analysis of passenger ships in collision and grounding*

Session 4: Consequence modelling III (14 January)

11.	Mihkel Kõrgesaar (Estonian Maritime Academy, Estonia):	*Computational tool for novel crashworthy ship structures*
12.	Preben Terndrup Pedersen (DTU, Denmark):	*Bow collisions against bridges*

13. Harikrishna Narasimhan (COWI, Denmark): *Consequence modelling of ship-bridge collisions*

Session 5: Current and future design codes (15 January)

14. Claus Kunz (Federal Waterways Engineering and Research Institute, Germany): *EN 1991-1-7 background information*

15. Inger Kroon (COWI, Denmark): *On acceptable risk level DS/EN 1991-1-7 DK NA:2013 Addendum bridges: 2015 Section 3.2 (1) Acceptable risk level*

16. Ton Vrouwenvelder (TNO, Netherlands): *Background of impact loading due to ISO 10252 and Eurocode EN 1991-1-7*

Session 6: Examples and applications (15 January)

17. Lars Christiansen Bagger (Ramboll, Denmark): *Collision loads against the Bjørnafjorden floating bridge*

18. Matt Carter (Arup, USA): *Queensferry Crossing marine risk assessment studies*

19. Stijn Joosten (Arup, Netherlands): *Ship collision risk study Netherlands*