Annual report of *ASEF/TWG/SWG2* on Containership Safety

Jiameng WU

Chairman of *ASEF/TWG/SWG2*

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Key principles/strategic policies of ASEF/TWG/SWG2

Exchange of information and views on IACS UR S11A "Longitudinal Strength Standard for Container Ships", UR S34 "Functional Requirements of Load Cases for Strength Assessments of Container Ships by Finite Element Analysis" and Class Rules under development, and clarification of Technical Background (TB) and/or rule change of IACS and/or relevant Classification Societies are to be requested by ASEF as appropriate, with a view to minimizing Shipbuilders' risks, and further develop discussions.

List of Participants of ASEF/TWG/SWG2

First Name	Family Name	Organization	ASEF Member
Jiameng	WU	Marine Design & Research Institute of China	Chairman/CANSI (AP(T)/CANSI)
Huaiyuan	REN	Dalian Shipbuilding Industry Co. Ltd.	CANSI
Jiaying	WANG	Hudong-Zhonghua Shipbuilding (Group) Co. Ltd.	CANSI
Deyu	WANG	Shanghai Jiaotong University	CANSI
Dajian	XIE	Nantong COSCO KHI Ship Engineering Co. Ltd.	CANSI
Byung-DO	LEE	STX Offshore & Shipbuilding	KOSHIPA
Dong-Ki	KANG	Hyundai Heavy Industries	KOSHIPA
Hoang Van	THOA	Technical & Production Department	SBIC
Tran Xuan	DUC	Shipbuilding Industry Designing Department	SBIC
Hiroaki	HIRASAWA	Japan Marine United Corporation	SAJ
O	KITAMURA	Mitsubishi Heavy Industries, Ltd.	AP(T)/SAJ

Activities of ASEF/TWG/SWG2

- IACS is progressing with the issue on **hull girder ultimate strength** considering the **whipping effect** by setting up a new Project Team (PH38). ***Chair of SWG2*** used a variety of forms to communicate with IACS SG or Hull panel Chair (by formal letter or via phone) with the assistance of ASEF SG. IACS finally agreed to organize an informal meeting between ASEF and IACS PT PH38 before they finalized their work under the umbrella of IACS Hull Panel.
- ***TWG/SWG2 experts from CANSI*** had carried out wave loads analysis for containerships considering the effect of non-uniform heading distribution and variant speed. The preliminary results were issued in an ISOPE(2017) paper of **Effect of Non-uniform Heading Distribution and Variant Speeds on EDW**.
- Impact of UR S11A and S34 on the scantlings by **FE consequence assessment** was carried out by ***TWG/SWG2 experts from CANSI***.
- Further study on the modeling of SWSF in loading manual and/or loading computer by **point load approach** was carried out by ***TWG/SWG2 experts from CANSI***, compared with the real distribution of SWSF in global FE analysis.

Information of working activities on whipping from IACS

- In IACS Council Meeting (C71), a new **Project Team PH38** (IACS Internal) was set up to carried out the research on the whipping effect on container ships, and to set the Min. Req. for the hull girder ultimate strength of container ships considering whipping effect.
- Schedule for PT PH38: about 2016.9~2017.12.
- ASEF made a request to IACS SG for further sharing of the information on the whipping effect on the containership on 30 Mar. 2017.

Active Shipbuilding Experts' Federation

ASEF

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【ASEF doc.03-2017】

Mr. Robert Ashdown
Secretary General
International Association of Classification Societies, Ltd. (IACS)
6th Floor, 36 Broadway, London, SW1H 0BH, United Kingdom

30 March 2017

Request for further sharing of the information on the whipping effect on the containership

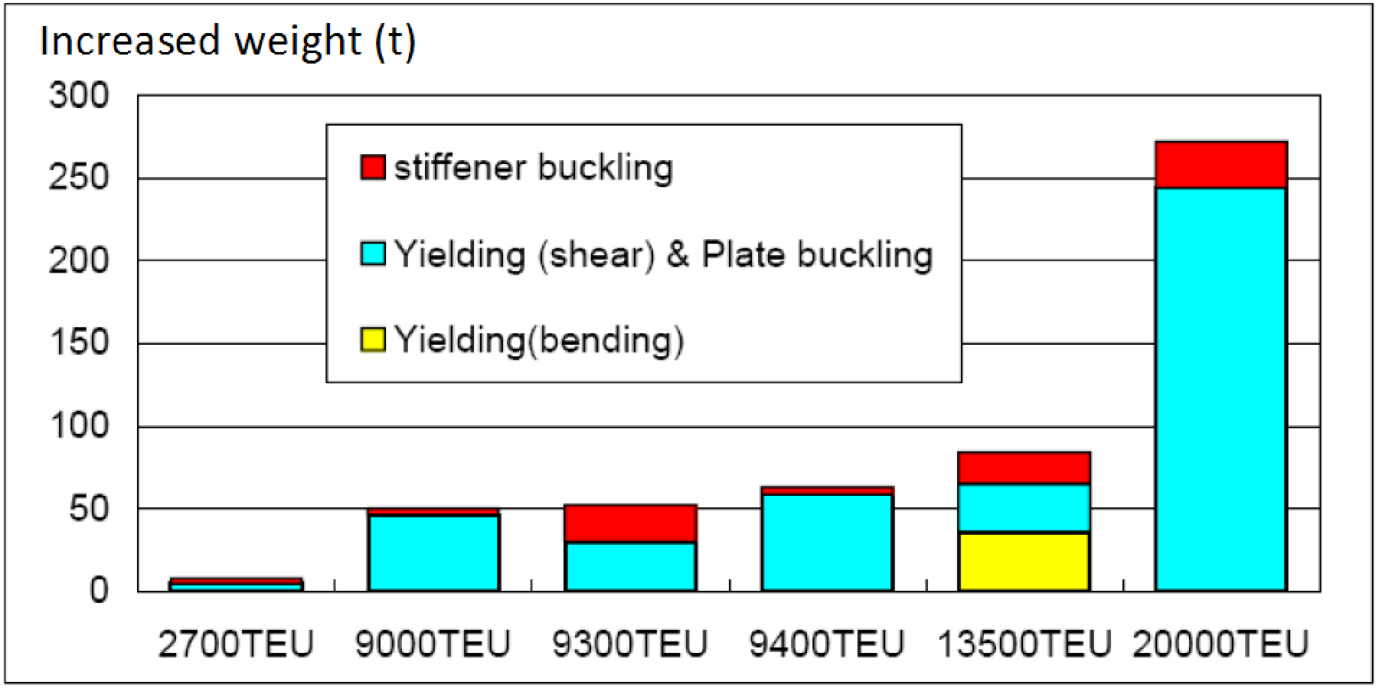
Dear Mr. Robert Ashdown,

The Active Shipbuilding Experts' Federation (ASEF) is grateful to IACS for the continued efforts you have put in towards the enhanced safety of containerships.

- ***Chair of SWG2*** had a phone conversation with IACS Hull Panel Chair Mr. Baumans, to explain the background and current status of ***SWG2*** for container ship safety and why ASEF showed great concerns on whipping effect on hull girder ultimate strength.
- On 11 May 2017, ASEF got the feedback from IACS SG that IACS was willing to agree for an **informal meeting** to be organized between ASEF and the Project Manager of PT PH38 before the Project Team finalized its work, probably at the end of 2017. But the arrangements for this meeting (timing, agenda etc.) will take place under the umbrella of IACS Hull Panel.

Impact of UR S11A and S34 on the scantlings by FE analysis

- At the 10th ASEF Forum, ***SWG2*** gave the report on the impact on Hull scantling (only by prescriptive requirement) due to UR S11A and summarized:
  - One CV of 13500TEU has problems on hull girder bending strength in the region of 0.3L-0.4L.
  - Plate buckling problems are always due to **shear buckling**.
  - Hull scantling may be decreased for some areas, but should be evaluated by FE analysis.



Source: Annual report of *ASEF/TWG/SWG2* at the 10th ASEF Forum

Impact of UR S11A and S34 on the scantlings by FE analysis

- For global FE analysis (**UR S11A impact**),
  - A simple approach with only hull girder loads applied;
  - Comparison of Stress components in two different Load cases considering different wave vertical bending moment by UR S11 and S11A respectively:
    - ✓ Head sea:

      SWBM+WBM_S11 *v.s.* SWBM+WBM_S11A;
    - ✓ oblique sea:

      SWBM+factor*WBM_S11+WTM+STM+WHM

      v.s.

      SWBM+factor*WBM_S11A+WTM+STM+WHM

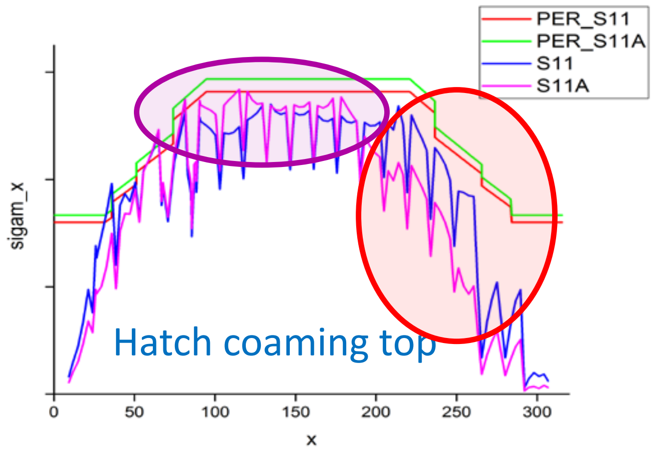
WBM	- vertical wave bending moment, determined by UR S11 or S11A
SWBM	- vertical still water bending moment
WTM	- wave torsional moment
STM	- still torsional moment
WHM	- wave horizontal moment
factor	- factor of WBM in oblique sea

(SWBM, WTM, STM, WHM, factor:) **Determined by individual Class Rule**

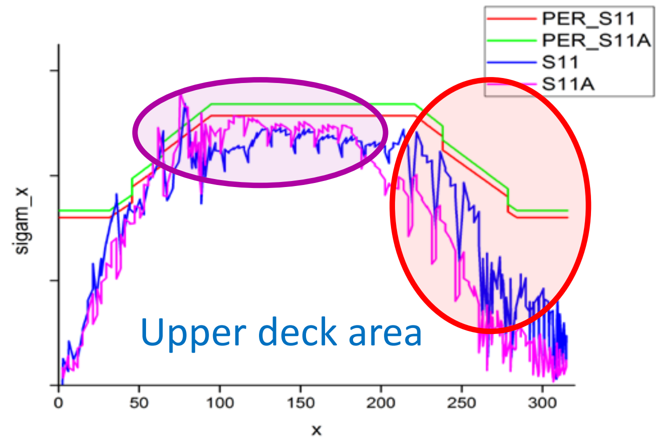
Impact of UR S11A and S34 on the scantlings by FE analysis

- 10000TEU CV
  (DNV Rule)

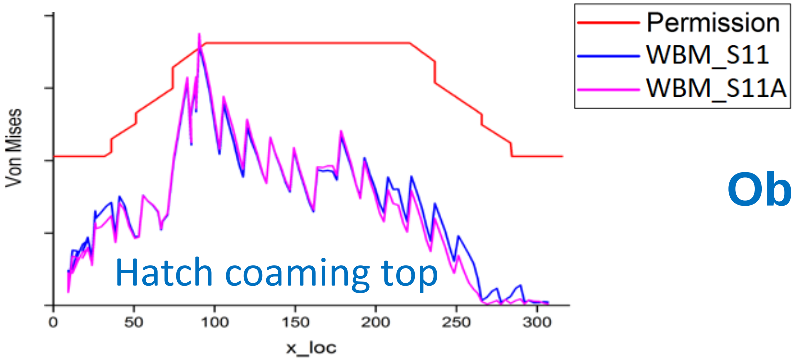
Head sea



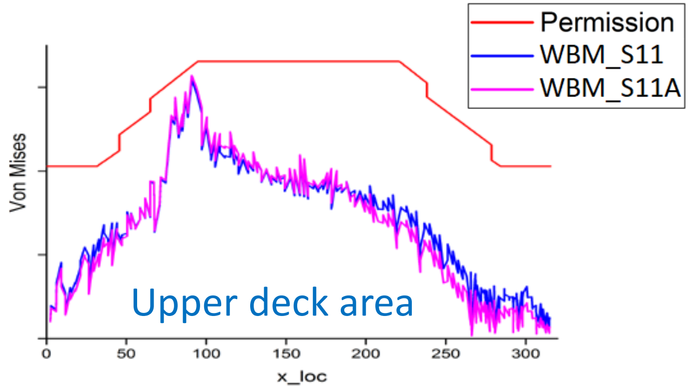
Head sea



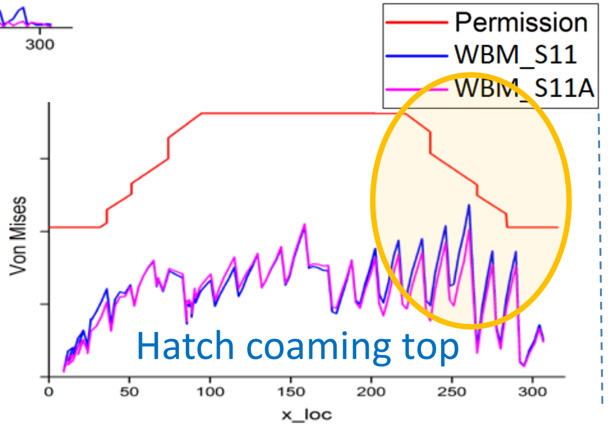
Oblique sea 1



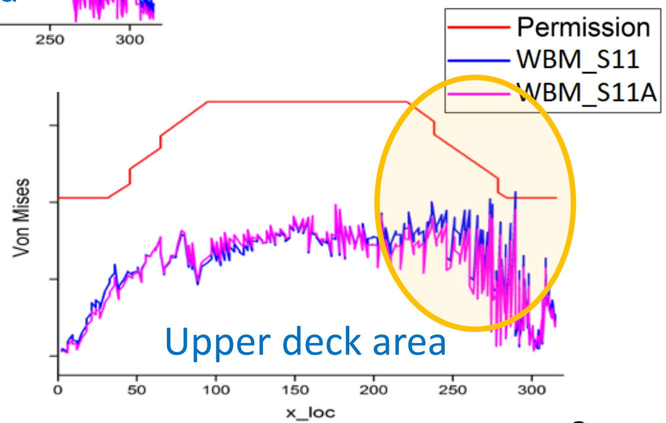
Oblique sea 1



Oblique sea 2

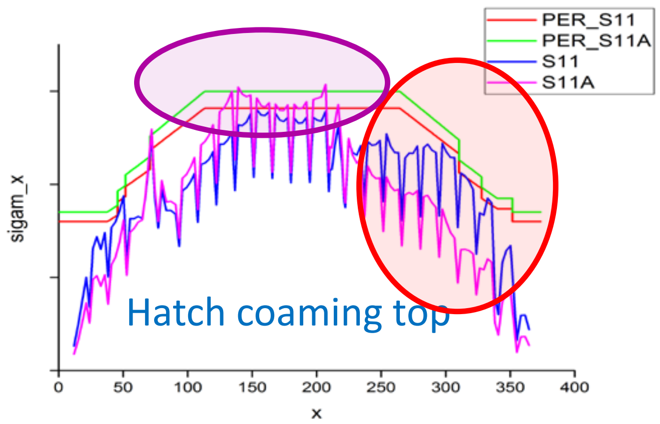


Oblique sea 2

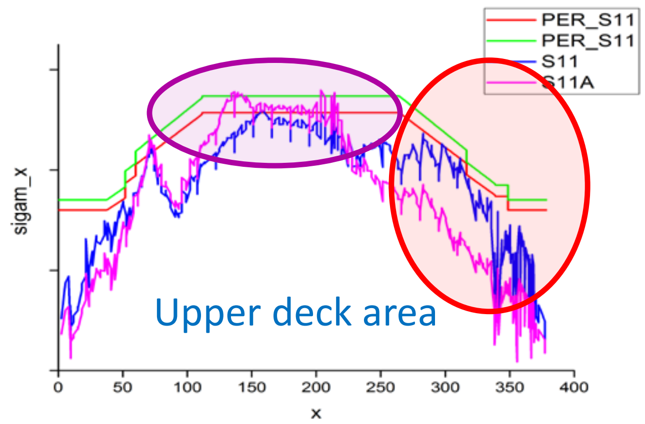


Impact of UR S11A and S34 on the scantlings by FE analysis

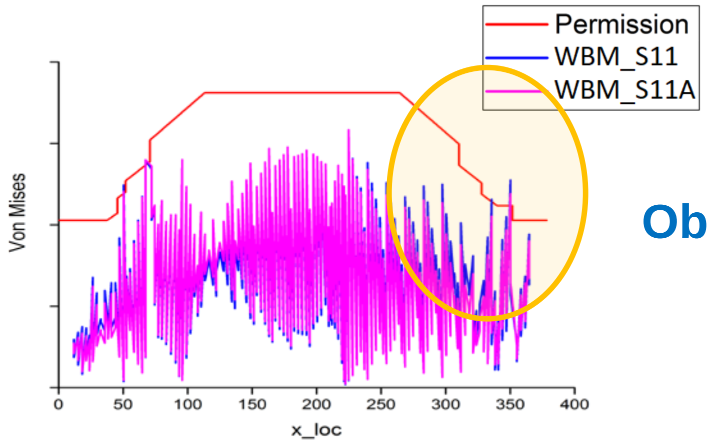
- 18000TEU CV
  (BV Rule)



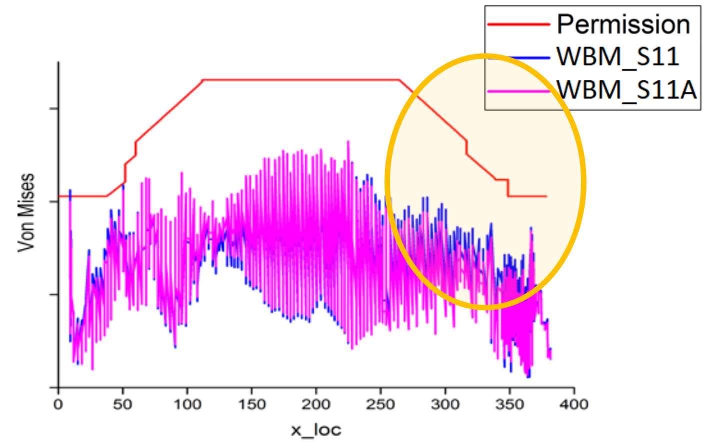
Head sea



Head sea



Oblique sea



Oblique sea

- For midship area, longitudinal stress in UR S11A is more than that in UR S11 for 10K_TEU CV and above.
- Although in fore part, longitudinal stress in UR S11A is much less than that in UR S11, but the Von Mises stress in oblique sea is almost the same considering the impact of UR S11 and S11A. That means **in fore part, scantlings may not be decreased unless by detail global FE analysis**.

Impact of UR S11A and S34 on the scantlings by FE analysis

- For cargo FE analysis (**UR S11A and S34 impact**),
  - **14500TEU CV**: **GL Notation** (GL 2014 Rule), has 'Empty Bay' case with no ballast in double bottom area, and draught to Tsc, required by Shipowner;
    - ✓ **UR S11A impact**: hull girder wave loads;
    - ✓ **UR S34 impact**: one bay empty FE load case, all tanks empty and draught to Tsc; (similar to the original case of 'Empty Bay')
    - ✓ **Other impact** due to New Rules (DNVGL Rules instead of GL Rules) for new load cases and new EDW in each load case, e.g. Beam sea case;
    - ✓ No oblique sea cases considered for cargo hold analysis in new DNVGL Rules.

No.	Rules	LC No.	Description	Container weight	Tank content	Draught	Dynamic load case
1	GL	LC1	Homogenous 40FT	On deck: 20t/FEU In hold: 20t/FEU	/	Tsc	Wave crest Vertical acceleration
	DNVGL	LC1	40ft Heavy	On deck: max 40ft stack weight In hold: 30.5t/FEU not exceeding max 40ft stack weight	All tanks empty	Tsc	HSM-2, HSA-2, FSM-2, BSR-1P, BSP-1P
2	GL	LC3	Light Loading 40FT	On deck: 16t/FEU In hold: 16t/FEU	/	Tsc	Wave crest Vertical acceleration
	DNVGL	LC2	40ft Light	On deck: 90% of max 40ft stack weight not exceeding 17t/FEU In hold: 55% of max 40ft stack weight not exceeding 16.5/FEU	All tanks empty	Tsc	HSM-2, HSA-2, FSM-2, BSR-1P, BSP-1P
3	GL	LC4	Light Loading 20ft	On deck: 16t/FEU In hold: 8t/TEU May be replace by the load case 'Empty Bay'.	/	Tsc	Wave crest Vertical acceleration
	DNVGL	LC3a LC3b	One bay empty	On deck: max 40ft stack weight In hold: 30.5t/FEU not exceeding max 40ft stack weight	All tanks empty	Tsc	HSM-2, HSA-2, FSM-2
4	GL	/	/	/	/	/	/
	DNVGL	LC4	20ft Heavy	On deck: max 20ft stack weight if mixed stowage is applicable, max 20ft + 40ft stack weight In hold: 24t/TEU not exceeding max 20ft stack weight	All tanks empty	0.9Tsc	HSM-1, HSA-1, FSM-1, BSR-1P, BSP-1P
5	GL	LC2	Heavy Loading 20FT	On deck: 30t/FEU In hold: 15t/TEU	/	Tsc	Wave trough Vertical acceleration
	DNVGL	LC5	Heavy deck light hold	On deck: max 20ft stack weight if mixed stowage is applicable, max 20ft + 40ft stack weight In hold: 16t/FEU	All tanks empty	0.9Tsc	HSM-1, HSA-1, FSM-1, BSR-1P, BSP-1P
6	GL	LC5	Pitching	On deck: max 20ft stack weight not exceeding to 100t/stack In hold: 30t/FEU	/	Tsc	Wave trough Vertical/Longitudinal acceleration
	DNVGL	LC6	Pitching	On deck: max 20ft stack weight if mixed stowage is applicable, max 20ft + 40ft stack weight In hold: 30.5t/FEU not exceeding max 40ft stack weight	All fuel oil tank full; All ballast tanks full	Tsc	HSM-1, HSA-1, FSM-1, BSR-1P, BSP-1P
7	GL	LC6	Flooded Condition	On deck: 28t/FEU In hold: centre: flooded; adjacent: 28t/FEU	/	T_{dam} + 1m	Static only
	DNVGL	LC7	Flooded damage	On deck: max 40ft stack weight In hold: centre: flooded; adjacent: 20t/FEU	All ballast tanks full at inclined side	T_{dam}	Static only

Impact of UR S11A and S34 on the scantlings by FE analysis

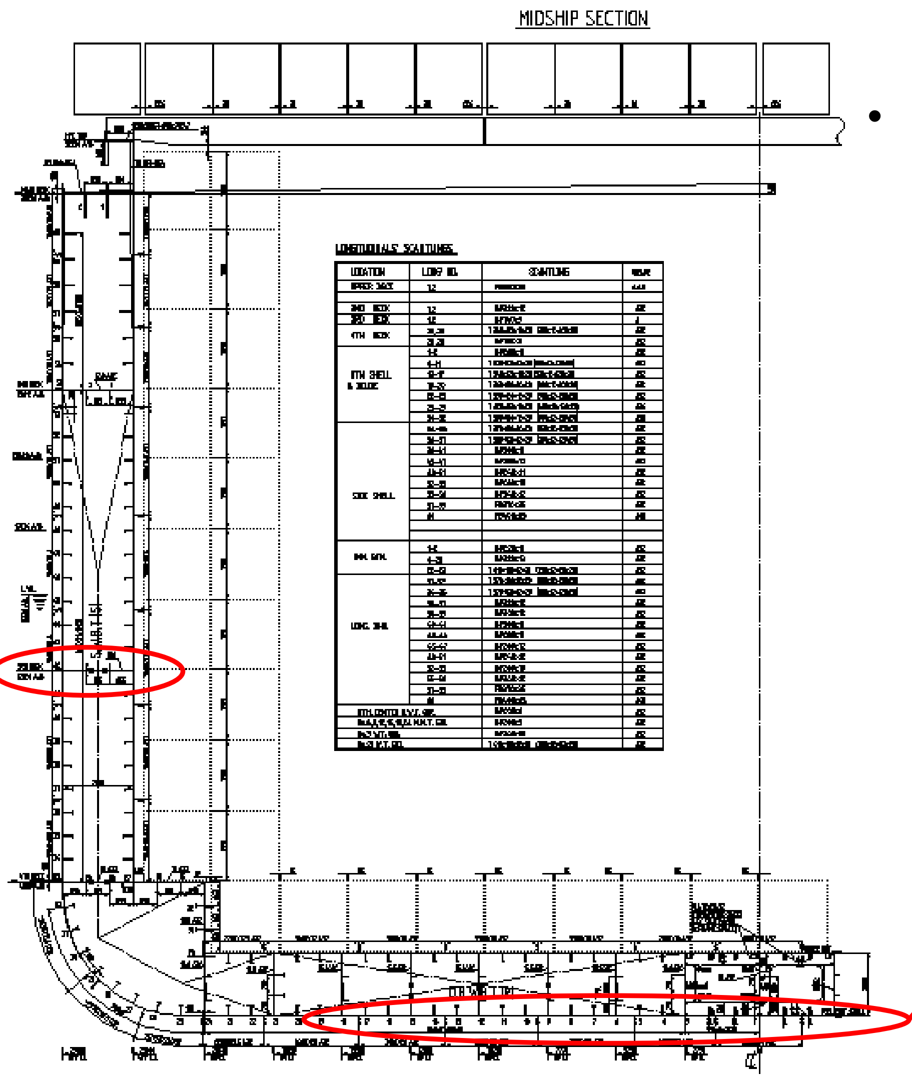
Results from cargo hold analysis for 14500TEU CV:

DK3

+0.5mm and Mild—>HT32

partially + 2mm near trans. WT BHD

due to yielding (dominated by LC1 **BSP-1P**)



- Several local buckling stiffeners are also added for other PSMs.
- As a conclusion, the reinforcement induced by new DNVGL Rule including URS34 and UR S11A in cargo hold FE analysis is **very limited** and **can be neglected** for the 14500TEU CV, because one bay empty condition has already been considered previously.

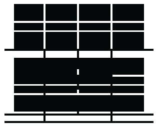
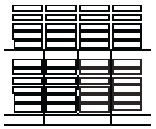
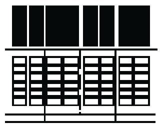
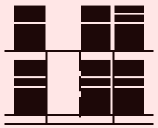
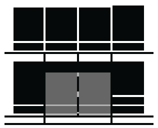
Bottom shell

Only few **buckling stiffeners** added near Supp. BHD due to buckling (dominated by one bay empty case of LC3)

Source: Research report from Hudong-zhonghua Shipyard

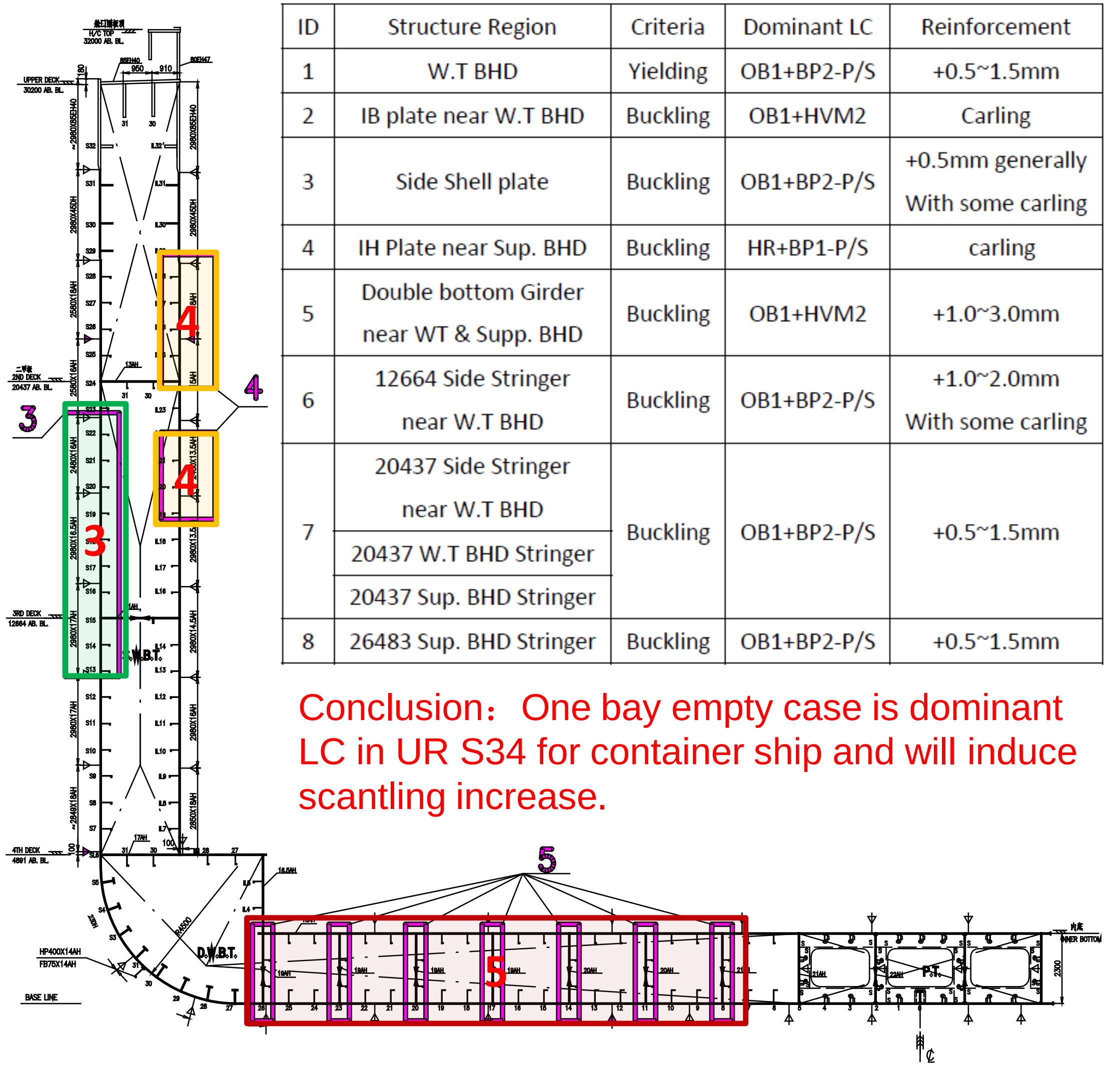
Impact of UR S11A and S34 on the scantlings by FE analysis

- For cargo FE analysis (**UR S11A and S34 impact**),
  - **18000TEU CV**: **BV Notation**, has one bay empty case but with ballast tank full, and draught not up to Tsc;
    - ✓ **UR S11A impact**: hull girder wave loads;
    - ✓ **UR S34 impact**: one bay empty FE load case, all tanks empty and draught to Tsc;
    - ✓ **Other impact** due to New BV Structural Rules for container ships (**NR625** instead of NI 532):
      - New EDW, especially **oblique EDW**;
      - Clear requirement for one bay empty case with all tanks empty and draught to Tsc;

Loading condition	Description	Loading pattern	Container loading (1)	Draught	SWBM	SWSF
BL-1	Ballast		Not loaded	T_{BAL}	from LM	Q_{sw}
HH	Homogeneous (heavy)		Heavy cargo 40'	T_{SC}	$M_{sw\text{-}max}$	Q_{sw}
HL	Homogeneous (light)		Light cargo 40'	T_{SC}	$M_{sw\text{-}max}$	Q_{sw}
HR	Homogeneous (reduced draught)		Heavy cargo 20'	$\leq 0{,}9 T_{SC}$	$M_{sw\text{-}min}$	Q_{sw}
DL	Maximum deck load		Heavy cargo 20' on deck Light cargo 20' in hold	$0{,}9\ T_{SC}$	$M_{sw\text{-}min}$ (2)	Q_{sw}
OB-1	One bay empty		Heavy cargo 40' One bay empty in hold and on deck (3)	T_{SC}	$M_{sw\text{-}max}$	Q_{sw}
FD	Flooding		Heavy cargo 40' Any cargo hold flooded	T_F	–	–

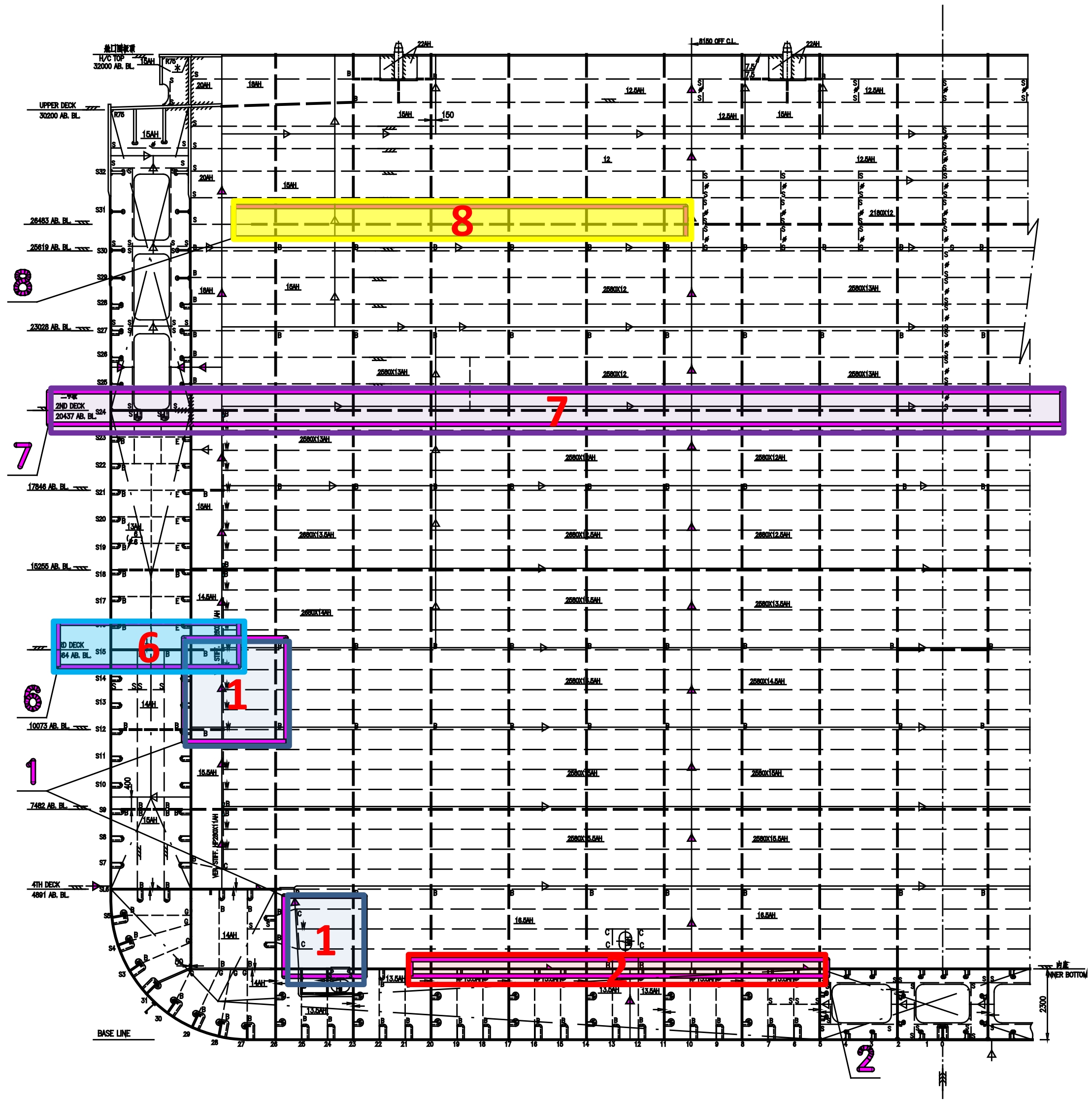
Impact of UR S11A and S34 on the scantlings by FE analysis

Results from cargo hold analysis for 18000TEU CV:



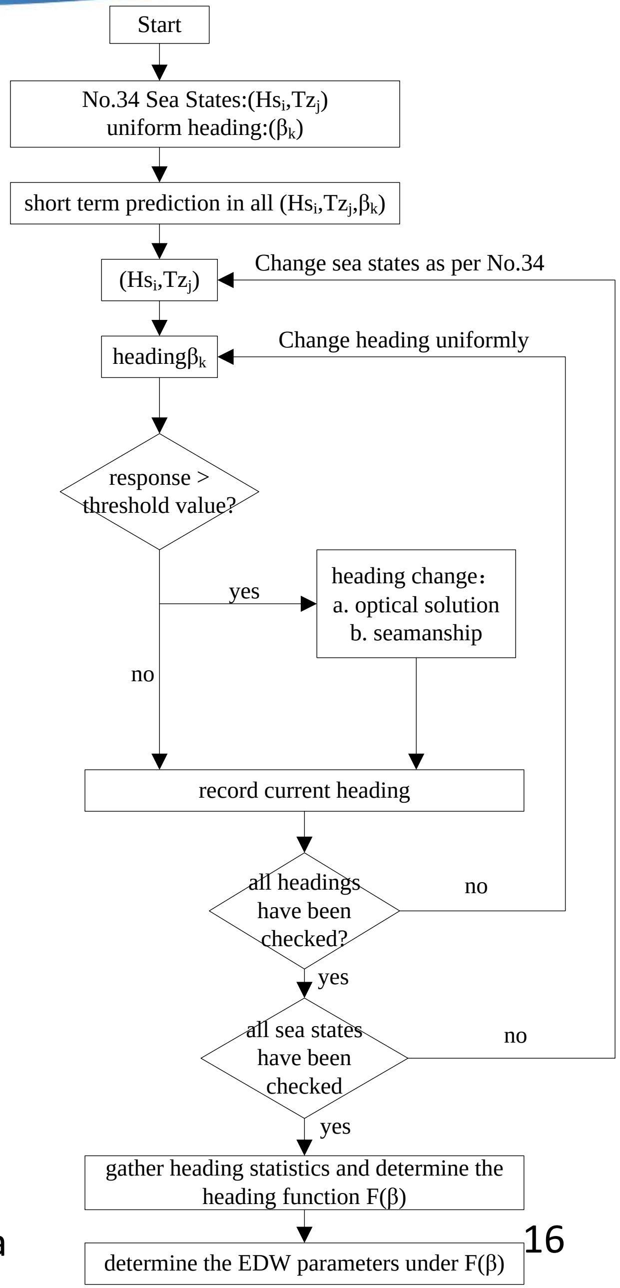
ID	Structure Region	Criteria	Dominant LC	Reinforcement
1	W.T BHD	Yielding	OB1+BP2-P/S	+0.5~1.5mm
2	IB plate near W.T BHD	Buckling	OB1+HVM2	Carling
3	Side Shell plate	Buckling	OB1+BP2-P/S	+0.5mm generally With some carling
4	IH Plate near Sup. BHD	Buckling	HR+BP1-P/S	carling
5	Double bottom Girder near WT & Supp. BHD	Buckling	OB1+HVM2	+1.0~3.0mm
6	12664 Side Stringer near W.T BHD	Buckling	OB1+BP2-P/S	+1.0~2.0mm With some carling
7	20437 Side Stringer near W.T BHD 20437 W.T BHD Stringer 20437 Sup. BHD Stringer	Buckling	OB1+BP2-P/S	+0.5~1.5mm
8	26483 Sup. BHD Stringer	Buckling	OB1+BP2-P/S	+0.5~1.5mm

Conclusion：One bay empty case is dominant LC in UR S34 for container ship and will induce scantling increase.



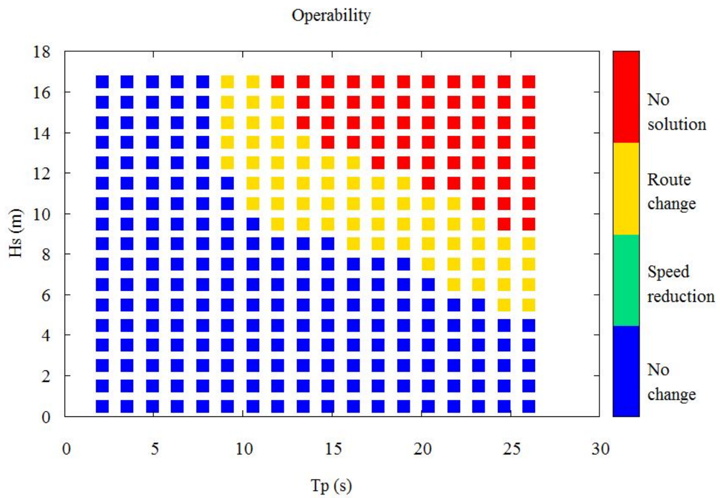
Heading effect for the wave loads of container ships

- *Background*:
  - Equal heading probability is the assumption of EDW for extreme wave loads in UR S11A and other Class Rules. But IMO GBS auditors objected to such concept in new CSR and issued the Non-conformity No.: IACS/2015/FR1-8/NC/01.
  - IACS made a study to demonstrate the impact on extreme wave loads of OTs & BCs does not exceed 5% with non-uniform heading distribution.
  - How about the impact on wave loads for container?
- *Procedure to determine the heading effect*:
  - Short-term predictions in all sea states and all headings, initially with uniform heading distribution.
  - Compare the motion response in every sea state and every heading with threshold value. If the response is less than threshold value, heading retains; otherwise, heading changes.
  - Two methods to change heading: optimal solution or seamanship.
  - Determine the EDW parameters by statistics.

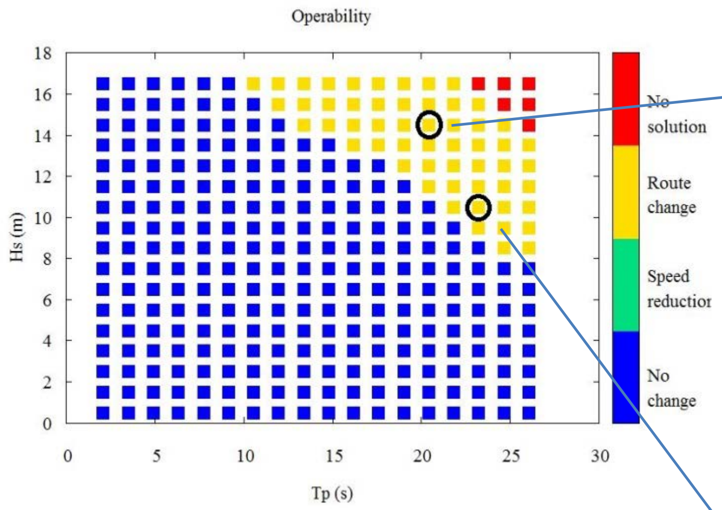


Heading effect for the wave loads of container ships

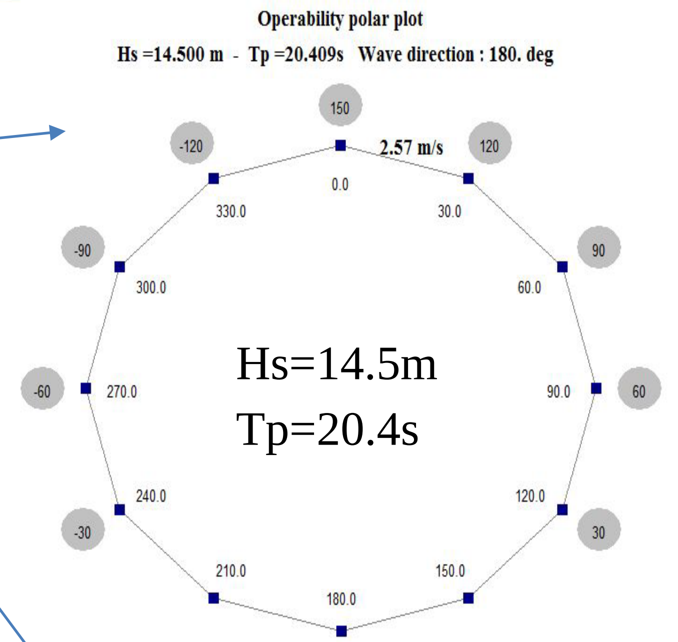
Heading change: $\theta_{roll} > \theta_{criterion}$

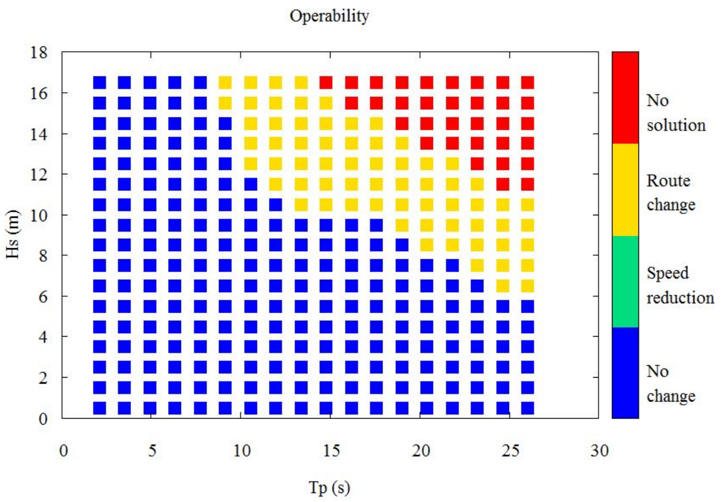


$\theta_{criterion} = 1.25$



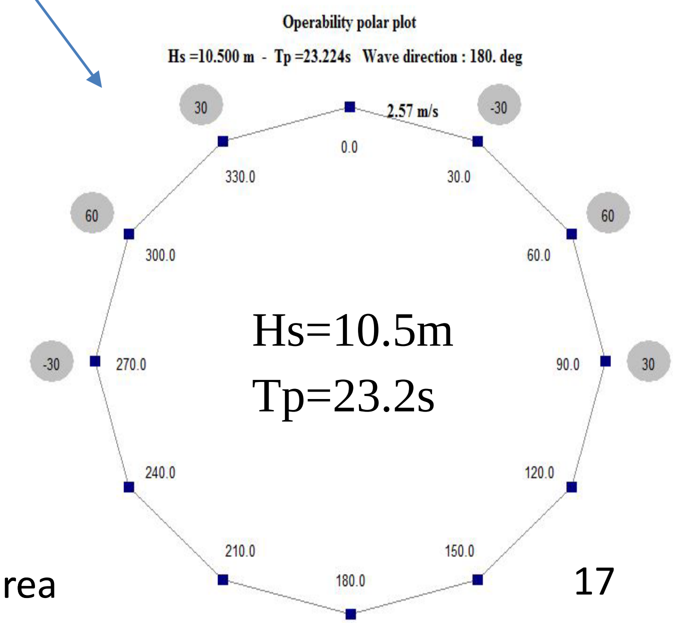
$\theta_{criterion} = 2.0$





$\theta_{criterion} = 1.5$

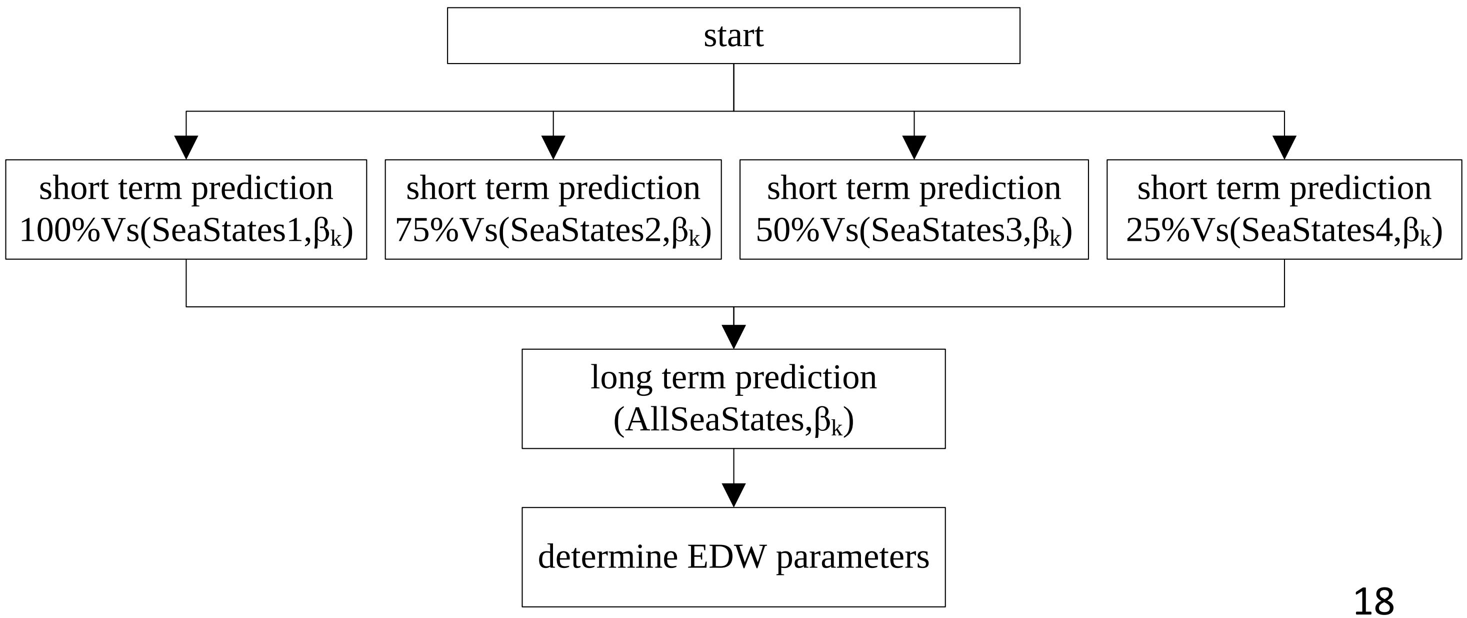
- ***Preliminary results for one typical container ship***:
  - For a 180K TEU container ship, it is found the heading effect for extreme wave loads could be neglected.



Speed effect for the wave loads of container ships

- *Background*:
  - 5 knots speed is the assumption of EDW for extreme wave loads in UR S11A and other Class Rules for container ships to maintain maneuvering and other operations.
  - But shipbuilders concerns were that 5 knots speed for CVs at rough sea seems rather risky due to the much slender hull form and the much bigger propulsion power of CVs.
  - How about the impact on EDW for container ships considering the speed effect?
- *Procedure to determine the speed effect:*
  - Set criteria for different speed with different range of Hs based on IACS Rec.34.
  - Carry out wave loads calculation considering the speed setting criteria.
  - Determine the speed effect for extreme wave loads.
- *Preliminary results for one typical container ship:*
  - For a 180K TEU container ship, it is found the speed effect for extreme wave loads could be up to **18%**.

$$V = \begin{cases} 100\%Vs & when\ 0m < Hs < 6.0m \\ 75\%Vs & when\ 6.0m < Hs < 9.0m \\ 50\%Vs & when\ 9.0m < Hs < 12.0m \\ 25\%Vs & when\ 12.0m \end{cases}$$



Joint effects of non-uniform headings and variant speed

Proceedings of the Twenty-seventh (2017) International Ocean and Polar Engineering Conference www.isope.org
San Francisco, CA, USA, June 25-30, 2017

ISBN 978-1-880653-97-5; ISSN 1098-6189

Effects of Non-uniform Heading Distribution and Variant Speeds on EDW

Yachong Liu, Jiameng Wu, Wenbo Zhu
Basic Research Department, Marine Design and Research Institute of China
Shanghai, China

- Preliminary conclusion:

  The non-uniform wave heading distribution for container ships may has little effect on long-term values, whereas the effects brought by variant speed (speed reduction in dependence of the actual wave condition) cannot be ignored.

SRA for the calibration of PSF for ULS check of container ships

- In **TB of UR S11A**, it is said that: "*The partial safety factors should ideally be calibrated based on structural reliability analysis combining wave loading and strength with probability density functions for parameters related to significant variation and uncertainty. The objective would then be to find partial safety factors that together give an acceptable low probability of failure. This has been the basis for some of the factors used in CSR, and some of these factors have therefore been assumed to have been representative also for container vessels*".
- ***ASEF/TWG/SWG2*** had planned to carry out calibration of PSF for container ships by means of Structural Reliability Analysis (SRA). But eventually it was found to be a huge work for data collection, calculation, calibration and review. And due to the fact that IACS had no plan, it was found that SRA work was too difficult to carry out currently. But, it was encouraged for CANSI, KOSHIPA and SAJ to provide correspondent research findings.
- So far no feedback has been available.

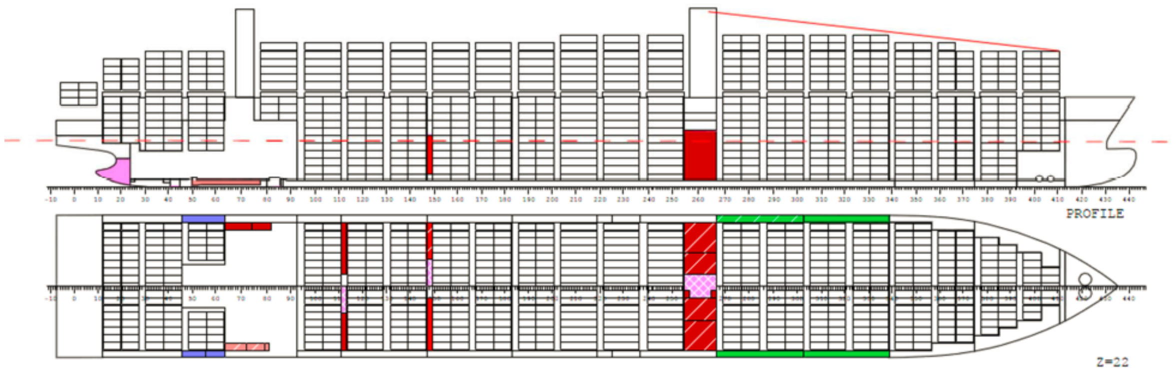
Modelling approach for containers in loading manual

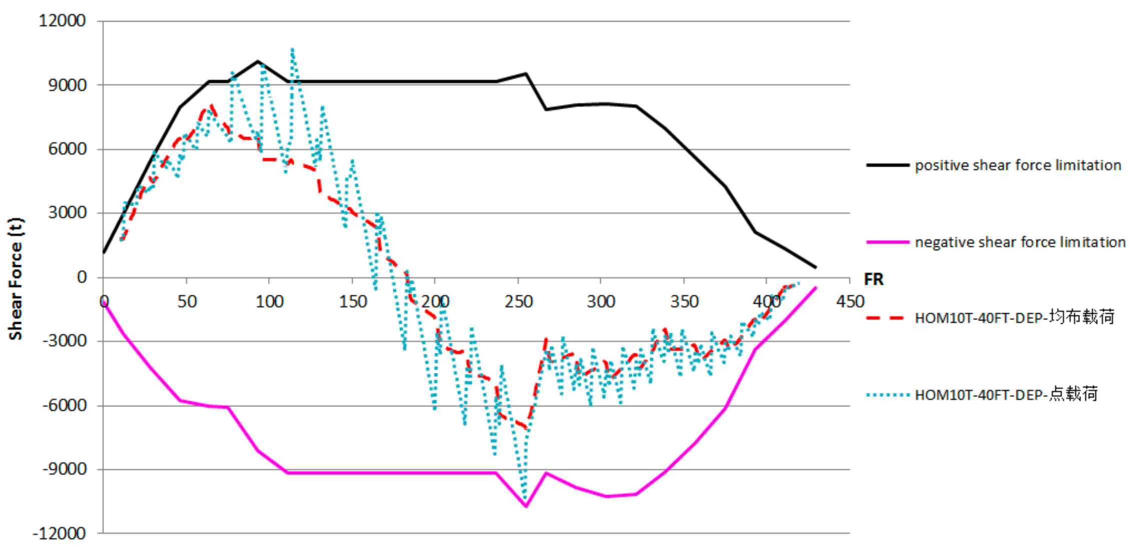
Accuracy for SWSF calculation in loading manual and loading computer

- The design SWSF is found to have margin normally and could be optimized to counteract or mitigate the adverse effect by the significant increase of wave shear force. But the hypothesis for optimization is the accuracy for SWSF calculation.
- The accuracy for SWSF calculation depends on:
  - The container weight is accurate.
  - The modeling of container in loading manual and/or loading computer is accurate.
- But unfortunately, the modeling approaches in loading manual and/or loading computer and in FE analysis are totally different.
- Normally, the weight of container is modeled as box or uniform loading in loading manual and/or loading computer.
- But the fact for real ship is: the weight of container in hold is directly transferred by container sockets, while **the weight of container on the hatch cover and the weight of hatch cover itself are transferred mostly by the transverse hatch coaming**. Both of such loads are concentrated loads, which will induce the sudden increase of shear force at the location with concentrated loads, same as the approach in global or cargo FE analysis.

Modelling approach for containers in loading manual

- For a 14500TEU container ship,
  - Comparison between two modelling approach for 40ft (20t) full loaded at Tsc, departure:
    - ✓ Container and hatch cover weight as uniform loads
    - ✓ Container and hatch cover weight as concentrated loads on fore and aft transverse BHD
  - It is found that:
    - ✓ **Big deviation** at the region of transverse BHD
    - ✓ For some area, shear force values induced by point load approach **exceed the envelop SWSF**
    - ✓ It is to be verified further in global FE analysis, where point load approach used.



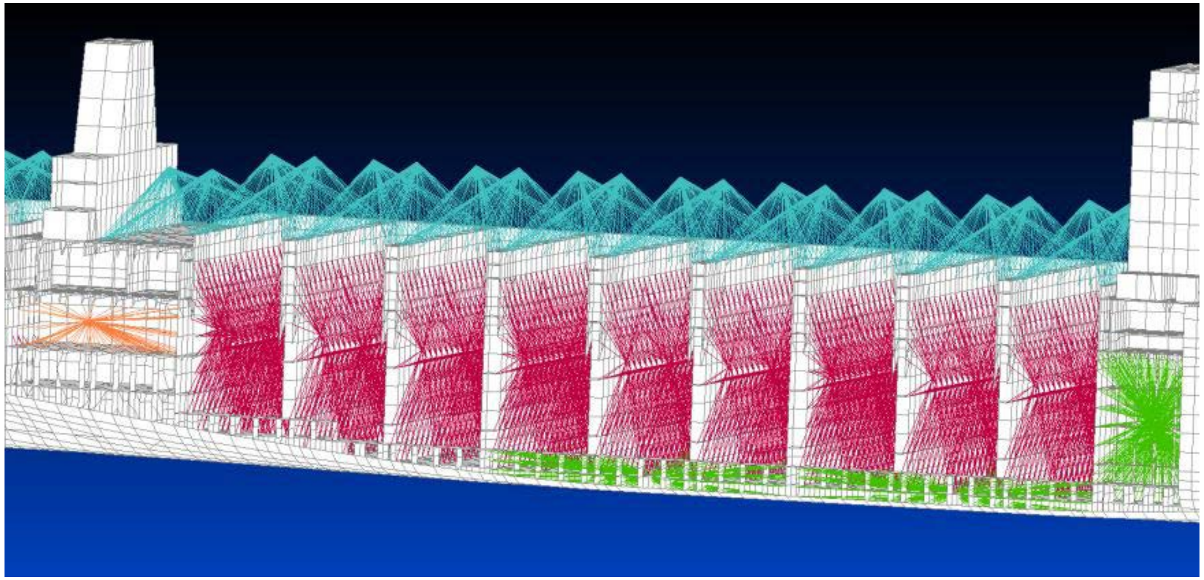


Source: Research report from Hudong-zhonghua Shipyard

How to model the container weight in global FEM?

- Normally, deadweight items (such as container stacks, hatch cover or liquids) are to be modeled as nodal masses linked to the model through additional elements designed in order to transfer loads without introducing artificial stiffness. Nodal masses are also to include the inertia properties of the items they represent.
- In FE analysis:
  - Containers in hold will be linked to nodes on trans. BHD in way of cell guides and nodes on inner bottom near container corner sockets (by MPC method in Patran).
  - Containers on hatch cover will be linked to nodes on hatch coaming (mostly on trans. hatch coaming) (by MPC method in Patran).
  - The weight of the hatch cover may be added to the weight of the containers on hatch cover.

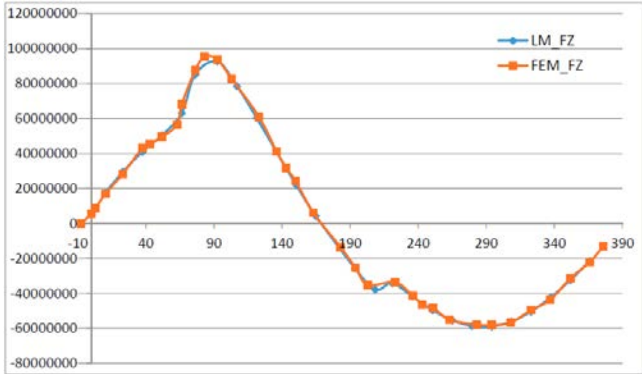
Such method is similar to point loads modeling approach!

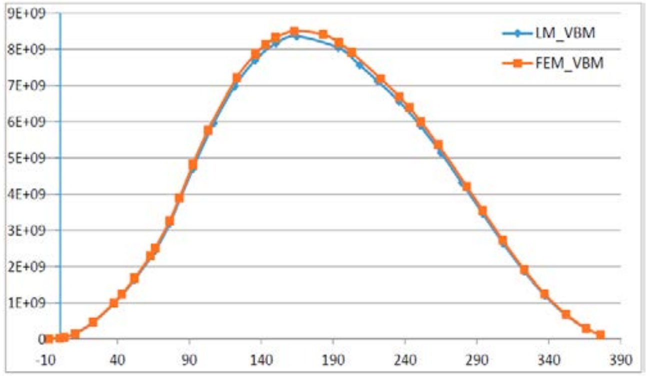


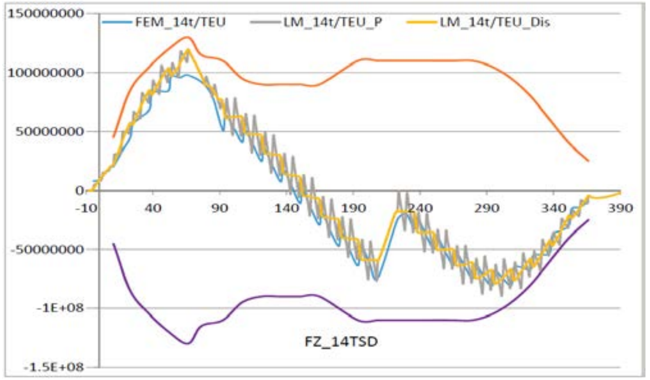
Source: BV Rules of **NR625**: Structural Rules of container ships

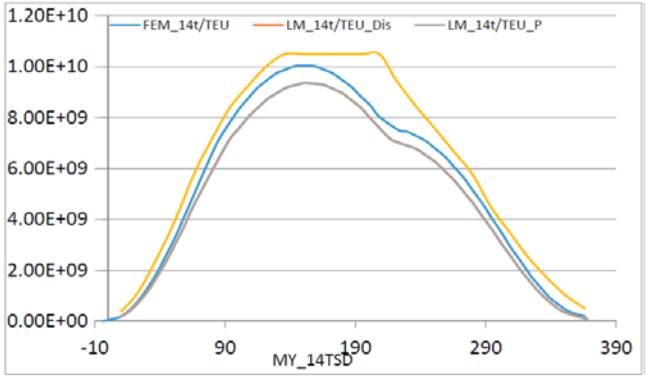
Modelling approach for containers in loading manual

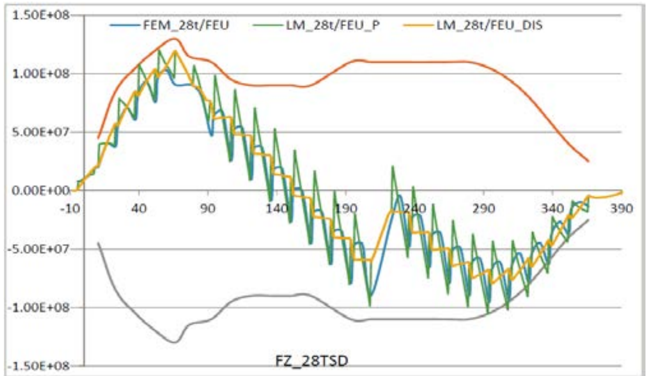
- For a 18000TEU CV,
  - Comparison of light weight in loading manual and global FE model
  - Comparison of a load condition with 20ft (14t) full loaded at Tsc in loading manual and global FE model
  - Comparison of a load condition with 40ft (28t) full loaded at Tsc in loading manual and global FE model

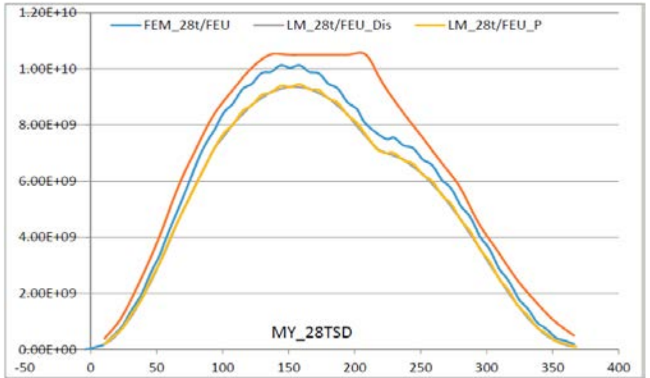






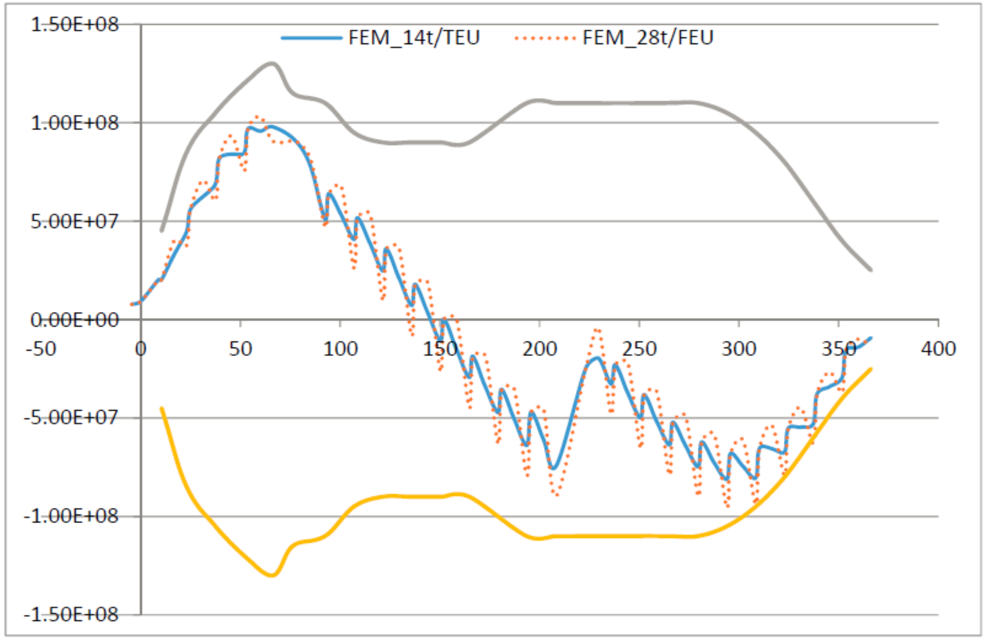


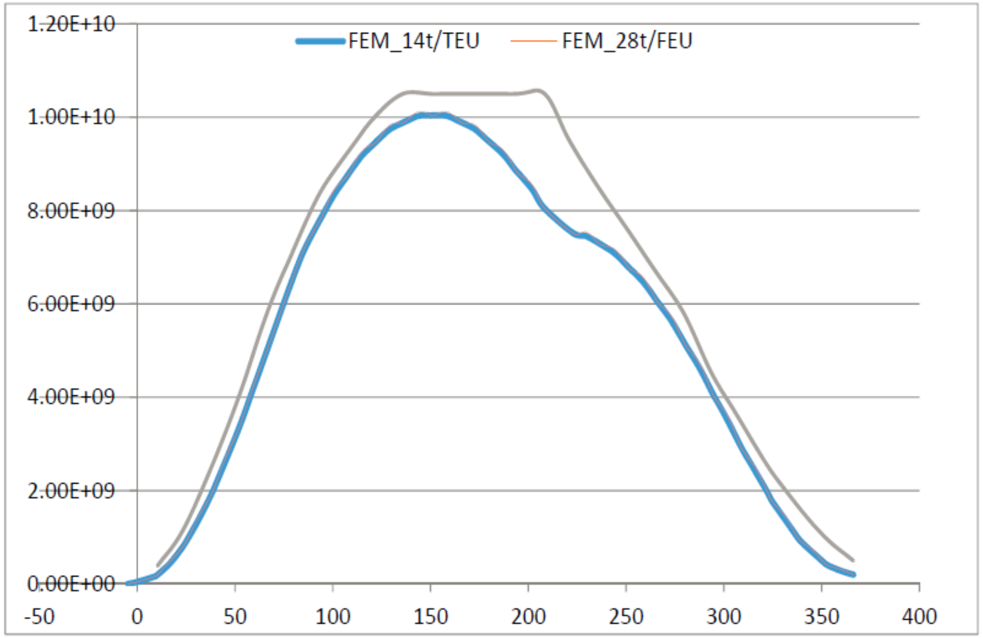




Modelling approach for containers in loading manual

- It is found that:
  - At the location of transverse BHD (W.T. or supporting BHD), the SWSF, by point load modeling approach, will have a sudden change, which is line with that by global FE.
  - Different modeling approach will only impact SWSF distribution but no effect on SWBM distribution.
  - SWSF when 40ft container loaded is more server than 2*20ft container loaded by point load modeling approach although the deadweight and SWBM is the same. (e.g. For 18000CV, approx. **30% increase of SWSF** due to the above issue.)
  - It is suggested to use point load modeling approach and consider 40ft container loading condition.





Possible further working plans for TWG/SWG2

- Exchange of information and views on whipping effect by IACS new UR after their finalized work (IACS PT PH38).

- Complete the impact analysis report on IACS UR S11A and S34, including the impact due to FE analysis.

- Complete the research on modeling approach for containers by point loads instead of current uniform loads.

Summary

- For whipping effect on **hull girder ultimate strength**, ***IACS*** has agreed to arrange an informal meeting between ASEF and IACS PT PH38 before they finalized their work.
- The main impact by **UR S11A** is buckling induced by increased wave shear force; while the main impact by **UR S34** is the one bay empty condition in cargo hold analysis.
- For EDW, the non-uniform wave bending distribution for container ships may has little effect on long-term values, whereas the effects brought by **variant speed** cannot be neglected.
- For SWSF calculation, container weight by **point load approach** is more reasonable and preferable due to its in line with the results by global FE. Also, **loading conditions of 40ft container (FEU)** are recommended to include in loading manual because such loading conditions will induce higher SWSF but no effect on SWBM.

Active Shipbuilding Experts' Federation

ASEF

Thank you for your attention.

ASEF/TWG/SWG2