Further impact on Bulker design by the current draft of CSR-H

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Current situation of Common Structural Rules

- Harmonized Common Structural Rules; **CSR-H**
  - Dec. 2013, CSR-H adopted by IACS Council
  - Jul.1 – Aug.15, Rule Change Proposal 1 (RCP1) for Industry and Technical committee (TC) review
  - Oct.1 – Nov.5, RCP1 revised version for TC review
  - Nov.6 – Mid Dec., Final work in IACS
  - Mid Dec., Adoption by IACS Council
  - Jan.1, 2015, Publication of Rule Change Notice (RCN)
  - Jul.1, 2015, Entry into force of RCN

Cape size bulk carrier Influenced by the Class Rules

- In case of 200,000 DWT type Bulk Carrier
  - In 2000, Hull structural weight ; 21,000 – 22,000 t (Class ; LR, NK, ABS)
  - Thereafter UR-S25, Double hull F.O.Tk, fore castle deck etc. applied
  - Since 2006, Common Structural Rules for Bulk Carrier (**CSR-BC**) applied
  - Hull structural weight increased by 10 – 15 %
  - It may depend on the original structural design (?)

Cape size bulk carrier Influenced by the Class Rules

- In case of 200,000 DWT type Bulk Carrier
  - In 2013 – 2014, verification of Harmonized common structural rules (**CSR-H**) for this type of bulk carriers
  - Software was provided by ClassNK
  - In general, impact on hull structural weight is bigger on bulk carrier than oil tanker
  - Hull structural weight increased by 4 – 5 %
  - This influence is bigger than expected by the shipbuilding industry.

Concern about the structural rules – forthcoming CSR-H

- Can heavier structures and more thickness lead to the robust bulk carriers ??
- Can the technical background explain the rationale for all requirements ??
- How can good balance between robustness and economic efficiency be achieved ??
- When can we end enhancement of the Structural Rules ??

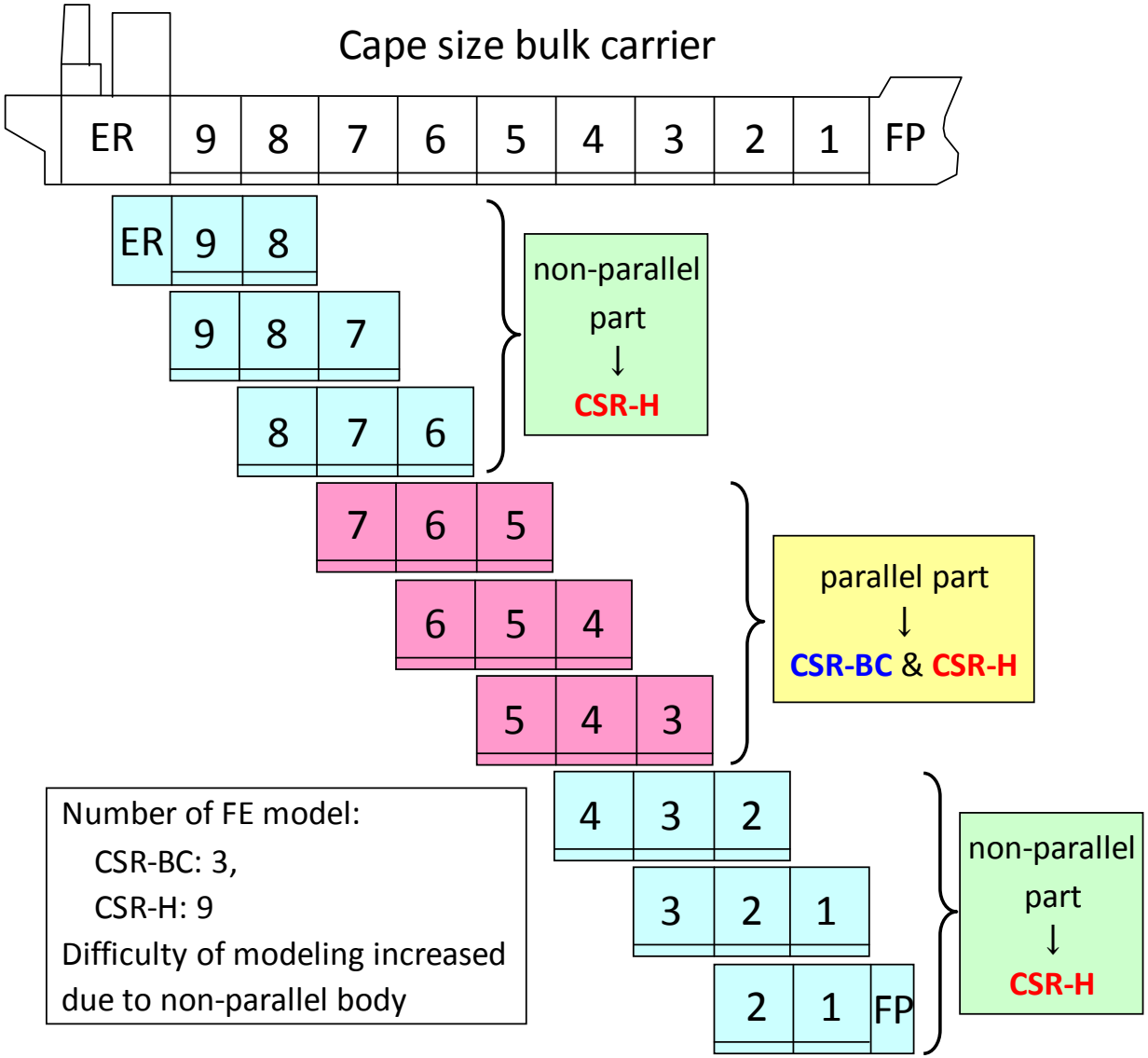
Impacts of CSR-H on bulk carrier -- Two different aspects --

- Impacts on design works
  - Huge number of FE analyses
  - Complicated structural design process
- Impacts on structural design and construction
  - Plate thickness requirement due to grab
  - Structural analyses for fore and aft cargo holds
  - More strict requirement for structural design principles in RCP1
  - Fatigue strength requirements

Huge number of FE analyses

- In case of Cape size bulk carrier with 9 holds
  - Three (3) FE models required by the current CSR-BC
  - Nine (9) FE models required by CSR-H
  - Increased loading cases for CSR-H
  - Some classification societies are ready to provide the special software for structural analyses
  - However it is time-consuming process to evaluate the analyses results and reflect the results to the structural design

Huge number of FE analyses



Complicated design process

- Mid part with parallel body
  - In general, midship section with longitudinal stiffener arrangement is decided at first
  - Then scantling calculation is carried out
  - FE analyses are also carried out for mid holds,
    i.e. No.6,5 and 4 holds in case of cape size bulker
  - This process may be same as that of current design with CSR-BC

Complicated design process

- Fore and Aft part outside of parallel body
  - At first, the initial structural arrangement should be given for longitudinal stiffeners and transverse web sections
  - For FE analyses of fore and aft part, it will take much time for making models because of complexity of hull structures
  - After many analyses final scantling can be decided but it will be at the later stage of design process
  - Is it possible to keep compatibility of FE models and design philosophy between mid and fore/aft ??

Plate thickness requirement due to grab

- Requirement
  - CSR-BC ; optional notation with grab weight of 20 t
  - CSR-H ; mandatory notation with grab weight of,

    20 t ; handymax

    30 t ; panamax

    35 t ; cape size
  - IACS relaxed the requirement by changing the plate thickness formula just before adoption by IACS council last year but it is still strict

Plate thickness requirement due to grab

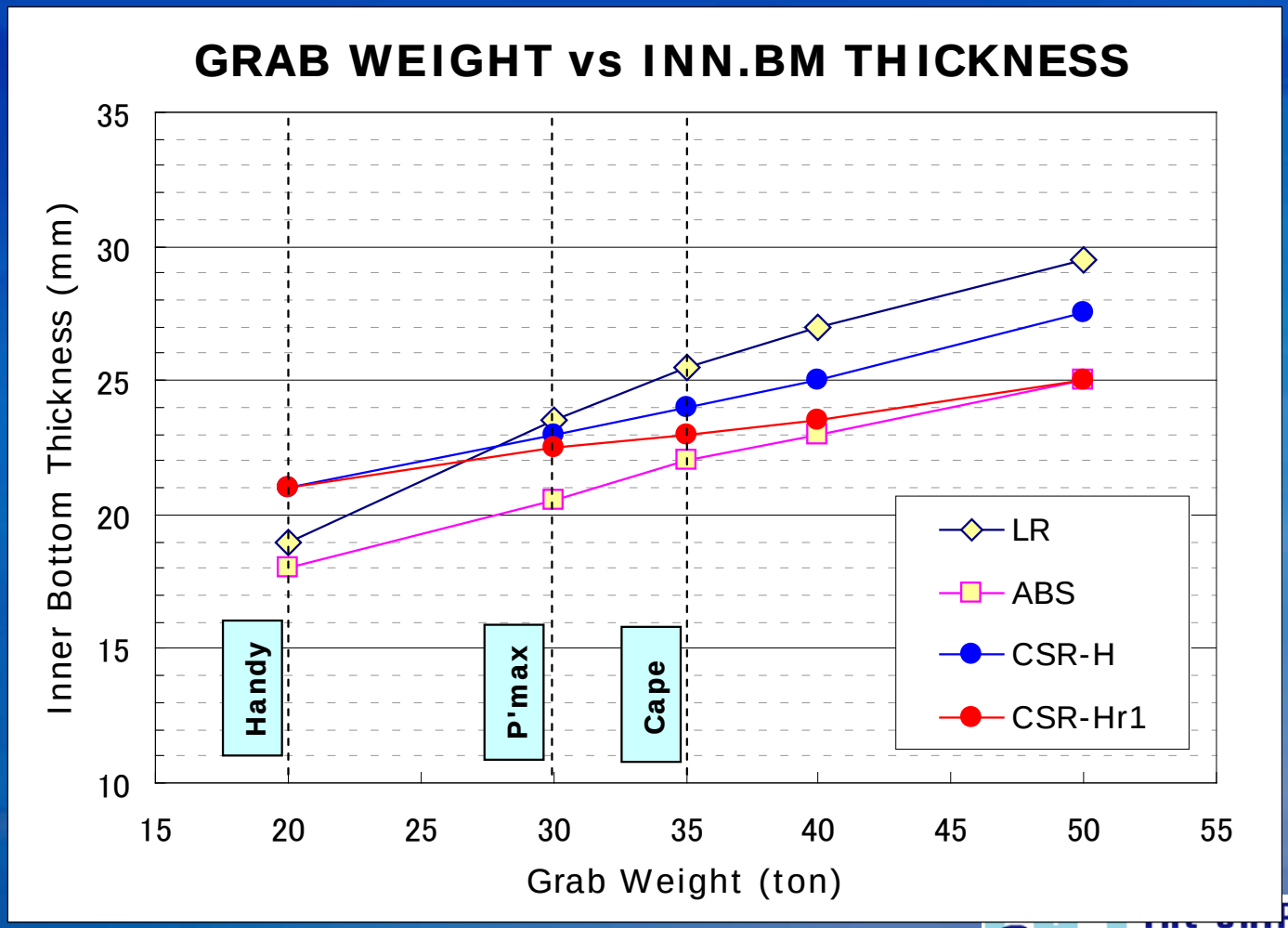
- Comparison between several requirements
  - Thickness of inner bottom plate will be decided by this simple formula in case of empty holds
  - There are not the rational technical background of this formula so far
  - The reasonability of this simple formula should be further researched and described in the technical background by IACS

$$t_{GR} = 0.62\sqrt{bk}\left(\frac{M_{GR}}{20}\right)^{0.25}$$

adapted from "Common Structural Rules for Bulk Carrier and Oil Tanker" (1Jan, 2014)

Plate thickness requirement due to grab

- Comparison between several requirements



Structural analysis for fore and aft cargo holds

- Big challenge to keep consistency with mid part
  - Loading conditions
  - Boundary conditions
  - Adjustment of hull girder shear force and bending moment
- Results of assessments
  - Consequence assessment by IACS shows severe results for buckling strength of outer shell in fore and aft part
  - The influence may differ for each vessel according to the original design

Structural analysis for fore and aft cargo holds

Table 13: Bulk Carriers – Overview of impact analyses for foremost and aftmost cargo hold finite element analyses

Bulk Carriers		Aftmost cargo hold		Foremost cargo hold	
		Yielding assessment	Buckling assessment	Yielding assessment	Buckling assessment
Capesize	BC1	Some increase is seen	Significant increase is seen	No results	
	BC2	Modest increase is seen	Significant increase is seen	No results	
	BC3	Modest increase is seen	Significant increase is seen	Modest increase is seen	Significant increase is seen
BabyCape	BC4	No increase is seen	Significant increase is seen	No increase is seen	Modest increase is seen
	BC5	Modest increase is seen	Significant increase is seen	Modest increase is seen	Modest increase is seen
Panamax	BC6	No increase is seen	Significant increase is seen	No increase is seen	Significant increase is seen
Handymax	BC8	No increase is seen	Significant increase is seen	No results	
	BC10	Modest impact is seen	Significant increase is seen	Modest impact is seen	Significant increase is seen

adapted from "Consequence Assessment (CA) – Summary Report" (1Jun, 2014)

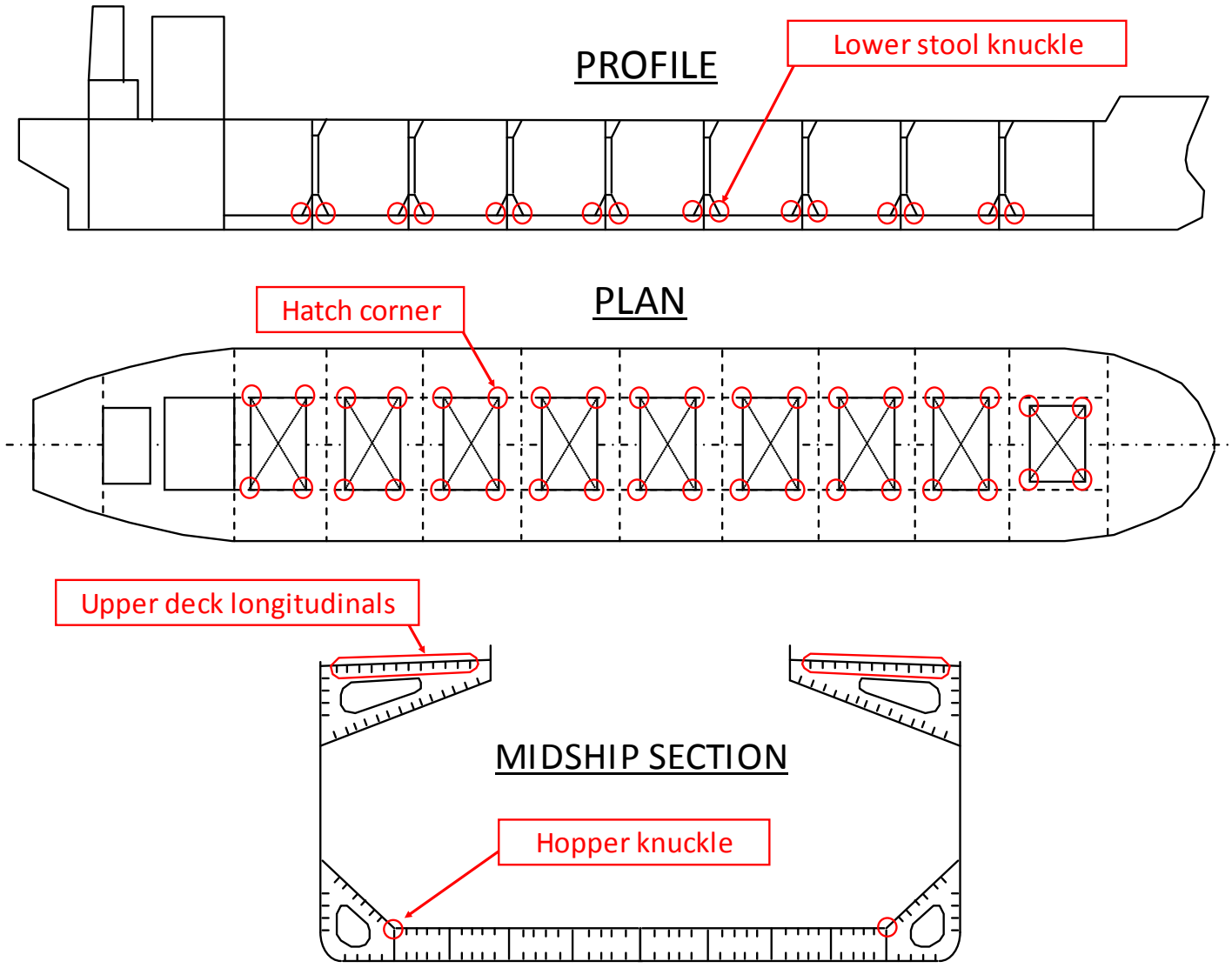
Structural design principles

- Sudden rule change in RCP1 of CSR-H
  - Deletion of the phrase of “ in general “
  - IACS accepted the strong request from shipping industry
  - Shipping industry has been showing objection to the vague expression
  - The shipbuilders’ association of Japan has expressed objections to RCP1 for several items
  - The reasons of objection are to keep flexibility of current design and possibility of new design

Fatigue strength requirements

- Big problems on bulk carrier design
  - Hatch corner
  - Hopper knuckle and lower stool knuckle
  - Upper deck longitudinal stiffeners

Fatigue strength requirements



Fatigue strength requirements

- Results of fatigue analyses with CSR-BC and CSR-H
  - Fatigue life of " XX years " gives big impact on ship designer and ship owner
  - According to the results of Consequence Assessment by IACS, for hopper knuckle and lower stool knuckle, fatigue life is increased in some vessels and vice versa
- Discrepancy between CSR-BC and CSR-H
  - These results show that fatigue life of existing vessels is less than 25 years in some cases
  - Which results should shipowners and shipbuilders believe ??

Fatigue strength requirements

- Fatigue life of upper deck longitudinal stiffeners
  - By our verification for cape size bulker, it is found that fatigue life of upper deck longitudinal stiffeners is less than 20 years by the application of CSR-H
  - When this vessel was designed with CSR-BC, fatigue life of more than 25 years was ensured
  - There are some reasons for these results
    - Correction factor due to warping effect; f_{warp}
    - Stress concentration factor changed from CSR-BC
    - Strict requirement for flat bar type longitudinals

Fatigue strength requirements

- Fatigue life of upper deck longitudinal stiffeners
  - Hull girder bending stress directly affects the fatigue damage of upper deck longitudinals
  - To extend the fatigue life, hull girder section modulus should be increased, i.e. upper deck plate thickness should be increased
  - To satisfy the requirement of CSR-H, thickness of upper deck should be increased by 15 – 30 mm
  - Therefore its thickness will be more than 50 mm
  - It may well be beyond the capacity of the shipyard's facility

Next age after entry into force of CSR-H

- Review of introductory concerns
  - Can heavier structures and more thickness lead to the robust bulk carriers ??

    → It is necessary not only to increase plate thickness but also to upgrade the quality of construction

  - Can the technical background explain the rationale for all requirements ??

    → Further investigation by IACS is expected for some items

Next age after entry into force of CSR-H

- Review of introductory concerns
  - How can good balance between robustness and economic efficiency be achieved ??

    → Shipbuilders should manage to find the optimized design by themselves

  - When can we end enhancement of the Structural Rules ??

    → No one knows, but before the Rules are further enhanced, the effects and results of the current rules are to be deeply reviewed by IACS including trouble records

Next age after entry into force of CSR-H; Conclusion

- Generally speaking, CSR-H will lead to the enhancement for bulk carrier design, and in this respect, though the toughness needs to be challenged, shipbuilders should welcome this development

- IACS is expected to solve the unsolved problems, such as fatigue strength requirement for bulk carrier

- IACS is also expected to share the trouble and casualty information of the currently operated vessels to the industries for the verification of reasonability of the structural rules

Next age after entry into force of CSR-H; Conclusion

- Shipbuilders should adequately prepare the company structures and design tools for CSR-H considering the heavy workload

- In connection with the above, IACS is also requested to prepare the efficient software tools by themselves for the effective and rapid approval work, because CSR-H will also give impacts on the workload of the Classification Society itself

Thank you for your attention