Common Structural Rules for Bulk Carriers, January 2006

Background Document

CHAPTER 5 – HULL GIRDER STRENGTH

NOTE:

- This TB is published to improve the transparency of CSRs and increase the understanding of CSRs in the industry.
- The content of the TB is not to be considered as requirements.
- This TB cannot be used to avoid any requirements in CSRs, and in cases where this TB deviates from the Rules, the Rules have precedence.
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IACS

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1.1.1

1.1.1.a Since regulations related to design loads were basically specified in Chapter 4 in CSR, regulations related to strength assessment were specified in Chapter 5, referring to the regulations of hull girder loads of Section 3, Chapter 4.

1.2 Hull girder transverse sections

1.2.1 General

1.2.1.a Since CSR is based on the net scantling approach, assessment of hull transverse section characteristics, stress assessment and so on, were required to be performed taking scantlings equal to the offered scantling minus $0.5t_c$. See the technical background of Chapter 3 Section 2.

1.2.2 Continuous trunks and continuous longitudinal hatch coamings

1.2.2.a This regulation is based on 2.1.2 of Sec. 1, Chapter 6, Part B of BV Rules in accordance with IACS UR S5.

1.2.3 Longitudinal ordinary stiffeners or girders welded above the strength deck

1.2.3.a This regulation is based on 2.1.3 of Sec. 1, Chapter 6, Part B of BV Rules in accordance with IACS UR S5.

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1.2.4.a This regulation is based on 2.1.4 of Sec. 1, Chapter 6, Part B of BV Rules in accordance with IACS UR S5.

1.2.5 Longitudinal bulkheads with vertical corrugations

1.2.5.a This regulation is based on 2.1.5 of Sec. 1, Chapter 6, Part B of BV Rules in accordance with IACS UR S5.

1.2.6 Members in materials other than steel

1.2.6.a The setting of longitudinal strength member of material other than steel of Young's Modulus 2.06×10^5 N/mm^2 was based on 2.1.6, Sec. 1, Chapter 6, Part B of the BV Rules.

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1.2.7.a This regulation is based on 2.1.7 of Sec. 1, Chapter 6, Part B of BV Rules in accordance with IACS UR S5.

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1.2.8.a This regulation is based on 2.1.8 of Sec. 1, Chapter 6, Part B of BV Rules in accordance with IACS UR S5.

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1.2.9.a This regulation is based on 2.1.9 of Sec. 1, Chapter 6, Part B of BV Rules in accordance with IACS UR S5.

1.3 Strength deck

1.3.1

1.3.1.a This regulation is based on 2.2.1 of Sec. 1, Chapter 6, Part B of the BV Rules. The treatment of 0.15L in relation to the application is consistent with the usage category of the steel.

1.3.2

1.3.2.a This regulation is based on 2.2.2 of Sec. 1, Chapter 6, Part B of the BV Rules. The treatment of 0.15L in relation to the application is consistent with the usage category of the steel.

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1.4.1

1.4.1.a This regulation is based on 2.3.1 of Sec. 1, Chapter 6, Part B of BV Rules.

1.4.2

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1.5.1

1.5.1.a This regulation is based on 2.4.1 of Sec. 1, Chapter 6, Part B of BV Rules.

1.6 First moment

1.6.1

1.6.1.a This regulation is based on 2.5.1 of Sec. 1, Chapter 6, Part B of BV Rules.

2. HULL GIRDER STRESSES

2.1 Normal stress

2.1.1 General

2.1.1.a Normal stress when a material other than steel is used is to be calculated by simplified formula using the ratio of Young's modulus. This regulation is based on 2.1.2 of Sec. 2, Chapter 6, Part B of BV Rules

2.1.2 Normal stresses induced by vertical bending moments

2.1.2.a The calculation formula for normal stress arising from vertical bending moment in the intact condition (non-flooded condition) is shown, and it is the same as in the existing rules such as BV Rules 2.1.1, Chapter 6 Section 2.

2.1.3 Normal stresses in flooded conditions of BC-A ships and BC-B ships

2.1.3.a According to IACS UR S17, the requirement of longitudinal strength of hull girder in flooded condition is to be complied with in respect of the flooding of any cargo hold of bulk carriers with notation BC-A or BC-B. The calculation formula for normal stress due to vertical bending moment in flooded condition is given, and it is the same as in the existing rules.

2.2 Shear stress

2.2.1 General

2.2.1.a Shear stress is to be calculated by direct analysis in the CSR. Shear force correction is to be made considering a simplified calculation method according to this regulation.

2.2.2 Simplified calculation of shear stresses induced by vertical shear forces

2.2.2.a Distribution coefficient of shear force and this correction method are according to 2.4.1 of Sec. 2, Chapter 6, Part B of the BV Rules.

2.2.3 Shear stresses in the flooded conditions of BC-A or BC-B ships

2.2.3.a Regulation for correcting the shear stress is specified similar to the intact condition if the mass of flooded water is included in the mass of cargo.

3. CHECKING CRITERIA

3.1 Normal stresses

3.1.1

3.1.1.a IACS UR S11 takes the permissible stress in the 0.4L region amidships based on the gross scantling approach as 175 N/mm^2 (based on mild steel). In CSR which uses the net scantling approach, since the figure is 0.9 times the original section modulus, which becomes the renewal criterion of various classification societies for hull transverse section, the permissible stress in the gross scantling approach is divided by 0.9 to arrive at the value of 190 N/mm^2 as the permissible stress (17.5 kgf/mm^2 /0.9 x 9.81 = 190). The corrosion amount specified in Section 3, Chapter 3 is applicable to existing ships (5 types of ships namely VLCC, Aframax, Capesize BC, Panamax BC and Handymax BC). Fig. 5.1 shows the ratio of the section modulus of deck and bottom to the original section modulus for each type of ship. From this figure, since the section modulus is about 0.9 times the original section modulus for all ship types, evaluation with the net scantling approach using the permissible value is equivalent to the method used in the existing rules.

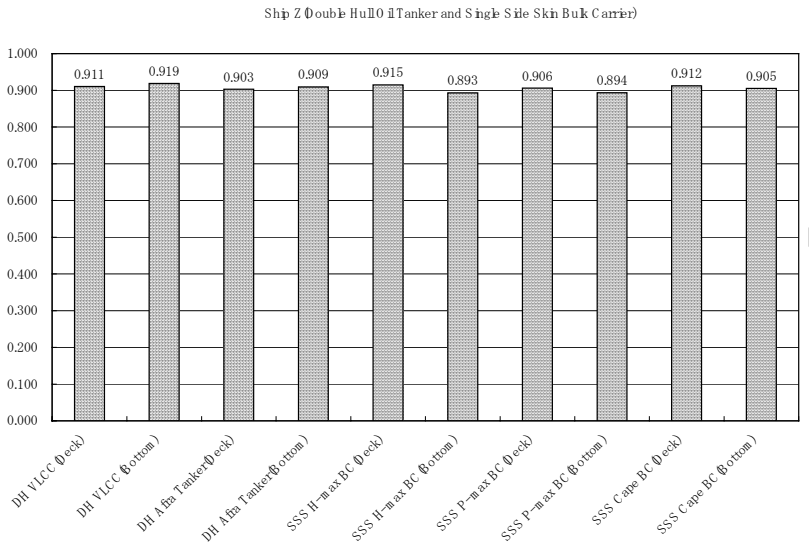

Fig. 5.1 Section modulus considering corrosion of BC and tankers

For ensuring continuity of longitudinal strength also in the region other than the 0.4L midship region, the permissible shear stress at locations in the 0.1L and 0.9L regions at the ends were taken as 130 N/mm².

3.1.1.b Generally, scantling of members contributing to the hull girder longitudinal strength may be gradually reduced, outside 0.4L amidships. In CSR, the gradual reduction of scantlings of structural members contributing to hull girder strength are unified by setting the allowable stress outside 0.4 L amidships.

3.2 Shear stresses

3.2.1

3.2.1.a Similar to stress due to vertical bending, the permissible shear stress by the net scantling approach was taken as 120 N/mm², which is equal to the permissible stress of 110 N/mm² according to existing rules divided by 0.9.

4. SECTION MODULUS AND MOMENT OF INERTIA

4.1 General

4.1.1

4.1.1.a This regulation is based on 4.1.1 of Sec. 2, Chapter 6, Part B of BV Rules.

4.1.2

4.1.2.a This regulation is based on 4.2.3 of Sec. 2, Chapter 6, Part B of BV Rules. See the background for Material factor k specified in 2.2.1 of Chapter 3 Section 1.

4.2 Section modulus within 0.4L amidships

4.2.1

4.2.1.a This regulation is based on the IACS UR S7 taking into account the coefficient 0.9 based on the net scantling approach.

4.2.2

4.2.2.a This regulation is based on the IACS UR S11 and UR S17.

4.2.3

4.2.3.a This regulation is based on 4.2.3 of Sec. 2, Chapter 6, Part B of BV Rules.

4.2.4

4.2.4.a This regulation is based on 4.2.4 of Sec. 2, Chapter 6, Part B of BV Rules.

4.3 Section modulus outside 0.4L amidship

4.3.1

4.3.1.a This regulation is based on 4.3.1 of Sec. 2, Chapter 6, Part B of BV Rules.

4.3.2

4.3.2.a This regulation is based on 4.3.2 of Sec. 2, Chapter 6, Part B of BV Rules.

4.4 Midship section moment of inertia

4.4.1

4.4.1.a This regulation is based on IACS UR S4.

4.5 Extent of higher strength steel

4.5.1

4.5.1.a This regulation is based on 4.5.1 of Sec. 2, Chapter 6, Part B of BV Rules.

4.5.2

4.5.2.a This regulation is based on 4.5.2 of Sec. 2, Chapter 6, Part B of BV Rules.

5. PERMISSIBLE STILL WATER BENDING MOMENT AND SHEAR FORCE

5.1 Permissible still water bending moment and shear force in intact condition

5.1.1 Permissible still water bending moment

5.1.1.a This regulation is based on 5.1.1 of Sec. 2, Chapter 6, Part B of BV Rules.

5.1.2 Permissible still water shear force – Direct calculation

5.1.2.a This regulation is based on 5.2.1 of Sec. 2, Chapter 6, Part B of BV Rules.

5.1.3 Permissible still water shear force – Simplified calculation

5.1.3.a This regulation is based on 5.2.2 of Sec. 2, Chapter 6, Part B of BV Rules

5.2 Permissible still water bending moment and shear force in harbour condition

5.2.1 Permissible still water bending moment

5.2.1.a This regulation is related to the concept on the vertical wave bending moment in harbour condition specified in Ch 4 Sec 3 in CSR.

5.2.2 Permissible still water shear force

5.2.2.a This regulation is related to the concepts on the vertical wave shear force in harbour condition specified in Ch 4 Sec 3 in CSR.

5.3 Permissible still water bending moment and shear force in flooded condition

5.3.1 Permissible still water bending moment

5.3.1.a This regulation is related to the vertical wave bending moment in flooded condition specified in Ch 4 Sec 3 in CSR.

5.3.2 Permissible still water shear force – Direct calculation

5.3.2.a This regulation is related to the concepts on the vertical shear force in flooded condition by direct calculation method specified in Ch 4 Sec 3 in CSR.

5.3.3 Permissible still water shear force – Simplified calculation

5.3.3.a This regulation is related to the concepts on the vertical shear force in flooded condition by simplified calculation method specified in Ch 4 Sec 3 in CSR.

SECTION 2 – ULTIMATE STRENGTH CHECK

1. APPLICATION

1.1 General

1.1.1

1.1.1.a The hull girder strength is the most important for hull structure. The ships length becomes longer, this strength is more important. Hence, the hull girder ultimate strength check is required to ships with length (L) not less than 150m.t

2. HULL GIRDER ULTIMATE STRENGTH CHECK

2.1 Hull girder loads

2.1.1 Bending moment

2.1.1.a The yielding strength of hull girder is checked by the working stress design method using the allowable stress as required in Chapter 5 Section 1. However, the working stress design method cannot be evaluated to the actual capacity of hull girder, even though the scantling of hull girder is considered reasonable and practicable. Hence, to estimate the actual capacity of hull girder, the ultimate strength hull girder is checked by the partial safety factor design method.

2.1.1.b Ultimate strength check is required to the ultimate condition such as ultimate wave loads which is expressed by multiplying the extreme wave loads by the partial safety factor and flooded condition.

2.2 Hull girder bending moment

2.2.1 Curve M-χ

2.2.1.a This regulation is based on 3.2.1 of Sec. 3, Chapter 6 of RINA Rules.

2.2.2 Hull girder transverse sections

2.2.2.a This regulation is based on 3.2.2 of Sec. 3, Chapter 6 of RINA Rules.

2.3 Checking criteria

2.3.1

2.3.1.a This regulation is based on 3.3.1 of Sec. 3, Chapter 6 of RINA Rules.

APPENDIX 1 – HULL GIRDER ULTIMATE STRENGTH

1. HULL GIRDER ULTIMATE STRENGTH CHECK

1.1 Introduction

1.1.1

1.1.1.a This Appendix describes details of the calculation method for hull girder ultimate strength. It is based on Part B, Chapter 6, Appendix 1 of BV Rules for the Classification of Steel Ships (April 2005).

2. CRITERIA FOR THE CALCULATION OF THE CURVE M-χ

2.1 Simplified method based on a incremental-iterative approach

2.1.1 Procedure

2.1.1.a This requirement is based on 1.2.1 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.1.2 Assumption

2.1.2.a This requirement is based on 1.2.2 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.2 Load-end shortening curves σ-ε

2.2.1 Plating panels and ordinary stiffeners

2.2.1.a This requirement is based on 1.3.1 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.2.2 Hard corners

2.2.2.a This requirement is based on 1.3.2 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.2.3 Elastic-plastic collapse of structural elements

2.2.3.a This requirement is based on 1.3.3 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.2.4 Beam column buckling

2.2.4.a This requirement is based on 1.3.4 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.2.5 Torsional buckling

2.2.5.a This requirement is based on 1.3.5 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.2.6 Web local buckling of ordinary stiffeners made of flanged profiles

2.2.6.a This requirement is based on 1.3.6 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.2.7 Web local buckling of ordinary stiffeners made of flat bars

2.2.7.a This requirement is based on 1.3.7 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.

2.2.8 Plate buckling

2.2.8.a This requirement is based on 1.3.8 of Part B, Chapter 6, Appendix 1 of BV Rules for Steel Ships.