IACS Common Structural Rules for Double Hull Oil Tankers, January 2006

Background Document

APPENDIX A – HULL GIRDER ULTIMATE 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.
- This TB provides the background for the first version (January 2006) of the CSRs, and is not subject to maintenance.

IACS
INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES LTD.

Enquiries should be addressed to the Permanent Secretary,
International Association of Classification Societies Ltd,
36 Broadway
London, SW1H 0BH
Telephone: +44 (0)20 7976 0660
Fax: +44 (0)20 7808 1100
Email: PERMSEC@IACS.ORG.UK

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1.1.1 Hull girder bending moment capacity

1.1.1.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

1.2 Application

1.2.1 General

1.2.1.a There are two methods of deriving the hull girder ultimate bending capacity in sagging included in the Rules. One is a single step method that does not require iteration. . The other method is the commonly used incremental-iterative method for calculation of the progressive failure of the hull girder. The incremental-iterative method specified in the Common Structural Rules for bulk Carriers (Jan 2006) is adopted.

1.2.1.b There are many methods for deriving hull girder ultimate strength capacity. They can be grouped as simplified formula, progressive failure analysis approach or nonlinear FEM approach. The Rules provide two methods in 1.2.1.a with all the details and assumptions specified in order to consistently calculate the capacity. Comparison studies performed indicate that the results of the tow methods are very similar.

1.3 Assumptions

1.3.1 General

1.3.1.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

1.4 Alternative Methods

1.4.1 General

1.4.1.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

2 CALCULATION OF HULL GIRDER ULTIMATE CAPACITY

2.1 Single Step Ultimate Capacity Method

2.1.1 Procedure

2.1.1.a The simplified single step procedure for calculating the hull girder ultimate strength is derived from the bending moment – curvature relationship given by:

$M_U = EI_{red}\Delta\kappa_1$ kNm

where:

EI_{red}	Reduced hull girder bending stiffness accounting for buckling of deck only
E	Young's modulus in N/mm²
$\Delta\kappa_1 = \dfrac{\varepsilon_{yd}}{z_{dk-mean} - z_{NA-red}}$	Incremental curvature from zero moment up to yield strain ε_{yd} in deck

2.1.2 Assumption

2.1.2.a The single step method is based on the following assumptions:

- The ultimate capacities of the deck panels are reached at a strain level corresponding to yield, and it is assumed that this condition of the deck gives the maximum ultimate bending capacity of hull girder.
- The ultimate capacities are to be calculated using the advanced buckling method in *Appendix D of the Rules*.
- Apart from the deck, the hull section behaves elastically.
- The location of the neutral axis is shifted so that force equilibrium is achieved.
- The strain at any point of the cross section is proportional to its distance from the neutral axis.

2.2 Simplified Method Based on an Incremental-iterative Approach

2.2.1 Procedure

2.2.1.a The simplified method based on an incremental-iterative approach is adopted from *Chapter 5, Section 2 and Section 5, Appendix 1 of the IACS Common Structural Rules for Bulk Carriers, January 2006,*. The background to this method is given in the background documentation to the IACS Common Structural Rules for Bulk Carriers, no further information is considered necessary.

2.2.2 Assumptions and modelling of the hull girder cross-section

2.2.2.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

2.2.3 Stress-strain Curves σ-ε (or Load-end Shortening Curves)

2.2.3.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

2.2.4 Beam column buckling

2.2.4.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

2.2.5 Torsional buckling of stiffeners

2.2.5.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

2.2.6 Web local buckling of stiffeners with flanged profiles

2.2.6.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

2.2.7 Web local buckling of flat bar stiffeners

2.2.7.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

2.2.8 Buckling of transversely stiffened plate panels

2.2.8.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.

3 ALTERNATIVE METHODS

3.1 General

3.1.1 Considerations for alternative models

3.1.1.a The present version of the Rules considers sagging only. The alternative methods are usually suitable for assessment of ultimate hull girder strength in both sagging and hogging.

3.2 Methods

3.2.1 Incremental-iterative procedure

3.2.1.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background. Note that the Incremental-iterative Approach specified in *Appendix A/ 2.1 of the Rules* is a simplified procedure which includes specifications about how to derive the stress strain curves of all structural members. Also note that these curves do not include the effects of biaxial stress, local pressure, shear and double bottom bending effects that may be important in hogging.

3.2.1.b The M-κ curve is to be based on the axial non-linear σ-ε curves for each individual stiffener/stiffened panel unit in the cross-section. In particular the method to derive the σ-ε curves, see *Figure A.3.a*, is to consider relevant structural effects such as:

(a) elastic buckling and post-buckling behaviour;

(b) inelastic material behaviour and post-ultimate behaviour;

(c) geometrical imperfections and residual stresses triggering the most critical inter-frame modes (geometrical out-of flatness of plate and stiffeners);

(d) simultaneous acting loads; bi-axial compression/tension, shear and lateral pressure effects on axial stress strain σ-ε curve;

(e) boundary conditions;

(f) interactions between buckling modes; plate buckling, torsional stiffener buckling, stiffener web buckling, lateral/global stiffener buckling;

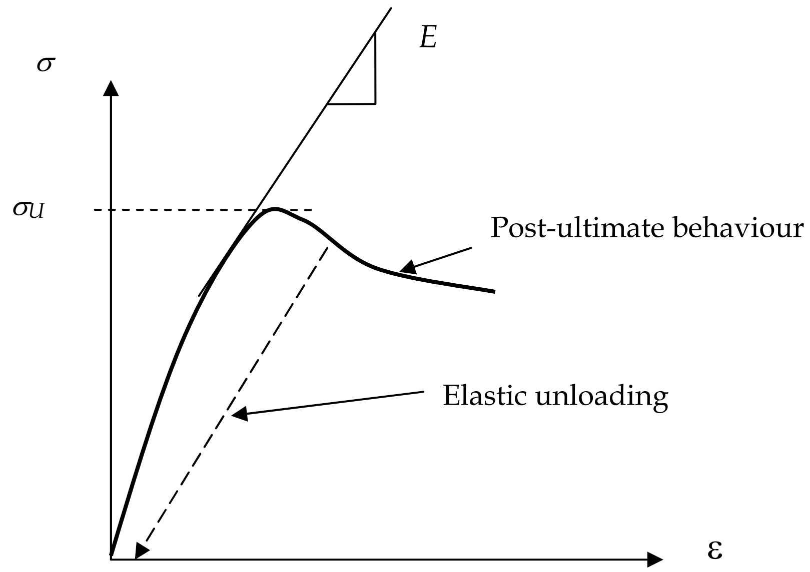
(g) elastic unloading;

(h) linearly varying shortenings/strains along element edges in ship sides etc.;

(i) the σ-ε curve for individual panels relates the axial load P of that panel and the corresponding axial end-shortening ε of the critical frame spacing where collapse is identified;

(j) effects of double bottom bending.

Figure A.3.a
σ-ε curves of compressed individual panels in hull girder section



3.2.2 Non-linear finite element analysis

3.2.2.a It is considered that for this topic no information in addition to that shown in the Rules is necessary to explain the background.