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.
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1 Advanced Buckling Analysis

1.1 General

1.1.1 Scope

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. However, please see Section 10 for further information.

1.1.2 Alternative procedures

1.1.2.a Use of alternative buckling procedures to the reference advances buckling analysis methodologies to be documented based on the cases as shown in Tables D1.1a-D1.1h. The results presented are loads giving buckling utilization factor 1.0 by use of the reference advanced buckling procedure for a stiffened panel with six stiffener spacings.

1.1.2.b Four stiffener types are considered: flat bars, HP bulb flats, angles and T bars. The following cases are considered:

- Case 1: Uni-axial compression in the direction of the stiffener; $\sigma_x$
- Case 2: Uni-axial compression, transverse; $\sigma_y$
- Case 3: Bi-axial compression with shear; $\sigma_x$, $\sigma_y$ and $\tau$
- Case 4: Bi-axial compression with shear and lateral pressure acting on stiffeners side; $\sigma_x$, $\sigma_y$, $\tau$ and $P$

1.1.2.c Results for Method 1 (Buckling capacity with allowance for redistribution of load) are shown in Table D1.1a (flat bars), Table D1.1b (HP bulb flats), Table D1.1c (Angles) and Table D1.1d (T bars).

1.1.2.d Results for Method 2 (Buckling capacity with no allowance for redistribution of load) are shown in Table D1.1e (flat bars), Table D1.1f (HP bulb flats), Table D1.1g (Angles) and Table D1.1h (T bars).

1.1.3 Definitions

1.1.3.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background. However, please see Section 10 for further information.
### Table D1.1a

**Flatbar stiffeners – Method 1: Ultimate Strength – Load cases with utilization buckling factor 1.0**

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Angles – Method 1: Ultimate Strength – Load cases with utilization buckling factor 1.0

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## Table D1.1d

T bars – Method 1: Ultimate Strength – Load cases with utilization buckling factor 1.0

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**Angles – Method 2: Buckling Strength – Load cases with utilization buckling factor 1.0**

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**T bars – Method 2: Buckling Strength – Load cases with utilization buckling factor 1.0**

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2 ADVANCED BUCKLING ANALYSIS METHOD

2.1 General

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

2.1.2 Non linear geometrical behaviour
2.1.2.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

2.1.3 Material behaviour and properties
2.1.3.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

2.1.4 Initial deflections – geometrical imperfections/out-of-flatness
2.1.4.a The geometric and material imperfections that are present in real structures are represented in the buckling models by a set of initial deformations. The model imperfections are characterized by imperfection shapes and amplitudes, of which the shape is the most important parameter. The imperfection shape is chosen as the one which is most critical with respect to the ultimate capacity of the panel, in order that the results are conservative for any stiffened panel. This means that the model imperfection shape is hence often different from the most typical initial deformation shapes occurring in real panels. The model imperfection shape used is scaled so that appropriate imperfection amplitudes are achieved for local deformation of the plate between stiffeners, sideways deformation of the webs, and for lateral deformation of the stiffeners. The default imperfection amplitudes used in the standard advanced buckling assessment program supplied by the Class Societies are as follows:
- Plate between stiffeners: \( s/200 \)
- Stiffener sideways: \( l/1000 \)
- Stiffener lateral: \( l/1000 \)

\( s \) being stiffener spacing, and \( l \) being stiffener span. As for the imperfection shapes, the imperfection amplitudes are chosen so as to be representative for any stiffened panel. The imperfection values must be considered in close relation to the imperfection shapes used, and they should therefore not be taken as equal to specified tolerance values (i.e. IACS Shipbuilding and Quality Repair Standard) or measured values of initial deformation.

2.1.5 Welding induced residual stress
2.1.5.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.
2.1.6 **Interactions between buckling modes and structural elements**

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

2.1.7 **Simultaneous acting loads**

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

2.1.8 **Boundary conditions**

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

2.1.9 **Model extent**

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

2.1.10 **Element size for non-linear finite element models**

2.1.10.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 APPLICATION AND STRUCTURAL MODELLING PRINCIPLES

3.1 General

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

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

3.1.3 Structural idealisation
3.1.3.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.
4 ASSESSMENT CRITERIA

4.1 General

4.1.1 Buckling strength assessment methods
4.1.1.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

4.1.2 Method 1: Buckling capacity with allowance for redistribution of load
   It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

4.1.3 Method 2: Buckling capacity with no allowance for redistribution of load
4.1.3.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

4.2 Utilisation Factors

4.2.1 General
4.2.1.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.
5 **STRENGTH ASSESSMENT (FEM) – BUCKLING PROCEDURE**

5.1 General

5.1.1 Scope

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

5.2 Structural Modelling and Capacity Assessment Method

5.2.1 General

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

5.2.2 Stiffened panels

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

5.2.3 Unstiffened panels

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

5.3 Load Application

5.3.1 General

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

5.3.2 Average membrane stresses

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

5.3.3 Averaged lateral pressure

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

5.4 Limitations of the Advanced Buckling Assessment Method

5.4.1 General

5.4.1.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.
6 **ULTIMATE HULL GIRDER STRENGTH ASSESSMENT**

6.1 General

6.1.1 Scope

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

6.2 Load Application

6.2.1 General

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

6.3 Structural Modelling and Buckling Assessment

6.3.1 General

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