SECTION 3 LAMINATE PANEL

1 General

1.1 Load conditions

1.1.1 As a general rule, the laminate panels are to be examined for the two following conditions:

- compression and shear buckling check, as defined in [2], where the laminate panels are submitted to global loads (as for example deck or bottom area under global hull bending, side shell or web of cross deck beam under global shear forces)
- local flexural and shear check, as defined in [7], where the laminate panels are submitted to lateral pressure.

1.2 Checking process

1.2.1 The laminate panel check consists in:

- estimating the loading condition of the laminate panel, as defined in this present section
- estimating the mechanical characteristics of the laminate, as defined in Ch 12, Sec 4
- comparing the safety factors and the appropriate minimum rules safety factors as defined in Ch 4, Sec 3, [5.4].

1.3 Calculation program process

1.3.1 All the following calculations may be automatically carried out by Bureau Veritas program (see Ch 1, Sec 4):

- critical buckling checks
- flexural moments distribution under hydrodynamic loads
- shear forces distribution under hydrodynamic loads
- laminate panel stress analysis
- dynamical amplification coefficient.

2 Buckling check of laminate panels

2.1 General

2.1.1 The requirements of this article apply for the global buckling of laminate panel subjected to in-plane compression stresses acting on one side or to in-plane shear stresses.

2.1.2 Only global buckling is examined for sandwich laminates. As a general rules, the buckling modes such as shear crimping, local face dimpling and face wrinkling are not sampling cases with usual sandwich used in yacht hull construction.

2.1.3 When particular sandwich designs are used such as foam core with low density, honeycomb core or thin faceskins, the buckling modes mentioned in [2.1.2] are to be specially examined.

2.1.4 The buckling check of the laminate panels as defined hereafter are based on the following hypothesis on boundary conditions:

- for monolithic laminate, all laminate edges are supposed simply supported in way of the laminate supports
- for sandwich laminate, all laminate edges are supposed clamped in way of the laminate supports.

2.1.5 Global laminate parameters

Global flexural rigidity, global shear rigidity and global tensile rigidity of laminates are defined in Ch 12, Sec 4, [5] and may be evaluated with Bureau Veritas program defined in Ch 1, Sec 4.

2.1.6 The hull areas to be checked according to the requirements of the present section are:

For compression buckling:

- bottom and decks panel
- side shell panel, in the upper area below strength deck
- deck area around mast of monohull sailing yachts
- bottom and deck panel of cross deck of catamarans, in way of transverse primary bulkheads.

For shear buckling:

- primary transverse bulkheads of catamarans
- hull side shells.

2.1.7 Loading principles

The loadings considered for buckling check are those inducing compression and shear stresses as shown in Fig 1 and Fig 2.

Figure 1 : Buckling of a rectangular laminate panel subjected to compression

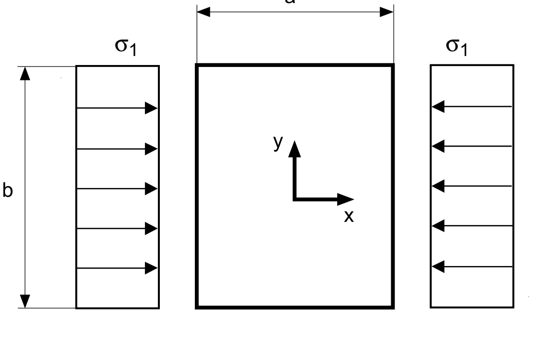
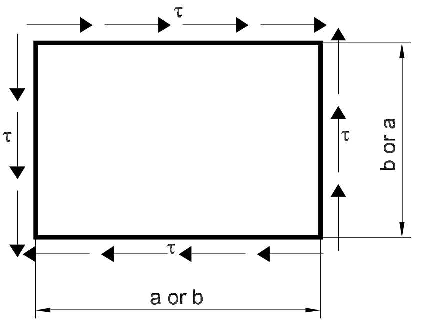


Figure 2 : Buckling of a rectangular laminate panel subjected to shear



3 Compression buckling check of monolithic laminates

3.1 General

3.1.1 For specific designs, other boundary conditions than those defined in [2.1.4] may be considered.

3.2 Hypothesis

3.2.1 Monolithic laminates are considered as orthotropic materials.

3.3 Critical compression buckling stress

3.3.1 Load in X-direction

The critical compression buckling stress, in N/mm², is estimated from the following formula:

$$\sigma_C = \frac{\pi^2 10^{-6}}{m^2 a^2 t}[D_{11} m^4 + 2(D_{12} + 2D_{33}) m^2 \alpha^2 + D_{22} \alpha^4]$$

where

a : Unloaded side of the laminate, parallel to the X-direction of the laminate, in m

b : Loaded side of the laminate, parallel to the Y-direction of the laminate, in m

α : Aspect ratio, $\alpha = a/b$

t : Laminate thickness, in mm

D_{11}, D_{12}, D_{22}, D_{33}: Global flexural rigidity matrix coefficients, as defined in Pt B, Ch 12, Sec 4, [4.1.1], in N.mm²/mm

Note 1: These coefficients are to be calculated for the laminate with the same global axis X and Y.

m : Number of half-waves in loading X-direction. This number depends on α, as follows:

if $\alpha \leq \sqrt{2}\left(\frac{D_{11}}{D_{22}}\right)^{\frac{1}{4}}$ $m = 1$

if $\sqrt{2}\left(\frac{D_{11}}{D_{22}}\right)^{\frac{1}{4}} < \alpha \leq \sqrt{6}\left(\frac{D_{11}}{D_{22}}\right)^{\frac{1}{4}}$ $m = 2$

if $\alpha > \sqrt{6}\left(\frac{D_{11}}{D_{22}}\right)^{\frac{1}{4}}$ $m = 3$

3.3.2 Load in Y-direction

The critical compression buckling stress, in N/mm², is estimated from the following formula:

$$\sigma_C = \frac{\pi^2 10^{-6}}{n^2 b^2 t}\left[\frac{D_{11}}{\alpha^4} + \frac{2(D_{12} + 2D_{33})}{\alpha^2} n^2 + D_{22} n^4\right]$$

where

a : Loaded side of the laminate, parallel to the X-direction of the laminate, in m

b : Unloaded side of the laminate, parallel to the Y-direction of the laminate, in m

α : Aspect ratio, $\alpha = a/b$

t : Laminate thickness, in mm

D_{11}, D_{12}, D_{22}, D_{33}: Global flexural rigidity matrix coefficients, as defined in Ch 12, Sec 4, [4.1.1], in N.mm²/mm

Note 1: These coefficients are to be calculated for the laminate with the same global axis X and Y.

n : Number of half-waves in loading Y-direction. This number depends on α, as follows:

if $1/\alpha \leq \sqrt{2}\left(\frac{D_{22}}{D_{11}}\right)^{\frac{1}{4}}$ $n = 1$

if $\sqrt{2}\left(\frac{D_{22}}{D_{11}}\right)^{\frac{1}{4}} < 1/\alpha \leq \sqrt{6}\left(\frac{D_{22}}{D_{11}}\right)^{\frac{1}{4}}$ $n = 2$

if $1/\alpha > \sqrt{6}\left(\frac{D_{22}}{D_{11}}\right)^{\frac{1}{4}}$ $n = 3$

3.4 Compression buckling criteria

3.4.1 The safety factor between the critical stress as calculated in [3.3] and the actual compression stress as calculated according to Ch 9, Sec 2, is to be not less than the minimum safety factor defined in Ch 4, Sec 3, [5.4].

4 Shear buckling check of monolithic laminates

4.1 General

4.1.1 For specific designs, other boundary conditions than those defined in [2.1.4] may be considered.

4.2 Hypothesis

4.2.1 Monolithic laminates are considered as orthotropic materials.

4.3 Critical shear buckling stress

4.3.1 The critical shear buckling stress, in N/mm², is estimated with the following formula:

$$\tau_C = C_\beta \frac{(D_{11} D_{22}^3)^{\frac{1}{4}}}{t\left(\frac{b}{2}\right)^2} 10^{-6}$$

where:

a : Side parallel to the X-direction of the laminate, in m

b : Side parallel to the Y-direction of the laminate, in m

t : Laminate thickness, in mm

D_{11}, D_{12}, D_{22}, D_{33}: Defined in [3.3.1], in N.mm²/mm

C_β : Coefficient depending on θ and β:

$C_\beta = (7,1\theta + 3,9)\beta^2 + (7,3\theta^3 - 11,7\theta^2 + 3,2\theta - 0,8)\beta + 5,2\theta + 8,1$

where:

$$\theta = \frac{D_{12} + 2D_{33}}{\sqrt{D_{11}D_{22}}}$$

$$\beta = \frac{b}{a}\left(\frac{D_{11}}{D_{22}}\right)^{\frac{1}{4}}$$

4.4 Shear buckling criteria

4.4.1 The safety factor between the critical stress as calculated in [4.3] and the actual compression stress as calculated according to Ch 9, Sec 2, is to be not less than the minimum safety factor defined in Ch 4, Sec 3, [5.4].

5 Compression buckling check of sandwich laminates

5.1 General

5.1.1 For specific designs, other boundary conditions than those defined in [2.1.4] may be considered.

5.2 Hypothesis

5.2.1 Sandwich faceskins are considered as orthotropic and core as isotropic materials.

5.3 Critical compression buckling stress

5.3.1 The critical compression buckling stress, in N/mm², is estimated from the following formula:

$$\sigma_c = E_t \frac{\pi^2 [EI]}{b^2 H} K_1 10^{-6}$$

where:

E_t : Minimum global tensile rigidity of the sandwich in the loading direction, in N/mm²:

$E_t = \min(E_{t,1}, E_{t,2})$

where

$E_{t,1}$: Global tensile rigidity of the upper faceskin of sandwich panel in the loading direction, as defined in Ch 12, Sec 4, [4.1.1]

$E_{t,2}$: Global tensile rigidity of the lower faceskin of sandwich panel in the loading direction, as defined in Pt B, Ch 12, Sec 4, [5.1]

[EI] : Global flexural rigidity of the sandwich panel to be obtained, in Nmm²/mm, from the following formula:

$$[EI] = \sqrt{D_{11}D_{22}}$$

D_{11} and D_{22} are the global flexural rigidity matrix coefficients of the sandwich panel, as defined in Pt B, Ch 12, Sec 4, [4.1.1]

H : Global compression rigidity, to be calculated, in N/mm, as follows:

$$H = E_{t,1}t_{F1} + E_{t,2}t_{F2} + E_C t_C$$

with

t_{F1} : Upper faceskin thickness, in mm

t_{F2} : Lower faceskin thickness, in mm

t_C : Core thickness, in mm

E_C : Core tensile rigidity, in N/mm²

Note 1: In case of anisotropic core, E_C is to be the core tensile rigidity in the loading direction.

b : Loaded side of the sandwich panel, in m

α : Aspect ratio, α=a/b

K_1 : Buckling coefficient, obtained from the following formulae:

- simply supported conditions (for information only):

  $K = 2V^2 - 4,1V + 3,1$

  if $\alpha \geq 0,9V^{-0,15} - 0,45$

  or $\alpha \geq 0,9$

  $K_1 = A\alpha^2 + B\alpha + C$

  if $\alpha < 0,9V^{-0,15} - 0,45$

  if $V \leq 0,2$

  $A = 120V^2 - 116V + 20,4$

  $B = -350V^2 + 227V - 36,8$

  $C = 205V^2 - 113,5V + 19,7$

  if $V > 0,2$

  $A = -2V + 2$

  $B = -10,8V^2 + 19,3V - 8,5$

  $C = 5V^2 - 10V + 6$

- clamped conditions:

  $K_1 = A\alpha^2 + B\alpha + C$

$$A = 0,1\left(\frac{1}{V^{1,2}} - 1\right)$$

$$B = -0,2\left(\frac{1}{V^{1,45}} - 1\right)$$

$$C = \frac{1}{V}$$

A is not more than 5,5

B is not less than -19,5

C is not more than 23,5

where:

$$V = \frac{\pi^2 [EI]}{b^2 G_C t_C} \cdot 10^{-6}$$

[EI] : Global flexural rigidity of the sandwich panel, in Nmm²/mm

G_C : Core shear rigidity (in laminate plane xy), in N/mm².

5.4 Compression buckling criteria

5.4.1 The safety factor between the critical stress as calculated in [5.3] and the actual compression stress as calculated according to Ch 9, Sec 2, is to not be less than the minimum safety factor defined in Ch 4, Sec 3, [5.4].

6 Shear buckling check of sandwich laminate

6.1 General

6.1.1 For specific designs, other boundary conditions than those defined in [2.1.4] may be considered.

6.2 Hypothesis

6.2.1 Sandwich faceskins are considered as orthotropic and core as isotropic materials.

6.3 Critical shear buckling stress

6.3.1 The critical shear buckling stress, in N/mm², is estimated with the following formula:

$$\tau_C = \frac{\pi^2 G_{XY}[EI]}{b^2 N} K_2 10^{-6}$$

where

[EI] : Global flexural rigidity of the sandwich panel, in N.mm²/mm, as defined in [5.3.1]

G_{XY} : Minimum global shear rigidity, in N/mm²

$G_{XY} = \min(G_{XY,1}, G_{XY,2})$

with

$G_{XY,1}$: Global shear rigidity of the upper faceskin of sandwich panel in laminate plane xy, as defined in Ch 12, Sec 4, [5.1]

$G_{XY,2}$: Global shear rigidity of the lower faceskin of sandwich panel in laminate plane xy, as defined in Ch 12, Sec 4, [5.1]

N : Global shear rigidity, in N/mm, to be calculated, as follows:

$N = G_{XY,1}t_{F1} + G_{XY,2}t_{F2} + G_C t_C$

With:

t_{F1}, t_{F2}, t_C, G_C: Defined in [5.3.1]

b : Smaller side of the laminate panel, in m

a : Longer side of the laminate panel, in m

K_2 : Buckling coefficient, obtained from the following formulae:

- simply supported conditions (for information only):

$$K_2 = \frac{4}{3}\,\frac{4 + 3\dfrac{b^2}{a^2}}{1 + \dfrac{1}{3}\left[13 + 9\dfrac{b^2}{a^2}\right]V}$$

if $0 \le V \le \dfrac{1}{1 + \dfrac{b^2}{a^2}}$

$$K_2 = \frac{1}{V}$$

if $V > \dfrac{1}{1 + \dfrac{b^2}{a^2}}$

- clamped conditions:

$$K_2 = \frac{1}{3}\,\frac{27 + 17\dfrac{b^2}{a^2}}{1 + \dfrac{1}{3}\left[23 + 13\dfrac{b^2}{a^2}\right]V}$$

if $0 \le V \le \dfrac{3}{4\left(1 + \dfrac{b^2}{a^2}\right)}$

$$K_2 = \frac{1}{V}$$

if $V > \dfrac{3}{4\left(1 + \dfrac{b^2}{a^2}\right)}$

where:

$$V = \left(\frac{\pi^2[EI]}{b^2 G_C t_C}\right) \times 10^{-6}$$

6.4 Shear buckling criteria

6.4.1 The safety factor between the critical stress as calculated in [6.3] and the actual compression stress as calculated according to Ch 9, Sec 2, is to be not less than the minimum safety factor defined in Ch 4, Sec 3, [5.4].

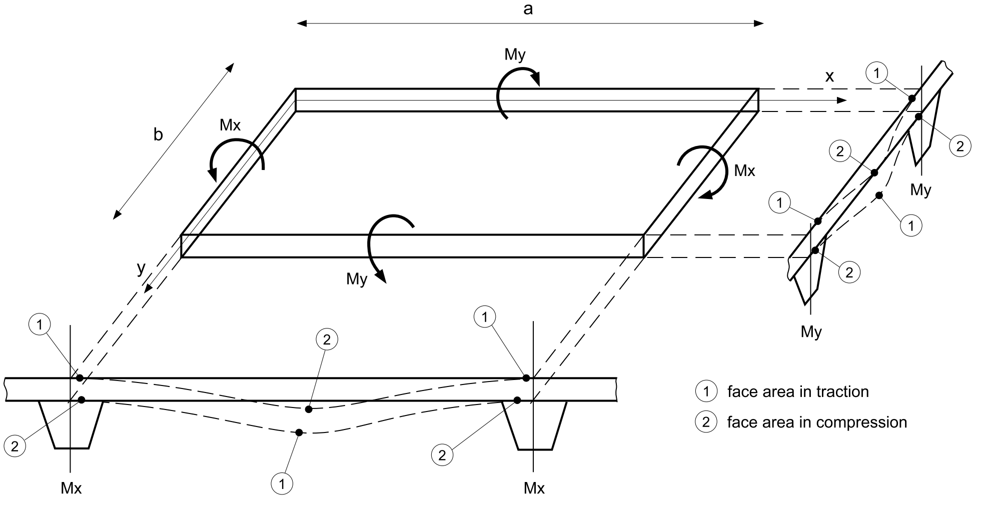
7 Laminate panel sustaining lateral pressure

7.1 General

7.1.1 The laminate panels are to be examined according to the following processes taking into account the type of lateral pressure:

- in case of hydrodynamic loads as defined in Ch 7, Sec 1 (for bottom, side, decks, superstructure, tanks...): as defined in [7.2]
- in case of bottom slamming loads as defined in Ch 7, Sec 2 (for bottom laminate panel): as defined in previous case plus as defined in [7.3]
- in case of impact pressure on side shell, as defined in Ch 7, Sec 1, [2.3] (for side shell of monohull and specific area for catamaran): as defined in the first previous cases plus as defined in [7.4]

Figure 3 : Flexural moments



7.1.2 Load point

Unless otherwise specified, lateral pressure is to be calculated at the middle of the plate panel.

7.2 Laminate panel under hydrodynamic loads

7.2.1 Flexural moment distribution at panel boundaries

Each side of the laminate panel is considered as clamped.

The absolute value of the moments M_X and M_Y, as shown on Fig 3, induced by the lateral pressure, are respectively the moment at the middle of side "b" and the moment at the middle of side "a". They are to be estimated, in kN.m per meter width, from the following formulae:

$$|M_X| = D_{11} \cdot A \cdot p_S \cdot \frac{10^{-6}}{8a^2} \cdot k_{S,X}$$

$$|M_Y| = D_{22} \cdot A \cdot p_S \cdot \frac{10^{-6}}{8b^2} \cdot k_{S,Y}$$

Note 1: The sign of the moments are to be chosen in order to respect the traction and compression areas of the laminate under lateral pressure, as shown on Fig 3.

where:

A : Parameter obtained from the following formula:

$$A = \frac{\beta \cdot a^4 \cdot 10^6}{7D_{11} + 4(D_{12} + 2D_{33})\alpha^2 + 7D_{22}\alpha^4}$$

a : Side of the laminate panel in x direction, in m

b : Side of the laminate panel in y direction, in m

α : Aspect ratio, $\alpha = a/b$

D_{11}, D_{12}, D_{22}, D_{33}: Global flexural rigidity matrix coefficients, as defined in Ch 12, Sec 4, [4.1.1], in $N.mm^2/mm$

Note 2: These coefficients are to be calculated for the laminate with the same global axis X and Y.

p_S : Local pressure, in kN/m^2, defined in Ch 7, Sec 1, for bottom, sides, decks, superstructure, tanks and bulkheads

β : Coefficient, equal to:

if $a \le b$ $\quad \beta = 6,15\left(\frac{a}{b}\right)^{0,07}$

if $a > b$ $\quad \beta = 6,15\left(\frac{b}{a}\right)^{0,07}$

β is not less than 5,5

$k_{S,X}$, $k_{S,Y}$: Reductor factor in case of shell plating with stiffeners with wide base, equal to:

$$k_{S,X} = 1 - 3\left(\frac{w_{S,X}}{a}\right)\left(1 - \frac{w_{S,X}}{a}\right)$$

$$k_{S,Y} = 1 - 3\left(\frac{w_{S,Y}}{b}\right)\left(1 - \frac{w_{S,Y}}{b}\right)$$

where $k_{S,X}$ and $k_{S,Y}$ are taken not less than 0,4 and where a, b, $w_{S,X}$ and $w_{S,Y}$, in m, are defined in Fig 4:

Figure 4 : defintion of $w_{S,X}$ and $w_{S,Y}$

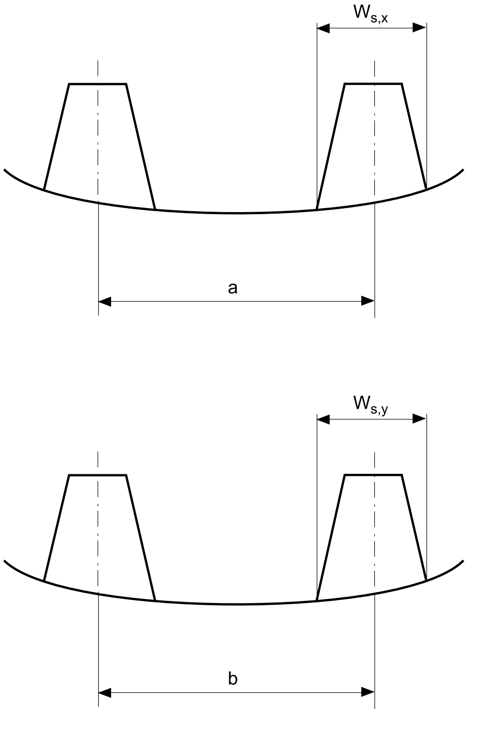
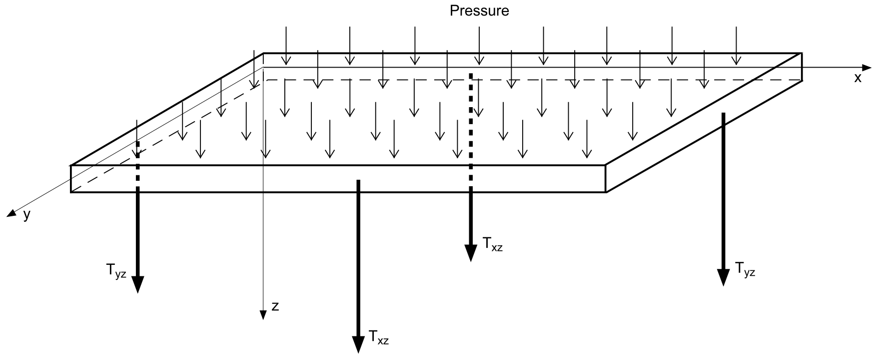


Figure 5 : Shear forces



7.2.2 Transversal shear forces distribution at panel boundaries

Each side of the laminate panel is considered as clamped.

Shear forces T_{XZ} and T_{YZ}, as shown on Fig 5, induced by the lateral pressure, are respectively the shear force on side "a" and the shear force on side "b". They are to be estimated, in kN per meter width, from the following formulae:

$$T_{YZ} = \frac{a p_S}{2\left(1 + \alpha^4 \frac{D_{22}}{D_{11}}\right)}$$

$$T_{XZ} = \alpha^3 \frac{D_{22}}{D_{11}} T_{YZ}$$

where

$\alpha = a/b$: Aspect ratio

a,b : Sides panel as defined in [7.2.1], in m

D_{11}, D_{12}, D_{22}, D_{33}: As defined in [7.2.1], in N.mm²/mm

p_S : As defined in [7.2.1], in kN/m².

7.2.3 Laminate panel stress analysis

Laminate panel stresses are to be checked according to Ch 12, Sec 4, [4], taking into account the values of flexural moments M_X and M_Y and the shear forces T_{XZ} and T_{YZ} as defined herebefore.

The safety coefficients between applied stresses and theoretical breaking stresses estimated in Ch 12, Sec 3, [5], are to be in accordance with the minimum appropriate safety coefficients defined in Ch 4, Sec 3, [5.4].

7.2.4 Calculation program process

The calculation of flexural moments, shear forces, elementary layer stresses can be automatically carried out by Bureau Veritas program defined in Ch 1, Sec 4.

7.3 Laminate bottom panel under slamming loads

7.3.1 Dynamical amplification phenomena

The dynamical slamming load amplification phenomena concerns only sandwich laminate sustaining lateral slamming loads.

As a general rules, this phenomena is not observed for monolithic laminate and is not to be taken into account.

7.3.2 Estimation of the dynamical amplification coefficient

The dynamical amplification coefficient is a coefficient increasing the slamming loads as defined in Ch 7, Sec 2 and to be taken into account for the sandwich laminate.

This coefficient K_{DA} is defined as follows:

- for monolithic laminate: $K_{DA} = 1$
- for sandwich laminate:

for $t_0/T < 0,9$: $K_{DA} = 0,98\left(1 + \frac{\sin(\pi t_0/T)}{\pi t_0/T}\right)$

for $0,9 \le t_0/T \le 2$: $K_{DA} = 1,1$

for $t_0/T > 2$: $K_{DA} = 1$

where

t_0 : Pulse rise time, in s, obtained from the following formula:

$$t_0 = 0,03\sqrt{\frac{L}{43}}$$

L : Rule length, in m, as defined in Ch 1, Sec 2, [3.2]

T : Sandwich panel proper period, in s, calculated as follows:

$$T = \frac{1}{f\sqrt{\dfrac{K}{K + \dfrac{\rho_W}{\pi W}}}}$$

K : Coefficient, in m⁻¹, equal to:

$$K = \sqrt{\frac{1}{a_S^2} + \frac{1}{b_L^2}}$$

a_S : Smaller side of the sandwich panel, in m

b_L : Longer side of the sandwich panel, in m

f : Proper frequency of the sandwich panel, in Hz, obtained from the following formula:

$$f = 150 a_S^{-1,8}$$

ρ_W : Water mass density, in general equal to 1025 kg/m³

W : Total laminate weight per square meter, in kg/m², as defined in Ch 12, Sec 4, [5.2].

7.3.3 Flexural moments and shear forces under slamming loads

The moments and shear forces induced by the lateral slamming pressure are to be estimated as defined in [7.2.1] and [7.2.2] herebefore with a local load p_{SI} equal to the slamming load defined in Ch 7, Sec 2, multiplied by K_{DA} defined in [7.3.2].

The stress analysis is to be carried out with the same manner than [7.2.3].

7.3.4 Calculation program process

The dynamical amplification calculation of the laminate panel can be automatically carried out by Bureau Veritas program defined in Ch 1, Sec 4.

7.4 Laminate panel under impact pressure on side shell

7.4.1 Dynamical amplification phenomena

The same dynamical amplification phenomena as defined in [7.3.1] is applied in case of impact pressure on side shell as defined in Ch 7, Sec 1, [2.3].

The amplification coefficient is to be estimated as defined in [7.3.2].

7.4.2 Sandwich analysis

In case of sandwich laminate under impact pressure on side shell, only the core shear stress is to be taken into account.

As a general rule, the core shear stress, in N/mm², is to be obtained from the following formula:

$$\tau = \frac{0,6 \cdot p_{smin}}{4t} K_{DA}$$

where

- p_{smin} : Impact pressure on side shell, in kN/m², as defined in Ch 7, Sec 1, [2.3]
  with $K_2 = 1$
- t : Thickness of the sandwich (core + faceskins), in mm
- K_{DA} : Dynamical amplification coefficient, as defined in [7.3.2]].

The shear safety factor between the applied core shear stress as calculated in [7.4.2] and the theoretical shear breaking stress of the core estimated in Ch 12, Sec 2, [4], is to be in accordance with the appropriate safety factor defined in Ch 4, Sec 3, [5.4].

7.4.3 Monolithic analysis

The absolute value of the moments M_X and M_Y, induced by the impact pressure on side shell, are respectively the moment at the middle of side "b" and the moment at the middle of side "a". They are to be estimated, in kN.m per meter width, from the following formulae:

$$|M_X| = D_{11} \cdot A \cdot p_{Smin} \cdot \frac{10^{-6}}{8a^2} \cdot coef_X \cdot k_{S,X}$$

$$|M_Y| = D_{22} \cdot A \cdot p_{Smin} \cdot \frac{10^{-6}}{8b^2} \cdot coef_Y \cdot k_{S,Y}$$

Note 1: The sign of the moments are to be chosen in order to respect the traction and compression areas of the laminate under lateral pressure, as shown on Fig 3.

where:

- A : Parameter obtained from the following formula:

$$A = \frac{\beta \cdot a^4 \cdot 10^6}{7D_{11} + 4(D_{12} + 2D_{33})\alpha^2 + 7D_{22}\alpha^4} K_{DA}$$

- a : Side of the laminate panel in x direction, in m
- b : Side of the laminate panel in y direction, in m
- α : Aspect ratio, $\alpha = a/b$
- D_{11}, D_{12}, D_{22}, D_{33}: Global flexural rigidity matrix coefficients, as defined in Ch 12, Sec 4, [4.1.1], in N.mm²/mm

Note 2: These coefficients are to be calculated for the laminate with the same global axis X and Y.

- p_{Smin} : Impact pressure on side shell, in kN/m², as defined in Ch 7, Sec 1, [2.3]
- K_{DA} : Dynamical amplication coefficient, $K_{DA} = 1$
- β : Coefficient, equal to:

  if $a \le b$ $\quad \beta = 6,15\left(\frac{a}{b}\right)^{0,07}$

  if $a > b$ $\quad \beta = 6,15\left(\frac{b}{a}\right)^{0,07}$

  β is not less than 5,5
- $coef_X$, $coef_Y$: Reduction coefficients (without dimension), due to a non-uniform lateral pressure on the panel, equal to:
  - $coef_X = \frac{1}{(1+a)^2}$ if $0,6(1+a) \le b$

    $coef_X = 1$ if $0,6(1+a) > b$
  - $coef_Y = \frac{1}{(1+b)^2}$ if $0,6(1+b) \le a$

    $coef_Y = 1$ if $0,6(1+b) > a$
- $k_{S,X}$, $k_{S,Y}$: Reduction factor as defined in [7.2.1].

Shear forces T_{XZ} and T_{YZ}, induced by the lateral pressure, are respectively the shear force on side "a" and the shear force on side "b". They are to be estimated, in kN per meter width, from the following formulae:

$$T_{YZ} = 0,3 \frac{p_{Smin}}{\left(1 + \alpha^3 \frac{D_{22}}{D_{11}}\right)} K_{DA}$$

$$T_{XZ} = \alpha^3 \frac{D_{22}}{D_{11}} T_{YZ}$$

where

- $\alpha = a/b$: Aspect ratio
- a,b : Sides panel as defined in [7.4.3], in m
- D_{11}, D_{12}, D_{22}, D_{33}: As defined in [7.4.3], in N.mm²/mm
- p_{Smin} : As defined in [7.4.3], in kN/m²
- K_{DA} : As defined in [7.4.3].

Laminate panel stresses are to be checked according to Ch 12, Sec 4, [4], taking into account the values of flexural moments M_X and M_Y and the shear forces T_{XZ} and T_{YZ} as defined herebefore.

The safety coefficients between applied stresses and theoretical breaking stresses estimated in Ch 12, Sec 3, [5], are to be in accordance with the minimum appropriate safety coefficients defined in Ch 4, Sec 3, [5.4].