SECTION 3 PLATING

Symbols

E : Young's modulus, in N/mm², to be taken equal to:
- for steels in general:
  $E = 2,06.10^5$ N/mm²
- for stainless steels:
  $E = 1,95.10^5$ N/mm²
- for aluminium alloys:
  $E = 7,0.10^4$ N/mm²

1 General

1.1 Insert plates and doublers

1.1.1 A local increase in plating thickness is generally to be achieved through insert plates. Local doublers are normally only allowed for temporary repair.

2 Buckling check of plating

2.1 General

2.1.1 The requirements of this Article apply for the buckling check of plating subjected to in-plane compression stresses, acting on one or two sides, or to shear stress.

Rectangular plate panels are considered as being simply supported. For specific designs, other boundary conditions may be considered, at the Society's discretion, provided that the necessary information is submitted for review.

2.2 Loading principles

2.2.1 Panel loaded by compression/bending stress

See Fig 1.

2.2.2 Panel loaded by shear stress

See Fig 2.

2.2.3 Panel loaded by compression stress on 4 edges

See Fig 3.

2.3 Load model and calculation

2.3.1 Sign convention for normal stresses

The sign convention for normal stresses is as follows:
- tension: positive
- compression: negative.

2.3.2 As a rule, the normal and shear stress considered for buckling check of plating are the stresses determined by a direct calculation taking into account the global loads as defined in Part B, Chapter 6 and the strength characteristics of hull girder transverse sections as defined in Ch 4, Sec 4, [2].

2.3.3 The hull areas to be checked according to the requirements of the present section are:
- bottom and decks plating
- side shell plating, in the upper area below strength deck
- deck area around mast of monohull sailing yachts (buckling under compression stress on four edges)
- bottom and deck plating of cross deck of catamarans, in way of transverse primary bulkheads
- primary transverse bulkheads of catamarans (buckling under shear stress).

Figure 1 : Buckling of a simply supported rectangular plate panel subjected to compression and bending, with and without shear

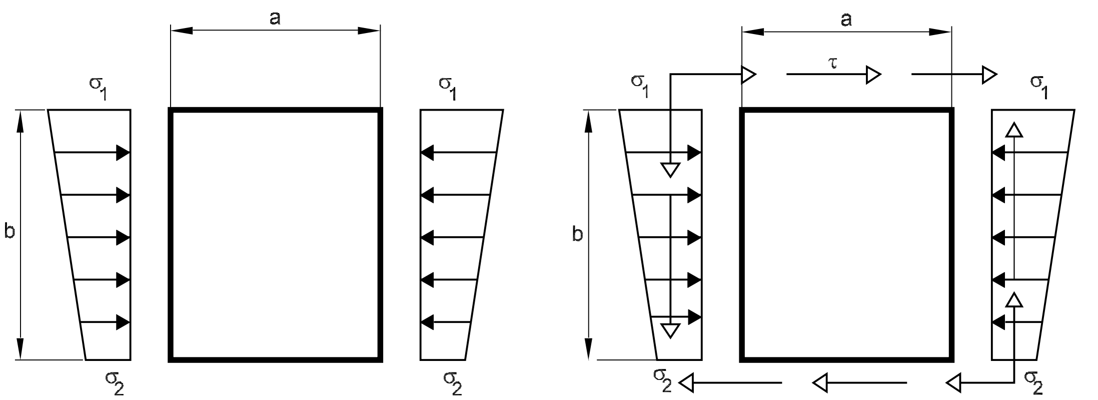


Figure 2 : Buckling of a simply supported rectangular plate panel subjected to shear

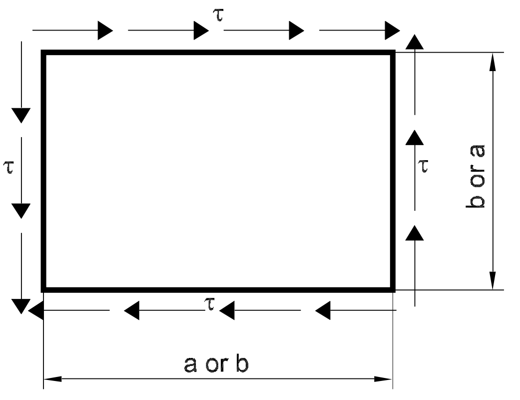
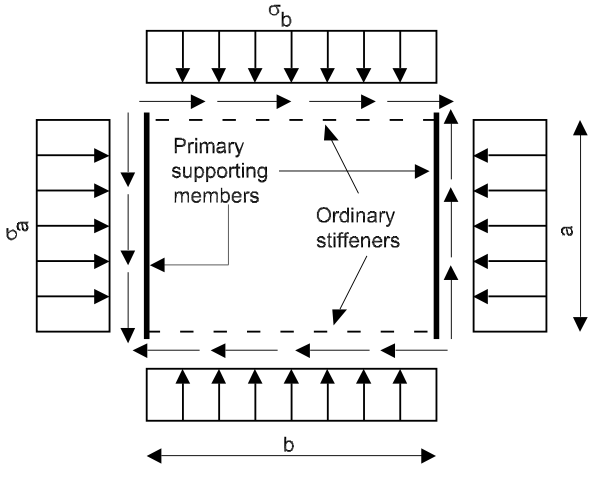


Figure 3 : Buckling of a simply supported rectangular plate panel subjected to bi-axial compression and shear



2.4 Critical stresses

2.4.1 Compression and bending for plane panel

The critical buckling stress is to be obtained, in N/mm², from the following formulae:

$$\sigma_c = \sigma_E \qquad \text{for } \sigma_E \le \frac{R_{p0,2}}{2}$$

$$\sigma_c = R_{p0,2}\left(1 - \frac{R_{p0,2}}{4\sigma_E}\right) \quad \text{for } \sigma_E > \frac{R_{p0,2}}{2}$$

where:

σ_E : Euler buckling stress, to be obtained, in N/mm², from the following formula:

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t}{b}\right)^2 K_1 \varepsilon 10^{-6}$$

$R_{p0,2}$: Minimum guaranteed yield stress, in N/mm², of the plating material, defined in Ch 4, Sec 3

t : Minimum thickness of the plate panel, in mm

a, b : Lengths, in m, of the sides of the panel, as shown in Fig 1and Fig 3

K_1 : Buckling factor defined in Tab 1

ε : Coefficient to be taken equal to:

- $\varepsilon = 1$ for $\alpha \ge 1$,
- $\varepsilon = 1,05$ for $\alpha < 1$ and side "b" stiffened by flat bar
- $\varepsilon = 1,10$ for $\alpha < 1$ and side "b" stiffened by bulb section
- $\varepsilon = 1,21$ for $\alpha < 1$ and side "b" stiffened by angle or T-section
- $\varepsilon = 1,30$ for $\alpha < 1$ and side "b" stiffened by primary supporting members.

$\alpha = a/b$

2.4.2 Shear for plane panel

The critical shear buckling stress is to be obtained, in N/mm², from the following formulae:

$$\tau_c = \tau_E \qquad \text{for } \tau_E \le \frac{R_{p0,2}}{2\sqrt{3}}$$

$$\tau_c = \frac{R_{p0,2}}{\sqrt{3}}\left(1 - \frac{R_{p0,2}}{4\sqrt{3}\,\tau_E}\right) \quad \text{for } \tau_E > \frac{R_{p0,2}}{2\sqrt{3}}$$

where:

τ_E : Euler shear buckling stress, to be obtained, in N/mm², from the following formula:

$$\tau_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t}{b}\right)^2 K_2 10^{-6}$$

K_2 : Buckling factor to be taken equal to:

$$K_2 = 5,34 + \frac{4}{\alpha^2} \qquad \text{for } \alpha > 1$$

$$K_2 = \frac{5,34}{\alpha^2} + 4 \qquad \text{for } \alpha \le 1$$

$R_{p0,2}$: Minimum guaranteed yield stress, in N/mm², of the plating material, defined in Ch 4, Sec 3

t : Minimum thickness of the plate panel, in mm.

a,b : Lengths, in m, of the sides of the panel, as shown in Fig 1 and Fig 3

$\alpha = a/b$

2.4.3 Bi-axial compression and shear for plane panel

The critical buckling stress $\sigma_{c,a}$ for compression on side "a" of the panel is to be obtained, in N/mm², from the following formula:

$$\sigma_{c,a} = \left(\frac{2,25}{\beta} - \frac{1,25}{\beta^2}\right) R_{p0,2}$$

where:

β : Slenderness of the panel, to be taken equal to:

$$\beta = 10^3 \frac{a}{t}\sqrt{\frac{R_{p0,2}}{E}}$$

without being taken less than 1,25.

t : Minimum thickness of the plate panel, in mm.

The critical buckling stress $\sigma_{c,b}$ for compression on side "b" of the panel is to be obtained, in N/mm², from the formulae in [2.4.1].

The critical shear buckling stress is to be obtained, in N/mm², from the formulae in [2.4.2].

Table 1 : Buckling factor K_1 for plate panels

Load pattern	Aspect ratio	Buckling factor K_1
$0 \le \psi \le 1$	$\alpha \ge 1$ $\alpha < 1$	$\frac{8,4}{\psi + 1,1}$ $\left(\alpha + \frac{1}{\alpha}\right)^2 \frac{2,1}{\psi + 1,1}$
$-1 < \psi < 0$		$(1+\psi)K_1' - \psi K_1'' + 10\psi(1+\psi)$
$\psi \le -1$	$\alpha\frac{1-\psi}{2} \ge \frac{2}{3}$	$23,9\left(\frac{1-\psi}{2}\right)^2$
	$\alpha\frac{1-\psi}{2} < \frac{2}{3}$	$\left(15,87 + \frac{1,87}{\left(\alpha\frac{1-\psi}{2}\right)^2} + 8,6\left(\alpha\frac{1-\psi}{2}\right)^2\right)\left(\frac{1-\psi}{2}\right)^2$

Note 1:

$\psi = \frac{\sigma_2}{\sigma_1}$

K_1' : Value of K_1 calculated for $\psi = 0$
K_1'' : Value of K_1 calculated for $\psi = -1$

2.5 Checking criteria

2.5.1 The safety factor between the critical stress as calculated in [2.4] and the actual compression and shear stress as calculated in [2.3.2] is to be not less than the minimum safety factor defined inCh 4, Sec 3, Tab 2 and Ch 4, Sec 3, Tab 4.

3 Plating sustaining lateral pressure

3.1 General

3.1.1 Load point

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

3.2 Plating scantling

3.2.1 As a rule, rule thickness of plates sustaining lateral pressure is given, in mm, by the formulae:

$$t = 22,4 \cdot coeff \cdot \mu \cdot s \cdot \sqrt{\frac{p}{\sigma_{ad}}}$$

where:

coeff : Coefficient equal to:

- In general case, coeff = 1
- In case of impact pressure on side shells (loads distributed on a part only of the elementary plate panel), as given in Ch 7, Sec 1, [2.3]:
  - coeff = 1, if

    $\frac{\ell}{0,6} \le 1 + s$
  - coeff = $(1+s)^{-1/2}$, if

    $\frac{\ell}{0,6} > 1 + s$

s : Smaller side, in m, of the elementary plate panel

μ : Aspect ratio coefficient of the elementary plate panel, equal to:

$$\sqrt{1,1 - \left(0,5 \cdot \frac{s^2}{\ell^2}\right)}$$

without being taken more than 1, where:

ℓ : Longer side, in m, of the elementary plate panel

p : Local pressure, in kN/m², given in Ch 7, Sec 1 for bottom, sides, decks and superstructures, and in Ch 7, Sec 2 for bottom slamming loads.

σ_{ad} : Rule admissible stress, in N/mm², defined in Ch 4, Sec 3, Tab 2 or Ch 4, Sec 3, Tab 4 whatever the case.