SECTION 10 PILLARS

1 General

1.1 Application

1.1.1 The requirements of this Section apply to pillars (independent profiles or bulkheads stiffeners) made of steel or aluminium alloys.

1.1.2 The present Section deals with the buckling check of the pillars.

The general requirements relating to pillars arrangement are given in Ch 8, Sec 7, [3].

2 Pillars made of steel

2.1 Buckling of pillars subjected to compression axial load

2.1.1 Compression axial load

Where pillars are aligned, the compression axial load F_A, in kN, is equal to the sum of loads supported by the pillar considered and those supported by the pillars located above, multiplied by a weighting factor.

The weighting factor depends on the relative position of each pillar with respect to that considered.

The compression axial load in the pillar is to be obtained, in kN, from the following formula:

$$F_A = A_D p_s + \sum_i r Q_i$$

where:

A_D : Area, in m², of the portion of the deck or the platform supported by the pillar considered

p_s : Pressure on deck, in kN/m², as defined in Ch 7, Sec 1, [3]

r : Coefficient which depends on the relative position of each pillar above the one considered, to be taken equal to:

- for the pillar immediately above that considered:

  $r = 0,9$

- for the ith pillar of the line above the pillar considered, to be taken not less than 0,478

  $r = 0,9^i$

Q_i : Vertical load, in kN, from the ith pillar of the line above the pillar considered, if any.

2.1.2 Critical column buckling stress of pillars

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

$$\sigma_{cB} = \sigma_{E1} \quad \text{for} \quad \sigma_{E1} \le \frac{R_{p0,2}}{2}$$

$$\sigma_{cB} = R_{p0,2}\left(1 - \frac{R_{p0,2}}{4\sigma_{E1}}\right) \quad \text{for} \quad \sigma_{E1} > \frac{R_{p0,2}}{2}$$

where:

σ_{E1} : Euler column buckling stress, to be obtained, in N/mm², from the following formula:

$$\sigma_{E1} = \pi^2 E \frac{I}{A(f\ell)^2} 10^{-4}$$

I : Minimum moment of inertia, in cm⁴, of the pillar

A : Cross-sectional area, in cm², of the pillar

ℓ : Span, in m, of the pillar

f : Coefficient, to be obtained from Tab 1

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

$R_{p0,2}$: Minimum guaranteed yield stress, in N/mm², as defined in Ch 4, Sec 3.

2.1.3 Critical local buckling stress of built-up pillars

The critical local buckling stress of built-up pillars is to be obtained, in N/mm², from the following formulae:

$$\sigma_{cL} = \sigma_{E2} \quad \text{for} \quad \sigma_{E2} \le \frac{R_{p0,2}}{2}$$

$$\sigma_{cL} = R_{p0,2}\left(1 - \frac{R_{p0,2}}{4\sigma_{E2}}\right) \quad \text{for} \quad \sigma_{E2} > \frac{R_{p0,2}}{2}$$

where:

σ_{E2} : Euler local buckling stress, to be taken equal to the lesser of the values obtained, in N/mm², from the following formulae:

- $\sigma_{E2} = 78\left(\frac{E}{206000}\right)\left(\frac{t_W}{h_W}\right)^2 10^4$

- $\sigma_{E2} = 32\left(\frac{E}{206000}\right)\left(\frac{t_F}{b_F}\right)^2 10^4$

h_W : Web height of built-up section, in mm

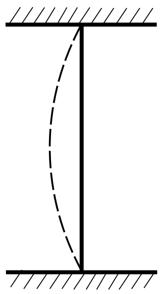
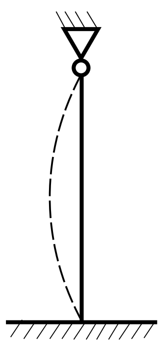
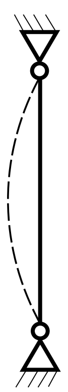
t_W : Web thickness of built-up section, in mm

b_F : Face plate width of built-up section, in mm

t_F : Face plate thickness of built-up section, in mm

$R_{p0,2}$: Minimum guaranteed yield stress, in N/mm², as defined in Ch 4, Sec 3.

Table 1 : Coefficient f

Boundary conditions of the pillar	f
Both ends fixed 	0,5
One end fixed, one end pinned 	$\frac{\sqrt{2}}{2}$
Both ends pinned 	1,0

2.1.4 Critical local buckling stress of pillars having hollow rectangular section

The critical local buckling stress of pillars having hollow rectangular section is to be obtained, in N/mm², from the following formulae:

$$\sigma_{cL} = \sigma_{E3} \quad \text{for} \quad \sigma_{E3} \le \frac{R_{p0,2}}{2}$$

$$\sigma_{cL} = R_{p0,2}\left(1 - \frac{R_{p0,2}}{4\sigma_{E3}}\right) \quad \text{for} \quad \sigma_{E3} > \frac{R_{p0,2}}{2}$$

where:

σ_{E3} : Euler local buckling stress, to be taken equal to the lesser of the values obtained, in N/mm², from the following formulae:

- $\sigma_{E3} = 78\left(\frac{E}{206000}\right)\left(\frac{t_2}{b}\right)^2 10^4$
- $\sigma_{E3} = 78\left(\frac{E}{206000}\right)\left(\frac{t_1}{h}\right)^2 10^4$

b : Length, in mm, of the shorter side of the section

t_2 : Web thickness, in mm, of the shorter side of the section

h : Length, in mm, of the longer side of the section

t_1 : Web thickness, in mm, of the longer side of the section

$R_{p0,2}$: Minimum guaranteed yield stress, in N/mm², as defined in Ch 4, Sec 3.

2.1.5 Checking criteria

The scantlings of steel pillars loaded by the compression axial load F_A defined in [2.1.1] are to comply with the formulae in Tab 2.

3 Pillars made of aluminium alloys

3.1 Buckling of pillars subjected to compression axial load

3.1.1 Compression axial load

Where pillars are aligned, the compression axial load F_A, in kN, is equal to the sum of loads supported by the pillar considered and those supported by the pillars located above, multiplied by a weighting factor.

The weighting factor depends on the relative position of each pillar with respect to that considered.

The compression axial load in the pillar is to be obtained, in kN, from the following formula:

$$F_A = A_D p_s + \sum_i r Q_i$$

where:

A_D : Area, in m², of the portion of the deck or the platform supported by the pillar considered

p_s : Pressure on deck, in kN/m², as defined in Ch 7, Sec 1, [3]

r : Coefficient which depends on the relative position of each pillar above the one considered, to be taken equal to:

- for the pillar immediately above that considered:

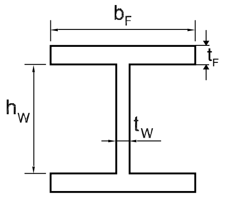
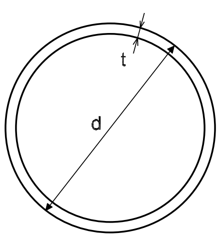
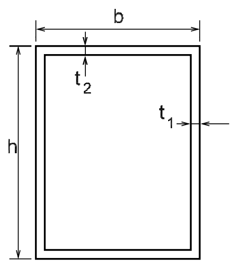
  $r = 0,9$

- for the i^{th} pillar of the line above the pillar considered, to be taken not less than 0,478:

  $r = 0,9^i$

Q_i : Vertical load, in kN, from the i^{th} pillar of the line above the pillar considered, if any.

Table 2 : Buckling check of steel pillars subject to compression axial load

Pillar cross-section	Column buckling check	Local buckling check	Geometric condition
Built-up 	$\frac{\sigma_{cB}}{SF} \geq 10\frac{F_A}{A}$	$\frac{\sigma_{cL}}{SF} \geq 10\frac{F_A}{A}$	$\frac{b_F}{t_F} \leq 40$
Hollow tubular 	$\frac{\sigma_{cB}}{SF} \geq 10\frac{F_A}{A}$	Not required	$\frac{d}{t} \leq 55$ $t \geq 5{,}5$ mm
Hollow rectangular 	$\frac{\sigma_{cB}}{SF} \geq 10\frac{F_A}{A}$	$\frac{\sigma_{cL}}{SF} \geq 10\frac{F_A}{A}$	$\frac{b}{t_2} \leq 55$ $\frac{h}{t_1} \leq 55$ $t_1 \geq 5{,}5$ mm $t_2 \geq 5{,}5$ mm

Note 1:

σ_{cB} : Critical column buckling stress, in N/mm^2, defined in [2.1.2]

σ_{cL} : Critical local buckling stress, in N/mm^2, defined in [2.1.3] for built-up section or in [2.1.4] for hollow rectangular section

SF : Safety factor, to be taken equal to:
- SF = 2,00 for column buckling
- SF = 1,05 for local buckling

F_A : Compression axial load in the pillar, in kN, defined in [2.1.1]

A : Sectional area, in cm^2, of the pillar.

3.1.2 Critical column buckling stress of pillars

The critical column buckling stress of pillars made of aluminium alloy is to be obtained, in N/mm^2, from the following formula:

$$\sigma_{cB} = 2 \cdot R_{p0,2}' \cdot C$$

where:

$R_{p\,0,2}'$: Minimum as-welded guaranteed yield stress of aluminium alloy used, in N/mm^2

C : Coefficient as given in Fig 1, and equal to:
- for alloys without heat treatment:

$$\frac{1}{1 + \lambda + \sqrt{(1 + \lambda)^2 - (0,68 \cdot \lambda)}}$$

- for alloys with heat treatment:

$$\frac{1}{1 + \lambda + \sqrt{(1 + \lambda)^2 - (3,2 \cdot \lambda)}}$$

Where:

$$\lambda = \frac{R_{p0,2}'}{\sigma_E}$$

$$\sigma_E = \frac{69,1}{\left(\frac{f \cdot \ell}{r}\right)^2}$$

ℓ : Length of pillar, in m

r : Minimum radius of gyration, in cm, of the pillar cross section, equal to:

$$r = \sqrt{\frac{I}{A}}$$

I : Minimum moment of inertia, in cm^4, of the pillar cross section

A : Area, in cm^2, of the pillar cross section

f : Coefficient given in Tab 3 depending on the conditions of fixing of the pillar.

3.1.3 Critical local buckling stress

The critical local buckling stress of pillars made of aluminium alloy is to be obtained, in N/mm^2, from the following formulae:

$$\sigma_{cL} = 2 \cdot R_{p0,2}' \cdot C$$

where:

C : Coefficient as defined in [3.1.4]

$$\lambda = \frac{R_{p0,2}'}{\sigma_{E1}}$$

$R_{p\,0,2}'$: Minimum as-welded guaranteed yield stress of aluminium alloy used, in N/mm^2

σ_{E1} : Stress defined below.

- For tubular pillars with a rectangular cross-section, the stress σ_{E1}, in N/mm^2, is given by:

$$\sigma_{E1} = 252000 \cdot \left(\frac{t}{b}\right)^2$$

where:

b : Greatest dimension of the cross-section, in mm

t : Plating thickness, in mm

- For tubular pillars with a circular cross-section, the stress σ_{E1}, in N/mm^2, is given by:

$$\sigma_{E1} = 43000 \cdot \frac{t}{D}$$

D : Outer diameter, in mm

t : Plating thickness, in mm.

- For pillars with I cross-sections, the stress σ_{E1}, in N/mm^2, is the lesser of the following values:

$$\sigma_{E1} = 252000 \cdot \left(\frac{t_w}{h_w}\right)^2$$

$$\sigma_{E1} = 105000 \cdot \left(\frac{t_f}{b_f}\right)^2$$

where:

t_w : Web thickness, in mm

h_w : Web height, in mm

t_f : Thickness of face plate, in mm

h_f : Width of face plate, in mm.

3.1.4 Checking criteria

The scantlings of aluminium pillars loaded by the compression axial load F_A defined in [3.1.1] are to comply with the formulae in Tab 4.

Table 3 : Coefficient f

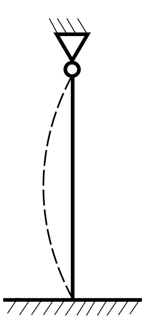
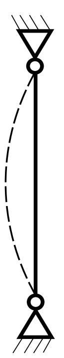
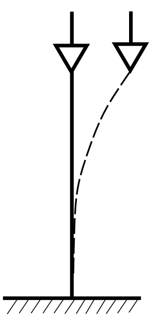
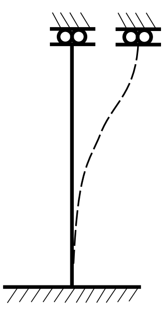
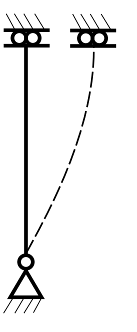
Conditions of fixity					
f	0,7	1,0	2,0	1,0	2,0

Figure 1 : Coefficient C

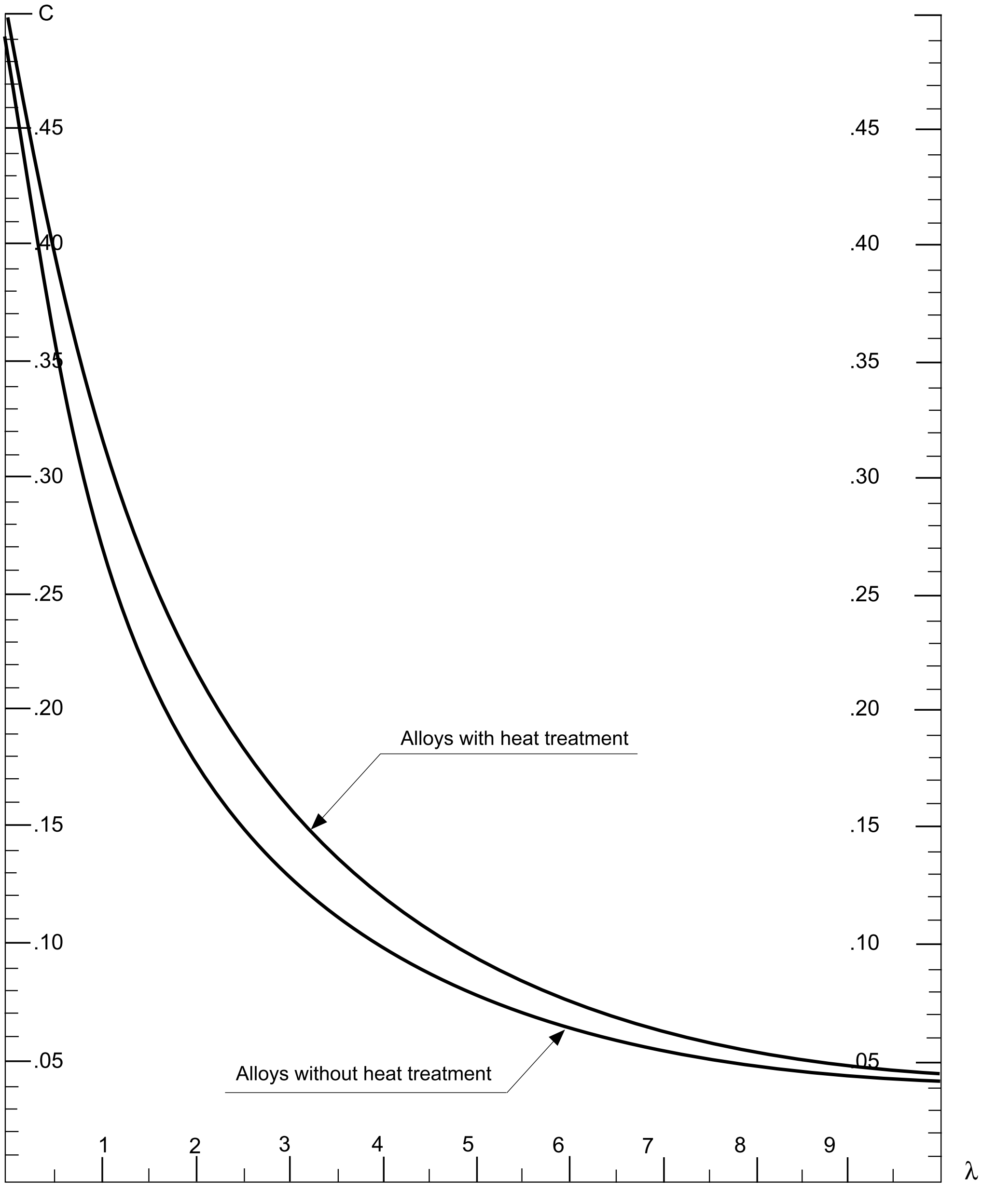
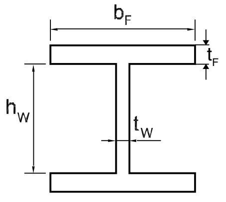
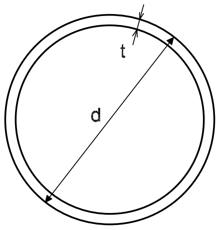
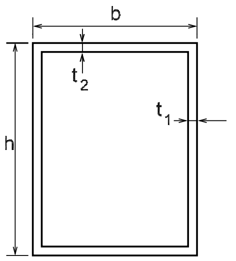


Table 4 : Buckling check of aluminium pillars subject to compression axial load

Pillar cross-section	Column buckling check	Local buckling check
Built-up 	$\frac{\sigma_{cB}}{SF} \geq 10\frac{F_A}{A}$	$\frac{\sigma_{cL}}{SF} \geq 10\frac{F_A}{A}$
Hollow tubular 	$\frac{\sigma_{cB}}{SF} \geq 10\frac{F_A}{A}$	$\frac{\sigma_{cL}}{SF} \geq 10\frac{F_A}{A}$
Hollow rectangular 	$\frac{\sigma_{cB}}{SF} \geq 10\frac{F_A}{A}$	$\frac{\sigma_{cL}}{SF} \geq 10\frac{F_A}{A}$

Note 1:

σ_{cB} : Critical column buckling stress, in N/mm², defined in [2.1.2]

σ_{cL} : Critical local buckling stress, in N/mm², defined in [2.1.3] for built-up section and circular or rectangular hollow section

SF : Safety factor, to be taken equal to:

- SF = 1,6+ 0,5 (fℓ/r) for column buckling
- SF = 1 for local buckling

F_A : Compression axial load in the pillar, in kN, defined in [2.1.1]

A : Sectional area, in cm², of the pillar.