The Second Generation Eurocodes

Key changes and benefits through design examples

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EN 1999 ‘Eurocode 9: Design of aluminium structures- Part 1-1: General rules’

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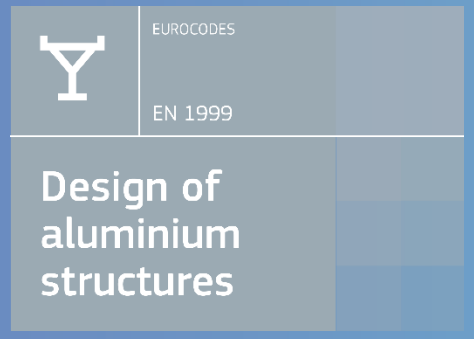
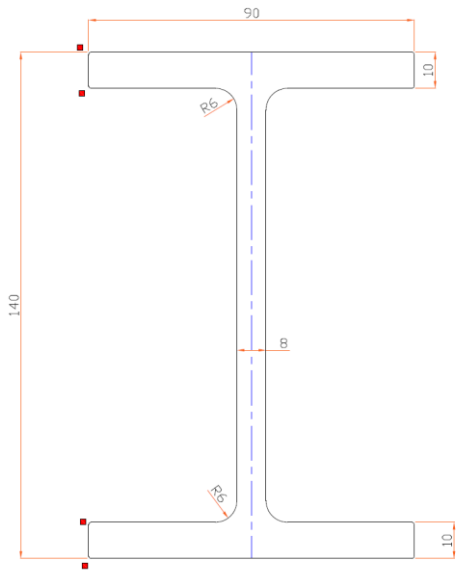


Serviceability check

Dead load: g = 1.50 kN/m

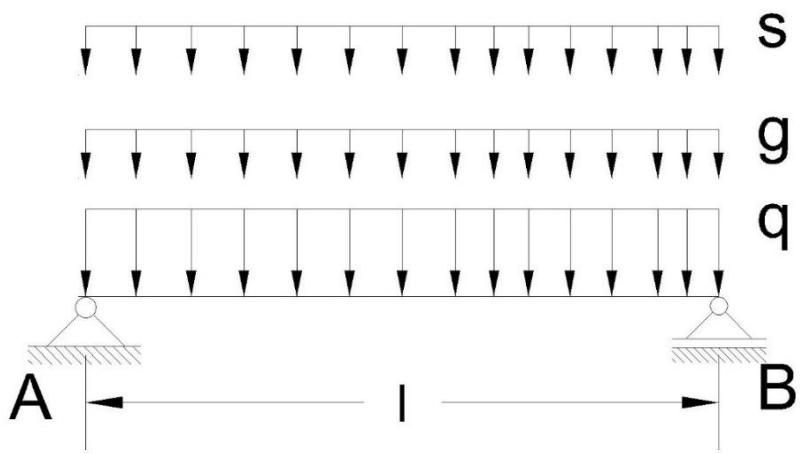
Imposed roof load: q = 2.80 kN/m

Snow load: s = 1.80 kN/m



EN AW 6005-T6

l=2.8m



Cosmos Aluminium profile

Serviceability limit state

- Serviceability limit state- Load combination

$$E_d = {'\gamma_{\mathrm{G}} G_k}' + {'\gamma_{\mathrm{Q}} Q_{k,1}}' + {'\gamma_{\mathrm{Q}} \psi_{0.2} Q_{k,2}}' = 1.00 \times 1.5 + 1.00 \times 2.8 + 0.7 \times 1.00 \times 1.80 \Rightarrow$$

$$E_d = 5.56\ kN/m$$

- Maximum deflection w

  Simply supported beam/ Uniform distributed load

$$w = \frac{5 \times q \times L^4}{384 \times E \times I} \longrightarrow w = \frac{5 \times E_d \times L^4}{384 \times E \times I_{yy}}$$

Limits

Limiting deflections

Element	Recommended deflection limit (see Note)
Cantilevers carrying floors	$L_s/180$
Beams carrying plaster or other brittle finish	$L_s/360$
Purlins and sheeting rails:	
a) under dead load only	$L_s/200$
b) under worst combination of dead, imposed, wind and snow loads	$L_s/100$
Curtain wall mullions and transoms:	
a) single glazed	$L_s/175$
b) double glazed	$L_s/250$
Tops of columns: horizontal deflection	$L_s/300$

NOTE L_s *is the length between supports.*

$$w_{max} = \frac{l}{360} = \frac{2800}{360} = 7.7\ mm$$

Moment of inertia

- Required moment of inertia

$$I_{yy} = \frac{5 \times E_d \times L^4}{384 \times E \times w} = \frac{5 \times 8.9 \times 4000^4}{384 \times 70.000 \times 7.77} \Rightarrow \quad I_{yy-req} = 8.255 \times 10^6 mm^4$$

- Cross section moment of inertia

$$I_{yy-I140} = 8.82438 \times 10^6 mm^4$$

Material

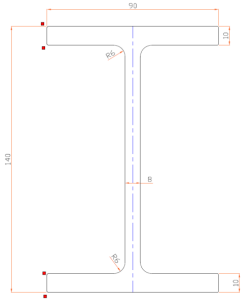
- Material properties

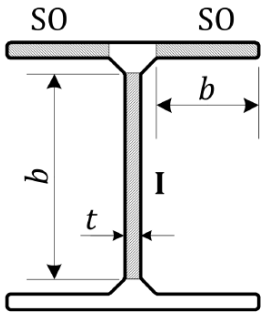
EN AW 6005A-T6/ Class A

6005A	EP/O		$10< t \leq 25$	200	250	8	115	165	0,58	0,66	A	20
	EP/H, ET	T6	$t \leq 5$	**215**	**255**	8			0,53	0,65	A	26
			$5 < t \leq 10$	**200**	**250**	8			0,58	0,66	A	20

$$\varepsilon = \sqrt{\frac{250}{200}} \Rightarrow \varepsilon = 1.12$$

Local buckling





- Outstand $\beta = \frac{b_f}{t_f} = \frac{37}{10} = 3.7$

- Slenderness limit

$\beta_3 = 6 \times \varepsilon = 6 \times 1.12 = 6.72$

$\beta_2 = 4.5 \times \varepsilon = 4.5 \times 1.12 = 5.04$

$\beta \leq 5.04 \rightarrow Flange\ Class\ 2$

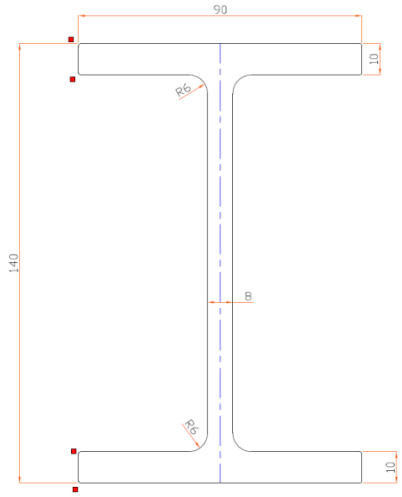
Table 8.1 — Slenderness parameters β_2/ε and β_3/ε [a]

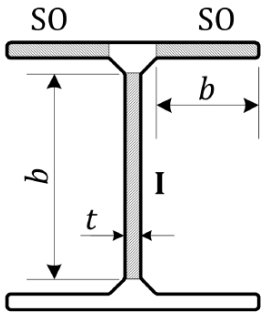
	Buckling Class according to Table 5.3 and Table 5.4	Internal part		Outstand part	
		β_2/ε	β_3/ε	β_2/ε	β_3/ε
Without welds	A	16	22	4,5	6
	B	16	20	4,5	5,5
	C	16	18	4,5	5
With welds	A	13	18	4,0	5
	B	13	16,5	3,8	4,5
	C	13	15	3,5	4

[a] with for (a): $\varepsilon = \sqrt{\frac{250}{f_o}}$ with f_o in MPa

EN 1999-1-1:2023/ Table 8.1

Local buckling





- Web $\beta = 0.4 \times \frac{h_w}{t_w} = \frac{112}{8} = 5.6$

- Slenderness limit

$\beta_3 = 22 \times \varepsilon = 22 \times 1.12 = 24.64$

$\beta_2 = 16 \times \varepsilon = 16 \times 1.12 = 17.92$

$\beta \leq 17.92 \rightarrow Flange\ class\ 2$

Table 8.1 — Slenderness parameters β_2/ε and β_3/ε [a]

	Buckling Class according to Table 5.3 and Table 5.4	Internal part		Outstand part	
		β_2/ε	β_3/ε	β_2/ε	β_3/ε
Without welds	A	16	22	4,5	6
	B	16	20	4,5	5,5
	C	16	18	4,5	5
With welds	A	13	18	4,0	5
	B	13	16,5	3,8	4,5
	C	13	15	3,5	4

[a] with for (a): $\varepsilon = \sqrt{\frac{250}{f_o}}$ with f_o in MPa

EN 1999-1-1:2023/ Table 8.1

Ultimate limit state

Verification against bending moment

$$E_d = {'\gamma_{\mathrm{G}} G_k}' + {'\gamma_{\mathrm{Q}} Q_{k,1}}' + {'\gamma_{\mathrm{Q}} \psi_{0.2} Q_{k,2}}' = 1.35 \times 1.5 + 1.50 \times 2.8 + 0.5 \times 1.50 \times 1.80 \Rightarrow$$

$$E_d = 7.575\ kN/m$$

$$\mathrm{M}_{Ed} = \mathrm{M}_{max} = \frac{q \times l^2}{8} = \frac{7.575 \times 2.8^2}{8} \Rightarrow M_{Ed} = 7.4235\ kNm$$

Simplified procedure

Alternative to the general procedure

$$N_{Rd} = \frac{\rho_{min} \times A_g \times f_o}{\gamma_{M1}}$$

$$M_{Rd} = \frac{\rho_{min} \times W_{el} \times f_o}{\gamma_{M1}}$$

EN1999-1-1:2023/ 8.4

Reduction factor ρ

ρ_{min} reduction factor ρ_c according to EN1999-1-1: 2023/ 8.1.5 for the most slender part of the cross-section, e.g. the part with the largest value of $(\beta_3 - \beta)/(\beta_3 - \beta_2)$,

β: slenderness parameter for the most critical section part (EN1999-1-1:2023/ 8.1.4.3)

β_2, β_3: limiting values for that same part (EN1999-1-1:2023/ Table 8.1)

A_g area of the gross cross-section

W_{el} section modulus of the gross cross-section

f_o characteristic value of strength (EN1999-1-1: 2023/ 8.1.2)

γ_{M1} partial factor (EN1999-1-1: 2023/ 8.1.3)

Bending moment resistance

If $\beta \leq \beta_3$ for all cross-section parts then ρ_{min} should be taken equal to 1.

$$\beta = \frac{b_f}{2 \times t_f} = \frac{180}{2 \times 12} = 7.5 = \beta_3 \rightarrow$$ ρ_{min}=1

$$\mathrm{M}_{Rd} = \frac{\rho_{min} \times W_{el} \times f_o}{\gamma_{M1}} = \frac{1.00 \times W_{el} \times 200}{1.1} = 111\ kNm >$$ $76.0725\ kNm$

Thank you!