Steel Design to Eurocode 3

Local Buckling and Cross-Section Classification

In Eurocode 3 you will need to refer to the following clauses when classifying a section and determining the cross-sectional resistance:

- Clause 5.5 covers the cross section classification
- Clauses 6.1 and 6.2 covers the cross-sectional resistance

Sections with slender webs or flanges will be more susceptible to local buckling, where the element will fail before the design strength is reached. Eurocode 3 takes into account the effects of local through the process of cross section classification.

Classes

BS 5950	EC3
Plastic	Class 1
Compact	Class 2
Semi-compact	Class 3
Slender	Class 4

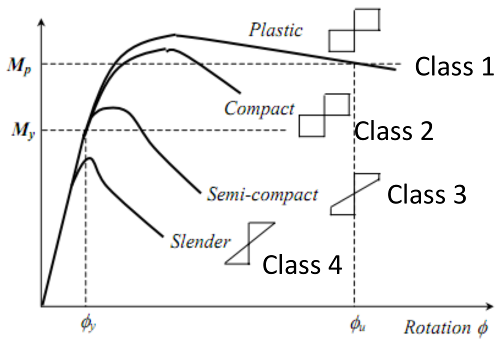


Image Source: http://www.steel-insdag.org/new/pdfs/Chapter8.pdf

Similarly to BS 5950, cross sections will be placed into one of four behaviour classes. Class 1 is the least susceptible to local buckling and class 4 is the most susceptible.

The classification of a section will depend mainly on:

- The material yield strength, f_y
- c/t ratio

Eurocode 3 defines the classes in Clause 5.5.2:

Class 1 cross-sections are those which can form a plastic hinge with the rotation capacity required from plastic analysis without reduction of the resistance.

Class 2 cross-sections are those which can develop their plastic moment resistance, but have limited rotation capacity because of local buckling.

Class 3 cross-sections are those in which the stress in the extreme compression fibre of the steel member assuming an elastic distribution of stresses can reach the yield strength, but local buckling is liable to prevent development of the plastic moment resistance.

Class 4 cross-sections are those in which local buckling will occur before the attainment of yield stress in one or more parts of the cross-section.

Limits

The limits between the classes depend on the ε factor which is calculated using f_y, the yield strength of the steel.

ε Factor

BS 5950	EC3
$\varepsilon = (275/p_y)^{0.5}$	$\varepsilon = (235/f_y)^{0.5}$

Values of ε are given at the bottom of Table 5.2:

f_y	235	275	355	420	460
ε	1.00	0.92	0.81	0.75	0.71

EN 1993-1-1 Table 5.2

f_y Yield Strength

The UK National Annex says that material properties should be taken from the product standards.

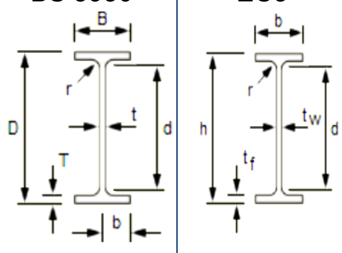
Extract from EN 10025-2 - f_y (yield strength) values for hot rolled steel:

Steel Grade	f_y (N/mm^2)			
	nominal thickness of element, t (mm)			
	t≤16	16< t ≤ 40	40 < t ≤ 63	63 < t ≤ 80
S 275	275	265	255	245
S 355	355	345	335	325

EN 10025-2 (Table 7)

c/t Width-to-Thickness Ratio

The width-to-thickness ratios differ in EC3 differs from BS 5950:

	BS 5950	EC3
		
Outstand Flange	b = B/2	c = (b – t_w – 2 r)/2
Internal Compression Part	d = D – 2 T – 2 r	c = h – 2 t_f – 2 r

Appropriate values of c and t are defined at the top of Table 5.2 for different types of sections.

Table 5.2

Internal compression parts and outstand flanges are assessed against the limiting width to thickness ratios for each class. The limits are provided in table 5.2.

Table 5.2 is made up of three sheets:

Sheet 1 – Internal Compression Parts

Sheet 2 – Outstand Flanges

Sheet 3 – Angles and Tubular Sections

Cross-section Classification

Class 1: Plastic

		BS (Table 11)	EC3 (Table 5.2)
Limits	Flange outstand	b/T = < 9 ε	c/t_f = < 9 ε
	Web in bending	d/t = < 80 ε	d/t_w = < 72 ε
	Web in compression		d/t_w = < 33 ε

Class 2: Compact

		BS (Table 11)	EC3 (Table 5.2)
Limits	Flange outstand	b/T = < 10 ε	c/t_f = < 10 ε
	Web in bending	d/t = < 100 ε	d/t_w = < 83 ε
	Web in compression		d/t_w = < 38 ε

Class 3: Semi-compact

		BS (Table 11)	EC3 (Table 5.2)
Limits	Flange outstand	b/T = < 15 ε	c/t_f = < 14 ε
	Web in bending	d/t = < 120 ε	d/t_w = < 142 ε
	Web in compression		d/t_w = < 42 ε

Class 4: Slender

An element that doesn't meet the class 3 limits should be taken as a class 4 section. Effective widths are assigned to Class 4 compression elements to make allowance for the reduction in resistance as a result of local buckling

To calculate the effective width of a Class 4 section, refer to the relevant section in the Eurocodes:

Section Type	Reference
Cold-formed sections	EN 1993-1-3
Hot-rolled and fabricated section	EN 1993-1-5
CHS	EN 1993-1-6

Overall Cross-Section Classification

Clause 5.5.2(6) states that a cross-section is classified according to the highest (least favourable) class of its compression parts.

Summary

1. Determine f_y (UK NA recommends you use the product standards)
2. Determine ε from Table 5.2
3. Substitute the value of ε into the class limits in Table 5.2 to work out the class of the flange and web

	Flange outstand limiting value, c/t_f	Web in bending limiting value, d/t_w
Class 1	9 ε	72 ε
Class 2	10 ε	83 ε
Class 3	14 ε	124 ε
Class 4	If it does not meet Class 3 requirements, the section is classified as Class 4	

4. Take the least favourable class from the flange and web results