Structural Steel and Timber Design SAB3233

Topic 5 Cross-section classification

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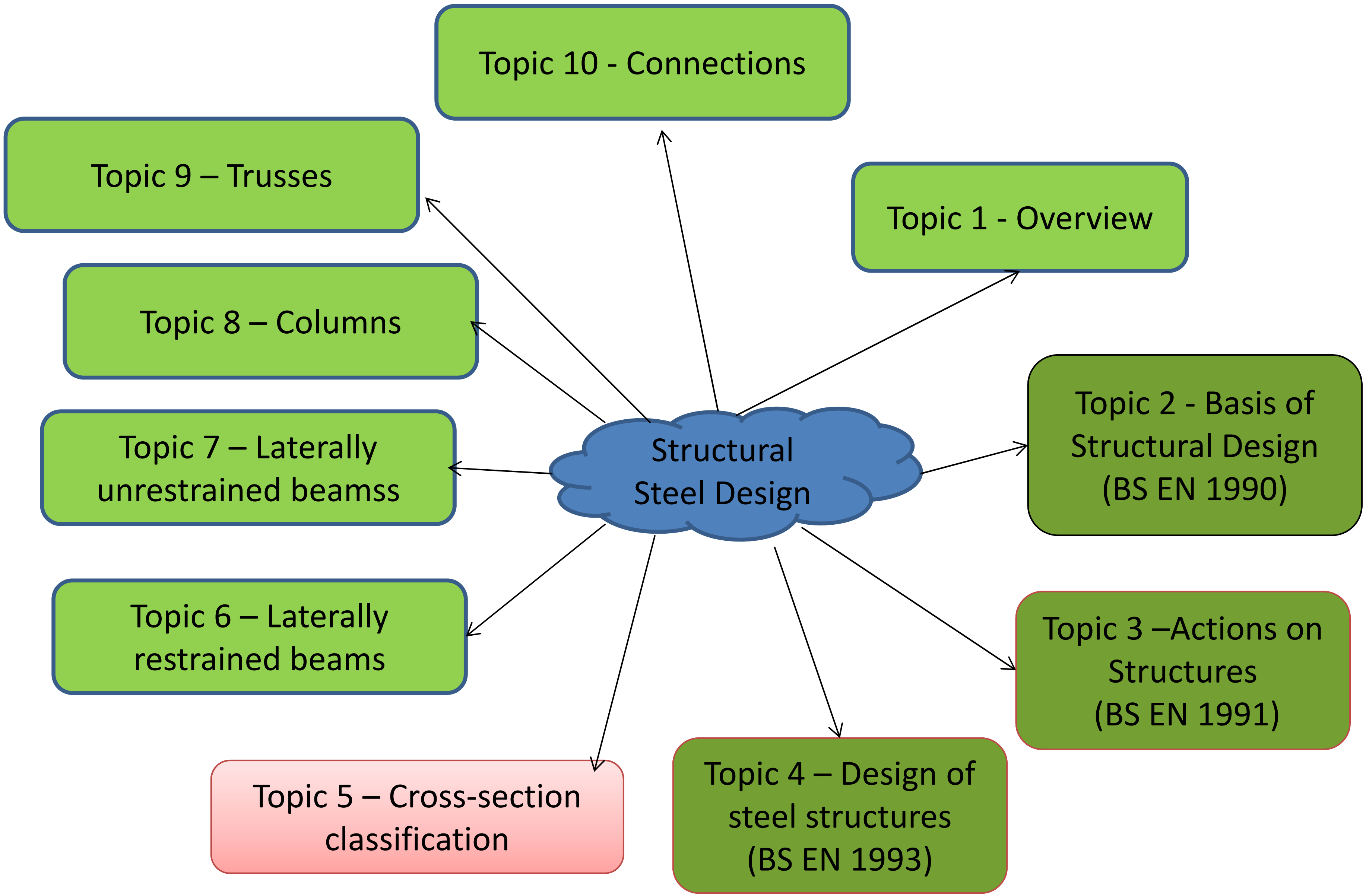
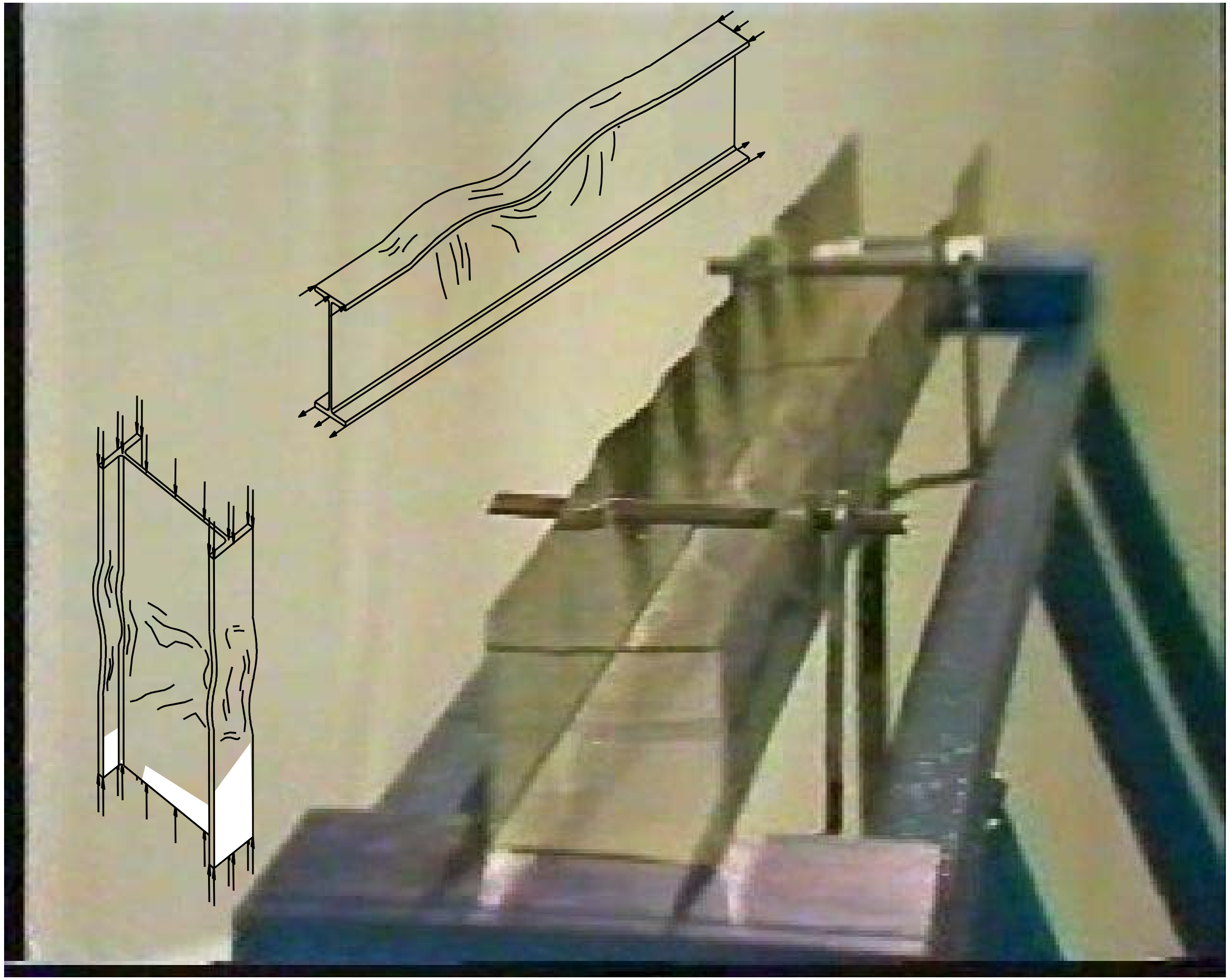

Topic 10 - Connections
Topic 9 – Trusses
Topic 1 - Overview
Topic 8 – Columns
Topic 2 - Basis of Structural Design (BS EN 1990)
Topic 7 – Laterally unrestrained beamss
Structural Steel Design
Topic 6 – Laterally restrained beams
Topic 3 –Actions on Structures (BS EN 1991)
Topic 4 – Design of steel structures (BS EN 1993)
Topic 5 – Cross-section classification

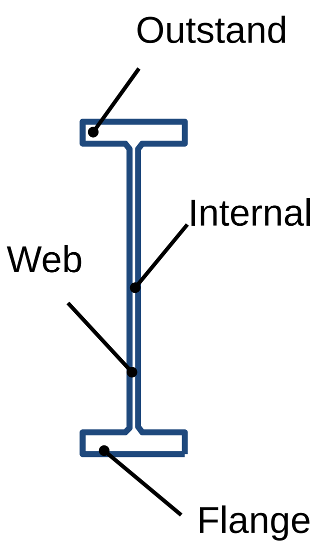


Basis of section classification

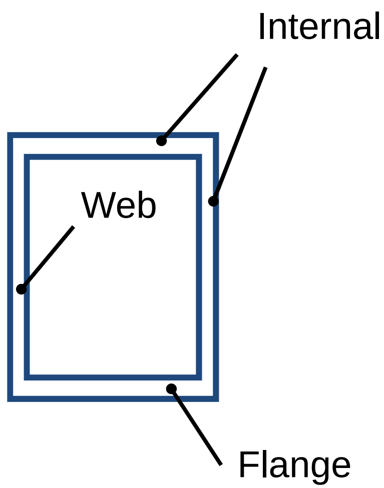
Rolled or welded sections may be considered an assembly of individual plate elements

Some are outstand
- flanges of I beams
- legs of angles and Tees

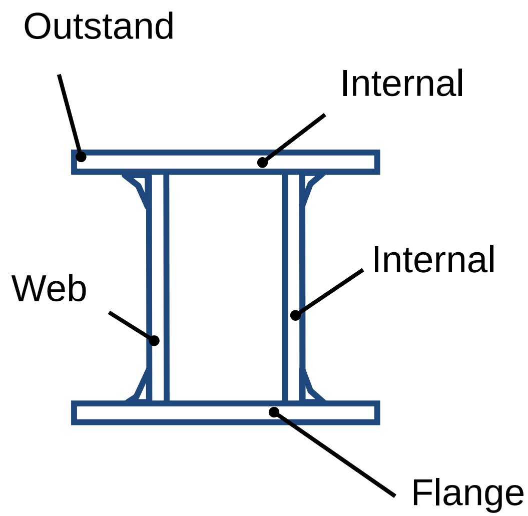
Some are internal
- webs of open beams
- flanges of boxes



Rolled I-section



Hollow section



Welded box section

Basis of section classification

- As the plate elements are relatively thin, when loaded in compression they may buckle locally
- The tendency of any plate element within the cross section to buckle may limit the axial load carrying capacity, or the bending resistance of the section, by preventing the attainment of yield.
- Avoidance of premature failure arising from the effects of local buckling may be achieved by limiting the width-to-thickness ratio for individual elements within the cross section.

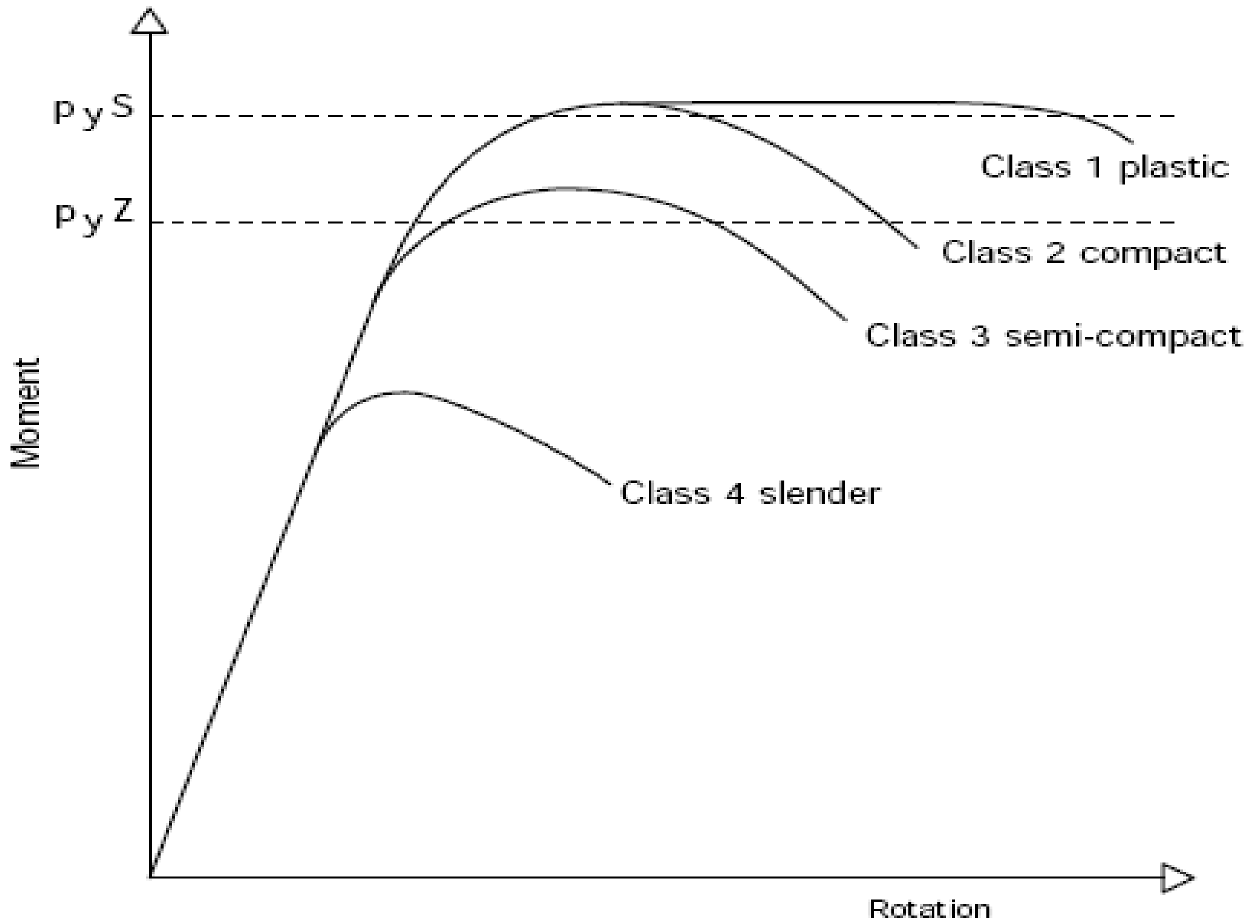
This is the basis of the section classification approach

Section Class

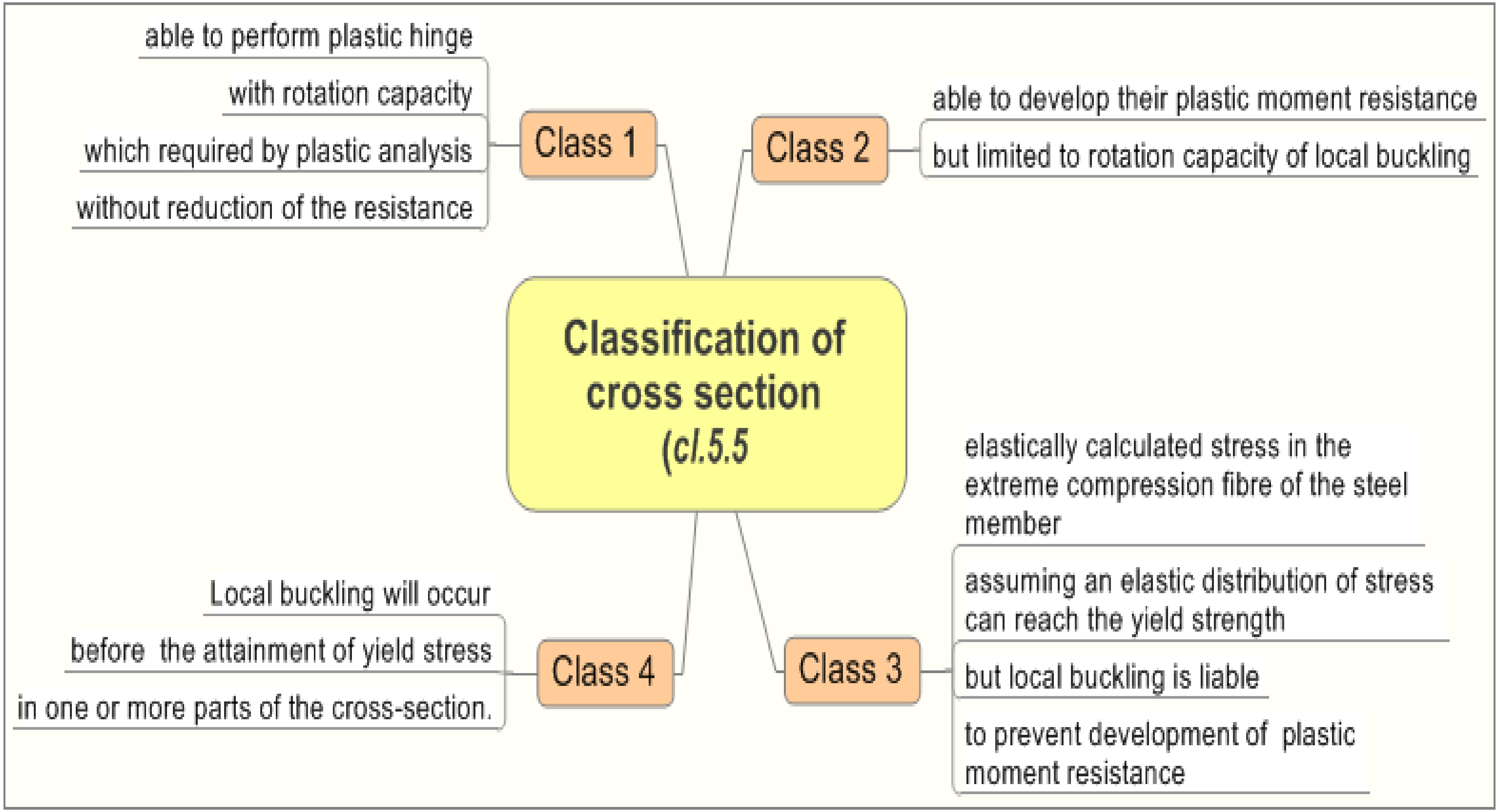
Classification

- EC3 defines four classes of cross section.
- The class into which a particular cross section falls depends upon
  - slenderness of each element (defined by a width-to-thickness ratio)
  - the compressive stress distribution
  - Classes are defined in terms of performance requirements for resistance of bending moments

Section Class



Section Class



ECTION CLASS

Classification process

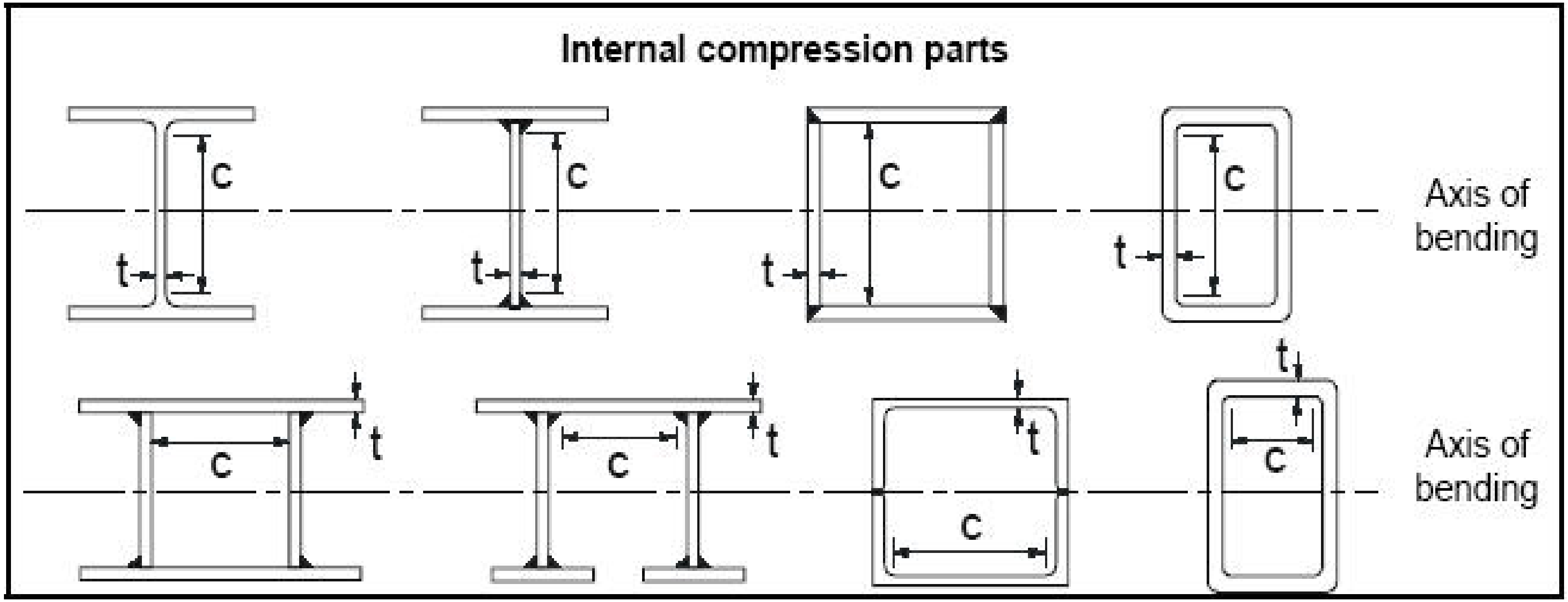
Limiting width-to-thickness ratios for sections refer Table 5.2 EN 1993:11:2005

Classification process follows five basic steps

- Evaluate the slenderness ratio (*c*/*T* or *d*/*t*)
- Evaluate the parameter ε
- Determine the class of that element based on limiting value of thickness ratio.
- Classify the complete cross-section according to the least favorable classification

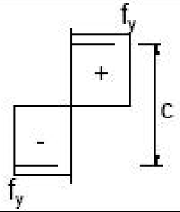
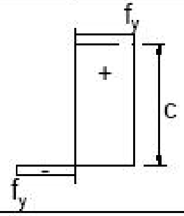
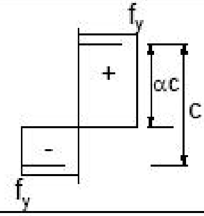
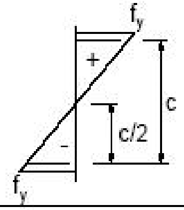
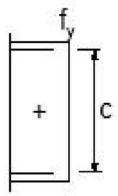
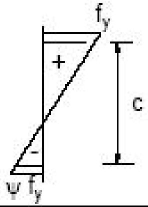
Limiting width-to-thickness ratio

Section Class



Limiting width-to-thickness ratio

SECTION CLASS

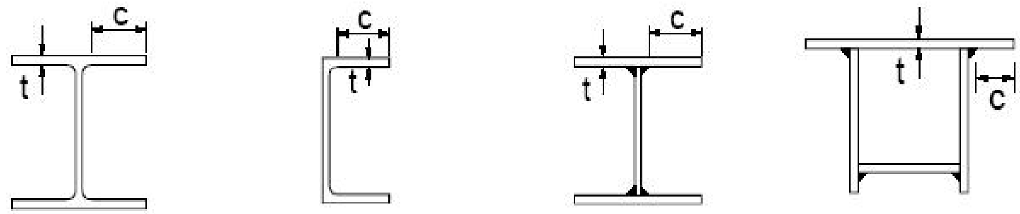
Class	Part subject to bending	Part subject to compression	Part subject to bending and compression
Stress distribution in parts (compression positive)			
1	$c/t \le 72\varepsilon$	$c/t \le 33\varepsilon$	when $\alpha > 0{,}5: \ c/t \le \frac{396\varepsilon}{13\alpha - 1}$ when $\alpha \le 0{,}5: \ c/t \le \frac{36\varepsilon}{\alpha}$
2	$c/t \le 83\varepsilon$	$c/t \le 38\varepsilon$	when $\alpha > 0{,}5: \ c/t \le \frac{456\varepsilon}{13\alpha - 1}$ when $\alpha \le 0{,}5: \ c/t \le \frac{41{,}5\varepsilon}{\alpha}$
Stress distribution in parts (compression positive)			
3	$c/t \le 124\varepsilon$	$c/t \le 42\varepsilon$	when $\psi > -1: \ c/t \le \frac{42\varepsilon}{0{,}67 + 0{,}33\psi}$ when $\psi \le -1^{*)}: \ c/t \le 62\varepsilon(1-\psi)\sqrt{(-\psi)}$

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

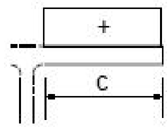
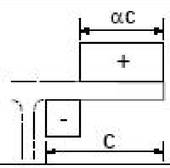
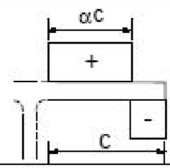
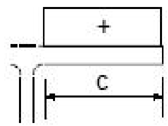
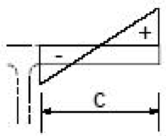
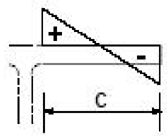
Limiting width-to-thickness ratio

SECTION CLASS

Outstand flanges



Rolled sections | Welded sections

Class	Part subject to compression	Part subject to bending and compression: Tip in compression	Part subject to bending and compression: Tip in tension
Stress distribution in parts (compression positive)			
1	$c/t \le 9\varepsilon$	$c/t \le \frac{9\varepsilon}{\alpha}$	$c/t \le \frac{9\varepsilon}{\alpha\sqrt{\alpha}}$
2	$c/t \le 10\varepsilon$	$c/t \le \frac{10\varepsilon}{\alpha}$	$c/t \le \frac{10\varepsilon}{\alpha\sqrt{\alpha}}$
Stress distribution in parts (compression positive)			
3	$c/t \le 14\varepsilon$	$c/t \le 21\varepsilon\sqrt{k_\sigma}$ For k_σ see EN 1993-1-5	

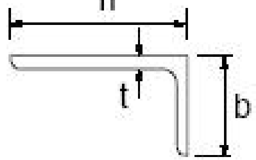
$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

Limiting width-to-thickness ratio

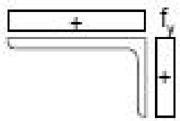
Section Class

Angles

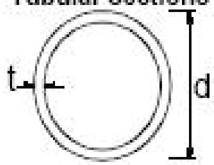
Refer also to "Outstand flanges" (see sheet 2 of 3)



Does not apply to angles in continuous contact with other components

Class	Section in compression
Stress distribution across section (compression positive)	
3	$h / t \le 15\varepsilon : \frac{b+h}{2t} \le 11,5\varepsilon$

Tubular sections



Class	Section in bending and/or compression
1	$d / t \le 50\varepsilon^2$
2	$d / t \le 70\varepsilon^2$
3	$d / t \le 90\varepsilon^2$ NOTE For $d / t > 90\varepsilon^2$ see EN 1993-1-6.

$\varepsilon = \sqrt{235 / f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71
	ε^2	1,00	0,85	0,66	0,56	0,51

Summary

- Structural sections may be considered as an assembly of individual plate elements.
- Plate elements may be internal or outstand
- When loaded in compression these plates may buckle locally
- Local buckling may limit the load carrying capacity of the section by preventing the attainment of yield strength
- Premature failure due to local buckling may be avoided by limiting the width to thickness ratio - or slenderness - of individual elements within the cross section.
- This is the basis of the section classification approach.
- EC3 defines four classes of cross-section.
- The class into which a particular cross-section falls depends upon the slenderness of each element and the compressive stress distribution

Thank You