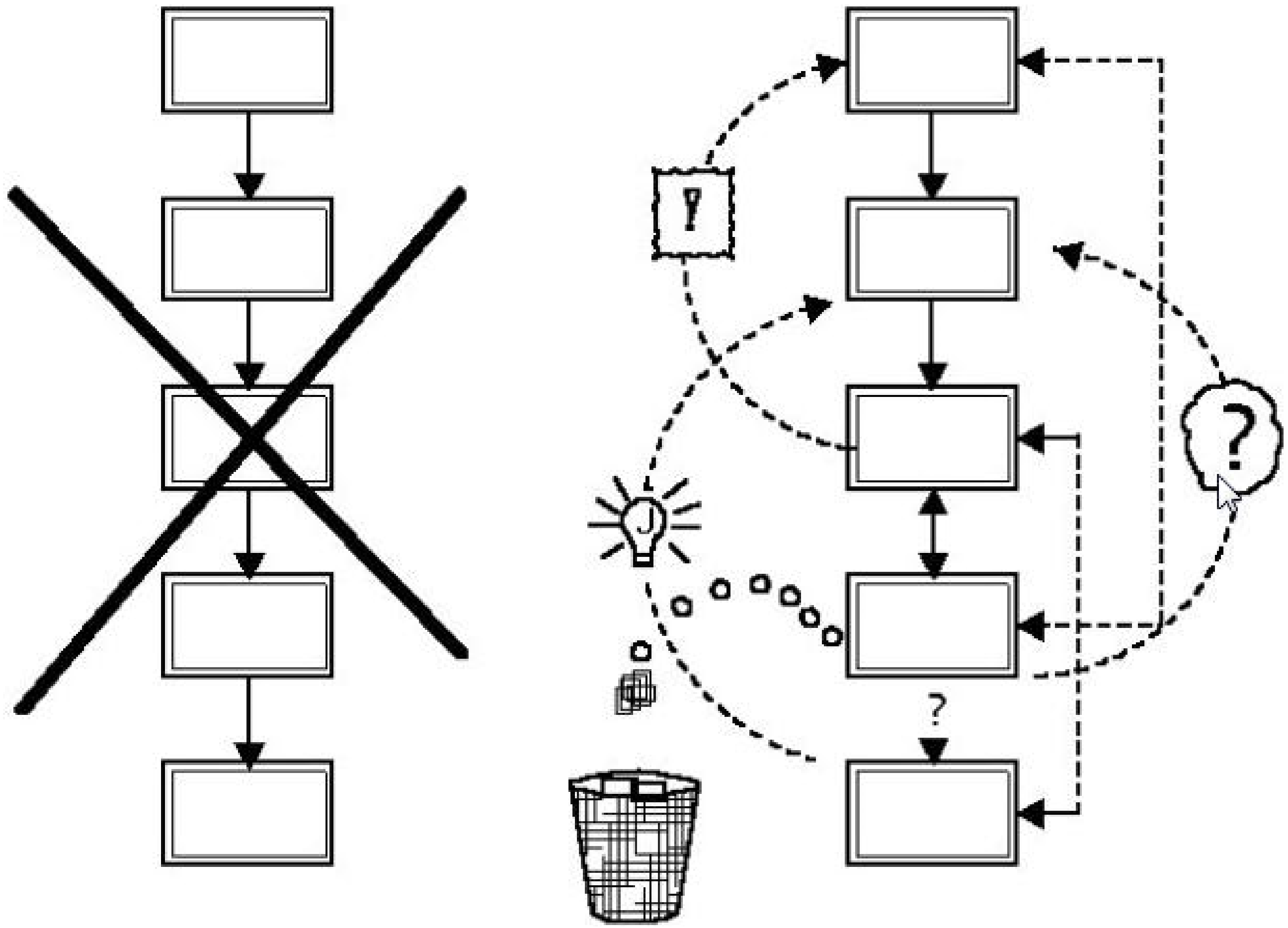
DESIGN CHECK :

- Generally, the section of beam is selected based on the moment capacity

- Once a trial section has been selected, design check is carried out to ensure that all the other strength components are satisfied

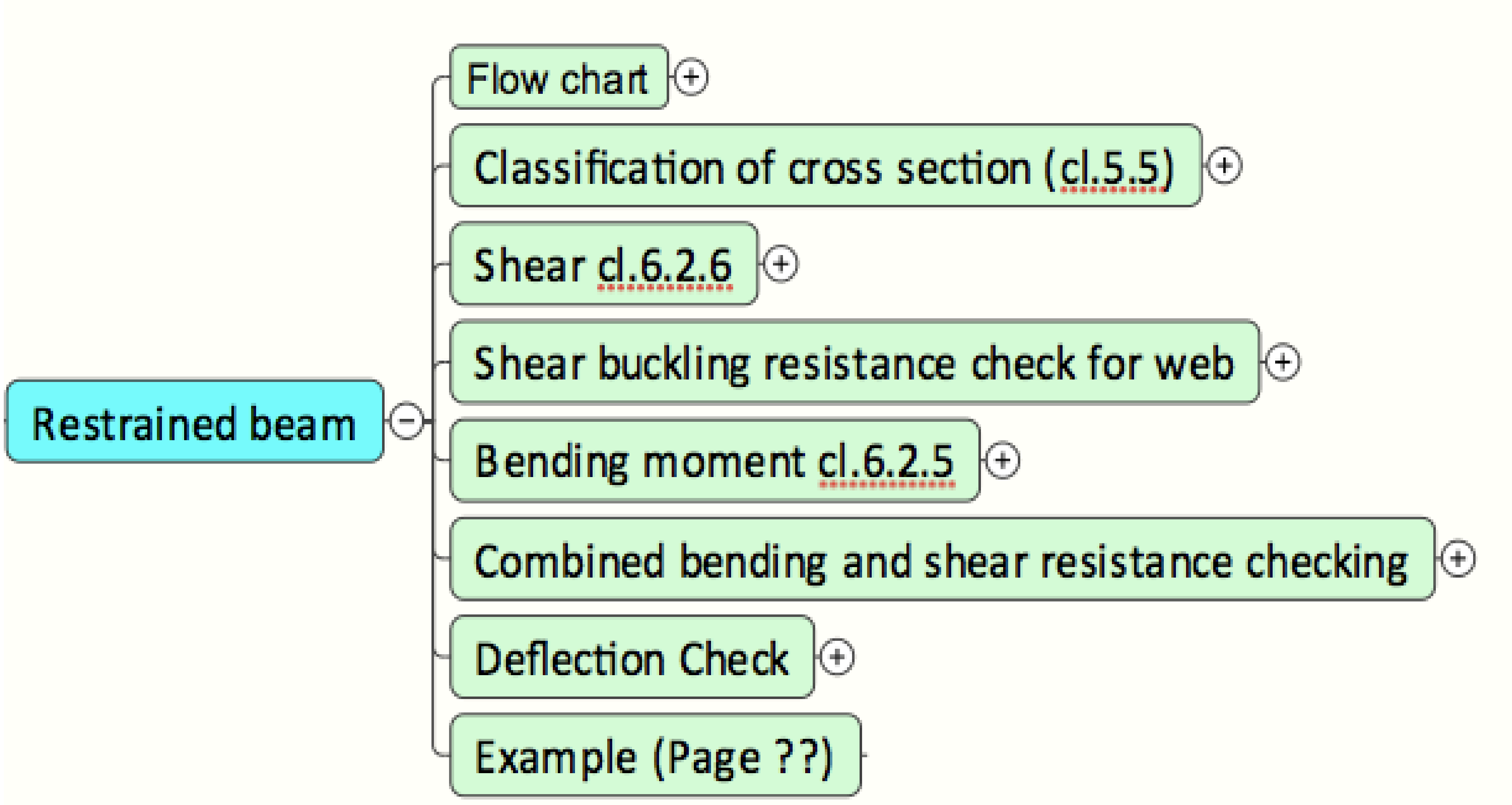
- The basic concept of design check is to ensure :

  Design resistance {R} > Design effects {E}



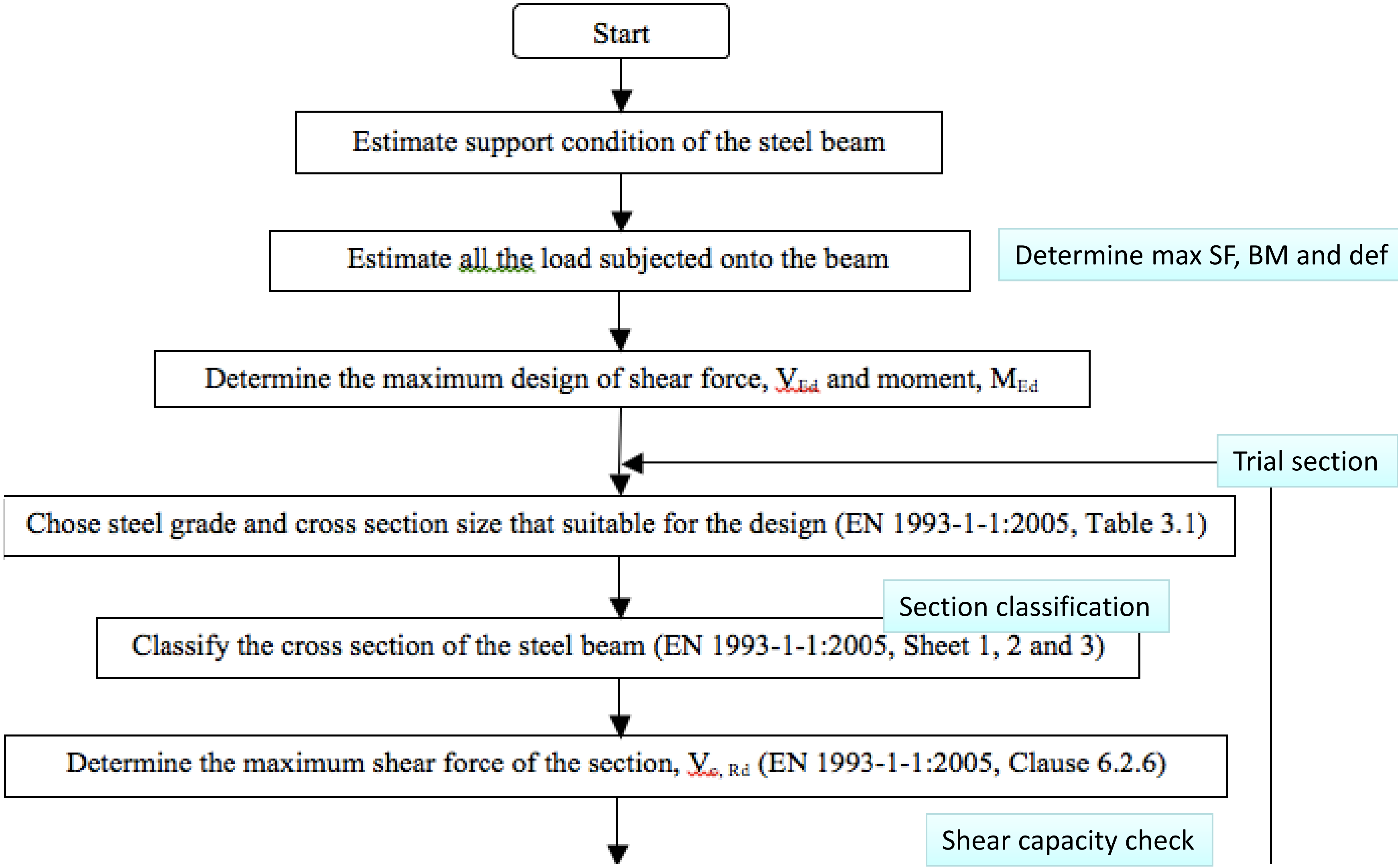
DESIGN PROCESS

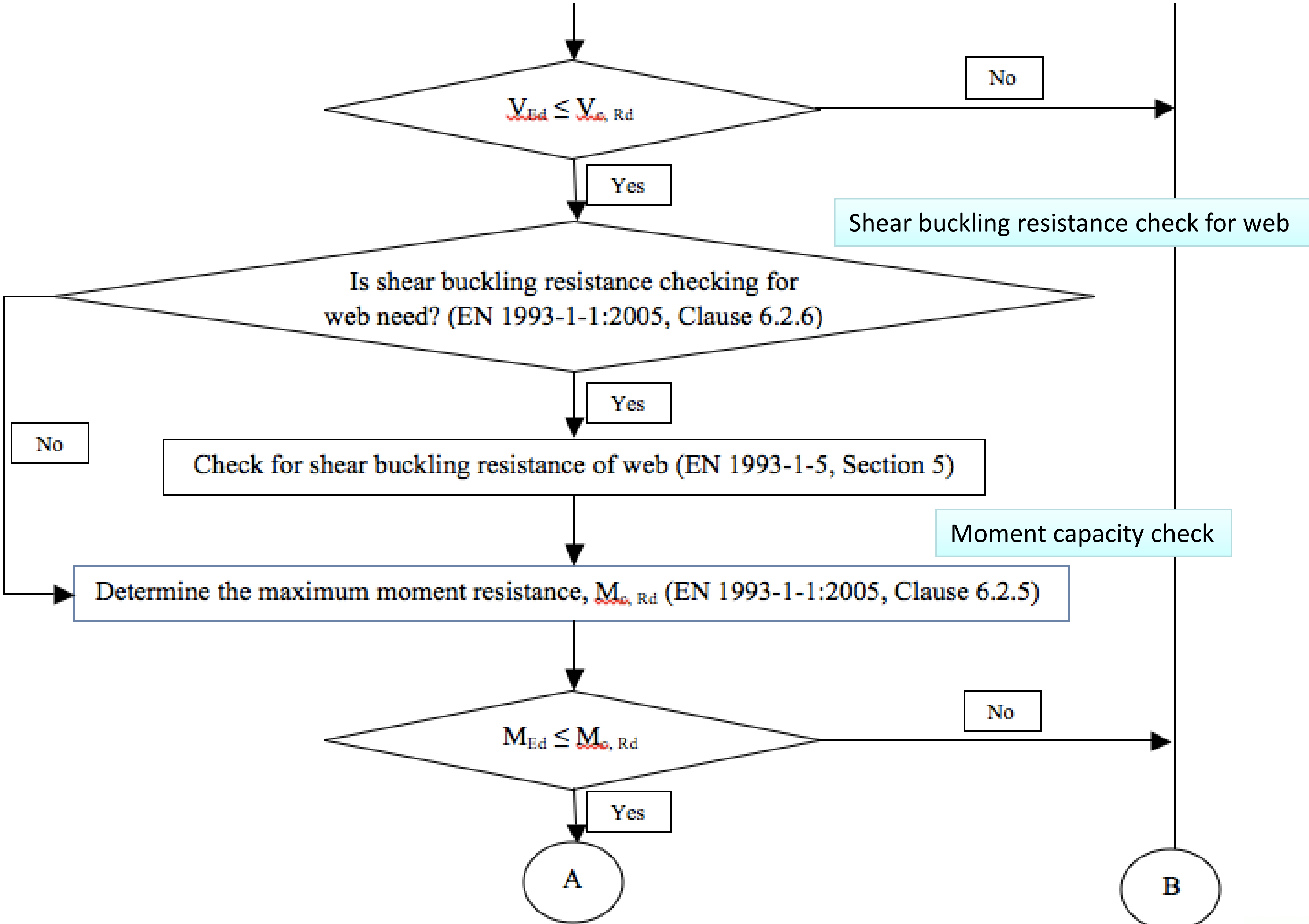
DESIGN CHECK :

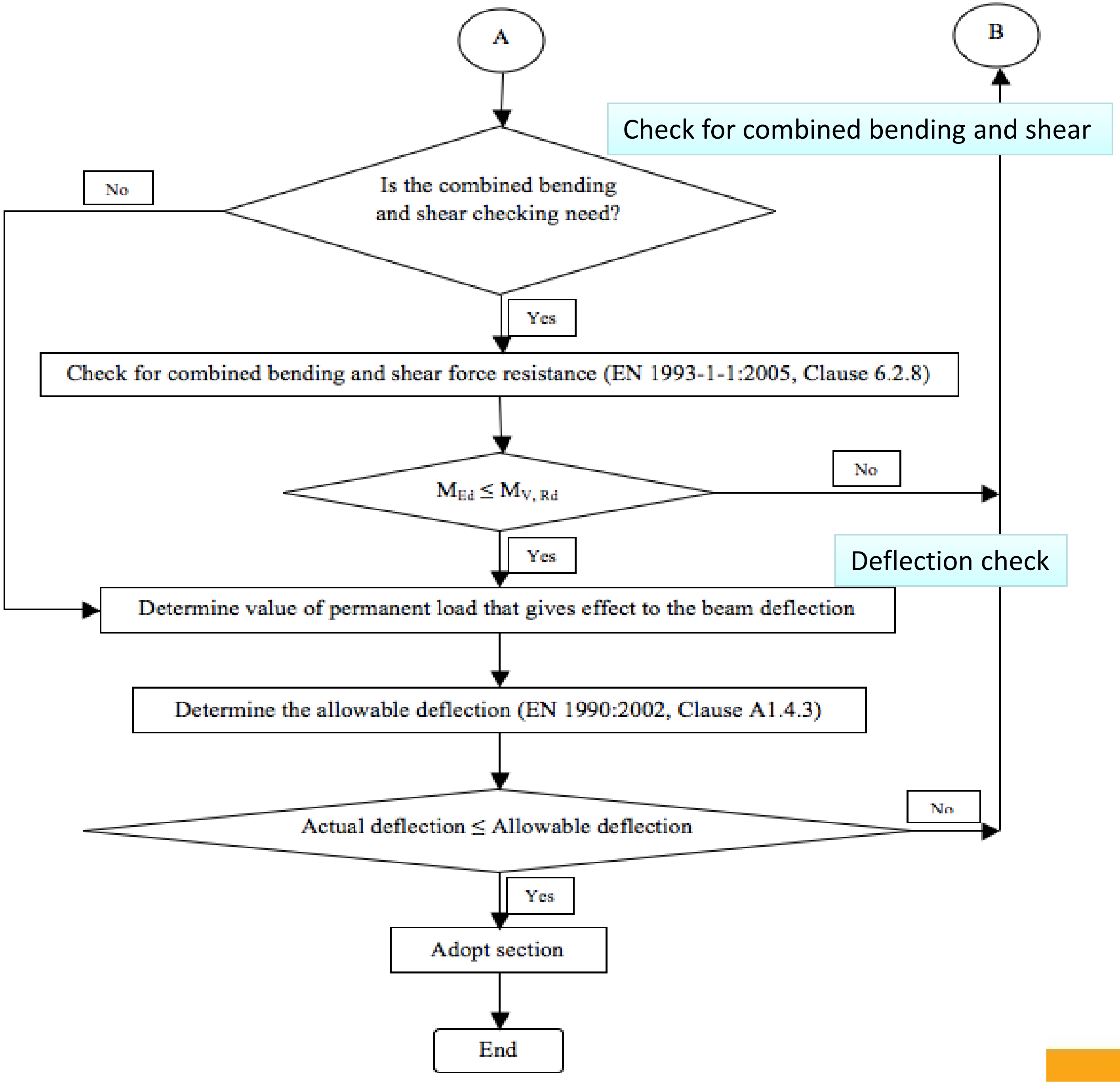


UTM

Design Procedure :

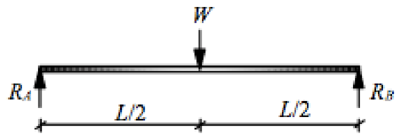
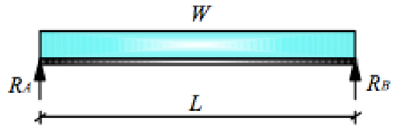
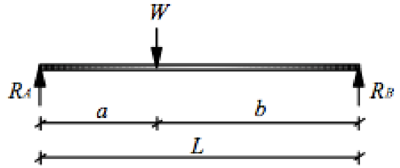
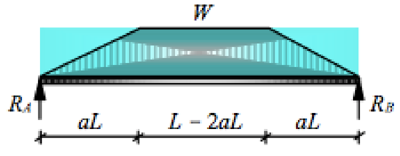
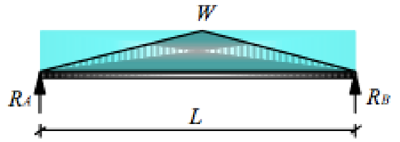
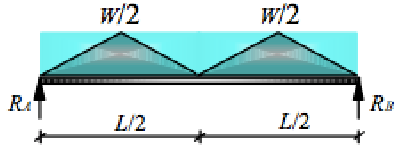
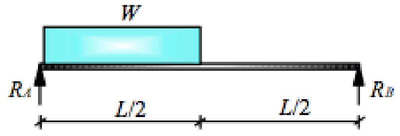



V_Ed ≤ V_c, Rd
No
Yes
Shear buckling resistance check for web
Is shear buckling resistance checking for web need? (EN 1993-1-1:2005, Clause 6.2.6)
Yes
No
Check for shear buckling resistance of web (EN 1993-1-5, Section 5)
Moment capacity check
Determine the maximum moment resistance, M_c, Rd (EN 1993-1-1:2005, Clause 6.2.5)
M_Ed ≤ M_c, Rd
No
Yes
A
B

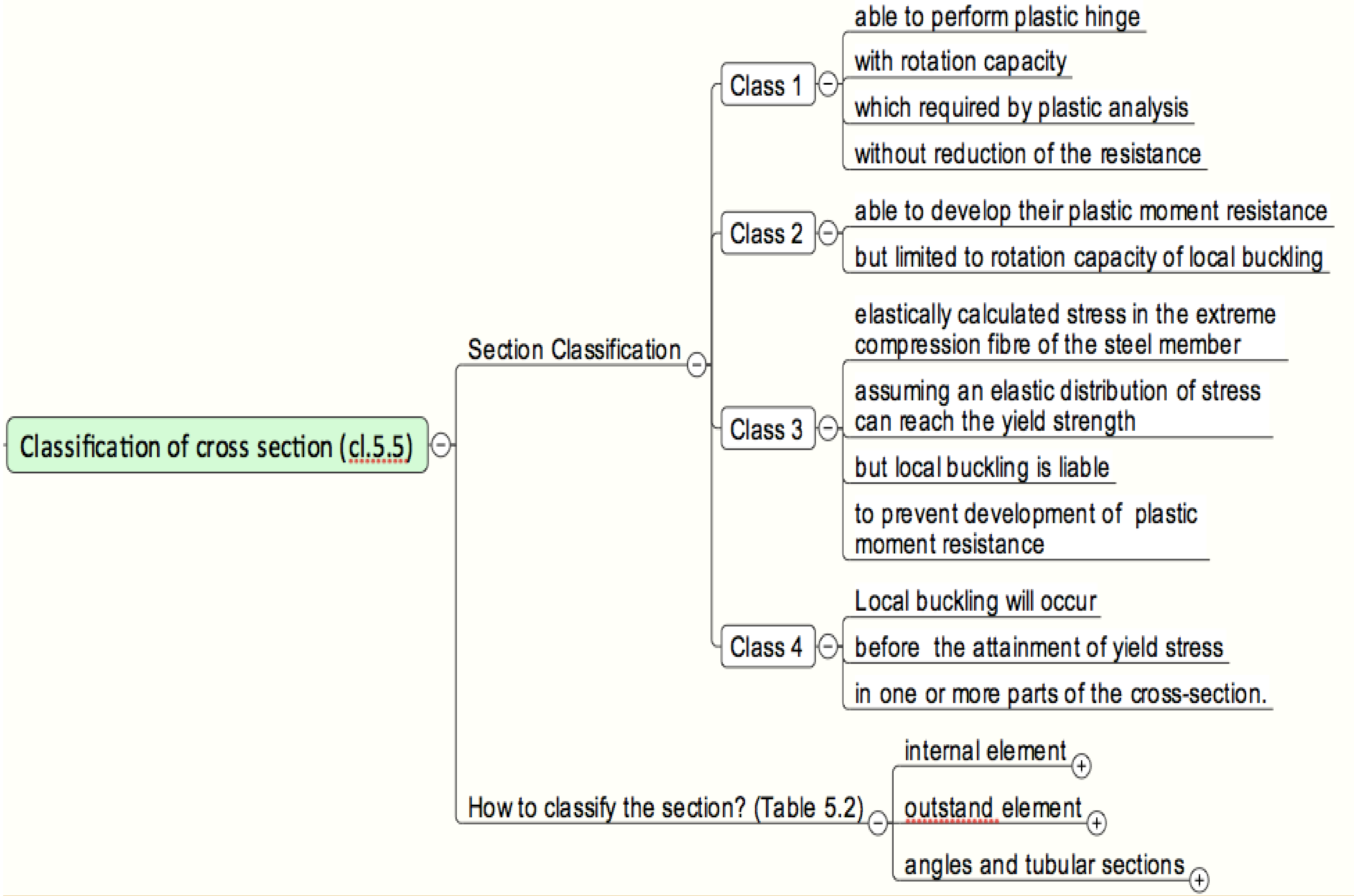

A
B
Check for combined bending and shear
Is the combined bending and shear checking need?
No
Yes
Check for combined bending and shear force resistance (EN 1993-1-1:2005, Clause 6.2.8)
$M_{Ed} \leq M_{V,Rd}$
No
Yes
Deflection check
Determine value of permanent load that gives effect to the beam deflection
Determine the allowable deflection (EN 1990:2002, Clause A1.4.3)
Actual deflection ≤ Allowable deflection
No
Yes
Adopt section
End

Determination of Maximum Beam Moment and Shear

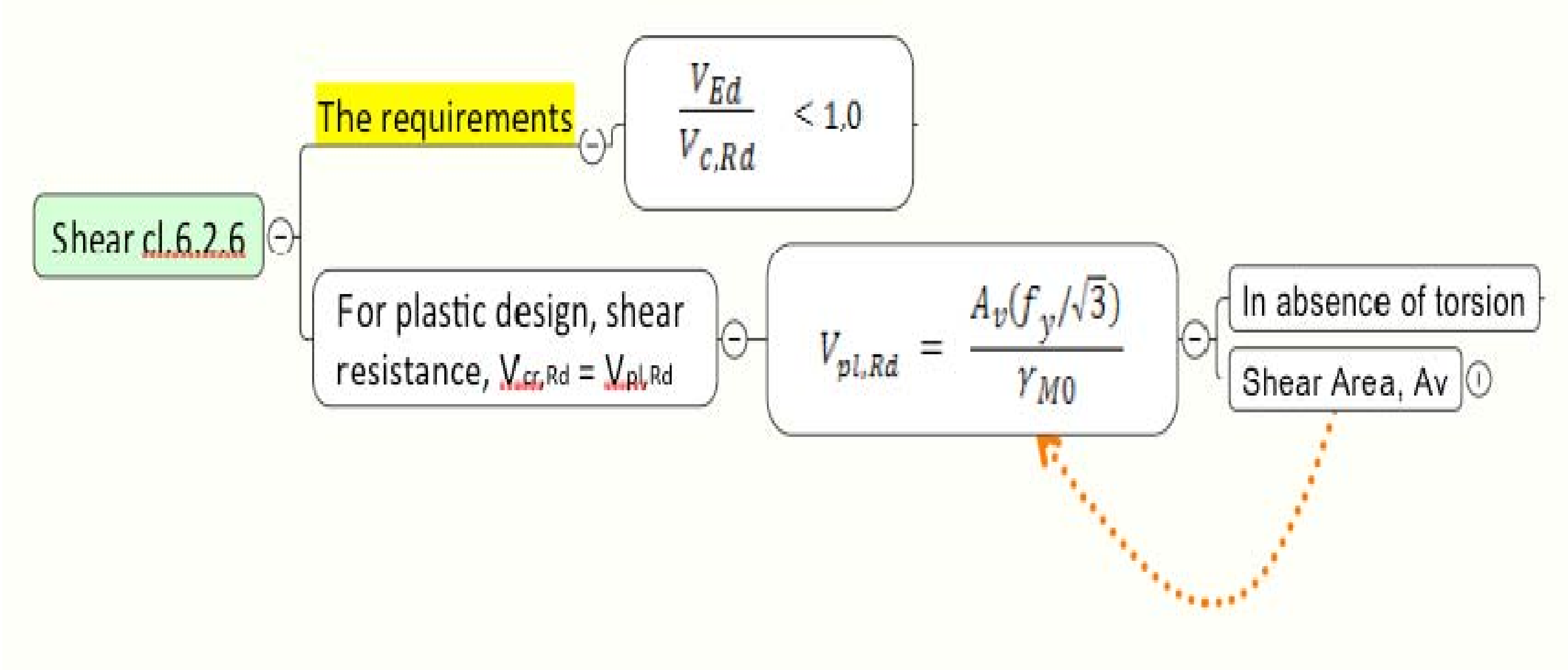
Table 1 Support reactions, maximum moment and deflection

Loading arrangement	Support reactions	Maximum bending moment	Maximum deflection
	$R_A = R_B = \frac{W}{2}$	$\frac{WL}{4}$	$\frac{WL^3}{48EI}$
	$R_A = R_B = \frac{W}{2}$	$\frac{WL}{8}$	$\frac{5WL^3}{384EI}$
	$R_A = \frac{Wb}{L}$ $R_B = \frac{Wa}{L}$	$\frac{Wab}{L}$	$\frac{Wab(L+b)}{27EIL}\sqrt{3a(L+b)}$ when $a > b$
	$R_A = R_B = \frac{W}{2}$	$WL\left[\frac{3-4a^2}{24(1-a)}\right]$	$\frac{WL^3}{1920EI}\frac{(4a^2-5)^2}{1-a}$
	$R_A = R_B = \frac{W}{2}$	$\frac{WL}{6}$	$\frac{WL^3}{60EI}$
	$R_A = R_B = \frac{W}{2}$	$\frac{WL}{8}$	$\frac{WL^3}{73.14EI}$
	$R_A = \frac{3W}{4}$ $R_B = \frac{W}{4}$	$\frac{9WL}{64}$	$0.006563\frac{WL^3}{EI}$

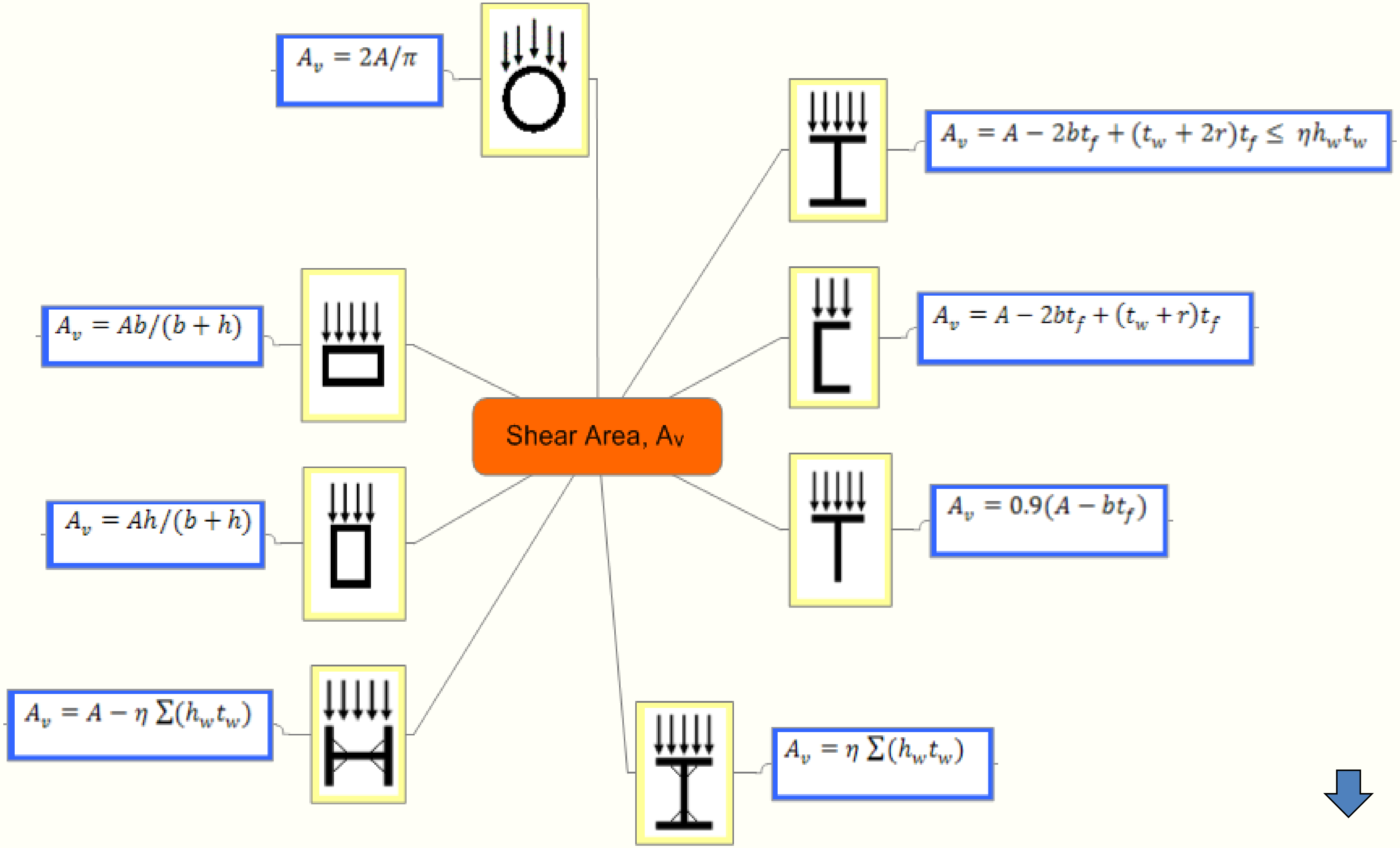
Classification of cross section



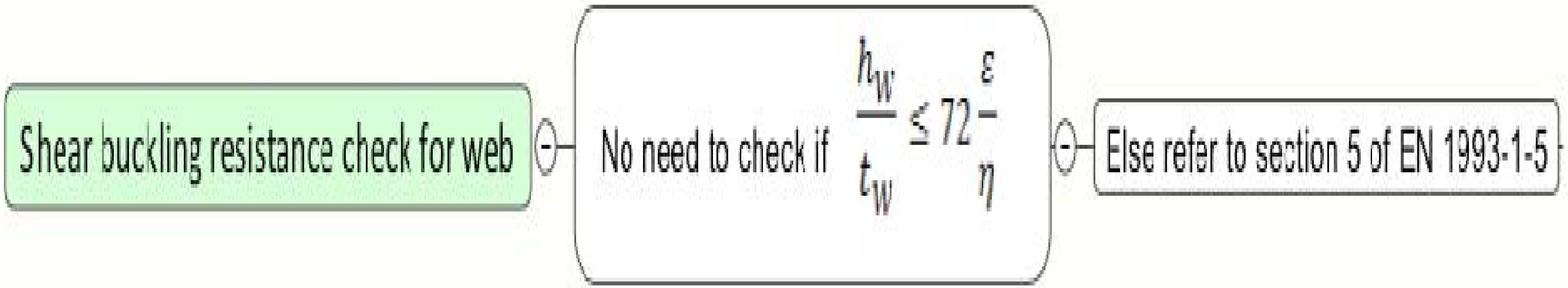
Shear check (cl.6.2.6)



Shear check (contd)



Shear buckling resistance check for web



Bending moment (cl.6.2.5)

- In a simple single span, failure occurs when design value of thebending moment M_{Ed} exceeds design moment resistance of the cross section $M_{c.Rd}$.
- Magnitude depends on section shape, material strength and section classification.
- Where shear force on cross-section is small its effect on the resistance moment may be neglected.

EC3 sets this limit as a shear force of 50% of the plastic shear resistance

Bending moment (cl.6.2.5)

Bending moment cl.6.2.5

$$\frac{M_{Ed}}{M_{c,Rd}} \leq 1{,}0$$

Design resistance of bending, $M_{c,Rd}$

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl} f_y}{\gamma_{M0}}$$

For class 1 or 2 cross-sections

W_{pl} plastic section modulus

$$M_{c,Rd} = M_{el,Rd} = \frac{W_{el,min} f_y}{\gamma_{M0}}$$

For class 3 cross-sections

$W_{el,min}$ elastic section modulus

$$M_{c,Rd} = \frac{W_{eff,min} f_y}{\gamma_{M0}}$$

For class 4 cross-sections

$W_{eff,min}$ effective section modulus

Combined Bending and Shear (cl.6.2.8)

Combined bending and shear resistance checking

- If $V_{Ed} < 0.5V_{c,Rd}$ the combined bending and shear resistance is not required
- If $V_{Ed} > 0.5V_{c,Rd}$, then the reduced moment resistance = design resistance of the cross section calculated using reduced yield strength

Bending and shear cl.6.2.8

- if $V_{Ed} > 0.5N_{pl,Rd}$
  - Reduced moment resistance should be taken in design resistance of cross section
    - Using reduced yield strength
- Reduced design strength for the shear area
  - $f_{yr} = (1-\rho)f_y$
    - $\rho = \left(\frac{2v_{Ed}}{V_{pl,Rd}} - 1\right)^2$ — general
    - $\rho = \left(\frac{2v_{Ed}}{V_{pl,T,Rd}} - 1\right)^2$ — With present of torsion
  - ρ taken as 0 — if $V_{Ed} \le 0.5N_{pl,T,Rd}$
- Alternatives

Combined Bending and Shear (cl.6.2.8) contd

- Alternative for I section (equal flanges) and bending about major axis, the reduced design plastic resistance moment allowing for the shear force is as follow:

Alternatives

$$M_{y,c,Rd} = \frac{\left[W_{pl,y} - \frac{\rho A_W^2}{4 t_W}\right] f_y}{\gamma_{M0}}$$

But $M_{y,V,Rd} \leq M_{y,c,Rd}$

$A_w = h_w t_w$

Deflection check

Deflection Check

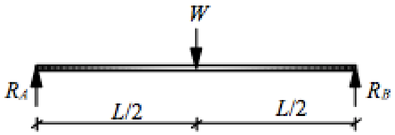
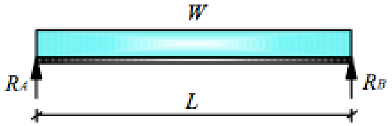
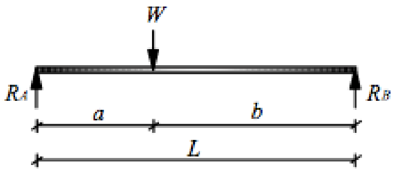
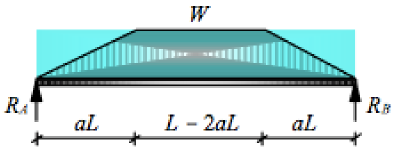
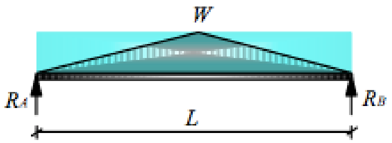
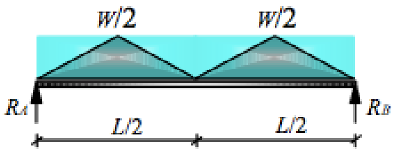
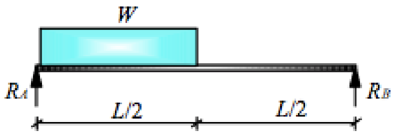
deflection limits

Table 2.3: The vertical deflection limits

Condition	Limits	
	d_{max}	d_2
Roofs generally	L/200	L/250
Roofs frequently carrying personnel	L/250	L/300
Floors generally	L/250	L/300
Floors and roofs supporting plaster	L/250	L/350
Floors supporting columns	L/400	L/500

deflection

Table 1 Support reactions, maximum moment and deflection

Loading arrangement	Support reactions	Maximum bending moment	Maximum deflection
	$R_A = R_B = \frac{W}{2}$	$\frac{WL}{4}$	$\frac{WL^3}{48EI}$
	$R_A = R_B = \frac{W}{2}$	$\frac{WL}{8}$	$\frac{5WL^3}{384EI}$
	$R_A = \frac{Wb}{L}$ $R_B = \frac{Wa}{L}$	$\frac{Wab}{L}$	$\frac{Wab(L+b)}{27EIL}\sqrt{3a(L+b)}$ when $a > b$
	$R_A = R_B = \frac{W}{2}$	$WL\left[\frac{3-4a^2}{24(1-a)}\right]$	$\frac{WL^3}{1920EI}\frac{(4a^2-5)^2}{1-a}$
	$R_A = R_B = \frac{W}{2}$	$\frac{WL}{6}$	$\frac{WL^3}{60EI}$
	$R_A = R_B = \frac{W}{2}$	$\frac{WL}{8}$	$\frac{WL^3}{73.14EI}$
	$R_A = \frac{3W}{4}$ $R_B = \frac{W}{4}$	$\frac{9WL}{64}$	$0.006563\frac{WL^3}{EI}$