CIV102 - STRUCTURES and MATERIALS

Topic: Design of Truss Members

1) $P_{cr} = \frac{\pi^2 E I}{L^2}$

i) Estimate Self Weight
ii) Calculate the Joint-Loads from Tributary Area
iii) Calculate Reaction Forces
iV) Solve for Member Internal Forces { Joints / Sections
v) Size the Cross Sections of Each Member to Safely Carry the Load

Size?

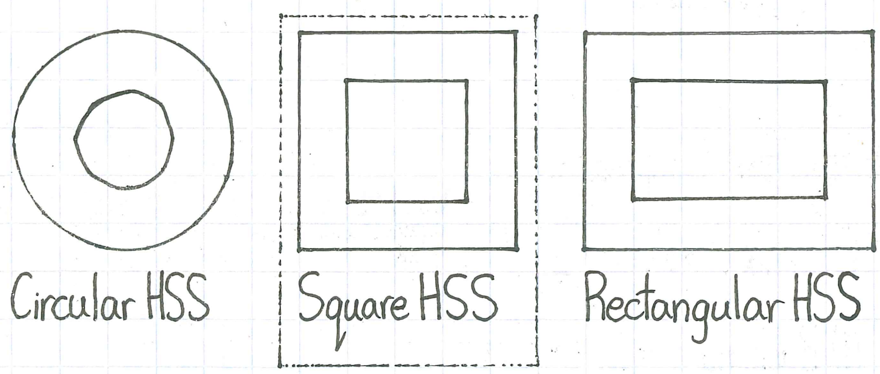
Tension $F_{fail} = A \cdot f_y$ (F: force, f_y: Strain)

Compression $F_{fail} = A \cdot f_y$
or
$F_{fail} = \frac{\pi^2 E I}{L^2}$ (I: Size term)

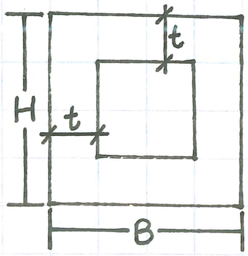
} Smaller will Govern

We Will Use HSS (Hollow Structural Section)

Steel, E = 200,000 MPa f_y = 350 MPa



HSS Designation



HSS H × B × t

Example HSS 305 × 305 × 12.7

Why HSS?

- Light
- Strong (High Second Moment of Area)
- Stiff

I, A Combined

$r = \sqrt{\frac{I}{A}}$ radius of gyration

- Geometric Property
- Theoretical Idea

2) Design for Tension

From Method of Joints $\longrightarrow F_{demand}$

$$F_{capacity} \geq F_{demand}$$

$$A \cdot f_y \geq F_{demand}$$

$$F_{safe} \geq F_{demand}$$

$$\frac{A \cdot f_y}{FOS} \geq F_{demand}$$

$$\frac{A \cdot f_y}{2} \geq F_{demand}$$

$$A \geq \frac{2F_{demand}}{f_y}$$

3) Design for Compression

i) Yield $\rightarrow A \geq \frac{2|F_{demand}|}{f_y}$ — Use FOS of 2 against compression yield

ii) Buckling $\rightarrow P_{cr} = \frac{\pi^2 E I}{L^2}$ $\qquad P_{safe} = \frac{\pi^2 E I}{FOS\, L^2}$

For buckling FOS = 3.0 $\rightarrow$ $\boxed{I \geq \frac{FOS\, L^2\, F_{demand}}{\pi^2 E}}$

Stress at Buckling

$$\frac{P_{cr}}{A} = \frac{\pi^2 E I}{A \cdot L^2} \qquad r = \sqrt{\frac{I}{A}}$$

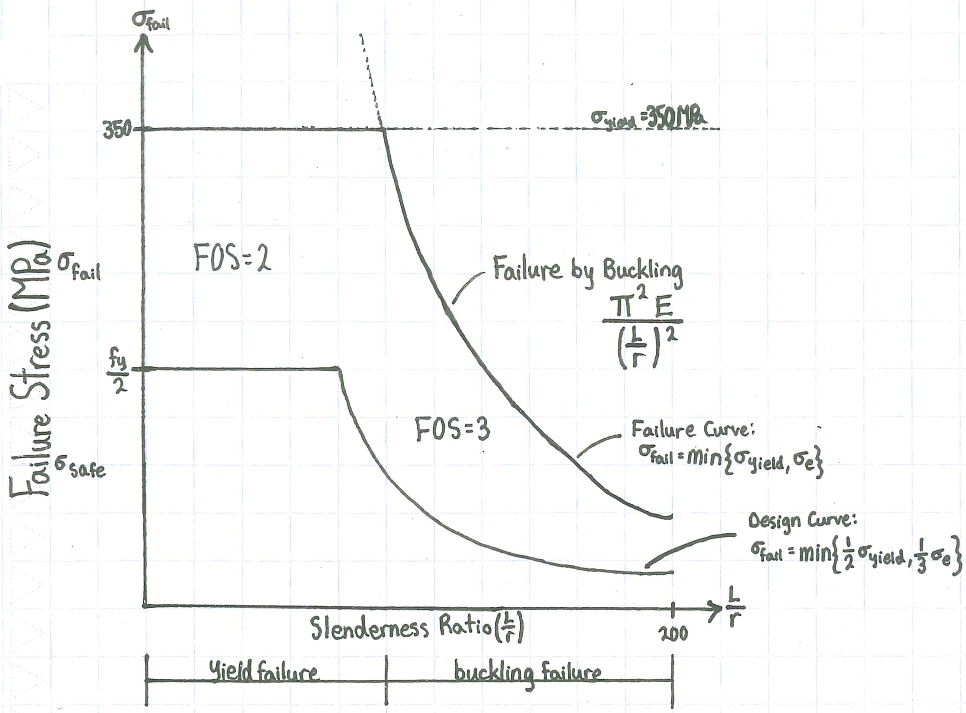
$$r^2 = \frac{I}{A}$$

$$\sigma_{Euler} = \frac{\pi^2 E\, r^2}{L^2}$$

$$= \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2}$$

$\frac{L}{r}$ = Slenderness Ratio

$\frac{L}{r} \leq 200$ always



Member Type	Cross-Sectional Area, A	Second Moment of Area, I	Radius of Gyration, r
Tension	$\geq \frac{2F_{demand}}{f_y}$	N/A	$\geq \frac{L}{200}$
Compression	$\geq \frac{2F_{demand}}{f_y}$	$\geq \frac{3.0 F_{demand} L^2}{\pi^2 E}$	$\geq \frac{L}{200}$

Example

$F_{demand} = 250\text{kN}$ Compression

$L = 5000\text{mm}$

$\sigma_y = f_y = 350\text{MPa}$

$A \geq \frac{2 \cdot 250000}{350}$

$\geq 1429\text{mm}^2$

$I \geq \frac{3.0(250000)(5000^2)}{\pi^2(200000)}$

$\geq 9.5 \times 10^6 \text{mm}^4$

$r \geq 25\text{mm}$

Select HSS 152 × 152 × 4.8