

IPE 270

S 235

$$V_{Ed} = 200 \text{ kN}$$

Comportamento elastico
(classe 3)

$$d. \quad \tau_{max} = \frac{V_{Ed} S_y}{I_y b}$$

$$b = t_w ; \quad S_y = \frac{W_{pl,y}}{2}$$

$$2. \quad \tau_{max} \leq \frac{f_y}{\sqrt{3} \gamma_{H0}}$$

	G kg/m	h mm	b mm	t _w mm	t _f mm	r mm	A cm ²	h _i mm	d mm	Ø	P _{min} mm	P _{max} mm	A _L m ² /m	A _G m ² /t
IPE A 270*	30.7	267	135	5.5	8.7	15	39.15	249.6	219.6	M16	70	72	1.037	33.75
IPE 270	36.1	270	135	6.6	10.2	15	45.95	249.6	219.6	M16	72	72	1.041	28.86

	G kg/m	I _y cm ⁴	W _{el,y} cm ³	W _{pl,y} † cm ³	i _y cm	A _{vz} cm ²	I _z cm ⁴	W _{el,z} cm ³	W _{pl,z} † cm ³	i _z cm	s _s mm	I _t cm ⁴	I _w × 10 ⁻³ cm ⁶	S235	S355	S460	S235	S355	S460
IPE A 270	30.7	4917	368.3	412.5	11.21	18.75	358.0	53.03	82.34	3.02	40.47	10.30	59.51	1	1	-	3	4	-
IPE 270	36.1	5790	428.9	484.0	11.23	22.14	419.9	62.20	96.95	3.02	44.57	15.94	70.58	1	1	-	2	3	-

$$b = t_w = 6.6 \text{ mm}$$

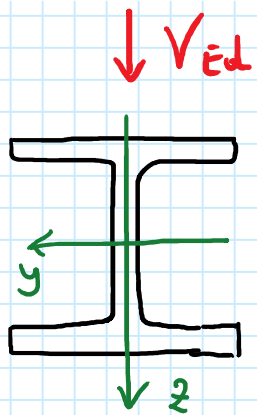
$$I_y = 5790 \text{ cm}^4$$

$$S_y = \frac{W_{\text{ply}}}{2} = \frac{484}{2} = 242 \text{ cm}^3$$

$$\sigma_{\text{max}} = \frac{200 \times 242}{5790 \times 6.6} \times \frac{10^3 \times 10^3}{10^6} = 126.7 \text{ MPa}$$

$$\sigma_{\text{max}} = 126.7 \text{ MPa} \leq \frac{f_y}{\sqrt{3} \gamma_{M0}} = \frac{235}{\sqrt{3} \times 1.05} = 129.2 \text{ MPa}$$

OK!



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Comportamento plastico
(classe 1 o 2)

$$1. \quad V_{c,Rd} = \frac{A_v f_y}{\sqrt{3} \gamma_{M0}}$$

$$A_v = A - 2 b t_f + (t_w + 2 r) t_f$$

$$2. \quad V_{Ed} \leq V_{c,Rd}$$

	G kg/m	h mm	b mm	t _w mm	t _f mm	r mm	A cm ²	h _i mm	d mm	Ø	p _{min} mm	p _{max} mm	A _L m ² /m	A _G m ² /t
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$$A = 45,95 \text{ cm}^2$$

$$b = 135 \text{ mm}$$

$$t_f = 10,2 \text{ mm}$$

$$t_w = 6,6 \text{ mm}$$

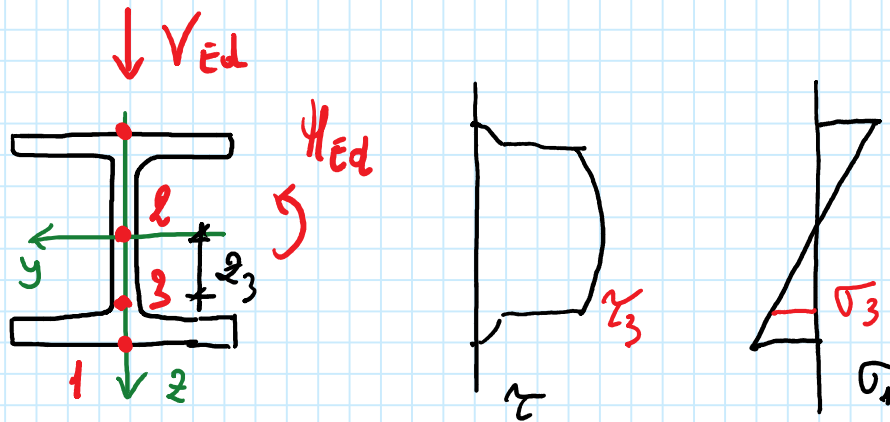
$$e = 15 \text{ mm}$$

$$A_v = 45,95 - 2 \times 135 \times 1,02 + (0,66 + 2 \times 1,5) \times 1,02 = 22,1 \text{ cm}^2$$

$$V_{c,Rd} = \frac{22,1 \times 235}{\sqrt{3} \times 1,05} \times \frac{1}{10} = 286,1 \text{ kN}$$

$$V_{Ed} = 200 \text{ kN} \leq V_{c,Rd} = 286,1 \text{ kN} \quad \text{OK!}$$

Taglio e flessione



Comportamento elastico

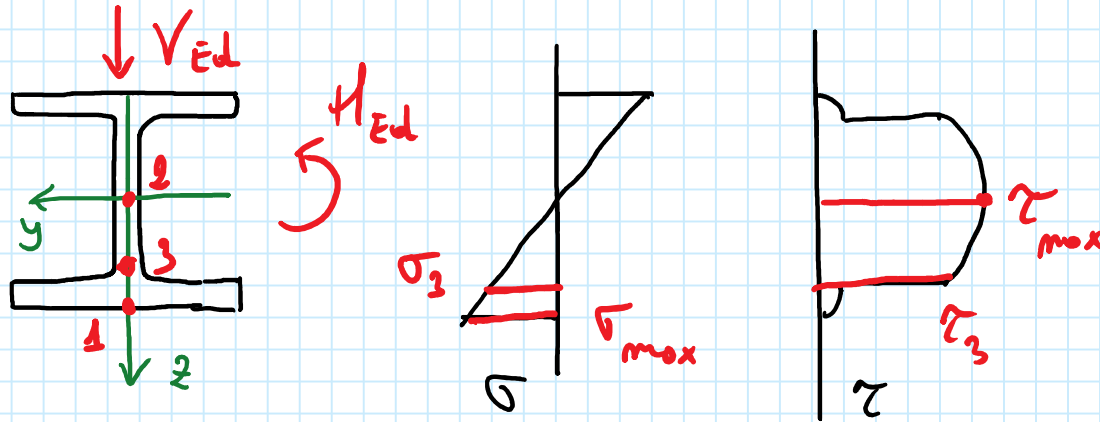
$$1. \quad \sigma_1 = \frac{M_{Ed} z}{I_y} = \frac{M_{Ed} (h/2)}{I_y} \leq \frac{f_y}{\gamma_{M0}}$$

$$2. \quad \tau_2 = \frac{V_{Ed} S_y}{I_y b} \leq \frac{f_y}{\sqrt{3} \gamma_{M0}}$$

$$3. \quad \sigma_3 = \frac{M_{Ed} z_3}{I_y} \quad \tau_3 = \frac{V_{Ed} S_y}{I_y b}$$

$$\sigma_{id,3} = \sqrt{\sigma_3^2 + 3\tau_3^2} \leq \frac{f_y}{\gamma_{M0}}$$

Flessione e taglio



Comportamento elastico
Classe 3

Le tensioni nel generico punto
si calcolano con Navier

$$\sigma = \frac{M_{Ed}}{I_y} z$$

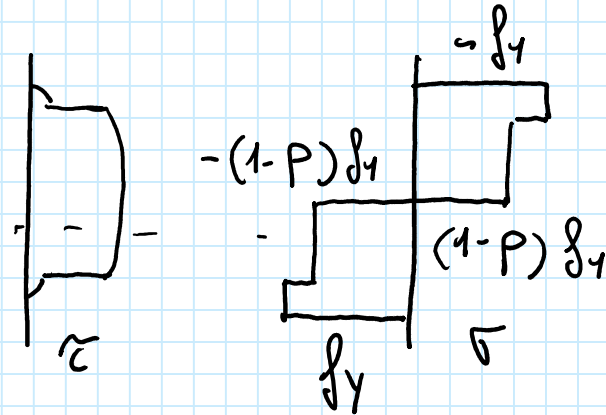
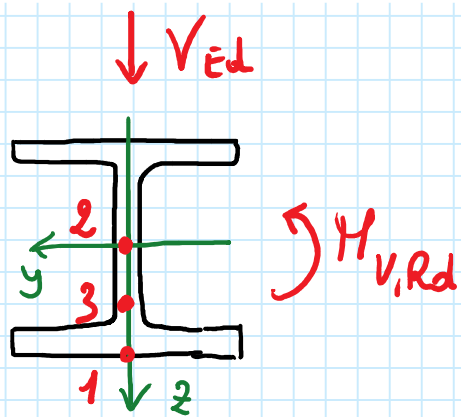
e Journeux-Ky

$$\tau = \frac{V_{Ed} S_y}{I_y b}$$

$$1. \quad \sigma_1 \leq \frac{f_y}{\gamma_{M0}}$$

$$2. \quad \tau_2 \leq \frac{f_y}{\sqrt{3} \gamma_{M0}}$$

$$3. \quad \sigma_{id} = \sqrt{\sigma_3^2 + 3\tau_3^2} \leq \frac{f_y}{\gamma_{M0}}$$



Comportamento plastico

Classe 4 e 2

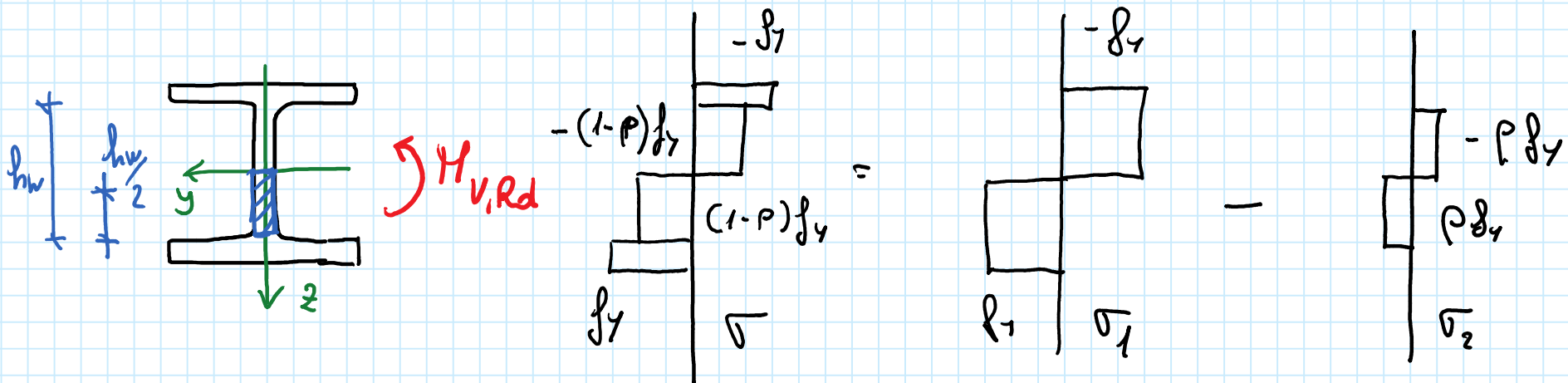
$$M_{Ed} \leq M_{V,Rd}$$

la plasticizzazione si avverte quando $\sigma_{id} = \sqrt{\sigma^2 + 3\tau^2} = f_y$,

Nell'anima per $\sigma < f_y$. Questo σ si assume pari a $(1-p)f_y$ con $0 \leq p \leq 1$

$$M_{V,Rd} = \int_A \sigma z dA$$

Il diagramma dello σ è quello indicato in figura.



$$\int \sigma z dA = \int_A \sigma_1 z dA - \int_A \sigma_2 z dA$$

$$H_{v,Rd} = \int_A \sigma z dA = W_{pl,y} f_y - W_{pl,w} p f_y = \left(W_{pl,y} - \frac{A_w^2 p}{4 t_w} \right) f_y$$

$$W_{pl,w} = 2 S_{1/2}^w = 2 \frac{h_w t_w}{2} \frac{h_w}{2} = \frac{t_w h_w^2}{4} \frac{t_w}{t_w} = \frac{t_w^2 h_w^2}{4 t_w} = \frac{A_w^2}{4 t_w}$$

Bisogna ancora considerare il coefficiente di riduzione per taglio γ_{H0} e calcolare p .

Momento resistente dovuto per effetto del taglio secondo la
NTE 18

$$M_{V,Rd} = M_{Rd} = W_{pl} \frac{I_y}{\gamma_{M0}}$$

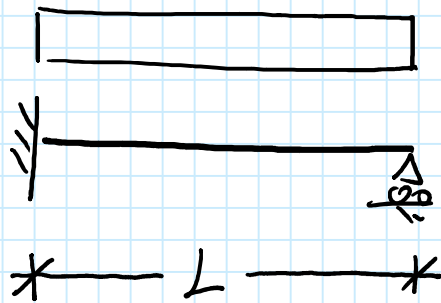
$$\text{se } V_{Ed} \leq 0,5 V_{e,Rd}$$

$$M_{V,Rd} = \left(W_{pl} - \frac{A_w^2 P}{4 t_w} \right) \frac{I_y}{\gamma_{M0}}$$

$$\text{se } V_{Ed} > 0,5 V_{e,Rd}$$

$$P = \left(2 \frac{V_{Ed}}{V_{e,Rd}} - 1 \right)^2$$

Applications numérique



$G_d + Q_d$

$M_{Ed} = (G_d + Q_d) \frac{L^2}{8}$

(M)

$V_{Ed} = 1.25 (G_d + Q_d) \frac{L}{2}$

(V)

IPE 270

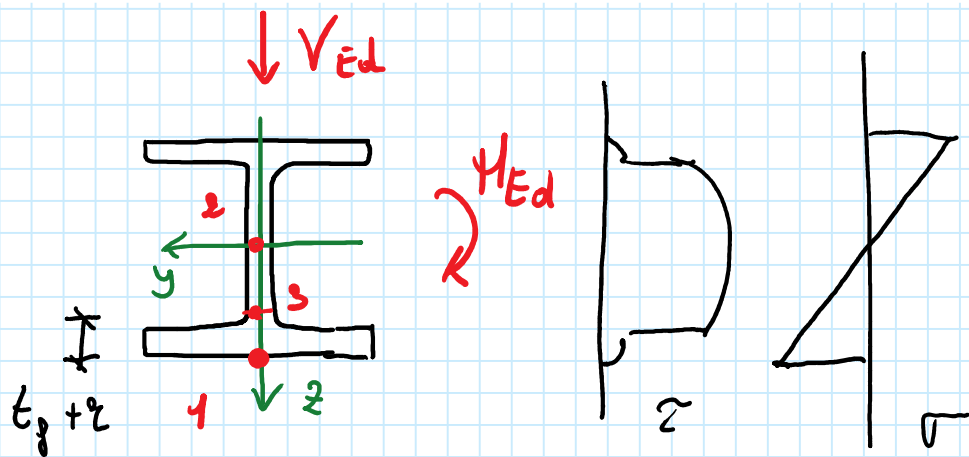
S 235

$M_{Ed} = 45 \text{ kNm}$

$V_{Ed} = 200 \text{ kN}$

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Comportamento elastico
(Classe 3)

$$d. \quad \sigma_{max} = \frac{M_{Ed} (h/2)}{I_y} = \frac{M_{Ed}}{W_{el,y}} = \frac{45}{428,9} \times \frac{10^3 \times 10^2}{10^3} = 174,9 \text{ MPa}$$

$$\sigma_{max} = 174,9 \text{ MPa} \leq \frac{f_y}{\gamma_{M0}} = \frac{235}{1,05} = 223,8 \quad \text{OK!}$$

$$2. \tau_{max} = \frac{V_2 S_{1/1}}{I_y b} = \frac{200 \times 242}{5790 \times 0,66} \times \frac{10^3}{10^3} = 126,6 \text{ MPa}$$

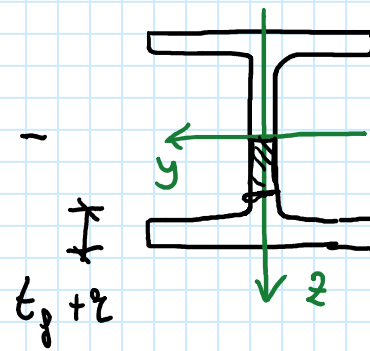
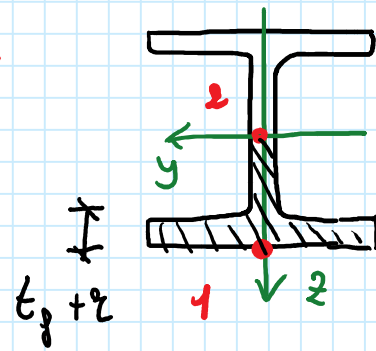
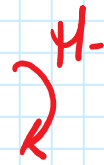
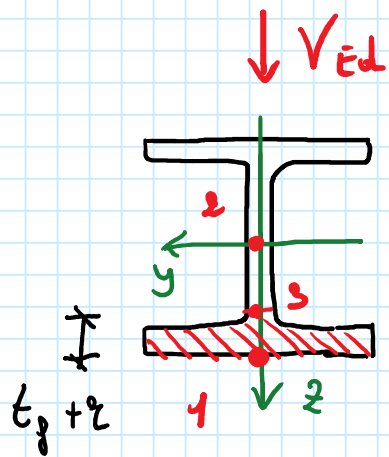
$$\tau_{max} = 126,6 \text{ MPa} \leq \frac{f_y}{\sqrt{3} \gamma_{M0}} = 129,2 \quad \text{OK!}$$

$$3. \text{ Calcolo } \sigma_3 \text{ e } \tau_3$$

$$\sigma_3 = \frac{M_{Ed}}{I_y} z_3 = \frac{95}{5790} \times 40,98 \times \frac{10^3 \times 10^3}{10^3} = 162,2 \text{ MPa}$$

$$z_3 = \frac{h}{2} - (t_f + e) = \frac{240}{2} - (10,2 + 15) = 109,8 \text{ mm}$$

$$\tau_3 = \frac{V_{Ed} S_y^3}{I_y b}$$



$$S_{1/2} = \frac{W_{pl,y}}{2}$$

$$\frac{t_w \left(\frac{h}{2} - t_f - e \right)^2}{2}$$

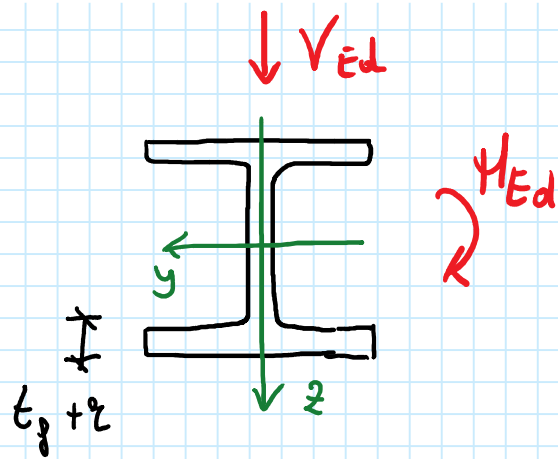
$$S_y^3 = \frac{W_{pl,y}}{2} - \frac{t_w \left(\frac{h}{2} - t_f - e \right)^2}{2} = \frac{484}{2} - \frac{6,6 \times (435 - 10,2 - 15)^2}{2 \times 10^3}$$

$$= 202,2 \text{ cm}^3$$

$$\tau_3 = \frac{200 \times 202,2}{5490 \times 0,66} \times 10 = 105,8 \text{ MPa}$$

$$\sigma_{id} = \sqrt{\sigma_3^2 + 3\tau_3^2} = \sqrt{142,2^2 + 3 \times 105,8^2} = 231,9 \text{ MPa} \leq \frac{f_y}{\gamma_{M0}} = 223,8 \text{ MPa}$$

$$\sigma_{id} = 231,9 \text{ MPa} \leq \frac{f_y}{\gamma_{M0}} = 223,8 \text{ MPa} \quad \text{No}$$



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Comportamento plastico
(Classe 1 o 2)

$$1. V_{Ed} \leq V_{c,Rd}$$

$$V_{Ed} = 200 \text{ kN} \leq V_{c,Rd} = 286,1 \text{ kN} \quad \text{OK!}$$

$$2. \frac{V_{Ed}}{V_{c,Rd}} = \frac{200}{286,1} = 0,699 > 0,5 \Rightarrow \text{de resistenza a flessione a ridotta per effetto del taglio}$$

3. Calcolo $M_{V,Rd}$

$$M_{V,Rd} = \left(W_{pl,y} - \frac{A_w^2 \rho}{h t_w} \right) \frac{f_y}{\gamma_{M0}} = \left(484 - \frac{16,5^2 \times 0,1585}{4 \times 0,66} \right) \frac{235}{1,05} \times \frac{1}{10^3}$$
$$= 104,7 \text{ kNm}$$

$$\rho = \left(2 \frac{V_{ed}}{V_{c,Rd}} - 1 \right)^2 = \left(2 \times \frac{200}{286,1} - 1 \right)^2 = 0,1585$$

$$A_w = t_w (h - 2 t_f) = \frac{6,6 \times (270 - 2 \times 10,2)}{10^2} = 16,5 \text{ cm}^2$$

4. $M_{Ed} = 75,0 \text{ kNm} \leq M_{V,Rd} = 104,7 \text{ kNm}$

OK!