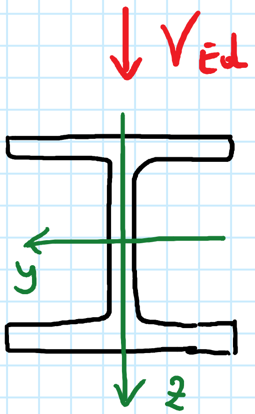


IPE 270

S 235

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

Comportamento plastico (classe 1 o 2)

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

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

2. $$V_{Ed} \le V_{c,Rd}$$

	G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A cm^2	h_i mm	d mm	∅	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	$I_w \times 10^{-3}$ cm^6	S 235	S 355	S 460	S 235	S 355	S 460
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	-

$A = 45,95 \ cm^2$

$b = 135 \ mm$

$t_f = 10,2 \ mm$

$t_w = 6,6 \ mm$

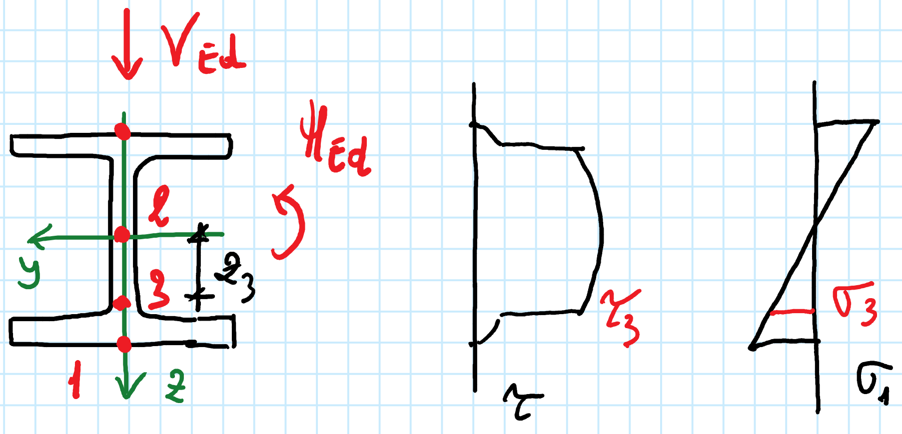
$r = 15 \ mm$

$A_v = 45,95 - 2 \times 13,5 \times 1,02 + (0,66 + 2 \times 1,5) \times 1,02 = 22,1 \ cm^2$

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

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

Taglio e flessione



Comportamento elastico

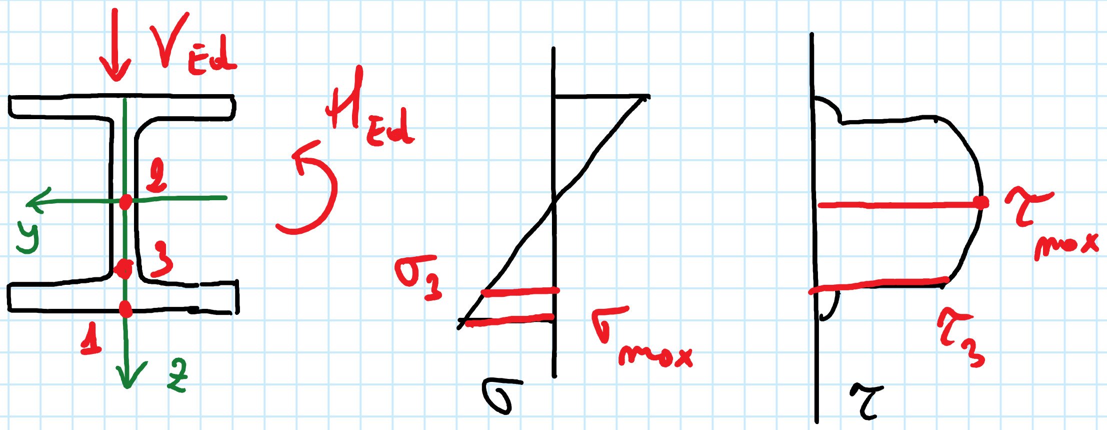
1. $$\sigma_1 = \frac{M_{Ed}}{I_y} z = \frac{M_{Ed}}{I_y}(h/2) \leq \frac{f_y}{\gamma_{M0}}$$

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

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

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

Flessione e taglio



Comportamento elastico

Classe 3

Le tensioni nel generico punto si calcolano con Navier

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

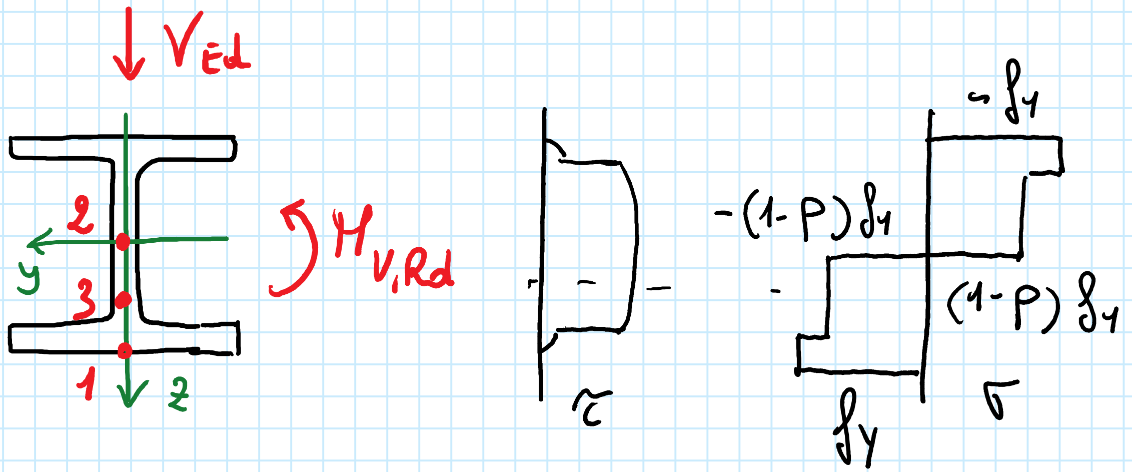
e Jourawsky

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

1. $\sigma_1 \leq f_y / \gamma_{M0}$

2. $\tau_2 \leq \dfrac{f_y}{\sqrt{3}\,\gamma_{M0}}$

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



Comportamento plastico

Classe 1 e 2

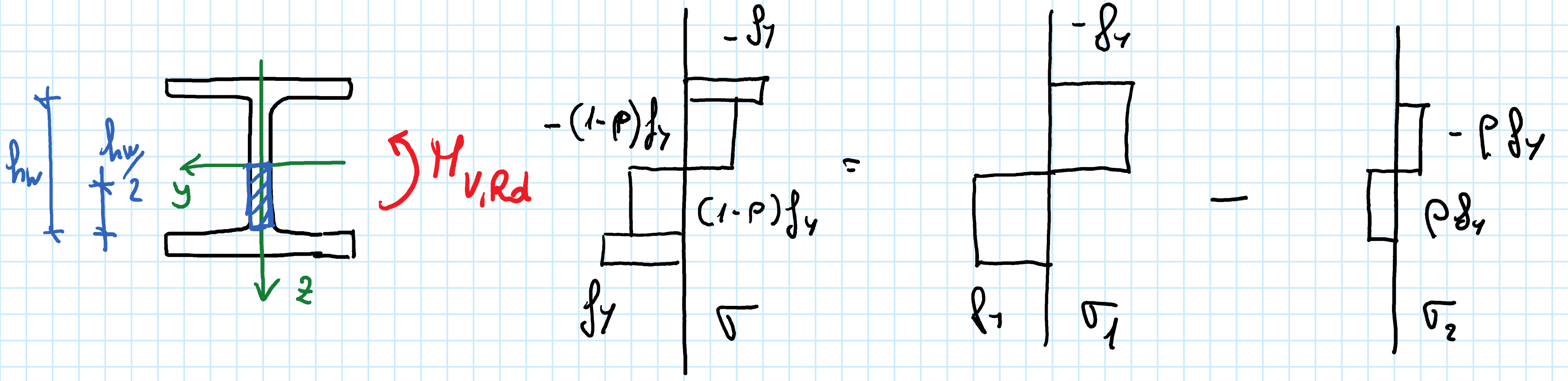
$$M_{Ed} \leq M_{V,Rd}$$

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

Nell'anima permane $\sigma < f_y$. Questa σ si assume pari a $(1-\rho)f_y$ con $0 < \rho < 1$

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

Il diagramma della σ è quello indicato in figura.



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

$$M_{V,Rd} = \int_A \sigma z \, dA = W_{pl} f_y - W_{pl,w} \rho f_y = \left(W_{pl} - \frac{A_w^2 \rho}{4 t_w} \right) f_y$$

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

Bisogna ancora considerare il coefficiente di sicurezza parziale γ_{M0} e calcolare ρ.

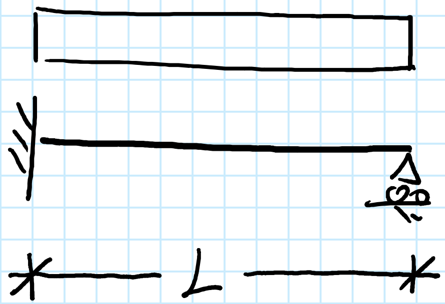
Momento resistente ridotto per effetto del taglio secondo le NTC 18

$$M_{V,Rd} = M_{Rd} = W_{pl} \frac{f_y}{\gamma_{M0}} \quad \text{se } V_{Ed} \leq 0,5\, V_{c,Rd}$$

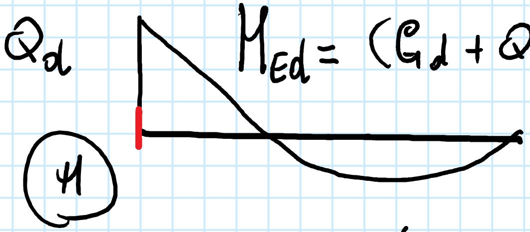
$$M_{V,Rd} = \left(W_{pl} - \frac{A_w^2\, \rho}{4\, t_w} \right) \frac{f_y}{\gamma_{M0}} \quad \text{se } V_{Ed} > 0,5\, V_{c,Rd}$$

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

Applicazioni numeriche



$G_d + Q_d$



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

$V_{Ed} = 1{,}25\, (G_d + Q_d)\, L/2$

IPE 270

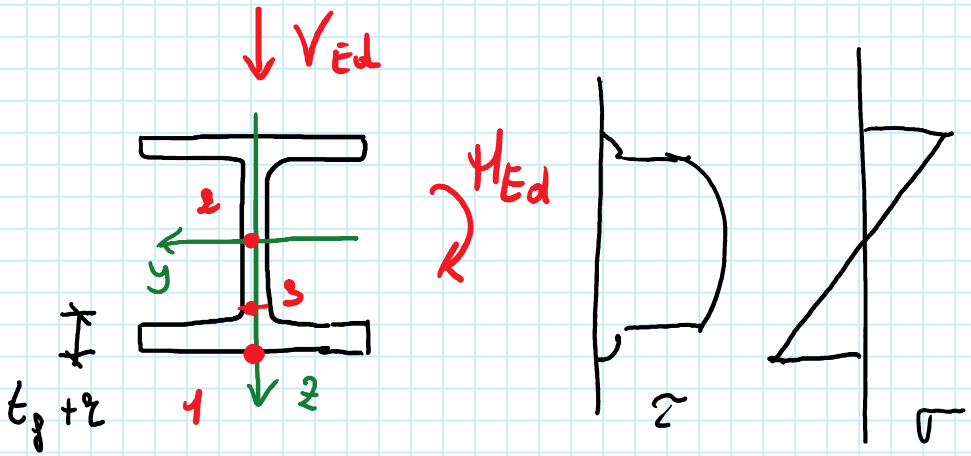
S 235

$M_{Ed} = 75$ kNm

$V_{Ed} = 200$ kN

	G kg/m	h mm	b mm	t_w mm	t_f mm	r mm	A cm^2	h_i mm	d mm	∅	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	$I_w \times 10^{-3}$ cm^6	S 235	S 355	S 460	S 235	S 355	S 460
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	-



IPE 270

S 235

$M_{Ed} = 75$ kNm

$V_{Ed} = 200$ kN

Comportamento elastico
(Classe 3)

1. $$\sigma_1 = \frac{M_{Ed}}{I_y}(h/2) = \frac{M_{Ed}}{W_{el,y}} = \frac{75}{428,9} \times \frac{10^3 \times 10^3}{10^3} = 174,9 \text{ MPa}$$

$$\sigma_1 = 174.9 \text{ MPa} \leq \frac{f_y}{\gamma_{M0}} = \frac{235}{1,05} = 223,8$$

OK!

2. $\tau_2 = \frac{V_z\, S_{1/2}}{I_y\, b} = \frac{200 \times 242}{5790 \times 0{,}66} \times \frac{10^3}{10^2} = 126{,}6 \text{ MPa}$

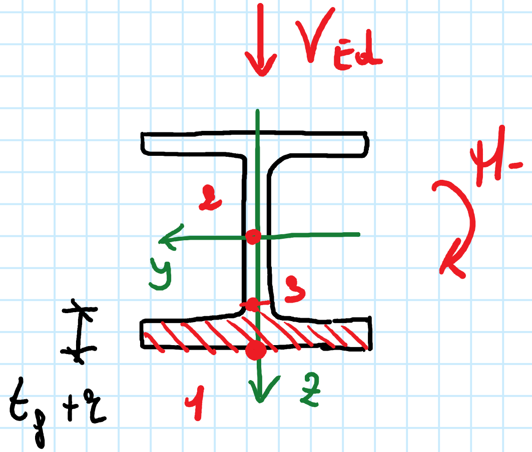
$\tau_2 = 126{,}6 \text{ MPa} \leq \frac{f_y}{\sqrt{3}\,\gamma_{M0}} = 129{,}2$ OK!

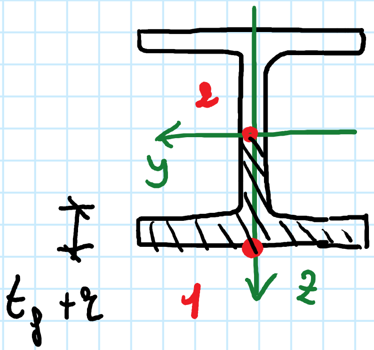
3. Calcolo σ_3 e τ_3

$\sigma_3 = \frac{M_{Ed}}{I_y} z_3 = \frac{75}{5790} \times 10{,}98 \times \frac{10^3 \times 10^3}{10^3} = 142{,}2 \text{ MPa}$

$z_3 = \frac{h}{2} - (t_f + r) = \frac{270}{2} - (10{,}2 + 15) = 109{,}8 \text{ mm}$

$\tau_3 = \frac{V_{Ed}\, S_y(z_3)}{I_y\, b}$





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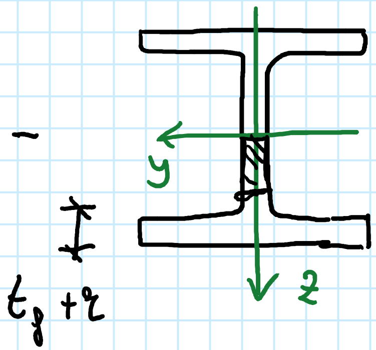


$$S_{1/2} = \frac{W_{pl,y}}{2} \qquad \frac{t_w \left(\frac{h}{2} - t_f - r\right)^2}{2}$$

$$S_y(z_3) = \frac{W_{pl,y}}{2} - t_w \frac{(h/2 - t_f - r)^2}{2} = \frac{484}{2} - 6{,}6 \times \frac{(135 - 10{,}2 - 15)^2}{2 \times 10^3}$$

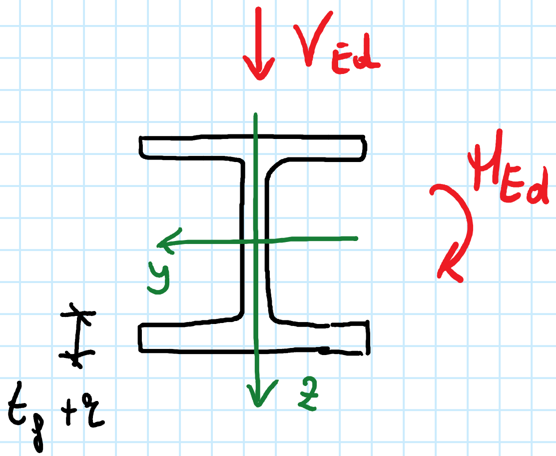
$$= 202.2 \ cm^3$$

$$\tau_3 = \frac{200 \times 202,2}{5790 \times 0,66} \times 10 = 105,8 \text{ MPa}$$

$$\sigma_{id} = \sqrt{\sigma_3^2 + 3\tau_3^2} = \sqrt{142,2^2 + 3 \times 105,8^2} = 232,0 \text{ MPa} \leq \frac{f_y}{\gamma_{M0}} = 223,8 \text{ MPa}$$

$$\sigma_{id} = 232,0 \text{ MPa} \leq \frac{f_y}{\gamma_{M0}} = 223,8 \text{ MPa}$$

NO



IPE 270

S 235

$M_{Ed} = 75$ kNm

$V_{Ed} = 200$ kN

Comportamento plastico (Classe 1 o 2)

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

   $V_{Ed} = 200$ kN $< V_{c,Rd} = 286,1$ kN   OK!

2. $\frac{V_{Ed}}{V_{c,Rd}} = \frac{200}{286,1} = 0,6991 > 0,5 \Longrightarrow$ La resistenza a flessione è ridotta per effetto del taglio

3. Calcolo $M_{V,Rd}$

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

$$= 104{,}7 \text{ KNm}$$

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

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

4. $M_{Ed} = 75{,}0$ KNm $\leq M_{V,Rd} = 104{,}7$ KNm OK!