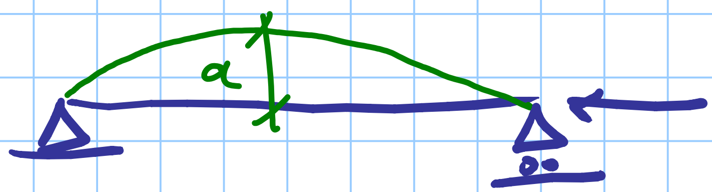
$$\frac{d^2 w}{dx^2} = -\frac{M}{EI}$$

con $M = N w$

$$\frac{d^2 w}{dx^2} = -\frac{N}{EI} w$$



$$w = a \sin \frac{\pi x}{l}$$

x $N = \dfrac{\pi^2 EI}{l_0^2}$

$$N_{cr} = \frac{\pi^2 E I}{l_0^2}$$

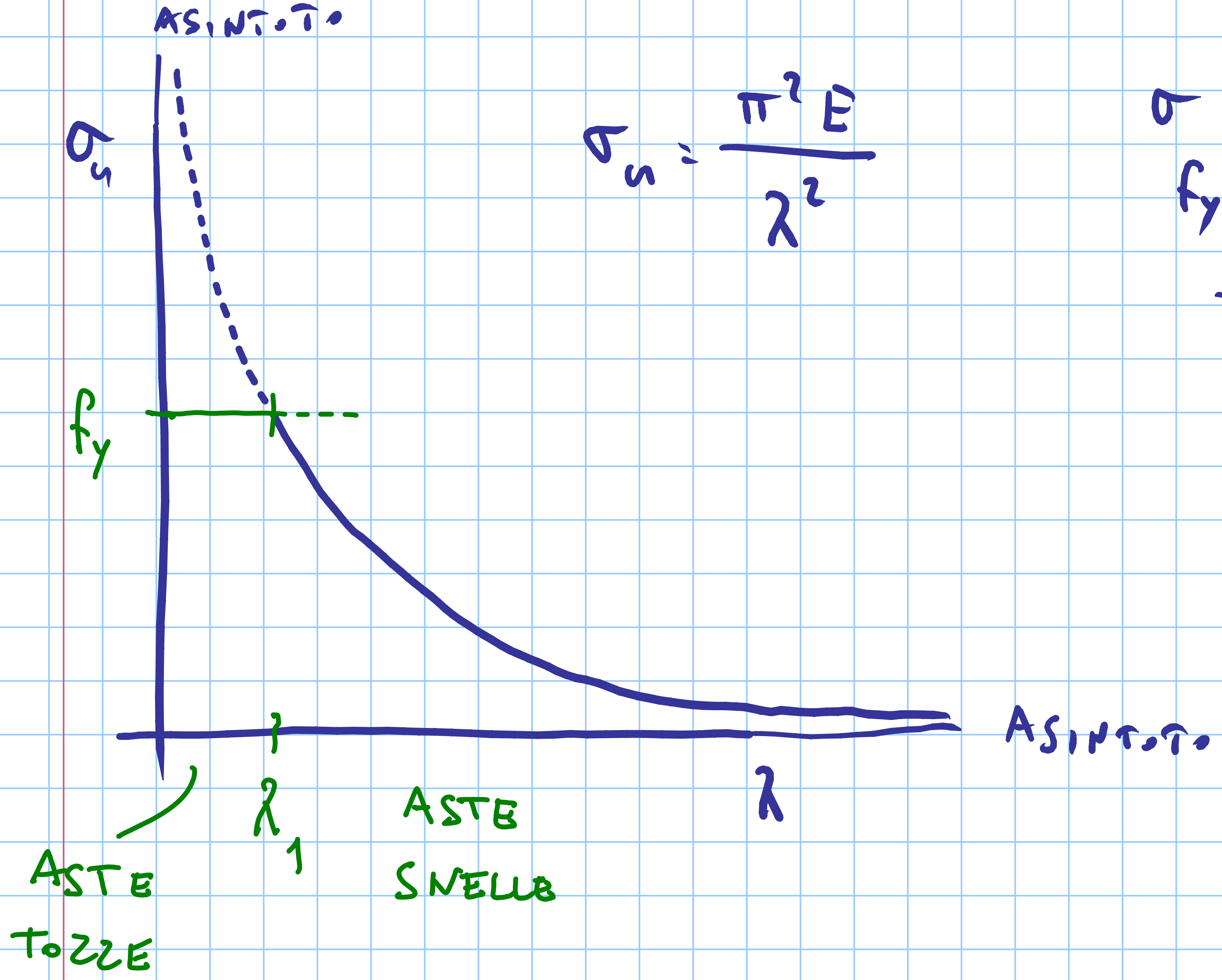
$$\sigma_{cr} = \frac{N_{cr}}{A} = \frac{\pi^2 E I}{l_0^2 A} = \frac{\pi^2 E i^2}{l_0^2}$$

$$I = A i^2$$

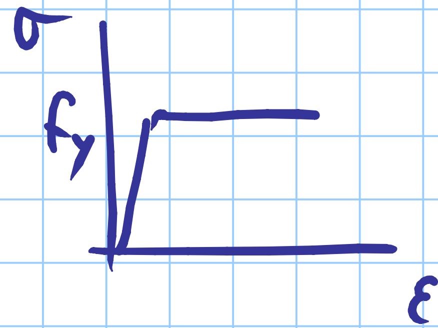
$$\frac{l_0}{i} = \lambda$$

SNELLEZZA

$$\sigma_{cr} = \frac{\pi^2 E}{\lambda^2}$$



$$\sigma_u = \frac{\pi^2 E}{\lambda^2}$$



$$f_y = \frac{\pi^2 E}{\lambda_1^2} \qquad \lambda_1 = \pi \sqrt{\frac{E}{f_y}}$$

$$\frac{\lambda}{\lambda_1} = \bar{\lambda}$$

SNELLEZZA NORMALIZZATA

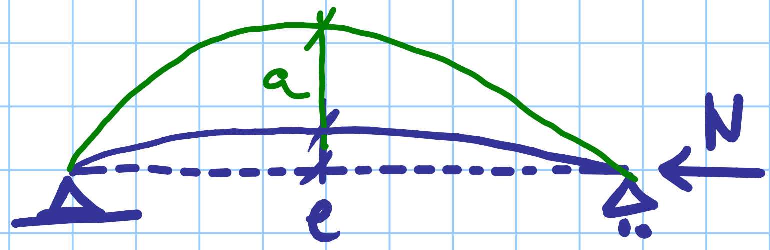
$\bar{\lambda} < 1$ aste tozze

$\bar{\lambda} > 1$ aste snelle

$$\sigma_{cr} = \frac{\pi^2 E}{\lambda^2} \qquad f_y = \frac{\pi^2 E}{\lambda_1^2}$$

$$\frac{f_y}{\sigma_u} = \frac{\dfrac{\pi^2 E}{\lambda_1^2}}{\dfrac{\pi^2 E}{\lambda^2}} = \frac{\lambda^2}{\lambda_1^2} \Rightarrow \frac{\lambda}{\lambda_1} = \sqrt{\frac{f_y}{\sigma_u}}$$

$$\bar{\lambda} = \frac{\lambda}{\lambda_1} = \sqrt{\frac{f_y}{\sigma_u}} = \sqrt{\frac{N_y}{N_u}}$$



$$w_i = e \sin \frac{\pi x}{l}$$

$$w = a \sin \frac{\pi x}{l}$$

$$\frac{d^2 w}{dx^2} = -\frac{M}{EI}$$

$$w_{Tot} = w_i + w$$

$$M = N \cdot w_{Tot}$$

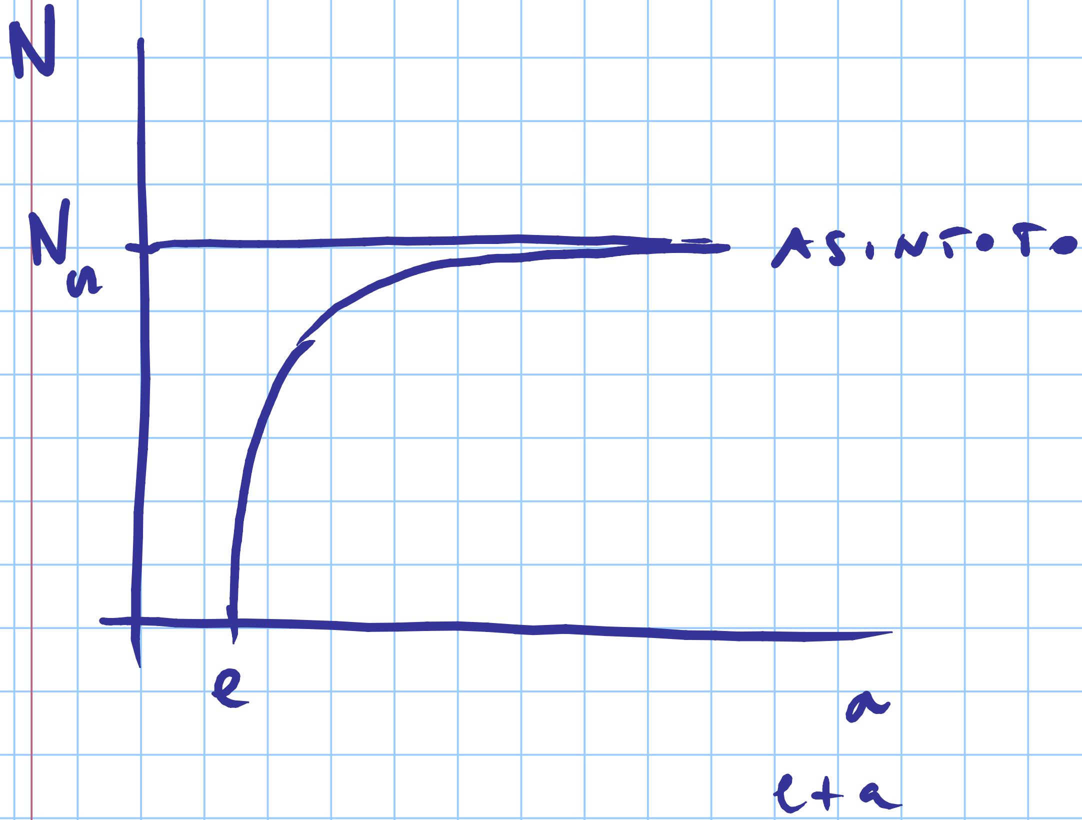
$$\frac{d^2 w}{dx^2} = -\frac{N}{EI}(w_i + w)$$

$$\frac{d^2 w_i}{dx^2} = -\frac{\pi^2}{l^2} w_i \qquad \frac{d^2 w}{dx^2} = -\frac{\pi^2}{l^2} w$$

$$-\frac{\pi^2}{\ell^2}\, a \cancel{\sin \frac{\pi x}{\ell}} = -\frac{N}{EI}(e+a) \cancel{\sin \frac{\pi x}{\ell}}$$

$$a\frac{\pi^2}{\ell^2} = (e+a)\frac{N}{EI} \quad \Rightarrow \quad a\, N_u = (e+a)\, N$$

$$a N_u - a N = e N \quad \Rightarrow \quad a = \frac{N}{N_u - N}\, e$$


N
N_u
ASINTOTO
e
a
e+a

$$M_{max} = N(e+a) \qquad a = \frac{N}{N_u - N} e$$

$$e + a = e + \frac{N}{N_u - N} e = \frac{N_u}{N_u - N} e$$

$$M = N(e+a) = N e \frac{N_u}{N_u - N}$$

presso-flessione $\qquad \sigma_{max} = \frac{N}{A} + \frac{M}{I} \frac{h}{2}$

$$\sigma_{max} = \frac{N}{A} + \frac{N}{A} e \frac{N_u}{N_u - N} \frac{A \, h/2}{I} =$$

$$= \frac{N}{A} \left[1 + \frac{N_u}{N_u - N} \underbrace{e \frac{A \, h/2}{I}} \right]$$

$$\eta = \alpha \left(\bar{\lambda} - 0.2 \right)$$

$$\sigma_{max} = \frac{N}{A} \left[1 + \eta \frac{N_u}{N_u - N} \right]$$

IMPERFEZIONE DELL'ASTA

N_u il valore per cui $\sigma_{max} = f_y$

$$f_y = \frac{N_u}{A}\left[1 + \eta \frac{N_{cr}}{N_{cr} - N_u}\right]$$

$$A \cdot f_y = N_y$$

$$1 = \frac{N_u}{N_y}\left[\frac{N_{cr} - N_u + \eta N_{cr}}{N_{cr} - N_u}\right]$$

$$\bar{\lambda} = \sqrt{\frac{N_y}{N_{cr}}}$$

$$\frac{N_{cr}}{N_y} = \frac{1}{\bar{\lambda}^2}$$

$$\frac{N_y}{N_u} = \bar{\lambda}^2$$

$$\frac{N_u}{N_y} = \chi$$

$$1 = \chi \frac{(1+\eta)/\bar{\lambda}^2 - \chi}{1/\bar{\lambda}^2 - \chi}$$

$$1 = \chi \frac{1+\eta - \bar{\lambda}^2 \chi}{1 - \bar{\lambda}^2 \chi}$$

$$1 - \bar{\lambda}^2 x = x(1+\eta) - \bar{\lambda}^2 x^2$$

equazione di 2° grado in x

$$\bar{\lambda}^2 x^2 - \underbrace{\left(1+\eta+\bar{\lambda}^2\right)}_{2\phi} x + 1 = 0$$

$$\phi = \frac{1}{2}\left(1 + \underset{\alpha(\bar{\lambda}-0.2)}{\underset{\downarrow}{\eta}} + \bar{\lambda}^2\right)$$

$$x = \frac{\phi - \sqrt{\phi^2 - \bar{\lambda}^2}}{\bar{\lambda}^2}$$

$$\frac{\phi + \sqrt{\phi^2 - \lambda^2}}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}}$$

$$\chi = \frac{[\phi]^2 - \left[\sqrt{\phi^2 - \bar{\lambda}^2}\right]^2}{\bar{\lambda}^2 \left[\phi + \sqrt{\phi^2 - \bar{\lambda}^2}\right]} = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}}$$

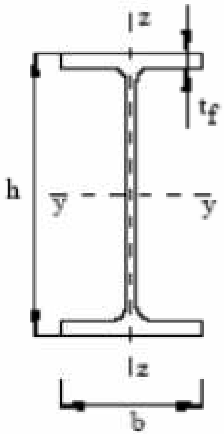
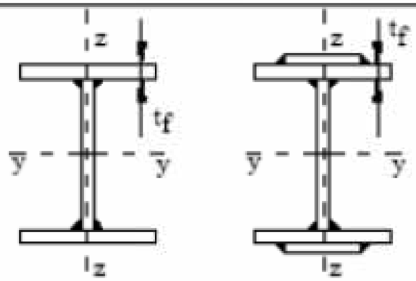
con $\phi = \frac{1}{2}\left[1 + \alpha(\bar{\lambda} - 0.2) + \bar{\lambda}^2\right]$

$$N_{b,Rd} = \chi A \frac{f_y}{\gamma_{M0}}$$

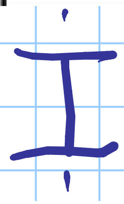
BUCKLING = instabilità

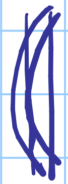
ai fini delle imperfezioni

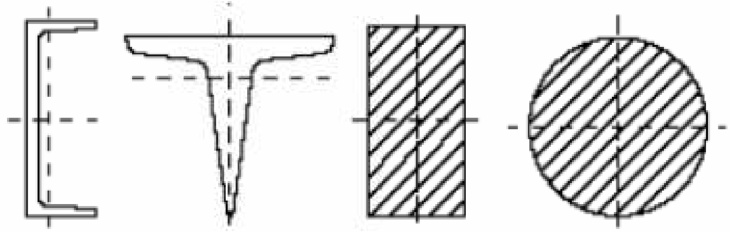
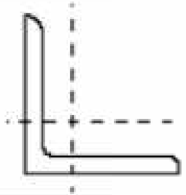
a	minore	$\alpha = 0.21$
b		0.34
c		0.49
d	maggiore	0.76

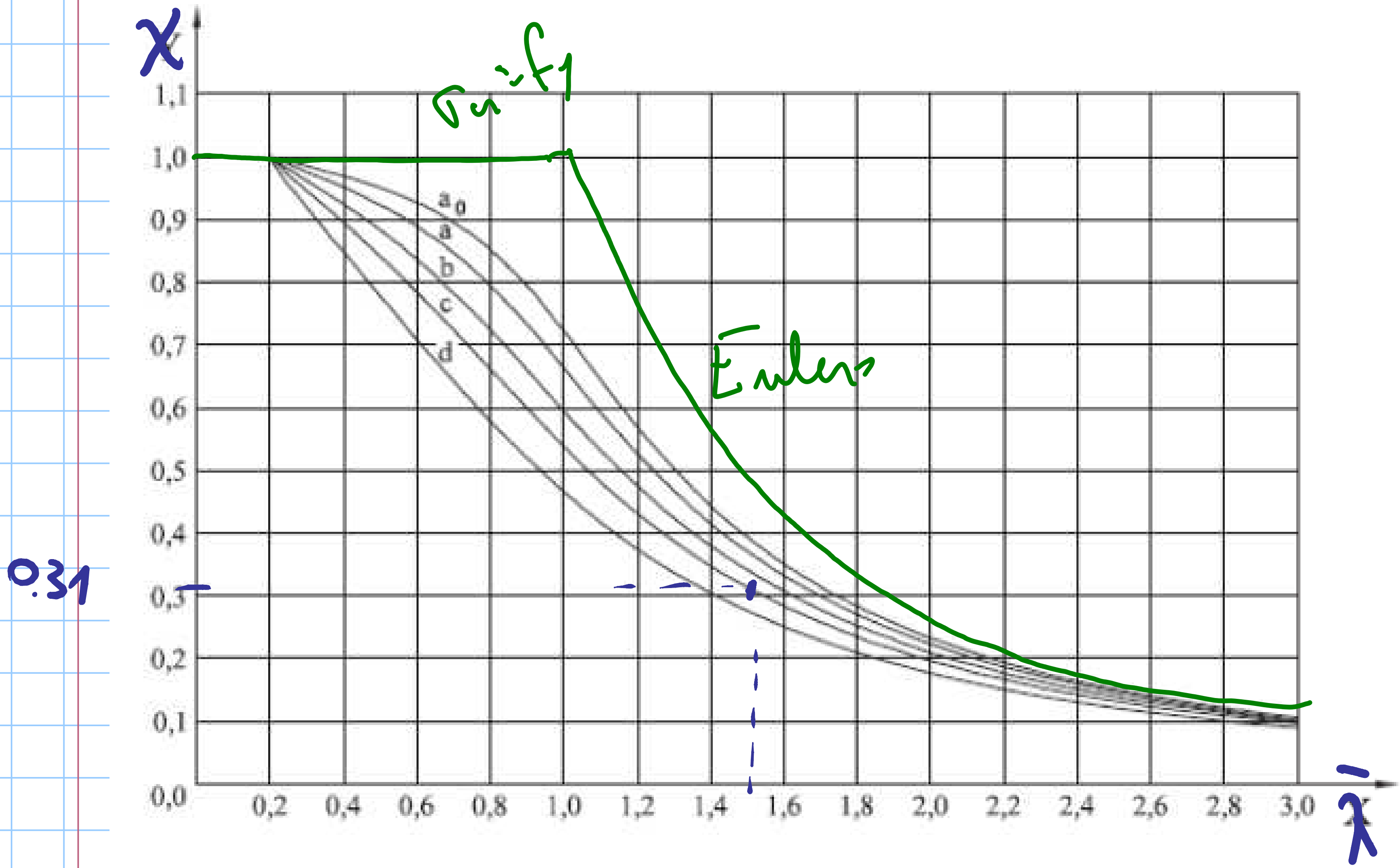
Sezione trasversale		Limiti		Inflessione intorno all'asse	Curva di instabilità S235, S275, S355, S420	Curva di instabilità S460
Sezioni laminate		$h/b > 1,2$	$t_f \le 40$ mm	y-y z-z	a b	a_0 a_0
			$40 \text{ mm} < t_f \le 100$ mm	y-y z-z	b c	a a
		$h/b \le 1,2$	$t_f \le 100$ mm	y-y z-z	b c	a a
			$t_f > 100$ mm	y-y z-z	d d	c c
Sezioni ad I saldate			$t_f \le 40$ mm	y-y z-z	b c	b c
			$t_f > 40$ mm	y-y z-z	c d	c d

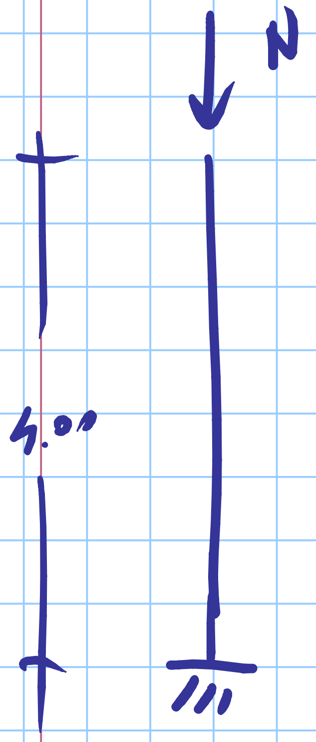
HEB 240





Sezioni piene, ad U e T		qualunque	c	c
Sezioni ad L		qualunque	b	b


χ
$\sigma_u = f_y$
1,1
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
0.31
a_0
a
b
c
d
Euler
0,2
0,4
0,6
0,8
1,0
1,2
1,4
1,6
1,8
2,0
2,2
2,4
2,6
2,8
3,0
$\bar{\lambda}$



HEB 240

$$A = 106.0 \times 10^2 \ mm^2$$

$$i_y = 10.31 \times 10 \ mm$$

$$i_z = 6.08 \times 10 \ mm$$

$$l_0 = 8000 \ mm$$

$$\lambda_z = \frac{l_0}{i_z} = \frac{8000}{60.8} = 131.6$$

S 275 $\qquad f_y = 275$ MPa

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = 3.14 \sqrt{\frac{210000}{275}} = 86.8$$

$$\bar{\lambda} = \frac{\lambda}{\lambda_1} = \frac{131.6}{86.8} = 1.52$$

$$N_{b,Rd} = 0.31 \times \underbrace{106 \times 10^2 \times \frac{275}{1.05}}_{2776} \times 10^{-3} = 860 \text{ KN}$$