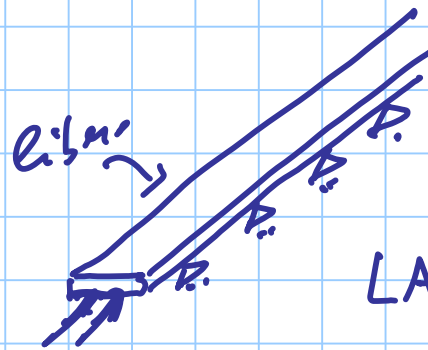


mezzo ala  
del I



LA STRA

ala della  
trave

TRAVE (D.S.V.)

monodimensional

una dimensione predominante  
(LUNGHEZZA)

due dimensioni (della sezione)  
COMPARABILI

LASTRA

una dimensione predominante  
(non necessariamente)

due dimensioni della sezione  
nettamente diverse

inglesi

PLATE

bidimensionali

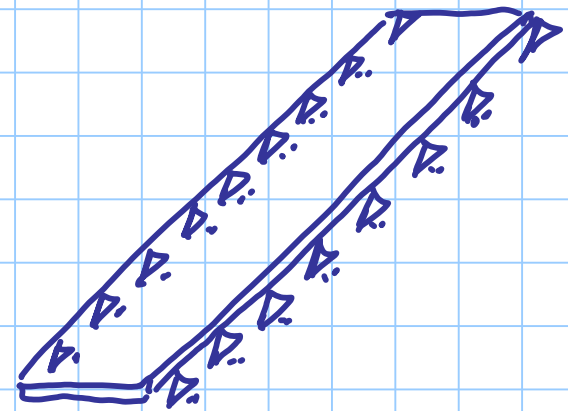
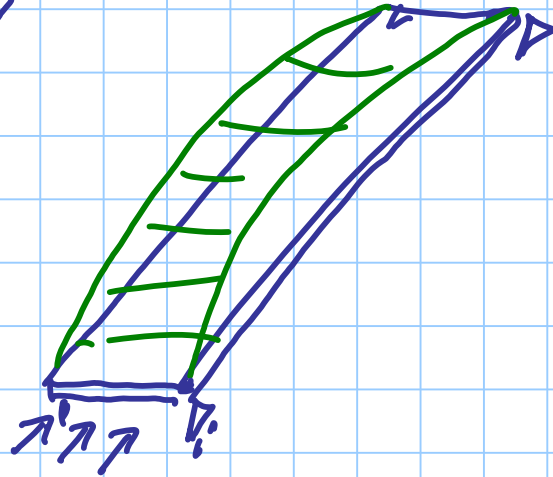
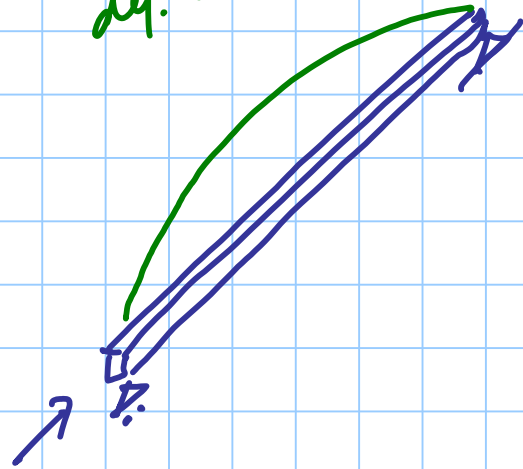
LASTRA

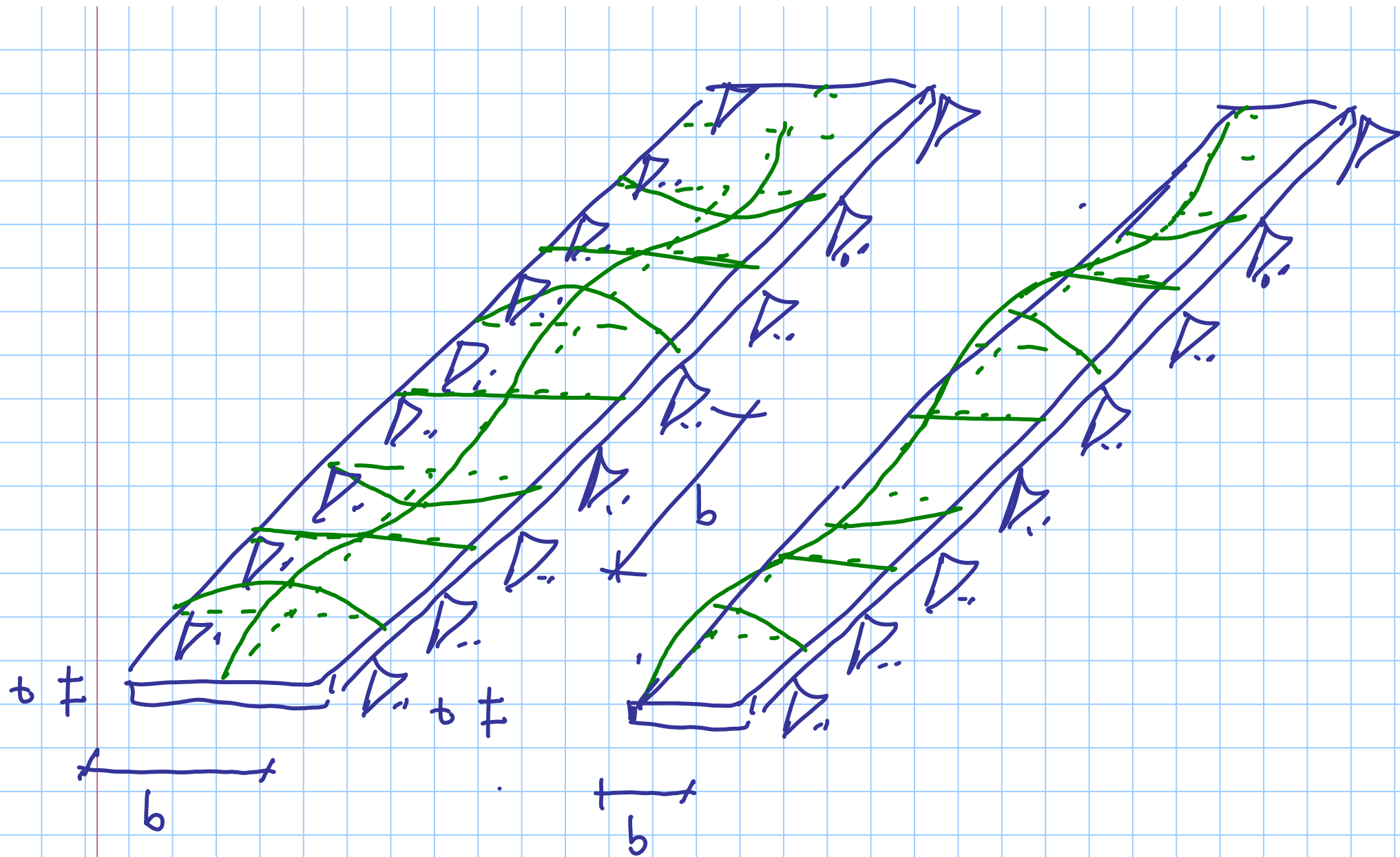
sollecitata nel piano

PIASTRA

sollecitata perpendicolarmente  
al piano

def. crit. son





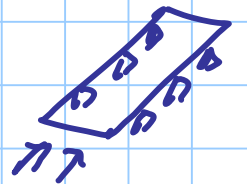
## TRAVE

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

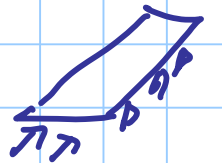
## LA STRA

$$N_{cr} = \frac{K \pi^2 EI}{(1-\nu^2) l^2}$$

$K = 4$  per lastre vincolate  
in due capi



$K = 0.43$  per lastre  
vincolate in 1 capo



TRAVE

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

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

LASTRA



$$A = b t$$

$$I = \frac{b t^3}{12}$$

$$\frac{I}{A} = \frac{t^2}{12}$$

$$\sigma_{cl} = \frac{k \pi^2 E}{12 (1 - \nu^2) \left( \frac{b}{t} \right)^2}$$

$$\lambda_p = \frac{b}{t} \sqrt{\frac{12 (1 - \nu^2)}{k}}$$

$$\sigma_{cl} = \frac{\pi^2 E}{\lambda_r^2}$$

LASTRA

$$\sigma_{c2} = \frac{\pi^2 E}{\lambda_p^2}$$

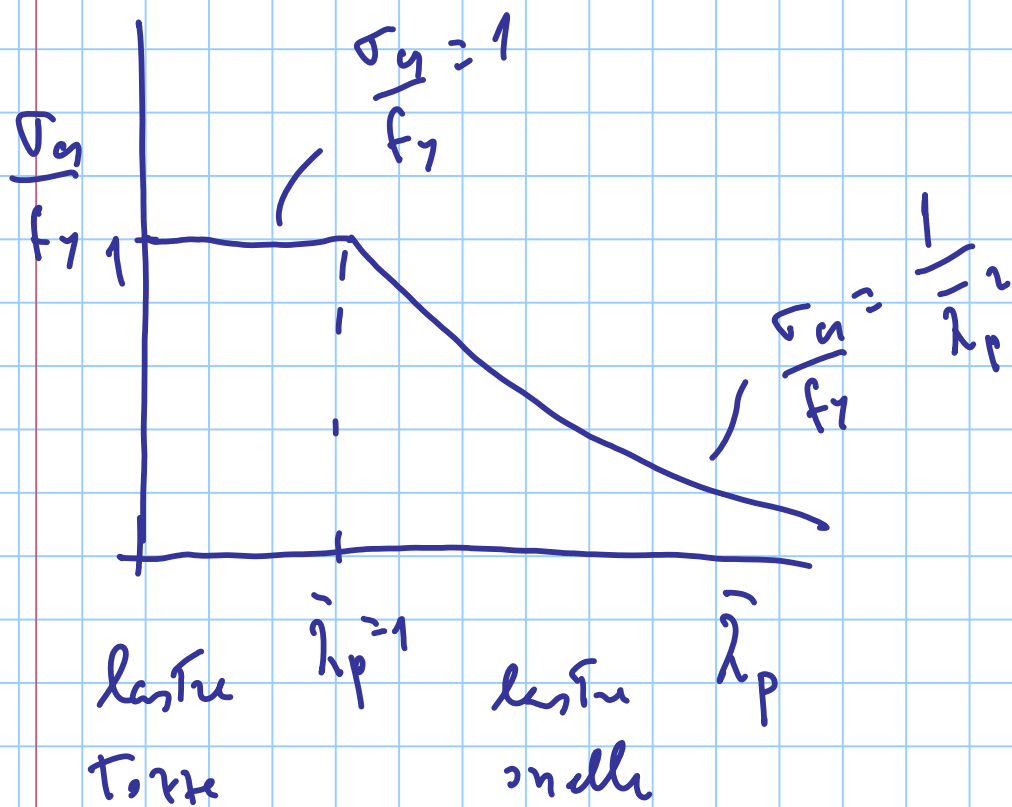
$$\lambda_{p1} \Leftrightarrow \sigma_c = f_y$$

$$f_y = \frac{\pi^2 E}{\lambda_{p1}^2}$$

smaller dimension  $\lambda_{p1}$

$$\bar{\lambda}_p = \frac{\lambda_p}{\lambda_{p1}} = \sqrt{\frac{f_y}{\sigma_c}} = \sqrt{\frac{A f_y}{N_c}}$$

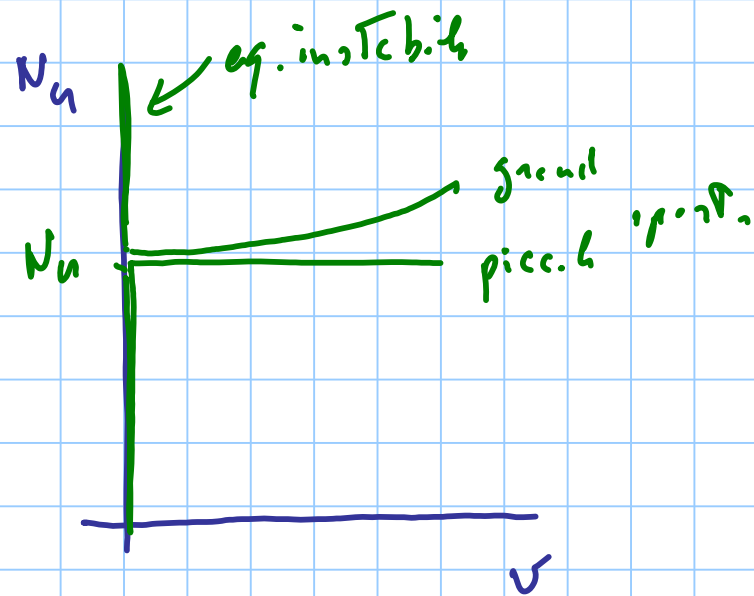
$$\frac{f_y}{\sigma_c} = \frac{\frac{\pi^2 E}{\lambda_{p1}^2}}{\frac{\pi^2 E}{\lambda_p^2}} = \frac{\lambda_p^2}{\lambda_{p1}^2}$$





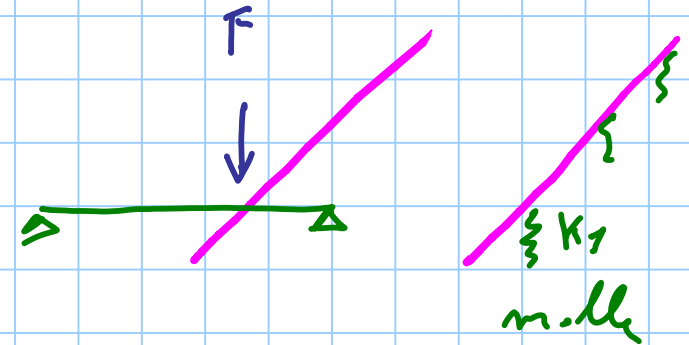
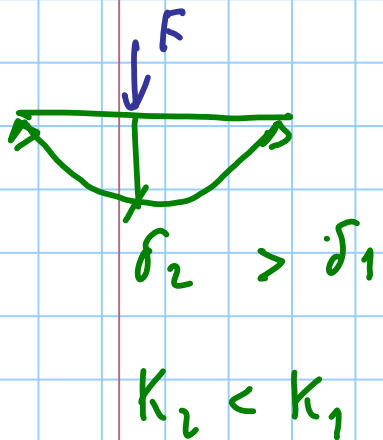
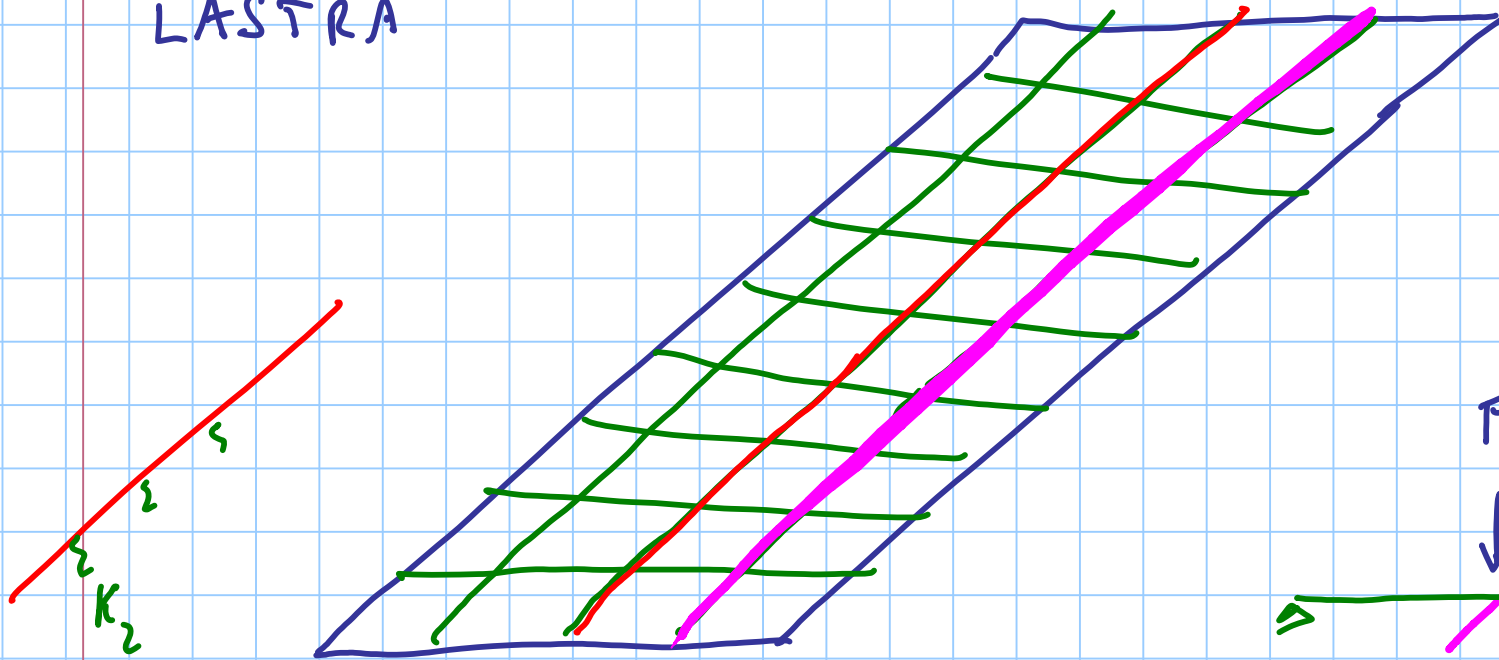
# COMPORTAMENTO POST-CRITICO

TRAVER

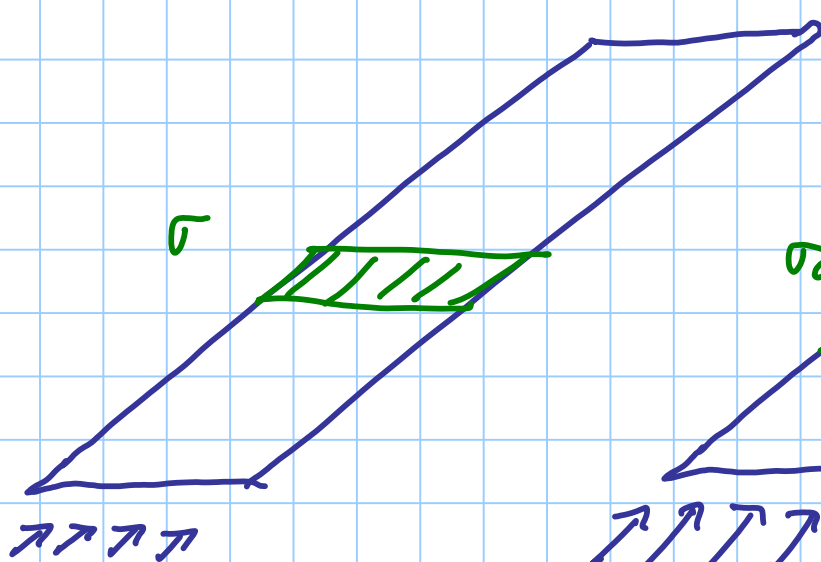


$N_u$  è il limite

LASTRA

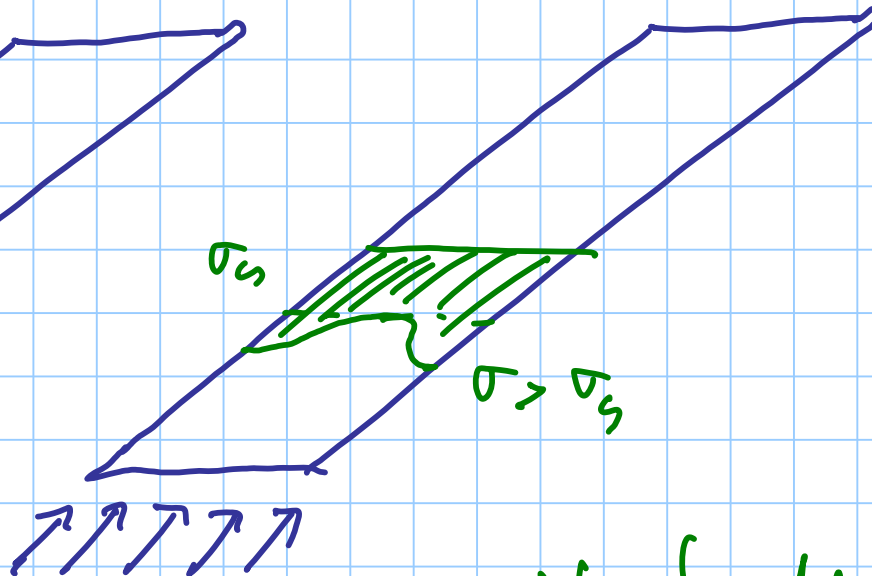


$$K_1 = \frac{F}{\delta_1} = \text{const}$$



$$N \leq N_u$$

$$\sigma \leq \sigma_u$$

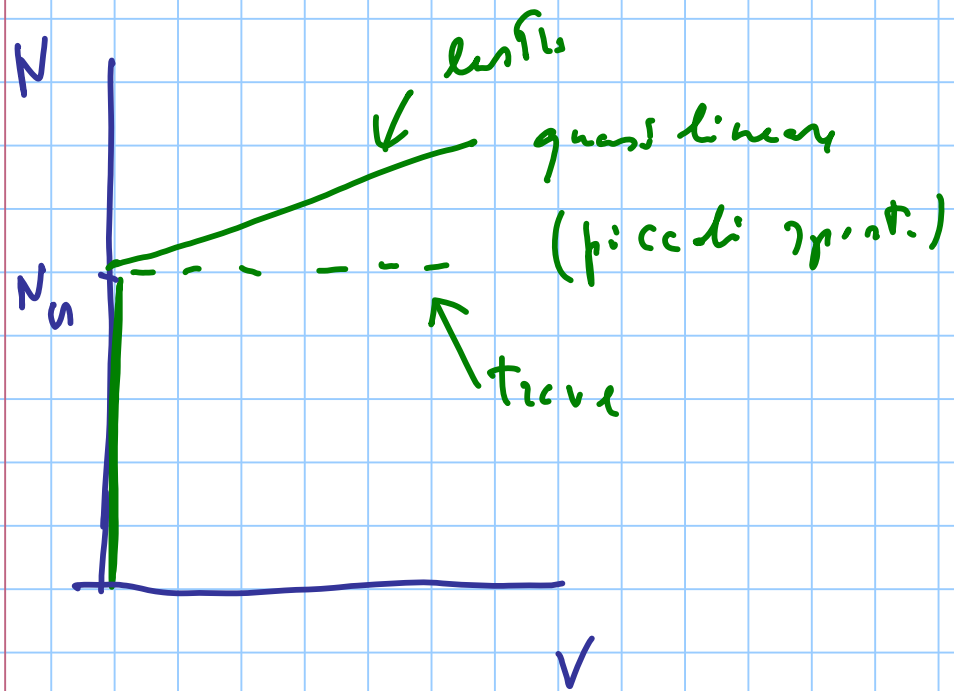


$$N > N_u$$

$$N = \int \sigma dA > N_u$$

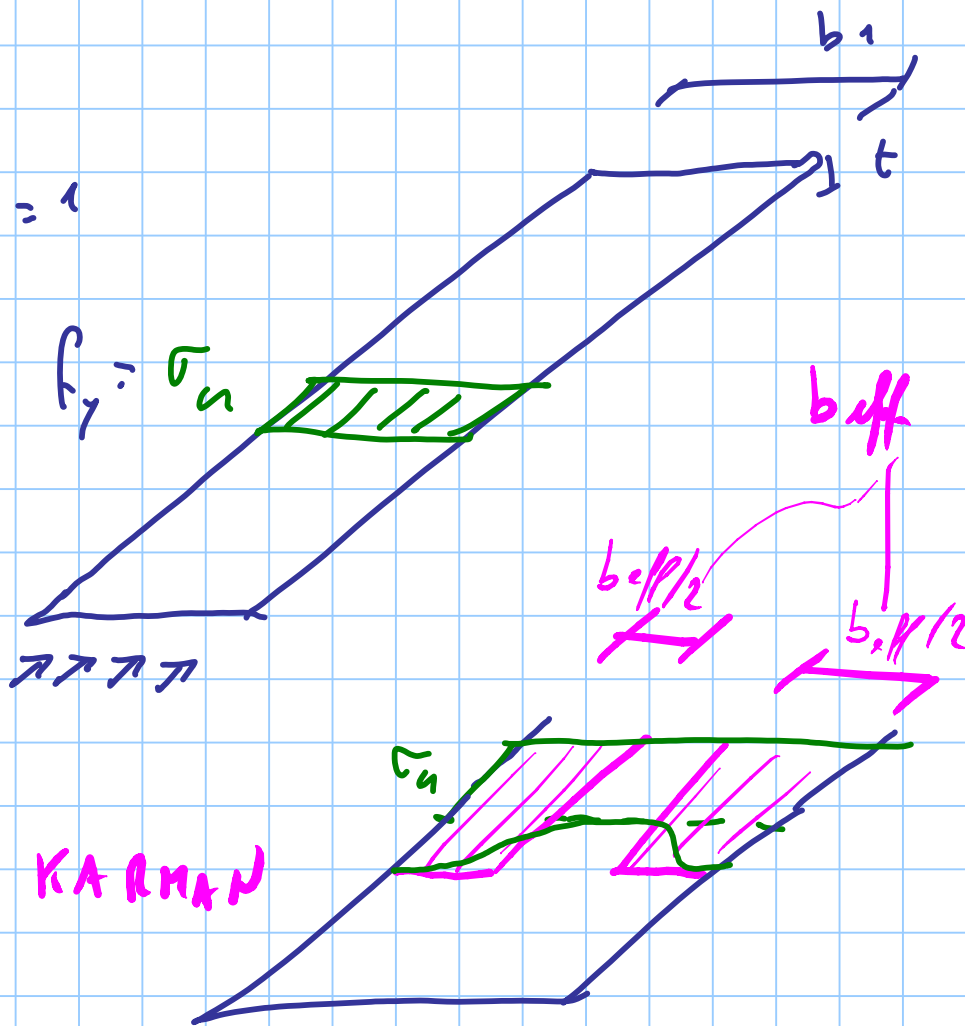
per aumentare  $N$  oltre  $N_u$

LASTRA



$$\bar{\lambda}_p = 1$$

$$f_y = \sigma_u$$



VON KARMAN

$\sigma_{\text{cost}}$   
 su una parte  
 $\int \sigma dA$   
 non cambi

$$b' > b_1$$

$$\sigma_u' < \sigma_{c2}$$

LASTRA  
 PERFETTA

$$f_0 \leq f_c$$

$$f_y < \sigma_{c2}$$

al limite  $\bar{\lambda}_p = 1$

$$f_y = \sigma_{c2}$$

$b_{\text{eff}}$   $\text{eff} \rightarrow \text{effective}$   
 efficacia

per lastre perfette

aumentando  $b$   
a partire da  $t$

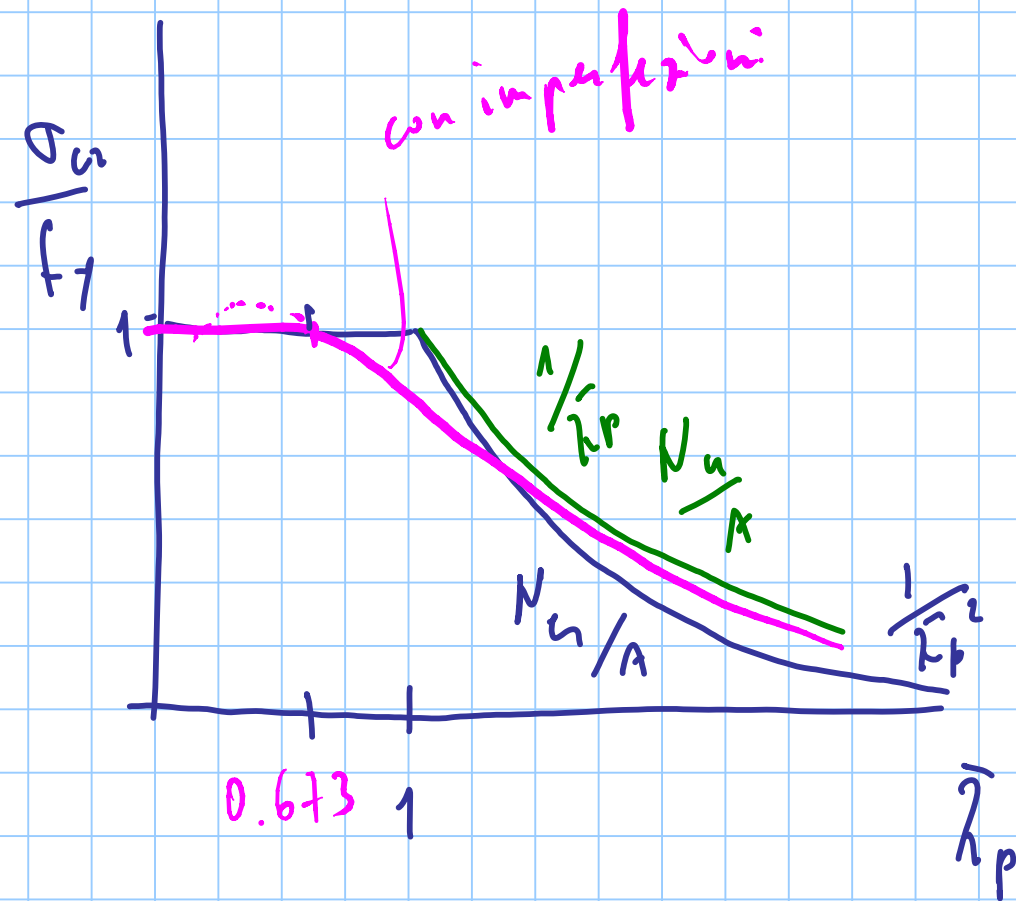
il carico critico si riduce

il carico ultimo non cambia

$$\bar{\lambda}_p = \frac{\lambda_p}{\lambda_{p1}} = \frac{b}{b_1}$$

$$b_1 = \frac{b}{\bar{\lambda}_p} = b_{eff}$$

$$N_b = f_y b_1 t = f_y \frac{b}{\bar{\lambda}_p} t$$



$$b_{eff} = \frac{\bar{\lambda}_p - 0.22}{\bar{\lambda}_p^2} \quad b \leq b$$

$$\lambda_p = \sqrt{\frac{f_y}{\sigma_a}} = \sqrt{\frac{f_y \cdot 12 (1-\nu^2) \left(\frac{b}{t}\right)^2}{k \pi^2 E}} =$$

$$= \frac{b}{t} \frac{1}{\sqrt{k}} \sqrt{\frac{f_y \cdot 12 (1-\nu^2)}{\pi^2 E}}$$

$$\approx f_y = 235 \text{ MPa}$$

$$\sqrt{\frac{f_y}{235}} \sqrt{\frac{235 \times 12 \times (1-0.3^2)}{3.14^2 \times 210000}} =$$

$$= 0.0352 = \frac{1}{28.5}$$



$$\bar{\lambda}_p = \frac{1}{\sqrt{\kappa}} \frac{b}{t} \frac{1}{28.4} \frac{1}{\sqrt{\frac{235}{f_y \epsilon}}} = \frac{b}{t} \frac{1}{28.4 \epsilon \sqrt{\kappa}}$$

S 235

$$\epsilon = 1$$

$$\kappa = 0.43$$

vincolo su  
un lato

S 275

$$\epsilon = 0.924$$

$$\kappa = 4$$

vincolo su  
due lati

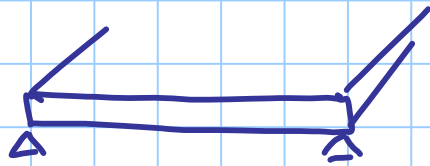
S 355

$$\epsilon = 0.814$$

$$\frac{\bar{\lambda}_p - 0.22}{\bar{\lambda}_p^2} = 1$$

$$\bar{\lambda}_p^2 - \bar{\lambda}_p + 0.22 = 0$$

$$\bar{\lambda}_p = \frac{1 \pm \sqrt{1 - 4 \times 0.22}}{2} = \frac{1 \pm 0.346}{2} = \begin{cases} 0.327 \\ 0.673 \end{cases}$$



$$b = 200 \text{ mm}$$

$$t = 5 \text{ mm}$$

$$K = 4$$

$$\frac{b}{t} = \frac{200}{5} = 40$$

S 235

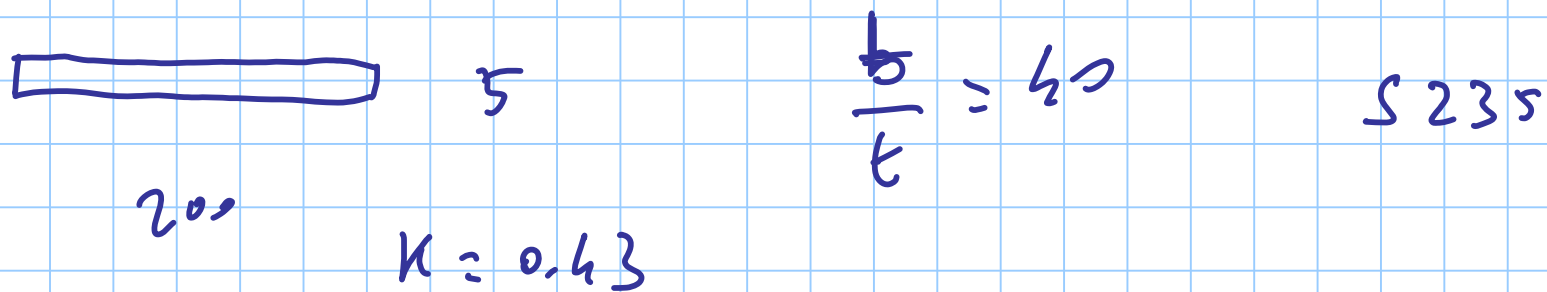
$$\sigma_{cr} = \frac{K \pi^2 E}{12 (1 - \nu^2) \left( \frac{b}{t} \right)^2} = 474.5 \text{ MPa} > f_y \quad \text{torsion}$$

$$\bar{\lambda}_p = \frac{b}{t} \frac{1}{28.4 \sqrt{k}} = \frac{40}{28.4 \times 1 \times \sqrt{4}} = 0.704 > 0.673$$

$$b_{eff} = \frac{0.704 - 0.22}{0.704^2} \times 200 = 0.977 \times 200 = 195.4 \text{ mm}$$

pu: poutre  $N = 195.4 \times 5 \times \frac{235}{1.05} \times 10^{-3} = 414 \text{ kN}$

idem, ma vis, le  $T_c$  de un  $\phi 6 \text{ Lfi}$



$\frac{b}{t} = 40$  S 235

$K = 0.43$

$$\bar{\lambda}_p = \frac{40}{28.4 \times 1 \times \sqrt{0.43}} = 2.148$$

$$b_{eff} = 0.418 \times 200 = 85.6 \text{ mm}$$

$$\lambda_p = \frac{b}{t} \frac{1}{28.4 \sqrt{K}} = 0.673$$

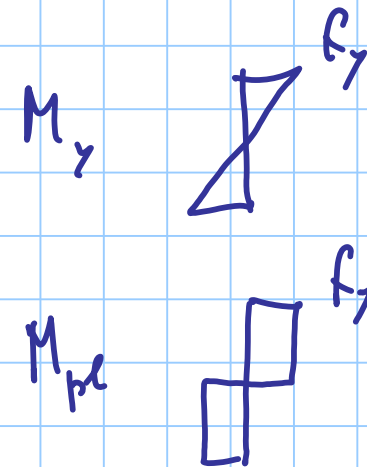
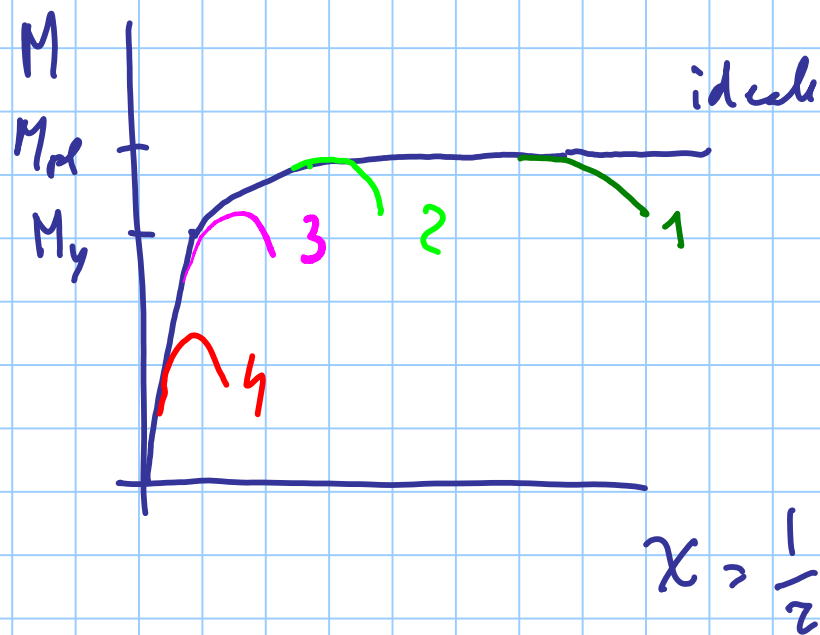
$$\frac{b}{t} = 0.673 \times 28.4 \sqrt{K} = 19.11 \sqrt{K}$$

$$K = 4 \quad \rightarrow \quad 38.22 \text{ } \epsilon$$

$$K = 0.43 \quad \rightarrow \quad 12.53 \text{ } \epsilon$$

# INSTABILITÀ LOCALE

instabilità delle parti compresse del profilo  
viste come lastre



## FLESSIONE

classe 1    porta  $M_{pl} = W_{pl} \frac{f_y}{\gamma_m}$     è molto utile

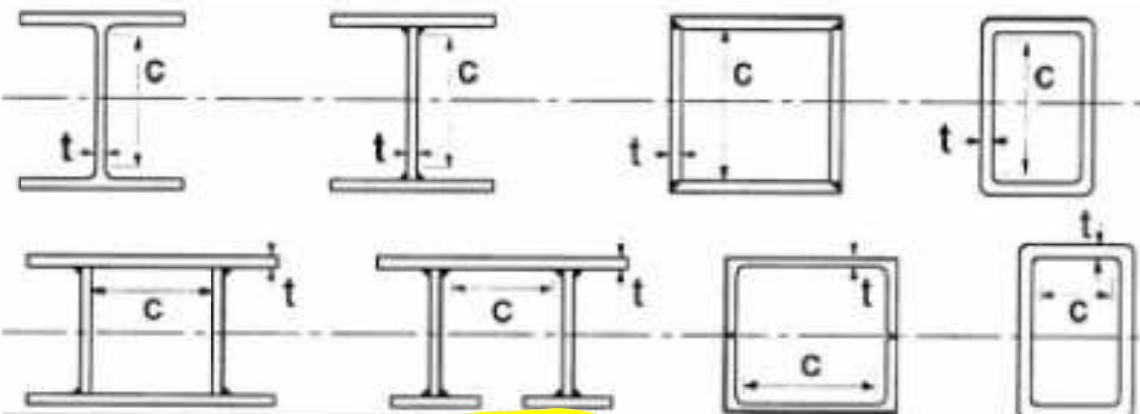
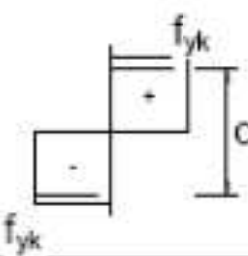
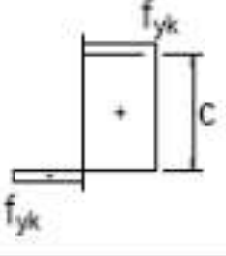
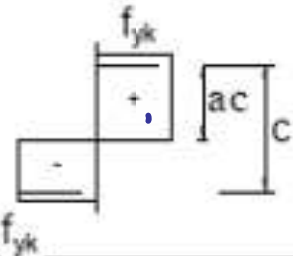
classe 2    porta  $M_{pl}$     è meno utile

classe 3    porta  $M_y = W_{el} \frac{f_y}{\gamma_m}$     è poco utile

classe 4    occorre determinare la sezione efficace

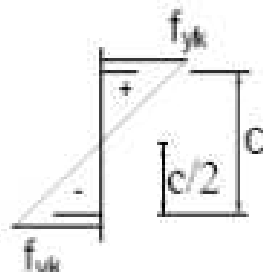
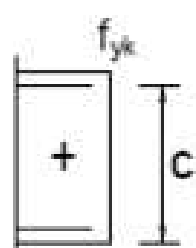
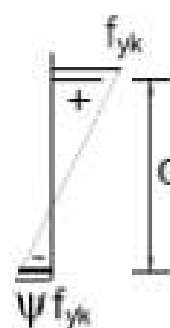
porta  $W_{el,eff} \frac{f_y}{\gamma_m}$

Tabella 4.2.I - Massimi rapporti larghezza spessore per parti compresse

			
Classe	Parte soggetta a flessione	Parte soggetta a compressione	Parte soggetta a flessione e a compressione
Distribuzione delle tensioni nelle parti (compressione positiva)			
1	$c/t \leq 72\epsilon$	$c/t \leq 33\epsilon$	quando $\alpha > 0,5: c/t \leq \frac{396\epsilon}{13\alpha - 1}$ quando $\alpha \leq 0,5: c/t \leq \frac{36\epsilon}{\alpha}$
2	$c/t \leq 83\epsilon$	$c/t \leq 38\epsilon$	quando $\alpha > 0,5: c/t \leq \frac{456\epsilon}{13\alpha - 1}$ quando $\alpha \leq 0,5: c/t \leq \frac{41,5\epsilon}{\alpha}$

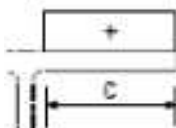
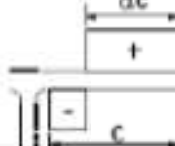
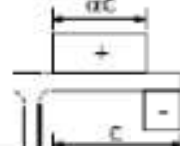
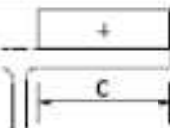
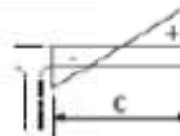
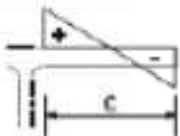
part.  
vincol  
in 2  
lati



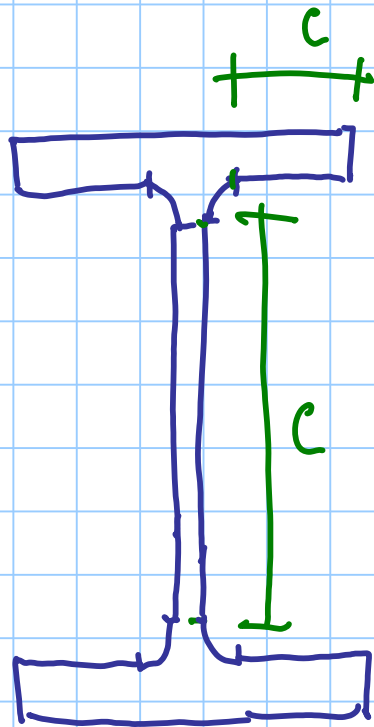
Distribuzione delle tensioni nelle parti (compressione positiva)						
3	$c/t \leq 12\epsilon$	$c/t \leq 42\epsilon$	quando $\psi > -1$ : $c/t \leq \frac{42\epsilon}{0,67+0,33\psi}$ quando $\psi \leq -1$ : $c/t \leq 62\epsilon(1-\psi)\sqrt{-\psi}$			
$\epsilon = \sqrt{235/f_{yk}}$	$f_{yk}$	235	275	355	420	460
	e	1,00	0,92	0,81	0,75	0,71

\*)  $\psi \leq -1$  si applica se la tensione di compressione  $\sigma \leq f_{yk}$  o la deformazione a trazione  $\epsilon_y > f_{yk}/E$

Tabella 4.2.II- Massimi rapporti larghezza spessore per parti compresse

Profilati laminati a caldo		Sezioni saldate				
Classe	Piattabande esterne soggette a compressione	Piattabande esterne soggette a flessione e a compressione				
		Con estremità in compressione		Con estremità in trazione		
Distribuzione delle tensioni nelle parti (compressione positiva)						
1	$c/t \leq 9\epsilon$	$c/t \leq \frac{9\epsilon}{\alpha}$		$c/t \leq \frac{9\epsilon}{\alpha\sqrt{\alpha}}$		
2	$c/t \leq 10\epsilon$	$c/t \leq \frac{10\epsilon}{\alpha}$		$c/t \leq \frac{9\epsilon}{\alpha\sqrt{\alpha}}$		
Distribuzione delle tensioni nelle parti (compressione positiva)						
3	$c/t \leq 14\epsilon$	$c/t \leq 21\epsilon\sqrt{k_e}$ Per $k_e$ vedere EN 1993-1-5				
$\epsilon = \sqrt{235/f_{yk}}$	$f_{yk}$	235	275	355	420	460
	$\epsilon$	1,00	0,92	0,81	0,75	0,71

parti  
vincolate  
solo  
da 1 lato



EC3    parte 1.3     $\frac{p_{rd}}{p_{rdi}}$   
parte 1.5    instab.  $\lambda_{cr}$   
parte 1.1    )  
              classific.