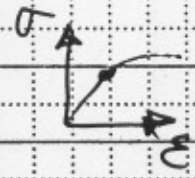
VERIFICA E DIMENSIONAMENTO DI STRUTTURE IN ACCIAIO

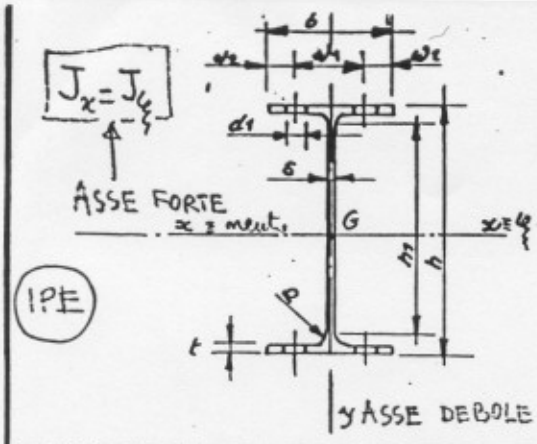
Schema di riferimento

	Tipo 1	Tipo 2
σ_R Rottura a trazione	370 ÷ 530 MPa *	620 ÷ 650 MPa *
σ_S Snervamento 	≥ 240 MPa *	≥ 360 MPa *
$\bar{\sigma}$ Ammissibile	160 MPa (*)	240 MPa (*)

* Da prove di laboratorio

(*) $\bar{\sigma} = \dfrac{\sigma_S}{\gamma}$ γ = coefficiente di sicurezza. Assunto pari a 1.5

$E = 2 \times 10^5$ MPa



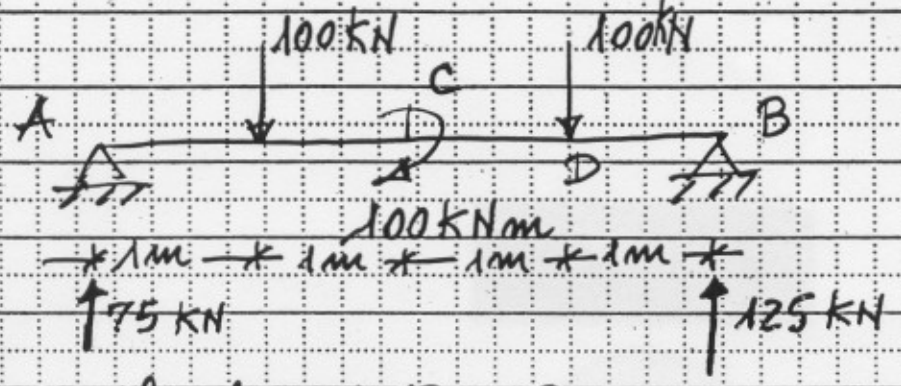
F = area della sezione
G = peso unitario = peso specifico [Kg/m³] × area sez. [m²] = Kg/m
U = area del contorno al m di lunghezza
J = momento d'inerzia della sezione rispetto all'asse....
W = modulo di resistenza " " "
i = $\sqrt{J/F}$ = raggio d'inerzia " " "
S_x = momento statico di 1/2 sezione risp. asse x
s_x = J_x/S_x distanza tra i centri di trazione e di compressione
s_K = max lungh. libera ammissibile per un I caricato di punta: max $\lambda = 250$ le tabelle che

Esempio di designazione: IPE 300

PROFILO	DIMENSIONI mm. h	b	s	t	r raggio	F cm²	G Kg/m	U m²/m	ASSI DI RIFERIMENTO x-x' J_x cm⁴	W_x cm³	i_x cm	y-y J_y cm⁴	W_y cm³	i_y cm	S_x cm³	s_x cm	s_K max m.	MOMENTO DI INERZIA POLARE RIDOTTO: J_p cm⁴	MODULO DI RESISTENZA ALL'INCOBBAMENTO C_M cm⁶	h_1 mm	FORI D'ALA w mm	w_2 mm	d_1 mm
80	80	46	3,8	5,2	5	7,64	6,00	0,326	80,1	20,0	3,24	8,49	3,63	1,05	11,6	6,90	2,64	0,559	0,118	60	–	–	–
100	100	55	4,1	5,7	7	10,3	8,10	0,400	171	34,2	4,07	15,9	5,79	1,24	19,7	8,68	3,11	0,883	0,351	75	–	–	–
120	120	64	4,4	6,3	7	13,2	10,4	0,475	318	53,0	4,90	27,7	8,65	1,45	34,4	10,5	3,62	1,37	0,890	93	–	–	–
140	140	73	4,7	6,9	7	16,4	12,9	0,551	541	77,3	5,74	44,9	12,3	1,65	44,2	12,3	4,14	2,04	1,88	112	38	17,5	11
160	160	82	5,0	7,4	9	20,1	15,8	0,623	869	109	6,58	68,3	16,7	1,84	61,9	14,0	4,61	2,82	3,86	127	42	20,0	13
180	180	91	5,3	8,0	9	23,9	18,8	0,698	1.317	146	7,42	101	22,2	2,05	83,2	15,8	5,13	3,92	7,43	146	48	21,5	13
200	200	100	5,6	8,5	12	28,5	22,4	0,768	1.943	194	8,26	142	28,5	2,24	110	17,6	5,69	5,17	13,0	159	54	23,0	13
220	220	110	5,9	9,2	12	33,4	26,2	0,848	2.772	252	9,11	205	37,3	2,48	145	19,4	6,20	7,09	22,7	178	58	26,0	17
240	240	120	6,2	9,8	15	39,1	30,7	0,922	3.892	324	9,97	284	47,3	2,63	183	21,2	6,73	9,78	37,4	190	64	28,0	17
270	270	135	6,6	10,2	15	45,9	36,1	1,041	5.790	429	11,2	420	62,2	3,02	242	23,9	7,56	11,9	70,6	220	72	31,5	17
300	300	150	7,1	10,7	15	53,8	42,2	1,159	8.356	557	12,5	604	80,5	3,36	314	26,6	8,58	15,6	126	248	80	35,0	21
330	330	160	7,5	11,5	18	62,6	49,1	1,254	11.770	713	13,7	788	98,5	3,55	402	29,3	8,87	20,5	199	274	86	37,0	21
360	360	170	8,0	12,7	18	72,7	57,1	1,353	16.270	904	15,0	1.043	123	3,79	510	31,9	9,47	28,9	314	299	92	39,0	23
400	400	180	8,6	13,5	21	84,5	66,3	1,467	23.130	1.160	16,5	1.318	146	3,96	654	35,4	9,88	37,4	490	331	96	42,0	23
450	450	190	9,4	14,6	21	98,8	77,6	1,605	33.740	1.500	18,5	1.676	176	4,12	851	39,7	10,3	53,1	791	379	102	44,0	25
500	500	200	10,2	16,0	21	116	90,7	1,744	48.200	1.930	20,4	2.142	214	4,31	1.100	43,9	10,8	74,2	1250	426	108	46,0	25
550	550	210	11,1	17,2	24	134	106	1,877	67.120	2.440	22,3	2.668	254	4,45	1.380	48,2	11,1	94,7	1880	468	116	47,0	25
600	600	220	12,0	19,0	24	156	122	2,015	92.080	3.070	24,3	3.387	308	4,66	1.760	52,4	11,7	133	2850	514	120	50,0	25

Le barre vengono fornite nelle lunghezze commerciali di m. 4 ÷ 14
Le massime lunghezze laminate dalla ITALSIDER sono: Per i profili 80 ÷ 140, m. 20; per i profili 160 ÷ 600, m. 21

VERIFICA



IPE 400
Acciaio tipo 1

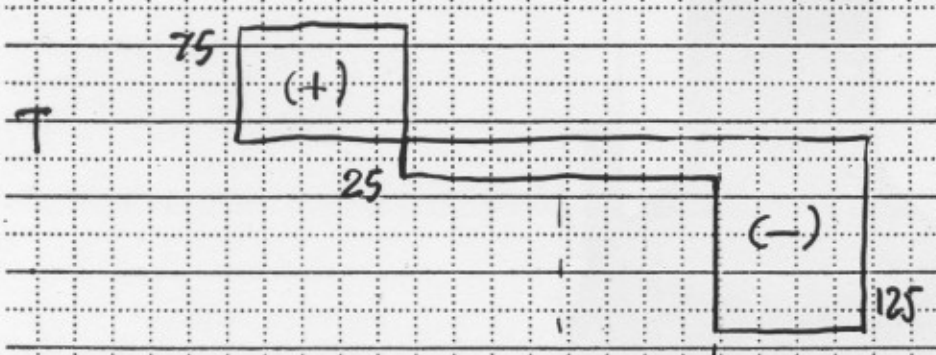
Equil. rotaz. intorno B:

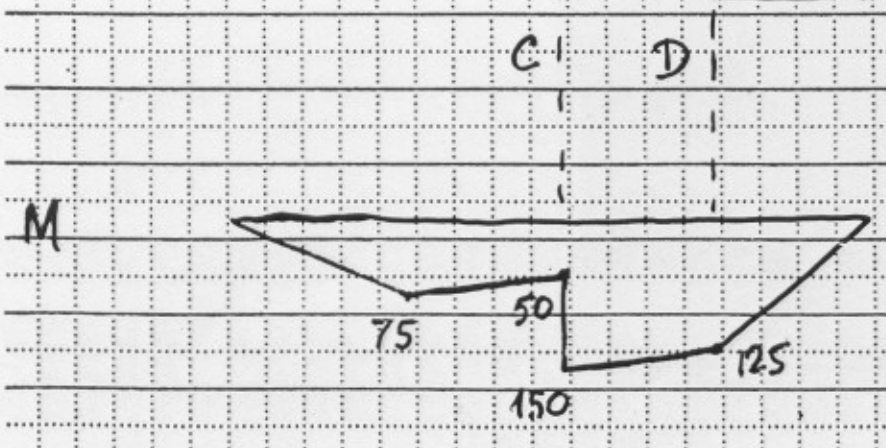
$4A - 100 \times 3 + 100 - 100 \times 1 = 0$

$A = 75$ KN

Equil. traslaz. verticale:

$B = 100 + 100 - 75 = 125$ KN



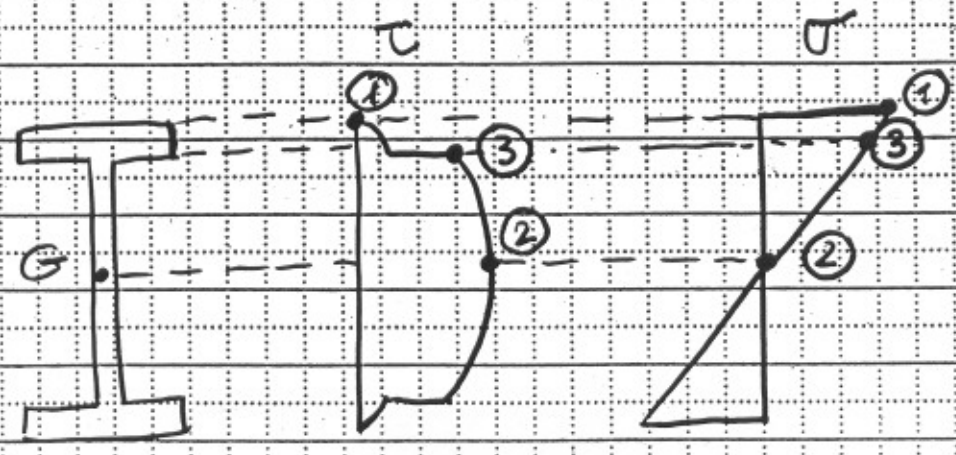


SEZIONI PIÙ SOLLECITATE

C { M = 150 KNm, T = 25 KN

D { M = 125 KNm, T = 125 KN

IPE 400



$\bar{\sigma} = 160$ MPa

Per le verifiche si assume il criterio delle tensioni ideali σ_{id} di Von Mises.

Stato monoassiale: $\boxed{\sigma_{id} = \sqrt{\sigma^2 + 3\tau^2} \leq \bar{\sigma}}$

Sezione C

1: Lembi estremi ($\tau = 0 \Rightarrow \sigma_{id} = \sigma$)

$$\sigma_{id} = \sigma_{max} = \frac{M}{W_x} = \frac{150 \times 10^6 \ \text{Nmm}}{1160 \times 10^3 \ \text{mm}^3} \cong 129 \text{ MPa} < \bar{\sigma}$$

$W_x = J_x / y_{max}$

2: Fibra baricentrica ($\sigma = 0 \Rightarrow \sigma_{id} = \tau\sqrt{3}$)

$$\sigma_{id} = \tau_{max}\sqrt{3} = \frac{T S_x}{J_x s}\sqrt{3} = \frac{25 \times 10^3 \times 654 \times 10^3}{23130 \times 10^4 \times 8.6}\sqrt{3}$$

$$\cong 14 \text{ MPa} < \bar{\sigma}$$

3: Attacco Ala - anima

$$\sigma = \frac{M y}{J_x} = \frac{150 \times 10^6 \times (200 - 13.5)}{23130 \times 10^4} \cong 121 \text{ MPa}$$

(120.9)

$$\uparrow \frac{T S_x}{J_x s}$$

$$\tau = \frac{25 \times 10^3 \times \left[\overbrace{180 \times 13.5 \times (200 - 13.5/2)}^{S_x \text{ ala}} \right]}{23130 \times 10^4 \times 8.6}$$ (5)

$8.6 \rightarrow$ anima, a vantaggio di sicurezza

$$\cong 6 \text{ MPa}$$

$$\sigma_{id} = \sqrt{121^2 + 3 \cdot 6^2} \cong 121 \text{ MPa} < \bar{\sigma}$$

(121.44)

Sezione (D) Cambiano solo le sollecitazioni

(1) : Lembi esterni

$$\sigma_{id} = \sigma_{max,(C)} \frac{125}{150} \cong 108 \text{ MPa} < \bar{\sigma}$$

$M_{(D)}$, $M_{(C)}$

(2) : Fibra baricentrica

$$\sigma_{id} = \tau_{max,(C)} \sqrt{3} \frac{125}{25} \cong 70 \text{ MPa} < \bar{\sigma}$$

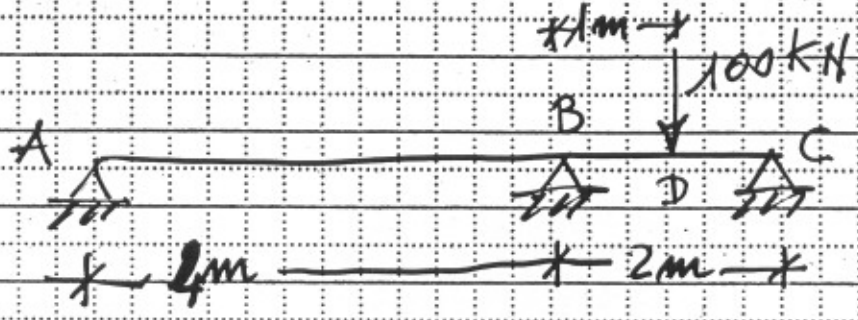
(3) : Attacco ala - anima

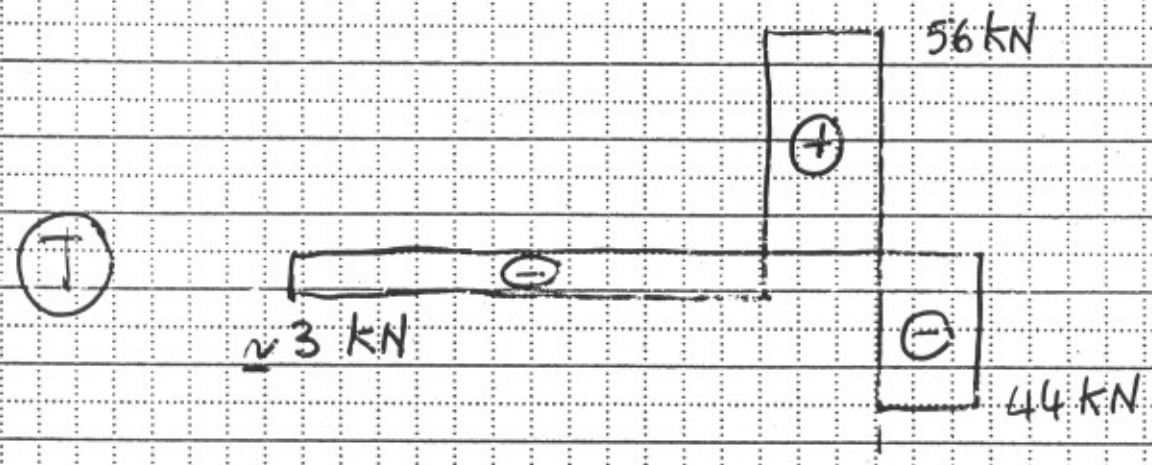
$$\sigma = \sigma_{(C)} \frac{125}{150} \cong 101 \text{ MPa}$$

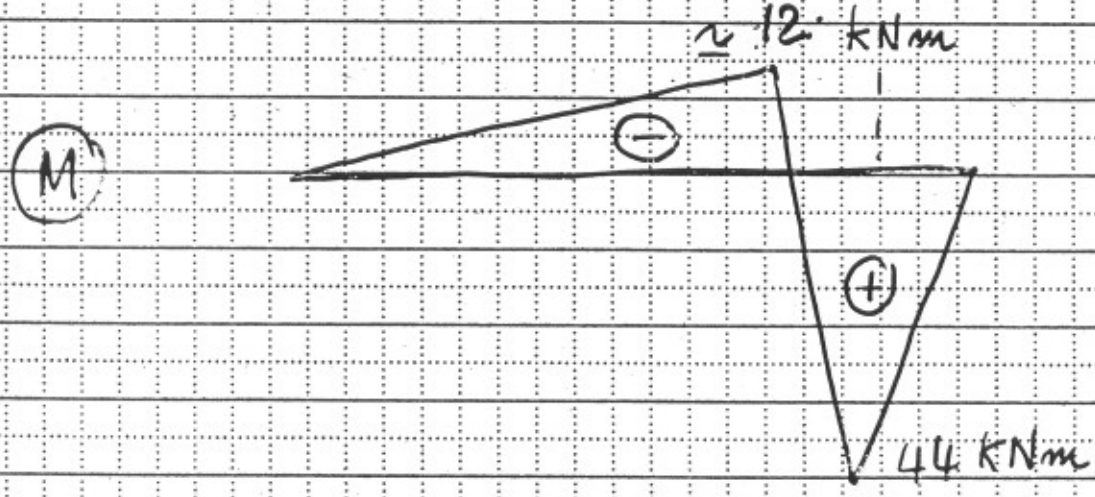
$$\tau = \tau_{(C)} \frac{125}{25} \cong 30 \text{ MPa}$$

$$\sigma_{id} = \sqrt{101^2 + 3 \times 30^2} \cong 114 \text{ MPa} < \bar{\sigma}$$

DIMENSIONAMENTO







SEZ. PIÙ SOLLECITATA:

D : $M = 44\ kNm$

$T = 56\ kN$

Acciaio tipo 1

Dimensionamento a flessione sez. (D)

Sagomario $\Rightarrow$ $\boxed{W_x \geq \frac{M}{\bar{\sigma}}} = \frac{44 \times 10^6}{160} = 275 \times 10^3 \ mm^3$

$\left(\sigma = \frac{M}{W_x}\right)$

$\Downarrow$

$\boxed{IPE\ 240}$ $\quad W_x = 324 \times 10^3 \ mm^3$

Verifiche sez. (D)

(1): Lembi estremi

Implicita nel dimensionamento

(2): Fibra baricentrica

$$\sigma_{id} = \tau_{max}\sqrt{3} = \frac{56 \times 10^3 \times 183 \times 10^3}{3892 \times 10^4 \times 6.2}\sqrt{3} \cong 74 \ MPa < \bar{\sigma}$$

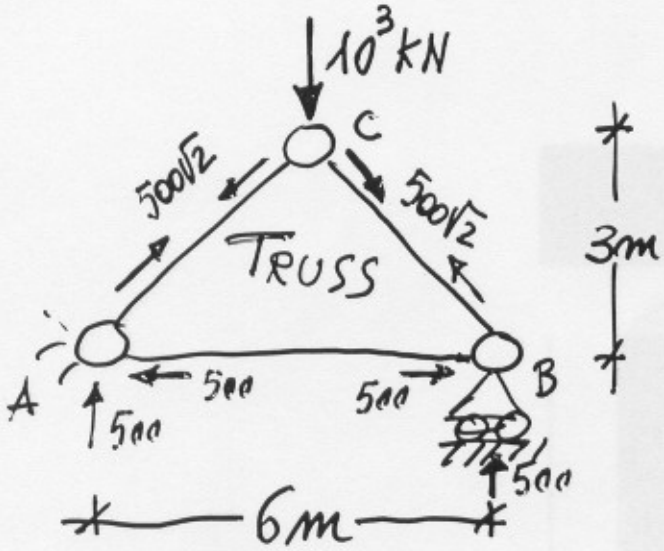
(3): Attacco ala-anima

$$\sigma = \frac{44 \times 10^6 \times (120 - 9.8)}{3892 \times 10^4} \cong 125 \ MPa$$

$$\tau = \frac{56 \times 10^3 \times [120 \times 9.8 \times (120 - 9.8/2)]}{3892 \times 10^4 \times 6.2} \cong 31 \ MPa$$

$$\sigma_{id} \cong 136 \ MPa < \bar{\sigma}$$

DIMENSIONAMENTO – TRAZIONE/COMPRESSIONE



Tirante AB

$$\begin{cases} N = 500 \text{ kN} \\ \text{Acciaio tipo 1} \end{cases} \qquad \sigma = \frac{N}{A}$$

Sagomare $\Rightarrow$ $\boxed{F(\text{area}) \geq \frac{N}{\sigma}}$ =

$$= \frac{500 \times 10^3}{160} \cong 31 \times 10^2 \text{ mm}^2$$

$\Downarrow$

Nessuna verifica è richiesta $\leftarrow$ $\boxed{\text{IPE 220}}$ $F = 33.4 \times 10^2$ mm²

Aste compresse

$$\begin{cases} N = 707.11 \text{ kN} \\ \text{Acciaio tipo 1} \end{cases}$$

$$F \geq \frac{707.11 \times 10^3}{160} \cong 44 \times 10^2 \text{ mm}^2 \rightarrow \boxed{\text{IPE 270}}$$

$F = 45.9 \times 10^2$ mm²

Verifica ad instabilità (metodo ω)

(amplifico N per tenere conto del carico di punta)

$$\sigma = \frac{\omega N}{A} \quad ; \quad \omega = \omega(\lambda) \quad ; \quad \lambda = \frac{l_0}{i_{min}}$$

$A \rightarrow F$

λ: snellezza

l_0 = lunghezza libera d'inflessione

i_{min} = raggio giratore minimo

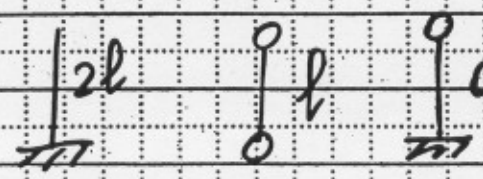
PROSPETTO 4-II*b*

Coefficienti Omega

Acciaio tipo 1; Curva *b* → IPE

λ	0	1	2	3	4	5	6	7	8	9	λ
0	1.00	1.00	1.00	1.00	1.00	1.00	1,01	1.01	1.01	1.01	0
10	1.01	1,01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.02	10
20	1.02	1.02	1.03	1.03	1.03	1.03	1.03	1.04	1.04	1.04	20
30	1.04	1.05	1.05	1.05	1.05	1.06	1.06	1.06	1.07	1.07	30
40	1.08	1.08	1.08	1.09	1.09	1.10	1.10	1.11	1.11	1.12	40
50	1.13	1.13	1.14	1.15	1.15	1.16	1.17	1.18	1.19	1.19	50
60	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.29	1.30	60
70	1.31	1.32	1.34	1.35	1.36	1.38	1.39	1.41	1.42	1.44	70
80	1.45	1.47	1.48	1.50	1.51	1.53	1.55	1.56	1.58	1.60	80
90	1.62	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.79	90
100	1.81	1.83	1.85	1.88	1.90	1.92	1.94	1.97	1.99	2.02	100
110	2.04	2.07	2.09	2.12	2.14	2.17	2.20	2.22	2.25	2.28	110
120	2.31	2.34	2.36	2.39	2.42	2.45	2.48	2.51	2.54	2.58	120
130	2.61	2.64	2.67	2.70	2.74	2.77	2.80	2.83	2.87	2.90	130
140	2.94	2.97	3.01	3.04	3.08	3.11	3.15	3.19	3.22	3.26	140
150	3.30	3.33	3.37	3.41	3.45	3.49	3.53	3.57	3.61	3.65	150
160	3.70	3.74	3.78	3.82	3.86	3.91	3.95	3.99	4.03	4.07	160
170	4.11	4.15	4.20	4.24	4.29	4.34	4.39	4.44	4.49	4.54	170
180	4.58	4.63	4.68	4.73	4.78	4.83	4.88	4.93	4.98	5.03	180
190	5.08	5.13	5.17	5.22	5.27	5.32	5.37	5.42	5.47	5.52	190
200	5.57	5.62	5.67	5.72	5.77	5.82	5.87	5.93	5.98	6.03	200
210	6.08	6.13	6.19	6.24	6.30	6.35	6.41	6.46	6.52	6.58	210
220	6.64	6.69	6.74	6.79	6.84	6.89	6.95	7.00	7.06	7.11	220
230	7.17	7.23	7.29	7.35	7.40	7.46	7.51	7.57	7.63	7.68	230
240	7.74	7.80	7.86	7.92	7.98	8.04	8.10	8.16	8.23	8.29	240
250	8.36										250

l_0 :



$$l_0 = l_{AC} = l_{BC} = 3\sqrt{2} = 4.24 \text{ m}$$

$$i_{min} = i_y = 30.2 \text{ mm}$$

Norme tecniche CNR

$$\lambda = \frac{4240}{30.2} = 140.39 \Rightarrow \boxed{\omega \cong 2.95}$$

$$\sigma = \frac{2.95 \times 707.11 \times 10^3}{45.9 \times 10^2} \cong 454 \text{ MPa} \gg \bar{\sigma}$$

$\boxed{\text{IPE 400}}$ $A = 84.5 \times 10^2 \text{ mm}^2$

$$\lambda = \frac{4240}{39.5} = 107.34 \Rightarrow \boxed{\omega \cong 1.98}$$

$$\sigma = \frac{1.98 \times 707.11 \times 10^3}{84.5 \times 10^2} \cong 166 \text{ MPa} \cong \bar{\sigma}$$

$\boxed{\text{IPE 450}}$