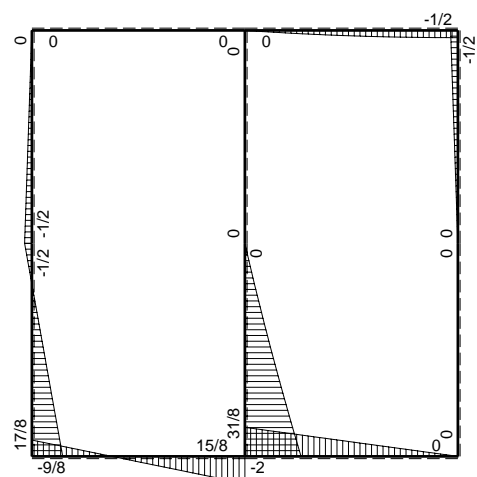
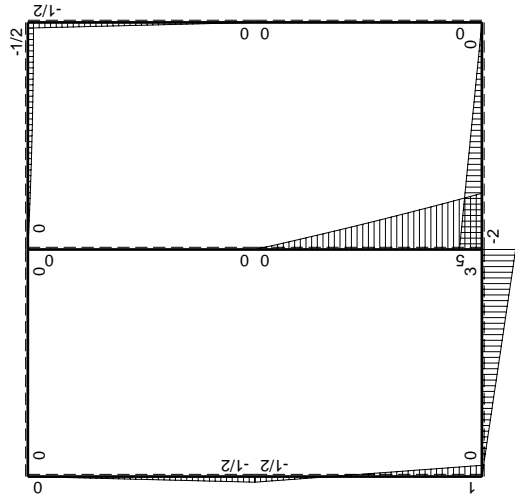
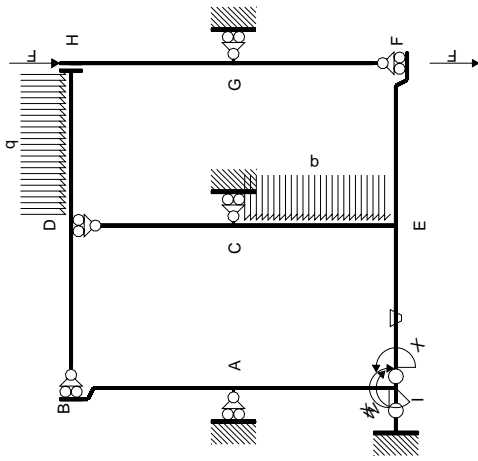


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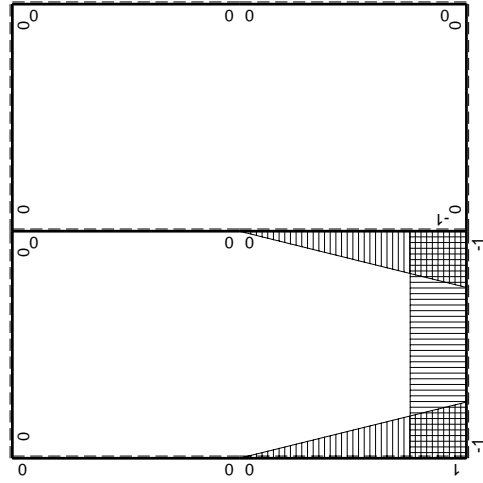


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-11/2Fx+1/2qx^2$	0	$-5Fb+21/2Fx-6Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-13/8+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx-1/2qx^2$	0	$-9/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-15/8Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 6x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [-5x + 21/4 x^2/b - 2x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5b + 21/4 b - 2b + 1/8 b) Fb 1/EJ = -13/8 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [-3/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

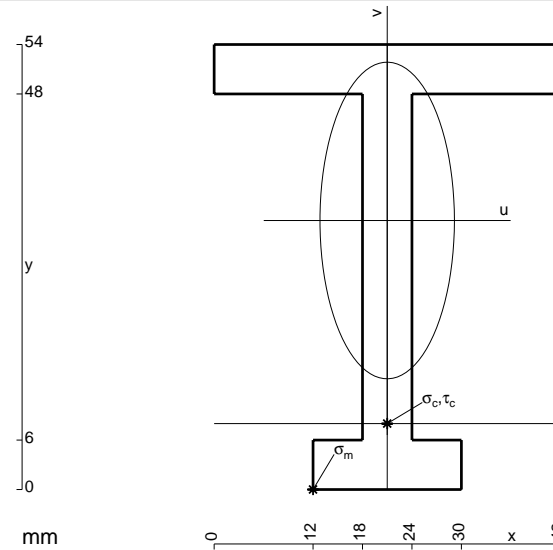
$$= (-3/2 b - 1/8 b) Fb 1/EJ = -13/8 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

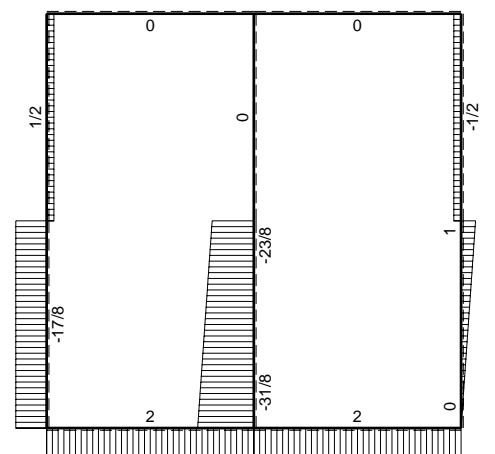
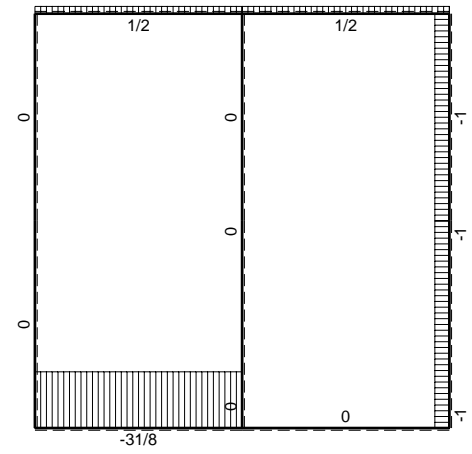
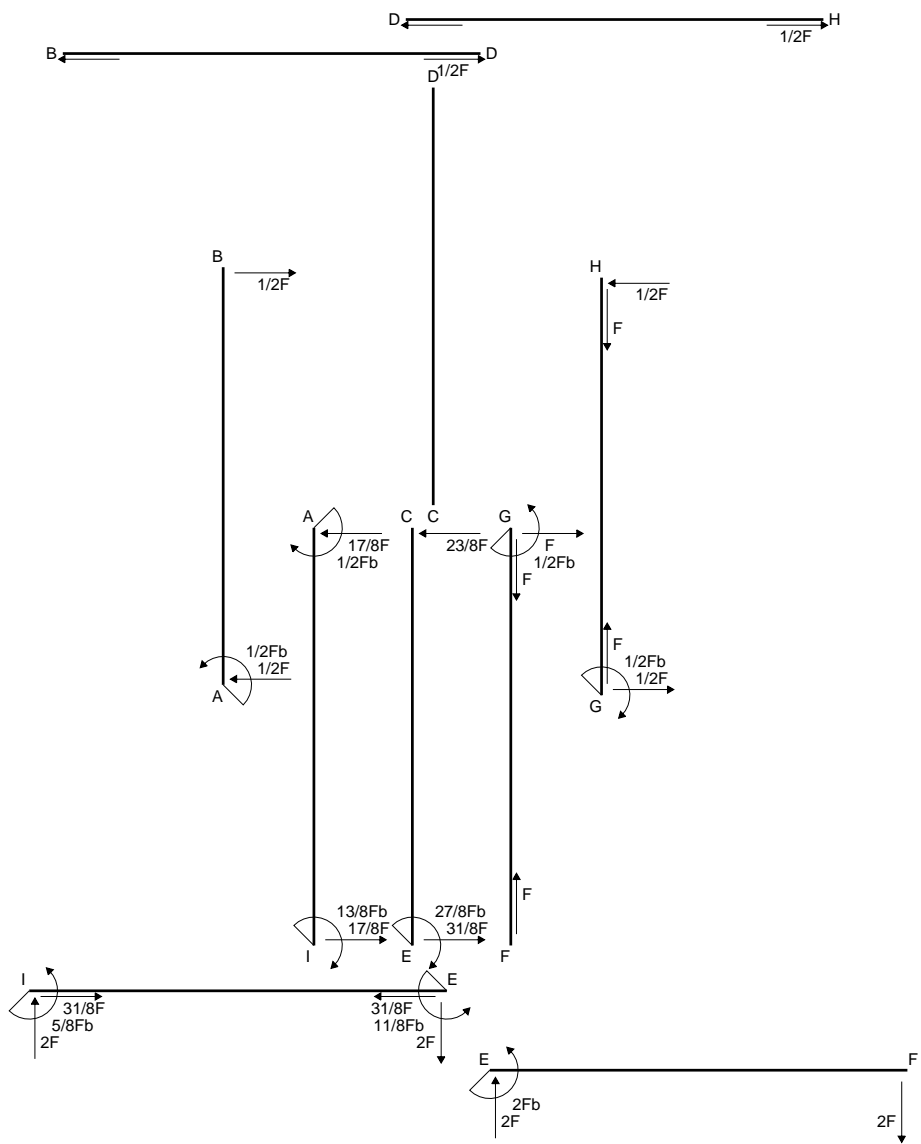
$$= (b - 5/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

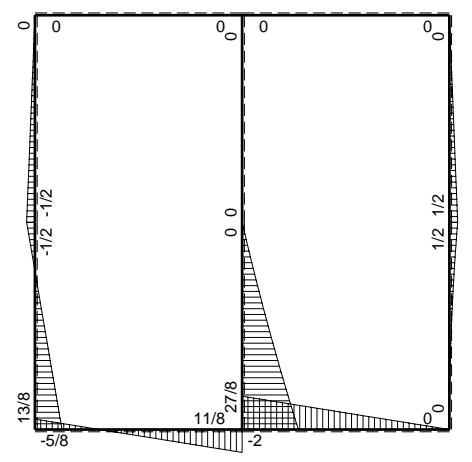


- A = 612. mm²
- J_u = 225968. mm⁴
- J_v = 40716. mm⁴
- y_g = 32.65 mm
- T_y = 2460. N
- M_x = -1451400. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -32.65 mm
- σ_m = -Mv/J_u = -209.7 N/mm²
- x_c = 21. mm
- y_c = 8. mm
- v_c = -24.65 mm
- σ_c = -Mv/J_u = -158.3 N/mm²
- τ_c = 6.368 N/mm²
- σ_o = √σ_c² + 3τ_c² = 158.7 N/mm²
- S = 3510. mm³

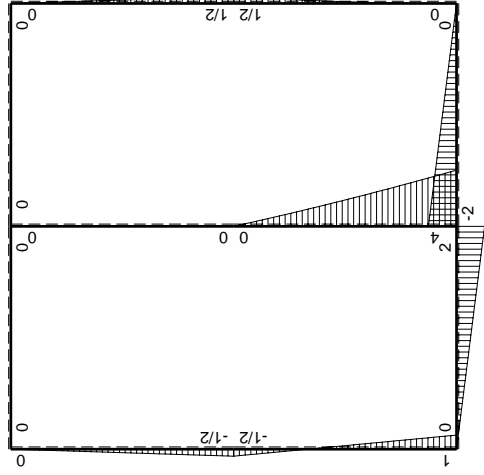
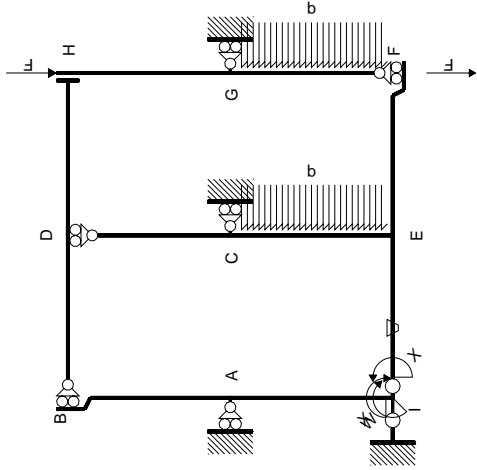


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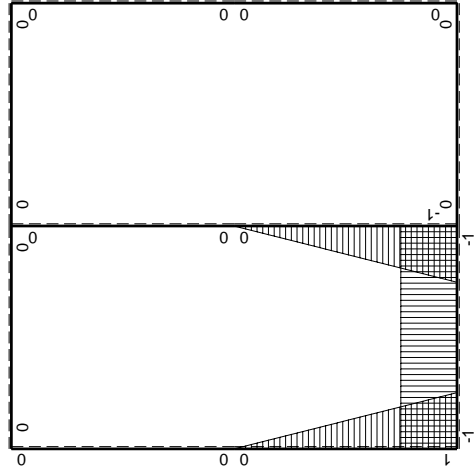


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0	
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fx$	0	0	0	0			
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1			
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2			
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2			
	totali							$-25/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$5/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx$$

$$= [-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb 1/EJ = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [-7/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

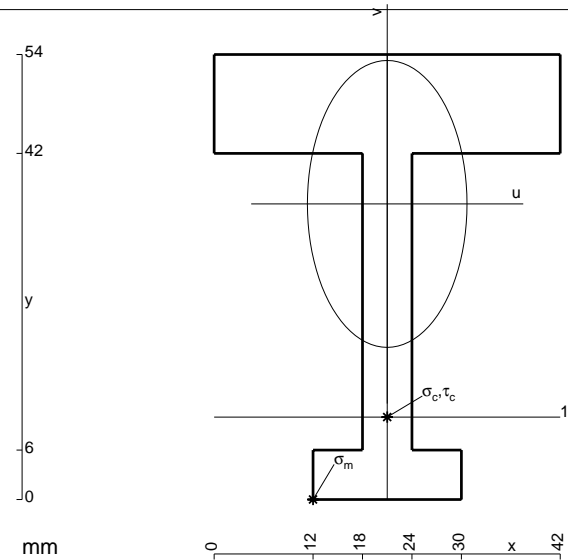
$$= (-7/6 b - 1/8 b) Fb 1/EJ = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 5/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$



$$A = 828. \text{ mm}^2$$

$$J_u = 250978. \text{ mm}^4$$

$$J_v = 77652. \text{ mm}^4$$

$$y_g = 35.87 \text{ mm}$$

$$T_y = 2400. \text{ N}$$

$$M_x = -1536000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -35.87 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

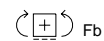
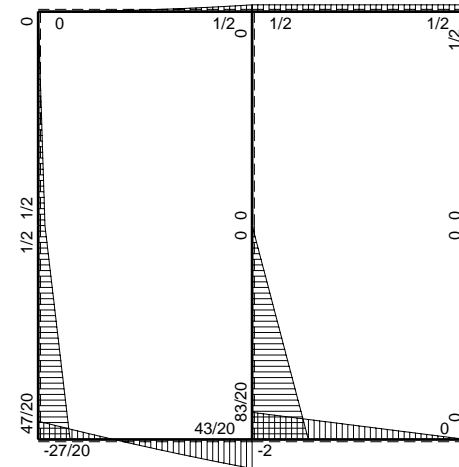
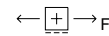
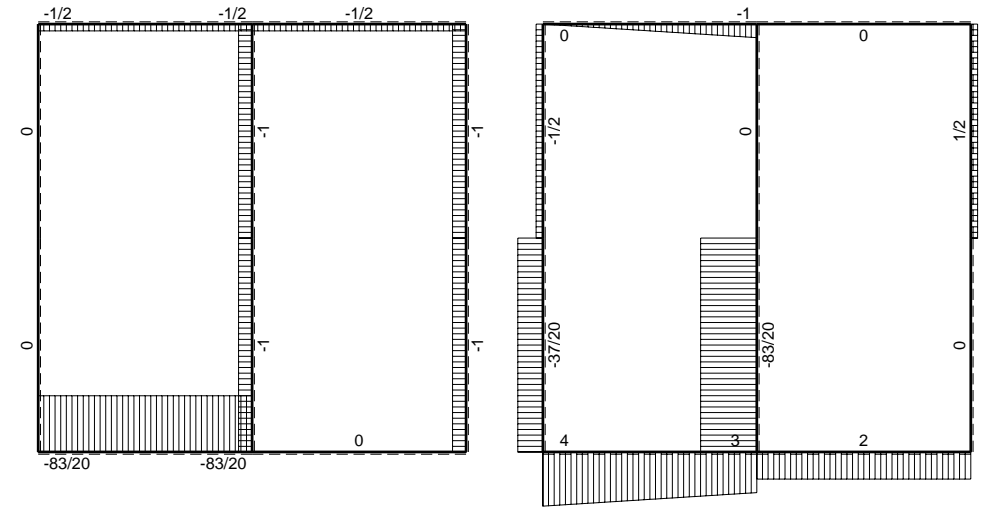
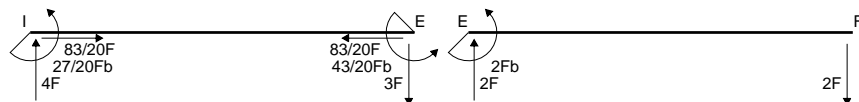
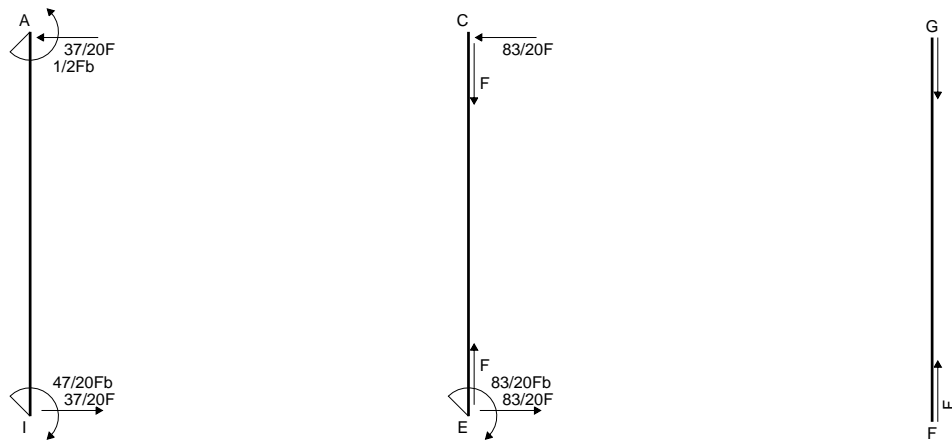
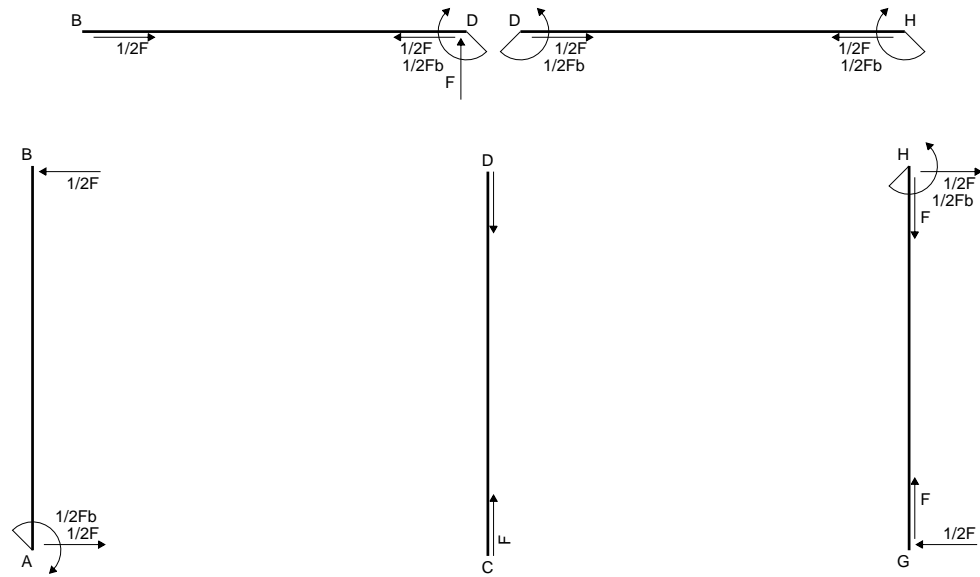
$$v_c = -25.87 \text{ mm}$$

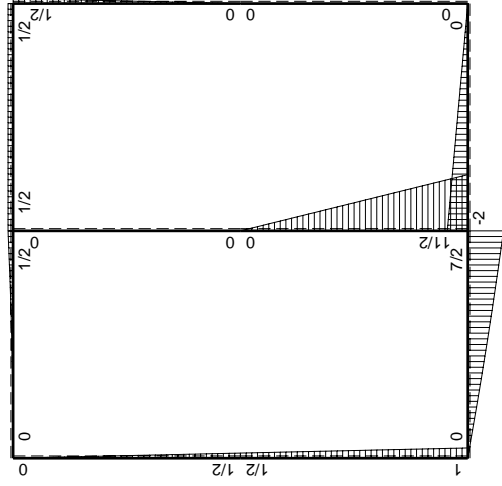
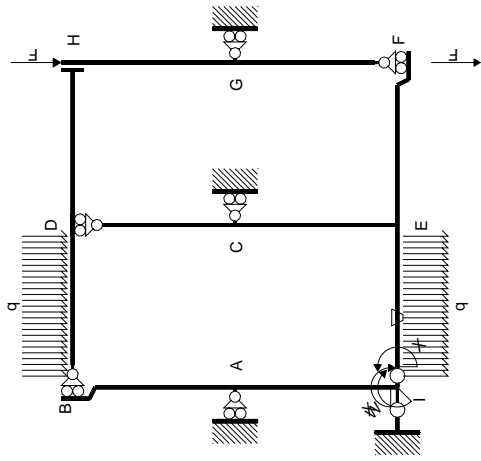
$$\sigma_c = -Mv/J_u = -158.3 \text{ N/mm}^2$$

$$\tau_c = 6.724 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 158.8 \text{ N/mm}^2$$

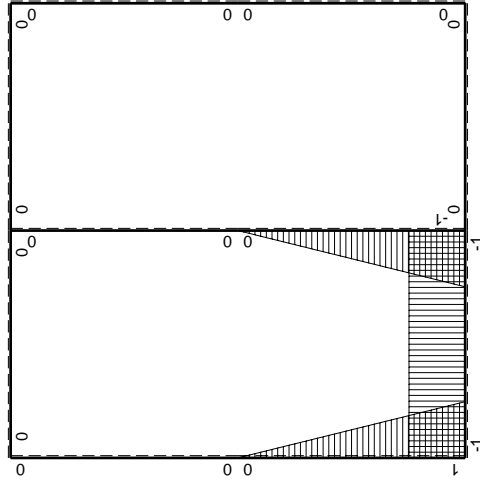
$$S = 4219. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$-1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0			
HD b	0	$1/2Fb$	0	0	0	0	0+0	0	
DH b	0	$-1/2Fb$	0	0	0	0			
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
BD b	0	$-1/2qx^2$	0	0	0	0			
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2			
	totali							$-9/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$27/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

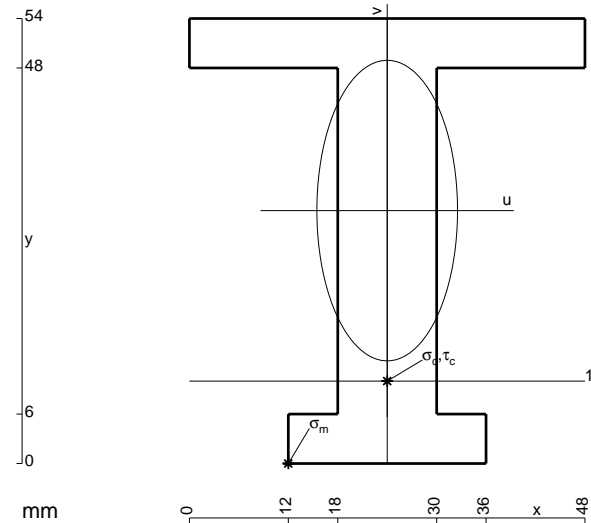
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 3/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

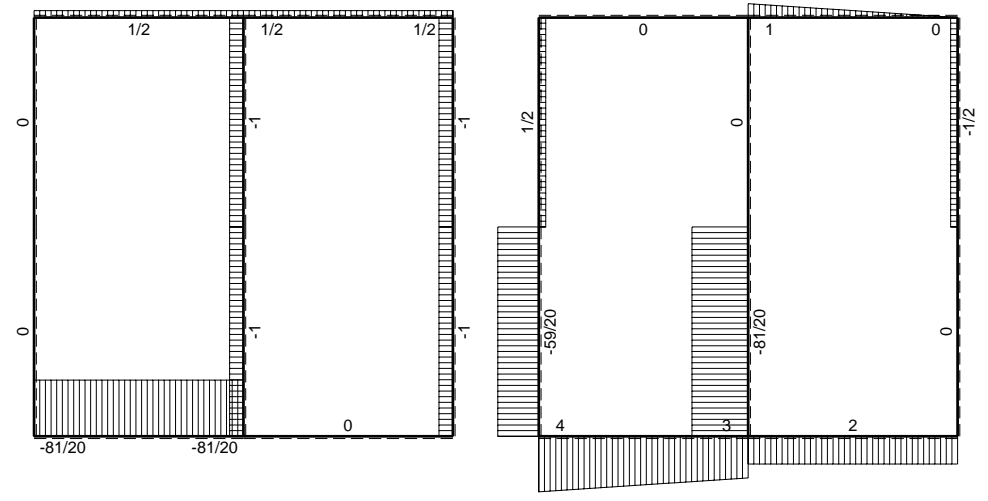
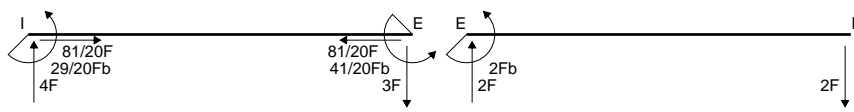
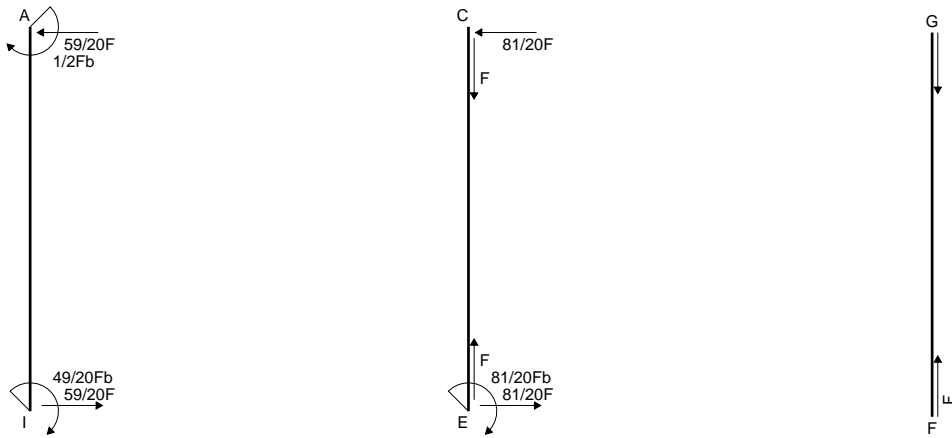
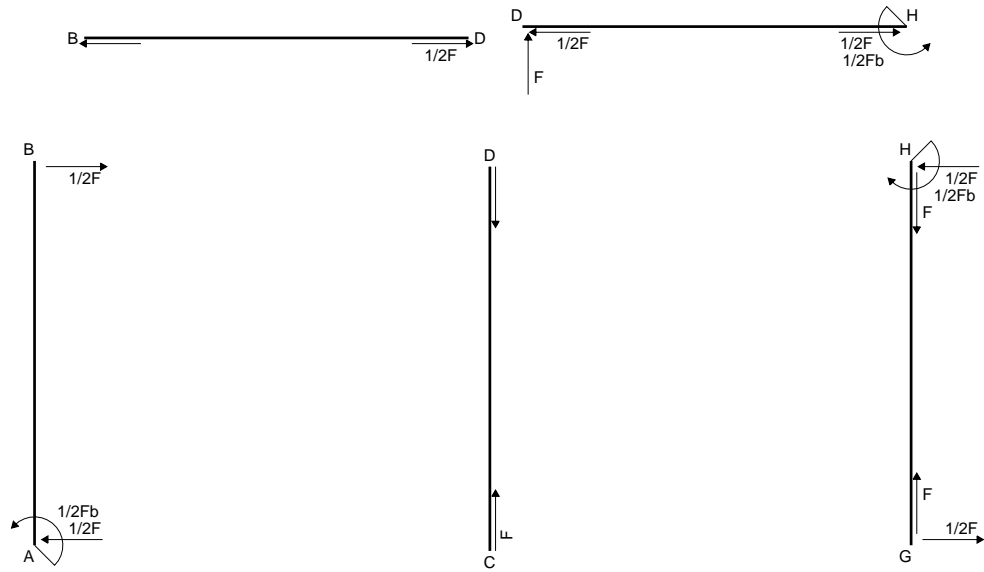
$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

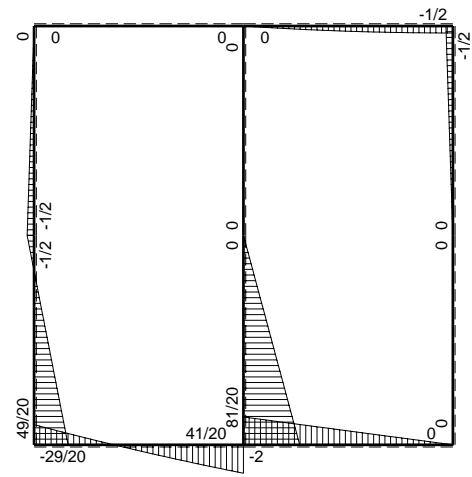


- A = 936. mm²
- J_u = 311455. mm⁴
- J_v = 68256. mm⁴
- y_g = 30.69 mm
- T_y = 3320. N
- M_x = -2324000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -30.69 mm
- σ_m = -Mv/J_u = -229. N/mm²
- x_c = 24. mm
- y_c = 10. mm
- v_c = -20.69 mm
- σ_c = -Mv/J_u = -154.4 N/mm²
- τ_c = 4.51 N/mm²
- σ_o = √σ²+3τ² = 154.6 N/mm²
- S = 5077. mm³

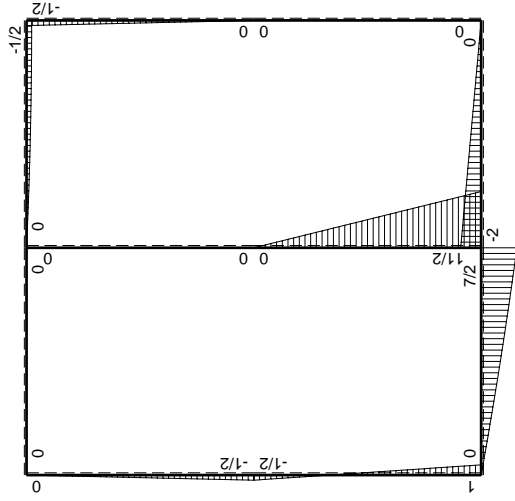
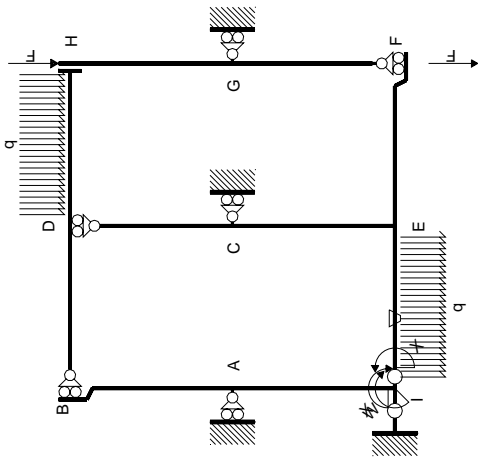


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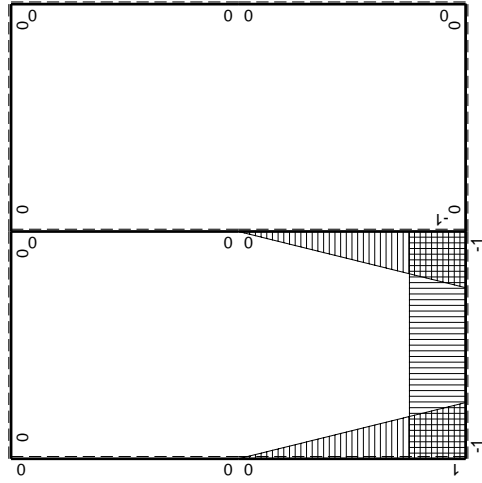


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

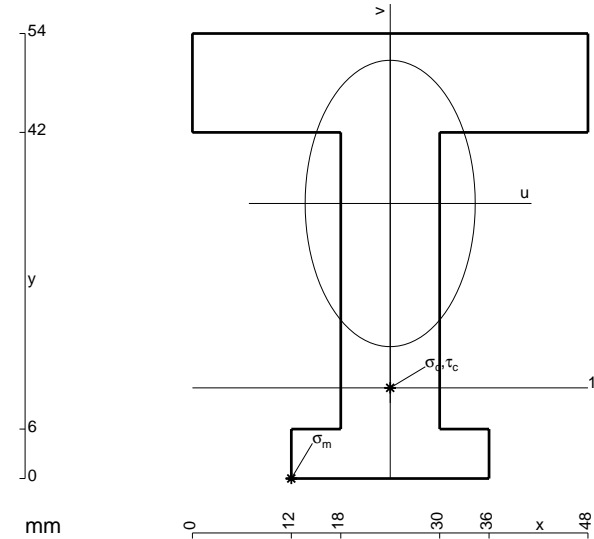
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 1152. \text{ mm}^2$$

$$J_u = 348030. \text{ mm}^4$$

$$J_v = 122688. \text{ mm}^4$$

$$y_g = 33.38 \text{ mm}$$

$$T_y = 3320. \text{ N}$$

$$M_x = -2490000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -33.38 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -238.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

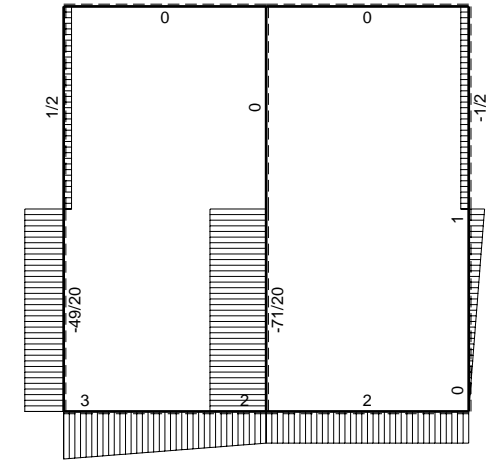
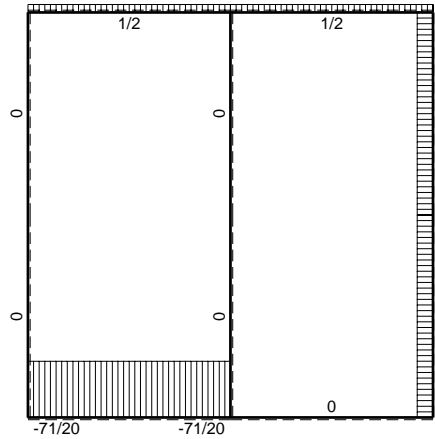
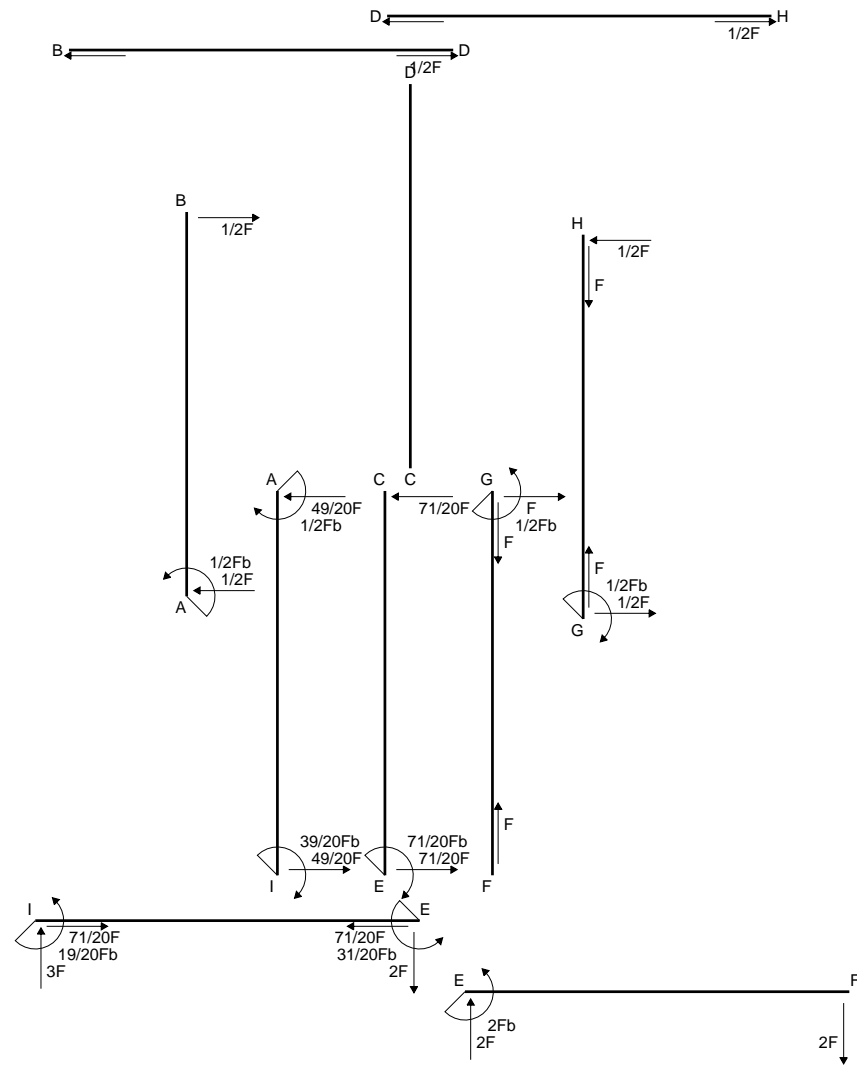
$$v_c = -22.38 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -160.1 \text{ N/mm}^2$$

$$\tau_c = 4.664 \text{ N/mm}^2$$

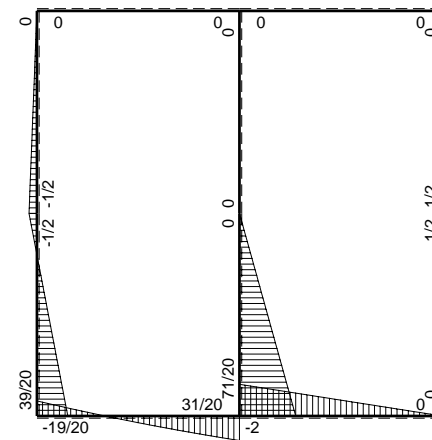
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 160.3 \text{ N/mm}^2$$

$$S = 5867. \text{ mm}^3$$

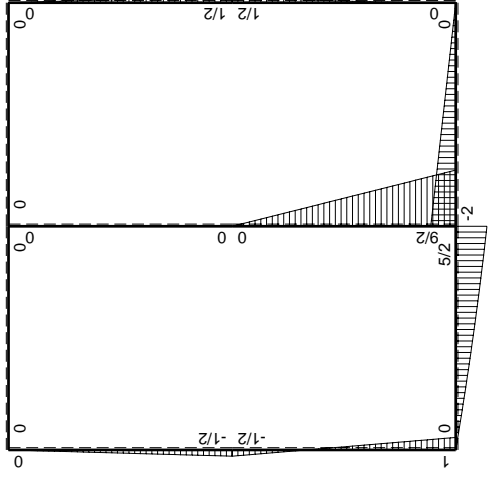
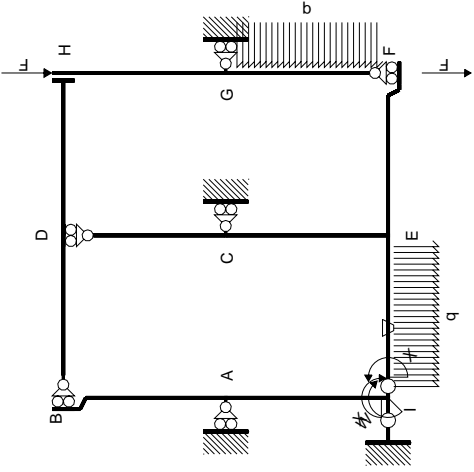


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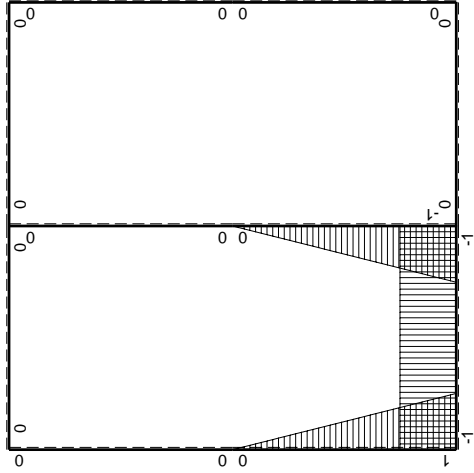


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-19/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb 1/EJ + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb 1/EJ + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb 1/EJ dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb 1/EJ dx = [-3/2 x^3/b^2]_0^b Fb 1/EJ$$

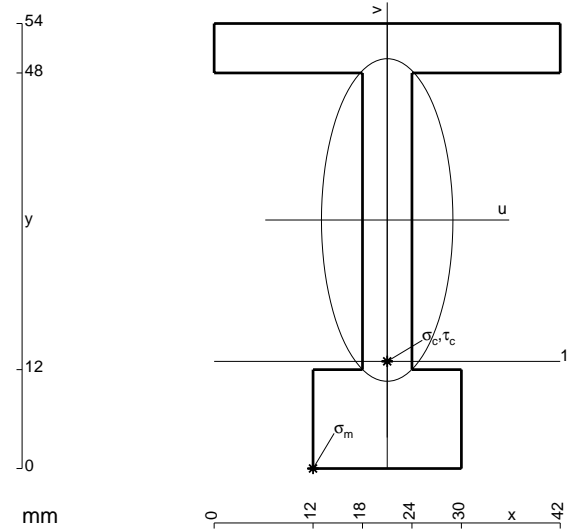
$$= (-3/2 b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

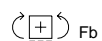
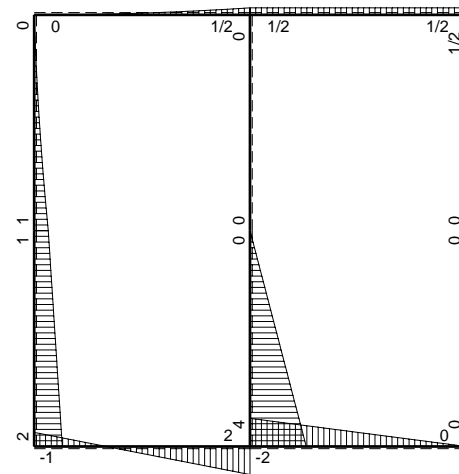
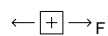
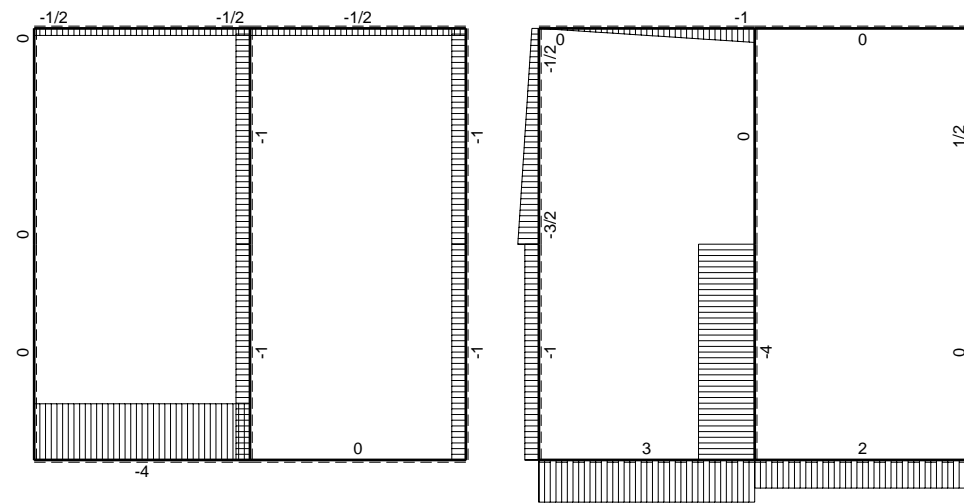
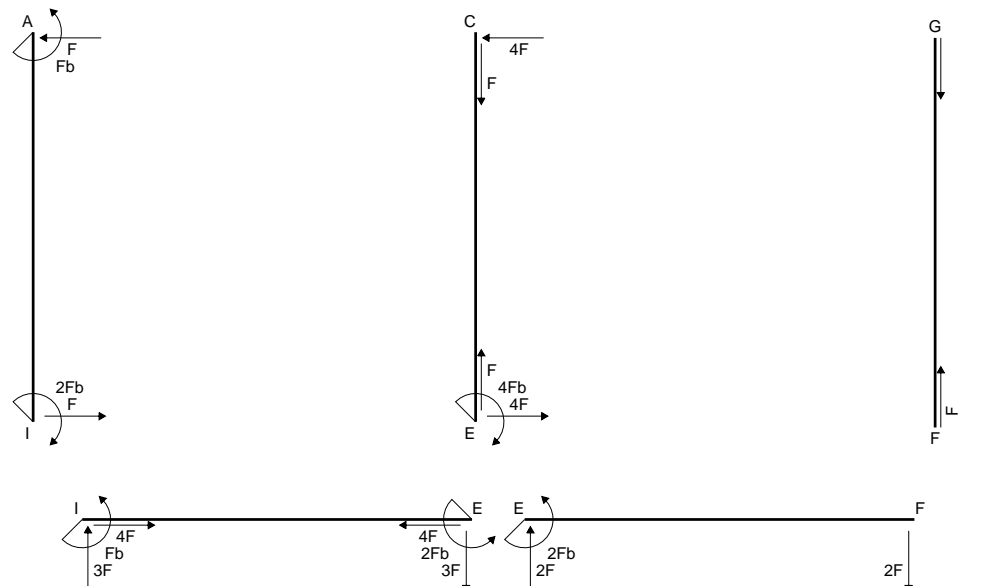
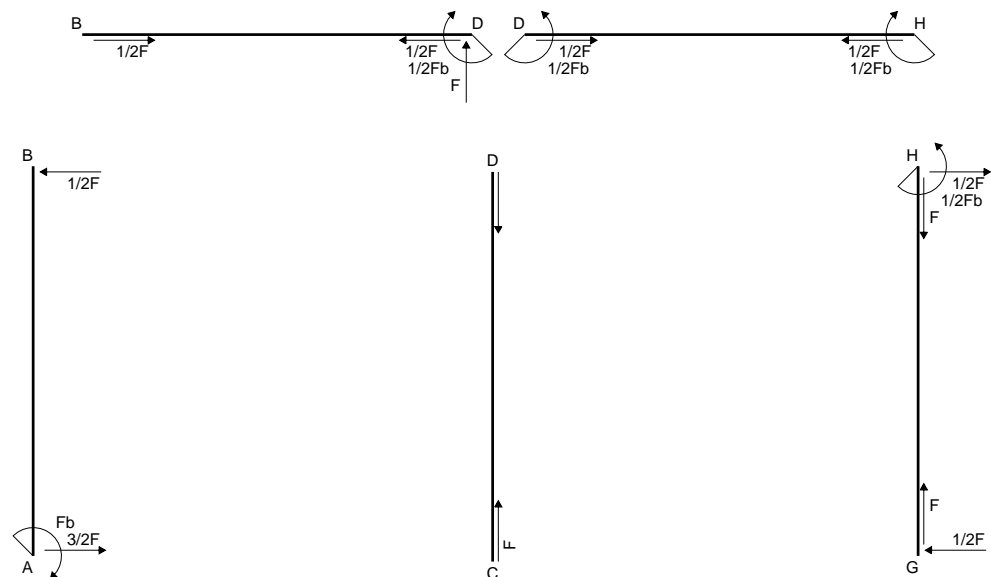
$$= (b - 5/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

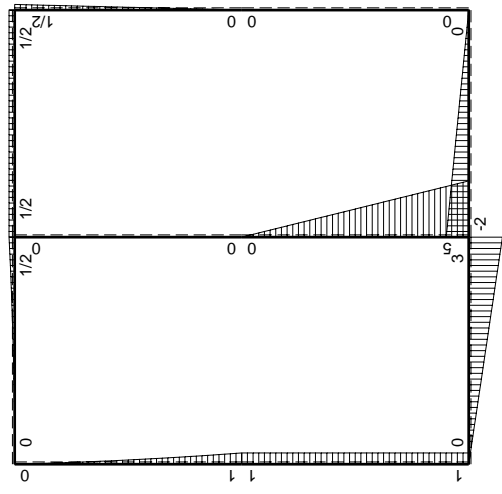
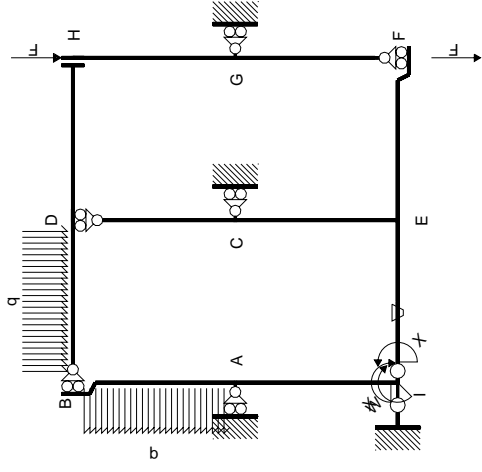
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$



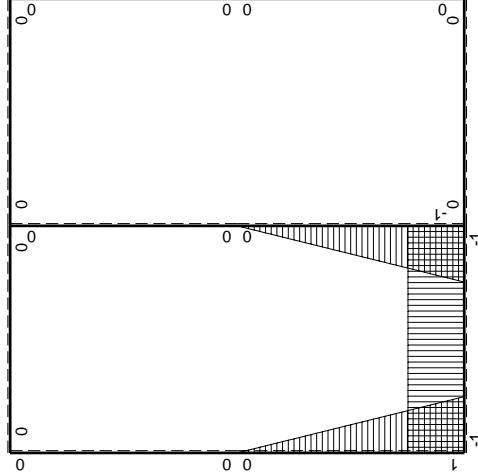
- A = 684. mm²
- J_u = 262207. mm⁴
- J_v = 43524. mm⁴
- y_g = 30.16 mm
- T_y = 2140. N
- M_x = -1733400. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -30.16 mm
- σ_m = -Mv/J_u = -199.4 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -17.16 mm
- σ_c = -Mv/J_u = -113.4 N/mm²
- τ_c = 7.242 N/mm²
- σ_o = √σ²+3τ² = 114.1 N/mm²
- S = 5324. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb	0	$Fb-Fx$	0	$1-2x/b+x^2/b^2$	$(1/2+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb$	0	Fx	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

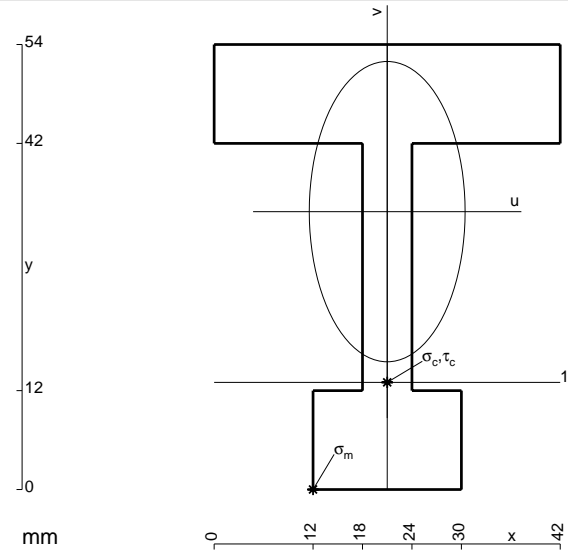
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - x/b) Fb \frac{1}{EJ} dx = [x - 1/2 x^2/b]_0^b Fb \frac{1}{EJ}$$

$$= (b - 1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b) Fb \frac{1}{EJ} dx = [1/2 x^2/b]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$



$$A = 900. \text{ mm}^2$$

$$J_u = 299017. \text{ mm}^4$$

$$J_v = 80460. \text{ mm}^4$$

$$y_g = 33.72 \text{ mm}$$

$$T_y = 2160. \text{ N}$$

$$M_x = -1857600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.72 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

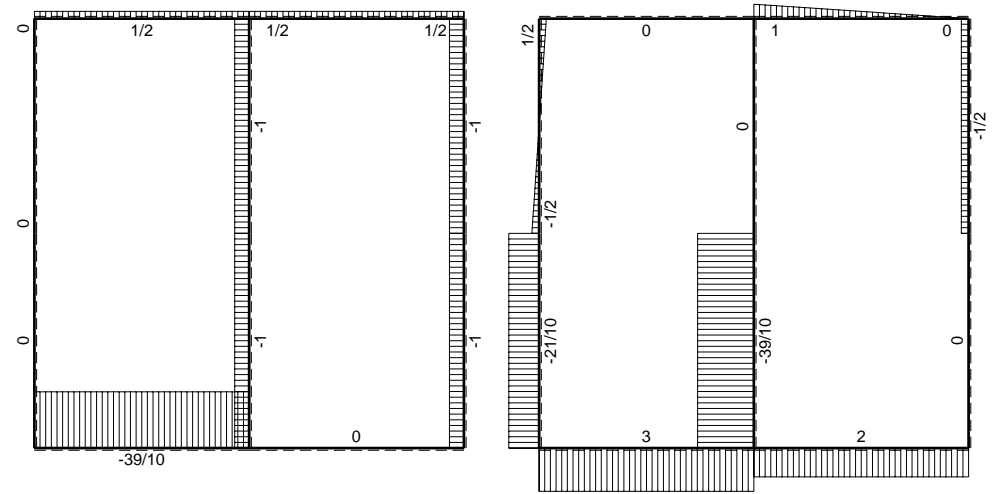
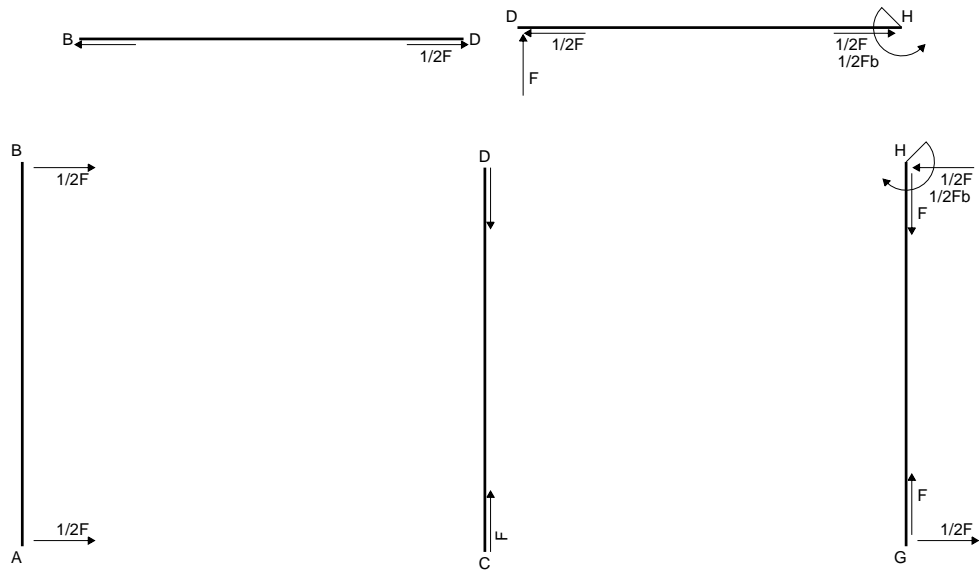
$$v_c = -20.72 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -128.7 \text{ N/mm}^2$$

$$\tau_c = 7.362 \text{ N/mm}^2$$

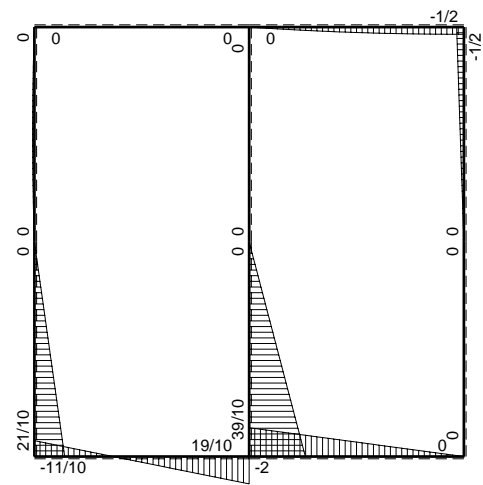
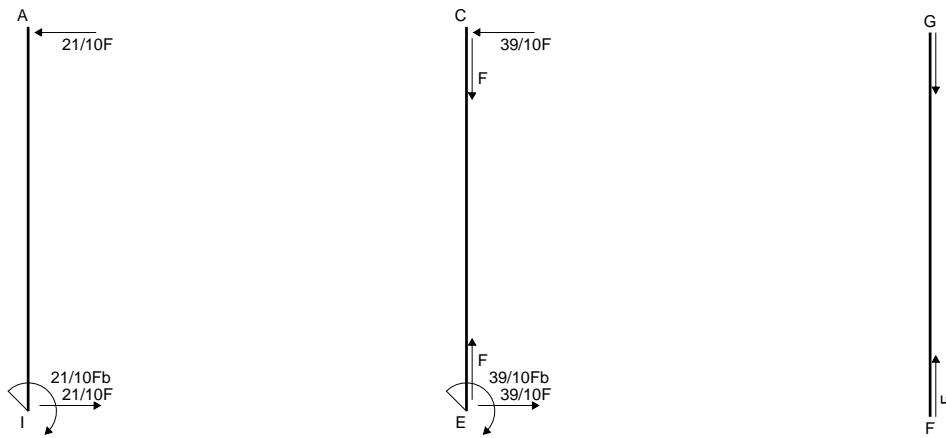
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 129.4 \text{ N/mm}^2$$

$$S = 6115. \text{ mm}^3$$

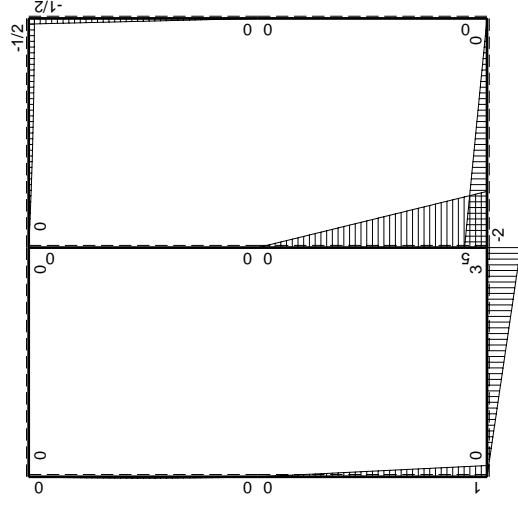
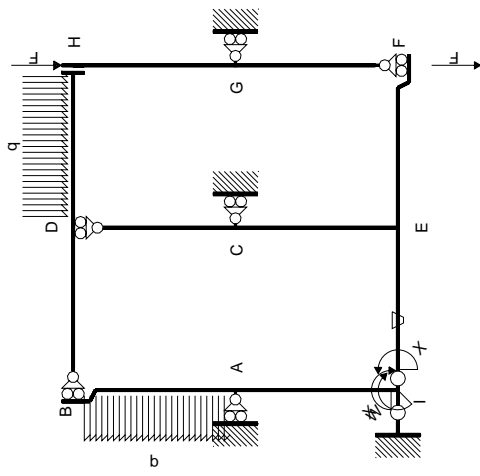


← ⊕ → F

↑ ⊕ ↓ F

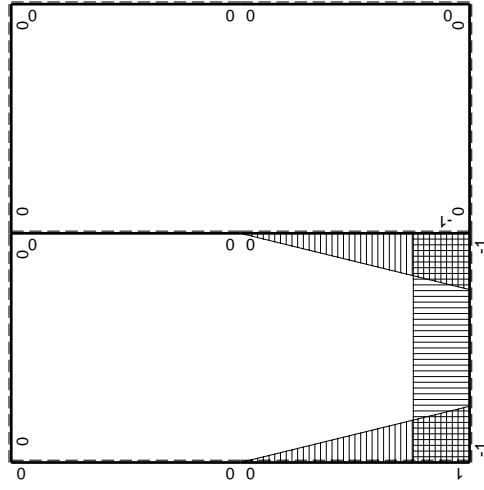


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

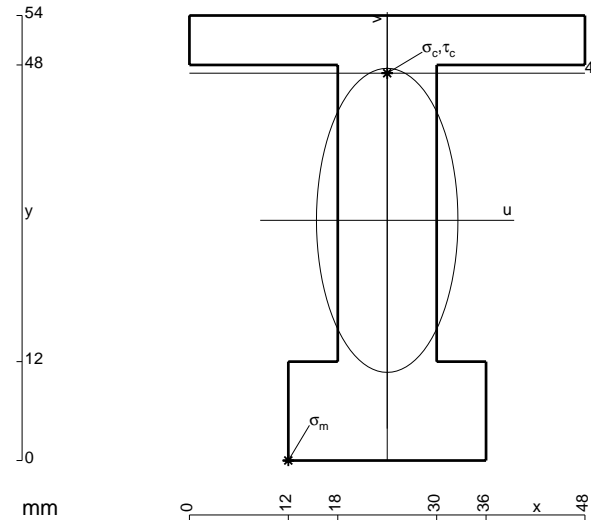
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

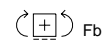
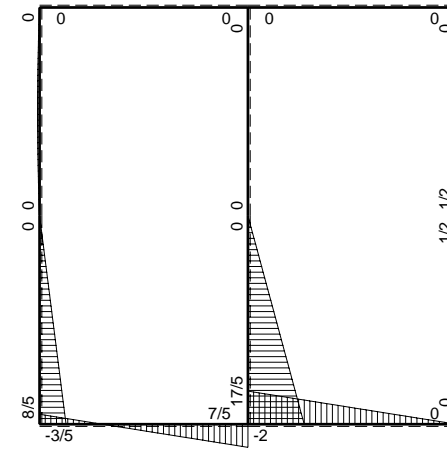
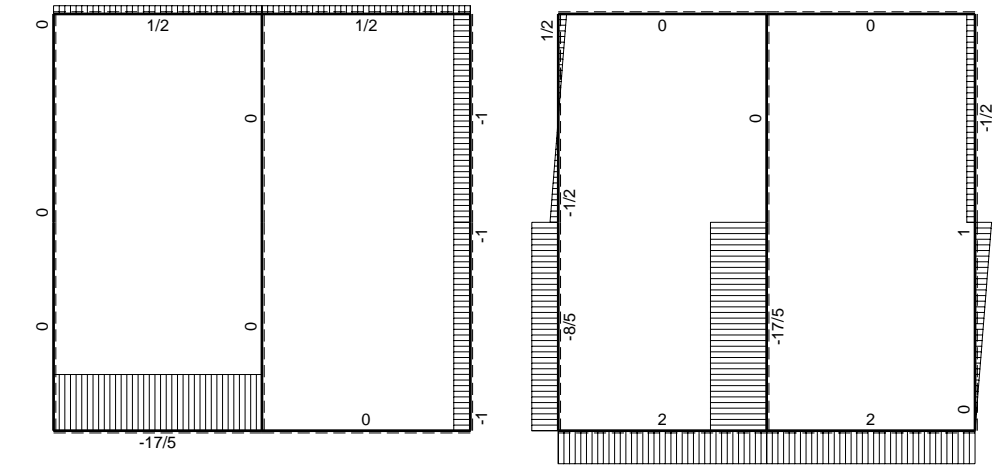
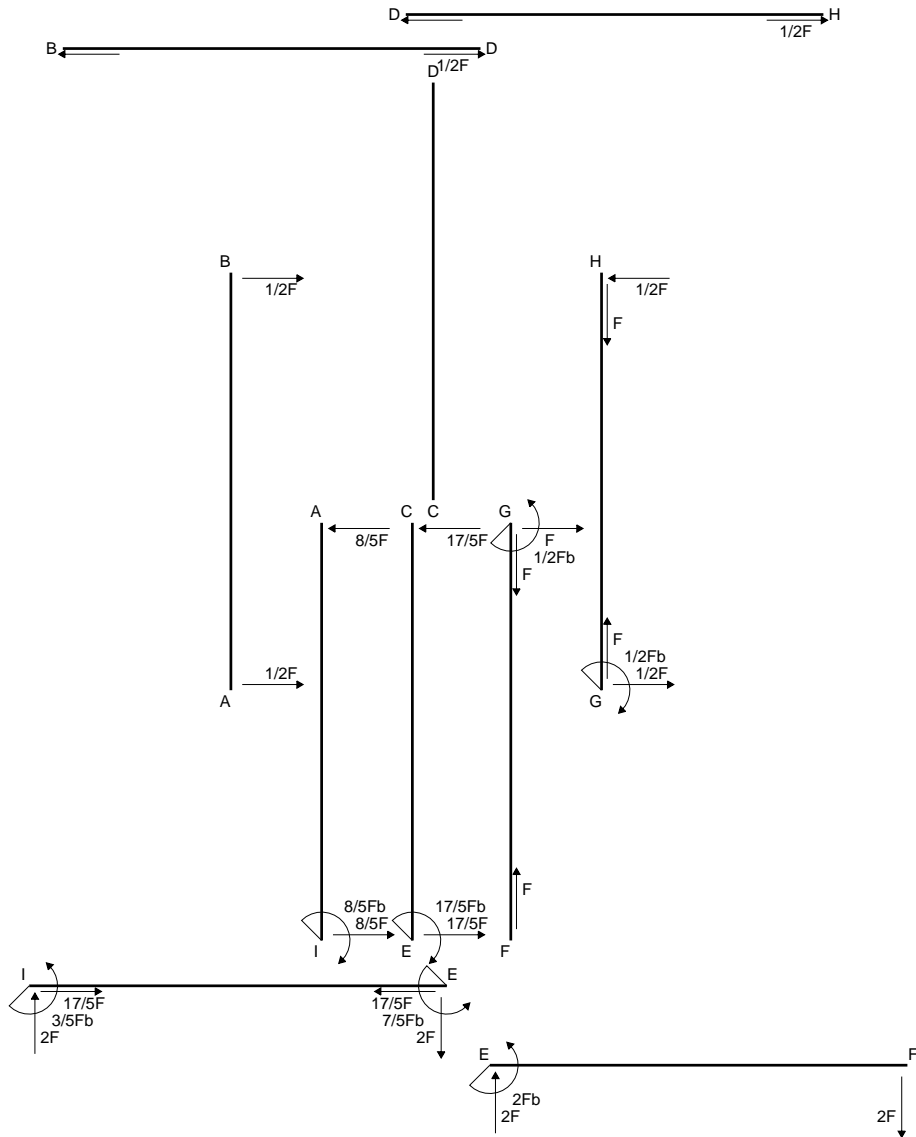
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

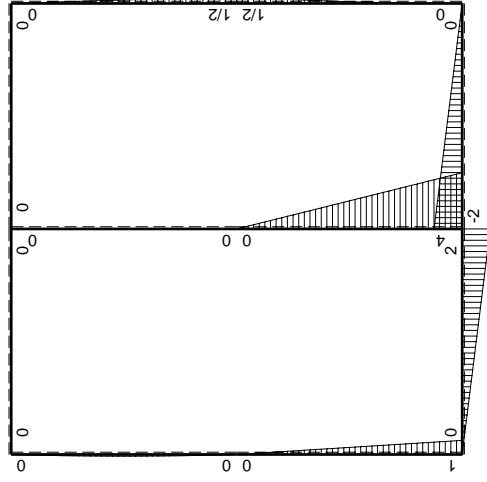
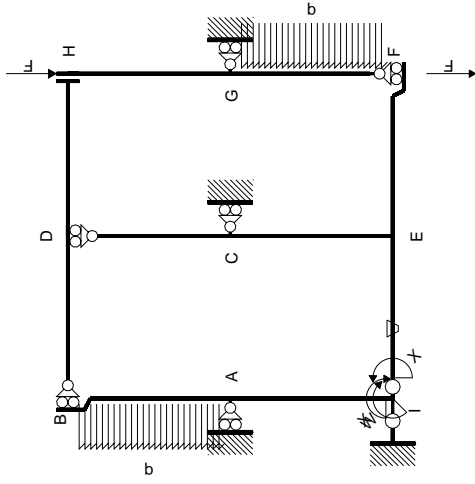
$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$



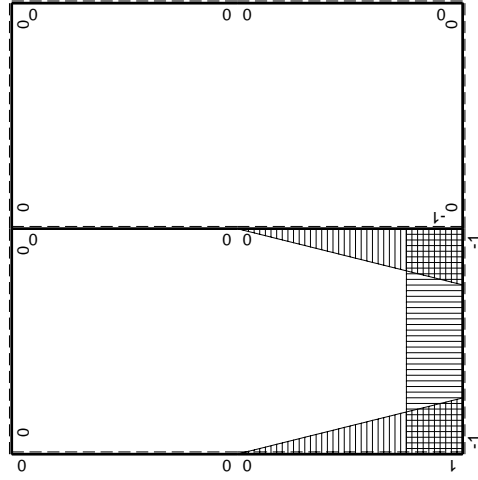
- A = 1008. mm²
- J_u = 343131. mm⁴
- J_v = 74304. mm⁴
- y_g = 29.14 mm
- T_y = 2840. N
- M_x = -2584400. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -29.14 mm
- σ_m = -Mv/J_u = -219.5 N/mm²
- x_c = 24. mm
- y_c = 47. mm
- v_c = 17.86 mm
- σ_c = -Mv/J_u = 134.5 N/mm²
- τ_c = 4.494 N/mm²
- σ_o = √σ²+3τ² = 134.7 N/mm²
- S = 6515. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

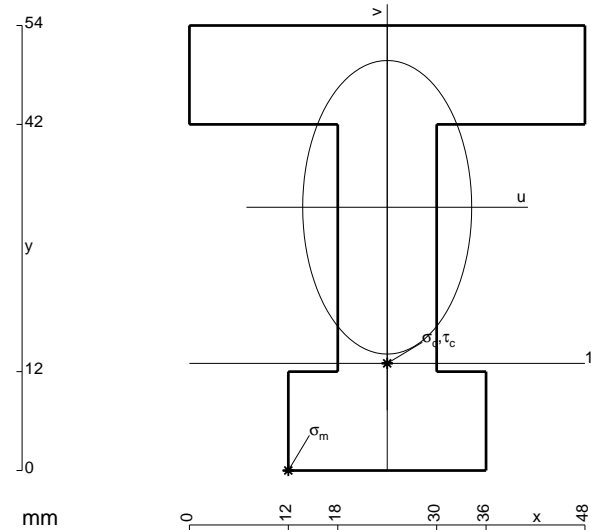
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$



$$A = 1224. \text{ mm}^2$$

$$J_u = 388508. \text{ mm}^4$$

$$J_v = 128736. \text{ mm}^4$$

$$y_g = 31.94 \text{ mm}$$

$$T_y = 2880. \text{ N}$$

$$M_x = -2793600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -31.94 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.7 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

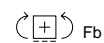
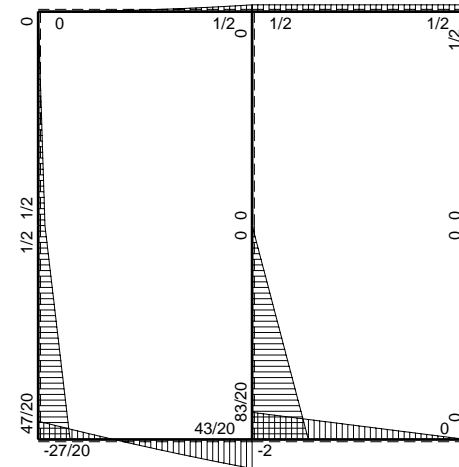
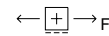
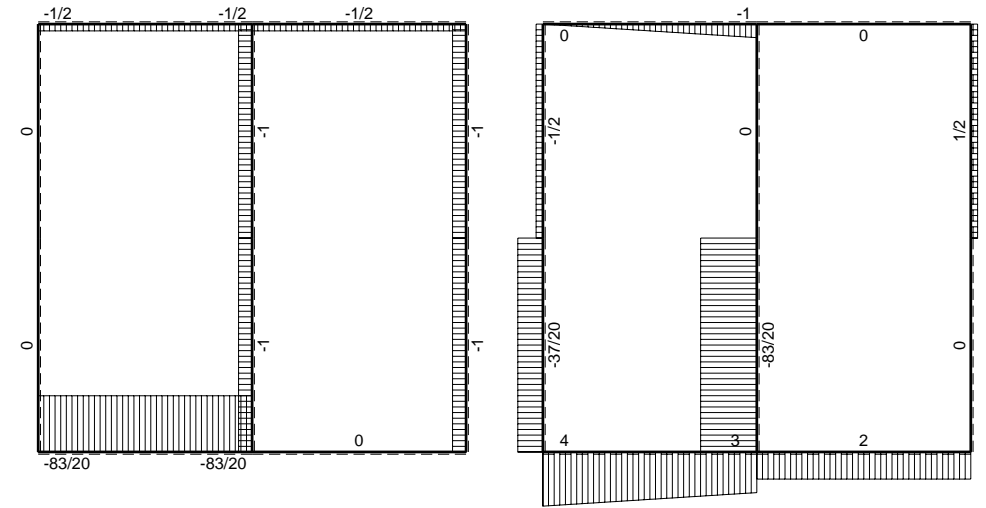
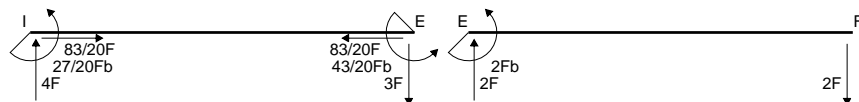
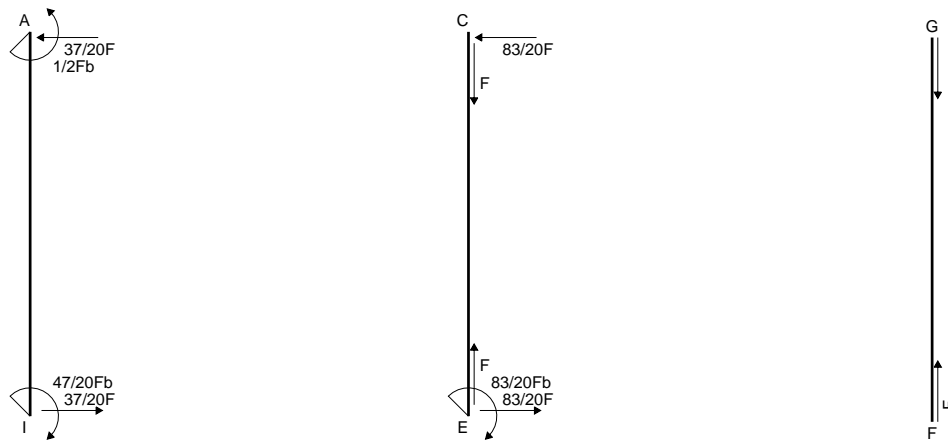
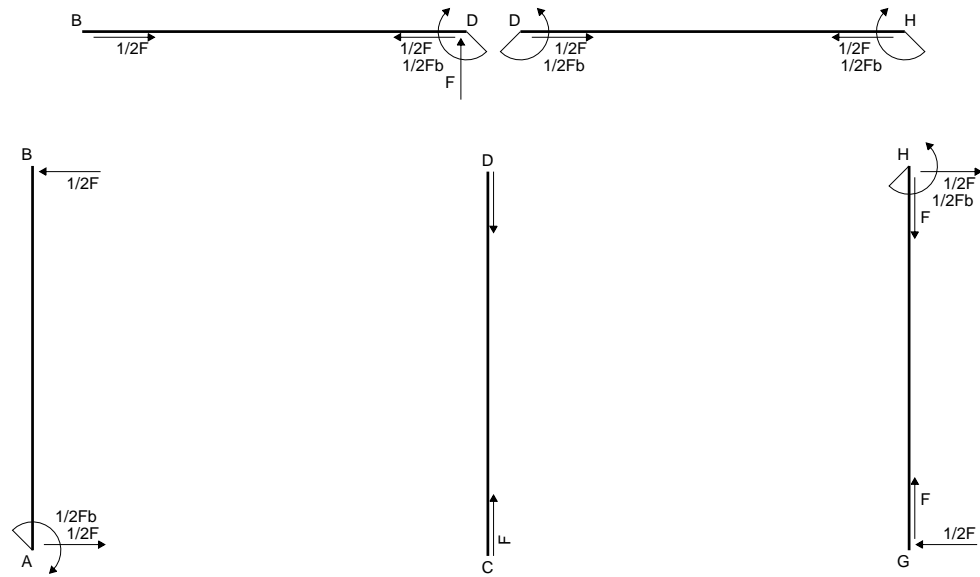
$$v_c = -18.94 \text{ mm}$$

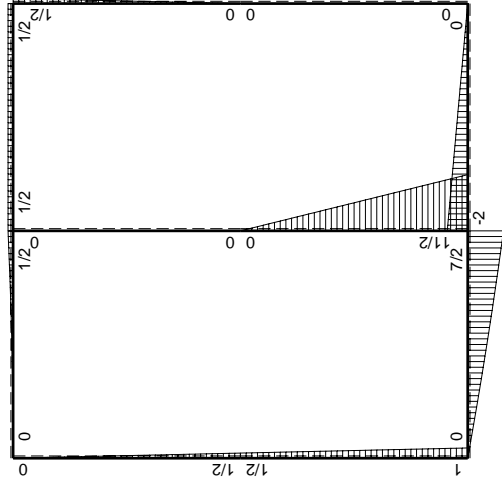
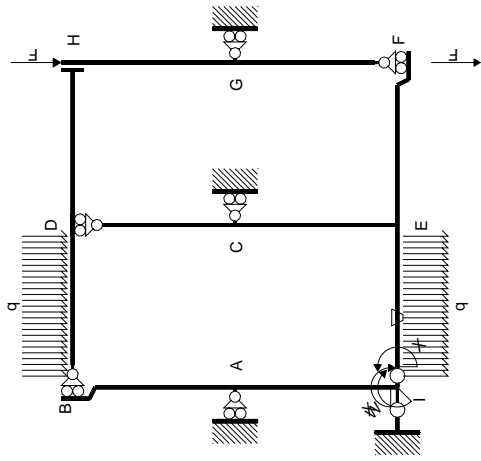
$$\sigma_c = -Mv/J_u = -136.2 \text{ N/mm}^2$$

$$\tau_c = 4.759 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 136.4 \text{ N/mm}^2$$

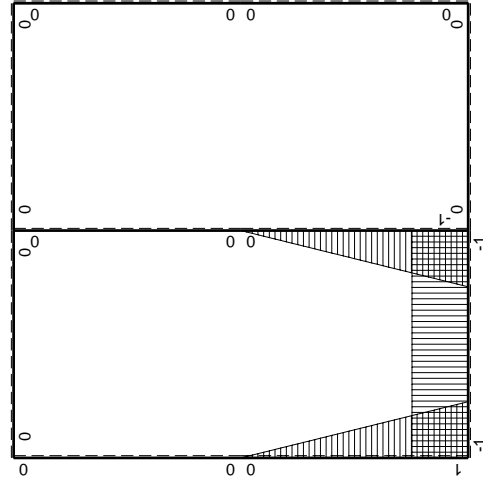
$$S = 7704. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$-1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0			
HD b	0	$1/2Fb$	0	0	0	0	0+0	0	
DH b	0	$-1/2Fb$	0	0	0	0			
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
BD b	0	$-1/2qx^2$	0	0	0	0			
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2			
	totali							$-9/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$27/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

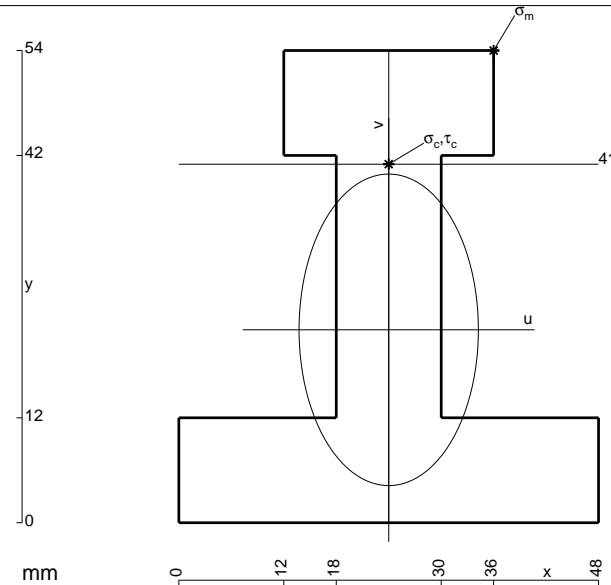
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 3/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

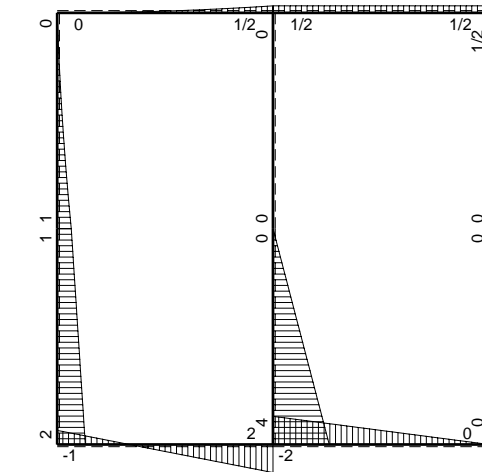
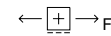
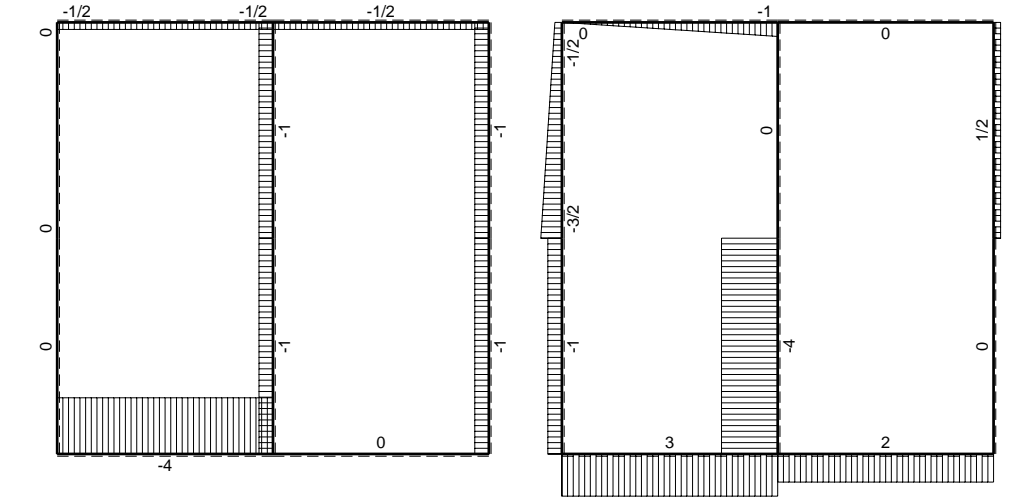
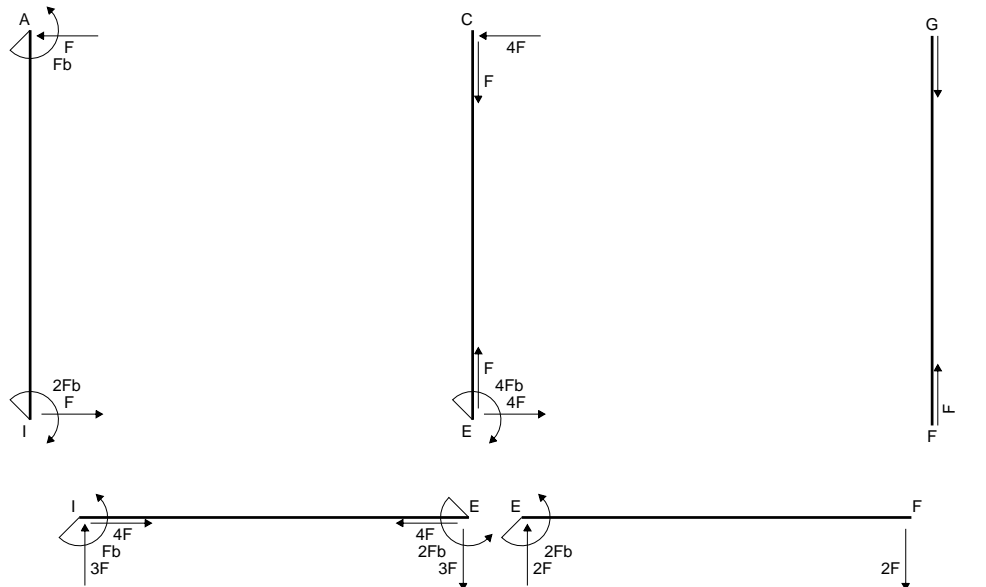
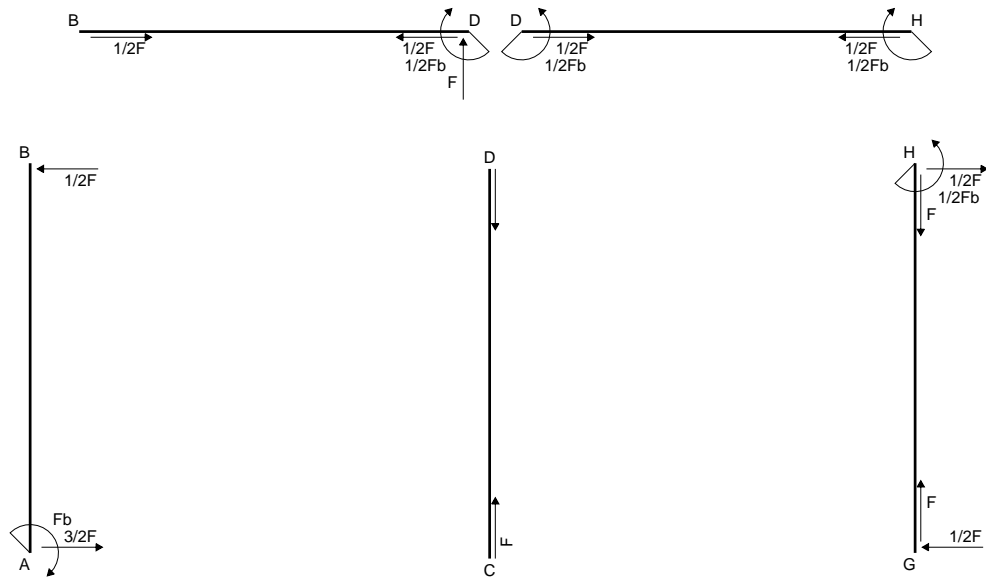
$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

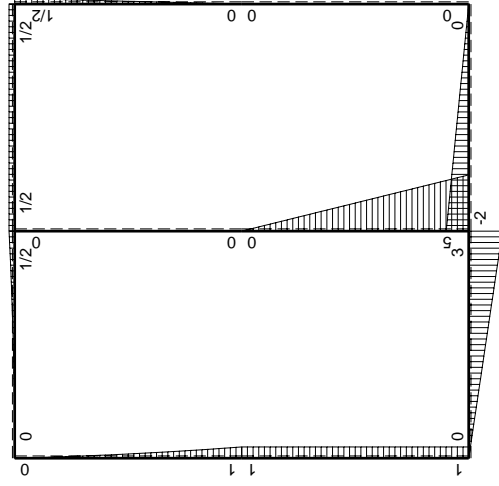
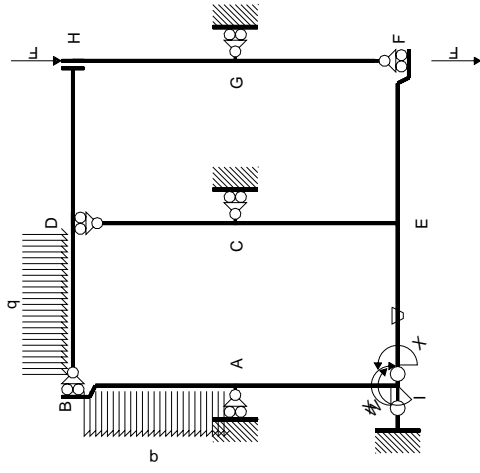
$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



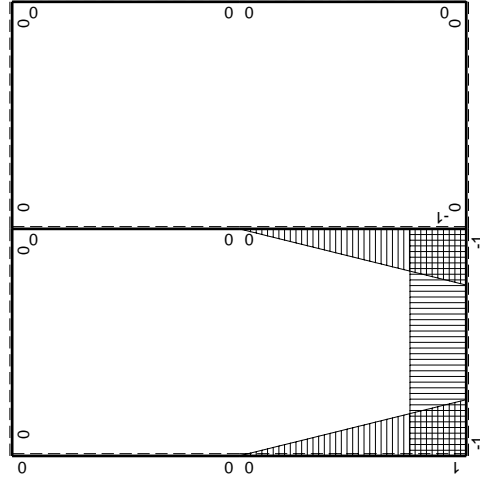
- A = 1224. mm²
- J_u = 388508. mm⁴
- J_v = 128736. mm⁴
- y_g = 22.06 mm
- T_y = 2860. N
- M_x = -2917200. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 31.94 mm
- σ_m = -Mv/J_u = 239.8 N/mm²
- x_c = 24. mm
- y_c = 41. mm
- v_c = 18.94 mm
- σ_c = -Mv/J_u = 142.2 N/mm²
- τ_c = 4.726 N/mm²
- σ_q = √σ²+3τ² = 142.5 N/mm²
- S = 7704. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb	0	$Fb-Fx$	0	$1-2x/b+x^2/b^2$	$(1/2+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb$	0	Fx	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

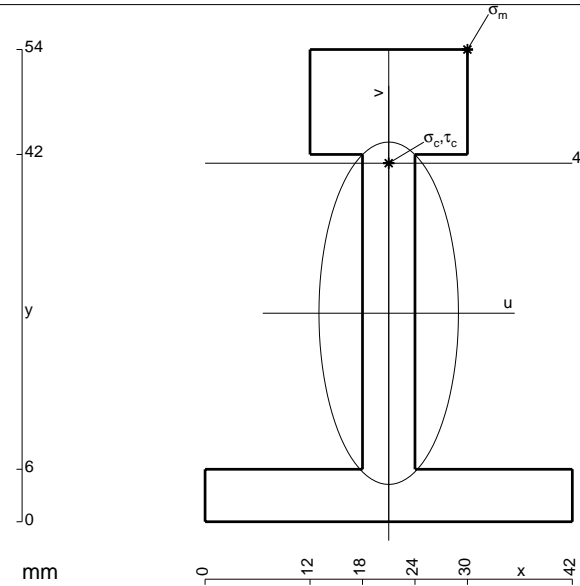
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - x/b) Fb \frac{1}{EJ} dx = [x - 1/2 x^2/b]_0^b Fb \frac{1}{EJ}$$

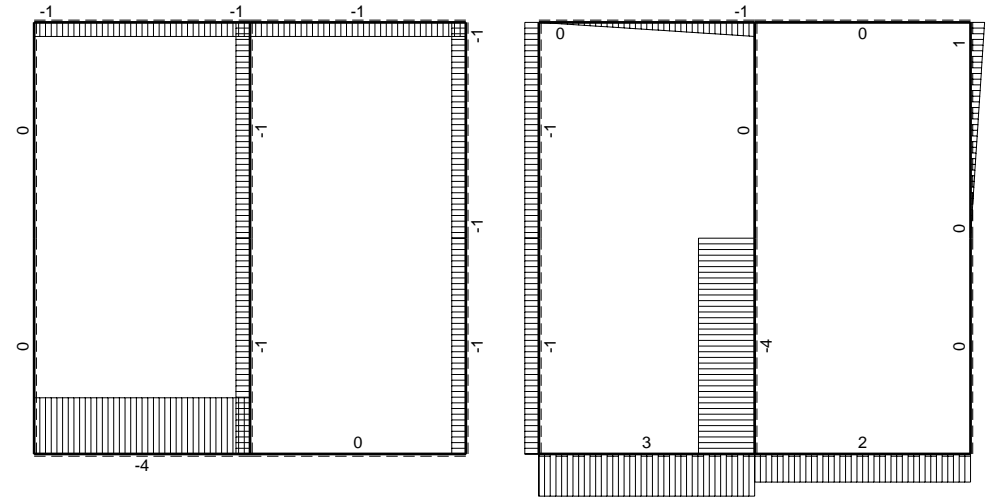
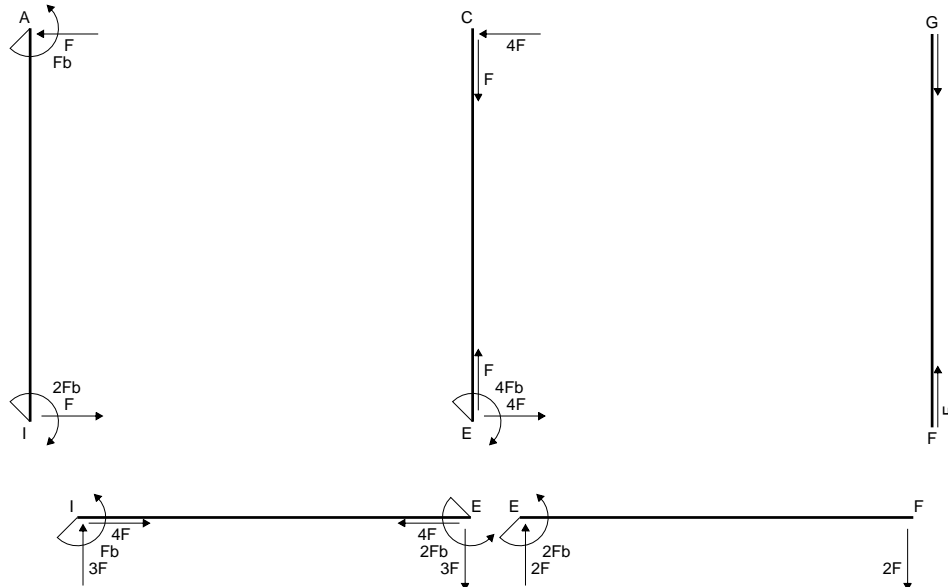
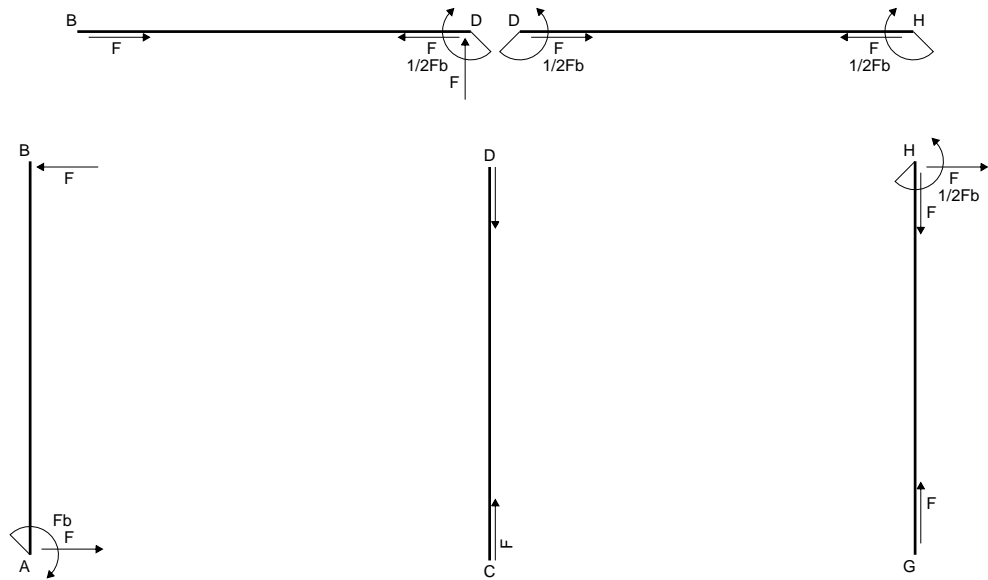
$$= (b - 1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b) Fb \frac{1}{EJ} dx = [1/2 x^2/b]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

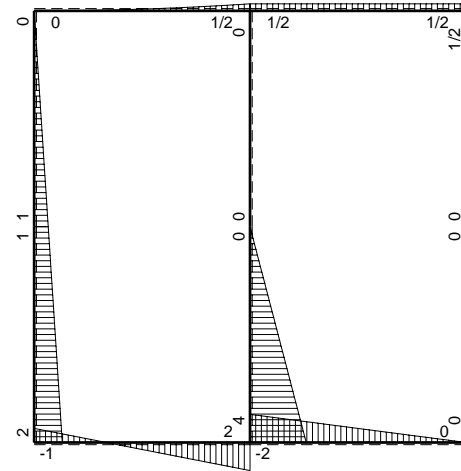


- A = 684. mm²
- J_u = 262207. mm⁴
- J_v = 43524. mm⁴
- y_g = 23.84 mm
- T_y = 3220. N
- M_x = -1738800. Nmm
- x_m = 30. mm
- y_m = 54. mm
- u_m = 9. mm
- v_m = 30.16 mm
- σ_m = -Mv/J_u = 200. N/mm²
- x_c = 21. mm
- y_c = 41. mm
- v_c = 17.16 mm
- σ_c = -Mv/J_u = 113.8 N/mm²
- τ_c = 10.9 N/mm²
- σ_q = √σ²+3τ² = 115.3 N/mm²
- S = 5324. mm³

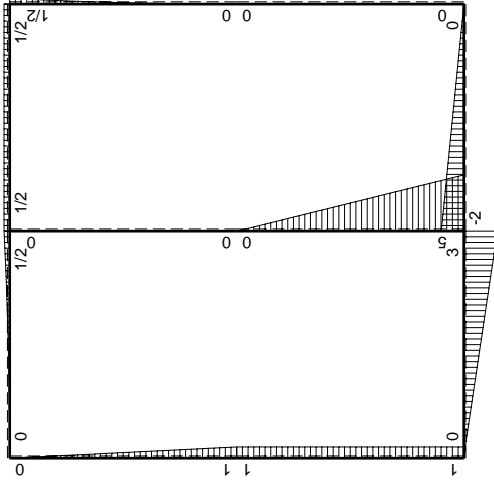
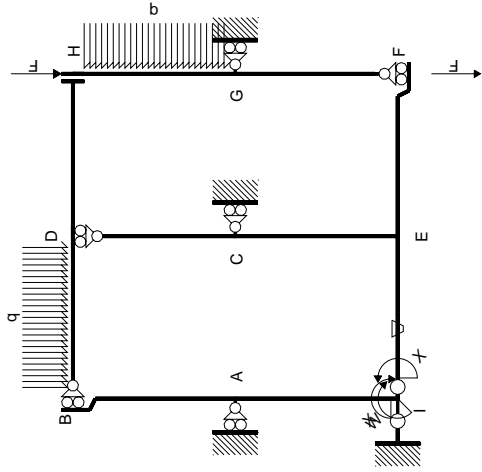


← ⊕ → F

↑ ⊕ ↓ F

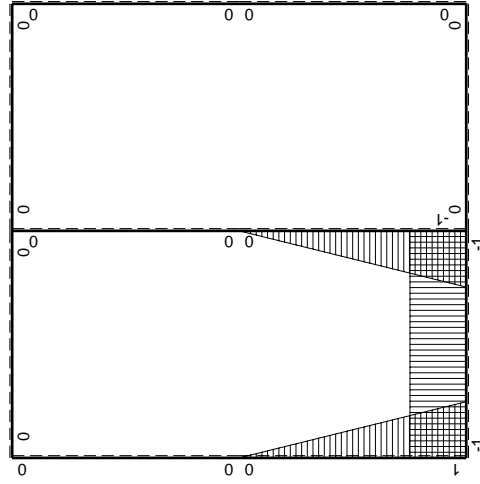


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-Fx	0	0	0	0	0+0	0
BA b	0	-Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	5Fb-5Fx	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-5Fx	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb	0	Fb-Fx	0	$1-2x/b+x^2/b^2$	$(1/2+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	-Fb	0	Fx	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

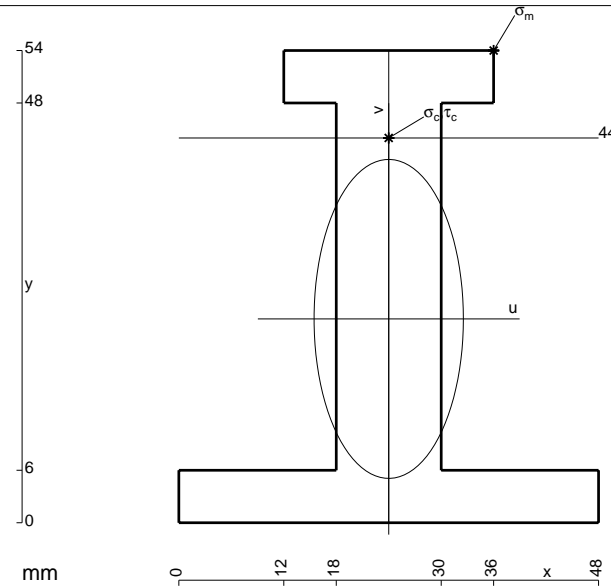
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - x/b) Fb \frac{1}{EJ} dx = [x - 1/2 x^2/b]_0^b Fb \frac{1}{EJ}$$

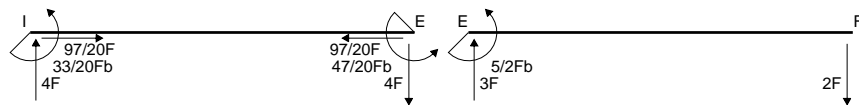
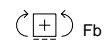
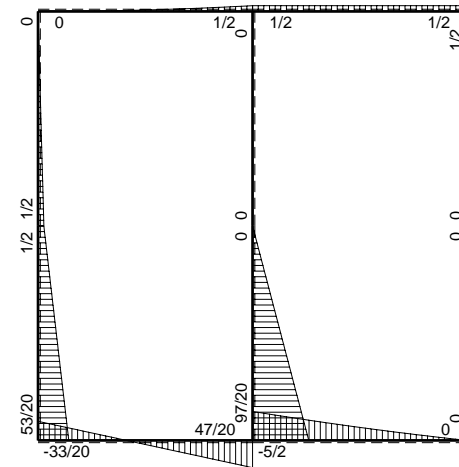
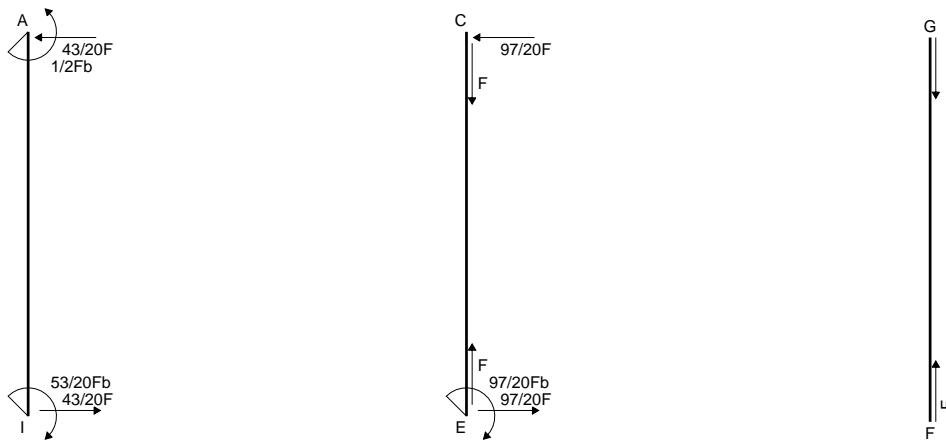
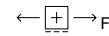
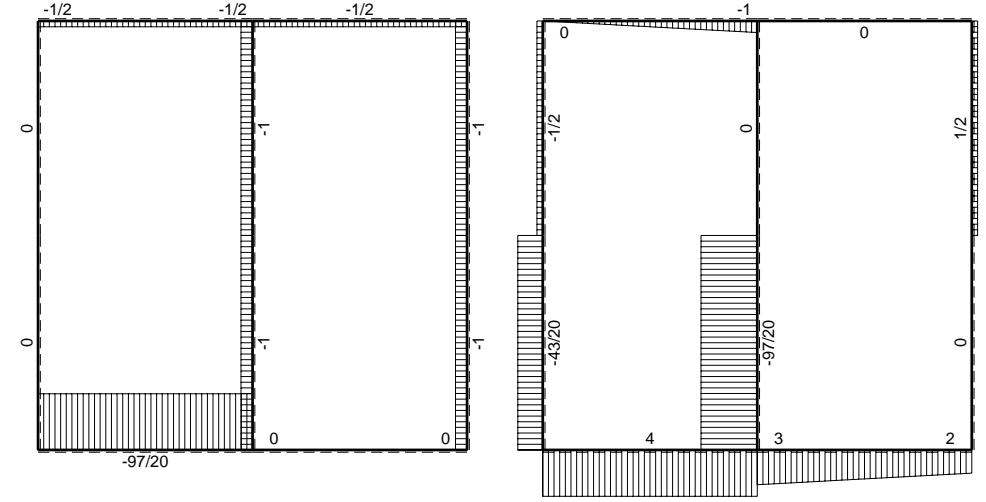
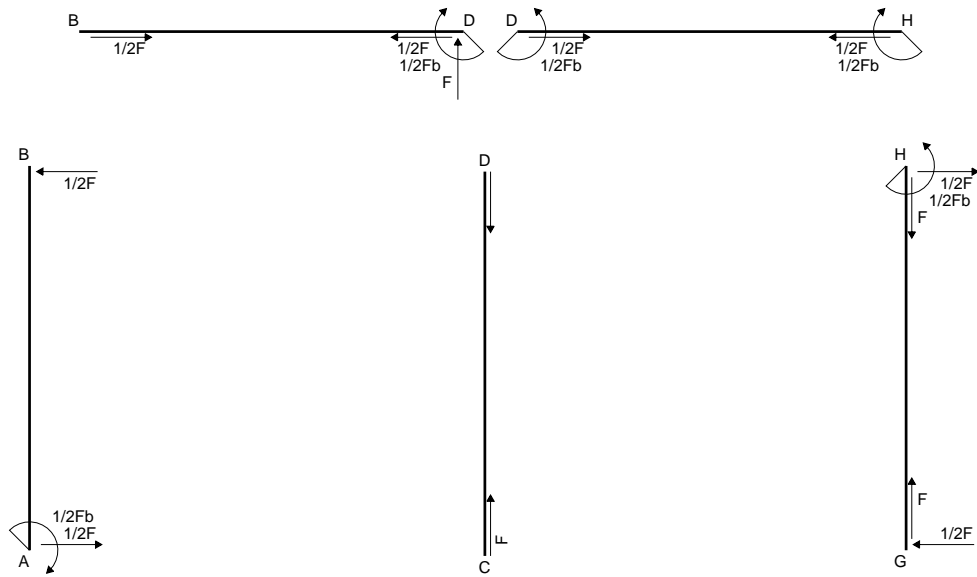
$$= (b - 1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

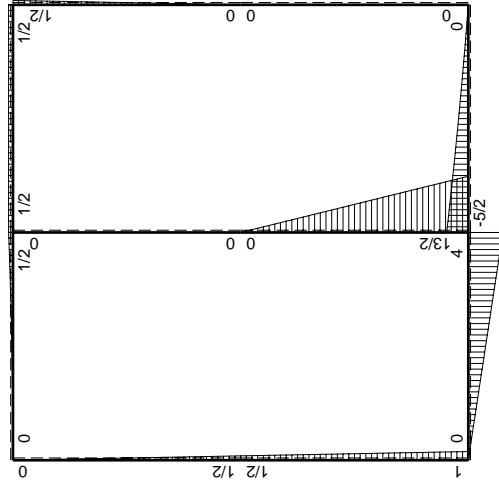
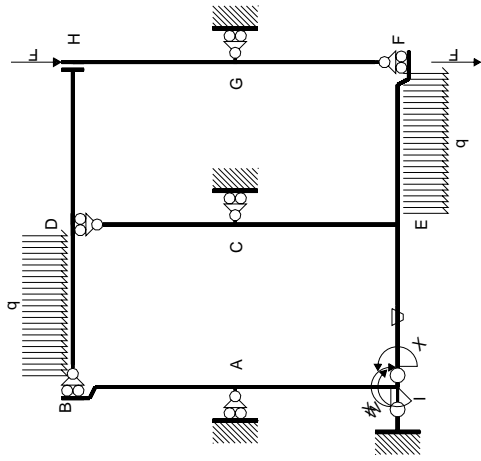
$$L_{AI}^{xo} = \int_0^b (x/b) Fb \frac{1}{EJ} dx = [1/2 x^2/b]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$



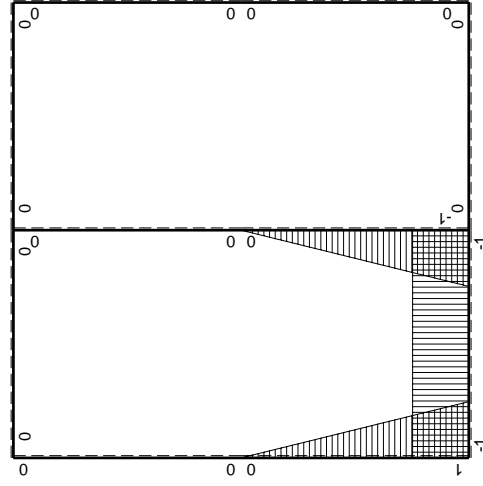
- A = 936. mm²
- J_u = 311455. mm⁴
- J_v = 68256. mm⁴
- y_g = 23.31 mm
- T_y = 3600. N
- M_x = -2124000. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 30.69 mm
- σ_m = -Mv/J_u = 209.3 N/mm²
- x_c = 24. mm
- y_c = 44. mm
- v_c = 20.69 mm
- σ_c = -Mv/J_u = 141.1 N/mm²
- τ_c = 4.89 N/mm²
- σ_q = √σ²+3τ² = 141.4 N/mm²
- S = 5077. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb 1/EJ dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb 1/EJ dx = [-13/6 x^3/b^2]_0^b Fb 1/EJ$$

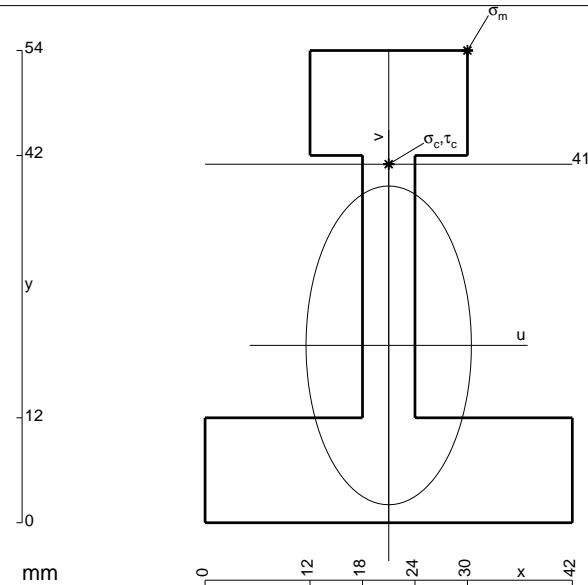
$$= (-13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [x - 3/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 3/4 b + 1/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b + 1/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$



$$A = 900. \text{ mm}^2$$

$$J_u = 299017. \text{ mm}^4$$

$$J_v = 80460. \text{ mm}^4$$

$$y_g = 20.28 \text{ mm}$$

$$T_y = 3630. \text{ N}$$

$$M_x = -1936000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 33.72 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 218.3 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

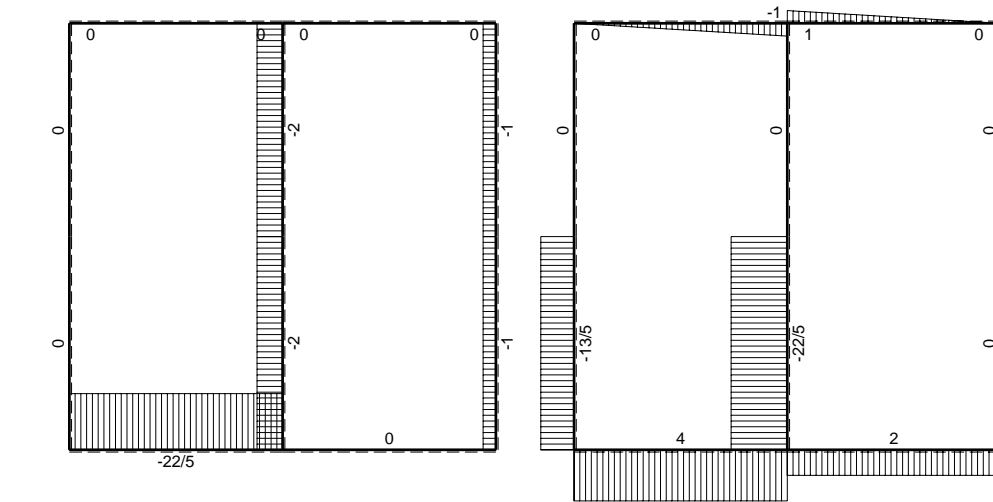
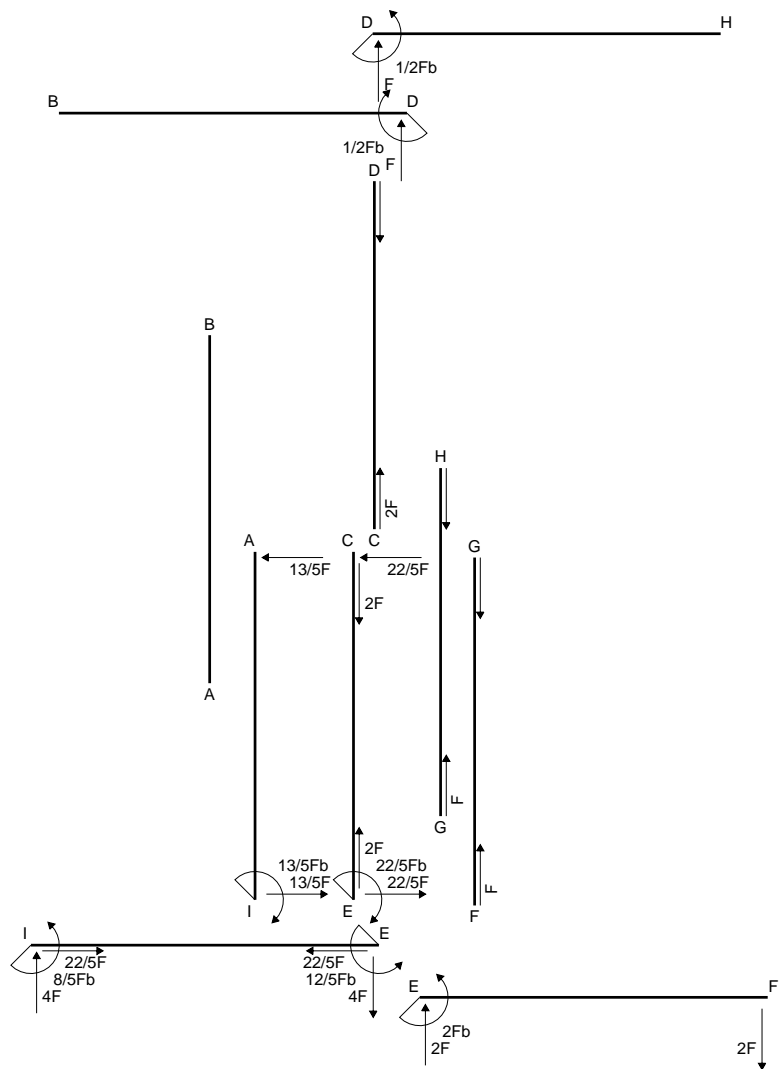
$$v_c = 20.72 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 134.2 \text{ N/mm}^2$$

$$\tau_c = 12.37 \text{ N/mm}^2$$

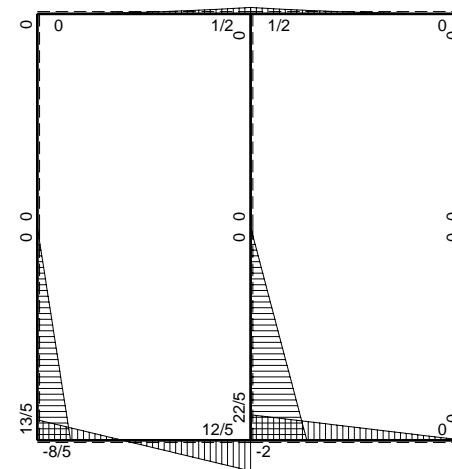
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 135.9 \text{ N/mm}^2$$

$$S = 6115. \text{ mm}^3$$

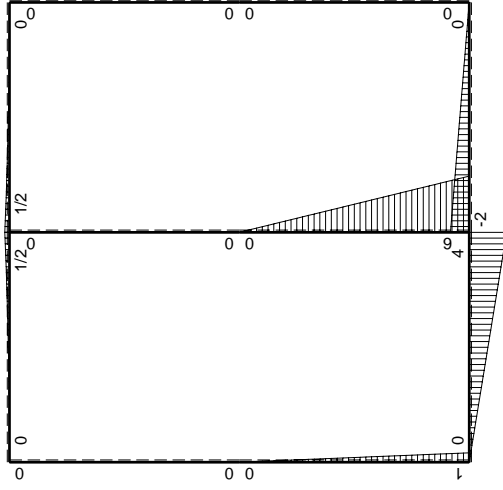
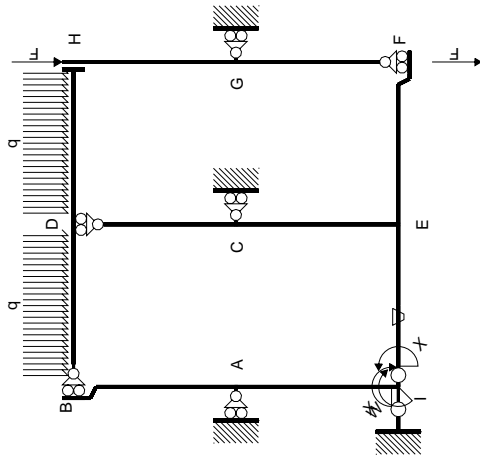


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↑ (+) ↓ Fb

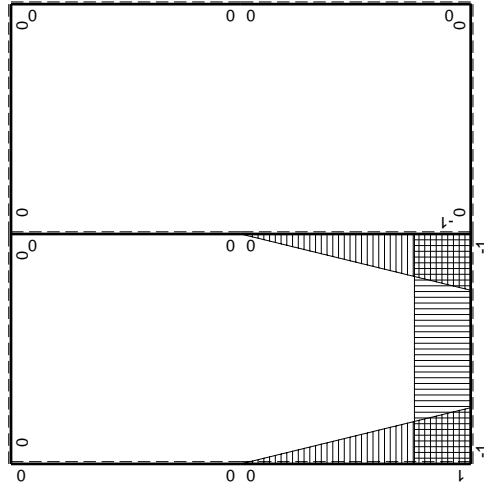


⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

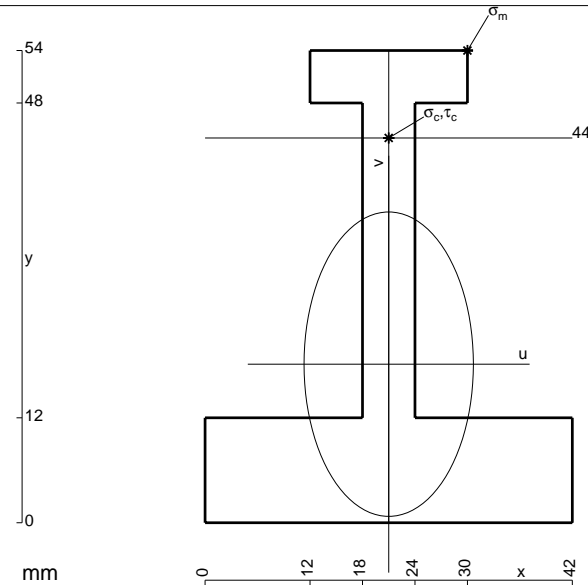
$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$



$$A = 828. \text{ mm}^2$$

$$J_u = 250978. \text{ mm}^4$$

$$J_v = 77652. \text{ mm}^4$$

$$y_g = 18.13 \text{ mm}$$

$$T_y = 2280. \text{ N}$$

$$M_x = -1596000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 35.87 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 228.1 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

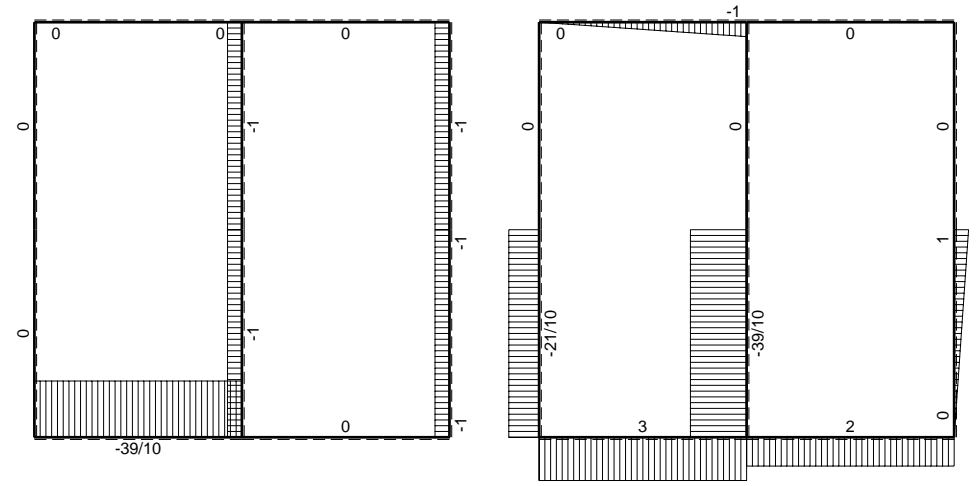
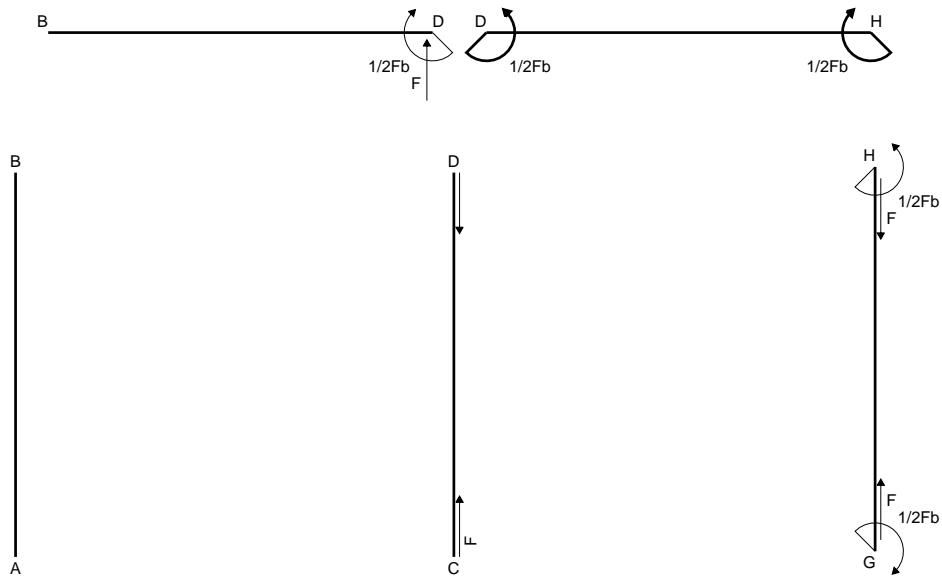
$$v_c = 25.87 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 164.5 \text{ N/mm}^2$$

$$\tau_c = 6.388 \text{ N/mm}^2$$

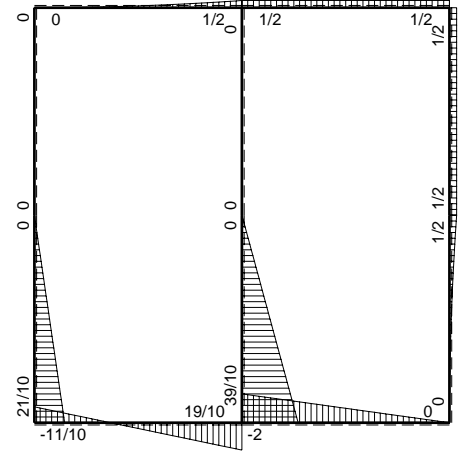
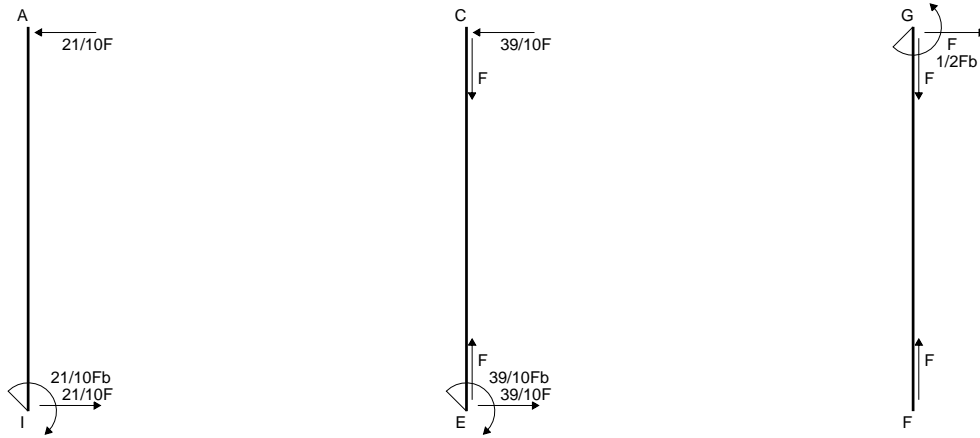
$$\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 164.9 \text{ N/mm}^2$$

$$S = 4219. \text{ mm}^3$$

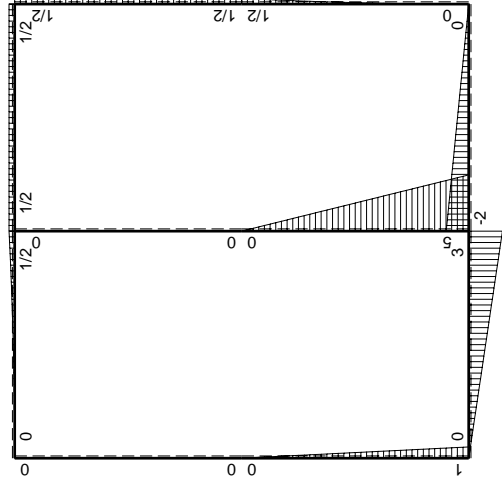
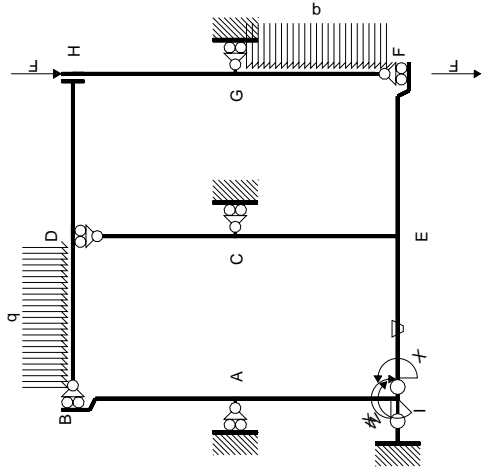


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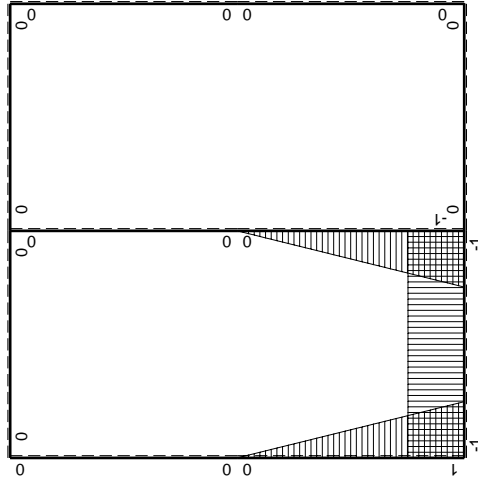


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

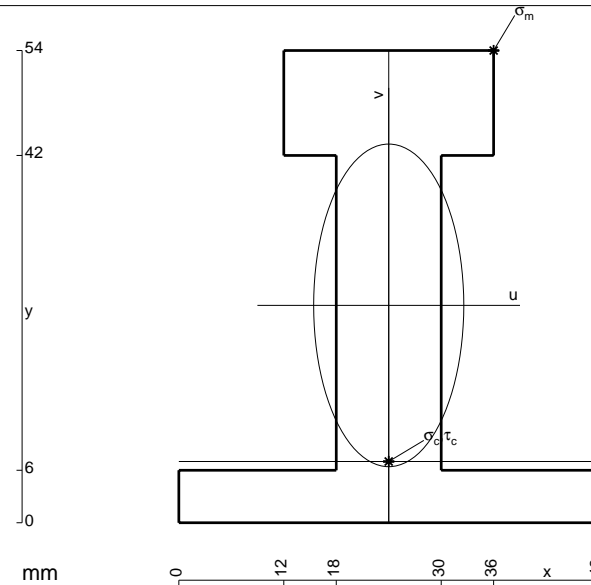
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

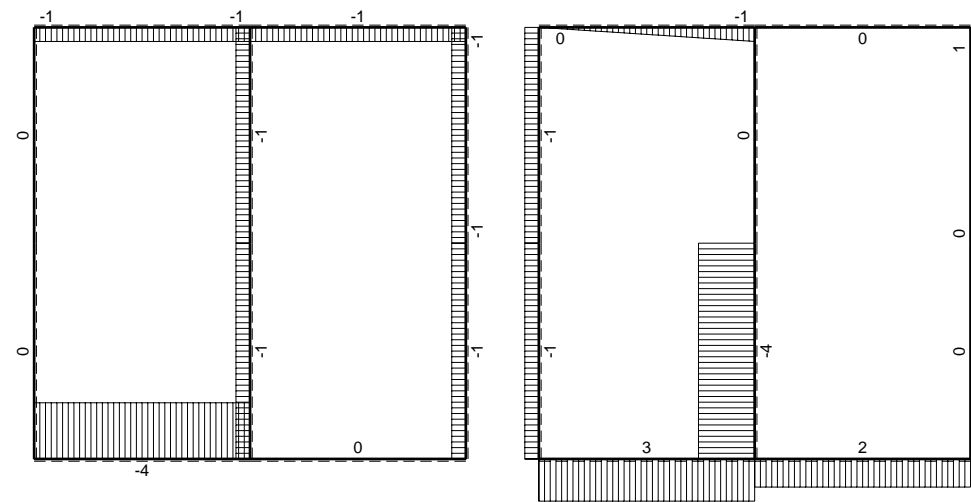
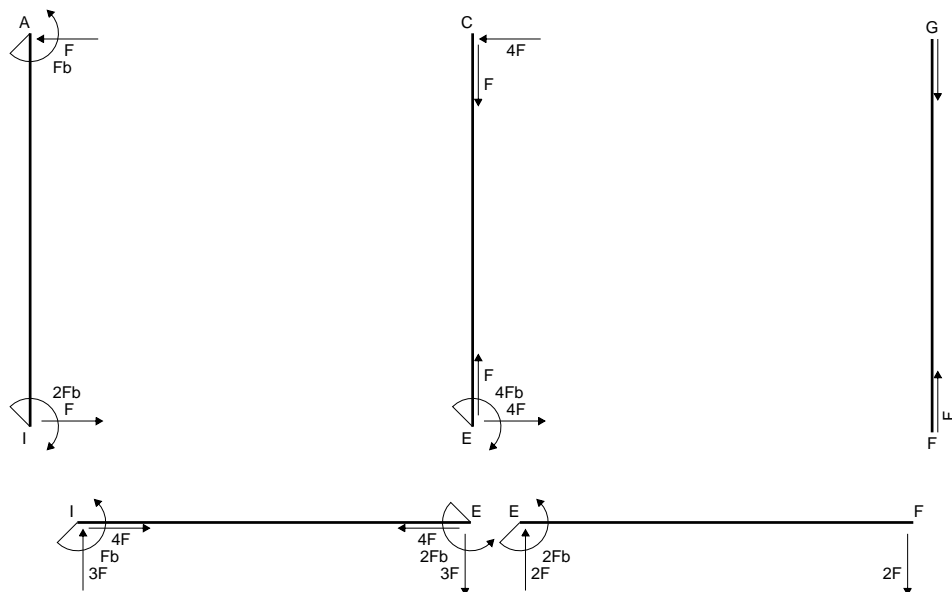
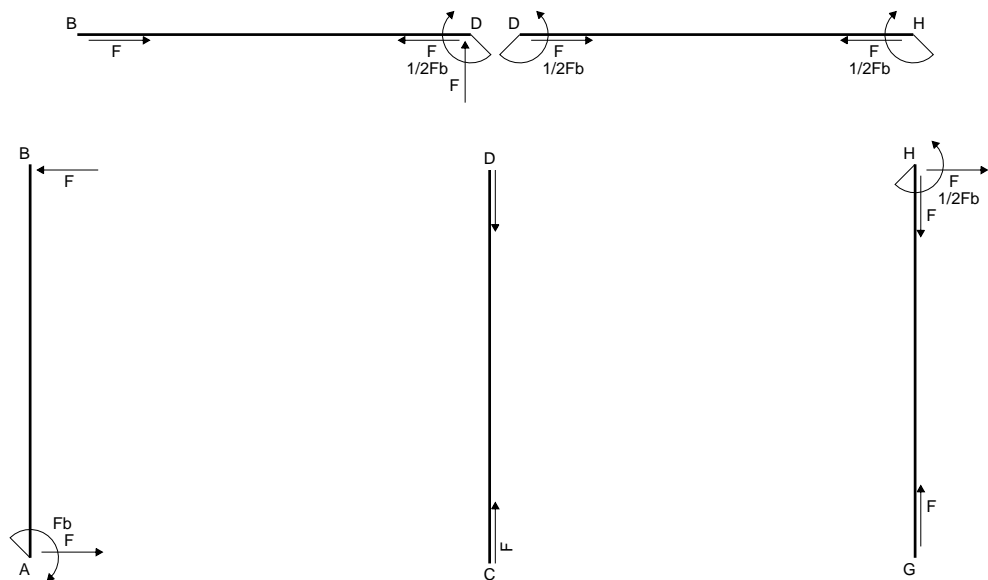
$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

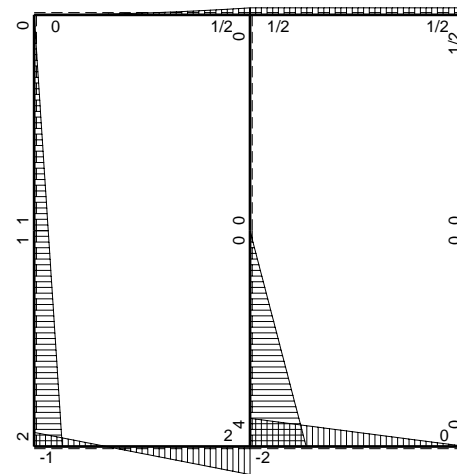


- A = 1008. mm²
- J_u = 343131. mm⁴
- J_v = 74304. mm⁴
- y_g = 24.86 mm
- T_y = 3760. N
- M_x = -2820000. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 29.14 mm
- σ_m = -Mv/J_u = 239.5 N/mm²
- x_c = 24. mm
- y_c = 7. mm
- v_c = -17.86 mm
- σ_c = -Mv/J_u = -146.8 N/mm²
- τ_c = 5.949 N/mm²
- σ_q = √σ²+3τ² = 147.1 N/mm²
- S = 6515. mm³

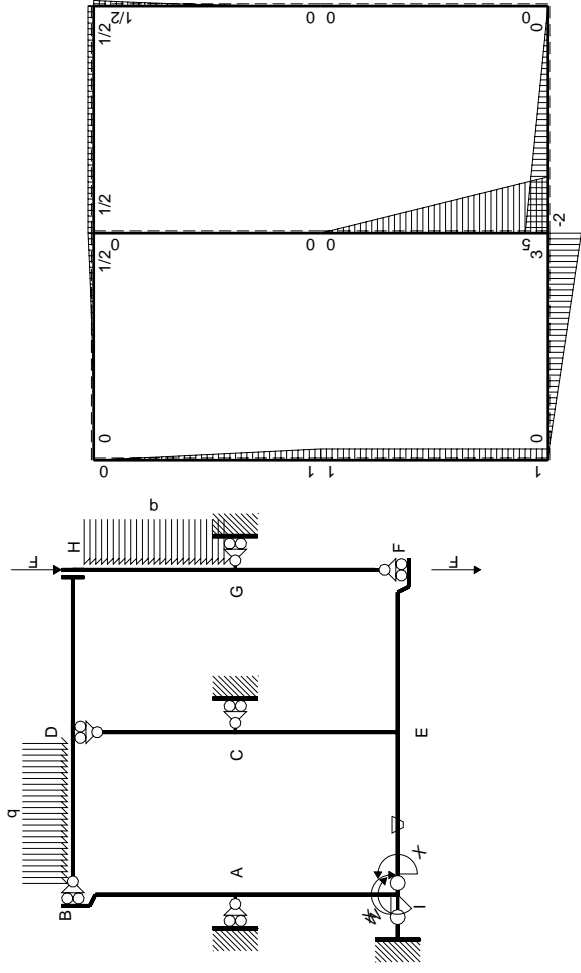


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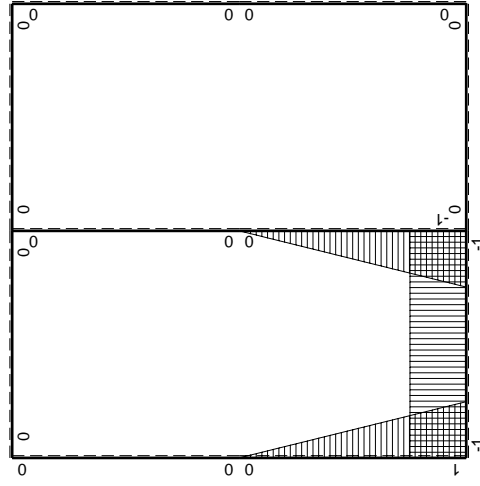


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-Fx	0	0	0	0	0+0	0
BA b	0	-Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	5Fb-5Fx	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-5Fx	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb	0	Fb-Fx	0	$1-2x/b+x^2/b^2$	$(1/2+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	-Fb	0	Fx	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

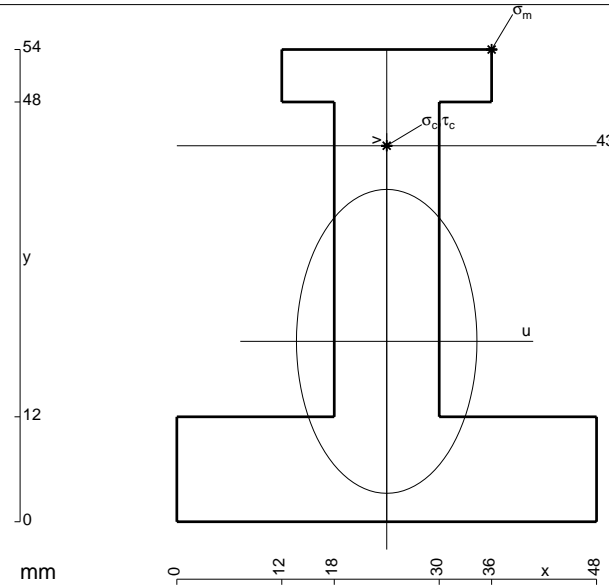
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - x/b) Fb \frac{1}{EJ} dx = [x - 1/2 x^2/b]_0^b Fb \frac{1}{EJ}$$

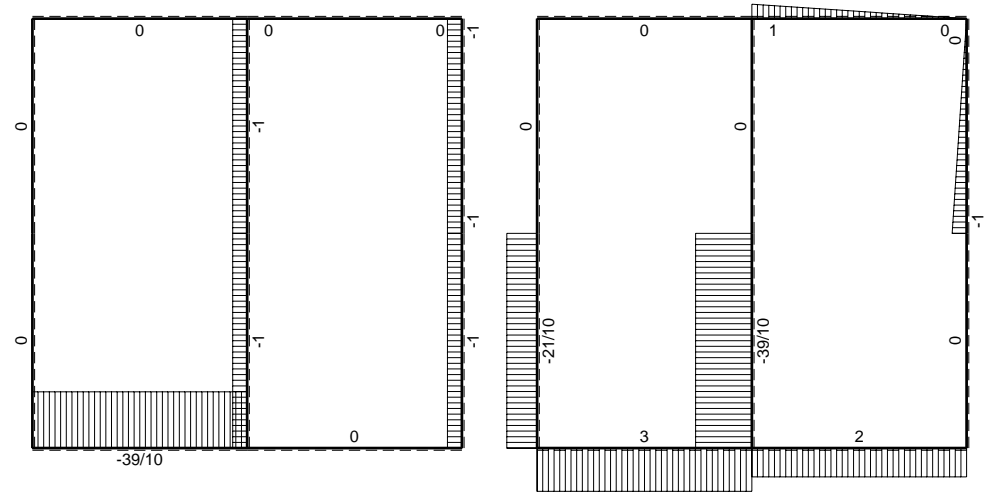
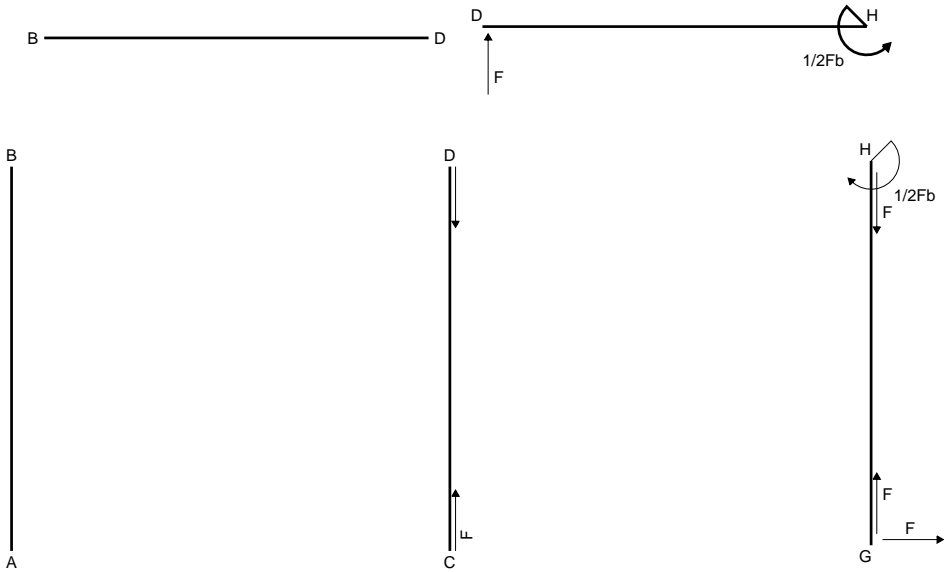
$$= (b - 1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b) Fb \frac{1}{EJ} dx = [1/2 x^2/b]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

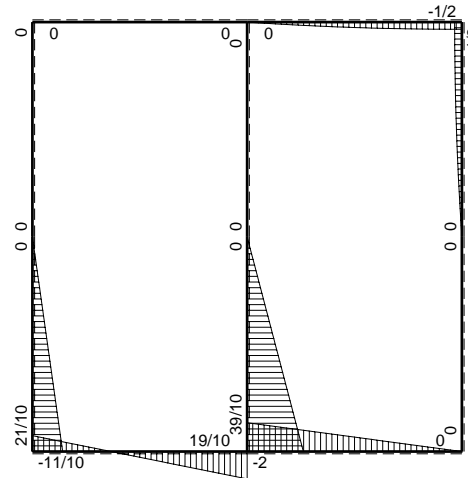
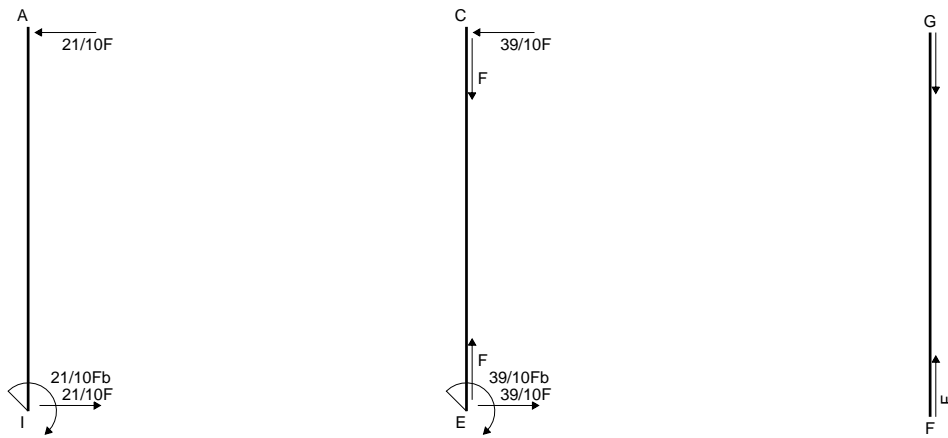


- A = 1152. mm²
- J_u = 348030. mm⁴
- J_v = 122688. mm⁴
- y_g = 20.63 mm
- T_y = 2560. N
- M_x = -2073600. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 33.38 mm
- σ_m = -Mv/J_u = 198.9 N/mm²
- x_c = 24. mm
- y_c = 43. mm
- v_c = 22.38 mm
- σ_c = -Mv/J_u = 133.3 N/mm²
- τ_c = 3.596 N/mm²
- σ_q = √σ²+3τ² = 133.5 N/mm²
- S = 5867. mm³

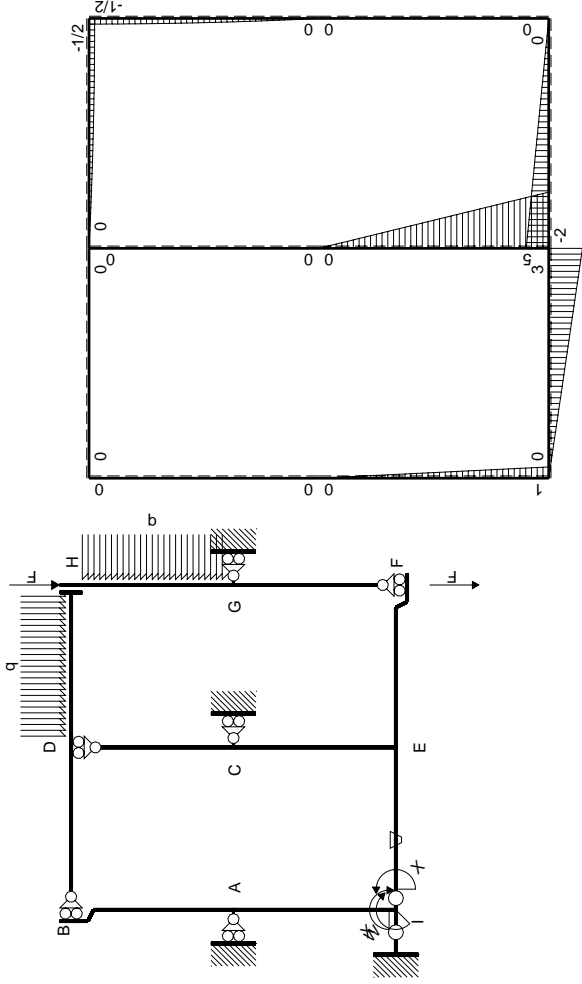


$\leftarrow \left[\oplus \right] \rightarrow F$

$\uparrow \left[\oplus \right] \downarrow F$

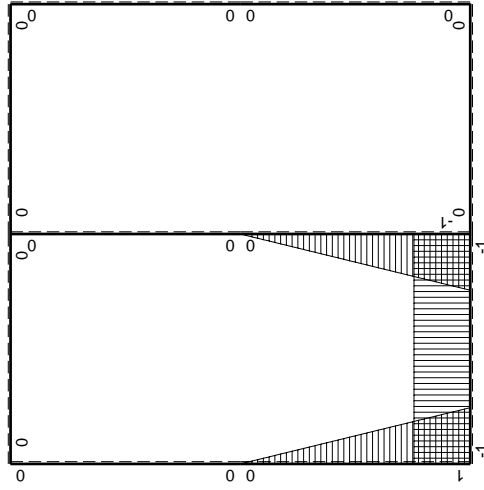


$\left[\oplus \right] F_b$



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	0	0	0	0	0	0+0	0	
BA b	0	0	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0	
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0			
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0	
DH b	0	$Fx-1/2qx^2$	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1			
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2			
	totali							$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

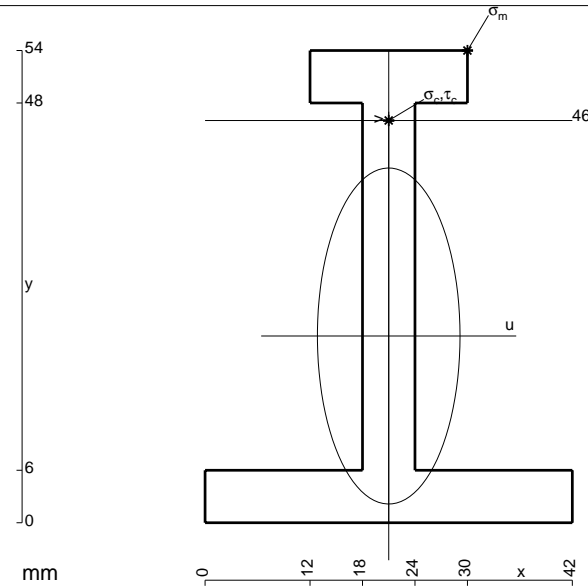
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$



$$A = 612. \text{ mm}^2$$

$$J_u = 225968. \text{ mm}^4$$

$$J_v = 40716. \text{ mm}^4$$

$$y_g = 21.35 \text{ mm}$$

$$T_y = 1680. \text{ N}$$

$$M_x = -1444800. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 32.65 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.7 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

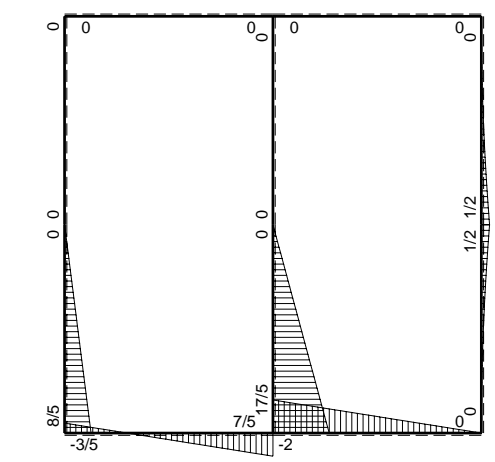
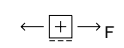
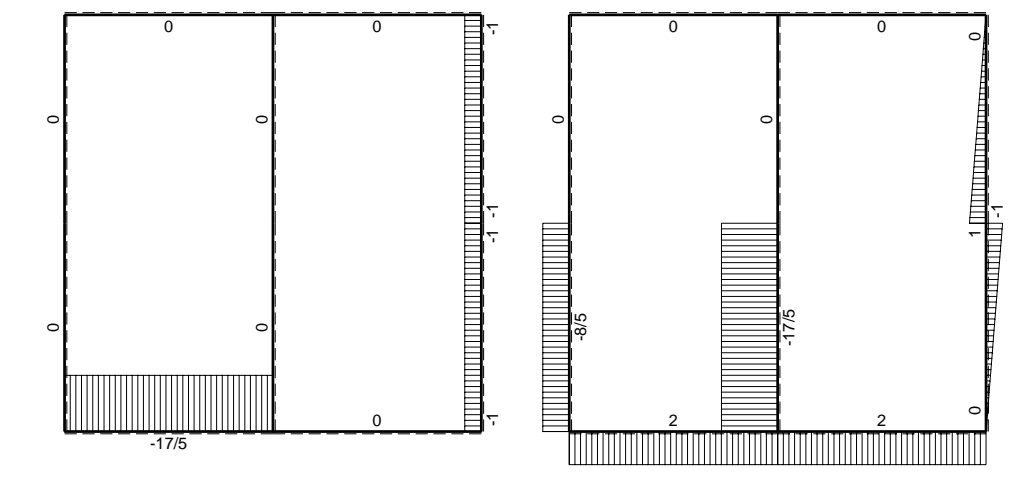
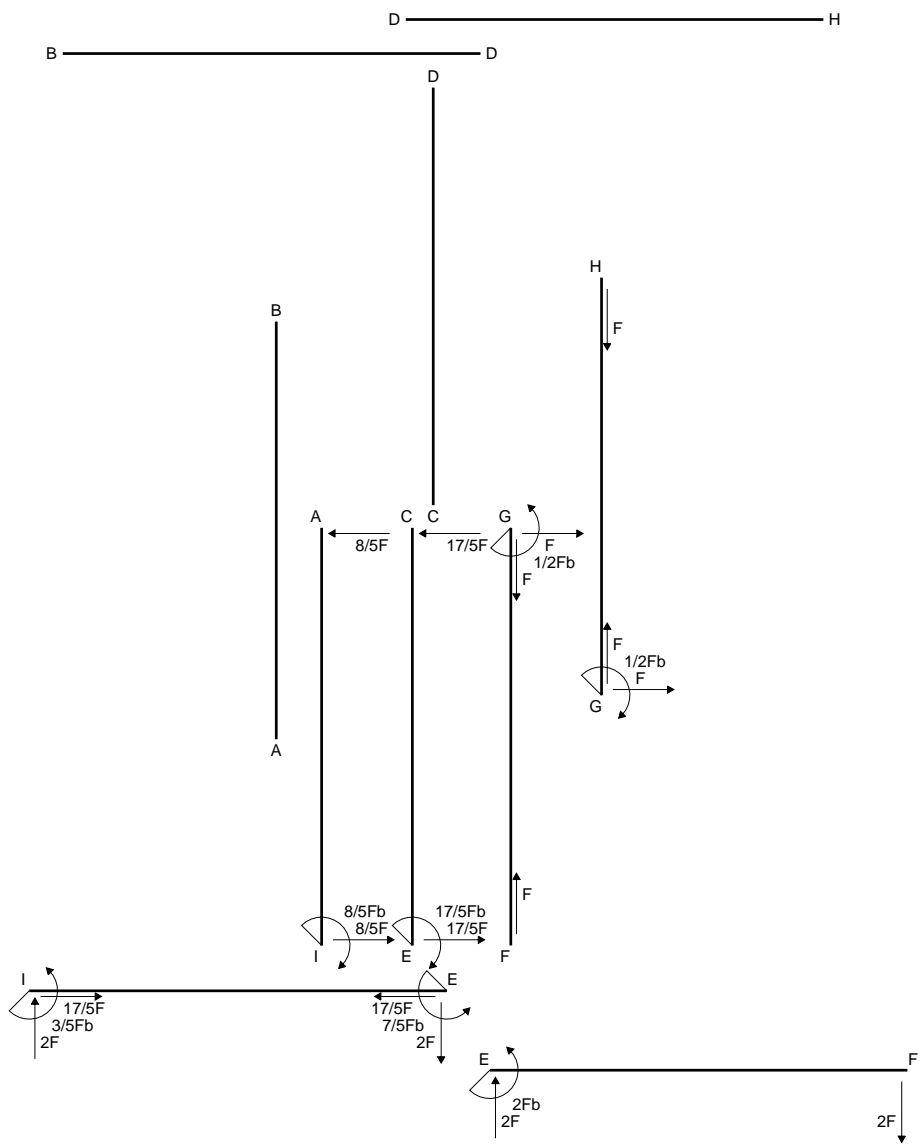
$$v_c = 24.65 \text{ mm}$$

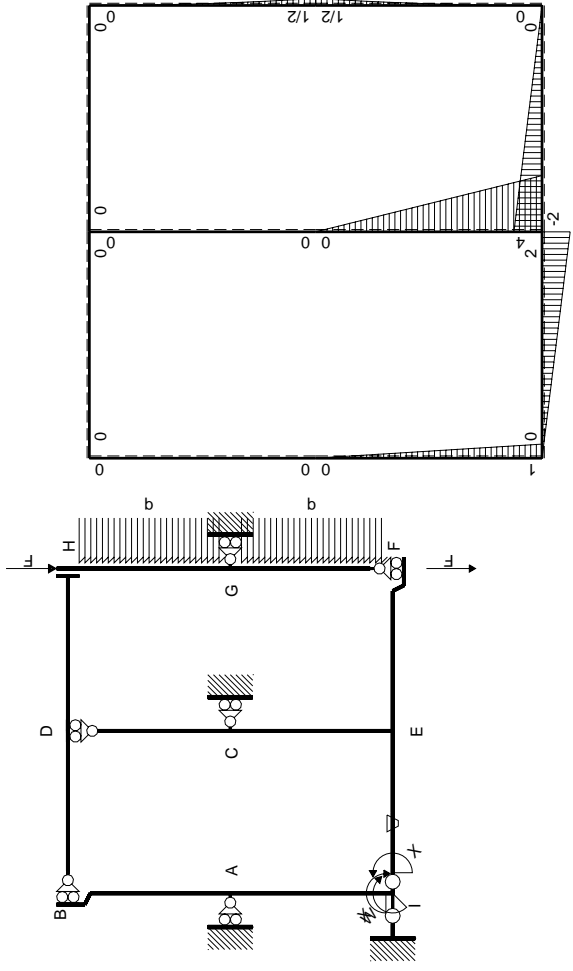
$$\sigma_c = -Mv/J_u = 157.6 \text{ N/mm}^2$$

$$\tau_c = 4.349 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 157.8 \text{ N/mm}^2$$

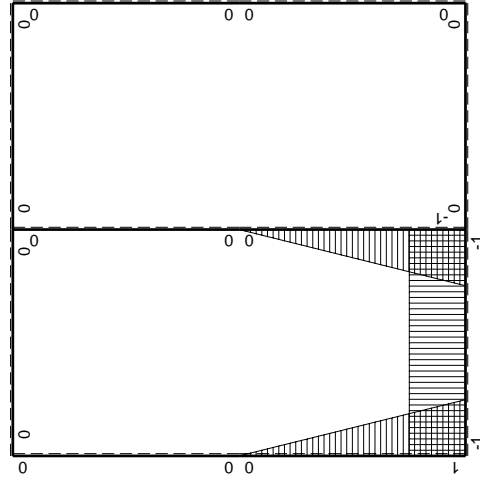
$$S = 3510. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb 1/EJ dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 4b - 4/3 b) Fb 1/EJ = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb 1/EJ dx = [-4/3 x^3/b^2]_0^b Fb 1/EJ$$

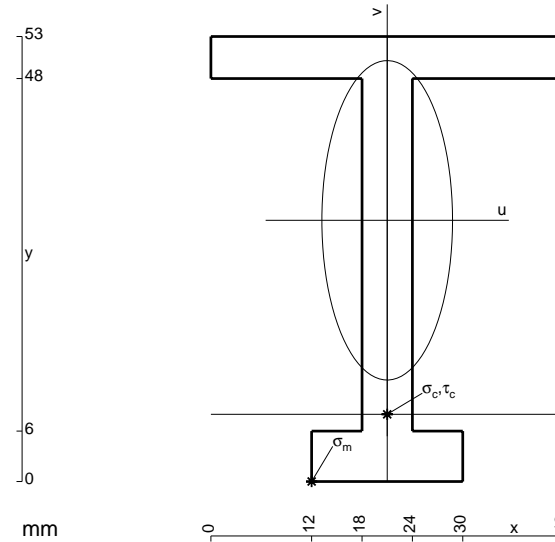
$$= (-4/3 b) Fb 1/EJ = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

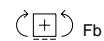
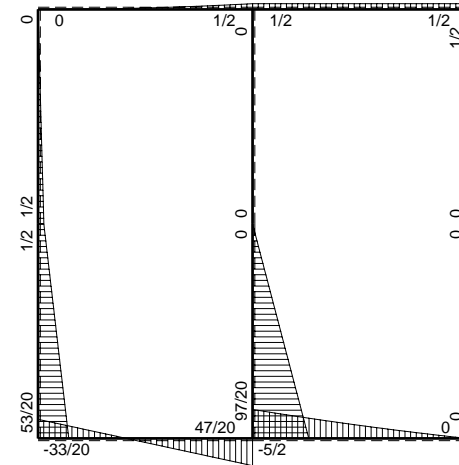
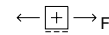
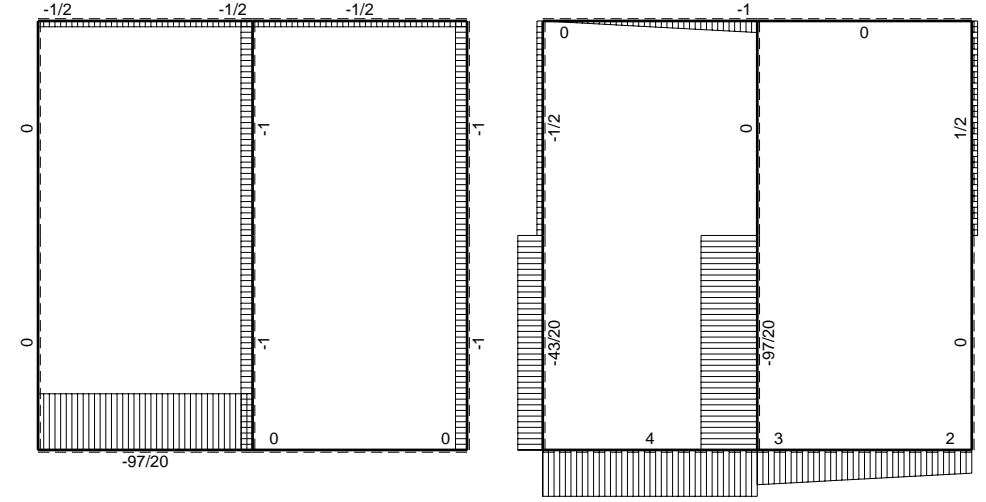
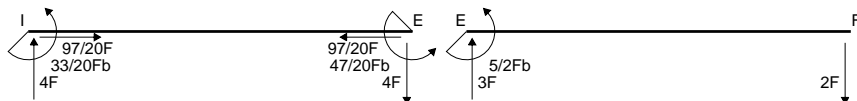
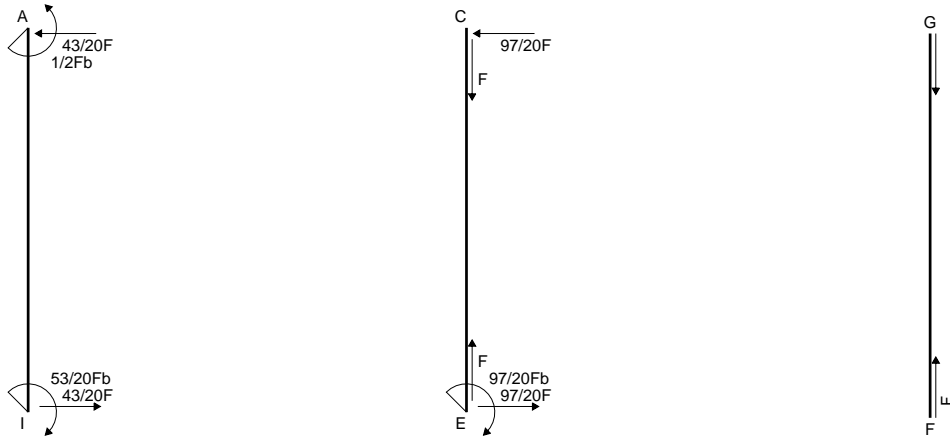
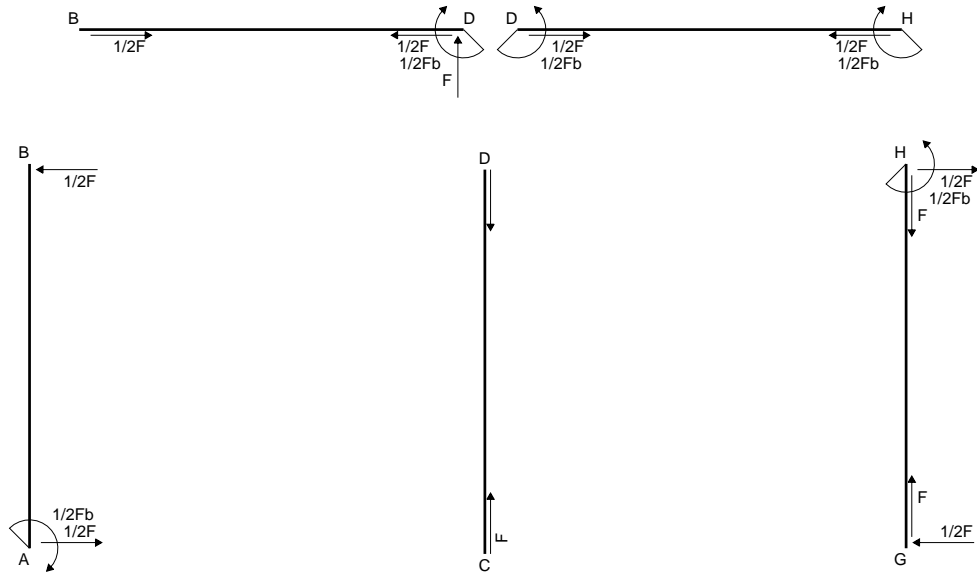
$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

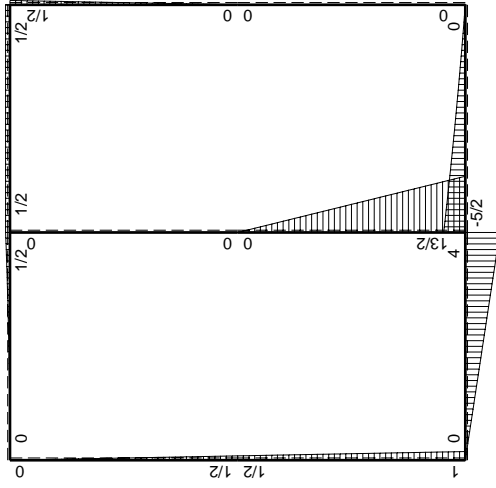
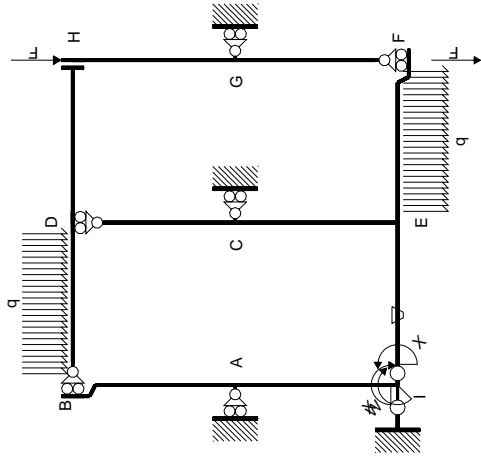
$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$



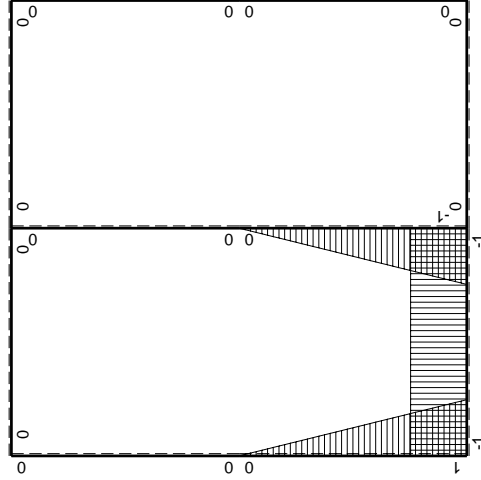
- A = 570. mm²
- J_u = 206355. mm⁴
- J_v = 34542. mm⁴
- y_g = 31.11 mm
- T_y = 1620. N
- M_x = -1458000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -31.11 mm
- σ_m = -Mv/J_u = -219.8 N/mm²
- x_c = 21. mm
- y_c = 8. mm
- v_c = -23.11 mm
- σ_c = -Mv/J_u = -163.3 N/mm²
- τ_c = 4.351 N/mm²
- σ_o = √σ_c² + 3τ_c² = 163.5 N/mm²
- S = 3325. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = - Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = - Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

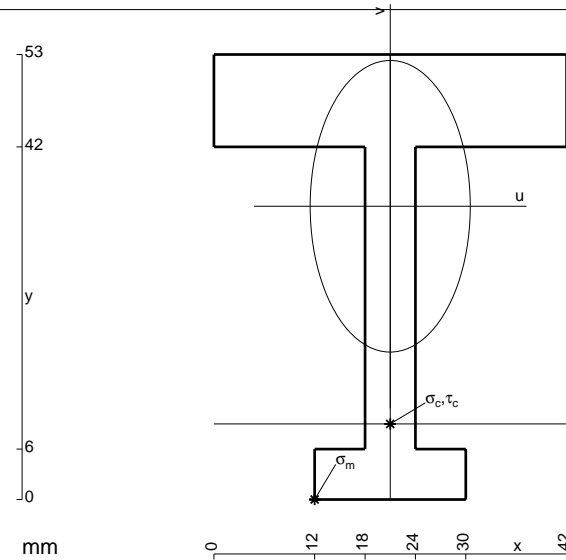
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 3/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

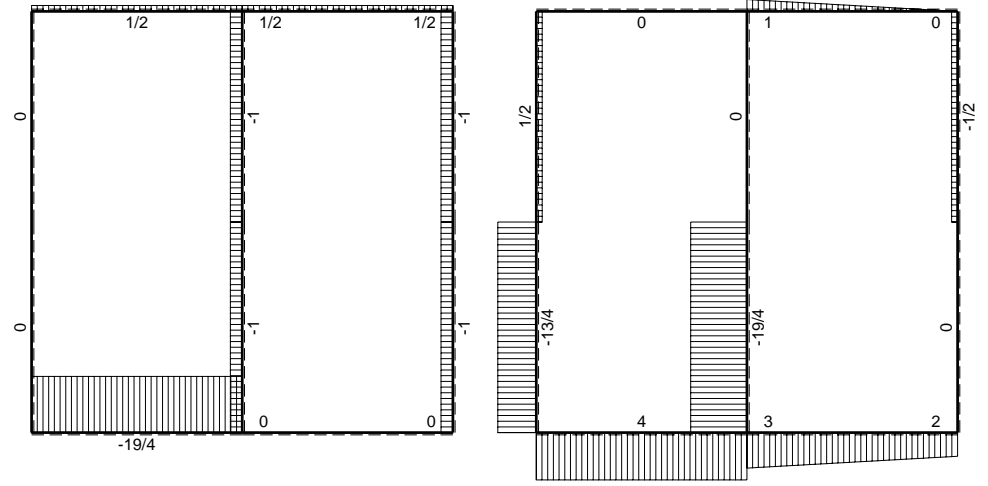
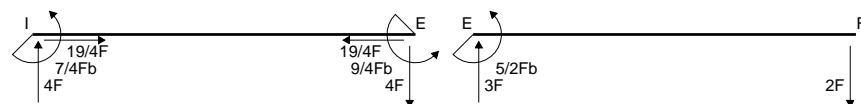
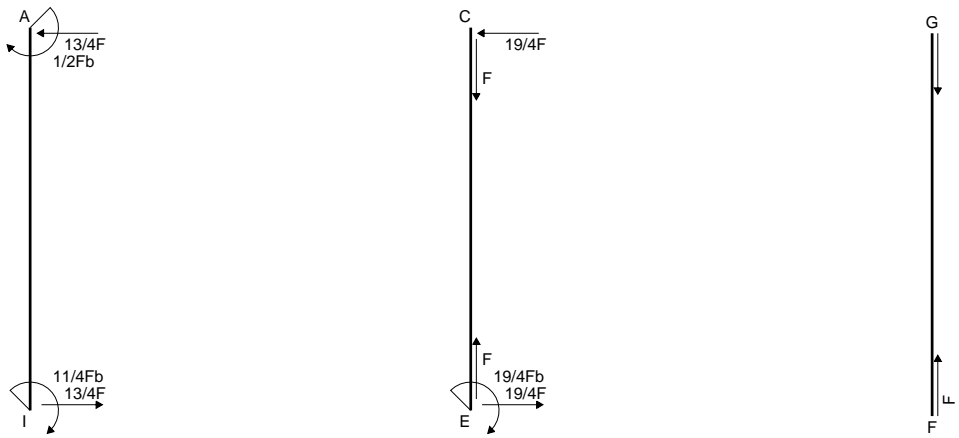
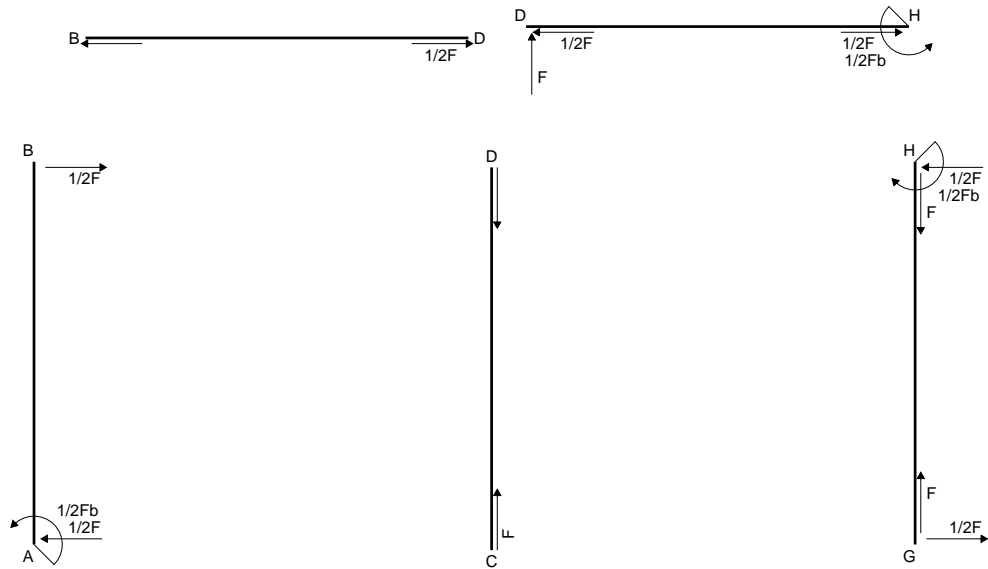
$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

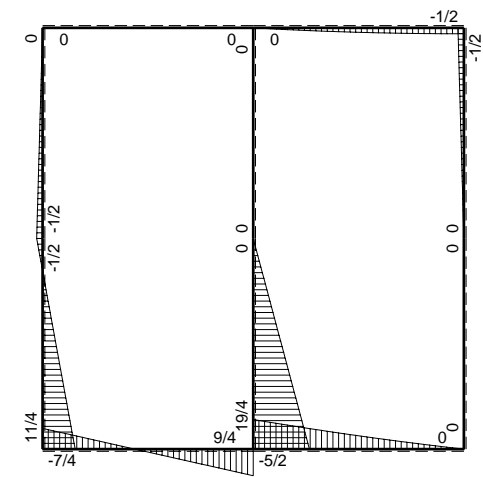


- A = 786. mm²
- J_u = 237222. mm⁴
- J_v = 71478. mm⁴
- y_g = 34.93 mm
- T_y = 1950. N
- M_x = -1543750. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -34.93 mm
- σ_m = -Mv/J_u = -227.3 N/mm²
- x_c = 21. mm
- y_c = 9. mm
- v_c = -25.93 mm
- σ_c = -Mv/J_u = -168.7 N/mm²
- τ_c = 5.4 N/mm²
- σ_q = √(σ² + 3τ²) = 169. N/mm²
- S = 3942. mm³

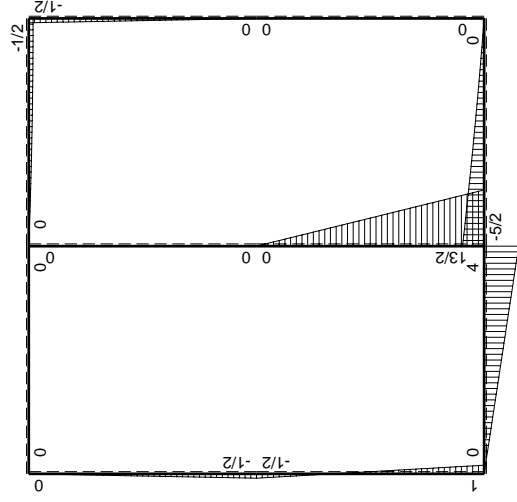
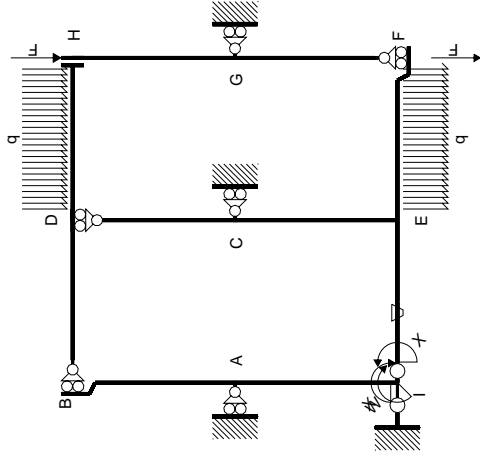


← ⊕ → F

↑ ⊕ ↓ F

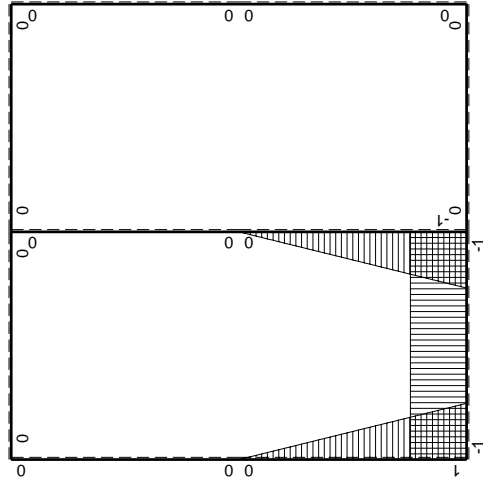


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

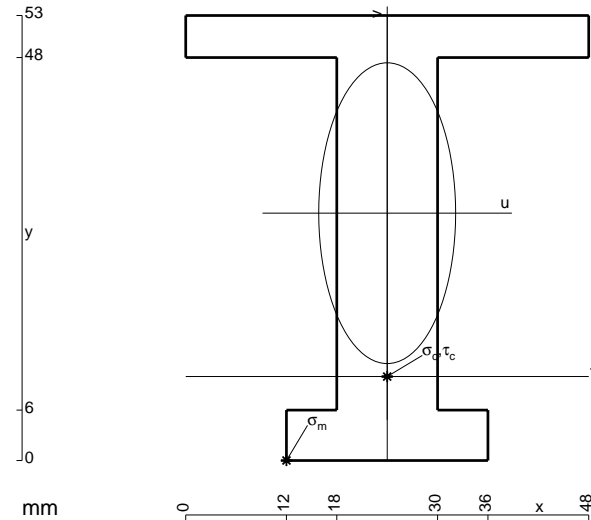
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 888. \text{ mm}^2$$

$$J_u = 285133. \text{ mm}^4$$

$$J_v = 59040. \text{ mm}^4$$

$$y_g = 29.46 \text{ mm}$$

$$T_y = 2760. \text{ N}$$

$$M_x = -2300000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.46 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -237.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

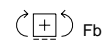
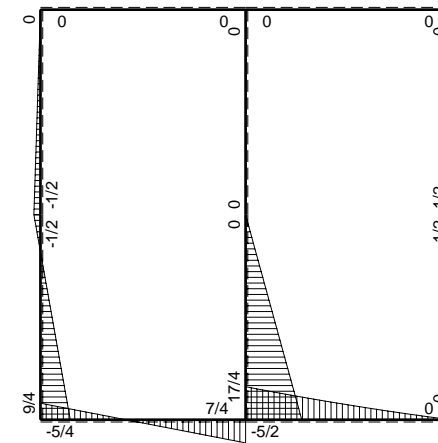
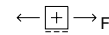
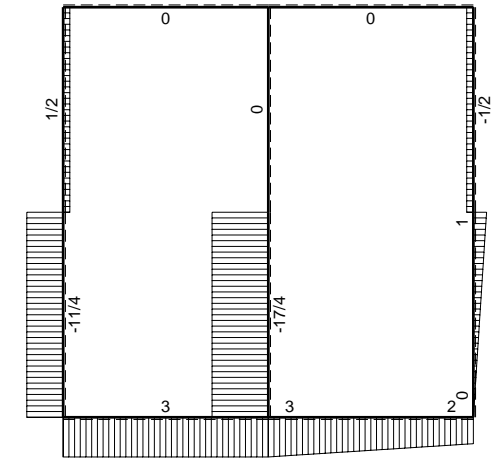
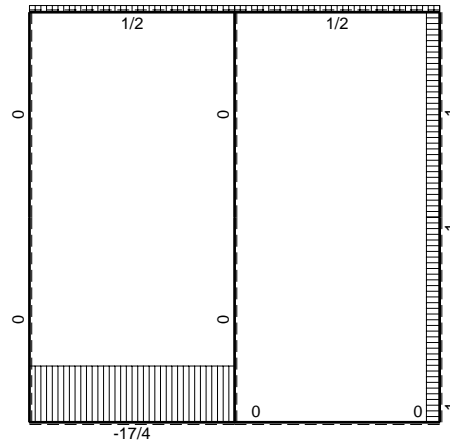
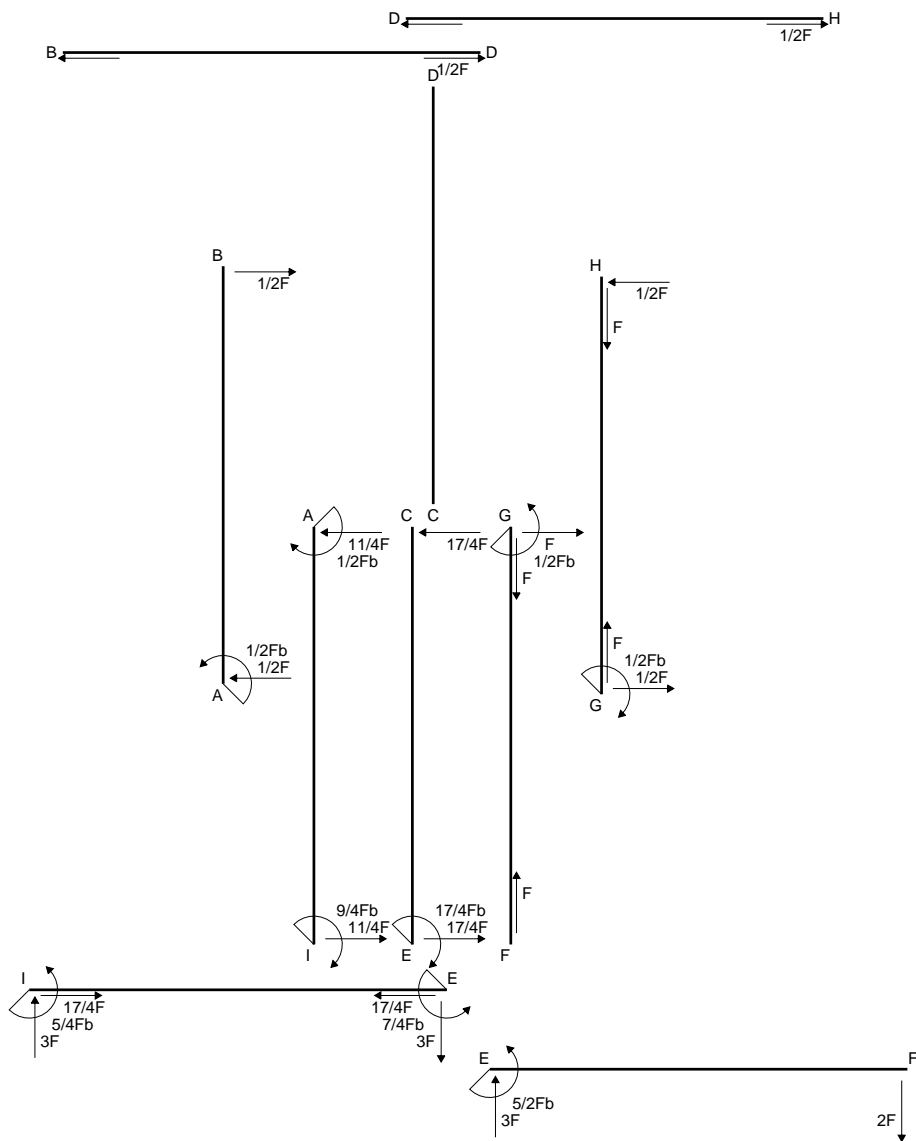
$$v_c = -19.46 \text{ mm}$$

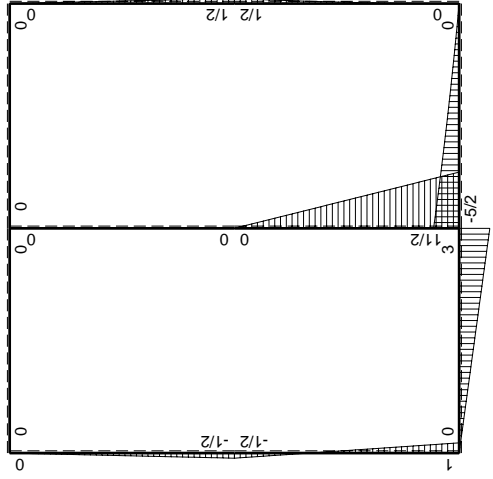
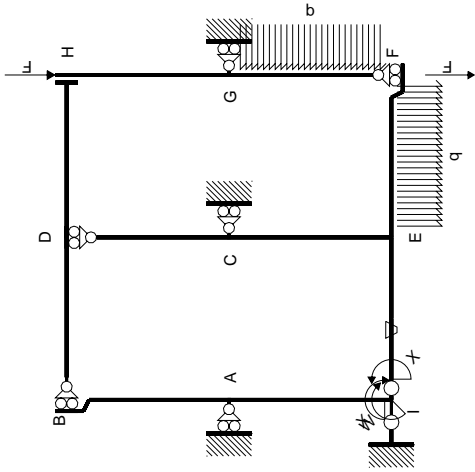
$$\sigma_c = -Mv/J_u = -157. \text{ N/mm}^2$$

$$\tau_c = 3.904 \text{ N/mm}^2$$

$$\sigma_\theta = \sqrt{\sigma^2 + 3\tau^2} = 157.1 \text{ N/mm}^2$$

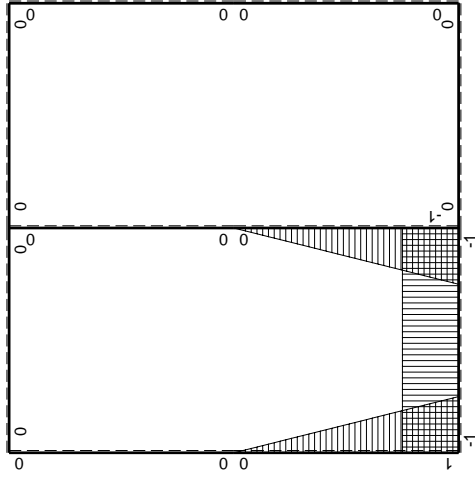
$$S = 4840. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0	
FE b	0	$2Fx+1/2qx^2$	0	0	0	0			
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0	
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fx$	0	0	0	0			
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1			
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2			
	totali							$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb 1/EJ dx = [-11/6 x^3/b^2]_0^b Fb 1/EJ$$

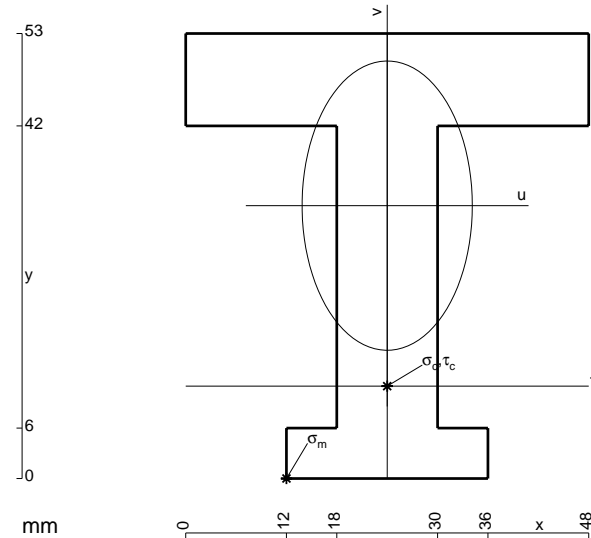
$$= (-11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

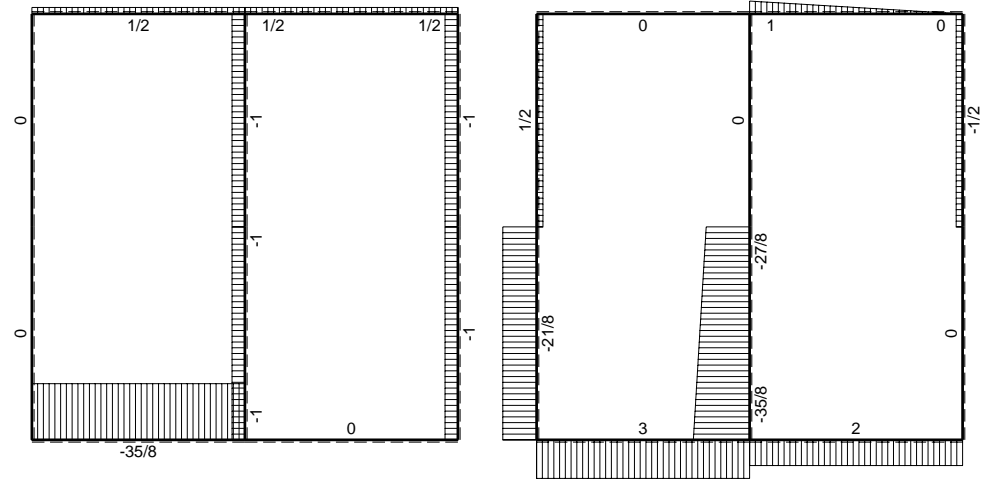
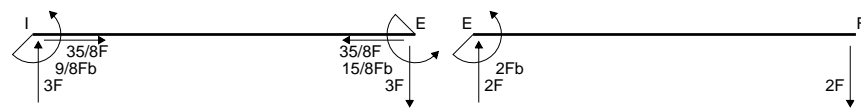
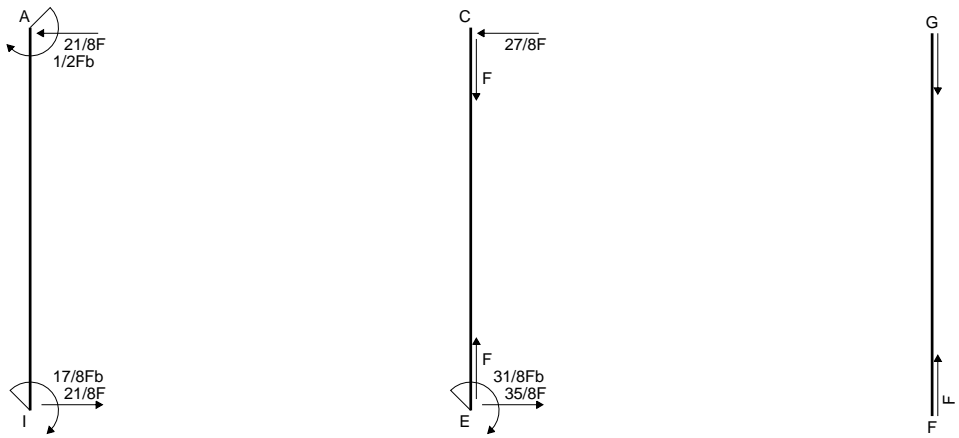
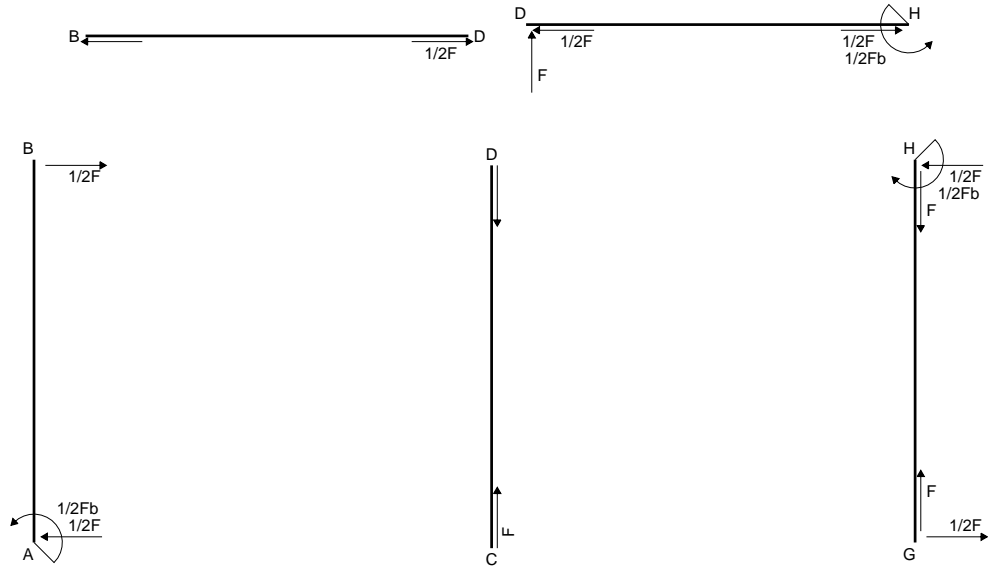
$$= (b - 5/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

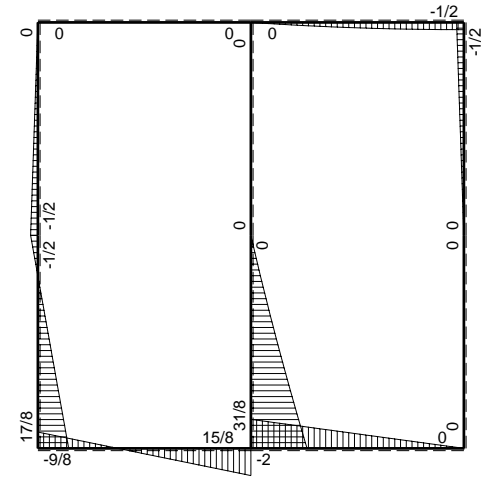


- A = 1104. mm²
- J_u = 327740. mm⁴
- J_v = 113472. mm⁴
- y_g = 32.5 mm
- T_y = 4560. N
- M_x = -2014000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -32.5 mm
- σ_m = -Mv/J_u = -199.7 N/mm²
- x_c = 24. mm
- y_c = 11. mm
- v_c = -21.5 mm
- σ_c = -Mv/J_u = -132.1 N/mm²
- τ_c = 6.595 N/mm²
- σ_o = √σ² + 3τ² = 132.6 N/mm²
- S = 5688. mm³

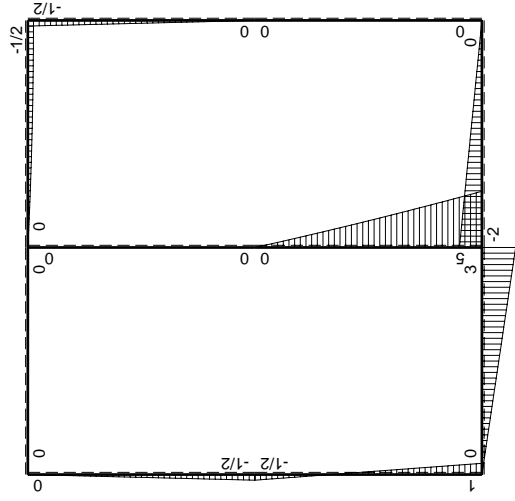
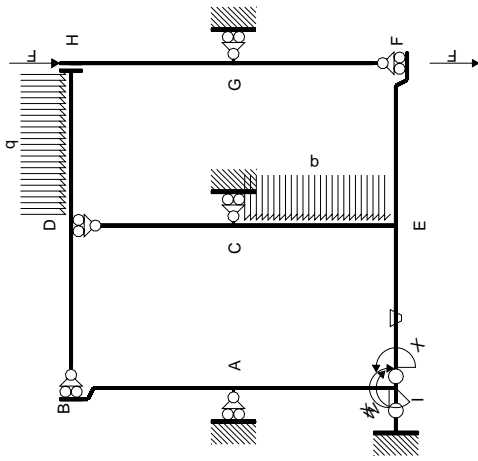


← ⊕ → F

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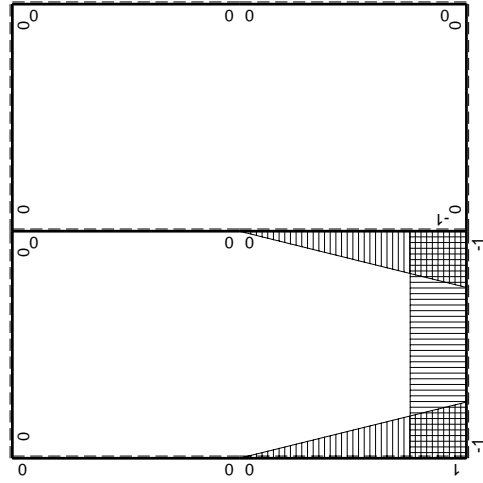


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-11/2Fx+1/2qx^2$	0	$-5Fb+21/2Fx-6Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-13/8+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx-1/2qx^2$	0	$-9/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-15/8Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 6x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-5x + 21/4 x^2/b - 2x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 21/4 b - 2b + 1/8 b) Fb \frac{1}{EJ} = -13/8 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

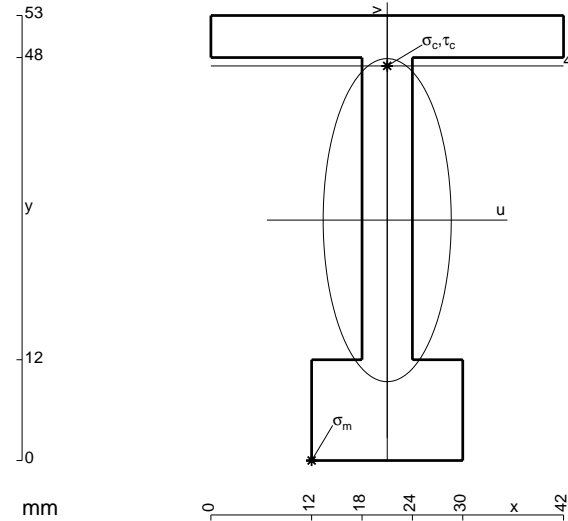
$$= (-3/2 b - 1/8 b) Fb \frac{1}{EJ} = -13/8 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

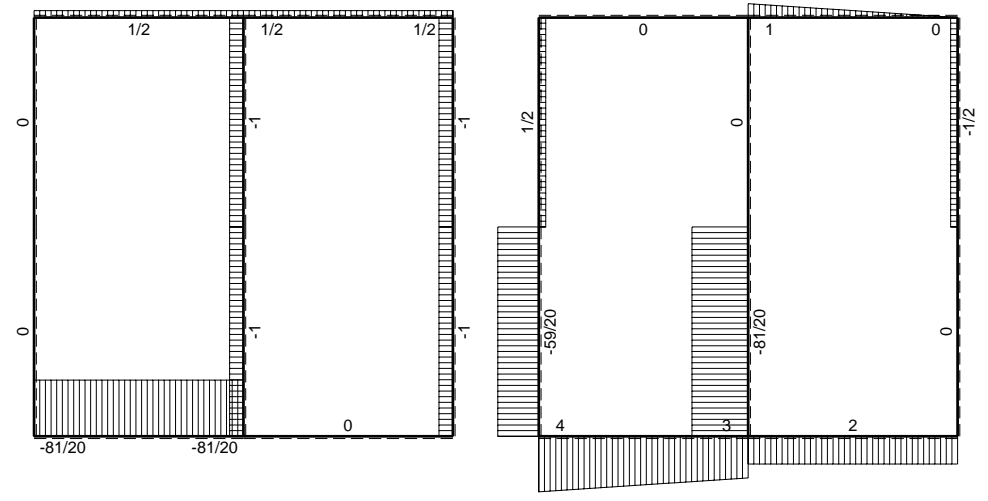
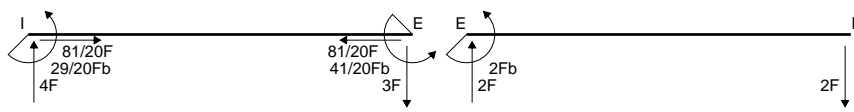
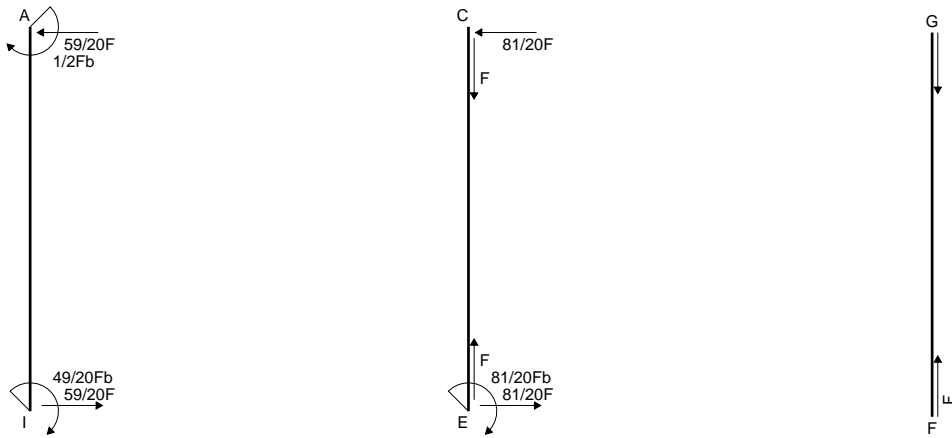
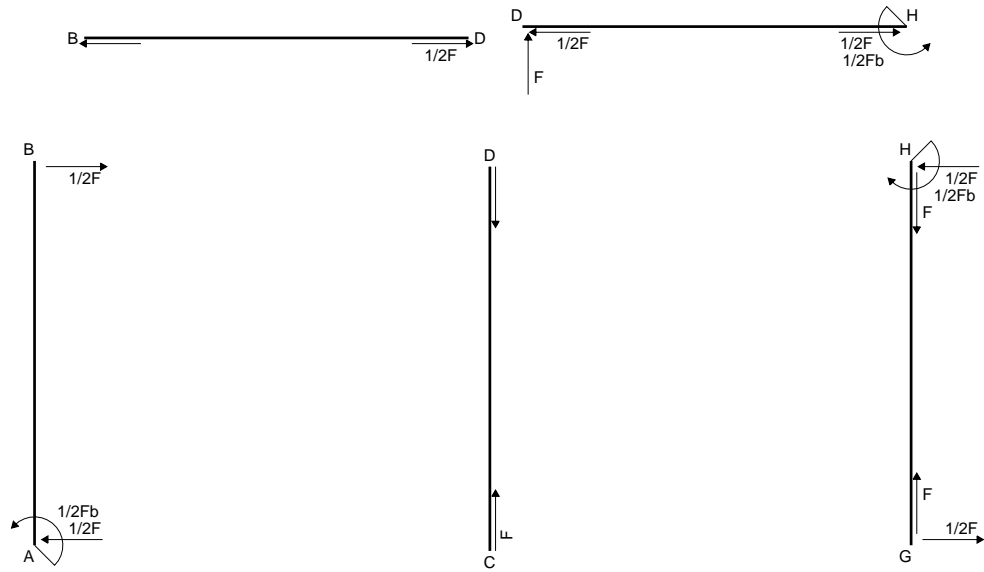
$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

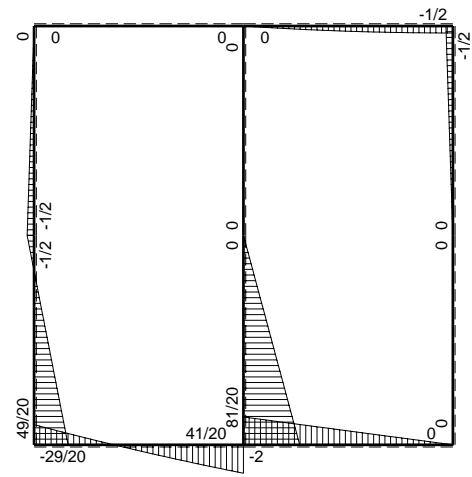


- A = 642. mm²
- J_u = 237823. mm⁴
- J_v = 37350. mm⁴
- y_g = 28.63 mm
- T_y = 3000. N
- M_x = -1740000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -28.63 mm
- σ_m = -Mv/J_u = -209.5 N/mm²
- x_c = 21. mm
- y_c = 47. mm
- v_c = 18.37 mm
- σ_c = -Mv/J_u = 134.4 N/mm²
- τ_c = 9.893 N/mm²
- σ_o = √σ²+3τ² = 135.5 N/mm²
- S = 4706. mm³

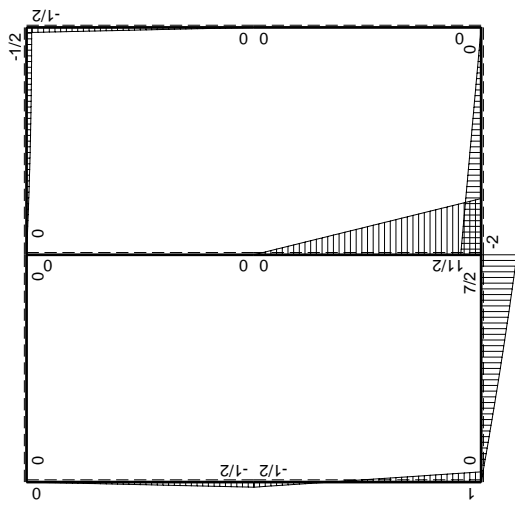
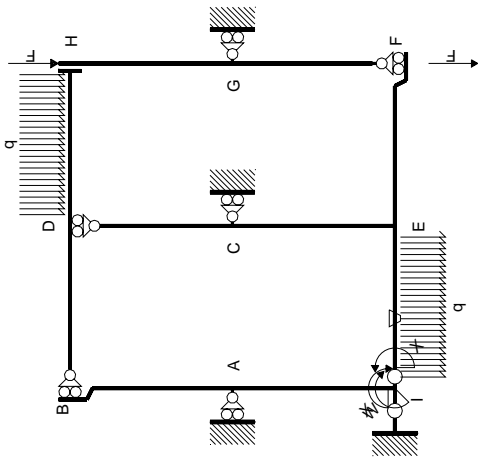


← ⊕ → F

↑ ⊕ ↓ F

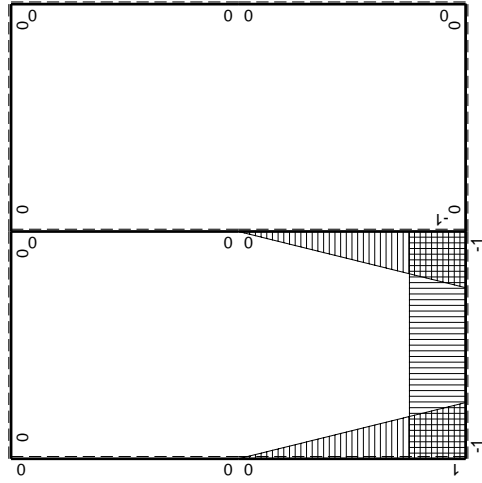


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb 1/EJ + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb 1/EJ + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb 1/EJ dx = [-11/6 x^3/b^2]_0^b Fb 1/EJ$$

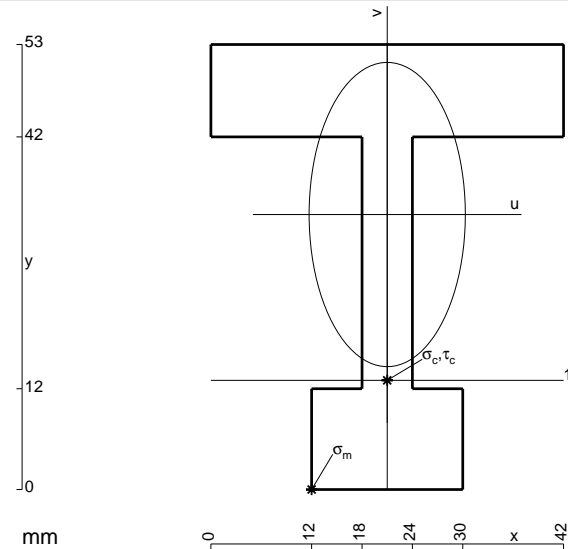
$$= (-11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

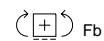
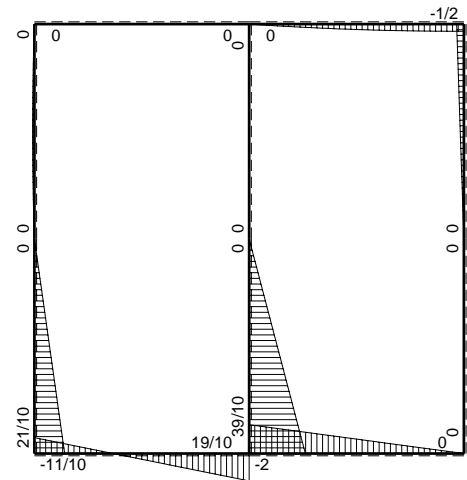
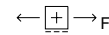
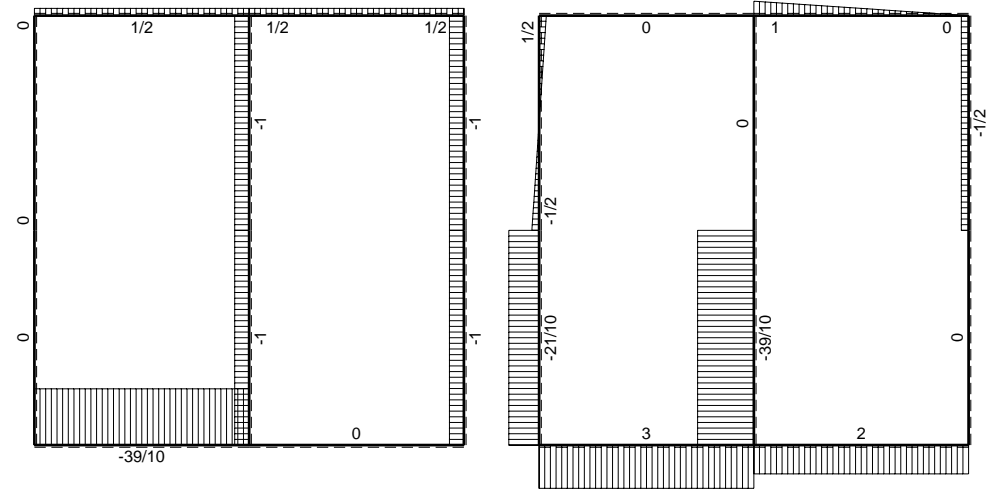
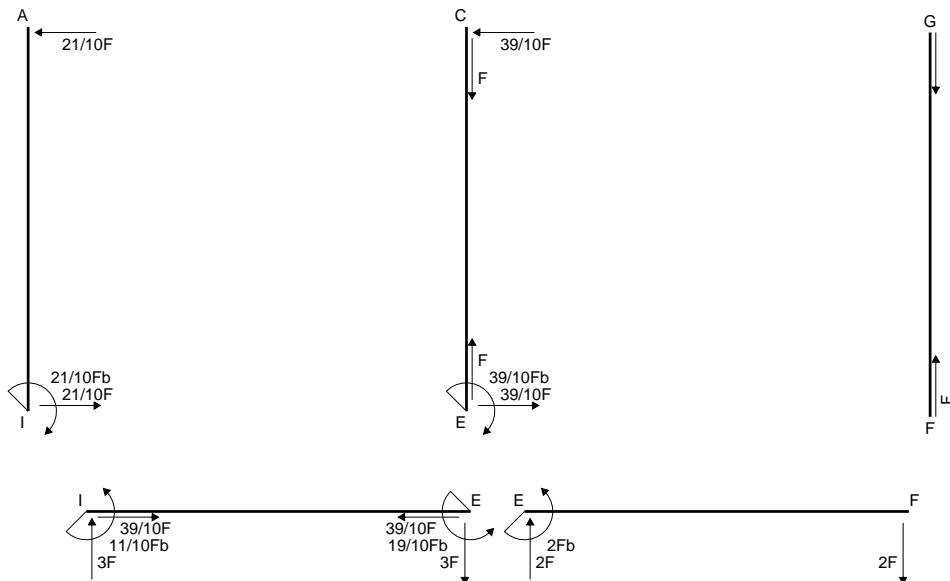
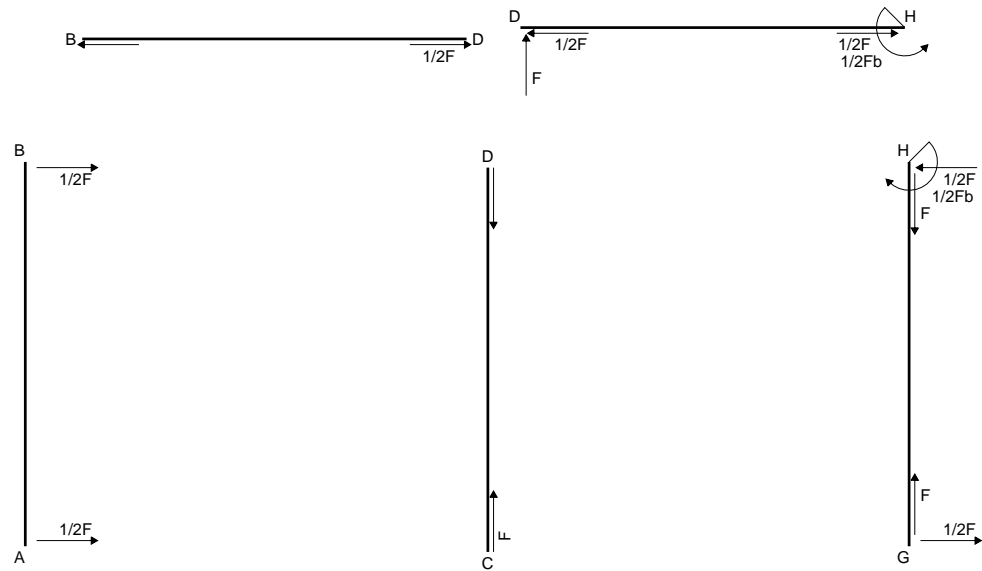
$$= (b - 5/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

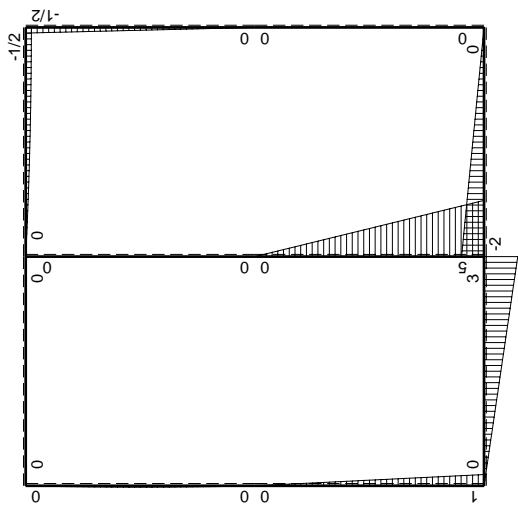
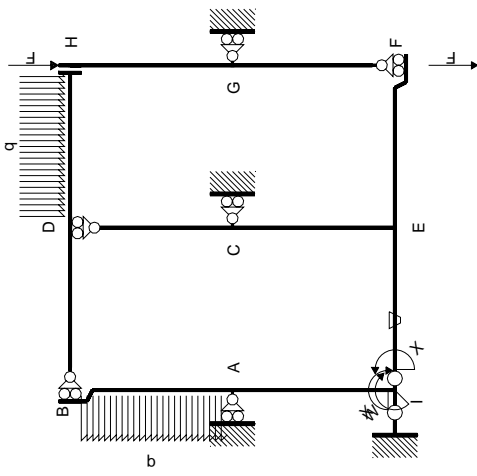
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$



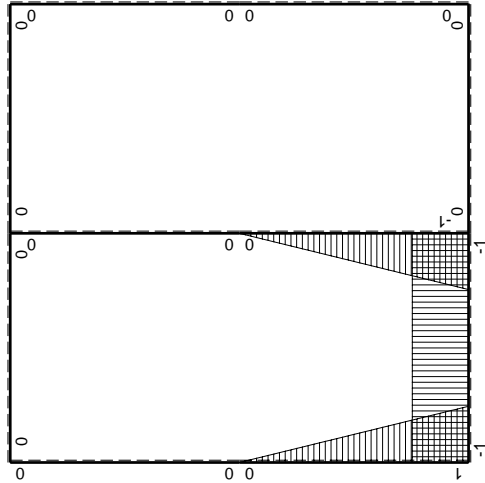
- A = 858. mm²
- J_u = 281777. mm⁴
- J_v = 74286. mm⁴
- y_g = 32.75 mm
- T_y = 3000. N
- M_x = -1890000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -32.75 mm
- σ_m = -Mv/J_u = -219.7 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -19.75 mm
- σ_c = -Mv/J_u = -132.5 N/mm²
- τ_c = 10.47 N/mm²
- σ_o = √σ² + 3τ² = 133.7 N/mm²
- S = 5900. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

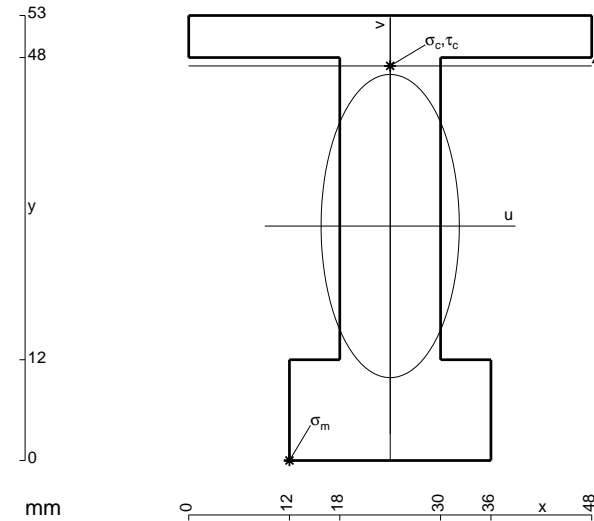
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

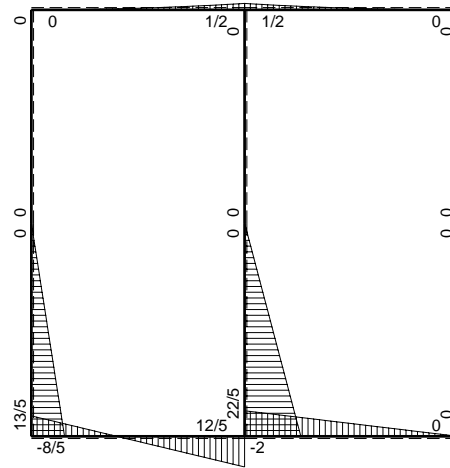
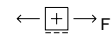
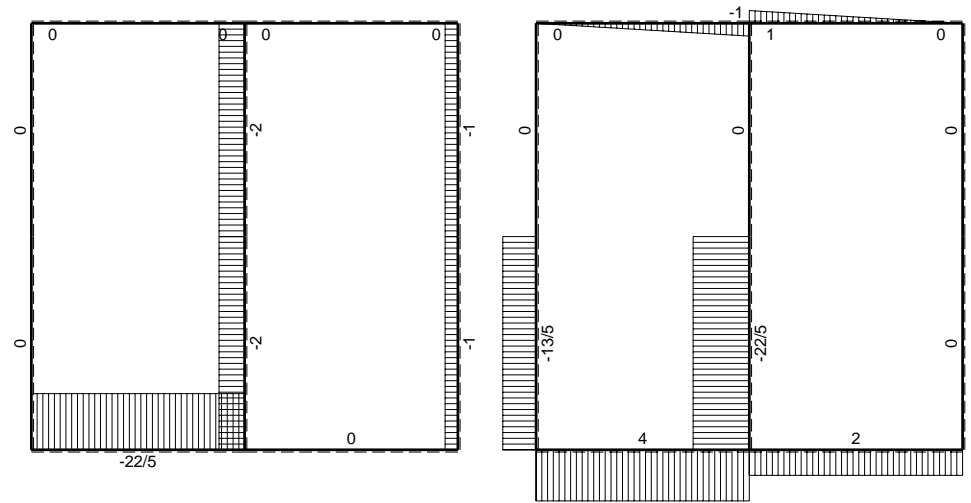
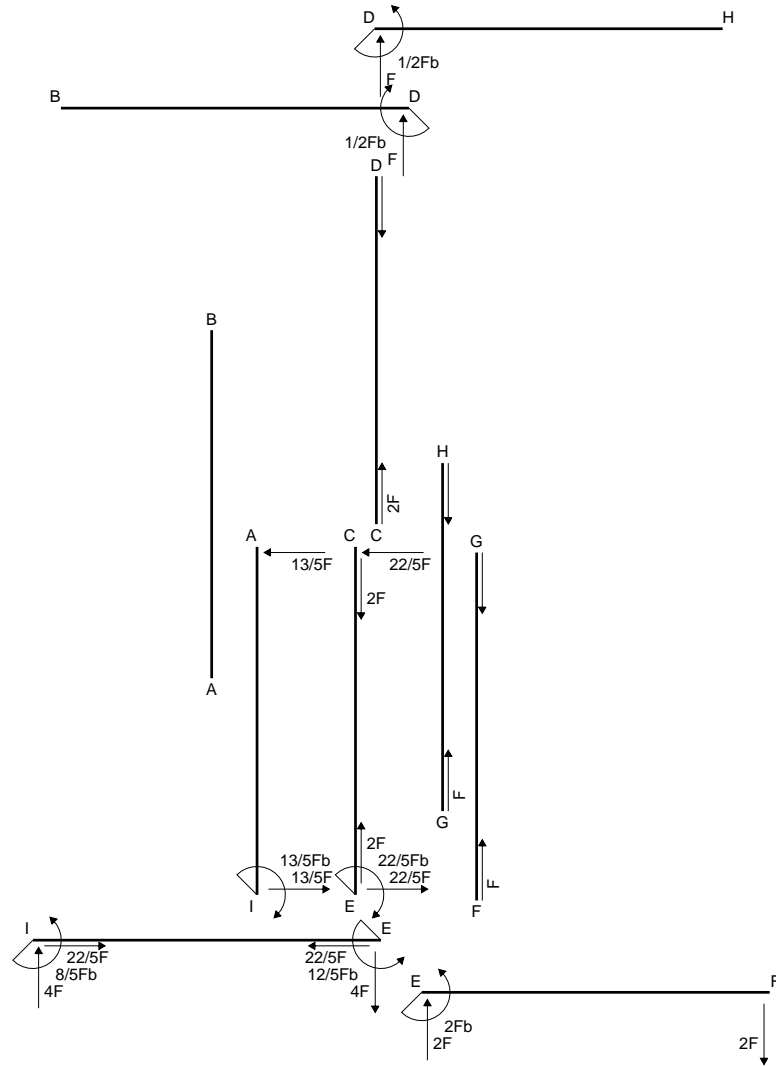
$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

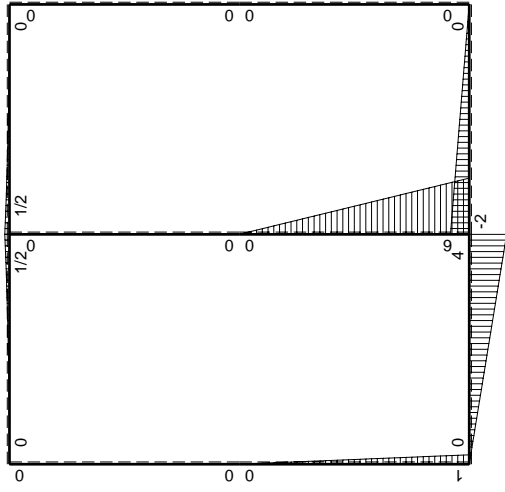
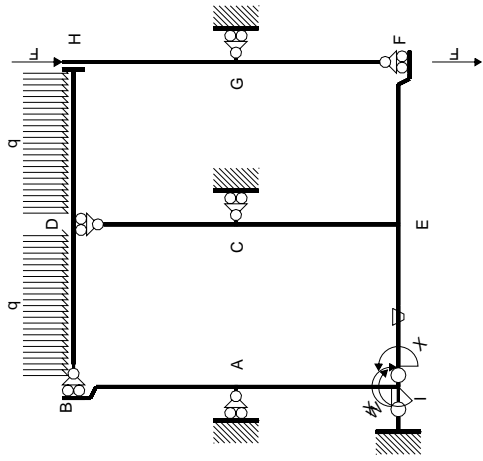
$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$



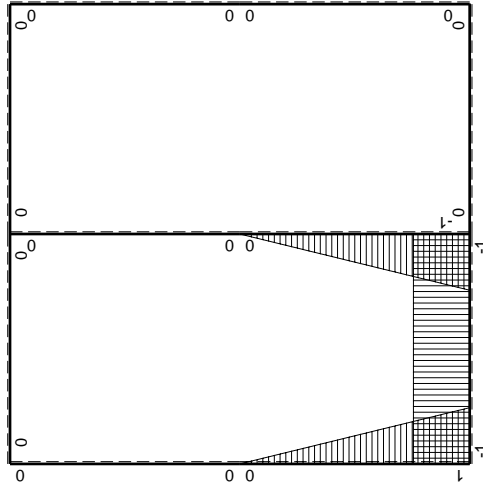
- A = 960. mm²
- J_u = 313227. mm⁴
- J_v = 65088. mm⁴
- y_g = 27.92 mm
- T_y = 3780. N
- M_x = -2570400. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -27.92 mm
- σ_m = -Mv/J_u = -229.2 N/mm²
- x_c = 24. mm
- y_c = 47. mm
- v_c = 19.08 mm
- σ_c = -Mv/J_u = 156.5 N/mm²
- τ_c = 5.685 N/mm²
- σ_o = √σ²+3τ² = 156.8 N/mm²
- S = 5653. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

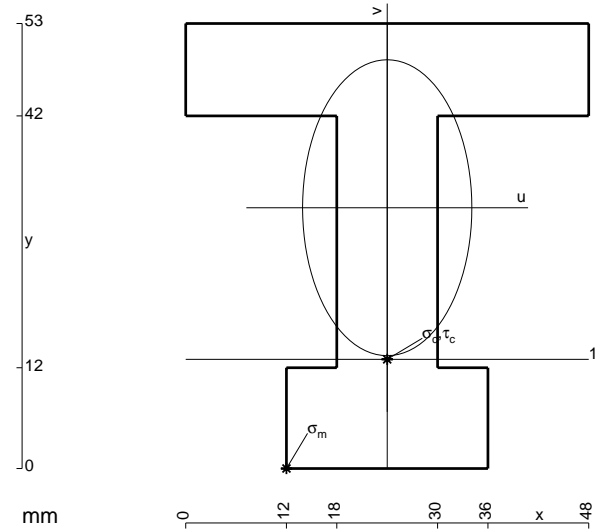
$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$



$$A = 1176. \text{ mm}^2$$

$$J_u = 365284. \text{ mm}^4$$

$$J_v = 119520. \text{ mm}^4$$

$$y_g = 31.06 \text{ mm}$$

$$T_y = 3800. \text{ N}$$

$$M_x = -2812000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -31.06 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.1 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

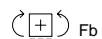
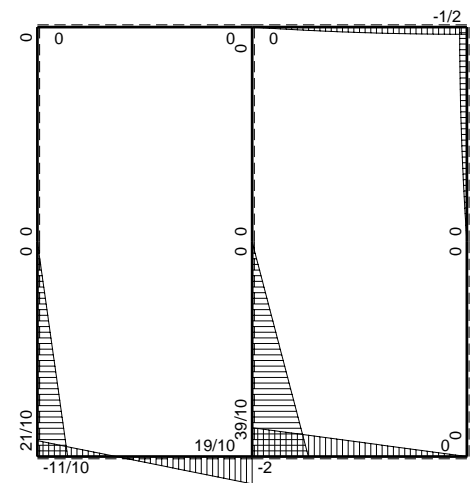
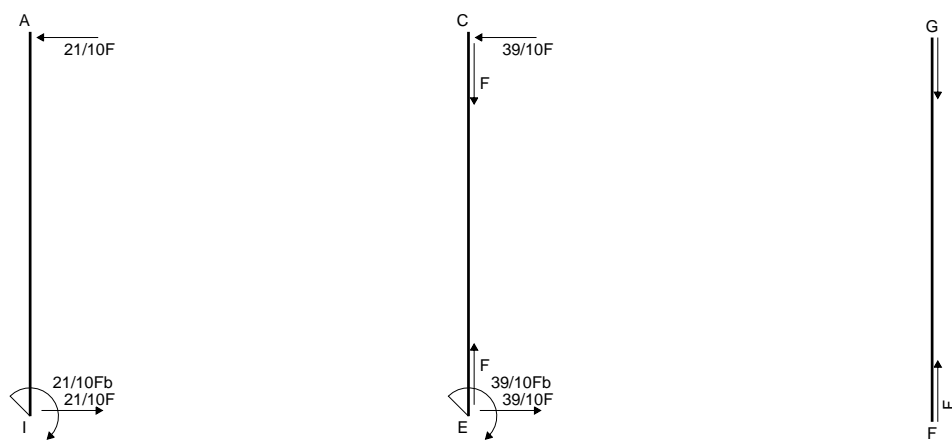
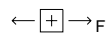
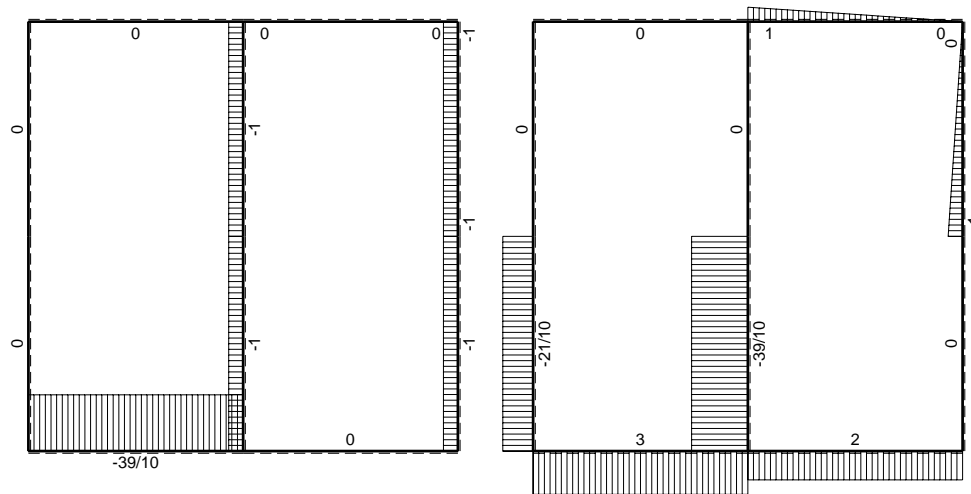
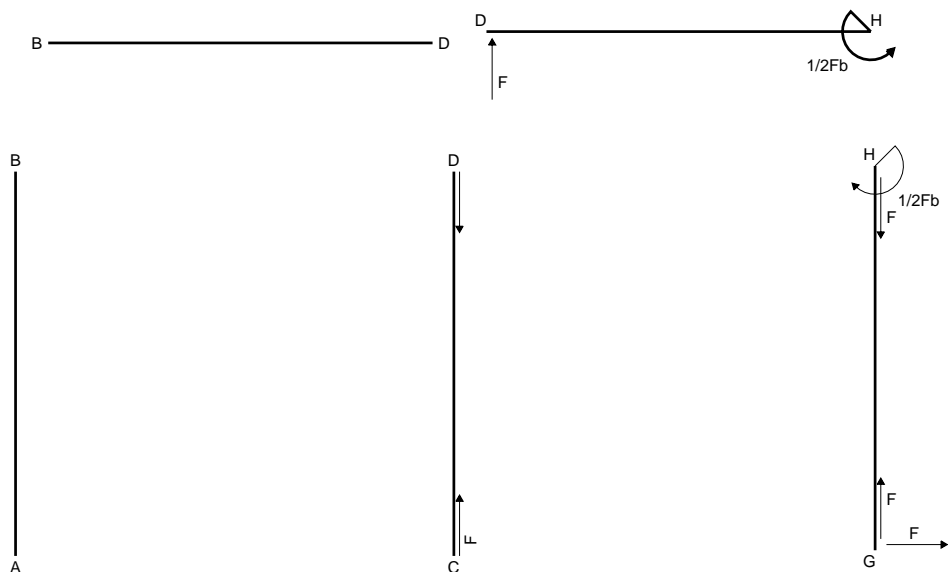
$$v_c = -18.06 \text{ mm}$$

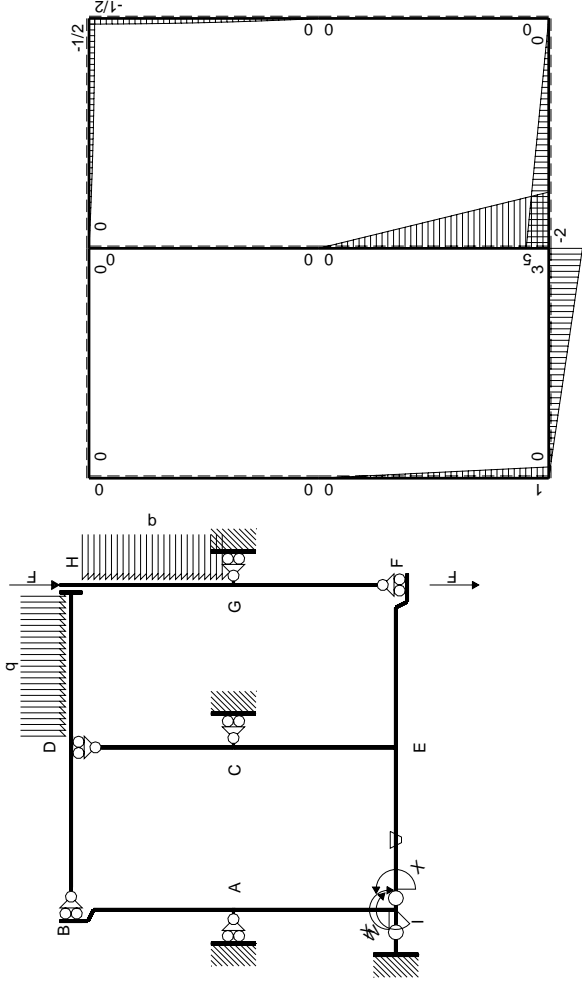
$$\sigma_c = -Mv/J_u = -139. \text{ N/mm}^2$$

$$\tau_c = 6.45 \text{ N/mm}^2$$

$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 139.5 \text{ N/mm}^2$$

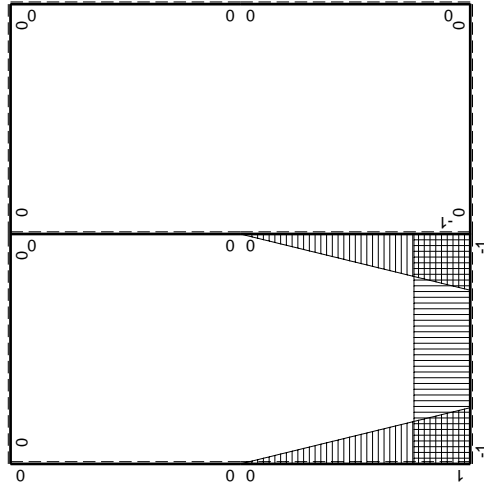
$$S = 7440. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

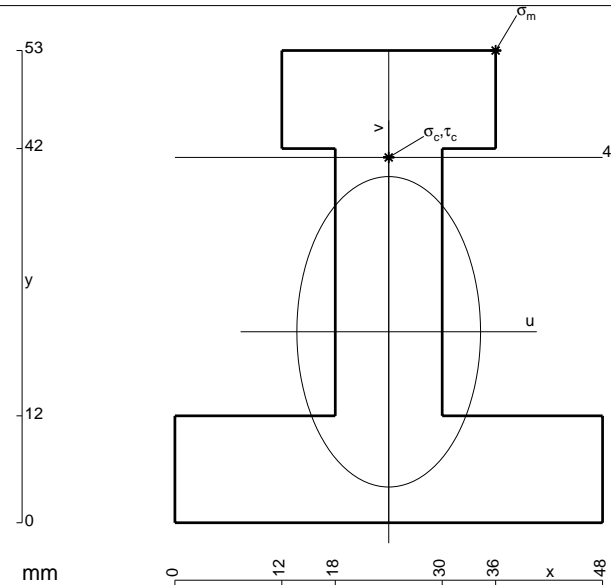
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$



$$A = 1200. \text{ mm}^2$$

$$J_u = 364306. \text{ mm}^4$$

$$J_v = 127584. \text{ mm}^4$$

$$y_g = 21.43 \text{ mm}$$

$$T_y = 2920. \text{ N}$$

$$M_x = -2306800. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 31.57 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

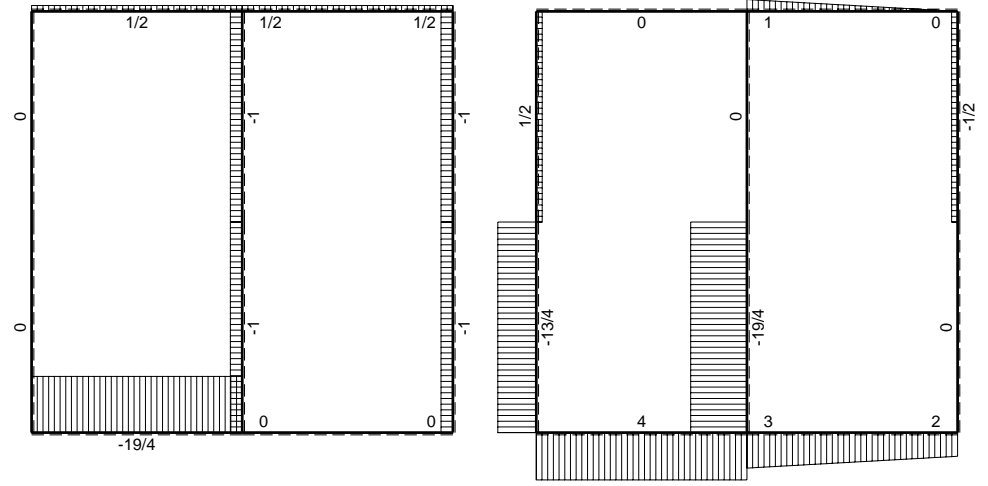
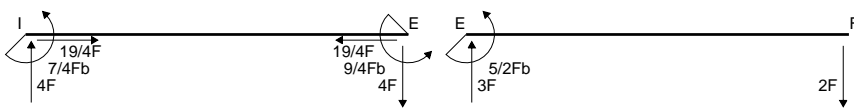
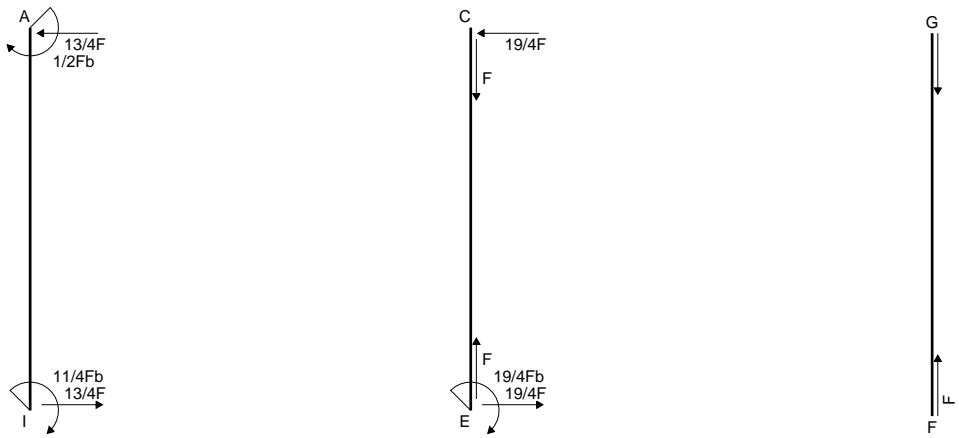
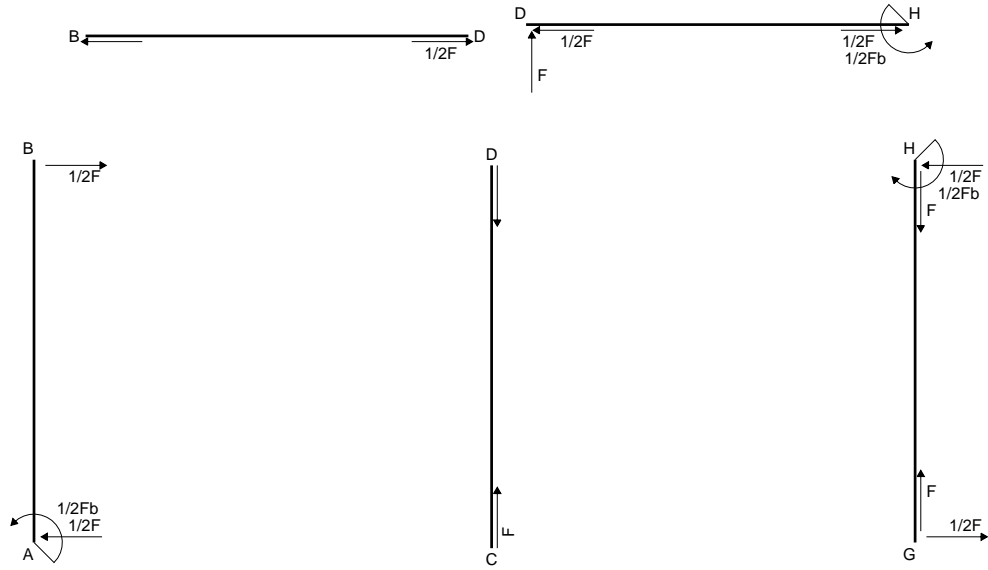
$$v_c = 19.57 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 123.9 \text{ N/mm}^2$$

$$\tau_c = 4.758 \text{ N/mm}^2$$

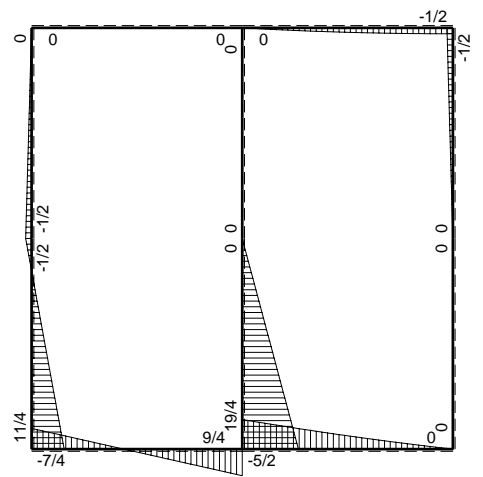
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 124.2 \text{ N/mm}^2$$

$$S = 7123. \text{ mm}^3$$

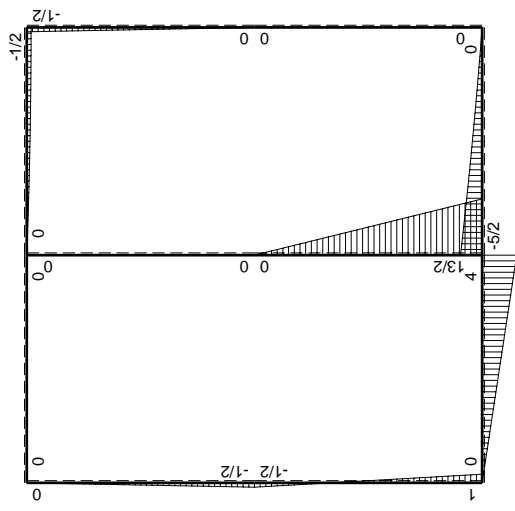
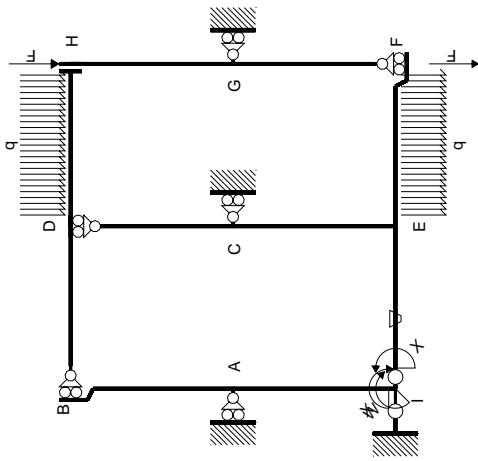


← ⊕ → F

↑ ⊕ ↓ F

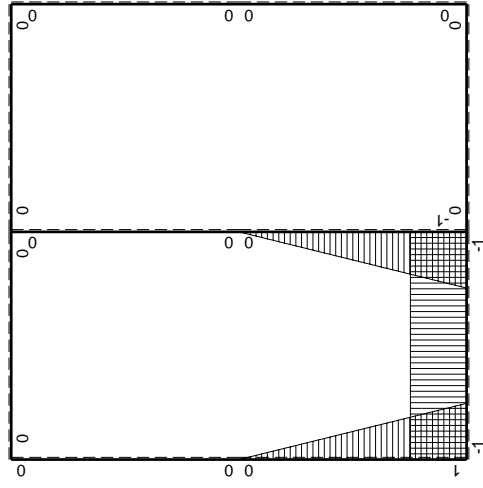


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

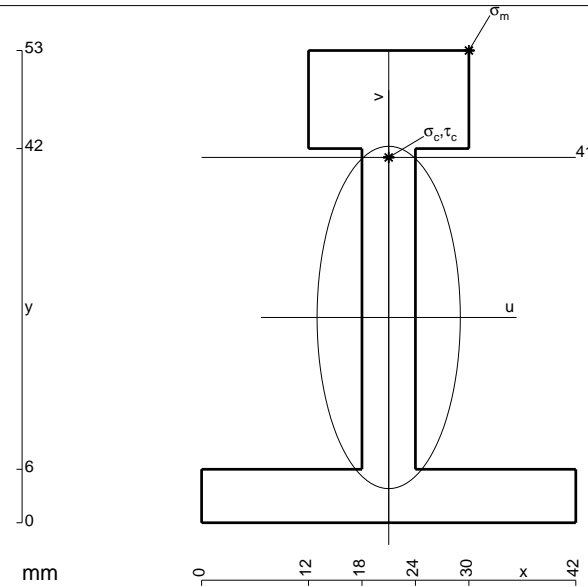
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 666. \text{ mm}^2$$

$$J_u = 245945. \text{ mm}^4$$

$$J_v = 43038. \text{ mm}^4$$

$$y_g = 23.04 \text{ mm}$$

$$T_y = 2460. \text{ N}$$

$$M_x = -1722000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 29.96 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.8 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

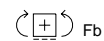
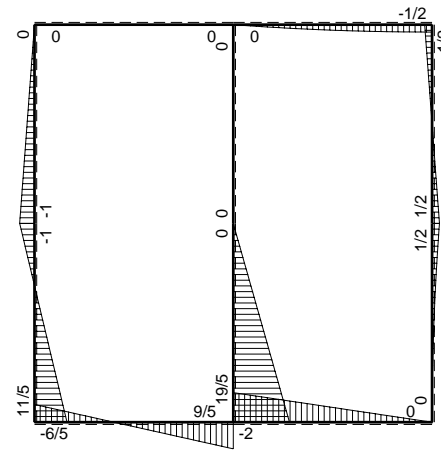
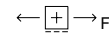
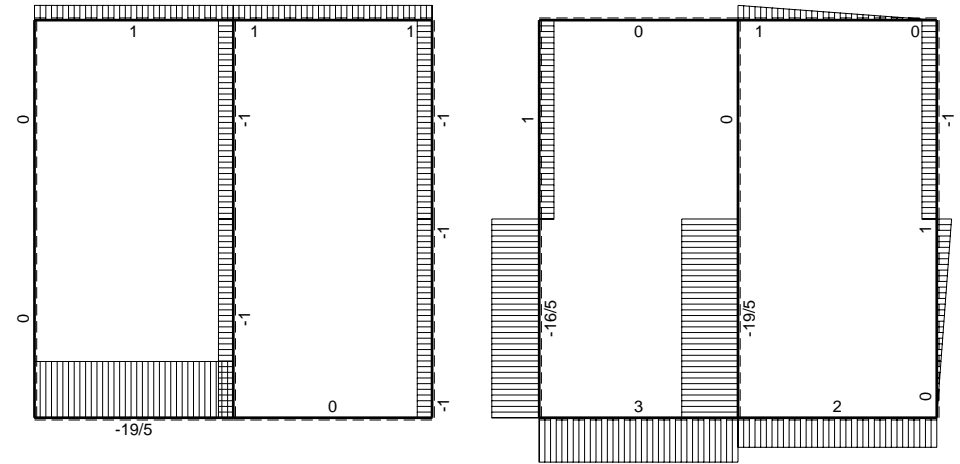
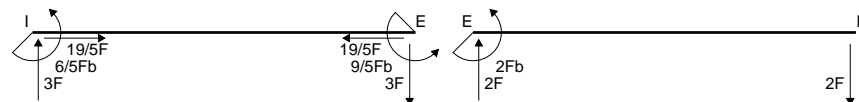
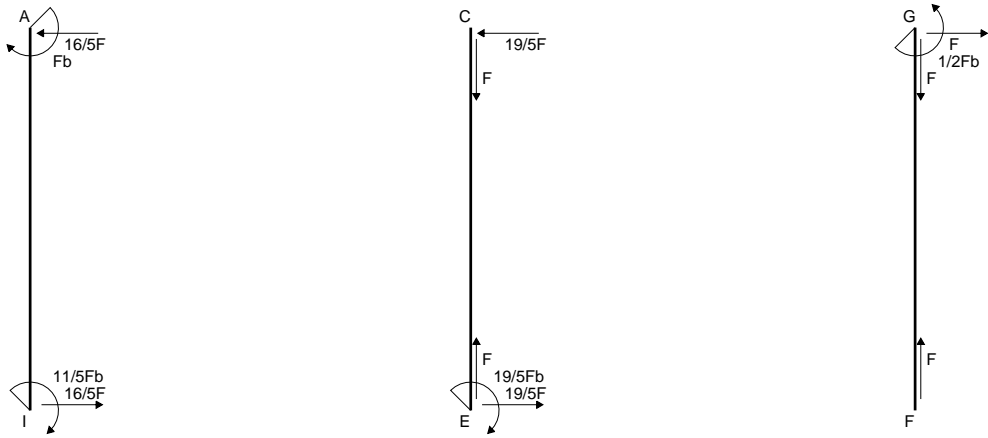
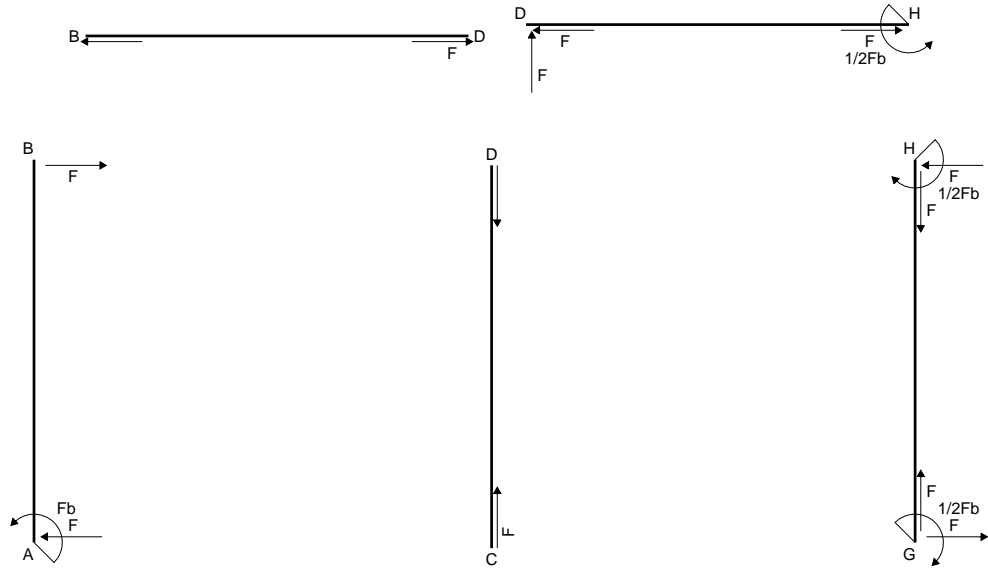
$$v_c = 17.96 \text{ mm}$$

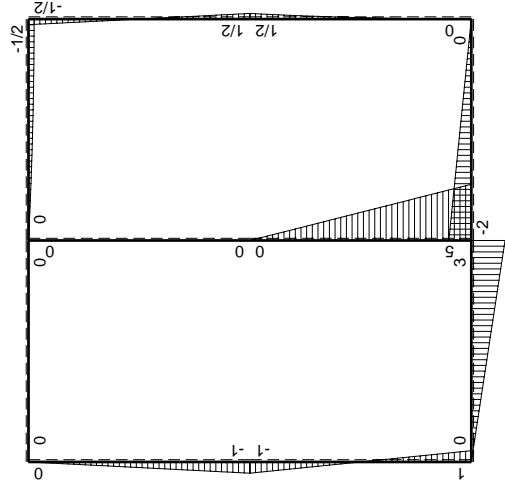
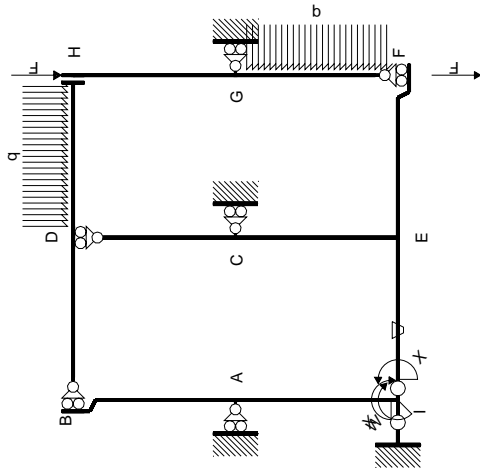
$$\sigma_c = -Mv/J_u = 125.7 \text{ N/mm}^2$$

$$\tau_c = 8.258 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 126.6 \text{ N/mm}^2$$

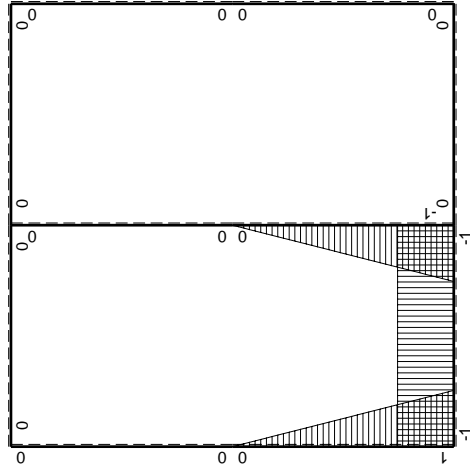
$$S = 4954. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	5Fb-5Fx	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-5Fx	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb-2Fx	0	$Fb-3Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-2Fx	0	$-Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

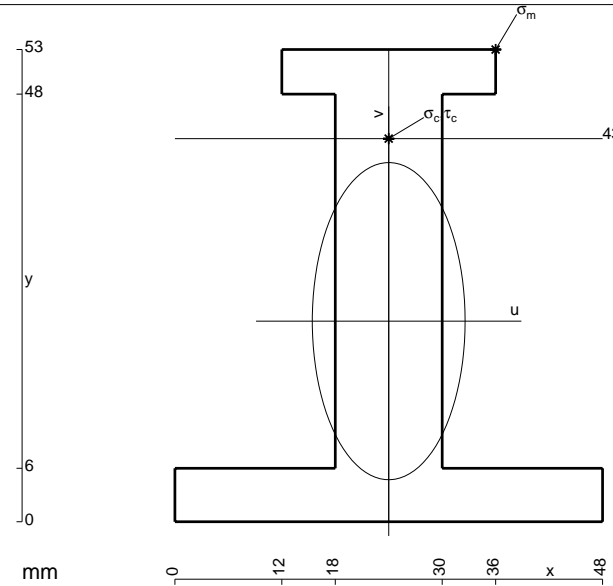
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 3x/b + 2x^2/b^2) Fb 1/EJ dx = [x - 3/2 x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

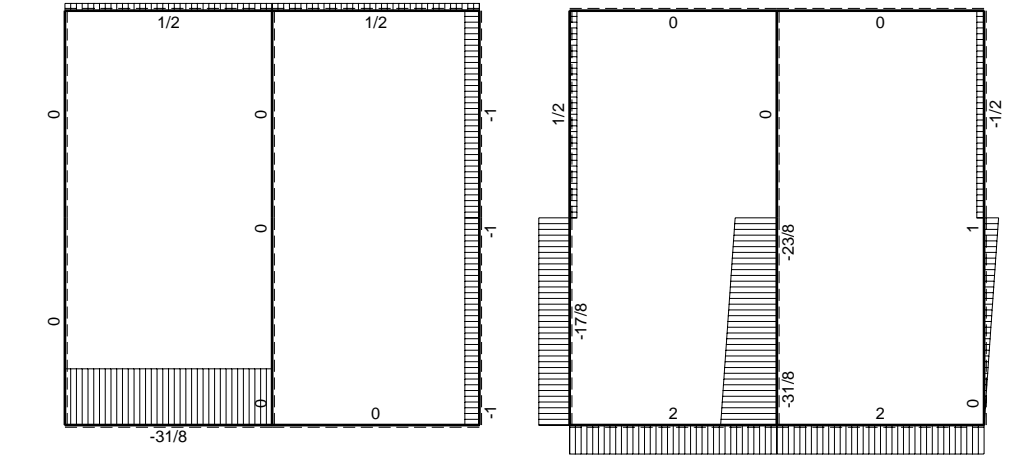
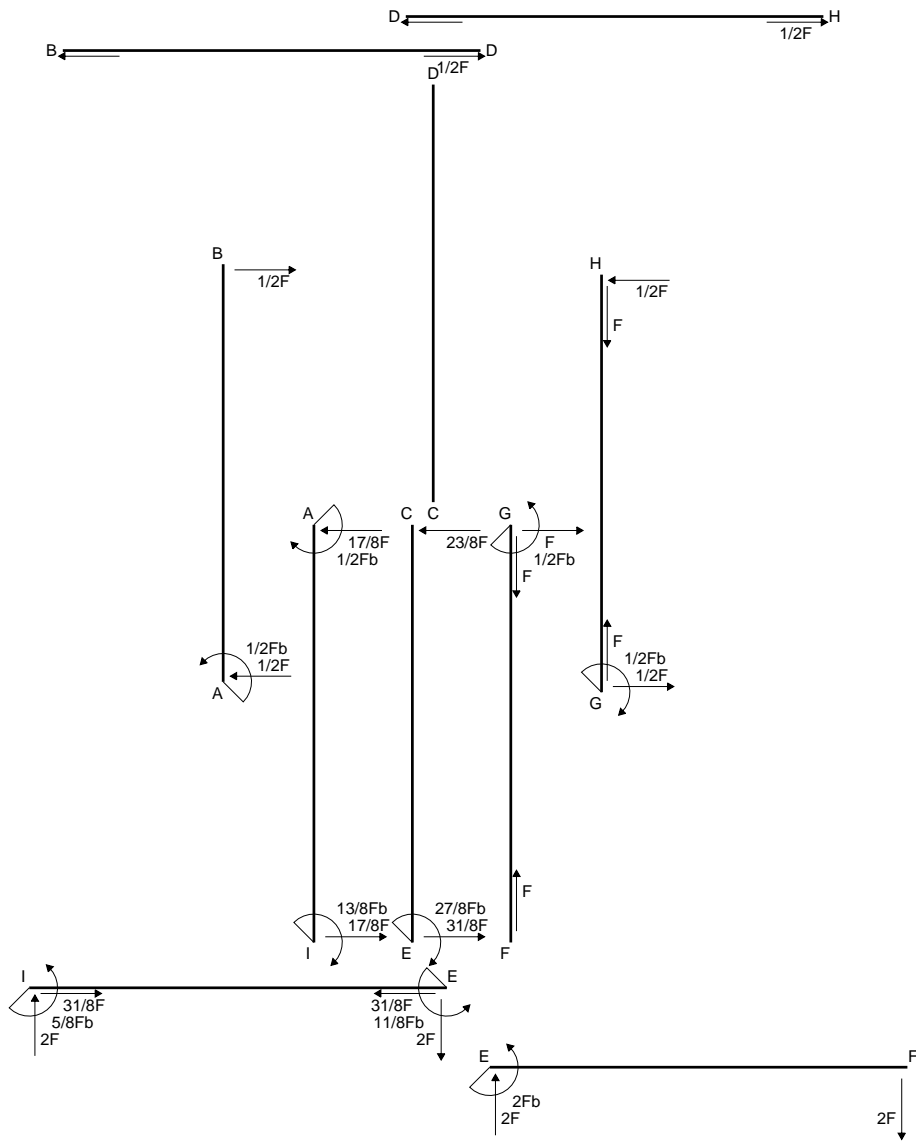
$$= (b - 3/2 b + 2/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-x/b + 2x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 2/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

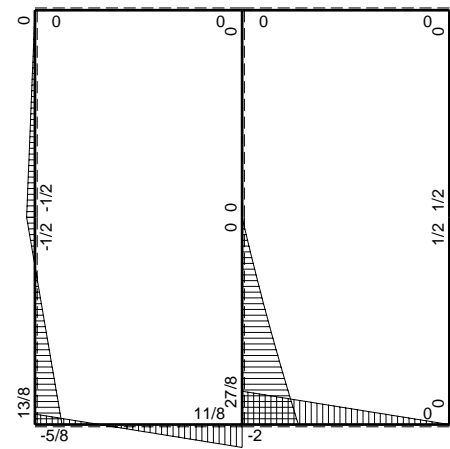


- A = 912. mm²
- J_u = 289000. mm⁴
- J_v = 67104. mm⁴
- y_g = 22.51 mm
- T_y = 2300. N
- M_x = -2070000. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 30.49 mm
- σ_m = -Mv/J_u = 218.4 N/mm²
- x_c = 24. mm
- y_c = 43. mm
- v_c = 20.49 mm
- σ_c = -Mv/J_u = 146.7 N/mm²
- τ_c = 3.142 N/mm²
- σ_q = √σ²+3τ² = 146.8 N/mm²
- S = 4738. mm³

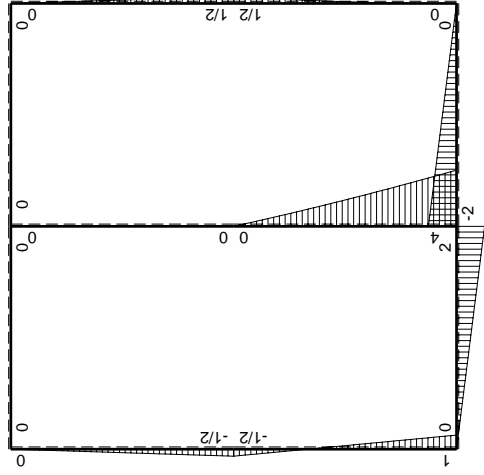
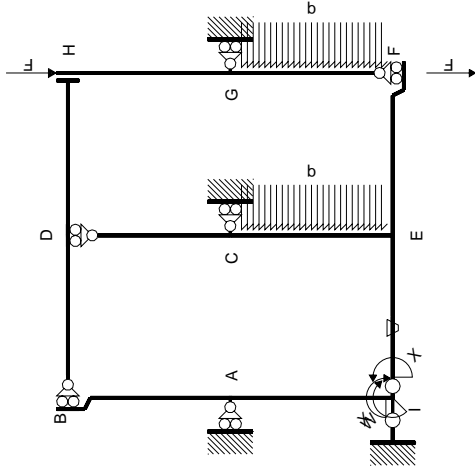


← ⊕ → F

↑ ⊕ ↓ F

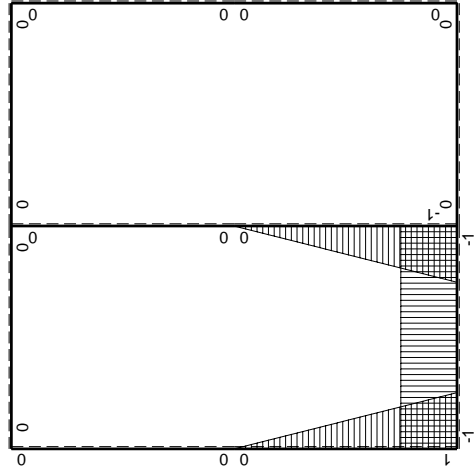


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= [-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-7/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

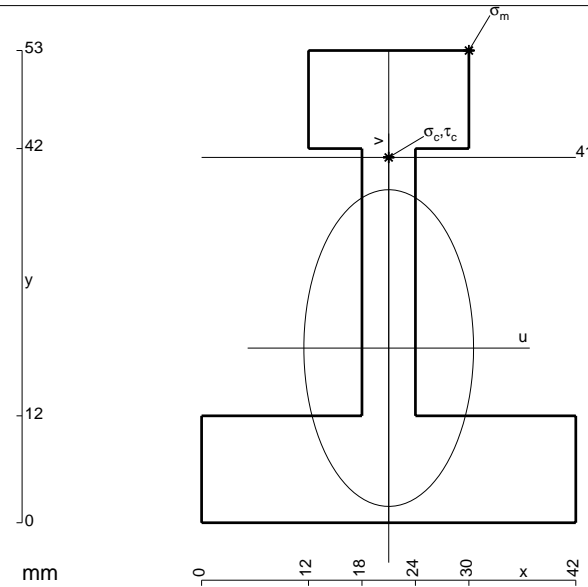
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 882. \text{ mm}^2$$

$$J_u = 278746. \text{ mm}^4$$

$$J_v = 79974. \text{ mm}^4$$

$$y_g = 19.6 \text{ mm}$$

$$T_y = 2020. \text{ N}$$

$$M_x = -1919000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 33.4 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

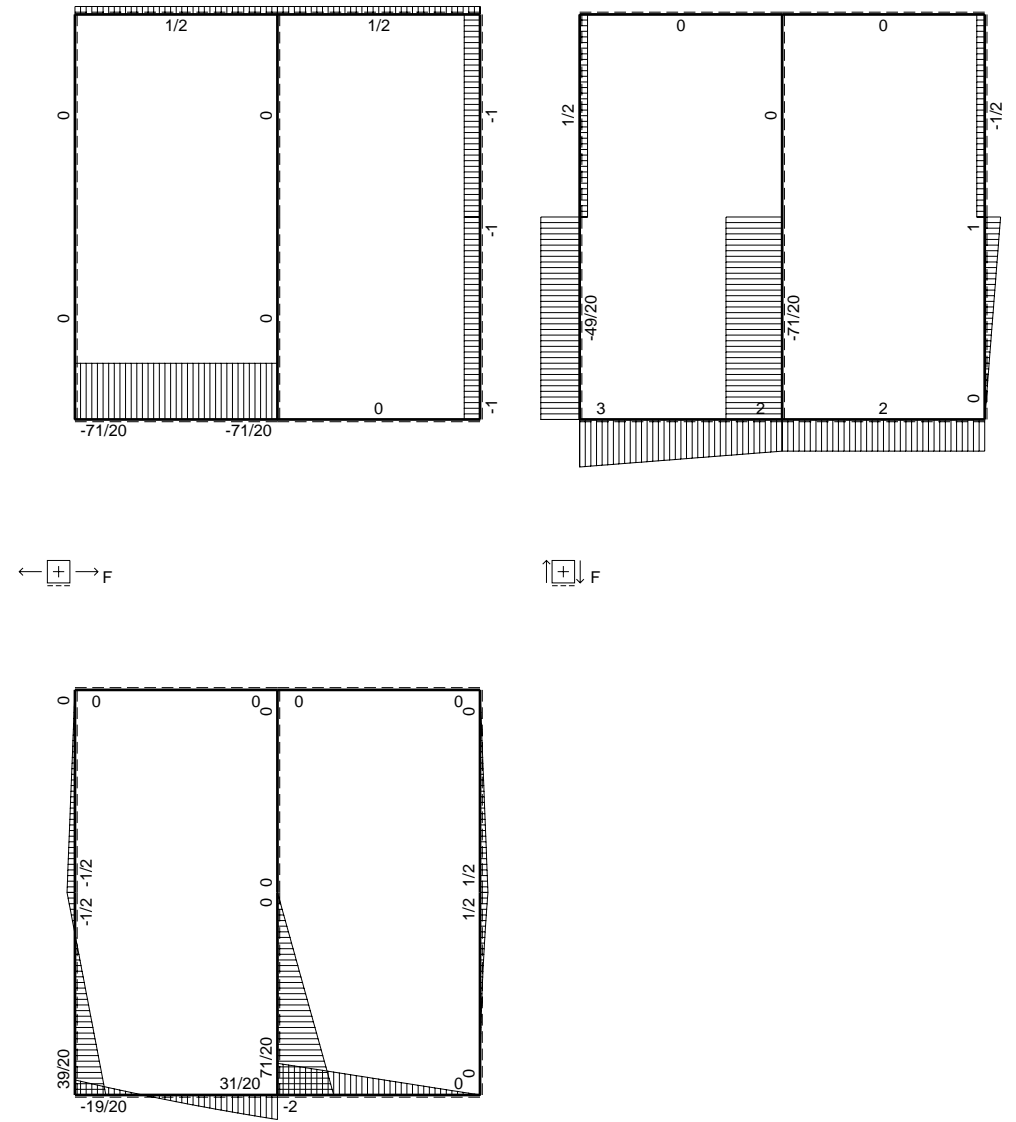
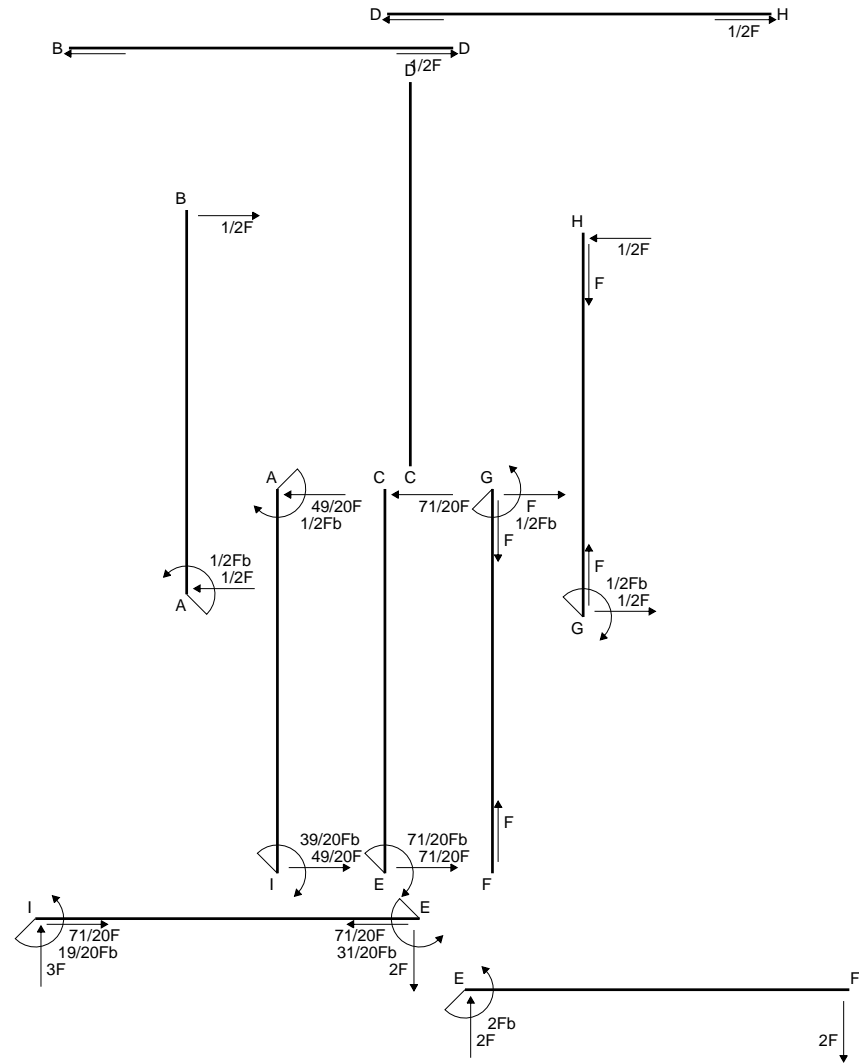
$$v_c = 21.4 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 147.3 \text{ N/mm}^2$$

$$\tau_c = 6.83 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 147.8 \text{ N/mm}^2$$

$$S = 5655. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-19/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

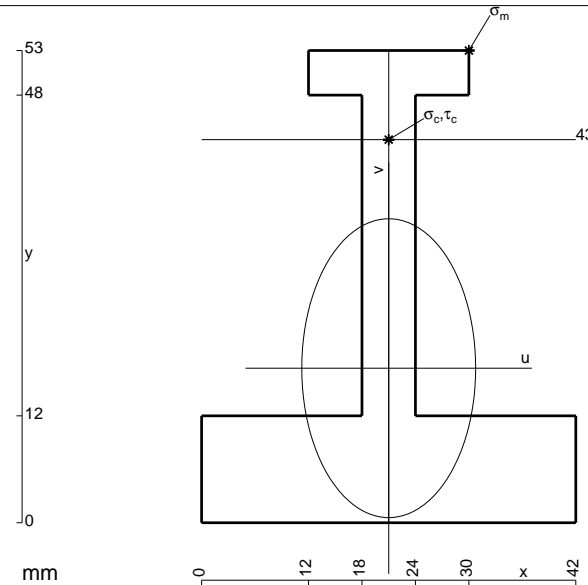
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

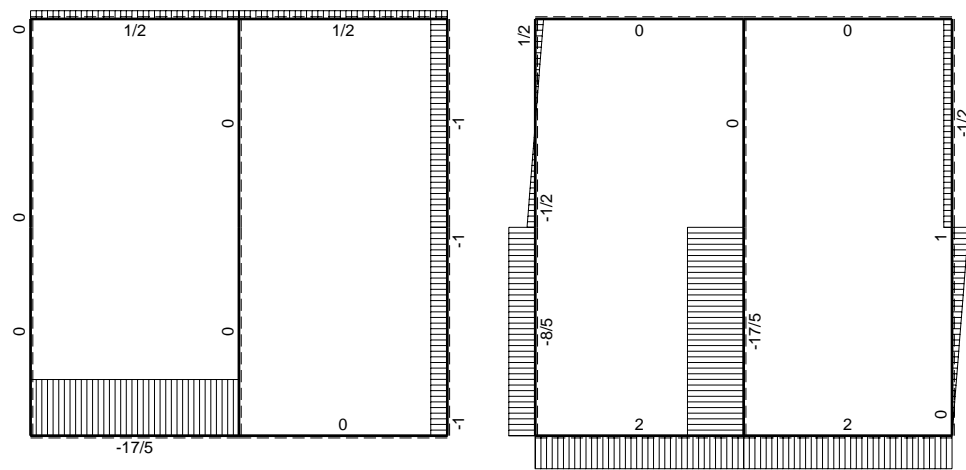
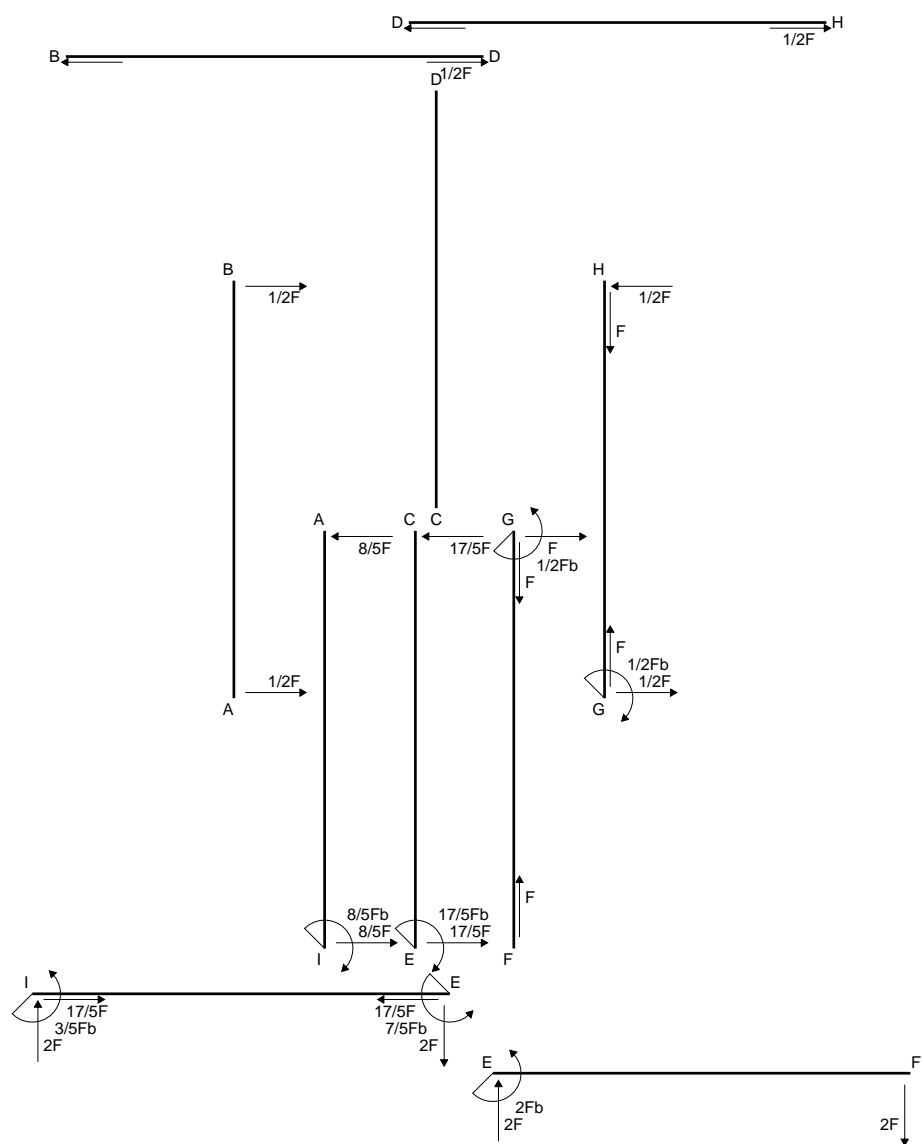
$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

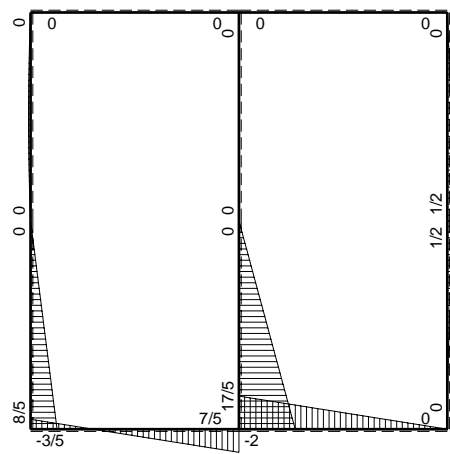


- A = 810. mm²
- J_u = 227958. mm⁴
- J_v = 77166. mm⁴
- y_g = 17.34 mm
- T_y = 1520. N
- M_x = -1520000. Nmm
- x_m = 30. mm
- y_m = 53. mm
- u_m = 9. mm
- v_m = 35.66 mm
- σ_m = -Mv/J_u = 237.7 N/mm²
- x_c = 21. mm
- y_c = 43. mm
- v_c = 25.66 mm
- σ_c = -Mv/J_u = 171.1 N/mm²
- τ_c = 4.255 N/mm²
- σ_q = √σ²+3τ² = 171.2 N/mm²
- S = 3829. mm³

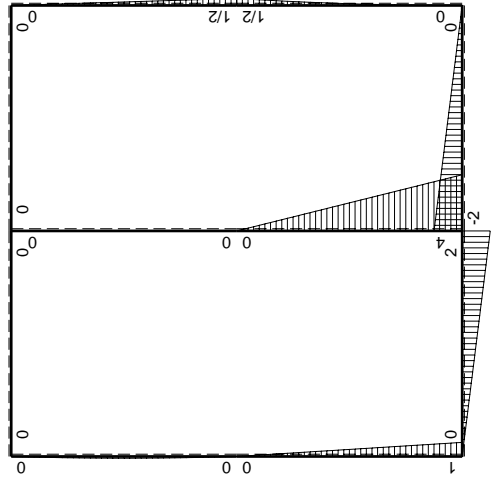
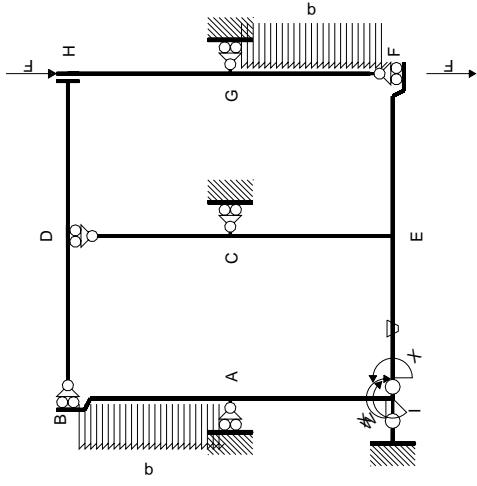


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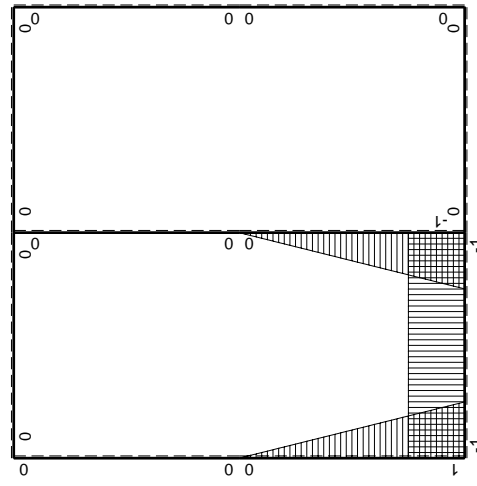


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

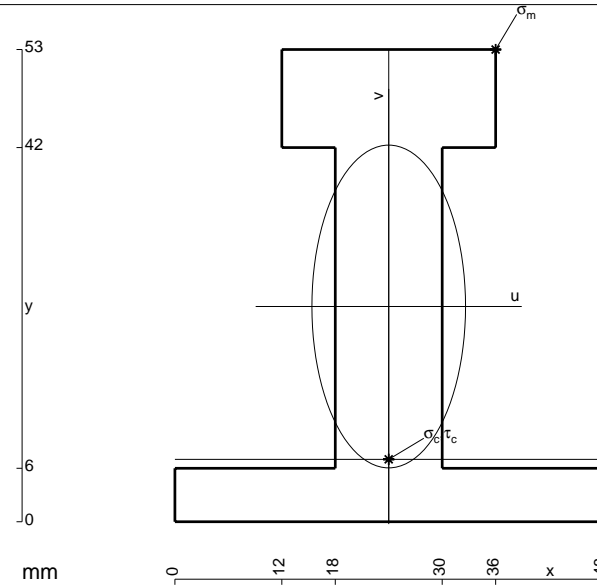
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

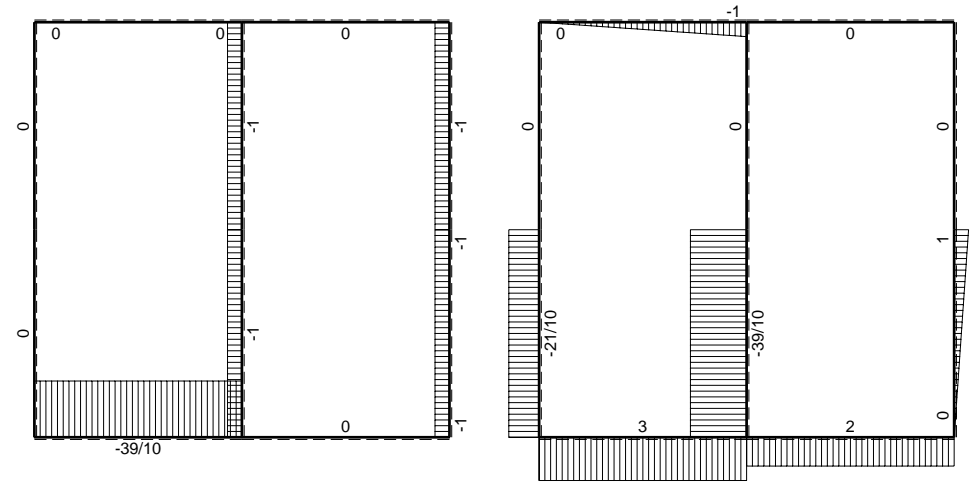
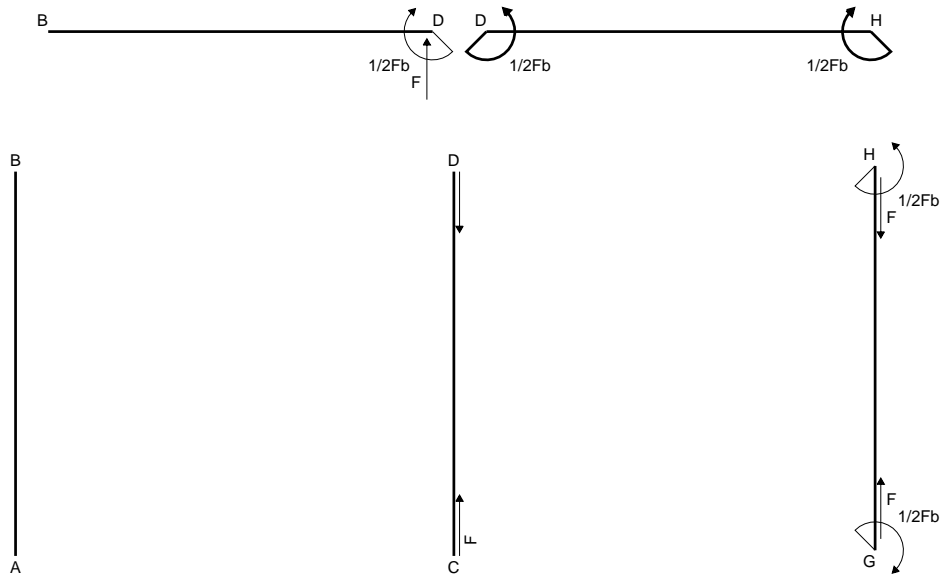
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

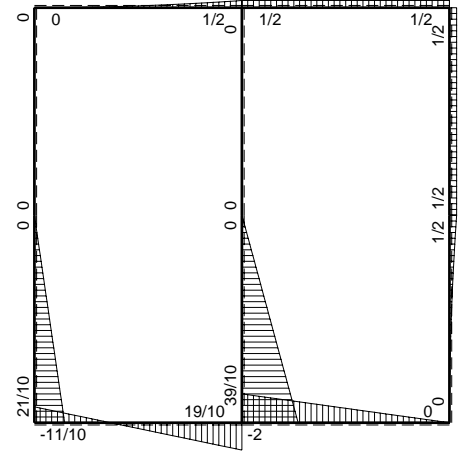
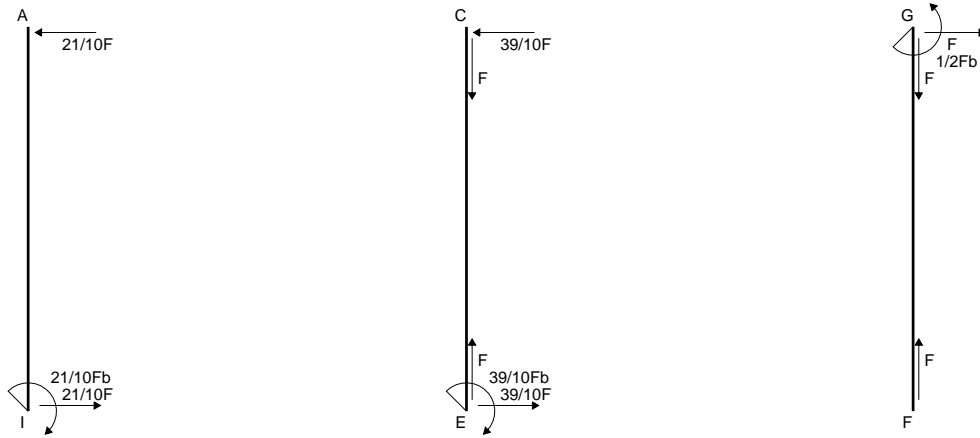


- A = 984. mm²
- J_u = 322959. mm⁴
- J_v = 73152. mm⁴
- y_g = 24.16 mm
- T_y = 4220. N
- M_x = -2236600. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 28.84 mm
- σ_m = -Mv/J_u = 199.7 N/mm²
- x_c = 24. mm
- y_c = 7. mm
- v_c = -17.16 mm
- σ_c = -Mv/J_u = -118.8 N/mm²
- τ_c = 6.866 N/mm²
- σ_q = √σ²+3τ² = 119.4 N/mm²
- S = 6306. mm³

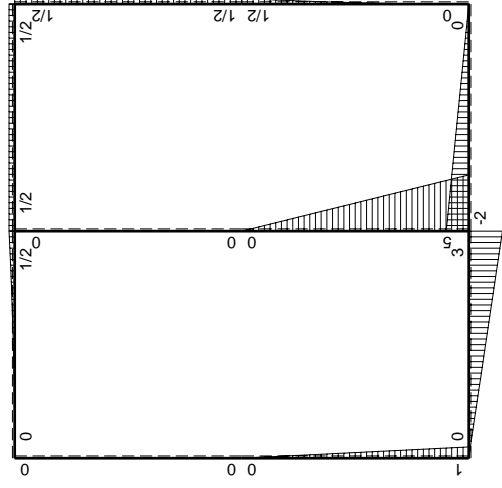
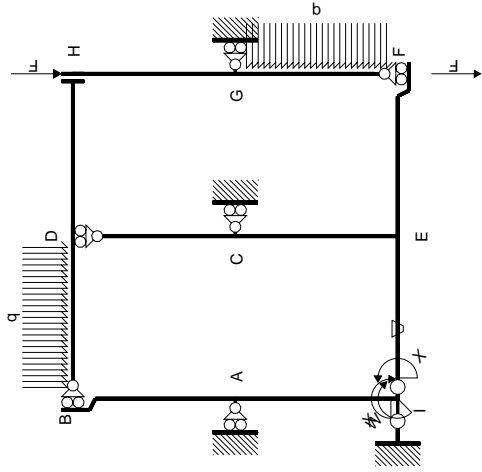


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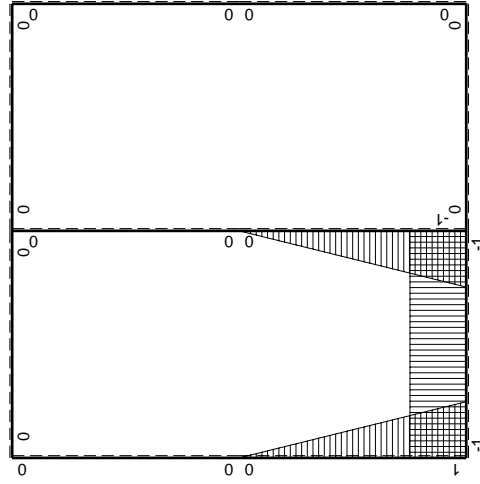


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

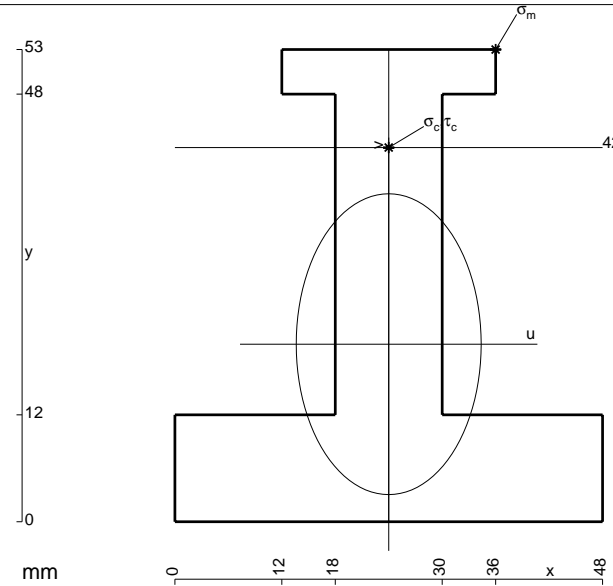
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

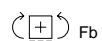
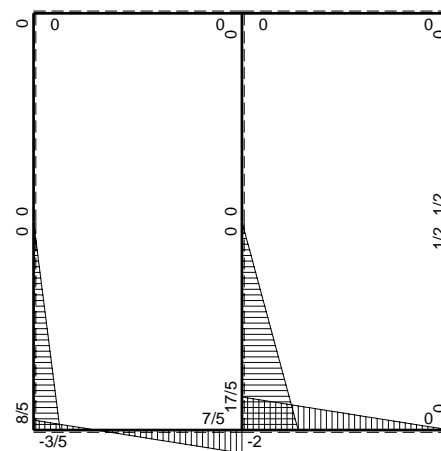
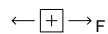
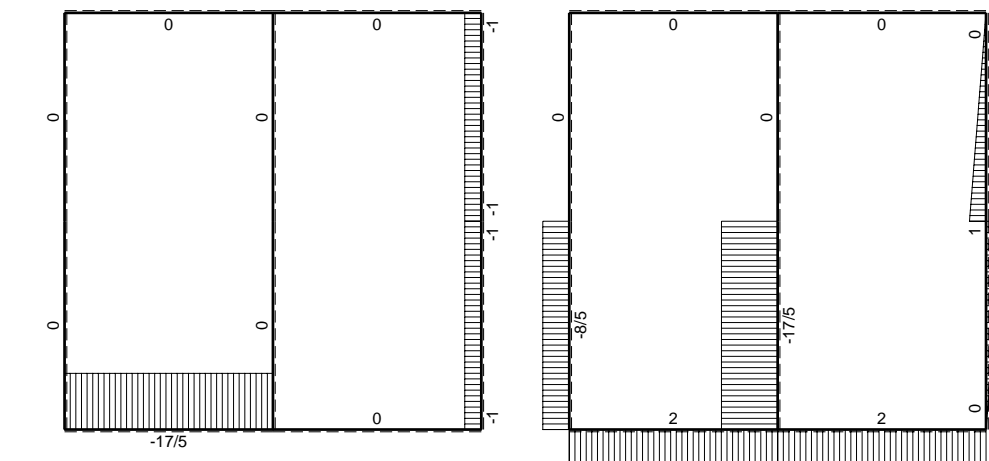
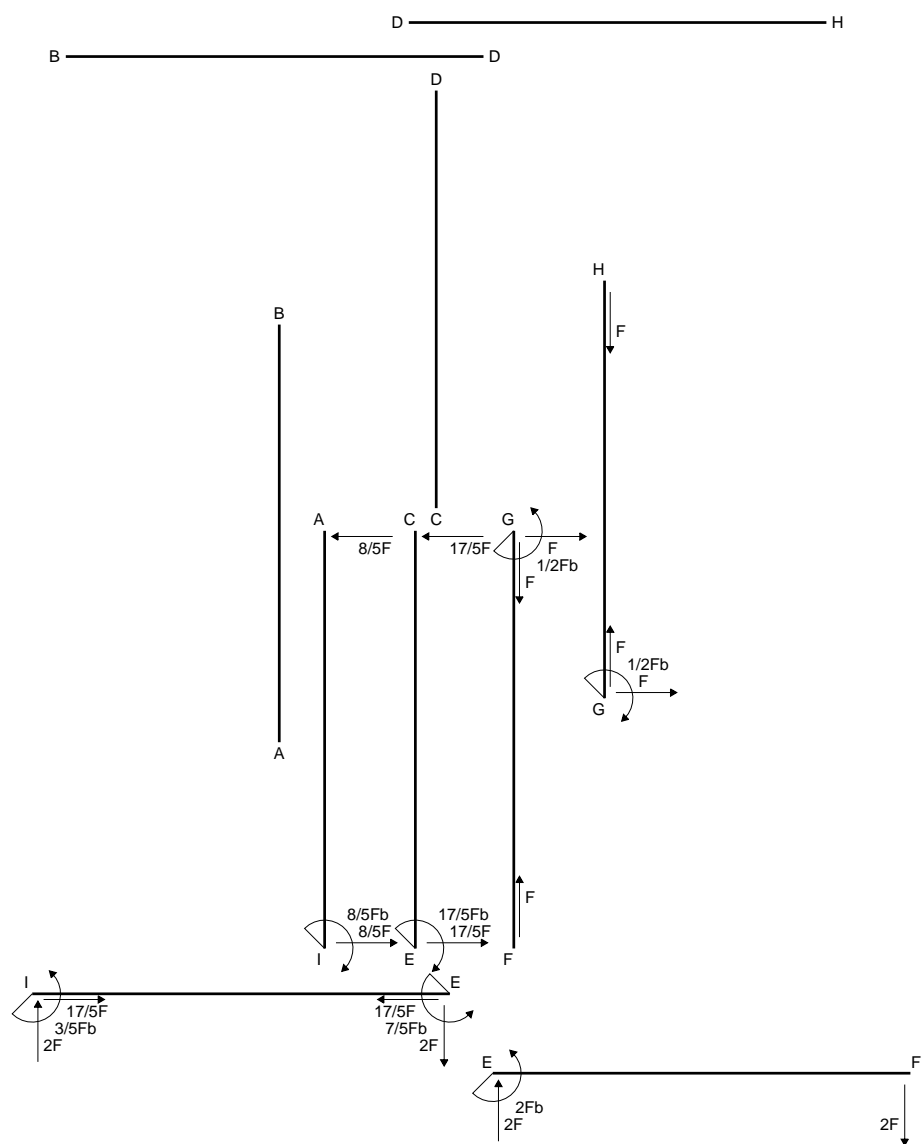
$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

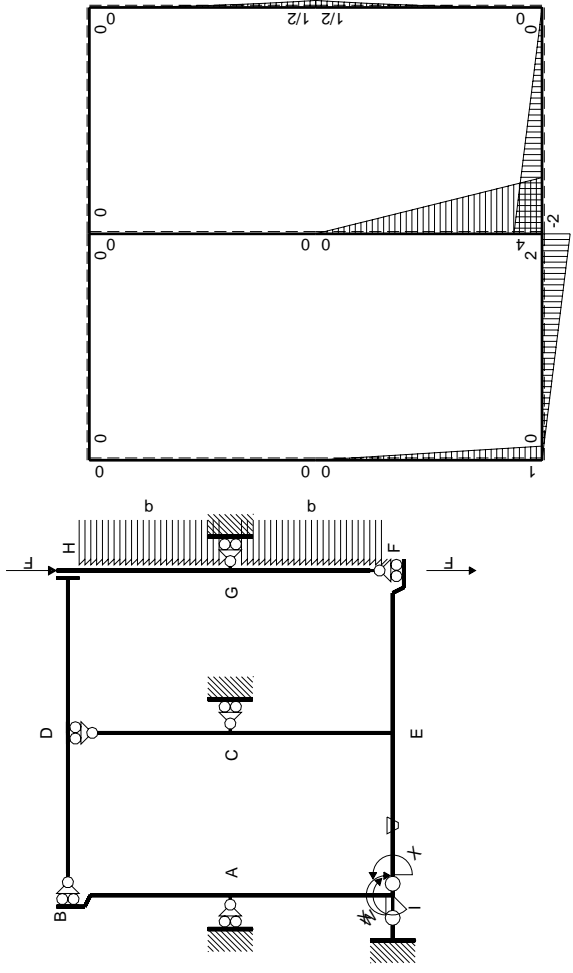
$$L_{AI}^{x_0} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$



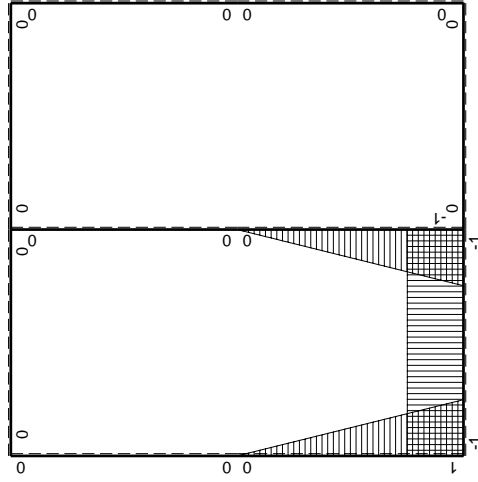
- A = 1128. mm²
- J_u = 321538. mm⁴
- J_v = 121536. mm⁴
- y_g = 19.93 mm
- T_y = 3500. N
- M_x = -2030000. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 33.07 mm
- σ_m = -Mv/J_u = 208.8 N/mm²
- x_c = 24. mm
- y_c = 42. mm
- v_c = 22.07 mm
- σ_c = -Mv/J_u = 139.4 N/mm²
- τ_c = 4.966 N/mm²
- σ_q = √σ²+3τ² = 139.6 N/mm²
- S = 5474. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb 1/EJ dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 4b - 4/3 b) Fb 1/EJ = -4/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-4x^2/b^2) Fb 1/EJ dx = [-4/3 x^3/b^2]_0^b Fb 1/EJ$$

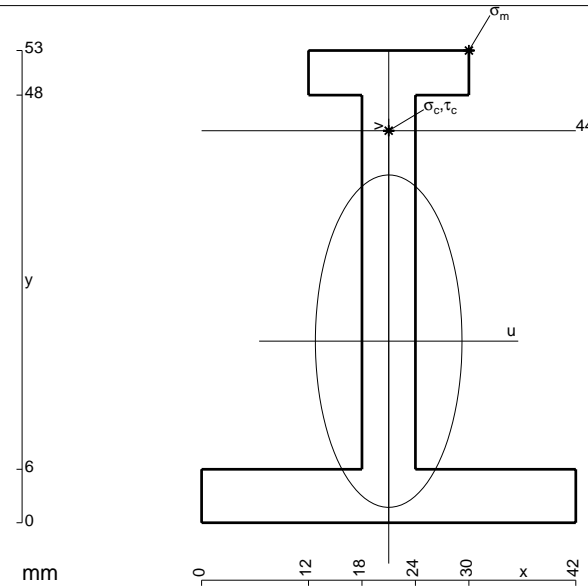
$$= (-4/3 b) Fb 1/EJ = -4/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 2x/b + x^2/b^2) Fb 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - b + 1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (x^2/b^2) Fb 1/EJ dx = [1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$



$$A = 594. \text{ mm}^2$$

$$J_u = 206801. \text{ mm}^4$$

$$J_v = 40230. \text{ mm}^4$$

$$y_g = 20.38 \text{ mm}$$

$$T_y = 2200. \text{ N}$$

$$M_x = -1386000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 32.62 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 218.6 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

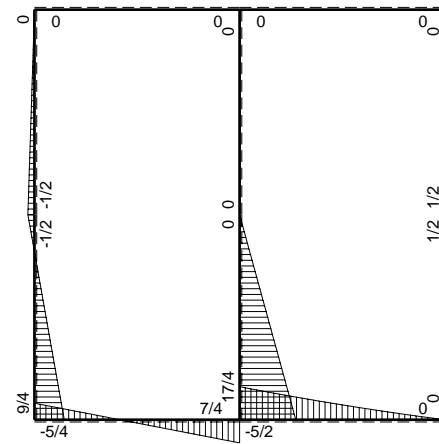
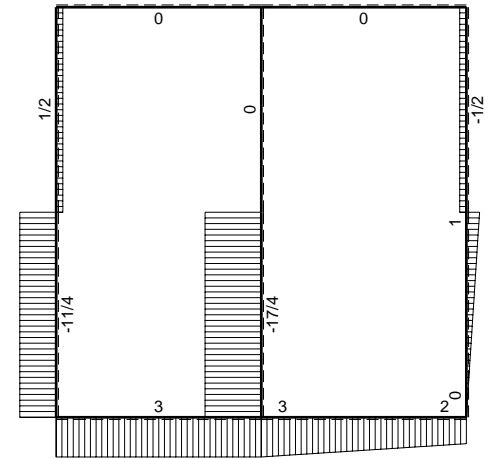
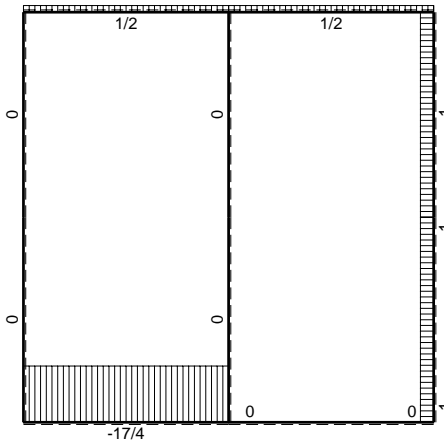
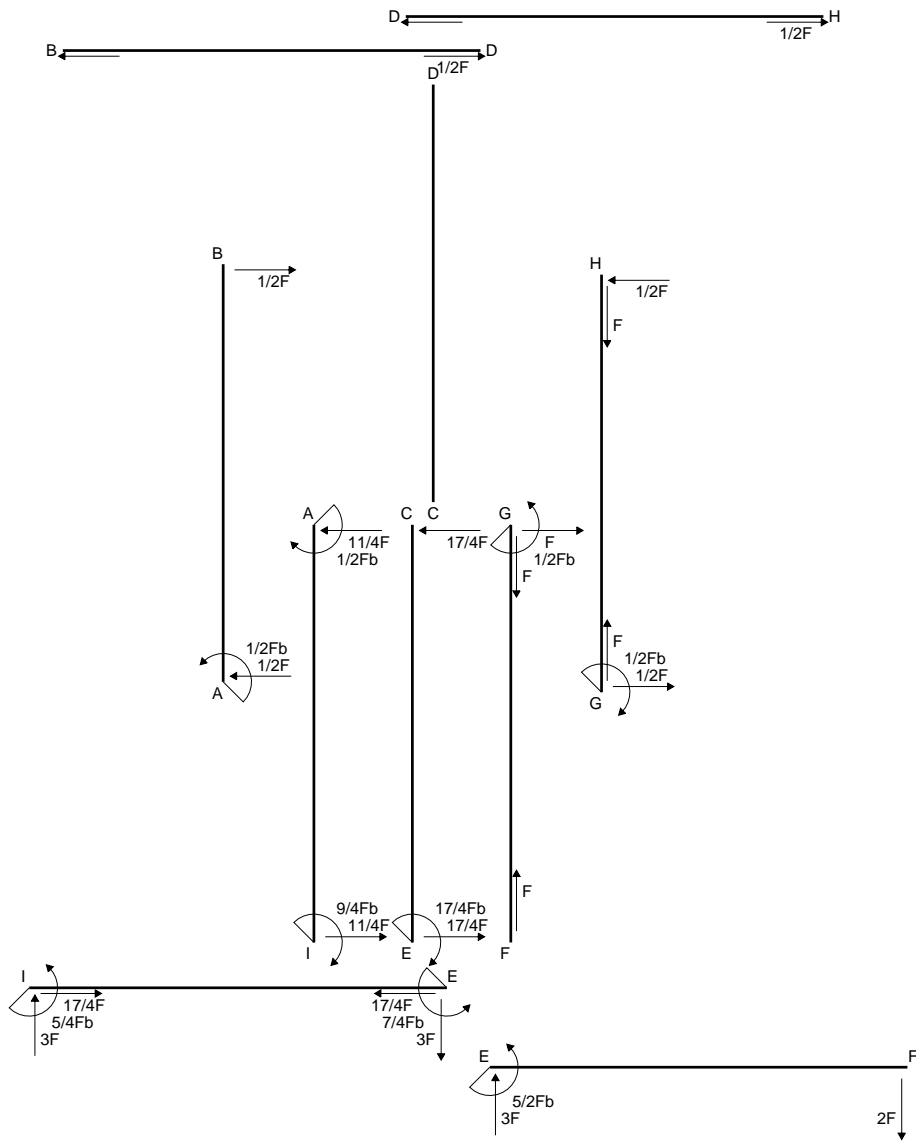
$$v_c = 23.62 \text{ mm}$$

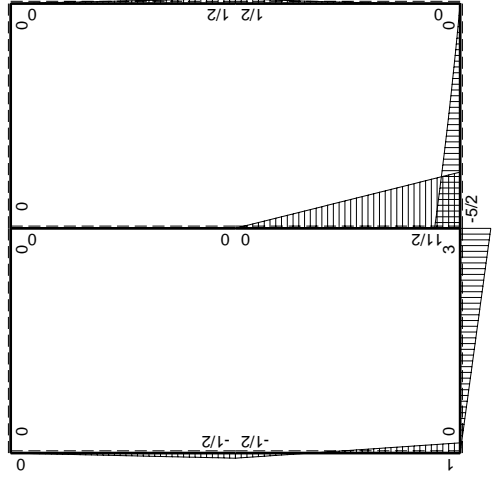
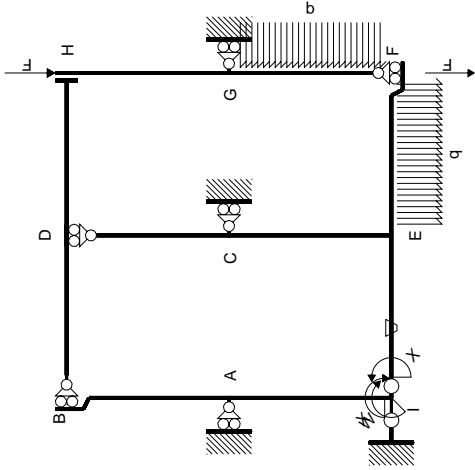
$$\sigma_c = -Mv/J_u = 158.3 \text{ N/mm}^2$$

$$\tau_c = 5.897 \text{ N/mm}^2$$

$$\sigma_{\varphi} = \sqrt{\sigma^2 + 3\tau^2} = 158.6 \text{ N/mm}^2$$

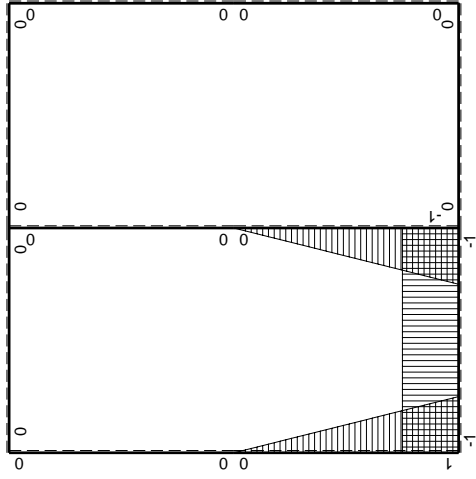
$$S = 3326. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb 1/EJ dx = [-11/6 x^3/b^2]_0^b Fb 1/EJ$$

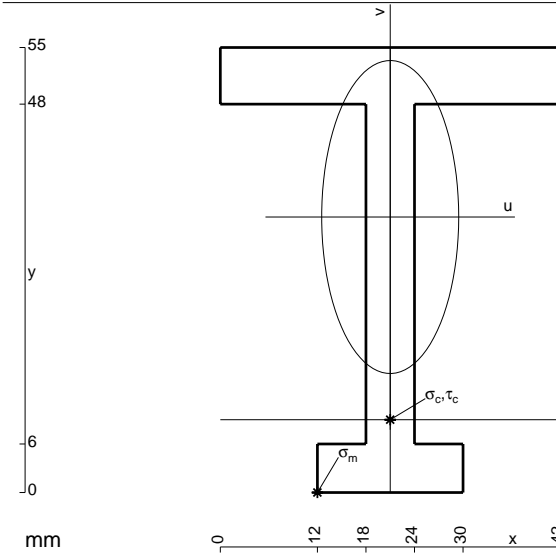
$$= (-11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

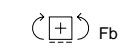
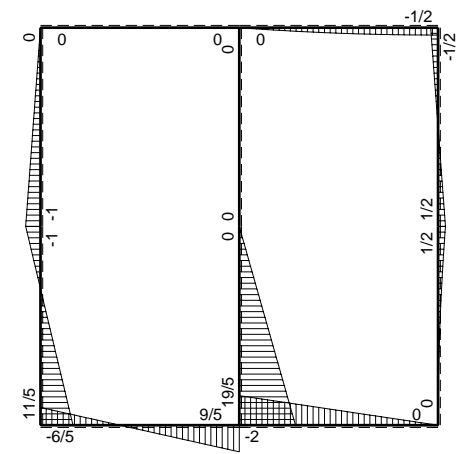
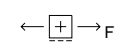
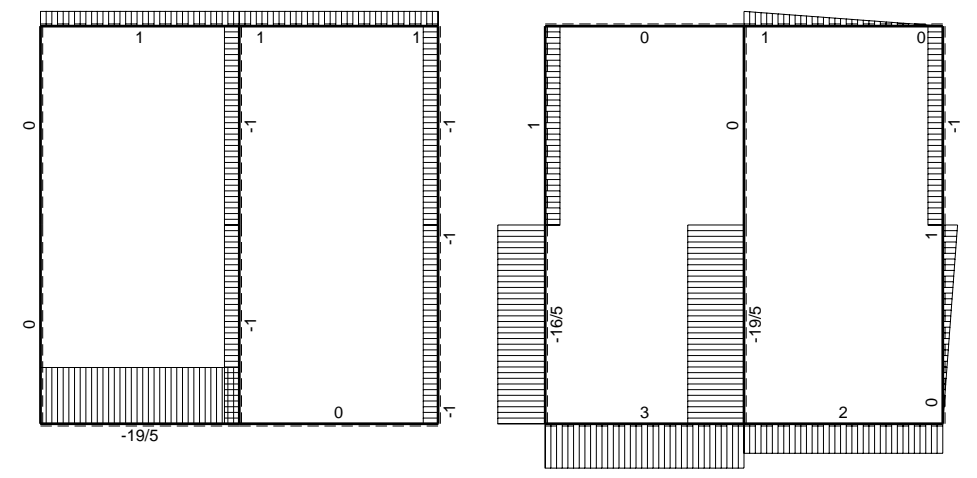
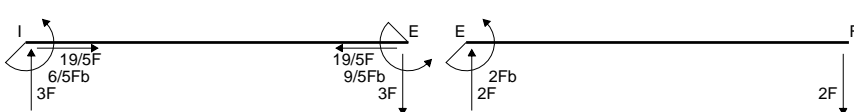
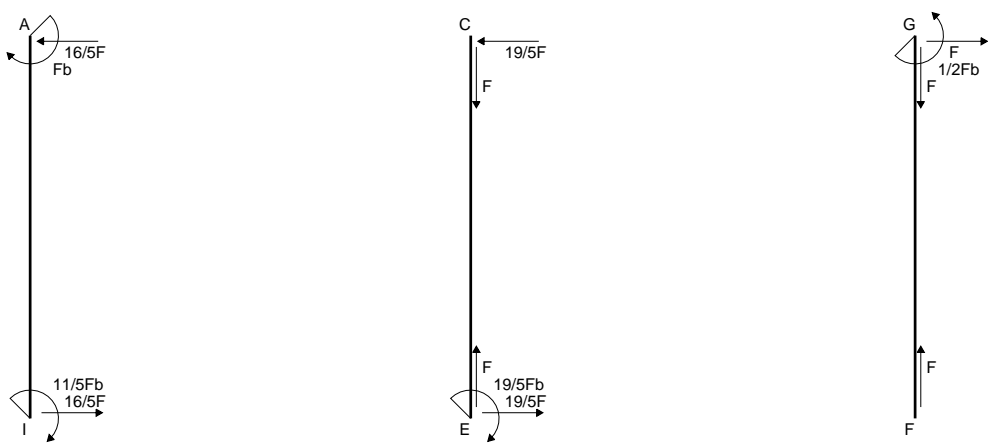
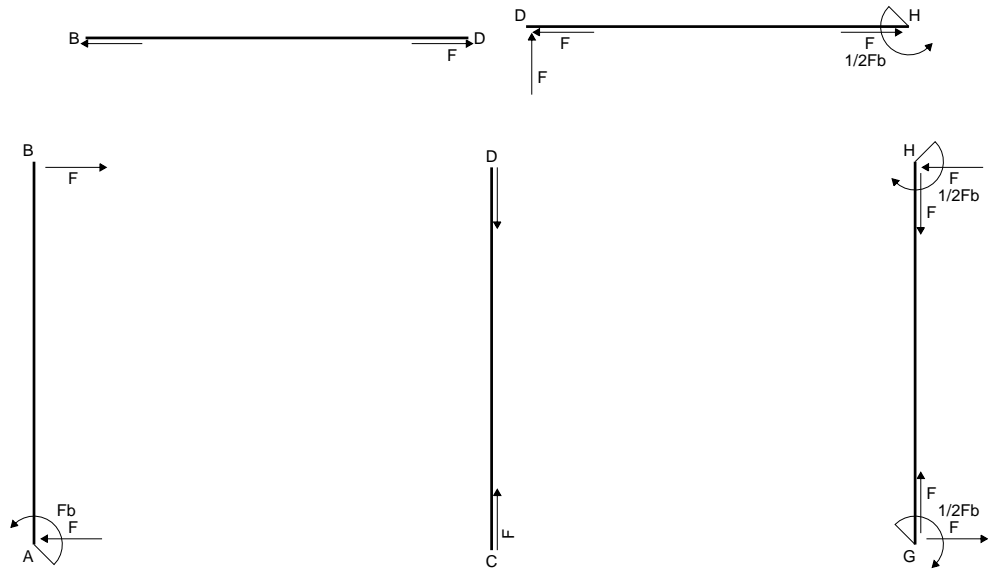
$$= (b - 5/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

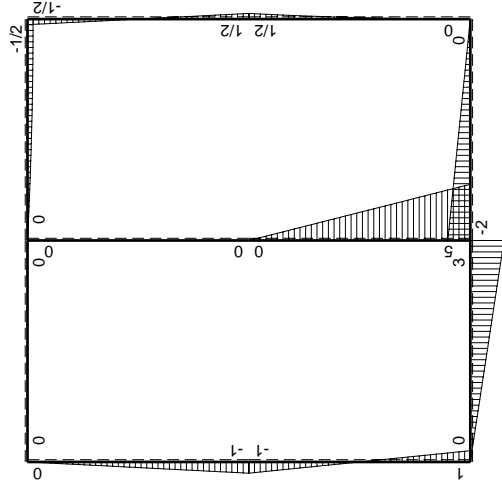
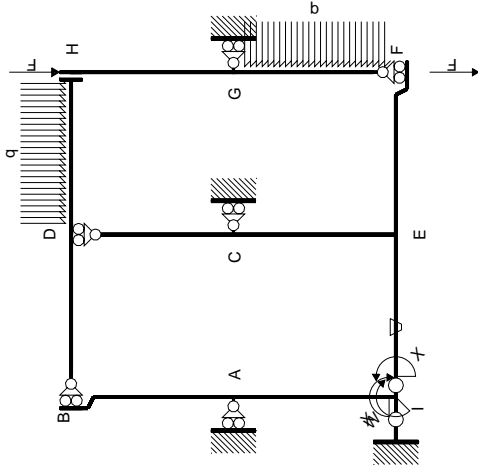
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$



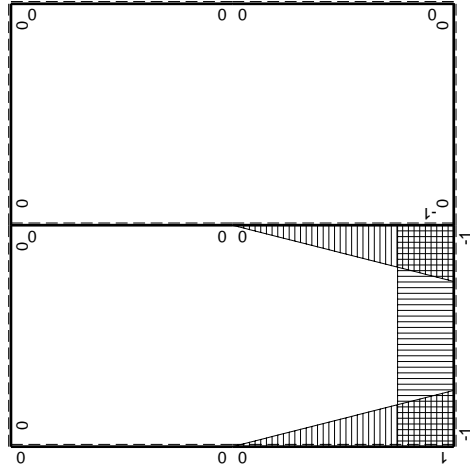
- A = 654. mm²
- J_u = 244740. mm⁴
- J_v = 46890. mm⁴
- y_g = 34.05 mm
- T_y = 2790. N
- M_x = -1650750. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -34.05 mm
- σ_m = -Mv/J_u = -229.7 N/mm²
- x_c = 21. mm
- y_c = 9. mm
- v_c = -25.05 mm
- σ_c = -Mv/J_u = -169. N/mm²
- τ_c = 7.279 N/mm²
- σ_o = √σ²+3τ² = 169.4 N/mm²
- S = 3831. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-2Fx$	0	$Fb-3Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-2Fx$	0	$-Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

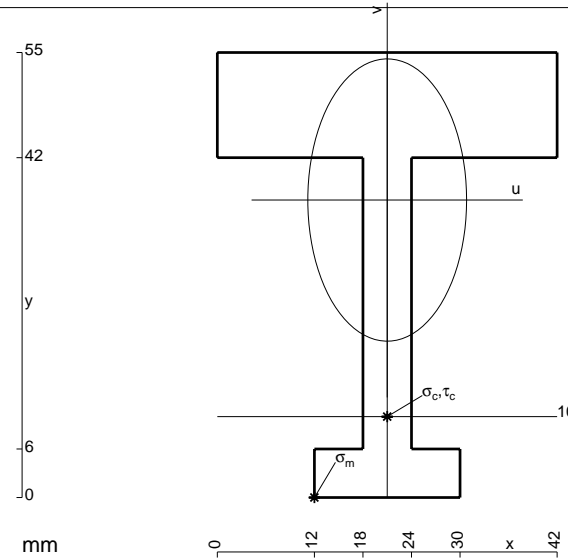
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3x/b + 2x^2/b^2) Fb 1/EJ dx = [x - 3/2 x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 3/2 b + 2/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + 2x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 2/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$



$$A = 870. \text{ mm}^2$$

$$J_u = 264856. \text{ mm}^4$$

$$J_v = 83826. \text{ mm}^4$$

$$y_g = 36.77 \text{ mm}$$

$$T_y = 2240. \text{ N}$$

$$M_x = -1724800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -36.77 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

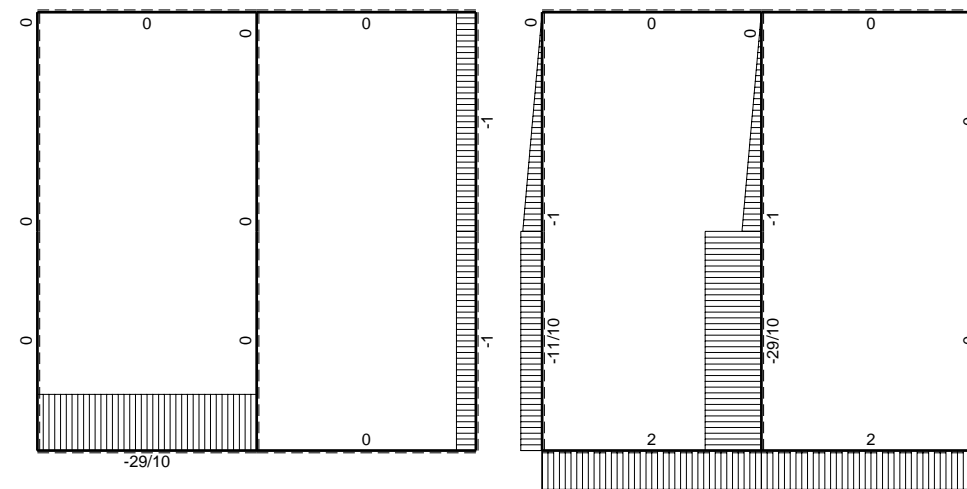
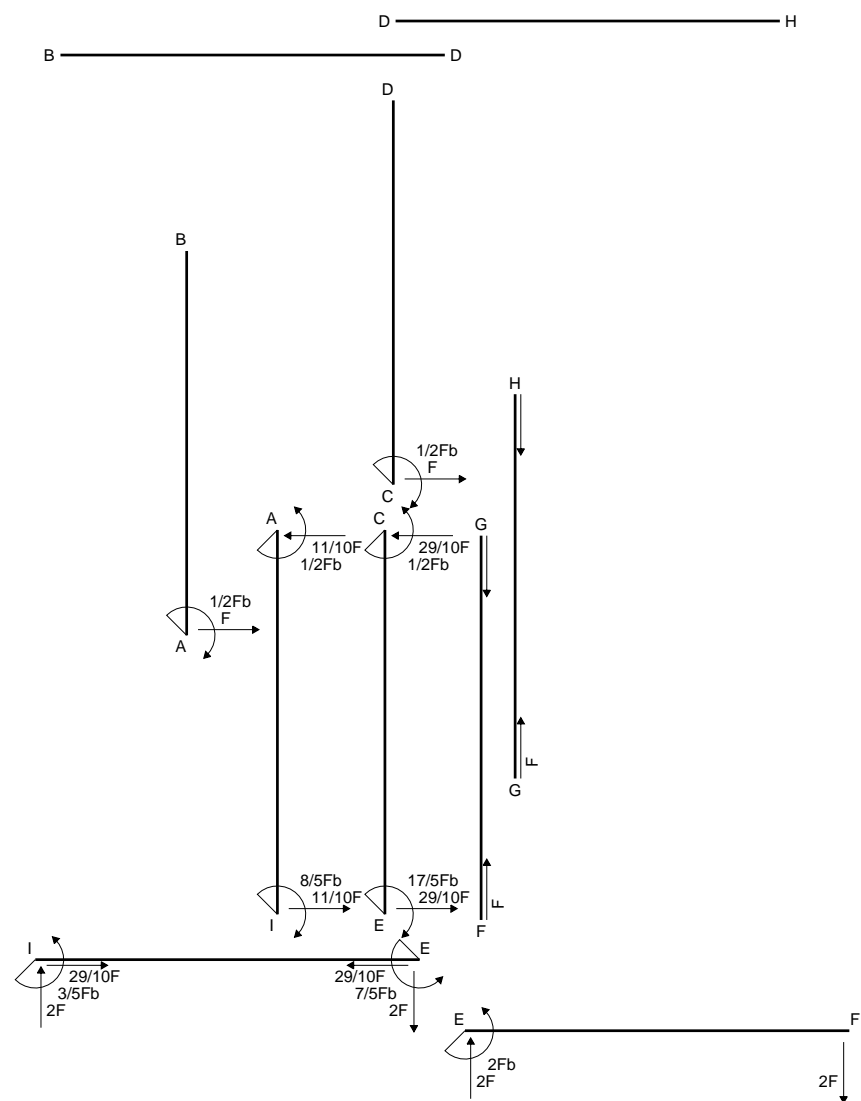
$$v_c = -26.77 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -174.3 \text{ N/mm}^2$$

$$\tau_c = 6.114 \text{ N/mm}^2$$

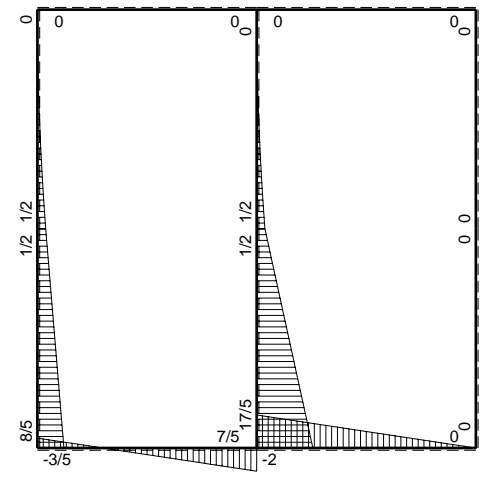
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 174.6 \text{ N/mm}^2$$

$$S = 4338. \text{ mm}^3$$

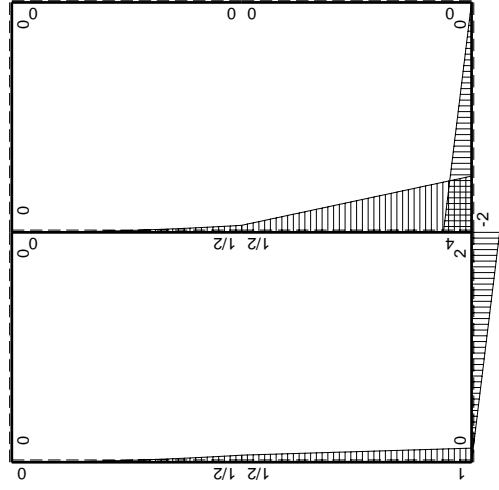
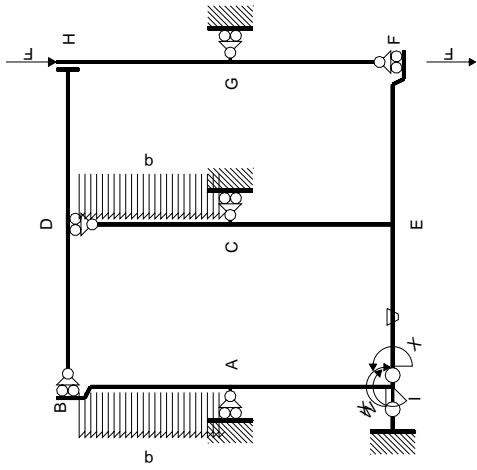


← ⊕ → F

↑ ⊕ ↓ F

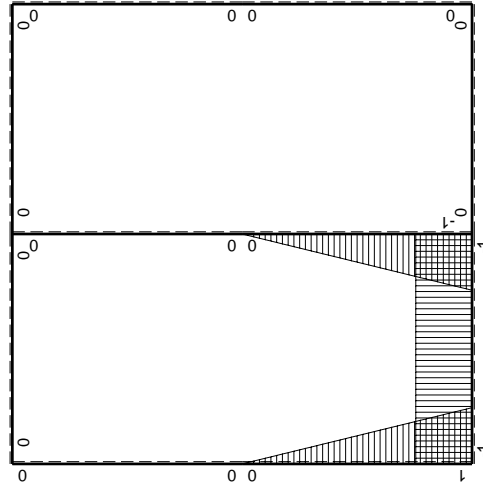


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2qx^2$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 15/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

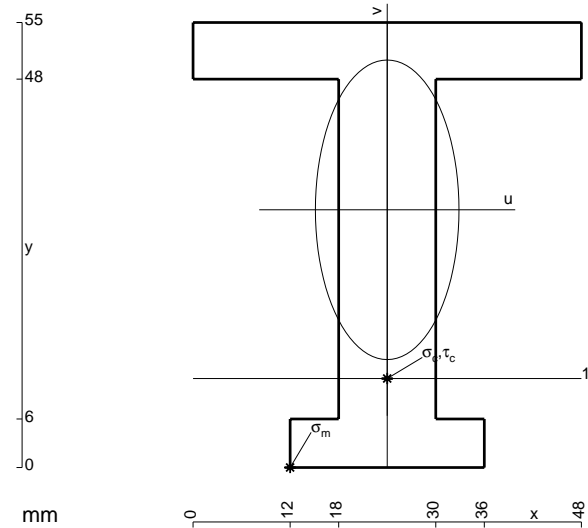
$$= (-1/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [x - 3/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 3/4 b + 1/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b + 1/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$



$$A = 984. \text{ mm}^2$$

$$J_u = 337339. \text{ mm}^4$$

$$J_v = 77472. \text{ mm}^4$$

$$y_g = 31.85 \text{ mm}$$

$$T_y = 2580. \text{ N}$$

$$M_x = -2115600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -31.85 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

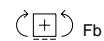
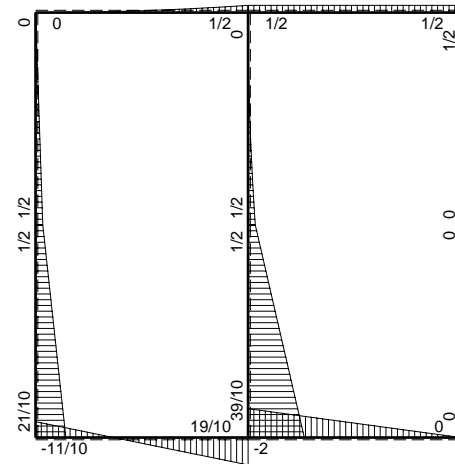
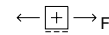
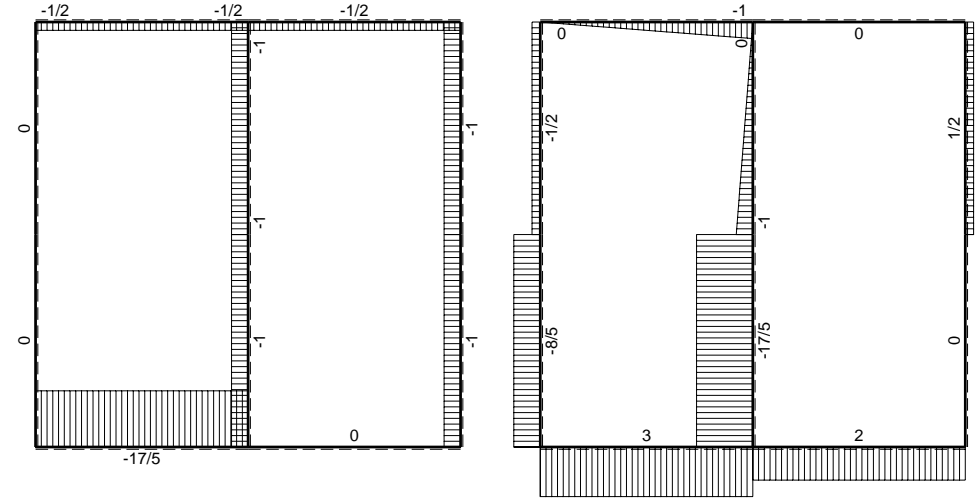
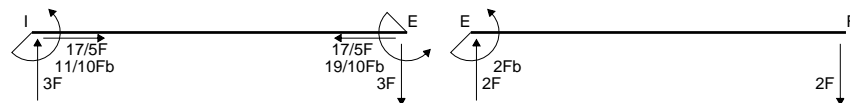
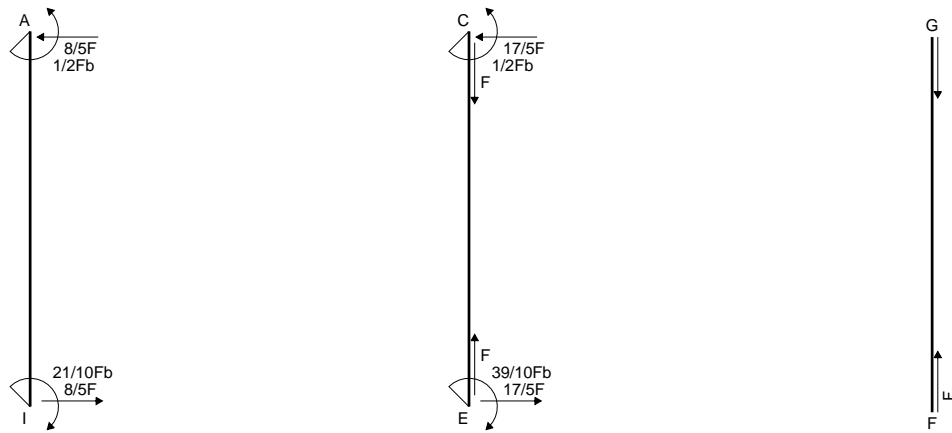
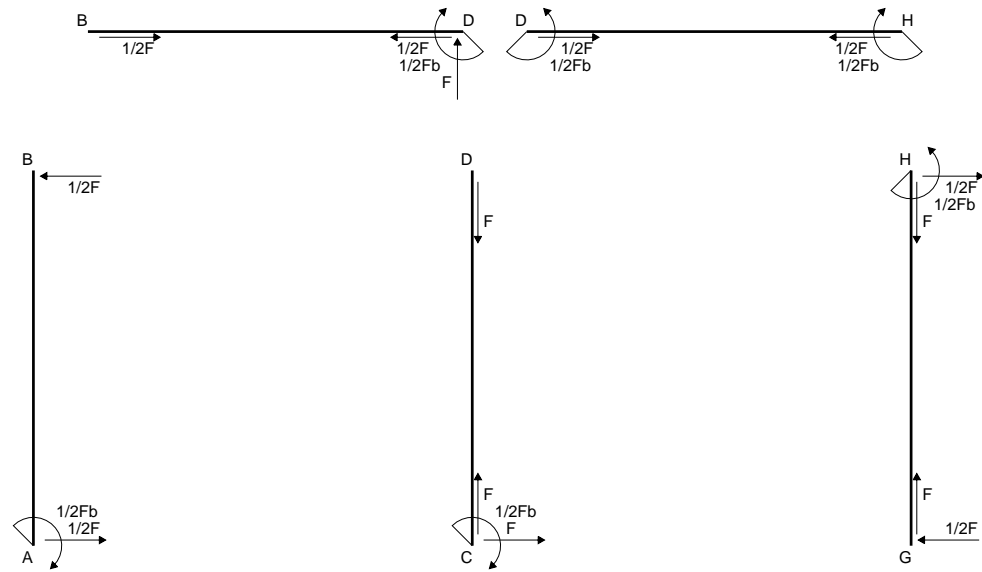
$$v_c = -20.85 \text{ mm}$$

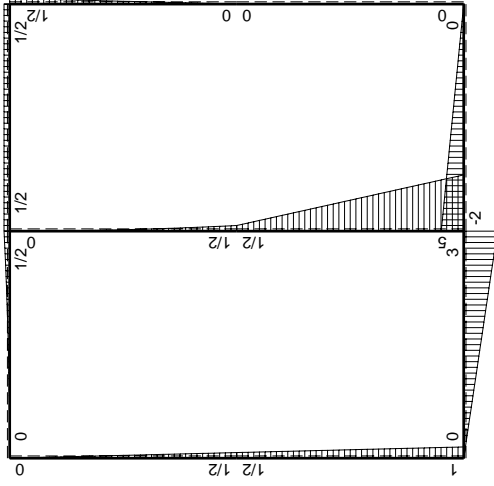
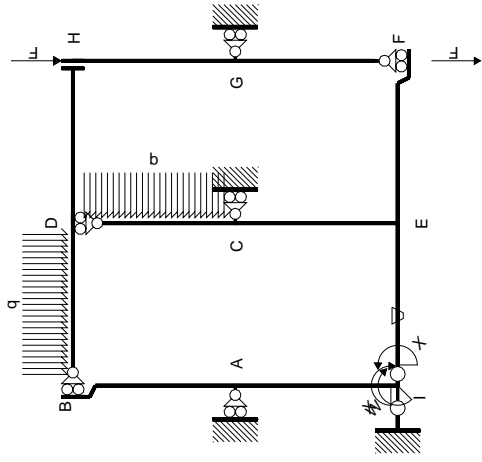
$$\sigma_c = -Mv/J_u = -130.8 \text{ N/mm}^2$$

$$\tau_c = 3.541 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 130.9 \text{ N/mm}^2$$

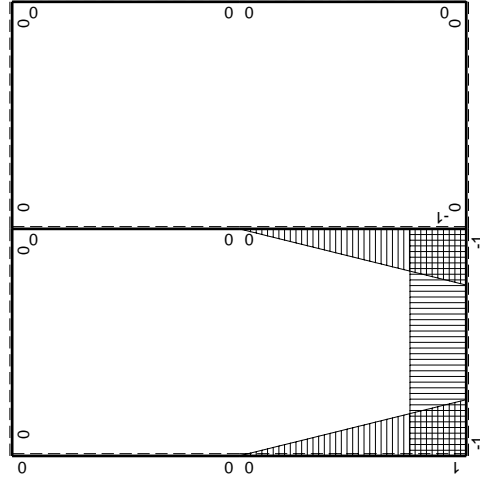
$$S = 5556. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

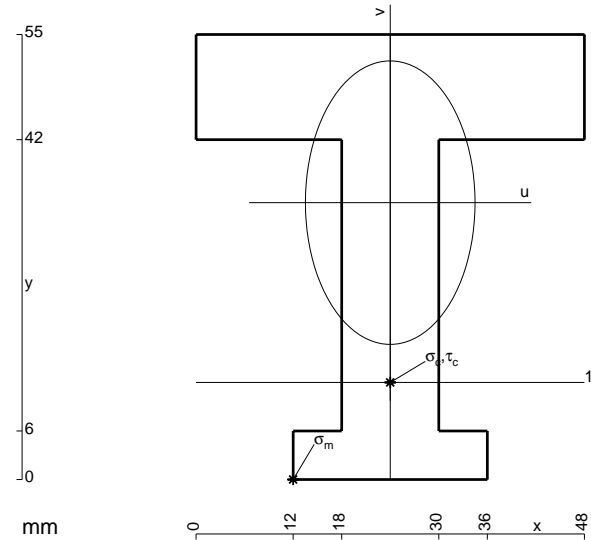
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 3/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

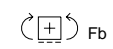
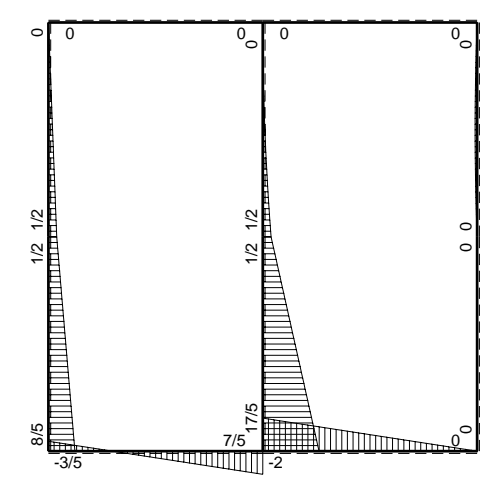
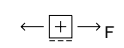
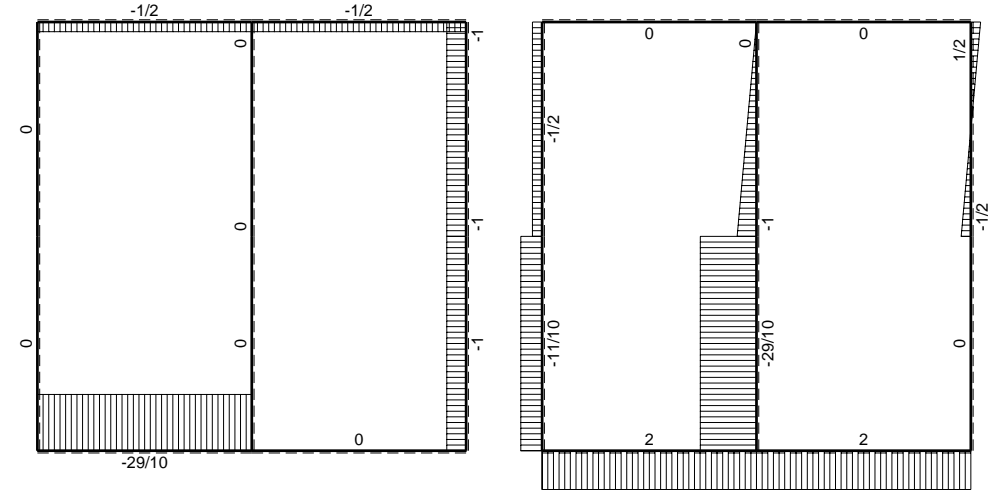
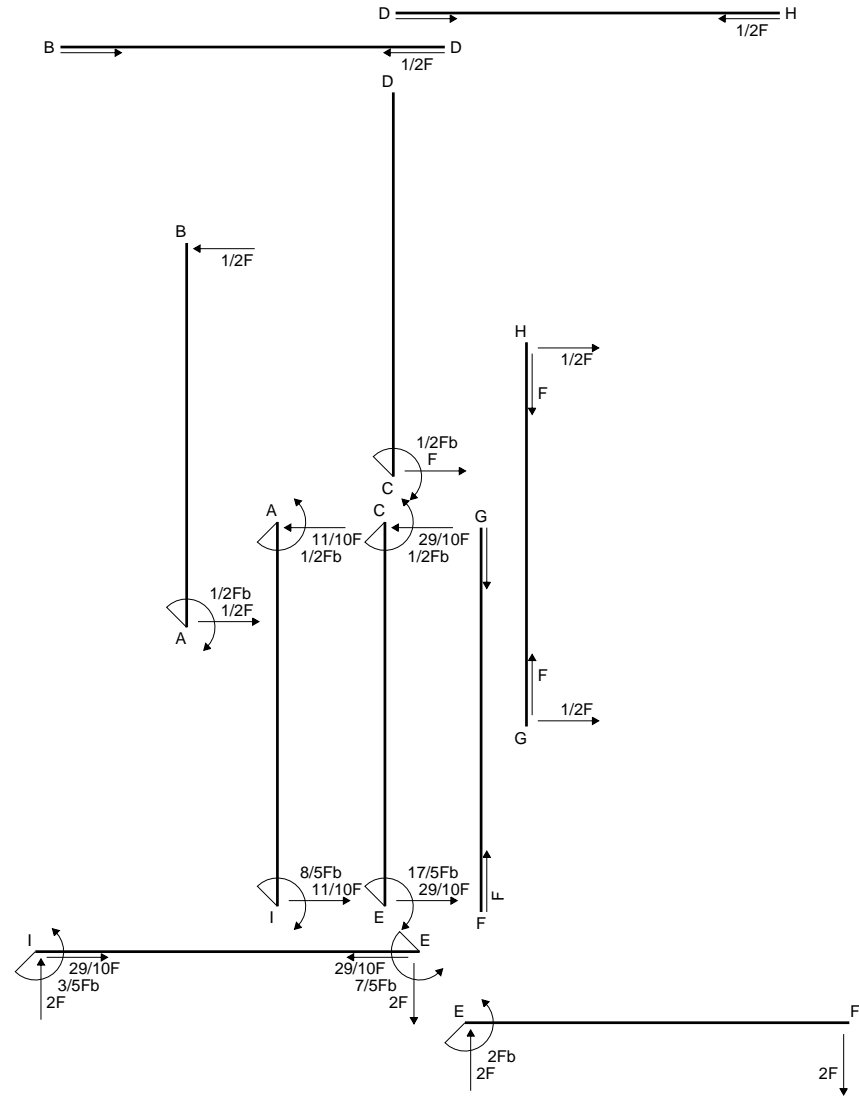
$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

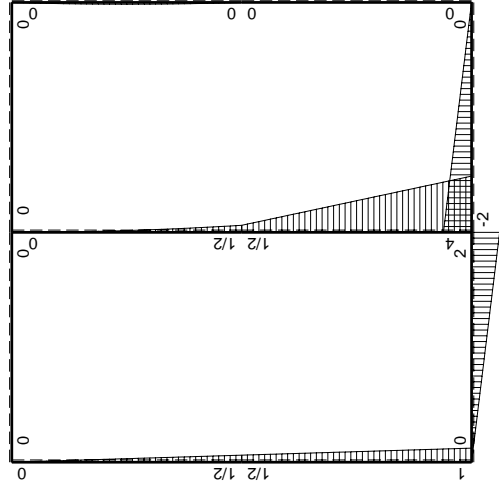
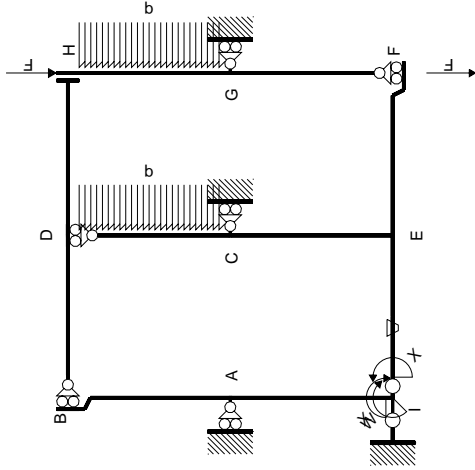
$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$




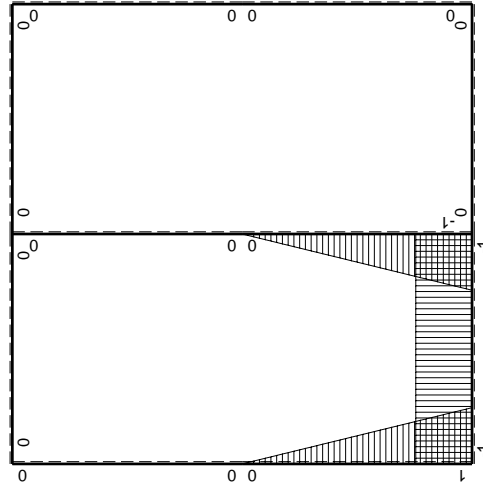
- A = 1200. mm²
- J_u = 368598. mm⁴
- J_v = 131904. mm⁴
- y_g = 34.22 mm
- T_y = 2560. N
- M_x = -2252800. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -34.22 mm
- σ_m = -Mv/J_u = -209.1 N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -22.22 mm
- σ_c = -Mv/J_u = -135.8 N/mm²
- τ_c = 3.653 N/mm²
- σ_ρ = √(σ² + 3τ²) = 136. N/mm²
- S = 6312. mm³





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

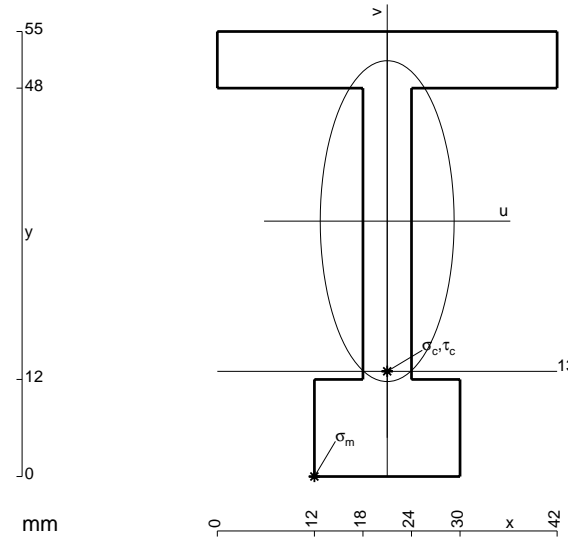
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 3/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



$$A = 726. \text{ mm}^2$$

$$J_u = 285657. \text{ mm}^4$$

$$J_v = 49698. \text{ mm}^4$$

$$y_g = 31.57 \text{ mm}$$

$$T_y = 2140. \text{ N}$$

$$M_x = -1990200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -31.57 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

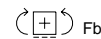
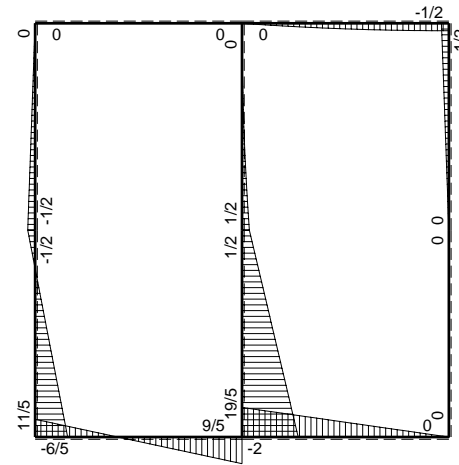
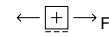
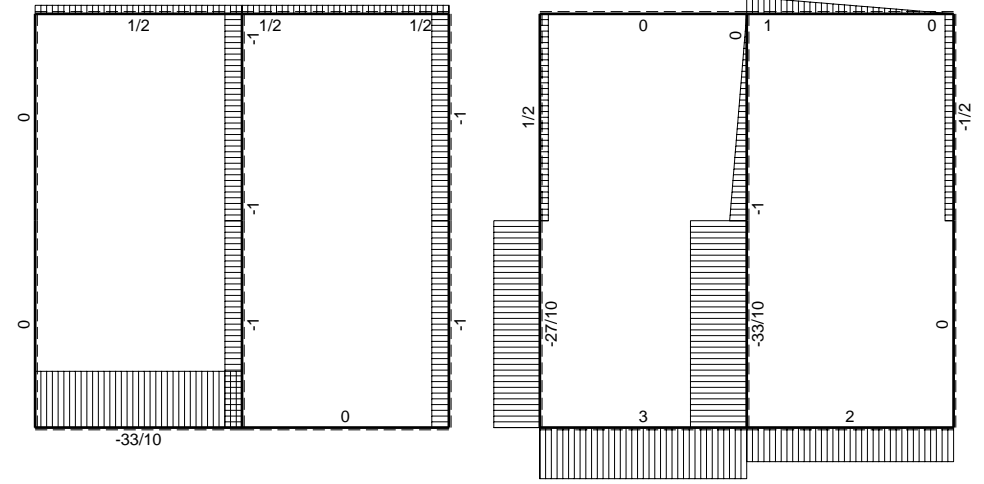
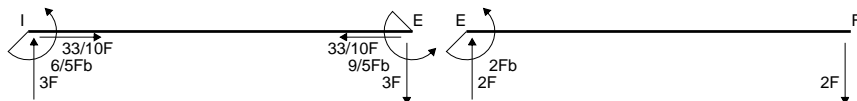
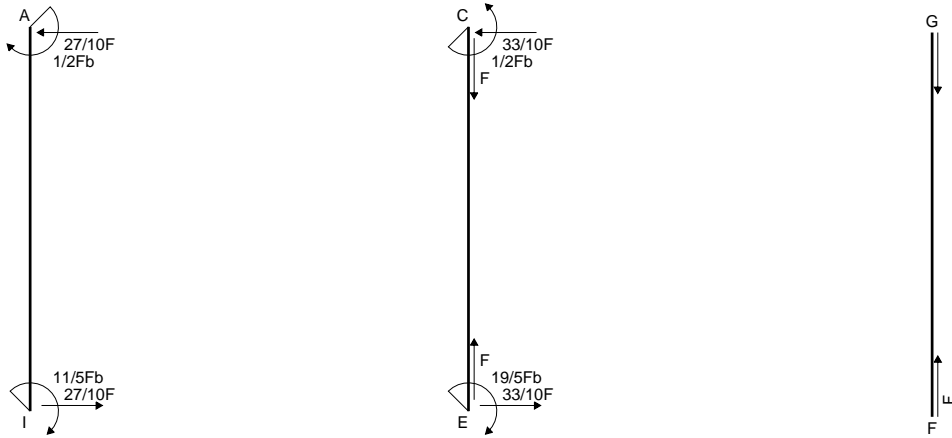
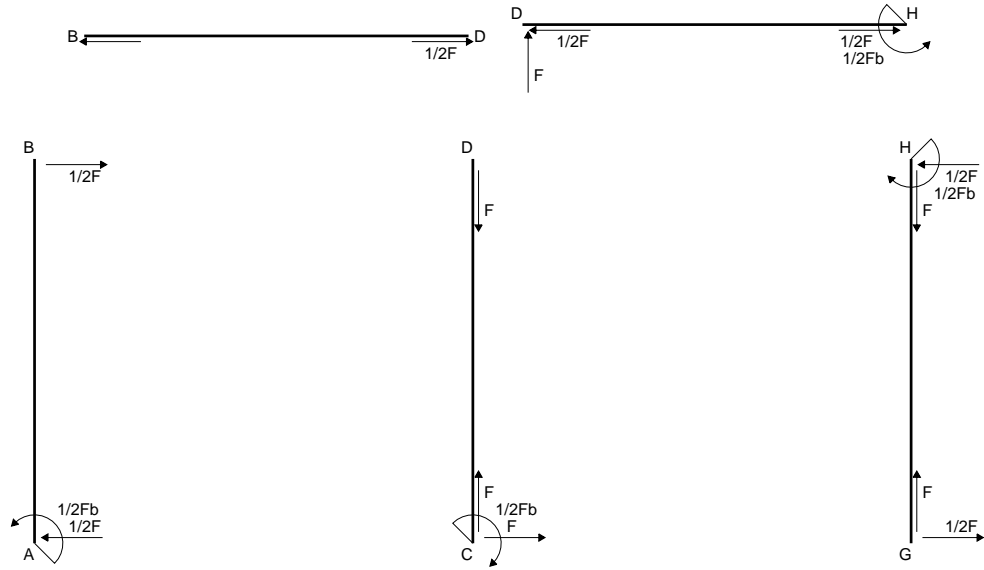
$$v_c = -18.57 \text{ mm}$$

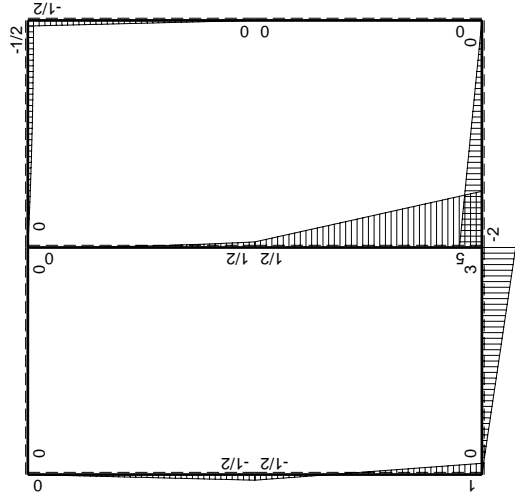
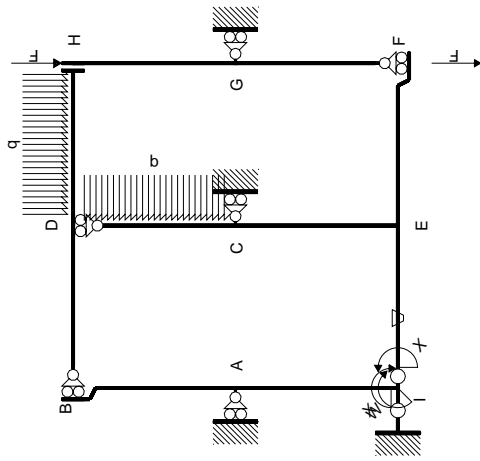
$$\sigma_c = -Mv/J_u = -129.4 \text{ N/mm}^2$$

$$\tau_c = 7.038 \text{ N/mm}^2$$

$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 129.9 \text{ N/mm}^2$$

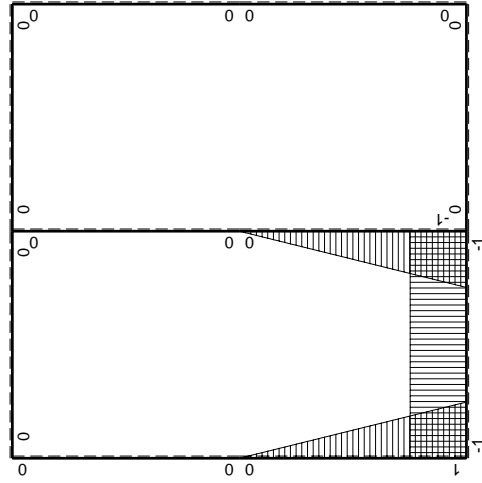
$$S = 5637. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

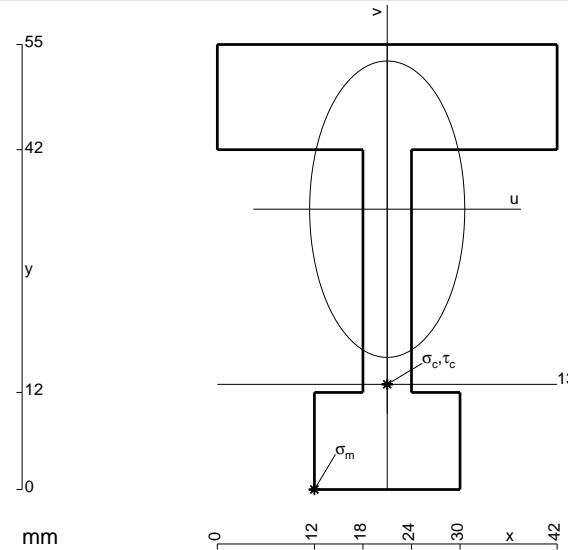
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

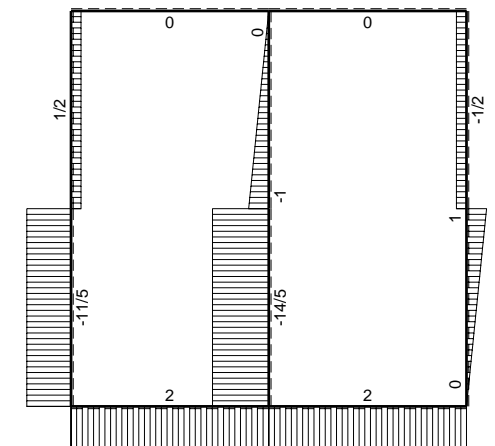
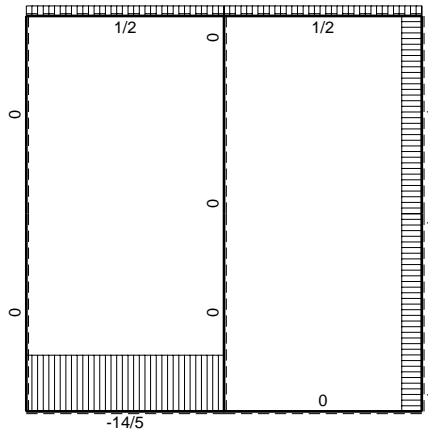
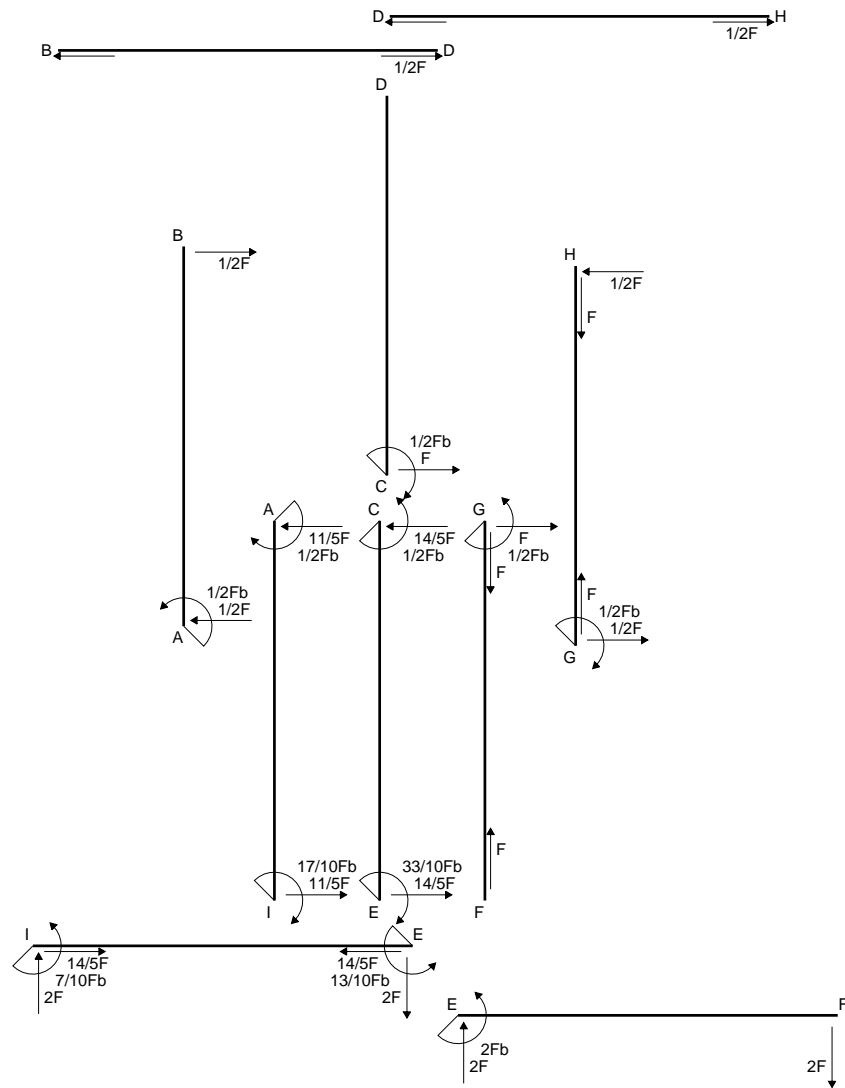
$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

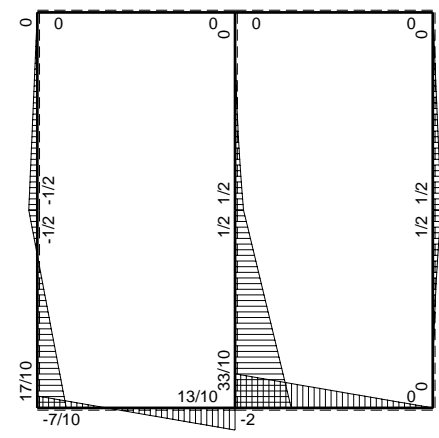


- A = 942. mm²
- J_u = 316348. mm⁴
- J_v = 86634. mm⁴
- y_g = 34.65 mm
- T_y = 2120. N
- M_x = -2098800. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -34.65 mm
- σ_m = -Mv/J_u = -229.9 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -21.65 mm
- σ_c = -Mv/J_u = -143.6 N/mm²
- τ_c = 7.059 N/mm²
- σ_o = √σ² + 3τ² = 144.1 N/mm²
- S = 6321. mm³

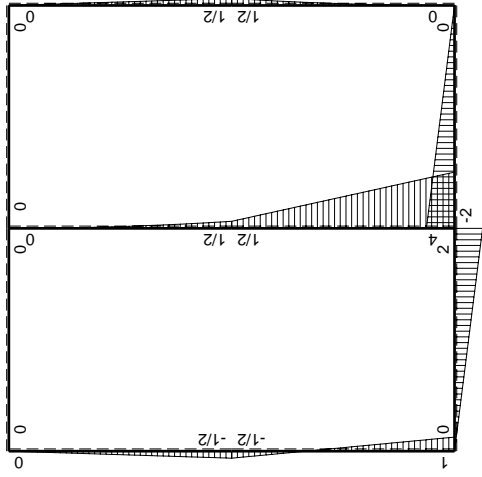
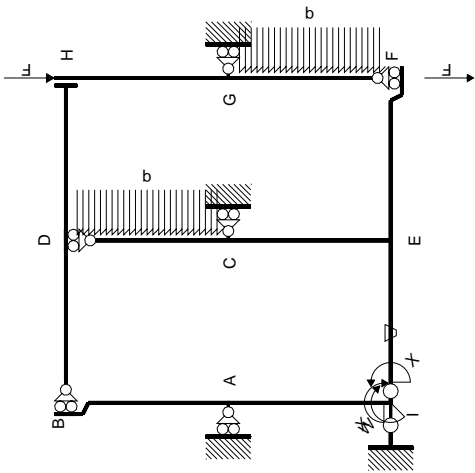


← ⊕ → F

↑ ⊕ ↓ F

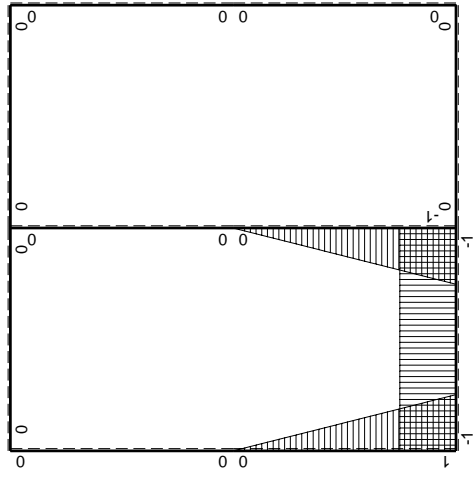


⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 15/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

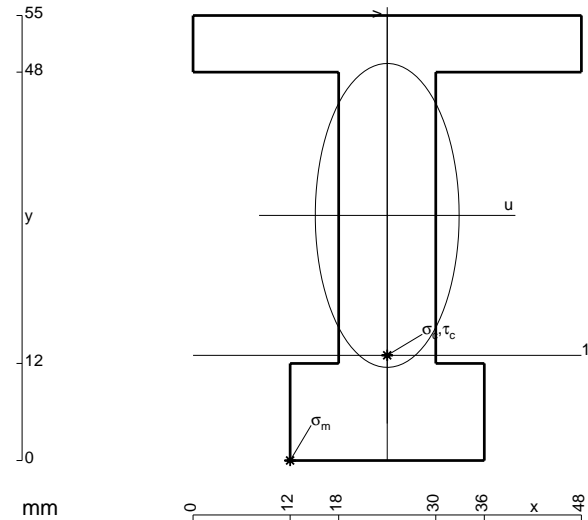
$$= (-1/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [x - 5/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 5/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$



$$A = 1056. \text{ mm}^2$$

$$J_u = 372596. \text{ mm}^4$$

$$J_v = 83520. \text{ mm}^4$$

$$y_g = 30.3 \text{ mm}$$

$$T_y = 2820. \text{ N}$$

$$M_x = -2932800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.3 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -238.5 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

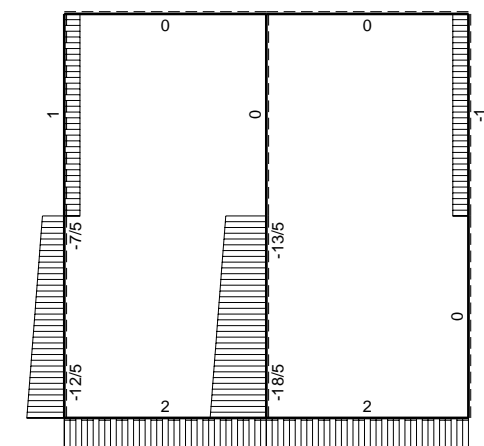
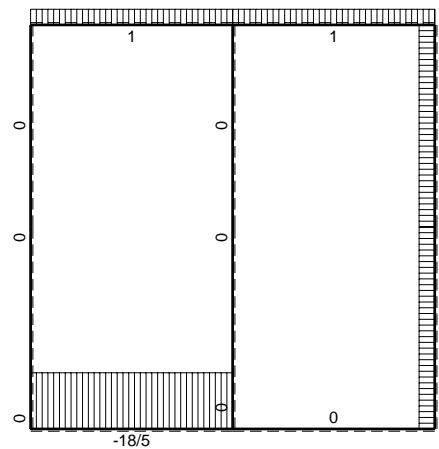
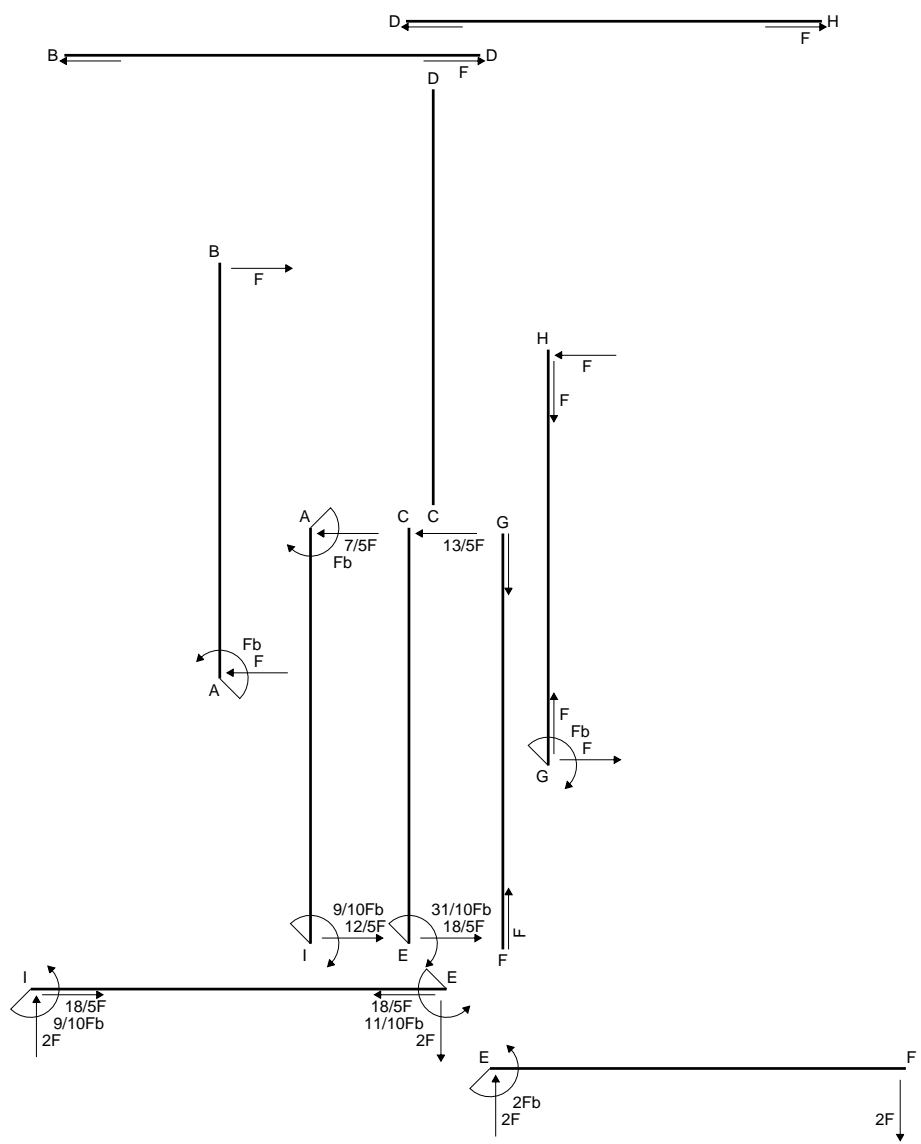
$$v_c = -17.3 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -136.1 \text{ N/mm}^2$$

$$\tau_c = 4.548 \text{ N/mm}^2$$

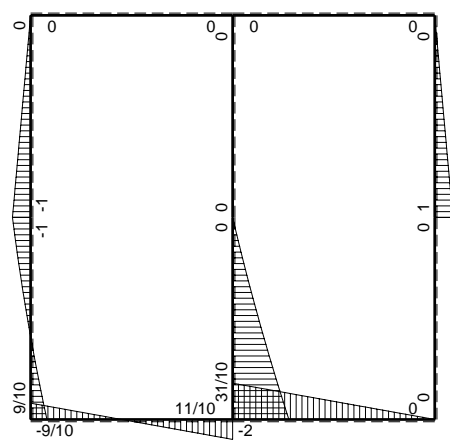
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 136.4 \text{ N/mm}^2$$

$$S = 7211. \text{ mm}^3$$

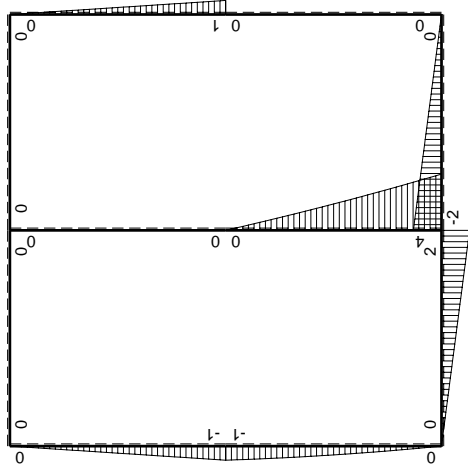
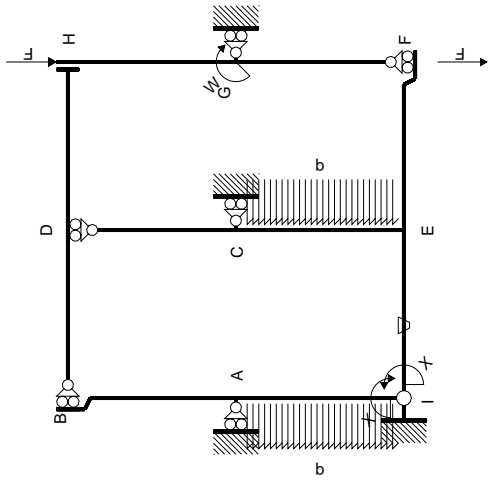


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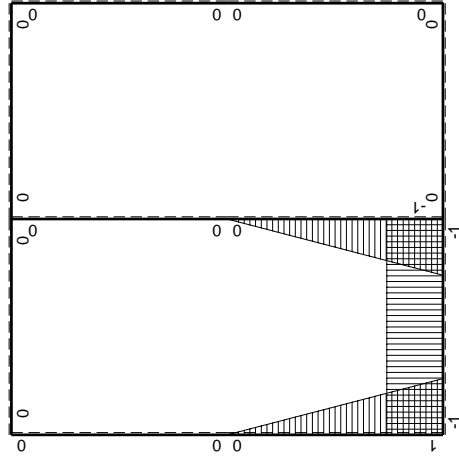


⊕ ⊖ F_b



Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M₁ flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fb+Fx	0	0	0	0	0+0	0	
BA b	0	Fx	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	Fb-Fx	0	0	0	0	0+0	0	
HG b	0	-Fx	0	0	0	0			
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ	
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1			
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2			
IA b	$1-x/b$	$-3/2Fx+1/2qx^2$	0	$-3/2Fx+2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-5/24+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$Fb-1/2Fx-1/2qx^2$	0	$-Fx+1/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2			
	totali							$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= [-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-7/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

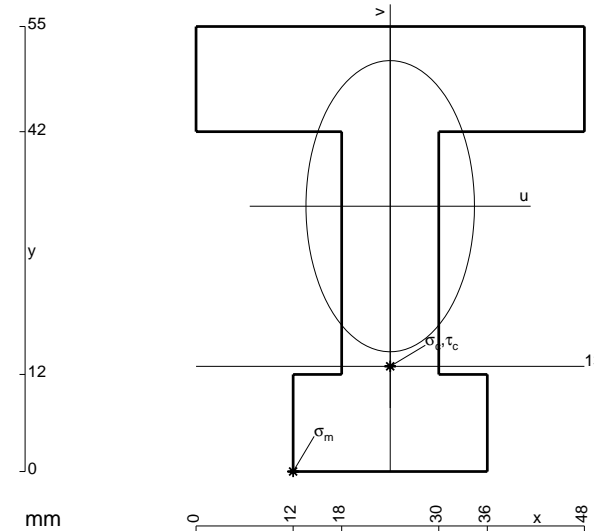
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 2x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 2/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 2/3 b - 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + 1/2 x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/6 b + 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$



$$A = 1272. \text{ mm}^2$$

$$J_u = 412017. \text{ mm}^4$$

$$J_v = 137952. \text{ mm}^4$$

$$y_g = 32.79 \text{ mm}$$

$$T_y = 4560. \text{ N}$$

$$M_x = -2508000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -32.79 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

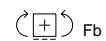
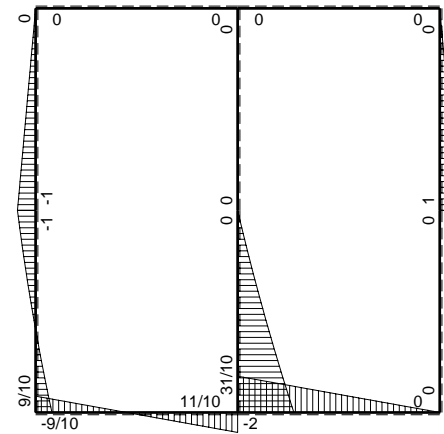
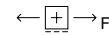
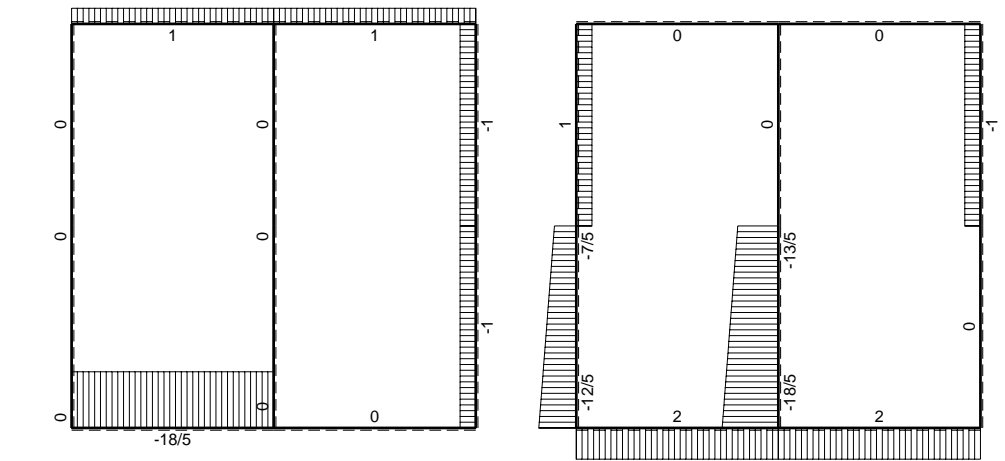
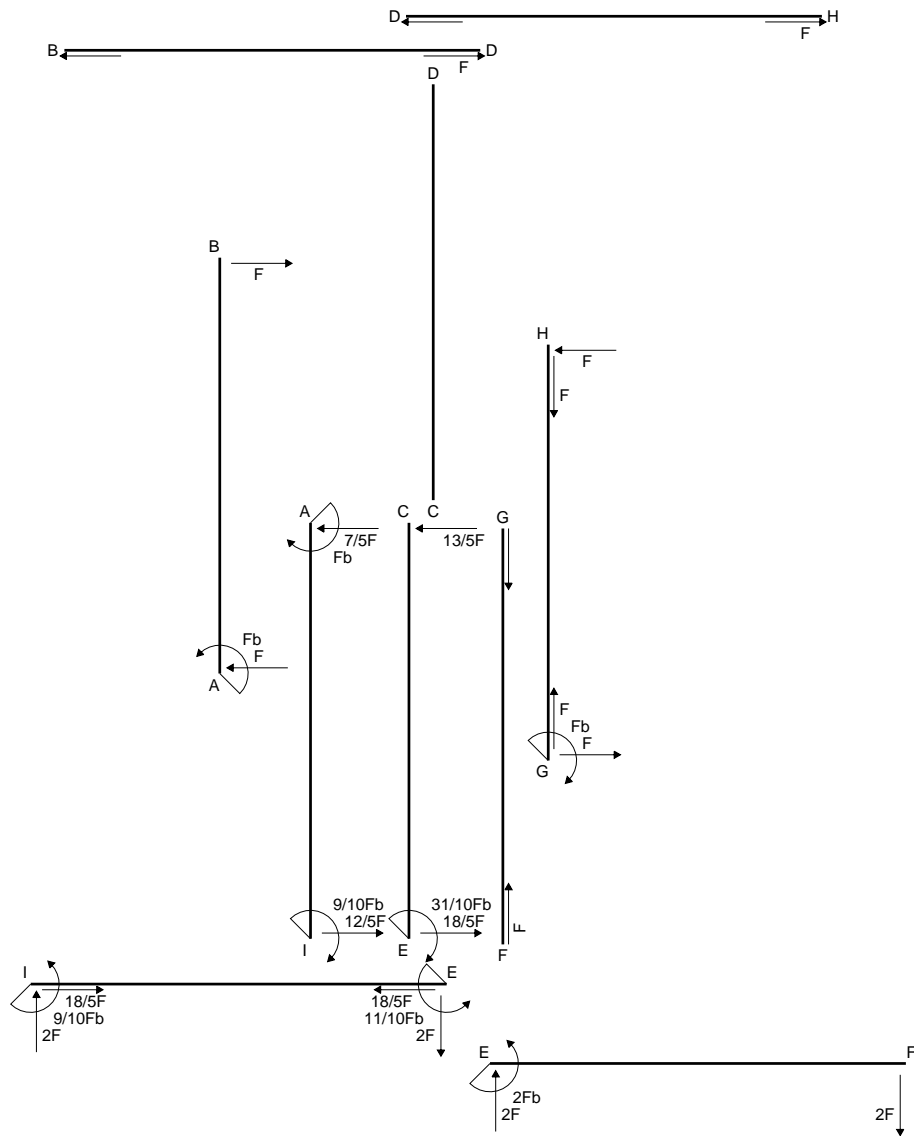
$$v_c = -19.79 \text{ mm}$$

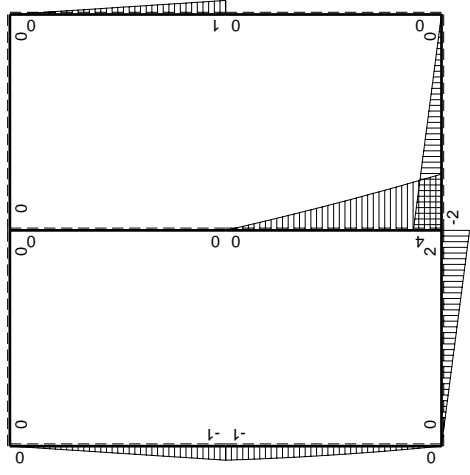
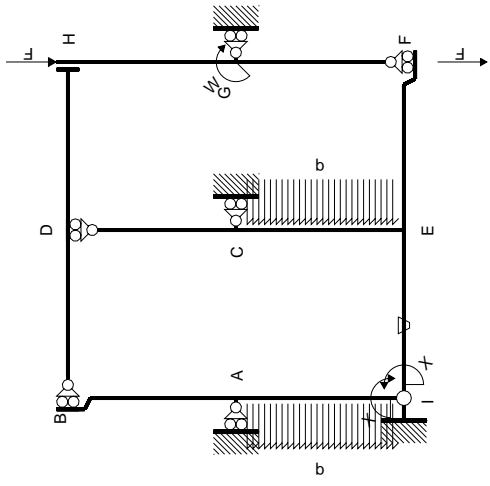
$$\sigma_c = -Mv/J_u = -120.5 \text{ N/mm}^2$$

$$\tau_c = 7.341 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 121.1 \text{ N/mm}^2$$

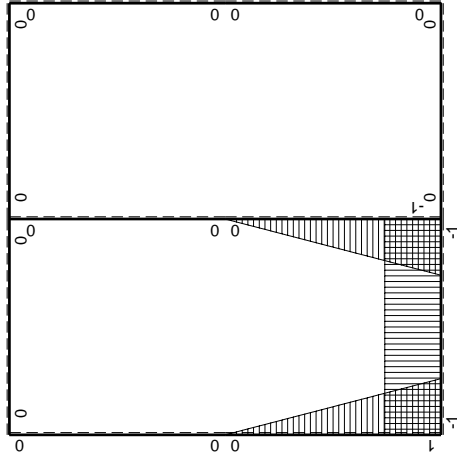
$$S = 7960. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	1/3Xb/EJ
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx+1/2qx^2$	0	$-3/2Fx+2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-5/24+0)Fb^2/EJ$	1/3Xb/EJ
AI b	$-x/b$	$Fb-1/2Fx-1/2qx^2$	0	$-Fx+1/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	5/3Xb/EJ
	iperstatica $X=W_{IE}$						9/10Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= [-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-7/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

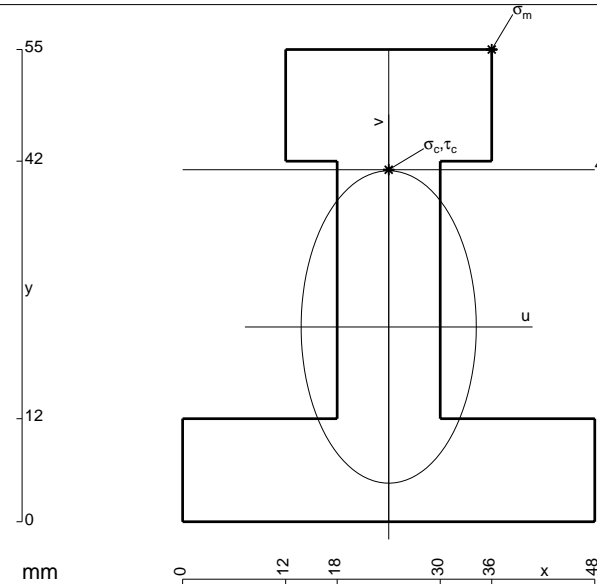
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 2x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 2/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

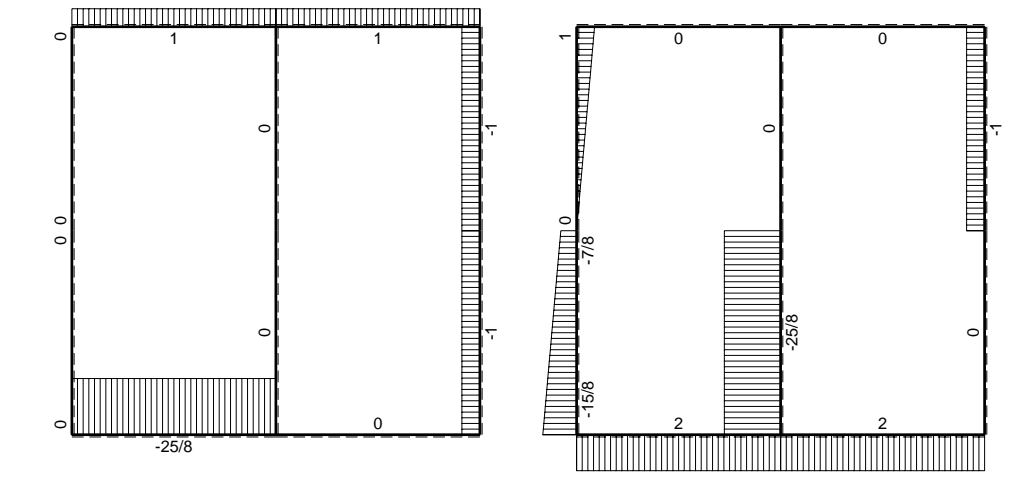
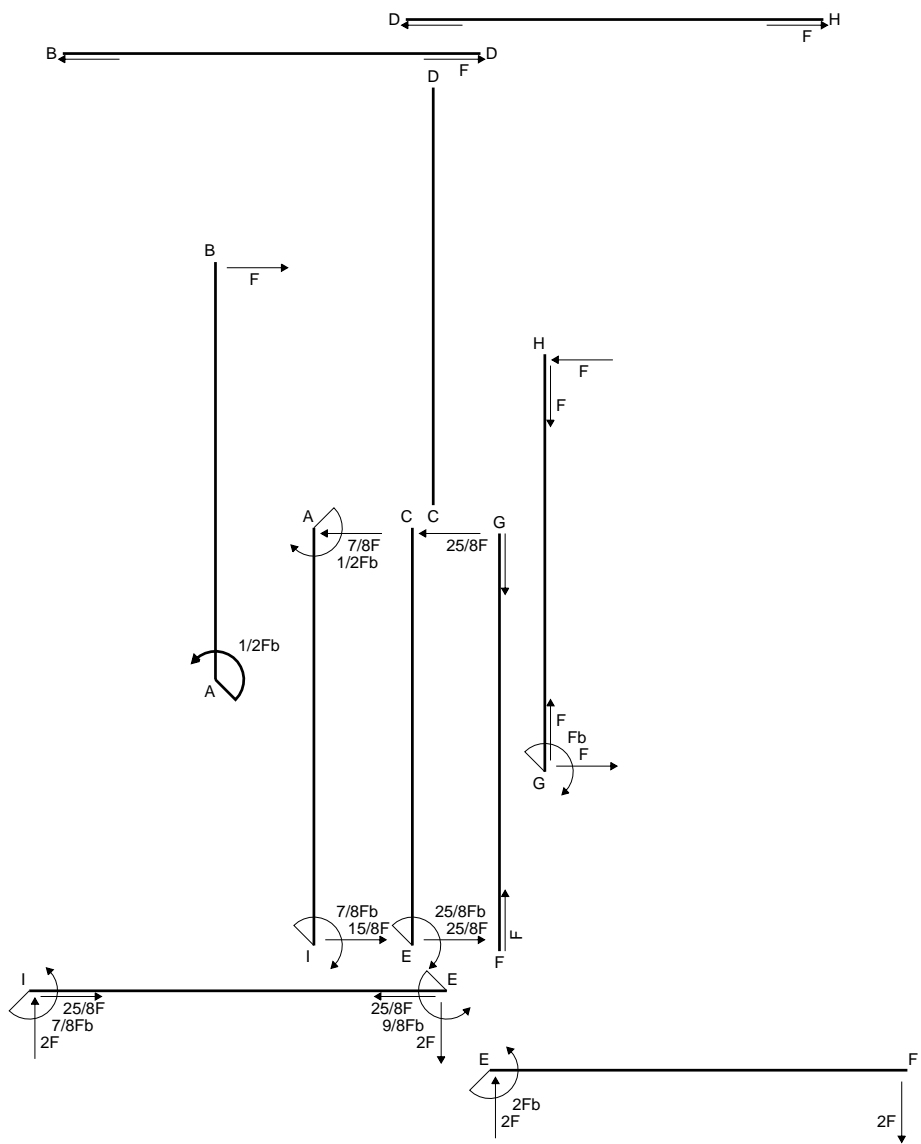
$$= (-3/4 b + 2/3 b - 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + 1/2 x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/6 b + 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

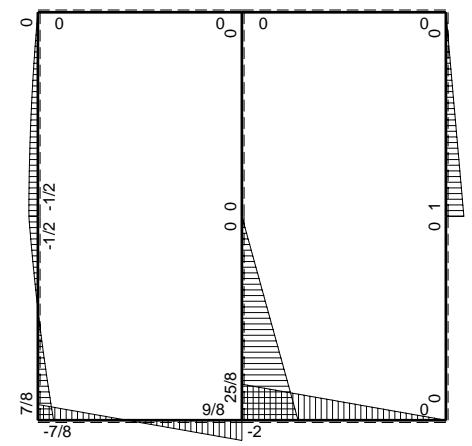


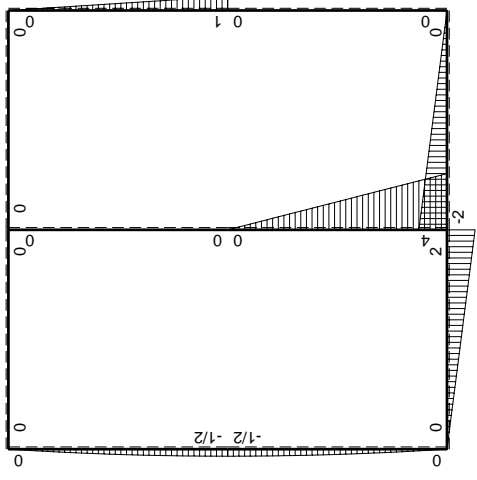
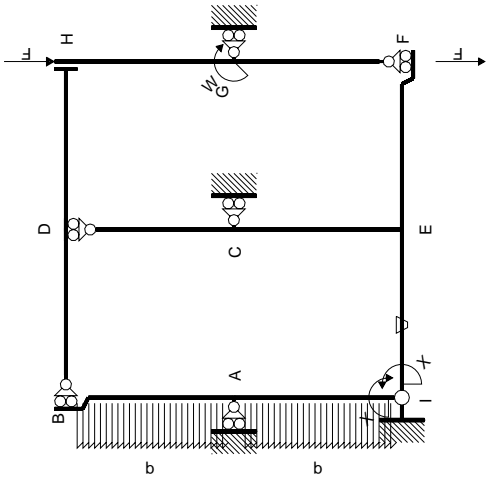
- A = 1248. mm²
- J_u = 413282. mm⁴
- J_v = 129888. mm⁴
- y_g = 22.68 mm
- T_y = 4460. N
- M_x = -2676000. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 32.32 mm
- σ_m = -Mv/J_u = 209.3 N/mm²
- x_c = 24. mm
- y_c = 41. mm
- v_c = 18.32 mm
- σ_c = -Mv/J_u = 118.6 N/mm²
- τ_c = 7.447 N/mm²
- σ_o = √σ²+3τ² = 119.3 N/mm²
- S = 8281. mm³



← ⊕ → F

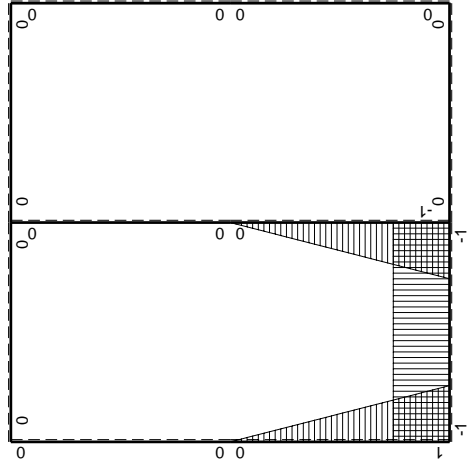
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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

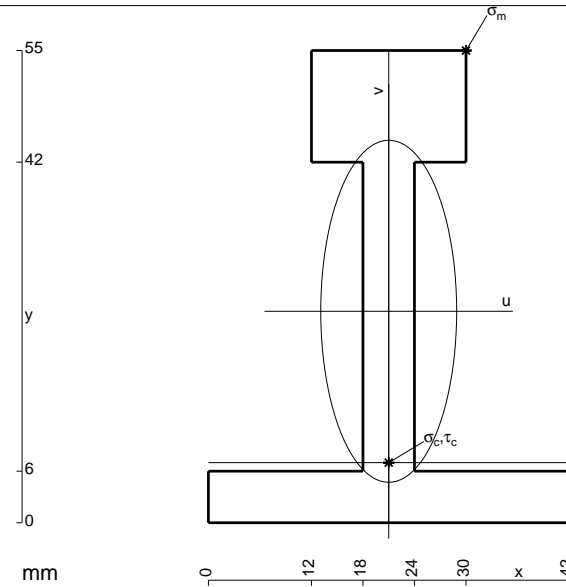
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 702. \text{ mm}^2$$

$$J_u = 278693. \text{ mm}^4$$

$$J_v = 44010. \text{ mm}^4$$

$$y_g = 24.63 \text{ mm}$$

$$T_y = 3040. \text{ N}$$

$$M_x = -2006400. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 30.37 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 218.7 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 7. \text{ mm}$$

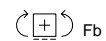
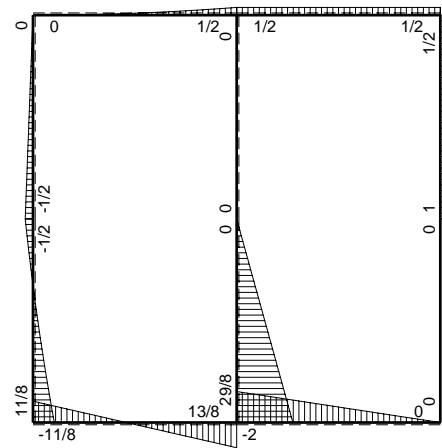
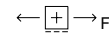
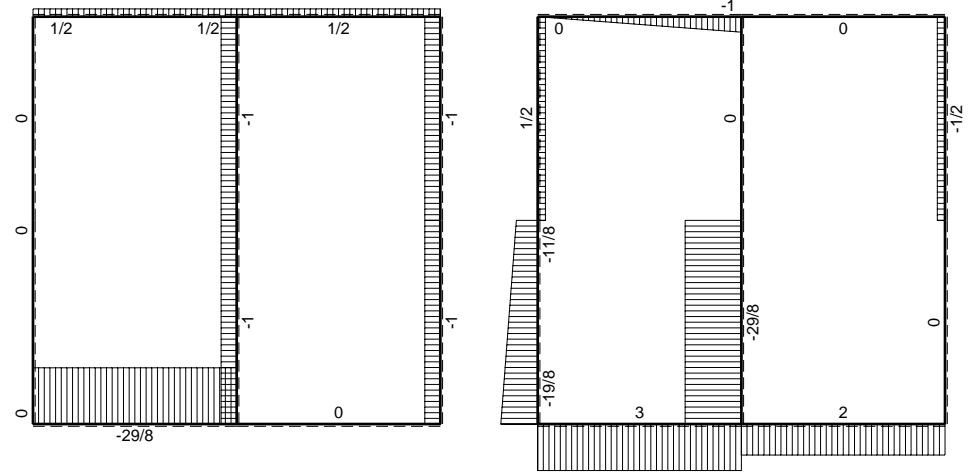
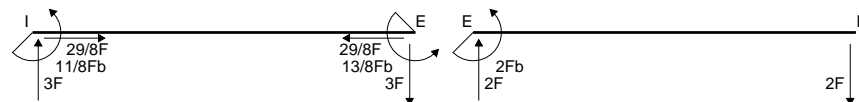
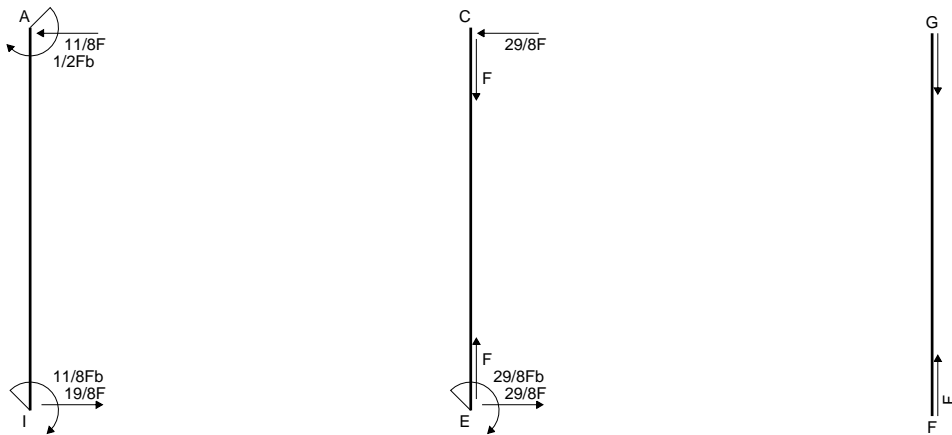
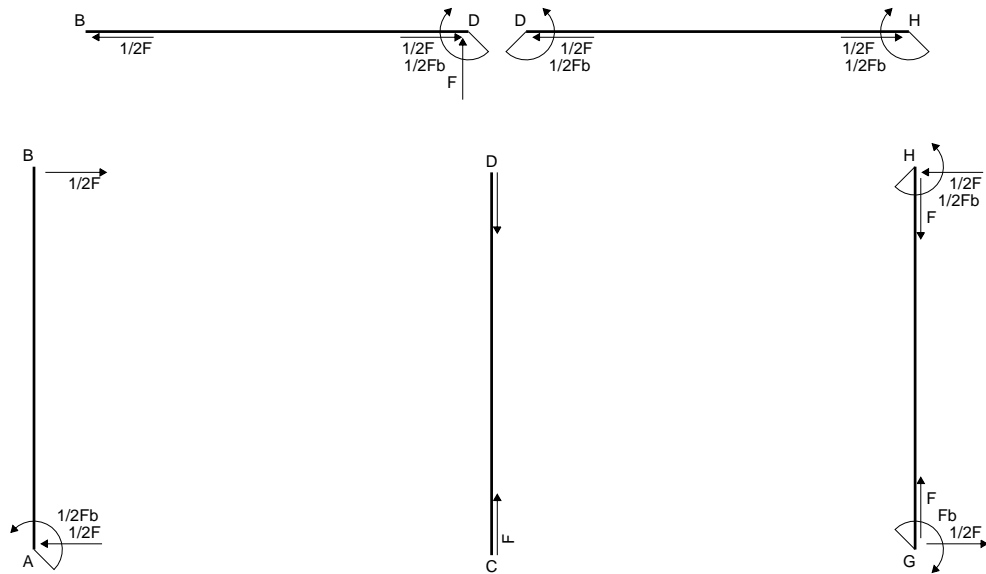
$$v_c = -17.63 \text{ mm}$$

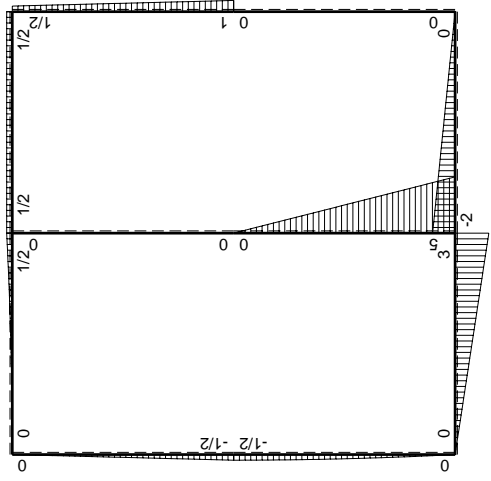
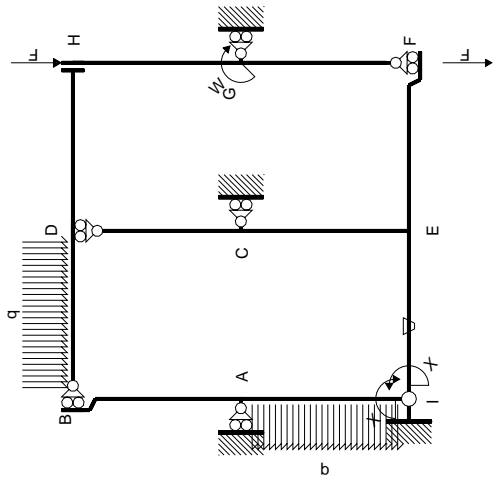
$$\sigma_c = -Mv/J_u = -126.9 \text{ N/mm}^2$$

$$\tau_c = 10.11 \text{ N/mm}^2$$

$$\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 128.1 \text{ N/mm}^2$$

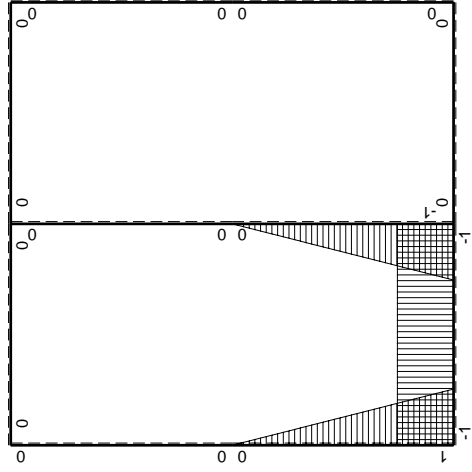
$$S = 5559. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fb+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

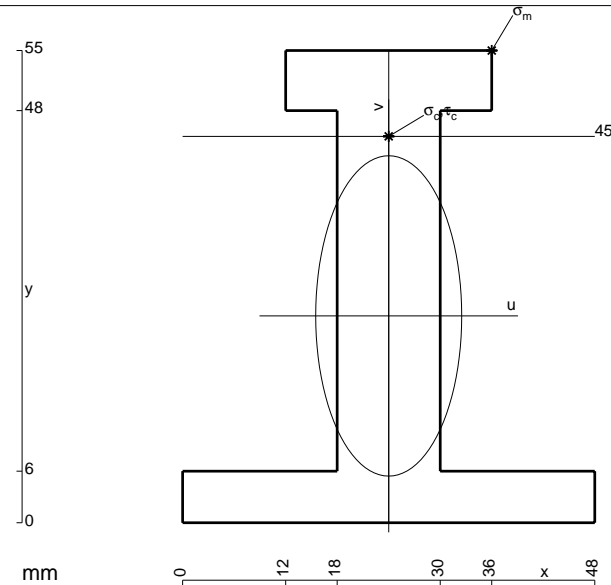
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

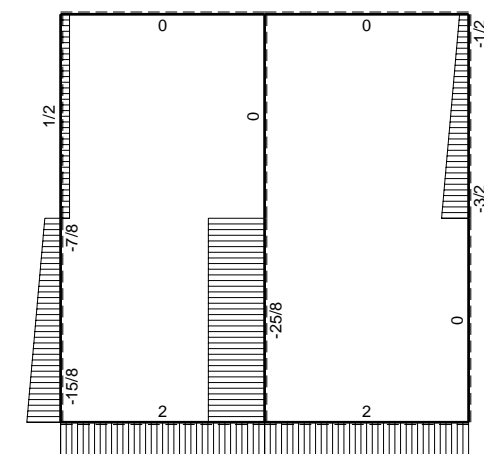
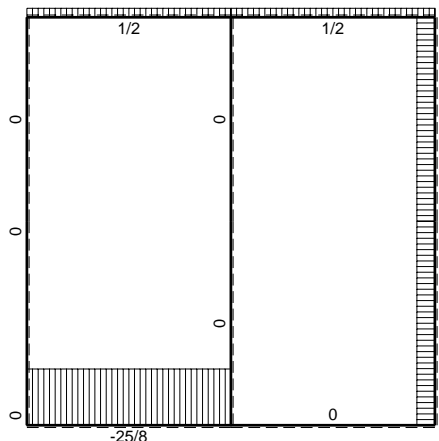
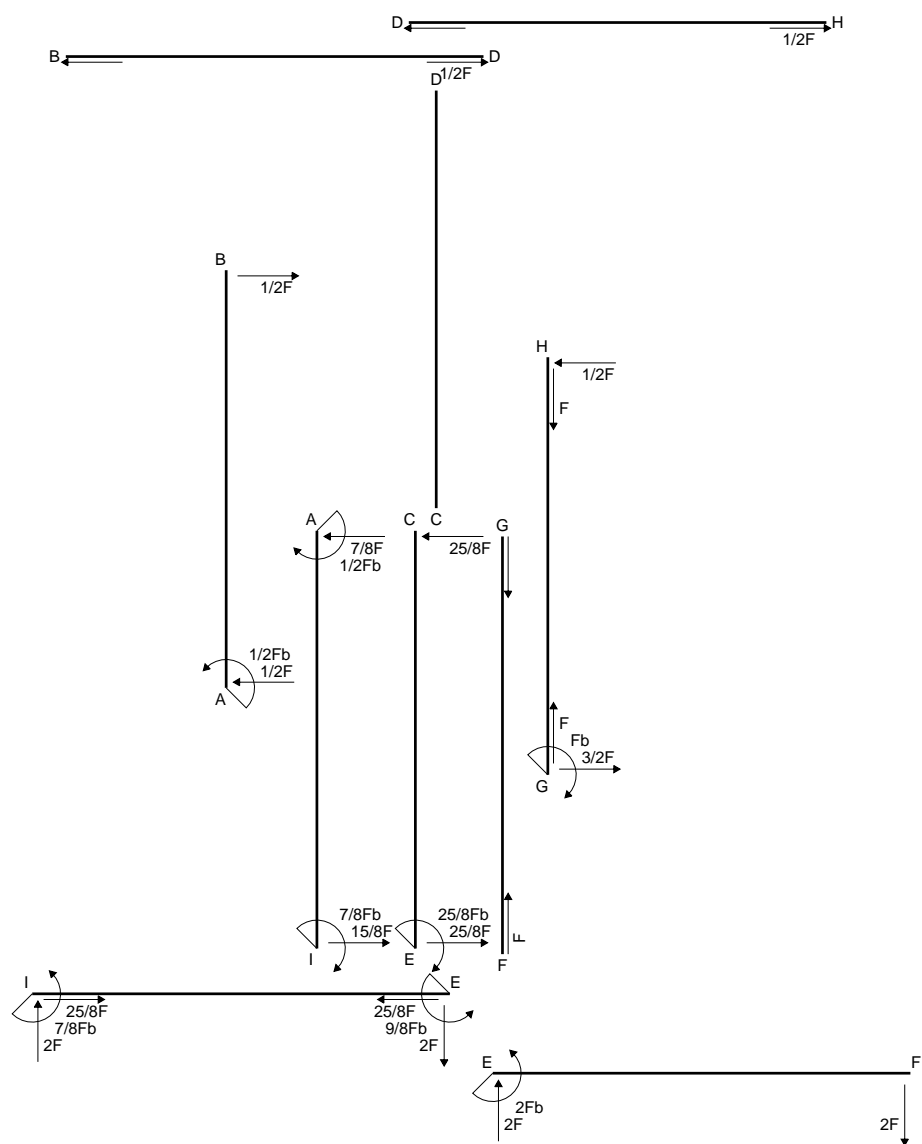
$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

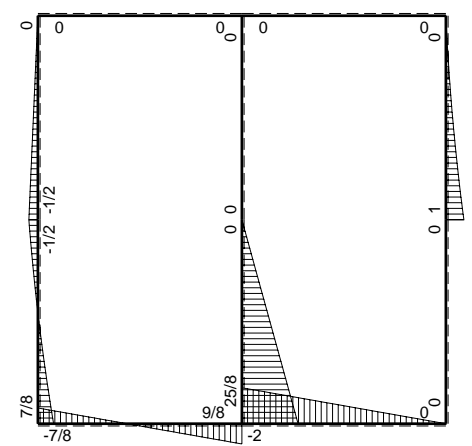


- A = 960. mm²
- J_u = 334225. mm⁴
- J_v = 69408. mm⁴
- y_g = 24.09 mm
- T_y = 3500. N
- M_x = -2485000. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 30.91 mm
- σ_m = -Mv/J_u = 229.8 N/mm²
- x_c = 24. mm
- y_c = 45. mm
- v_c = 20.91 mm
- σ_c = -Mv/J_u = 155.5 N/mm²
- τ_c = 4.723 N/mm²
- σ_q = √σ²+3τ² = 155.7 N/mm²
- S = 5412. mm³

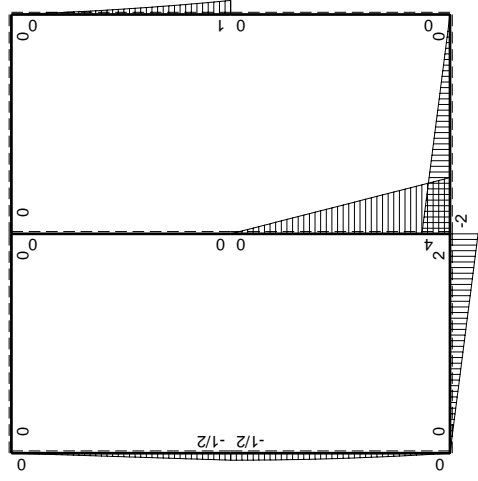
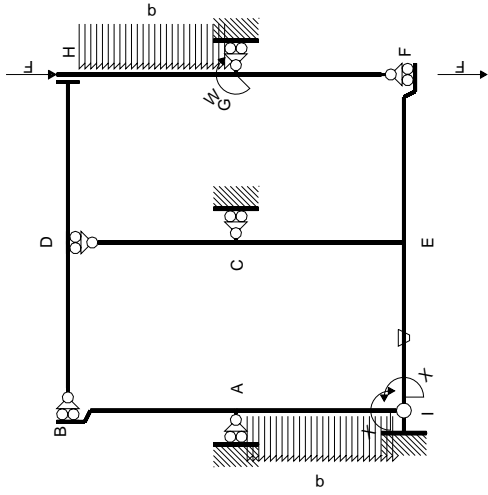


← ⊕ → F

↑ ⊕ ↓ F

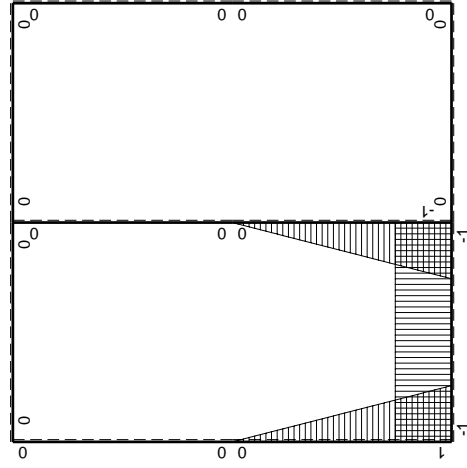


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

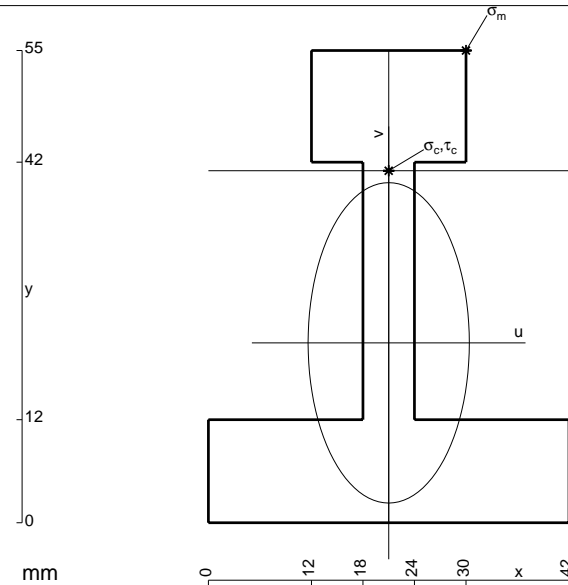
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

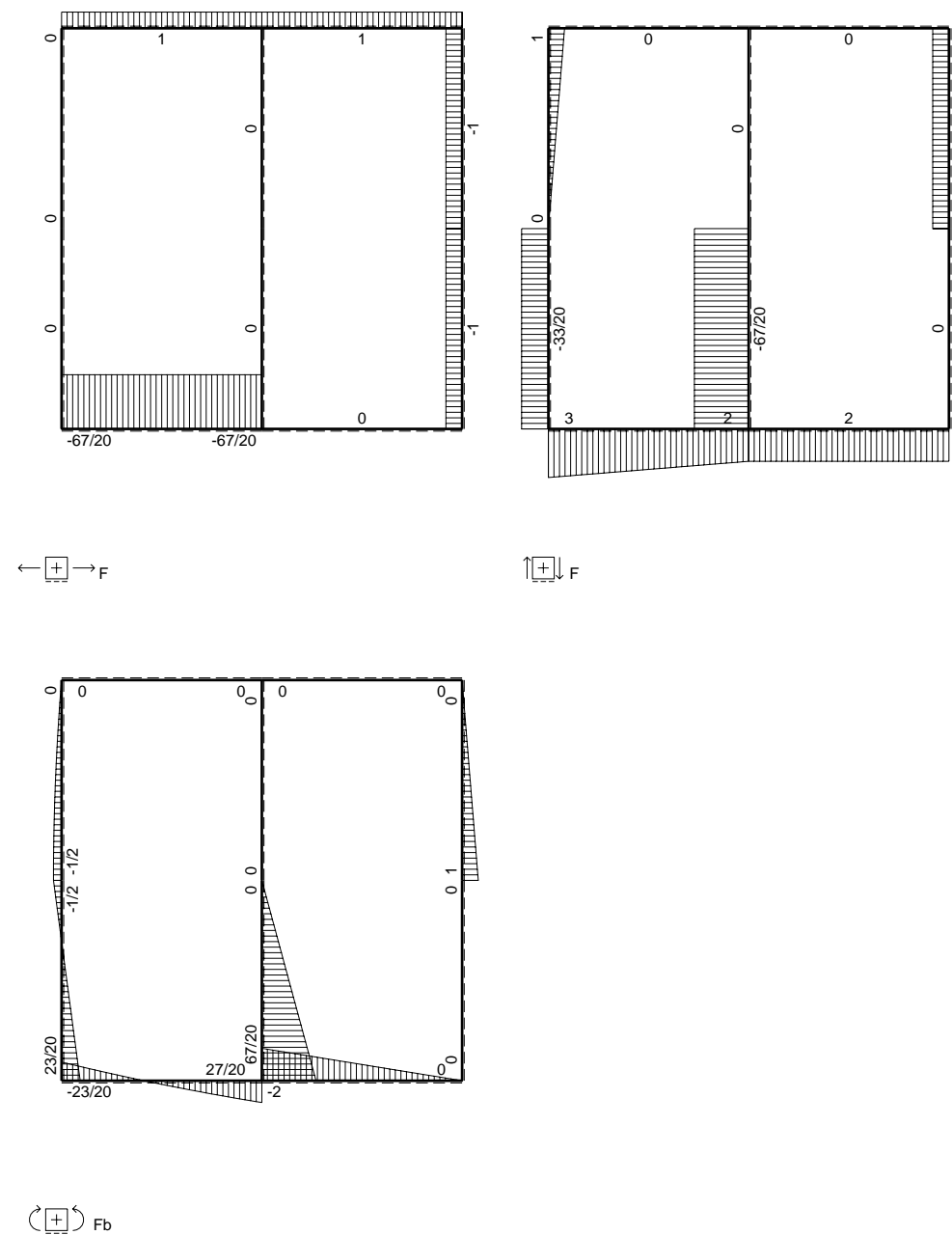
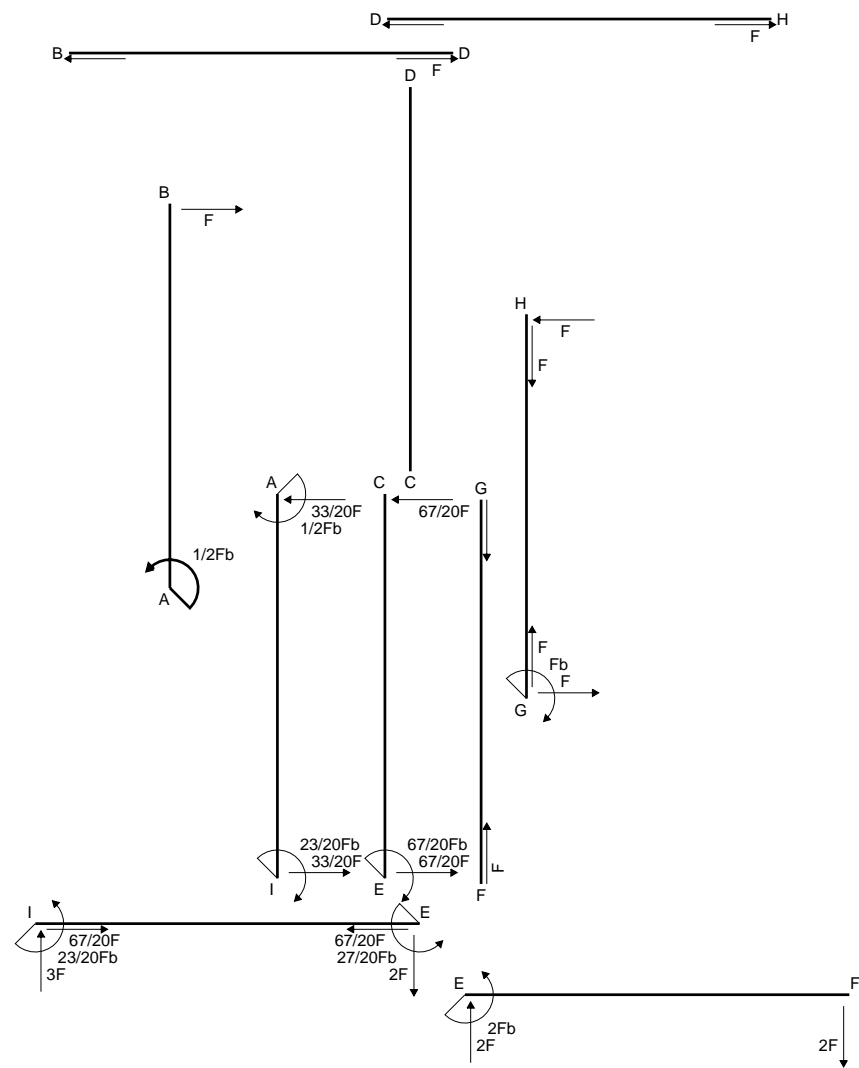
$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

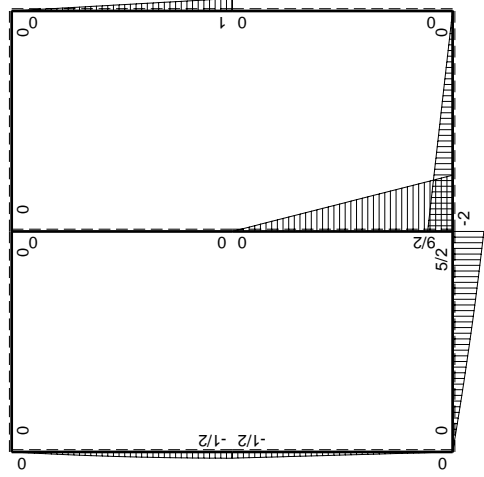
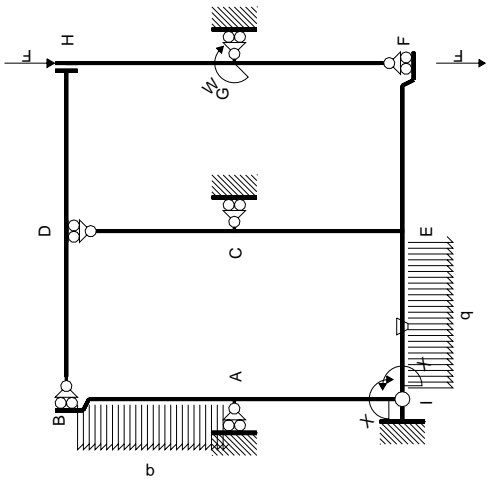
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



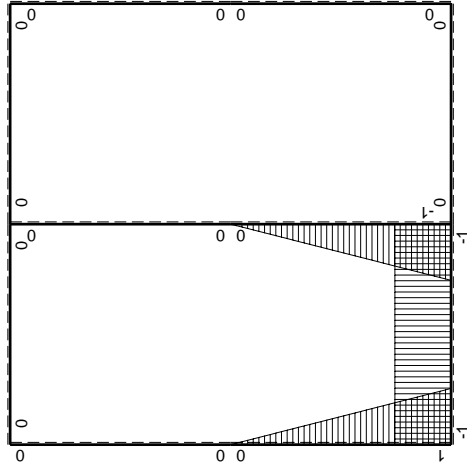
- A = 918. mm²
- J_u = 319684. mm⁴
- J_v = 80946. mm⁴
- y_g = 20.95 mm
- T_y = 2920. N
- M_x = -2248400. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 34.05 mm
- σ_m = -Mv/J_u = 239.5 N/mm²
- x_c = 21. mm
- y_c = 41. mm
- v_c = 20.05 mm
- σ_c = -Mv/J_u = 141. N/mm²
- τ_c = 10. N/mm²
- σ_q = √σ²+3τ² = 142.1 N/mm²
- S = 6570. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

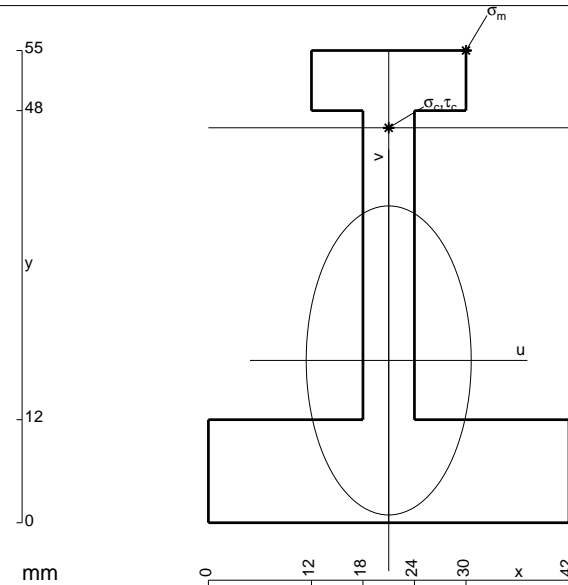
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

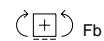
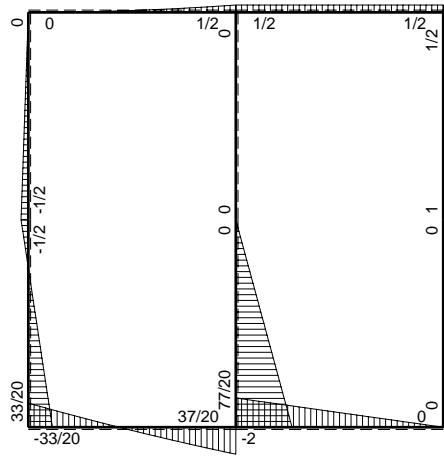
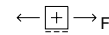
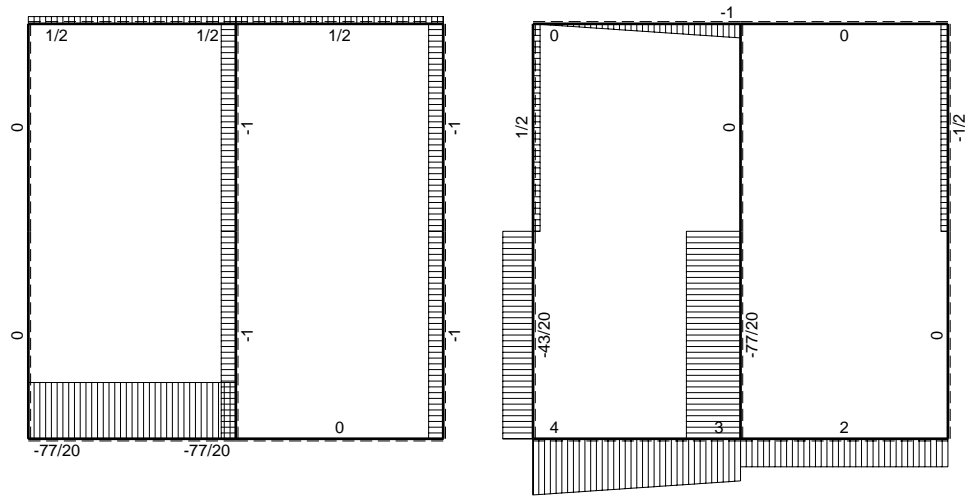
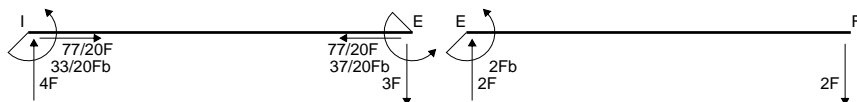
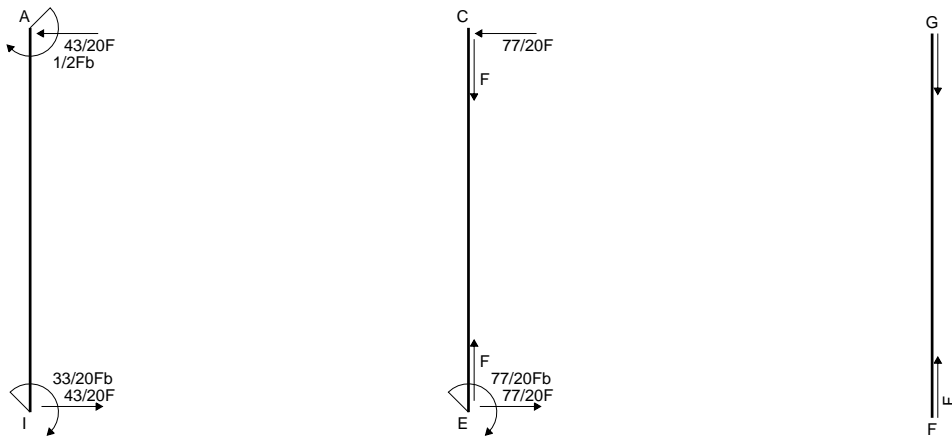
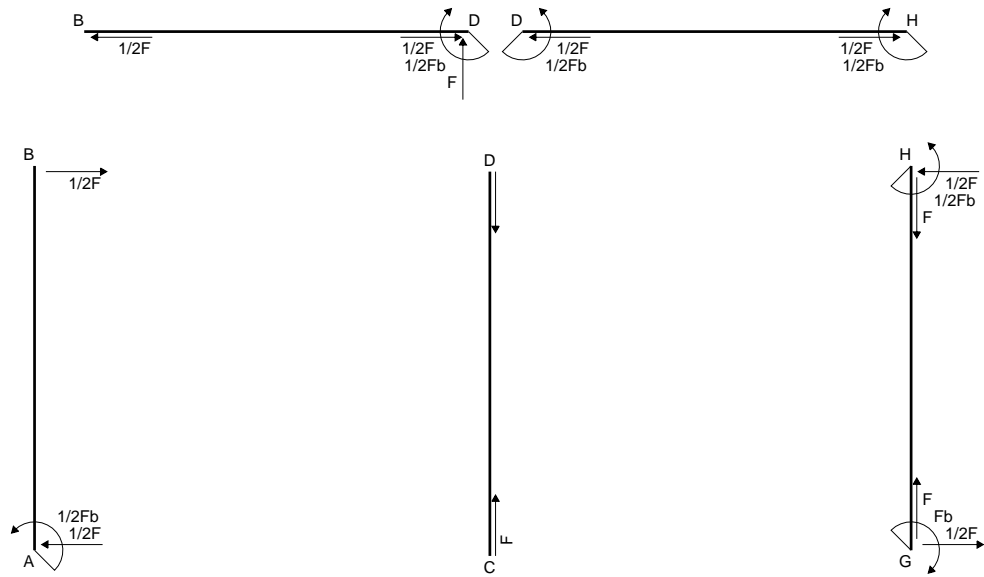
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

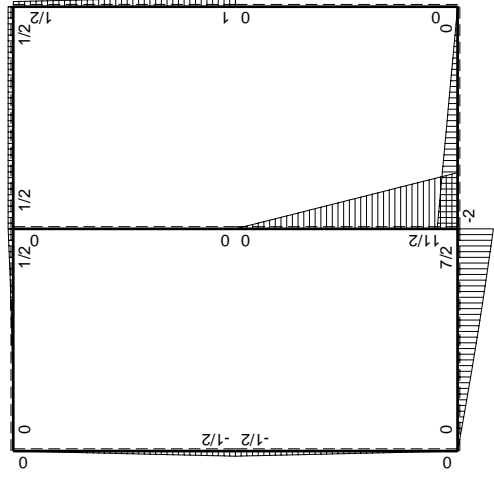
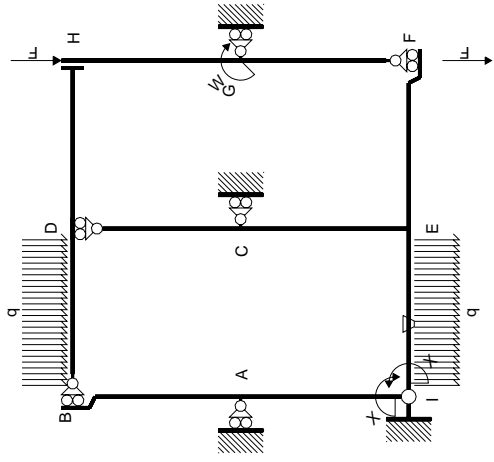
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



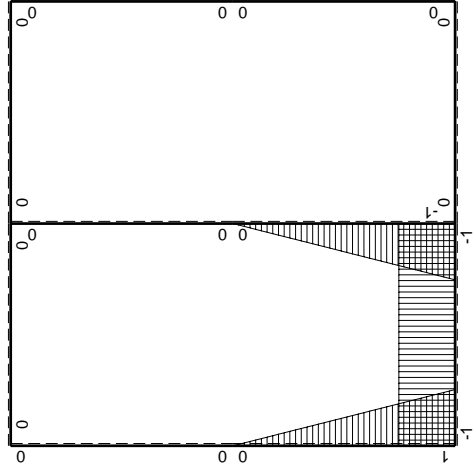
- A = 846. mm²
- J_u = 274282. mm⁴
- J_v = 78138. mm⁴
- y_g = 18.9 mm
- T_y = 1840. N
- M_x = -1508800. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 36.1 mm
- σ_m = -Mv/J_u = 198.6 N/mm²
- x_c = 21. mm
- y_c = 46. mm
- v_c = 27.1 mm
- σ_c = -Mv/J_u = 149.1 N/mm²
- τ_c = 4.969 N/mm²
- σ_q = √σ²+3τ² = 149.3 N/mm²
- S = 4444. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

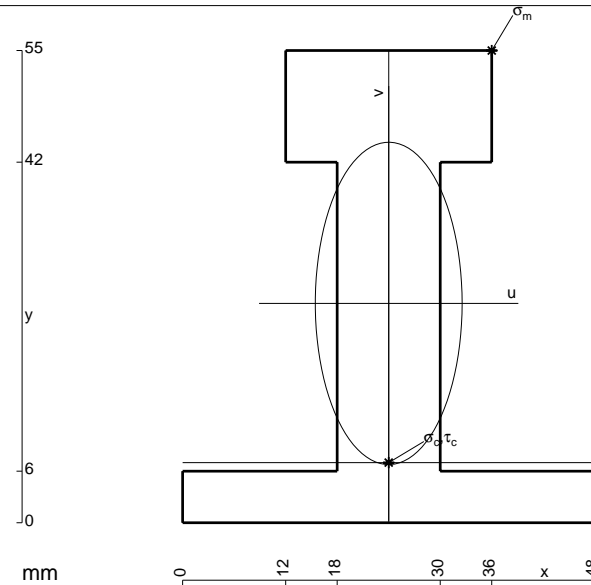
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1032. \text{ mm}^2$$

$$J_u = 363732. \text{ mm}^4$$

$$J_v = 75456. \text{ mm}^4$$

$$y_g = 25.55 \text{ mm}$$

$$T_y = 2940. \text{ N}$$

$$M_x = -2587200. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 29.45 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.5 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 7. \text{ mm}$$

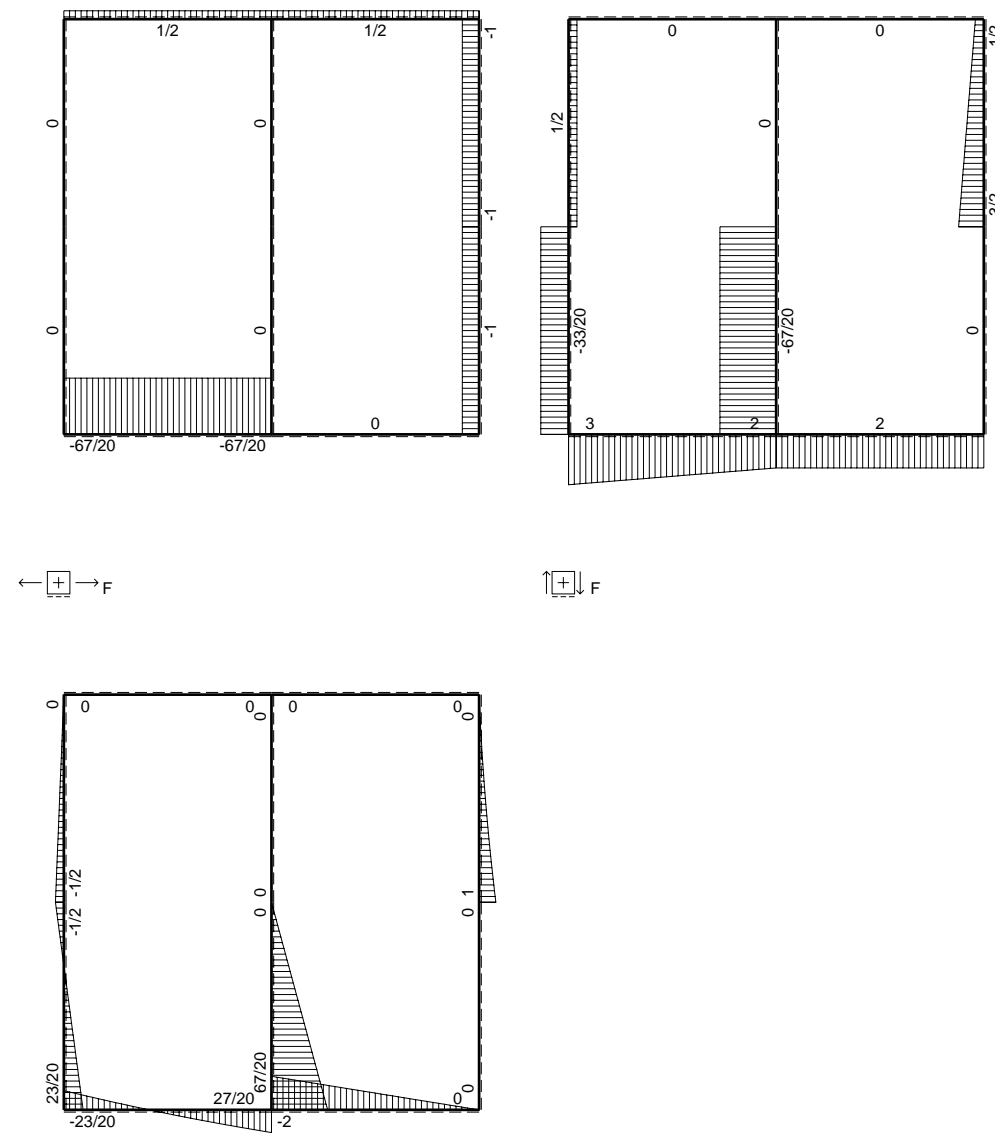
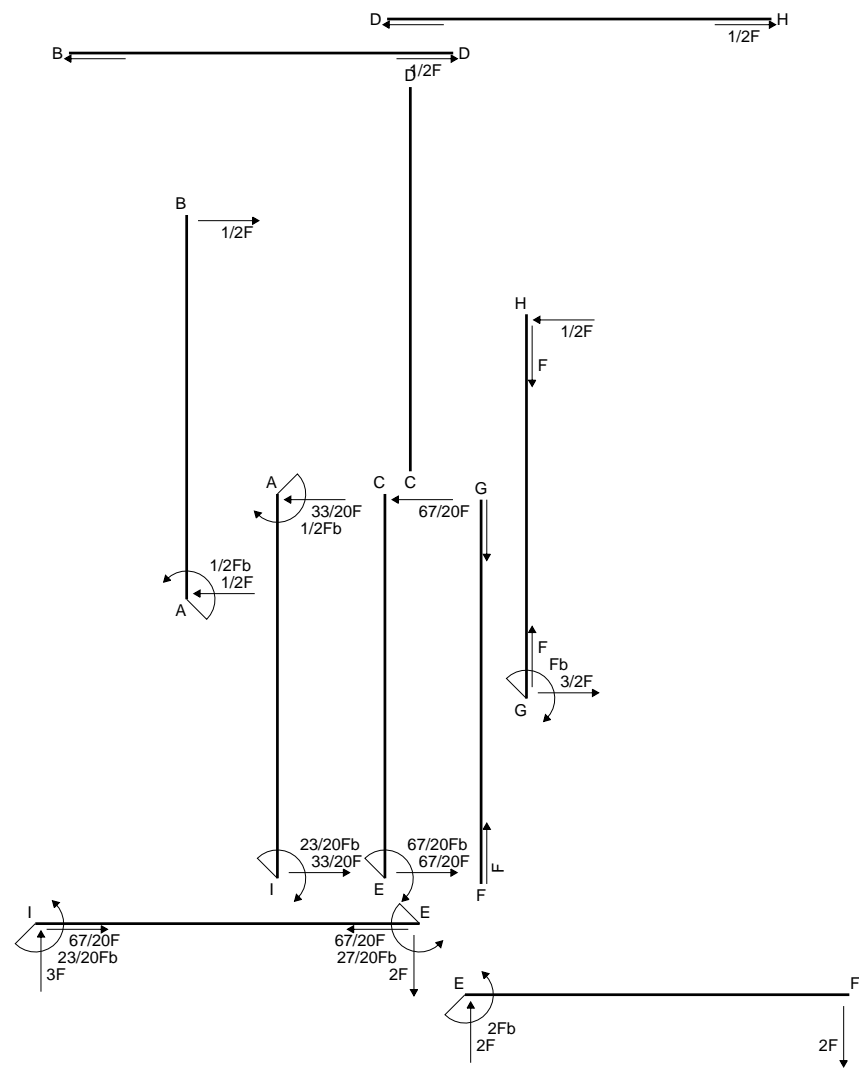
$$v_c = -18.55 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -131.9 \text{ N/mm}^2$$

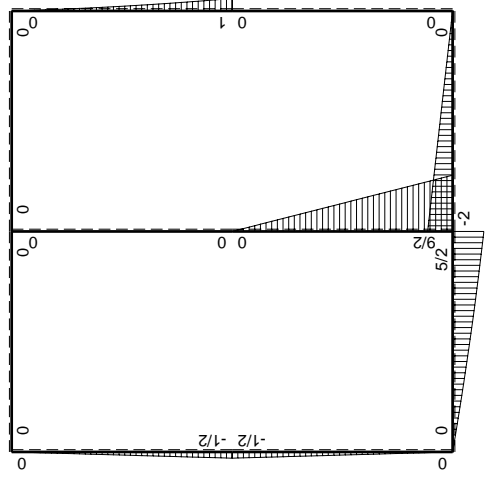
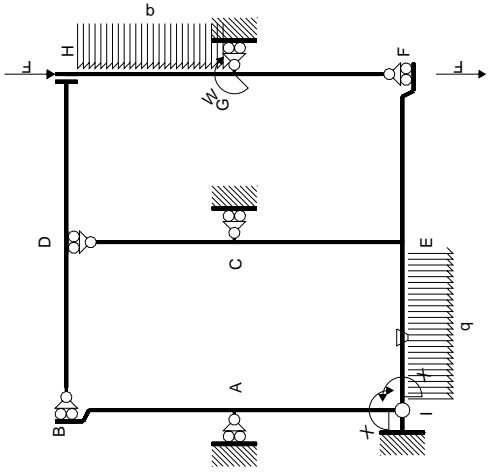
$$\tau_c = 4.528 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 132.2 \text{ N/mm}^2$$

$$S = 6722. \text{ mm}^3$$

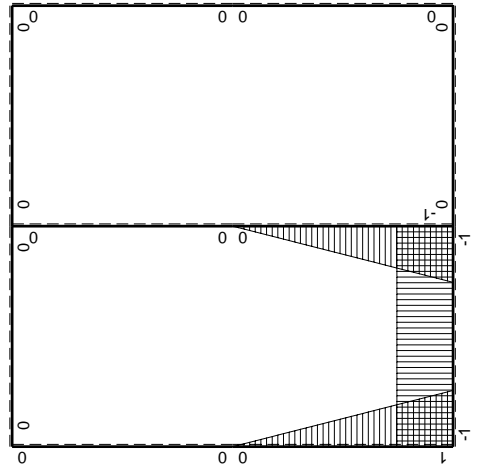


$\left[\begin{matrix} + \\ + \end{matrix} \right] F_b$



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

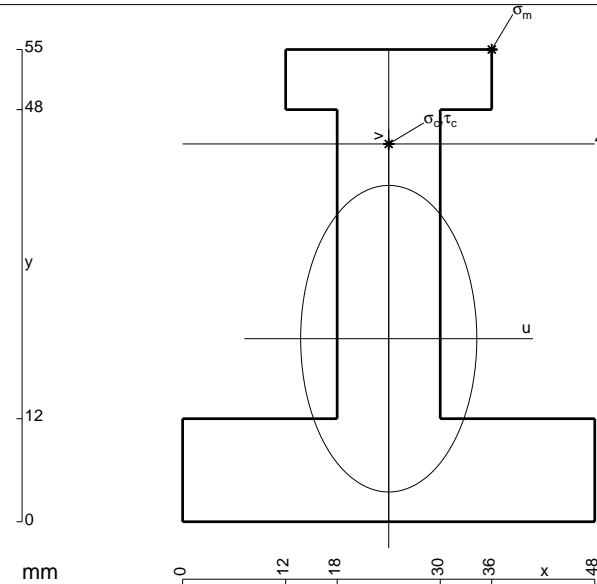
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

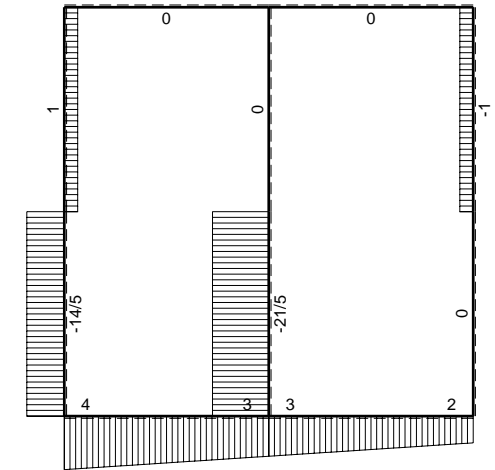
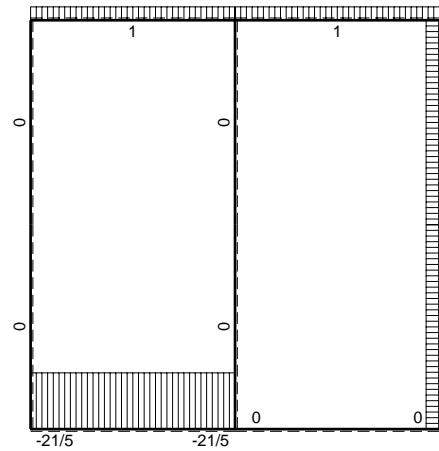
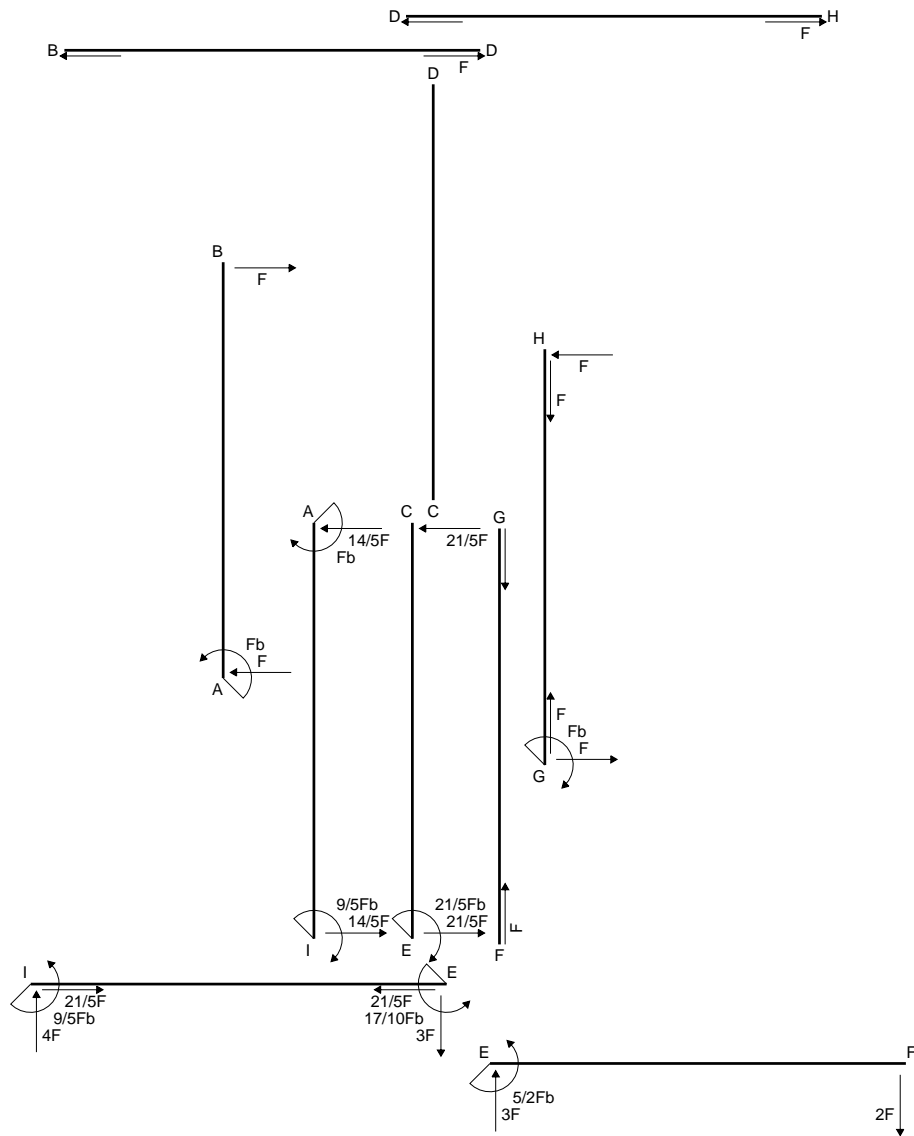
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

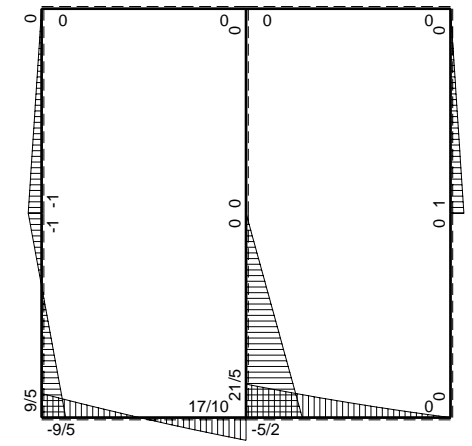


- A = 1176. mm²
- J_u = 375010. mm⁴
- J_v = 123840. mm⁴
- y_g = 21.32 mm
- T_y = 2620. N
- M_x = -2436600. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 33.68 mm
- σ_m = -Mv/J_u = 218.9 N/mm²
- x_c = 24. mm
- y_c = 44. mm
- v_c = 22.68 mm
- σ_c = -Mv/J_u = 147.4 N/mm²
- τ_c = 3.642 N/mm²
- σ_q = √σ²+3τ² = 147.5 N/mm²
- S = 6256. mm³

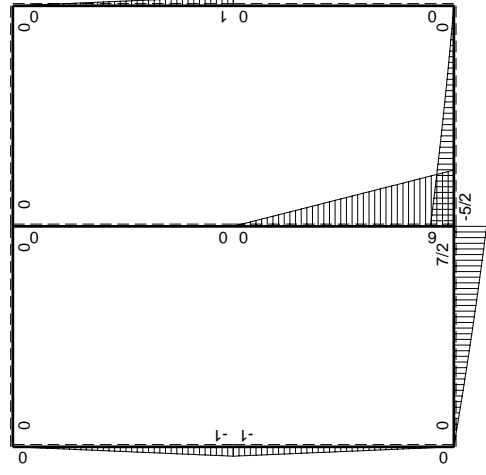
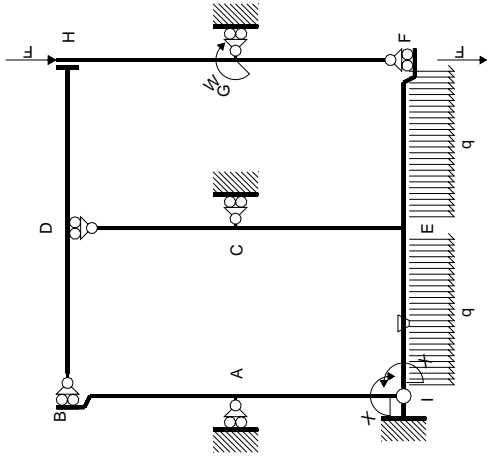


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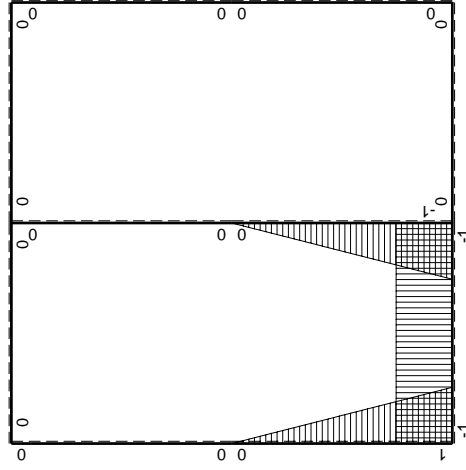


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0	0+0	0
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0	0+0	0
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0	0+0	0
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0	0+0	0
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0	0+0	0
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0	0+0	0
IE b	-1	$4Fx-1/2qx^2$	-Fb/EJ	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb 1/EJ + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb 1/EJ + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

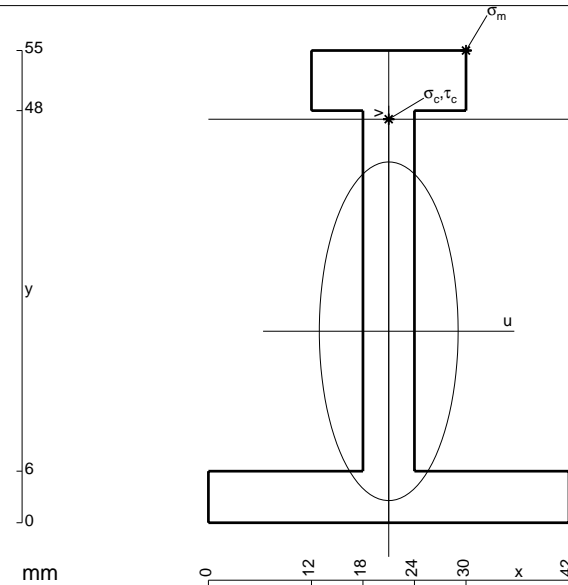
$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

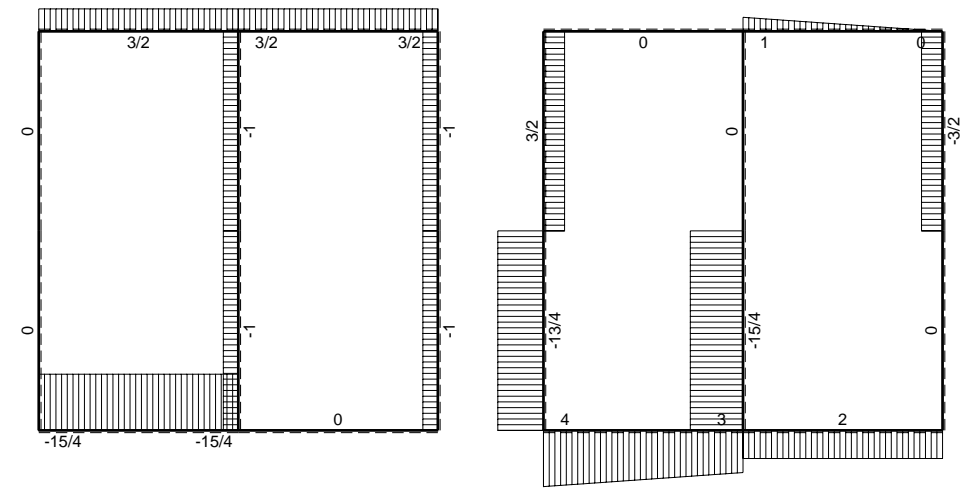
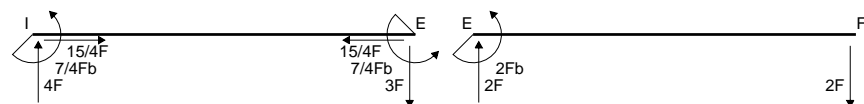
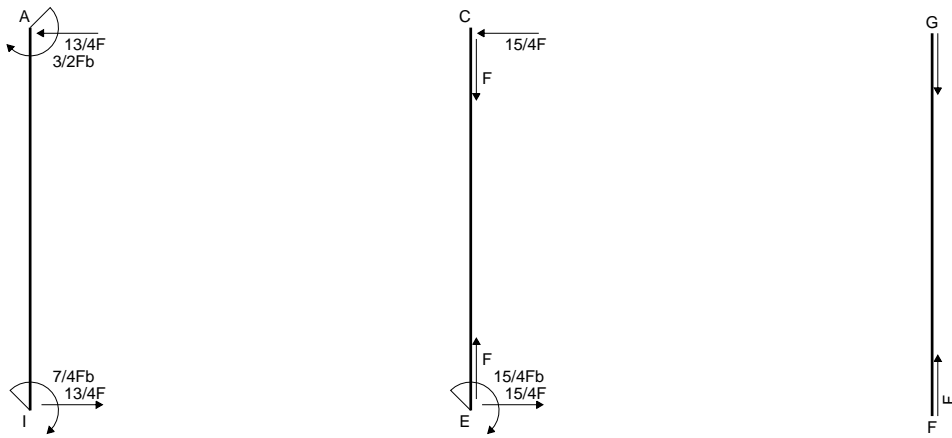
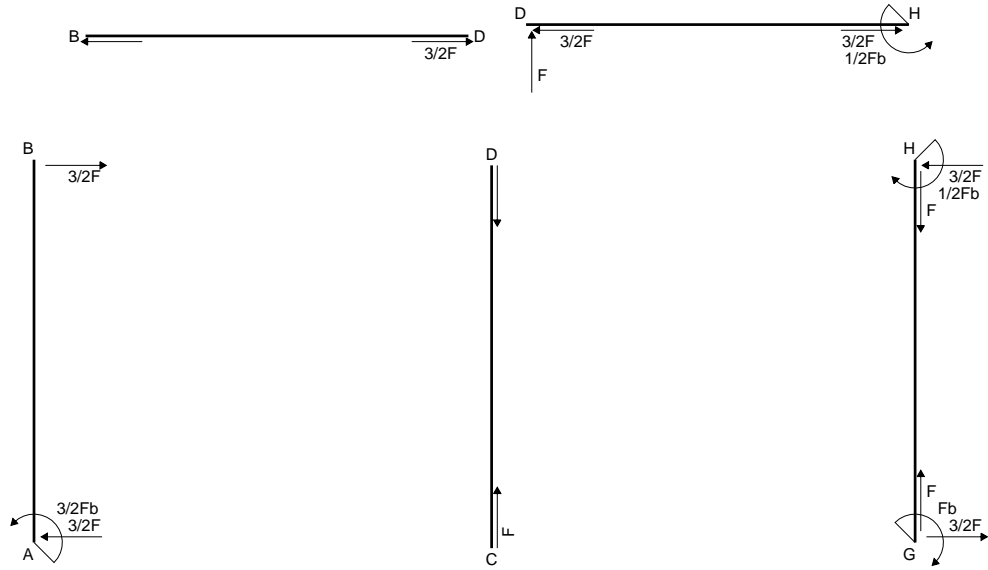
$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

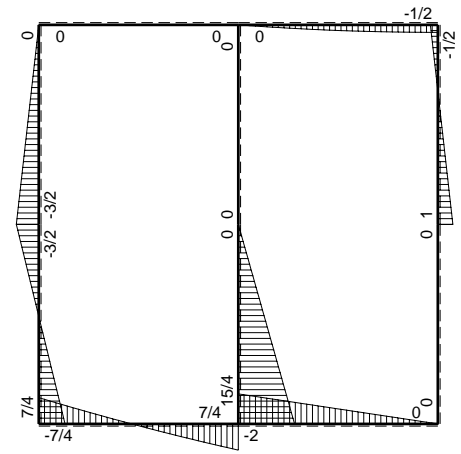


- A = 630. mm²
- J_u = 245181. mm⁴
- J_v = 41202. mm⁴
- y_g = 22.3 mm
- T_y = 2070. N
- M_x = -1707750. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 32.7 mm
- σ_m = -Mv/J_u = 227.8 N/mm²
- x_c = 21. mm
- y_c = 47. mm
- v_c = 24.7 mm
- σ_c = -Mv/J_u = 172. N/mm²
- τ_c = 5.39 N/mm²
- σ_q = √σ²+3τ² = 172.3 N/mm²
- S = 3830. mm³

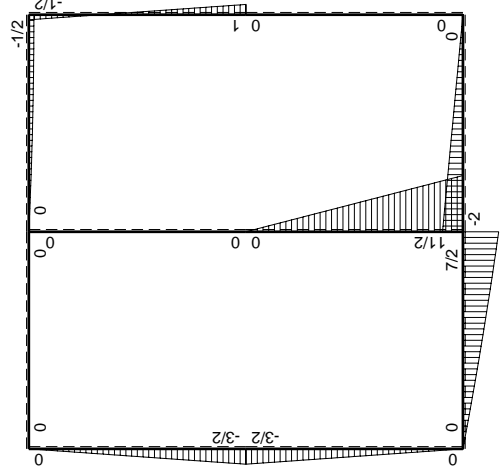
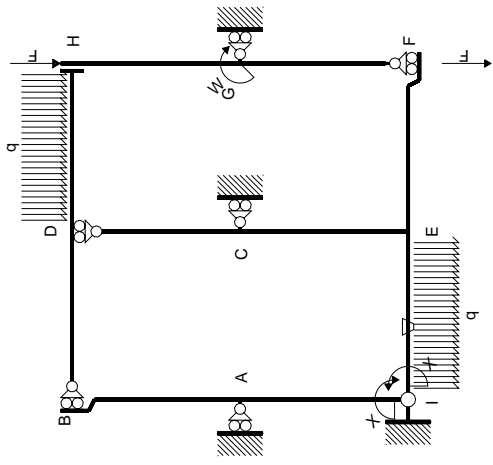


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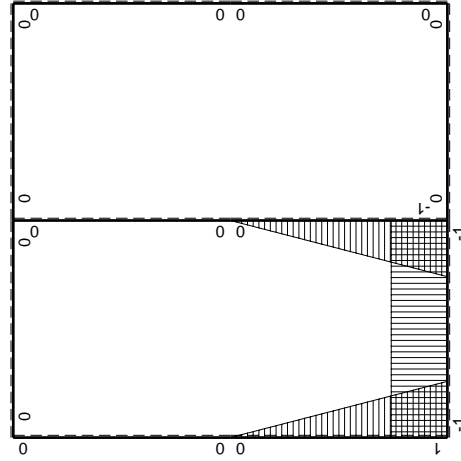


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0	
BA b	0	$3/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0	
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0			
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0	
DH b	0	$Fx-1/2qx^2$	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2			
	totali							$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

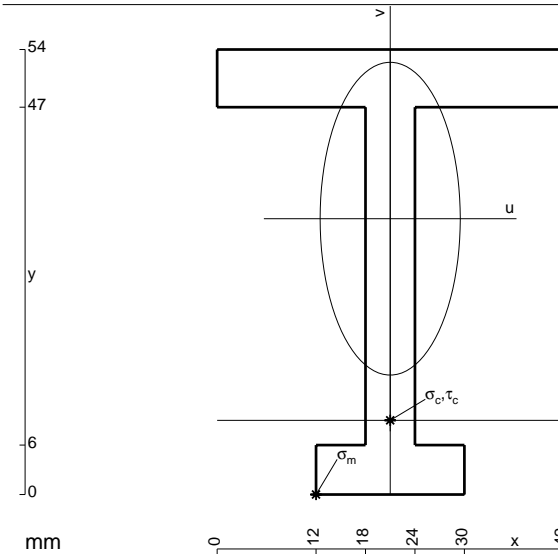
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 648. \text{ mm}^2$$

$$J_u = 233472. \text{ mm}^4$$

$$J_v = 46872. \text{ mm}^4$$

$$y_g = 33.47 \text{ mm}$$

$$T_y = 1640. \text{ N}$$

$$M_x = -1672800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.47 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.8 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

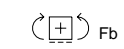
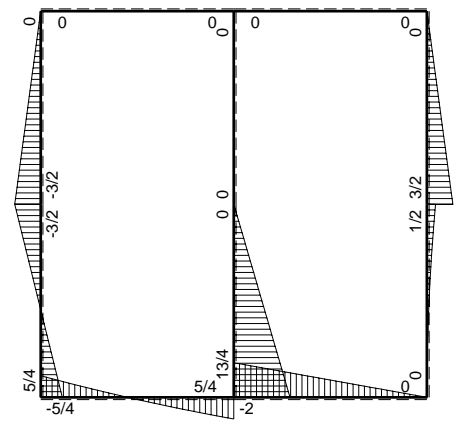
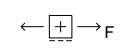
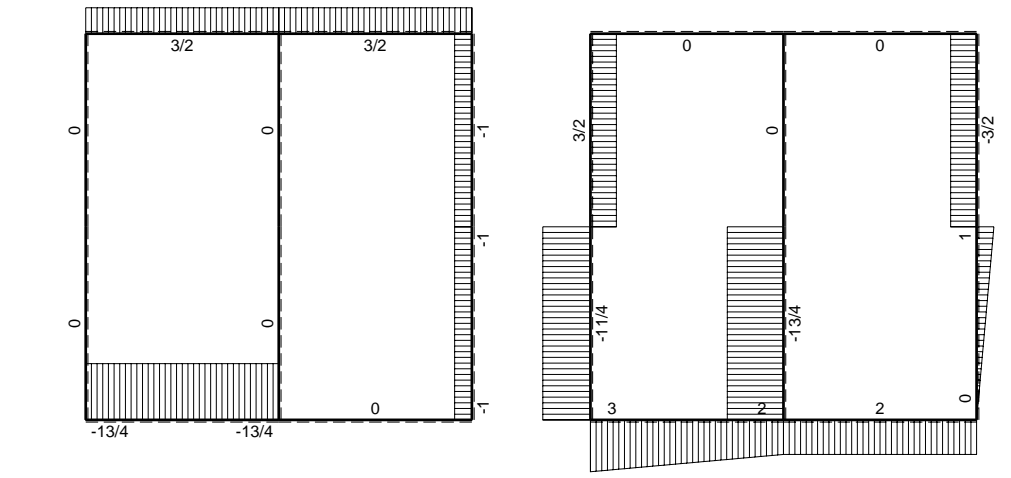
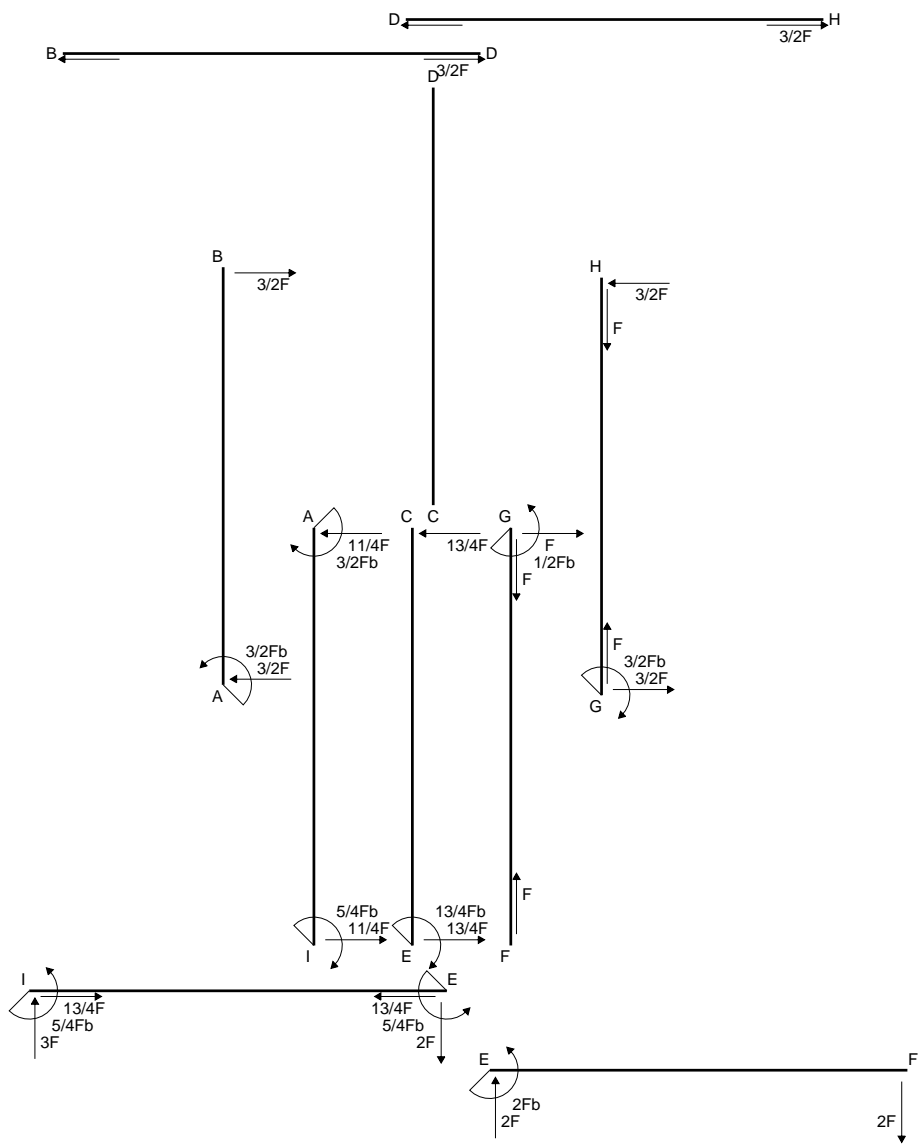
$$v_c = -24.47 \text{ mm}$$

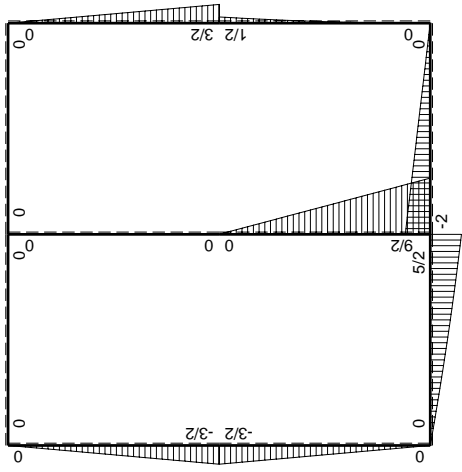
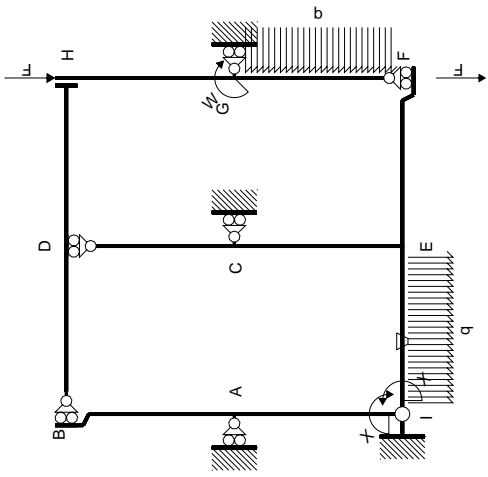
$$\sigma_c = -Mv/J_u = -175.3 \text{ N/mm}^2$$

$$\tau_c = 4.4 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 175.5 \text{ N/mm}^2$$

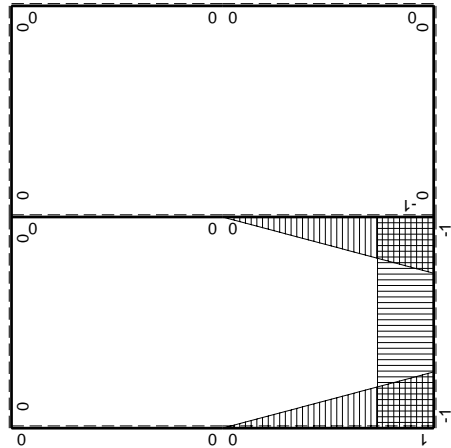
$$S = 3759. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

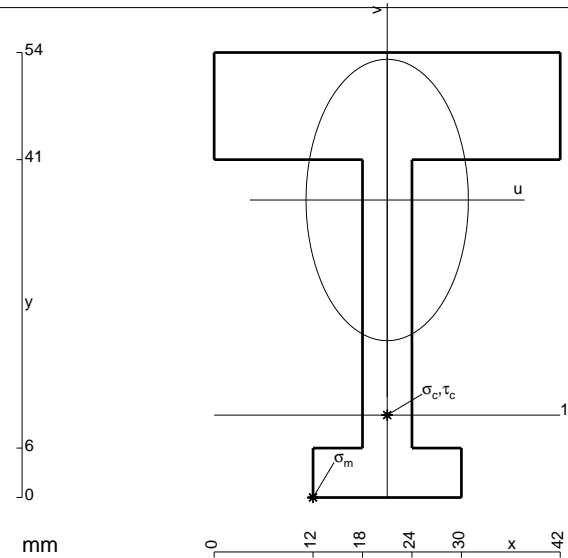
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 864. \text{ mm}^2$$

$$J_u = 252075. \text{ mm}^4$$

$$J_v = 83808. \text{ mm}^4$$

$$y_g = 36.1 \text{ mm}$$

$$T_y = 2580. \text{ N}$$

$$M_x = -1393200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -36.1 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

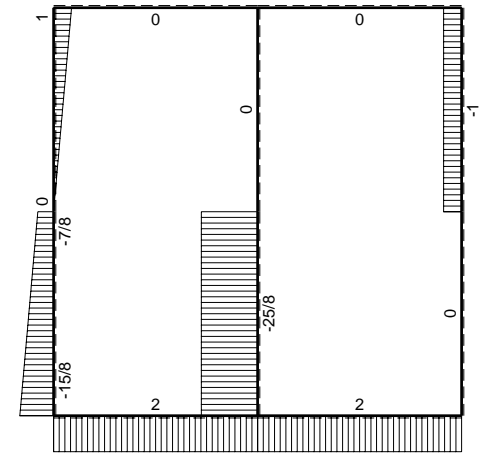
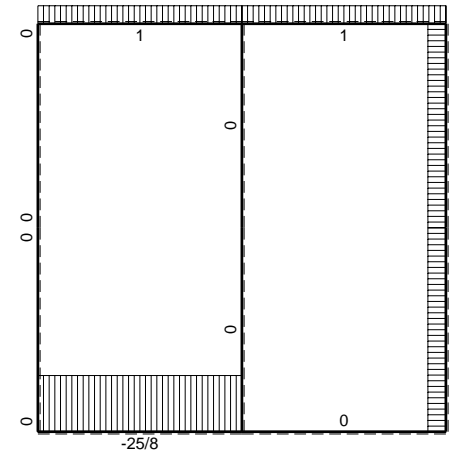
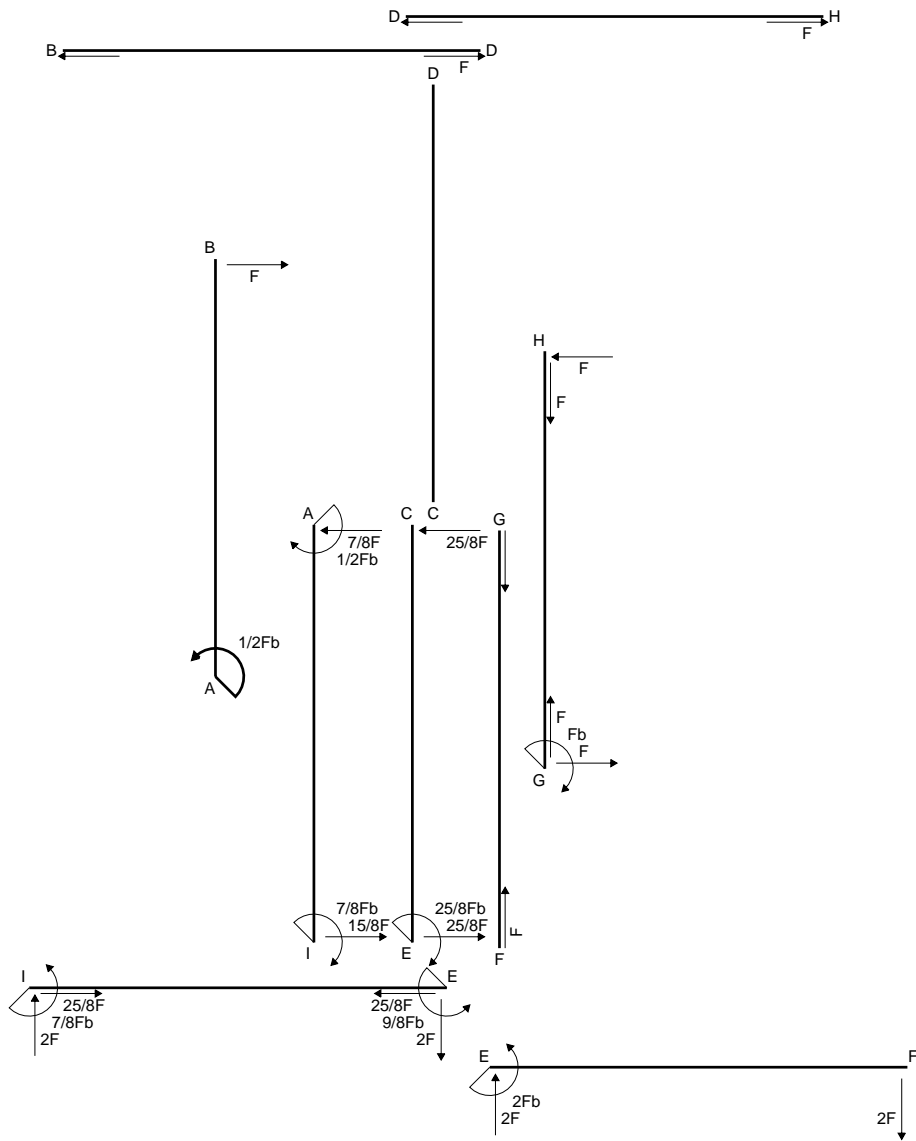
$$v_c = -26.1 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -144.3 \text{ N/mm}^2$$

$$\tau_c = 7.249 \text{ N/mm}^2$$

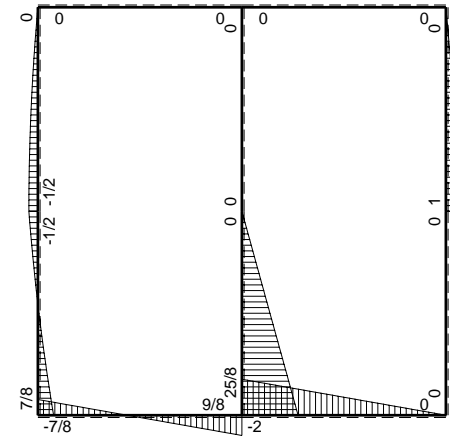
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 144.8 \text{ N/mm}^2$$

$$S = 4250. \text{ mm}^3$$

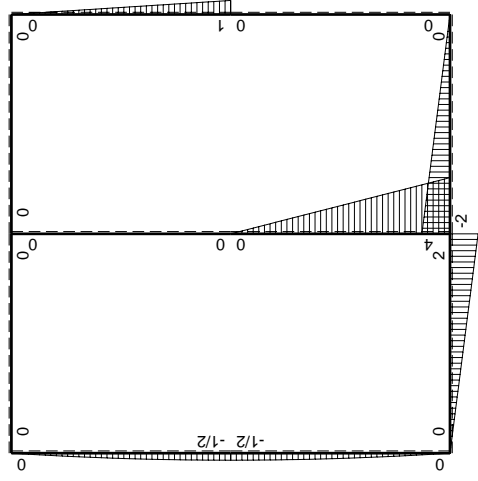
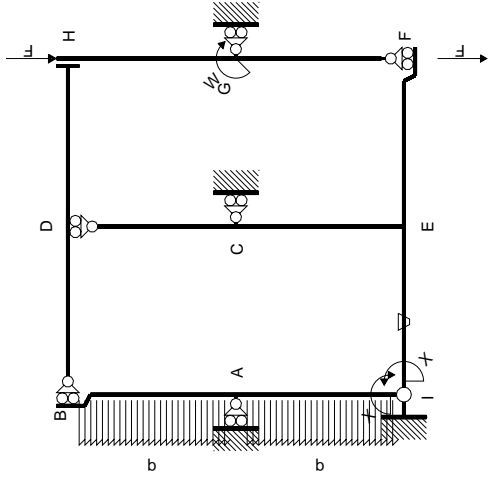


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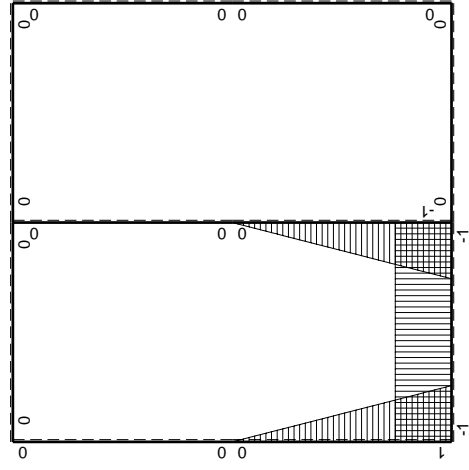


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

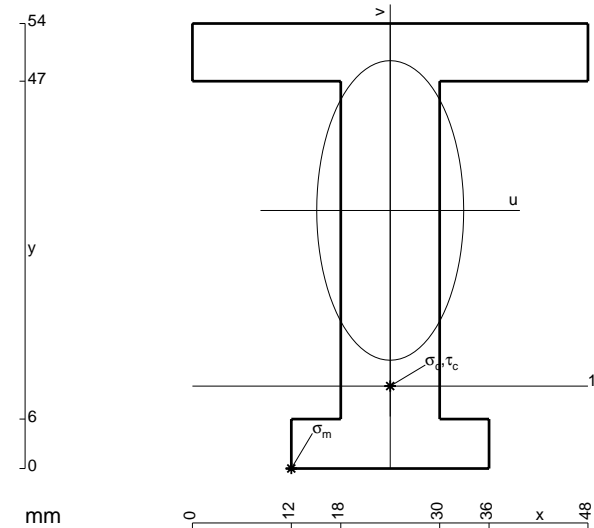
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 972. \text{ mm}^2$$

$$J_u = 321252. \text{ mm}^4$$

$$J_v = 77328. \text{ mm}^4$$

$$y_g = 31.31 \text{ mm}$$

$$T_y = 3640. \text{ N}$$

$$M_x = -2147600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -31.31 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.3 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

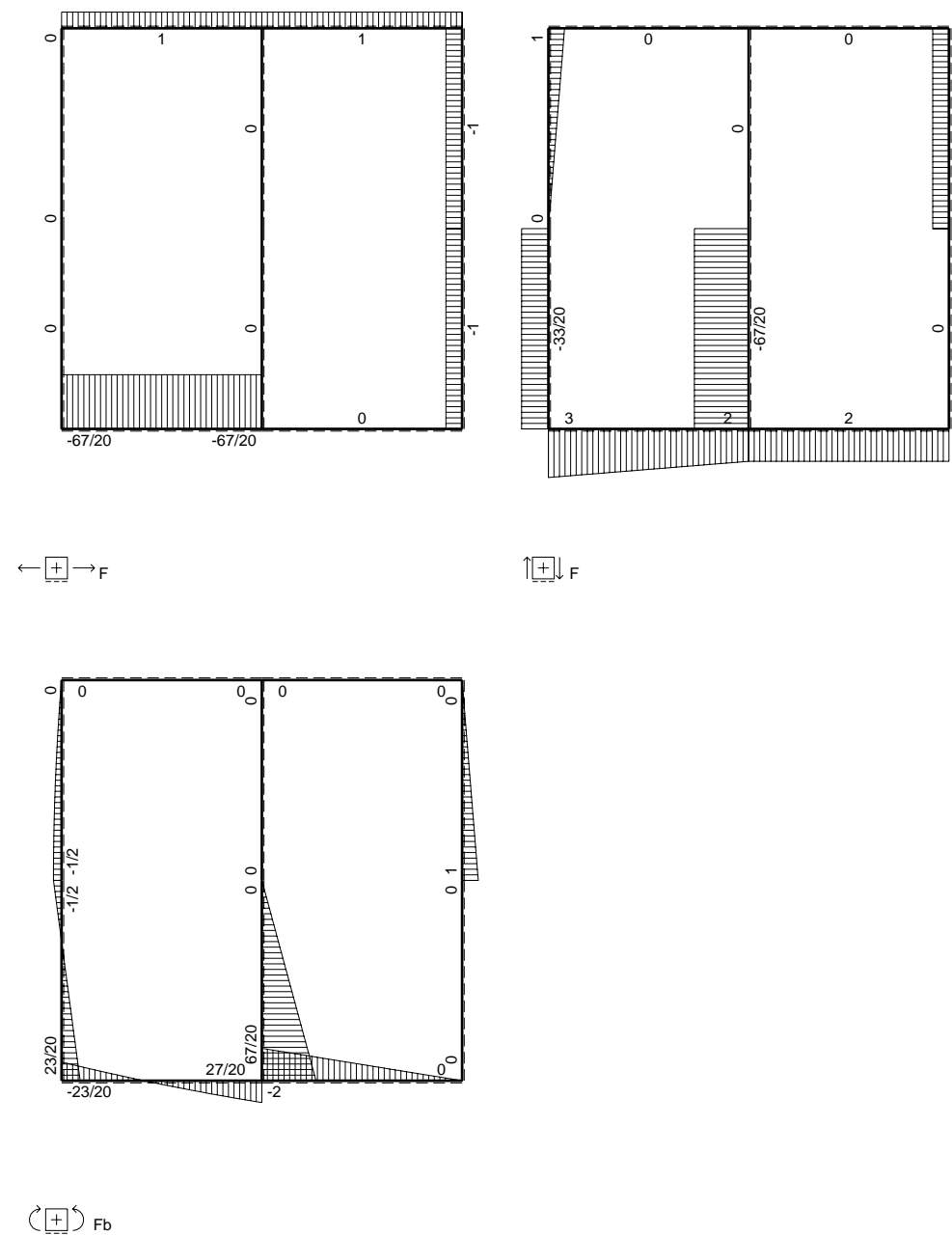
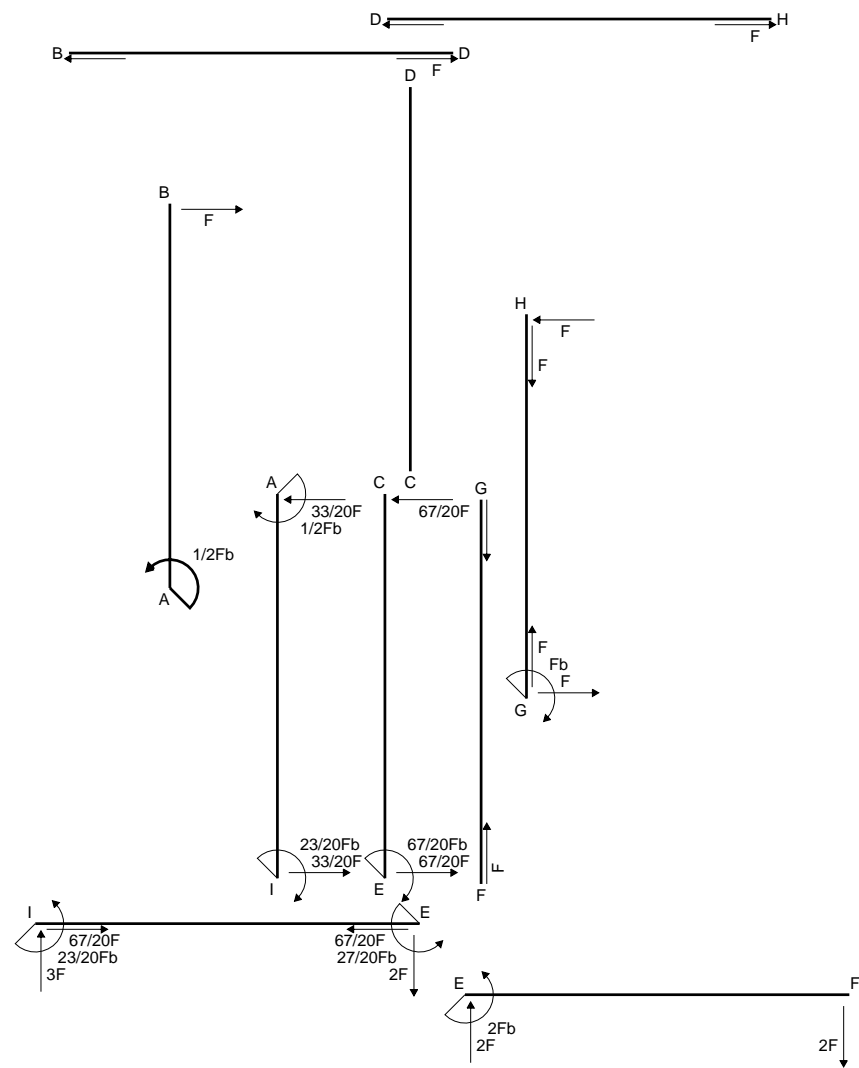
$$v_c = -21.31 \text{ mm}$$

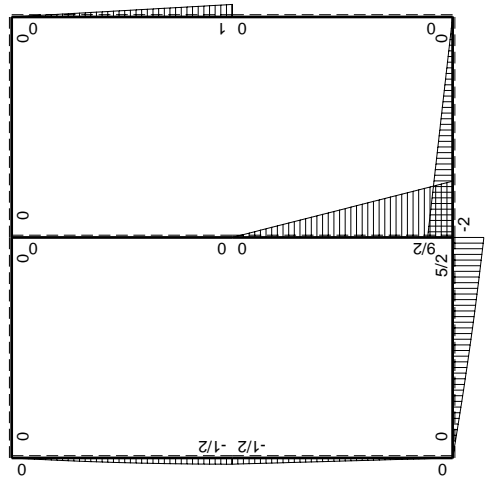
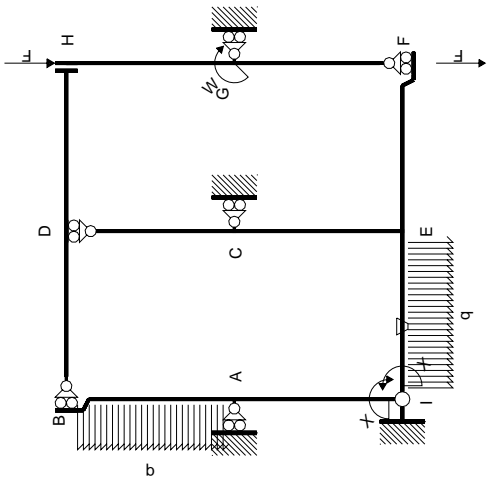
$$\sigma_c = -Mv/J_u = -142.5 \text{ N/mm}^2$$

$$\tau_c = 4.907 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 142.7 \text{ N/mm}^2$$

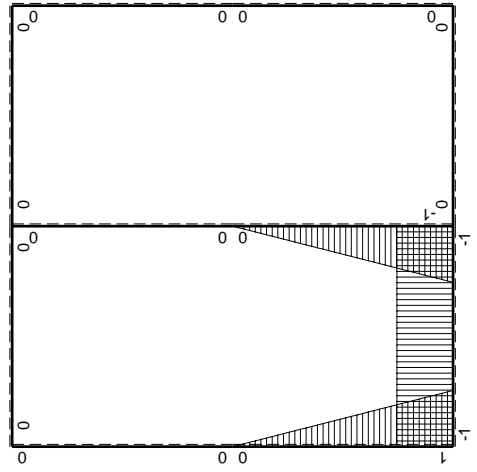
$$S = 5196. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flexione da carichi assegnati



M_x flexione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0	
BA b	0	$Fx-1/2qx^2$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0	
HG b	0	$-Fx$	0	0	0	0			
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2			
	totali							$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

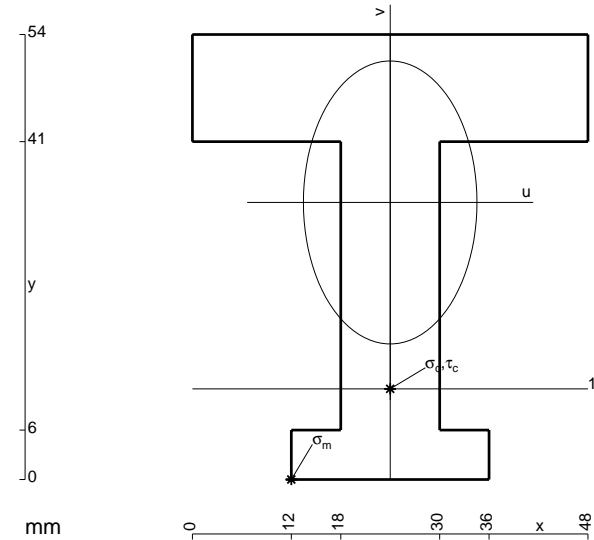
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1188. \text{ mm}^2$$

$$J_u = 350338. \text{ mm}^4$$

$$J_v = 131760. \text{ mm}^4$$

$$y_g = 33.62 \text{ mm}$$

$$T_y = 3580. \text{ N}$$

$$M_x = -2291200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -33.62 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

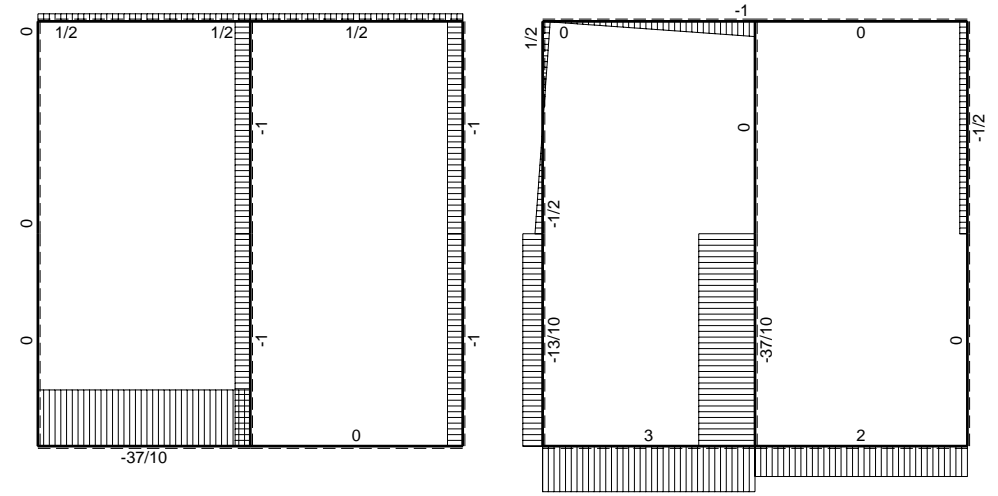
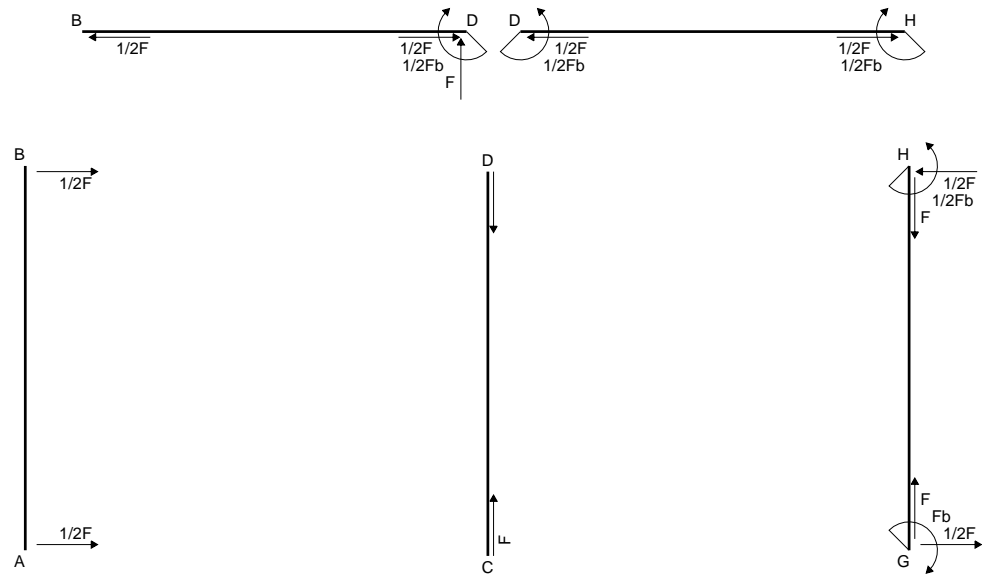
$$v_c = -22.62 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -147.9 \text{ N/mm}^2$$

$$\tau_c = 5.038 \text{ N/mm}^2$$

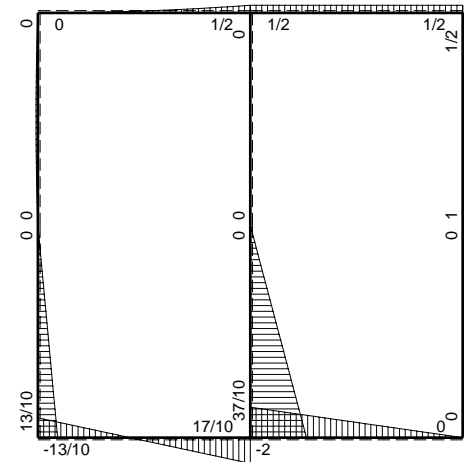
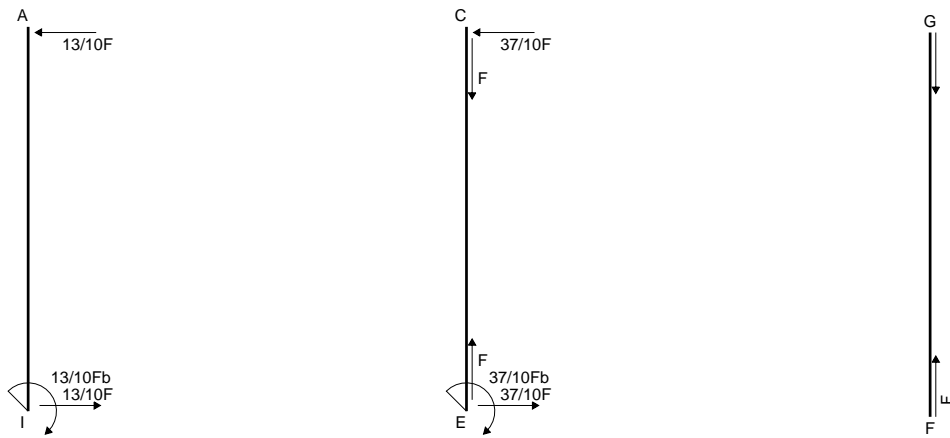
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 148.2 \text{ N/mm}^2$$

$$S = 5917. \text{ mm}^3$$

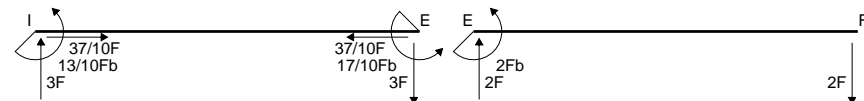


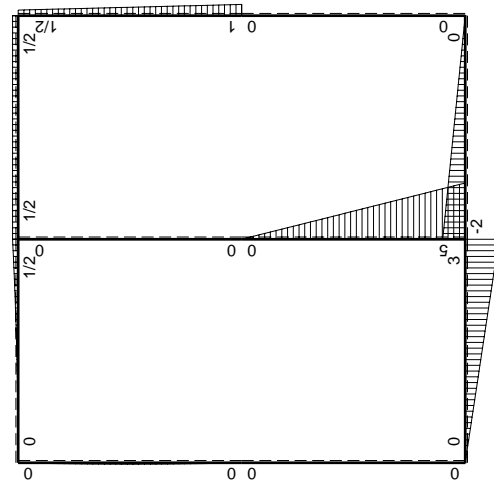
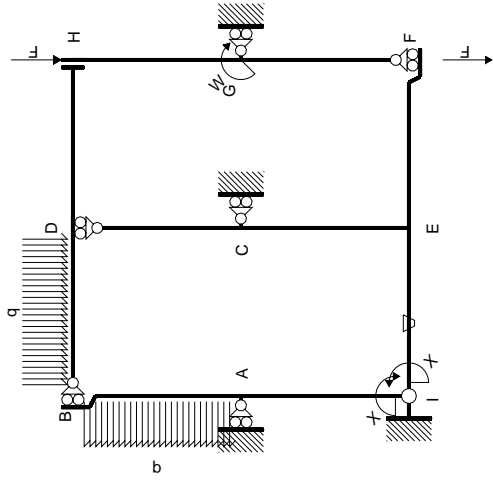
← ⊕ → F

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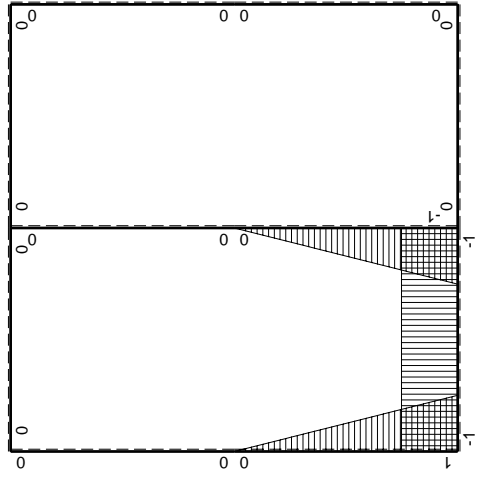
⊕ ⊖ Fb





Schema di calcolo iperstatico

M_0 flexione da carichi assegnati



M_1 flexione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

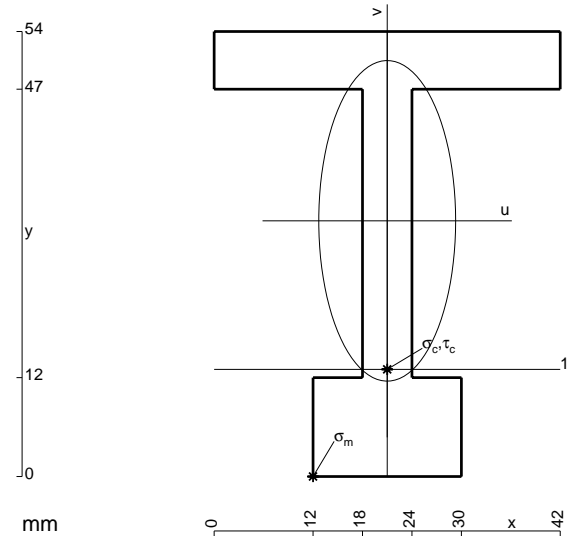
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$



$$A = 720. \text{ mm}^2$$

$$J_u = 272496. \text{ mm}^4$$

$$J_v = 49680. \text{ mm}^4$$

$$y_g = 31.02 \text{ mm}$$

$$T_y = 2880. \text{ N}$$

$$M_x = -2016000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -31.02 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

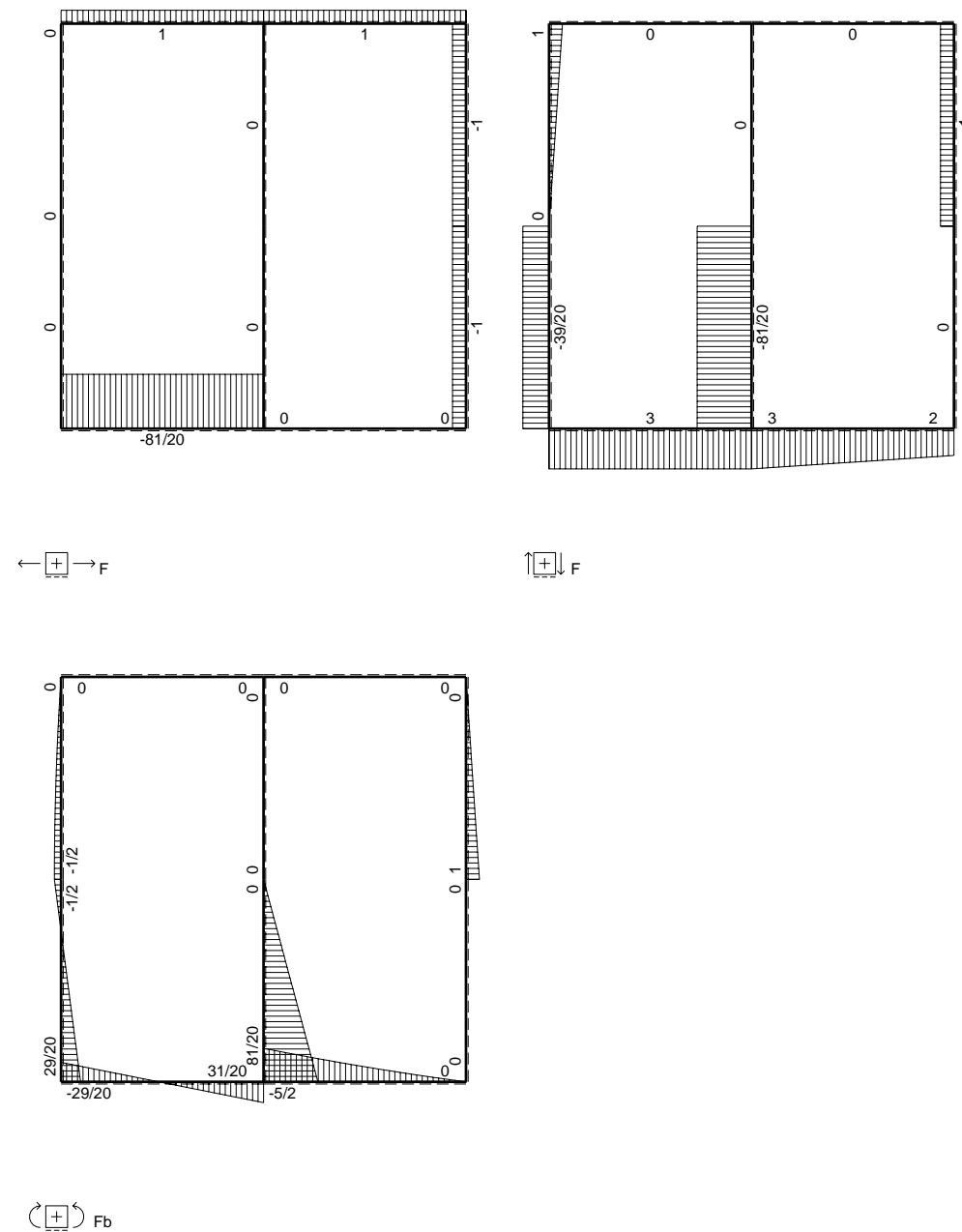
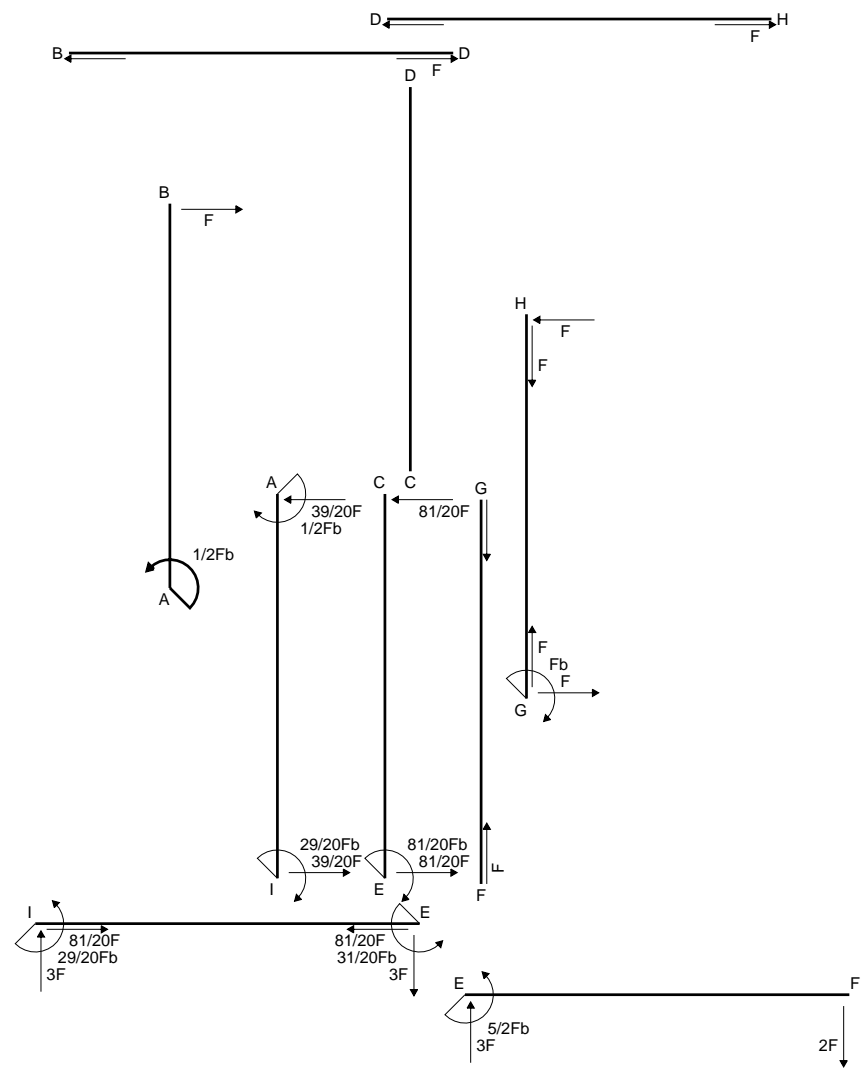
$$v_c = -18.02 \text{ mm}$$

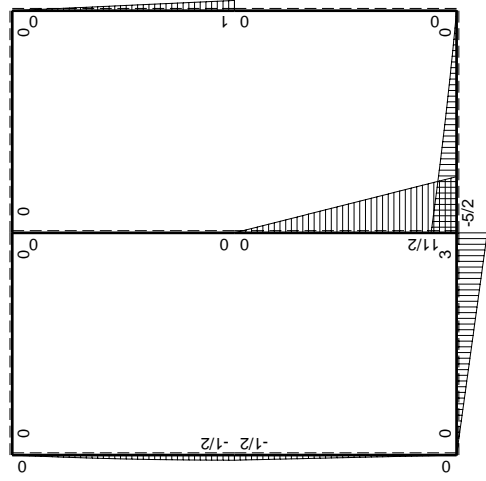
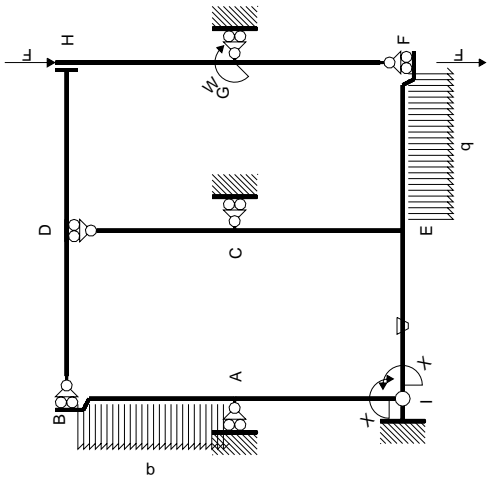
$$\sigma_c = -Mv/J_u = -133.4 \text{ N/mm}^2$$

$$\tau_c = 9.717 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 134.4 \text{ N/mm}^2$$

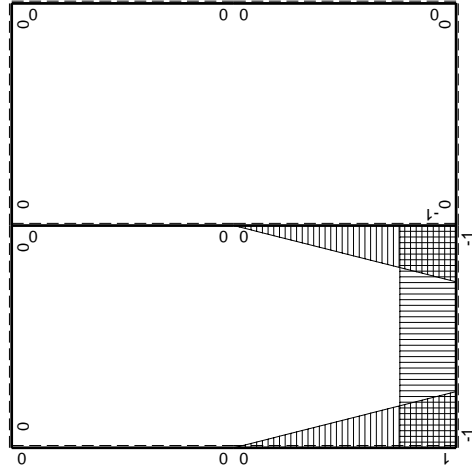
$$S = 5517. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb 1/EJ dx = [-11/6 x^3/b^2]_0^b Fb 1/EJ$$

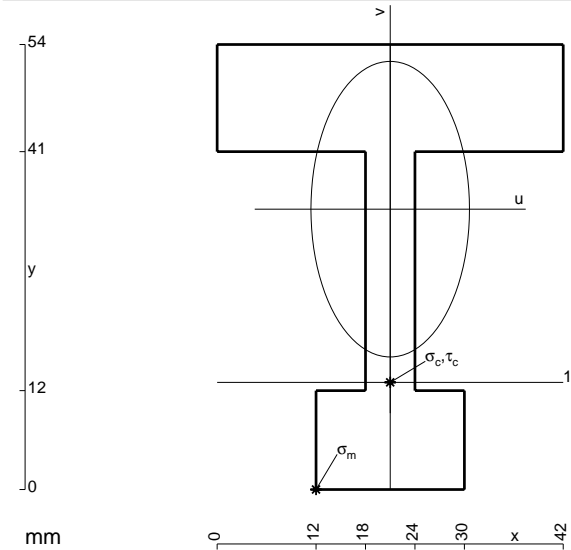
$$= (-11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

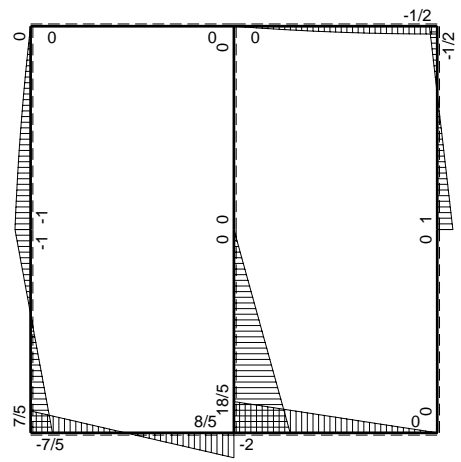
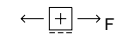
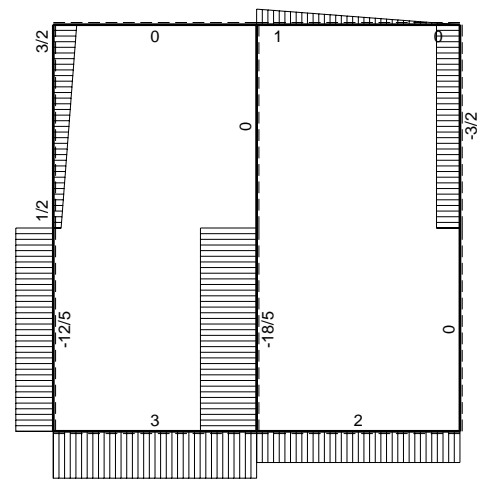
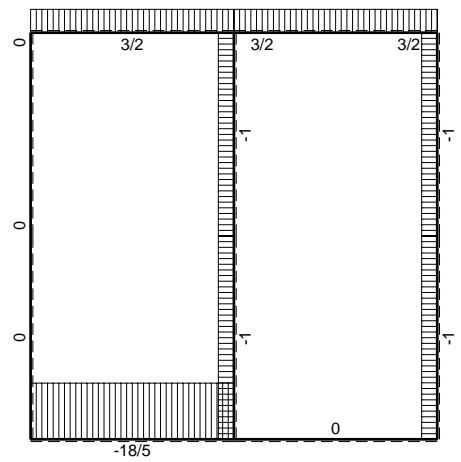
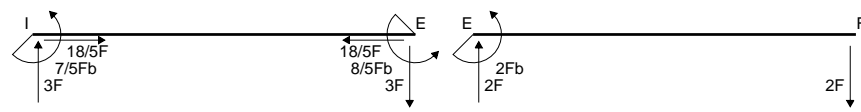
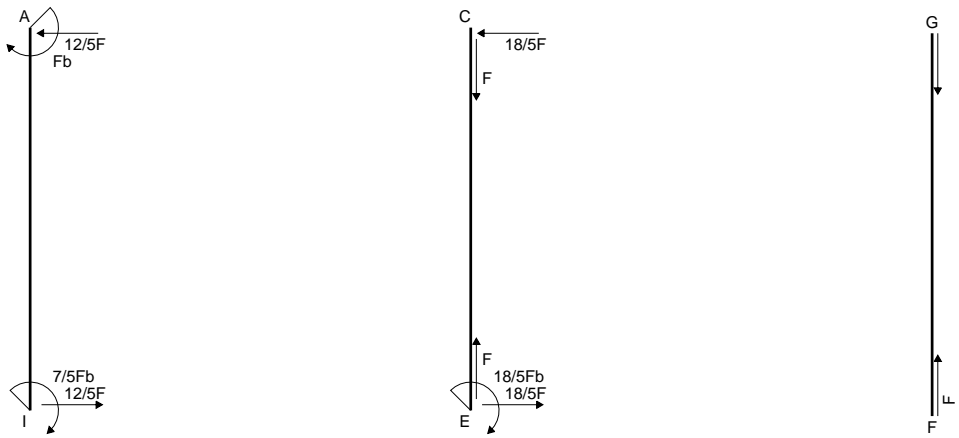
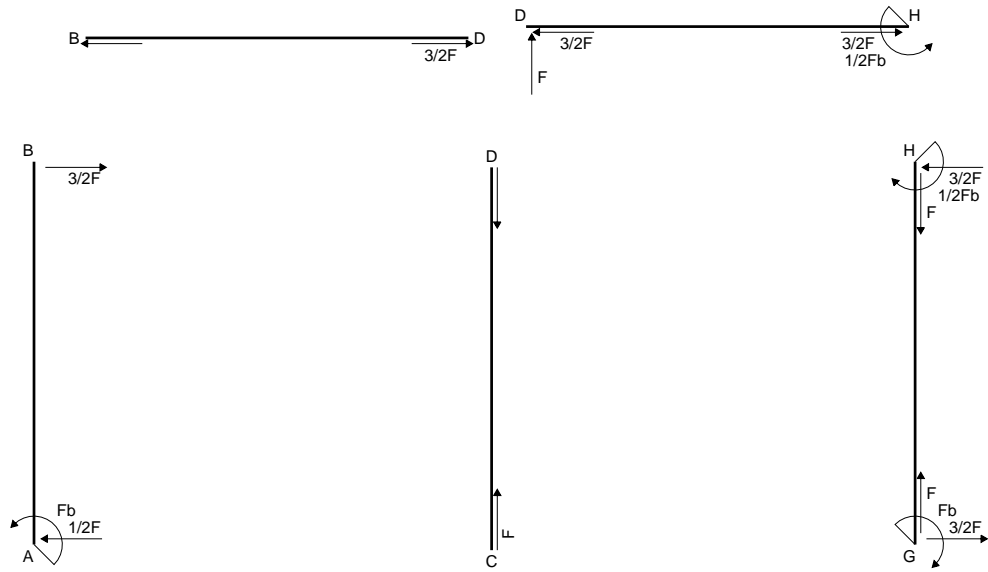
$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



- A = 936. mm²
- J_u = 301116. mm⁴
- J_v = 86616. mm⁴
- y_g = 34.02 mm
- T_y = 3390. N
- M_x = -2118750. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -34.02 mm
- σ_m = -Mv/J_u = -239.4 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -21.02 mm
- σ_c = -Mv/J_u = -147.9 N/mm²
- τ_c = 11.6 N/mm²
- σ_o = √σ²+3τ² = 149.3 N/mm²
- S = 6181. mm³



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-Fb+1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$3/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

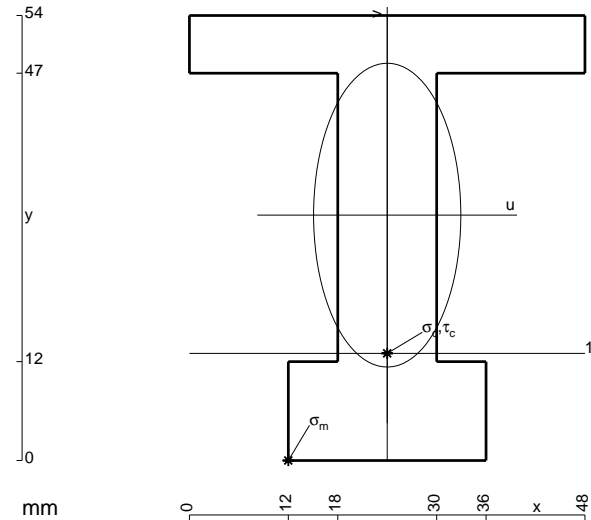
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

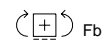
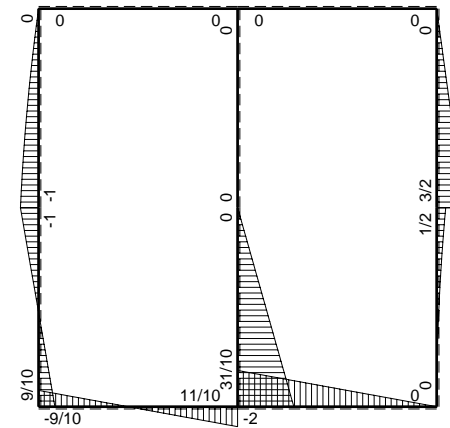
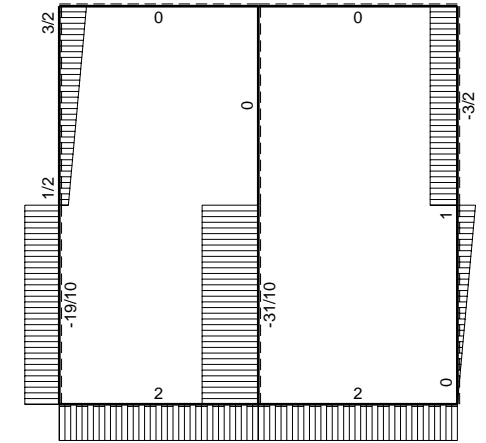
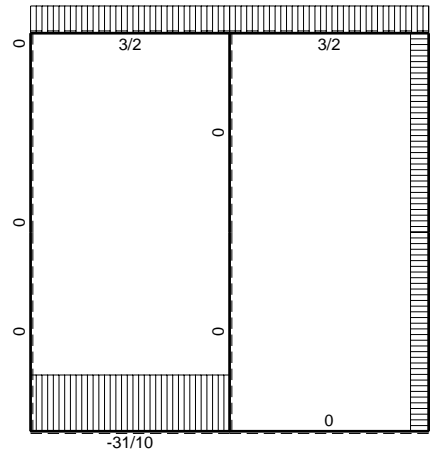
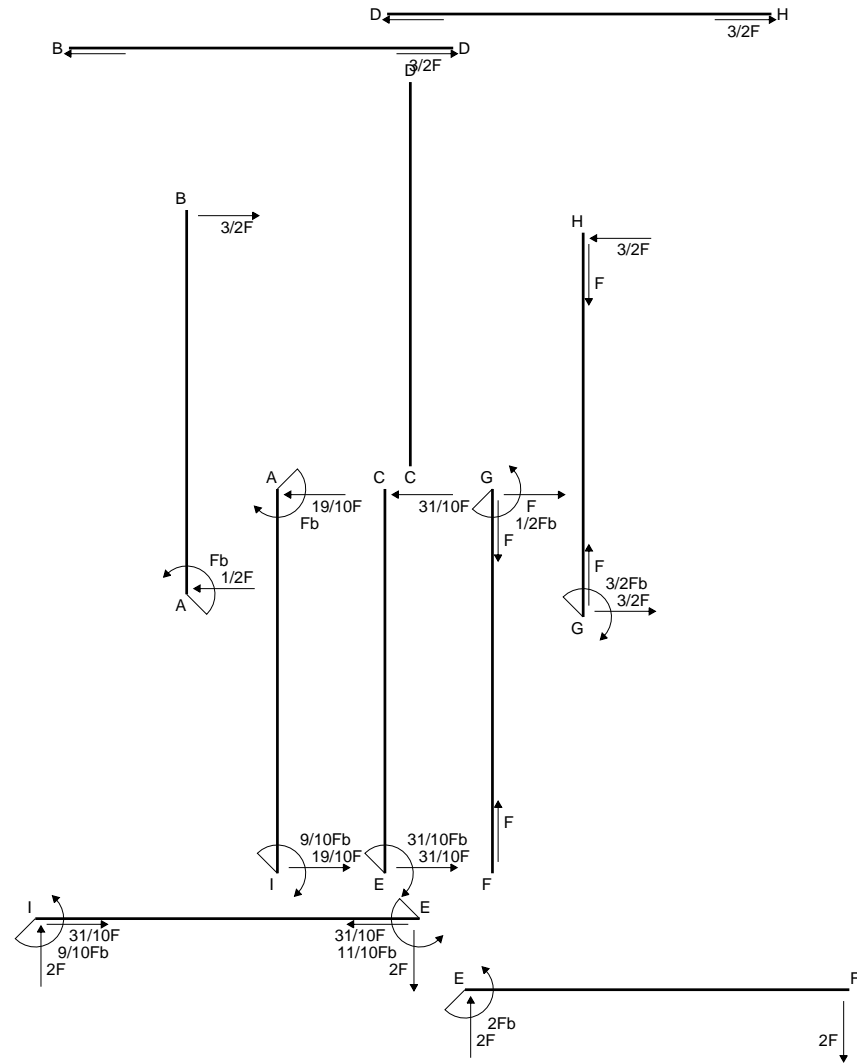
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

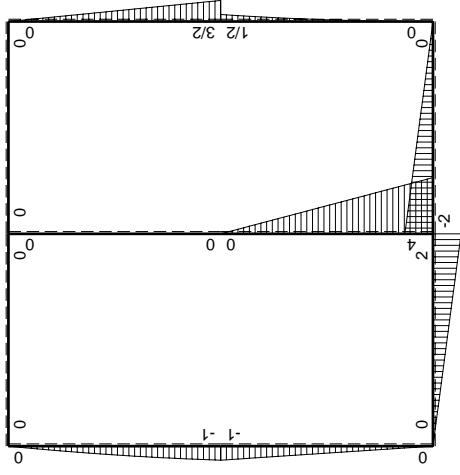
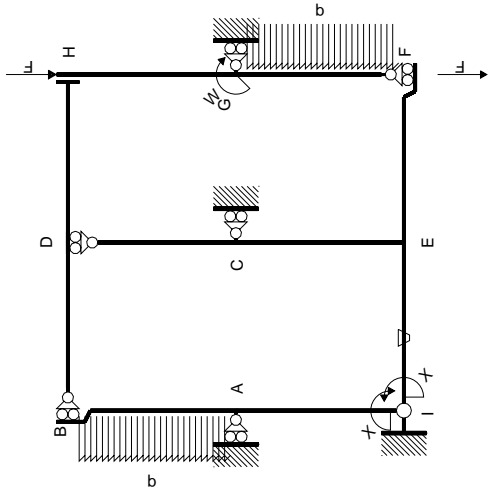
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



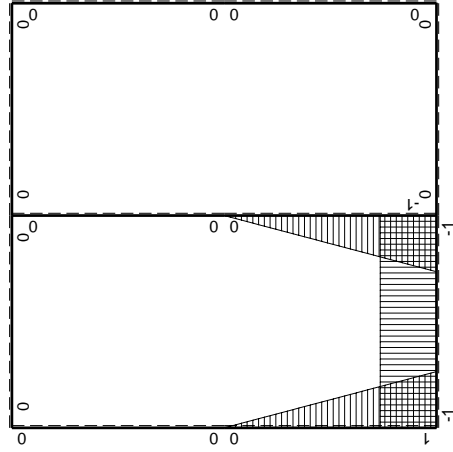
- A = 1044. mm²
- J_u = 354848. mm⁴
- J_v = 83376. mm⁴
- y_g = 29.78 mm
- T_y = 2940. N
- M_x = -2381400. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -29.78 mm
- σ_m = -Mv/J_u = -199.8 N/mm²
- x_c = 24. mm
- y_c = 13. mm
- v_c = -16.78 mm
- σ_c = -Mv/J_u = -112.6 N/mm²
- τ_c = 4.871 N/mm²
- σ_o = √σ² + 3τ² = 112.9 N/mm²
- S = 7055. mm³





Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$-Fb+1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$3/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

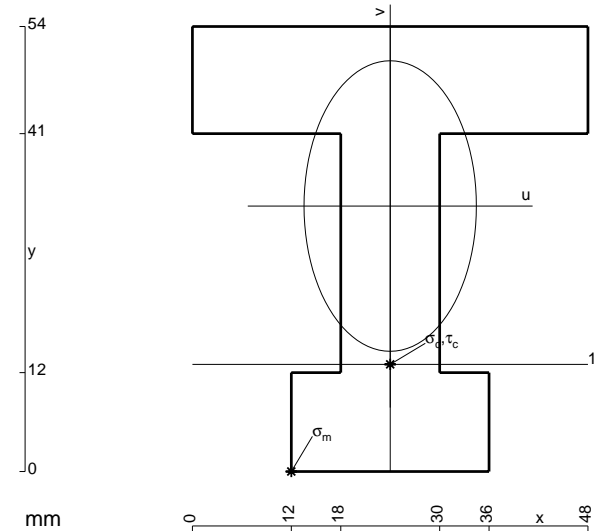
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1260. \text{ mm}^2$$

$$J_u = 391706. \text{ mm}^4$$

$$J_v = 137808. \text{ mm}^4$$

$$y_g = 32.21 \text{ mm}$$

$$T_y = 2960. \text{ N}$$

$$M_x = -2545600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -32.21 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.4 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

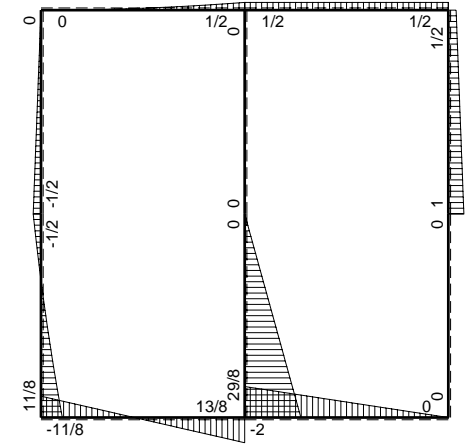
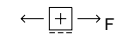
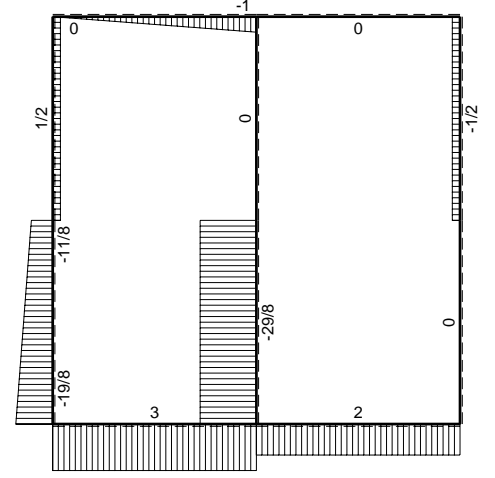
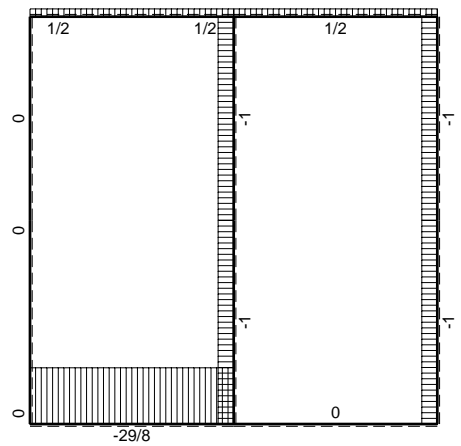
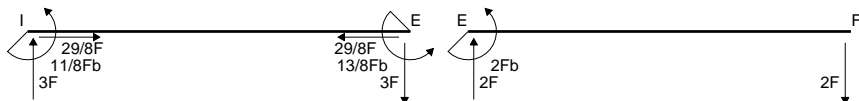
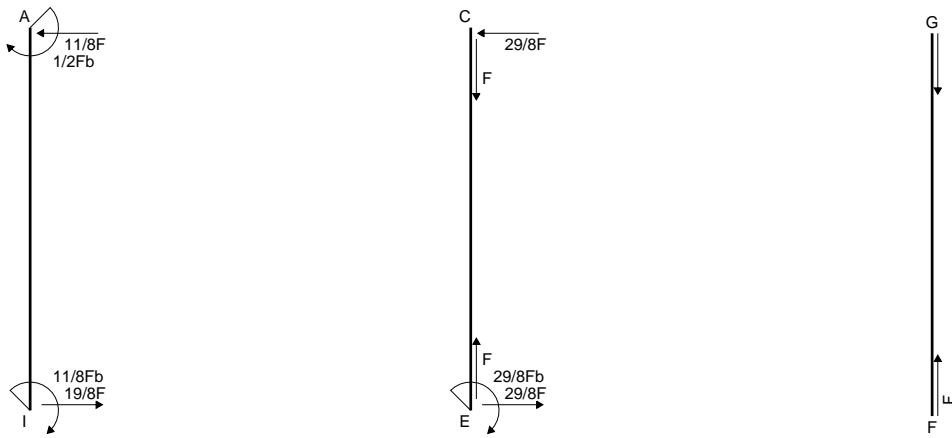
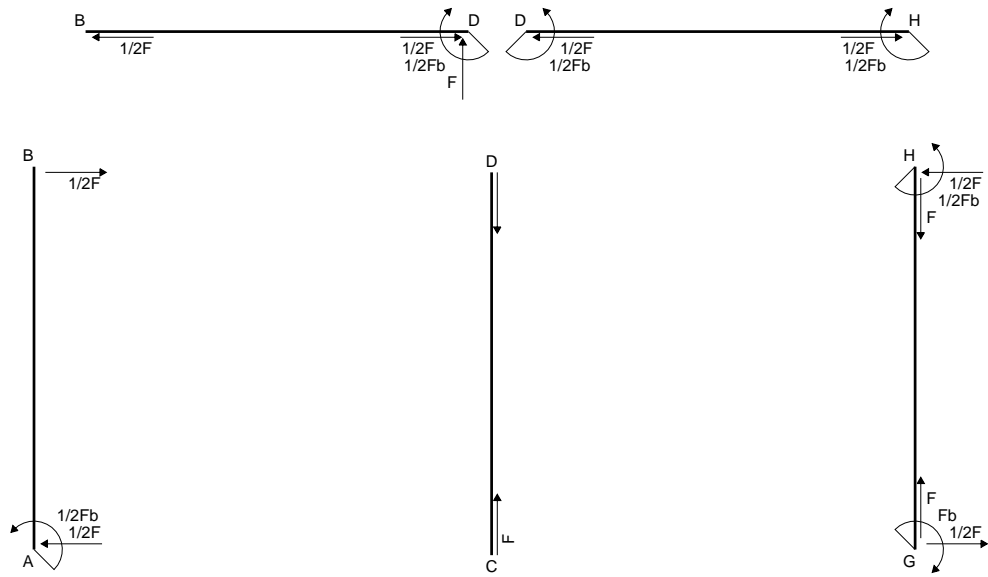
$$v_c = -19.21 \text{ mm}$$

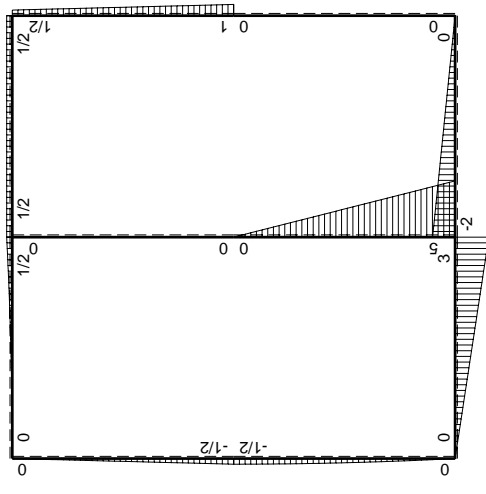
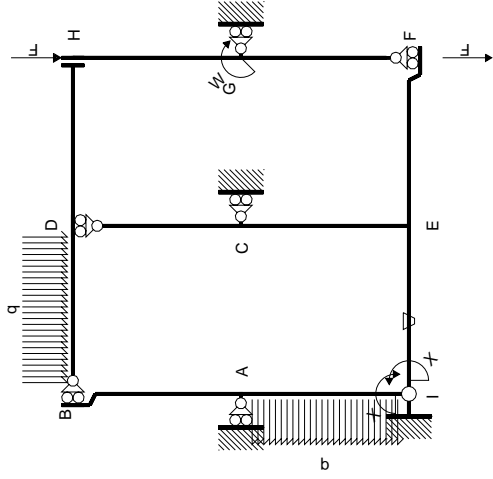
$$\sigma_c = -Mv/J_u = -124.9 \text{ N/mm}^2$$

$$\tau_c = 4.903 \text{ N/mm}^2$$

$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 125.2 \text{ N/mm}^2$$

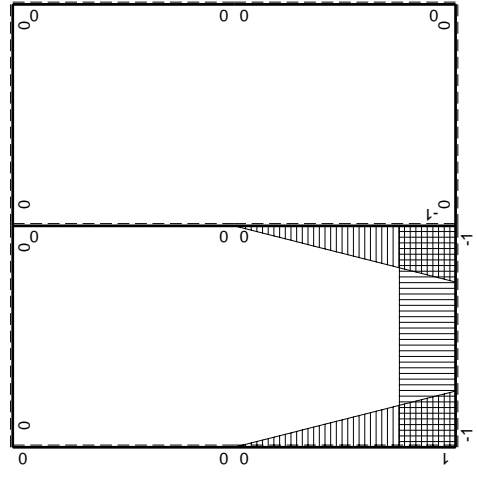
$$S = 7786. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fb+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

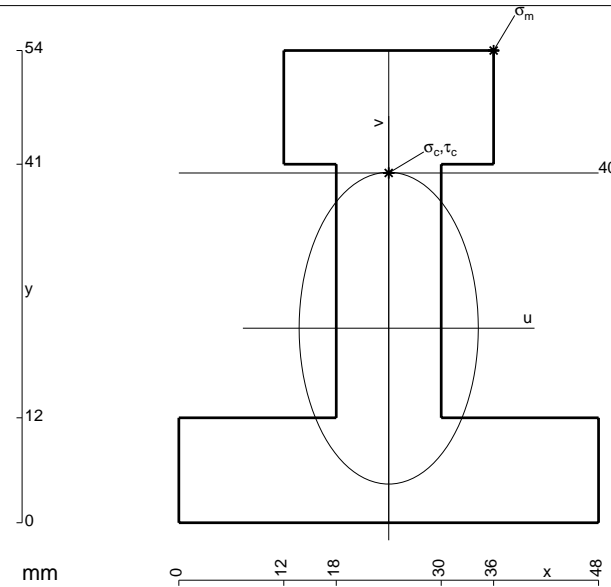
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 1236. \text{ mm}^2$$

$$J_u = 393000. \text{ mm}^4$$

$$J_v = 129744. \text{ mm}^4$$

$$y_g = 22.25 \text{ mm}$$

$$T_y = 2980. \text{ N}$$

$$M_x = -2711800. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 31.75 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.1 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

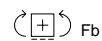
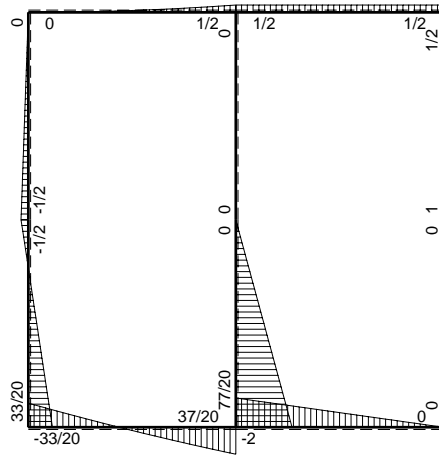
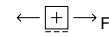
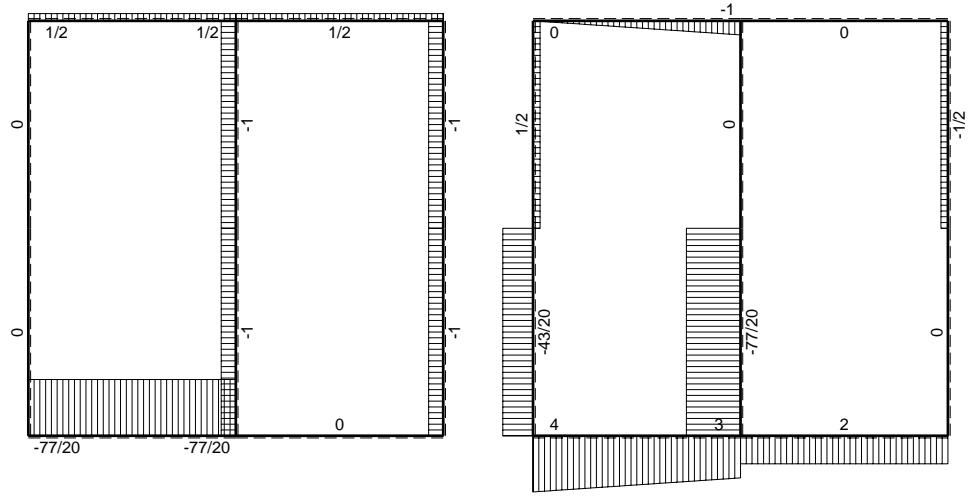
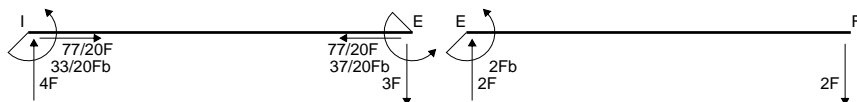
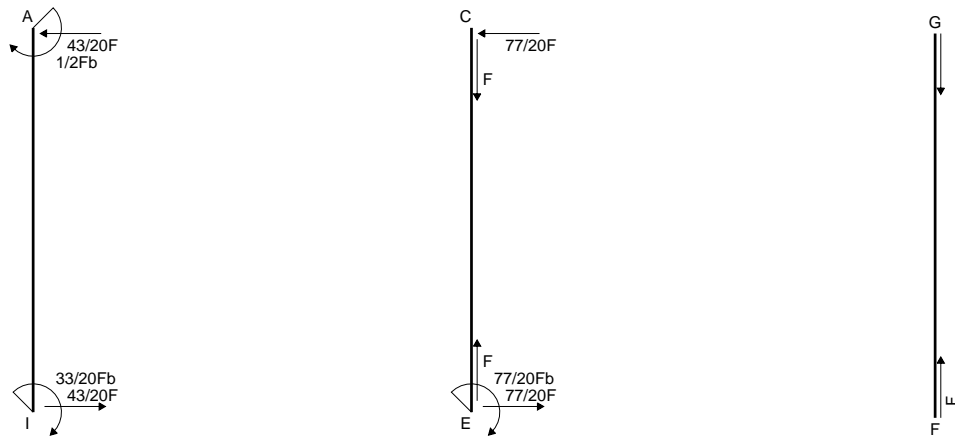
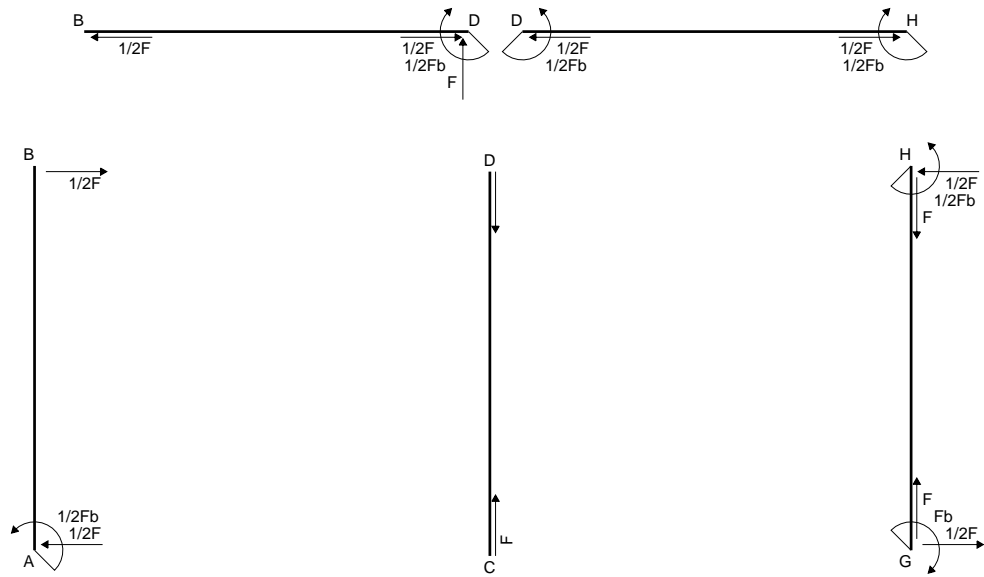
$$v_c = 17.75 \text{ mm}$$

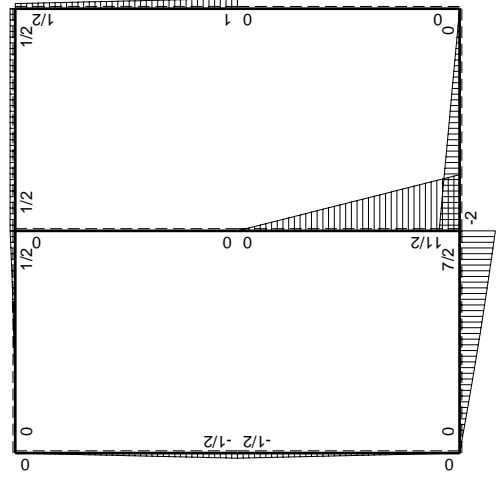
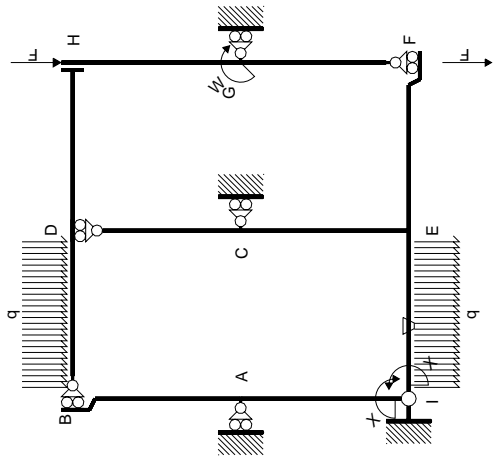
$$\sigma_c = -Mv/J_u = 122.5 \text{ N/mm}^2$$

$$\tau_c = 5.117 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 122.8 \text{ N/mm}^2$$

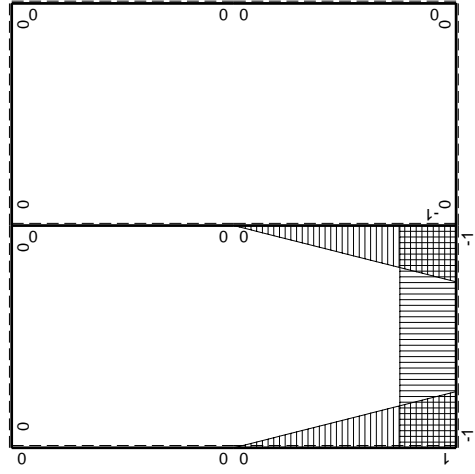
$$S = 8098. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

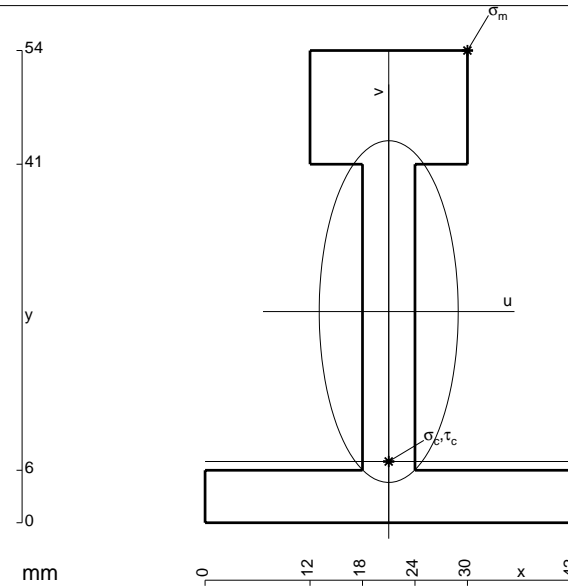
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

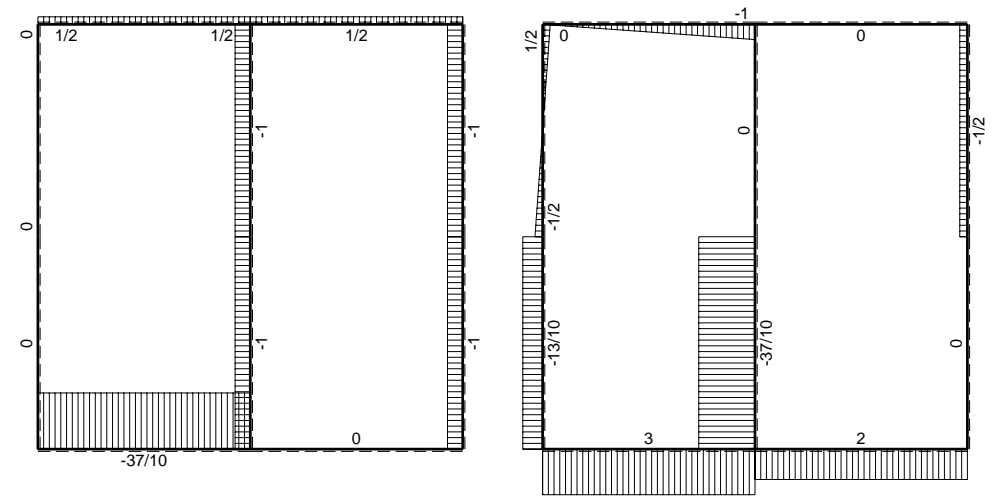
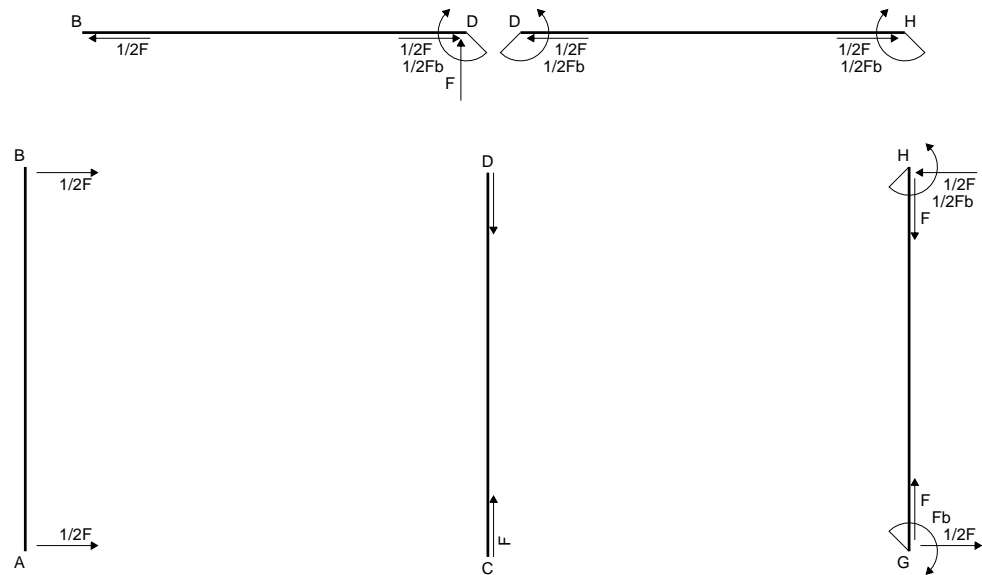
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

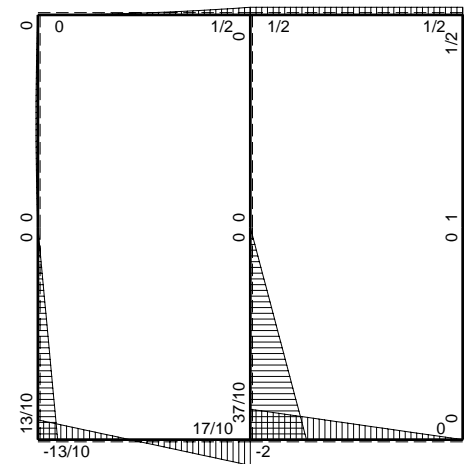
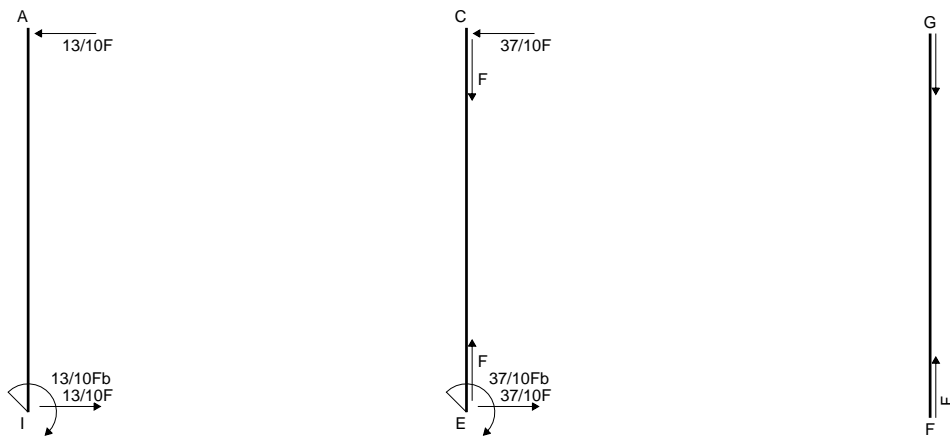


- A = 696. mm²
- J_u = 265885. mm⁴
- J_v = 43992. mm⁴
- y_g = 24.15 mm
- T_y = 2100. N
- M_x = -2037000. Nmm
- x_m = 30. mm
- y_m = 54. mm
- u_m = 9. mm
- v_m = 29.85 mm
- σ_m = -Mv/J_u = 228.7 N/mm²
- x_c = 21. mm
- y_c = 7. mm
- v_c = -17.15 mm
- σ_c = -Mv/J_u = -131.4 N/mm²
- τ_c = 7.154 N/mm²
- σ_q = √σ²+3τ² = 131.9 N/mm²
- S = 5435. mm³

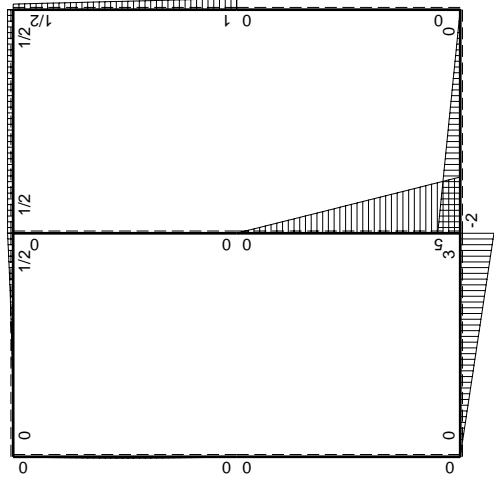
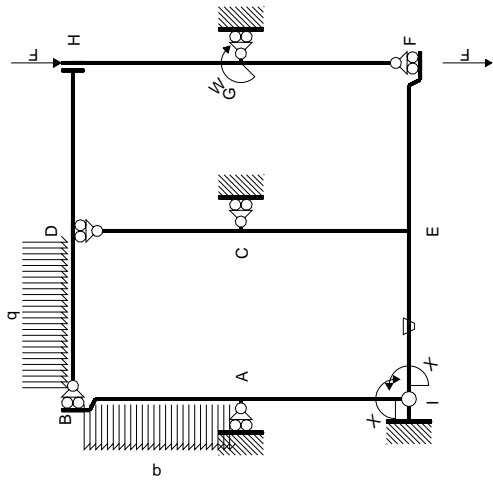


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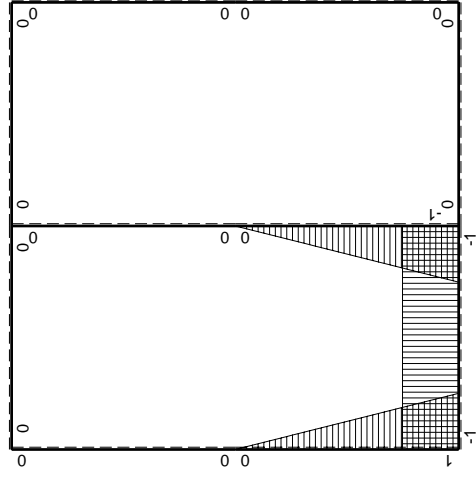


⊕ ⊖ Fb



Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M₁ flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

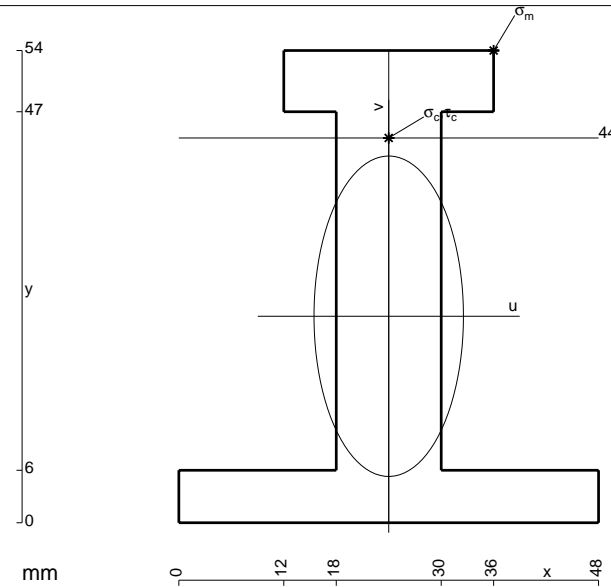
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

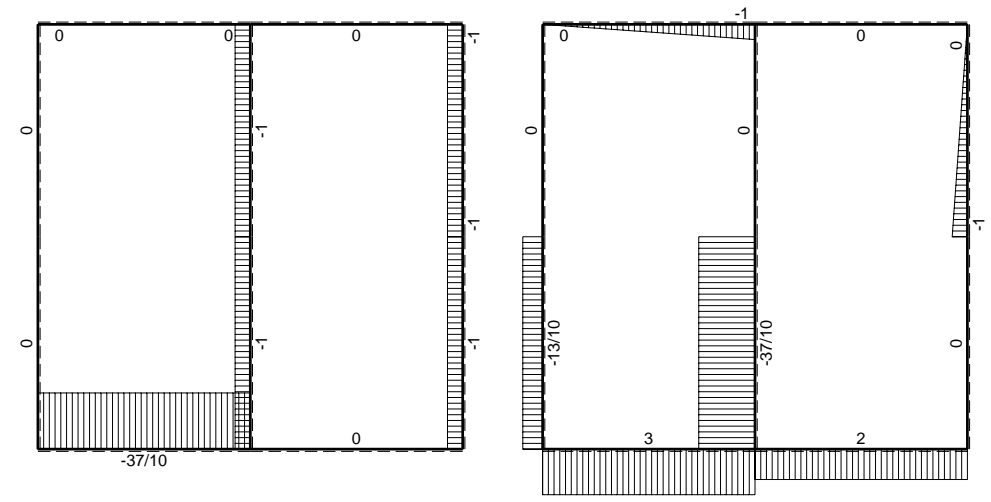
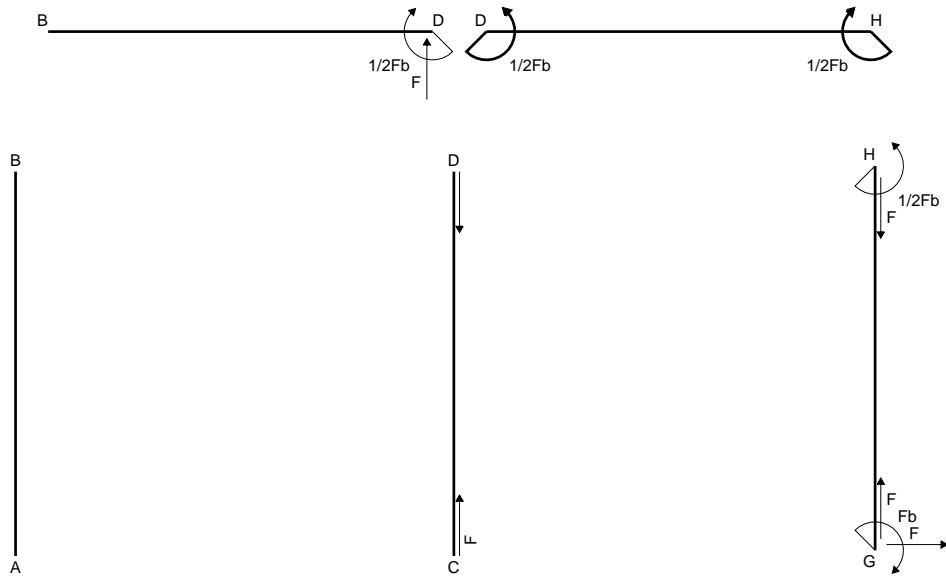
$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

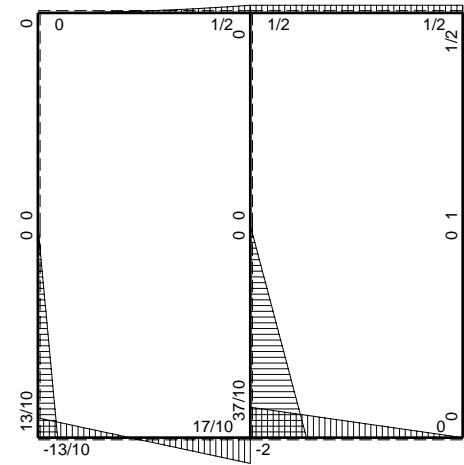
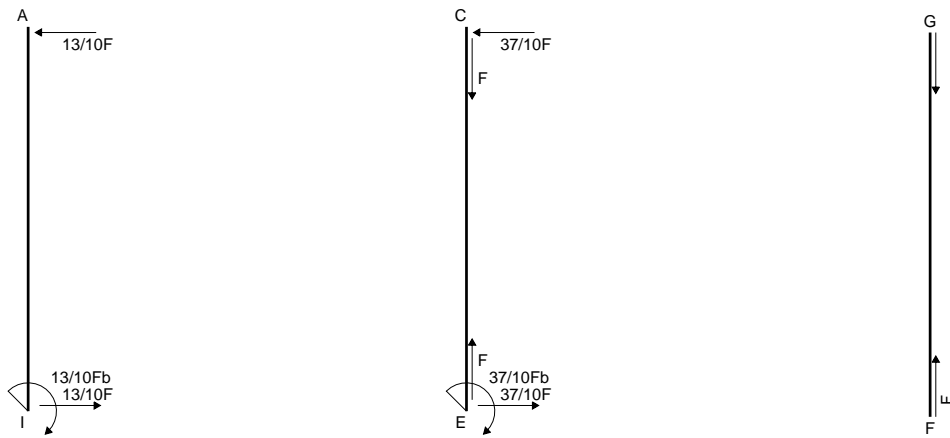


- A = 948. mm²
- J_u = 318391. mm⁴
- J_v = 69264. mm⁴
- y_g = 23.61 mm
- T_y = 2460. N
- M_x = -2509200. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 30.39 mm
- σ_m = -Mv/J_u = 239.5 N/mm²
- x_c = 24. mm
- y_c = 44. mm
- v_c = 20.39 mm
- σ_c = -Mv/J_u = 160.7 N/mm²
- τ_c = 3.416 N/mm²
- σ_q = √σ²+3τ² = 160.8 N/mm²
- S = 5305. mm³

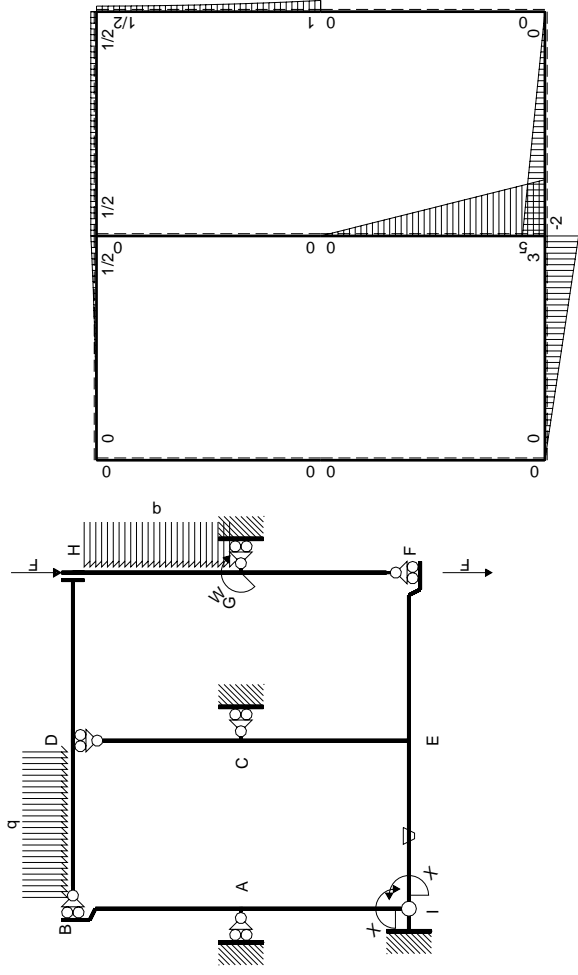


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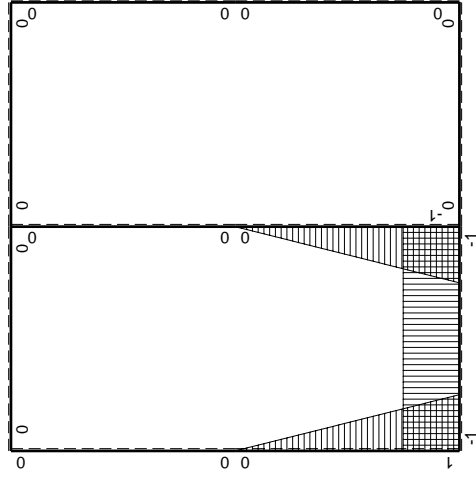


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

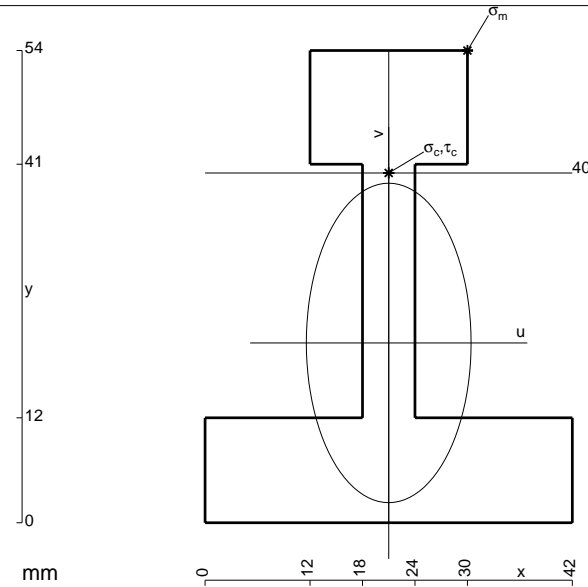
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$



$$A = 912. \text{ mm}^2$$

$$J_u = 304351. \text{ mm}^4$$

$$J_v = 80928. \text{ mm}^4$$

$$y_g = 20.56 \text{ mm}$$

$$T_y = 3360. \text{ N}$$

$$M_x = -1814400. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 33.44 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

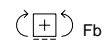
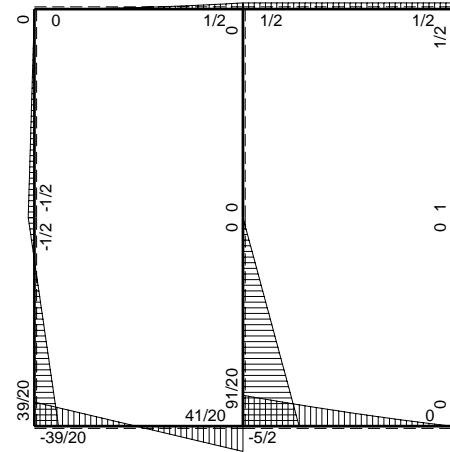
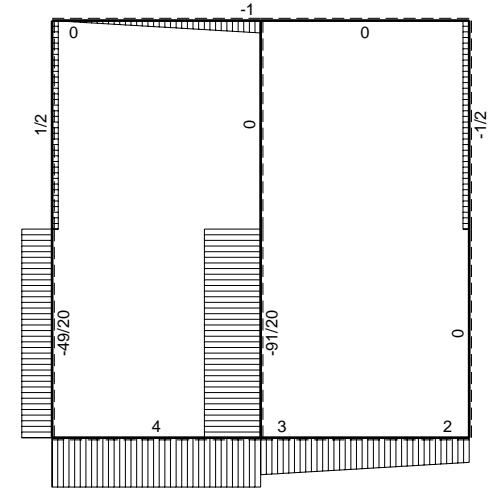
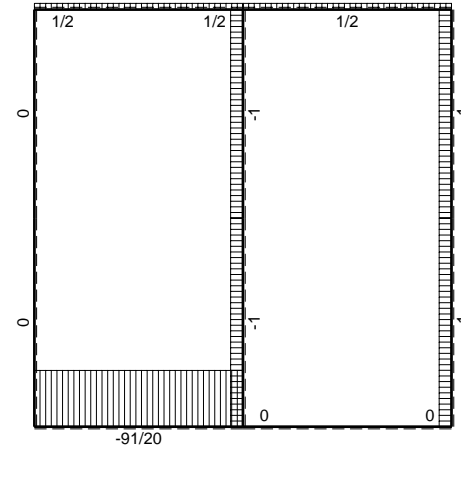
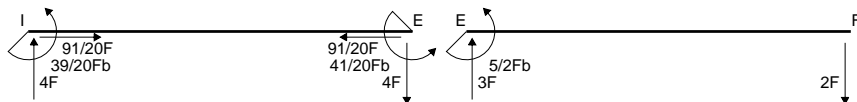
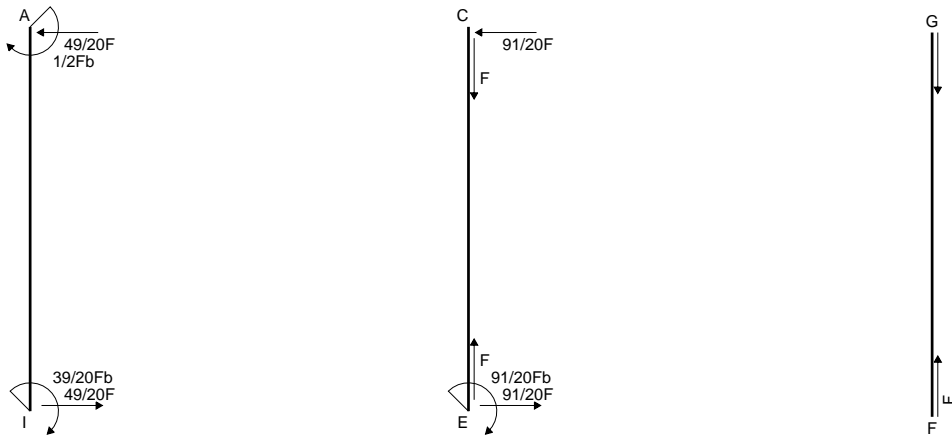
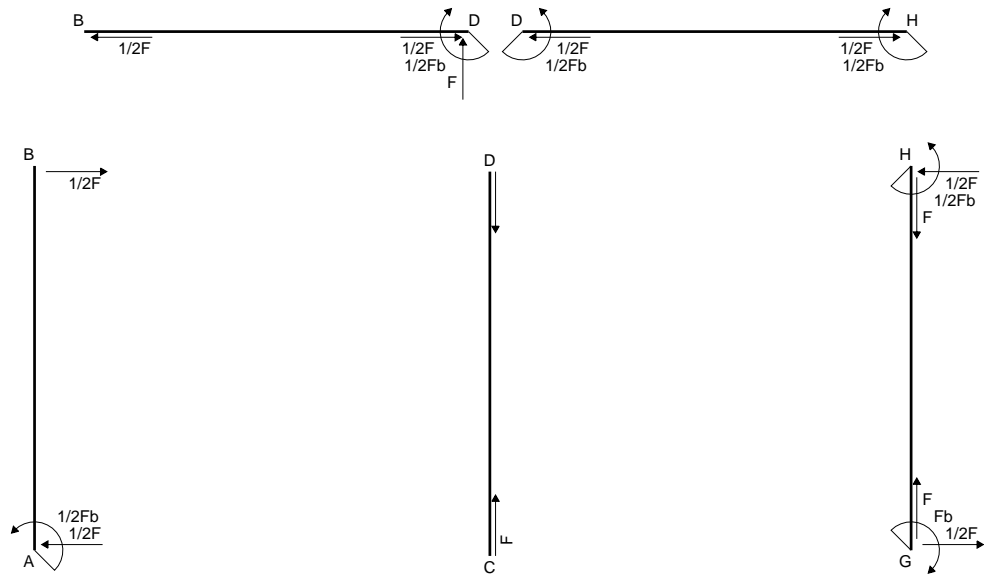
$$v_c = 19.44 \text{ mm}$$

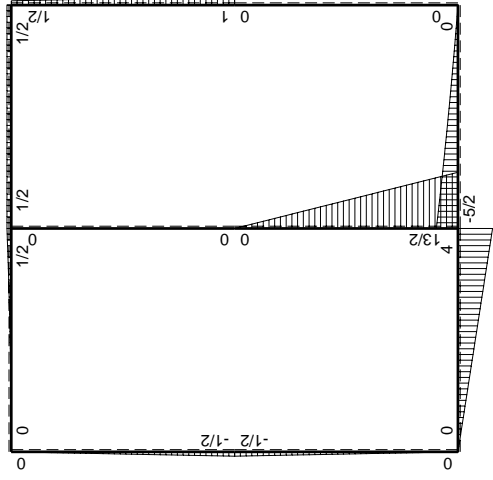
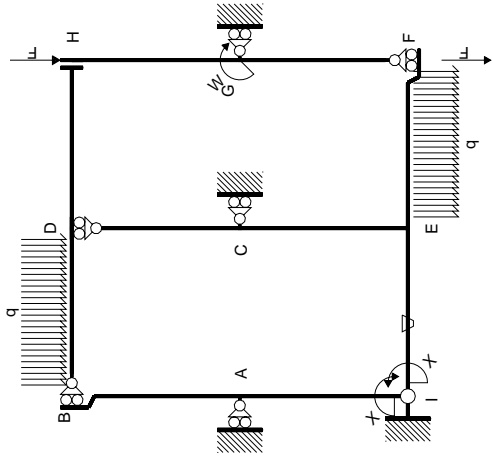
$$\sigma_c = -Mv/J_u = 115.9 \text{ N/mm}^2$$

$$\tau_c = 11.82 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 117.7 \text{ N/mm}^2$$

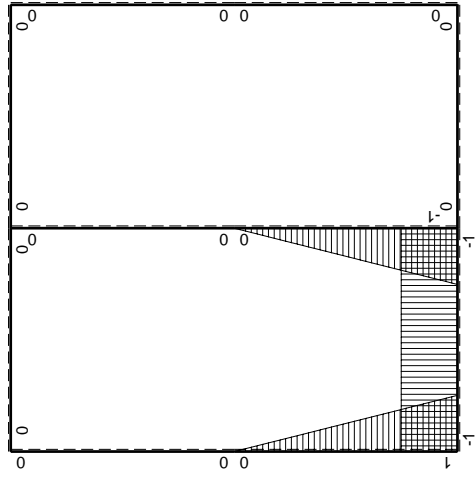
$$S = 6424. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-13/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$39/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

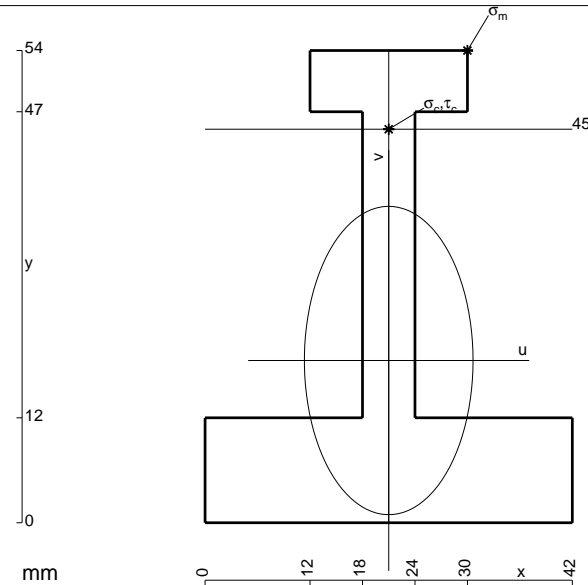
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

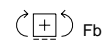
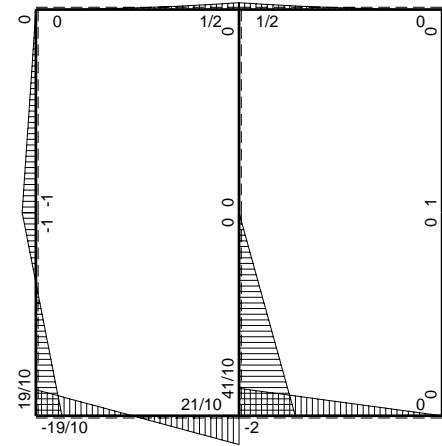
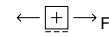
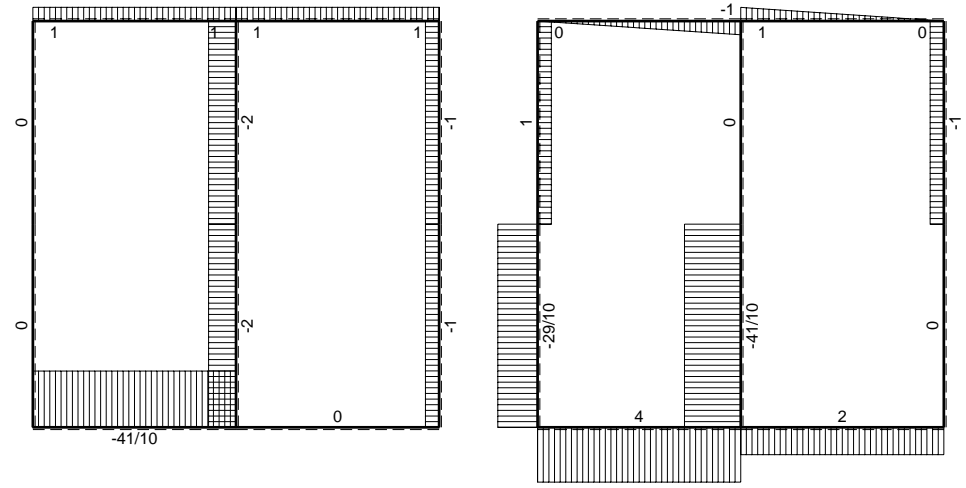
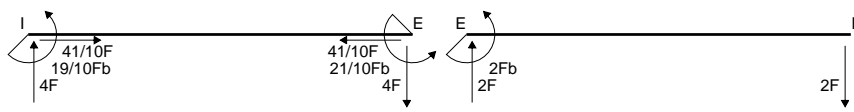
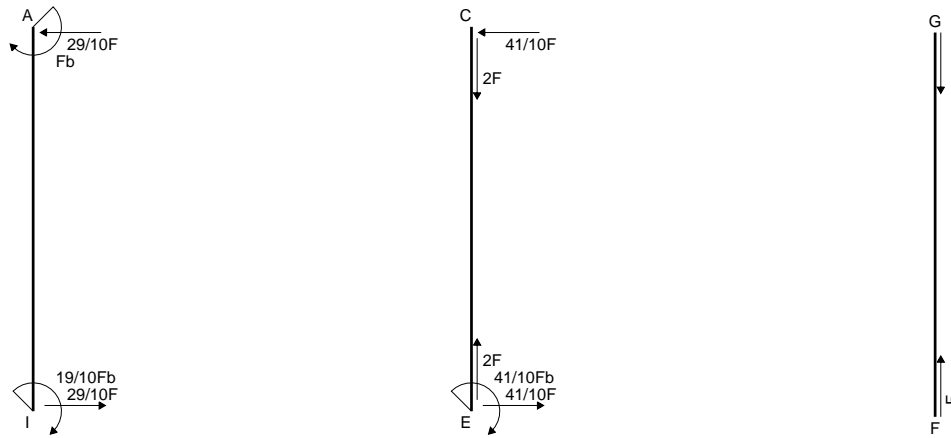
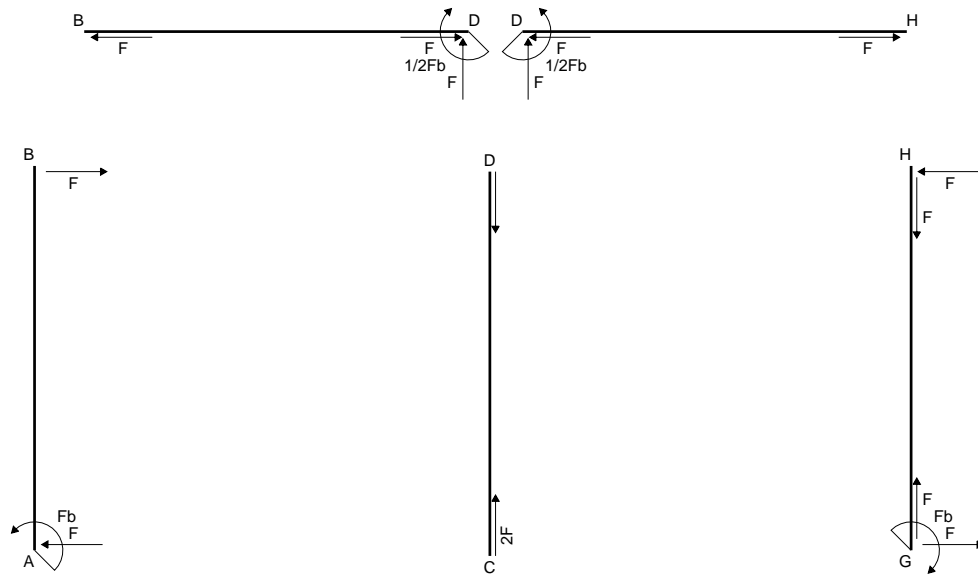
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

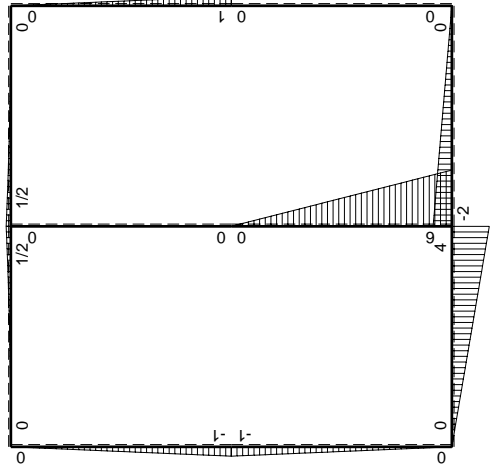
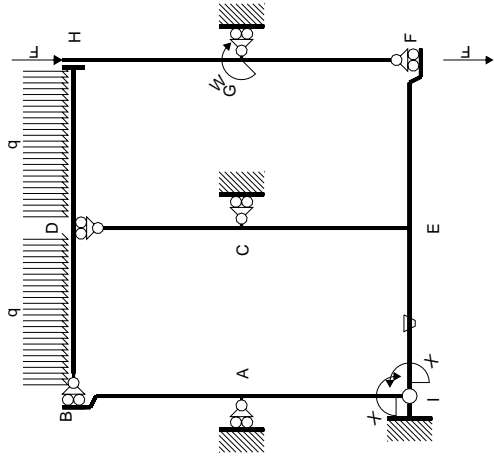
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



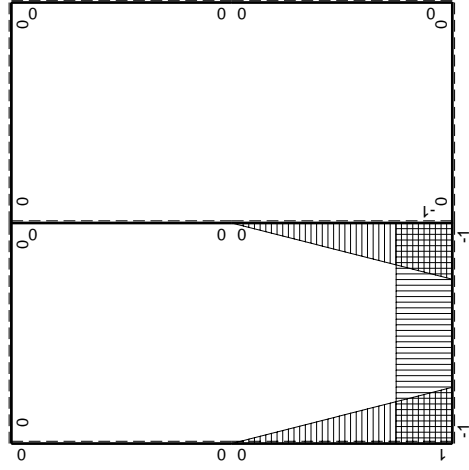
- A = 840. mm²
- J_u = 261182. mm⁴
- J_v = 78120. mm⁴
- y_g = 18.55 mm
- T_y = 3120. N
- M_x = -1534000. Nmm
- x_m = 30. mm
- y_m = 54. mm
- u_m = 9. mm
- v_m = 35.45 mm
- σ_m = -Mv/J_u = 208.2 N/mm²
- x_c = 21. mm
- y_c = 45. mm
- v_c = 26.45 mm
- σ_c = -Mv/J_u = 155.3 N/mm²
- τ_c = 8.671 N/mm²
- σ_q = √σ²+3τ² = 156.1 N/mm²
- S = 4355. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	4Fx	-Fb/EJ	-4Fx	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-4Fb+4Fx	Fb/EJ	-4Fb+4Fx	Fb/EJ	1		
EC b	$-1+x/b$	6Fb-6Fx	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-6Fx	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-19/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						19/10Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

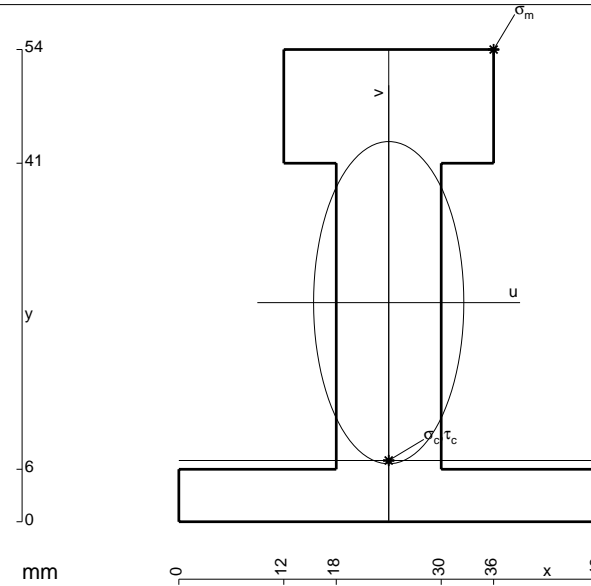
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

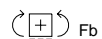
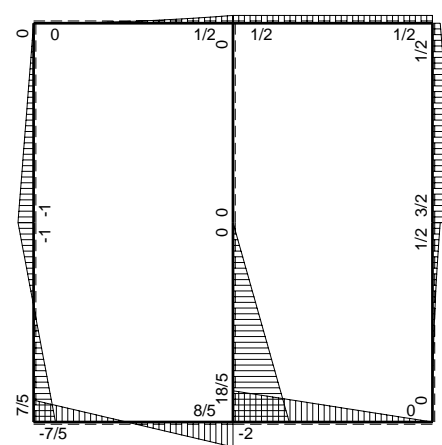
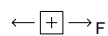
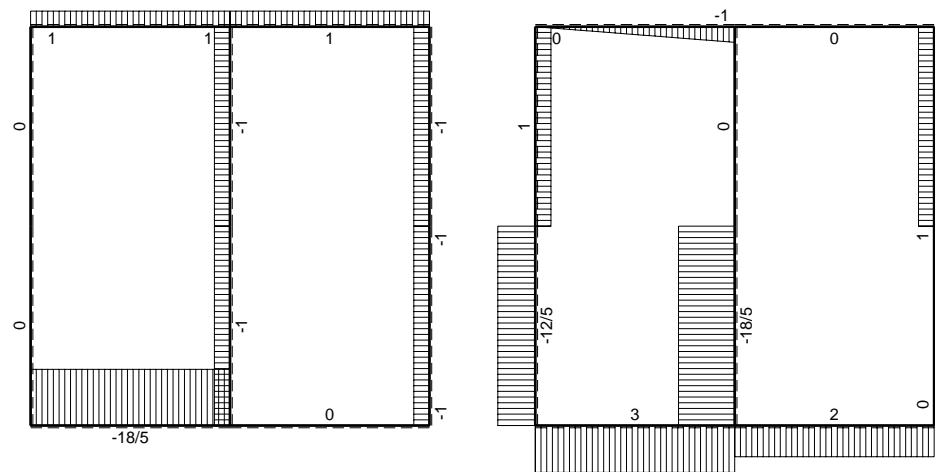
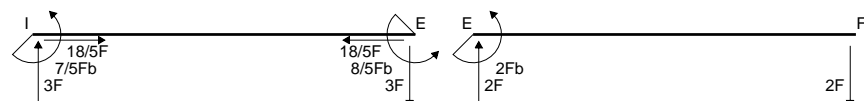
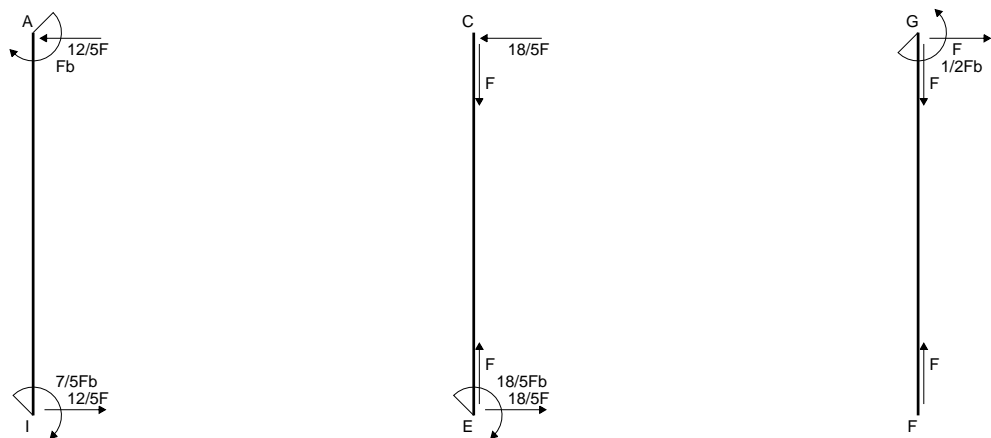
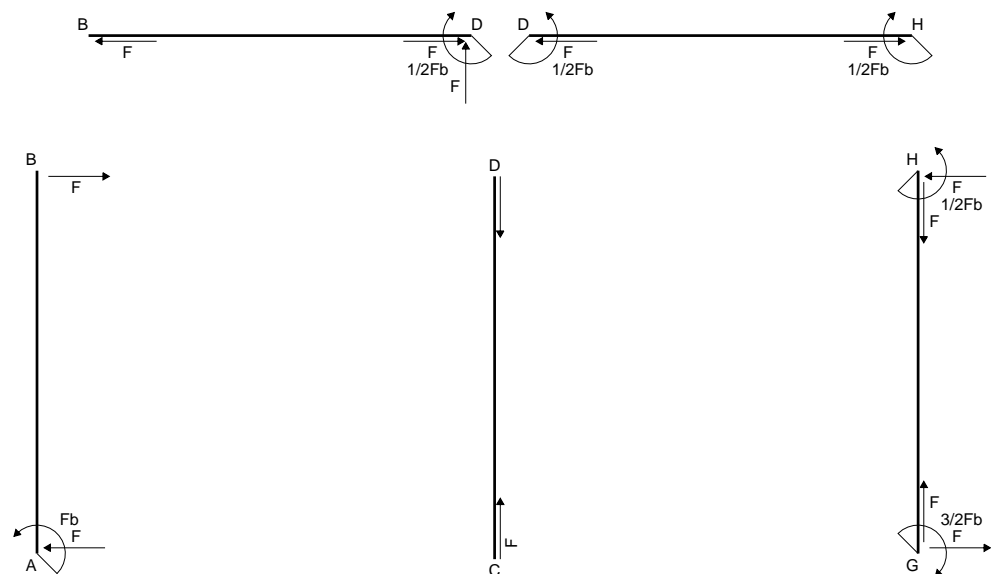
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

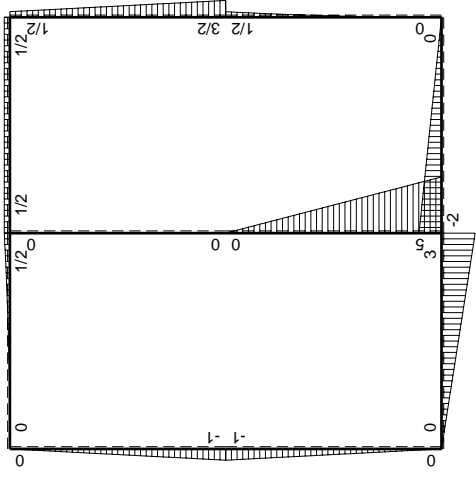
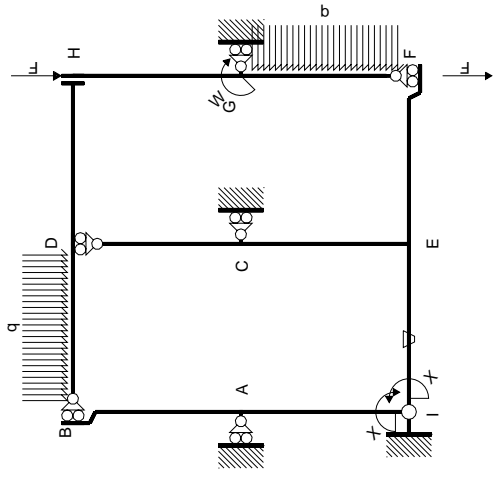
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



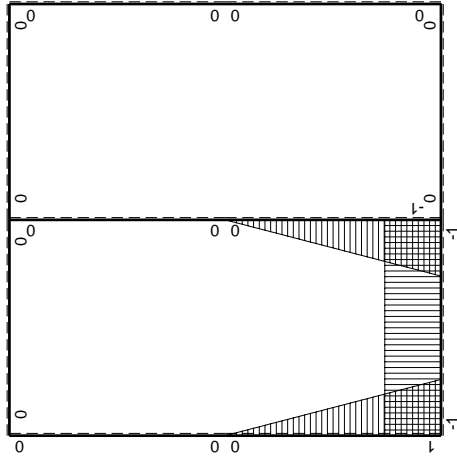
- A = 1020. mm²
- J_u = 346417. mm⁴
- J_v = 75312. mm⁴
- y_g = 25.05 mm
- T_y = 4100. N
- M_x = -2624000. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 28.95 mm
- σ_m = -Mv/J_u = 219.3 N/mm²
- x_c = 24. mm
- y_c = 7. mm
- v_c = -18.05 mm
- σ_c = -Mv/J_u = -136.7 N/mm²
- τ_c = 6.484 N/mm²
- σ_q = √σ²+3τ² = 137.2 N/mm²
- S = 6574. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

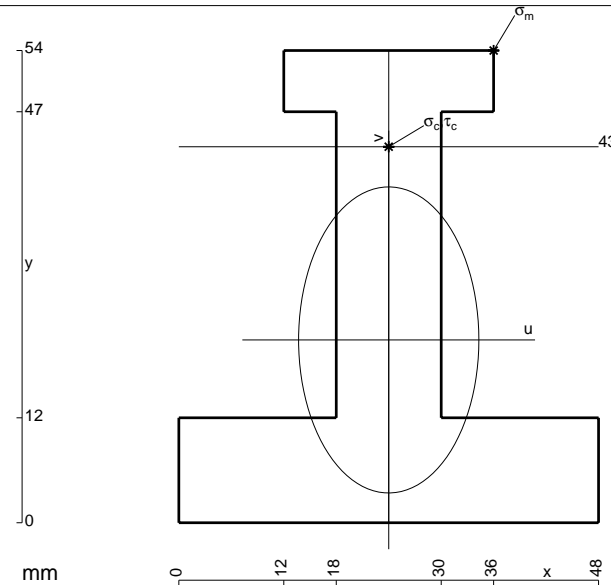
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



$$A = 1164. \text{ mm}^2$$

$$J_u = 356609. \text{ mm}^4$$

$$J_v = 123696. \text{ mm}^4$$

$$y_g = 20.9 \text{ mm}$$

$$T_y = 3540. \text{ N}$$

$$M_x = -2478000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 33.1 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 230. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

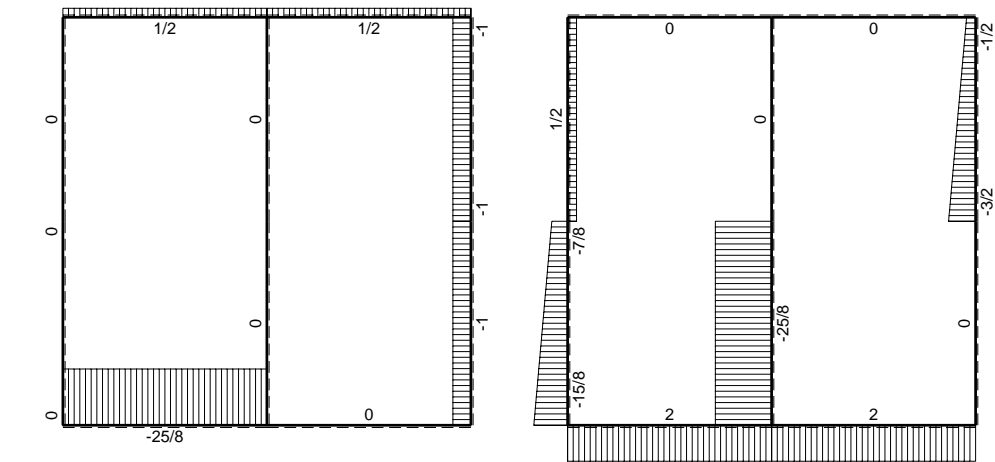
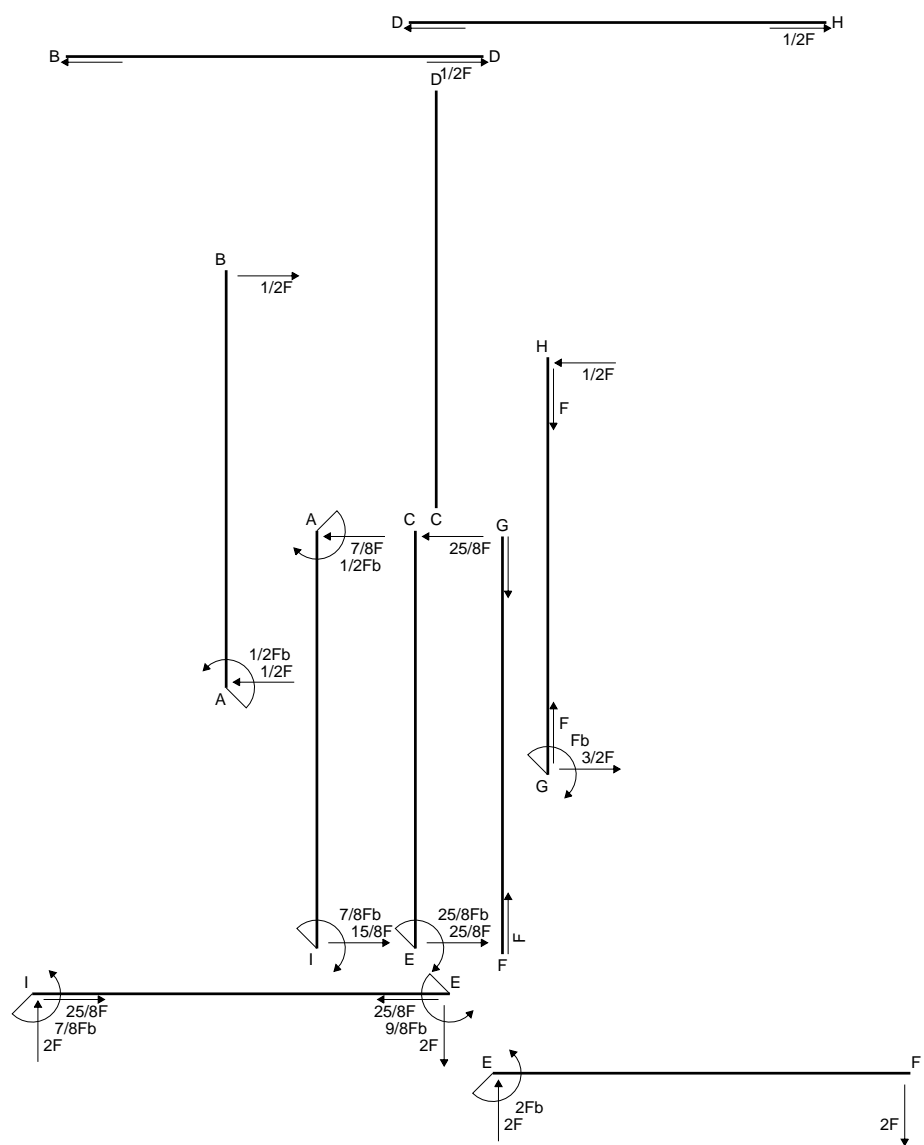
$$v_c = 22.1 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 153.6 \text{ N/mm}^2$$

$$\tau_c = 5.07 \text{ N/mm}^2$$

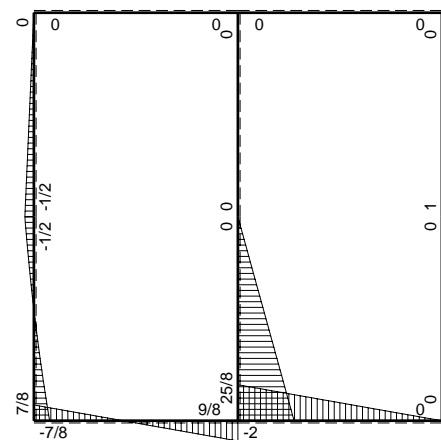
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 153.8 \text{ N/mm}^2$$

$$S = 6129. \text{ mm}^3$$

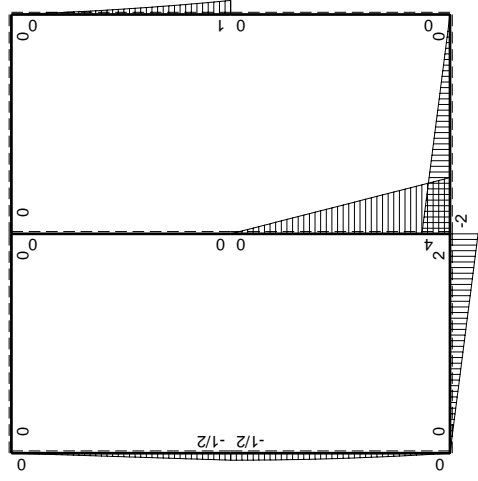
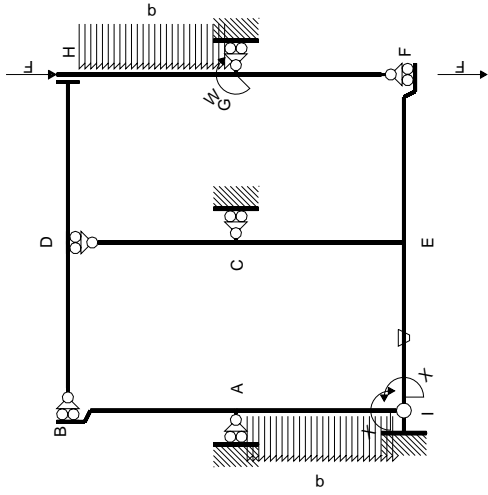


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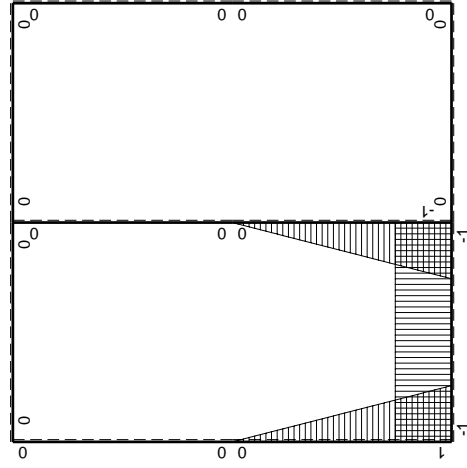


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

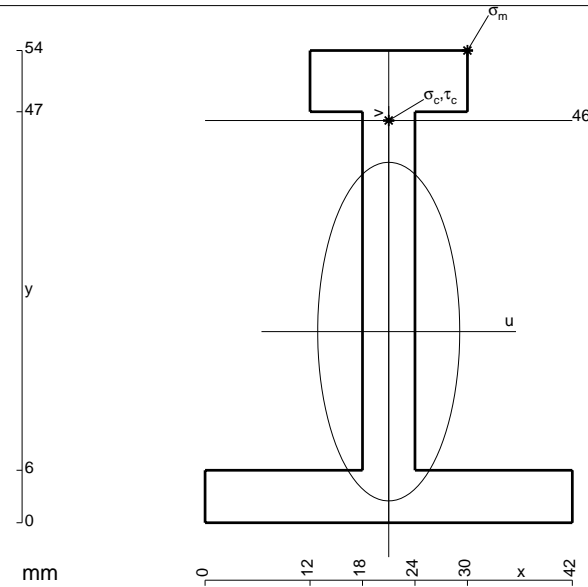
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 624. \text{ mm}^2$$

$$J_u = 234015. \text{ mm}^4$$

$$J_v = 41184. \text{ mm}^4$$

$$y_g = 21.86 \text{ mm}$$

$$T_y = 2320. \text{ N}$$

$$M_x = -1740000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 32.14 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239. \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

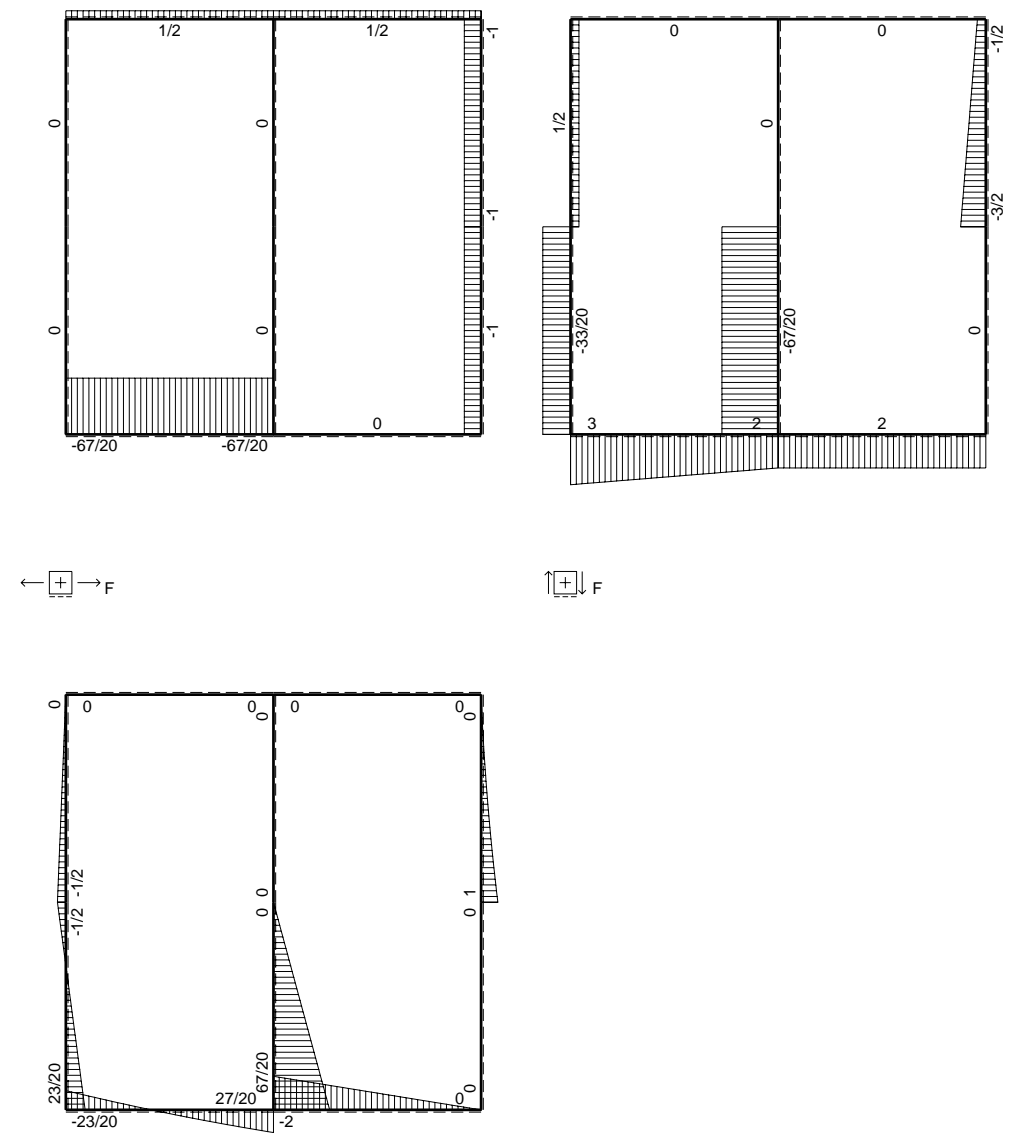
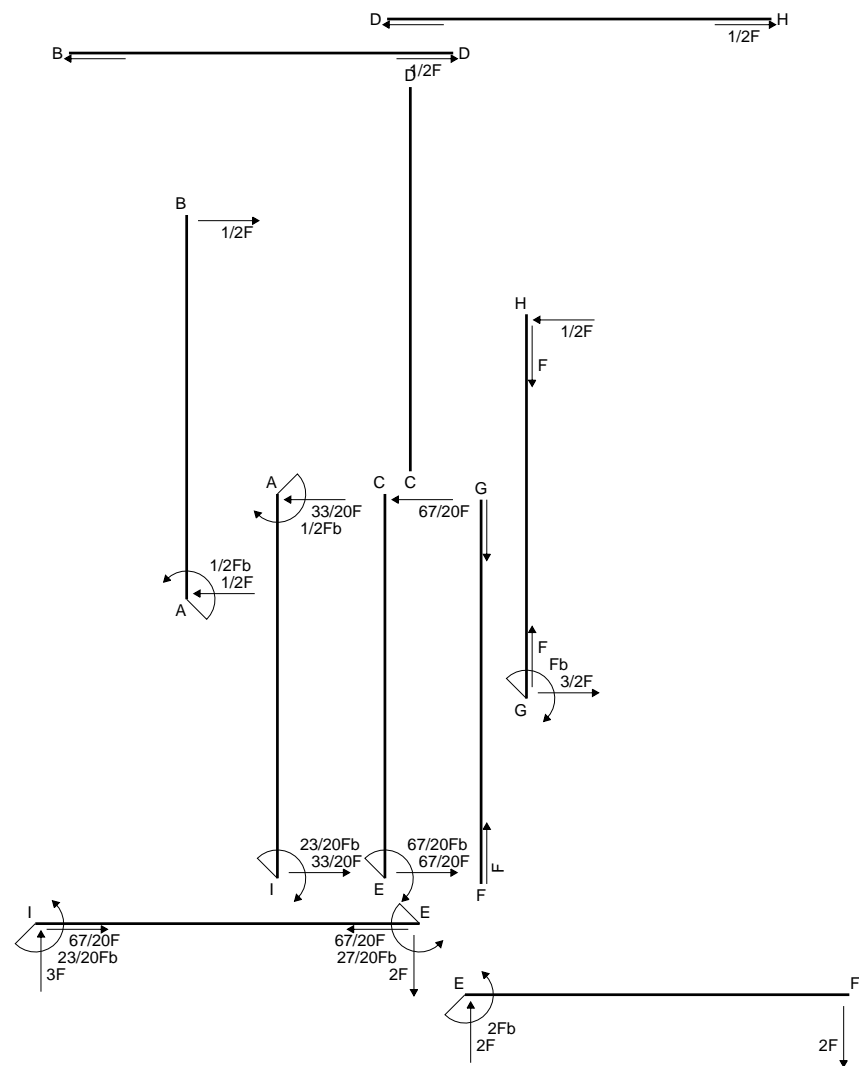
$$v_c = 24.14 \text{ mm}$$

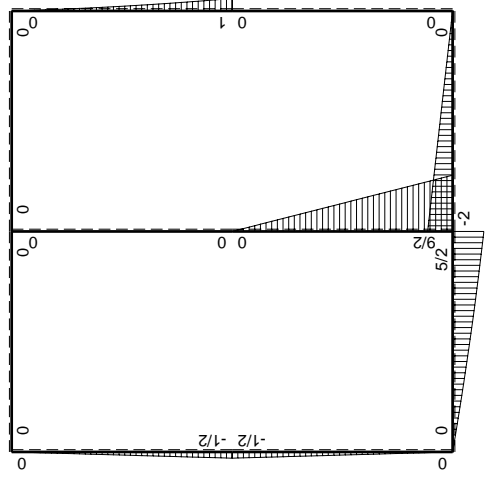
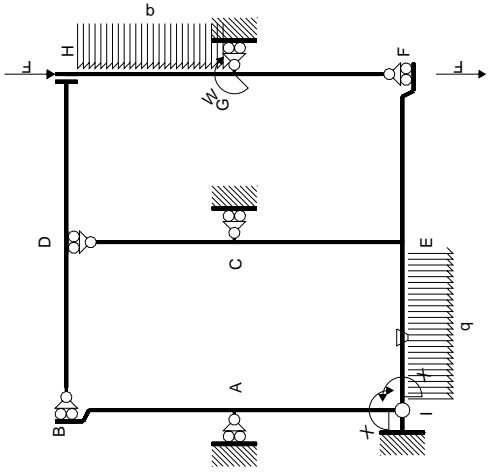
$$\sigma_c = -Mv/J_u = 179.5 \text{ N/mm}^2$$

$$\tau_c = 6.208 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 179.8 \text{ N/mm}^2$$

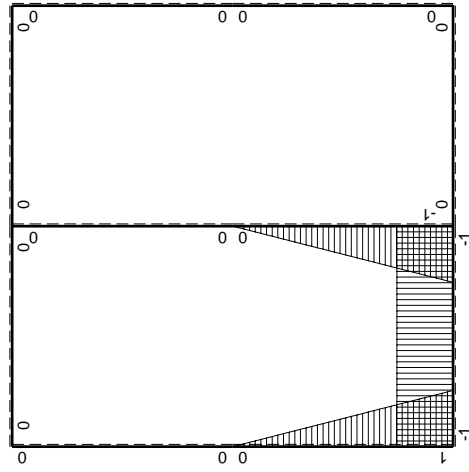
$$S = 3757. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

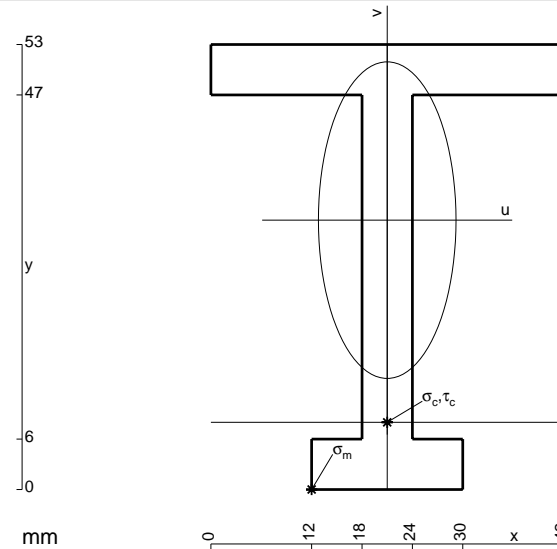
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

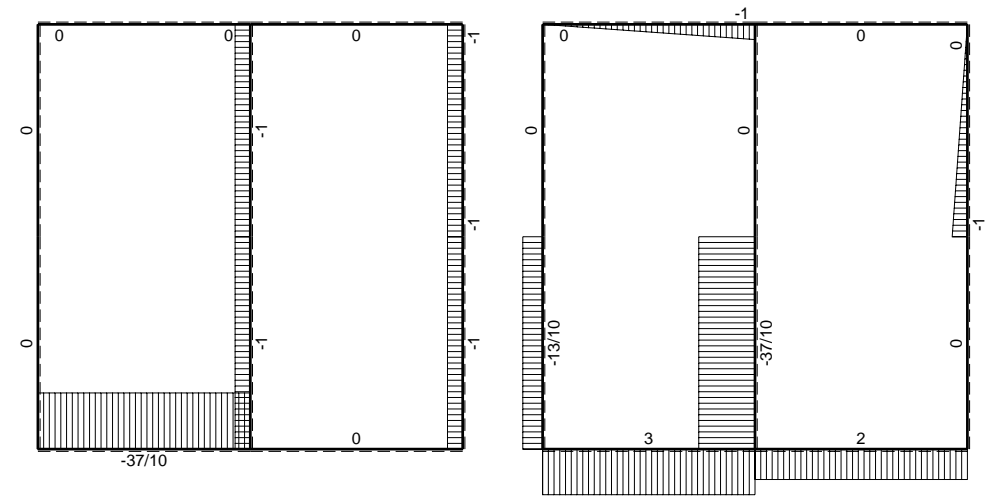
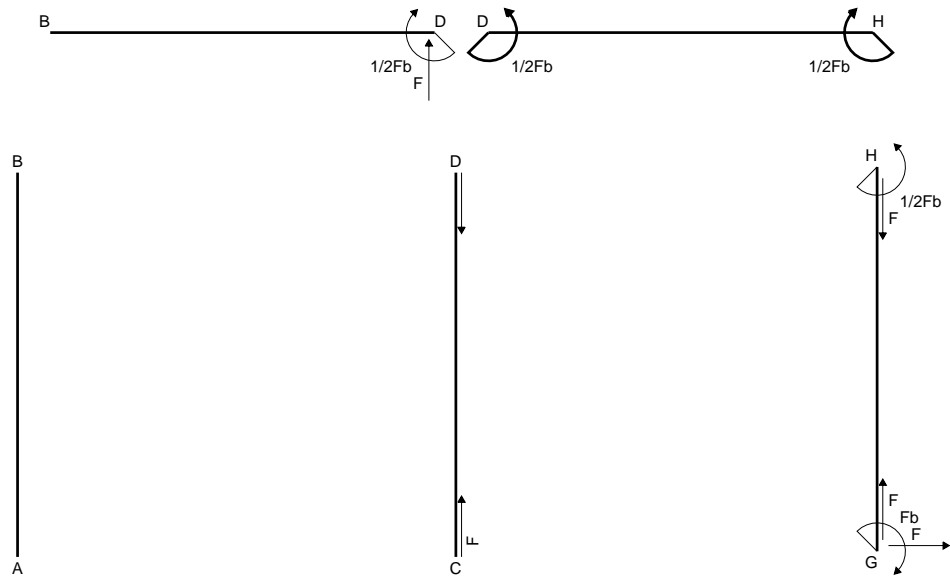
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

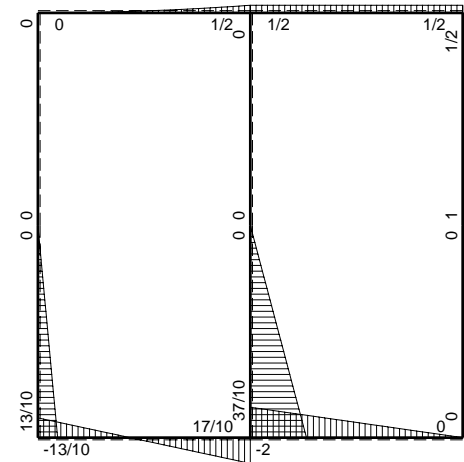
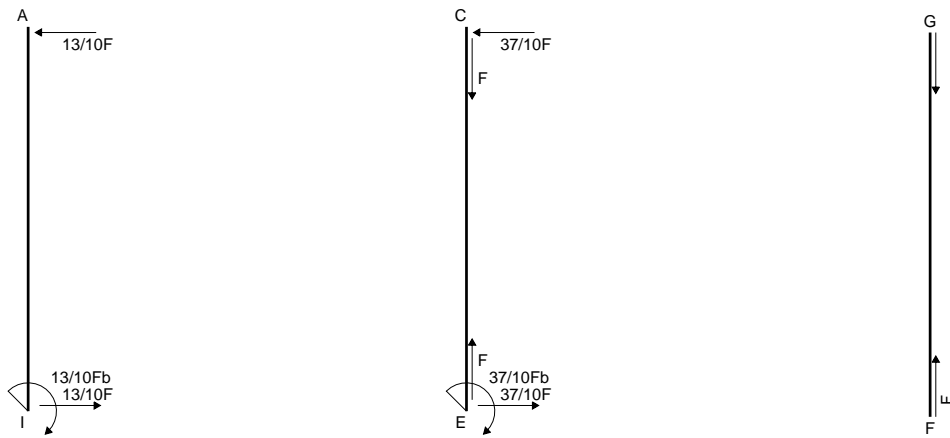


- A = 606. mm²
- J_u = 215454. mm⁴
- J_v = 40698. mm⁴
- y_g = 32.08 mm
- T_y = 1700. N
- M_x = -1343000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -32.08 mm
- σ_m = -Mv/J_u = -200. N/mm²
- x_c = 21. mm
- y_c = 8. mm
- v_c = -24.08 mm
- σ_c = -Mv/J_u = -150.1 N/mm²
- τ_c = 4.527 N/mm²
- σ_o = √σ² + 3τ² = 150.3 N/mm²
- S = 3442. mm³

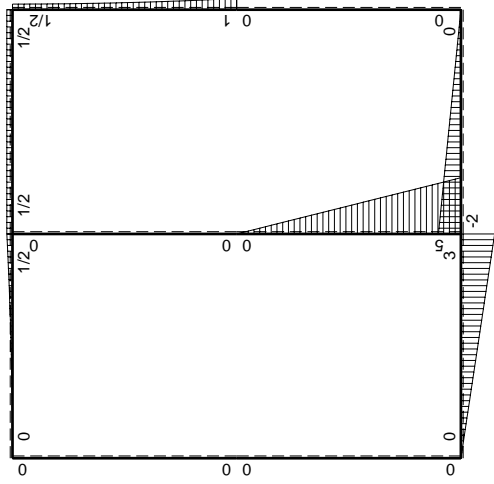
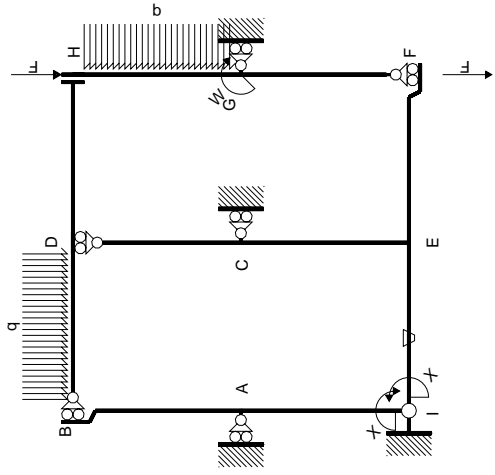


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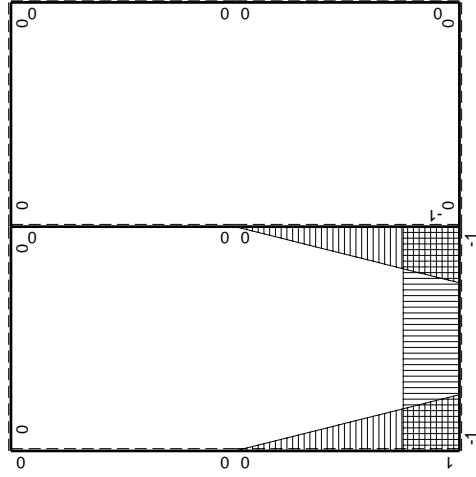


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

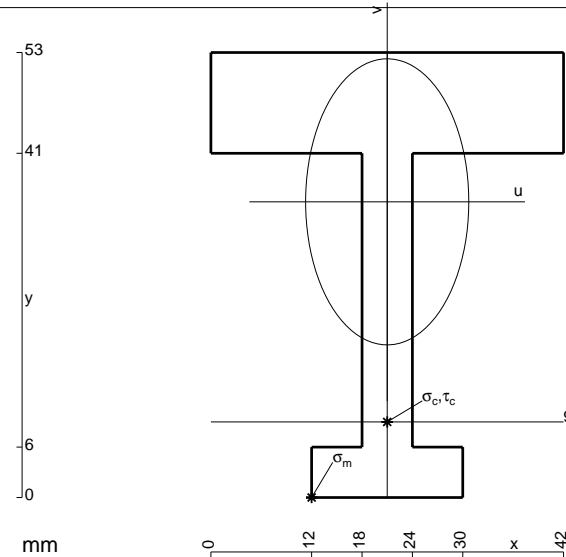
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$



$$A = 822. \text{ mm}^2$$

$$J_u = 238712. \text{ mm}^4$$

$$J_v = 77634. \text{ mm}^4$$

$$y_g = 35.22 \text{ mm}$$

$$T_y = 1680. \text{ N}$$

$$M_x = -1411200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -35.22 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.2 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

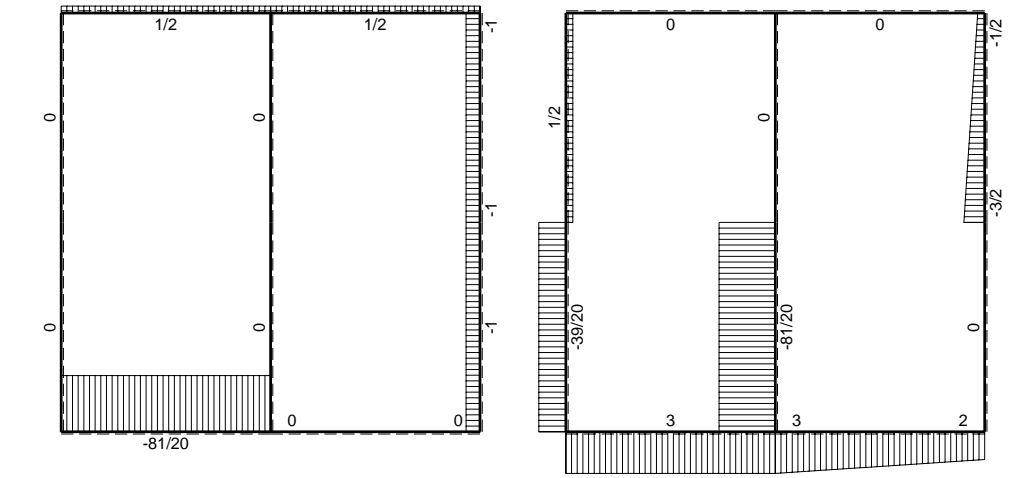
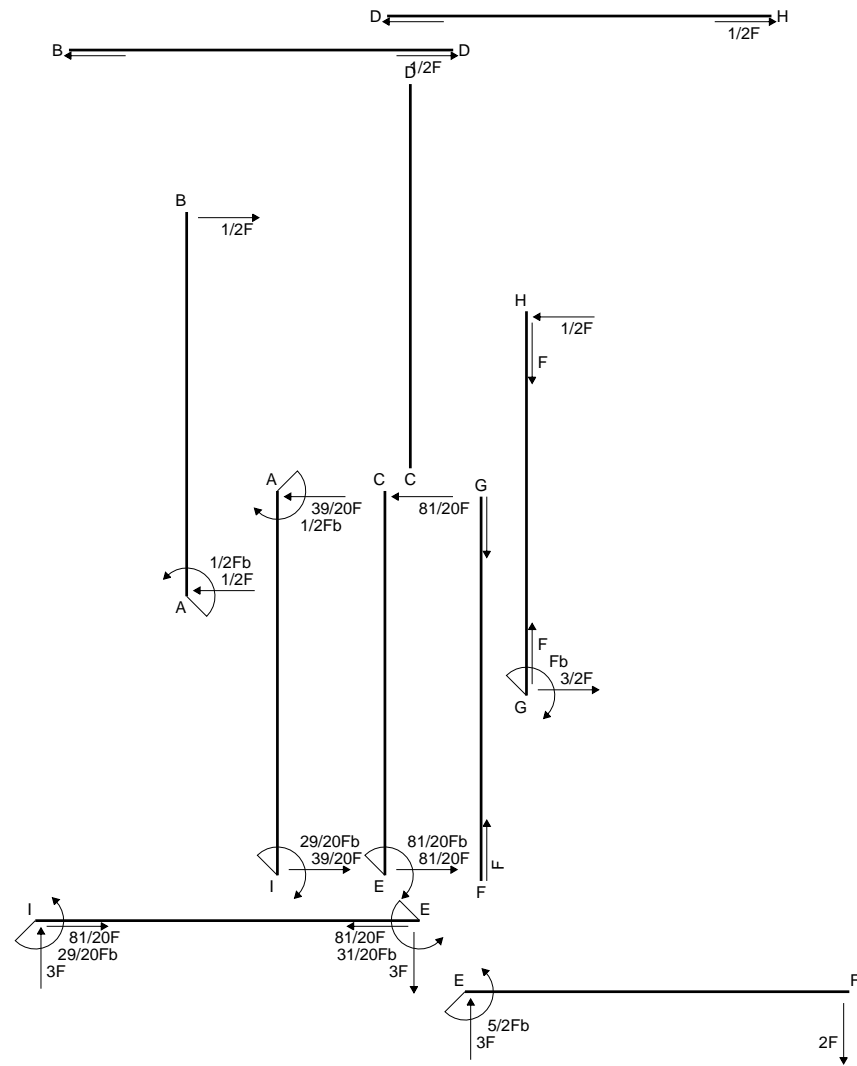
$$v_c = -26.22 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -155. \text{ N/mm}^2$$

$$\tau_c = 4.666 \text{ N/mm}^2$$

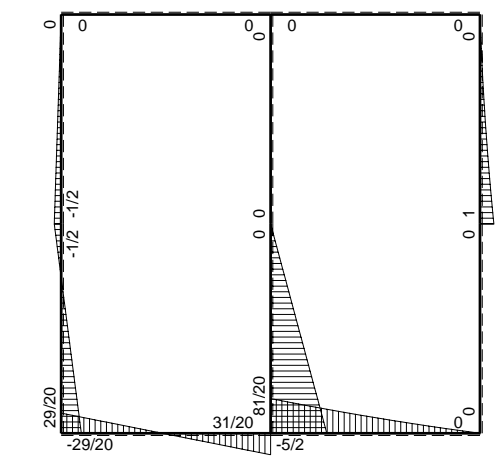
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 155.2 \text{ N/mm}^2$$

$$S = 3978. \text{ mm}^3$$

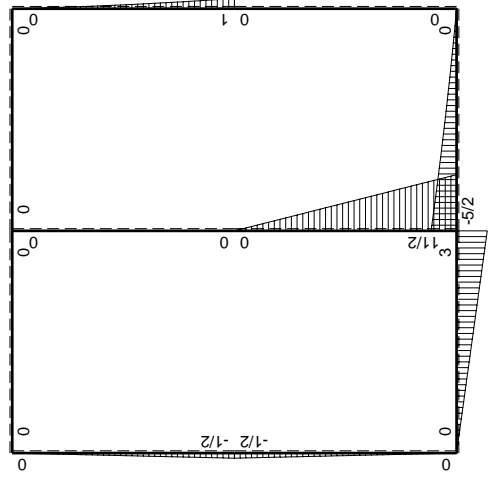
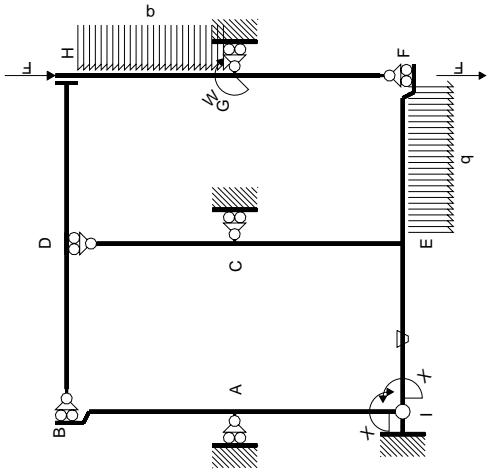


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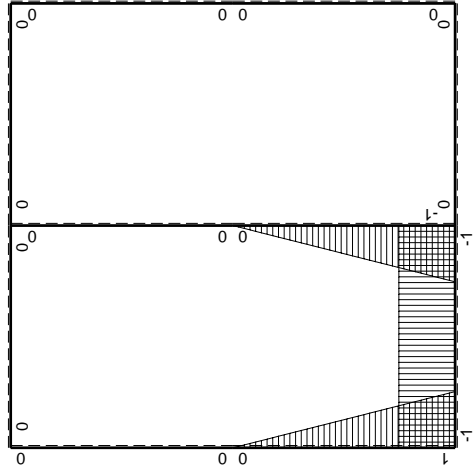


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

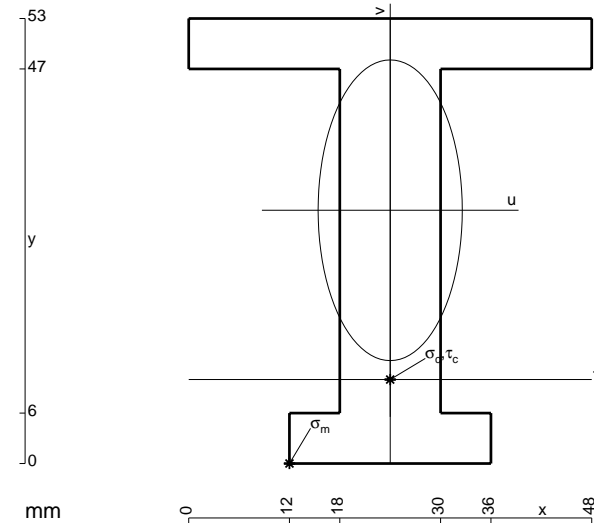
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 924. \text{ mm}^2$$

$$J_u = 296396. \text{ mm}^4$$

$$J_v = 68112. \text{ mm}^4$$

$$y_g = 30.16 \text{ mm}$$

$$T_y = 2880. \text{ N}$$

$$M_x = -2160000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.16 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

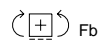
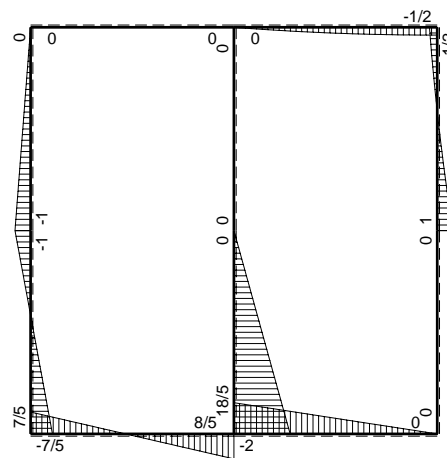
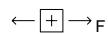
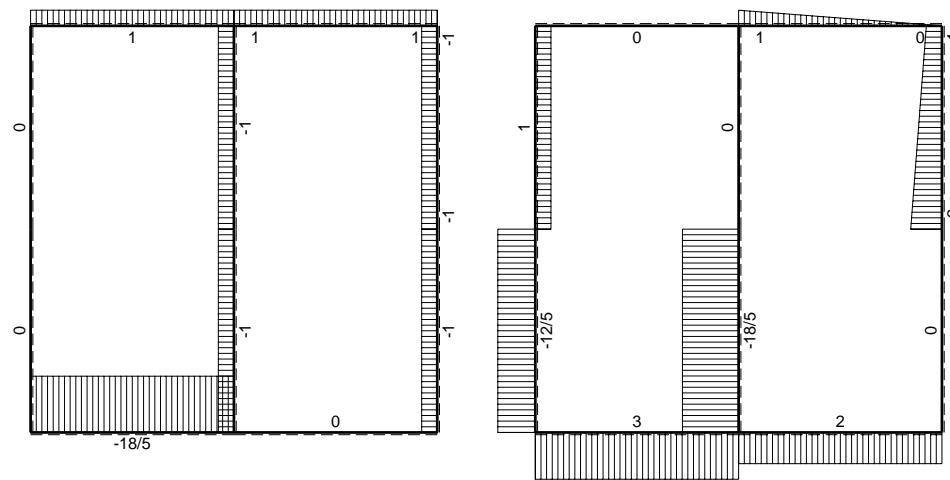
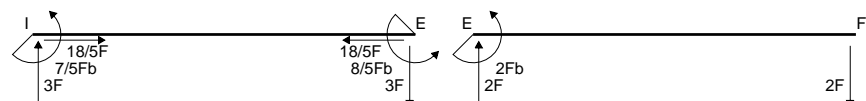
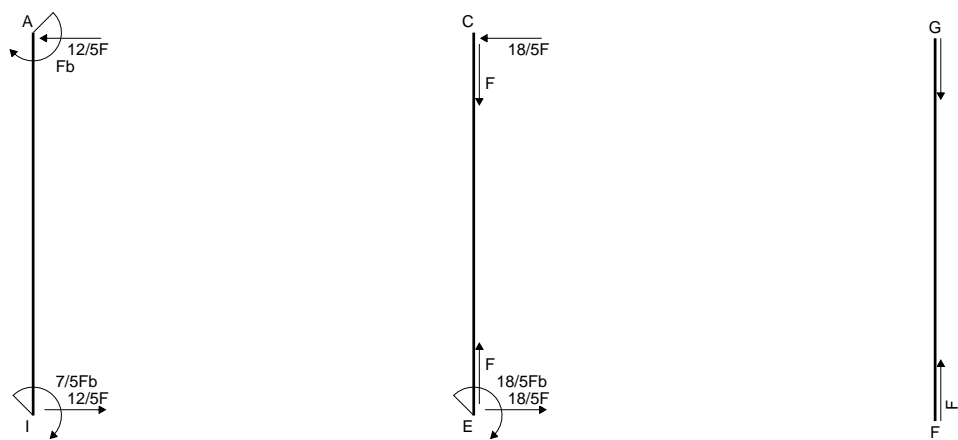
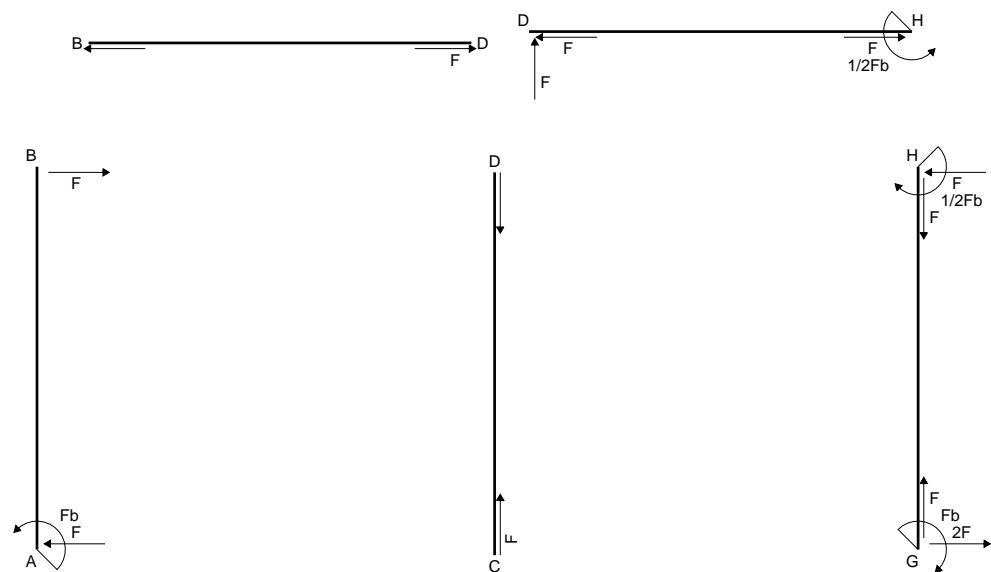
$$v_c = -20.16 \text{ mm}$$

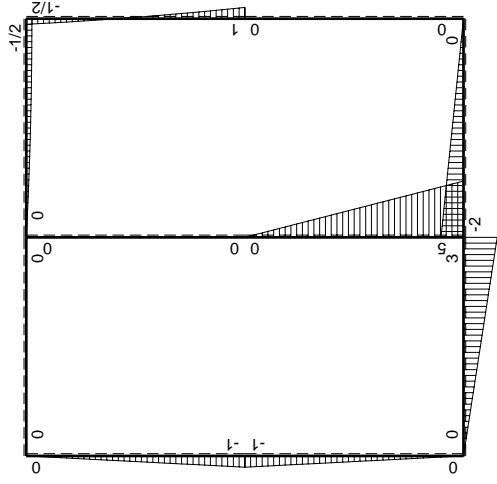
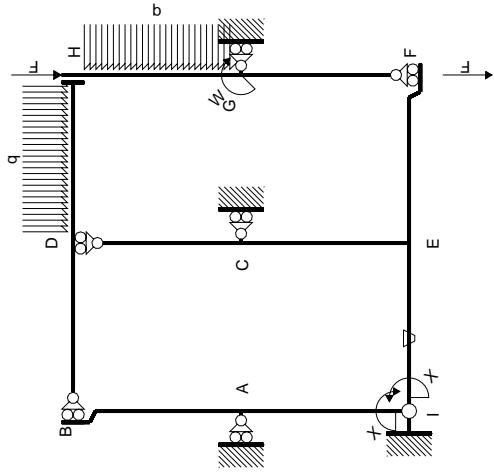
$$\sigma_c = -Mv/J_u = -146.9 \text{ N/mm}^2$$

$$\tau_c = 4.029 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 147.1 \text{ N/mm}^2$$

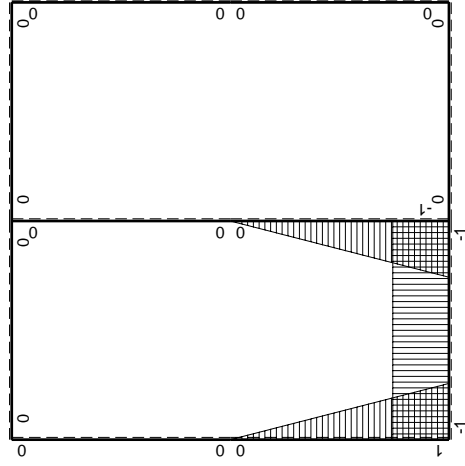
$$S = 4975. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

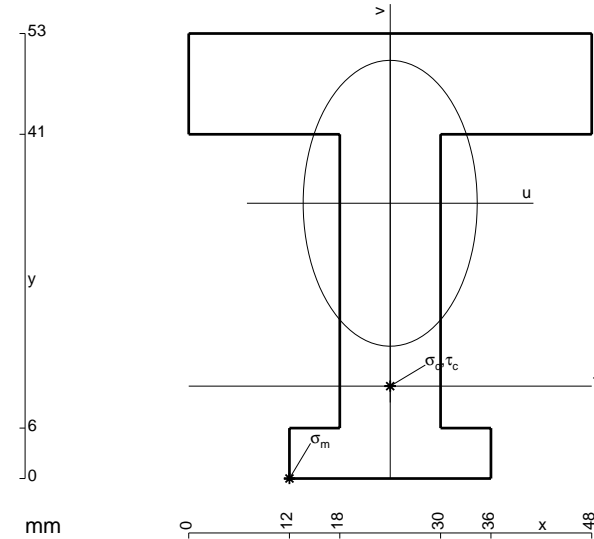
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

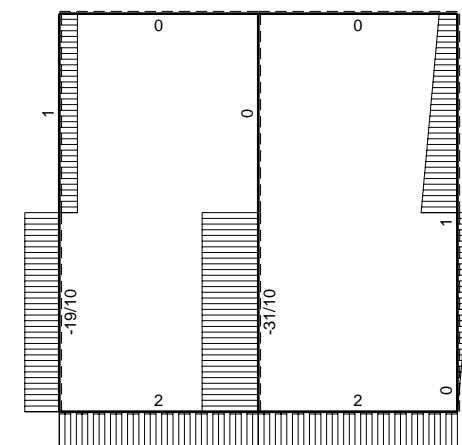
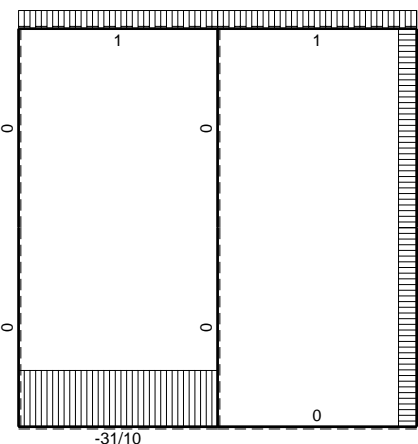
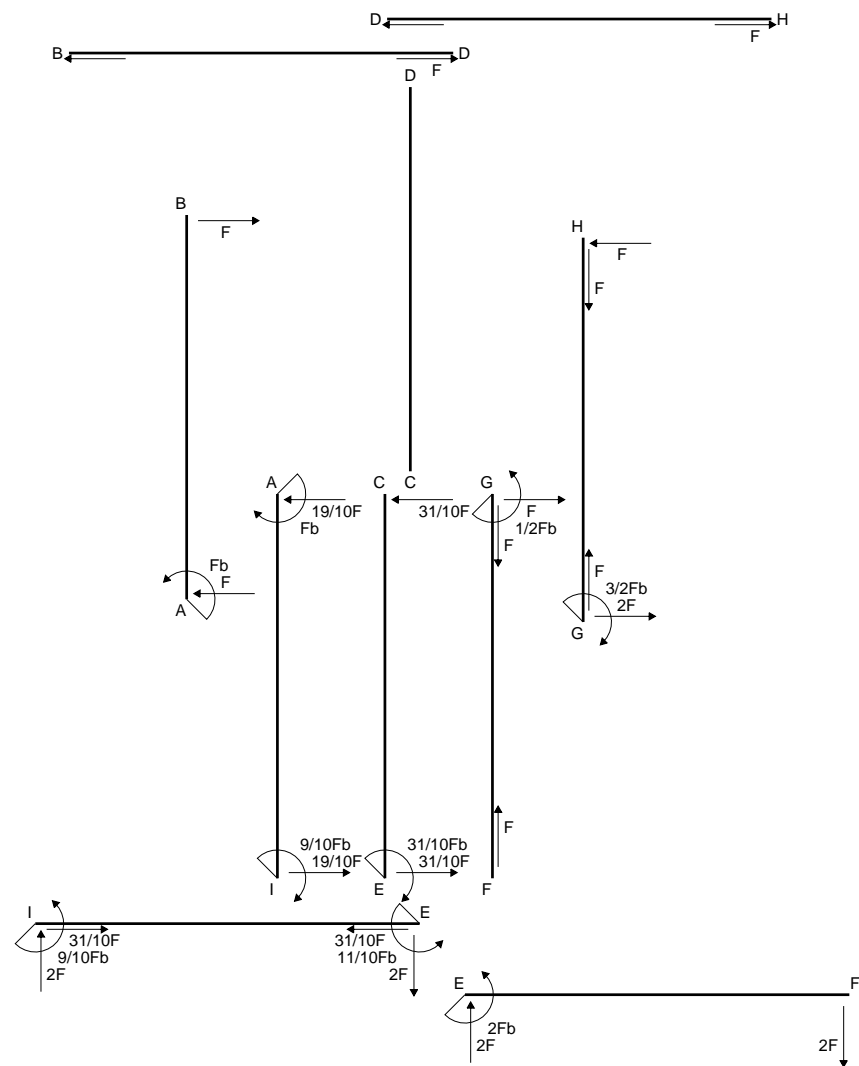
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

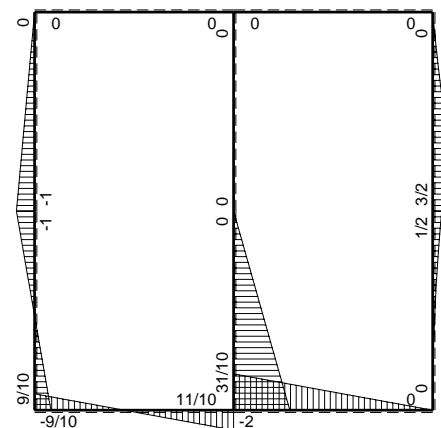


- A = 1140. mm²
- J_u = 330567. mm⁴
- J_v = 122544. mm⁴
- y_g = 32.78 mm
- T_y = 2440. N
- M_x = -2318000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -32.78 mm
- σ_m = -Mv/J_u = -229.9 N/mm²
- x_c = 24. mm
- y_c = 11. mm
- v_c = -21.78 mm
- σ_c = -Mv/J_u = -152.8 N/mm²
- τ_c = 3.534 N/mm²
- σ_o = √σ²+3τ² = 152.9 N/mm²
- S = 5746. mm³

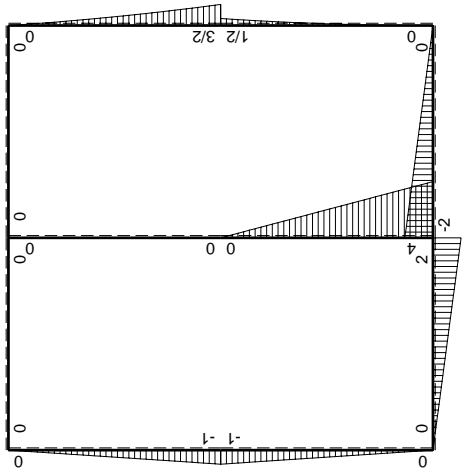
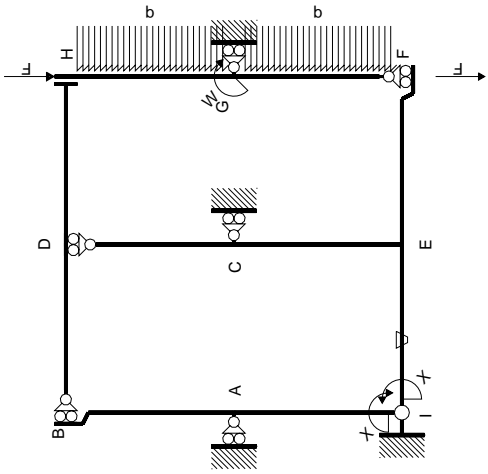


← (+) → F

↑ (+) ↓ F

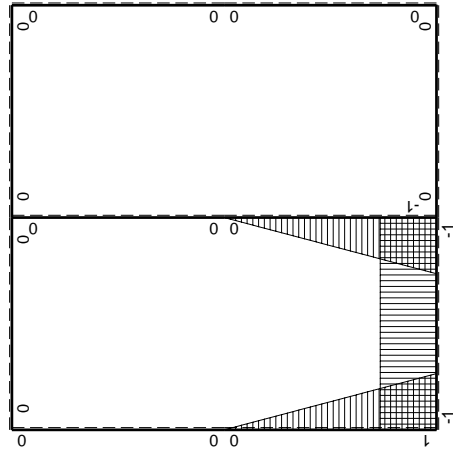


⊙ (+) ⊙ F_b



Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

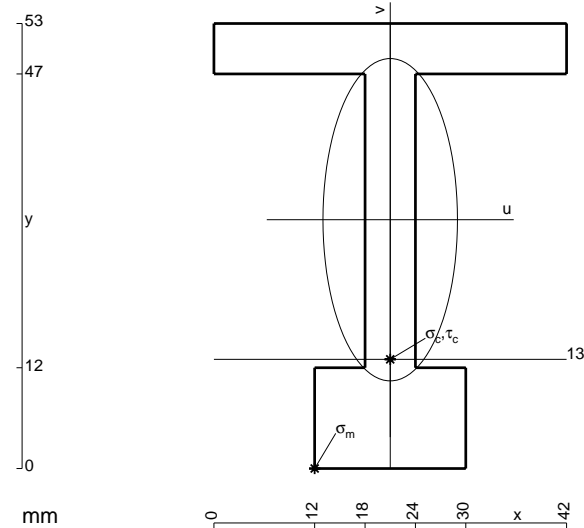
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 678. \text{ mm}^2$$

$$J_u = 249963. \text{ mm}^4$$

$$J_v = 43506. \text{ mm}^4$$

$$y_g = 29.63 \text{ mm}$$

$$T_y = 2020. \text{ N}$$

$$M_x = -2020000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -29.63 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

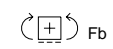
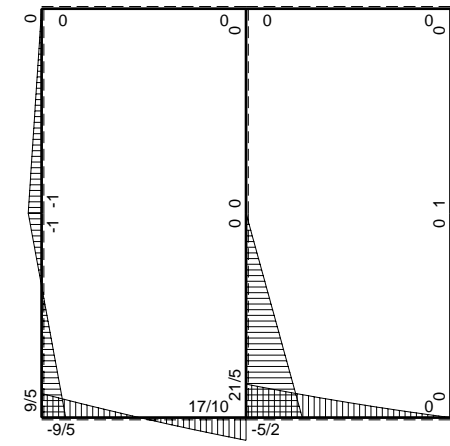
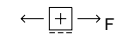
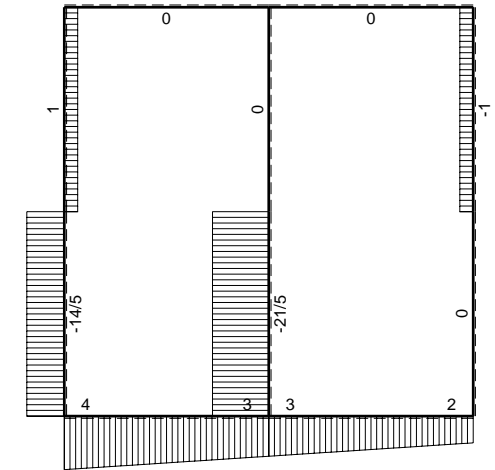
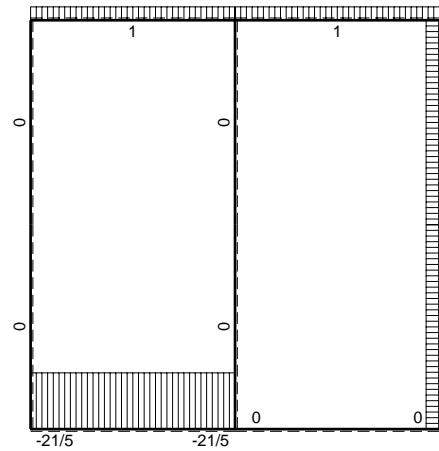
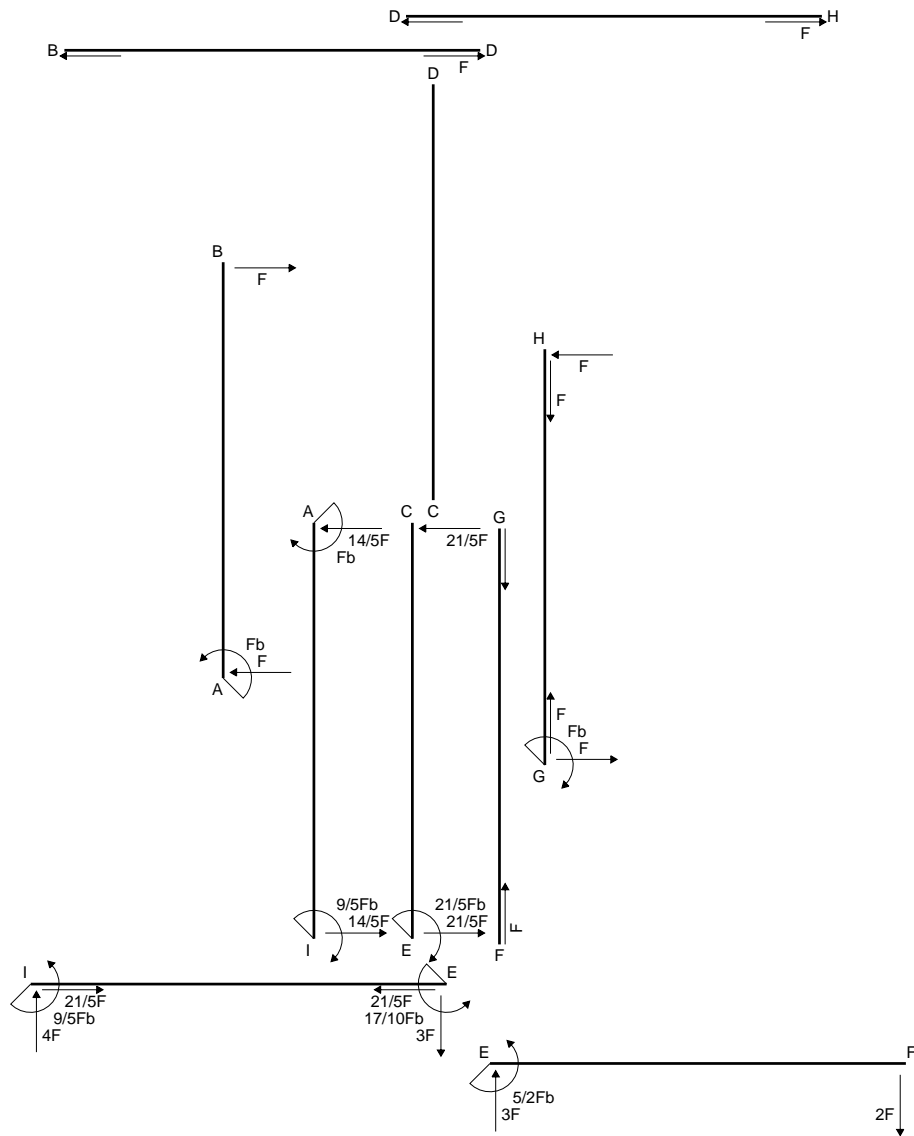
$$v_c = -16.63 \text{ mm}$$

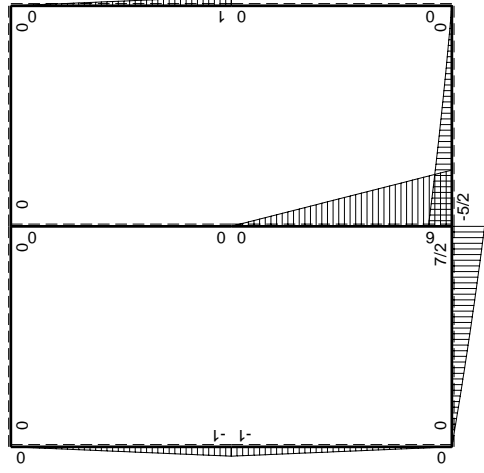
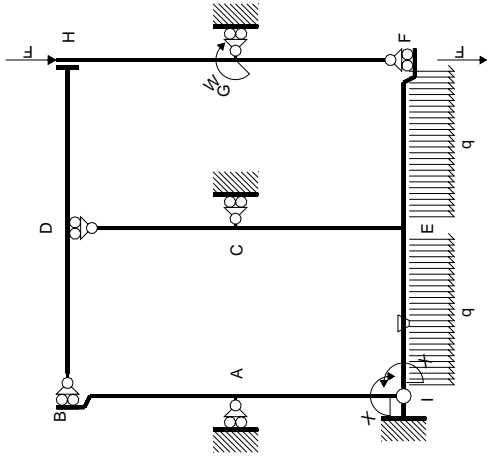
$$\sigma_c = -Mv/J_u = -134.4 \text{ N/mm}^2$$

$$\tau_c = 7.014 \text{ N/mm}^2$$

$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 135. \text{ N/mm}^2$$

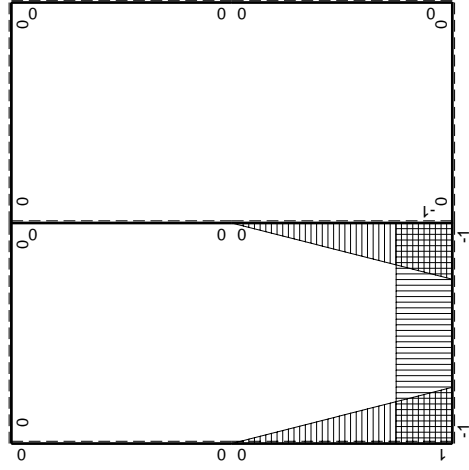
$$S = 5207. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fb+Fx	0	0	0	0	0+0	0	
BA b	0	Fx	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0	
FE b	0	$2Fx+1/2qx^2$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	Fb-Fx	0	0	0	0	0+0	0	
HG b	0	-Fx	0	0	0	0			
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$4Fx-1/2qx^2$	-Fb/EJ	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2			
	totali							$-3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$9/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

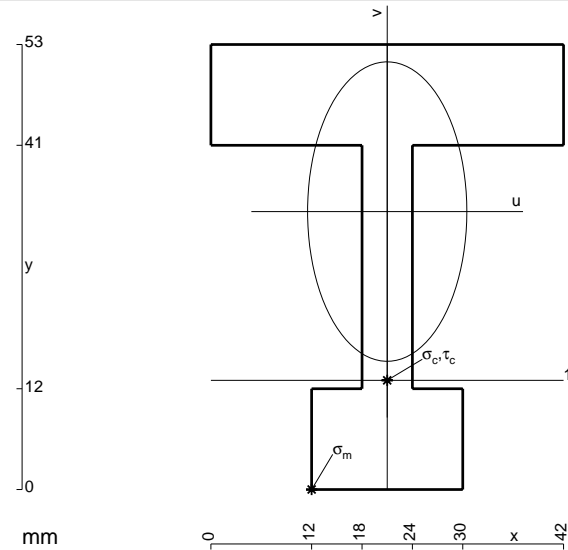
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

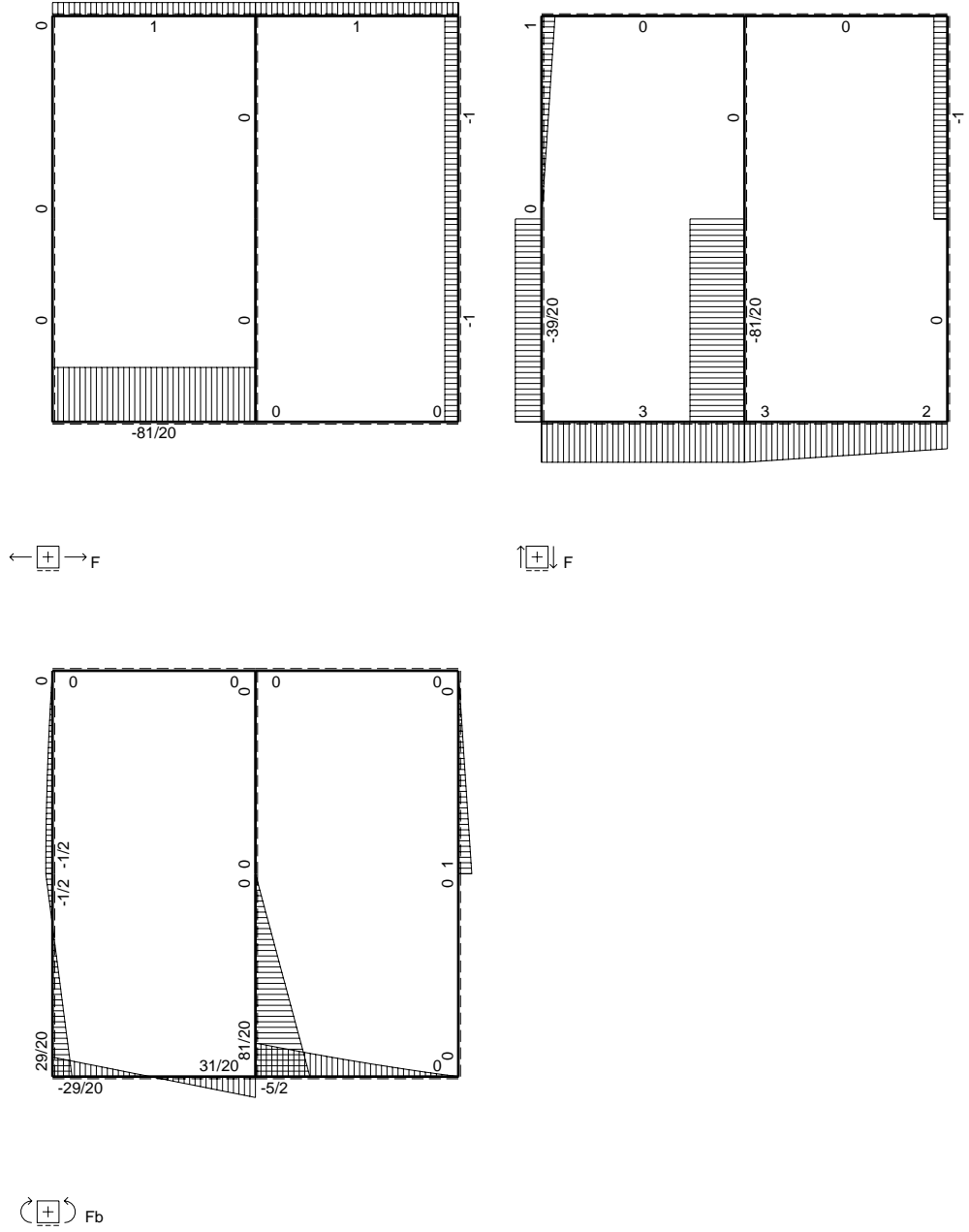
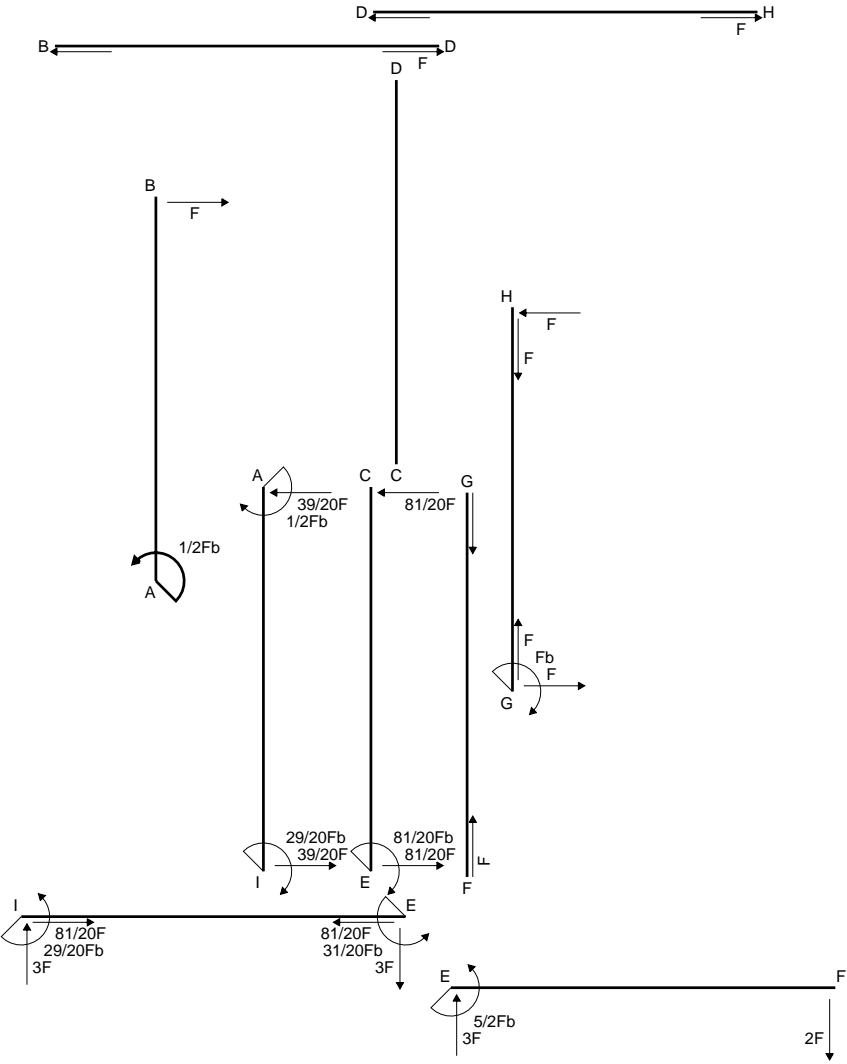
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

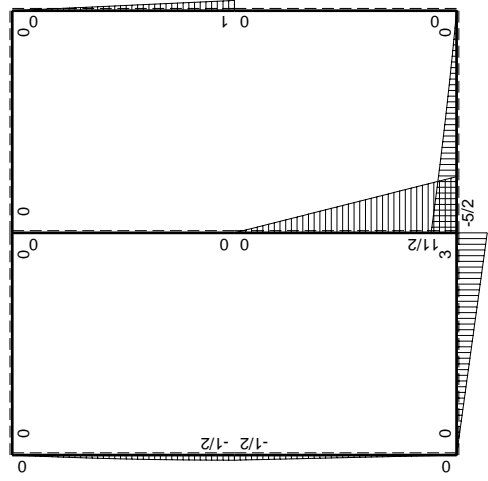
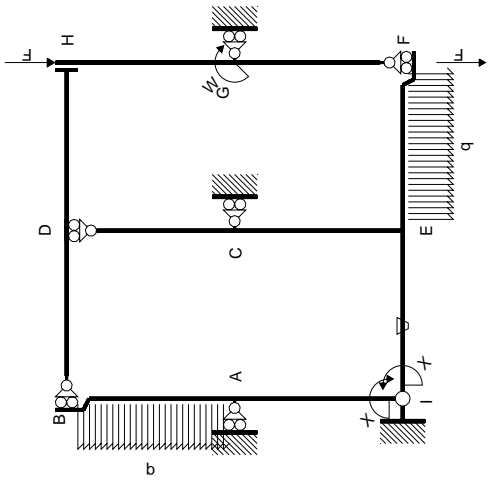
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



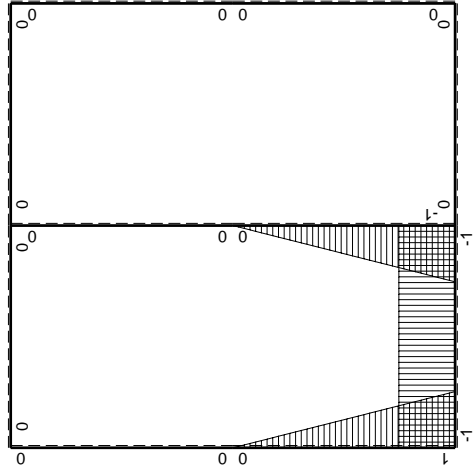
- A = 894. mm²
- J_u = 284424. mm⁴
- J_v = 80442. mm⁴
- y_g = 33.1 mm
- T_y = 3870. N
- M_x = -1709250. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -33.1 mm
- σ_m = -Mv/J_u = -198.9 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -20.1 mm
- σ_c = -Mv/J_u = -120.8 N/mm²
- τ_c = 13.56 N/mm²
- σ_o = √σ² + 3τ² = 123.1 N/mm²
- S = 5978. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb 1/EJ dx = [-11/6 x^3/b^2]_0^b Fb 1/EJ$$

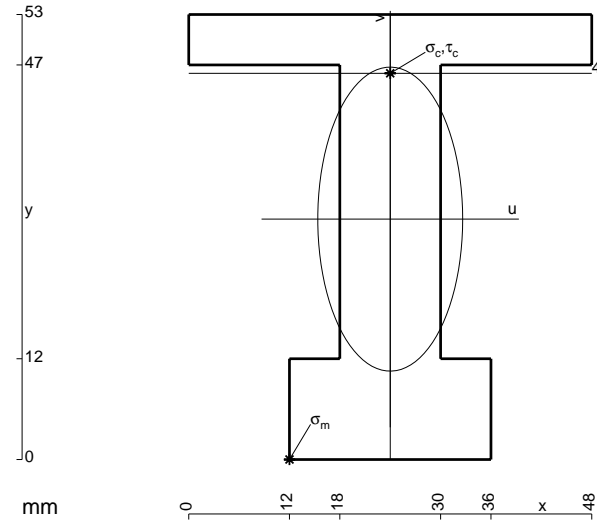
$$= (-11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

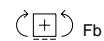
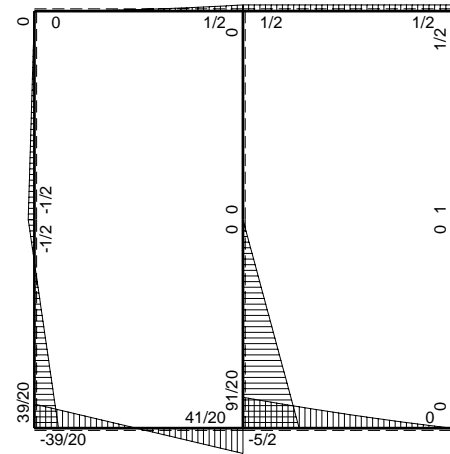
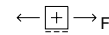
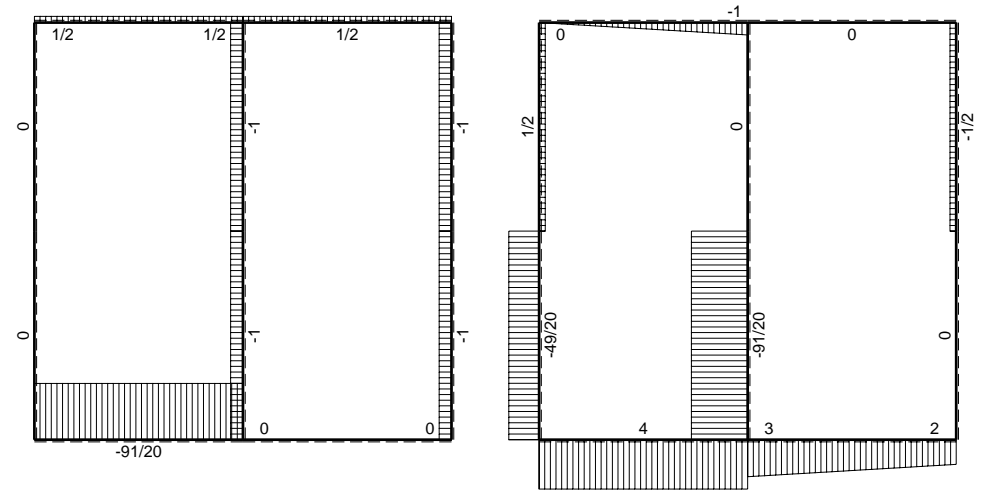
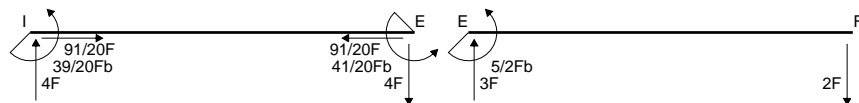
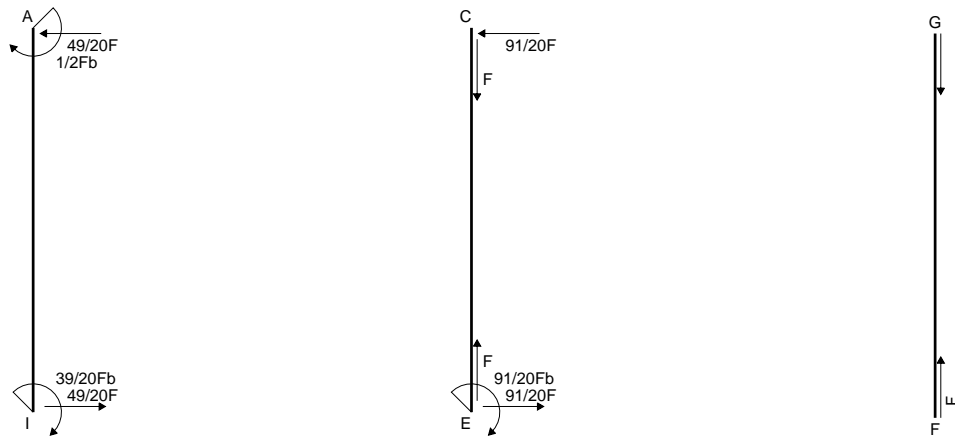
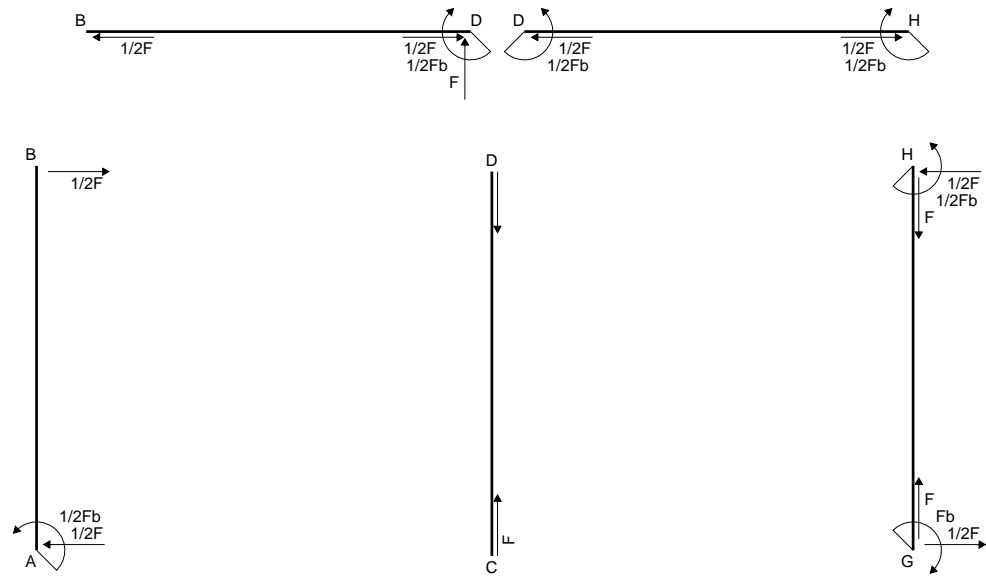
$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

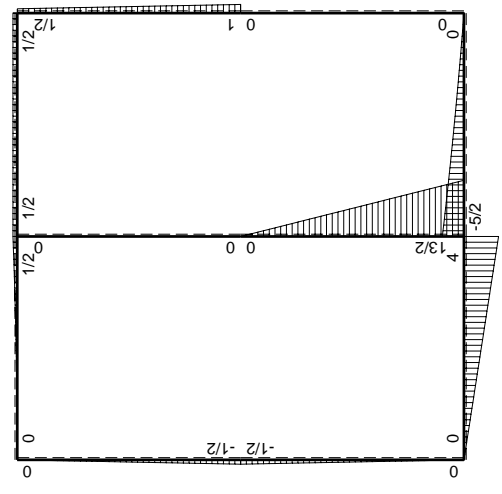
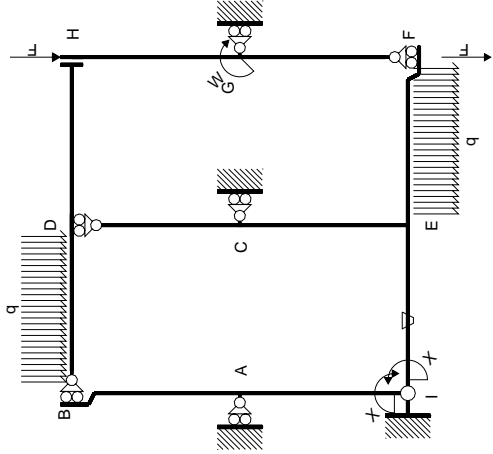
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



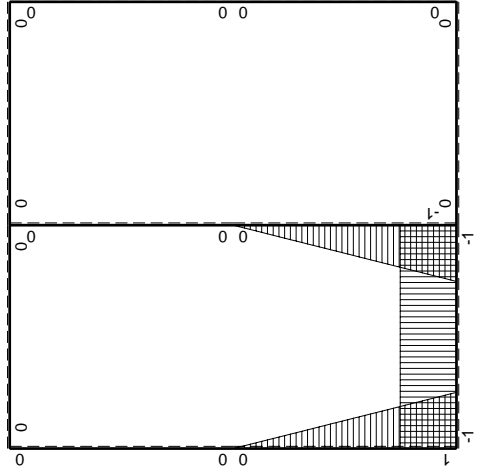
- A = 996. mm²
- J_u = 326526. mm⁴
- J_v = 74160. mm⁴
- y_g = 28.63 mm
- T_y = 4950. N
- M_x = -2392500. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -28.63 mm
- σ_m = -Mv/J_u = -209.8 N/mm²
- x_c = 24. mm
- y_c = 46. mm
- v_c = 17.37 mm
- σ_c = -Mv/J_u = 127.3 N/mm²
- τ_c = 8.045 N/mm²
- σ_ρ = √(σ² + 3τ²) = 128. N/mm²
- S = 6368. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-13/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$39/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb 1/EJ dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb 1/EJ dx = [-13/6 x^3/b^2]_0^b Fb 1/EJ$$

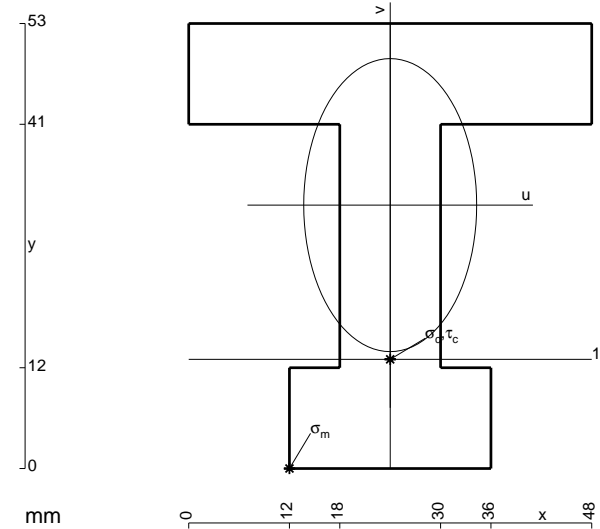
$$= (-13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

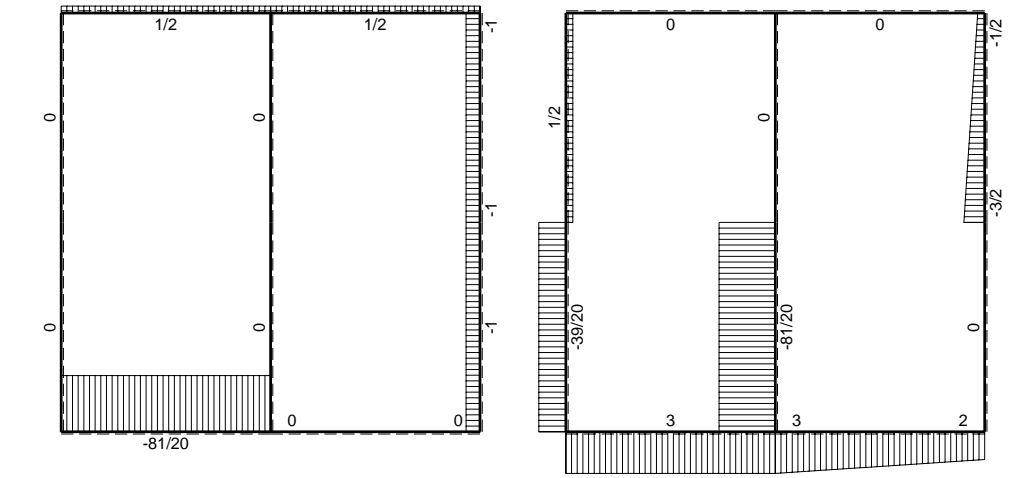
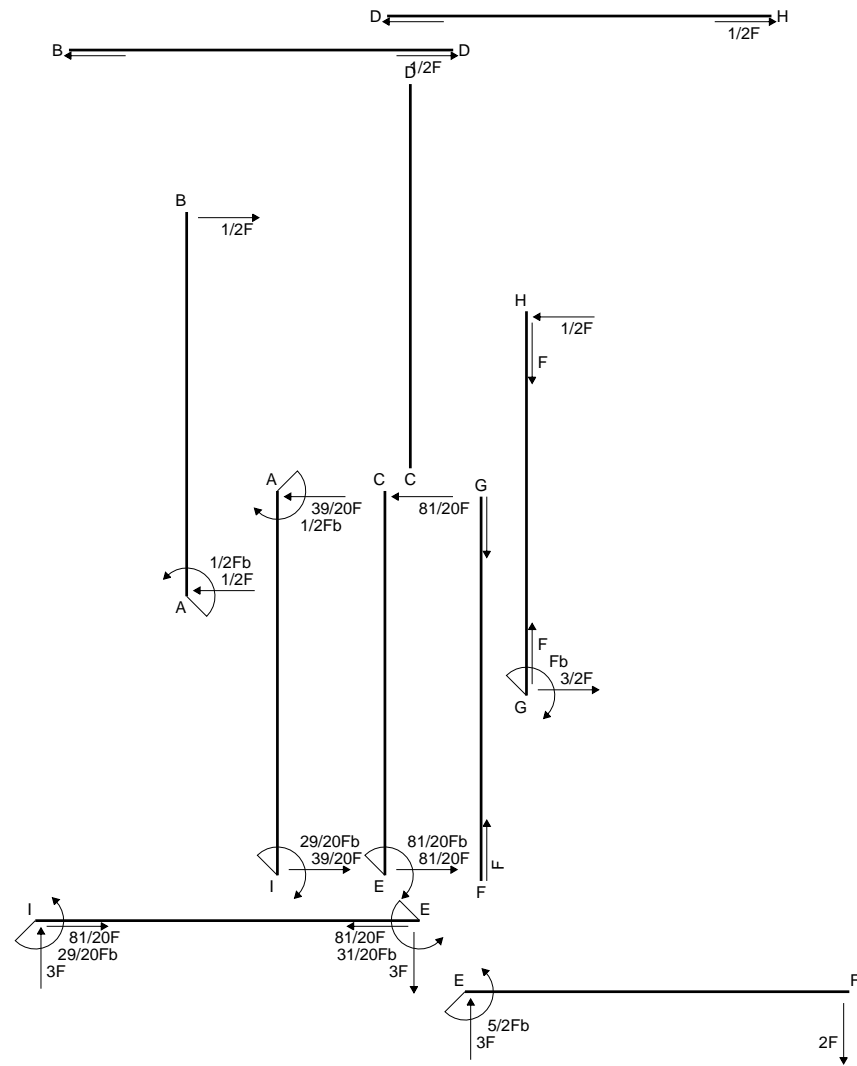
$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

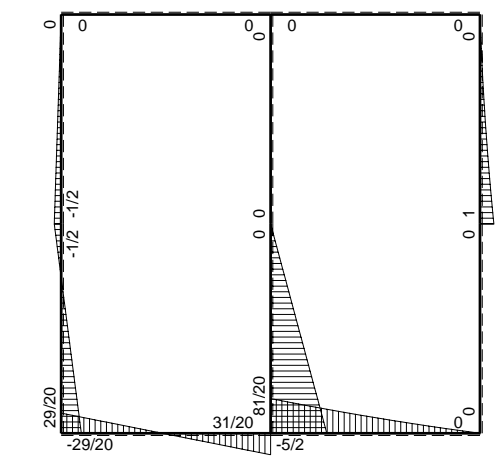


- A = 1212. mm²
- J_u = 369093. mm⁴
- J_v = 128592. mm⁴
- y_g = 31.37 mm
- T_y = 4920. N
- M_x = -2583000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -31.37 mm
- σ_m = -Mv/J_u = -219.5 N/mm²
- x_c = 24. mm
- y_c = 13. mm
- v_c = -18.37 mm
- σ_c = -Mv/J_u = -128.6 N/mm²
- τ_c = 8.368 N/mm²
- σ_ρ = √σ² + 3τ² = 129.4 N/mm²
- S = 7533. mm³

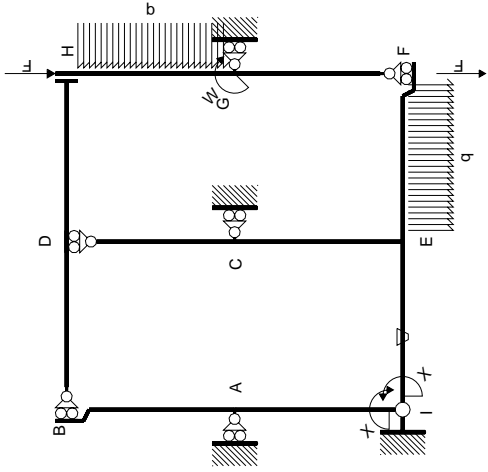


← ⊕ → F

↑ ⊕ ↓ F

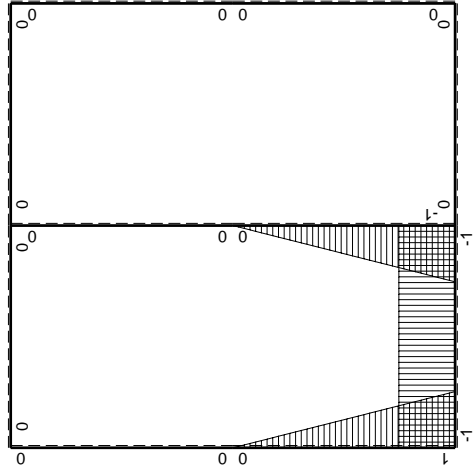
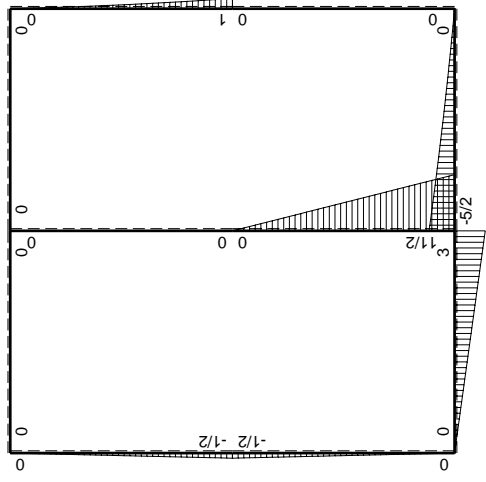


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

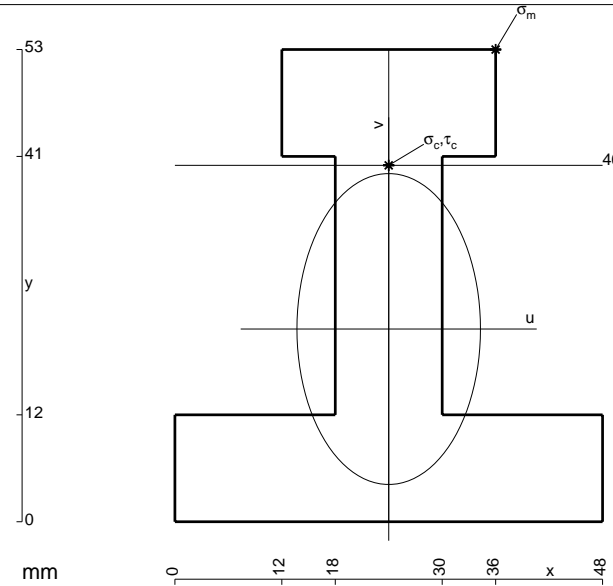
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

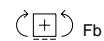
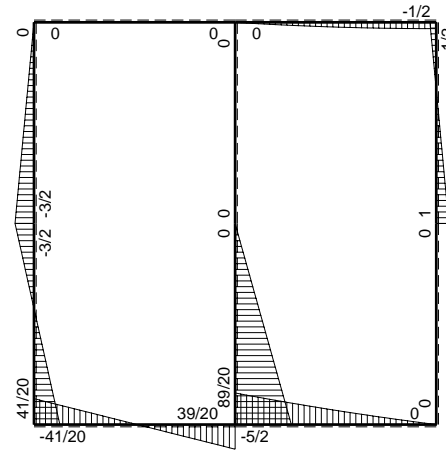
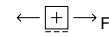
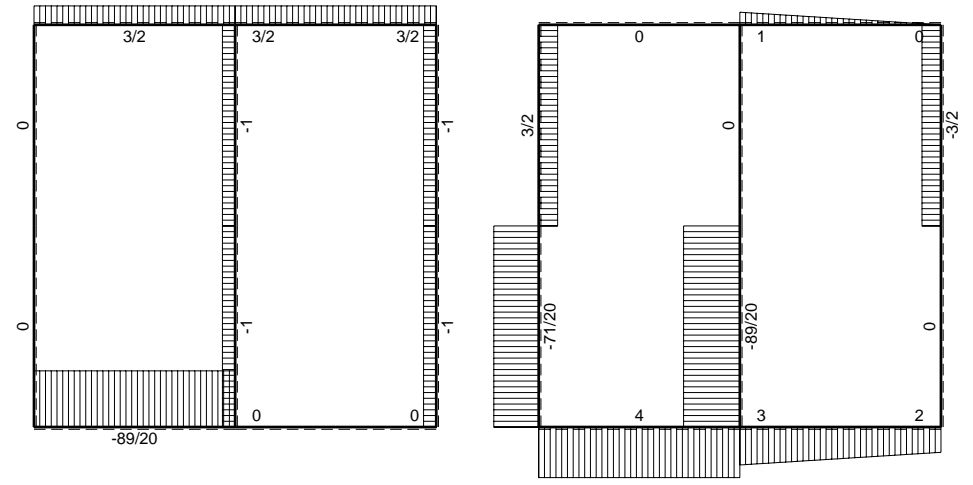
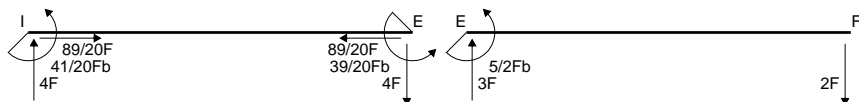
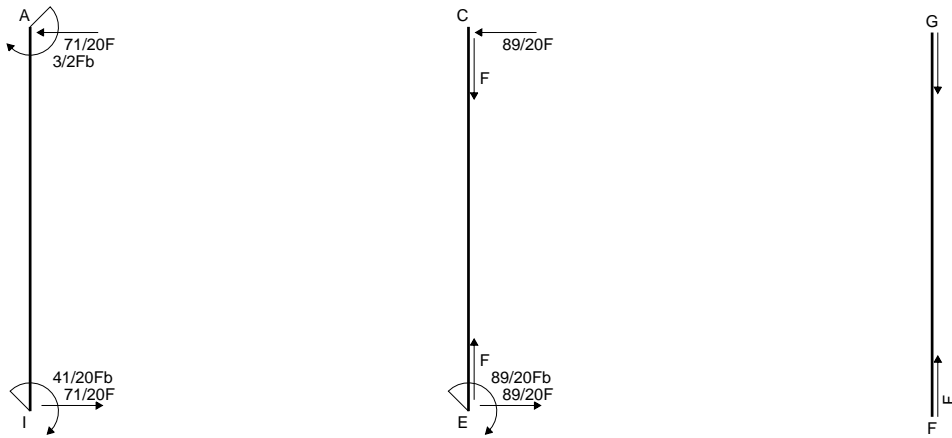
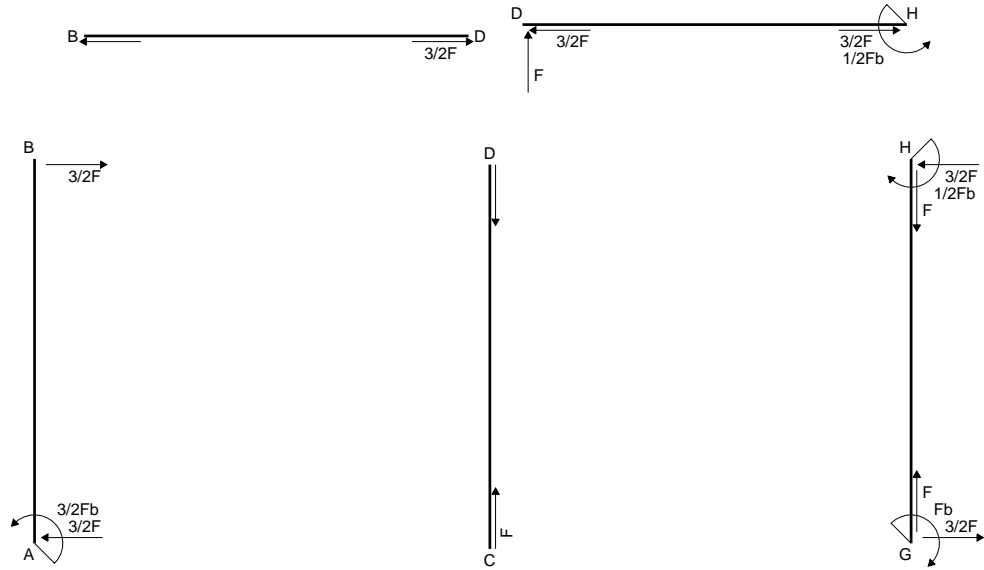
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

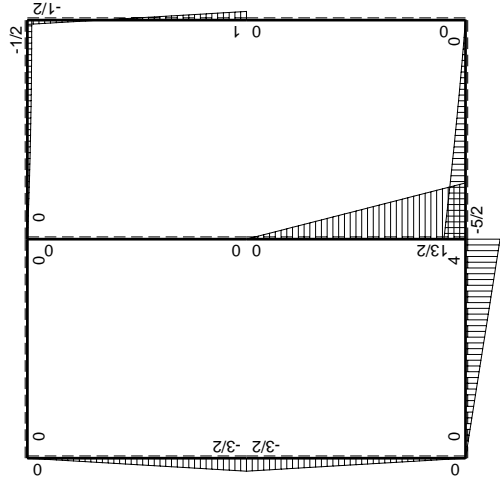
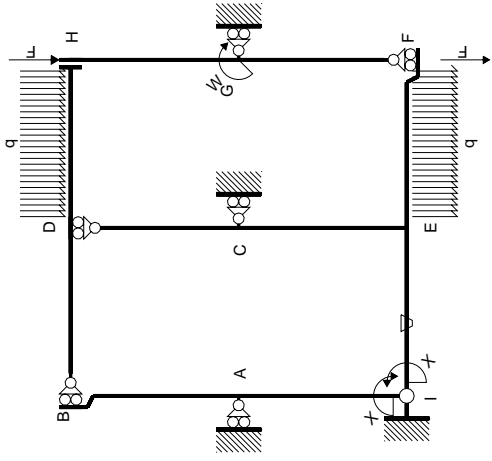
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



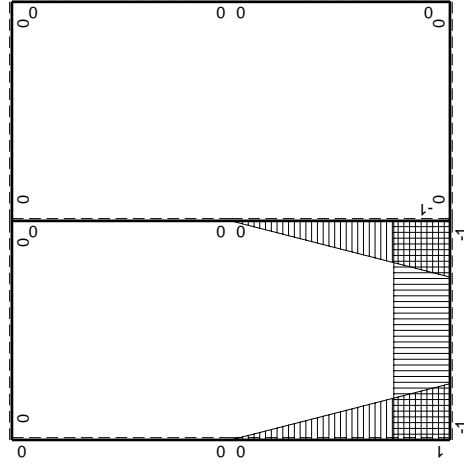
- A = 1212. mm²
- J_u = 369093. mm⁴
- J_v = 128592. mm⁴
- y_g = 21.63 mm
- T_y = 4770. N
- M_x = -2703000. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 31.37 mm
- σ_m = -Mv/J_u = 229.7 N/mm²
- x_c = 24. mm
- y_c = 40. mm
- v_c = 18.37 mm
- σ_c = -Mv/J_u = 134.5 N/mm²
- τ_c = 8.113 N/mm²
- σ_q = √σ²+3τ² = 135.3 N/mm²
- S = 7533. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-41/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$41/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

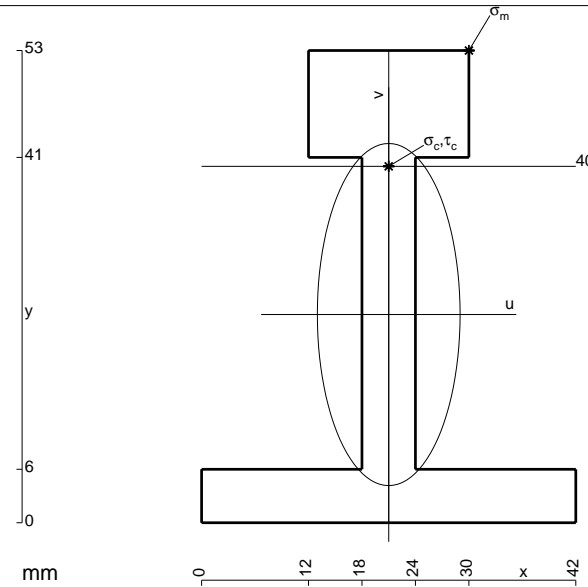
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 678. \text{ mm}^2$$

$$J_u = 249963. \text{ mm}^4$$

$$J_v = 43506. \text{ mm}^4$$

$$y_g = 23.37 \text{ mm}$$

$$T_y = 3270. \text{ N}$$

$$M_x = -2016500. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 29.63 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239.1 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

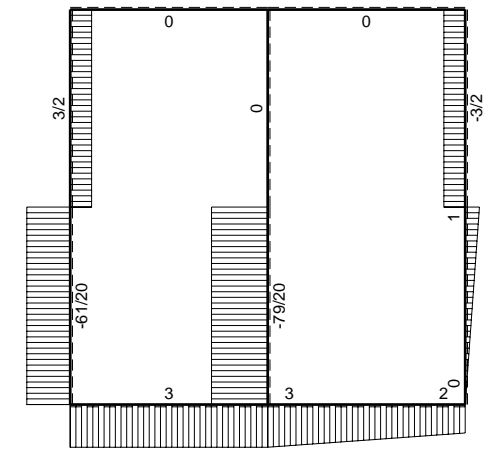
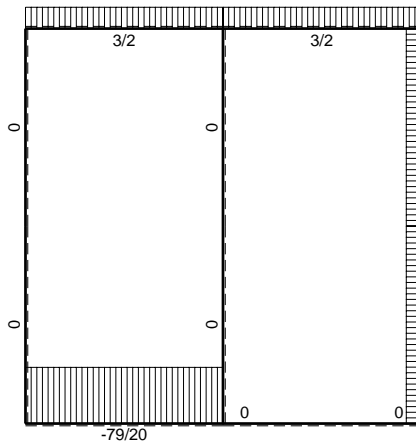
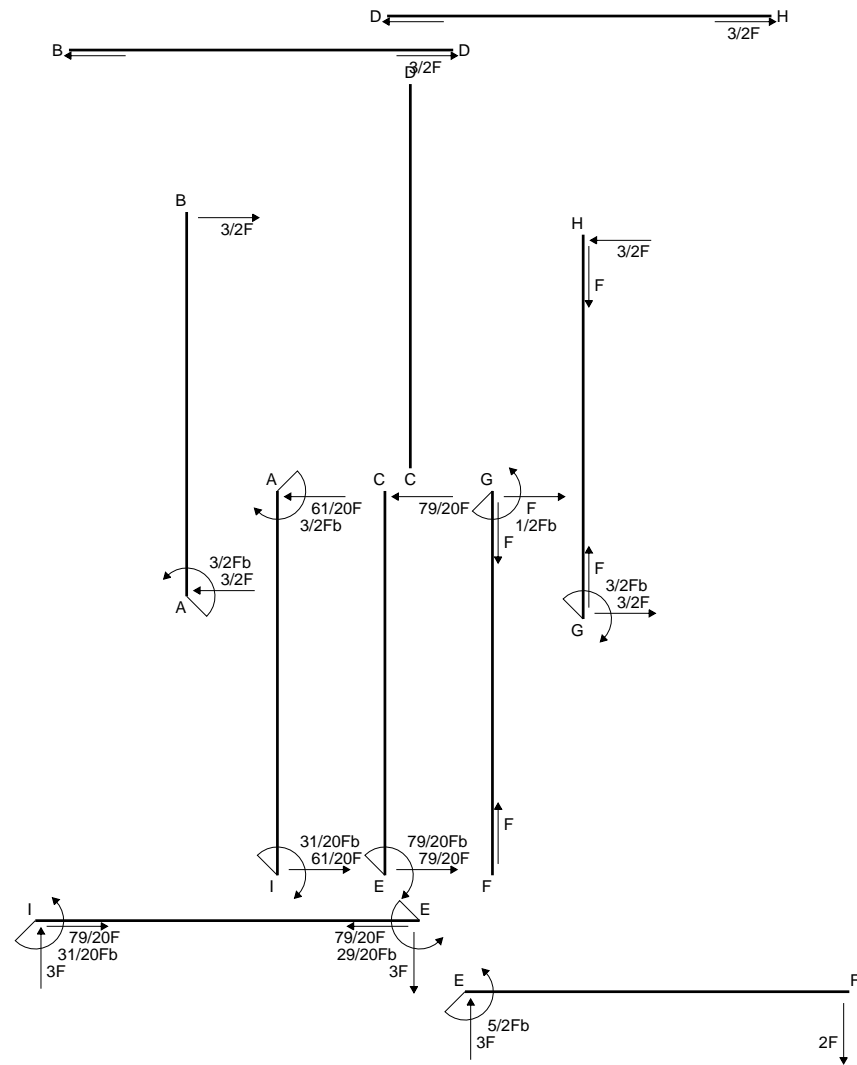
$$v_c = 16.63 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 134.2 \text{ N/mm}^2$$

$$\tau_c = 11.35 \text{ N/mm}^2$$

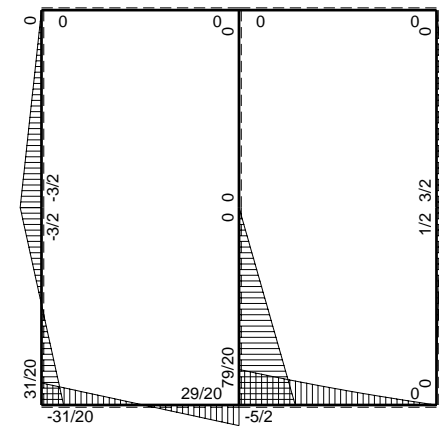
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 135.6 \text{ N/mm}^2$$

$$S = 5207. \text{ mm}^3$$

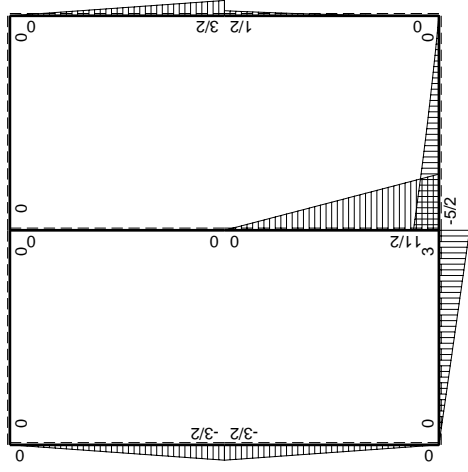
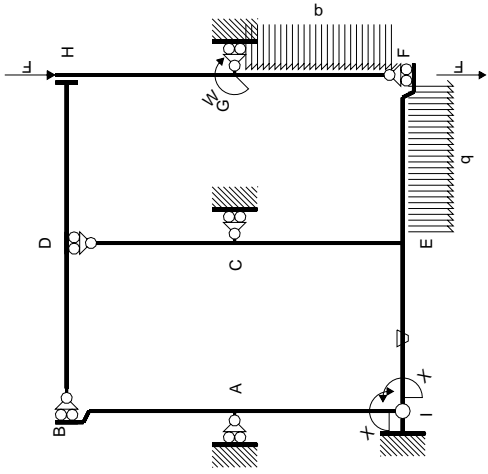


← ⊕ → F

↑ ⊕ ↓ F

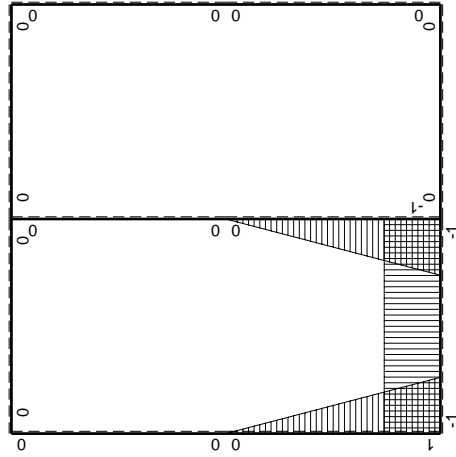


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

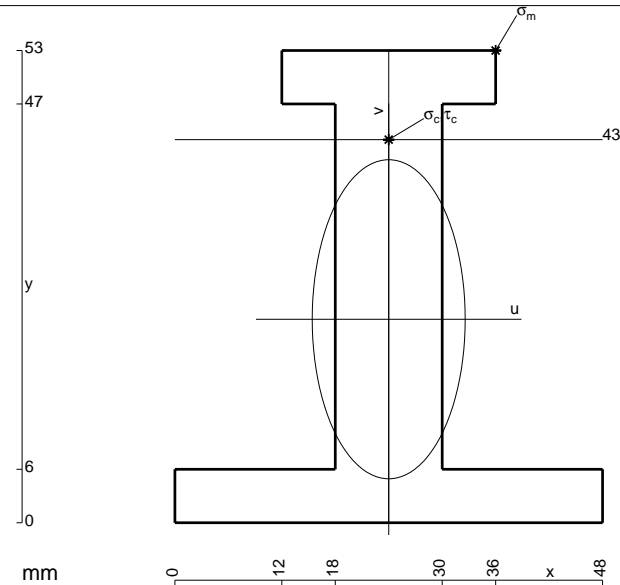
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 924. \text{ mm}^2$$

$$J_u = 296396. \text{ mm}^4$$

$$J_v = 68112. \text{ mm}^4$$

$$y_g = 22.84 \text{ mm}$$

$$T_y = 2970. \text{ N}$$

$$M_x = -1955250. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.16 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

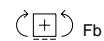
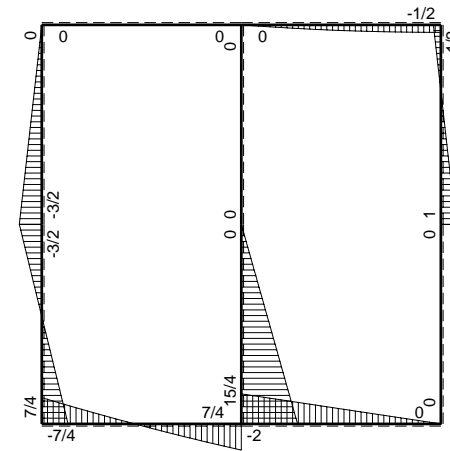
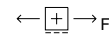
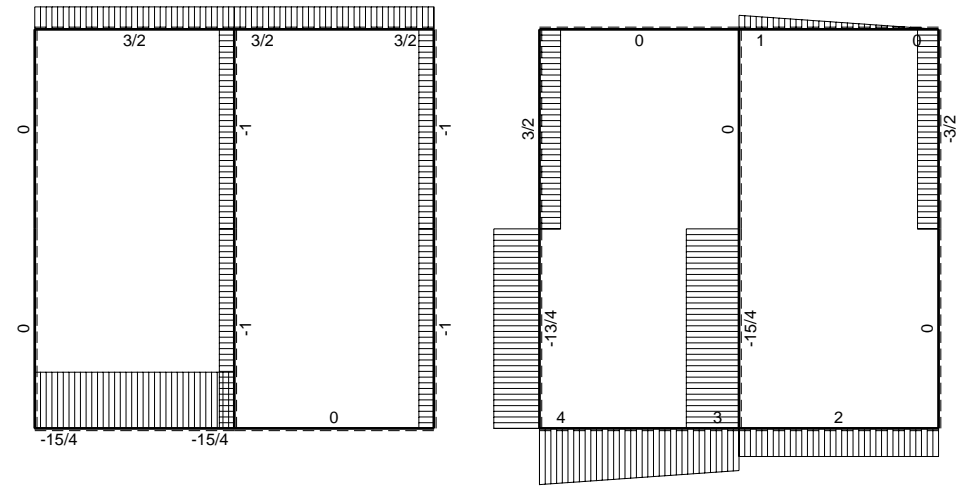
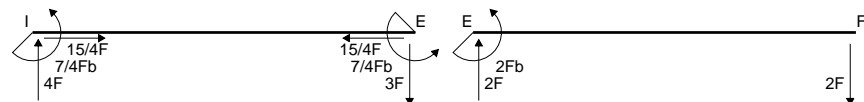
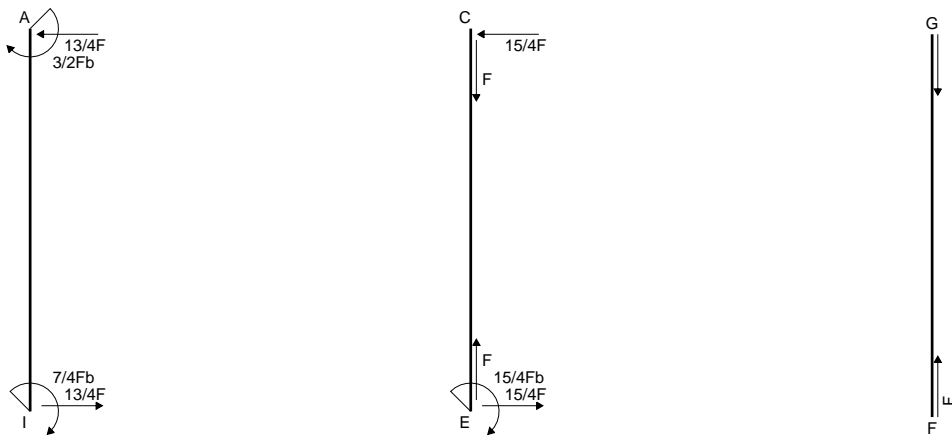
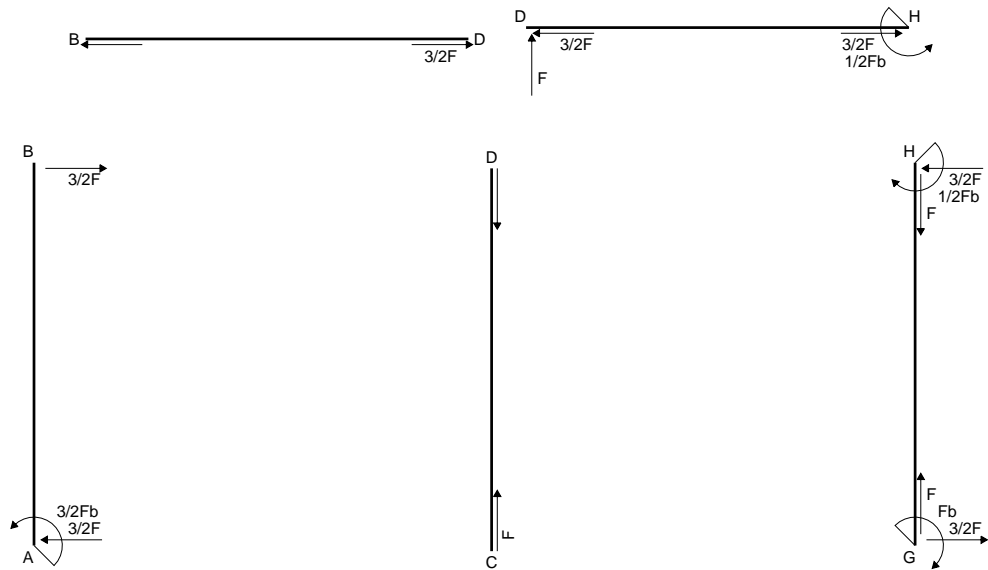
$$v_c = 20.16 \text{ mm}$$

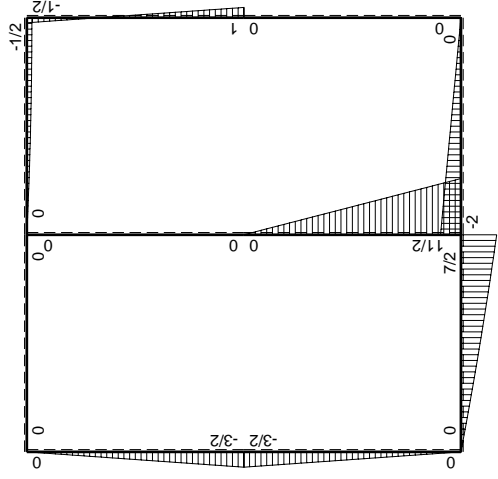
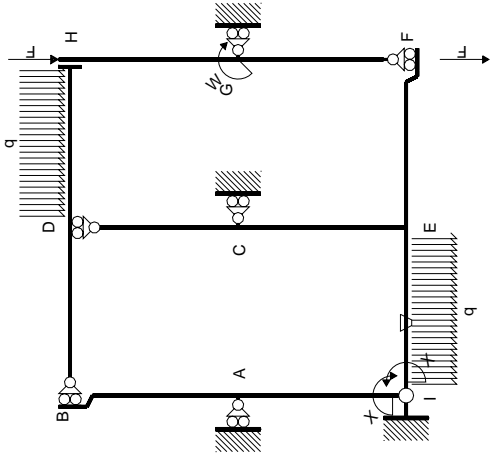
$$\sigma_c = -Mv/J_u = 133. \text{ N/mm}^2$$

$$\tau_c = 4.154 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 133.2 \text{ N/mm}^2$$

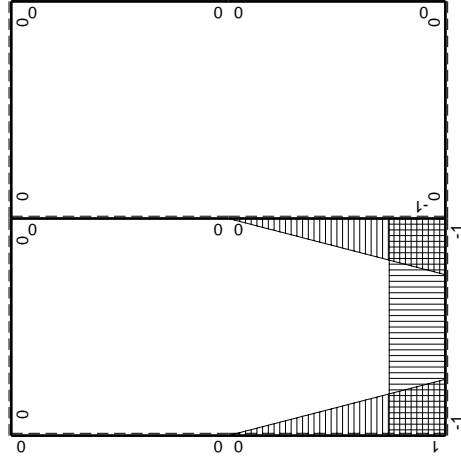
$$S = 4975. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

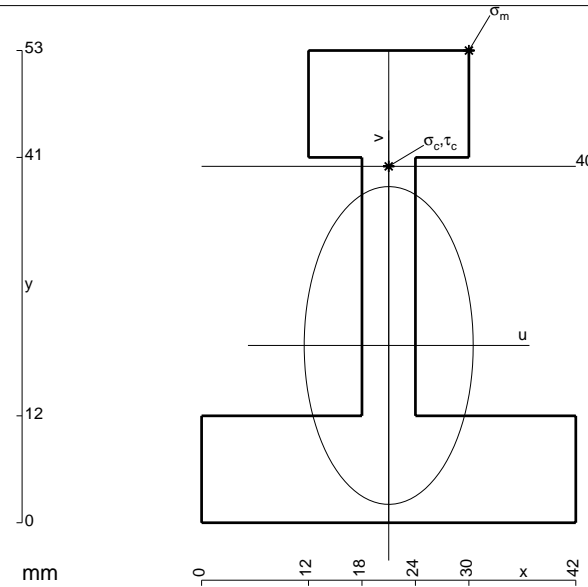
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 894. \text{ mm}^2$$

$$J_u = 284424. \text{ mm}^4$$

$$J_v = 80442. \text{ mm}^4$$

$$y_g = 19.9 \text{ mm}$$

$$T_y = 2140. \text{ N}$$

$$M_x = -1797600. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 33.1 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.2 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

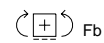
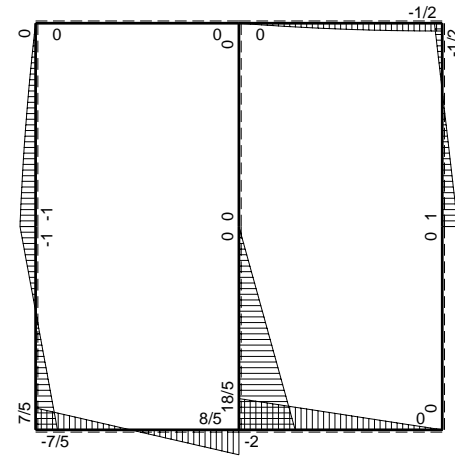
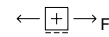
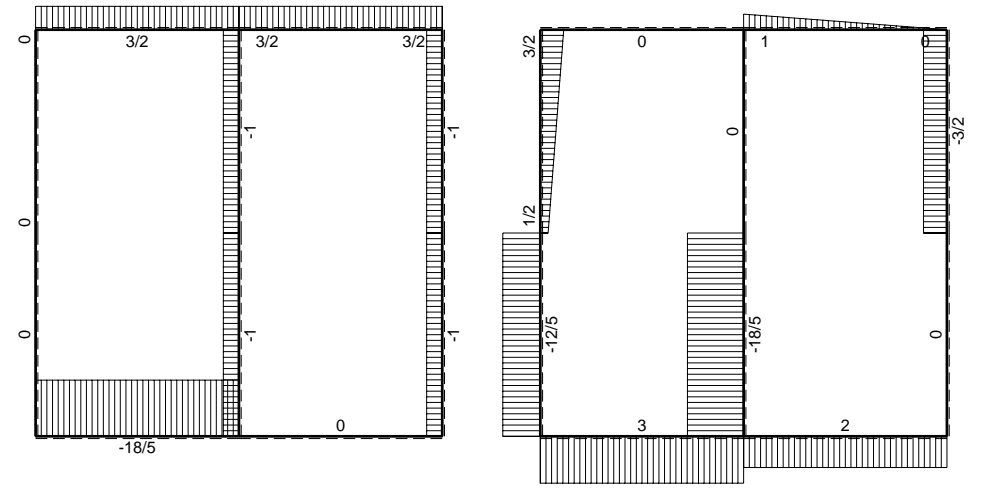
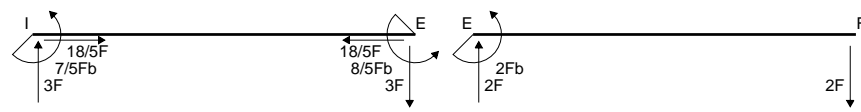
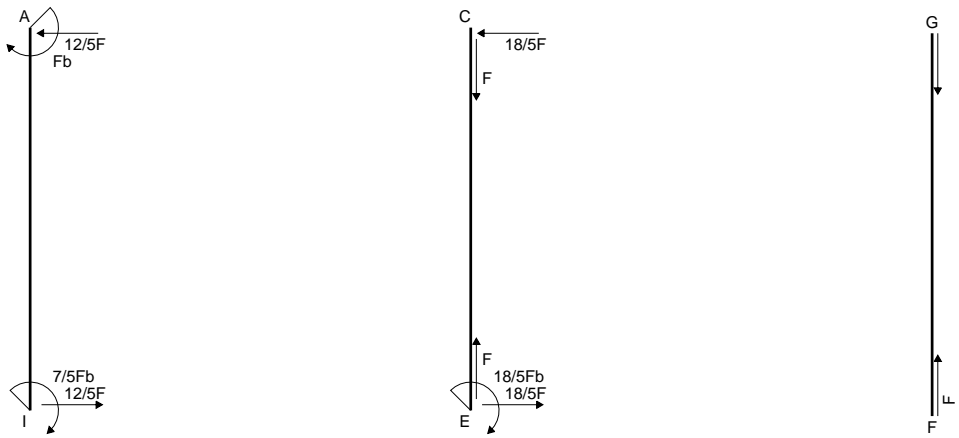
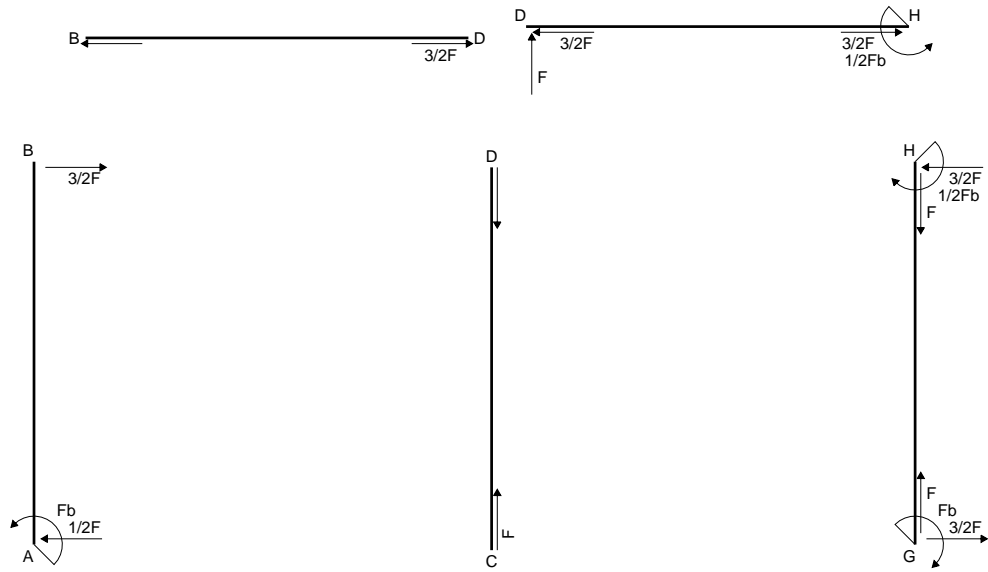
$$v_c = 20.1 \text{ mm}$$

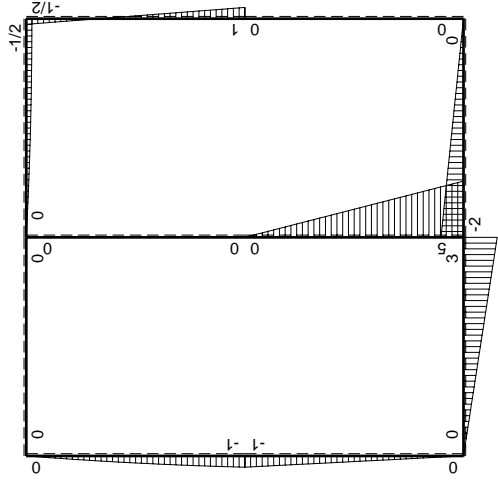
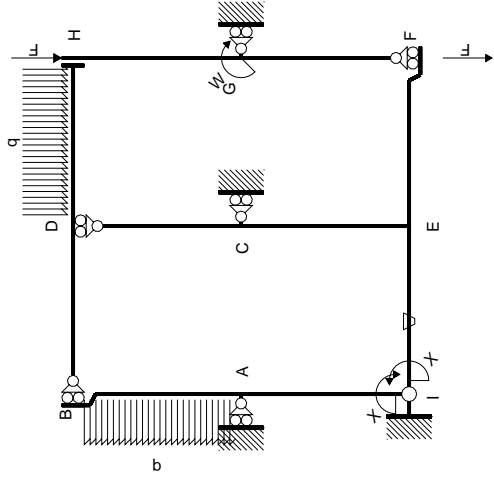
$$\sigma_c = -Mv/J_u = 127.1 \text{ N/mm}^2$$

$$\tau_c = 7.497 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 127.7 \text{ N/mm}^2$$

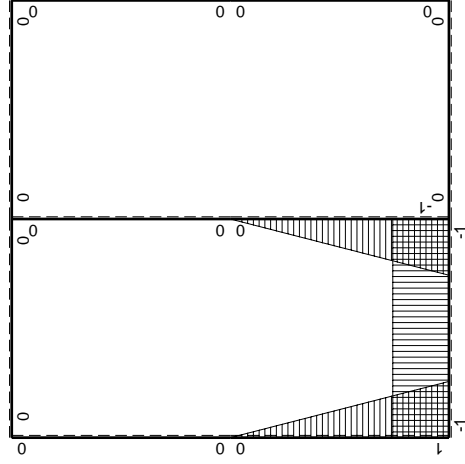
$$S = 5978. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-Fb+1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$3/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

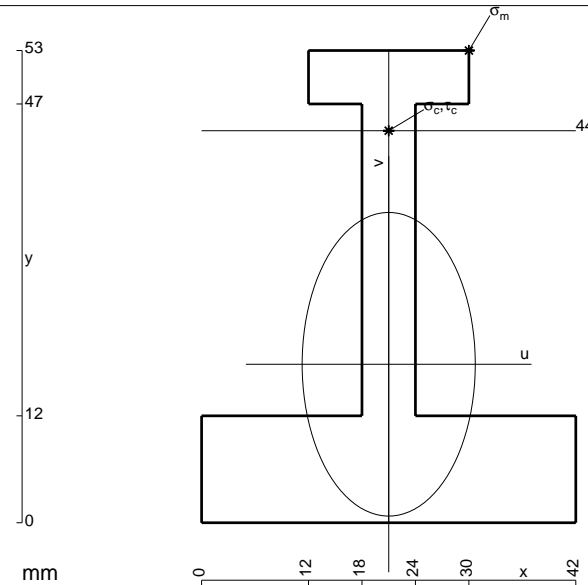
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

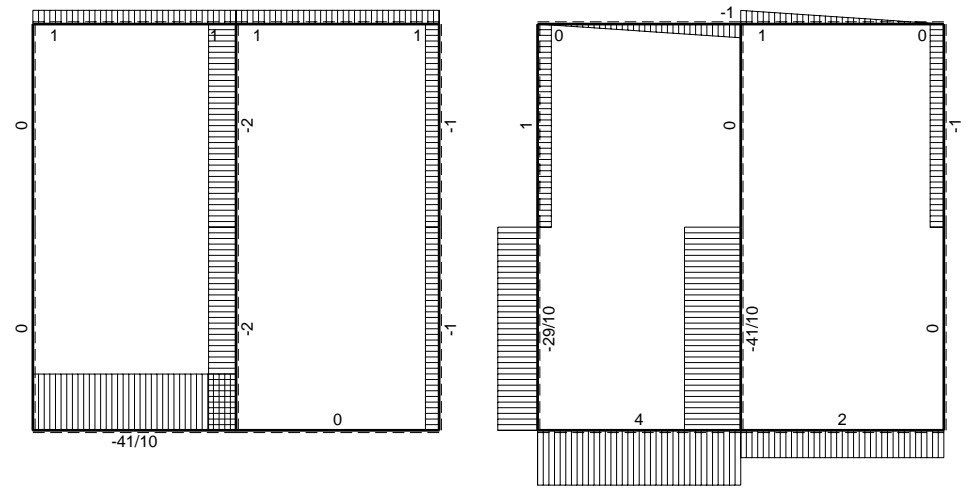
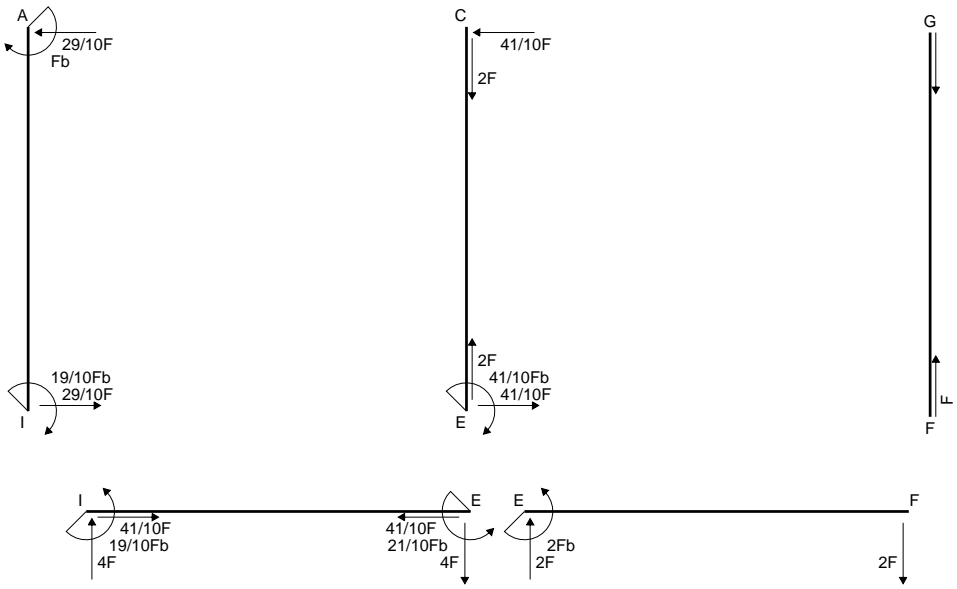
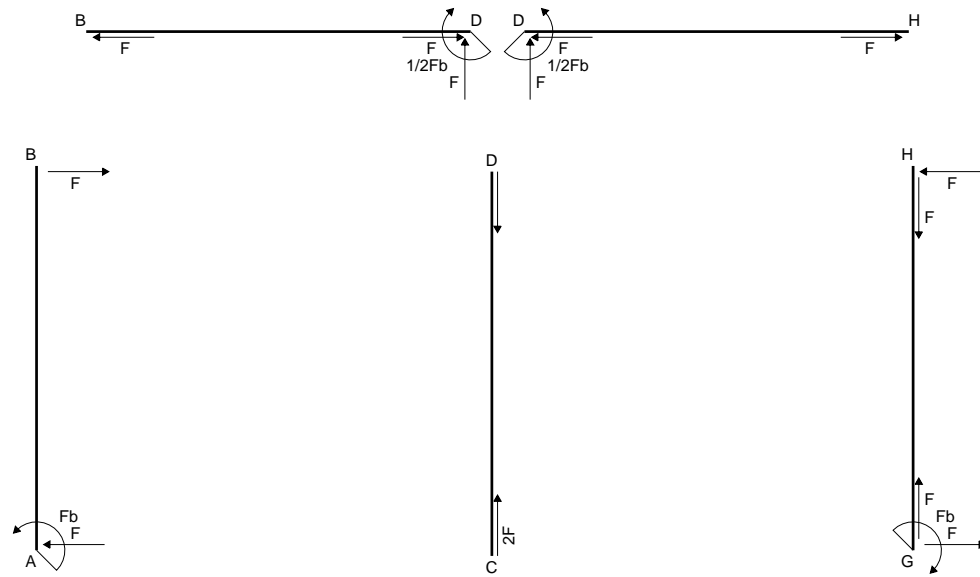
$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

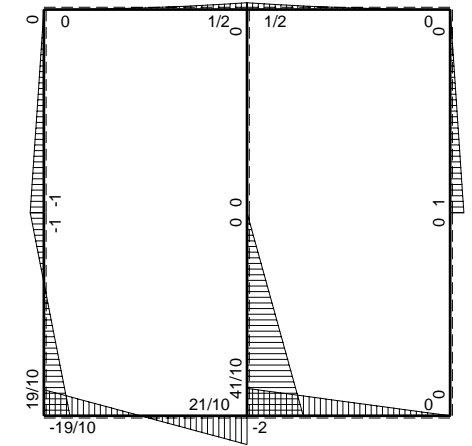


- A = 822. mm²
- J_u = 238712. mm⁴
- J_v = 77634. mm⁴
- y_g = 17.78 mm
- T_y = 1640. N
- M_x = -1476000. Nmm
- x_m = 30. mm
- y_m = 53. mm
- u_m = 9. mm
- v_m = 35.22 mm
- σ_m = -Mv/J_u = 217.7 N/mm²
- x_c = 21. mm
- y_c = 44. mm
- v_c = 26.22 mm
- σ_c = -Mv/J_u = 162.1 N/mm²
- τ_c = 4.555 N/mm²
- σ_q = √σ²+3τ² = 162.3 N/mm²
- S = 3978. mm³

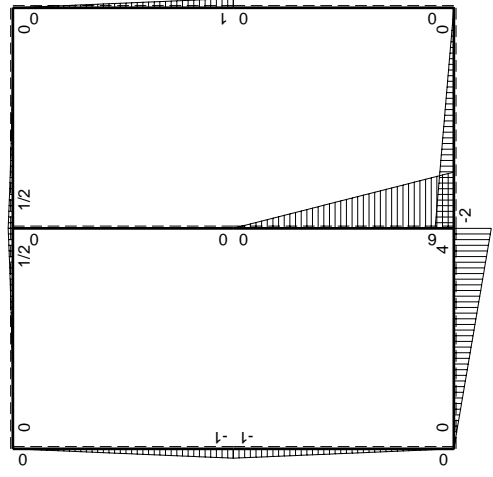
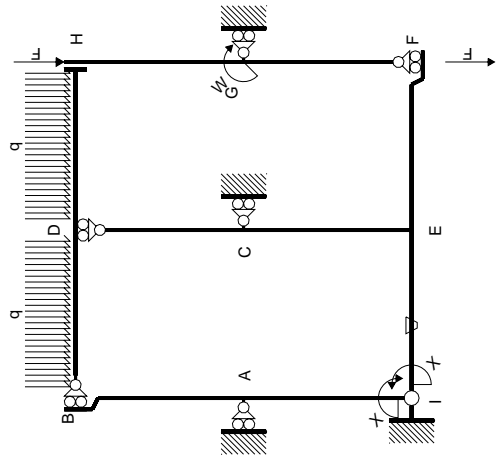


← ⊕ → F

↑ ⊕ ↓ F

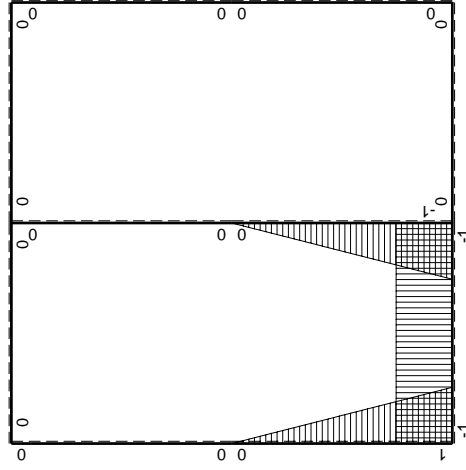


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	4Fx	-Fb/EJ	-4Fx	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-4Fb+4Fx	Fb/EJ	-4Fb+4Fx	Fb/EJ	1		
EC b	$-1+x/b$	6Fb-6Fx	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-6Fx	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-19/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						19/10Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

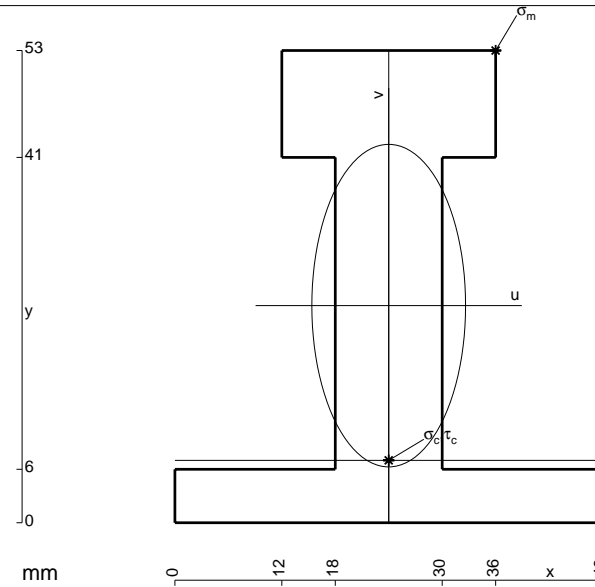
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 996. \text{ mm}^2$$

$$J_u = 326526. \text{ mm}^4$$

$$J_v = 74160. \text{ mm}^4$$

$$y_g = 24.37 \text{ mm}$$

$$T_y = 2760. \text{ N}$$

$$M_x = -2622000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.63 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 7. \text{ mm}$$

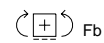
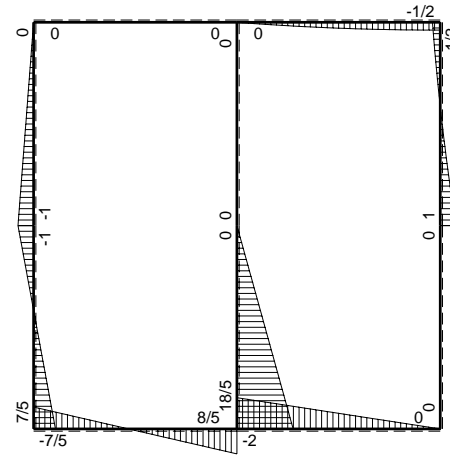
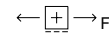
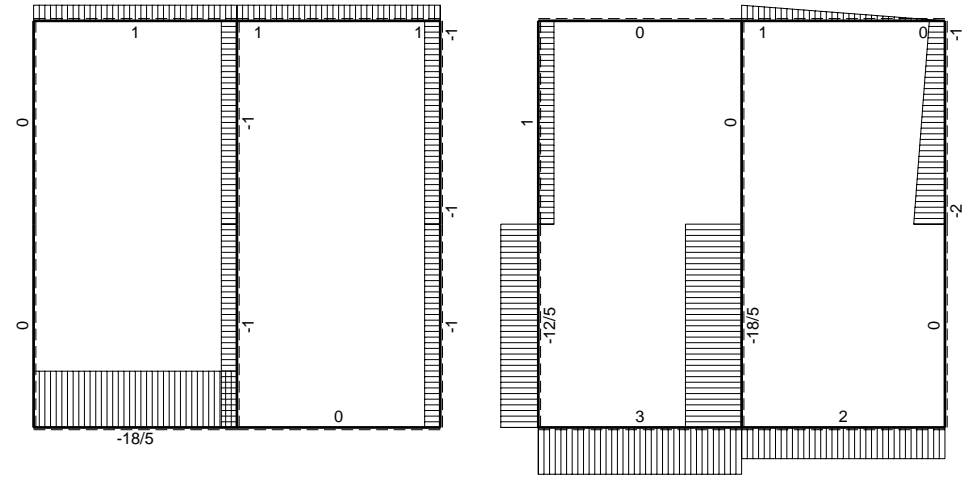
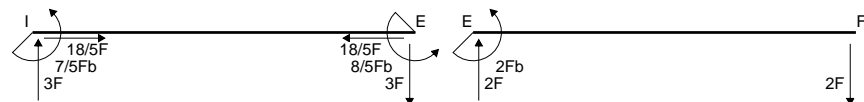
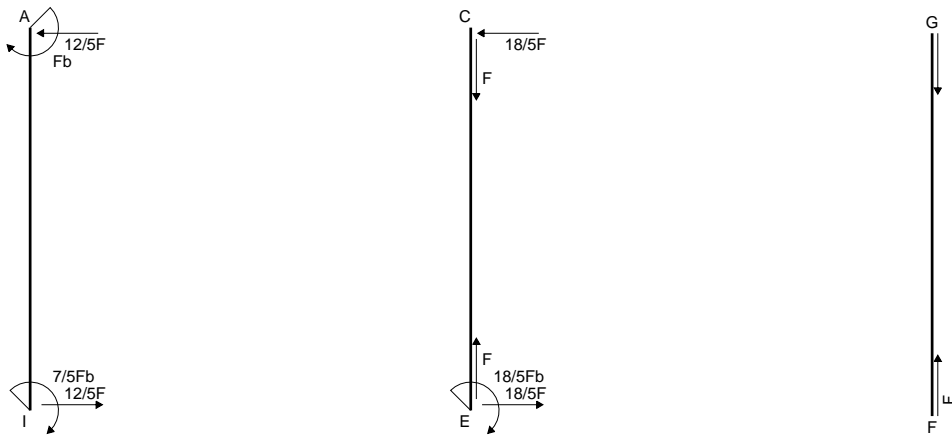
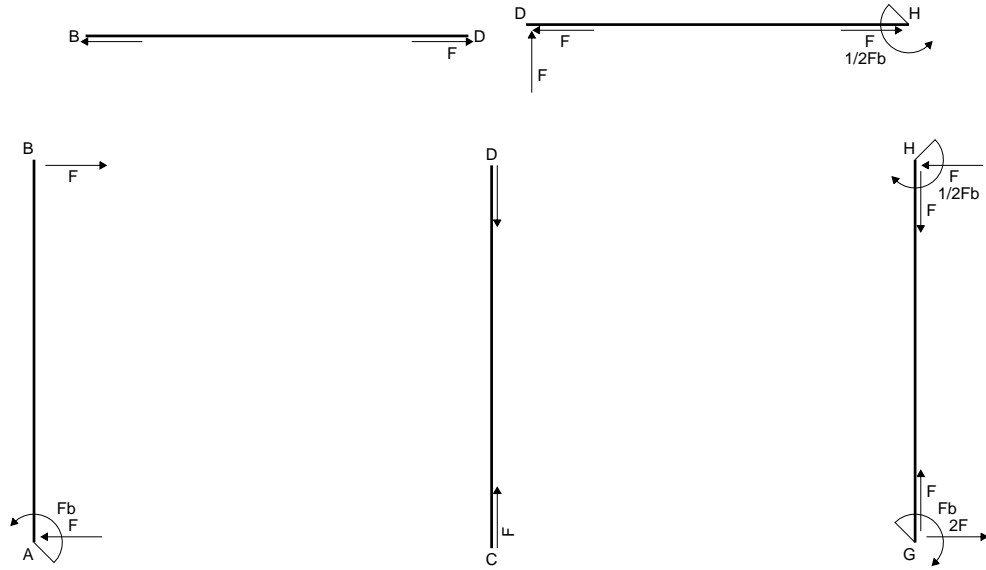
$$v_c = -17.37 \text{ mm}$$

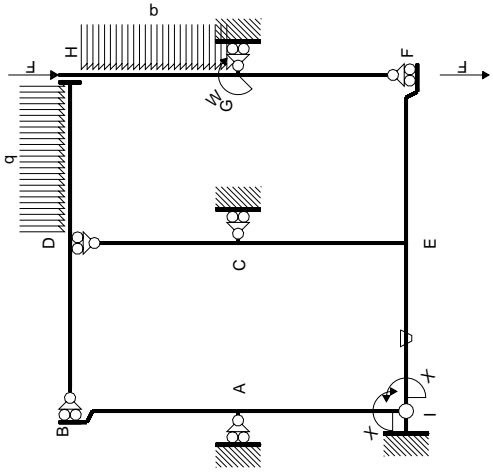
$$\sigma_c = -Mv/J_u = -139.5 \text{ N/mm}^2$$

$$\tau_c = 4.486 \text{ N/mm}^2$$

$$\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 139.7 \text{ N/mm}^2$$

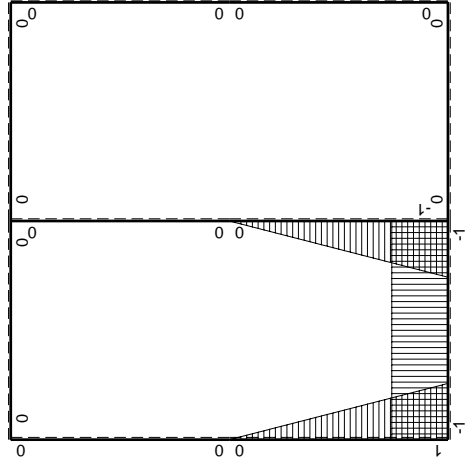
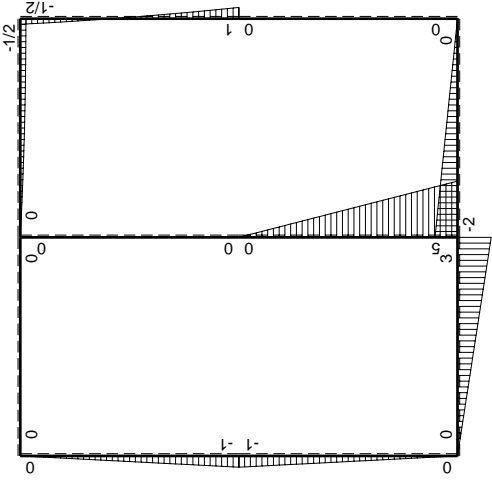
$$S = 6368. \text{ mm}^3$$





Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

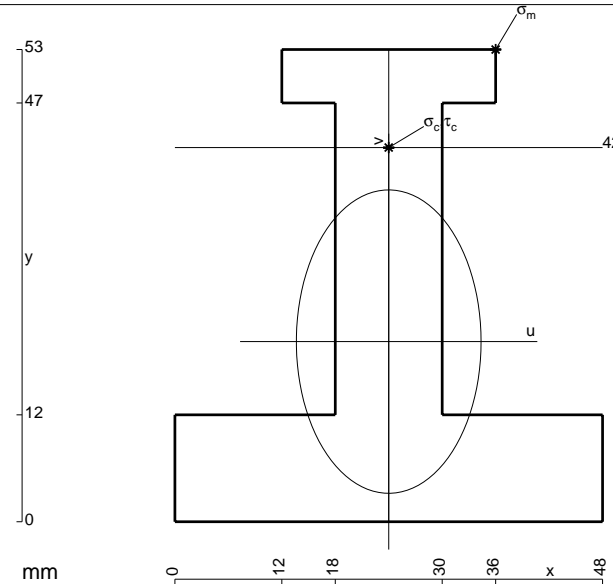
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

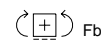
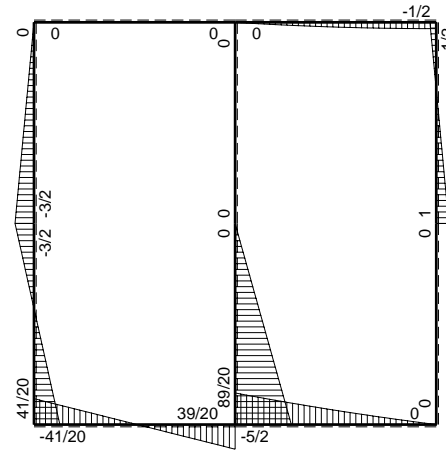
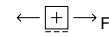
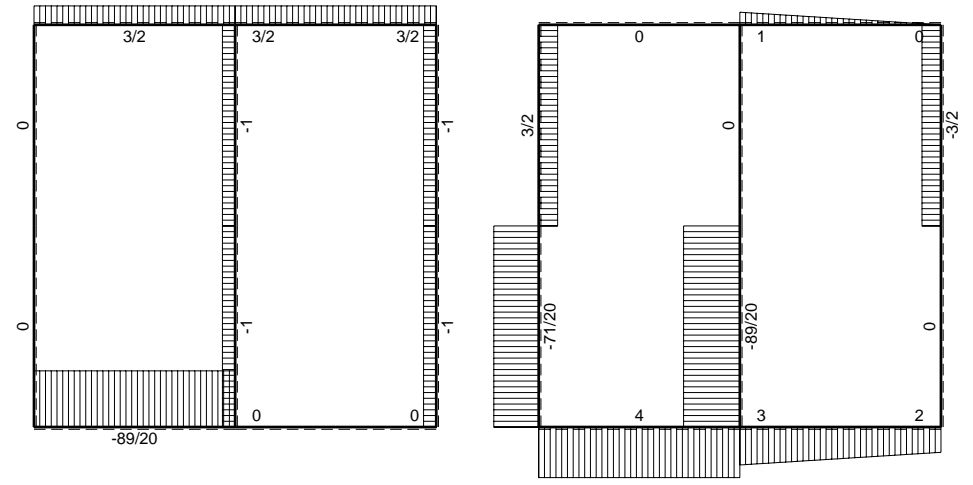
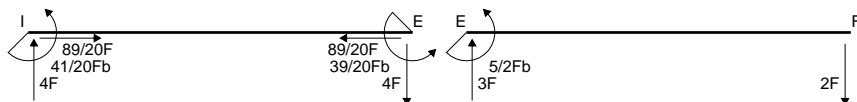
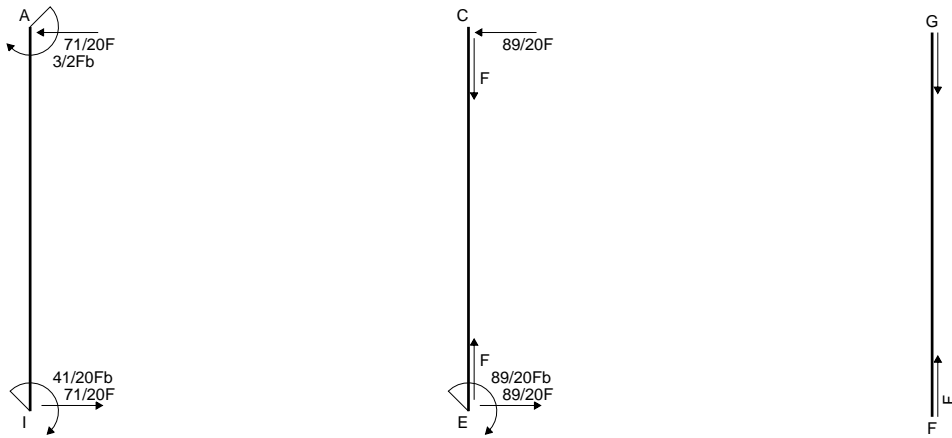
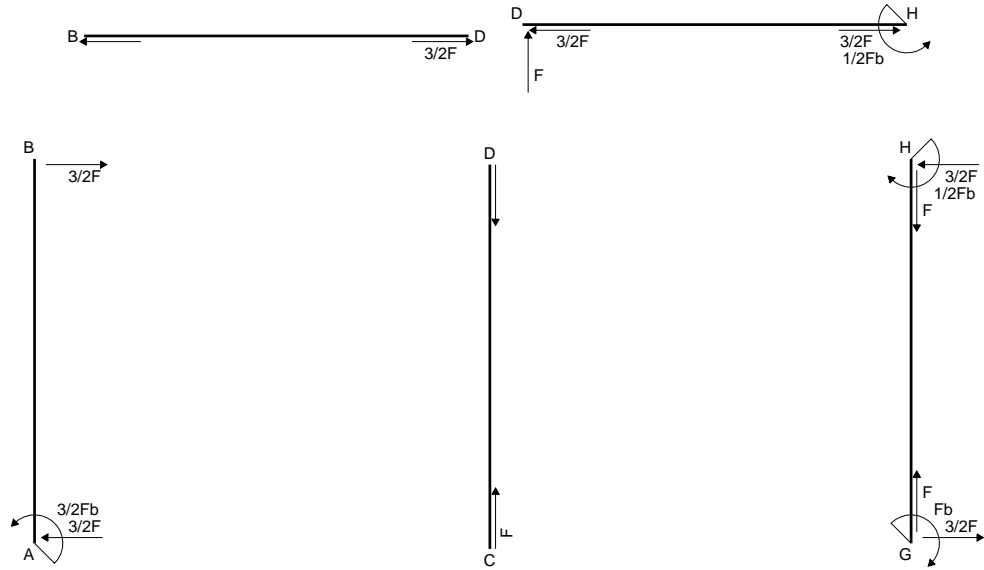
$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

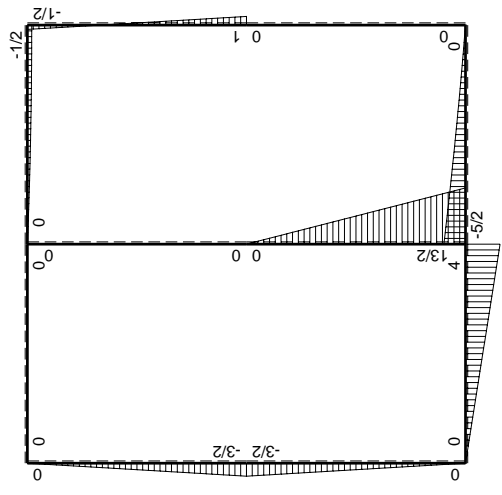
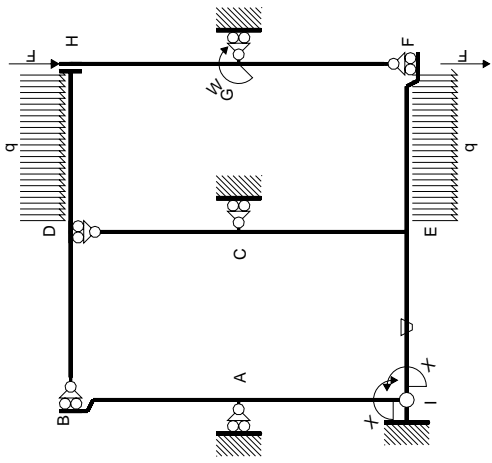
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



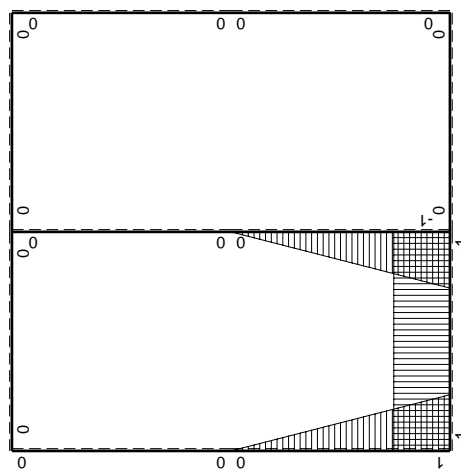
- A = 1140. mm²
- J_u = 330567. mm⁴
- J_v = 122544. mm⁴
- y_g = 20.22 mm
- T_y = 2400. N
- M_x = -2400000. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 32.78 mm
- σ_m = -Mv/J_u = 238. N/mm²
- x_c = 24. mm
- y_c = 42. mm
- v_c = 21.78 mm
- σ_c = -Mv/J_u = 158.2 N/mm²
- τ_c = 3.476 N/mm²
- σ_q = √σ²+3τ² = 158.3 N/mm²
- S = 5746. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-41/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$41/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = - Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = - Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

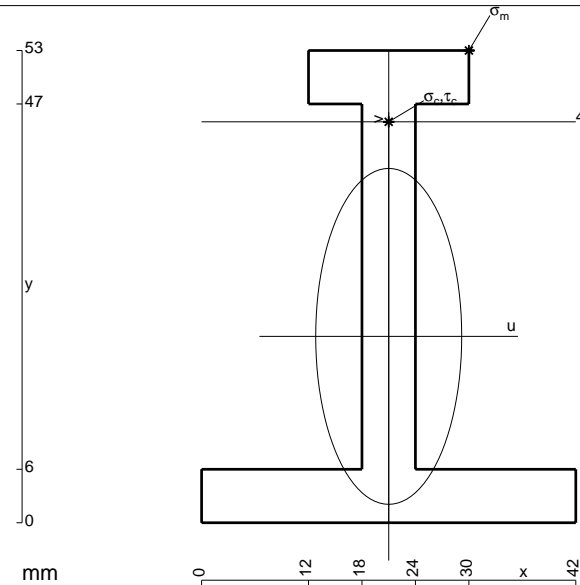
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

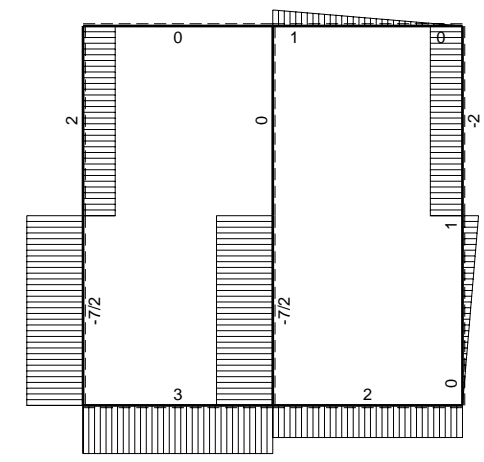
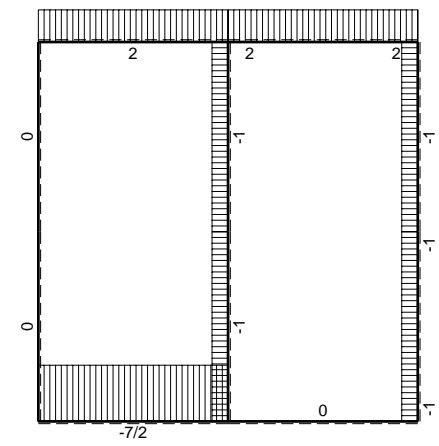
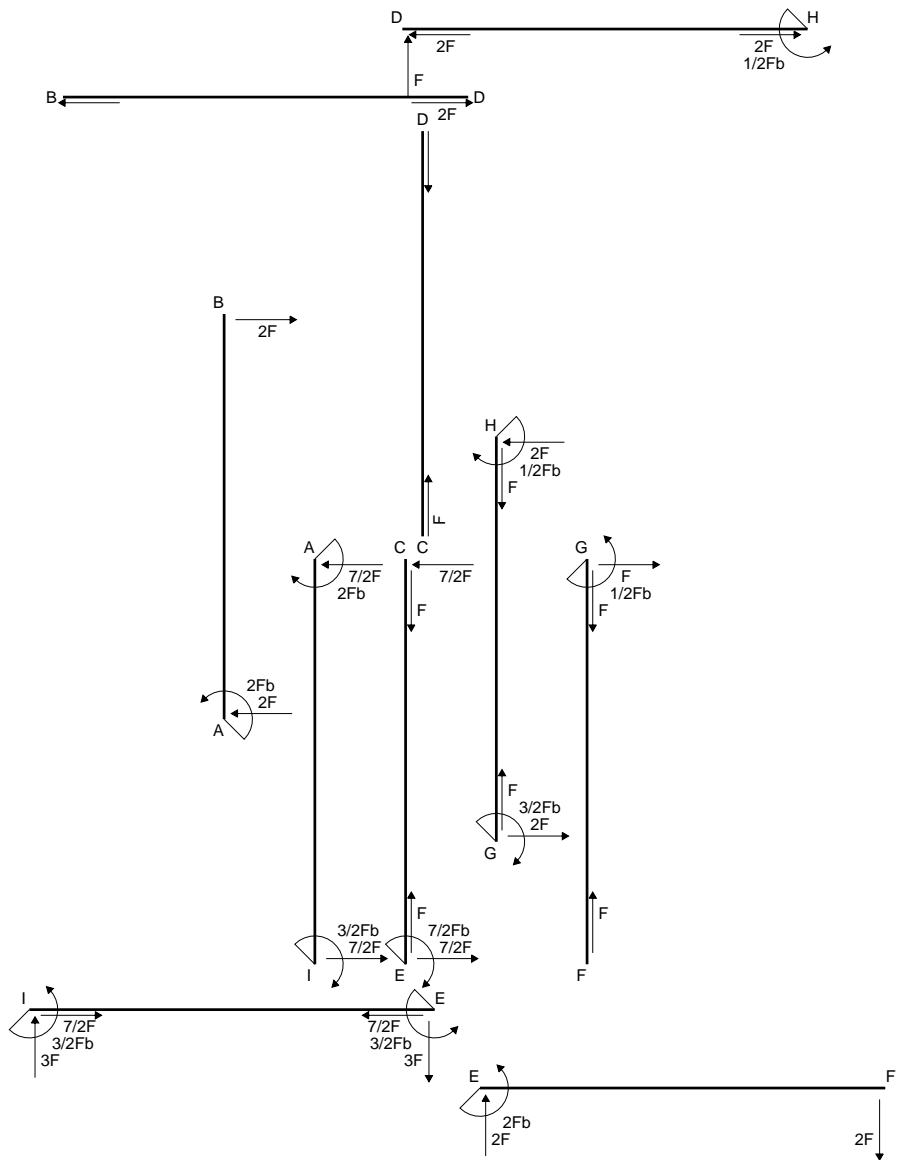
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

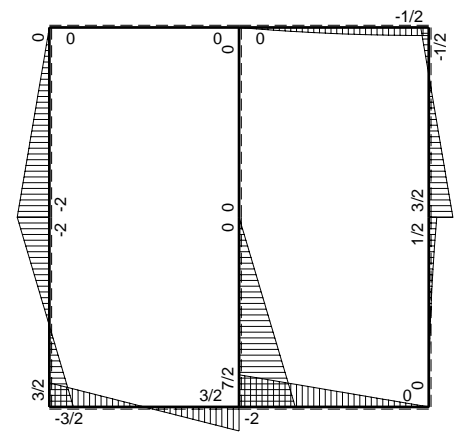


- A = 606. mm²
- J_u = 215454. mm⁴
- J_v = 40698. mm⁴
- y_g = 20.92 mm
- T_y = 3030. N
- M_x = -1338250. Nmm
- x_m = 30. mm
- y_m = 53. mm
- u_m = 9. mm
- v_m = 32.08 mm
- σ_m = -Mv/J_u = 199.3 N/mm²
- x_c = 21. mm
- y_c = 45. mm
- v_c = 24.08 mm
- σ_c = -Mv/J_u = 149.6 N/mm²
- τ_c = 8.068 N/mm²
- σ_q = √σ²+3τ² = 150.2 N/mm²
- S = 3442. mm³

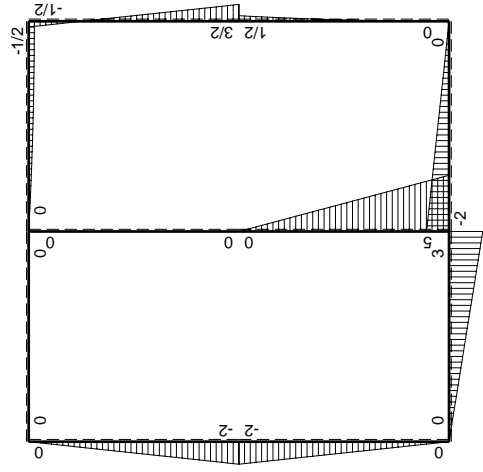
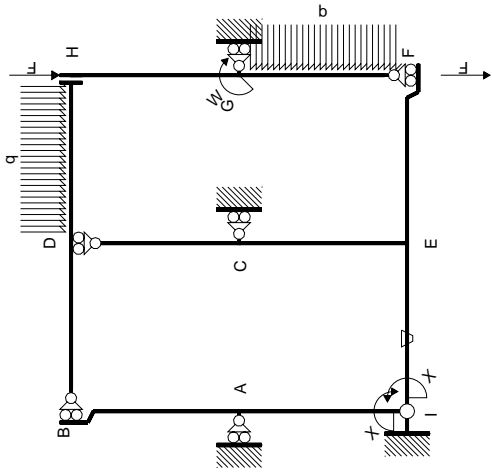


← ⊕ → F

↑ ⊕ ↓ F

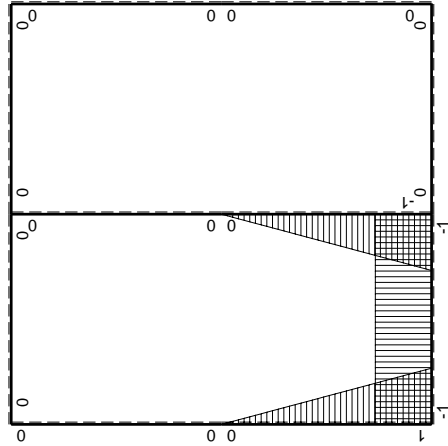


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fb+2Fx	0	0	0	0	0+0	0
BA b	0	2Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-2Fx$	0	$-2Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$2Fb-2Fx$	0	$-2Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

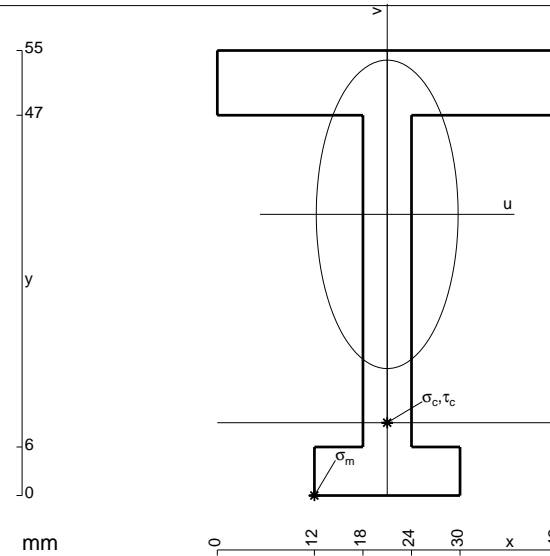
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb 1/EJ dx = [-x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-b + 2/3 b) Fb 1/EJ = -1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb 1/EJ dx = [-x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-b + 2/3 b) Fb 1/EJ = -1/3 Fb^2/EJ$$



$$A = 690. \text{ mm}^2$$

$$J_u = 250916. \text{ mm}^4$$

$$J_v = 53046. \text{ mm}^4$$

$$y_g = 34.75 \text{ mm}$$

$$T_y = 2520. \text{ N}$$

$$M_x = -1512000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.75 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

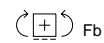
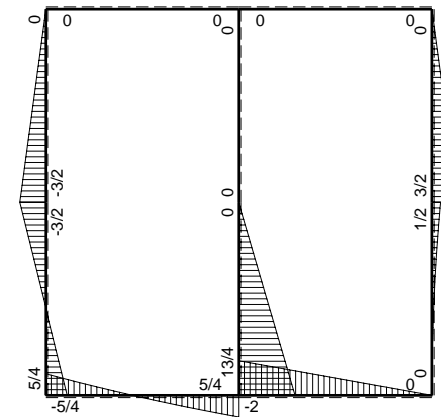
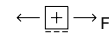
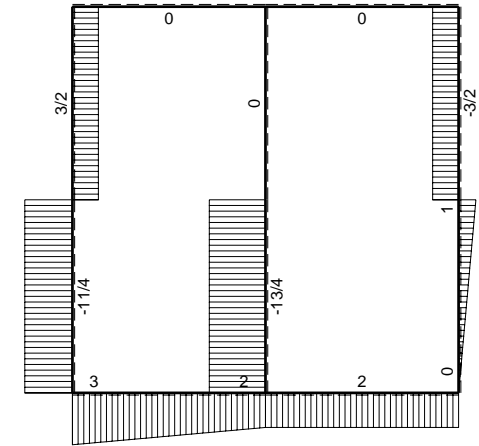
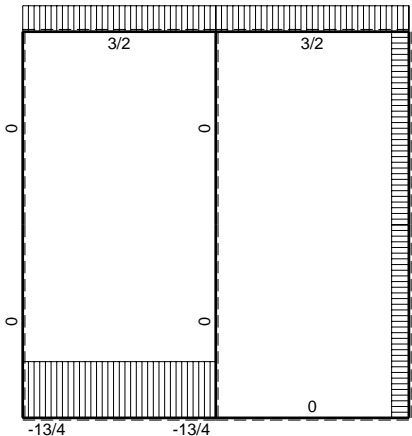
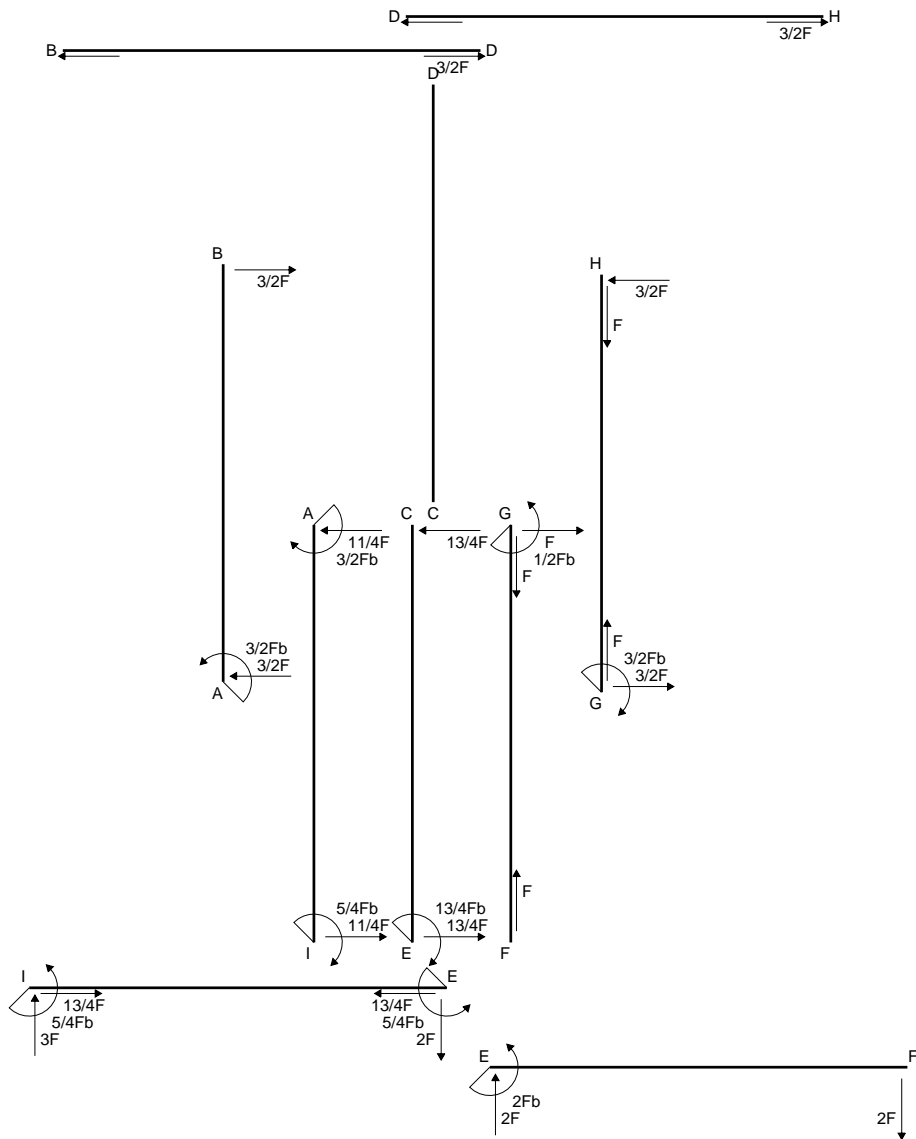
$$v_c = -25.75 \text{ mm}$$

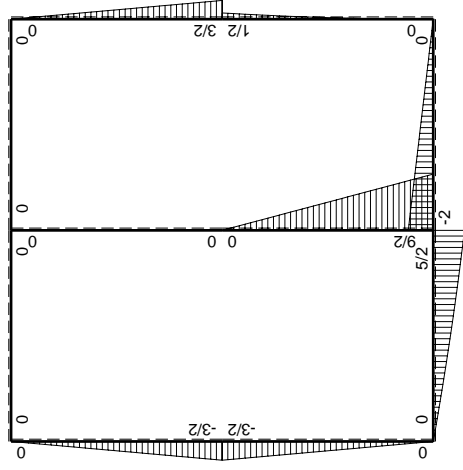
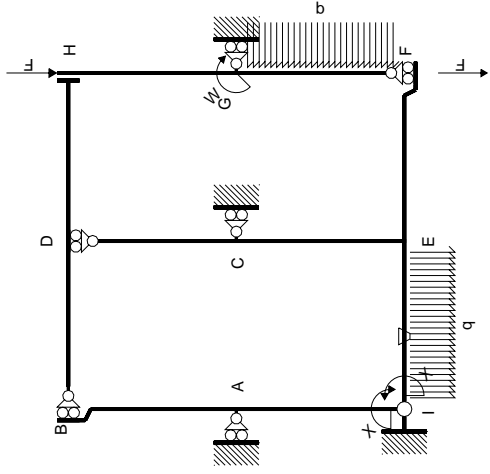
$$\sigma_c = -Mv/J_u = -155.2 \text{ N/mm}^2$$

$$\tau_c = 6.561 \text{ N/mm}^2$$

$$\sigma_\rho = \sqrt{\sigma_c^2 + 3\tau_c^2} = 155.6 \text{ N/mm}^2$$

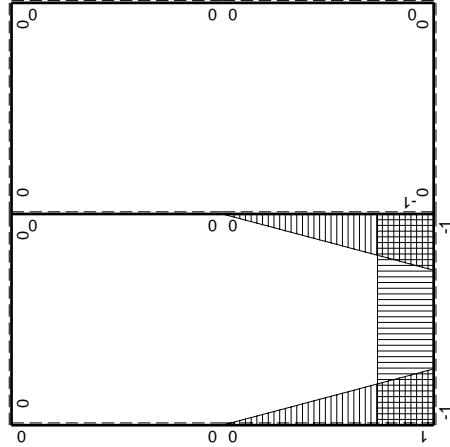
$$S = 3920. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

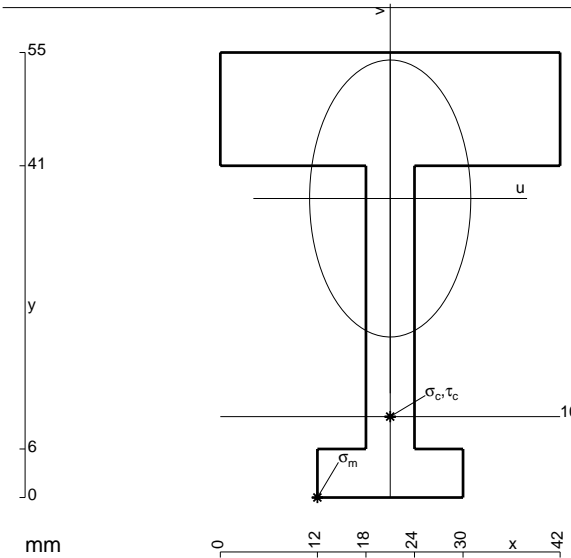
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 906. \text{ mm}^2$$

$$J_u = 265632. \text{ mm}^4$$

$$J_v = 89982. \text{ mm}^4$$

$$y_g = 36.96 \text{ mm}$$

$$T_y = 2380. \text{ N}$$

$$M_x = -1570800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -36.96 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

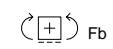
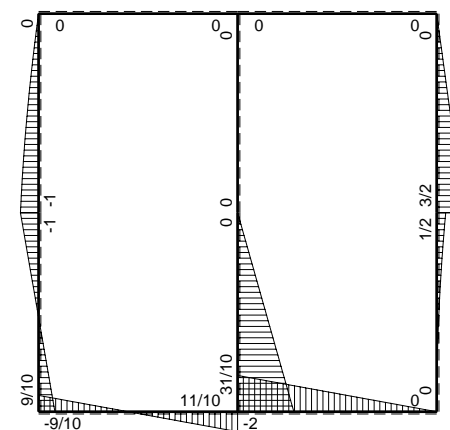
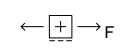
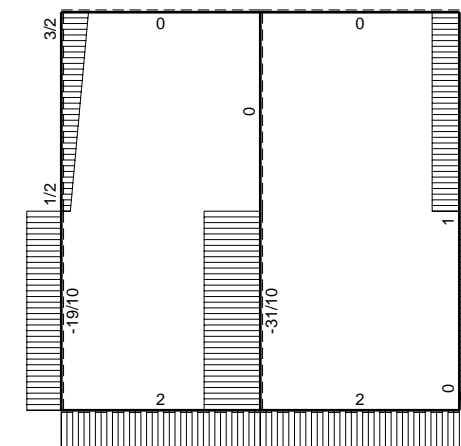
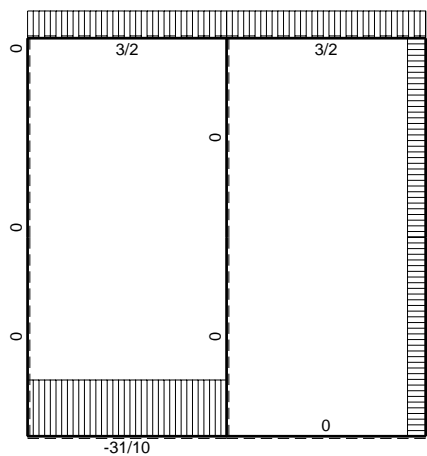
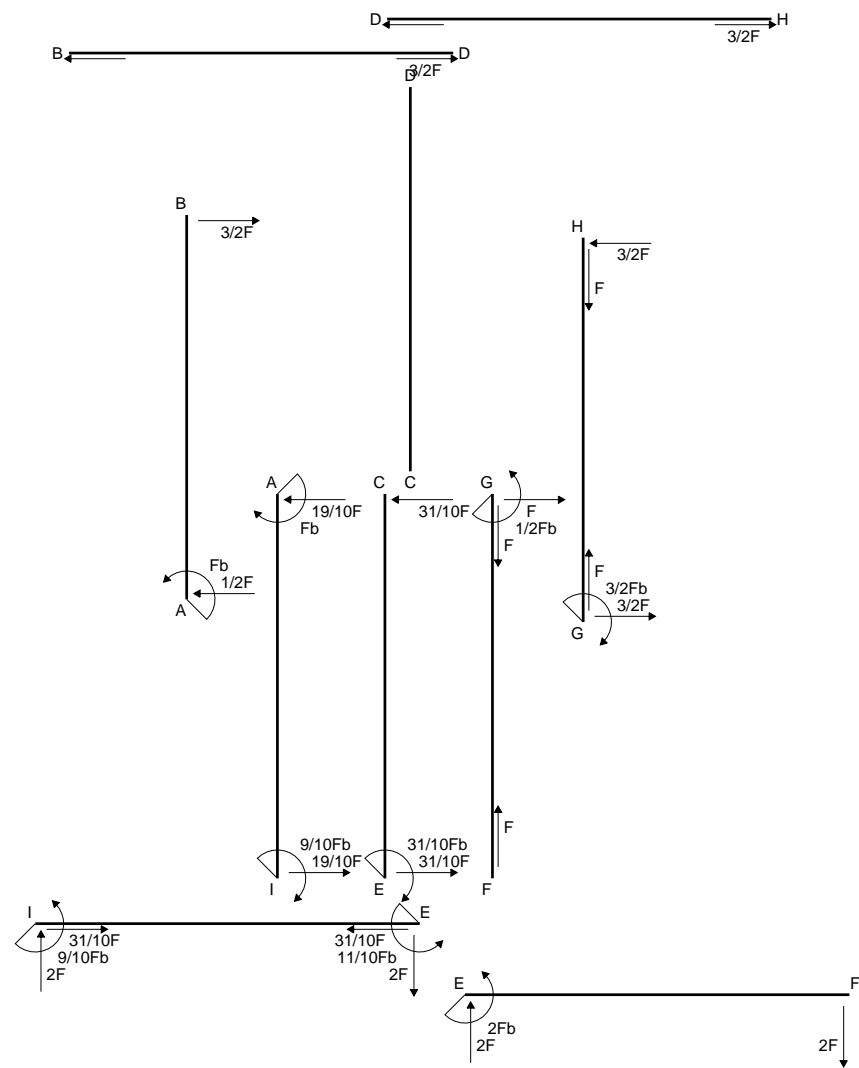
$$v_c = -26.96 \text{ mm}$$

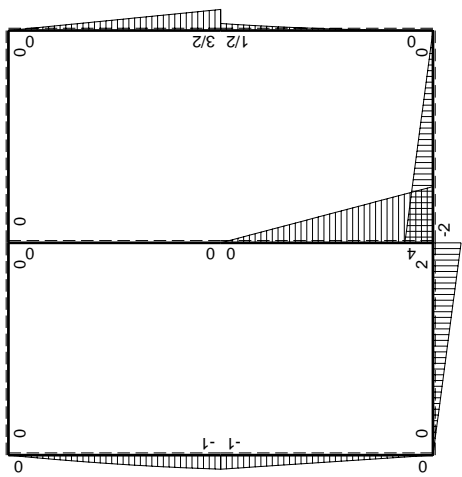
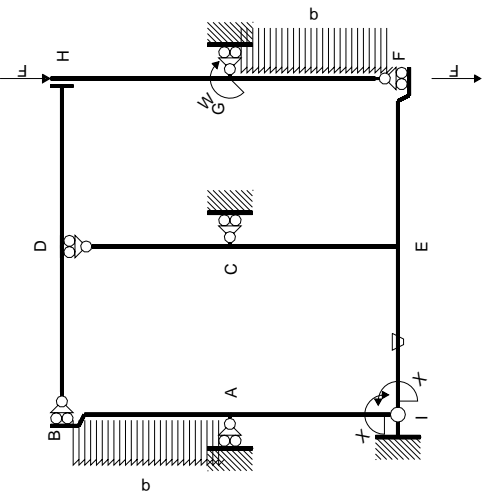
$$\sigma_c = -Mv/J_u = -159.4 \text{ N/mm}^2$$

$$\tau_c = 6.514 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 159.8 \text{ N/mm}^2$$

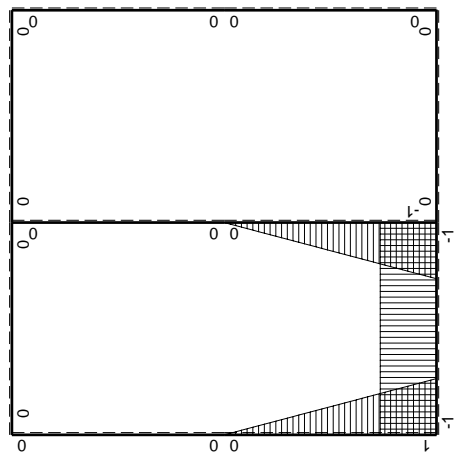
$$S = 4362. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$-Fb+1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$3/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb 1/EJ dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 4b - 4/3 b) Fb 1/EJ = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb 1/EJ dx = [-4/3 x^3/b^2]_0^b Fb 1/EJ$$

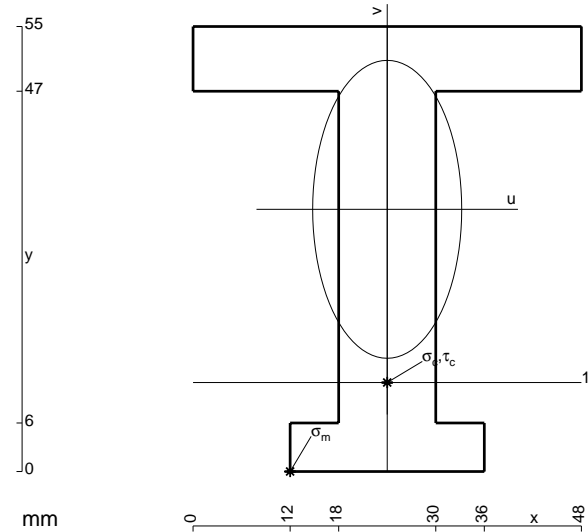
$$= (-4/3 b) Fb 1/EJ = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



$$A = 1020. \text{ mm}^2$$

$$J_u = 345844. \text{ mm}^4$$

$$J_v = 86544. \text{ mm}^4$$

$$y_g = 32.41 \text{ mm}$$

$$T_y = 3440. \text{ N}$$

$$M_x = -2442400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -32.41 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -228.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

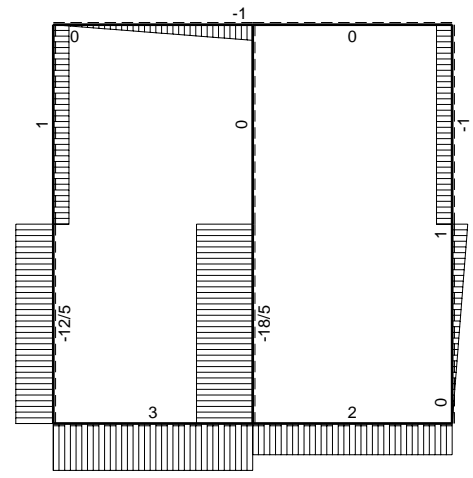
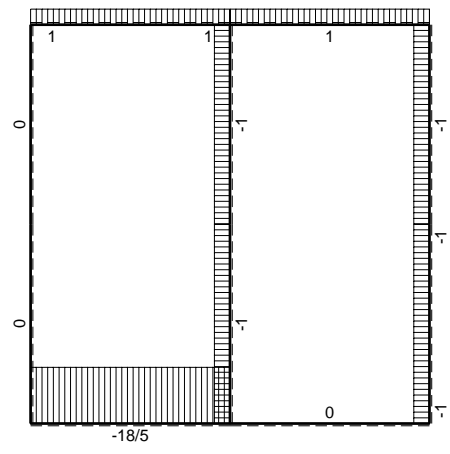
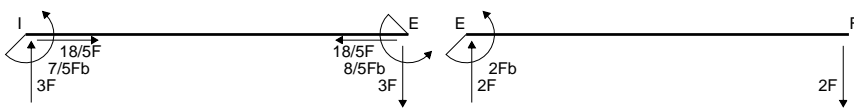
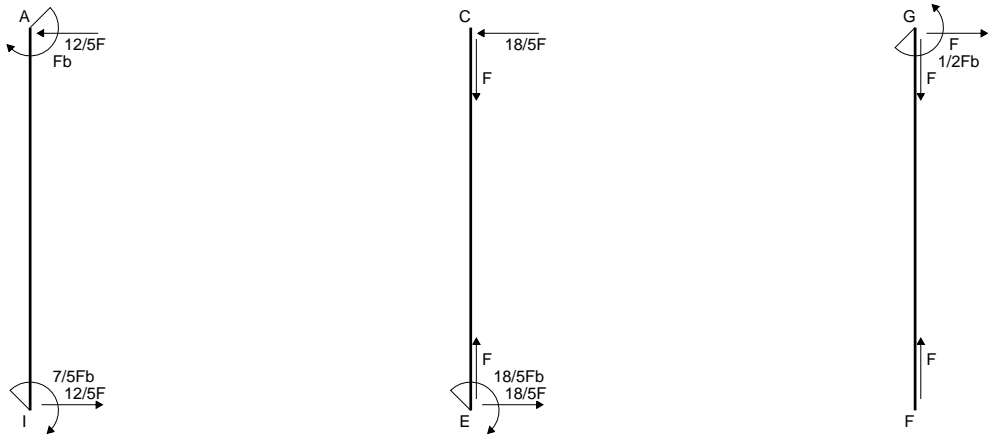
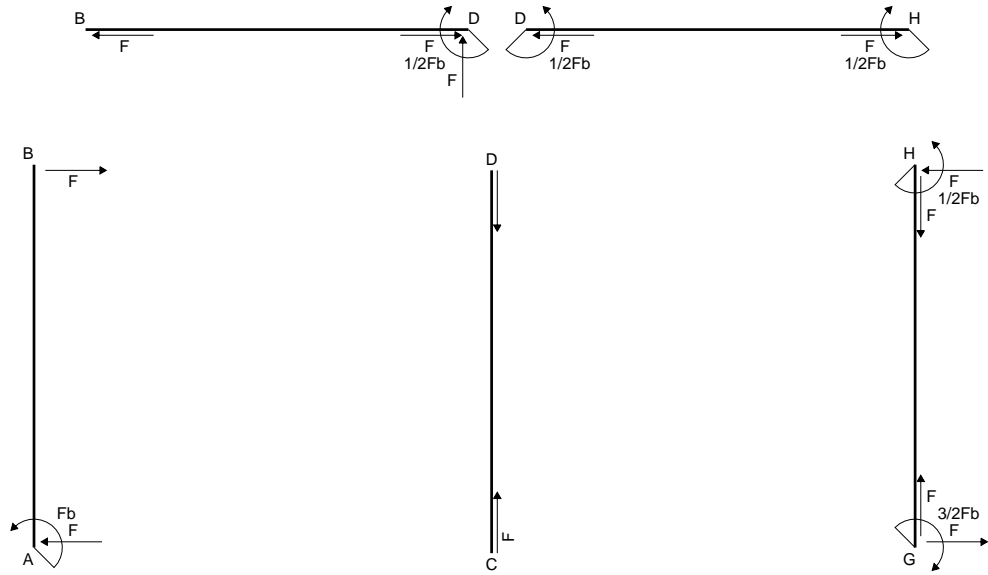
$$v_c = -21.41 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -151.2 \text{ N/mm}^2$$

$$\tau_c = 4.699 \text{ N/mm}^2$$

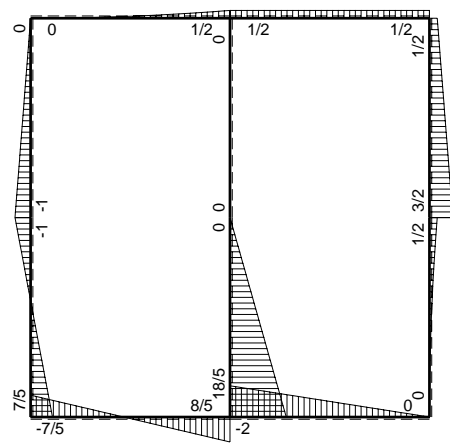
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 151.4 \text{ N/mm}^2$$

$$S = 5669. \text{ mm}^3$$

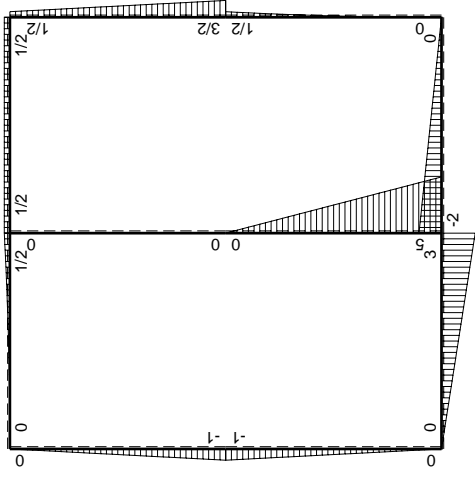
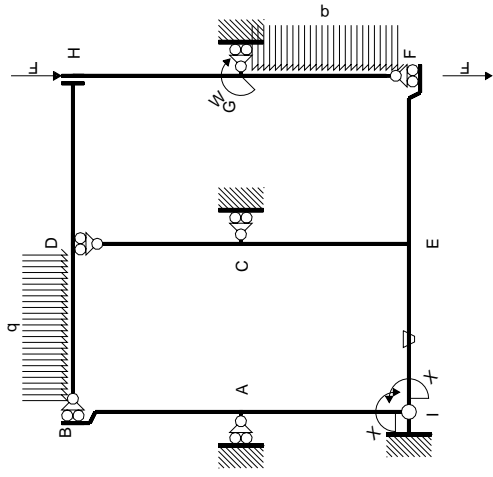


← ⊕ → F

↑ ⊕ ↓ F

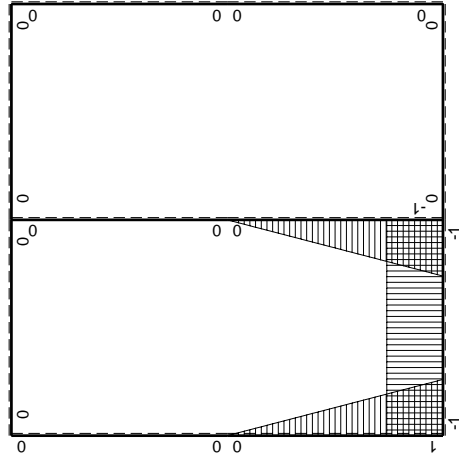


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

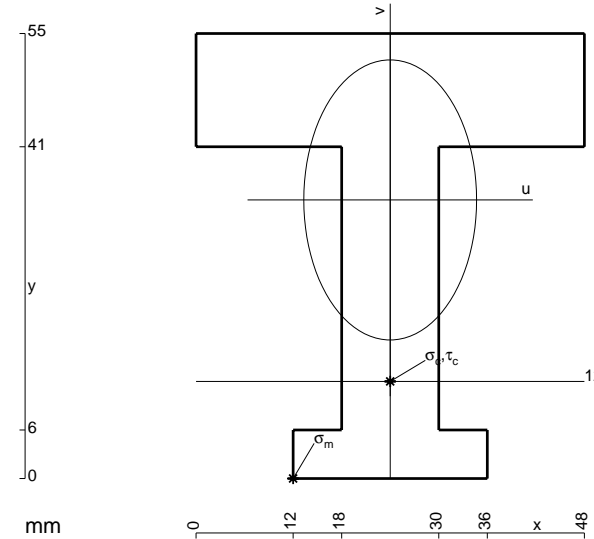
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

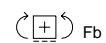
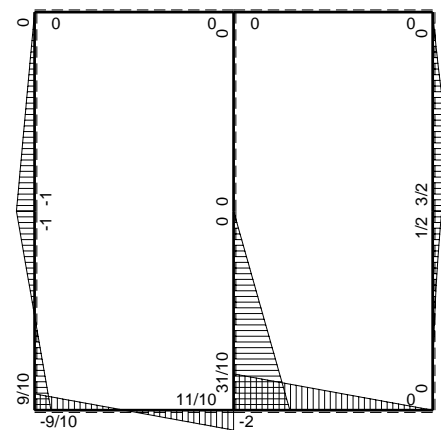
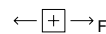
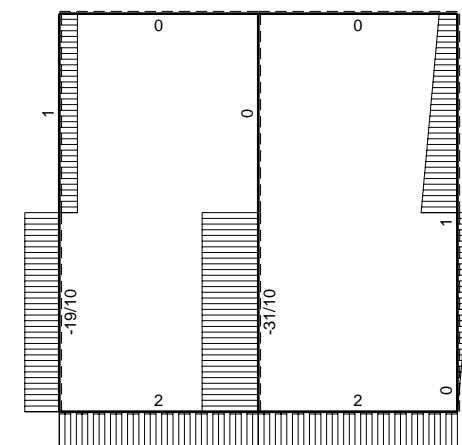
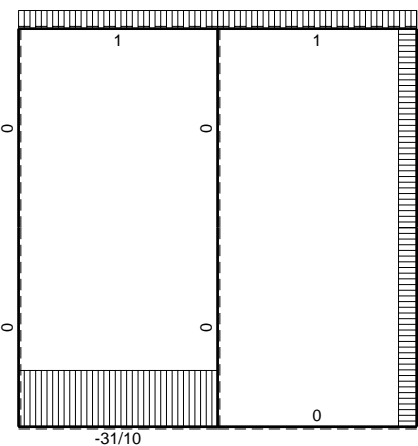
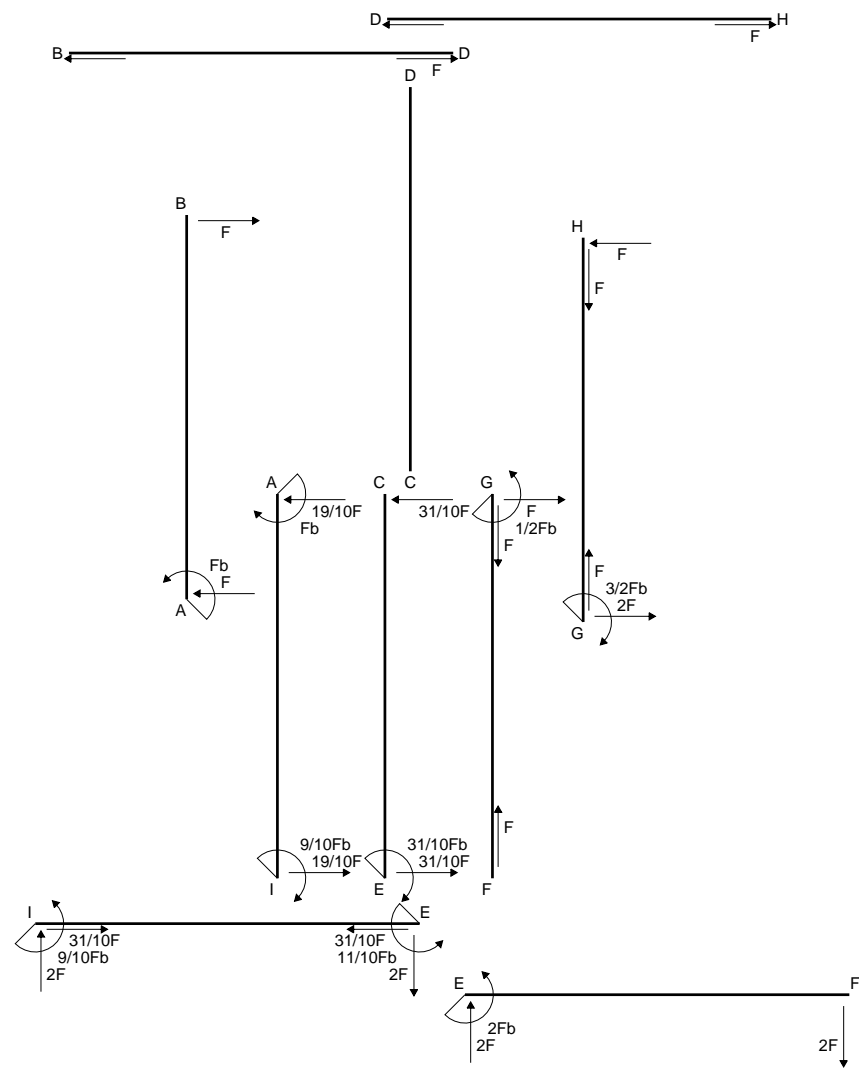
$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

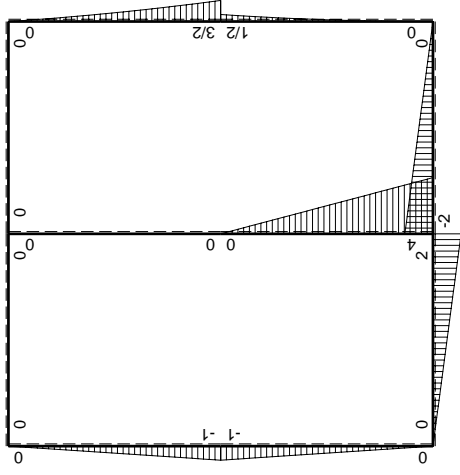
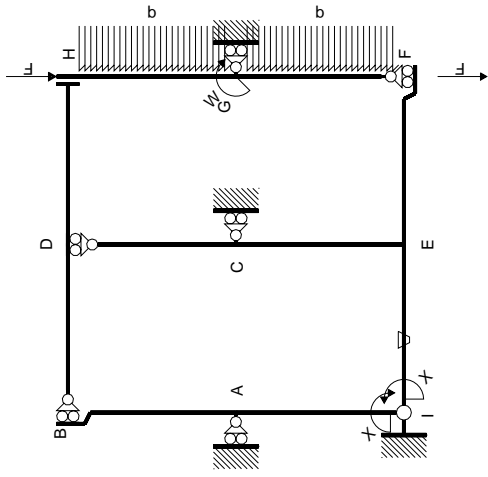
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



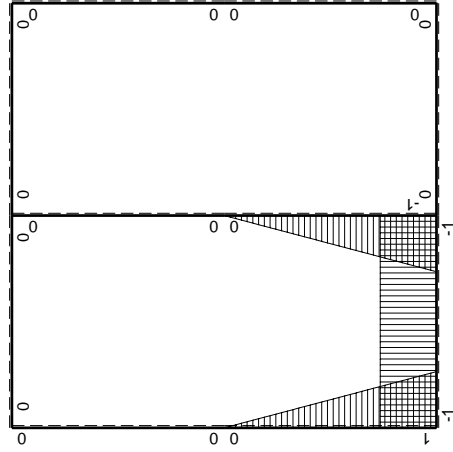
- A = 1236. mm²
- J_u = 370453. mm⁴
- J_v = 140976. mm⁴
- y_g = 34.43 mm
- T_y = 3340. N
- M_x = -2571800. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -34.43 mm
- σ_m = -Mv/J_u = -239. N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -22.43 mm
- σ_c = -Mv/J_u = -155.7 N/mm²
- τ_c = 4.776 N/mm²
- σ_o = √σ_c² + 3τ_c² = 155.9 N/mm²
- S = 6357. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

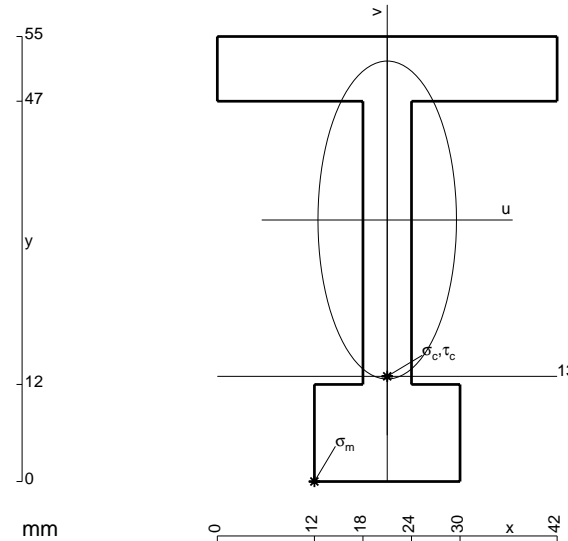
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

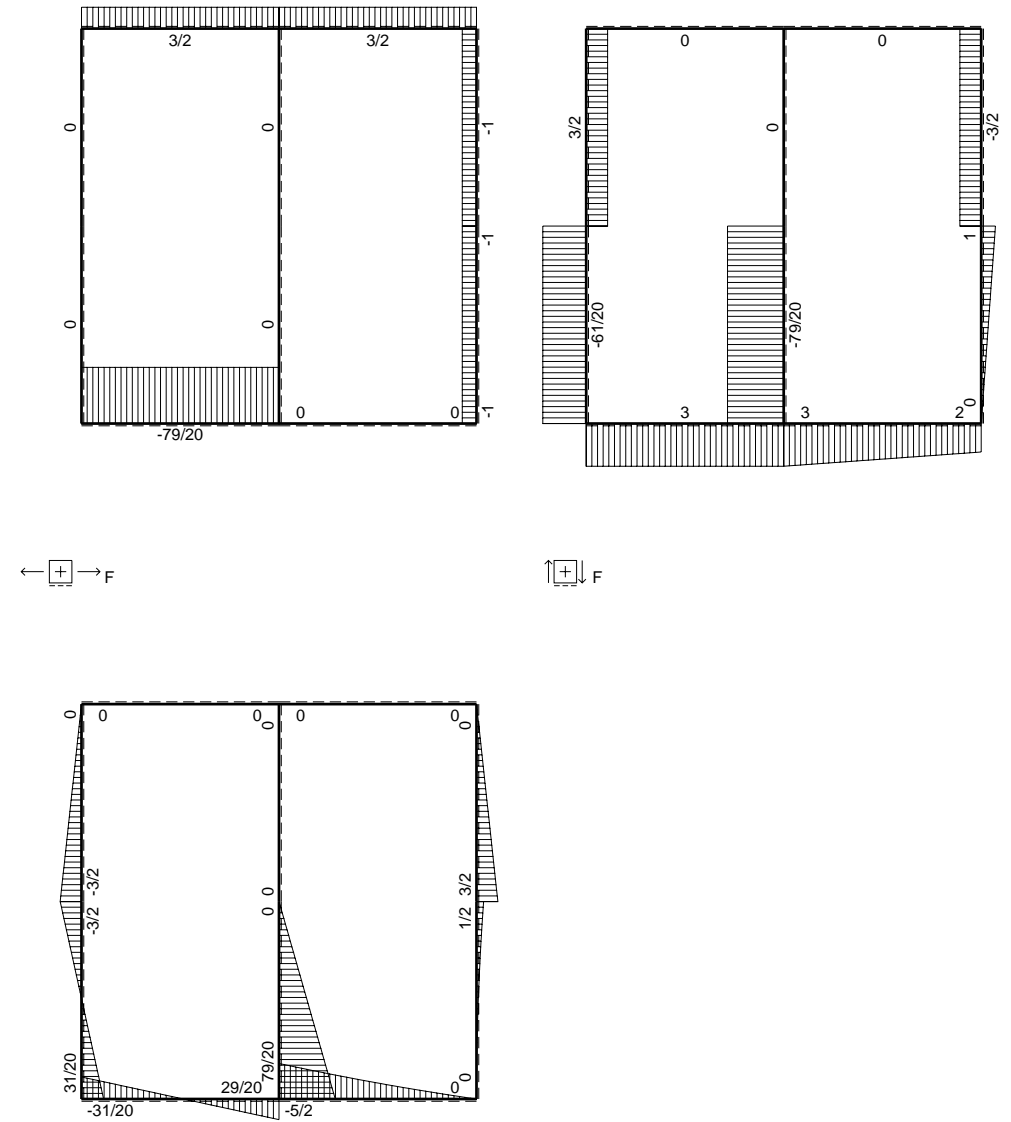
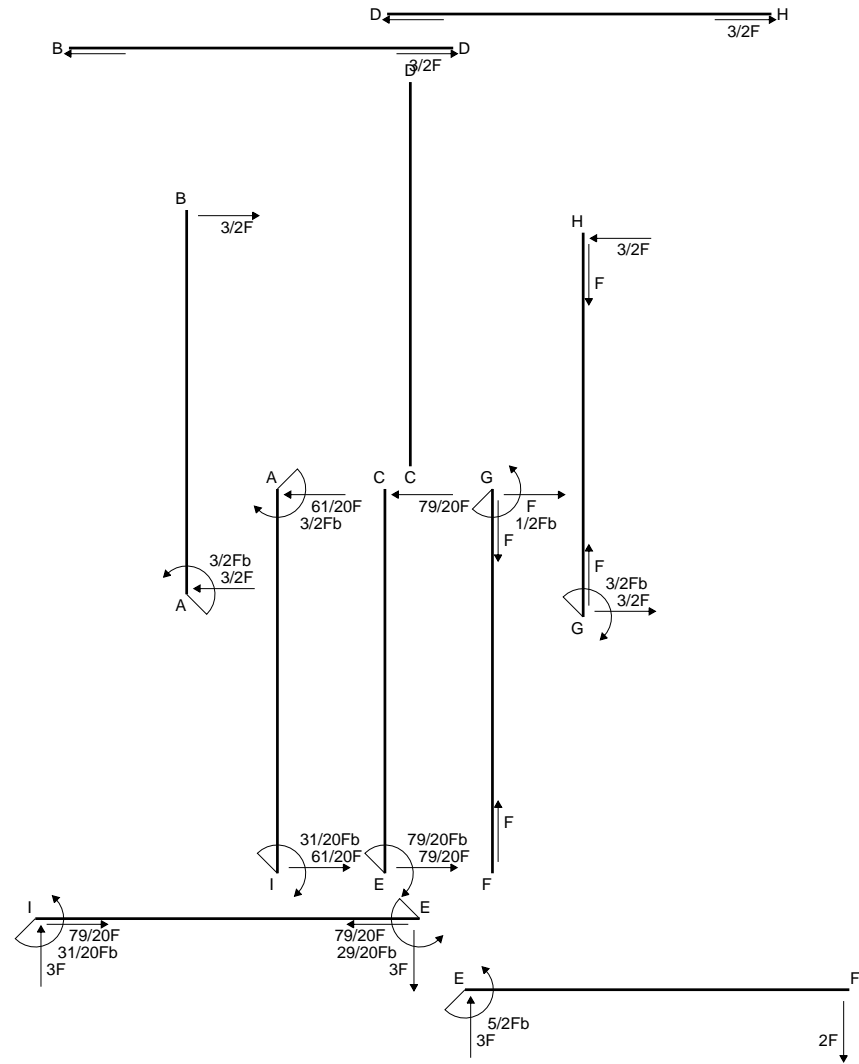
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

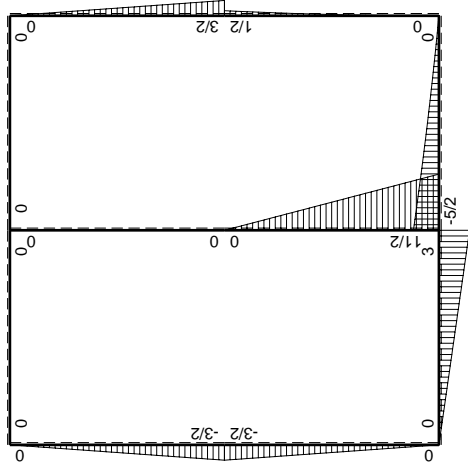
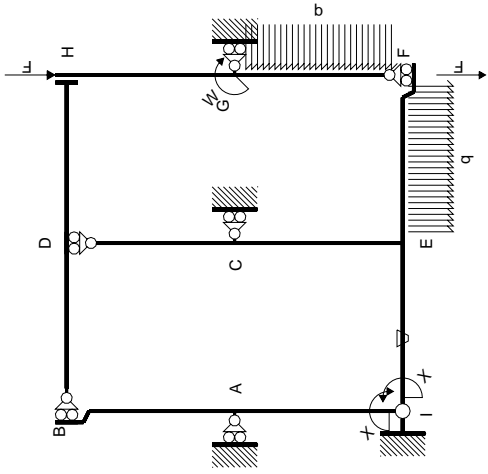
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



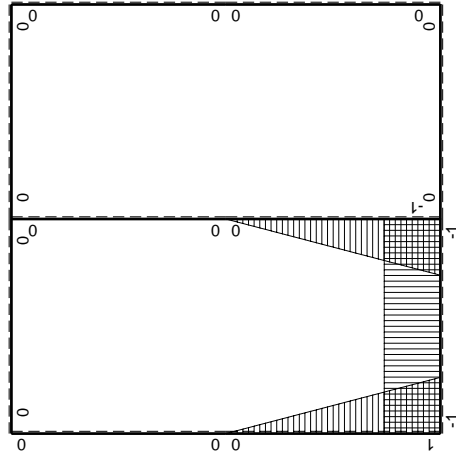
- A = 762. mm²
- J_u = 294369. mm⁴
- J_v = 55854. mm⁴
- y_g = 32.32 mm
- T_y = 2220. N
- M_x = -1820400. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -32.32 mm
- σ_m = -Mv/J_u = -199.9 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -19.32 mm
- σ_c = -Mv/J_u = -119.5 N/mm²
- τ_c = 7.295 N/mm²
- σ_q = √σ²+3τ² = 120.1 N/mm²
- S = 5804. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0	
BA b	0	$3/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0	
FE b	0	$2Fx+1/2qx^2$	0	0	0	0			
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0	
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-3/2Fx$	0	0	0	0			
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1			
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2			
	totali							$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb 1/EJ dx = [-11/6 x^3/b^2]_0^b Fb 1/EJ$$

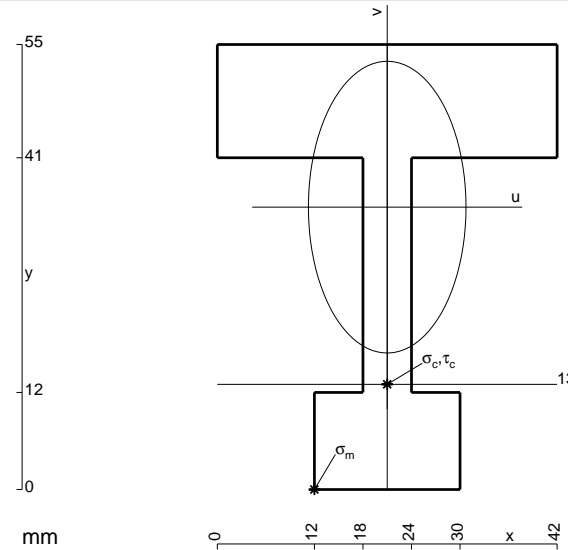
$$= (-11/6 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

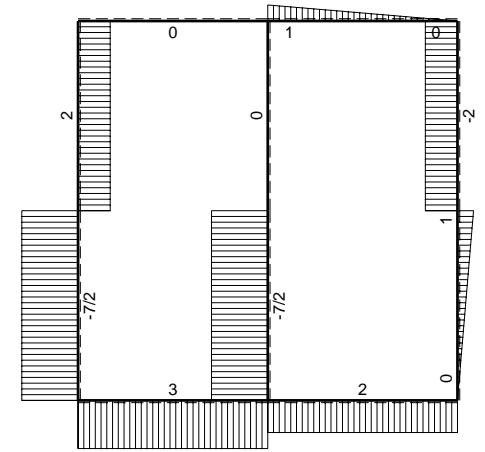
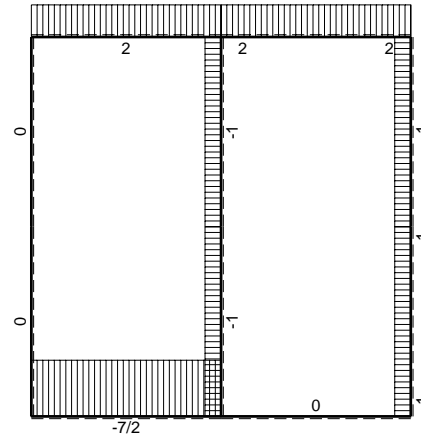
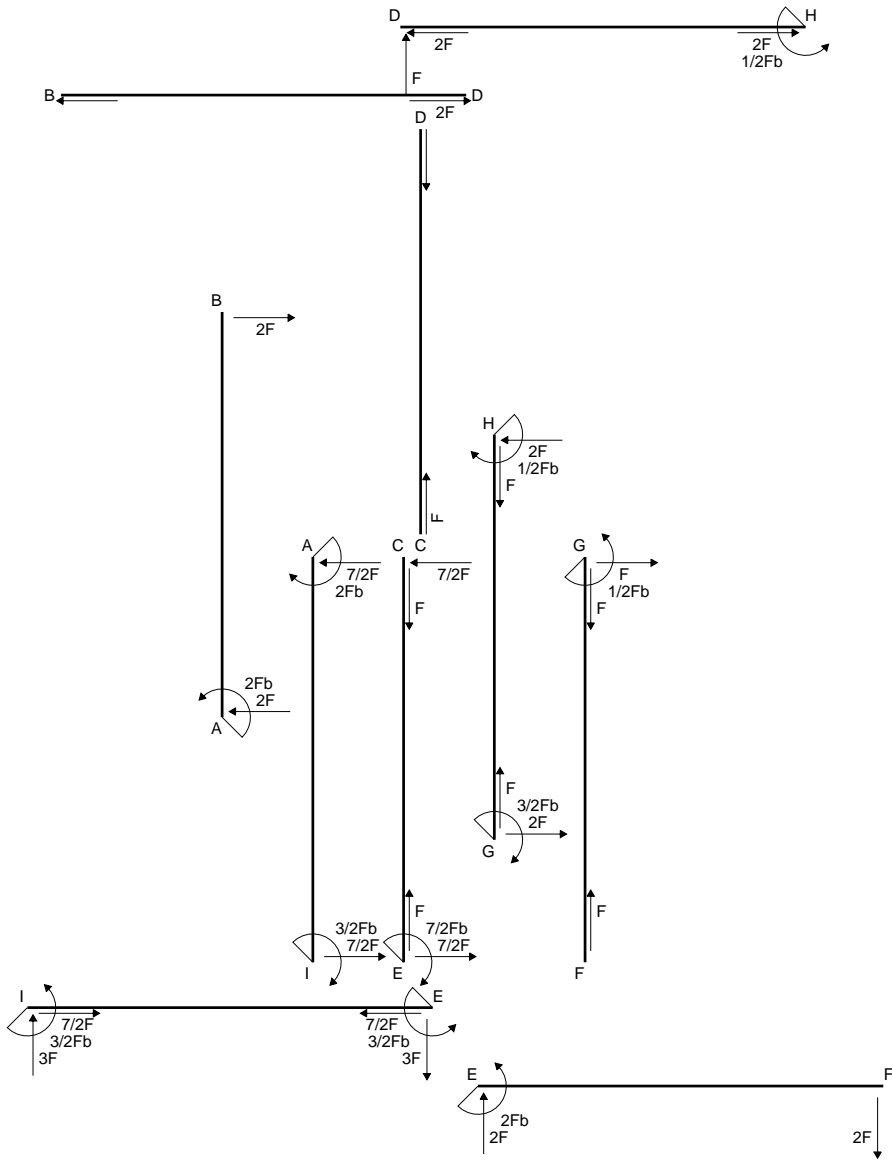
$$= (-3/4 b + 1/2 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/4 b + 1/2 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

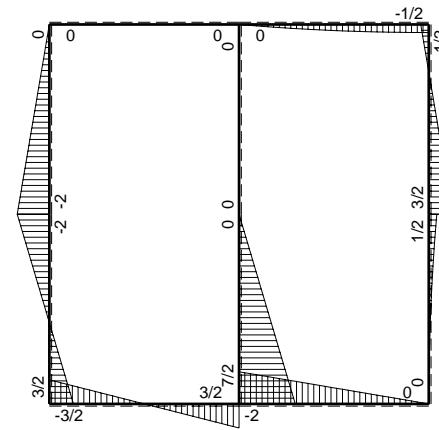


- A = 978. mm²
- J_u = 317980. mm⁴
- J_v = 92790. mm⁴
- y_g = 34.9 mm
- T_y = 2580. N
- M_x = -1892000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -34.9 mm
- σ_m = -Mv/J_u = -207.6 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -21.9 mm
- σ_c = -Mv/J_u = -130.3 N/mm²
- τ_c = 8.623 N/mm²
- σ_o = √σ² + 3τ² = 131.2 N/mm²
- S = 6377. mm³

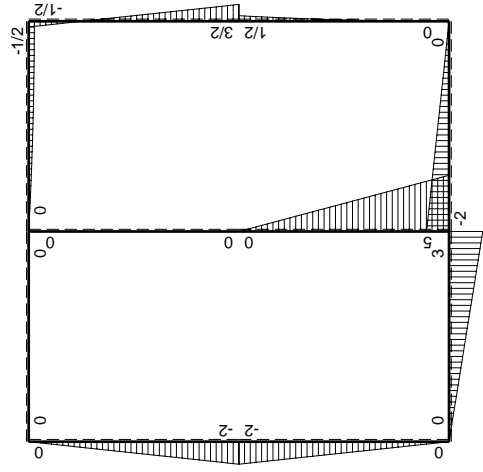
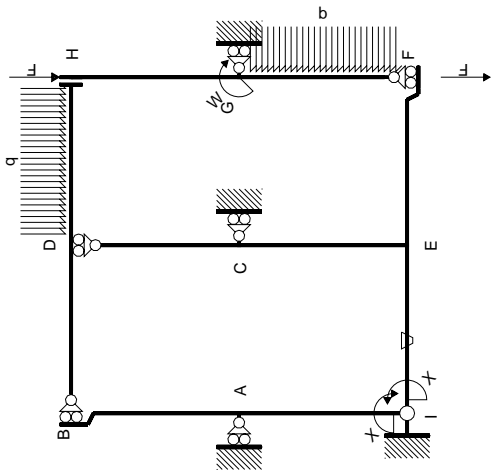


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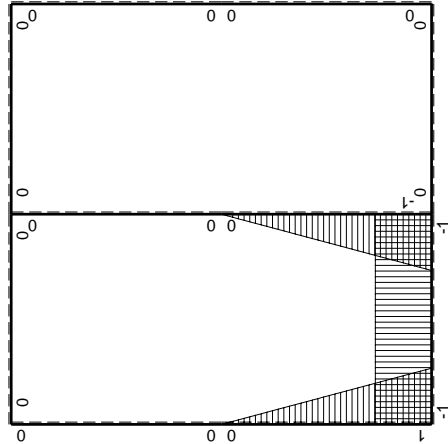


⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fb+2Fx	0	0	0	0	0+0	0
BA b	0	2Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-2Fx$	0	$-2Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$2Fb-2Fx$	0	$-2Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

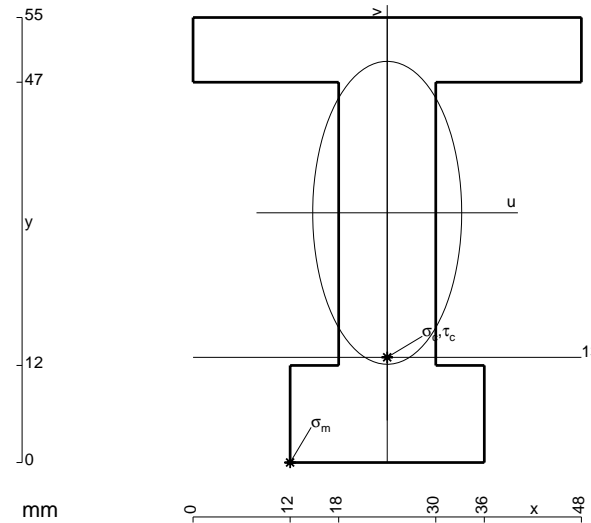
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb 1/EJ dx = [-x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

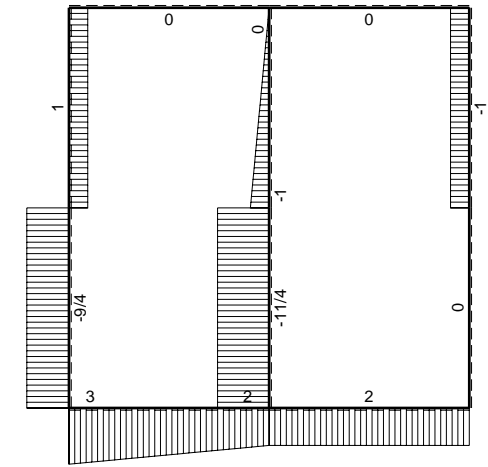
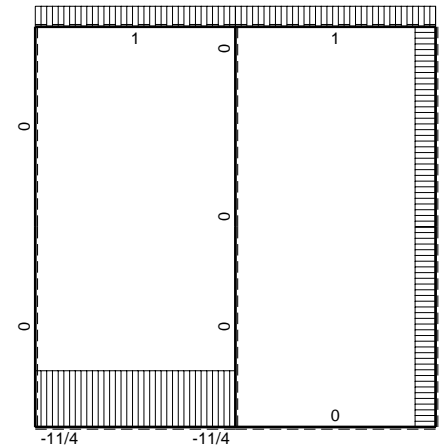
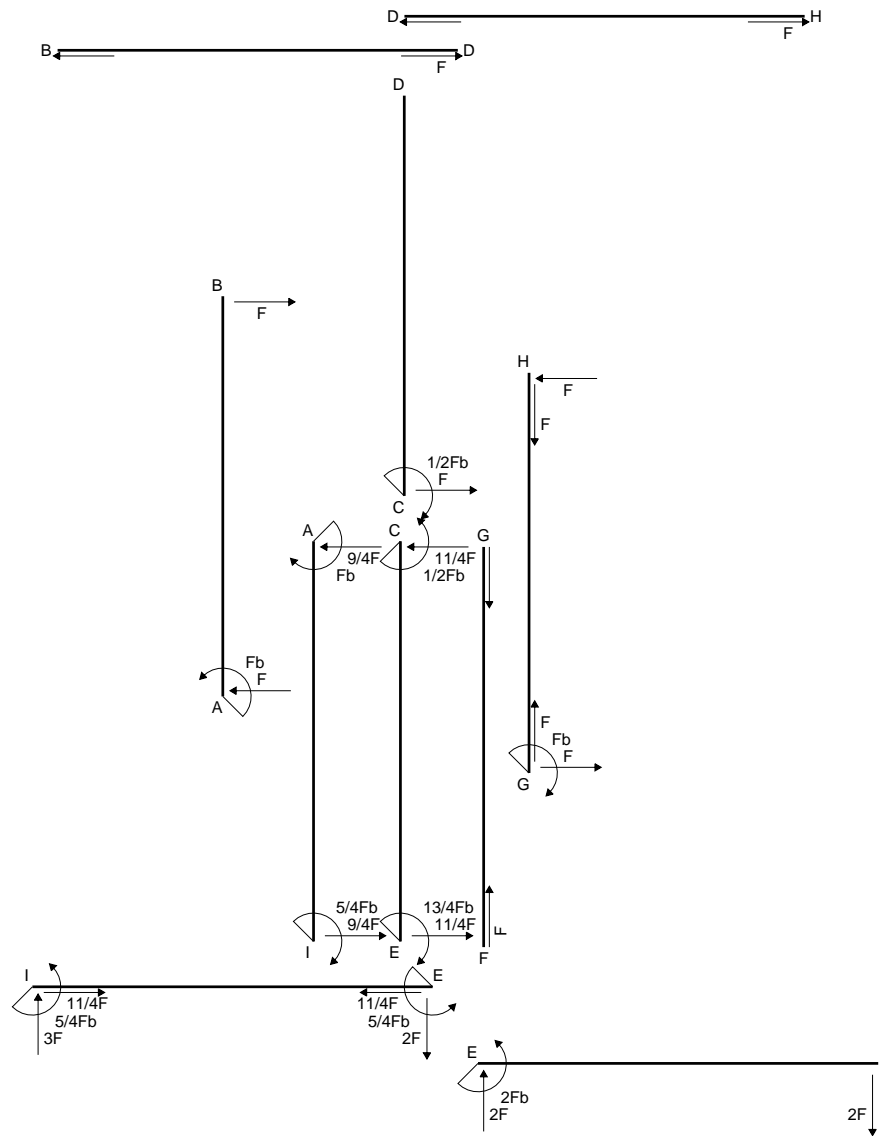
$$= (-b + 2/3 b) Fb 1/EJ = -1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb 1/EJ dx = [-x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-b + 2/3 b) Fb 1/EJ = -1/3 Fb^2/EJ$$

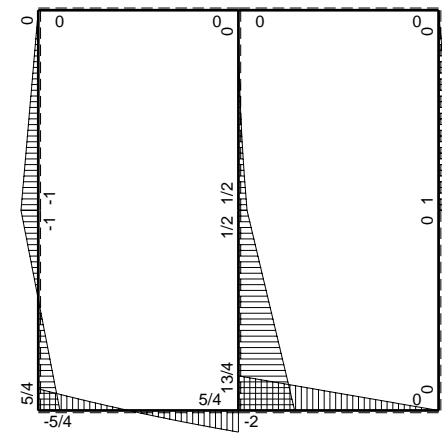


- A = 1092. mm²
- J_u = 382903. mm⁴
- J_v = 92592. mm⁴
- y_g = 30.86 mm
- T_y = 2920. N
- M_x = -2715600. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -30.86 mm
- σ_m = -Mv/J_u = -218.9 N/mm²
- x_c = 24. mm
- y_c = 13. mm
- v_c = -17.86 mm
- σ_c = -Mv/J_u = -126.7 N/mm²
- τ_c = 4.69 N/mm²
- σ_o = √σ²+3τ² = 126.9 N/mm²
- S = 7381. mm³

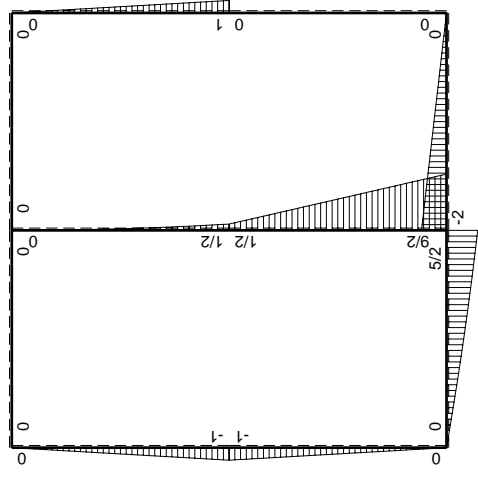
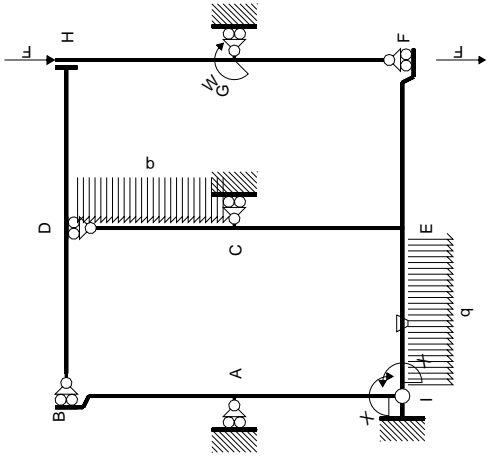


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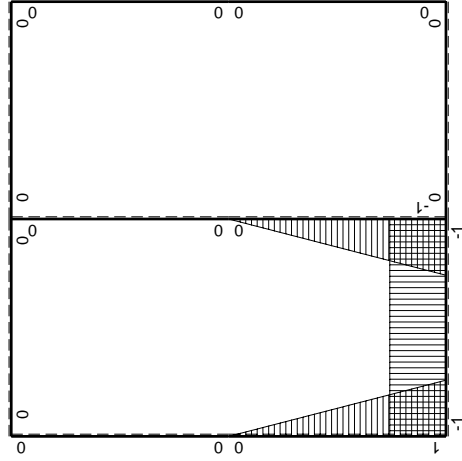


⊙ (+) ⊙ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fb+Fx	0	0	0	0	0+0	0	
BA b	0	Fx	0	0	0	0	0+0	0	
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
DC b	0	$-1/2qx^2$	0	0	0	0	0+0	0	
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0	0+0	0	
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0	0+0	0	
GH b	0	Fb-Fx	0	0	0	0	0+0	0	
HG b	0	-Fx	0	0	0	0	0+0	0	
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0	0+0	0	
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0	0+0	0	
IE b	-1	$3Fx-1/2qx^2$	-Fb/EJ	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$9/2Fb-4Fx$	0	$-9/2Fb+17/2Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-19/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-1/2Fb-4Fx$	0	$-1/2Fb-4Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2			
	totali							$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 17/2 x/b - 4 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 17/4 x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 17/4 b - 4/3 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 4 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

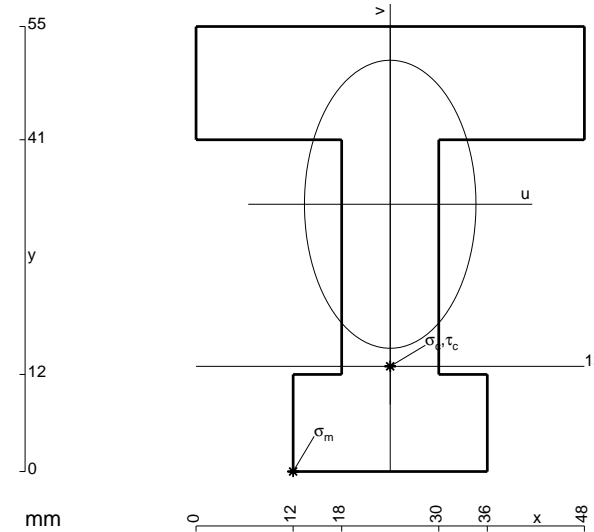
$$= (-1/4 b - 4/3 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

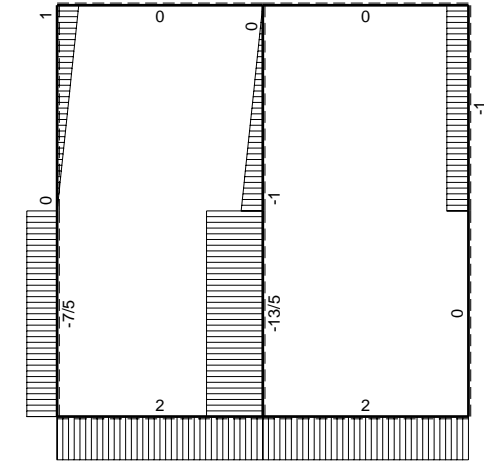
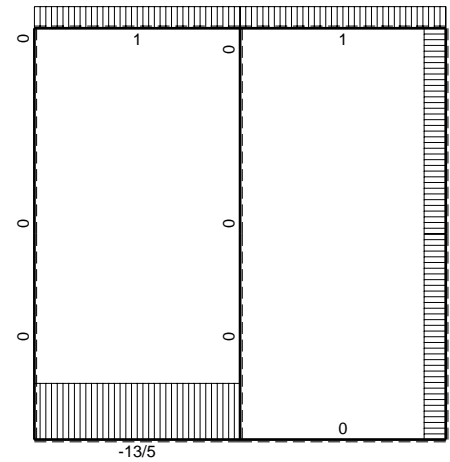
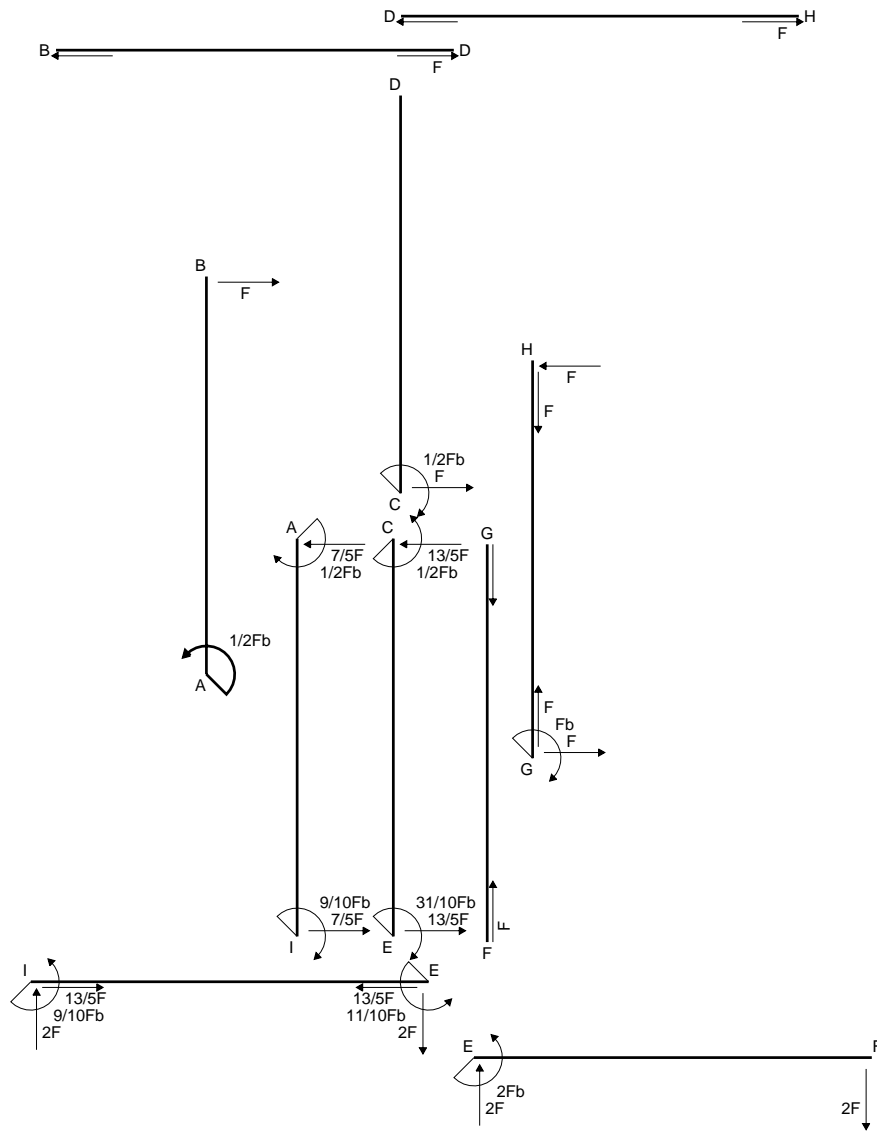
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

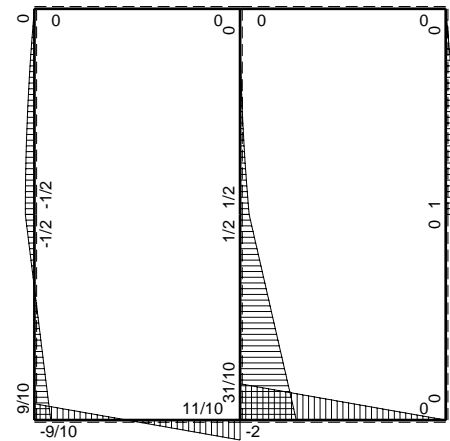


- A = 1308. mm²
- J_u = 414675. mm⁴
- J_v = 147024. mm⁴
- y_g = 33.03 mm
- T_y = 2900. N
- M_x = -2871000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -33.03 mm
- σ_m = -Mv/J_u = -228.7 N/mm²
- x_c = 24. mm
- y_c = 13. mm
- v_c = -20.03 mm
- σ_c = -Mv/J_u = -138.7 N/mm²
- τ_c = 4.681 N/mm²
- σ_o = √σ² + 3τ² = 138.9 N/mm²
- S = 8032. mm³

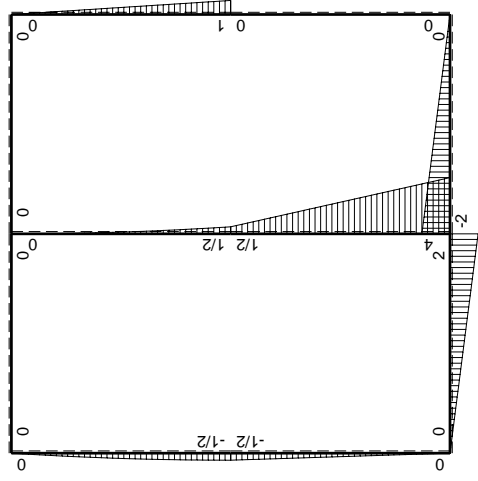
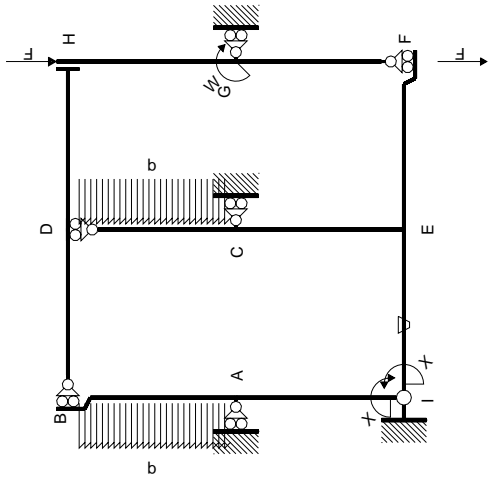


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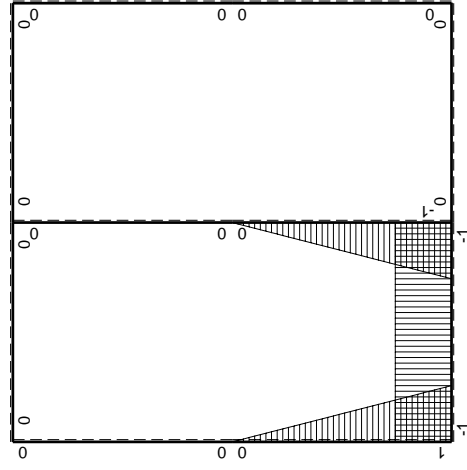


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 15/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

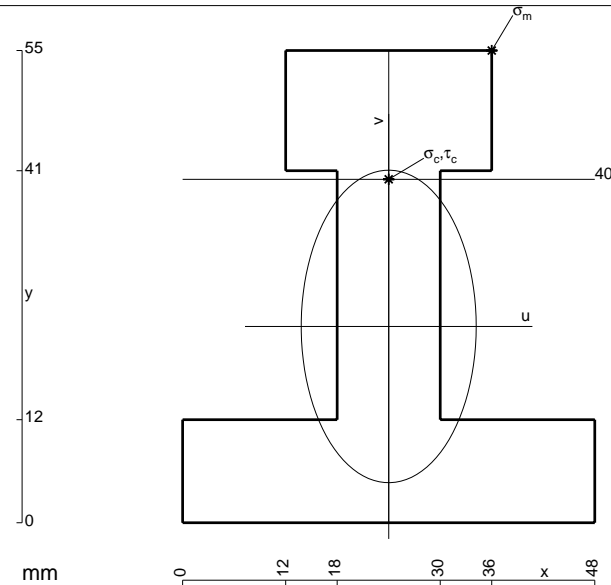
$$= (-1/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



$$A = 1260. \text{ mm}^2$$

$$J_u = 417492. \text{ mm}^4$$

$$J_v = 130896. \text{ mm}^4$$

$$y_g = 22.86 \text{ mm}$$

$$T_y = 2980. \text{ N}$$

$$M_x = -3099200. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 32.14 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

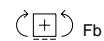
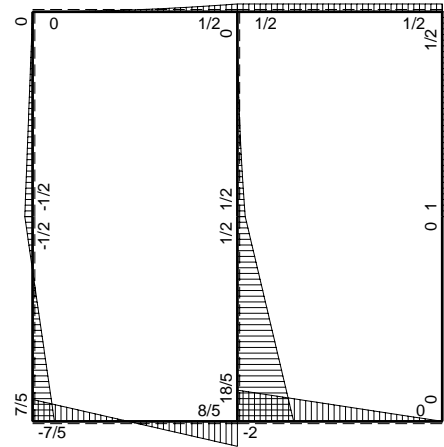
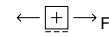
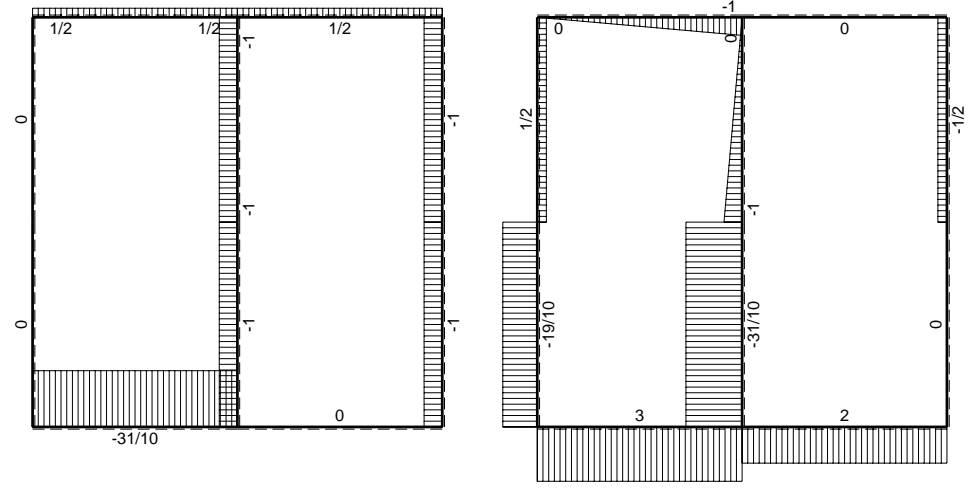
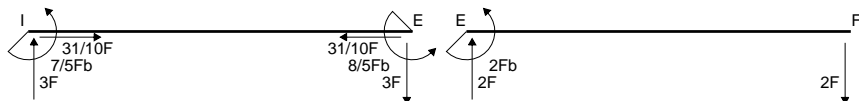
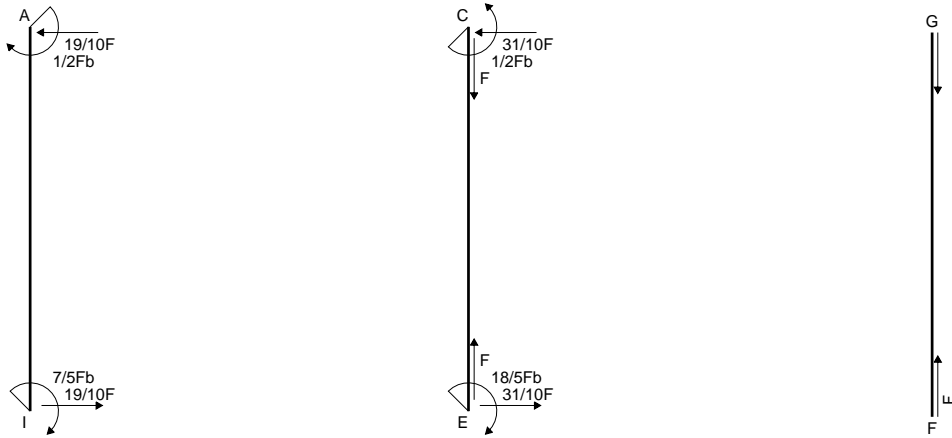
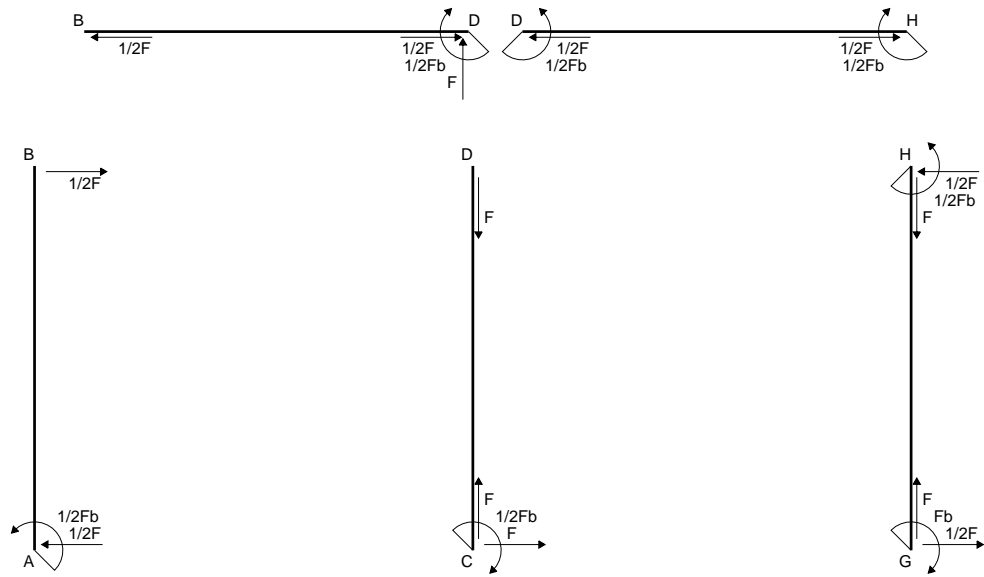
$$v_c = 17.14 \text{ mm}$$

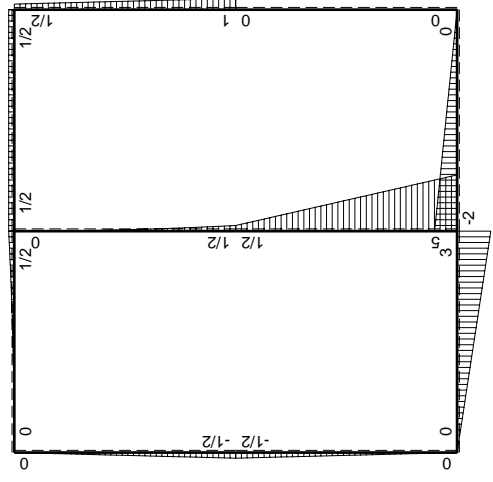
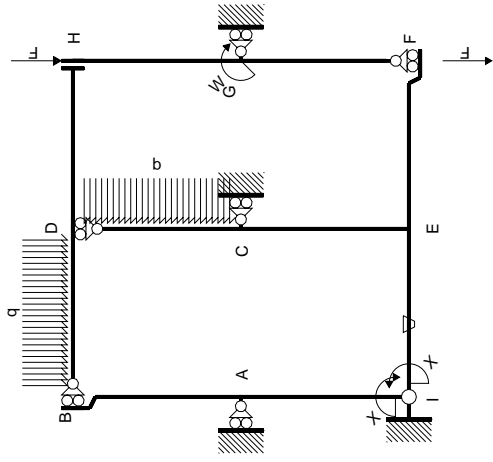
$$\sigma_c = -Mv/J_u = 127.2 \text{ N/mm}^2$$

$$\tau_c = 5.15 \text{ N/mm}^2$$

$$\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 127.5 \text{ N/mm}^2$$

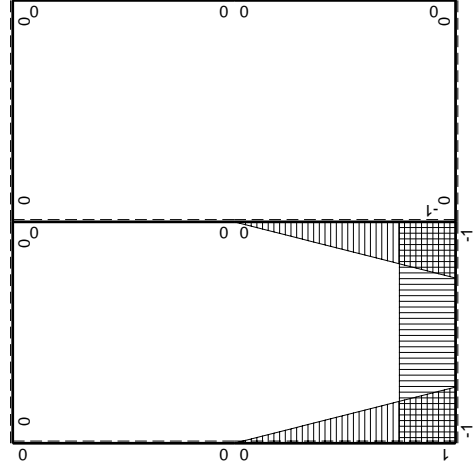
$$S = 8658. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

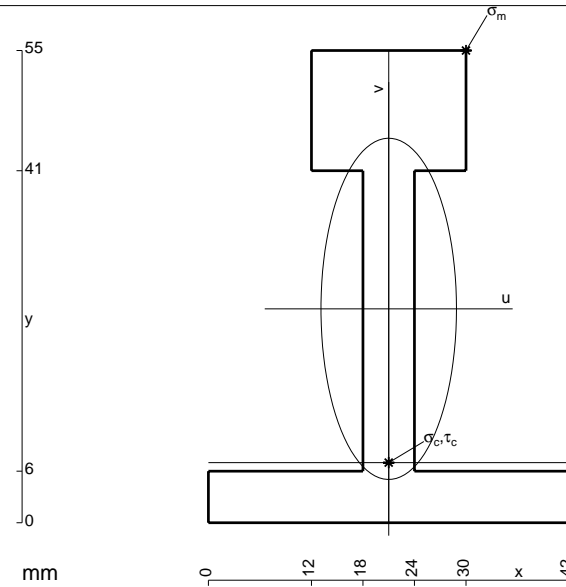
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 714. \text{ mm}^2$$

$$J_u = 282052. \text{ mm}^4$$

$$J_v = 44478. \text{ mm}^4$$

$$y_g = 24.91 \text{ mm}$$

$$T_y = 3400. \text{ N}$$

$$M_x = -1870000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 30.09 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 7. \text{ mm}$$

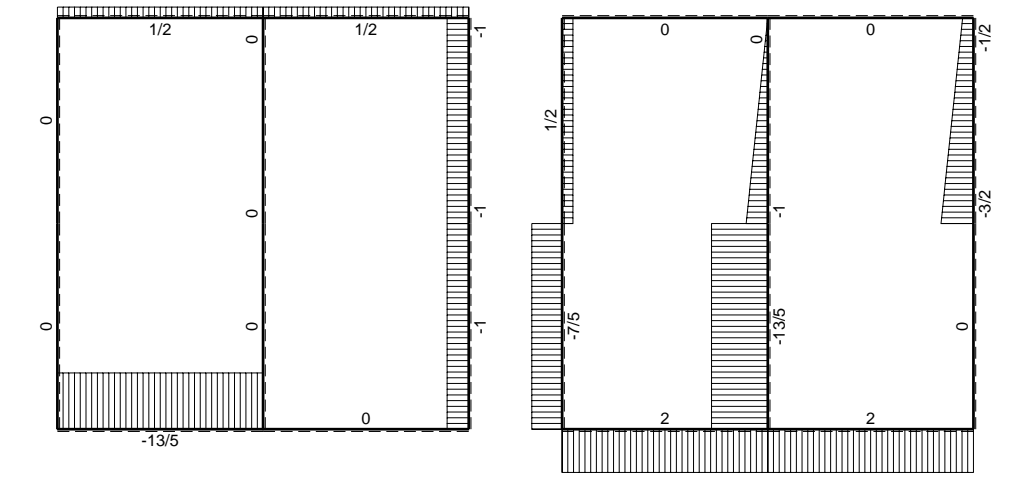
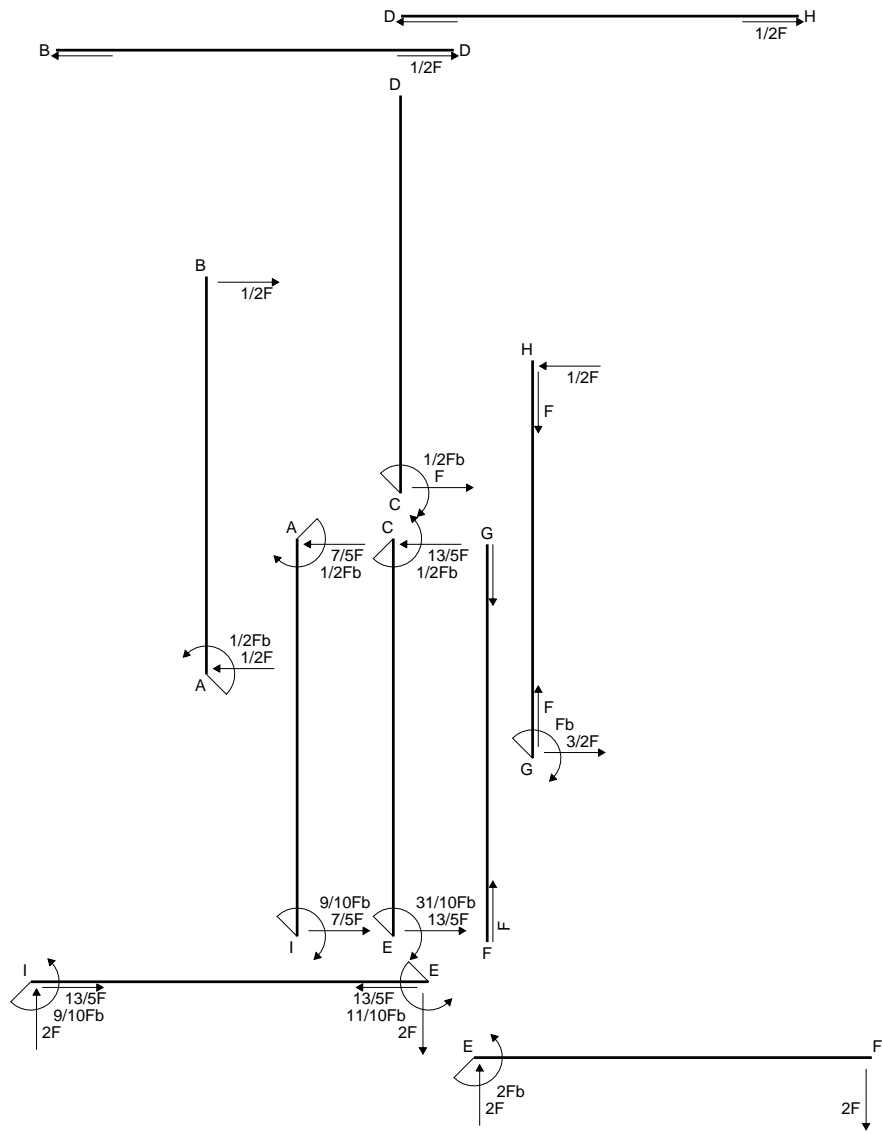
$$v_c = -17.91 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -118.8 \text{ N/mm}^2$$

$$\tau_c = 11.32 \text{ N/mm}^2$$

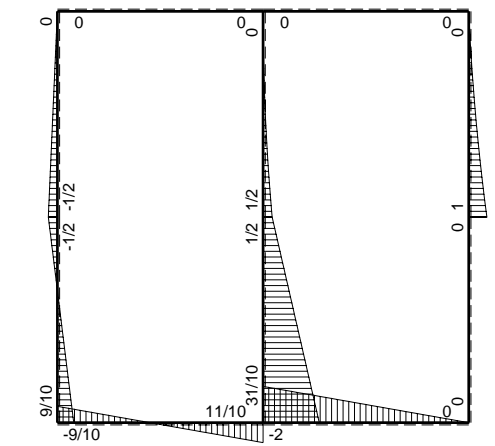
$$\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 120.4 \text{ N/mm}^2$$

$$S = 5632. \text{ mm}^3$$

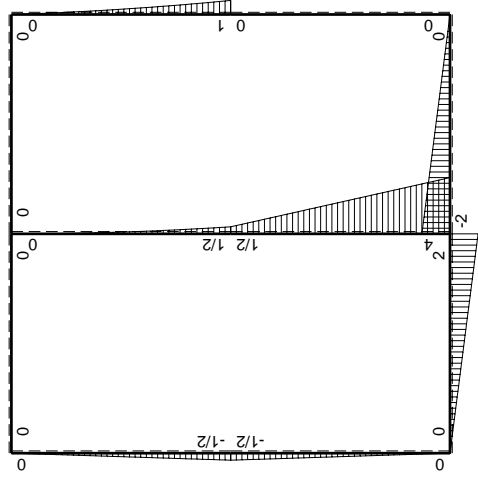
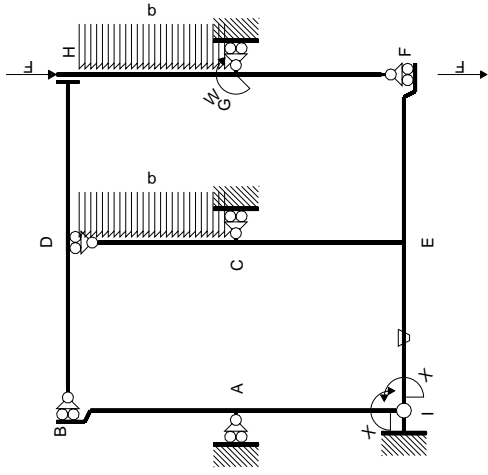


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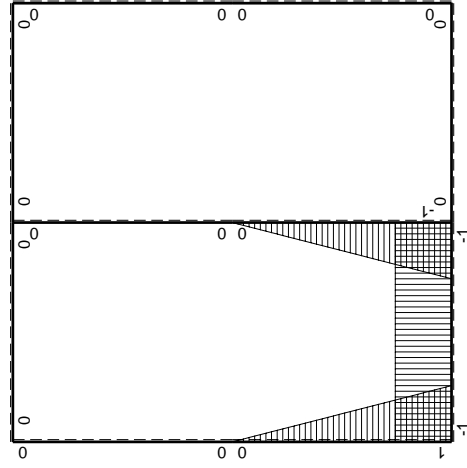


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 15/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

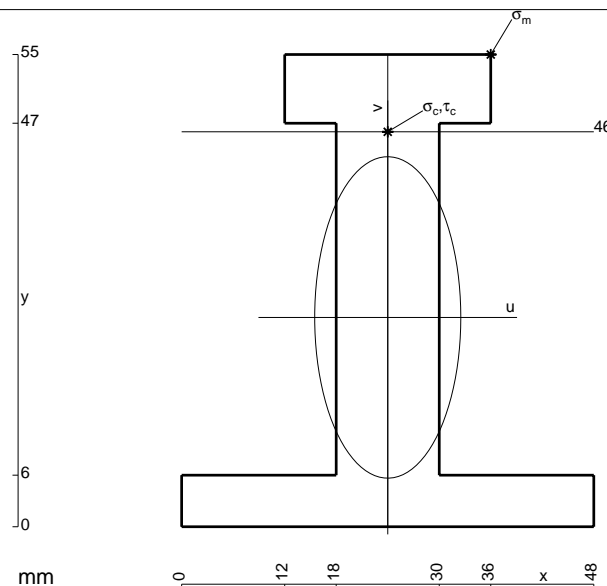
$$= (-1/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

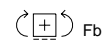
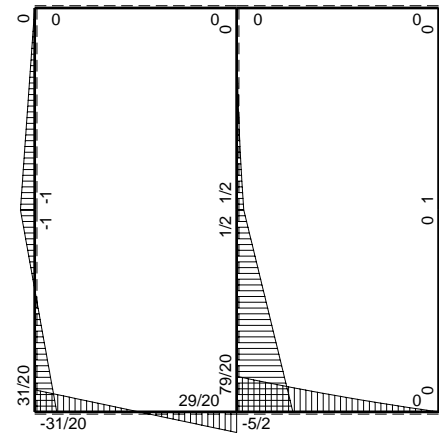
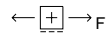
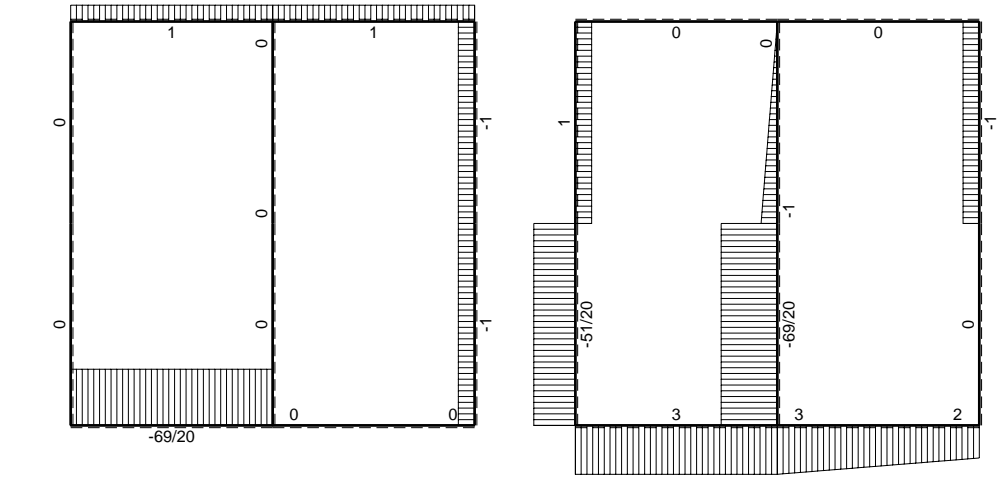
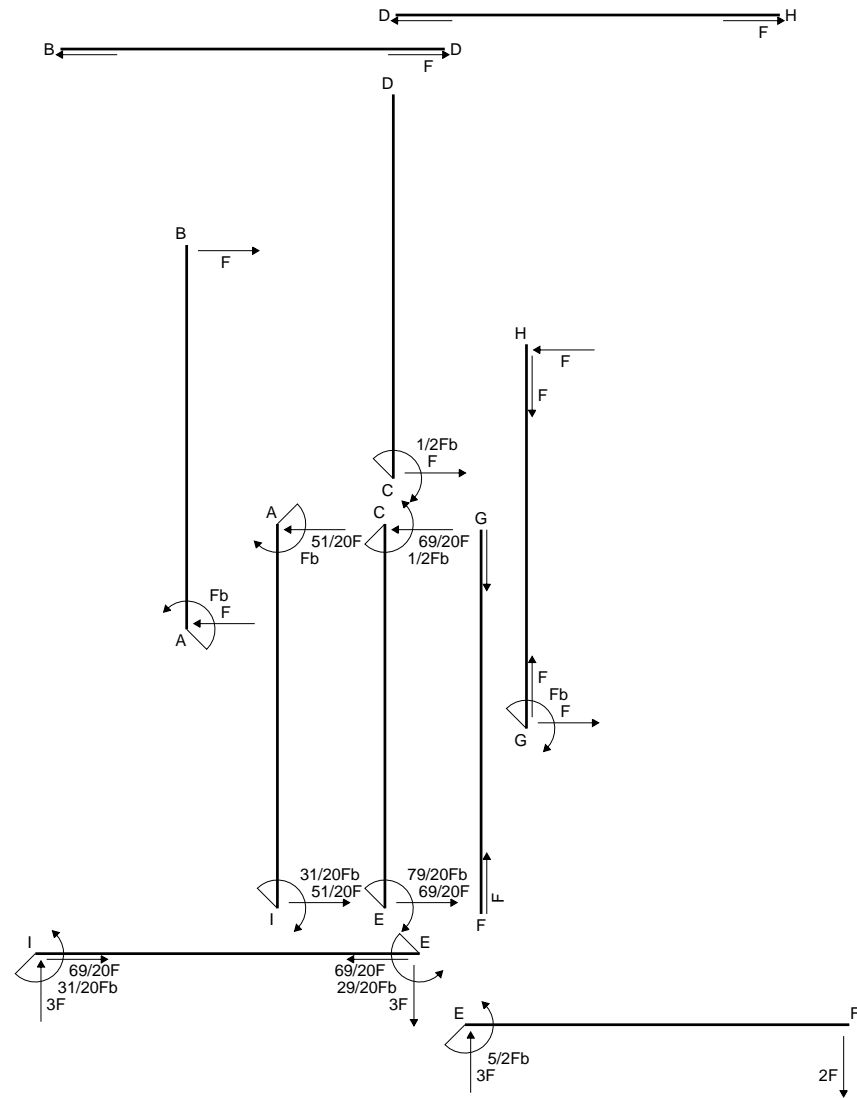
$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

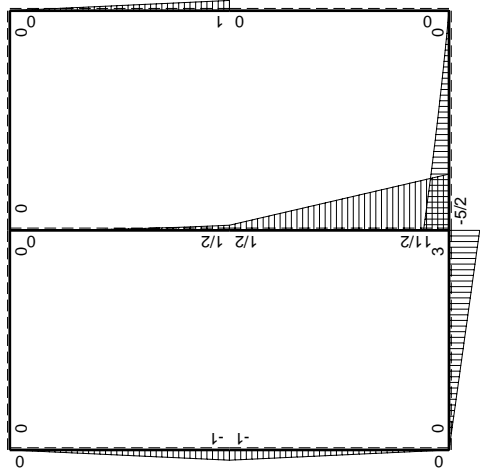
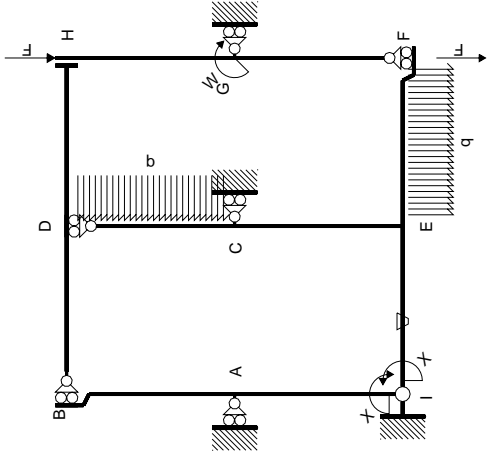
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



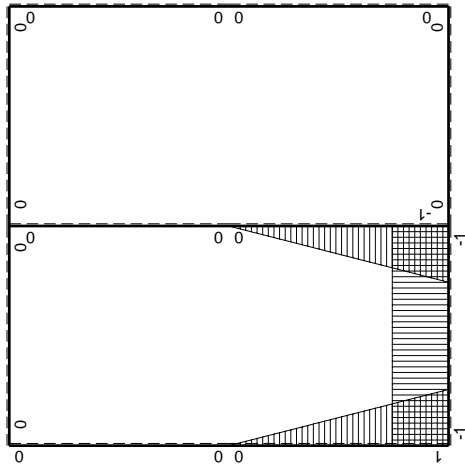
- A = 972. mm²
- J_u = 340722. mm⁴
- J_v = 70416. mm⁴
- y_g = 24.38 mm
- T_y = 3880. N
- M_x = -2328000. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 30.62 mm
- σ_m = -Mv/J_u = 209.2 N/mm²
- x_c = 24. mm
- y_c = 46. mm
- v_c = 21.62 mm
- σ_c = -Mv/J_u = 147.7 N/mm²
- τ_c = 5.103 N/mm²
- σ_q = √σ²+3τ² = 148. N/mm²
- S = 5377. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-5Fx$	0	$-11/2Fb+21/2Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-23/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-5Fx$	0	$-1/2Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						31/20Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-11/2 + 21/2 x/b - 5x^2/b^2) Fb 1/EJ dx = [-11/2 x + 21/4 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-11/2 b + 21/4 b - 5/3 b) Fb 1/EJ = -23/12 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-1/2 x/b - 5x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

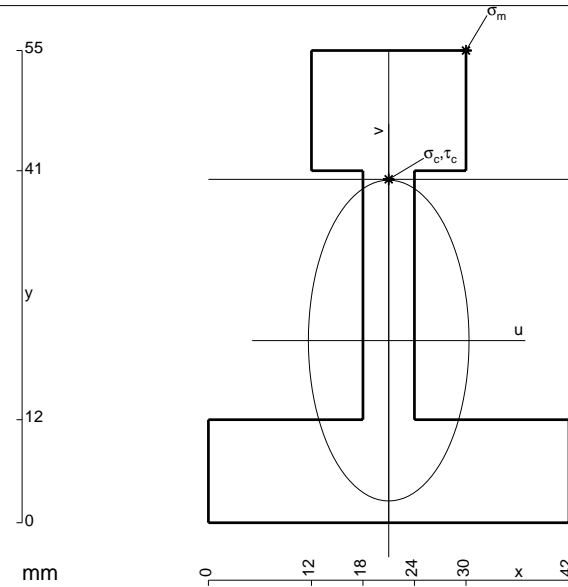
$$= (-1/4 b - 5/3 b) Fb 1/EJ = -23/12 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

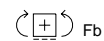
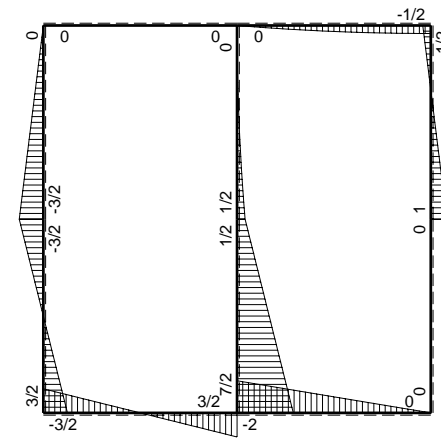
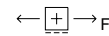
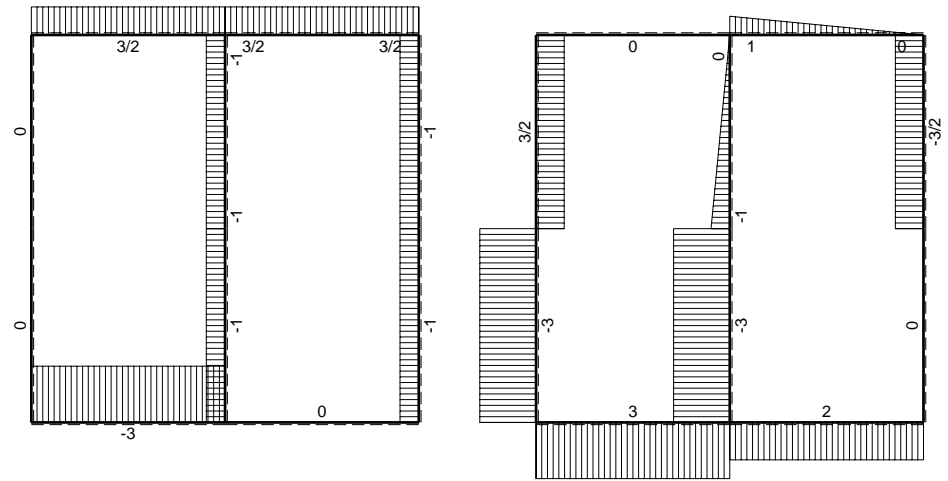
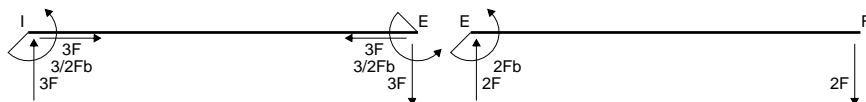
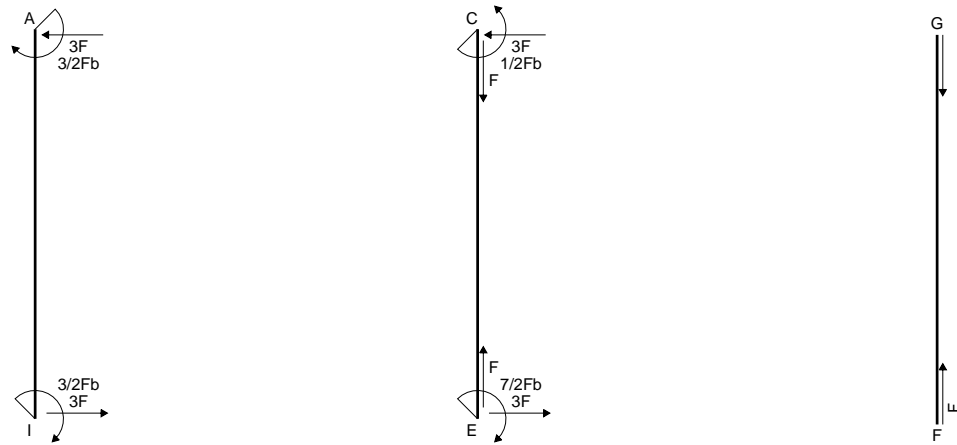
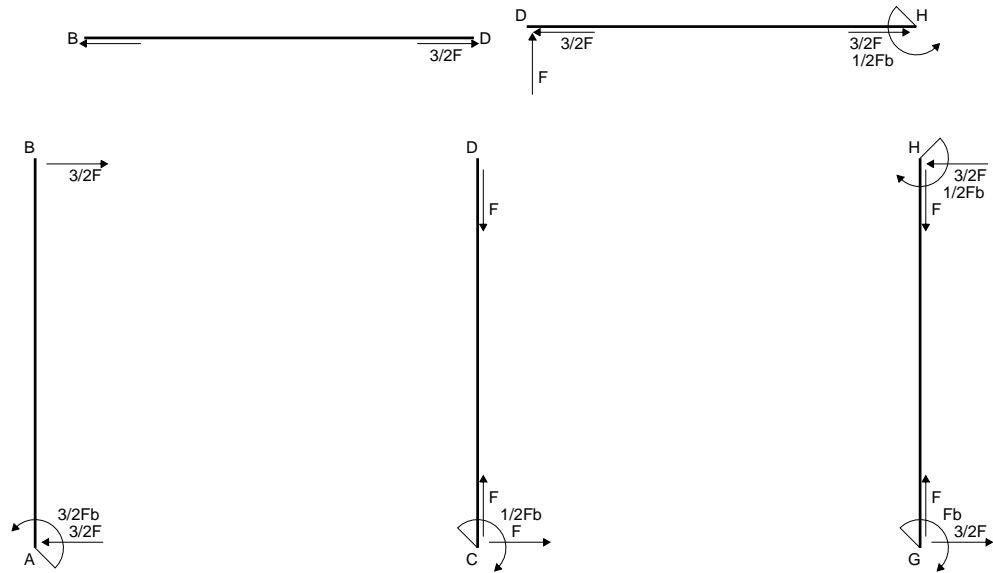
$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

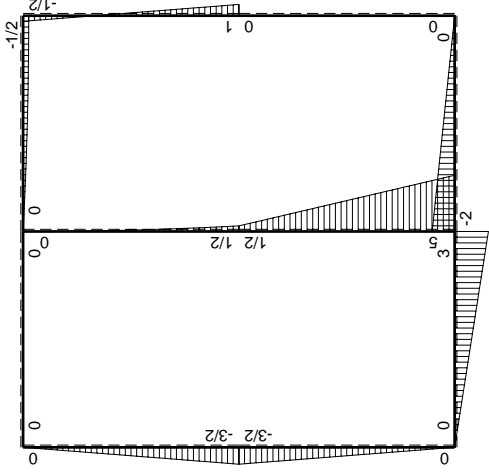
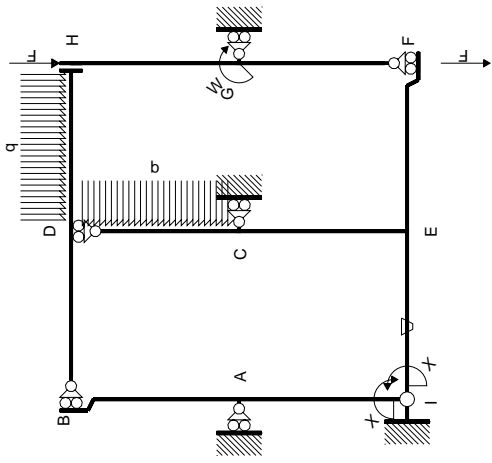
$$L_{AI}^{x\theta} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



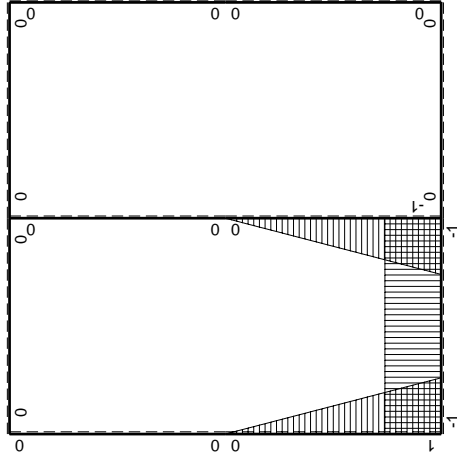
- A = 930. mm²
- J_u = 324687. mm⁴
- J_v = 81414. mm⁴
- y_g = 21.22 mm
- T_y = 3840. N
- M_x = -2112000. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 33.78 mm
- σ_m = -Mv/J_u = 219.8 N/mm²
- x_c = 21. mm
- y_c = 40. mm
- v_c = 18.78 mm
- σ_c = -Mv/J_u = 122.2 N/mm²
- τ_c = 13.53 N/mm²
- σ_q = √σ²+3τ² = 124.4 N/mm²
- S = 6865. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb 1/EJ dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 19/4 b - 3/2 b) Fb 1/EJ = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb 1/EJ$$

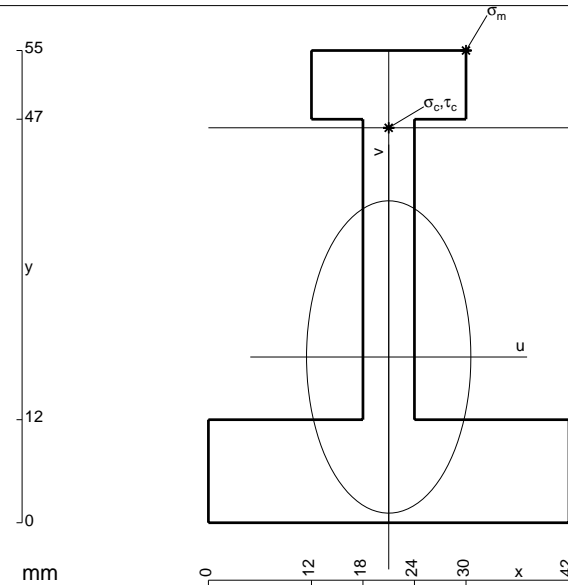
$$= (-1/4 b - 3/2 b) Fb 1/EJ = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

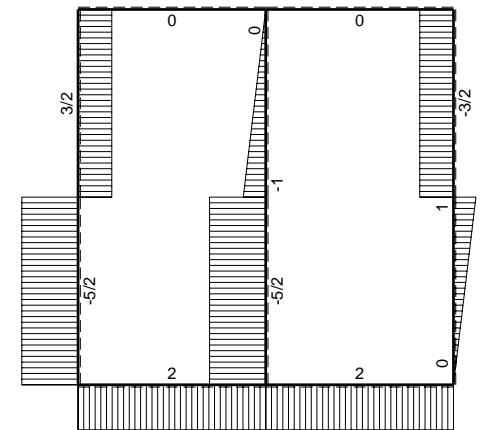
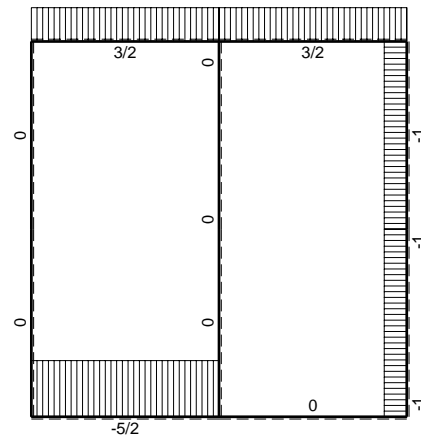
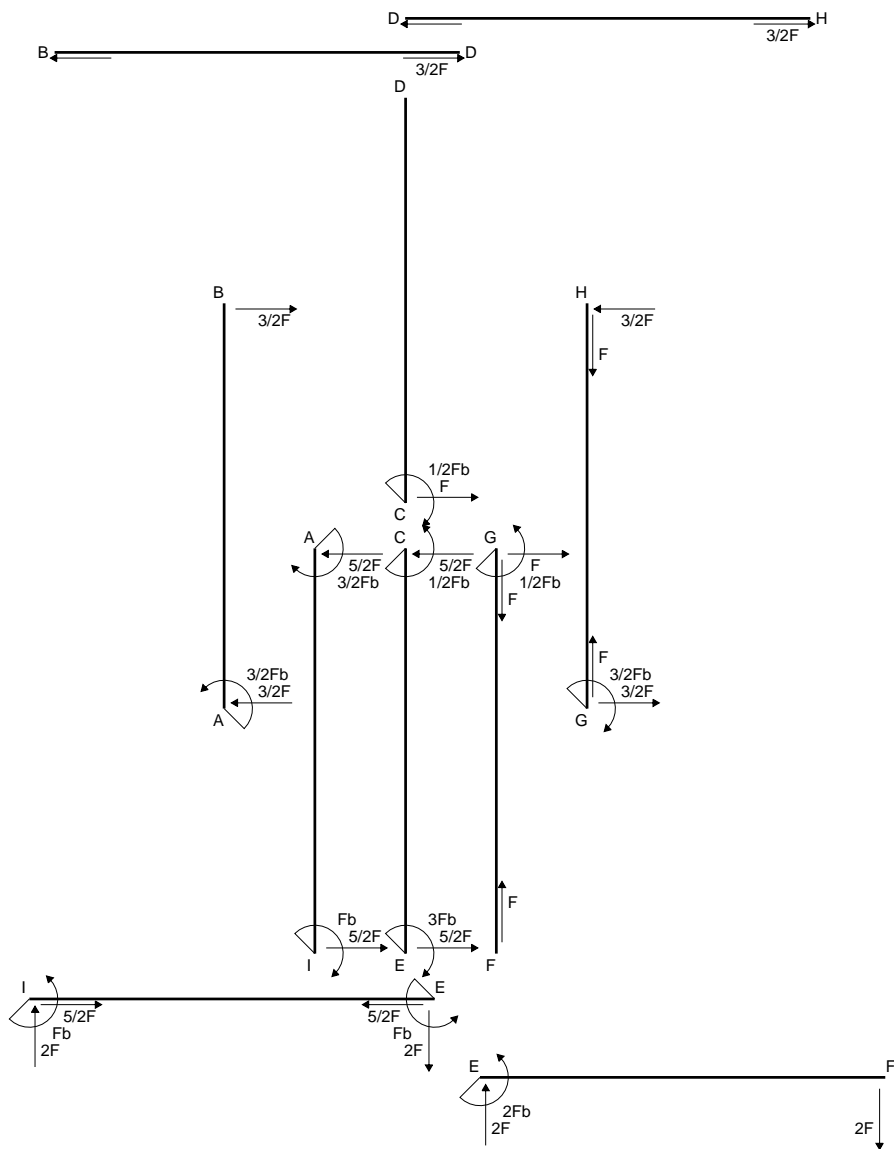
$$= (-3/4 b + 1/2 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/4 b + 1/2 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

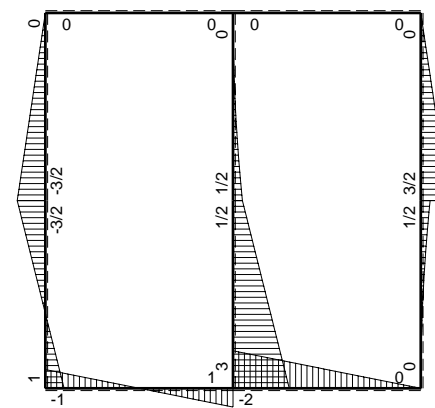


- A = 858. mm²
- J_u = 283959. mm⁴
- J_v = 78606. mm⁴
- y_g = 19.3 mm
- T_y = 2560. N
- M_x = -1817600. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 35.7 mm
- σ_m = -Mv/J_u = 228.5 N/mm²
- x_c = 21. mm
- y_c = 46. mm
- v_c = 26.7 mm
- σ_c = -Mv/J_u = 170.9 N/mm²
- τ_c = 7.103 N/mm²
- σ_q = √σ²+3τ² = 171.3 N/mm²
- S = 4727. mm³

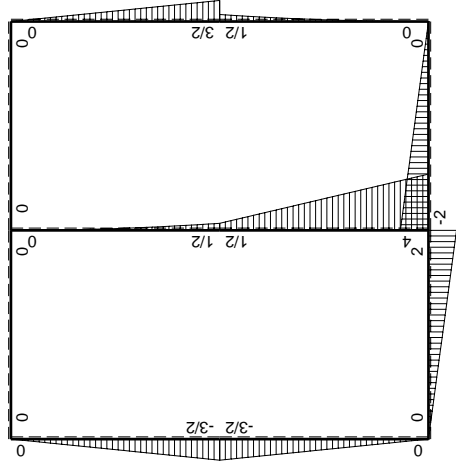
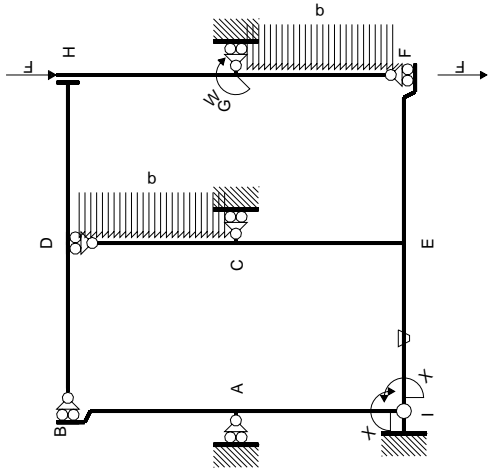


← ⊕ → F

↑ ⊕ ↓ F

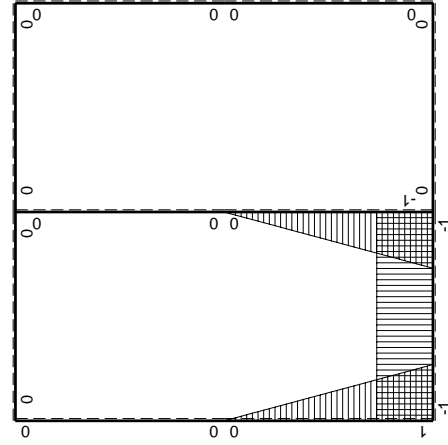


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

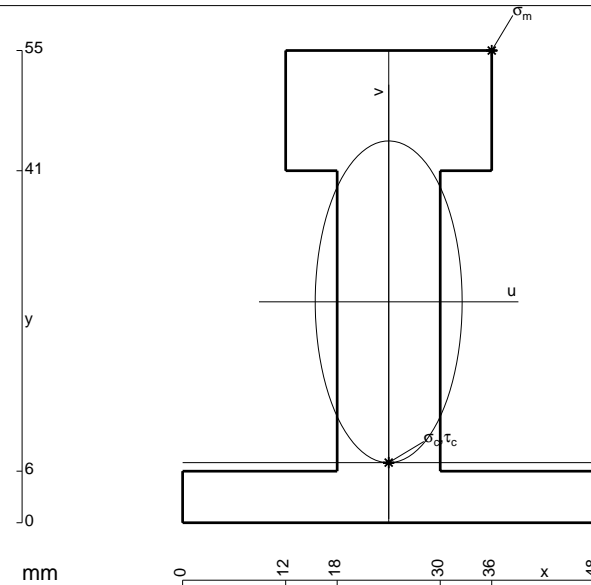
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

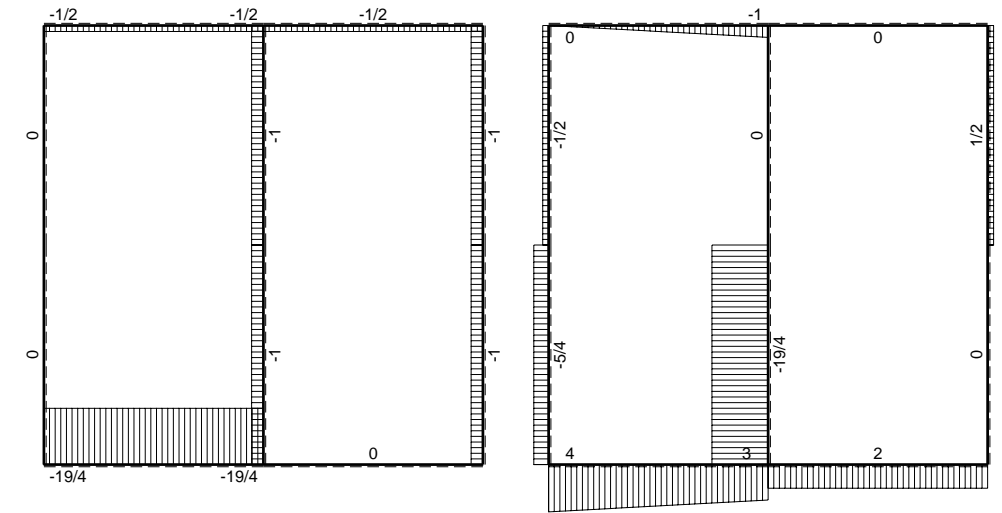
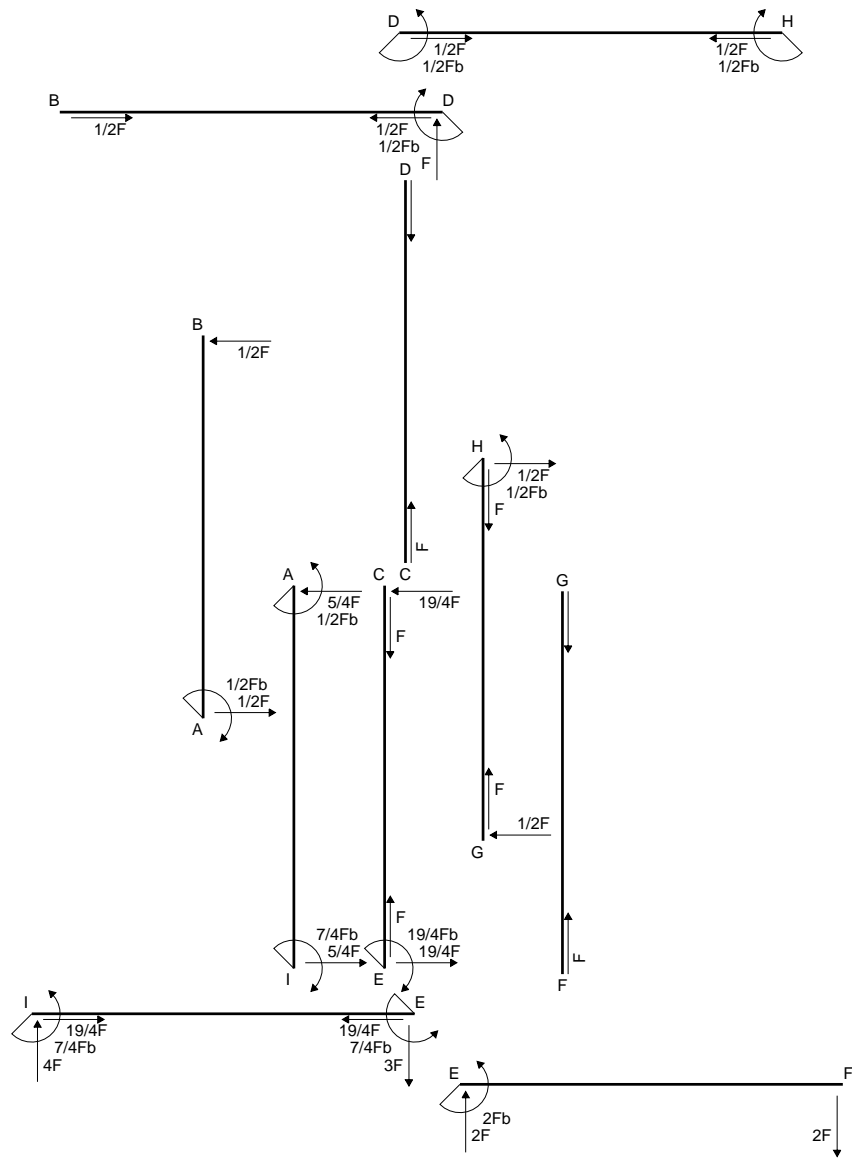
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

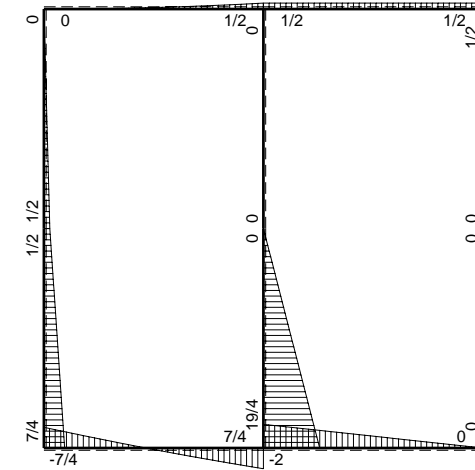


- A = 1044. mm²
- J_u = 366752. mm⁴
- J_v = 76464. mm⁴
- y_g = 25.73 mm
- T_y = 3900. N
- M_x = -3003000. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 29.27 mm
- σ_m = -Mv/J_u = 239.7 N/mm²
- x_c = 24. mm
- y_c = 7. mm
- v_c = -18.73 mm
- σ_c = -Mv/J_u = -153.4 N/mm²
- τ_c = 6.005 N/mm²
- σ_q = √σ²+3τ² = 153.7 N/mm²
- S = 6777. mm³

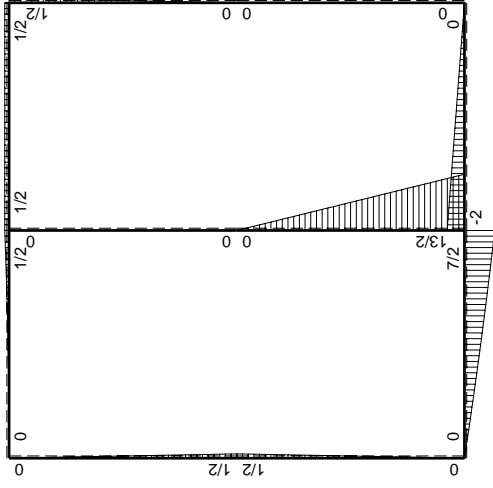
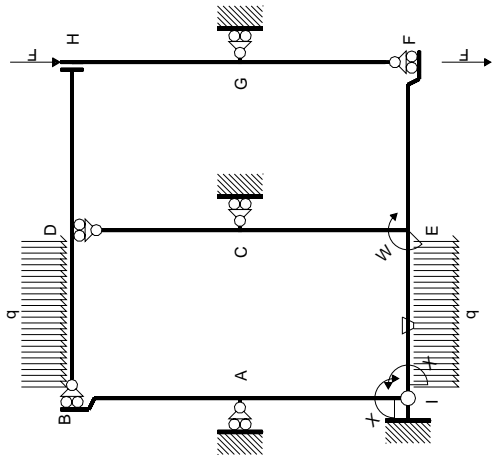


← ⊕ → F

↑ ⊕ ↓ F

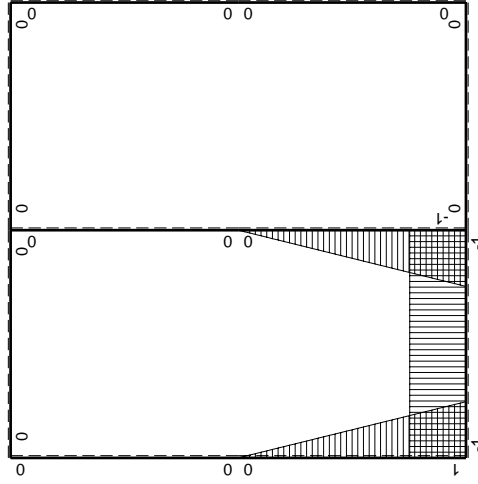


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$-1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0			
HD b	0	$1/2Fb$	0	0	0	0	0+0	0	
DH b	0	$-1/2Fb$	0	0	0	0			
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
BD b	0	$-1/2qx^2$	0	0	0	0			
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2			
	totali							$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

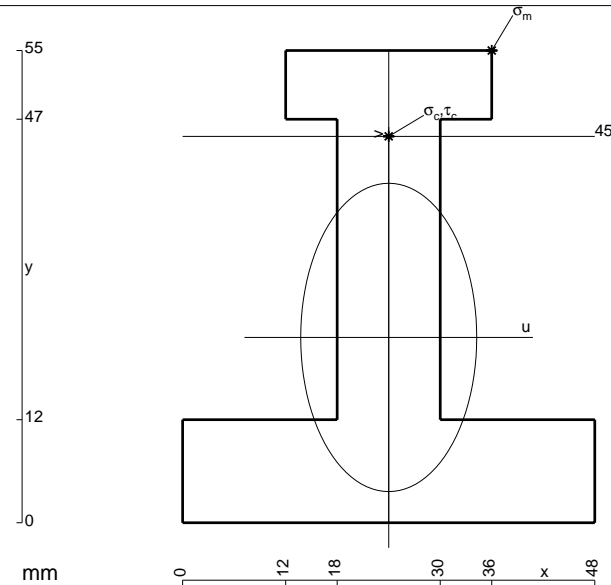
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

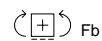
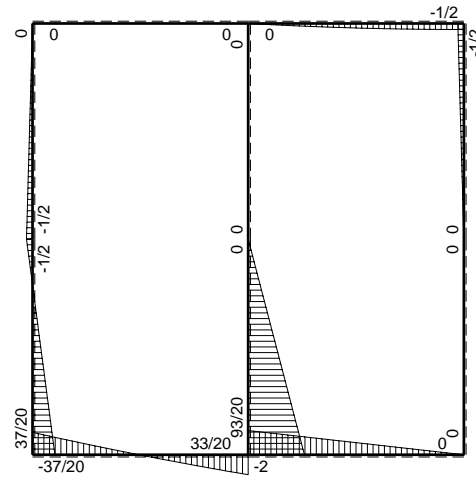
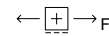
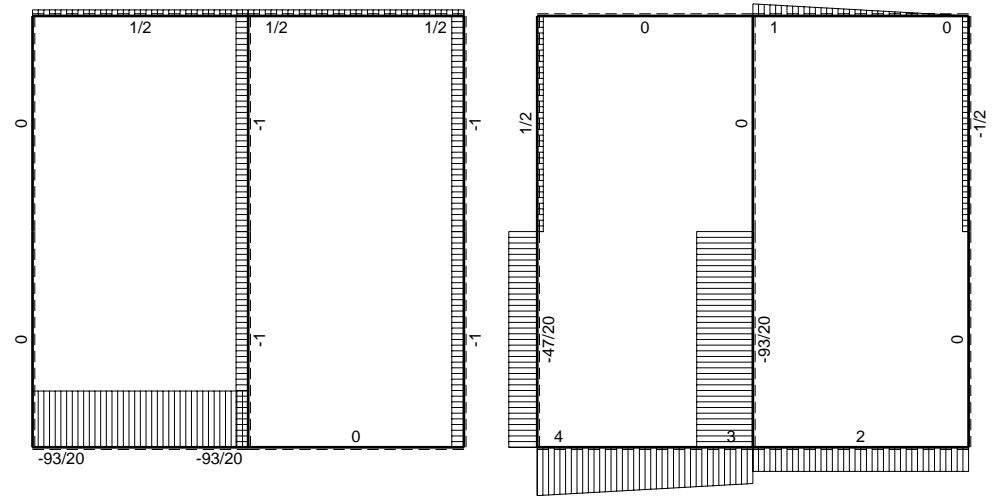
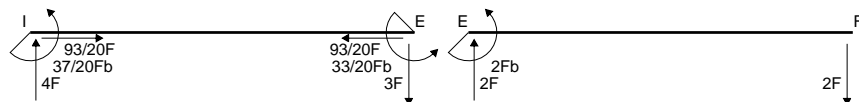
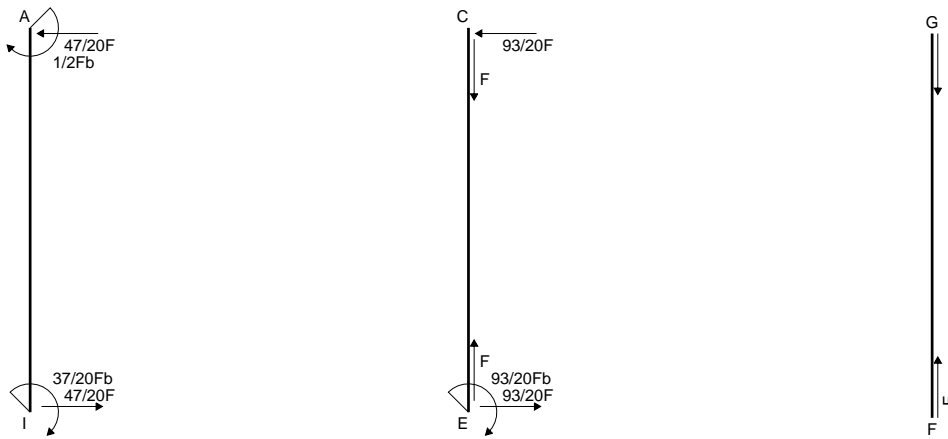
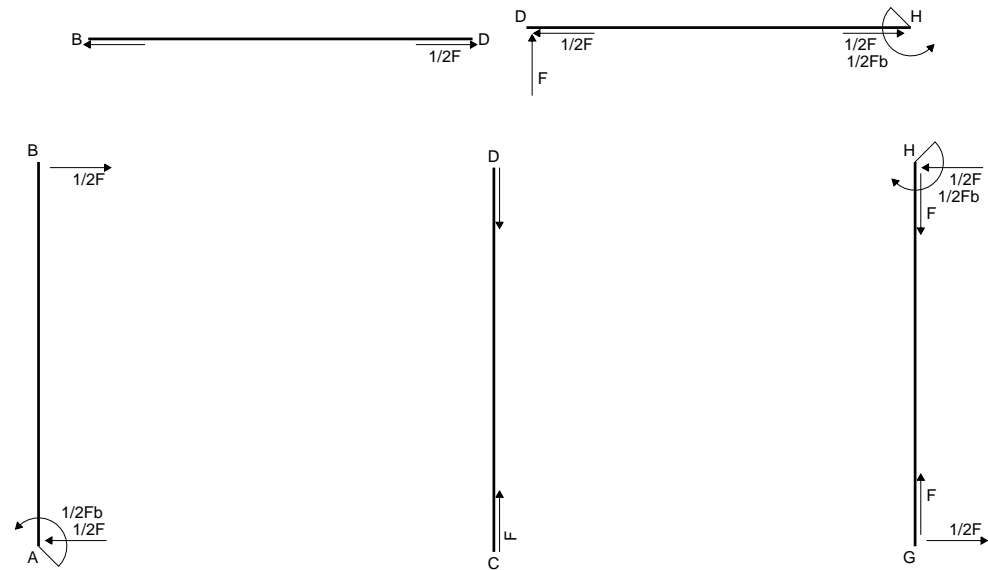
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

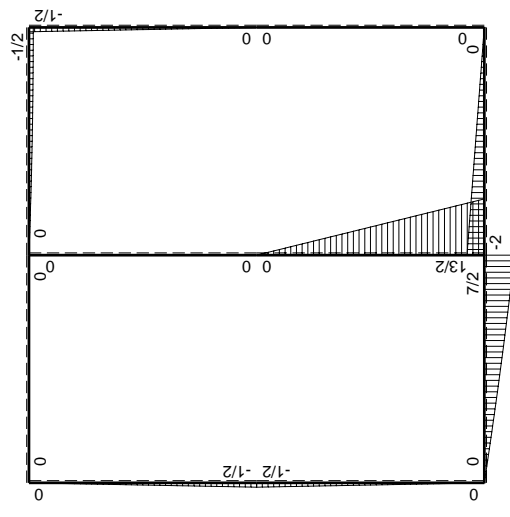
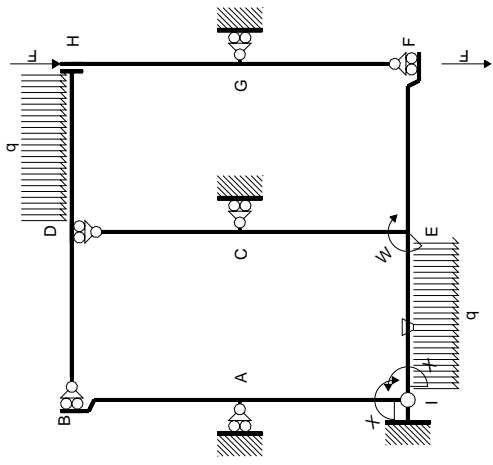
$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



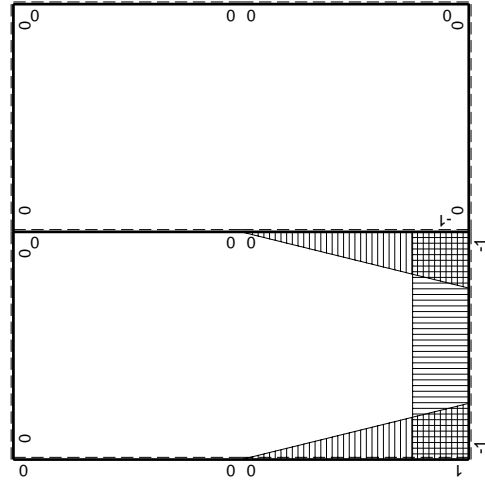
- A = 1188. mm²
- J_u = 383155. mm⁴
- J_v = 124848. mm⁴
- y_g = 21.58 mm
- T_y = 2780. N
- M_x = -2279600. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 33.42 mm
- σ_m = -Mv/J_u = 198.8 N/mm²
- x_c = 24. mm
- y_c = 45. mm
- v_c = 23.42 mm
- σ_c = -Mv/J_u = 139.3 N/mm²
- τ_c = 3.77 N/mm²
- σ_q = √σ²+3τ² = 139.5 N/mm²
- S = 6235. mm³





Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0			
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0	
DH b	0	$Fx-1/2qx^2$	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2			
	totali							$-37/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$37/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb 1/EJ + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb 1/EJ + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb 1/EJ dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb 1/EJ dx = [-13/6 x^3/b^2]_0^b Fb 1/EJ$$

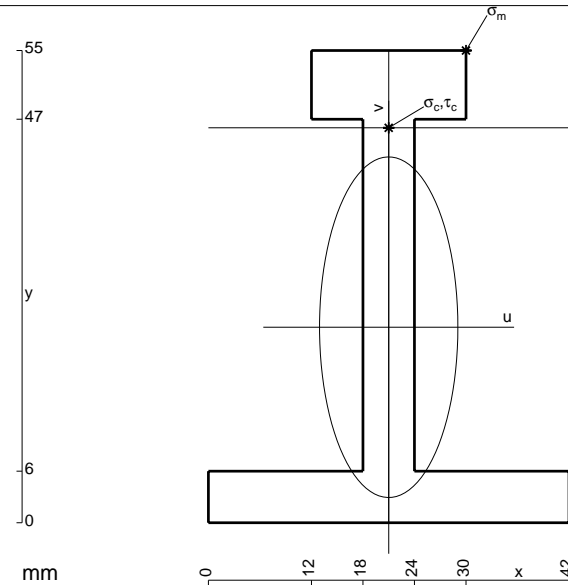
$$= (-13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

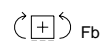
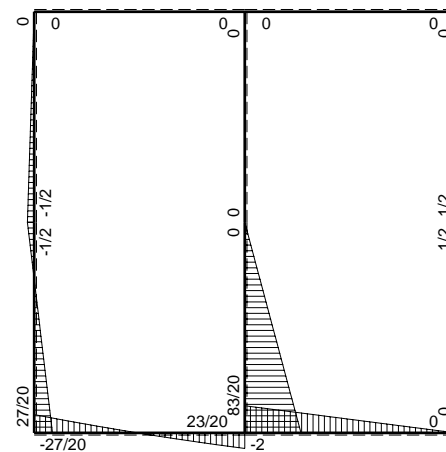
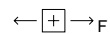
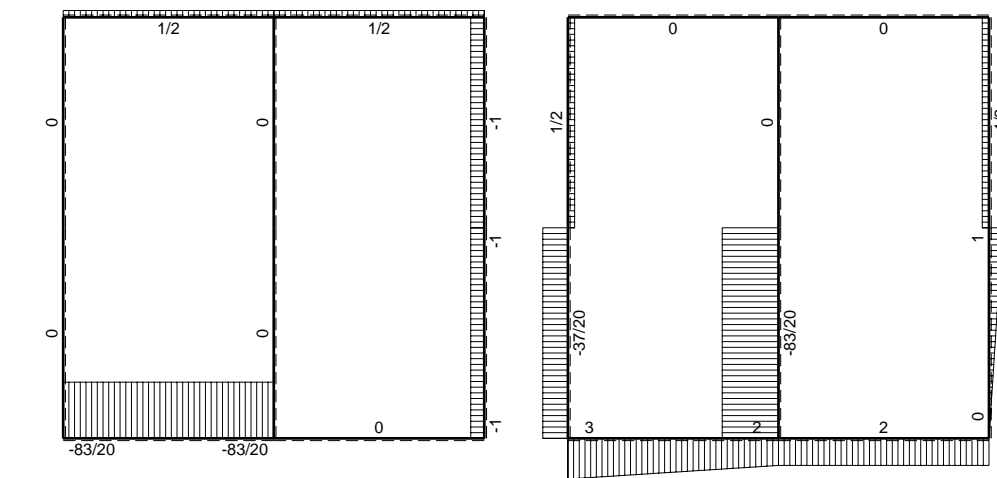
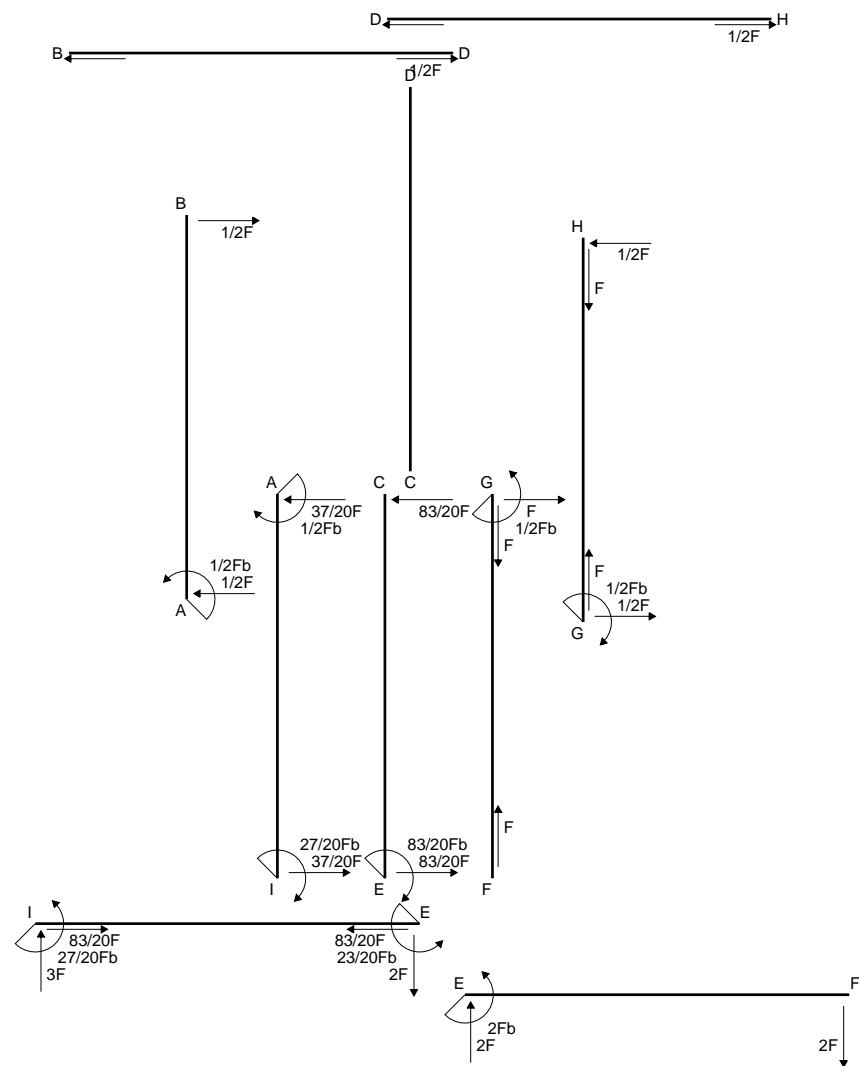
$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

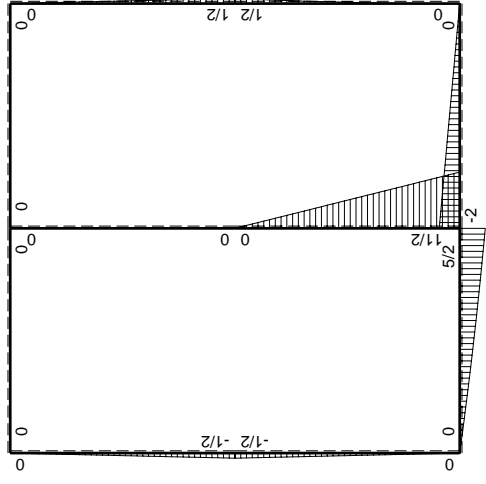
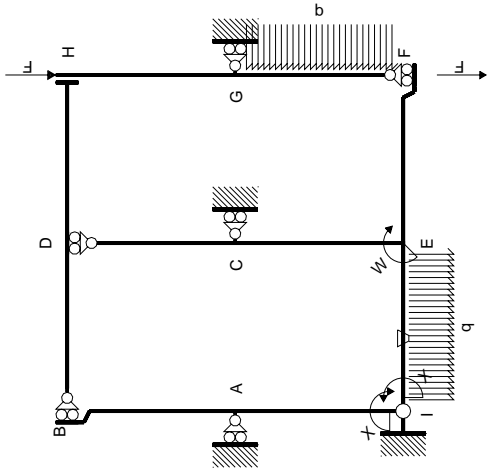
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



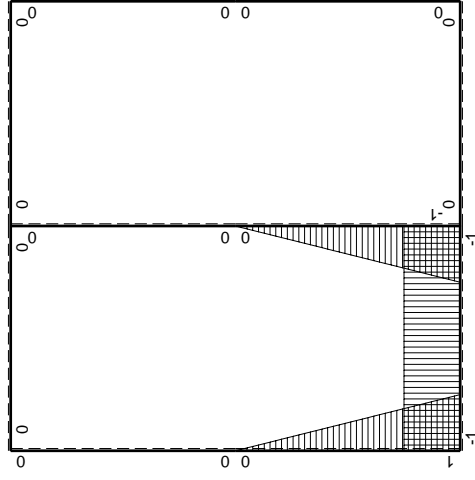
- A = 642. mm²
- J_u = 252660. mm⁴
- J_v = 41670. mm⁴
- y_g = 22.77 mm
- T_y = 1860. N
- M_x = -1636800. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 32.23 mm
- σ_m = -Mv/J_u = 208.8 N/mm²
- x_c = 21. mm
- y_c = 46. mm
- v_c = 23.23 mm
- σ_c = -Mv/J_u = 150.5 N/mm²
- τ_c = 5.162 N/mm²
- σ_q = √σ²+3τ² = 150.7 N/mm²
- S = 4207. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-9/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$27/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

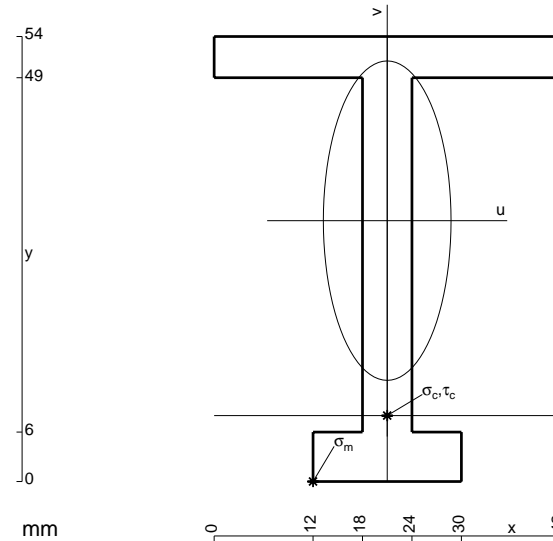
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

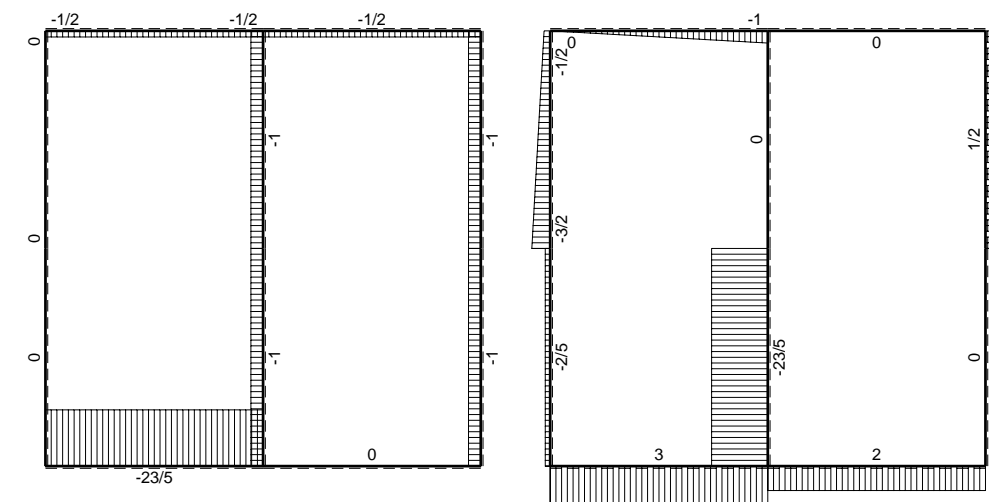
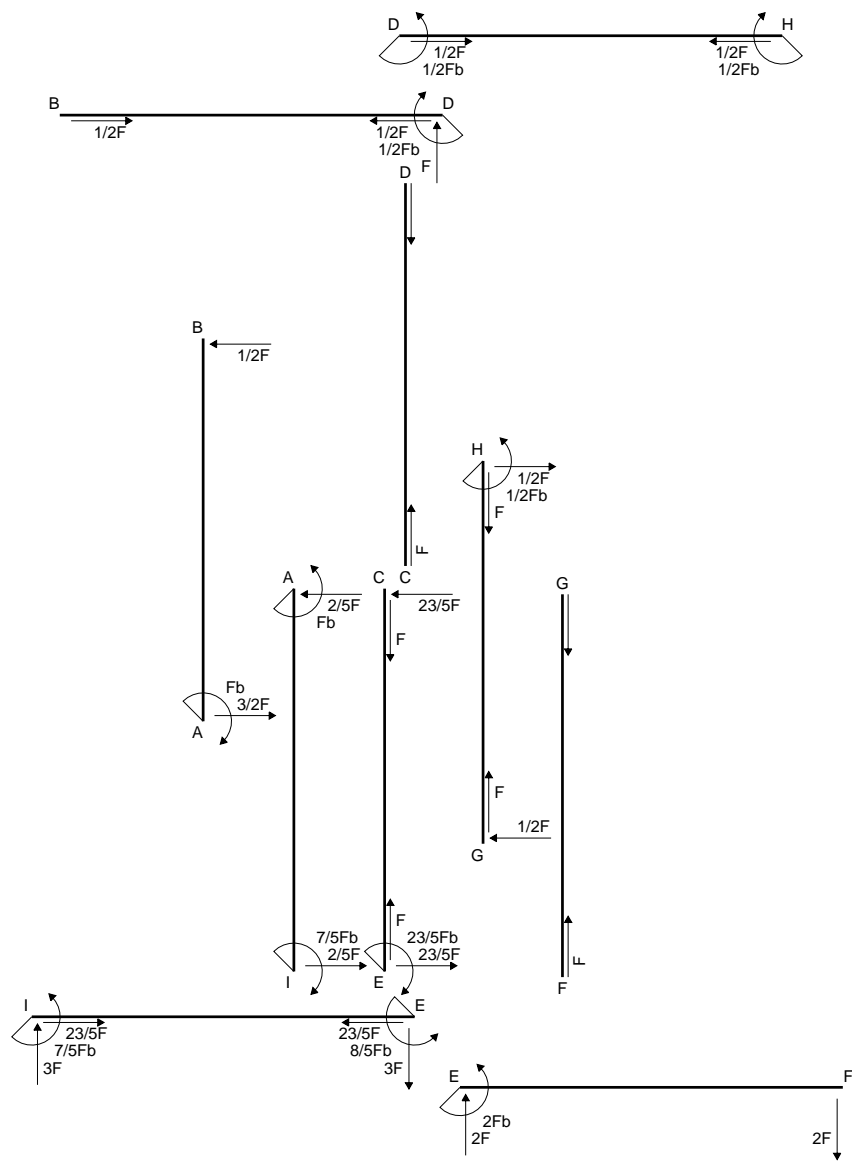
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

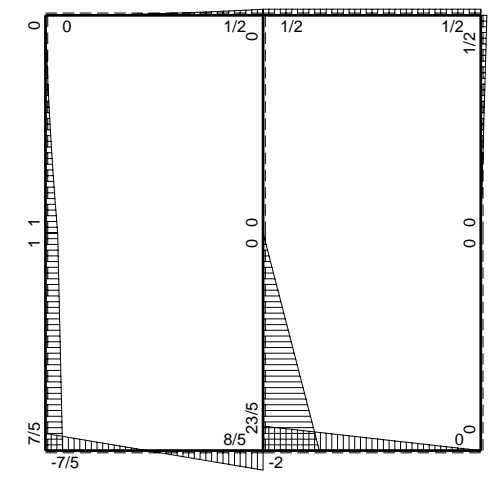


- A = 576. mm²
- J_u = 216352. mm⁴
- J_v = 34560. mm⁴
- y_g = 31.66 mm
- T_y = 1640. N
- M_x = -1492400. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -31.66 mm
- σ_m = -Mv/J_u = -218.4 N/mm²
- x_c = 21. mm
- y_c = 8. mm
- v_c = -23.66 mm
- σ_c = -Mv/J_u = -163.2 N/mm²
- τ_c = 4.284 N/mm²
- σ_o = √σ² + 3τ² = 163.4 N/mm²
- S = 3391. mm³

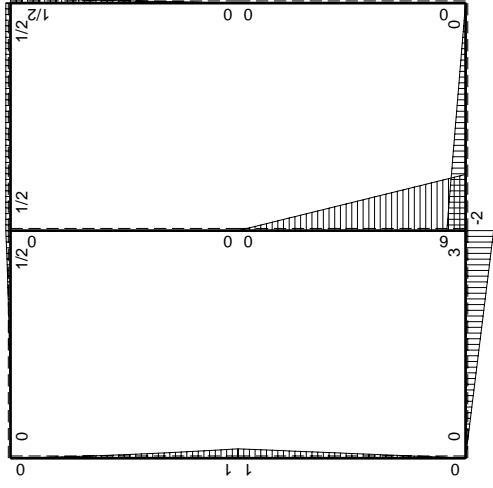
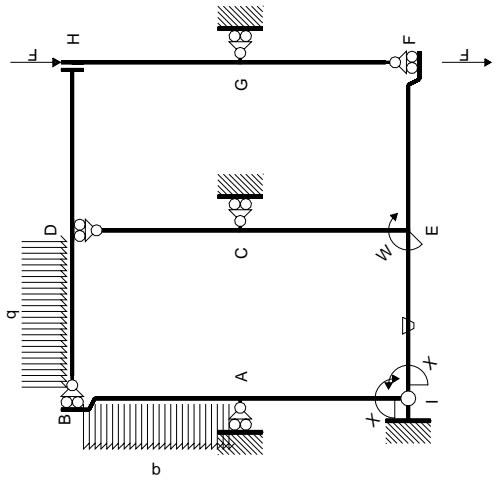


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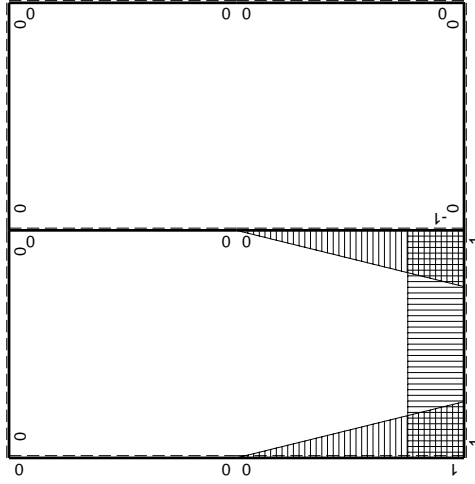


⊕ ⊖ Fb



Schema di calcolo iperstatico

(+) M₀ flessione da carichi assegnati



(+) M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

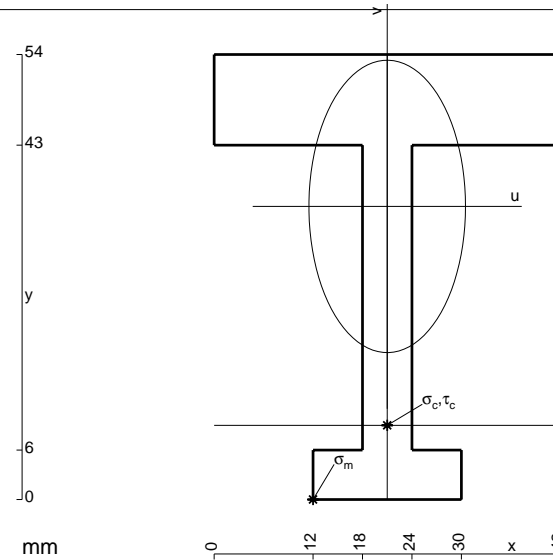
$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

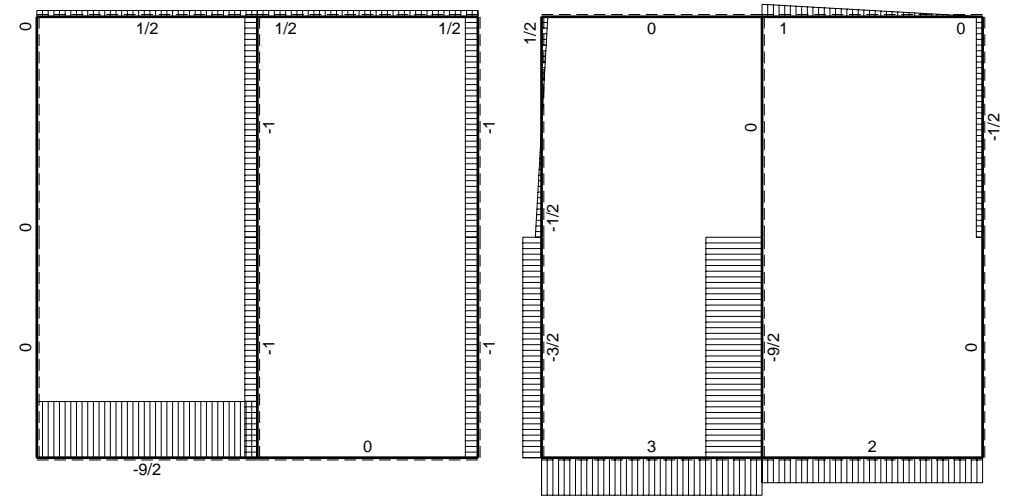
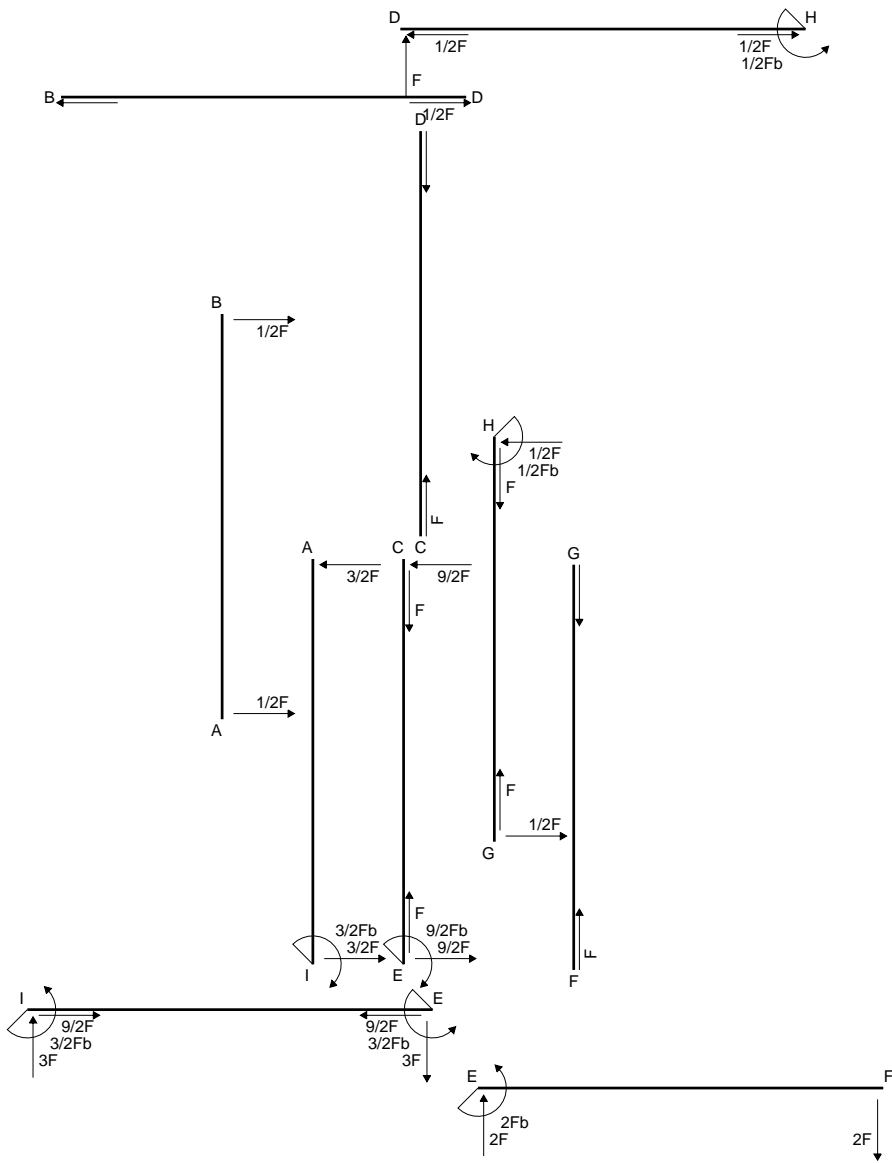
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

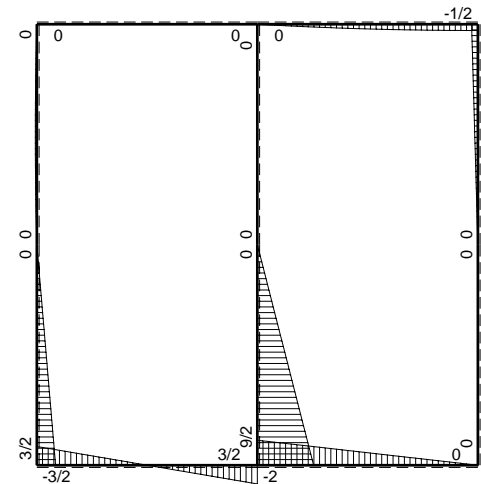


- A = 792. mm²
- J_u = 249320. mm⁴
- J_v = 71496. mm⁴
- y_g = 35.57 mm
- T_y = 1660. N
- M_x = -1610200. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -35.57 mm
- σ_m = -Mv/J_u = -229.7 N/mm²
- x_c = 21. mm
- y_c = 9. mm
- v_c = -26.57 mm
- σ_c = -Mv/J_u = -171.6 N/mm²
- τ_c = 4.464 N/mm²
- σ_o = √σ² + 3τ² = 171.8 N/mm²
- S = 4023. mm³

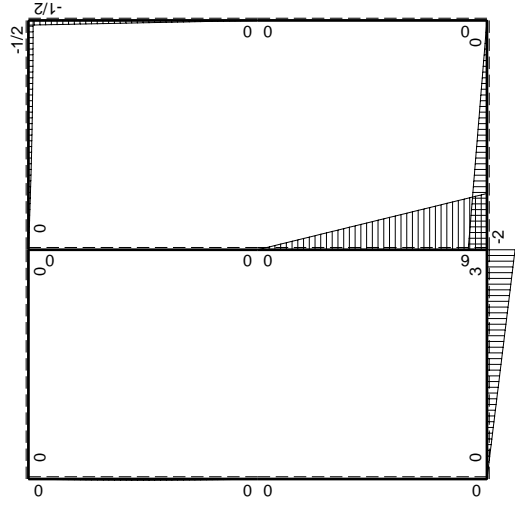
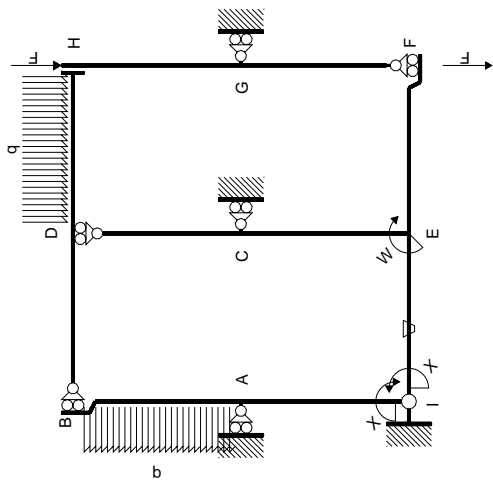


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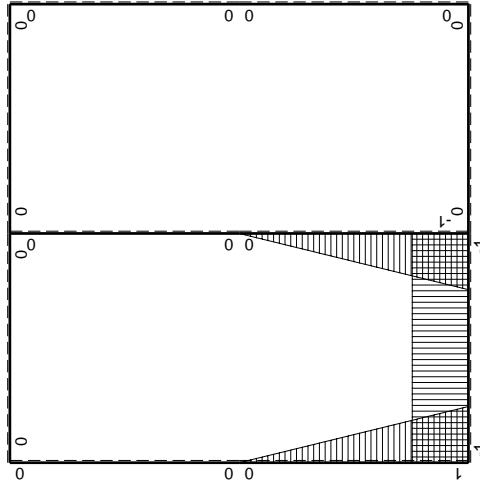


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

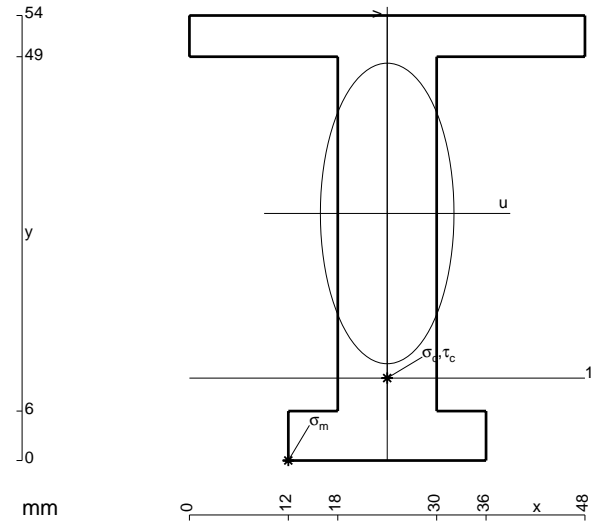
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$



$$A = 900. \text{ mm}^2$$

$$J_u = 299580. \text{ mm}^4$$

$$J_v = 59184. \text{ mm}^4$$

$$y_g = 29.98 \text{ mm}$$

$$T_y = 2340. \text{ N}$$

$$M_x = -2386800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.98 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -238.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

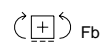
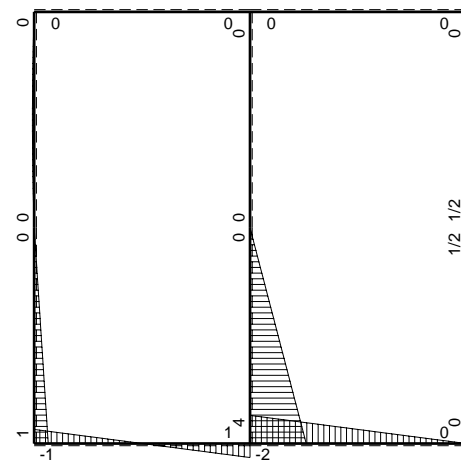
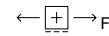
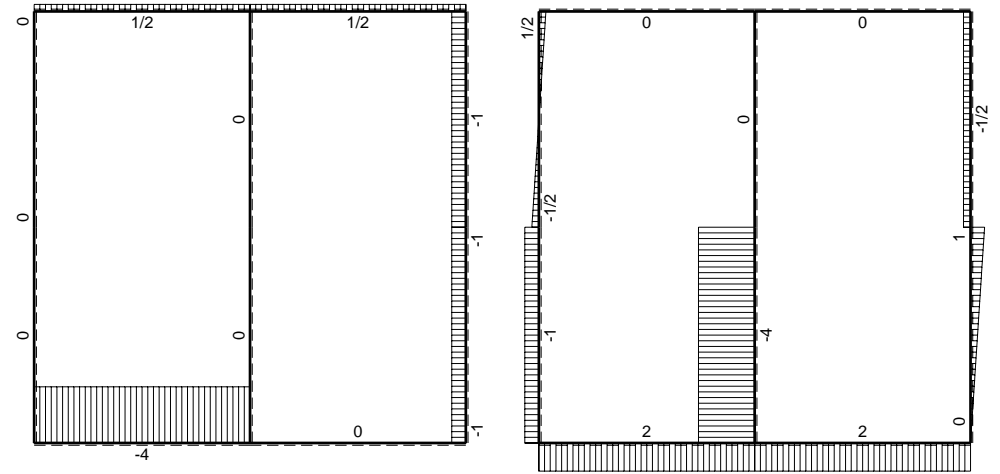
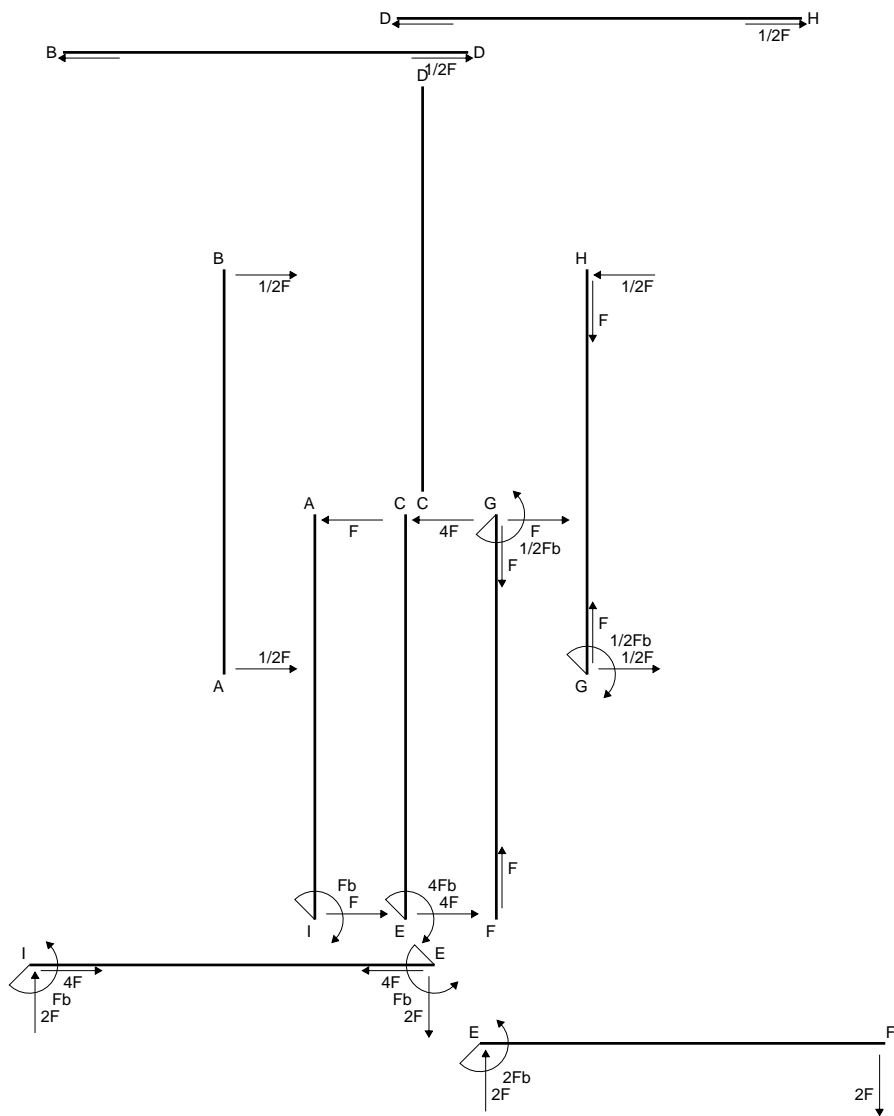
$$v_c = -19.98 \text{ mm}$$

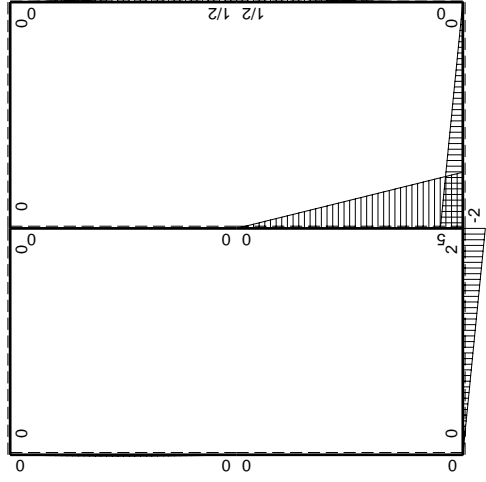
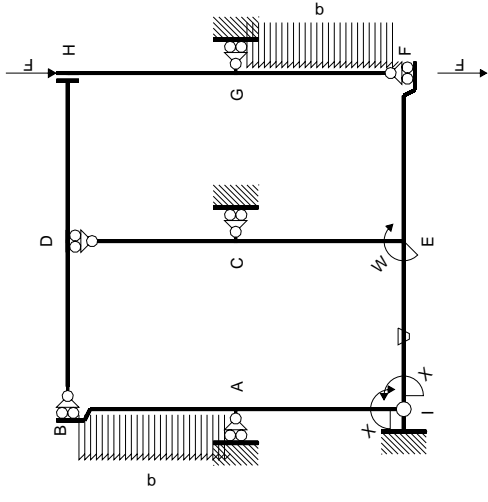
$$\sigma_c = -Mv/J_u = -159.2 \text{ N/mm}^2$$

$$\tau_c = 3.216 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 159.3 \text{ N/mm}^2$$

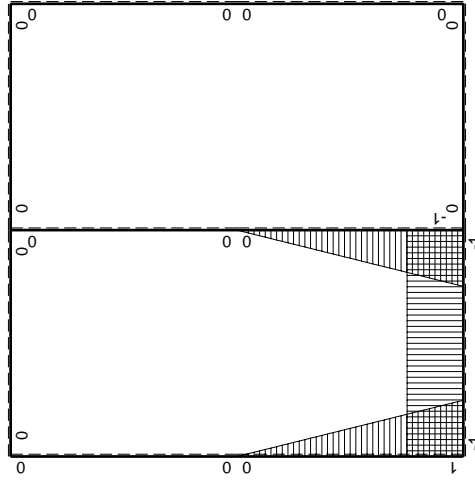
$$S = 4940. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

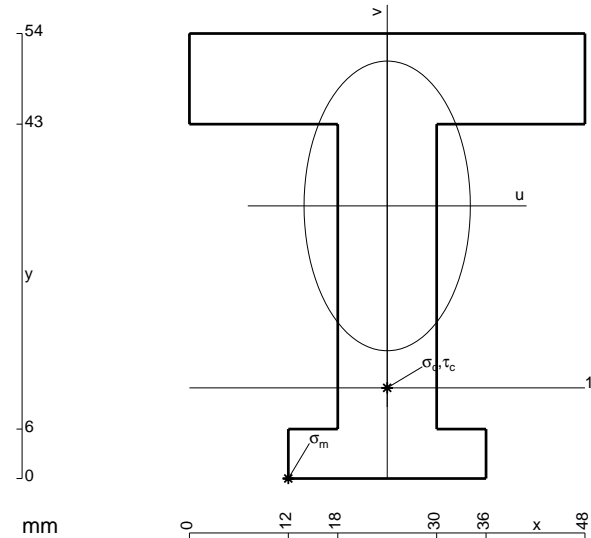
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$



$$A = 1116. \text{ mm}^2$$

$$J_u = 344933. \text{ mm}^4$$

$$J_v = 113616. \text{ mm}^4$$

$$y_g = 33.08 \text{ mm}$$

$$T_y = 3860. \text{ N}$$

$$M_x = -2084400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -33.08 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

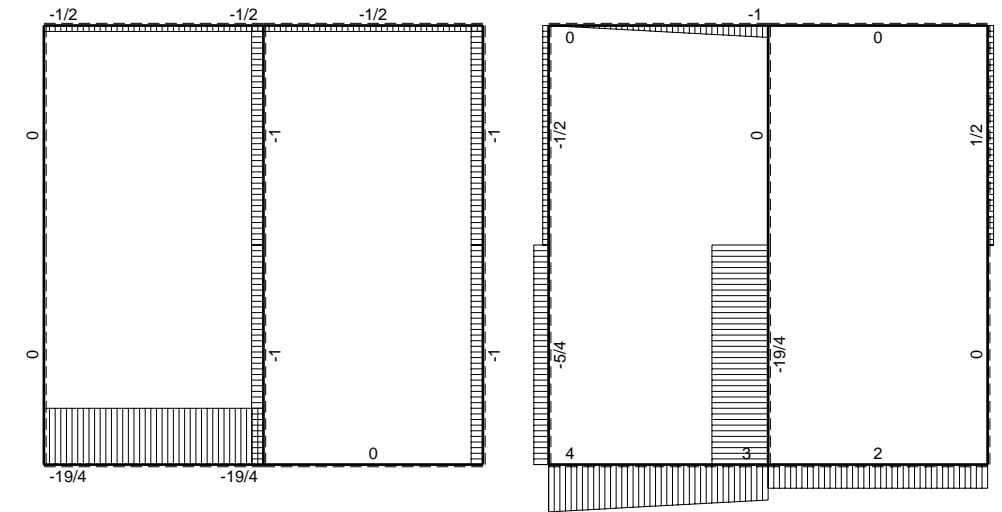
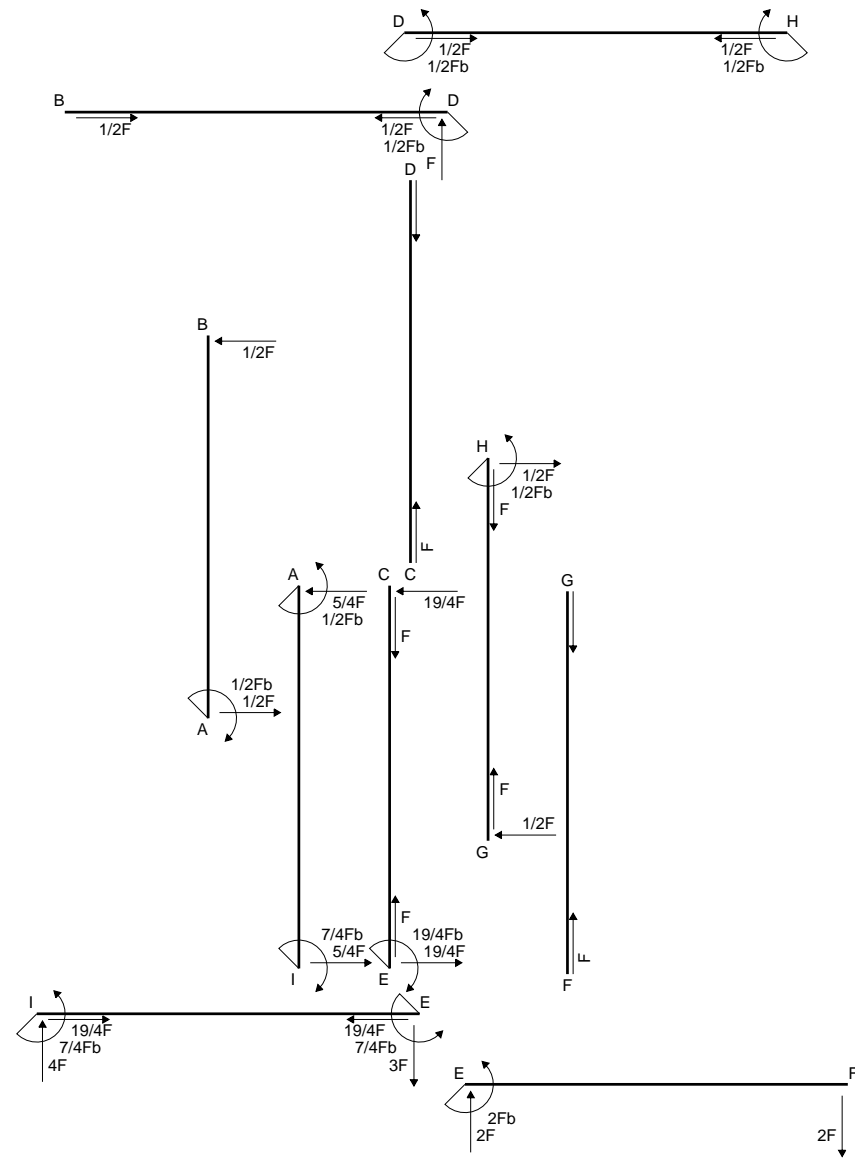
$$v_c = -22.08 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -133.4 \text{ N/mm}^2$$

$$\tau_c = 5.415 \text{ N/mm}^2$$

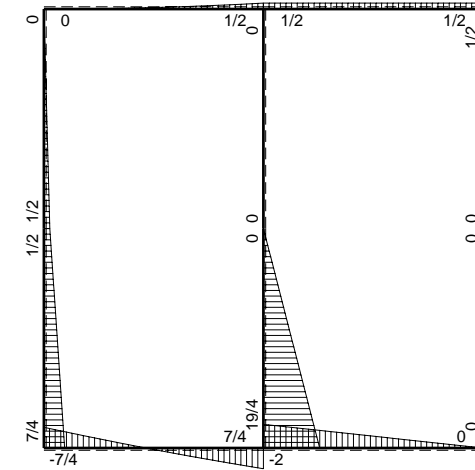
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 133.8 \text{ N/mm}^2$$

$$S = 5806. \text{ mm}^3$$

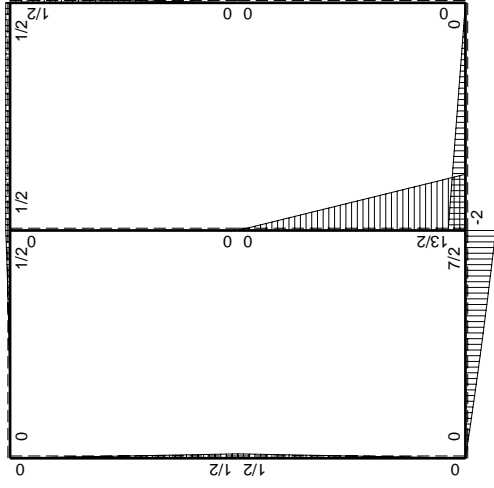
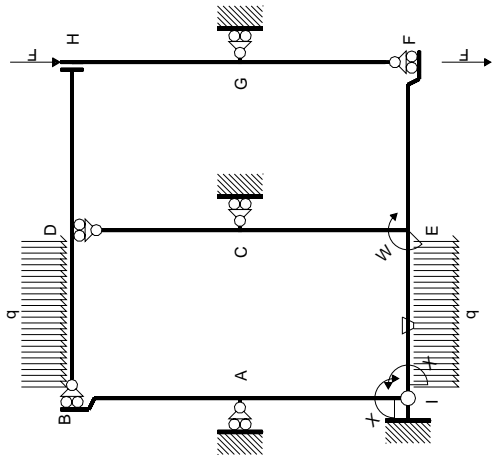


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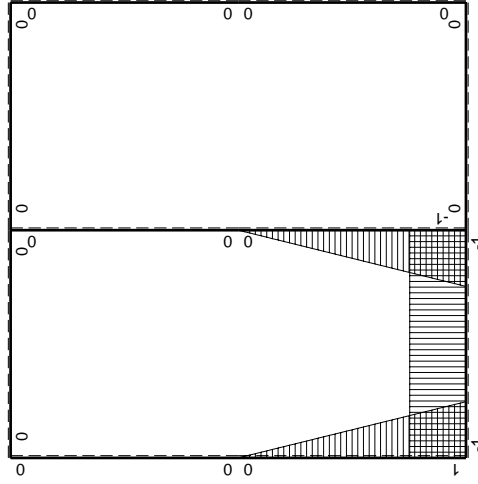


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

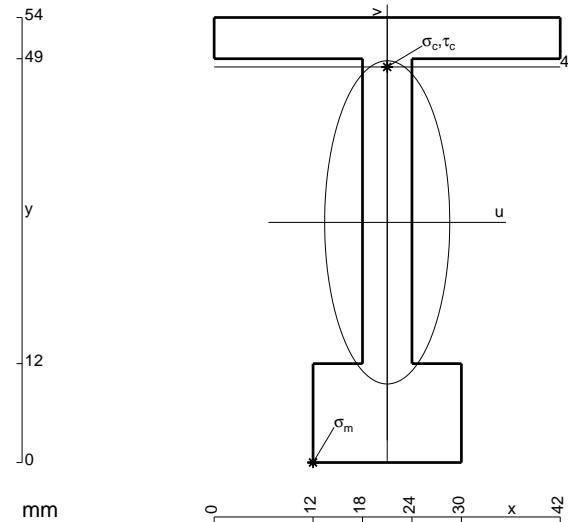
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

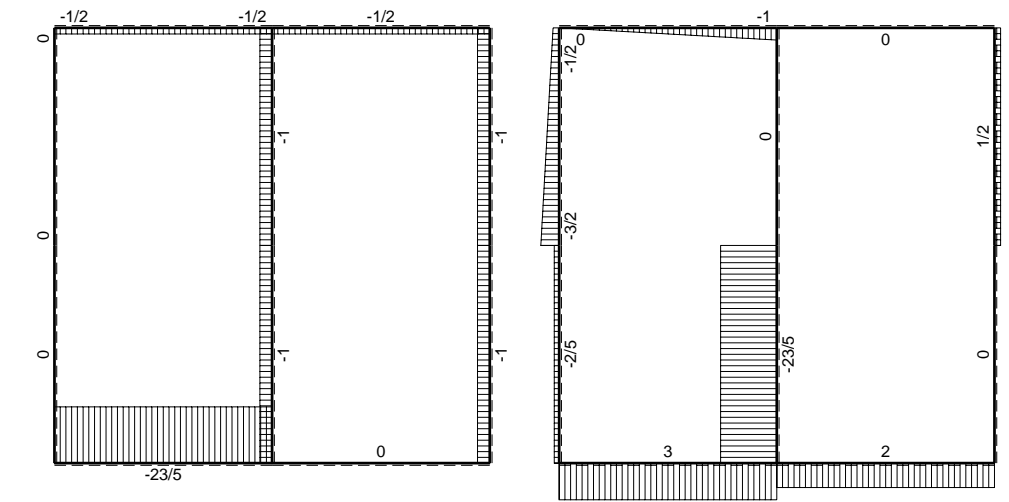
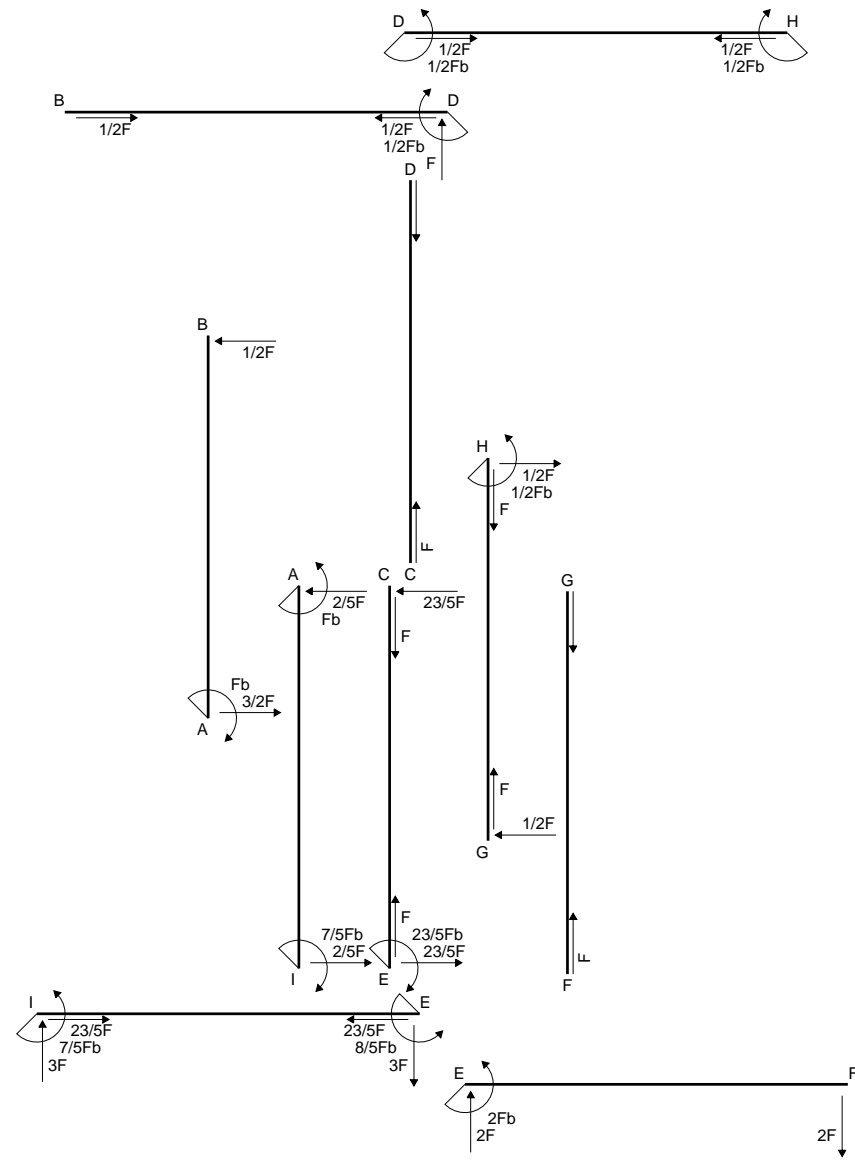
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

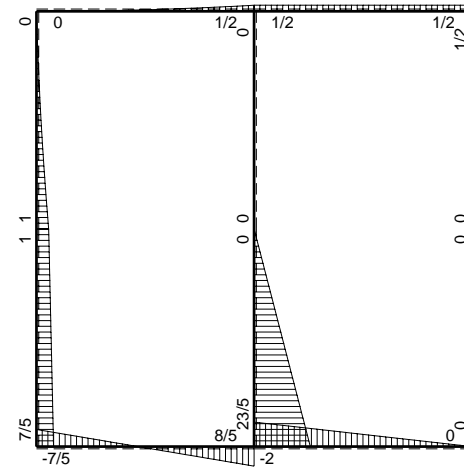


- A = 648. mm²
- J_u = 249419. mm⁴
- J_v = 37368. mm⁴
- y_g = 29.14 mm
- T_y = 3040. N
- M_x = -1793600. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -29.14 mm
- σ_m = -Mv/J_u = -209.5 N/mm²
- x_c = 21. mm
- y_c = 48. mm
- v_c = 18.86 mm
- σ_c = -Mv/J_u = 135.6 N/mm²
- τ_c = 9.775 N/mm²
- σ_o = √σ²+3τ² = 136.7 N/mm²
- S = 4812. mm³

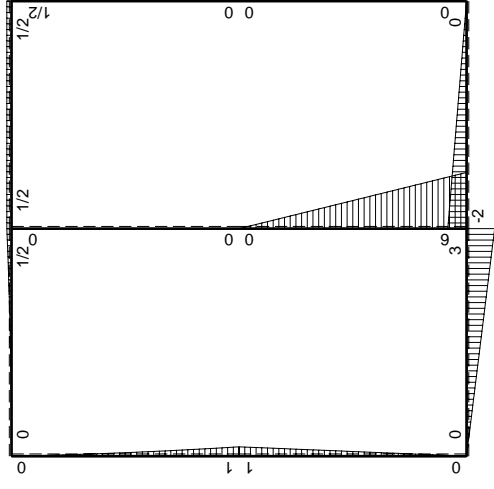
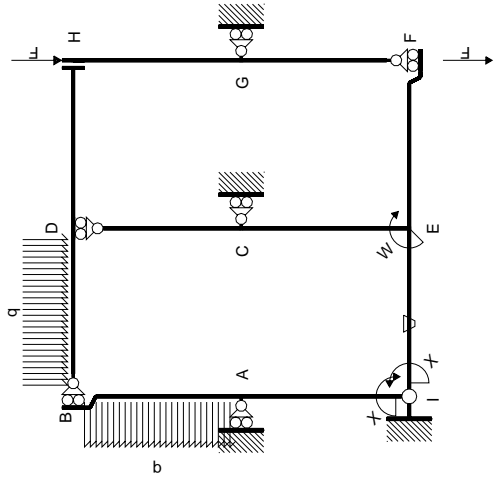


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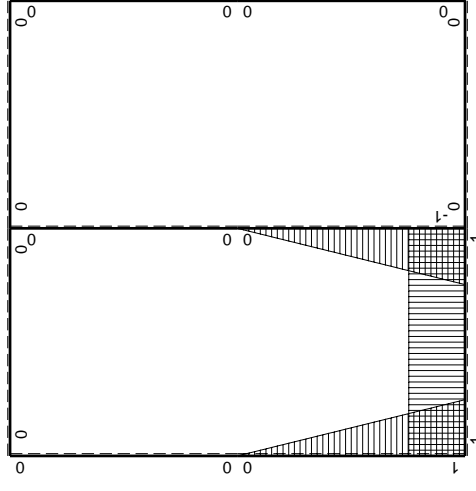


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

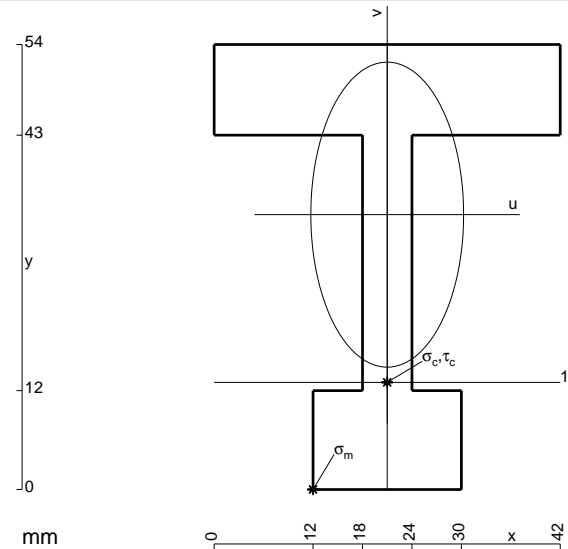
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 864. \text{ mm}^2$$

$$J_u = 296124. \text{ mm}^4$$

$$J_v = 74304. \text{ mm}^4$$

$$y_g = 33.35 \text{ mm}$$

$$T_y = 3040. \text{ N}$$

$$M_x = -1945600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.35 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.1 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

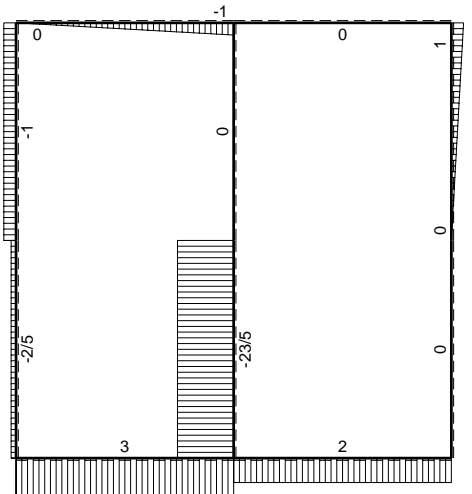
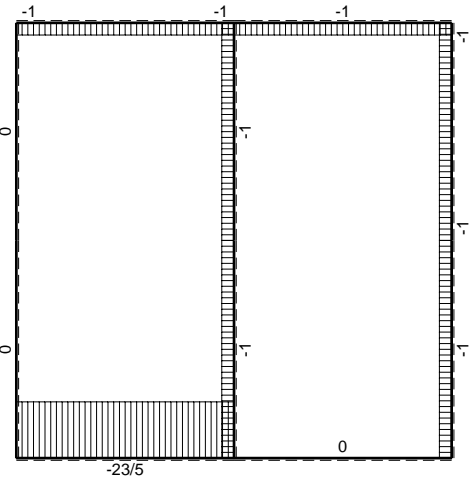
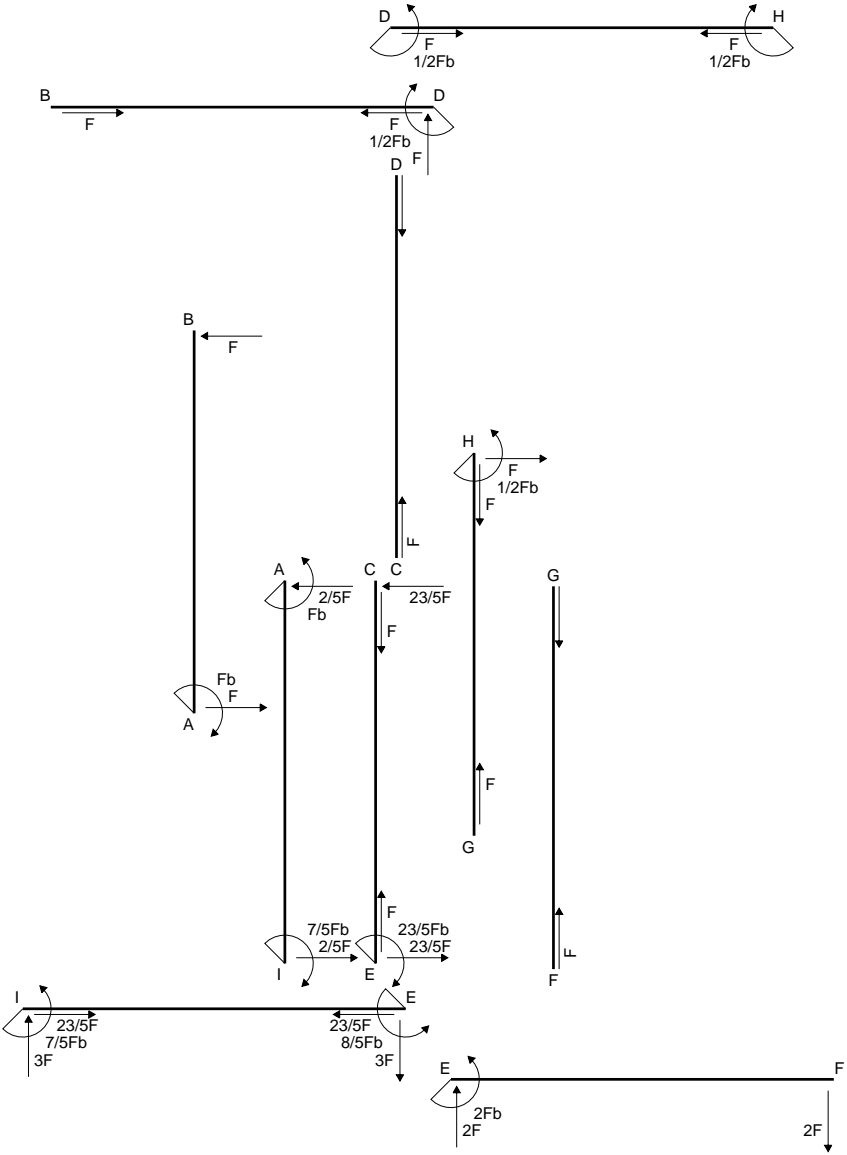
$$v_c = -20.35 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -133.7 \text{ N/mm}^2$$

$$\tau_c = 10.32 \text{ N/mm}^2$$

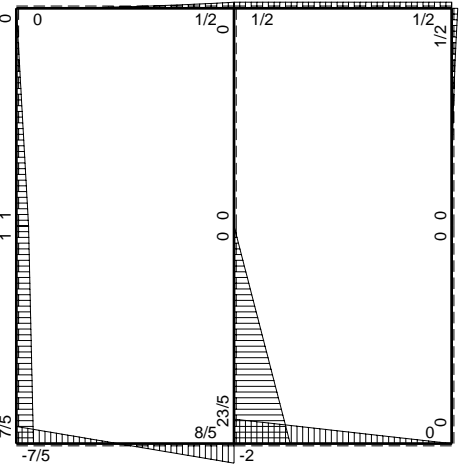
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 134.9 \text{ N/mm}^2$$

$$S = 6034. \text{ mm}^3$$

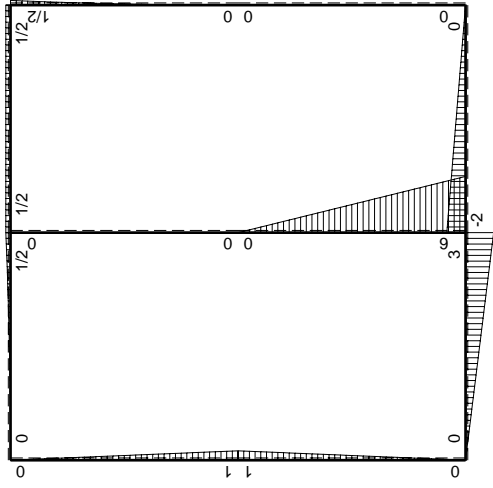
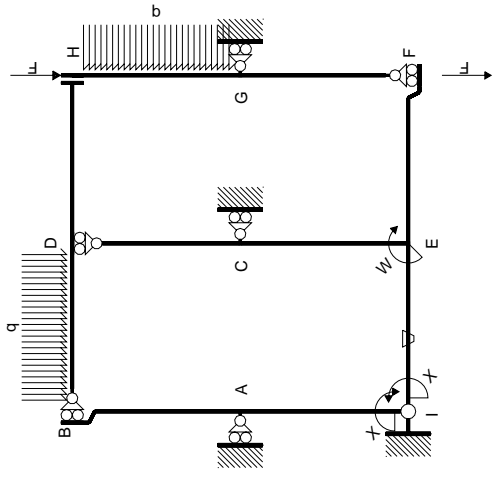


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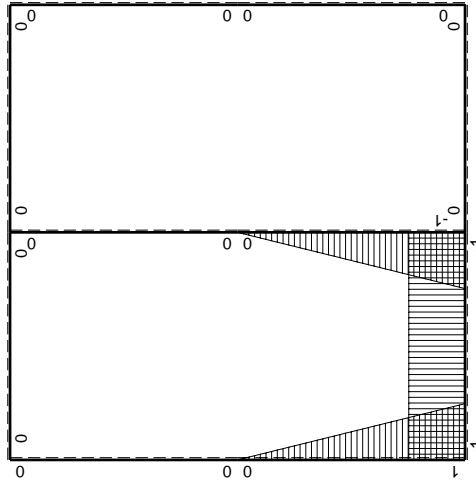


⊕ ⊖ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-Fx	0	0	0	0	0+0	0
BA b	0	-Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	6Fb-6Fx	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-6Fx	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	-Fb+Fx	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

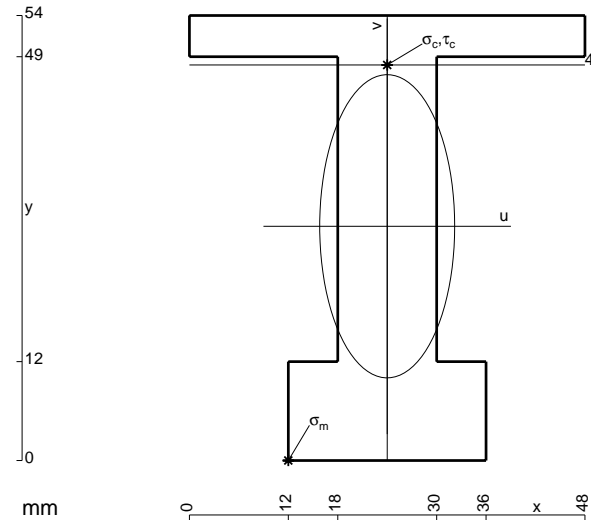
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

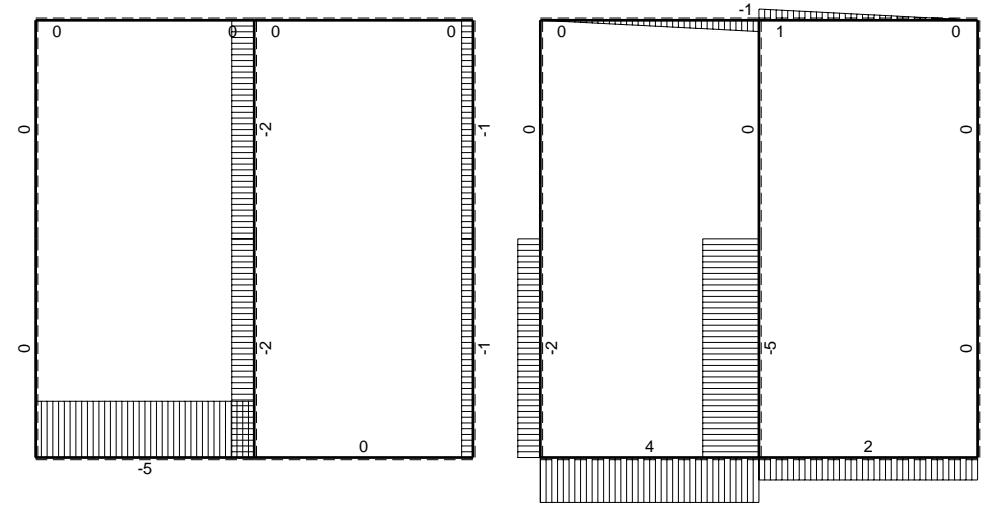
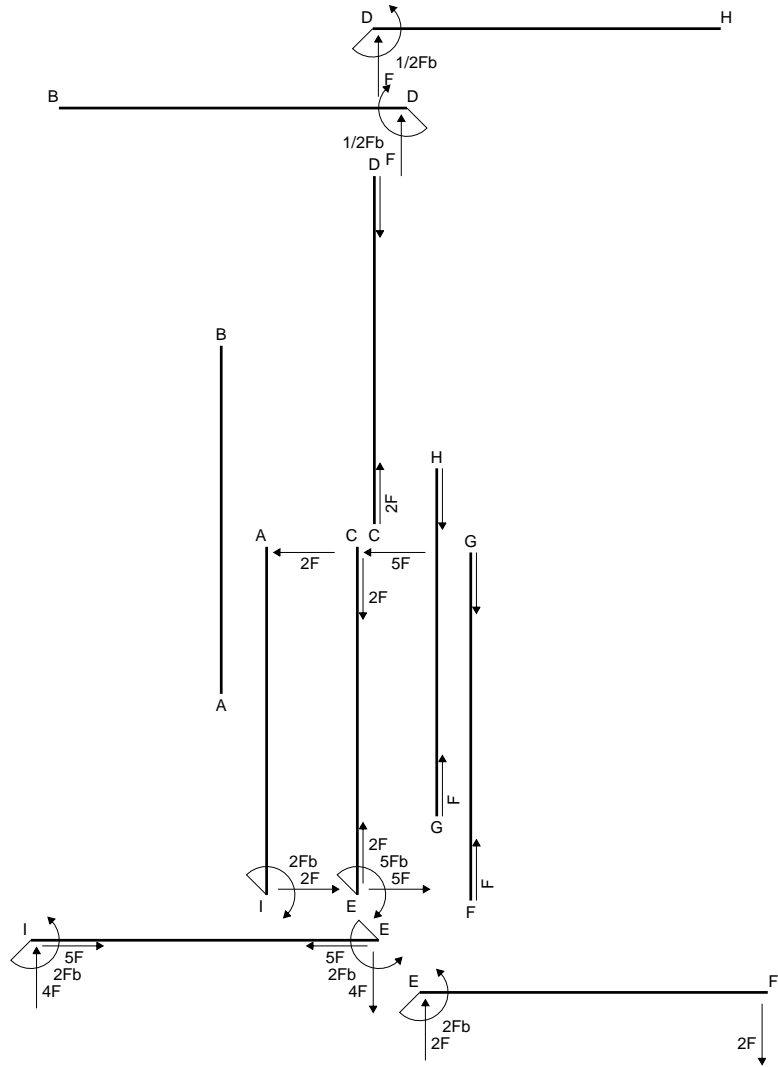
$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

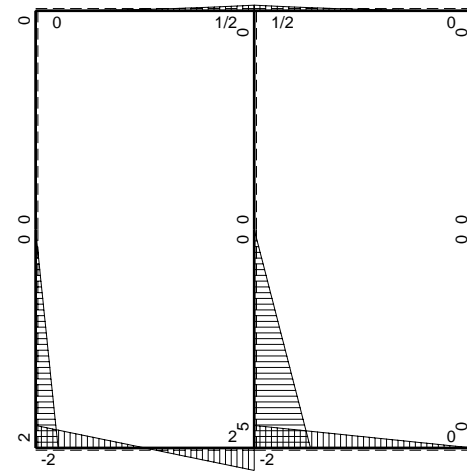


- A = 972. mm²
- J_u = 329140. mm⁴
- J_v = 65232. mm⁴
- y_g = 28.43 mm
- T_y = 3800. N
- M_x = -2660000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -28.43 mm
- σ_m = -Mv/J_u = -229.7 N/mm²
- x_c = 24. mm
- y_c = 48. mm
- v_c = 19.57 mm
- σ_c = -Mv/J_u = 158.2 N/mm²
- τ_c = 5.56 N/mm²
- σ_o = √σ² + 3τ² = 158.5 N/mm²
- S = 5779. mm³

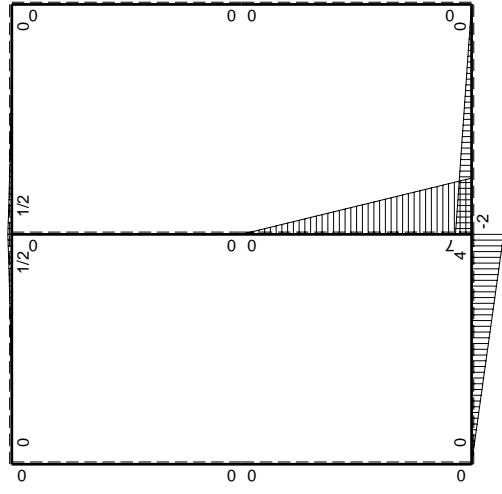
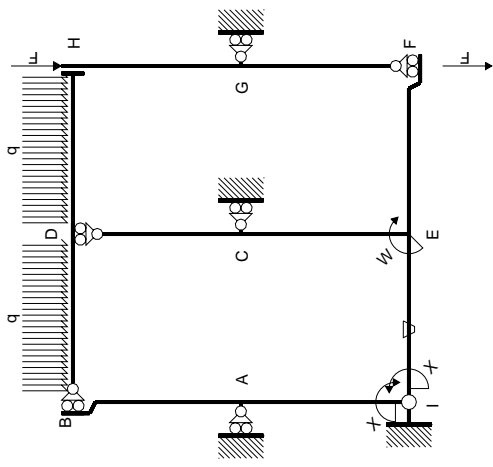


← (+) → F

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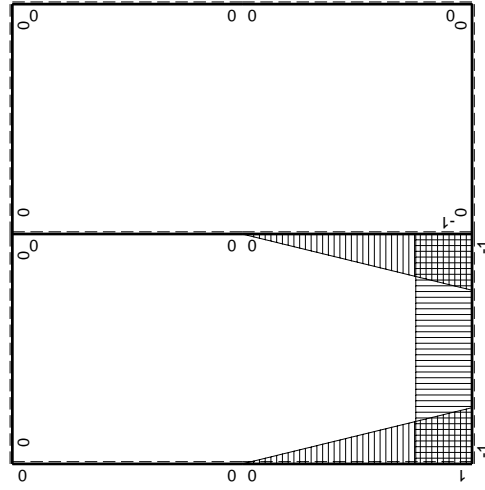


⊕ (+) ⊖ (-) F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	0	0	0	0	0	0+0	0	
BA b	0	0	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	0	0	0	0	0	0+0	0	
HG b	0	0	0	0	0	0			
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0	
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
BD b	0	$-1/2qx^2$	0	0	0	0			
IE b	-1	4Fx	-Fb/EJ	-4Fx	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	-4Fb+4Fx	Fb/EJ	-4Fb+4Fx	Fb/EJ	1			
EC b	$-1+x/b$	7Fb-7Fx	0	$-7Fb+14Fx-7Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/3+0)Fb^2/EJ$	1/3Xb/EJ	
CE b	x/b	-7Fx	0	$-7Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	1/3Xb/EJ	
AI b	$-x/b$	0	0	0	0	x^2/b^2			
	totali							$-10/3Fb^2/EJ$	5/3Xb/EJ
	iperstatica $X=W_{IE}$							2Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

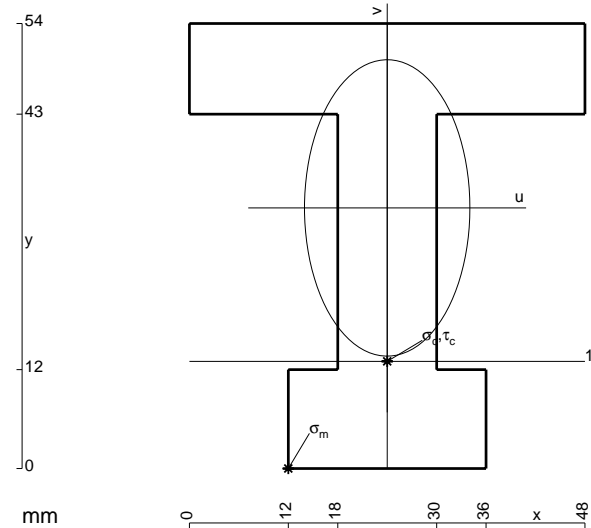
$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-7 + 14x/b - 7x^2/b^2) Fb 1/EJ dx = [-7x + 7x^2/b - 7/3 x^3/b^2]_0^b Fb 1/EJ$$

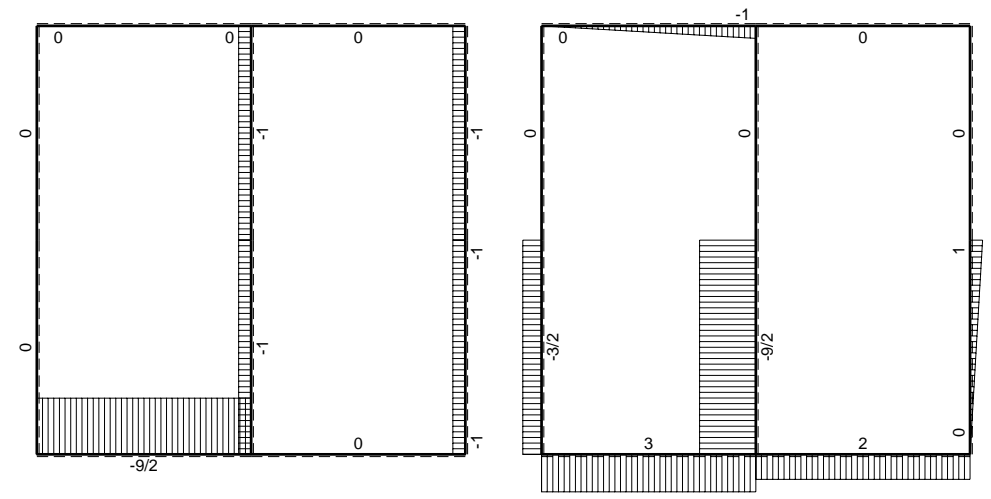
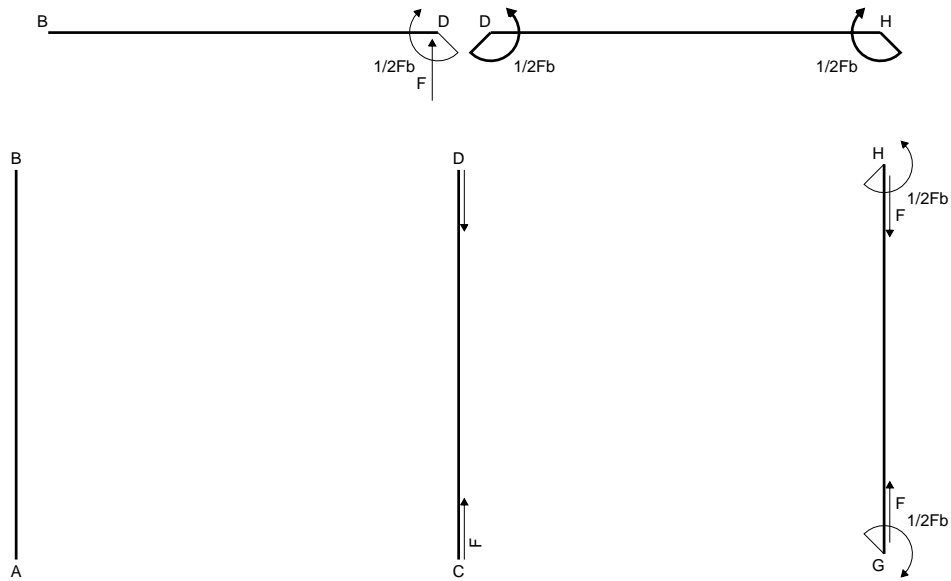
$$= (-7b + 7b - 7/3 b) Fb 1/EJ = -7/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7x^2/b^2) Fb 1/EJ dx = [-7/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-7/3 b) Fb 1/EJ = -7/3 Fb^2/EJ$$

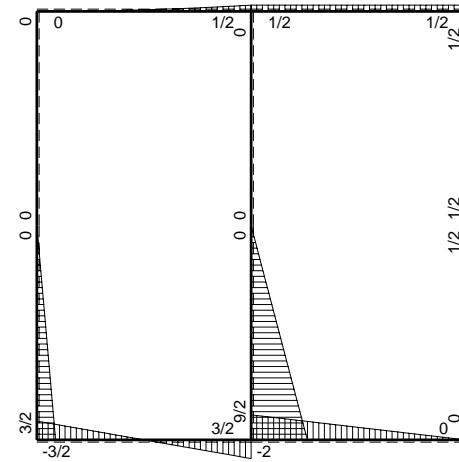
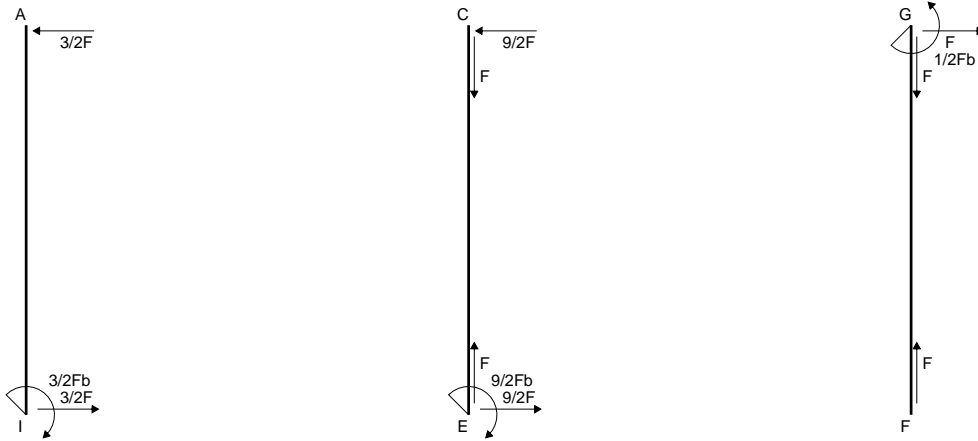


- A = 1188. mm²
- J_u = 384370. mm⁴
- J_v = 119664. mm⁴
- y_g = 31.62 mm
- T_y = 3880. N
- M_x = -2910000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -31.62 mm
- σ_m = -Mv/J_u = -239.4 N/mm²
- x_c = 24. mm
- y_c = 13. mm
- v_c = -18.62 mm
- σ_c = -Mv/J_u = -141. N/mm²
- τ_c = 6.4 N/mm²
- σ_o = √σ²+3τ² = 141.4 N/mm²
- S = 7608. mm³

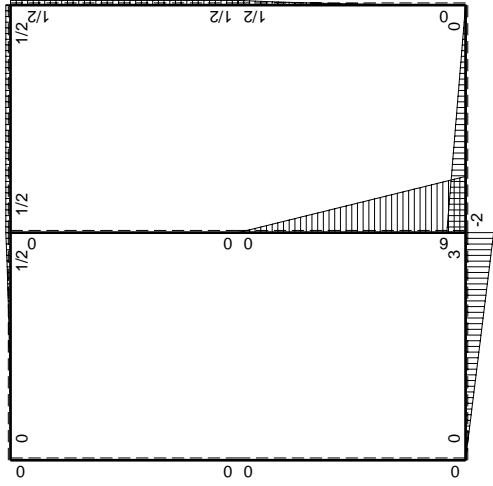
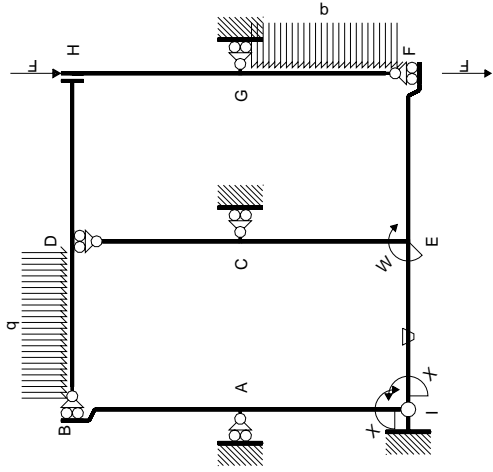


← ⊕ → F

↑ ⊕ ↓ F

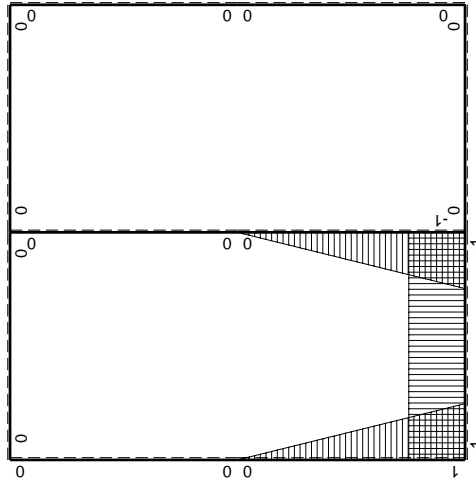


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	0	0	0	0	0	0+0	0	
BA b	0	0	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	1/2qx ²	0	0	0	0	0+0	0	
GF b	0	-1/2Fb+Fx-1/2qx ²	0	0	0	0			
GH b	0	1/2Fb	0	0	0	0	0+0	0	
HG b	0	-1/2Fb	0	0	0	0			
HD b	0	1/2Fb	0	0	0	0	0+0	0	
DH b	0	-1/2Fb	0	0	0	0			
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0	0+0	0	
BD b	0	-1/2qx ²	0	0	0	0			
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ	
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1			
EC b	-1+x/b	6Fb-6Fx	0	-6Fb+12Fx-6Fx ² /b	0	1-2x/b+x ² /b ²	(-2+0)Fb ² /EJ	1/3Xb/EJ	
CE b	x/b	-6Fx	0	-6Fx ² /b	0	x ² /b ²			
IA b	1-x/b	0	0	0	0	1-2x/b+x ² /b ²	0+0	1/3Xb/EJ	
AI b	-x/b	0	0	0	0	x ² /b ²			
	totali							-5/2Fb ² /EJ	5/3Xb/EJ
	iperstatica $X=W_{IE}$							3/2Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

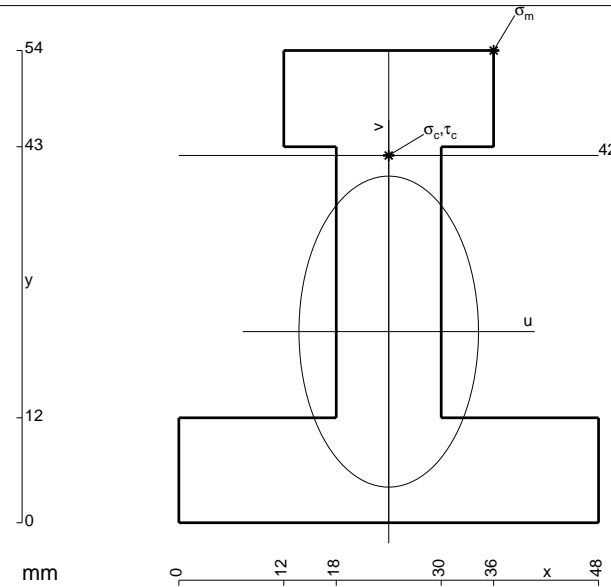
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

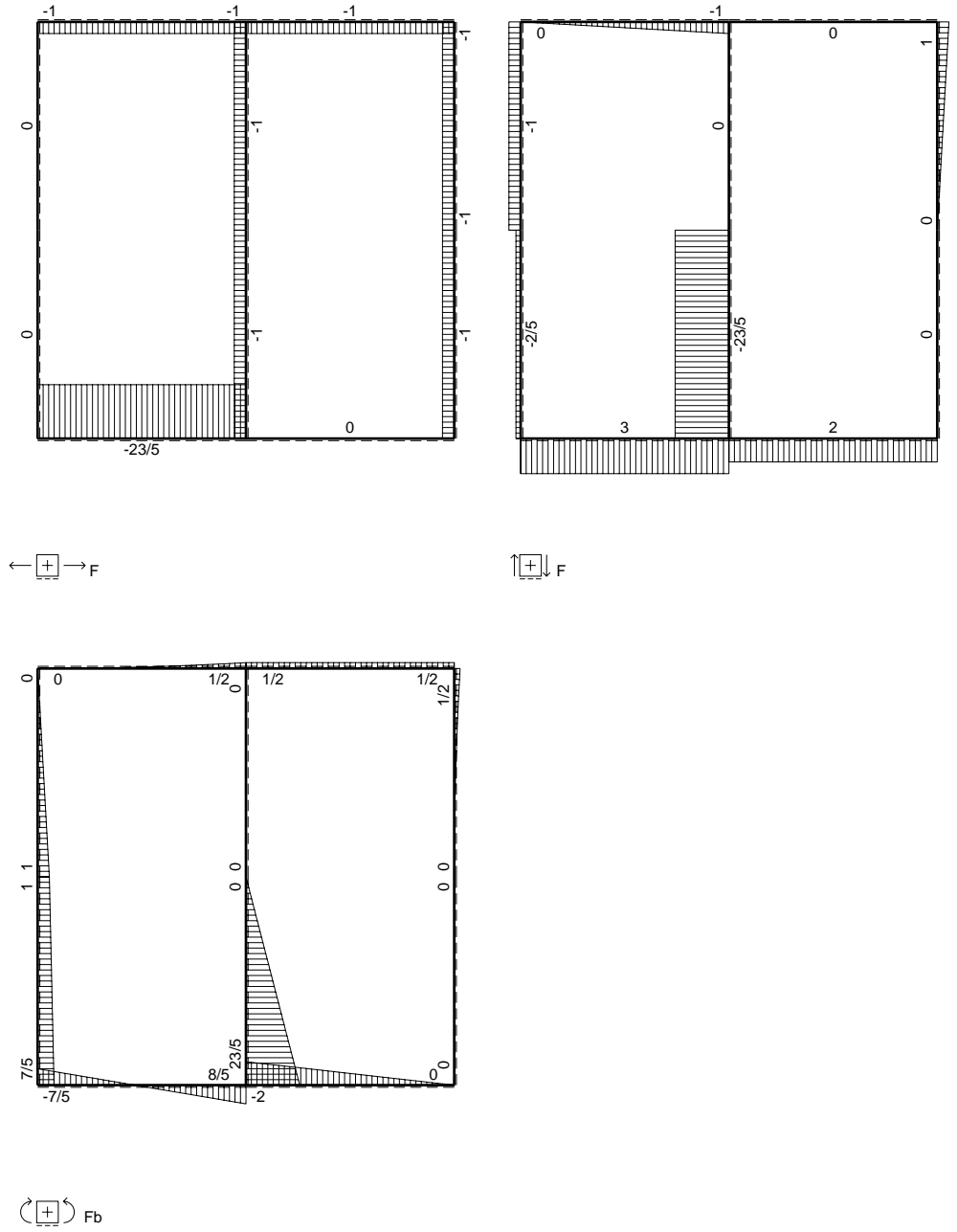
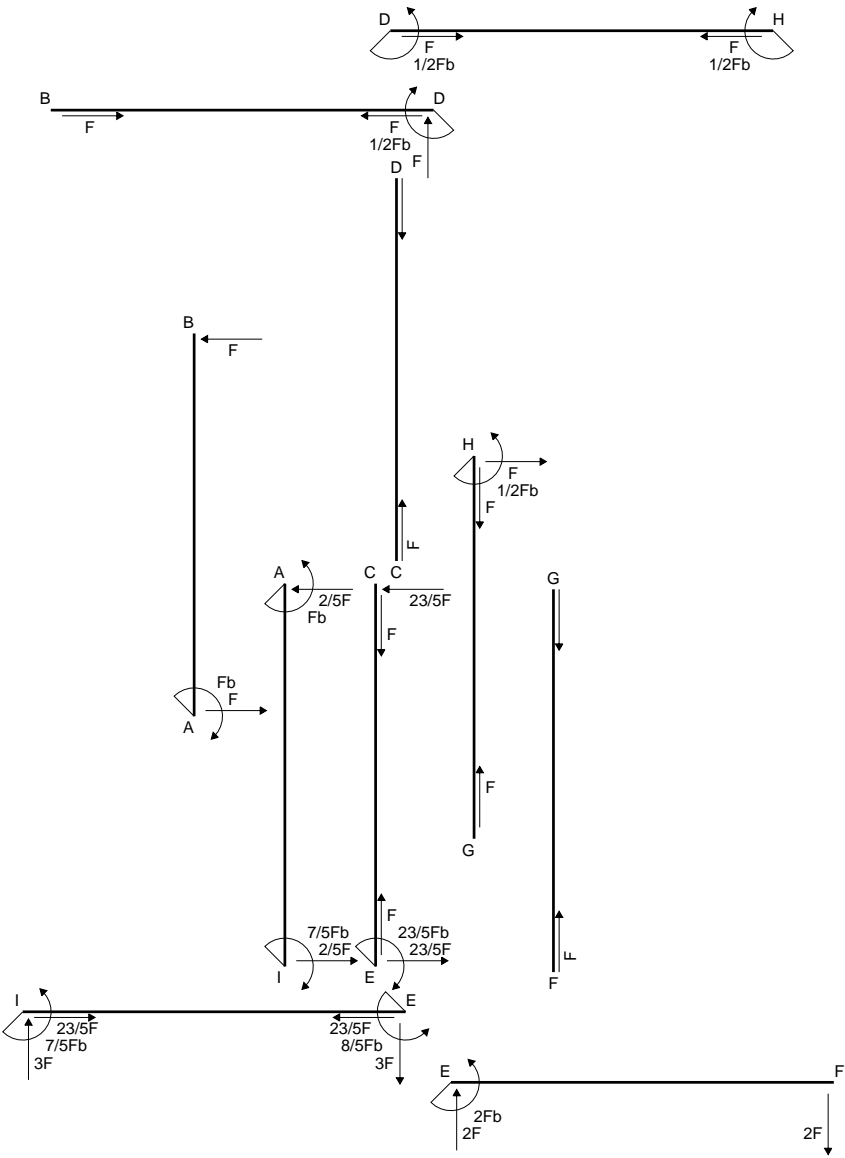
$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

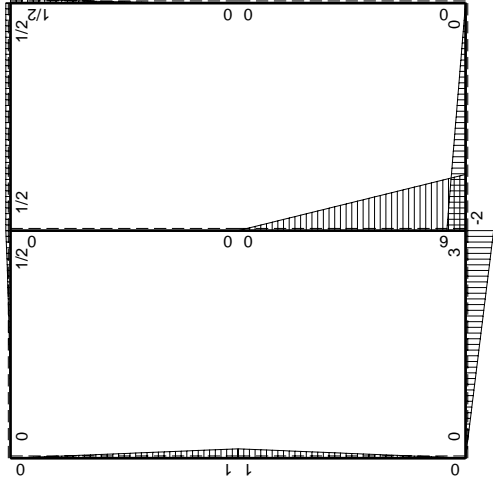
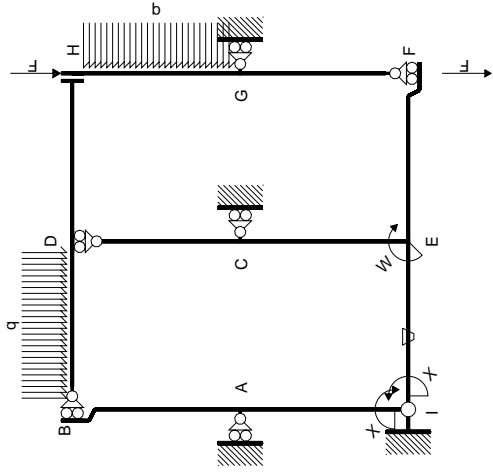
$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$



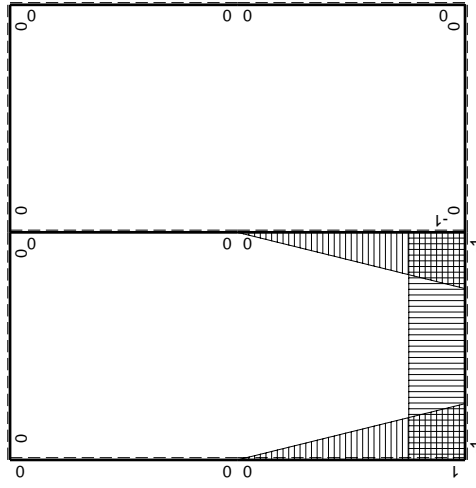
- A = 1212. mm²
- J_u = 383443. mm⁴
- J_v = 127728. mm⁴
- y_g = 21.86 mm
- T_y = 2940. N
- M_x = -2381400. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 32.14 mm
- σ_m = -Mv/J_u = 199.6 N/mm²
- x_c = 24. mm
- y_c = 42. mm
- v_c = 20.14 mm
- σ_c = -Mv/J_u = 125.1 N/mm²
- τ_c = 4.653 N/mm²
- σ_q = √σ²+3τ² = 125.4 N/mm²
- S = 7282. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-Fx	0	0	0	0	0+0	0
BA b	0	-Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

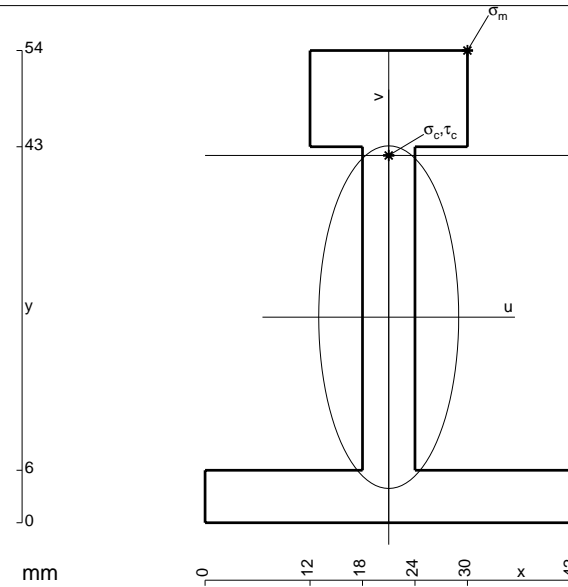
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

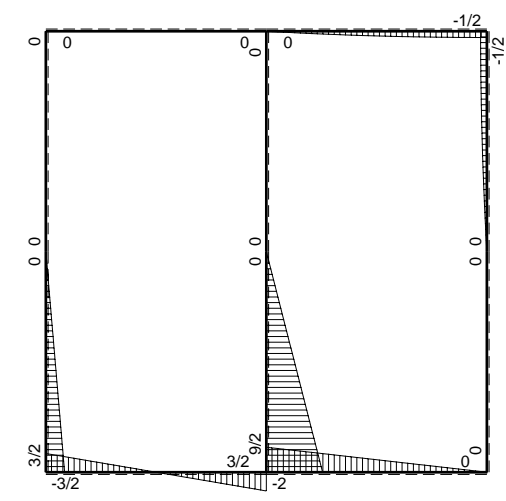
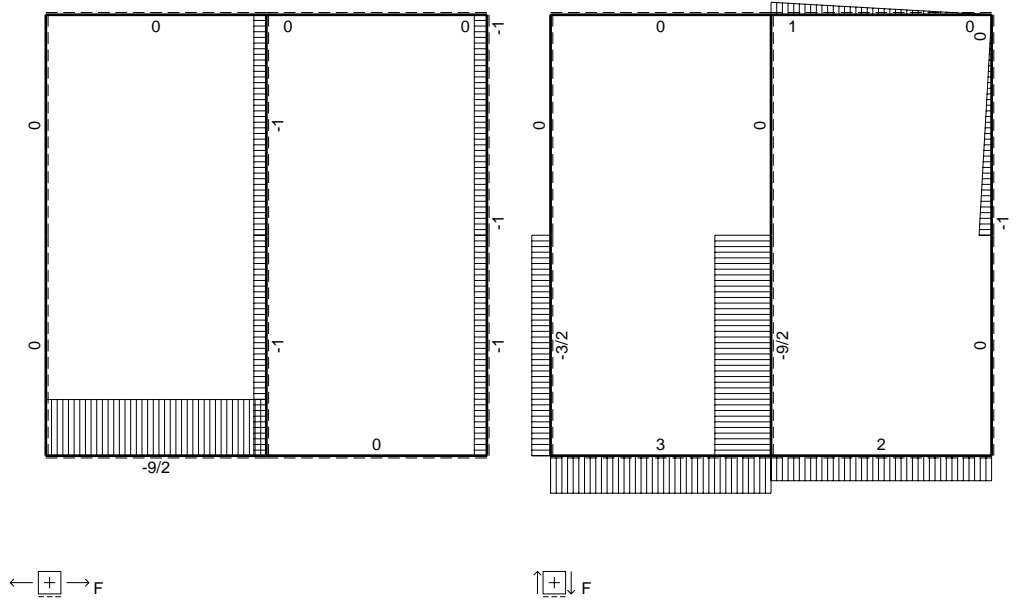
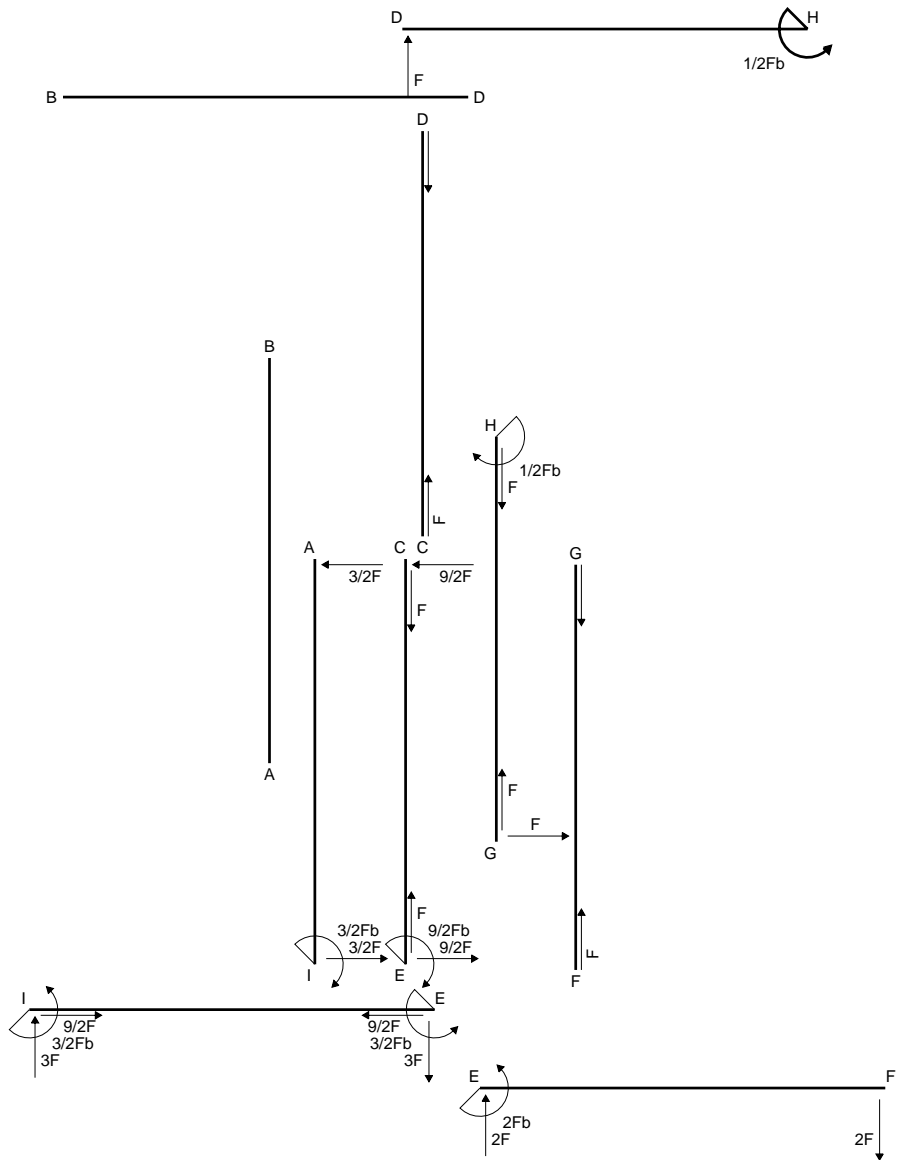
$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

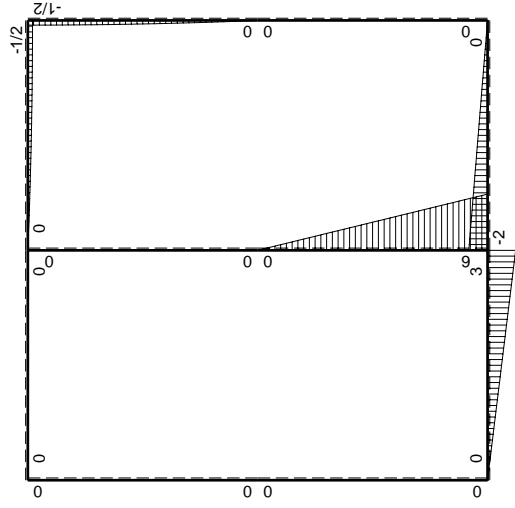
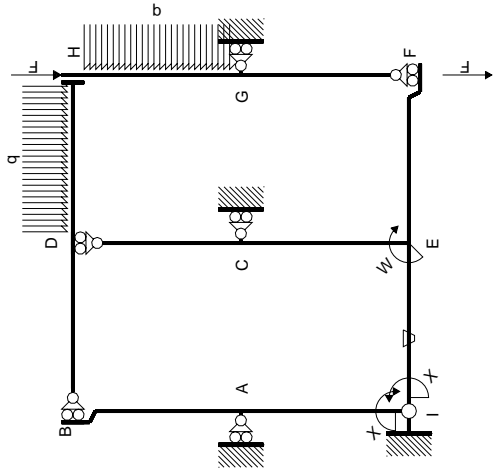
$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



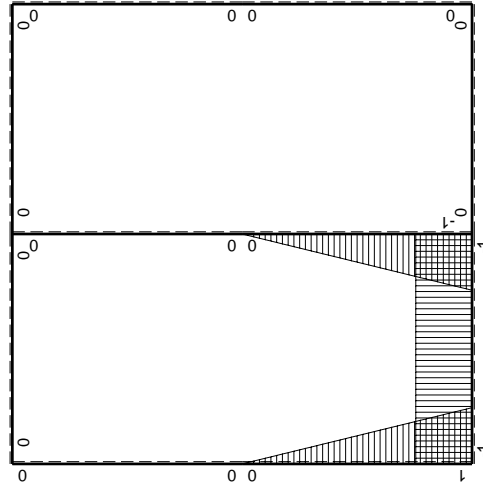
- A = 672. mm²
- J_u = 257954. mm⁴
- J_v = 43056. mm⁴
- y_g = 23.51 mm
- T_y = 2060. N
- M_x = -1771600. Nmm
- x_m = 30. mm
- y_m = 54. mm
- u_m = 9. mm
- v_m = 30.49 mm
- σ_m = -Mv/J_u = 209.4 N/mm²
- x_c = 21. mm
- y_c = 42. mm
- v_c = 18.49 mm
- σ_c = -Mv/J_u = 127. N/mm²
- τ_c = 6.738 N/mm²
- σ_q = √σ²+3τ² = 127.5 N/mm²
- S = 5062. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

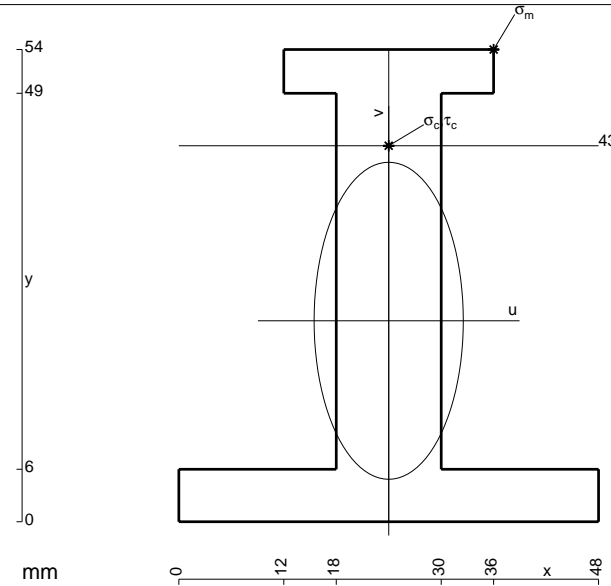
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

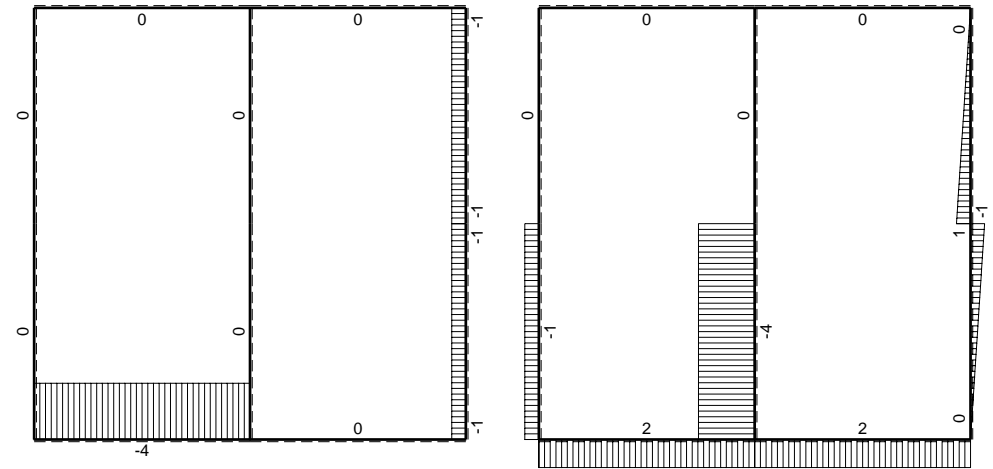
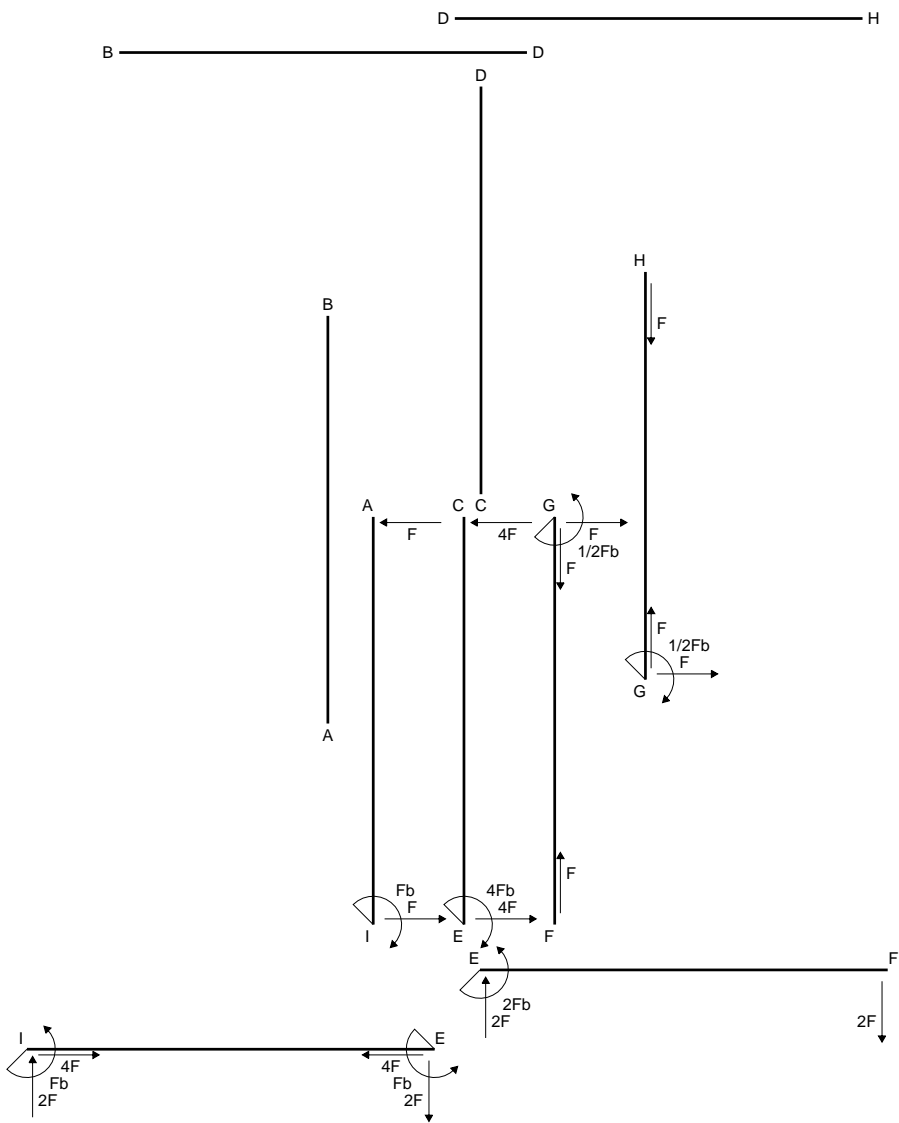
$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

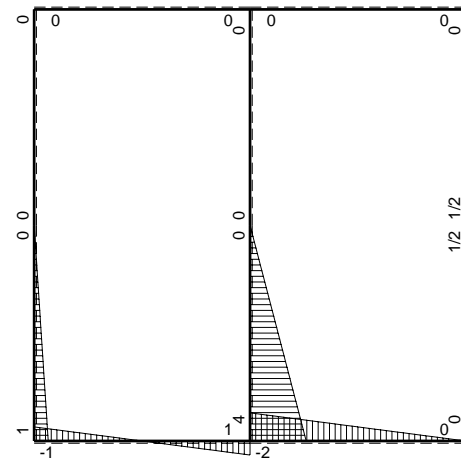


- A = 924. mm²
- J_u = 303740. mm⁴
- J_v = 67248. mm⁴
- y_g = 22.98 mm
- T_y = 2360. N
- M_x = -2147600. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 31.02 mm
- σ_m = -Mv/J_u = 219.3 N/mm²
- x_c = 24. mm
- y_c = 43. mm
- v_c = 20.02 mm
- σ_c = -Mv/J_u = 141.5 N/mm²
- τ_c = 3.289 N/mm²
- σ_q = √σ²+3τ² = 141.7 N/mm²
- S = 5080. mm³

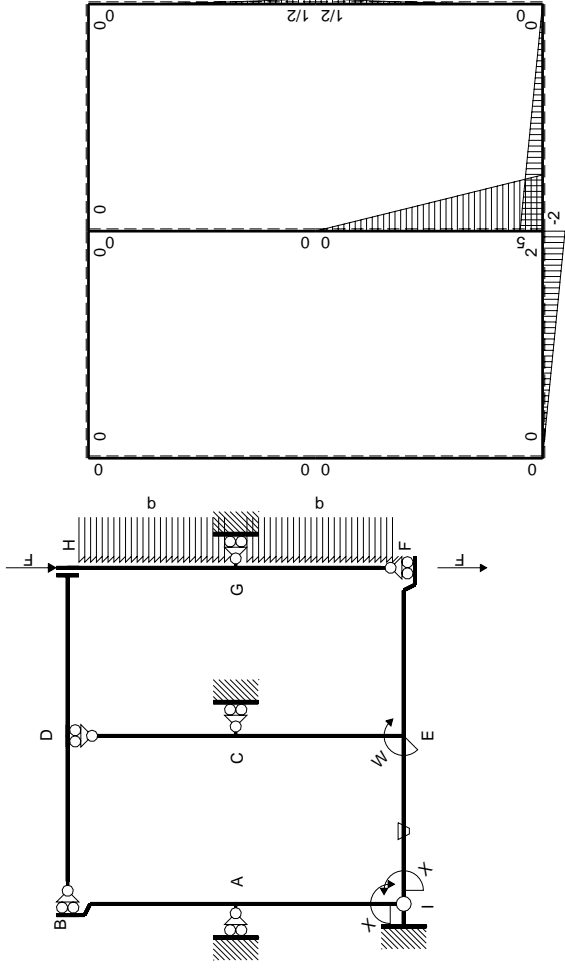


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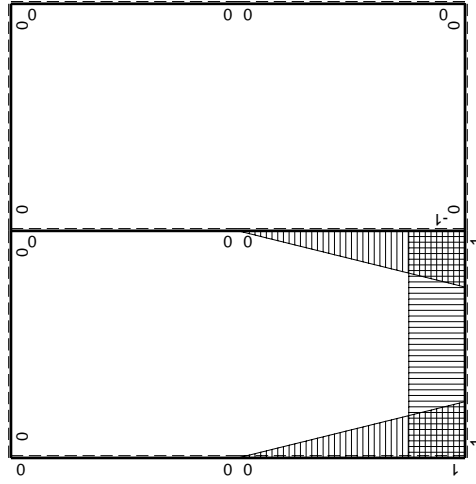


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

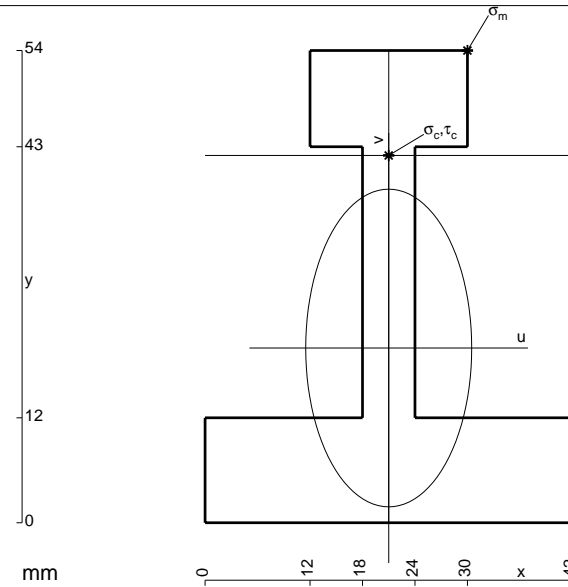
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$



$$A = 888. \text{ mm}^2$$

$$J_u = 293012. \text{ mm}^4$$

$$J_v = 79992. \text{ mm}^4$$

$$y_g = 19.98 \text{ mm}$$

$$T_y = 2040. \text{ N}$$

$$M_x = -1978800. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 34.02 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.8 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 42. \text{ mm}$$

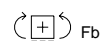
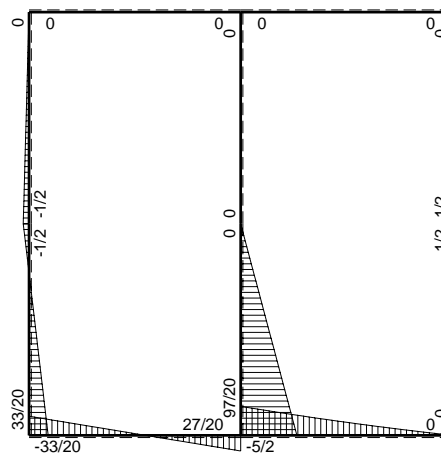
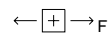
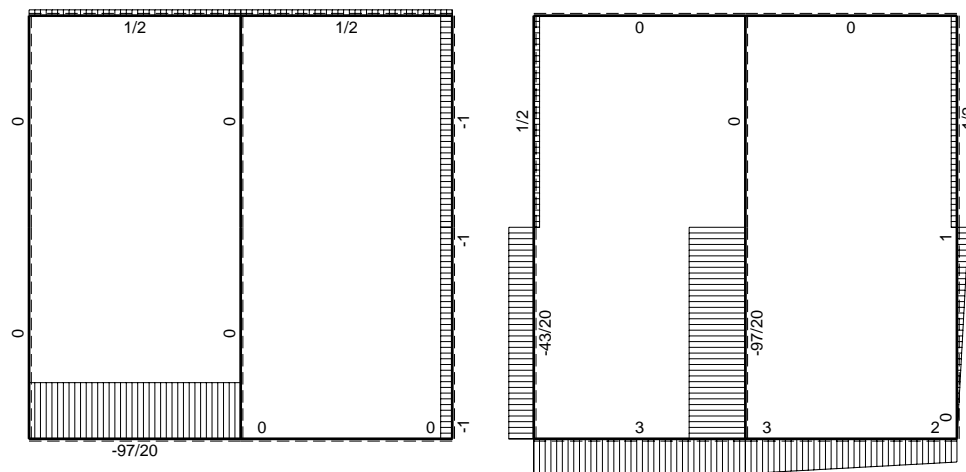
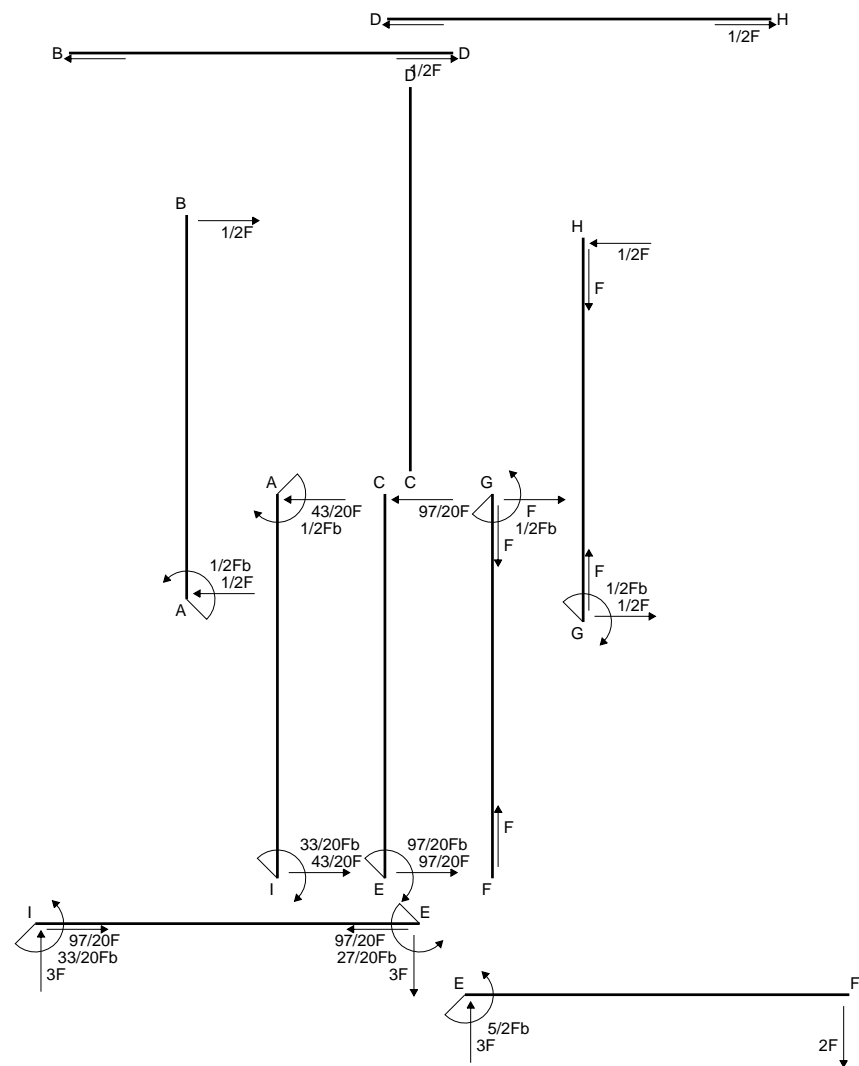
$$v_c = 22.02 \text{ mm}$$

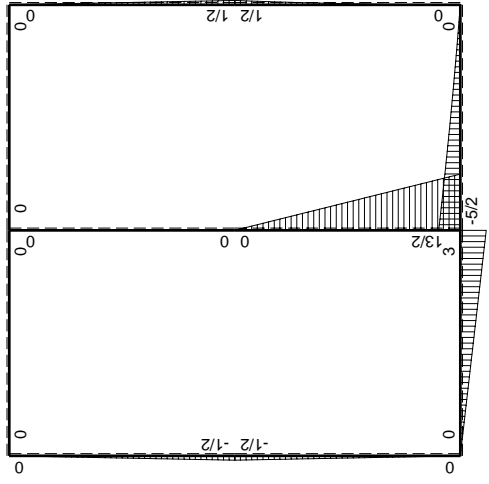
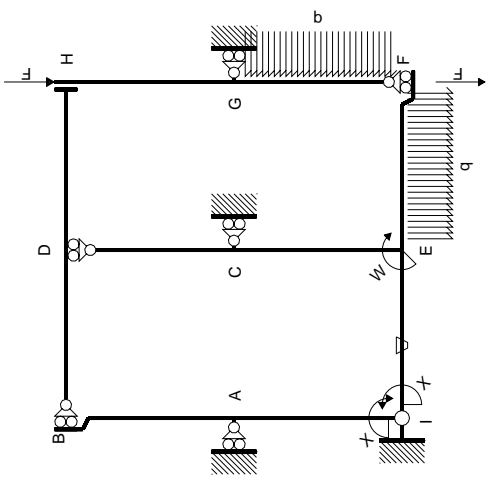
$$\sigma_c = -Mv/J_u = 148.7 \text{ N/mm}^2$$

$$\tau_c = 6.709 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 149.2 \text{ N/mm}^2$$

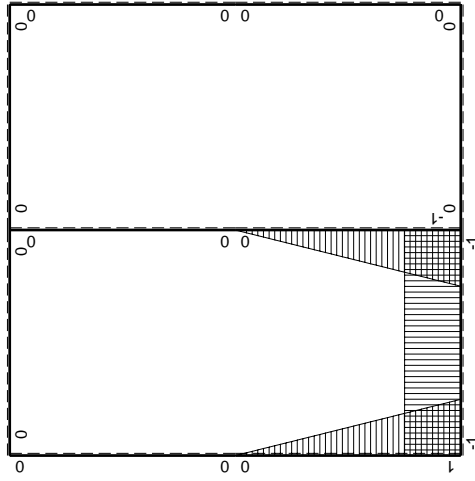
$$S = 5782. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0	
FE b	0	$2Fx+1/2qx^2$	0	0	0	0			
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0	
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fx$	0	0	0	0			
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1			
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2			
	totali							$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

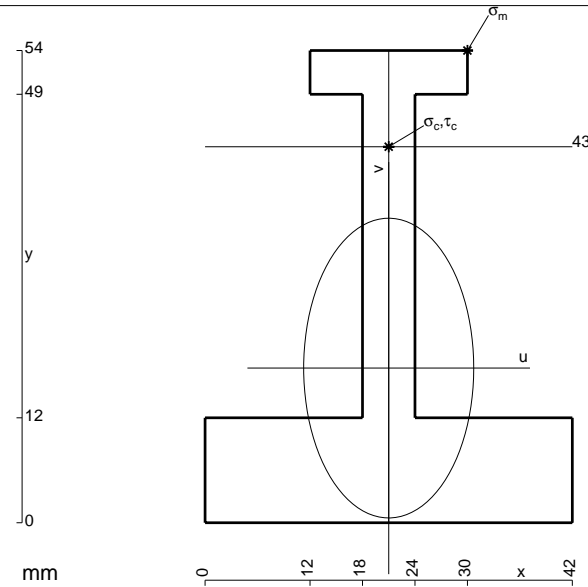
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 816. \text{ mm}^2$$

$$J_u = 239746. \text{ mm}^4$$

$$J_v = 77184. \text{ mm}^4$$

$$y_g = 17.68 \text{ mm}$$

$$T_y = 1860. \text{ N}$$

$$M_x = -1581000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 36.32 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

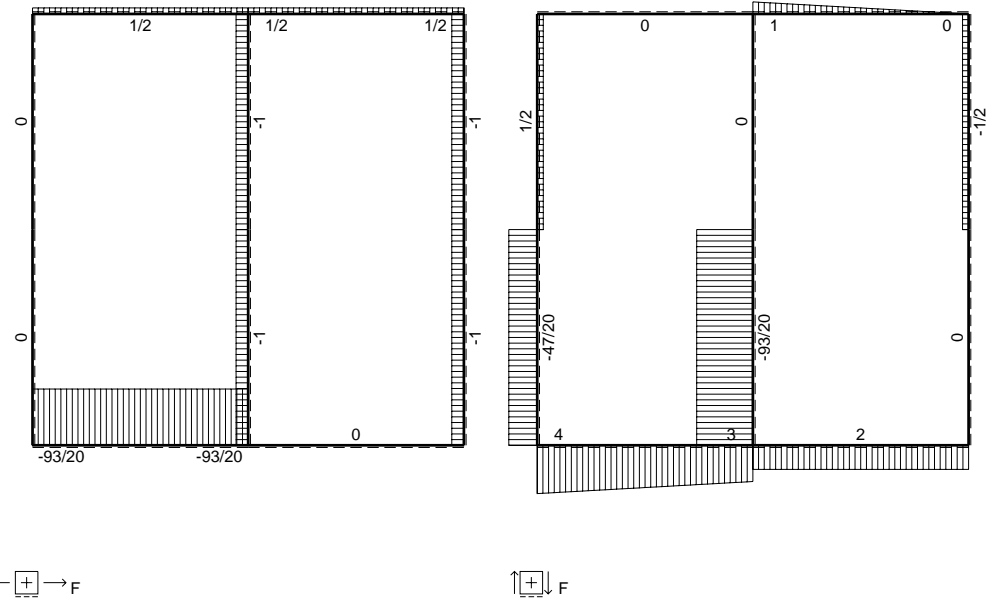
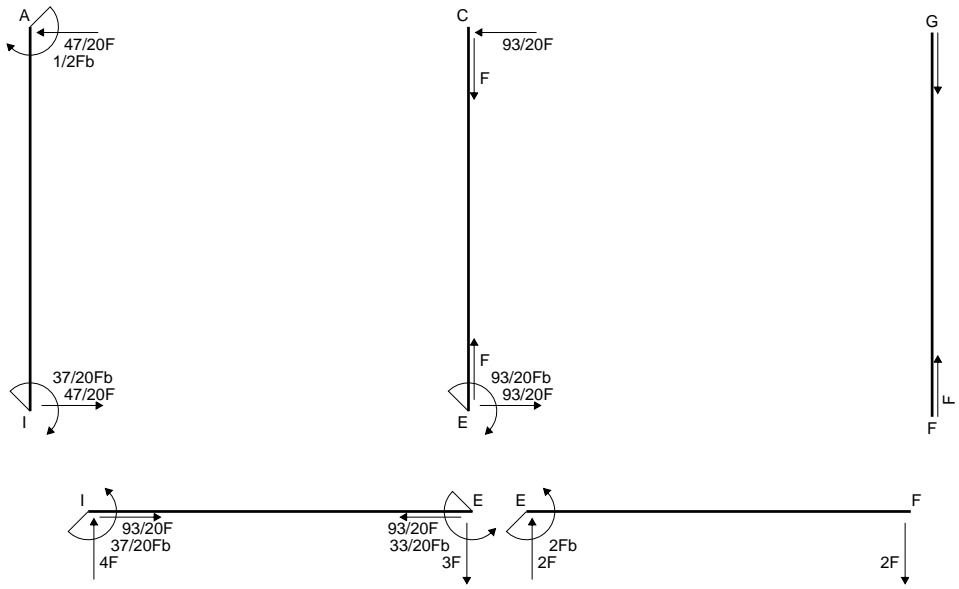
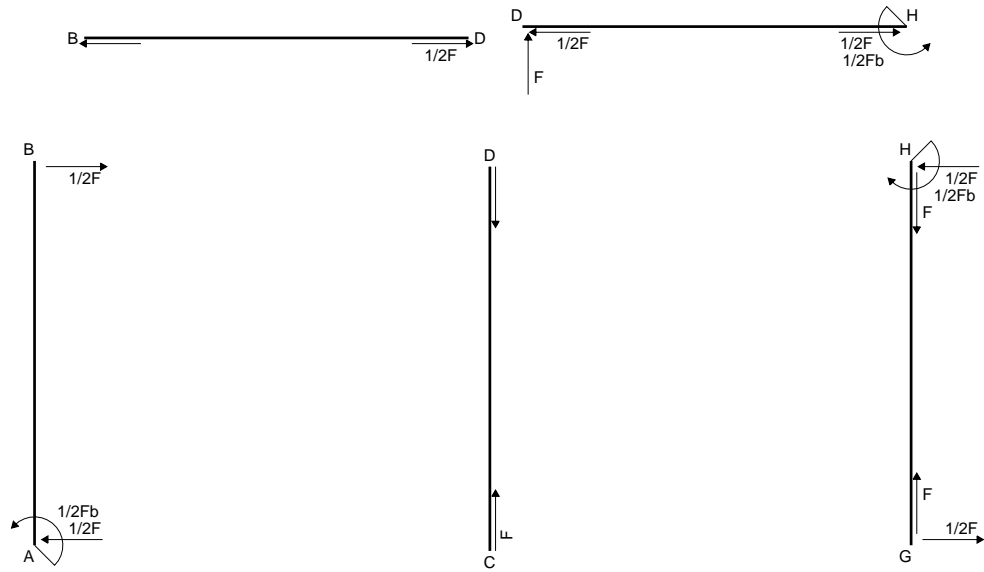
$$v_c = 25.32 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 166.9 \text{ N/mm}^2$$

$$\tau_c = 5.253 \text{ N/mm}^2$$

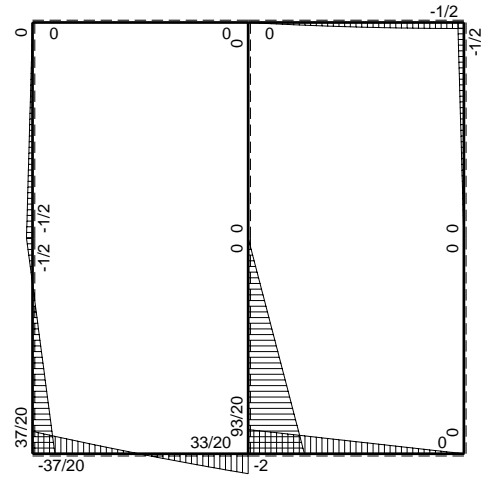
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 167.2 \text{ N/mm}^2$$

$$S = 4063. \text{ mm}^3$$

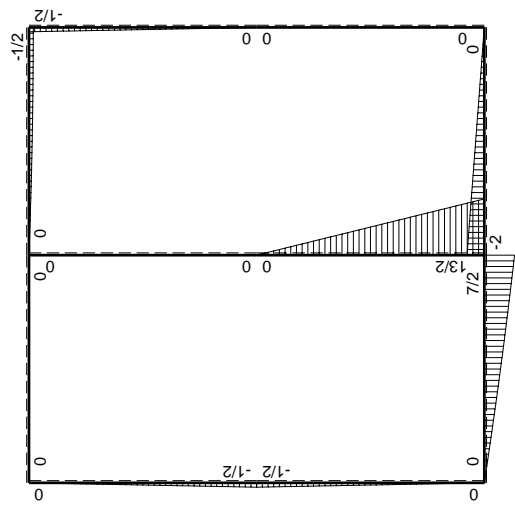
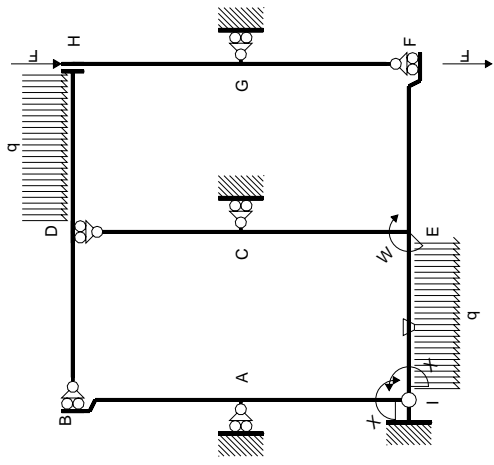


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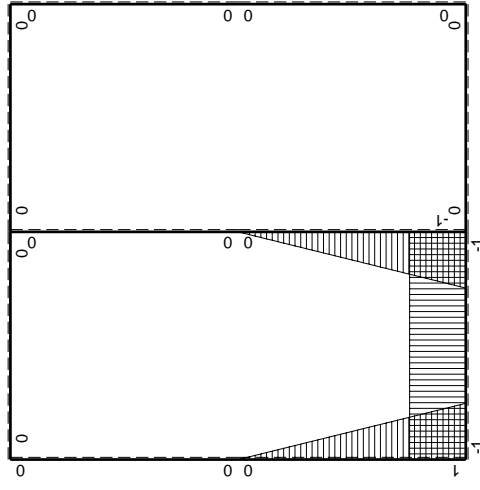


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-1/2Fb+1/2Fx	0	0	0	0	0+0	0	
BA b	0	1/2Fx	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	-1/2Fx	0	0	0	0	0+0	0	
HG b	0	1/2Fb-1/2Fx	0	0	0	0			
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0	
DH b	0	Fx-1/2qx ²	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	4Fx-1/2qx ²	-Fb/EJ	-4Fx+1/2Fx ² /b	Fb/EJ	1	(-11/6+1)Fb ² /EJ	Xb/EJ	
EI b	1	-7/2Fb+3Fx+1/2qx ²	Fb/EJ	-7/2Fb+3Fx+1/2Fx ² /b	Fb/EJ	1			
EC b	-1+x/b	13/2Fb-13/2Fx	0	-13/2Fb+13Fx-13/2Fx ² /b	0	1-2x/b+x ² /b ²	(-13/6+0)Fb ² /EJ	1/3Xb/EJ	
CE b	x/b	-13/2Fx	0	-13/2Fx ² /b	0	x ² /b ²			
IA b	1-x/b	-1/2Fx	0	-1/2Fx+1/2Fx ² /b	0	1-2x/b+x ² /b ²	(-1/12+0)Fb ² /EJ	1/3Xb/EJ	
AI b	-x/b	1/2Fb-1/2Fx	0	-1/2Fx+1/2Fx ² /b	0	x ² /b ²			
	totali							-37/12Fb ² /EJ	5/3Xb/EJ
	iperstatica $X=W_{IE}$							37/20Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

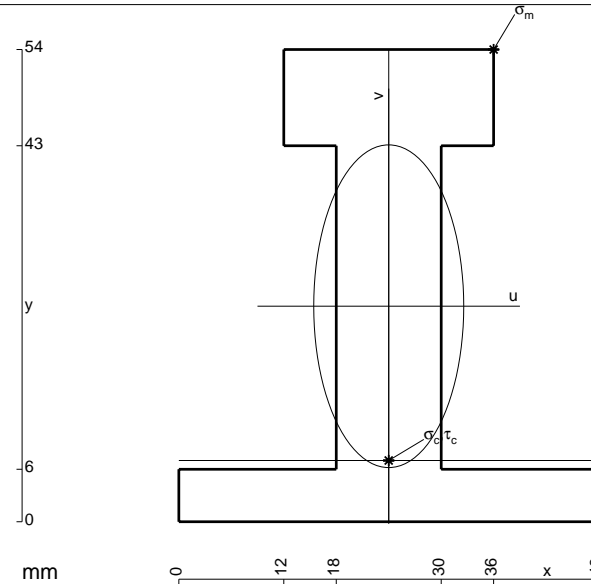
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 996. \text{ mm}^2$$

$$J_u = 339350. \text{ mm}^4$$

$$J_v = 73296. \text{ mm}^4$$

$$y_g = 24.64 \text{ mm}$$

$$T_y = 4280. \text{ N}$$

$$M_x = -2311200. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 29.36 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 7. \text{ mm}$$

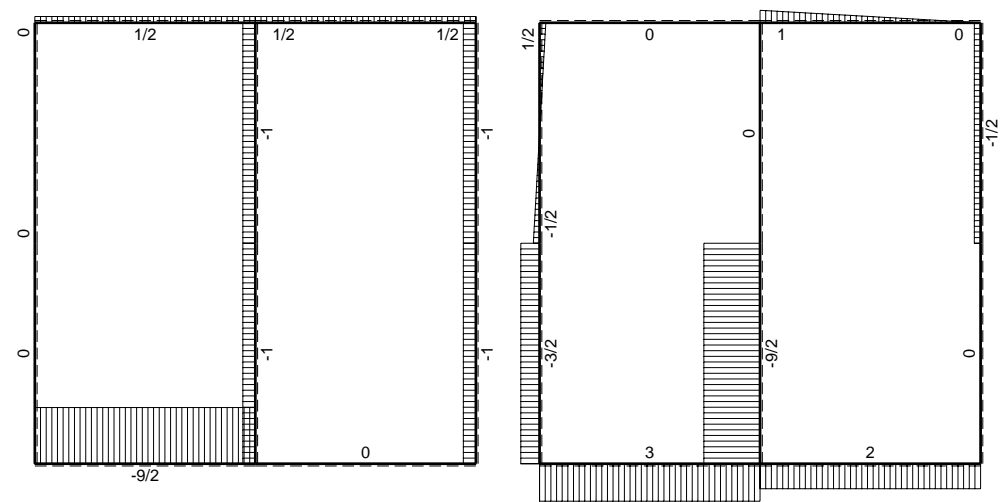
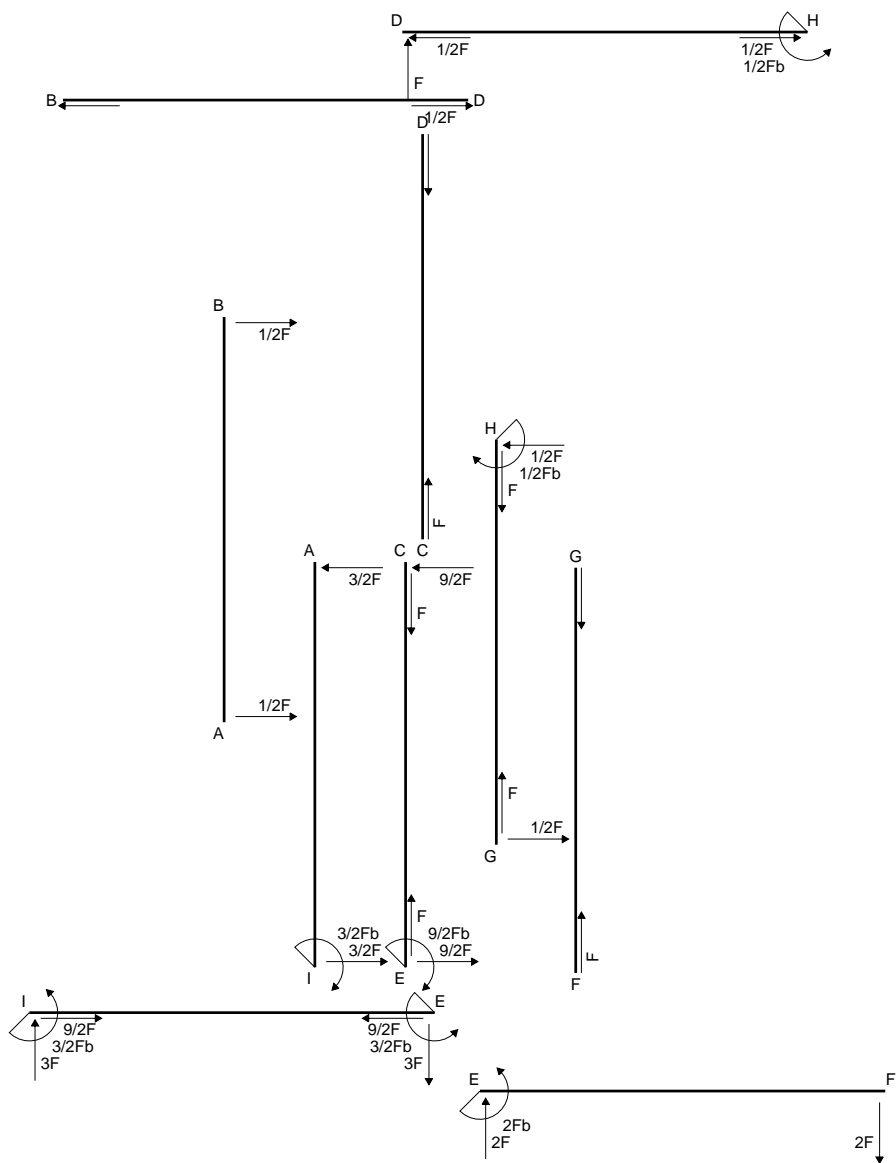
$$v_c = -17.64 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -120.2 \text{ N/mm}^2$$

$$\tau_c = 6.781 \text{ N/mm}^2$$

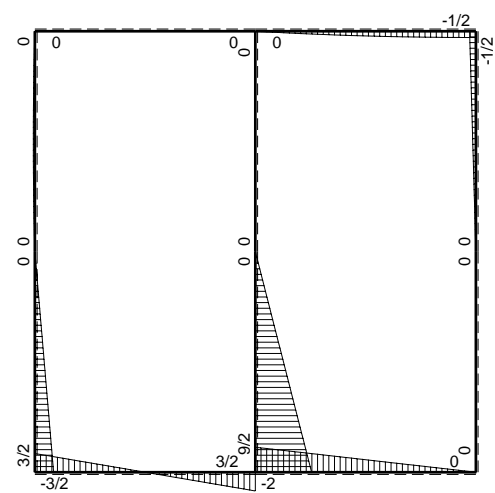
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 120.7 \text{ N/mm}^2$$

$$S = 6451. \text{ mm}^3$$

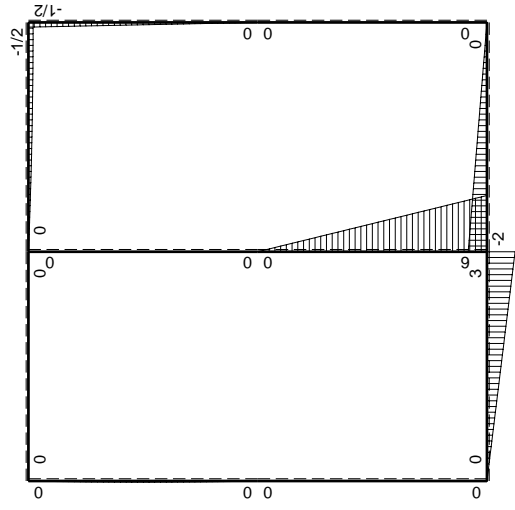
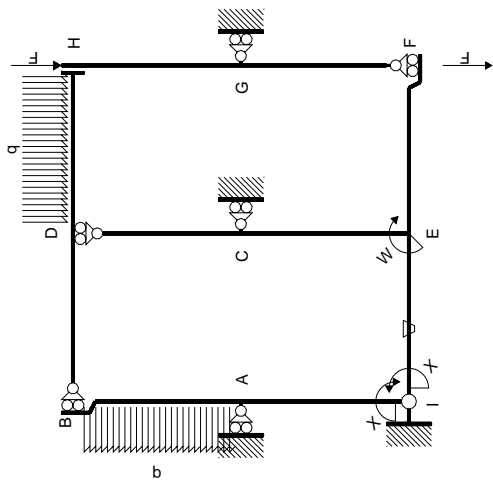


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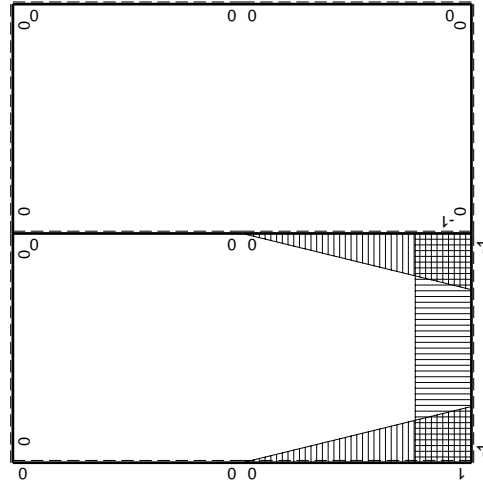


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

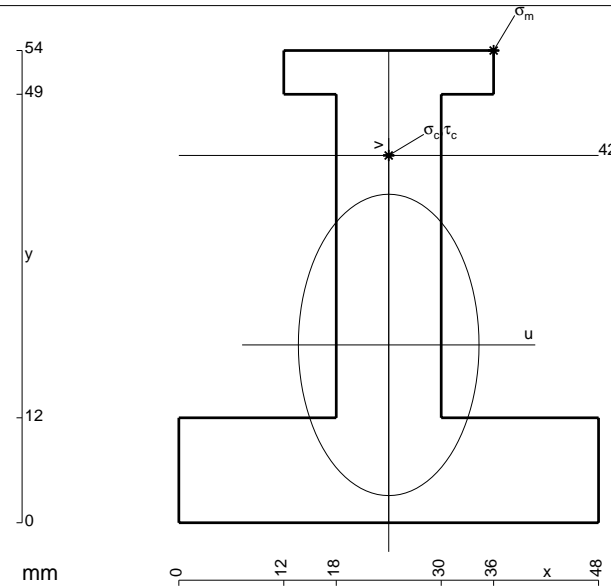
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

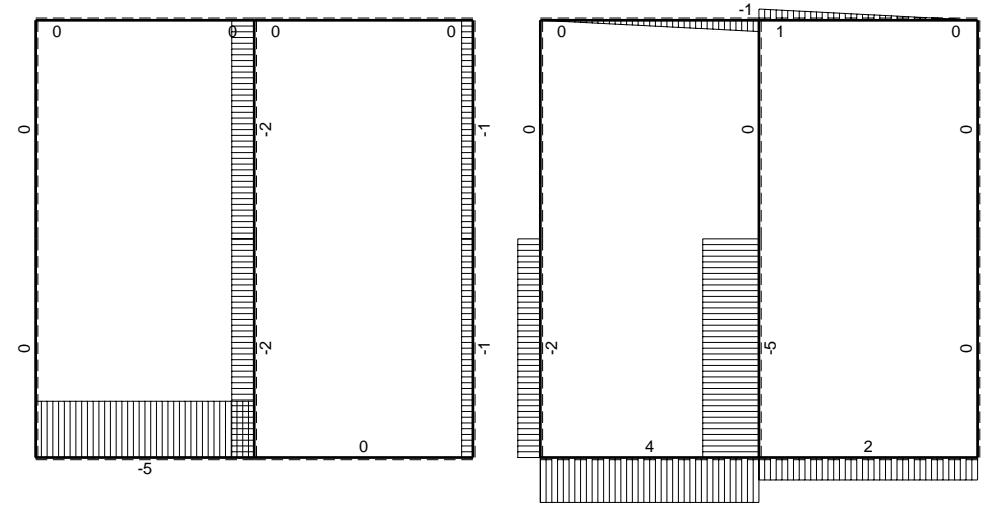
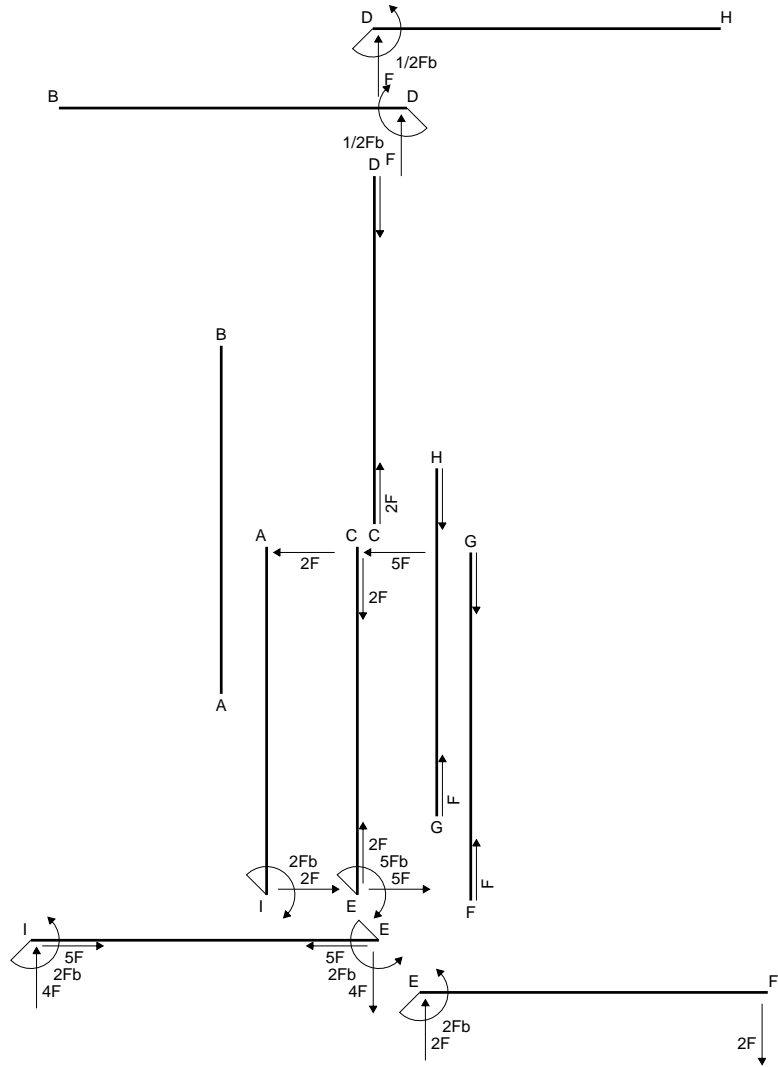
$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

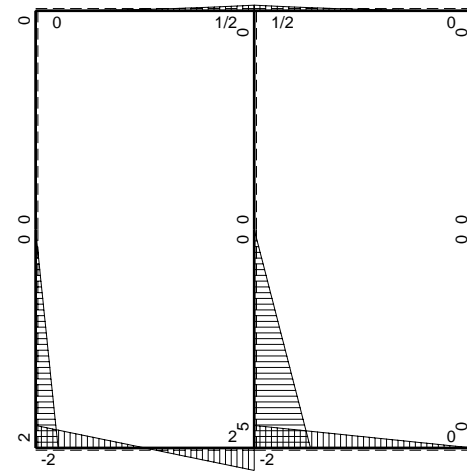


- A = 1140. mm²
- J_u = 338607. mm⁴
- J_v = 121680. mm⁴
- y_g = 20.33 mm
- T_y = 3560. N
- M_x = -2100400. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 33.67 mm
- σ_m = -Mv/J_u = 208.8 N/mm²
- x_c = 24. mm
- y_c = 42. mm
- v_c = 21.67 mm
- σ_c = -Mv/J_u = 134.4 N/mm²
- τ_c = 5.129 N/mm²
- σ_q = √σ²+3τ² = 134.7 N/mm²
- S = 5854. mm³

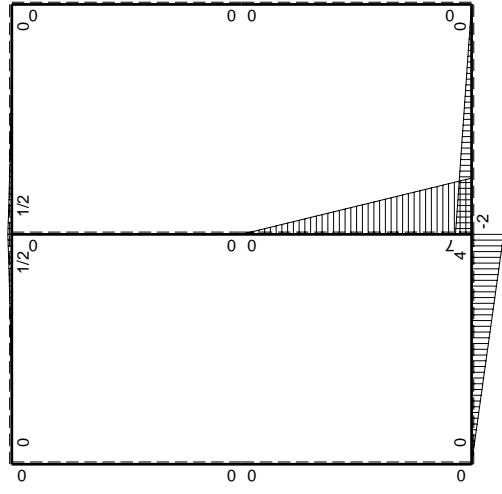
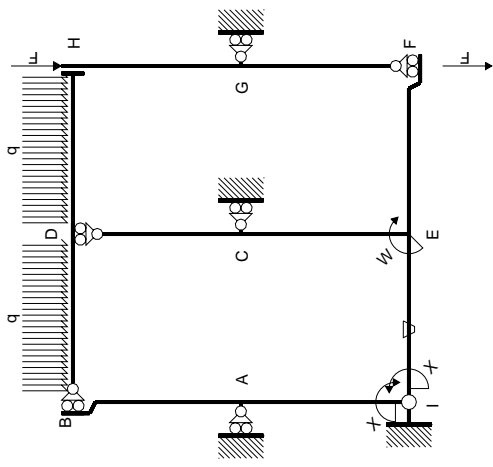


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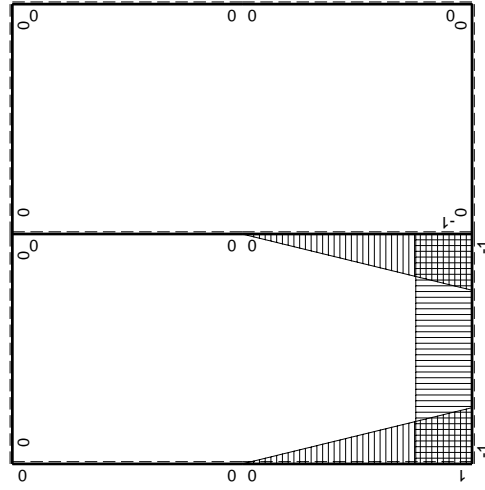


⊕ (+) ⊖ (-) F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$7Fb-7Fx$	0	$-7Fb+14Fx-7Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-7Fx$	0	$-7Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-10/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

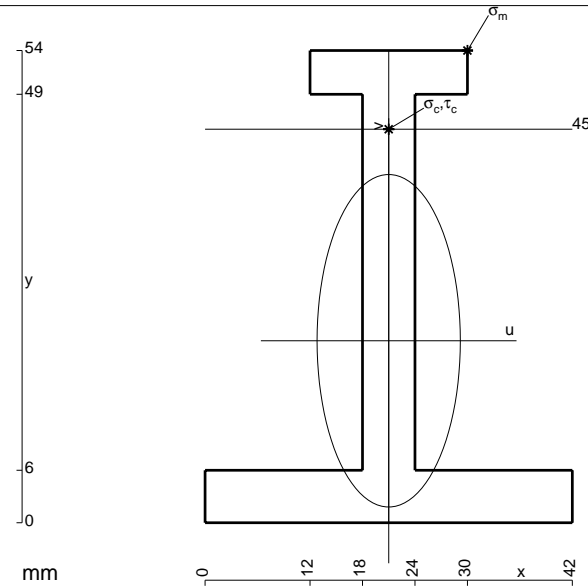
$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-7 + 14x/b - 7x^2/b^2) Fb 1/EJ dx = [-7x + 7x^2/b - 7/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-7b + 7b - 7/3 b) Fb 1/EJ = -7/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7x^2/b^2) Fb 1/EJ dx = [-7/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-7/3 b) Fb 1/EJ = -7/3 Fb^2/EJ$$



$$A = 600. \text{ mm}^2$$

$$J_u = 216946. \text{ mm}^4$$

$$J_v = 40248. \text{ mm}^4$$

$$y_g = 20.81 \text{ mm}$$

$$T_y = 2240. \text{ N}$$

$$M_x = -1433600. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 33.19 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.3 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 45. \text{ mm}$$

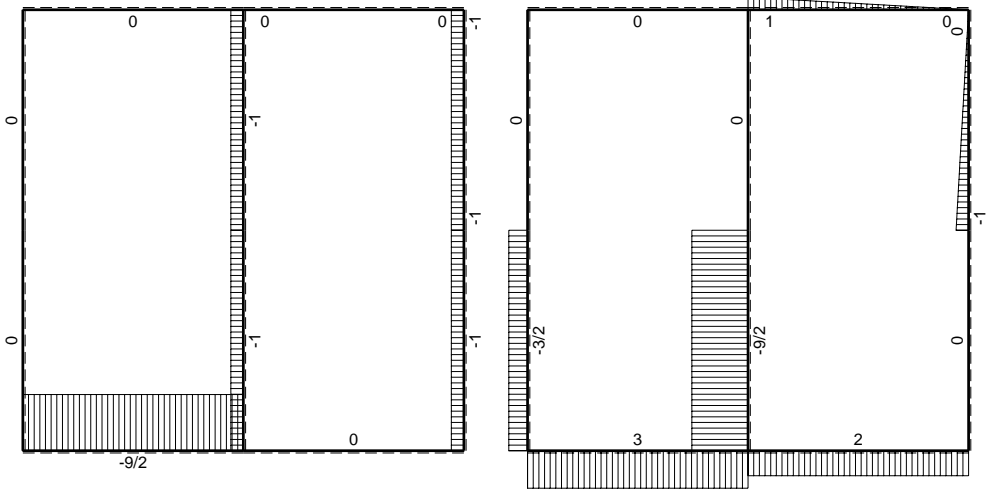
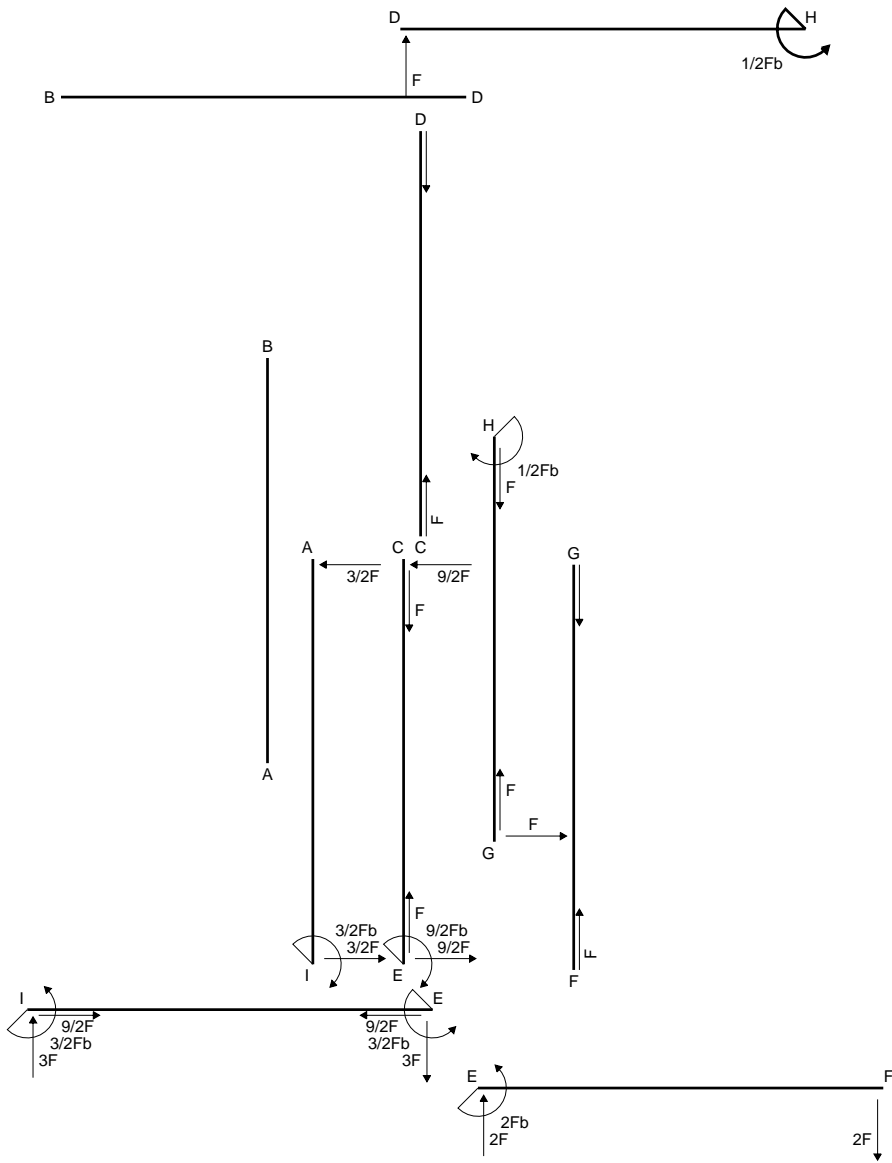
$$v_c = 24.19 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 159.9 \text{ N/mm}^2$$

$$\tau_c = 5.835 \text{ N/mm}^2$$

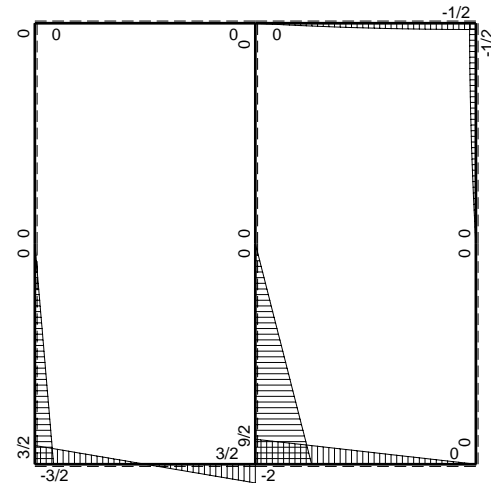
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 160.2 \text{ N/mm}^2$$

$$S = 3391. \text{ mm}^3$$

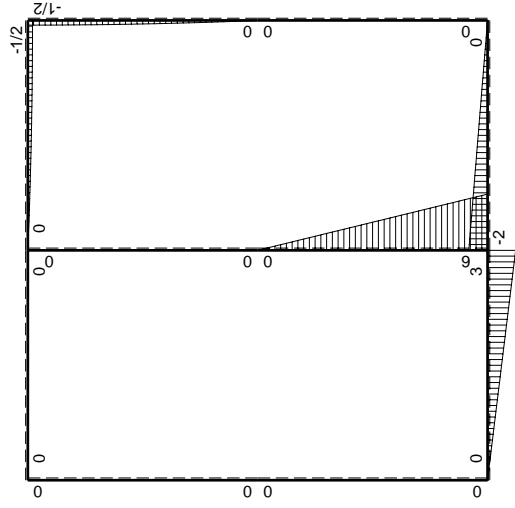
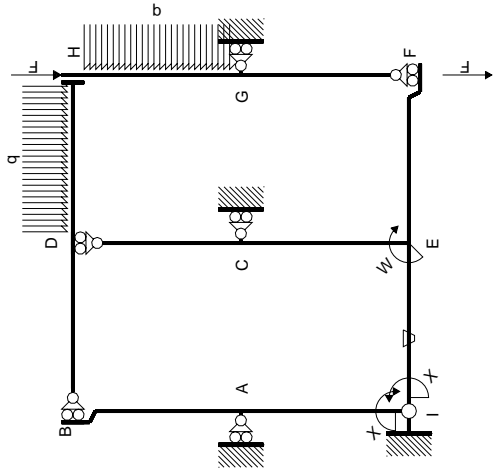


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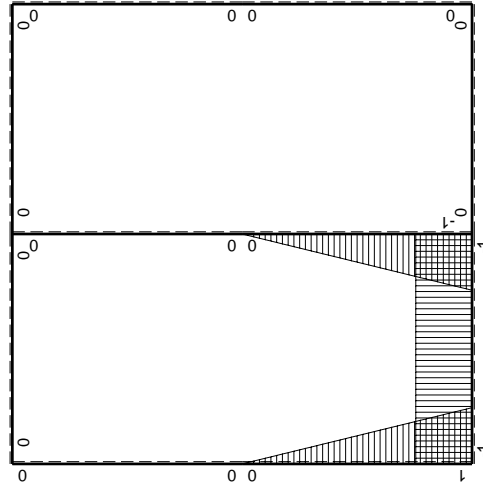


⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

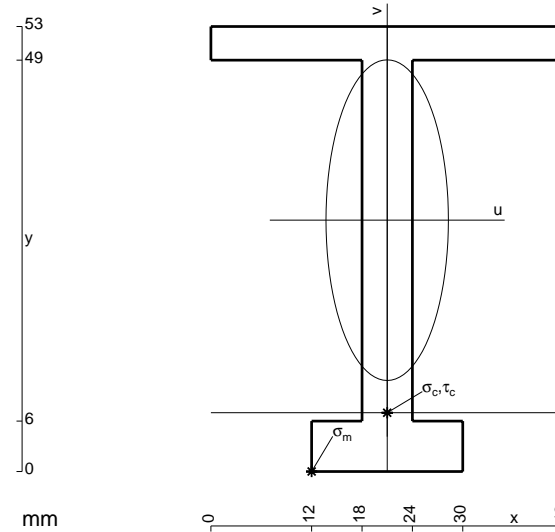
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

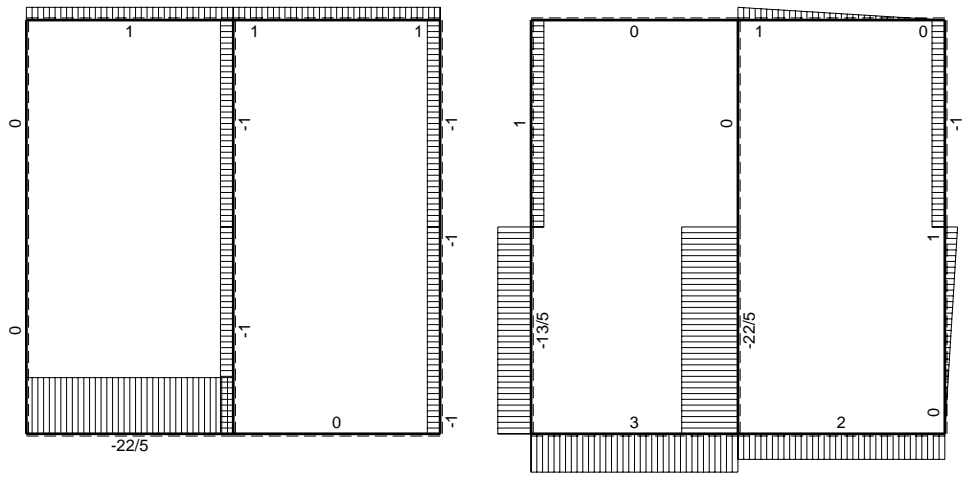
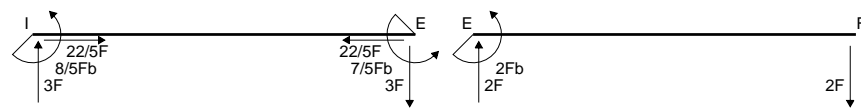
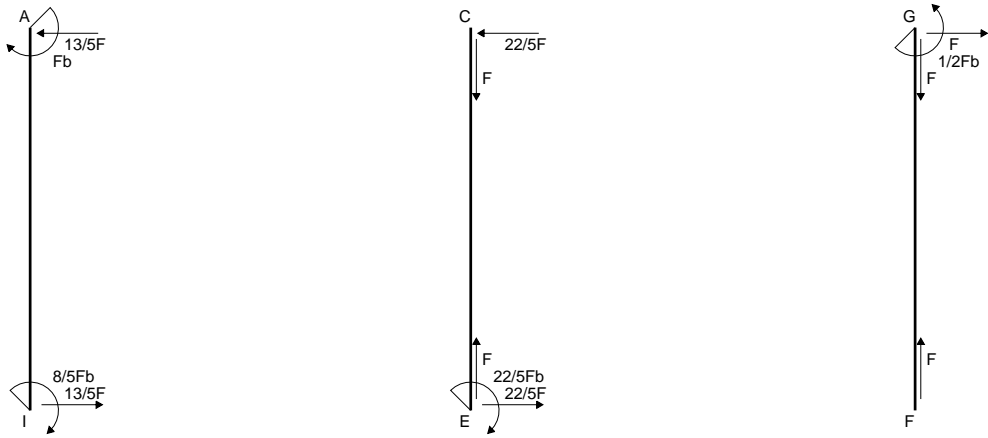
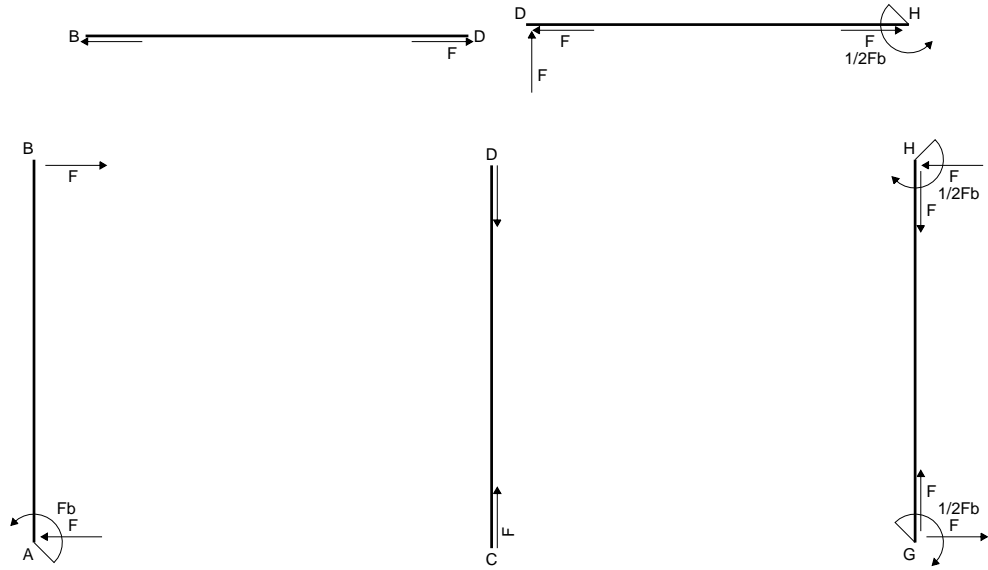
$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

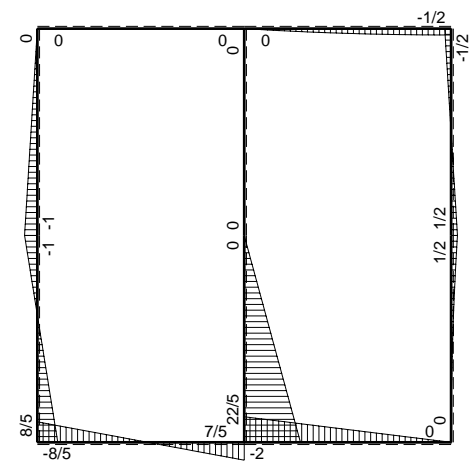


- A = 534. mm²
- J_u = 194732. mm⁴
- J_v = 28386. mm⁴
- y_g = 29.94 mm
- T_y = 2200. N
- M_x = -1496000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -29.94 mm
- σ_m = -Mv/J_u = -230. N/mm²
- x_c = 21. mm
- y_c = 7. mm
- v_c = -22.94 mm
- σ_c = -Mv/J_u = -176.2 N/mm²
- τ_c = 5.743 N/mm²
- σ_o = √σ²+3τ² = 176.5 N/mm²
- S = 3050. mm³

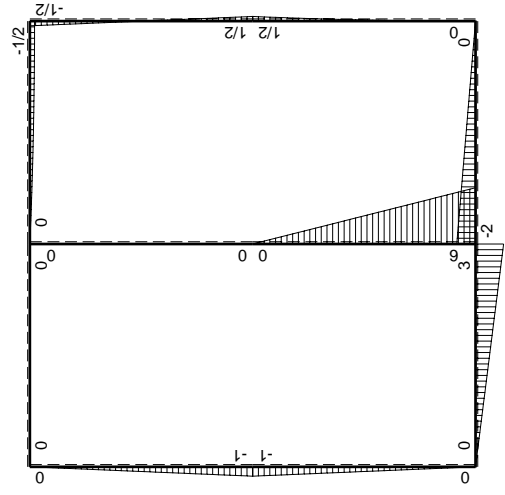
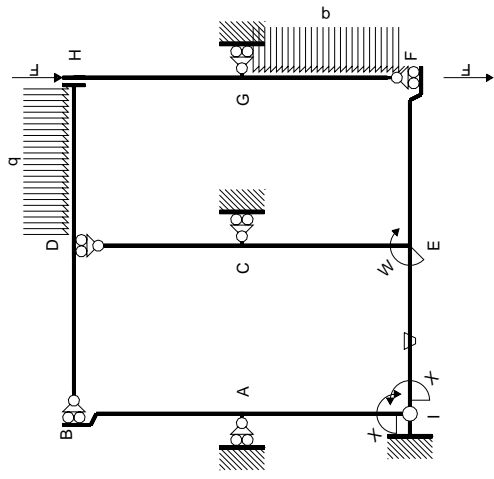


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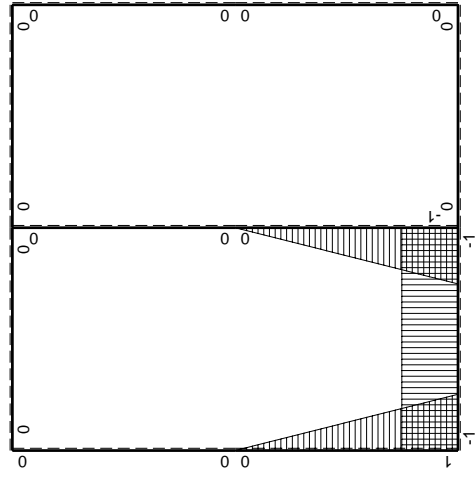


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

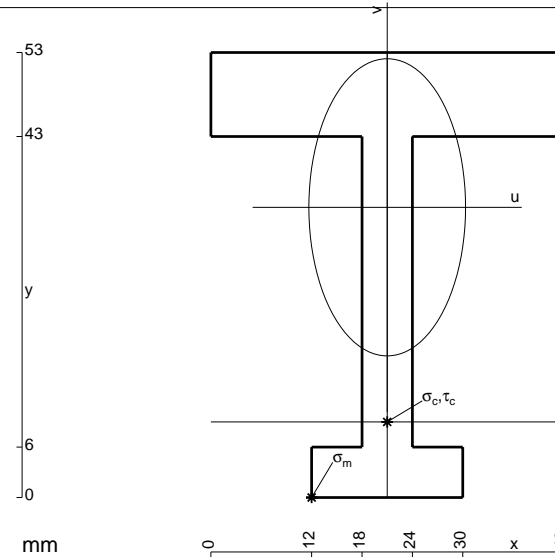
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 750. \text{ mm}^2$$

$$J_u = 235055. \text{ mm}^4$$

$$J_v = 65322. \text{ mm}^4$$

$$y_g = 34.56 \text{ mm}$$

$$T_y = 2200. \text{ N}$$

$$M_x = -1628000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.56 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

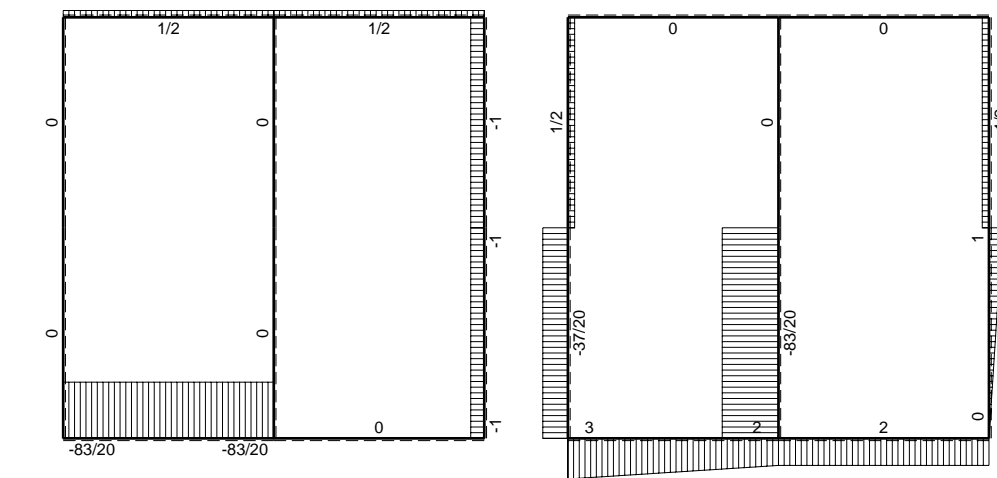
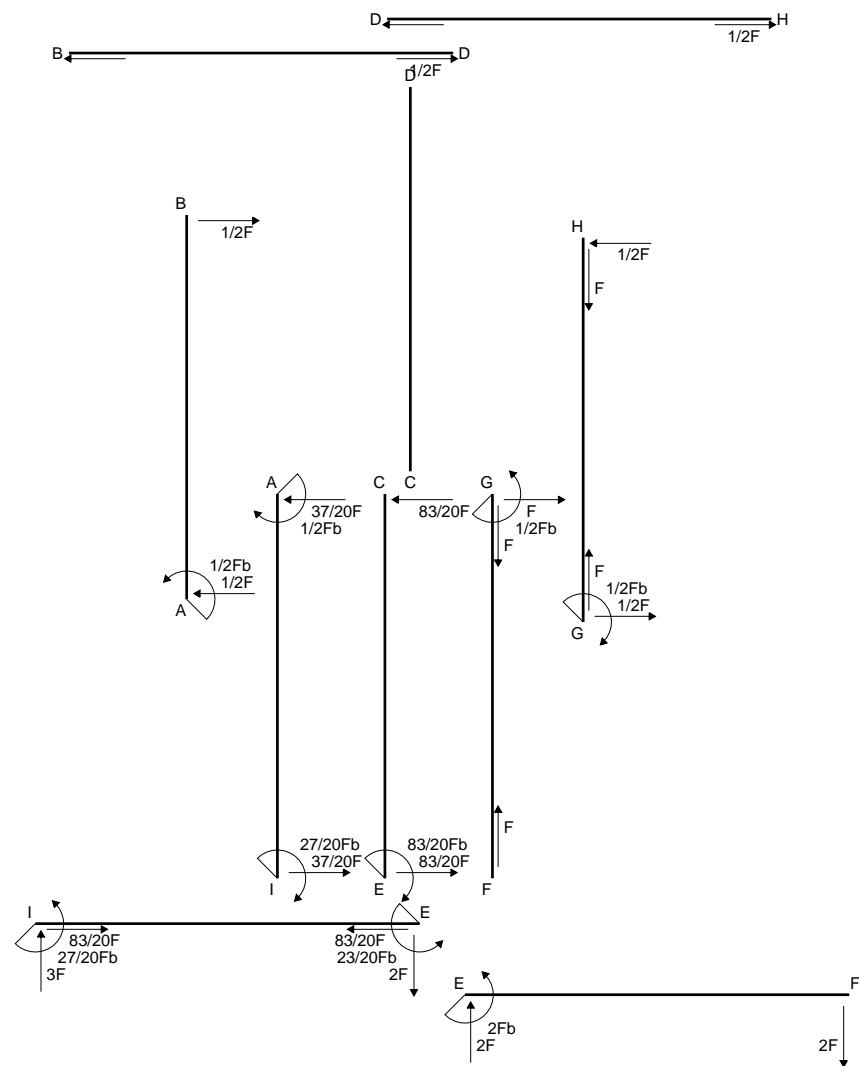
$$v_c = -25.56 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -177.1 \text{ N/mm}^2$$

$$\tau_c = 6.078 \text{ N/mm}^2$$

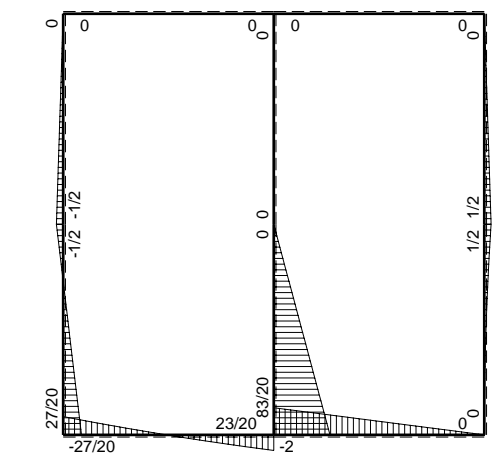
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 177.4 \text{ N/mm}^2$$

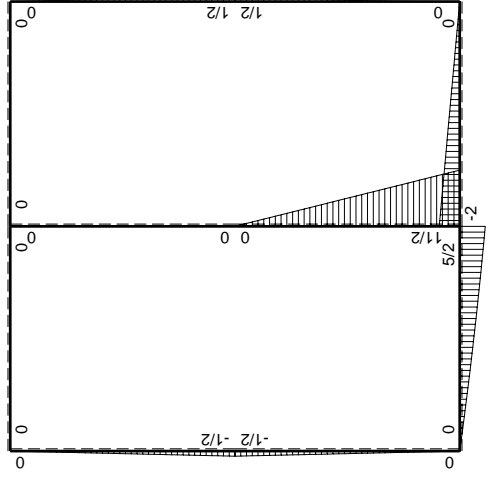
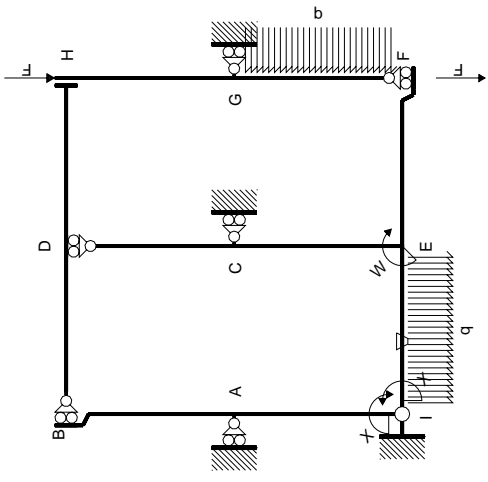
$$S = 3896. \text{ mm}^3$$



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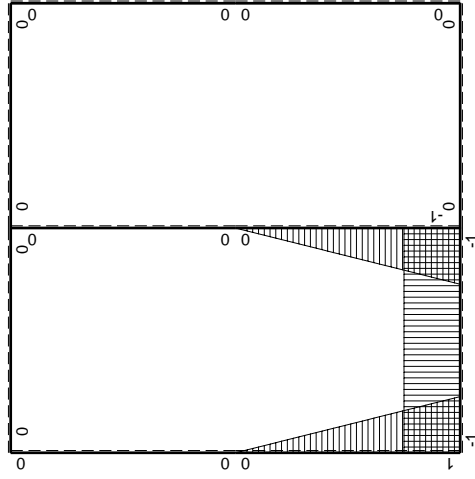
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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$	
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0	
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fx$	0	0	0	0			
HD b	0	0	0	0	0	0	0+0	0	
DH b	0	0	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2			
	totali							$-9/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$27/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

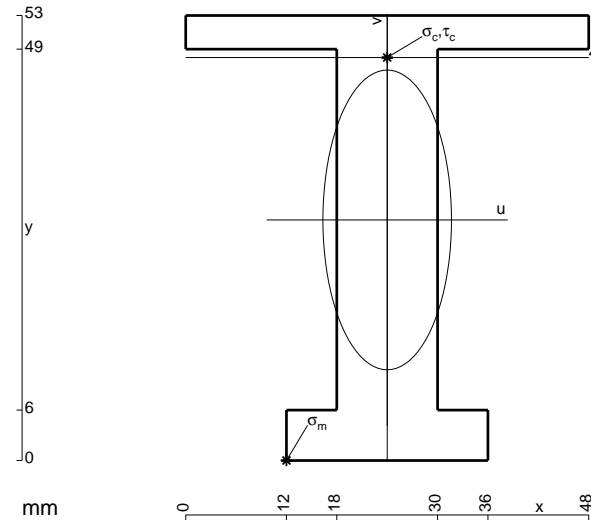
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

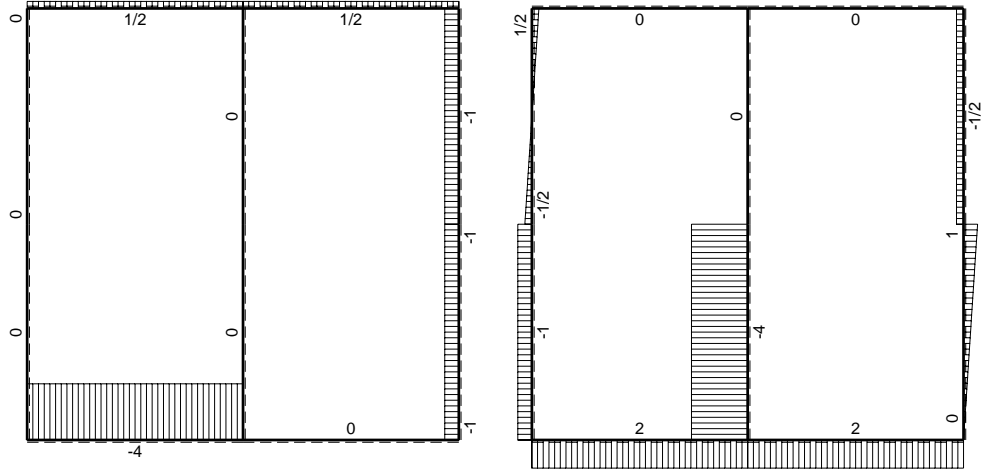
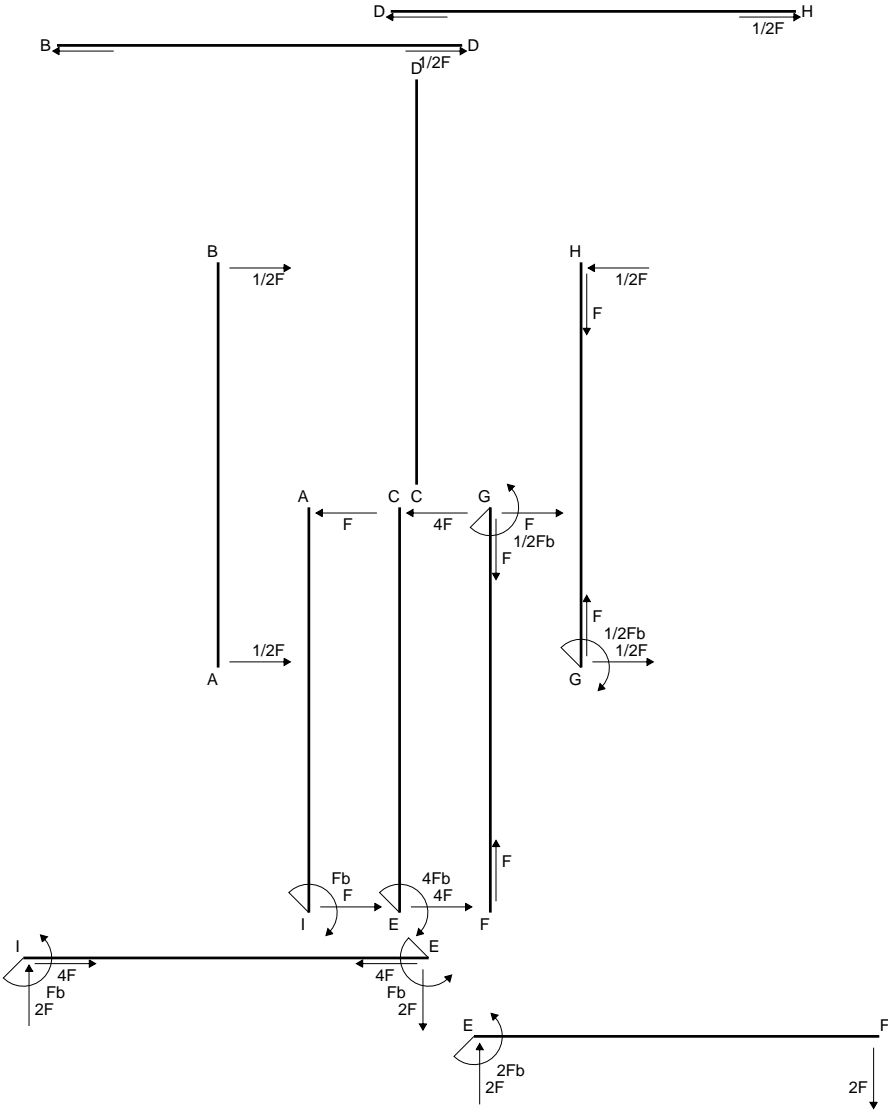
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

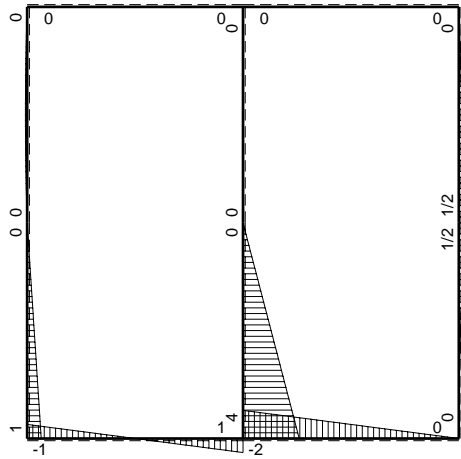


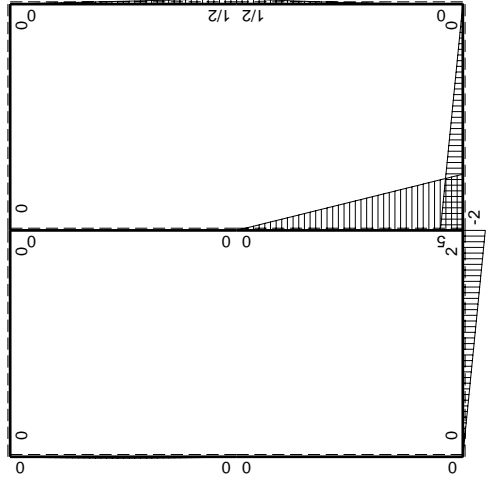
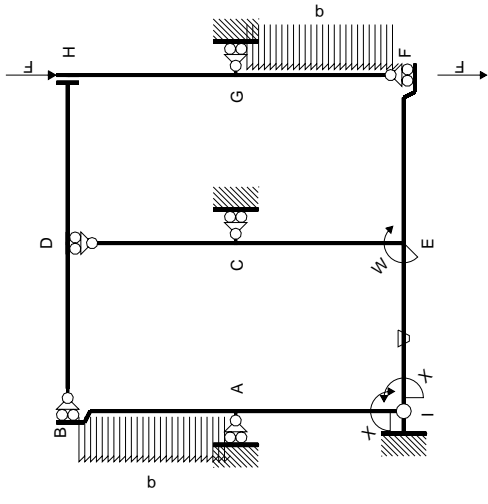
- A = 852. mm²
- J_u = 271527. mm⁴
- J_v = 49968. mm⁴
- y_g = 28.65 mm
- T_y = 2380. N
- M_x = -1880200. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -28.65 mm
- σ_m = -Mv/J_u = -198.4 N/mm²
- x_c = 24. mm
- y_c = 48. mm
- v_c = 19.35 mm
- σ_c = -Mv/J_u = 134. N/mm²
- τ_c = 3.308 N/mm²
- σ_o = √σ²+3τ² = 134.1 N/mm²
- S = 4528. mm³



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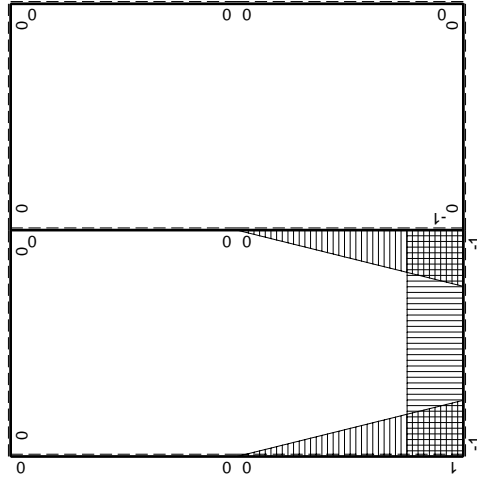
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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

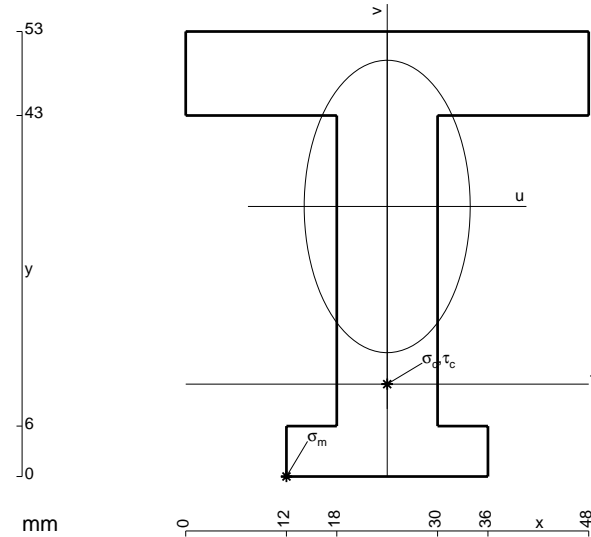
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

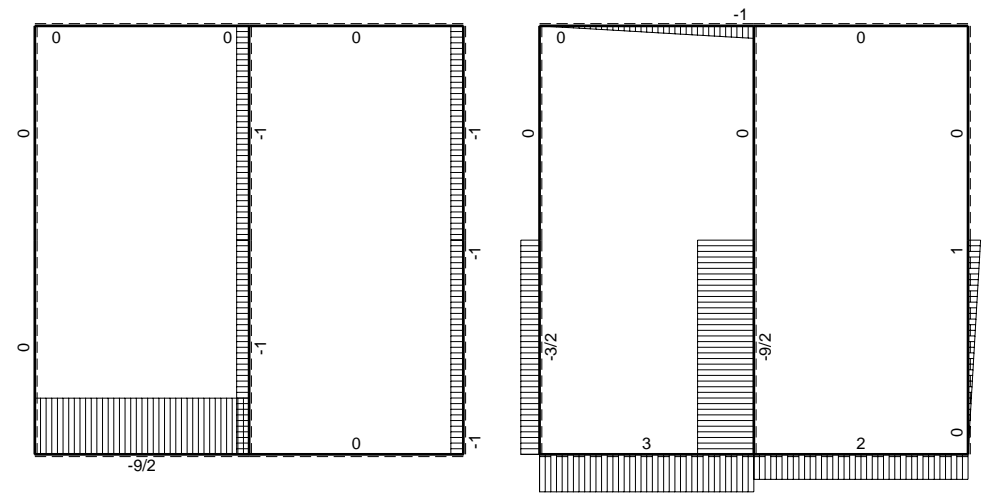
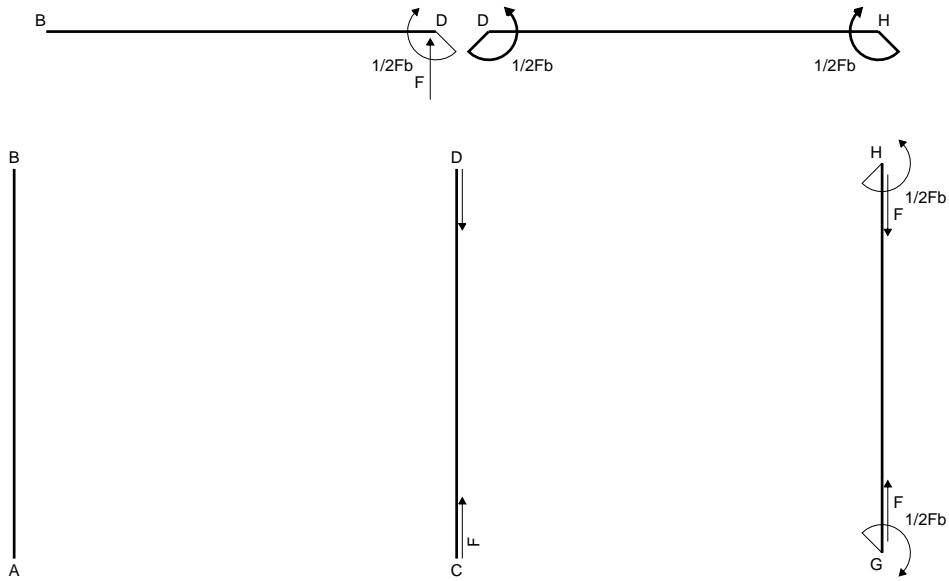
$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

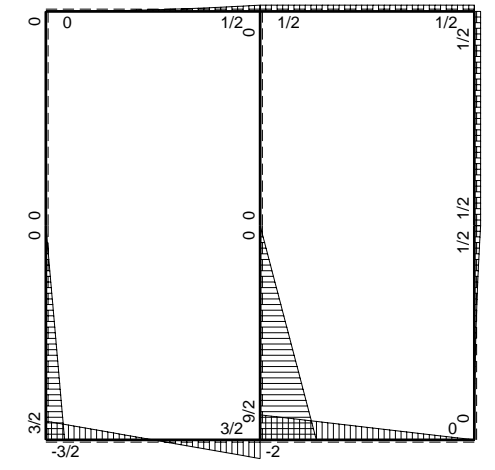
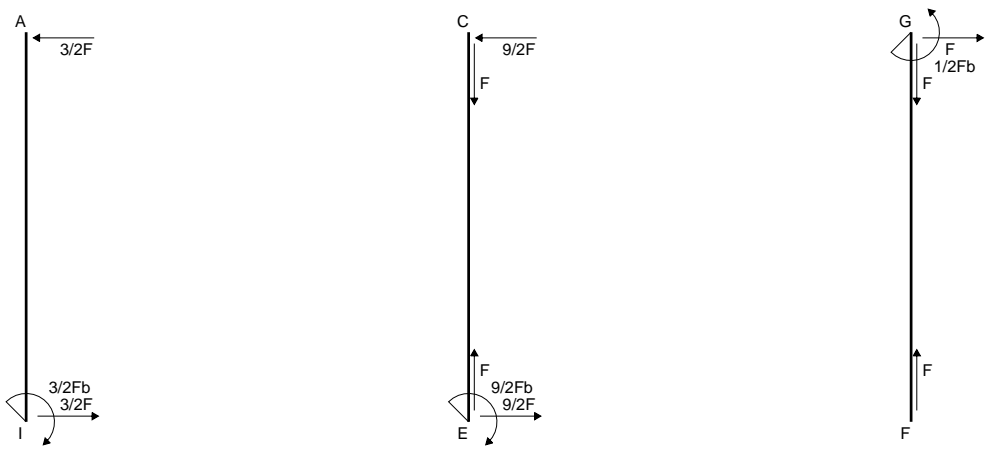


- A = 1068. mm²
- J_u = 324016. mm⁴
- J_v = 104400. mm⁴
- y_g = 32.16 mm
- T_y = 2500. N
- M_x = -2100000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -32.16 mm
- σ_m = -Mv/J_u = -208.5 N/mm²
- x_c = 24. mm
- y_c = 11. mm
- v_c = -21.16 mm
- σ_c = -Mv/J_u = -137.2 N/mm²
- τ_c = 3.613 N/mm²
- σ₀ = √σ_c² + 3τ_c² = 137.3 N/mm²
- S = 5619. mm³

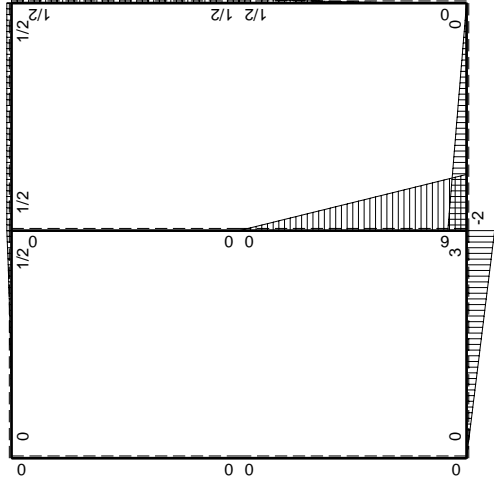
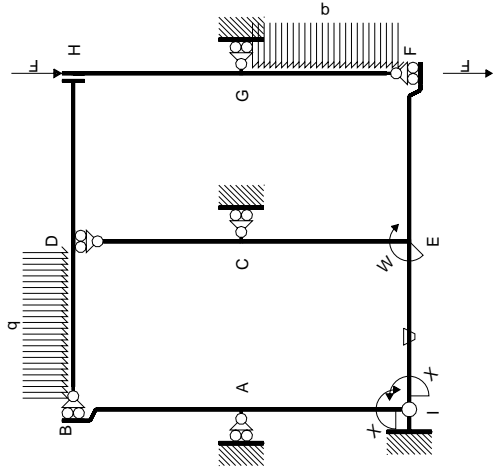


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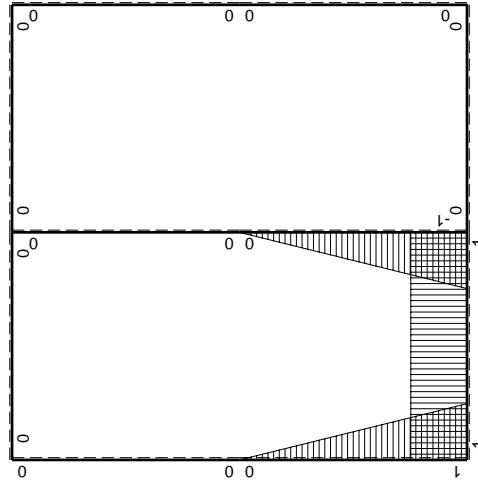


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

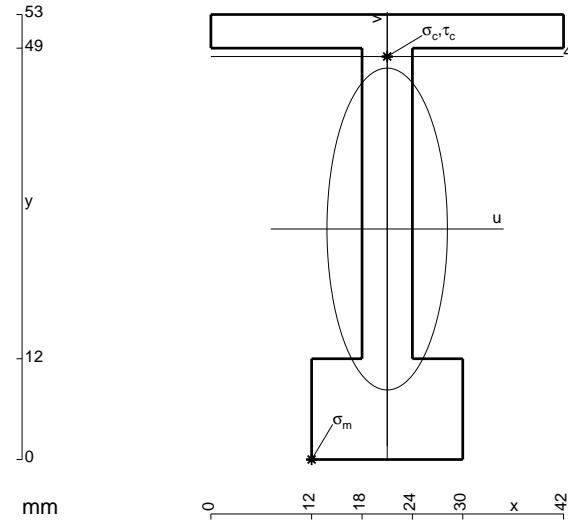
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = [-2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$



$$A = 606. \text{ mm}^2$$

$$J_u = 222763. \text{ mm}^4$$

$$J_v = 31194. \text{ mm}^4$$

$$y_g = 27.45 \text{ mm}$$

$$T_y = 1980. \text{ N}$$

$$M_x = -1782000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -27.45 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.6 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 48. \text{ mm}$$

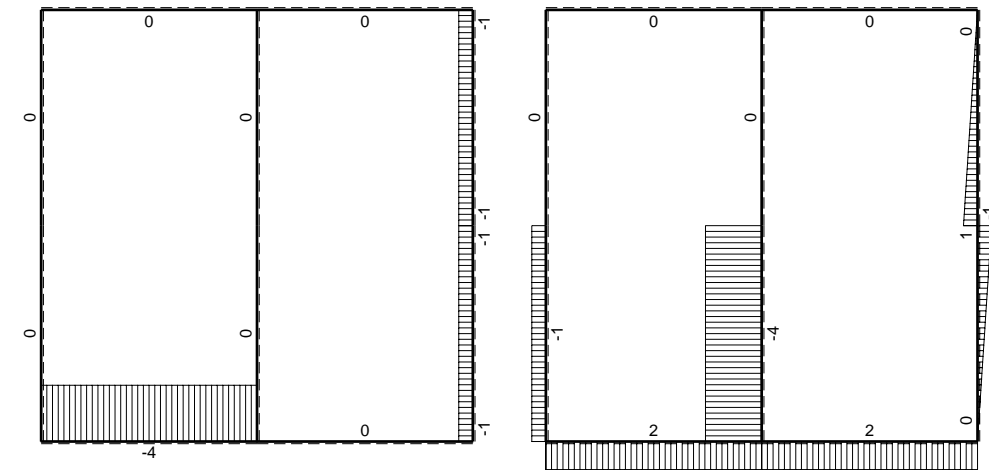
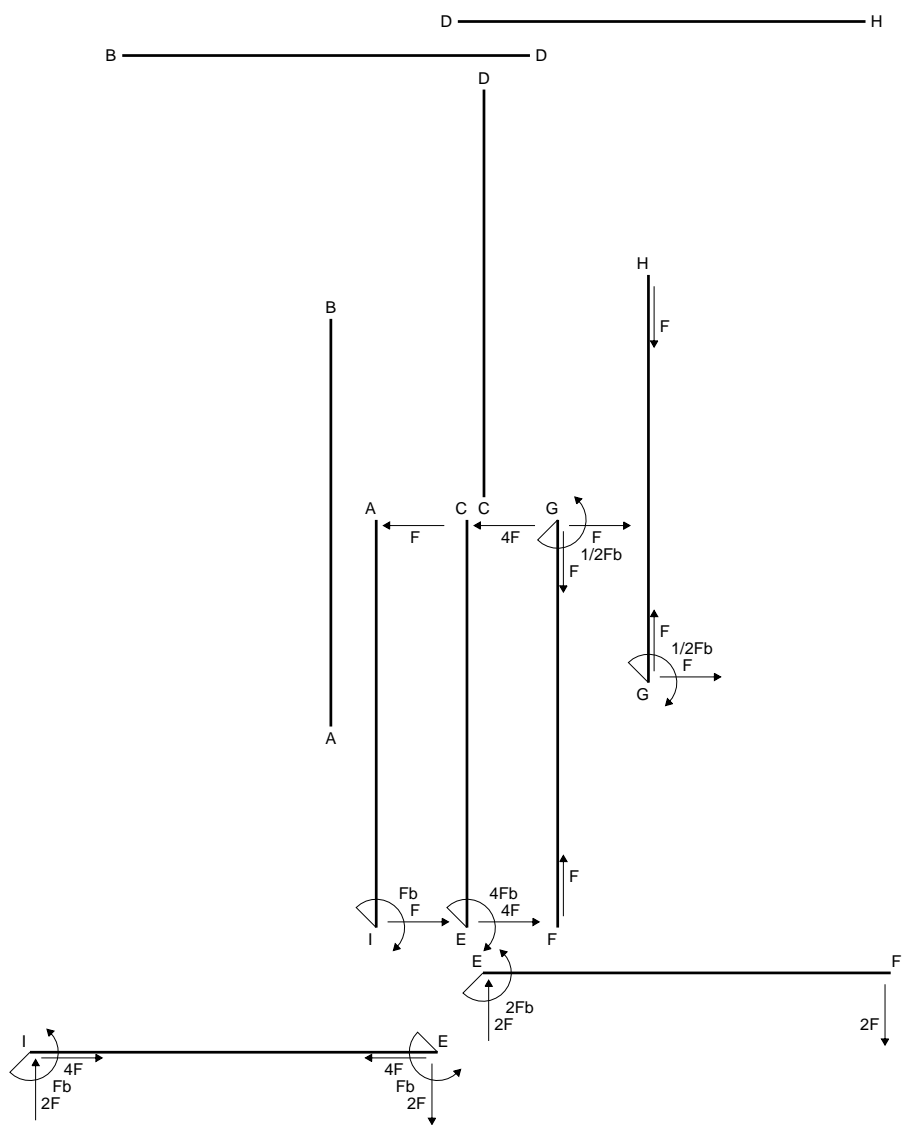
$$v_c = 20.55 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 164.4 \text{ N/mm}^2$$

$$\tau_c = 6.048 \text{ N/mm}^2$$

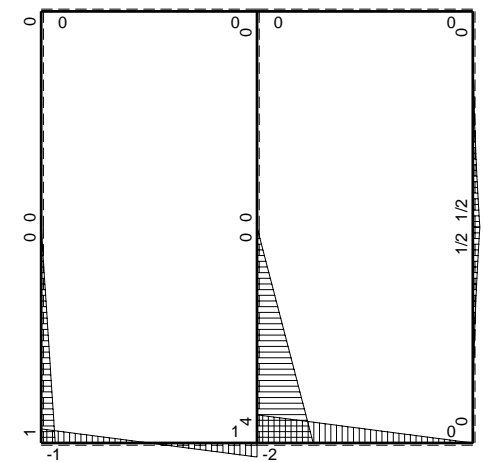
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 164.7 \text{ N/mm}^2$$

$$S = 4083. \text{ mm}^3$$

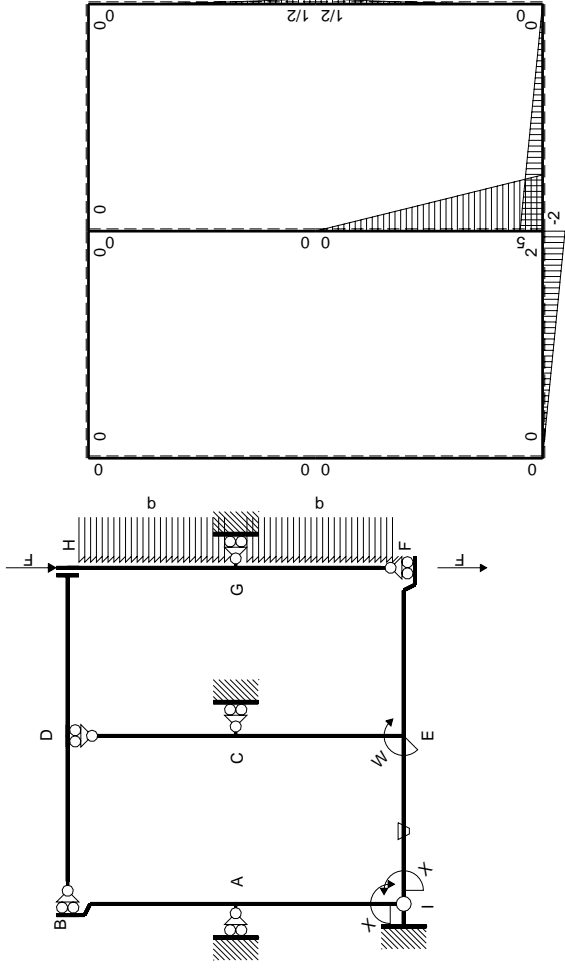


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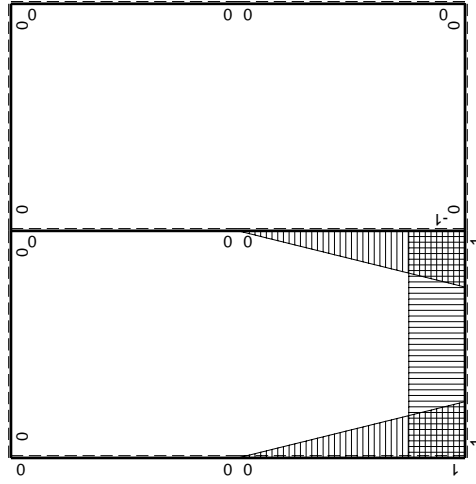


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

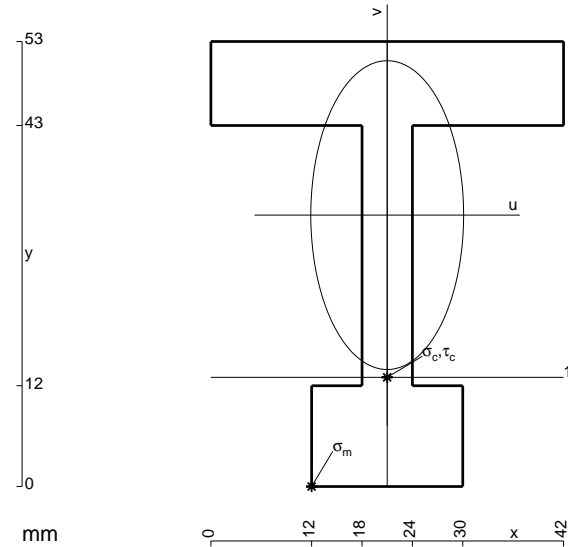
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

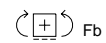
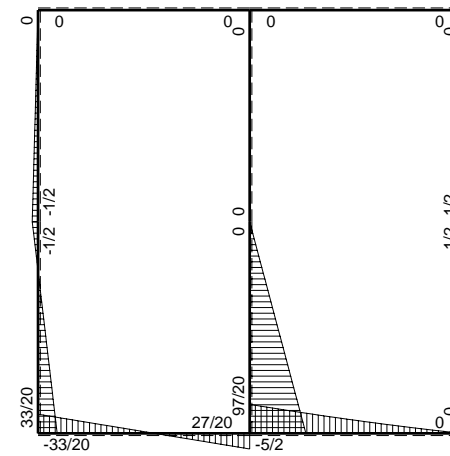
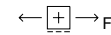
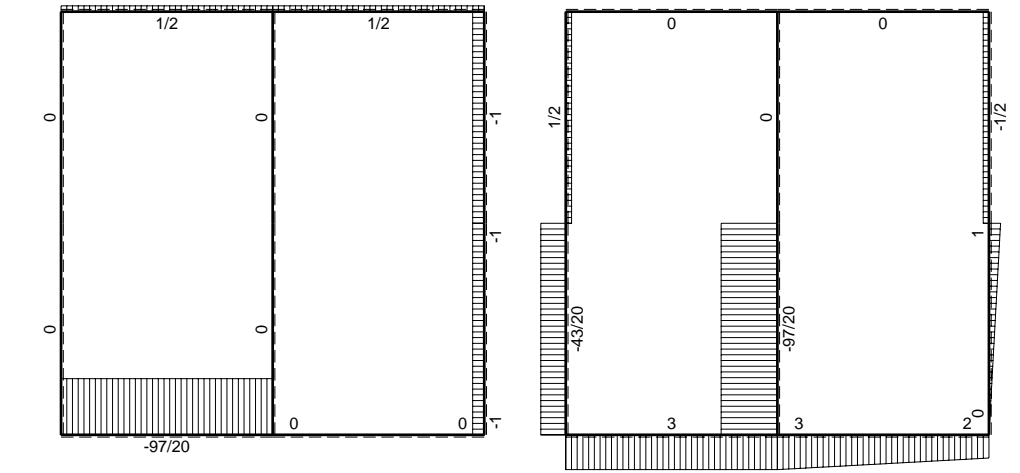
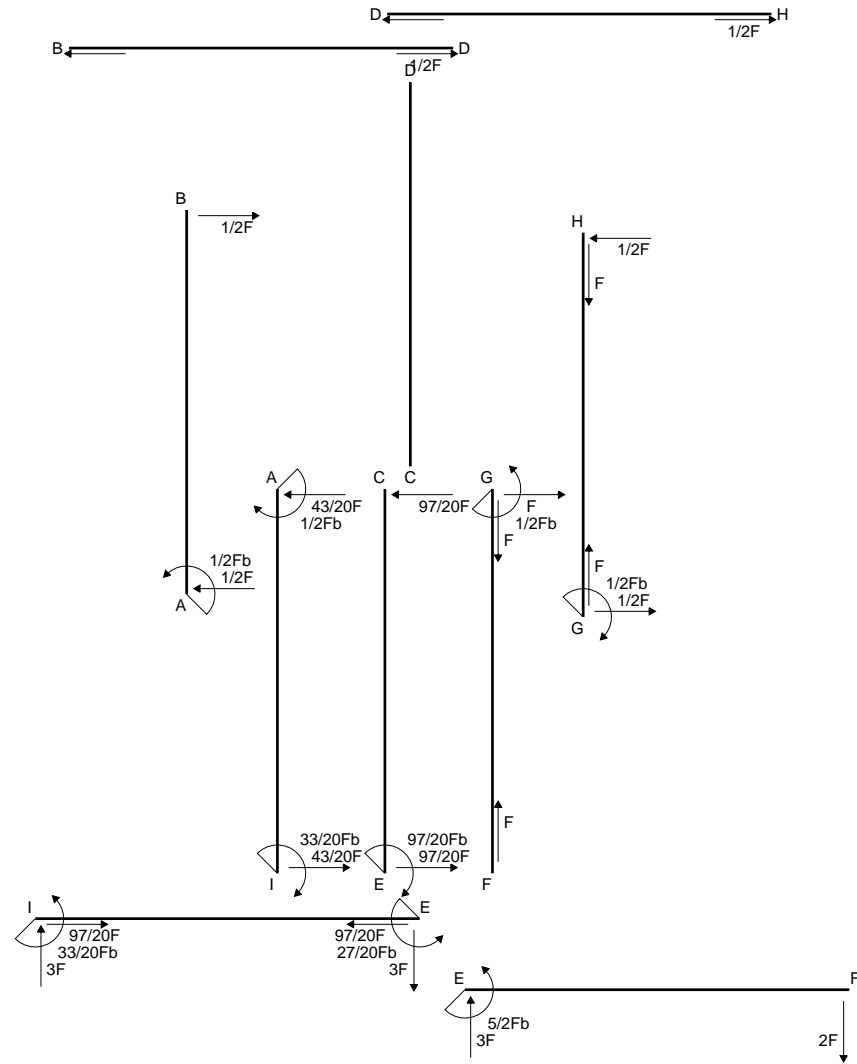
$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

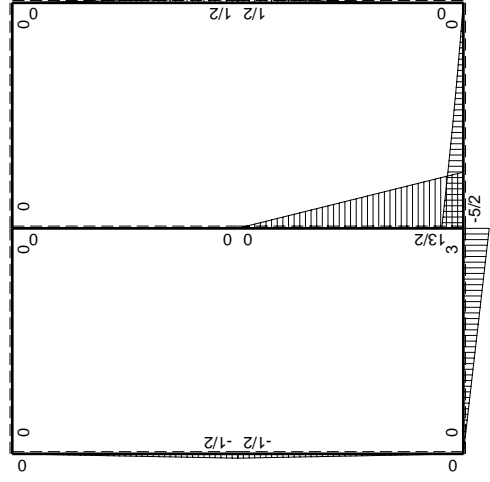
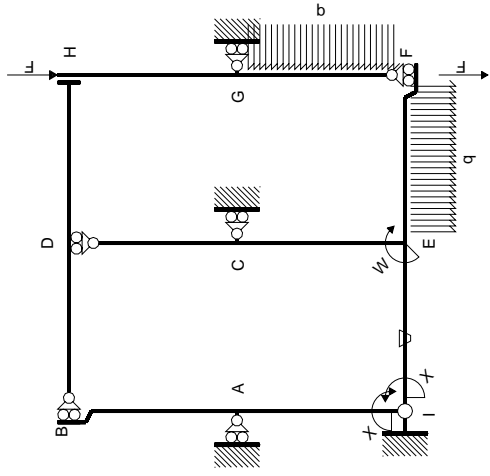
$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$



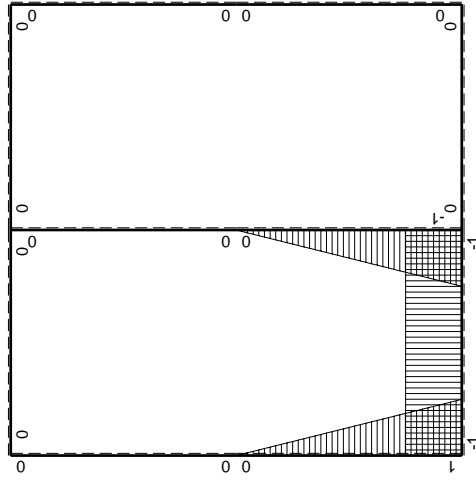
- A = 822. mm²
- J_u = 278203. mm⁴
- J_v = 68130. mm⁴
- y_g = 32.32 mm
- T_y = 2080. N
- M_x = -1976000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -32.32 mm
- σ_m = -Mv/J_u = -229.6 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -19.32 mm
- σ_c = -Mv/J_u = -137.3 N/mm²
- τ_c = 7.234 N/mm²
- σ_o = √σ² + 3τ² = 137.8 N/mm²
- S = 5805. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

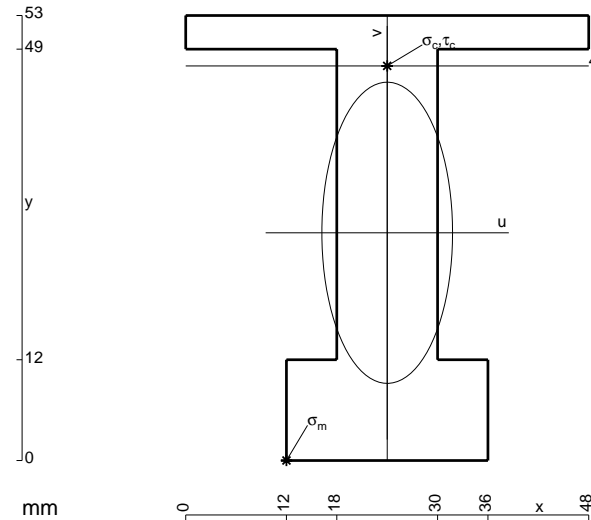
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

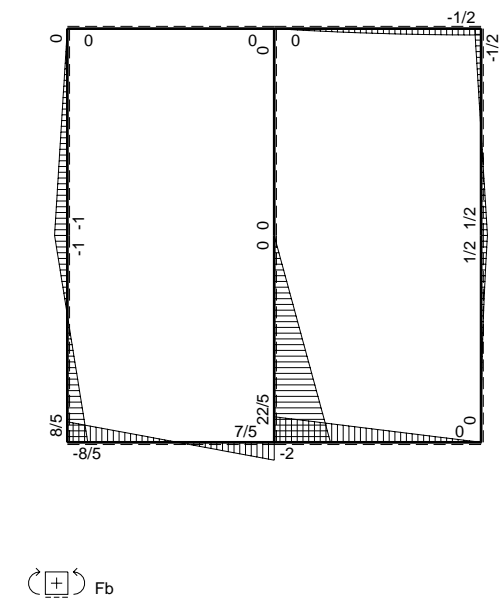
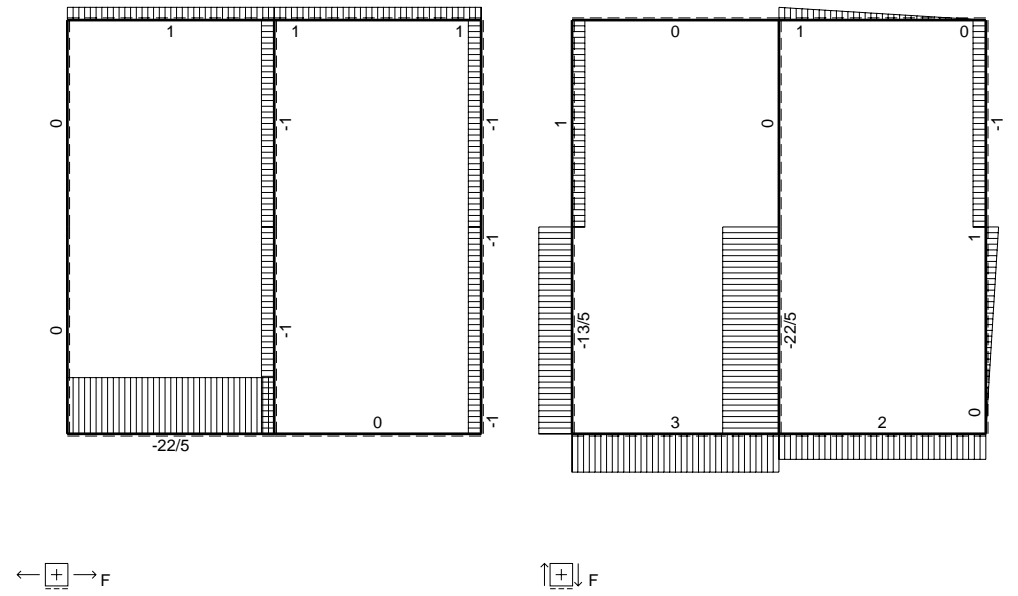
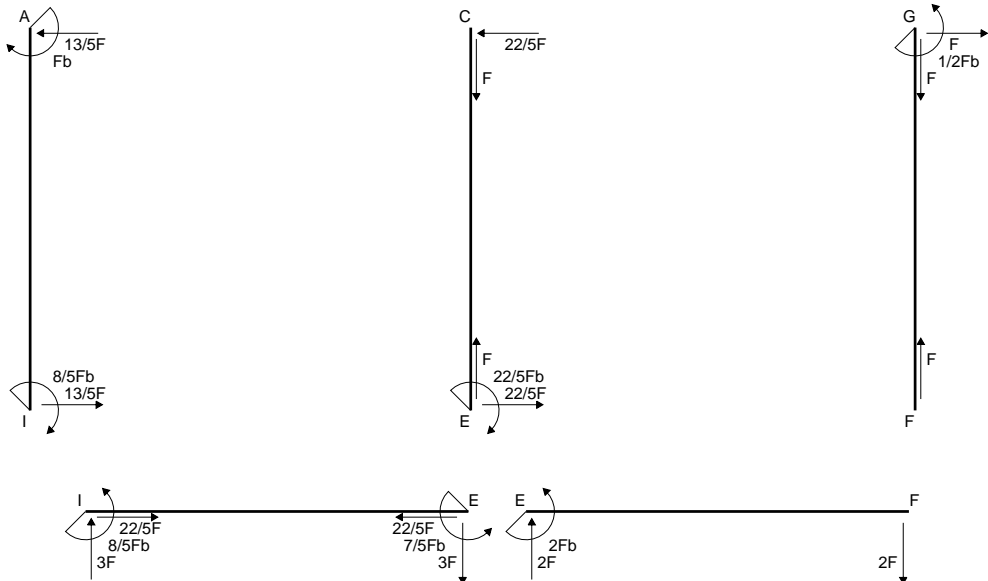
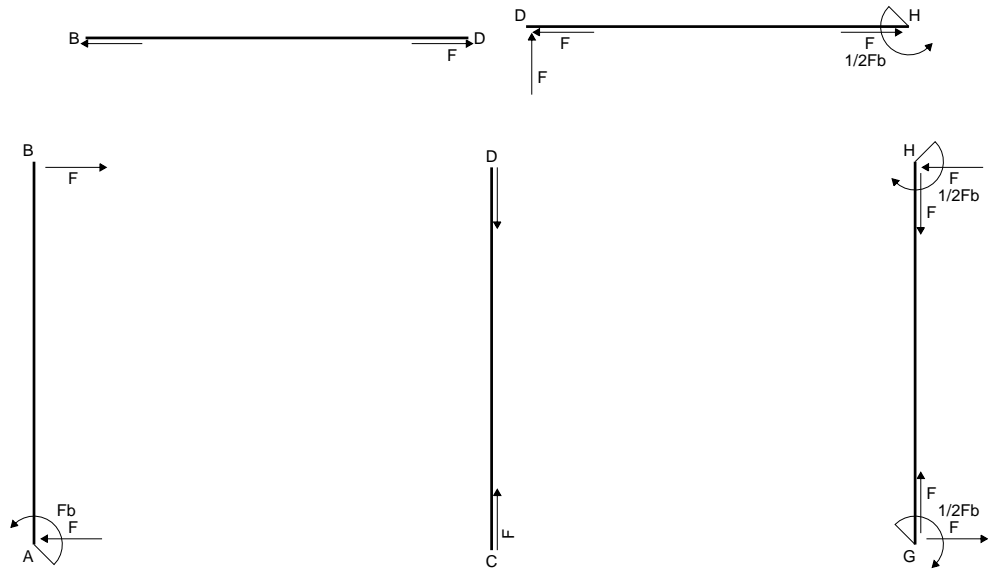
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

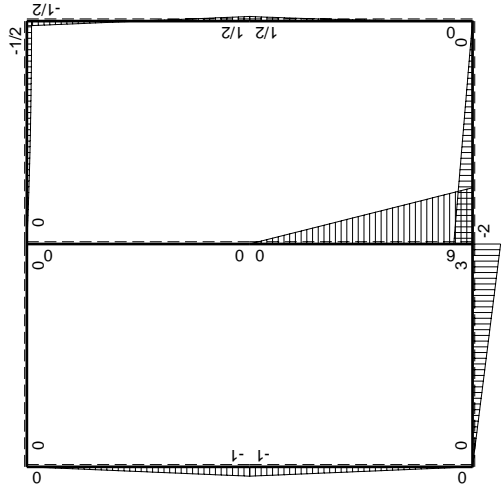
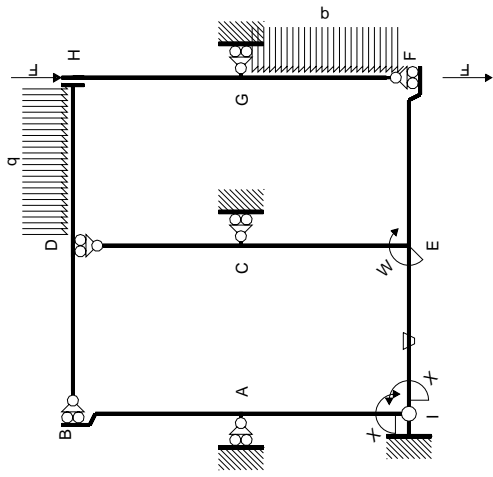
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



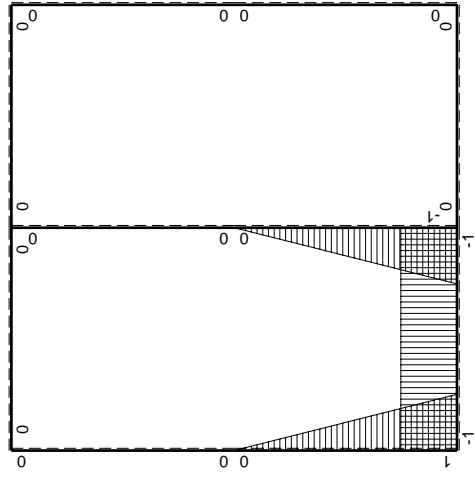
- A = 924. mm²
- J_u = 297390. mm⁴
- J_v = 56016. mm⁴
- y_g = 27.12 mm
- T_y = 3150. N
- M_x = -2625000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -27.12 mm
- σ_m = -Mv/J_u = -239.4 N/mm²
- x_c = 24. mm
- y_c = 47. mm
- v_c = 19.88 mm
- σ_c = -Mv/J_u = 175.4 N/mm²
- τ_c = 4.489 N/mm²
- σ_o = √σ²+3τ² = 175.6 N/mm²
- S = 5085. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	6Fb-6Fx	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	1/3Xb/EJ
CE b	x/b	-6Fx	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	1/3Xb/EJ
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	5/3Xb/EJ
	iperstatica $X=W_{IE}$						8/5Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

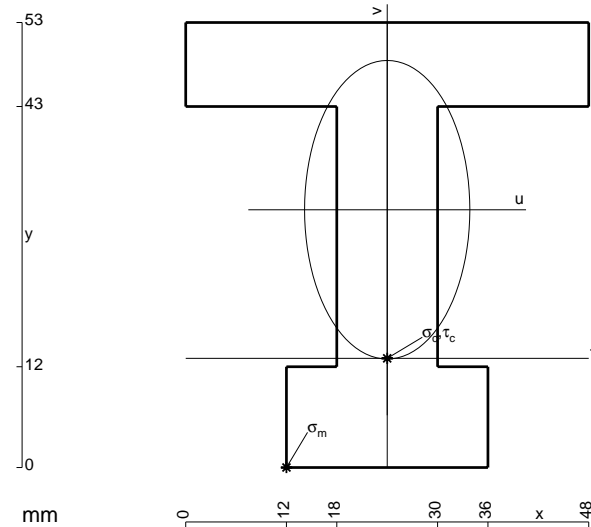
$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

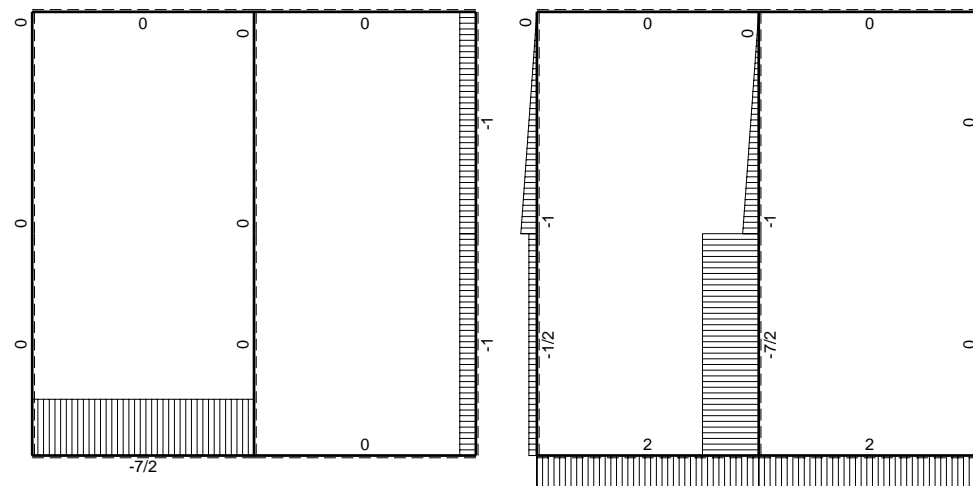
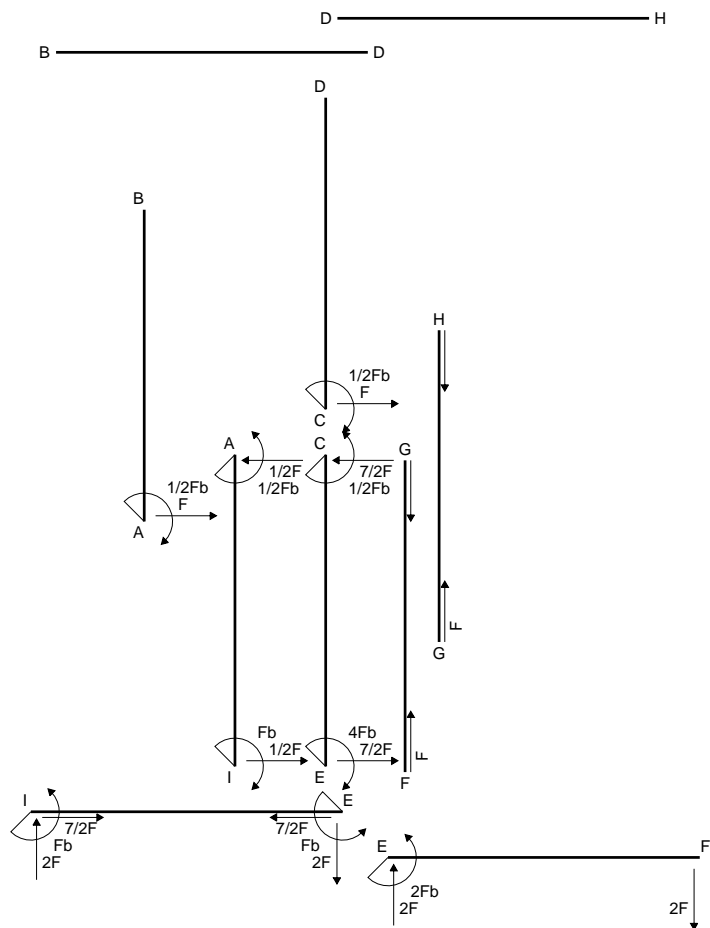
$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

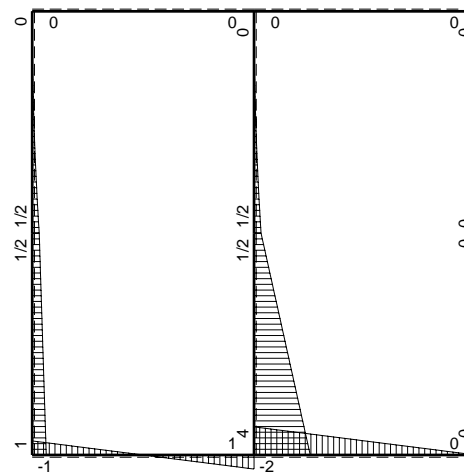


- A = 1140. mm²
- J_u = 360421. mm⁴
- J_v = 110448. mm⁴
- y_g = 30.7 mm
- T_y = 4420. N
- M_x = -2342600. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -30.7 mm
- σ_m = -Mv/J_u = -199.5 N/mm²
- x_c = 24. mm
- y_c = 13. mm
- v_c = -17.7 mm
- σ_c = -Mv/J_u = -115. N/mm²
- τ_c = 7.493 N/mm²
- σ_o = √σ² + 3τ² = 115.8 N/mm²
- S = 7332. mm³

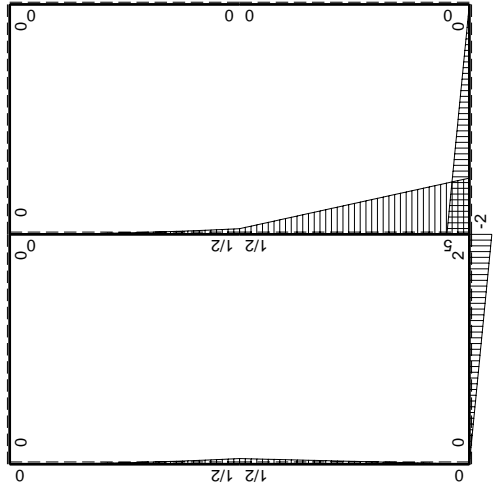
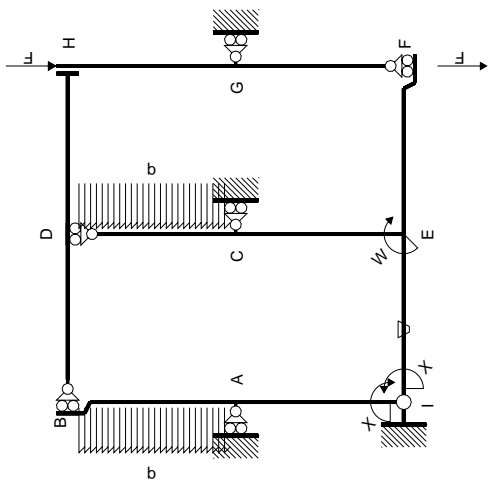


← ⊕ → F

↑ ⊕ ↓ F

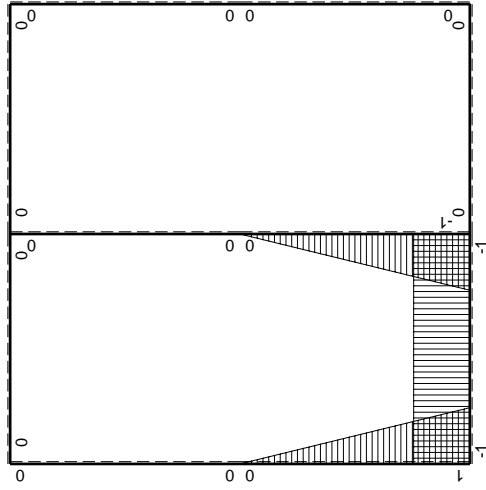


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2qx^2$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

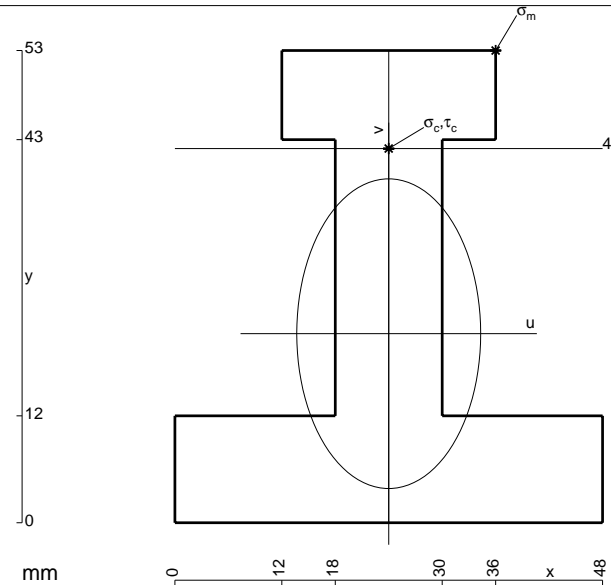
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 1188. \text{ mm}^2$$

$$J_u = 358924. \text{ mm}^4$$

$$J_v = 126576. \text{ mm}^4$$

$$y_g = 21.22 \text{ mm}$$

$$T_y = 4080. \text{ N}$$

$$M_x = -2366400. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 31.78 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.5 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 42. \text{ mm}$$

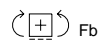
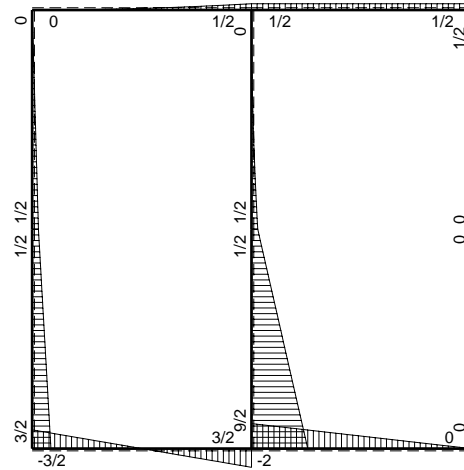
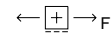
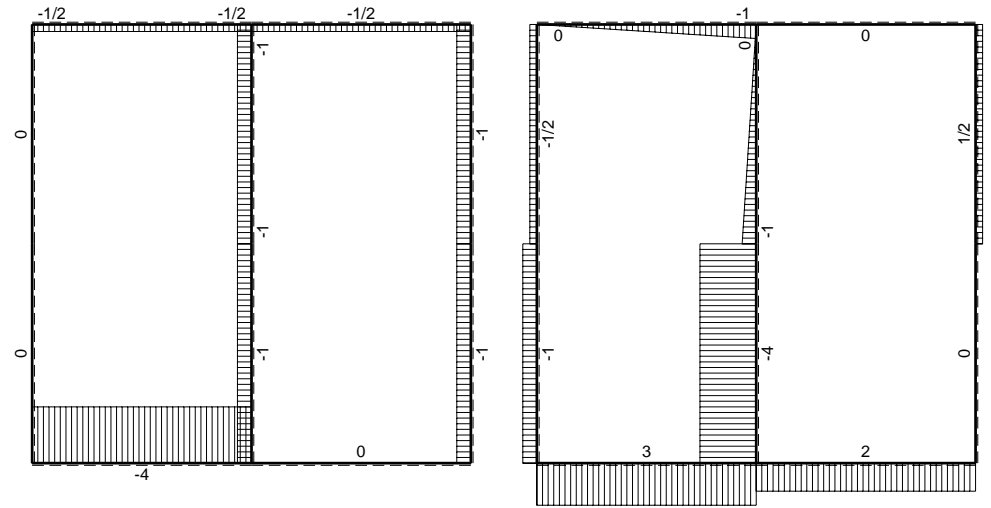
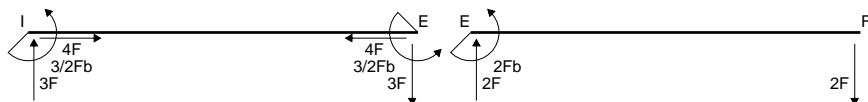
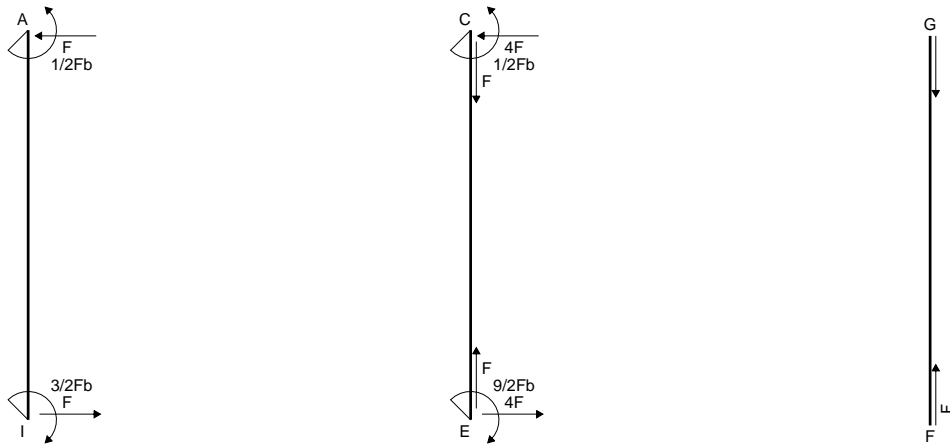
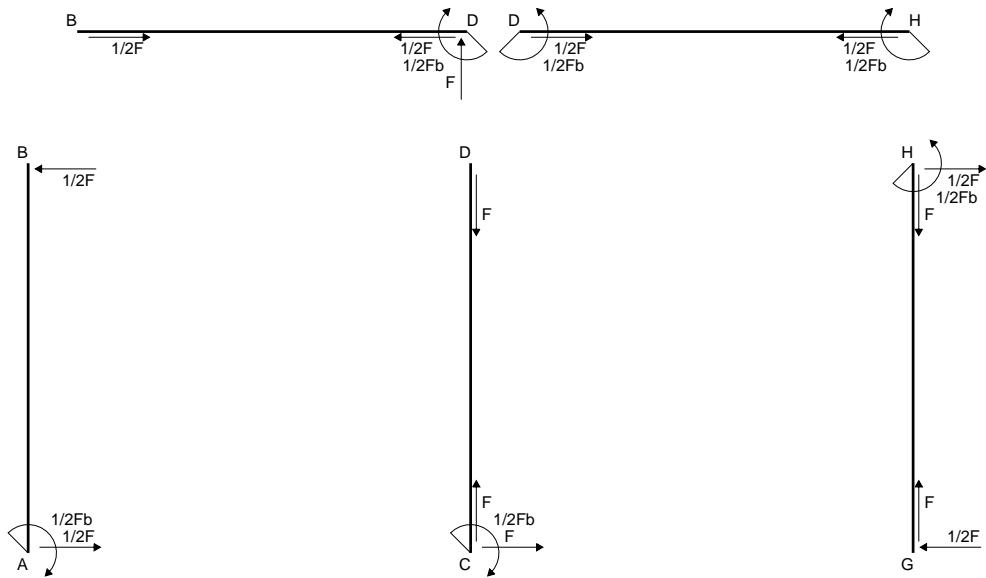
$$v_c = 20.78 \text{ mm}$$

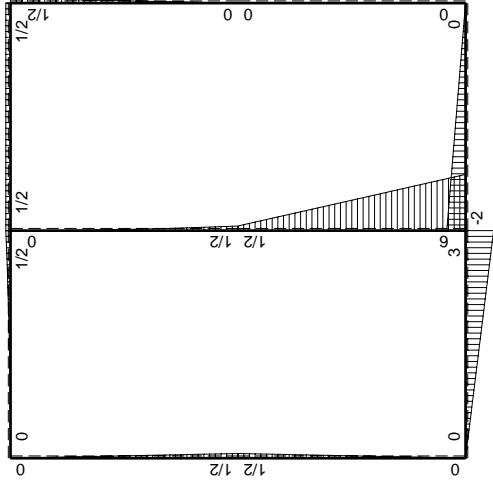
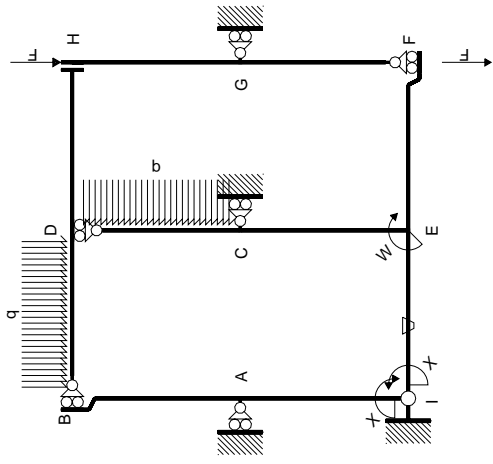
$$\sigma_c = -Mv/J_u = 137. \text{ N/mm}^2$$

$$\tau_c = 6.331 \text{ N/mm}^2$$

$$\sigma_\varphi = \sqrt{\sigma^2 + 3\tau^2} = 137.5 \text{ N/mm}^2$$

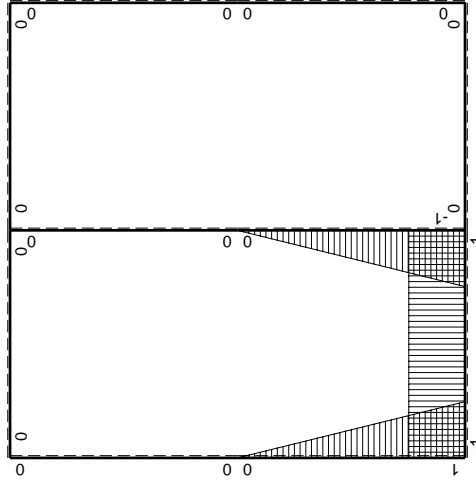
$$S = 6683. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-11/2Fx$	0	$-6Fb+23/2Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-25/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-11/2Fx$	0	$-1/2Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 23/2 x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-6x + 23/4 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 23/4 b - 11/6 b) Fb 1/EJ = -25/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

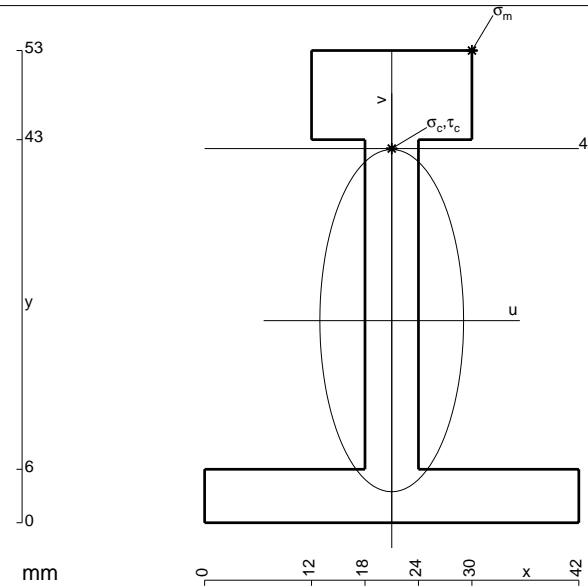
$$= (-1/4 b - 11/6 b) Fb 1/EJ = -25/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$



$$A = 654. \text{ mm}^2$$

$$J_u = 241316. \text{ mm}^4$$

$$J_v = 42570. \text{ mm}^4$$

$$y_g = 22.68 \text{ mm}$$

$$T_y = 2760. \text{ N}$$

$$M_x = -1738800. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 30.32 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 218.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 42. \text{ mm}$$

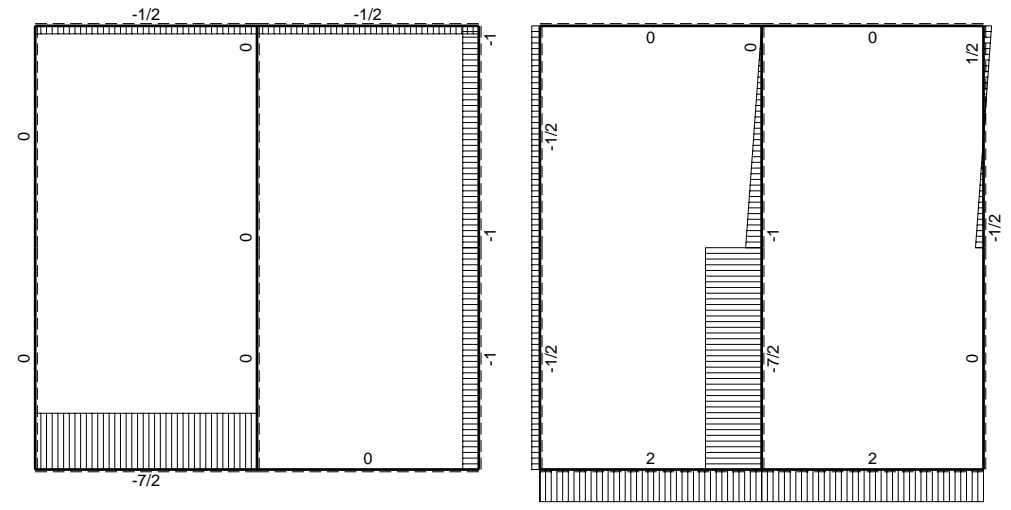
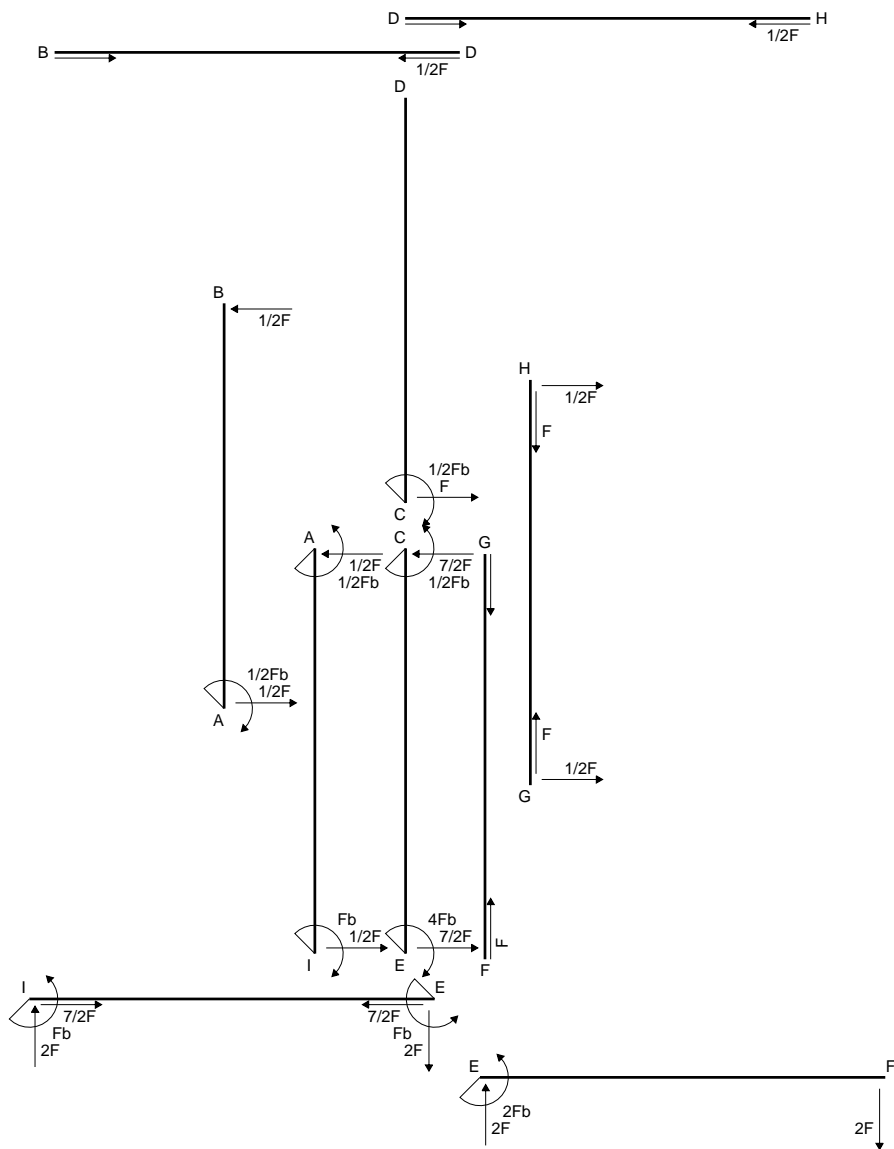
$$v_c = 19.32 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 139.2 \text{ N/mm}^2$$

$$\tau_c = 8.913 \text{ N/mm}^2$$

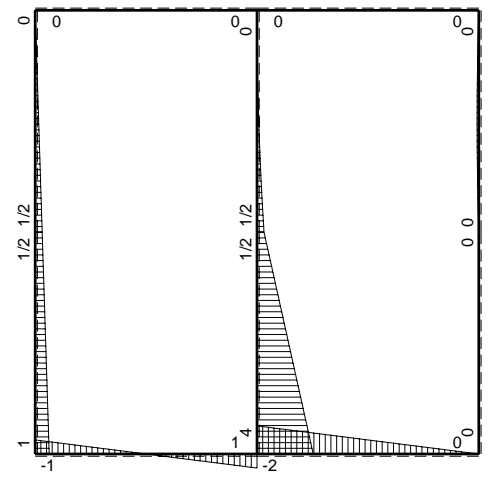
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 140. \text{ N/mm}^2$$

$$S = 4676. \text{ mm}^3$$

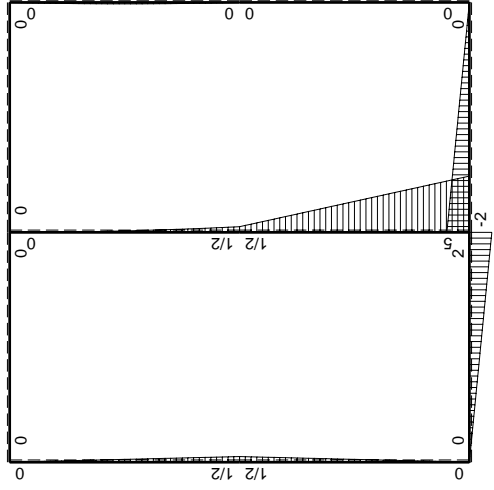
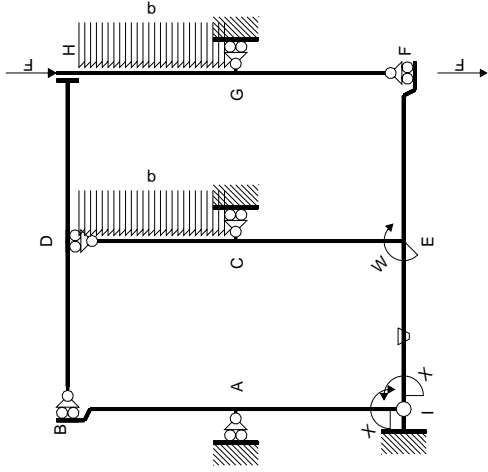


← ⊕ → F

↑ ⊕ ↓ F

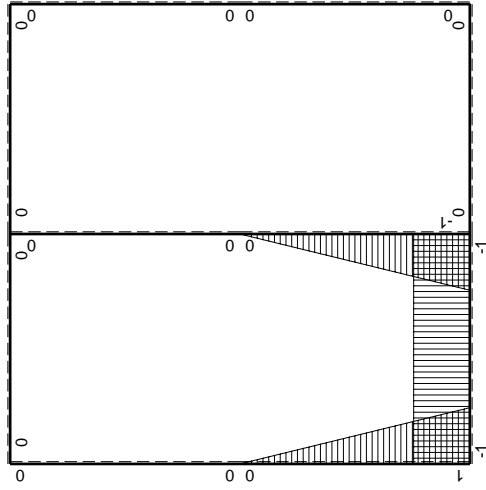


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

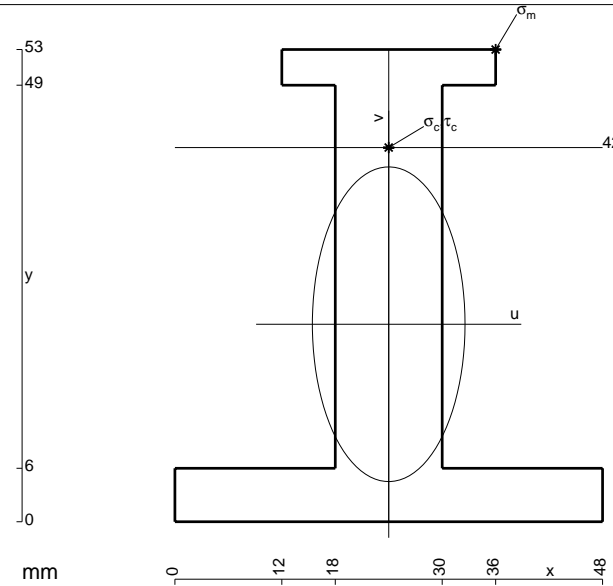
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

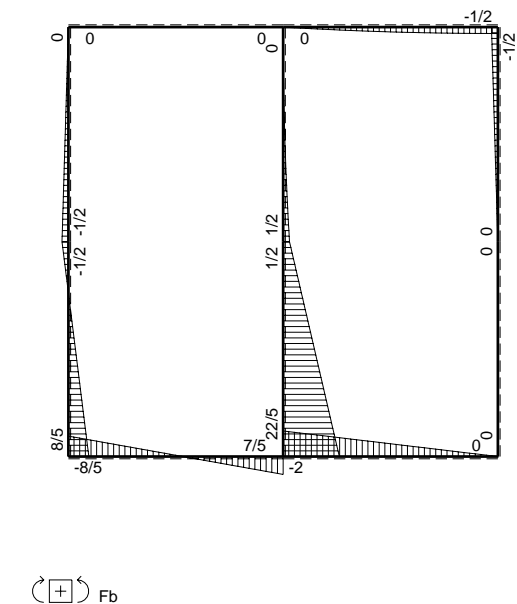
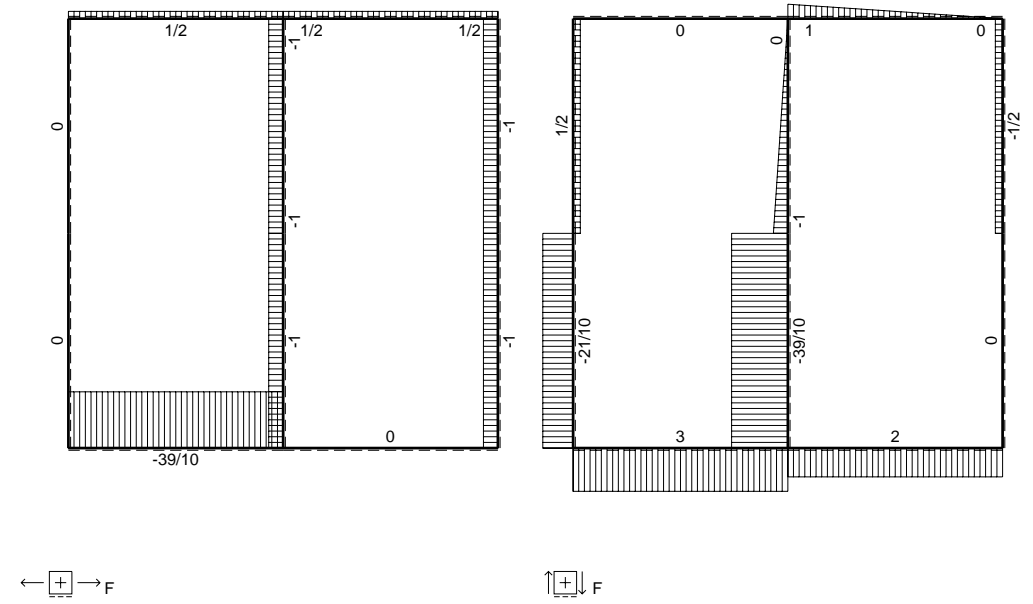
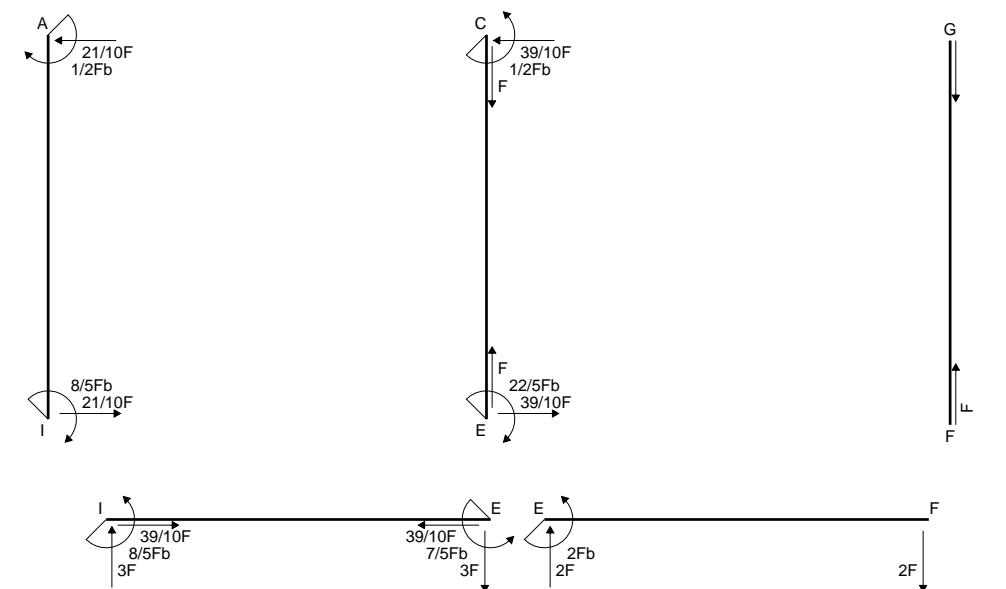
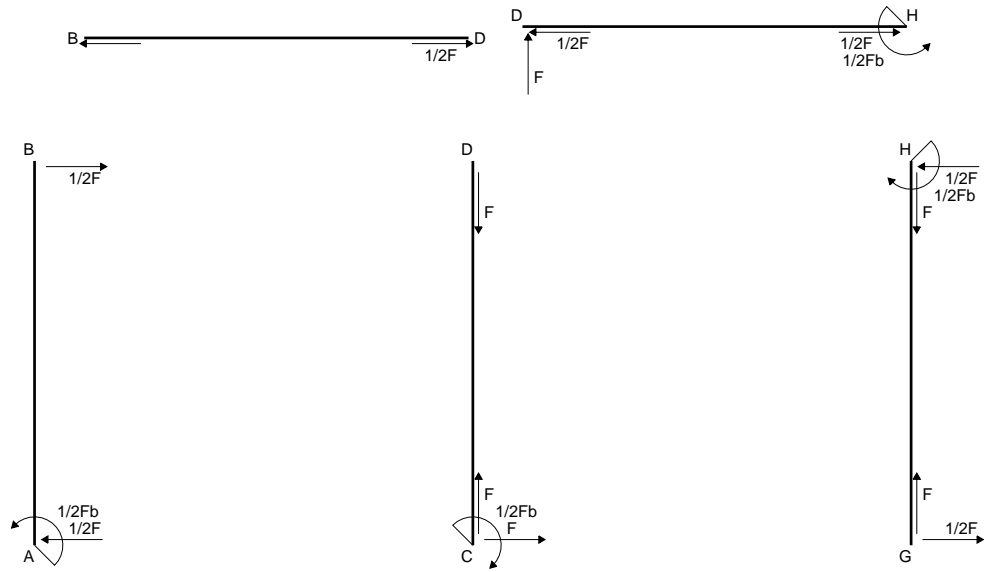
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

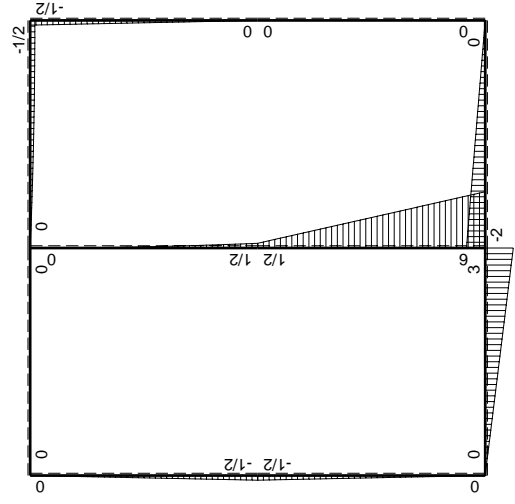
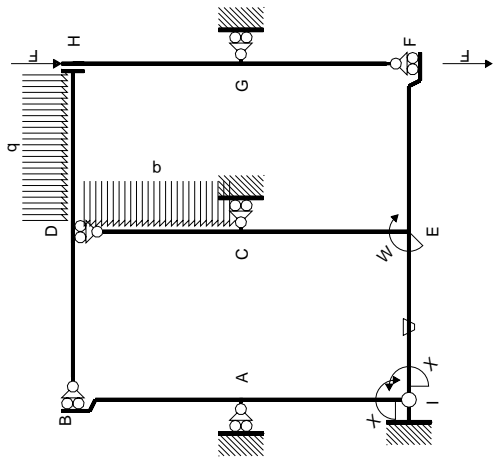
$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



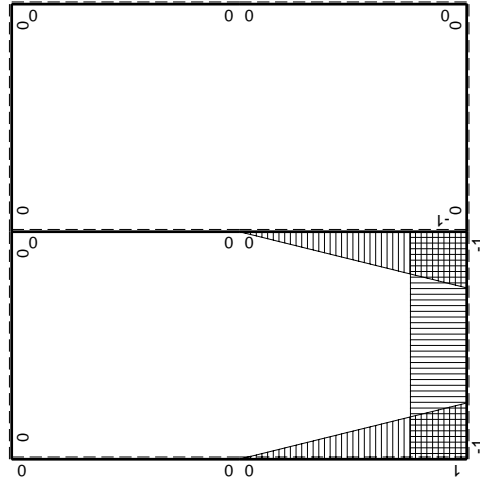
- A = 900. mm²
- J_u = 280787. mm⁴
- J_v = 66096. mm⁴
- y_g = 22.17 mm
- T_y = 3080. N
- M_x = -2094400. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 30.83 mm
- σ_m = -Mv/J_u = 230. N/mm²
- x_c = 24. mm
- y_c = 42. mm
- v_c = 19.83 mm
- σ_c = -Mv/J_u = 147.9 N/mm²
- τ_c = 4.322 N/mm²
- σ_q = √σ_c² + 3τ_c² = 148.1 N/mm²
- S = 4728. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-11/2Fx$	0	$-6Fb+23/2Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-25/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-11/2Fx$	0	$-1/2Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 23/2 x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-6x + 23/4 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 23/4 b - 11/6 b) Fb 1/EJ = -25/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 11/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 11/6 x^3/b^2]_0^b Fb 1/EJ$$

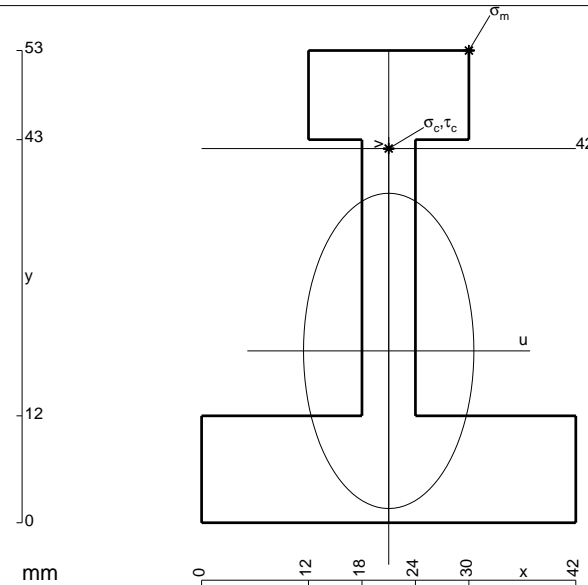
$$= (-1/4 b - 11/6 b) Fb 1/EJ = -25/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

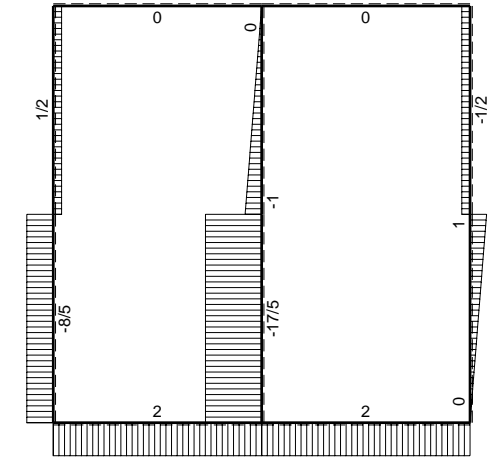
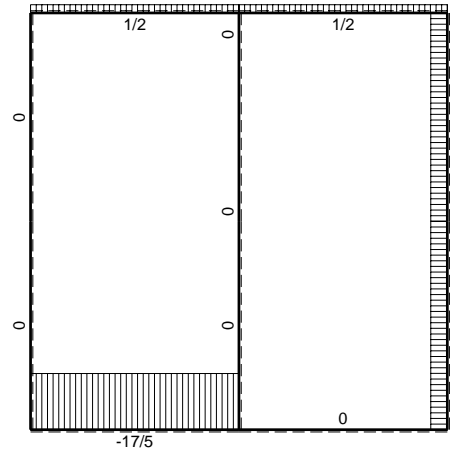
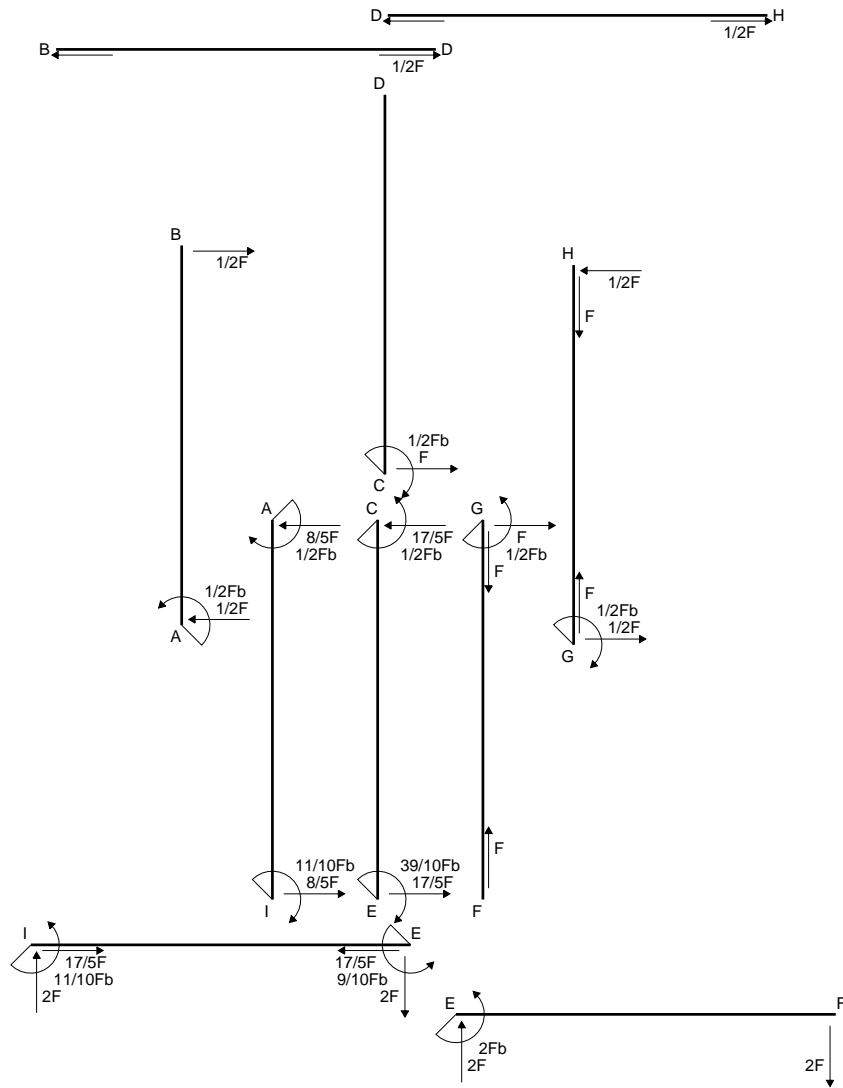
$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

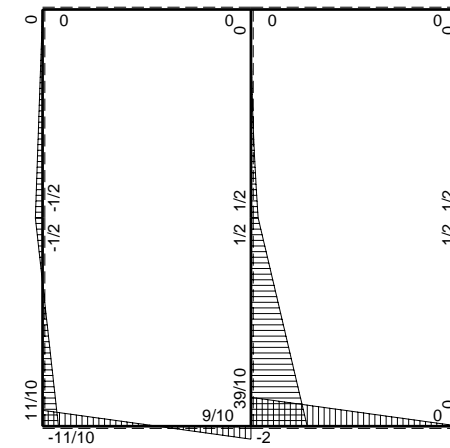


- A = 870. mm²
- J_u = 272367. mm⁴
- J_v = 79506. mm⁴
- y_g = 19.29 mm
- T_y = 2620. N
- M_x = -1938800. Nmm
- x_m = 30. mm
- y_m = 53. mm
- u_m = 9. mm
- v_m = 33.71 mm
- σ_m = -Mv/J_u = 240. N/mm²
- x_c = 21. mm
- y_c = 42. mm
- v_c = 22.71 mm
- σ_c = -Mv/J_u = 161.7 N/mm²
- τ_c = 8.51 N/mm²
- σ_q = √σ²+3τ² = 162.4 N/mm²
- S = 5308. mm³

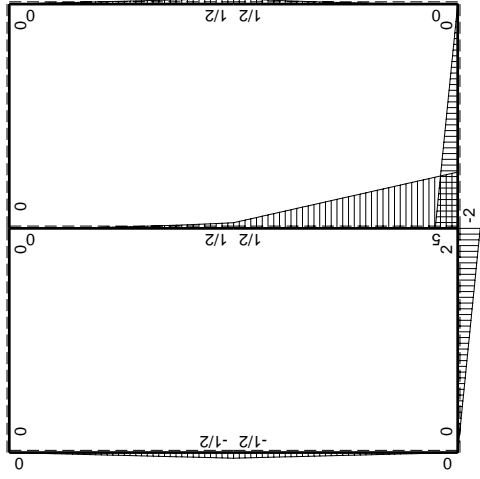
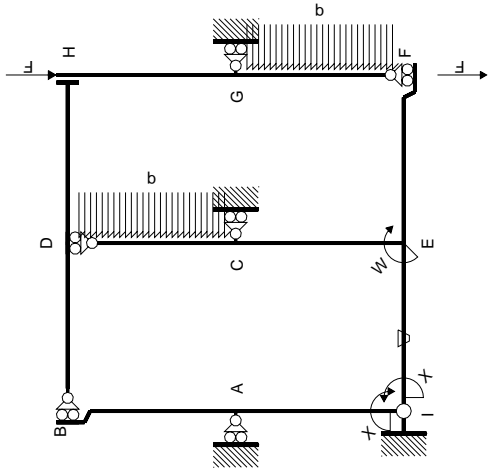


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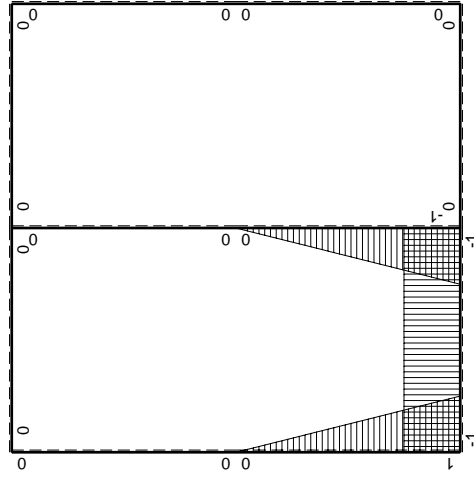


⊙ (+) ⊙ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb 1/EJ dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 19/4 b - 3/2 b) Fb 1/EJ = -7/4 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb 1/EJ$$

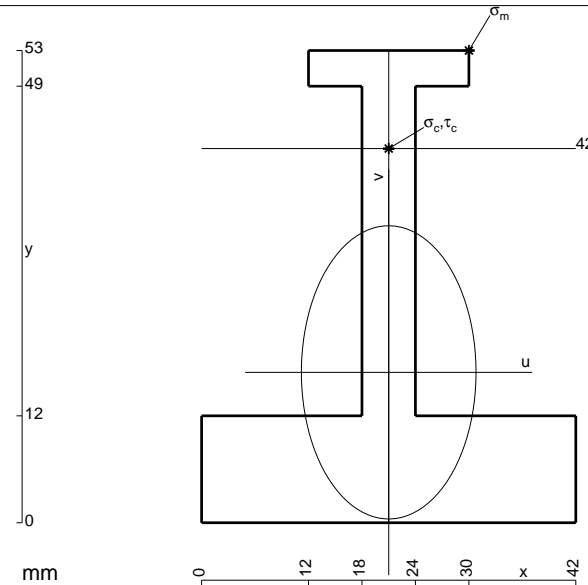
$$= (-1/4 b - 3/2 b) Fb 1/EJ = -7/4 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



$$A = 798. \text{ mm}^2$$

$$J_u = 216134. \text{ mm}^4$$

$$J_v = 76698. \text{ mm}^4$$

$$y_g = 16.88 \text{ mm}$$

$$T_y = 1500. \text{ N}$$

$$M_x = -1185000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 36.12 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 198.1 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 42. \text{ mm}$$

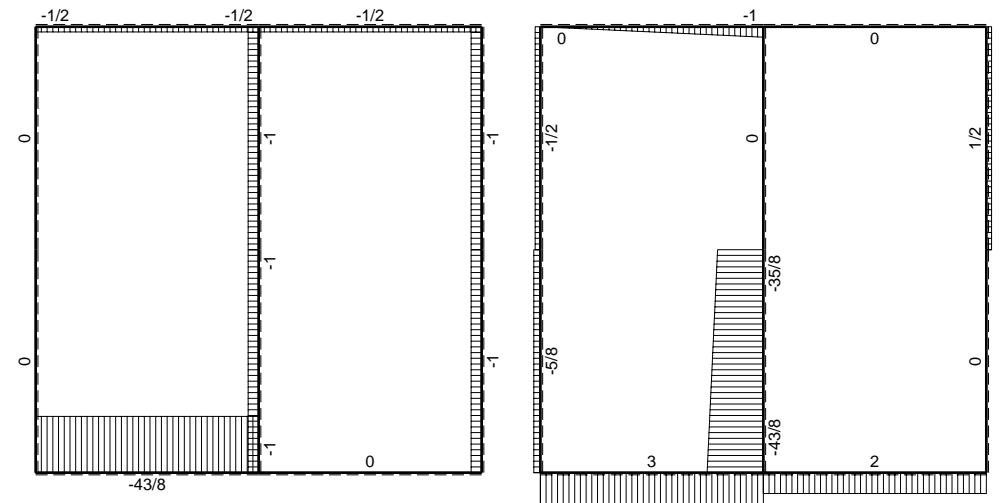
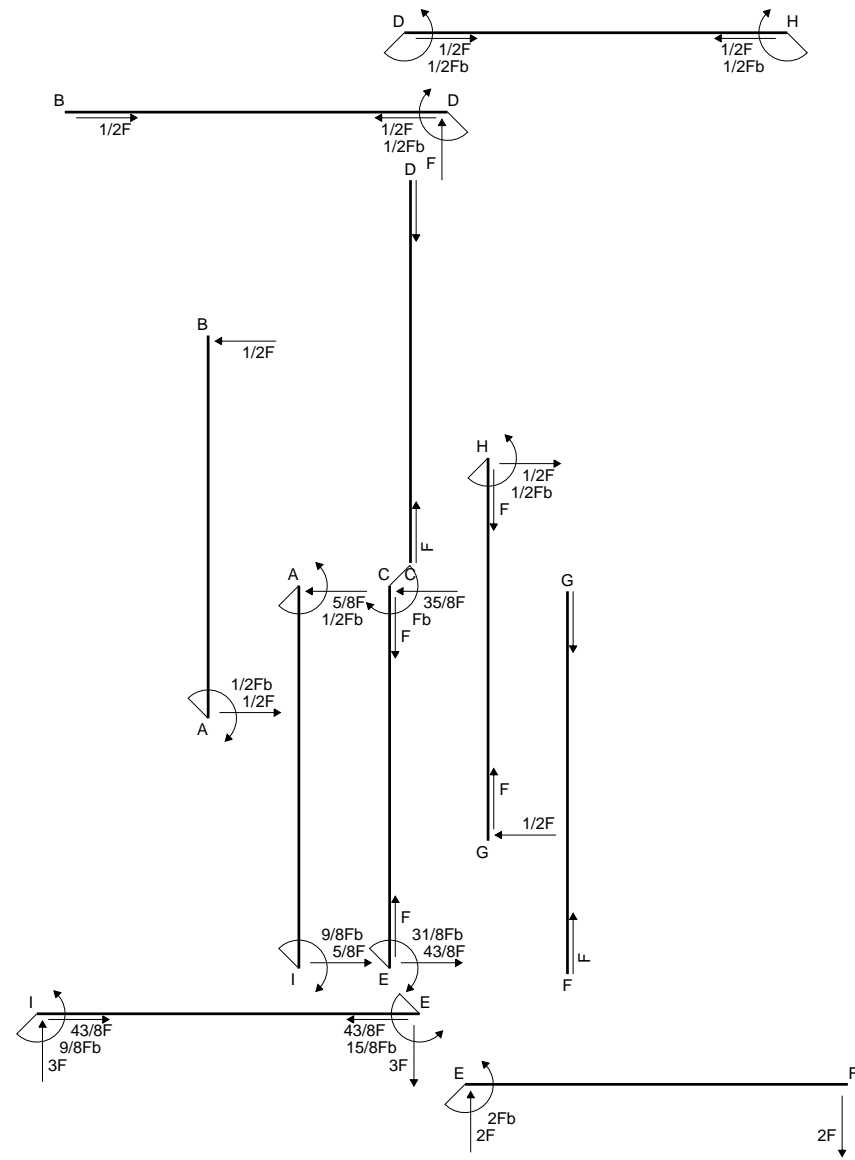
$$v_c = 25.12 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 137.7 \text{ N/mm}^2$$

$$\tau_c = 4.233 \text{ N/mm}^2$$

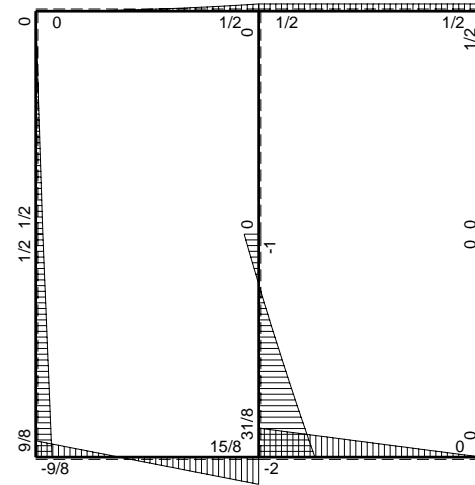
$$\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 137.9 \text{ N/mm}^2$$

$$S = 3659. \text{ mm}^3$$

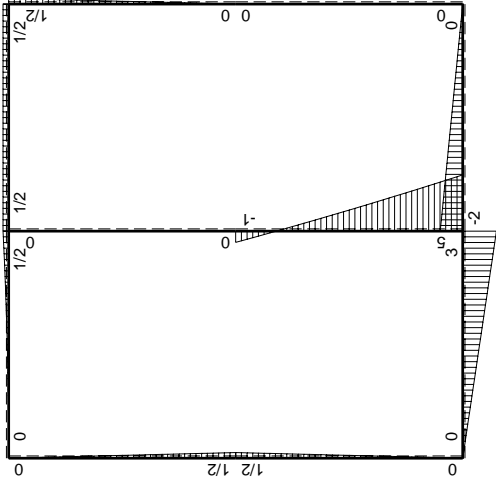
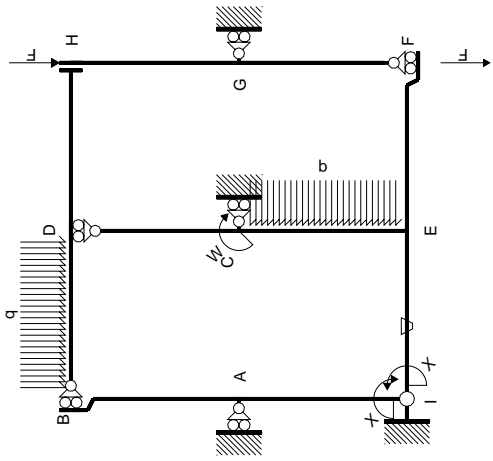


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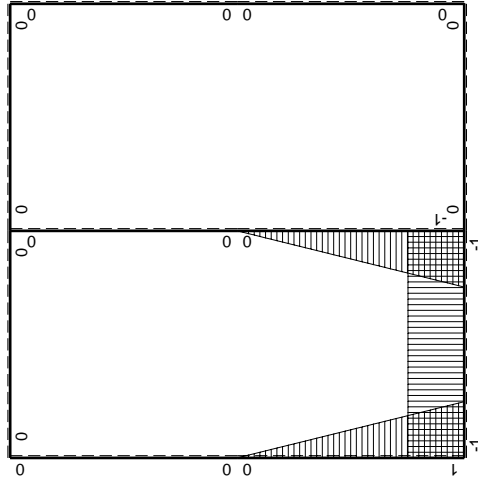


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-13/2Fx+1/2qx^2$	0	$-5Fb+23/2Fx-7Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-35/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-11/2Fx-1/2qx^2$	0	$Fx-11/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-15/8Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 23/2 x/b - 7x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= [-5x + 23/4 x^2/b - 7/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 23/4 b - 7/3 b + 1/8 b) Fb \frac{1}{EJ} = -35/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 11/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 11/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

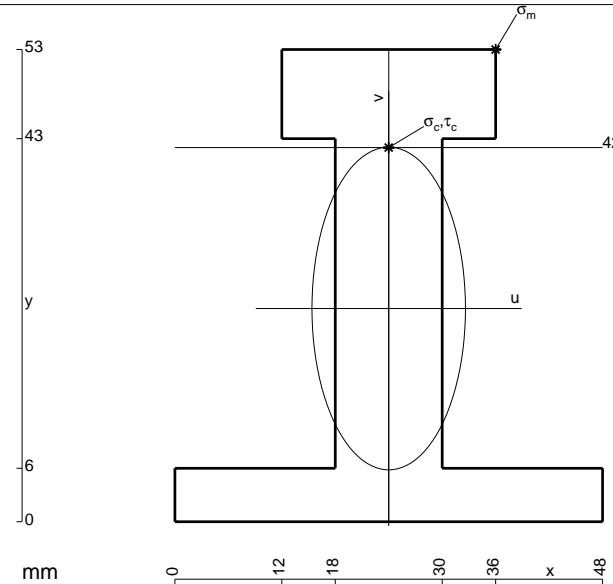
$$= (1/2 b - 11/6 b - 1/8 b) Fb \frac{1}{EJ} = -35/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

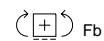
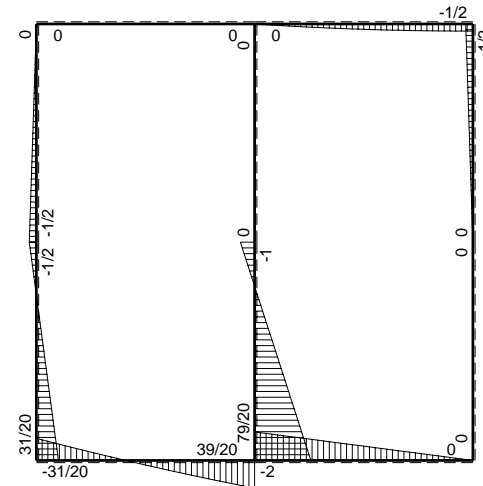
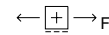
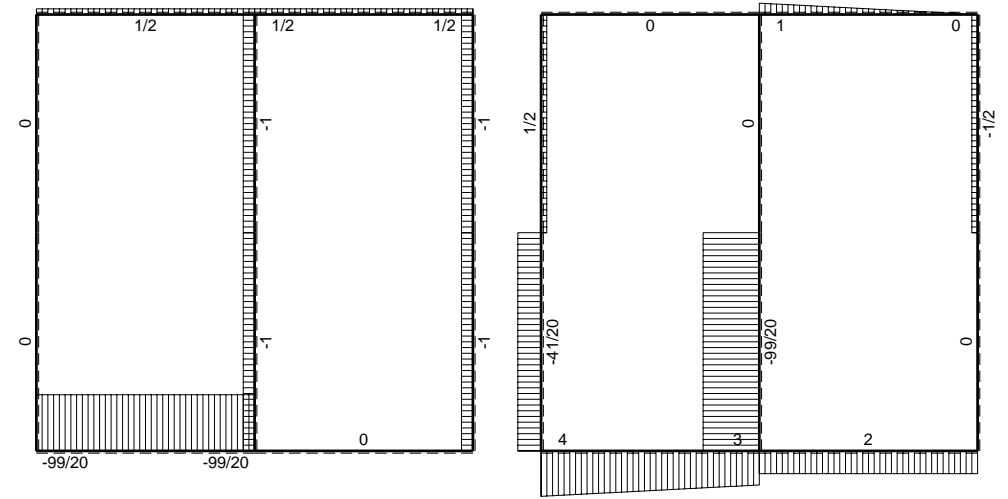
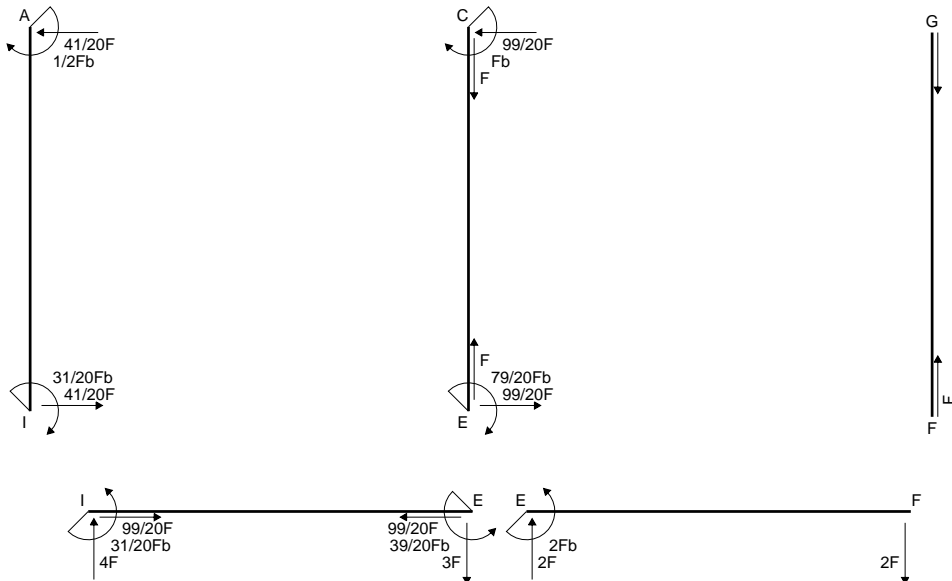
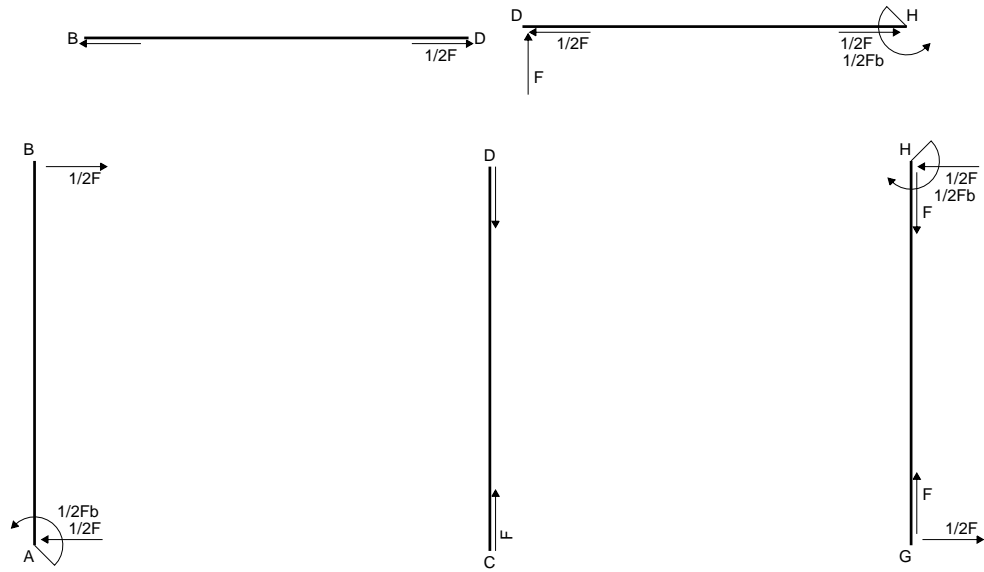
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

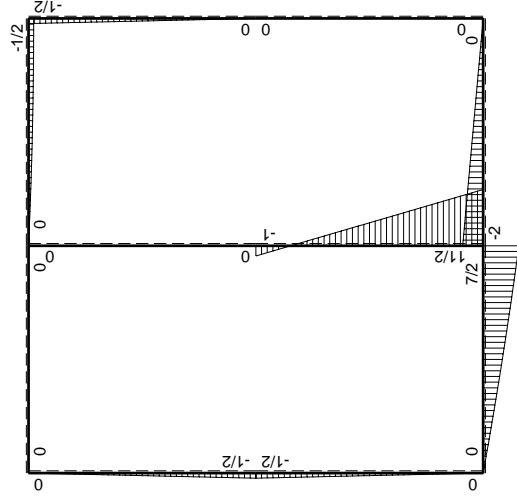
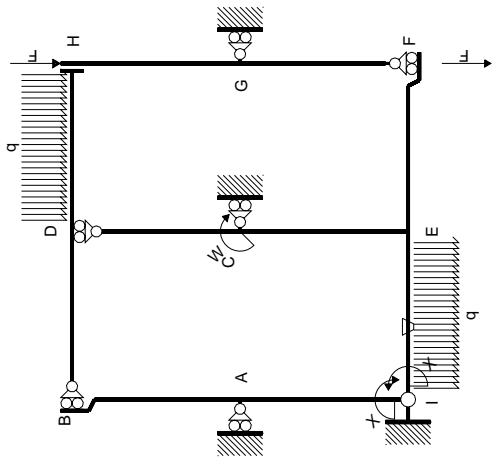
$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



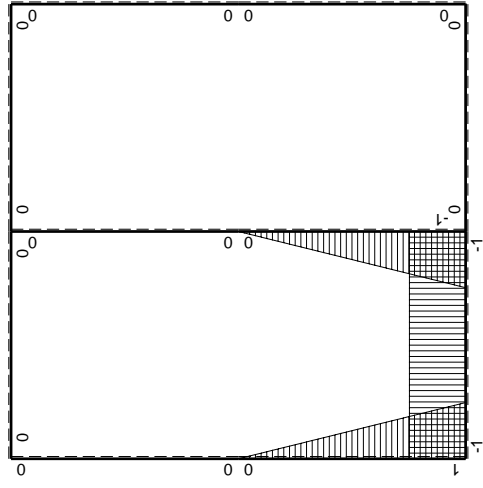
- A = 972. mm²
- J_u = 318872. mm⁴
- J_v = 72144. mm⁴
- y_g = 23.93 mm
- T_y = 2740. N
- M_x = -2301600. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 29.07 mm
- σ_m = -Mv/J_u = 209.8 N/mm²
- x_c = 24. mm
- y_c = 42. mm
- v_c = 18.07 mm
- σ_c = -Mv/J_u = 130.4 N/mm²
- τ_c = 4.296 N/mm²
- σ_q = √σ²+3τ² = 130.6 N/mm²
- S = 5999. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-13/2Fx$	0	$-11/2Fb+12Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-13/2Fx$	0	$Fx-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 12x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 6x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 6b - 13/6 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

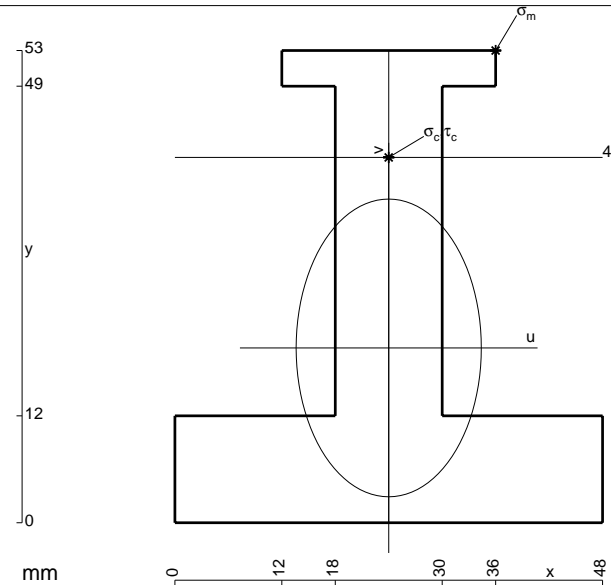
$$= (1/2 b - 13/6 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

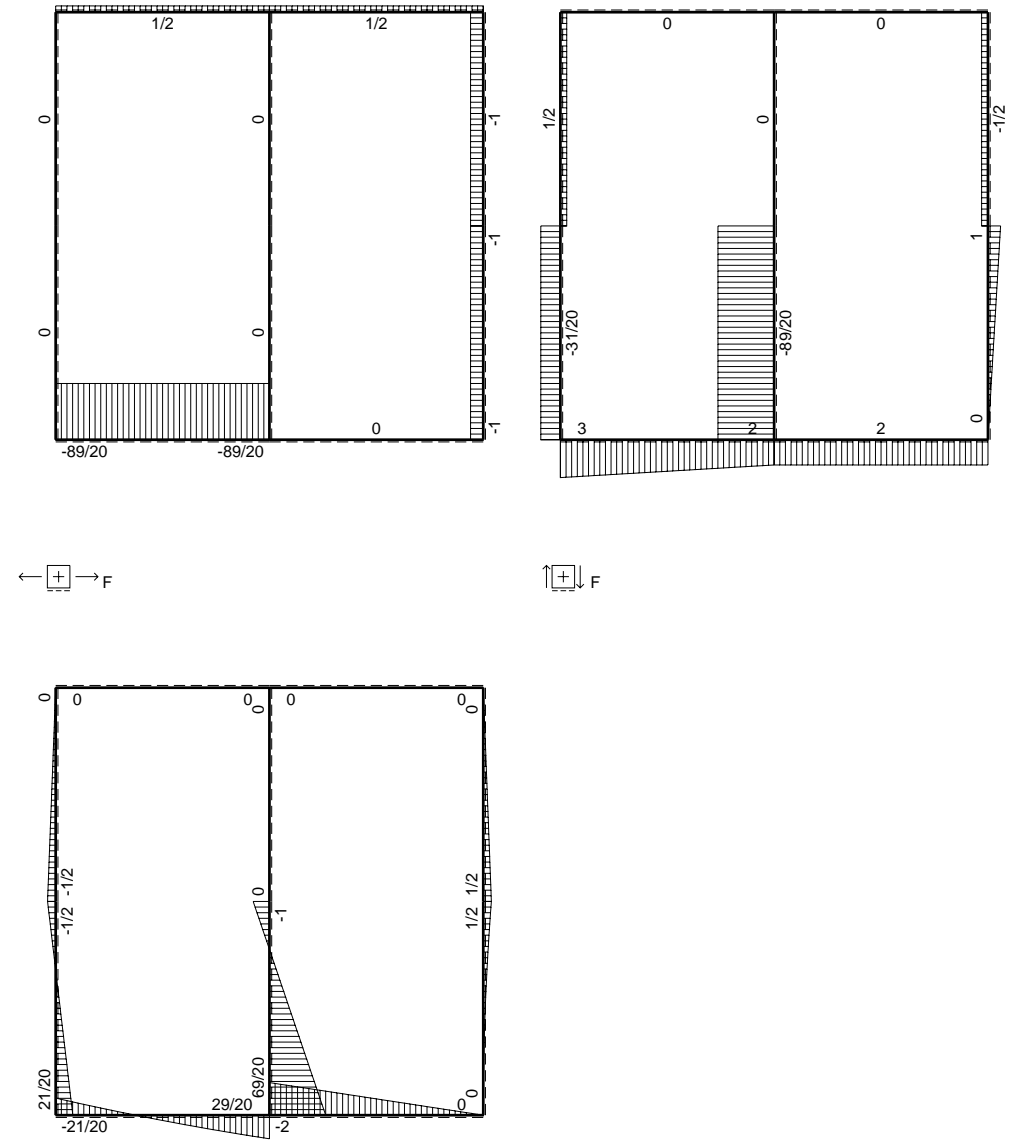
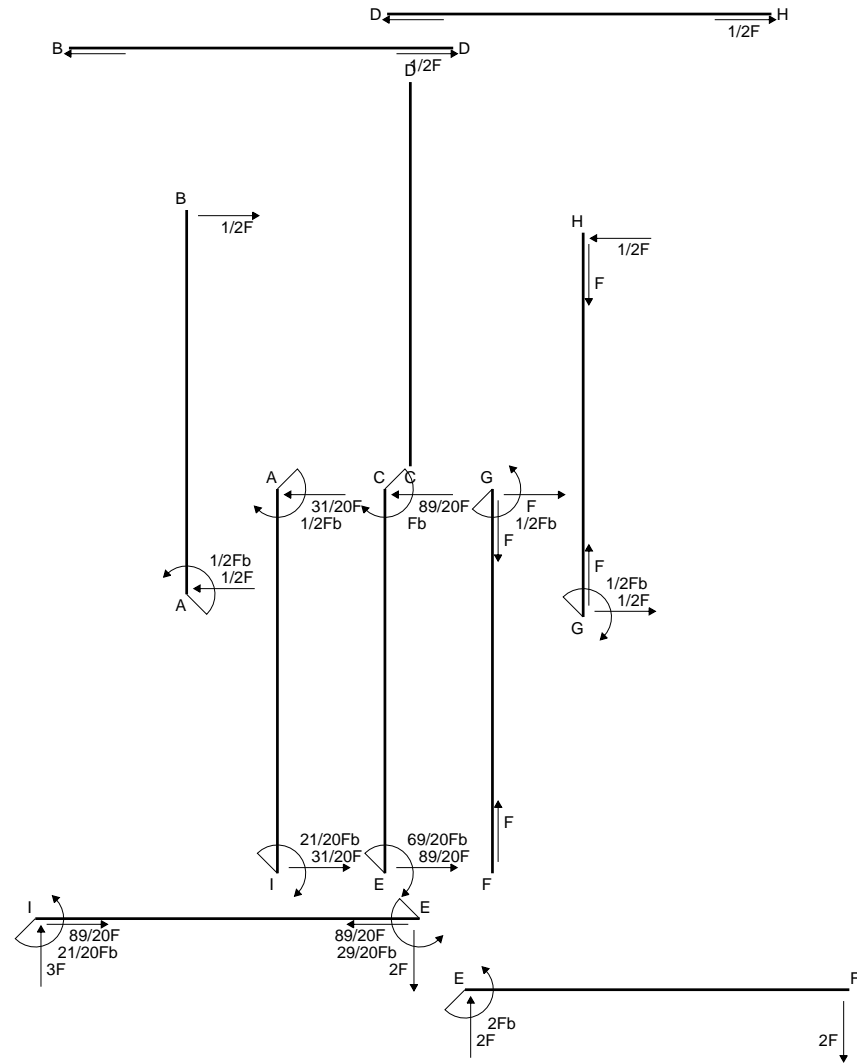
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

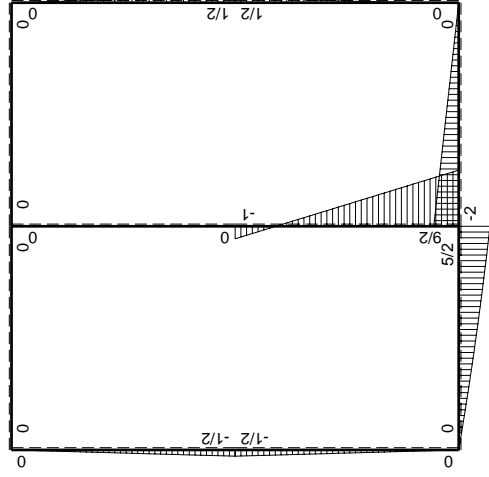
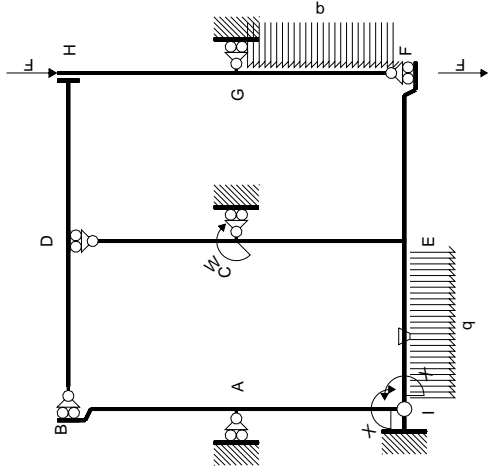
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



- A = 1116. mm²
- J_u = 311633. mm⁴
- J_v = 120528. mm⁴
- y_g = 19.62 mm
- T_y = 2280. N
- M_x = -2052000. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 33.38 mm
- σ_m = -M_v/J_u = 219.8 N/mm²
- x_c = 24. mm
- y_c = 41. mm
- v_c = 21.38 mm
- σ_c = -M_v/J_u = 140.8 N/mm²
- τ_c = 3.322 N/mm²
- σ_q = √σ² + 3τ² = 140.9 N/mm²
- S = 5449. mm³

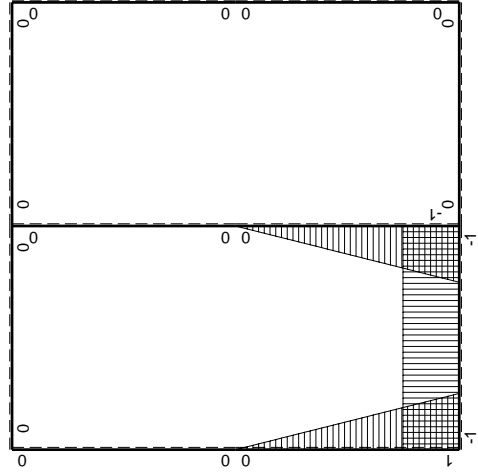


⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-11/2Fx$	0	$-9/2Fb+10Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-11/2Fx$	0	$Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$21/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 10x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 5x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 5b - 11/6 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

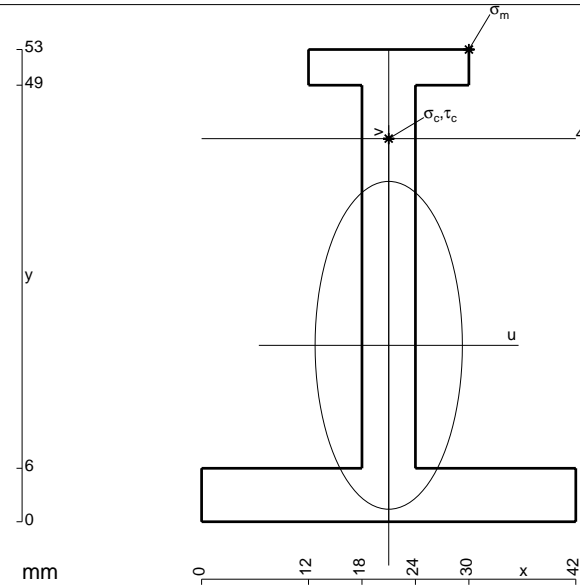
$$= (1/2 b - 11/6 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

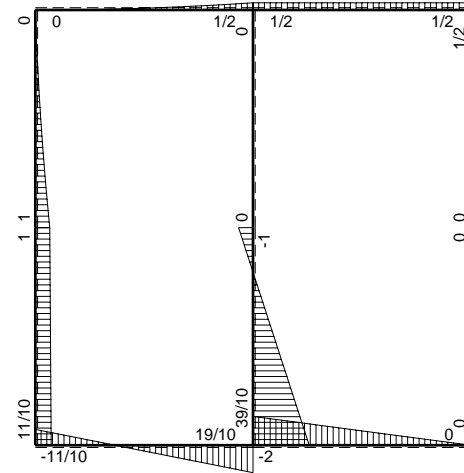
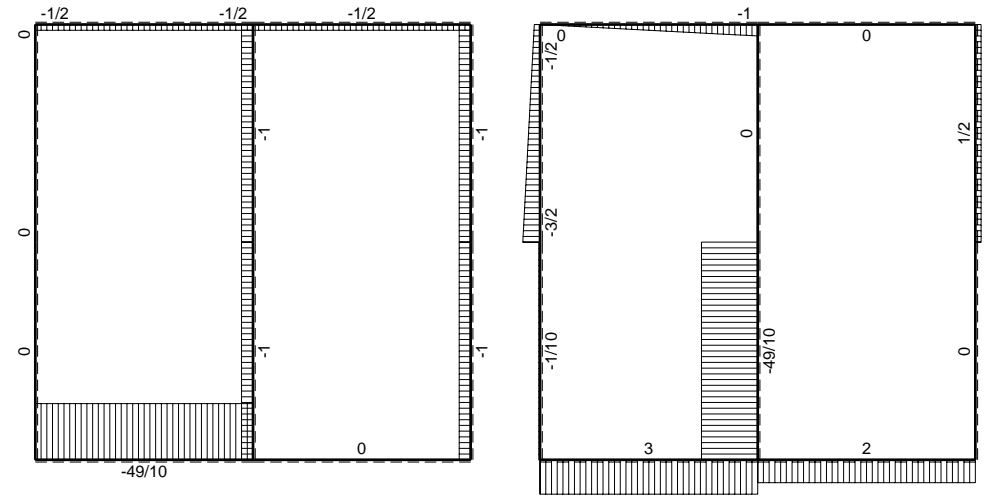
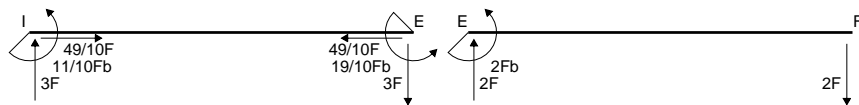
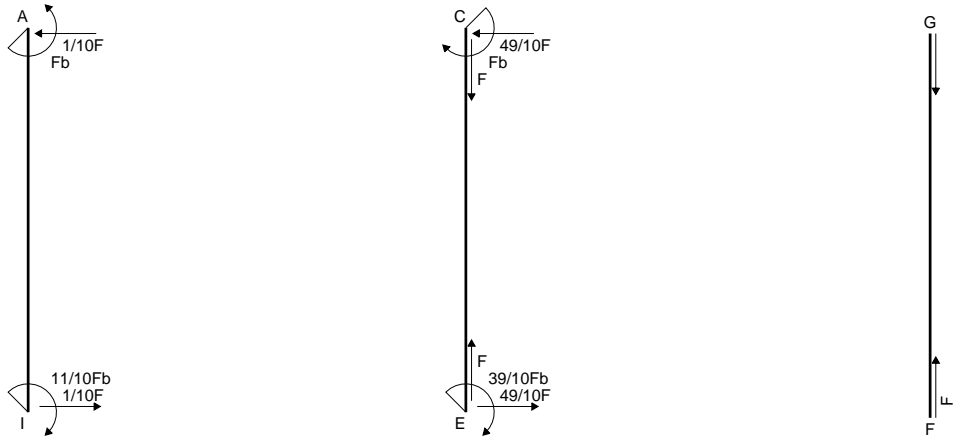
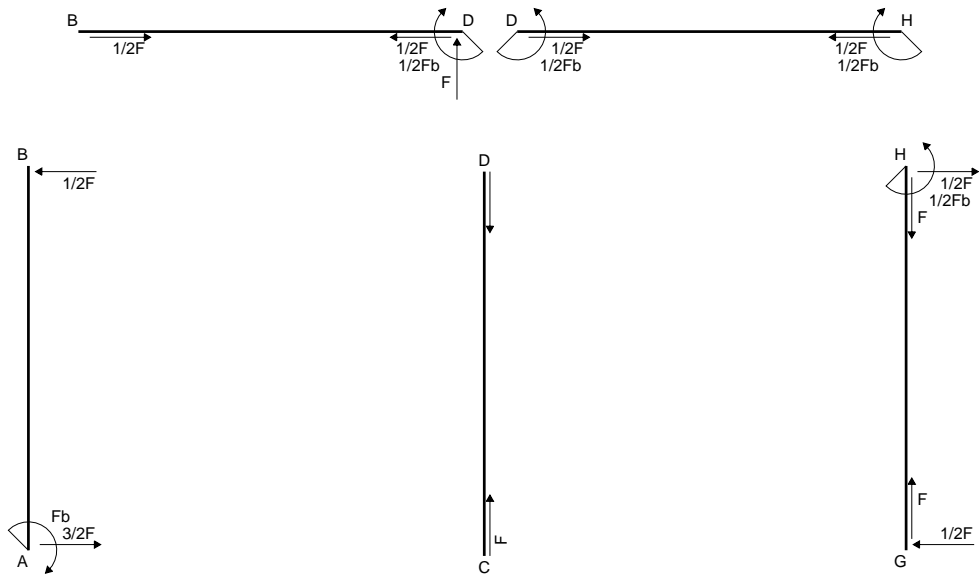
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

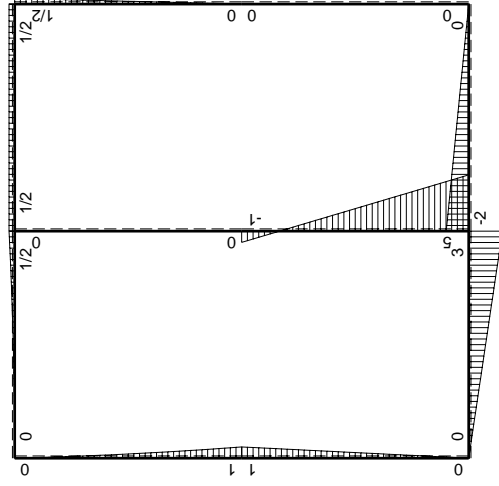
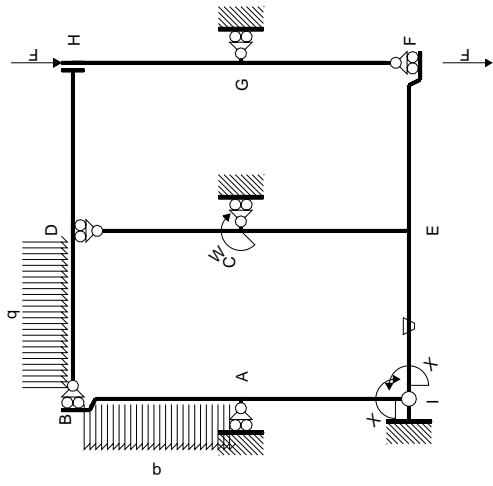
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



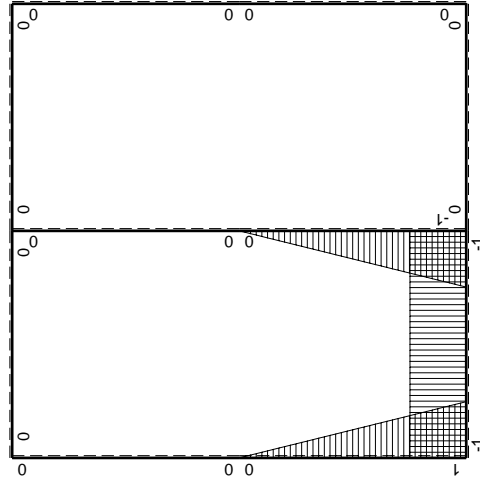
- A = 582. mm²
- J_u = 197114. mm⁴
- J_v = 39762. mm⁴
- y_g = 19.8 mm
- T_y = 1420. N
- M_x = -1349000. Nmm
- x_m = 30. mm
- y_m = 53. mm
- u_m = 9. mm
- v_m = 33.2 mm
- σ_m = -Mv/J_u = 227.2 N/mm²
- x_c = 21. mm
- y_c = 43. mm
- v_c = 23.2 mm
- σ_c = -Mv/J_u = 158.8 N/mm²
- τ_c = 3.83 N/mm²
- σ_q = √σ²+3τ² = 158.9 N/mm²
- S = 3190. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

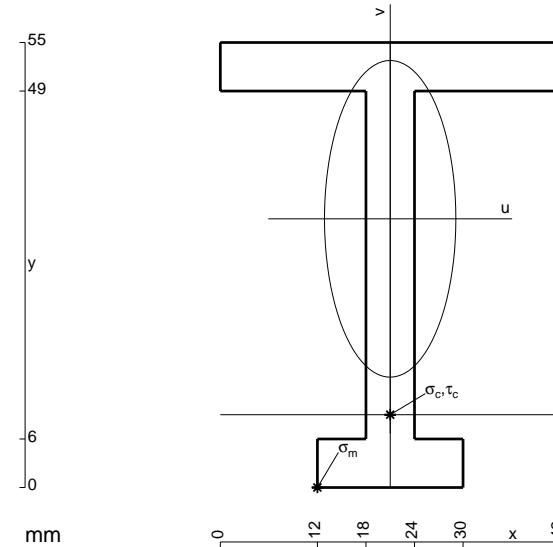
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 618. \text{ mm}^2$$

$$J_u = 236783. \text{ mm}^4$$

$$J_v = 40734. \text{ mm}^4$$

$$y_g = 33.21 \text{ mm}$$

$$T_y = 1640. \text{ N}$$

$$M_x = -1705600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.21 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.2 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

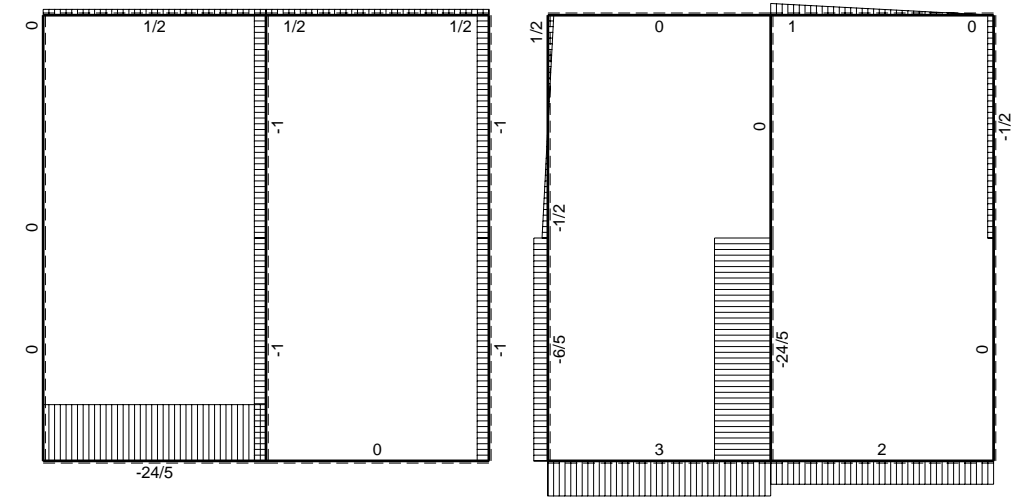
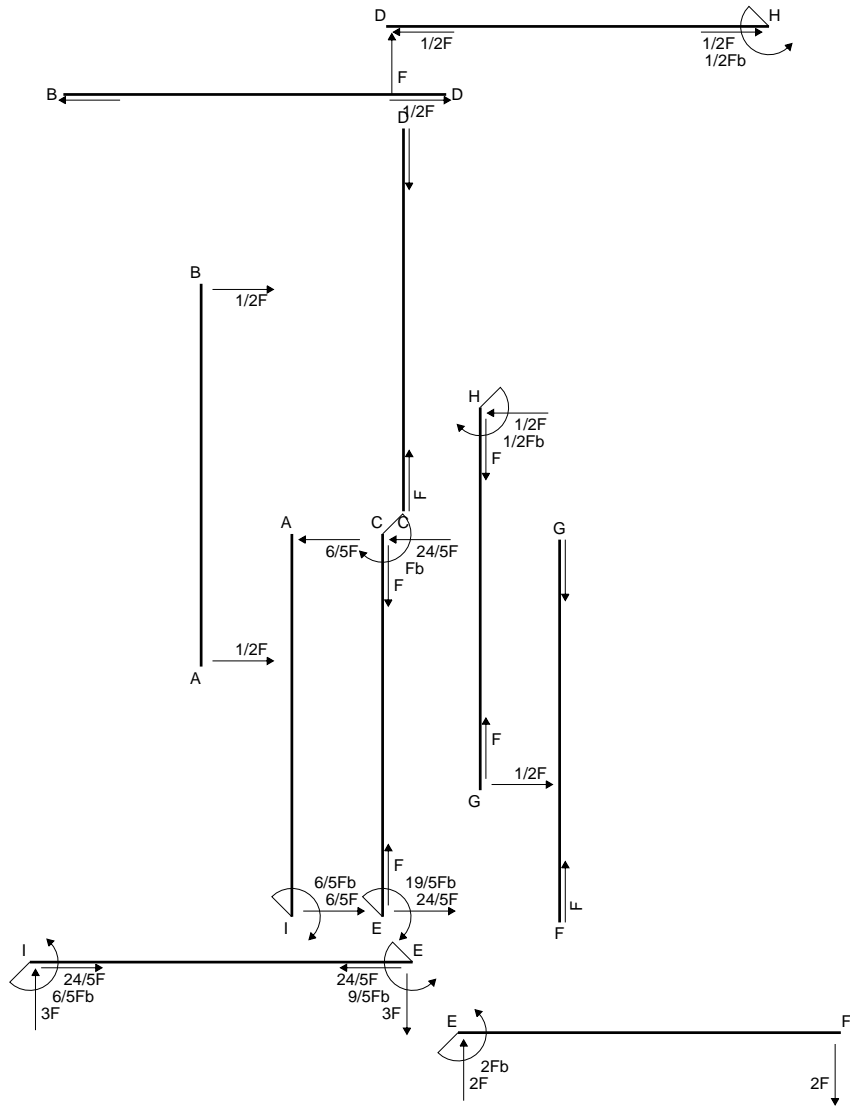
$$v_c = -24.21 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -174.4 \text{ N/mm}^2$$

$$\tau_c = 4.3 \text{ N/mm}^2$$

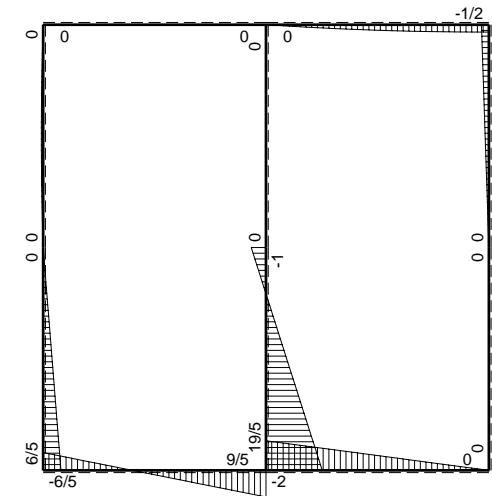
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 174.5 \text{ N/mm}^2$$

$$S = 3725. \text{ mm}^3$$

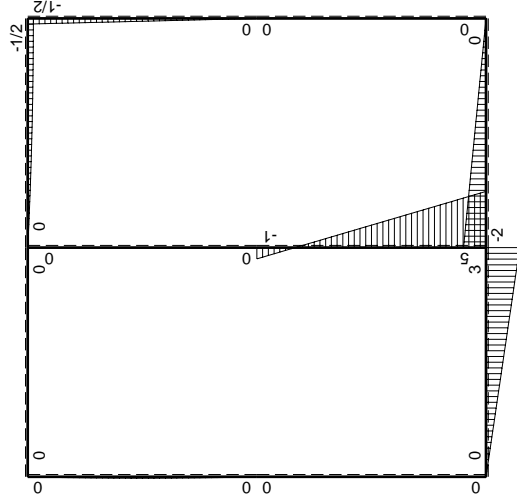
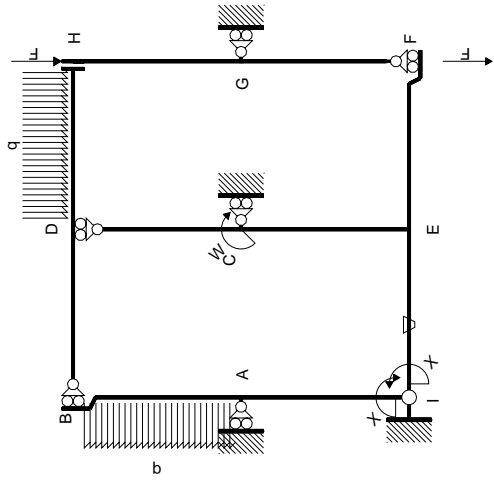


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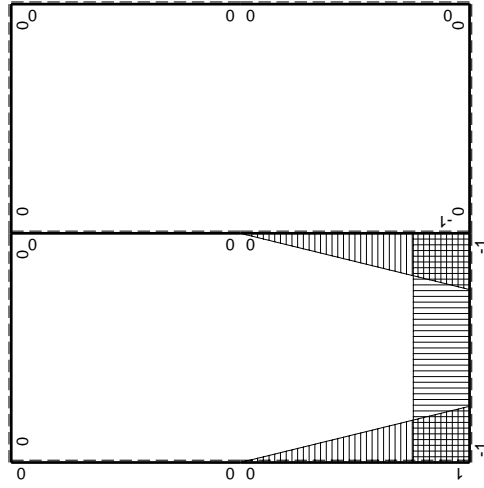


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

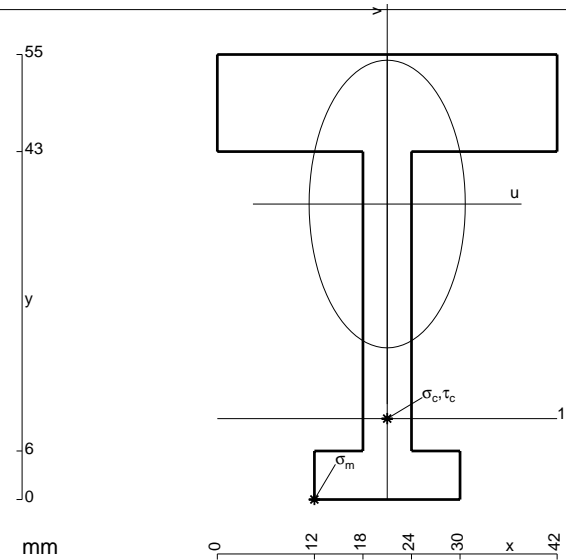
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb 1/EJ dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 11/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$



$$A = 834. \text{ mm}^2$$

$$J_u = 263619. \text{ mm}^4$$

$$J_v = 77670. \text{ mm}^4$$

$$y_g = 36.52 \text{ mm}$$

$$T_y = 2620. \text{ N}$$

$$M_x = -1441000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -36.52 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.6 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

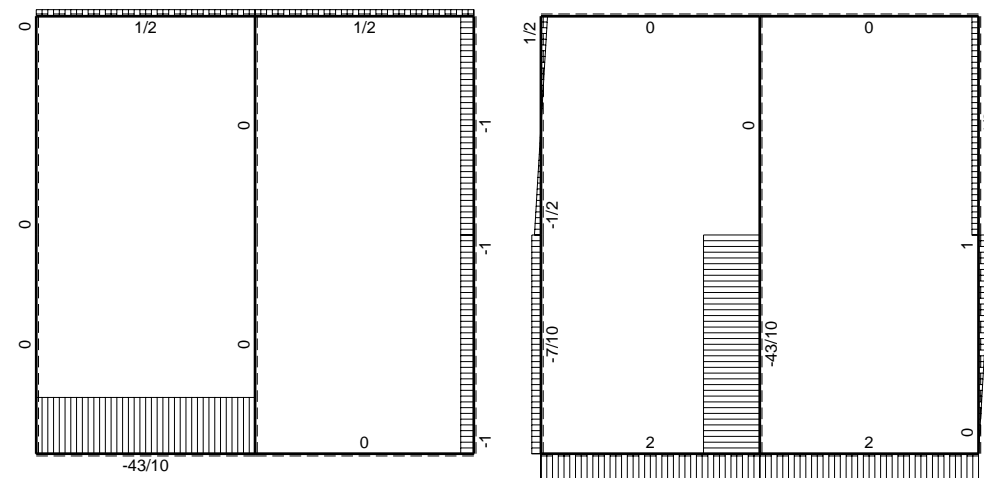
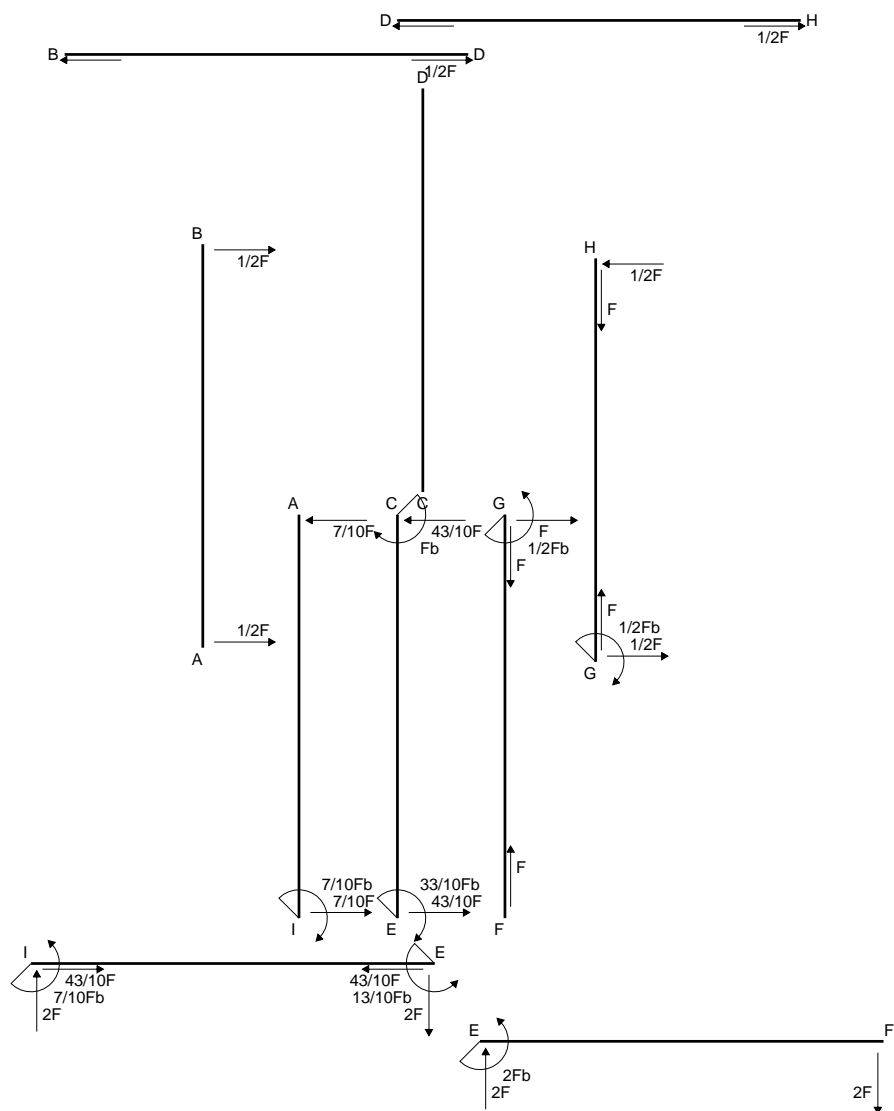
$$v_c = -26.52 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -145. \text{ N/mm}^2$$

$$\tau_c = 7.131 \text{ N/mm}^2$$

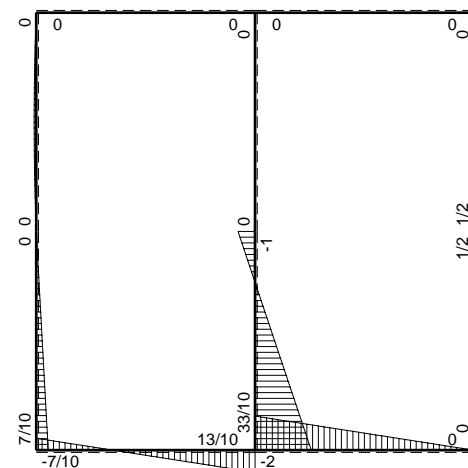
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 145.5 \text{ N/mm}^2$$

$$S = 4305. \text{ mm}^3$$

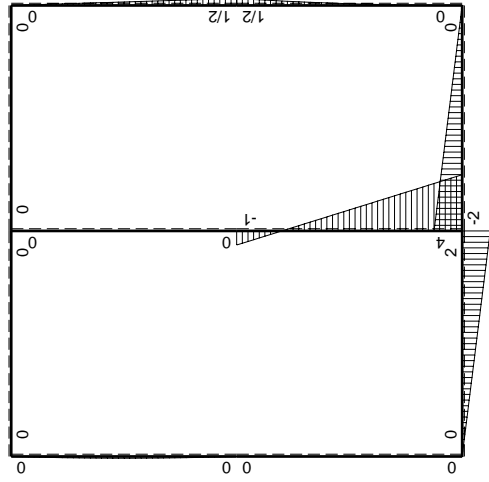
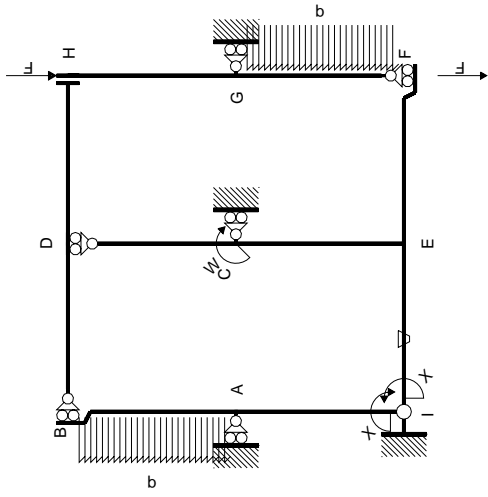


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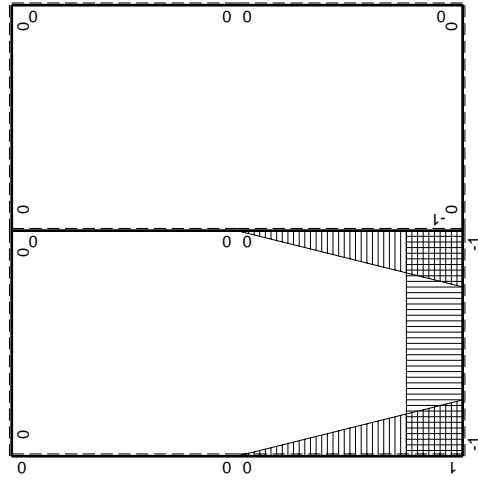


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-5Fx$	0	$-4Fb+9Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-5Fx$	0	$Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

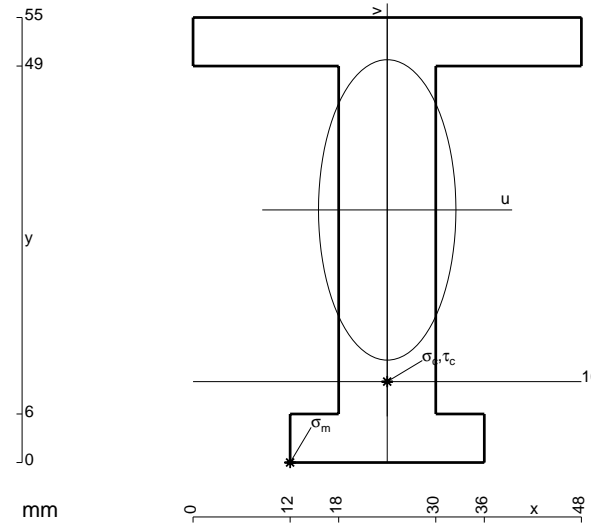
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 9x/b - 5x^2/b^2) Fb 1/EJ dx = [-4x + 9/2 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 9/2 b - 5/3 b) Fb 1/EJ = -7/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 5x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 5/3 b) Fb 1/EJ = -7/6 Fb^2/EJ$$



$$A = 948. \text{ mm}^2$$

$$J_u = 326981. \text{ mm}^4$$

$$J_v = 68400. \text{ mm}^4$$

$$y_g = 31.22 \text{ mm}$$

$$T_y = 3660. \text{ N}$$

$$M_x = -2196000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -31.22 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.7 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

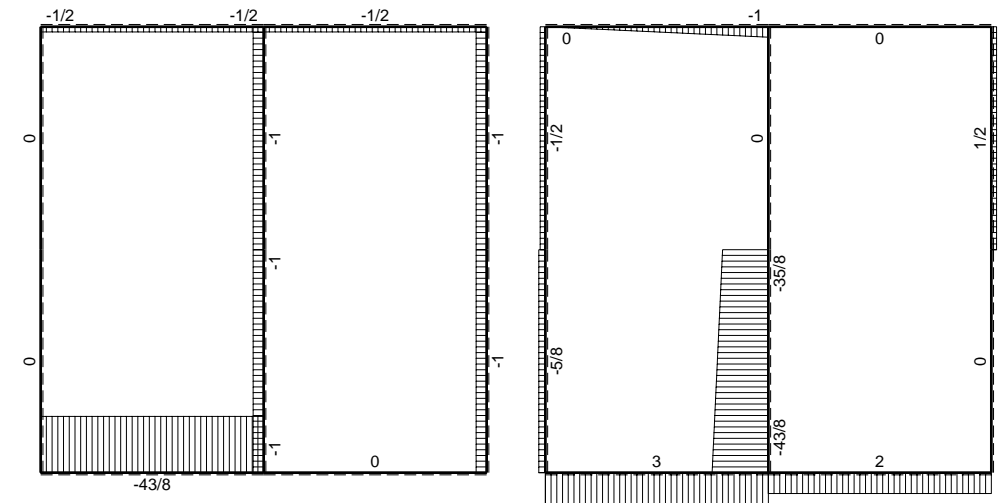
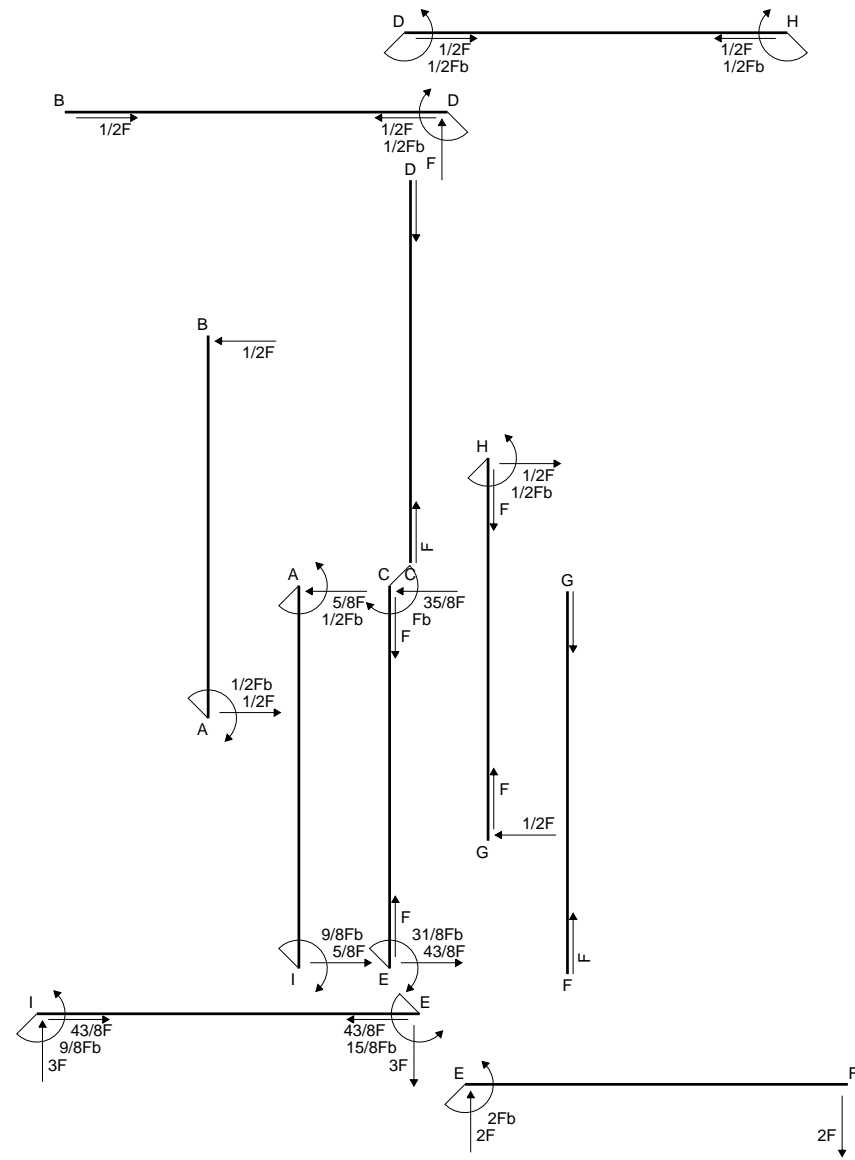
$$v_c = -21.22 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -142.5 \text{ N/mm}^2$$

$$\tau_c = 4.83 \text{ N/mm}^2$$

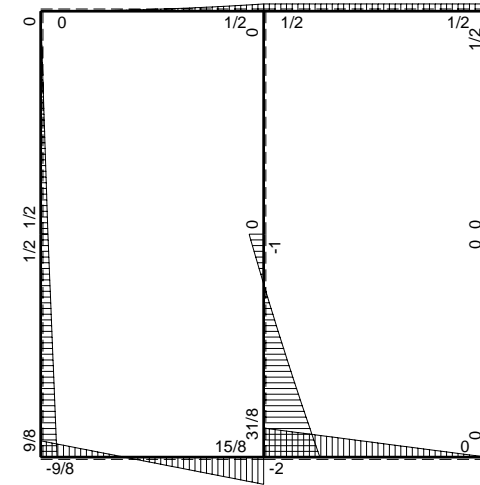
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 142.8 \text{ N/mm}^2$$

$$S = 5179. \text{ mm}^3$$

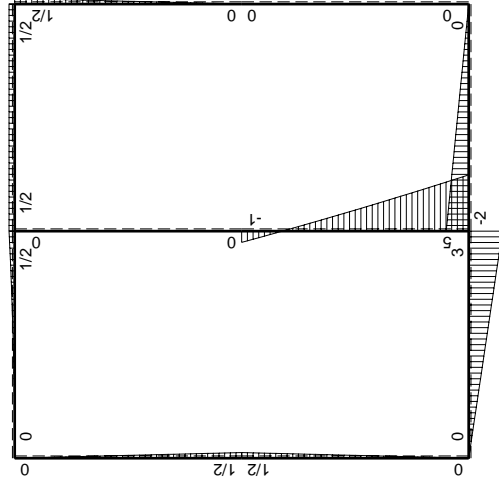
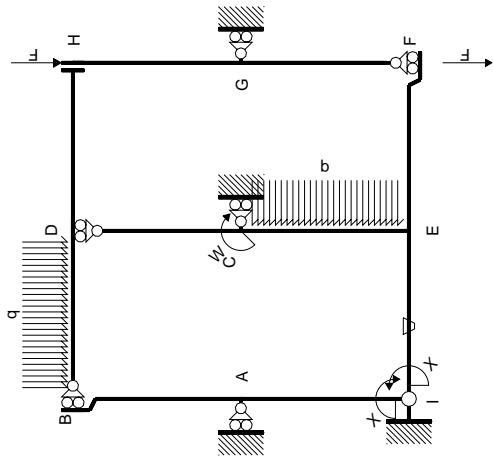


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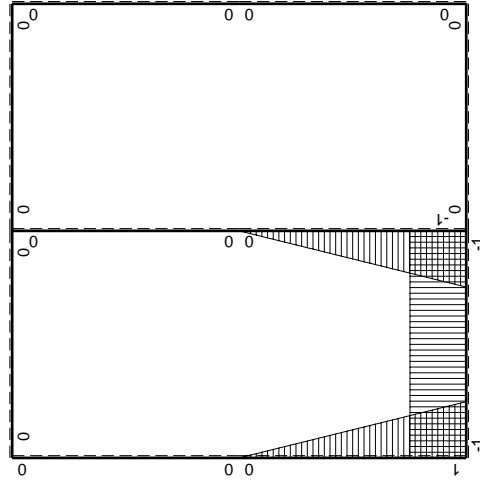


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-13/2Fx+1/2qx^2$	0	$-5Fb+23/2Fx-7Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-35/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-11/2Fx-1/2qx^2$	0	$Fx-11/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-15/8Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 23/2 x/b - 7x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= [-5x + 23/4 x^2/b - 7/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 23/4 b - 7/3 b + 1/8 b) Fb \frac{1}{EJ} = -35/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 11/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 11/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

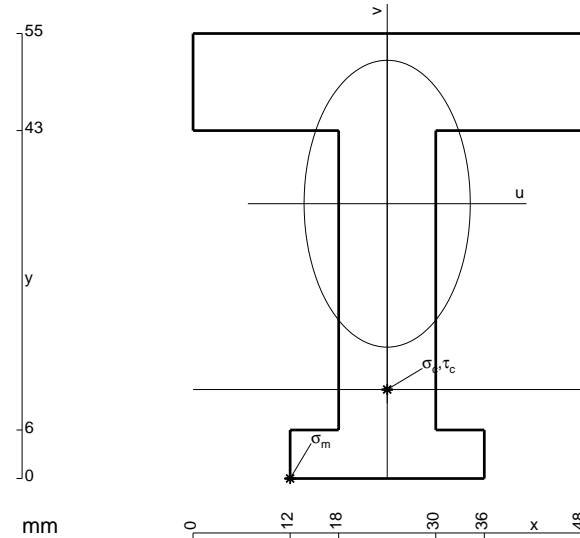
$$= (1/2 b - 11/6 b - 1/8 b) Fb \frac{1}{EJ} = -35/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

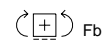
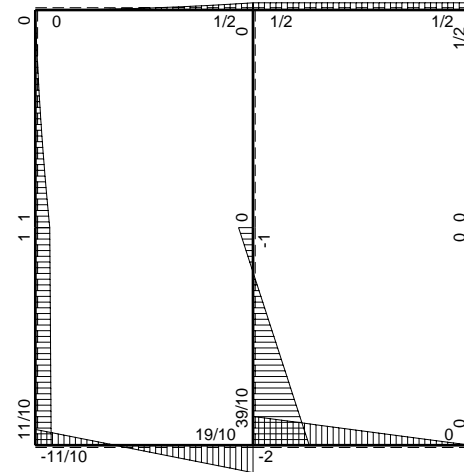
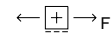
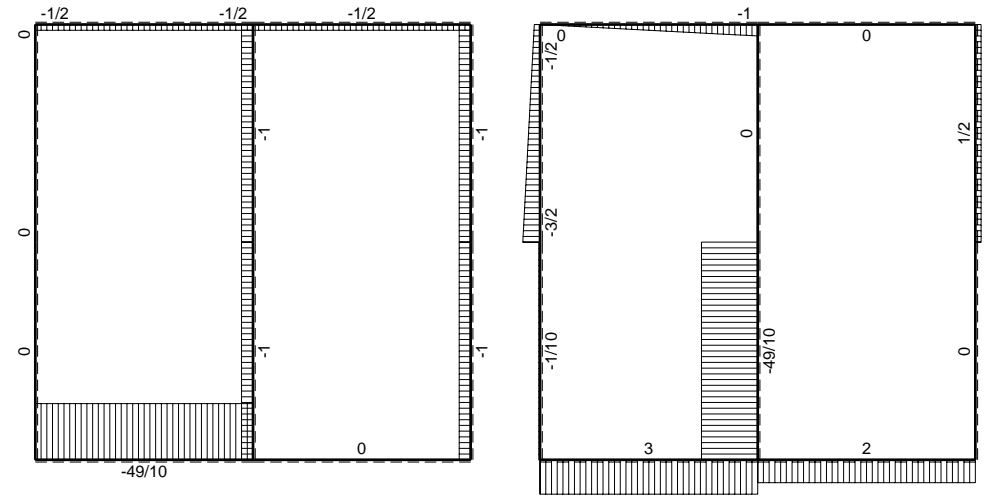
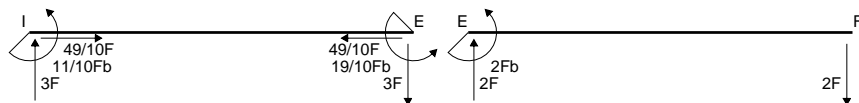
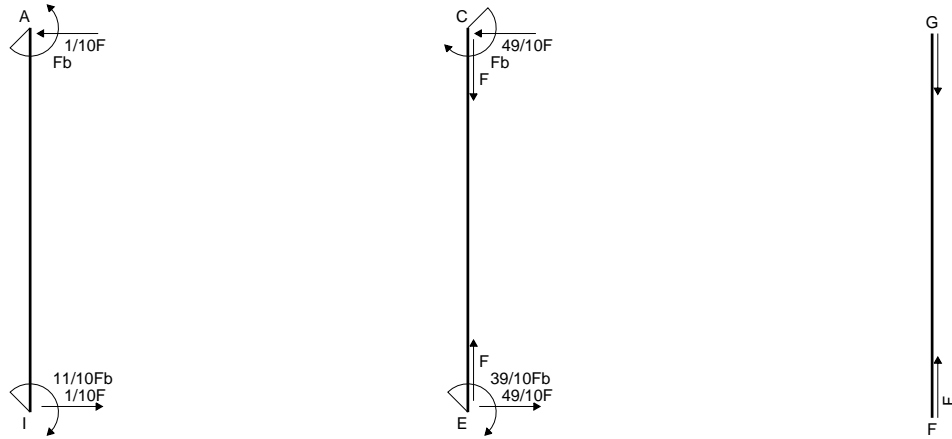
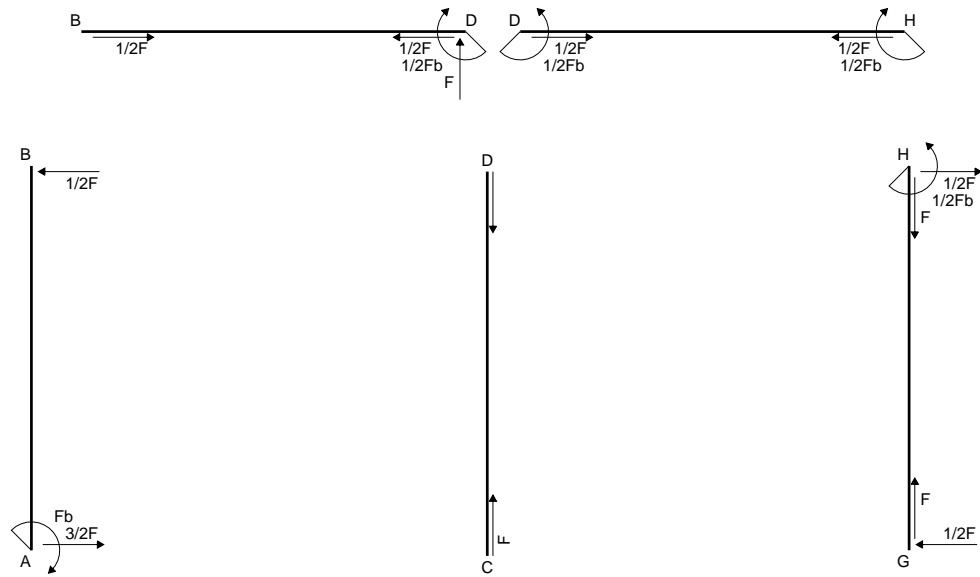
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

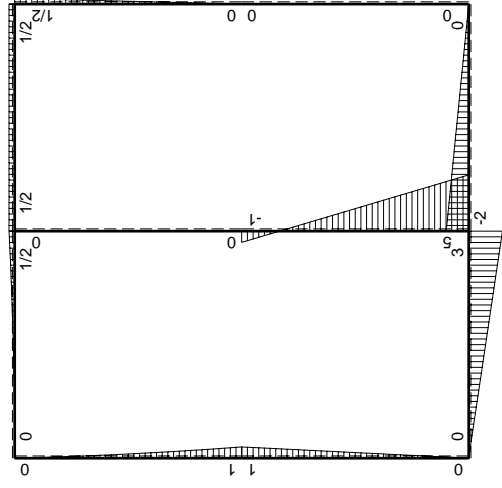
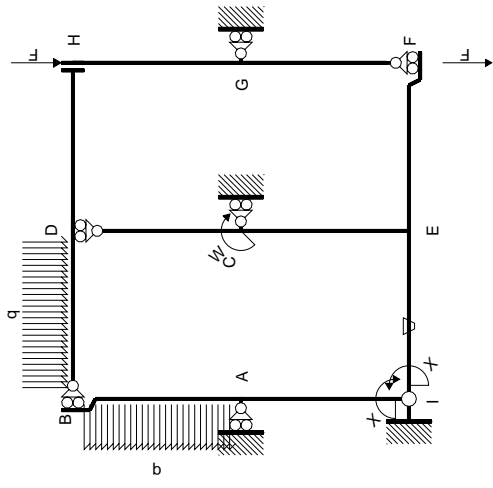
$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



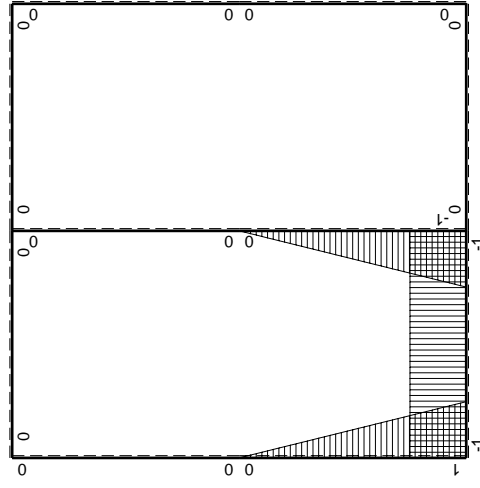
- A = 1164. mm²
- J_u = 366051. mm⁴
- J_v = 122832. mm⁴
- y_g = 33.96 mm
- T_y = 3580. N
- M_x = -2362800. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -33.96 mm
- σ_m = -Mv/J_u = -219.2 N/mm²
- x_c = 24. mm
- y_c = 11. mm
- v_c = -22.96 mm
- σ_c = -Mv/J_u = -148.2 N/mm²
- τ_c = 4.879 N/mm²
- σ_o = √σ²+3τ² = 148.5 N/mm²
- S = 5987. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb 1/EJ dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 11/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

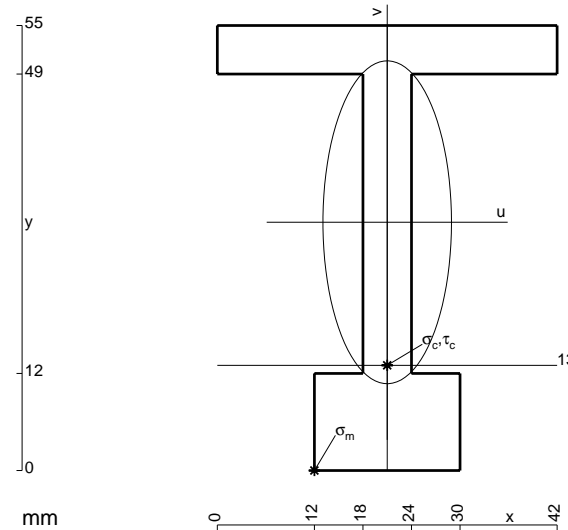
$$= (1/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

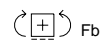
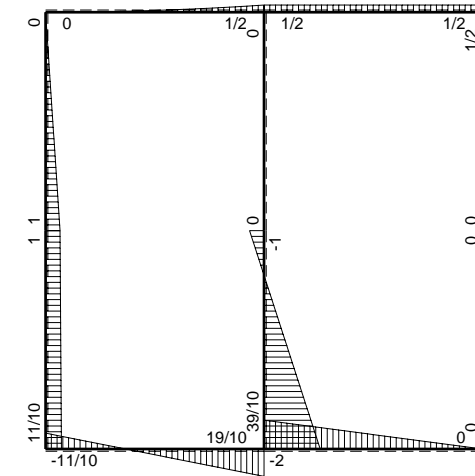
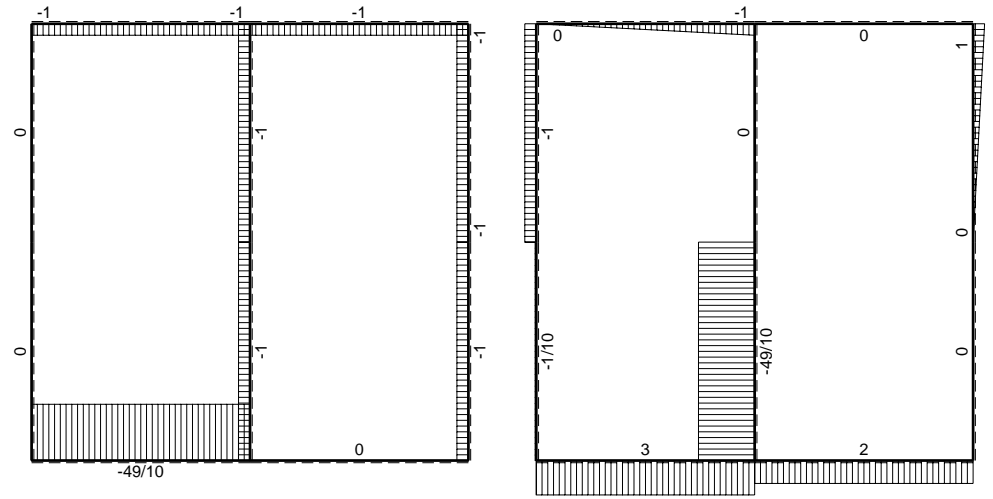
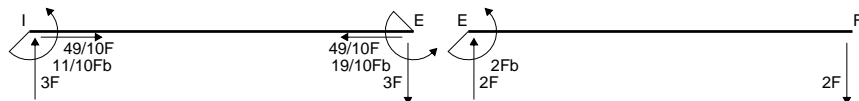
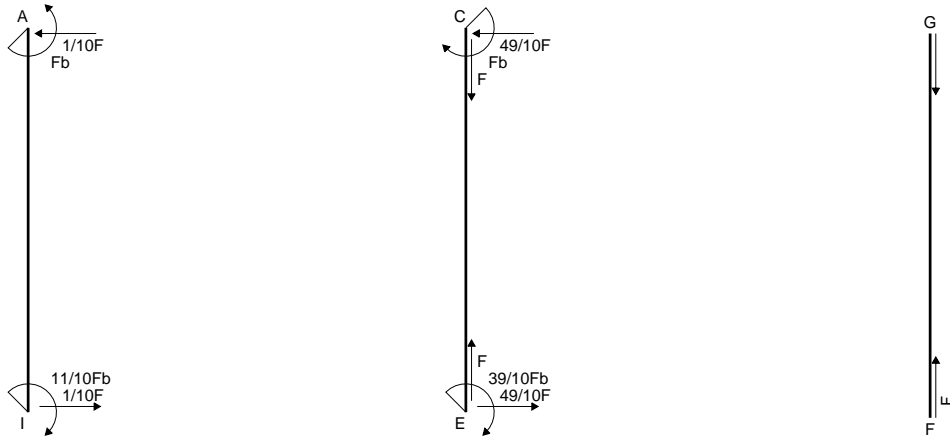
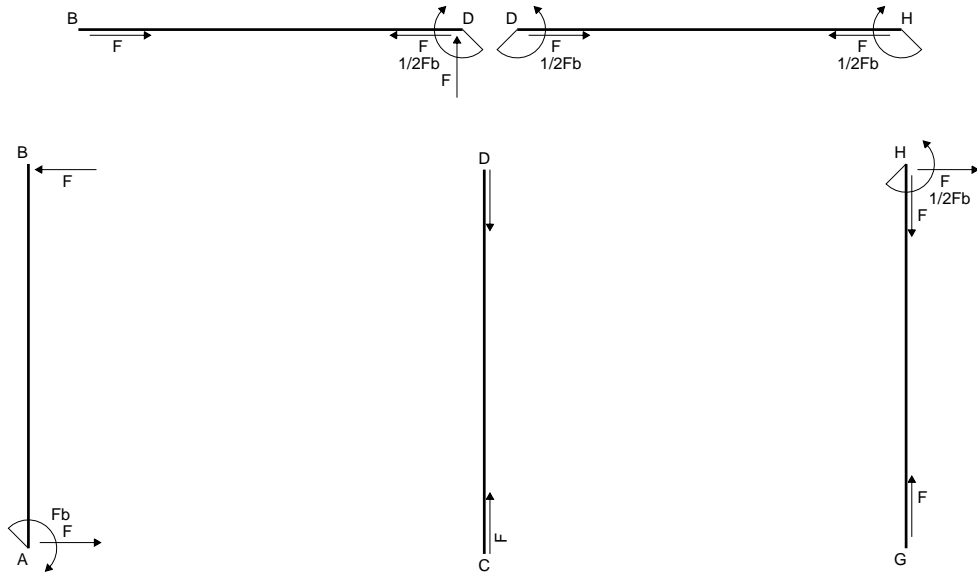
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

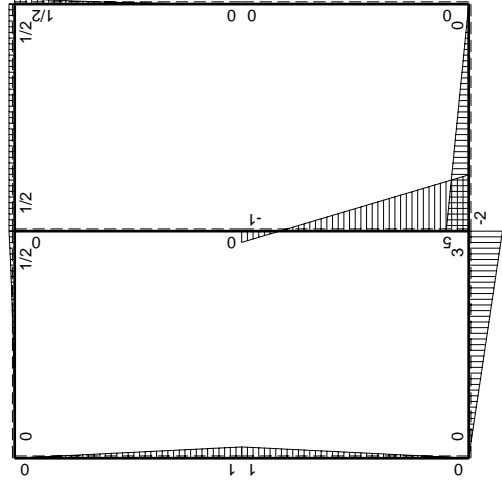
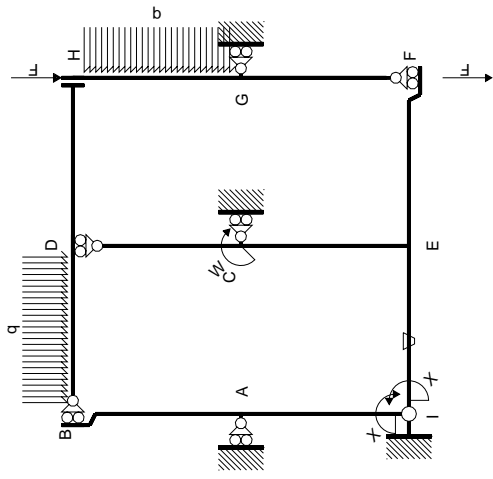
$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$



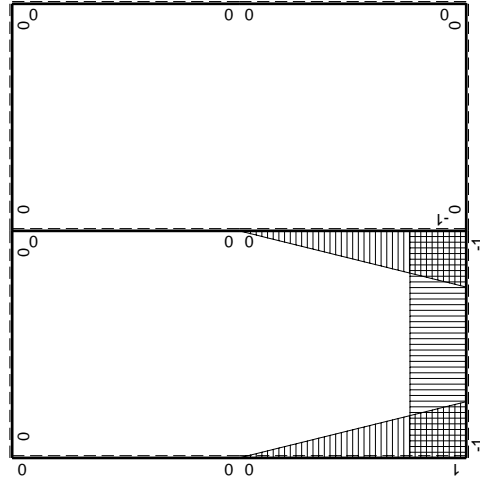
- A = 690. mm²
- J_u = 274792. mm⁴
- J_v = 43542. mm⁴
- y_g = 30.68 mm
- T_y = 2900. N
- M_x = -2059000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -30.68 mm
- σ_m = -Mv/J_u = -229.9 N/mm²
- x_c = 21. mm
- y_c = 13. mm
- v_c = -17.68 mm
- σ_c = -Mv/J_u = -132.5 N/mm²
- τ_c = 9.569 N/mm²
- σ_o = √σ² + 3τ² = 133.5 N/mm²
- S = 5441. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-Fx	0	0	0	0	0+0	0
BA b	0	-Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	5Fb-6Fx	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	Fb-6Fx	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	-Fb+Fx	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

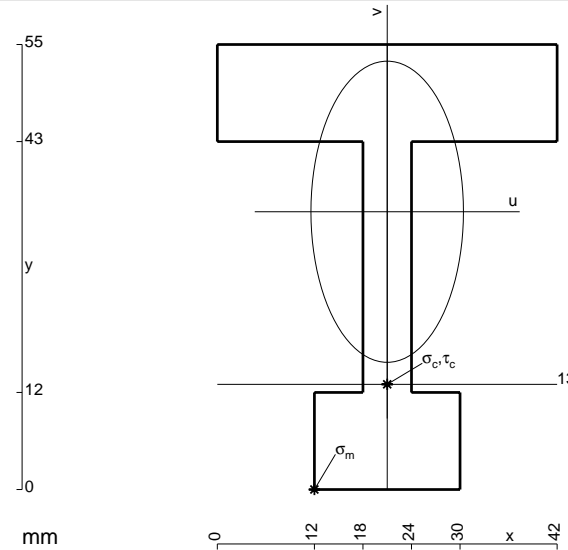
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 906. \text{ mm}^2$$

$$J_u = 314037. \text{ mm}^4$$

$$J_v = 80478. \text{ mm}^4$$

$$y_g = 34.33 \text{ mm}$$

$$T_y = 2840. \text{ N}$$

$$M_x = -2186800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.33 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.1 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

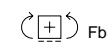
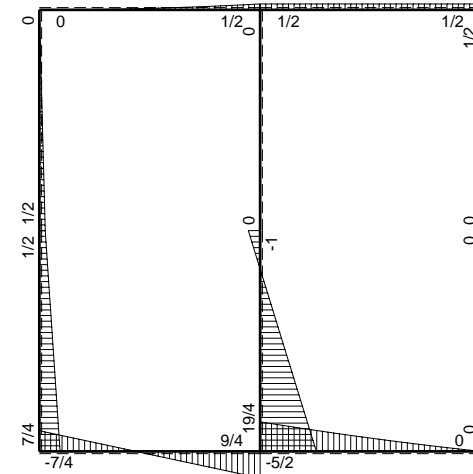
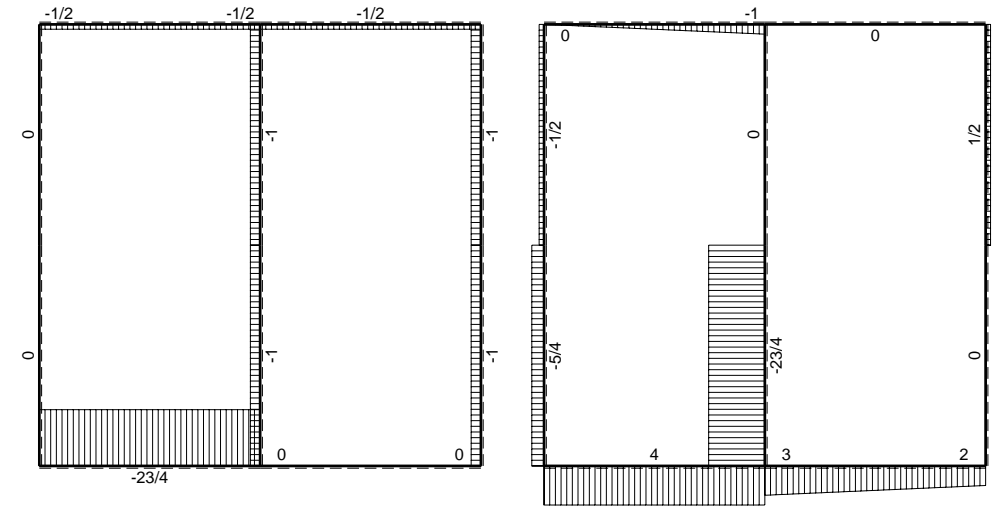
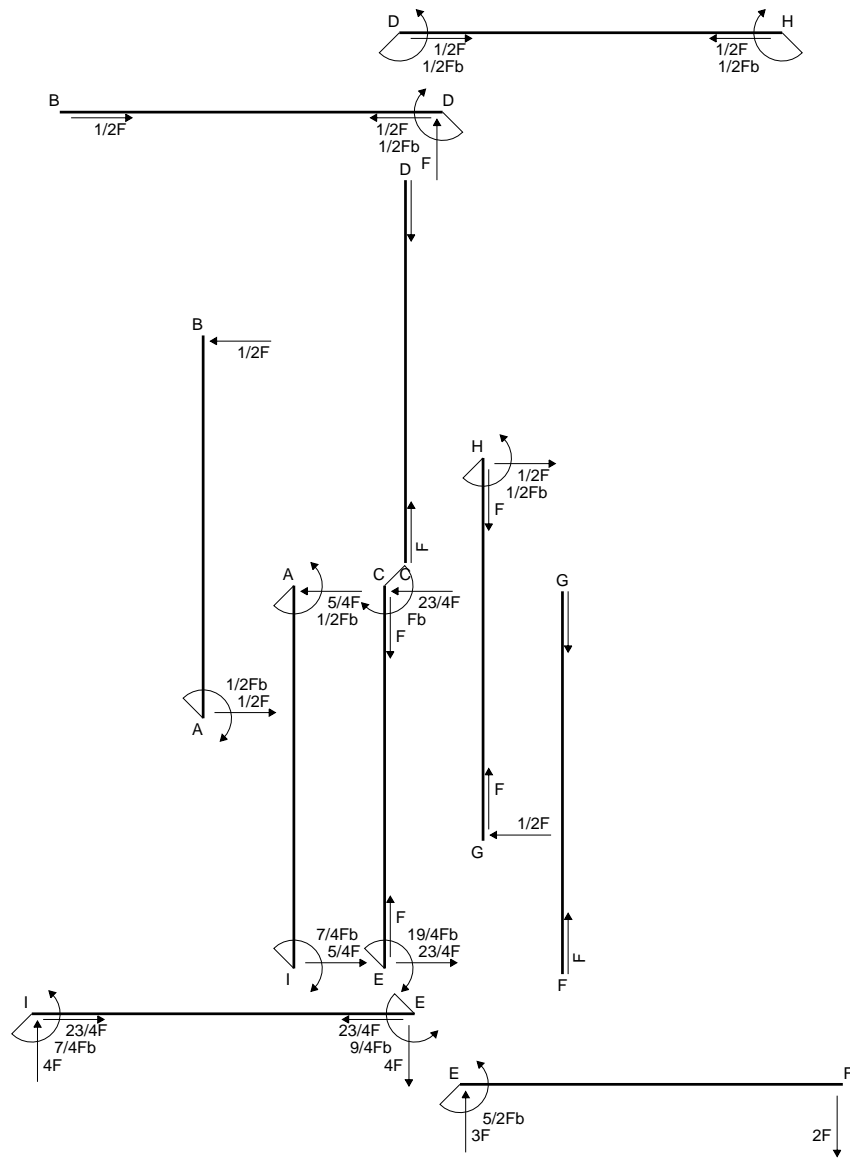
$$v_c = -21.33 \text{ mm}$$

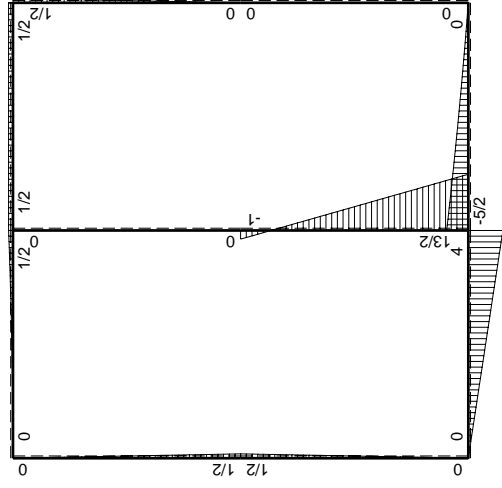
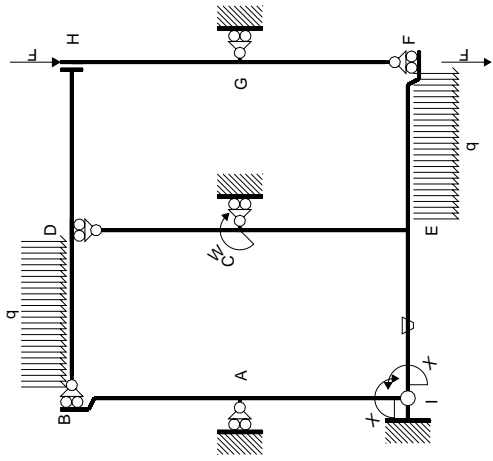
$$\sigma_c = -Mv/J_u = -148.6 \text{ N/mm}^2$$

$$\tau_c = 9.422 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 149.5 \text{ N/mm}^2$$

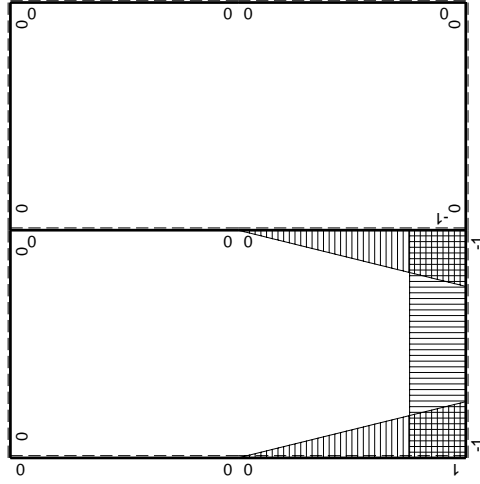
$$S = 6251. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-15/2Fx$	0	$-13/2Fb+14Fx-15/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-15/2Fx$	0	$Fx-15/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 14x/b - 15/2 x^2/b^2) Fb 1/EJ dx = [-13/2 x + 7x^2/b - 5/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-13/2 b + 7b - 5/2 b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 15/2 x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 5/2 x^3/b^2]_0^b Fb 1/EJ$$

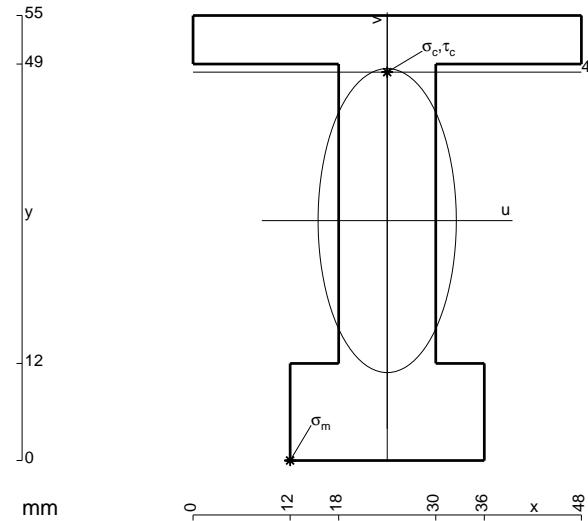
$$= (1/2 b - 5/2 b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

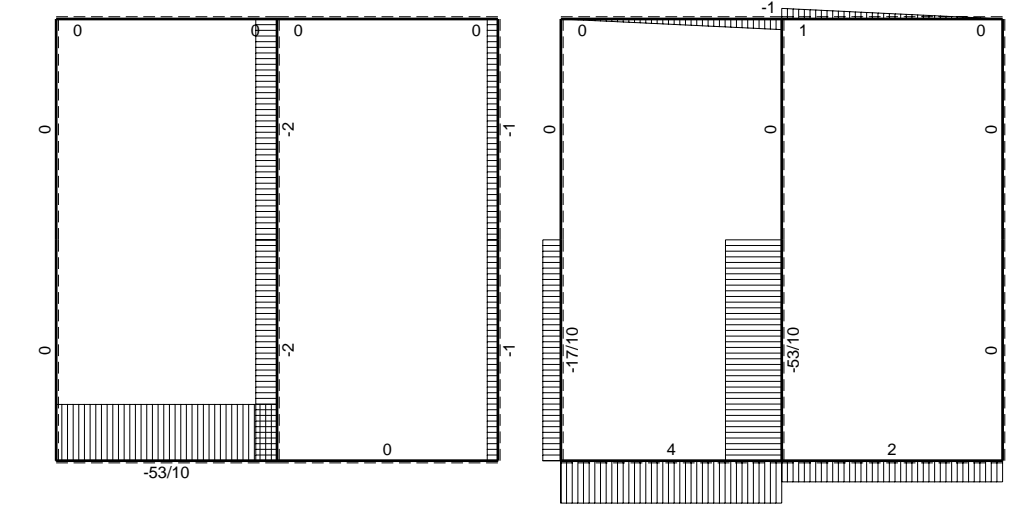
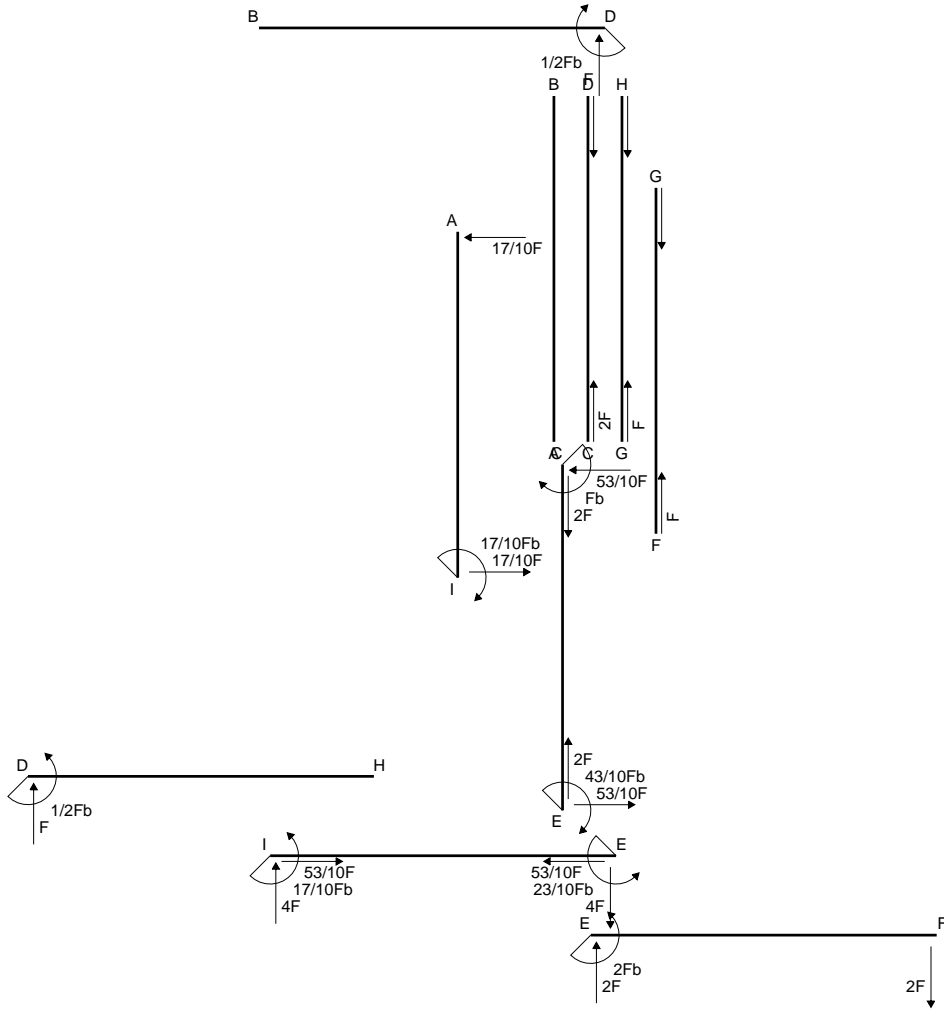
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

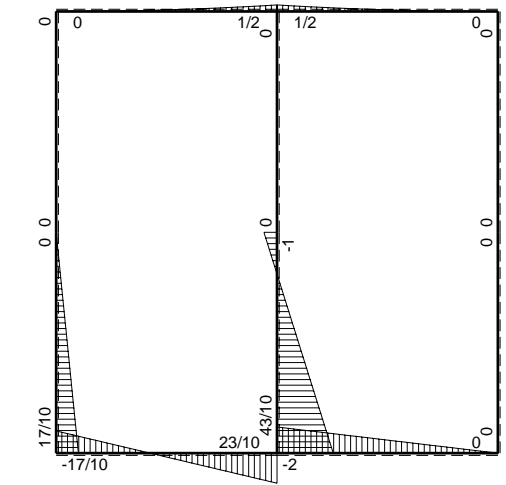


- A = 1020. mm²
- J_u = 360241. mm⁴
- J_v = 74448. mm⁴
- y_g = 29.65 mm
- T_y = 3540. N
- M_x = -2419000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -29.65 mm
- σ_m = -Mv/J_u = -199.1 N/mm²
- x_c = 24. mm
- y_c = 48. mm
- v_c = 18.35 mm
- σ_c = -Mv/J_u = 123.2 N/mm²
- τ_c = 5.456 N/mm²
- σ_o = √σ²+3τ² = 123.6 N/mm²
- S = 6662. mm³

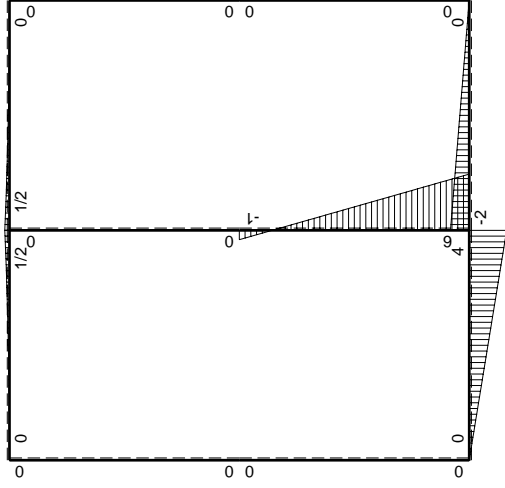
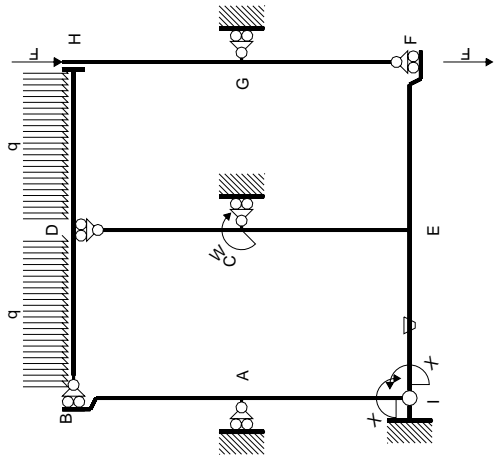


← ⊕ → F

↑ ⊕ ↓ F

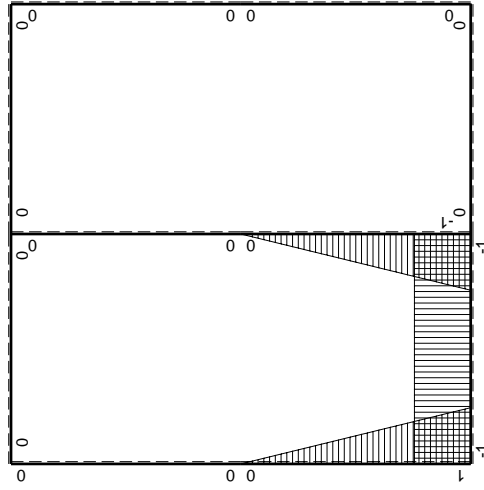


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-7Fx$	0	$-6Fb+13Fx-7Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-7Fx$	0	$Fx-7Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-17/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$17/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

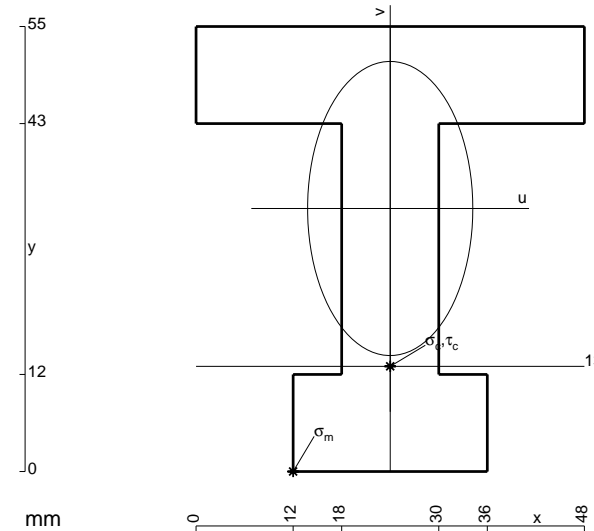
$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 13x/b - 7x^2/b^2) Fb 1/EJ dx = [-6x + 13/2 x^2/b - 7/3 x^3/b^2]_0^b Fb 1/EJ$$

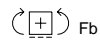
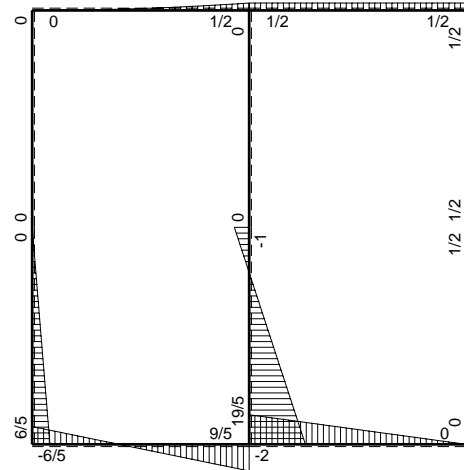
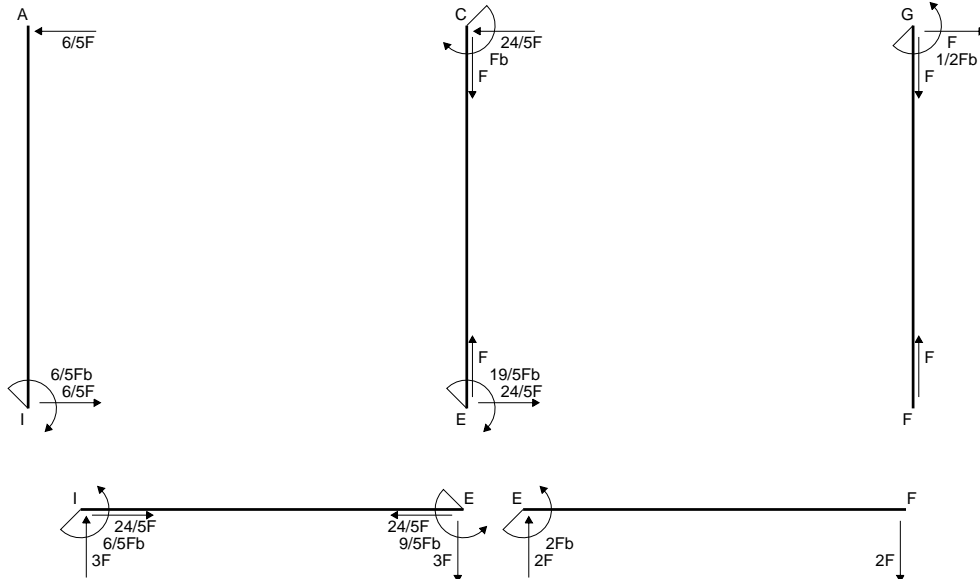
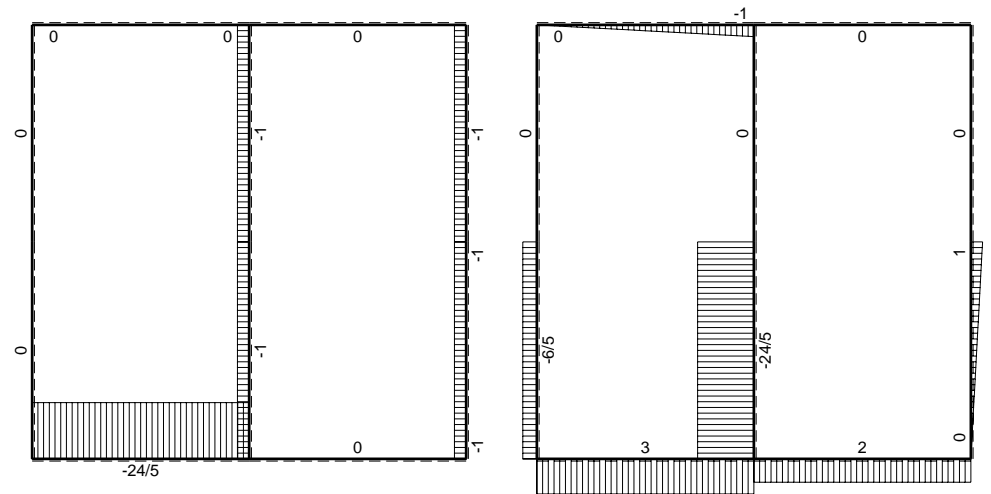
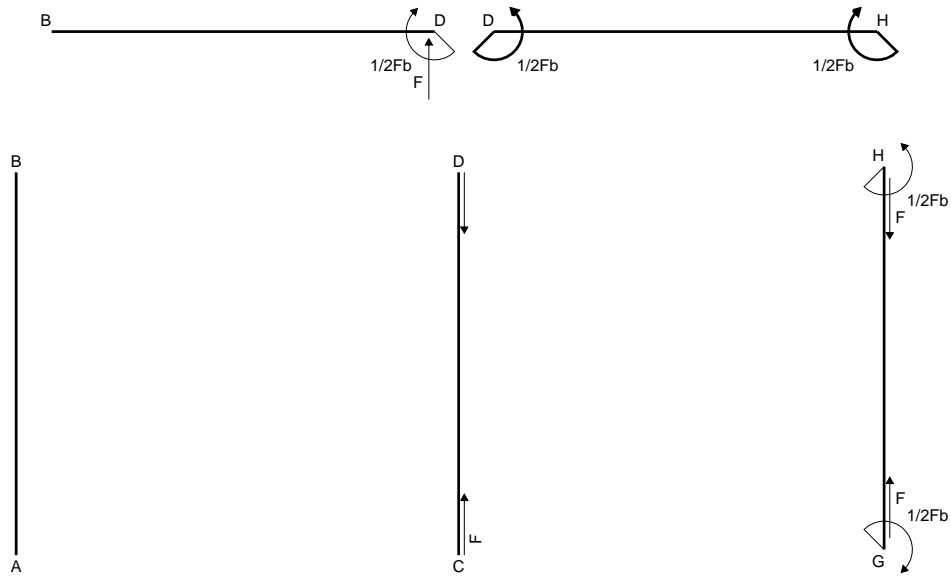
$$= (-6b + 13/2 b - 7/3 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

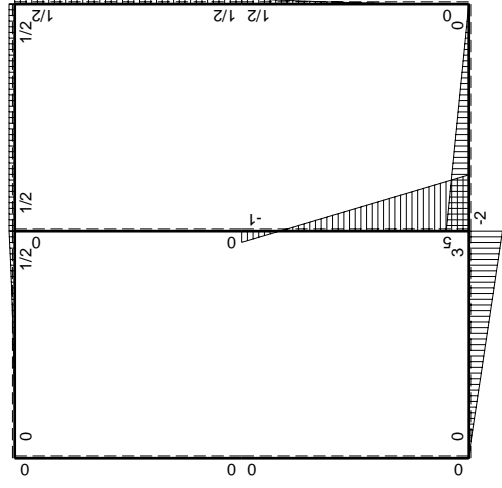
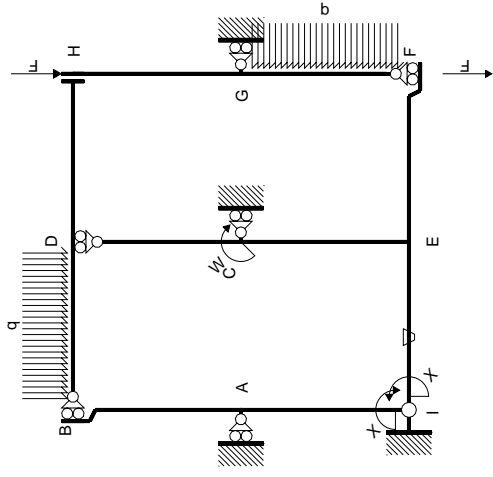
$$L_{CE}^{xo} = \int_0^b (x/b - 7x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 7/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 7/3 b) Fb 1/EJ = -11/6 Fb^2/EJ$$



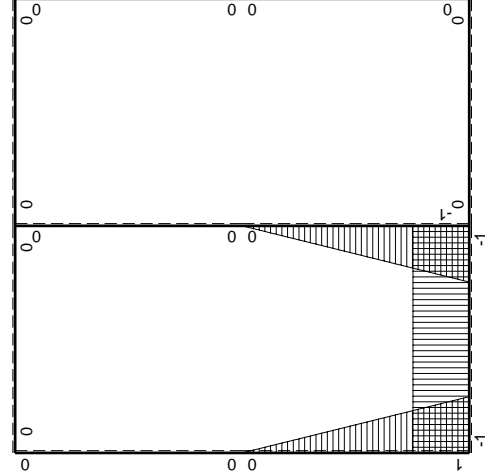
- A = 1236. mm²
- J_u = 408523. mm⁴
- J_v = 128880. mm⁴
- y_g = 32.51 mm
- T_y = 2980. N
- M_x = -2622400. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -32.51 mm
- σ_m = -Mv/J_u = -208.7 N/mm²
- x_c = 24. mm
- y_c = 13. mm
- v_c = -19.51 mm
- σ_c = -Mv/J_u = -125.2 N/mm²
- τ_c = 4.787 N/mm²
- σ_ρ = √σ² + 3τ² = 125.5 N/mm²
- S = 7875. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

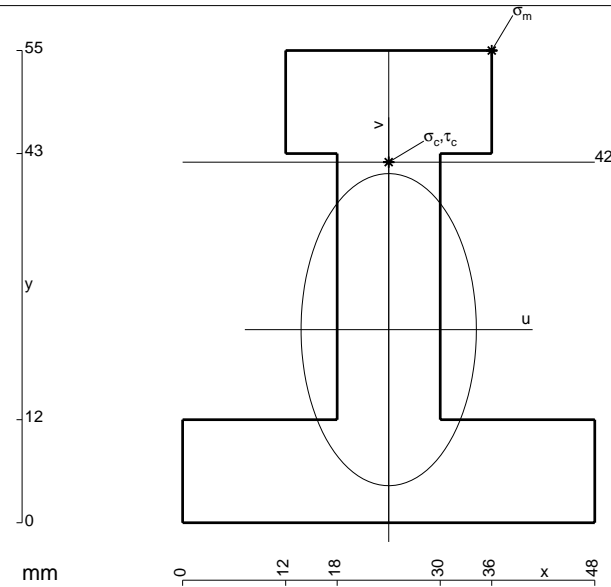
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb 1/EJ dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 11/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$



$$A = 1236. \text{ mm}^2$$

$$J_u = 408523. \text{ mm}^4$$

$$J_v = 128880. \text{ mm}^4$$

$$y_g = 22.49 \text{ mm}$$

$$T_y = 2960. \text{ N}$$

$$M_x = -2752800. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 32.51 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.1 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 42. \text{ mm}$$

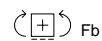
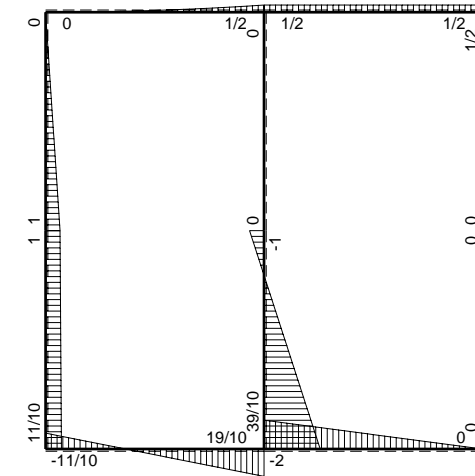
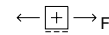
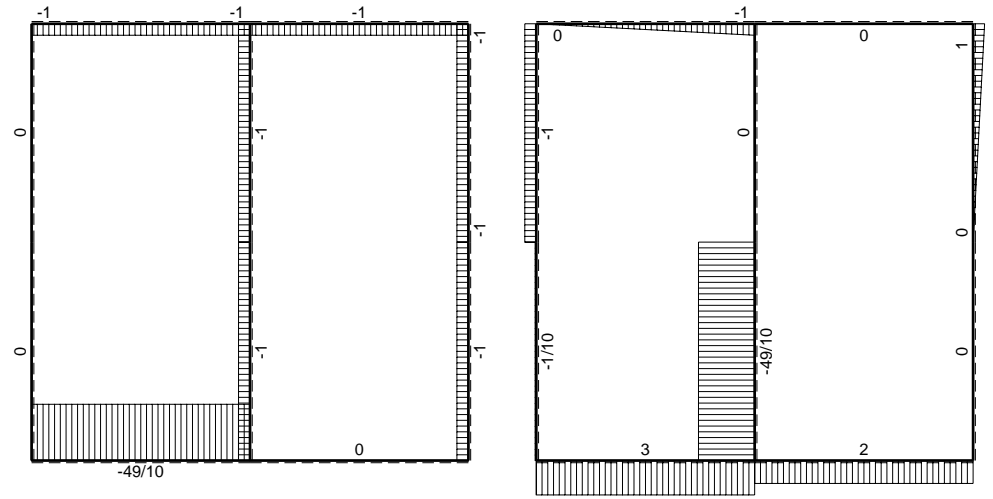
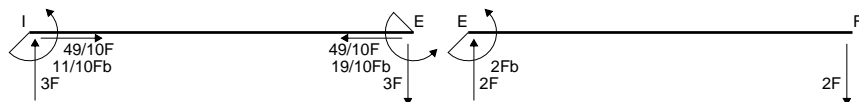
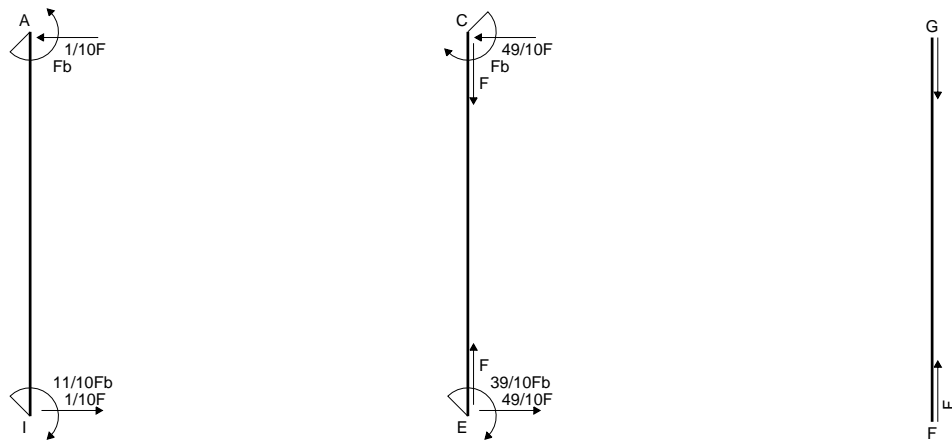
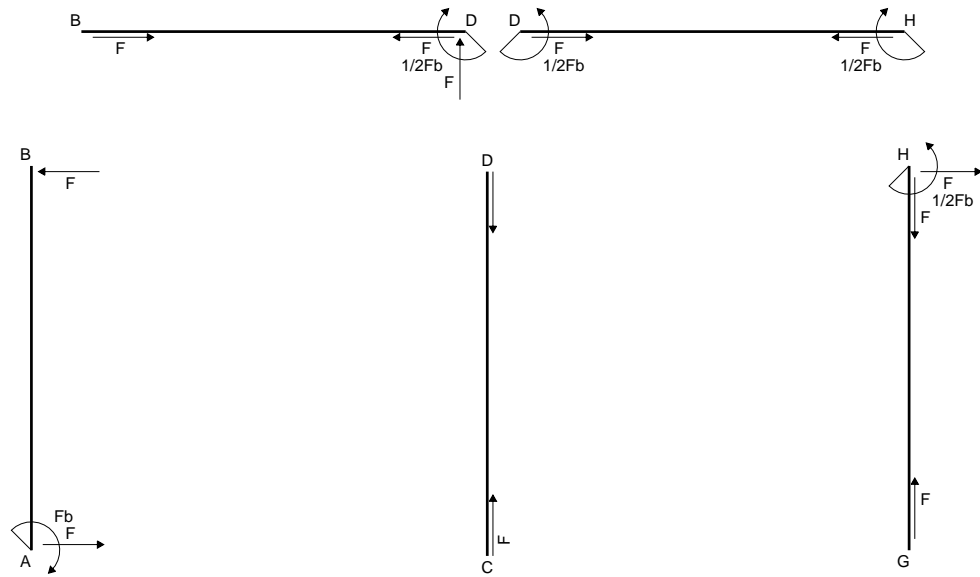
$$v_c = 19.51 \text{ mm}$$

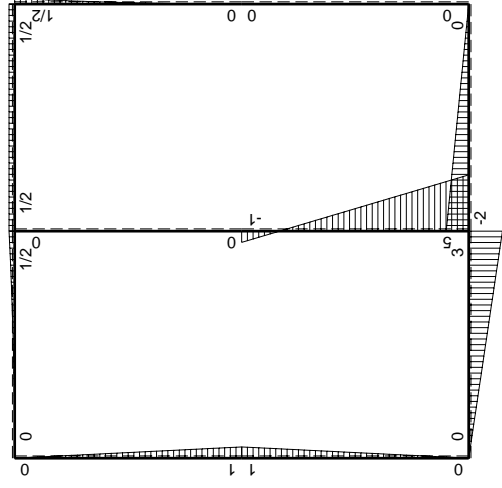
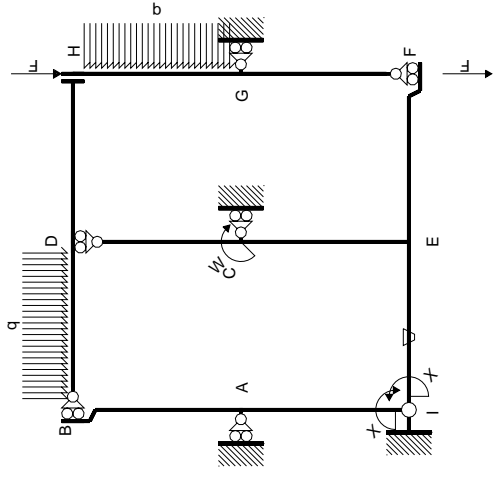
$$\sigma_c = -Mv/J_u = 131.5 \text{ N/mm}^2$$

$$\tau_c = 4.755 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 131.7 \text{ N/mm}^2$$

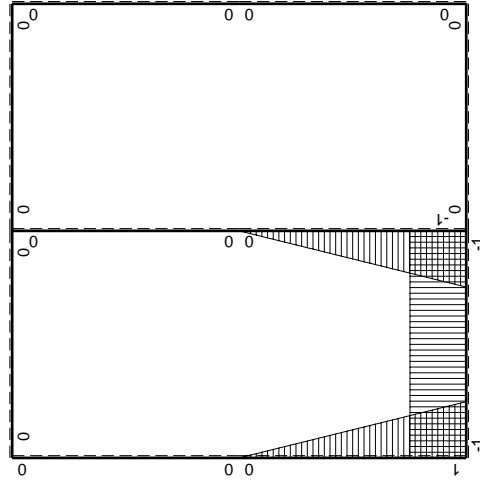
$$S = 7875. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-Fx	0	0	0	0	0+0	0
BA b	0	-Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	5Fb-6Fx	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	Fb-6Fx	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	-Fb+Fx	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

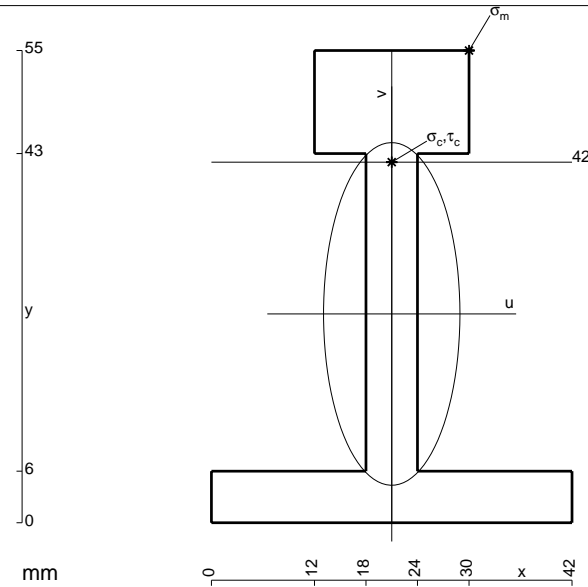
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

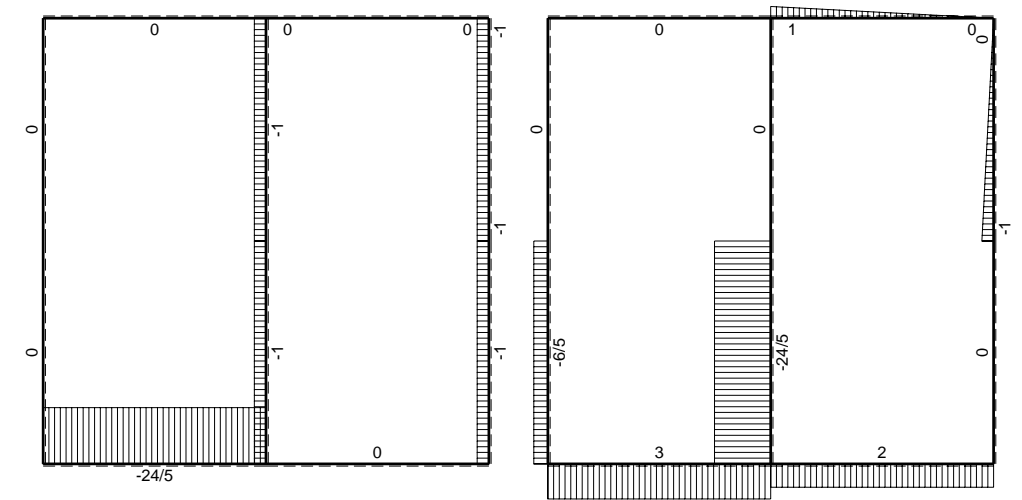
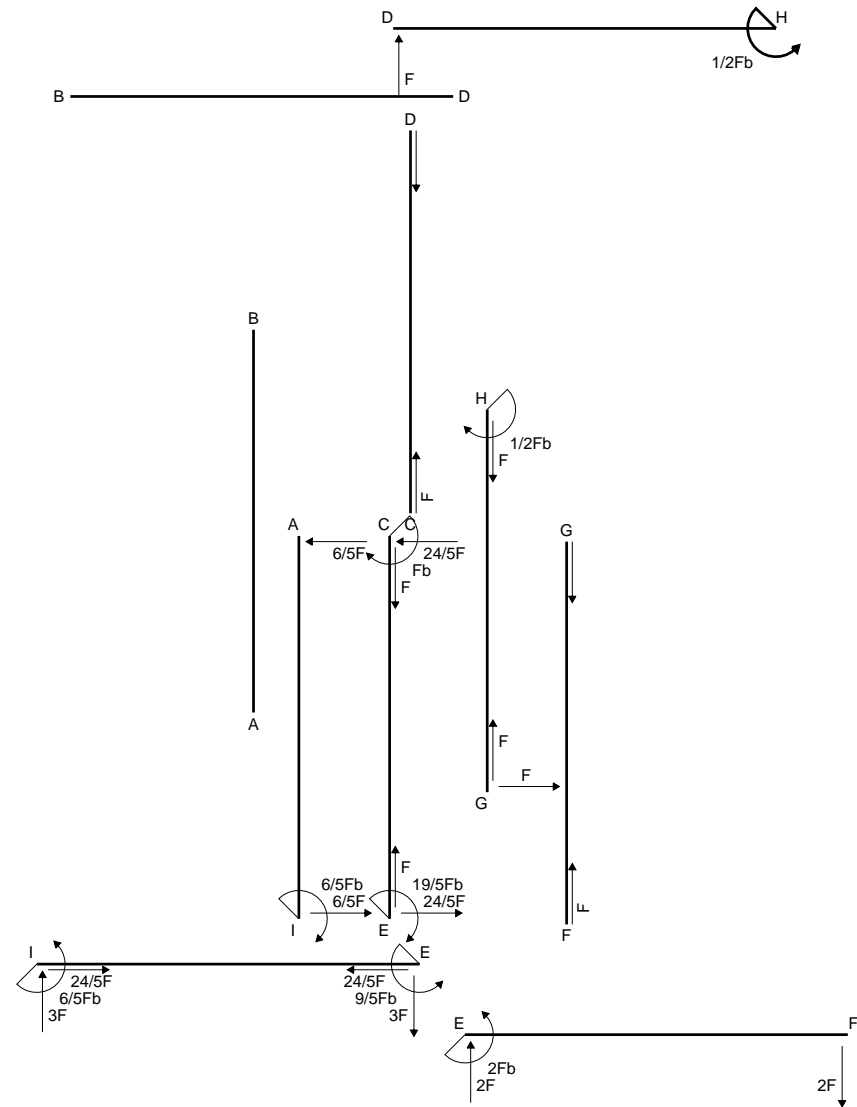
$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

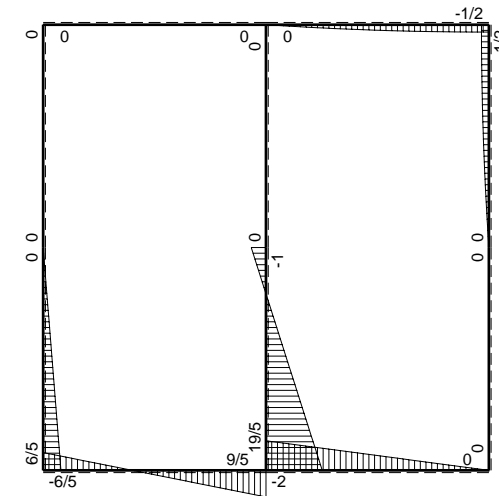


- A = 690. mm²
- J_u = 274793. mm⁴
- J_v = 43542. mm⁴
- y_g = 24.32 mm
- T_y = 2080. N
- M_x = -2059200. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 30.68 mm
- σ_m = -Mv/J_u = 229.9 N/mm²
- x_c = 21. mm
- y_c = 42. mm
- v_c = 17.68 mm
- σ_c = -Mv/J_u = 132.5 N/mm²
- τ_c = 6.864 N/mm²
- σ_q = √(σ²+3τ²) = 133. N/mm²
- S = 5441. mm³

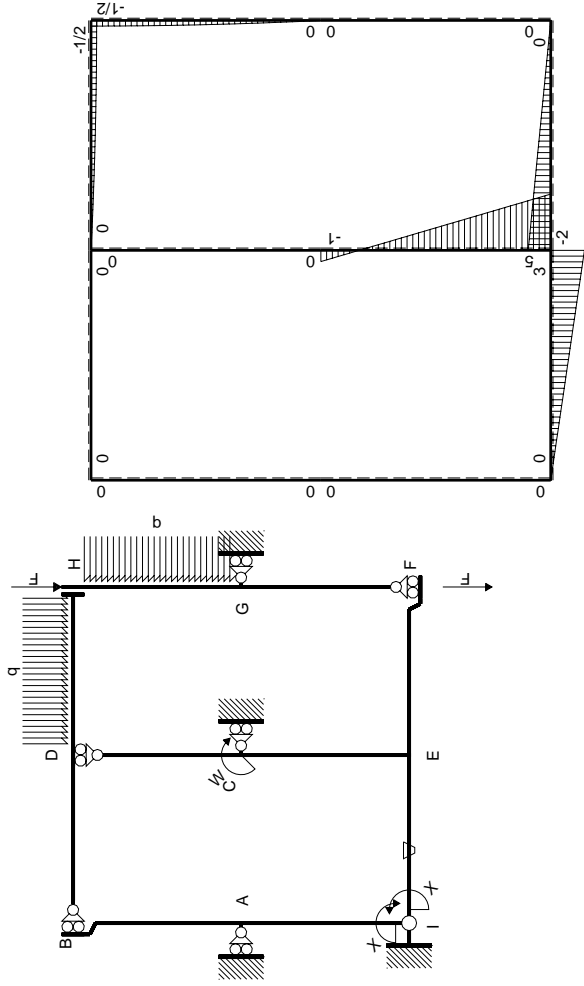


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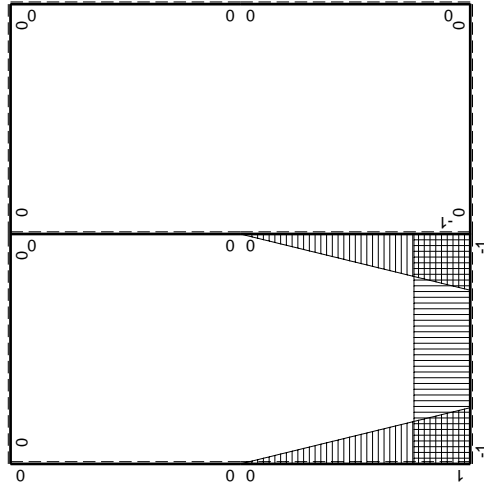


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	0	0	0	0	0	0+0	0	
BA b	0	0	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	-Fx+1/2qx ²	0	0	0	0	0+0	0	
HG b	0	1/2Fb-1/2qx ²	0	0	0	0			
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0	
DH b	0	Fx-1/2qx ²	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ	
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1			
EC b	-1+x/b	5Fb-6Fx	0	-5Fb+11Fx-6Fx ² /b	0	1-2x/b+x ² /b ²	(-3/2+0)Fb ² /EJ	1/3Xb/EJ	
CE b	x/b	Fb-6Fx	0	Fx-6Fx ² /b	0	x ² /b ²			
IA b	1-x/b	0	0	0	0	1-2x/b+x ² /b ²	0+0	1/3Xb/EJ	
AI b	-x/b	0	0	0	0	x ² /b ²			
	totali							-2Fb ² /EJ	5/3Xb/EJ
	iperstatica $X=W_{IE}$							6/5Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

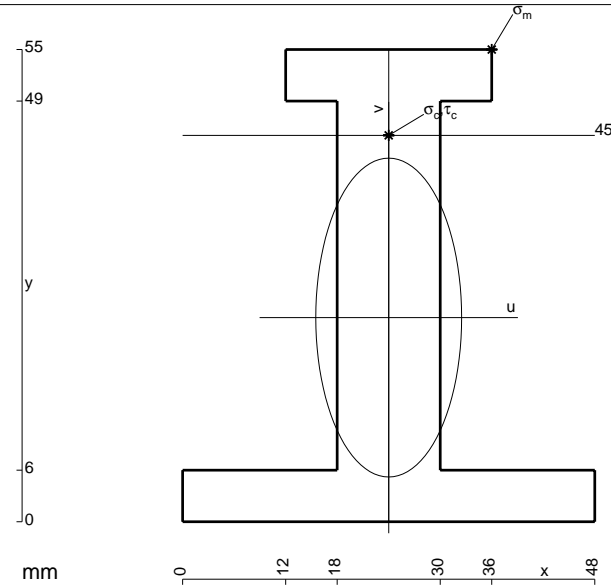
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb 1/EJ dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

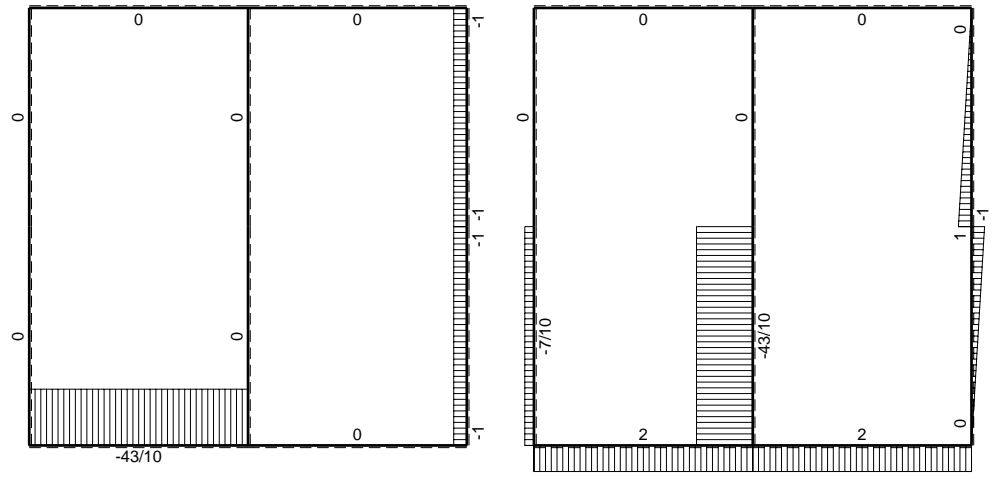
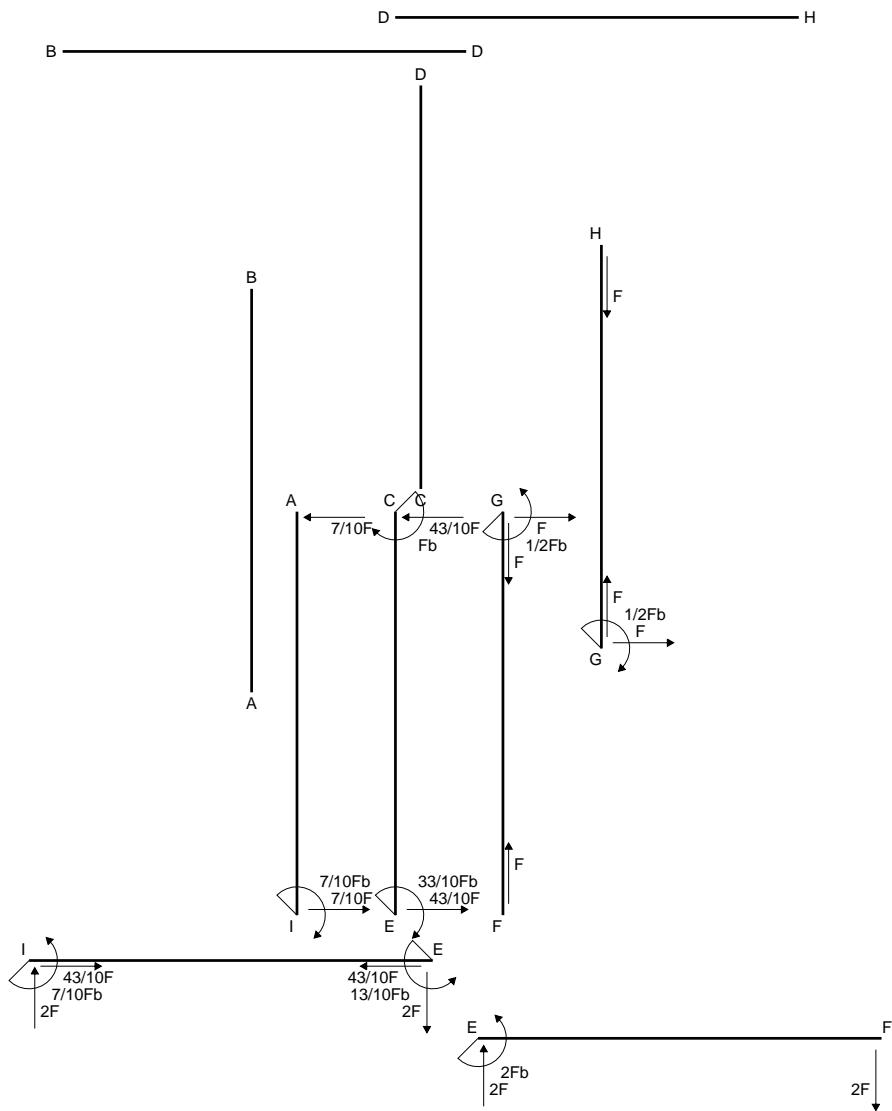
$$= (-5b + 11/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

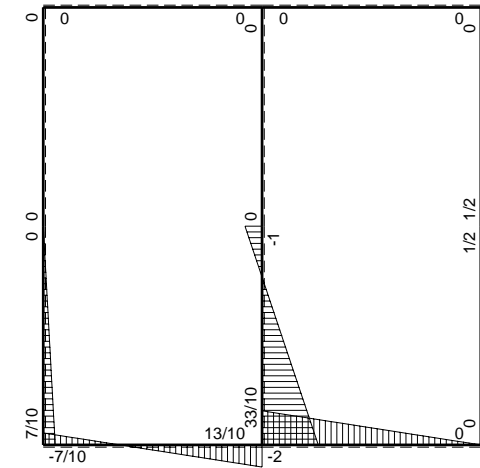


- A = 948. mm²
- J_u = 326982. mm⁴
- J_v = 68400. mm⁴
- y_g = 23.78 mm
- T_y = 2400. N
- M_x = -2496000. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 31.22 mm
- σ_m = -Mv/J_u = 238.3 N/mm²
- x_c = 24. mm
- y_c = 45. mm
- v_c = 21.22 mm
- σ_c = -Mv/J_u = 162. N/mm²
- τ_c = 3.167 N/mm²
- σ_q = √σ²+3τ² = 162.1 N/mm²
- S = 5179. mm³

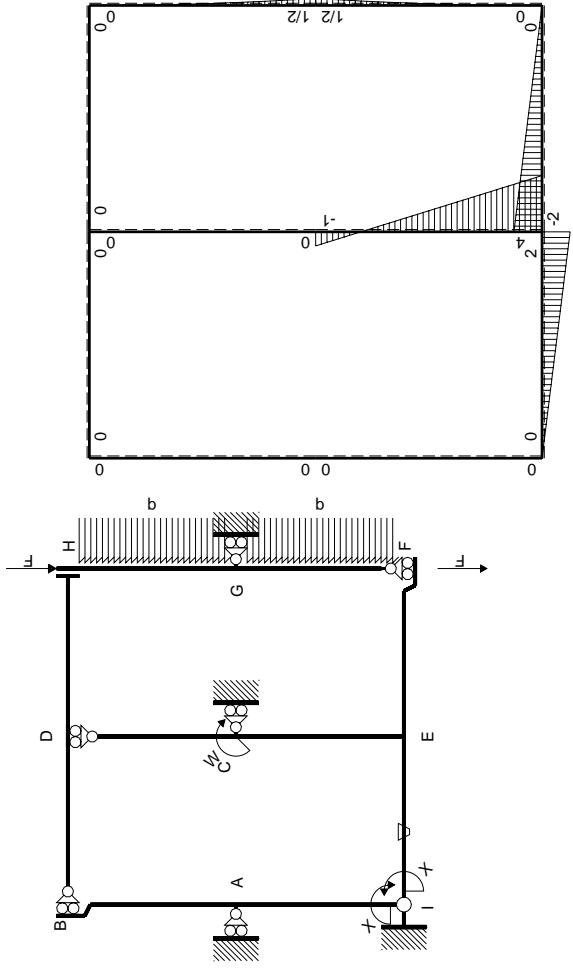


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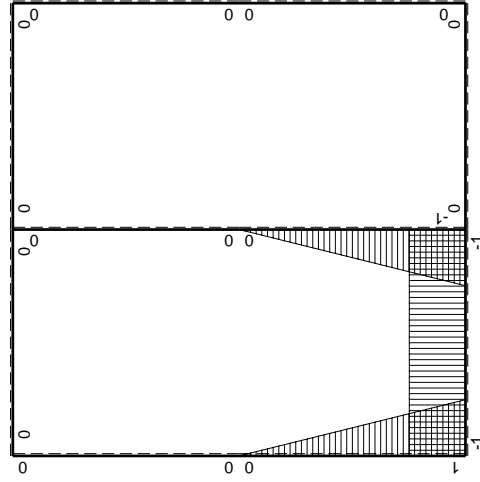


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-5Fx$	0	$-4Fb+9Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-5Fx$	0	$Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

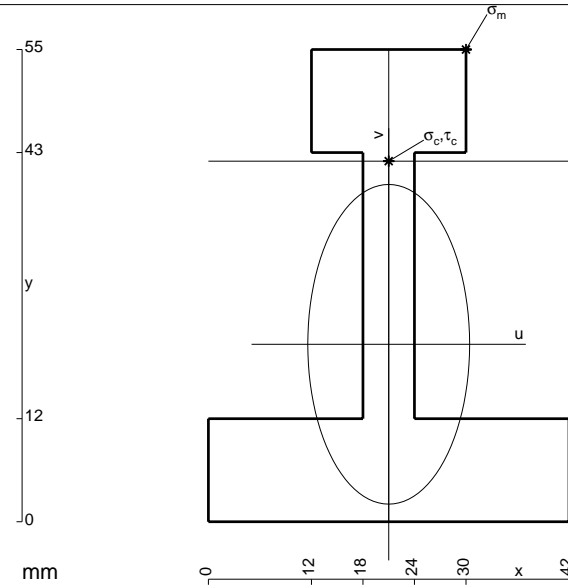
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 9x/b - 5x^2/b^2) Fb 1/EJ dx = [-4x + 9/2 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

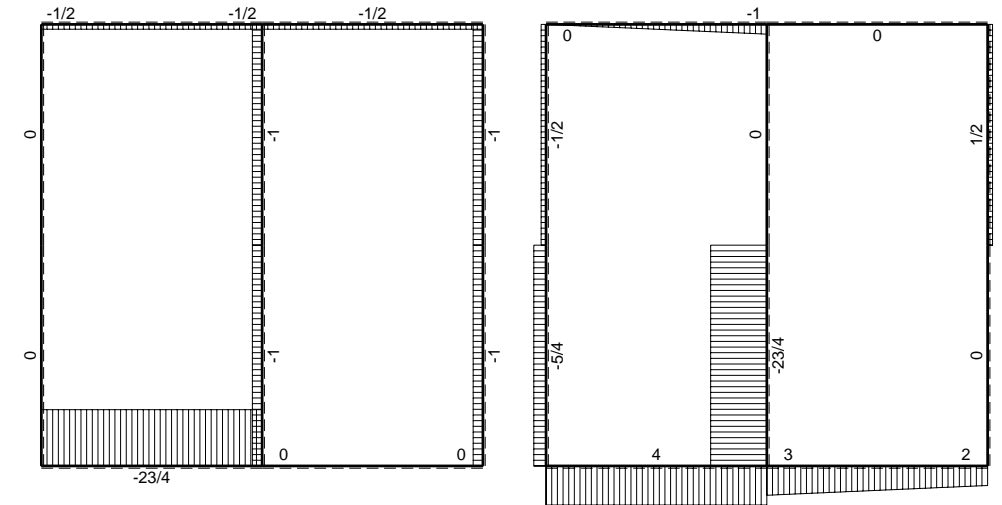
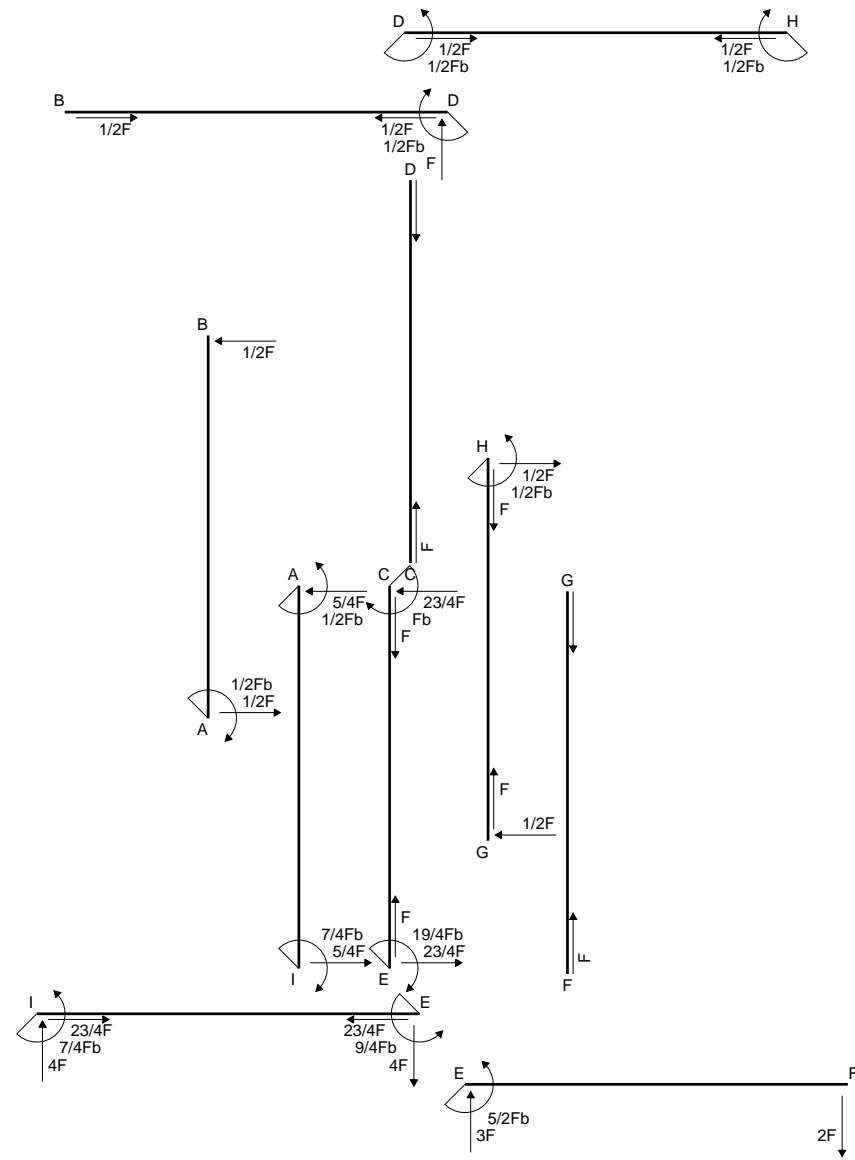
$$= (-4b + 9/2 b - 5/3 b) Fb 1/EJ = -7/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 5x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 5/3 b) Fb 1/EJ = -7/6 Fb^2/EJ$$

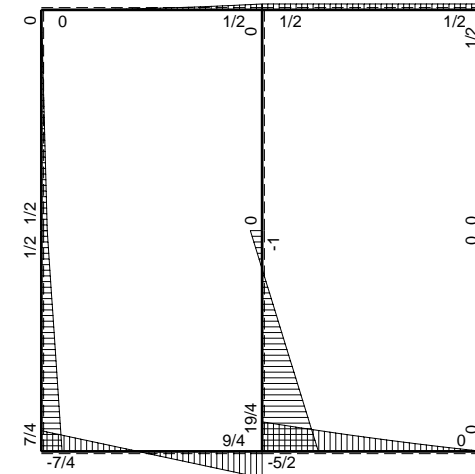


- A = 906. mm²
- J_u = 314037. mm⁴
- J_v = 80478. mm⁴
- y_g = 20.67 mm
- T_y = 3320. N
- M_x = -1826000. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 34.33 mm
- σ_m = -Mv/J_u = 199.6 N/mm²
- x_c = 21. mm
- y_c = 42. mm
- v_c = 21.33 mm
- σ_c = -Mv/J_u = 124.1 N/mm²
- τ_c = 11.01 N/mm²
- σ_q = √σ²+3τ² = 125.5 N/mm²
- S = 6251. mm³

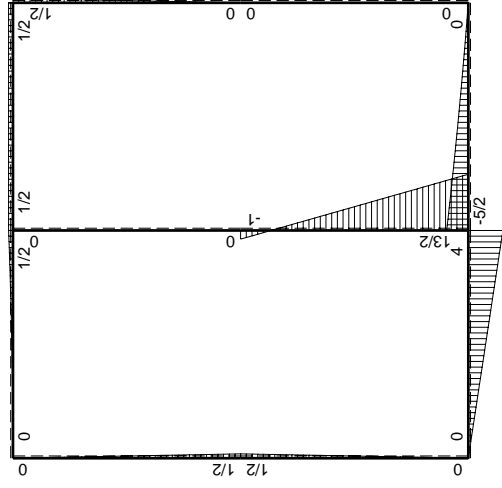
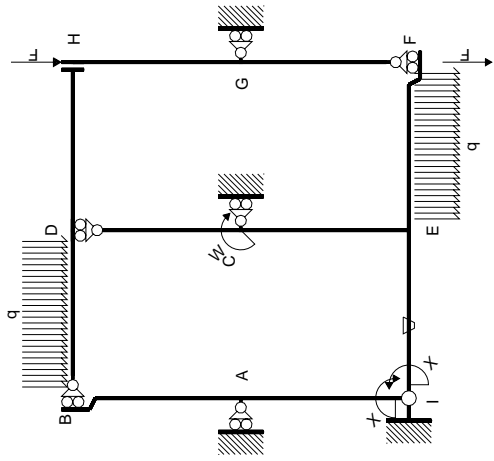


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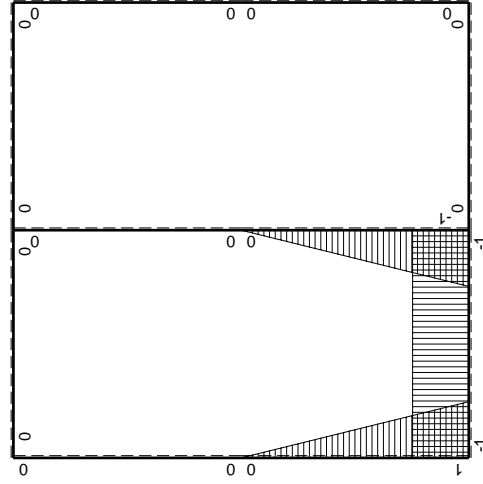


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-15/2Fx$	0	$-13/2Fb+14Fx-15/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-15/2Fx$	0	$Fx-15/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-13/2 + 14x/b - 15/2 x^2/b^2) Fb 1/EJ dx = [-13/2 x + 7x^2/b - 5/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-13/2 b + 7b - 5/2 b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (x/b - 15/2 x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 5/2 x^3/b^2]_0^b Fb 1/EJ$$

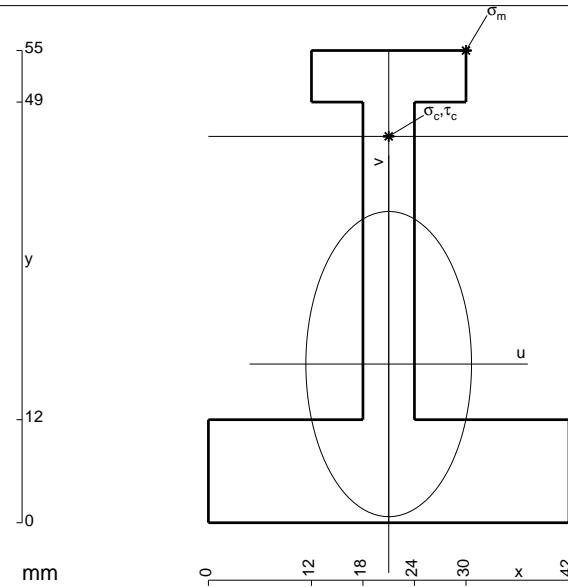
$$= (1/2 b - 5/2 b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

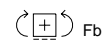
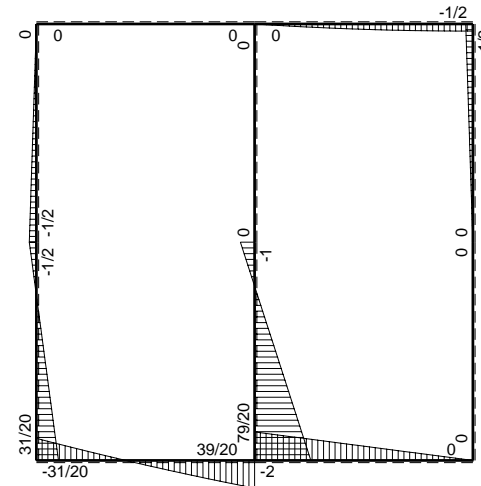
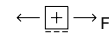
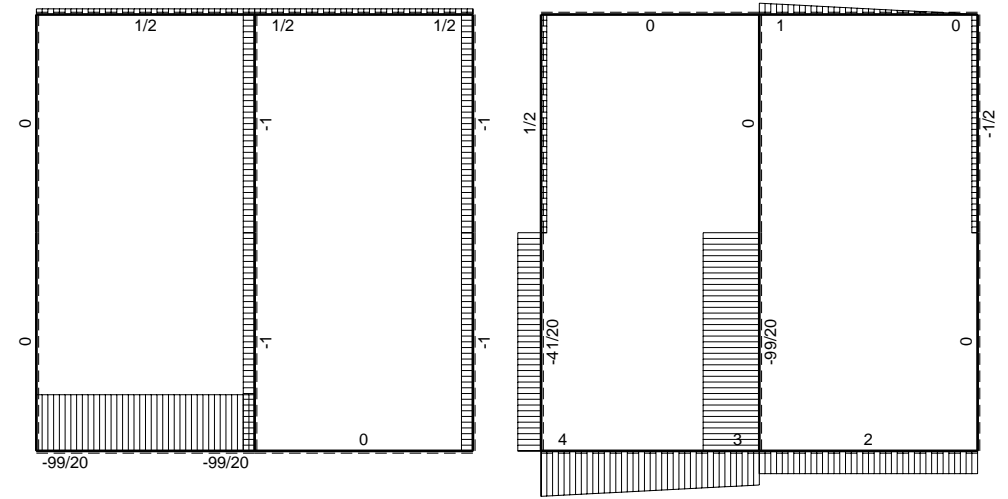
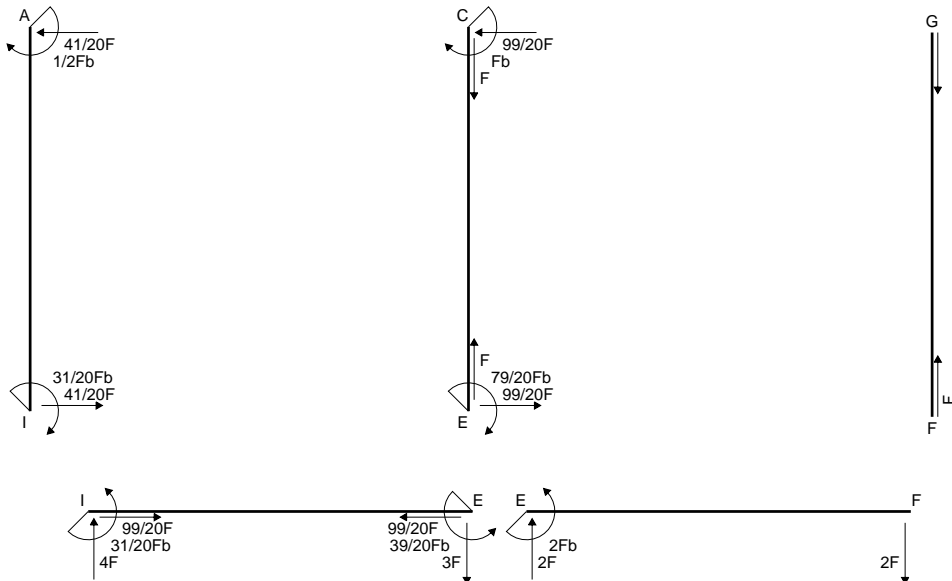
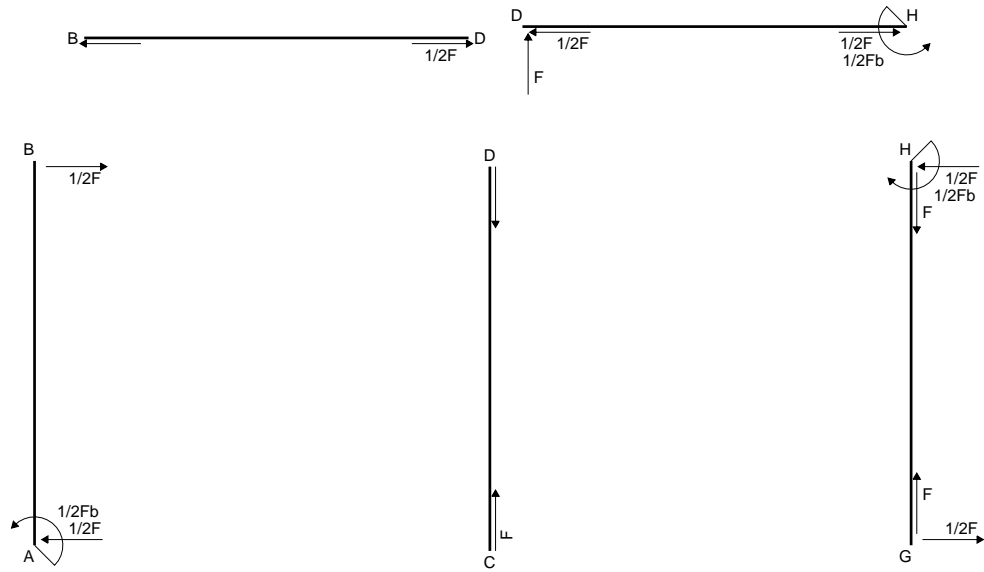
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

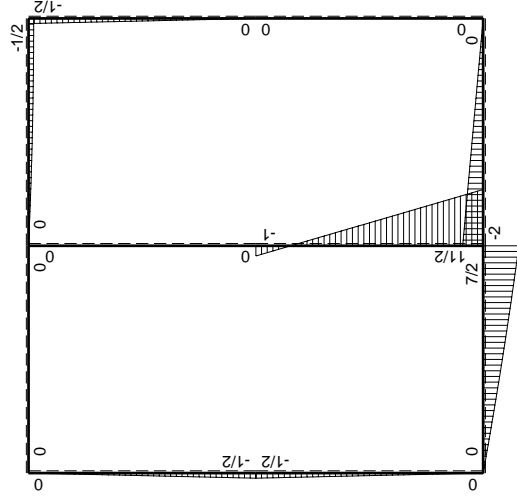
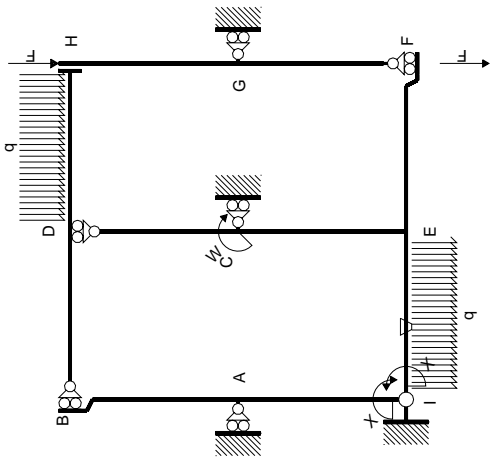
$$L_{AI}^{x_0} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$



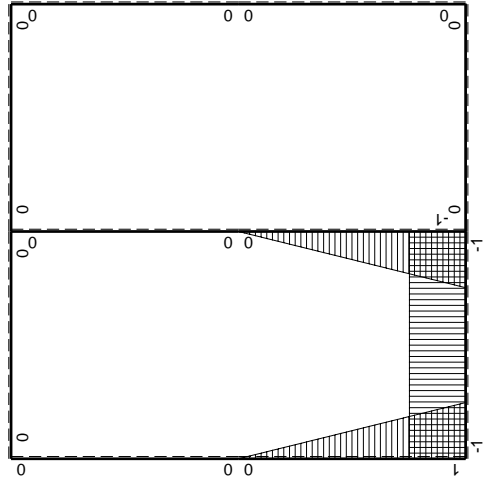
- A = 834. mm²
- J_u = 263619. mm⁴
- J_v = 77670. mm⁴
- y_g = 18.48 mm
- T_y = 3030. N
- M_x = -1515000. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 36.52 mm
- σ_m = -Mv/J_u = 209.9 N/mm²
- x_c = 21. mm
- y_c = 45. mm
- v_c = 26.52 mm
- σ_c = -Mv/J_u = 152.4 N/mm²
- τ_c = 8.247 N/mm²
- σ_q = √σ²+3τ² = 153.1 N/mm²
- S = 4305. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-13/2Fx$	0	$-11/2Fb+12Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-13/2Fx$	0	$Fx-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 12x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 6x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 6b - 13/6 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

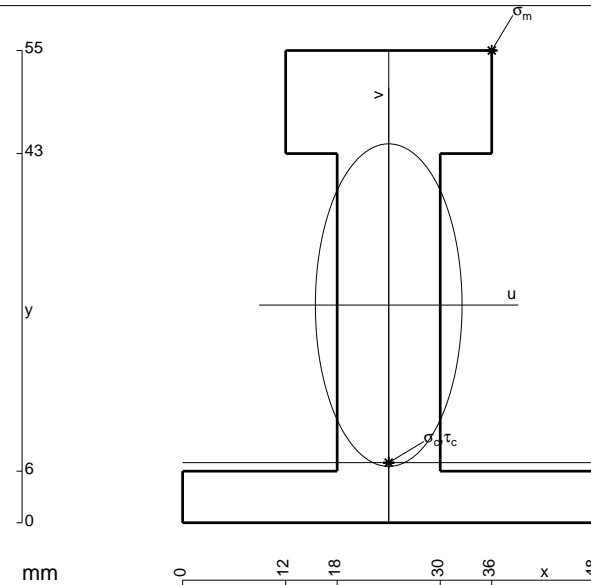
$$= (1/2 b - 13/6 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

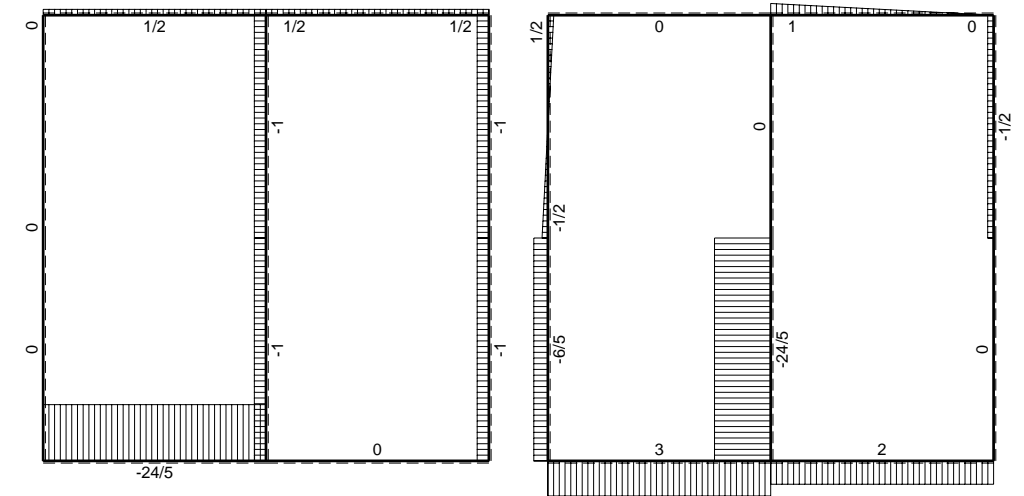
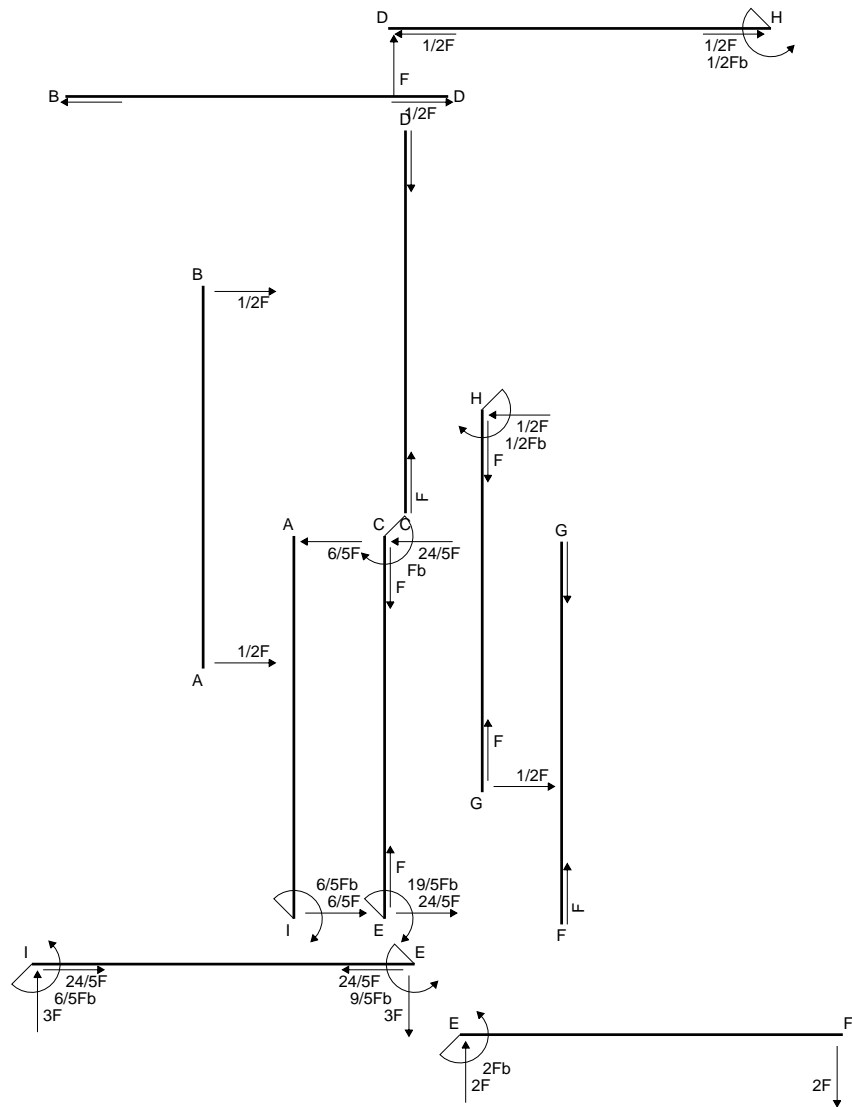
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

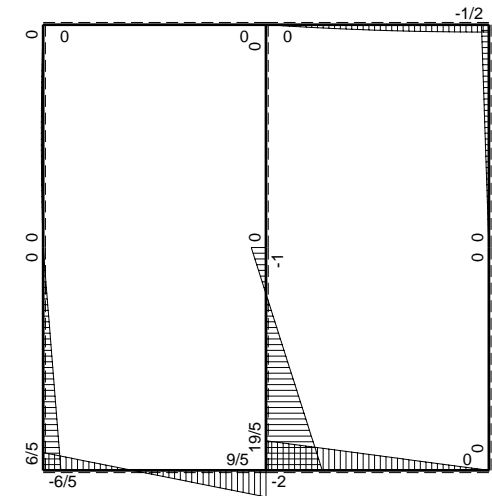


- A = 1020. mm²
- J_u = 360241. mm⁴
- J_v = 74448. mm⁴
- y_g = 25.35 mm
- T_y = 4040. N
- M_x = -2666400. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 29.65 mm
- σ_m = -Mv/J_u = 219.5 N/mm²
- x_c = 24. mm
- y_c = 7. mm
- v_c = -18.35 mm
- σ_c = -Mv/J_u = -135.8 N/mm²
- τ_c = 6.226 N/mm²
- σ_q = √σ² + 3τ² = 136.2 N/mm²
- S = 6662. mm³

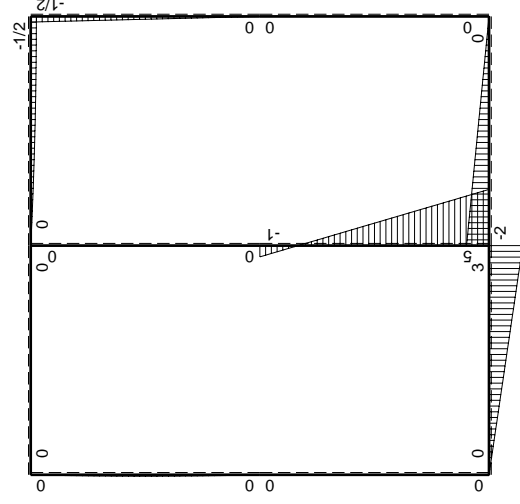
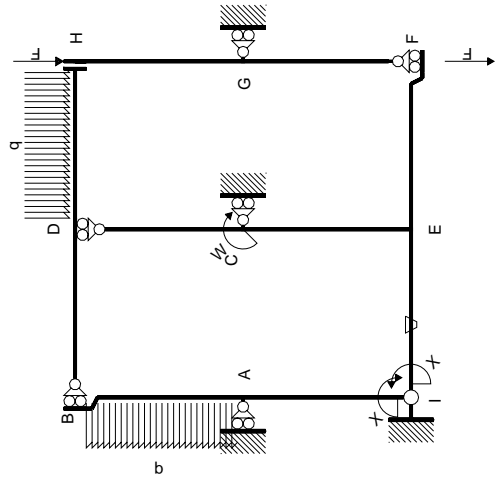


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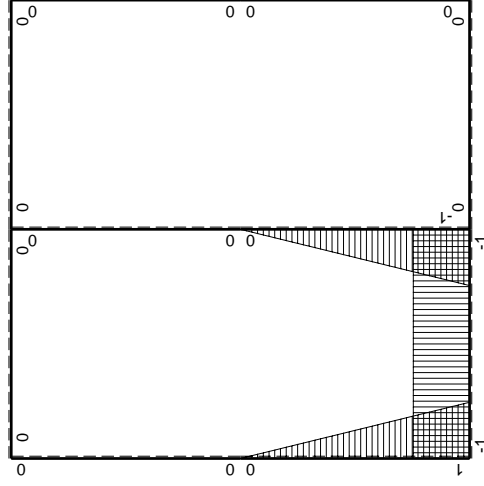


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

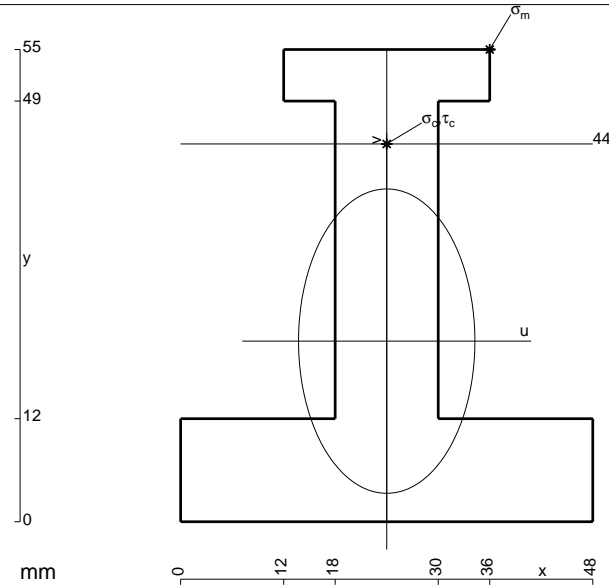
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb 1/EJ dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

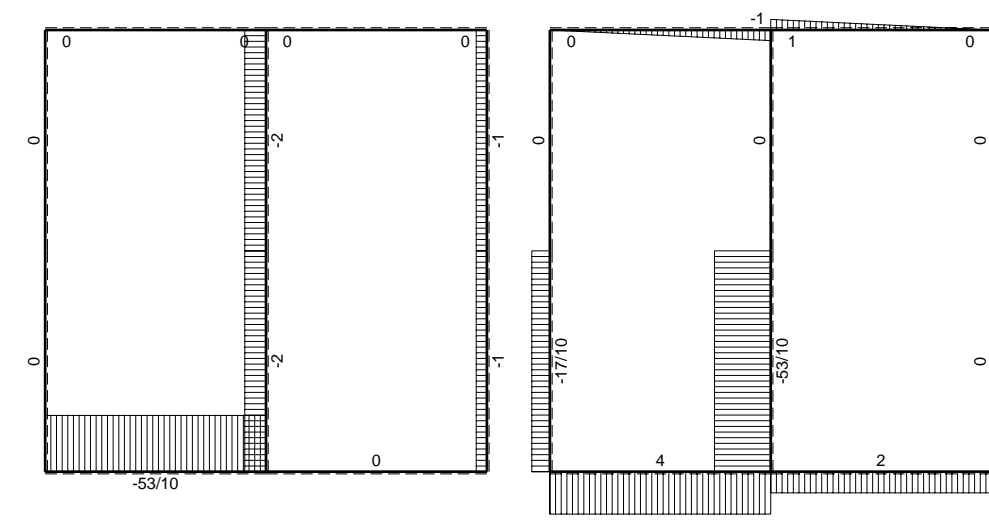
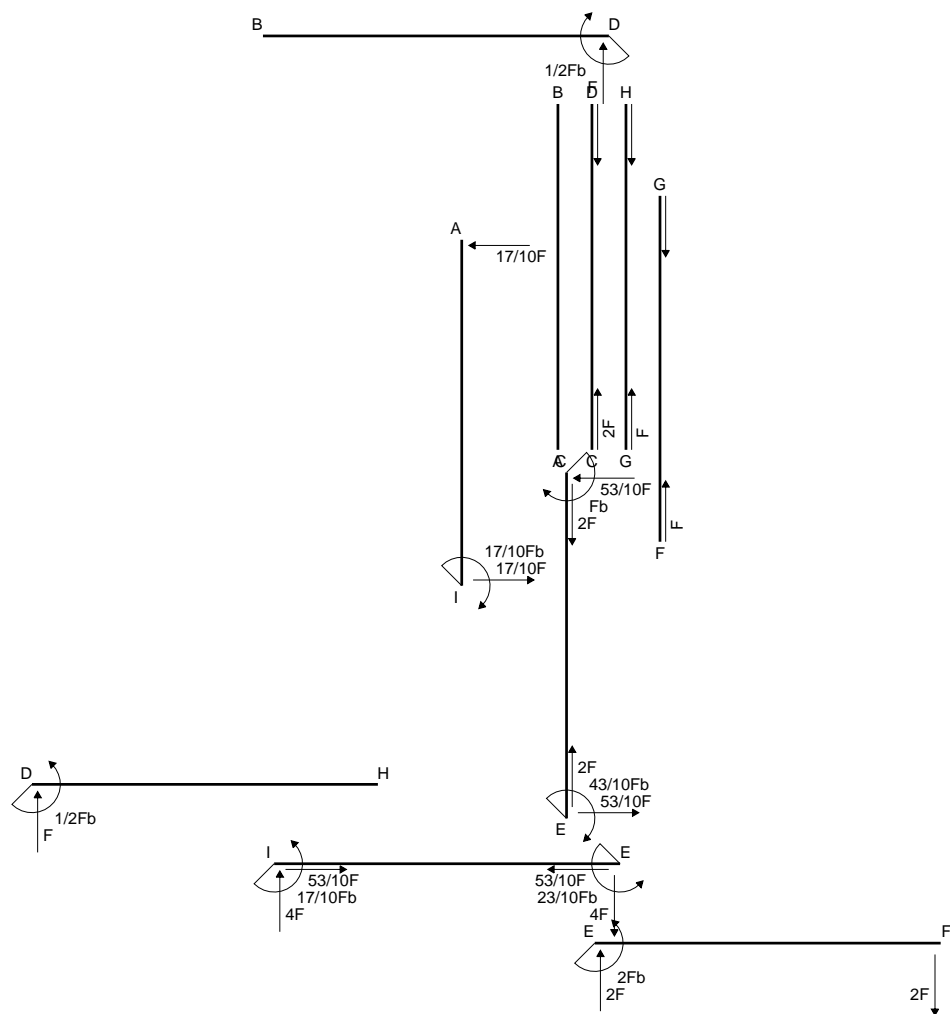
$$= (-5b + 11/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

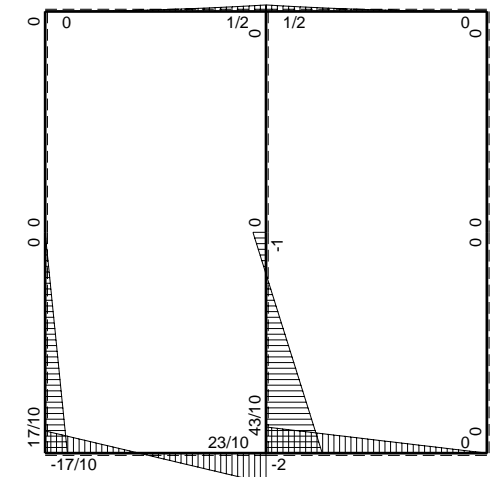


- A = 1164. mm²
- J_u = 366050. mm⁴
- J_v = 122832. mm⁴
- y_g = 21.04 mm
- T_y = 3480. N
- M_x = -2470800. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 33.96 mm
- σ_m = -Mv/J_u = 229.3 N/mm²
- x_c = 24. mm
- y_c = 44. mm
- v_c = 22.96 mm
- σ_c = -Mv/J_u = 155. N/mm²
- τ_c = 4.743 N/mm²
- σ_q = √σ²+3τ² = 155.2 N/mm²
- S = 5987. mm³

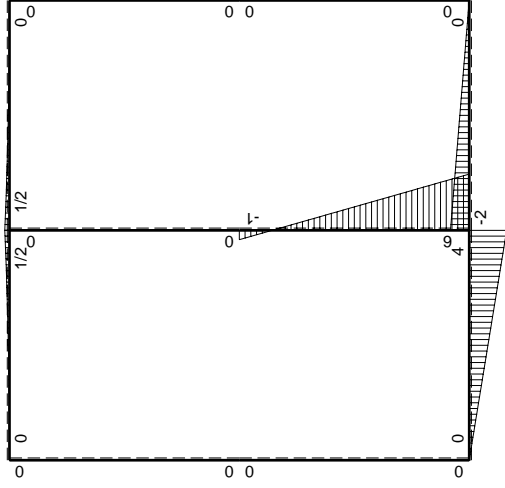
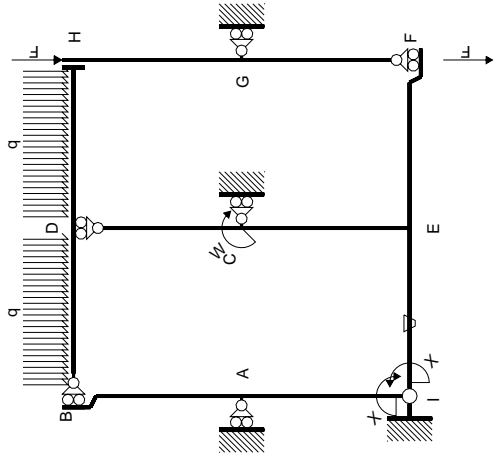


← ⊕ → F

↑ ⊕ ↓ F

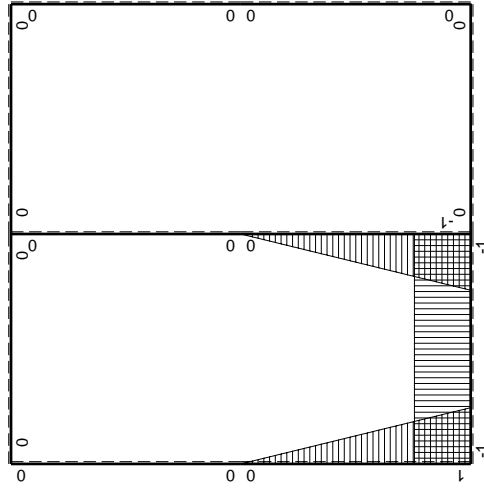


⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-7Fx$	0	$-6Fb+13Fx-7Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-7Fx$	0	$Fx-7Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-17/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$17/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = - Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

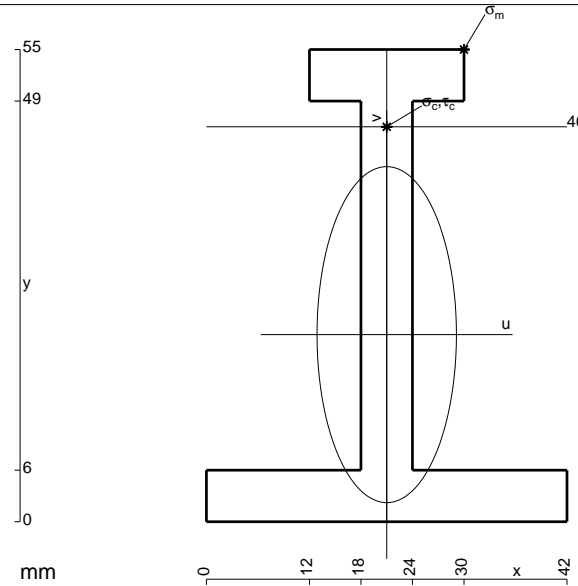
$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = - Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 13x/b - 7x^2/b^2) Fb 1/EJ dx = [-6x + 13/2 x^2/b - 7/3 x^3/b^2]_0^b Fb 1/EJ$$

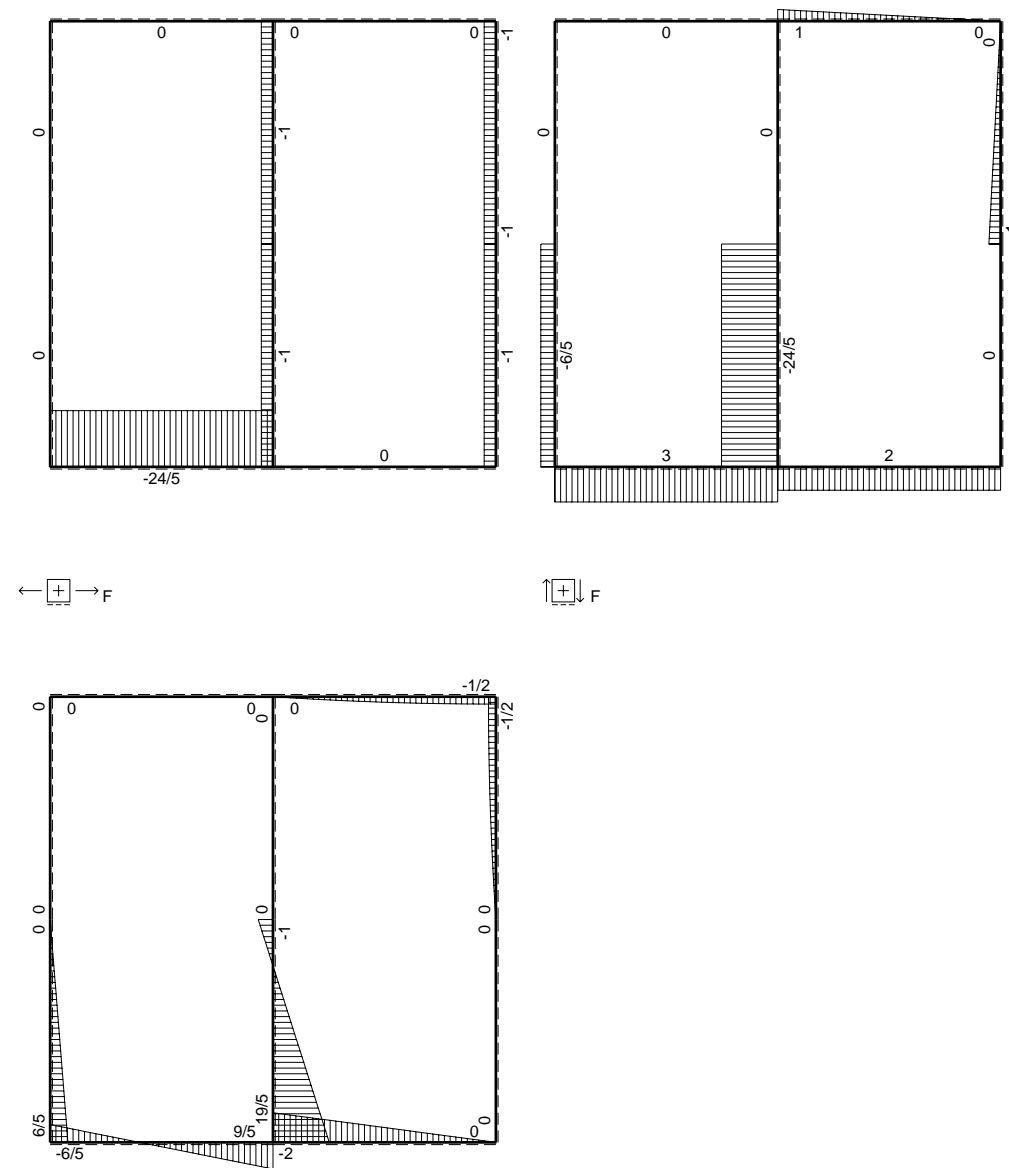
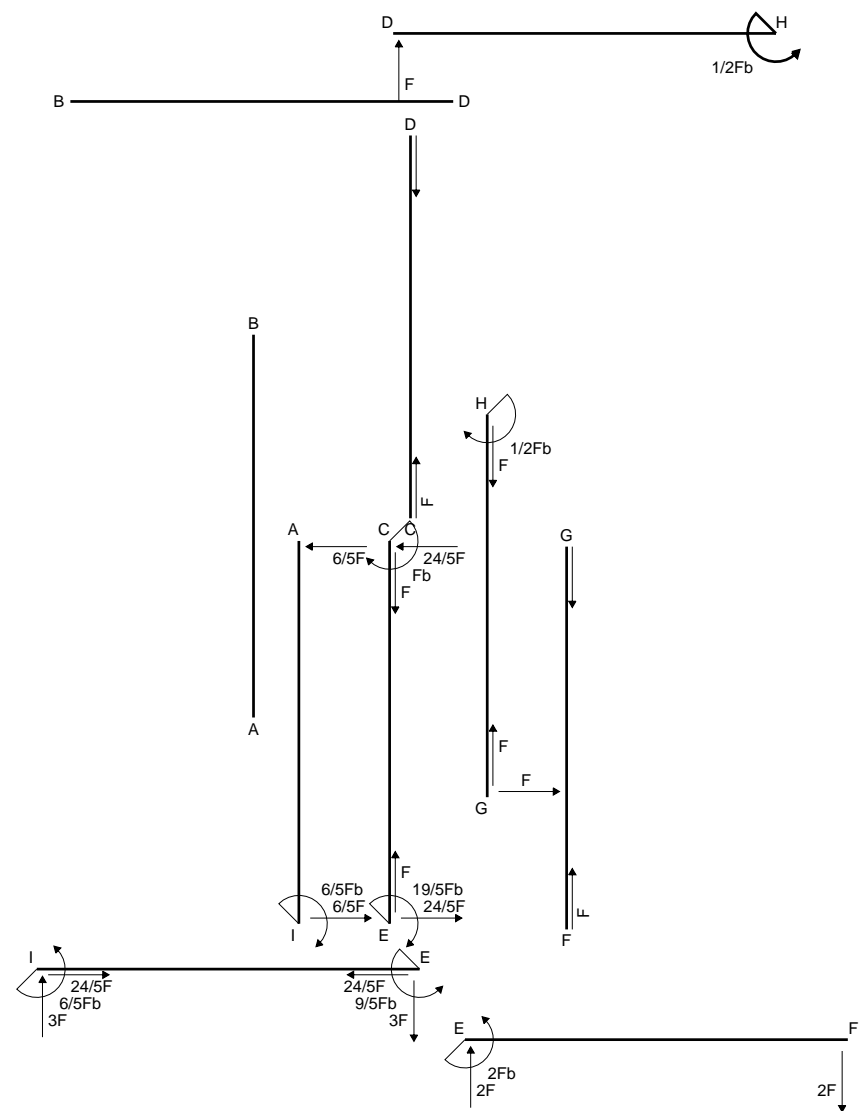
$$= (-6b + 13/2 b - 7/3 b) Fb 1/EJ = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 7x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 7/3 x^3/b^2]_0^b Fb 1/EJ$$

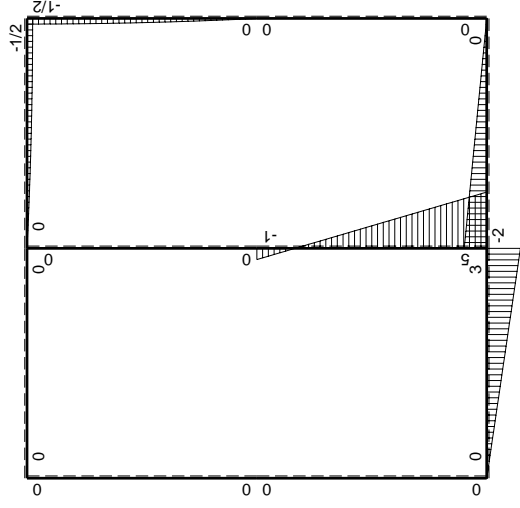
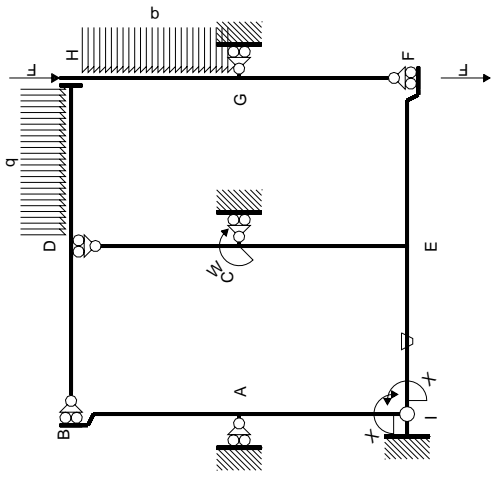
$$= (1/2 b - 7/3 b) Fb 1/EJ = -11/6 Fb^2/EJ$$



- A = 618. mm²
- J_u = 236783. mm⁴
- J_v = 40734. mm⁴
- y_g = 21.79 mm
- T_y = 2220. N
- M_x = -1709400. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 33.21 mm
- σ_m = -Mv/J_u = 239.7 N/mm²
- x_c = 21. mm
- y_c = 46. mm
- v_c = 24.21 mm
- σ_c = -Mv/J_u = 174.8 N/mm²
- τ_c = 5.821 N/mm²
- σ_q = √σ²+3τ² = 175.1 N/mm²
- S = 3725. mm³

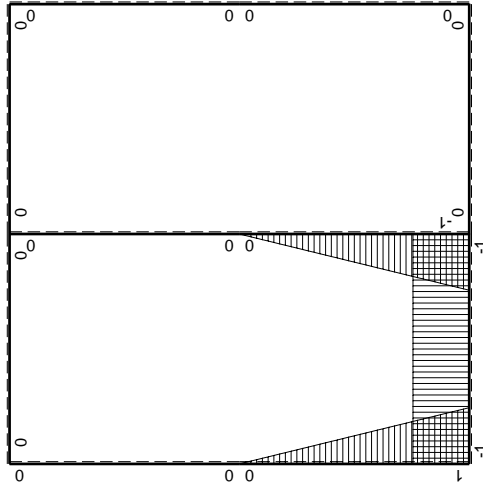


$\boxed{+}$ \curvearrowright F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	0	0	0	0	0	0+0	0	
BA b	0	0	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	-Fx+1/2qx ²	0	0	0	0	0+0	0	
HG b	0	1/2Fb-1/2qx ²	0	0	0	0			
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0	
DH b	0	Fx-1/2qx ²	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ	
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1			
EC b	-1+x/b	5Fb-6Fx	0	-5Fb+11Fx-6Fx ² /b	0	1-2x/b+x ² /b ²	(-3/2+0)Fb ² /EJ	1/3Xb/EJ	
CE b	x/b	Fb-6Fx	0	Fx-6Fx ² /b	0	x ² /b ²			
IA b	1-x/b	0	0	0	0	1-2x/b+x ² /b ²	0+0	1/3Xb/EJ	
AI b	-x/b	0	0	0	0	x ² /b ²			
	totali							-2Fb ² /EJ	5/3Xb/EJ
	iperstatica $X=W_{IE}$							6/5Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

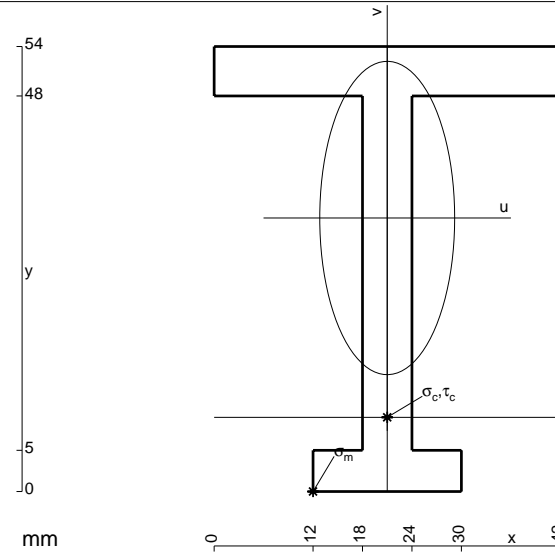
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb 1/EJ dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 11/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$



$$A = 600. \text{ mm}^2$$

$$J_u = 216946. \text{ mm}^4$$

$$J_v = 40248. \text{ mm}^4$$

$$y_g = 33.19 \text{ mm}$$

$$T_y = 1600. \text{ N}$$

$$M_x = -1296000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.19 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -198.3 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

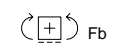
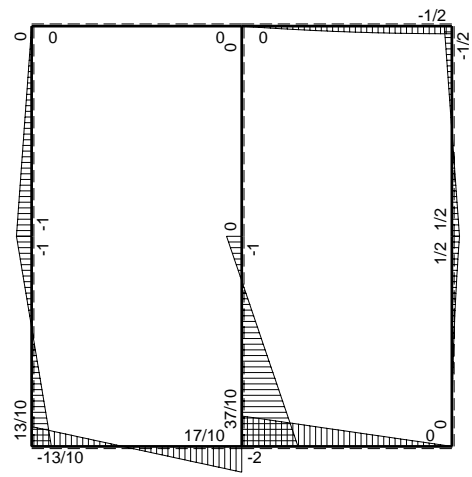
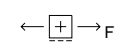
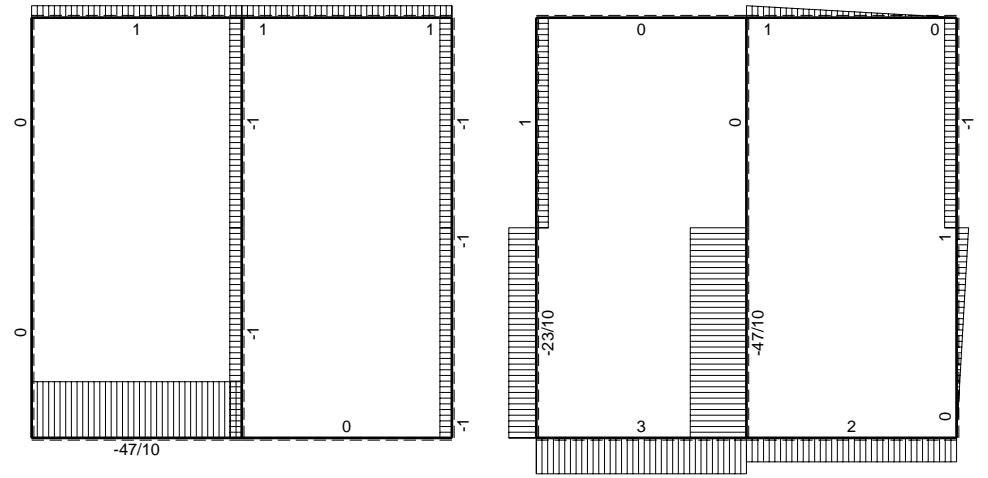
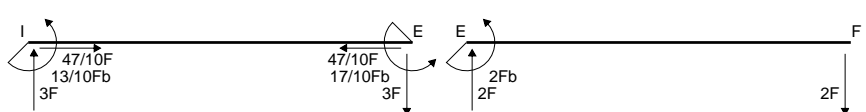
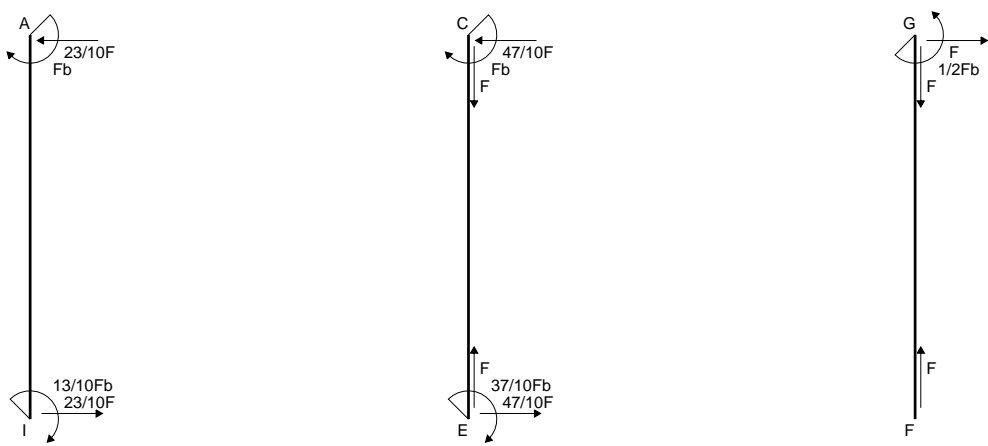
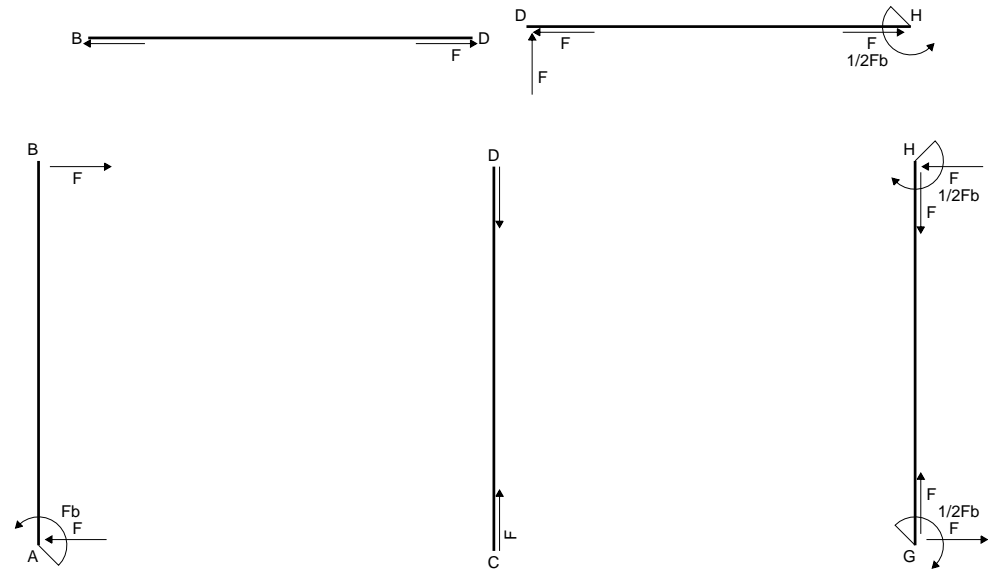
$$v_c = -24.19 \text{ mm}$$

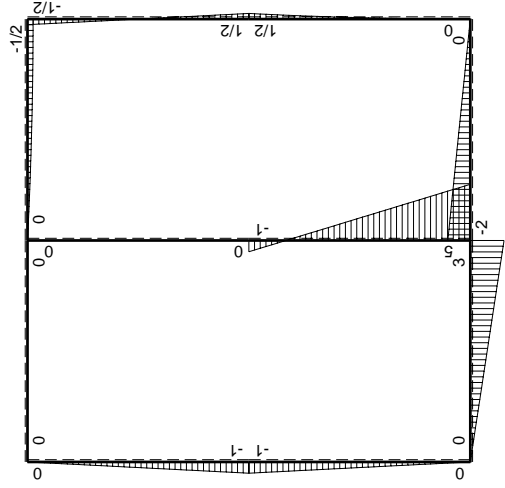
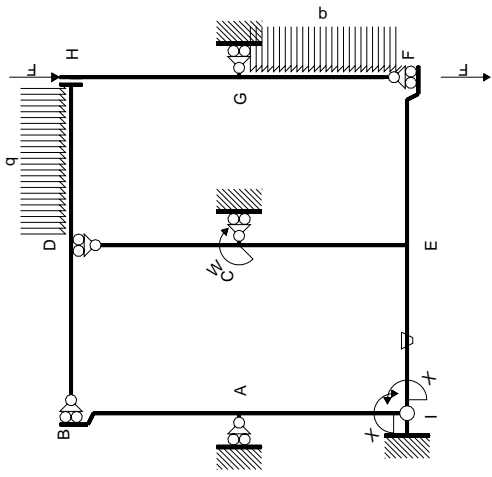
$$\sigma_c = -Mv/J_u = -144.5 \text{ N/mm}^2$$

$$\tau_c = 4.168 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 144.7 \text{ N/mm}^2$$

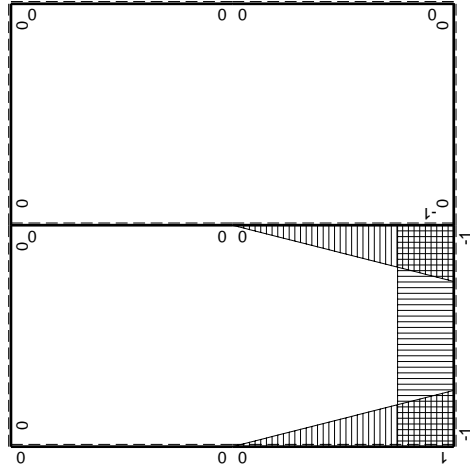
$$S = 3391. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

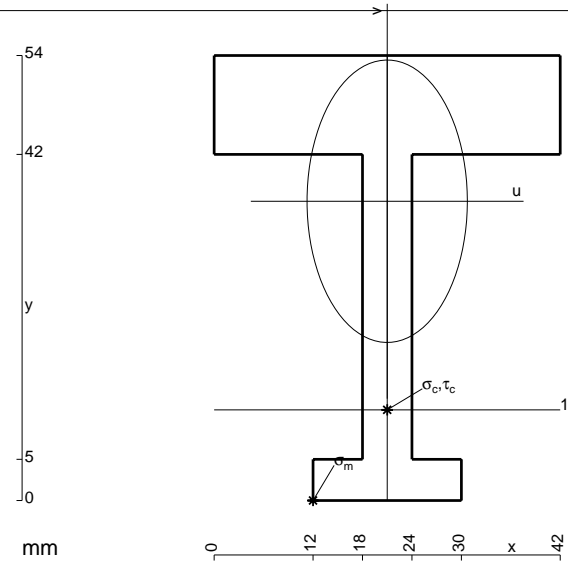
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 816. \text{ mm}^2$$

$$J_u = 239746. \text{ mm}^4$$

$$J_v = 77184. \text{ mm}^4$$

$$y_g = 36.32 \text{ mm}$$

$$T_y = 1600. \text{ N}$$

$$M_x = -1376000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -36.32 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

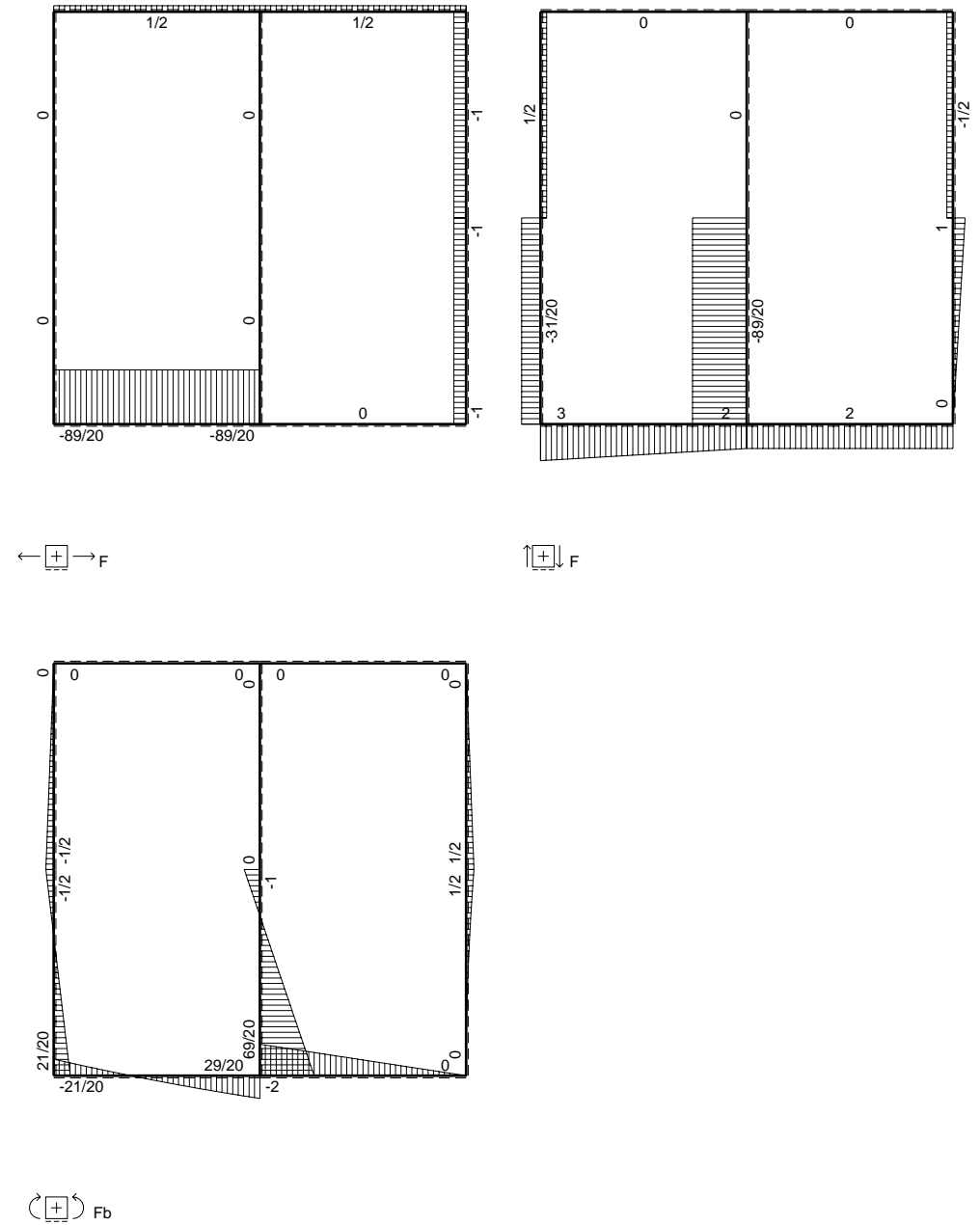
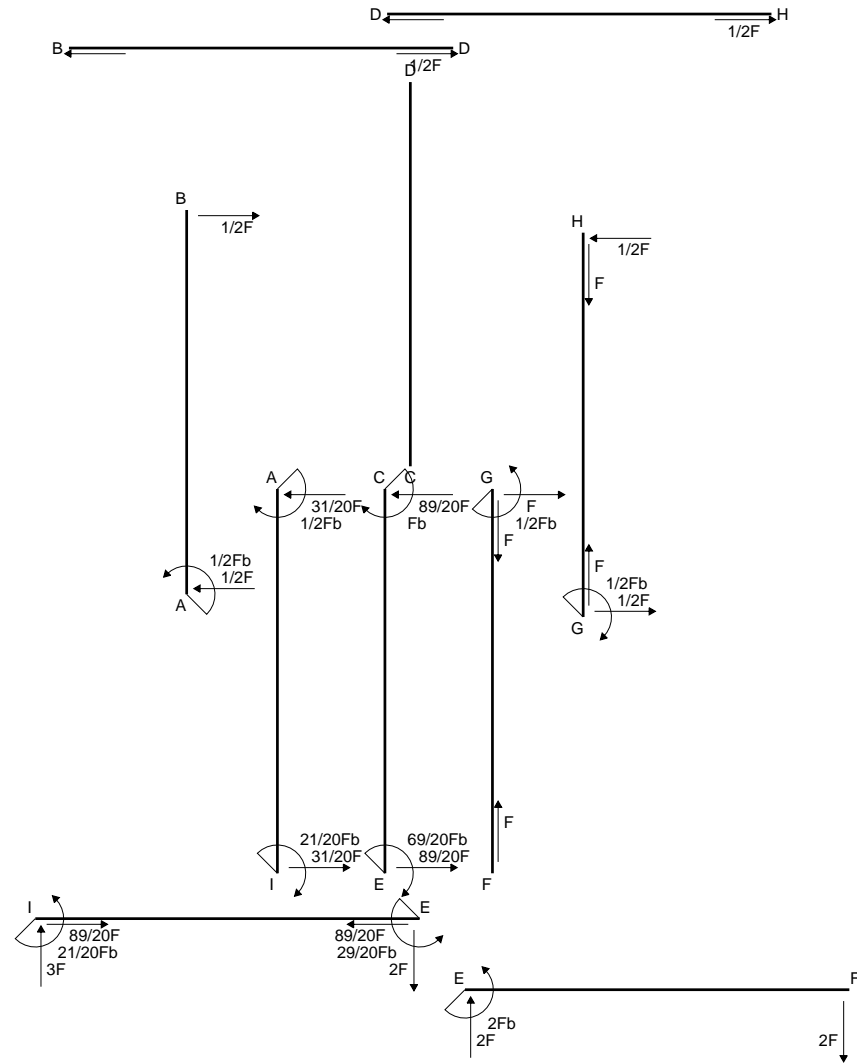
$$v_c = -25.32 \text{ mm}$$

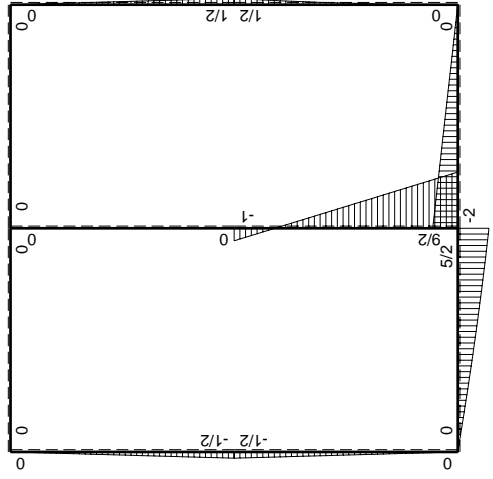
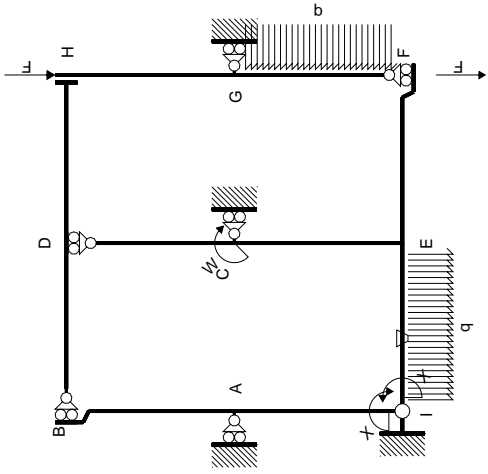
$$\sigma_c = -Mv/J_u = -145.3 \text{ N/mm}^2$$

$$\tau_c = 4.519 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 145.5 \text{ N/mm}^2$$

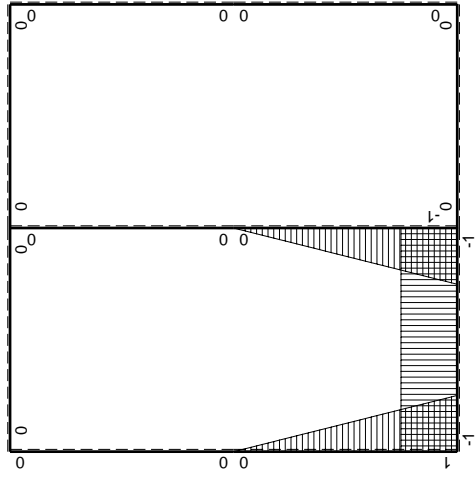
$$S = 4063. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-11/2Fx$	0	$-9/2Fb+10Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-11/2Fx$	0	$Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$21/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 10x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 5x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 5b - 11/6 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

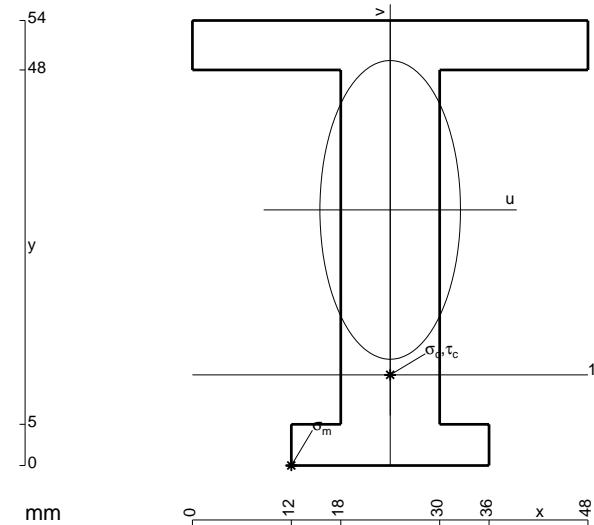
$$= (1/2 b - 11/6 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

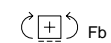
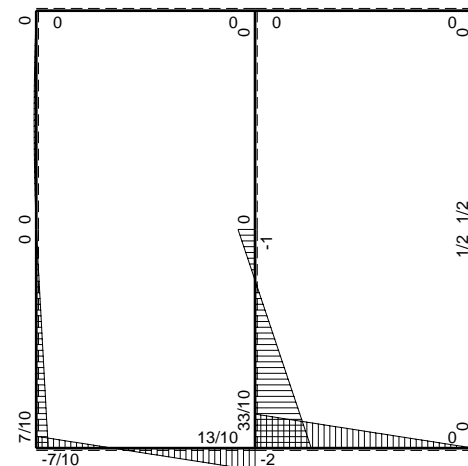
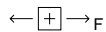
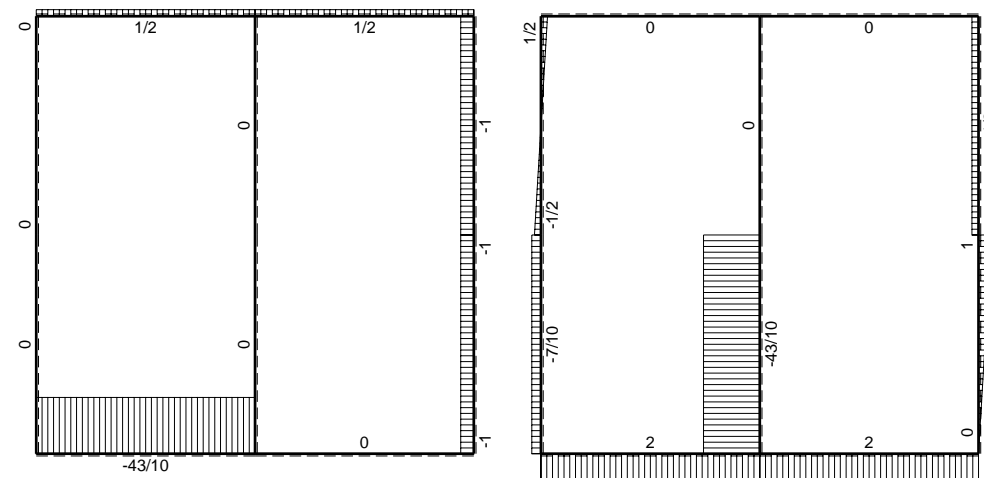
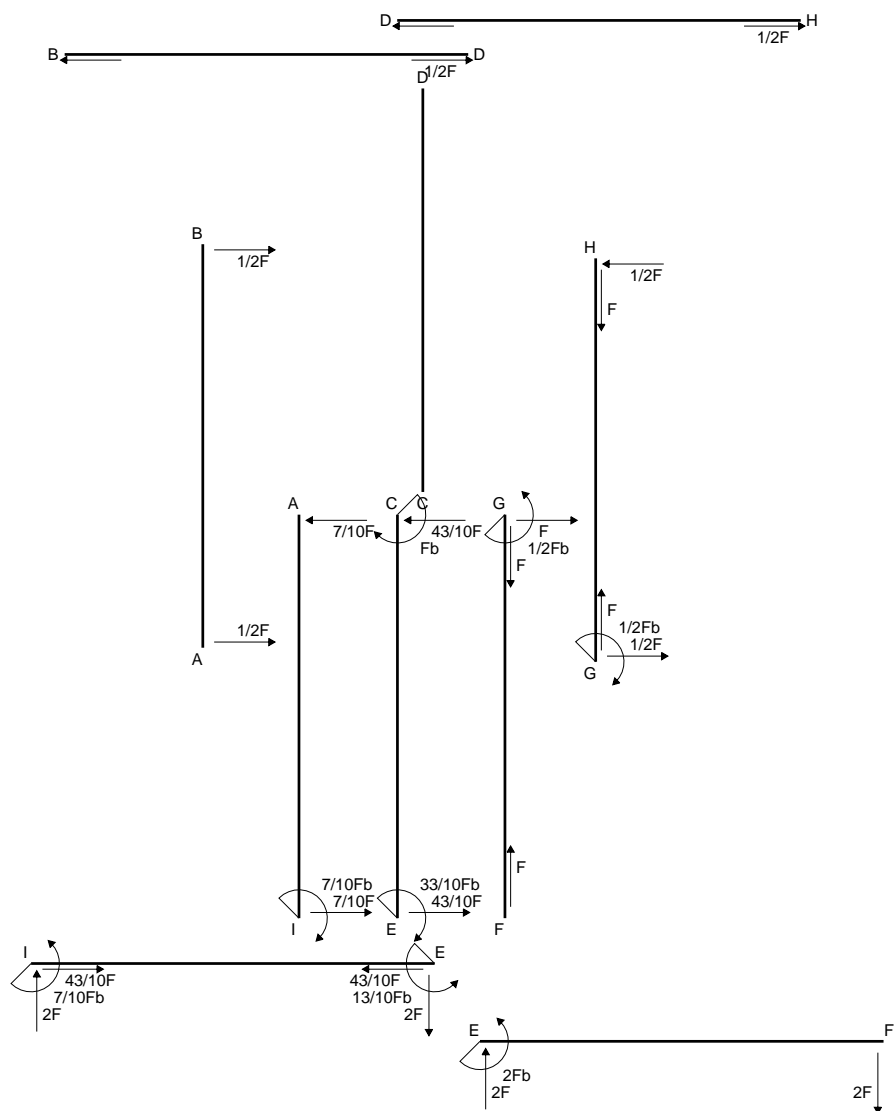
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

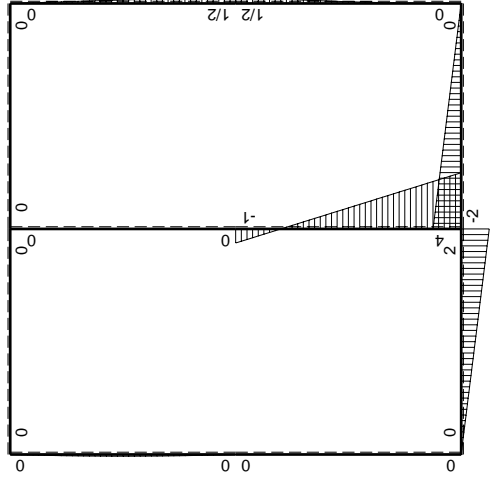
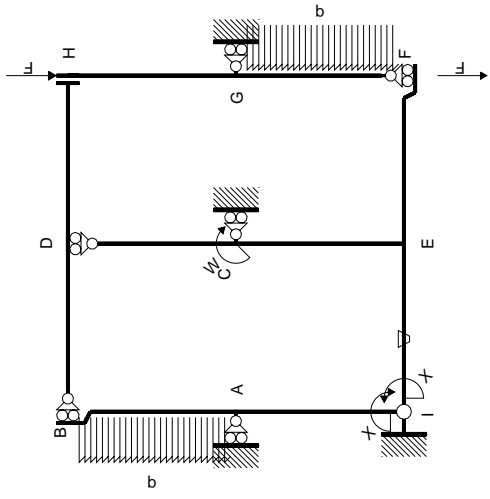
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



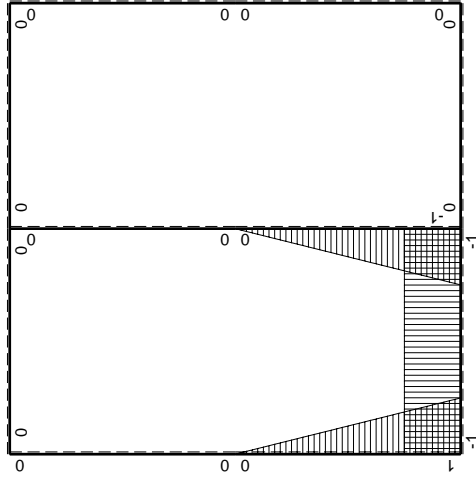
- A = 924. mm²
- J_u = 303740. mm⁴
- J_v = 67248. mm⁴
- y_g = 31.02 mm
- T_y = 2360. N
- M_x = -2147600. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -31.02 mm
- σ_m = -Mv/J_u = -219.3 N/mm²
- x_c = 24. mm
- y_c = 11. mm
- v_c = -20.02 mm
- σ_c = -Mv/J_u = -141.5 N/mm²
- τ_c = 3.289 N/mm²
- σ₀ = √σ²+3τ² = 141.7 N/mm²
- S = 5080. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-5Fx$	0	$-4Fb+9Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-5Fx$	0	$Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

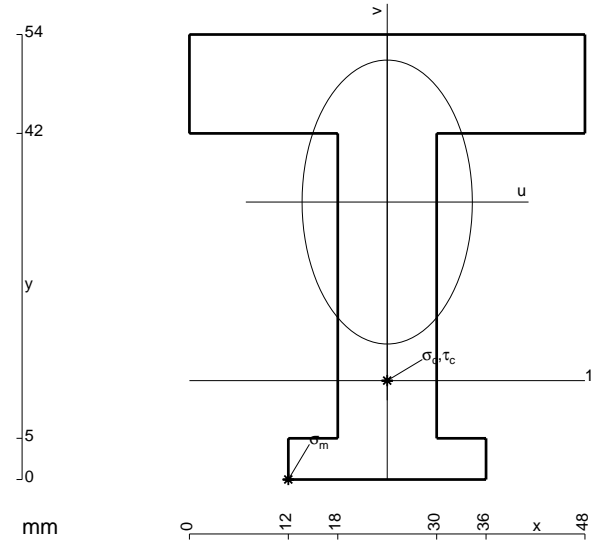
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 9x/b - 5x^2/b^2) Fb 1/EJ dx = [-4x + 9/2 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

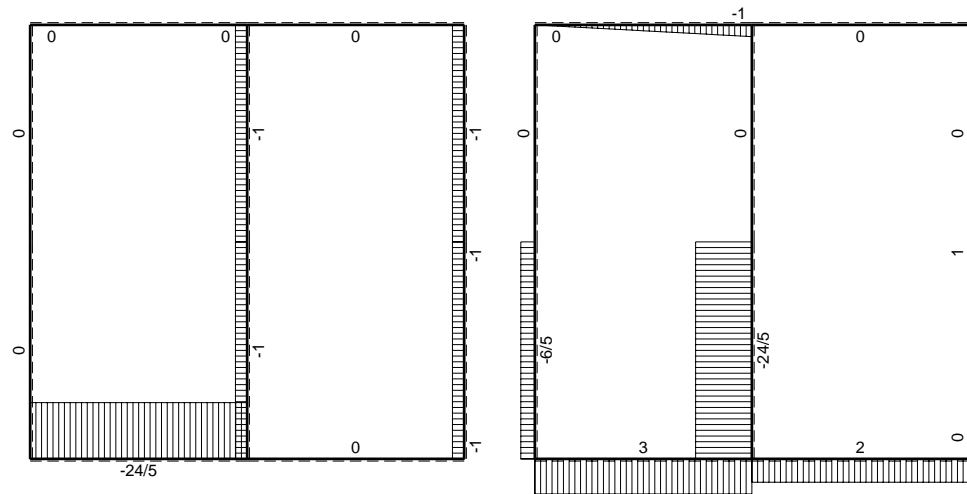
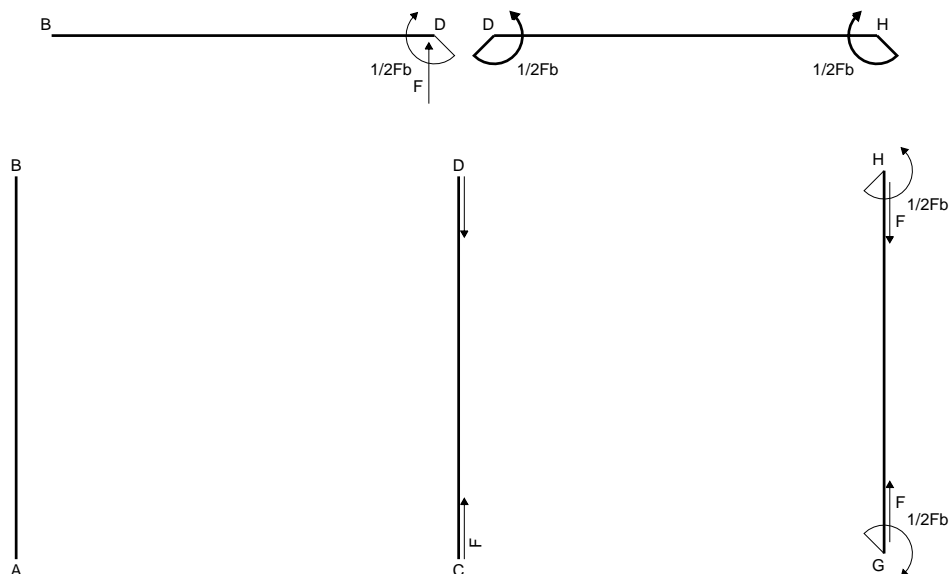
$$= (-4b + 9/2 b - 5/3 b) Fb 1/EJ = -7/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 5x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 5/3 b) Fb 1/EJ = -7/6 Fb^2/EJ$$

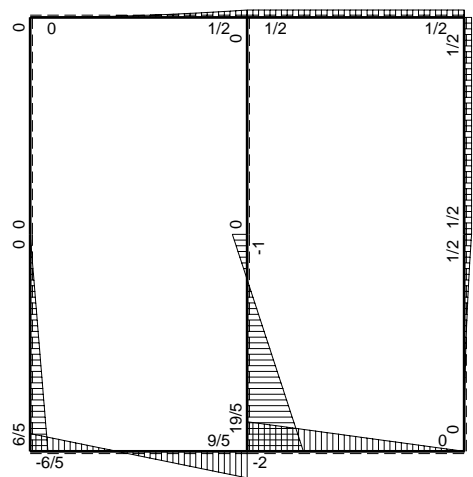
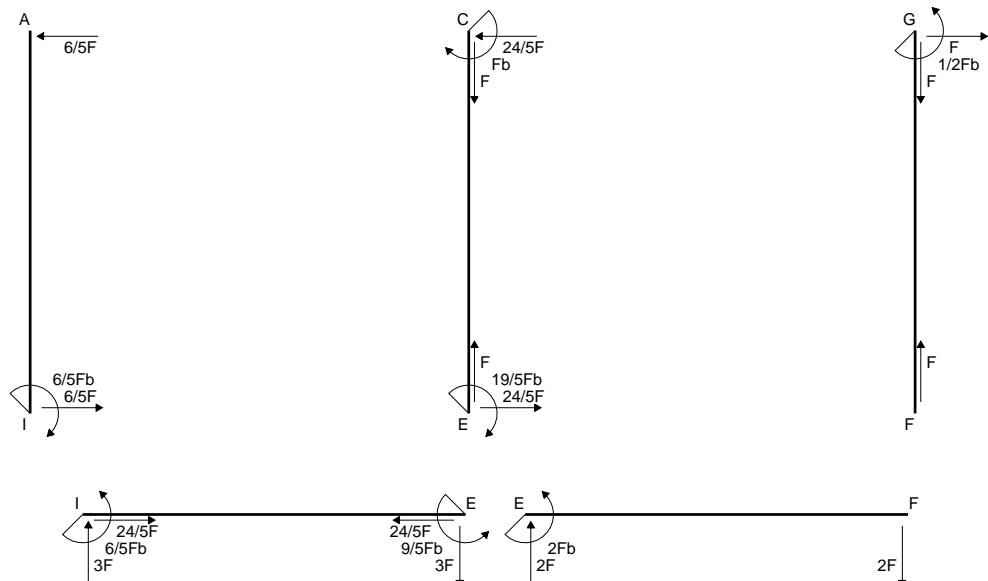


- A = 1140. mm²
- J_u = 338607. mm⁴
- J_v = 121680. mm⁴
- y_g = 33.67 mm
- T_y = 2380. N
- M_x = -2308600. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -33.67 mm
- σ_m = -Mv/J_u = -229.5 N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -21.67 mm
- σ_c = -Mv/J_u = -147.7 N/mm²
- τ_c = 3.429 N/mm²
- σ_o = √σ²+3τ² = 147.9 N/mm²
- S = 5854. mm³

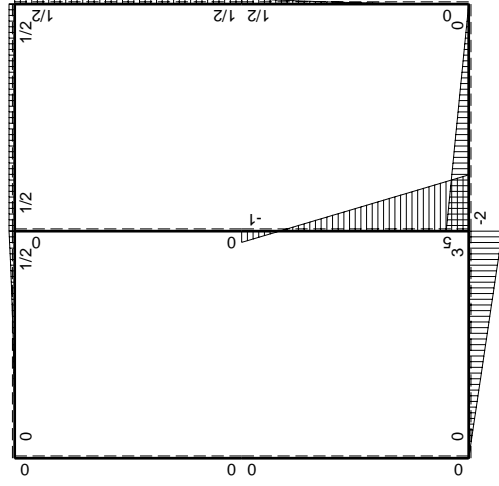
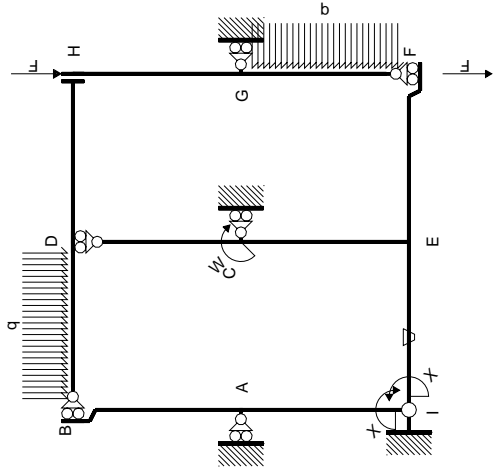


← ⊕ → F

↑ ⊕ ↓ F

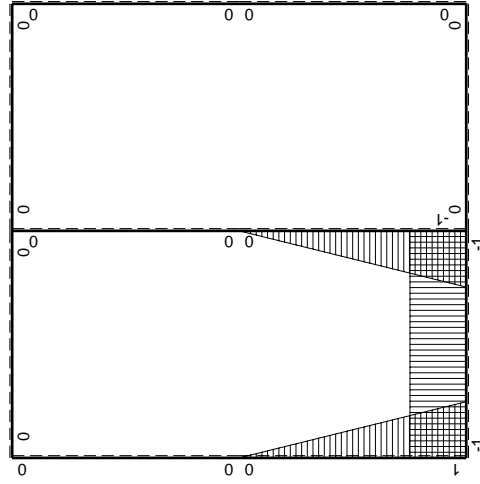


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	0	0	0	0	0	0+0	0	
BA b	0	0	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0	
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
GH b	0	$1/2Fb$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fb$	0	0	0	0			
HD b	0	$1/2Fb$	0	0	0	0	0+0	0	
DH b	0	$-1/2Fb$	0	0	0	0			
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
BD b	0	$-1/2qx^2$	0	0	0	0			
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1			
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$	
AI b	$-x/b$	0	0	0	0	x^2/b^2			
	totali							$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

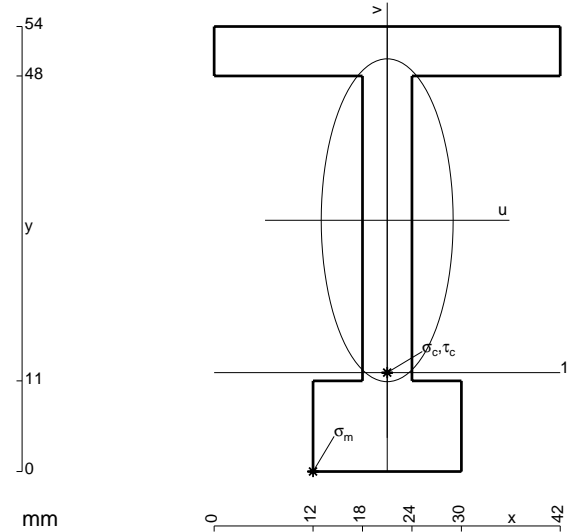
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb 1/EJ dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

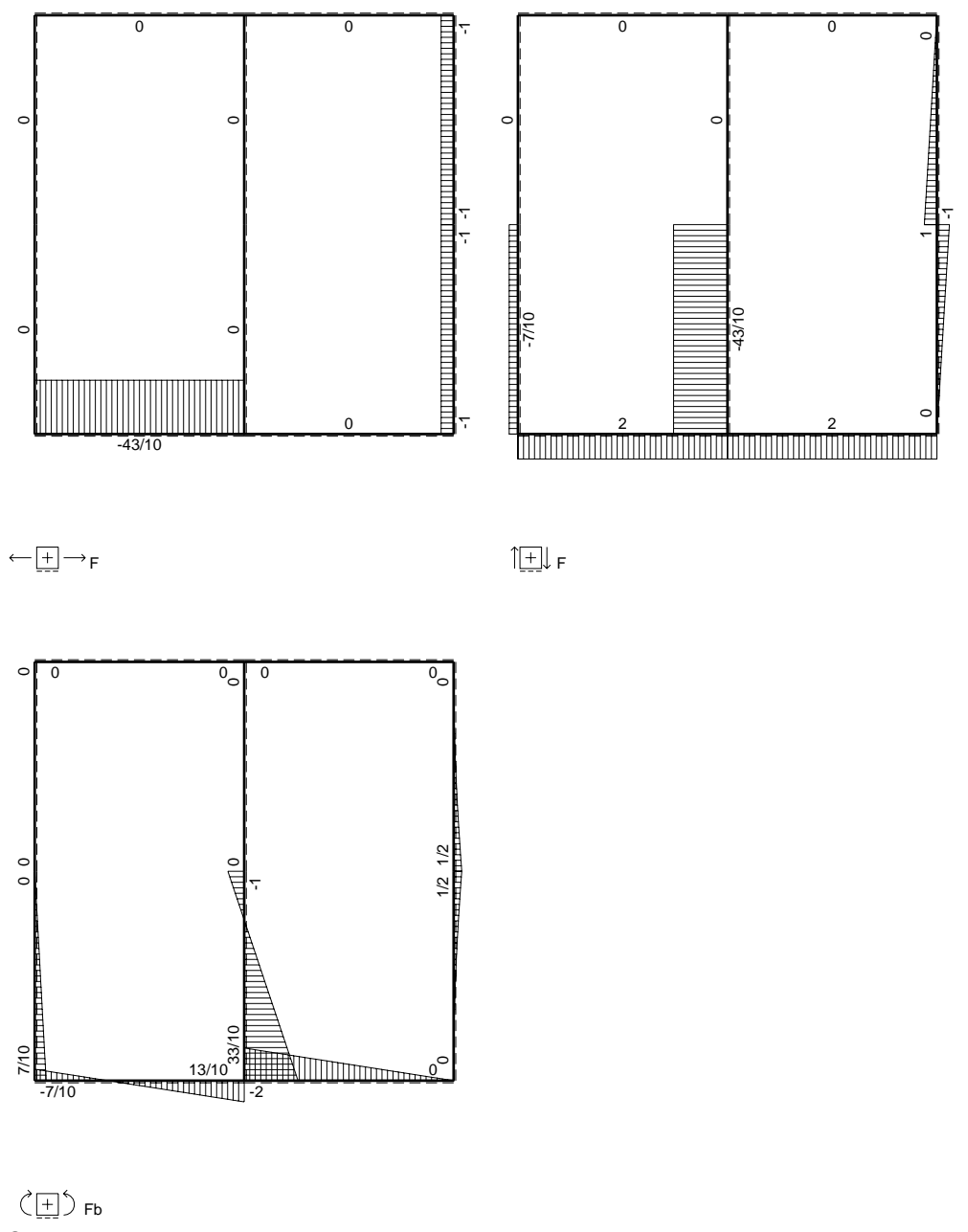
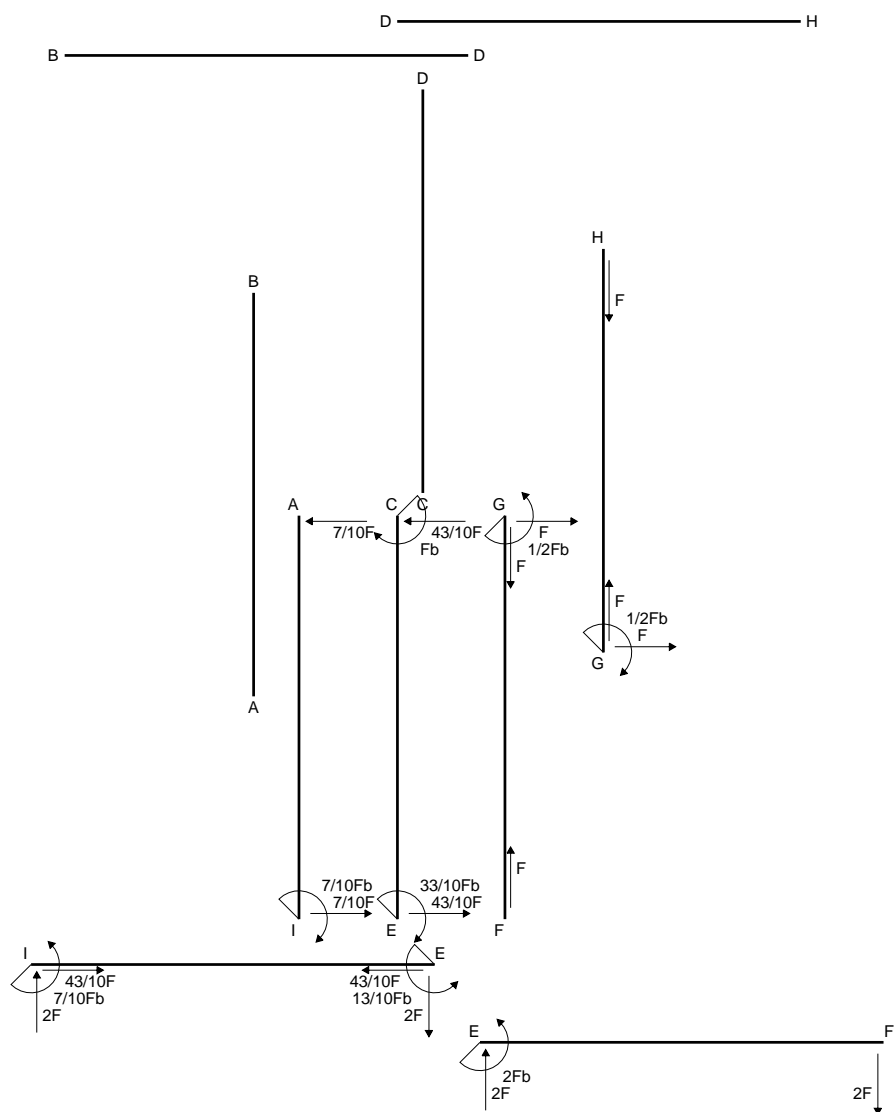
$$= (-5b + 11/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$

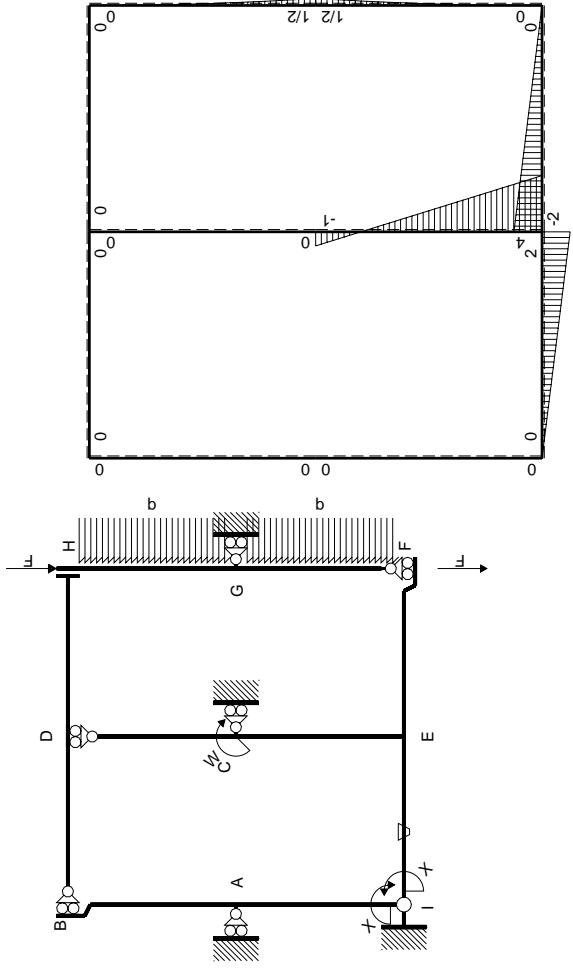
$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 2b) Fb 1/EJ = -3/2 Fb^2/EJ$$



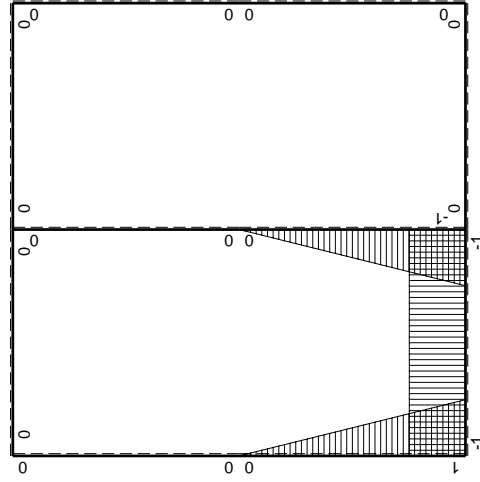
- A = 672. mm²
- J_u = 257954. mm⁴
- J_v = 43056. mm⁴
- y_g = 30.49 mm
- T_y = 1980. N
- M_x = -2019600. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -30.49 mm
- σ_m = -Mv/J_u = -238.7 N/mm²
- x_c = 21. mm
- y_c = 12. mm
- v_c = -18.49 mm
- σ_c = -Mv/J_u = -144.8 N/mm²
- τ_c = 6.476 N/mm²
- σ_o = √σ²+3τ² = 145.2 N/mm²
- S = 5062. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-5Fx$	0	$-4Fb+9Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-5Fx$	0	$Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

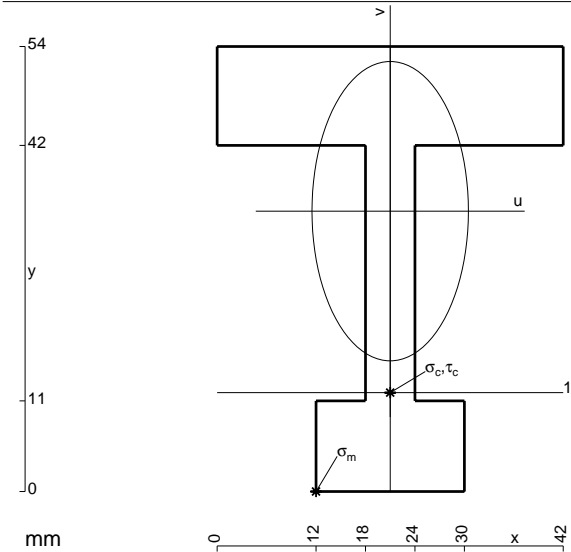
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 9x/b - 5x^2/b^2) Fb 1/EJ dx = [-4x + 9/2 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 9/2 b - 5/3 b) Fb 1/EJ = -7/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 5x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 5/3 b) Fb 1/EJ = -7/6 Fb^2/EJ$$



$$A = 888. \text{ mm}^2$$

$$J_u = 293012. \text{ mm}^4$$

$$J_v = 79992. \text{ mm}^4$$

$$y_g = 34.02 \text{ mm}$$

$$T_y = 3180. \text{ N}$$

$$M_x = -1717200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.02 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

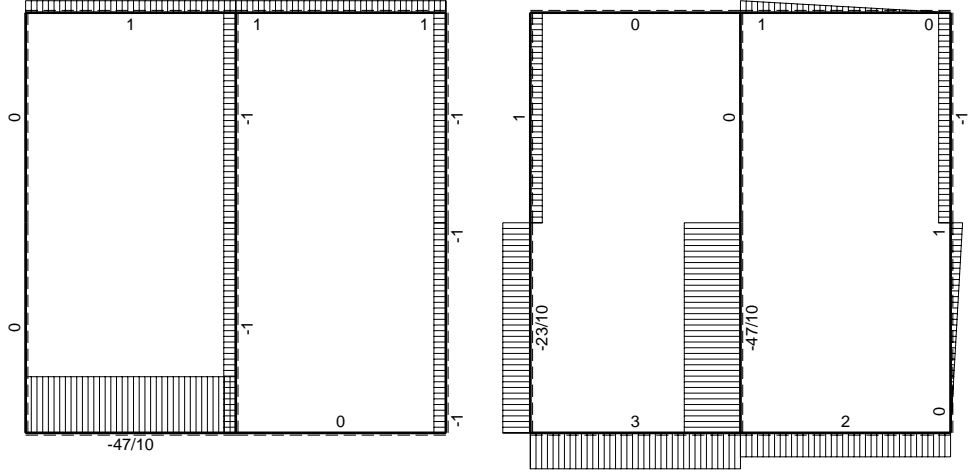
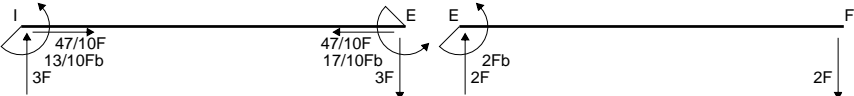
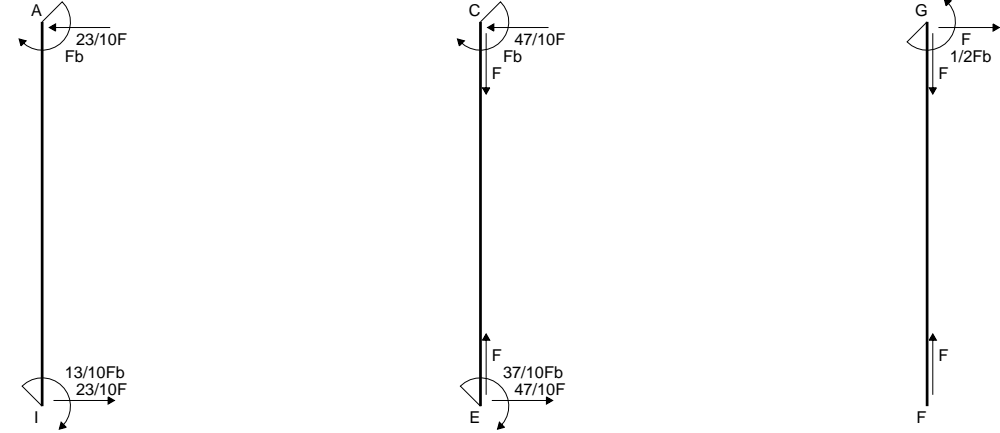
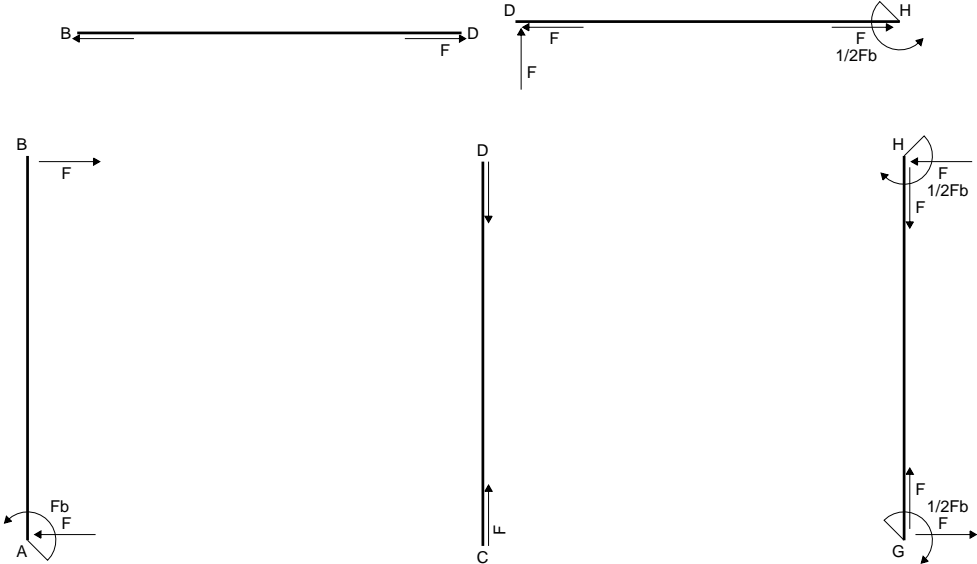
$$v_c = -22.02 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -129.1 \text{ N/mm}^2$$

$$\tau_c = 10.46 \text{ N/mm}^2$$

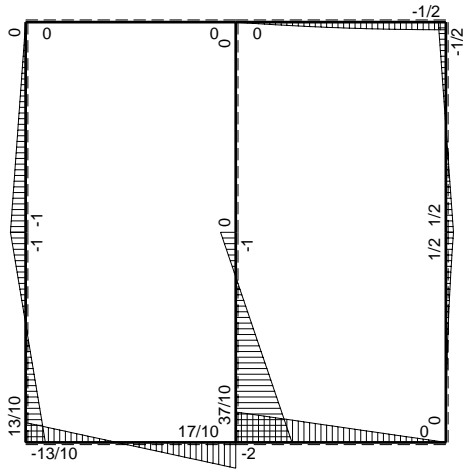
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 130.3 \text{ N/mm}^2$$

$$S = 5782. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	5Fb-6Fx	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	Fb-6Fx	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 11/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = [1/2 x^2/b - 2x^3/b^2]_0^b Fb \frac{1}{EJ}$$

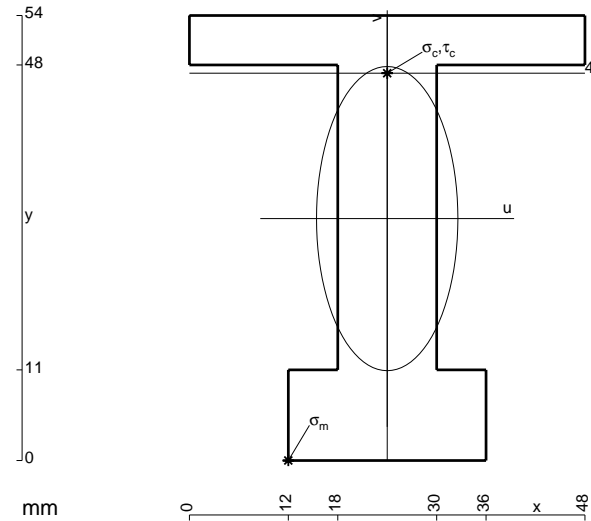
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

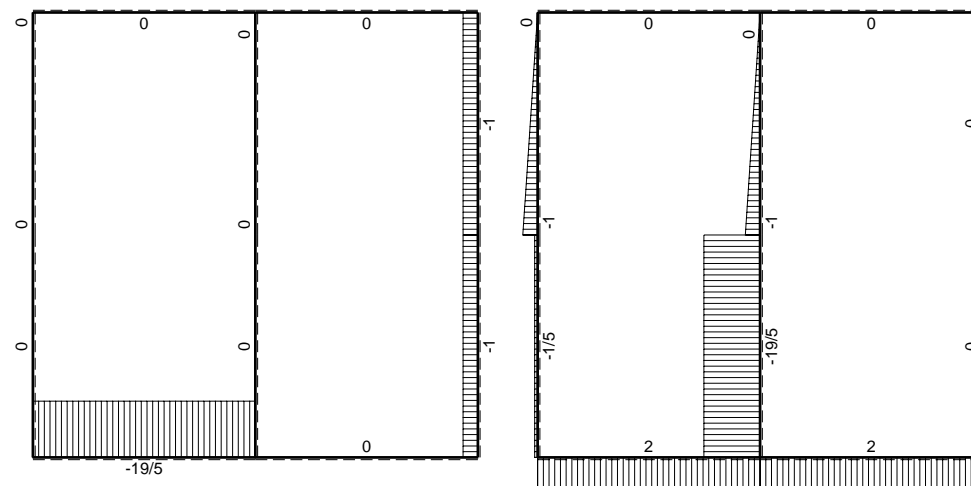
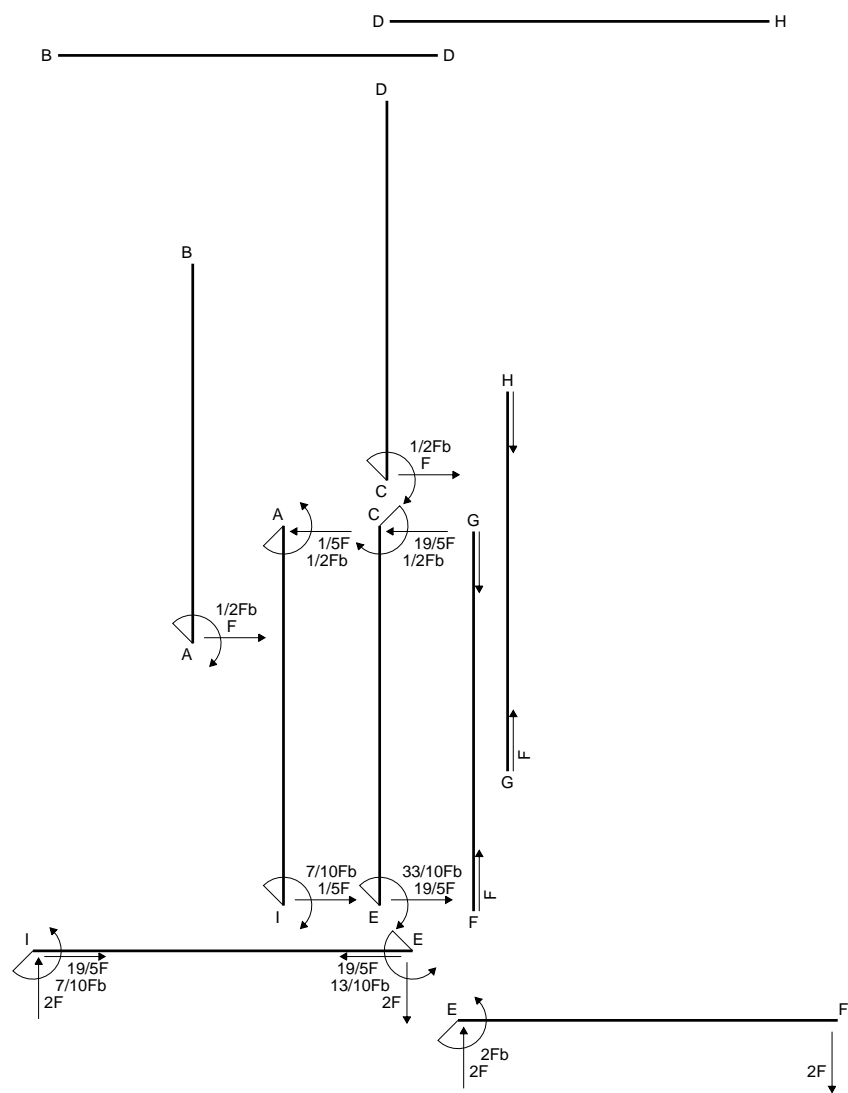
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

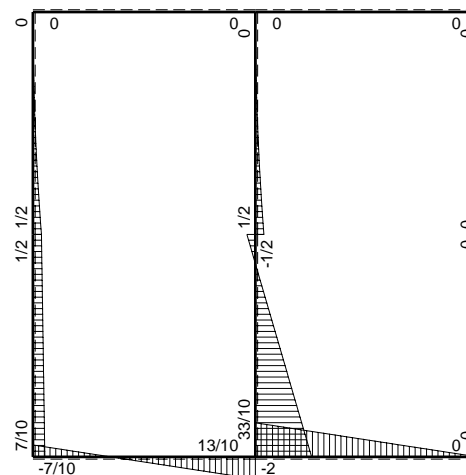


- A = 996. mm²
- J_u = 339350. mm⁴
- J_v = 73296. mm⁴
- y_g = 29.36 mm
- T_y = 4100. N
- M_x = -2419000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -29.36 mm
- σ_m = -Mv/J_u = -209.3 N/mm²
- x_c = 24. mm
- y_c = 47. mm
- v_c = 17.64 mm
- σ_c = -Mv/J_u = 125.8 N/mm²
- τ_c = 6.495 N/mm²
- σ_o = √σ²+3τ² = 126.3 N/mm²
- S = 6451. mm³

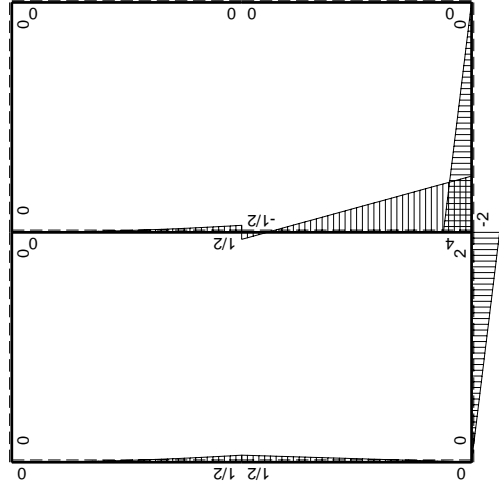
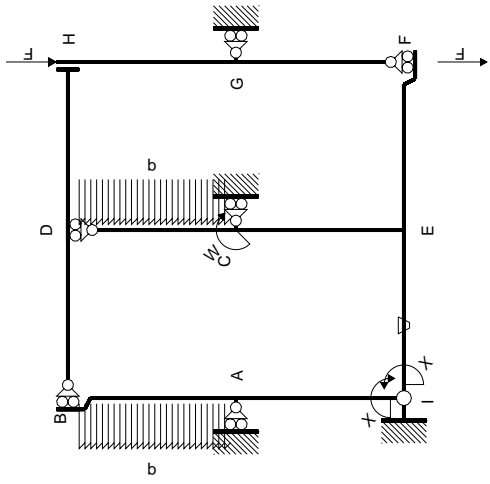


← ⊕ → F

↑ ⊕ ↓ F

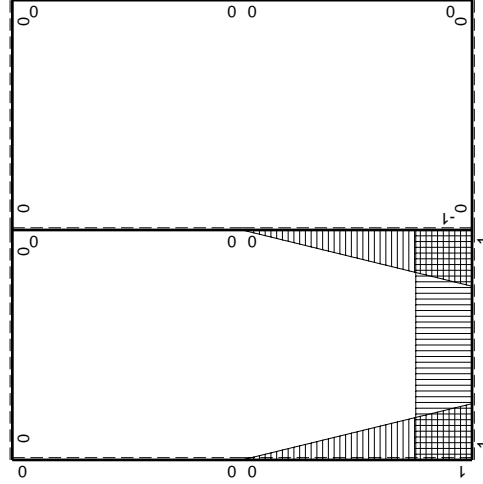


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2qx^2$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx$	0	$-4Fb+17/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-9/2Fx$	0	$1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 17/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

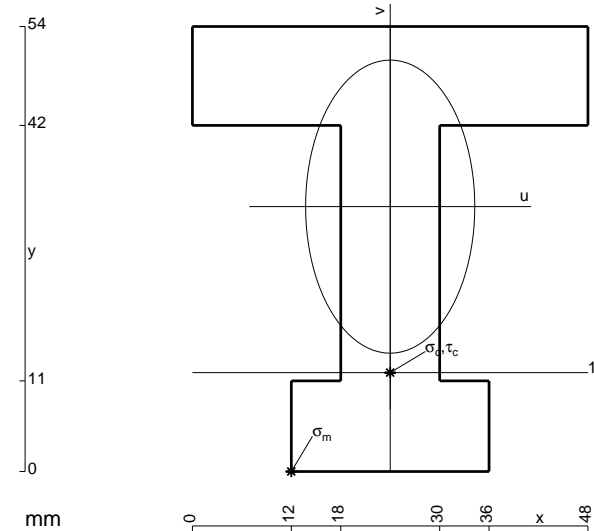
$$= (1/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

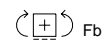
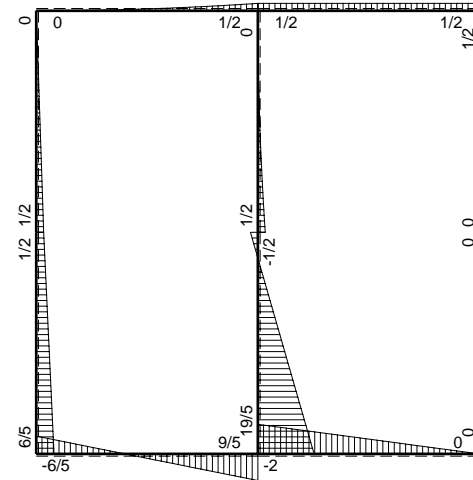
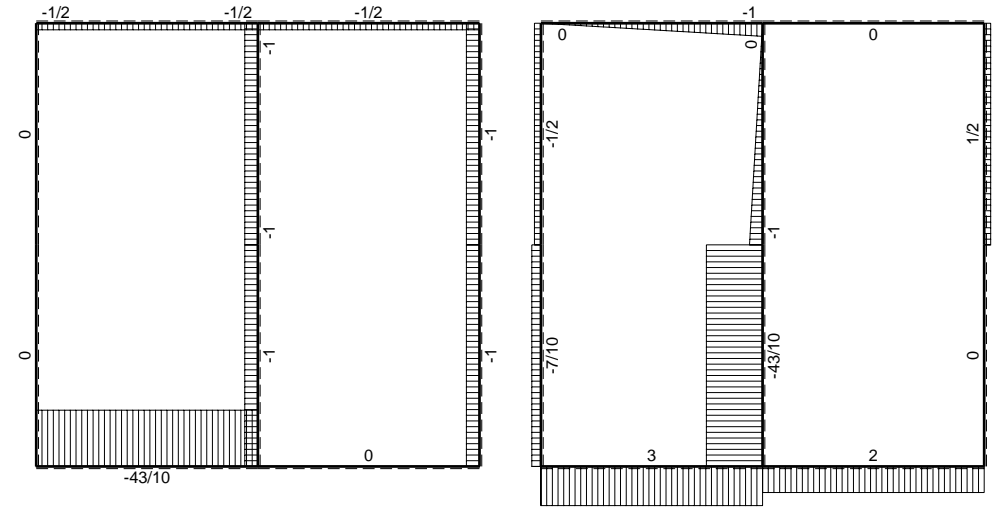
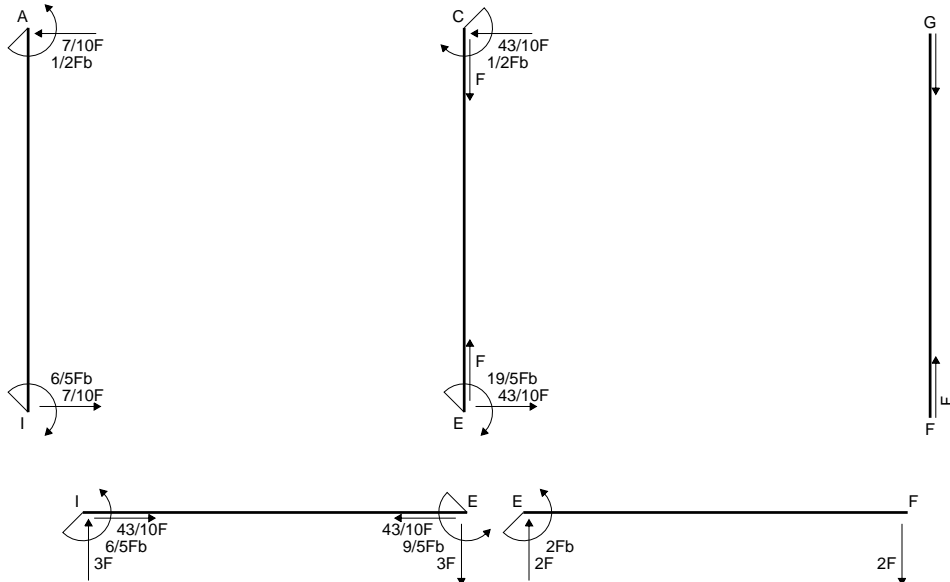
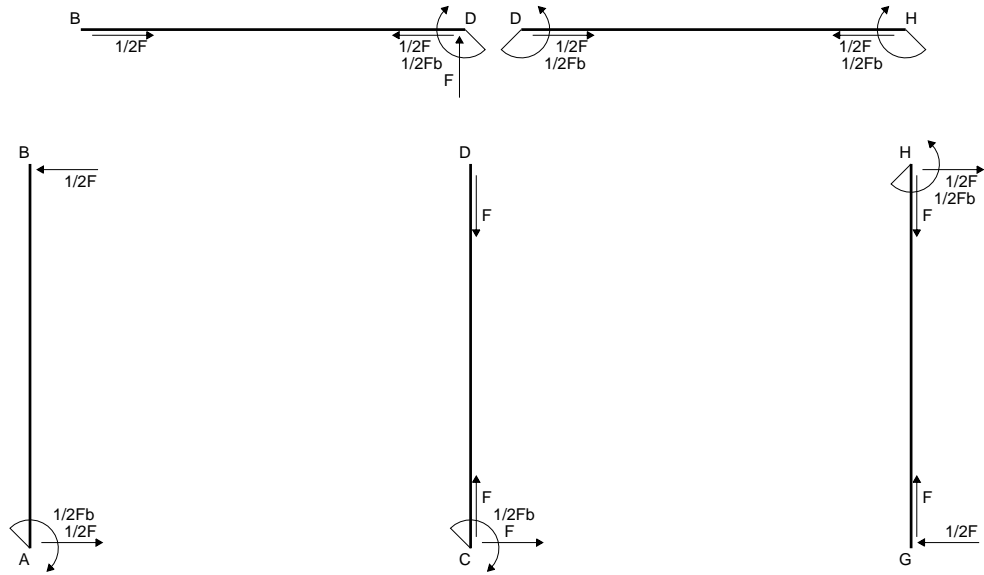
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

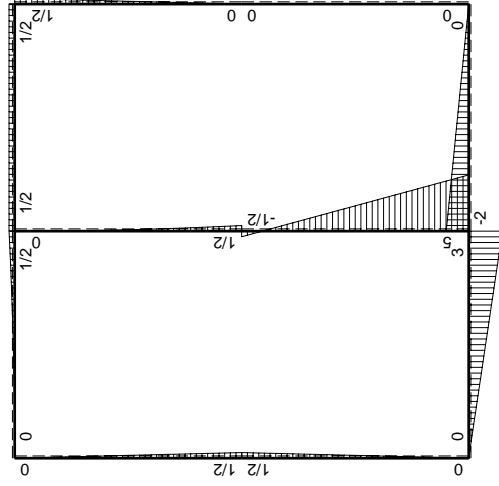
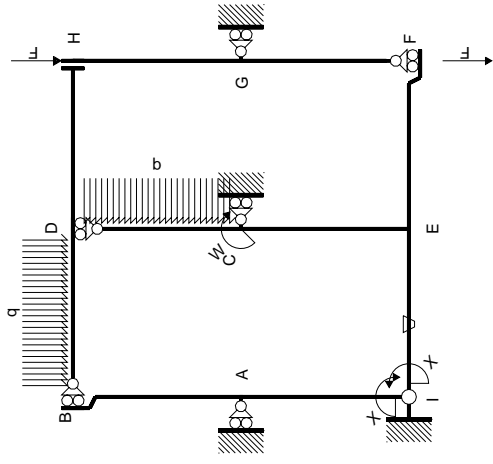
$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



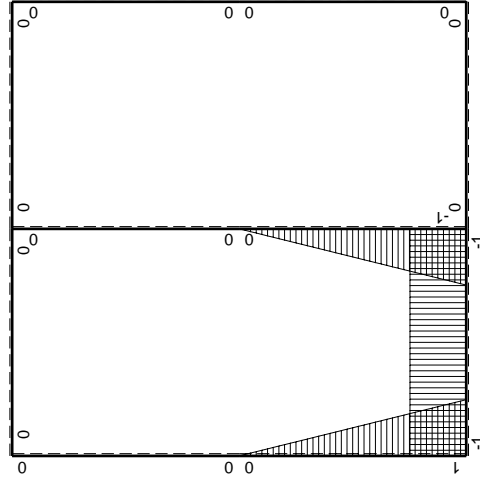
- A = 1212. mm²
- J_u = 383443. mm⁴
- J_v = 127728. mm⁴
- y_g = 32.14 mm
- T_y = 4100. N
- M_x = -2624000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -32.14 mm
- σ_m = -Mv/J_u = -220. N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -20.14 mm
- σ_c = -Mv/J_u = -137.8 N/mm²
- τ_c = 6.488 N/mm²
- σ_o = √σ²+3τ² = 138.3 N/mm²
- S = 7282. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$-1/2Fx$	0	0	0	0			
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
DC b	0	$-1/2qx^2$	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0			
HD b	0	$1/2Fb$	0	0	0	0	0+0	0	
DH b	0	$-1/2Fb$	0	0	0	0			
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
BD b	0	$-1/2qx^2$	0	0	0	0			
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1			
EC b	$-1+x/b$	$5Fb-11/2Fx$	0	$-5Fb+21/2Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-19/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$1/2Fb-11/2Fx$	0	$1/2Fx-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2			
	totali							$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 21/4 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 21/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

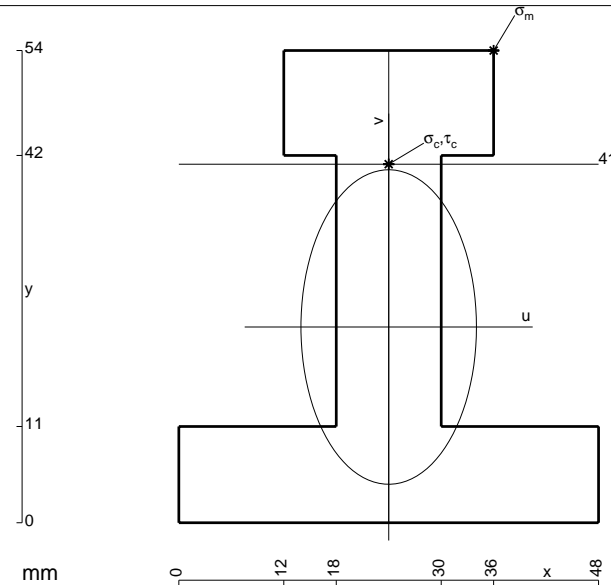
$$= (1/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

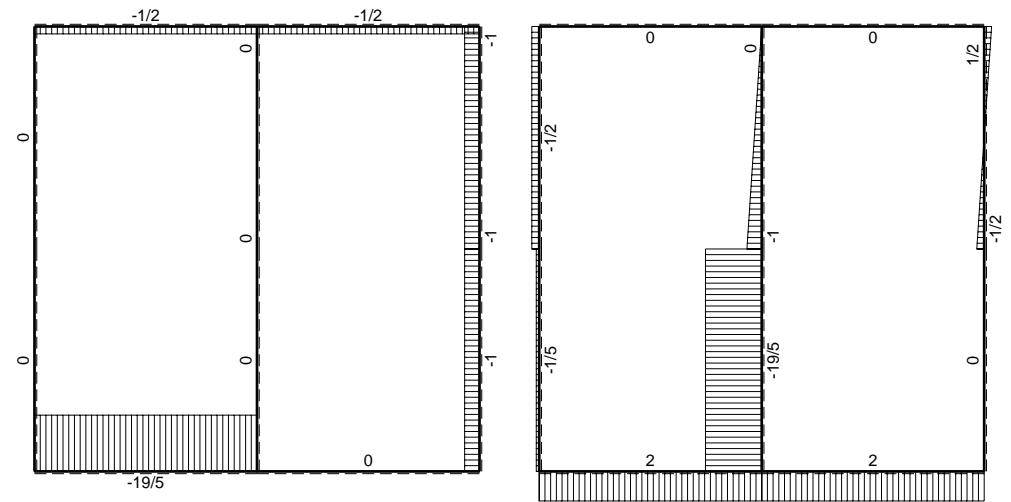
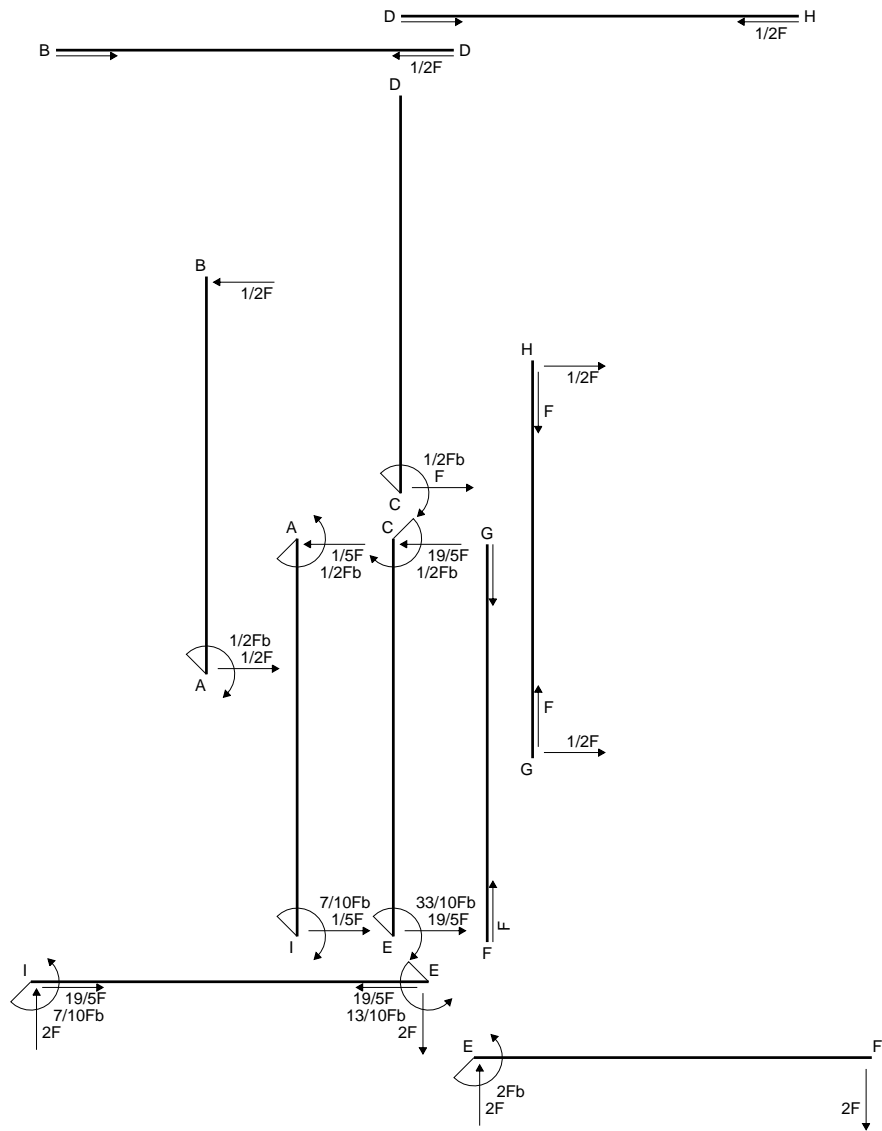
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

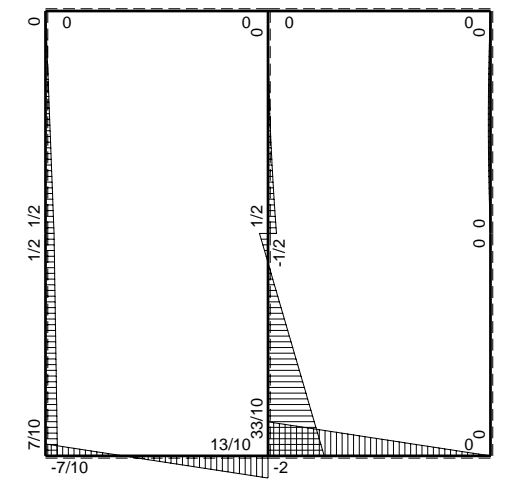


- A = 1188. mm²
- J_u = 384370. mm⁴
- J_v = 119664. mm⁴
- y_g = 22.38 mm
- T_y = 3980. N
- M_x = -2786000. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 31.62 mm
- σ_m = -Mv/J_u = 229.2 N/mm²
- x_c = 24. mm
- y_c = 41. mm
- v_c = 18.62 mm
- σ_c = -Mv/J_u = 135. N/mm²
- τ_c = 6.565 N/mm²
- σ_q = √σ²+3τ² = 135.4 N/mm²
- S = 7608. mm³

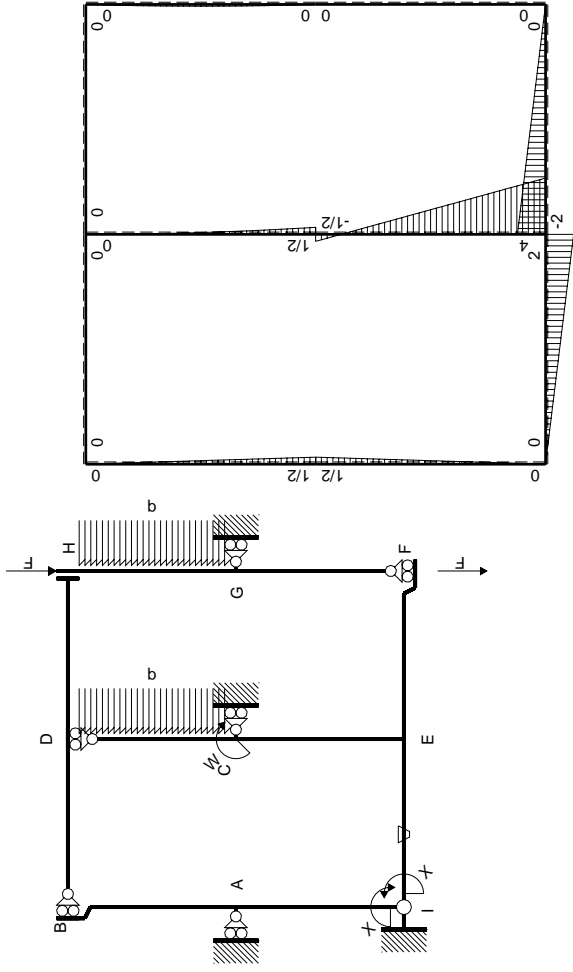


← ⊕ → F

↑ ⊕ ↓ F

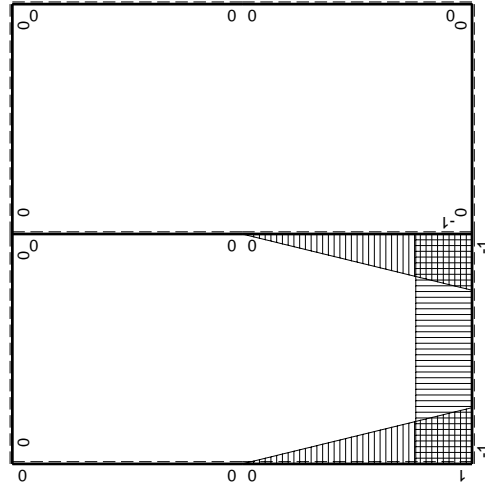


⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx$	0	$-4Fb+17/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-9/2Fx$	0	$1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 17/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

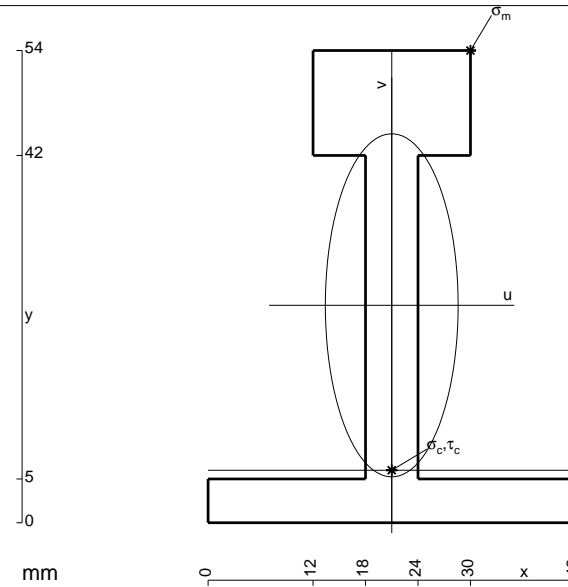
$$= (1/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

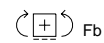
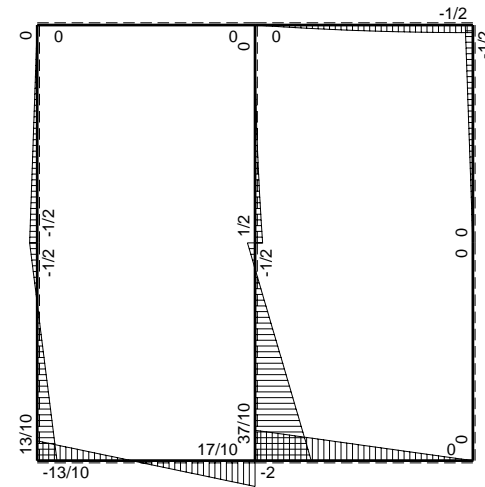
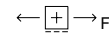
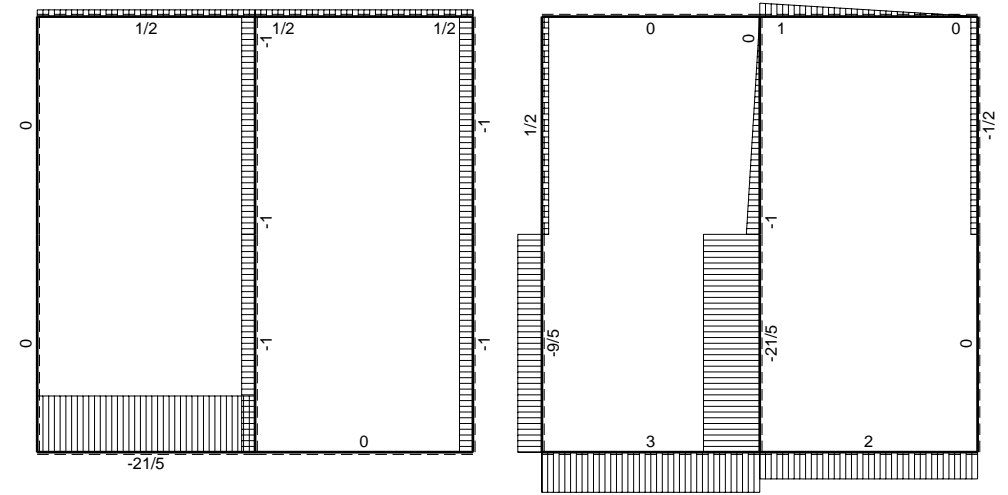
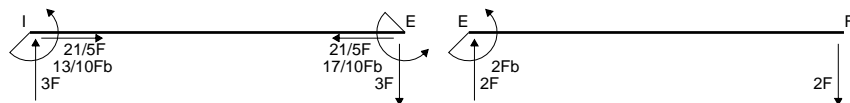
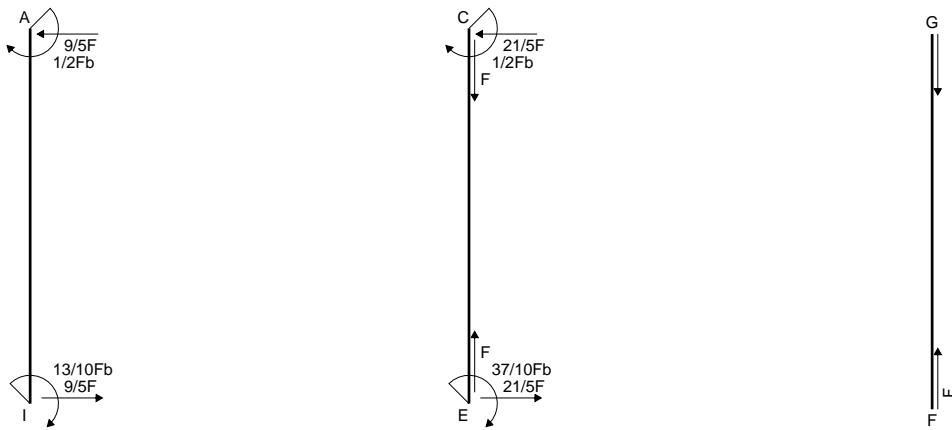
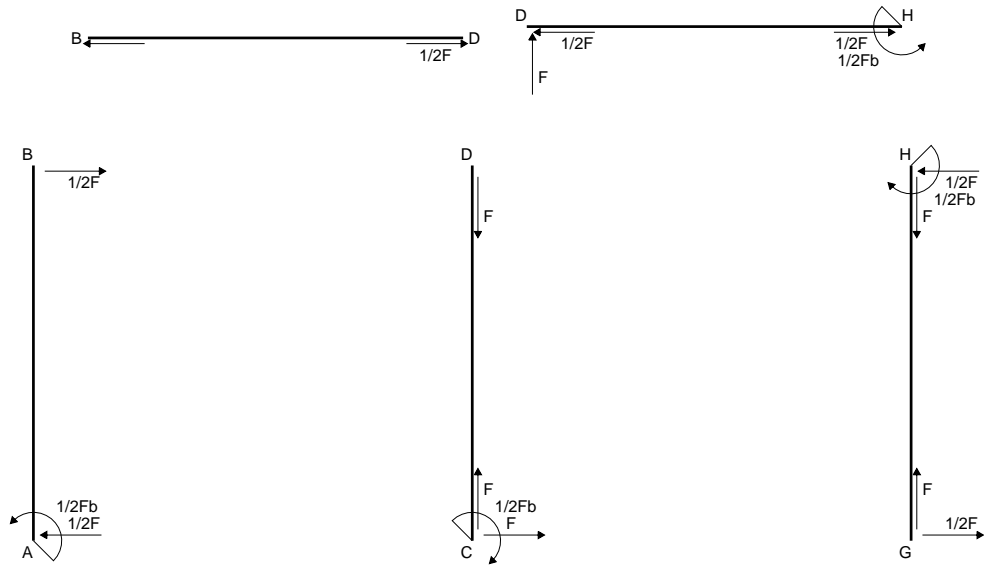
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

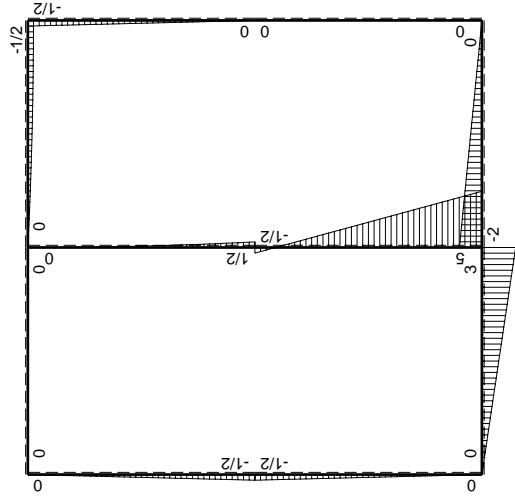
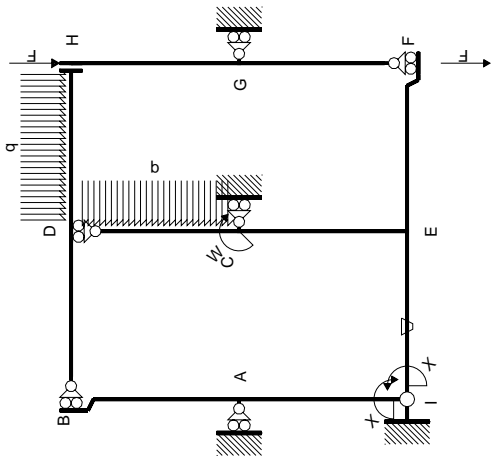
$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



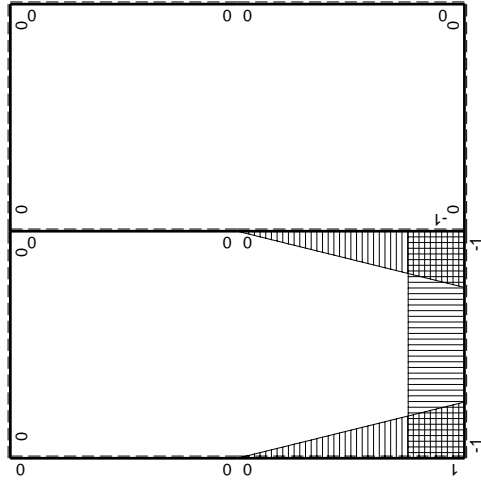
- A = 648. mm²
- J_u = 249420. mm⁴
- J_v = 37368. mm⁴
- y_g = 24.86 mm
- T_y = 2720. N
- M_x = -2040000. Nmm
- x_m = 30. mm
- y_m = 54. mm
- u_m = 9. mm
- v_m = 29.14 mm
- σ_m = -Mv/J_u = 238.3 N/mm²
- x_c = 21. mm
- y_c = 6. mm
- v_c = -18.86 mm
- σ_c = -Mv/J_u = -154.3 N/mm²
- τ_c = 8.746 N/mm²
- σ_ρ = √(σ² + 3τ²) = 155. N/mm²
- S = 4812. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-11/2Fx$	0	$-5Fb+21/2Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-19/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-11/2Fx$	0	$1/2Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 21/4 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 21/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

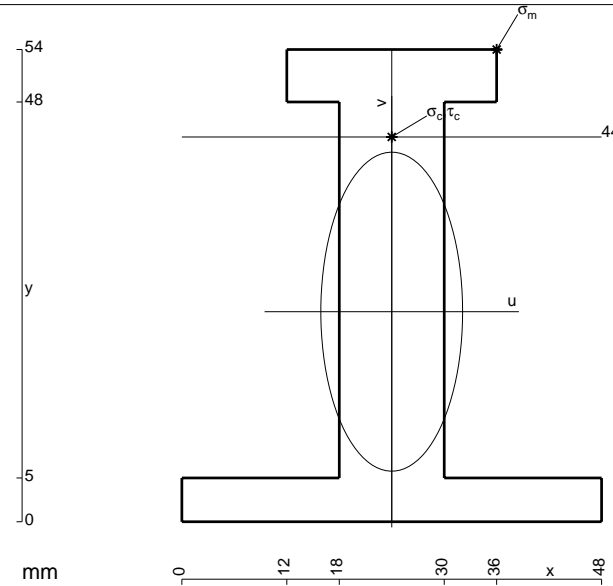
$$= (1/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

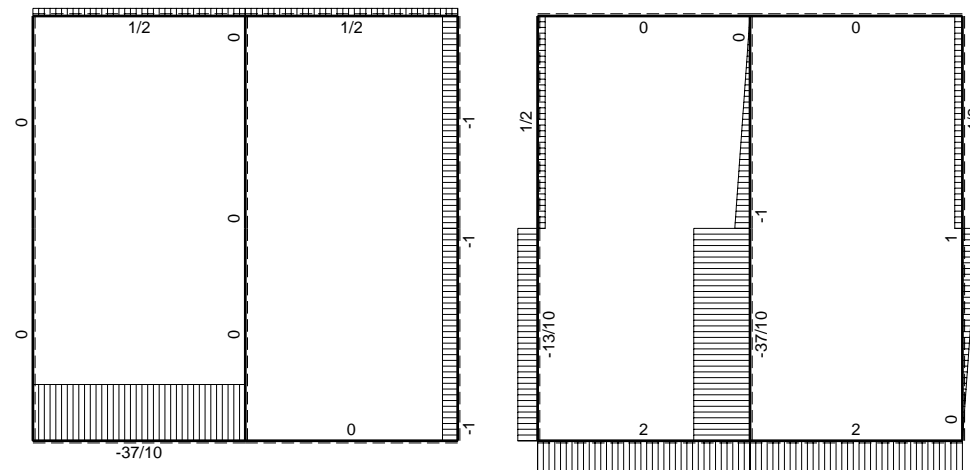
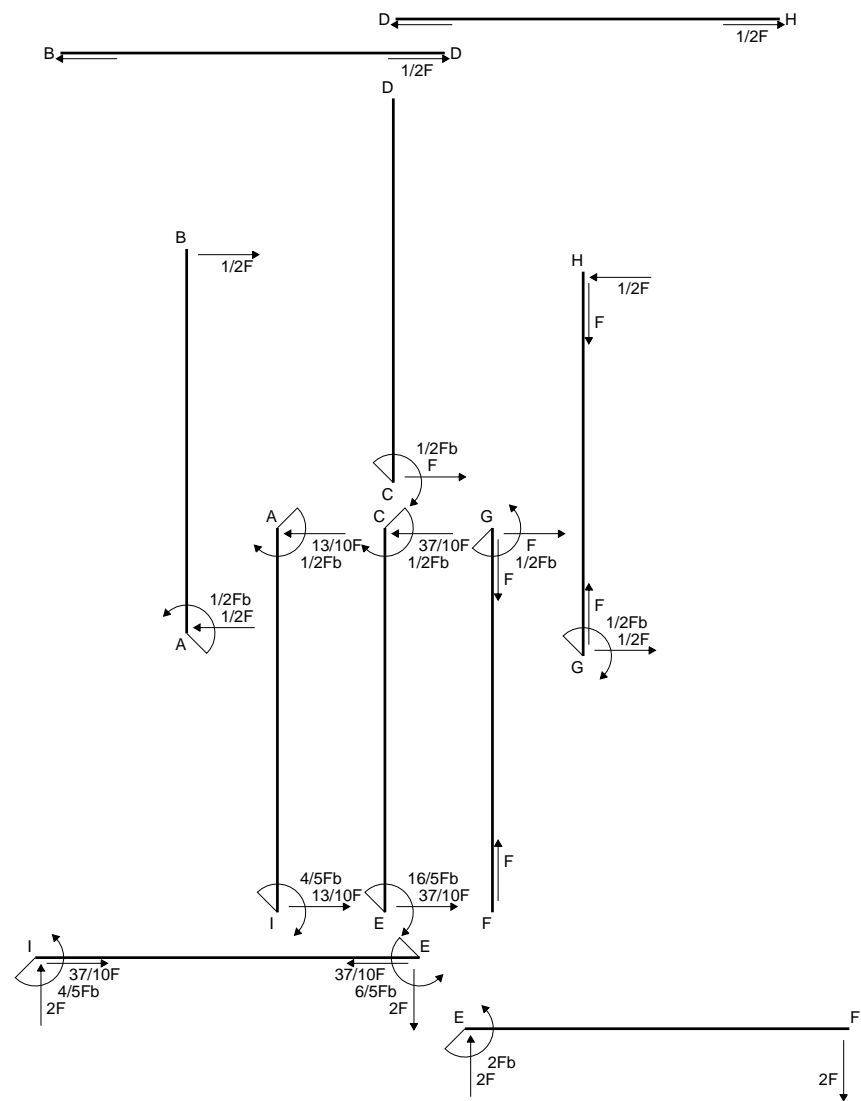
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

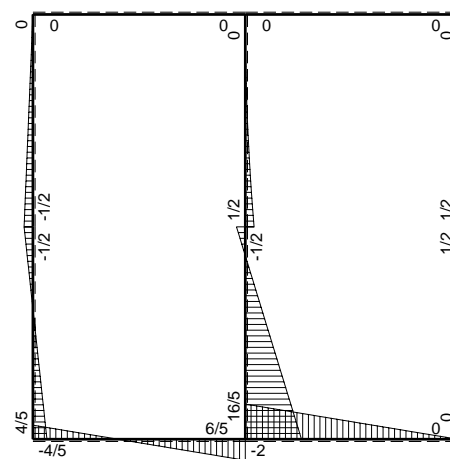


- A = 900. mm²
- J_u = 299580. mm⁴
- J_v = 59184. mm⁴
- y_g = 24.02 mm
- T_y = 2460. N
- M_x = -1992600. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 29.98 mm
- σ_m = -Mv/J_u = 199.4 N/mm²
- x_c = 24. mm
- y_c = 44. mm
- v_c = 19.98 mm
- σ_c = -Mv/J_u = 132.9 N/mm²
- τ_c = 3.381 N/mm²
- σ_q = √(σ² + 3τ²) = 133. N/mm²
- S = 4940. mm³

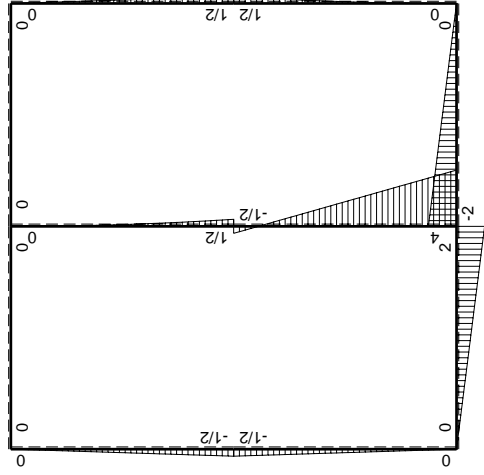
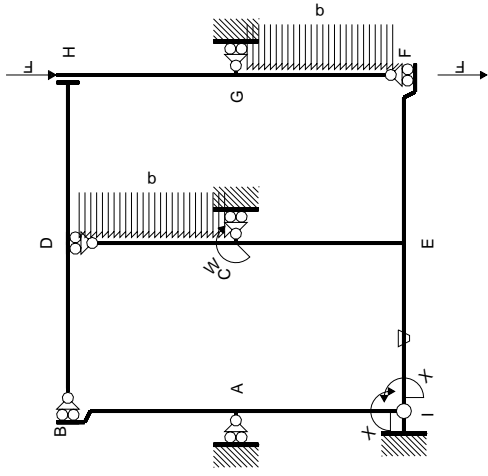


← ⊕ → F

↑ ⊕ ↓ F

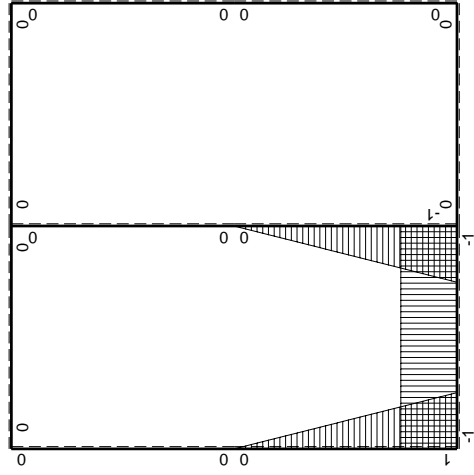


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx$	0	$-4Fb+17/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-9/2Fx$	0	$1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-4/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$4/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 17/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

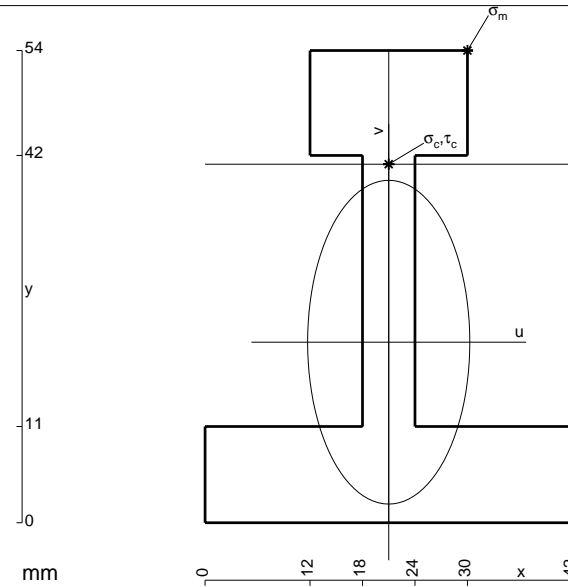
$$= (1/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

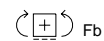
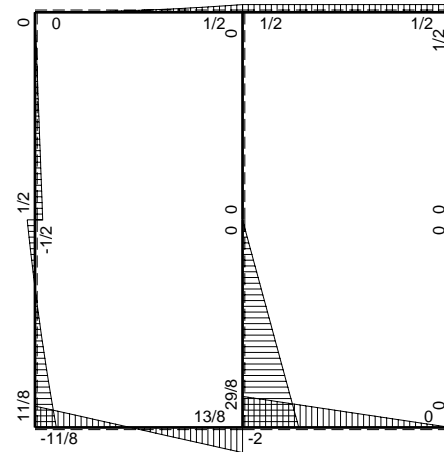
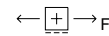
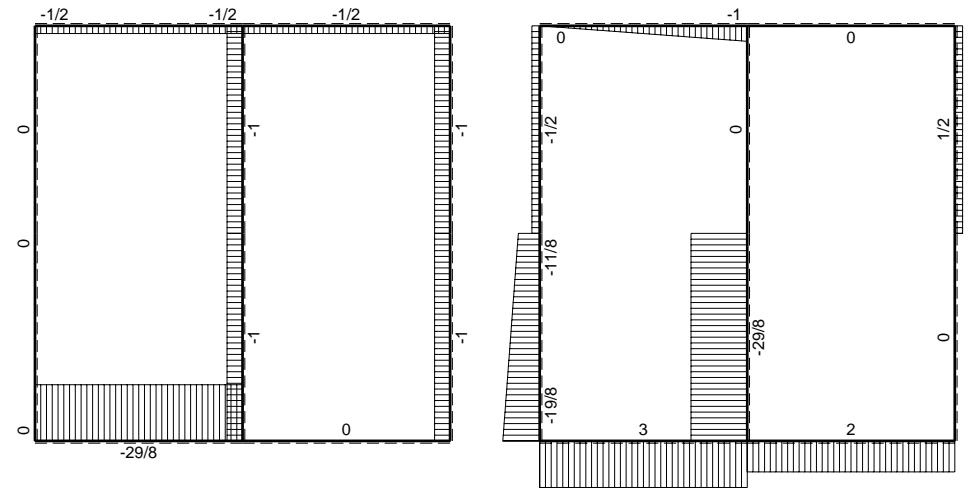
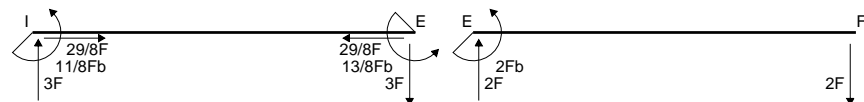
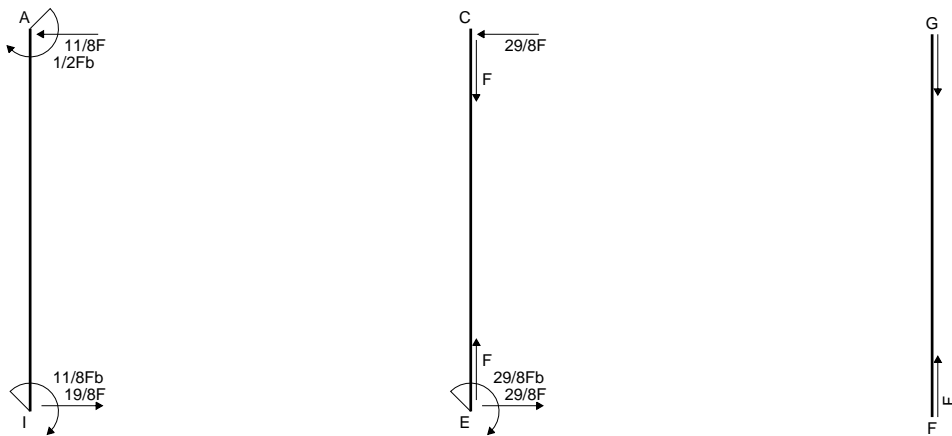
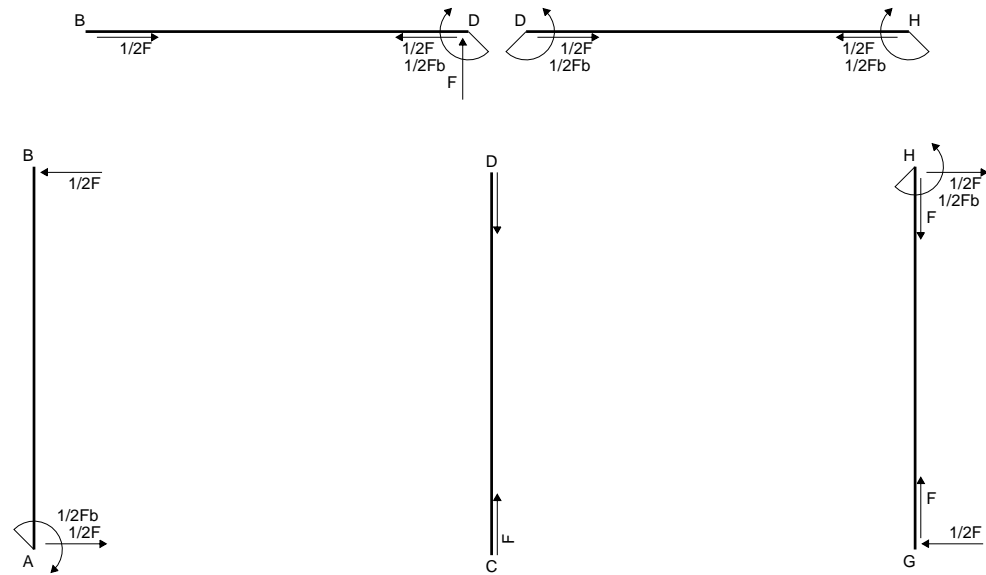
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

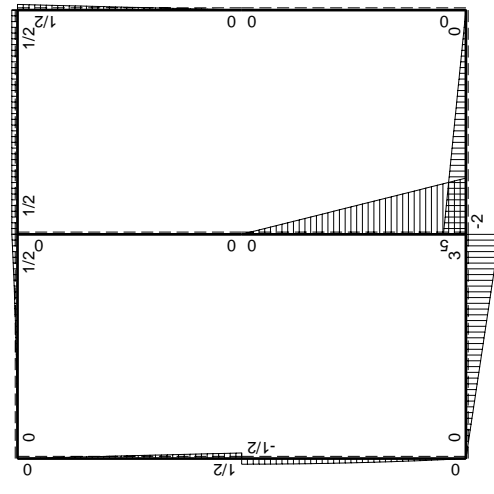
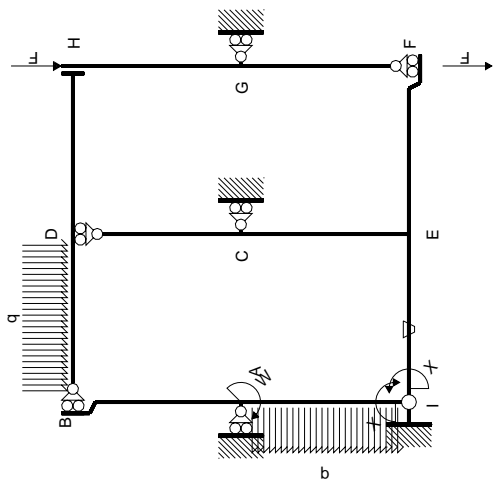
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



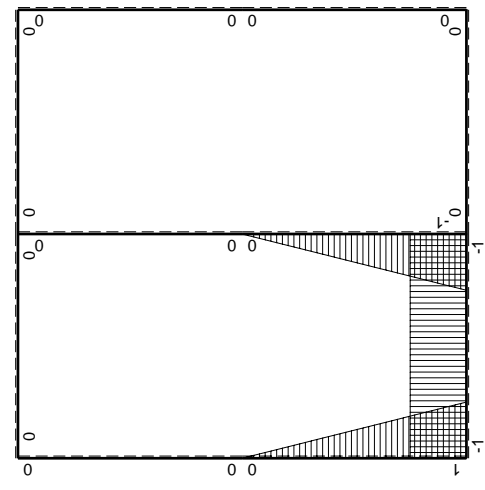
- A = 864. mm²
- J_u = 296124. mm⁴
- J_v = 74304. mm⁴
- y_g = 20.65 mm
- T_y = 2160. N
- M_x = -1857600. Nmm
- x_m = 30. mm
- y_m = 54. mm
- u_m = 9. mm
- v_m = 33.35 mm
- σ_m = -Mv/J_u = 209.2 N/mm²
- x_c = 21. mm
- y_c = 41. mm
- v_c = 20.35 mm
- σ_c = -Mv/J_u = 127.7 N/mm²
- τ_c = 7.335 N/mm²
- σ_q = √σ²+3τ² = 128.3 N/mm²
- S = 6034. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fb+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

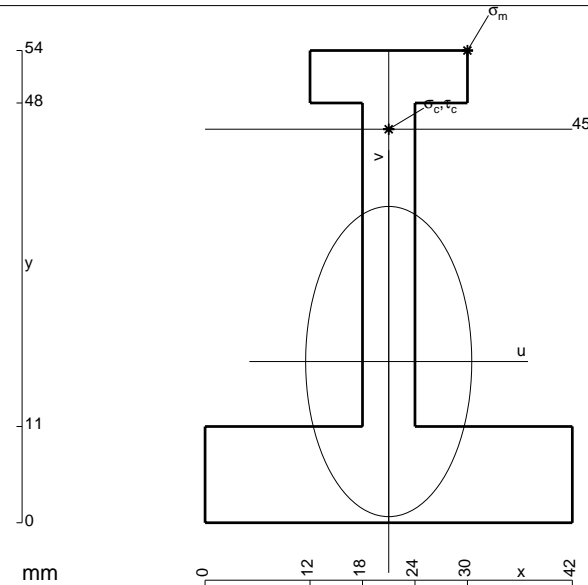
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

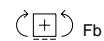
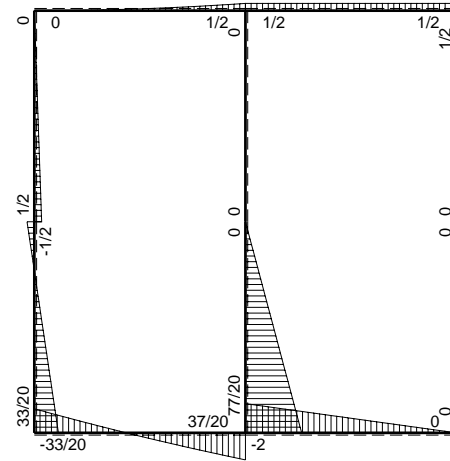
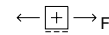
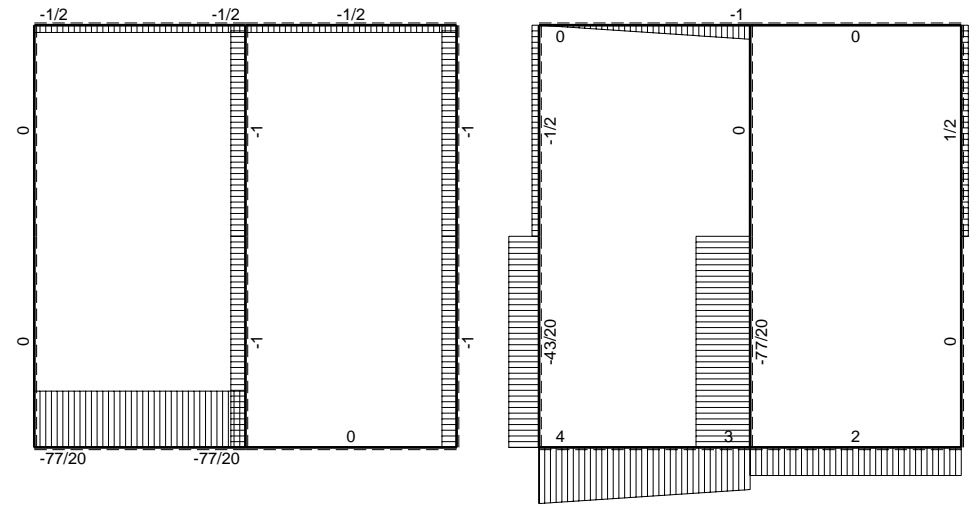
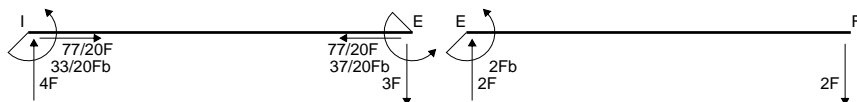
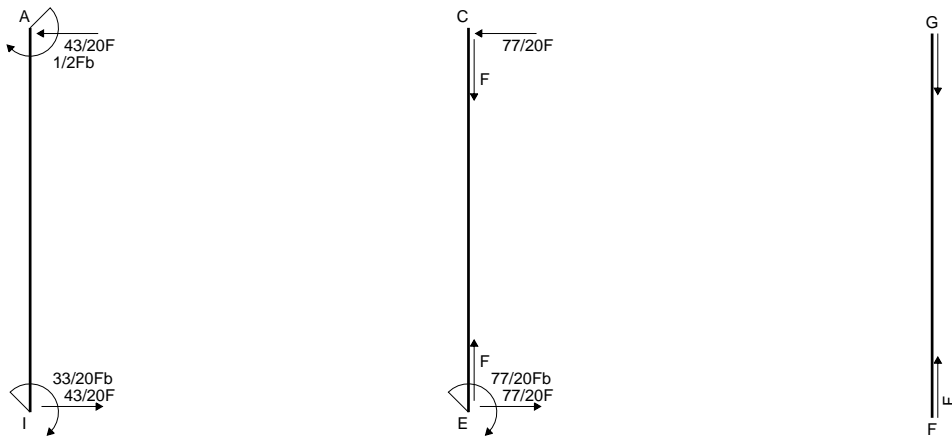
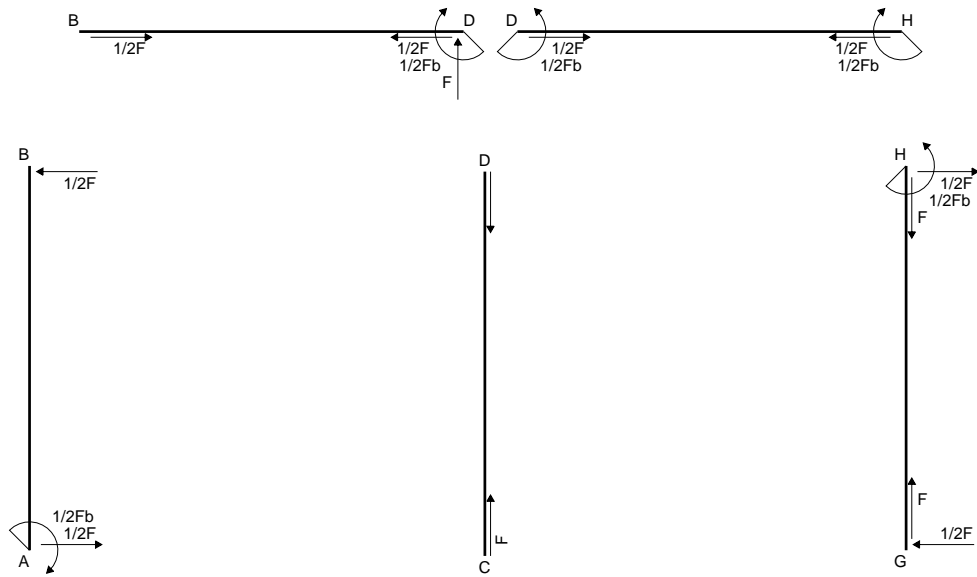
$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

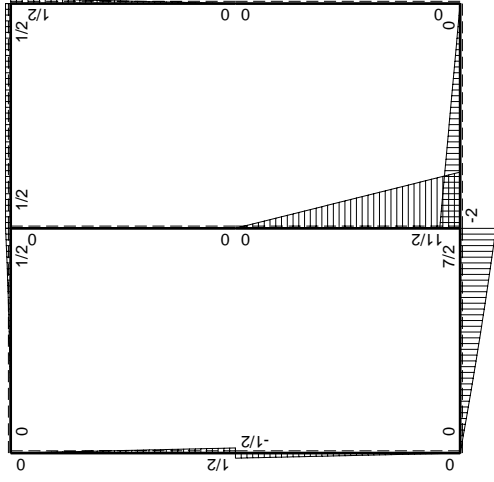
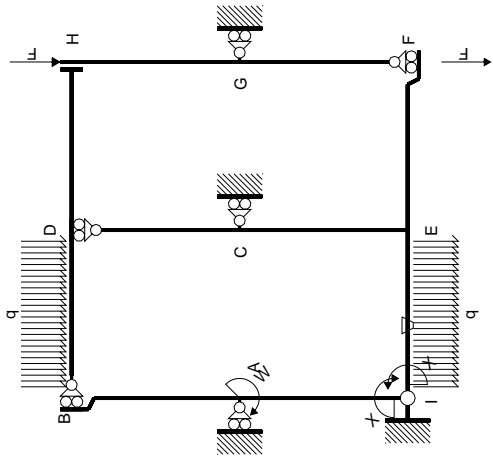
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



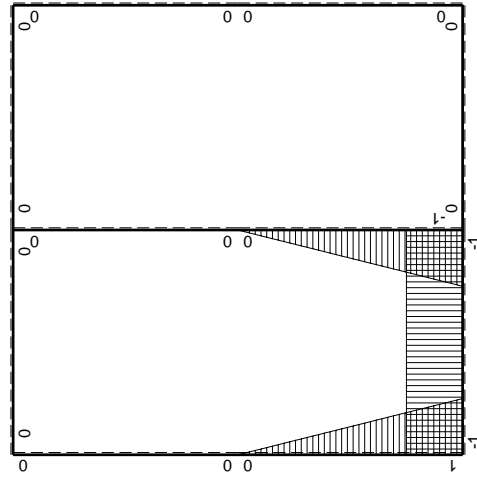
- A = 792. mm²
- J_u = 249320. mm⁴
- J_v = 71496. mm⁴
- y_g = 18.43 mm
- T_y = 1680. N
- M_x = -1528800. Nmm
- x_m = 30. mm
- y_m = 54. mm
- u_m = 9. mm
- v_m = 35.57 mm
- σ_m = -Mv/J_u = 218.1 N/mm²
- x_c = 21. mm
- y_c = 45. mm
- v_c = 26.57 mm
- σ_c = -Mv/J_u = 162.9 N/mm²
- τ_c = 4.518 N/mm²
- σ_q = √σ²+3τ² = 163.1 N/mm²
- S = 4023. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

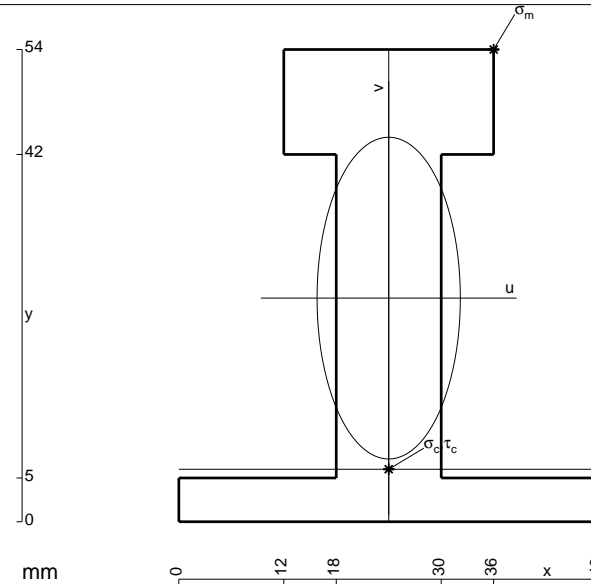
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

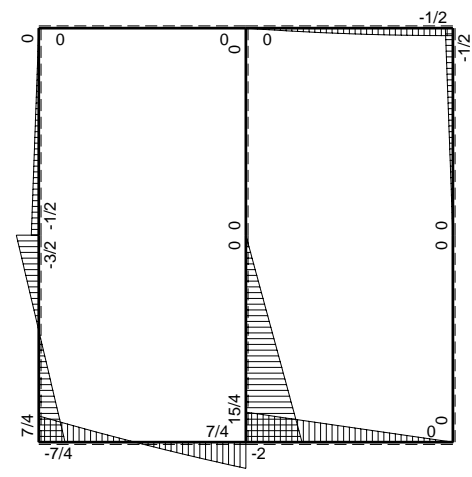
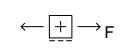
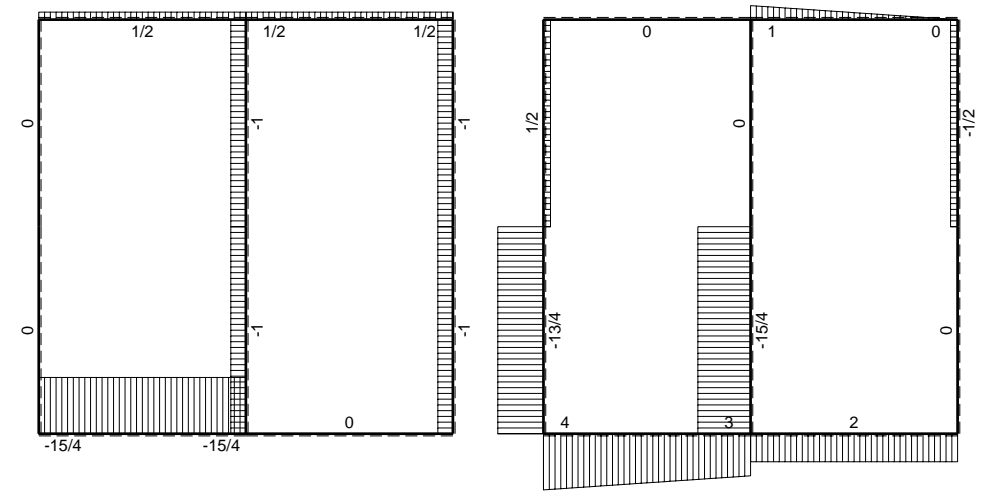
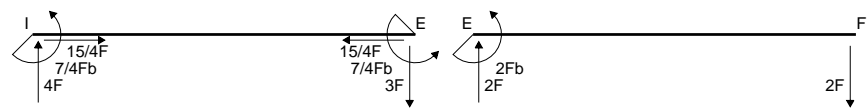
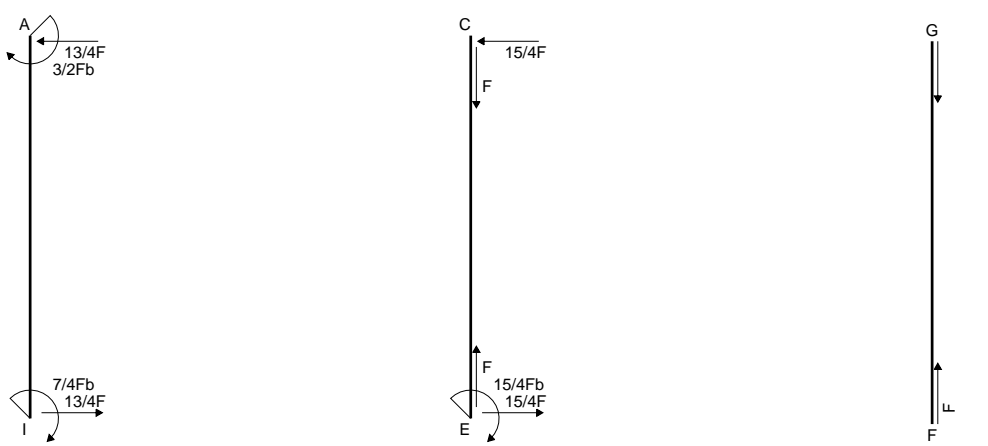
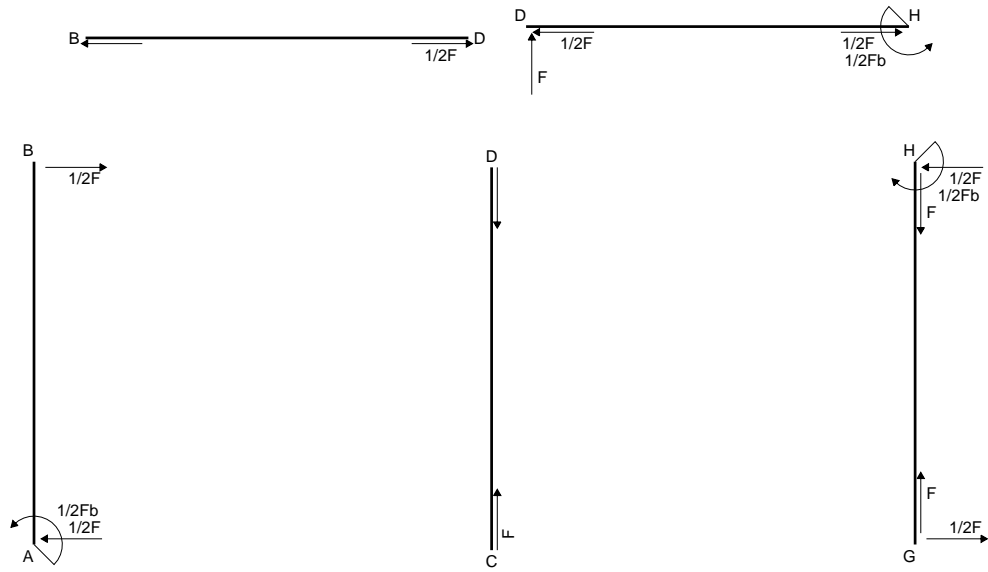
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

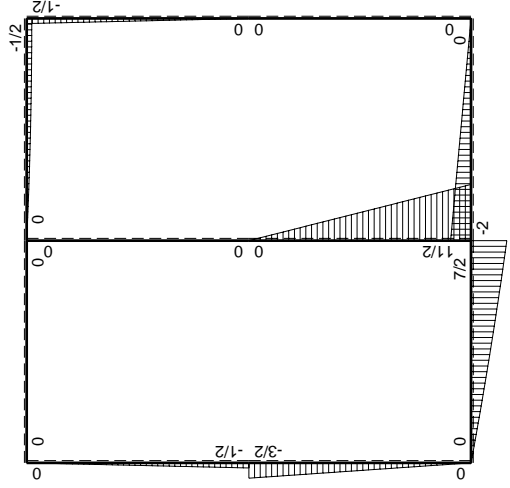
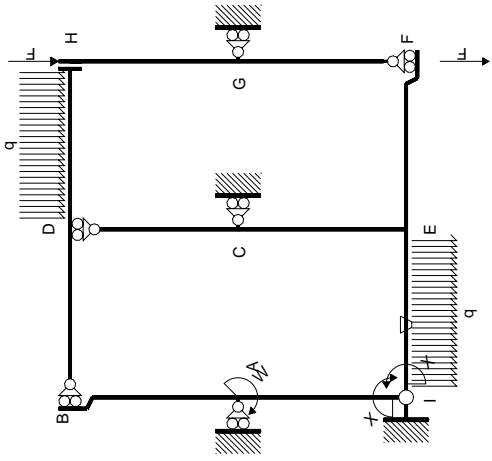
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



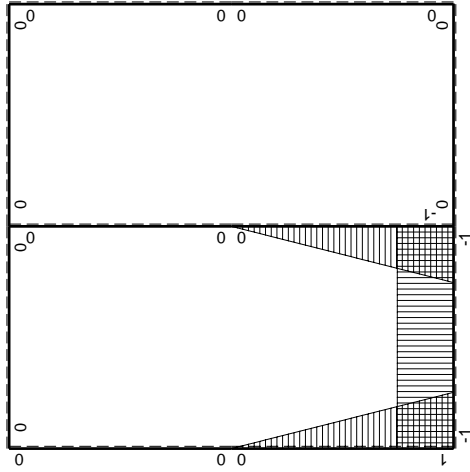
- A = 972. mm²
- J_u = 329140. mm⁴
- J_v = 65232. mm⁴
- y_g = 25.57 mm
- T_y = 2740. N
- M_x = -2657800. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 28.43 mm
- σ_m = -Mv/J_u = 229.5 N/mm²
- x_c = 24. mm
- y_c = 6. mm
- v_c = -19.57 mm
- σ_c = -Mv/J_u = -158.1 N/mm²
- τ_c = 4.009 N/mm²
- σ_q = √σ² + 3τ² = 158.2 N/mm²
- S = 5779. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

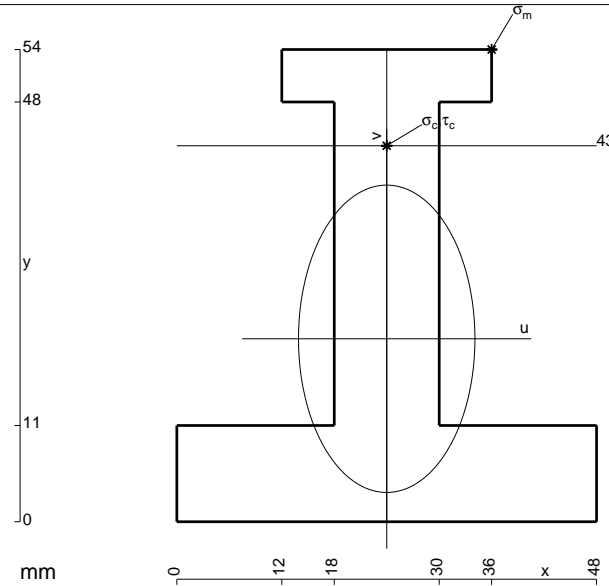
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 1116. \text{ mm}^2$$

$$J_u = 344933. \text{ mm}^4$$

$$J_v = 113616. \text{ mm}^4$$

$$y_g = 20.92 \text{ mm}$$

$$T_y = 2440. \text{ N}$$

$$M_x = -2488800. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 33.08 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.7 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

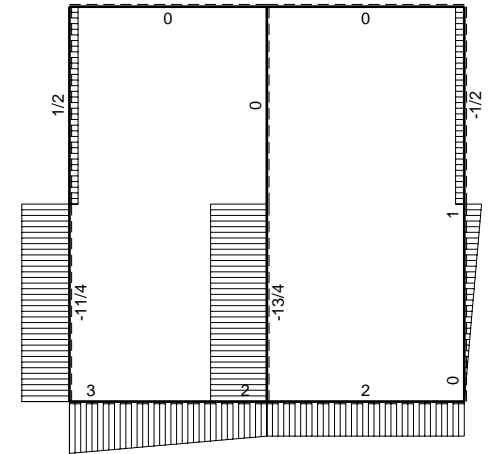
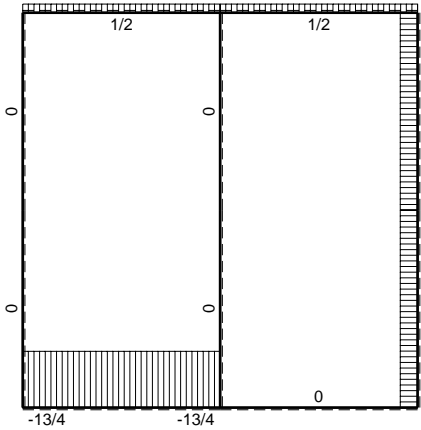
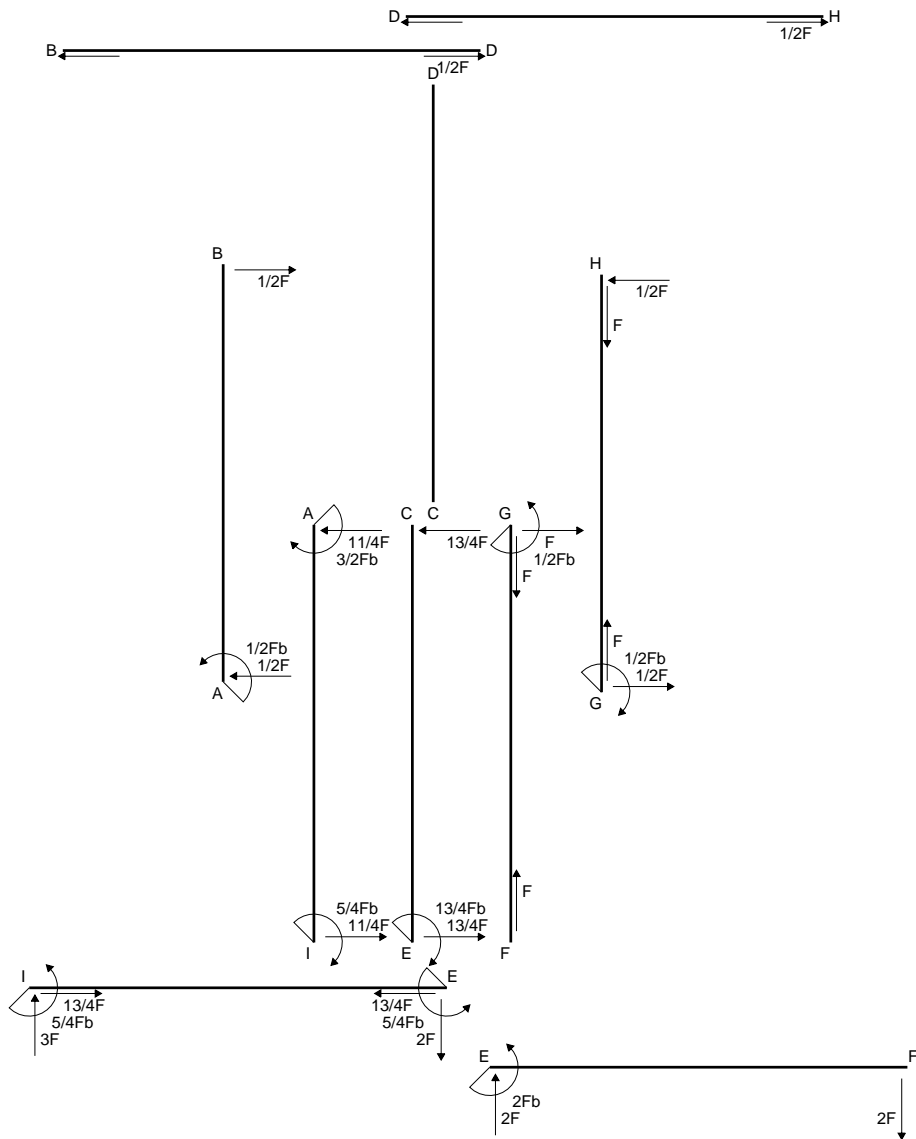
$$v_c = 22.08 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 159.3 \text{ N/mm}^2$$

$$\tau_c = 3.423 \text{ N/mm}^2$$

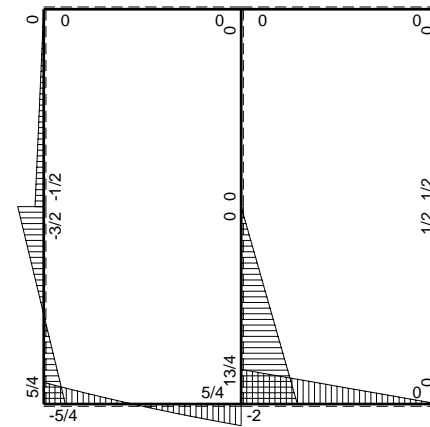
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 159.4 \text{ N/mm}^2$$

$$S = 5806. \text{ mm}^3$$

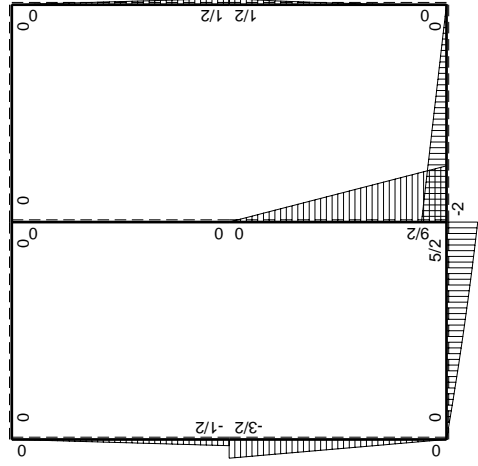
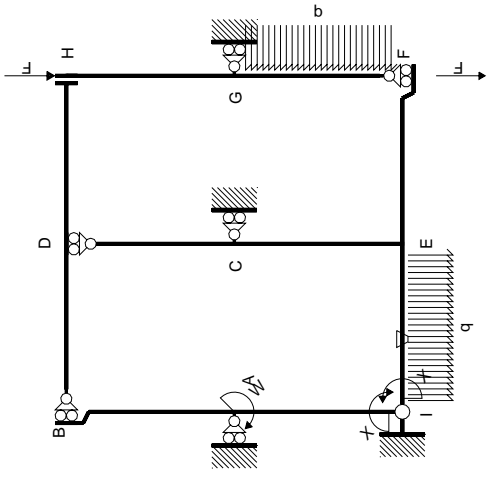


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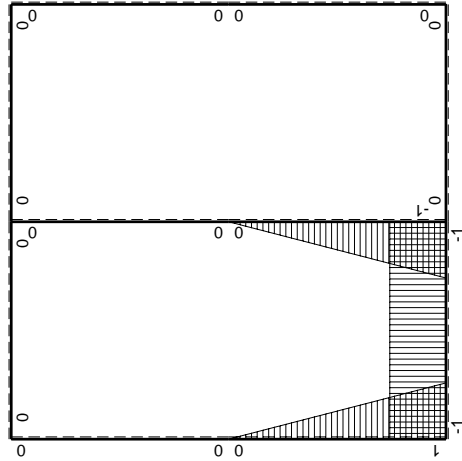


⊕ ⊖ F_b



Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M₁ flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

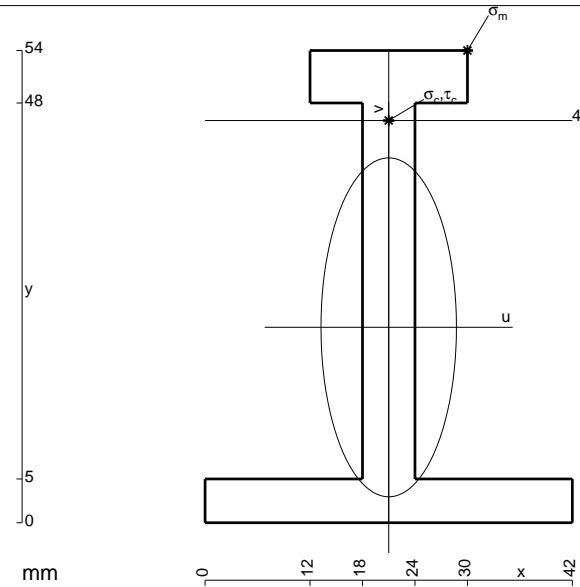
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

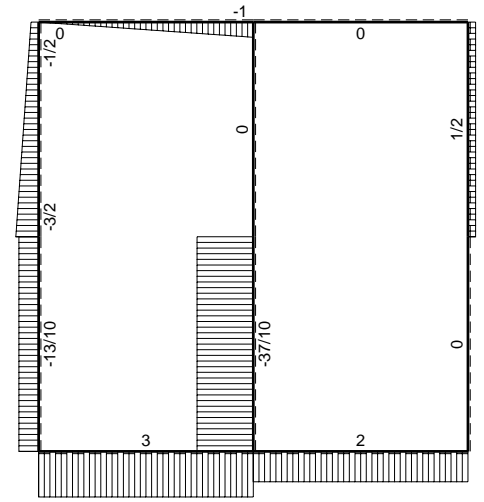
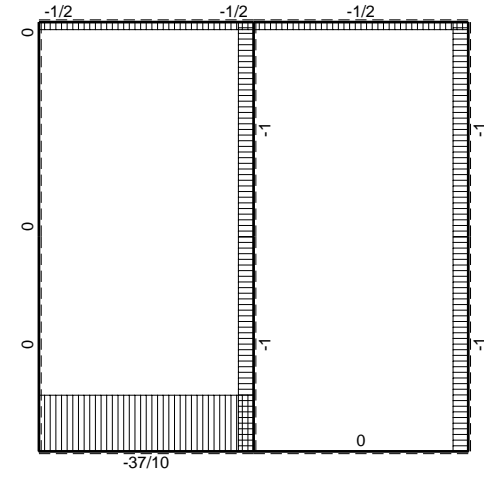
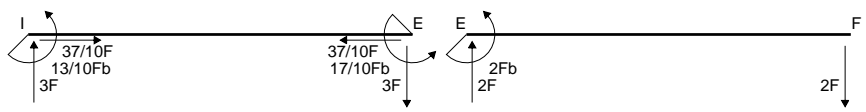
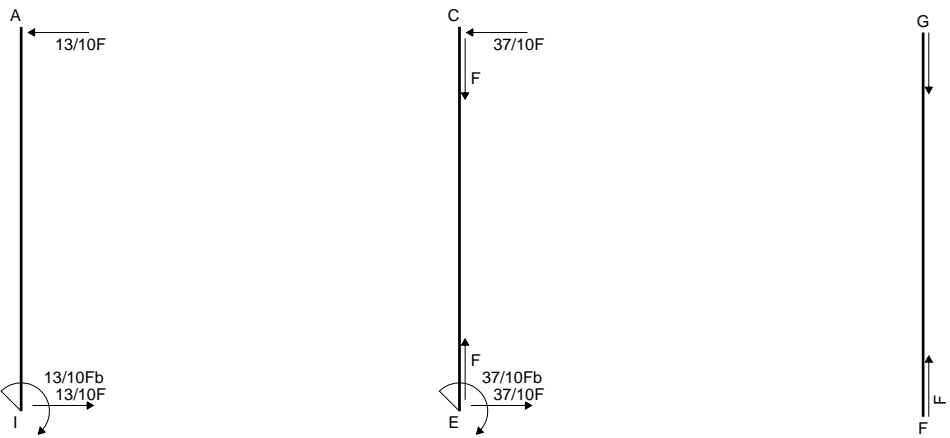
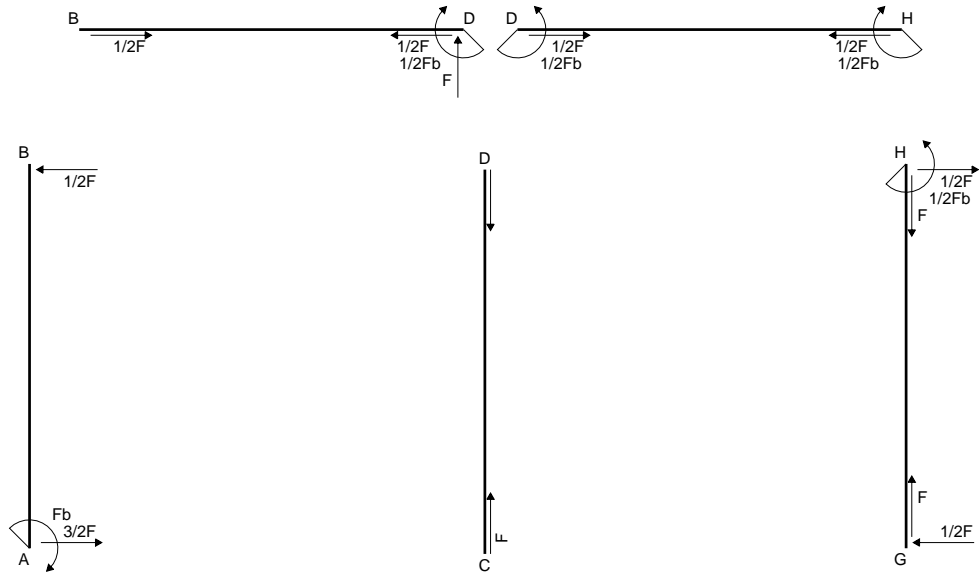
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

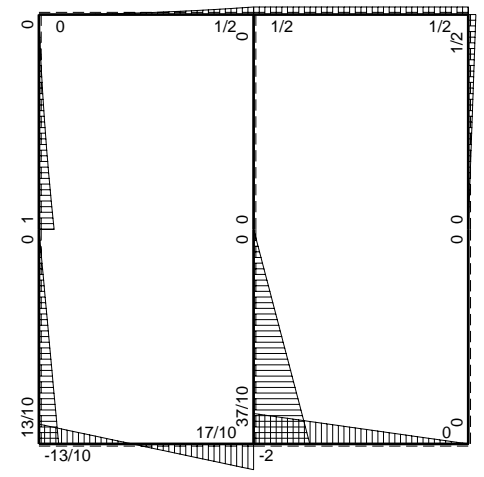


- A = 576. mm²
- J_u = 216352. mm⁴
- J_v = 34560. mm⁴
- y_g = 22.34 mm
- T_y = 2520. N
- M_x = -1360800. Nmm
- x_m = 30. mm
- y_m = 54. mm
- u_m = 9. mm
- v_m = 31.66 mm
- σ_m = -Mv/J_u = 199.1 N/mm²
- x_c = 21. mm
- y_c = 46. mm
- v_c = 23.66 mm
- σ_c = -Mv/J_u = 148.8 N/mm²
- τ_c = 6.582 N/mm²
- σ_q = √σ²+3τ² = 149.2 N/mm²
- S = 3391. mm³



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

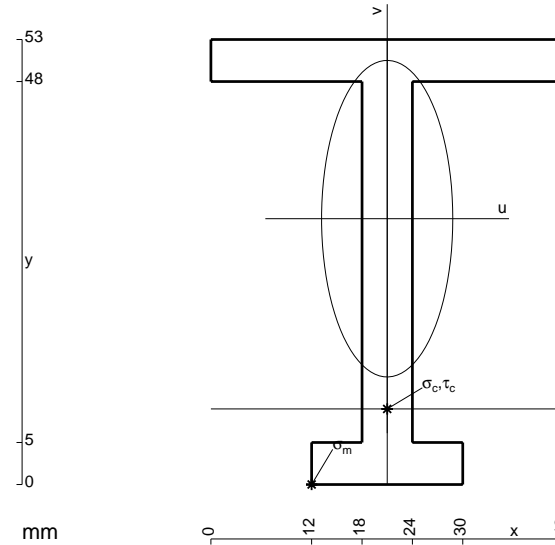
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$



$$A = 558. \text{ mm}^2$$

$$J_u = 198314. \text{ mm}^4$$

$$J_v = 34074. \text{ mm}^4$$

$$y_g = 31.66 \text{ mm}$$

$$T_y = 2260. \text{ N}$$

$$M_x = -1310800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -31.66 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.3 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

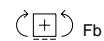
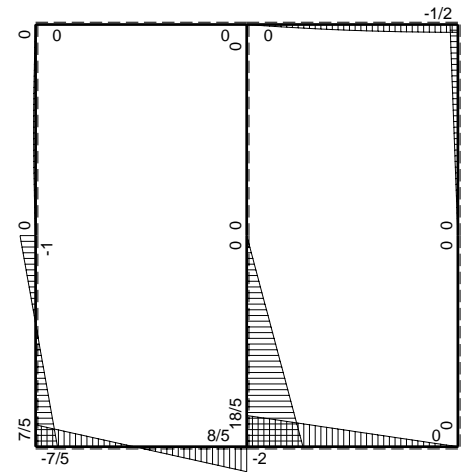
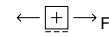
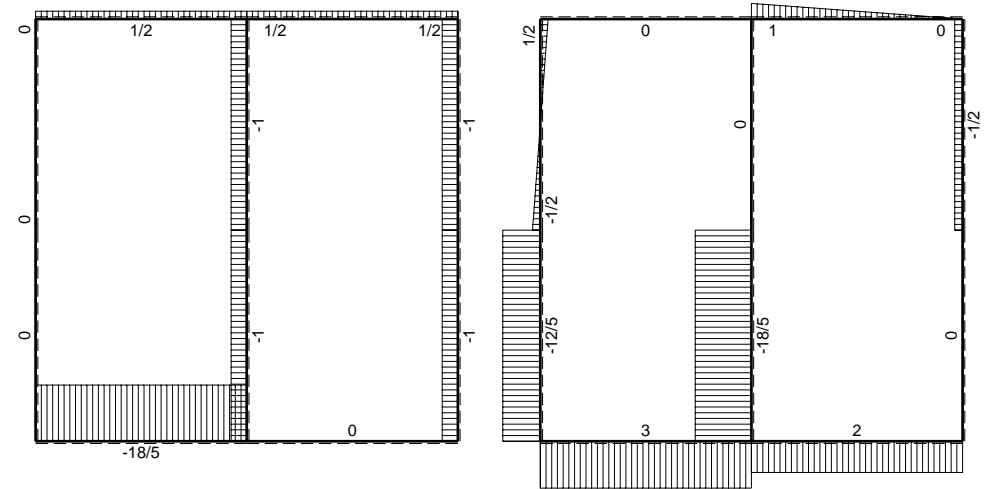
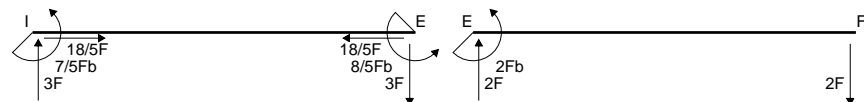
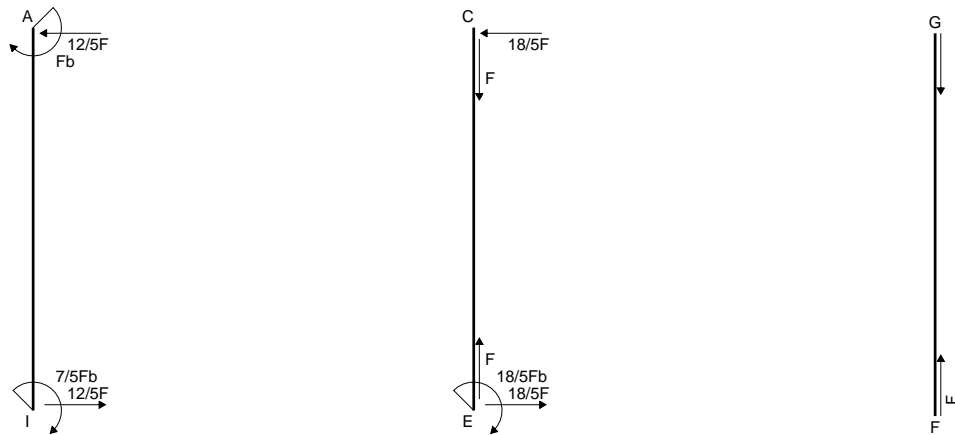
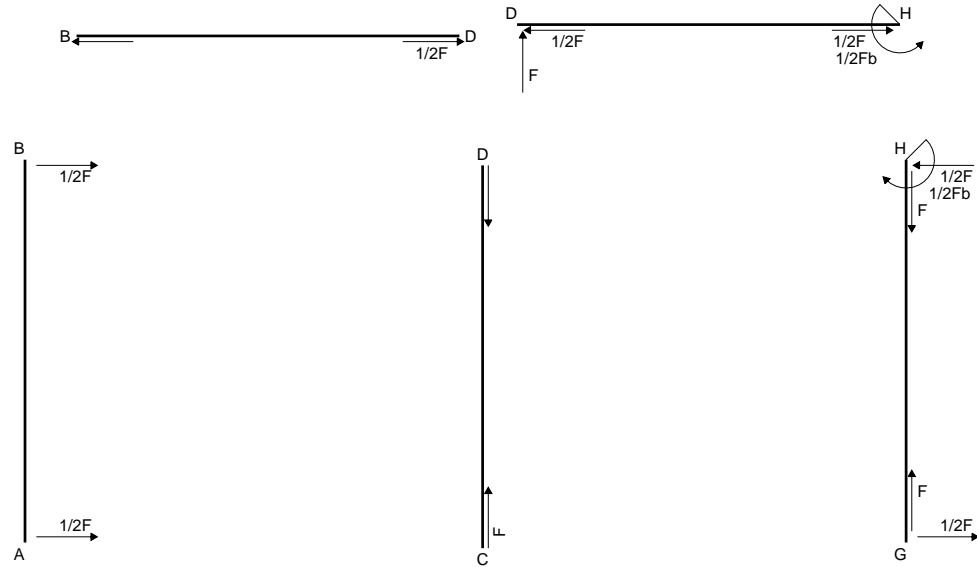
$$v_c = -22.66 \text{ mm}$$

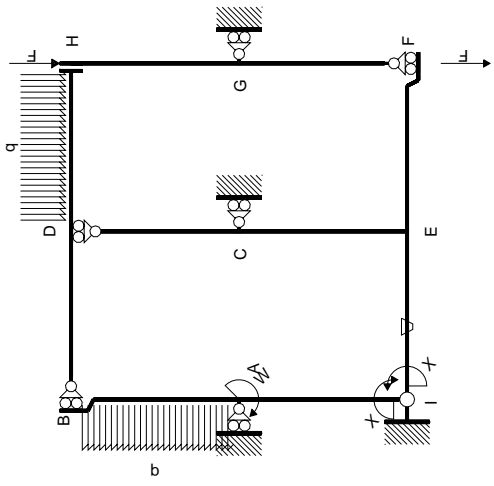
$$\sigma_c = -Mv/J_u = -149.8 \text{ N/mm}^2$$

$$\tau_c = 6.109 \text{ N/mm}^2$$

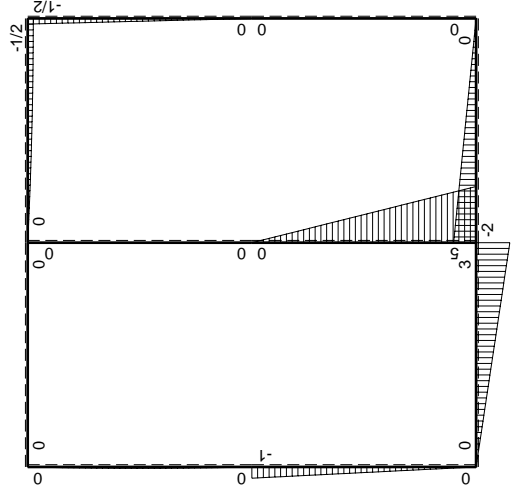
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 150.2 \text{ N/mm}^2$$

$$S = 3216. \text{ mm}^3$$

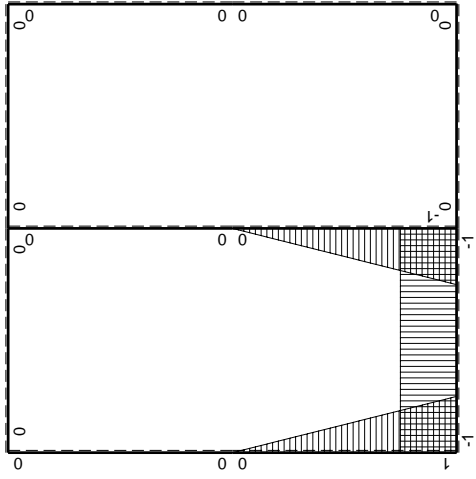




Schema di calcolo iperstatico



M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

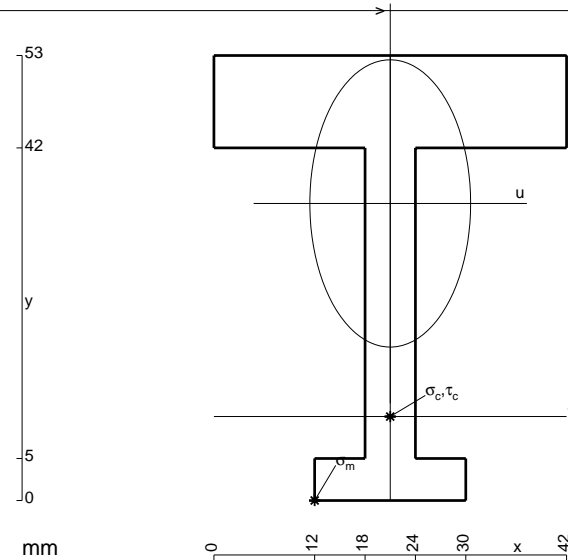
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 774. \text{ mm}^2$$

$$J_u = 226668. \text{ mm}^4$$

$$J_v = 71010. \text{ mm}^4$$

$$y_g = 35.38 \text{ mm}$$

$$T_y = 2220. \text{ N}$$

$$M_x = -1398600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -35.38 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218.3 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

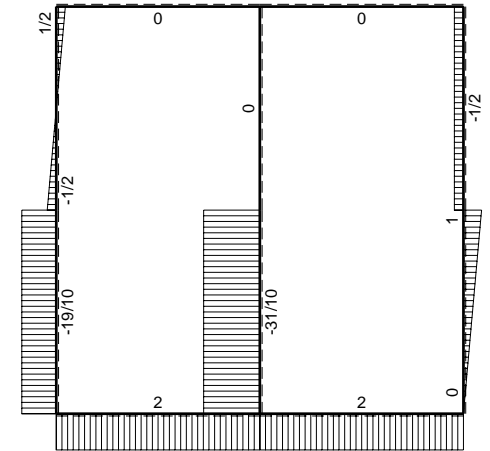
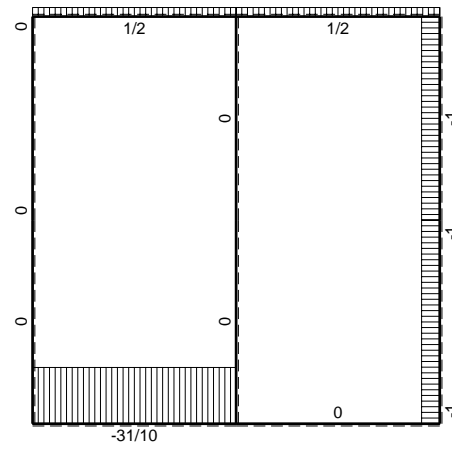
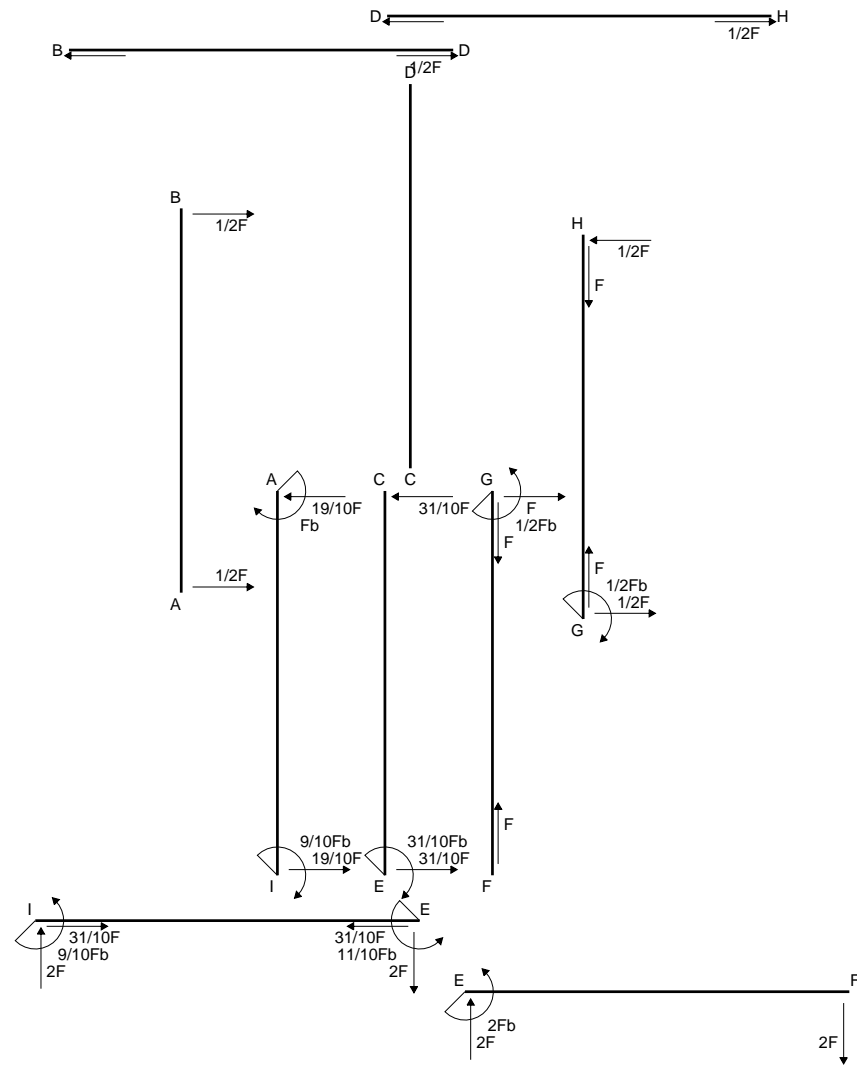
$$v_c = -25.38 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -156.6 \text{ N/mm}^2$$

$$\tau_c = 6.196 \text{ N/mm}^2$$

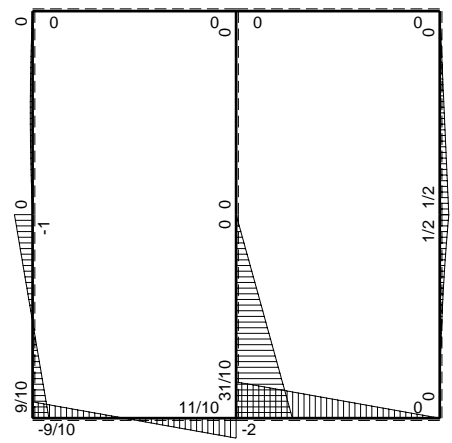
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 157. \text{ N/mm}^2$$

$$S = 3796. \text{ mm}^3$$

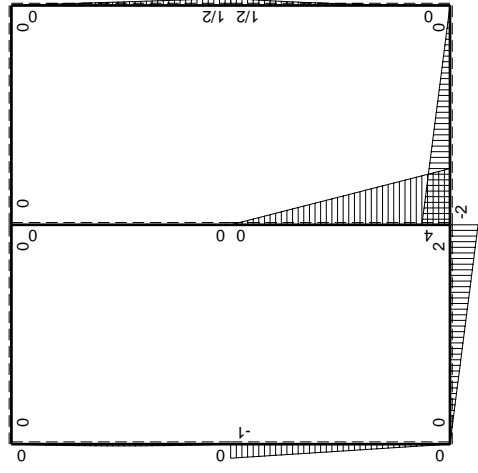
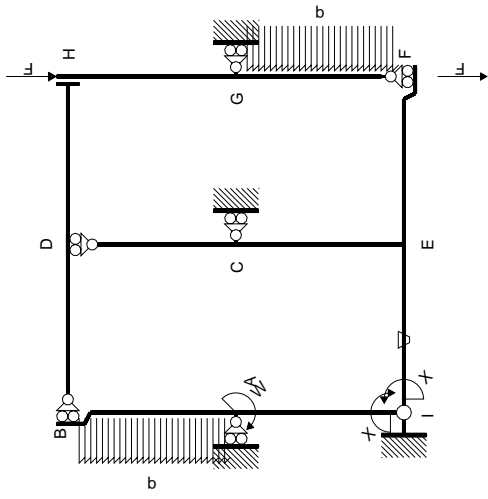


← (+) → F

↑ (+) ↓ F

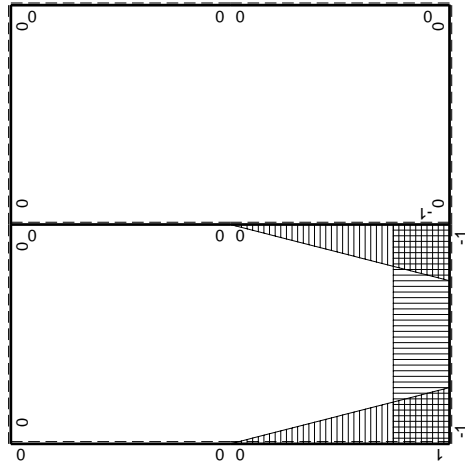


⊙ (+) ⊙ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

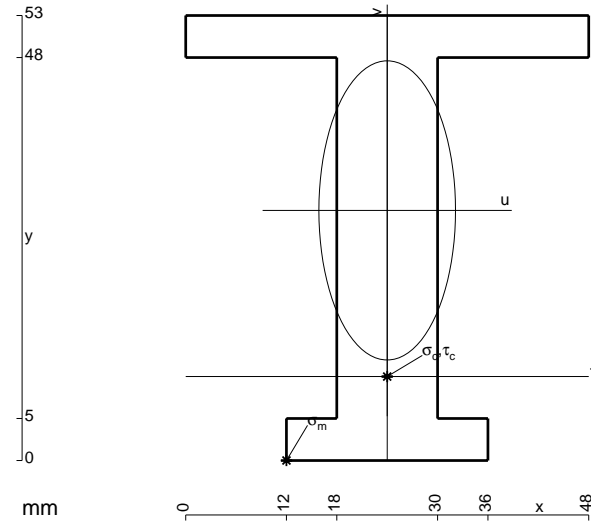
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

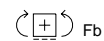
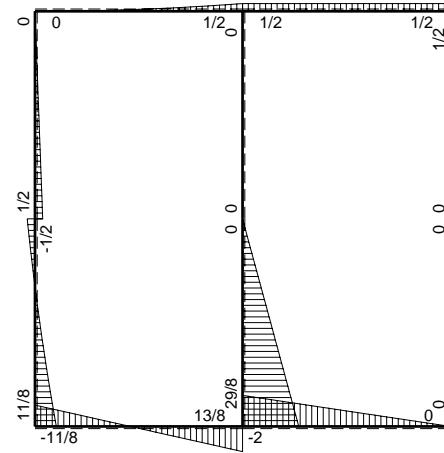
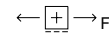
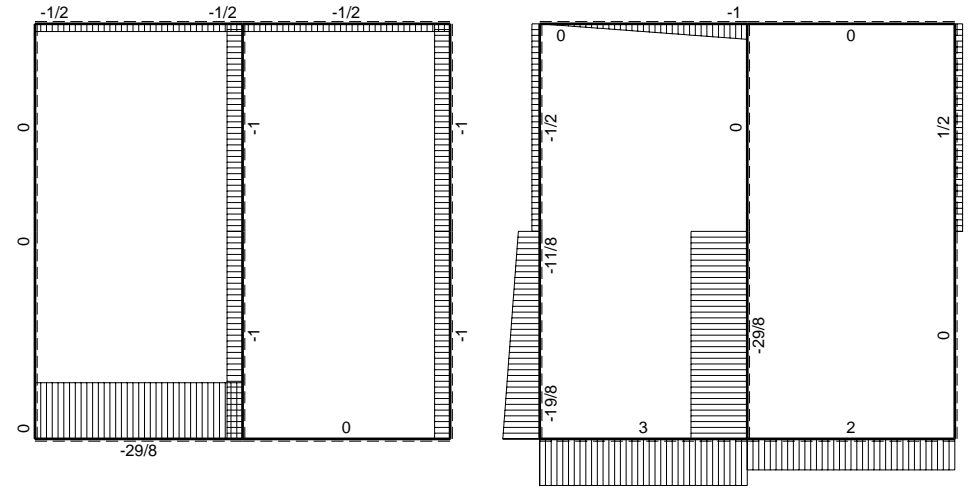
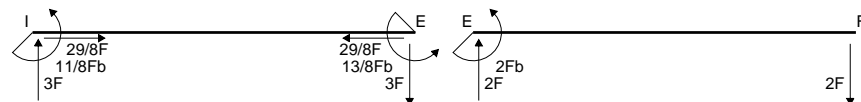
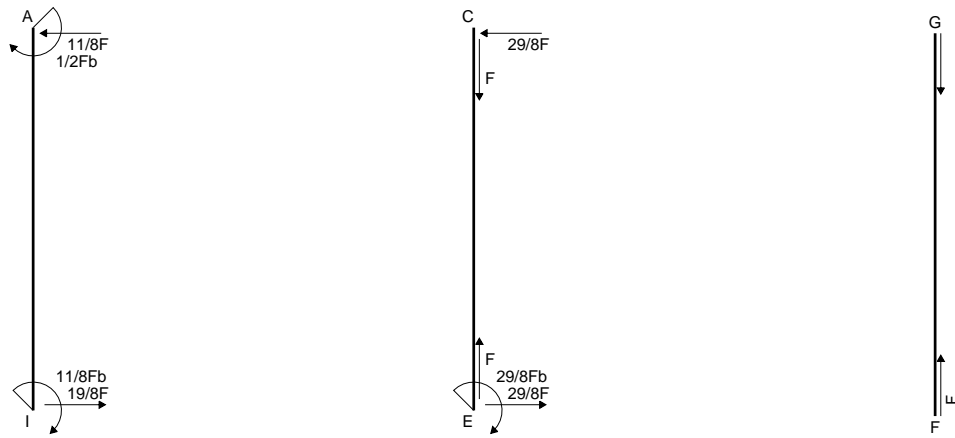
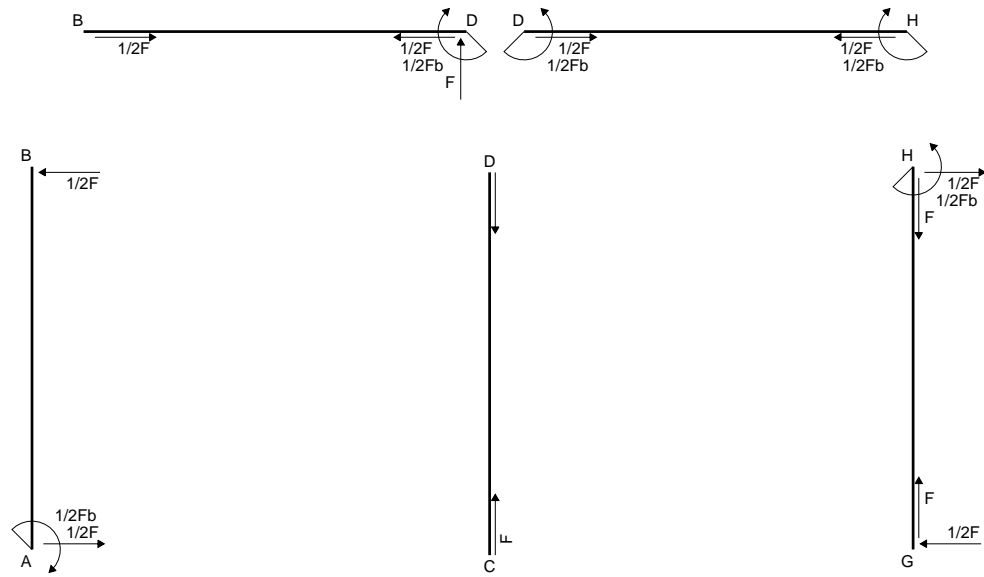
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

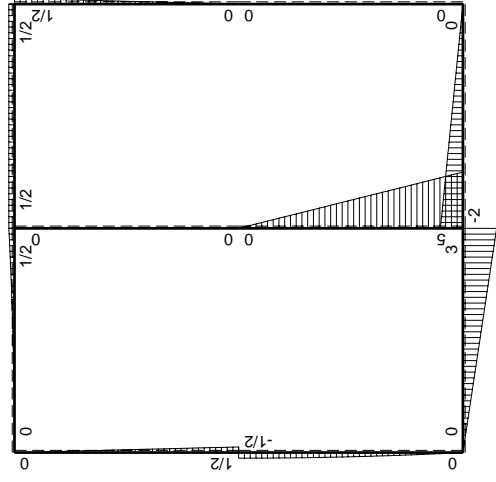
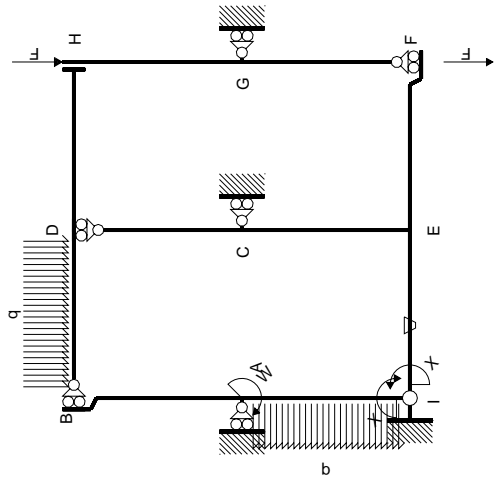
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



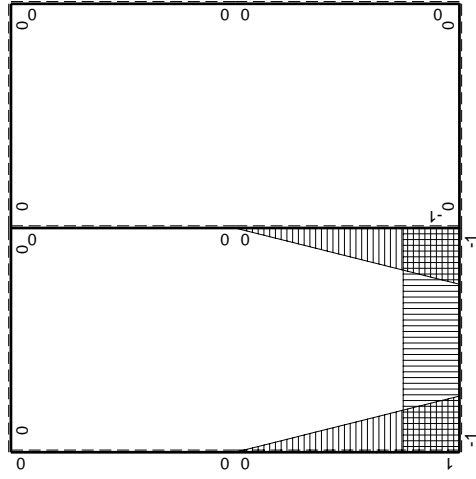
- A = 876. mm²
- J_u = 278148. mm⁴
- J_v = 58032. mm⁴
- y_g = 29.79 mm
- T_y = 3140. N
- M_x = -2135200. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -29.79 mm
- σ_m = -Mv/J_u = -228.7 N/mm²
- x_c = 24. mm
- y_c = 10. mm
- v_c = -19.79 mm
- σ_c = -Mv/J_u = -151.9 N/mm²
- τ_c = 4.339 N/mm²
- σ_o = √σ_c² + 3τ_c² = 152.1 N/mm²
- S = 4612. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fb+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

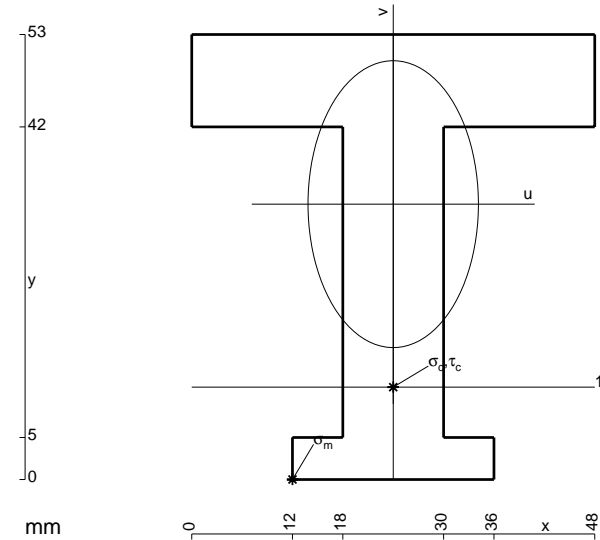
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

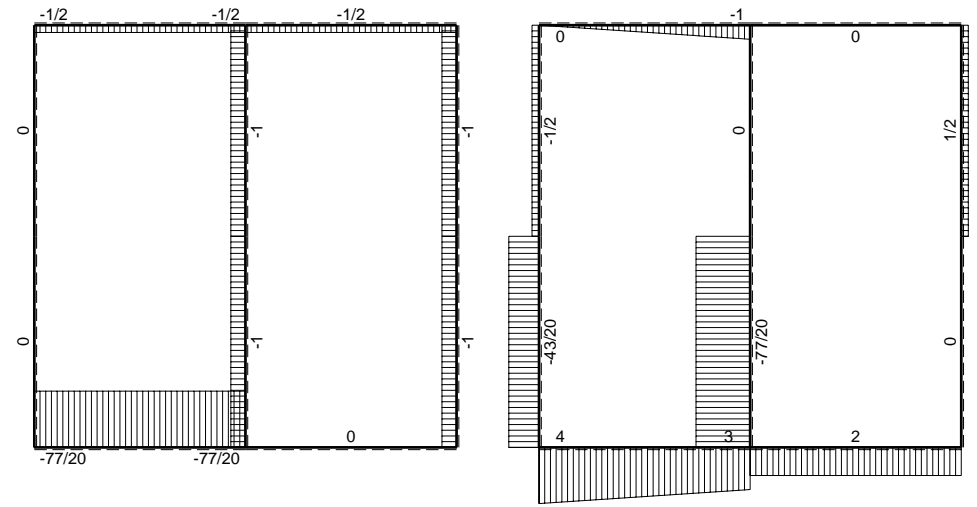
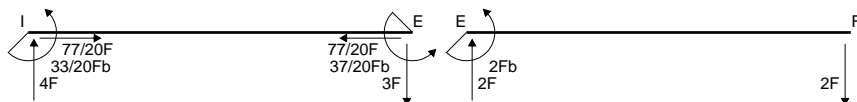
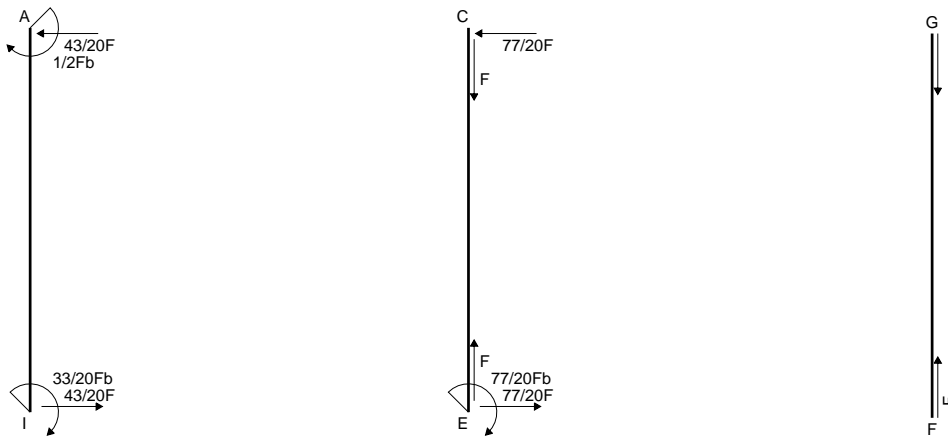
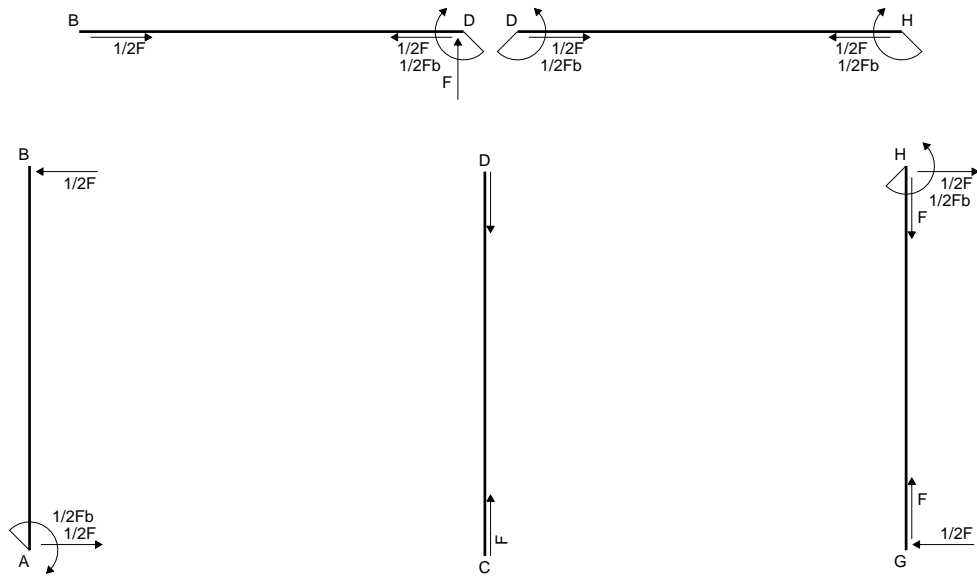
$$= (-1/2 b + 1/2 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb 1/EJ dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

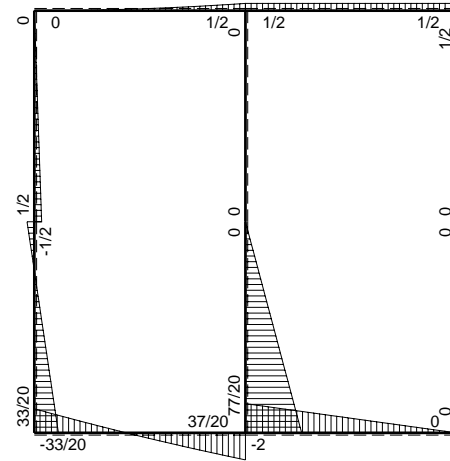


- A = 1092. mm²
- J_u = 318895. mm⁴
- J_v = 112464. mm⁴
- y_g = 32.8 mm
- T_y = 3140. N
- M_x = -2323600. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -32.8 mm
- σ_m = -Mv/J_u = -239. N/mm²
- x_c = 24. mm
- y_c = 11. mm
- v_c = -21.8 mm
- σ_c = -Mv/J_u = -158.8 N/mm²
- τ_c = 4.448 N/mm²
- σ_ρ = √(σ² + 3τ²) = 159. N/mm²
- S = 5421. mm³

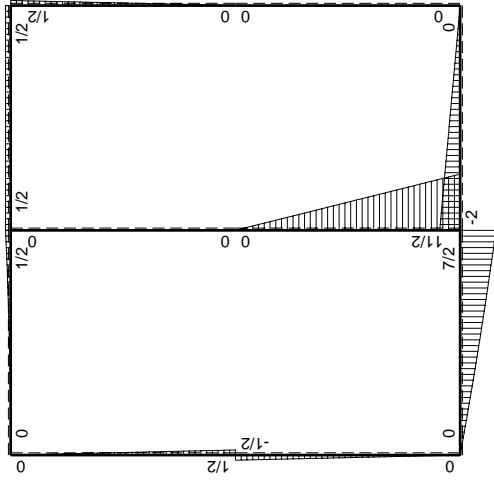
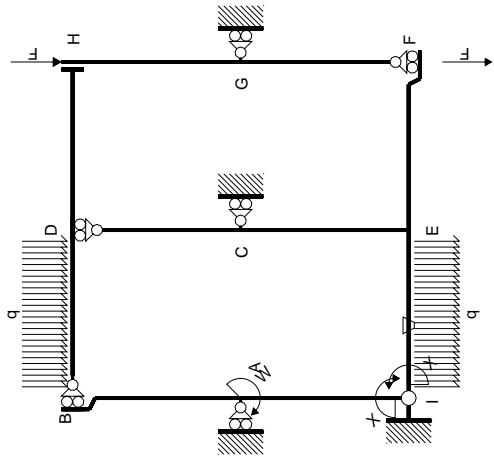


← ⊕ → F

↑ ⊕ ↓ F

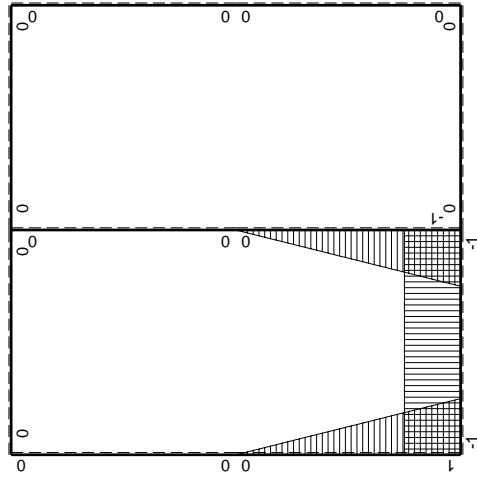


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$-1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0			
HD b	0	$1/2Fb$	0	0	0	0	0+0	0	
DH b	0	$-1/2Fb$	0	0	0	0			
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
BD b	0	$-1/2qx^2$	0	0	0	0			
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2			
	totali							$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

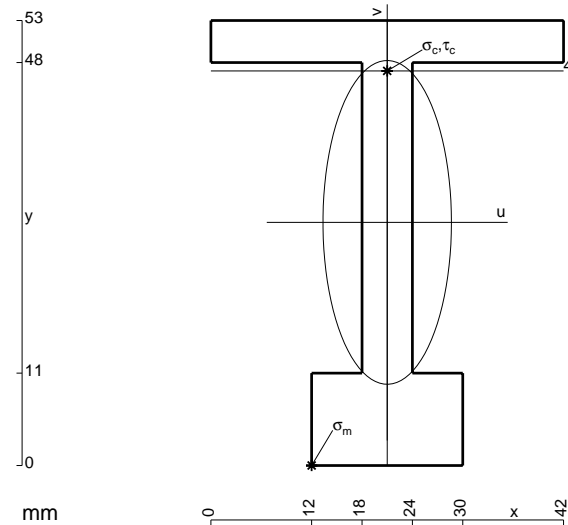
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

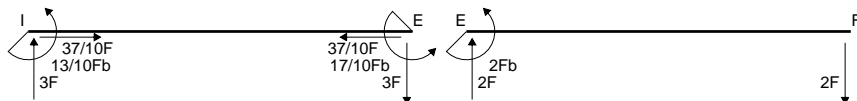
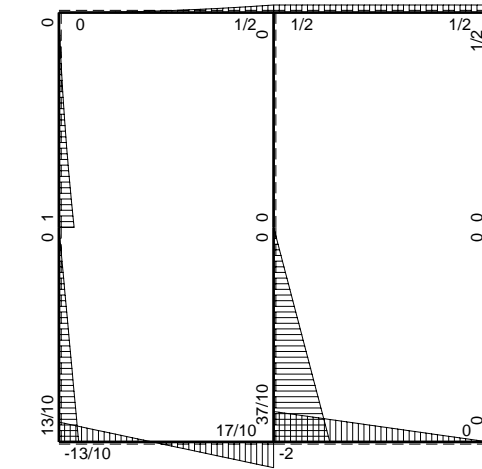
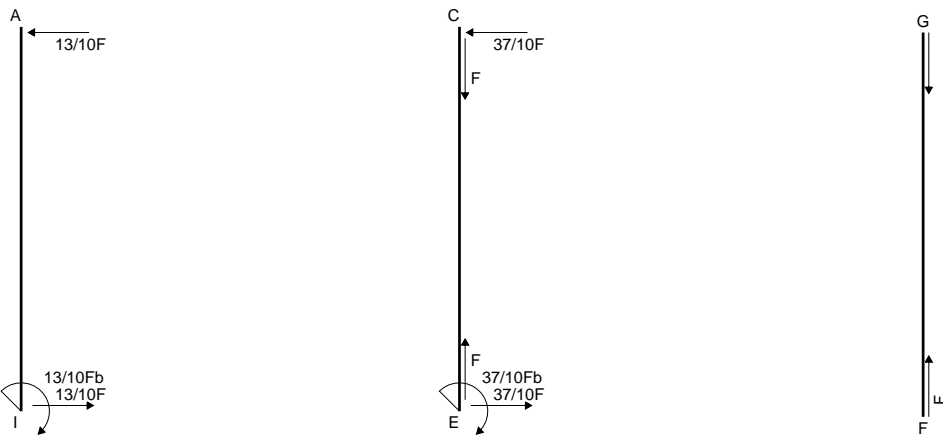
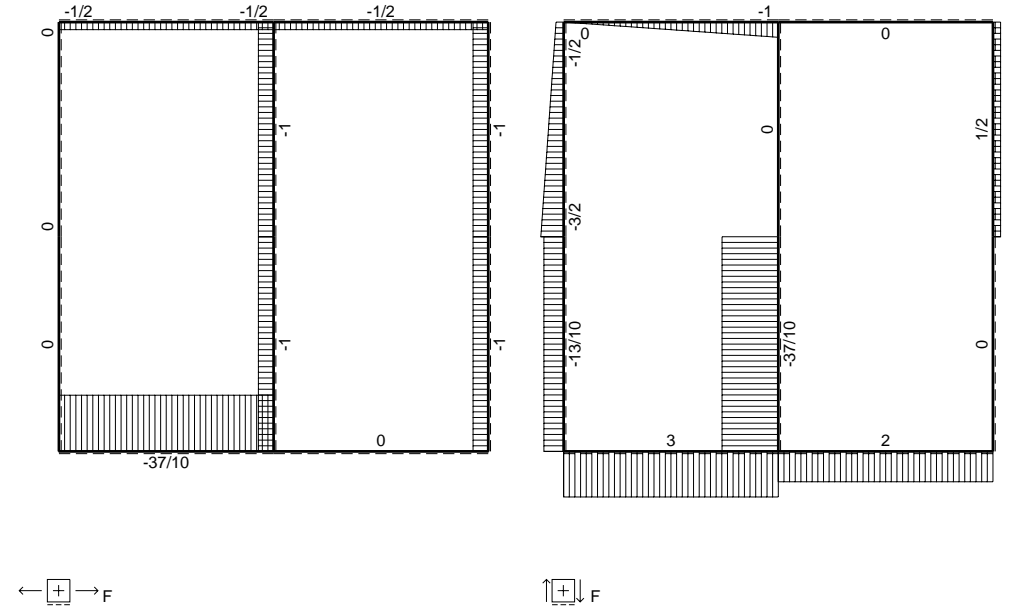
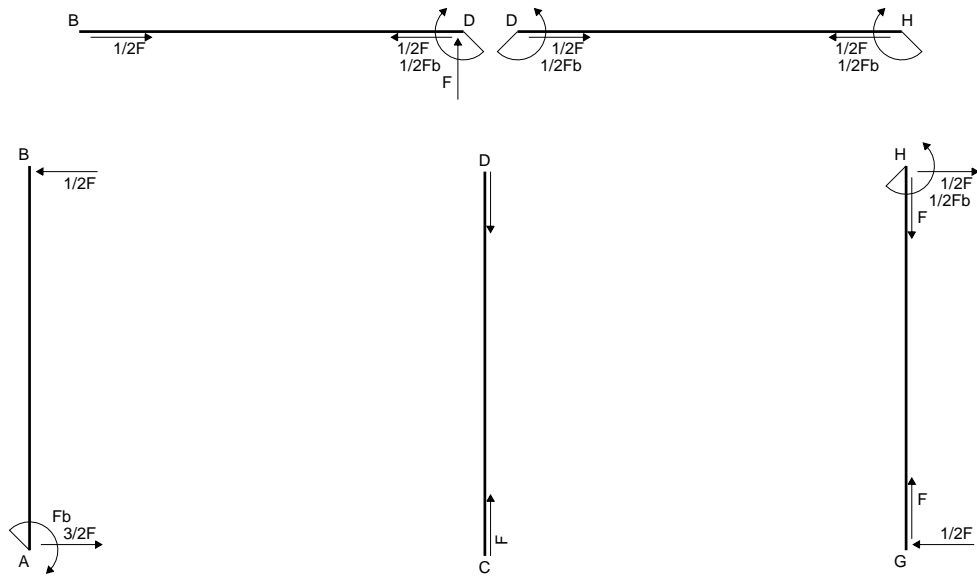
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

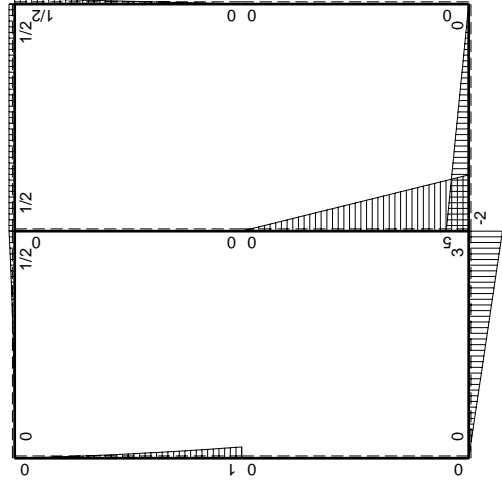
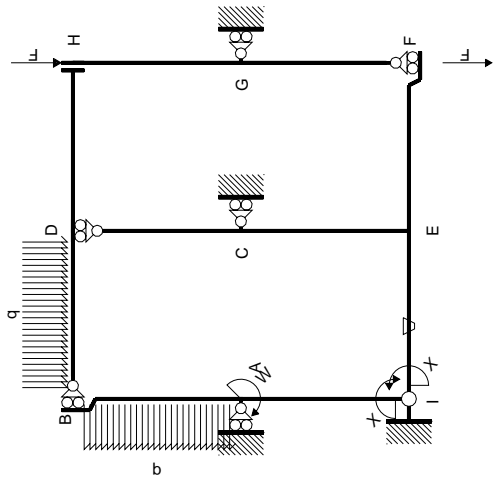
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



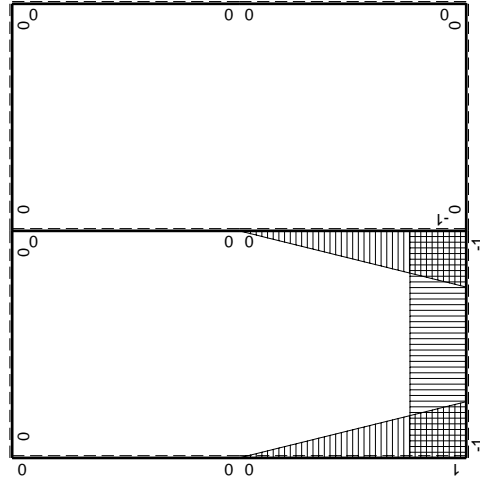
- A = 630. mm²
- J_u = 234233. mm⁴
- J_v = 36882. mm⁴
- y_g = 28.96 mm
- T_y = 2040. N
- M_x = -1611600. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -28.96 mm
- σ_m = -Mv/J_u = -199.2 N/mm²
- x_c = 21. mm
- y_c = 47. mm
- v_c = 18.04 mm
- σ_c = -Mv/J_u = 124.1 N/mm²
- τ_c = 6.728 N/mm²
- σ_o = √σ²+3τ² = 124.7 N/mm²
- S = 4635. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

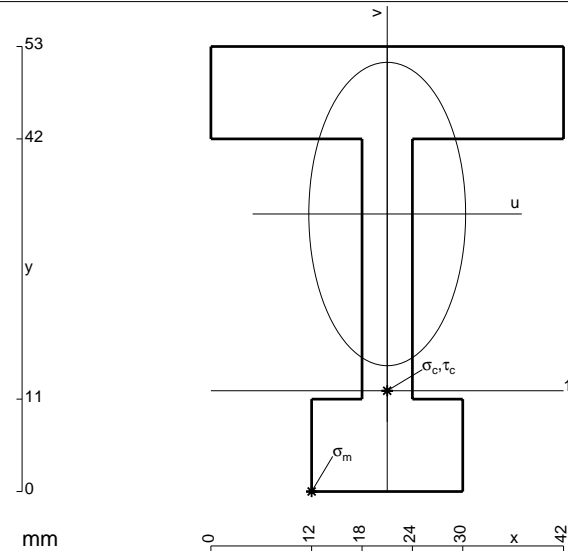
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$



$$A = 846. \text{ mm}^2$$

$$J_u = 276280. \text{ mm}^4$$

$$J_v = 73818. \text{ mm}^4$$

$$y_g = 33.05 \text{ mm}$$

$$T_y = 2080. \text{ N}$$

$$M_x = -1747200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.05 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209. \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

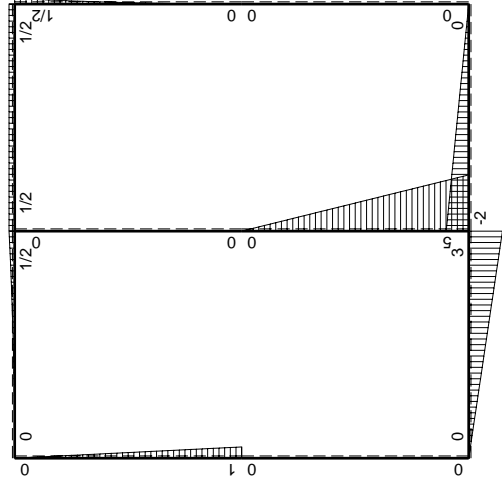
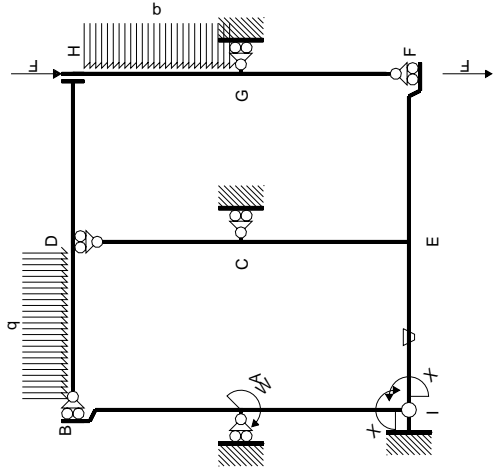
$$v_c = -21.05 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -133.1 \text{ N/mm}^2$$

$$\tau_c = 7.008 \text{ N/mm}^2$$

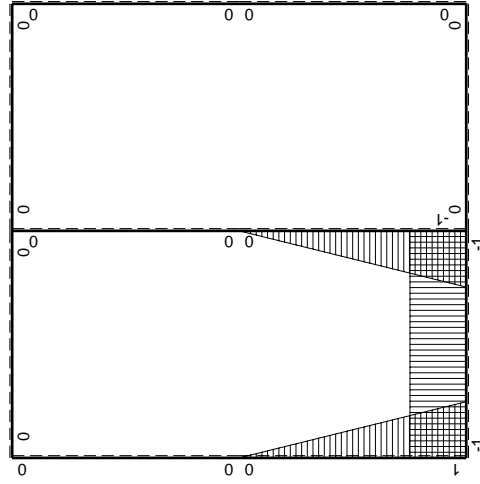
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 133.7 \text{ N/mm}^2$$

$$S = 5585. \text{ mm}^3$$



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	Fb-Fx	0	0	0	0	0+0	0	
BA b	0	-Fx	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0	
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
HD b	0	$1/2Fb$	0	0	0	0	0+0	0	
DH b	0	$-1/2Fb$	0	0	0	0			
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0	
BD b	0	$-1/2qx^2$	0	0	0	0			
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1			
EC b	$-1+x/b$	5Fb-5Fx	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	-5Fx	0	$-5Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$	
AI b	$-x/b$	0	0	0	0	x^2/b^2			
	totali							$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

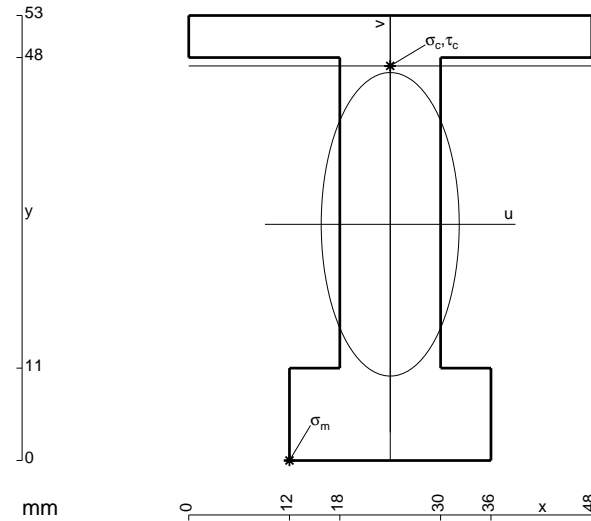
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

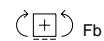
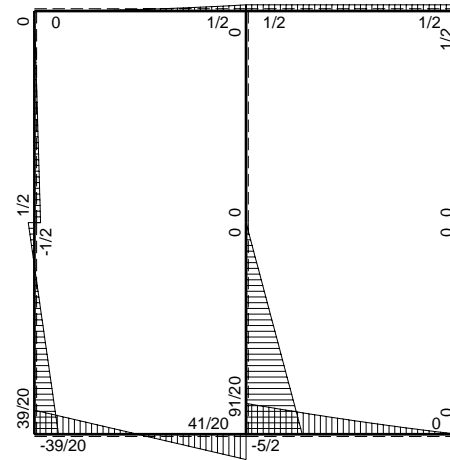
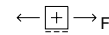
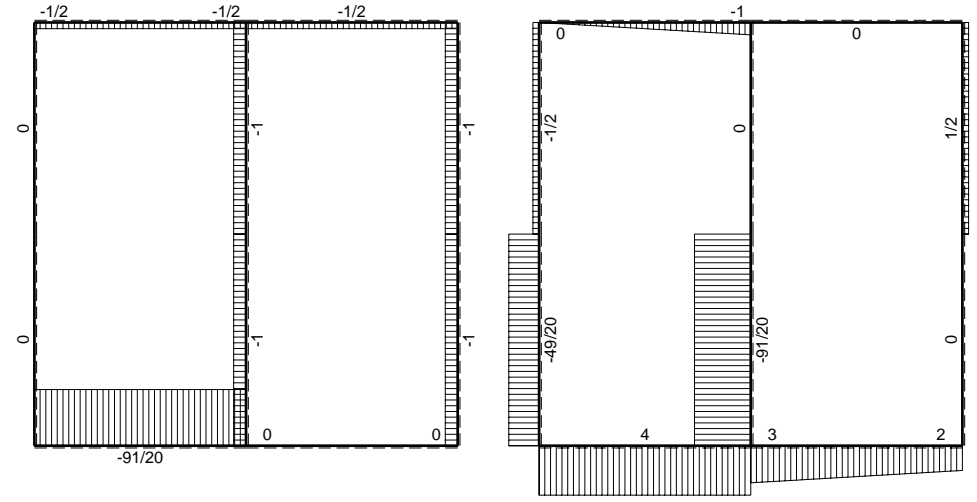
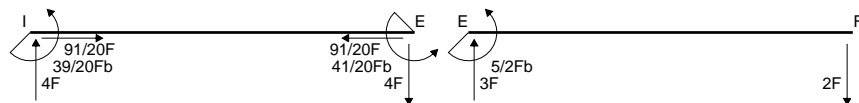
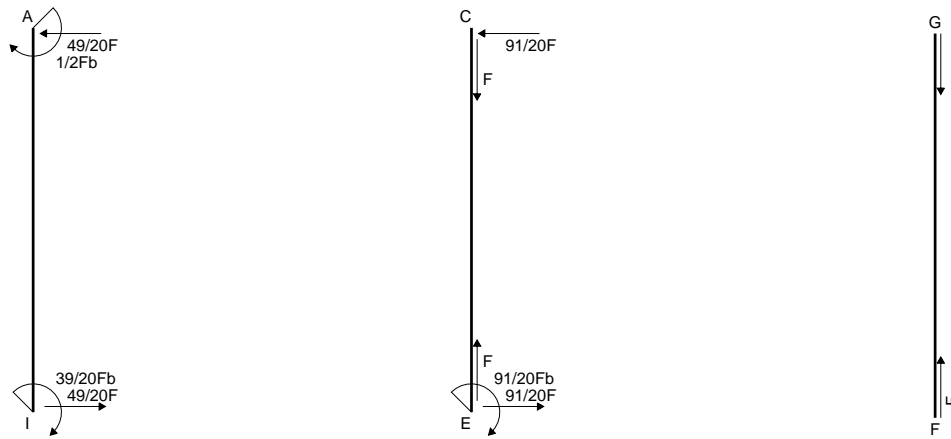
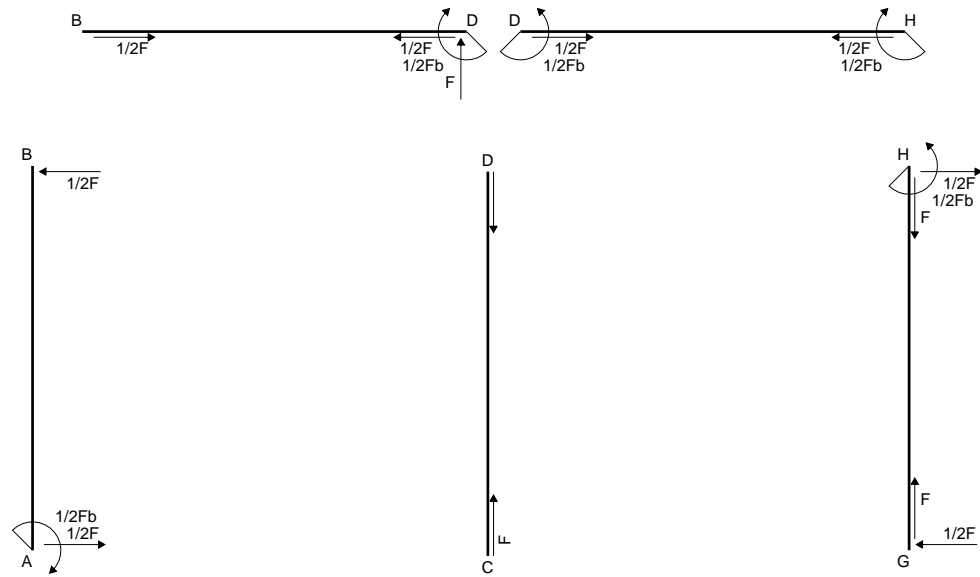
$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

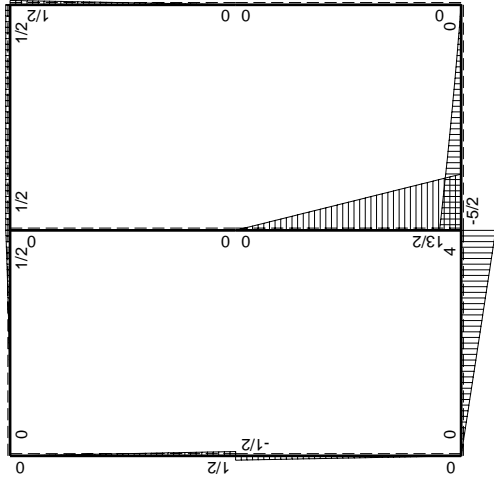
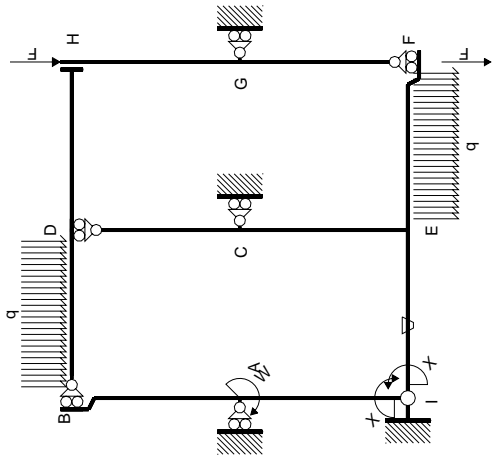
$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$



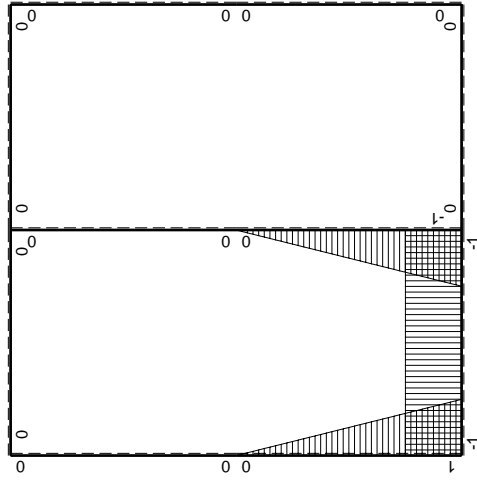
- A = 948. mm²
- J_u = 309947. mm⁴
- J_v = 64080. mm⁴
- y_g = 28.13 mm
- T_y = 2680. N
- M_x = -2412000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -28.13 mm
- σ_m = -Mv/J_u = -218.9 N/mm²
- x_c = 24. mm
- y_c = 47. mm
- v_c = 18.87 mm
- σ_c = -Mv/J_u = 146.8 N/mm²
- τ_c = 4.035 N/mm²
- σ_q = √σ²+3τ² = 147. N/mm²
- S = 5601. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-13/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$39/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

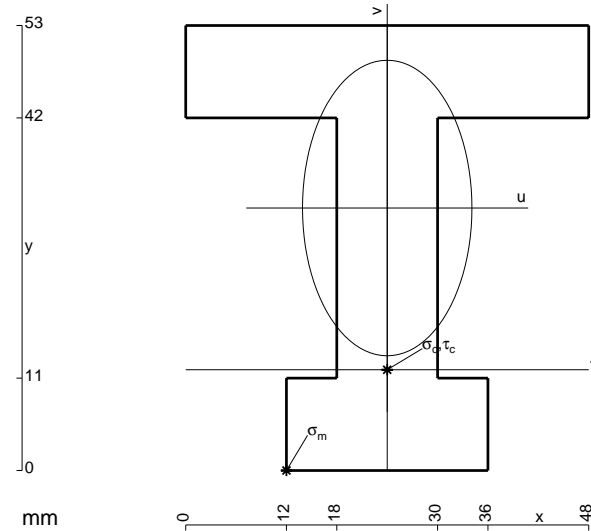
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

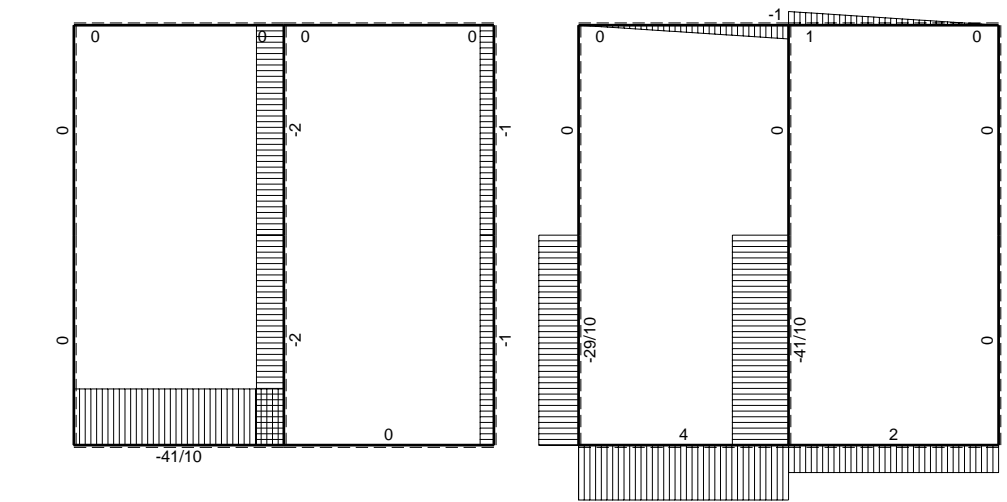
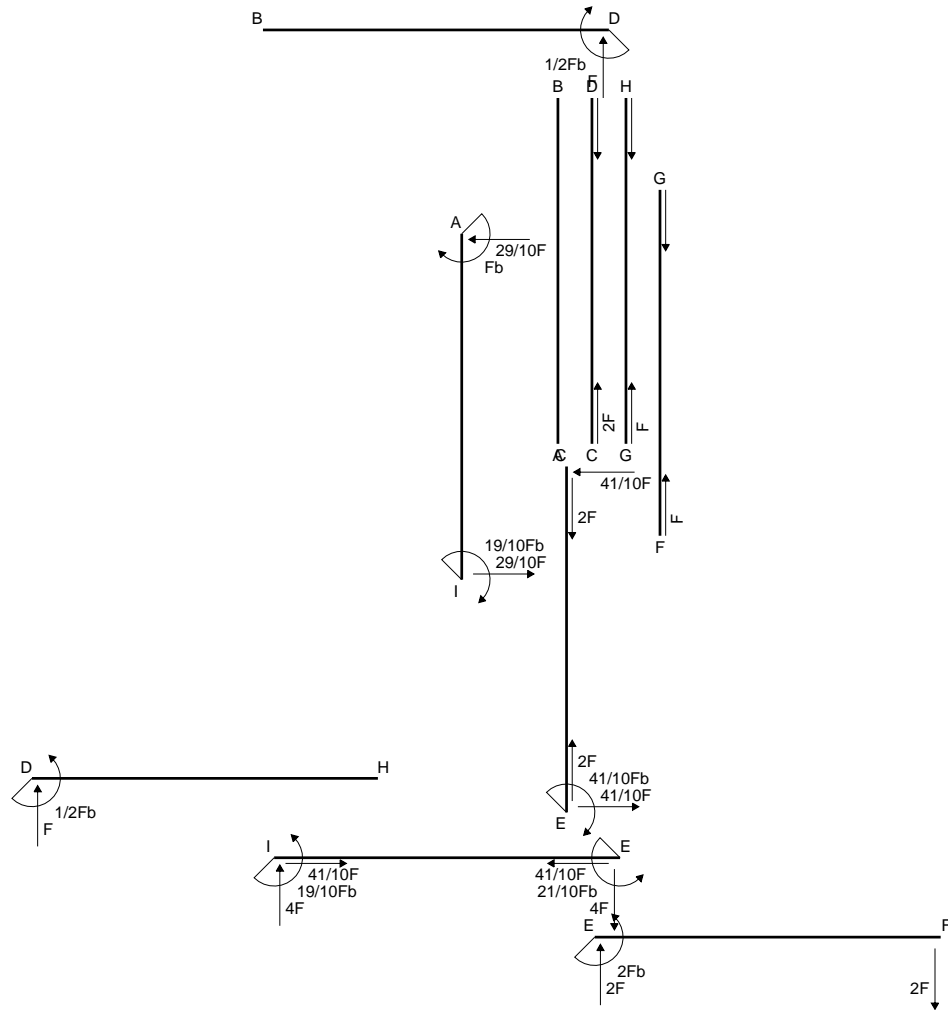
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

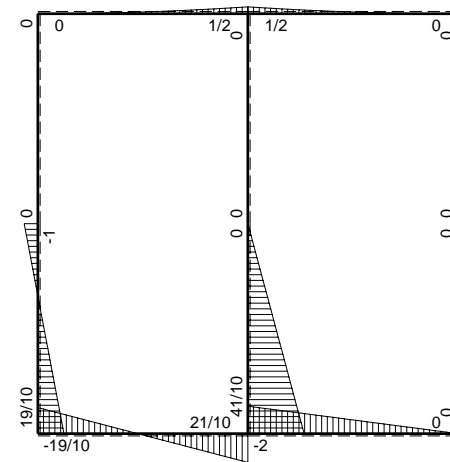


- A = 1164. mm²
- J_u = 360644. mm⁴
- J_v = 118512. mm⁴
- y_g = 31.26 mm
- T_y = 3330. N
- M_x = -2636250. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -31.26 mm
- σ_m = -Mv/J_u = -228.5 N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -19.26 mm
- σ_c = -Mv/J_u = -140.8 N/mm²
- τ_c = 5.416 N/mm²
- σ_o = √σ²+3τ² = 141.1 N/mm²
- S = 7039. mm³

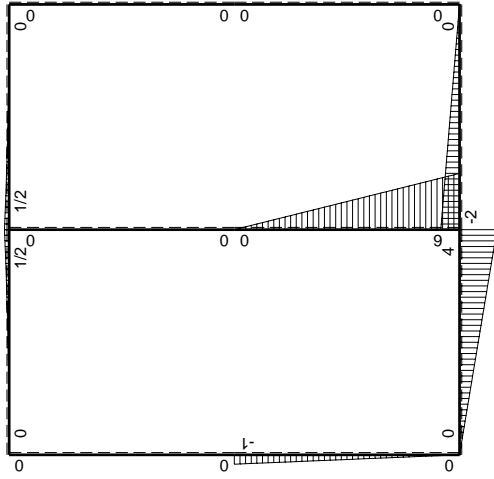
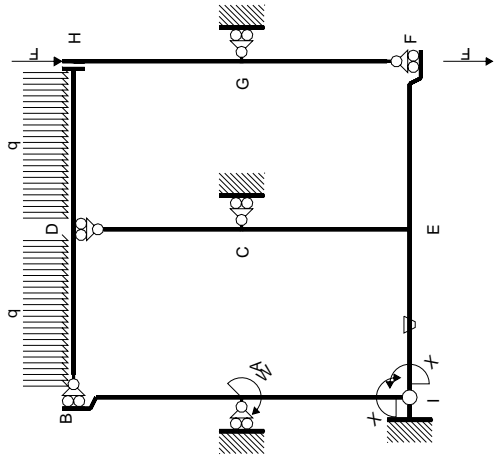


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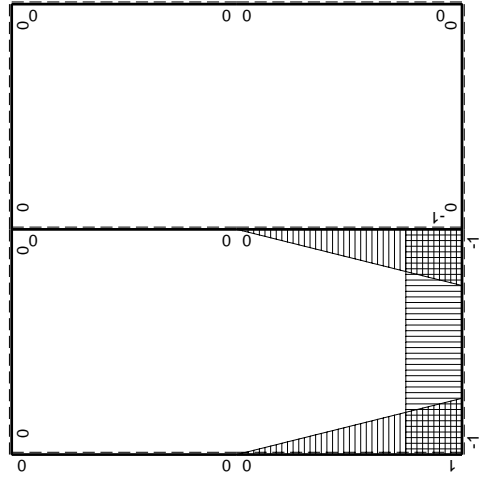


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-19/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

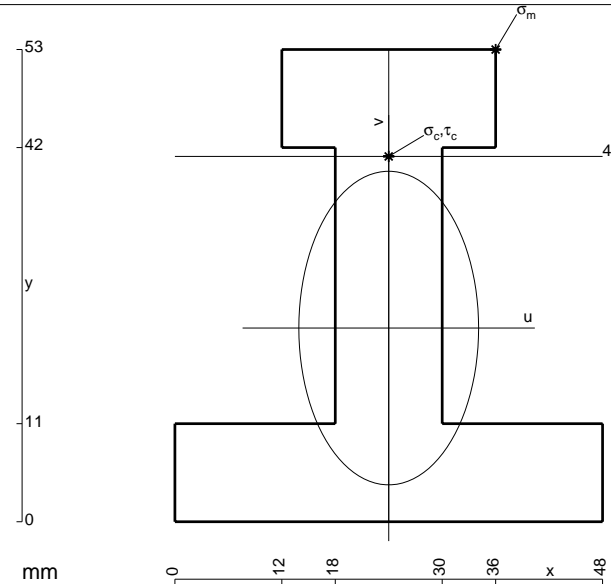
$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

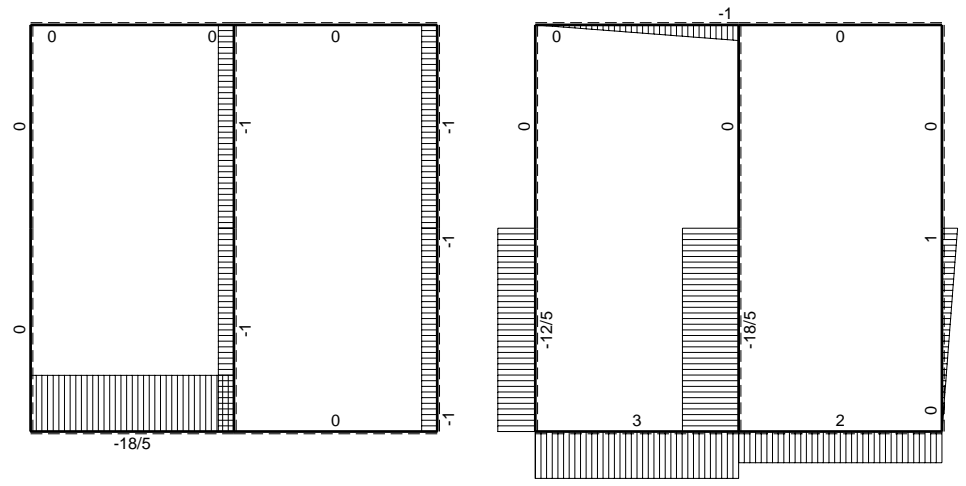
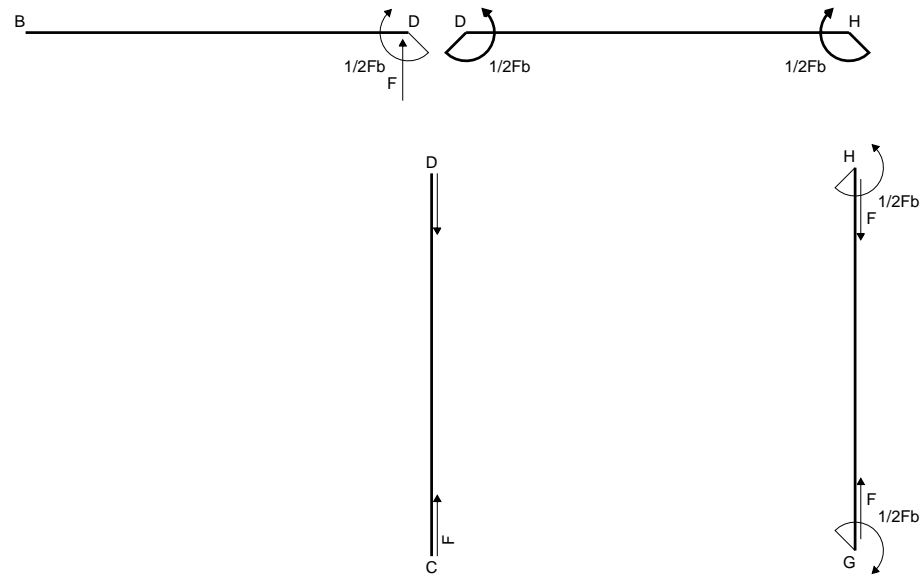
$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

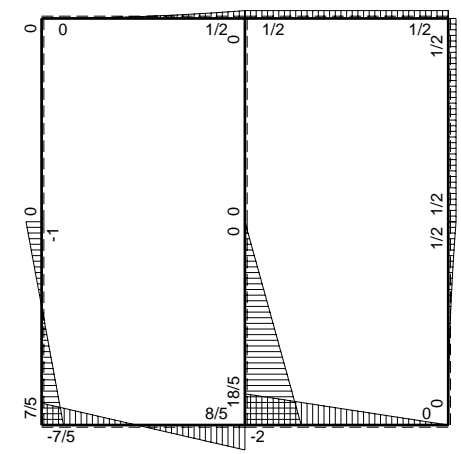
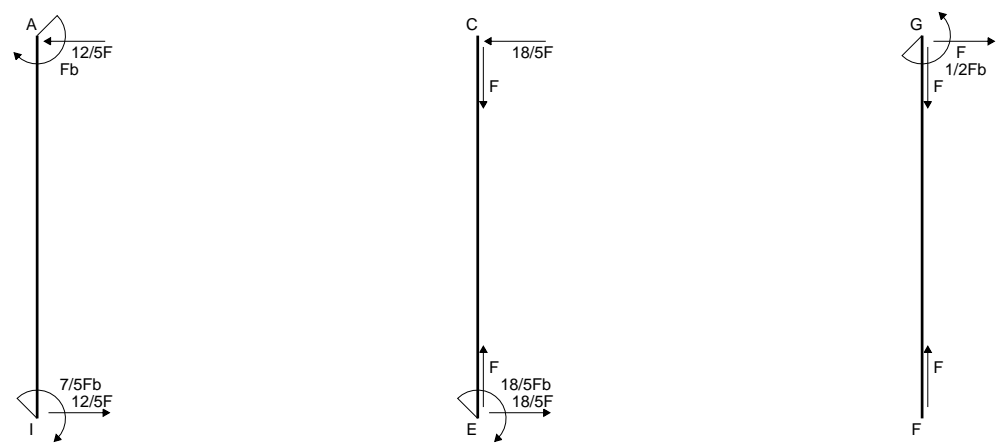


- A = 1164. mm²
- J_u = 360644. mm⁴
- J_v = 118512. mm⁴
- y_g = 21.74 mm
- T_y = 2760. N
- M_x = -2760000. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 31.26 mm
- σ_m = -M_v/J_u = 239.3 N/mm²
- x_c = 24. mm
- y_c = 41. mm
- v_c = 19.26 mm
- σ_c = -M_v/J_u = 147.4 N/mm²
- τ_c = 4.489 N/mm²
- σ_q = √σ²+3τ² = 147.6 N/mm²
- S = 7039. mm³

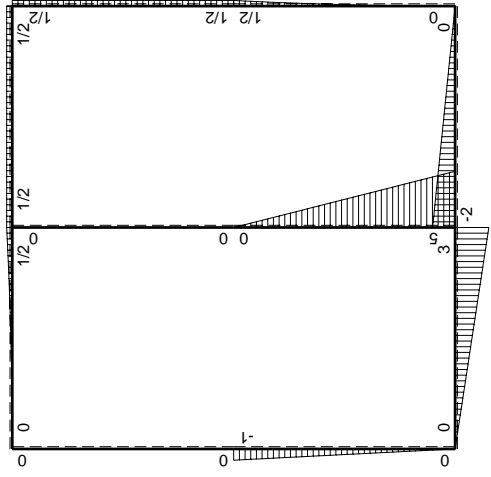
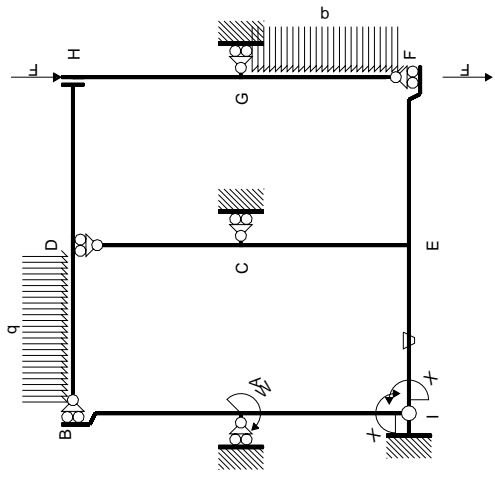


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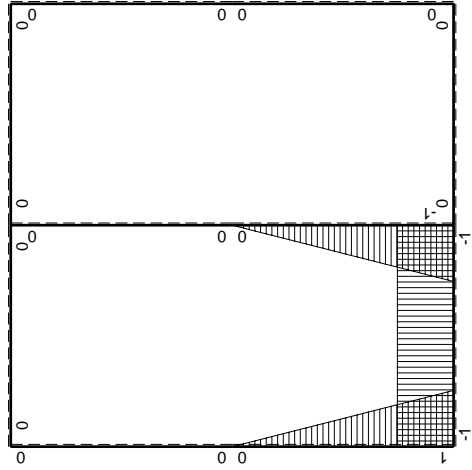


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

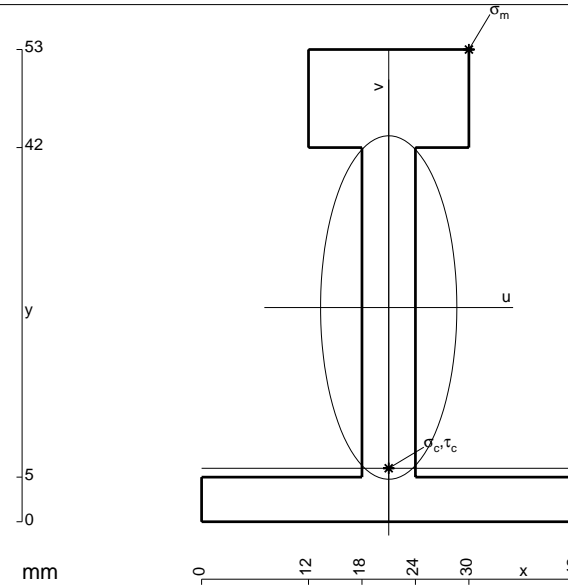
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

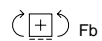
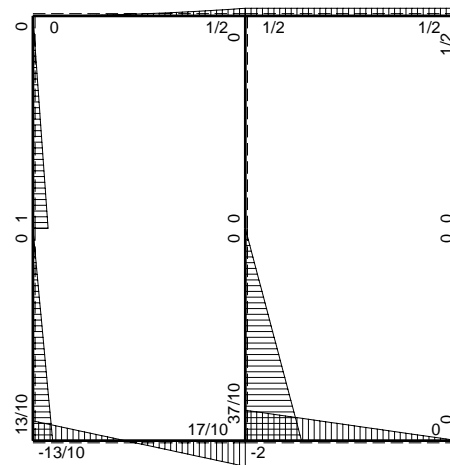
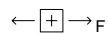
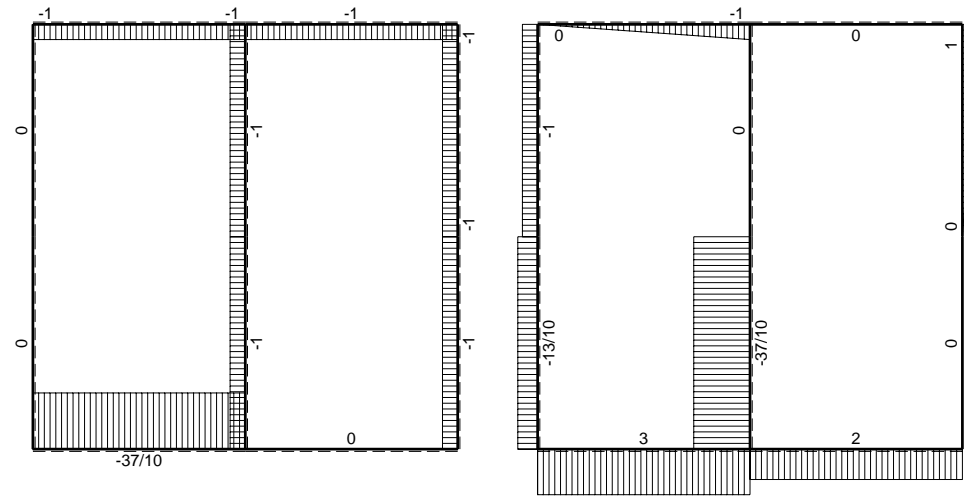
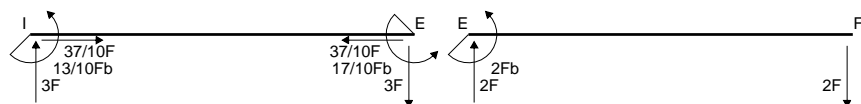
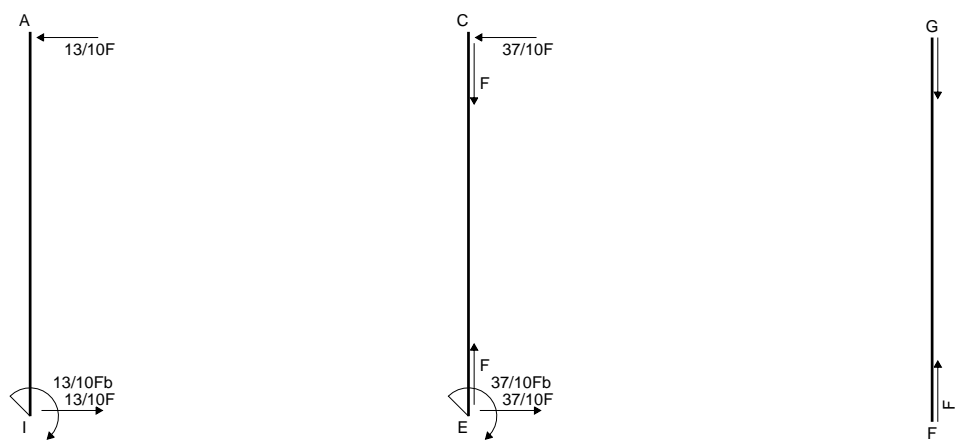
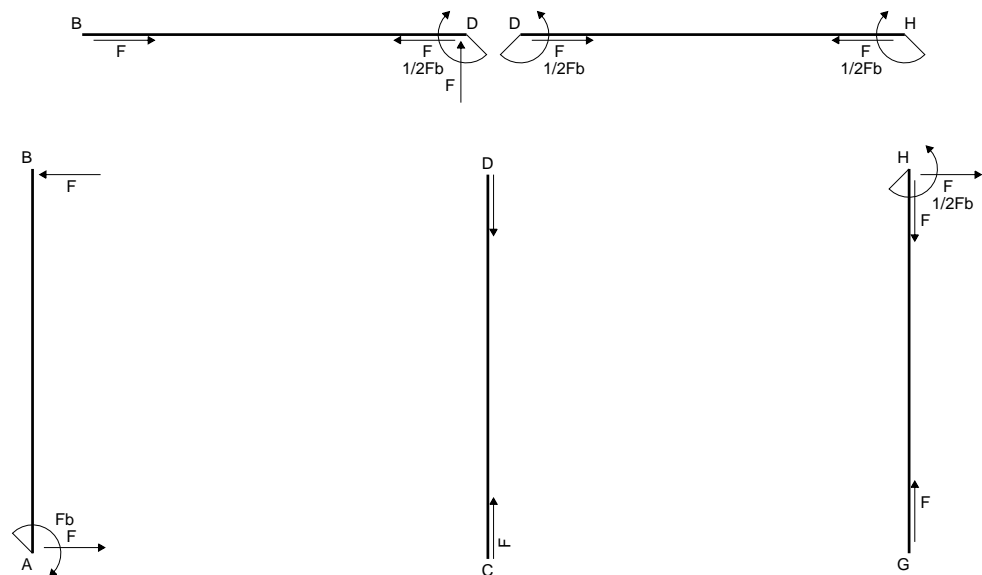
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

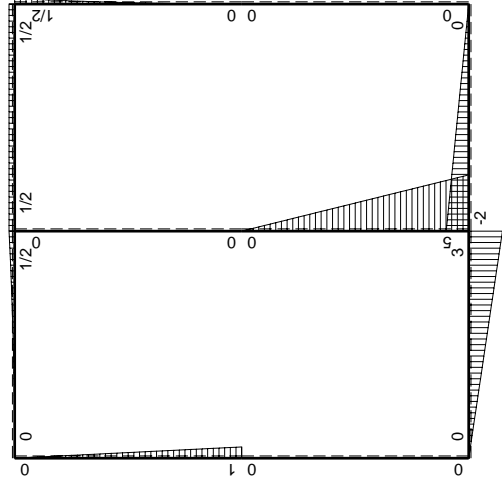
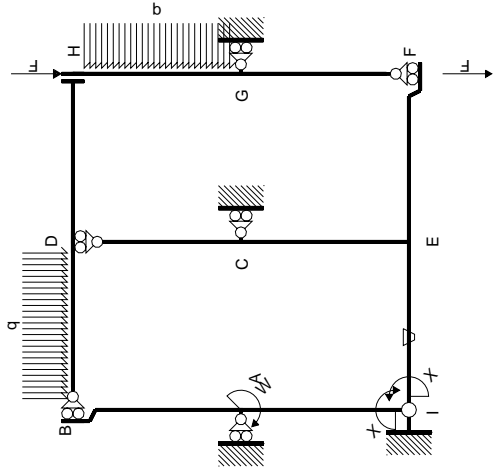
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



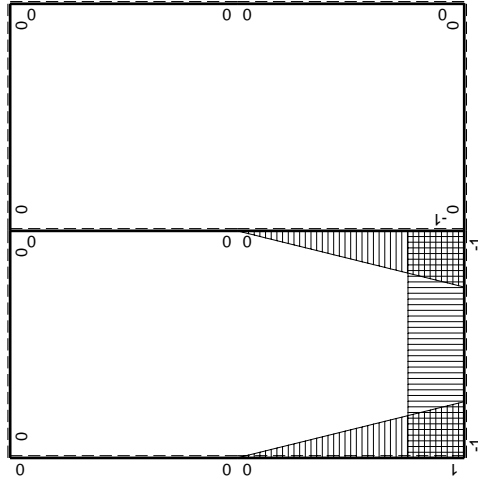
- A = 630. mm²
- J_u = 234233. mm⁴
- J_v = 36882. mm⁴
- y_g = 24.04 mm
- T_y = 3040. N
- M_x = -1611200. Nmm
- x_m = 30. mm
- y_m = 53. mm
- u_m = 9. mm
- v_m = 28.96 mm
- σ_m = -Mv/J_u = 199.2 N/mm²
- x_c = 21. mm
- y_c = 6. mm
- v_c = -18.04 mm
- σ_c = -Mv/J_u = -124.1 N/mm²
- τ_c = 10.03 N/mm²
- σ_q = √σ²+3τ² = 125.3 N/mm²
- S = 4635. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-Fx	0	0	0	0	0+0	0
BA b	0	-Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	5Fb-5Fx	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-5Fx	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

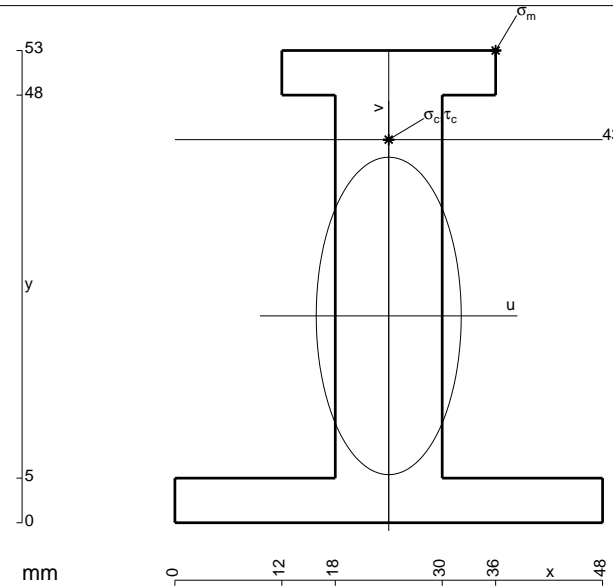
$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

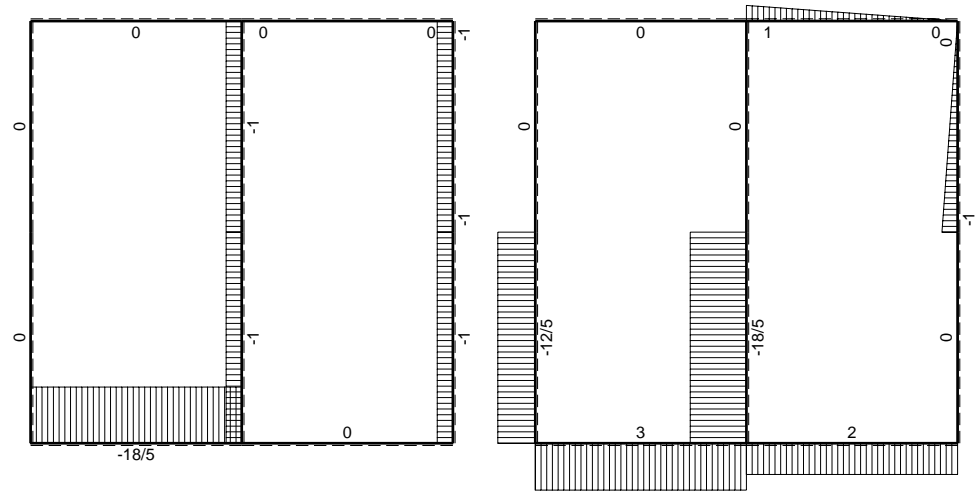
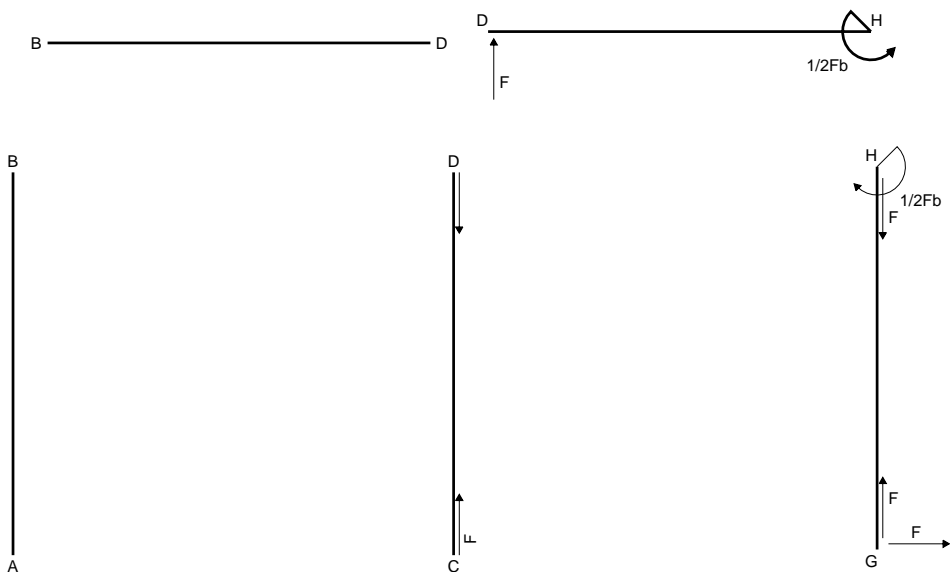
$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

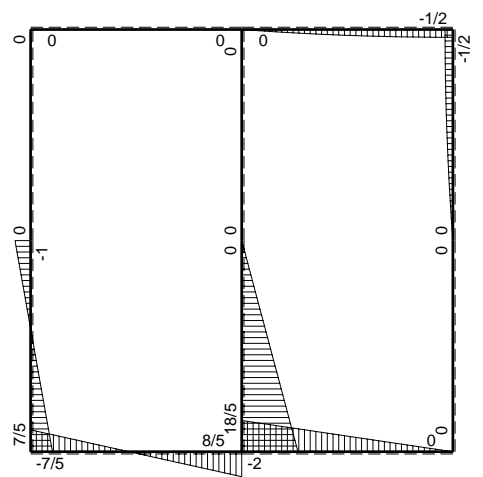
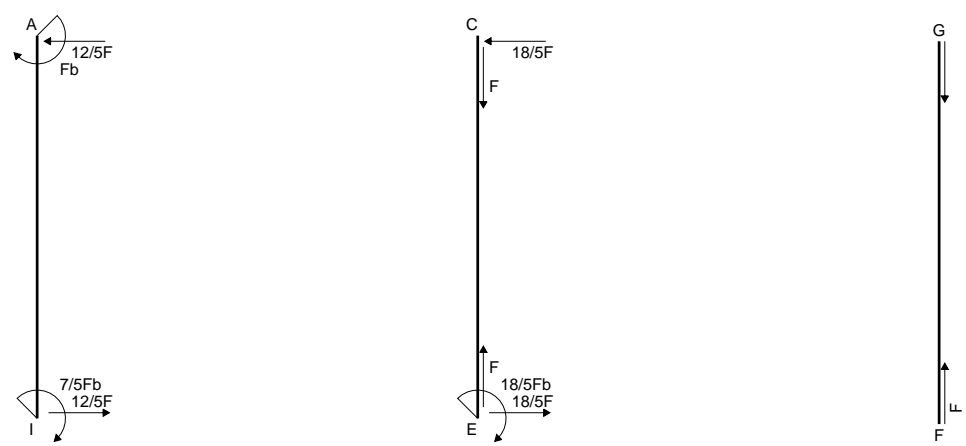


- A = 876. mm²
- J_u = 278149. mm⁴
- J_v = 58032. mm⁴
- y_g = 23.21 mm
- T_y = 3380. N
- M_x = -1960400. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 29.79 mm
- σ_m = -Mv/J_u = 209.9 N/mm²
- x_c = 24. mm
- y_c = 43. mm
- v_c = 19.79 mm
- σ_c = -Mv/J_u = 139.5 N/mm²
- τ_c = 4.67 N/mm²
- σ_q = √σ²+3τ² = 139.7 N/mm²
- S = 4612. mm³

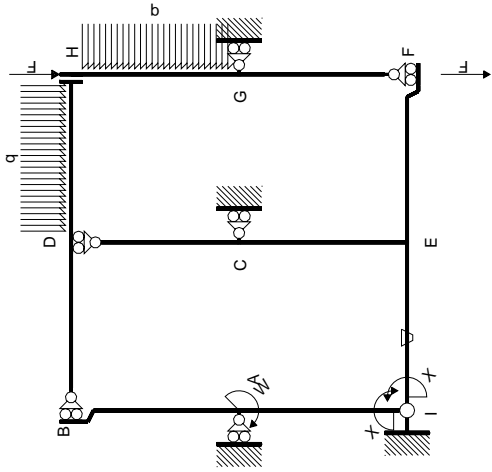


← ⊕ → F

↑ ⊕ ↓ F

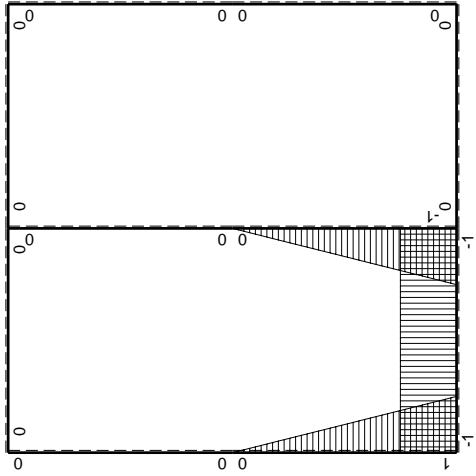
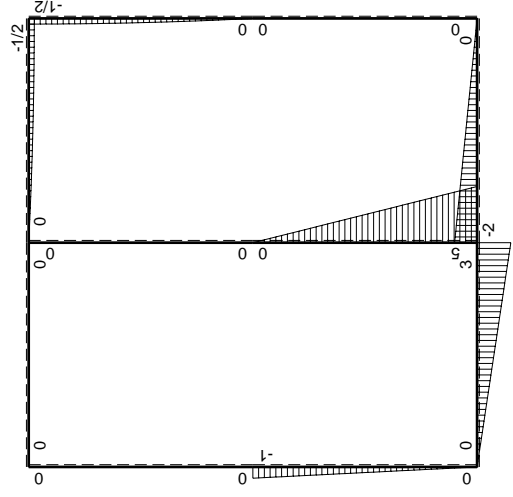


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

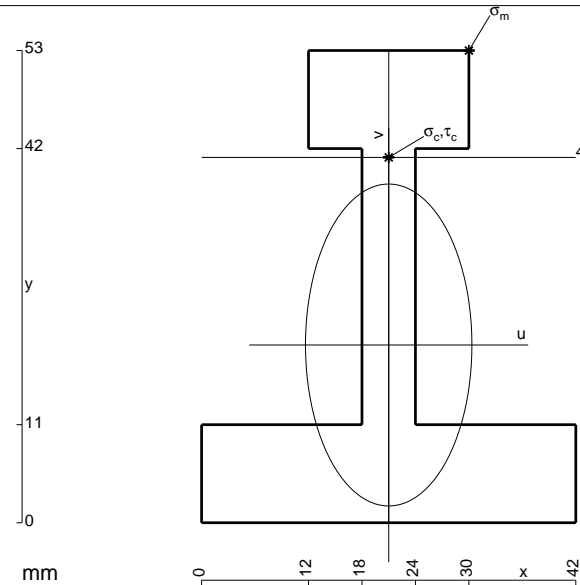
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

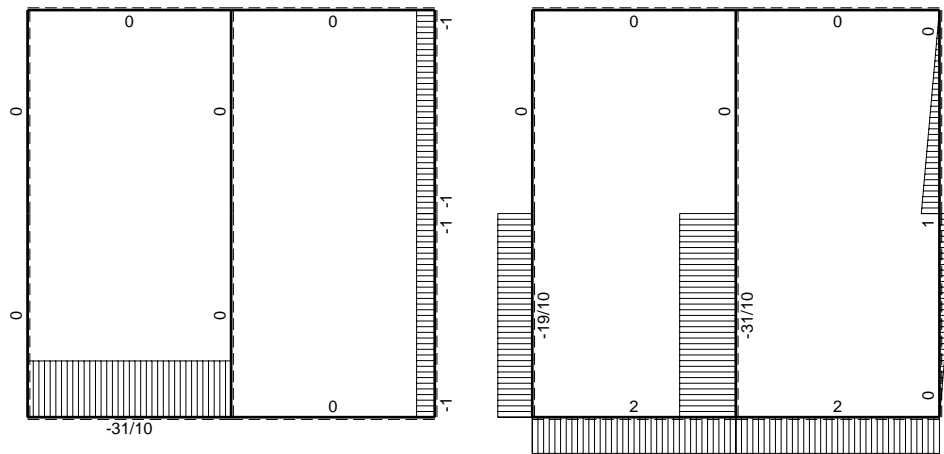
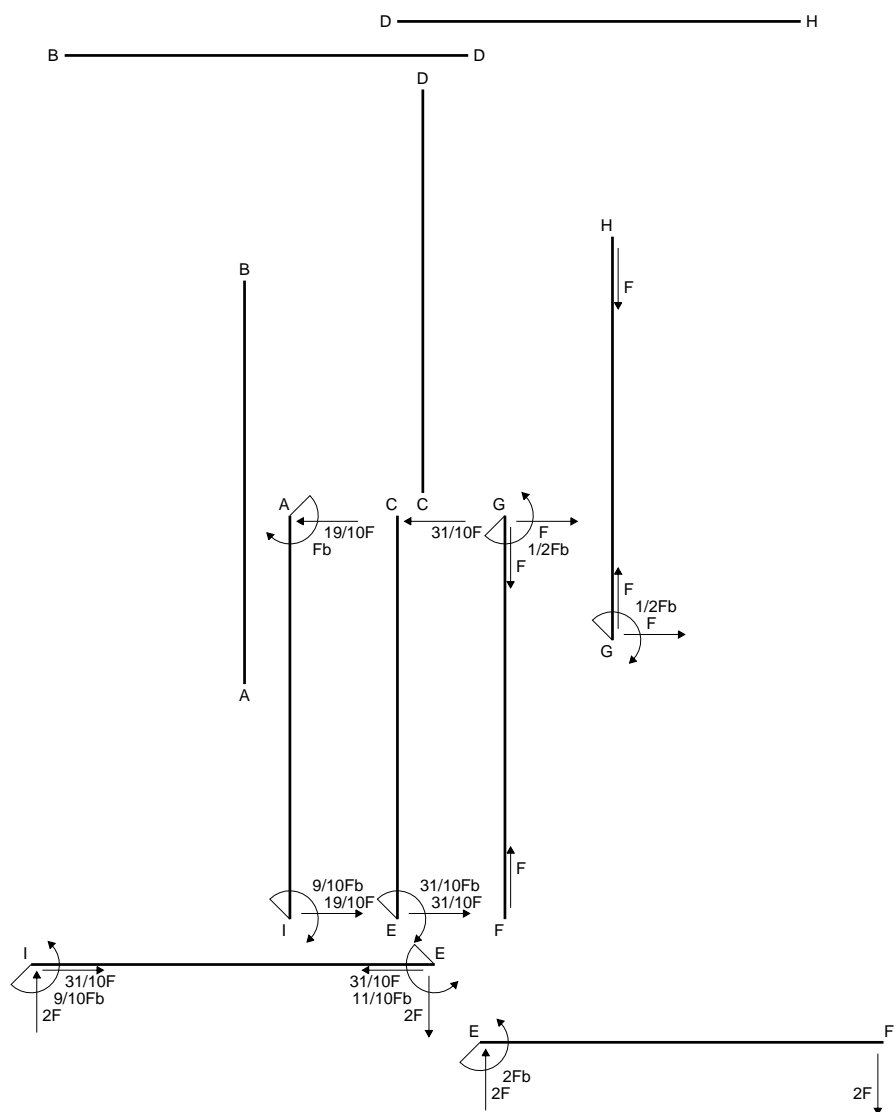
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

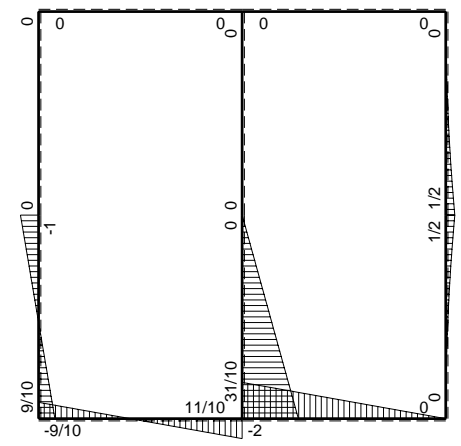


- A = 846. mm²
- J_u = 276280. mm⁴
- J_v = 73818. mm⁴
- y_g = 19.95 mm
- T_y = 2900. N
- M_x = -1827000. Nmm
- x_m = 30. mm
- y_m = 53. mm
- u_m = 9. mm
- v_m = 33.05 mm
- σ_m = -Mv/J_u = 218.6 N/mm²
- x_c = 21. mm
- y_c = 41. mm
- v_c = 21.05 mm
- σ_c = -Mv/J_u = 139.2 N/mm²
- τ_c = 9.77 N/mm²
- σ_q = √σ²+3τ² = 140.2 N/mm²
- S = 5585. mm³

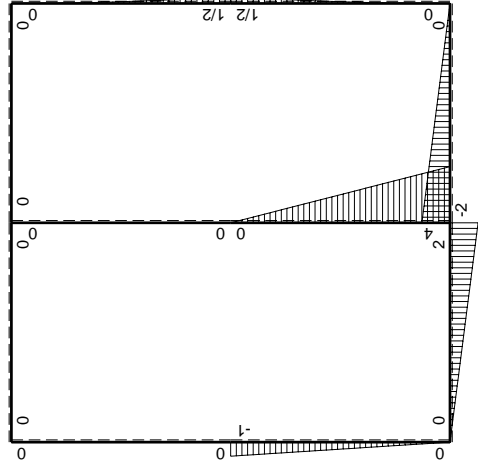
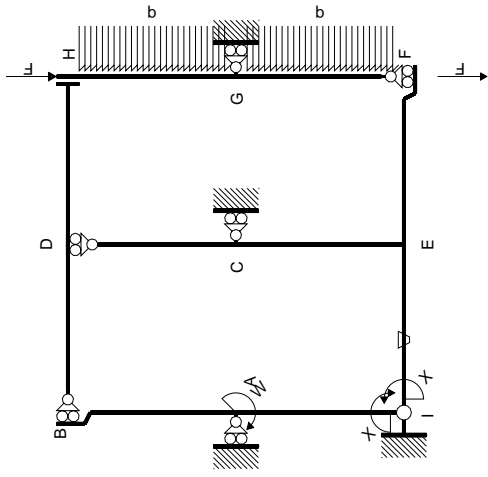


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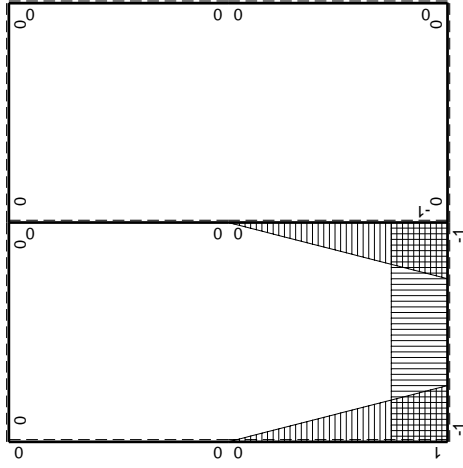


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

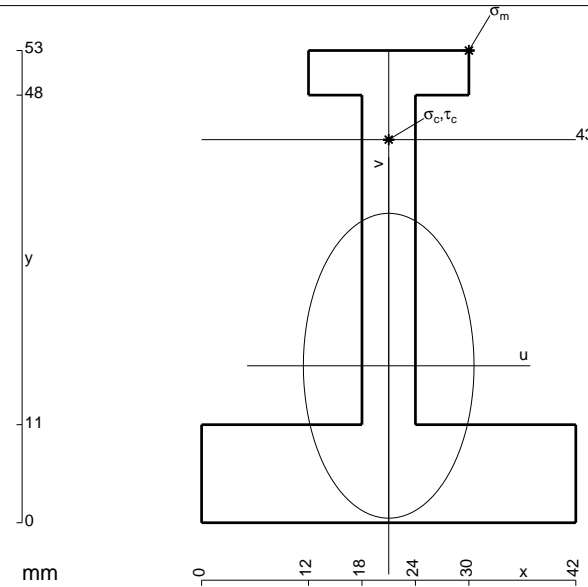
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 774. \text{ mm}^2$$

$$J_u = 226668. \text{ mm}^4$$

$$J_v = 71010. \text{ mm}^4$$

$$y_g = 17.62 \text{ mm}$$

$$T_y = 2160. \text{ N}$$

$$M_x = -1468800. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 35.38 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.3 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

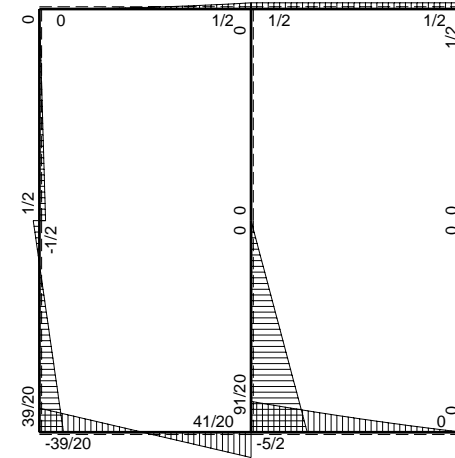
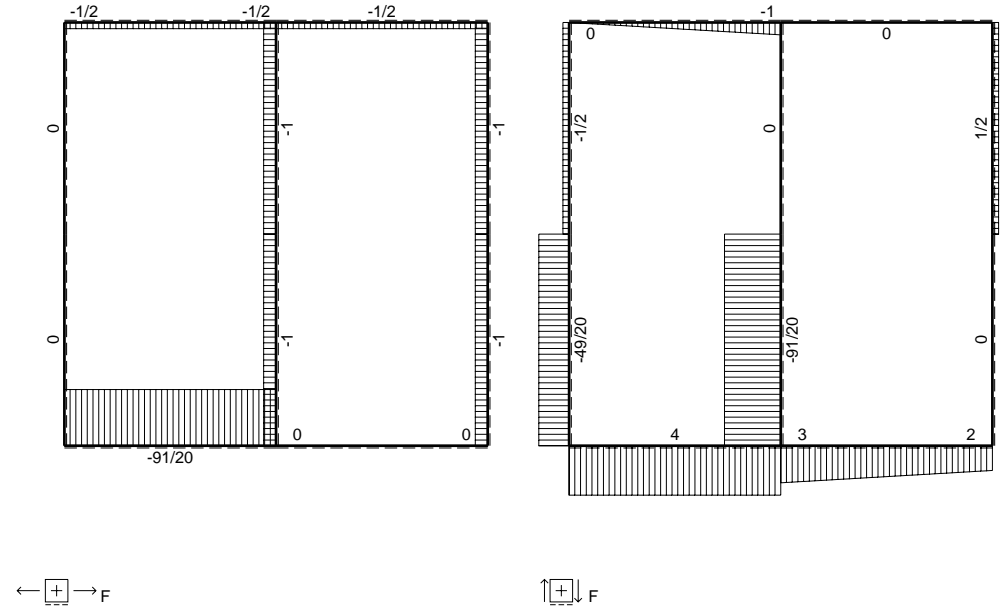
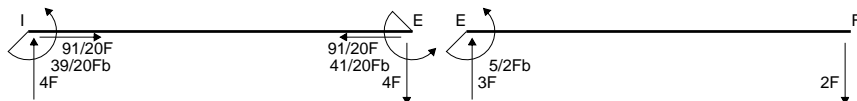
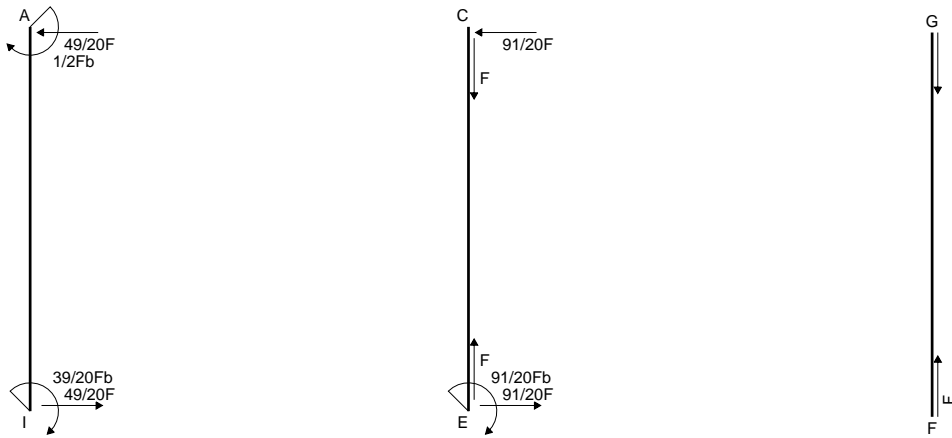
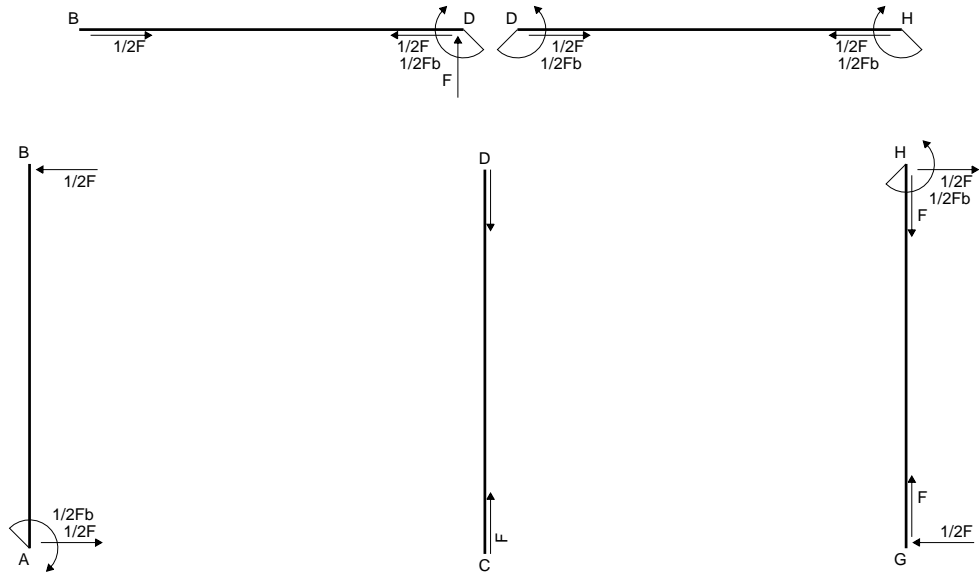
$$v_c = 25.38 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 164.5 \text{ N/mm}^2$$

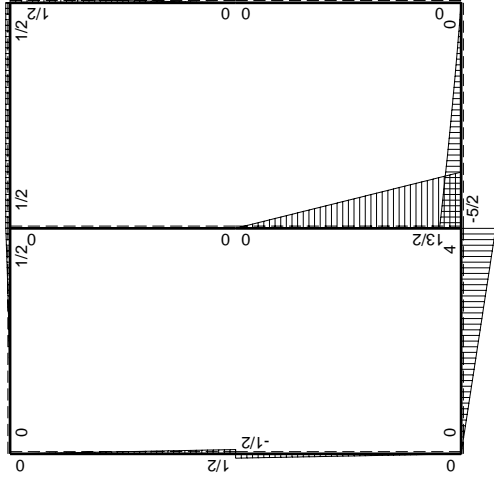
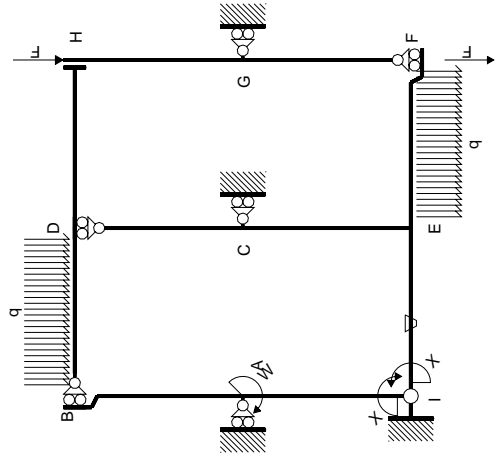
$$\tau_c = 6.029 \text{ N/mm}^2$$

$$\sigma_\varphi = \sqrt{\sigma^2 + 3\tau^2} = 164.8 \text{ N/mm}^2$$

$$S = 3796. \text{ mm}^3$$

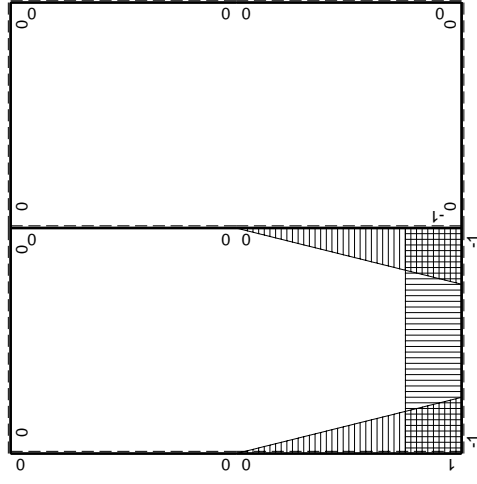


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-13/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$39/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

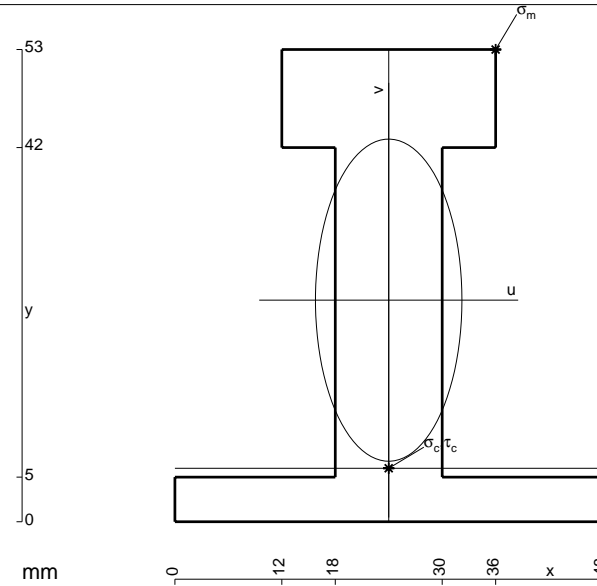
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

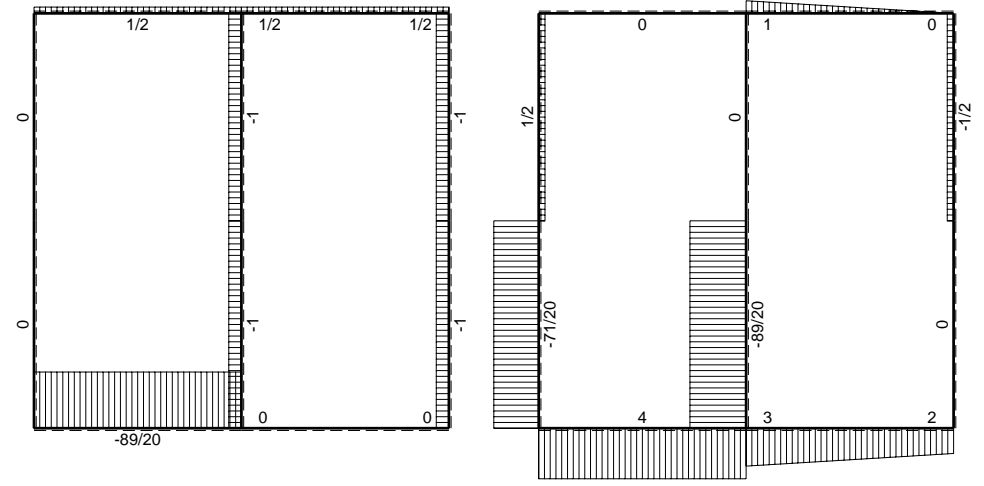
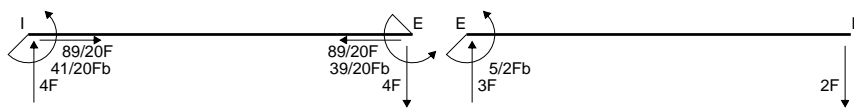
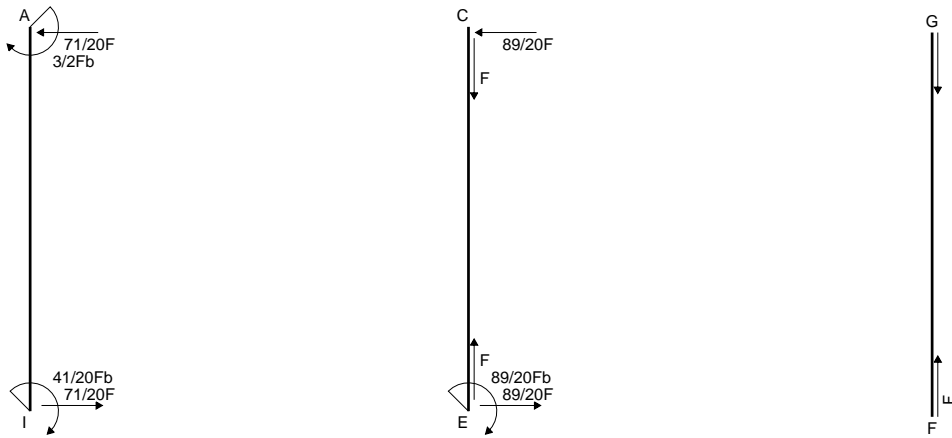
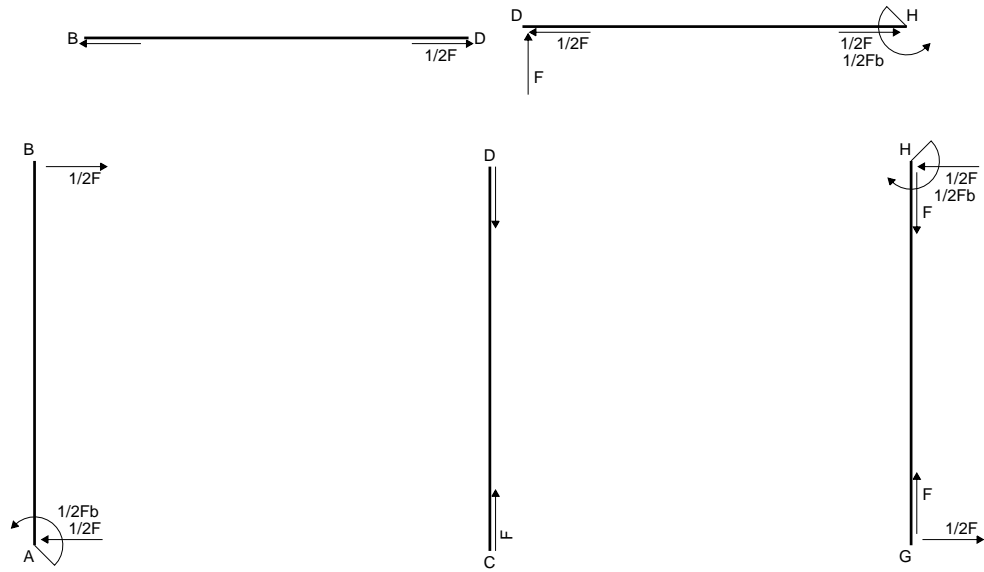
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

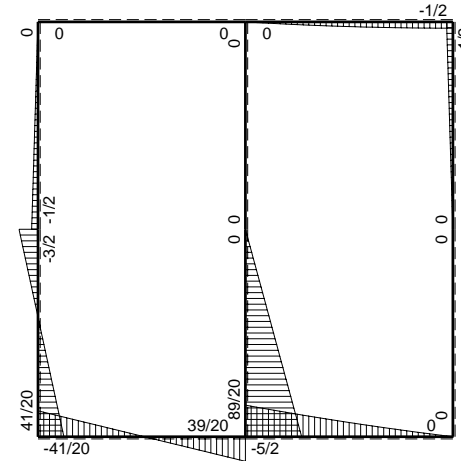


- A = 948. mm²
- J_u = 309947. mm⁴
- J_v = 64080. mm⁴
- y_g = 24.87 mm
- T_y = 4260. N
- M_x = -2627000. Nmm
- x_m = 36. mm
- y_m = 53. mm
- u_m = 12. mm
- v_m = 28.13 mm
- σ_m = -Mv/J_u = 238.4 N/mm²
- x_c = 24. mm
- y_c = 6. mm
- v_c = -18.87 mm
- σ_c = -Mv/J_u = -159.9 N/mm²
- τ_c = 6.415 N/mm²
- σ_q = √σ² + 3τ² = 160.3 N/mm²
- S = 5601. mm³

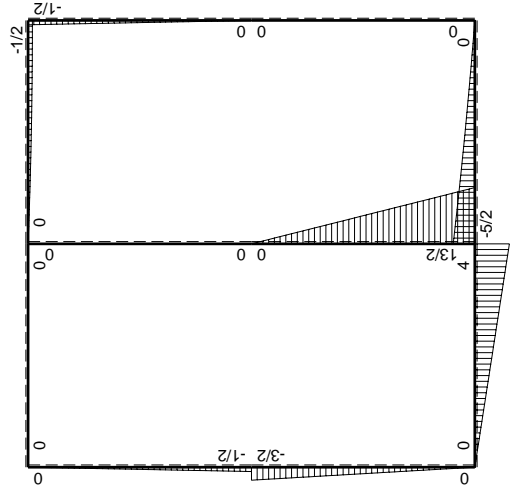
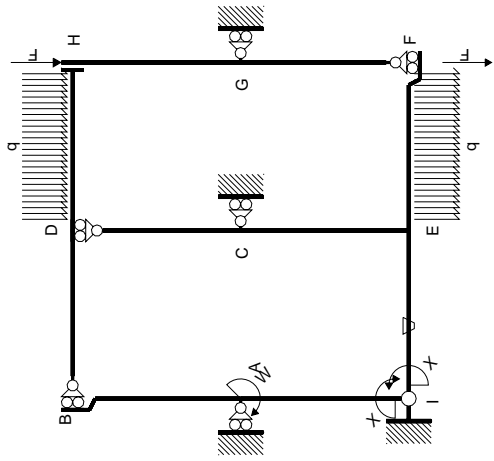


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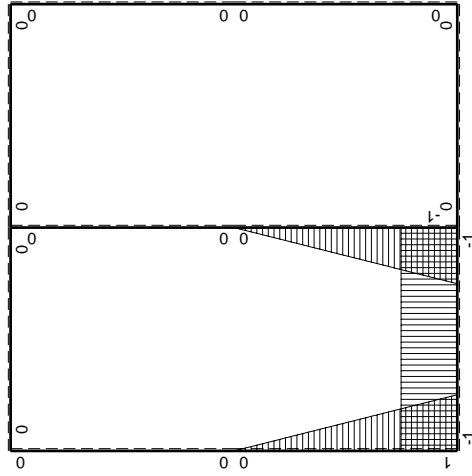


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-41/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$41/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-13/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

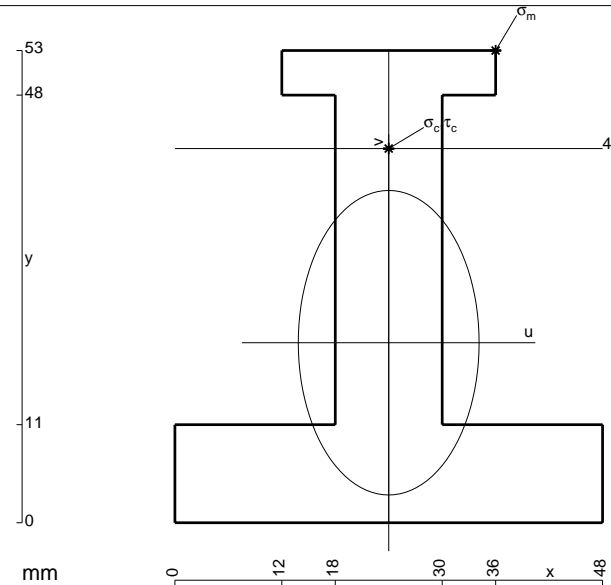
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 1092. \text{ mm}^2$$

$$J_u = 318895. \text{ mm}^4$$

$$J_v = 112464. \text{ mm}^4$$

$$y_g = 20.2 \text{ mm}$$

$$T_y = 2940. \text{ N}$$

$$M_x = -1935500. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 32.8 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199.1 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 42. \text{ mm}$$

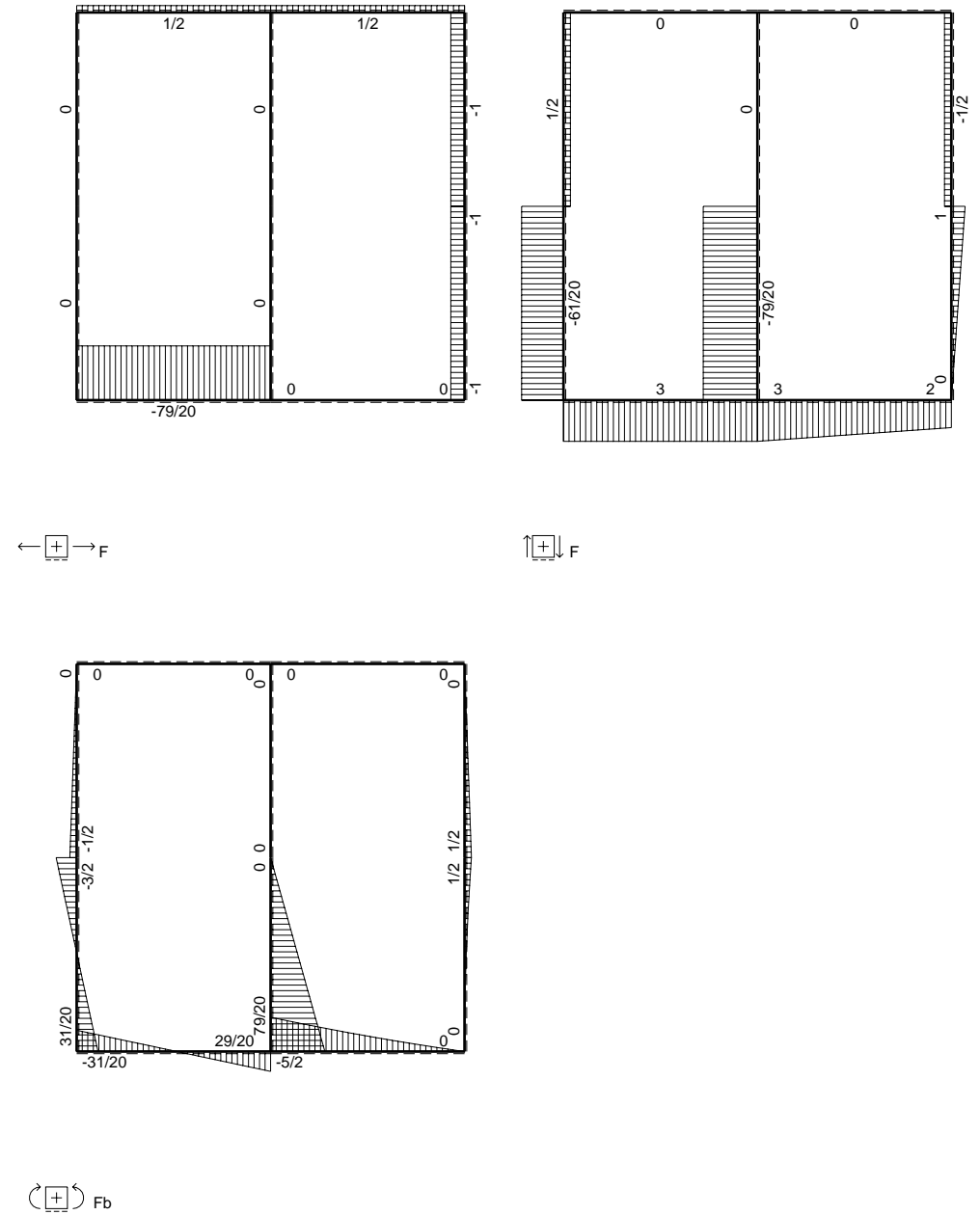
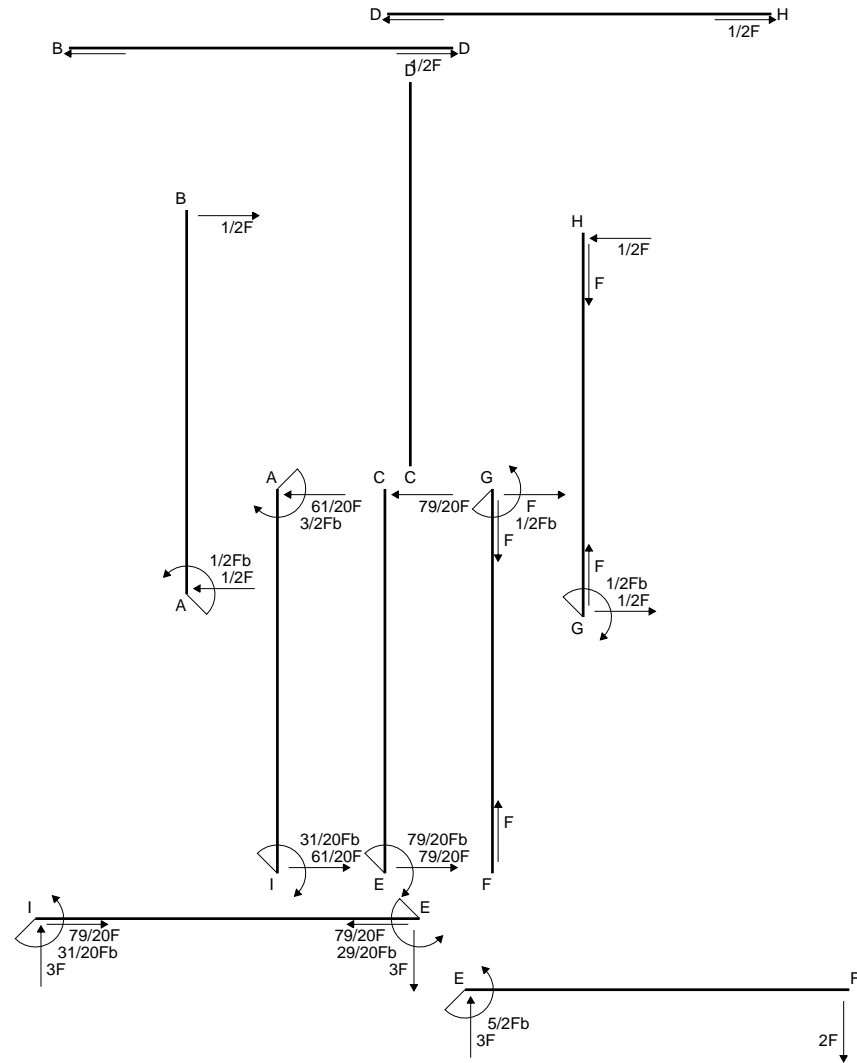
$$v_c = 21.8 \text{ mm}$$

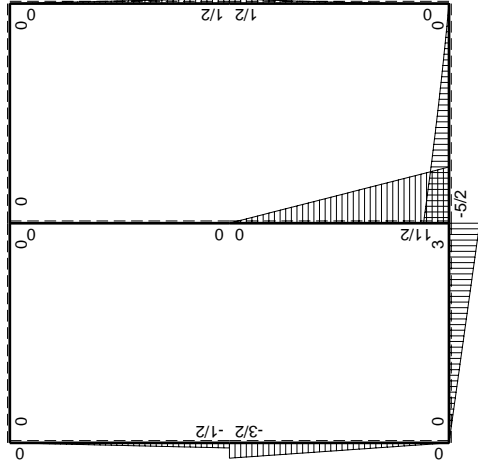
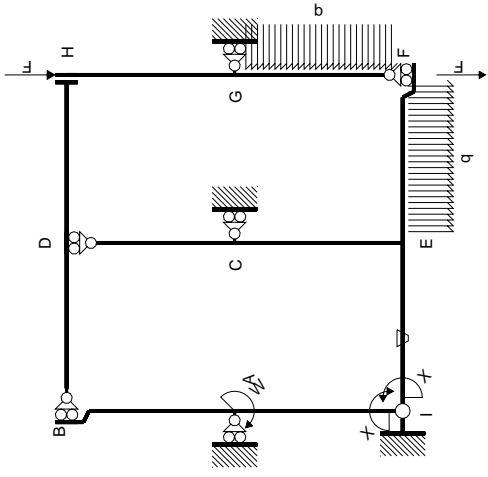
$$\sigma_c = -Mv/J_u = 132.3 \text{ N/mm}^2$$

$$\tau_c = 4.165 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 132.5 \text{ N/mm}^2$$

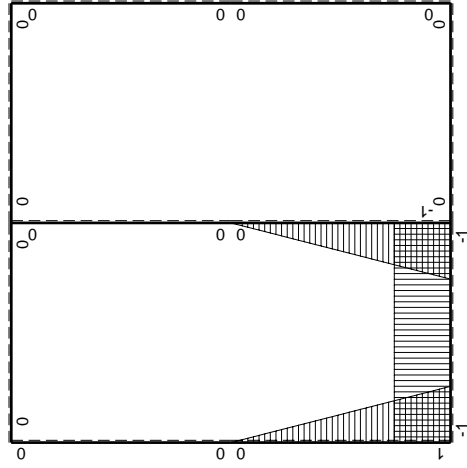
$$S = 5421. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

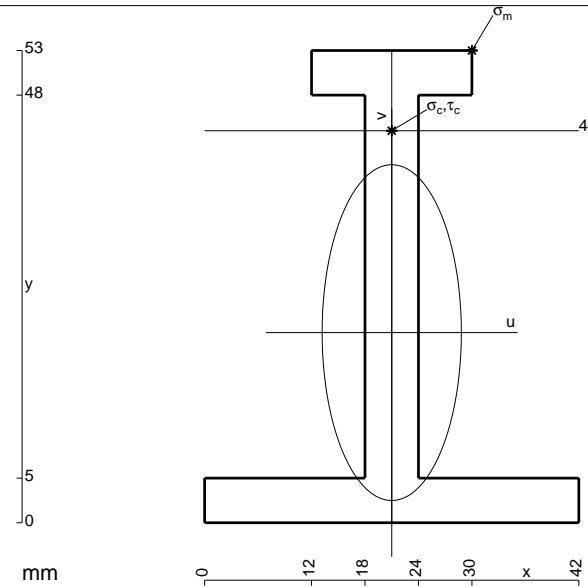
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 558. \text{ mm}^2$$

$$J_u = 198314. \text{ mm}^4$$

$$J_v = 34074. \text{ mm}^4$$

$$y_g = 21.34 \text{ mm}$$

$$T_y = 1860. \text{ N}$$

$$M_x = -1302000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 31.66 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 207.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

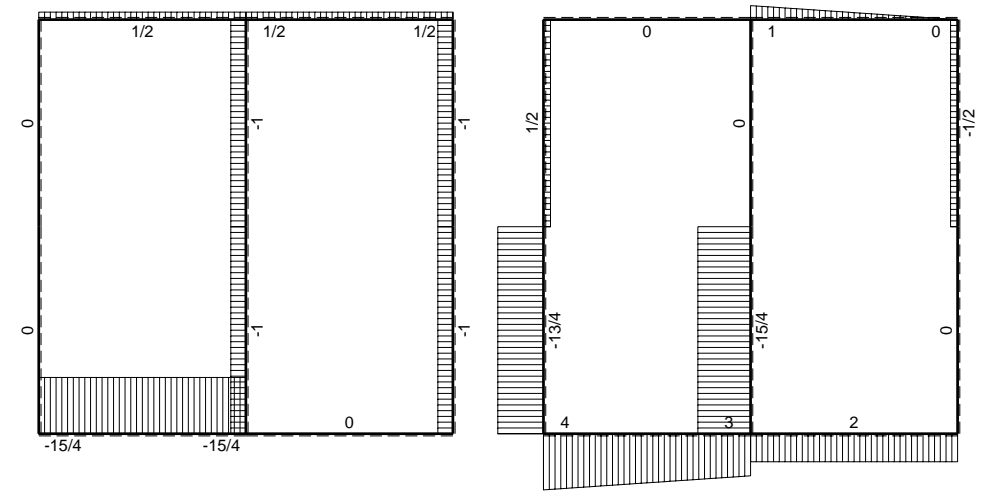
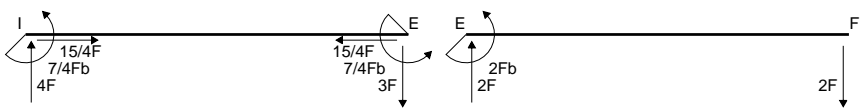
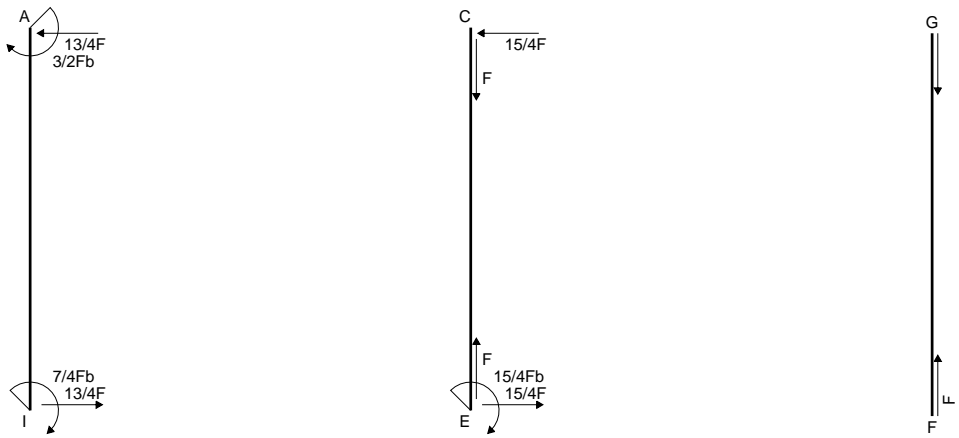
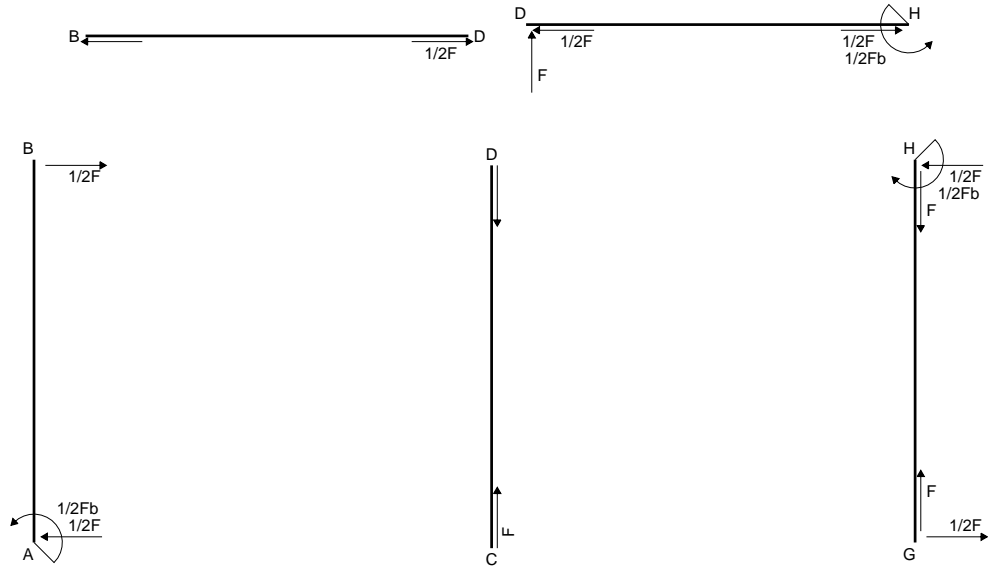
$$v_c = 22.66 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 148.8 \text{ N/mm}^2$$

$$\tau_c = 5.028 \text{ N/mm}^2$$

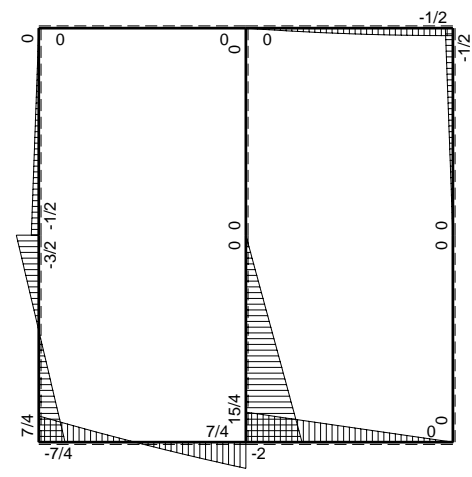
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 149. \text{ N/mm}^2$$

$$S = 3216. \text{ mm}^3$$

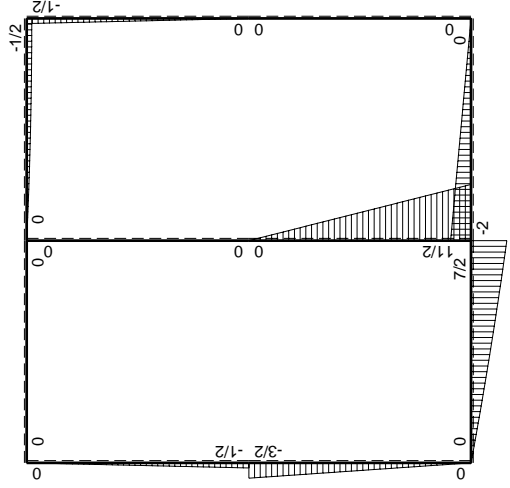
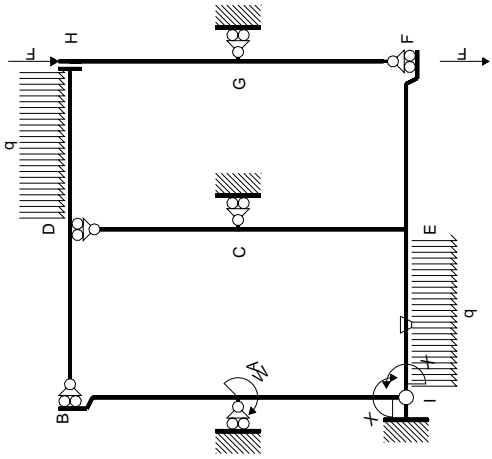


← ⊕ → F

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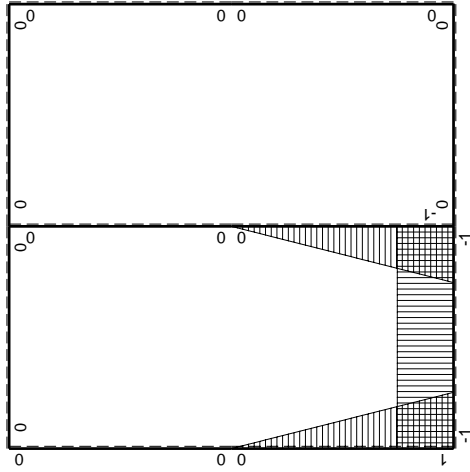


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0	
BA b	0	$1/2Fx$	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0	
FE b	0	$2Fx$	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0	
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0			
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0	
DH b	0	$Fx-1/2qx^2$	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ	
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1			
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$	
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$	
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2			
	totali							$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$							$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-2x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

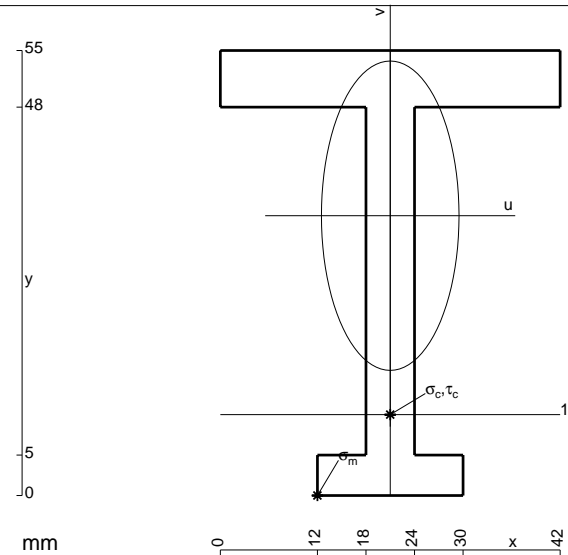
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 642. \text{ mm}^2$$

$$J_u = 234775. \text{ mm}^4$$

$$J_v = 46422. \text{ mm}^4$$

$$y_g = 34.58 \text{ mm}$$

$$T_y = 1600. \text{ N}$$

$$M_x = -1488000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.58 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.2 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

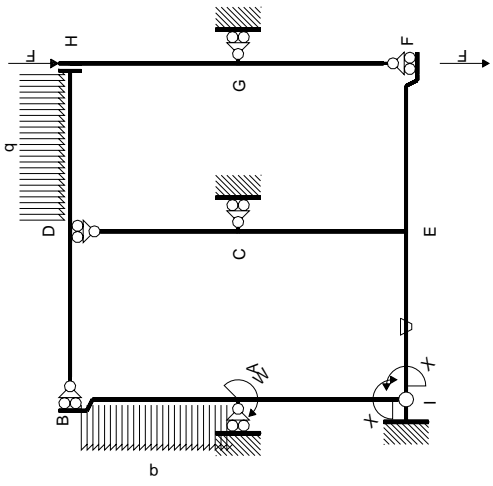
$$v_c = -24.58 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -155.8 \text{ N/mm}^2$$

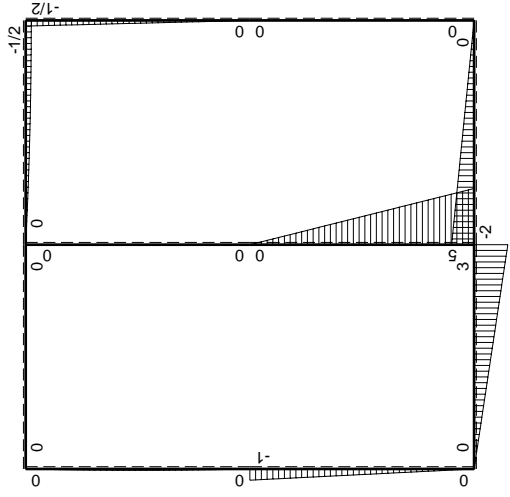
$$\tau_c = 4.203 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 156. \text{ N/mm}^2$$

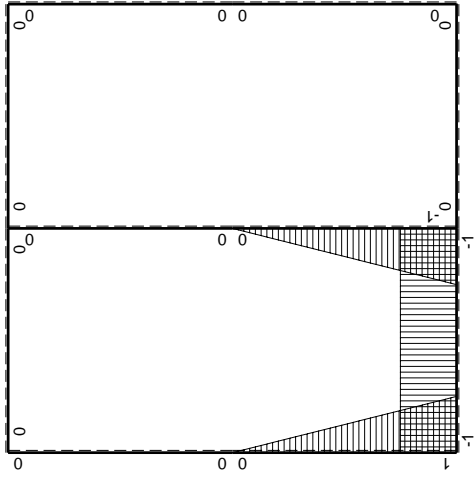
$$S = 3700. \text{ mm}^3$$



Schema di calcolo iperstatico



M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

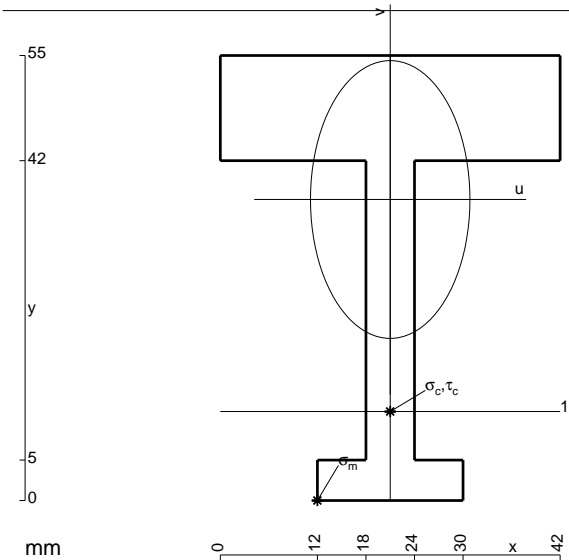
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

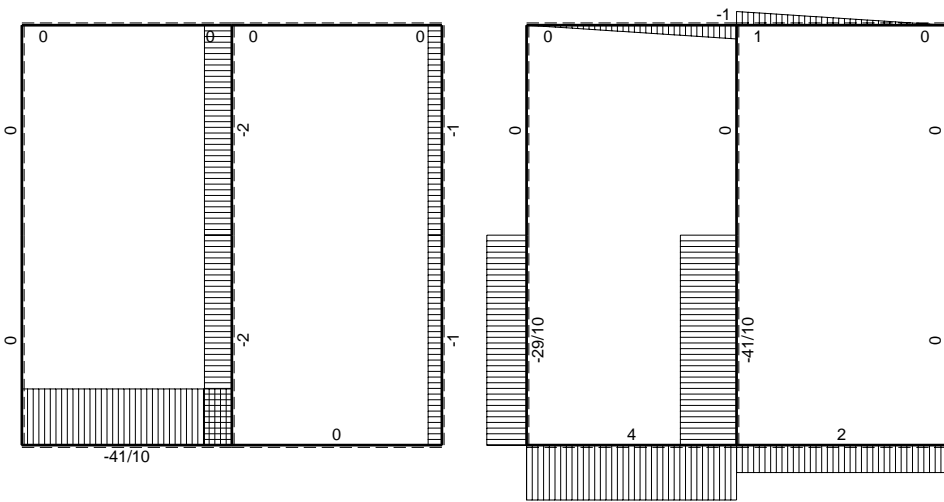
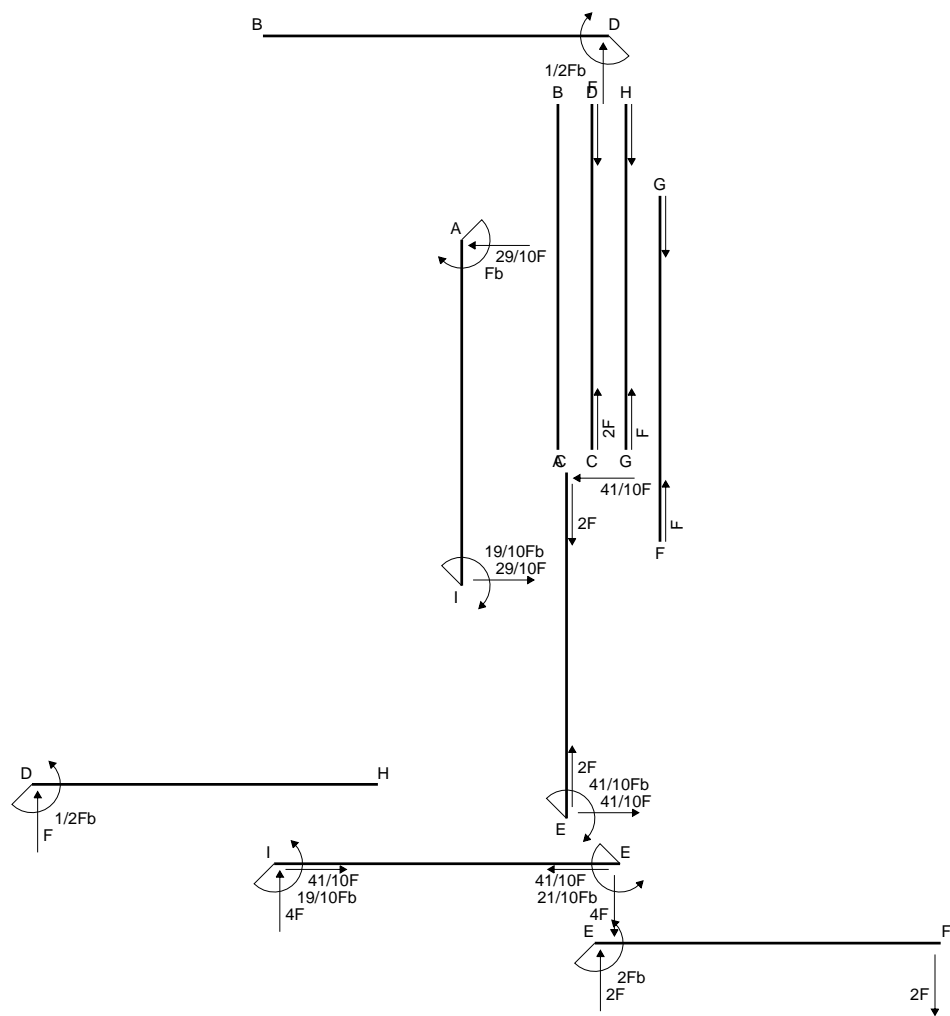
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

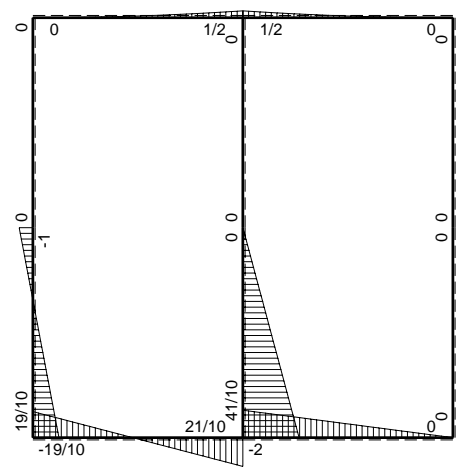


- A = 858. mm²
- J_u = 252957. mm⁴
- J_v = 83358. mm⁴
- y_g = 37.21 mm
- T_y = 1560. N
- M_x = -1544400. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -37.21 mm
- σ_m = -Mv/J_u = -227.2 N/mm²
- x_c = 21. mm
- y_c = 11. mm
- v_c = -26.21 mm
- σ_c = -Mv/J_u = -160. N/mm²
- τ_c = 4.291 N/mm²
- σ_o = √σ²+3τ² = 160.2 N/mm²
- S = 4175. mm³

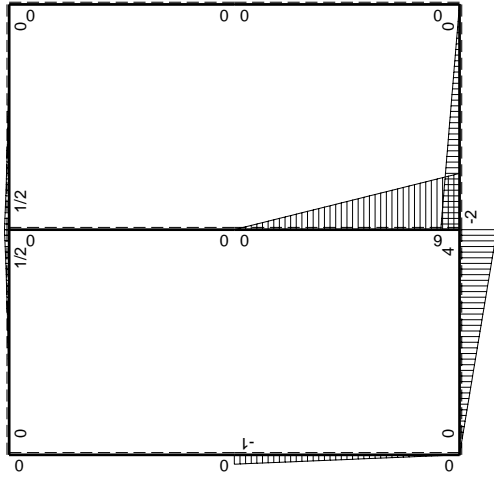
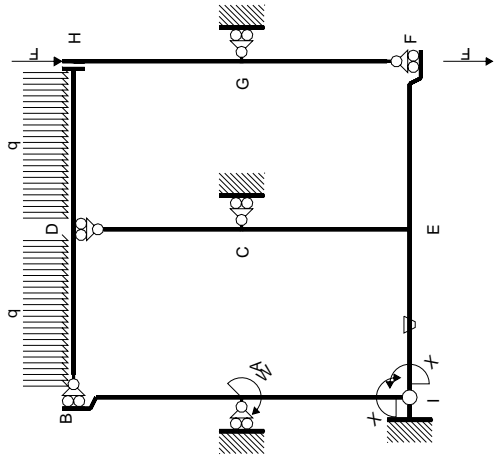


← ⊕ → F

↑ ⊕ ↓ F

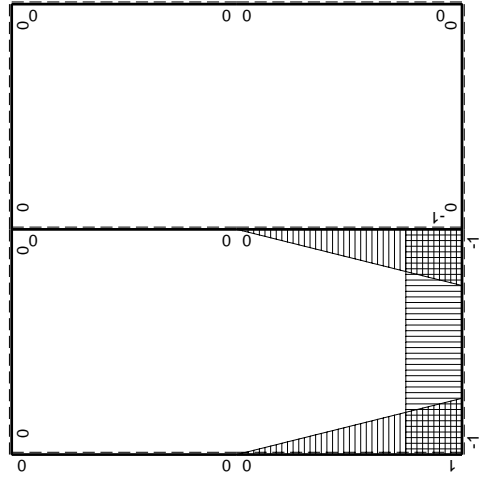


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-19/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb 1/EJ dx = [-6x + 6x^2/b - 2x^3/b^2]_0^b Fb 1/EJ$$

$$= (-6b + 6b - 2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb 1/EJ dx = [-2x^3/b^2]_0^b Fb 1/EJ$$

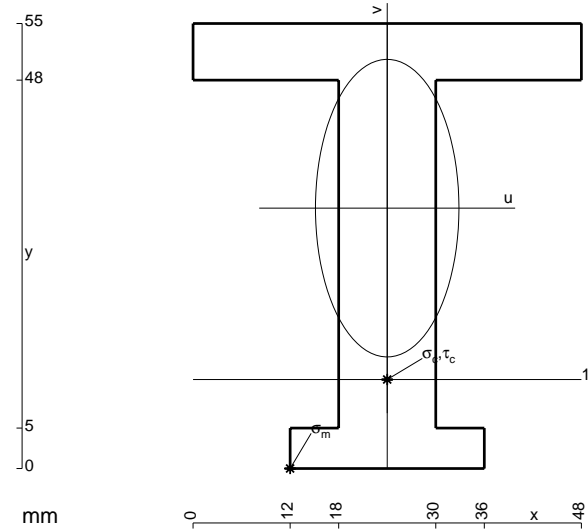
$$= (-2b) Fb 1/EJ = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



$$A = 972. \text{ mm}^2$$

$$J_u = 328901. \text{ mm}^4$$

$$J_v = 76464. \text{ mm}^4$$

$$y_g = 32.18 \text{ mm}$$

$$T_y = 2340. \text{ N}$$

$$M_x = -2433600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -32.18 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -238.1 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

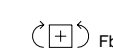
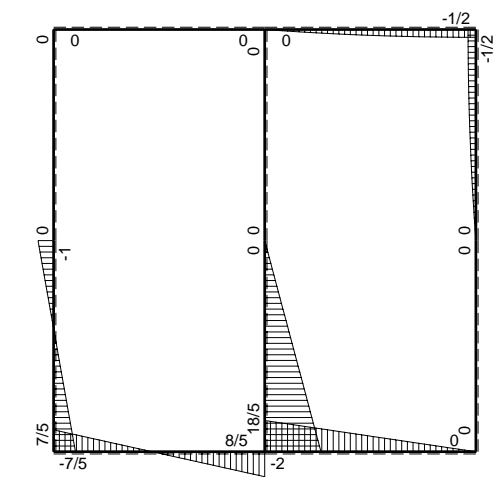
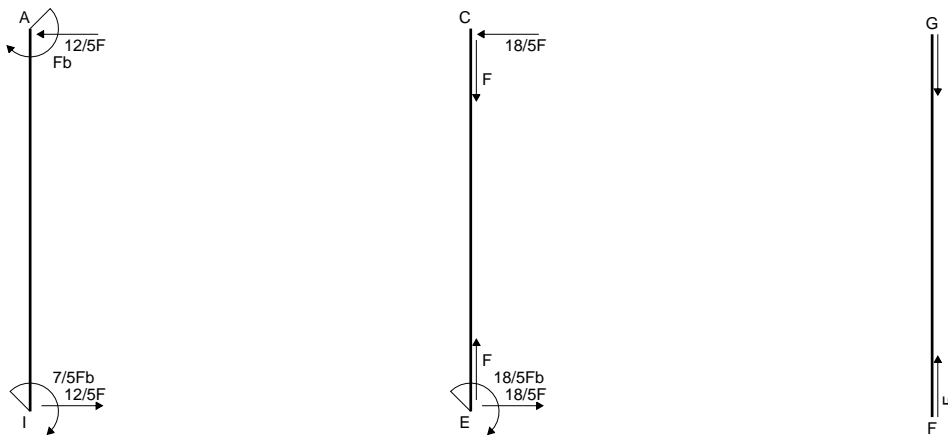
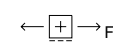
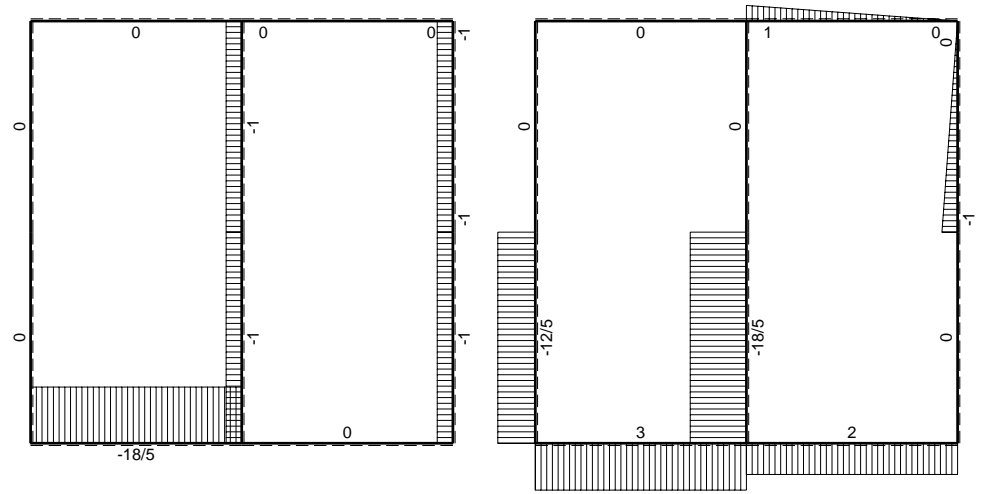
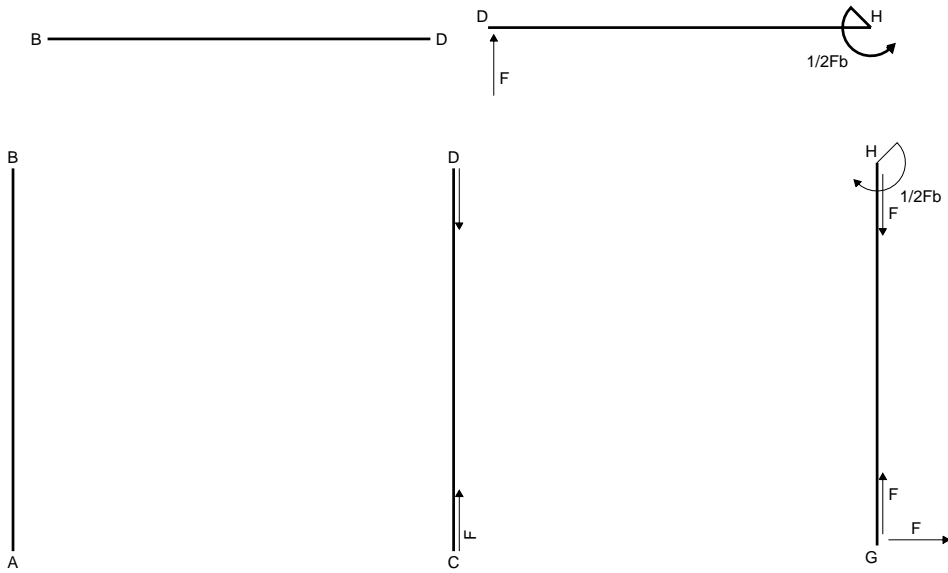
$$v_c = -21.18 \text{ mm}$$

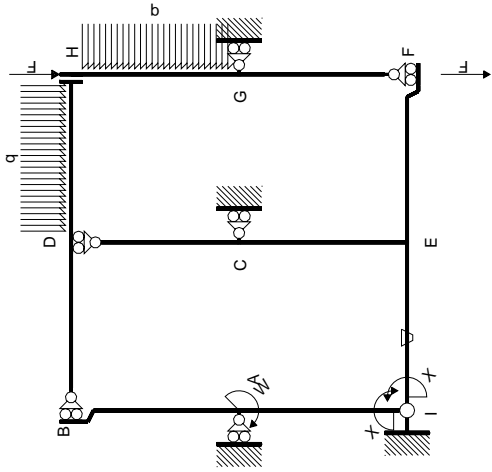
$$\sigma_c = -Mv/J_u = -156.7 \text{ N/mm}^2$$

$$\tau_c = 3.144 \text{ N/mm}^2$$

$$\sigma_\rho = \sqrt{\sigma_c^2 + 3\tau_c^2} = 156.8 \text{ N/mm}^2$$

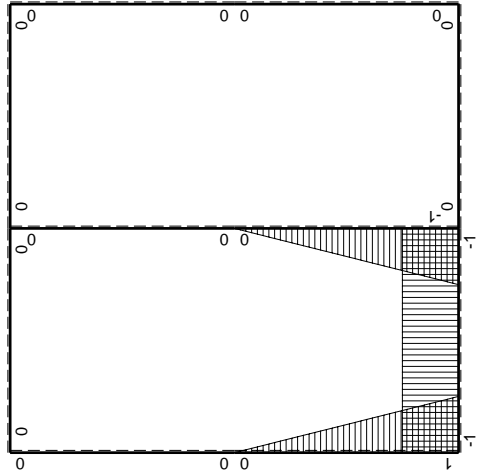
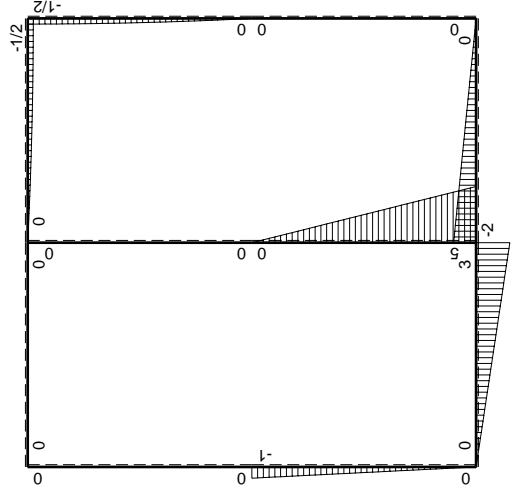
$$S = 5302. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

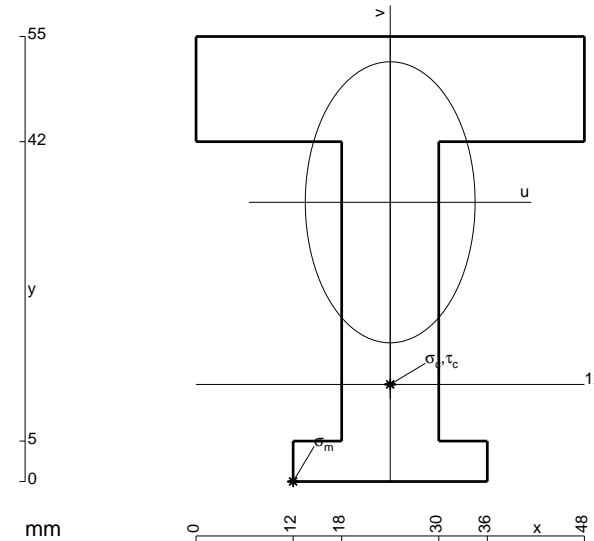
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

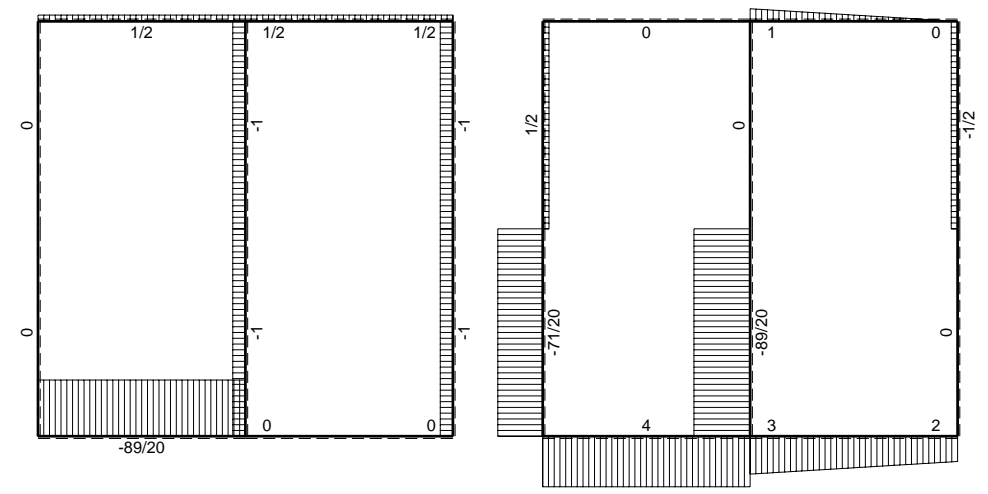
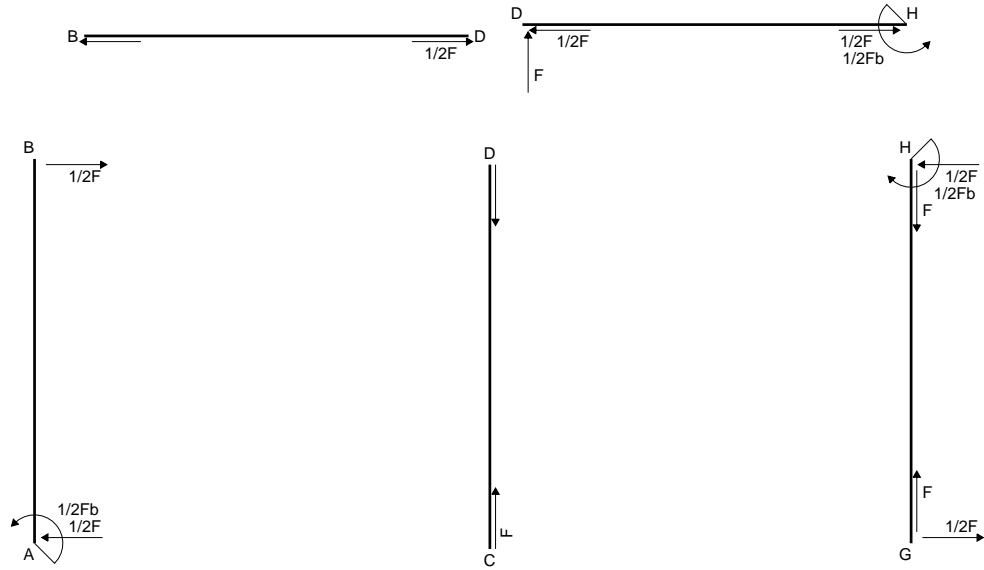
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

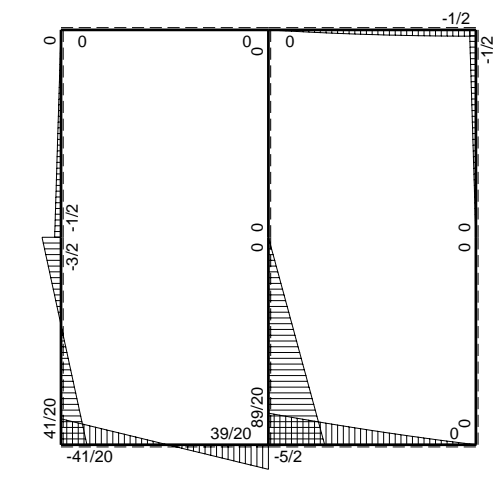
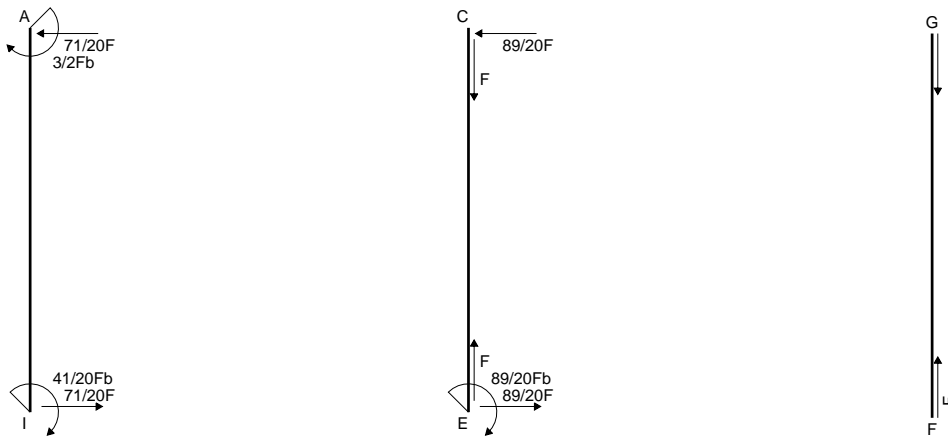


- A = 1188. mm²
- J_u = 358599. mm⁴
- J_v = 130896. mm⁴
- y_g = 34.51 mm
- T_y = 3760. N
- M_x = -2068000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -34.51 mm
- σ_m = -Mv/J_u = -199. N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -22.51 mm
- σ_c = -Mv/J_u = -129.8 N/mm²
- τ_c = 5.265 N/mm²
- σ_o = √σ²+3τ² = 130.1 N/mm²
- S = 6026. mm³

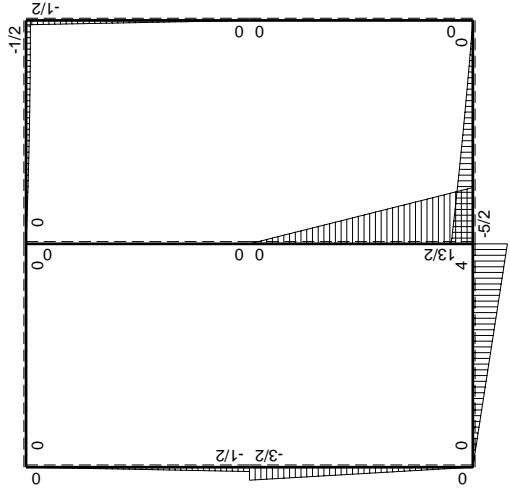
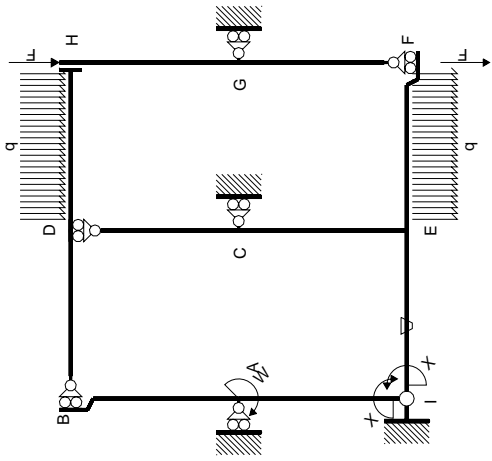


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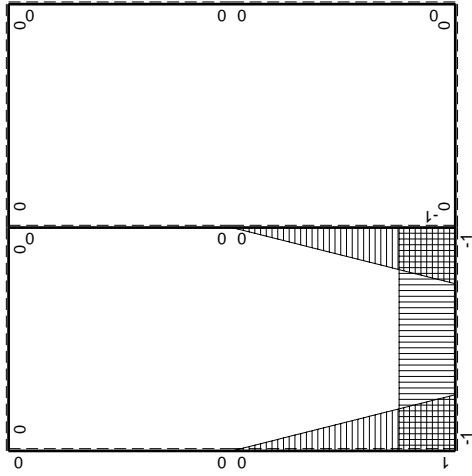


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-41/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$41/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-2x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-2b) Fb 1/EJ + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-4x + 2x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-4b + 2b) Fb 1/EJ + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb 1/EJ dx = [-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb 1/EJ dx = [-13/6 x^3/b^2]_0^b Fb 1/EJ$$

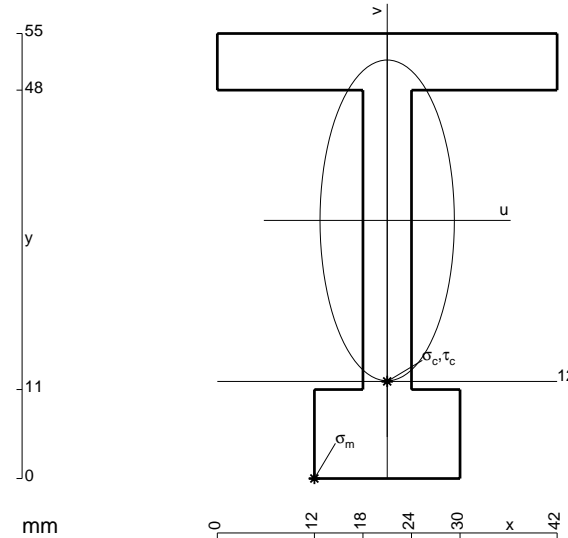
$$= (-13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

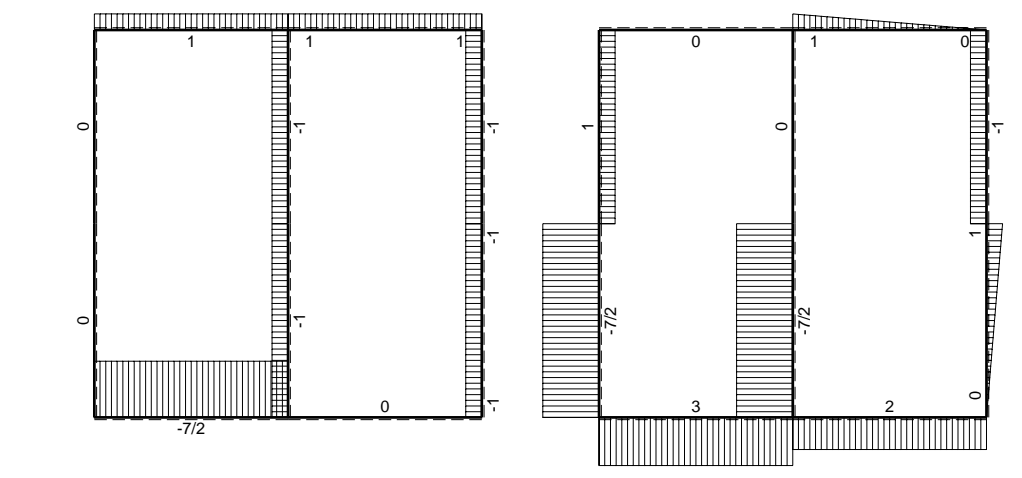
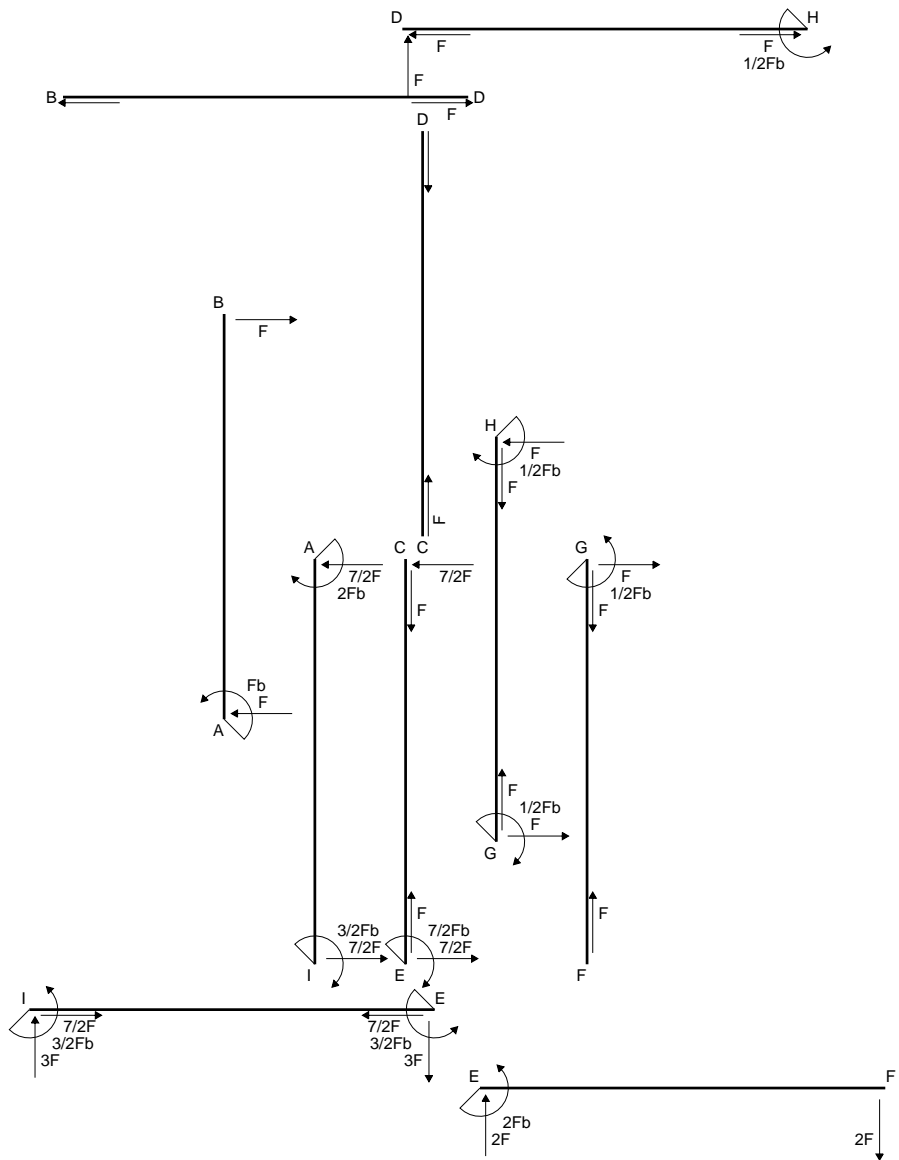
$$= (-3/4 b + 1/2 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb 1/EJ dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/4 b + 1/2 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

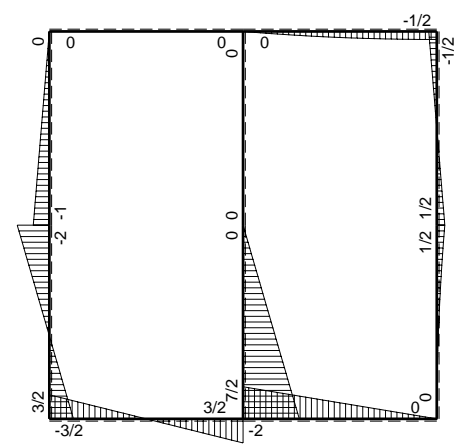


- A = 714. mm²
- J_u = 280743. mm⁴
- J_v = 49230. mm⁴
- y_g = 31.9 mm
- T_y = 3690. N
- M_x = -1845000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -31.9 mm
- σ_m = -Mv/J_u = -209.7 N/mm²
- x_c = 21. mm
- y_c = 12. mm
- v_c = -19.9 mm
- σ_c = -Mv/J_u = -130.8 N/mm²
- τ_c = 11.72 N/mm²
- σ_o = √σ²+3τ² = 132.4 N/mm²
- S = 5350. mm³

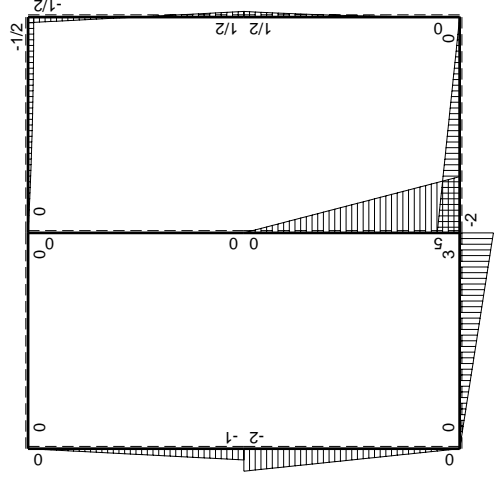
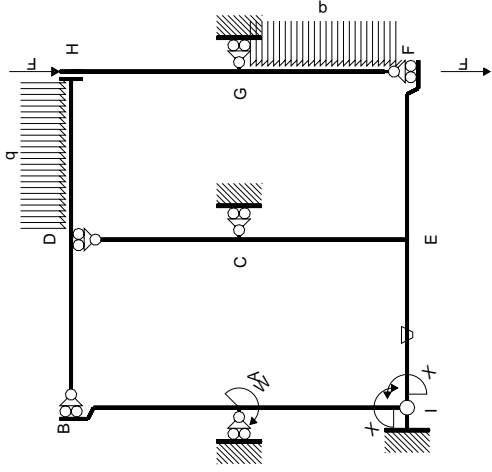


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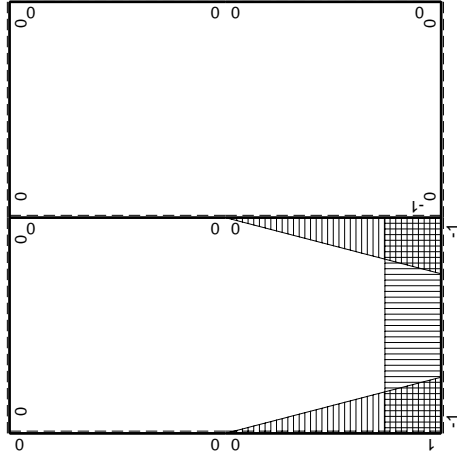


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-2Fx$	0	$-2Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$2Fb-2Fx$	0	$-2Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

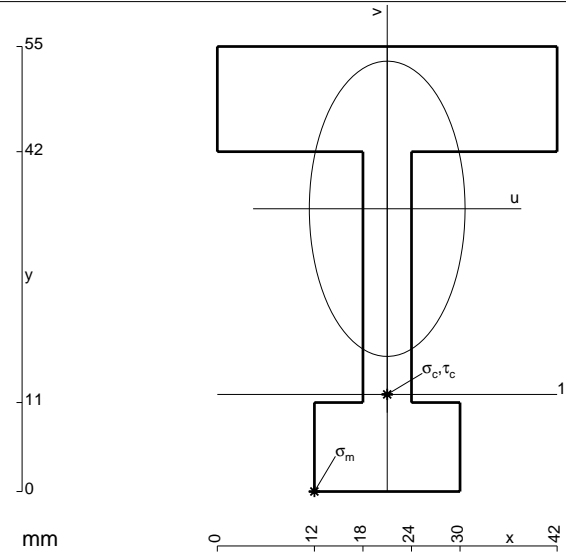
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb 1/EJ dx = [-x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-b + 2/3 b) Fb 1/EJ = -1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb 1/EJ dx = [-x^2/b + 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-b + 2/3 b) Fb 1/EJ = -1/3 Fb^2/EJ$$



$$A = 930. \text{ mm}^2$$

$$J_u = 309835. \text{ mm}^4$$

$$J_v = 86166. \text{ mm}^4$$

$$y_g = 34.95 \text{ mm}$$

$$T_y = 2940. \text{ N}$$

$$M_x = -1940400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.95 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

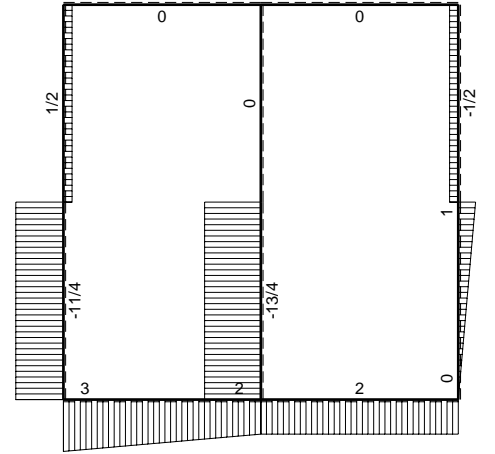
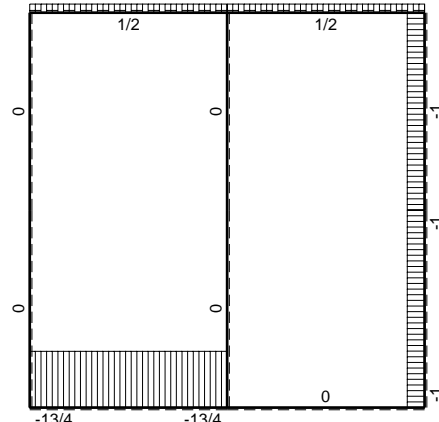
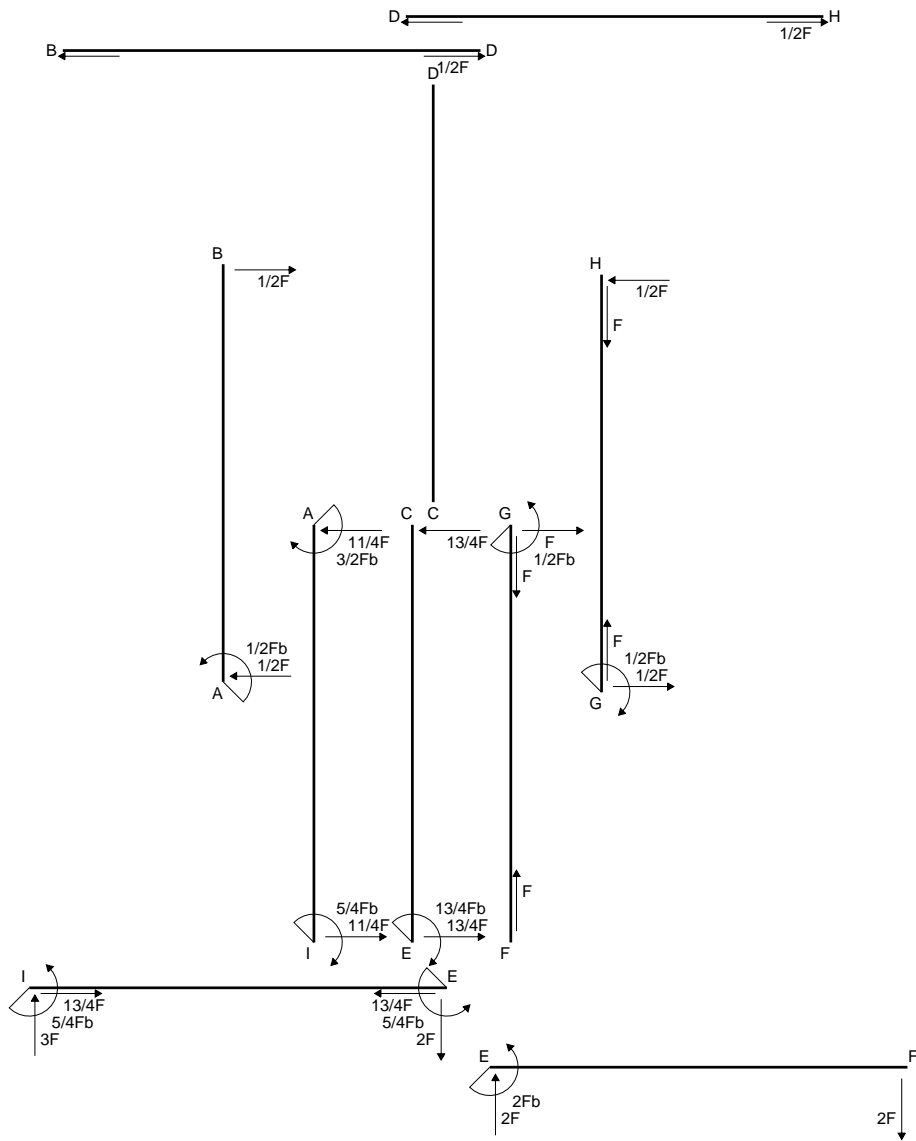
$$v_c = -22.95 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -143.7 \text{ N/mm}^2$$

$$\tau_c = 9.443 \text{ N/mm}^2$$

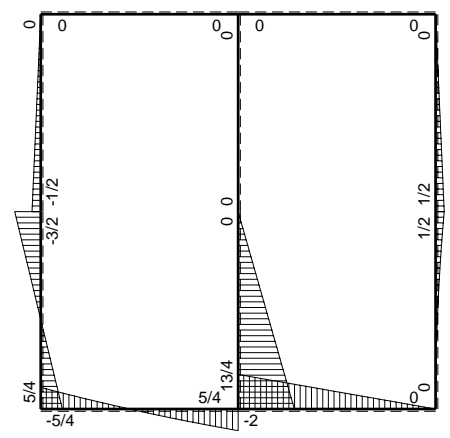
$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 144.6 \text{ N/mm}^2$$

$$S = 5971. \text{ mm}^3$$



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↑ ⊕ ↓ F



⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

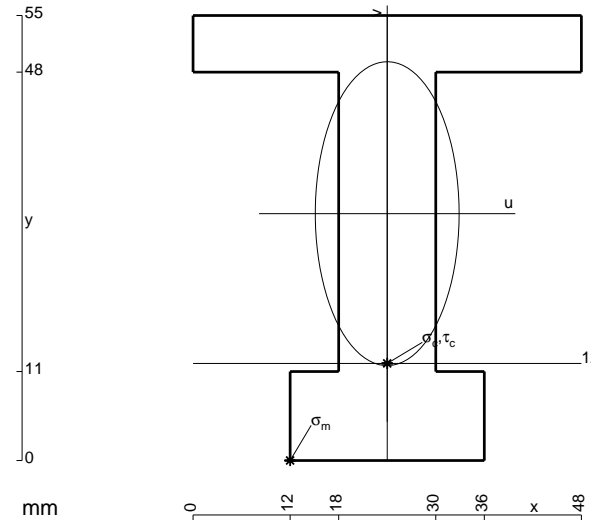
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 1044. \text{ mm}^2$$

$$J_u = 368307. \text{ mm}^4$$

$$J_v = 82512. \text{ mm}^4$$

$$y_g = 30.51 \text{ mm}$$

$$T_y = 3900. \text{ N}$$

$$M_x = -2769000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.51 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.4 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

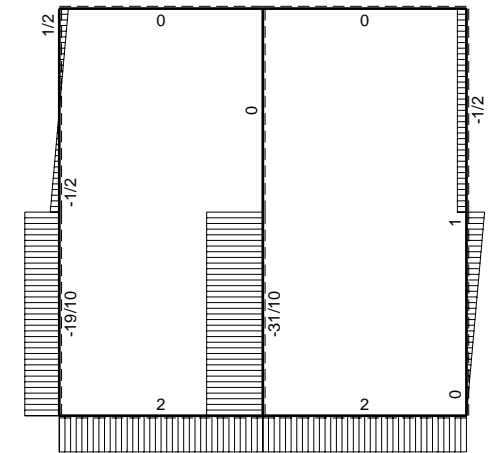
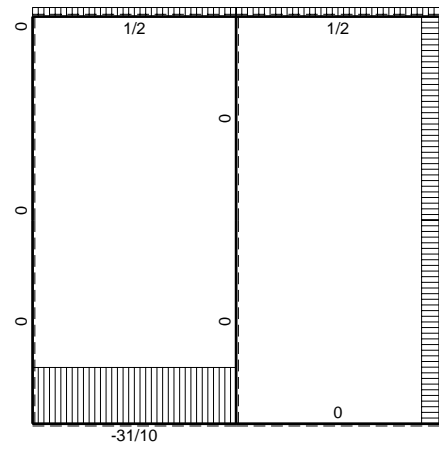
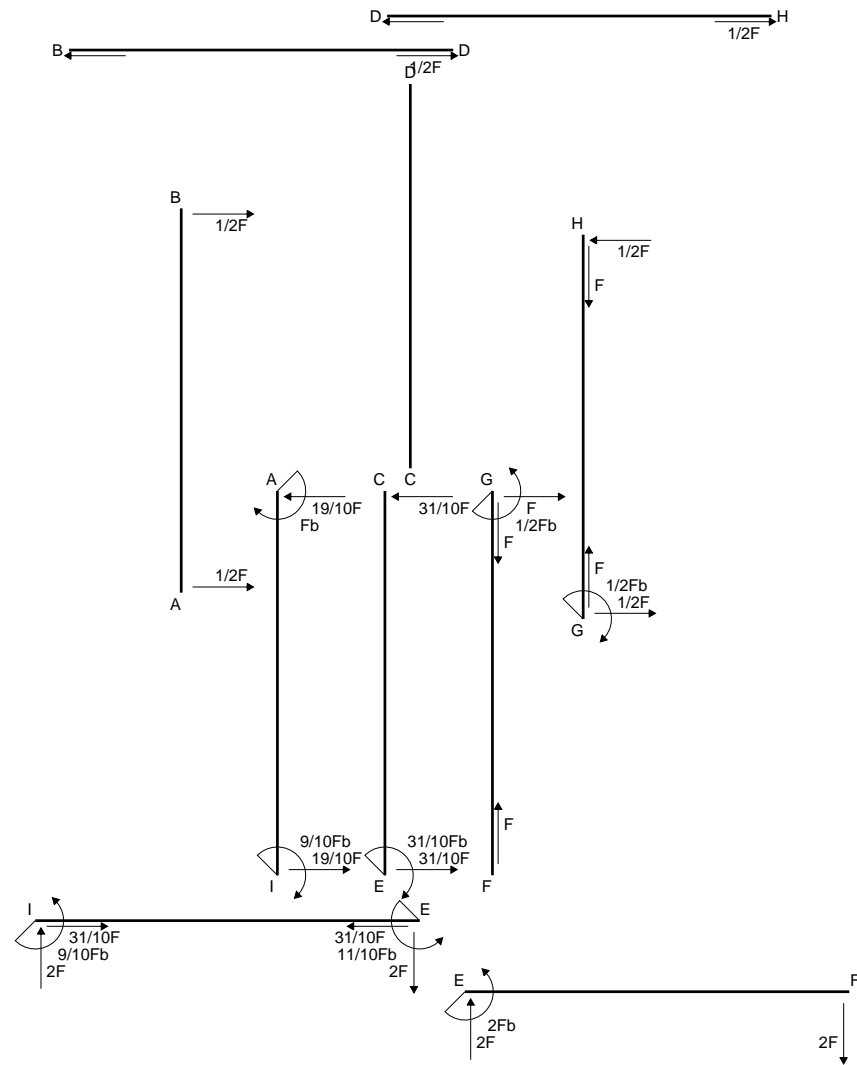
$$v_c = -18.51 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -139.2 \text{ N/mm}^2$$

$$\tau_c = 6.028 \text{ N/mm}^2$$

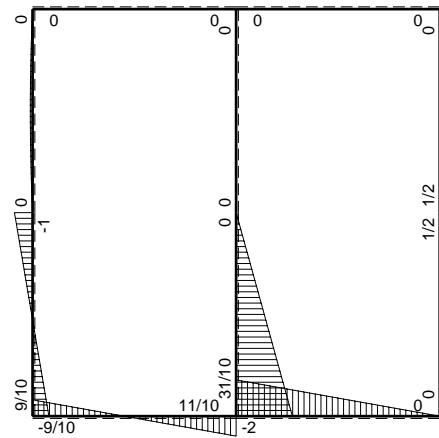
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 139.6 \text{ N/mm}^2$$

$$S = 6831. \text{ mm}^3$$

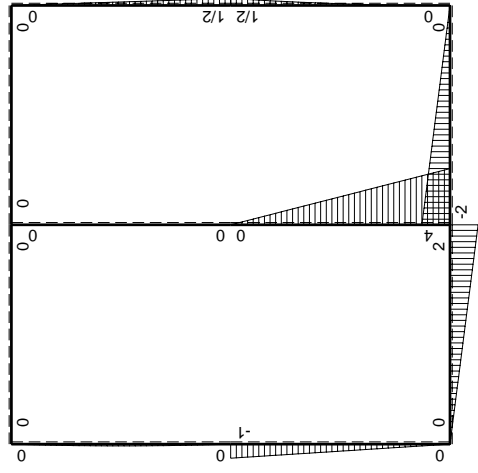
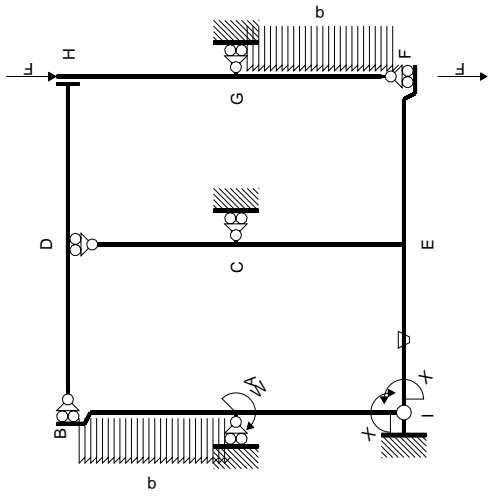


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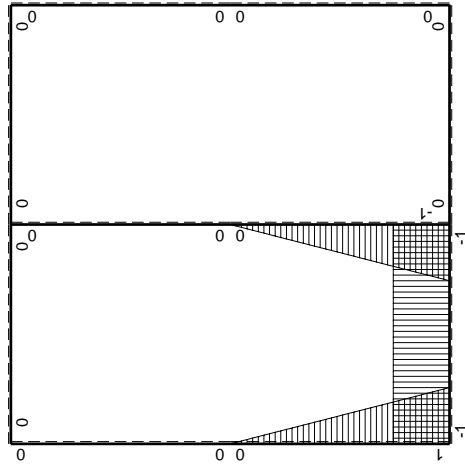


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

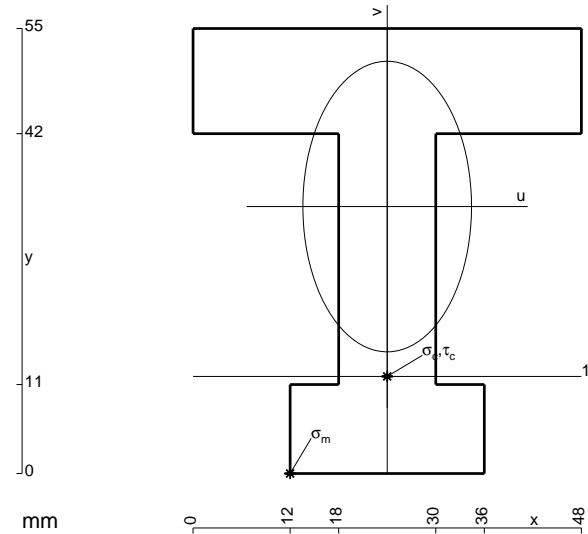
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1260. \text{ mm}^2$$

$$J_u = 406524. \text{ mm}^4$$

$$J_v = 136944. \text{ mm}^4$$

$$y_g = 33. \text{ mm}$$

$$T_y = 3840. \text{ N}$$

$$M_x = -2956800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -33. \text{ mm}$$

$$\sigma_m = -Mv/J_u = -240. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

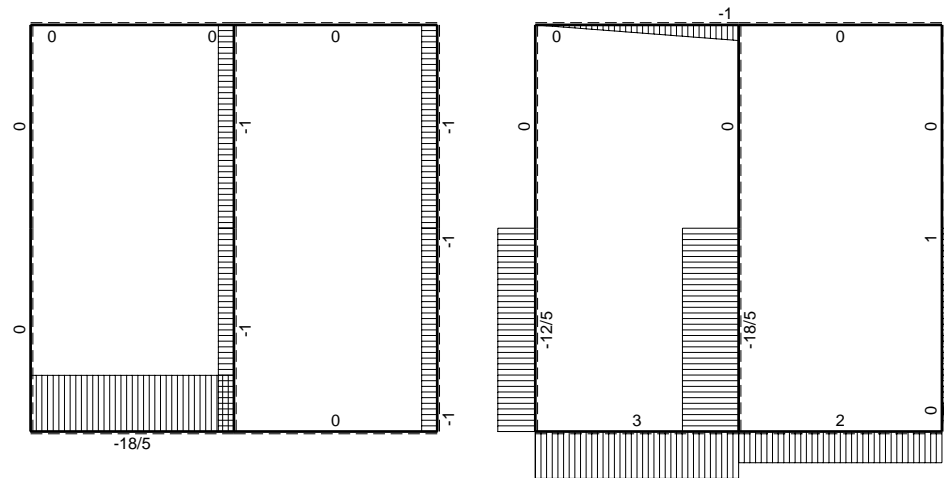
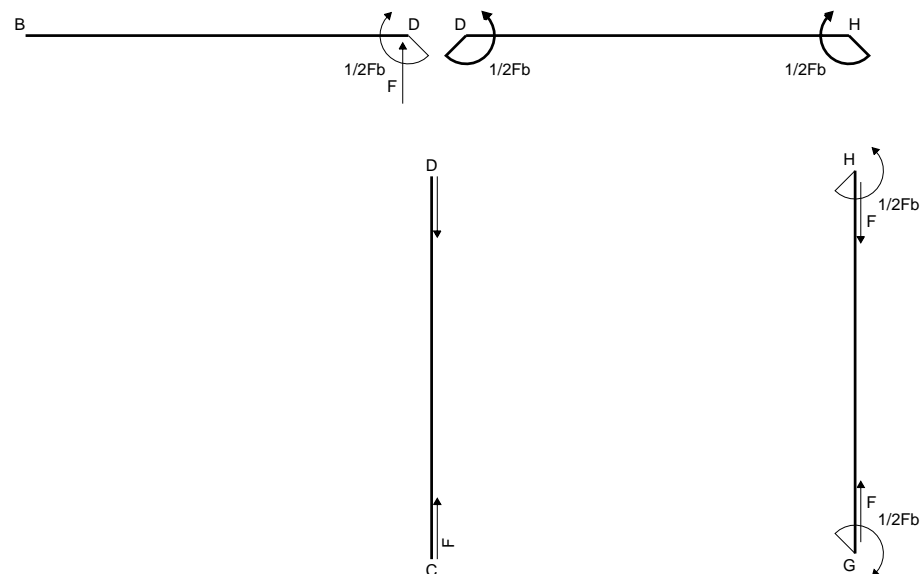
$$v_c = -21. \text{ mm}$$

$$\sigma_c = -Mv/J_u = -152.7 \text{ N/mm}^2$$

$$\tau_c = 5.917 \text{ N/mm}^2$$

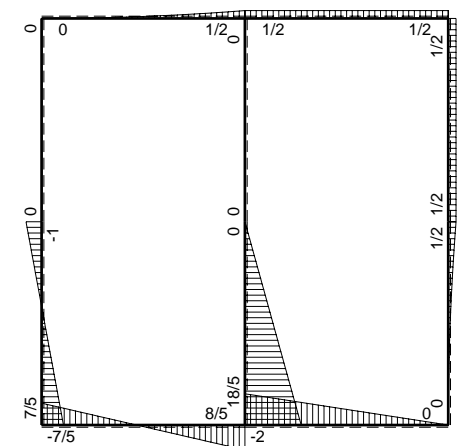
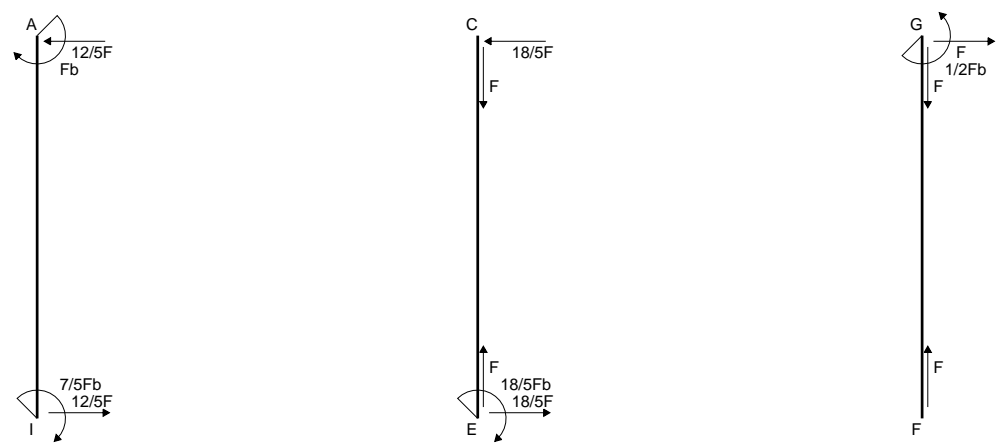
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 153.1 \text{ N/mm}^2$$

$$S = 7517. \text{ mm}^3$$

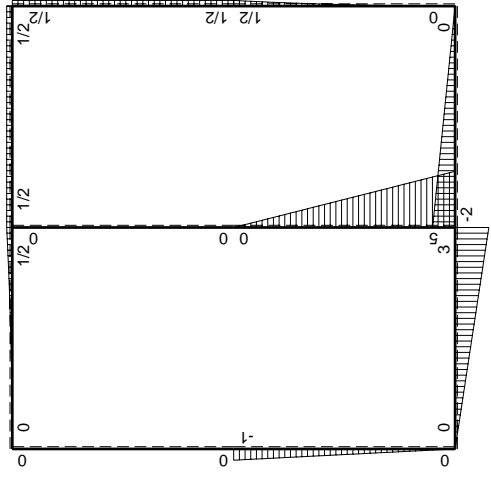
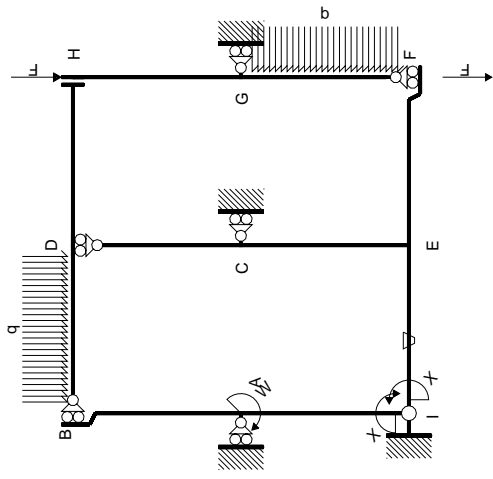


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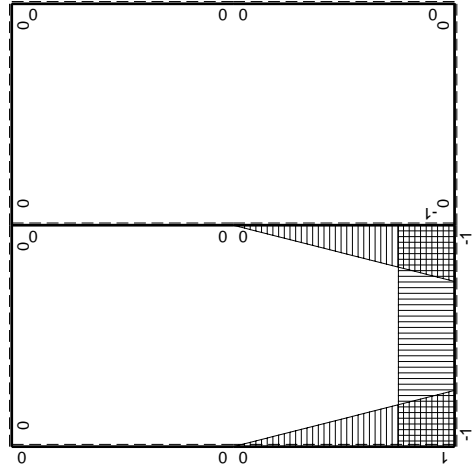


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-3/2 b) Fb 1/EJ + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb 1/EJ + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb 1/EJ dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5b + 5b - 5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb 1/EJ dx = [-5/3 x^3/b^2]_0^b Fb 1/EJ$$

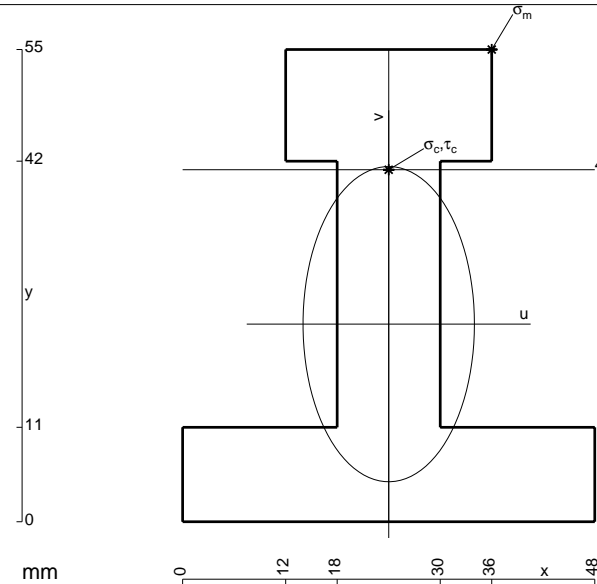
$$= (-5/3 b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

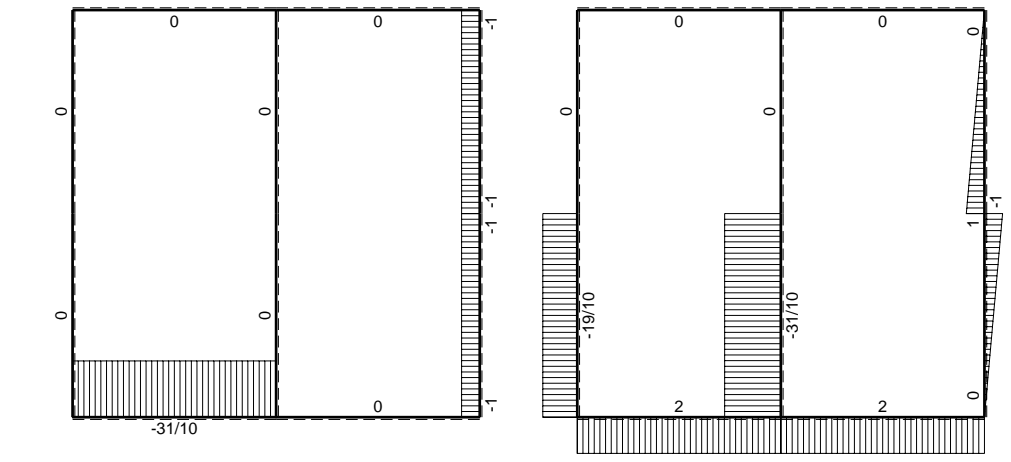
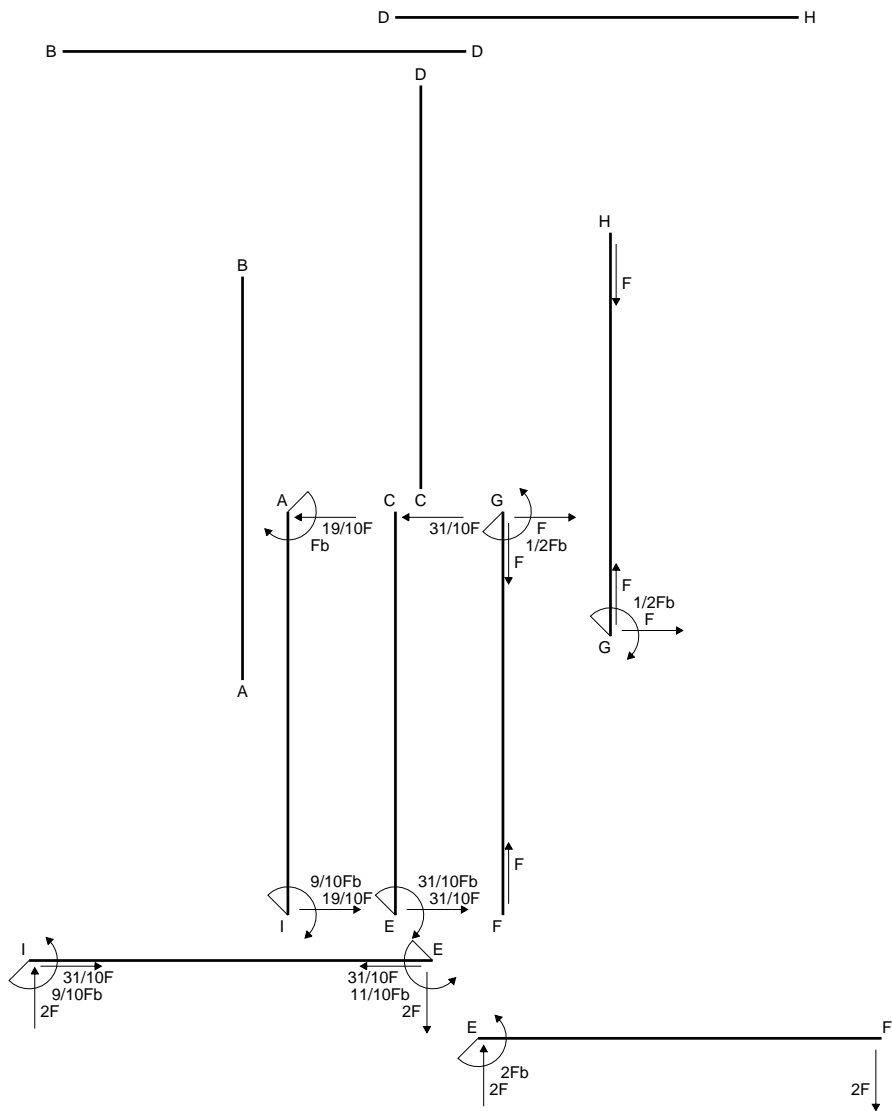
$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb 1/EJ dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/3 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

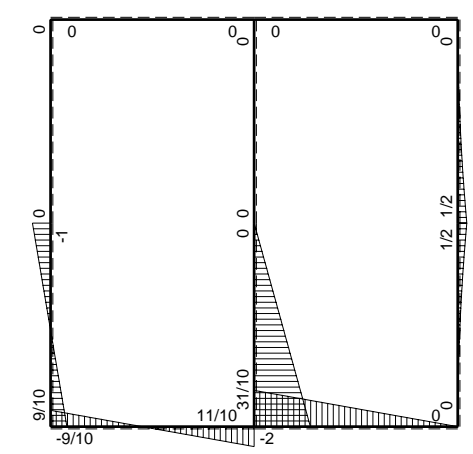


- A = 1212. mm²
- J_u = 408644. mm⁴
- J_v = 120816. mm⁴
- y_g = 23.01 mm
- T_y = 3100. N
- M_x = -2542000. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 31.99 mm
- σ_m = -Mv/J_u = 199. N/mm²
- x_c = 24. mm
- y_c = 41. mm
- v_c = 17.99 mm
- σ_c = -Mv/J_u = 111.9 N/mm²
- τ_c = 5.167 N/mm²
- σ_q = √σ²+3τ² = 112.2 N/mm²
- S = 8173. mm³

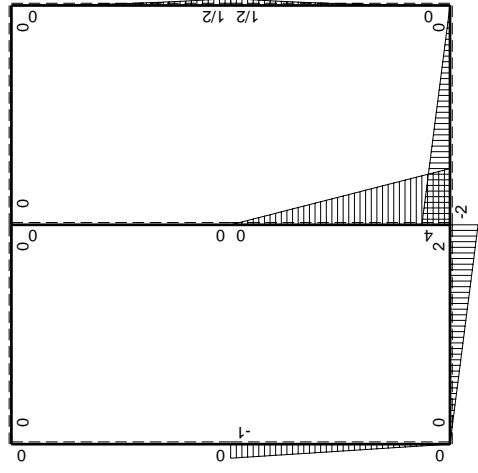
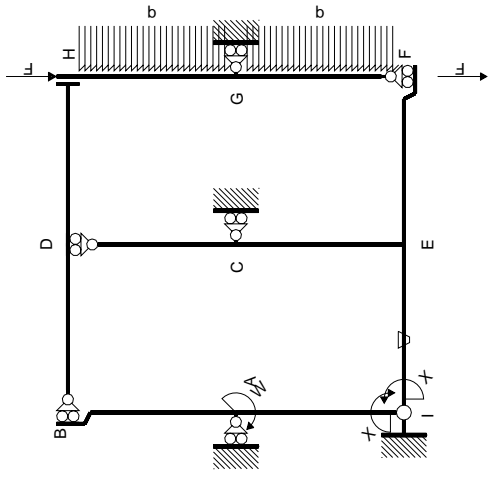


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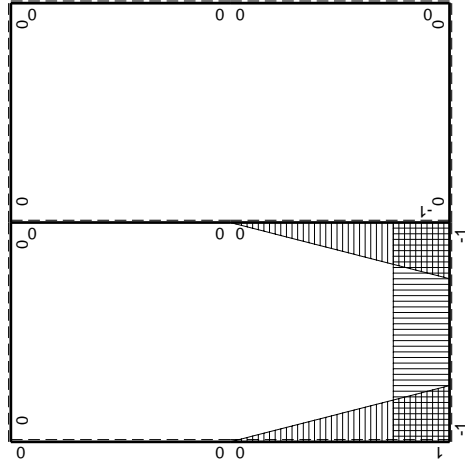


⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

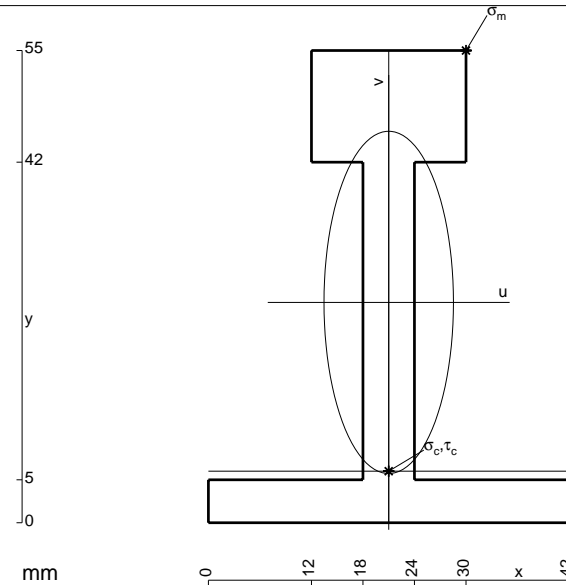
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 666. \text{ mm}^2$$

$$J_u = 264806. \text{ mm}^4$$

$$J_v = 37854. \text{ mm}^4$$

$$y_g = 25.66 \text{ mm}$$

$$T_y = 2140. \text{ N}$$

$$M_x = -1883200. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 29.34 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.6 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 6. \text{ mm}$$

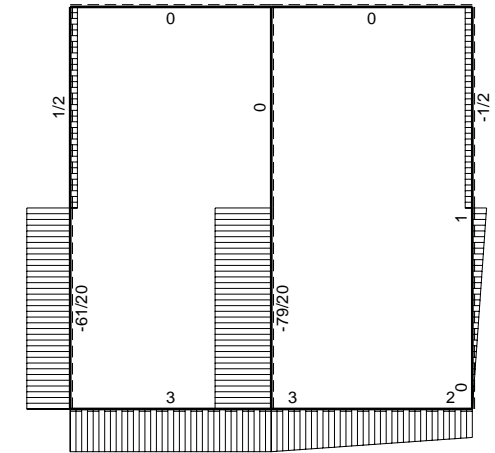
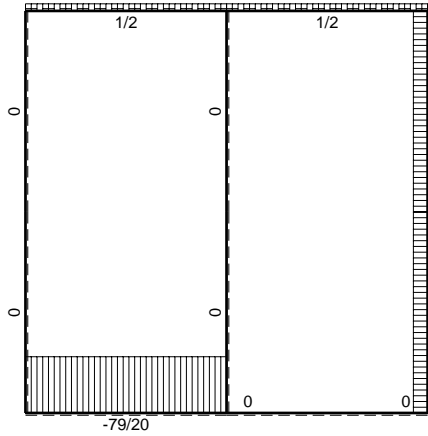
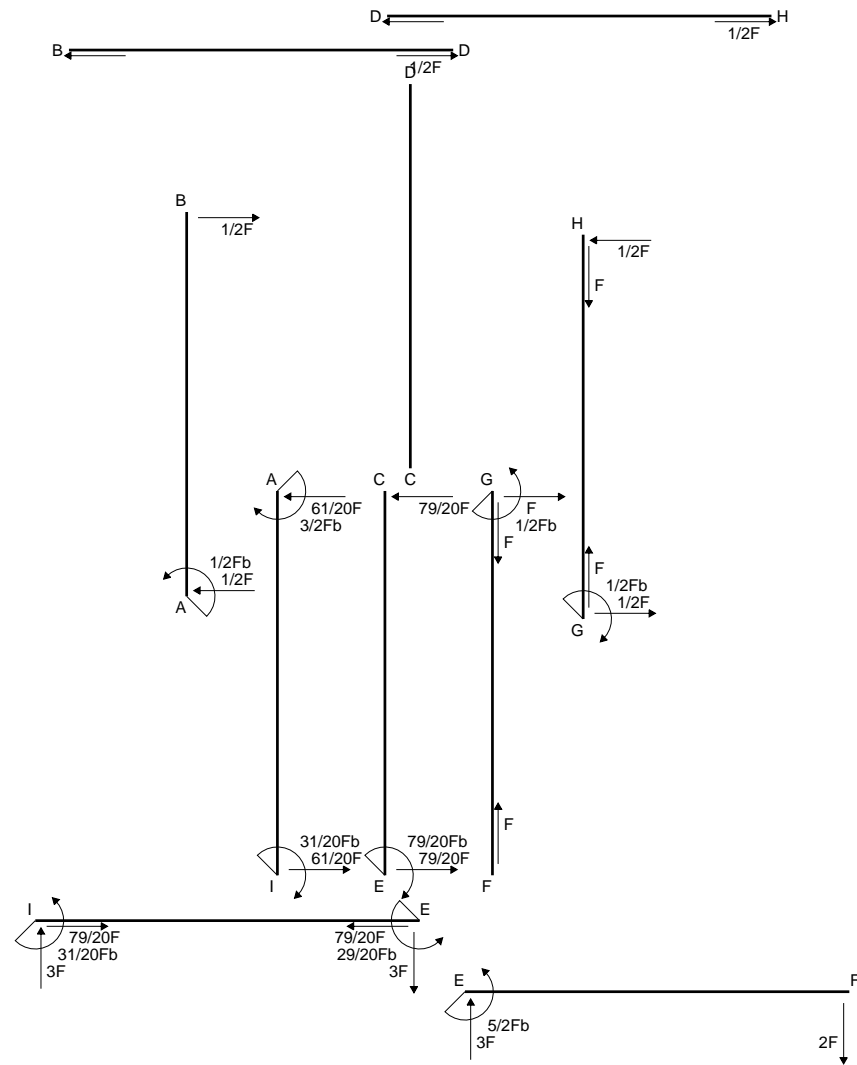
$$v_c = -19.66 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -139.8 \text{ N/mm}^2$$

$$\tau_c = 6.714 \text{ N/mm}^2$$

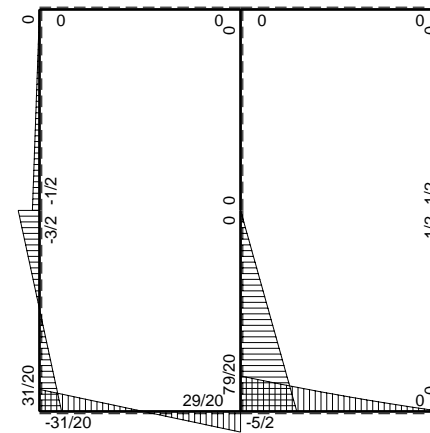
$$\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 140.3 \text{ N/mm}^2$$

$$S = 4985. \text{ mm}^3$$

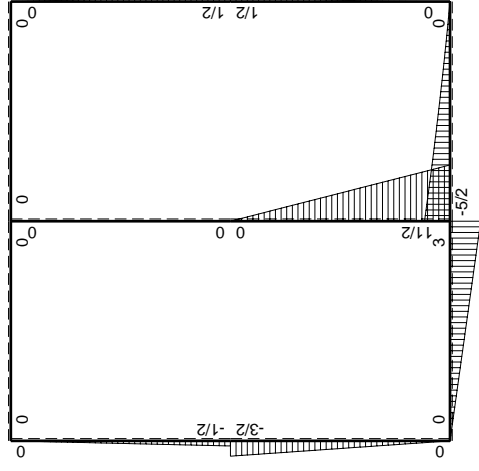
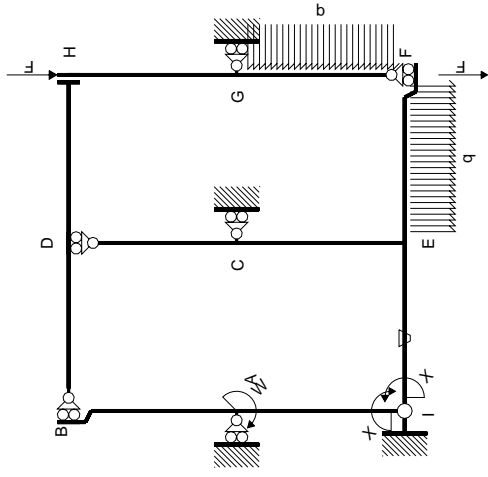


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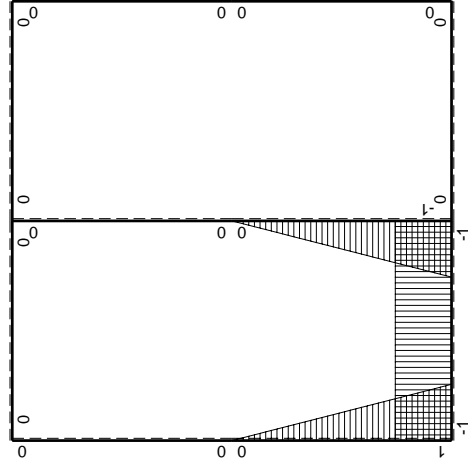


⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

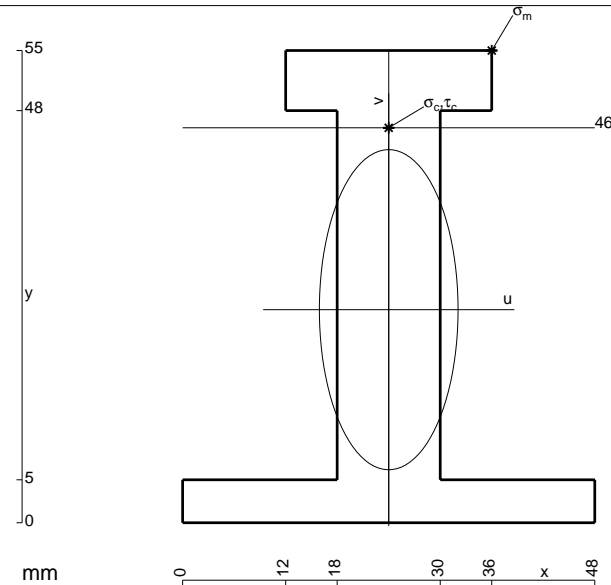
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

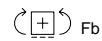
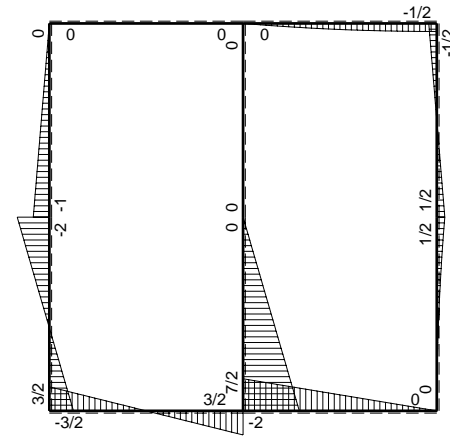
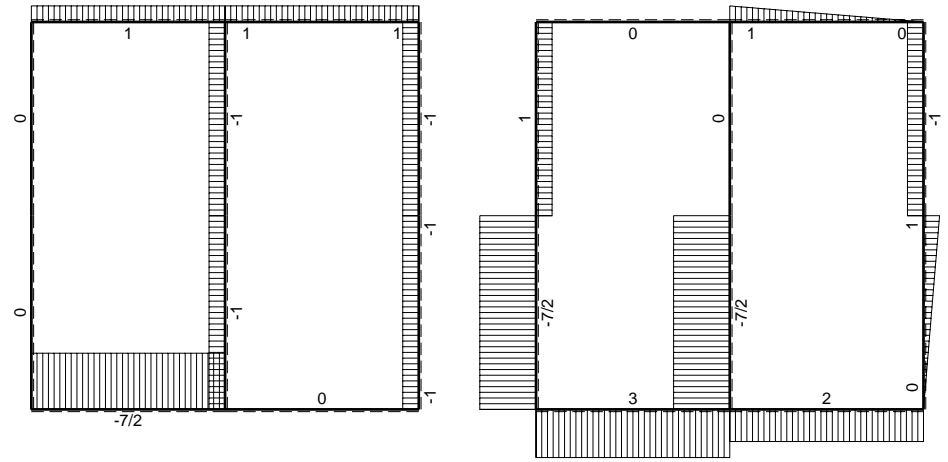
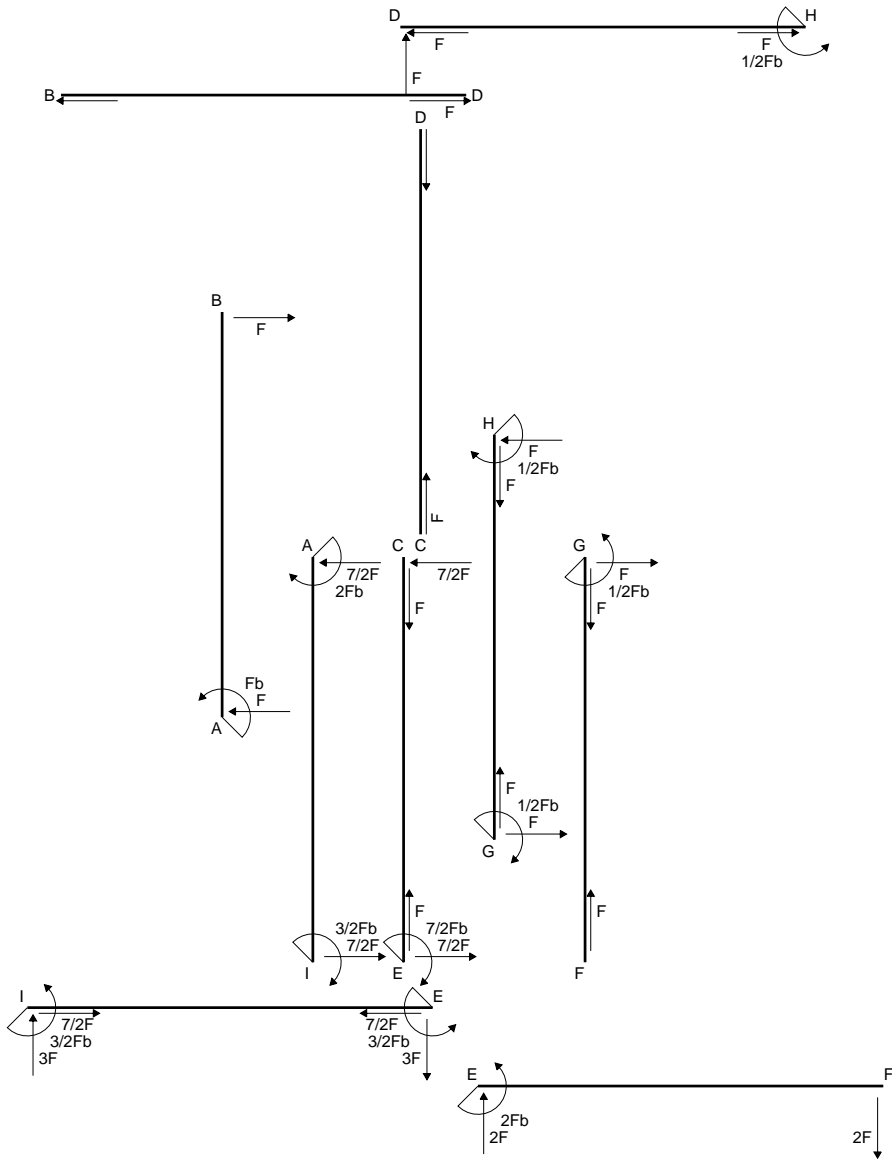
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



- A = 924. mm²
- J_u = 321299. mm⁴
- J_v = 60336. mm⁴
- y_g = 24.81 mm
- T_y = 3000. N
- M_x = -2325000. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 30.19 mm
- σ_m = -Mv/J_u = 218.4 N/mm²
- x_c = 24. mm
- y_c = 46. mm
- v_c = 21.19 mm
- σ_c = -Mv/J_u = 153.3 N/mm²
- τ_c = 3.903 N/mm²
- σ_q = √σ_c² + 3τ_c² = 153.5 N/mm²
- S = 5016. mm³



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fb+Fx	0	0	0	0	0+0	0	
BA b	0	Fx	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0	
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0			
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0	
HG b	0	$1/2Fb-Fx$	0	0	0	0			
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0	
DH b	0	$Fx-1/2qx^2$	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ	
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1			
EC b	$-1+x/b$	5Fb-5Fx	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	1/3Xb/EJ	
CE b	x/b	-5Fx	0	$-5Fx^2/b$	0	x^2/b^2			
IA b	$1-x/b$	-2Fx	0	$-2Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/3+0)Fb^2/EJ$	1/3Xb/EJ	
AI b	$-x/b$	2Fb-2Fx	0	$-2Fx+2Fx^2/b$	0	x^2/b^2			
	totali							$-5/2Fb^2/EJ$	5/3Xb/EJ
	iperstatica $X=W_{IE}$							3/2Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

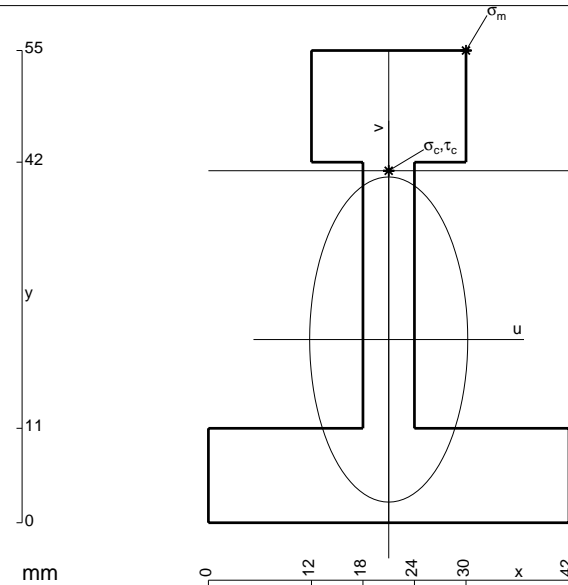
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = [-x^2/b + 2/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

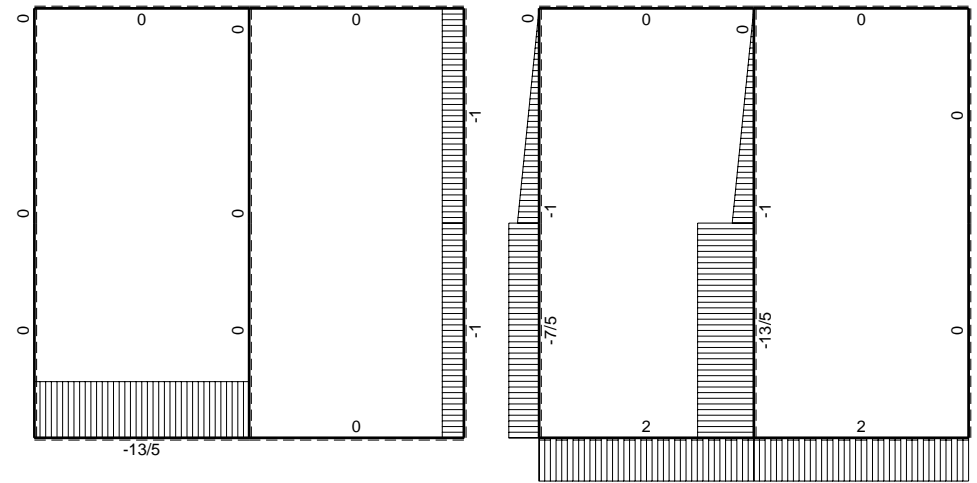
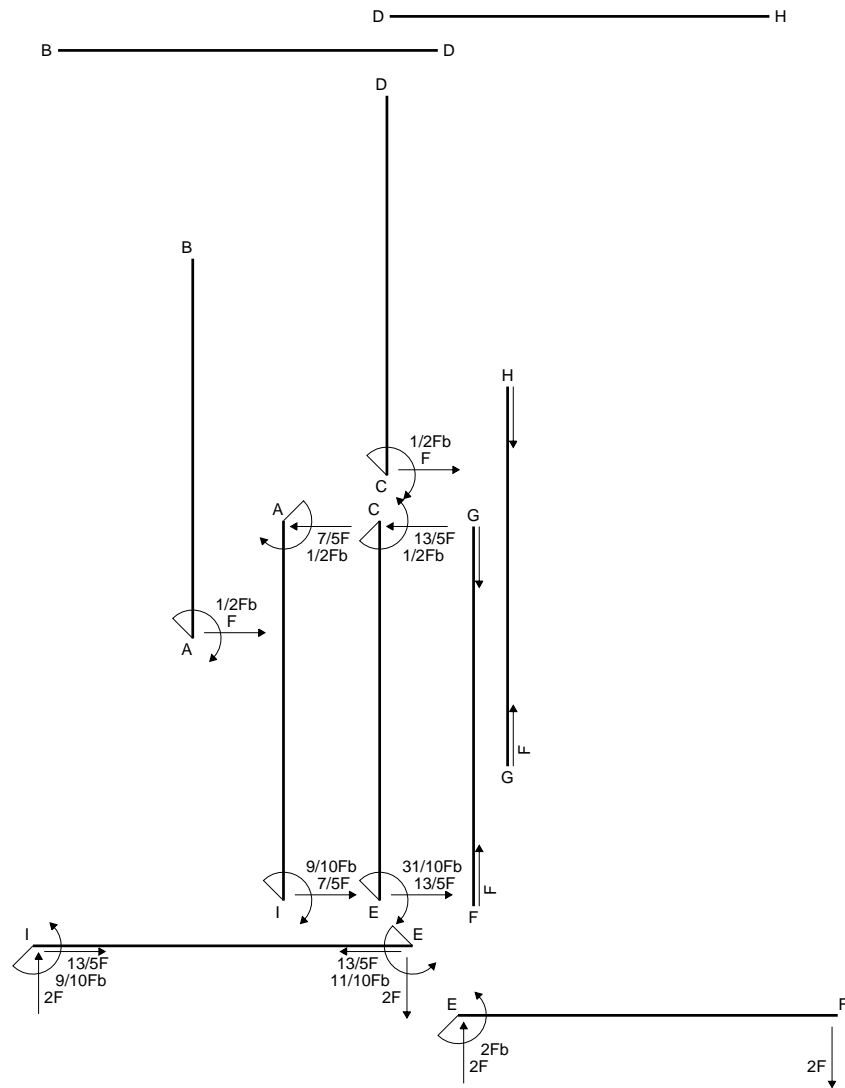
$$= (-b + 2/3 b) Fb \frac{1}{EJ} = -1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = [-x^2/b + 2/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-b + 2/3 b) Fb \frac{1}{EJ} = -1/3 Fb^2/EJ$$

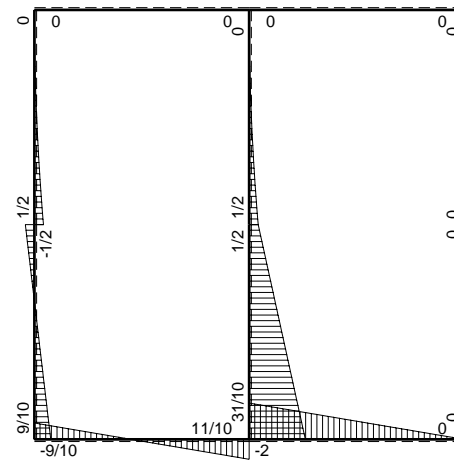


- A = 882. mm²
- J_u = 316334. mm⁴
- J_v = 74790. mm⁴
- y_g = 21.34 mm
- T_y = 2180. N
- M_x = -2158200. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 33.66 mm
- σ_m = -Mv/J_u = 229.7 N/mm²
- x_c = 21. mm
- y_c = 41. mm
- v_c = 19.66 mm
- σ_c = -Mv/J_u = 134.2 N/mm²
- τ_c = 7.44 N/mm²
- σ_q = √σ²+3τ² = 134.8 N/mm²
- S = 6477. mm³

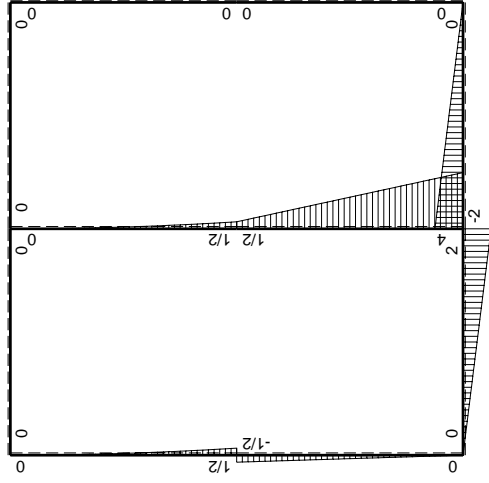
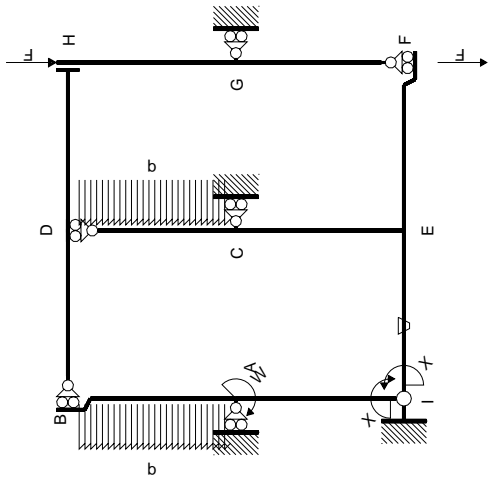


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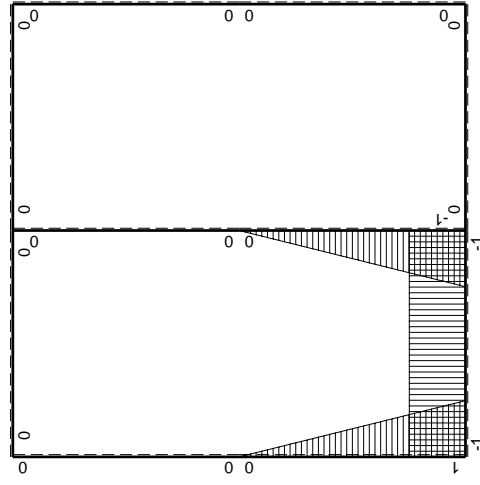


⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2qx^2$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) 1/EJ dx = [x]_0^b 1/EJ$$

$$= (b) 1/EJ = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb 1/EJ dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb 1/EJ + [x]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb 1/EJ dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb 1/EJ + [-x]_0^b \theta$$

$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-4b + 15/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb 1/EJ$$

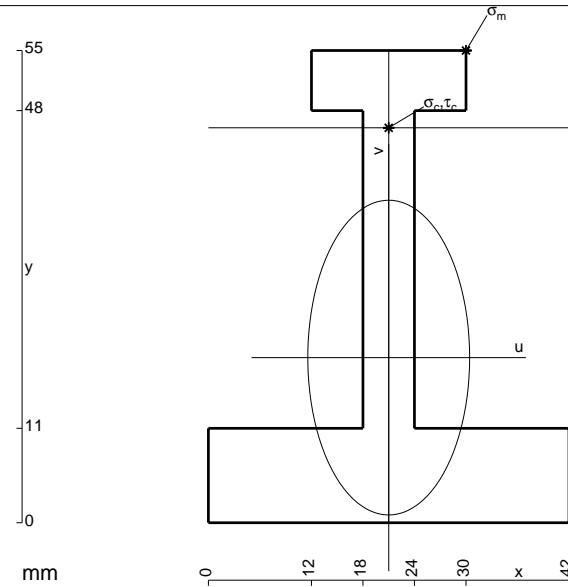
$$= (-1/4 b - 7/6 b) Fb 1/EJ = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

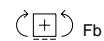
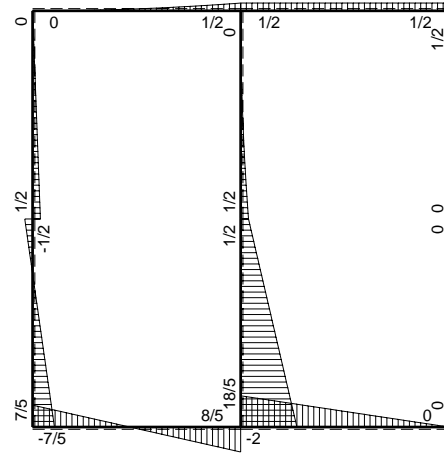
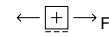
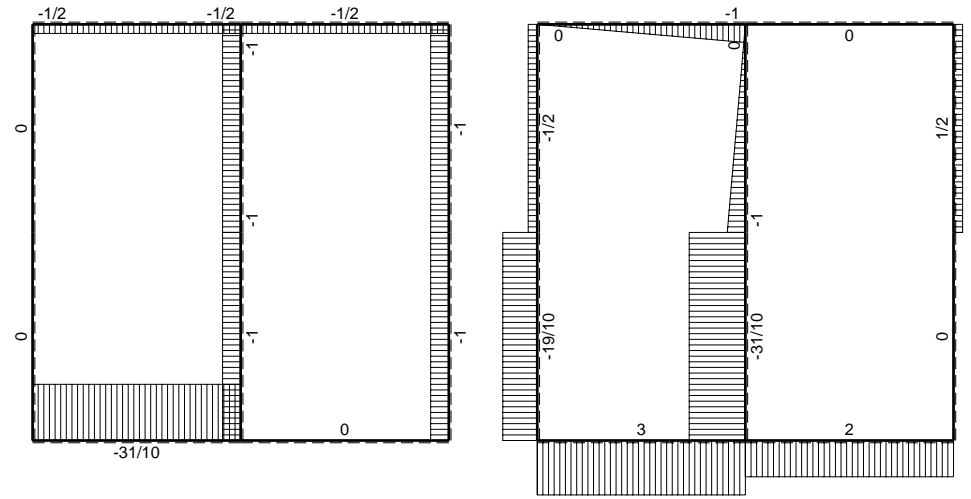
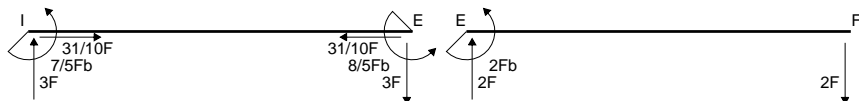
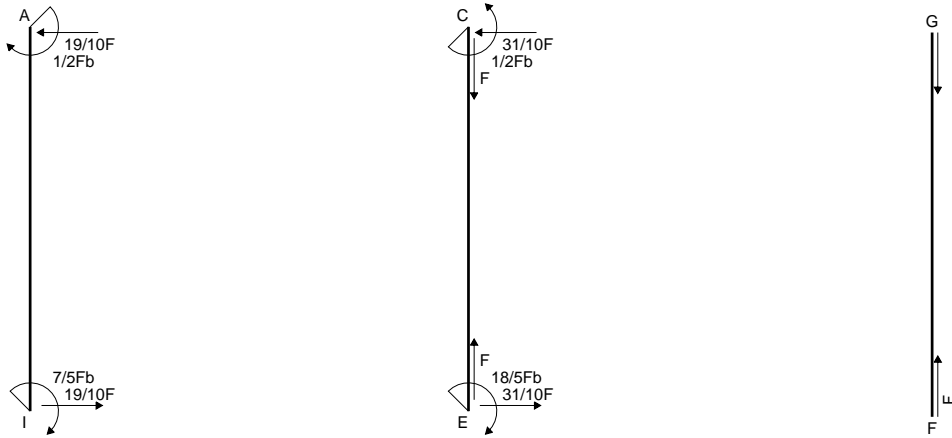
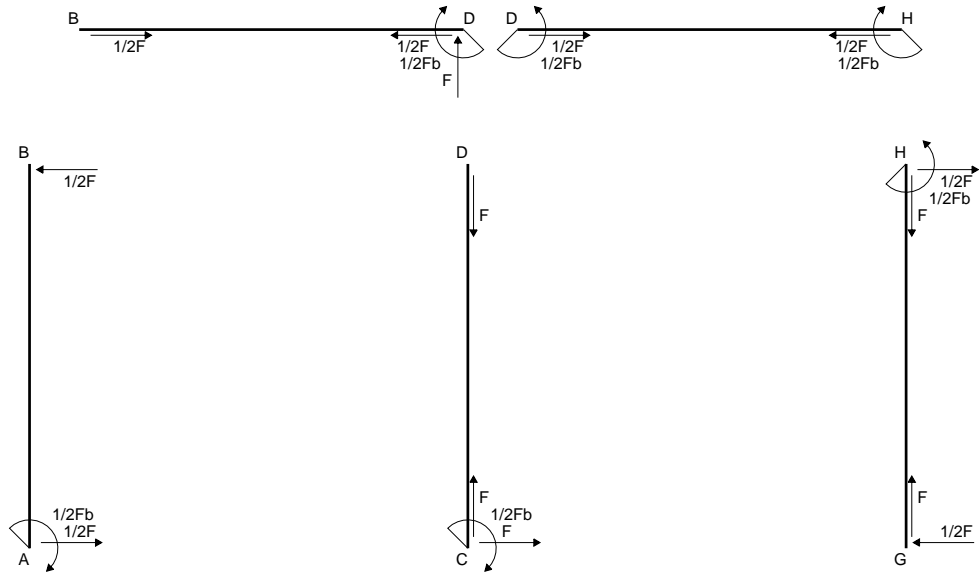
$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



- A = 810. mm²
- J_u = 272218. mm⁴
- J_v = 71982. mm⁴
- y_g = 19.23 mm
- T_y = 1740. N
- M_x = -1809600. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 35.77 mm
- σ_m = -Mv/J_u = 237.8 N/mm²
- x_c = 21. mm
- y_c = 46. mm
- v_c = 26.77 mm
- σ_c = -Mv/J_u = 177.9 N/mm²
- τ_c = 4.686 N/mm²
- σ_q = √σ²+3τ² = 178.1 N/mm²
- S = 4399. mm³



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

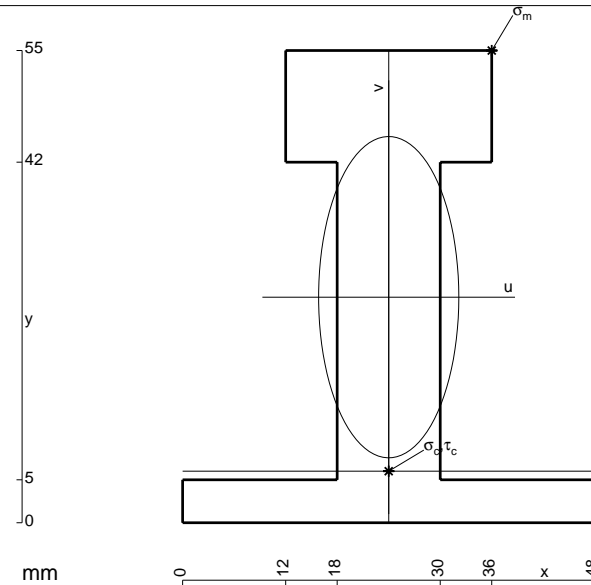
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

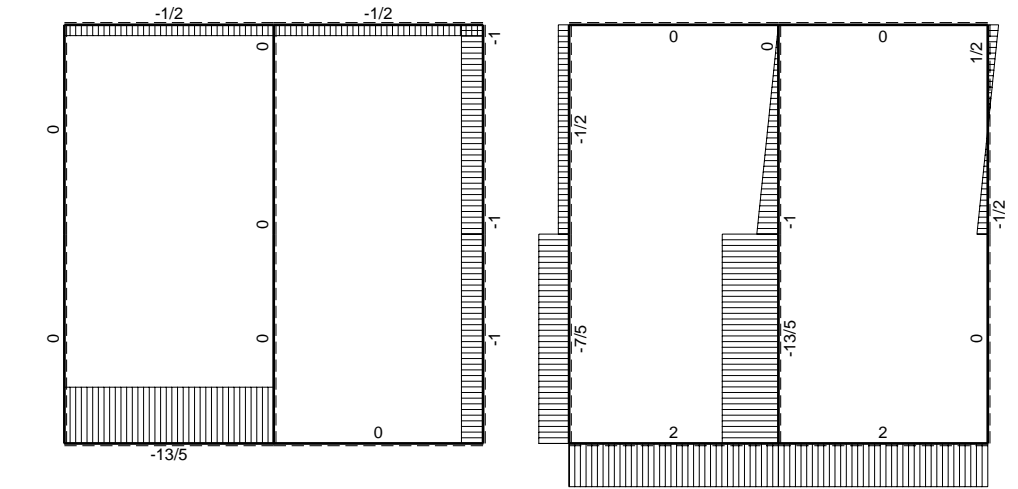
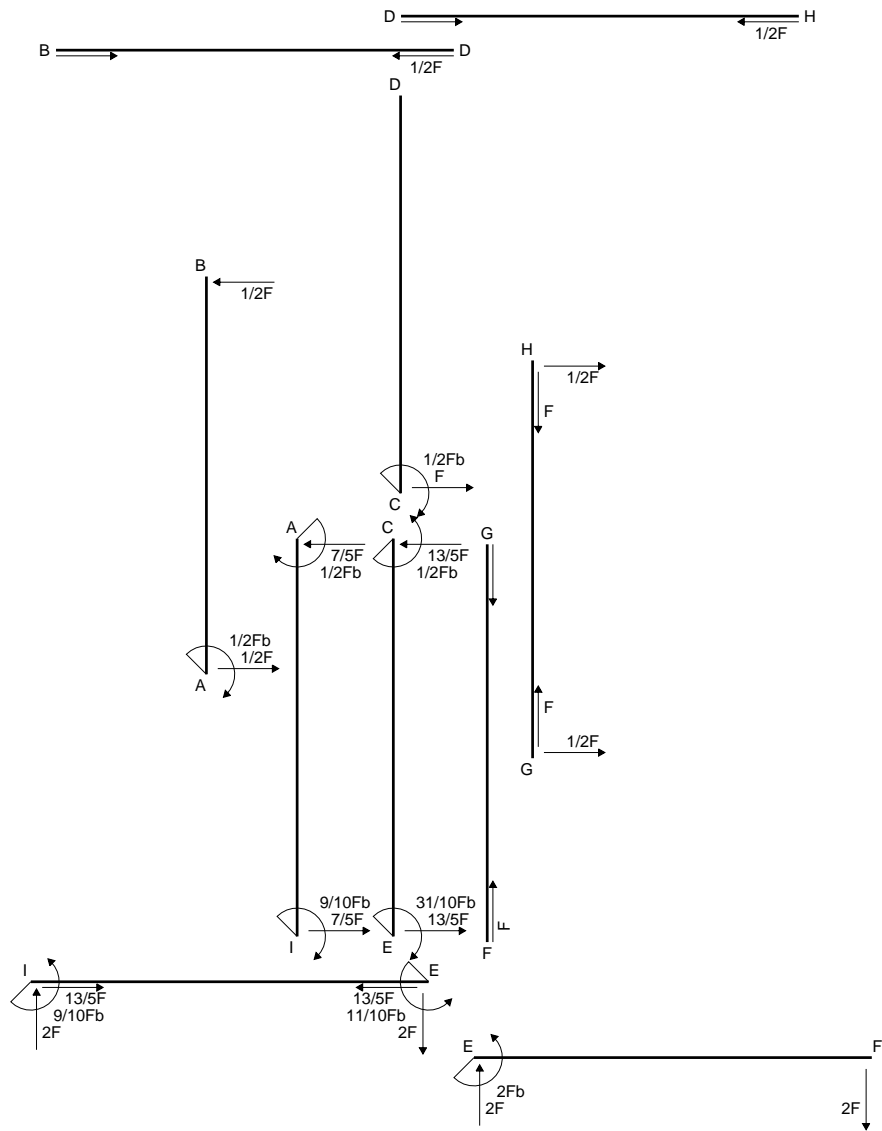
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

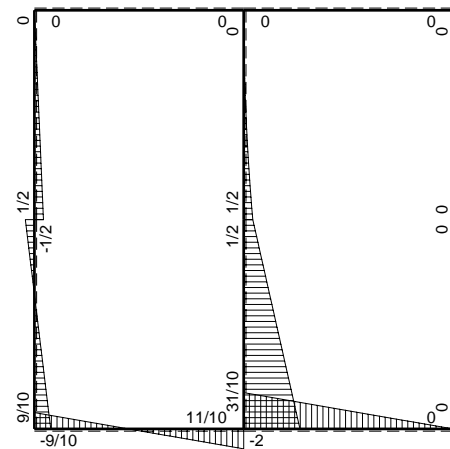


- A = 996. mm²
- J_u = 348739. mm⁴
- J_v = 66384. mm⁴
- y_g = 26.27 mm
- T_y = 4400. N
- M_x = -2420000. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 28.73 mm
- σ_m = -Mv/J_u = 199.4 N/mm²
- x_c = 24. mm
- y_c = 6. mm
- v_c = -20.27 mm
- σ_c = -Mv/J_u = -140.7 N/mm²
- τ_c = 6.26 N/mm²
- σ_q = √σ² + 3τ² = 141.1 N/mm²
- S = 5954. mm³

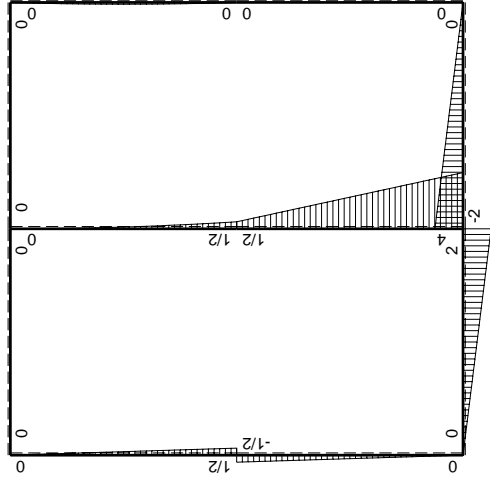
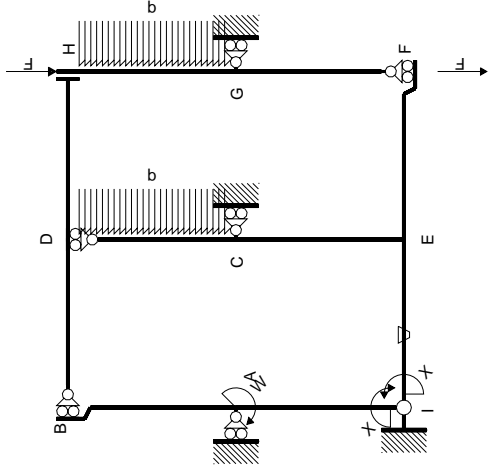


← ⊕ → F

↑ ⊕ ↓ F

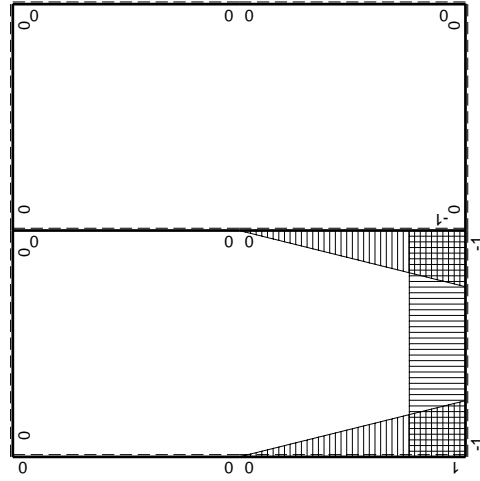


⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

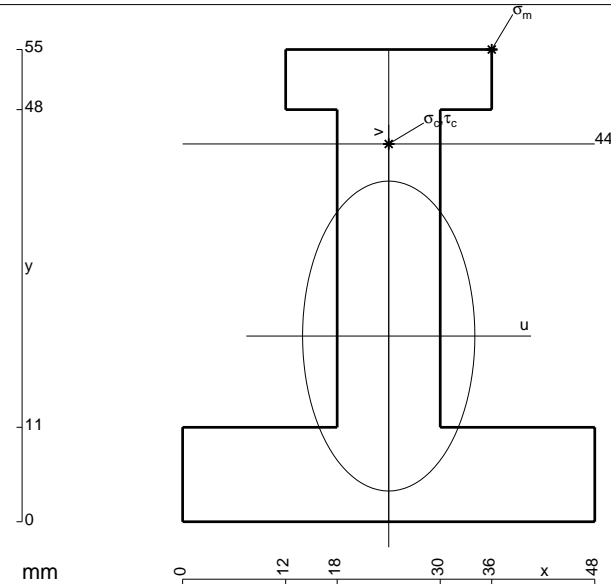
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1140. \text{ mm}^2$$

$$J_u = 371429. \text{ mm}^4$$

$$J_v = 114768. \text{ mm}^4$$

$$y_g = 21.63 \text{ mm}$$

$$T_y = 3880. \text{ N}$$

$$M_x = -2328000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 33.37 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.2 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

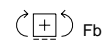
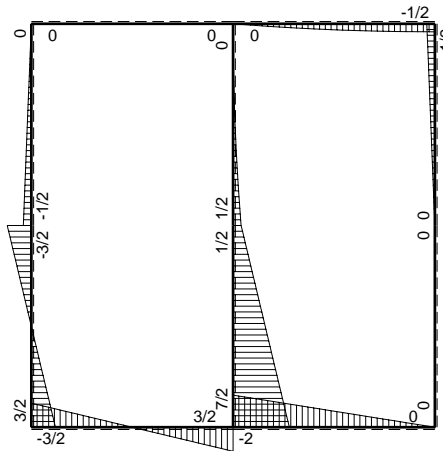
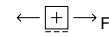
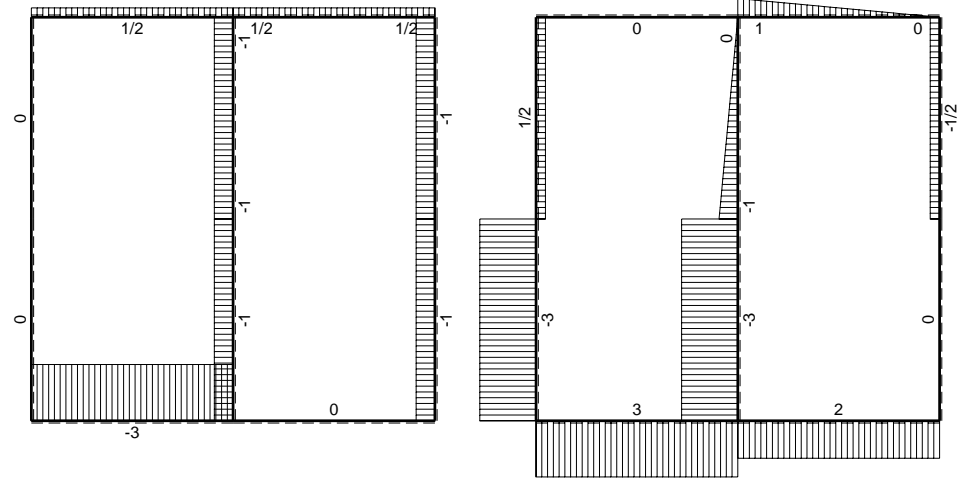
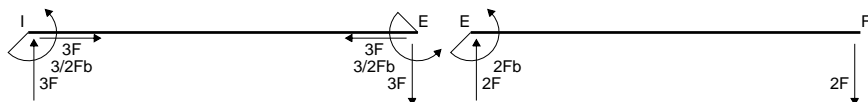
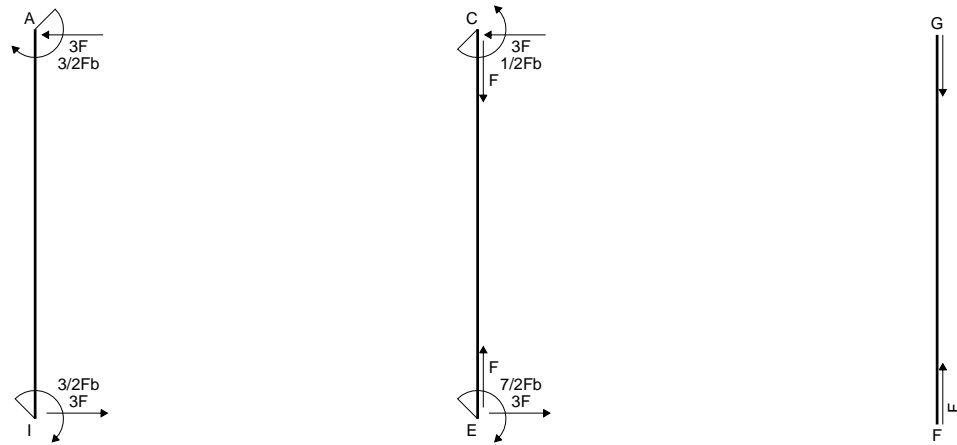
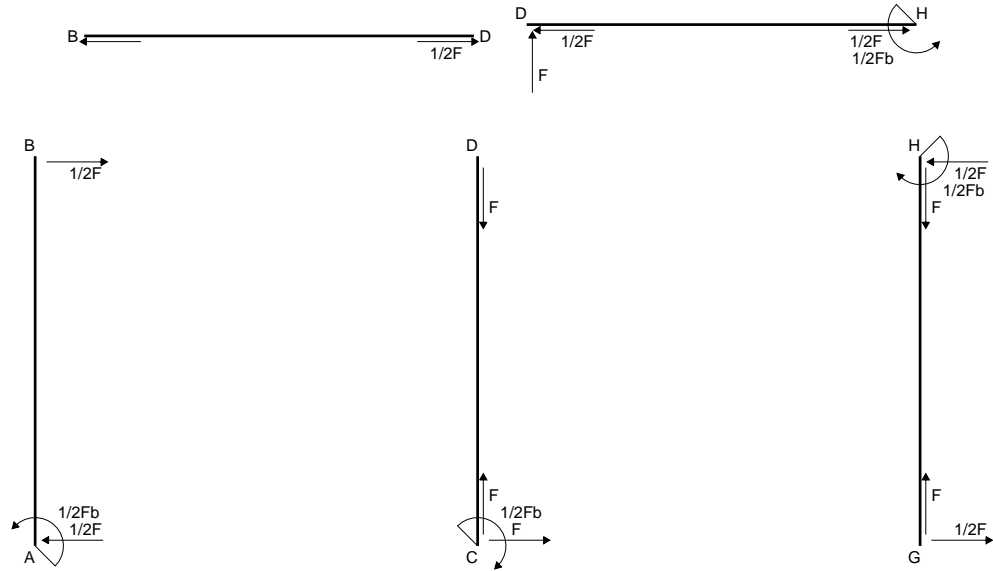
$$v_c = 22.37 \text{ mm}$$

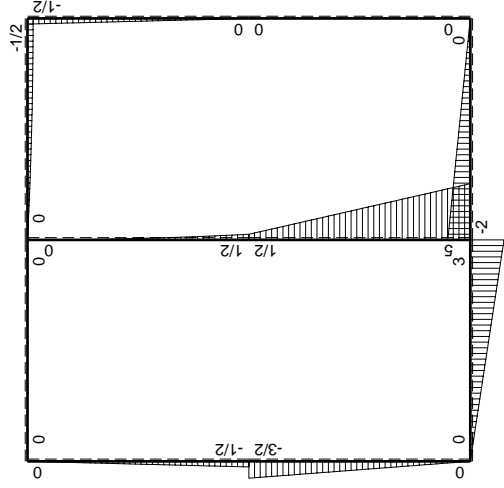
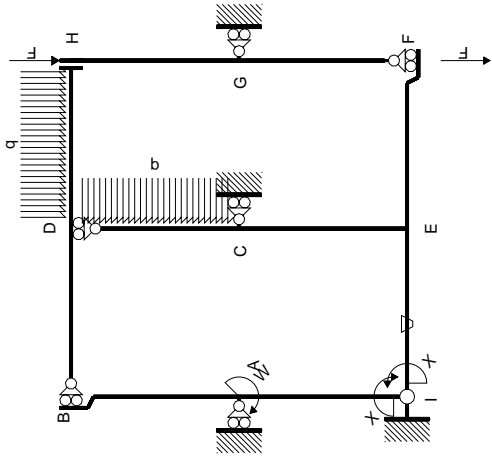
$$\sigma_c = -Mv/J_u = 140.2 \text{ N/mm}^2$$

$$\tau_c = 5.387 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 140.5 \text{ N/mm}^2$$

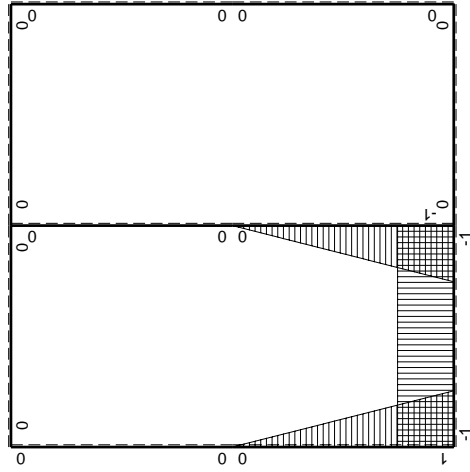
$$S = 6189. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 19/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

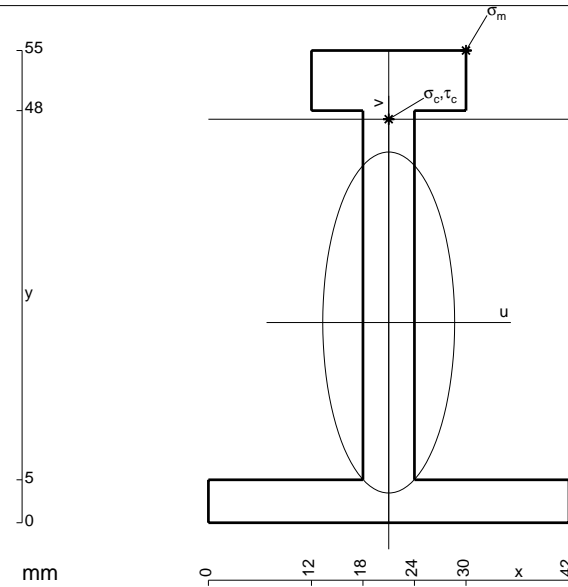
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

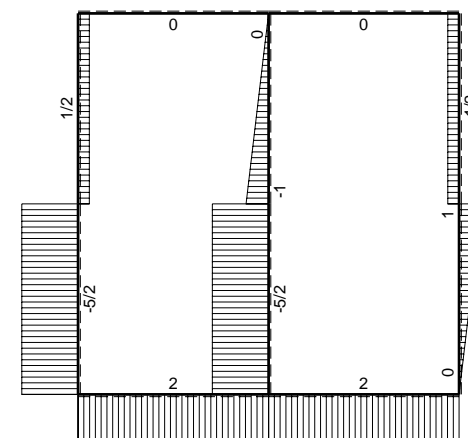
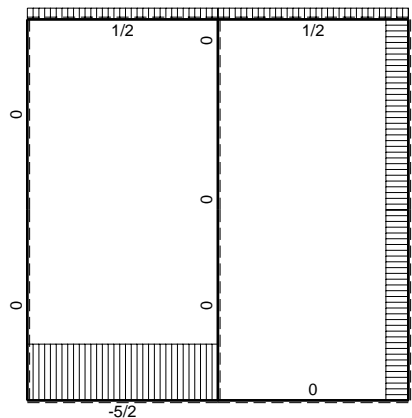
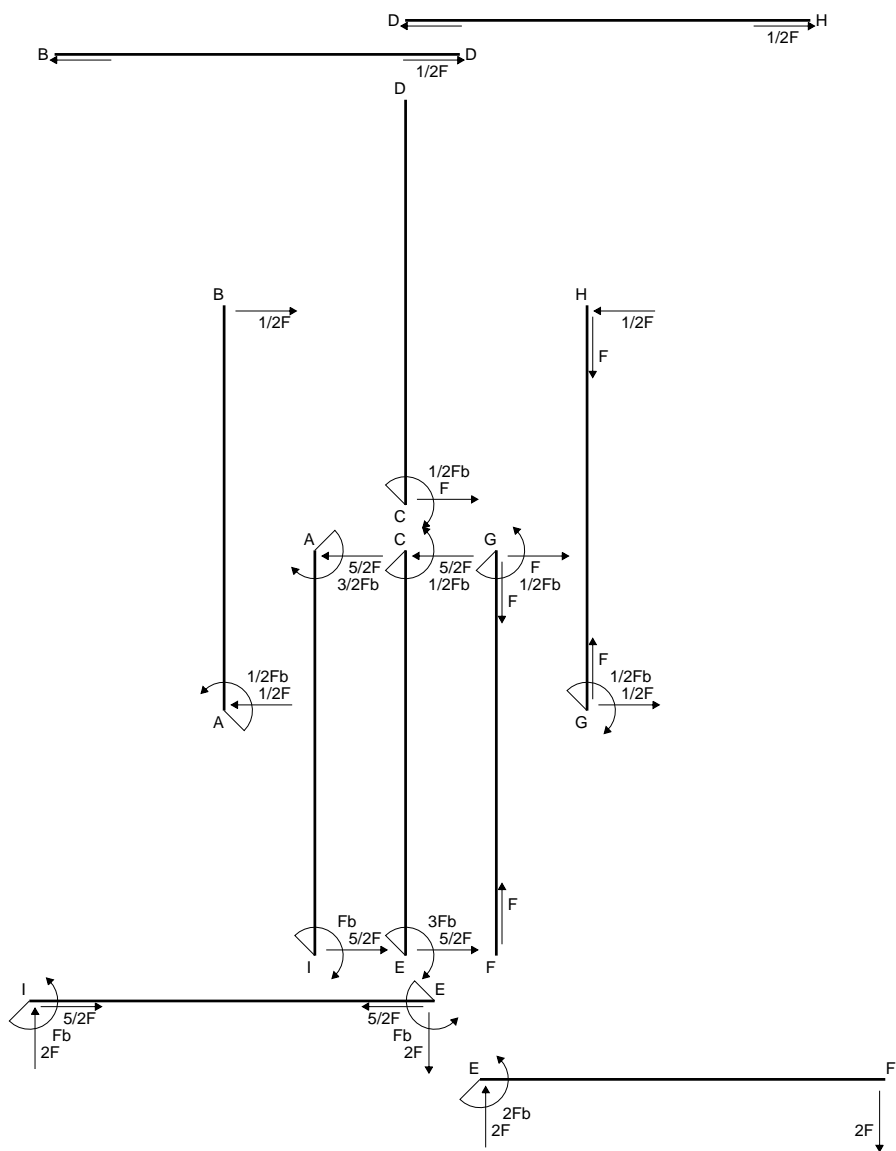
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

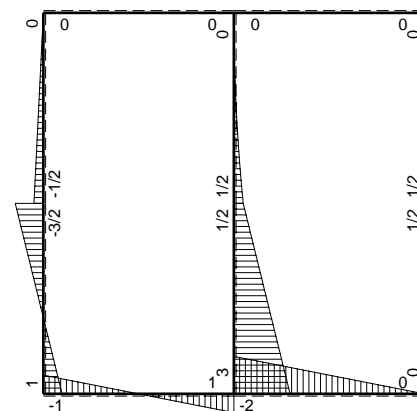


- A = 594. mm²
- J_u = 234402. mm⁴
- J_v = 35046. mm⁴
- y_g = 23.32 mm
- T_y = 2460. N
- M_x = -1623600. Nmm
- x_m = 30. mm
- y_m = 55. mm
- u_m = 9. mm
- v_m = 31.68 mm
- σ_m = -Mv/J_u = 219.4 N/mm²
- x_c = 21. mm
- y_c = 47. mm
- v_c = 23.68 mm
- σ_c = -Mv/J_u = 164. N/mm²
- τ_c = 6.465 N/mm²
- σ_q = √σ²+3τ² = 164.4 N/mm²
- S = 3696. mm³

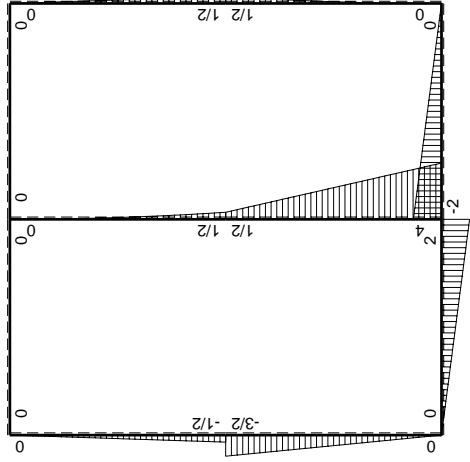
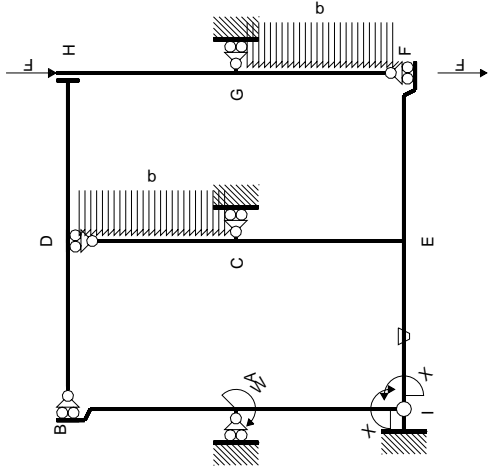


← ⊕ → F

↑ ⊕ ↓ F

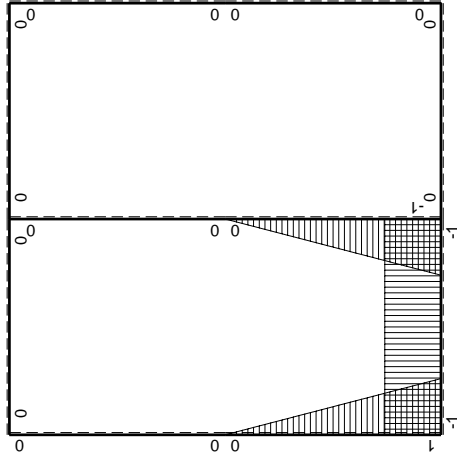


⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 15/4 x^2/b - 7/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b - 7/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

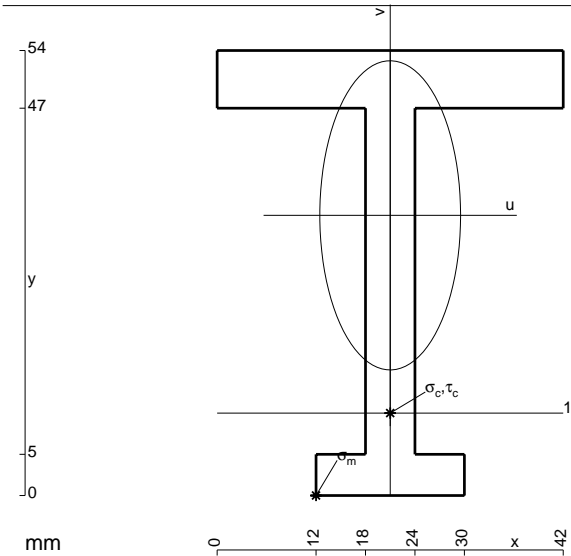
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

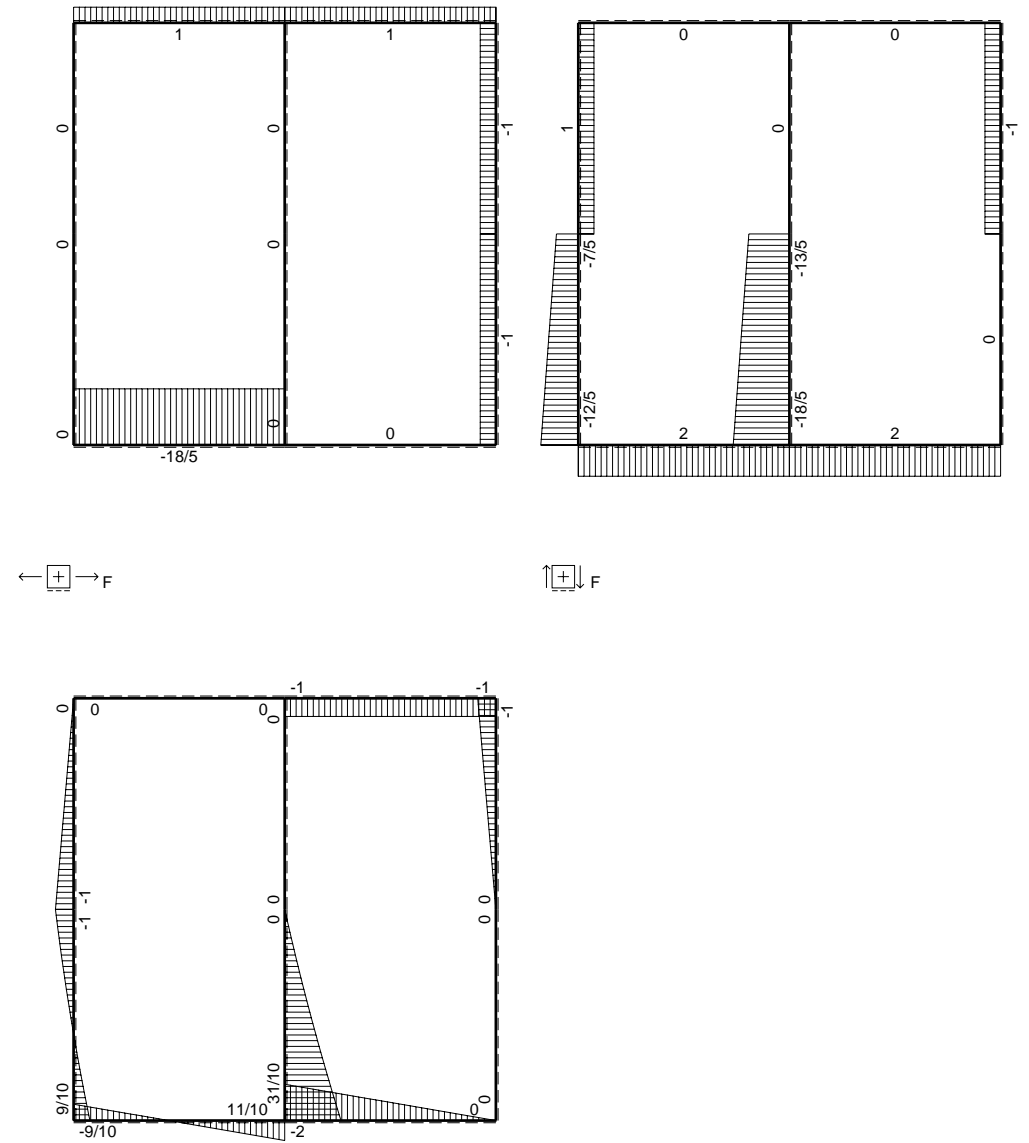
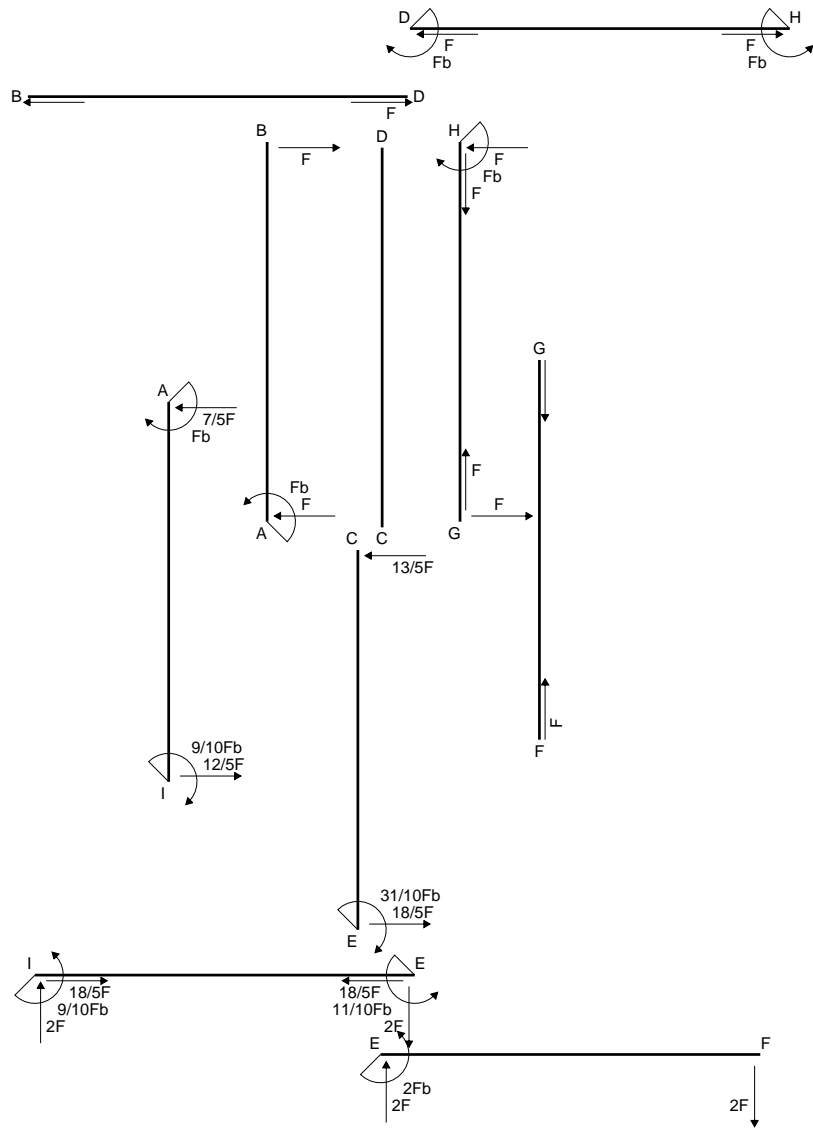
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 1/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

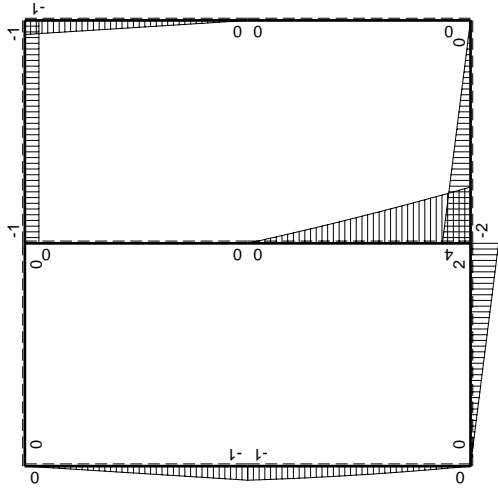
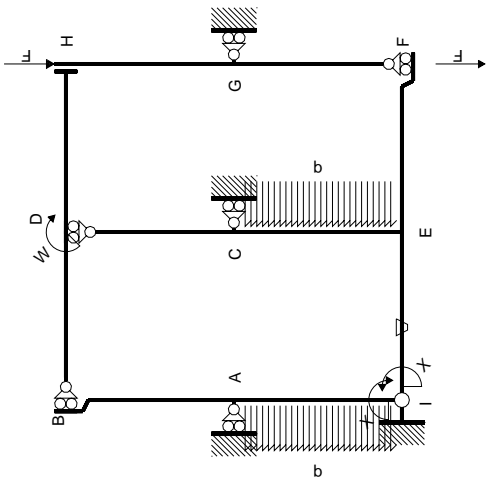
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



- A = 636. mm²
- J_u = 223904. mm⁴
- J_v = 46404. mm⁴
- y_g = 34. mm
- T_y = 2160. N
- M_x = -1512000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -34. mm
- σ_m = -Mv/J_u = -229.6 N/mm²
- x_c = 21. mm
- y_c = 10. mm
- v_c = -24. mm
- σ_c = -Mv/J_u = -162.1 N/mm²
- τ_c = 5.836 N/mm²
- σ_o = √σ_c² + 3τ_c² = 162.4 N/mm²
- S = 3630. mm³

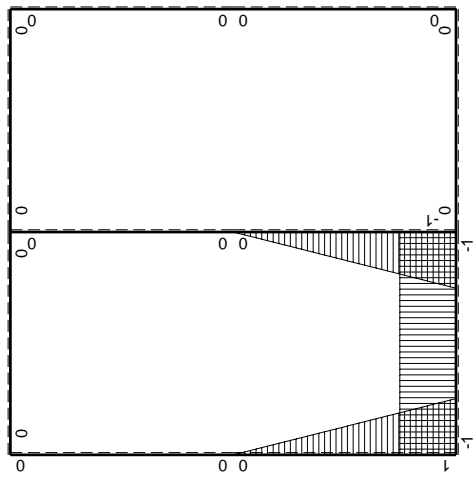


⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	-Fb+Fx	0	0	0	0	0+0	0	
BA b	0	Fx	0	0	0	0			
CD b	0	0	0	0	0	0	0+0	0	
DC b	0	0	0	0	0	0			
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0	
FE b	0	2Fx	0	0	0	0			
FG b	0	0	0	0	0	0	0+0	0	
GF b	0	0	0	0	0	0			
GH b	0	-Fx	0	0	0	0	0+0	0	
HG b	0	Fb-Fx	0	0	0	0			
HD b	0	-Fb	0	0	0	0	0+0	0	
DH b	0	Fb	0	0	0	0			
DB b	0	0	0	0	0	0	0+0	0	
BD b	0	0	0	0	0	0			
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ	
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1			
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	1/3Xb/EJ	
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2			
IA b	$1-x/b$	$-3/2Fx+1/2qx^2$	0	$-3/2Fx+2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-5/24+0)Fb^2/EJ$	1/3Xb/EJ	
AI b	$-x/b$	$Fb-1/2Fx-1/2qx^2$	0	$-Fx+1/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2			
	totali							$-3/2Fb^2/EJ$	5/3Xb/EJ
	iperstatica $X=W_{IE}$							9/10Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= [-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-7/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

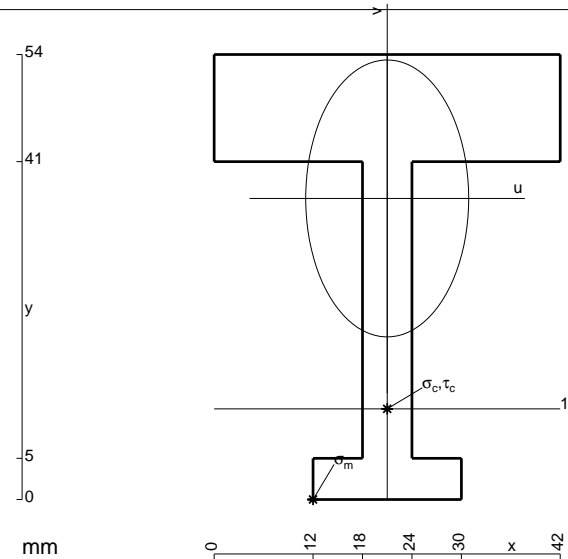
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 2x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 2/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

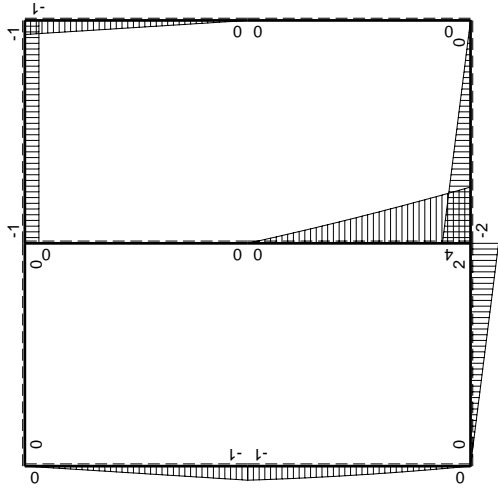
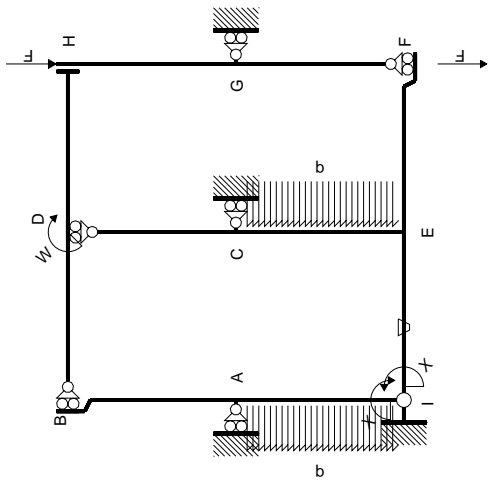
$$= (-3/4 b + 2/3 b - 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + 1/2 x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/6 b + 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

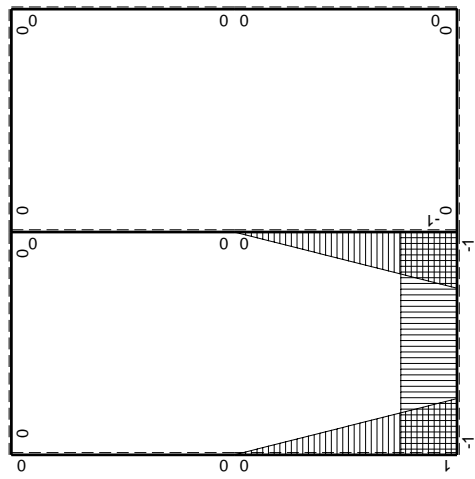


- A = 852. mm²
- J_u = 240676. mm⁴
- J_v = 83340. mm⁴
- y_g = 36.54 mm
- T_y = 2100. N
- M_x = -1575000. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -36.54 mm
- σ_m = -Mv/J_u = -239.1 N/mm²
- x_c = 21. mm
- y_c = 11. mm
- v_c = -25.54 mm
- σ_c = -Mv/J_u = -167.1 N/mm²
- τ_c = 5.948 N/mm²
- σ_o = √σ²+3τ² = 167.4 N/mm²
- S = 4090. mm³



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-Fx	0	0	0	0	0+0	0
HG b	0	Fb-Fx	0	0	0	0		
HD b	0	-Fb	0	0	0	0	0+0	0
DH b	0	Fb	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	1/3Xb/EJ
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx+1/2qx^2$	0	$-3/2Fx+2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-5/24+0)Fb^2/EJ$	1/3Xb/EJ
AI b	$-x/b$	$Fb-1/2Fx-1/2qx^2$	0	$-Fx+1/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	5/3Xb/EJ
	iperstatica $X=W_{IE}$						9/10Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= [-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-7/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

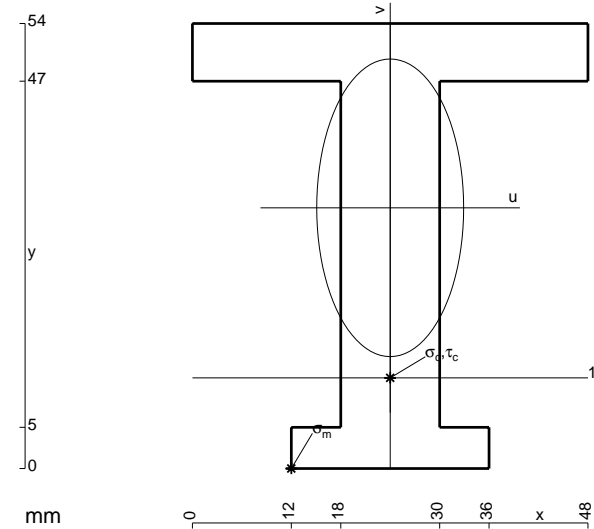
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 2x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-3/4 x^2/b + 2/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

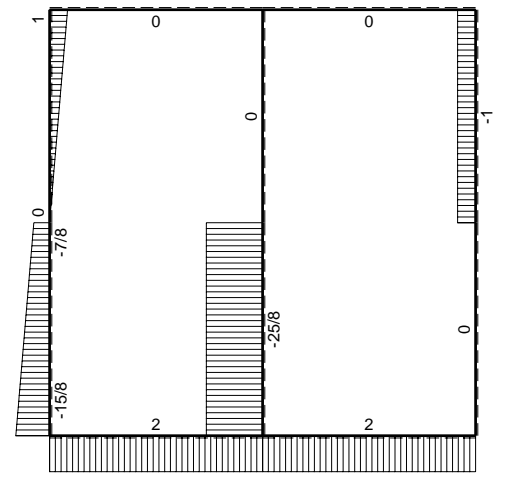
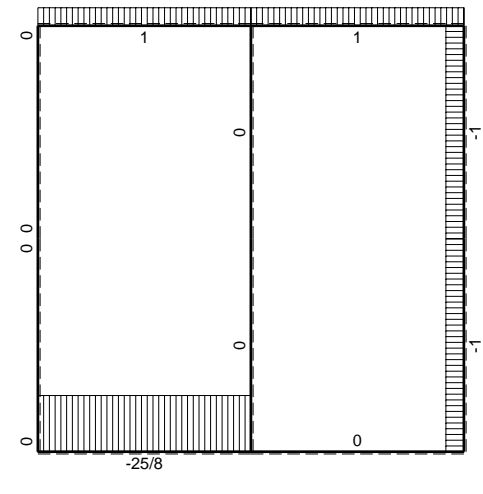
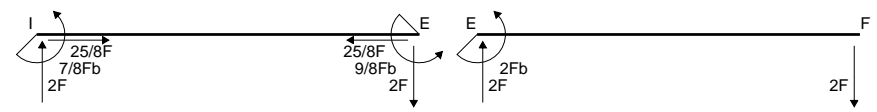
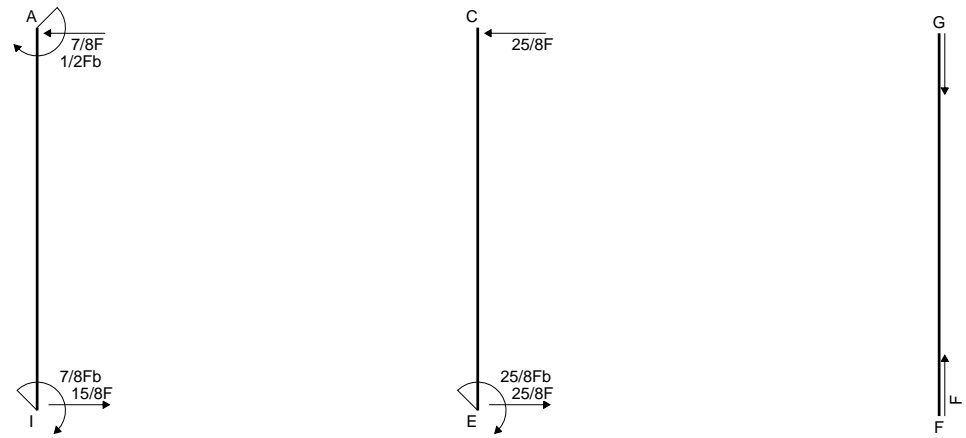
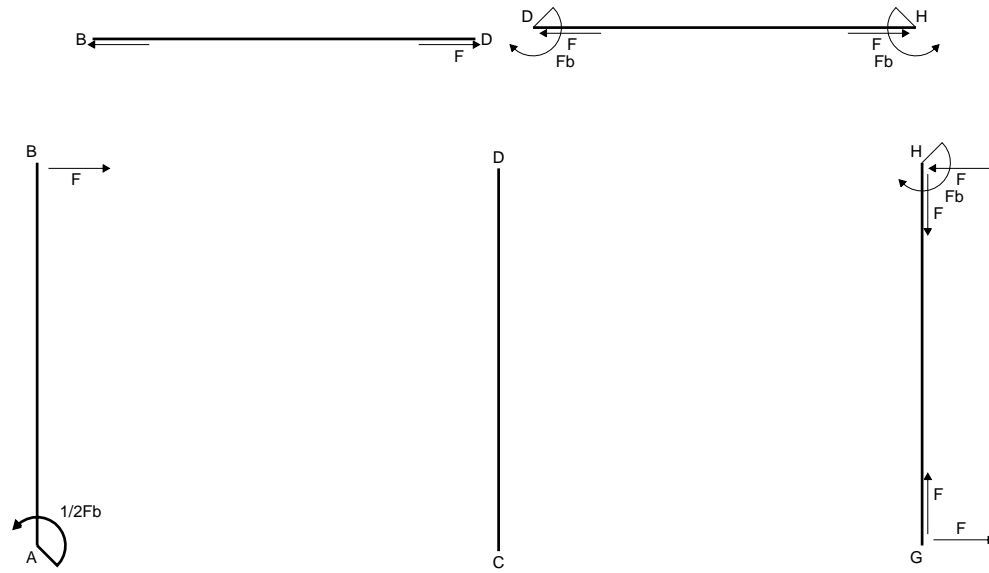
$$= (-3/4 b + 2/3 b - 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + 1/2 x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/6 b + 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

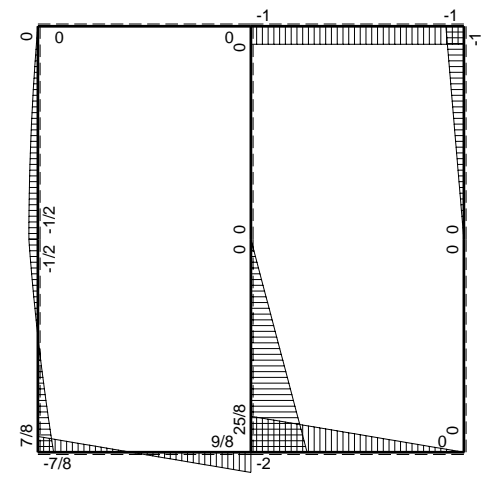


- A = 960. mm²
- J_u = 313154. mm⁴
- J_v = 76320. mm⁴
- y_g = 31.64 mm
- T_y = 2440. N
- M_x = -1976400. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -31.64 mm
- σ_m = -Mv/J_u = -199.7 N/mm²
- x_c = 24. mm
- y_c = 11. mm
- v_c = -20.64 mm
- σ_c = -Mv/J_u = -130.2 N/mm²
- τ_c = 3.375 N/mm²
- σ_o = √σ²+3τ² = 130.4 N/mm²
- S = 5198. mm³

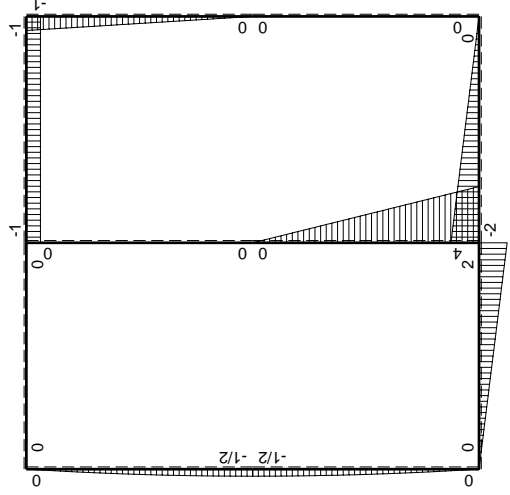
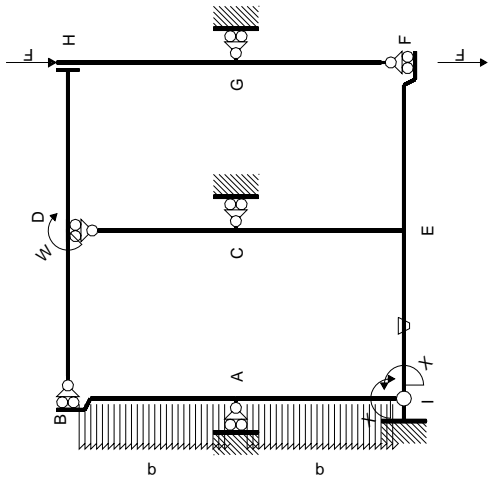


← ⊕ → F

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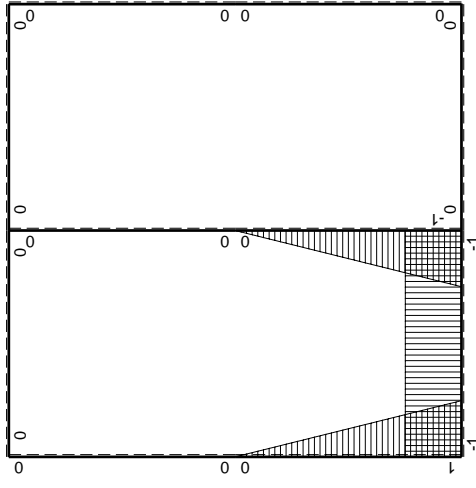


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx$	0	0	0	0	0+0	0
HG b	0	$Fb-Fx$	0	0	0	0		
HD b	0	$-Fb$	0	0	0	0	0+0	0
DH b	0	Fb	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

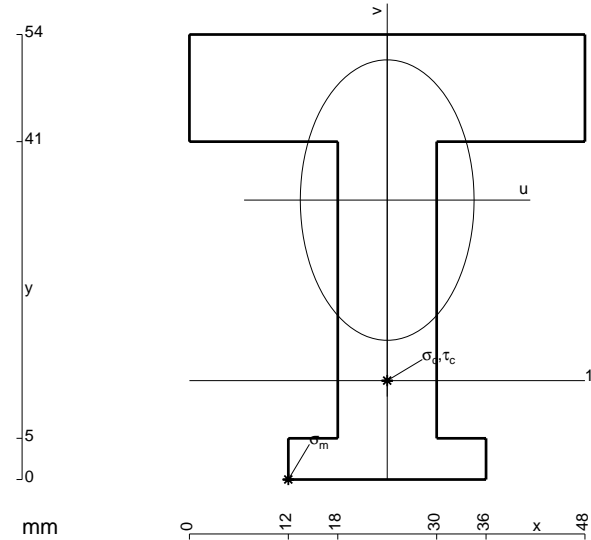
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

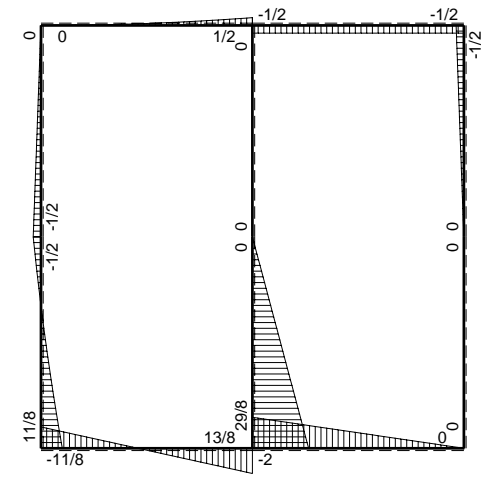
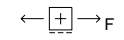
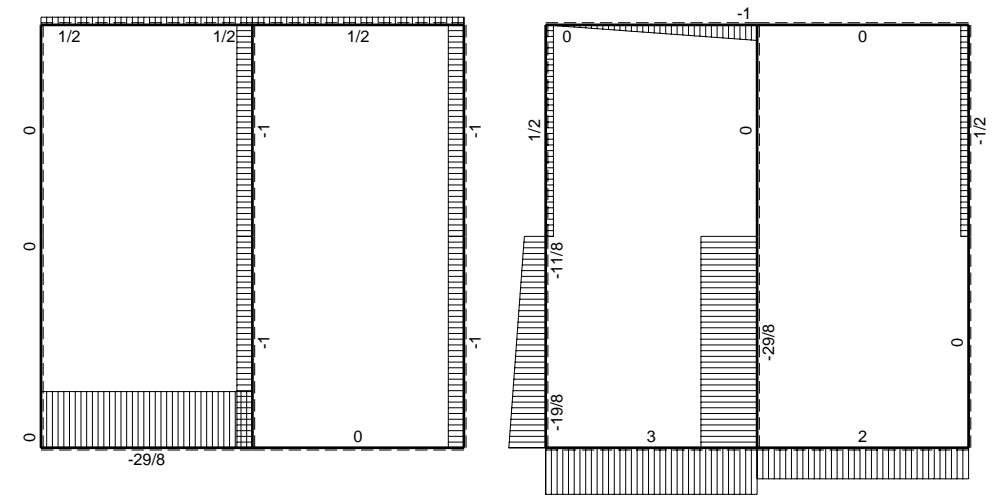
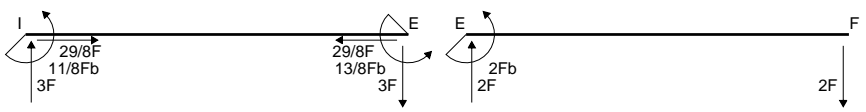
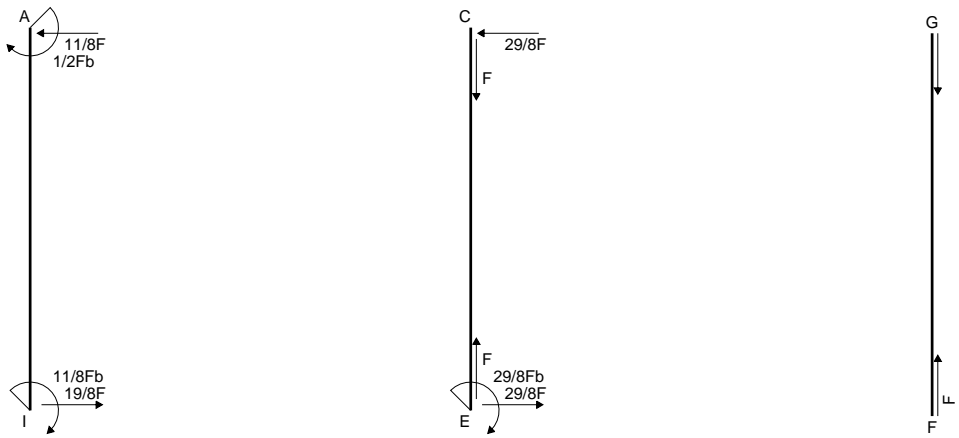
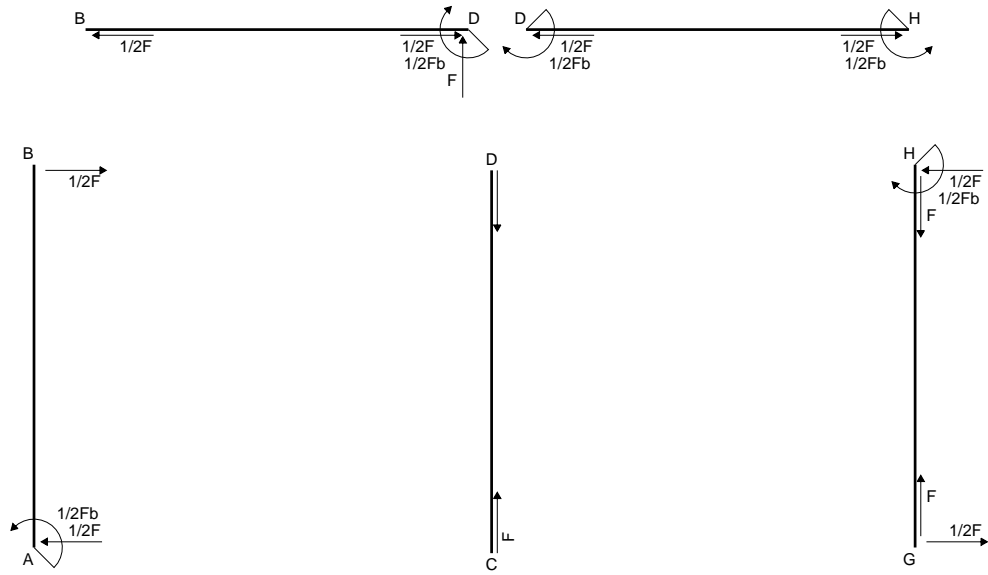
$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

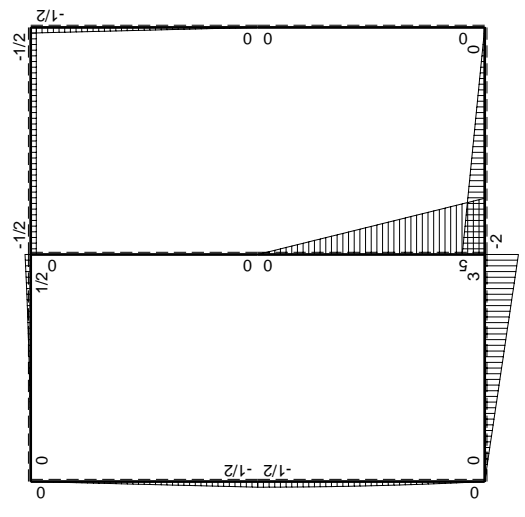
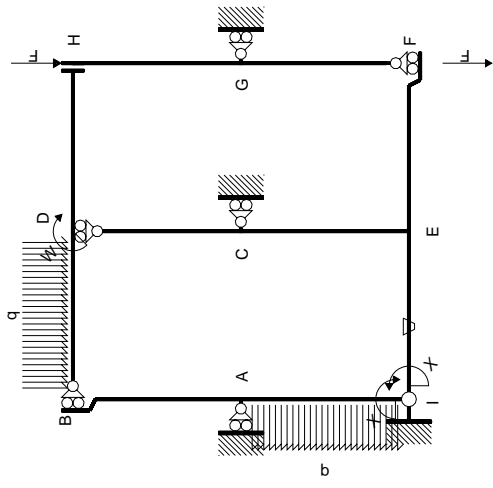
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



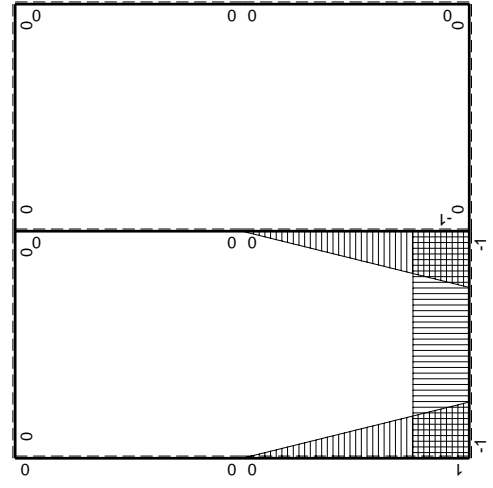
- A = 1176. mm²
- J_u = 340750. mm⁴
- J_v = 130752. mm⁴
- y_g = 33.91 mm
- T_y = 2440. N
- M_x = -2098400. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -33.91 mm
- σ_m = -Mv/J_u = -208.8 N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -21.91 mm
- σ_c = -Mv/J_u = -134.9 N/mm²
- τ_c = 3.523 N/mm²
- σ_o = √σ²+3τ² = 135.1 N/mm²
- S = 5903. mm³





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb$	0	0	0	0	0+0	0
DH b	0	$1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fb+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-3x + 3/2 x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 5x^2/b - 5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = [-5/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

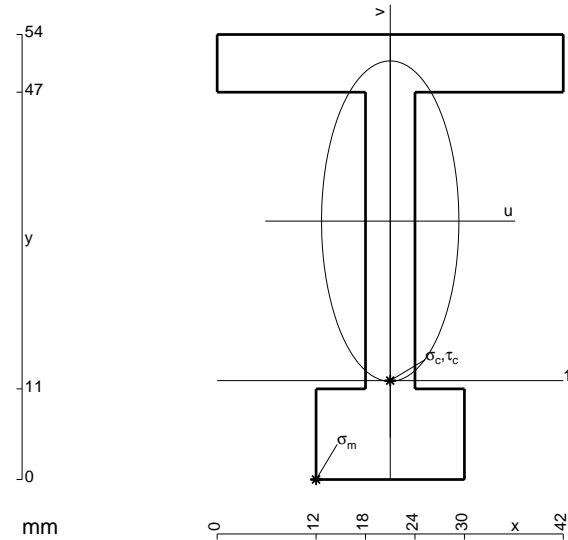
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

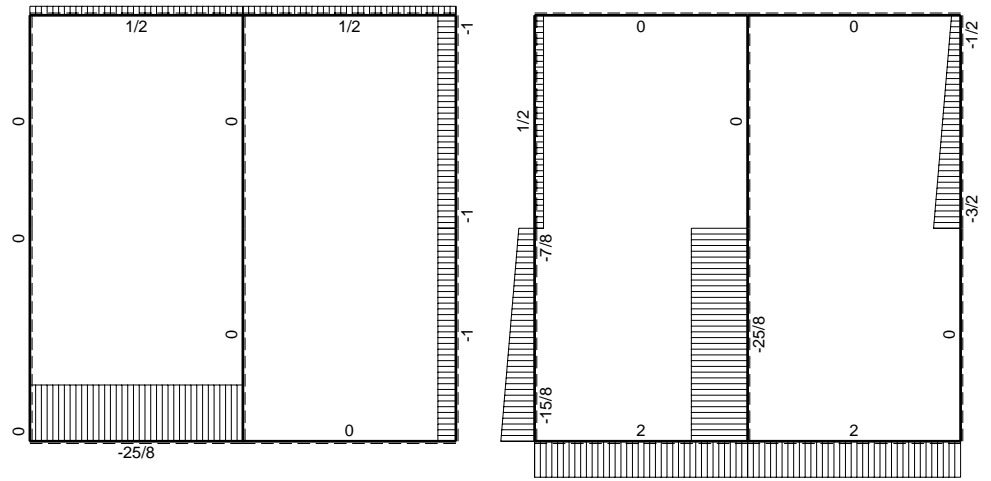
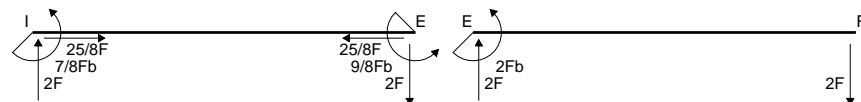
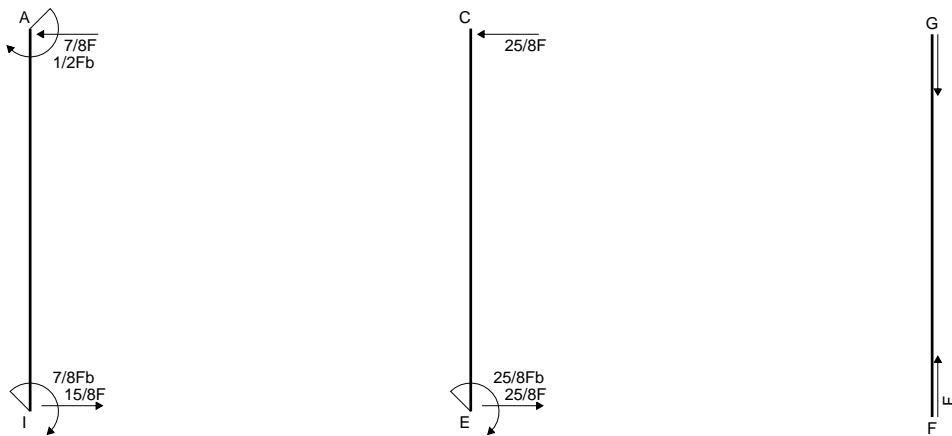
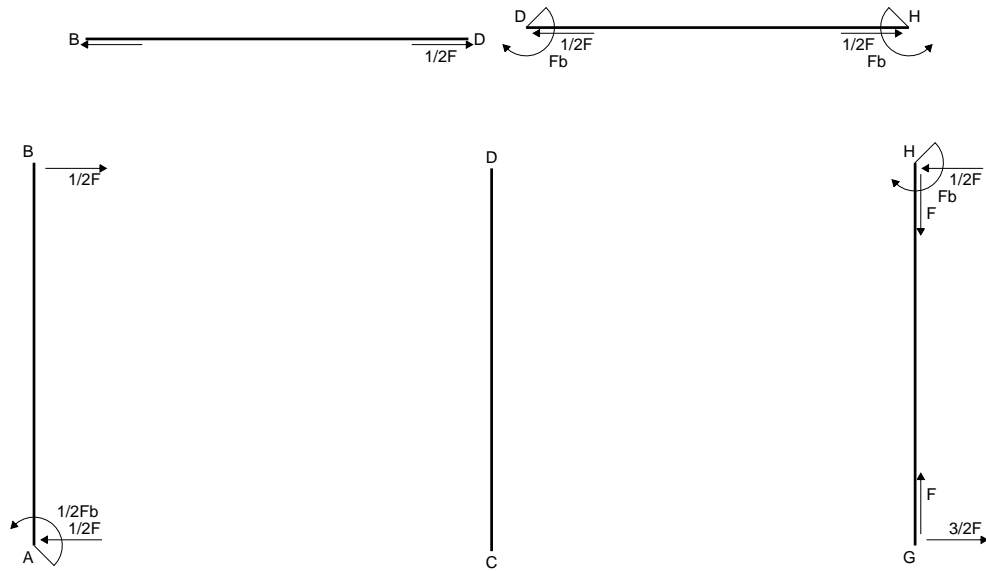
$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

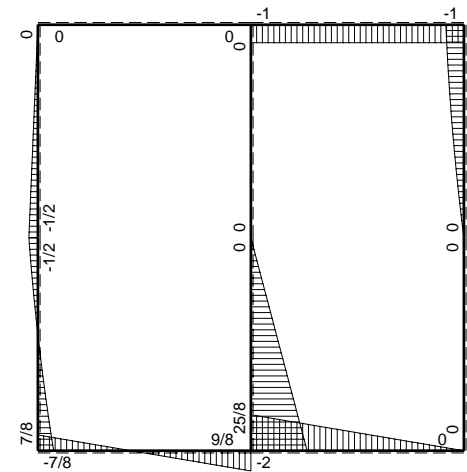


- A = 708. mm²
- J_u = 267842. mm⁴
- J_v = 49212. mm⁴
- y_g = 31.36 mm
- T_y = 2060. N
- M_x = -1874600. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -31.36 mm
- σ_m = -Mv/J_u = -219.5 N/mm²
- x_c = 21. mm
- y_c = 12. mm
- v_c = -19.36 mm
- σ_c = -Mv/J_u = -135.5 N/mm²
- τ_c = 6.715 N/mm²
- σ_q = √(σ² + 3τ²) = 136. N/mm²
- S = 5239. mm³



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	-1/2Fb+1/2Fx	0	0	0	0	0+0	0
BA b	0	1/2Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-3/2Fx+1/2qx ²	0	0	0	0	0+0	0
HG b	0	Fb-1/2Fx-1/2qx ²	0	0	0	0		
HD b	0	-Fb	0	0	0	0	0+0	0
DH b	0	Fb	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	(-1+1)Fb ² /EJ	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	-1+x/b	4Fb-4Fx	0	-4Fb+8Fx-4Fx ² /b	0	1-2x/b+x ² /b ²	(-4/3+0)Fb ² /EJ	1/3Xb/EJ
CE b	x/b	-4Fx	0	-4Fx ² /b	0	x ² /b ²		
IA b	1-x/b	-Fx+1/2qx ²	0	-Fx+3/2Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(-1/8+0)Fb ² /EJ	1/3Xb/EJ
AI b	-x/b	1/2Fb-1/2qx ²	0	-1/2Fx+1/2qx ³ /b	0	x ² /b ²		
	totali						-35/24Fb ² /EJ	5/3Xb/EJ
	iperstatica $X=W_{IE}$						7/8Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-x^2/b]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = [-2x + x^2/b]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = [-4x + 4x^2/b - 4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = [-4/3 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

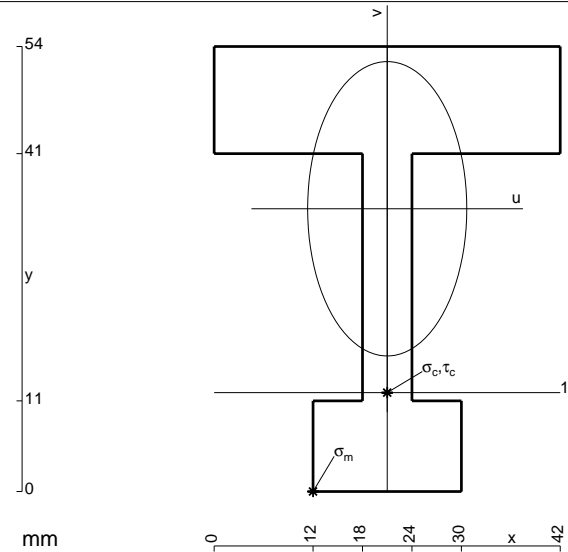
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/8 x^4/b^3]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 924. \text{ mm}^2$$

$$J_u = 294950. \text{ mm}^4$$

$$J_v = 86148. \text{ mm}^4$$

$$y_g = 34.31 \text{ mm}$$

$$T_y = 2020. \text{ N}$$

$$M_x = -1959400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.31 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -227.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

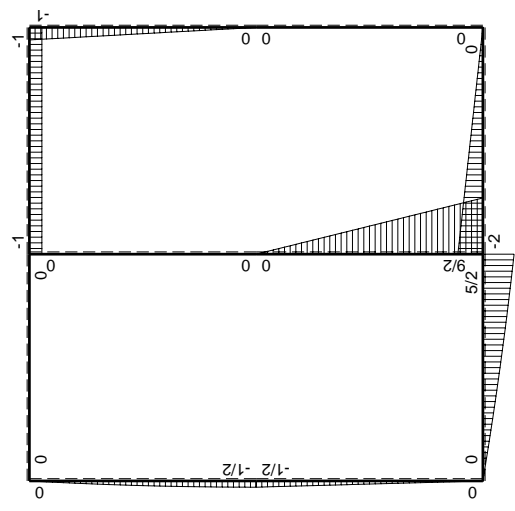
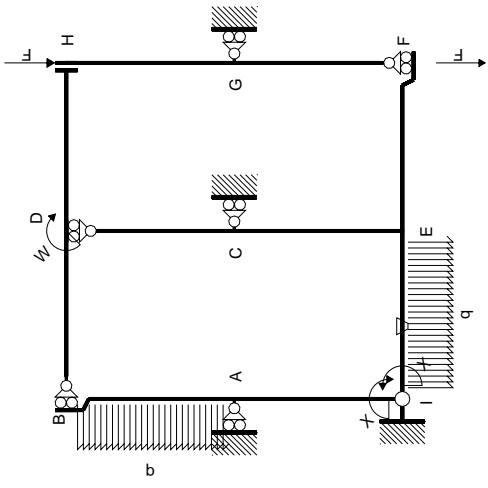
$$v_c = -22.31 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -148.2 \text{ N/mm}^2$$

$$\tau_c = 6.668 \text{ N/mm}^2$$

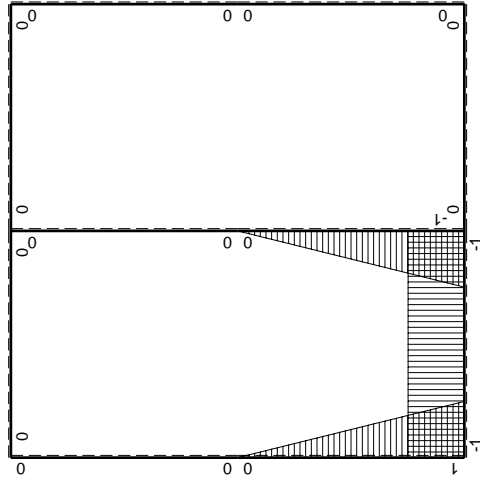
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 148.7 \text{ N/mm}^2$$

$$S = 5842. \text{ mm}^3$$



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx$	0	0	0	0	0+0	0
HG b	0	$Fb-Fx$	0	0	0	0		
HD b	0	$-Fb$	0	0	0	0	0+0	0
DH b	0	Fb	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = [x]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = [x - x^2/b + 1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = [1/3 x^3/b^2]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = [-3/2 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [x]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= [-5/2 x + x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ} + [-x]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-3/2 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

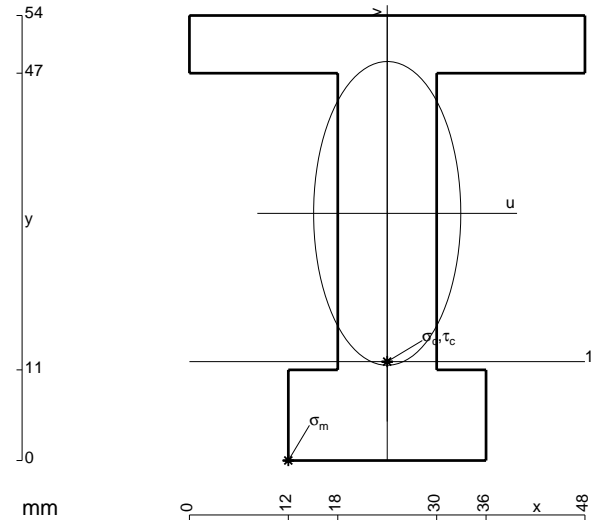
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



- A = 1032. mm²
- J_u = 350792. mm⁴
- J_v = 82368. mm⁴
- y_g = 29.99 mm
- T_y = 2740. N
- M_x = -2794800. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -29.99 mm
- σ_m = -Mv/J_u = -238.9 N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -17.99 mm
- σ_c = -Mv/J_u = -143.3 N/mm²
- τ_c = 4.352 N/mm²
- σ_o = √σ²+3τ² = 143.5 N/mm²
- S = 6687. mm³