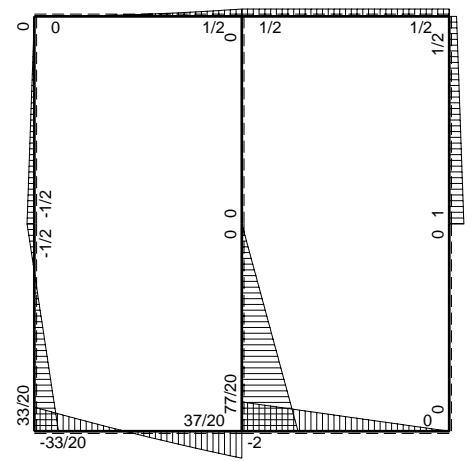
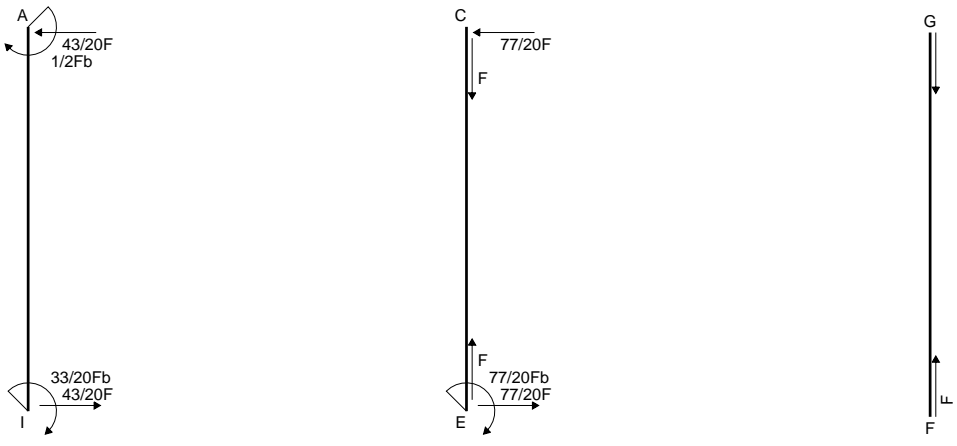
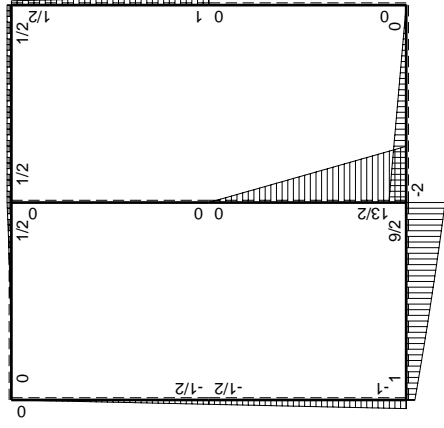
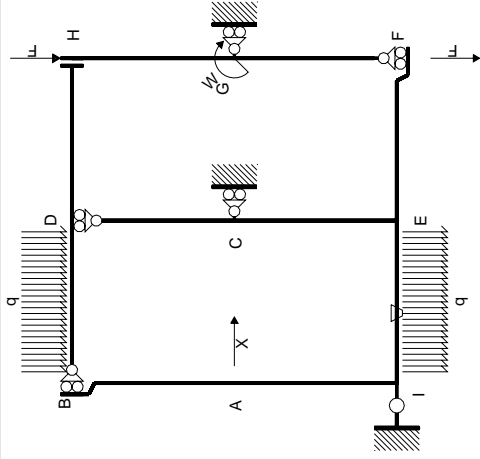


← ⊕ → F

↑ ⊕ ↓ F

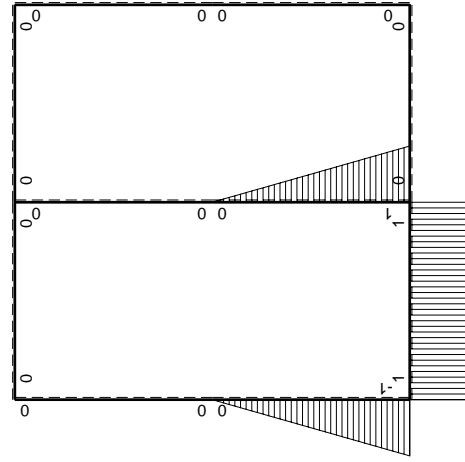


⊕ ⊕ Fb



Schema di calcolo iperstatico

(\oplus) M_0 flessione da carichi assegnati



(\oplus) M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=H_A$

→	$M_x(x)$	$M_o(x)$	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	b	$Fb+4Fx-1/2qx^2$	$-Fb/EJ$	$Fb^2+4Fbx-1/2Fx^2$	$-Fb^2/EJ$	b^2	$(17/6-1)Fb^3/EJ$	Xb^3/EJ
EI b	-b	$-9/2Fb+3Fx+1/2qx^2$	Fb/EJ	$9/2Fb^2-3Fbx-1/2Fx^2$	$-Fb^2/EJ$	b^2		
EC b	b-x	$13/2Fb-13/2Fx$	0	$13/2Fb^2-13Fbx+13/2Fx^2$	0	$b^2-2bx+x^2$	$(13/6+0)Fb^3/EJ$	$1/3Xb^3/EJ$
CE b	-x	$-13/2Fx$	0	$13/2Fx^2$	0	x^2		
IA b	-b+x	$-Fb+1/2Fx$	0	$Fb^2-3/2Fbx+1/2Fx^2$	0	$b^2-2bx+x^2$	$(5/12+0)Fb^3/EJ$	$1/3Xb^3/EJ$
AI b	x	$1/2Fb+1/2Fx$	0	$1/2Fbx+1/2Fx^2$	0	x^2		
	totali						$53/12Fb^3/EJ$	$5/3Xb^3/EJ$
	iperstatica $X=H_A$						$-53/20F$	

Sviluppi di calcolo iperstatica

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$= (b + 2b - 1/6 b) Fb^2 1/EJ + (-b) \theta = 11/6 Fb^3/EJ$$

$$L_{EI}^{xo} = \int_0^b (9/2 - 3x/b - 1/2 x^2/b^2) Fb^2 1/EJ dx + \int_0^b (1) \theta dx$$

$$= [9/2 x - 3/2 x^2/b - 1/6 x^3/b^2]_0^b Fb^2 1/EJ + [x]_0^b \theta$$

$$= (9/2 b - 3/2 b - 1/6 b) Fb^2 1/EJ + (b) \theta = 11/6 Fb^3/EJ$$

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

$$= (13/2 b - 13/2 b + 13/6 b) Fb^2 1/EJ = 13/6 Fb^3/EJ$$

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

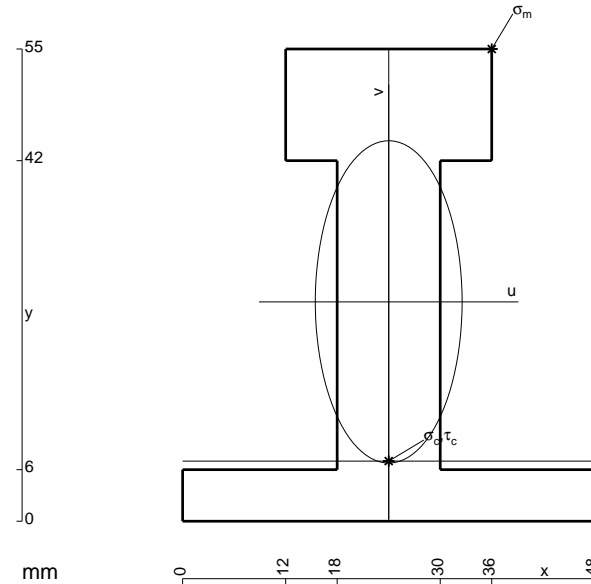
$$= (13/6 b) Fb^2 1/EJ = 13/6 Fb^3/EJ$$

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

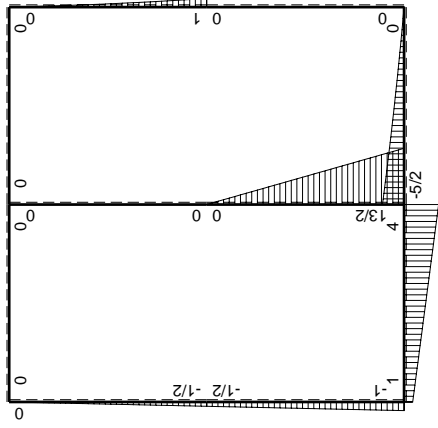
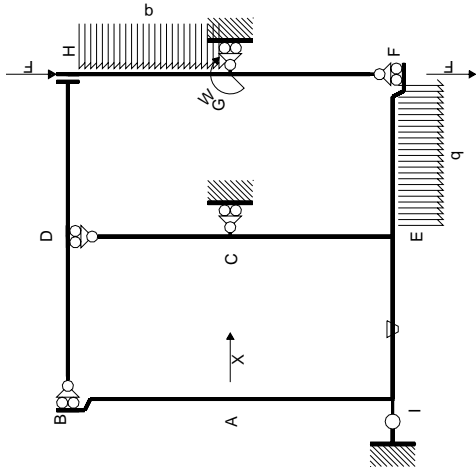
$$= (b - 3/4 b + 1/6 b) Fb^2 1/EJ = 5/12 Fb^3/EJ$$

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

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

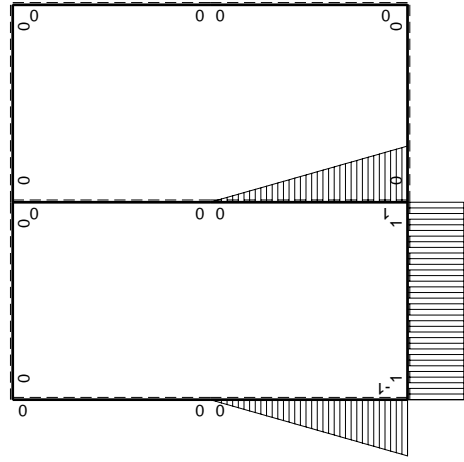


- A = 1032. mm²
- J_u = 363732. mm⁴
- J_v = 75456. mm⁴
- y_g = 25.55 mm
- T_y = 2940. N
- M_x = -2587200. Nmm
- x_m = 36. mm
- y_m = 55. mm
- u_m = 12. mm
- v_m = 29.45 mm
- σ_m = -Mv/J_u = 209.5 N/mm²
- x_c = 24. mm
- y_c = 7. mm
- v_c = -18.55 mm
- σ_c = -Mv/J_u = -131.9 N/mm²
- τ_c = 4.528 N/mm²
- σ_o = √σ²+3τ² = 132.2 N/mm²
- S = 6722. mm³



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica X=H_A

→	M _x (x)	M _o (x)	θ	M _x M _o	M _x θ	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	b	Fb+3Fx	-Fb/EJ	Fb ² +3Fbx	-Fb ² /EJ	b ²	(5/2-1)Fb ³ /EJ	Xb ³ /EJ	
EI b	-b	-4Fb+3Fx	Fb/EJ	4Fb ² -3Fbx	-Fb ² /EJ	b ²			
EC b	b-x	13/2Fb-13/2Fx	0	13/2Fb ² -13Fbx+13/2Fx ²	0	b ² -2bx+x ²	(13/6+0)Fb ³ /EJ	1/3Xb ³ /EJ	
CE b	-x	-13/2Fx	0	13/2Fx ²	0	x ²			
IA b	-b+x	-Fb+1/2Fx	0	Fb ² -3/2Fbx+1/2Fx ²	0	b ² -2bx+x ²	(5/12+0)Fb ³ /EJ	1/3Xb ³ /EJ	
AI b	x	1/2Fb+1/2Fx	0	1/2Fbx+1/2Fx ²	0	x ²			
	totali							49/12Fb ³ /EJ	5/3Xb ³ /EJ
	iperstatica X=H _A							-49/20F	

Sviluppi di calcolo iperstatica

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$= (13/2 b - 13/2 b + 13/6 b) Fb^2 1/EJ = 13/6 Fb^3/EJ$$

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

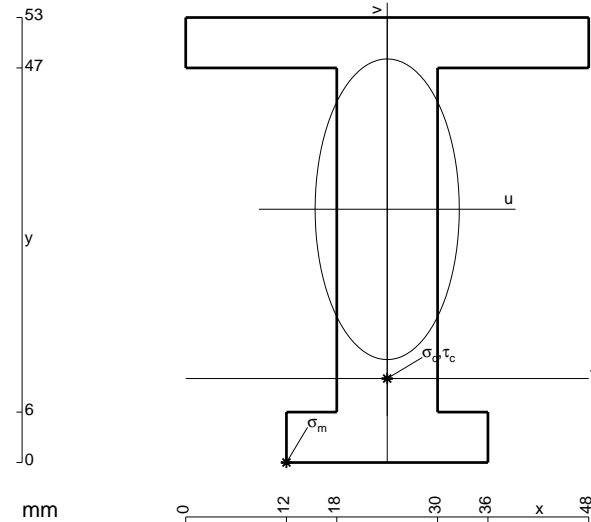
$$= (13/6 b) Fb^2 1/EJ = 13/6 Fb^3/EJ$$

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

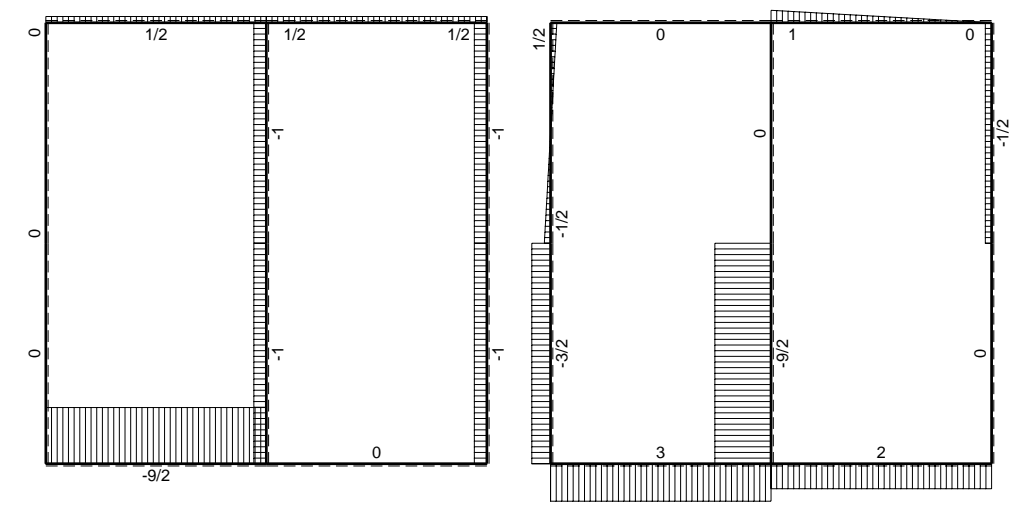
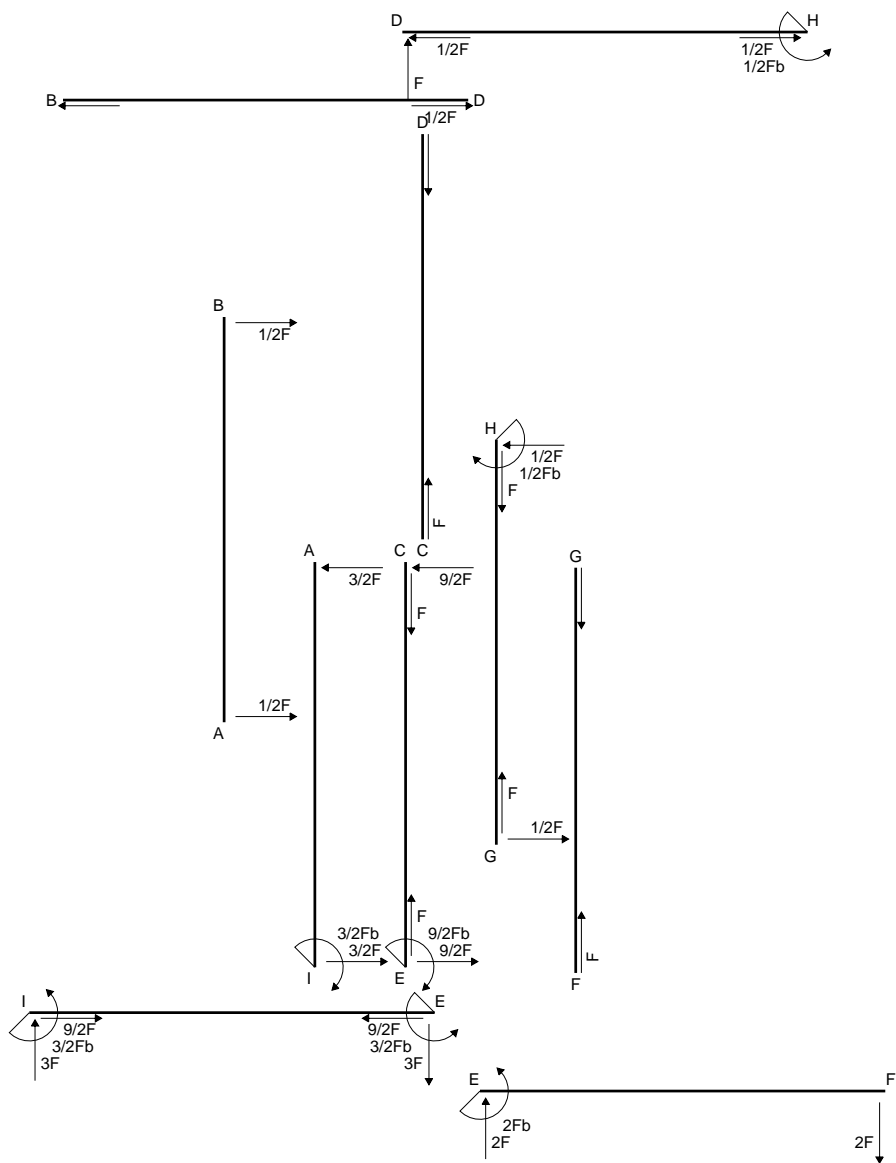
$$= (b - 3/4 b + 1/6 b) Fb^2 1/EJ = 5/12 Fb^3/EJ$$

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

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

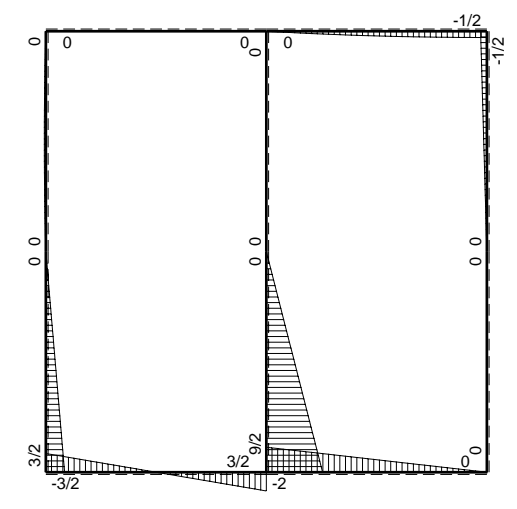


- A = 924. mm²
- J_u = 296396. mm⁴
- J_v = 68112. mm⁴
- y_g = 30.16 mm
- T_y = 2880. N
- M_x = -2160000. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -30.16 mm
- σ_m = -Mv/J_u = -219.8 N/mm²
- x_c = 24. mm
- y_c = 10. mm
- v_c = -20.16 mm
- σ_c = -Mv/J_u = -146.9 N/mm²
- τ_c = 4.029 N/mm²
- σ_o = √σ² + 3τ² = 147.1 N/mm²
- S = 4975. mm³

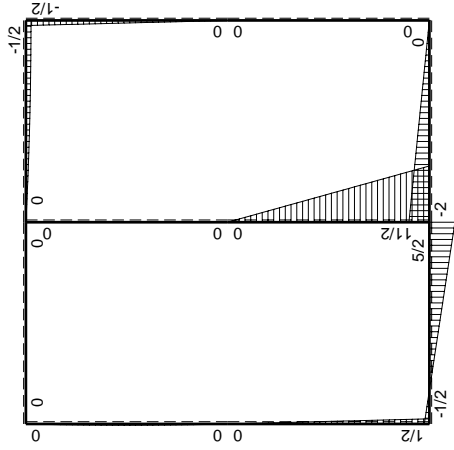
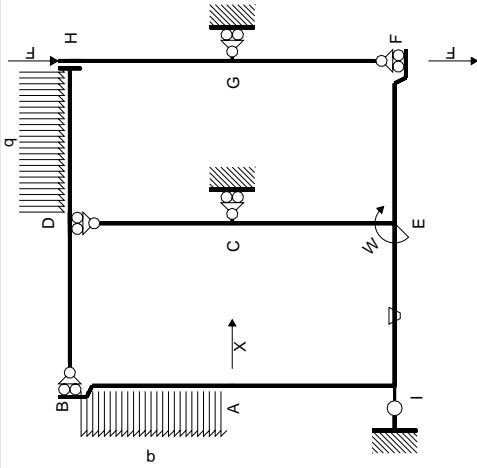


← ⊕ → F

↑ ⊕ ↓ F

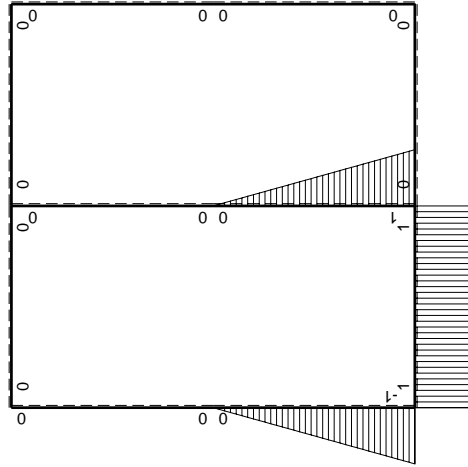


⊕ ⊖ F_b



Schema di calcolo iperstatico

(\oplus) M_0 flessione da carichi assegnati



(\oplus) M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=H_A$

→	$M_x(x)$	$M_o(x)$	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	b	$-1/2Fb+3Fx$	$-Fb/EJ$	$-1/2Fb^2+3Fbx$	$-Fb^2/EJ$	b^2	$(1-1)Fb^3/EJ$	Xb^3/EJ
EI b	-b	$-5/2Fb+3Fx$	Fb/EJ	$5/2Fb^2-3Fbx$	$-Fb^2/EJ$	b^2		
EC b	b-x	$11/2Fb-11/2Fx$	0	$11/2Fb^2-11Fbx+11/2Fx^2$	0	$b^2-2bx+x^2$	$(11/6+0)Fb^3/EJ$	$1/3Xb^3/EJ$
CE b	-x	$-11/2Fx$	0	$11/2Fx^2$	0	x^2		
IA b	-b+x	$1/2Fb-1/2Fx$	0	$-1/2Fb^2+Fbx-1/2Fx^2$	0	$b^2-2bx+x^2$	$(-1/6+0)Fb^3/EJ$	$1/3Xb^3/EJ$
AI b	x	$-1/2Fx$	0	$-1/2Fx^2$	0	x^2		
	totali						$5/3Fb^3/EJ$	$5/3Xb^3/EJ$
	iperstatica $X=H_A$						-F	

Sviluppi di calcolo iperstatica

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

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

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

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

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

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

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

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

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

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

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

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

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

$$= (-1/2 b + 3/2 b) Fb^2 1/EJ + (-b) \theta = 0$$

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

$$= (5/2 b - 3/2 b) Fb^2 1/EJ + (b) \theta = 0$$

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

$$= (11/2 b - 11/2 b + 11/6 b) Fb^2 1/EJ = 11/6 Fb^3/EJ$$

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

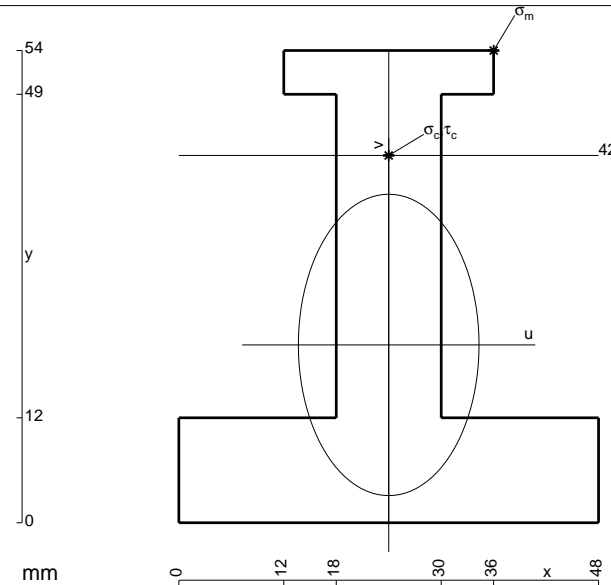
$$= (11/6 b) Fb^2 1/EJ = 11/6 Fb^3/EJ$$

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

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

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

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



$$A = 1140. \text{ mm}^2$$

$$J_u = 338607. \text{ mm}^4$$

$$J_v = 121680. \text{ mm}^4$$

$$y_g = 20.33 \text{ mm}$$

$$T_y = 3560. \text{ N}$$

$$M_x = -2100400. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

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

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

$$v_m = 33.67 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.8 \text{ N/mm}^2$$

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

$$y_c = 42. \text{ mm}$$

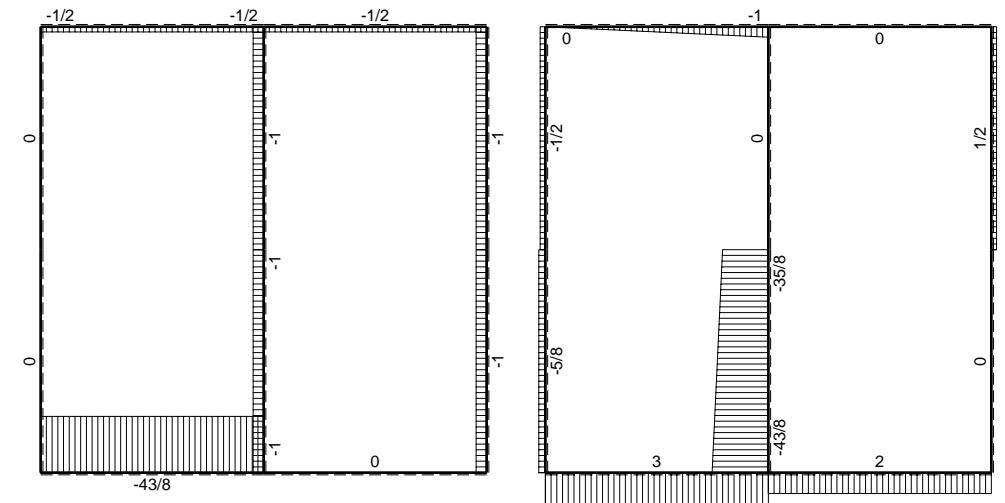
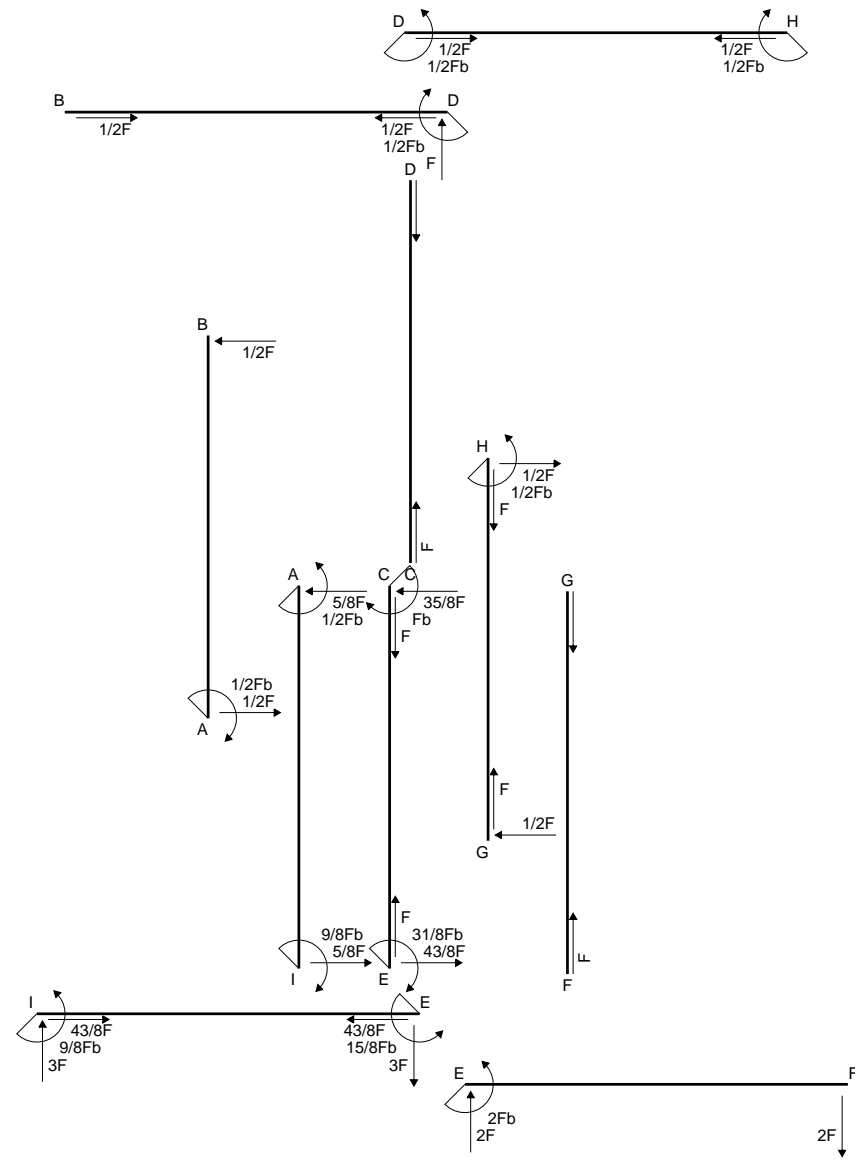
$$v_c = 21.67 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 134.4 \text{ N/mm}^2$$

$$\tau_c = 5.129 \text{ N/mm}^2$$

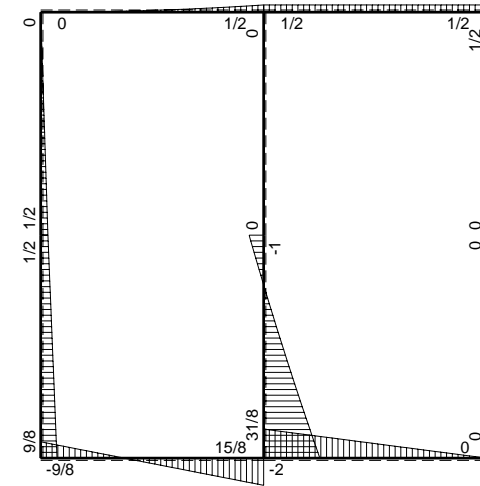
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 134.7 \text{ N/mm}^2$$

$$S = 5854. \text{ mm}^3$$

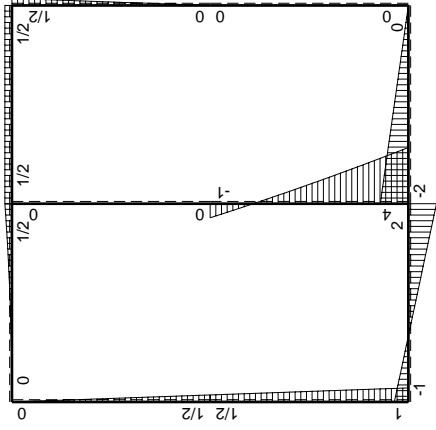
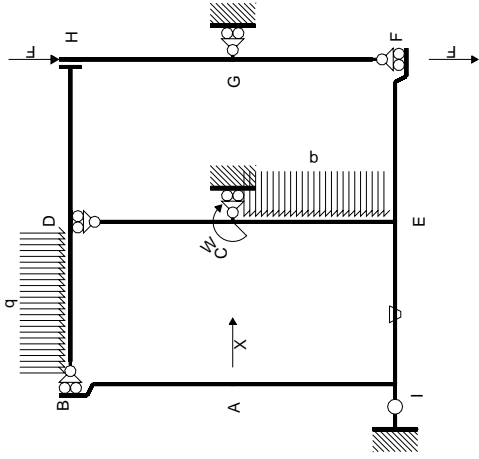


← ⊕ → F

↑ ⊕ ↓ F

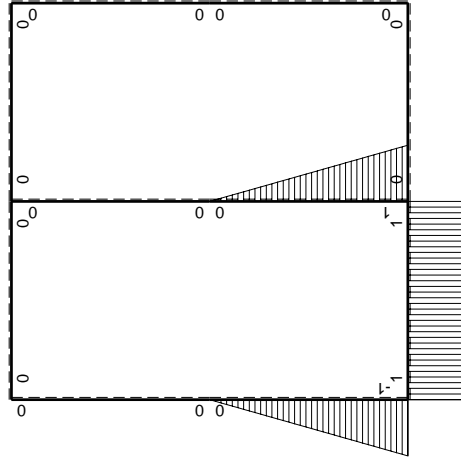


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica X=H_A

→	M _x (x)	M _o (x)	θ	M _x M _o	M _x θ	M _x M _x	∫M _x (M _o /EJ+θ)dx	∫XM _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	b	-Fb+3Fx	-Fb/EJ	-Fb ² +3Fbx	-Fb ² /EJ	b ²	(1/2-1)Fb ³ /EJ	Xb ³ /EJ	
EI b	-b	-2Fb+3Fx	Fb/EJ	2Fb ² -3Fbx	-Fb ² /EJ	b ²			
EC b	b-x	4Fb-11/2Fx+1/2qx ²	0	4Fb ² -19/2Fbx+6Fx ² -1/2qx ³	0	b ² -2bx+x ²	(9/8+0)Fb ³ /EJ	1/3Xb ³ /EJ	
CE b	-x	Fb-9/2Fx-1/2qx ²	0	-Fbx+9/2Fx ² +1/2qx ³	0	x ²			
IA b	-b+x	Fb-1/2Fx	0	-Fb ² +3/2Fbx-1/2Fx ²	0	b ² -2bx+x ²	(-5/12+0)Fb ³ /EJ	1/3Xb ³ /EJ	
AI b	x	-1/2Fb-1/2Fx	0	-1/2Fbx-1/2Fx ²	0	x ²			
	totali							5/24Fb ³ /EJ	5/3Xb ³ /EJ
	iperstatica X=H _A							-1/8F	

Sviluppi di calcolo iperstatica

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$L_{EC}^{xo} = \int_0^b (4 - 19/2 x/b + 6x^2/b^2 - 1/2 x^3/b^3) Fb^2 1/EJ dx = [4x - 19/4 x^2/b + 2x^3/b^2 - 1/8 x^4/b^3]_0^b Fb^2 1/EJ$$

$$= (4b - 19/4 b + 2b - 1/8 b) Fb^2 1/EJ = 9/8 Fb^3/EJ$$

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

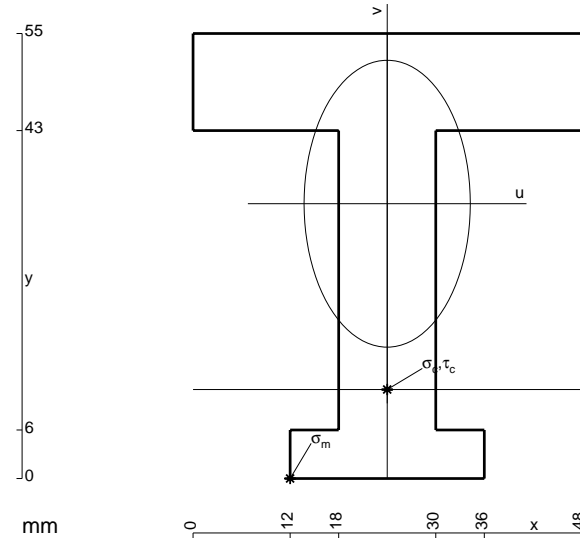
$$= (-1/2 b + 3/2 b + 1/8 b) Fb^2 1/EJ = 9/8 Fb^3/EJ$$

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

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

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

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



- 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

Quadro contributi PLV per iperstatica X=H_A

→	M _x (x)	M _o (x)	θ	M _x M _o	M _x θ	M _x M _x	∫M _x (M _o /EJ+θ)dx	∫xM _x M _x /EJdx	
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	b	4Fx	-Fb/EJ	4Fbx	-Fb ² /EJ	b ²	(2-1)Fb ³ /EJ	Xb ³ /EJ	
EI b	-b	-4Fb+4Fx	Fb/EJ	4Fb ² -4Fbx	-Fb ² /EJ	b ²			
EC b	b-x	6Fb-7Fx	0	6Fb ² -13Fbx+7Fx ²	0	b ² -2bx+x ²	(11/6+0)Fb ³ /EJ	1/3Xb ³ /EJ	
CE b	-x	Fb-7Fx	0	-Fbx+7Fx ²	0	x ²			
IA b	-b+x	0	0	0	0	b ² -2bx+x ²	0+0	1/3Xb ³ /EJ	
AI b	x	0	0	0	0	x ²			
	totali							17/6Fb ³ /EJ	5/3Xb ³ /EJ
	iperstatica X=H _A							-17/10F	

Sviluppi di calcolo iperstatica

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

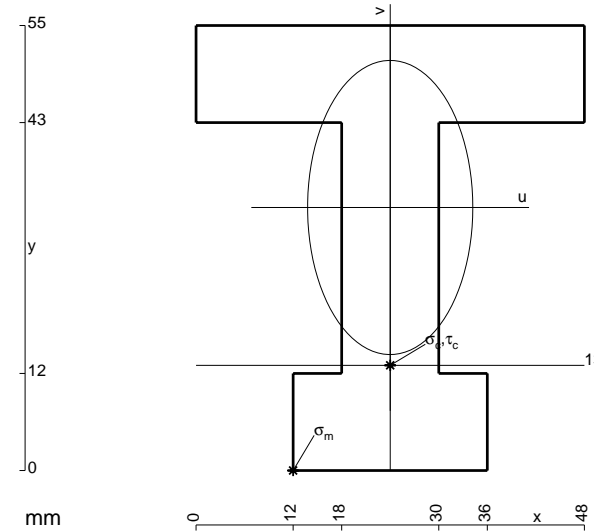
$$= (4b - 2b) Fb^2 1/EJ + (b) \theta = Fb^3/EJ$$

$$L_{EC}^{xo} = \int_0^b (6 - 13x/b + 7x^2/b^2) Fb^2 1/EJ dx = [6x - 13/2 x^2/b + 7/3 x^3/b^2]_0^b Fb^2 1/EJ$$

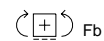
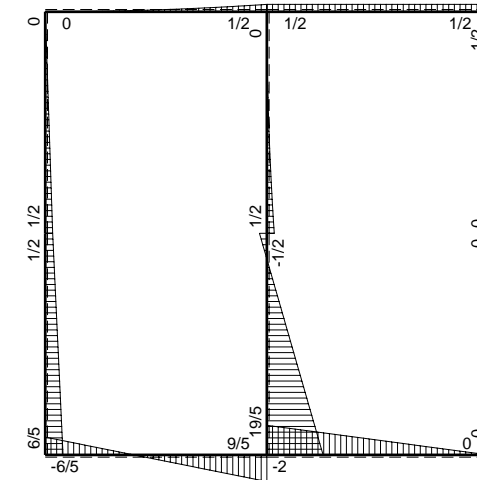
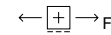
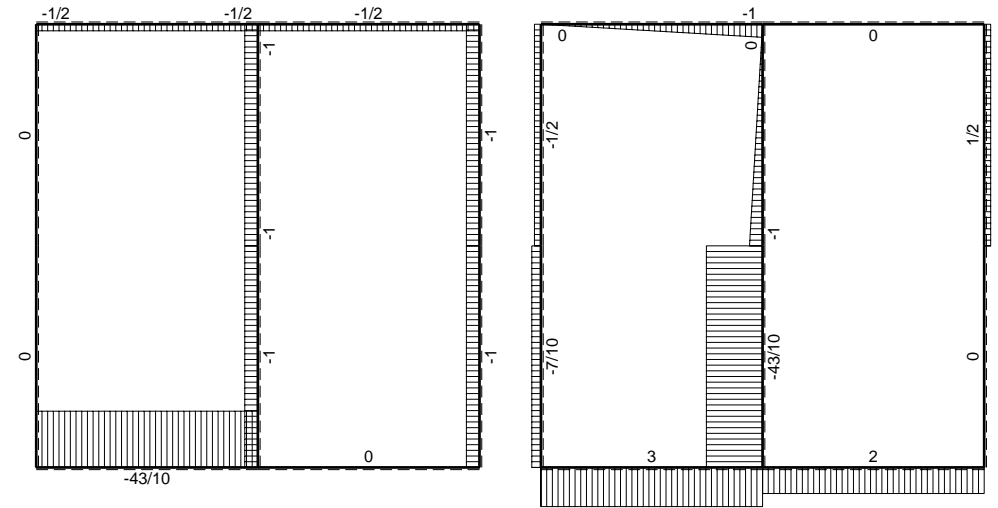
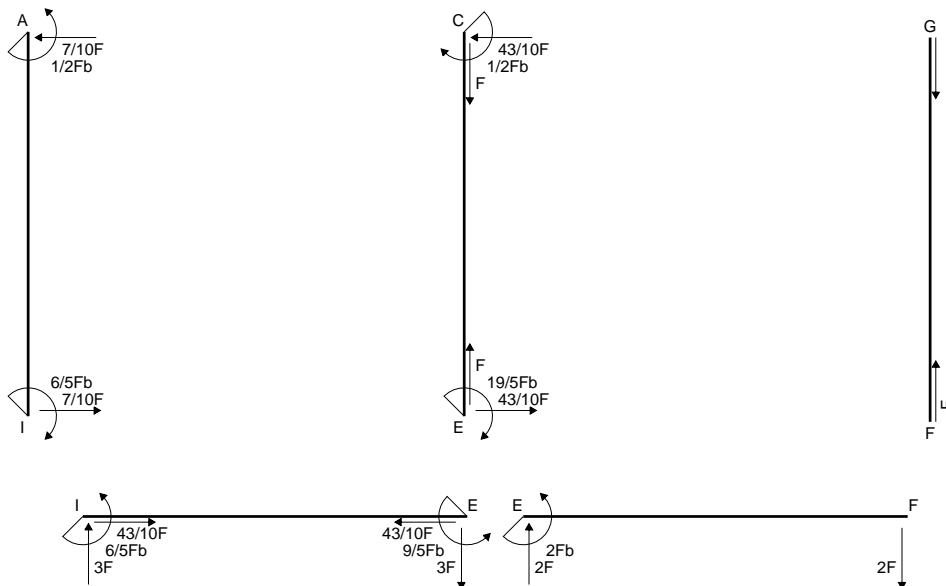
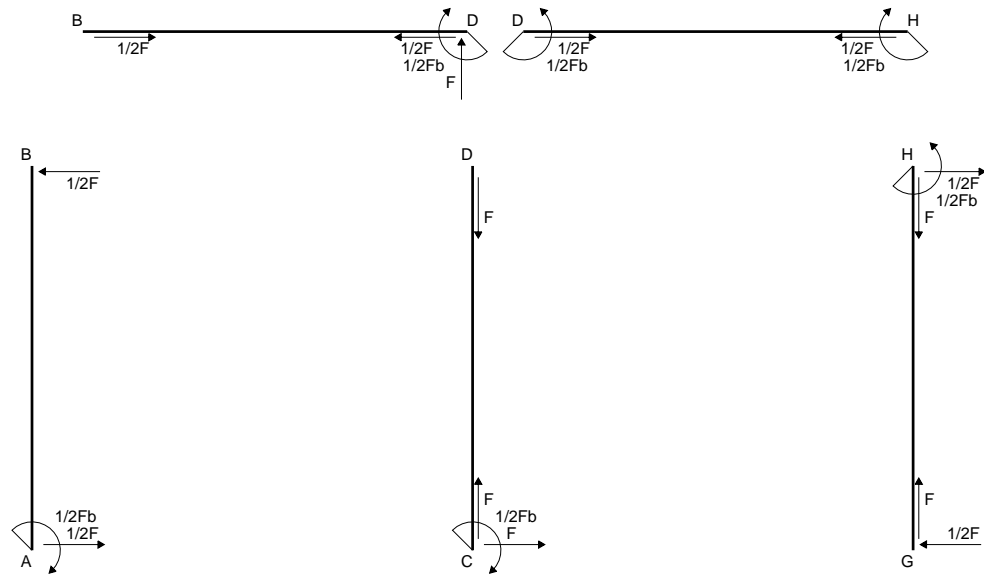
$$= (6b - 13/2 b + 7/3 b) Fb^2 1/EJ = 11/6 Fb^3/EJ$$

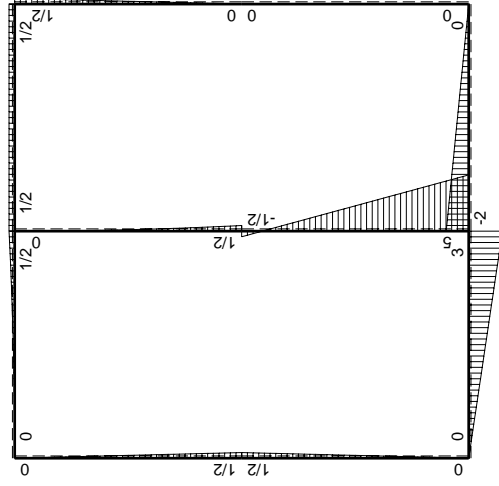
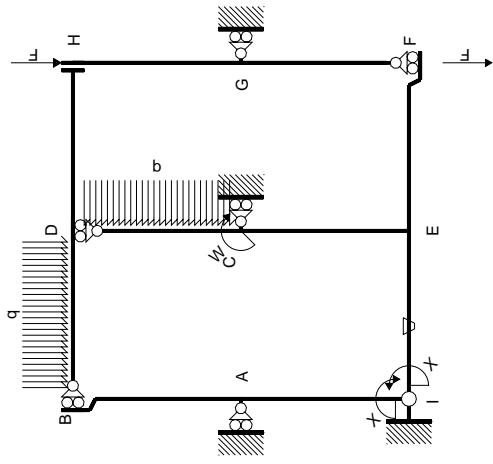
$$L_{CE}^{xo} = \int_0^b (-x/b + 7x^2/b^2) Fb^2 1/EJ dx = [-1/2 x^2/b + 7/3 x^3/b^2]_0^b Fb^2 1/EJ$$

$$= (-1/2 b + 7/3 b) Fb^2 1/EJ = 11/6 Fb^3/EJ$$



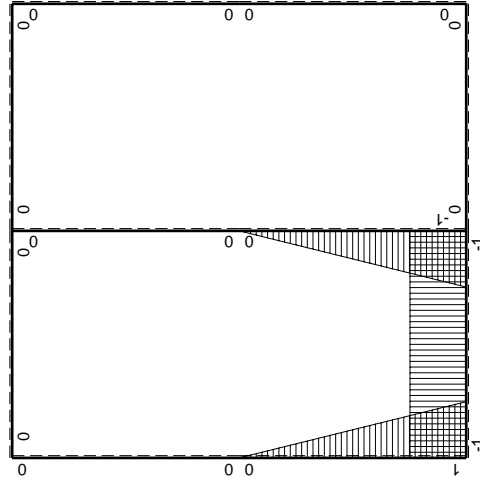
$A = 1236. \text{ mm}^2$
 $J_u = 408523. \text{ mm}^4$
 $J_v = 128880. \text{ mm}^4$
 $y_g = 32.51 \text{ mm}$
 $T_y = 2980. \text{ N}$
 $M_x = -2622400. \text{ Nmm}$
 $x_m = 12. \text{ mm}$
 $u_m = -12. \text{ mm}$
 $v_m = -32.51 \text{ mm}$
 $\sigma_m = -Mv/J_u = -208.7 \text{ N/mm}^2$
 $x_c = 24. \text{ mm}$
 $y_c = 13. \text{ mm}$
 $v_c = -19.51 \text{ mm}$
 $\sigma_c = -Mv/J_u = -125.2 \text{ N/mm}^2$
 $\tau_c = 4.787 \text{ N/mm}^2$
 $\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 125.5 \text{ N/mm}^2$
 $S = 7875. \text{ mm}^3$





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	$1/2Fb-1/2Fx$	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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [-5x + 21/4 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 21/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = [1/4 x^2/b - 11/6 x^3/b^2]_0^b Fb \frac{1}{EJ}$$

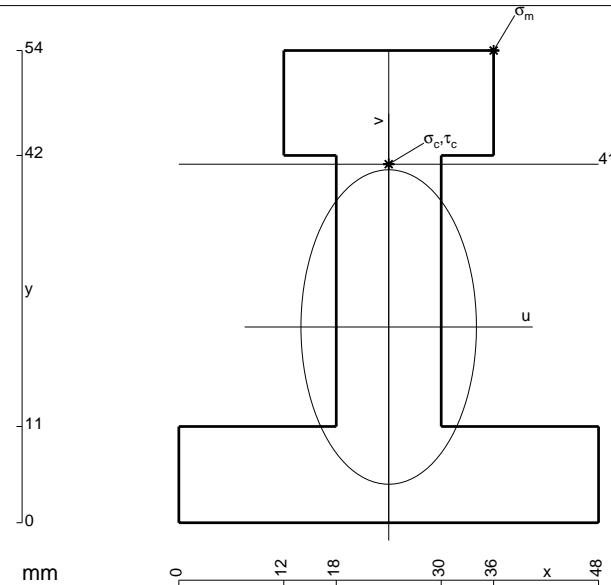
$$= (1/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

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

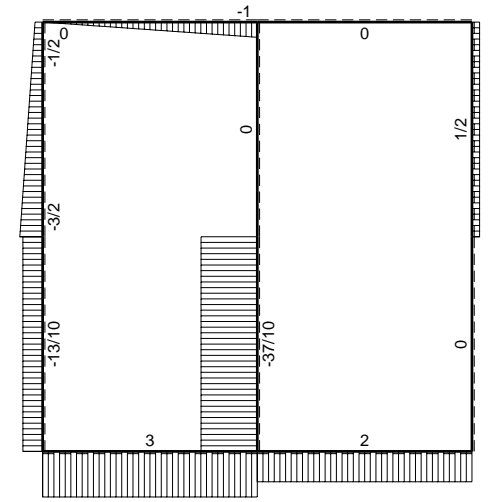
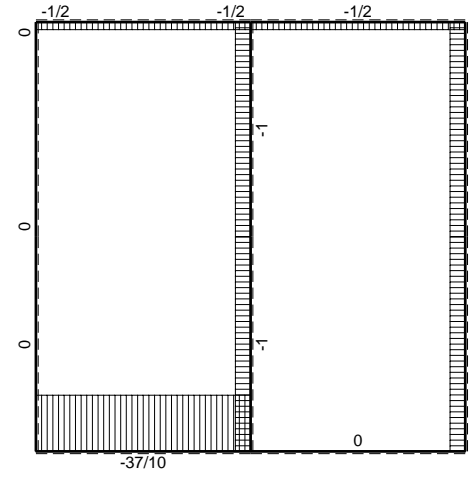
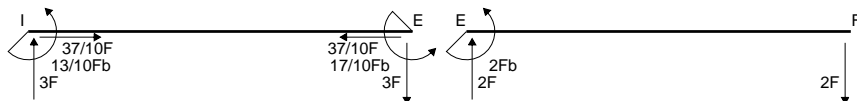
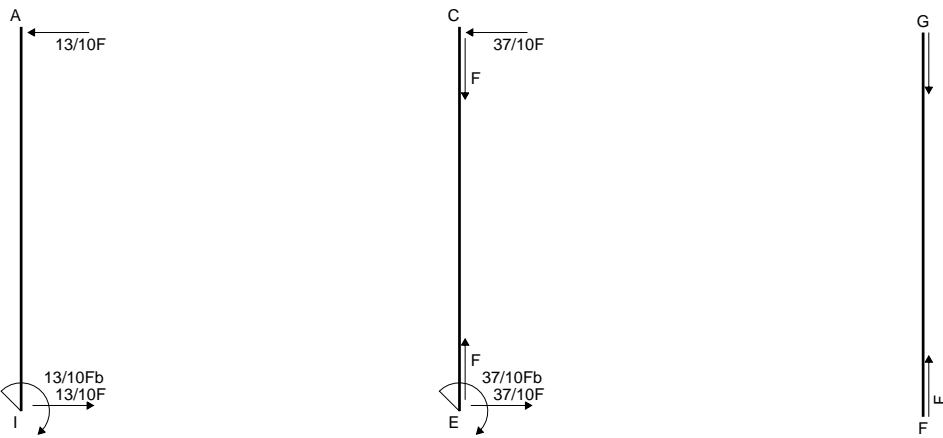
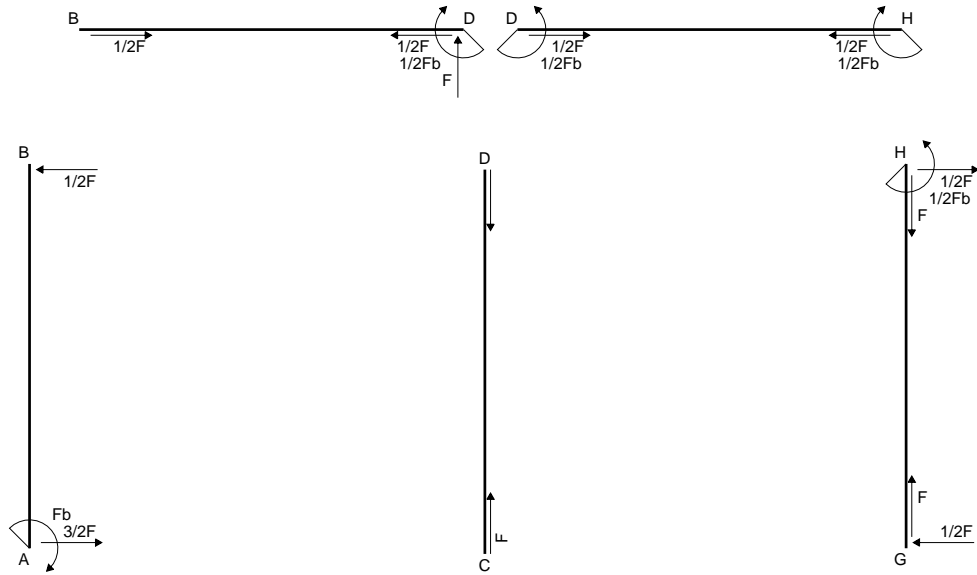
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

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

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

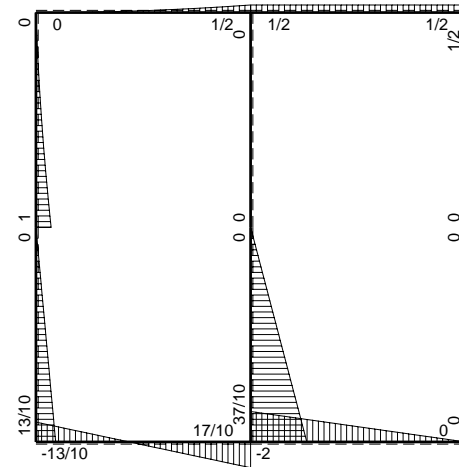


- A = 1188. mm²
- J_u = 384370. mm⁴
- J_v = 119664. mm⁴
- y_g = 22.38 mm
- T_y = 3980. N
- M_x = -2786000. Nmm
- x_m = 36. mm
- y_m = 54. mm
- u_m = 12. mm
- v_m = 31.62 mm
- σ_m = -Mv/J_u = 229.2 N/mm²
- x_c = 24. mm
- y_c = 41. mm
- v_c = 18.62 mm
- σ_c = -Mv/J_u = 135. N/mm²
- τ_c = 6.565 N/mm²
- σ_q = √σ²+3τ² = 135.4 N/mm²
- S = 7608. mm³



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica X=H_C

→	M _x (x)	M _o (x)	θ	M _x M _o	M _x θ	M _x M _x	∫M _x (M _o /EJ+θ)dx	∫xM _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	-b	-5Fb+3Fx	-Fb/EJ	5Fb ² -3Fbx	Fb ² /EJ	b ²	(7/2+1)Fb ³ /EJ	Xb ³ /EJ
EI b	b	2Fb+3Fx	Fb/EJ	2Fb ² +3Fbx	Fb ² /EJ	b ²		
EC b	-b+x	0	0	0	0	b ² -2bx+x ²	0+0	1/3Xb ³ /EJ
CE b	x	0	0	0	0	x ²		
IA b	b-x	5Fb-5Fx	0	5Fb ² -10Fbx+5Fx ²	0	b ² -2bx+x ²	(5/3+0)Fb ³ /EJ	1/3Xb ³ /EJ
AI b	-x	-5Fx	0	5Fx ²	0	x ²		
	totali						37/6Fb ³ /EJ	5/3Xb ³ /EJ
	iperstatica X=H _C						-37/10F	

Sviluppi di calcolo iperstatica

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

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

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

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

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

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

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

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

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

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

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

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

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

$$= (5b - 3/2 b) Fb^2 1/EJ + (b) \theta = 9/2 Fb^3/EJ$$

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

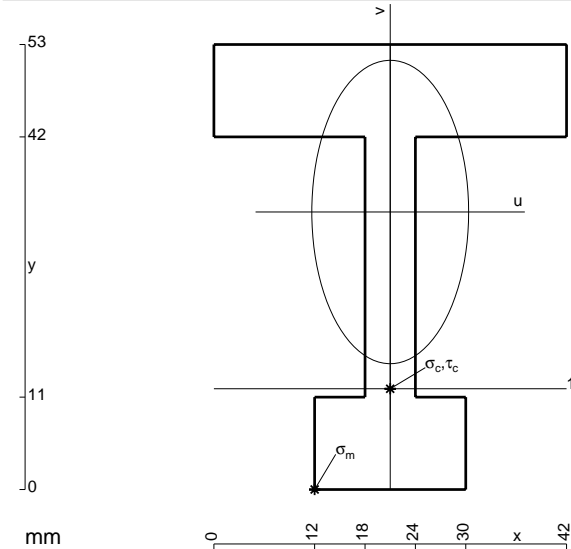
$$= (2b + 3/2 b) Fb^2 1/EJ + (-b) \theta = 9/2 Fb^3/EJ$$

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

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

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

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



- A = 846. mm²
- J_u = 276280. mm⁴
- J_v = 73818. mm⁴
- y_g = 33.05 mm
- T_y = 2080. N
- M_x = -1747200. Nmm
- x_m = 12. mm
- u_m = -9. mm
- v_m = -33.05 mm
- σ_m = -Mv/J_u = -209. N/mm²
- x_c = 21. mm
- y_c = 12. mm
- v_c = -21.05 mm
- σ_c = -Mv/J_u = -133.1 N/mm²
- τ_c = 7.008 N/mm²
- σ_o = √σ² + 3τ² = 133.7 N/mm²
- S = 5585. 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	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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

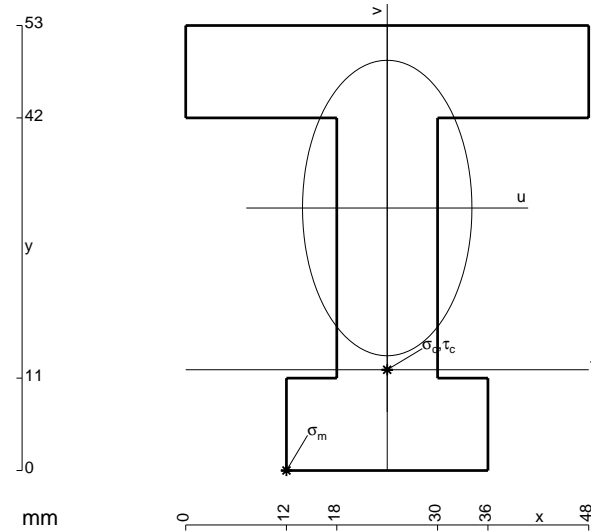
$$= (-13/6 b) Fb 1/EJ = -13/6 Fb^2/EJ$$

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

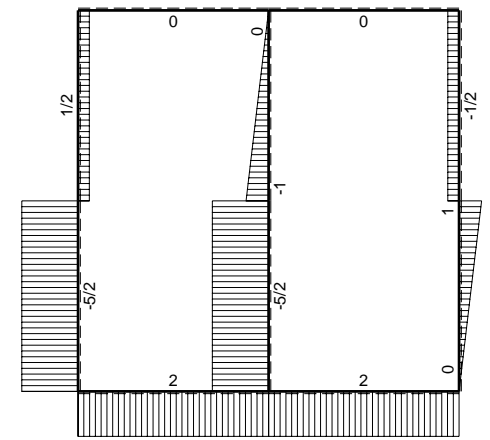
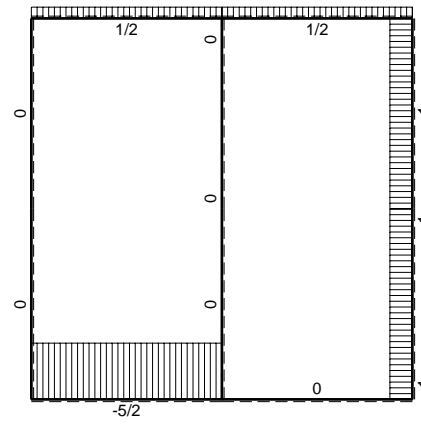
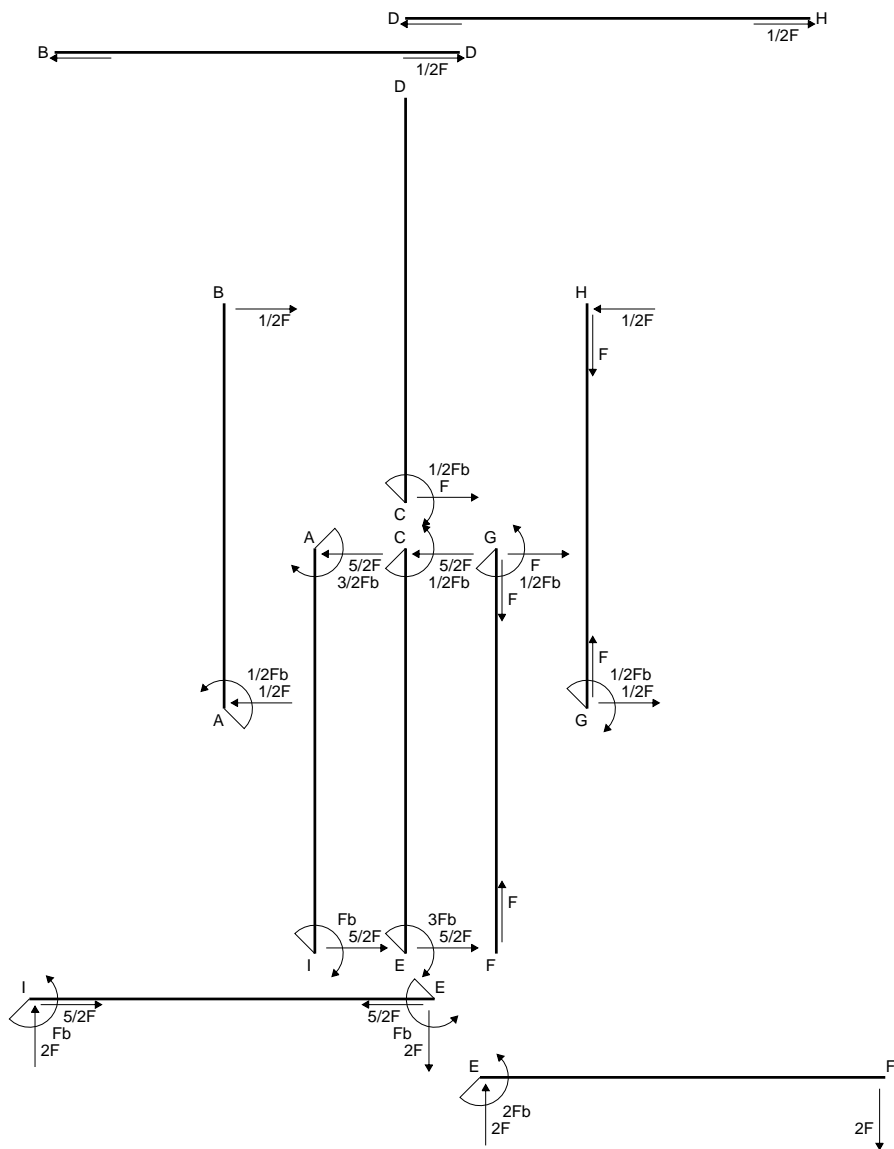
$$= (-1/4 b + 1/6 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

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

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

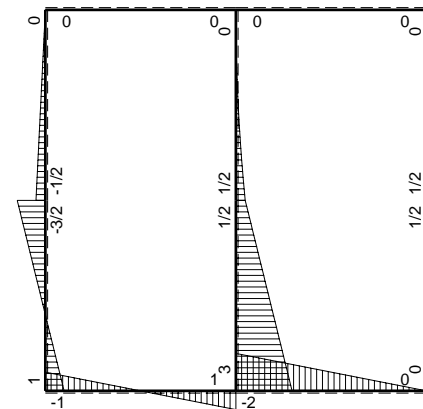


- A = 1164. mm²
- J_u = 360644. mm⁴
- J_v = 118512. mm⁴
- y_g = 31.26 mm
- T_y = 3330. N
- M_x = -2636250. Nmm
- x_m = 12. mm
- u_m = -12. mm
- v_m = -31.26 mm
- σ_m = -Mv/J_u = -228.5 N/mm²
- x_c = 24. mm
- y_c = 12. mm
- v_c = -19.26 mm
- σ_c = -Mv/J_u = -140.8 N/mm²
- τ_c = 5.416 N/mm²
- σ_o = √σ²+3τ² = 141.1 N/mm²
- S = 7039. mm³

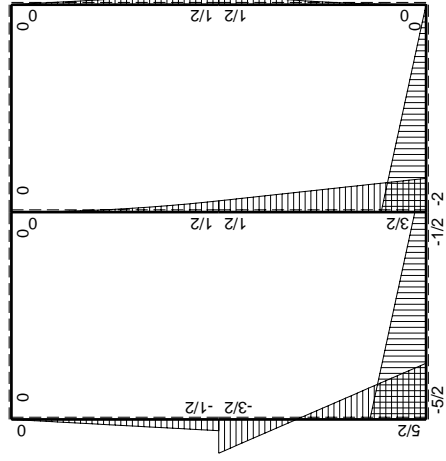
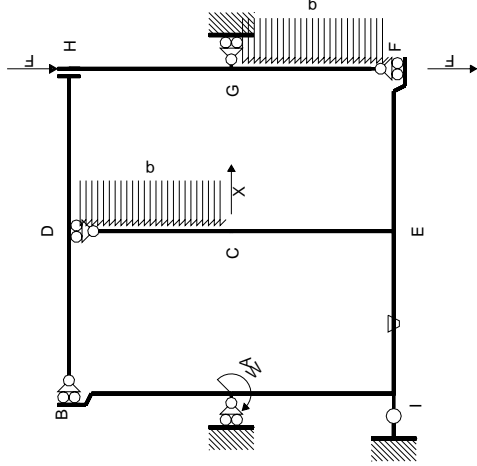


← ⊕ → F

↑ ⊕ ↓ F

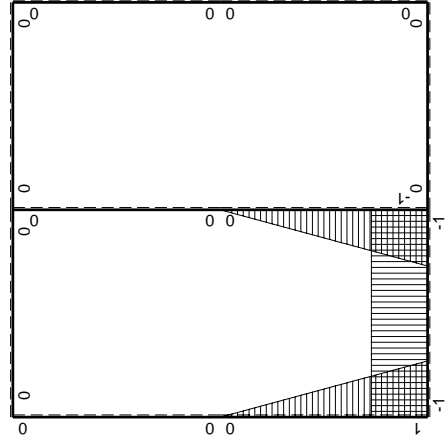


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=H_c$

→	$M_x(x)$	$M_o(x)$	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	-b	$-5/2Fb+2Fx$	$-Fb/EJ$	$5/2Fb^2-2Fbx$	Fb^2/EJ	b^2	$(3/2+1)Fb^3/EJ$	Xb^3/EJ
EI b	b	$1/2Fb+2Fx$	Fb/EJ	$1/2Fb^2+2Fbx$	Fb^2/EJ	b^2		
EC b	$-b+x$	$3/2Fb-Fx$	0	$-3/2Fb^2+5/2Fbx-Fx^2$	0	$b^2-2bx+x^2$	$(-7/12+0)Fb^3/EJ$	$1/3Xb^3/EJ$
CE b	x	$-1/2Fb-Fx$	0	$-1/2Fbx-Fx^2$	0	x^2		
IA b	$b-x$	$5/2Fb-4Fx$	0	$5/2Fb^2-13/2Fbx+4Fx^2$	0	$b^2-2bx+x^2$	$(7/12+0)Fb^3/EJ$	$1/3Xb^3/EJ$
AI b	-x	$3/2Fb-4Fx$	0	$-3/2Fbx+4Fx^2$	0	x^2		
	totali						$5/2Fb^3/EJ$	$5/3Xb^3/EJ$
	iperstatica $X=H_c$						$-3/2F$	

Sviluppi di calcolo iperstatica

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$= (-3/2 b + 5/4 b - 1/3 b) Fb^2 1/EJ = -7/12 Fb^3/EJ$$

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

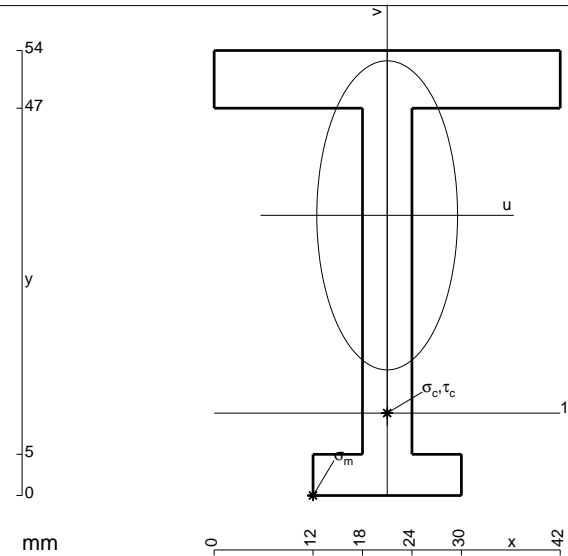
$$= (-1/4 b - 1/3 b) Fb^2 1/EJ = -7/12 Fb^3/EJ$$

$$L_{IA}^{xo} = \int_0^b (5/2 - 13/2 x/b + 4x^2/b^2) Fb^2 1/EJ dx = [5/2 x - 13/4 x^2/b + 4/3 x^3/b^2]_0^b Fb^2 1/EJ$$

$$= (5/2 b - 13/4 b + 4/3 b) Fb^2 1/EJ = 7/12 Fb^3/EJ$$

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

$$= (-3/4 b + 4/3 b) Fb^2 1/EJ = 7/12 Fb^3/EJ$$



$$A = 636. \text{ mm}^2$$

$$J_u = 223904. \text{ mm}^4$$

$$J_v = 46404. \text{ mm}^4$$

$$y_g = 34. \text{ mm}$$

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

$$M_x = -1512000. \text{ Nmm}$$

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

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

$$v_m = -34. \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.6 \text{ N/mm}^2$$

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

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

$$v_c = -24. \text{ mm}$$

$$\sigma_c = -Mv/J_u = -162.1 \text{ N/mm}^2$$

$$\tau_c = 5.836 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 162.4 \text{ N/mm}^2$$

$$S = 3630. \text{ mm}^3$$