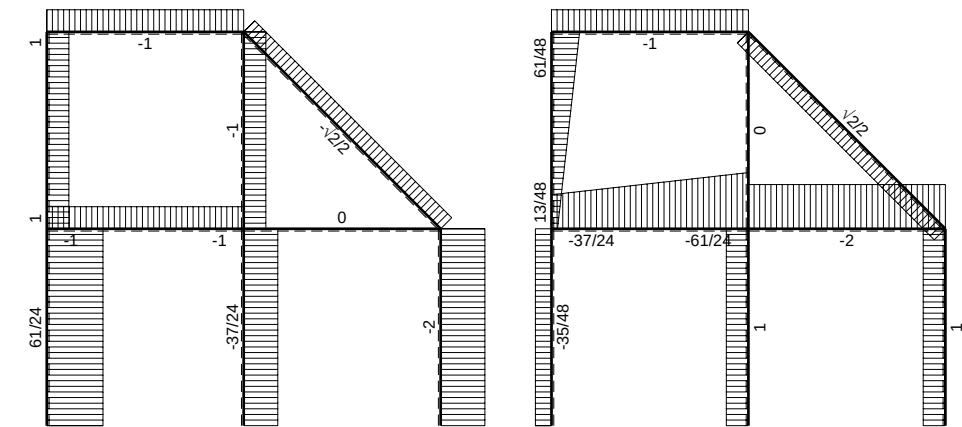
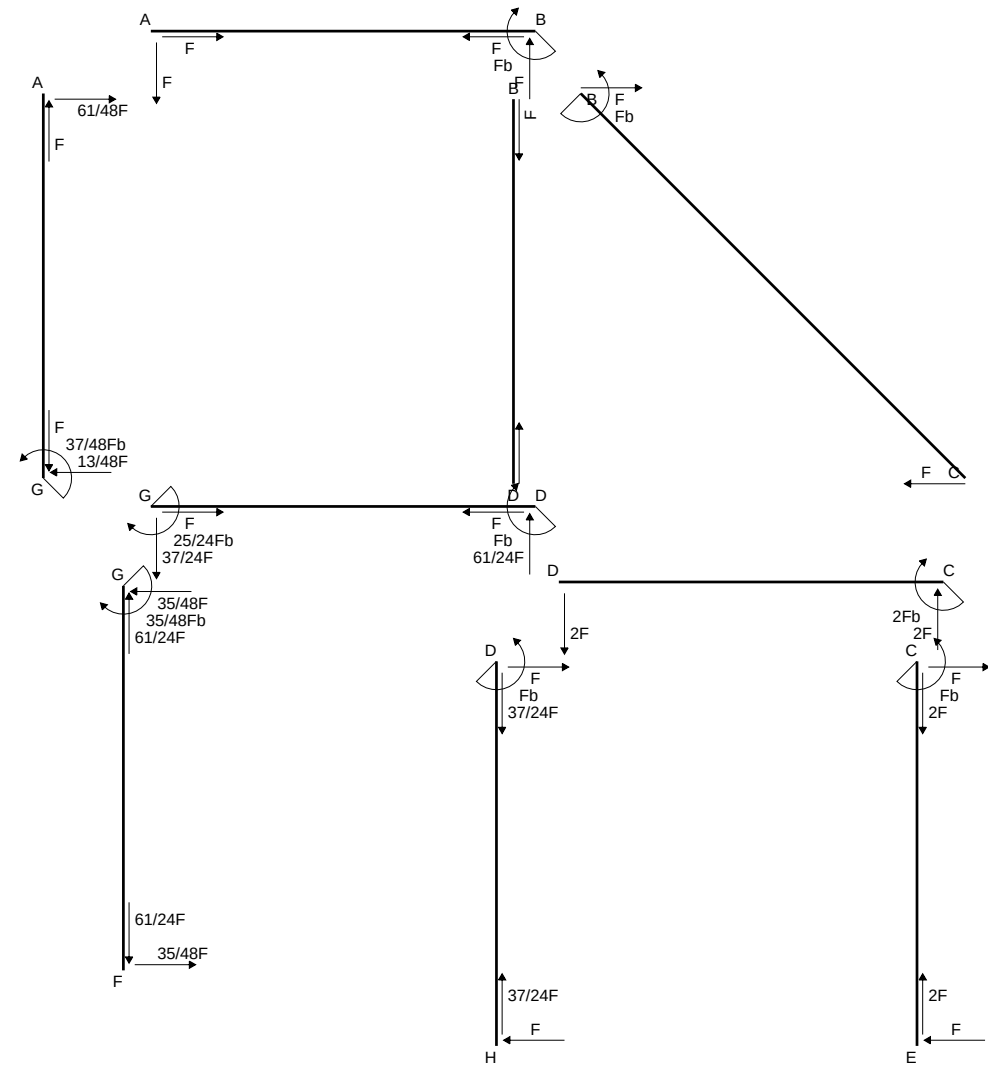
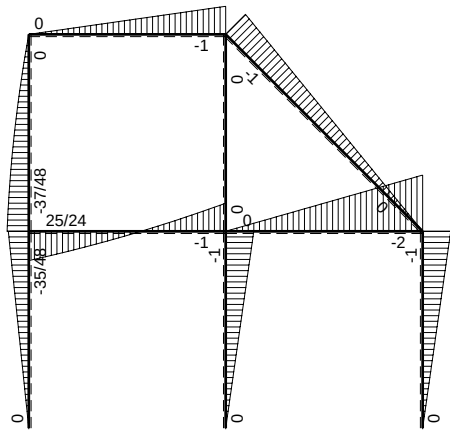


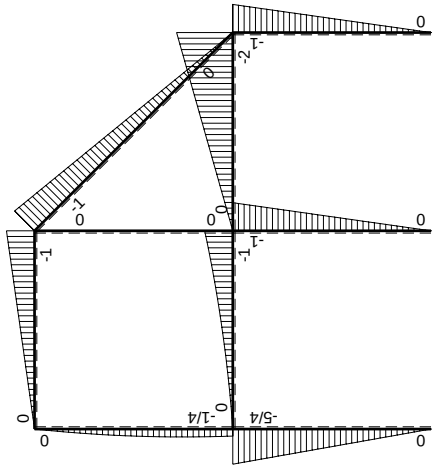
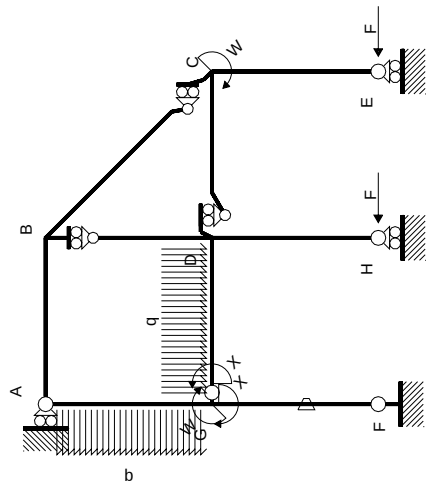


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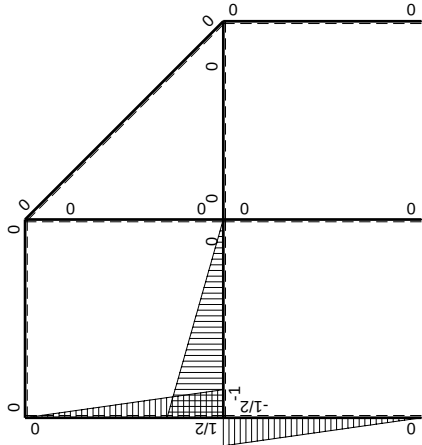


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(5/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						25/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-25/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

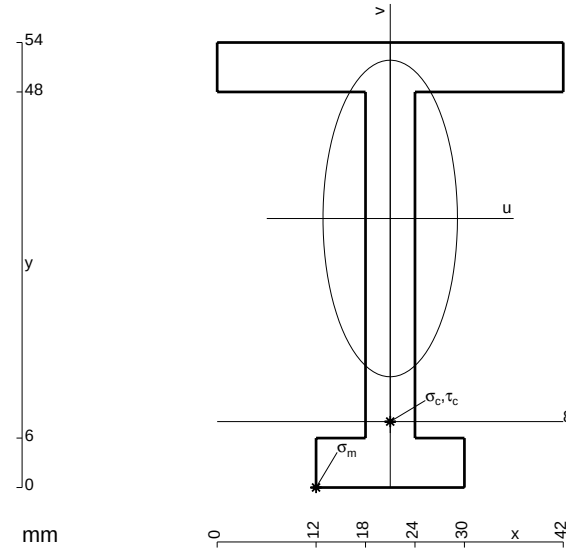
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

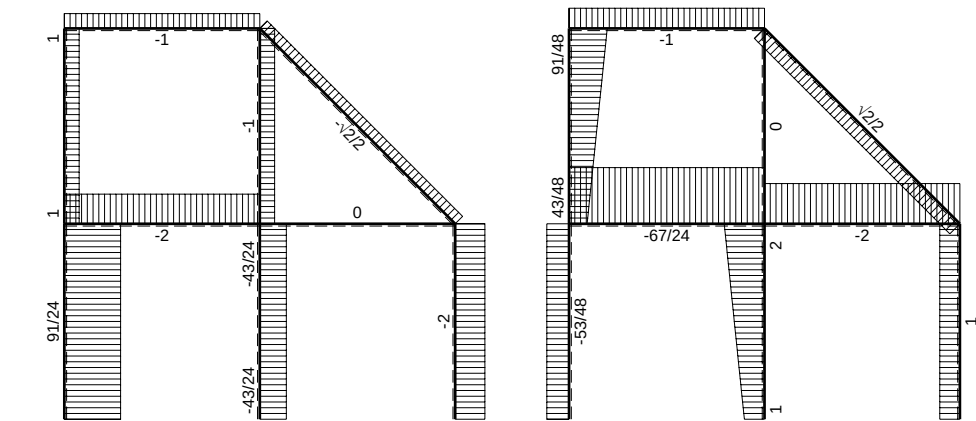
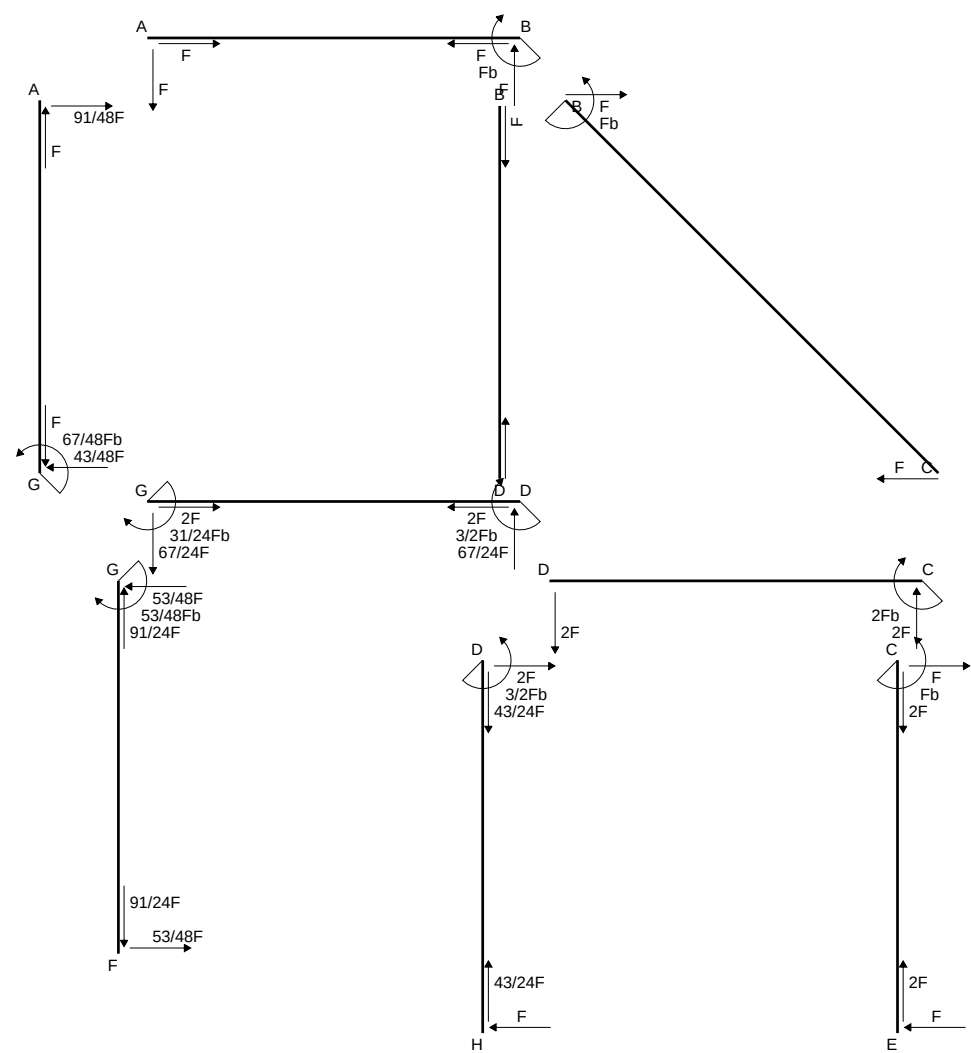
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

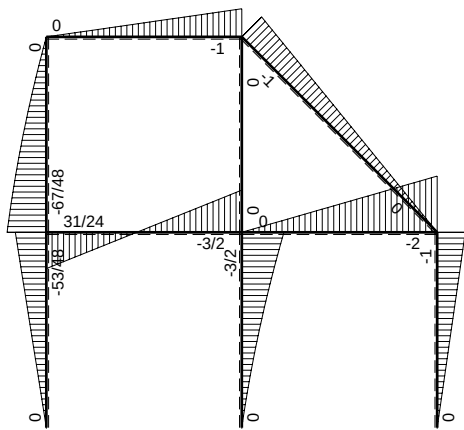


$$\begin{aligned} A &= 612. \text{ mm}^2 \\ J_u &= 225968. \text{ mm}^4 \\ J_v &= 40716. \text{ mm}^4 \\ y_g &= 32.65 \text{ mm} \\ T_y &= -2580. \text{ N} \\ M_x &= -1444800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -32.65 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 8. \text{ mm} \\ v_c &= -24.65 \text{ mm} \\ \sigma_c &= -Mv/J_u = -157.6 \text{ N/mm}^2 \\ \tau_c &= 6.679 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 158. \text{ N/mm}^2 \\ S^* &= 3510. \text{ mm}^3 \end{aligned}$$

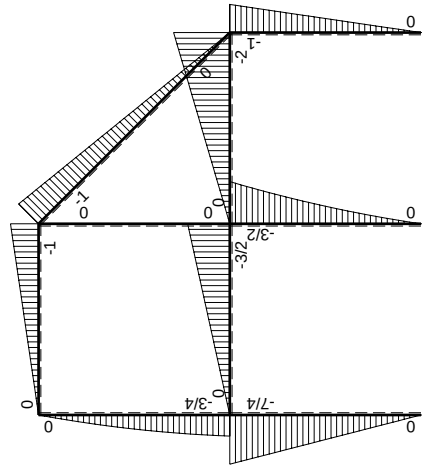
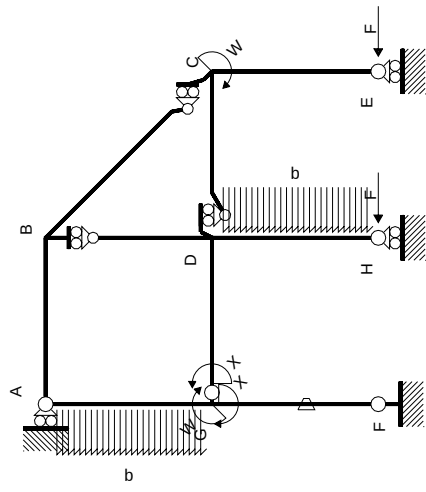


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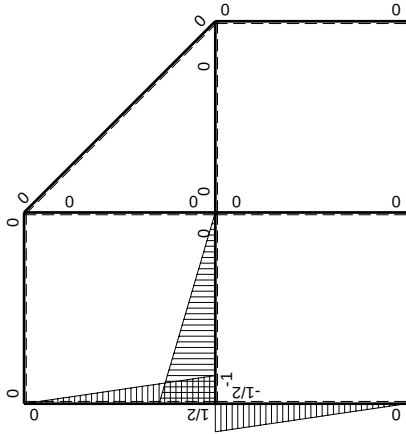


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



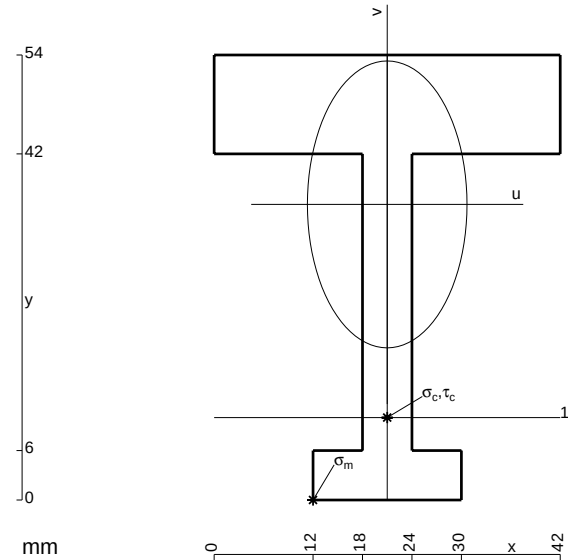
M_x flessione da iperstatica $X=1$

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

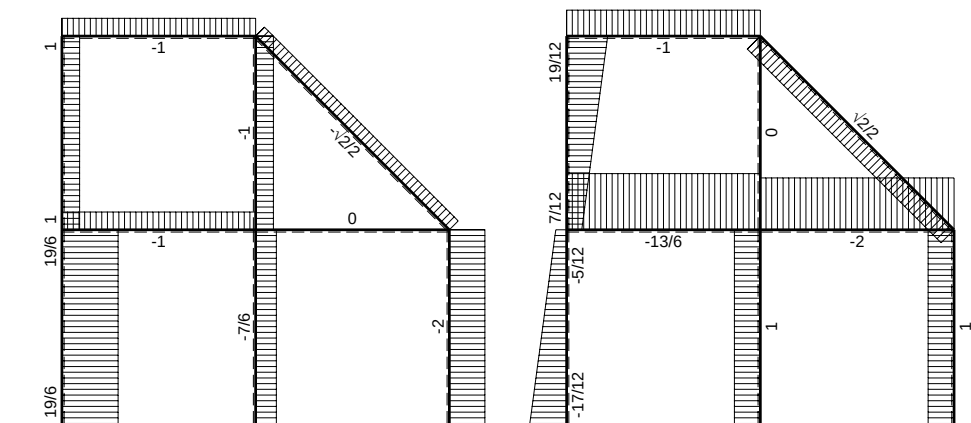
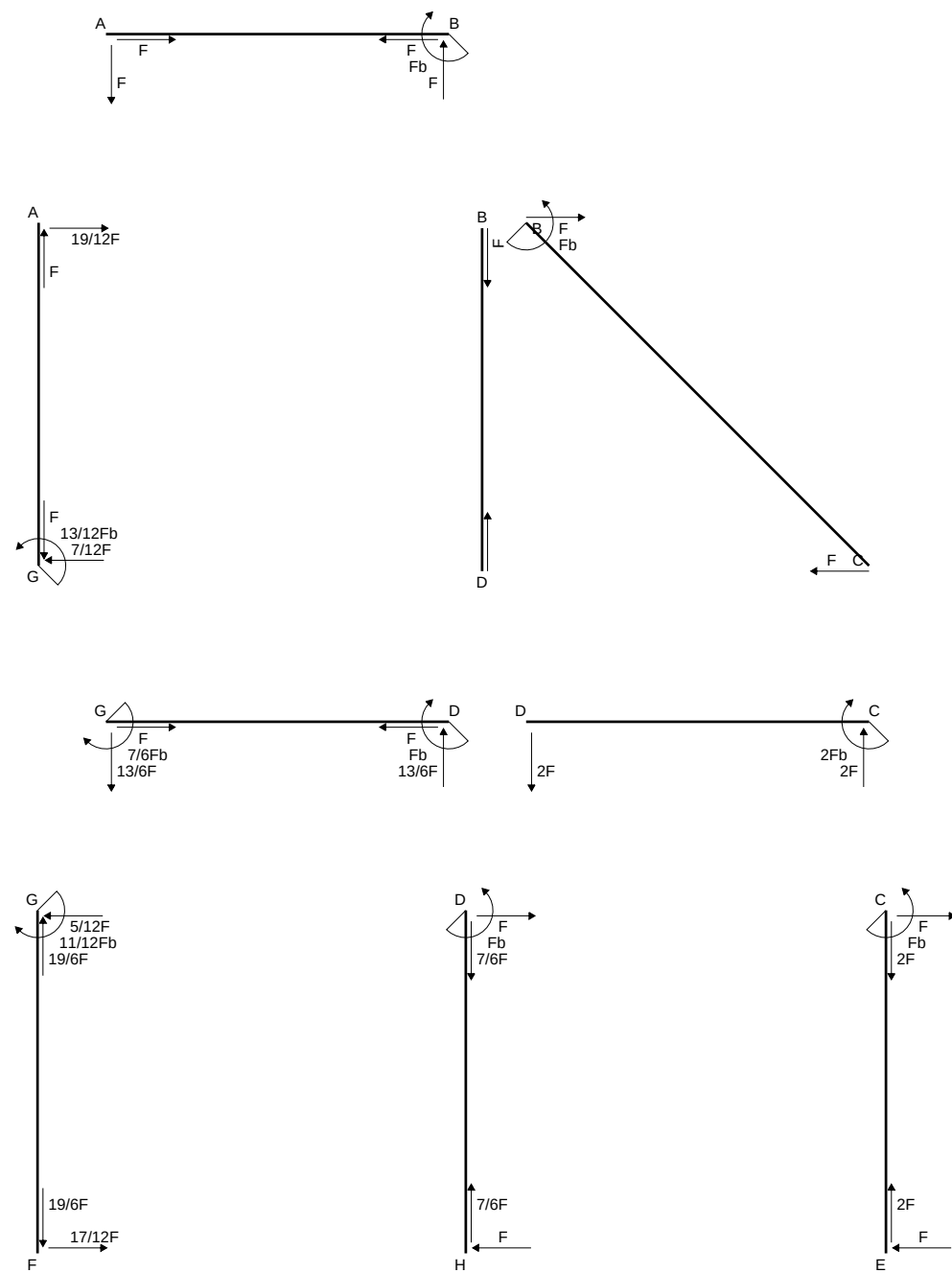
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx	-Fb/EJ	$7/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/24+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$7/4Fb-7/4Fx$	Fb/EJ	$7/8Fb-7/4Fx+7/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	-1+x/b	-3/2Fx	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	-1/2x/b	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$31/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-31/24Fb	

Sviluppi di calcolo iperstatica

$$\begin{aligned}
L_{FG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GF}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GD}^{xx} &= \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{DG}^{xx} &= \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{GA}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{AG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{FG}^{xo} &= \int_0^b \left(\frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{13}{24} Fb^2/EJ \\
L_{GF}^{xo} &= \int_0^b \left(\frac{7}{8} - \frac{7}{4} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx \\
&= \left[\frac{7}{8} x - \frac{7}{8} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{7}{8} b - \frac{7}{8} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{13}{24} Fb^2/EJ \\
L_{GD}^{xo} &= \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ \\
L_{DG}^{xo} &= \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ \\
L_{GA}^{xo} &= \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx \\
&= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ \\
L_{AG}^{xo} &= \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ
\end{aligned}$$

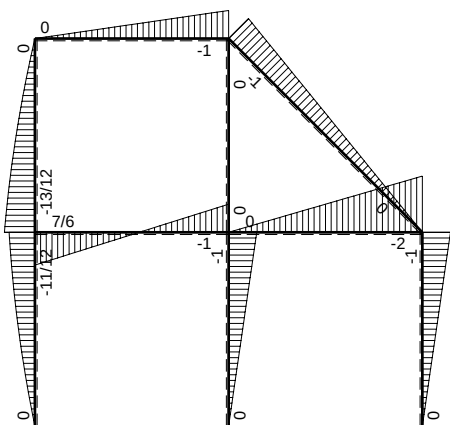


$$\begin{aligned}
A &= 828. \text{ mm}^2 \\
J_u &= 250978. \text{ mm}^4 \\
J_v &= 77652. \text{ mm}^4 \\
y_g &= 35.87 \text{ mm} \\
T_y &= -2520. \text{ N} \\
M_x &= -1537200. \text{ Nmm} \\
x_m &= 12. \text{ mm} \\
u_m &= -9. \text{ mm} \\
v_m &= -35.87 \text{ mm} \\
\sigma_m &= -Mv/J_u = -219.7 \text{ N/mm}^2 \\
x_c &= 21. \text{ mm} \\
y_c &= 10. \text{ mm} \\
v_c &= -25.87 \text{ mm} \\
\sigma_c &= -Mv/J_u = -158.4 \text{ N/mm}^2 \\
\tau_c &= 7.06 \text{ N/mm}^2 \\
\sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 158.9 \text{ N/mm}^2 \\
S &= 4219. \text{ mm}^3
\end{aligned}$$

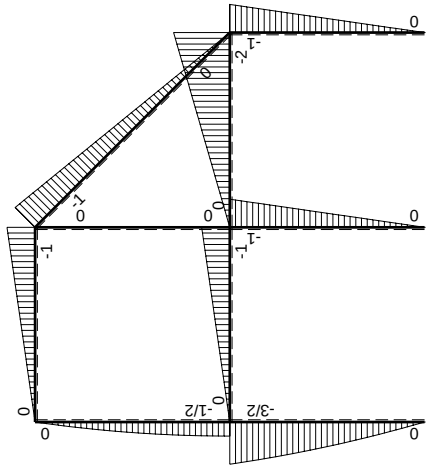
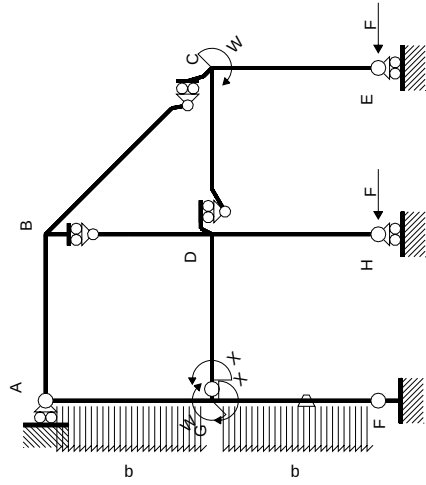


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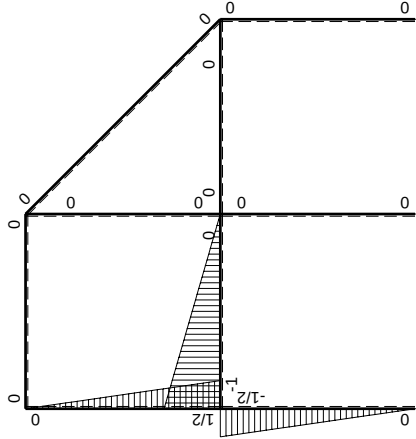


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-2Fx+1/2qx ²	-Fb/EJ	Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(13/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-Fx-1/2qx ²	Fb/EJ	3/4Fb-5/4Fx+1/4Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2qx ²	0	-1/4Fb+1/4Fx+1/4Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-5/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx-1/2qx ²	0	-1/2Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						7/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{3} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{3} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{25}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{4} - \frac{5}{4} x/b + \frac{1}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{5}{8} x^2/b + \frac{1}{12} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{4} b - \frac{5}{8} b + \frac{1}{12} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{25}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

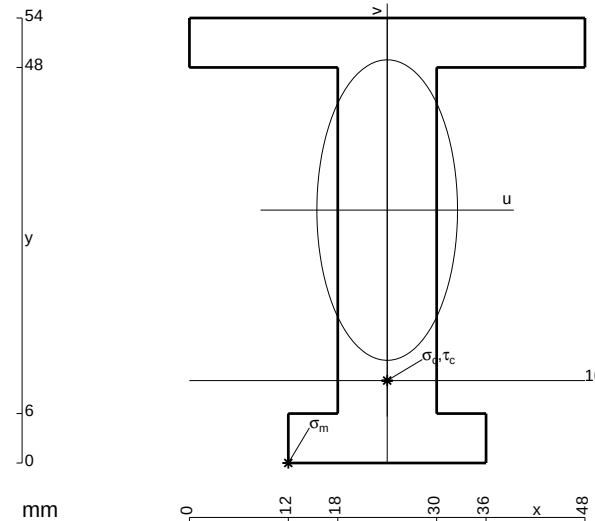
$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{4} x/b + \frac{1}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{1}{4} x + \frac{1}{8} x^2/b + \frac{1}{12} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

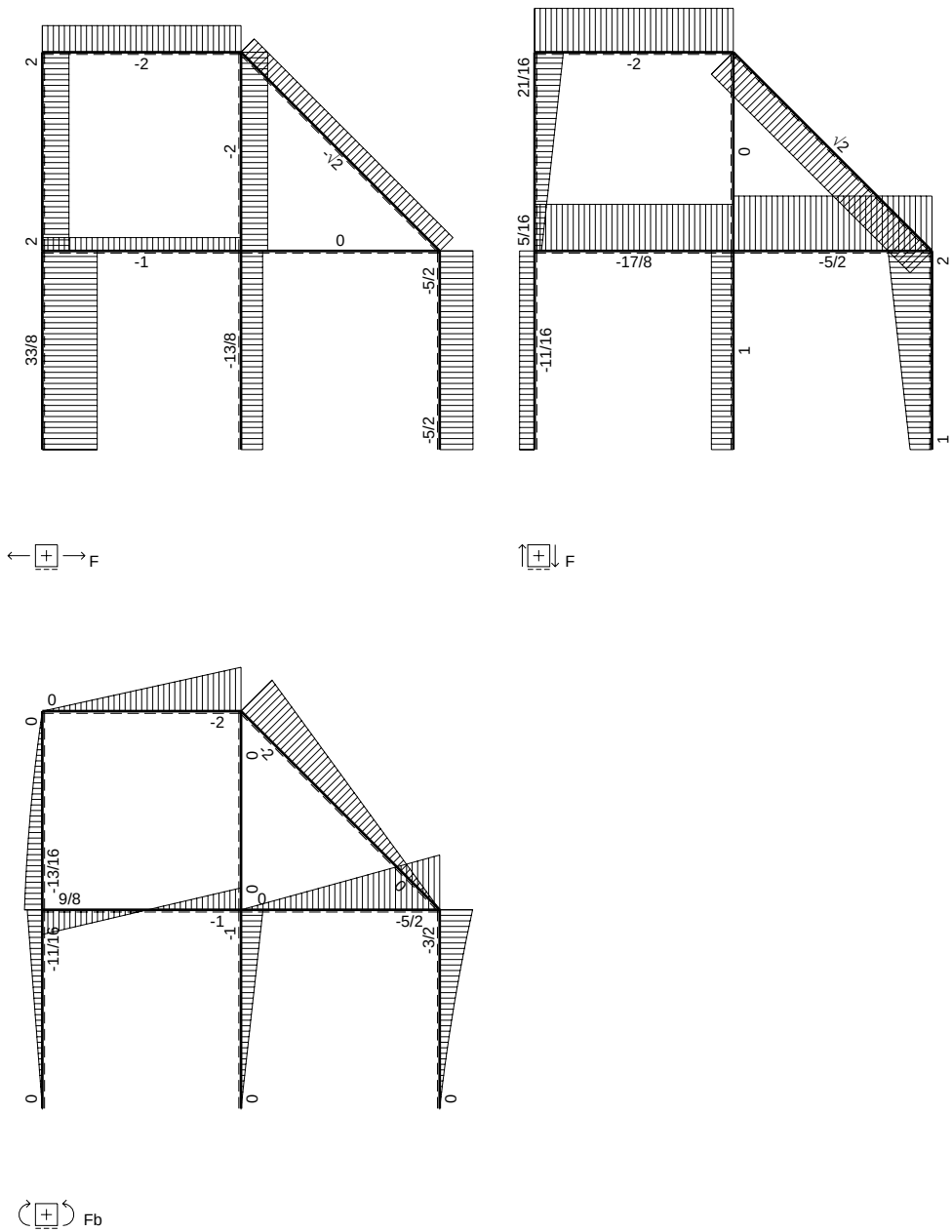
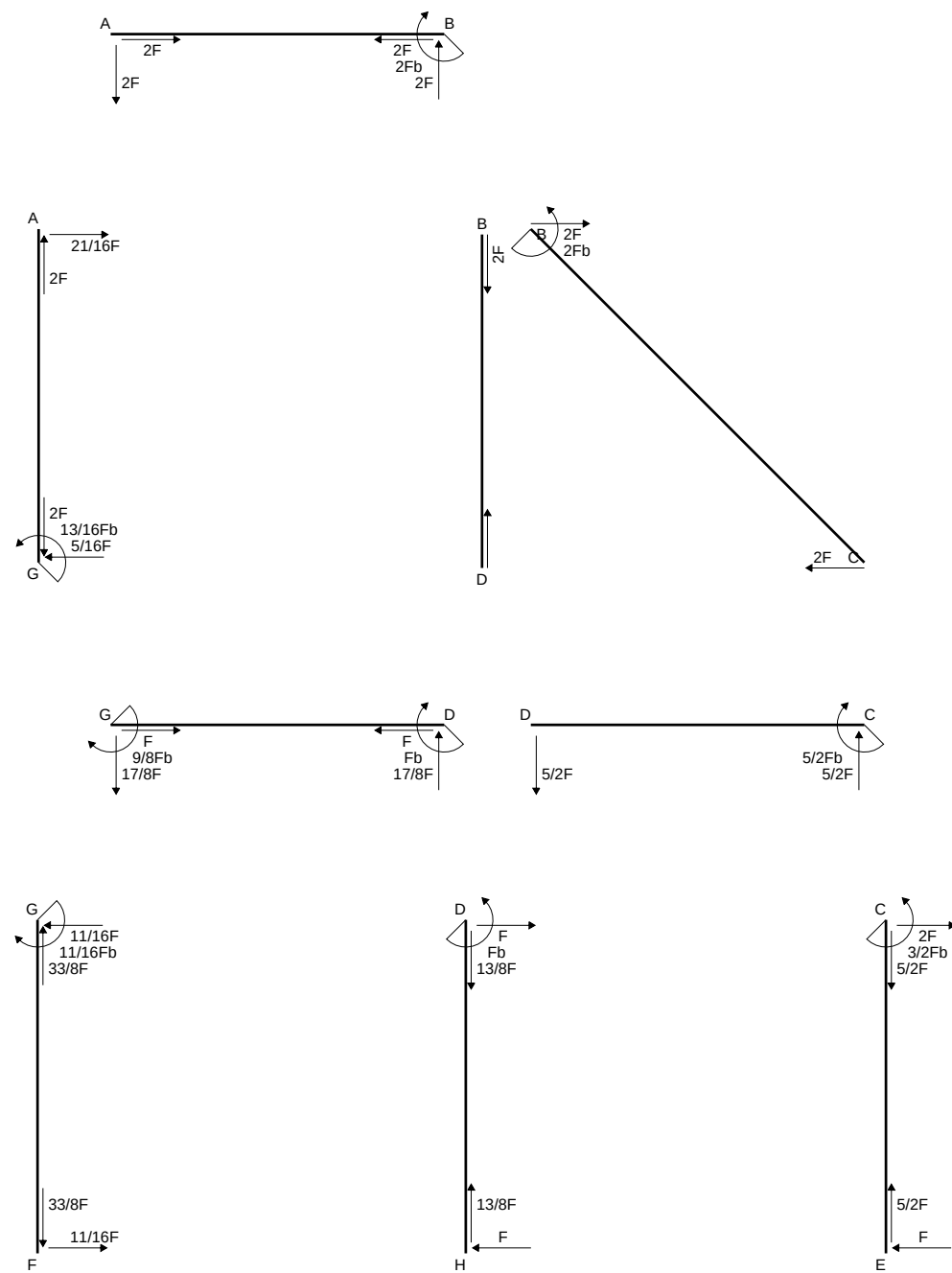
$$= \left(-\frac{1}{4} b + \frac{1}{8} b + \frac{1}{12} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{5}{48} Fb^2/EJ$$

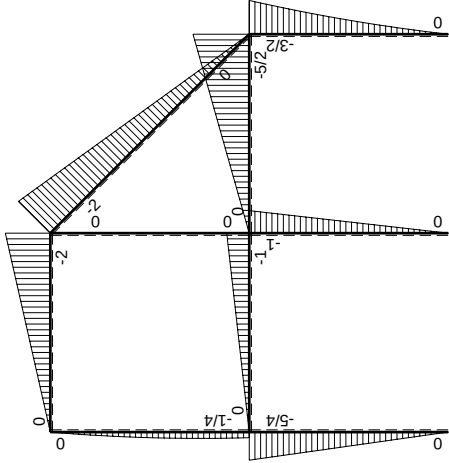
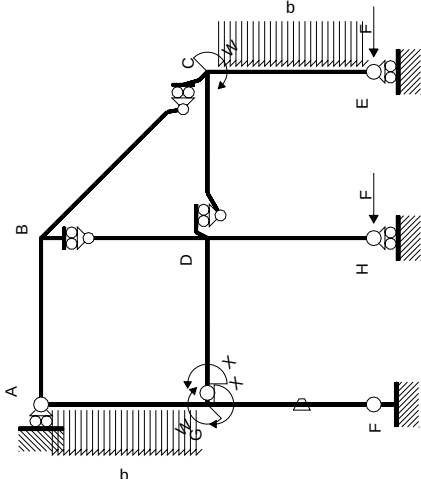
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{5}{48} Fb^2/EJ$$



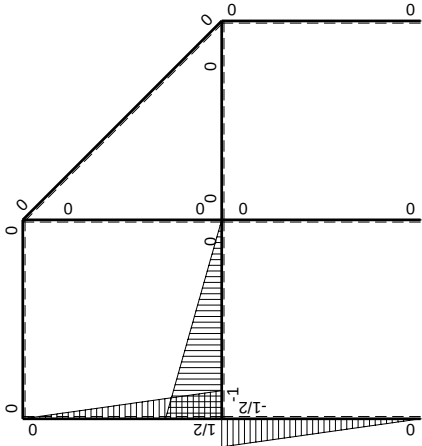
$$\begin{aligned} A &= 936. \text{ mm}^2 \\ J_u &= 311455. \text{ mm}^4 \\ J_v &= 68256. \text{ mm}^4 \\ y_g &= 30.69 \text{ mm} \\ T_y &= -3520. \text{ N} \\ M_x &= -2323200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.69 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -20.69 \text{ mm} \\ \sigma_c &= -Mv/J_u = -154.3 \text{ N/mm}^2 \\ \tau_c &= 4.782 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 154.6 \text{ N/mm}^2 \\ S &= 5077. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(5/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

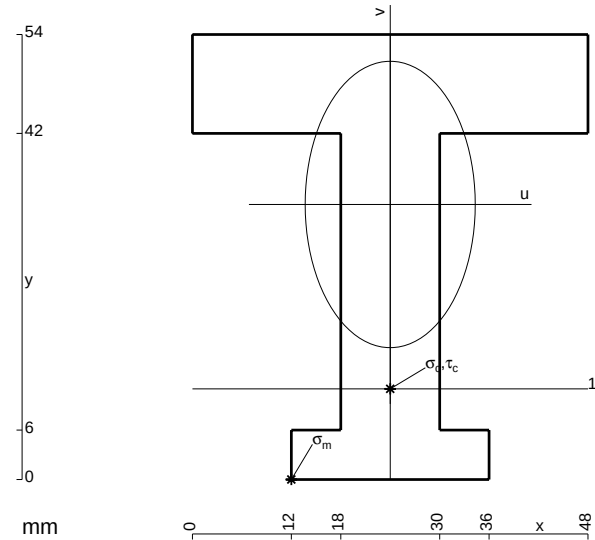
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$



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

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

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

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

$$T_y = -3500. \text{ N}$$

$$M_x = -2485000. \text{ Nmm}$$

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

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

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

$$\sigma_m = -Mv/J_u = -238.3 \text{ N/mm}^2$$

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

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

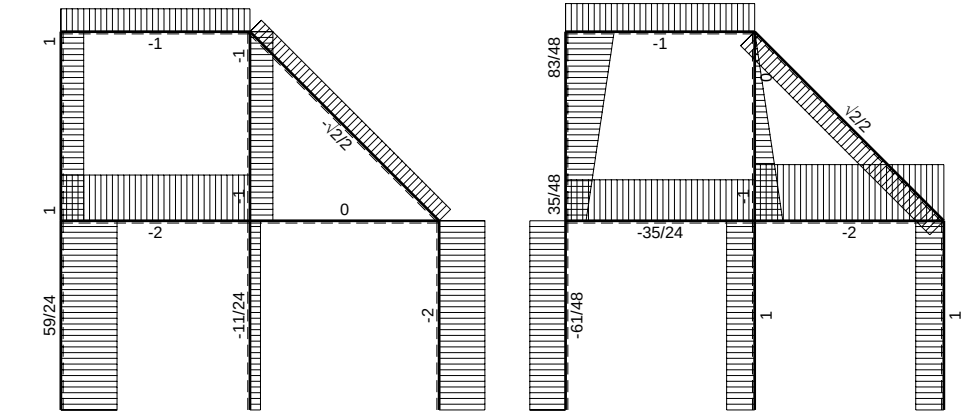
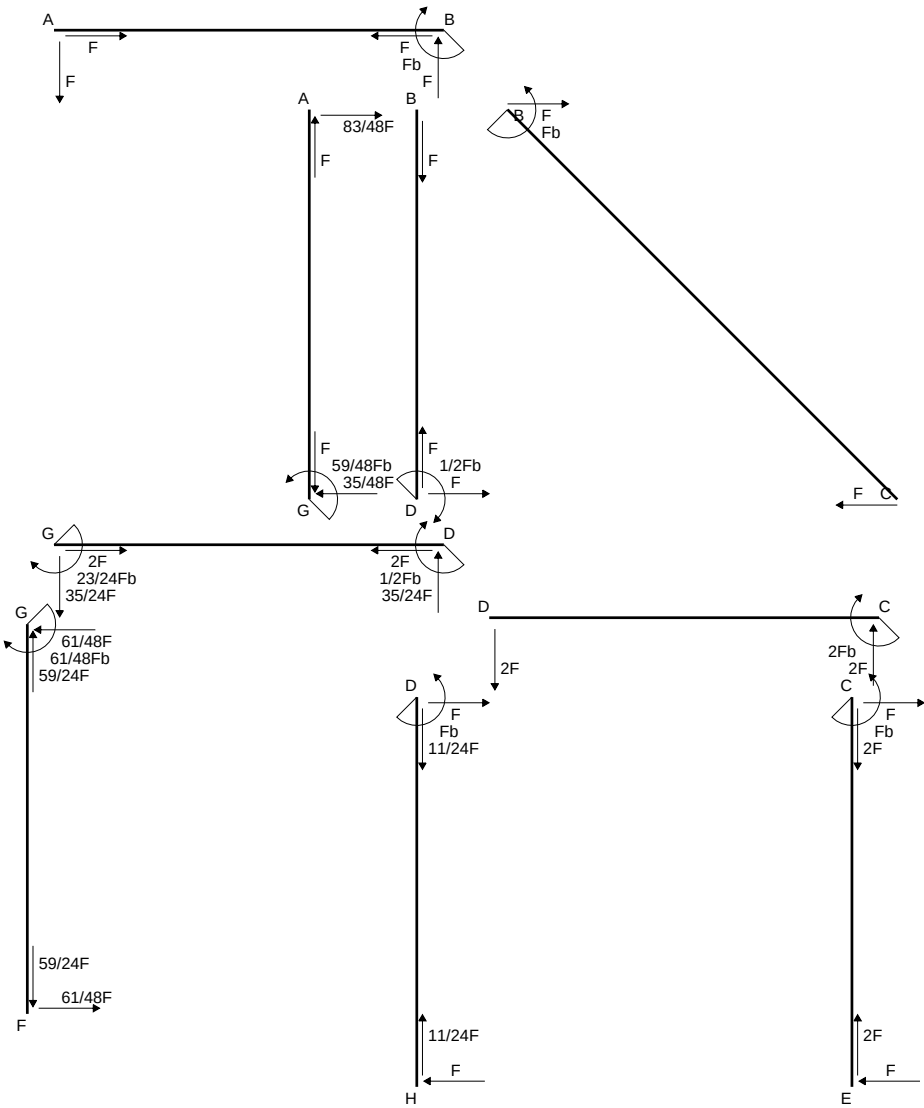
$$v_c = -22.38 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -159.8 \text{ N/mm}^2$$

$$\tau_c = 4.916 \text{ N/mm}^2$$

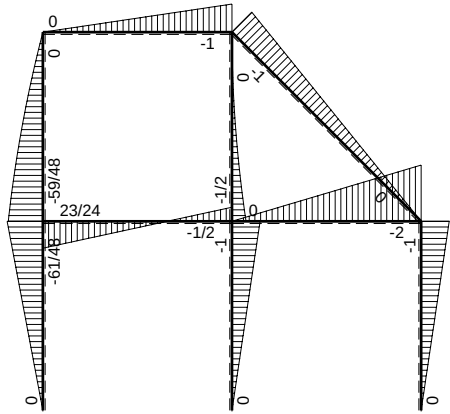
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 160. \text{ N/mm}^2$$

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



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx	-Fb/EJ	7/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(7/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	7/4Fb-7/4Fx	Fb/EJ	7/8Fb-7/4Fx+7/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx ²	0	-3/8Fb+1/2Fx+1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-7/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx ²	0	-5/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						23/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-23/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{13}{24} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{7}{8} - \frac{7}{4} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{8} x - \frac{7}{8} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{8} b - \frac{7}{8} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{13}{24} Fb^2/EJ$$

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

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

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

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

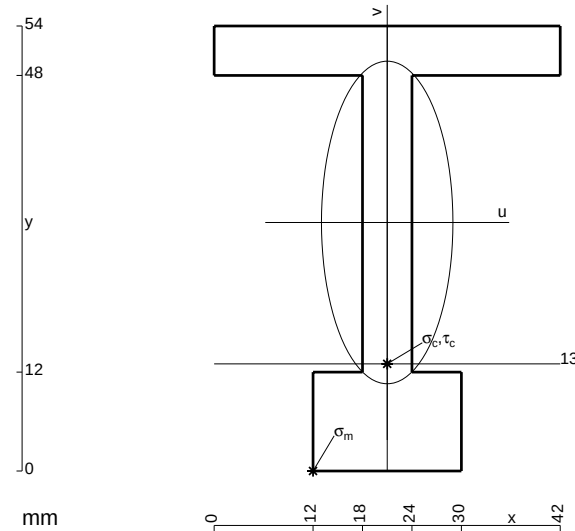
$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

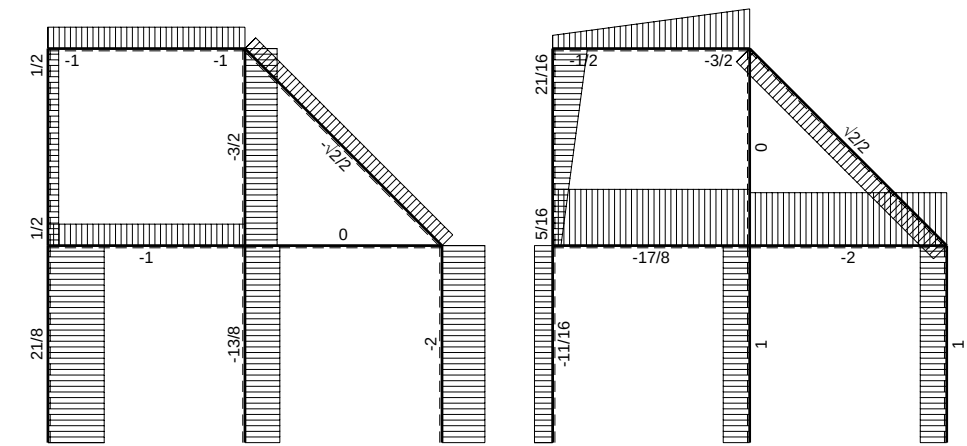
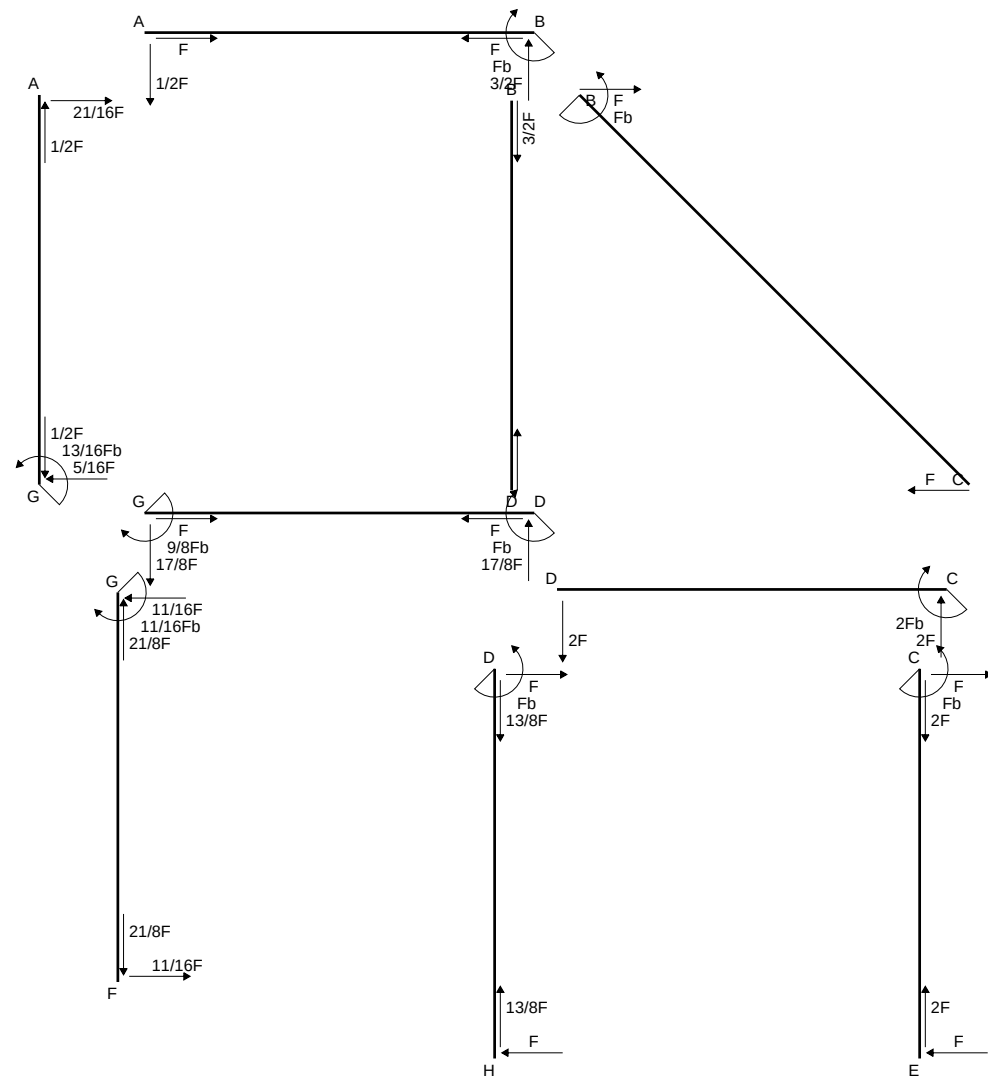
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

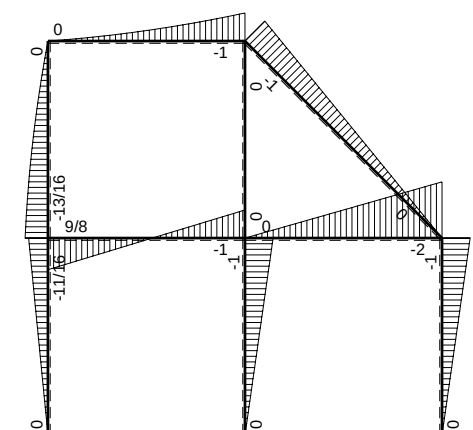


$$\begin{aligned} A &= 684. \text{ mm}^2 \\ J_u &= 262207. \text{ mm}^4 \\ J_v &= 43524. \text{ mm}^4 \\ y_g &= 30.16 \text{ mm} \\ T_y &= -2280. \text{ N} \\ M_x &= -1732800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -30.16 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.16 \text{ mm} \\ \sigma_c &= -Mv/J_u = -113.4 \text{ N/mm}^2 \\ \tau_c &= 7.716 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 114.2 \text{ N/mm}^2 \\ S &= 5324. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx$	$-Fb/EJ$	$5/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(5/24+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-5/4Fx$	Fb/EJ	$5/8Fb-5/4Fx+5/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb-1/4Fx+1/2qx^2$	0	$-1/8Fb+3/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/16+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx-1/2qx^2$	0	$-3/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$9/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

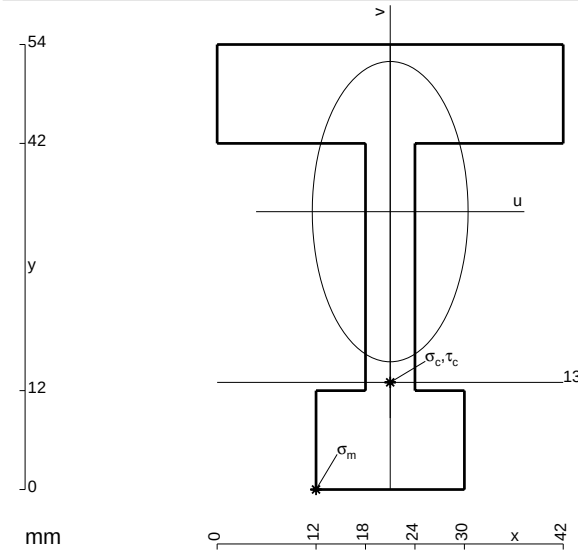
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

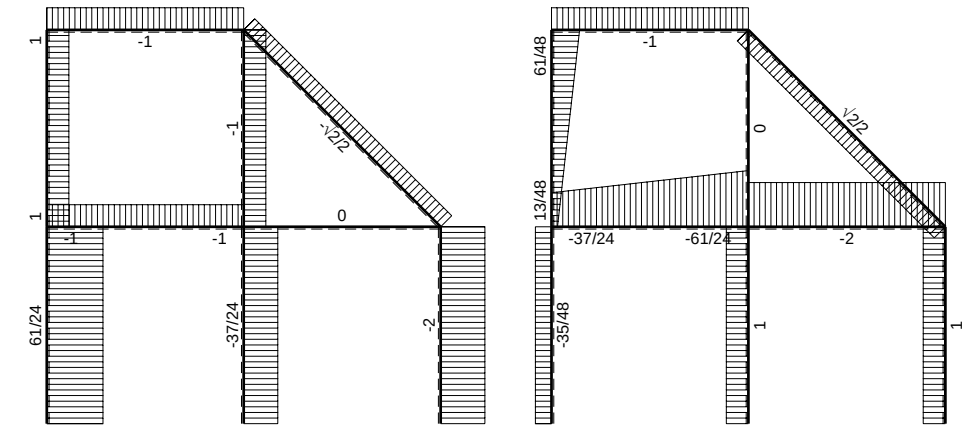
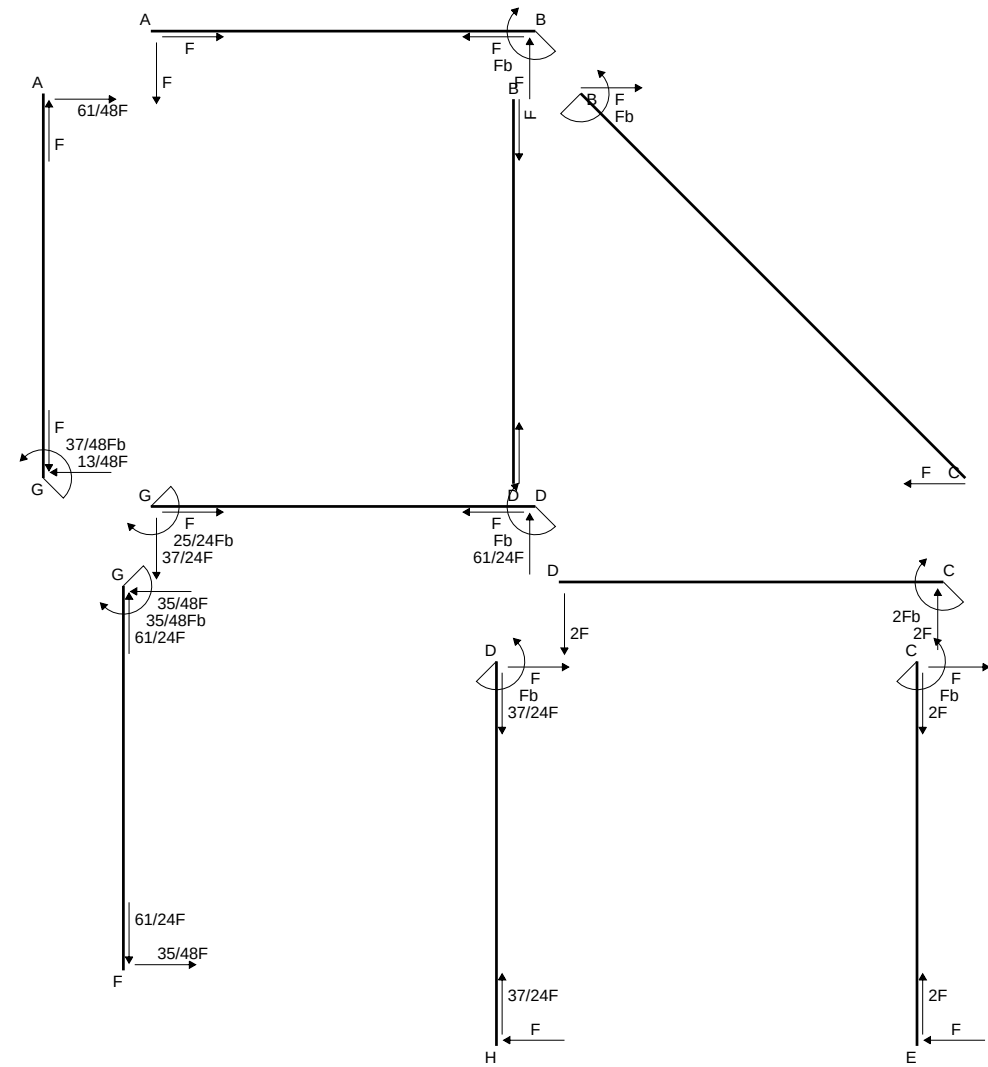
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

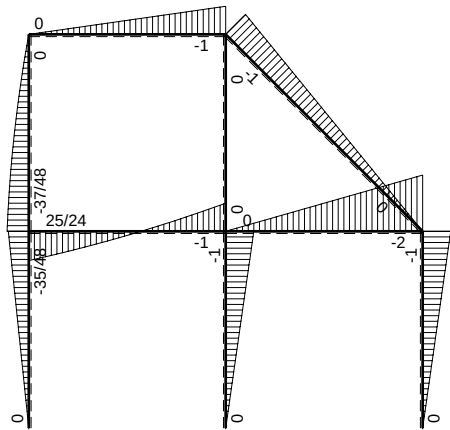


$$\begin{aligned} A &= 900. \text{ mm}^2 \\ J_u &= 299017. \text{ mm}^4 \\ J_v &= 80460. \text{ mm}^4 \\ y_g &= 33.72 \text{ mm} \\ T_y &= -2280. \text{ N} \\ M_x &= -1846800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -33.72 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -20.72 \text{ mm} \\ \sigma_c &= -Mv/J_u = -128. \text{ N/mm}^2 \\ \tau_c &= 7.771 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 128.7 \text{ N/mm}^2 \\ S &= 6115. \text{ mm}^3 \end{aligned}$$

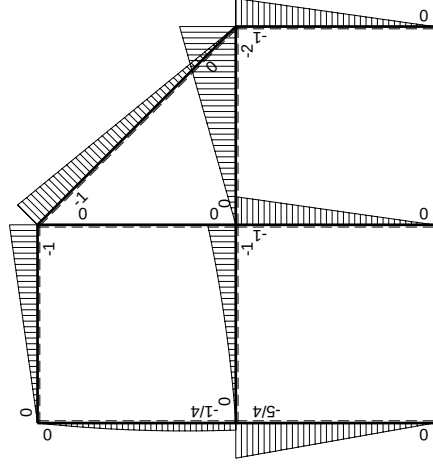
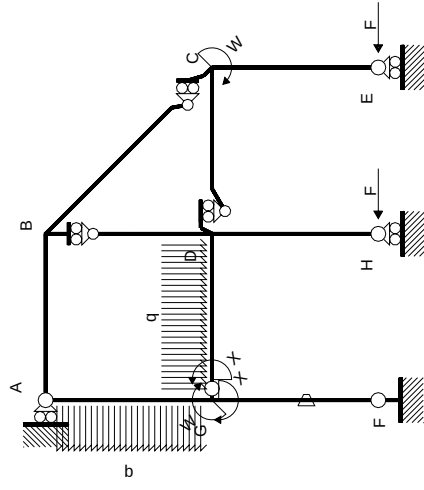


← $\boxed{+}$ → F

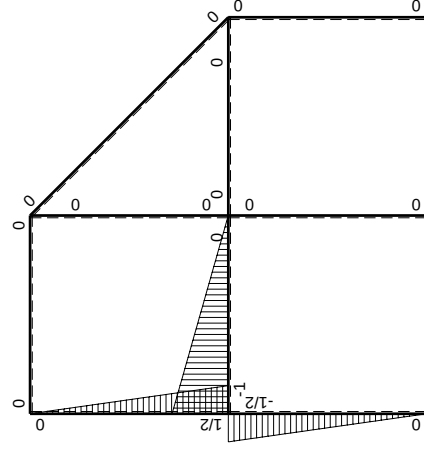
↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico



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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(5/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						25/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-25/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

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

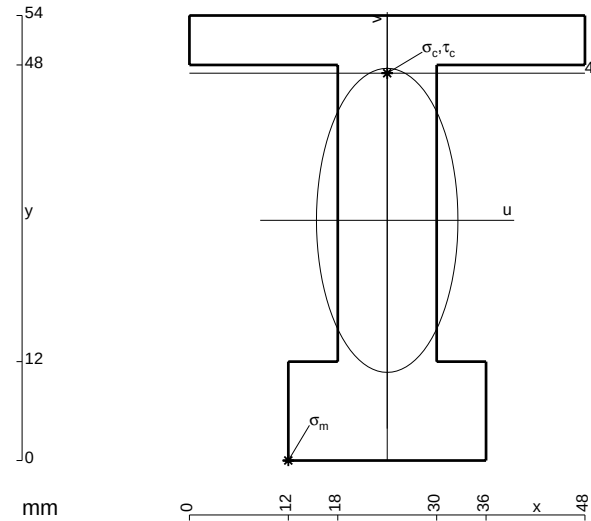
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

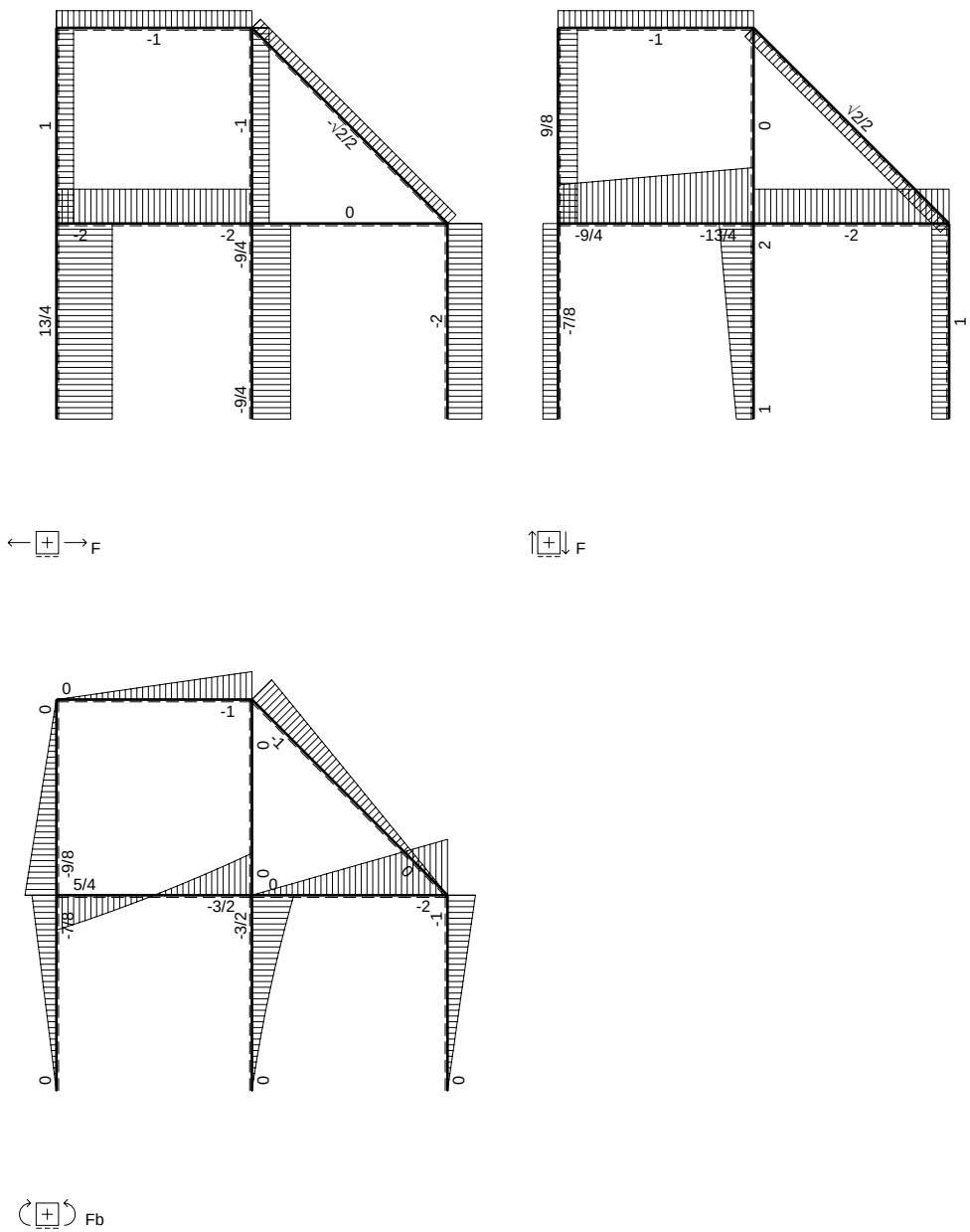
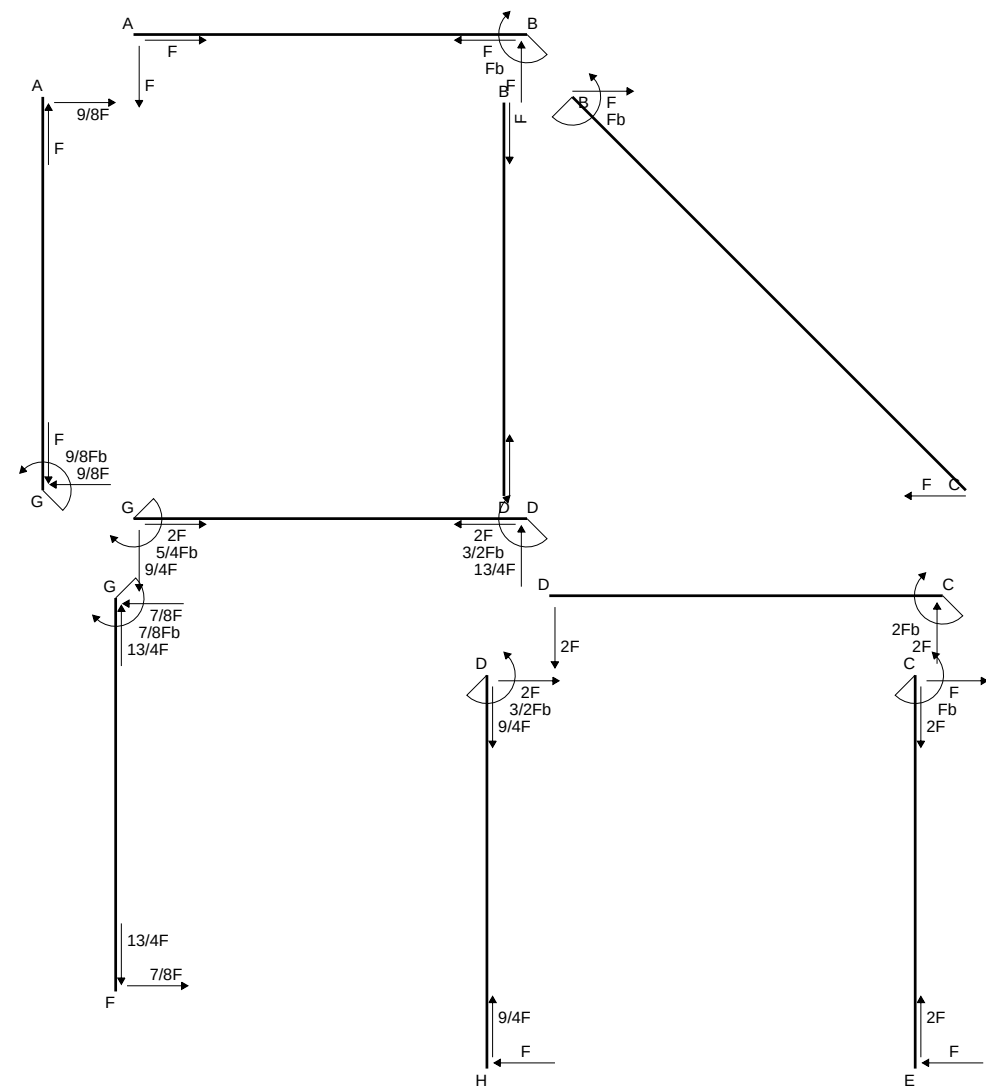
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

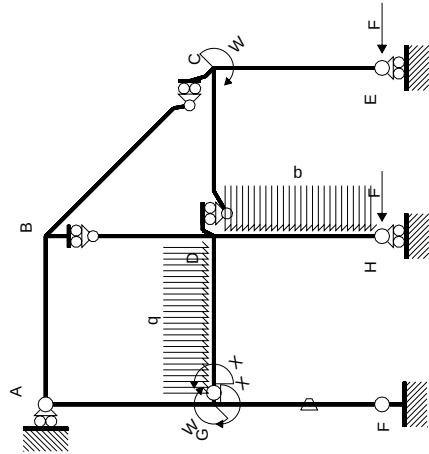
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$



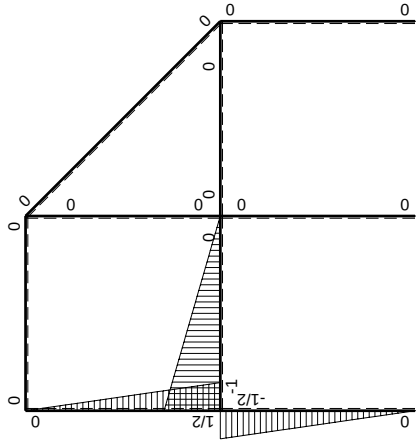
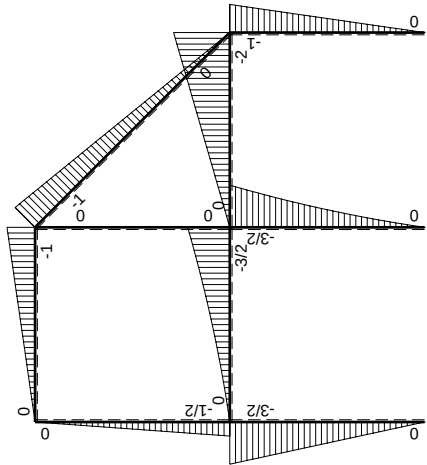
$$\begin{aligned} A &= 1008. \text{ mm}^2 \\ J_u &= 343131. \text{ mm}^4 \\ J_v &= 74304. \text{ mm}^4 \\ y_g &= 29.14 \text{ mm} \\ T_y &= -3000. \text{ N} \\ M_x &= -2580000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.14 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.1 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 47. \text{ mm} \\ v_c &= 17.86 \text{ mm} \\ \sigma_c &= -Mv/J_u = 134.3 \text{ N/mm}^2 \\ \tau_c &= 4.747 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 134.5 \text{ N/mm}^2 \\ S &= 6515. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati

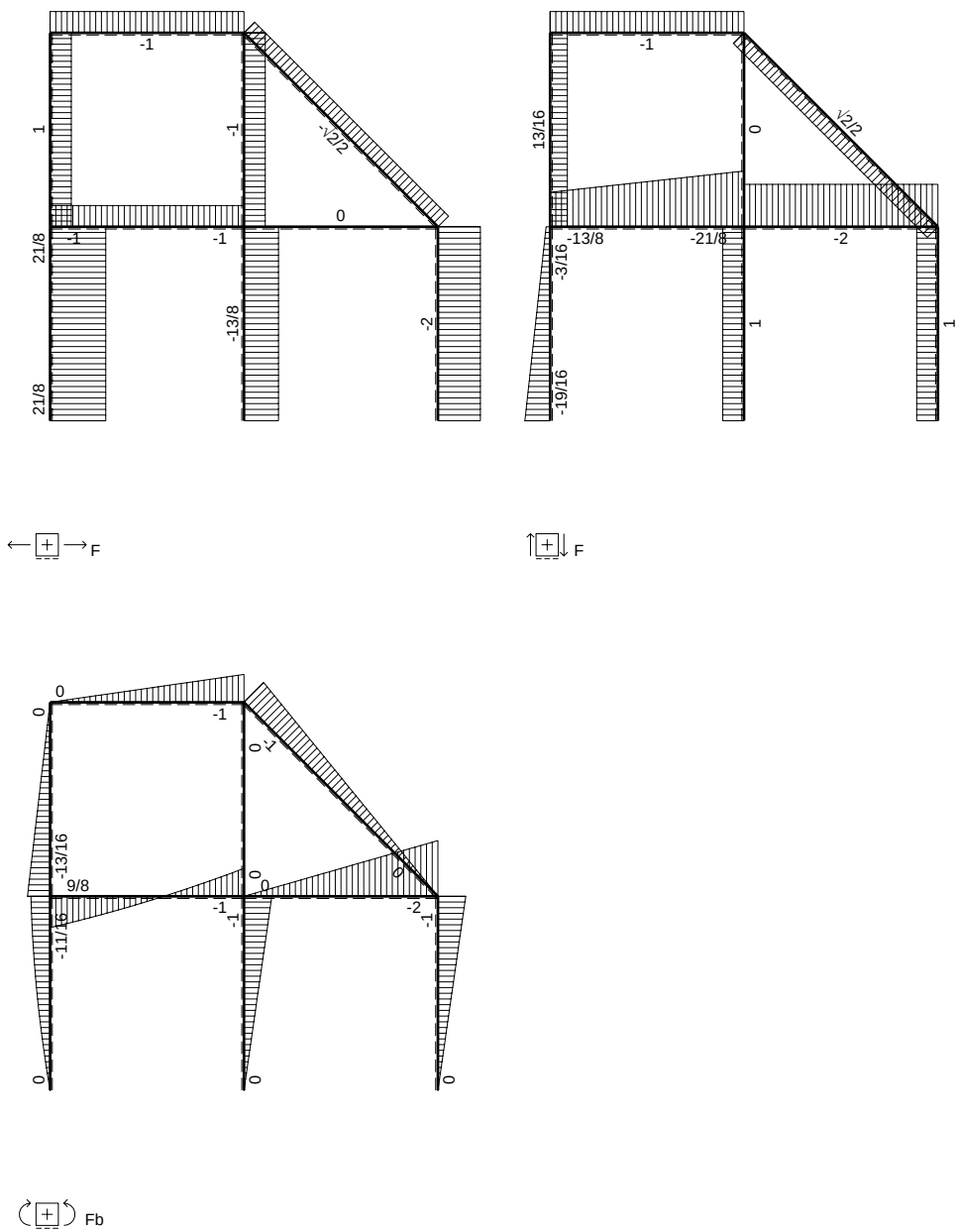
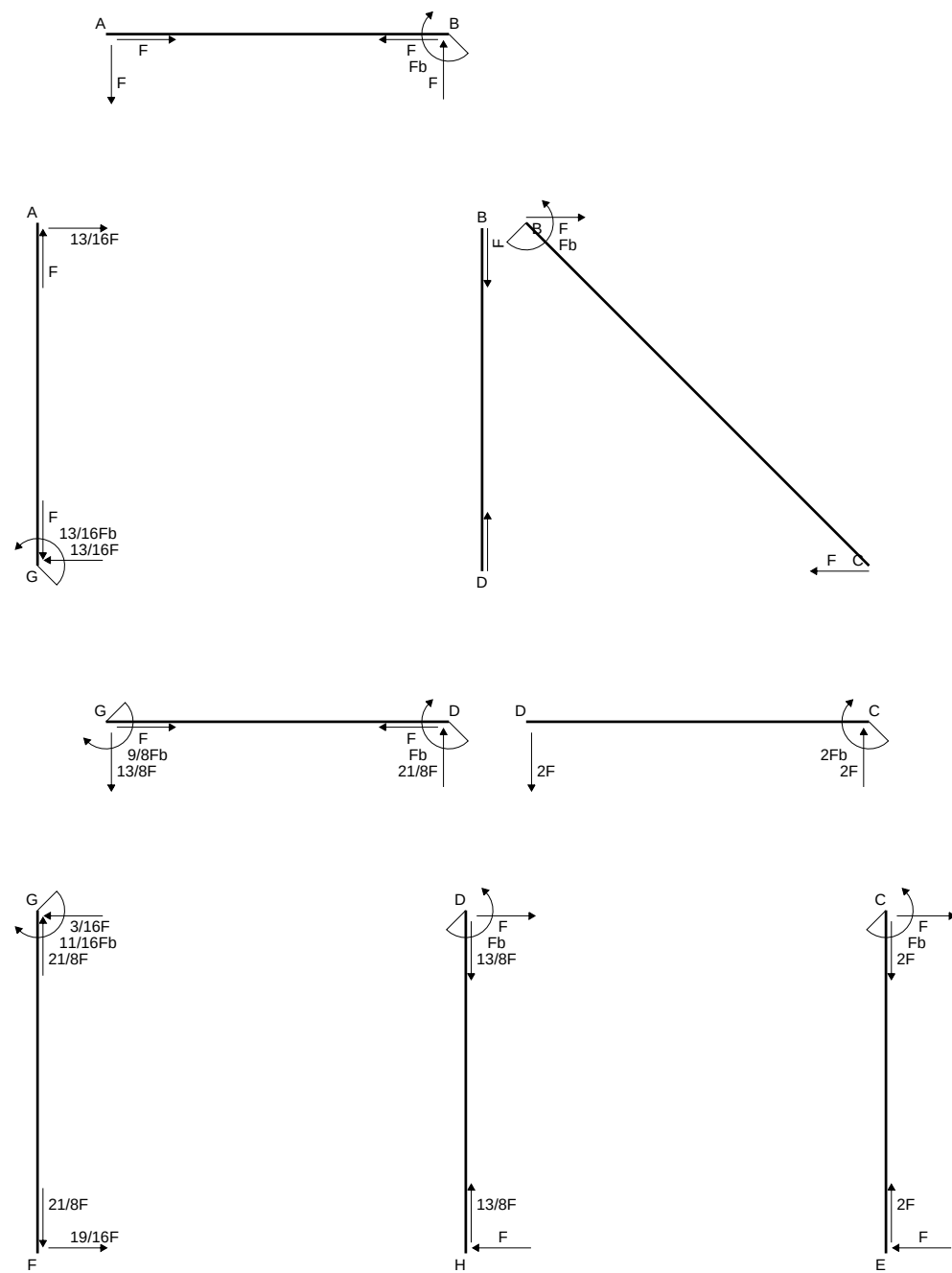


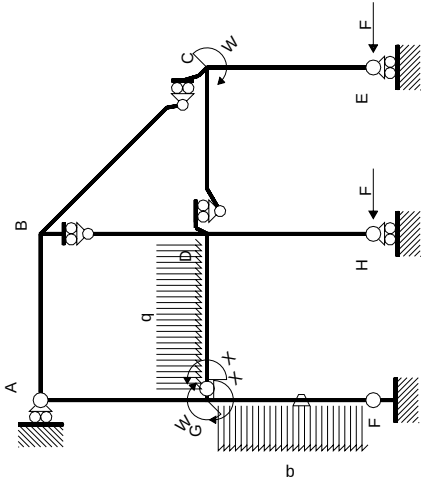
M_1 flessione da iperstatica X=1

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-Fx-1/2qx ²	0	Fx-1/2Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(5/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx ²	0	3/2Fx-2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						5/8Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/4Fb	

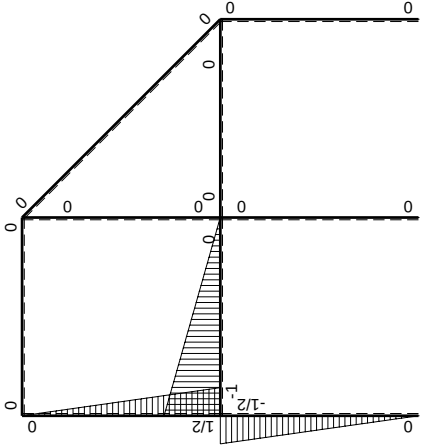
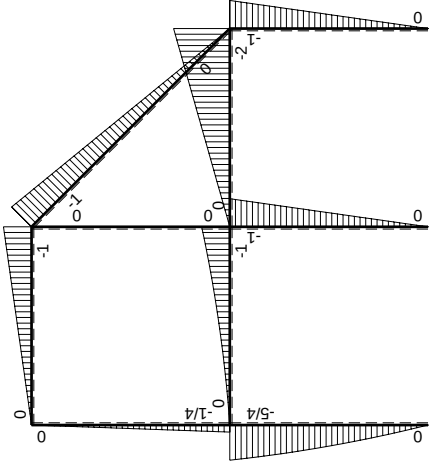
Sviluppi di calcolo iperstatica





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx+1/2qx ²	-Fb/EJ	7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(11/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx ²	Fb/EJ	5/8Fb-Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx ² /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

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

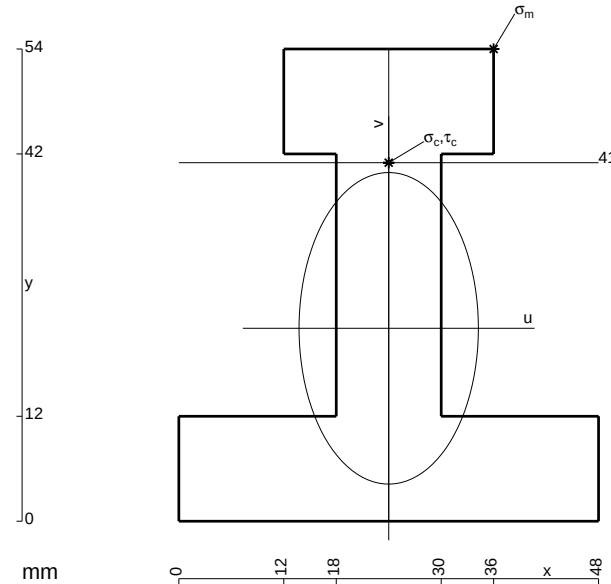
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

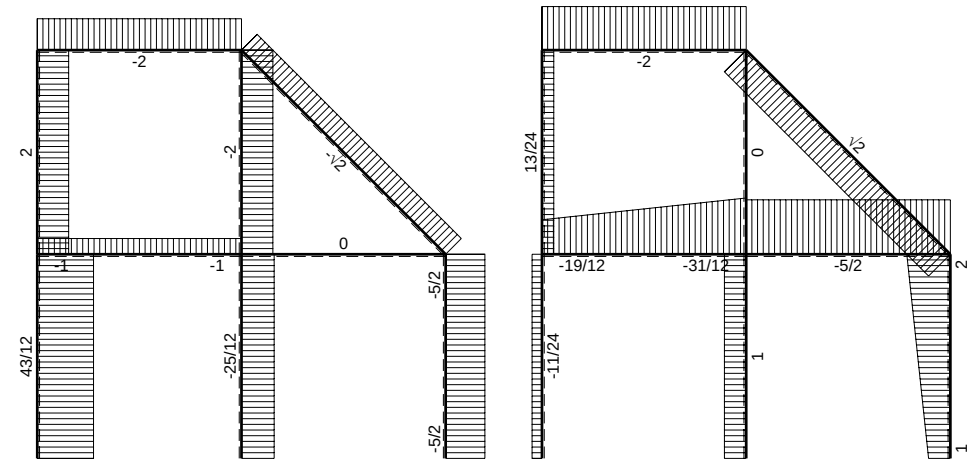
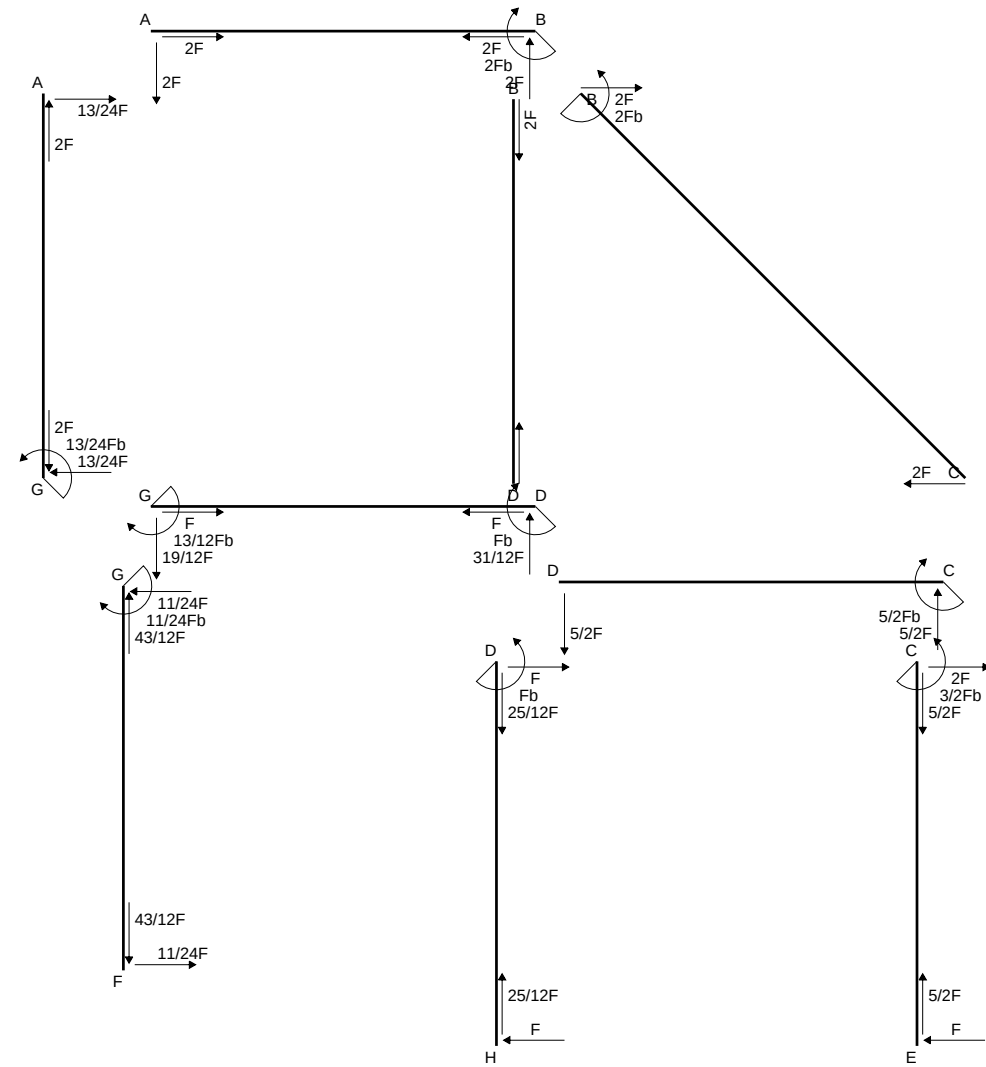
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

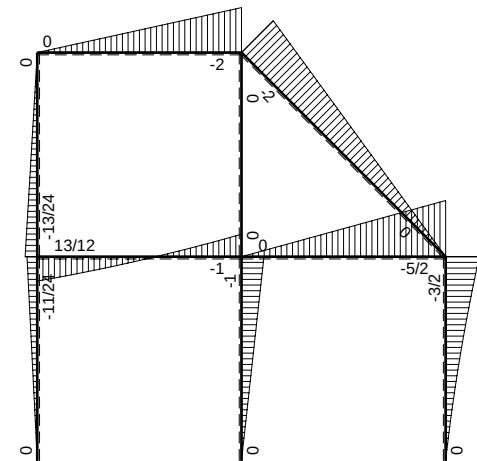


$$\begin{aligned} A &= 1224. \text{ mm}^2 \\ J_u &= 388508. \text{ mm}^4 \\ J_v &= 128736. \text{ mm}^4 \\ y_g &= 22.06 \text{ mm} \\ T_y &= -3040. \text{ N} \\ M_x &= -2918400. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.94 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 18.94 \text{ mm} \\ \sigma_c &= -Mv/J_u = 142.3 \text{ N/mm}^2 \\ \tau_c &= 5.024 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 142.5 \text{ N/mm}^2 \\ S &= 7704. \text{ mm}^3 \end{aligned}$$

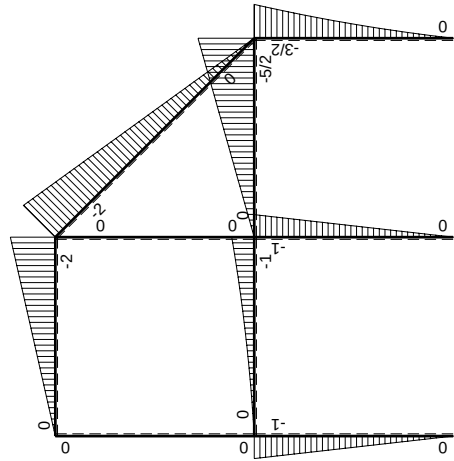
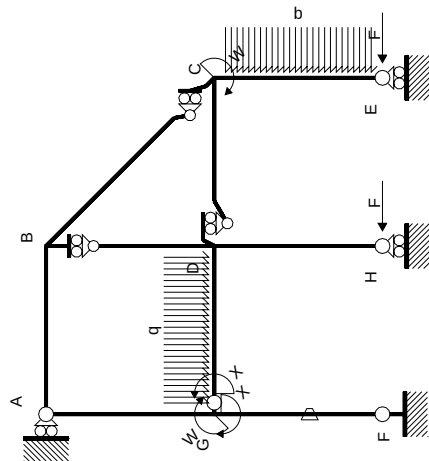


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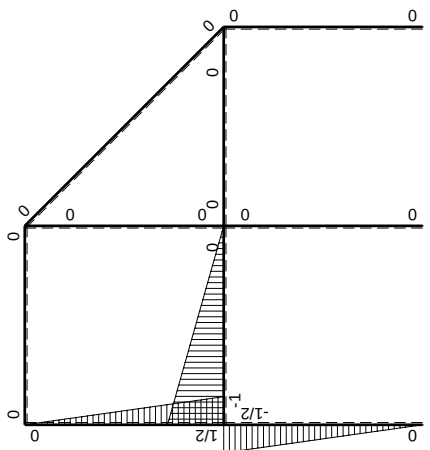


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x ² /b ²	0+0	1/12Xb/EJ
AG b	-1/2x/b	0	0	0	0	1/4x ² /b ²		
	totali						13/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

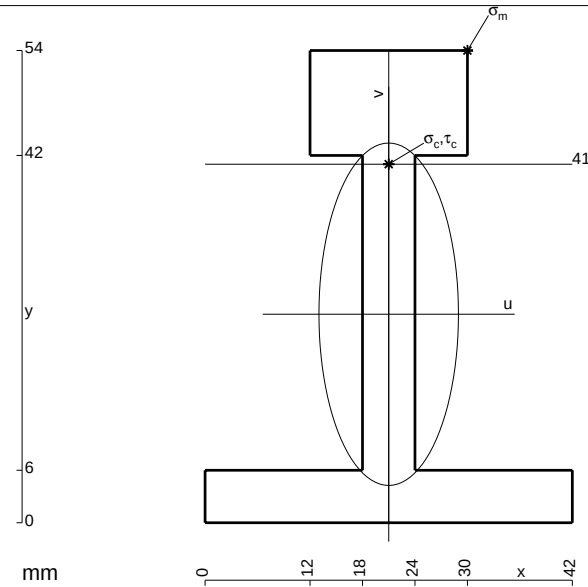
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

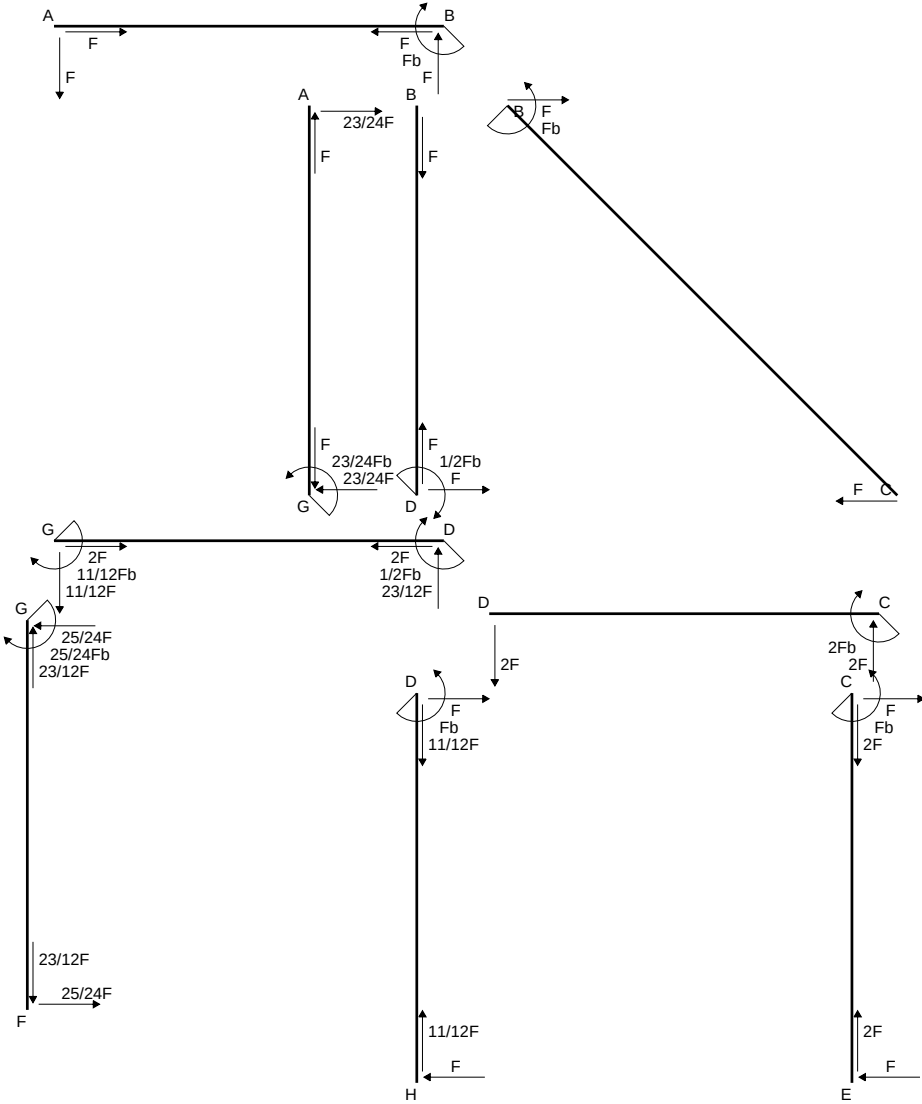
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$



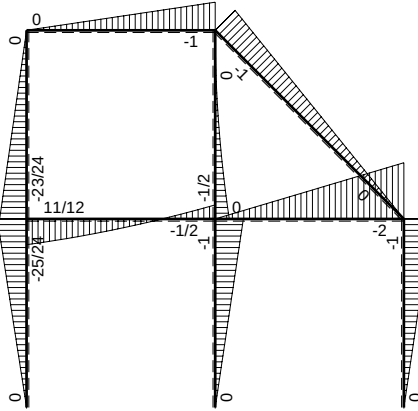
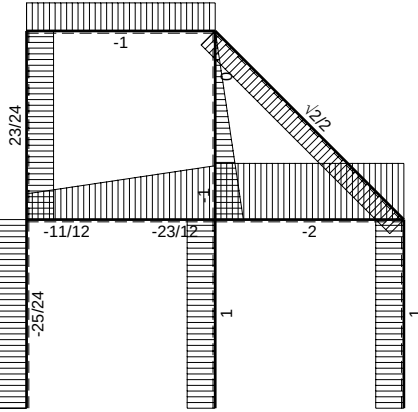
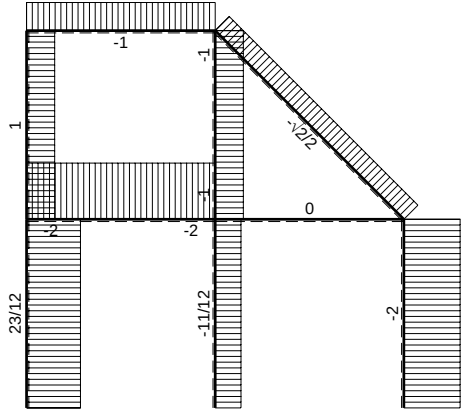
$$\begin{aligned} A &= 684. \text{ mm}^2 \\ J_u &= 262207. \text{ mm}^4 \\ J_v &= 43524. \text{ mm}^4 \\ y_g &= 23.84 \text{ mm} \\ T_y &= -3400. \text{ N} \\ M_x &= -1734000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 30.16 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 17.16 \text{ mm} \\ \sigma_c &= -Mv/J_u = 113.5 \text{ N/mm}^2 \\ \tau_c &= 11.51 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 115.2 \text{ N/mm}^2 \\ S &= 5324. \text{ mm}^3 \end{aligned}$$

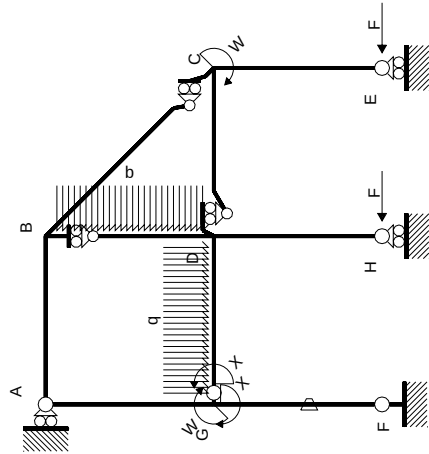


$\leftarrow \boxed{+} \rightarrow F$

$\uparrow \boxed{+} \downarrow F$

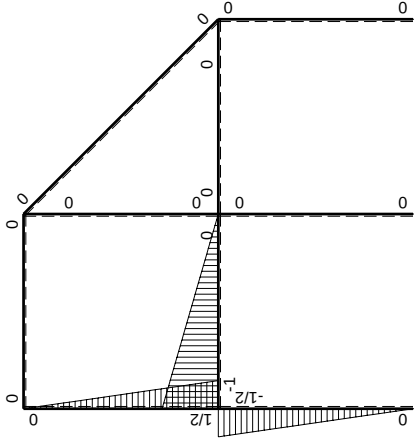
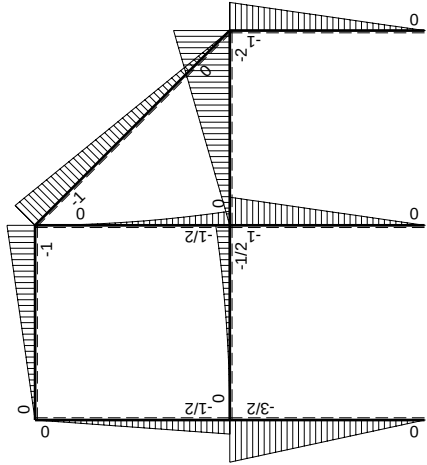
$\curvearrowright \boxed{+} \curvearrowleft F_b$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati

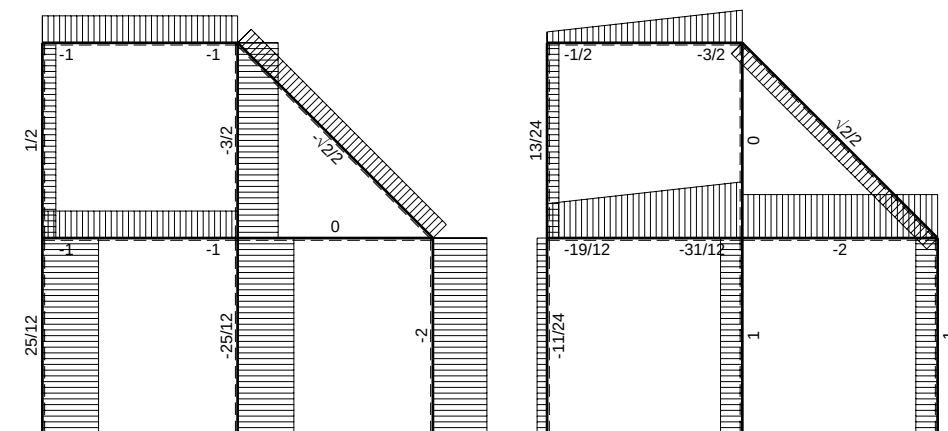
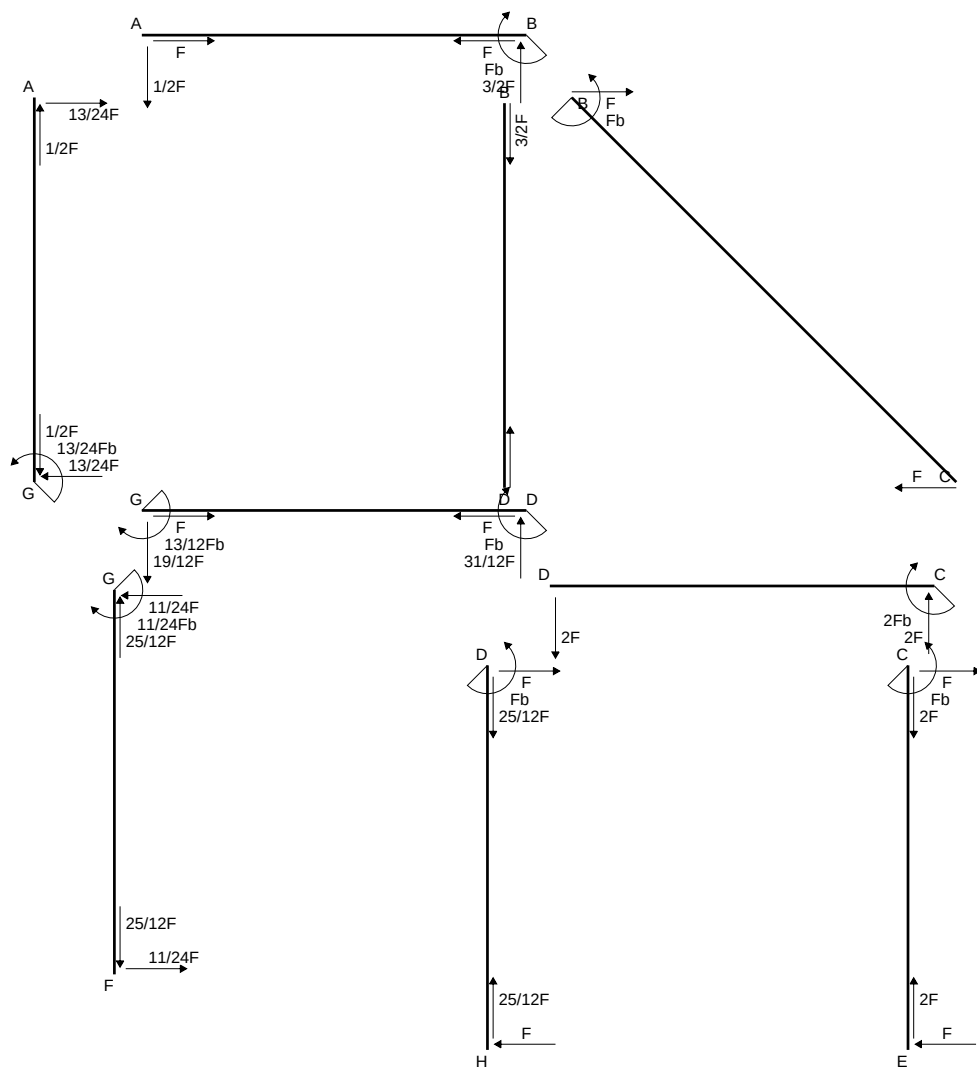


M_x flessione da iperstatica $X=1$

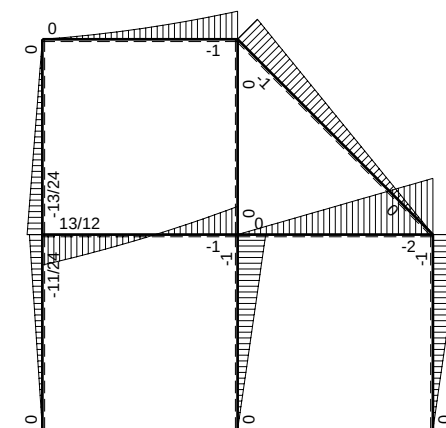
Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2qx^2$	0	$1/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-Fx+1/2qx^2$	0	$1/2Fx-Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$11/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-11/12Fb$	

Sviluppi di calcolo iperstatica


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

↑ + ↓ F



 Fb

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$13/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-13/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

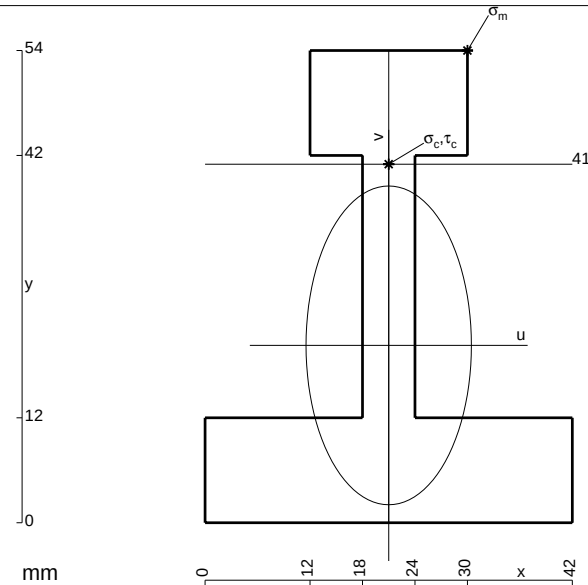
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

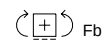
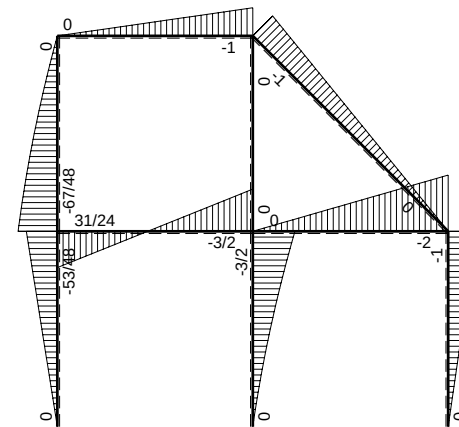
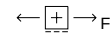
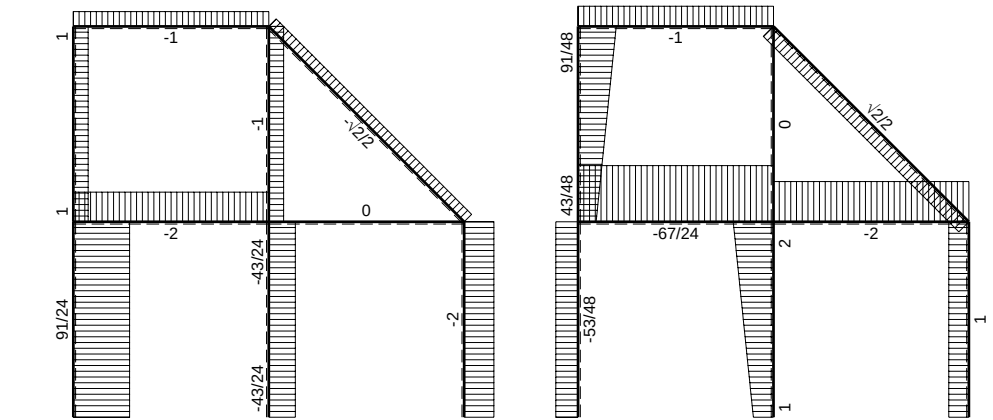
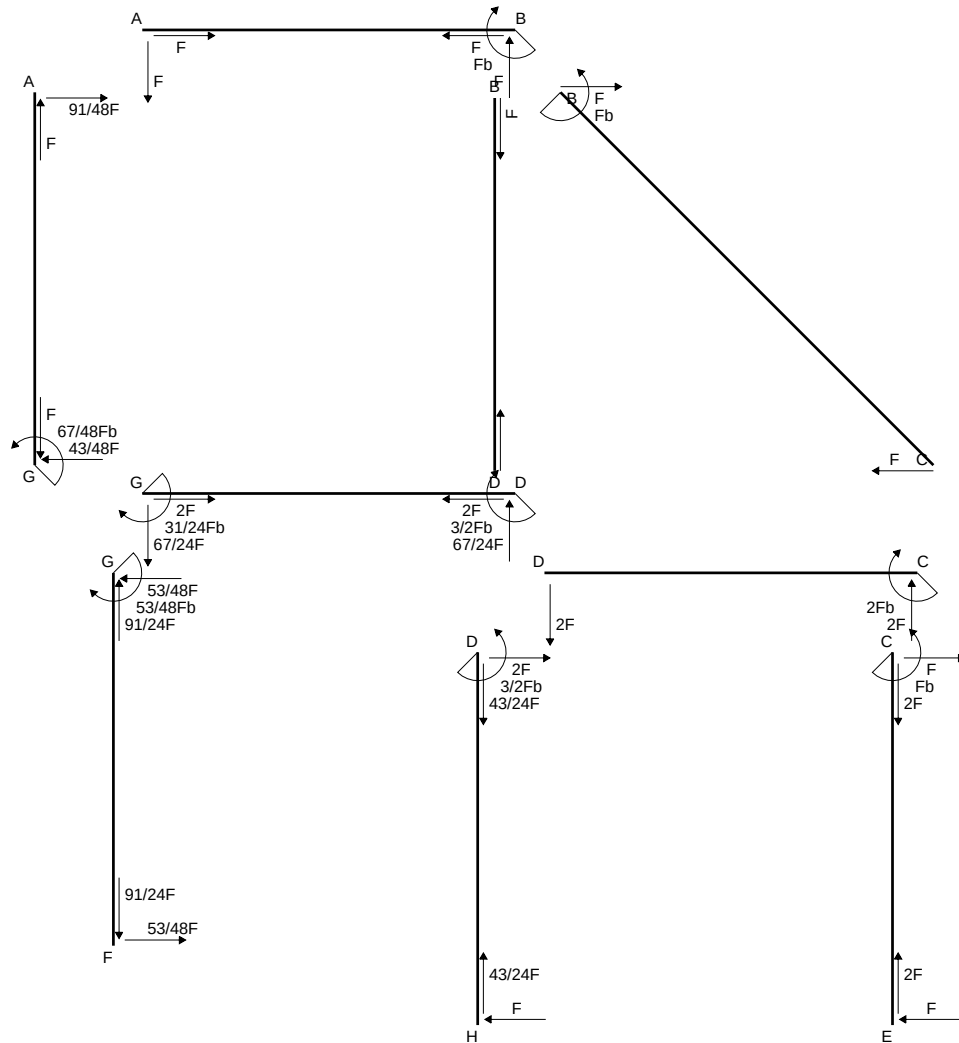
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

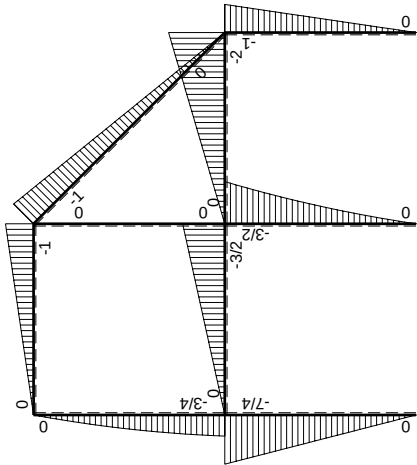
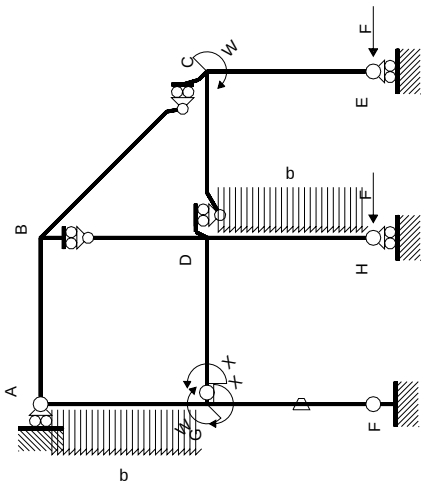
$$L_{DG}^{x_0} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$



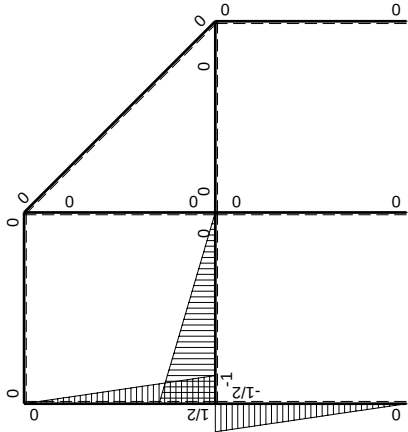
$$\begin{aligned} A &= 900. \text{ mm}^2 \\ J_u &= 299017. \text{ mm}^4 \\ J_v &= 80460. \text{ mm}^4 \\ y_g &= 20.28 \text{ mm} \\ T_y &= -3180. \text{ N} \\ M_x &= -1939800. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.72 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 20.72 \text{ mm} \\ \sigma_c &= -Mv/J_u = 134.4 \text{ N/mm}^2 \\ \tau_c &= 10.84 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 135.7 \text{ N/mm}^2 \\ S &= 6115. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx	-Fb/EJ	$7/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/24+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$7/4Fb-7/4Fx$	Fb/EJ	$7/8Fb-7/4Fx+7/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	-1+x/b	-3/2Fx	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	-1/2x/b	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$31/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-31/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{13}{24} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{7}{8} - \frac{7}{4} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{8} x - \frac{7}{8} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{8} b - \frac{7}{8} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{13}{24} Fb^2/EJ$$

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

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

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

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

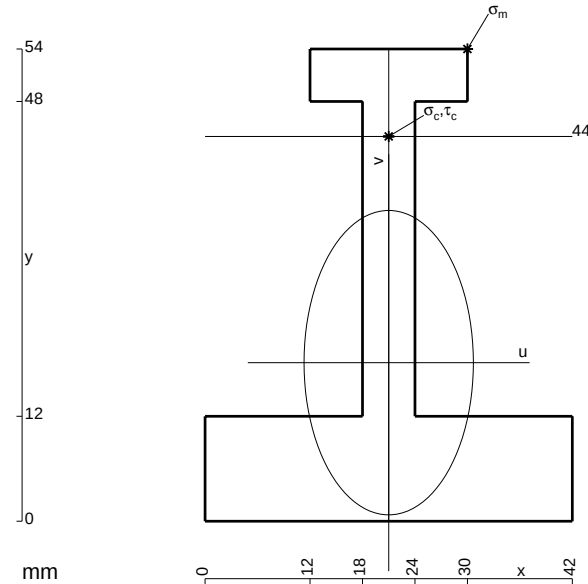
$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

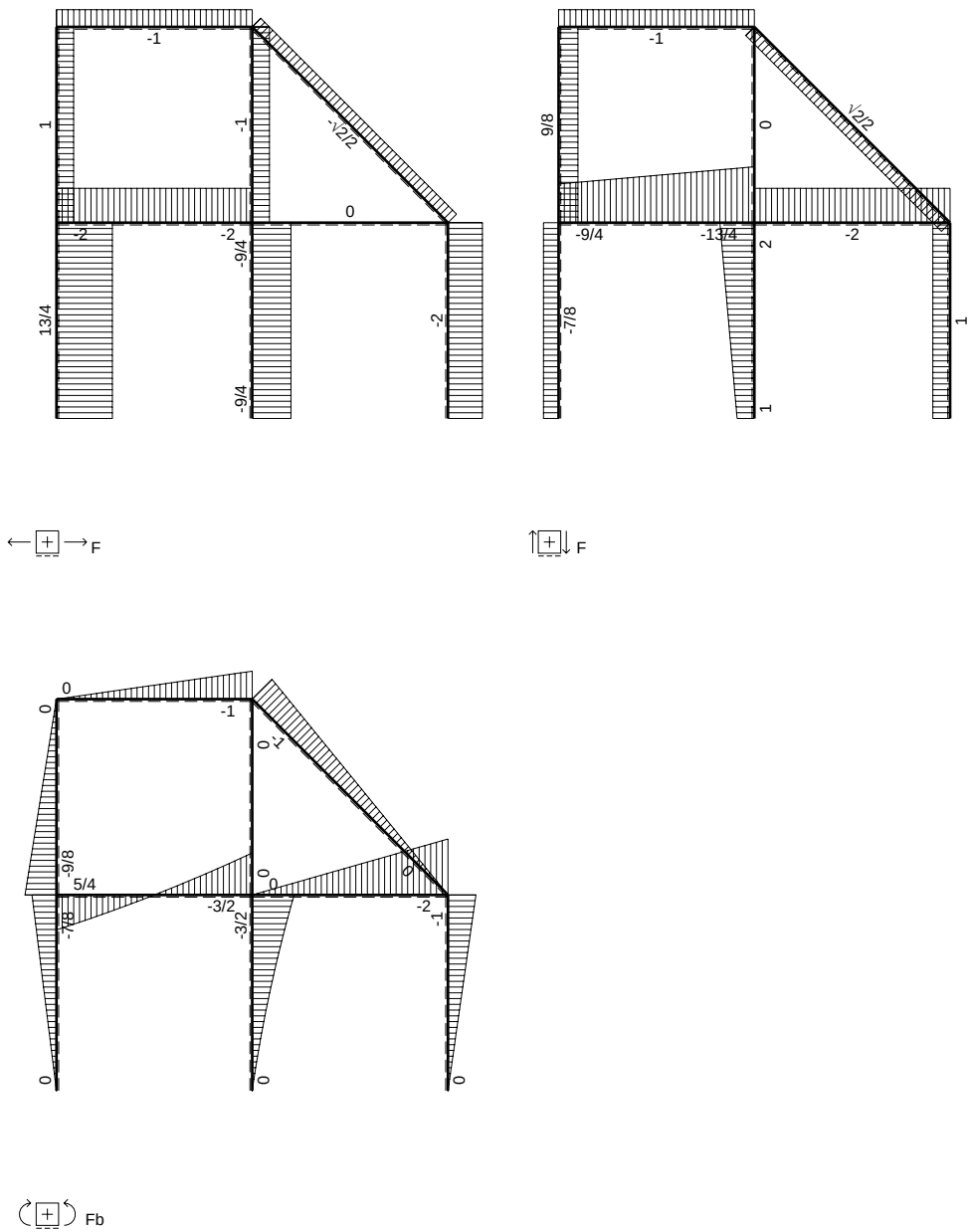
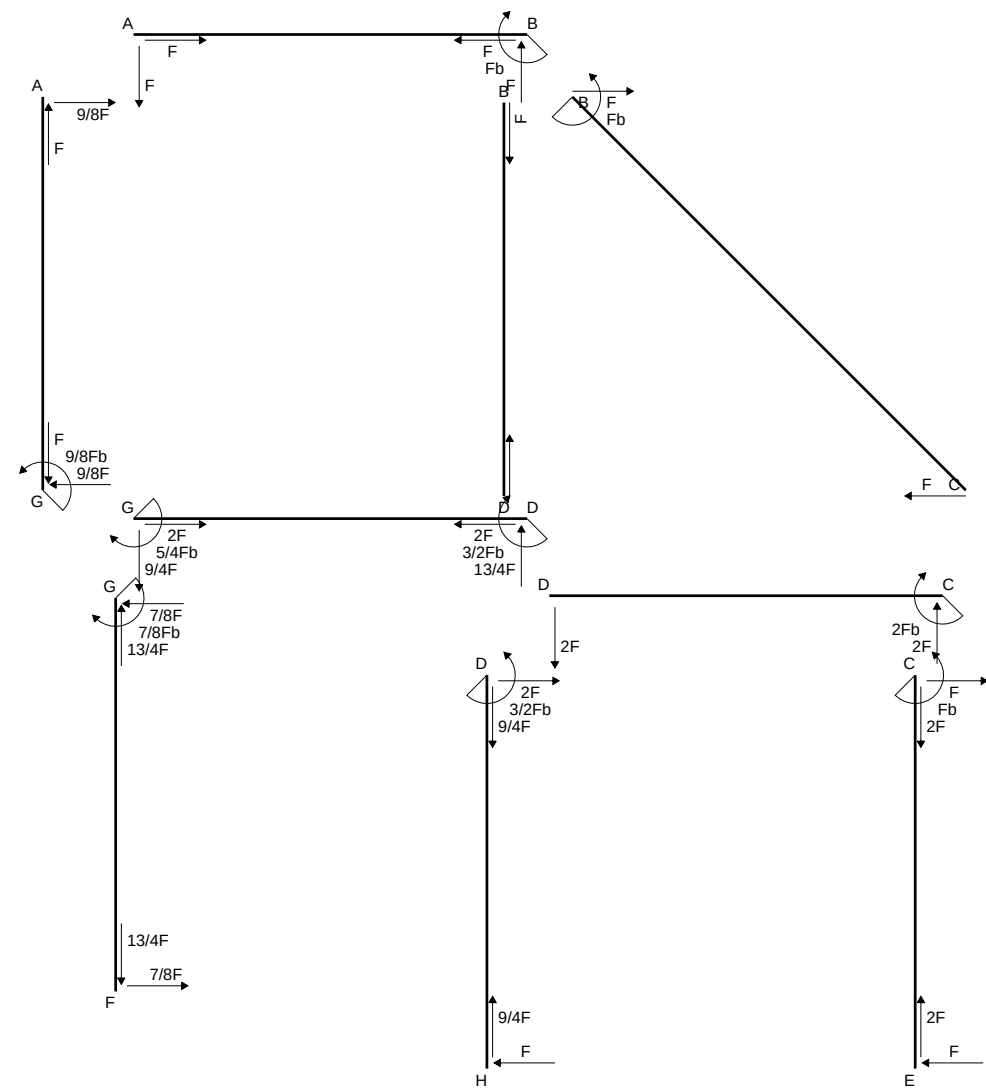
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



$$\begin{aligned} A &= 828. \text{ mm}^2 \\ J_u &= 250978. \text{ mm}^4 \\ J_v &= 77652. \text{ mm}^4 \\ y_g &= 18.13 \text{ mm} \\ T_y &= -2420. \text{ N} \\ M_x &= -1597200. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 35.87 \text{ mm} \\ \sigma_m &= -Mv/J_u = 228.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 25.87 \text{ mm} \\ \sigma_c &= -Mv/J_u = 164.6 \text{ N/mm}^2 \\ \tau_c &= 6.78 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 165.1 \text{ N/mm}^2 \\ S &= 4219. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-Fx-1/2qx ²	0	Fx-1/2Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(5/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx ²	0	3/2Fx-2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						5/8Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left(\frac{1}{2} b - \frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

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

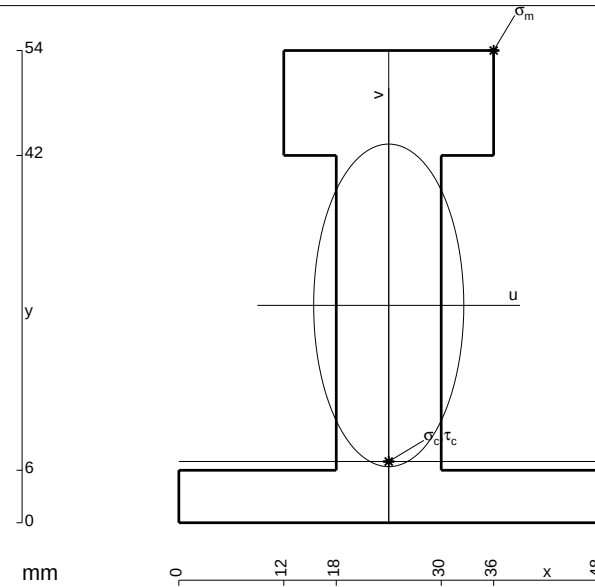
$$= \left(\frac{3}{4} b - \frac{2}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

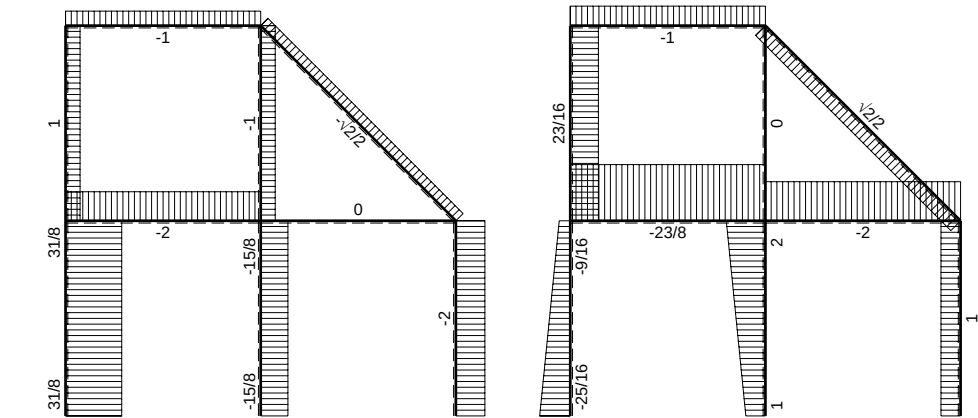
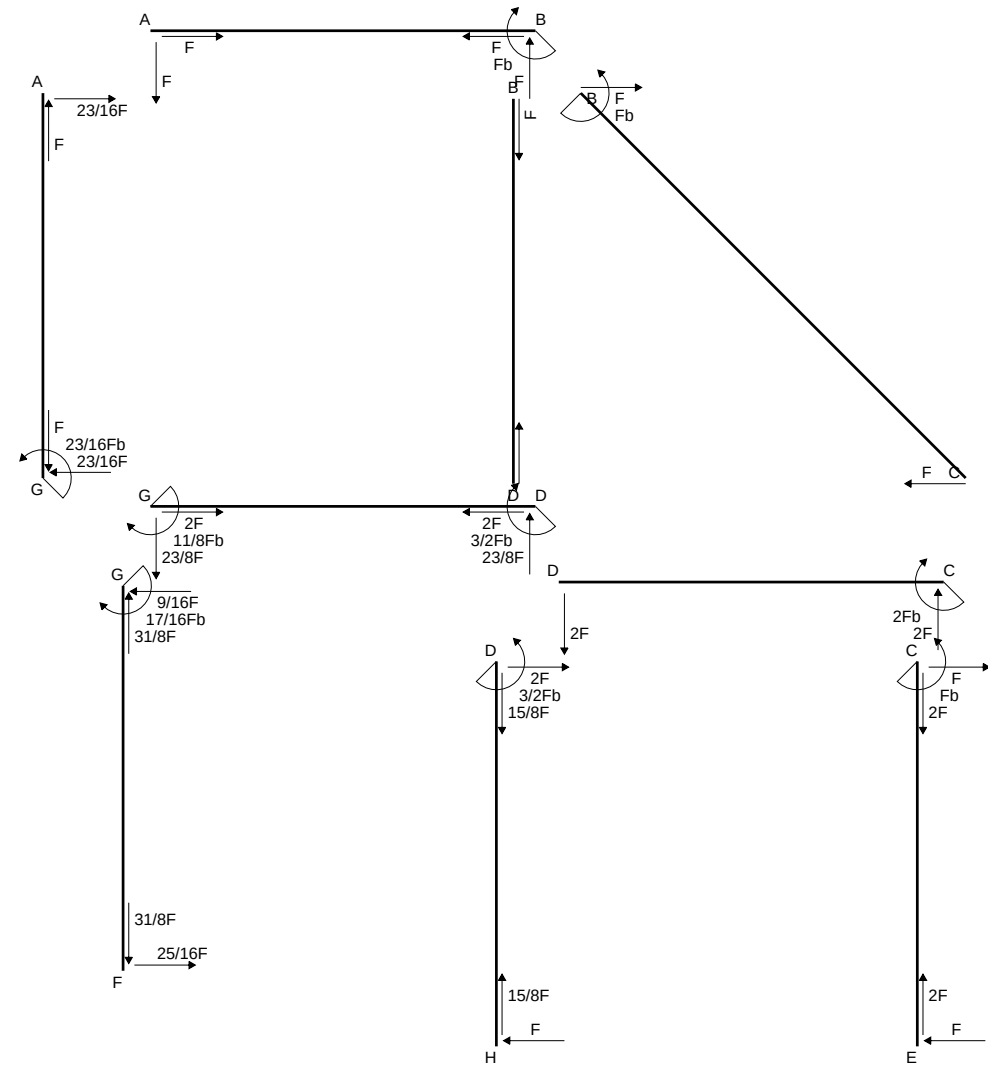
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

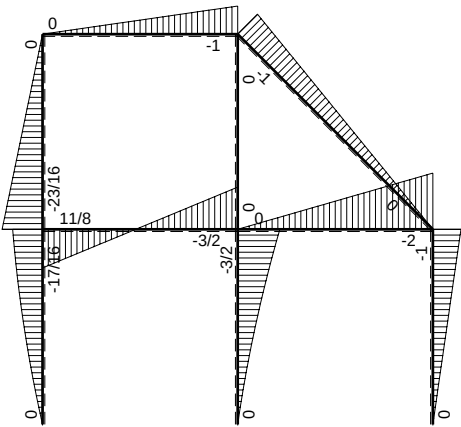


$$\begin{aligned} A &= 1008. \text{ mm}^2 \\ J_u &= 343131. \text{ mm}^4 \\ J_v &= 74304. \text{ mm}^4 \\ y_g &= 24.86 \text{ mm} \\ T_y &= -3960. \text{ N} \\ M_x &= -2811600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.14 \text{ mm} \\ \sigma_m &= -Mv/J_u = 238.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -17.86 \text{ mm} \\ \sigma_c &= -Mv/J_u = -146.3 \text{ N/mm}^2 \\ \tau_c &= 6.266 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 146.7 \text{ N/mm}^2 \\ S &= 6515. \text{ mm}^3 \end{aligned}$$

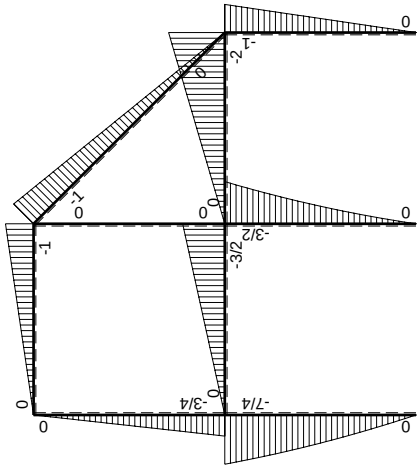
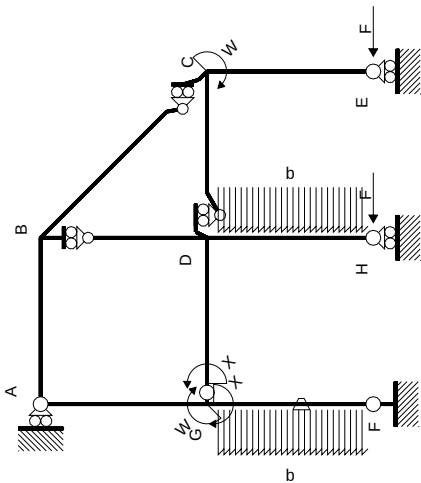


← ⊕ → F

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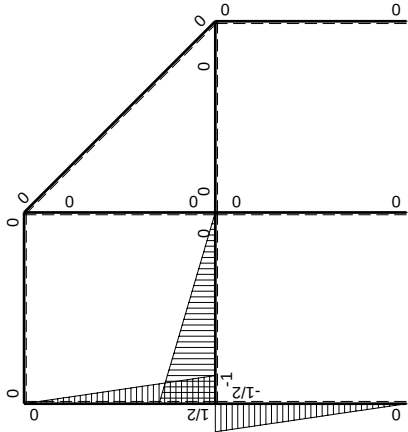


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



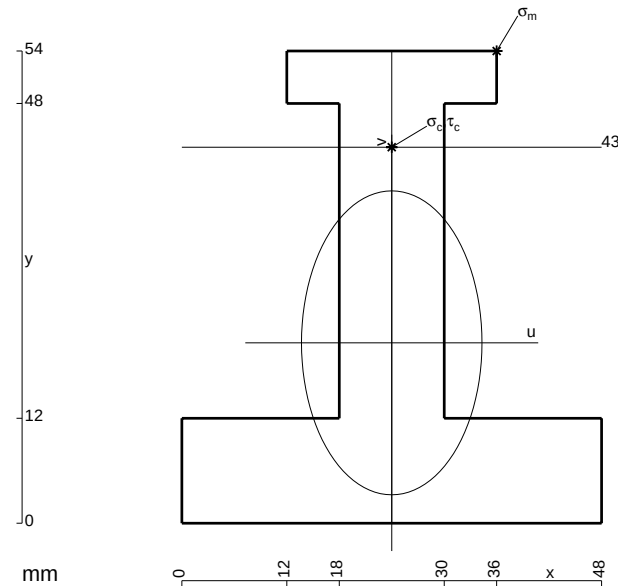
M_x flessione da iperstatica $X=1$

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

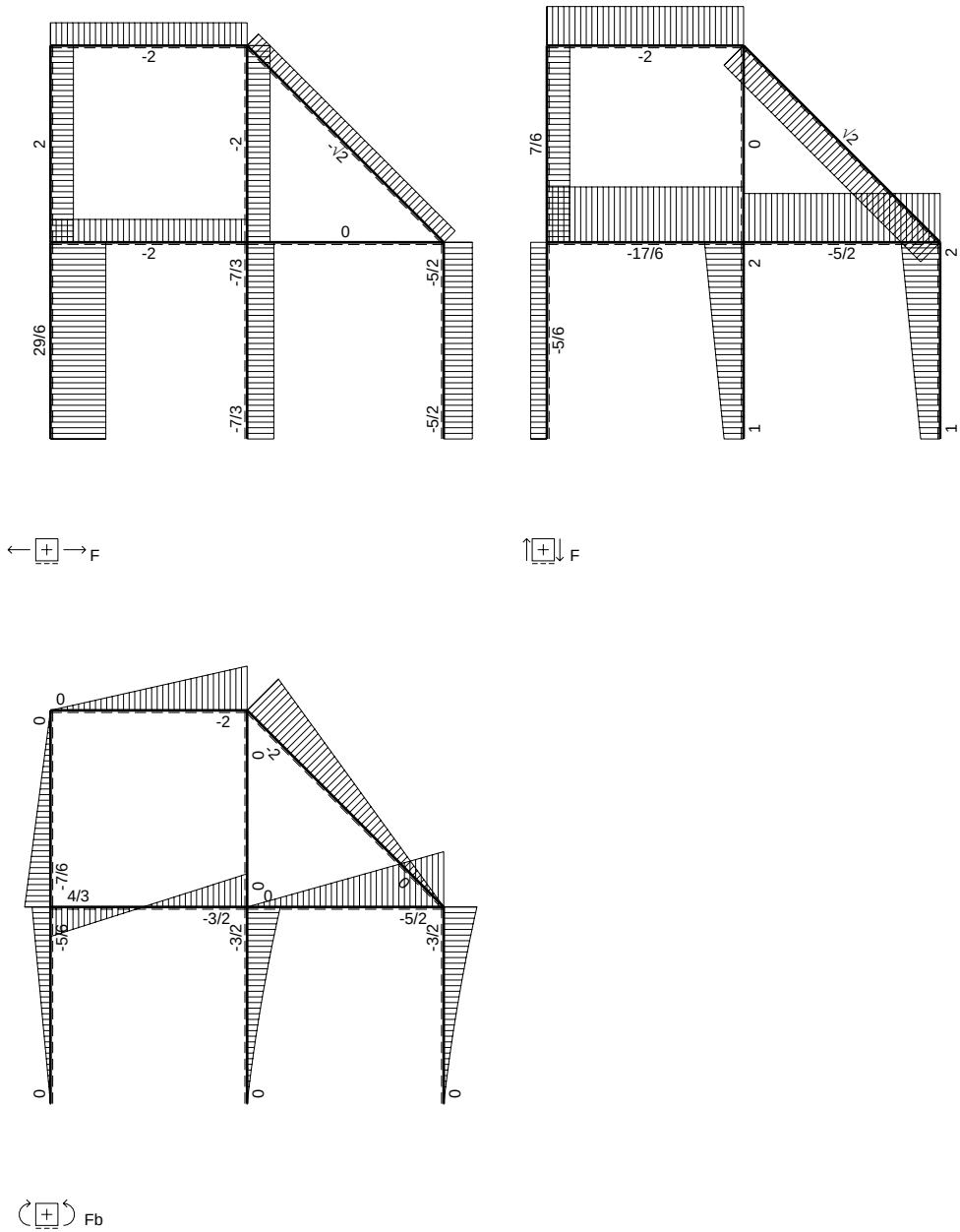
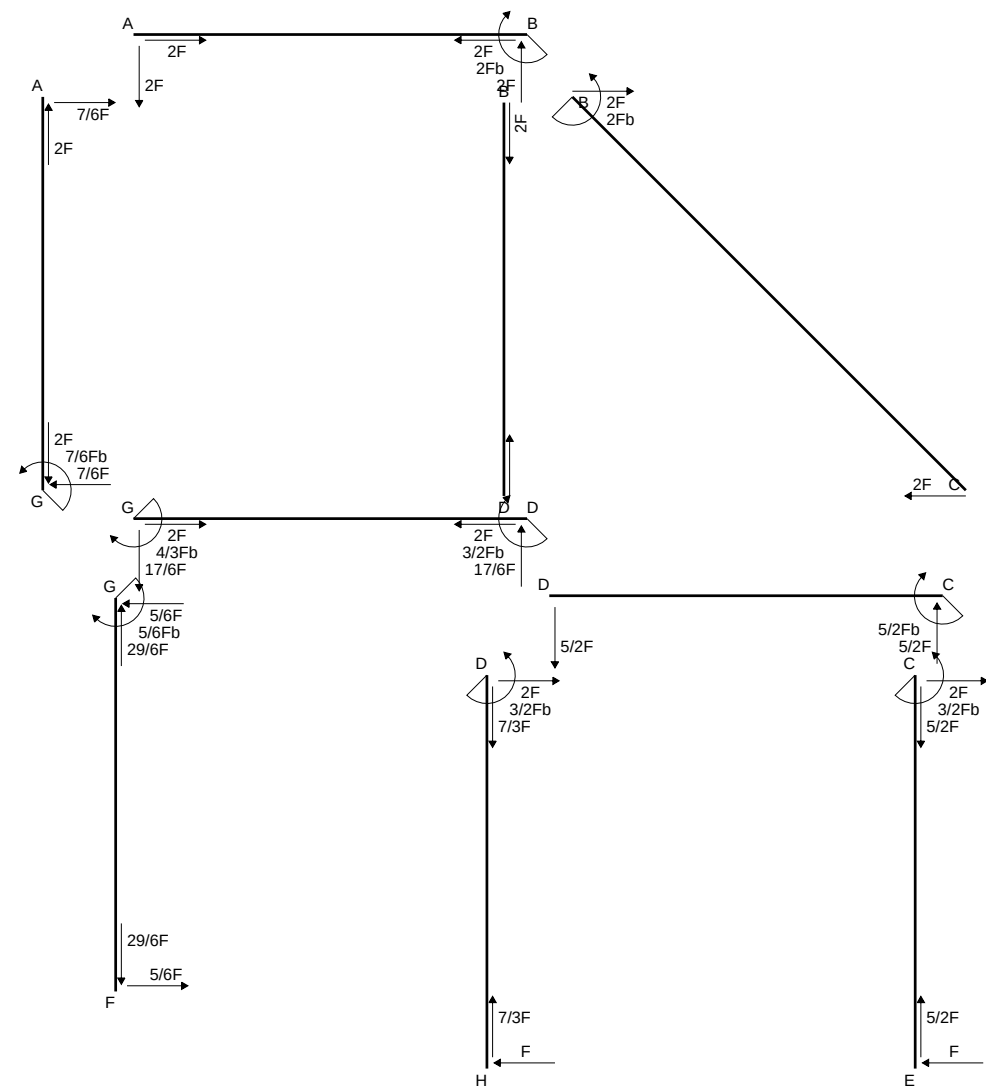
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-9/4Fx+1/2qx ²	-Fb/EJ	9/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(5/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	7/4Fb-5/4Fx-1/2qx ²	Fb/EJ	7/8Fb-3/2Fx+3/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/8+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx ² /b	0	1/4x ² /b ²		
	totali						11/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/8Fb	

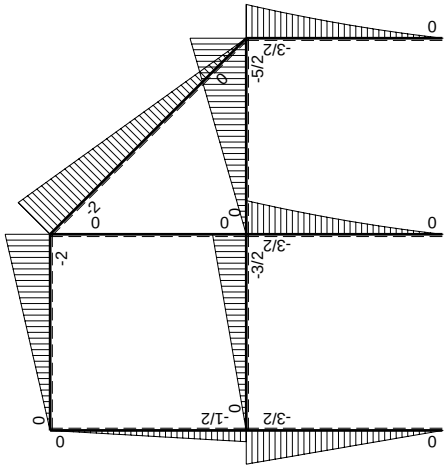
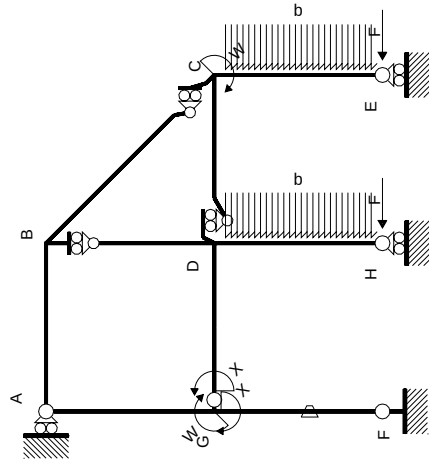
Sviluppi di calcolo iperstatica

$$\begin{aligned}
L_{FG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GF}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GD}^{xx} &= \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{DG}^{xx} &= \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{GA}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{AG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{FG}^{x_0} &= \int_0^b \left(\frac{9}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx \\
&= \left[\frac{3}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{9}{16} Fb^2/EJ \\
L_{GF}^{x_0} &= \int_0^b \left(\frac{7}{8} - \frac{3}{2} x/b + \frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx \\
&= \left[\frac{7}{8} x - \frac{3}{4} x^2/b + \frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{7}{8} b - \frac{3}{4} b + \frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{9}{16} Fb^2/EJ \\
L_{GD}^{x_0} &= \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ \\
L_{DG}^{x_0} &= \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ \\
L_{GA}^{x_0} &= \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ \\
L_{AG}^{x_0} &= \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ
\end{aligned}$$



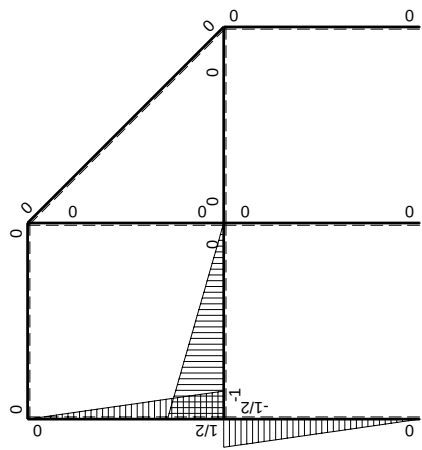
$$\begin{aligned}
A &= 1152. \text{ mm}^2 \\
J_u &= 348030. \text{ mm}^4 \\
J_v &= 122688. \text{ mm}^4 \\
y_g &= 20.63 \text{ mm} \\
T_y &= -2740. \text{ N} \\
M_x &= -2082400. \text{ Nmm} \\
x_m &= 36. \text{ mm} \\
y_m &= 54. \text{ mm} \\
u_m &= 12. \text{ mm} \\
v_m &= 33.38 \text{ mm} \\
\sigma_m &= -Mv/J_u = 199.7 \text{ N/mm}^2 \\
x_c &= 24. \text{ mm} \\
y_c &= 43. \text{ mm} \\
v_c &= 22.38 \text{ mm} \\
\sigma_c &= -Mv/J_u = 133.9 \text{ N/mm}^2 \\
\tau_c &= 3.849 \text{ N/mm}^2 \\
\sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 134. \text{ N/mm}^2 \\
S &= 5867. \text{ mm}^3
\end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						2/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-4/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

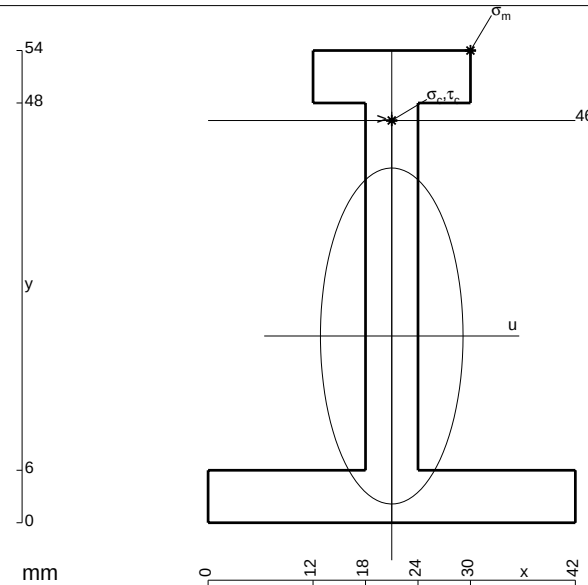
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

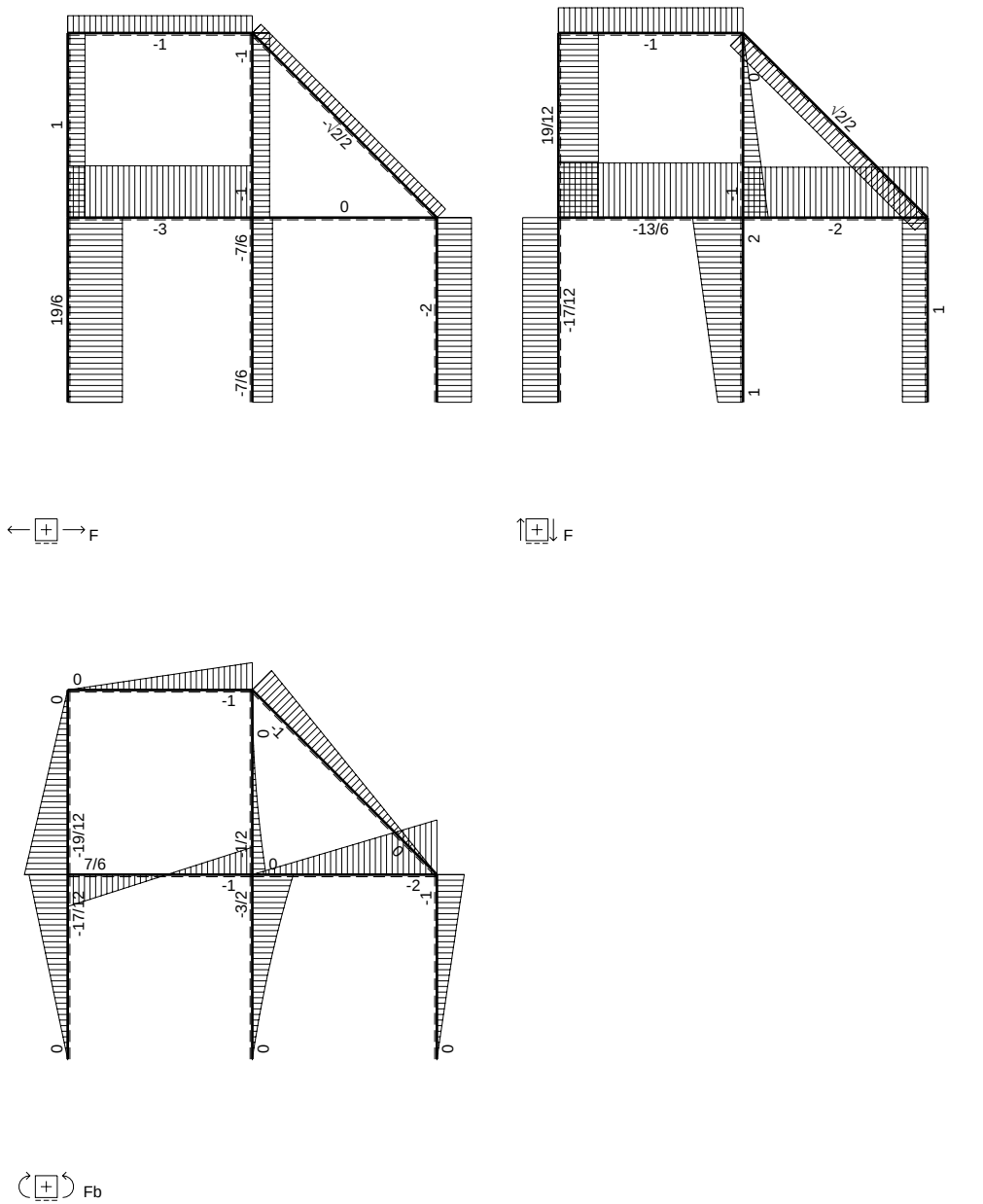
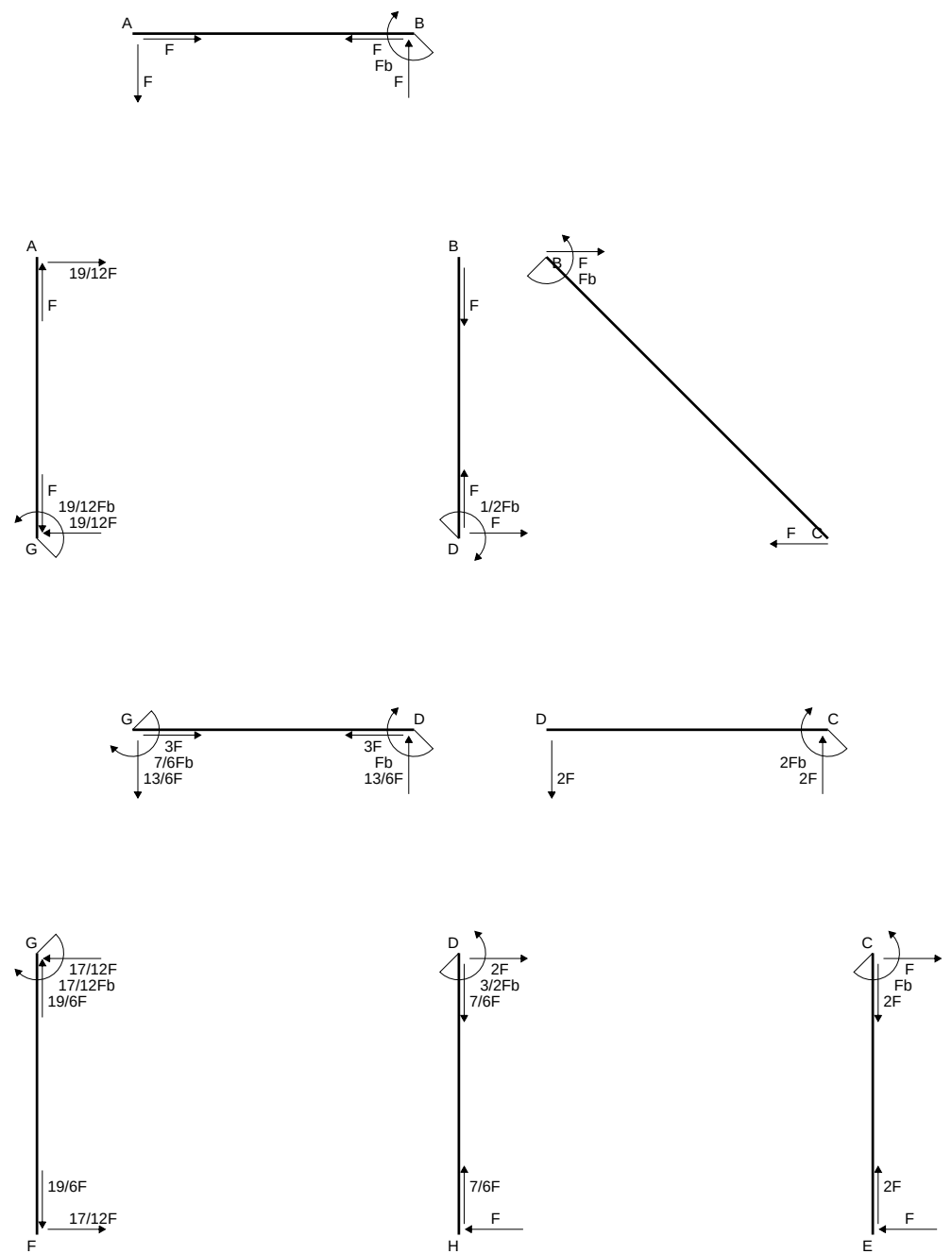
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

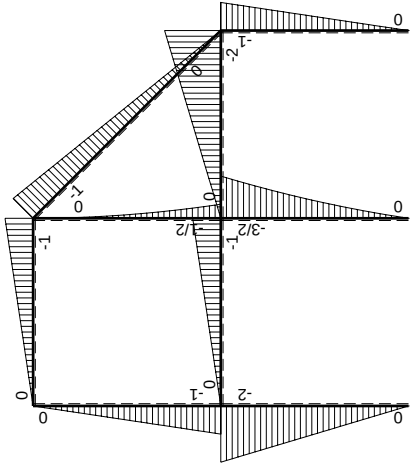
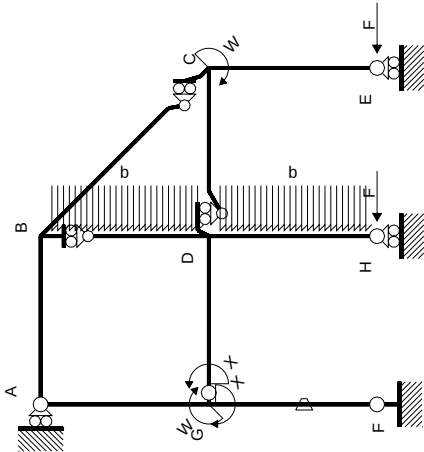
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



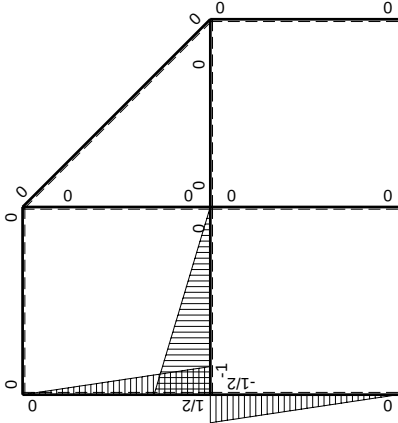
$$\begin{aligned} A &= 612. \text{ mm}^2 \\ J_u &= 225968. \text{ mm}^4 \\ J_v &= 40716. \text{ mm}^4 \\ y_g &= 21.35 \text{ mm} \\ T_y &= -1775. \text{ N} \\ M_x &= -1437750. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 32.65 \text{ mm} \\ \sigma_m &= -Mv/J_u = 207.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 24.65 \text{ mm} \\ \sigma_c &= -Mv/J_u = 156.8 \text{ N/mm}^2 \\ \tau_c &= 4.595 \text{ N/mm}^2 \\ \sigma_\varphi &= \sqrt{\sigma^2 + 3\tau^2} = 157. \text{ N/mm}^2 \\ S &= 3510. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-2Fx	-Fb/EJ	Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/3+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	2Fb-2Fx	Fb/EJ	Fb-2Fx+Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						7/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{3} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(b - b + \frac{1}{3} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{12} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

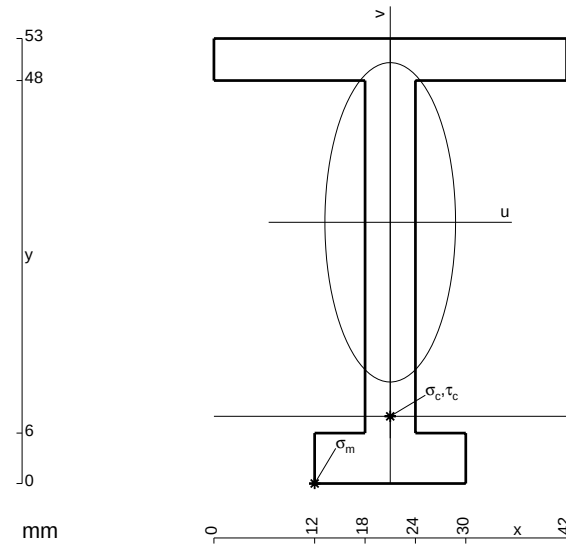
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

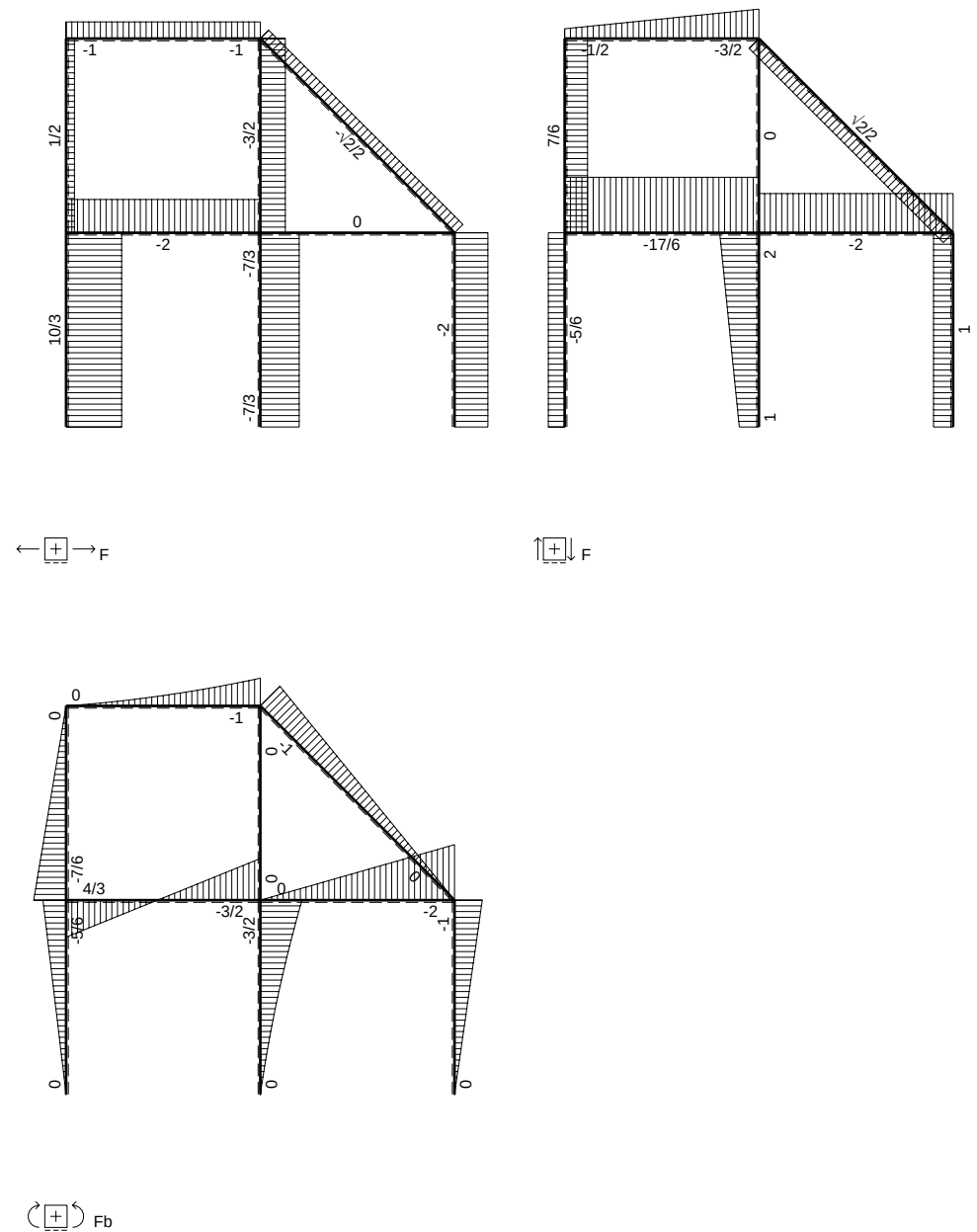
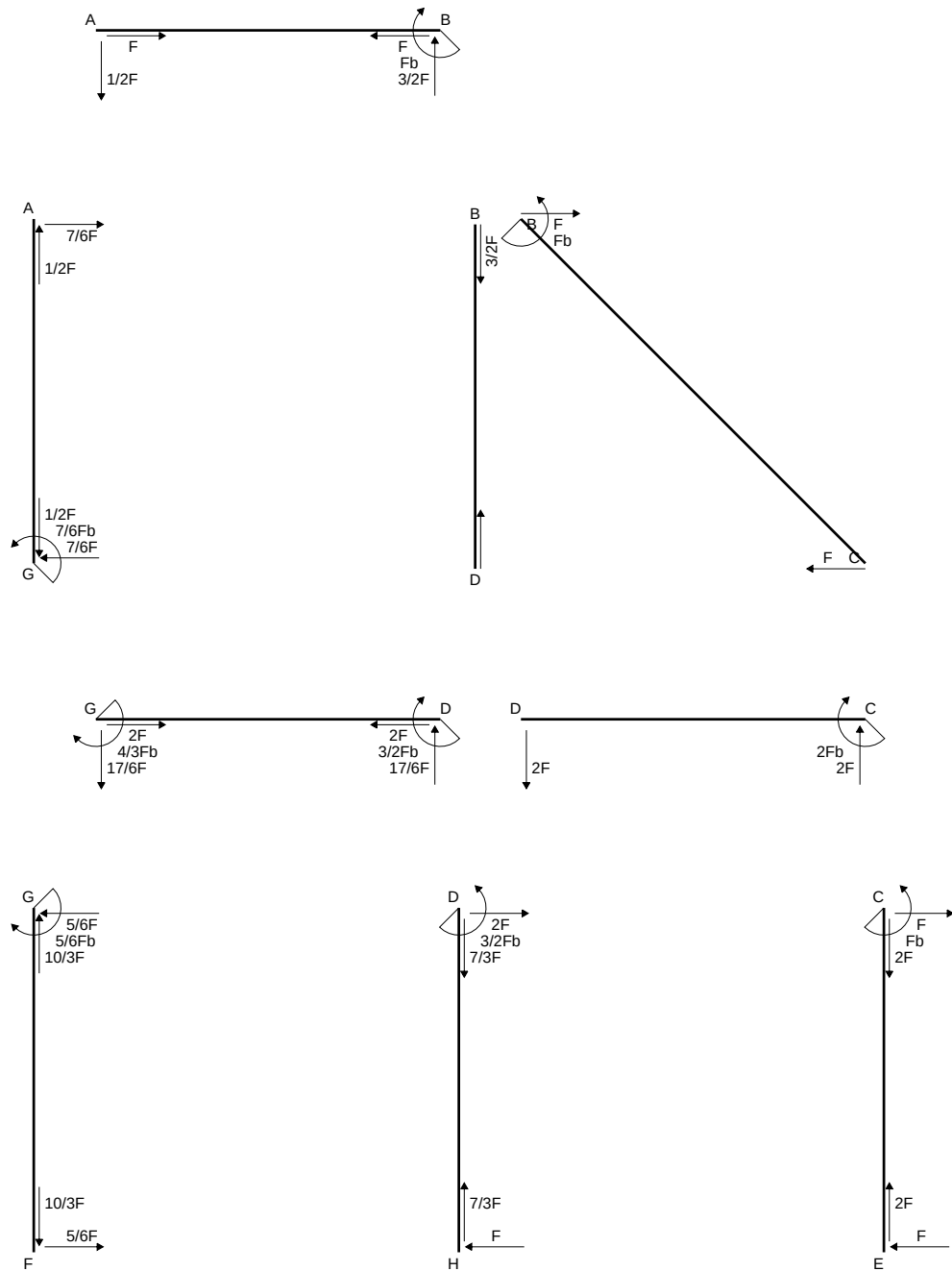
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

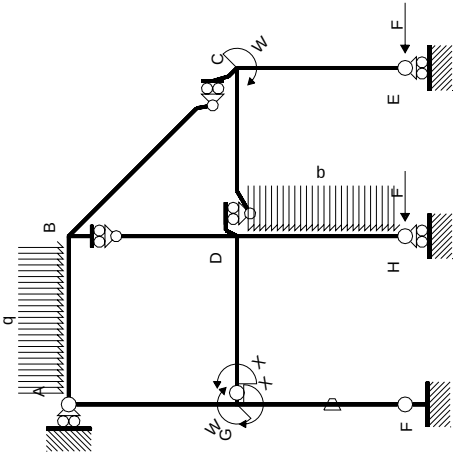
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



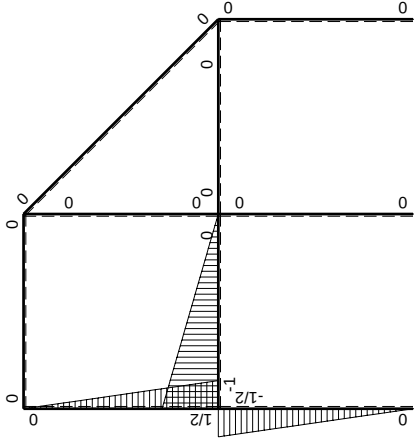
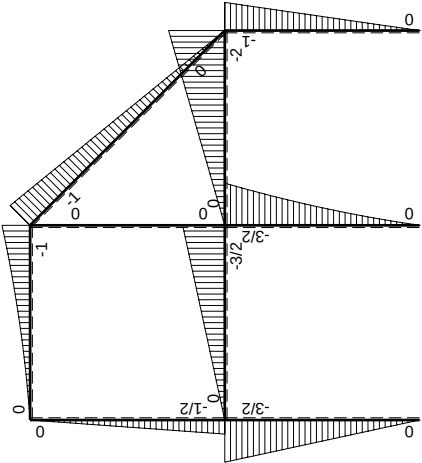
$$\begin{aligned} A &= 570. \text{ mm}^2 \\ J_u &= 206355. \text{ mm}^4 \\ J_v &= 34542. \text{ mm}^4 \\ y_g &= 31.11 \text{ mm} \\ T_y &= -1700. \text{ N} \\ M_x &= -1445000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -31.11 \text{ mm} \\ \sigma_m &= -Mv/J_u = -217.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 8. \text{ mm} \\ v_c &= -23.11 \text{ mm} \\ \sigma_c &= -Mv/J_u = -161.8 \text{ N/mm}^2 \\ \tau_c &= 4.566 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 162. \text{ N/mm}^2 \\ S^* &= 3325. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$2/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-4/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GD}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

$$L_{DG}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

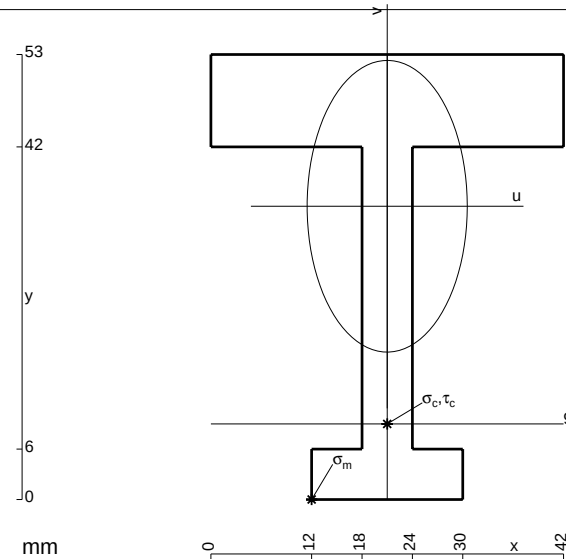
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

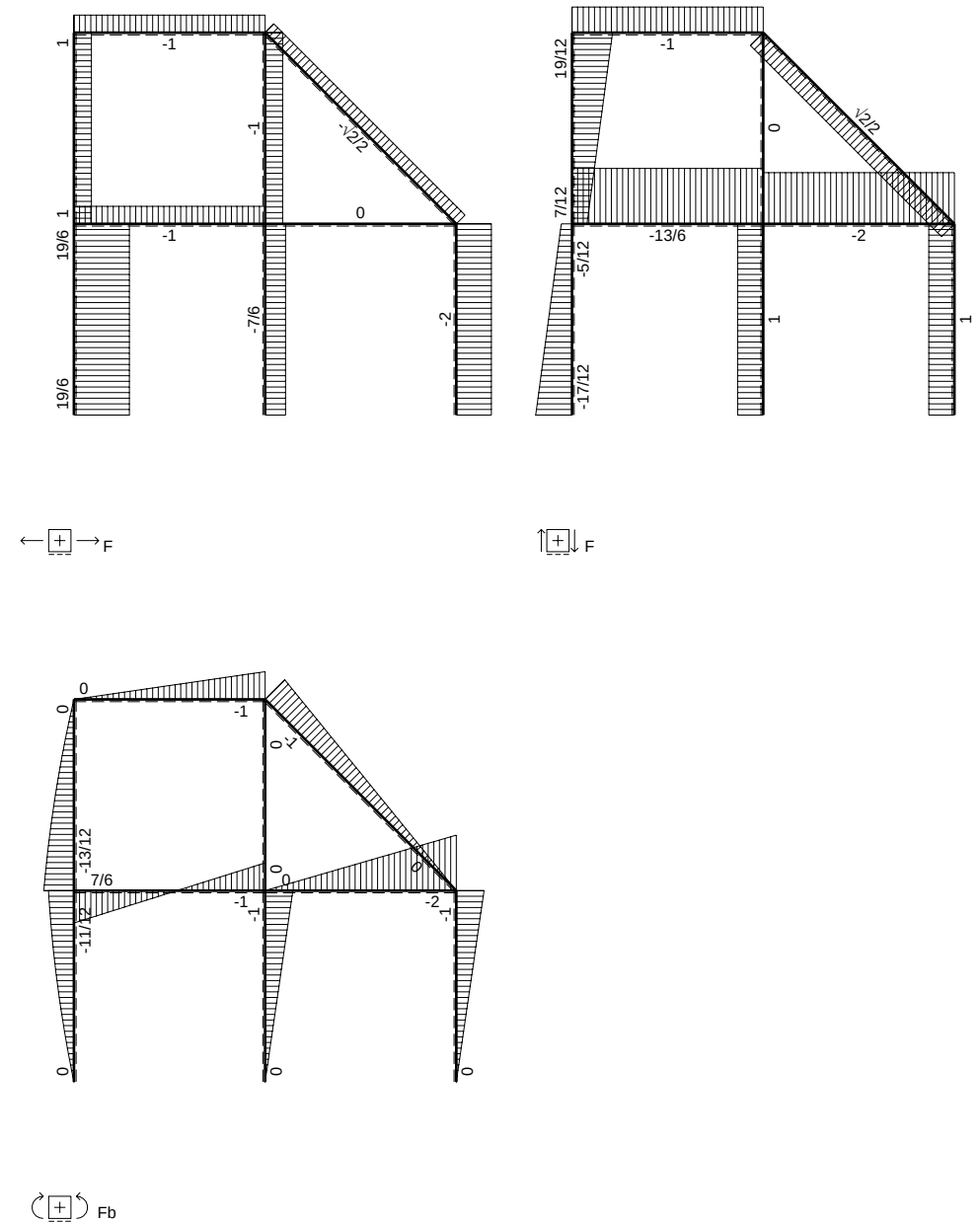
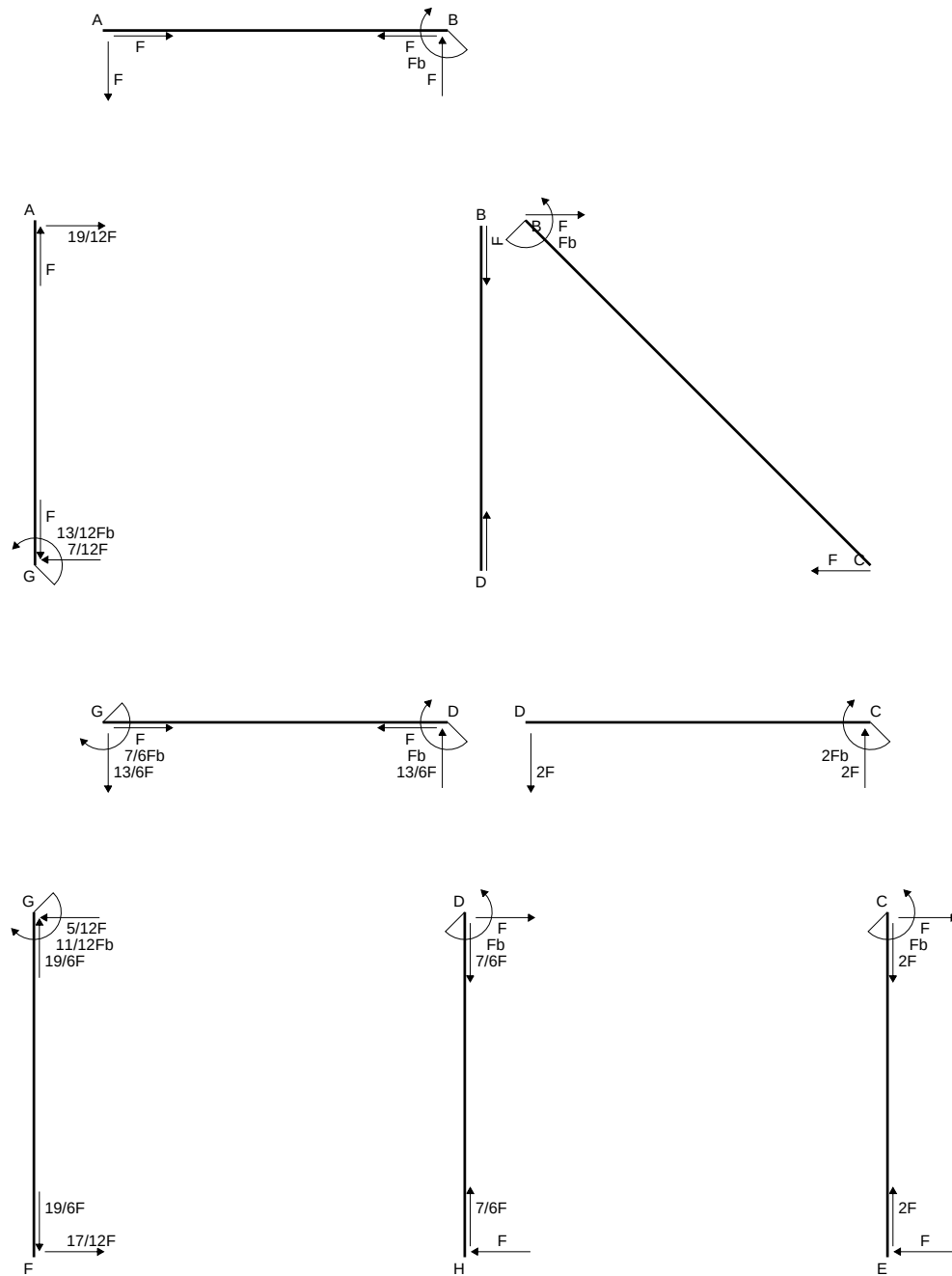
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

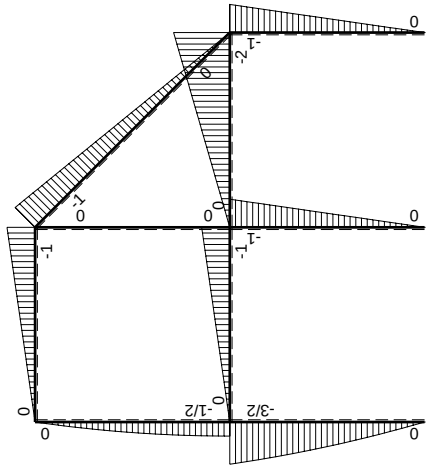
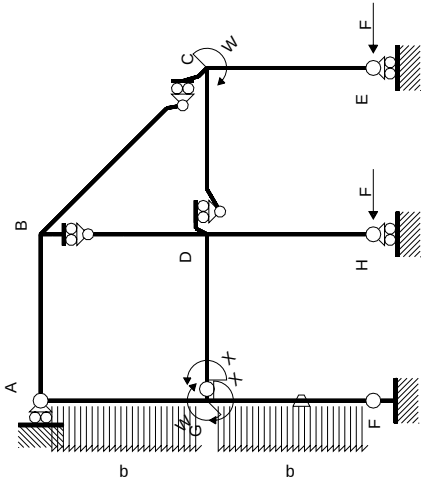
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



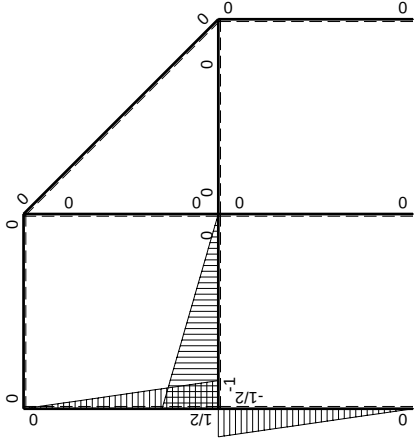
$$\begin{aligned} A &= 786. \text{ mm}^2 \\ J_u &= 237222. \text{ mm}^4 \\ J_v &= 71478. \text{ mm}^4 \\ y_g &= 34.93 \text{ mm} \\ T_y &= -1720. \text{ N} \\ M_x &= -1548000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.93 \text{ mm} \\ \sigma_m &= -Mv/J_u = -227.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -25.93 \text{ mm} \\ \sigma_c &= -Mv/J_u = -169.2 \text{ N/mm}^2 \\ \tau_c &= 4.763 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 169.4 \text{ N/mm}^2 \\ S &= 3942. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-2Fx+1/2qx ²	-Fb/EJ	Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(13/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-Fx-1/2qx ²	Fb/EJ	3/4Fb-5/4Fx+1/4Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2qx ²	0	-1/4Fb+1/4Fx+1/4Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-5/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx-1/2qx ²	0	-1/2Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						7/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{3} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{3} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{25}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{4} - \frac{5}{4} x/b + \frac{1}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{5}{8} x^2/b + \frac{1}{12} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{4} b - \frac{5}{8} b + \frac{1}{12} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{25}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

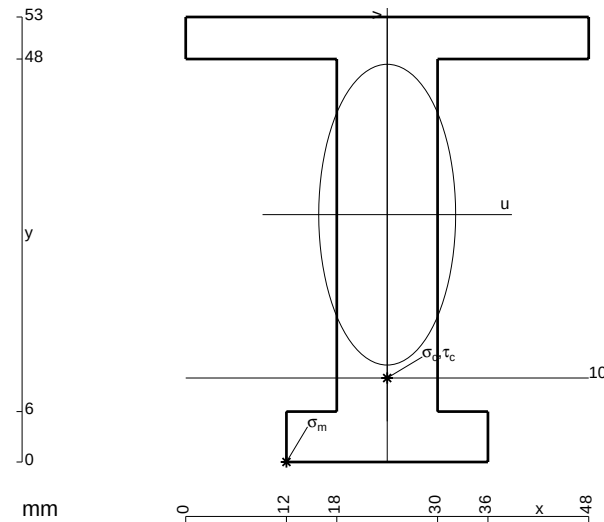
$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{4} x/b + \frac{1}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{1}{4} x + \frac{1}{8} x^2/b + \frac{1}{12} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

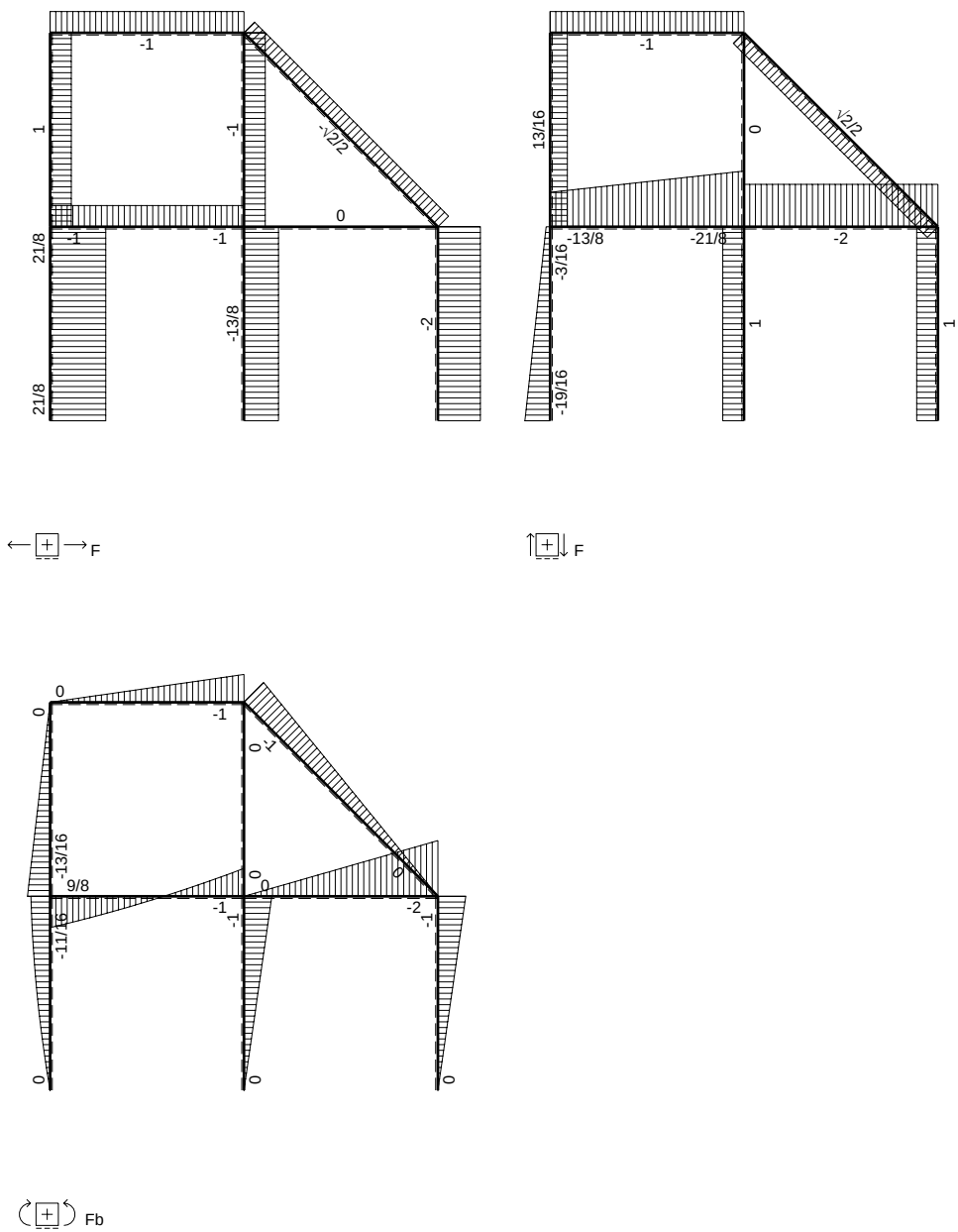
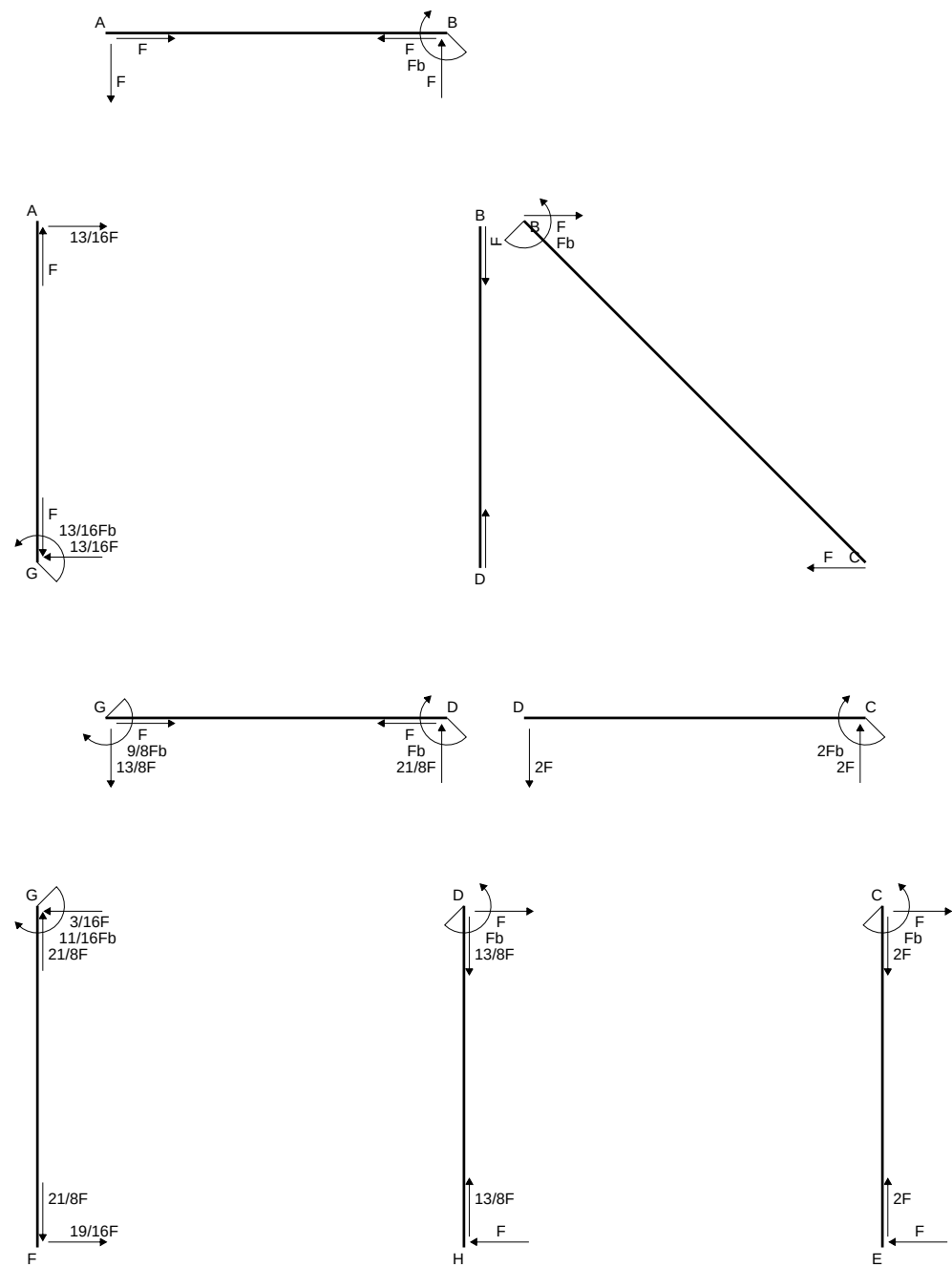
$$= \left(-\frac{1}{4} b + \frac{1}{8} b + \frac{1}{12} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{5}{48} Fb^2/EJ$$

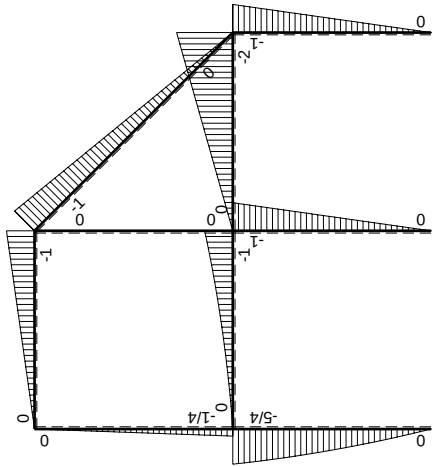
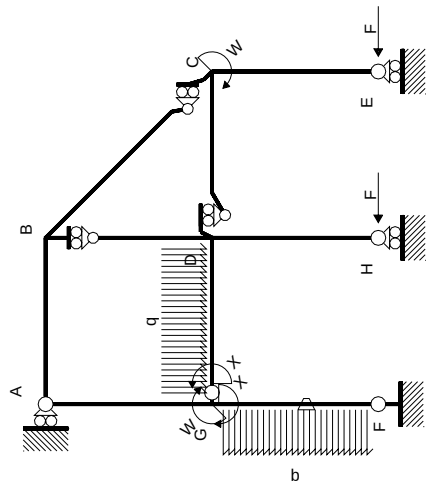
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{5}{48} Fb^2/EJ$$



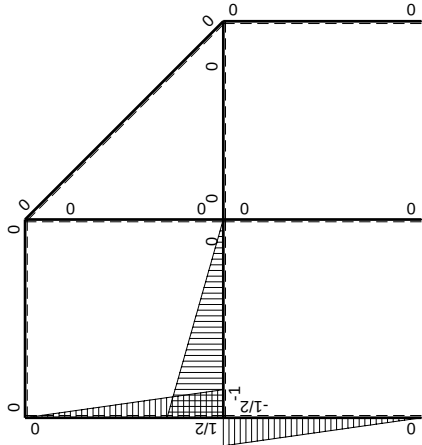
$$\begin{aligned} A &= 888. \text{ mm}^2 \\ J_u &= 285133. \text{ mm}^4 \\ J_v &= 59040. \text{ mm}^4 \\ y_g &= 29.46 \text{ mm} \\ T_y &= -2440. \text{ N} \\ M_x &= -2318000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.46 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -19.46 \text{ mm} \\ \sigma_c &= -Mv/J_u = -158.2 \text{ N/mm}^2 \\ \tau_c &= 3.452 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 158.3 \text{ N/mm}^2 \\ S &= 4840. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx+1/2qx ²	-Fb/EJ	7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(11/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx ²	Fb/EJ	5/8Fb-Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx ² /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

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

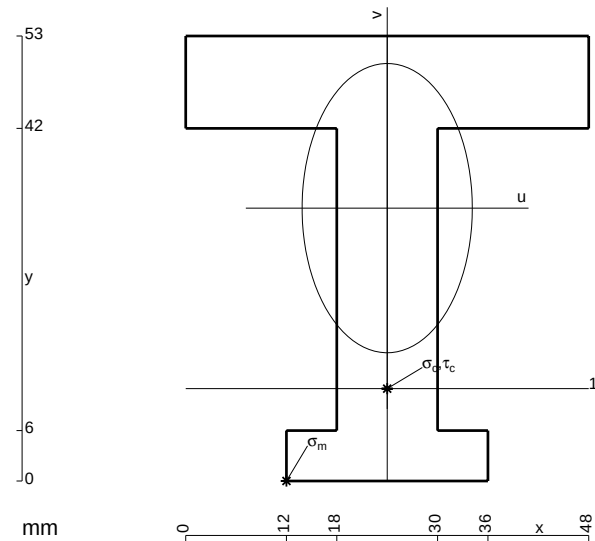
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

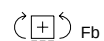
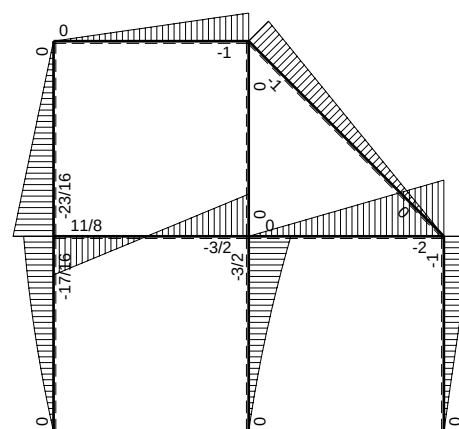
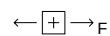
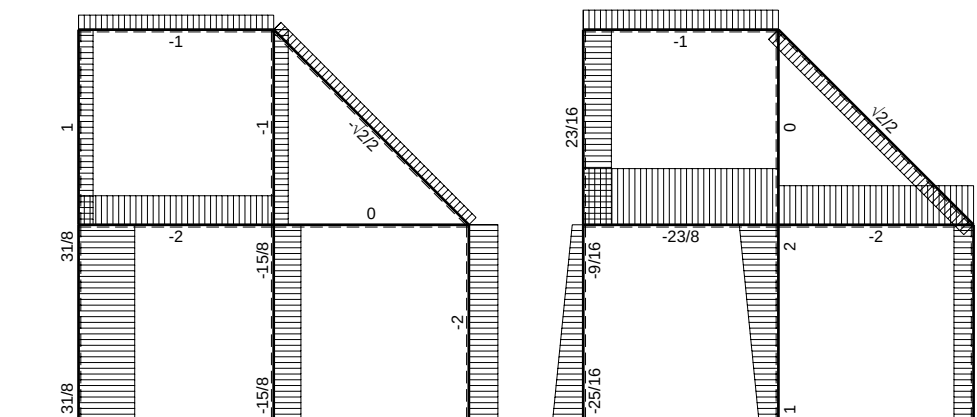
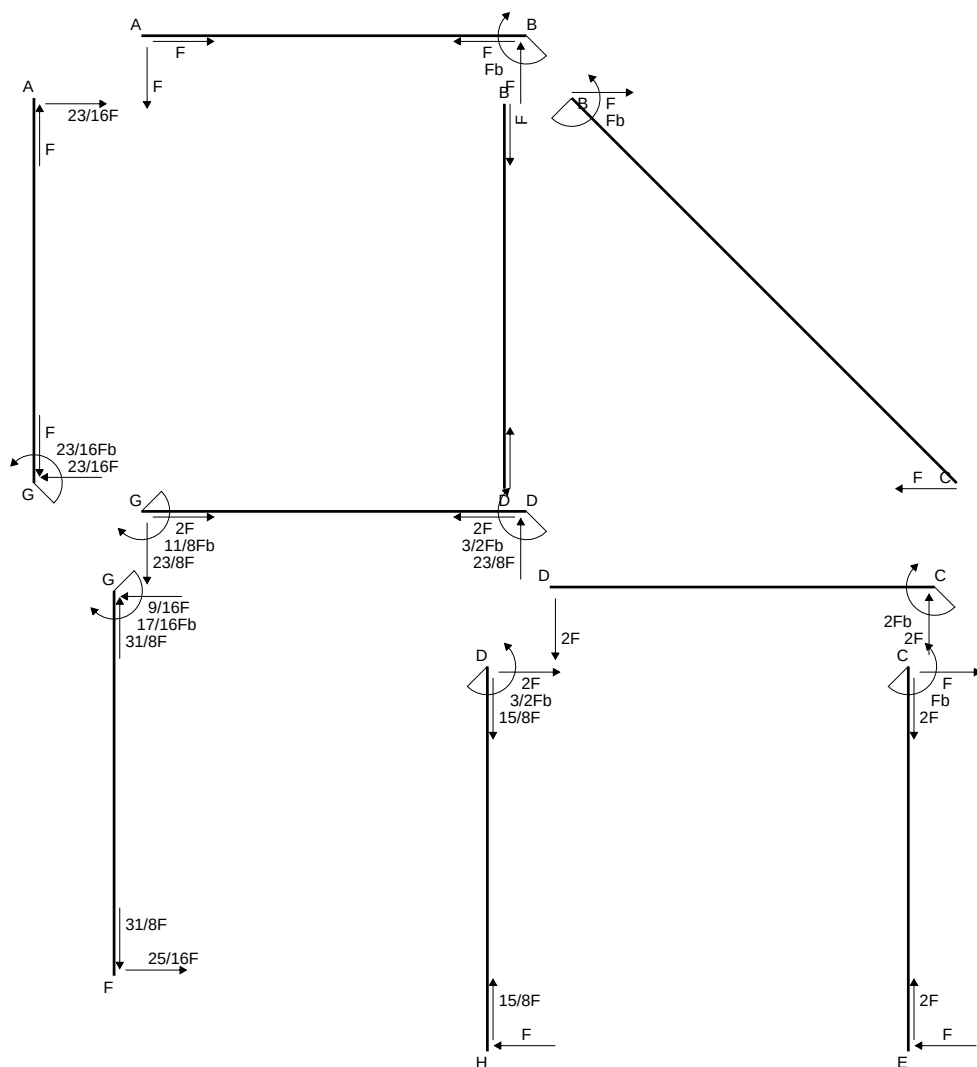
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

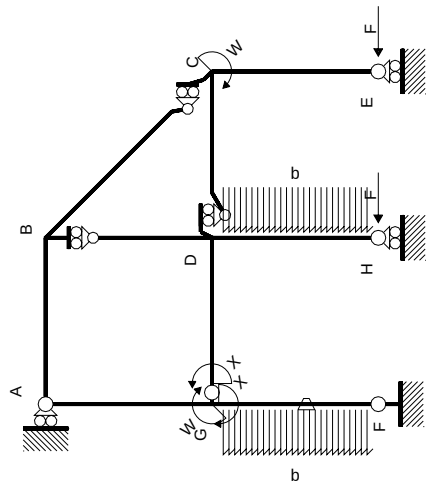
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



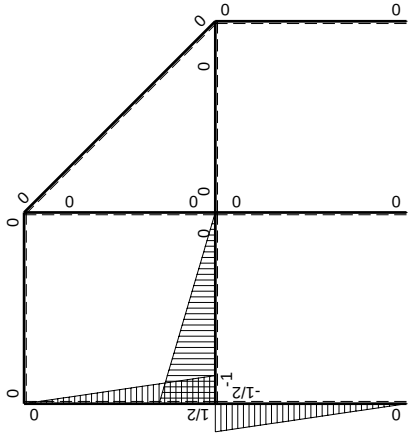
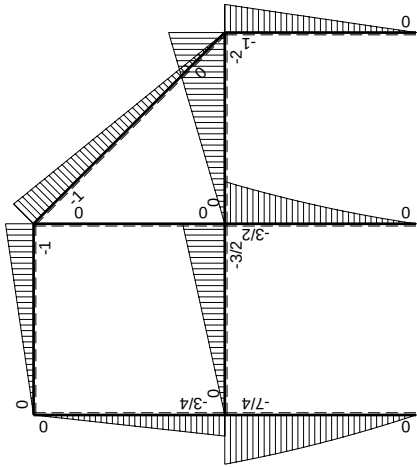
$$\begin{aligned} A &= 1104. \text{ mm}^2 \\ J_u &= 327740. \text{ mm}^4 \\ J_v &= 113472. \text{ mm}^4 \\ y_g &= 32.5 \text{ mm} \\ T_y &= -4020. \text{ N} \\ M_x &= -2010000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.5 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -21.5 \text{ mm} \\ \sigma_c &= -Mv/J_u = -131.9 \text{ N/mm}^2 \\ \tau_c &= 5.814 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 132.2 \text{ N/mm}^2 \\ S &= 5688. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-9/4Fx+1/2qx ²	-Fb/EJ	9/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(5/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	7/4Fb-5/4Fx-1/2qx ²	Fb/EJ	7/8Fb-3/2Fx+3/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/8+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx ² /b	0	1/4x ² /b ²		
	totali						11/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{9}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{9}{16} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{7}{8} - \frac{3}{2} x/b + \frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{8} x - \frac{3}{4} x^2/b + \frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{8} b - \frac{3}{4} b + \frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{9}{16} Fb^2/EJ$$

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

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

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

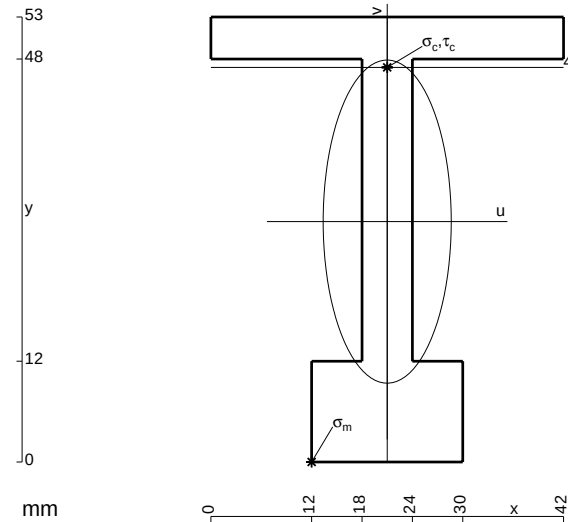
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

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

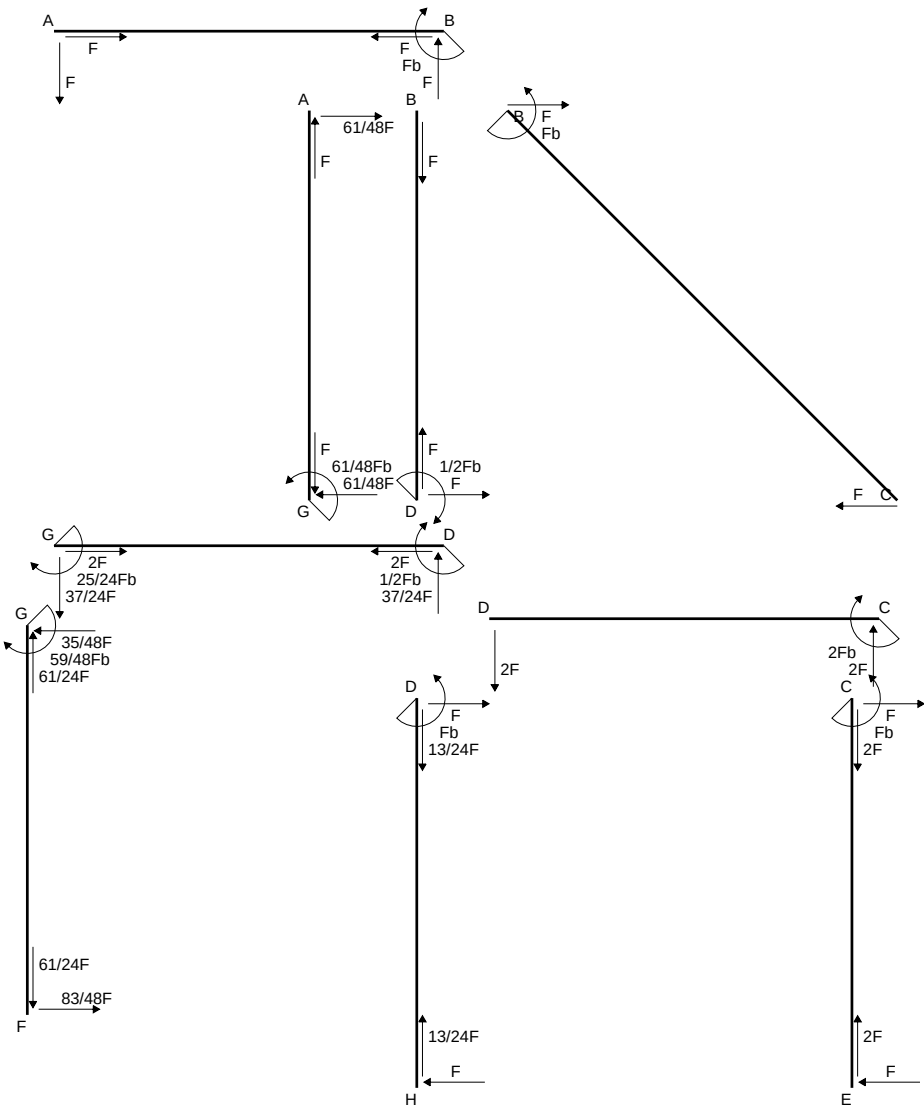
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



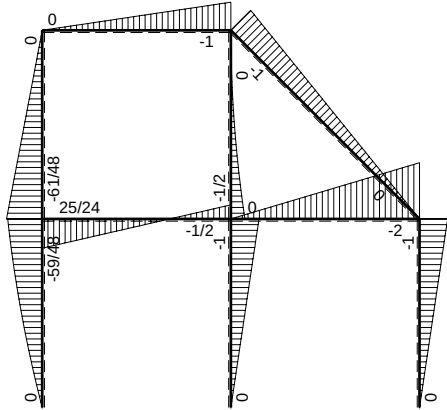
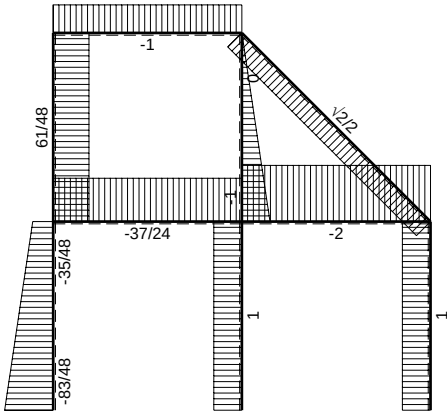
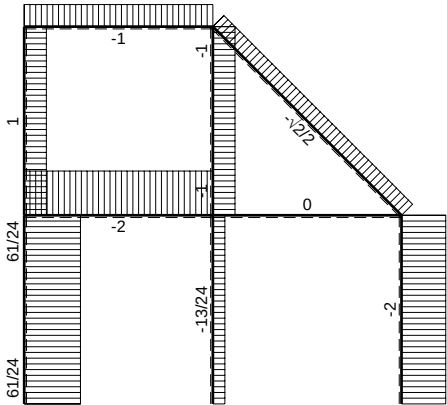
$$\begin{aligned} A &= 642. \text{ mm}^2 \\ J_u &= 237823. \text{ mm}^4 \\ J_v &= 37350. \text{ mm}^4 \\ y_g &= 28.63 \text{ mm} \\ T_y &= -3160. \text{ N} \\ M_x &= -1738000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -28.63 \text{ mm} \\ \sigma_m &= -Mv/J_u = -209.2 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 47. \text{ mm} \\ v_c &= 18.37 \text{ mm} \\ \sigma_c &= -Mv/J_u = 134.2 \text{ N/mm}^2 \\ \tau_c &= 10.42 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 135.4 \text{ N/mm}^2 \\ S &= 4706. \text{ mm}^3 \end{aligned}$$

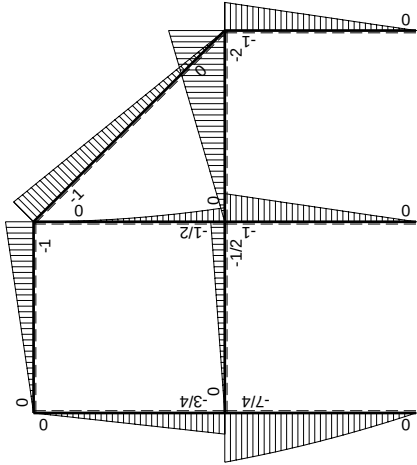
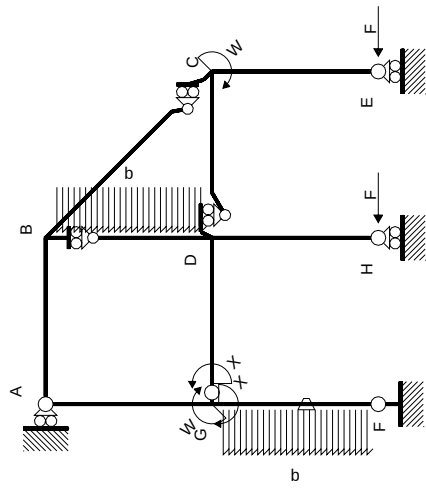


$\leftarrow \boxed{+} \rightarrow F$

$\uparrow \boxed{+} \downarrow F$

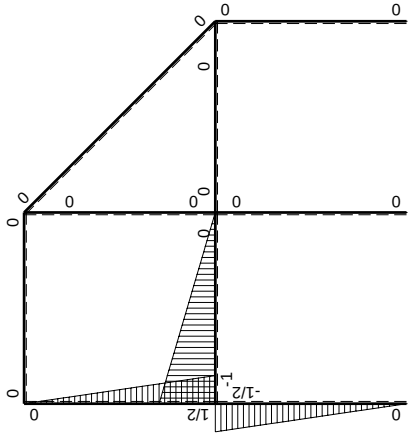
$\curvearrowright \boxed{+} \curvearrowleft F_b$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-9/4Fx+1/2qx ²	-Fb/EJ	9/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(5/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	7/4Fb-5/4Fx-1/2qx ²	Fb/EJ	7/8Fb-3/2Fx+3/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/8+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx ² /b	0	1/4x ² /b ²		
	totali						25/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-25/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(9/8 x^2/b^2 - 1/4 x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(1/2 x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{9}{16} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(7/8 - 3/2 x/b + 3/8 x^2/b^2 + 1/4 x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-1/2 + 1/2 x/b \right) \theta dx$$

$$= \left[\frac{7}{8} x - \frac{3}{4} x^2/b + \frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{8} b - \frac{3}{4} b + \frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{9}{16} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(1/2 x/b - 1/2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

$$L_{DG}^{x_0} = \int_0^b \left(1/2 x/b - 1/2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

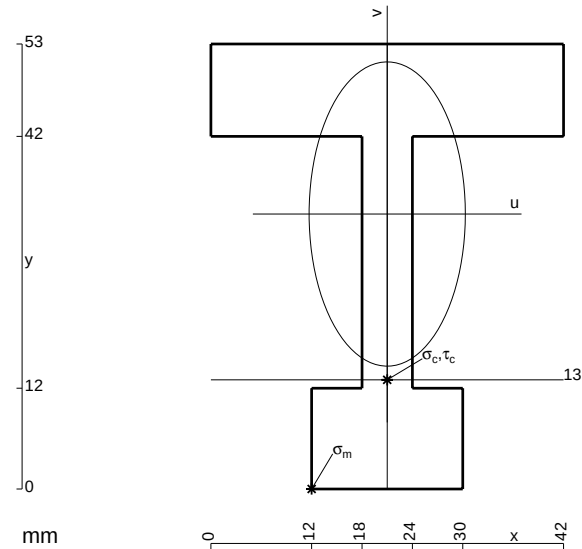
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-3/8 + 3/4 x/b - 3/8 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

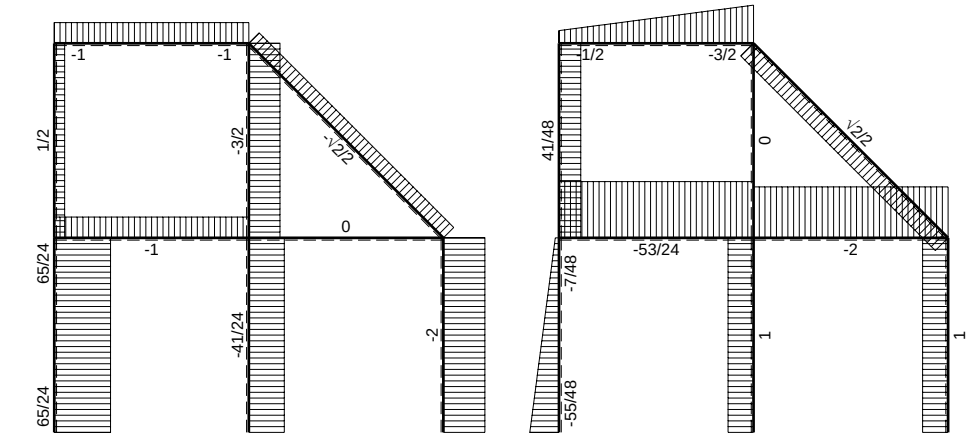
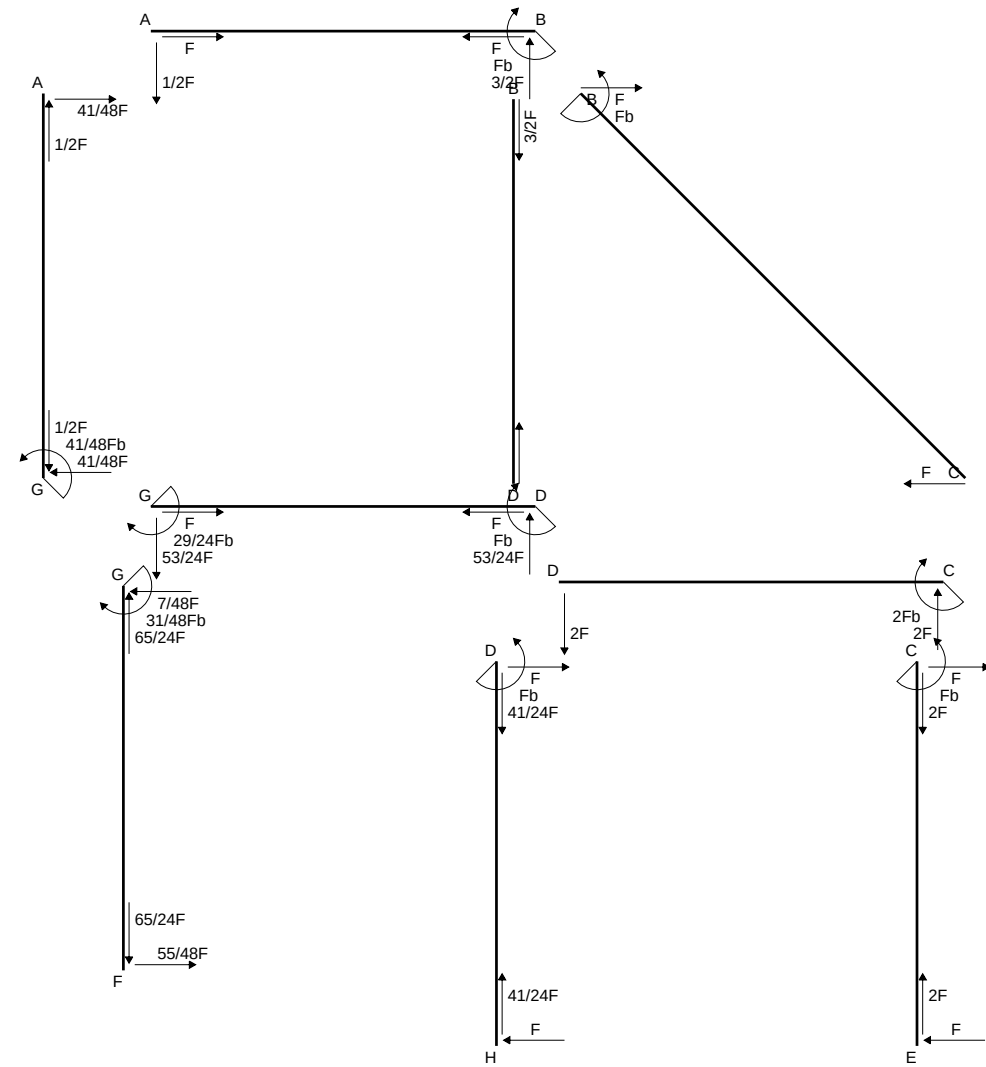
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-3/8 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

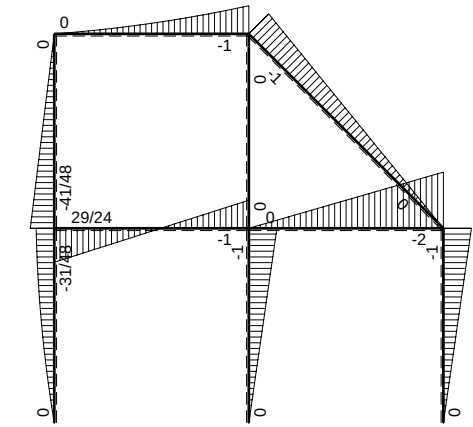


$$\begin{aligned} A &= 858. \text{ mm}^2 \\ J_u &= 281777. \text{ mm}^4 \\ J_v &= 74286. \text{ mm}^4 \\ y_g &= 32.75 \text{ mm} \\ T_y &= -3140. \text{ N} \\ M_x &= -1884000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -32.75 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -19.75 \text{ mm} \\ \sigma_c &= -Mv/J_u = -132.1 \text{ N/mm}^2 \\ \tau_c &= 10.96 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 133.4 \text{ N/mm}^2 \\ S &= 5900. \text{ mm}^3 \end{aligned}$$

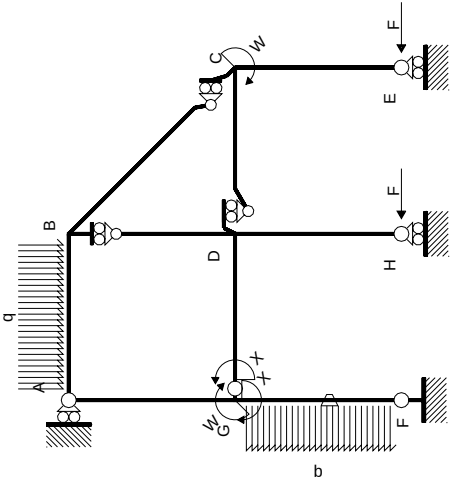


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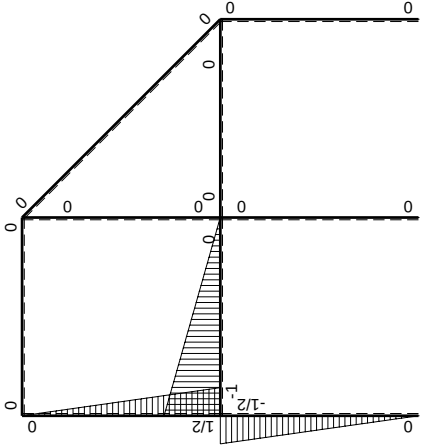
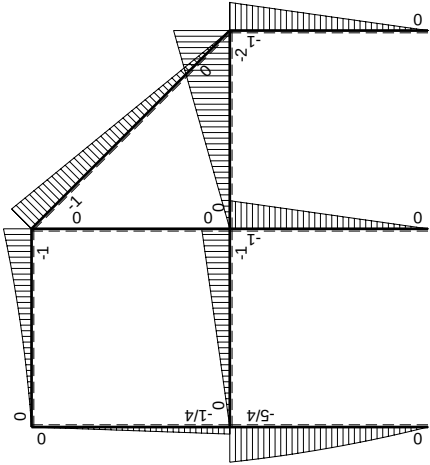


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-7/4Fx+1/2qx^2$	$-Fb/EJ$	$7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(11/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$5/8Fb-Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb+1/4Fx$	0	$-1/8Fb+1/4Fx-1/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/4Fx$	0	$-1/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$29/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-29/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

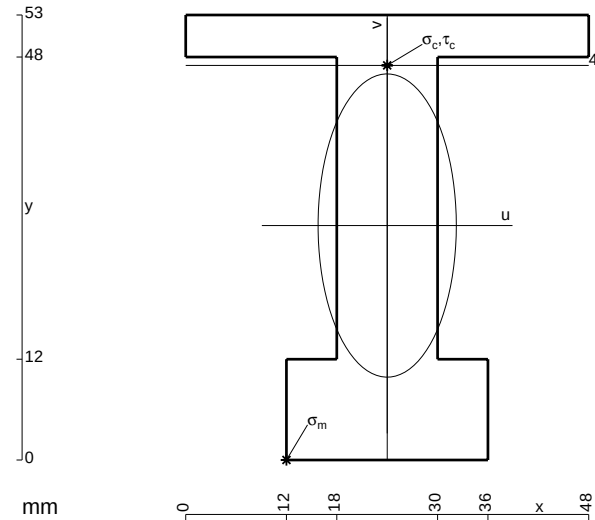
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

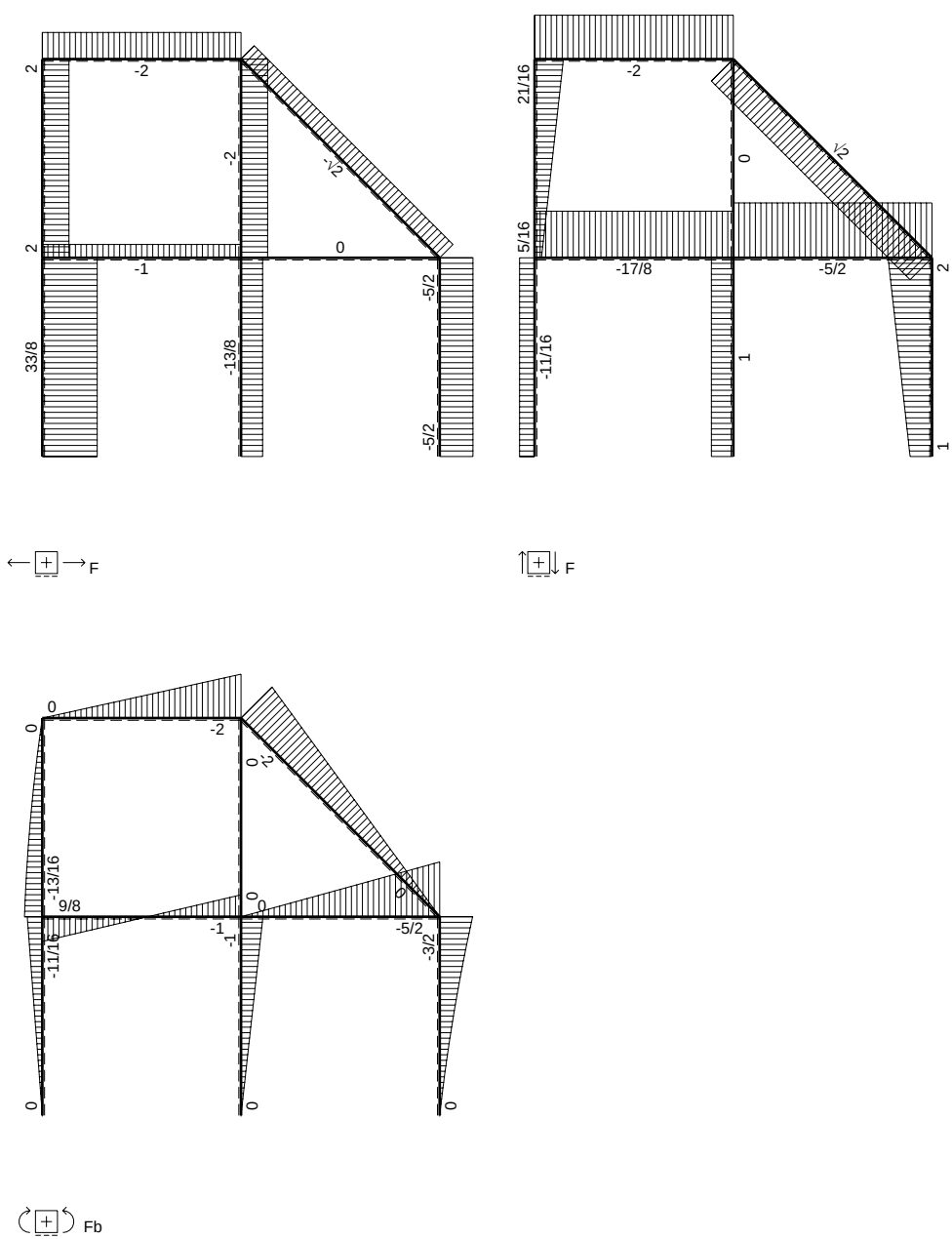
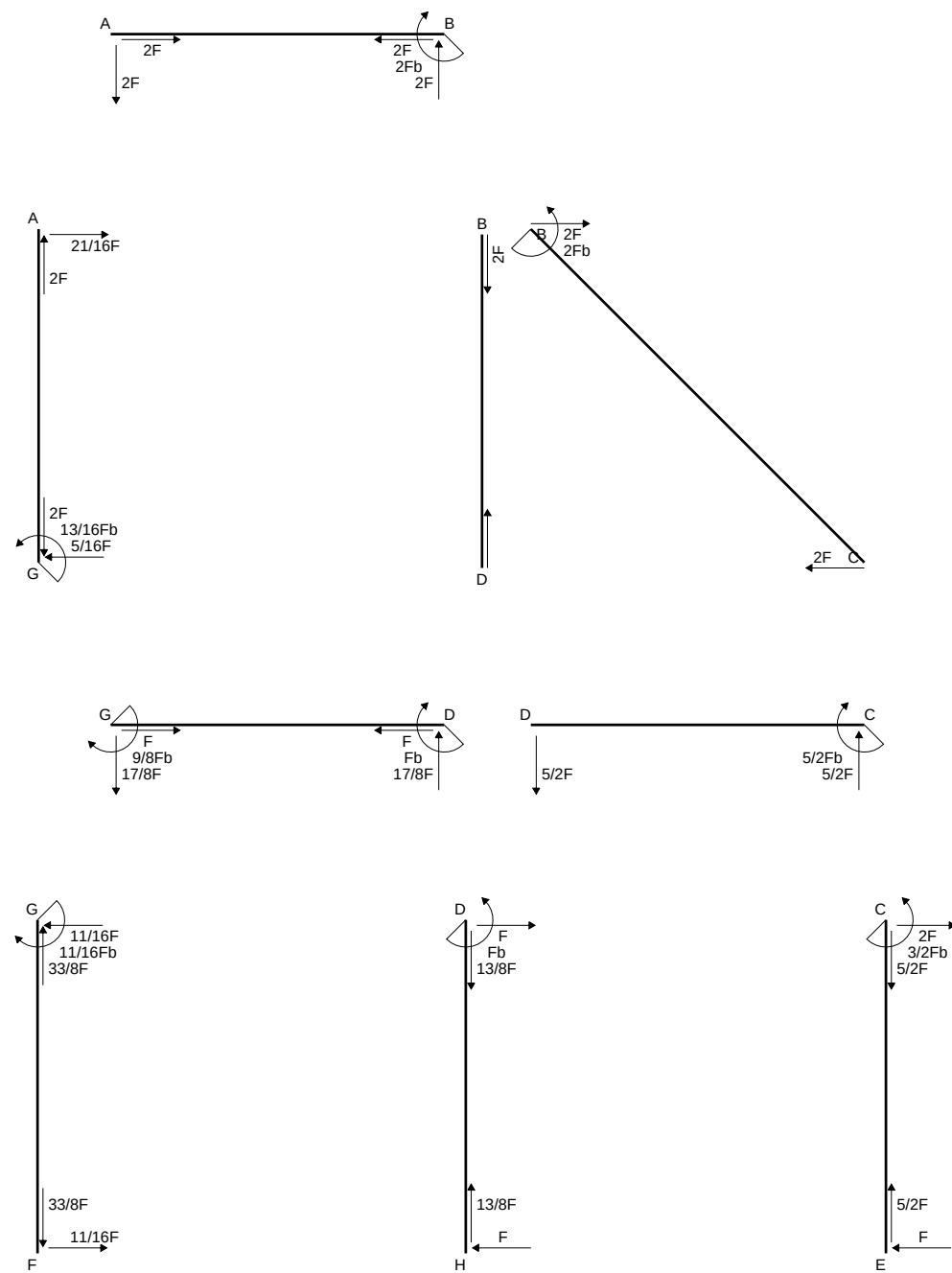
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

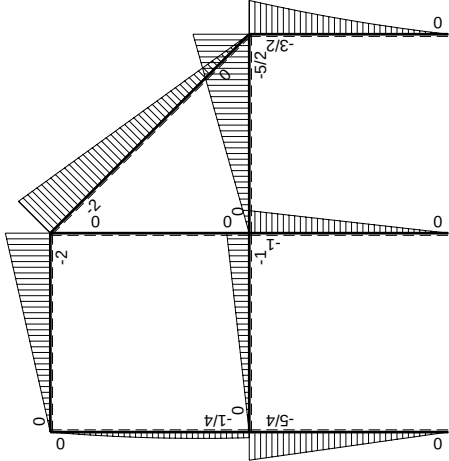
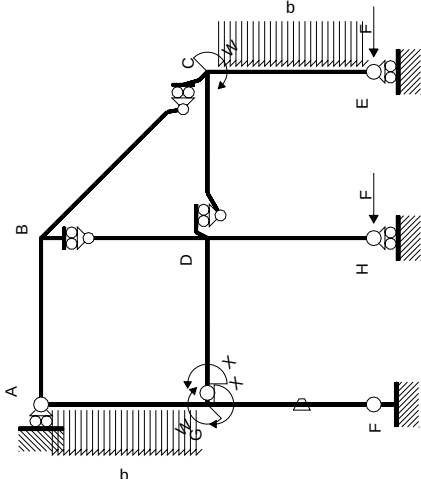
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



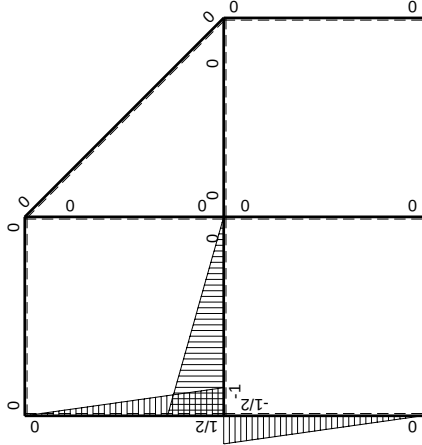
$$\begin{aligned} A &= 960. \text{ mm}^2 \\ J_u &= 313227. \text{ mm}^4 \\ J_v &= 65088. \text{ mm}^4 \\ y_g &= 27.92 \text{ mm} \\ T_y &= -3960. \text{ N} \\ M_x &= -2574000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -27.92 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 47. \text{ mm} \\ v_c &= 19.08 \text{ mm} \\ \sigma_c &= -Mv/J_u = 156.8 \text{ N/mm}^2 \\ \tau_c &= 5.956 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 157.1 \text{ N/mm}^2 \\ S &= 5653. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(5/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

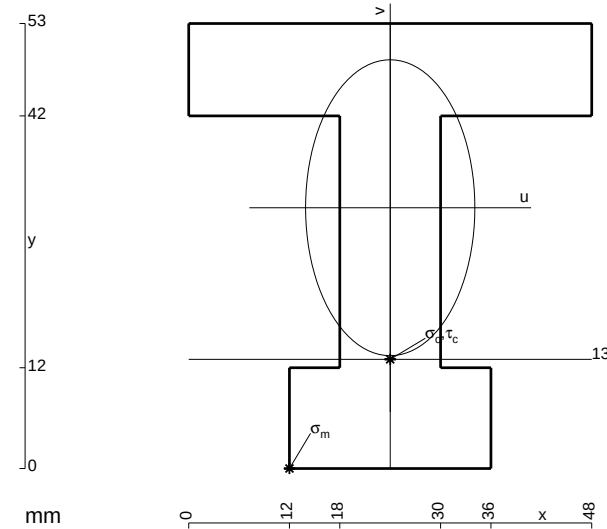
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

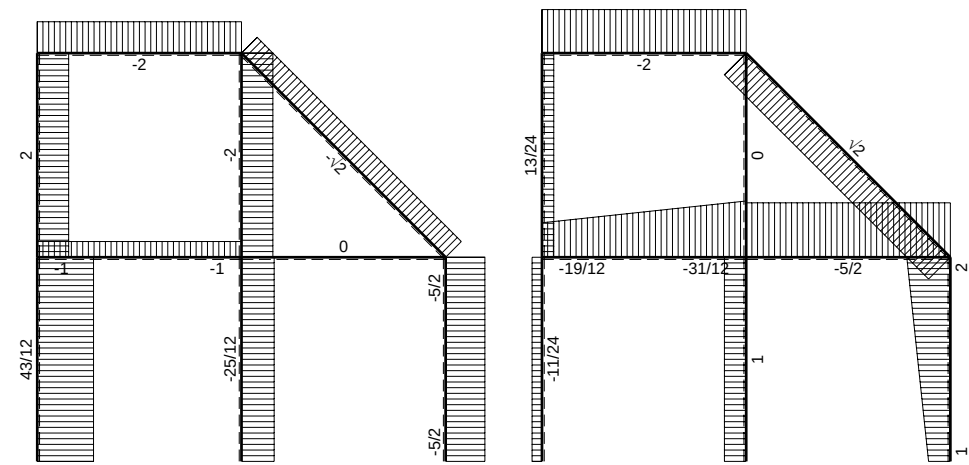
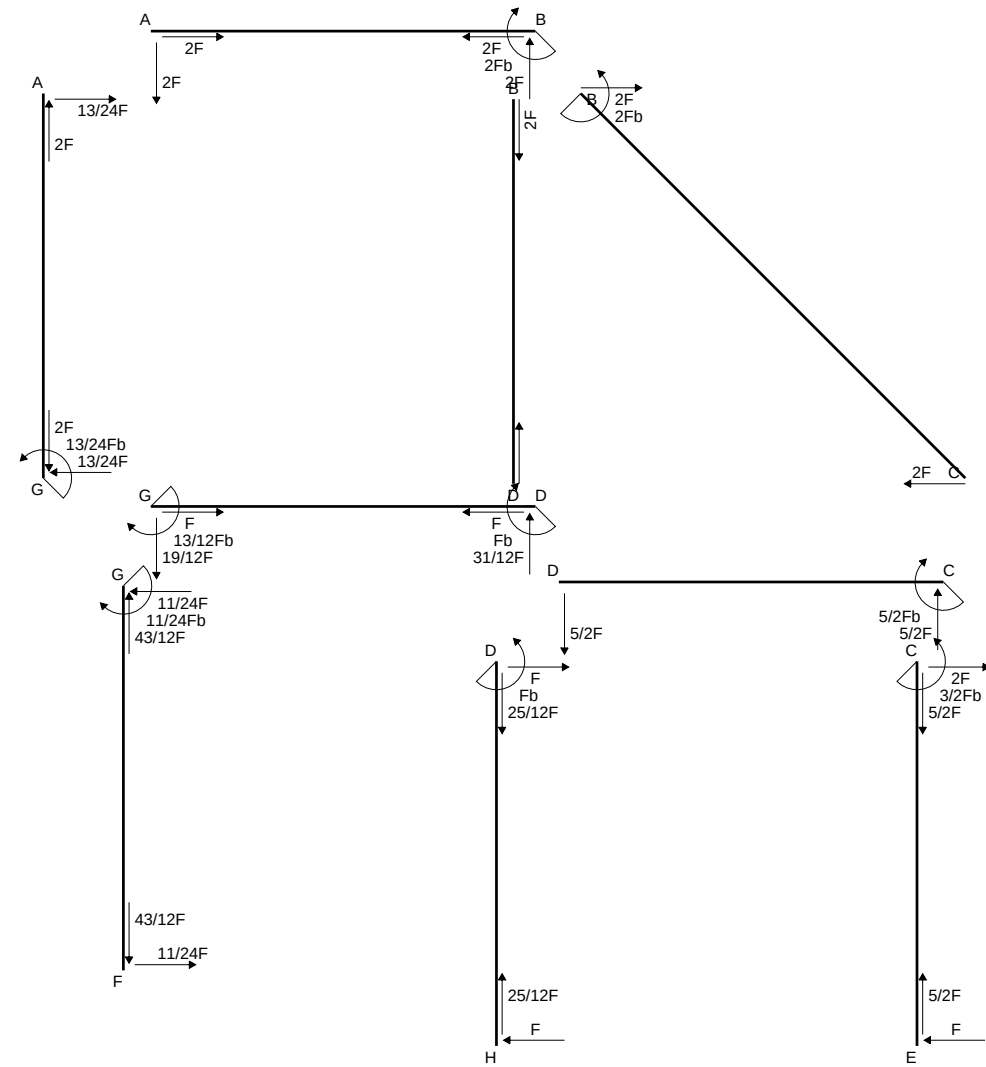
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

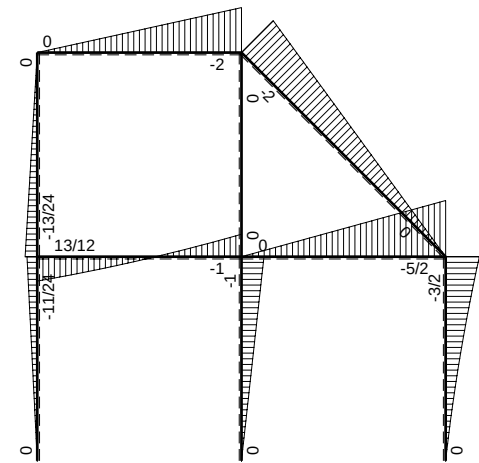


$$\begin{aligned} A &= 1176. \text{ mm}^2 \\ J_u &= 365284. \text{ mm}^4 \\ J_v &= 119520. \text{ mm}^4 \\ y_g &= 31.06 \text{ mm} \\ T_y &= -4025. \text{ N} \\ M_x &= -2817500. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.06 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -18.06 \text{ mm} \\ \sigma_c &= -Mv/J_u = -139.3 \text{ N/mm}^2 \\ \tau_c &= 6.832 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 139.8 \text{ N/mm}^2 \\ S &= 7440. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F_b

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x ² /b ²	0+0	1/12Xb/EJ
AG b	-1/2x/b	0	0	0	0	1/4x ² /b ²		
	totali						13/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

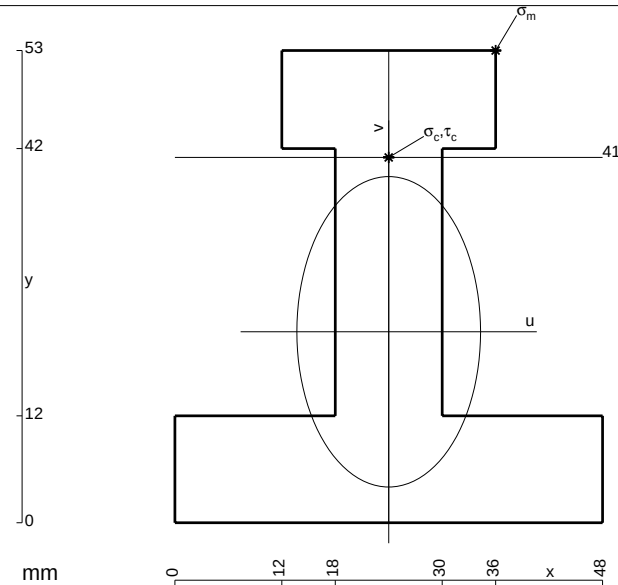
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

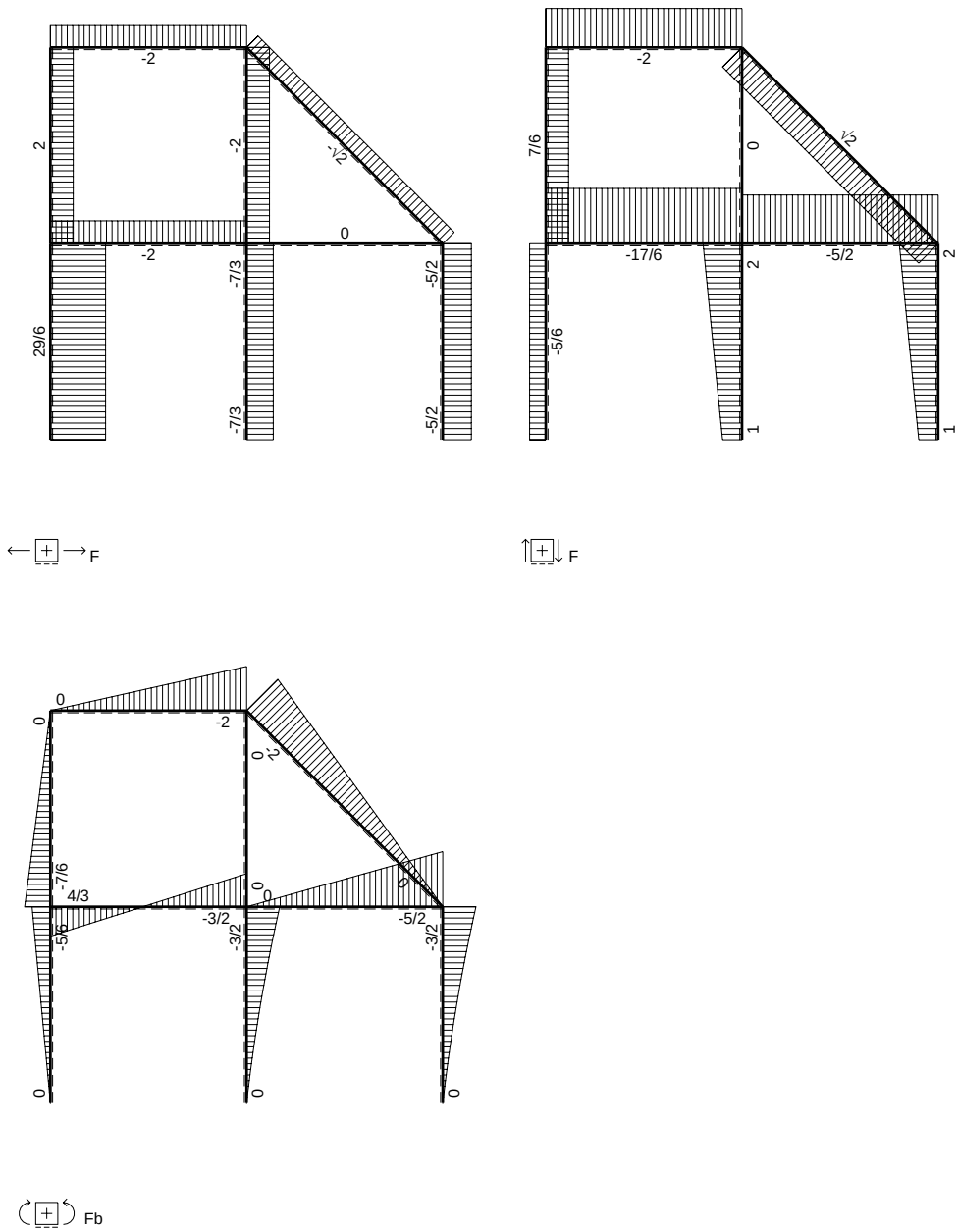
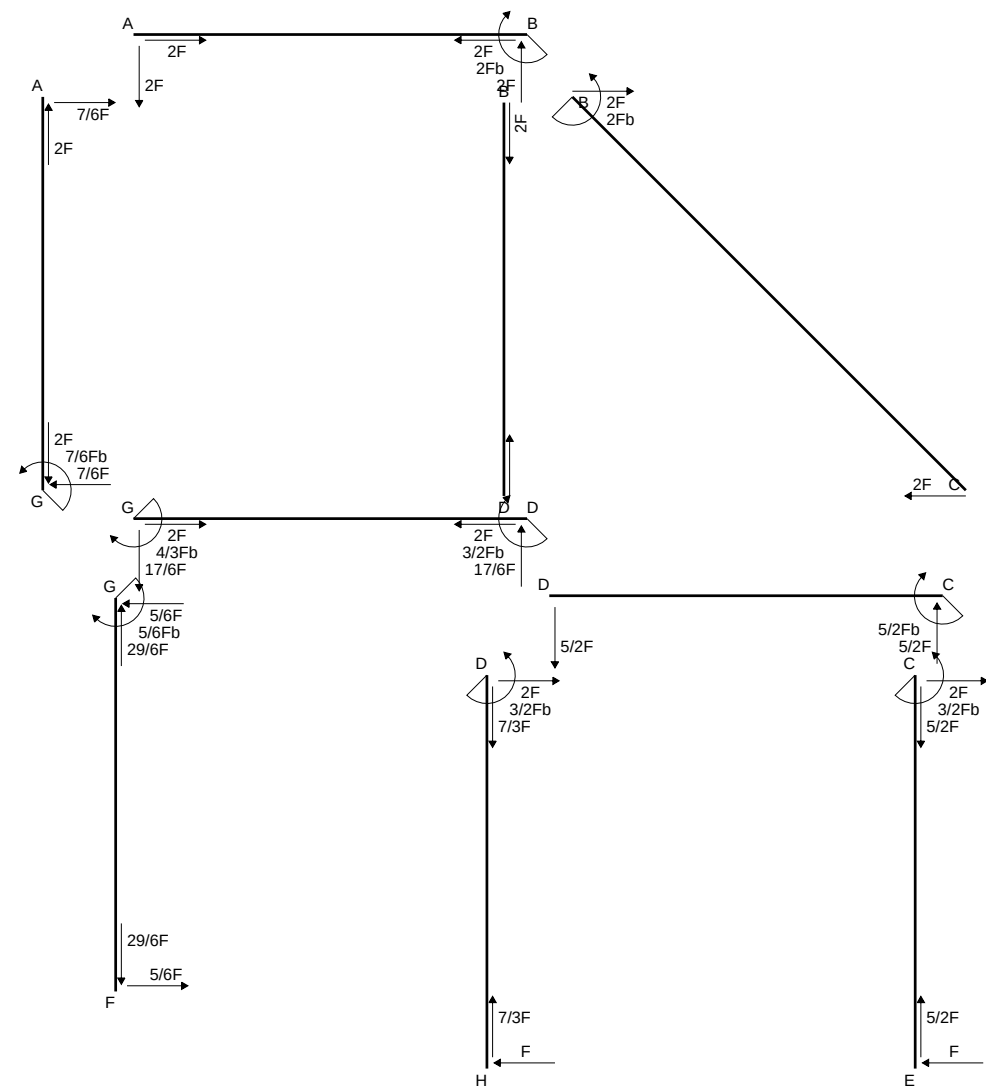
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

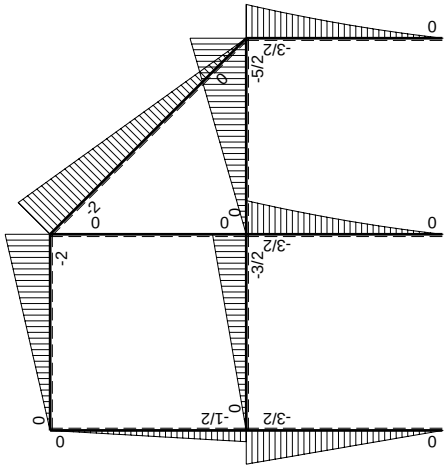
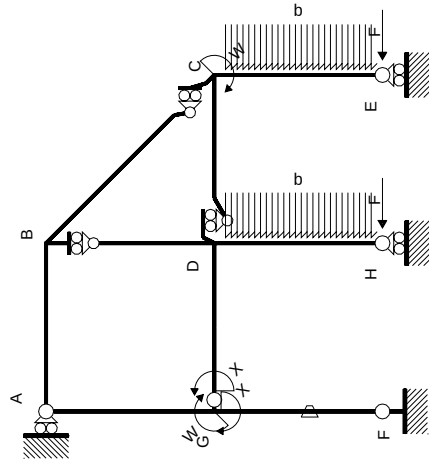
$$L_{DG}^{x\theta} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$



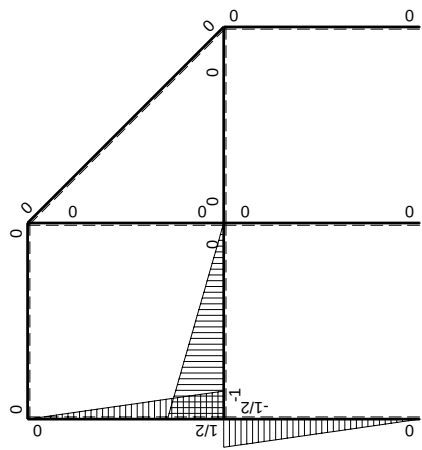
$$\begin{aligned} A &= 1200. \text{ mm}^2 \\ J_u &= 364306. \text{ mm}^4 \\ J_v &= 127584. \text{ mm}^4 \\ y_g &= 21.43 \text{ mm} \\ T_y &= -3075. \text{ N} \\ M_x &= -2306250. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.57 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 19.57 \text{ mm} \\ \sigma_c &= -Mv/J_u = 123.9 \text{ N/mm}^2 \\ \tau_c &= 5.01 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 124.2 \text{ N/mm}^2 \\ S &= 7123. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_0 flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						2/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-4/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

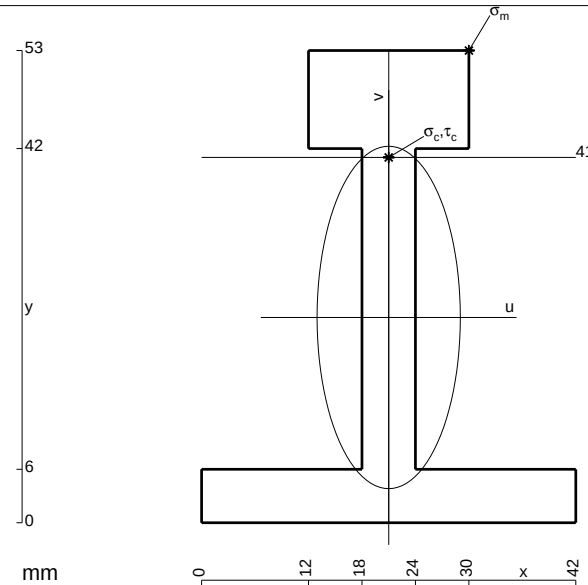
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

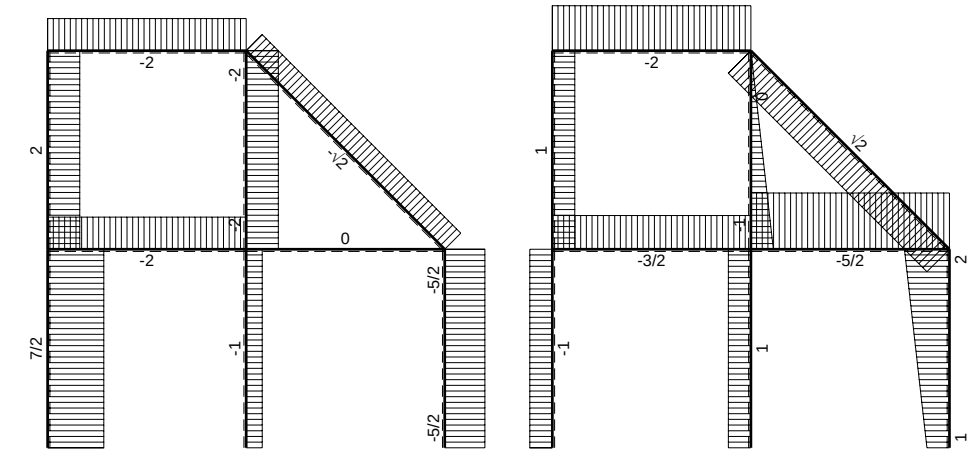
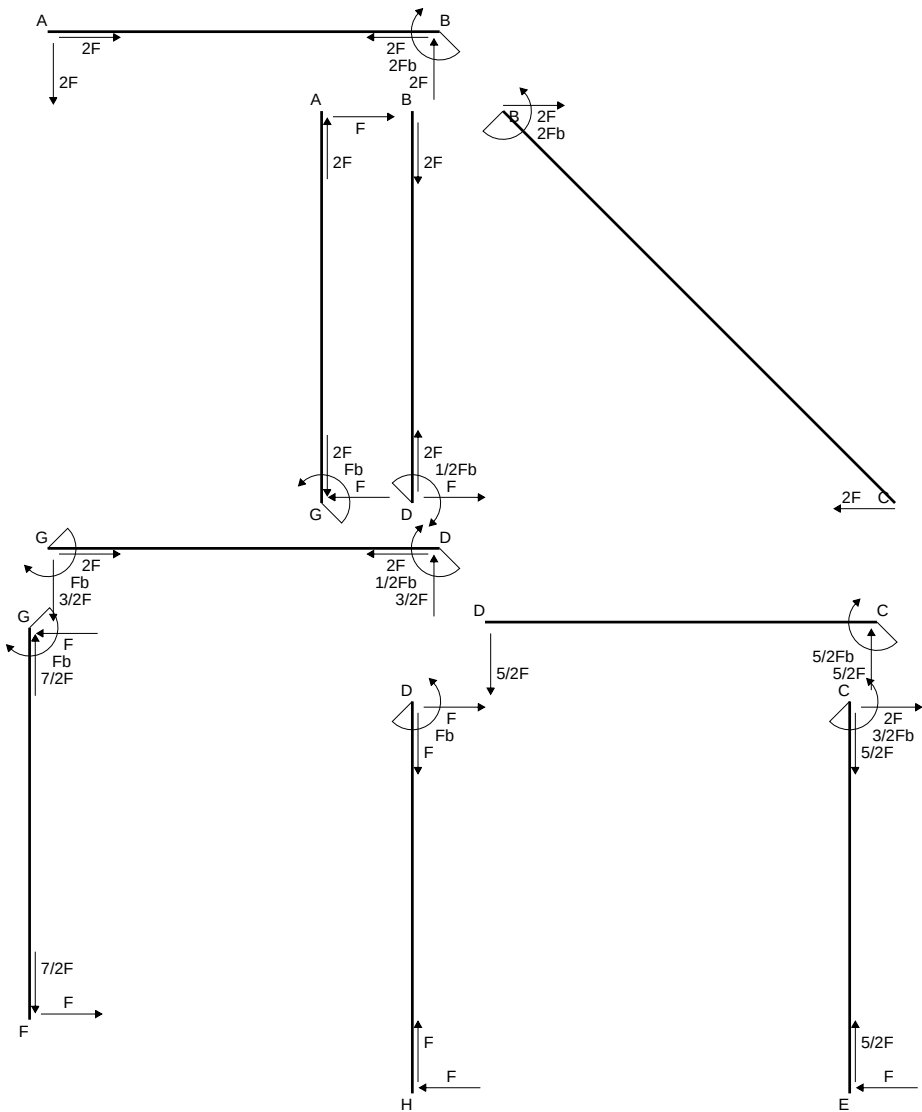
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

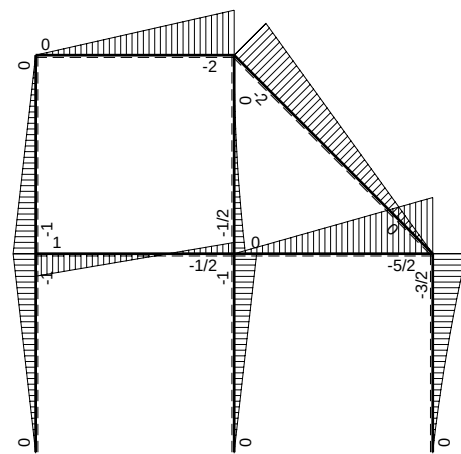


$$\begin{aligned} A &= 666. \text{ mm}^2 \\ J_u &= 245945. \text{ mm}^4 \\ J_v &= 43038. \text{ mm}^4 \\ y_g &= 23.04 \text{ mm} \\ T_y &= -2150. \text{ N} \\ M_x &= -1720000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 29.96 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 17.96 \text{ mm} \\ \sigma_c &= -Mv/J_u = 125.6 \text{ N/mm}^2 \\ \tau_c &= 7.217 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 126.2 \text{ N/mm}^2 \\ S &= 4954. \text{ mm}^3 \end{aligned}$$

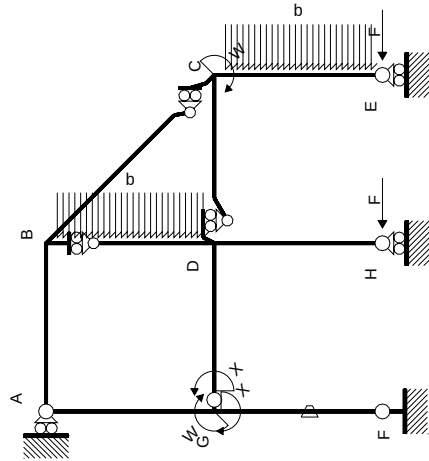


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↑ $\boxed{+}$ ↓ F

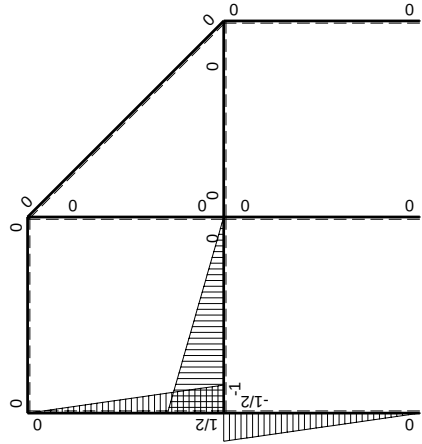
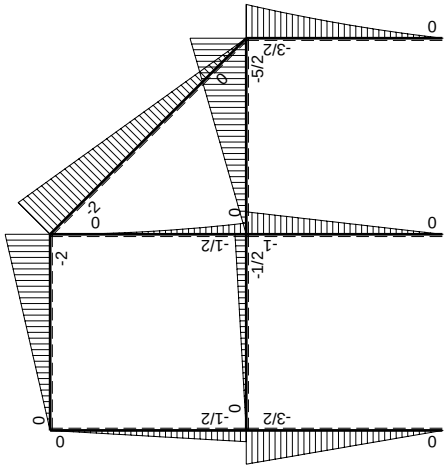


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati

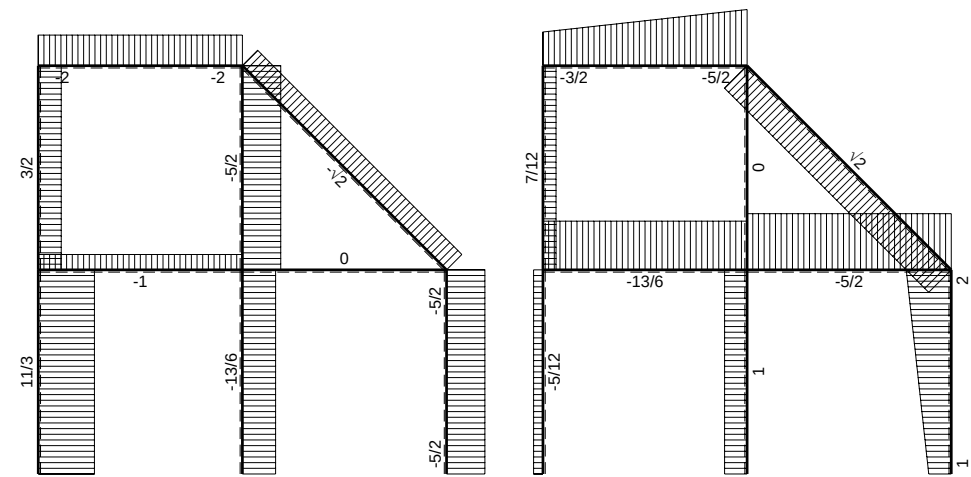
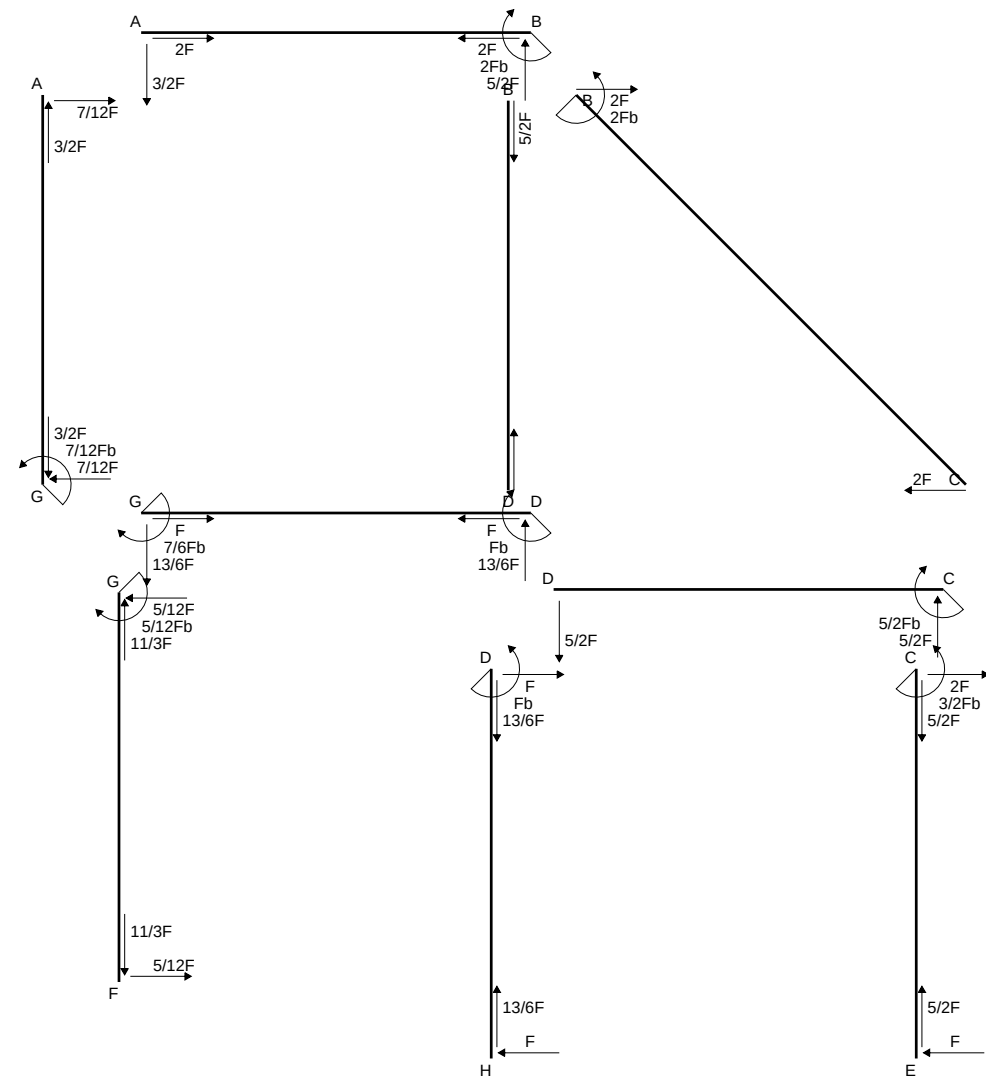


M_0 flessione da iperstatica $X=1$

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

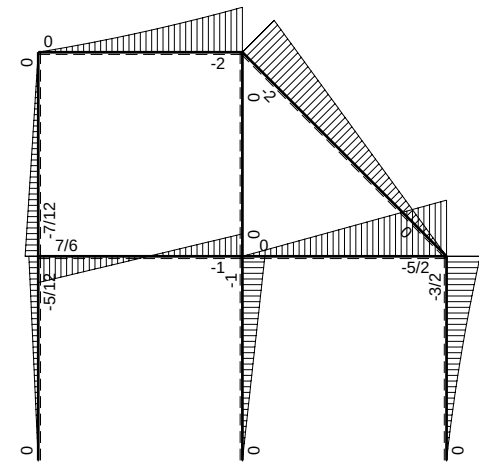
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						1/2Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F_b

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

→	$M_x(x)$	$M_o(x)$	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	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$7/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

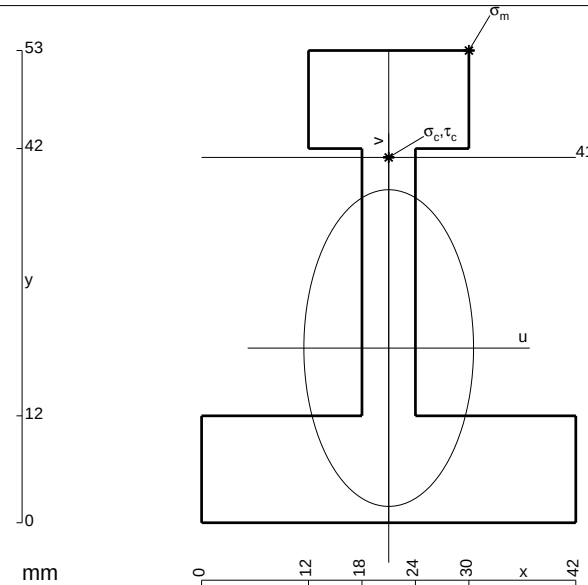
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

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

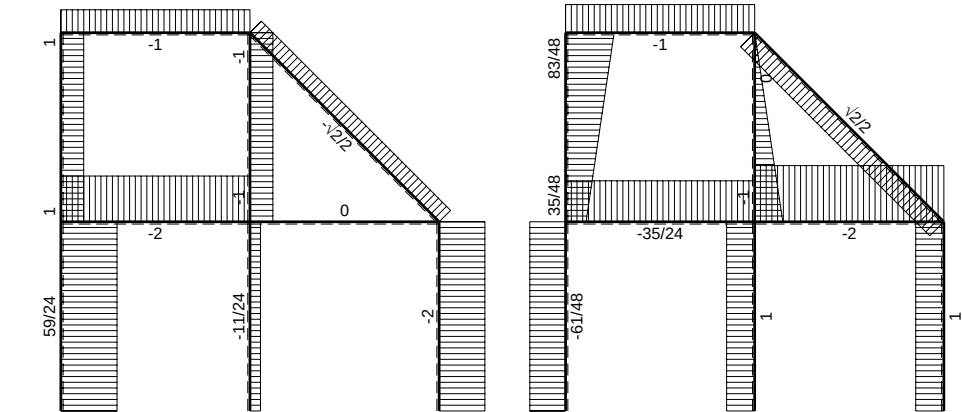
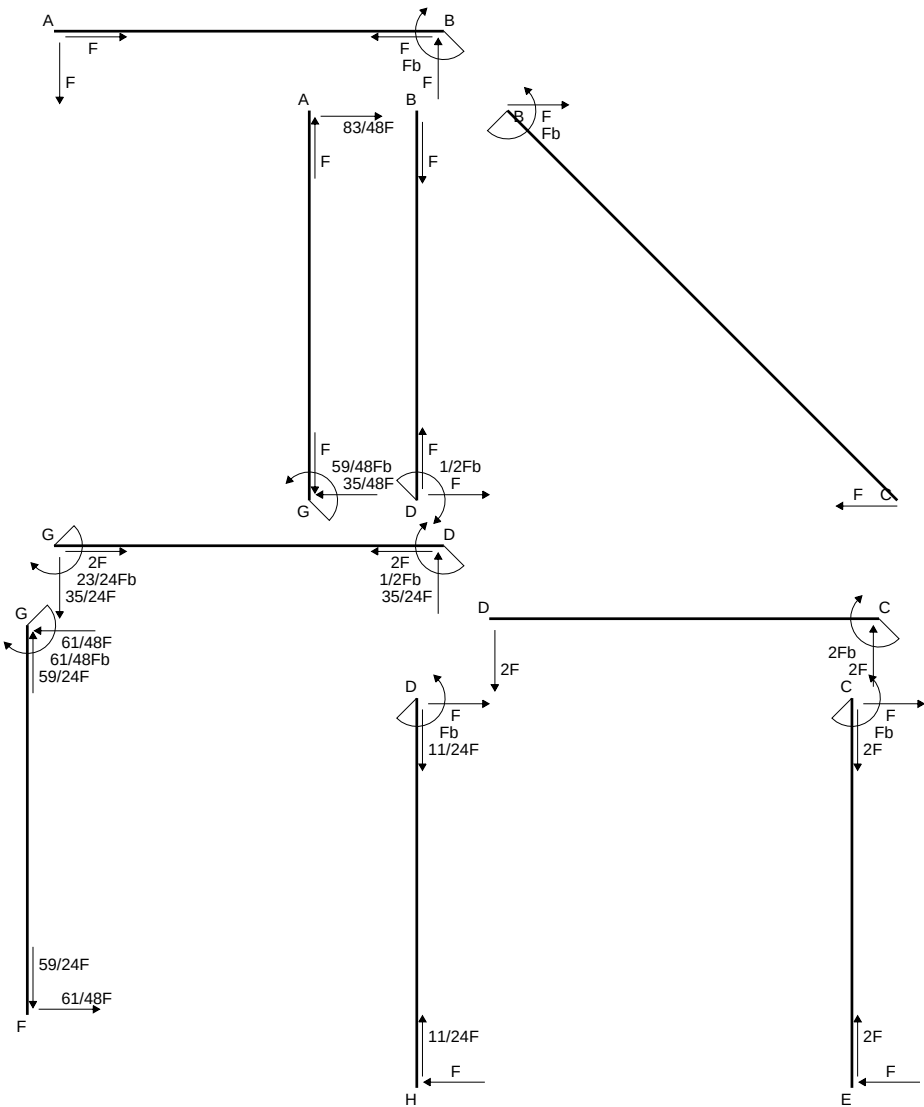
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

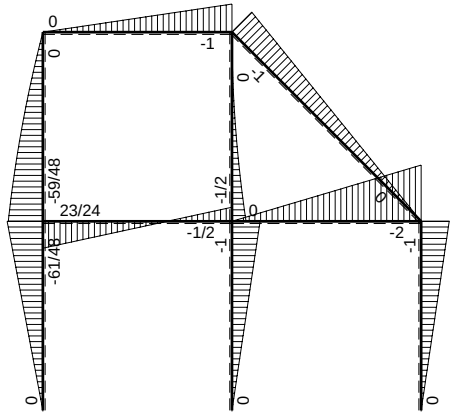


$$\begin{aligned} A &= 882. \text{ mm}^2 \\ J_u &= 278746. \text{ mm}^4 \\ J_v &= 79974. \text{ mm}^4 \\ y_g &= 19.6 \text{ mm} \\ T_y &= -2125. \text{ N} \\ M_x &= -1912500. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.4 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.1 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 21.4 \text{ mm} \\ \sigma_c &= -Mv/J_u = 146.8 \text{ N/mm}^2 \\ \tau_c &= 7.185 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 147.3 \text{ N/mm}^2 \\ S &= 5655. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx	-Fb/EJ	7/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(7/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	7/4Fb-7/4Fx	Fb/EJ	7/8Fb-7/4Fx+7/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx ²	0	-3/8Fb+1/2Fx+1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-7/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx ²	0	-5/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						23/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-23/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{13}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{7}{8} - \frac{7}{4} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{8} x - \frac{7}{8} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{8} b - \frac{7}{8} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{13}{24} Fb^2/EJ$$

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

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

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

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

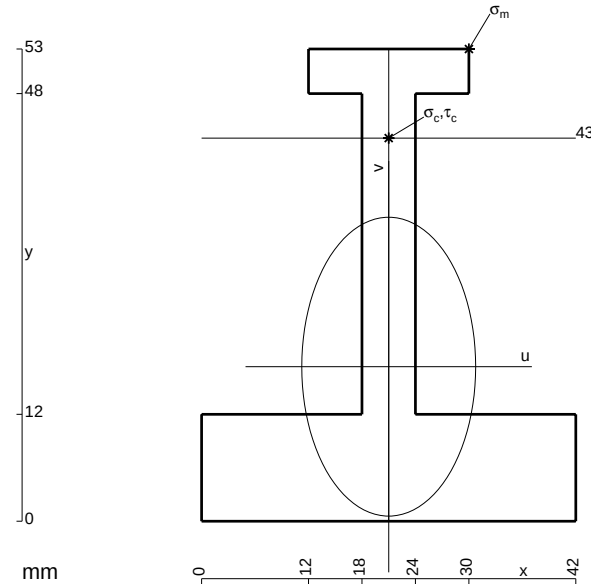
$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

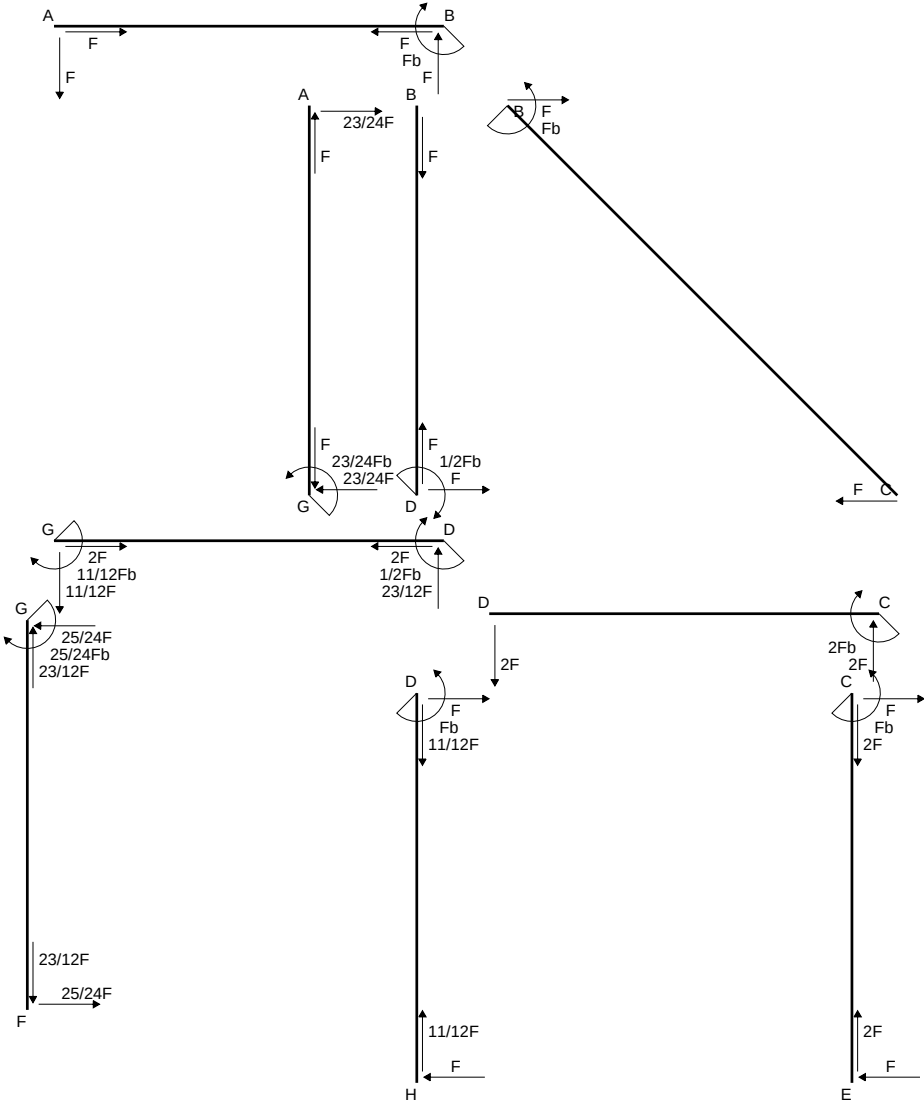
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



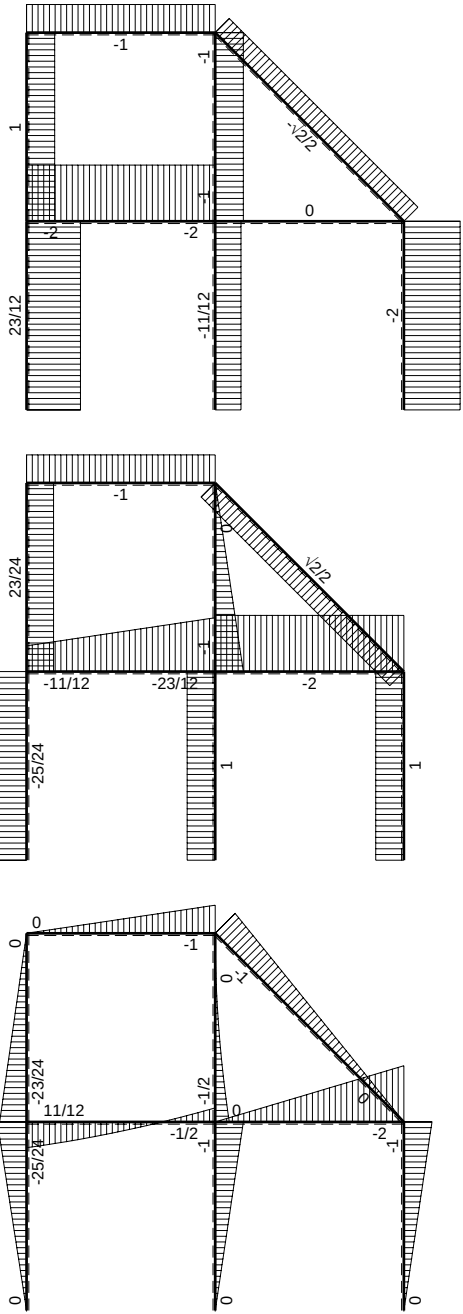
$$\begin{aligned} A &= 810. \text{ mm}^2 \\ J_u &= 227958. \text{ mm}^4 \\ J_v &= 77166. \text{ mm}^4 \\ y_g &= 17.34 \text{ mm} \\ T_y &= -1600. \text{ N} \\ M_x &= -1520000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 35.66 \text{ mm} \\ \sigma_m &= -Mv/J_u = 237.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 25.66 \text{ mm} \\ \sigma_c &= -Mv/J_u = 171.1 \text{ N/mm}^2 \\ \tau_c &= 4.479 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 171.2 \text{ N/mm}^2 \\ S &= 3829. \text{ mm}^3 \end{aligned}$$

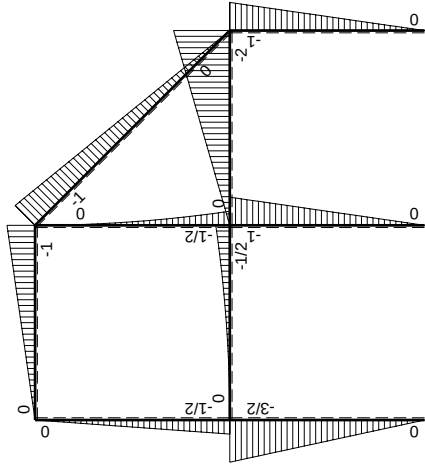
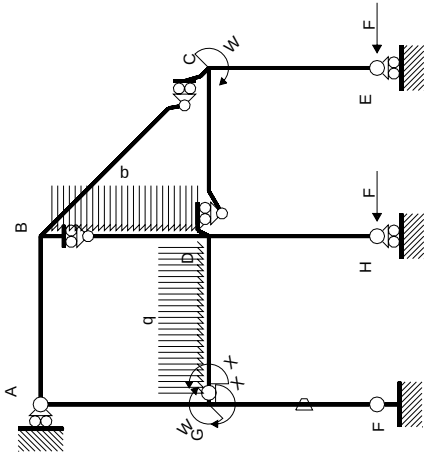


$\leftarrow \boxed{+} \rightarrow F$

$\uparrow \boxed{+} \downarrow F$

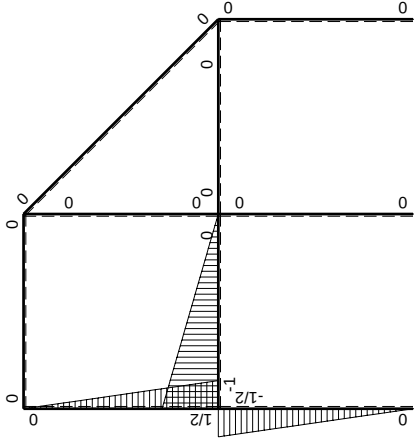
$\curvearrowright \boxed{+} \curvearrowleft Fb$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2qx^2$	0	$1/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-Fx+1/2qx^2$	0	$1/2Fx-Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$11/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-11/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left(\frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

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

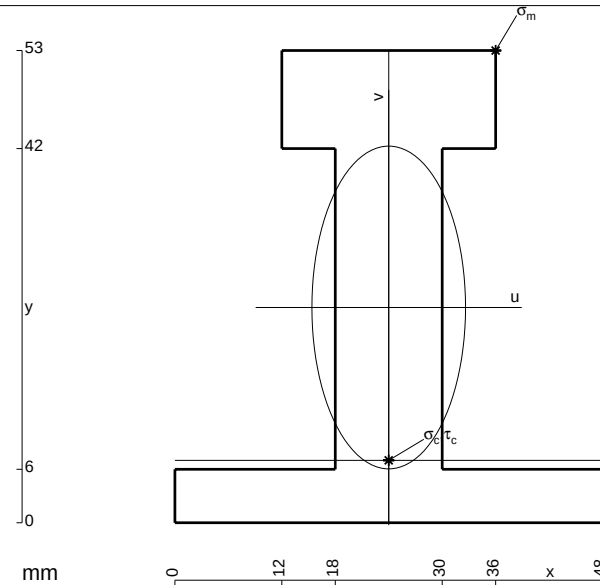
$$= \left(\frac{1}{4} b - \frac{1}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

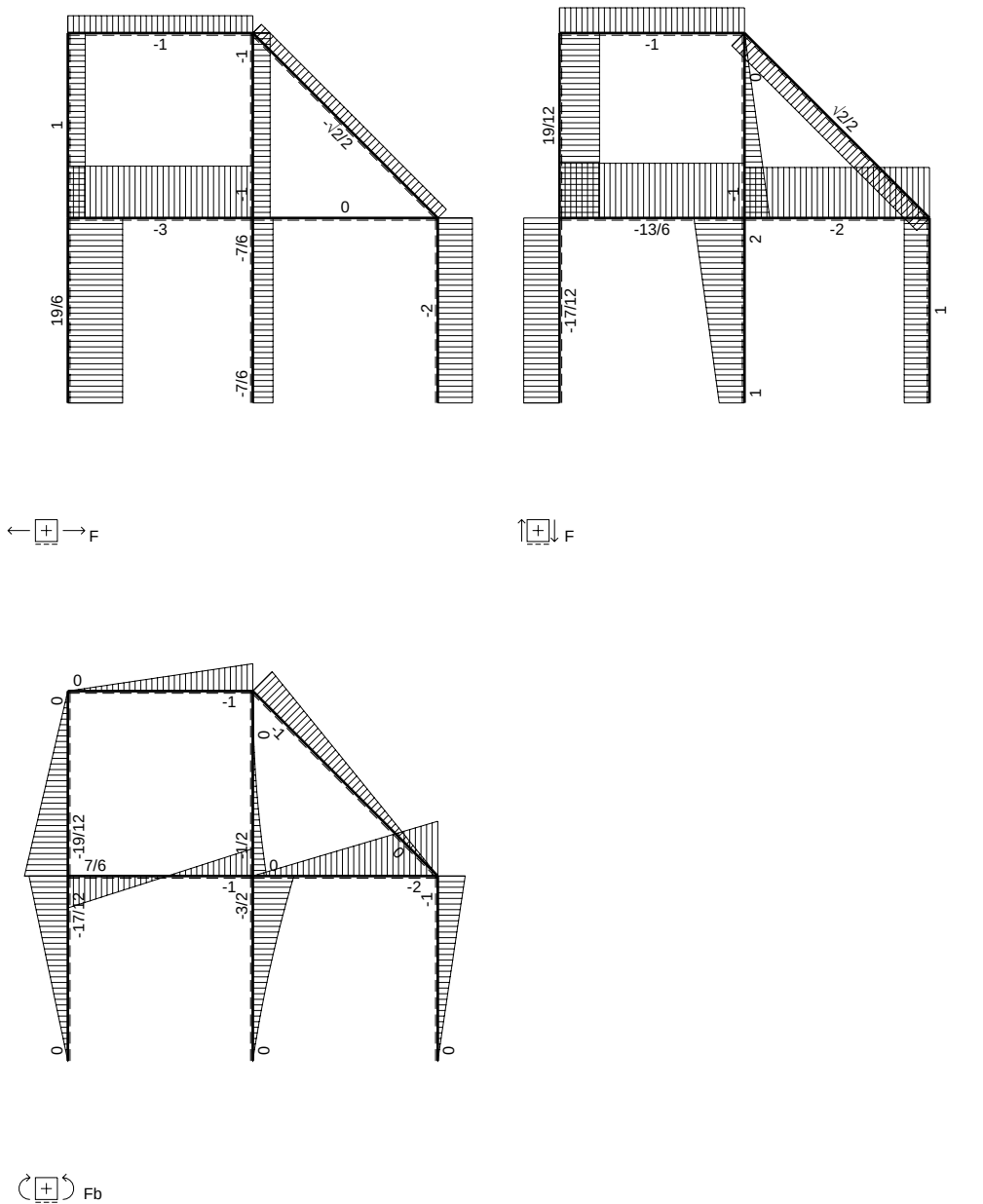
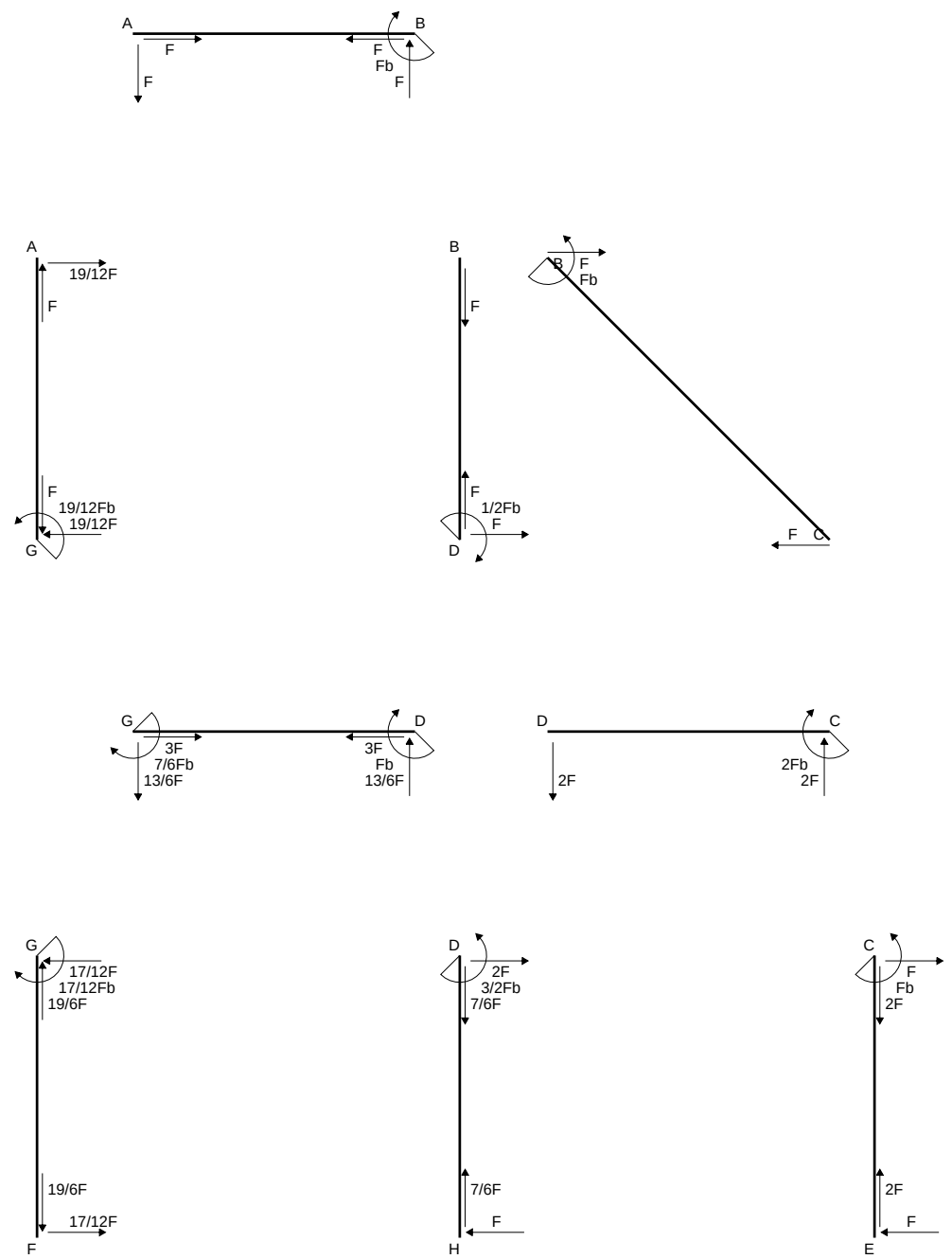
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

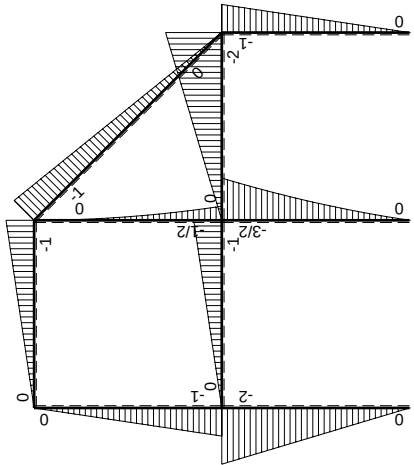
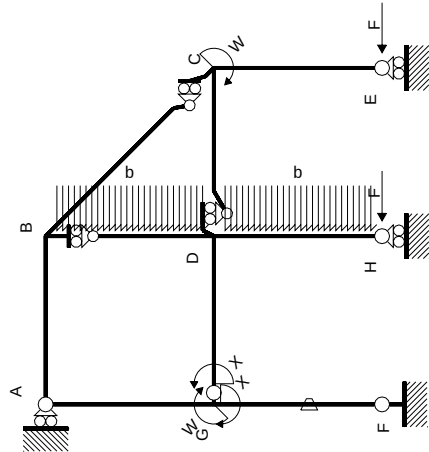
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



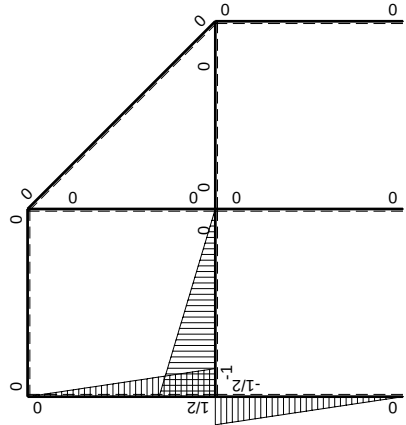
$$\begin{aligned} A &= 984. \text{ mm}^2 \\ J_u &= 322959. \text{ mm}^4 \\ J_v &= 73152. \text{ mm}^4 \\ y_g &= 24.16 \text{ mm} \\ T_y &= -4460. \text{ N} \\ M_x &= -2230000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.84 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.1 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -17.16 \text{ mm} \\ \sigma_c &= -Mv/J_u = -118.5 \text{ N/mm}^2 \\ \tau_c &= 7.257 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 119.1 \text{ N/mm}^2 \\ S &= 6306. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-2Fx	-Fb/EJ	Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/3+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	2Fb-2Fx	Fb/EJ	Fb-2Fx+Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						7/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{3} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(b - b + \frac{1}{3} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{12} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

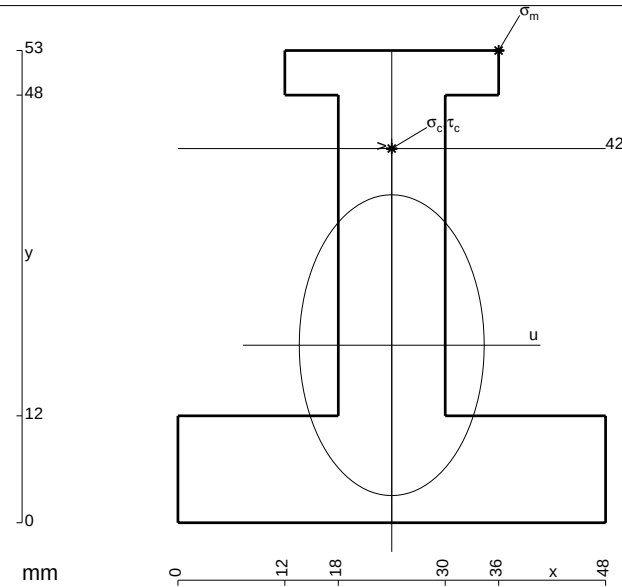
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

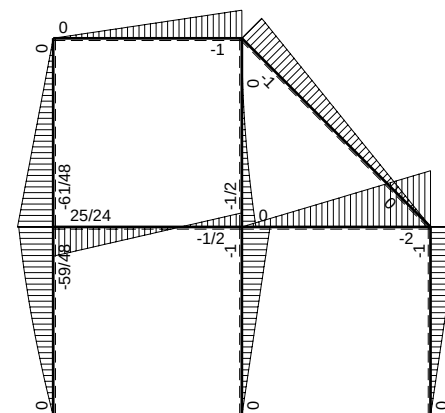
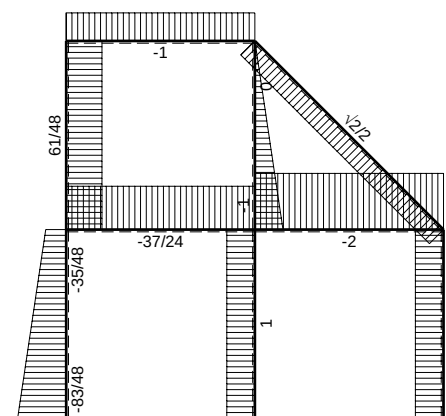
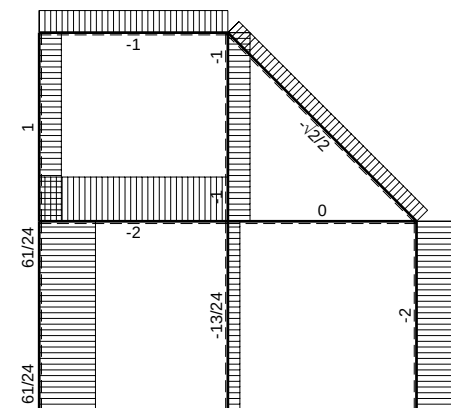
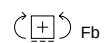
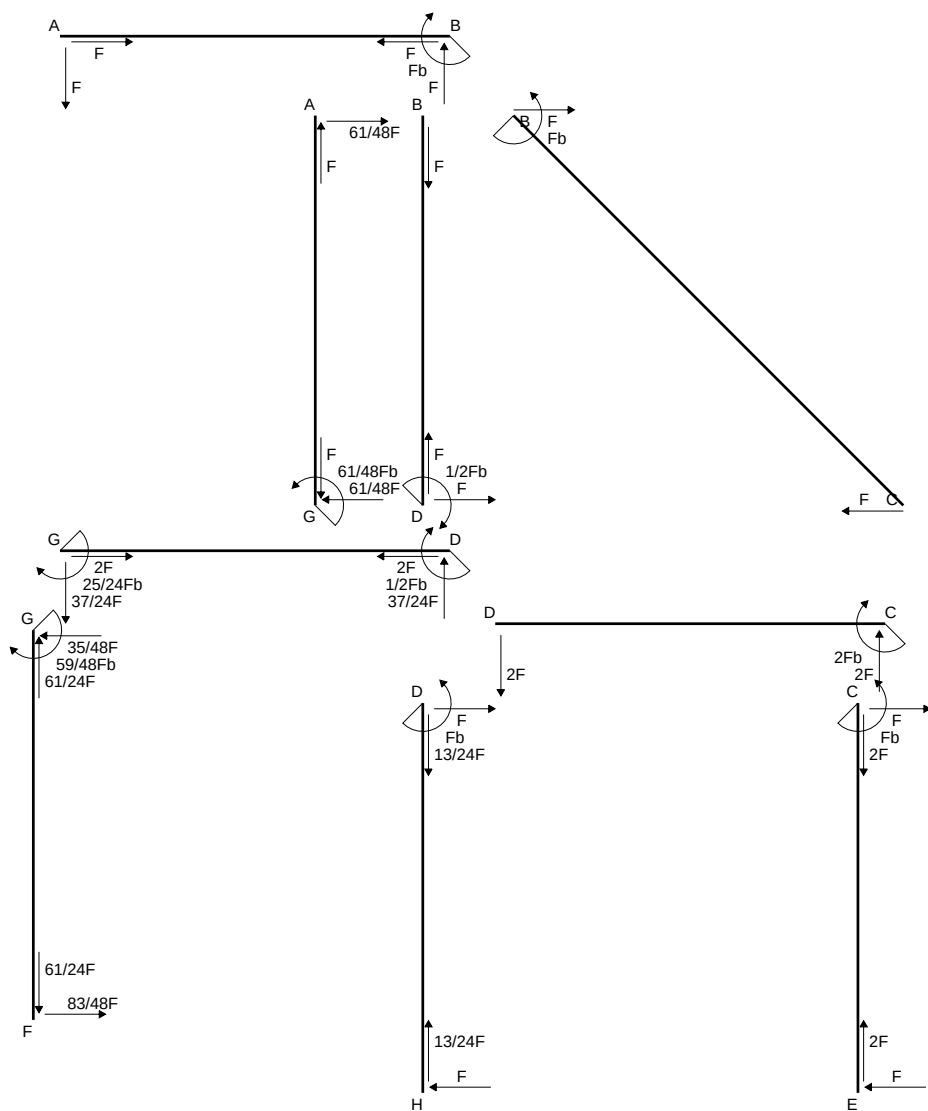
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



$$\begin{aligned} A &= 1128. \text{ mm}^2 \\ J_u &= 321538. \text{ mm}^4 \\ J_v &= 121536. \text{ mm}^4 \\ y_g &= 19.93 \text{ mm} \\ T_y &= -3700. \text{ N} \\ M_x &= -2035000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 33.07 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 22.07 \text{ mm} \\ \sigma_c &= -Mv/J_u = 139.7 \text{ N/mm}^2 \\ \tau_c &= 5.249 \text{ N/mm}^2 \\ \sigma_\rho &= \sqrt{\sigma^2 + 3\tau^2} = 140. \text{ N/mm}^2 \\ S &= 5474. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-9/4Fx+1/2qx^2$	$-Fb/EJ$	$9/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(5/16+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$7/4Fb-5/4Fx-1/2qx^2$	Fb/EJ	$7/8Fb-3/2Fx+3/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$25/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-25/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{9}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{9}{16} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{7}{8} - \frac{3}{2} x/b + \frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{8} x - \frac{3}{4} x^2/b + \frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{8} b - \frac{3}{4} b + \frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{9}{16} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

$$L_{DG}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

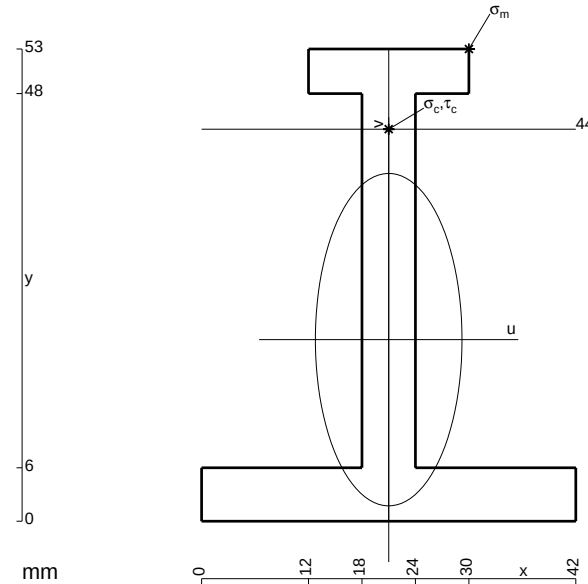
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

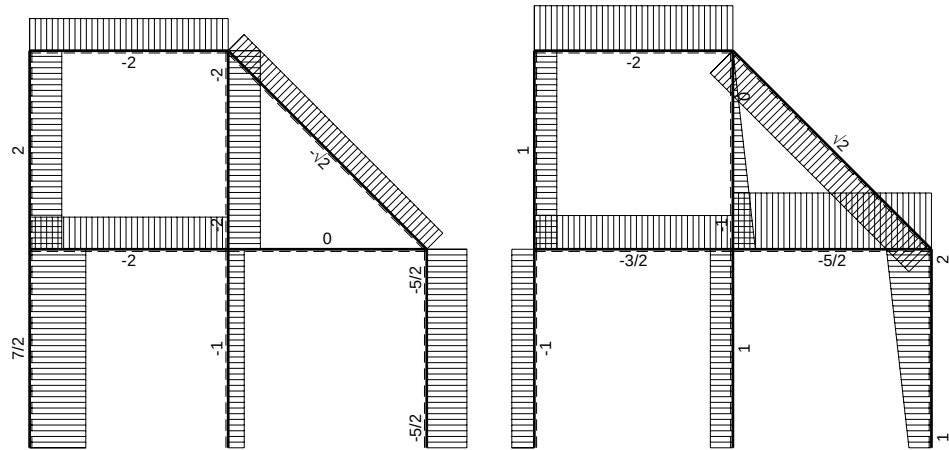
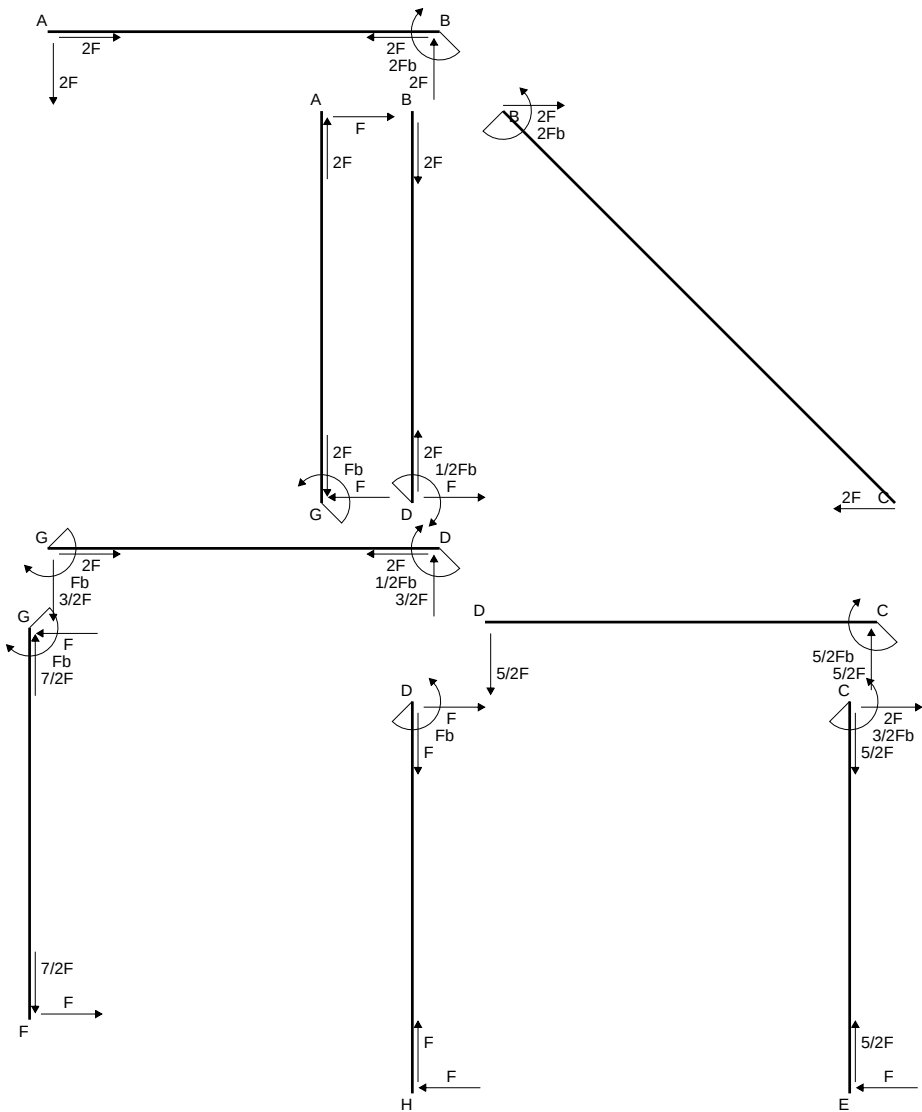
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

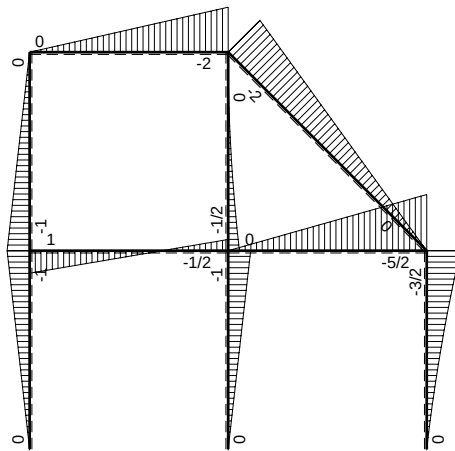


$$\begin{aligned} A &= 594. \text{ mm}^2 \\ J_u &= 206801. \text{ mm}^4 \\ J_v &= 40230. \text{ mm}^4 \\ y_g &= 20.38 \text{ mm} \\ T_y &= -2320. \text{ N} \\ M_x &= -1392000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 32.62 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219.6 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 23.62 \text{ mm} \\ \sigma_c &= -Mv/J_u = 159. \text{ N/mm}^2 \\ \tau_c &= 6.218 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 159.4 \text{ N/mm}^2 \\ S &= 3326. \text{ mm}^3 \end{aligned}$$

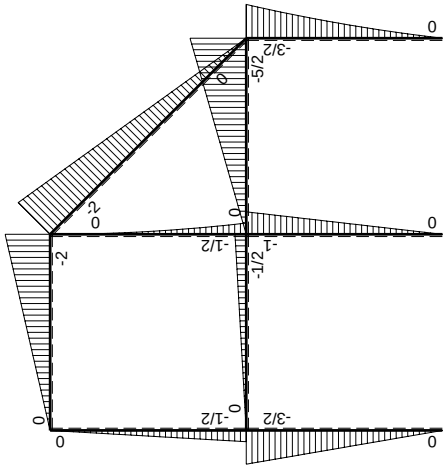
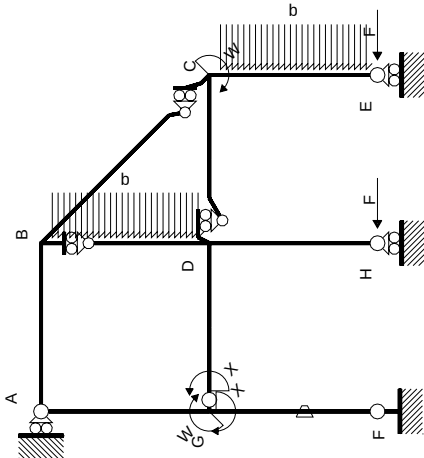


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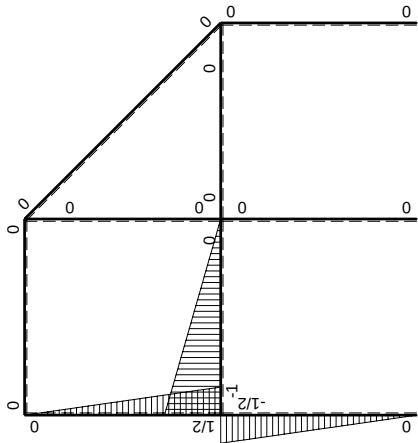


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						1/2Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

$$L_{DG}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

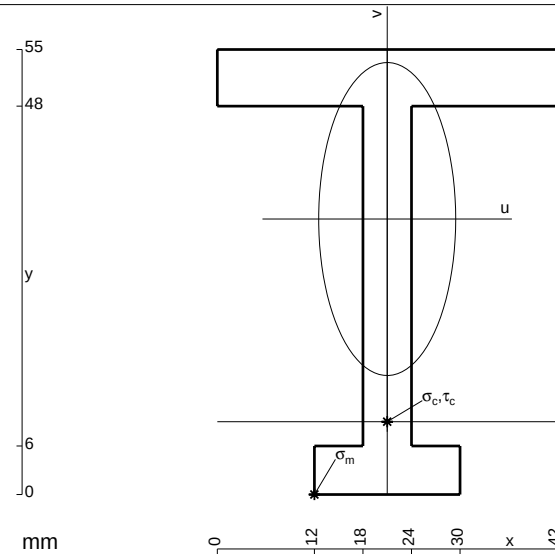
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

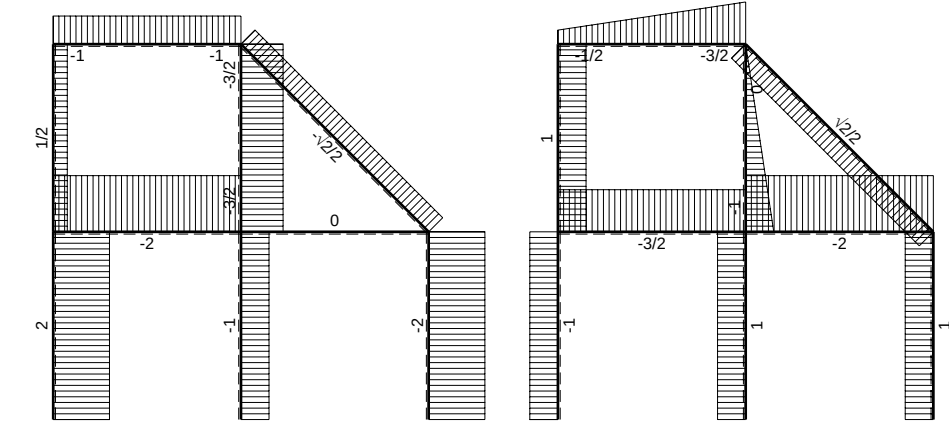
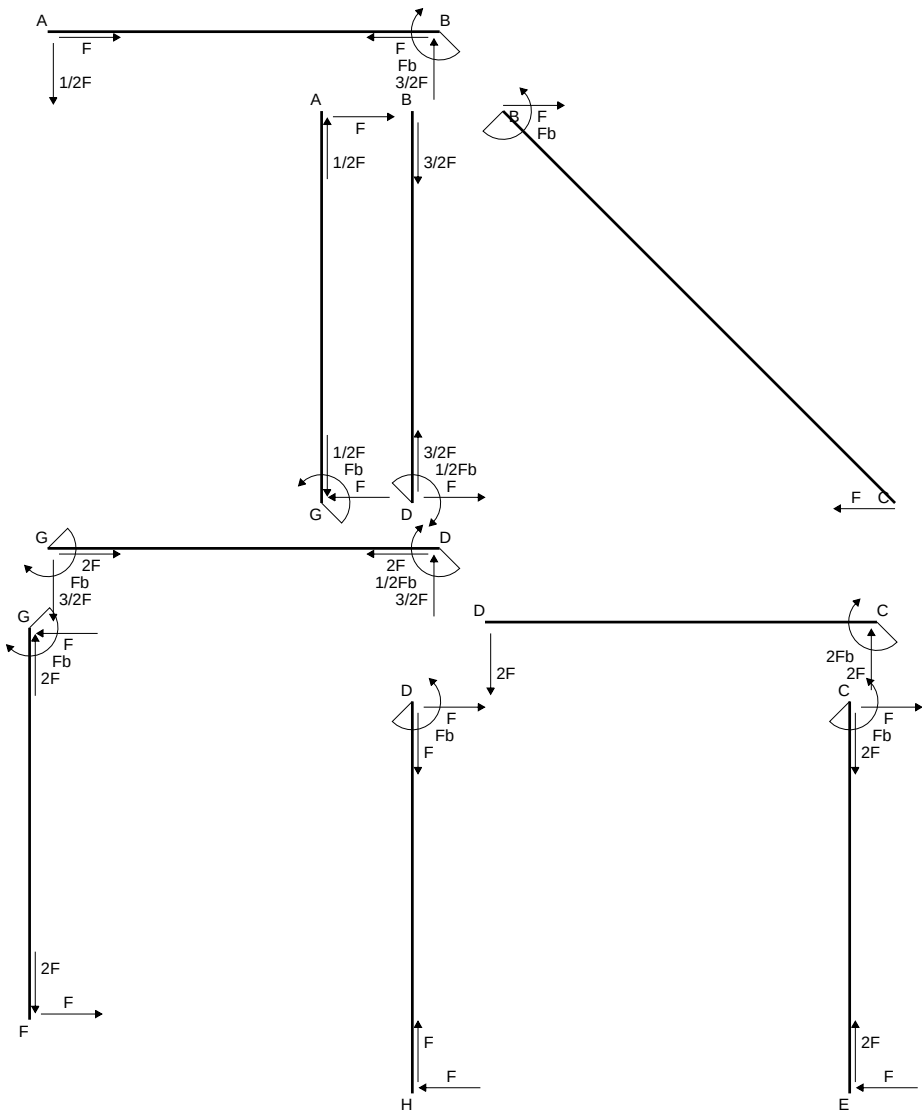
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

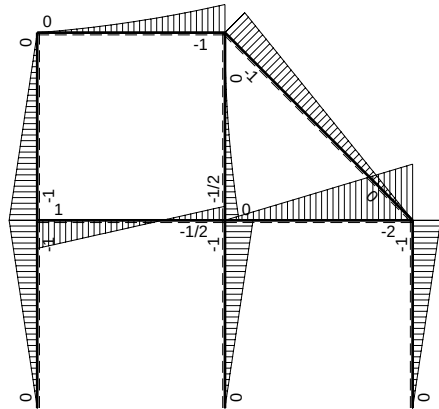


$$\begin{aligned} A &= 654. \text{ mm}^2 \\ J_u &= 244740. \text{ mm}^4 \\ J_v &= 46890. \text{ mm}^4 \\ y_g &= 34.05 \text{ mm} \\ T_y &= -2450. \text{ N} \\ M_x &= -1641500. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.05 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -25.05 \text{ mm} \\ \sigma_c &= -Mv/J_u = -168. \text{ N/mm}^2 \\ \tau_c &= 6.392 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 168.4 \text{ N/mm}^2 \\ S &= 3831. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

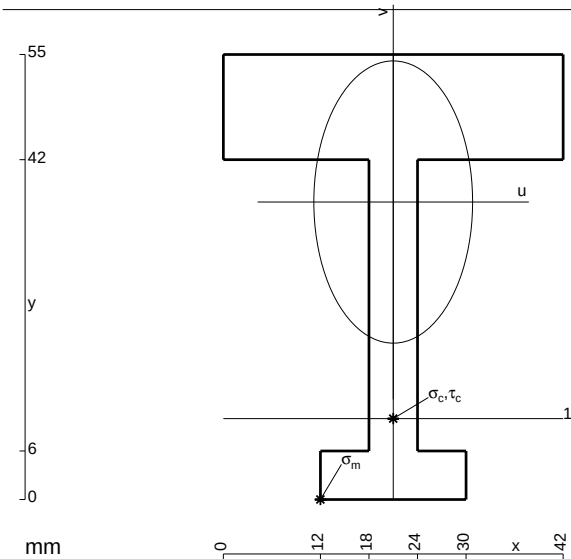
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

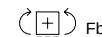
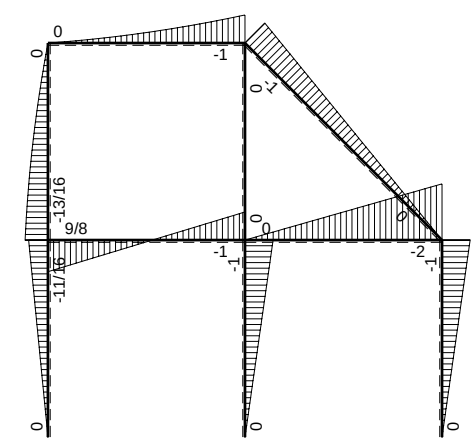
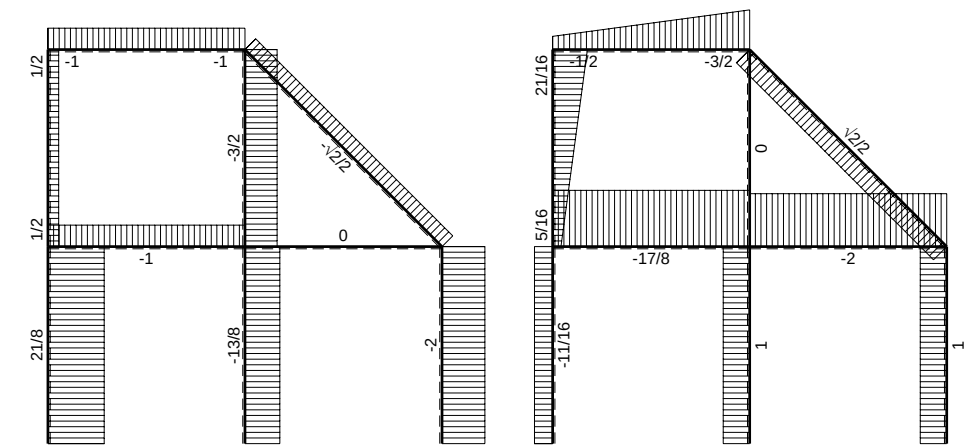
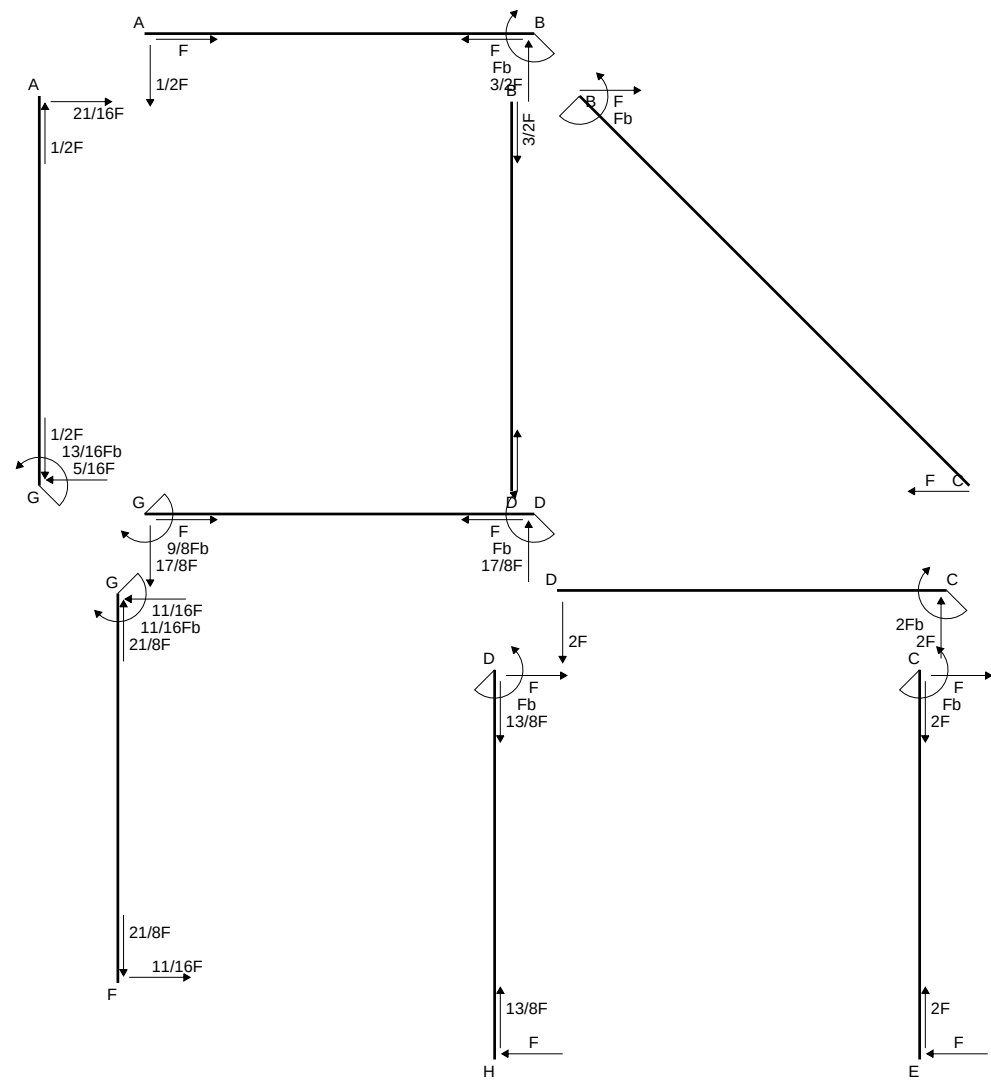
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



$$\begin{aligned} A &= 870. \text{ mm}^2 \\ J_u &= 264856. \text{ mm}^4 \\ J_v &= 83826. \text{ mm}^4 \\ y_g &= 36.77 \text{ mm} \\ T_y &= -2400. \text{ N} \\ M_x &= -1728000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -36.77 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -26.77 \text{ mm} \\ \sigma_c &= -Mv/J_u = -174.6 \text{ N/mm}^2 \\ \tau_c &= 6.551 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 175. \text{ N/mm}^2 \\ S^* &= 4338. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx$	$-Fb/EJ$	$5/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(5/24+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-5/4Fx$	Fb/EJ	$5/8Fb-5/4Fx+5/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb-1/4Fx+1/2qx^2$	0	$-1/8Fb+3/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/16+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx-1/2qx^2$	0	$-3/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$9/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

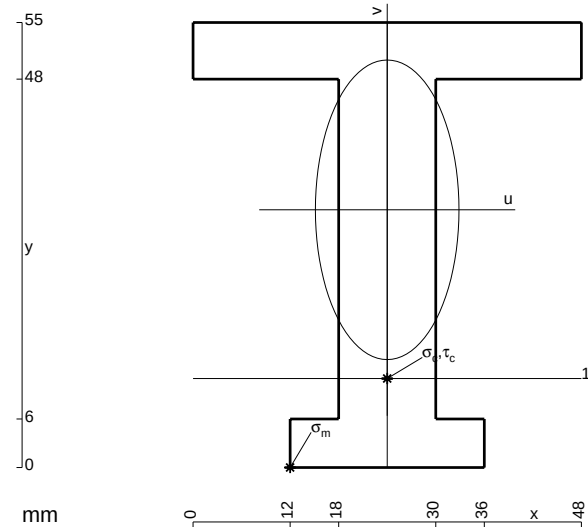
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

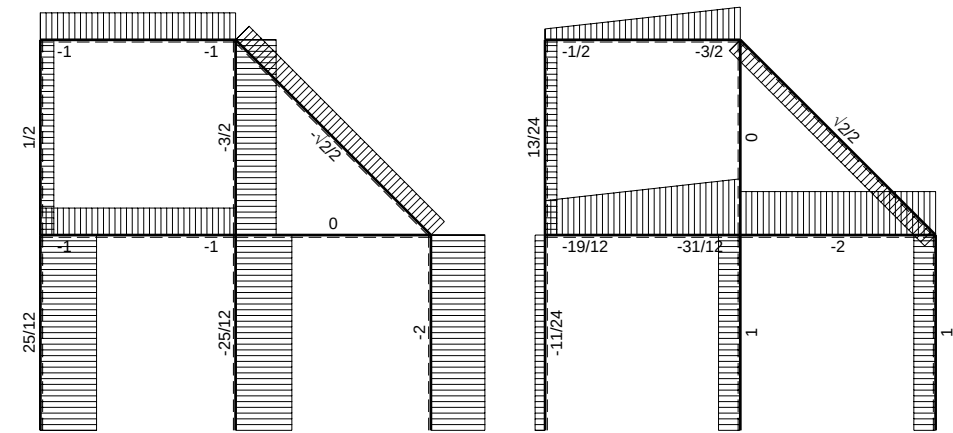
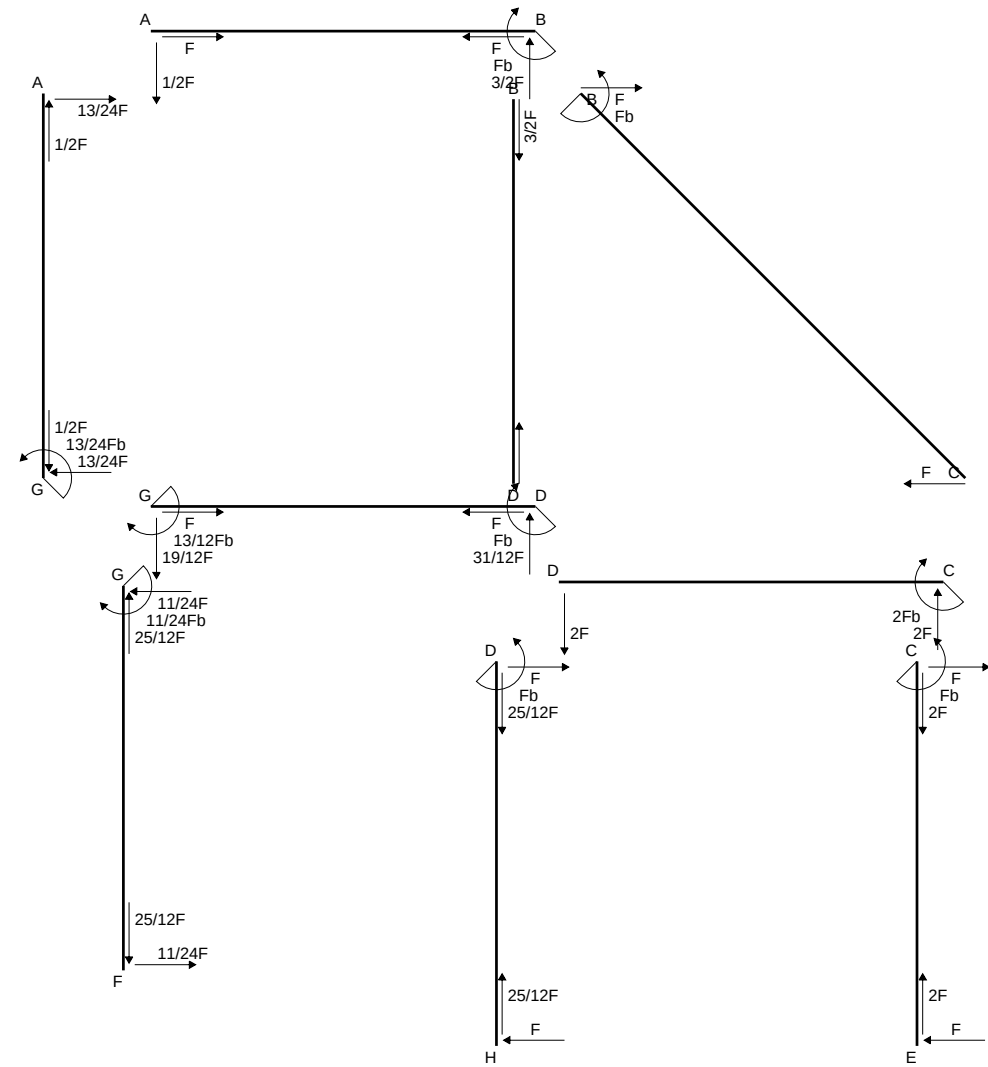
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

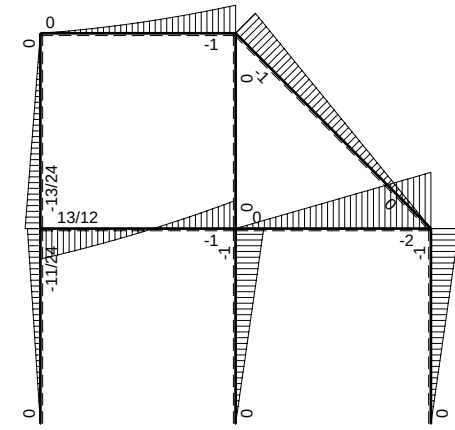


$$\begin{aligned} A &= 984. \text{ mm}^2 \\ J_u &= 337339. \text{ mm}^4 \\ J_v &= 77472. \text{ mm}^4 \\ y_g &= 31.85 \text{ mm} \\ T_y &= -2700. \text{ N} \\ M_x &= -2106000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.85 \text{ mm} \\ \sigma_m &= -Mv/J_u = -198.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -20.85 \text{ mm} \\ \sigma_c &= -Mv/J_u = -130.2 \text{ N/mm}^2 \\ \tau_c &= 3.706 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 130.3 \text{ N/mm}^2 \\ S &= 5556. \text{ mm}^3 \end{aligned}$$



← + → F

↑ + ↓ F



← + → F_b

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$13/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-13/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb 1/EJ \, dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta \, dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb 1/EJ + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb 1/EJ \, dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb 1/EJ + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

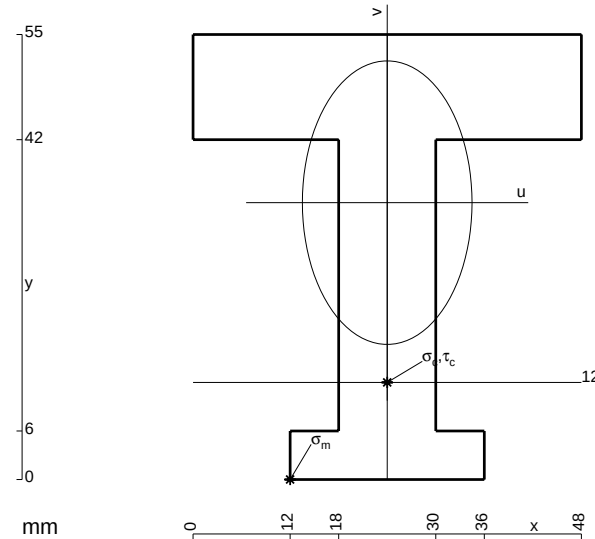
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb 1/EJ + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = 5/12 \, Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb 1/EJ \, dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb 1/EJ$$

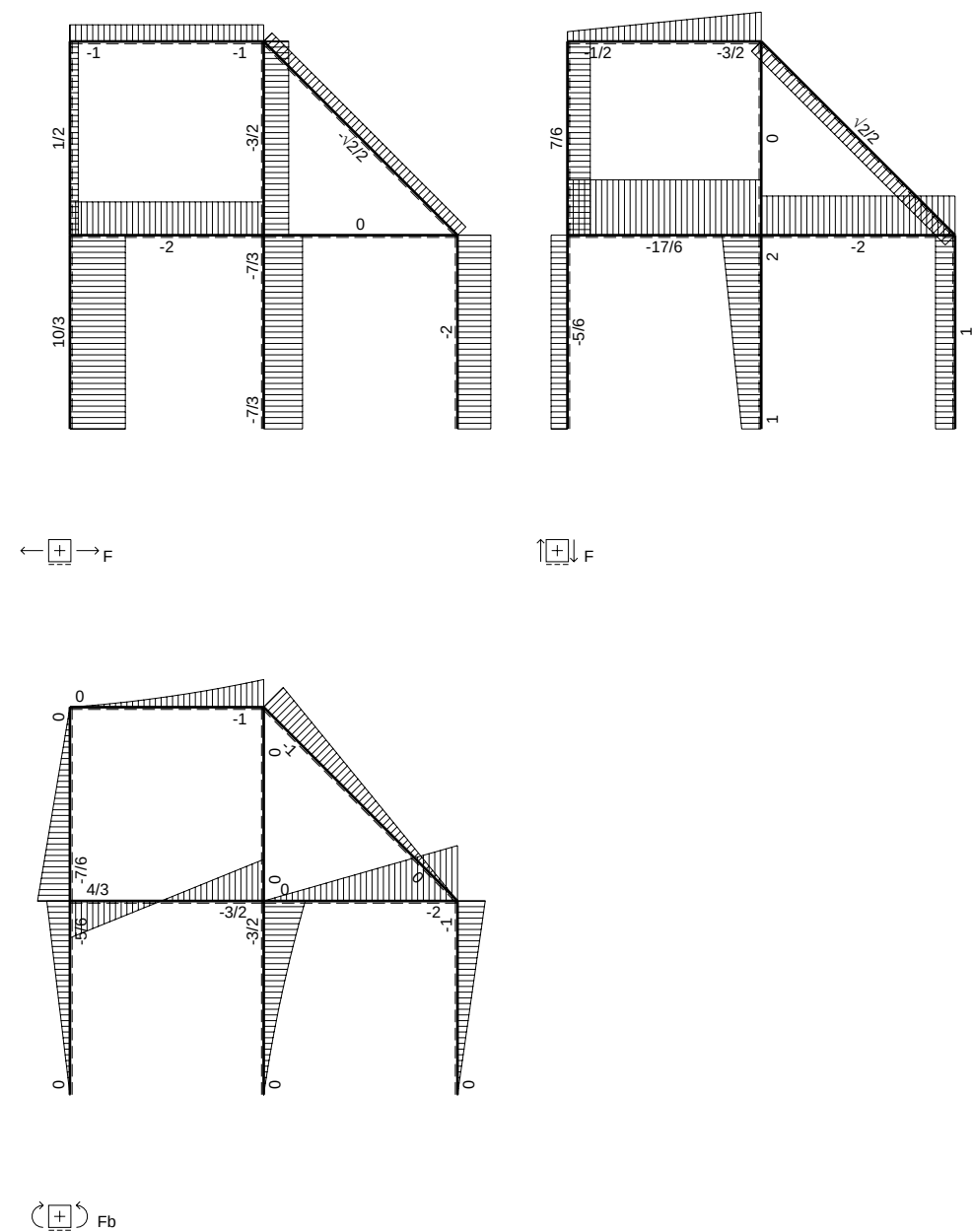
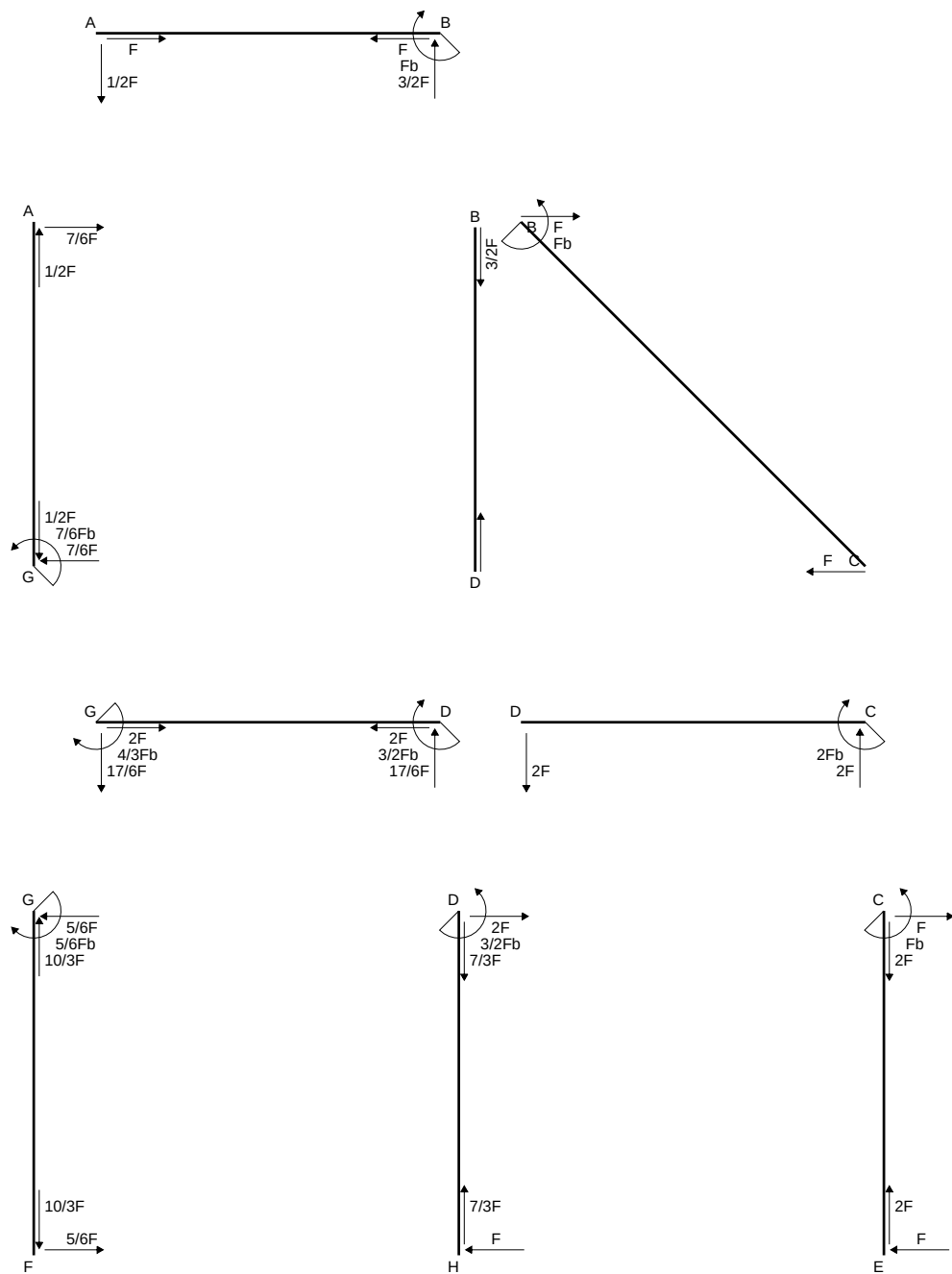
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb 1/EJ = 1/8 \, Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^2 \right) Fb 1/EJ \, dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb 1/EJ$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb 1/EJ = 1/8 \, Fb^2/EJ$$



$$\begin{aligned} A &= 1200. \text{ mm}^2 \\ J_u &= 368598. \text{ mm}^4 \\ J_v &= 131904. \text{ mm}^4 \\ y_g &= 34.22 \text{ mm} \\ T_y &= -2720. \text{ N} \\ M_x &= -2257600. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -34.22 \text{ mm} \\ \sigma_m &= -Mv/J_u = -209.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -22.22 \text{ mm} \\ \sigma_c &= -Mv/J_u = -136.1 \text{ N/mm}^2 \\ \tau_c &= 3.881 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 136.3 \text{ N/mm}^2 \\ S &= 6312. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$2/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-4/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

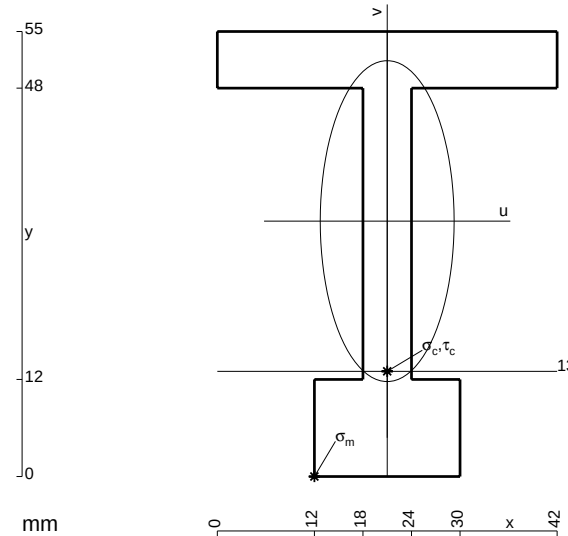
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

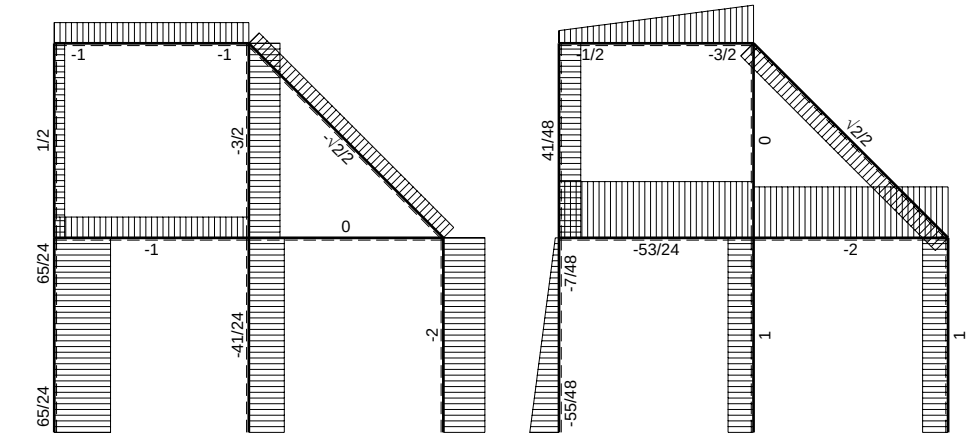
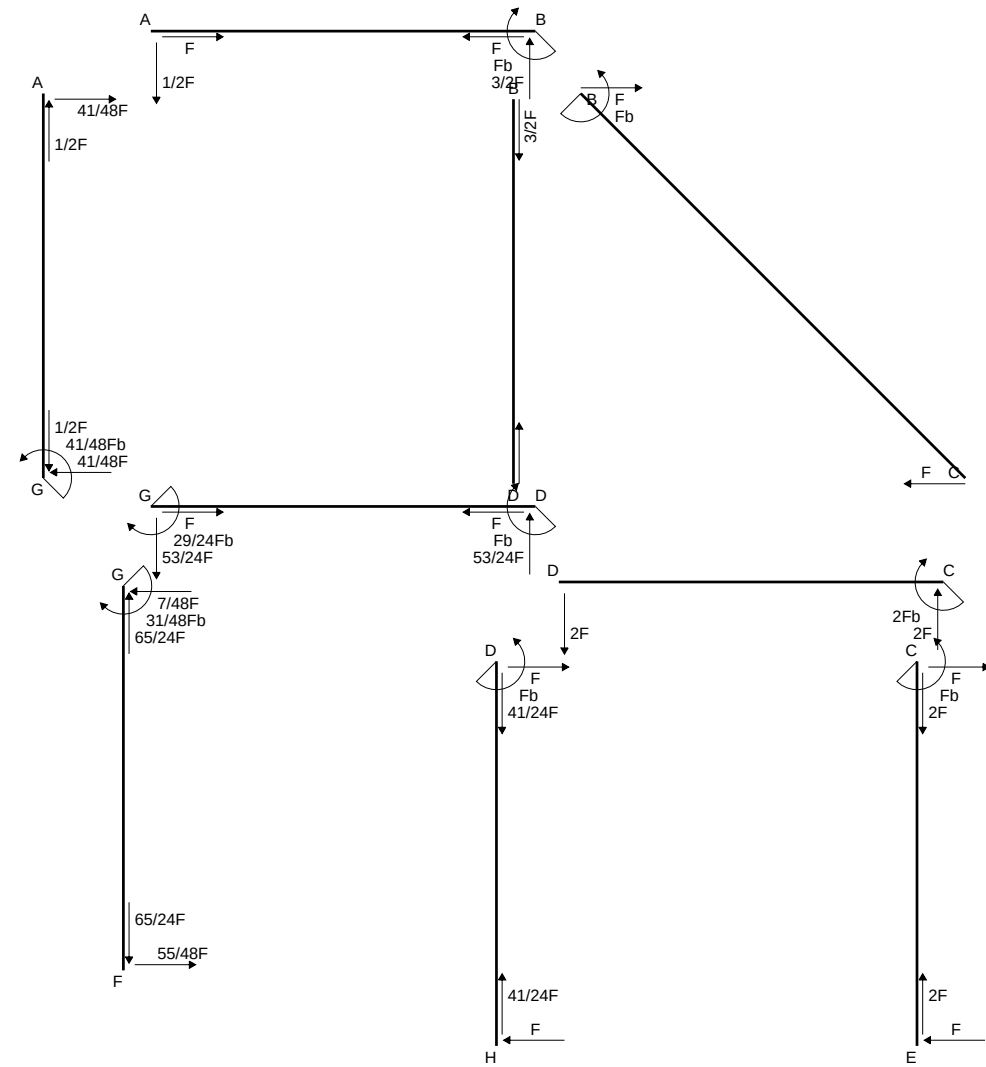
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

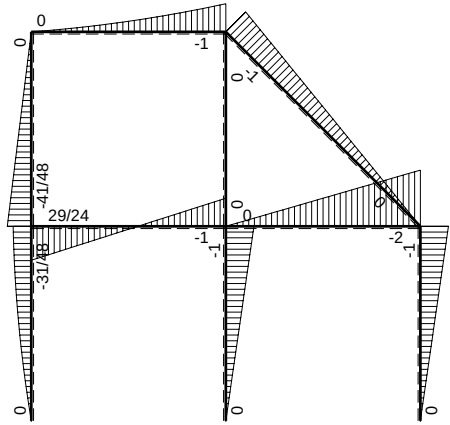


$$\begin{aligned} A &= 726. \text{ mm}^2 \\ J_u &= 285657. \text{ mm}^4 \\ J_v &= 49698. \text{ mm}^4 \\ y_g &= 31.57 \text{ mm} \\ T_y &= -2260. \text{ N} \\ M_x &= -1988800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -31.57 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -18.57 \text{ mm} \\ \sigma_c &= -Mv/J_u = -129.3 \text{ N/mm}^2 \\ \tau_c &= 7.432 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 129.9 \text{ N/mm}^2 \\ S &= 5637. \text{ mm}^3 \end{aligned}$$

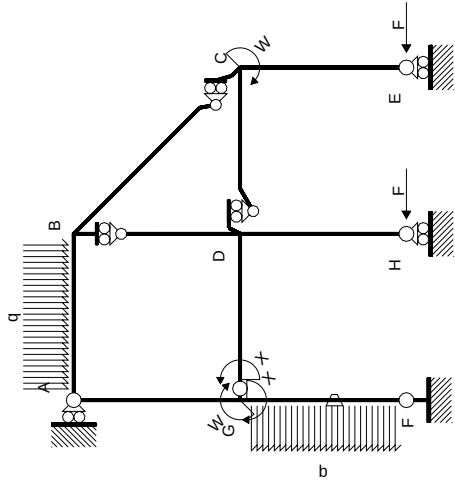


← ⊕ → F

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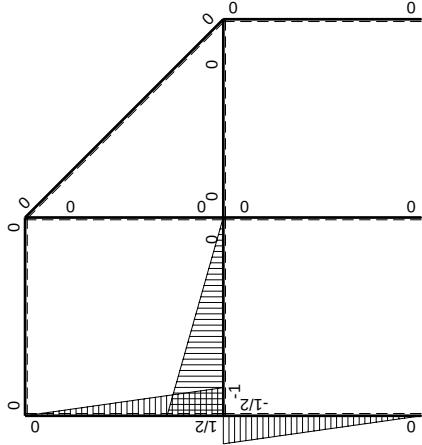
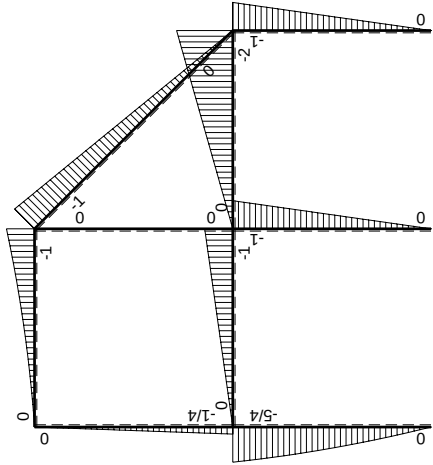


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-7/4Fx+1/2qx^2$	$-Fb/EJ$	$7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(11/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$5/8Fb-Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb+1/4Fx$	0	$-1/8Fb+1/4Fx-1/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/4Fx$	0	$-1/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$29/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-29/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

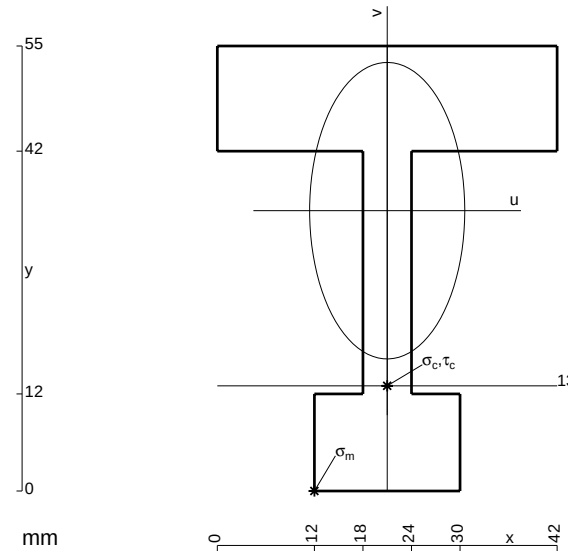
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

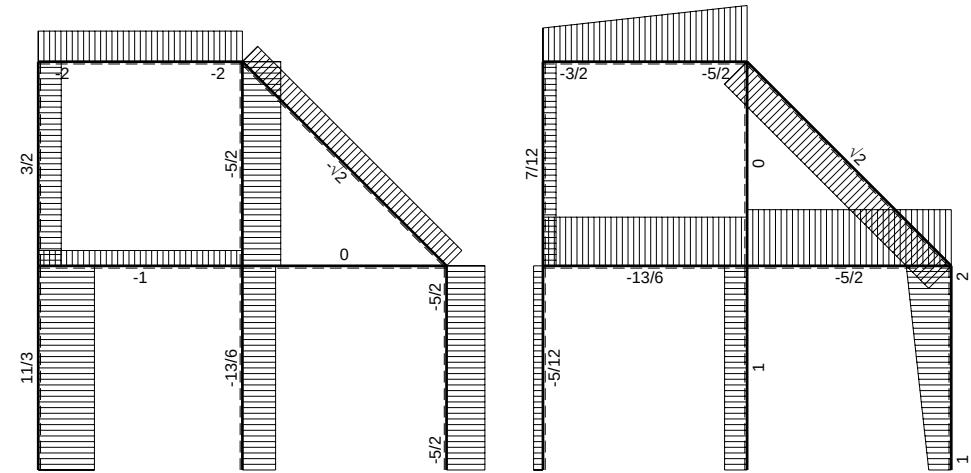
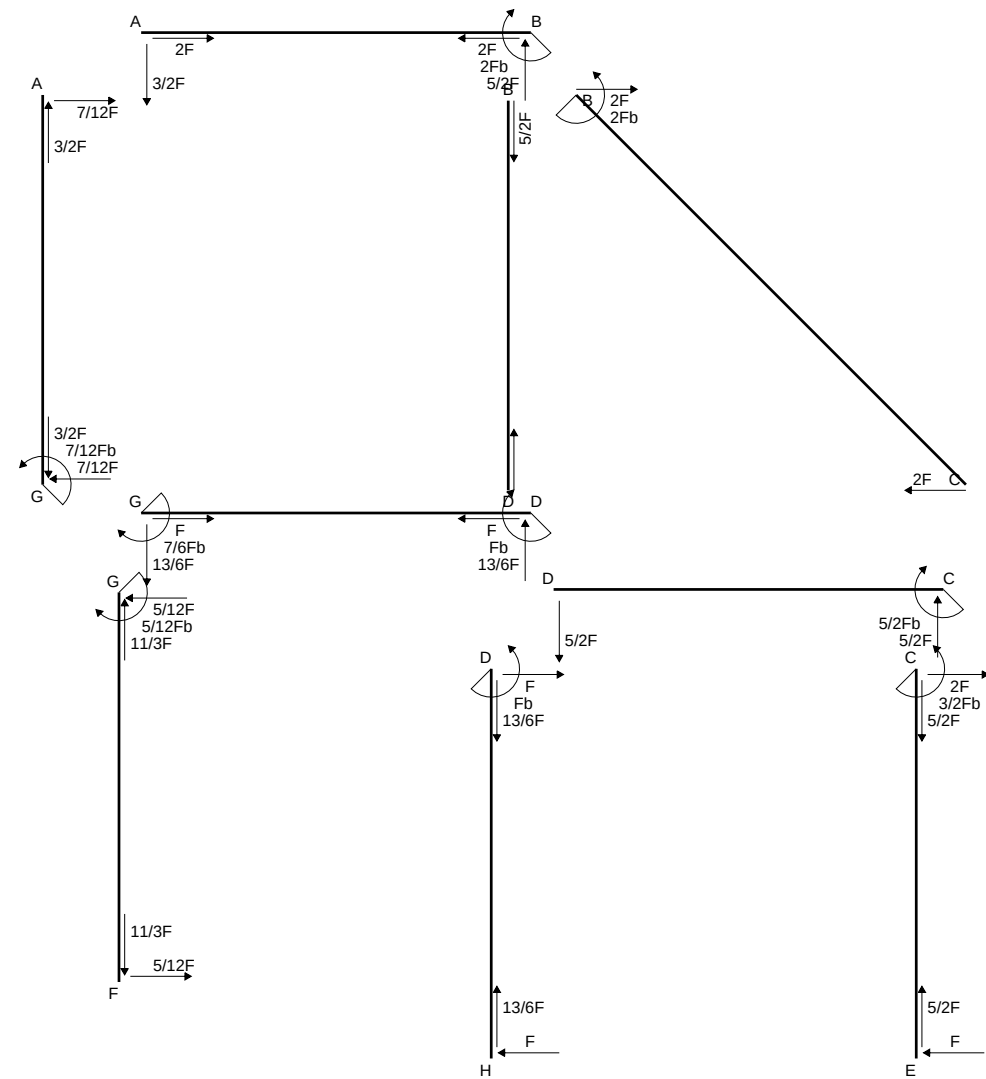
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

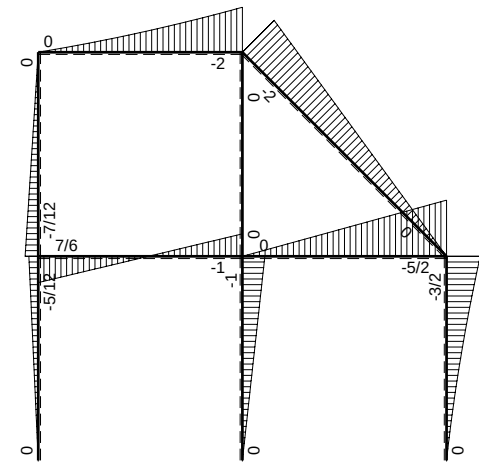


$$\begin{aligned} A &= 942. \text{ mm}^2 \\ J_u &= 316348. \text{ mm}^4 \\ J_v &= 86634. \text{ mm}^4 \\ y_g &= 34.65 \text{ mm} \\ T_y &= -2240. \text{ N} \\ M_x &= -2083200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.65 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.2 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -21.65 \text{ mm} \\ \sigma_c &= -Mv/J_u = -142.5 \text{ N/mm}^2 \\ \tau_c &= 7.459 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 143.1 \text{ N/mm}^2 \\ S &= 6321. \text{ mm}^3 \end{aligned}$$

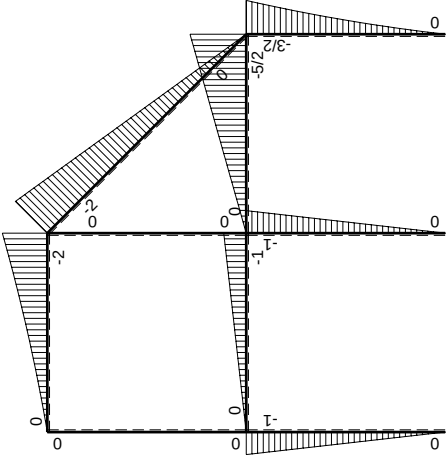
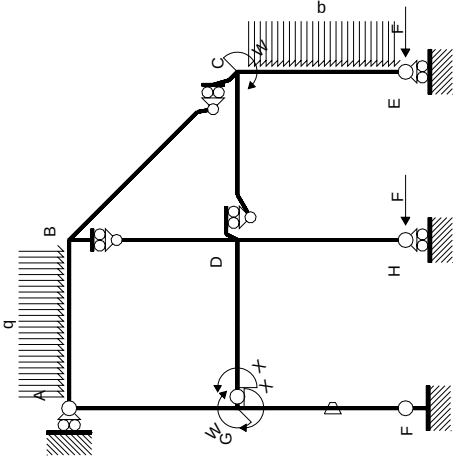


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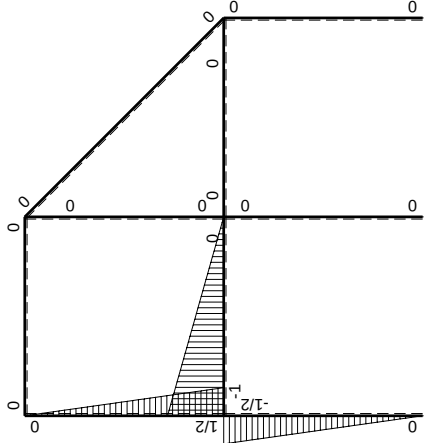


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$7/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

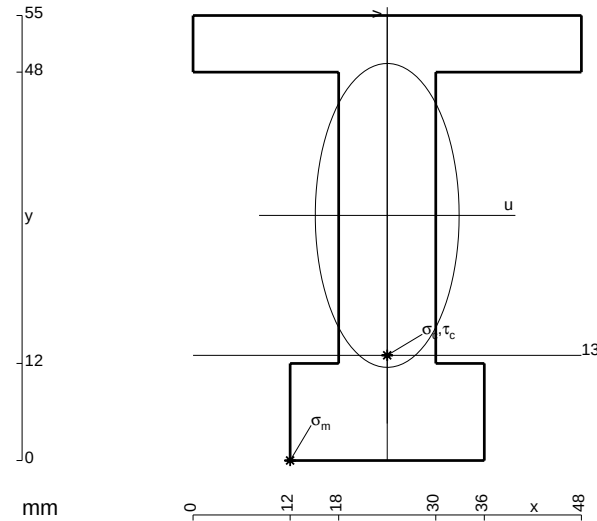
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

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

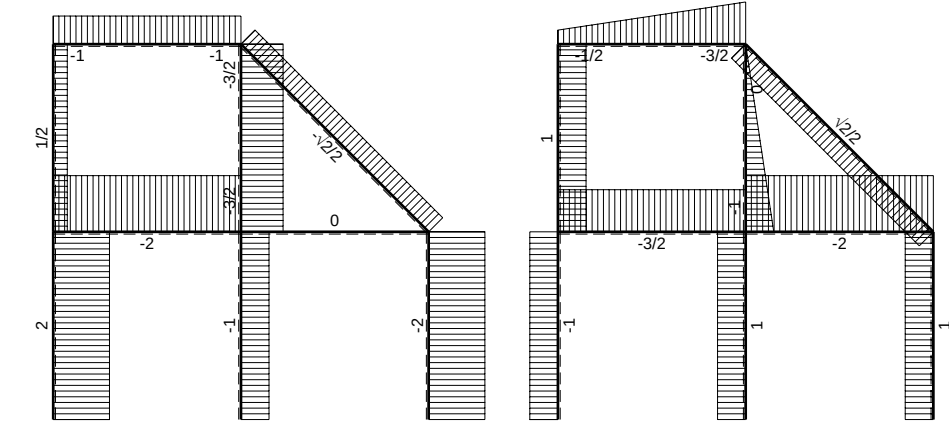
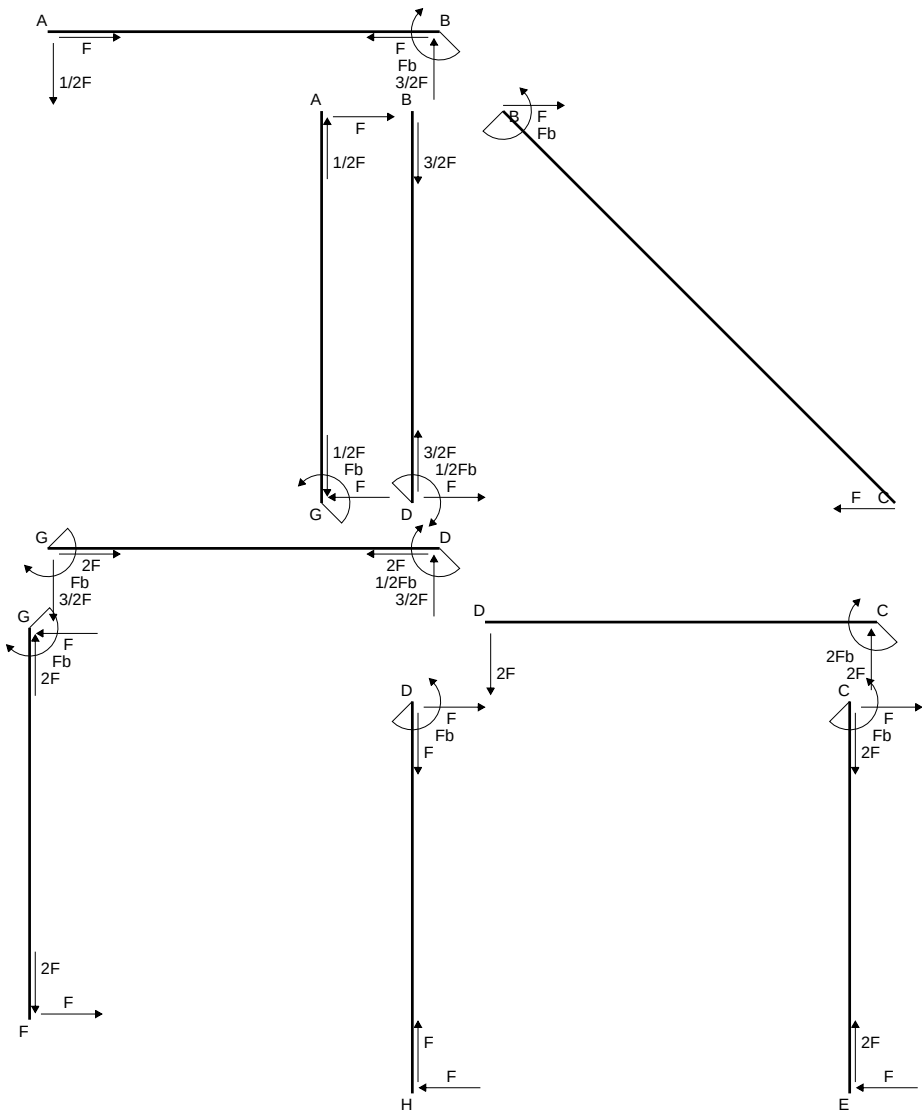
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

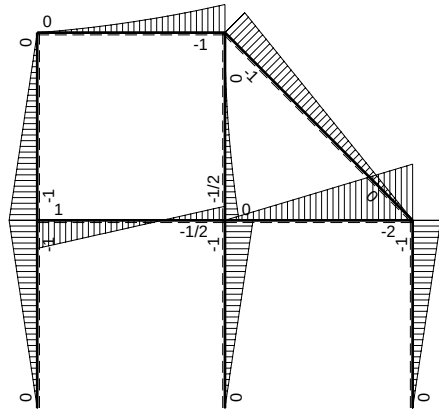


$$\begin{aligned} A &= 1056. \text{ mm}^2 \\ J_u &= 372596. \text{ mm}^4 \\ J_v &= 83520. \text{ mm}^4 \\ y_g &= 30.3 \text{ mm} \\ T_y &= -3000. \text{ N} \\ M_x &= -2940000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.3 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.3 \text{ mm} \\ \sigma_c &= -Mv/J_u = -136.5 \text{ N/mm}^2 \\ \tau_c &= 4.838 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 136.7 \text{ N/mm}^2 \\ S &= 7211. \text{ mm}^3 \end{aligned}$$



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↺ $\boxed{+}$ ↻ F_b

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

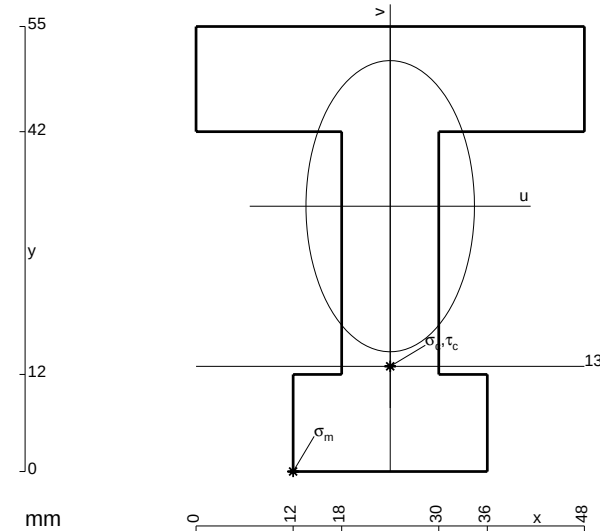
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

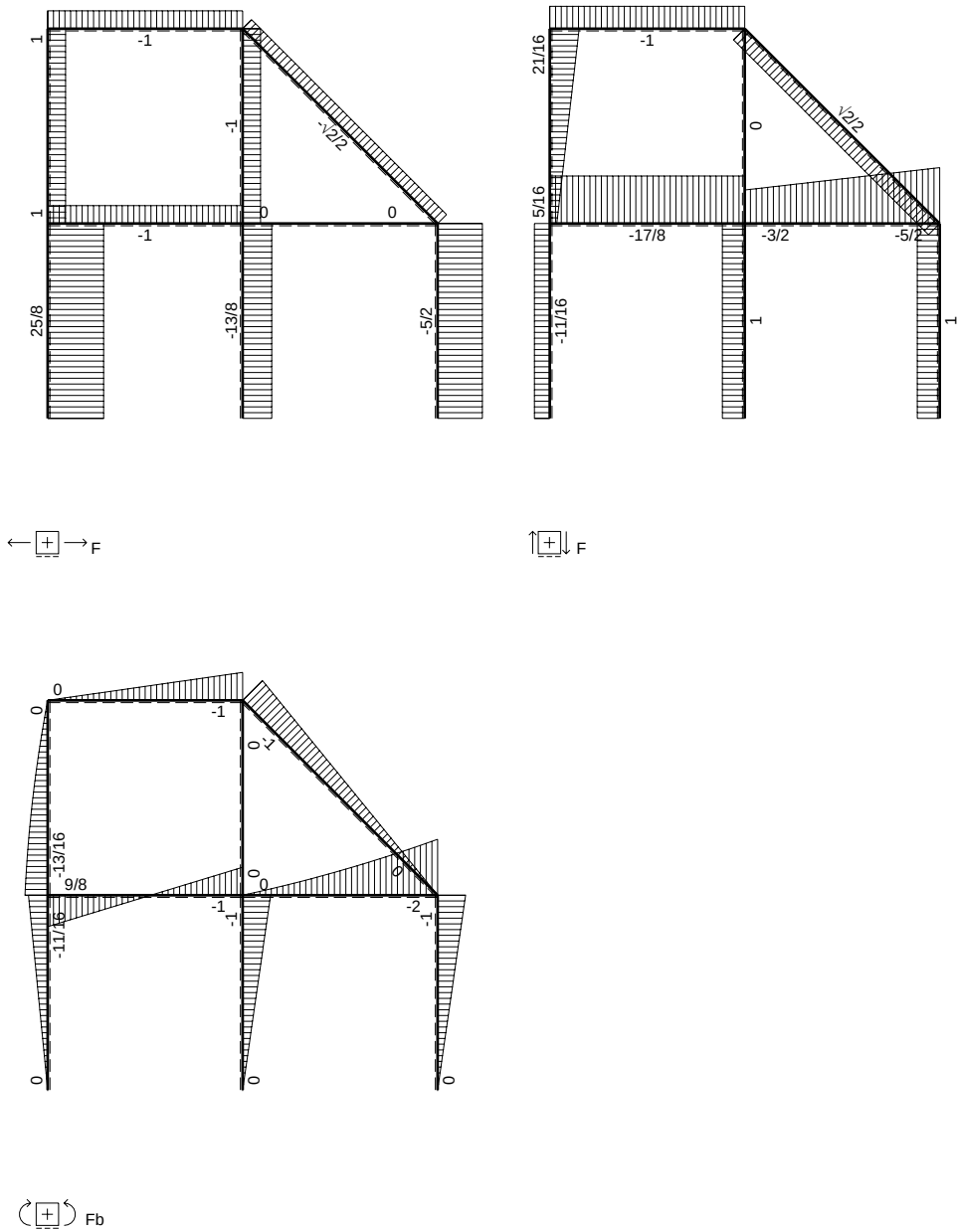
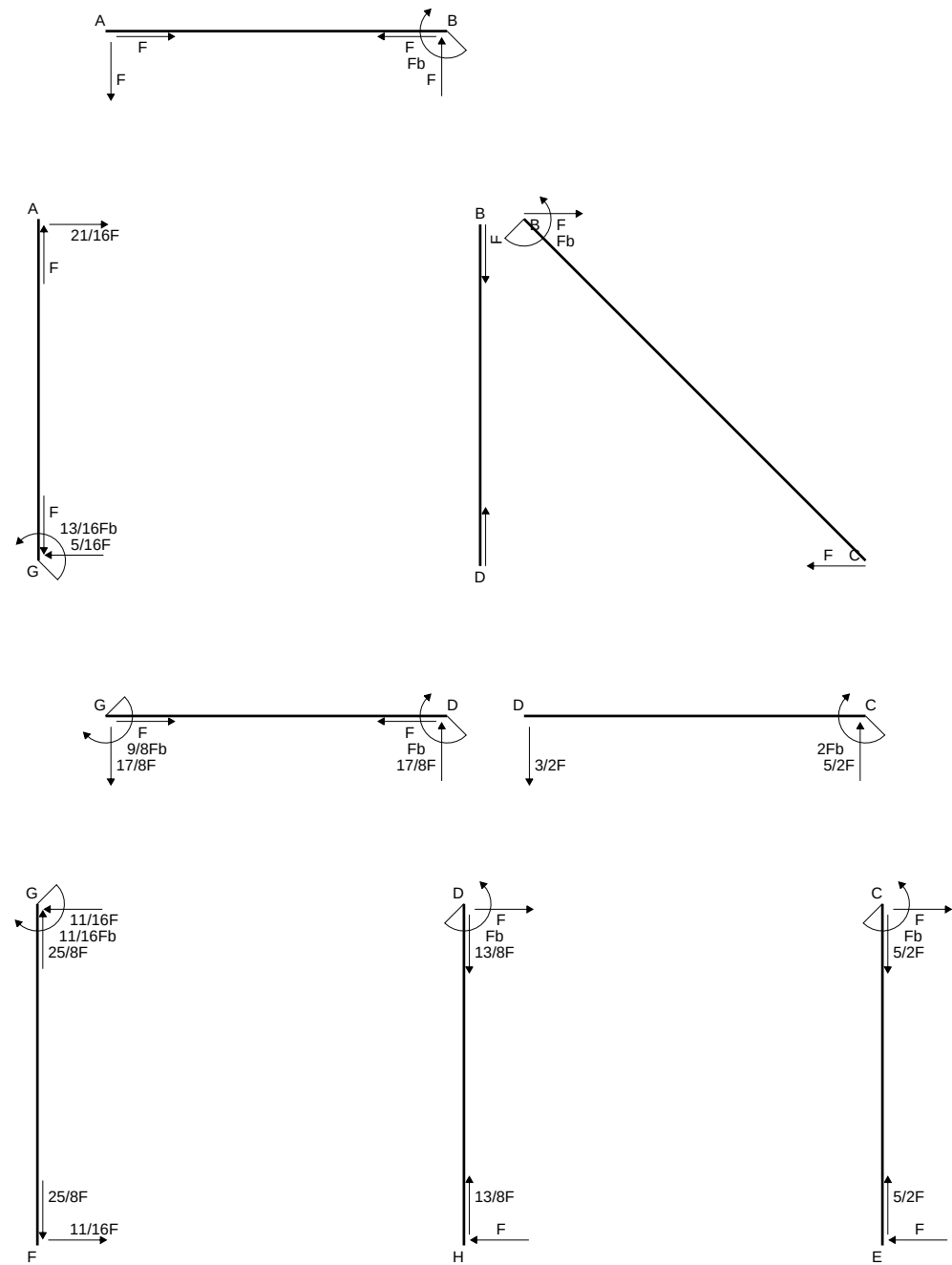
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

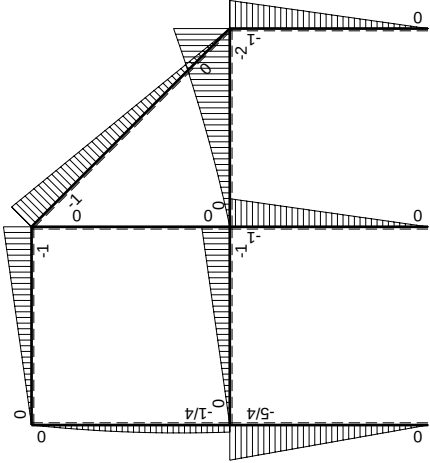
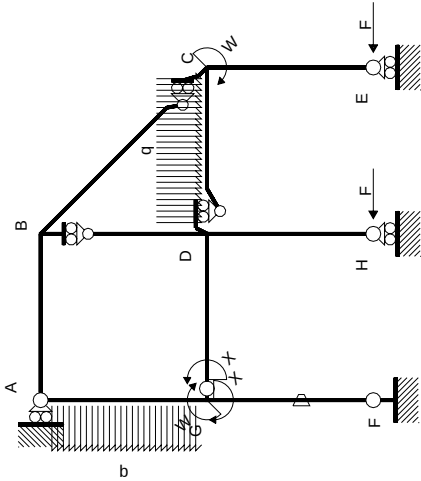
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



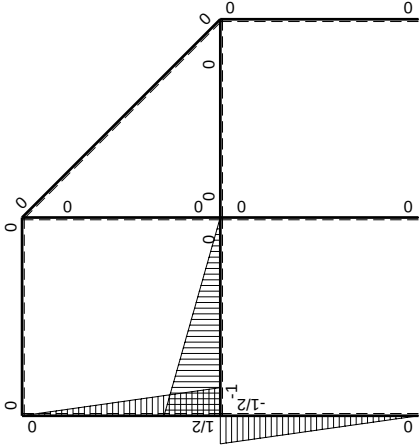
$$\begin{aligned} A &= 1272. \text{ mm}^2 \\ J_u &= 412017. \text{ mm}^4 \\ J_v &= 137952. \text{ mm}^4 \\ y_g &= 32.79 \text{ mm} \\ T_y &= -4820. \text{ N} \\ M_x &= -2506400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.79 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -19.79 \text{ mm} \\ \sigma_c &= -Mv/J_u = -120.4 \text{ N/mm}^2 \\ \tau_c &= 7.76 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 121.2 \text{ N/mm}^2 \\ S &= 7960. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-3/2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx ²	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(5/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

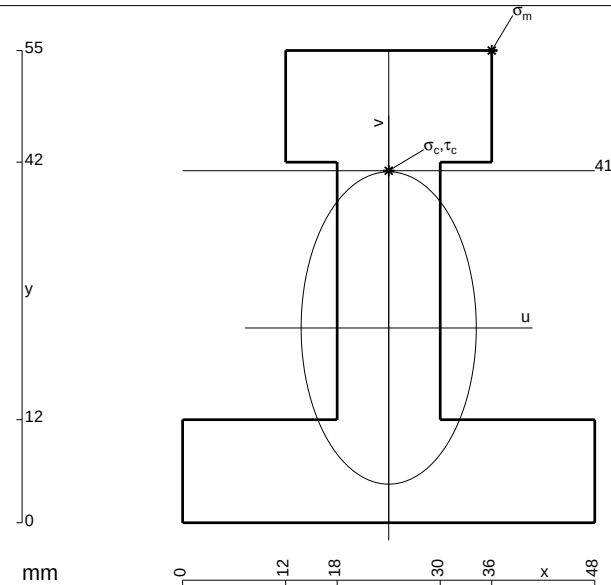
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

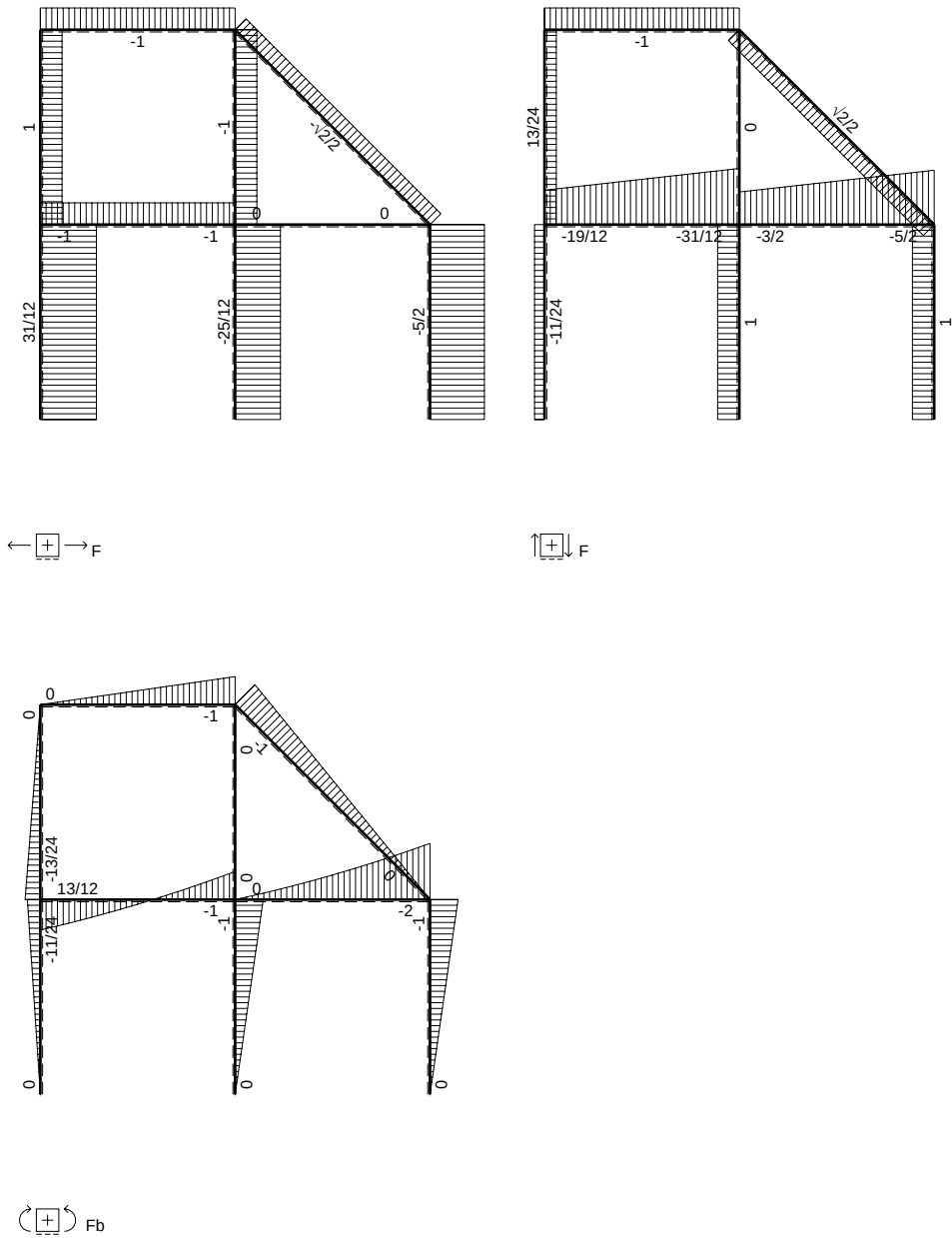
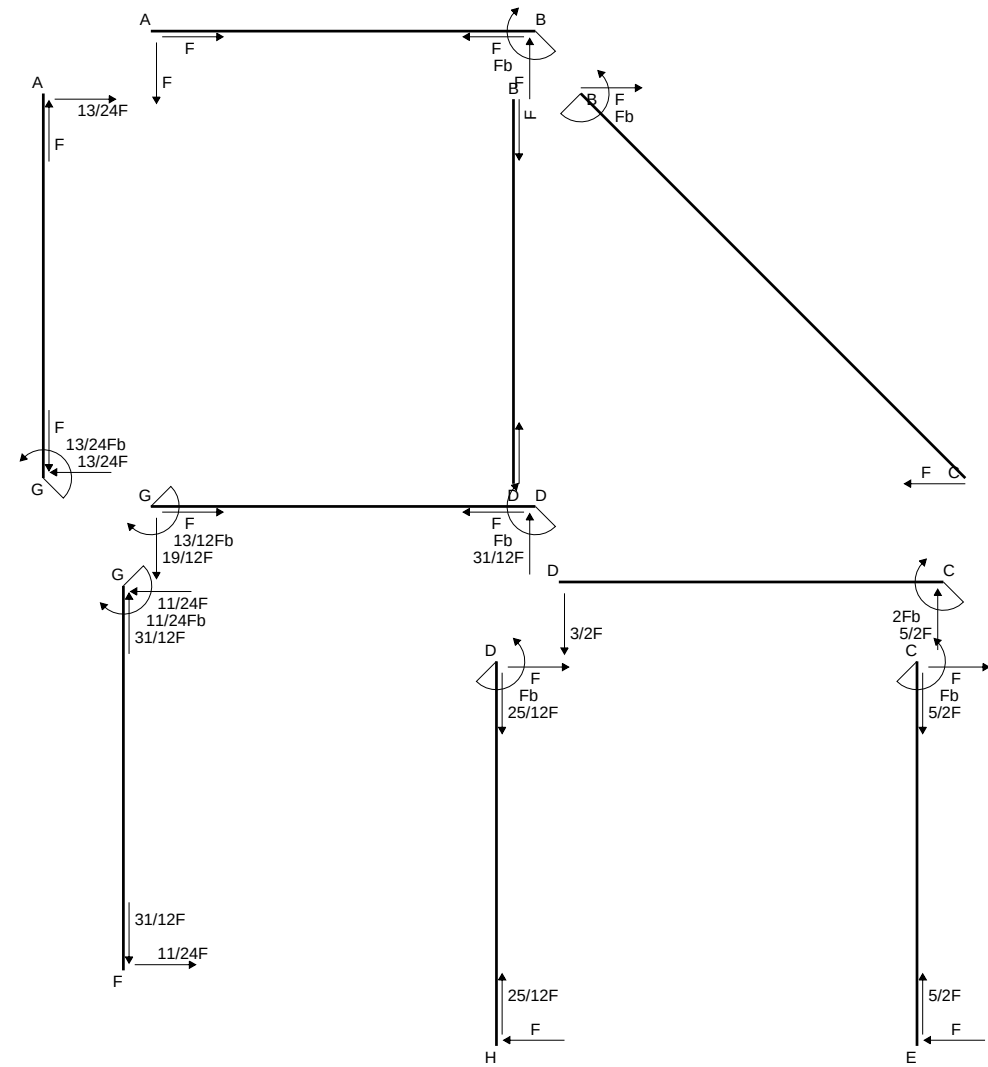
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$



$$\begin{aligned} A &= 1248. \text{ mm}^2 \\ J_u &= 413282. \text{ mm}^4 \\ J_v &= 129888. \text{ mm}^4 \\ y_g &= 22.68 \text{ mm} \\ T_y &= -5875. \text{ N} \\ M_x &= -2679000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 32.32 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 18.32 \text{ mm} \\ \sigma_c &= -Mv/J_u = 118.7 \text{ N/mm}^2 \\ \tau_c &= 9.81 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 119.9 \text{ N/mm}^2 \\ S &= 8281. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-3/2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx ²	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x ² /b ²	0+0	1/12Xb/EJ
AG b	-1/2x/b	0	0	0	0	1/4x ² /b ²		
	totali						13/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

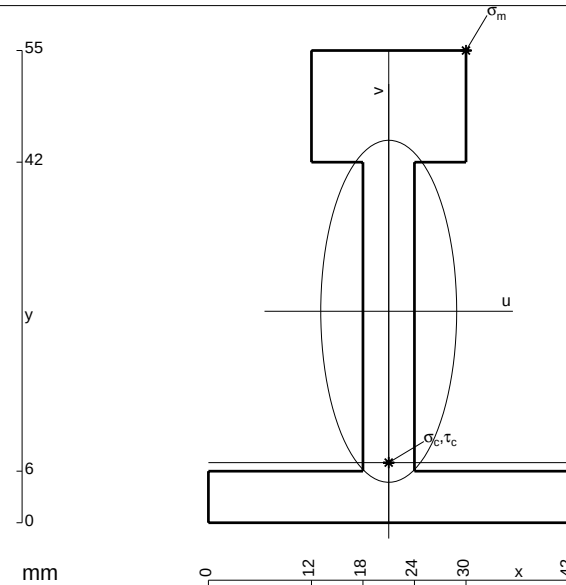
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

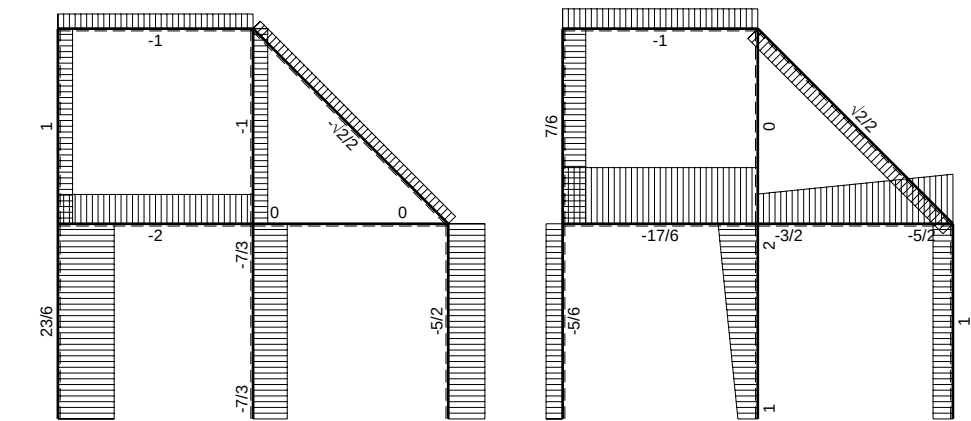
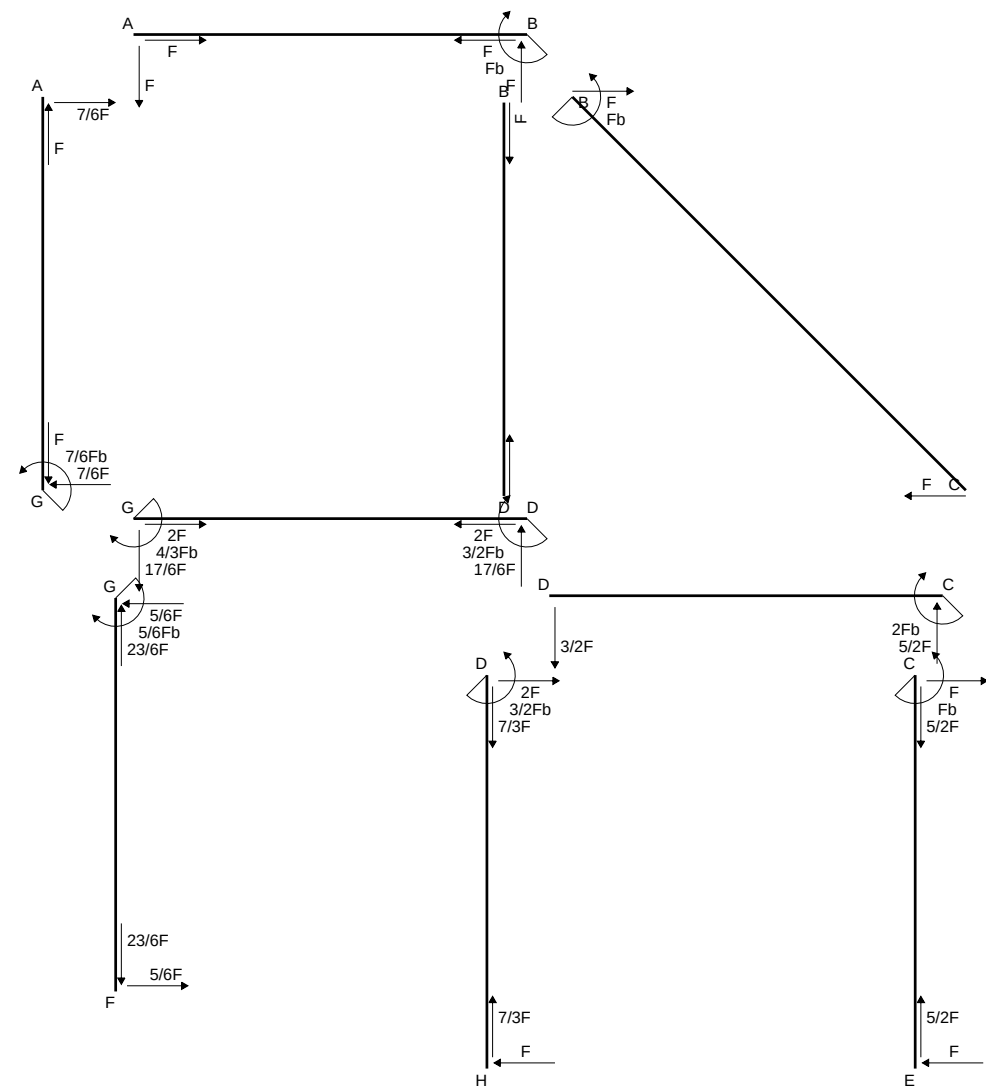
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

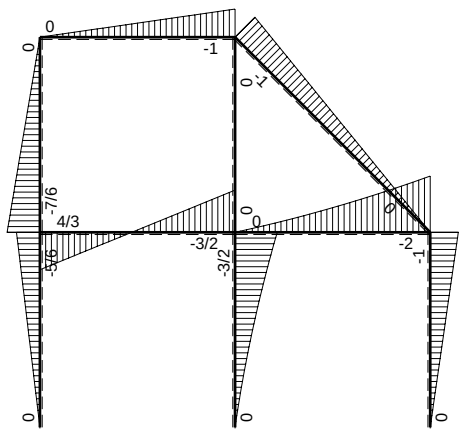


$$\begin{aligned} A &= 702. \text{ mm}^2 \\ J_u &= 278693. \text{ mm}^4 \\ J_v &= 44010. \text{ mm}^4 \\ y_g &= 24.63 \text{ mm} \\ T_y &= -4050. \text{ N} \\ M_x &= -2008800. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 30.37 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -17.63 \text{ mm} \\ \sigma_c &= -Mv/J_u = -127.1 \text{ N/mm}^2 \\ \tau_c &= 13.46 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 129.2 \text{ N/mm}^2 \\ S &= 5559. \text{ mm}^3 \end{aligned}$$



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↑ ⊕ ↓ F



⊕ ⊖ Fb

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$2/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-4/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

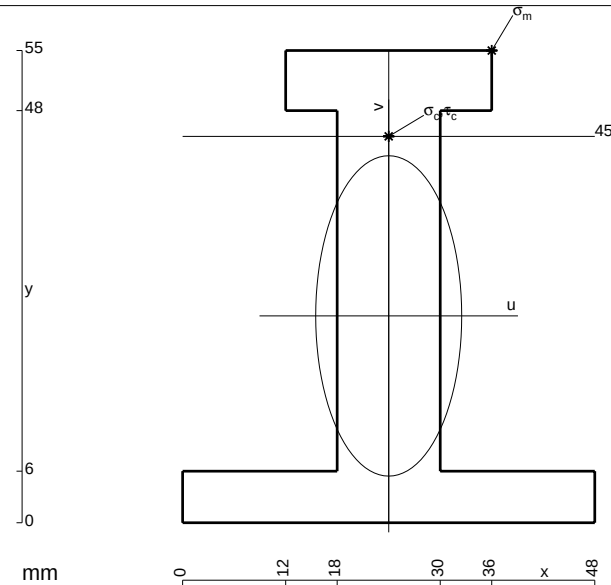
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

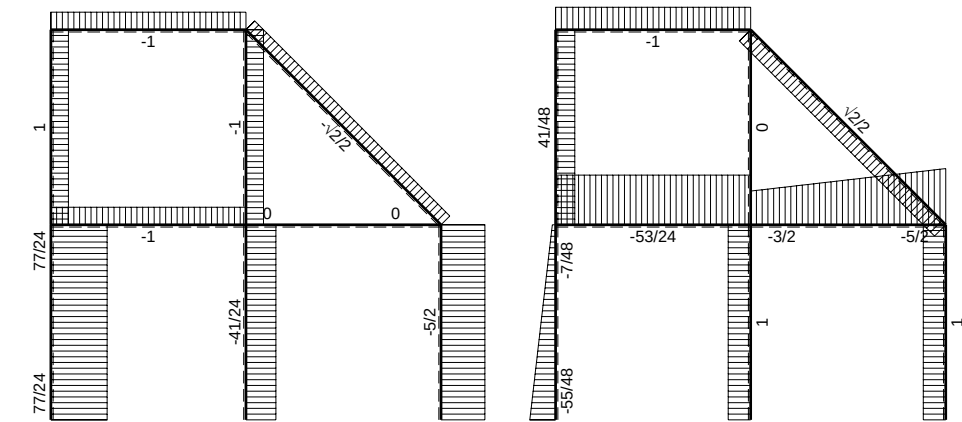
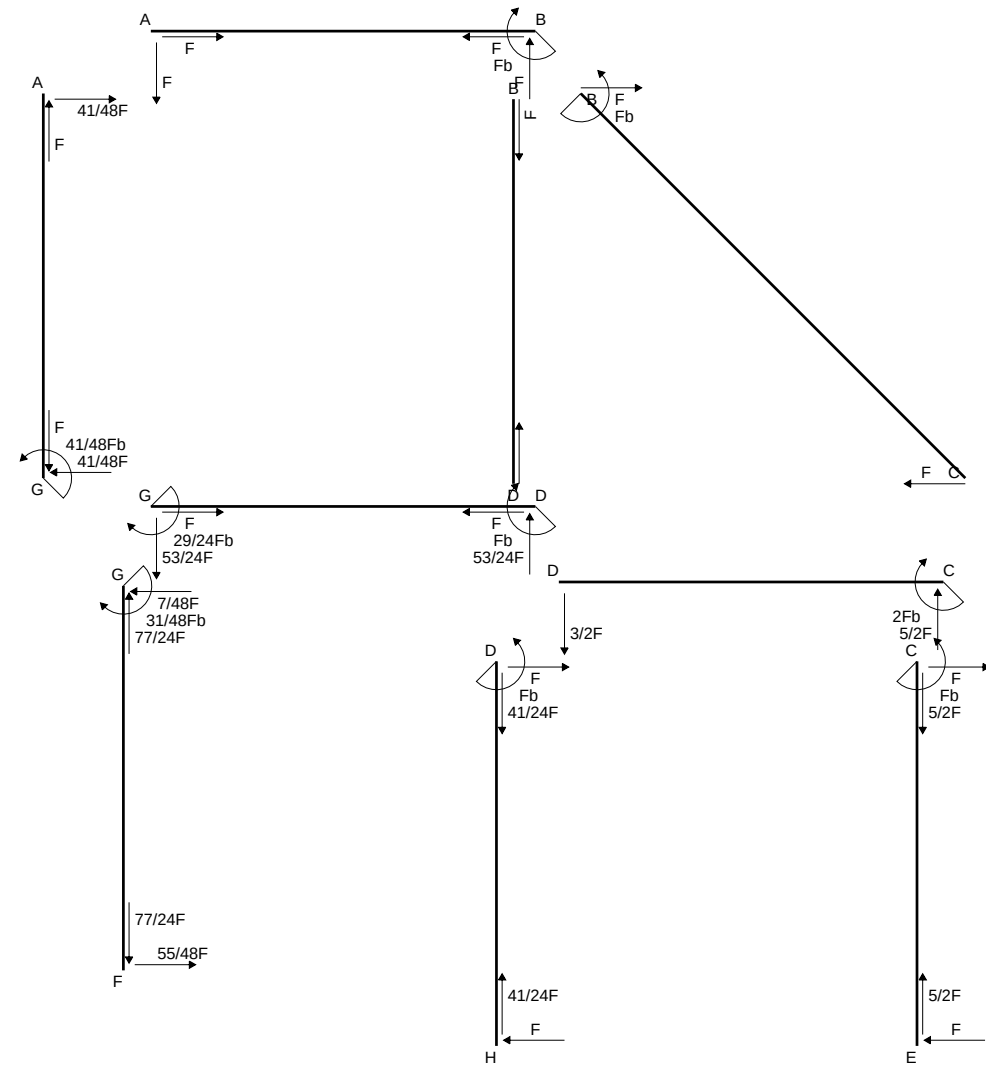
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

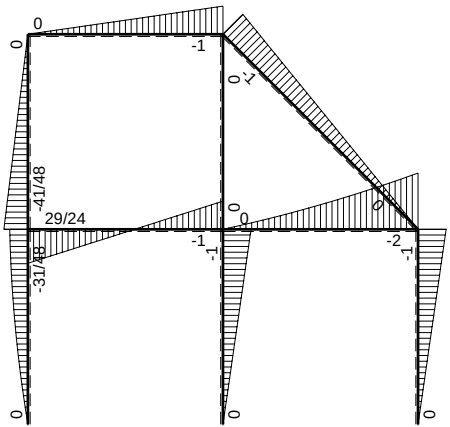


$$\begin{aligned} A &= 960. \text{ mm}^2 \\ J_u &= 334225. \text{ mm}^4 \\ J_v &= 69408. \text{ mm}^4 \\ y_g &= 24.09 \text{ mm} \\ T_y &= -4625. \text{ N} \\ M_x &= -2479000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.91 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 20.91 \text{ mm} \\ \sigma_c &= -Mv/J_u = 155.1 \text{ N/mm}^2 \\ \tau_c &= 6.241 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 155.5 \text{ N/mm}^2 \\ S &= 5412. \text{ mm}^3 \end{aligned}$$

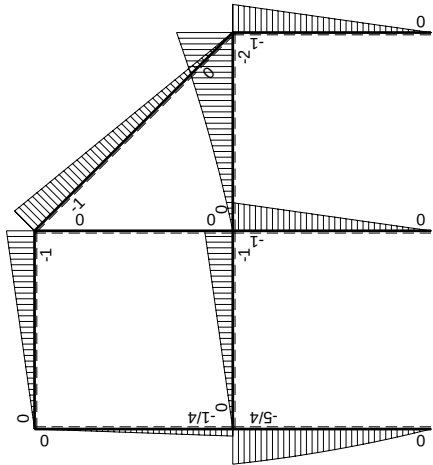
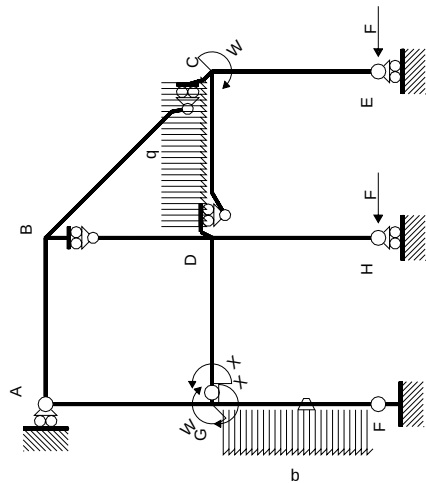


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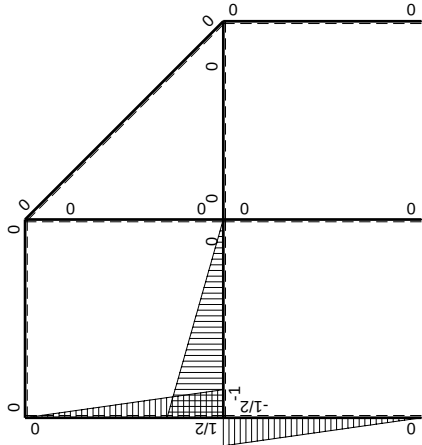


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-7/4Fx+1/2qx^2$	$-Fb/EJ$	$7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(11/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$5/8Fb-Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	-Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	Fb-Fx	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb+1/4Fx$	0	$-1/8Fb+1/4Fx-1/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/4Fx$	0	$-1/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$29/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-29/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

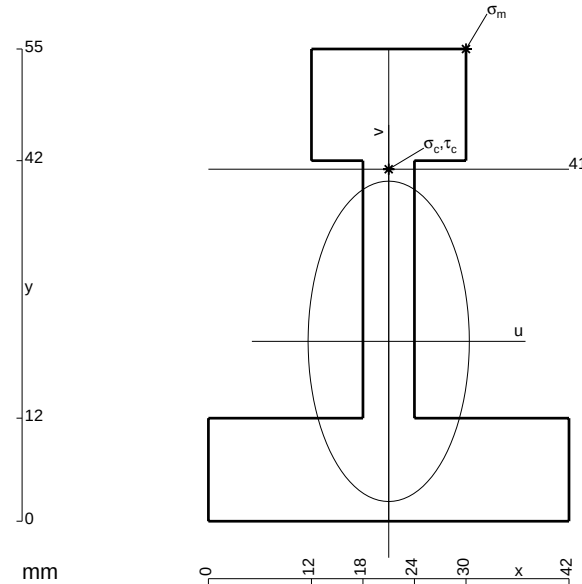
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

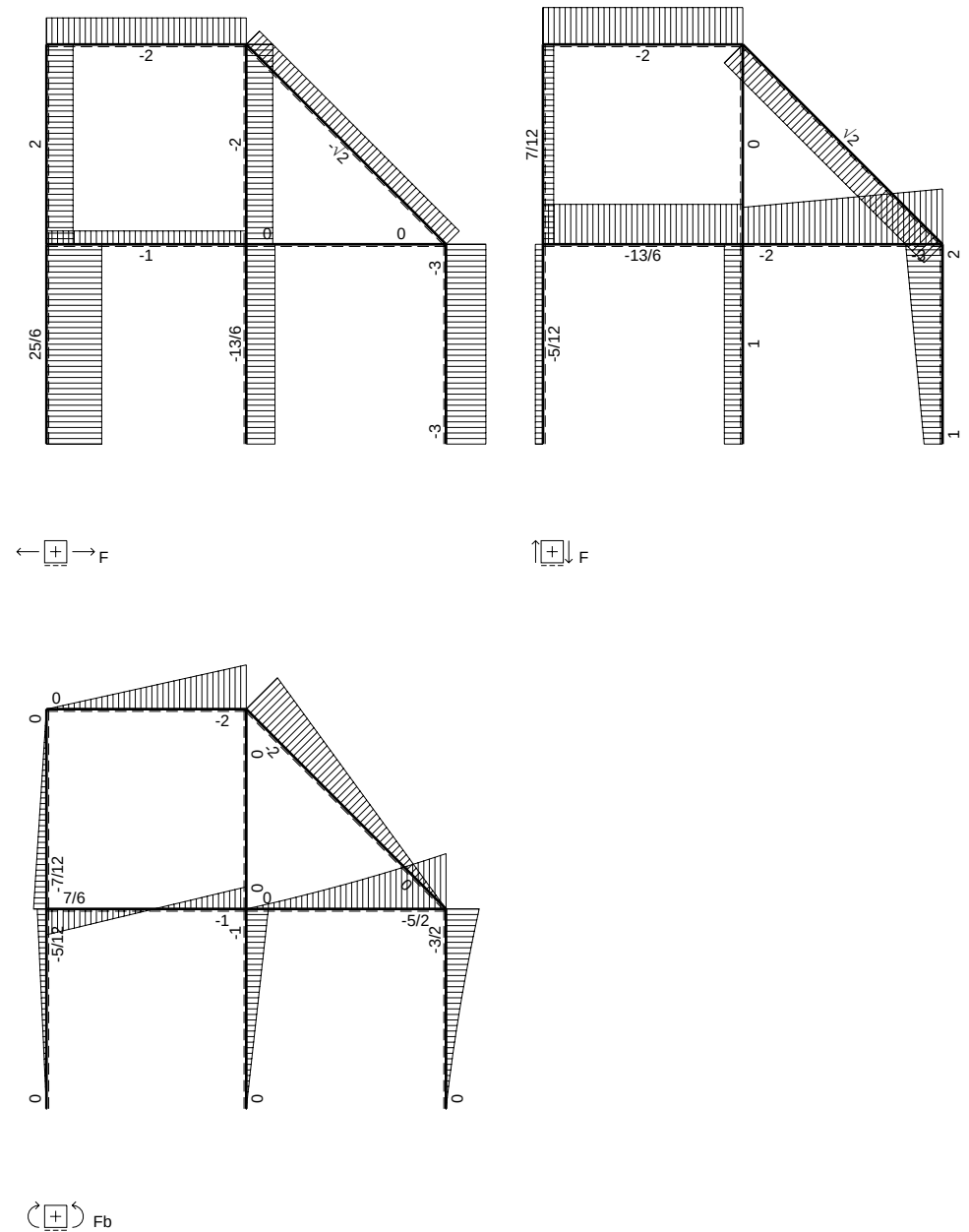
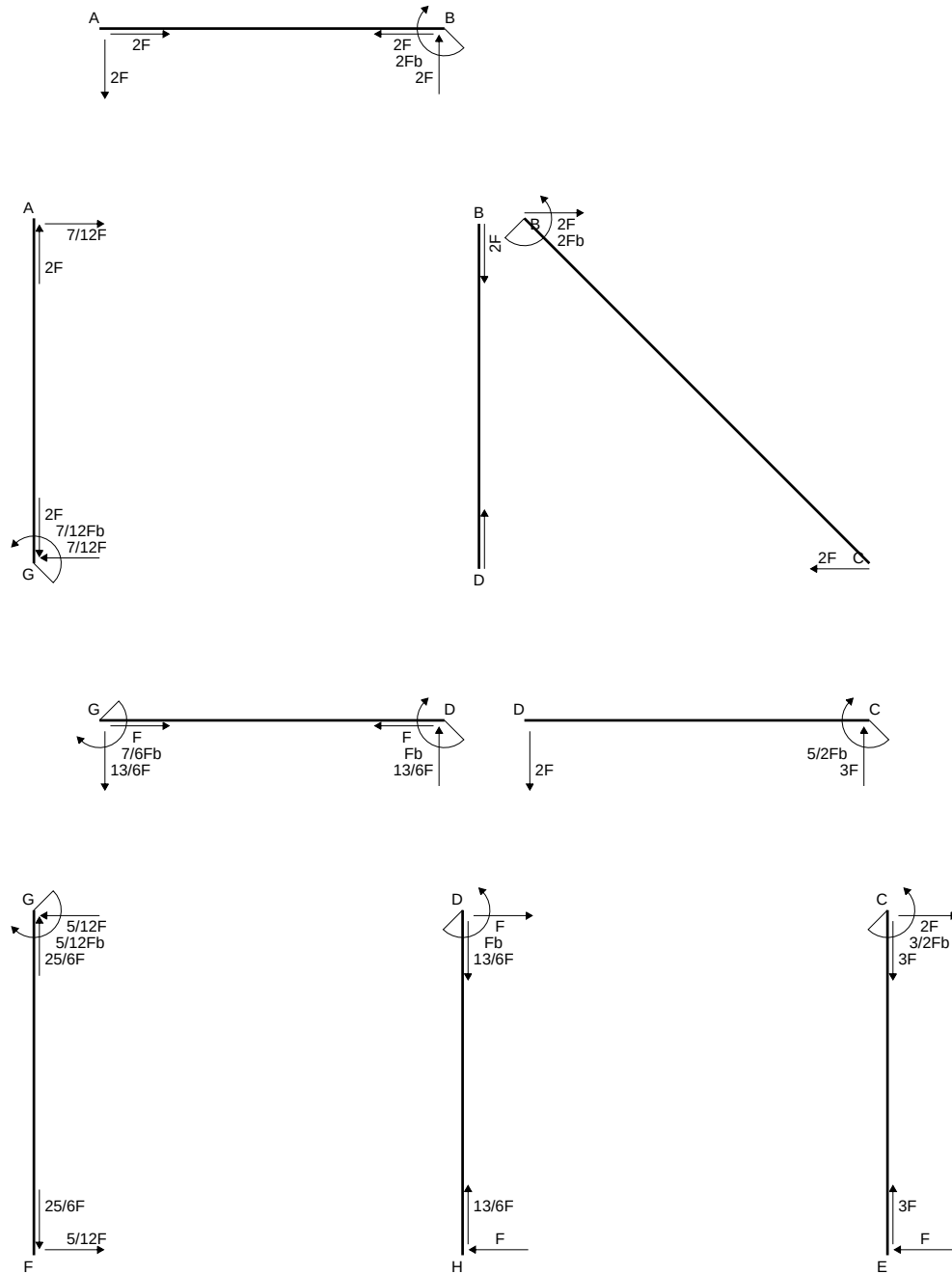
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

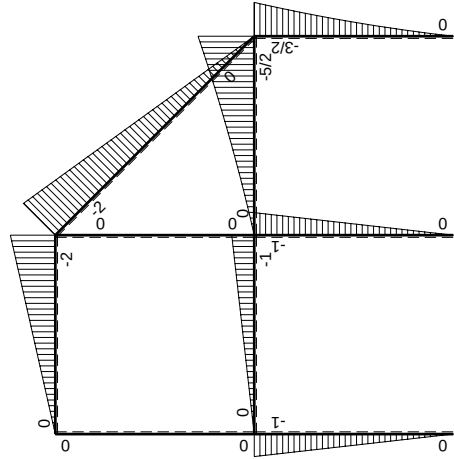
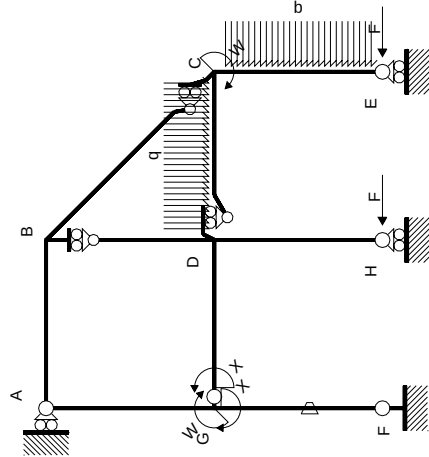
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



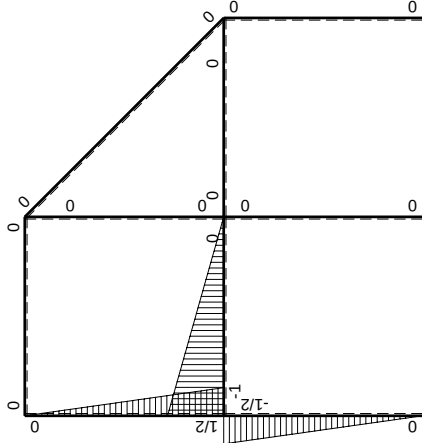
$$\begin{aligned} A &= 918. \text{ mm}^2 \\ J_u &= 319684. \text{ mm}^4 \\ J_v &= 80946. \text{ mm}^4 \\ y_g &= 20.95 \text{ mm} \\ T_y &= -3900. \text{ N} \\ M_x &= -2246400. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 34.05 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 20.05 \text{ mm} \\ \sigma_c &= -Mv/J_u = 140.9 \text{ N/mm}^2 \\ \tau_c &= 13.36 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 142.8 \text{ N/mm}^2 \\ S &= 6570. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati

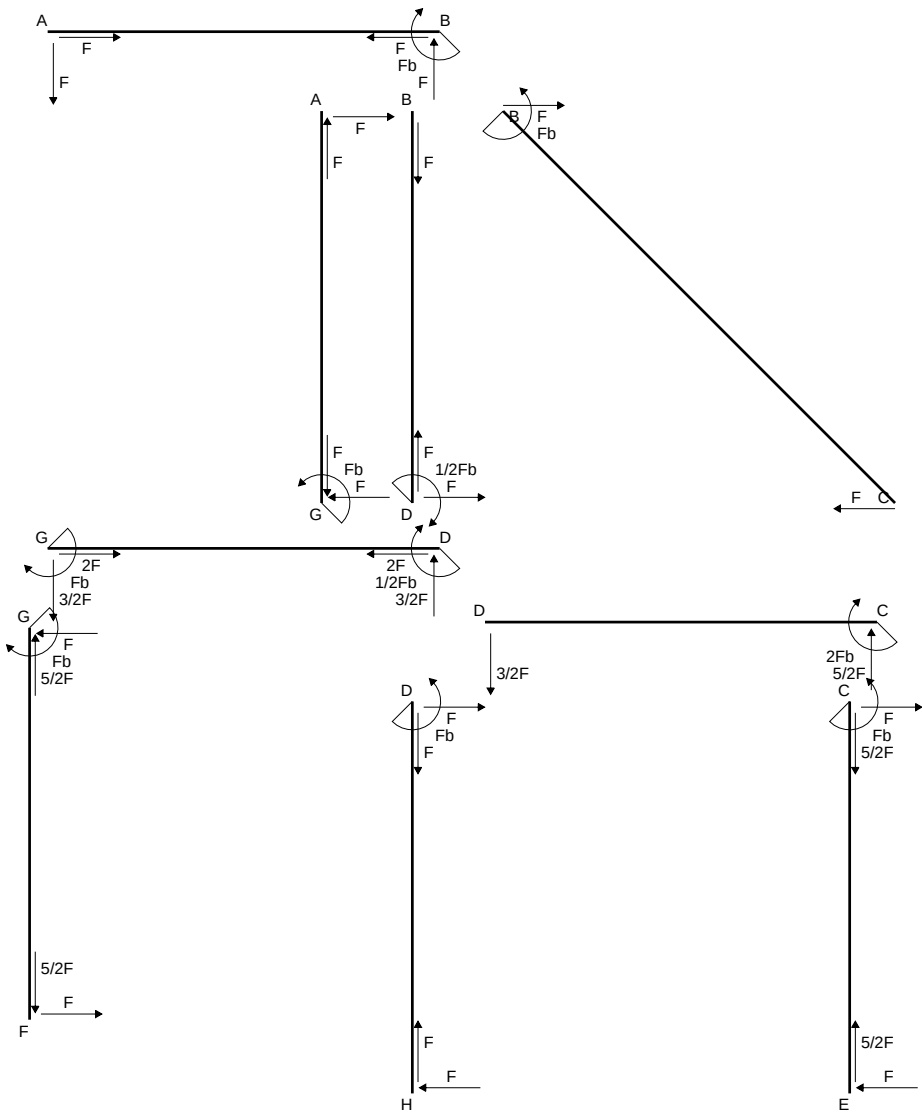


M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx- $1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-3Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	-Fx	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	Fb-Fx	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	-Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	Fb-Fx	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$7/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/6Fb$	

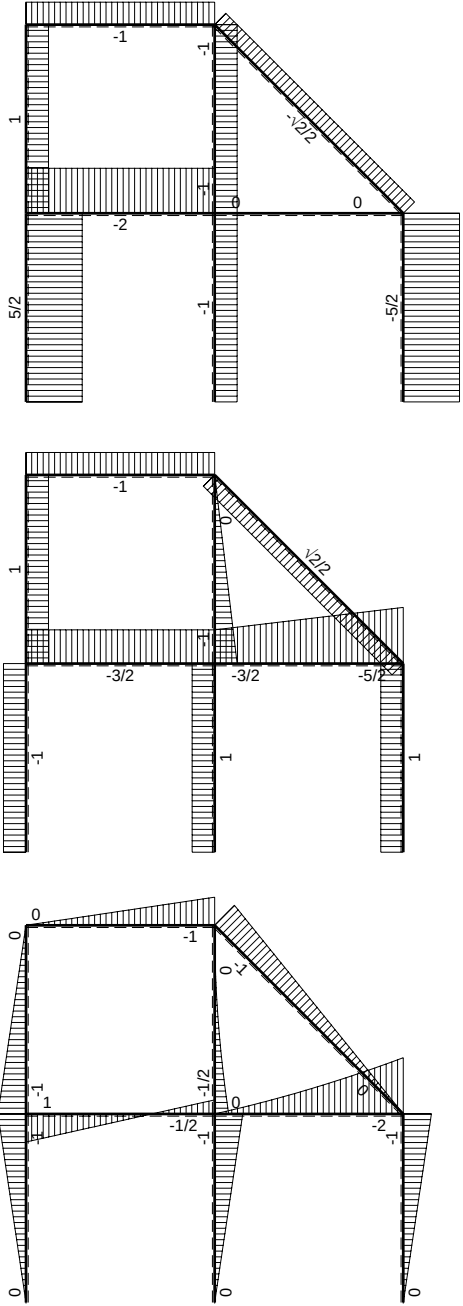
Sviluppi di calcolo iperstatica

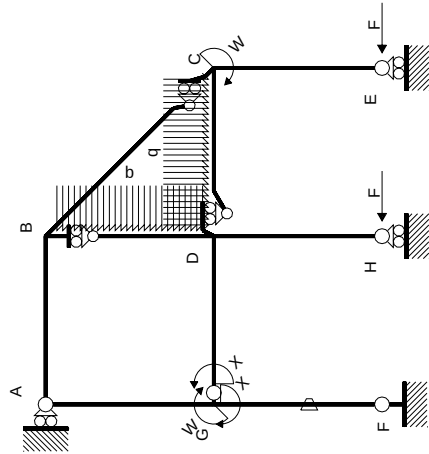


← ⊕ → F

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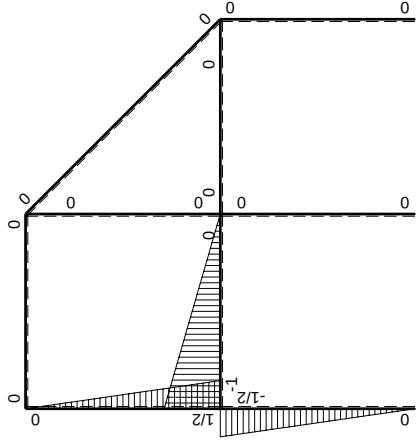
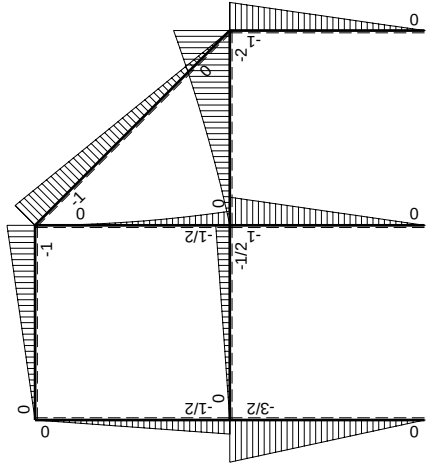
⊕ Fb





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-3/2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx ²	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						1/2Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

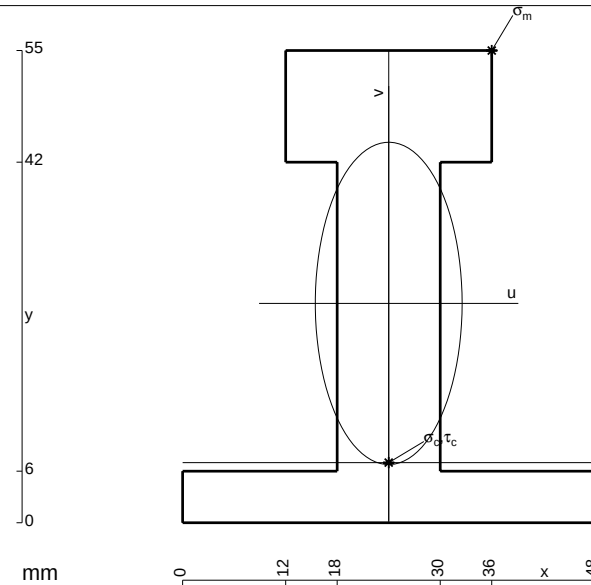
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

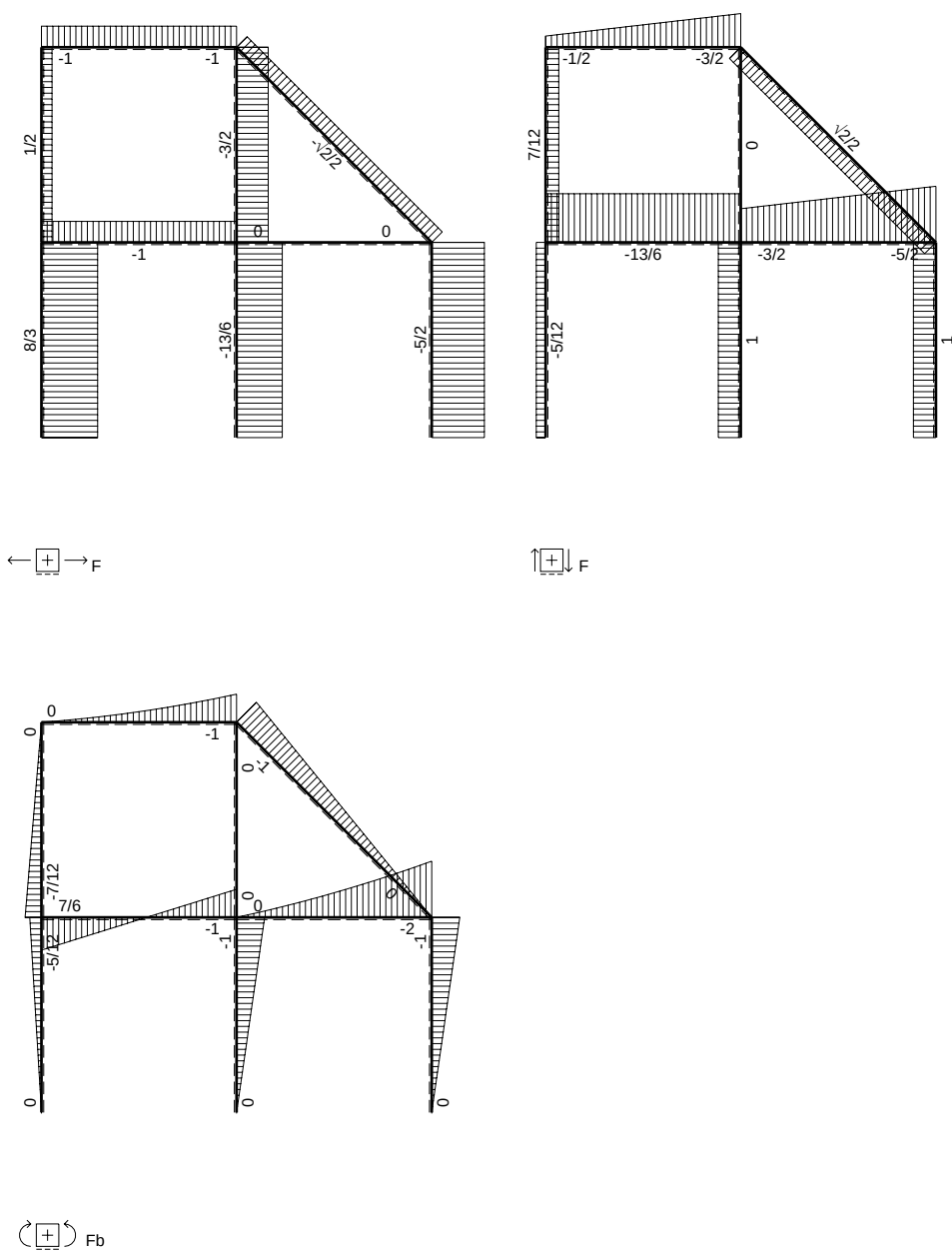
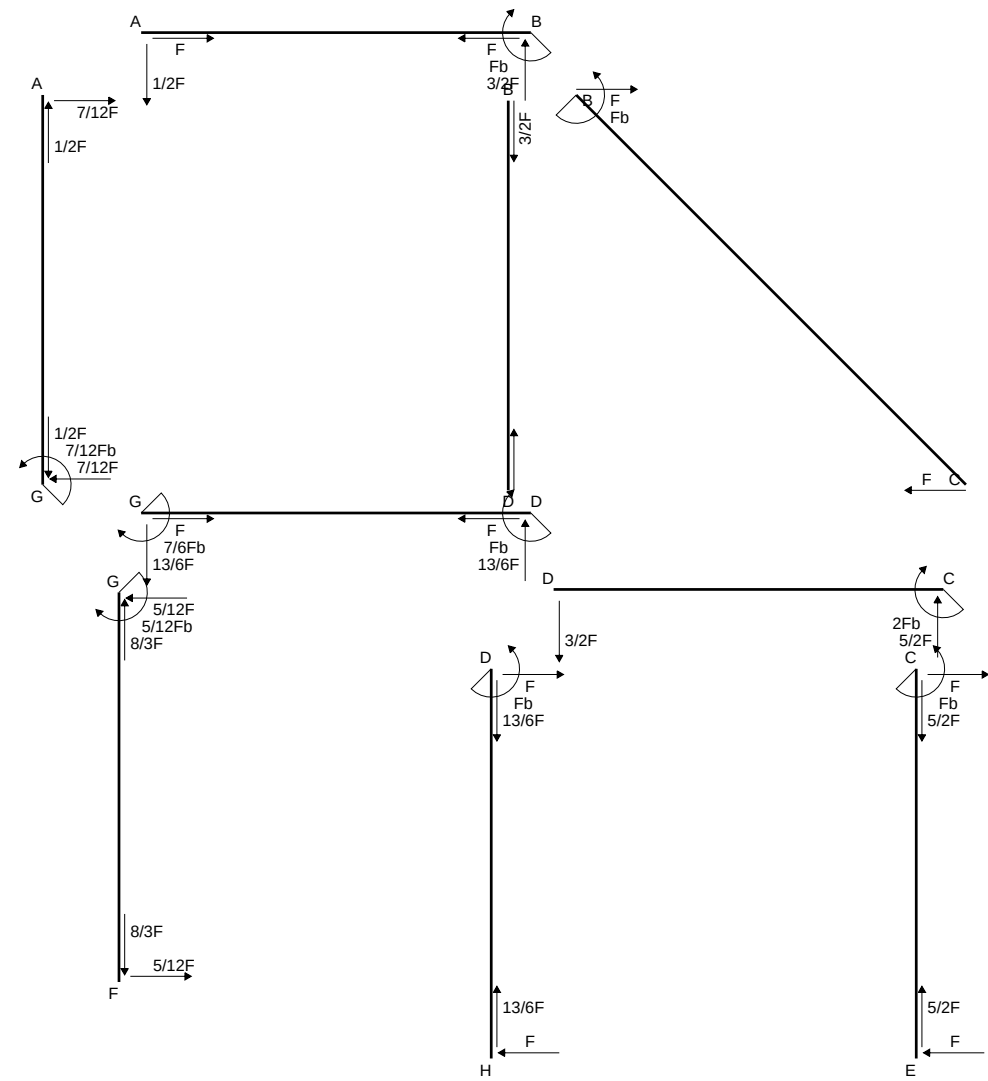
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

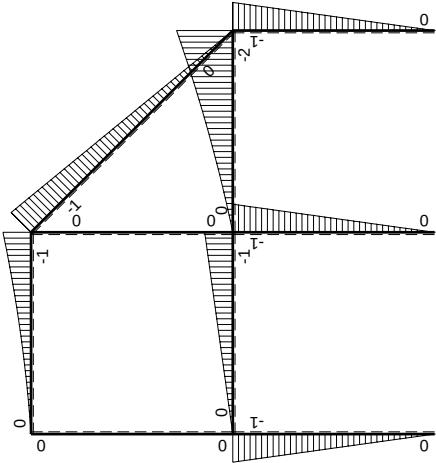
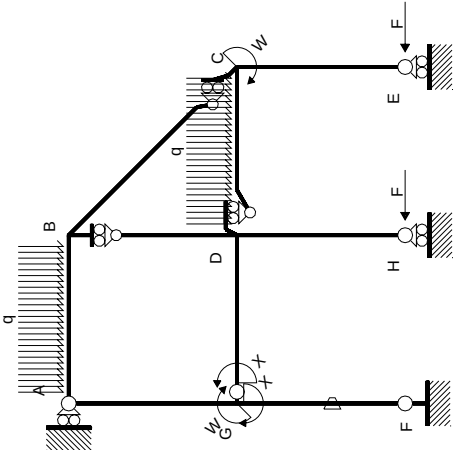
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



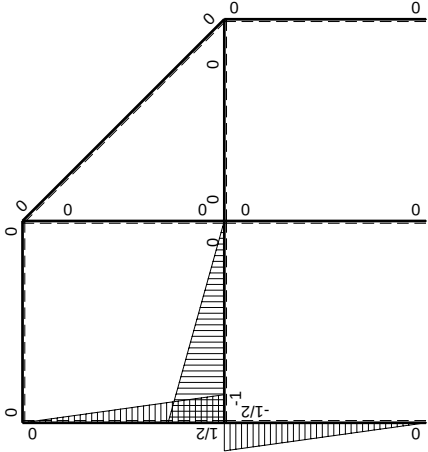
$$\begin{aligned} A &= 1032. \text{ mm}^2 \\ J_u &= 363732. \text{ mm}^4 \\ J_v &= 75456. \text{ mm}^4 \\ y_g &= 25.55 \text{ mm} \\ T_y &= -3900. \text{ N} \\ M_x &= -2589600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.45 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -18.55 \text{ mm} \\ \sigma_c &= -Mv/J_u = -132. \text{ N/mm}^2 \\ \tau_c &= 6.006 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 132.5 \text{ N/mm}^2 \\ S &= 6722. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$7/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

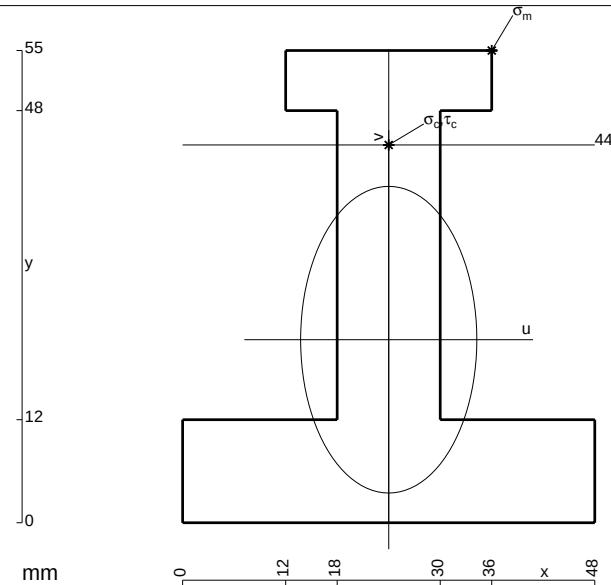
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

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

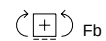
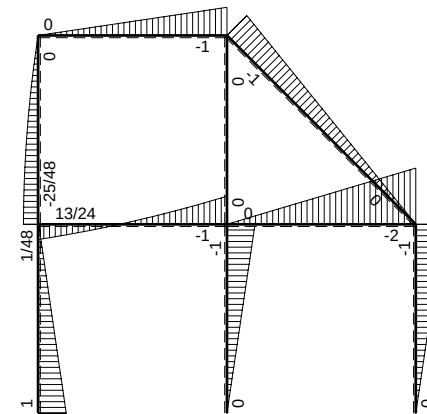
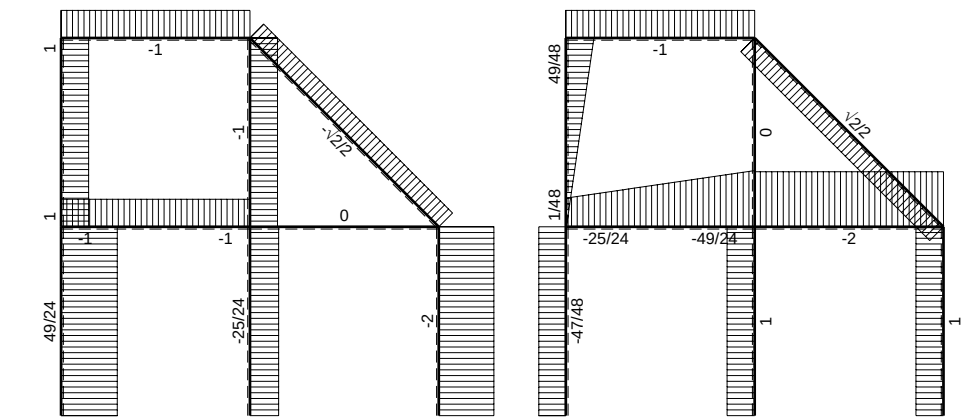
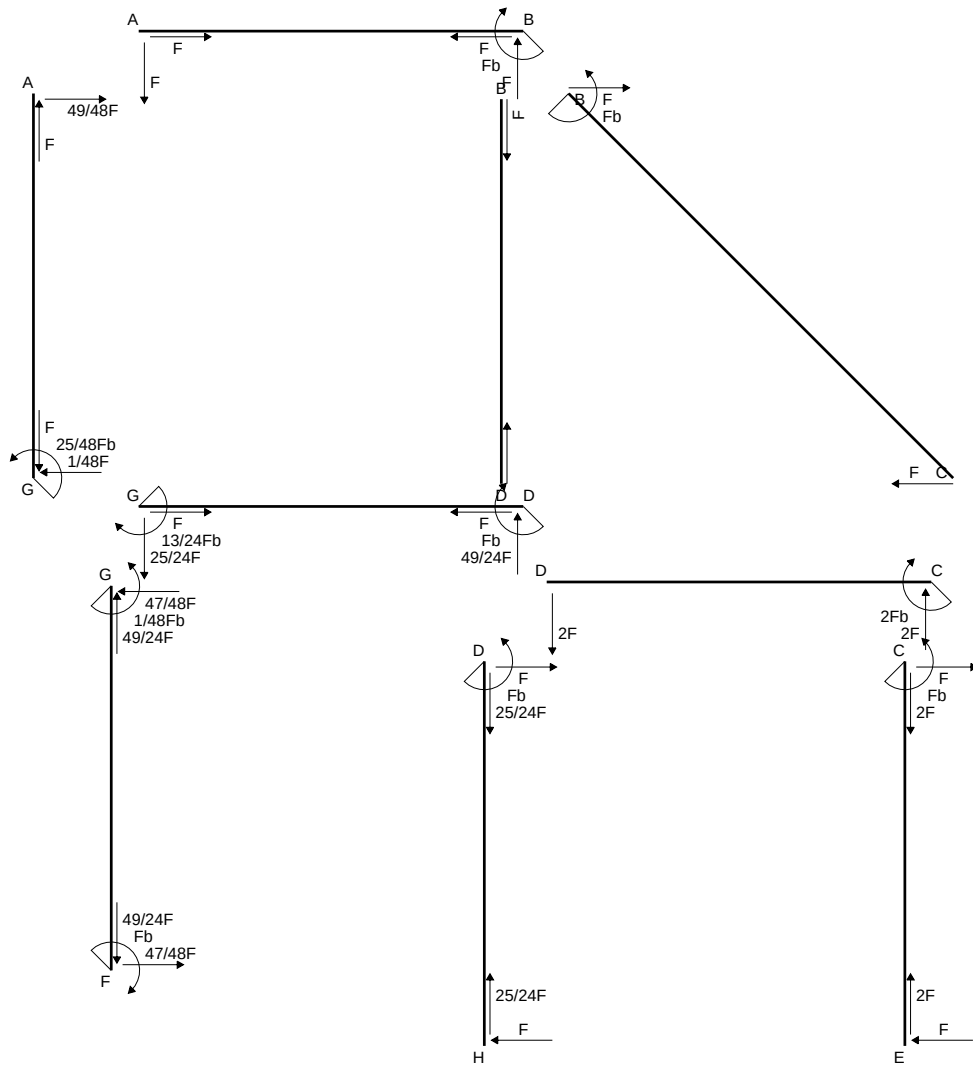
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

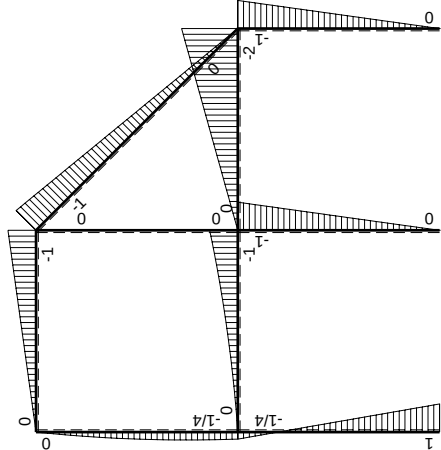
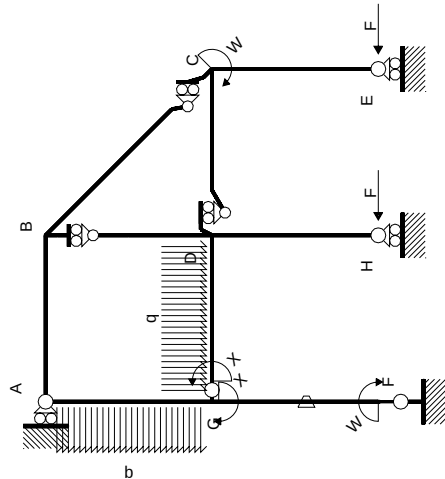
$$L_{DG}^{x\theta} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$



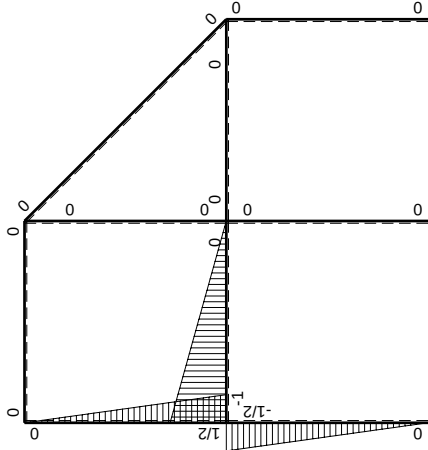
$$\begin{aligned} A &= 1176. \text{ mm}^2 \\ J_u &= 375010. \text{ mm}^4 \\ J_v &= 123840. \text{ mm}^4 \\ y_g &= 21.32 \text{ mm} \\ T_y &= -3475. \text{ N} \\ M_x &= -2446400. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 33.68 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 22.68 \text{ mm} \\ \sigma_c &= -Mv/J_u = 148. \text{ N/mm}^2 \\ \tau_c &= 4.831 \text{ N/mm}^2 \\ \sigma_o^* &= \sqrt{\sigma^2 + 3\tau^2} = 148.2 \text{ N/mm}^2 \\ S &= 6256. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						13/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + 5/8 x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + 5/24 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + 5/24 b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{8} - 3/4 x/b + 5/8 x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - 3/8 x^2/b + 5/24 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - 3/8 b + 5/24 b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = 5/24 Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - 3/2 x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

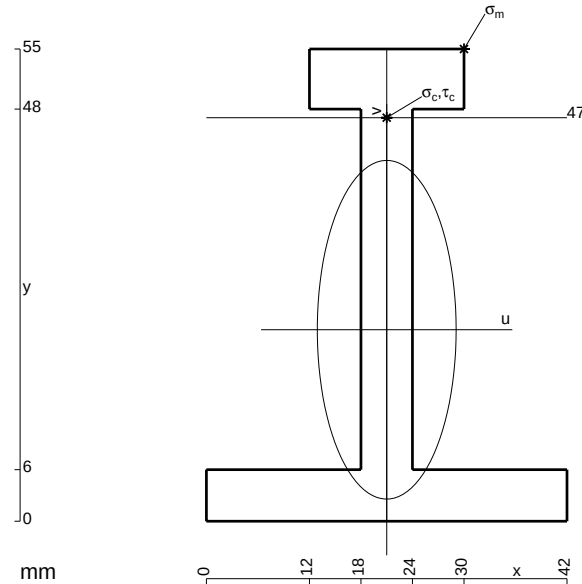
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{8} + 3/8 x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

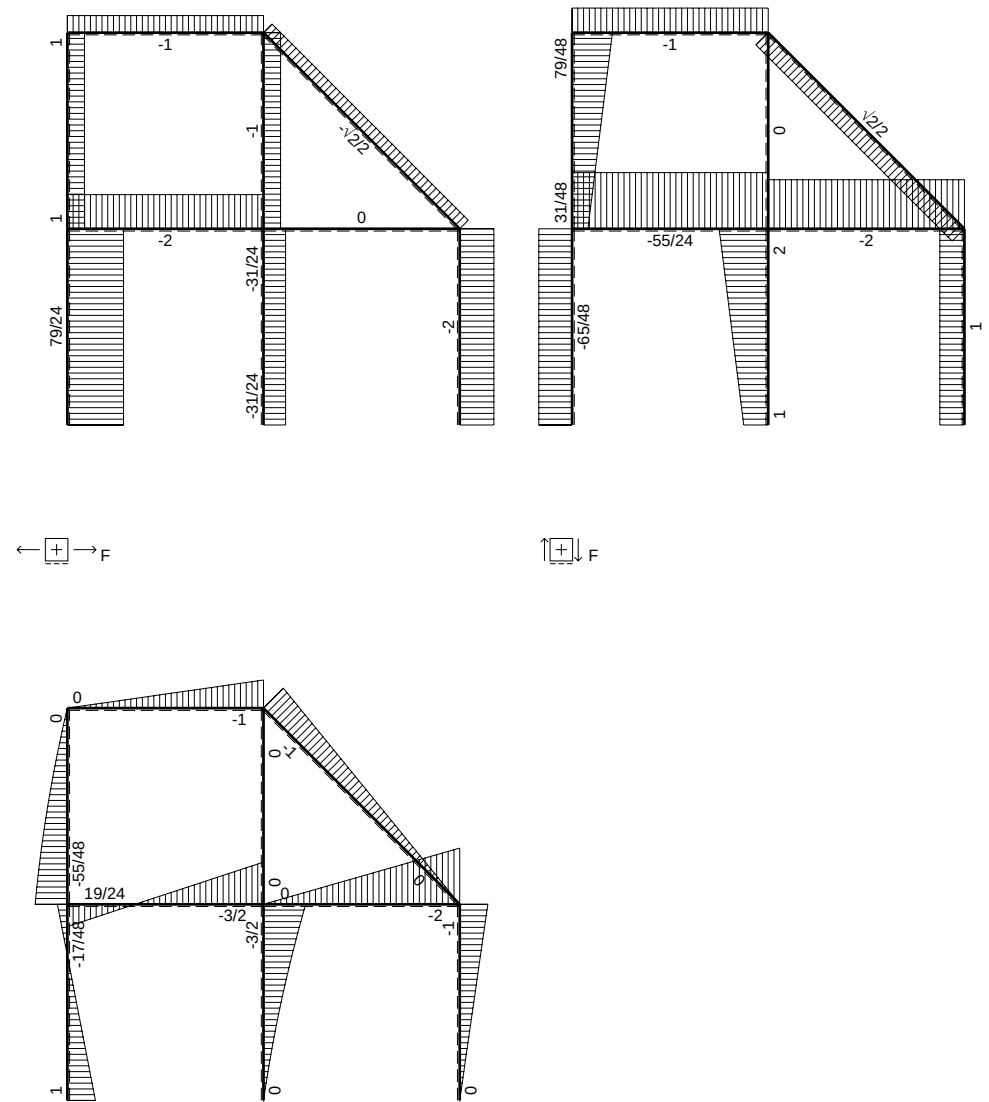
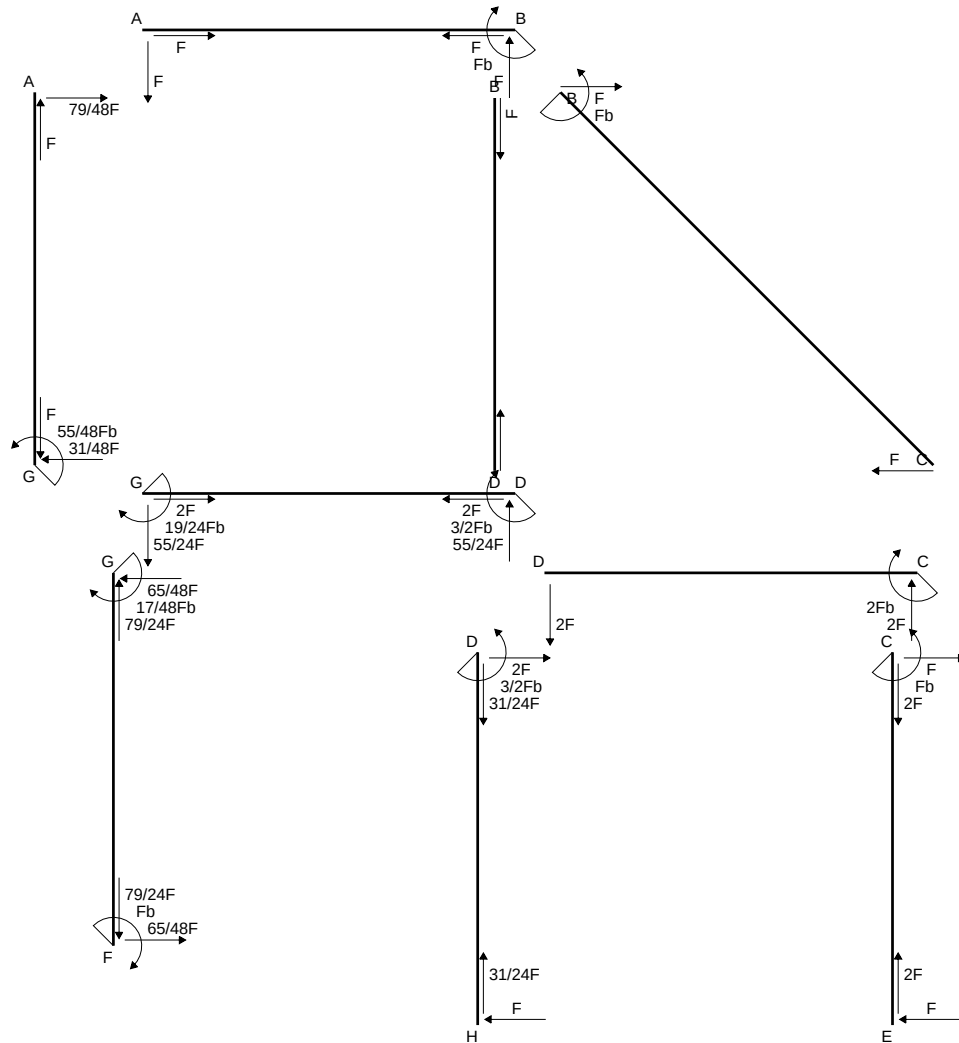
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

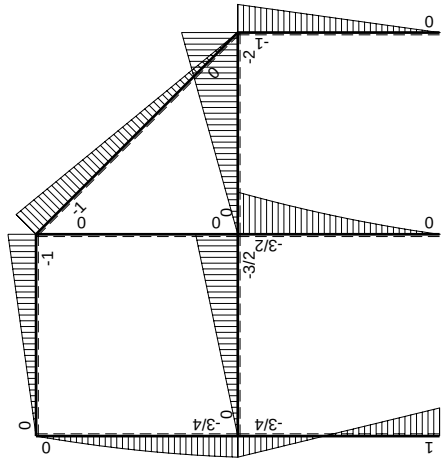
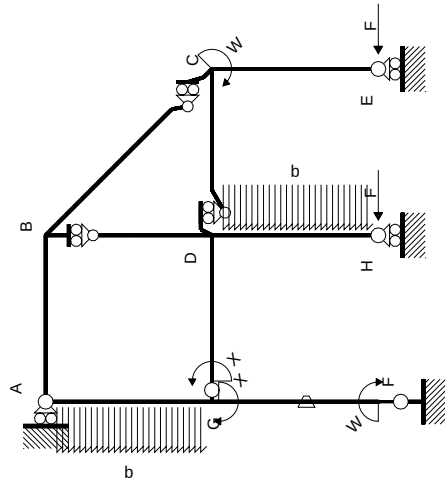
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$



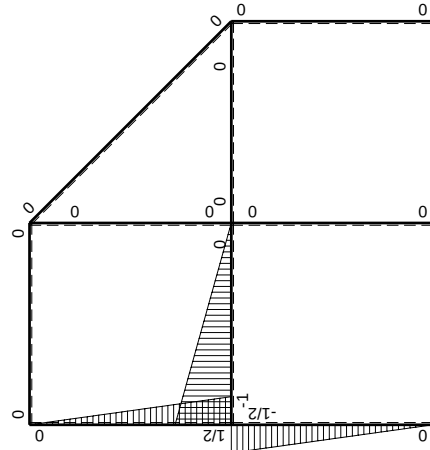
$$\begin{aligned} A &= 630. \text{ mm}^2 \\ J_u &= 245181. \text{ mm}^4 \\ J_v &= 41202. \text{ mm}^4 \\ y_g &= 22.3 \text{ mm} \\ T_y &= -1840. \text{ N} \\ M_x &= -1711200. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 32.7 \text{ mm} \\ \sigma_m &= -Mv/J_u = 228.2 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 47. \text{ mm} \\ v_c &= 24.7 \text{ mm} \\ \sigma_c &= -Mv/J_u = 172.4 \text{ N/mm}^2 \\ \tau_c &= 4.791 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 172.6 \text{ N/mm}^2 \\ S &= 3830. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-7/4Fx	-Fb/EJ	-1/2Fx+7/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-7/4Fx	Fb/EJ	3/8Fb-5/4Fx+7/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx ²	0	-3/8Fb+1/2Fx+1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-7/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx ²	0	-5/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						19/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-19/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{5}{4} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{5}{8} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{5}{8} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{24} Fb^2/EJ$$

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

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

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

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

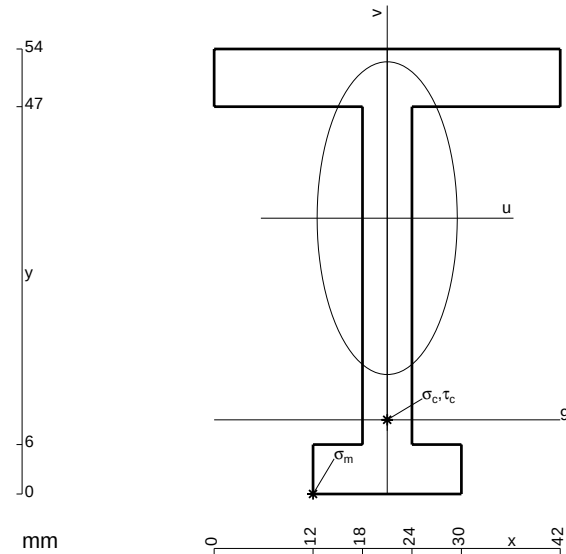
$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

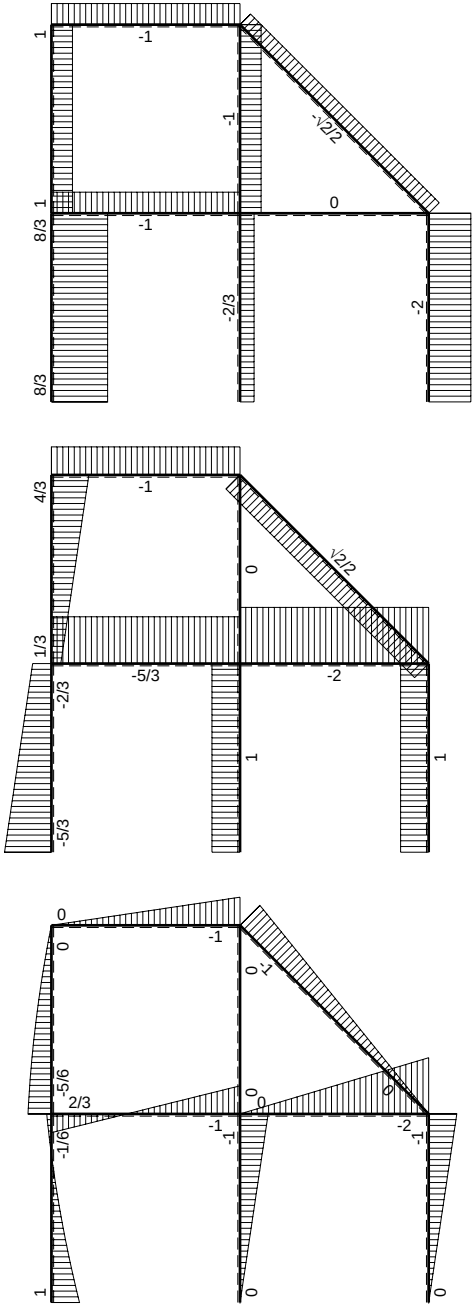
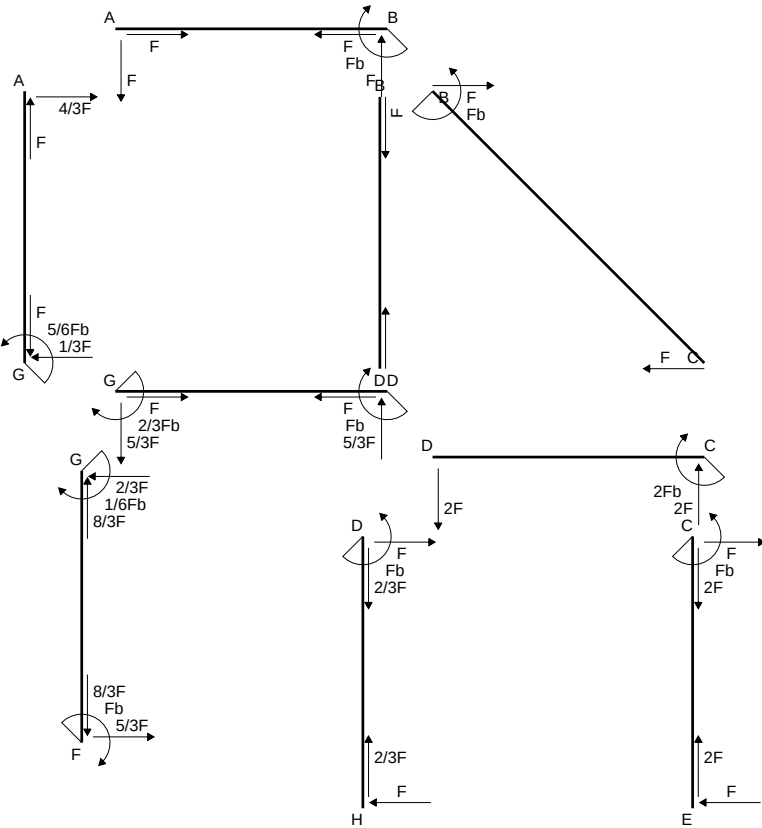
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

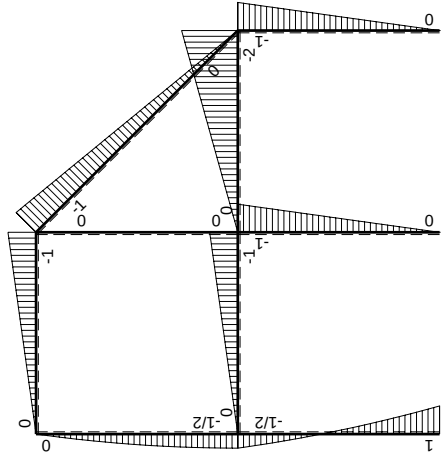
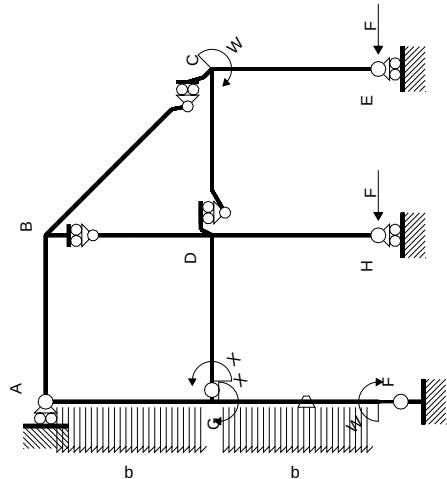
$$L_{AG}^{xo} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



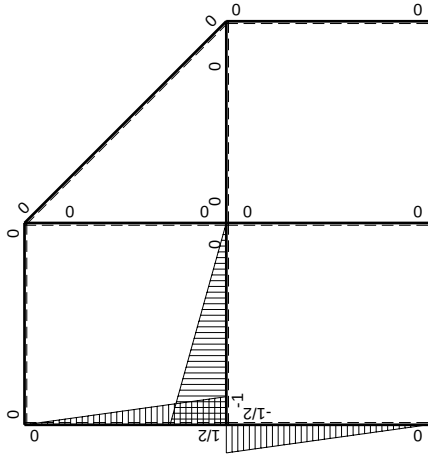
$$\begin{aligned} A &= 648. \text{ mm}^2 \\ J_u &= 233472. \text{ mm}^4 \\ J_v &= 46872. \text{ mm}^4 \\ y_g &= 33.47 \text{ mm} \\ T_y &= -1740. \text{ N} \\ M_x &= -1670400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -33.47 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -24.47 \text{ mm} \\ \sigma_c &= -Mv/J_u = -175.1 \text{ N/mm}^2 \\ \tau_c &= 4.669 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 175.3 \text{ N/mm}^2 \\ S &= 3759. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-2Fx+1/2qx ²	-Fb/EJ	-1/2Fx+Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(1/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-Fx-1/2qx ²	Fb/EJ	1/4Fb-3/4Fx+1/4Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2qx ²	0	-1/4Fb+1/4Fx+1/4Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-5/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx-1/2qx ²	0	-1/2Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						1/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{3} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{3} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{13}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{4} - \frac{3}{4} x/b + \frac{1}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{3}{8} x^2/b + \frac{1}{12} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{3}{8} b + \frac{1}{12} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{13}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

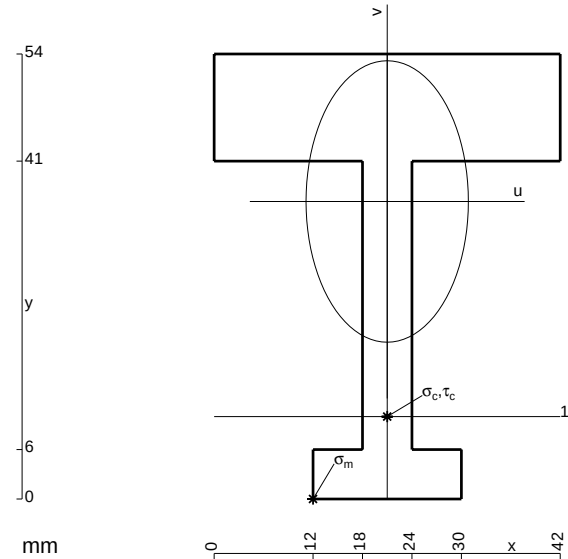
$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{4} + \frac{1}{4} x/b + \frac{1}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{1}{4} x + \frac{1}{8} x^2/b + \frac{1}{12} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

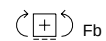
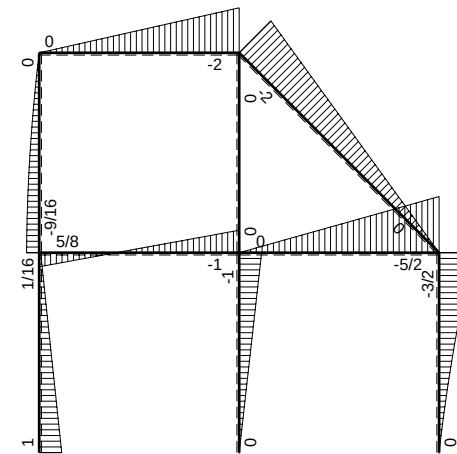
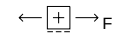
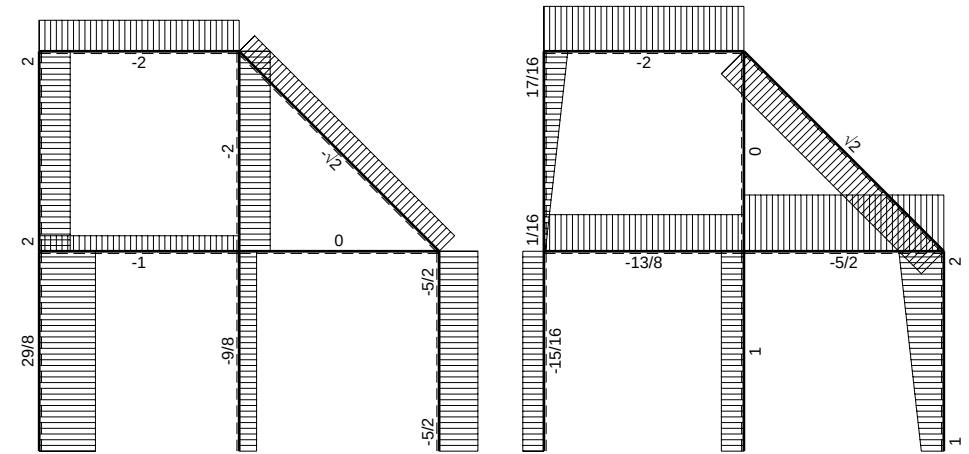
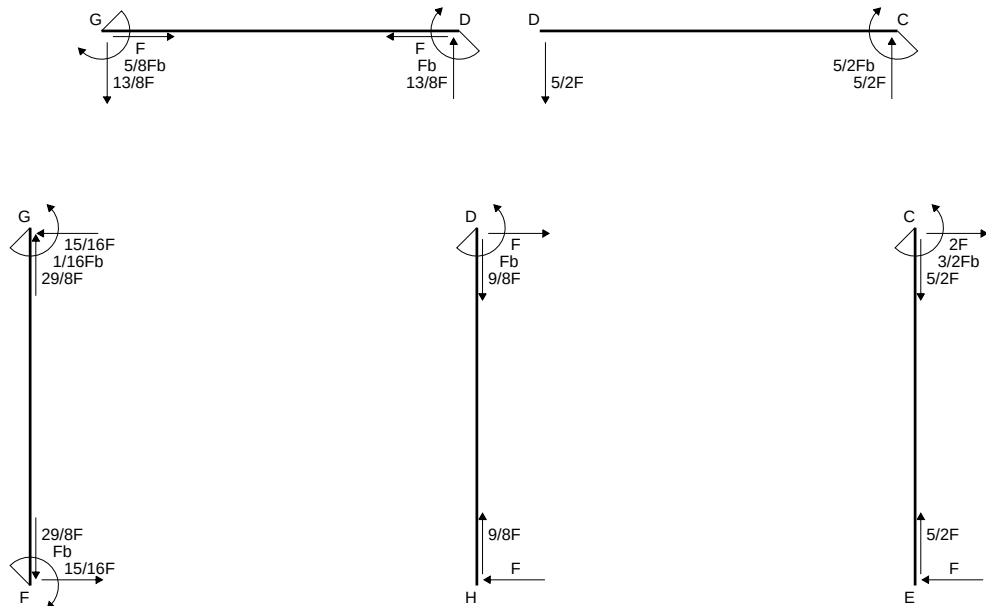
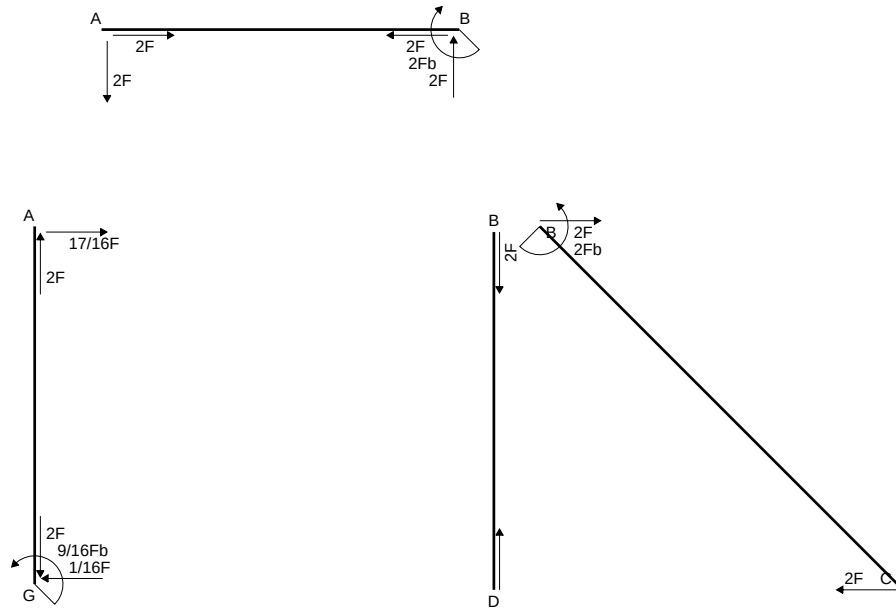
$$= \left(-\frac{1}{4} b + \frac{1}{8} b + \frac{1}{12} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{5}{48} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{2} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{5}{48} Fb^2/EJ$$



$$\begin{aligned} A &= 864. \text{ mm}^2 \\ J_u &= 252075. \text{ mm}^4 \\ J_v &= 83808. \text{ mm}^4 \\ y_g &= 36.1 \text{ mm} \\ T_y &= -2720. \text{ N} \\ M_x &= -1387200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -36.1 \text{ mm} \\ \sigma_m &= -Mv/J_u = -198.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -26.1 \text{ mm} \\ \sigma_c &= -Mv/J_u = -143.7 \text{ N/mm}^2 \\ \tau_c &= 7.643 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 144.3 \text{ N/mm}^2 \\ S &= 4250. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						5/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{8} - \frac{3}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{3}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{3}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

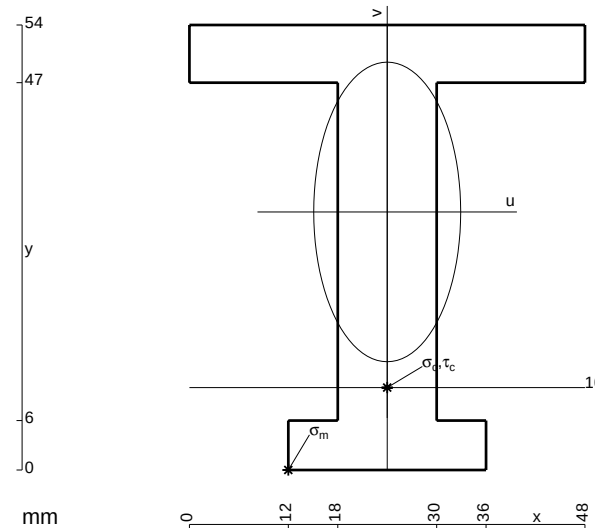
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

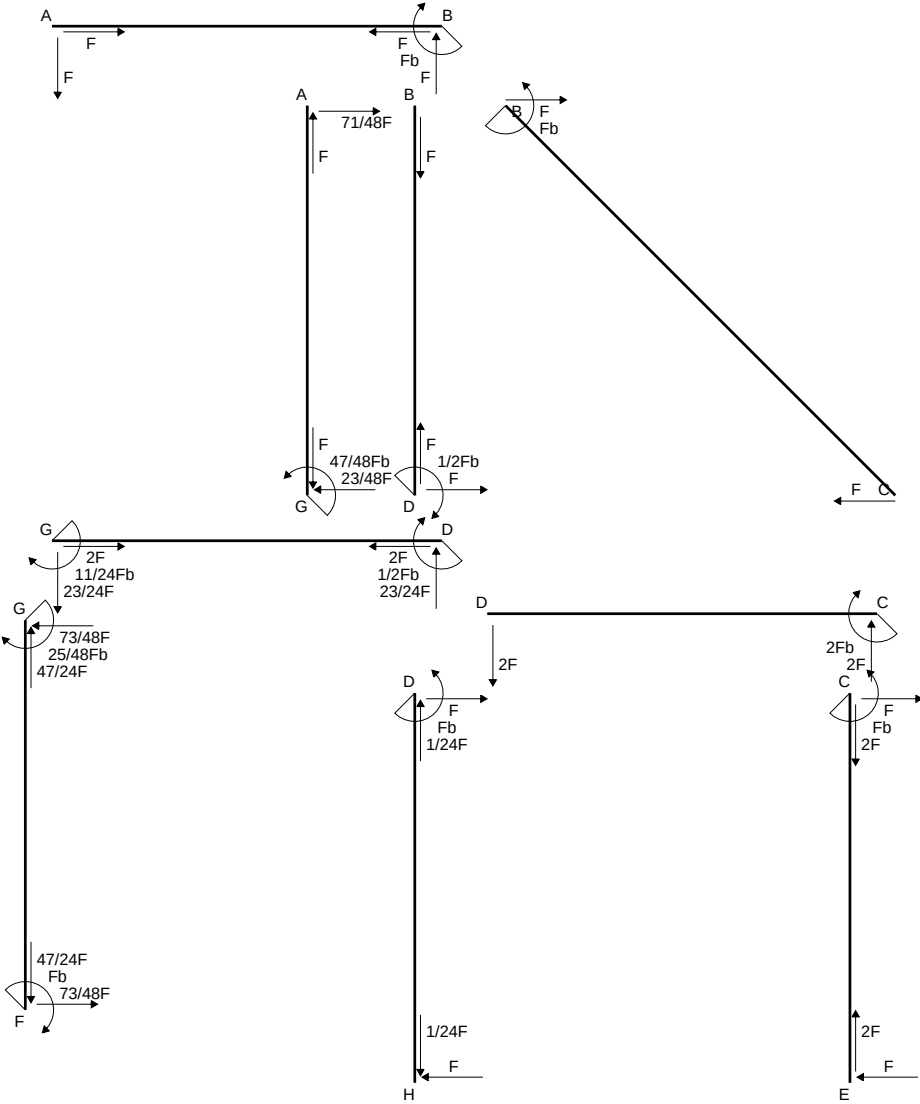
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$



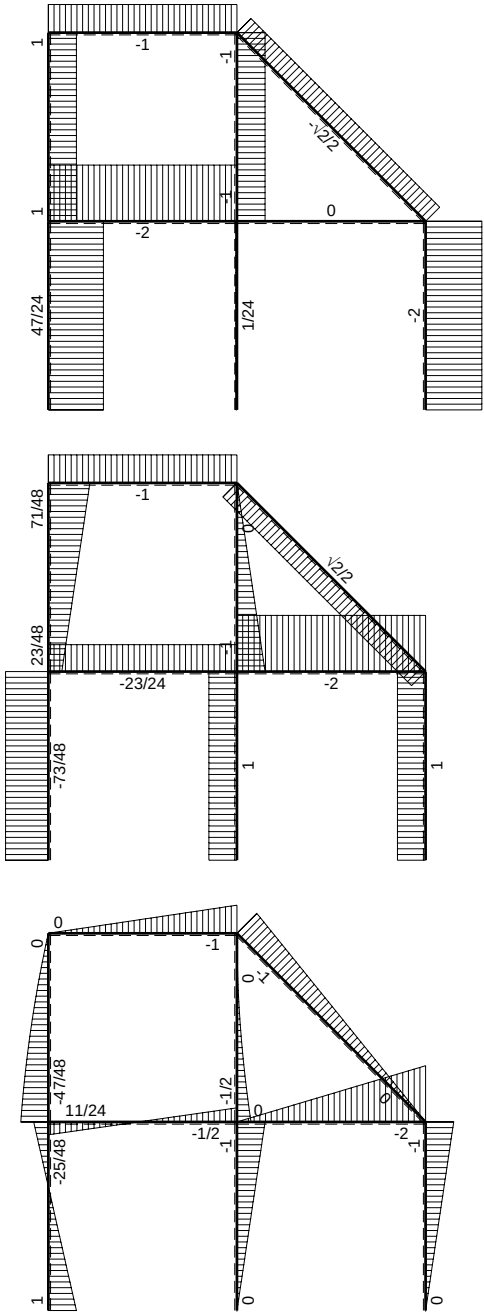
$$\begin{aligned} A &= 972. \text{ mm}^2 \\ J_u &= 321252. \text{ mm}^4 \\ J_v &= 77328. \text{ mm}^4 \\ y_g &= 31.31 \text{ mm} \\ T_y &= -3825. \text{ N} \\ M_x &= -2142000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.31 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -21.31 \text{ mm} \\ \sigma_c &= -Mv/J_u = -142.1 \text{ N/mm}^2 \\ \tau_c &= 5.156 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 142.4 \text{ N/mm}^2 \\ S &= 5196. \text{ mm}^3 \end{aligned}$$

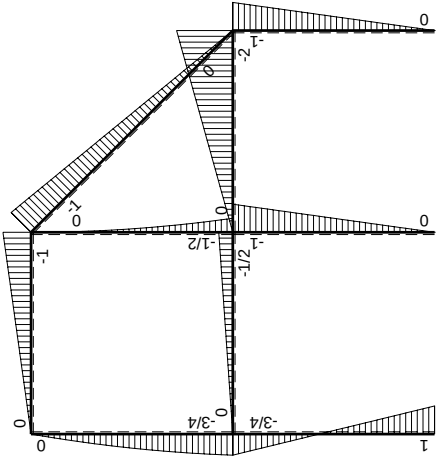
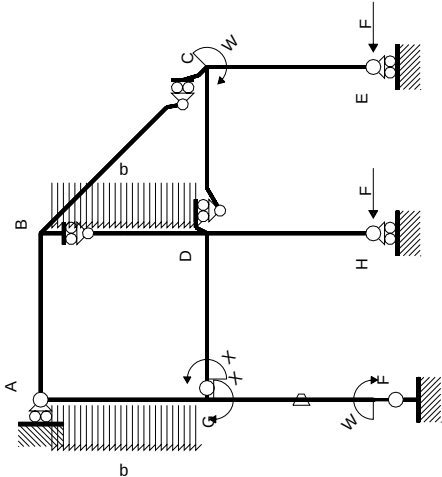


$\leftarrow \boxed{+} \rightarrow F$

$\uparrow \boxed{+} \downarrow F$

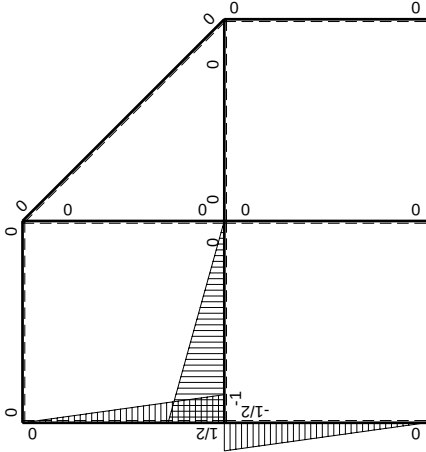
$\curvearrowright \boxed{+} \curvearrowleft F_b$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-7/4Fx	-Fb/EJ	-1/2Fx+7/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-7/4Fx	Fb/EJ	3/8Fb-5/4Fx+7/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx ²	0	-3/8Fb+1/2Fx+1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-7/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx ²	0	-5/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						11/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{5}{4} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{5}{8} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{5}{8} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{24} Fb^2/EJ$$

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

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

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

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

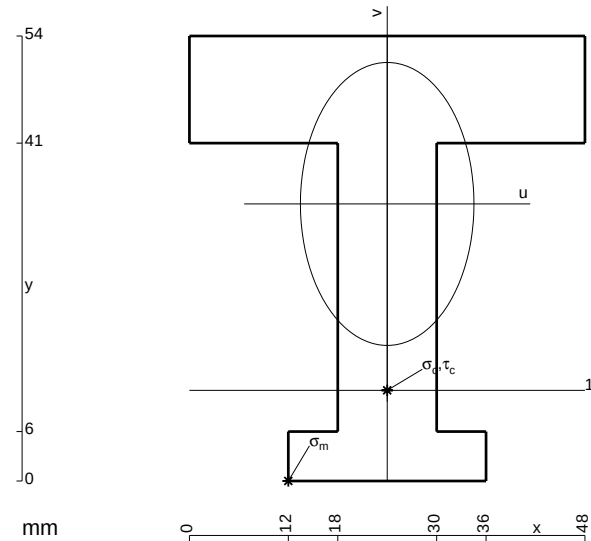
$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

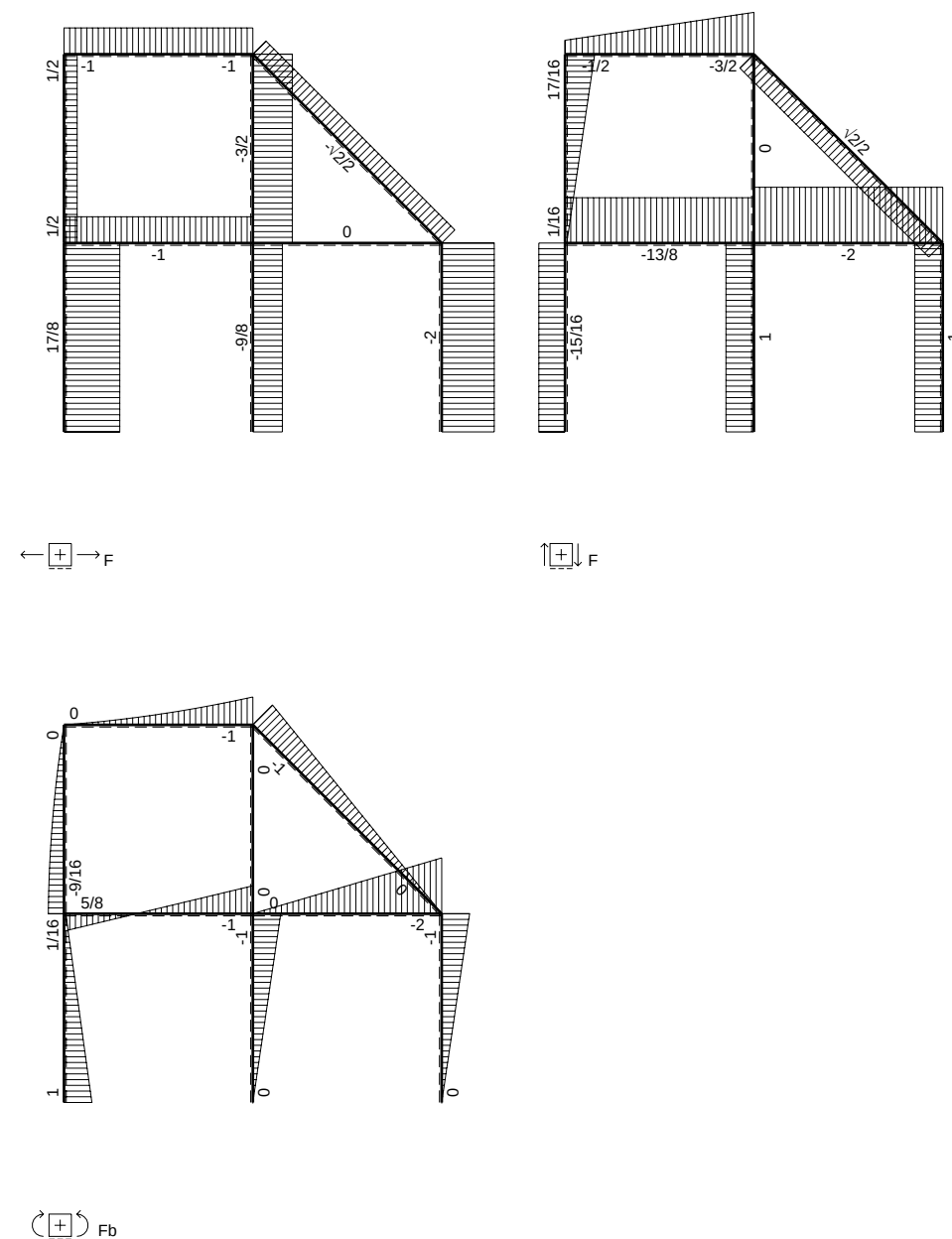
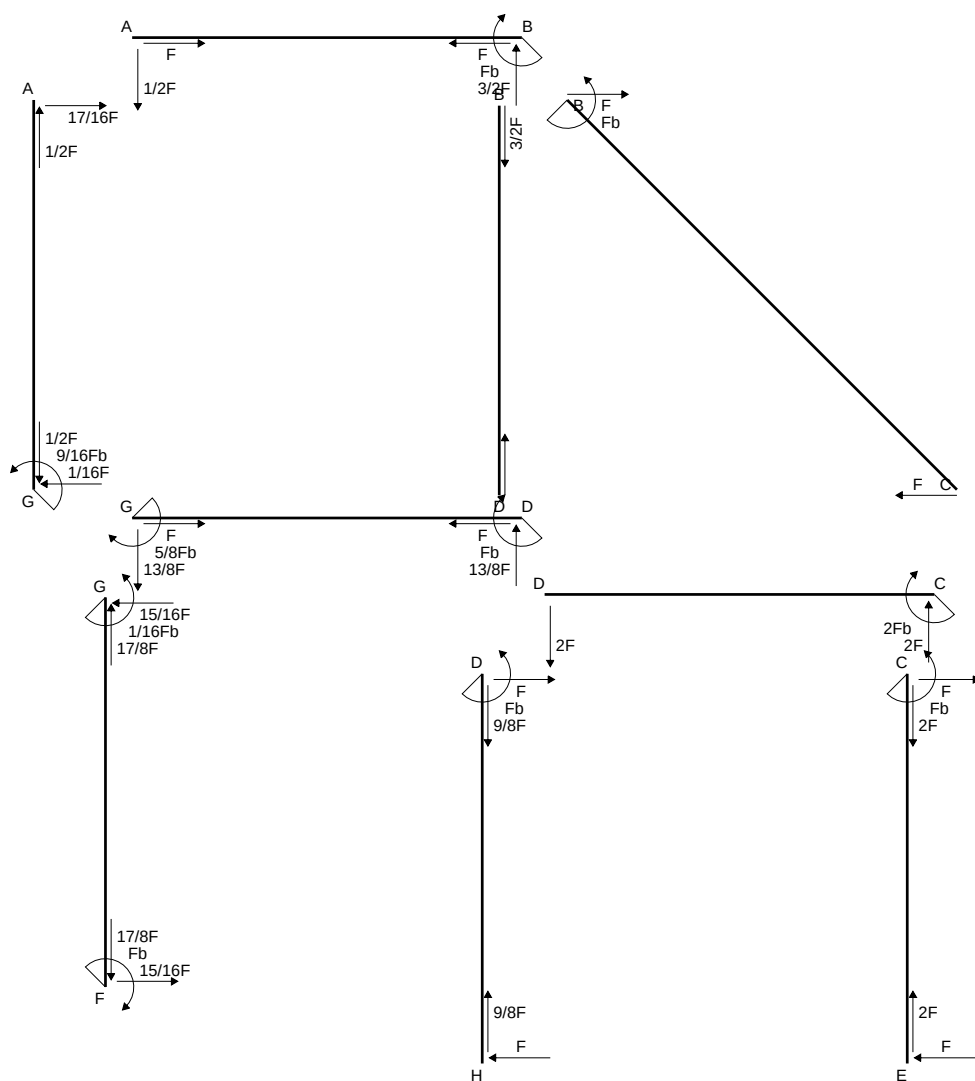
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

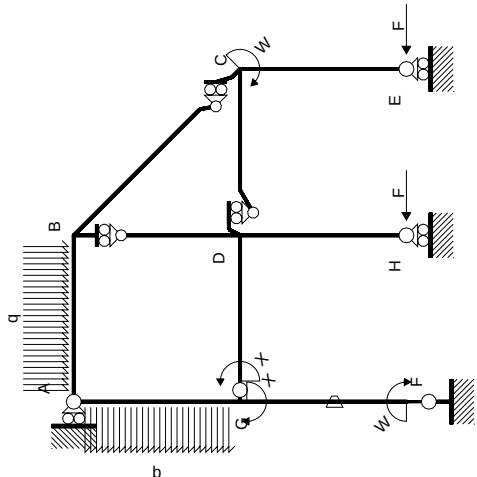
$$L_{AG}^{xo} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



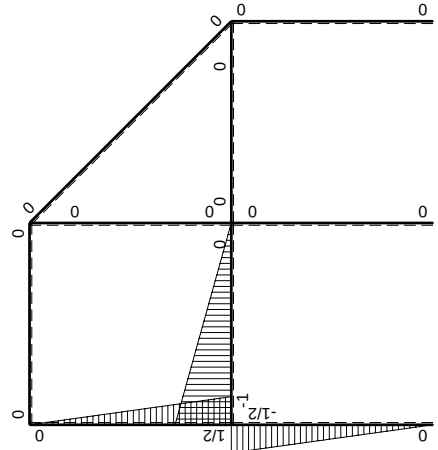
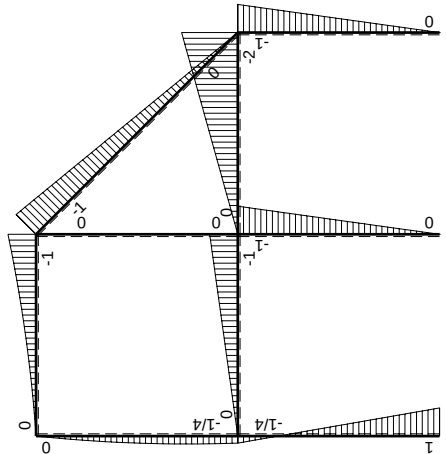
$$\begin{aligned} A &= 1188. \text{ mm}^2 \\ J_u &= 350338. \text{ mm}^4 \\ J_v &= 131760. \text{ mm}^4 \\ y_g &= 33.62 \text{ mm} \\ T_y &= -3740. \text{ N} \\ M_x &= -2281400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -33.62 \text{ mm} \\ \sigma_m &= -Mv/J_u = -218.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -22.62 \text{ mm} \\ \sigma_c &= -Mv/J_u = -147.3 \text{ N/mm}^2 \\ \tau_c &= 5.264 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 147.6 \text{ N/mm}^2 \\ S &= 5917. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-5/4Fx$	$-Fb/EJ$	$-1/2Fx+5/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/24+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/4Fb-5/4Fx$	Fb/EJ	$1/8Fb-3/4Fx+5/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb-1/4Fx+1/2qx^2$	0	$-1/8Fb+3/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/16+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx-1/2qx^2$	0	$-3/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$5/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{8} - \frac{3}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{3}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{3}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

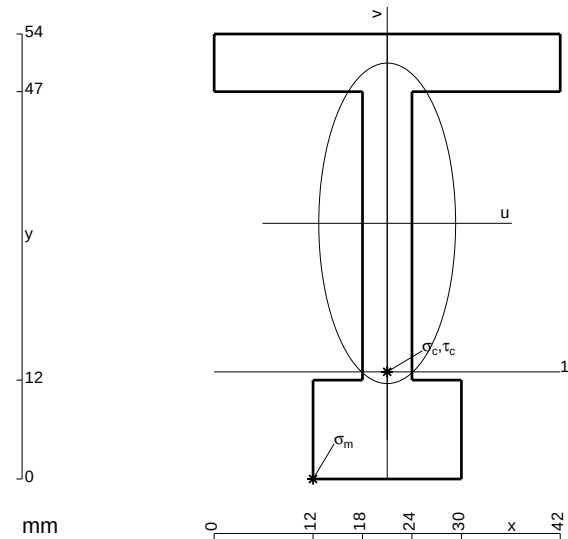
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

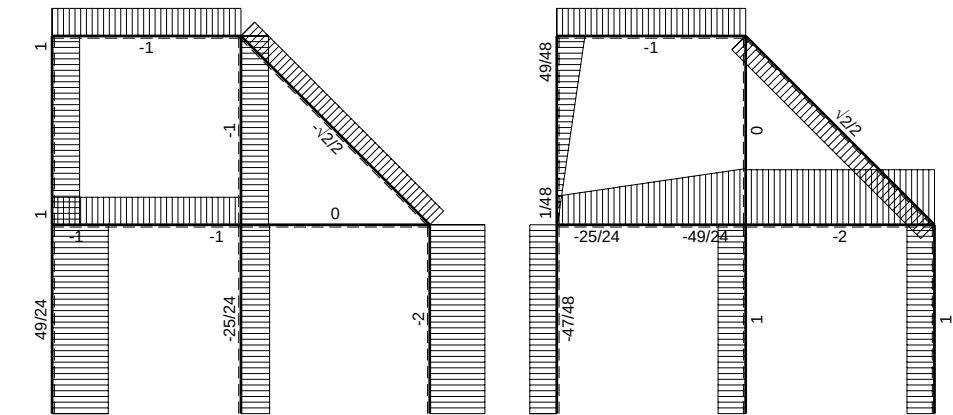
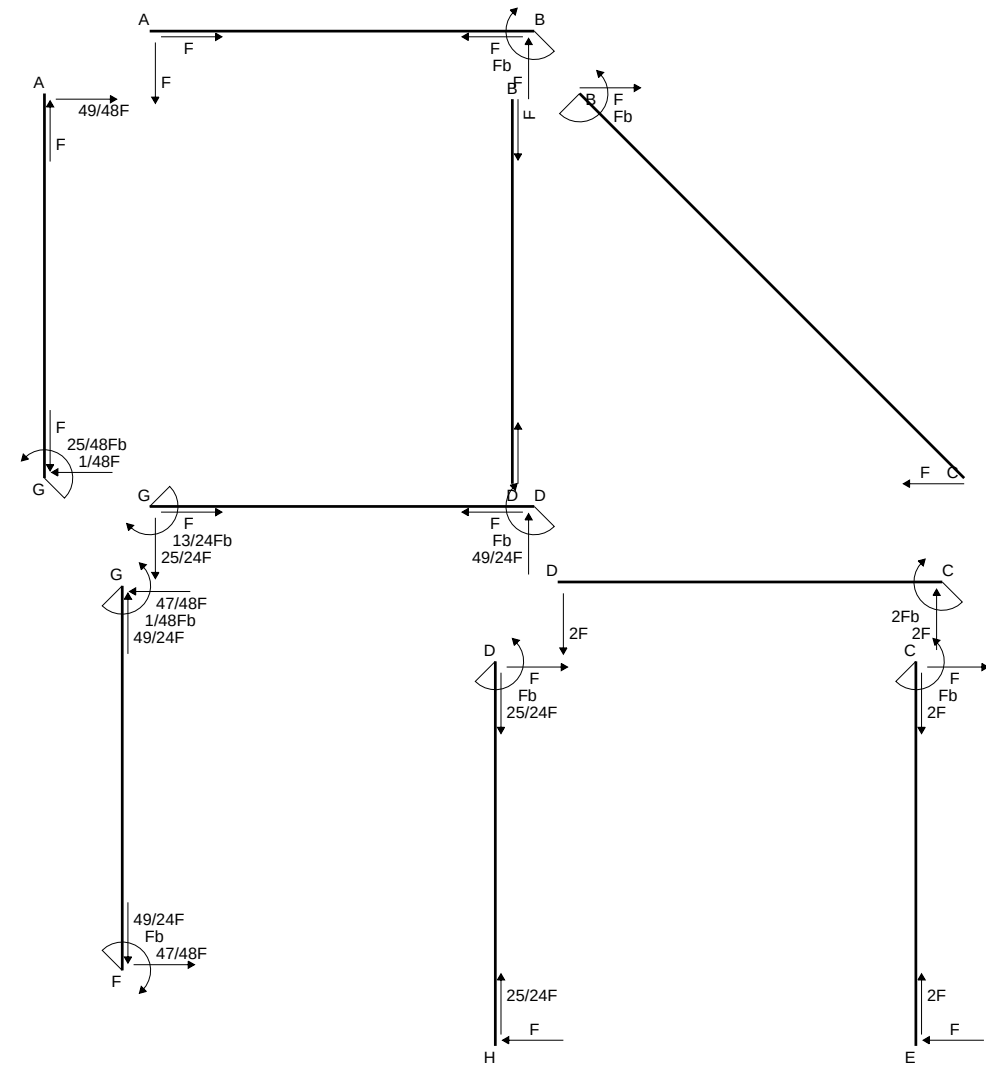
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

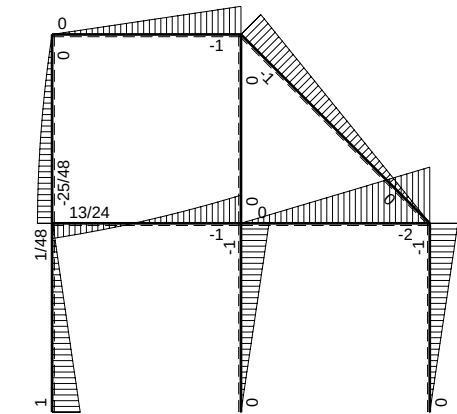


$$\begin{aligned} A &= 720. \text{ mm}^2 \\ J_u &= 272496. \text{ mm}^4 \\ J_v &= 49680. \text{ mm}^4 \\ y_g &= 31.02 \text{ mm} \\ T_y &= -3060. \text{ N} \\ M_x &= -2019600. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -31.02 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -18.02 \text{ mm} \\ \sigma_c &= -Mv/J_u = -133.6 \text{ N/mm}^2 \\ \tau_c &= 10.32 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 134.8 \text{ N/mm}^2 \\ S &= 5517. \text{ mm}^3 \end{aligned}$$

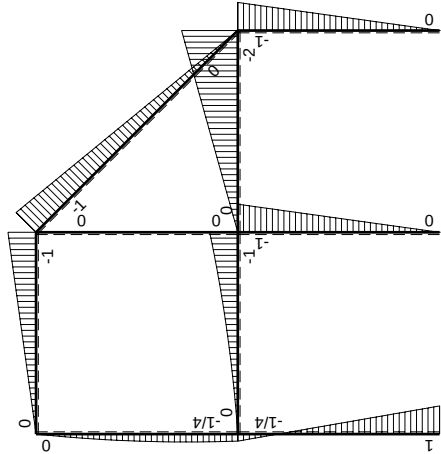
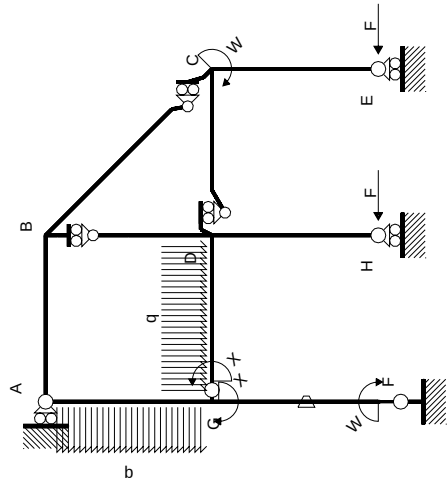


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

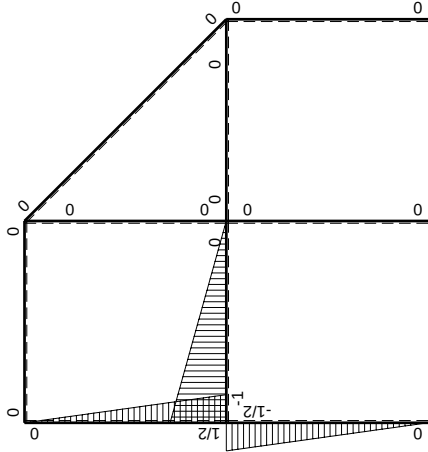


↺ $\boxed{+}$ ↻ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						13/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{8} - \frac{3}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{3}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{3}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

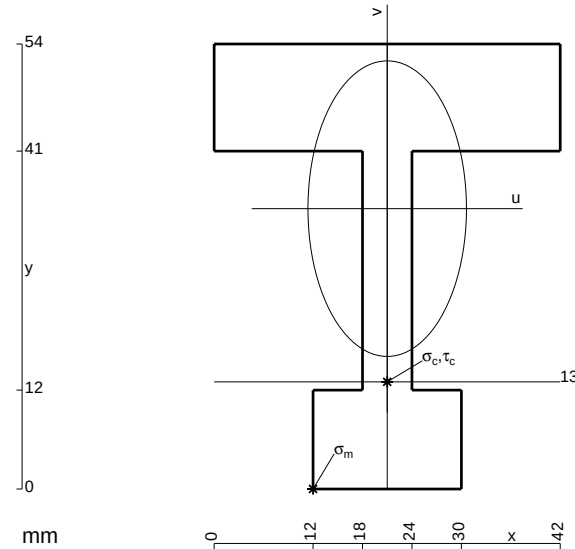
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

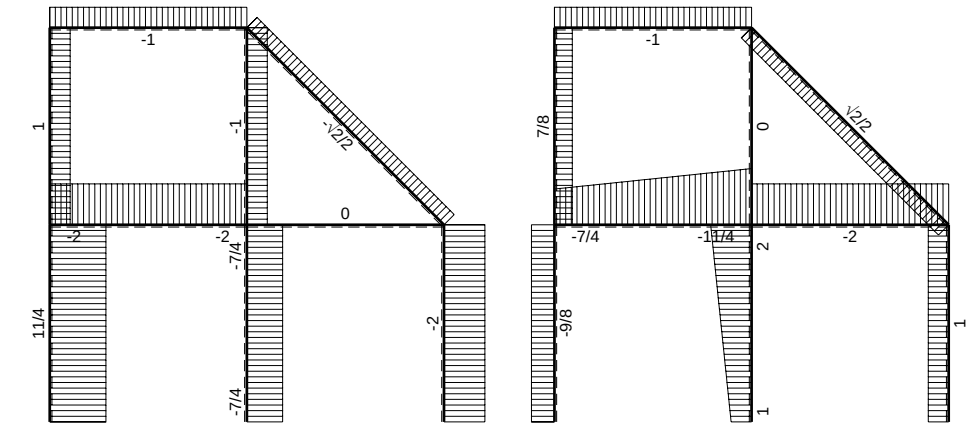
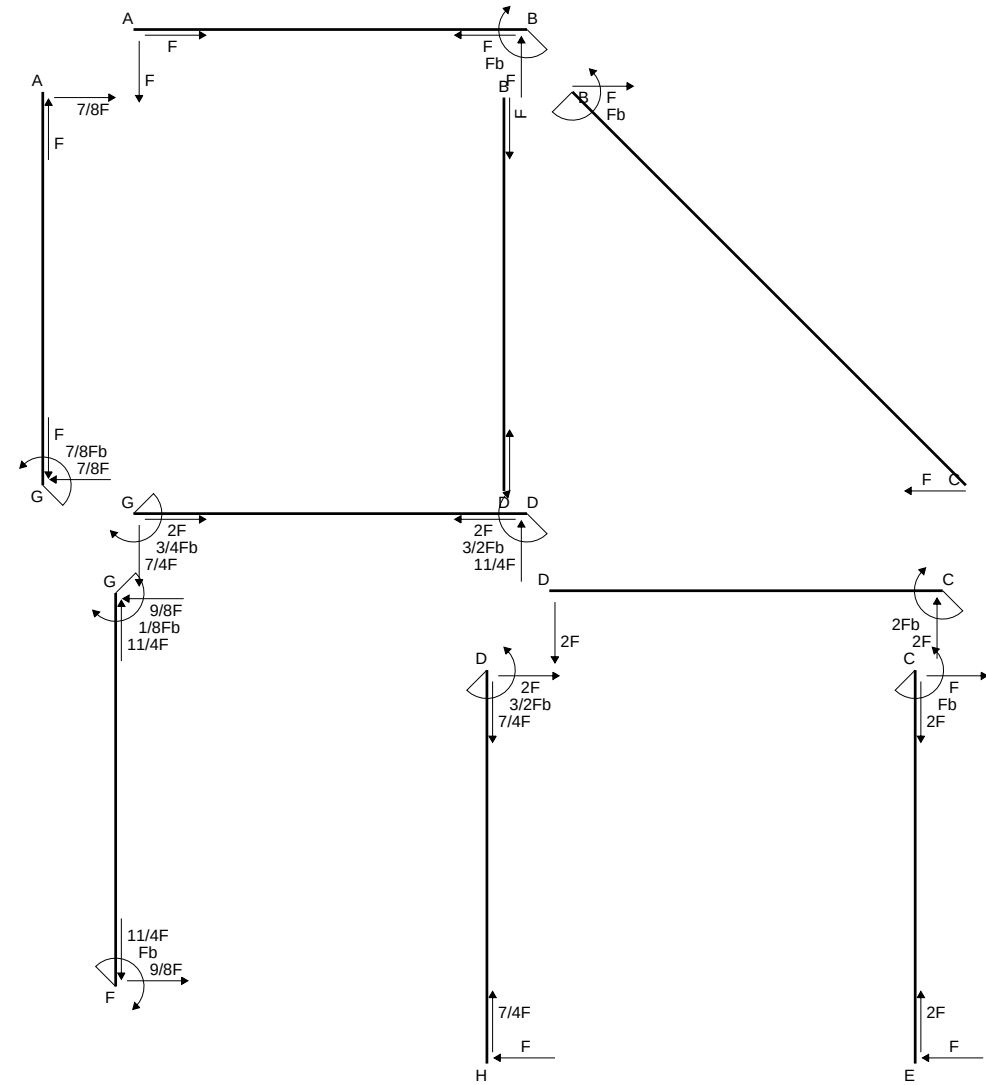
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

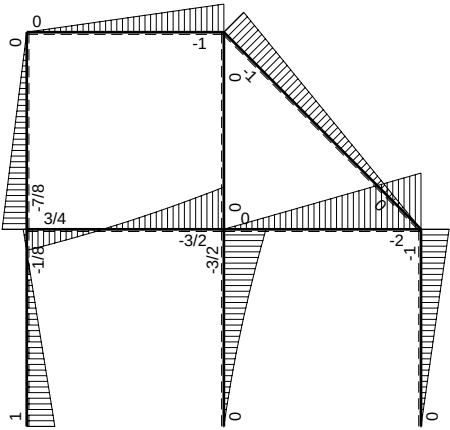


$$\begin{aligned} A &= 936. \text{ mm}^2 \\ J_u &= 301116. \text{ mm}^4 \\ J_v &= 86616. \text{ mm}^4 \\ y_g &= 34.02 \text{ mm} \\ T_y &= -2980. \text{ N} \\ M_x &= -2115800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.02 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -21.02 \text{ mm} \\ \sigma_c &= -Mv/J_u = -147.7 \text{ N/mm}^2 \\ \tau_c &= 10.2 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 148.7 \text{ N/mm}^2 \\ S &= 6181. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(0+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-Fx-1/2qx ²	0	Fx-1/2Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(5/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx ²	0	3/2Fx-2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						3/8Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-3/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left(\frac{1}{2} b - \frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

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

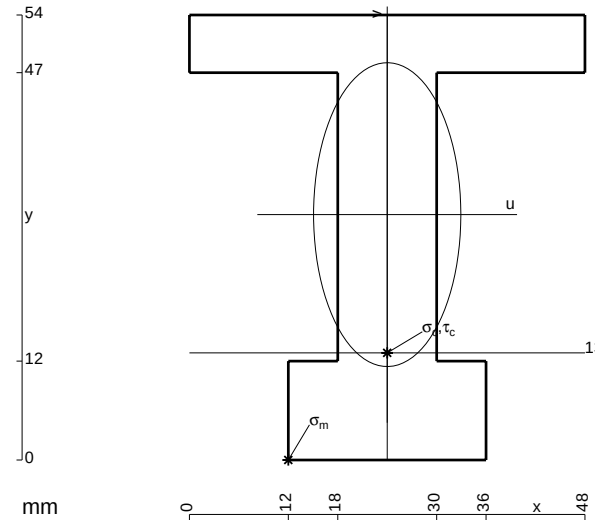
$$= \left(\frac{3}{4} b - \frac{2}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

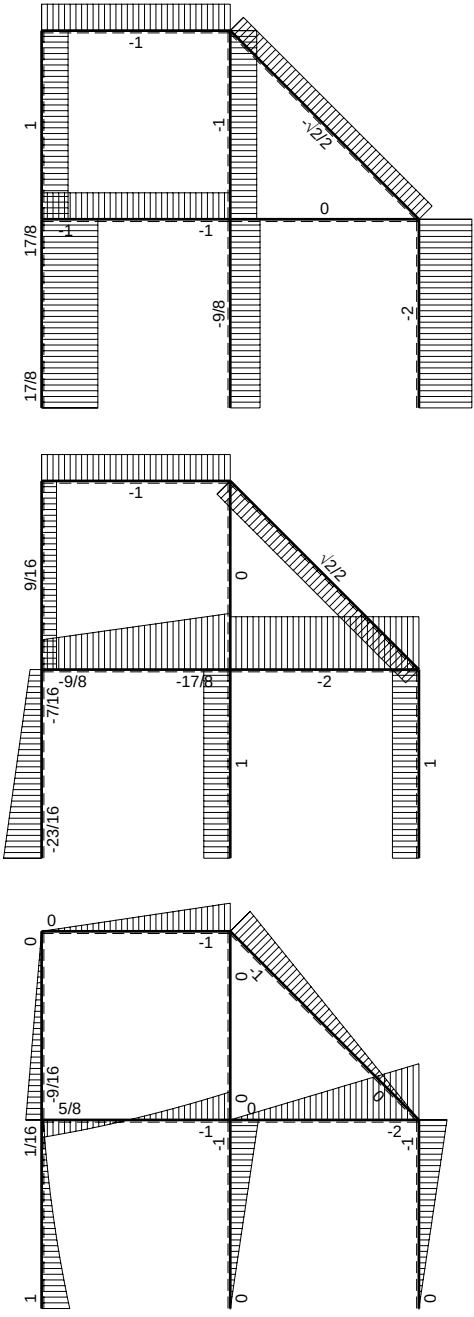
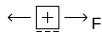
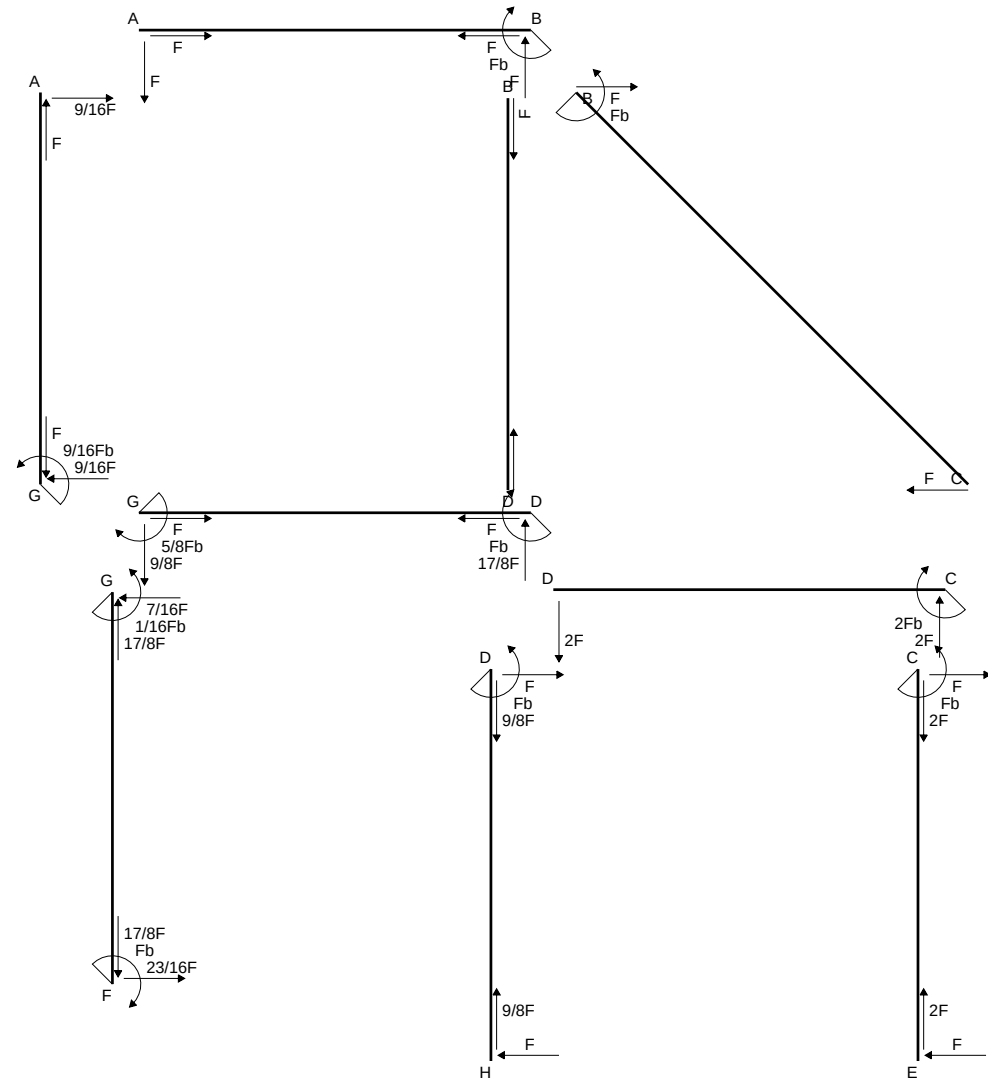
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

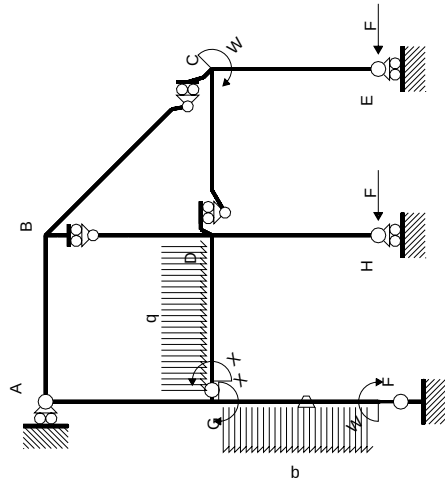
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



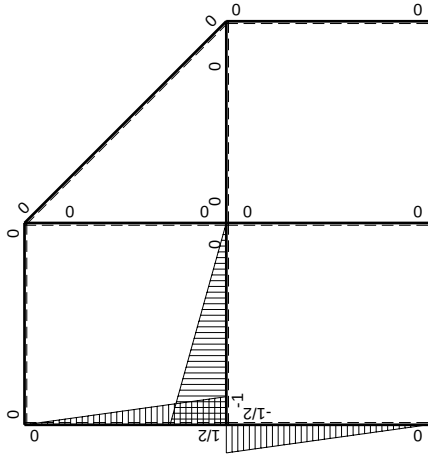
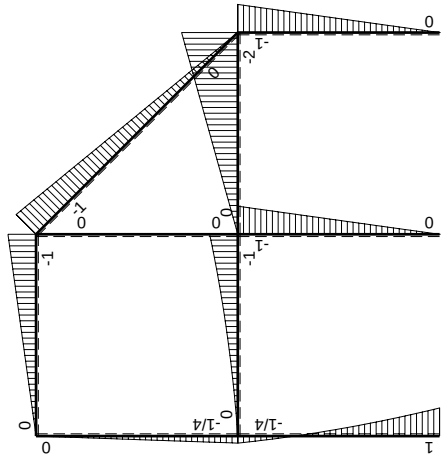
$$\begin{aligned} A &= 1044. \text{ mm}^2 \\ J_u &= 354848. \text{ mm}^4 \\ J_v &= 83376. \text{ mm}^4 \\ y_g &= 29.78 \text{ mm} \\ T_y &= -3120. \text{ N} \\ M_x &= -2371200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.78 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -16.78 \text{ mm} \\ \sigma_c &= -Mv/J_u = -112.1 \text{ N/mm}^2 \\ \tau_c &= 5.169 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 112.5 \text{ N/mm}^2 \\ S &= 7055. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-7/4Fx+1/2qx ²	-Fb/EJ	-1/2Fx+7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(-1/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx ²	Fb/EJ	1/8Fb-1/2Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx ² /b	0	1/4x ² /b ²		
	totali						5/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{8} - \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{1}{4} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

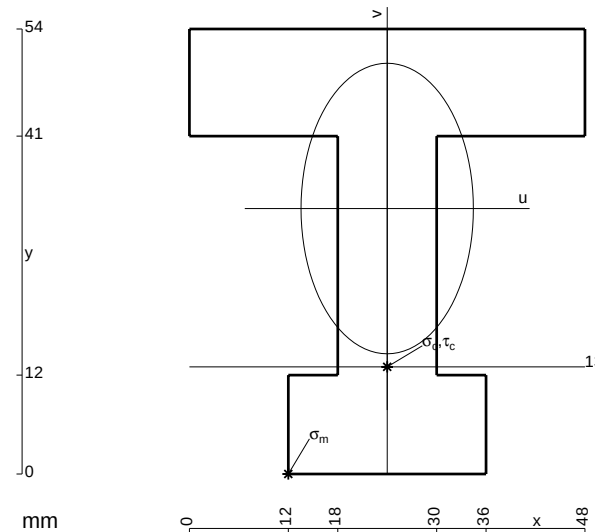
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

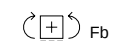
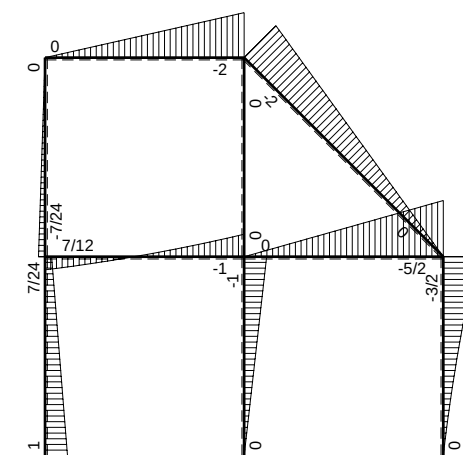
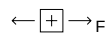
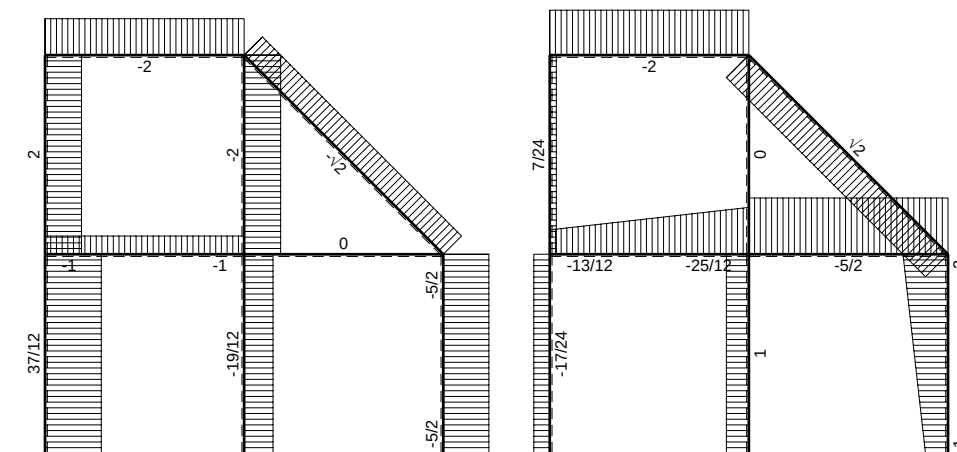
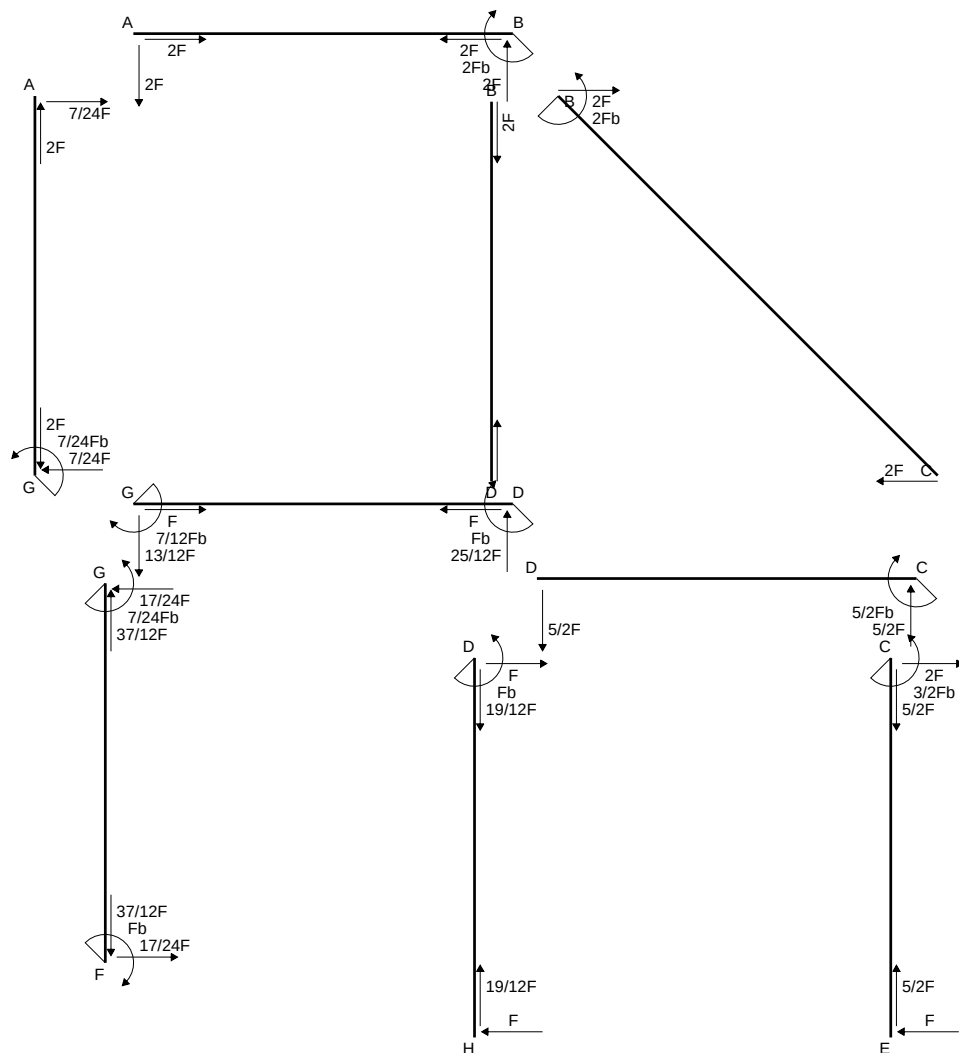
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

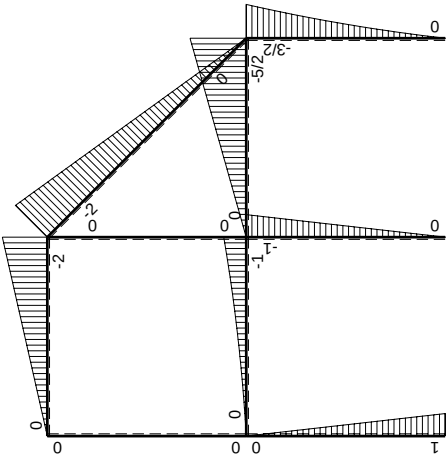
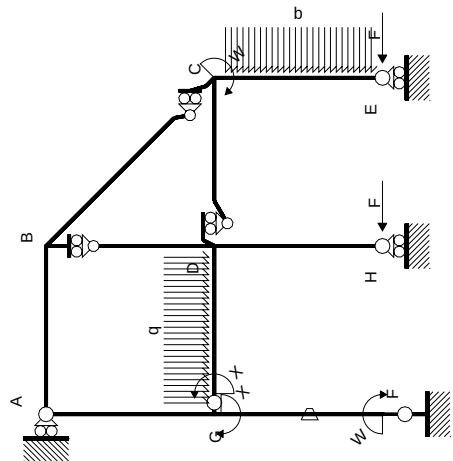
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



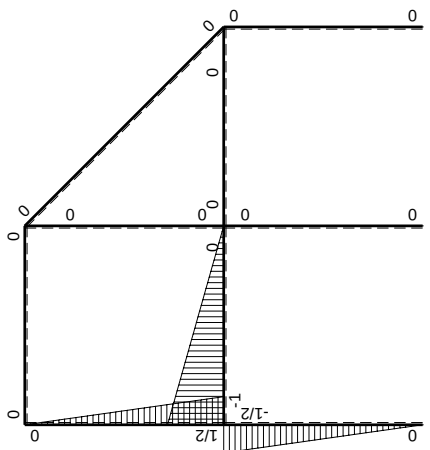
$$\begin{aligned} A &= 1260. \text{ mm}^2 \\ J_u &= 391706. \text{ mm}^4 \\ J_v &= 137808. \text{ mm}^4 \\ y_g &= 32.21 \text{ mm} \\ T_y &= -3140. \text{ N} \\ M_x &= -2543400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.21 \text{ mm} \\ \sigma_m &= -Mv/J_u = -209.2 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -19.21 \text{ mm} \\ \sigma_c &= -Mv/J_u = -124.8 \text{ N/mm}^2 \\ \tau_c &= 5.201 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 125.1 \text{ N/mm}^2 \\ S &= 7786. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-Fx	-Fb/EJ	-1/2Fx+1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	-Fx	Fb/EJ	-1/2Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x ² /b ²	0+0	1/12Xb/EJ
AG b	-1/2x/b	0	0	0	0	1/4x ² /b ²		
	totali						7/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

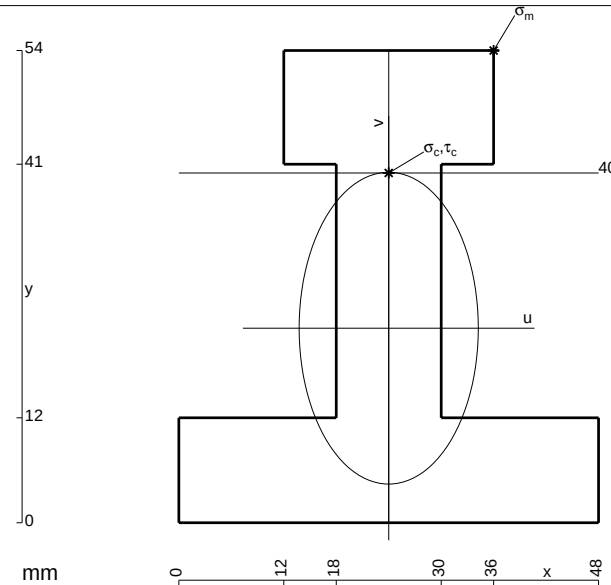
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

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

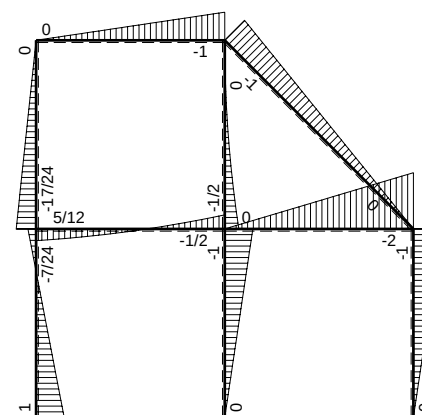
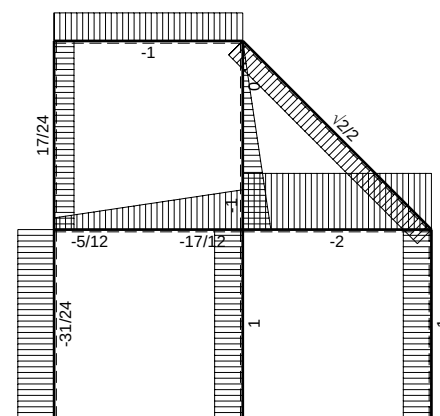
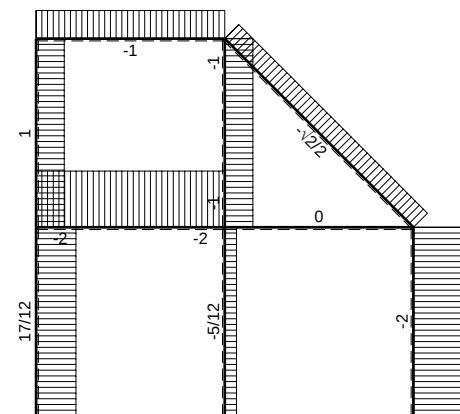
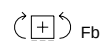
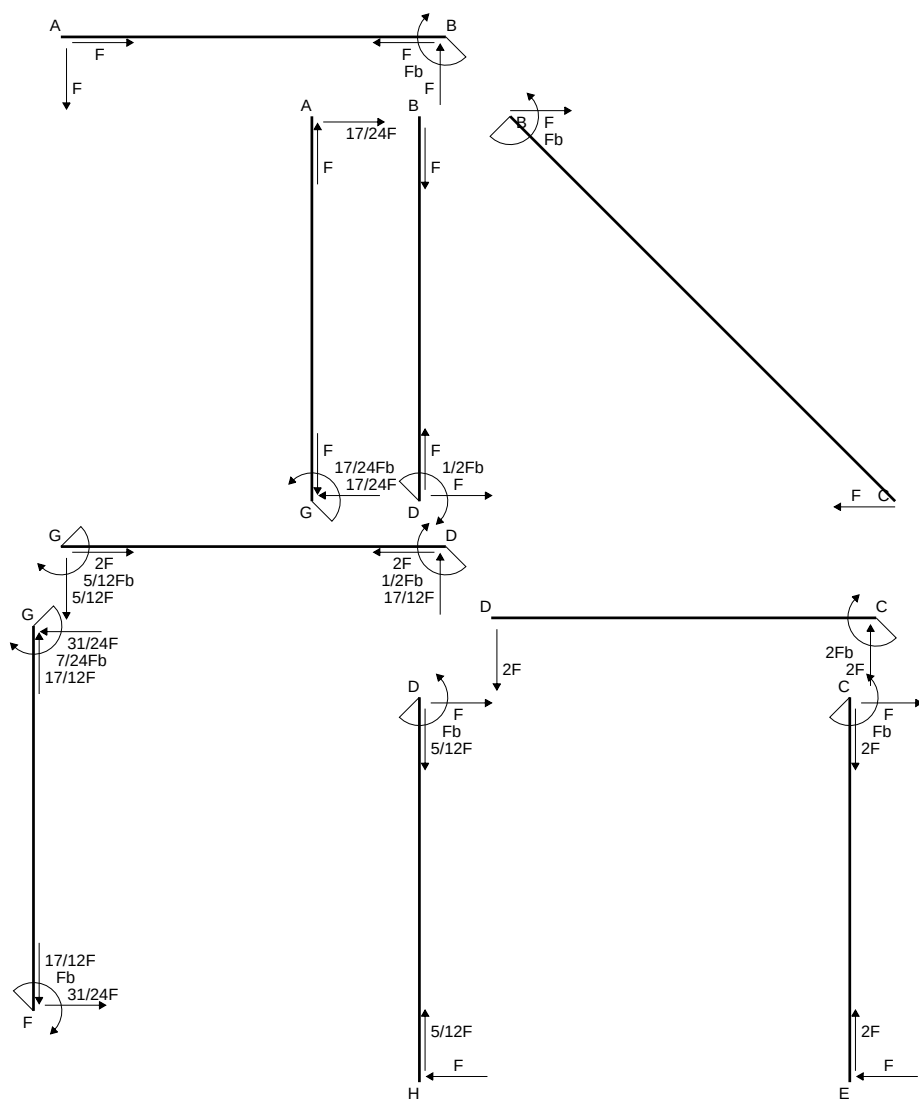
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

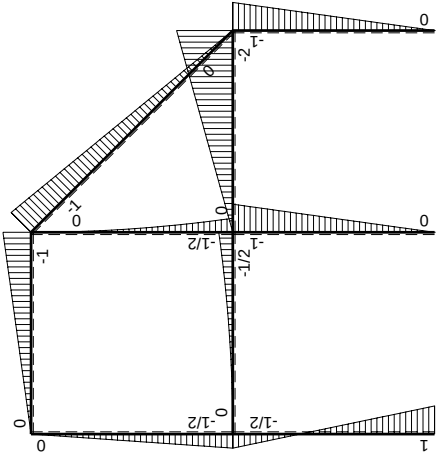
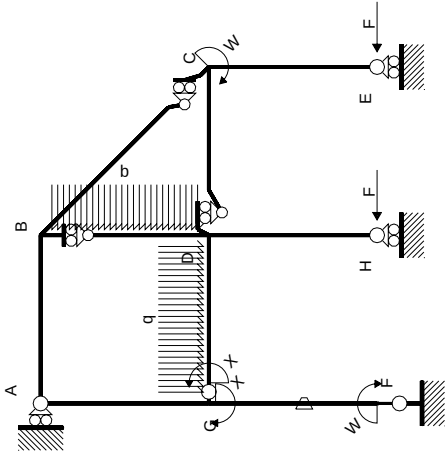
$$L_{DG}^{xo} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$



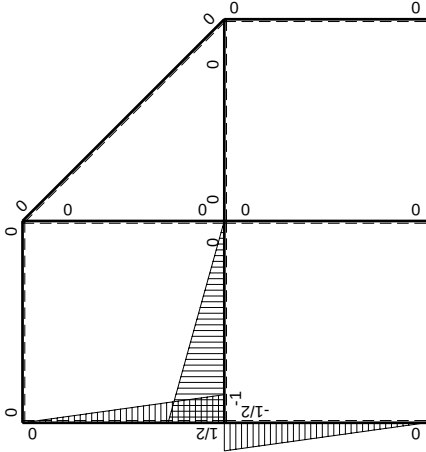
$$\begin{aligned} A &= 1236. \text{ mm}^2 \\ J_u &= 393000. \text{ mm}^4 \\ J_v &= 129744. \text{ mm}^4 \\ y_g &= 22.25 \text{ mm} \\ T_y &= -3150. \text{ N} \\ M_x &= -2709000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.75 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 17.75 \text{ mm} \\ \sigma_c &= -Mv/J_u = 122.4 \text{ N/mm}^2 \\ \tau_c &= 5.409 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 122.7 \text{ N/mm}^2 \\ S &= 8098. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(0+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2qx ²	0	1/2Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-Fx+1/2qx ²	0	1/2Fx-Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						5/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left(\frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

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

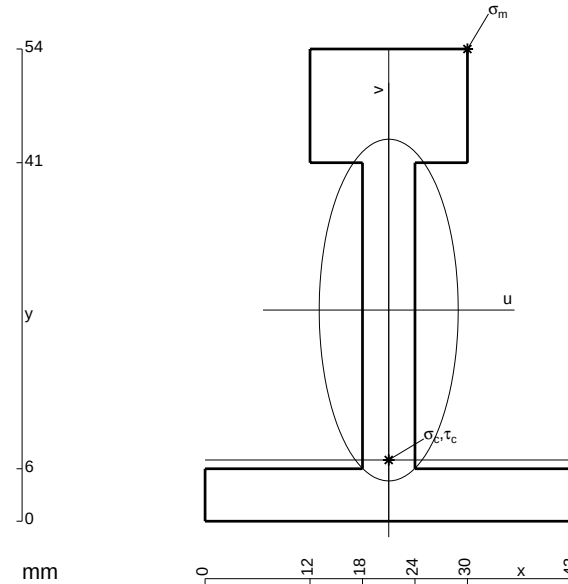
$$= \left(\frac{1}{4} b - \frac{1}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

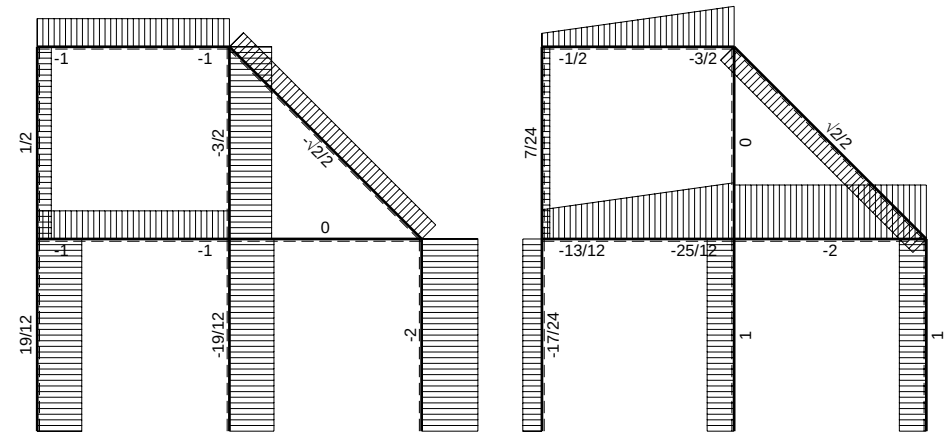
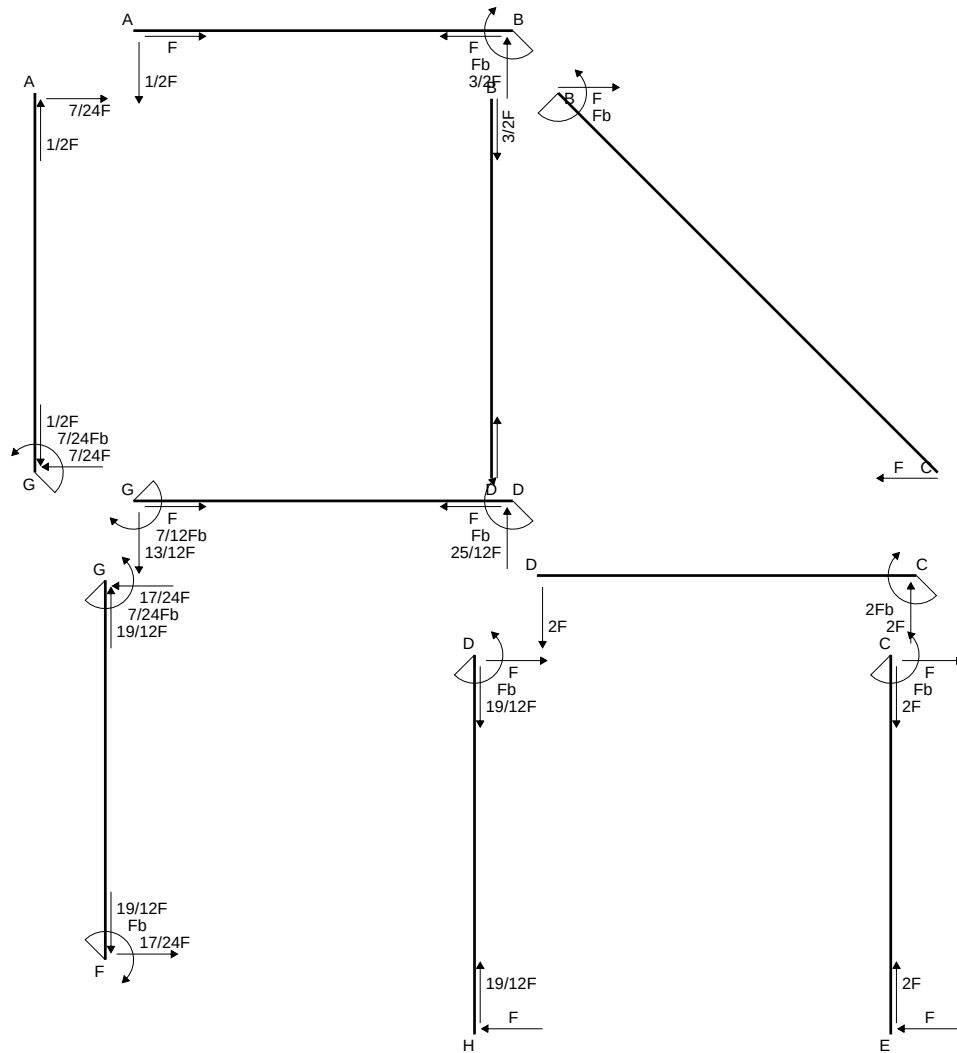
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

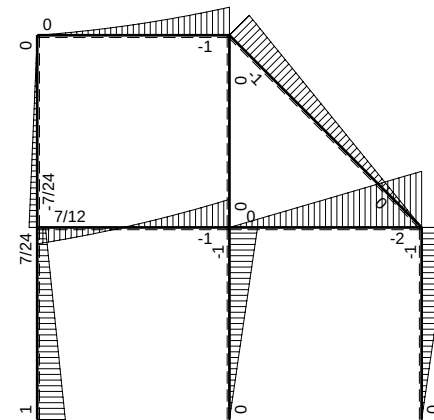
$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

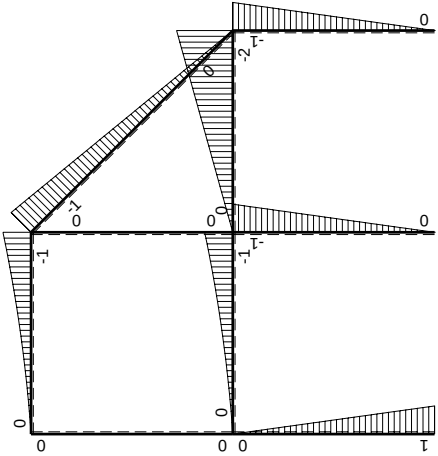
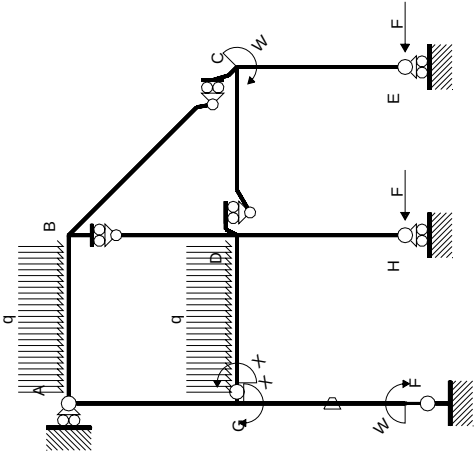


$$\begin{aligned} A &= 696. \text{ mm}^2 \\ J_u &= 265885. \text{ mm}^4 \\ J_v &= 43992. \text{ mm}^4 \\ y_g &= 24.15 \text{ mm} \\ T_y &= -2240. \text{ N} \\ M_x &= -2038400. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 29.85 \text{ mm} \\ \sigma_m &= -Mv/J_u = 228.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -17.15 \text{ mm} \\ \sigma_c &= -Mv/J_u = -131.5 \text{ N/mm}^2 \\ \tau_c &= 7.631 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 132.1 \text{ N/mm}^2 \\ S &= 5435. \text{ mm}^3 \end{aligned}$$



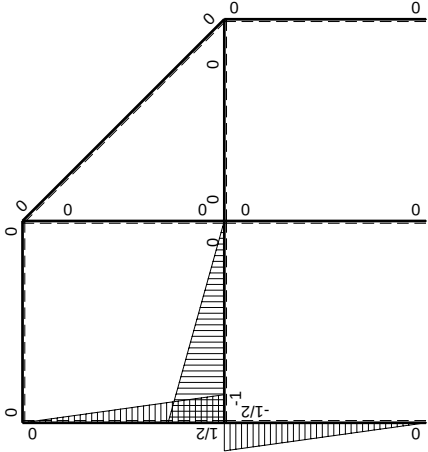
A diagram showing a positive charge, represented by a square box with a '+' sign inside. A horizontal arrow points to the right from the charge, labeled with the letter 'F', representing the direction of the electric force.





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-Fx$	$-Fb/EJ$	$-1/2Fx+1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$-Fx$	Fb/EJ	$-1/2Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$7/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

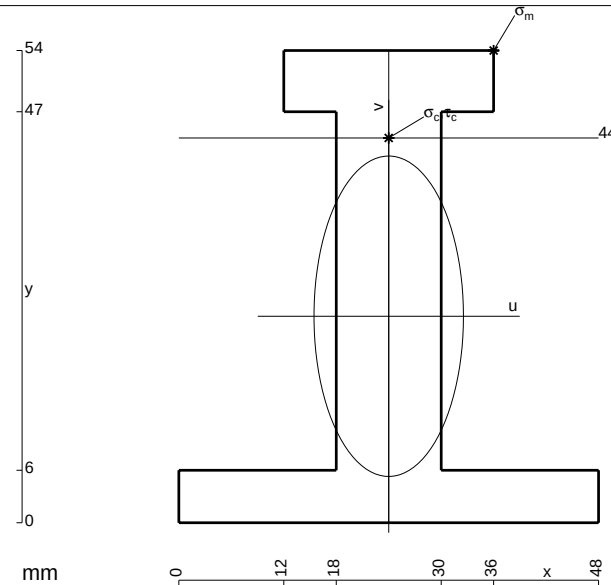
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

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

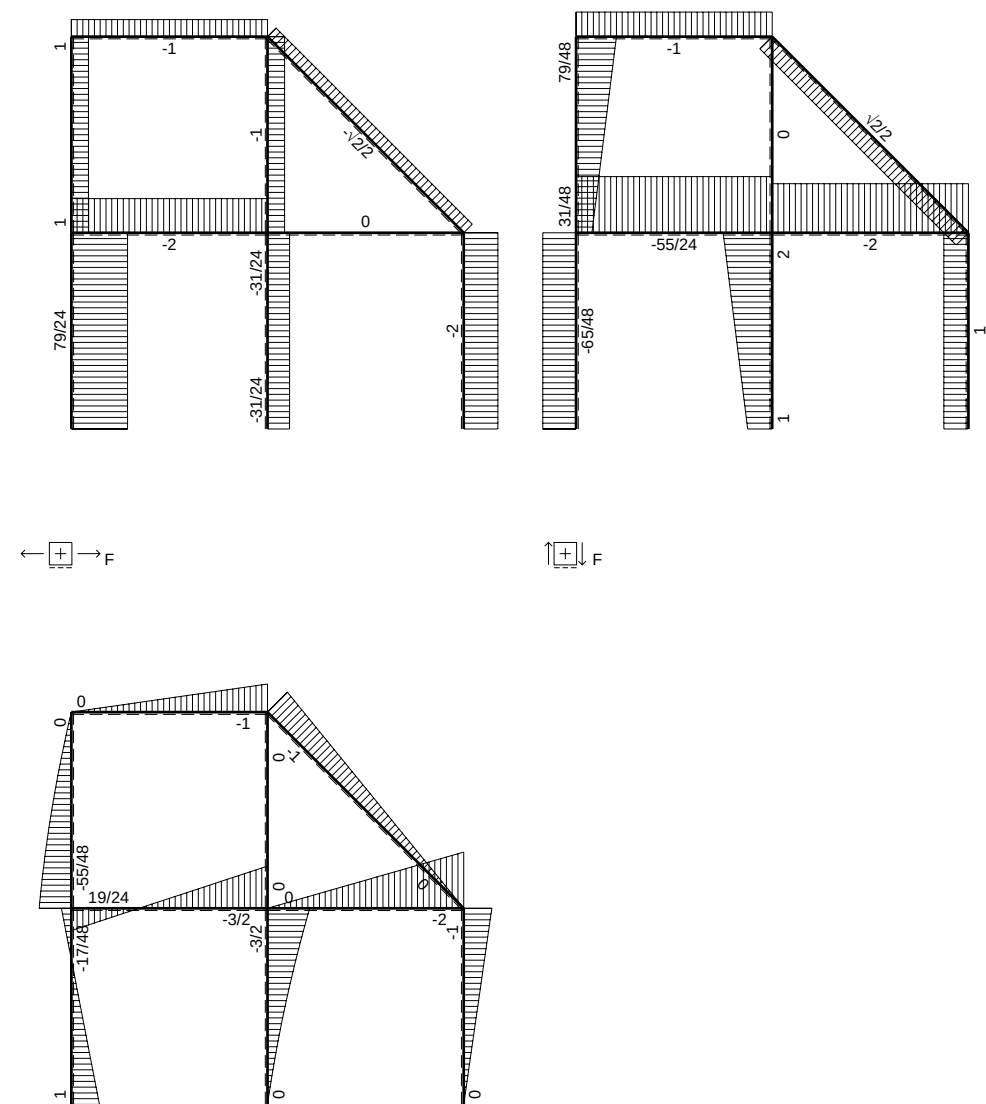
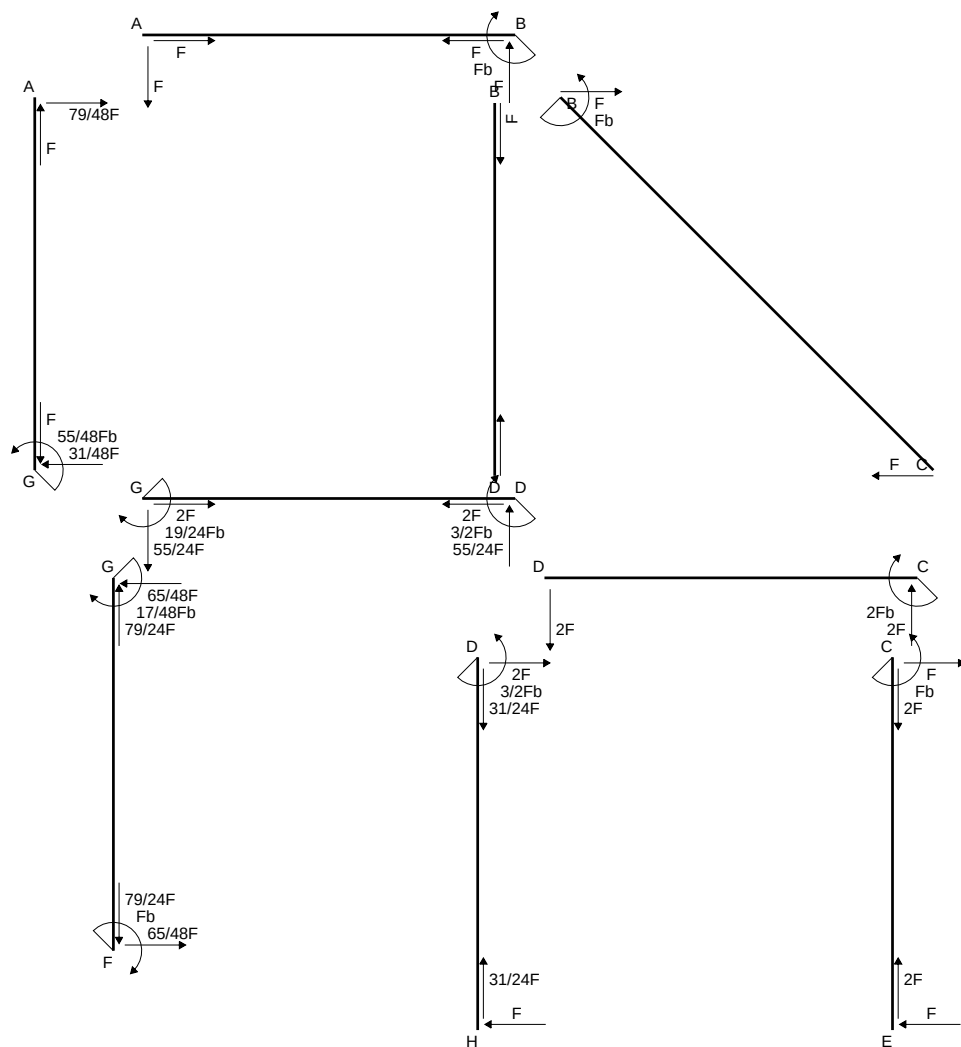
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$



$$\begin{aligned} A &= 948. \text{ mm}^2 \\ J_u &= 318391. \text{ mm}^4 \\ J_v &= 69264. \text{ mm}^4 \\ y_g &= 23.61 \text{ mm} \\ T_y &= -2600. \text{ N} \\ M_x &= -2496000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.39 \text{ mm} \\ \sigma_m &= -Mv/J_u = 238.2 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 20.39 \text{ mm} \\ \sigma_c &= -Mv/J_u = 159.8 \text{ N/mm}^2 \\ \tau_c &= 3.61 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 159.9 \text{ N/mm}^2 \\ S &= 5305. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-7/4Fx	-Fb/EJ	-1/2Fx+7/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-7/4Fx	Fb/EJ	3/8Fb-5/4Fx+7/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx ²	0	-3/8Fb+1/2Fx+1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-7/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx ²	0	-5/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						19/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-19/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{5}{4} x/b + \frac{7}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{5}{8} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{5}{8} b + \frac{7}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{24} Fb^2/EJ$$

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

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

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

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

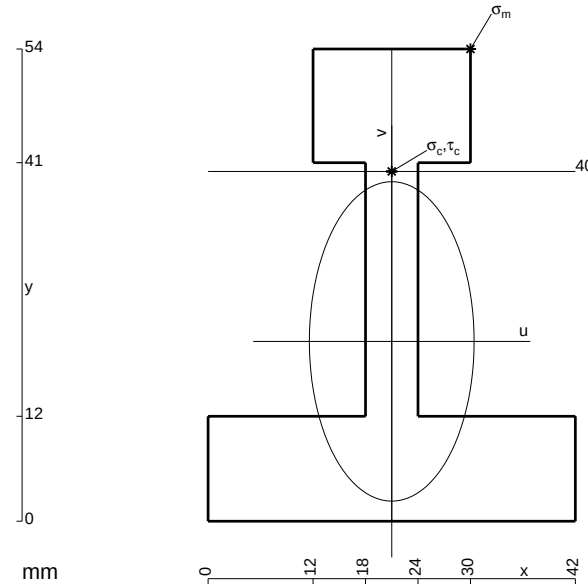
$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

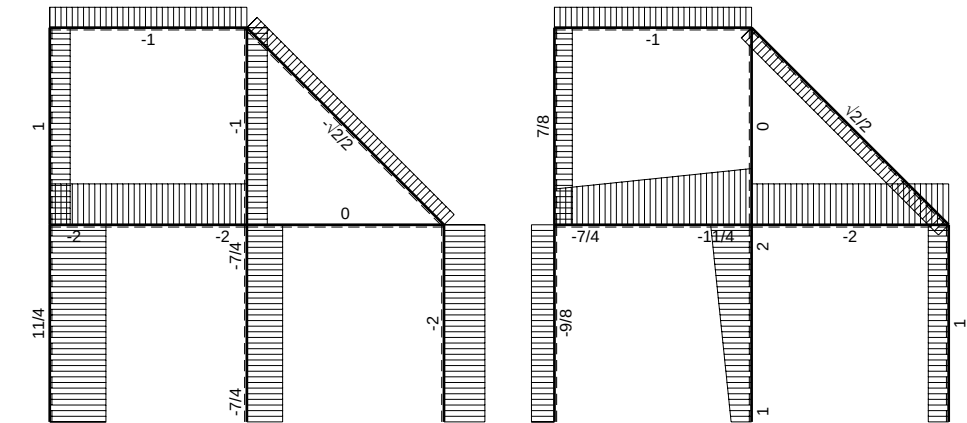
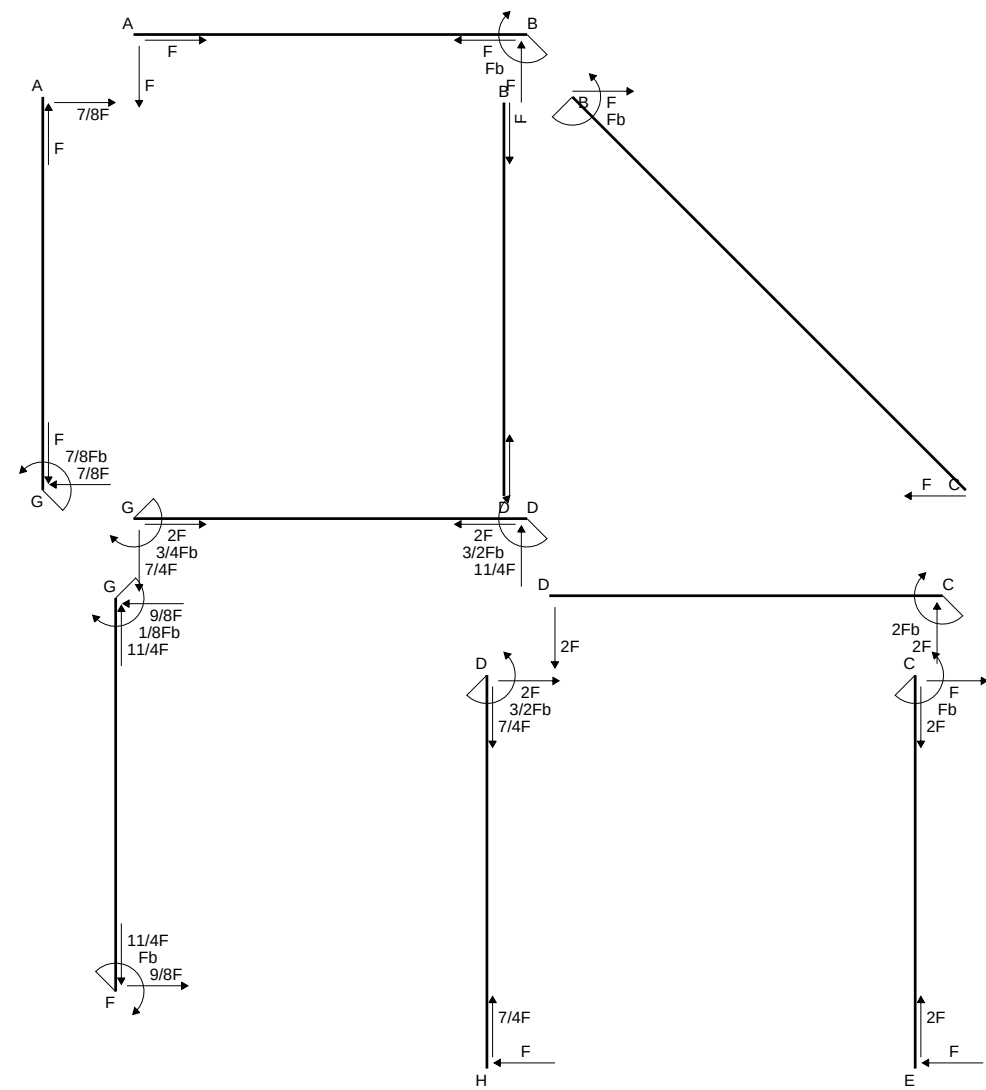
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

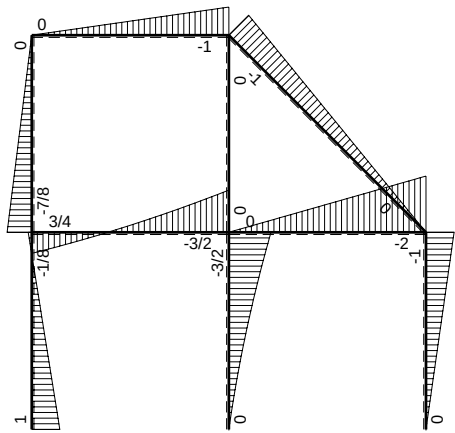


$$\begin{aligned} A &= 912. \text{ mm}^2 \\ J_u &= 304351. \text{ mm}^4 \\ J_v &= 80928. \text{ mm}^4 \\ y_g &= 20.56 \text{ mm} \\ T_y &= -3560. \text{ N} \\ M_x &= -1815600. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.44 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 19.44 \text{ mm} \\ \sigma_c &= -Mv/J_u = 116. \text{ N/mm}^2 \\ \tau_c &= 12.52 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 118. \text{ N/mm}^2 \\ S &= 6424. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(0+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-Fx-1/2qx ²	0	Fx-1/2Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(5/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx ²	0	3/2Fx-2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						3/8Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-3/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left(\frac{1}{2} b - \frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

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

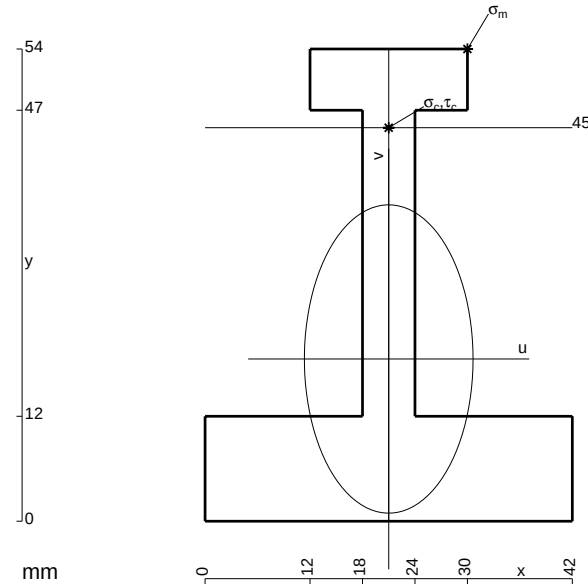
$$= \left(\frac{3}{4} b - \frac{2}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

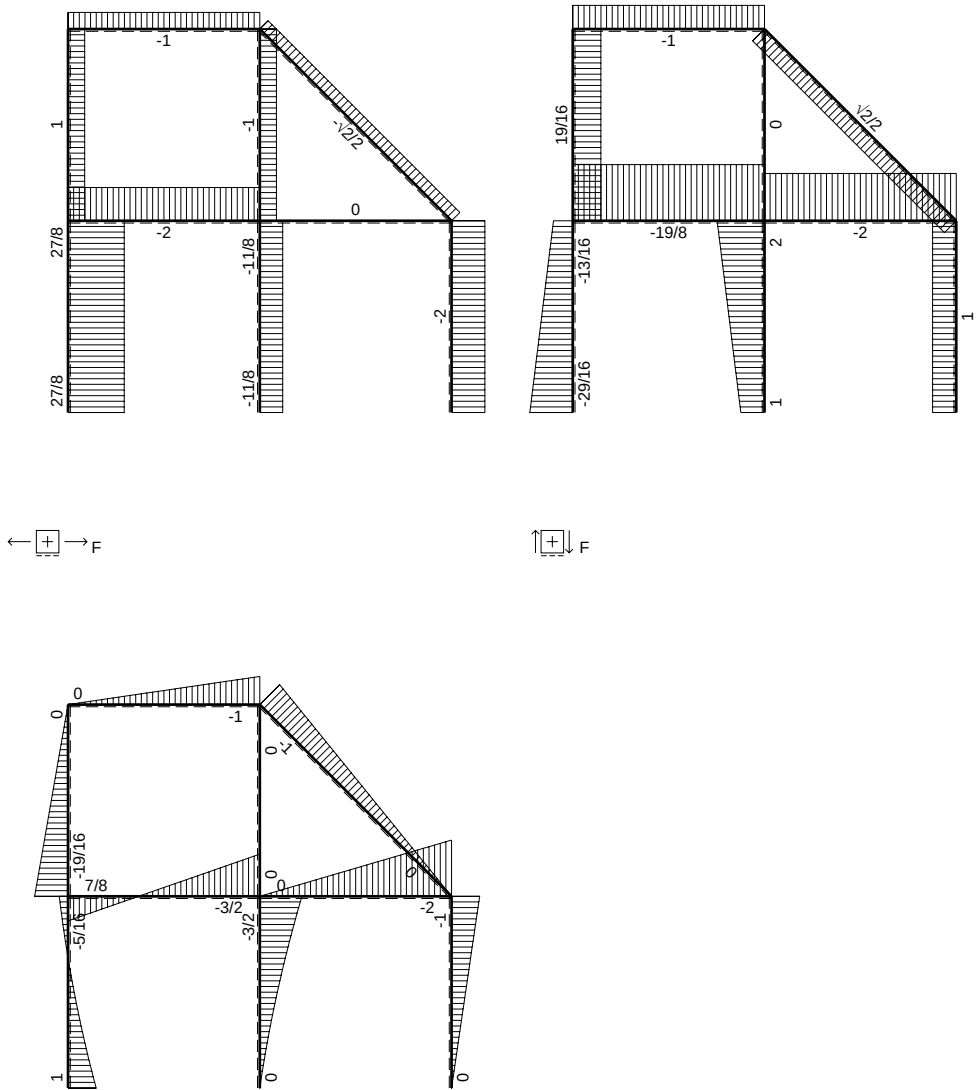
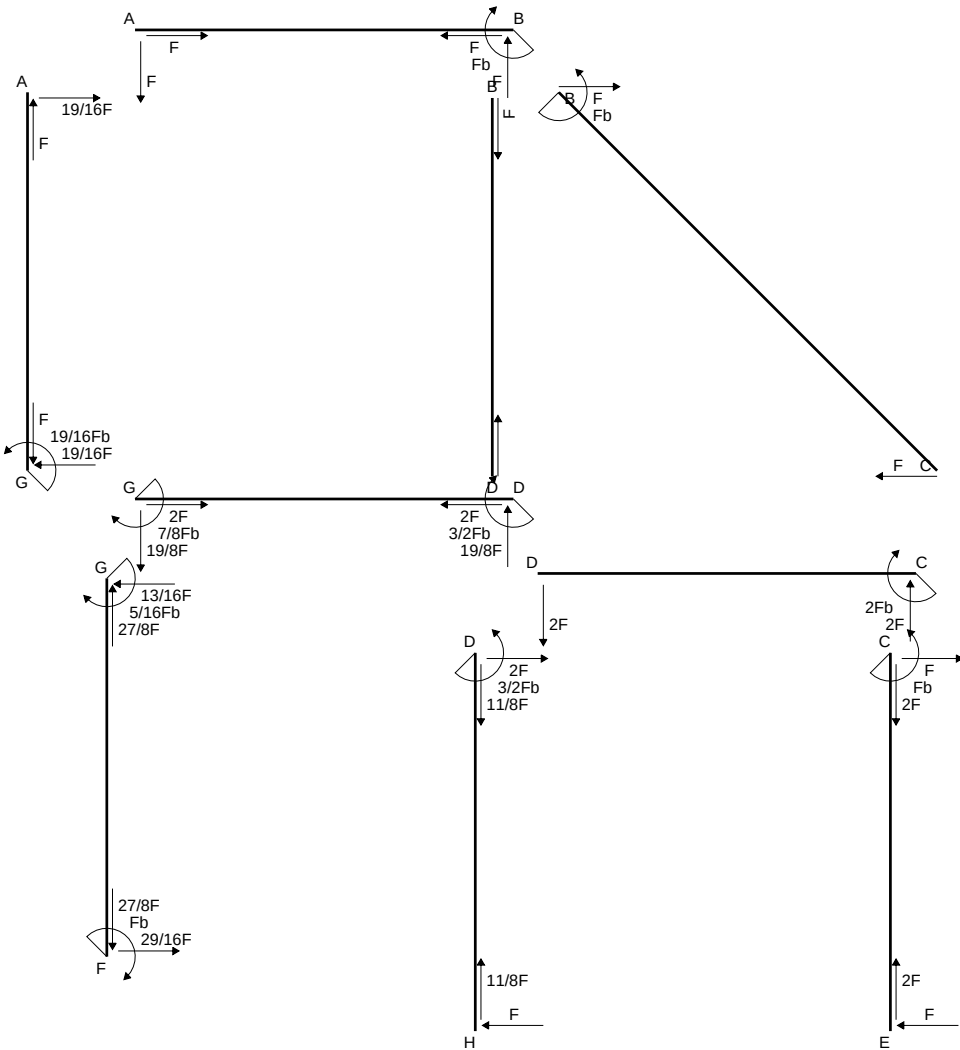
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

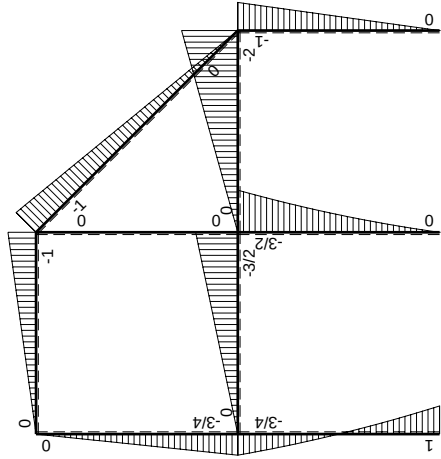
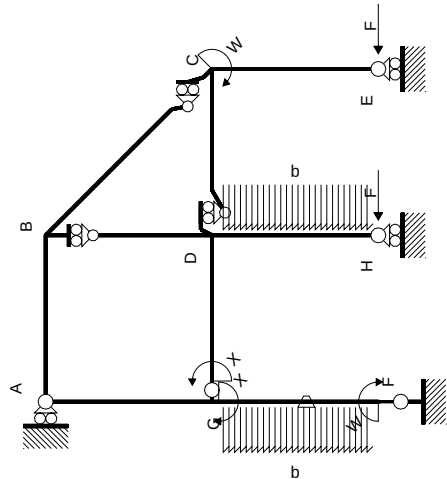
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



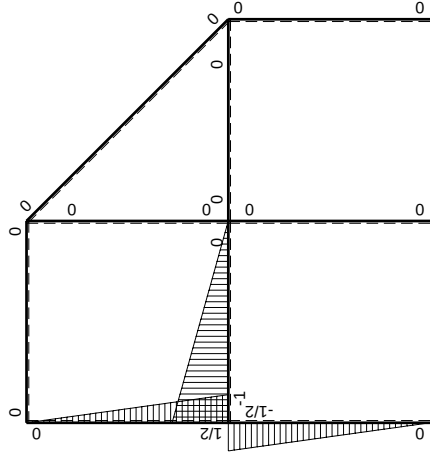
$$\begin{aligned} A &= 840. \text{ mm}^2 \\ J_u &= 261182. \text{ mm}^4 \\ J_v &= 78120. \text{ mm}^4 \\ y_g &= 18.55 \text{ mm} \\ T_y &= -2760. \text{ N} \\ M_x &= -1545600. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 35.45 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 26.45 \text{ mm} \\ \sigma_c &= -Mv/J_u = 156.5 \text{ N/mm}^2 \\ \tau_c &= 7.67 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 157.1 \text{ N/mm}^2 \\ S &= 4355. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-9/4Fx+1/2qx ²	-Fb/EJ	-1/2Fx+9/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(1/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-5/4Fx-1/2qx ²	Fb/EJ	3/8Fb-Fx+3/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/8+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx ² /b	0	1/4x ² /b ²		
	totali						7/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + \frac{9}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{3}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{16} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{8} - x/b + \frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{2} x^2/b + \frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{2} b + \frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{16} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

$$L_{DG}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

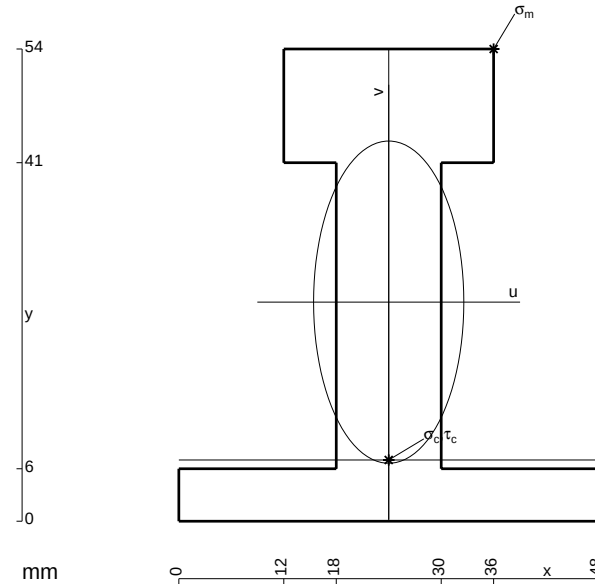
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

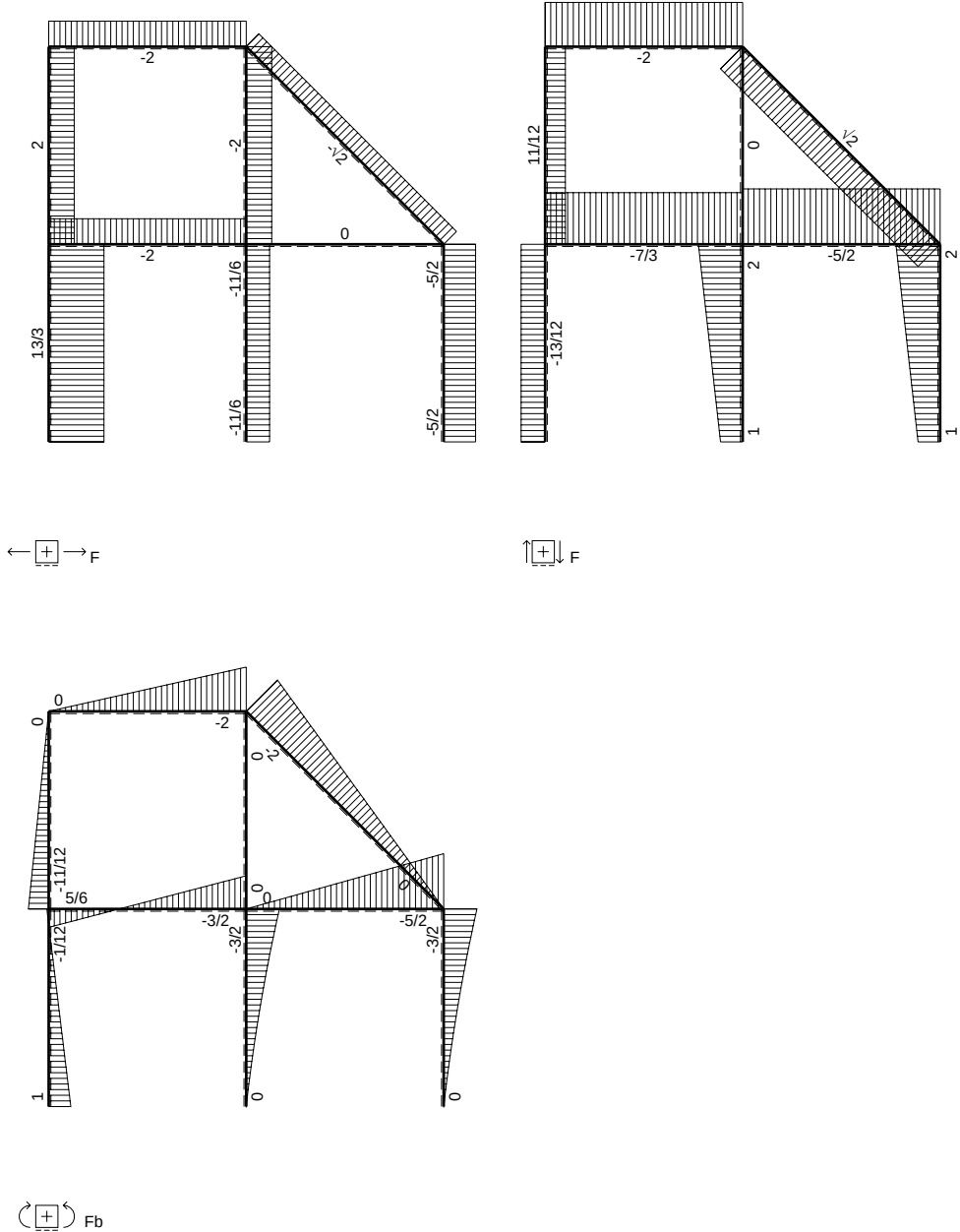
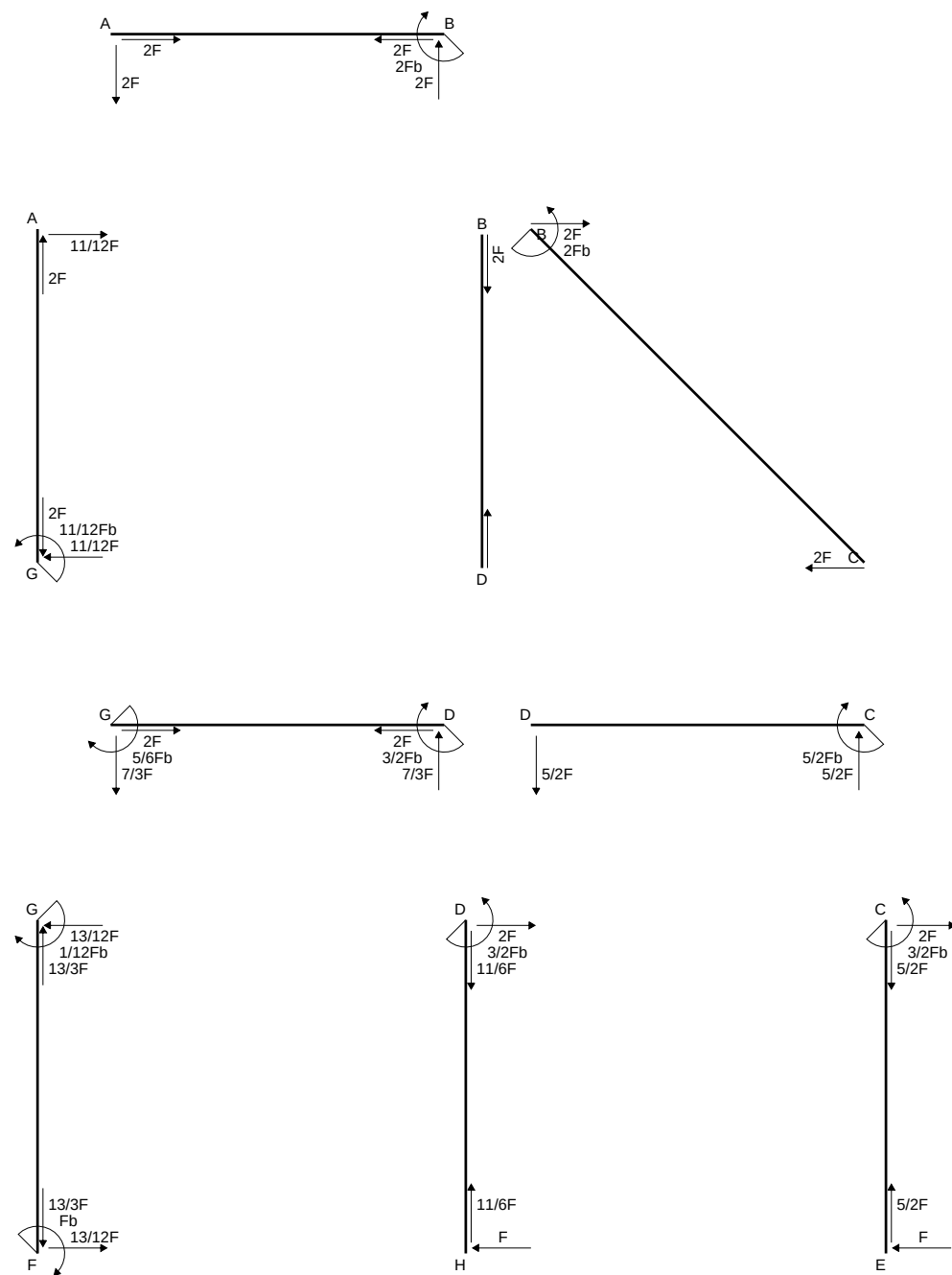
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

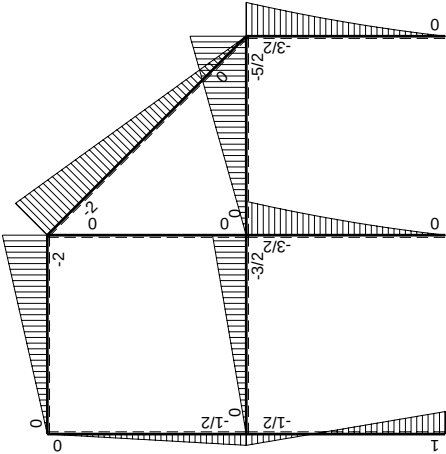
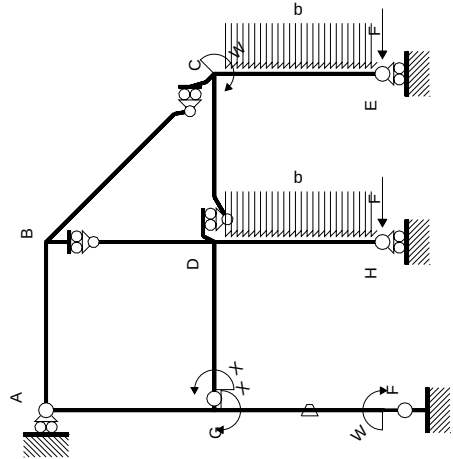
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



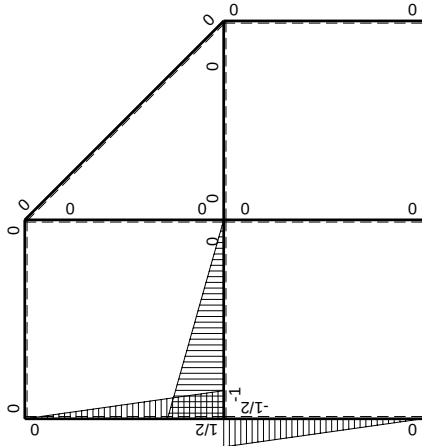
$$\begin{aligned} A &= 1020. \text{ mm}^2 \\ J_u &= 346417. \text{ mm}^4 \\ J_v &= 75312. \text{ mm}^4 \\ y_g &= 25.05 \text{ mm} \\ T_y &= -4300. \text{ N} \\ M_x &= -2623000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.95 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219.2 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -18.05 \text{ mm} \\ \sigma_c &= -Mv/J_u = -136.7 \text{ N/mm}^2 \\ \tau_c &= 6.8 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 137.2 \text{ N/mm}^2 \\ S &= 6574. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(0+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						5/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

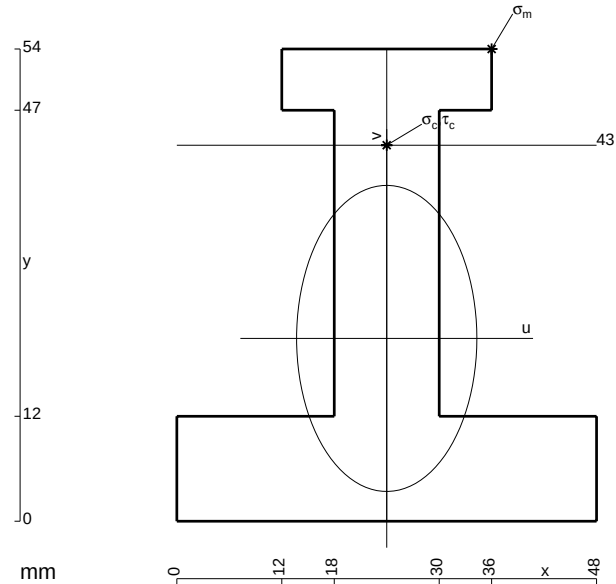
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

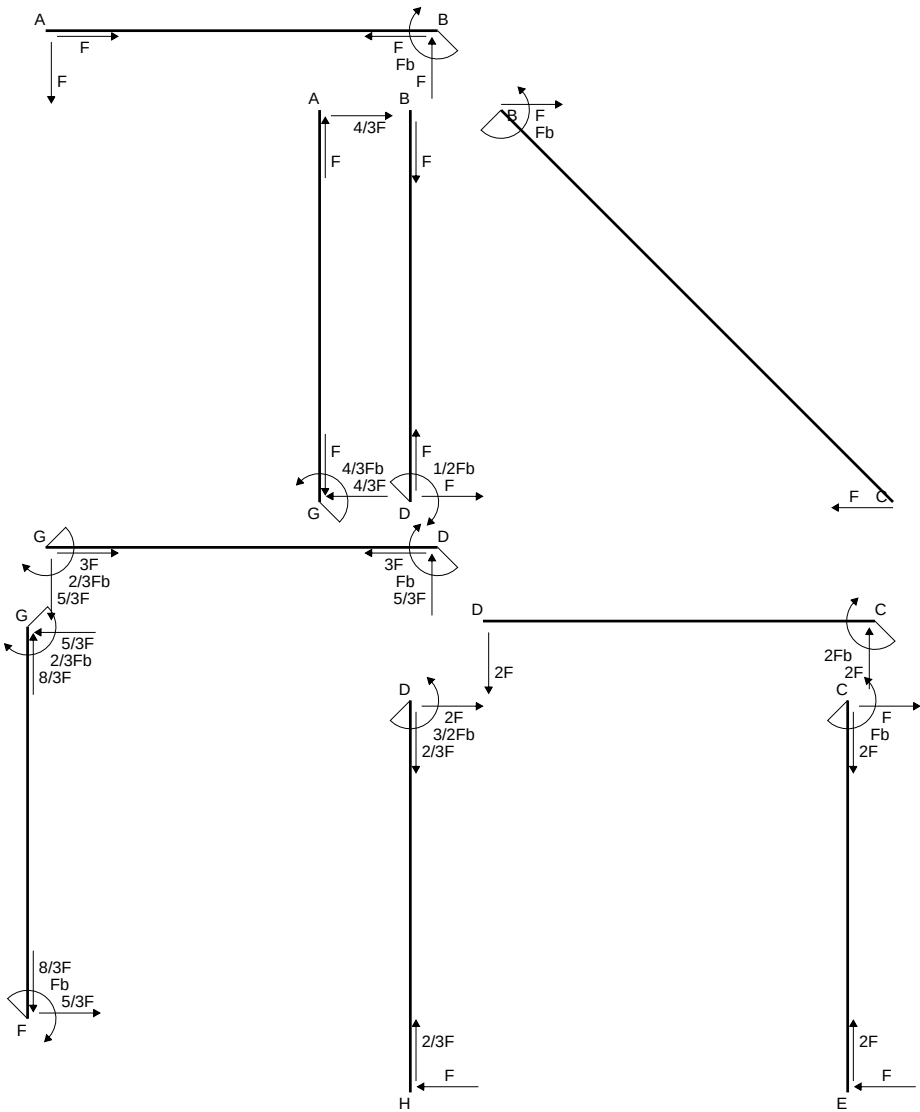
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



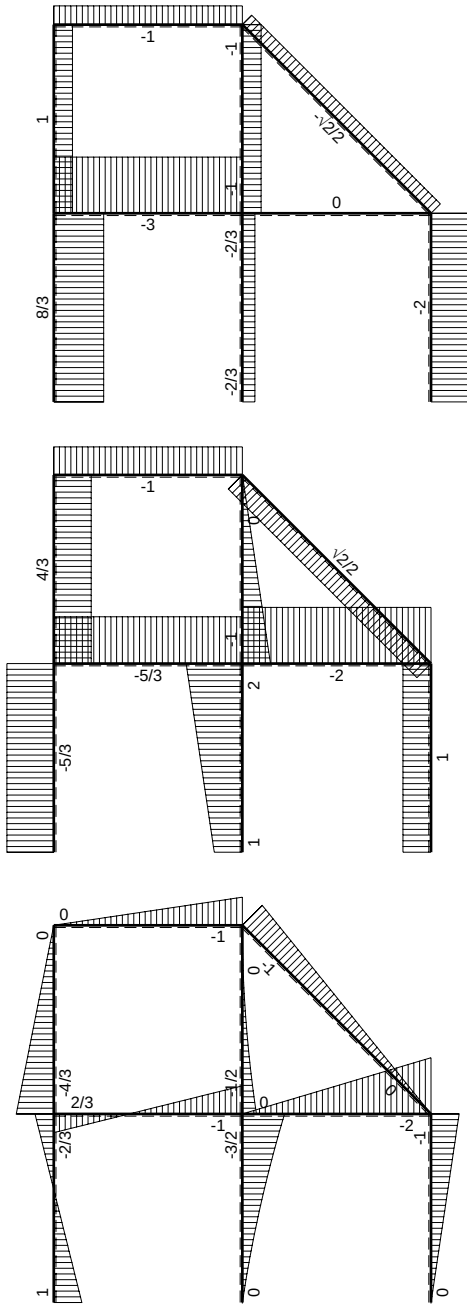
$$\begin{aligned} A &= 1164. \text{ mm}^2 \\ J_u &= 356609. \text{ mm}^4 \\ J_v &= 123696. \text{ mm}^4 \\ y_g &= 20.9 \text{ mm} \\ T_y &= -3750. \text{ N} \\ M_x &= -2475000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 33.1 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 22.1 \text{ mm} \\ \sigma_c &= -Mv/J_u = 153.4 \text{ N/mm}^2 \\ \tau_c &= 5.371 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 153.6 \text{ N/mm}^2 \\ S &= 6129. \text{ mm}^3 \end{aligned}$$

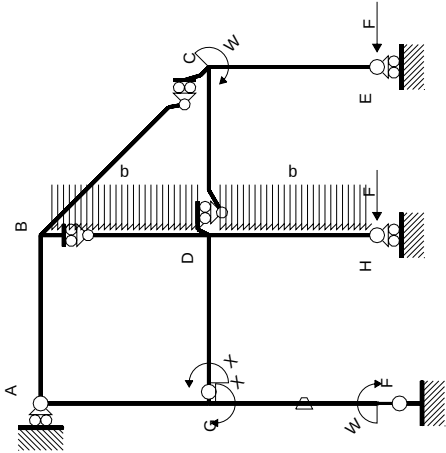


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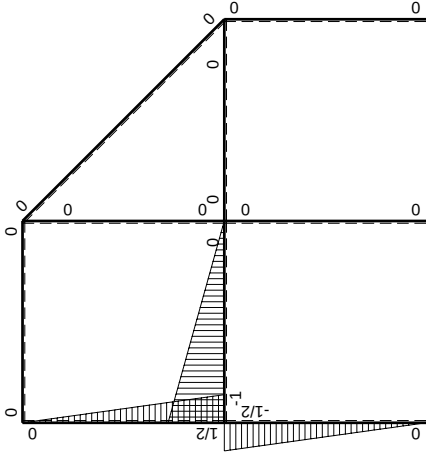
$\curvearrowright \boxed{+} \curvearrowleft Fb$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-2Fx	-Fb/EJ	-1/2Fx+Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-2Fx	Fb/EJ	1/2Fb-3/2Fx+Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						1/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left[\frac{1}{2} x - \frac{3}{4} x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

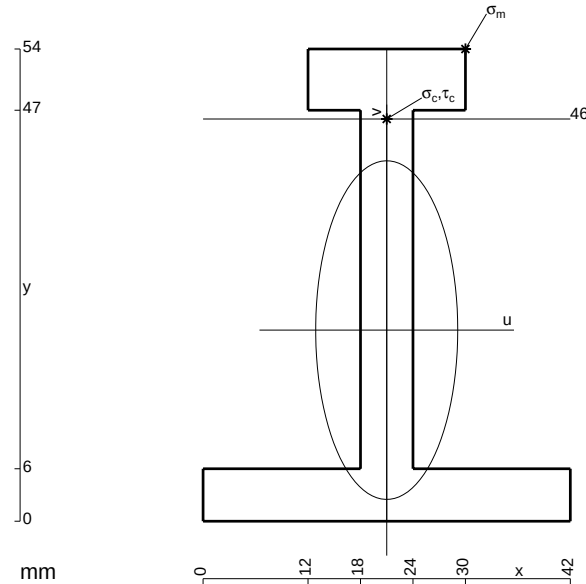
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

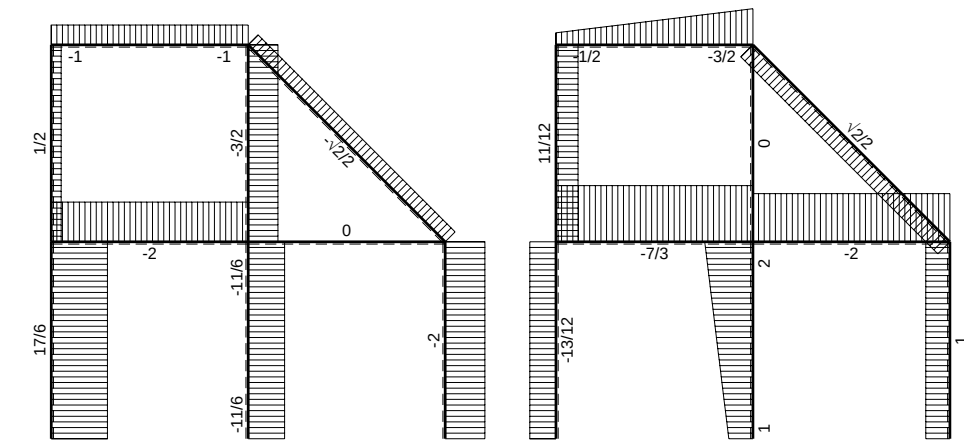
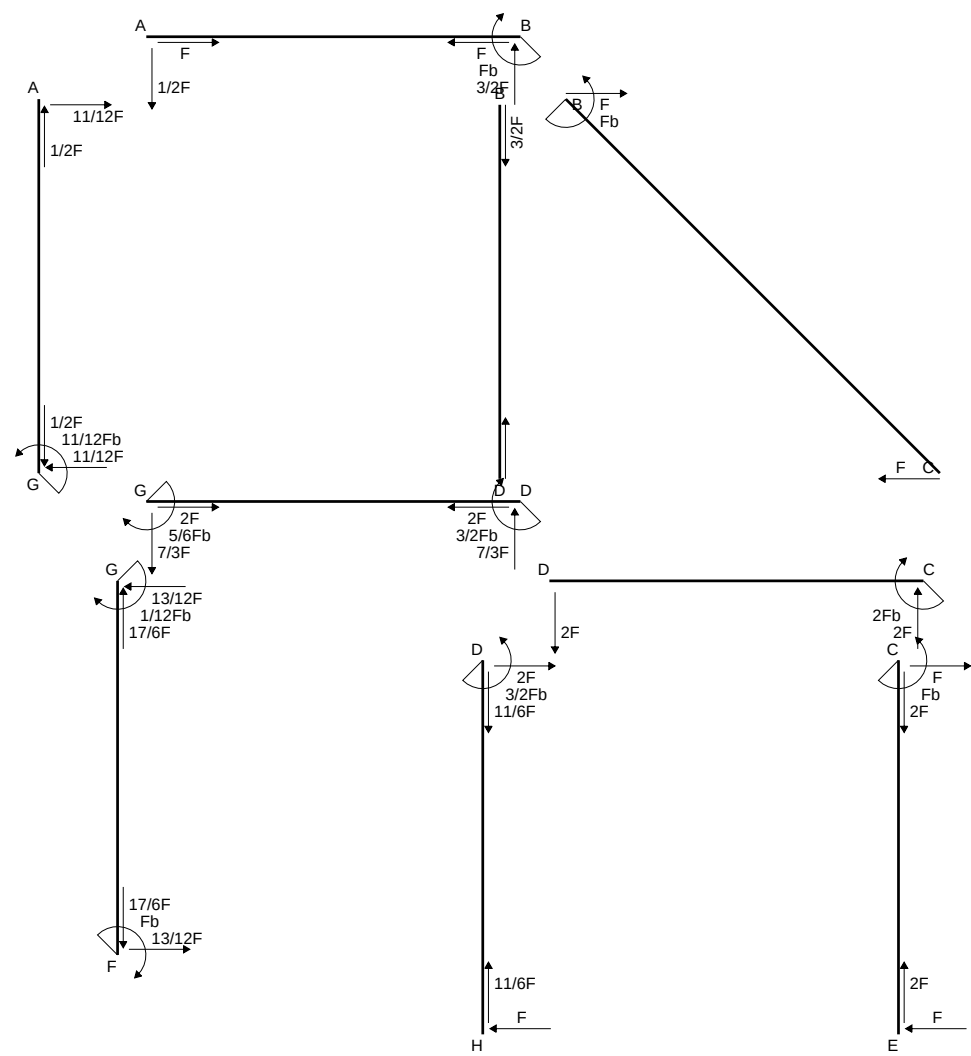
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

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

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

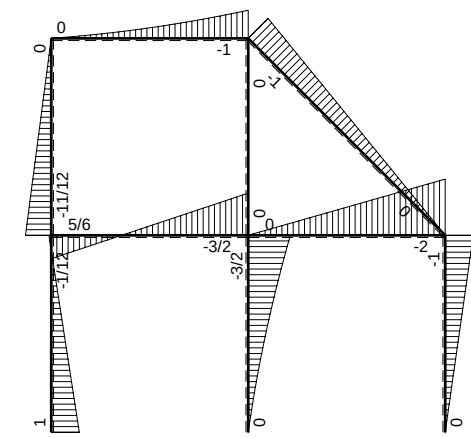


$$\begin{aligned} A &= 624. \text{ mm}^2 \\ J_u &= 234015. \text{ mm}^4 \\ J_v &= 41184. \text{ mm}^4 \\ y_g &= 21.86 \text{ mm} \\ T_y &= -2460. \text{ N} \\ M_x &= -1746600. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 32.14 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 24.14 \text{ mm} \\ \sigma_c &= -Mv/J_u = 180.2 \text{ N/mm}^2 \\ \tau_c &= 6.582 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 180.6 \text{ N/mm}^2 \\ S &= 3757. \text{ mm}^3 \end{aligned}$$

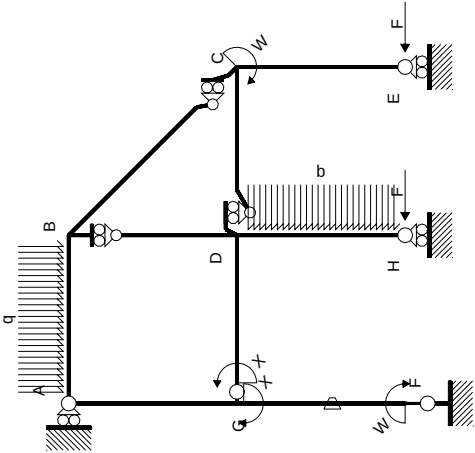


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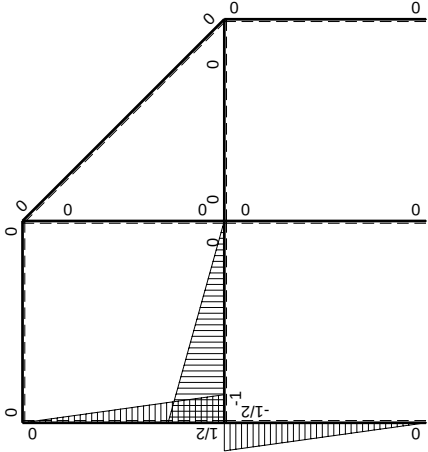
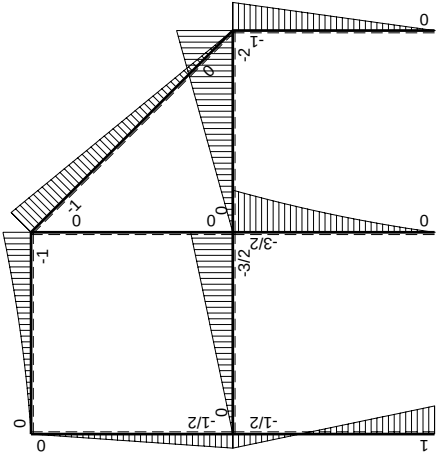


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-3/2Fx$	$-Fb/EJ$	$-1/2Fx+3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(0+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-3/2Fx$	Fb/EJ	$1/4Fb-Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

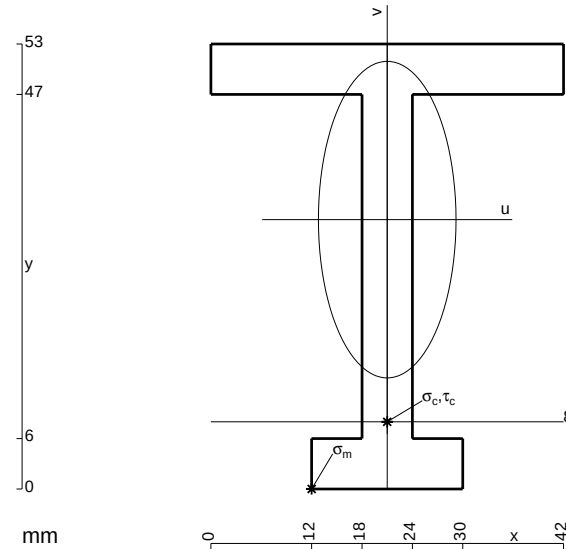
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

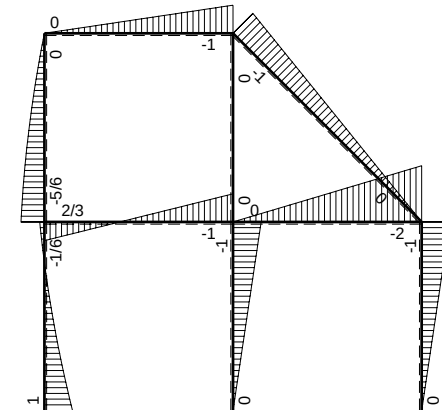
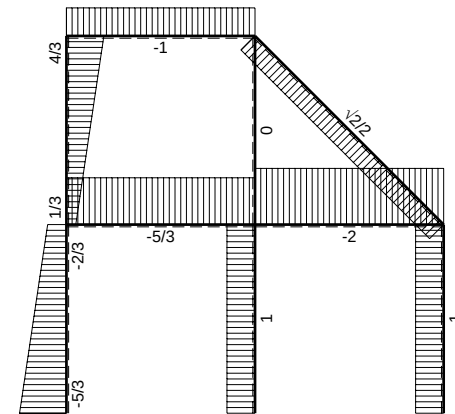
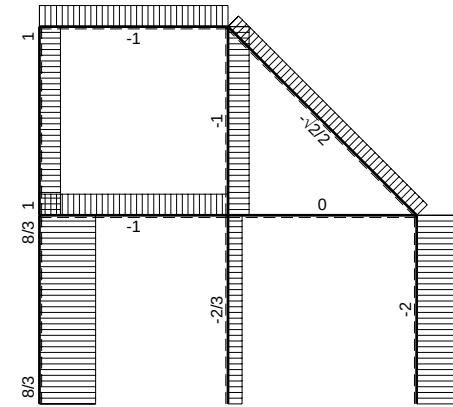
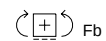
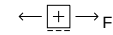
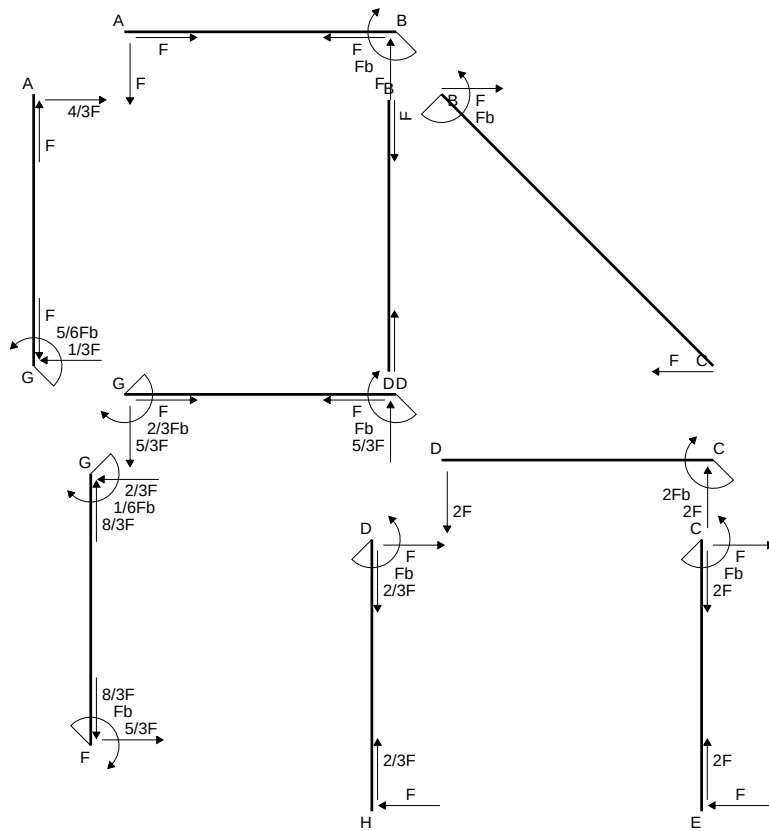
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



$$\begin{aligned} A &= 606. \text{ mm}^2 \\ J_u &= 215454. \text{ mm}^4 \\ J_v &= 40698. \text{ mm}^4 \\ y_g &= 32.08 \text{ mm} \\ T_y &= -1780. \text{ N} \\ M_x &= -1335000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -32.08 \text{ mm} \\ \sigma_m &= -Mv/J_u = -198.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 8. \text{ mm} \\ v_c &= -24.08 \text{ mm} \\ \sigma_c &= -Mv/J_u = -149.2 \text{ N/mm}^2 \\ \tau_c &= 4.74 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 149.5 \text{ N/mm}^2 \\ S &= 3442. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-2Fx+1/2qx ²	-Fb/EJ	-1/2Fx+Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(1/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-Fx-1/2qx ²	Fb/EJ	1/4Fb-3/4Fx+1/4Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2qx ²	0	-1/4Fb+1/4Fx+1/4Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-5/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx-1/2qx ²	0	-1/2Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						1/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{3} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{3} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{13}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{3}{4} x/b + \frac{1}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{3}{8} x^2/b + \frac{1}{12} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{3}{8} b + \frac{1}{12} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{13}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

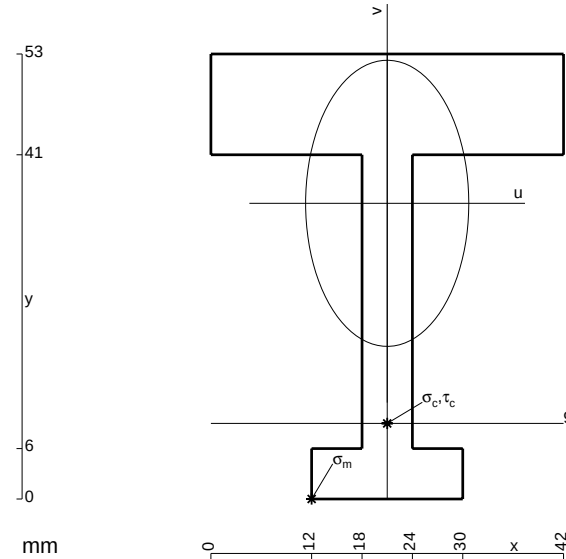
$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{4} x/b + \frac{1}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{1}{4} x + \frac{1}{8} x^2/b + \frac{1}{12} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

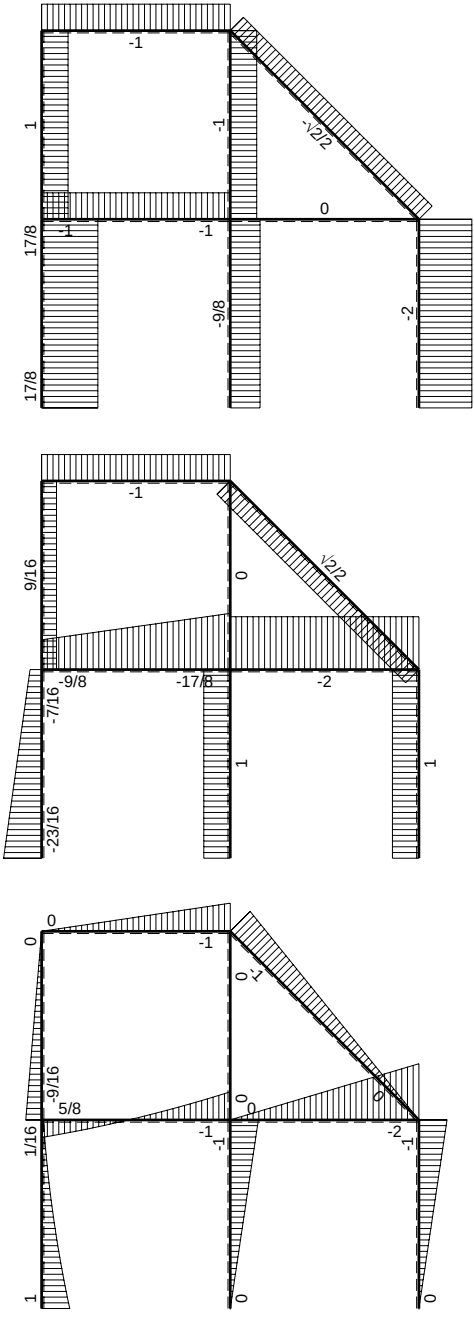
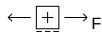
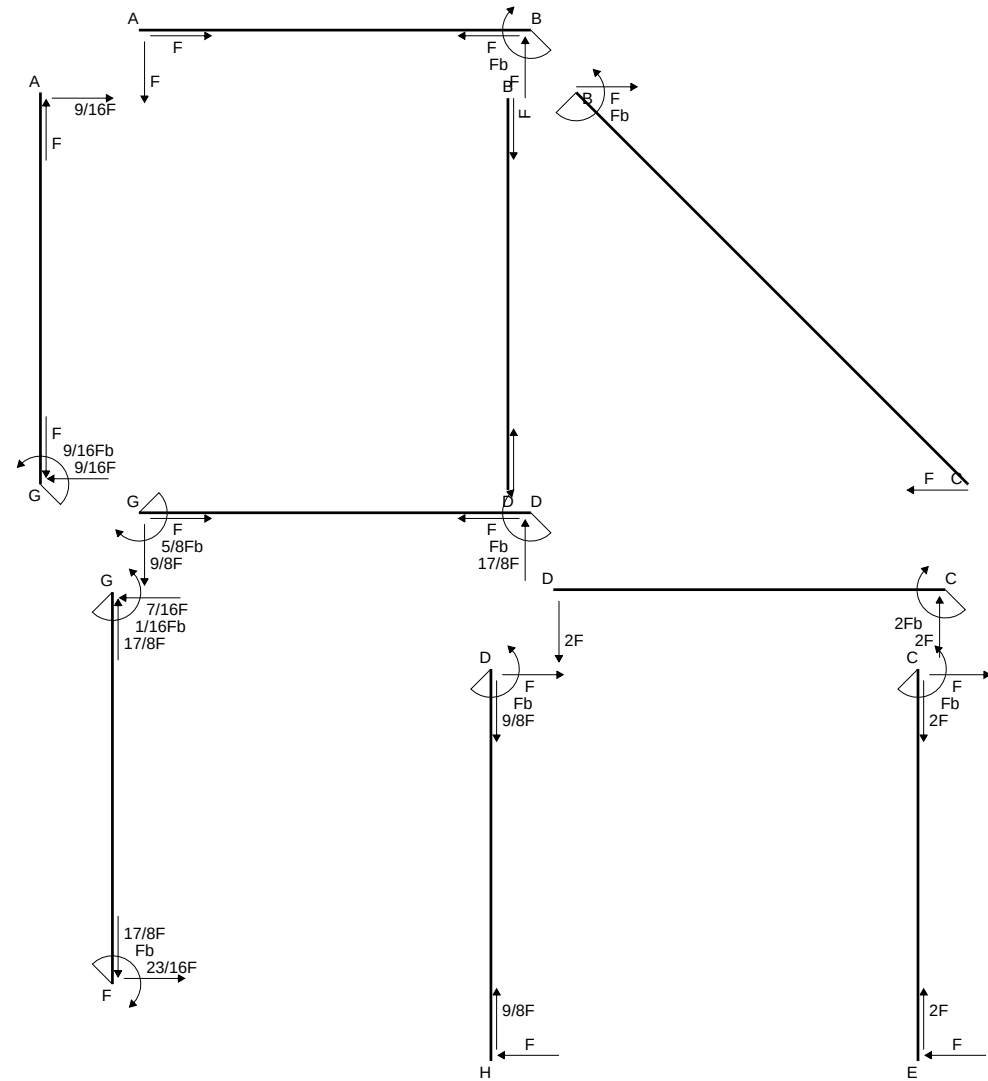
$$= \left(-\frac{1}{4} b + \frac{1}{8} b + \frac{1}{12} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{5}{48} Fb^2/EJ$$

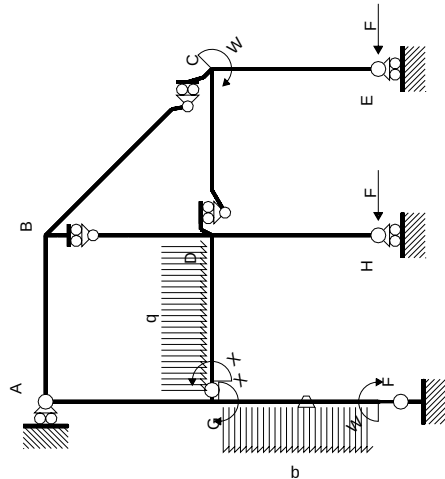
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{5}{48} Fb^2/EJ$$



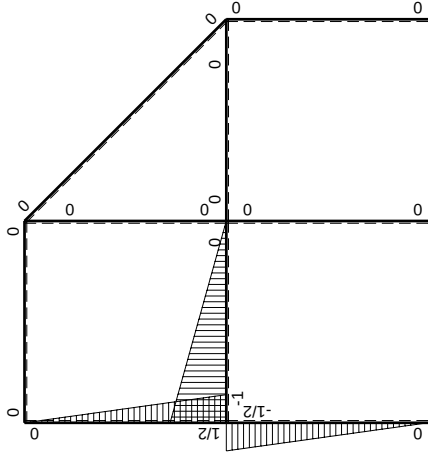
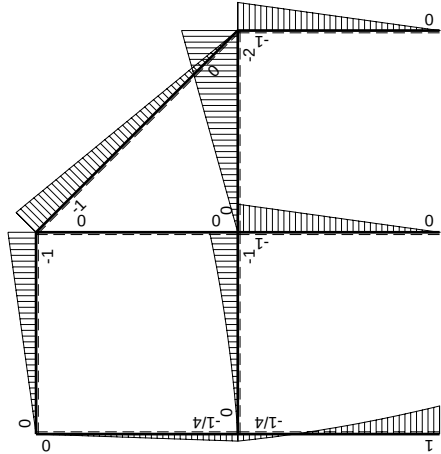
$$\begin{aligned} A &= 822. \text{ mm}^2 \\ J_u &= 238712. \text{ mm}^4 \\ J_v &= 77634. \text{ mm}^4 \\ y_g &= 35.22 \text{ mm} \\ T_y &= -1760. \text{ N} \\ M_x &= -1408000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -35.22 \text{ mm} \\ \sigma_m &= -Mv/J_u = -207.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -26.22 \text{ mm} \\ \sigma_c &= -Mv/J_u = -154.6 \text{ N/mm}^2 \\ \tau_c &= 4.888 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 154.9 \text{ N/mm}^2 \\ S &= 3978. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-7/4Fx+1/2qx ²	-Fb/EJ	-1/2Fx+7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(-1/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx ²	Fb/EJ	1/8Fb-1/2Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx ² /b	0	1/4x ² /b ²		
	totali						5/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{8} - \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{1}{4} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

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

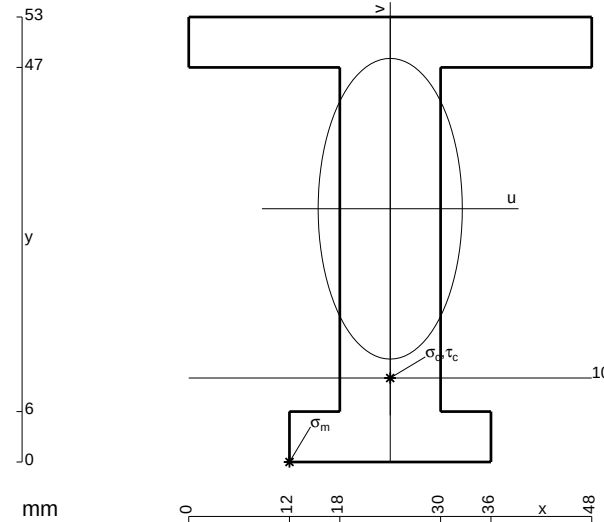
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

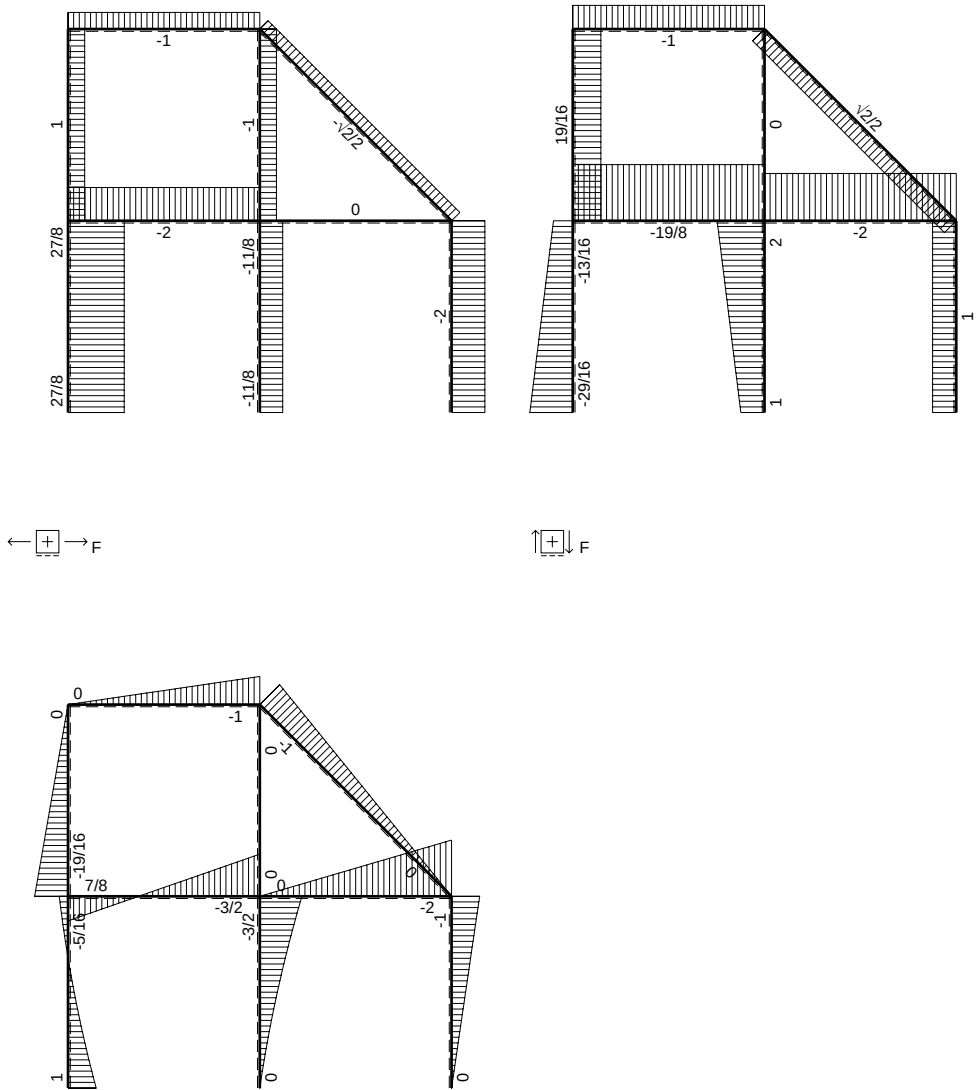
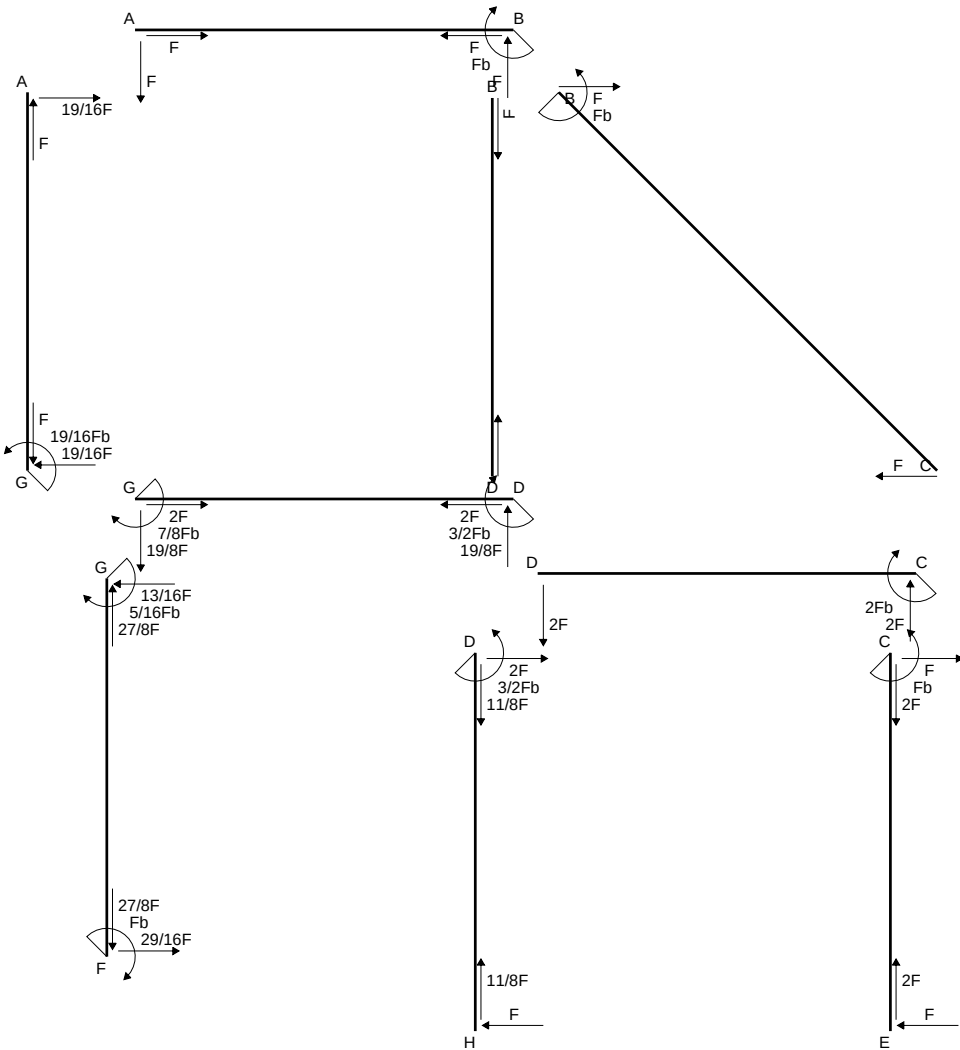
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



$$\begin{aligned} A &= 924. \text{ mm}^2 \\ J_u &= 296396. \text{ mm}^4 \\ J_v &= 68112. \text{ mm}^4 \\ y_g &= 30.16 \text{ mm} \\ T_y &= -2540. \text{ N} \\ M_x &= -2159000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.16 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -20.16 \text{ mm} \\ \sigma_c &= -Mv/J_u = -146.9 \text{ N/mm}^2 \\ \tau_c &= 3.553 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 147. \text{ N/mm}^2 \\ S &= 4975. \text{ mm}^3 \end{aligned}$$



$\left[\begin{smallmatrix} + \\ + \end{smallmatrix} \right] Fb$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-9/4Fx+1/2qx ²	-Fb/EJ	-1/2Fx+9/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(1/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-5/4Fx-1/2qx ²	Fb/EJ	3/8Fb-Fx+3/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/8+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx ² /b	0	1/4x ² /b ²		
	totali						7/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + \frac{9}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{3}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{16} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{8} - x/b + \frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{2} x^2/b + \frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{2} b + \frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{16} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

$$L_{DG}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

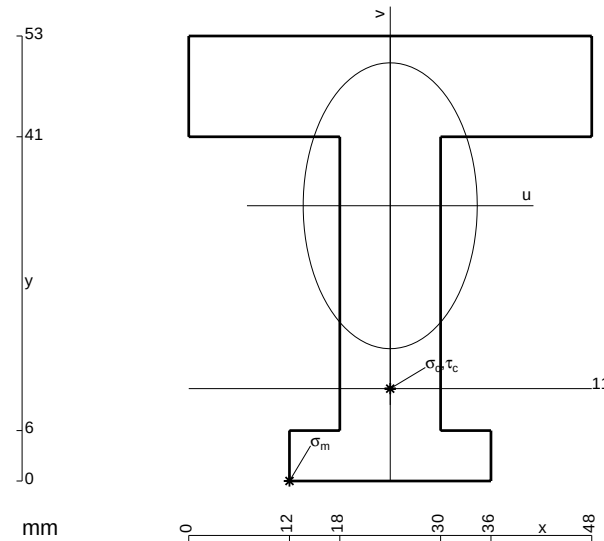
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

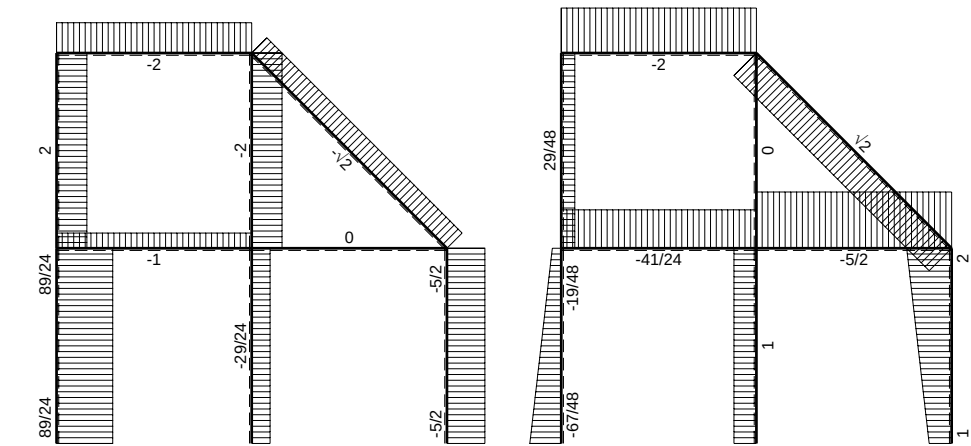
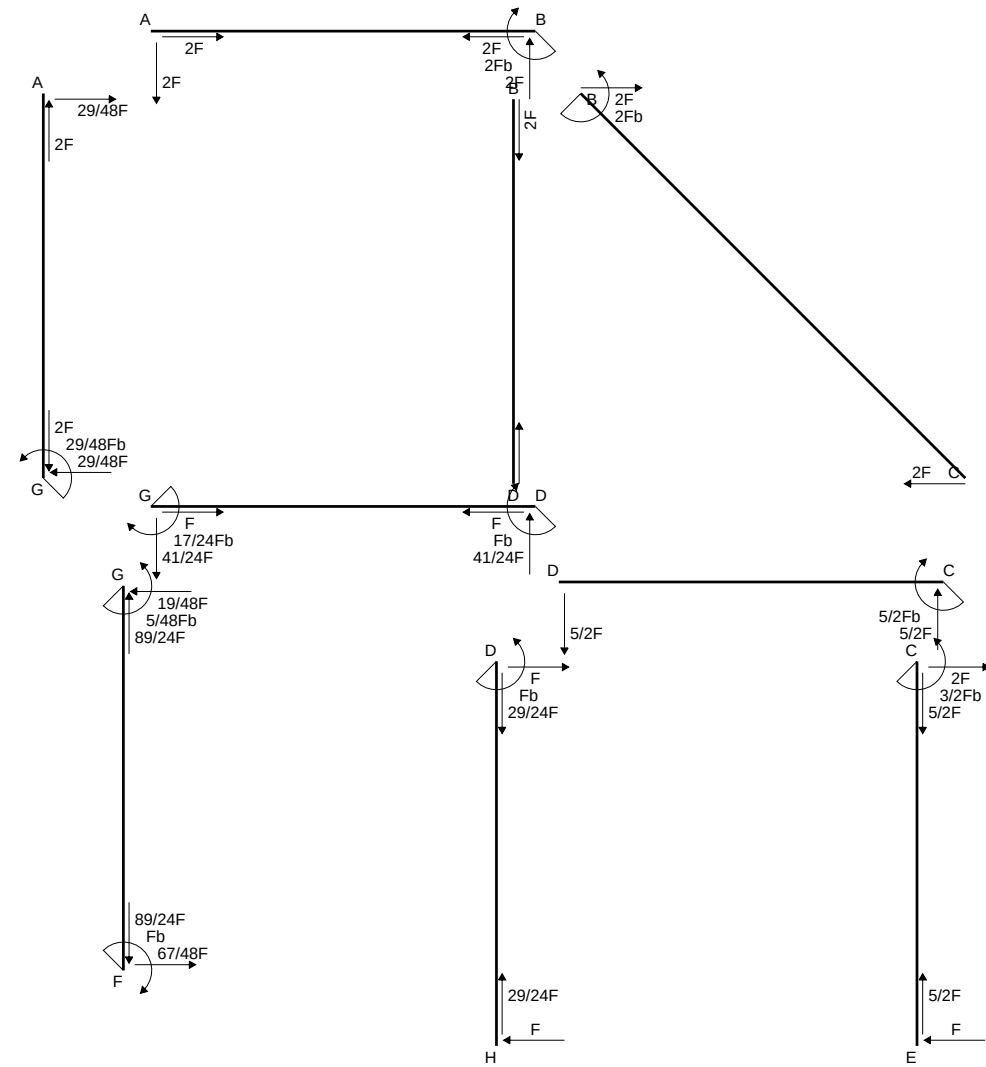
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

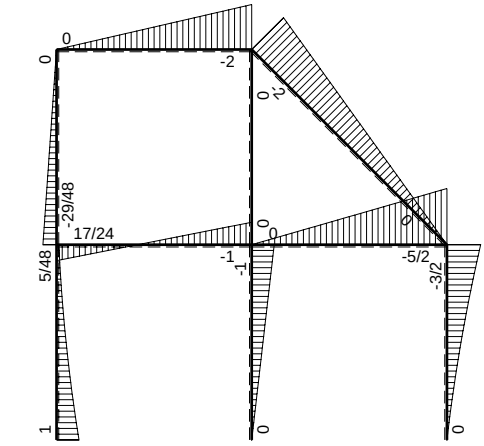


$$\begin{aligned} A &= 1140. \text{ mm}^2 \\ J_u &= 330567. \text{ mm}^4 \\ J_v &= 122544. \text{ mm}^4 \\ y_g &= 32.78 \text{ mm} \\ T_y &= -2560. \text{ N} \\ M_x &= -2304000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.78 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -21.78 \text{ mm} \\ \sigma_c &= -Mv/J_u = -151.8 \text{ N/mm}^2 \\ \tau_c &= 3.708 \text{ N/mm}^2 \\ \sigma_q &= \sqrt{\sigma^2 + 3\tau^2} = 152. \text{ N/mm}^2 \\ S &= 5746. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ Fb

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-7/4Fx+1/2qx ²	-Fb/EJ	-1/2Fx+7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(-1/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx ²	Fb/EJ	1/8Fb-1/2Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx ² /b	0	1/4x ² /b ²		
	totali						17/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-17/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{8} - \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{1}{4} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

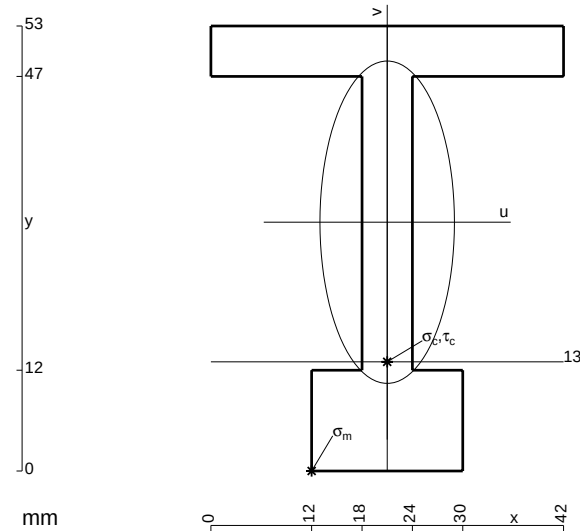
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

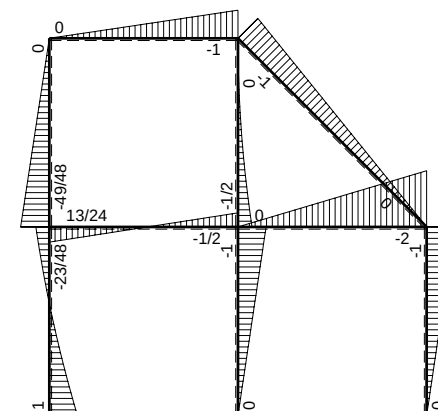
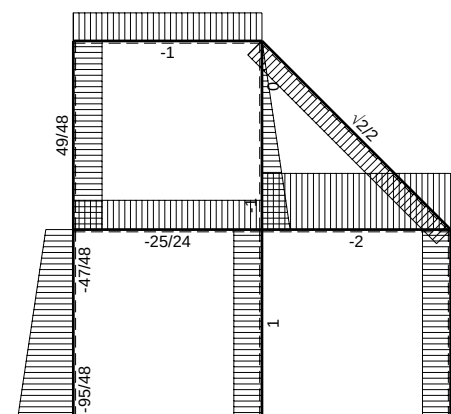
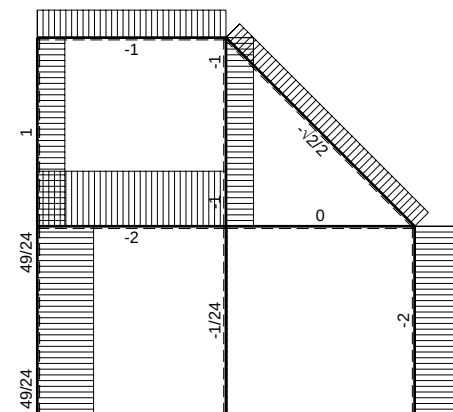
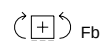
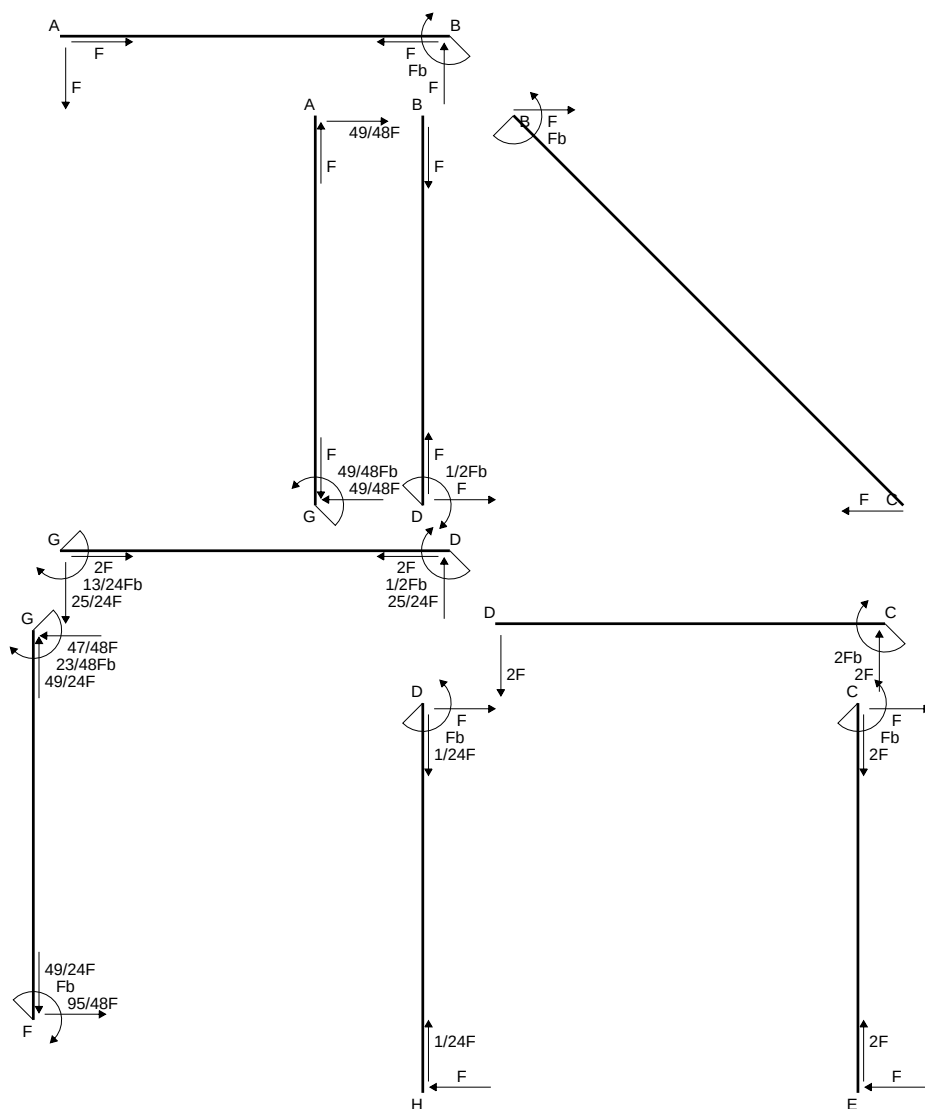
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



$$\begin{aligned} A &= 678. \text{ mm}^2 \\ J_u &= 249963. \text{ mm}^4 \\ J_v &= 43506. \text{ mm}^4 \\ y_g &= 29.63 \text{ mm} \\ T_y &= -2125. \text{ N} \\ M_x &= -2018750. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -29.63 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -16.63 \text{ mm} \\ \sigma_c &= -Mv/J_u = -134.3 \text{ N/mm}^2 \\ \tau_c &= 7.378 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 134.9 \text{ N/mm}^2 \\ S &= 5207. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-9/4Fx+1/2qx^2$	$-Fb/EJ$	$-1/2Fx+9/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/16+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-5/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-Fx+3/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$13/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-13/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + \frac{9}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{3}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{16} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{8} - x/b + \frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{2} x^2/b + \frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{2} b + \frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{16} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

$$L_{DG}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

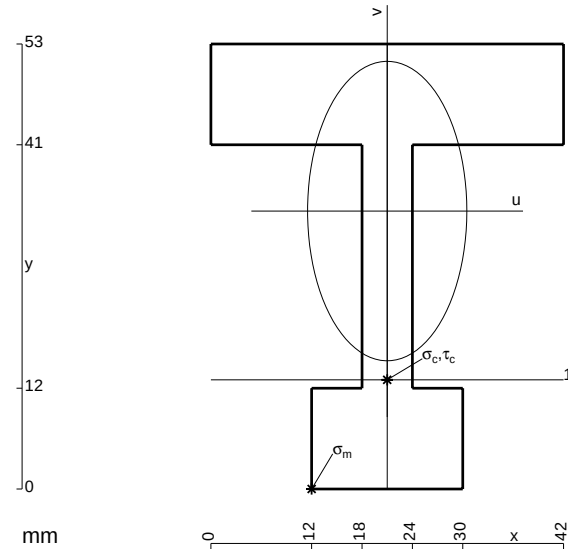
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

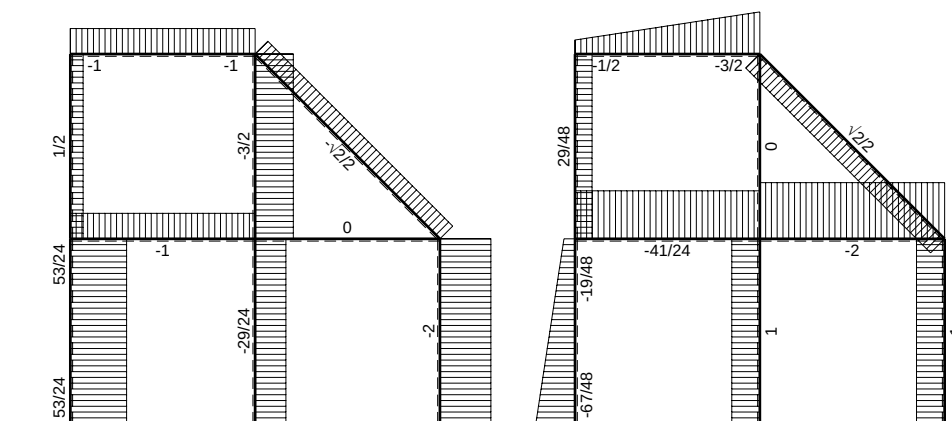
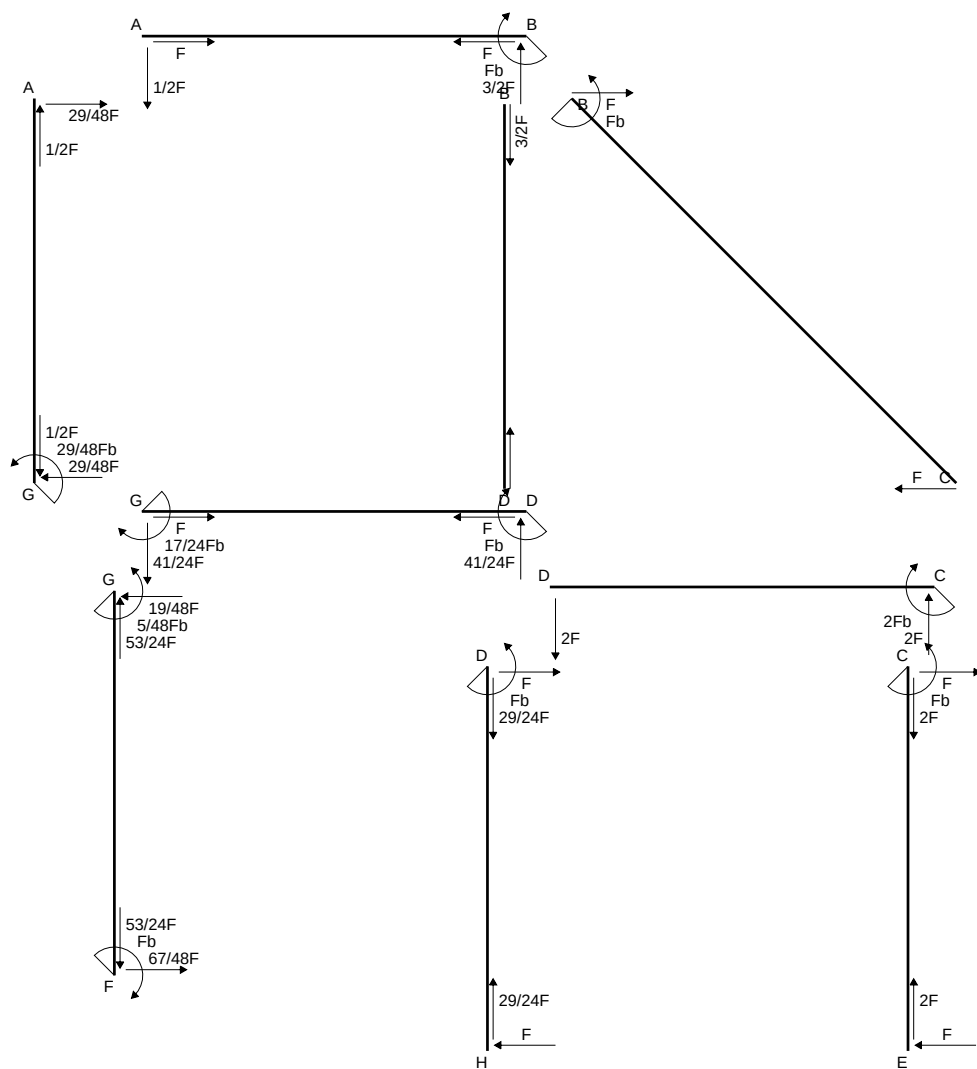
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

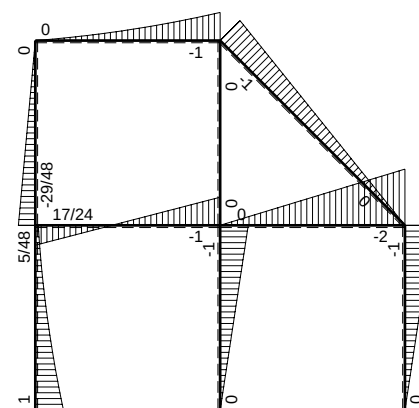
$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

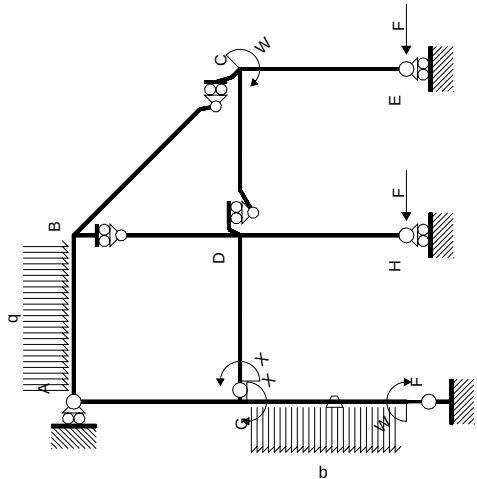


$$\begin{aligned} A &= 894. \text{ mm}^2 \\ J_u &= 284424. \text{ mm}^4 \\ J_v &= 80442. \text{ mm}^4 \\ y_g &= 33.1 \text{ mm} \\ T_y &= -3420. \text{ N} \\ M_x &= -1710000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -33.1 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -20.1 \text{ mm} \\ \sigma_c &= -Mv/J_u = -120.9 \text{ N/mm}^2 \\ \tau_c &= 11.98 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 122.6 \text{ N/mm}^2 \\ S &= 5978. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

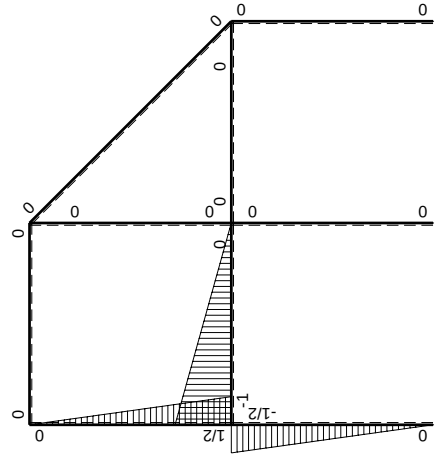
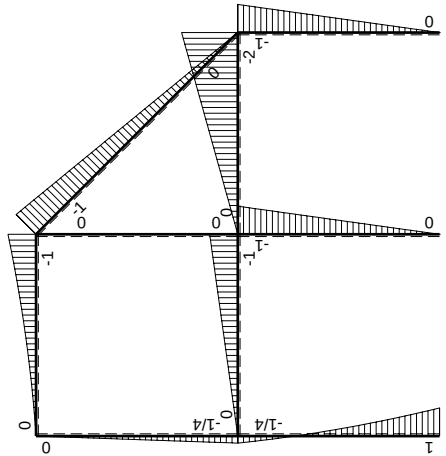
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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-7/4Fx+1/2qx^2$	$-Fb/EJ$	$-1/2Fx+7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$1/8Fb-1/2Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb+1/4Fx$	0	$-1/8Fb+1/4Fx-1/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/4Fx$	0	$-1/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$17/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-17/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{8} - \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{1}{4} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

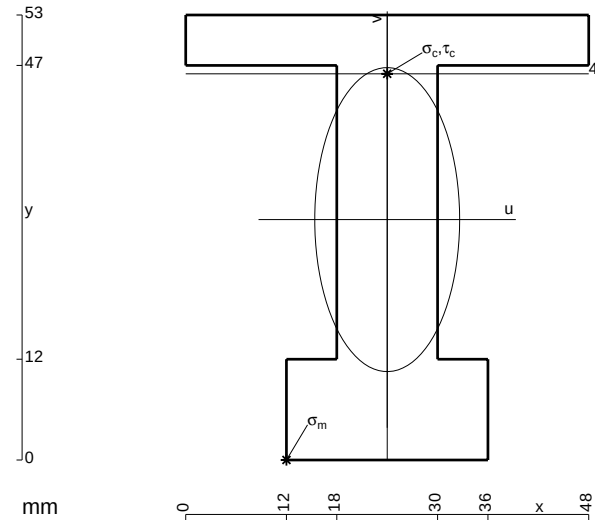
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

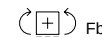
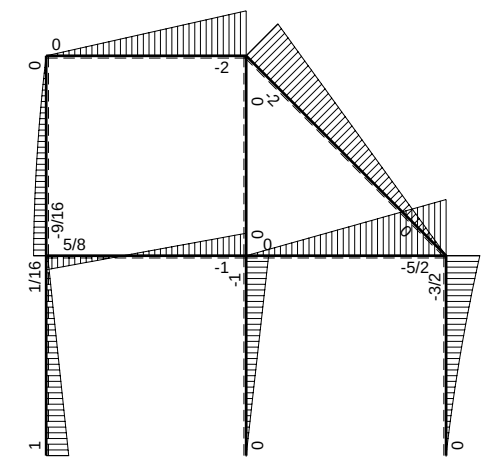
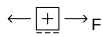
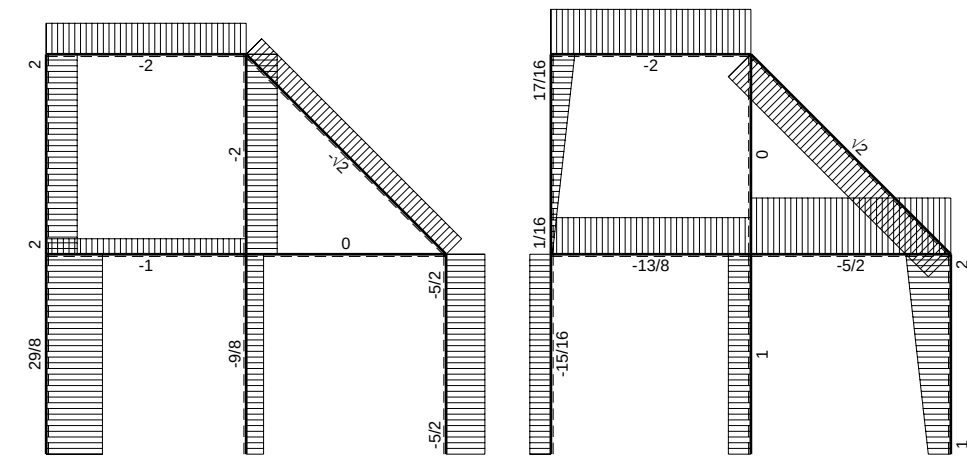
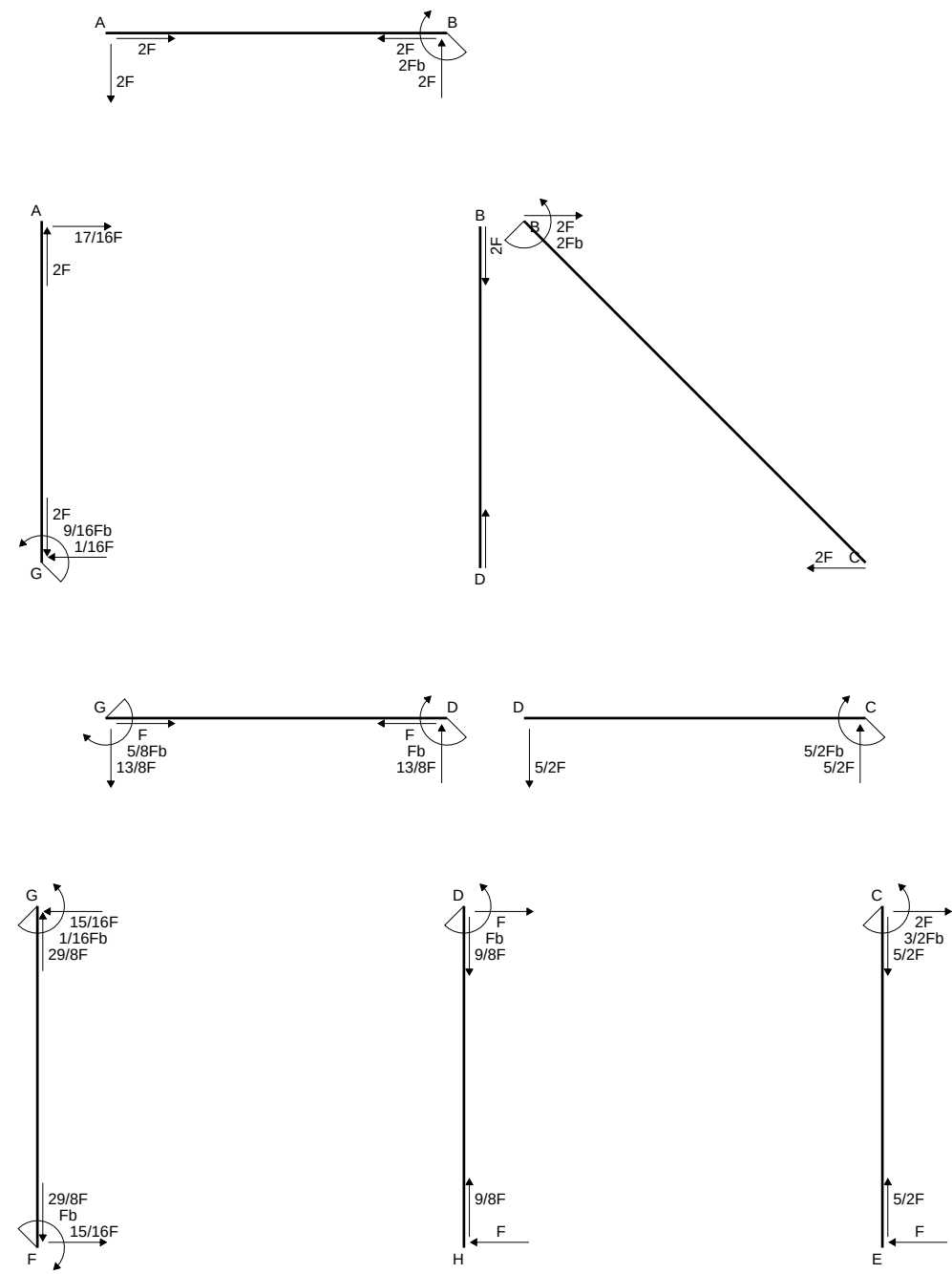
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

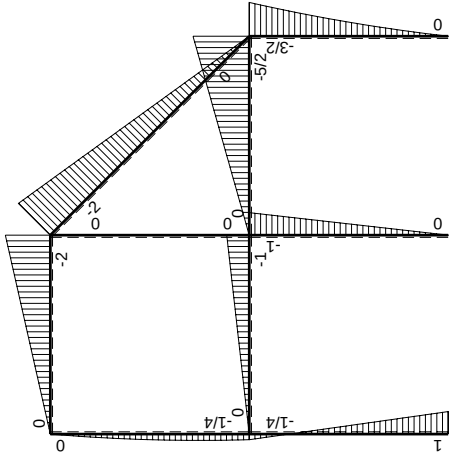
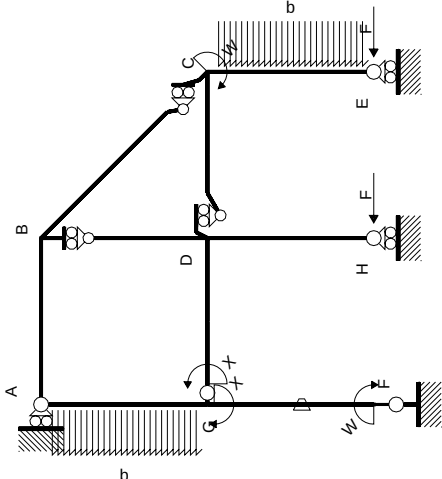
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



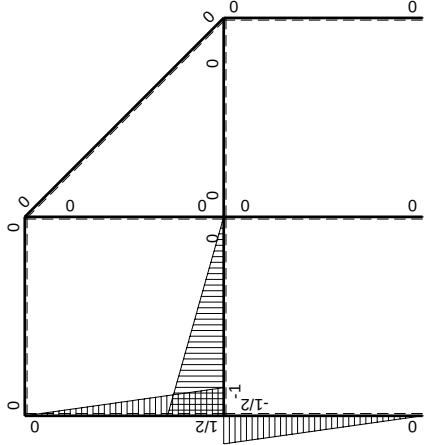
$$\begin{aligned} A &= 996. \text{ mm}^2 \\ J_u &= 326526. \text{ mm}^4 \\ J_v &= 74160. \text{ mm}^4 \\ y_g &= 28.63 \text{ mm} \\ T_y &= -4340. \text{ N} \\ M_x &= -2387000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -28.63 \text{ mm} \\ \sigma_m &= -Mv/J_u = -209.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 17.37 \text{ mm} \\ \sigma_c &= -Mv/J_u = 127. \text{ N/mm}^2 \\ \tau_c &= 7.054 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 127.5 \text{ N/mm}^2 \\ S &= 6368. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						5/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{8} - \frac{3}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{3}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{3}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

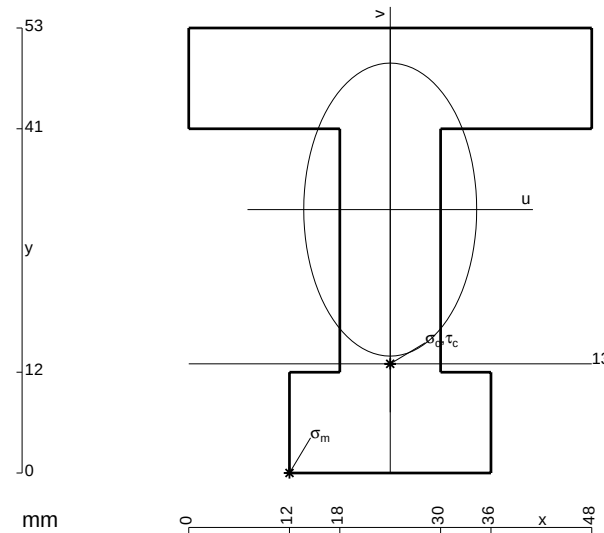
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

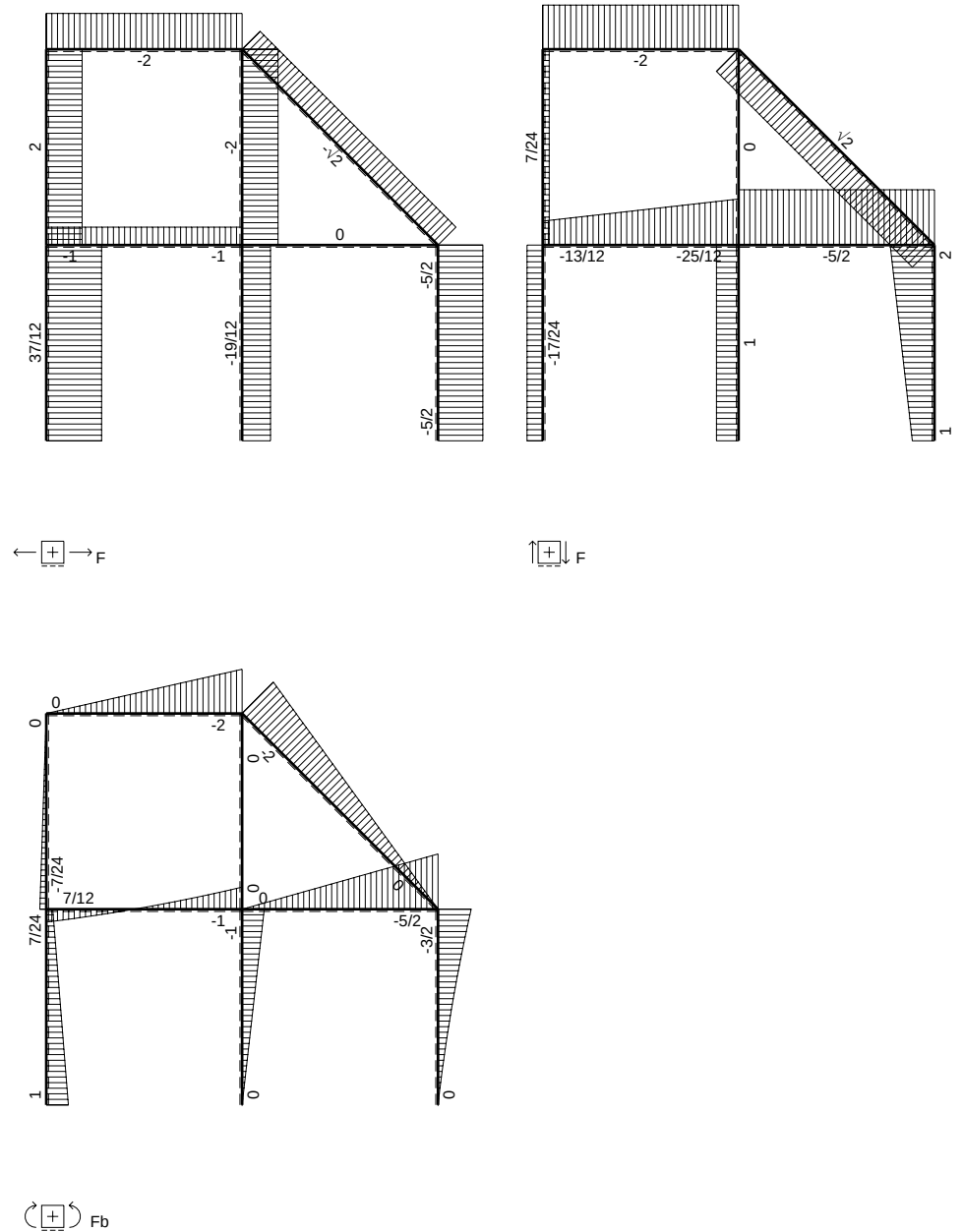
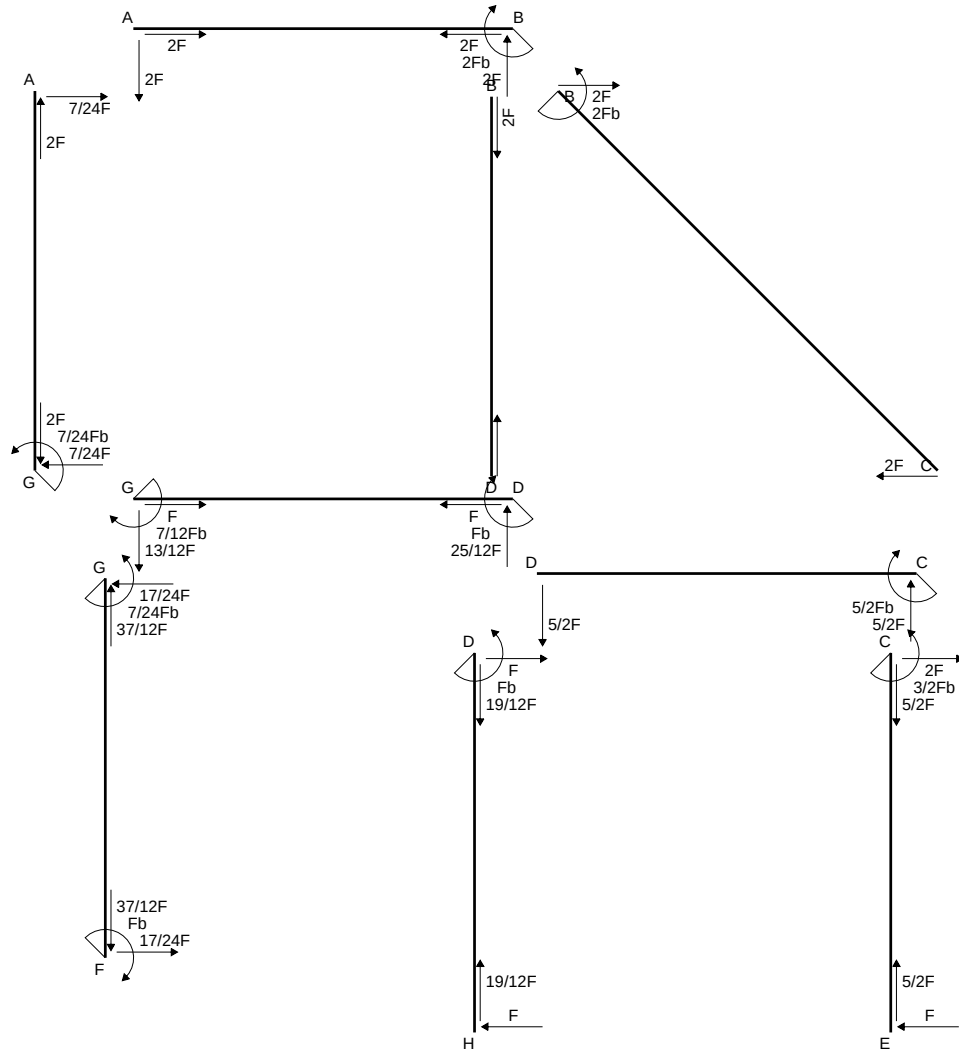
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

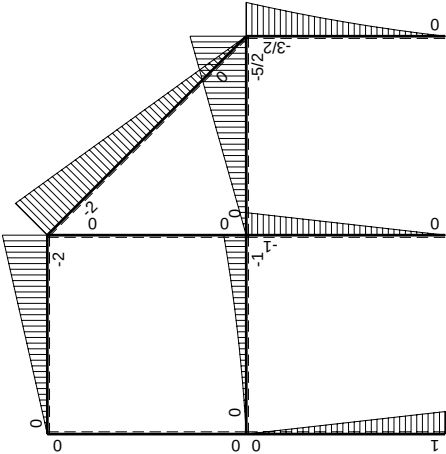
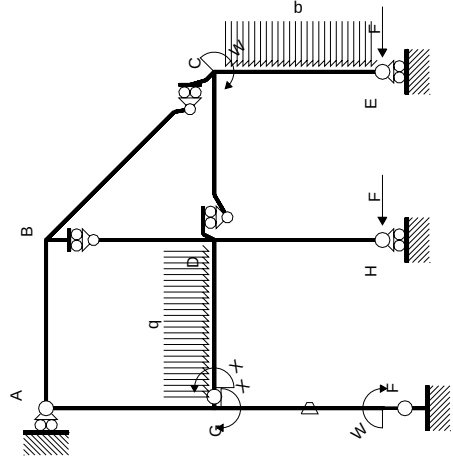
$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$



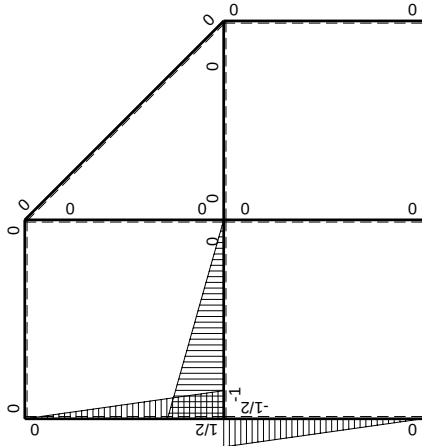
$$\begin{aligned} A &= 1212. \text{ mm}^2 \\ J_u &= 369093. \text{ mm}^4 \\ J_v &= 128592. \text{ mm}^4 \\ y_g &= 31.37 \text{ mm} \\ T_y &= -4300. \text{ N} \\ M_x &= -2580000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.37 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -18.37 \text{ mm} \\ \sigma_c &= -Mv/J_u = -128.4 \text{ N/mm}^2 \\ \tau_c &= 7.314 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 129. \text{ N/mm}^2 \\ S &= 7533. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-Fx	-Fb/EJ	-1/2Fx+1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	-Fx	Fb/EJ	-1/2Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x ² /b ²	0+0	1/12Xb/EJ
AG b	-1/2x/b	0	0	0	0	1/4x ² /b ²		
	totali						7/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

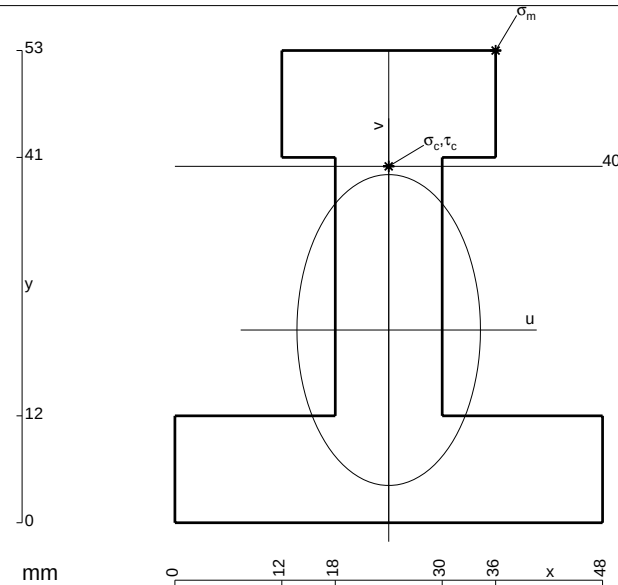
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

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

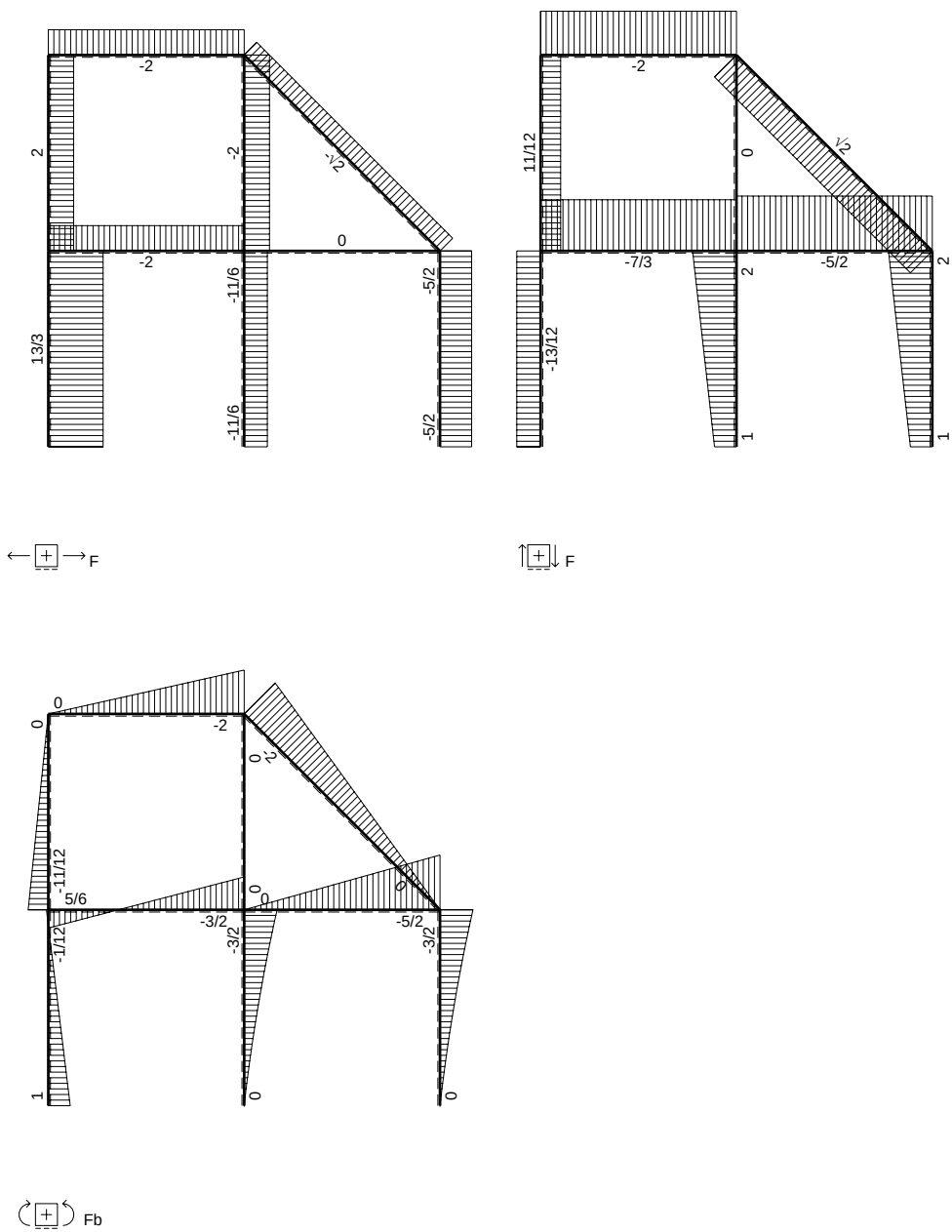
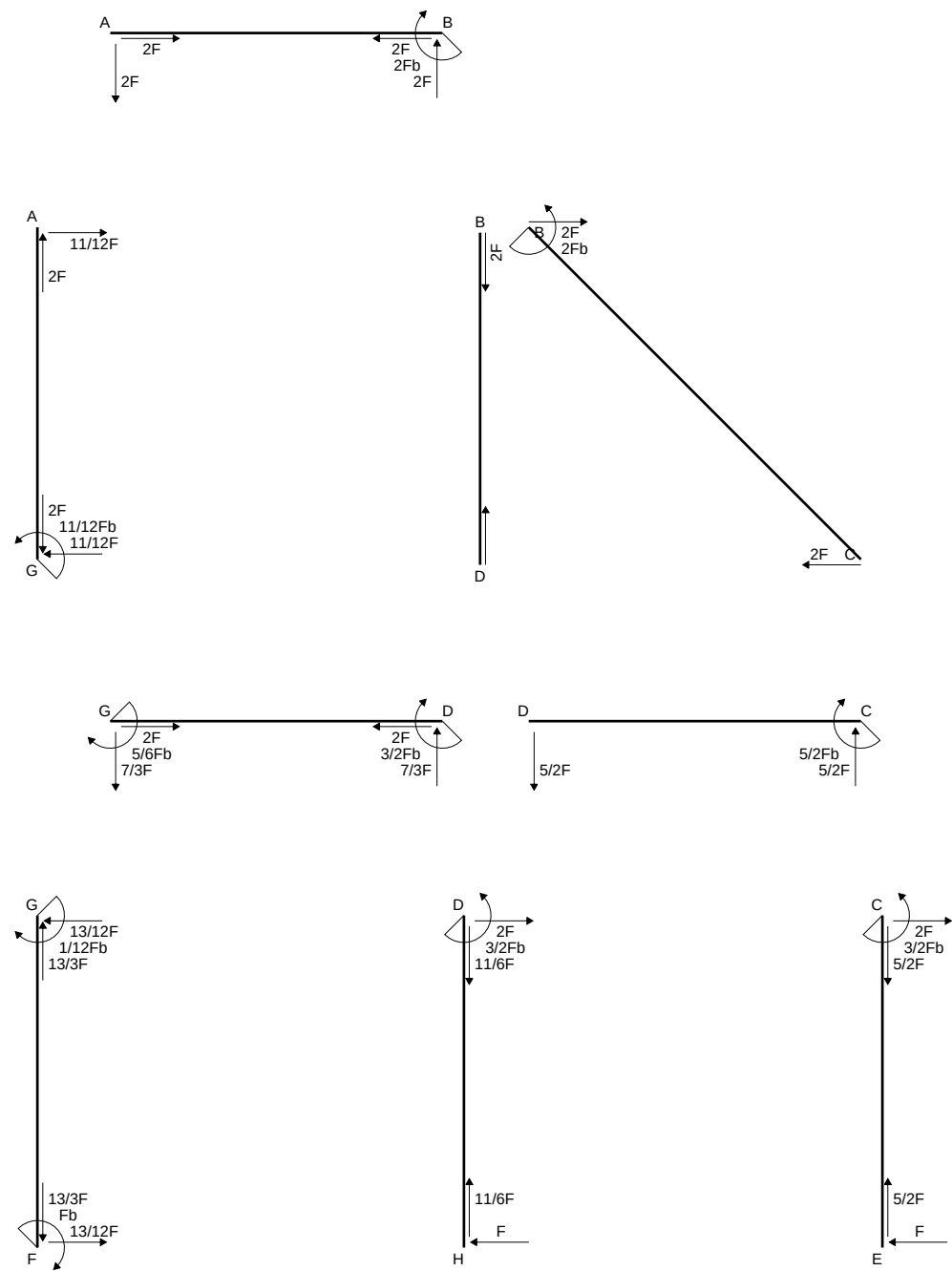
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$



$$\begin{aligned} A &= 1212. \text{ mm}^2 \\ J_u &= 369093. \text{ mm}^4 \\ J_v &= 128592. \text{ mm}^4 \\ y_g &= 21.63 \text{ mm} \\ T_y &= -4150. \text{ N} \\ M_x &= -2697500. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.37 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 18.37 \text{ mm} \\ \sigma_c &= -Mv/J_u = 134.3 \text{ N/mm}^2 \\ \tau_c &= 7.059 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 134.8 \text{ N/mm}^2 \\ S &= 7533. \text{ mm}^3 \end{aligned}$$



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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(0+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						5/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

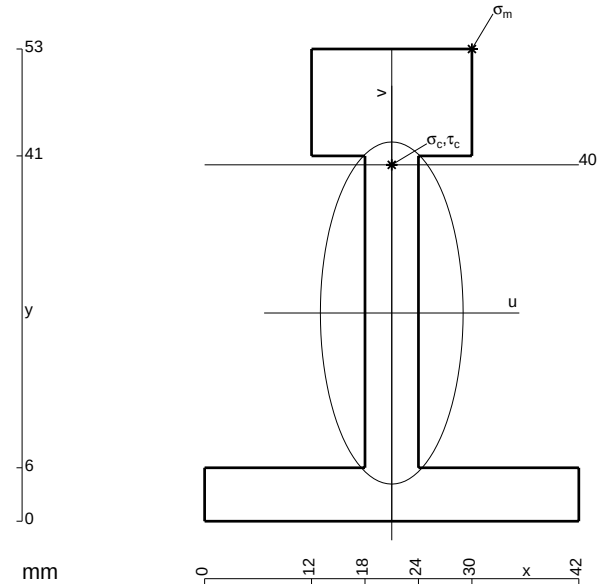
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

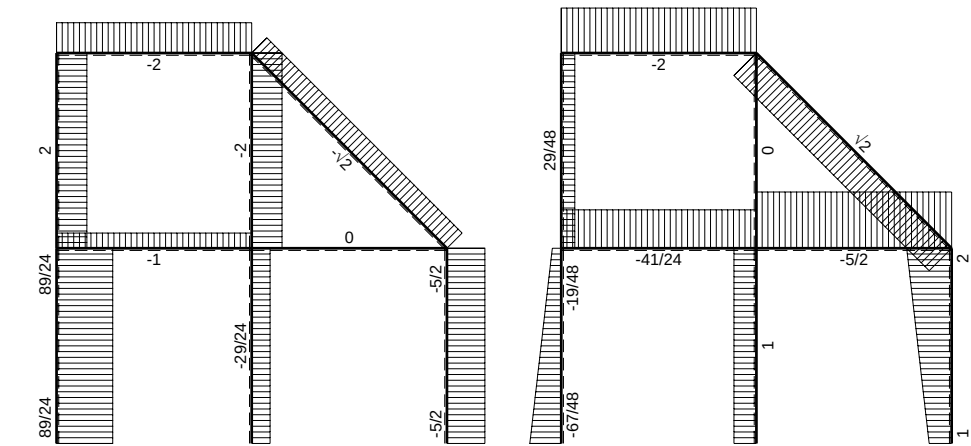
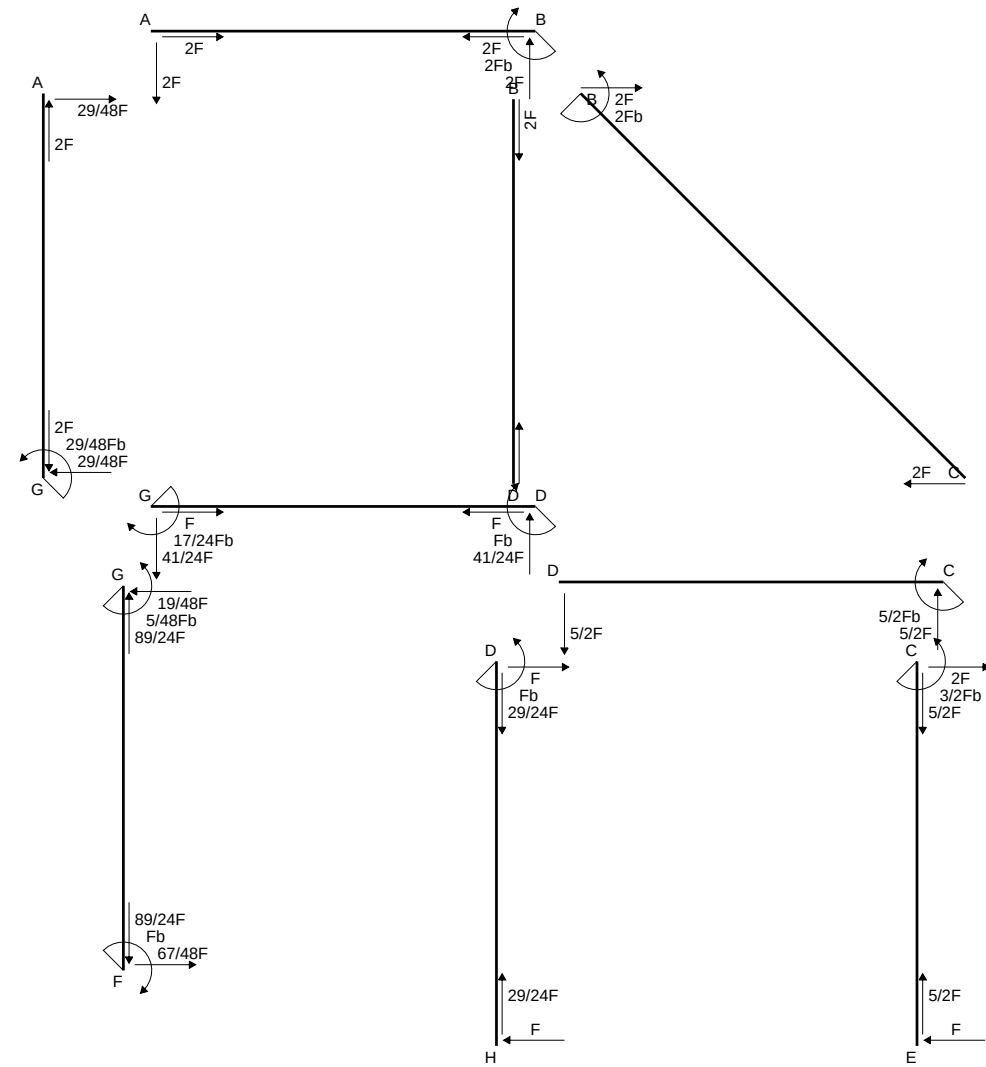
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

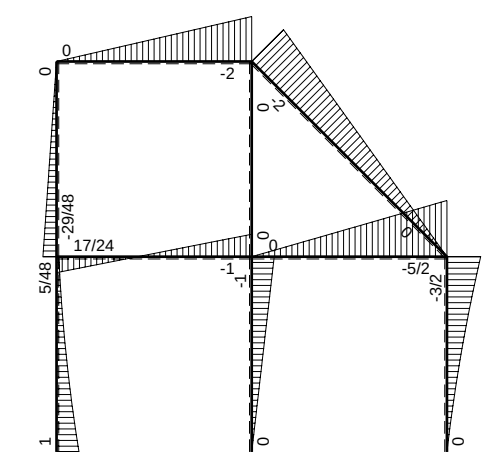


$$\begin{aligned} A &= 678. \text{ mm}^2 \\ J_u &= 249963. \text{ mm}^4 \\ J_v &= 43506. \text{ mm}^4 \\ y_g &= 23.37 \text{ mm} \\ T_y &= -2875. \text{ N} \\ M_x &= -2012500. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 29.63 \text{ mm} \\ \sigma_m &= -Mv/J_u = 238.6 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 16.63 \text{ mm} \\ \sigma_c &= -Mv/J_u = 133.9 \text{ N/mm}^2 \\ \tau_c &= 9.982 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 135. \text{ N/mm}^2 \\ S &= 5207. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-7/4Fx+1/2qx ²	-Fb/EJ	-1/2Fx+7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(-1/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx ²	Fb/EJ	1/8Fb-1/2Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx ² /b	0	1/4x ² /b ²		
	totali						17/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-17/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{8} - \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{1}{4} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

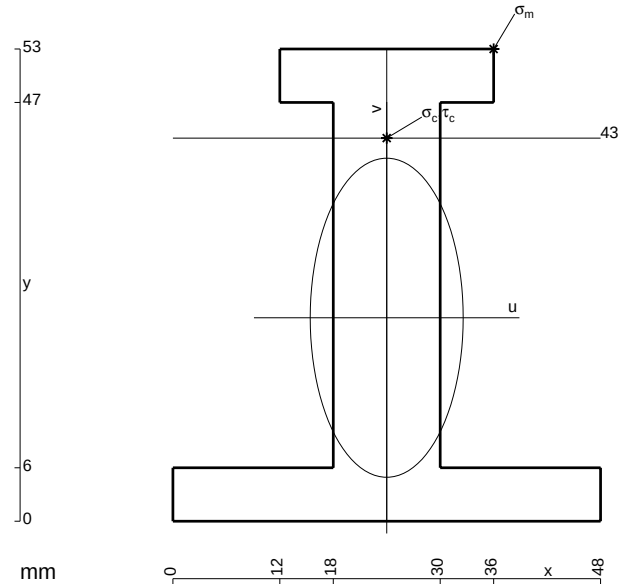
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

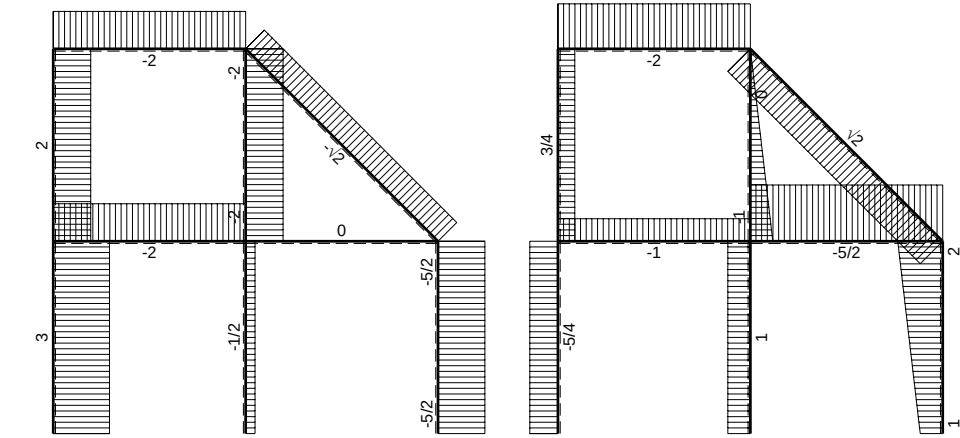
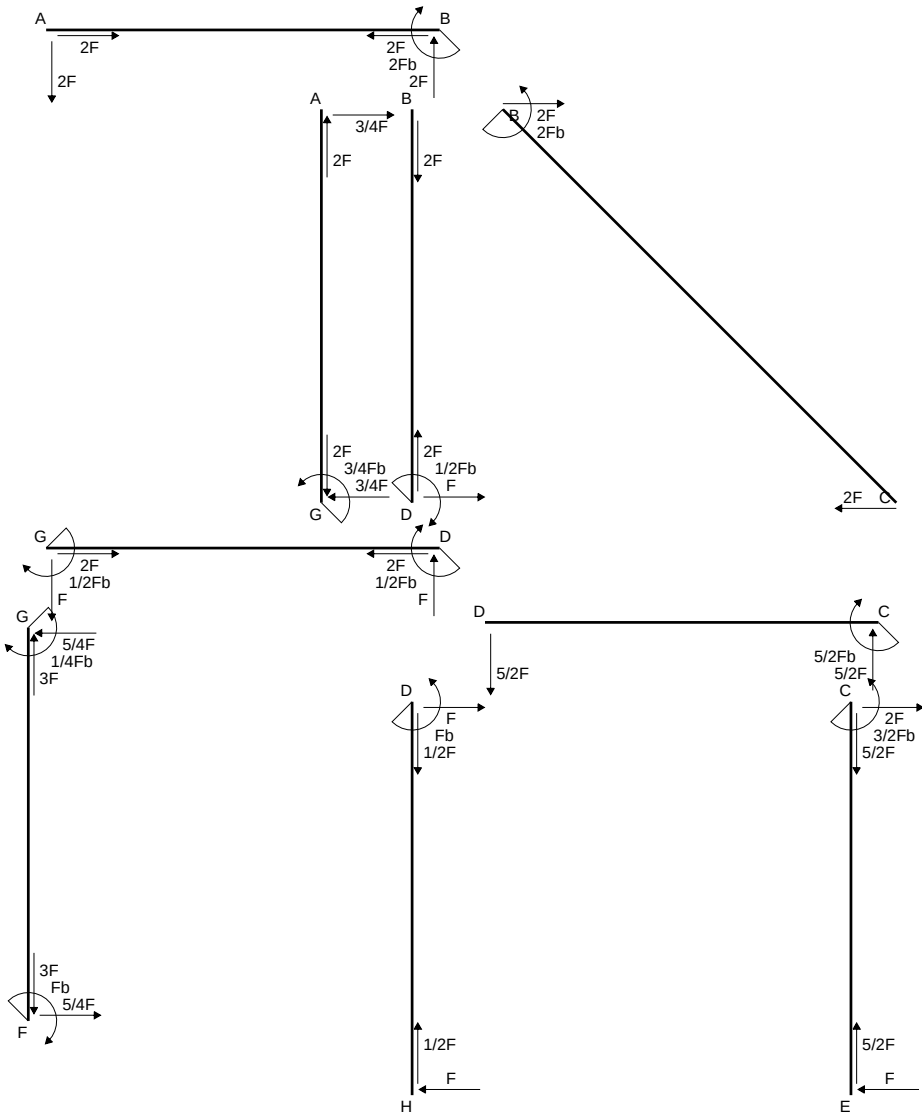
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

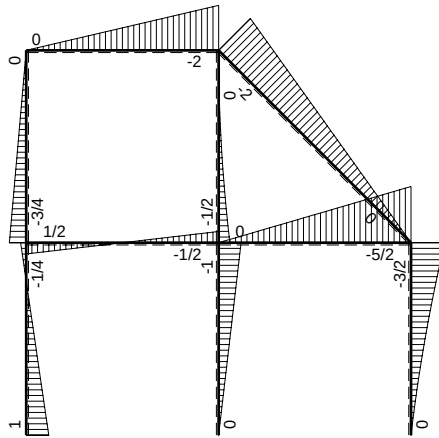


$$\begin{aligned} A &= 924. \text{ mm}^2 \\ J_u &= 296396. \text{ mm}^4 \\ J_v &= 68112. \text{ mm}^4 \\ y_g &= 22.84 \text{ mm} \\ T_y &= -2600. \text{ N} \\ M_x &= -1950000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.16 \text{ mm} \\ \sigma_m &= -Mv/J_u = 198.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 20.16 \text{ mm} \\ \sigma_c &= -Mv/J_u = 132.6 \text{ N/mm}^2 \\ \tau_c &= 3.637 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 132.8 \text{ N/mm}^2 \\ S &= 4975. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ F_b

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(0+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						1/4Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-1/2Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

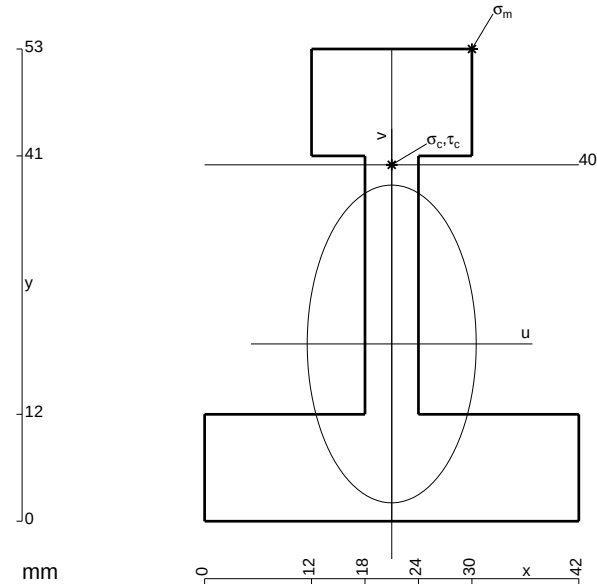
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

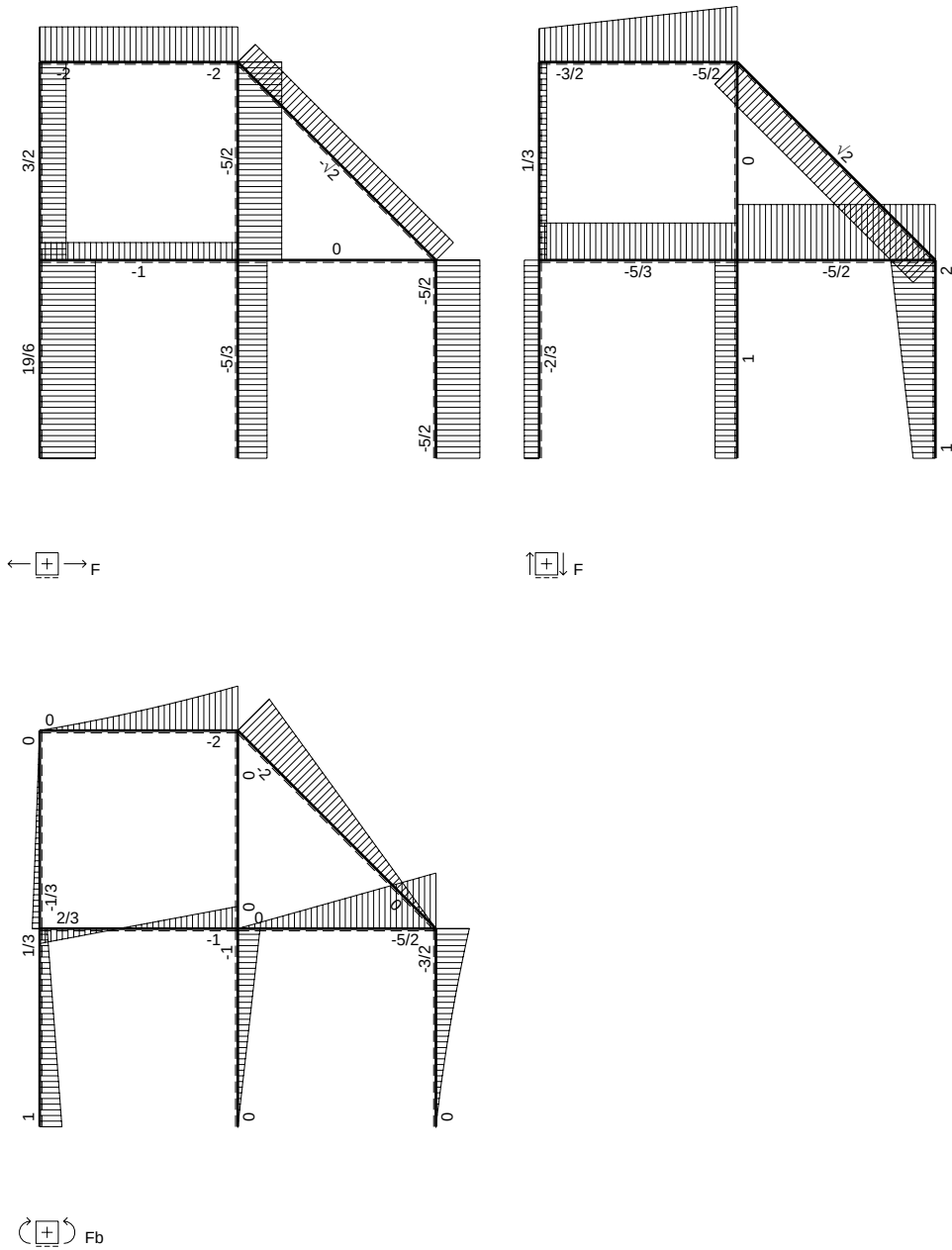
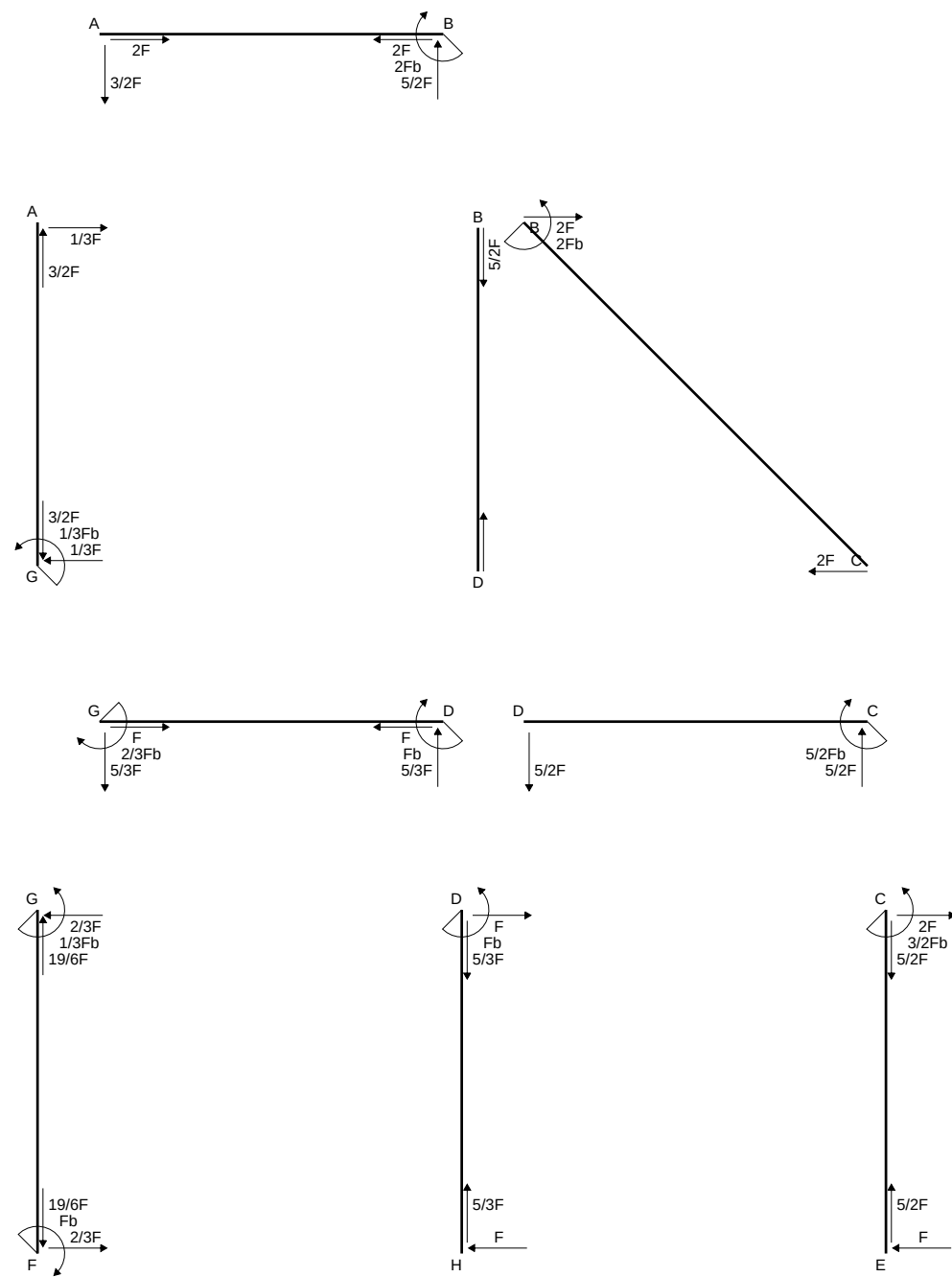
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

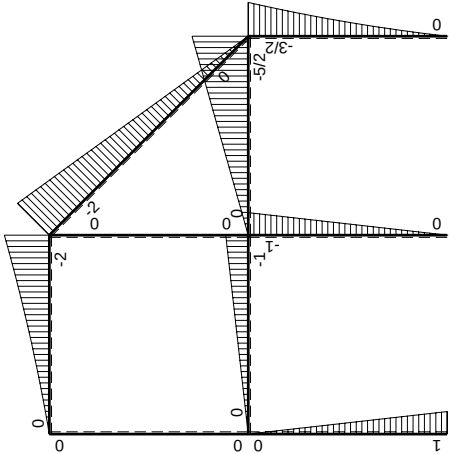
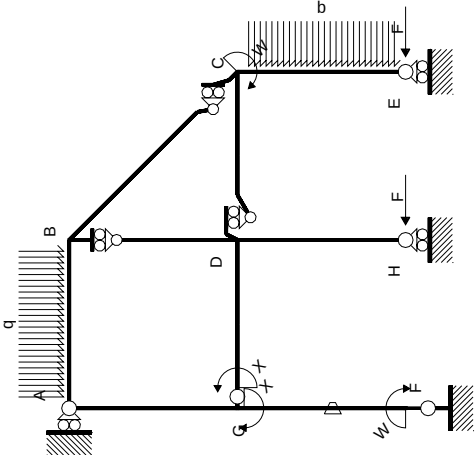
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



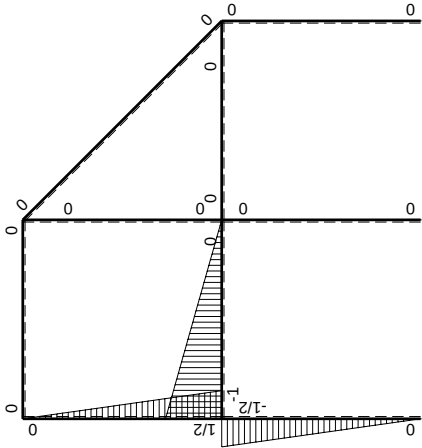
$$\begin{aligned} A &= 894. \text{ mm}^2 \\ J_u &= 284424. \text{ mm}^4 \\ J_v &= 80442. \text{ mm}^4 \\ y_g &= 19.9 \text{ mm} \\ T_y &= -2250. \text{ N} \\ M_x &= -1800000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.1 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 20.1 \text{ mm} \\ \sigma_c &= -Mv/J_u = 127.2 \text{ N/mm}^2 \\ \tau_c &= 7.882 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 128. \text{ N/mm}^2 \\ S &= 5978. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$Fb-Fx$	$-Fb/EJ$	$-1/2Fx+1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$-Fx$	Fb/EJ	$-1/2Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$1/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-2/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb 1/EJ \, dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb 1/EJ + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb 1/EJ + \left(\frac{1}{4} b \right) \theta = 1/6 \, Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb 1/EJ \, dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb 1/EJ + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

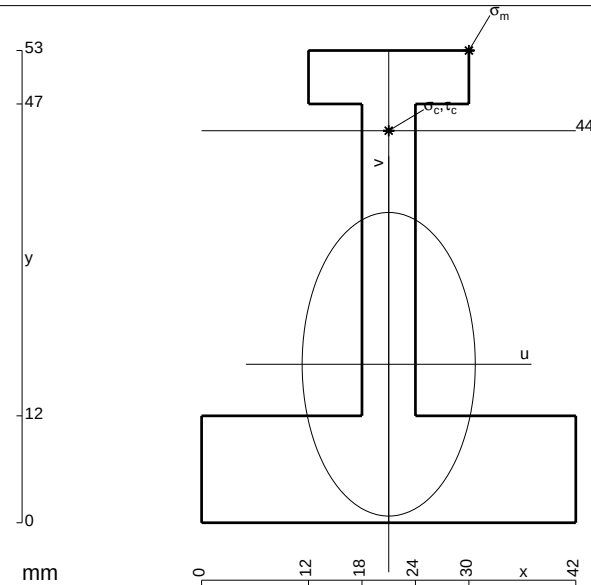
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb 1/EJ + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = 1/6 \, Fb^2/EJ$$

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

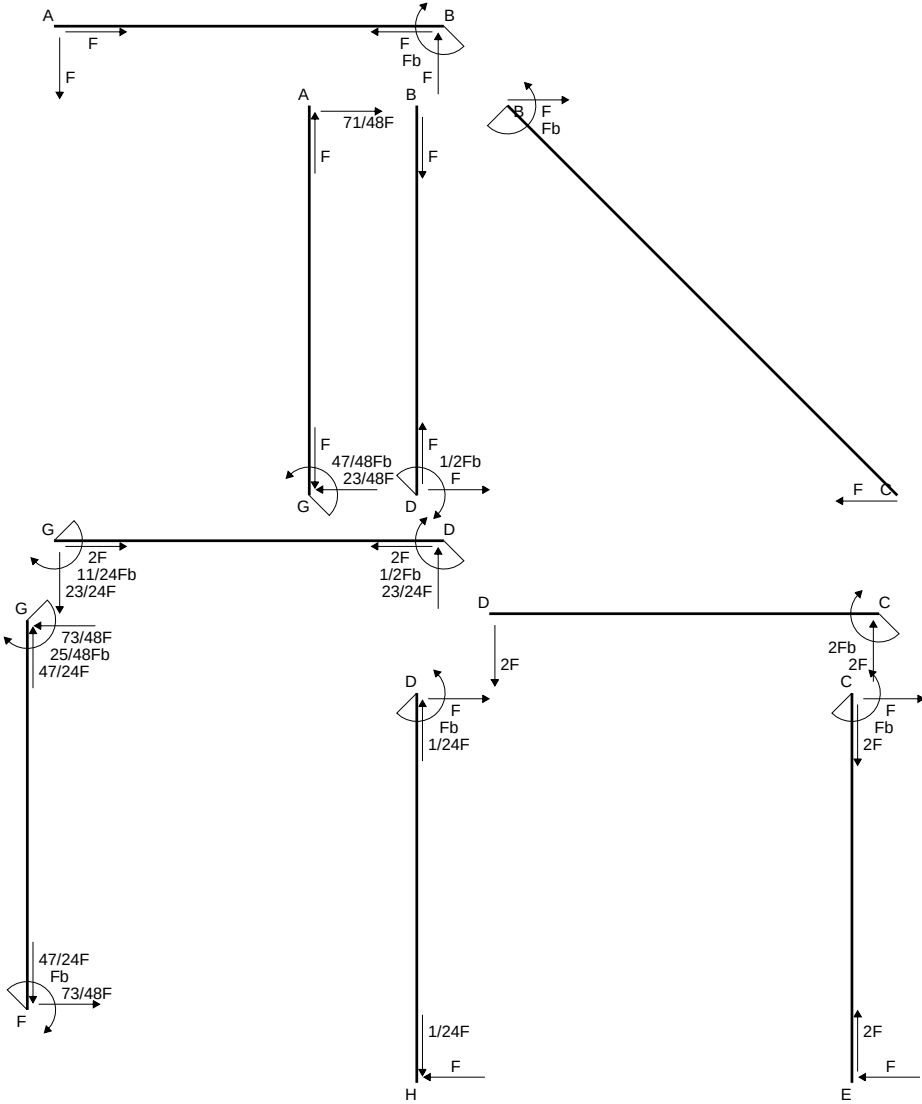
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb 1/EJ = 1/6 \, Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb 1/EJ = 1/6 \, Fb^2/EJ$$



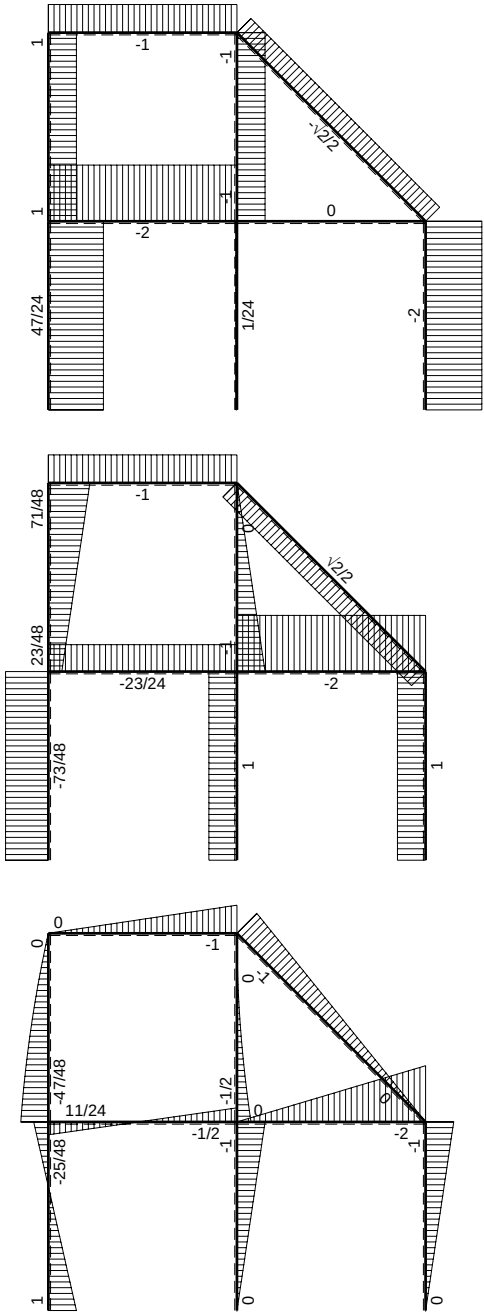
$$\begin{aligned} A &= 822. \text{ mm}^2 \\ J_u &= 238712. \text{ mm}^4 \\ J_v &= 77634. \text{ mm}^4 \\ y_g &= 17.78 \text{ mm} \\ T_y &= -1750. \text{ N} \\ M_x &= -1487500. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 35.22 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 26.22 \text{ mm} \\ \sigma_c &= -Mv/J_u = 163.4 \text{ N/mm}^2 \\ \tau_c &= 4.861 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 163.6 \text{ N/mm}^2 \\ S &= 3978. \text{ mm}^3 \end{aligned}$$



$\leftarrow \boxed{+} \rightarrow F$

$\uparrow \boxed{+} \downarrow F$

$\curvearrowright \boxed{+} \curvearrowleft Fb$



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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-7/4Fx	-Fb/EJ	-1/2Fx+7/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-7/4Fx	Fb/EJ	3/8Fb-5/4Fx+7/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx ²	0	-3/8Fb+1/2Fx+1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-7/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx ²	0	-5/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						11/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 \right) Fb 1/EJ \, dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb 1/EJ + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b \right) Fb 1/EJ + \left(\frac{1}{4} b \right) \theta = \frac{7}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{5}{4} x/b + \frac{7}{8} x^2/b^2 \right) Fb 1/EJ \, dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[\frac{3}{8} x - \frac{5}{8} x^2/b + \frac{7}{24} x^3/b^2 \right]_0^b Fb 1/EJ + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{5}{8} b + \frac{7}{24} b \right) Fb 1/EJ + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{24} Fb^2/EJ$$

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

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

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

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

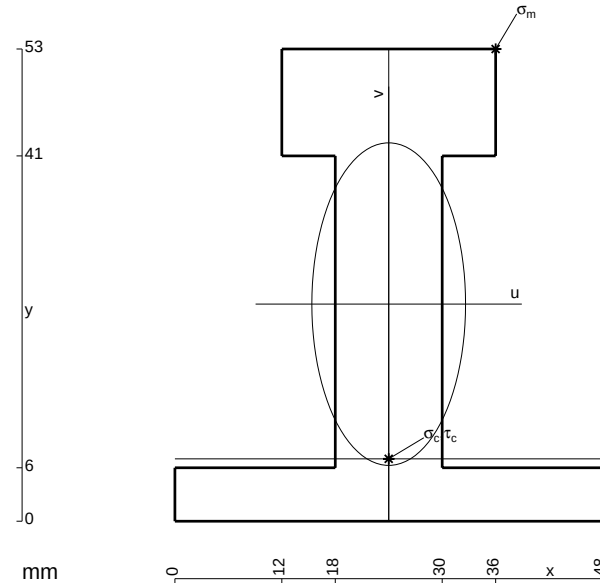
$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb 1/EJ \, dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb 1/EJ$$

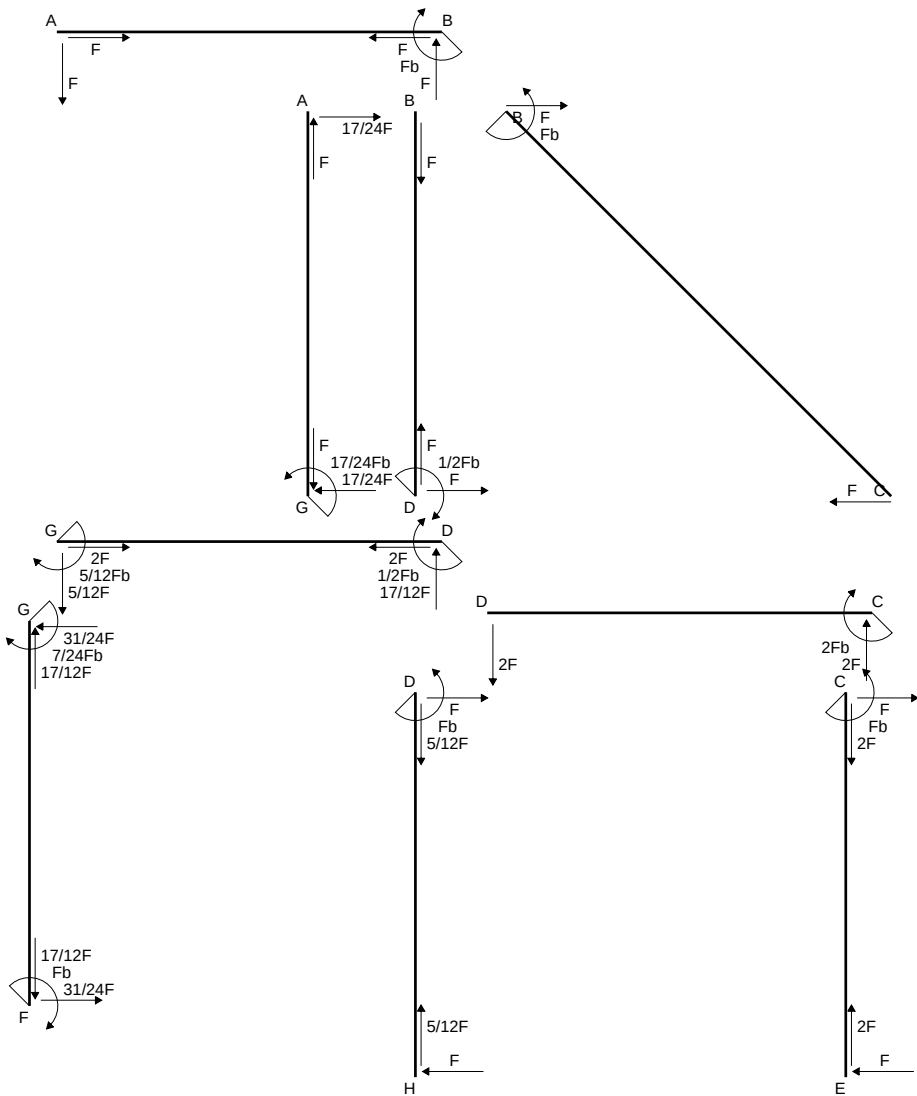
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb 1/EJ = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb 1/EJ \, dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb 1/EJ$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb 1/EJ = -\frac{7}{48} Fb^2/EJ$$



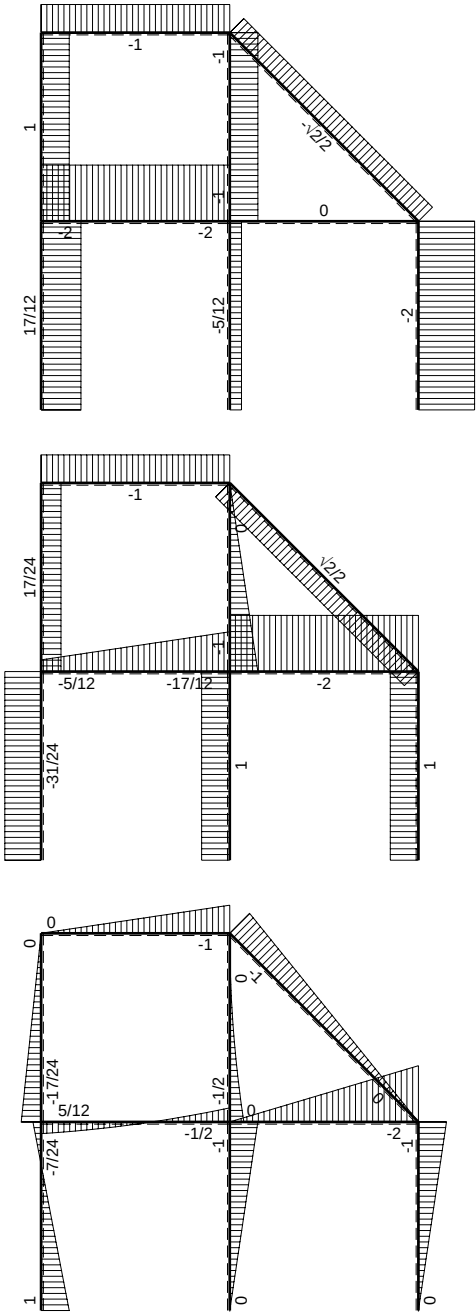
$$\begin{aligned} A &= 996. \text{ mm}^2 \\ J_u &= 326526. \text{ mm}^4 \\ J_v &= 74160. \text{ mm}^4 \\ y_g &= 24.37 \text{ mm} \\ T_y &= -2900. \text{ N} \\ M_x &= -2610000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.63 \text{ mm} \\ \sigma_m &= -Mv/J_u = 228.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -17.37 \text{ mm} \\ \sigma_c &= -Mv/J_u = -138.8 \text{ N/mm}^2 \\ \tau_c &= 4.713 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 139.1 \text{ N/mm}^2 \\ S &= 6368. \text{ mm}^3 \end{aligned}$$

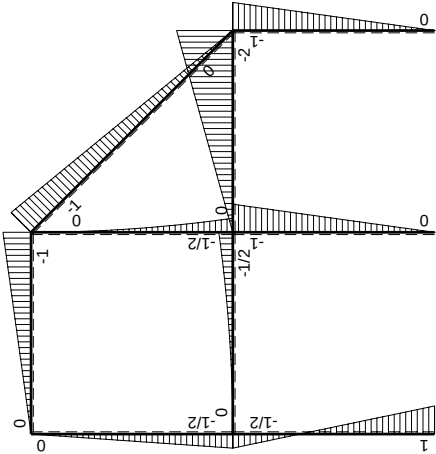
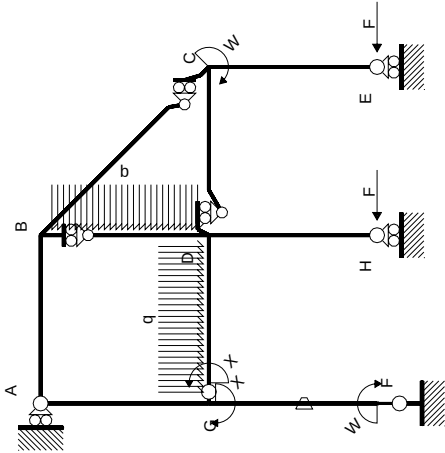


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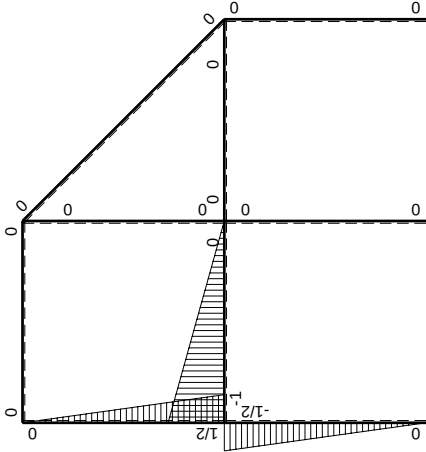
$\curvearrowright \boxed{+} \curvearrowleft F_b$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-3/2Fx$	$-Fb/EJ$	$-1/2Fx+3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(0+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-3/2Fx$	Fb/EJ	$1/4Fb-Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2qx^2$	0	$1/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-Fx+1/2qx^2$	0	$1/2Fx-Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left(\frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

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

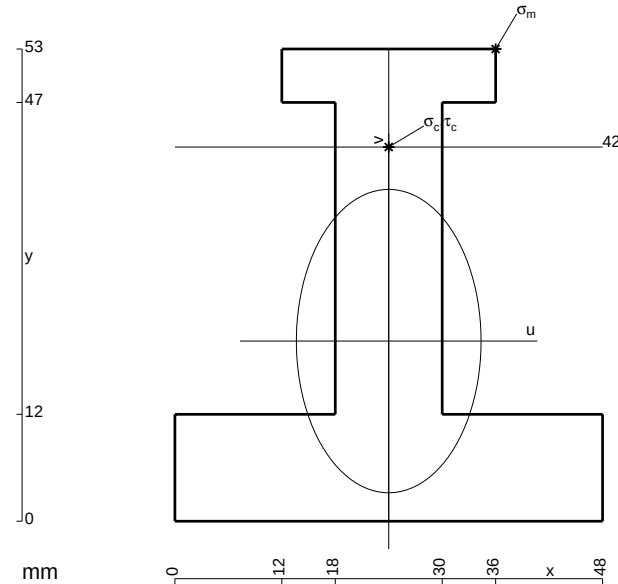
$$= \left(\frac{1}{4} b - \frac{1}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

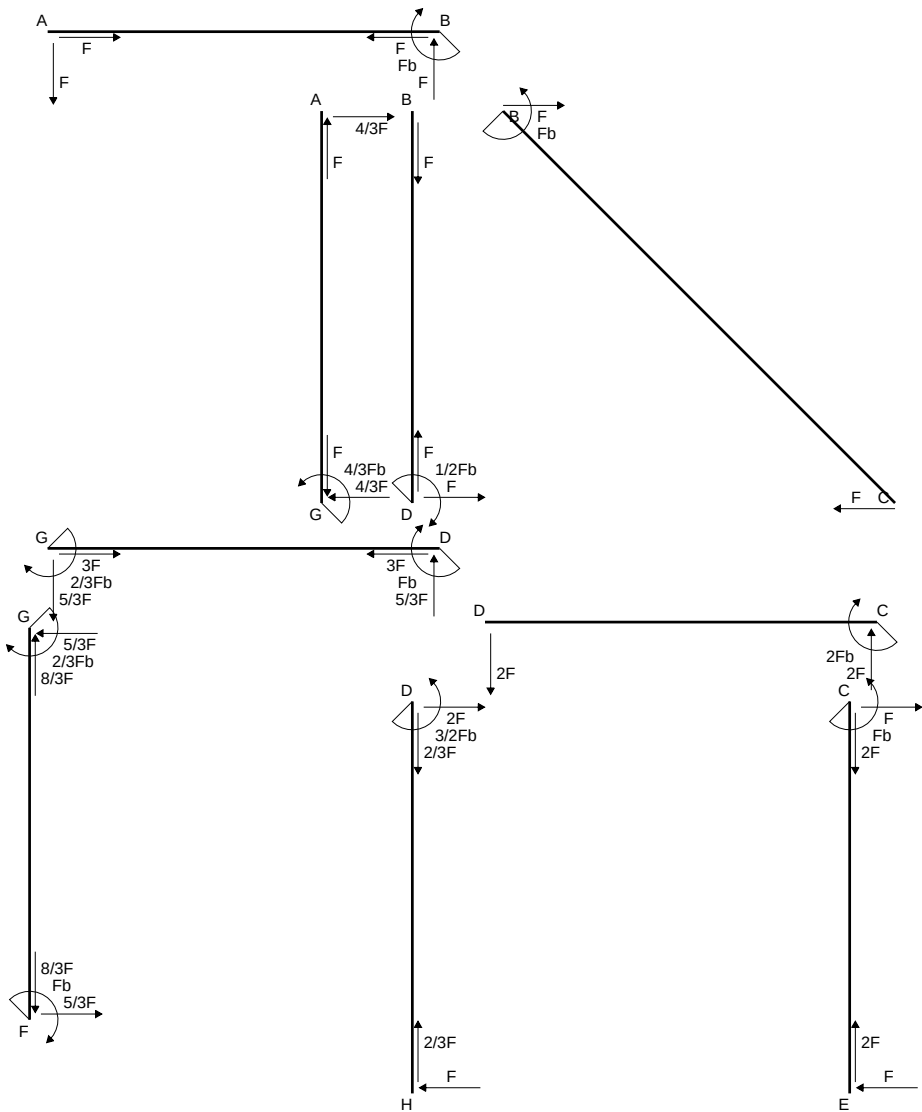
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



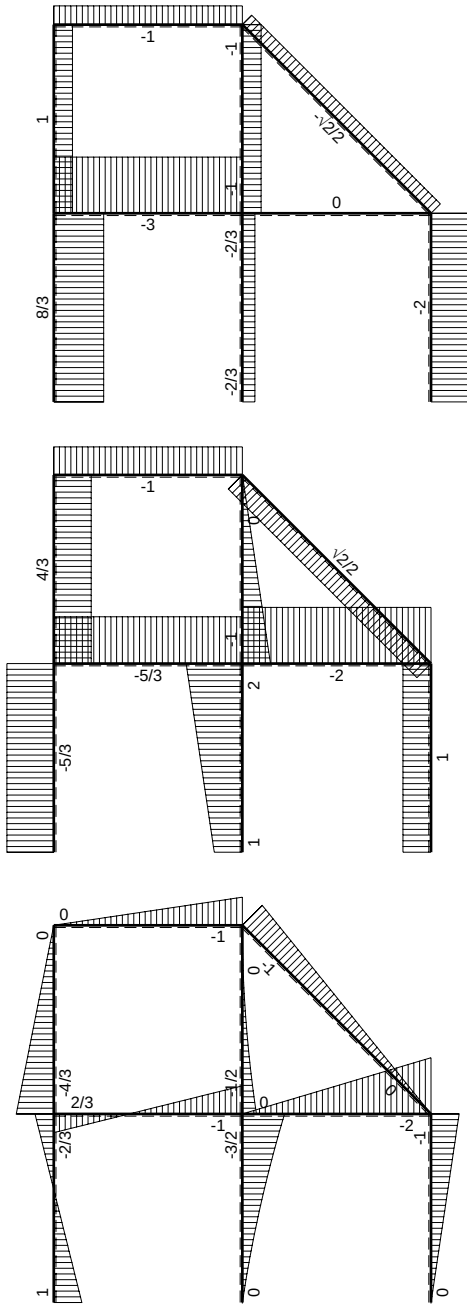
$$\begin{aligned} A &= 1140. \text{ mm}^2 \\ J_u &= 330567. \text{ mm}^4 \\ J_v &= 122544. \text{ mm}^4 \\ y_g &= 20.22 \text{ mm} \\ T_y &= -2540. \text{ N} \\ M_x &= -2413000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 32.78 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 21.78 \text{ mm} \\ \sigma_c &= -Mv/J_u = 159. \text{ N/mm}^2 \\ \tau_c &= 3.679 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 159.1 \text{ N/mm}^2 \\ S &= 5746. \text{ mm}^3 \end{aligned}$$

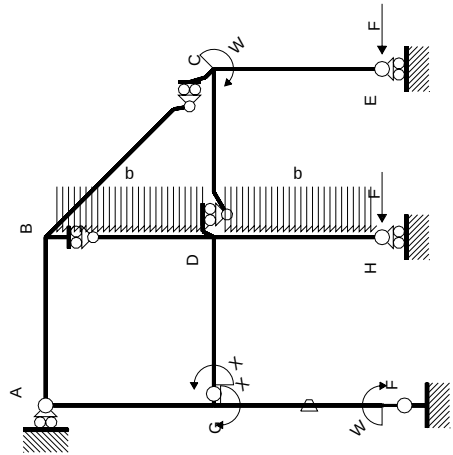


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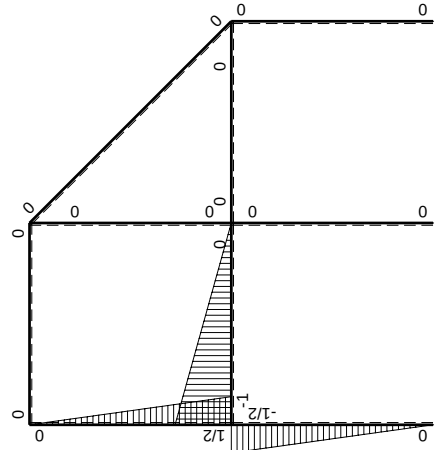
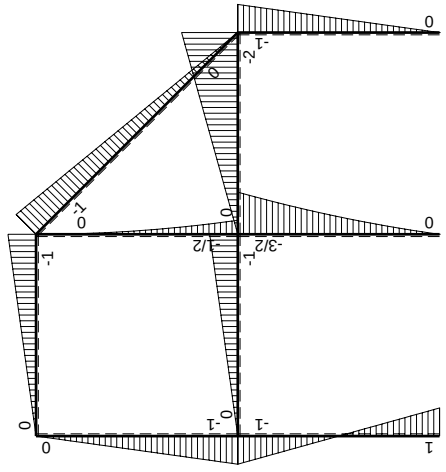
$\curvearrowright \boxed{+} \curvearrowleft Fb$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-2Fx	-Fb/EJ	-1/2Fx+Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-2Fx	Fb/EJ	1/2Fb-3/2Fx+Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						1/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left[\frac{1}{2} x - \frac{3}{4} x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

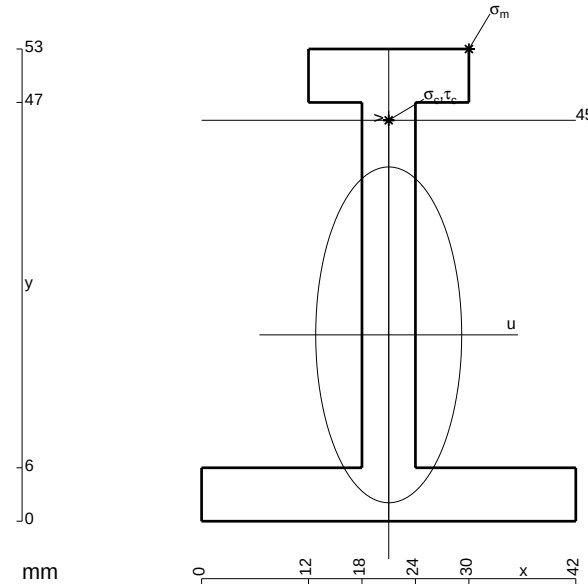
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

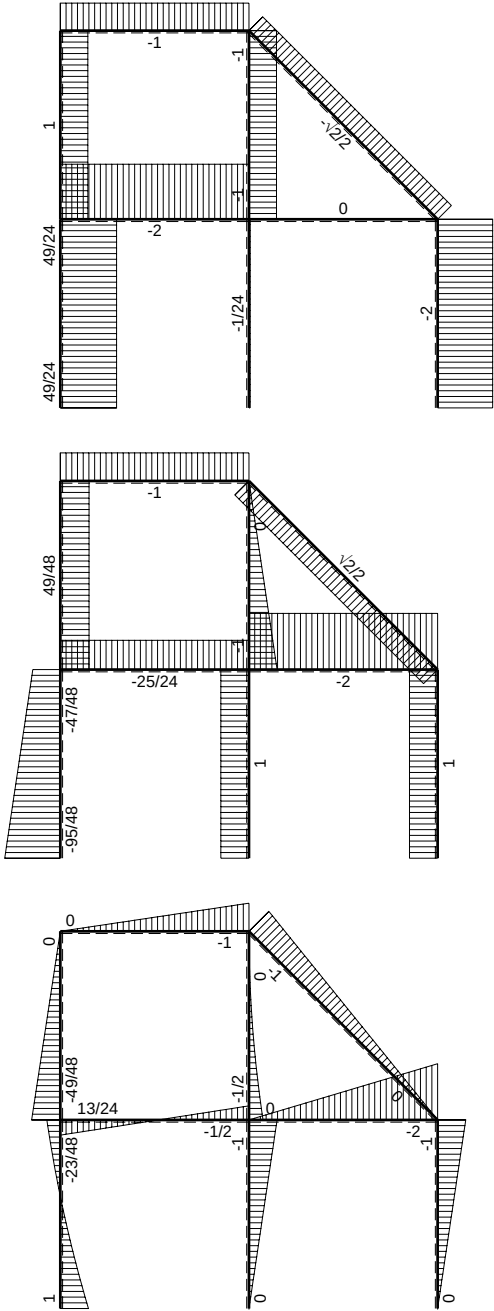
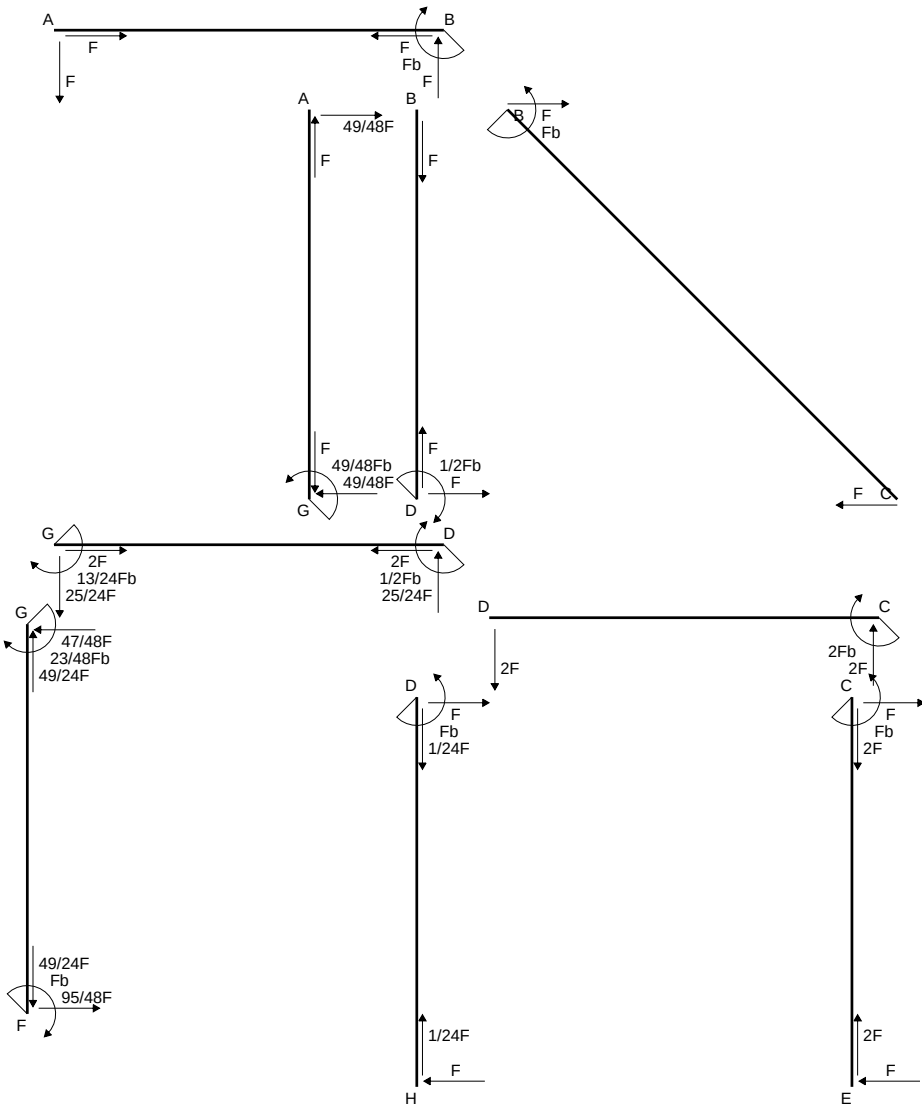
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

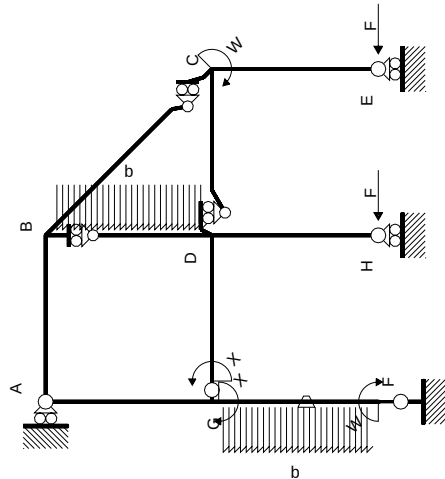
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



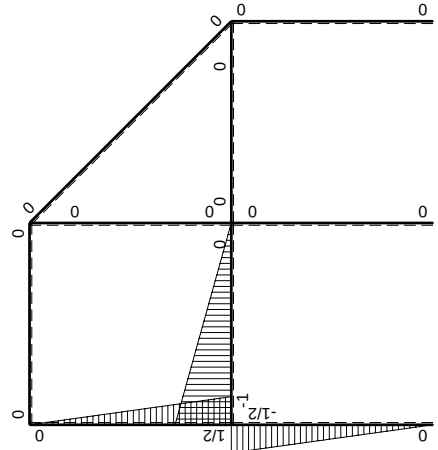
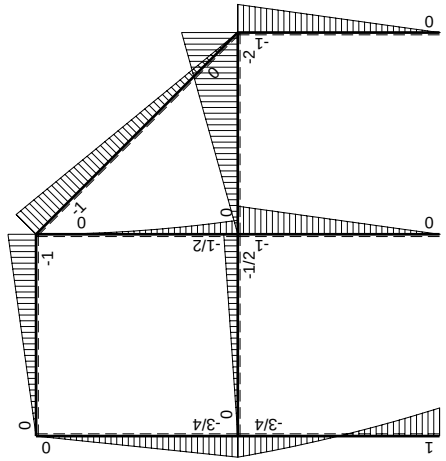
$$\begin{aligned} A &= 606. \text{ mm}^2 \\ J_u &= 215454. \text{ mm}^4 \\ J_v &= 40698. \text{ mm}^4 \\ y_g &= 20.92 \text{ mm} \\ T_y &= -2680. \text{ N} \\ M_x &= -1340000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 32.08 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 24.08 \text{ mm} \\ \sigma_c &= -Mv/J_u = 149.8 \text{ N/mm}^2 \\ \tau_c &= 7.136 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 150.3 \text{ N/mm}^2 \\ S &= 3442. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati

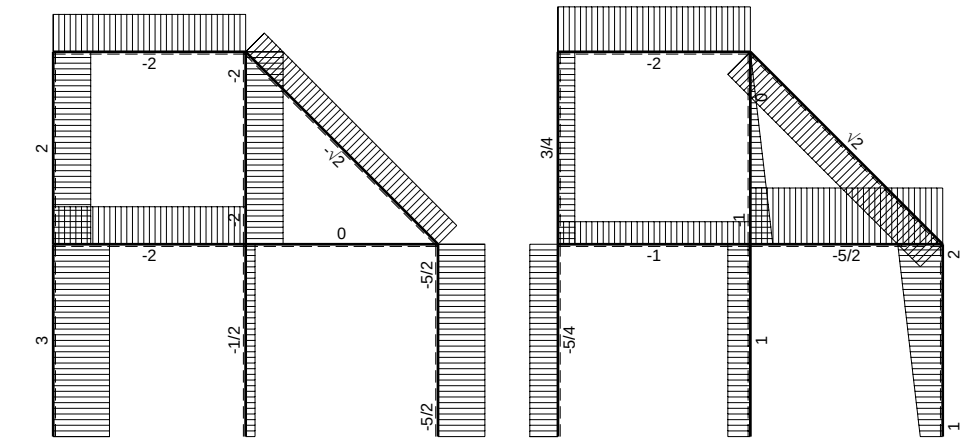
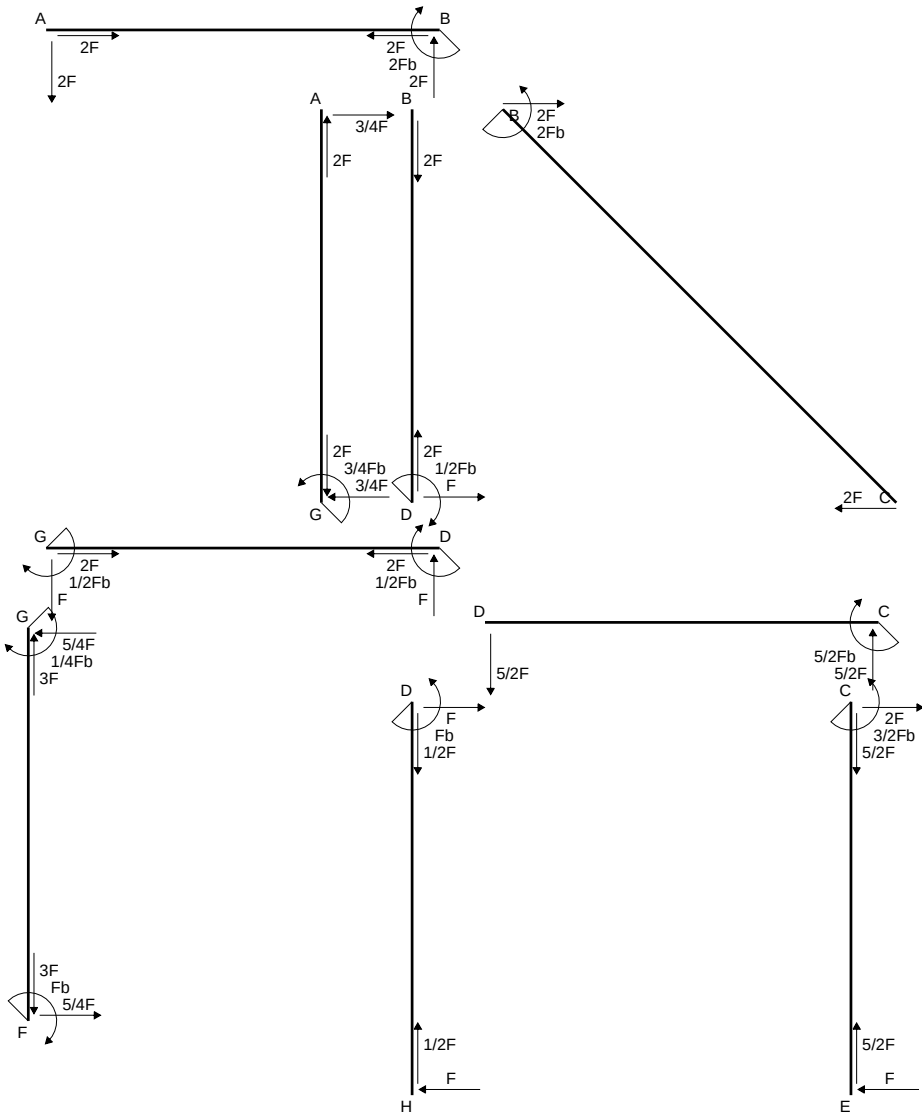


M_x flessione da iperstatica $X=1$

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

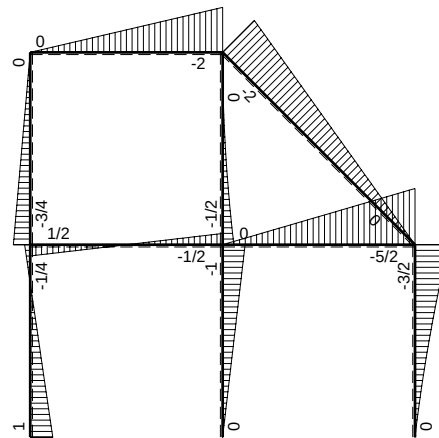
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-9/4Fx+1/2qx ²	-Fb/EJ	-1/2Fx+9/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(1/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-5/4Fx-1/2qx ²	Fb/EJ	3/8Fb-Fx+3/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/8+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx ² /b	0	1/4x ² /b ²		
	totali						13/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/24Fb	

Sviluppi di calcolo iperstatica

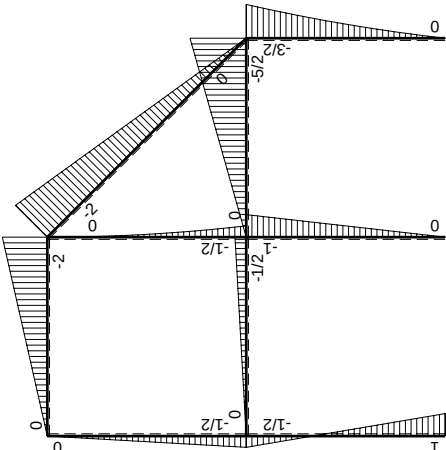
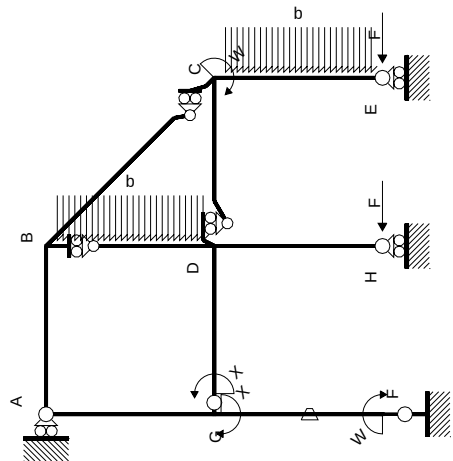


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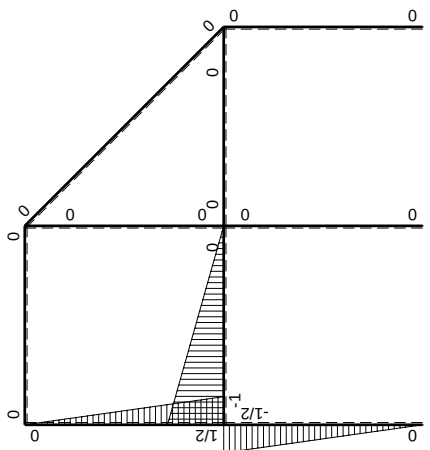


↺ $\boxed{+}$ ↻ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$Fb-3/2Fx$	$-Fb/EJ$	$-1/2Fx+3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(0+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-3/2Fx$	Fb/EJ	$1/4Fb-Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/4Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-1/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

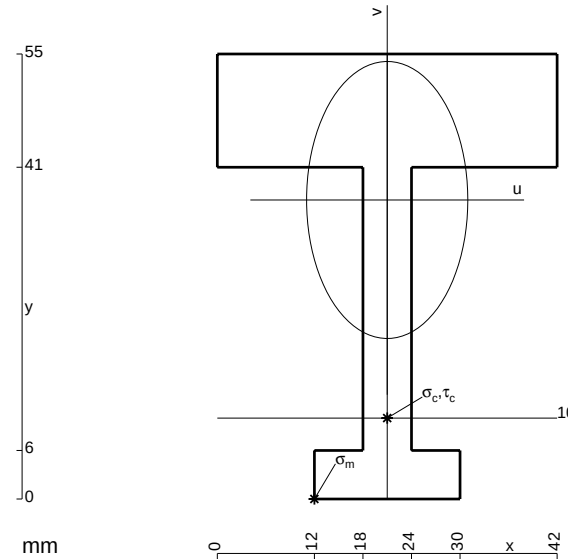
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

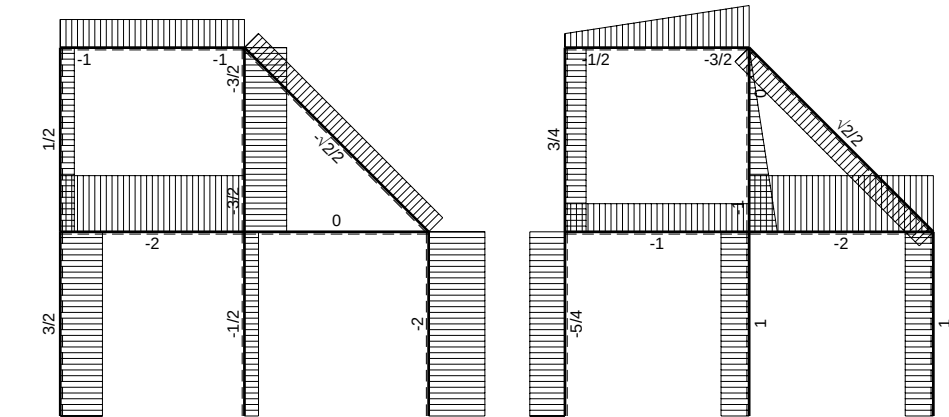
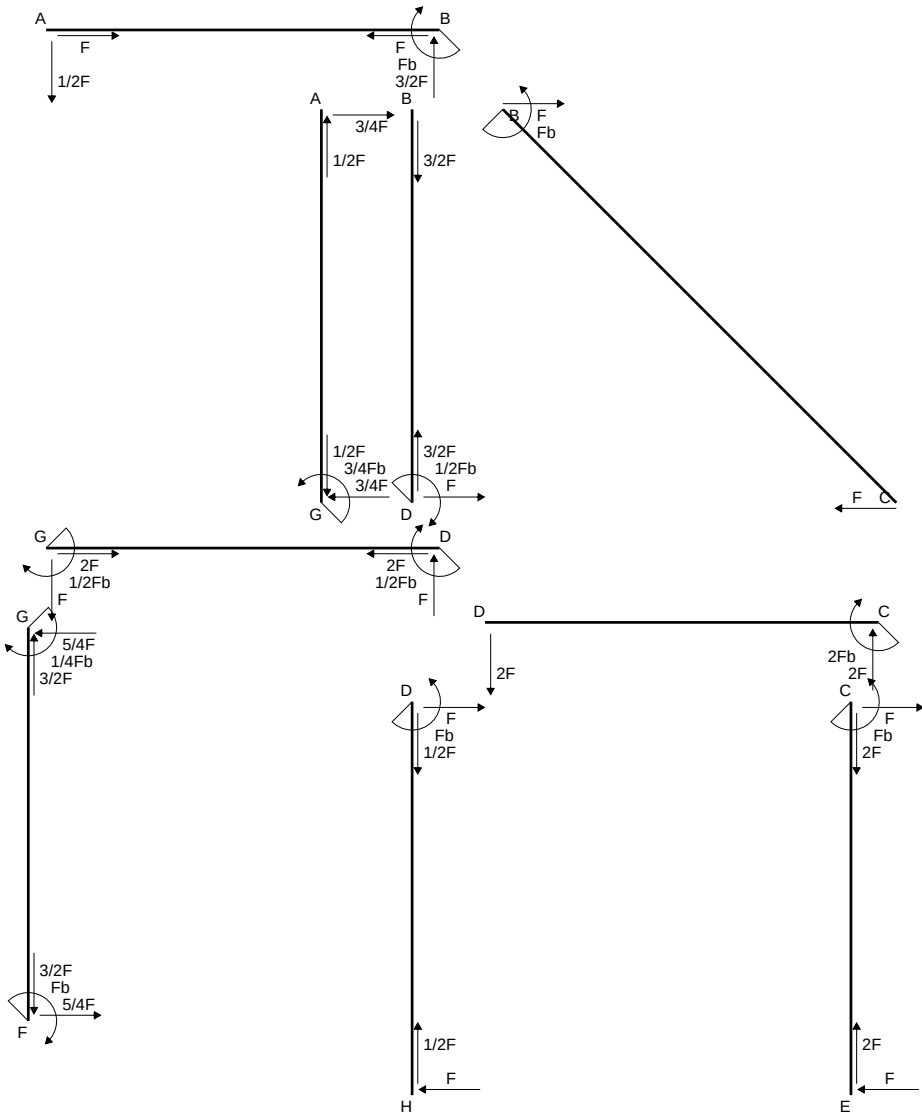
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

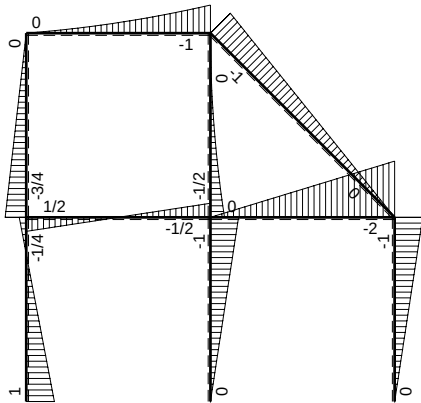


$$\begin{aligned} A &= 906. \text{ mm}^2 \\ J_u &= 265632. \text{ mm}^4 \\ J_v &= 89982. \text{ mm}^4 \\ y_g &= 36.96 \text{ mm} \\ T_y &= -2550. \text{ N} \\ M_x &= -1581000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -36.96 \text{ mm} \\ \sigma_m &= -Mv/J_u = -220. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -26.96 \text{ mm} \\ \sigma_c &= -Mv/J_u = -160.4 \text{ N/mm}^2 \\ \tau_c &= 6.98 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 160.9 \text{ N/mm}^2 \\ S &= 4362. \text{ mm}^3 \end{aligned}$$

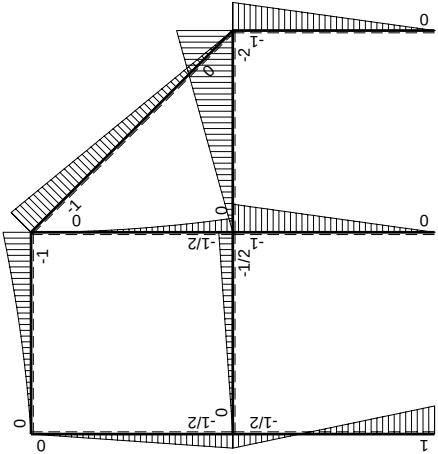
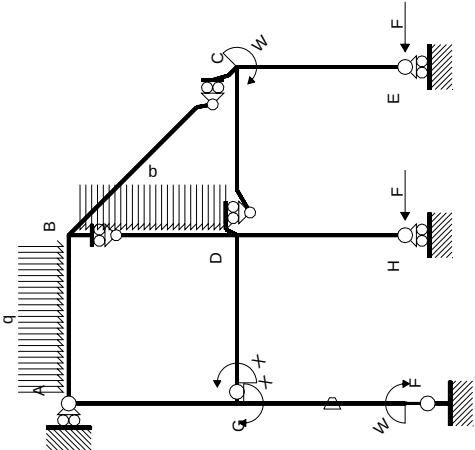


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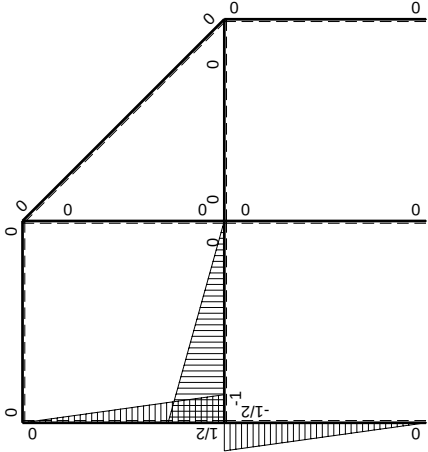


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-3/2Fx$	$-Fb/EJ$	$-1/2Fx+3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(0+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-3/2Fx$	Fb/EJ	$1/4Fb-Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/4Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-1/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

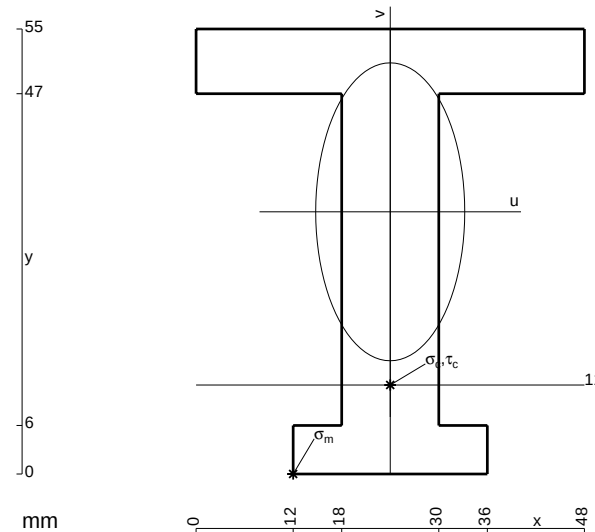
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

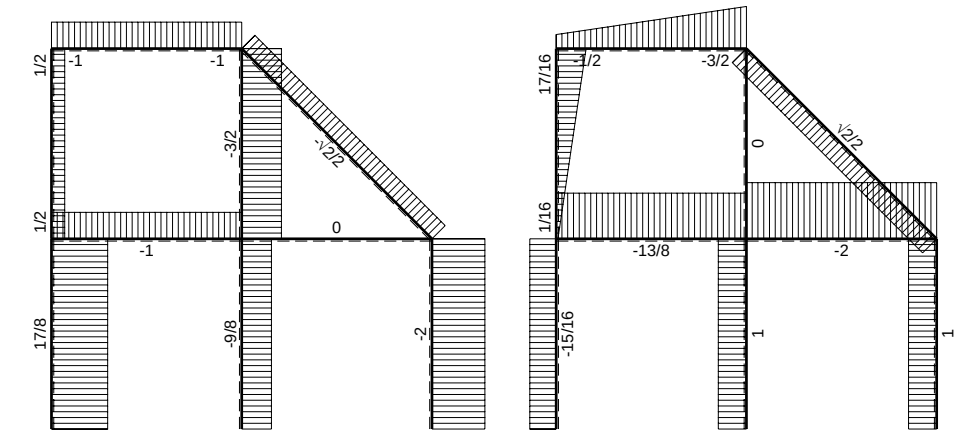
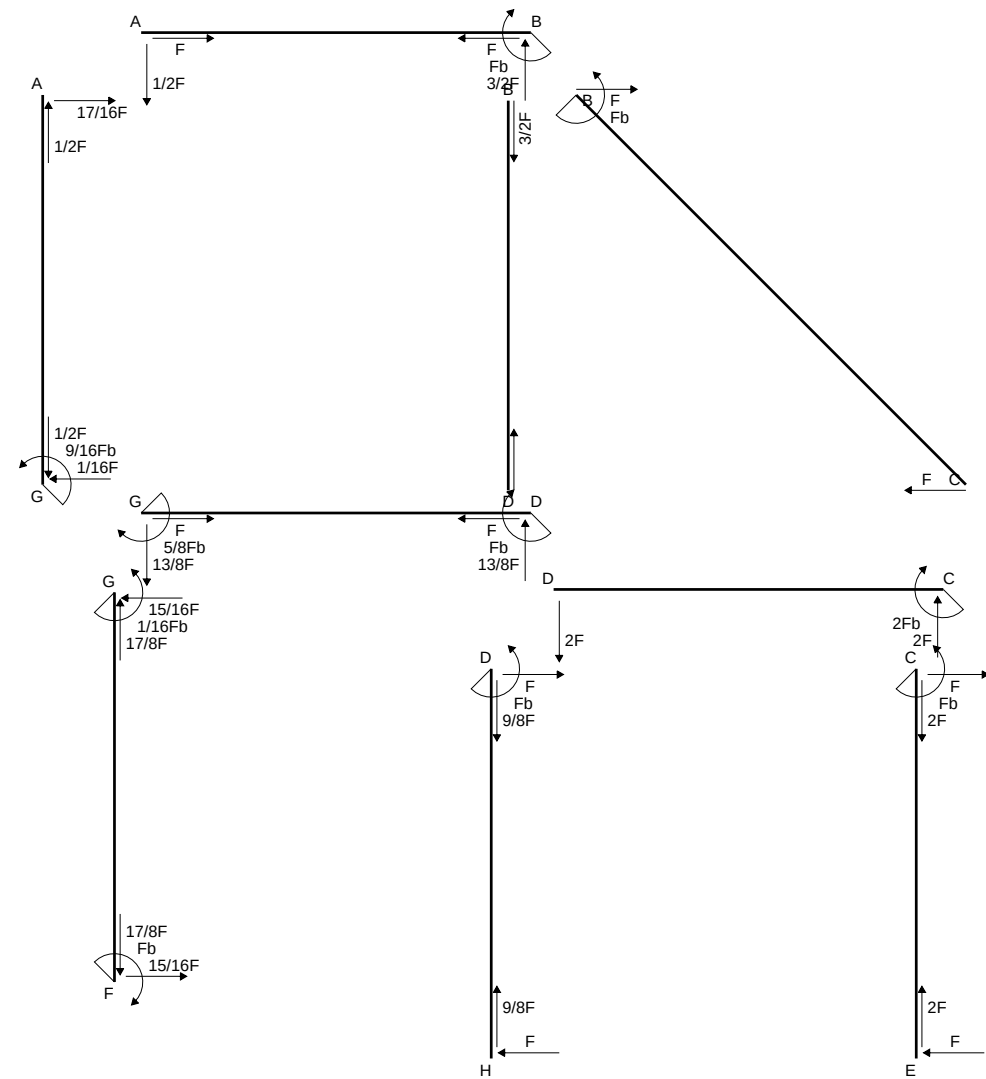
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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

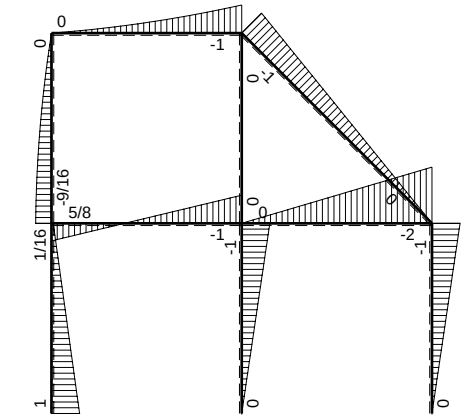


$$\begin{aligned} A &= 1020. \text{ mm}^2 \\ I_u &= 345844. \text{ mm}^4 \\ I_v &= 86544. \text{ mm}^4 \\ y_g &= 32.41 \text{ mm} \\ T_y &= -3660. \text{ N} \\ M_x &= -2452200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.41 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -21.41 \text{ mm} \\ \sigma_c &= -Mv/J_u = -151.8 \text{ N/mm}^2 \\ \tau_c &= 4.999 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 152. \text{ N/mm}^2 \\ S &= 5669. \text{ mm}^3 \end{aligned}$$

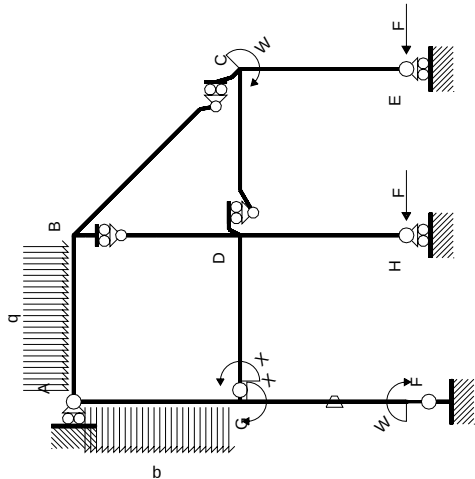


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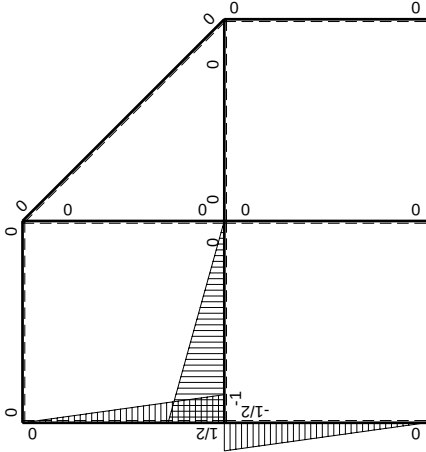
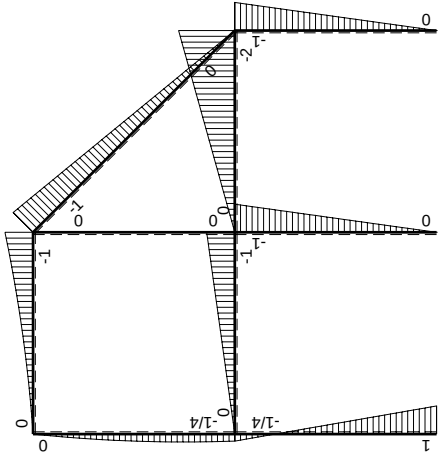


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-5/4Fx$	$-Fb/EJ$	$-1/2Fx+5/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/24+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/4Fb-5/4Fx$	Fb/EJ	$1/8Fb-3/4Fx+5/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb-1/4Fx+1/2qx^2$	0	$-1/8Fb+3/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/16+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx-1/2qx^2$	0	$-3/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$5/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{8} - \frac{3}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{3}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{3}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{24} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

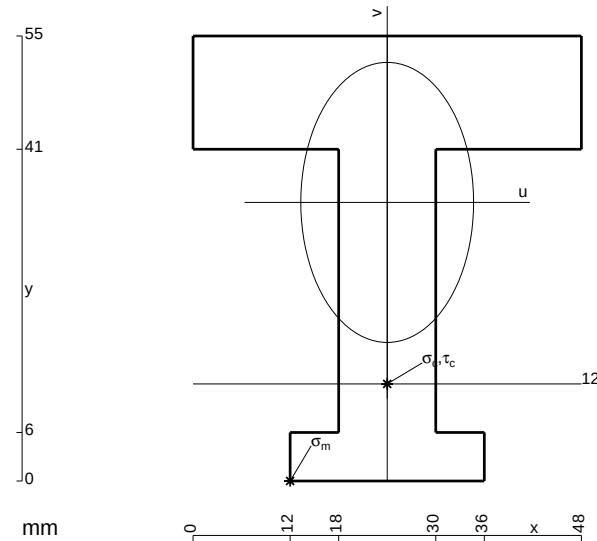
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{3}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

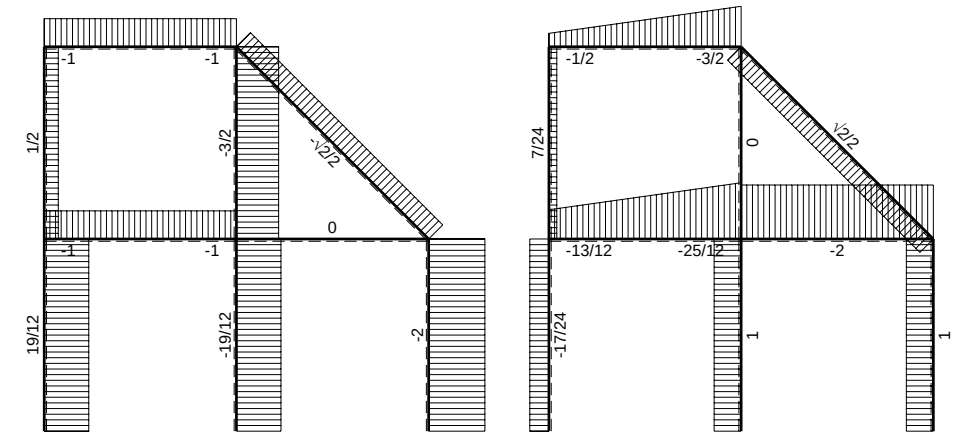
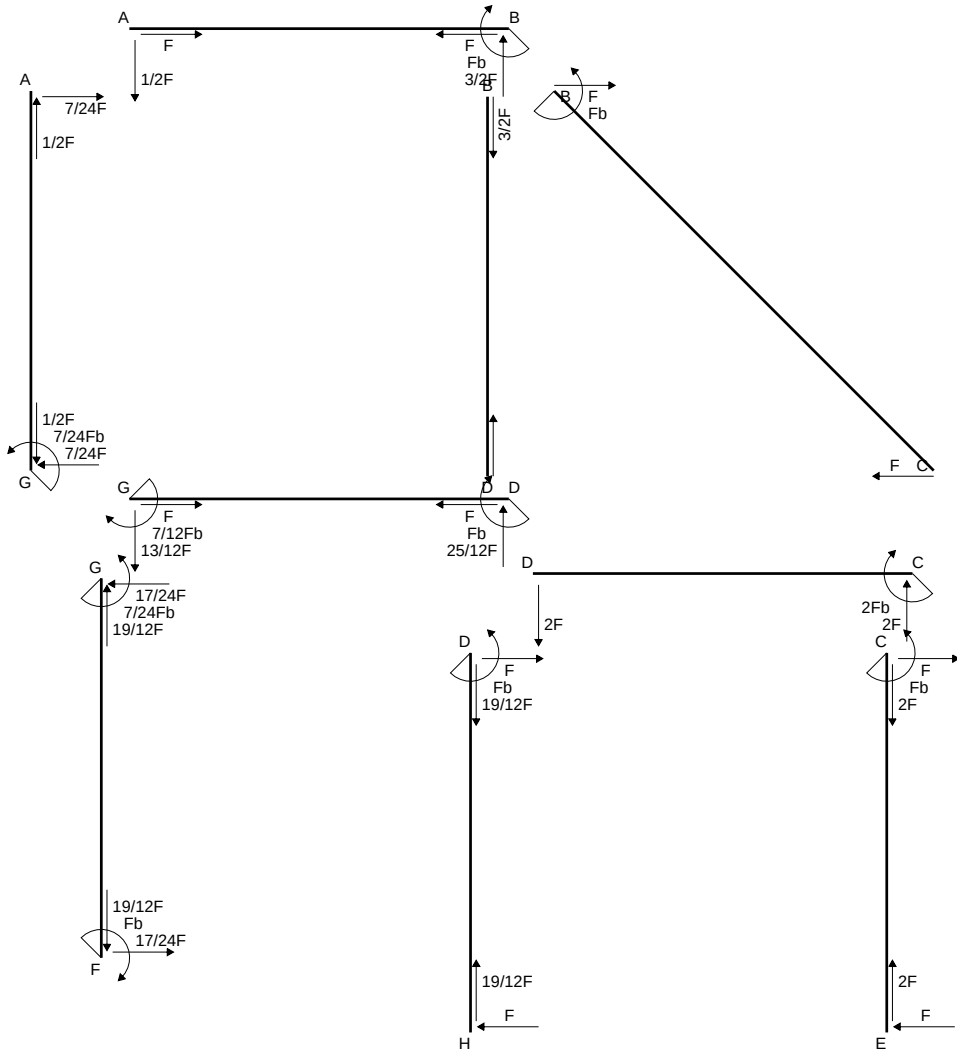
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

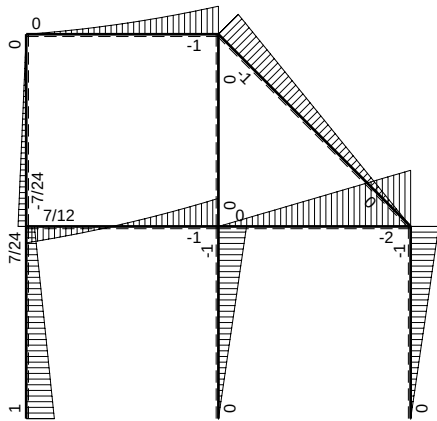


$$\begin{aligned} A &= 1236. \text{ mm}^2 \\ J_u &= 370453. \text{ mm}^4 \\ J_v &= 140976. \text{ mm}^4 \\ y_g &= 34.43 \text{ mm} \\ T_y &= -3580. \text{ N} \\ M_x &= -2577600. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -34.43 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -22.43 \text{ mm} \\ \sigma_c &= -Mv/J_u = -156.1 \text{ N/mm}^2 \\ \tau_c &= 5.12 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 156.3 \text{ N/mm}^2 \\ S &= 6357. \text{ mm}^3 \end{aligned}$$

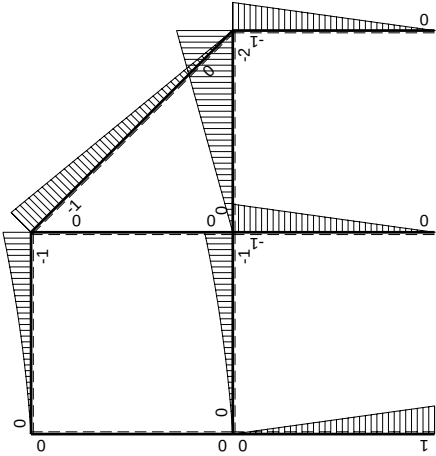
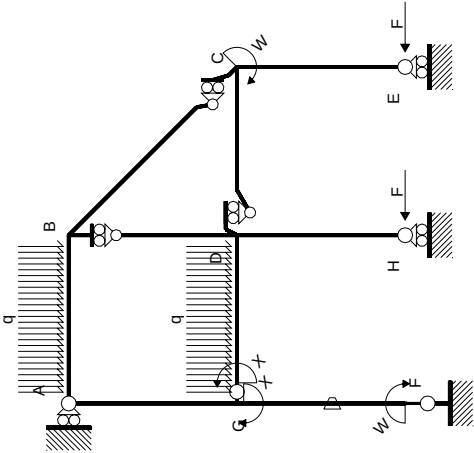


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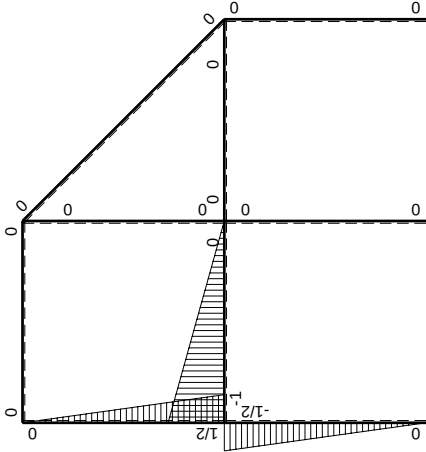


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-Fx$	$-Fb/EJ$	$-1/2Fx+1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$-Fx$	Fb/EJ	$-1/2Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$7/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

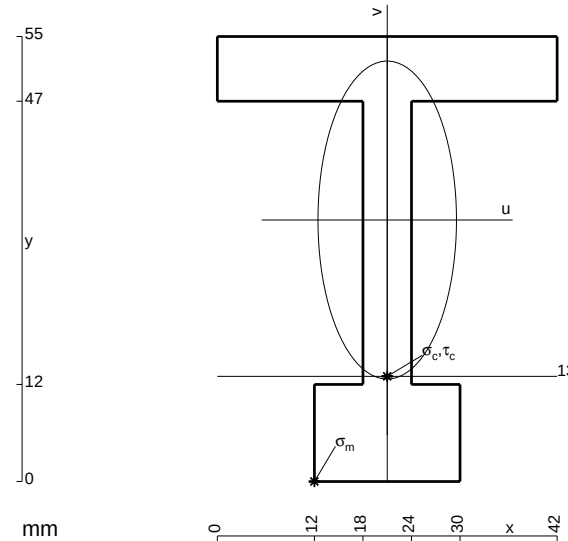
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

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

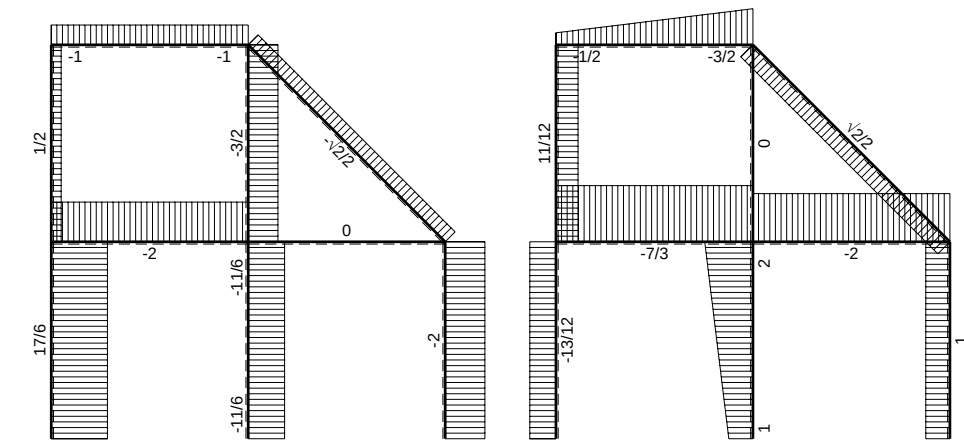
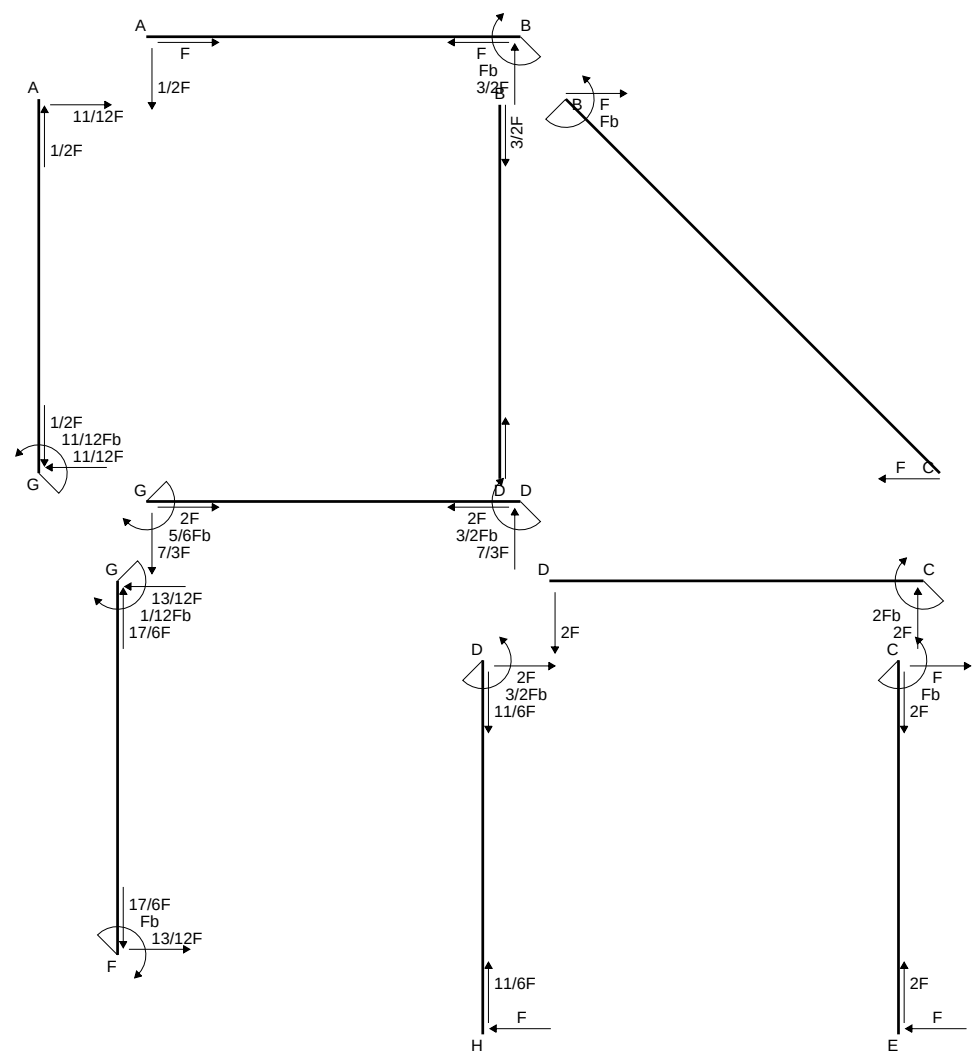
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

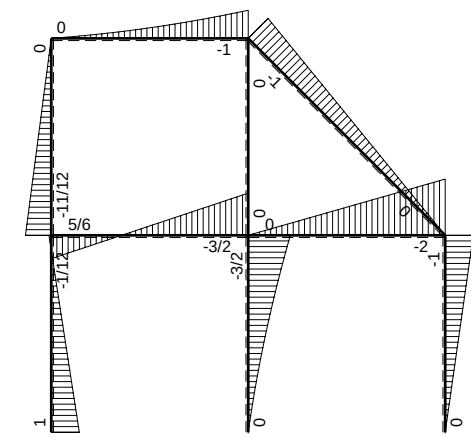


$$\begin{aligned} A &= 762. \text{ mm}^2 \\ J_u &= 294369. \text{ mm}^4 \\ J_v &= 55854. \text{ mm}^4 \\ y_g &= 32.32 \text{ mm} \\ T_y &= -2320. \text{ N} \\ M_x &= -1809600. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -32.32 \text{ mm} \\ \sigma_m &= -Mv/J_u = -198.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -19.32 \text{ mm} \\ \sigma_c &= -Mv/J_u = -118.8 \text{ N/mm}^2 \\ \tau_c &= 7.624 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 119.5 \text{ N/mm}^2 \\ S &= 5804. \text{ mm}^3 \end{aligned}$$

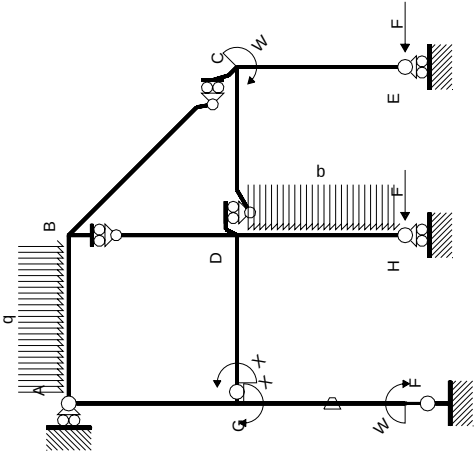


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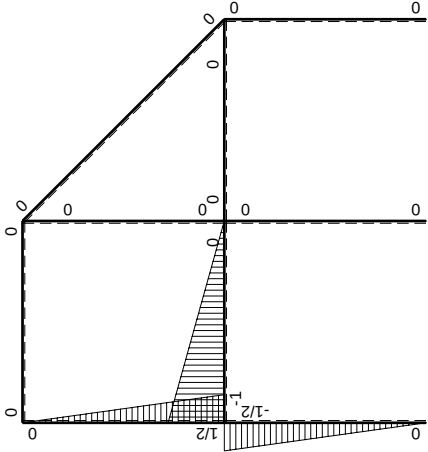
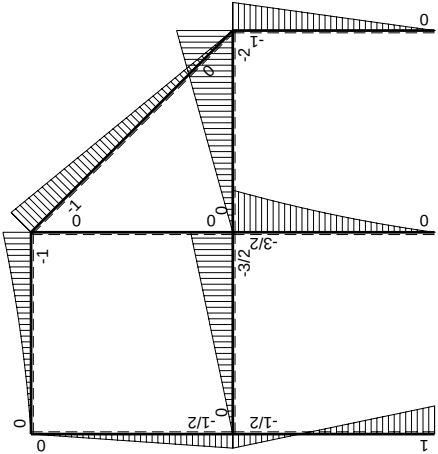


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-3/2Fx$	$-Fb/EJ$	$-1/2Fx+3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(0+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-3/2Fx$	Fb/EJ	$1/4Fb-Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

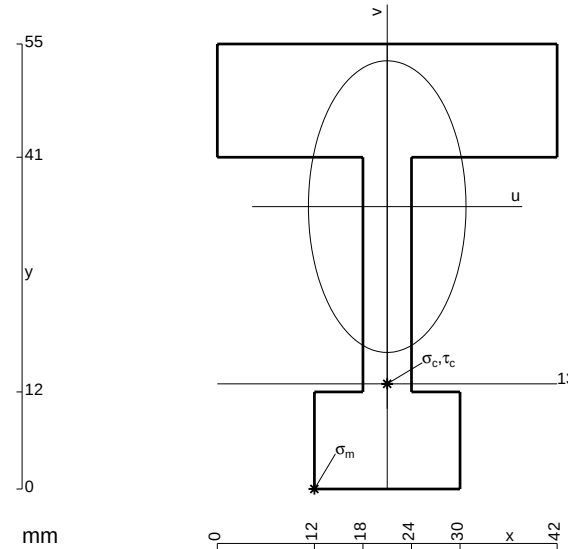
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

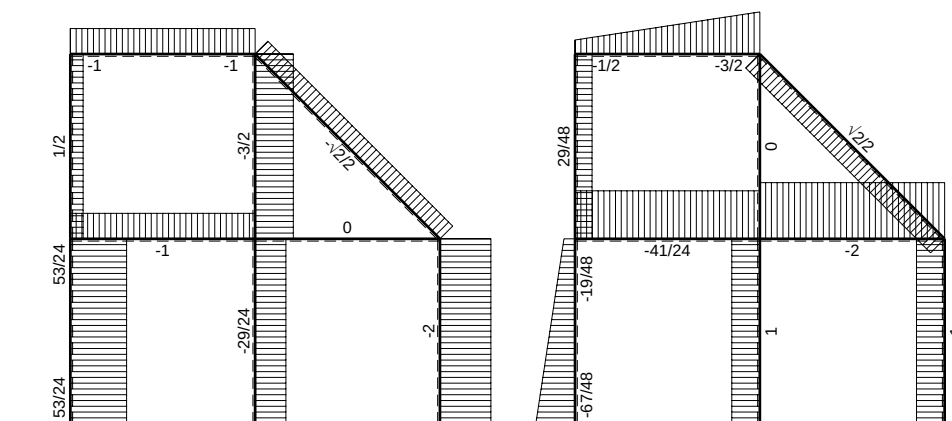
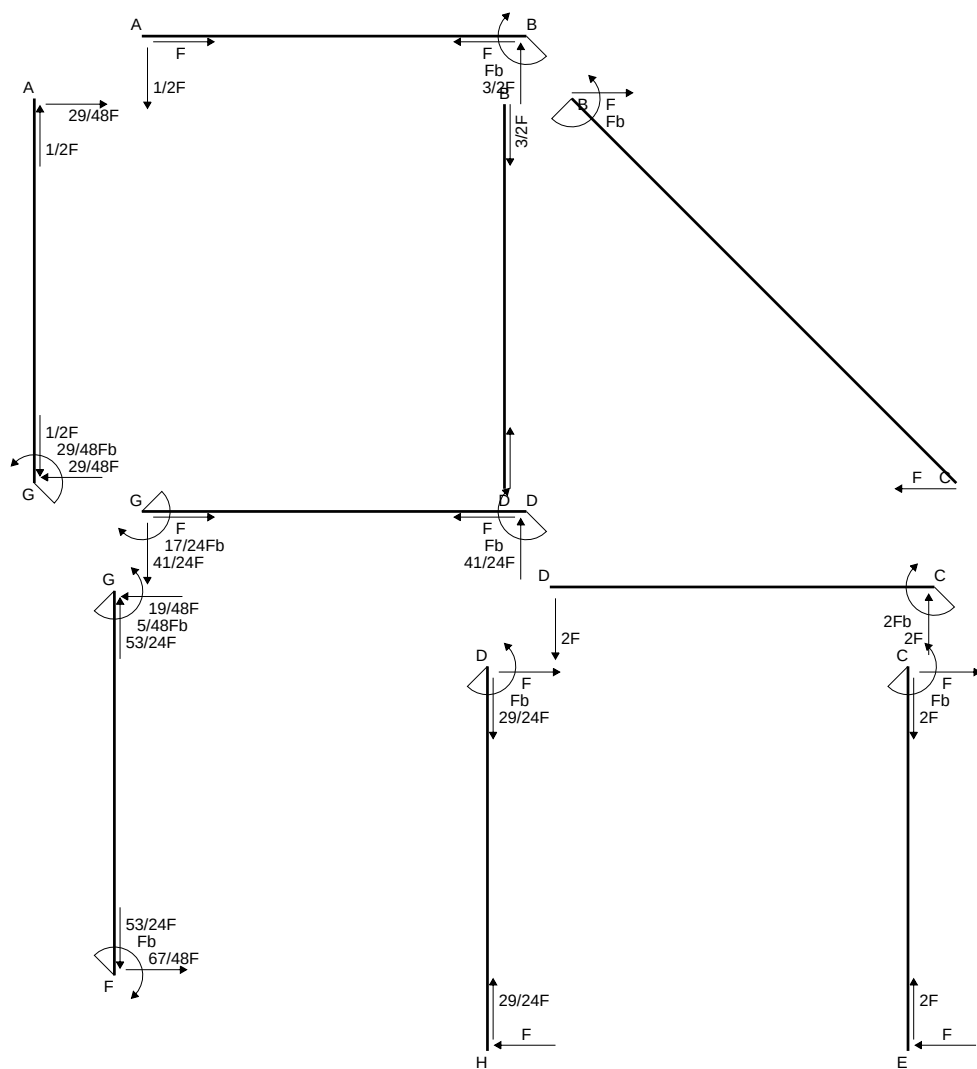
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

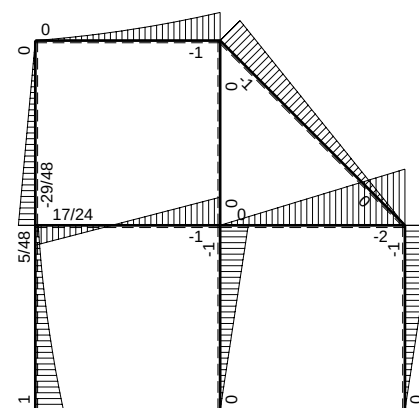
$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

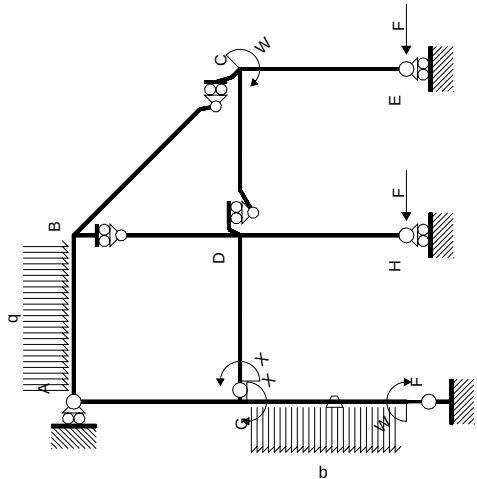


$$\begin{aligned} A &= 978. \text{ mm}^2 \\ J_u &= 317980. \text{ mm}^4 \\ J_v &= 92790. \text{ mm}^4 \\ y_g &= 34.9 \text{ mm} \\ T_y &= -2300. \text{ N} \\ M_x &= -1909000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.9 \text{ mm} \\ \sigma_m &= -Mv/J_u = -209.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -21.9 \text{ mm} \\ \sigma_c &= -Mv/J_u = -131.5 \text{ N/mm}^2 \\ \tau_c &= 7.687 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 132.1 \text{ N/mm}^2 \\ S &= 6377. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

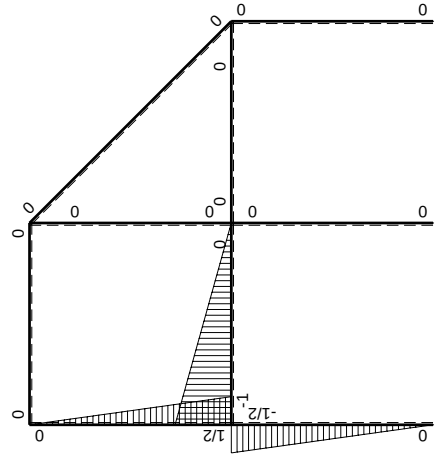
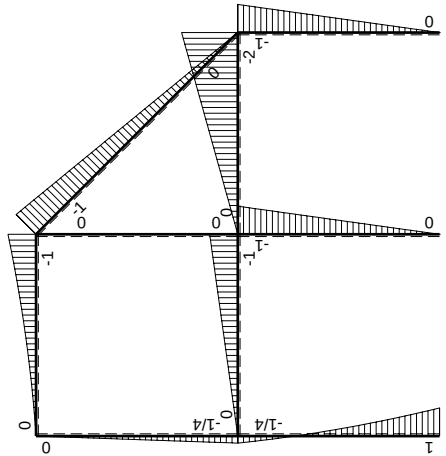
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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-7/4Fx+1/2qx^2$	$-Fb/EJ$	$-1/2Fx+7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$1/8Fb-1/2Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb+1/4Fx$	0	$-1/8Fb+1/4Fx-1/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/4Fx$	0	$-1/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$17/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-17/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{8} - \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{1}{4} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

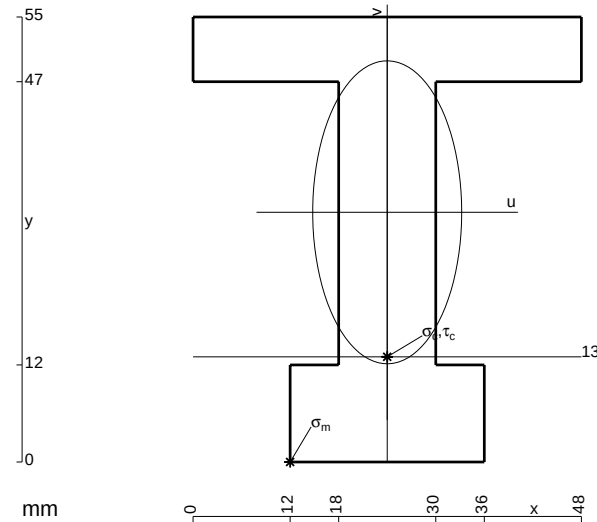
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

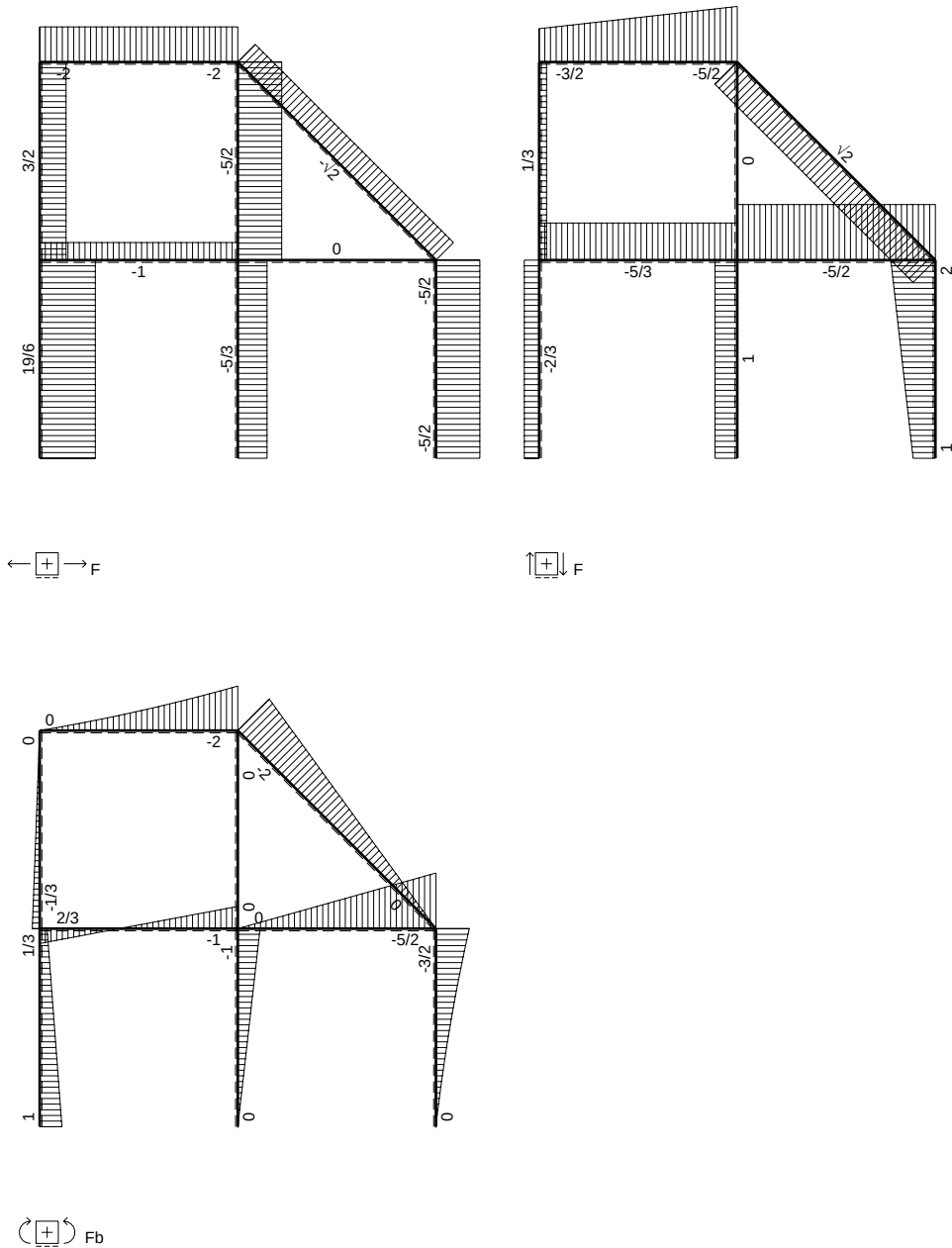
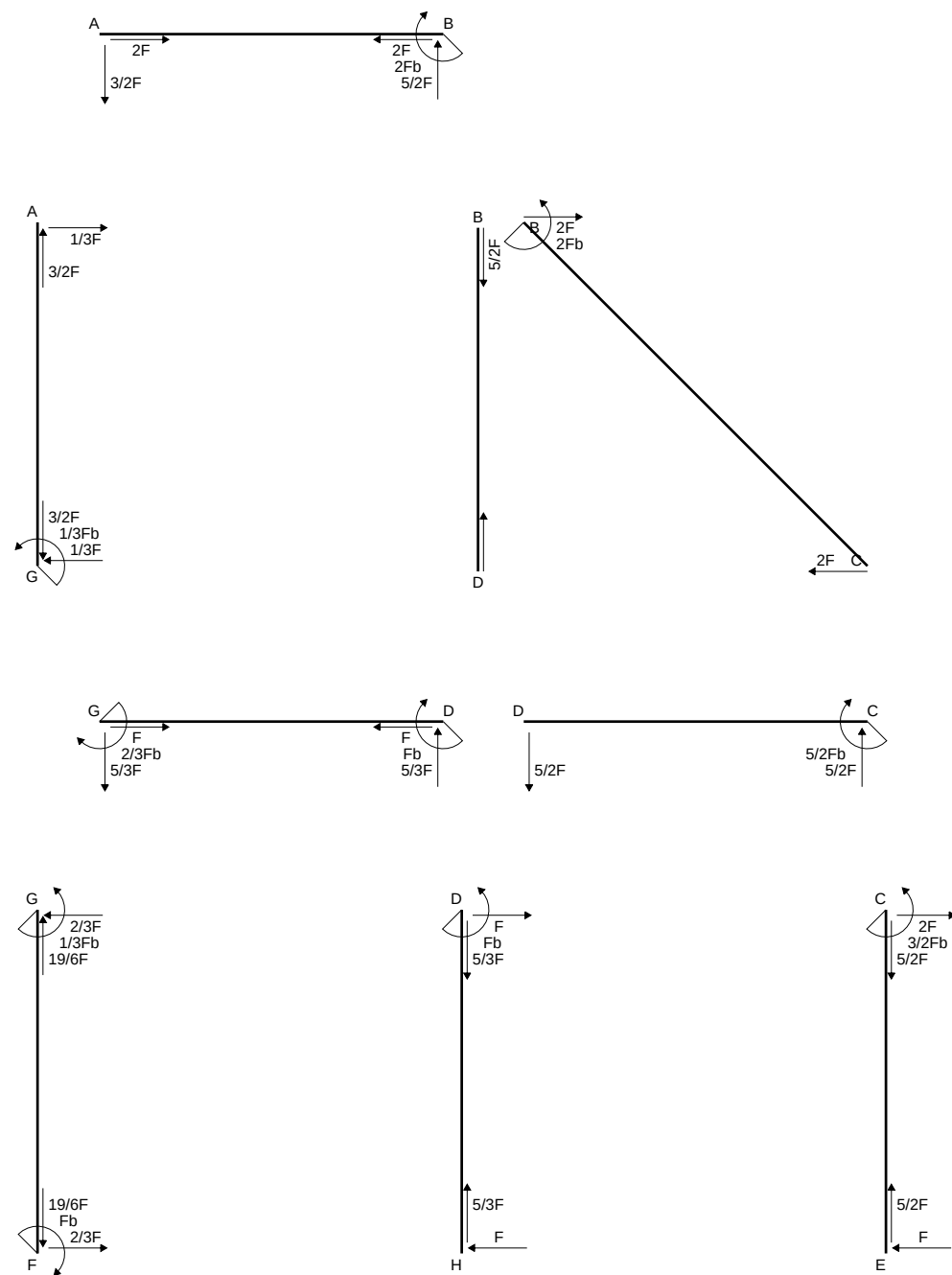
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

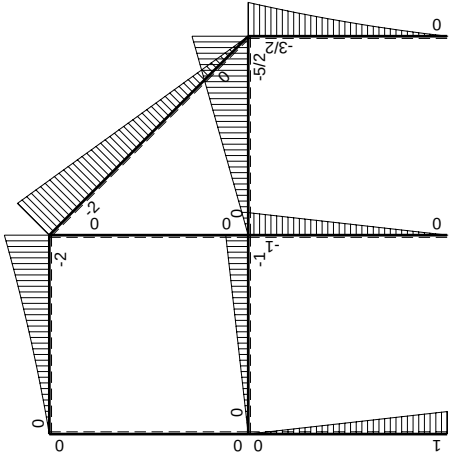
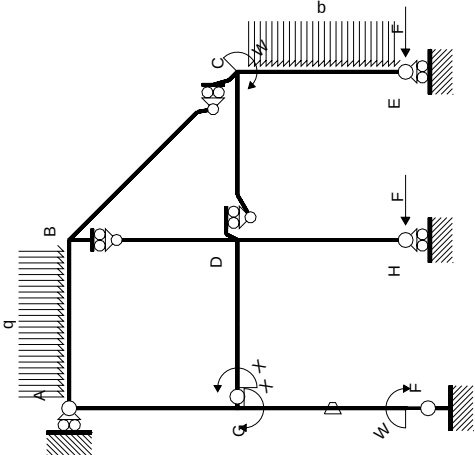
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



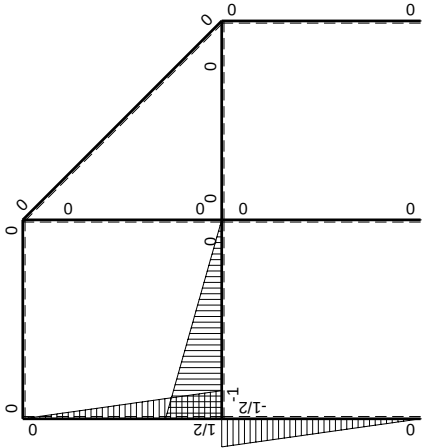
$$\begin{aligned} A &= 1092. \text{ mm}^2 \\ J_u &= 382903. \text{ mm}^4 \\ J_v &= 92592. \text{ mm}^4 \\ y_g &= 30.86 \text{ mm} \\ T_y &= -3100. \text{ N} \\ M_x &= -2728000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.86 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.86 \text{ mm} \\ \sigma_c &= -Mv/J_u = -127.3 \text{ N/mm}^2 \\ \tau_c &= 4.98 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 127.6 \text{ N/mm}^2 \\ S &= 7381. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$Fb-Fx$	$-Fb/EJ$	$-1/2Fx+1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$-Fx$	Fb/EJ	$-1/2Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$1/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-2/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

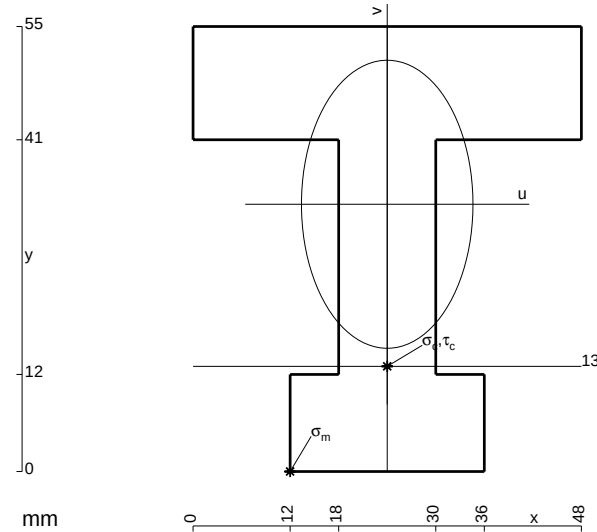
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

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

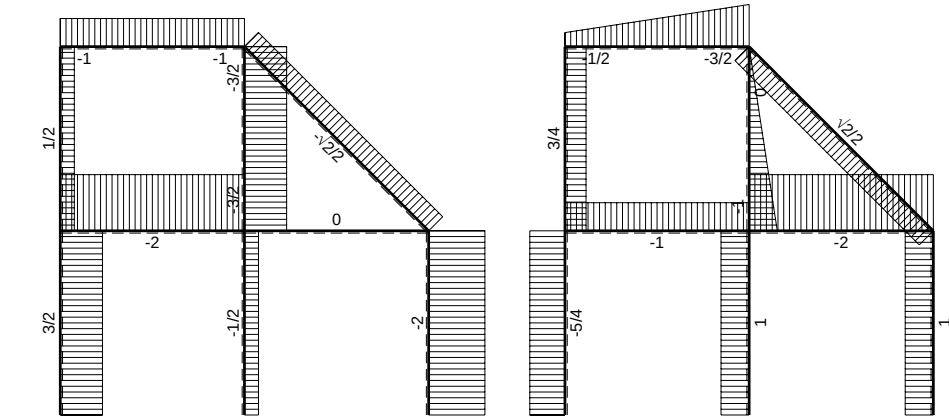
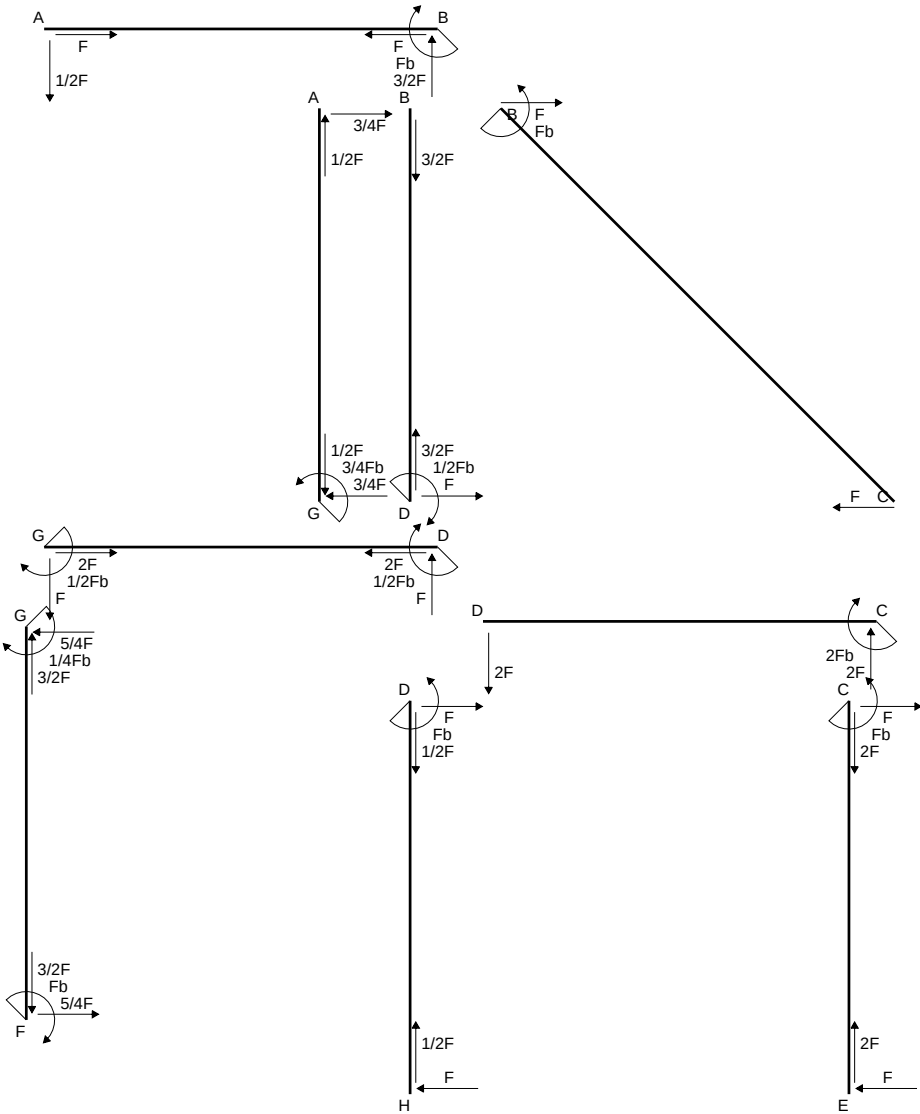
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

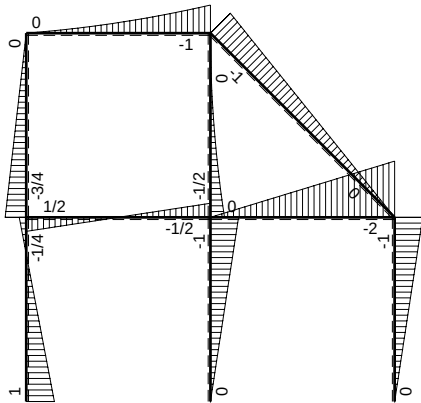


$$\begin{aligned} A &= 1308. \text{ mm}^2 \\ J_u &= 414675. \text{ mm}^4 \\ J_v &= 147024. \text{ mm}^4 \\ y_g &= 33.03 \text{ mm} \\ T_y &= -3100. \text{ N} \\ M_x &= -2883000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -33.03 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -20.03 \text{ mm} \\ \sigma_c &= -Mv/J_u = -139.3 \text{ N/mm}^2 \\ \tau_c &= 5.004 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 139.5 \text{ N/mm}^2 \\ S &= 8032. \text{ mm}^3 \end{aligned}$$

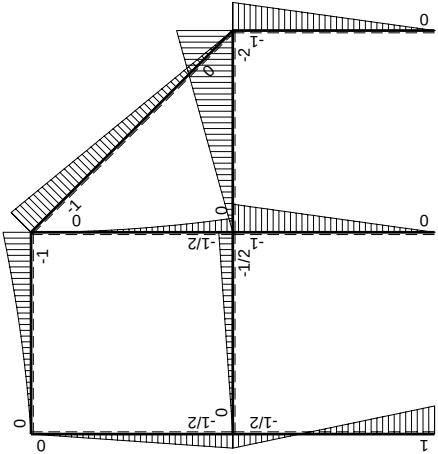
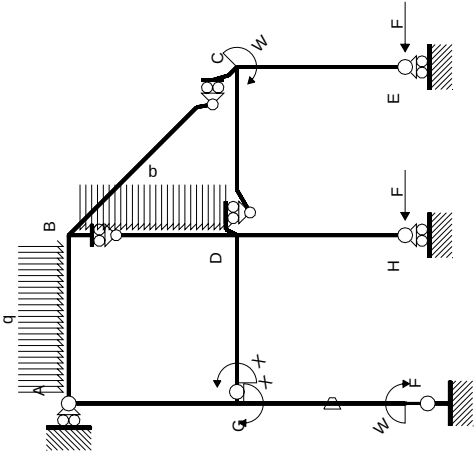


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

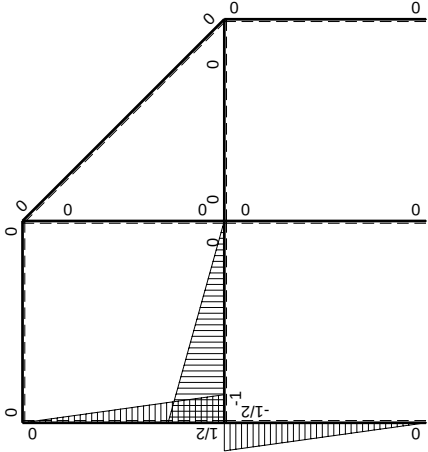


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-3/2Fx$	$-Fb/EJ$	$-1/2Fx+3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(0+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-3/2Fx$	Fb/EJ	$1/4Fb-Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/4Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-1/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

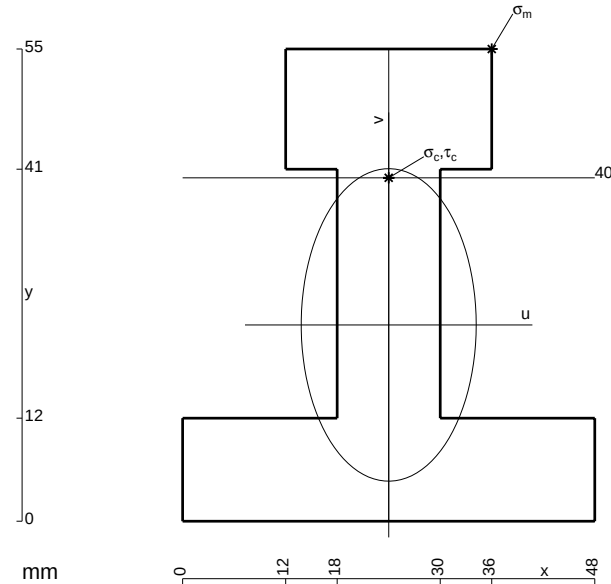
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

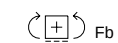
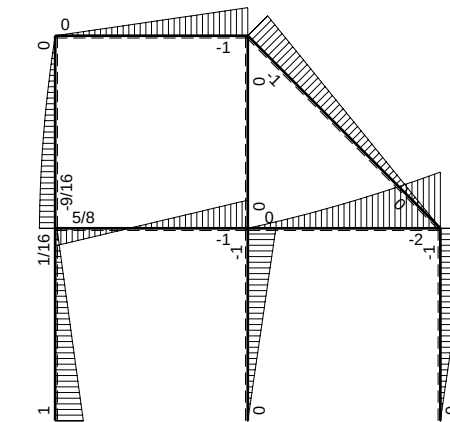
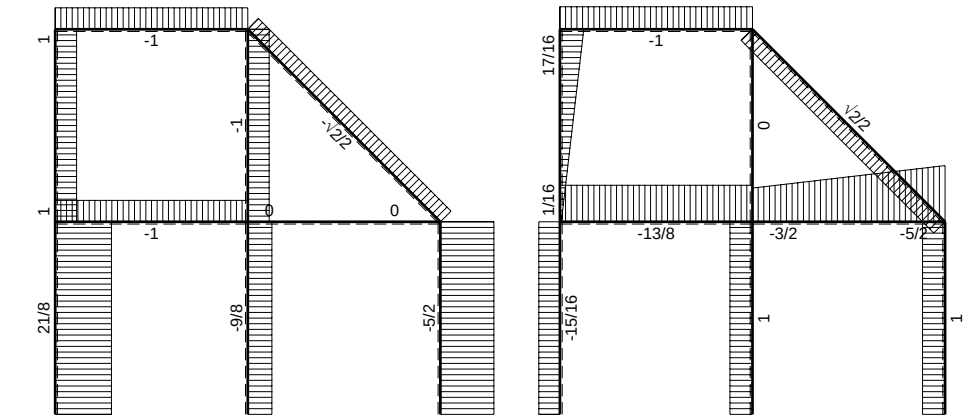
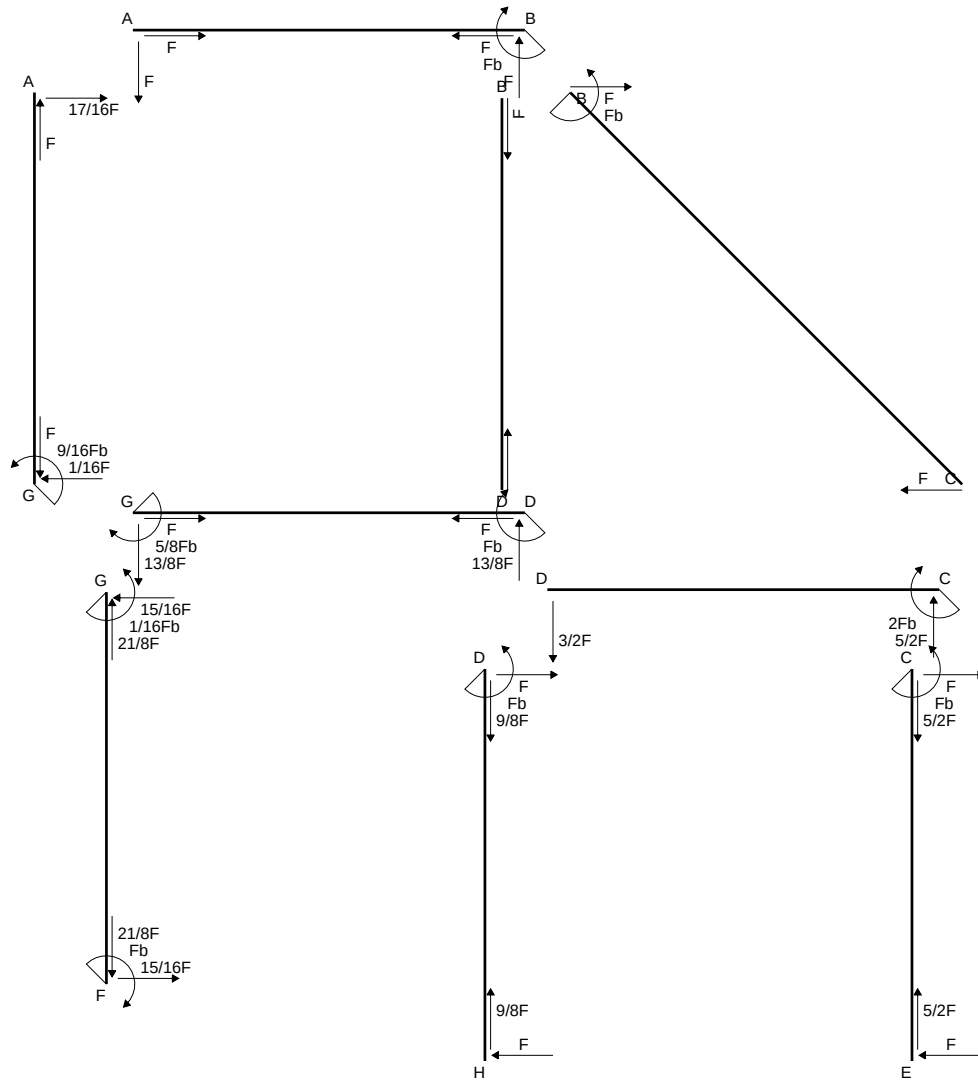
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

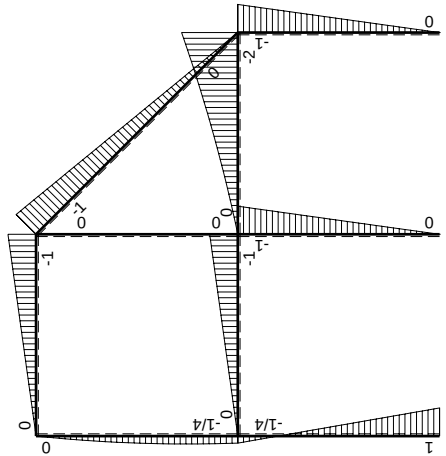
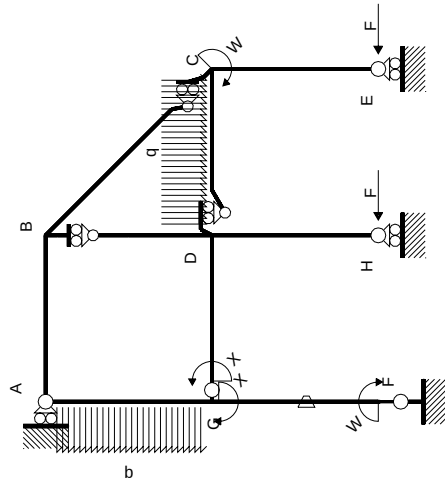
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



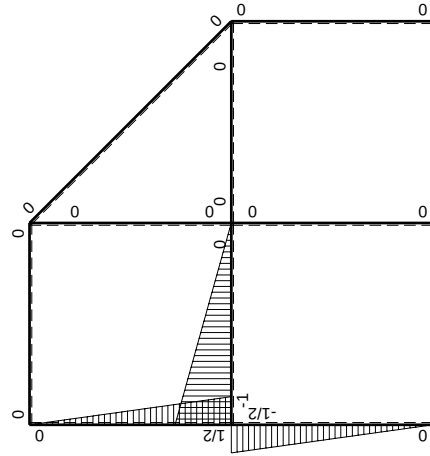
$$\begin{aligned} A &= 1260. \text{ mm}^2 \\ J_u &= 417492. \text{ mm}^4 \\ J_v &= 130896. \text{ mm}^4 \\ y_g &= 22.86 \text{ mm} \\ T_y &= -3180. \text{ N} \\ M_x &= -3116400. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 32.14 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 17.14 \text{ mm} \\ \sigma_c &= -Mv/J_u = 127.9 \text{ N/mm}^2 \\ \tau_c &= 5.496 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 128.3 \text{ N/mm}^2 \\ S &= 8658. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-3/2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx ²	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx ²	0	-1/8Fb+3/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx ²	0	-3/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						5/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + 5/8 x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + 5/24 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + 5/24 b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{8} - 3/4 x/b + 5/8 x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - 3/8 x^2/b + 5/24 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - 3/8 b + 5/24 b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = 5/24 Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

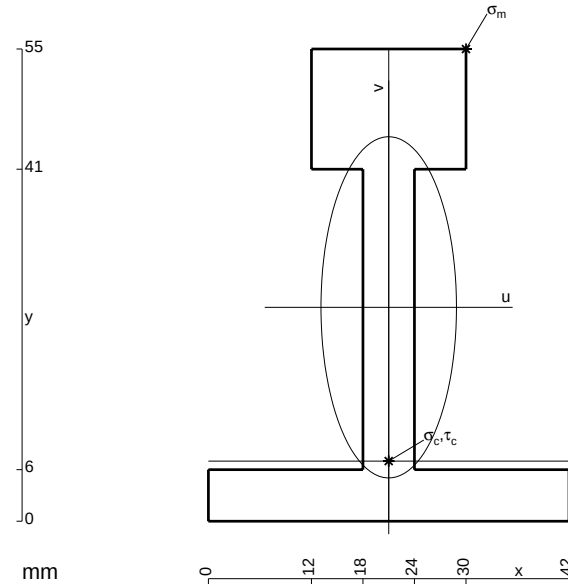
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + 3/8 x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

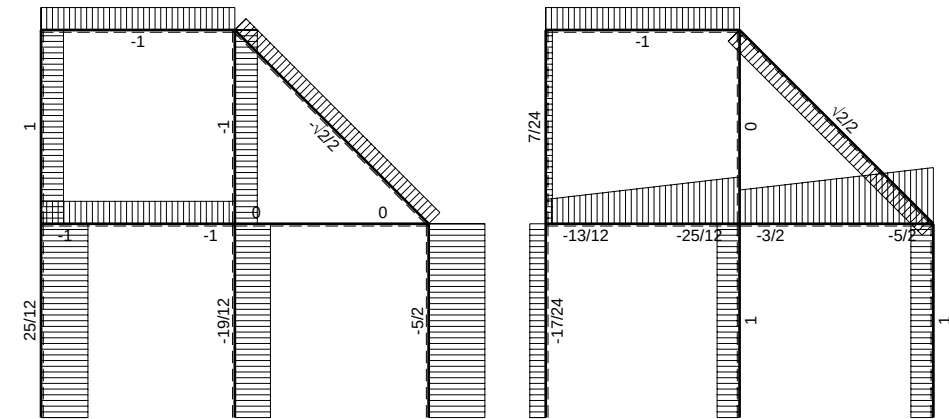
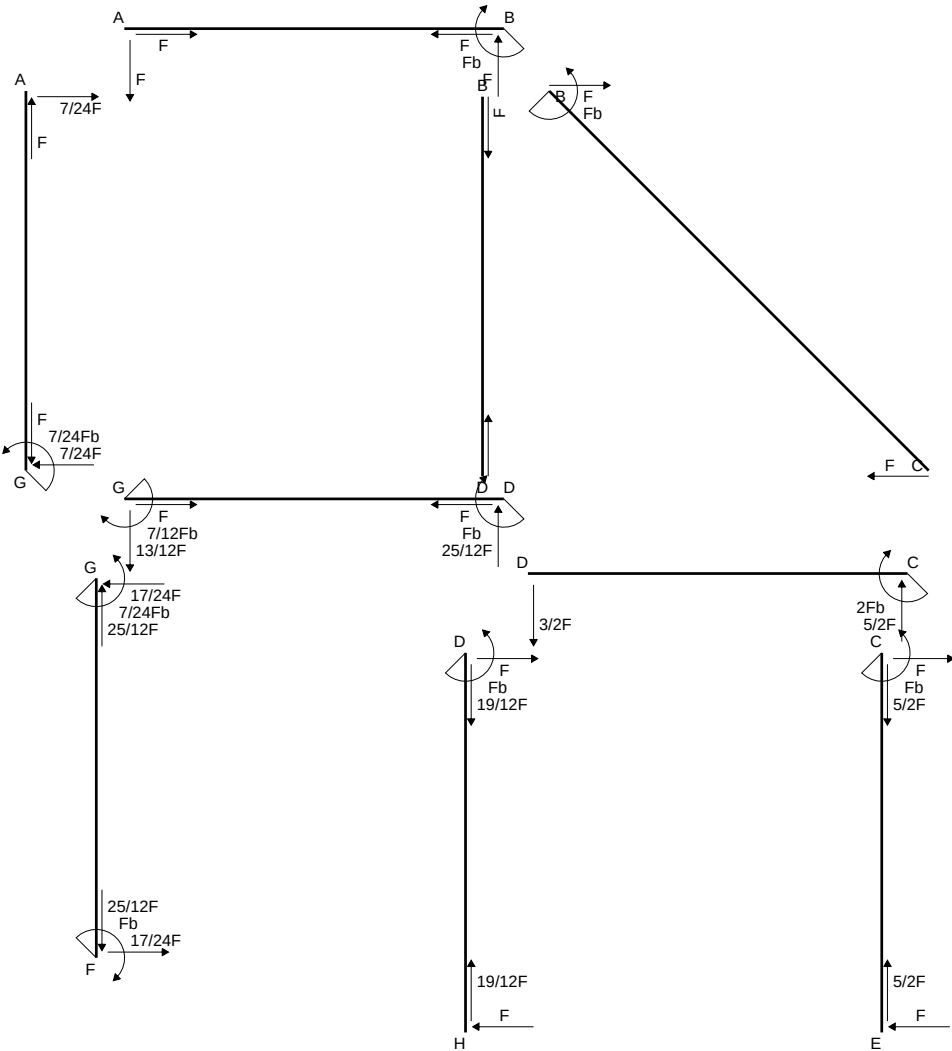
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-3/8 x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{1}{16} Fb^2/EJ$$

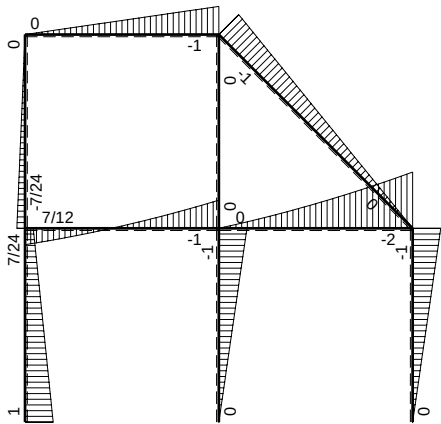


$$\begin{aligned} A &= 714. \text{ mm}^2 \\ J_u &= 282052. \text{ mm}^4 \\ J_v &= 44478. \text{ mm}^4 \\ y_g &= 24.91 \text{ mm} \\ T_y &= -4500. \text{ N} \\ M_x &= -1872000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 30.09 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -17.91 \text{ mm} \\ \sigma_c &= -Mv/J_u = -118.9 \text{ N/mm}^2 \\ \tau_c &= 14.98 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 121.7 \text{ N/mm}^2 \\ S &= 5632. \text{ mm}^3 \end{aligned}$$

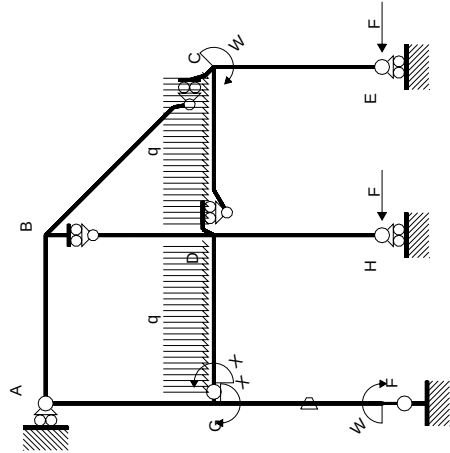


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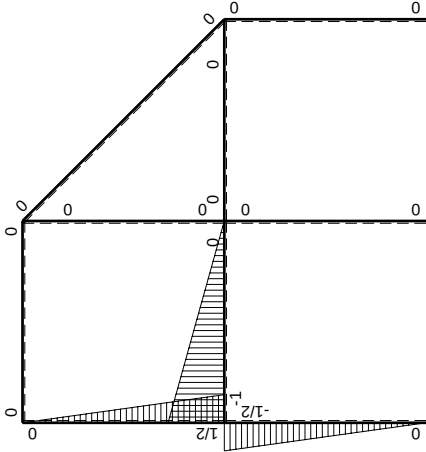
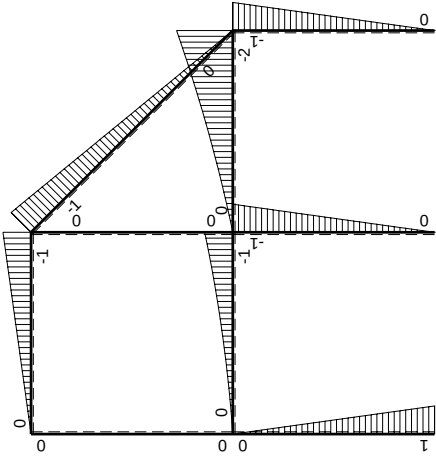


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-3/2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx ²	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-Fx	-Fb/EJ	-1/2Fx+1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	-Fx	Fb/EJ	-1/2Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	1/2Fx-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(1/8+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx ²	0	Fx-3/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x ² /b ²	0+0	1/12Xb/EJ
AG b	-1/2x/b	0	0	0	0	1/4x ² /b ²		
	totali						7/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

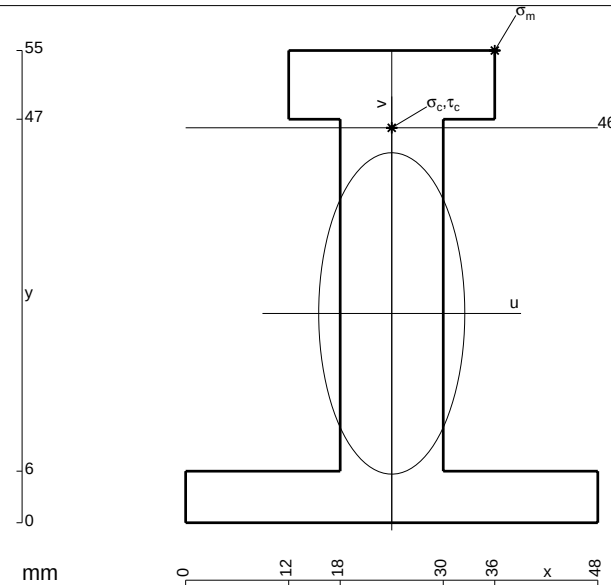
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

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

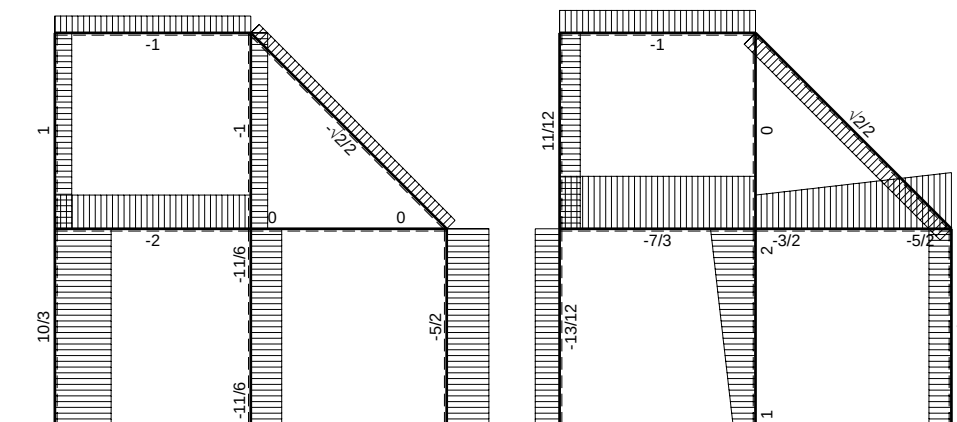
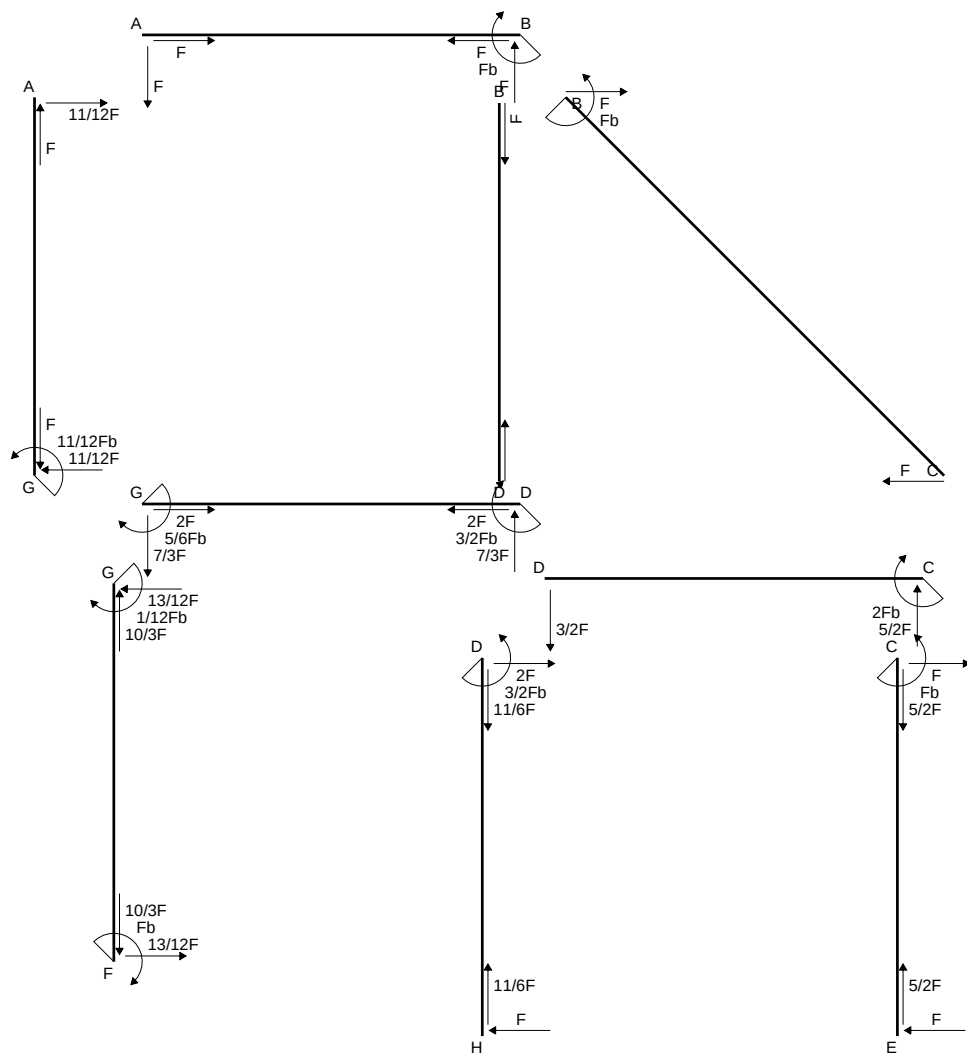
$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

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

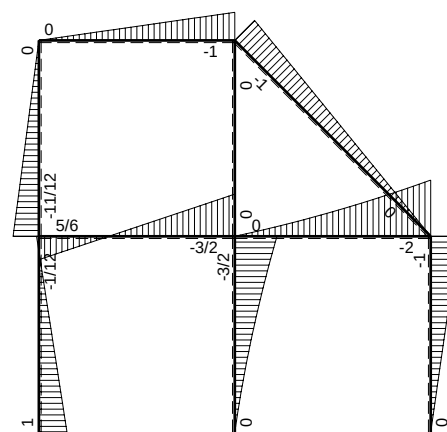
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$



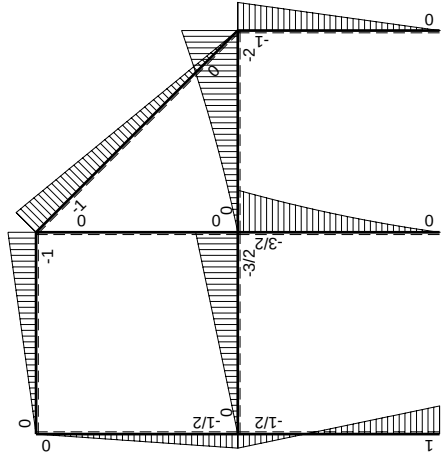
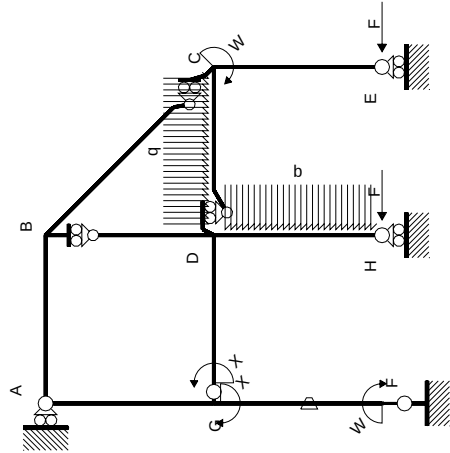
$$\begin{aligned} A &= 972. \text{ mm}^2 \\ J_u &= 340722. \text{ mm}^4 \\ J_v &= 70416. \text{ mm}^4 \\ y_g &= 24.38 \text{ mm} \\ T_y &= -5100. \text{ N} \\ M_x &= -2325600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.62 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 21.62 \text{ mm} \\ \sigma_c &= -Mv/J_u = 147.6 \text{ N/mm}^2 \\ \tau_c &= 6.707 \text{ N/mm}^2 \\ \sigma_p &= \sqrt{\sigma^2 + 3\tau^2} = 148. \text{ N/mm}^2 \\ S &= 5377. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow_F$$

$\uparrow \boxed{+} \downarrow F$

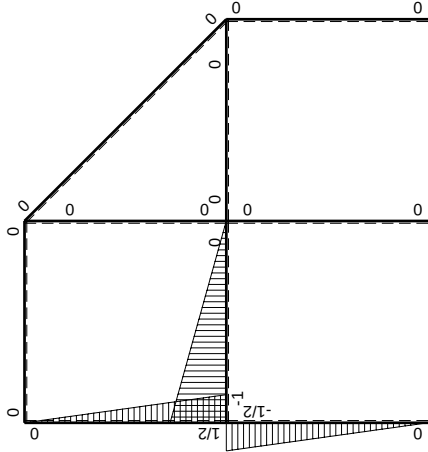


 F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-3/2Fx$	$-Fb/EJ$	$-1/2Fx+3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(0+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-3/2Fx$	Fb/EJ	$1/4Fb-Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

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

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

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

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

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

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

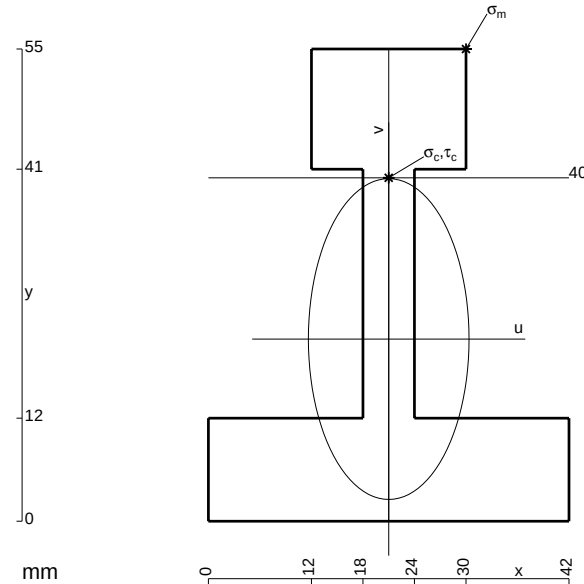
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

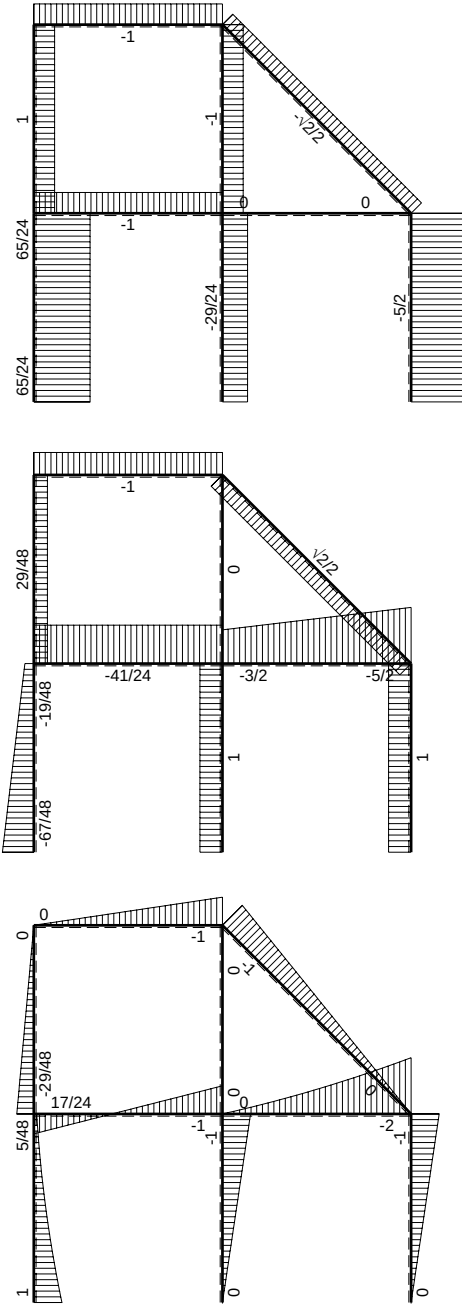
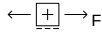
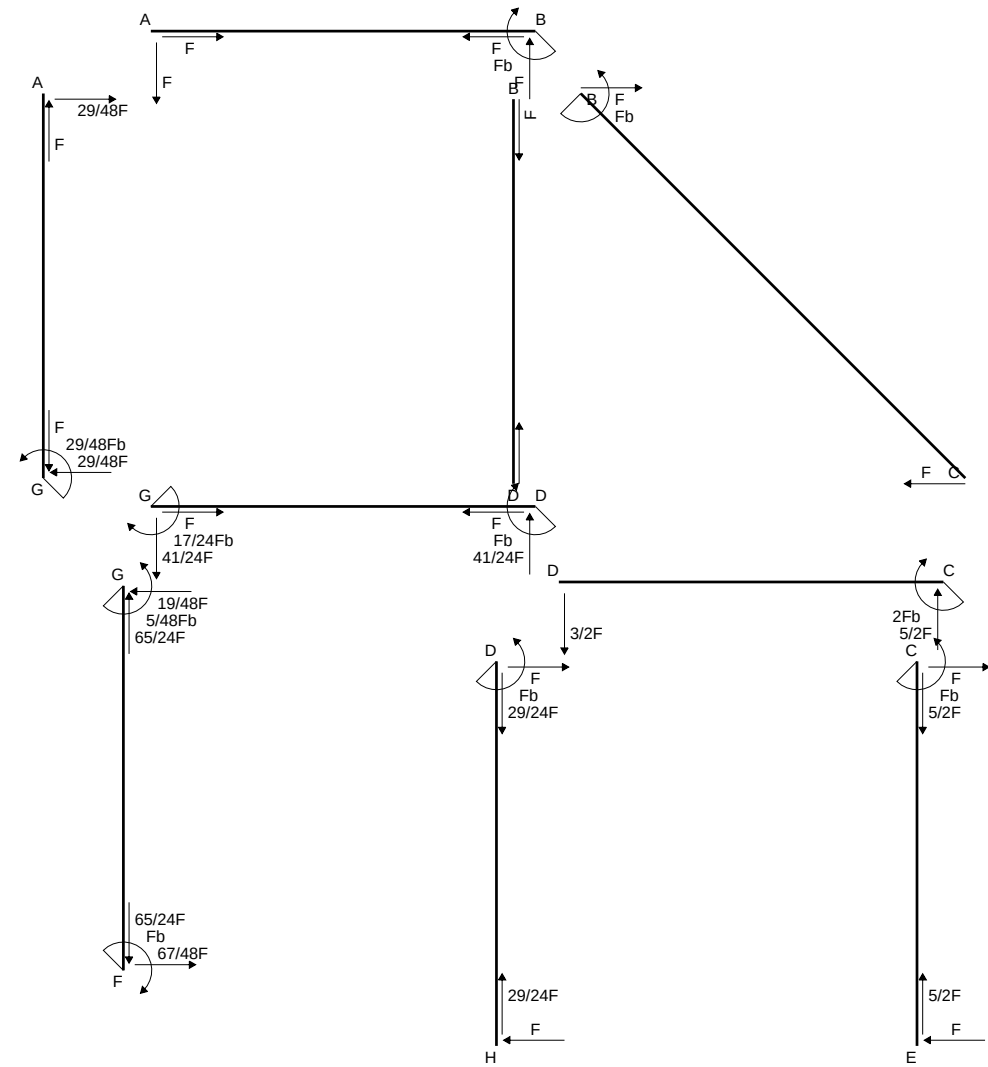
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

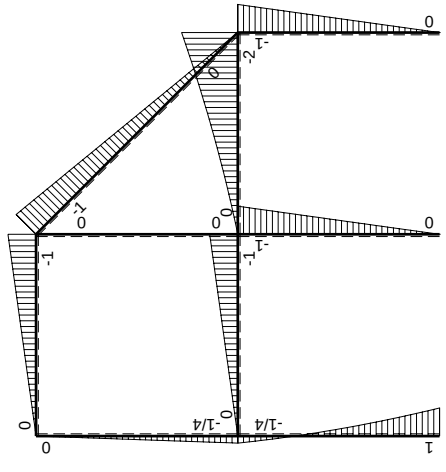
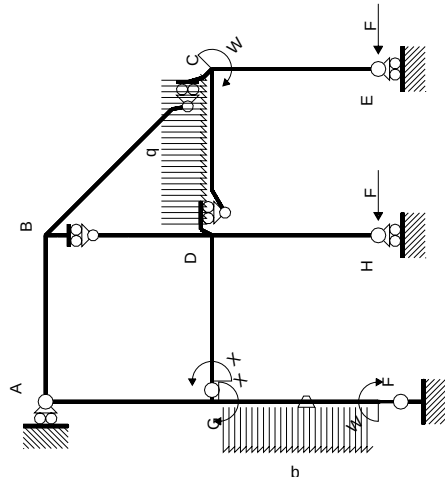
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

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



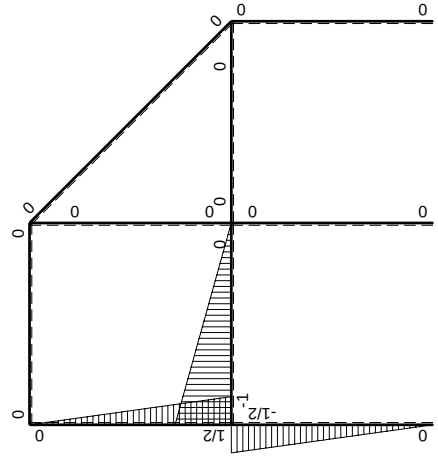
$$\begin{aligned} A &= 930. \text{ mm}^2 \\ J_u &= 324687. \text{ mm}^4 \\ J_v &= 81414. \text{ mm}^4 \\ y_g &= 21.22 \text{ mm} \\ T_y &= -4250. \text{ N} \\ M_x &= -2108000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.78 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 18.78 \text{ mm} \\ \sigma_c &= -Mv/J_u = 122. \text{ N/mm}^2 \\ \tau_c &= 14.98 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 124.7 \text{ N/mm}^2 \\ S &= 6865. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-7/4Fx+1/2qx^2$	$-Fb/EJ$	$-1/2Fx+7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$1/8Fb-1/2Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	-Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	Fb-Fx	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/4Fb+1/4Fx$	0	$-1/8Fb+1/4Fx-1/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/4Fx$	0	$-1/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$17/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-17/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

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

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

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

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

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{8} - \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{8} x - \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b - \frac{1}{4} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{48} Fb^2/EJ$$

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

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

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

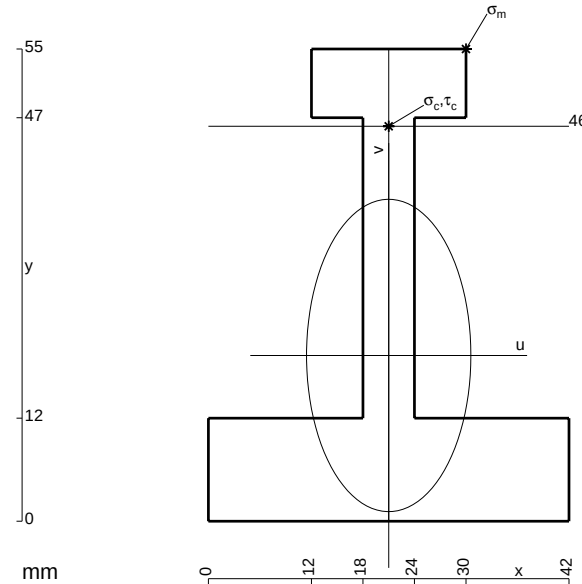
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{8} + \frac{1}{4} x/b - \frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x + \frac{1}{8} x^2/b - \frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

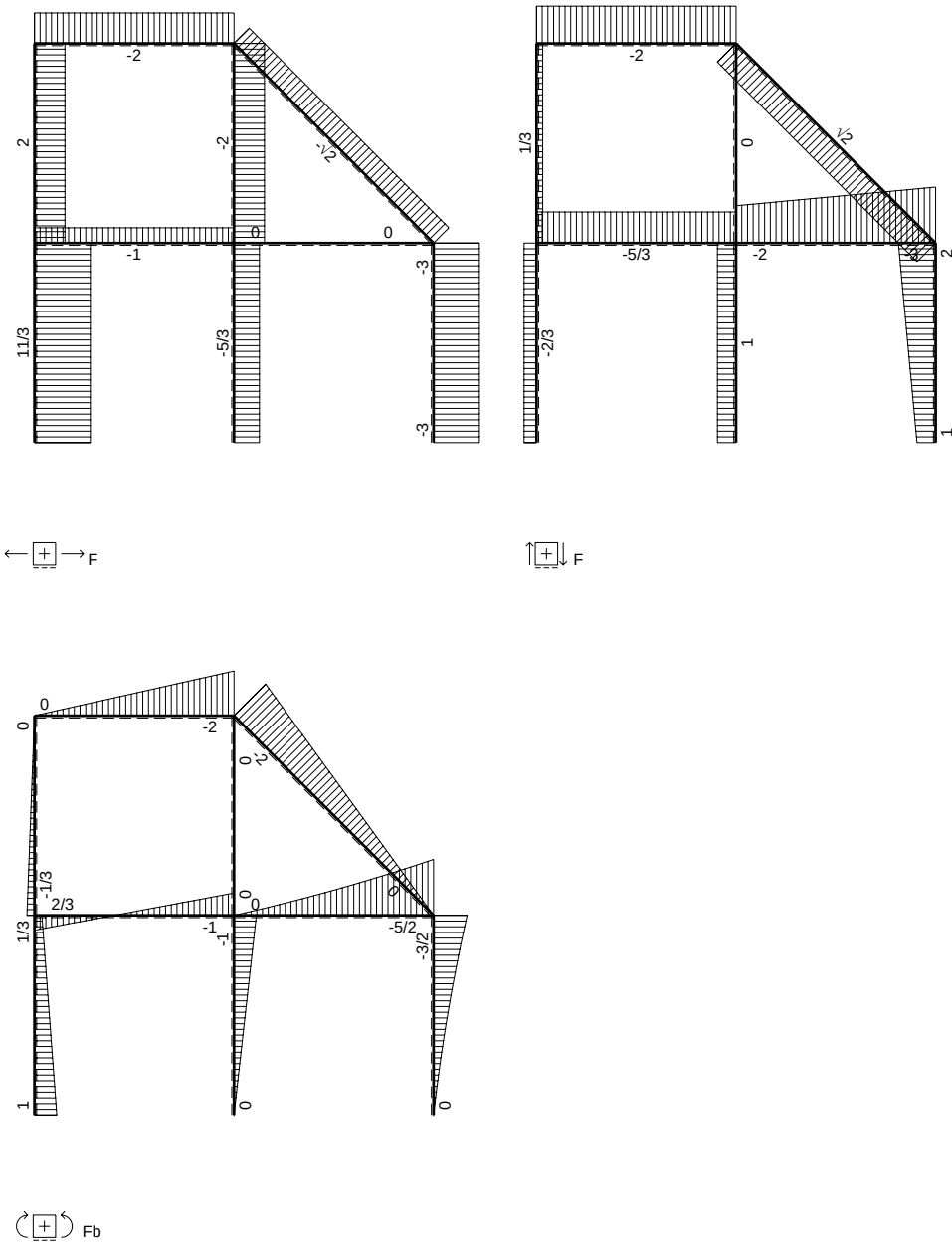
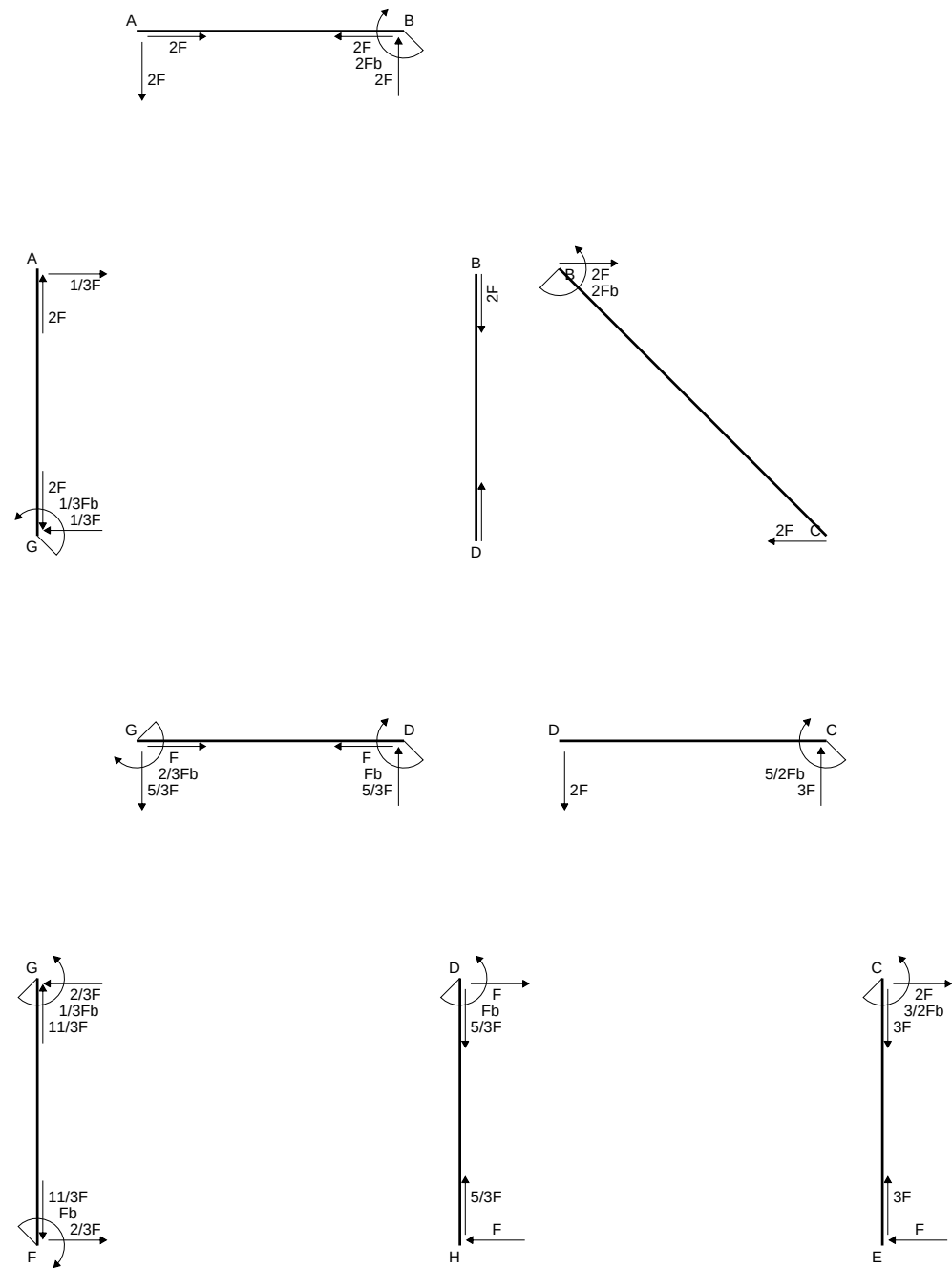
$$= \left(-\frac{1}{8} b + \frac{1}{8} b - \frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$

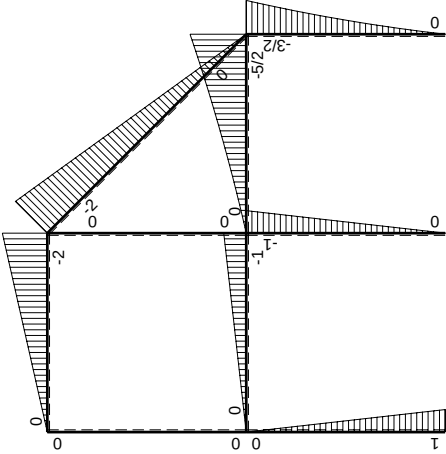
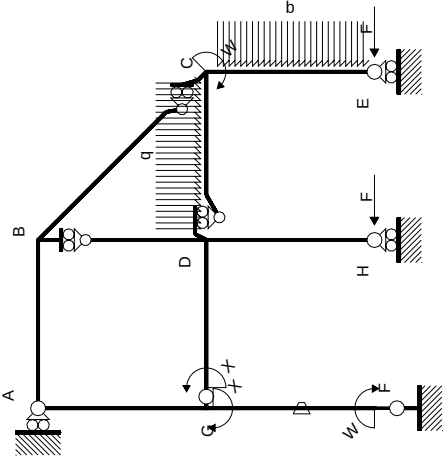
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{24} b \right) Fb \frac{1}{EJ} = -\frac{1}{24} Fb^2/EJ$$



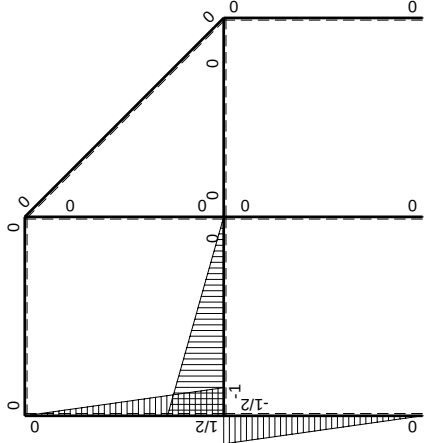
$$\begin{aligned} A &= 858. \text{ mm}^2 \\ J_u &= 283959. \text{ mm}^4 \\ J_v &= 78606. \text{ mm}^4 \\ y_g &= 19.3 \text{ mm} \\ T_y &= -3400. \text{ N} \\ M_x &= -1822400. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 35.7 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.1 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 26.7 \text{ mm} \\ \sigma_c &= -Mv/J_u = 171.3 \text{ N/mm}^2 \\ \tau_c &= 9.434 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 172.1 \text{ N/mm}^2 \\ S &= 4727. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

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

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	5/2Fb-3Fx+1/2qx ²	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	Fb-Fx	-Fb/EJ	-1/2Fx+1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(-1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	-Fx	Fb/EJ	-1/2Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x ² /b ²	0+0	1/12Xb/EJ
AG b	-1/2x/b	0	0	0	0	1/4x ² /b ²		
	totali						1/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

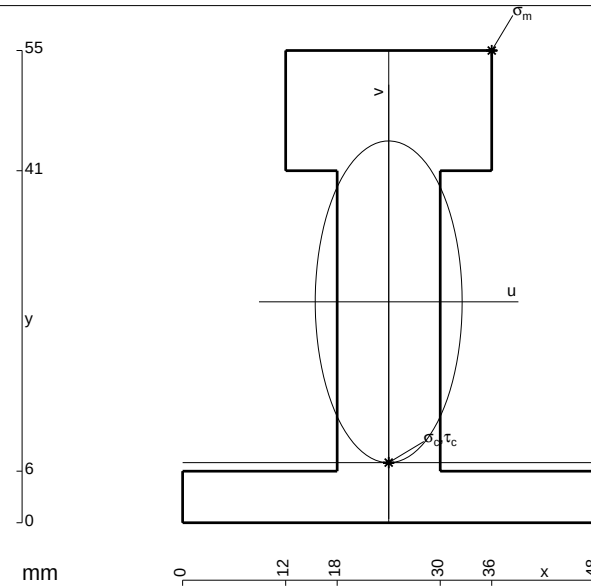
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{6} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

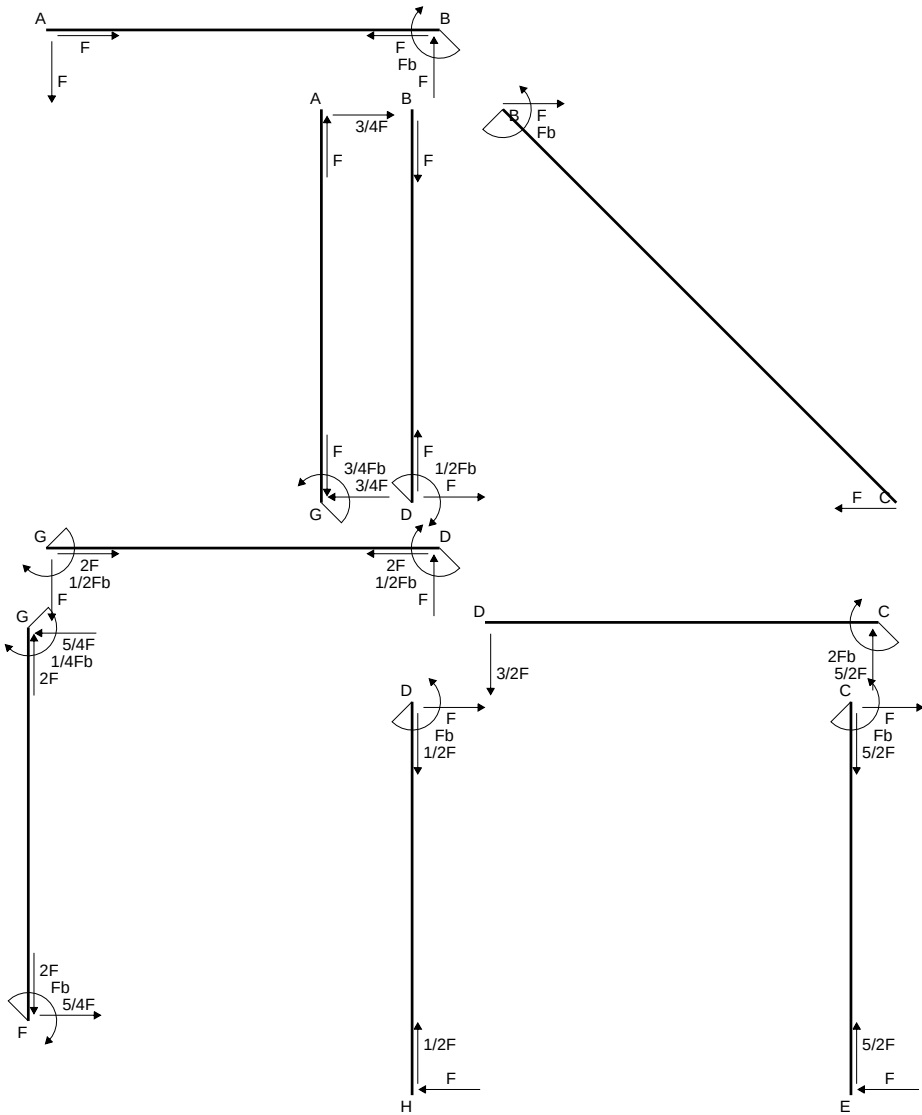
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$



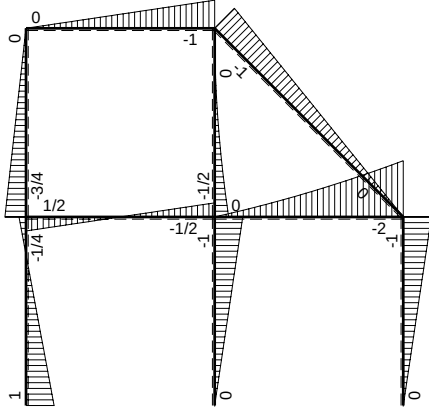
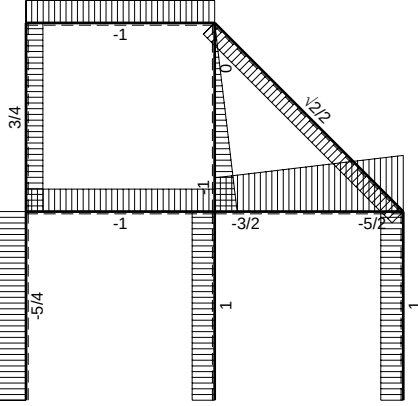
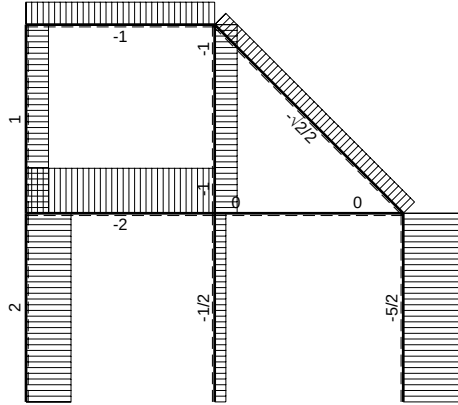
$$\begin{aligned} A &= 1044. \text{ mm}^2 \\ J_u &= 366752. \text{ mm}^4 \\ J_v &= 76464. \text{ mm}^4 \\ y_g &= 25.73 \text{ mm} \\ T_y &= -5010. \text{ N} \\ M_x &= -3006000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.27 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -18.73 \text{ mm} \\ \sigma_c &= -Mv/J_u = -153.5 \text{ N/mm}^2 \\ \tau_c &= 7.715 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 154.1 \text{ N/mm}^2 \\ S &= 6777. \text{ mm}^3 \end{aligned}$$



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↑ ⊕ ↓ F

⊕ ⊖ Fb



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-3/2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx ²	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(0+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						1/4Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-1/2Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{4} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{2} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{2} b + \frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{4} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

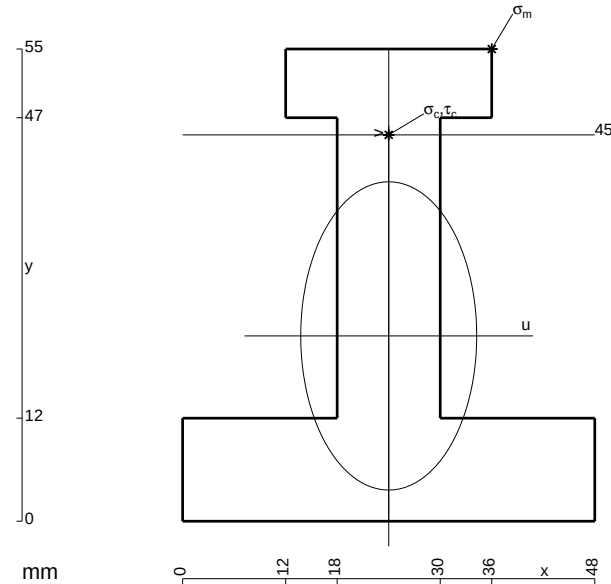
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

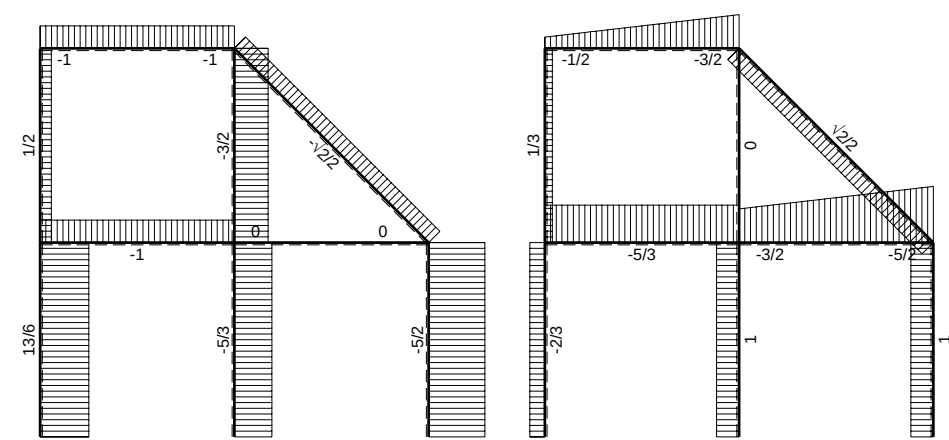
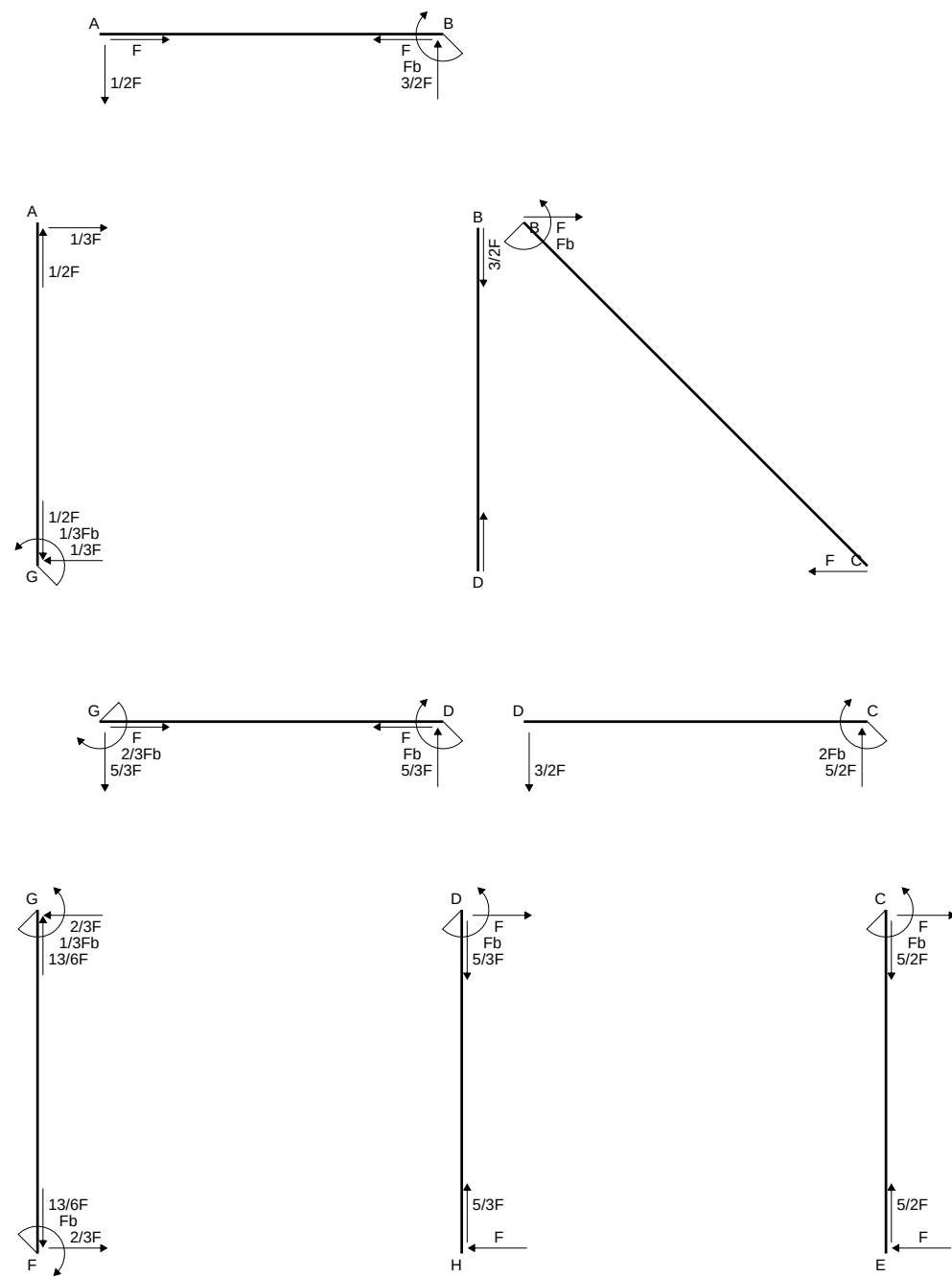
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

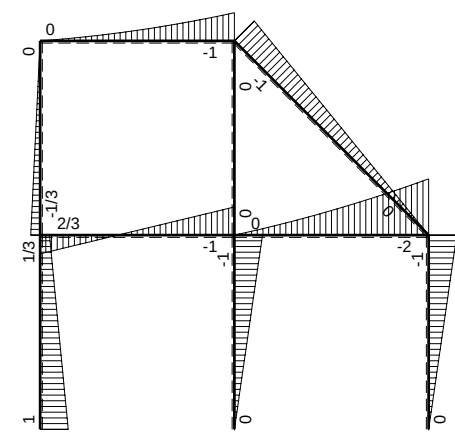


$$\begin{aligned} A &= 1188. \text{ mm}^2 \\ J_u &= 383155. \text{ mm}^4 \\ J_v &= 124848. \text{ mm}^4 \\ y_g &= 21.58 \text{ mm} \\ T_y &= -3650. \text{ N} \\ M_x &= -2277600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 33.42 \text{ mm} \\ \sigma_m &= -Mv/J_u = 198.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 23.42 \text{ mm} \\ \sigma_c &= -Mv/J_u = 139.2 \text{ N/mm}^2 \\ \tau_c &= 4.949 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 139.5 \text{ N/mm}^2 \\ S &= 6235. \text{ mm}^3 \end{aligned}$$

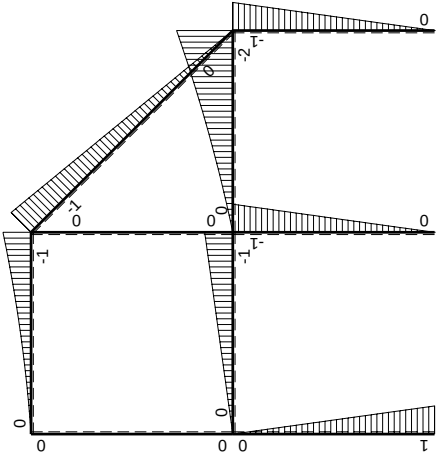
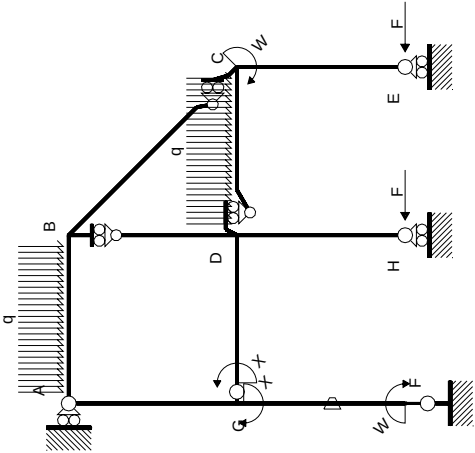


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↑ ⊕ ↓ F_b

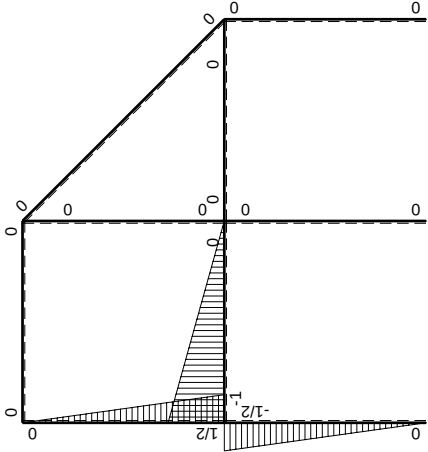


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$Fb-Fx$	$-Fb/EJ$	$-1/2Fx+1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$-Fx$	Fb/EJ	$-1/2Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	0	0	0	0	$1/4-1/2x/b+1/4x^2/b^2$	0+0	$1/12Xb/EJ$
AG b	$-1/2x/b$	0	0	0	0	$1/4x^2/b^2$		
	totali						$1/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-2/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) 1/EJ \, dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(b - b + \frac{1}{3} b \right) 1/EJ = 1/3 \, b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{3} b \right) 1/EJ = 1/3 \, b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \, 1/EJ \, dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \, 1/EJ + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \, 1/EJ + \left(\frac{1}{4} b \right) \theta = 1/6 \, Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(-\frac{1}{2} x/b + \frac{1}{2} x^2/b^2 \right) Fb \, 1/EJ \, dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[-\frac{1}{4} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \, 1/EJ + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

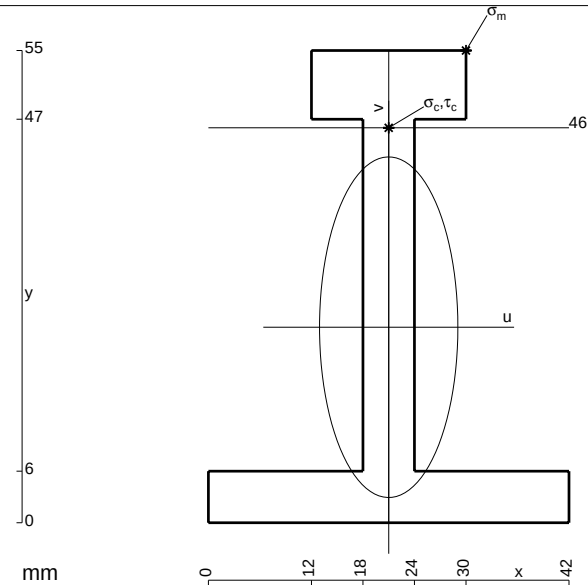
$$= \left(-\frac{1}{4} b + \frac{1}{6} b \right) Fb \, 1/EJ + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = 1/6 \, Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \, 1/EJ \, dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \, 1/EJ$$

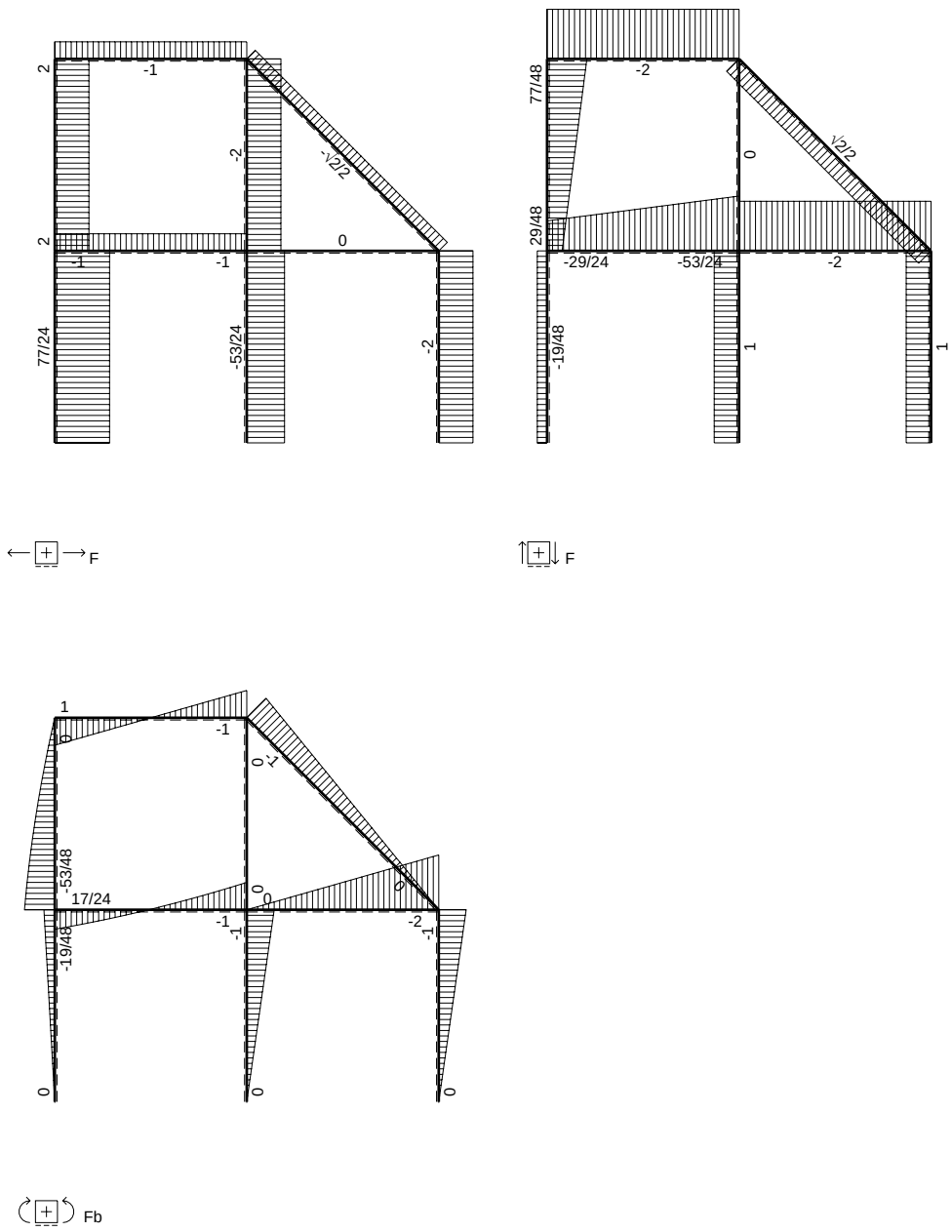
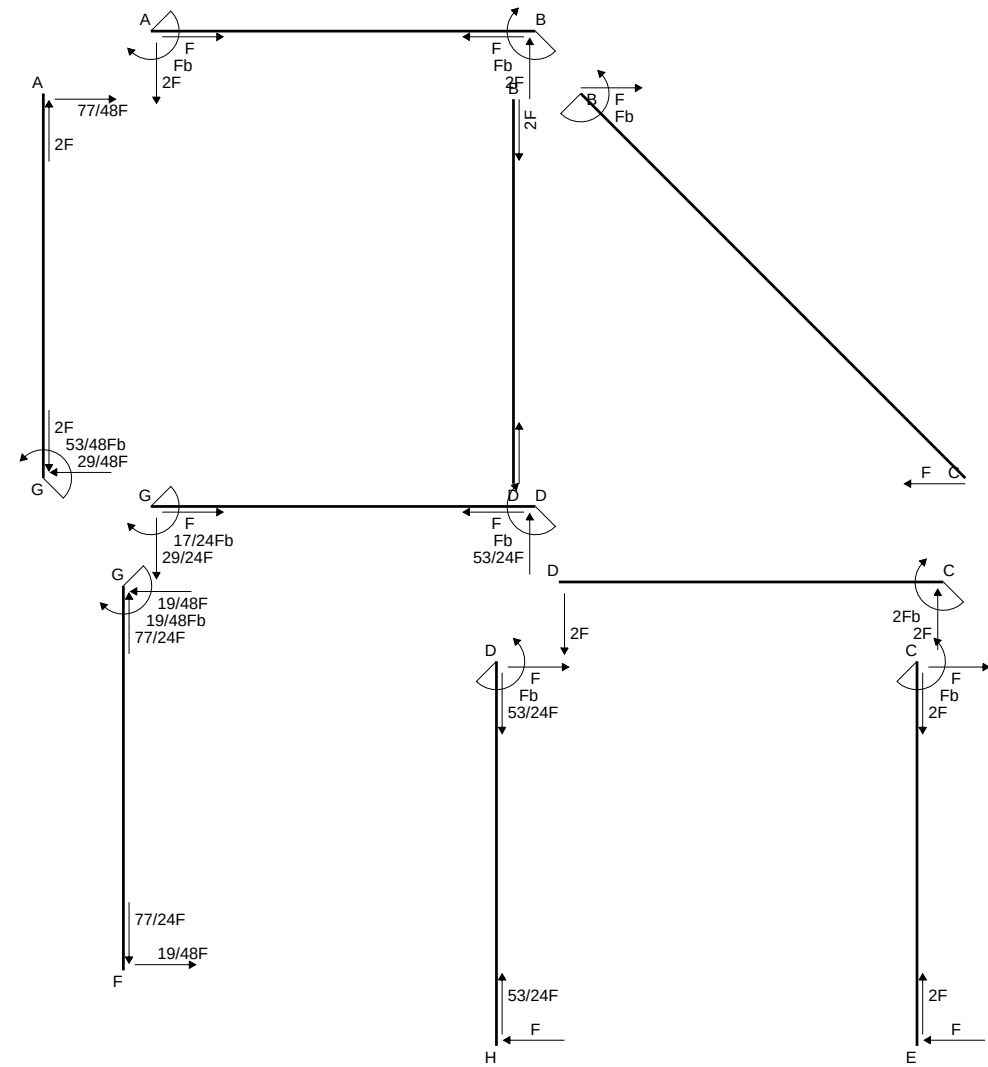
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \, 1/EJ = 1/6 \, Fb^2/EJ$$

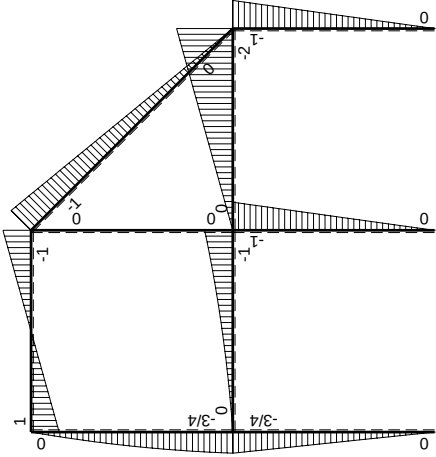
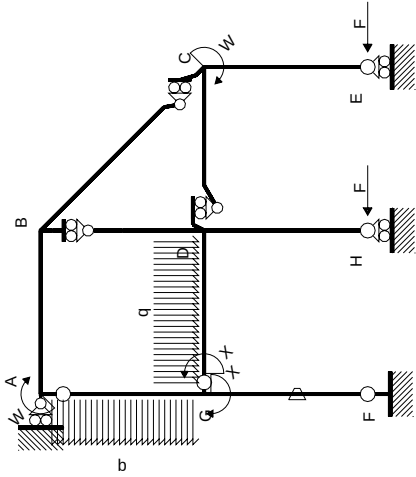
$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \, 1/EJ \, dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \, 1/EJ$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \, 1/EJ = 1/6 \, Fb^2/EJ$$



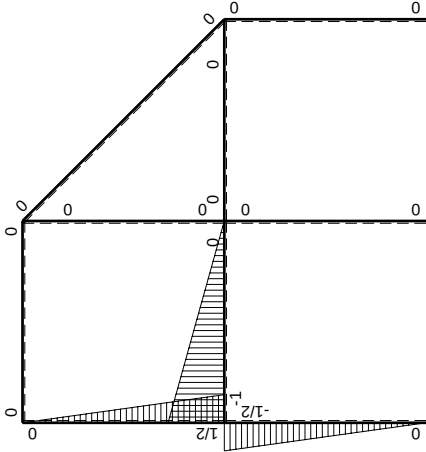
$$\begin{aligned} A &= 642. \text{ mm}^2 \\ J_u &= 252660. \text{ mm}^4 \\ J_v &= 41670. \text{ mm}^4 \\ y_g &= 22.77 \text{ mm} \\ T_y &= -2475. \text{ N} \\ M_x &= -1643400. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 32.23 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.6 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 23.23 \text{ mm} \\ \sigma_c &= -Mv/J_u = 151.1 \text{ N/mm}^2 \\ \tau_c &= 6.869 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 151.6 \text{ N/mm}^2 \\ S &= 4207. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



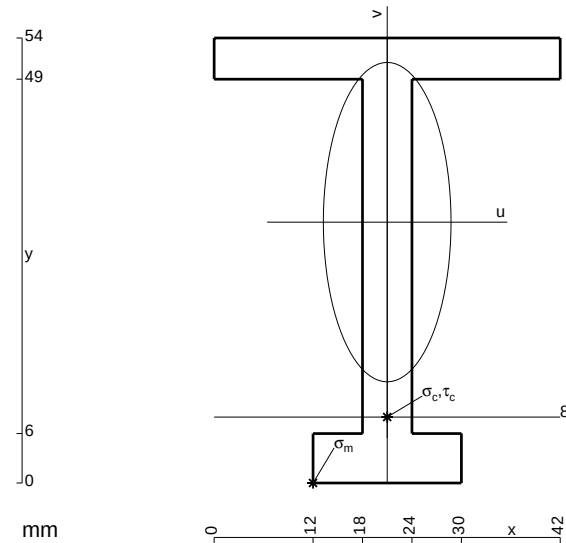
M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

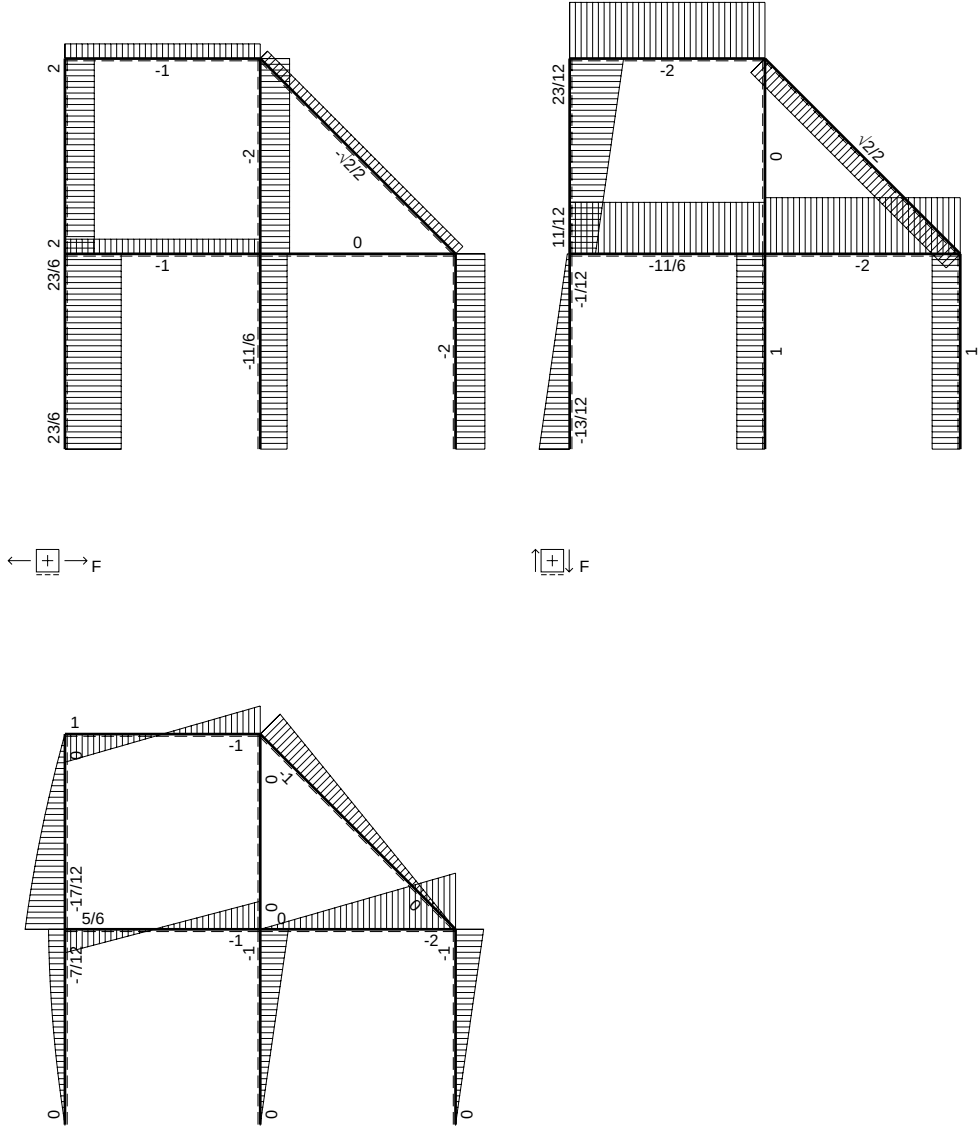
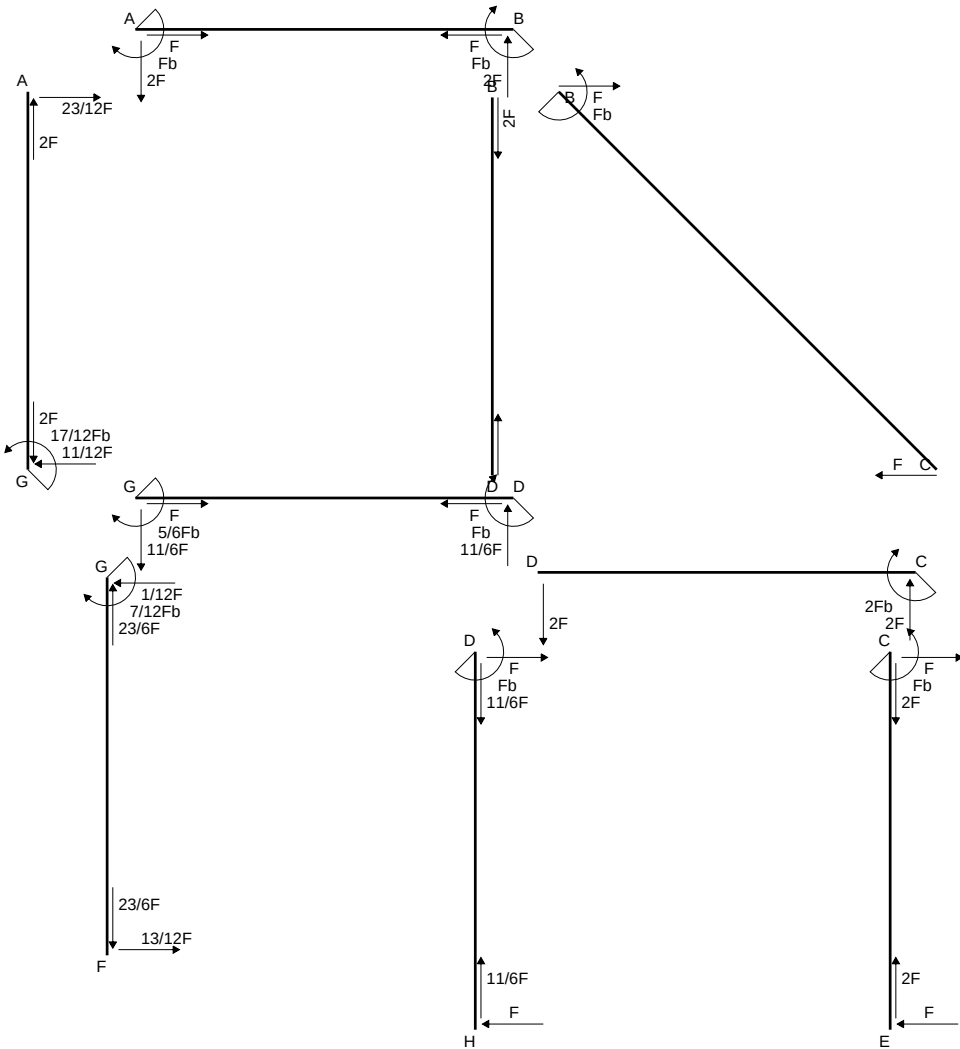
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/4Fx$	$-Fb/EJ$	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$17/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-17/24Fb$	

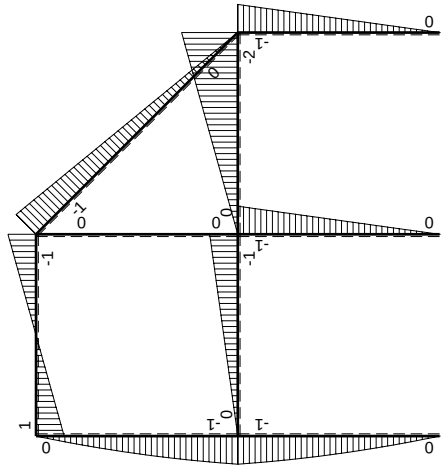
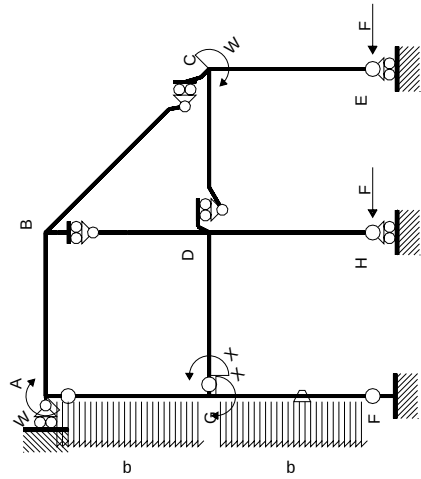
Sviluppi di calcolo iperstatica

$$\begin{aligned}
L_{FG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GF}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GD}^{xx} &= \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{DG}^{xx} &= \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{GA}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{AG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{FG}^{x\theta} &= \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ \\
L_{GF}^{x\theta} &= \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx \\
&= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ \\
L_{GD}^{x\theta} &= \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ \\
L_{DG}^{x\theta} &= \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ \\
L_{GA}^{x\theta} &= \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx \\
&= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ \\
L_{AG}^{x\theta} &= \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ
\end{aligned}$$



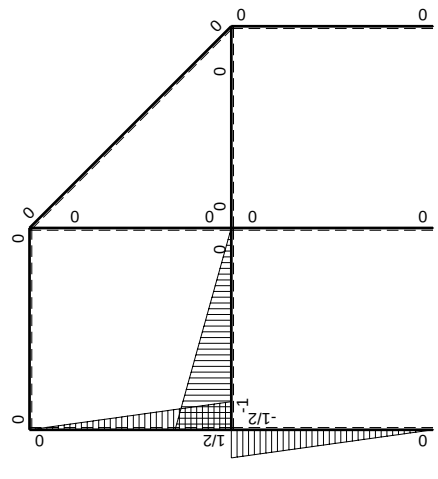
$$\begin{aligned}
A &= 576. \text{ mm}^2 \\
J_u &= 216352. \text{ mm}^4 \\
J_v &= 34560. \text{ mm}^4 \\
y_g &= 31.66 \text{ mm} \\
T_y &= -1740. \text{ N} \\
M_x &= -1496400. \text{ Nmm} \\
x_m &= 12. \text{ mm} \\
u_m &= -9. \text{ mm} \\
v_m &= -31.66 \text{ mm} \\
\sigma_m &= -Mv/J_u = -219. \text{ N/mm}^2 \\
x_c &= 21. \text{ mm} \\
y_c &= 8. \text{ mm} \\
v_c &= -23.66 \text{ mm} \\
\sigma_c &= -Mv/J_u = -163.6 \text{ N/mm}^2 \\
\tau_c &= 4.545 \text{ N/mm}^2 \\
\sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 163.8 \text{ N/mm}^2 \\
S &= 3391. \text{ mm}^3
\end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx+1/2qx^2$	$-Fb/EJ$	$3/4Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(3/16+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-1/2Fx-1/2qx^2$	Fb/EJ	$1/2Fb-3/4Fx+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+1/2Fx+1/2qx^2$	0	$-1/2Fb+3/4Fx-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-3/16+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/2Fx-1/2qx^2$	0	$-3/4Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{3}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - \frac{3}{4} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{3}{8} x^2/b + \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{3}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

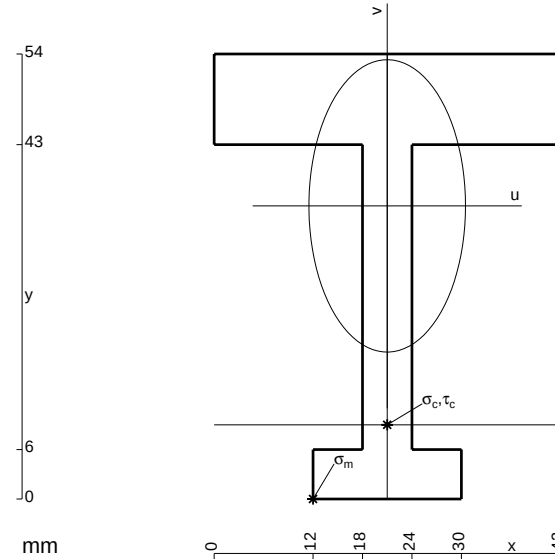
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + \frac{3}{4} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{3}{8} x^2/b - \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

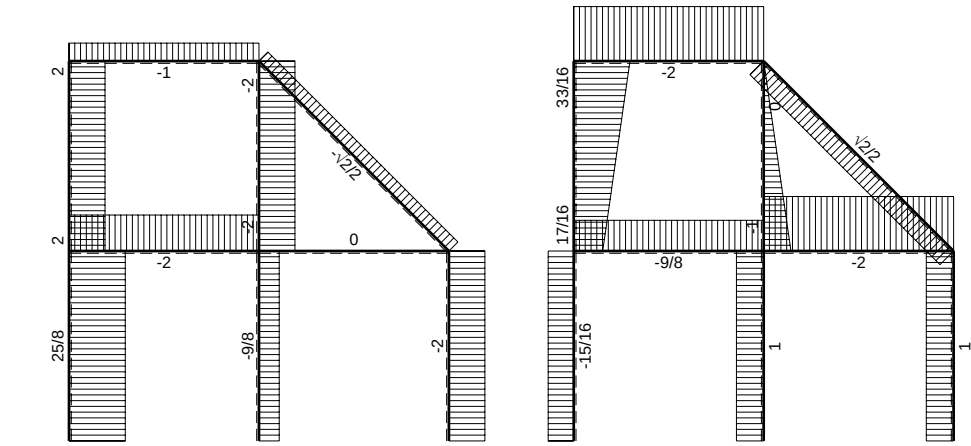
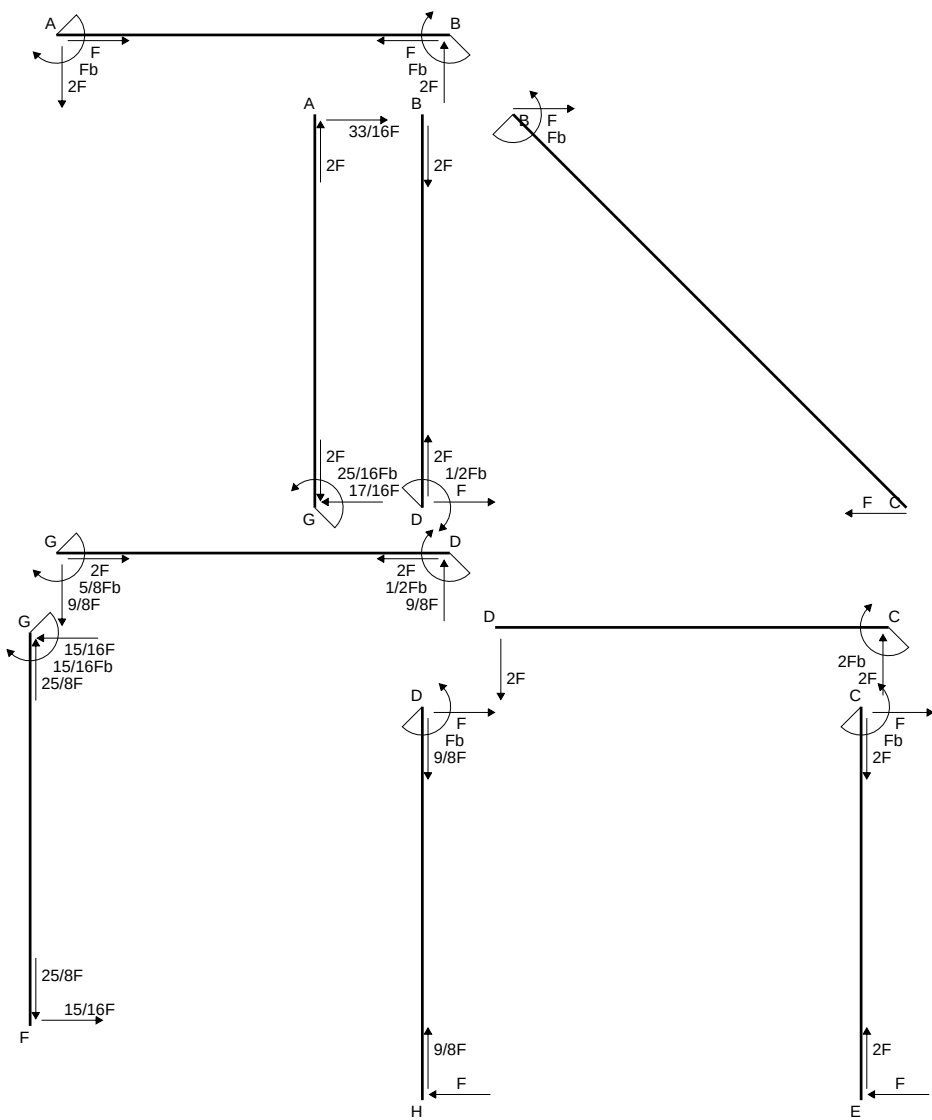
$$= \left(-\frac{1}{2} b + \frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{4} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$

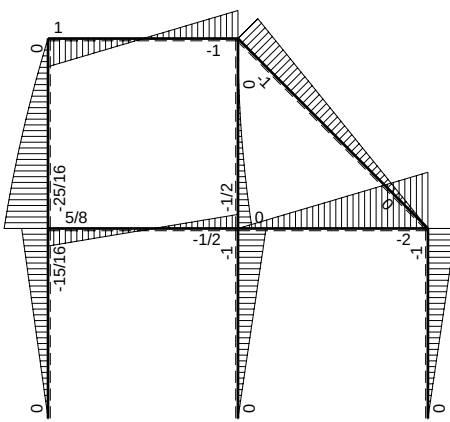


$$\begin{aligned} A &= 792. \text{ mm}^2 \\ J_u &= 249320. \text{ mm}^4 \\ J_v &= 71496. \text{ mm}^4 \\ y_g &= 35.57 \text{ mm} \\ T_y &= -1760. \text{ N} \\ M_x &= -1601600. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -35.57 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -26.57 \text{ mm} \\ \sigma_c &= -Mv/J_u = -170.7 \text{ N/mm}^2 \\ \tau_c &= 4.733 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 170.9 \text{ N/mm}^2 \\ S &= 4023. \text{ mm}^3 \end{aligned}$$

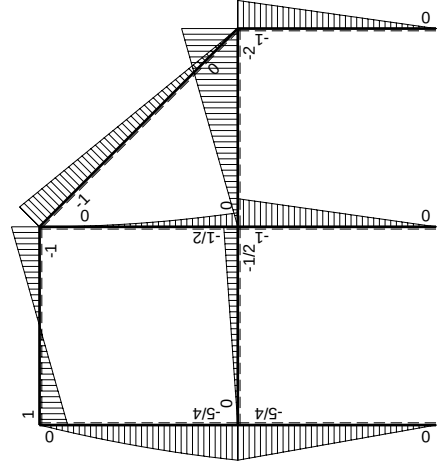
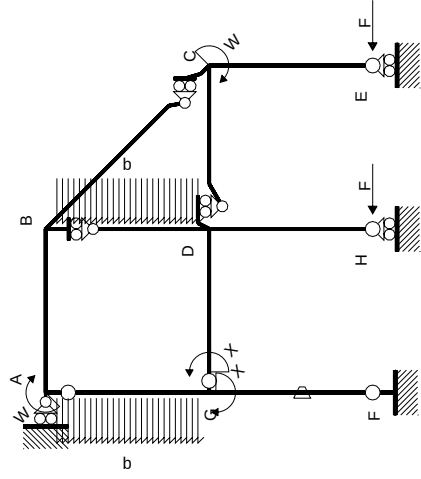


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

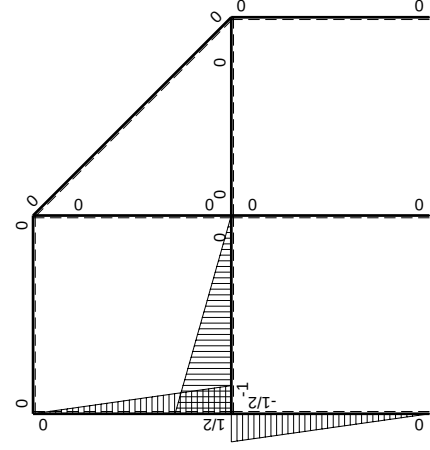


↺ $\boxed{+}$ ↻ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx$	$-Fb/EJ$	$5/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(5/24+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-5/4Fx$	Fb/EJ	$5/8Fb-5/4Fx+5/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-5/4Fb+3/4Fx+1/2qx^2$	0	$-5/8Fb+Fx-1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-11/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$7/4Fx-1/2qx^2$	0	$-7/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$5/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

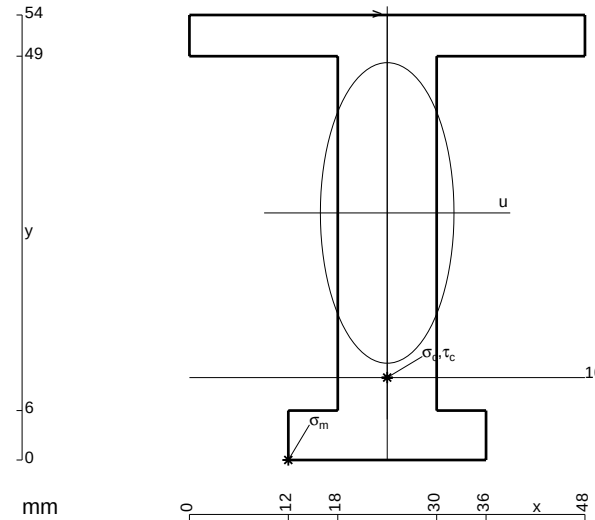
$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{5}{8} + x/b - \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{5}{8} x + \frac{1}{2} x^2/b - \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

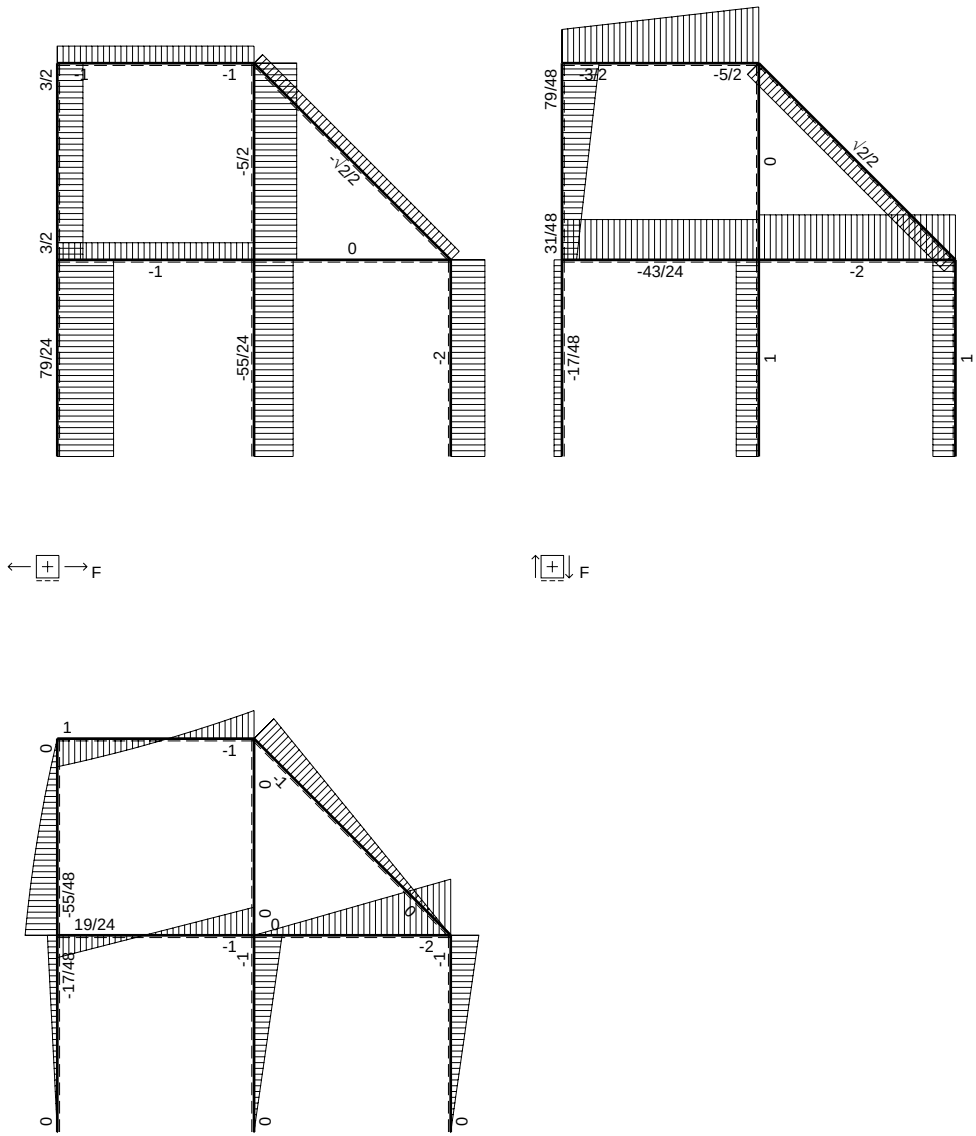
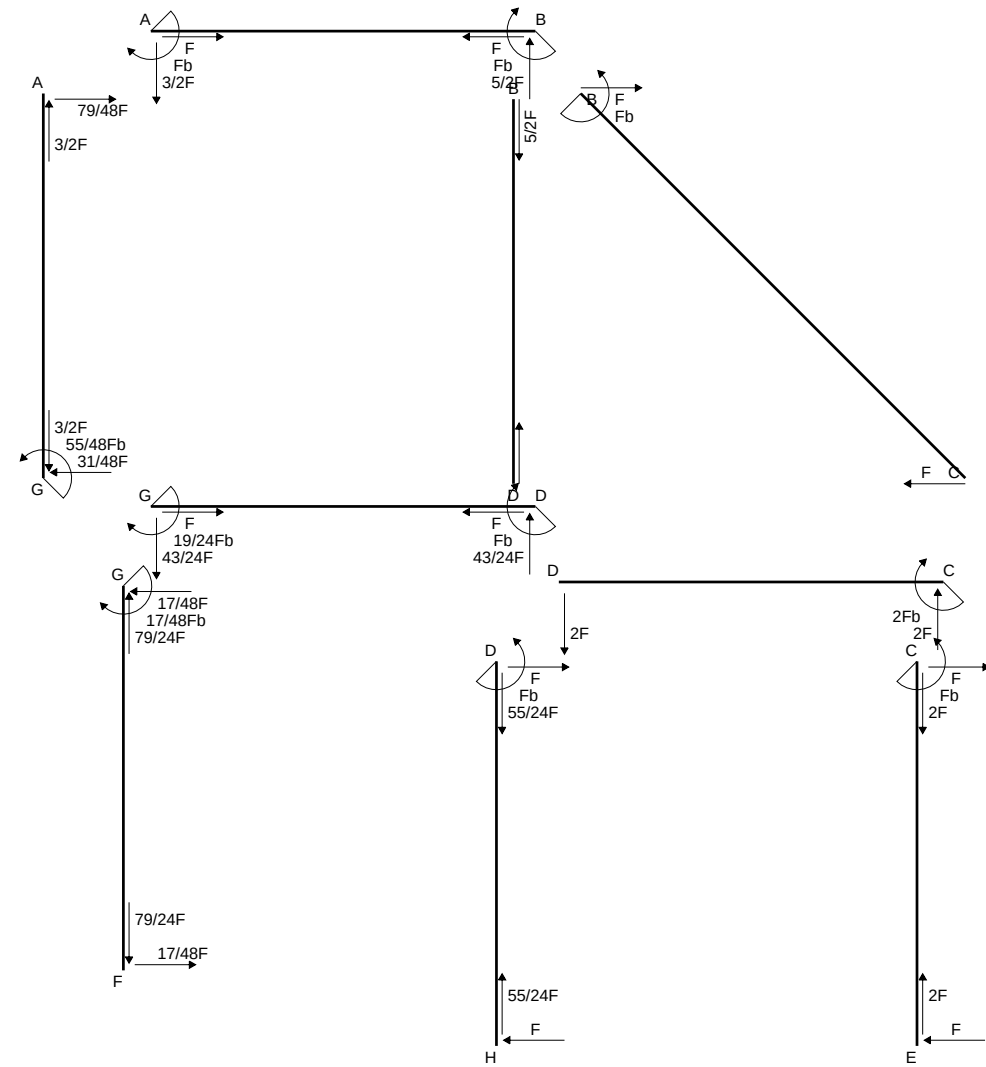
$$= \left(-\frac{5}{8} b + \frac{1}{2} b - \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{11}{48} Fb^2/EJ$$

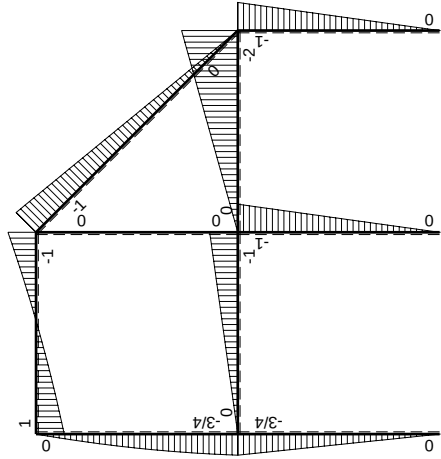
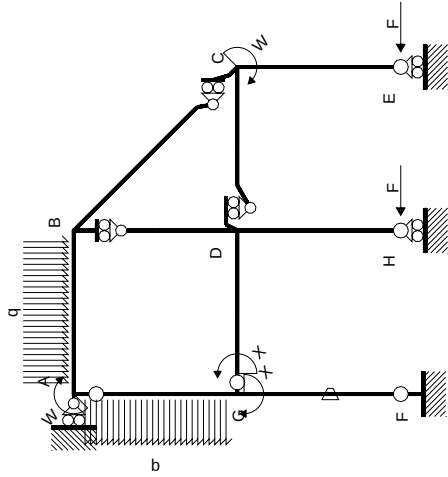
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{7}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{7}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{7}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{11}{48} Fb^2/EJ$$



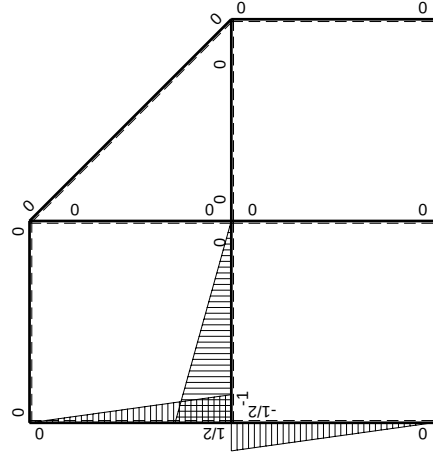
$$\begin{aligned} A &= 900. \text{ mm}^2 \\ J_u &= 299580. \text{ mm}^4 \\ J_v &= 59184. \text{ mm}^4 \\ y_g &= 29.98 \text{ mm} \\ T_y &= -2480. \text{ N} \\ M_x &= -2380800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.98 \text{ mm} \\ \sigma_m &= -Mv/J_u = -238.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -19.98 \text{ mm} \\ \sigma_c &= -Mv/J_u = -158.8 \text{ N/mm}^2 \\ \tau_c &= 3.408 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 158.9 \text{ N/mm}^2 \\ S &= 4940. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



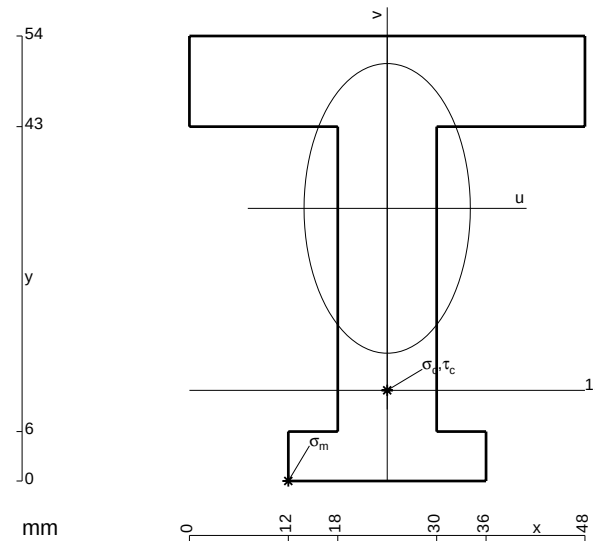
M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

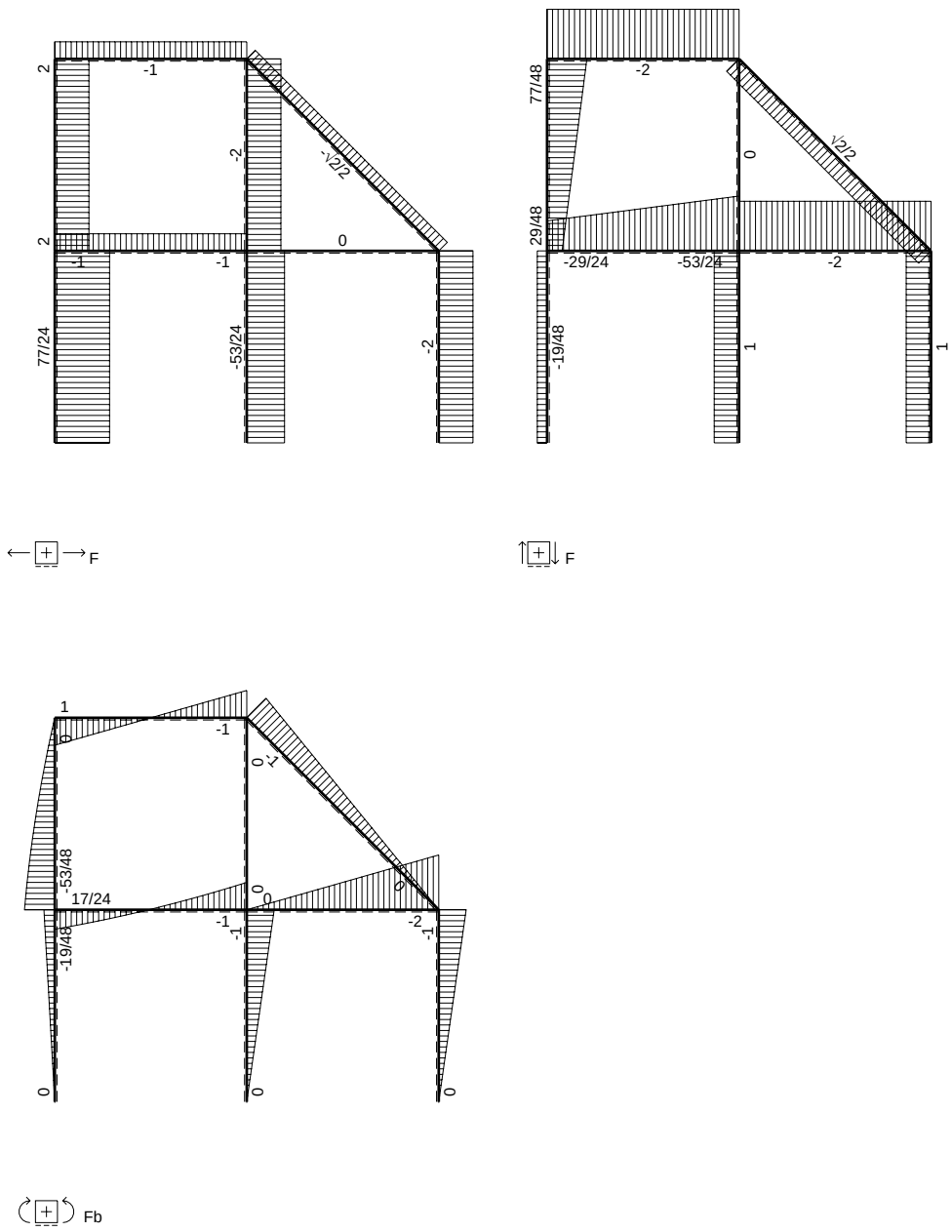
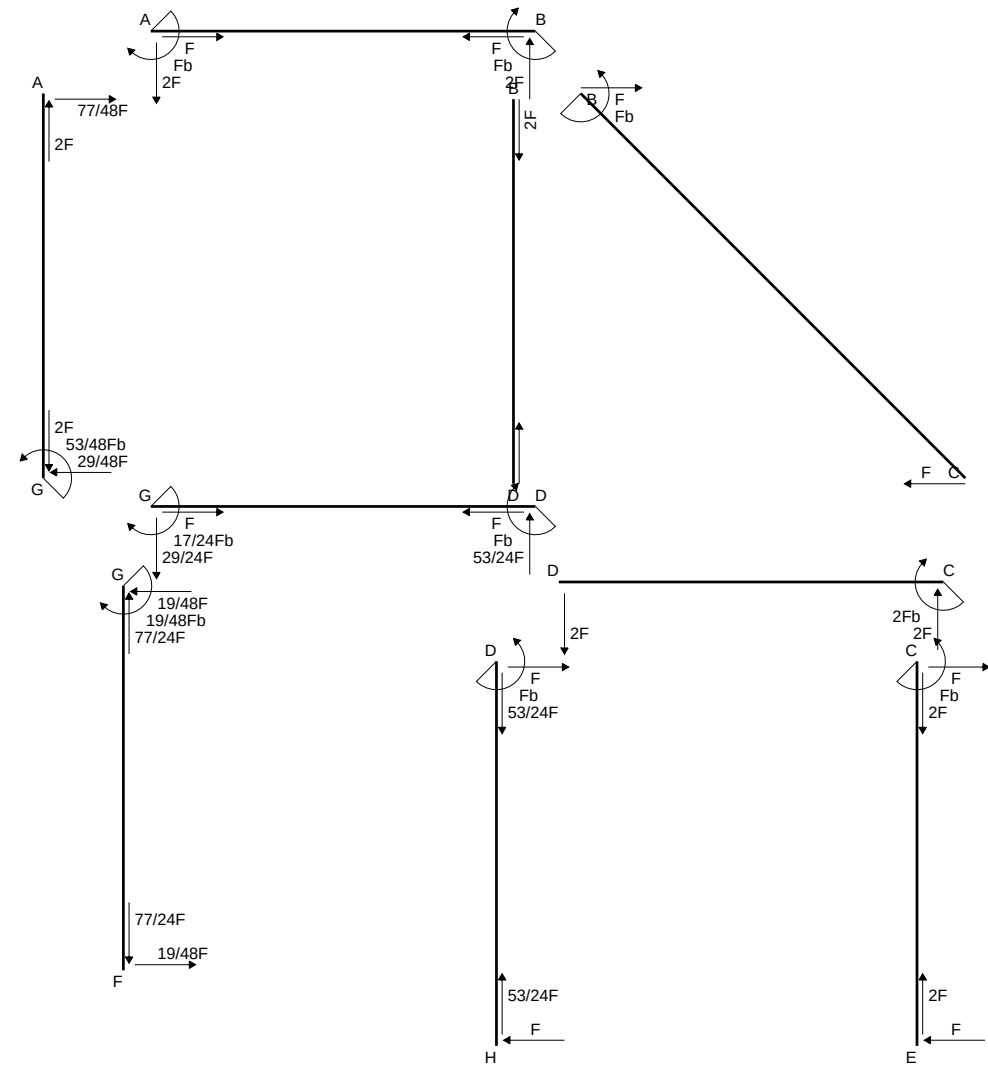
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/4Fx$	$-Fb/EJ$	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$19/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-19/24Fb$	

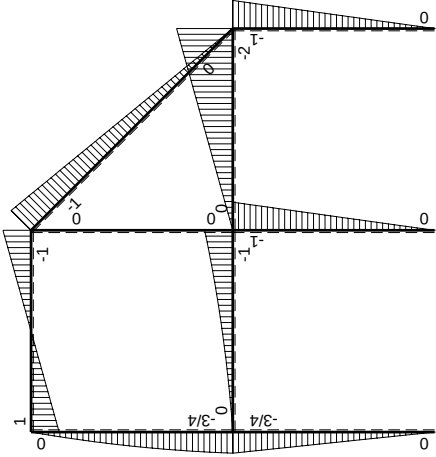
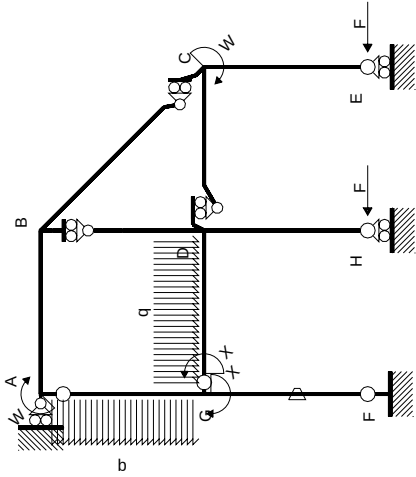
Sviluppi di calcolo iperstatica

$$\begin{aligned}
L_{FG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GF}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GD}^{xx} &= \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{DG}^{xx} &= \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{GA}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{AG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{FG}^{x_0} &= \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ \\
L_{GF}^{x_0} &= \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx \\
&= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ \\
L_{GD}^{x_0} &= \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ \\
L_{DG}^{x_0} &= \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ \\
L_{GA}^{x_0} &= \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx \\
&= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ \\
L_{AG}^{x_0} &= \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ
\end{aligned}$$



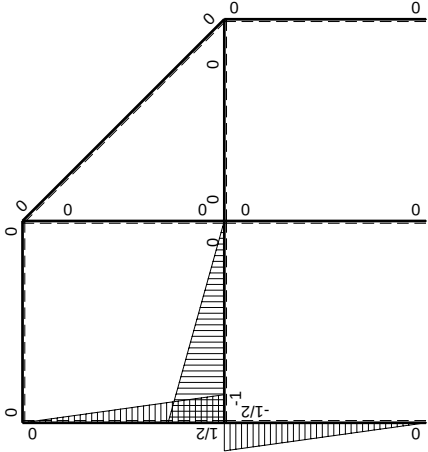
$$\begin{aligned}
A &= 1116. \text{ mm}^2 \\
J_u &= 344933. \text{ mm}^4 \\
J_v &= 113616. \text{ mm}^4 \\
y_g &= 33.08 \text{ mm} \\
T_y &= -4080. \text{ N} \\
M_x &= -2080800. \text{ Nmm} \\
x_m &= 12. \text{ mm} \\
u_m &= -12. \text{ mm} \\
v_m &= -33.08 \text{ mm} \\
\sigma_m &= -Mv/J_u = -199.6 \text{ N/mm}^2 \\
x_c &= 24. \text{ mm} \\
y_c &= 11. \text{ mm} \\
v_c &= -22.08 \text{ mm} \\
\sigma_c &= -Mv/J_u = -133.2 \text{ N/mm}^2 \\
\tau_c &= 5.723 \text{ N/mm}^2 \\
\sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 133.6 \text{ N/mm}^2 \\
S &= 5806. \text{ mm}^3
\end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/4Fx$	$-Fb/EJ$	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$17/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-17/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

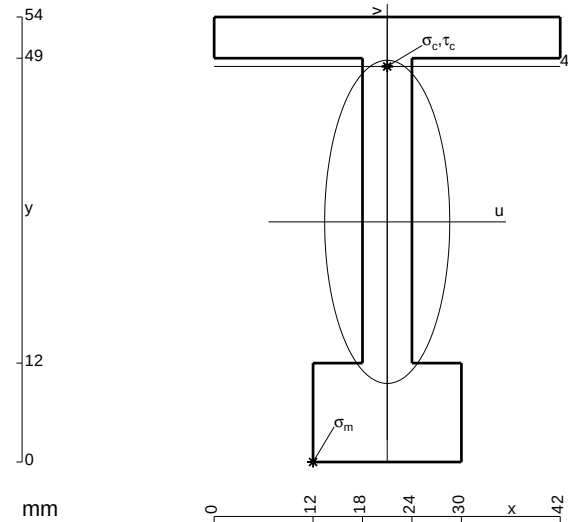
$$L_{GA}^{x_0} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

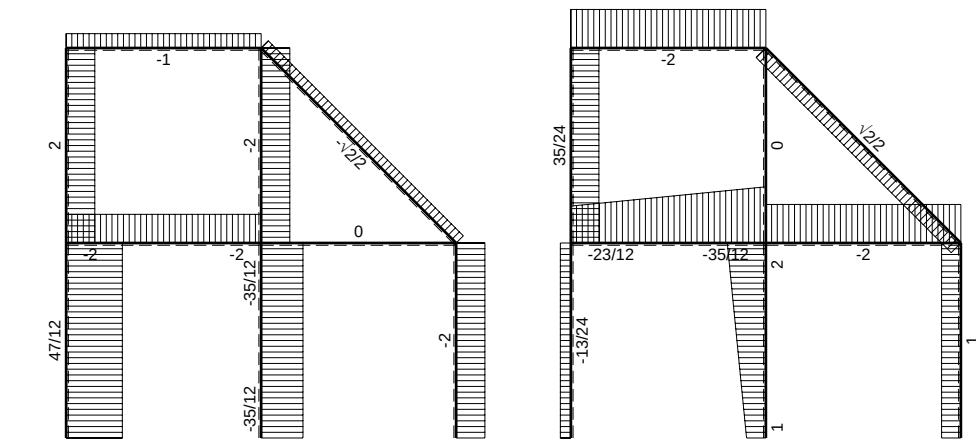
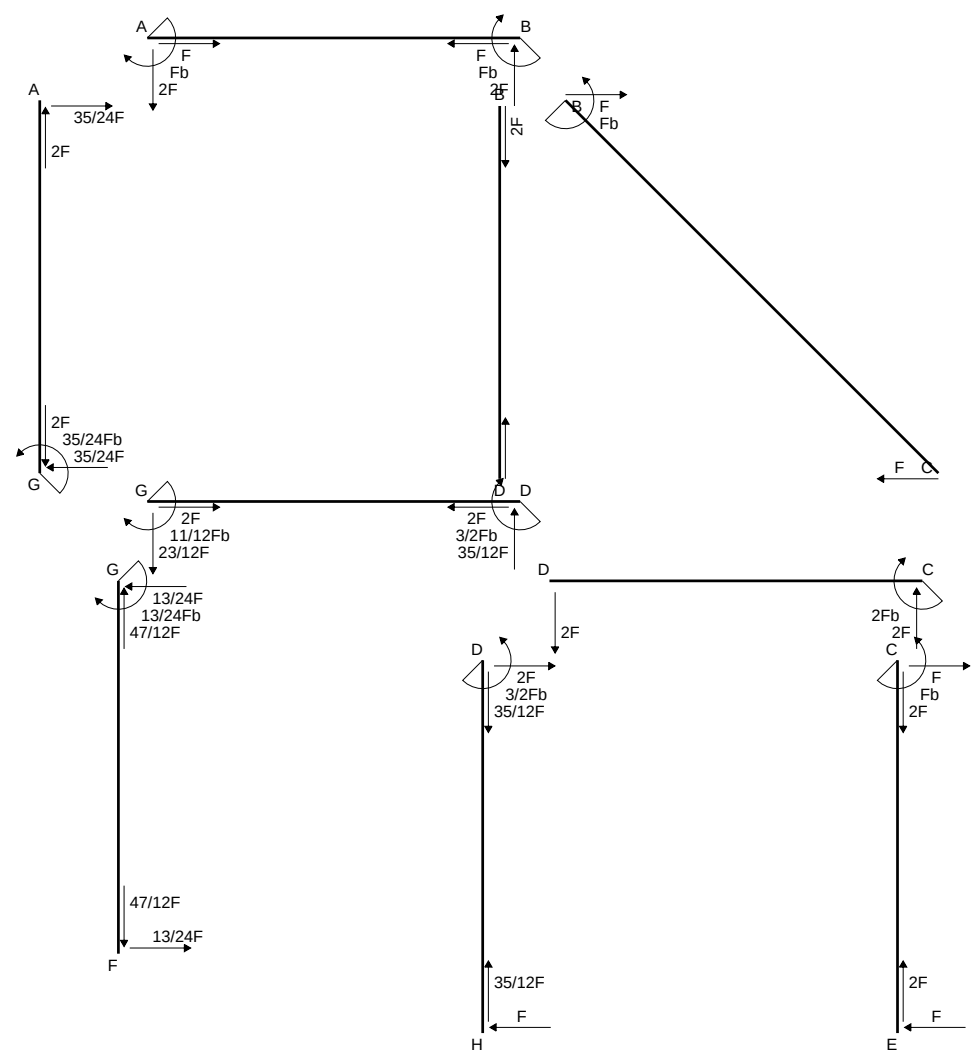
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

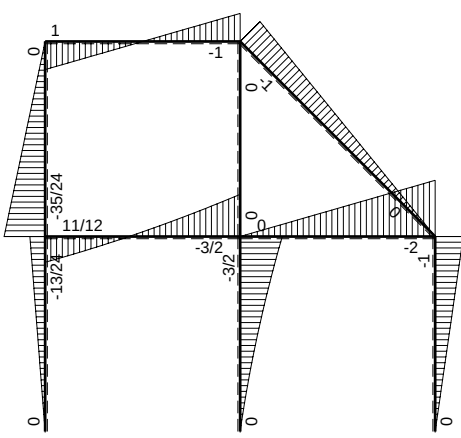


$$\begin{aligned} A &= 648. \text{ mm}^2 \\ J_u &= 249419. \text{ mm}^4 \\ J_v &= 37368. \text{ mm}^4 \\ y_g &= 29.14 \text{ mm} \\ T_y &= -3200. \text{ N} \\ M_x &= -1792000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -29.14 \text{ mm} \\ \sigma_m &= -Mv/J_u = -209.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 48. \text{ mm} \\ v_c &= 18.86 \text{ mm} \\ \sigma_c &= -Mv/J_u = 135.5 \text{ N/mm}^2 \\ \tau_c &= 10.29 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 136.7 \text{ N/mm}^2 \\ S &= 4812. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx-1/2qx^2$	0	$Fx-1/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(5/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-2Fx+1/2qx^2$	0	$3/2Fx-2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$11/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-11/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(x/b - \frac{1}{2} x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - 2 x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{2}{3} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

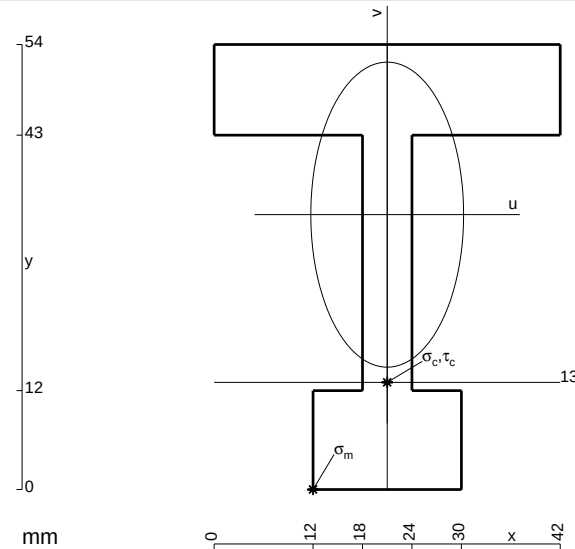
$$= \left(\frac{3}{4} b - \frac{2}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

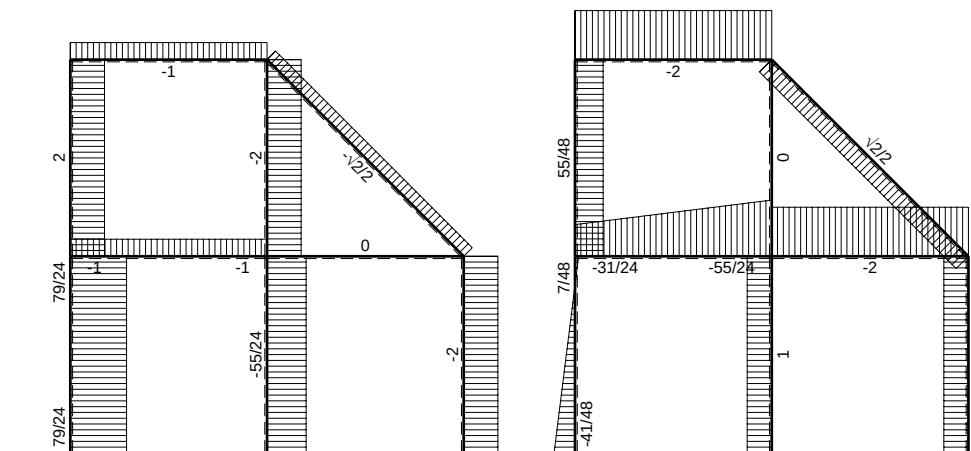
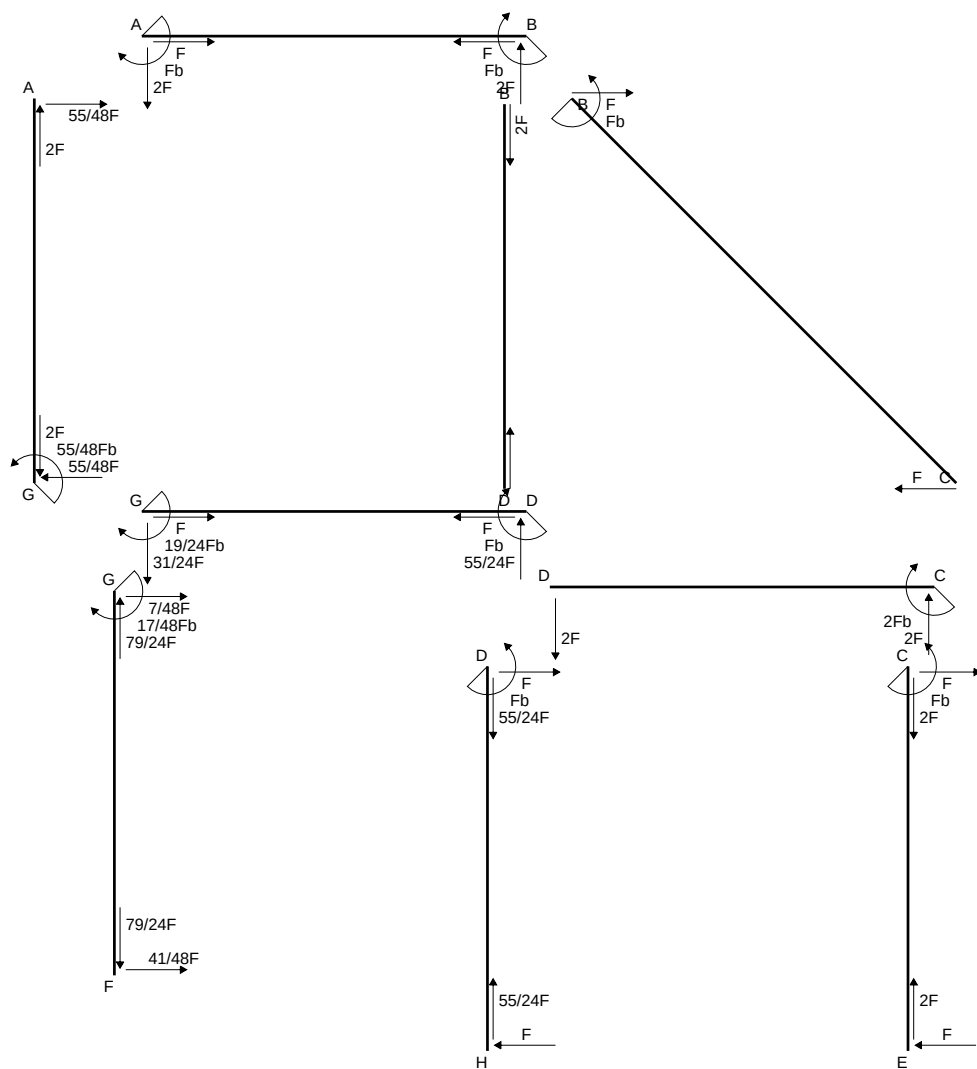
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

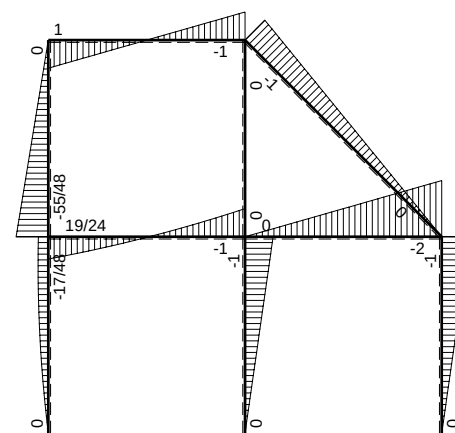
$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



$$\begin{aligned} A &= 864. \text{ mm}^2 \\ J_u &= 296124. \text{ mm}^4 \\ J_v &= 74304. \text{ mm}^4 \\ y_g &= 33.35 \text{ mm} \\ T_y &= -3200. \text{ N} \\ M_x &= -1952000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -33.35 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -20.35 \text{ mm} \\ \sigma_c &= -Mv/J_u = -134.2 \text{ N/mm}^2 \\ \tau_c &= 10.87 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 135.5 \text{ N/mm}^2 \\ S &= 6034. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

$\uparrow \boxed{+} \downarrow F$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$19/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-19/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

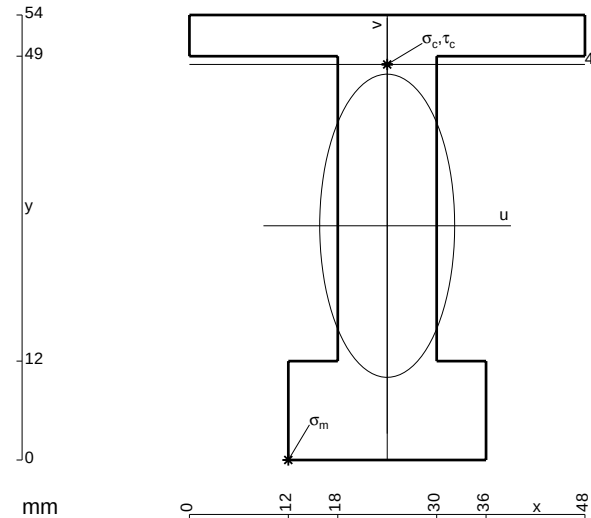
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

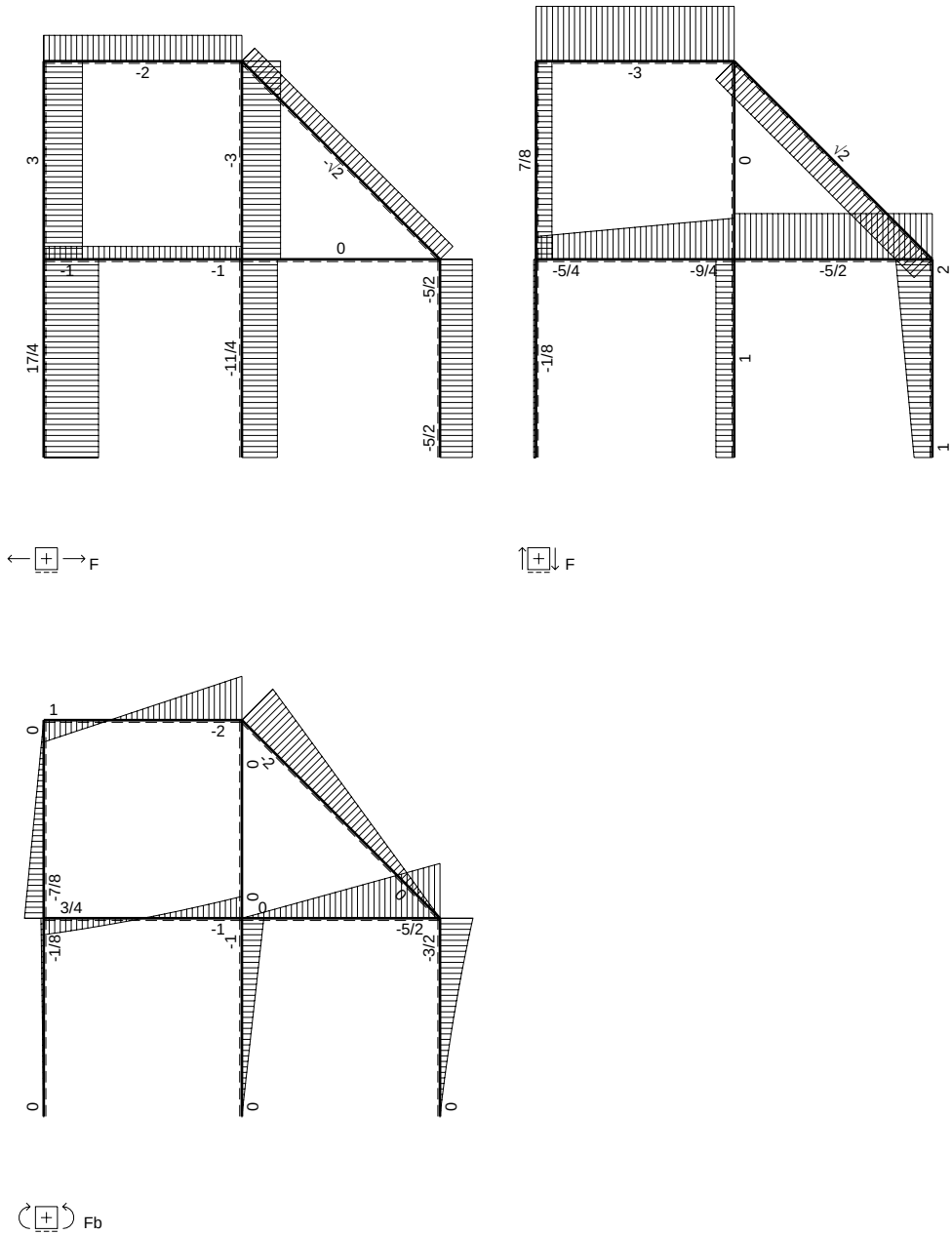
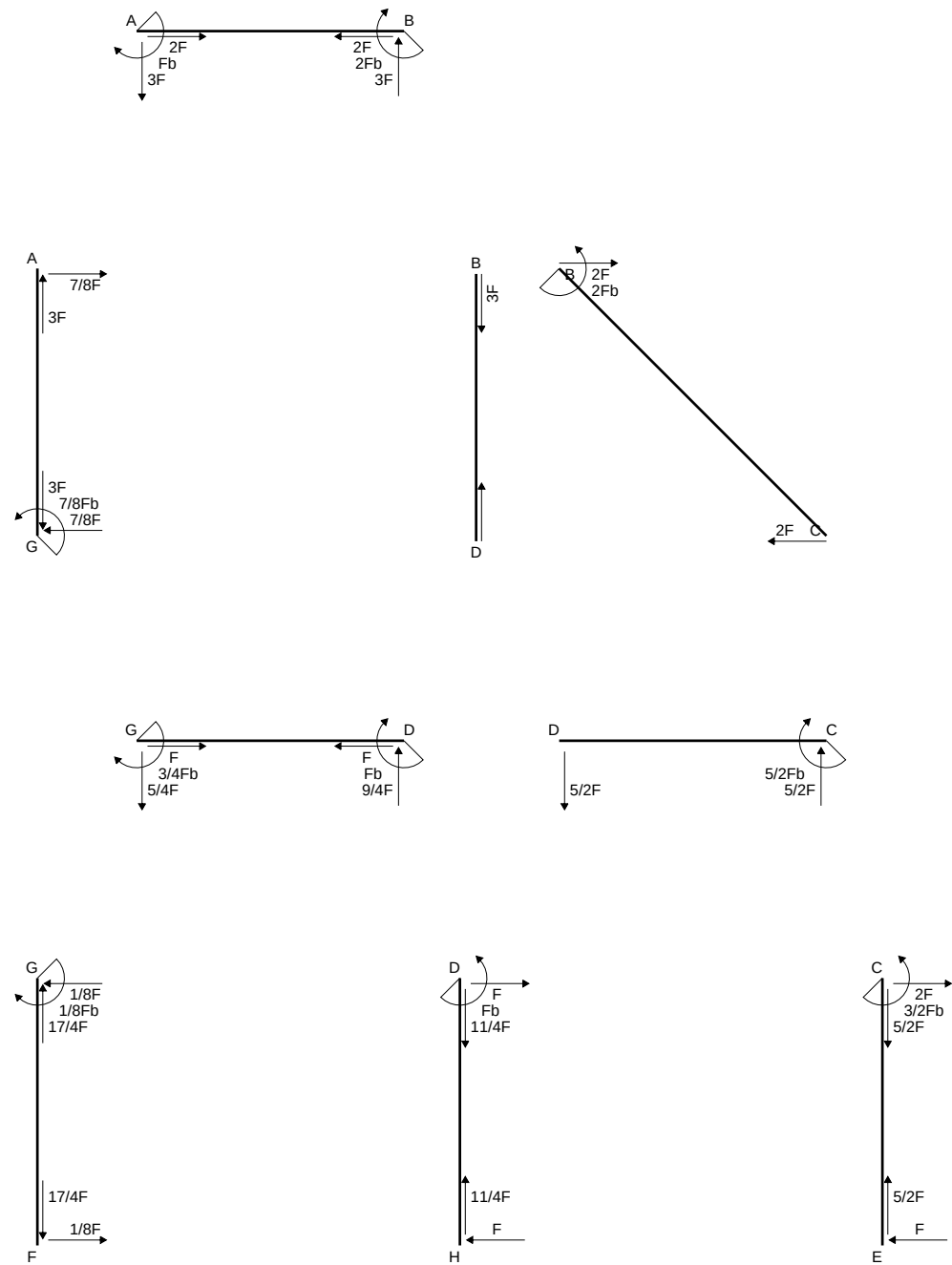
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

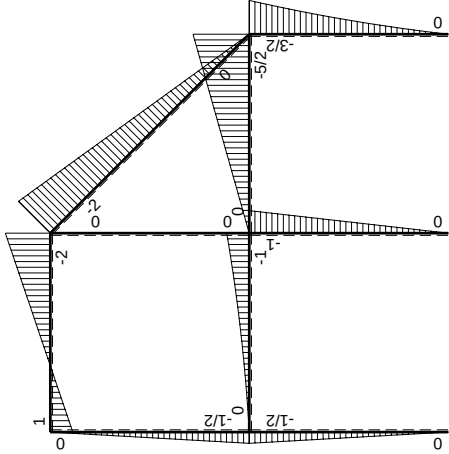
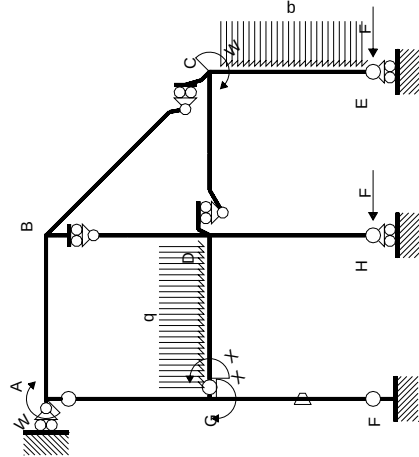
$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$



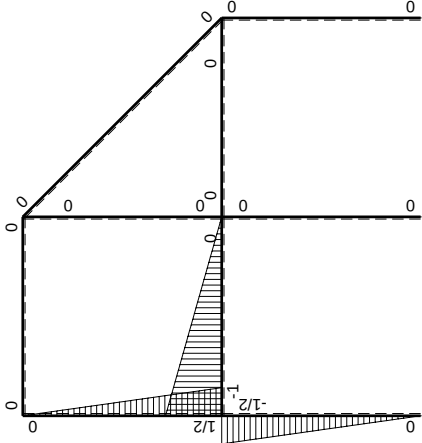
$$\begin{aligned} A &= 972. \text{ mm}^2 \\ J_u &= 329140. \text{ mm}^4 \\ J_v &= 65232. \text{ mm}^4 \\ y_g &= 28.43 \text{ mm} \\ T_y &= -4020. \text{ N} \\ M_x &= -2653200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -28.43 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.1 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 48. \text{ mm} \\ v_c &= 19.57 \text{ mm} \\ \sigma_c &= -Mv/J_u = 157.8 \text{ N/mm}^2 \\ \tau_c &= 5.882 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 158.1 \text{ N/mm}^2 \\ S &= 5779. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$3/8Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-3/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

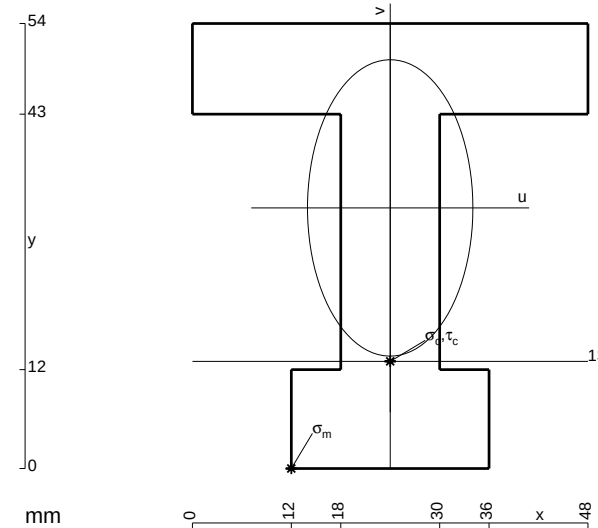
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

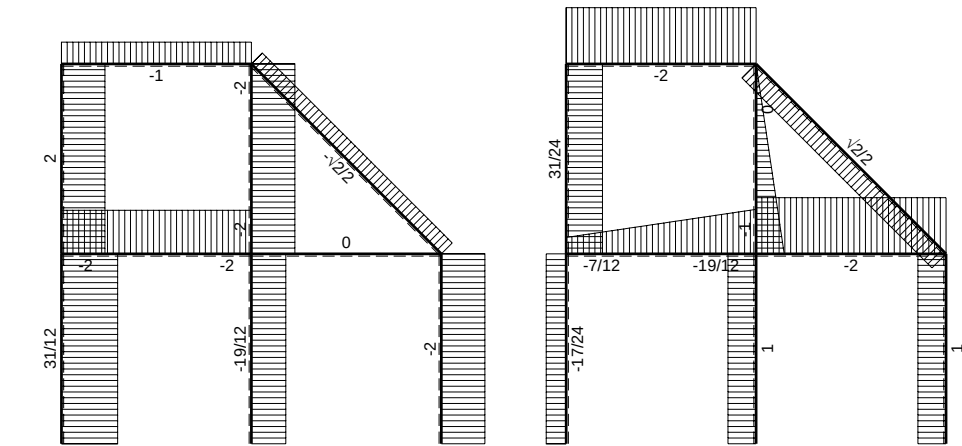
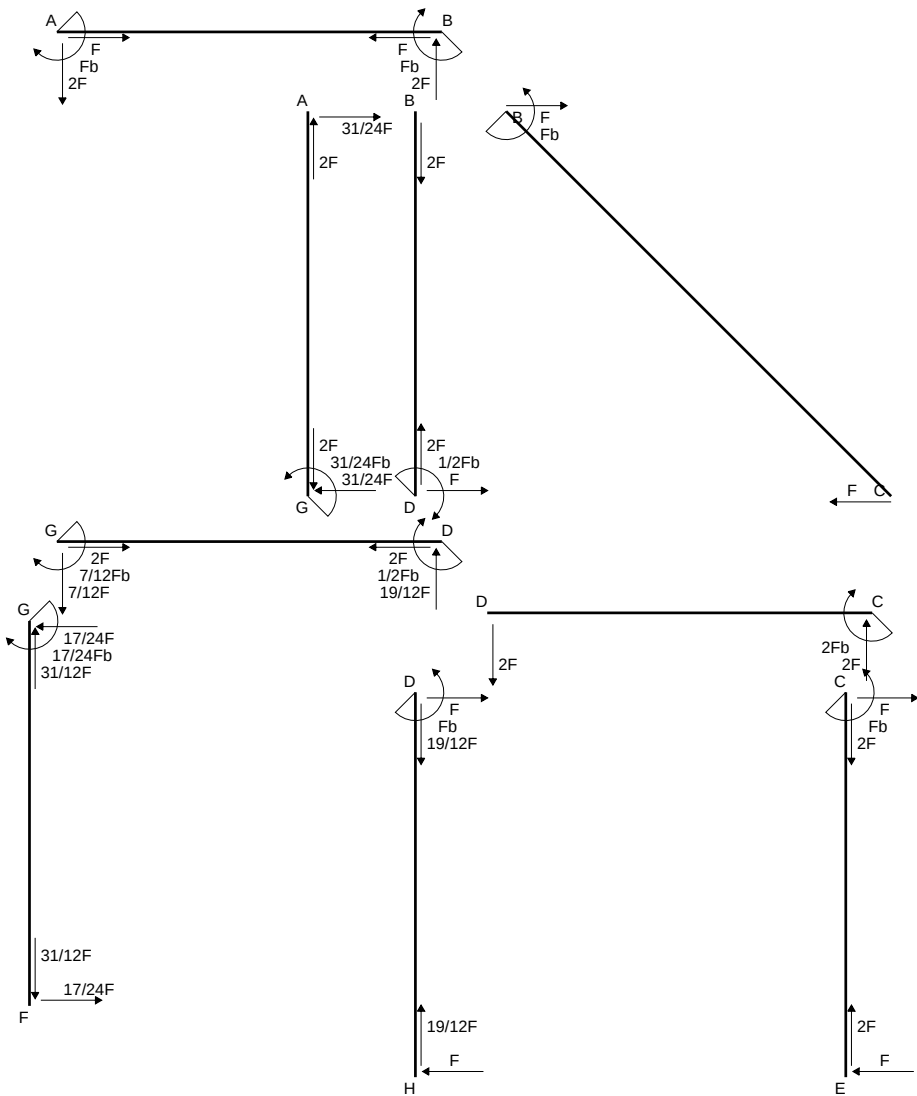
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

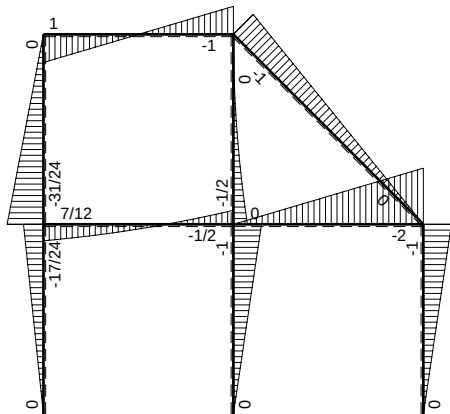


$$\begin{aligned} A &= 1188. \text{ mm}^2 \\ J_u &= 384370. \text{ mm}^4 \\ J_v &= 119664. \text{ mm}^4 \\ y_g &= 31.62 \text{ mm} \\ T_y &= -4100. \text{ N} \\ M_x &= -2911000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.62 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -18.62 \text{ mm} \\ \sigma_c &= -Mv/J_u = -141. \text{ N/mm}^2 \\ \tau_c &= 6.763 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 141.5 \text{ N/mm}^2 \\ S &= 7608. \text{ mm}^3 \end{aligned}$$

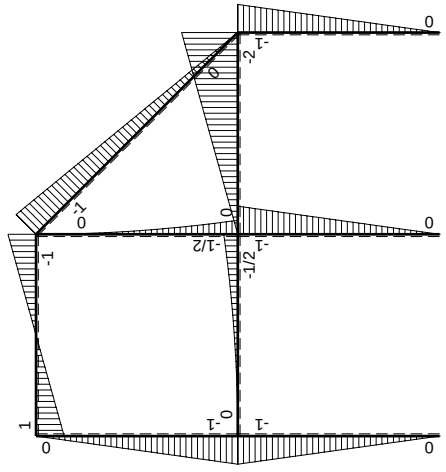
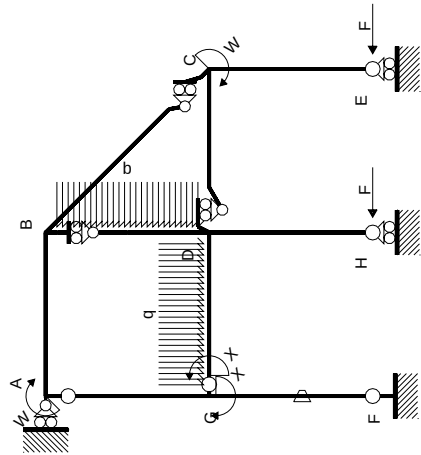


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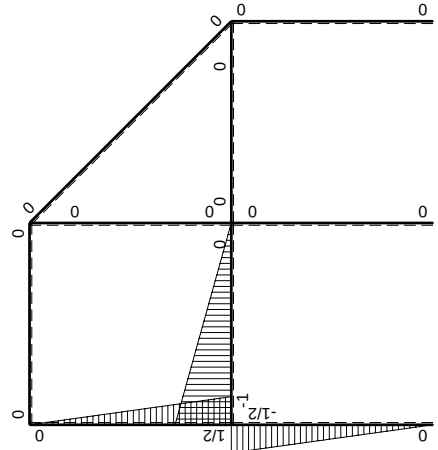


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2qx^2$	0	$1/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-Fx+1/2qx^2$	0	$1/2Fx-Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{6} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{3} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

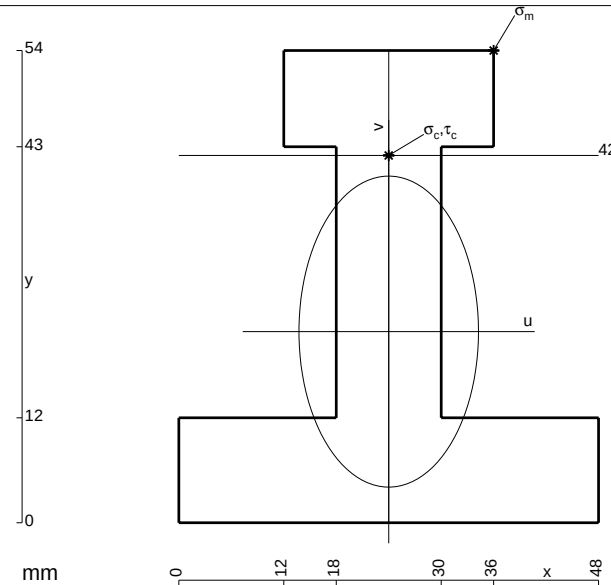
$$= \left(\frac{1}{4} b - \frac{1}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

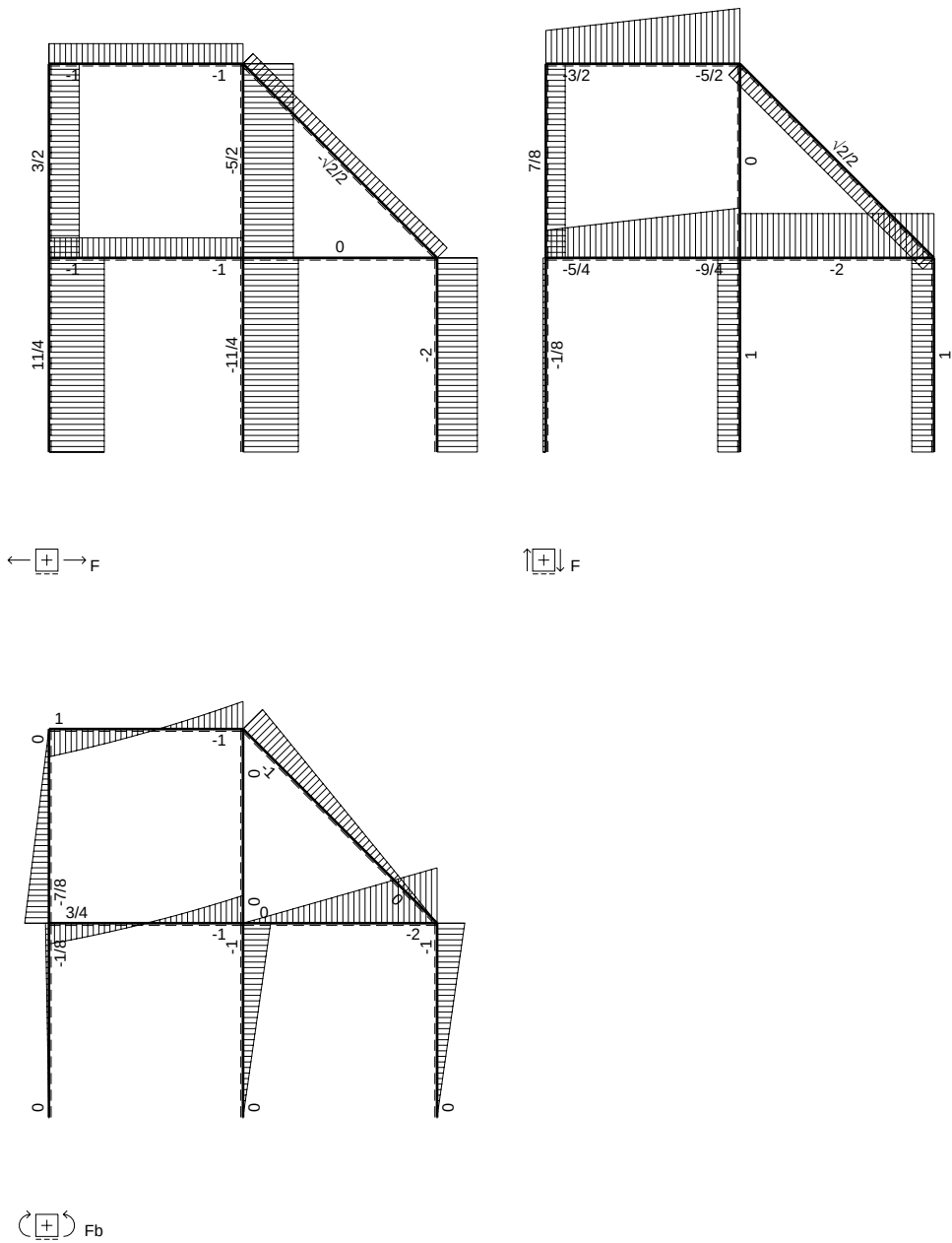
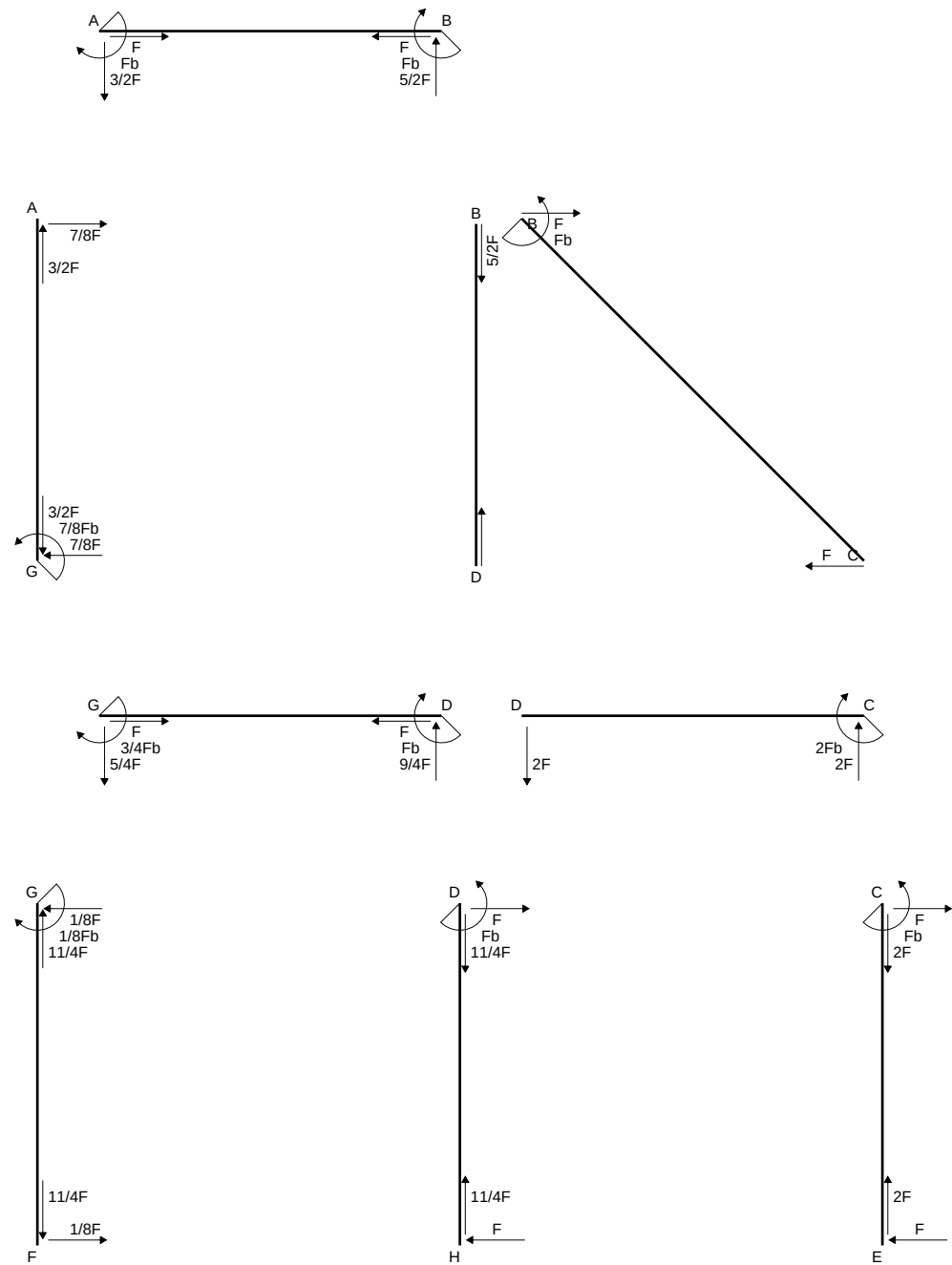
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

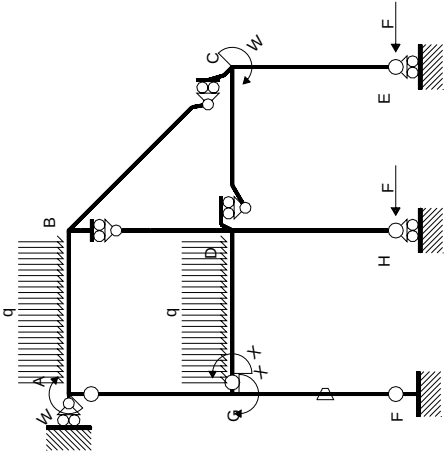
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



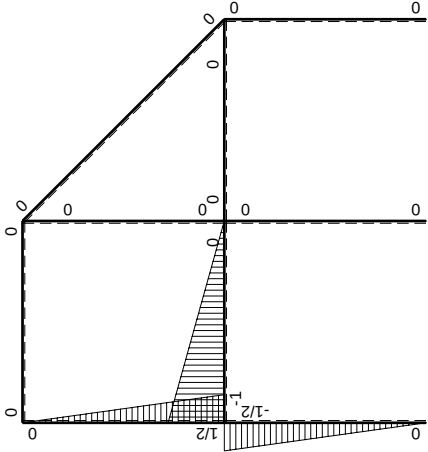
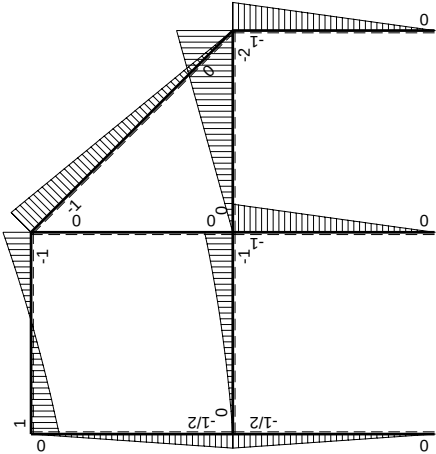
$$\begin{aligned} A &= 1212. \text{ mm}^2 \\ J_u &= 383443. \text{ mm}^4 \\ J_v &= 127728. \text{ mm}^4 \\ y_g &= 21.86 \text{ mm} \\ T_y &= -3120. \text{ N} \\ M_x &= -2371200. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 32.14 \text{ mm} \\ \sigma_m &= -Mv/J_u = 198.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 20.14 \text{ mm} \\ \sigma_c &= -Mv/J_u = 124.6 \text{ N/mm}^2 \\ \tau_c &= 4.937 \text{ N/mm}^2 \\ \sigma_o^* &= \sqrt{\sigma^2 + 3\tau^2} = 124.9 \text{ N/mm}^2 \\ S &= 7282. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$3/8Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-3/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

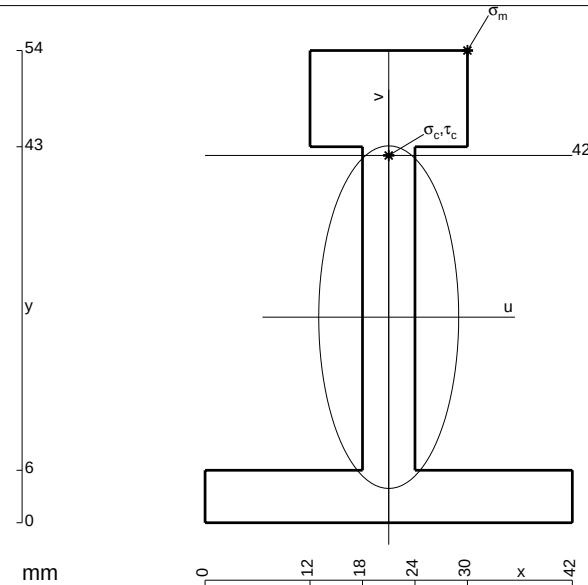
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

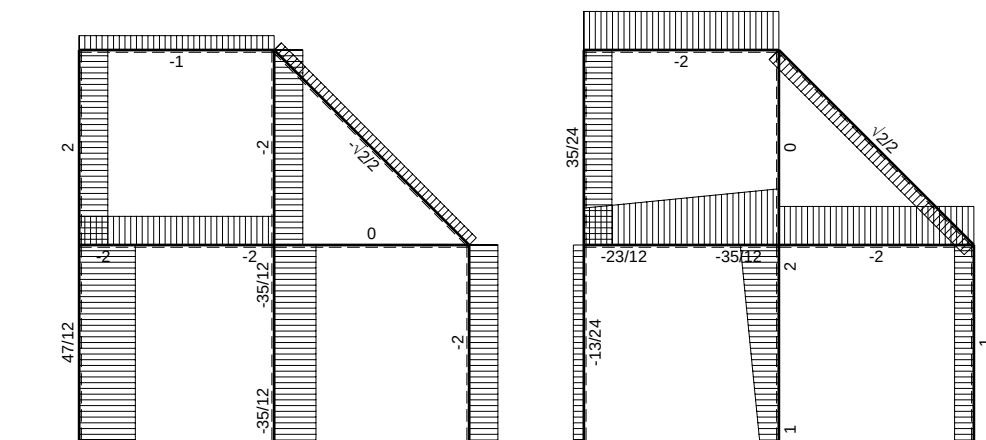
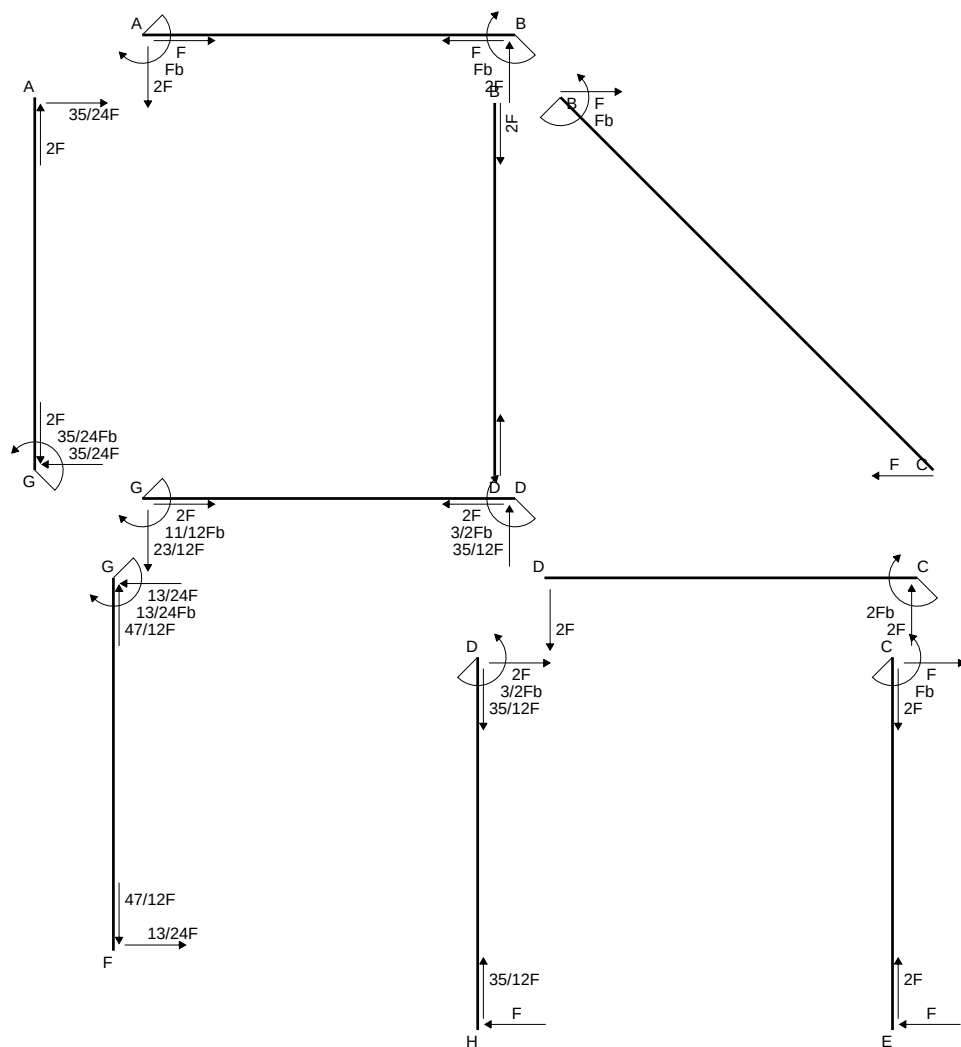
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

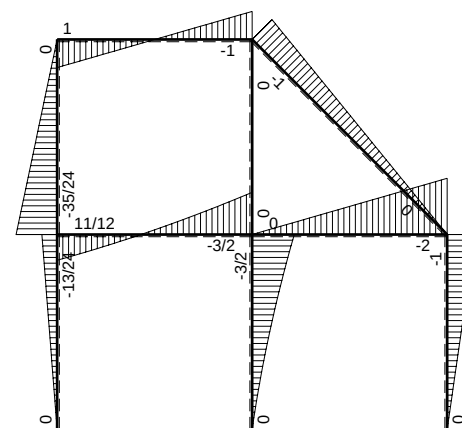
$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$



$$\begin{aligned} A &= 672. \text{ mm}^2 \\ J_u &= 257954. \text{ mm}^4 \\ J_v &= 43056. \text{ mm}^4 \\ y_g &= 23.51 \text{ mm} \\ T_y &= -2180. \text{ N} \\ M_x &= -1765800. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 30.49 \text{ mm} \\ \sigma_m &= -Mv/J_u = 208.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 18.49 \text{ mm} \\ \sigma_c &= -Mv/J_u = 126.6 \text{ N/mm}^2 \\ \tau_c &= 7.13 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 127.2 \text{ N/mm}^2 \\ S &= 5062. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

↑ $\boxed{+}$ ↓ F

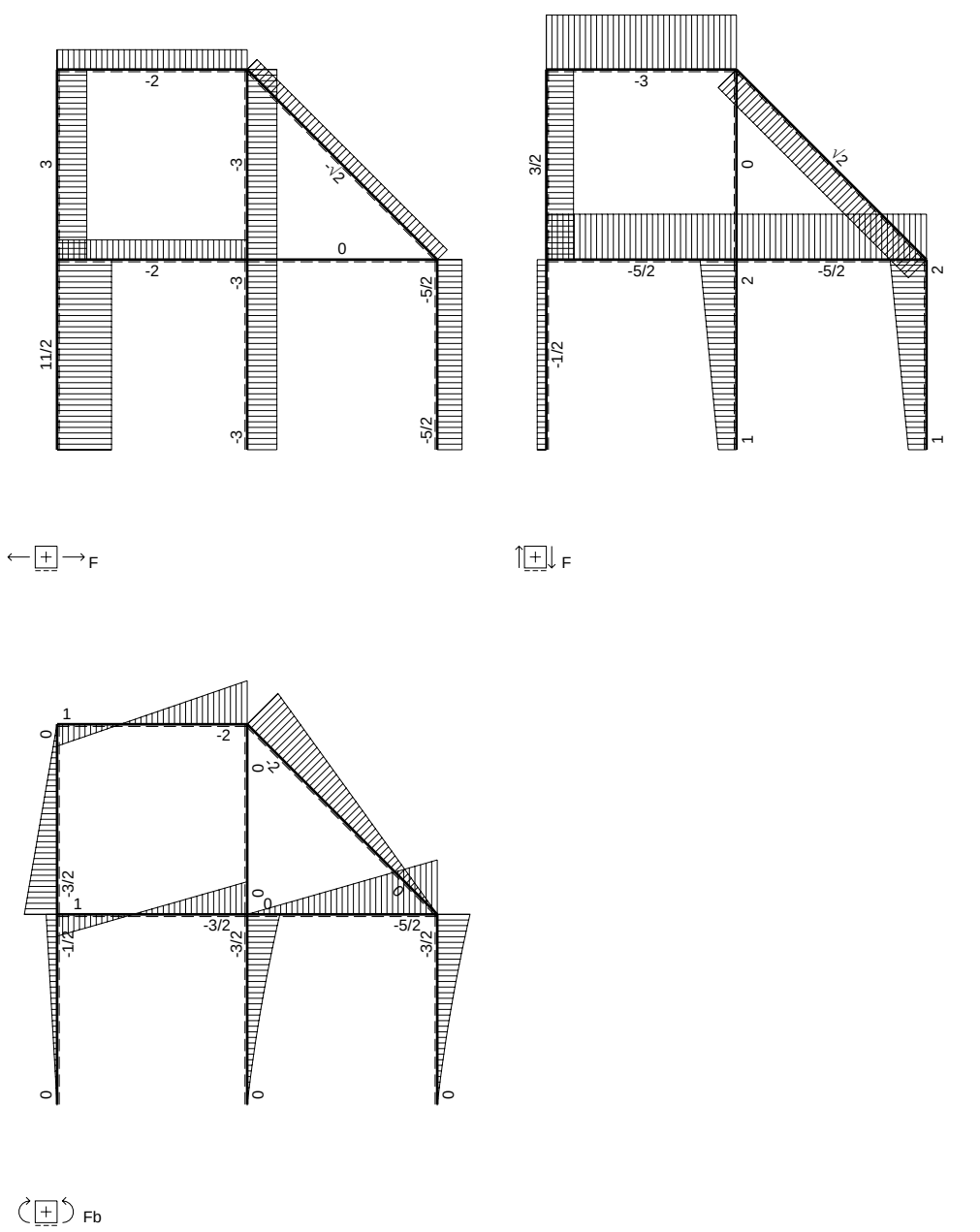
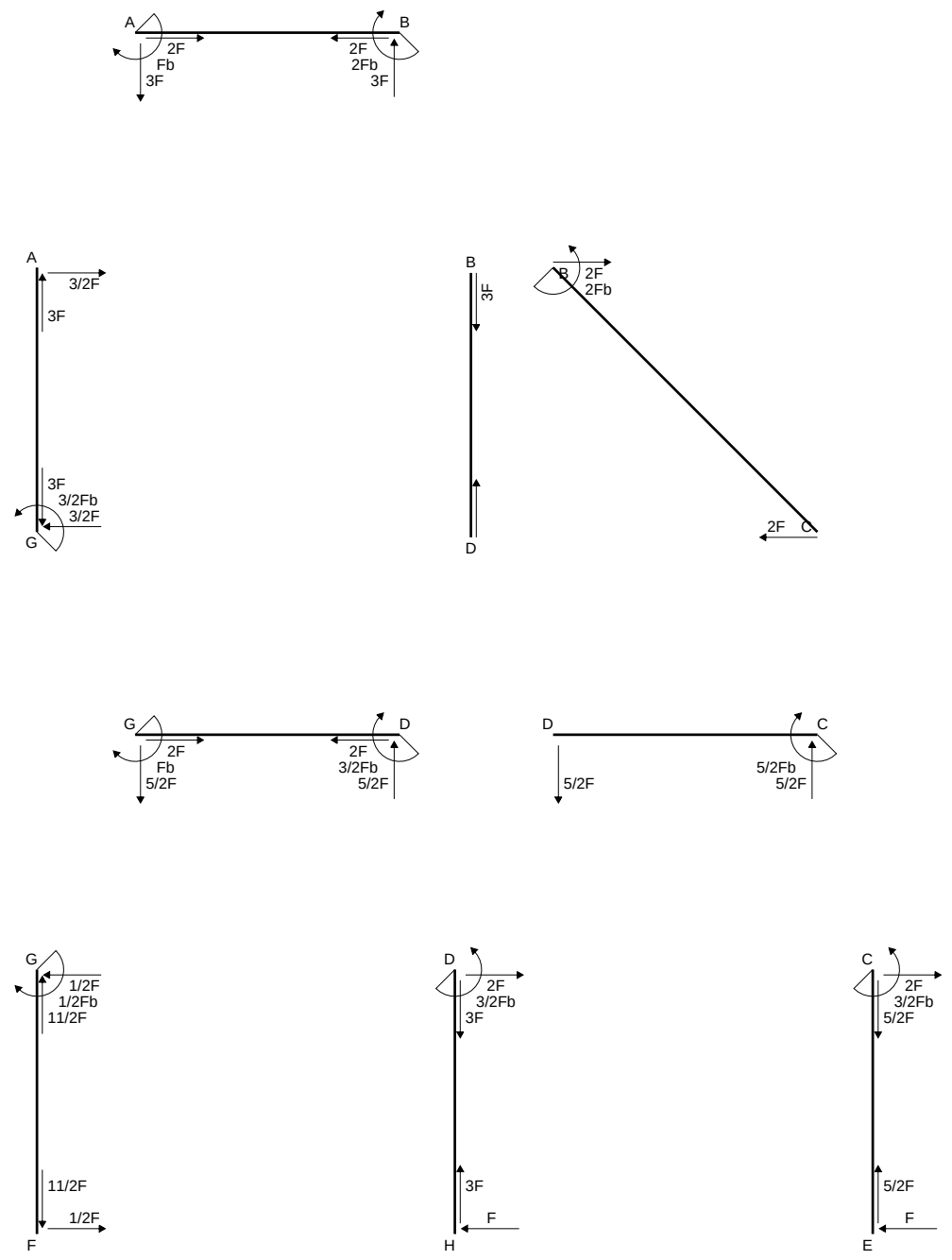


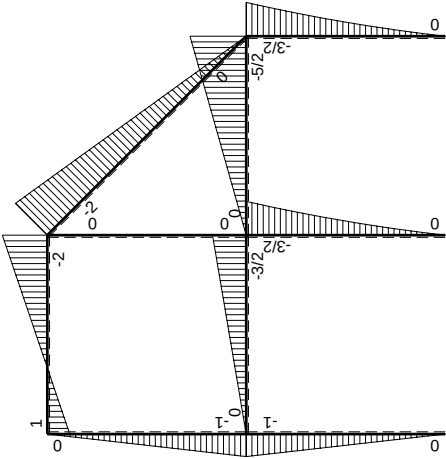
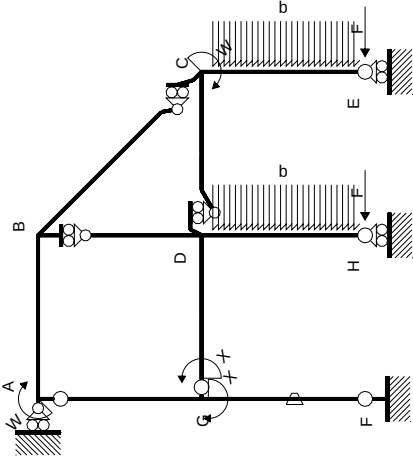
 F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx-1/2qx^2$	0	$Fx-1/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(5/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-2Fx+1/2qx^2$	0	$3/2Fx-2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$11/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-11/12Fb$	

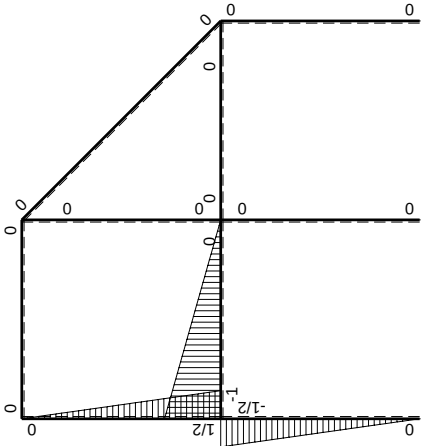
Sviluppi di calcolo iperstatica





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

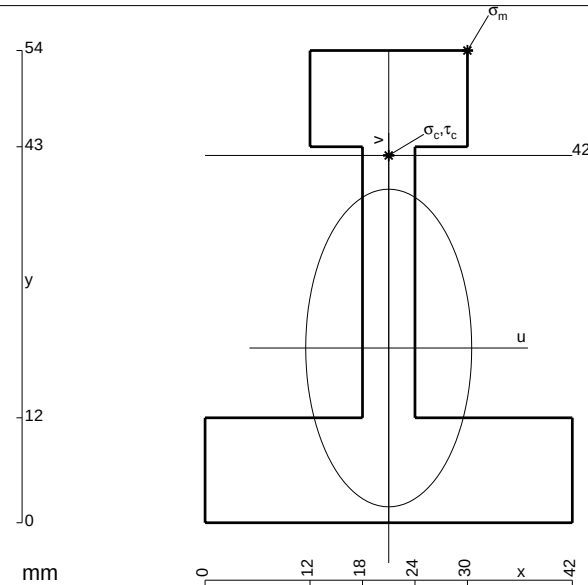
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

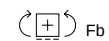
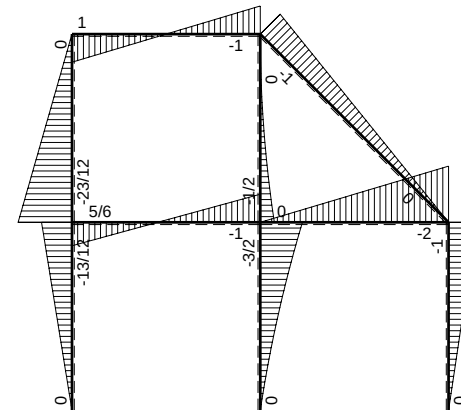
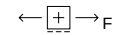
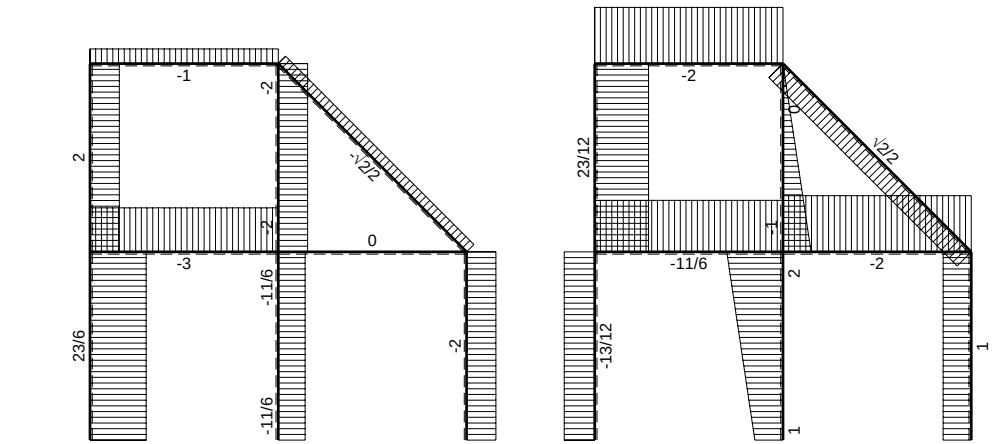
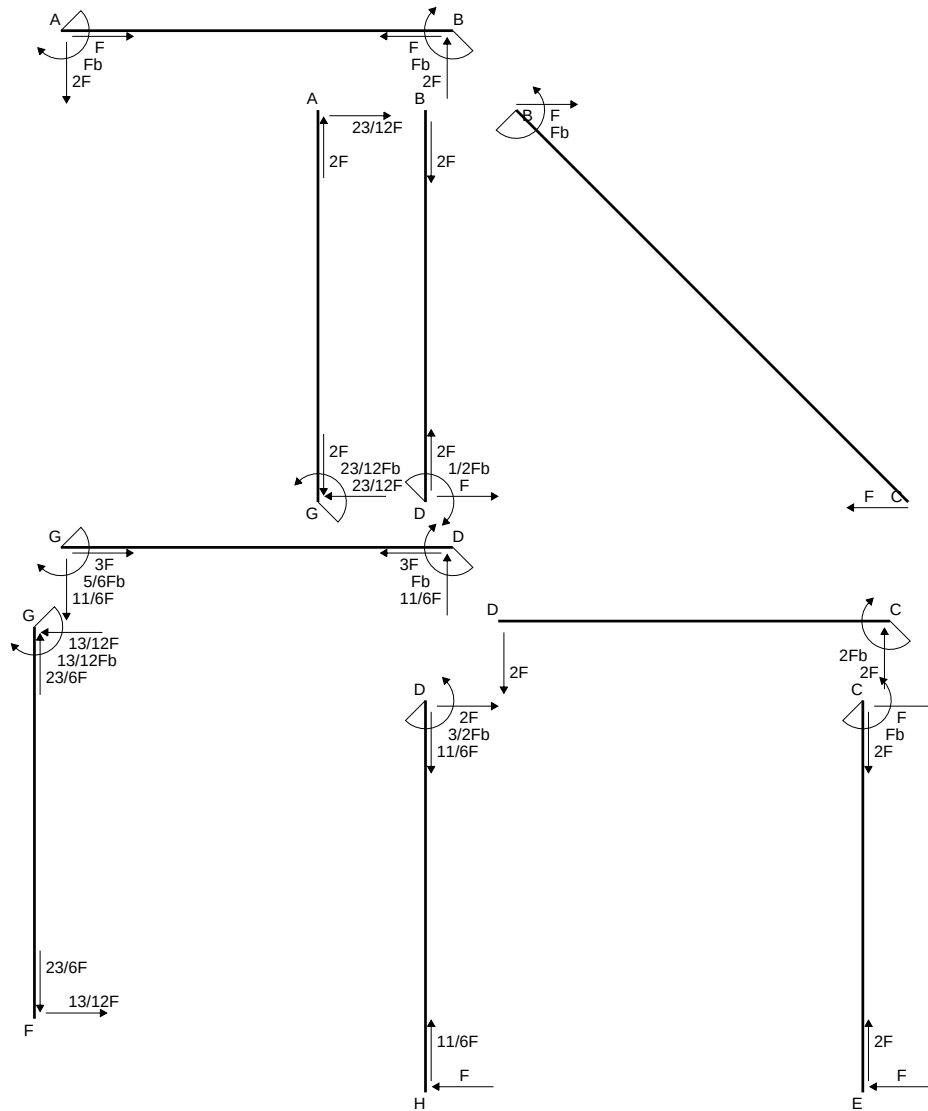
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

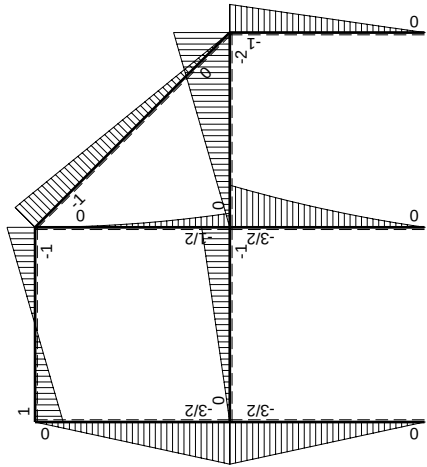
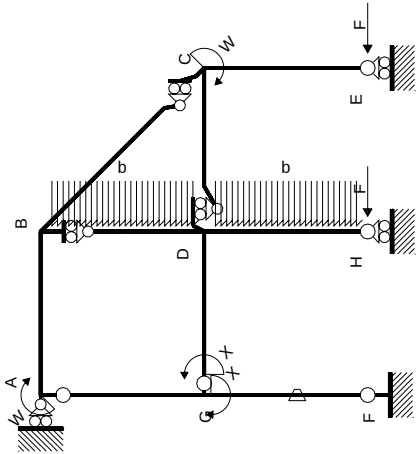
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



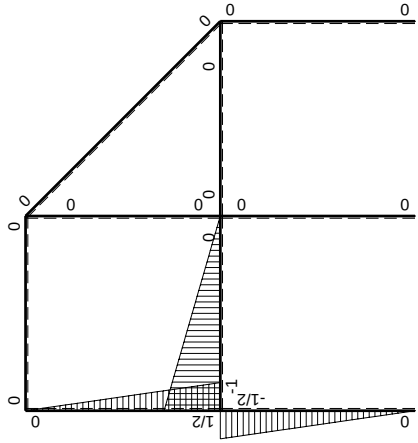
$$\begin{aligned} A &= 888. \text{ mm}^2 \\ J_u &= 293012. \text{ mm}^4 \\ J_v &= 79992. \text{ mm}^4 \\ y_g &= 19.98 \text{ mm} \\ T_y &= -2175. \text{ N} \\ M_x &= -1979250. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 34.02 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 22.02 \text{ mm} \\ \sigma_c &= -Mv/J_u = 148.7 \text{ N/mm}^2 \\ \tau_c &= 7.153 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 149.3 \text{ N/mm}^2 \\ S &= 5782. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/2Fb+3/2Fx$	0	$-3/4Fb+3/2Fx-3/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/2Fx$	0	$-3/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{2} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{4} b - \frac{3}{4} b + \frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{2} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

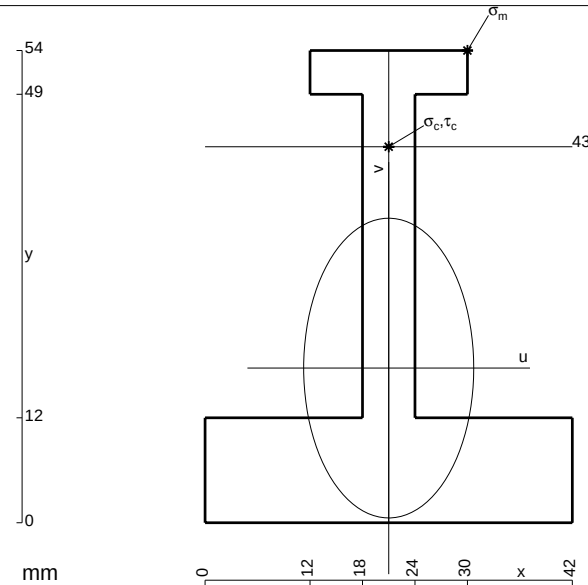
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{3}{4} + \frac{3}{2} x/b - \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{4} x + \frac{3}{4} x^2/b - \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

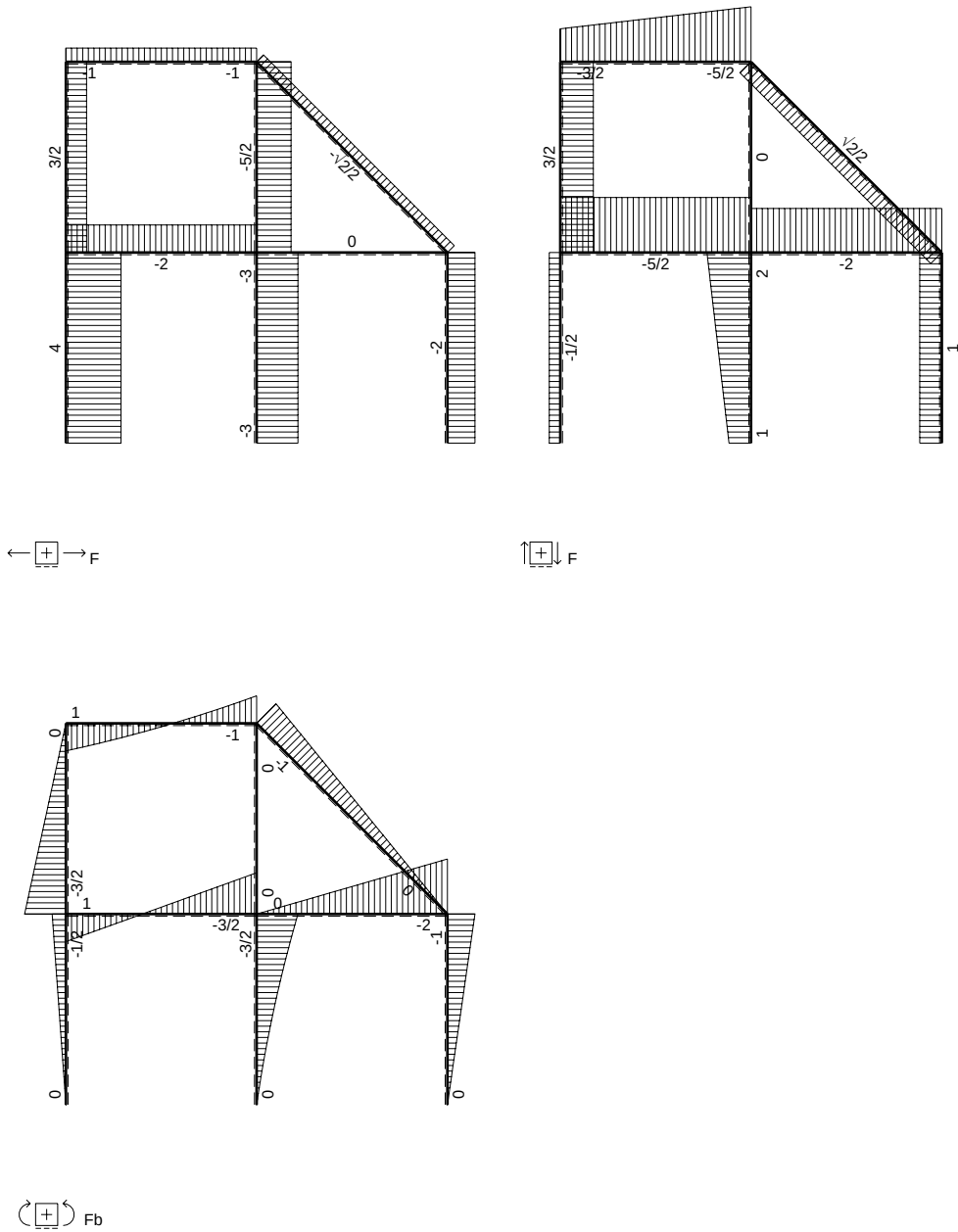
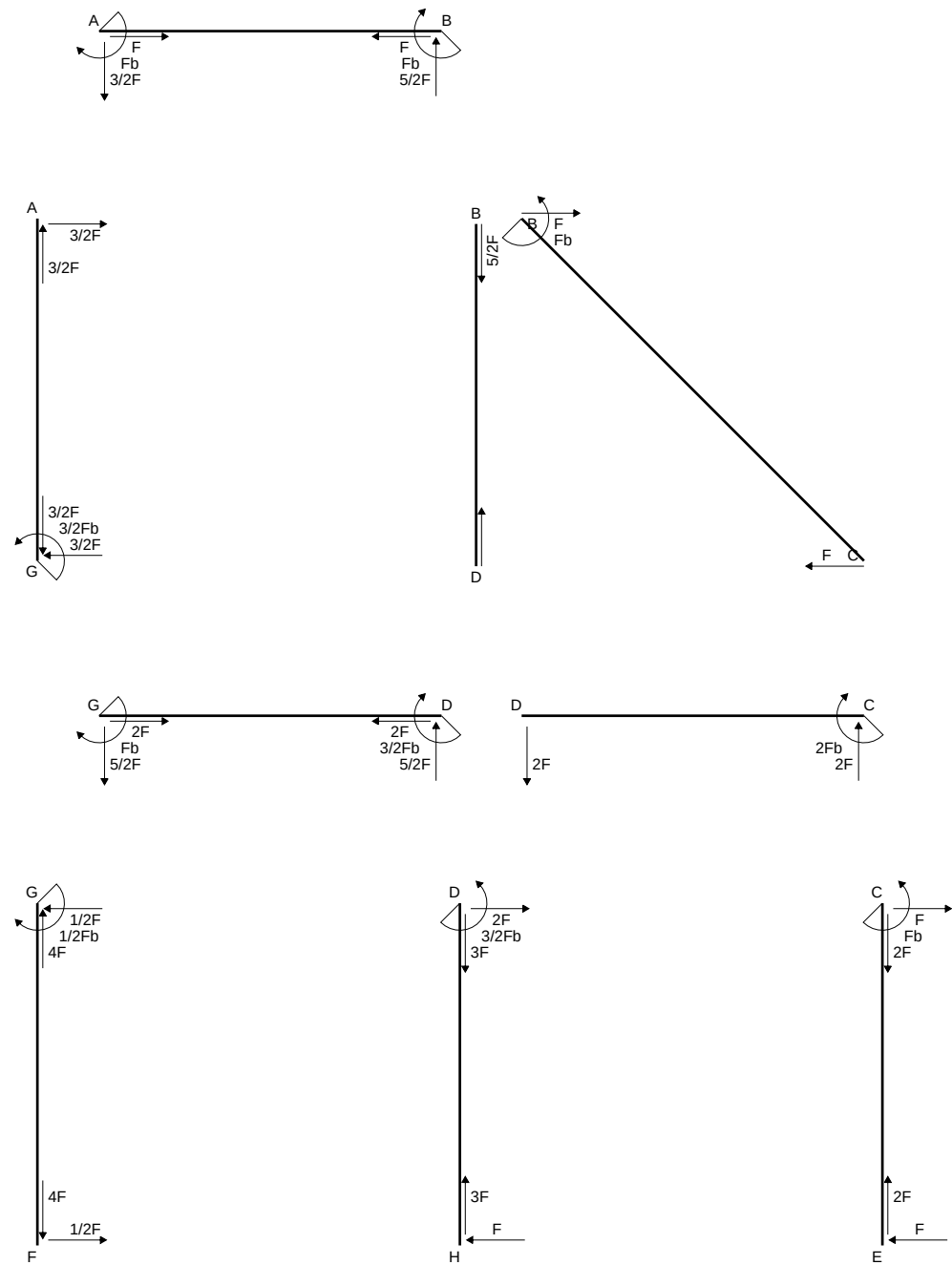
$$= \left(-\frac{3}{4} b + \frac{3}{4} b - \frac{1}{4} b \right) Fb \frac{1}{EJ} = -\frac{1}{4} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{4} b \right) Fb \frac{1}{EJ} = -\frac{1}{4} Fb^2/EJ$$



$$\begin{aligned} A &= 816. \text{ mm}^2 \\ J_u &= 239746. \text{ mm}^4 \\ J_v &= 77184. \text{ mm}^4 \\ y_g &= 17.68 \text{ mm} \\ T_y &= -1640. \text{ N} \\ M_x &= -1574400. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 36.32 \text{ mm} \\ \sigma_m &= -Mv/J_u = 238.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 25.32 \text{ mm} \\ \sigma_c &= -Mv/J_u = 166.3 \text{ N/mm}^2 \\ \tau_c &= 4.632 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 166.4 \text{ N/mm}^2 \\ S &= 4063. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	-Fx	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

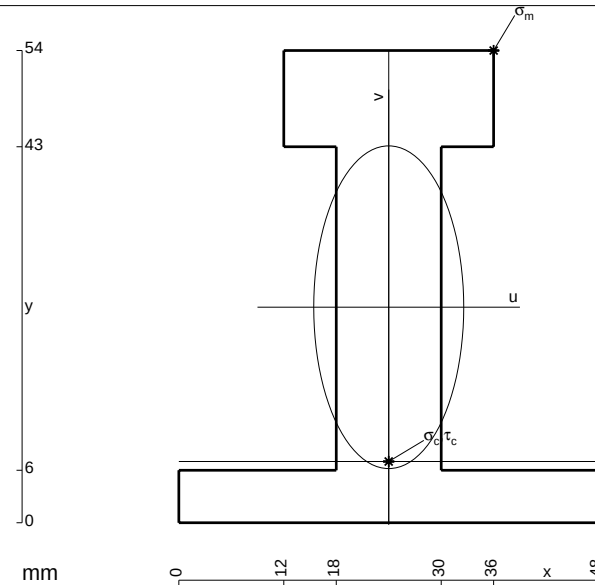
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

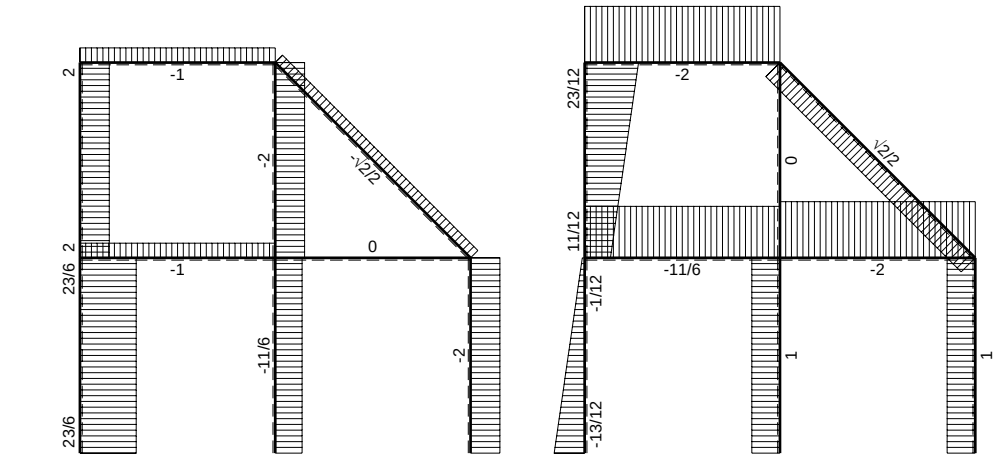
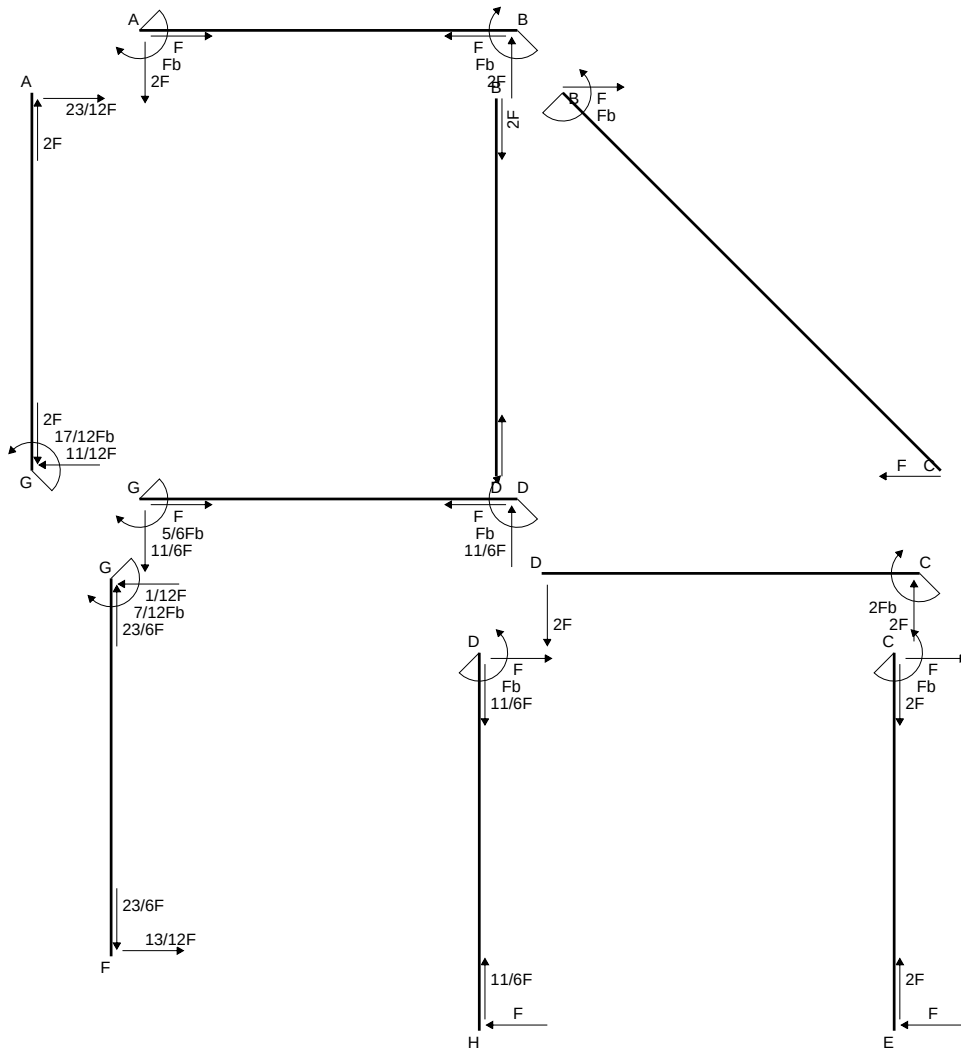
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

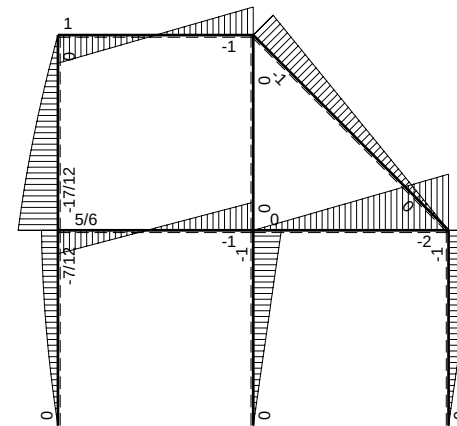
$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

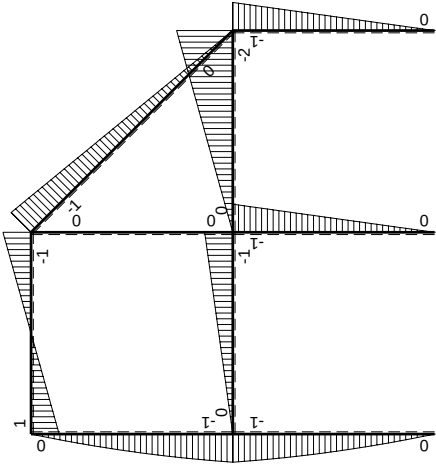
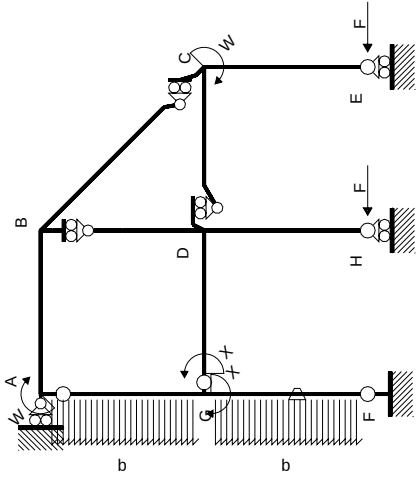


$$\begin{aligned} A &= 996. \text{ mm}^2 \\ J_u &= 339350. \text{ mm}^4 \\ J_v &= 73296. \text{ mm}^4 \\ y_g &= 24.64 \text{ mm} \\ T_y &= -4520. \text{ N} \\ M_x &= -2305200. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.36 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -17.64 \text{ mm} \\ \sigma_c &= -Mv/J_u = -119.9 \text{ N/mm}^2 \\ \tau_c &= 7.161 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 120.5 \text{ N/mm}^2 \\ S &= 6451. \text{ mm}^3 \end{aligned}$$



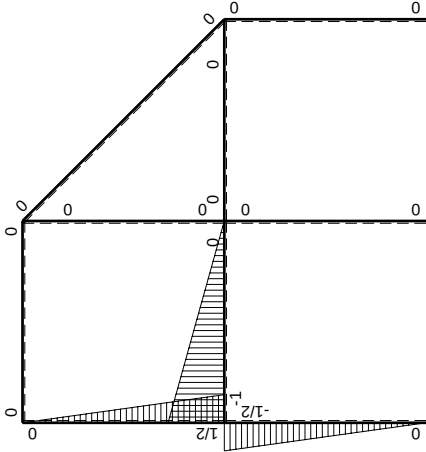
A diagram showing a positive charge, represented by a square box with a '+' sign inside. A horizontal arrow points to the left from the charge, and another horizontal arrow points to the right from the charge, labeled with the letter 'F'.





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx+1/2qx^2$	$-Fb/EJ$	$3/4Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(3/16+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-1/2Fx-1/2qx^2$	Fb/EJ	$1/2Fb-3/4Fx+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+1/2Fx+1/2qx^2$	0	$-1/2Fb+3/4Fx-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-3/16+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/2Fx-1/2qx^2$	0	$-3/4Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{3}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - \frac{3}{4} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{3}{8} x^2/b + \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{3}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

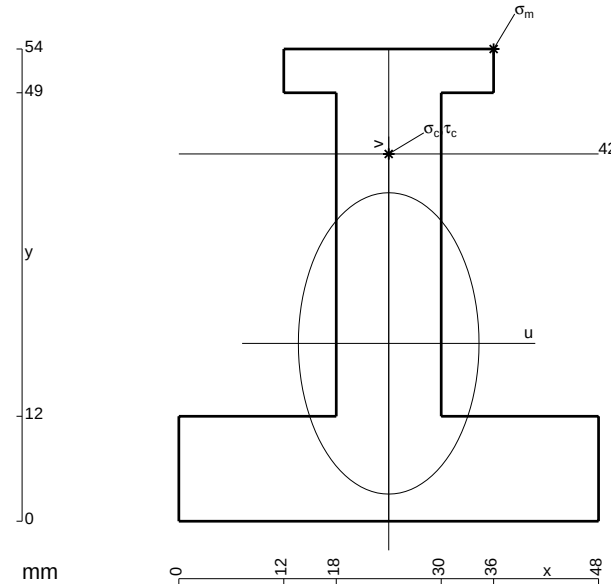
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{2} + \frac{3}{4} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{3}{8} x^2/b - \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

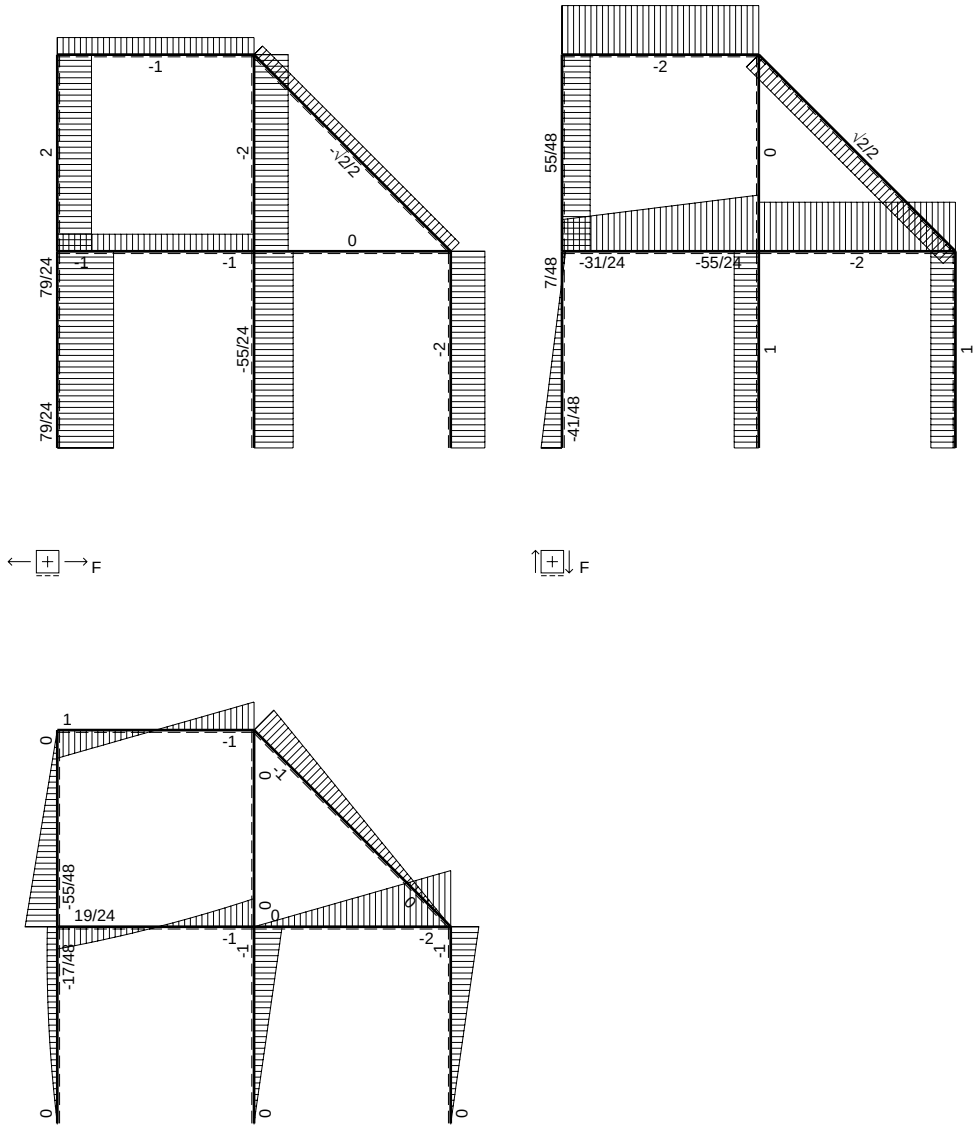
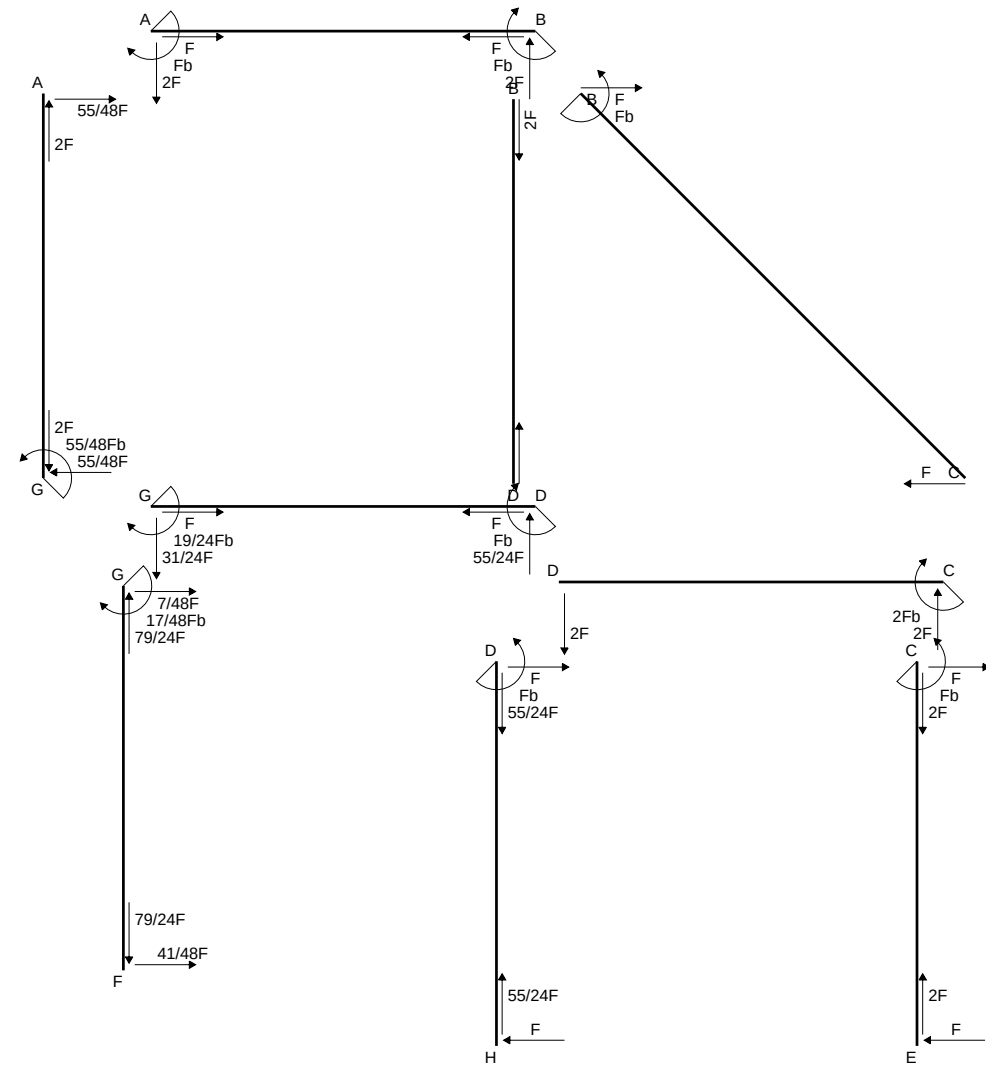
$$= \left(-\frac{1}{2} b + \frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

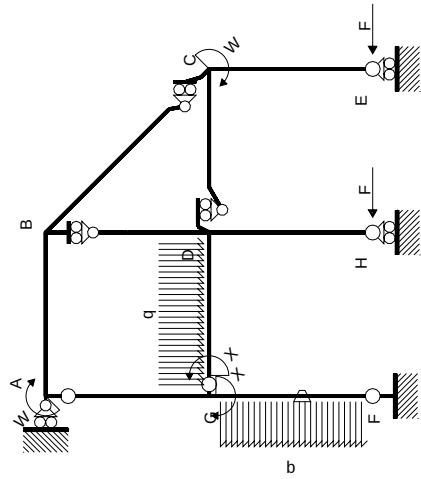
$$= \left(-\frac{1}{4} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$



$$\begin{aligned} A &= 1140. \text{ mm}^2 \\ J_u &= 338607. \text{ mm}^4 \\ J_v &= 121680. \text{ mm}^4 \\ y_g &= 20.33 \text{ mm} \\ T_y &= -3760. \text{ N} \\ M_x &= -2105600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 33.67 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 21.67 \text{ mm} \\ \sigma_c &= -Mv/J_u = 134.7 \text{ N/mm}^2 \\ \tau_c &= 5.417 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 135.1 \text{ N/mm}^2 \\ S &= 5854. \text{ mm}^3 \end{aligned}$$

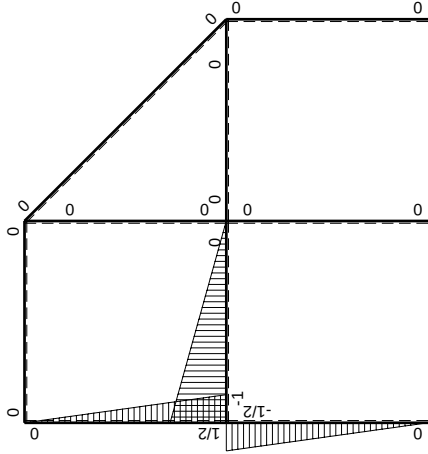
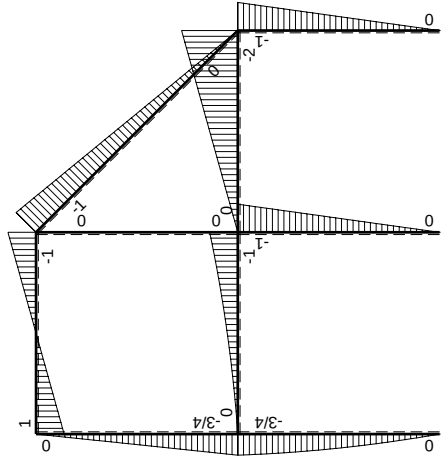


$\left[\begin{array}{c} \uparrow \\ \downarrow \end{array} \right] F$



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$19/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-19/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

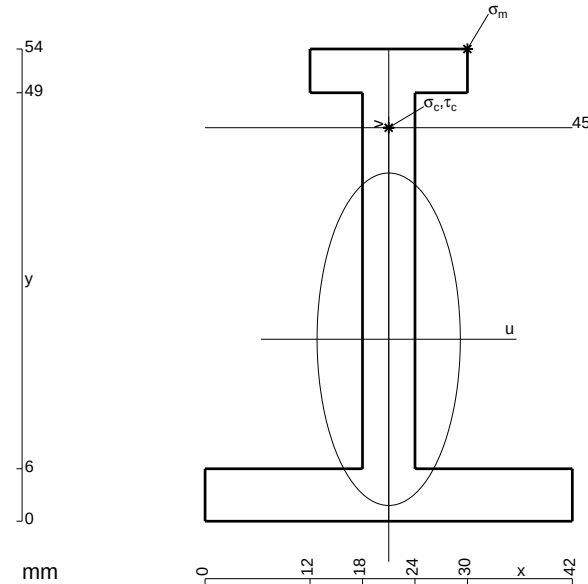
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

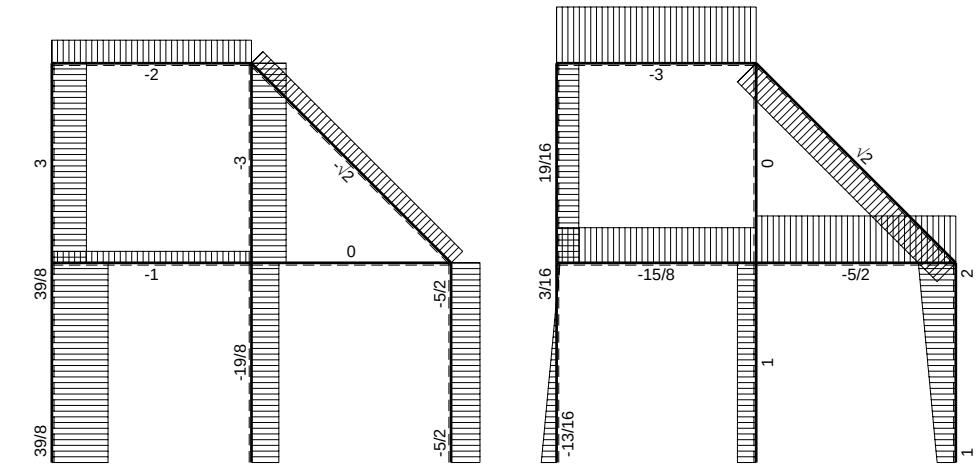
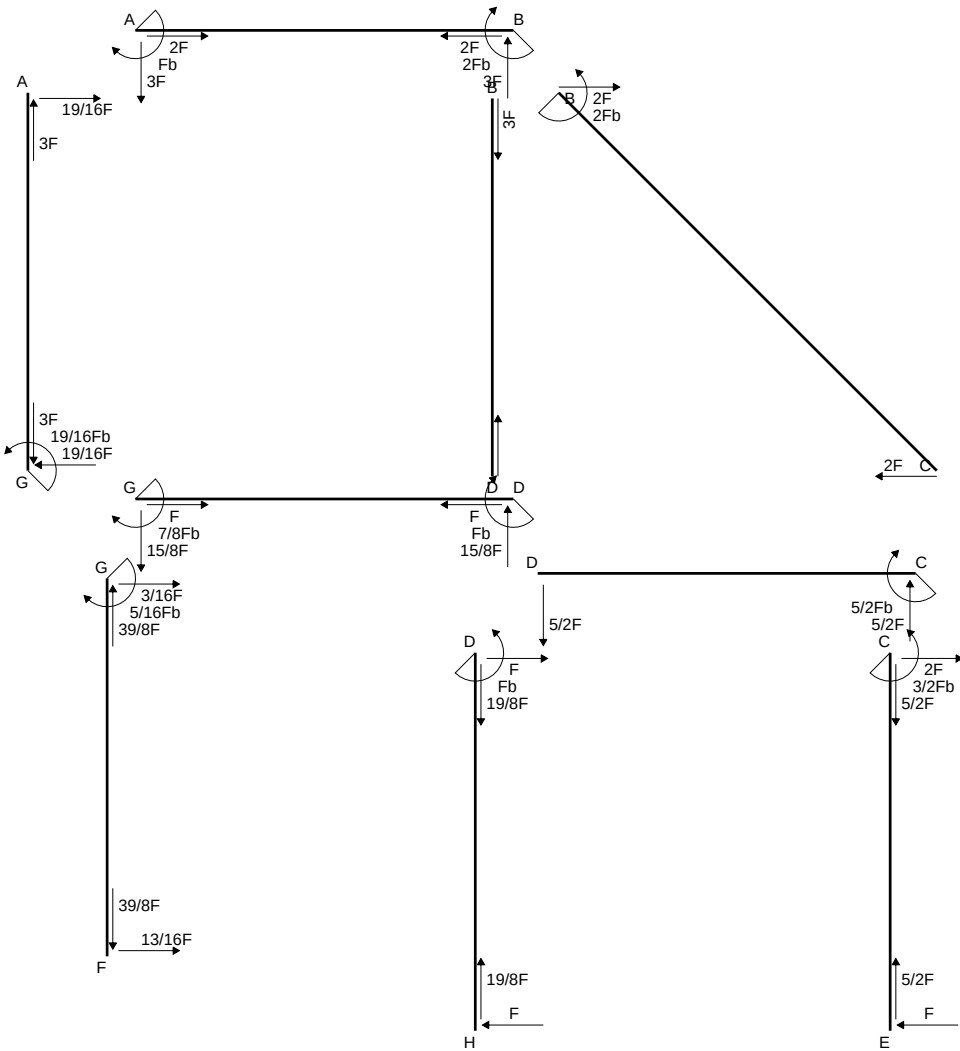
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

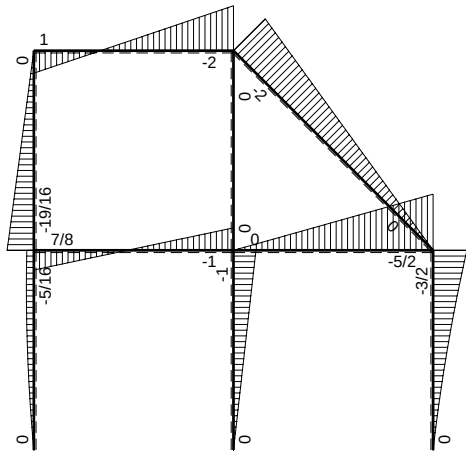


$$\begin{aligned} A &= 600. \text{ mm}^2 \\ J_u &= 216946. \text{ mm}^4 \\ J_v &= 40248. \text{ mm}^4 \\ y_g &= 20.81 \text{ mm} \\ T_y &= -2340. \text{ N} \\ M_x &= -1427400. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.19 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 24.19 \text{ mm} \\ \sigma_c &= -Mv/J_u = 159.2 \text{ N/mm}^2 \\ \tau_c &= 6.095 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 159.5 \text{ N/mm}^2 \\ S &= 3391. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

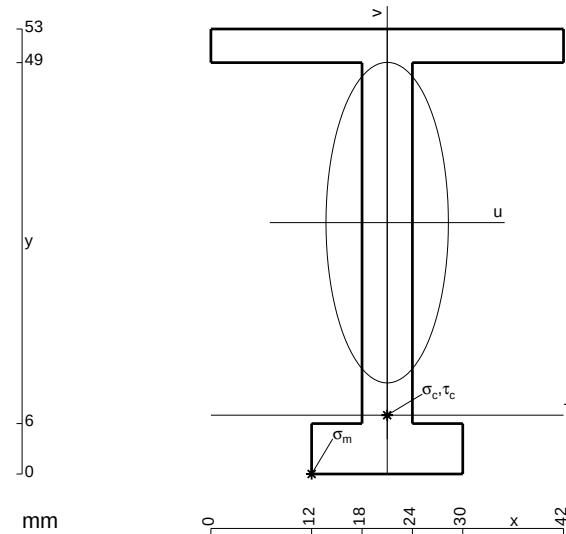
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

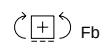
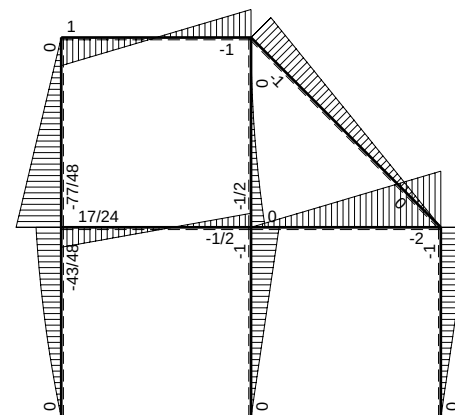
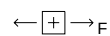
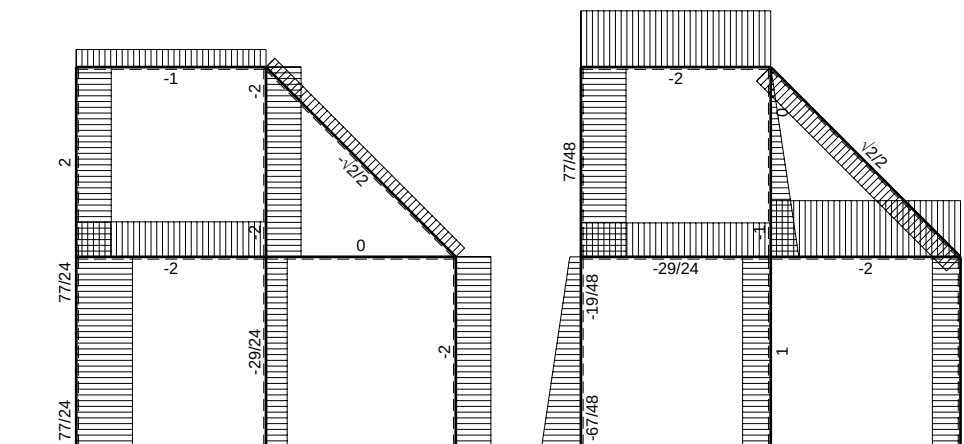
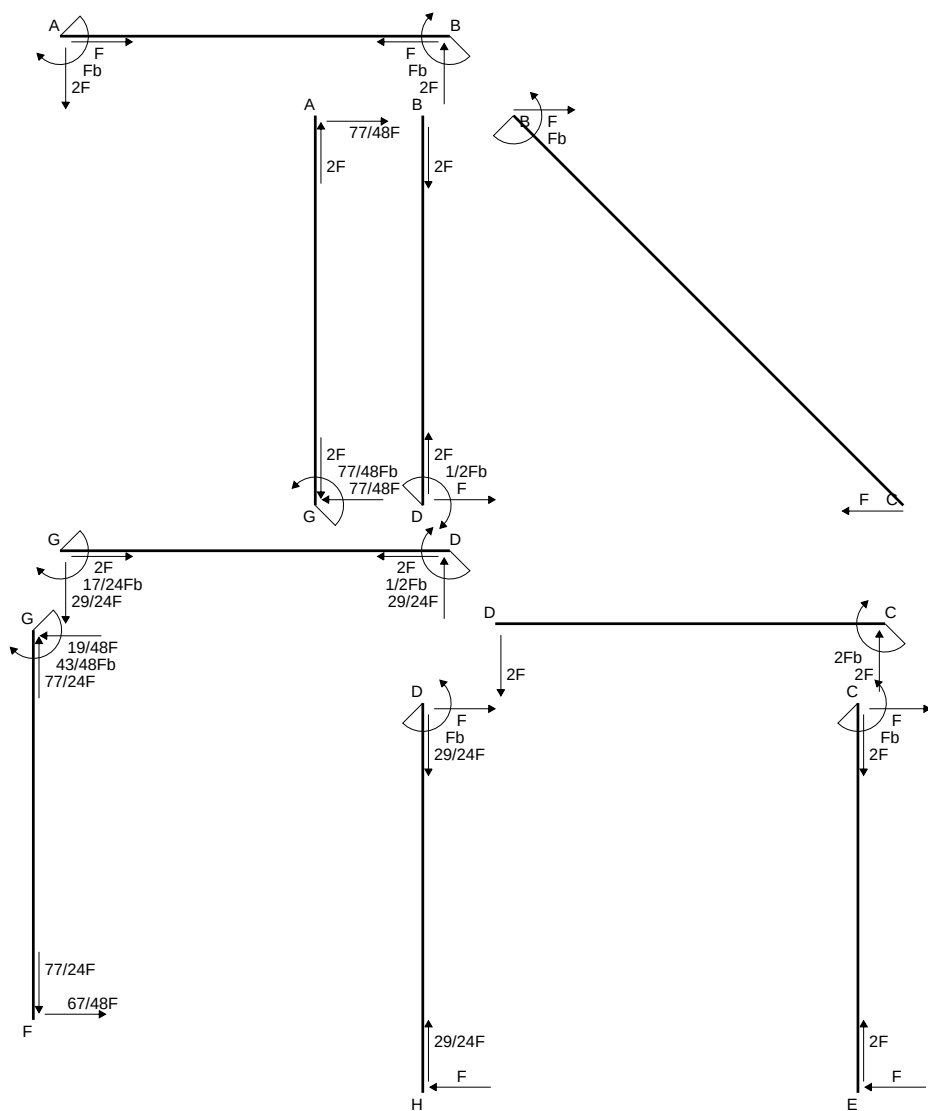
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$



$$\begin{aligned} A &= 534. \text{ mm}^2 \\ J_u &= 194732. \text{ mm}^4 \\ J_v &= 28386. \text{ mm}^4 \\ y_g &= 29.94 \text{ mm} \\ T_y &= -2300. \text{ N} \\ M_x &= -1495000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -29.94 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -22.94 \text{ mm} \\ \sigma_c &= -Mv/J_u = -176.1 \text{ N/mm}^2 \\ \tau_c &= 6.004 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 176.4 \text{ N/mm}^2 \\ S &= 3050. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-7/4Fx+1/2qx^2$	$-Fb/EJ$	$7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(11/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$5/8Fb-Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-5/4Fb+5/4Fx$	0	$-5/8Fb+5/4Fx-5/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-5/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx$	0	$-5/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$17/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-17/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

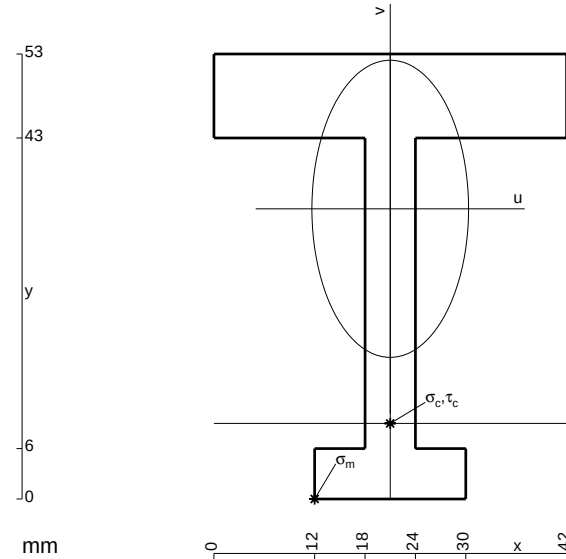
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{5}{8} + \frac{5}{4} x/b - \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{8} x + \frac{5}{8} x^2/b - \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

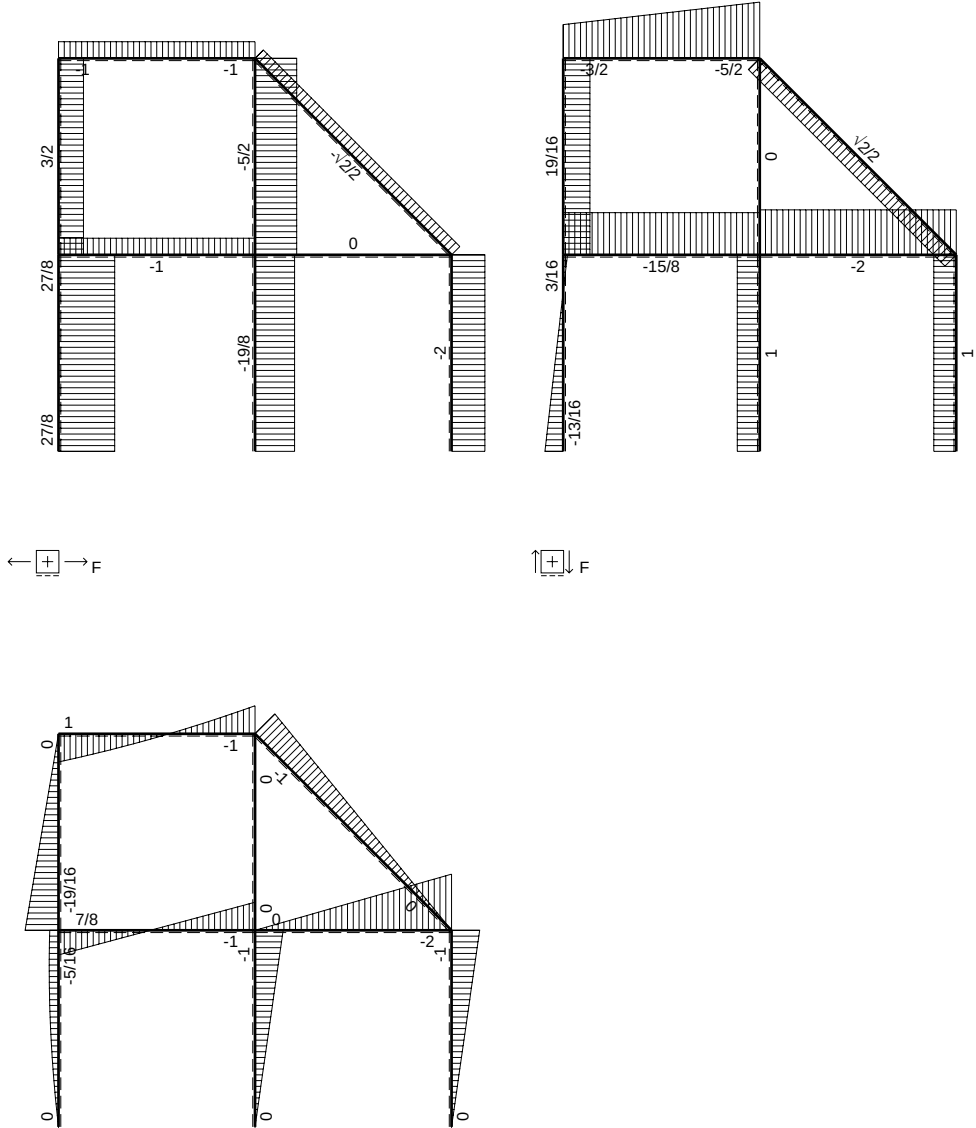
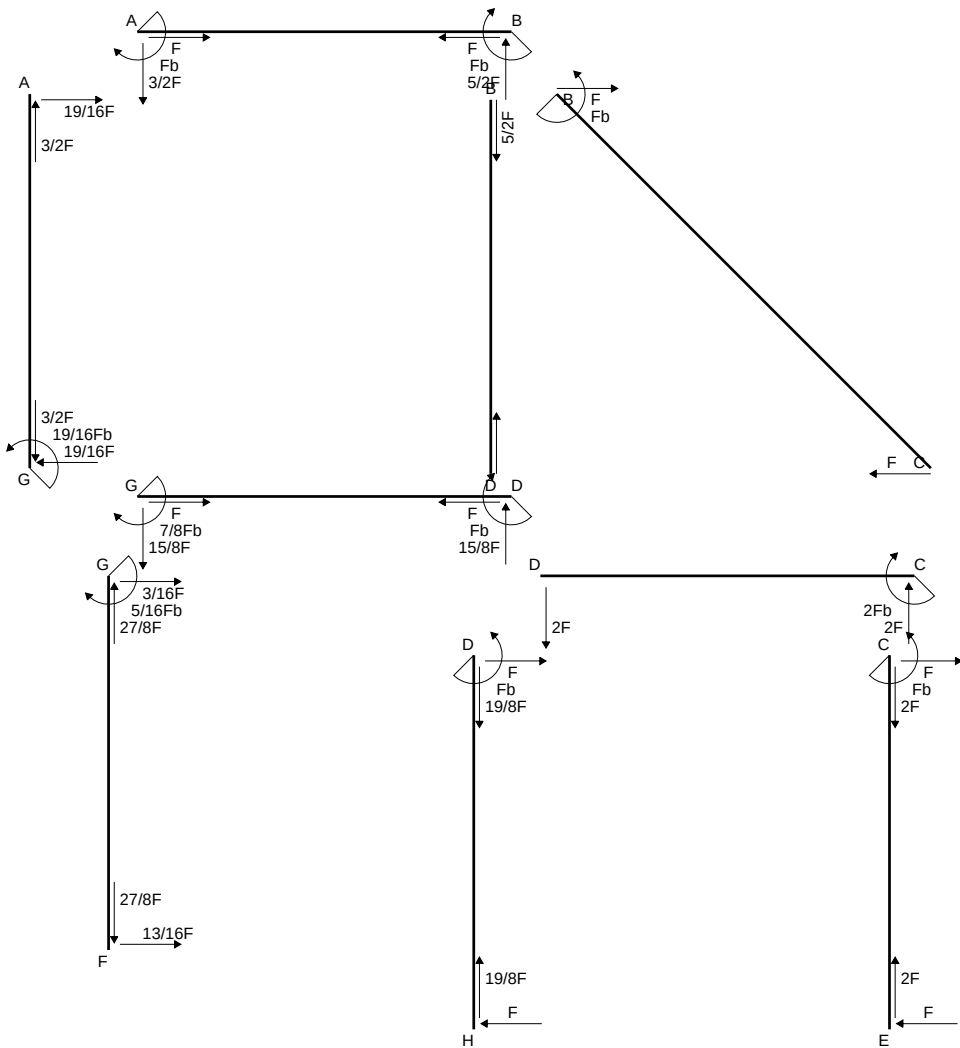
$$= \left(-\frac{5}{8} b + \frac{5}{8} b - \frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$

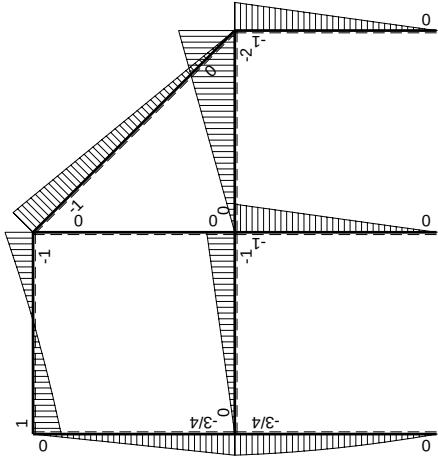
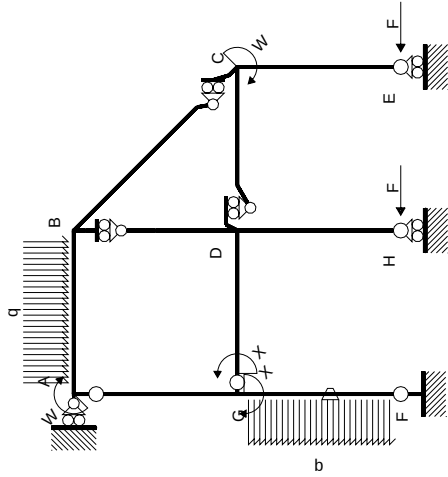
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$



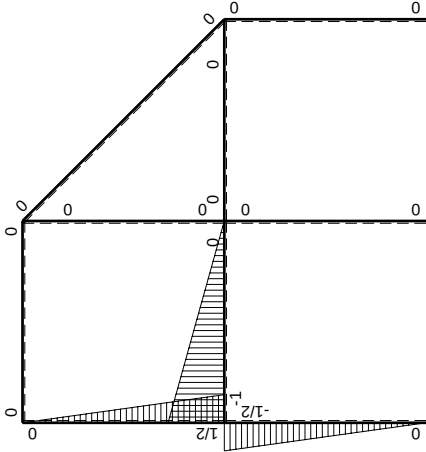
$$\begin{aligned} A &= 750. \text{ mm}^2 \\ J_u &= 235055. \text{ mm}^4 \\ J_v &= 65322. \text{ mm}^4 \\ y_g &= 34.56 \text{ mm} \\ T_y &= -2320. \text{ N} \\ M_x &= -1624000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.56 \text{ mm} \\ \sigma_m &= -Mv/J_u = -238.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -25.56 \text{ mm} \\ \sigma_c &= -Mv/J_u = -176.6 \text{ N/mm}^2 \\ \tau_c &= 6.409 \text{ N/mm}^2 \\ \sigma_\theta &= \sqrt{\sigma^2 + 3\tau^2} = 177. \text{ N/mm}^2 \\ S &= 3896. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

Mx flessione da carichi assegnati

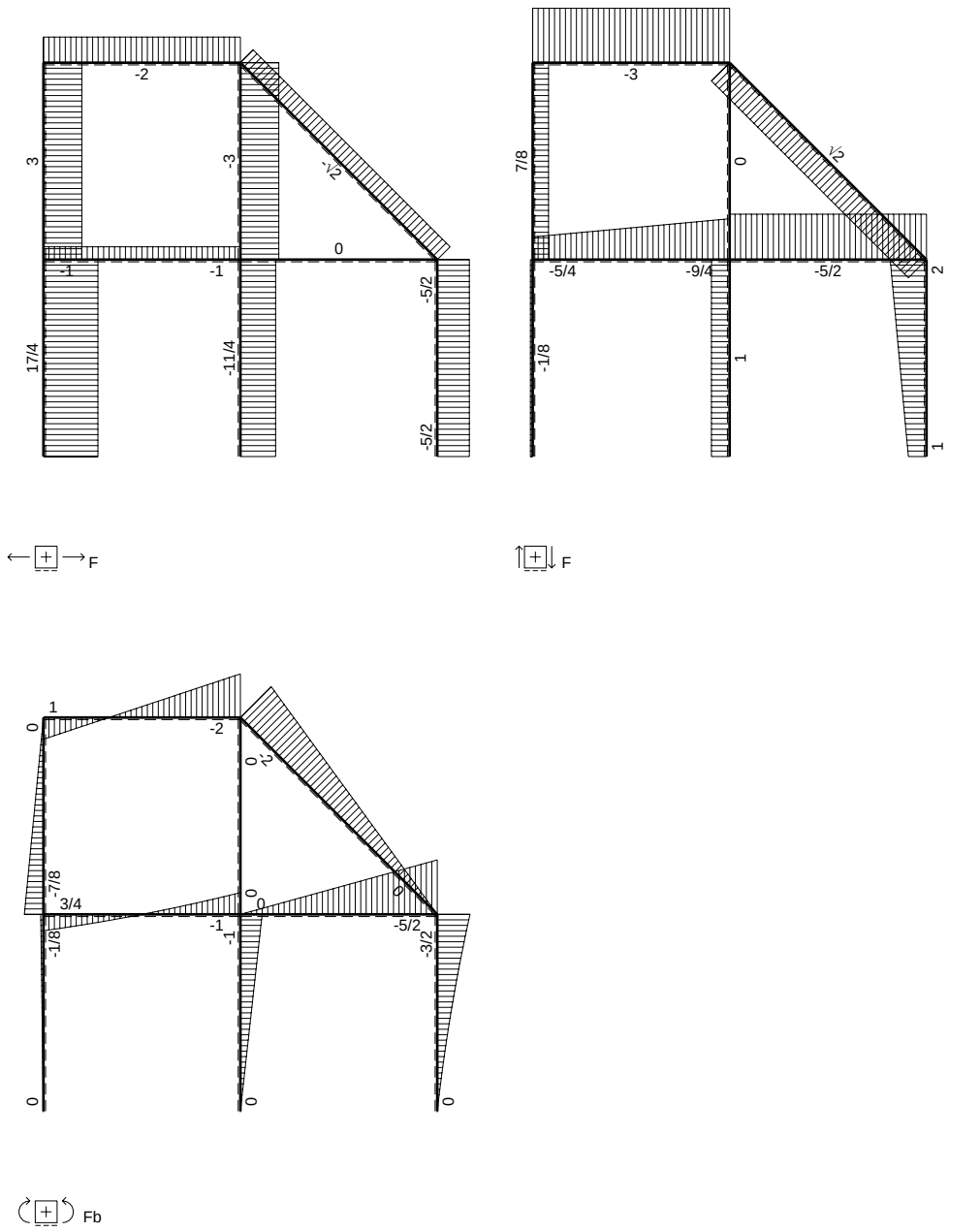
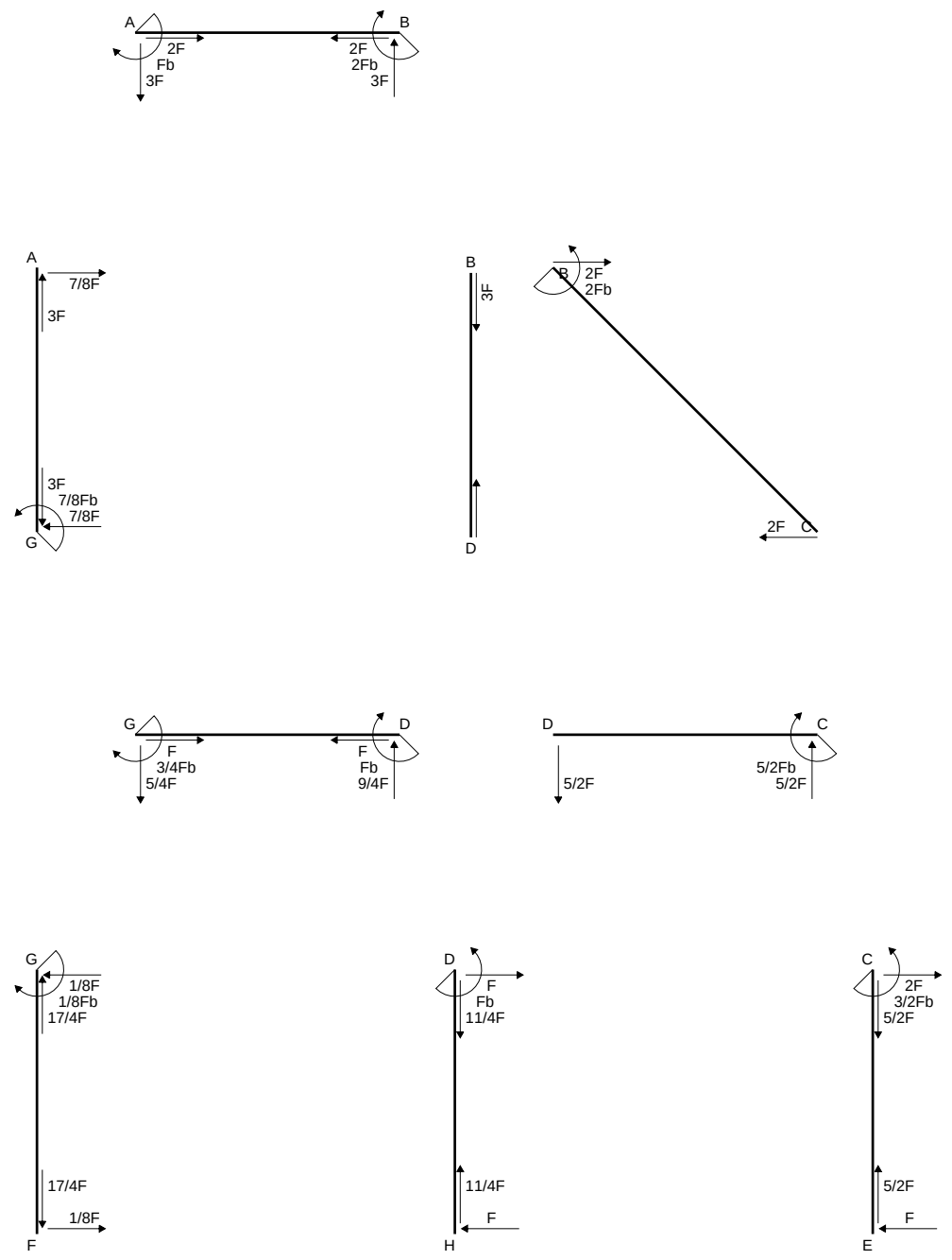


Mx flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	-Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/8Fb$	

Sviluppi di calcolo iperstatica



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$3/8Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-3/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

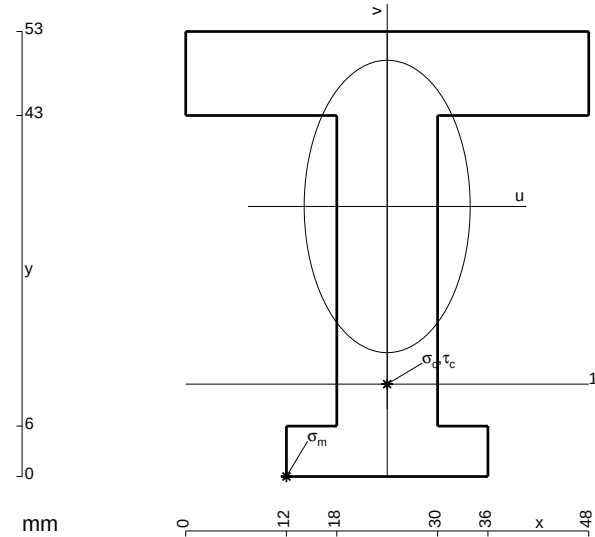
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

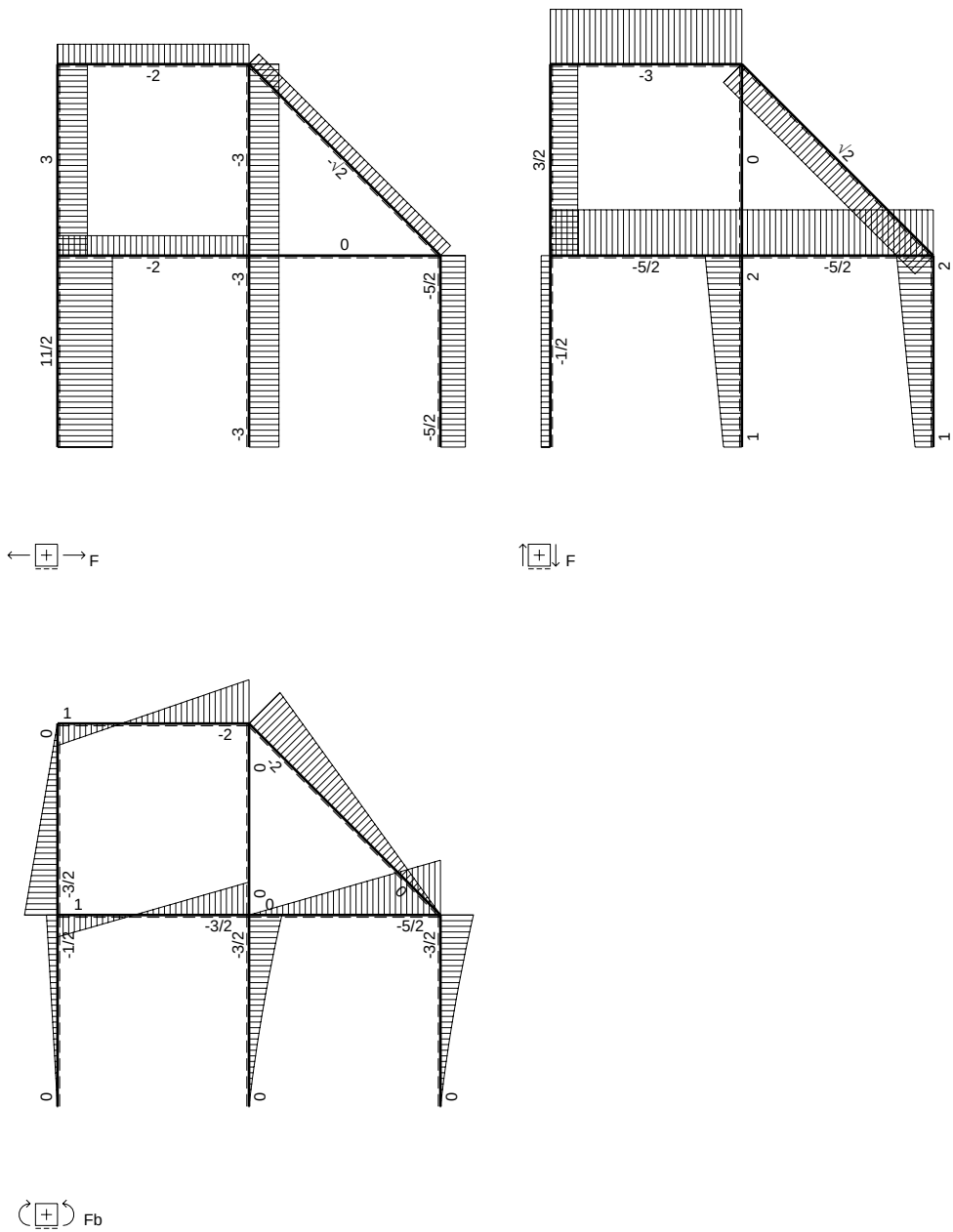
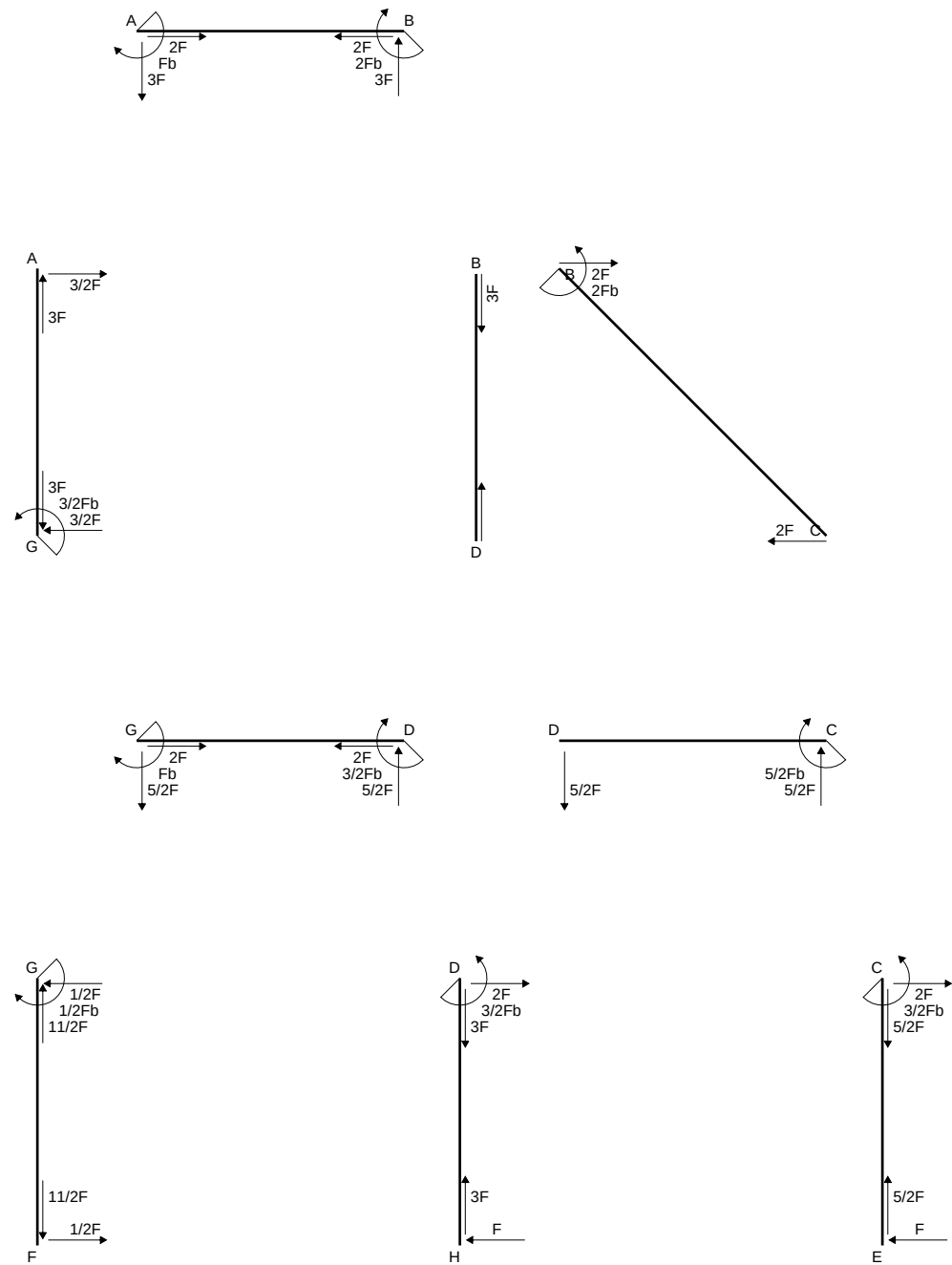
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$



$$\begin{aligned} A &= 1068. \text{ mm}^2 \\ J_u &= 324016. \text{ mm}^4 \\ J_v &= 104400. \text{ mm}^4 \\ y_g &= 32.16 \text{ mm} \\ T_y &= -2625. \text{ N} \\ M_x &= -2100000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.16 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -21.16 \text{ mm} \\ \sigma_c &= -Mv/J_u = -137.2 \text{ N/mm}^2 \\ \tau_c &= 3.794 \text{ N/mm}^2 \\ \sigma_\theta &= \sqrt{\sigma^2 + 3\tau^2} = 137.3 \text{ N/mm}^2 \\ S &= 5619. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

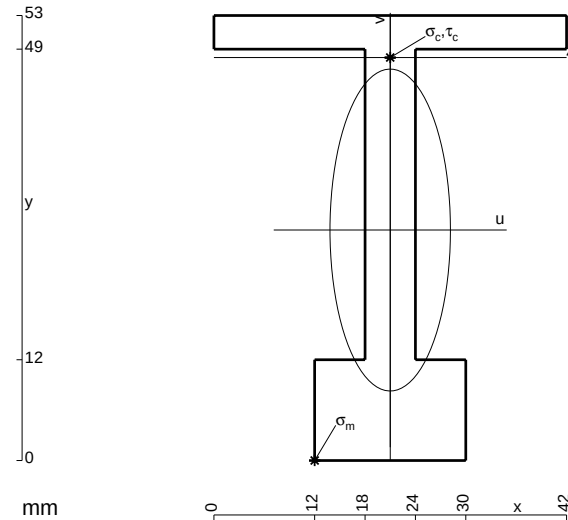
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

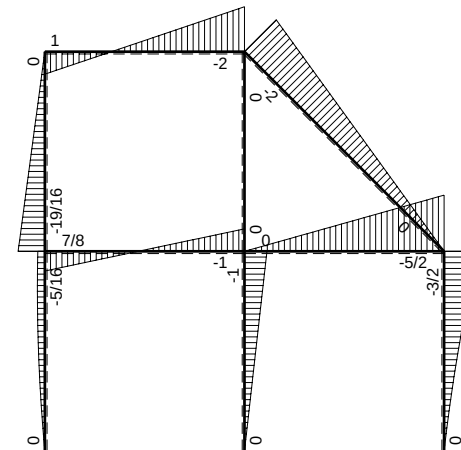
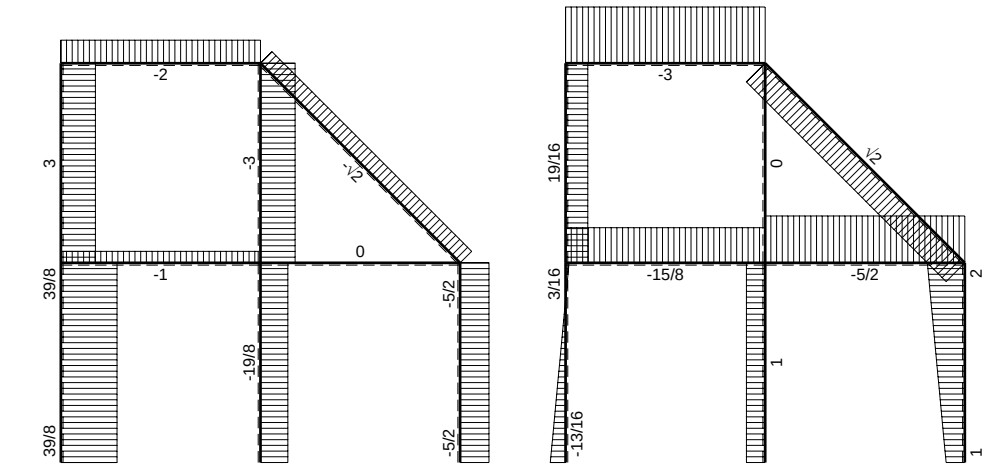
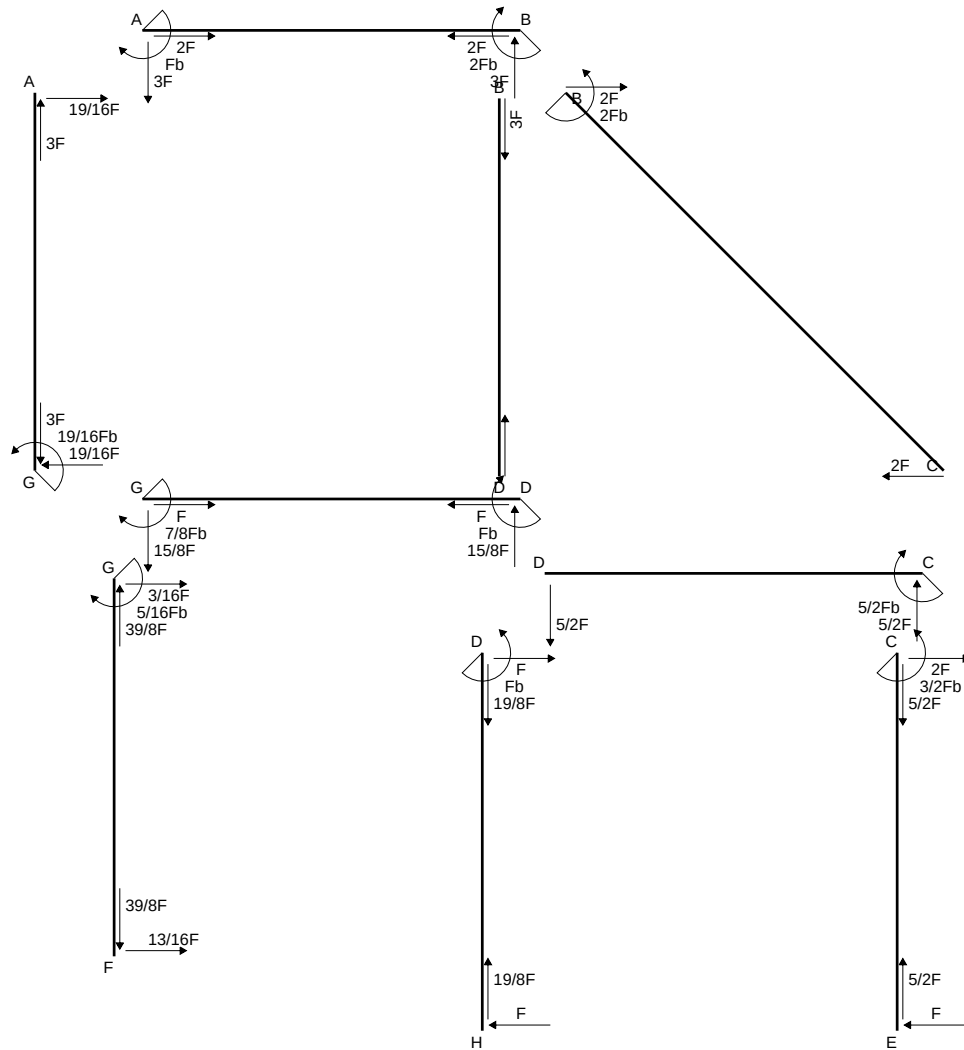
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



$$\begin{aligned} A &= 606. \text{ mm}^2 \\ J_u &= 222763. \text{ mm}^4 \\ J_v &= 31194. \text{ mm}^4 \\ y_g &= 27.45 \text{ mm} \\ T_y &= -2100. \text{ N} \\ M_x &= -1785000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -27.45 \text{ mm} \\ \sigma_m &= -Mv/J_u = -220. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 48. \text{ mm} \\ v_c &= 20.55 \text{ mm} \\ \sigma_c &= -Mv/J_u = 164.7 \text{ N/mm}^2 \\ \tau_c &= 6.415 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 165. \text{ N/mm}^2 \\ S^* &= 4083. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

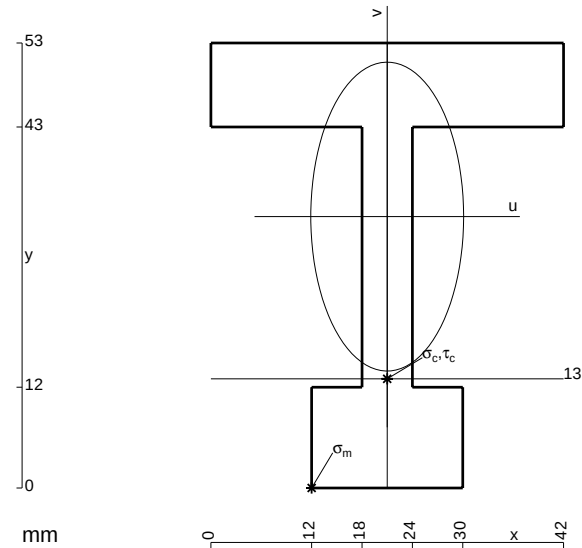
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

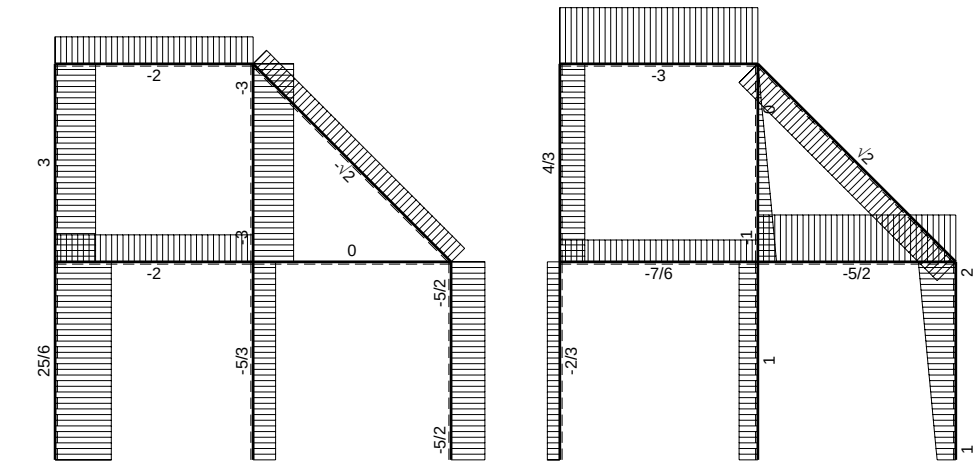
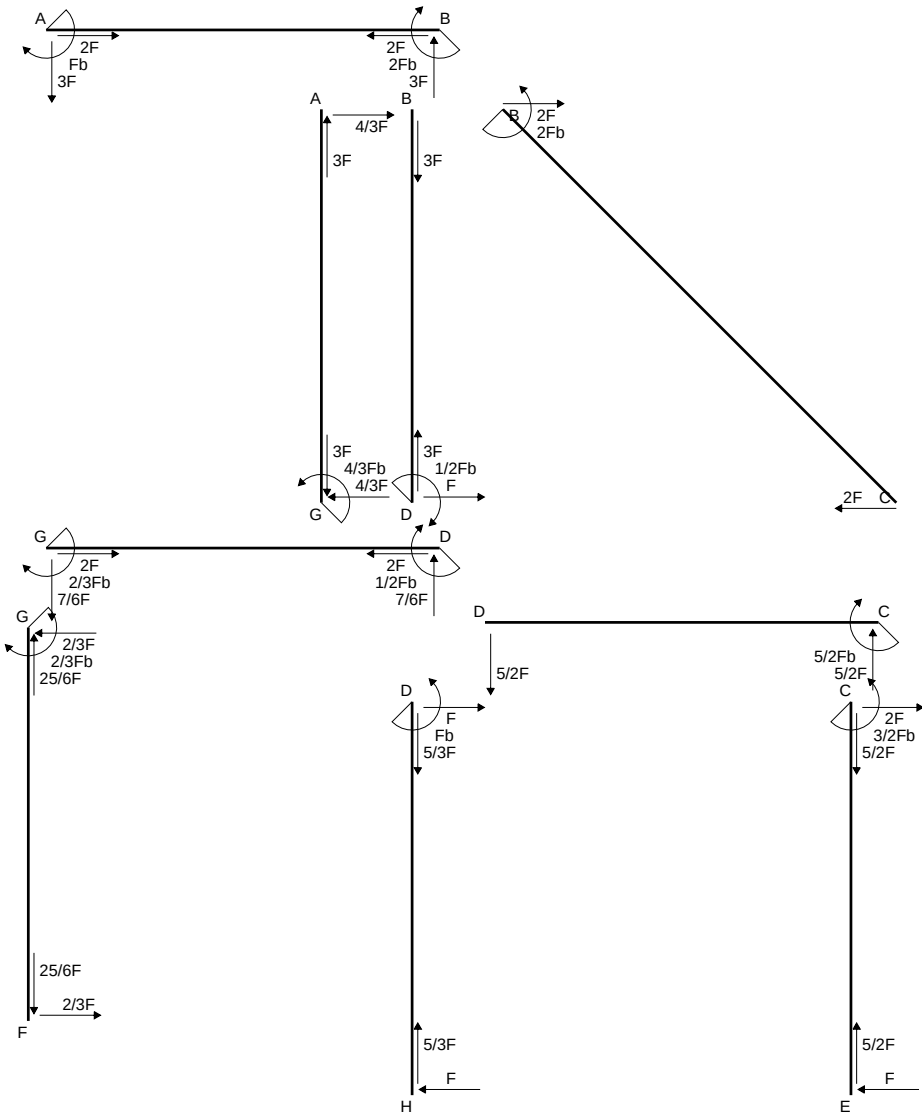
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

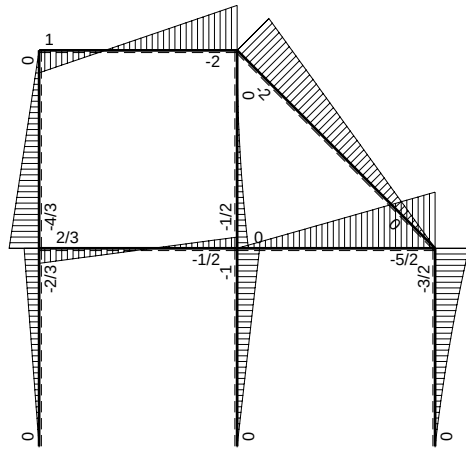


$$\begin{aligned} A &= 822. \text{ mm}^2 \\ J_u &= 278203. \text{ mm}^4 \\ J_v &= 68130. \text{ mm}^4 \\ y_g &= 32.32 \text{ mm} \\ T_y &= -2175. \text{ N} \\ M_x &= -1957500. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -32.32 \text{ mm} \\ \sigma_m &= -Mv/J_u = -227.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -19.32 \text{ mm} \\ \sigma_c &= -Mv/J_u = -136. \text{ N/mm}^2 \\ \tau_c &= 7.564 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 136.6 \text{ N/mm}^2 \\ S &= 5805. \text{ mm}^3 \end{aligned}$$

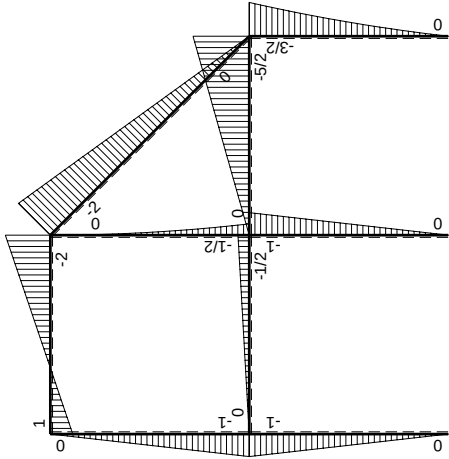
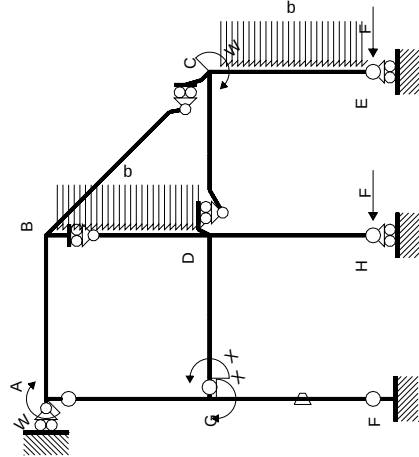


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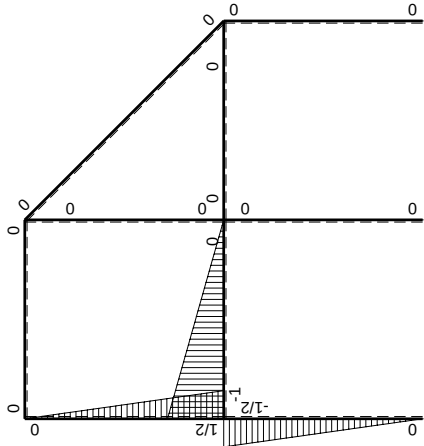


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Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-2/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

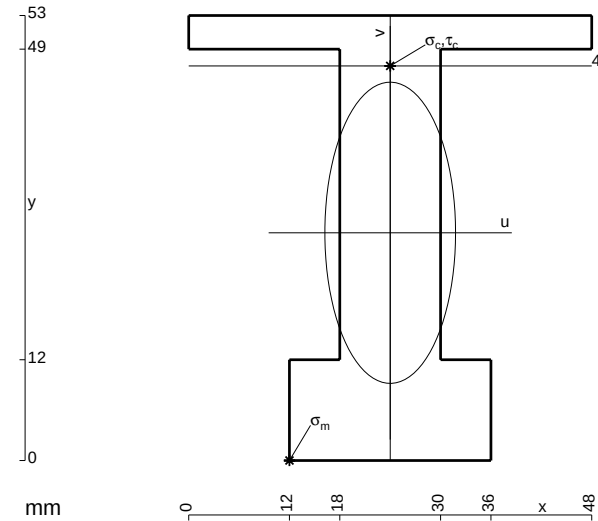
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

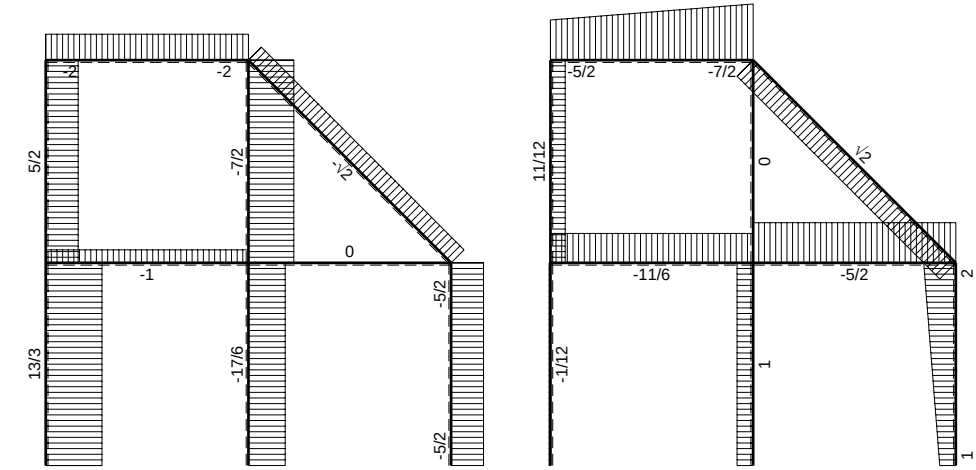
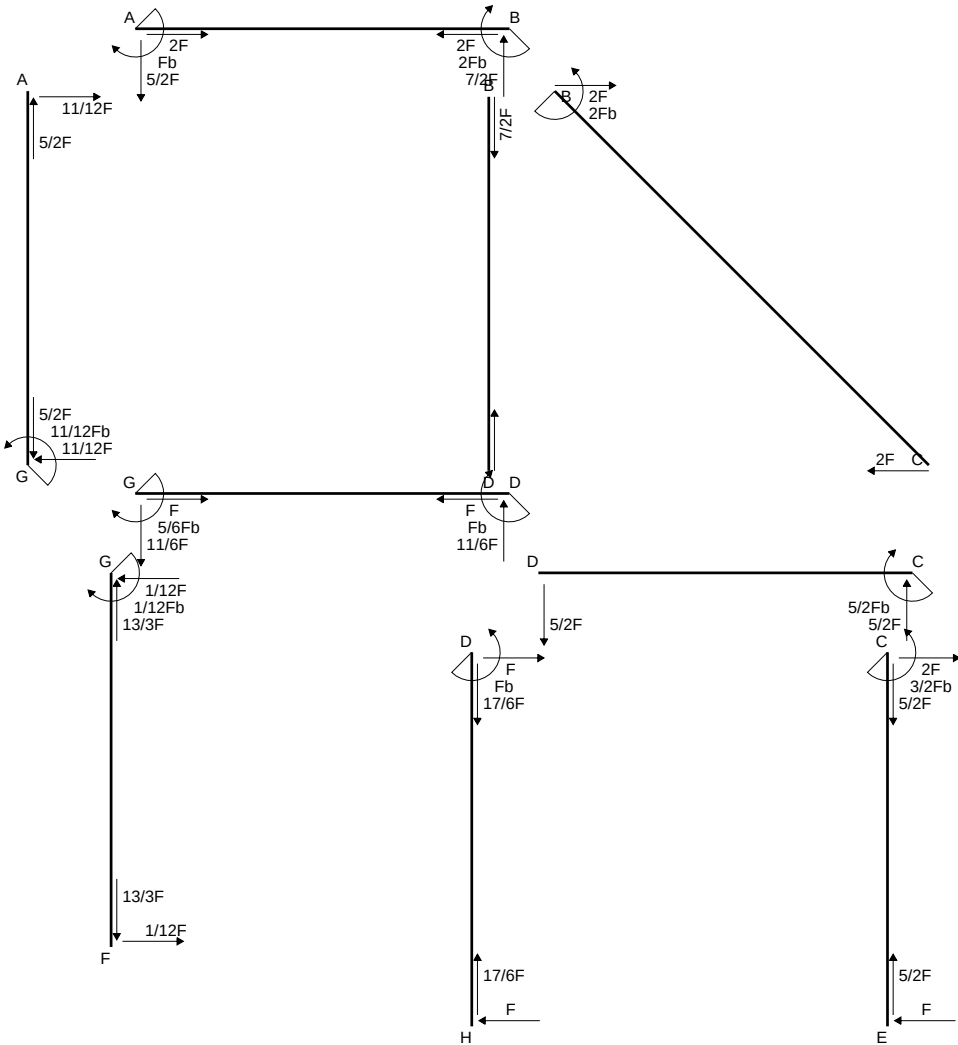
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

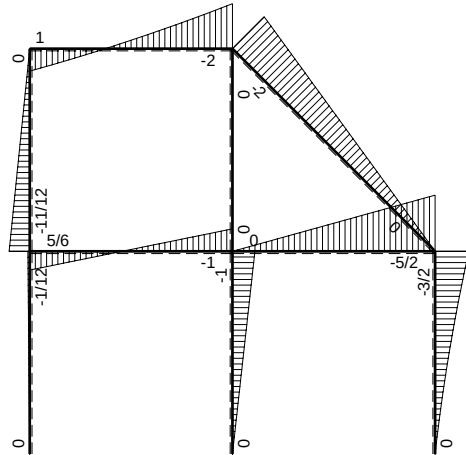


$$\begin{aligned} A &= 924. \text{ mm}^2 \\ J_u &= 297390. \text{ mm}^4 \\ J_v &= 56016. \text{ mm}^4 \\ y_g &= 27.12 \text{ mm} \\ T_y &= -2750. \text{ N} \\ M_x &= -2612500. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -27.12 \text{ mm} \\ \sigma_m &= -Mv/J_u = -238.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 47. \text{ mm} \\ v_c &= 19.88 \text{ mm} \\ \sigma_c &= -Mv/J_u = 174.6 \text{ N/mm}^2 \\ \tau_c &= 3.919 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 174.7 \text{ N/mm}^2 \\ S &= 5085. \text{ mm}^3 \end{aligned}$$

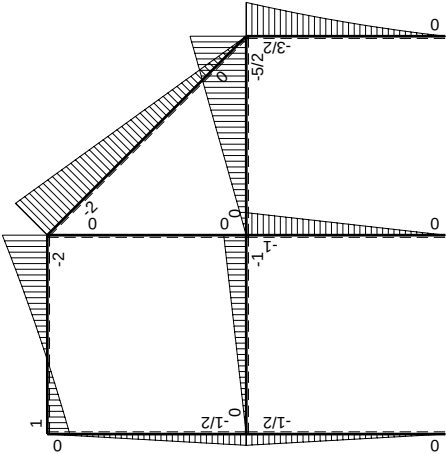
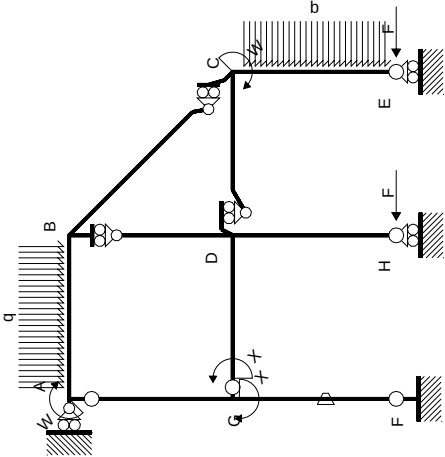


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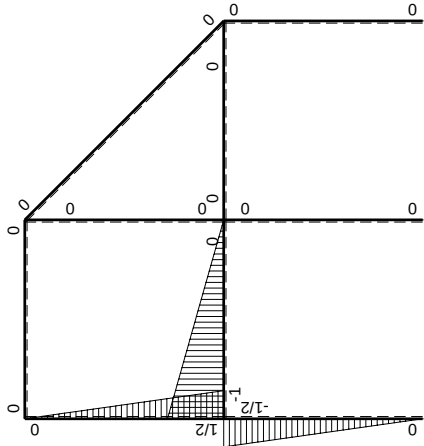


⊕ ⊖ F_b



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$2Fb-7/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

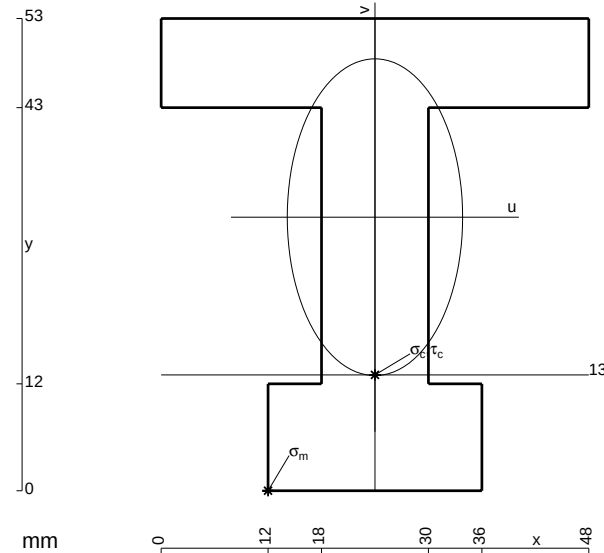
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

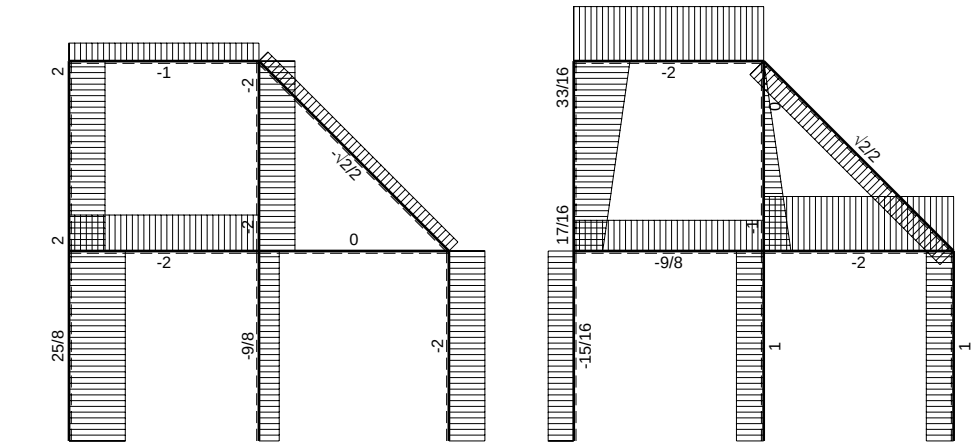
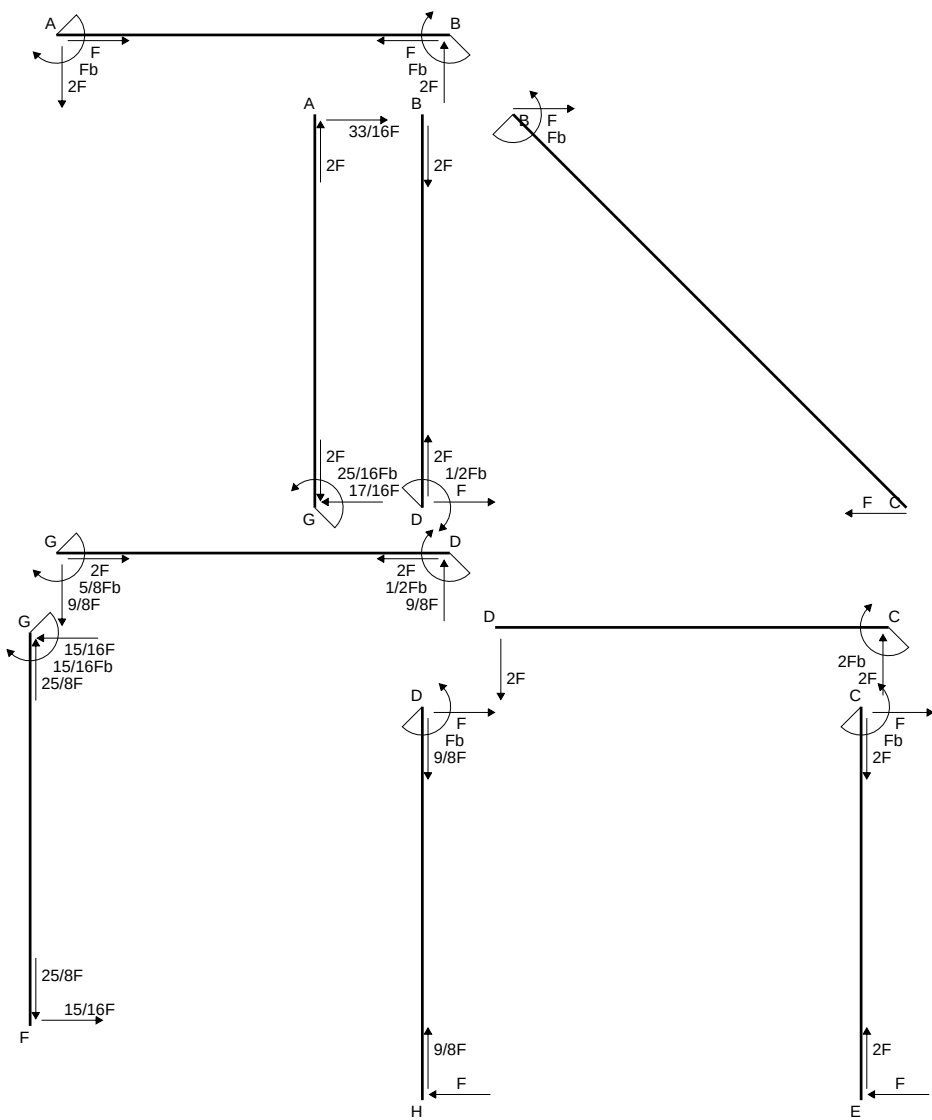
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

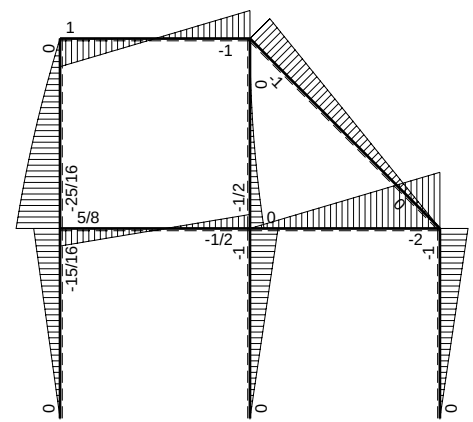


$$\begin{aligned} A &= 1140. \text{ mm}^2 \\ J_u &= 360421. \text{ mm}^4 \\ J_v &= 110448. \text{ mm}^4 \\ y_g &= 30.7 \text{ mm} \\ N &= -4600. \text{ N} \\ T_y &= -8050. \text{ N} \\ M_x &= -2300000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.7 \text{ mm} \\ \sigma_m &= N/A - Mv/J_u = -199.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.7 \text{ mm} \\ \sigma_c &= N/A - Mv/J_u = -117. \text{ N/mm}^2 \\ \tau_c &= 13.65 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 119.3 \text{ N/mm}^2 \\ S &= 7332. \text{ mm}^3 \end{aligned}$$

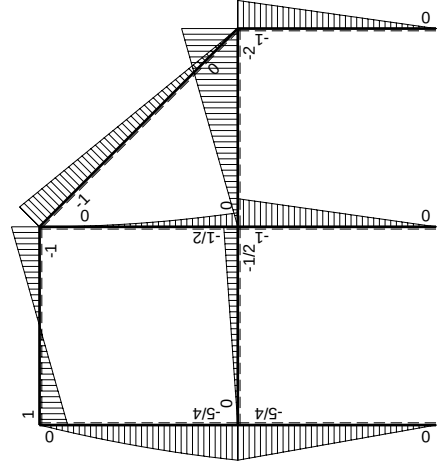
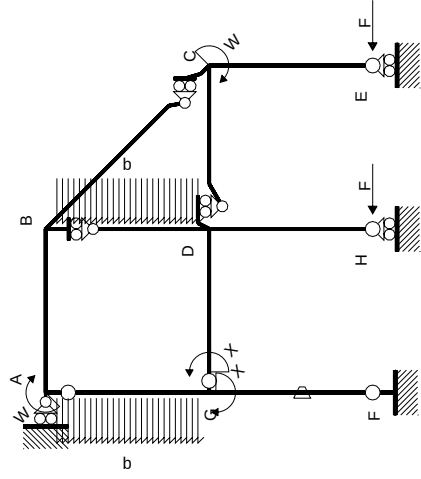


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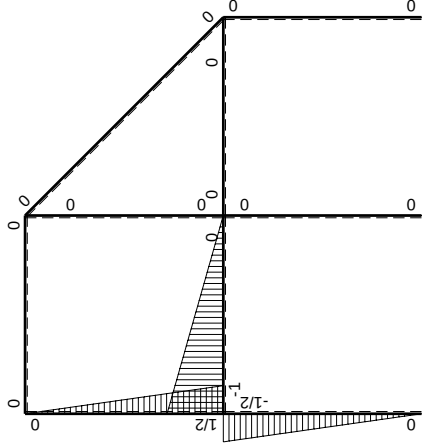


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx$	$-Fb/EJ$	$5/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(5/24+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-5/4Fx$	Fb/EJ	$5/8Fb-5/4Fx+5/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-5/4Fb+3/4Fx+1/2qx^2$	0	$-5/8Fb+Fx-1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-11/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$7/4Fx-1/2qx^2$	0	$-7/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$5/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

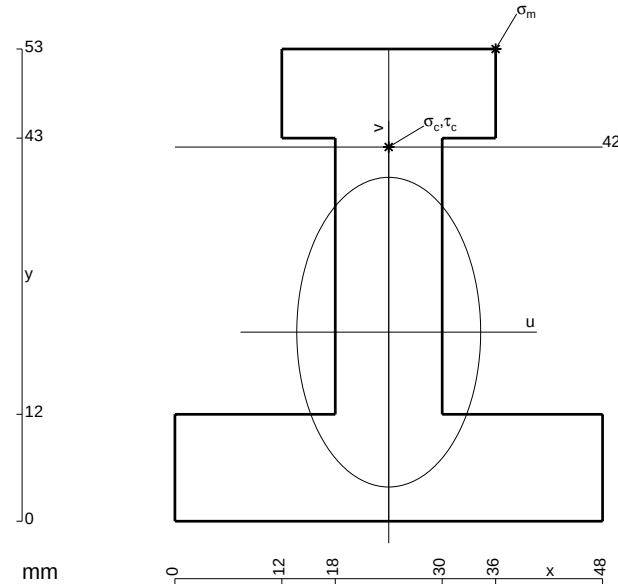
$$L_{GA}^{xo} = \int_0^b \left(-\frac{5}{8} + x/b - \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{5}{8} x + \frac{1}{2} x^2/b - \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

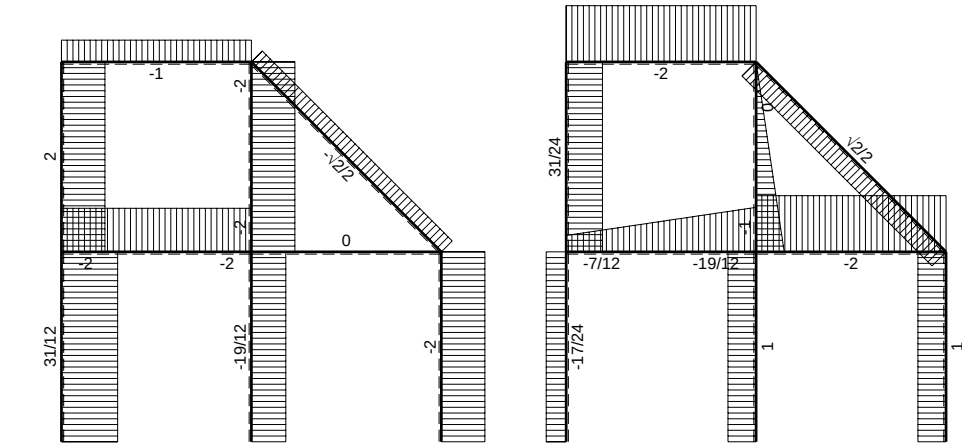
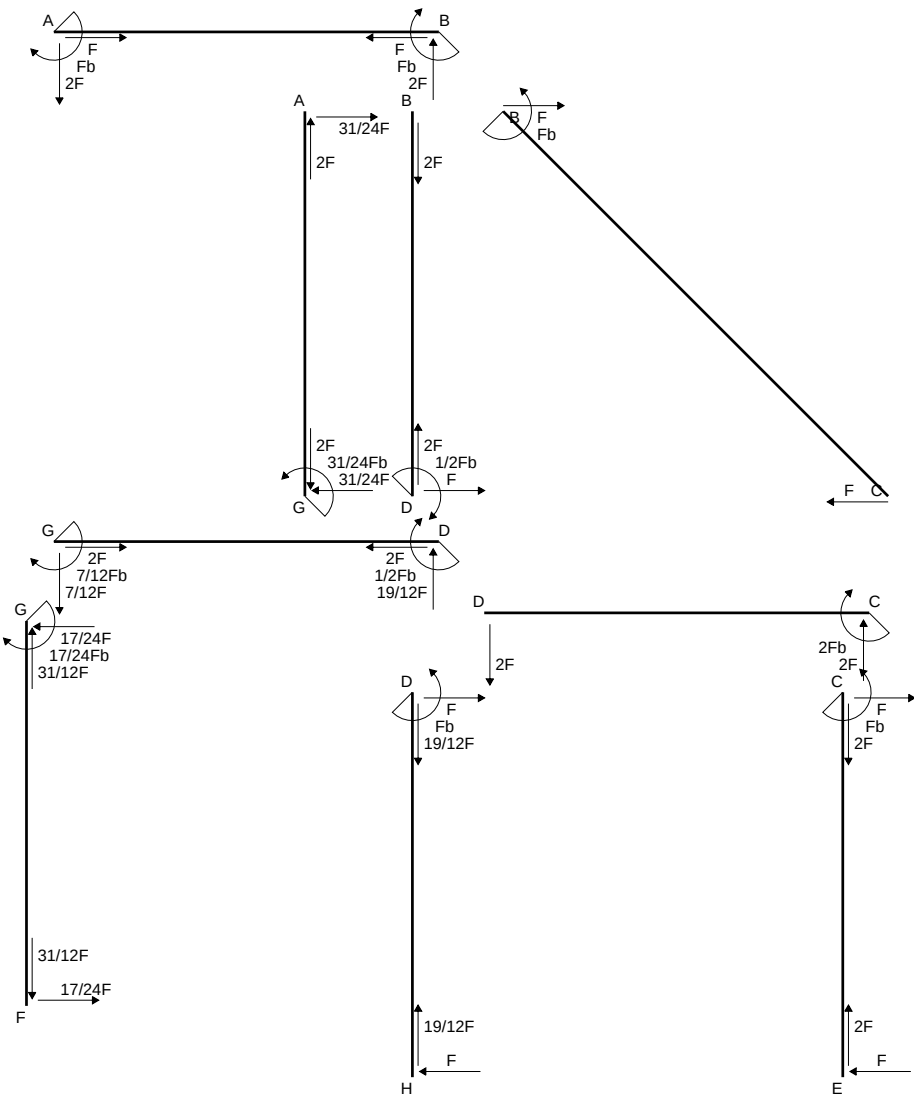
$$= \left(-\frac{5}{8} b + \frac{1}{2} b - \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{11}{48} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{7}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{7}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{7}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{11}{48} Fb^2/EJ$$

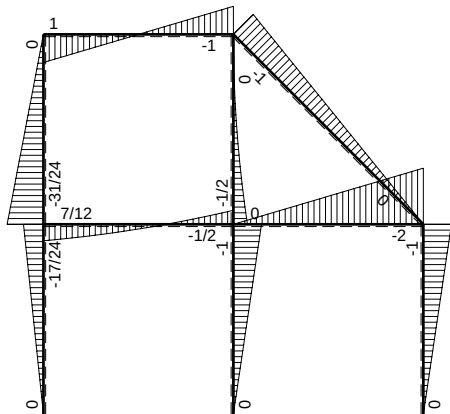


$$\begin{aligned} A &= 1188. \text{ mm}^2 \\ J_u &= 358924. \text{ mm}^4 \\ J_v &= 126576. \text{ mm}^4 \\ y_g &= 21.22 \text{ mm} \\ T_y &= -4300. \text{ N} \\ M_x &= -2365000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.78 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 20.78 \text{ mm} \\ \sigma_c &= -Mv/J_u = 136.9 \text{ N/mm}^2 \\ \tau_c &= 6.672 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 137.4 \text{ N/mm}^2 \\ S &= 6683. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2qx^2$	0	$1/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-Fx+1/2qx^2$	0	$1/2Fx-Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{6} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{1}{2} x/b - x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{3} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

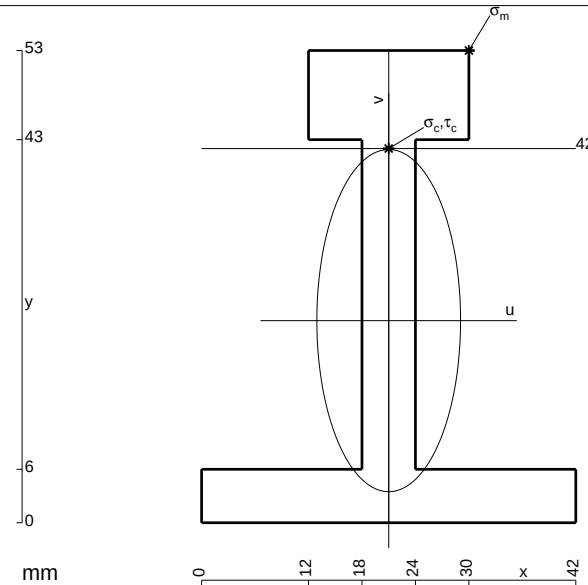
$$= \left(\frac{1}{4} b - \frac{1}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

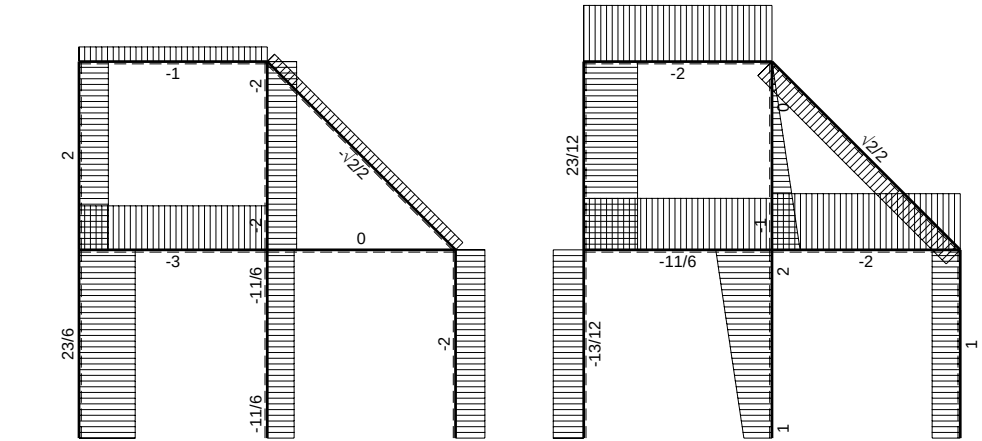
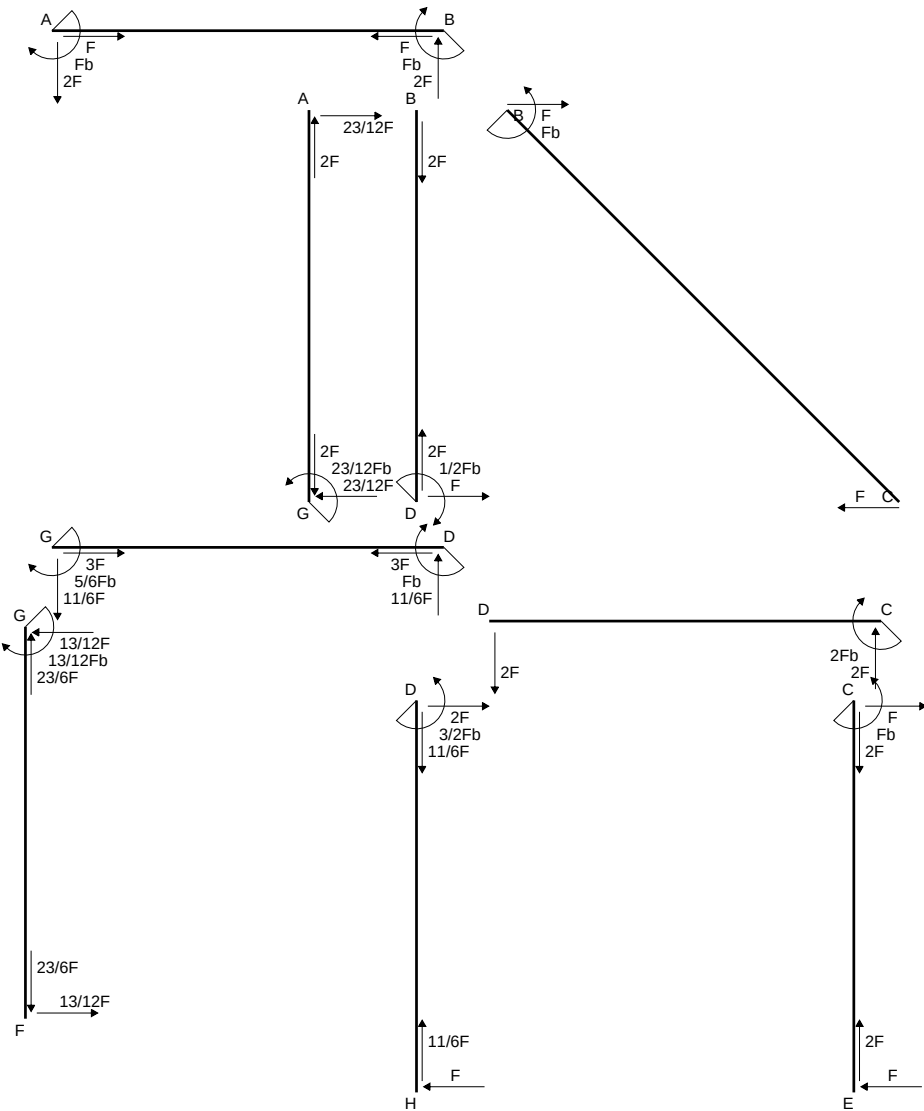
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

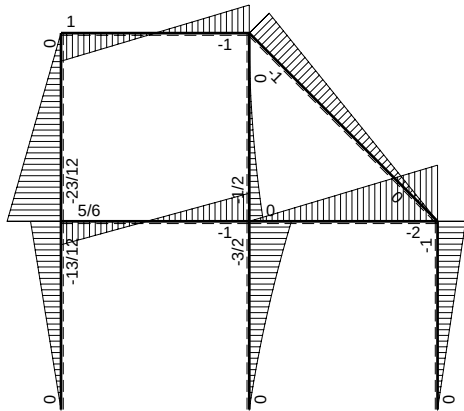


$$\begin{aligned} A &= 654. \text{ mm}^2 \\ J_u &= 241316. \text{ mm}^4 \\ J_v &= 42570. \text{ mm}^4 \\ y_g &= 22.68 \text{ mm} \\ T_y &= -2900. \text{ N} \\ M_x &= -1740000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 30.32 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.6 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 19.32 \text{ mm} \\ \sigma_c &= -Mv/J_u = 139.3 \text{ N/mm}^2 \\ \tau_c &= 9.365 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 140.2 \text{ N/mm}^2 \\ S &= 4676. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/2Fb-3/2Fx$	Fb/EJ	$3/4Fb-3/2Fx+3/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/2Fb+3/2Fx$	0	$-3/4Fb+3/2Fx-3/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/2Fx$	0	$-3/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{2} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{4} b - \frac{3}{4} b + \frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{2} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

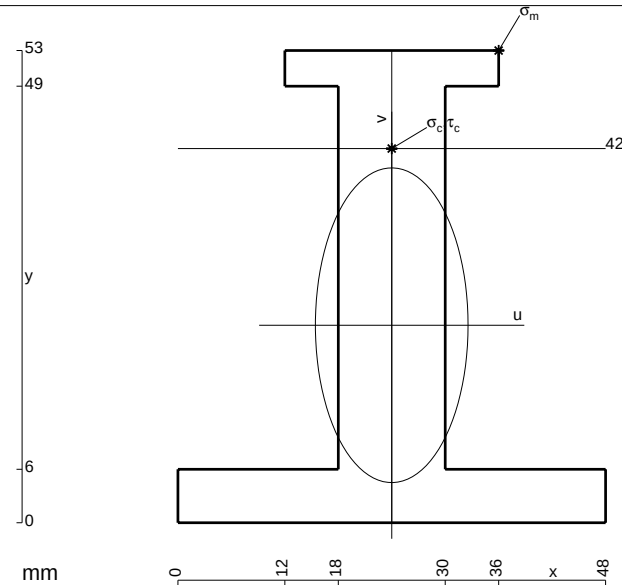
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{4} + \frac{3}{2} x/b - \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{4} x + \frac{3}{4} x^2/b - \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

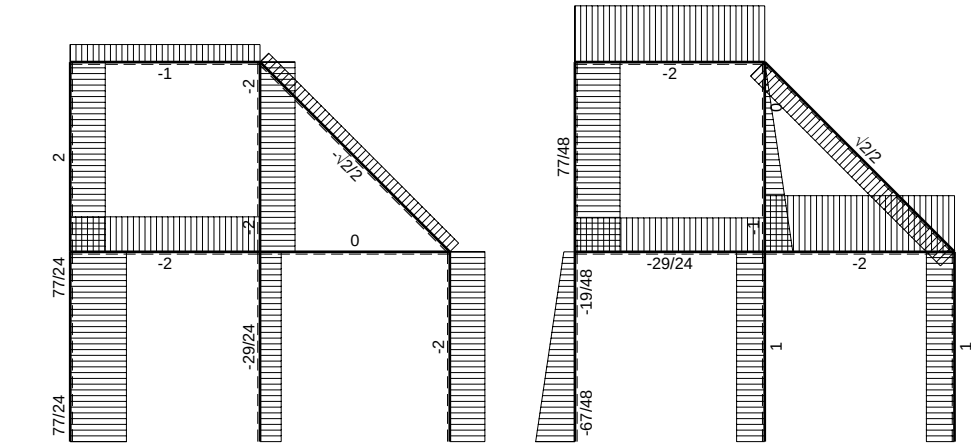
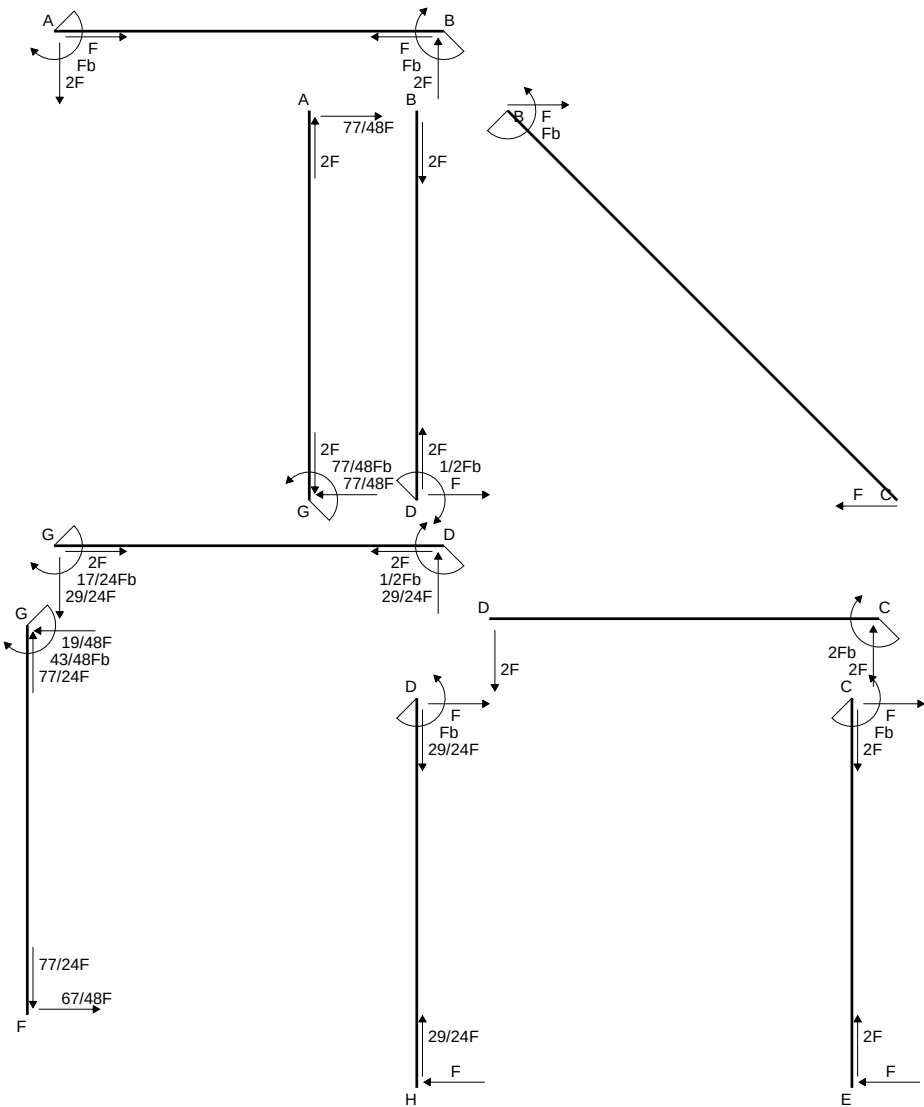
$$= \left(-\frac{3}{4} b + \frac{3}{4} b - \frac{1}{4} b \right) Fb \frac{1}{EJ} = -\frac{1}{4} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{4} b \right) Fb \frac{1}{EJ} = -\frac{1}{4} Fb^2/EJ$$

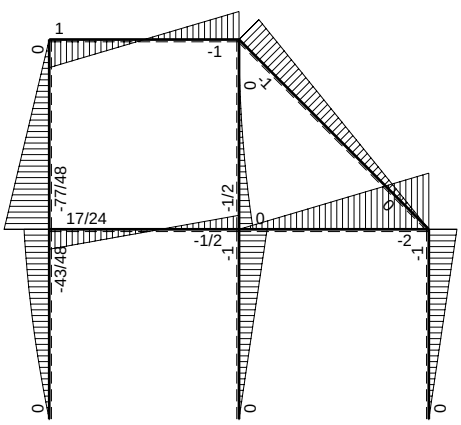


$$\begin{aligned} A &= 900. \text{ mm}^2 \\ J_u &= 280787. \text{ mm}^4 \\ J_v &= 66096. \text{ mm}^4 \\ y_g &= 22.17 \text{ mm} \\ T_y &= -3220. \text{ N} \\ M_x &= -2093000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.83 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 19.83 \text{ mm} \\ \sigma_c &= -Mv/J_u = 147.8 \text{ N/mm}^2 \\ \tau_c &= 4.518 \text{ N/mm}^2 \\ \sigma_\varphi &= \sqrt{\sigma^2 + 3\tau^2} = 148. \text{ N/mm}^2 \\ S &= 4728. \text{ mm}^3 \end{aligned}$$

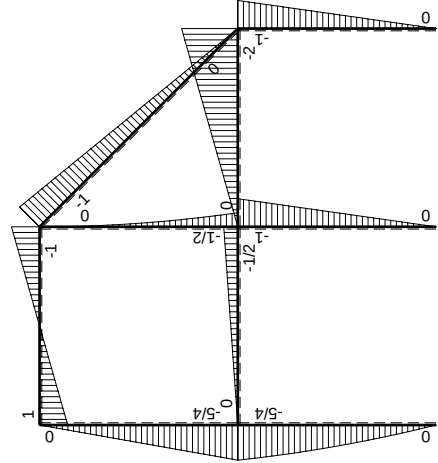
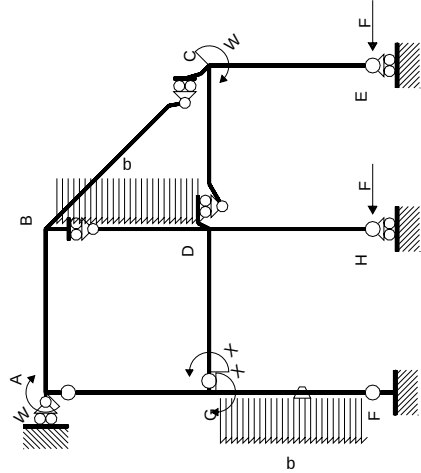


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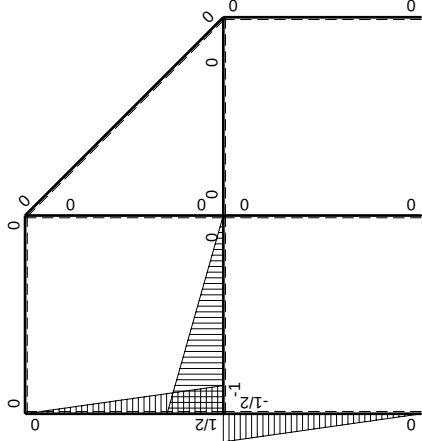


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-7/4Fx+1/2qx^2$	$-Fb/EJ$	$7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(11/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$5/8Fb-Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-5/4Fb+5/4Fx$	0	$-5/8Fb+5/4Fx-5/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-5/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx$	0	$-5/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$17/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-17/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

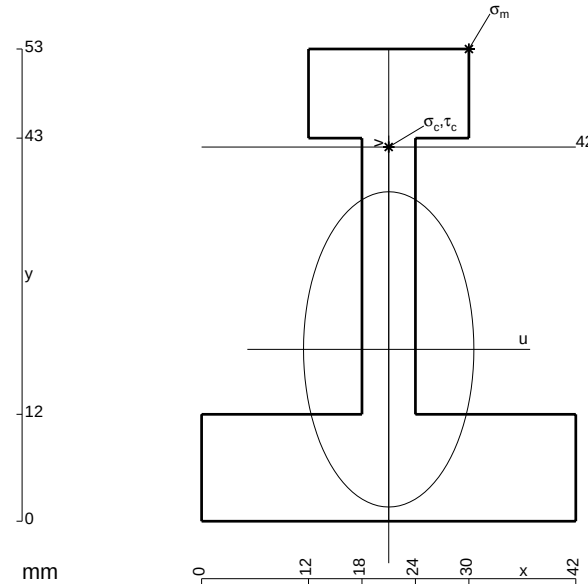
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{5}{8} + \frac{5}{4} x/b - \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{8} x + \frac{5}{8} x^2/b - \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

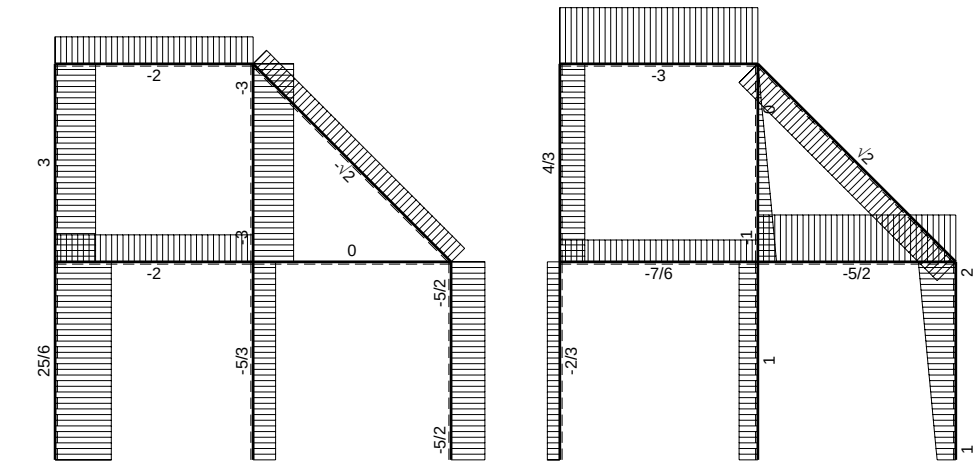
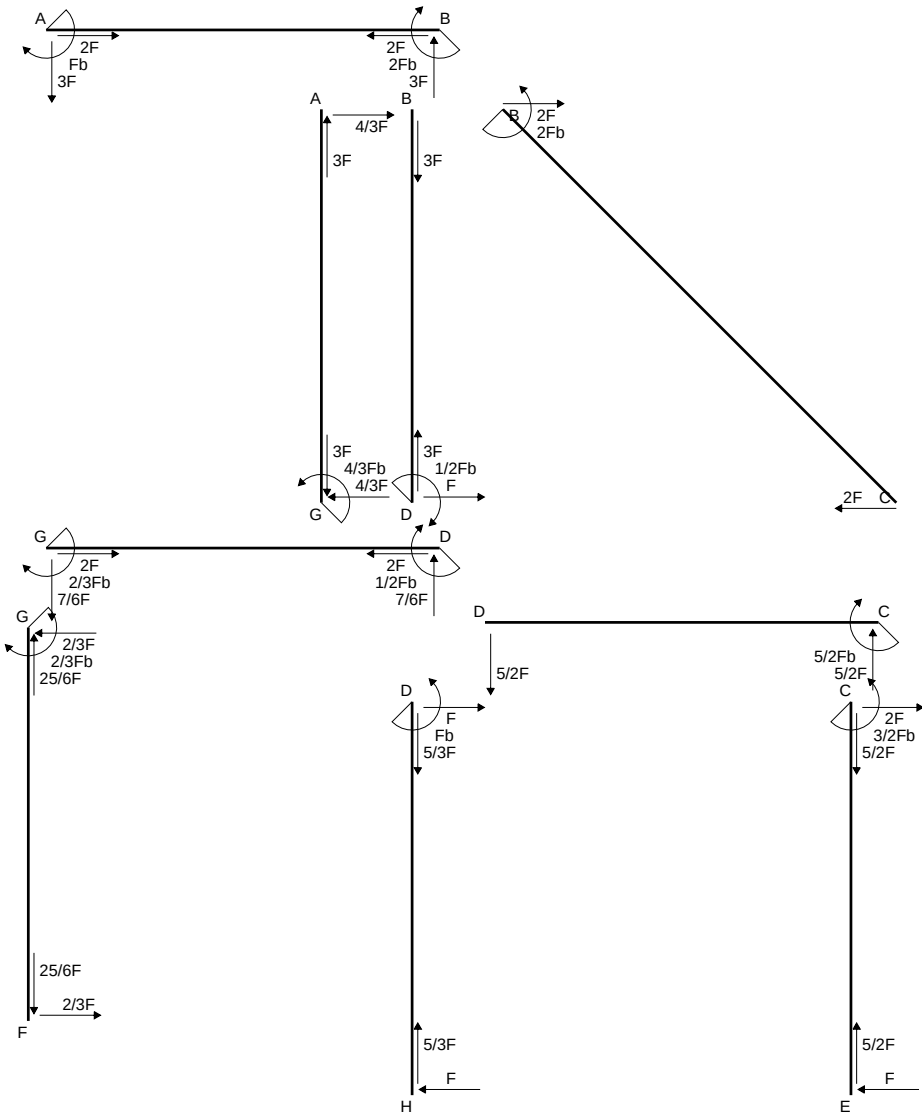
$$= \left(-\frac{5}{8} b + \frac{5}{8} b - \frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$

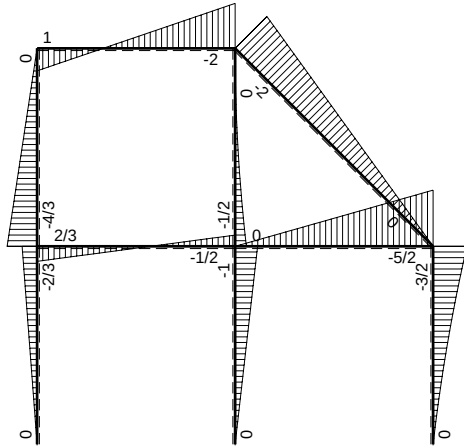


$$\begin{aligned} A &= 870. \text{ mm}^2 \\ J_u &= 272367. \text{ mm}^4 \\ J_v &= 79506. \text{ mm}^4 \\ y_g &= 19.29 \text{ mm} \\ T_y &= -2760. \text{ N} \\ M_x &= -1932000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.71 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.1 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 22.71 \text{ mm} \\ \sigma_c &= -Mv/J_u = 161.1 \text{ N/mm}^2 \\ \tau_c &= 8.964 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 161.9 \text{ N/mm}^2 \\ S &= 5308. \text{ mm}^3 \end{aligned}$$

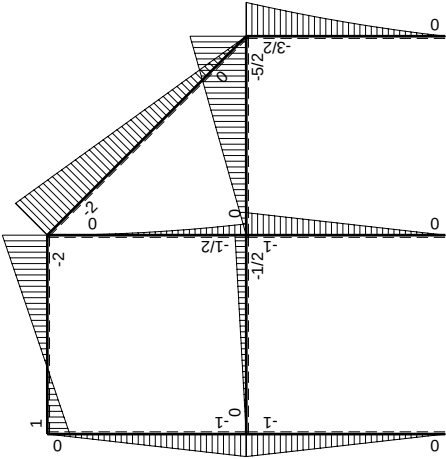
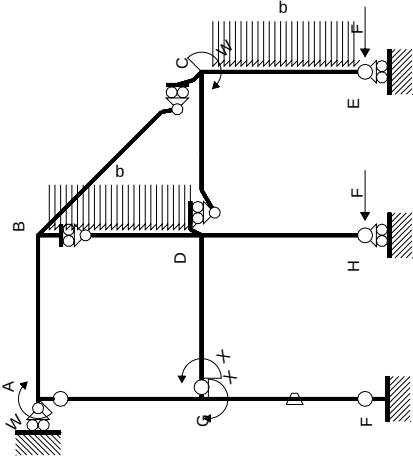


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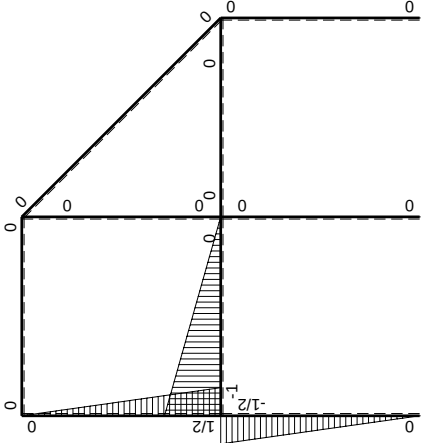


⊕ ⊕ F_b



Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-2/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

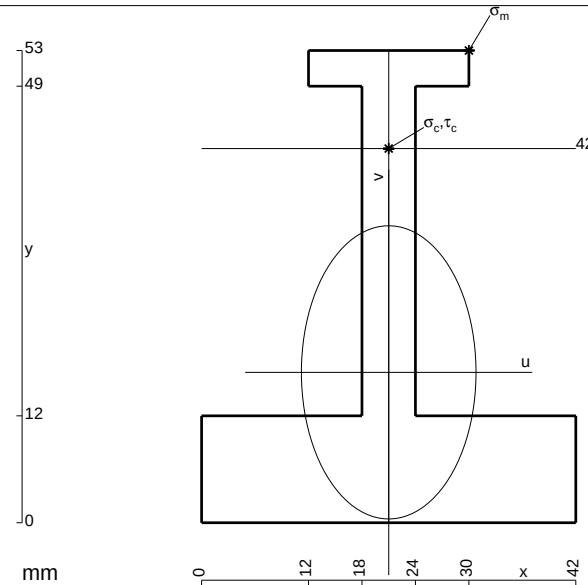
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

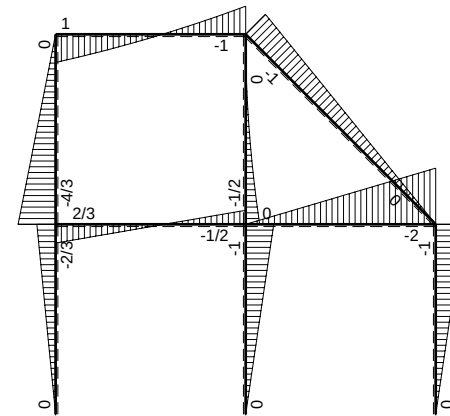
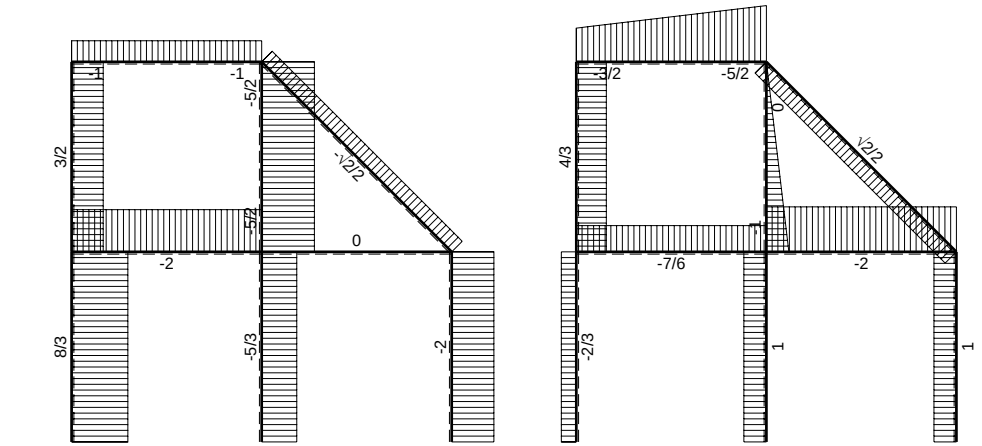
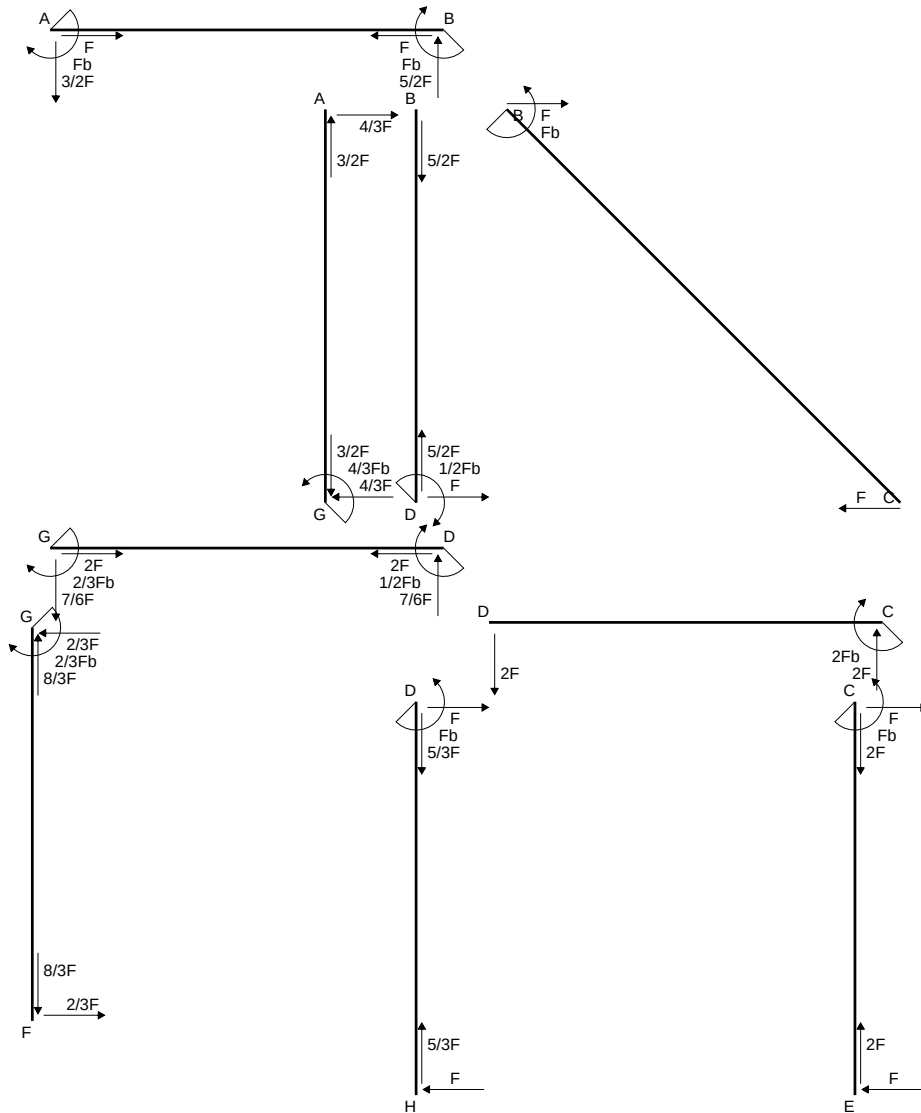
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



$$\begin{aligned} A &= 798. \text{ mm}^2 \\ J_u &= 216134. \text{ mm}^4 \\ J_v &= 76698. \text{ mm}^4 \\ y_g &= 16.88 \text{ mm} \\ T_y &= -1575. \text{ N} \\ M_x &= -1181250. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 36.12 \text{ mm} \\ \sigma_m &= -Mv/J_u = 197.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 25.12 \text{ mm} \\ \sigma_c &= -Mv/J_u = 137.3 \text{ N/mm}^2 \\ \tau_c &= 4.444 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 137.5 \text{ N/mm}^2 \\ S &= 3659. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$Fb-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-2/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

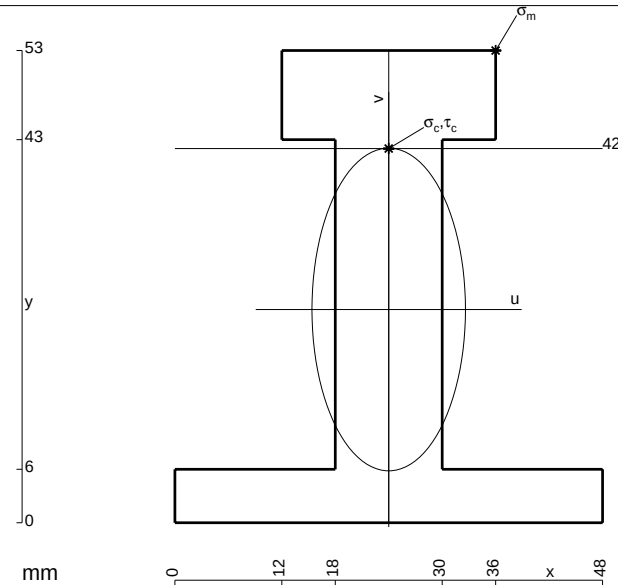
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

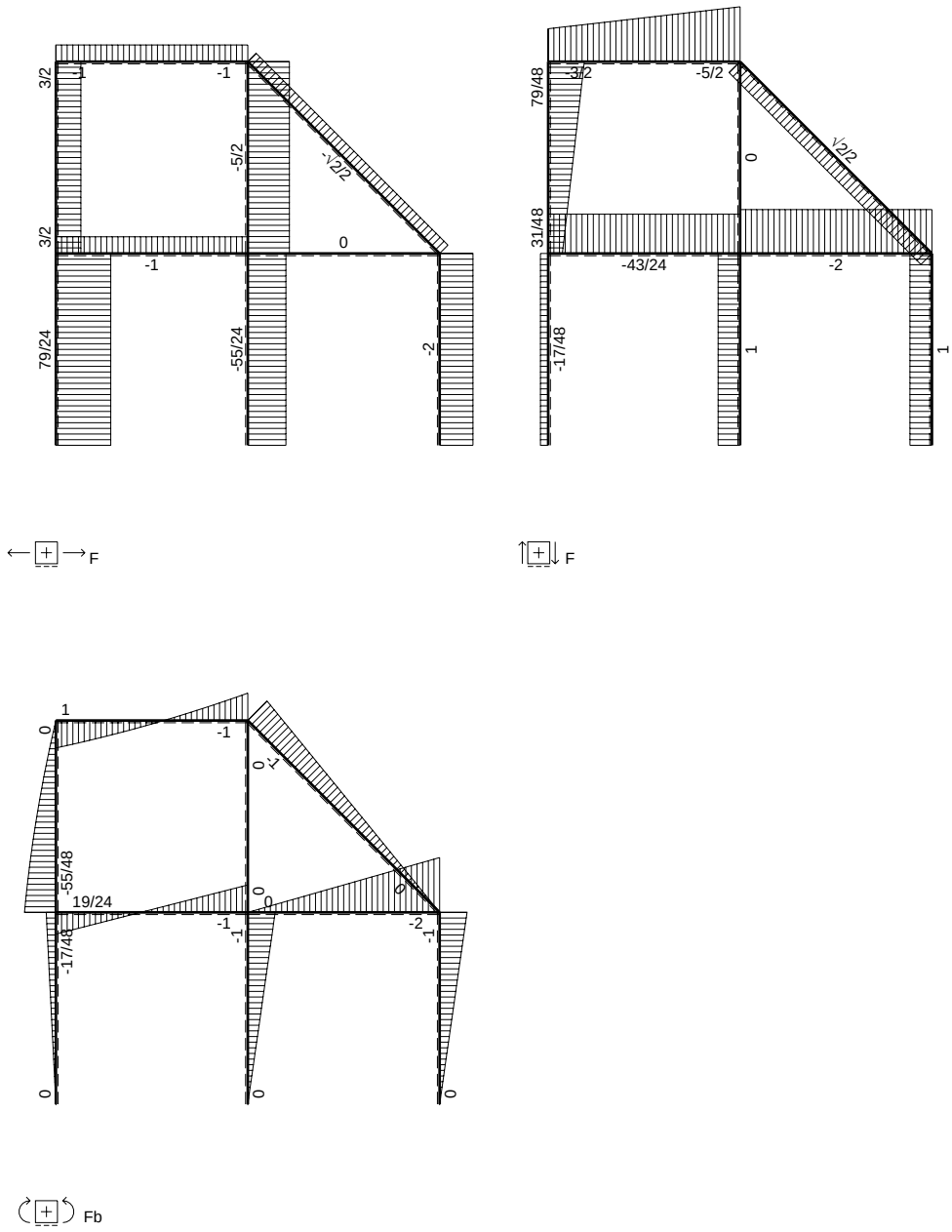
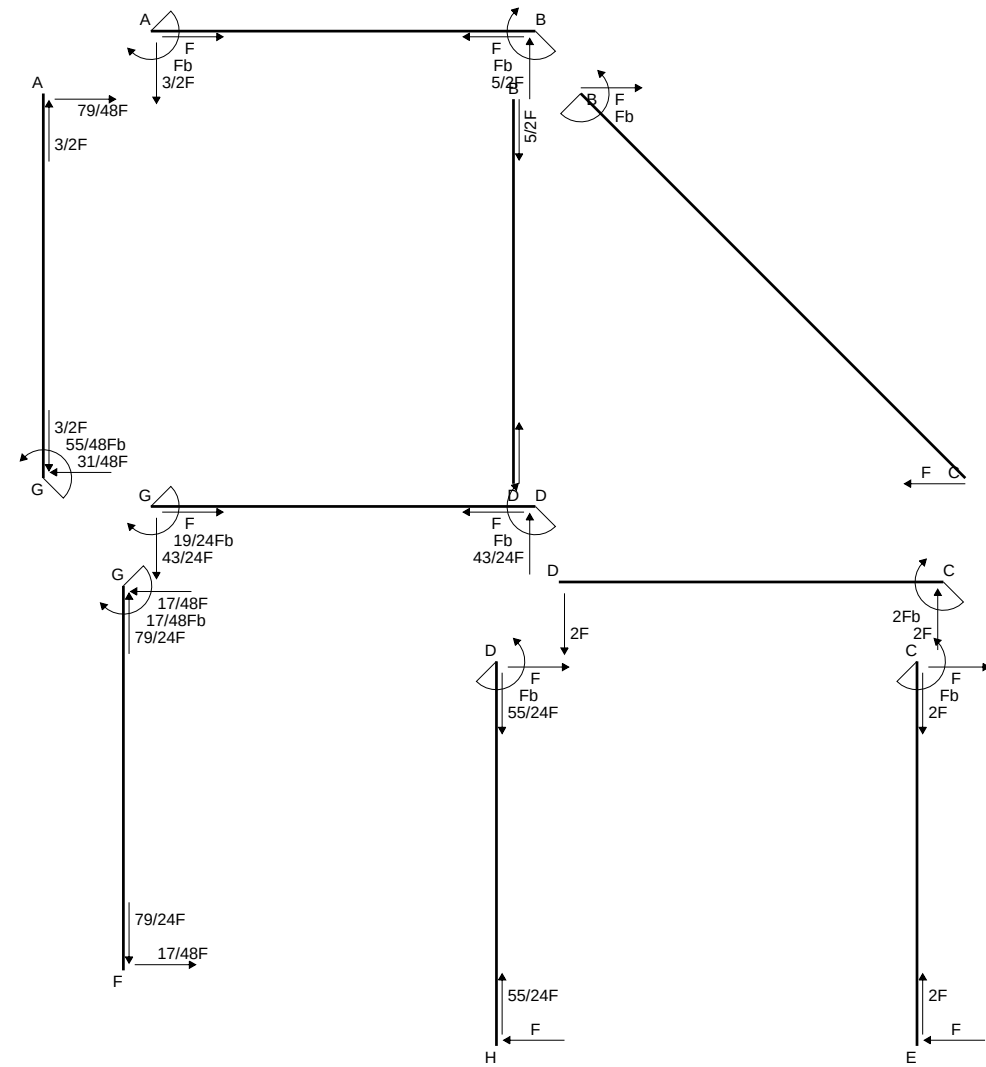
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



$$\begin{aligned} A &= 972. \text{ mm}^2 \\ J_u &= 318872. \text{ mm}^4 \\ J_v &= 72144. \text{ mm}^4 \\ y_g &= 23.93 \text{ mm} \\ T_y &= -2860. \text{ N} \\ M_x &= -2288000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.07 \text{ mm} \\ \sigma_m &= -Mv/J_u = 208.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 18.07 \text{ mm} \\ \sigma_c &= -Mv/J_u = 129.6 \text{ N/mm}^2 \\ \tau_c &= 4.484 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 129.9 \text{ N/mm}^2 \\ S &= 5999. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/4Fx$	$-Fb/EJ$	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$19/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-19/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

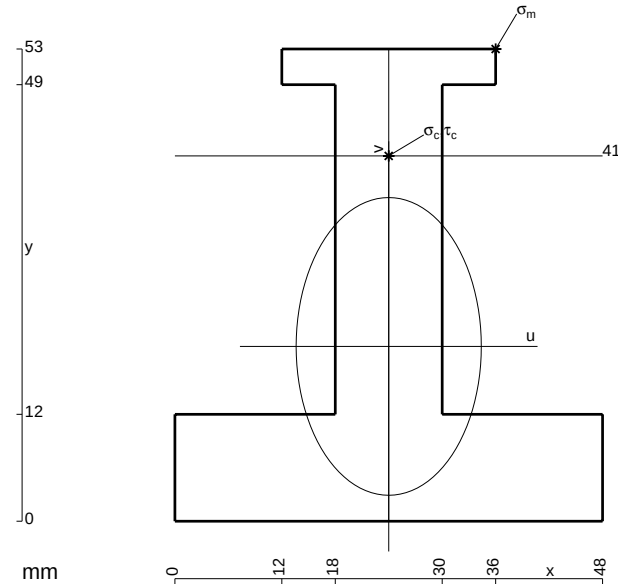
$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

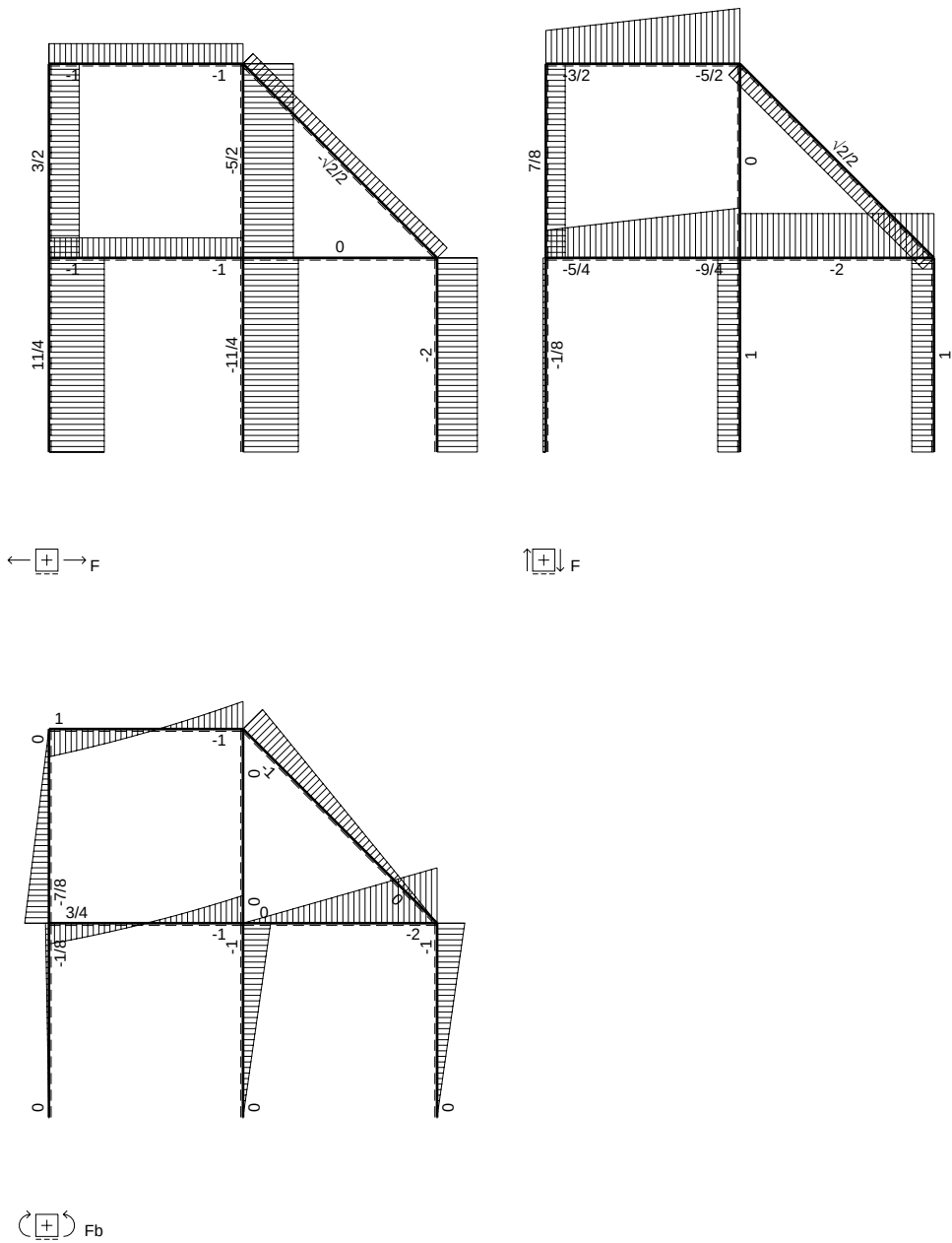
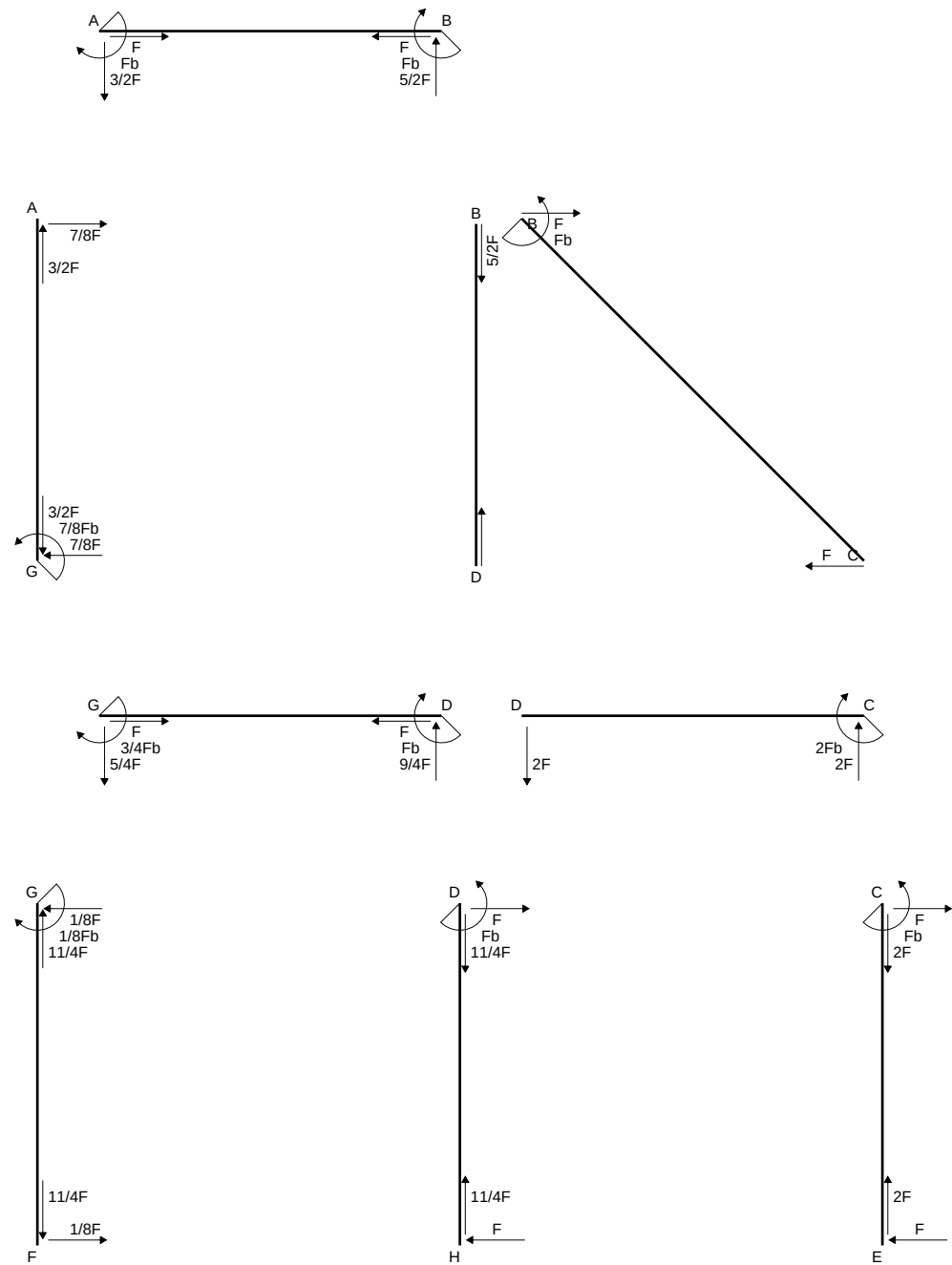
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

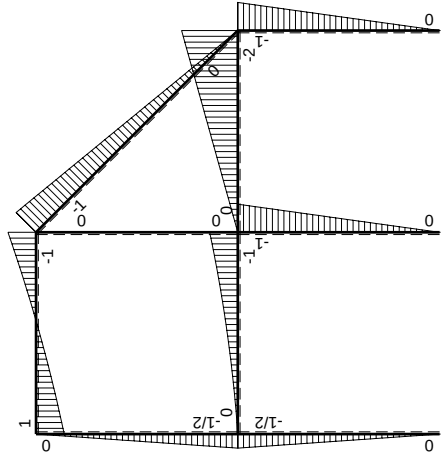
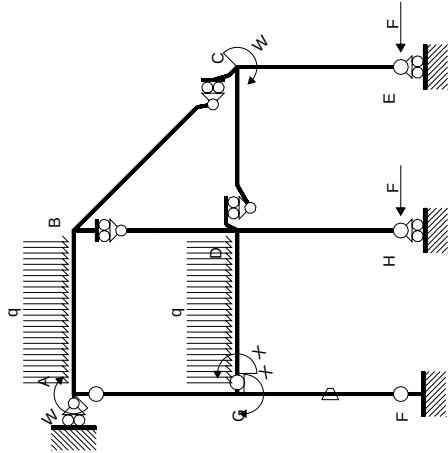
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



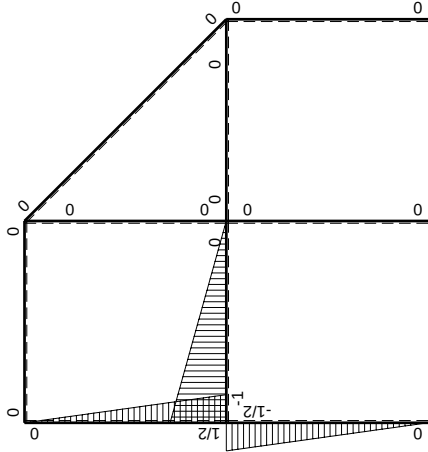
$$\begin{aligned} A &= 1116. \text{ mm}^2 \\ J_u &= 311633. \text{ mm}^4 \\ J_v &= 120528. \text{ mm}^4 \\ y_g &= 19.62 \text{ mm} \\ T_y &= -2400. \text{ N} \\ M_x &= -2040000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 33.38 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 21.38 \text{ mm} \\ \sigma_c &= -Mv/J_u = 140. \text{ N/mm}^2 \\ \tau_c &= 3.497 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 140.1 \text{ N/mm}^2 \\ S &= 5449. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$3/8Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-3/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

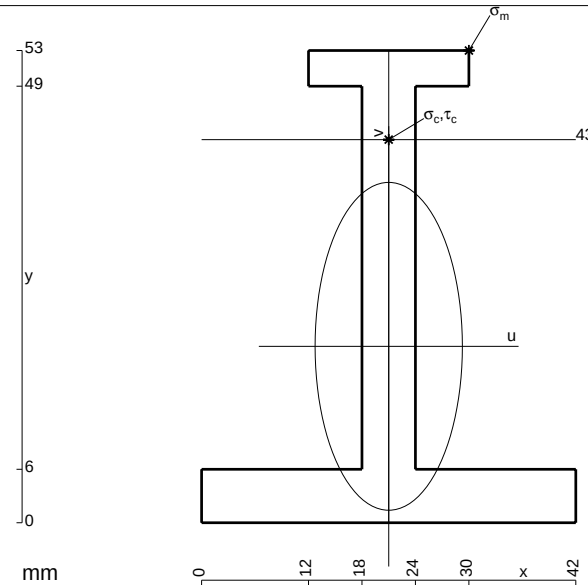
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

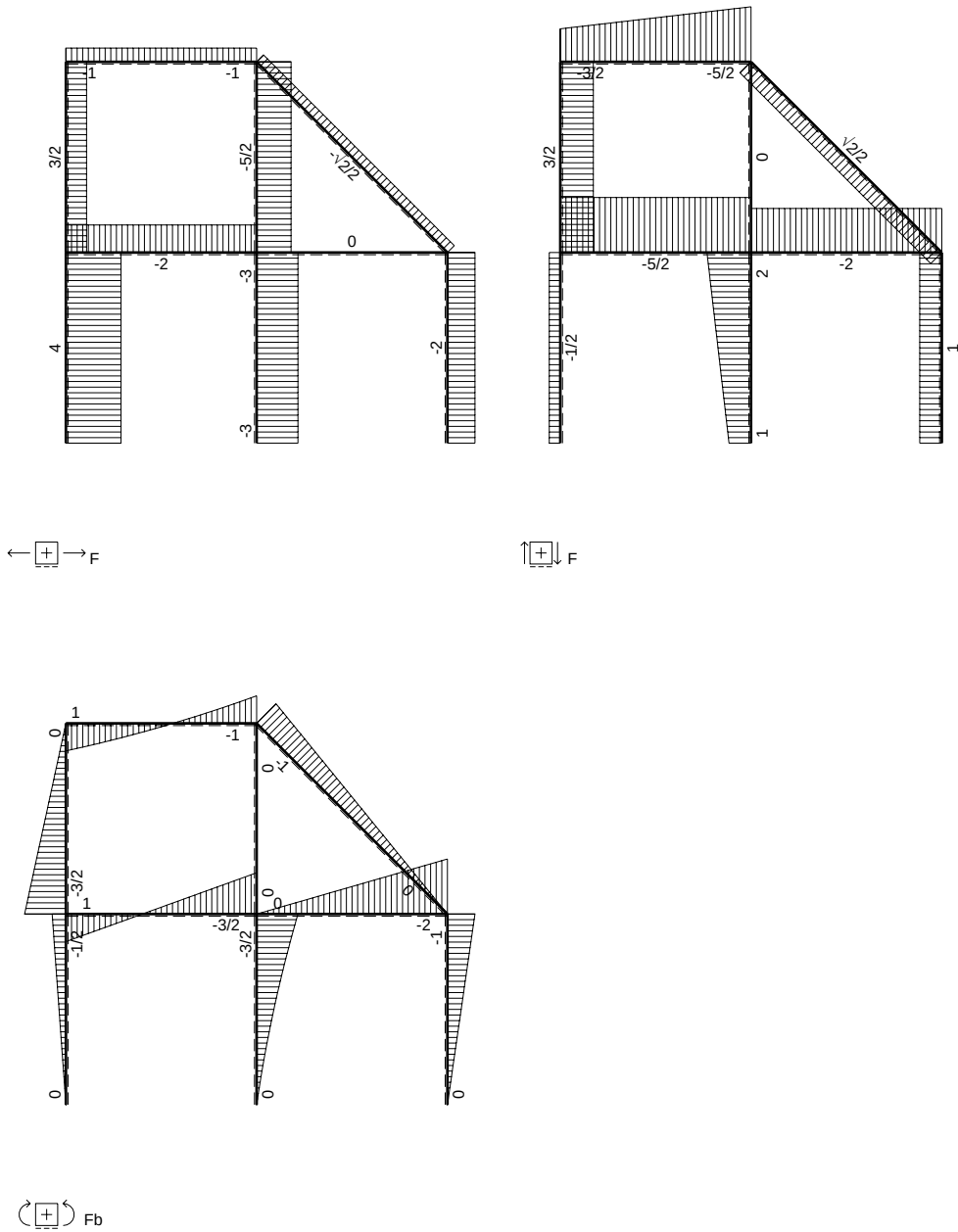
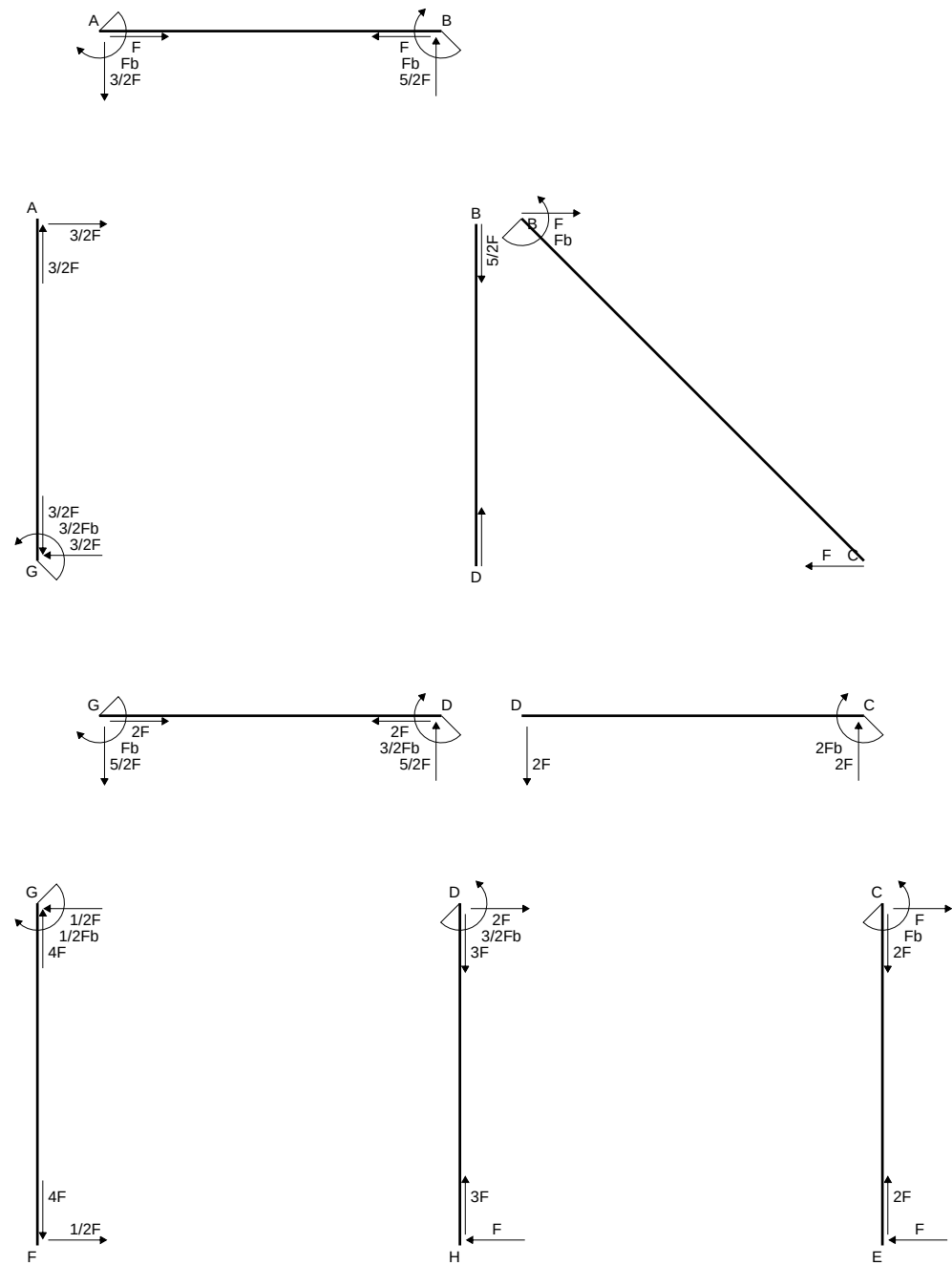
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

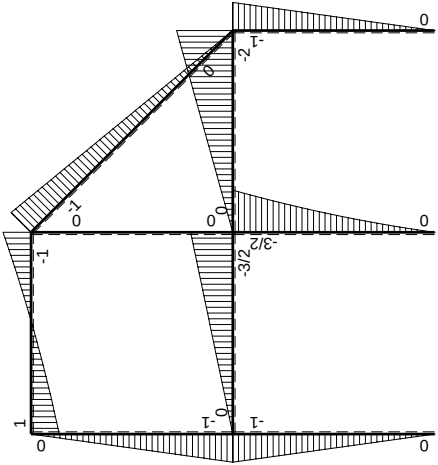
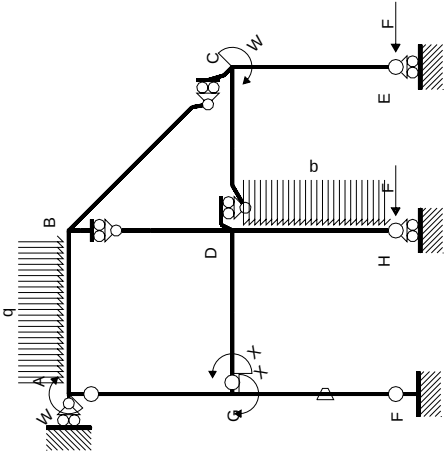
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$



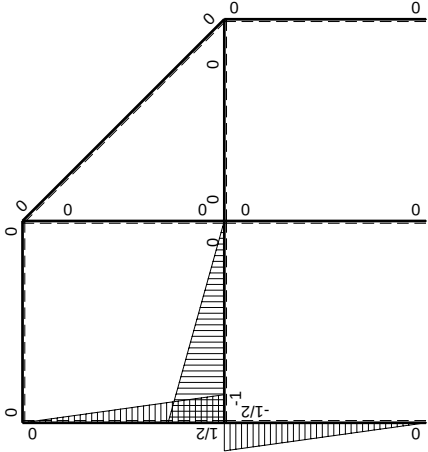
$$\begin{aligned} A &= 582. \text{ mm}^2 \\ J_u &= 197114. \text{ mm}^4 \\ J_v &= 39762. \text{ mm}^4 \\ y_g &= 19.8 \text{ mm} \\ T_y &= -1500. \text{ N} \\ M_x &= -1350000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.2 \text{ mm} \\ \sigma_m &= -Mv/J_u = 227.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 23.2 \text{ mm} \\ \sigma_c &= -Mv/J_u = 158.9 \text{ N/mm}^2 \\ \tau_c &= 4.046 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 159.1 \text{ N/mm}^2 \\ S &= 3190. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	-Fx	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

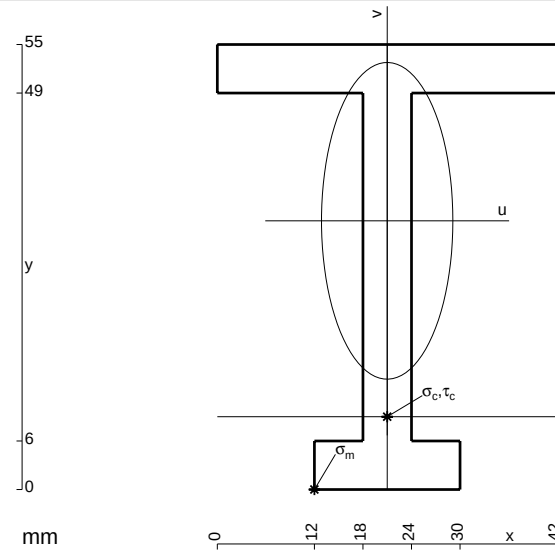
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

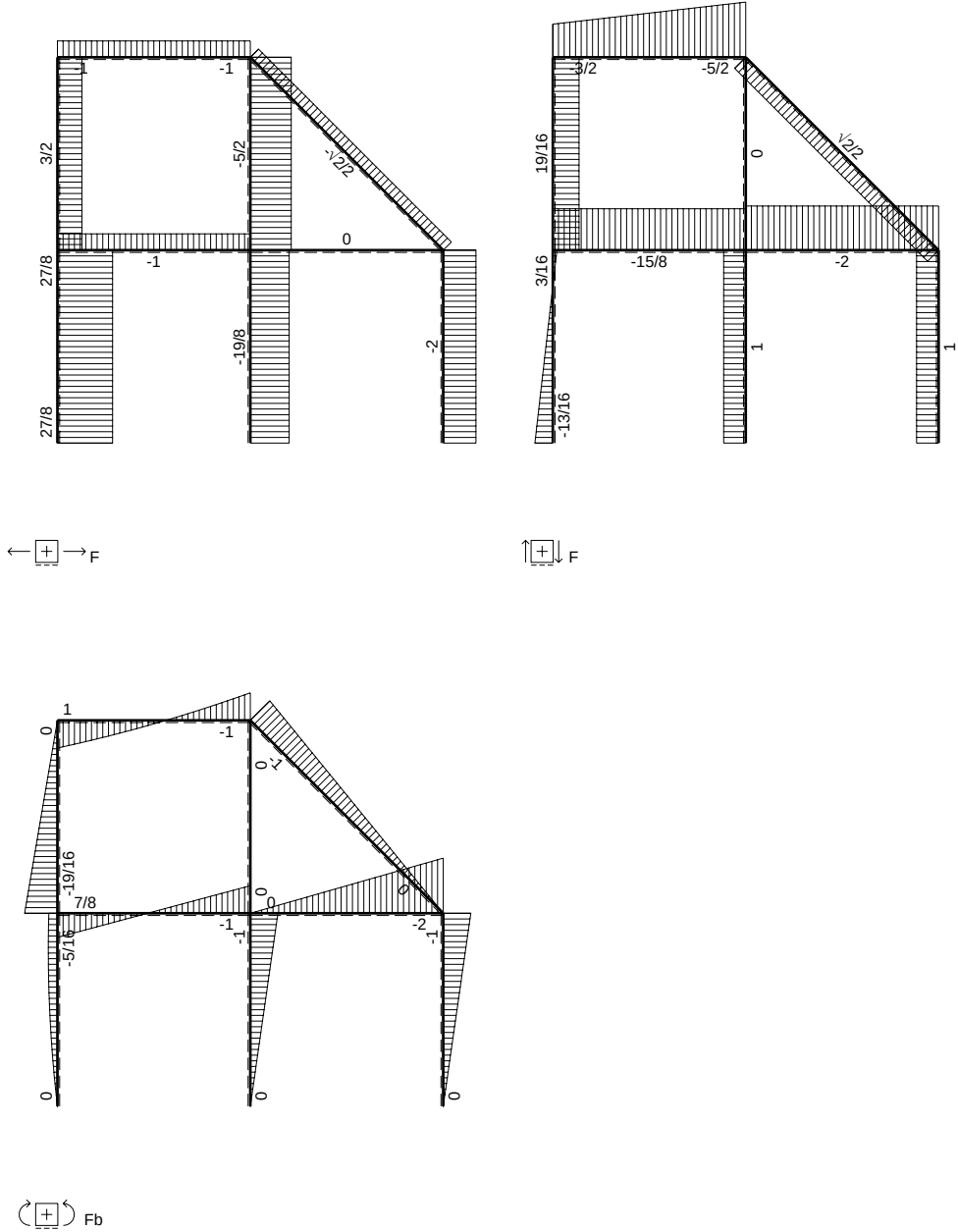
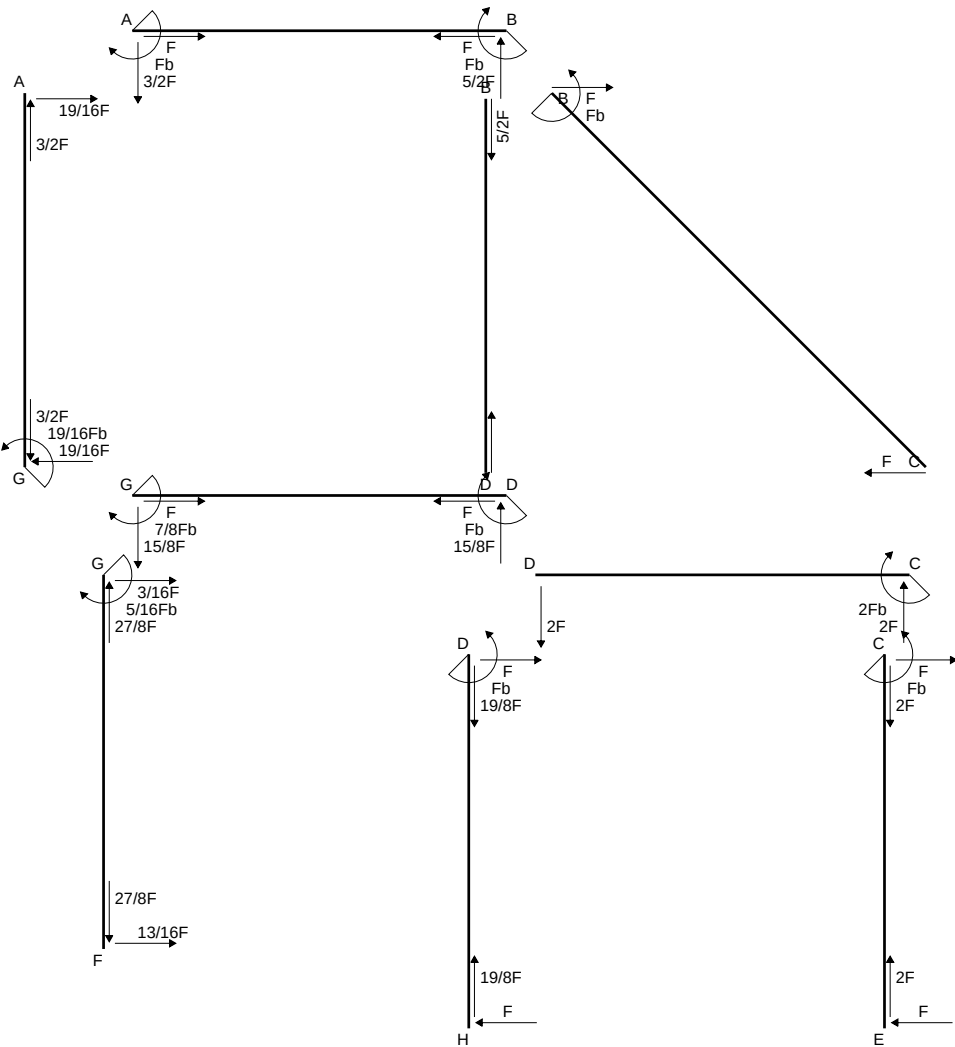
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

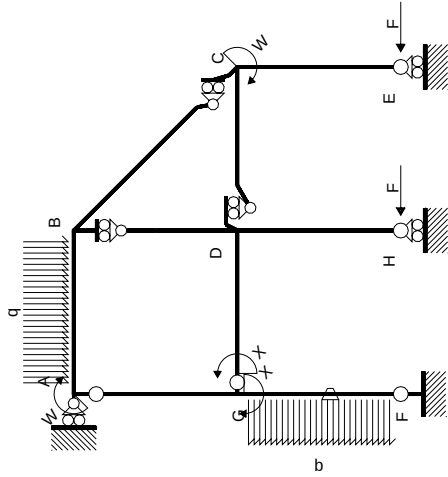
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



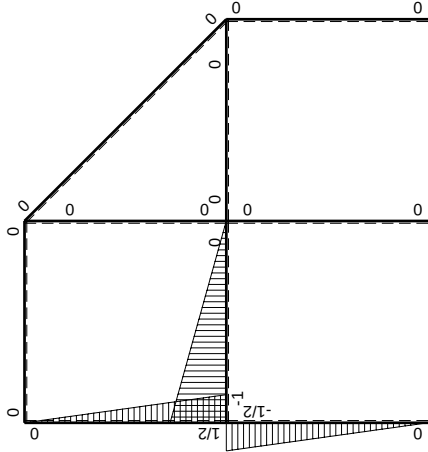
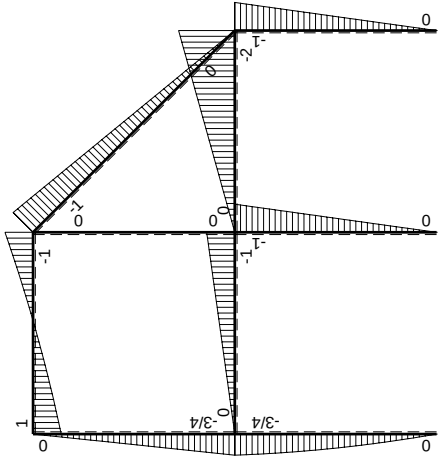
$$\begin{aligned} A &= 618. \text{ mm}^2 \\ J_u &= 236783. \text{ mm}^4 \\ J_v &= 40734. \text{ mm}^4 \\ y_g &= 33.21 \text{ mm} \\ T_y &= -1740. \text{ N} \\ M_x &= -1705200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -33.21 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.2 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -24.21 \text{ mm} \\ \sigma_c &= -Mv/J_u = -174.3 \text{ N/mm}^2 \\ \tau_c &= 4.563 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 174.5 \text{ N/mm}^2 \\ S &= 3725. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	-Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

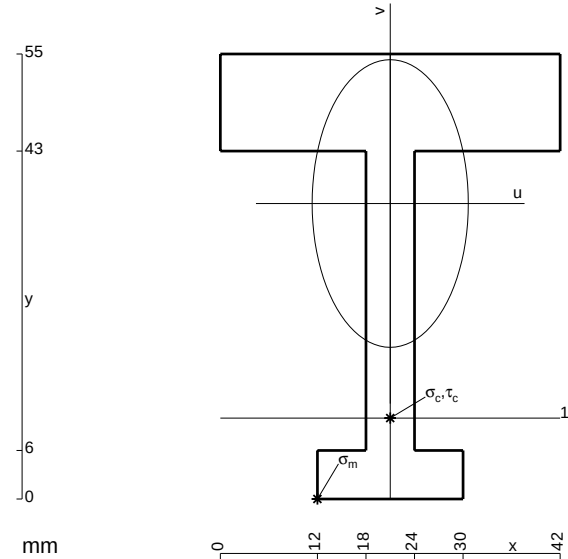
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

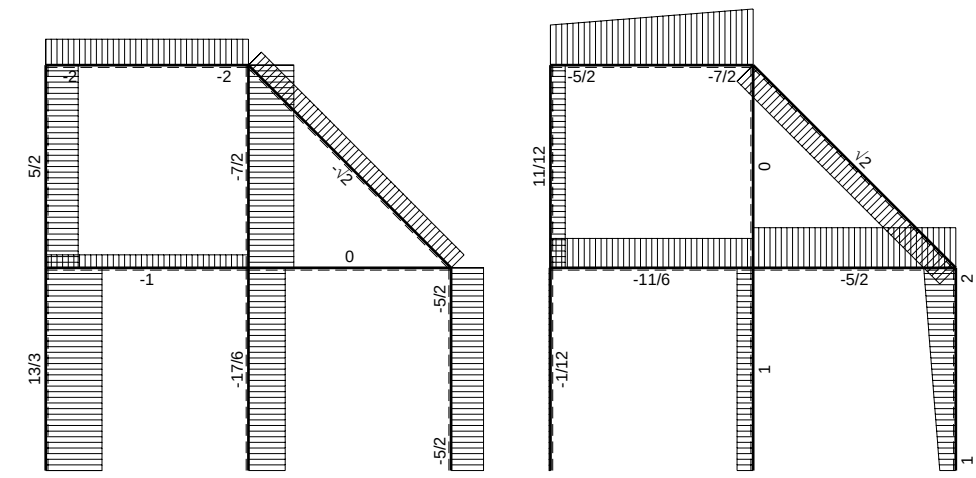
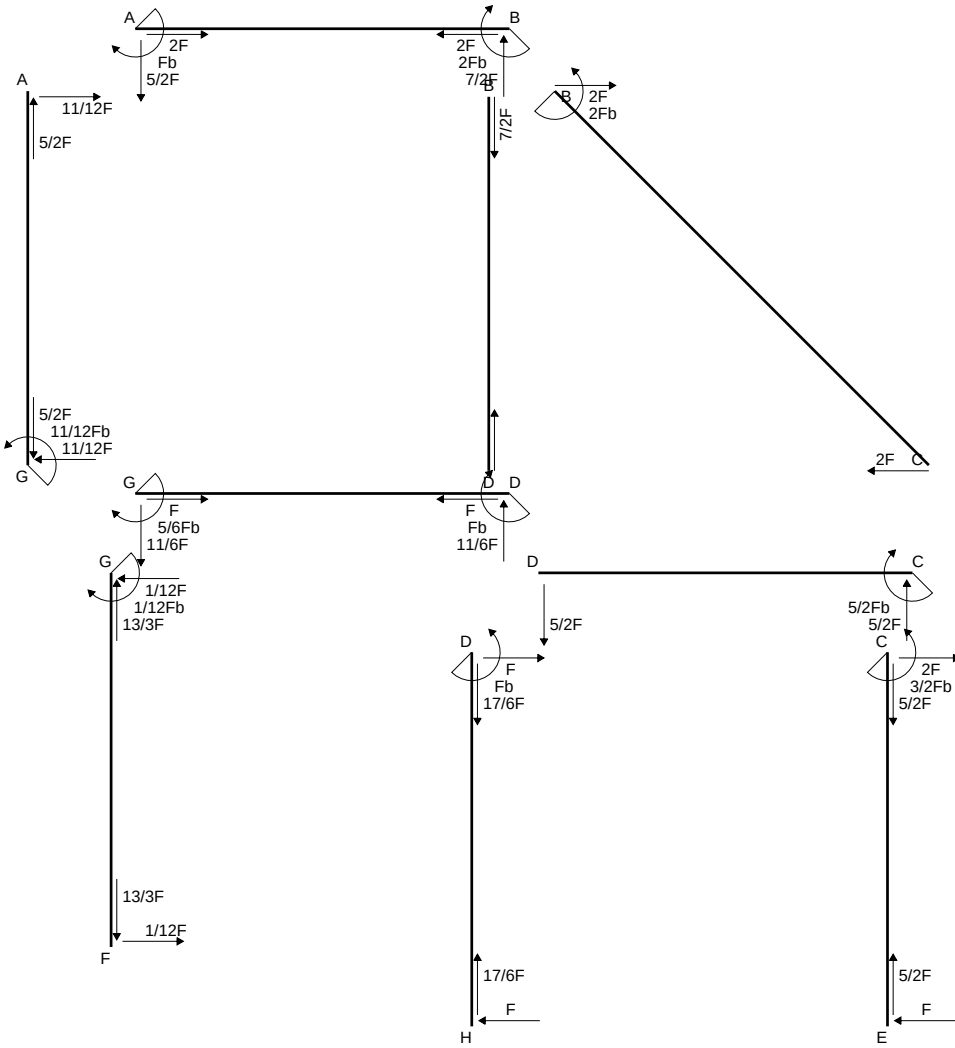
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

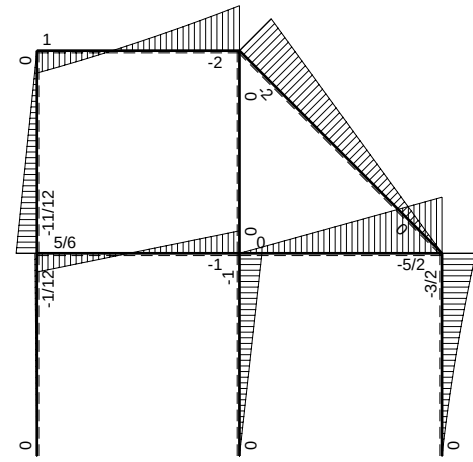


$$\begin{aligned} A &= 834. \text{ mm}^2 \\ J_u &= 263619. \text{ mm}^4 \\ J_v &= 77670. \text{ mm}^4 \\ y_g &= 36.52 \text{ mm} \\ T_y &= -2760. \text{ N} \\ M_x &= -1435200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -36.52 \text{ mm} \\ \sigma_m &= -Mv/J_u = -198.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -26.52 \text{ mm} \\ \sigma_c &= -Mv/J_u = -144.4 \text{ N/mm}^2 \\ \tau_c &= 7.512 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 145. \text{ N/mm}^2 \\ S &= 4305. \text{ mm}^3 \end{aligned}$$

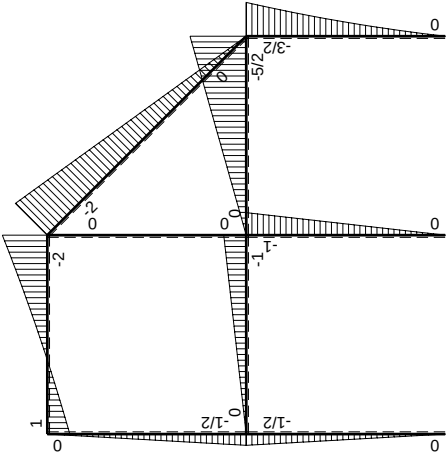
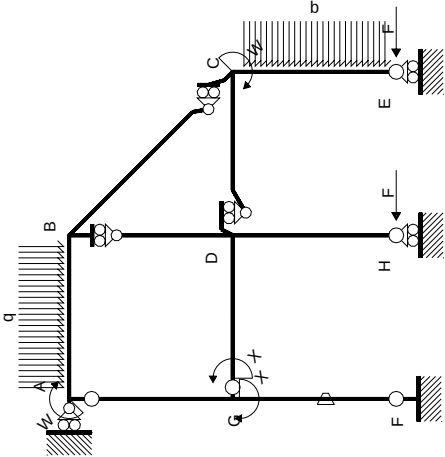


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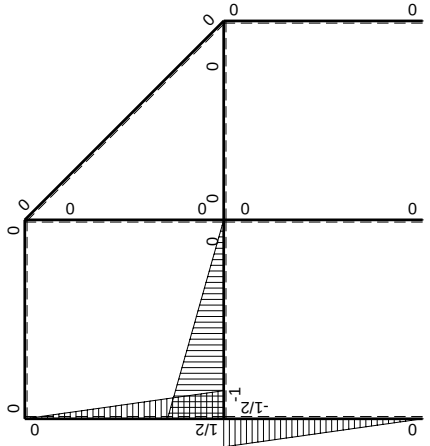


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$2Fb-7/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

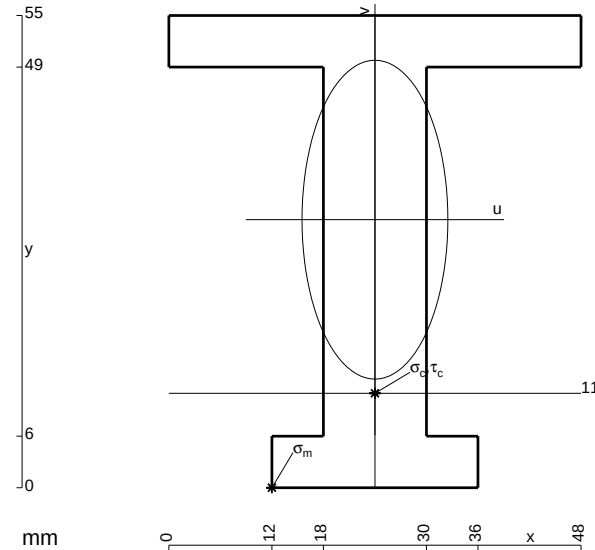
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

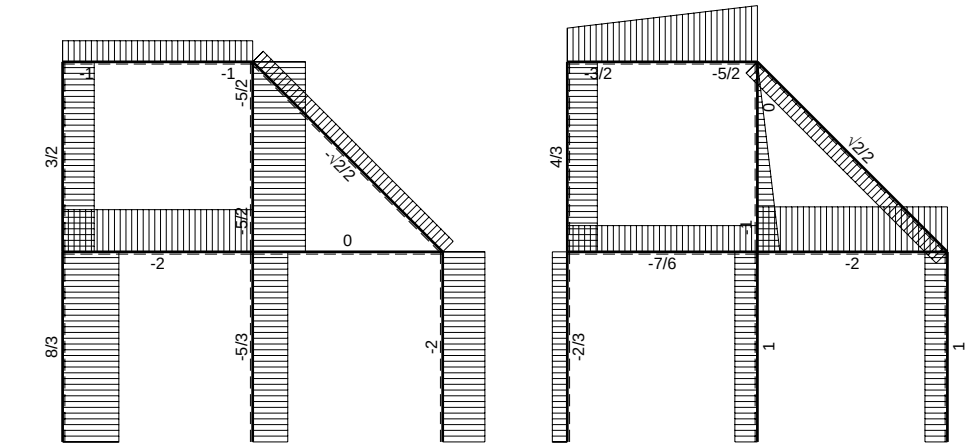
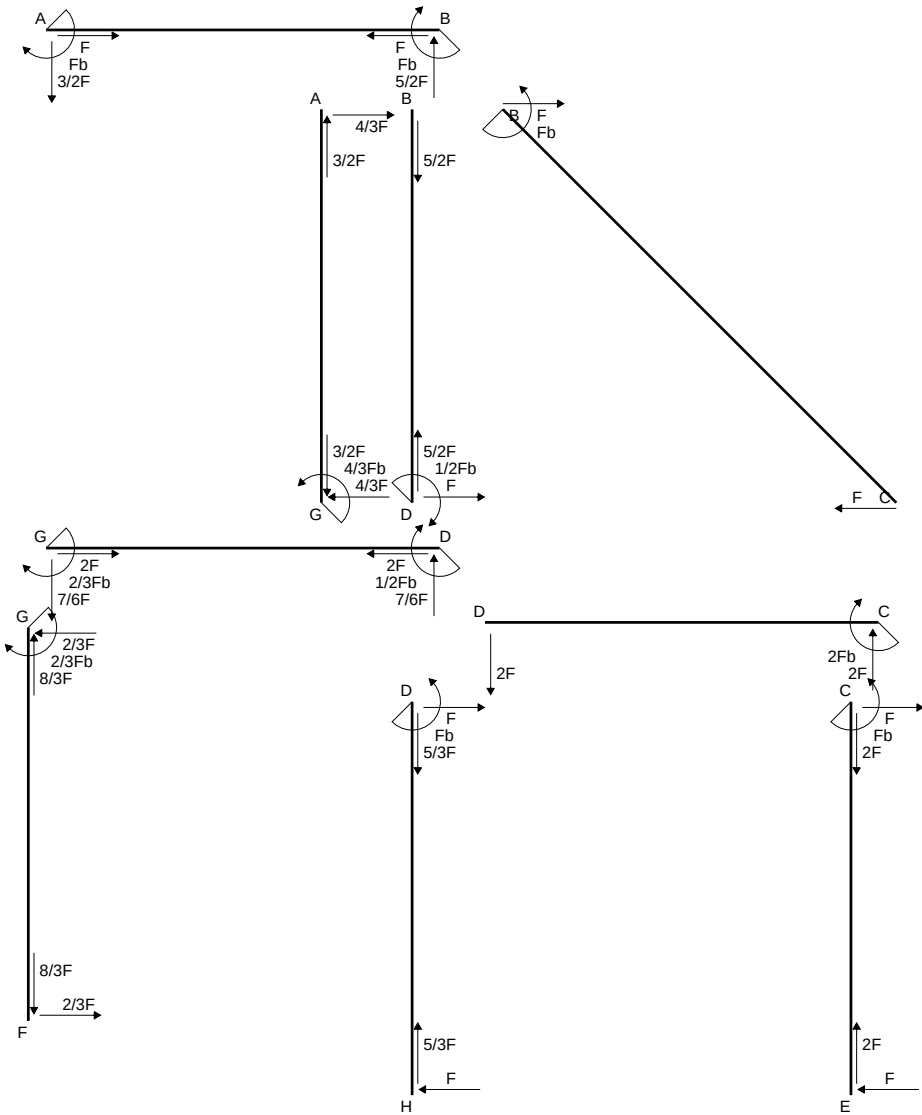
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

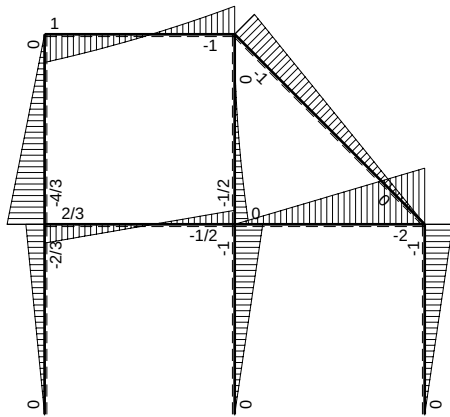


$$\begin{aligned} A &= 948. \text{ mm}^2 \\ J_u &= 326981. \text{ mm}^4 \\ J_v &= 68400. \text{ mm}^4 \\ y_g &= 31.22 \text{ mm} \\ N &= -3780. \text{ N} \\ T_y &= -6615. \text{ N} \\ M_x &= -2154600. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.22 \text{ mm} \\ \sigma_m &= N/A - Mv/J_u = -209.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -20.22 \text{ mm} \\ \sigma_c &= N/A - Mv/J_u = -137.2 \text{ N/mm}^2 \\ \tau_c &= 9.15 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 138.1 \text{ N/mm}^2 \\ S &= 5427. \text{ mm}^3 \end{aligned}$$

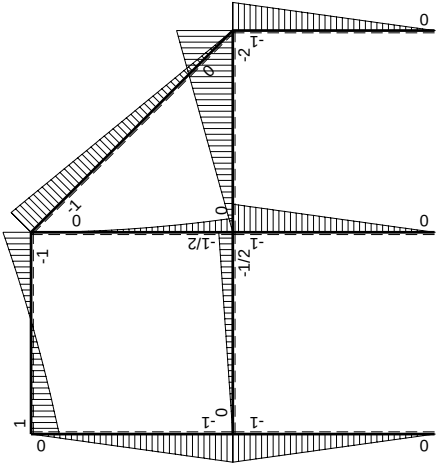
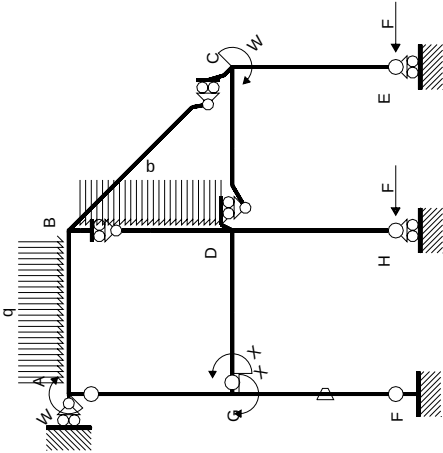


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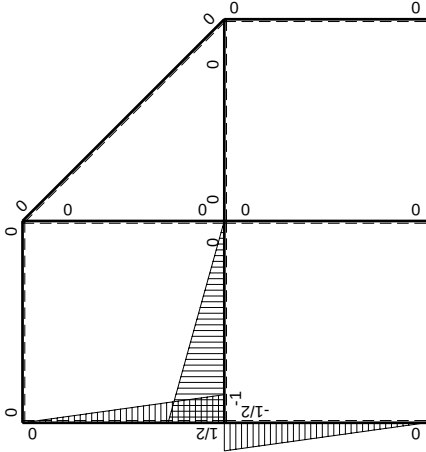


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$Fb-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-2/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

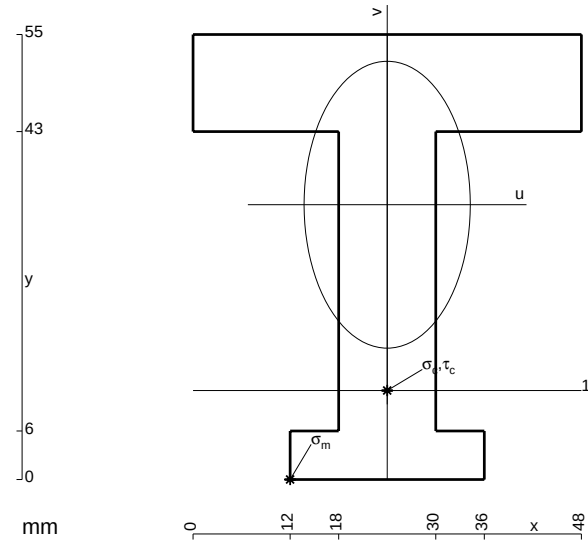
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

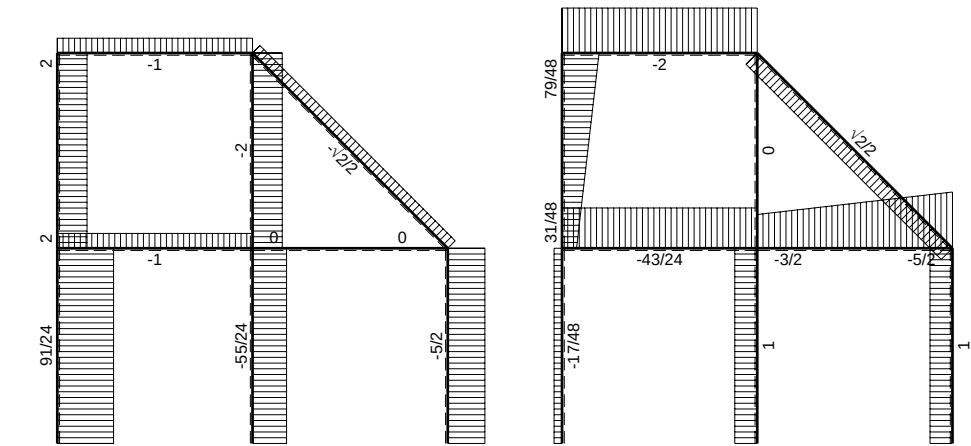
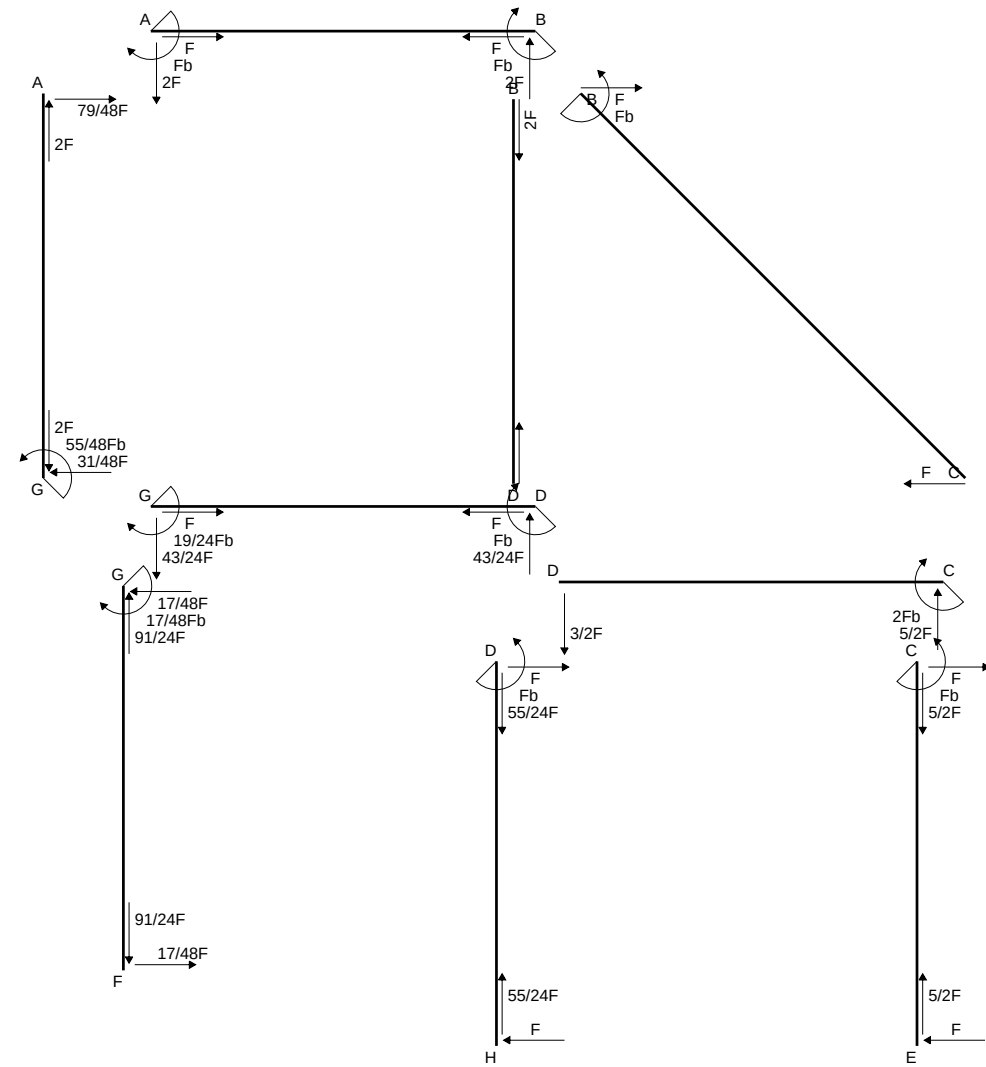
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

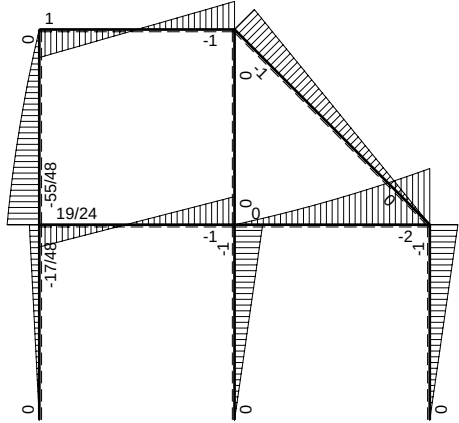


$$\begin{aligned} A &= 1164. \text{ mm}^2 \\ J_u &= 366051. \text{ mm}^4 \\ J_v &= 122832. \text{ mm}^4 \\ y_g &= 33.96 \text{ mm} \\ T_y &= -3820. \text{ N} \\ M_x &= -2368400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -33.96 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -22.96 \text{ mm} \\ \sigma_c &= -Mv/J_u = -148.6 \text{ N/mm}^2 \\ \tau_c &= 5.206 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 148.9 \text{ N/mm}^2 \\ S &= 5987. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/4Fx$	$-Fb/EJ$	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$19/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-19/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

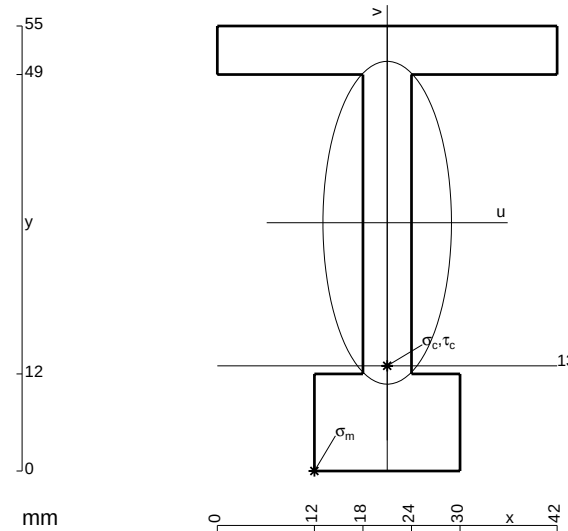
$$L_{GA}^{x_0} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

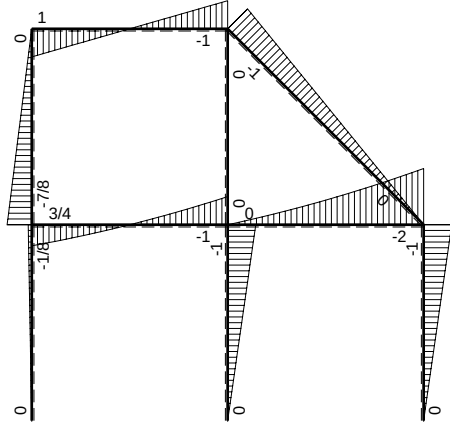
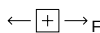
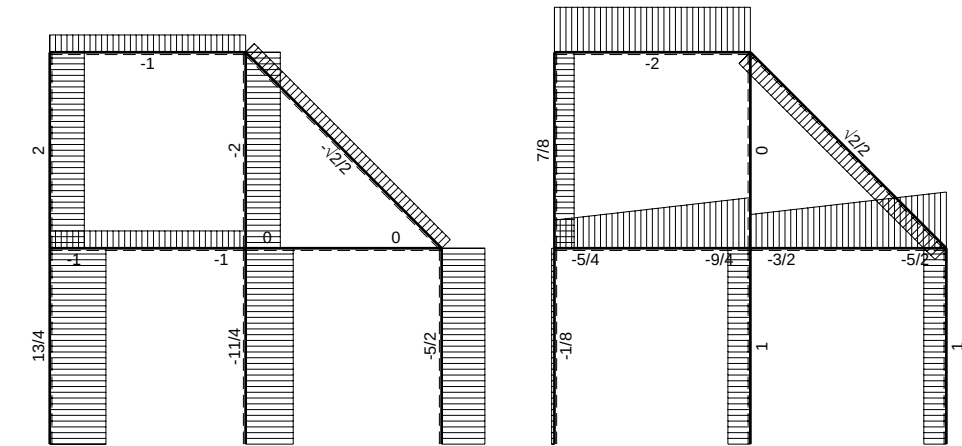
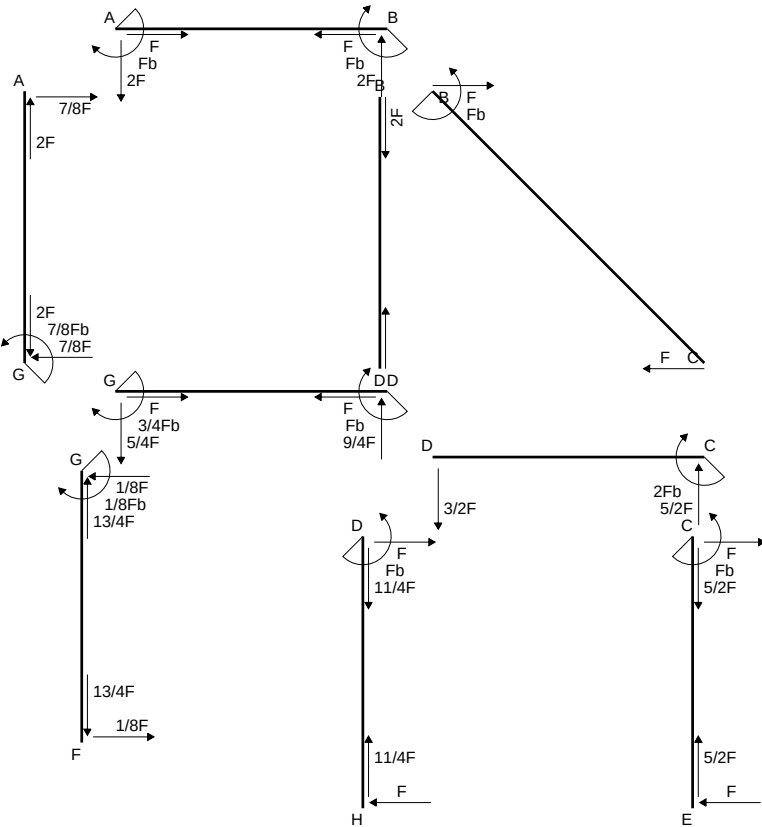
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

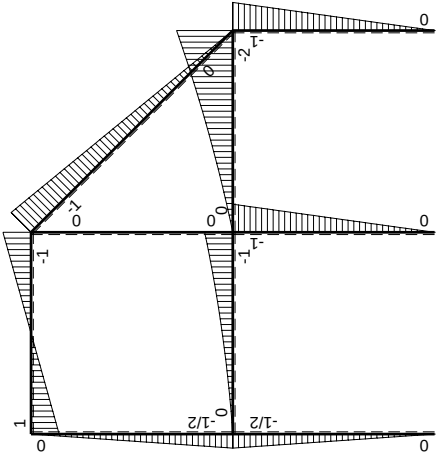
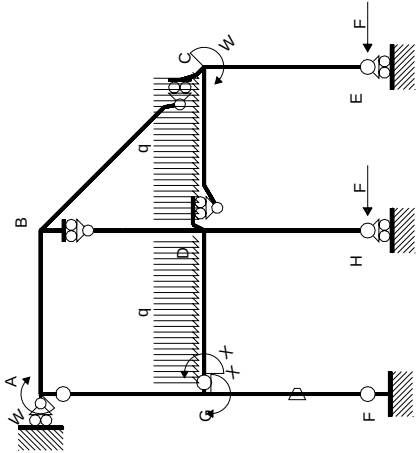
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



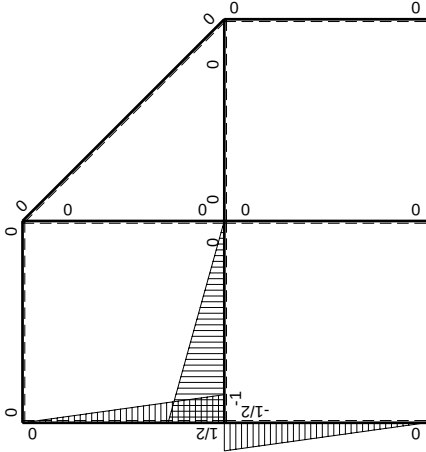
$$\begin{aligned} A &= 690. \text{ mm}^2 \\ J_u &= 274792. \text{ mm}^4 \\ J_v &= 43542. \text{ mm}^4 \\ y_g &= 30.68 \text{ mm} \\ T_y &= -3825. \text{ N} \\ M_x &= -2050200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -30.68 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.68 \text{ mm} \\ \sigma_c &= -Mv/J_u = -131.9 \text{ N/mm}^2 \\ \tau_c &= 12.62 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 133.7 \text{ N/mm}^2 \\ S &= 5441. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx-1/2qx^2$	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$3/8Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-3/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

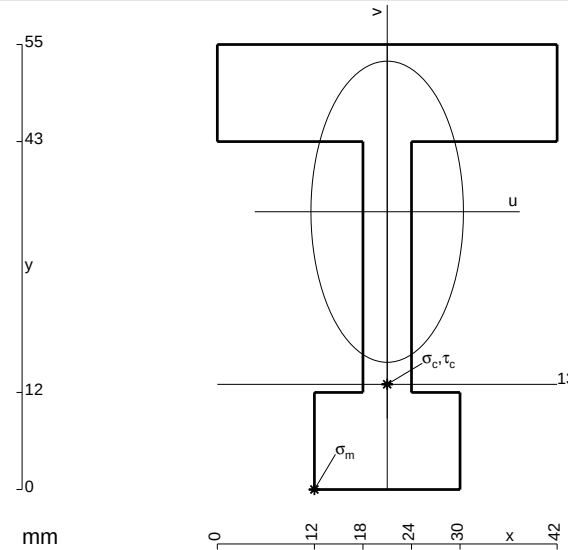
$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

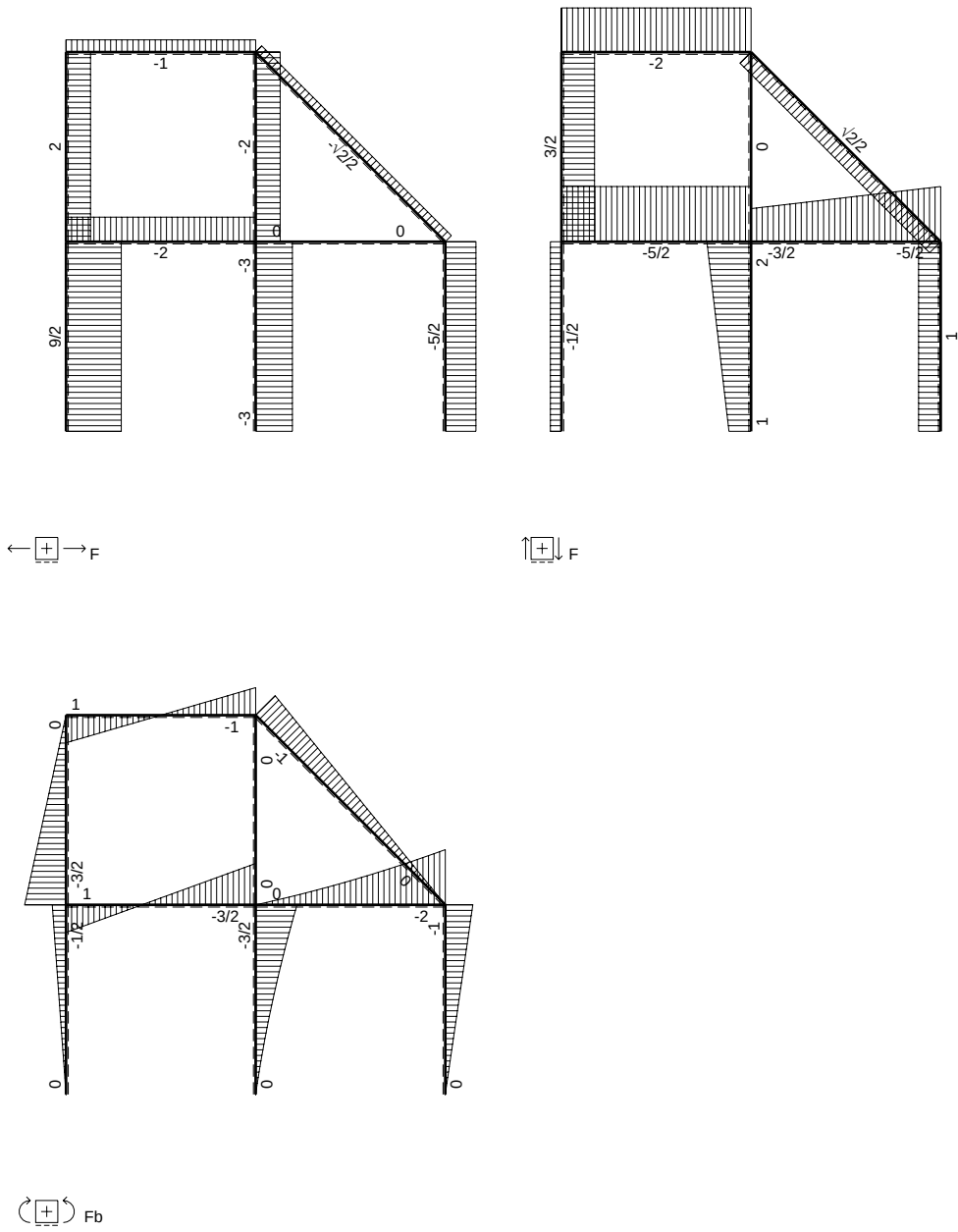
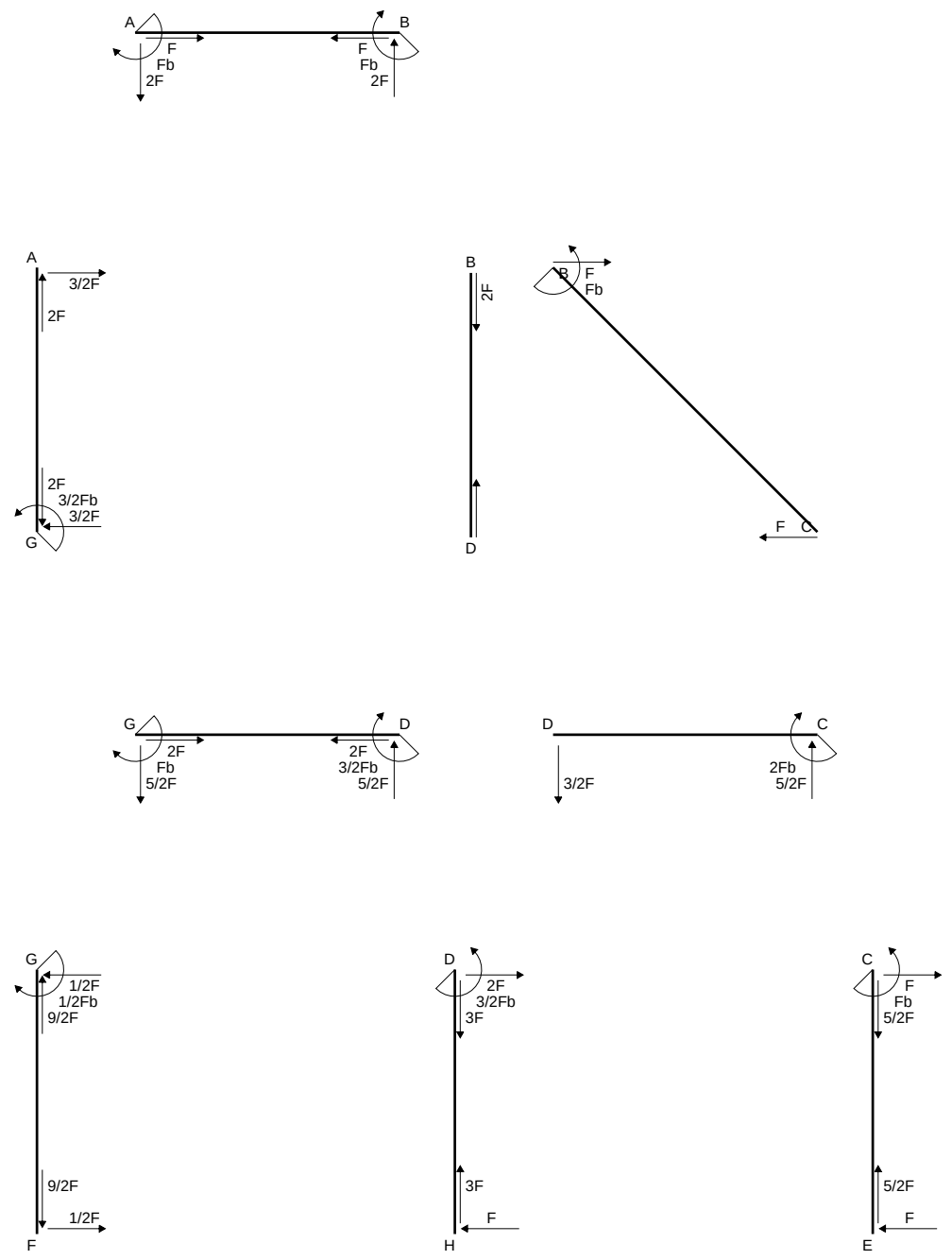
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$



$$\begin{aligned} A &= 906. \text{ mm}^2 \\ J_u &= 314037. \text{ mm}^4 \\ J_v &= 80478. \text{ mm}^4 \\ y_g &= 34.33 \text{ mm} \\ T_y &= -3800. \text{ N} \\ M_x &= -2188800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.33 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -21.33 \text{ mm} \\ \sigma_c &= -Mv/J_u = -148.7 \text{ N/mm}^2 \\ \tau_c &= 12.61 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 150.3 \text{ N/mm}^2 \\ S &= 6251. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

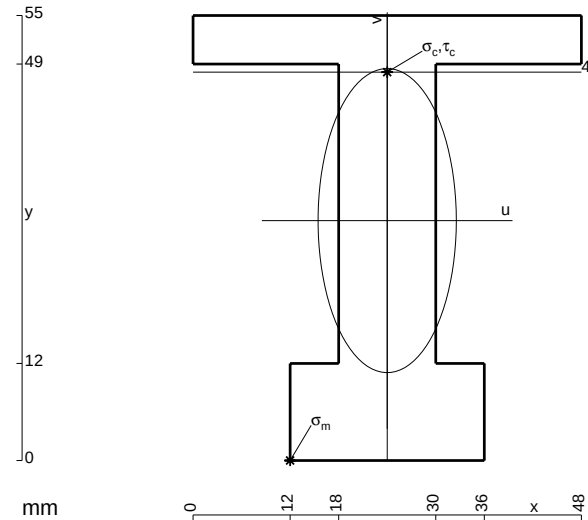
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

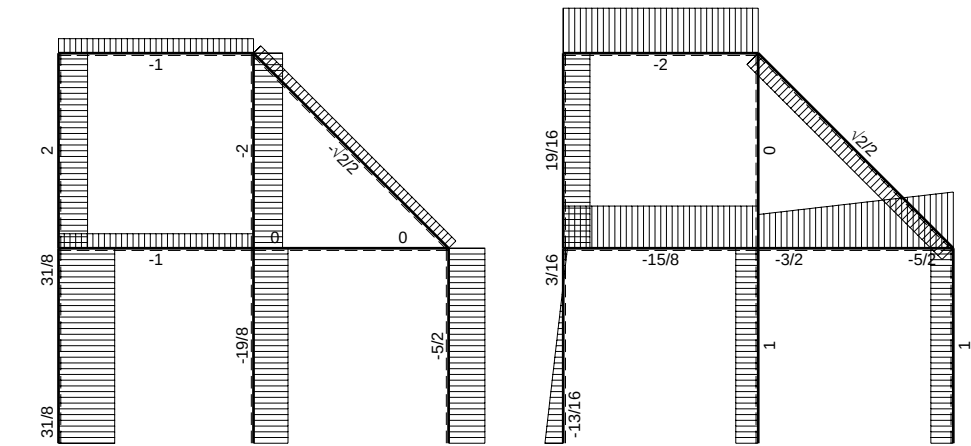
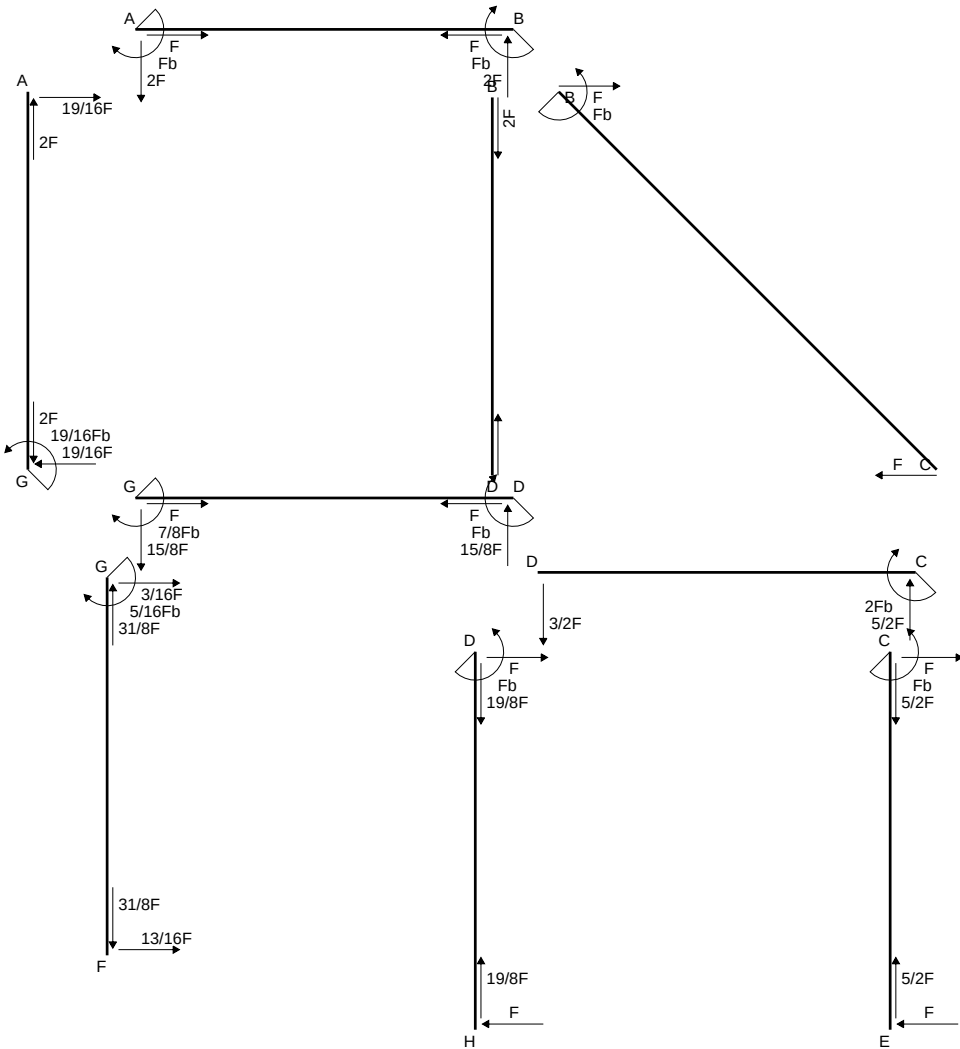
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

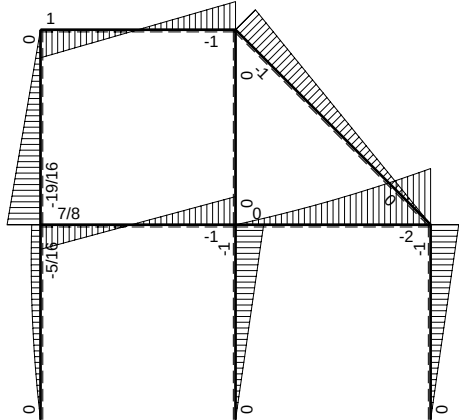


$$\begin{aligned} A &= 1020. \text{ mm}^2 \\ J_u &= 360241. \text{ mm}^4 \\ J_v &= 74448. \text{ mm}^4 \\ y_g &= 29.65 \text{ mm} \\ T_y &= -3875. \text{ N} \\ M_x &= -2418000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.65 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 48. \text{ mm} \\ v_c &= 18.35 \text{ mm} \\ \sigma_c &= -Mv/J_u = 123.1 \text{ N/mm}^2 \\ \tau_c &= 5.972 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 123.6 \text{ N/mm}^2 \\ S &= 6662. \text{ mm}^3 \end{aligned}$$

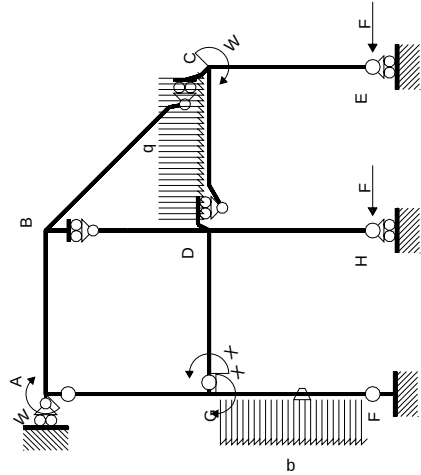


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

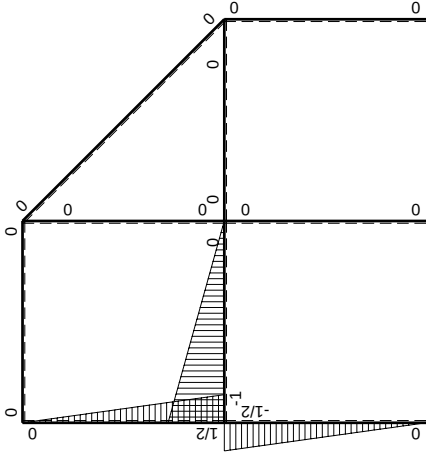


↺ $\boxed{+}$ ↻ F_b

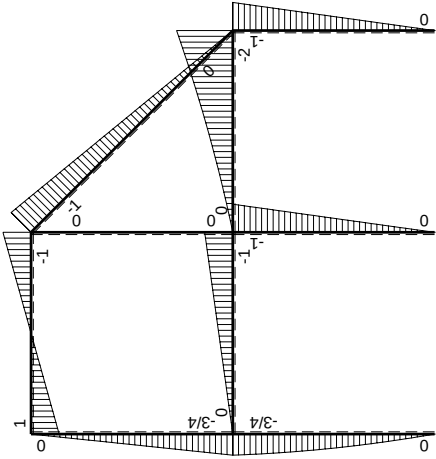


Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

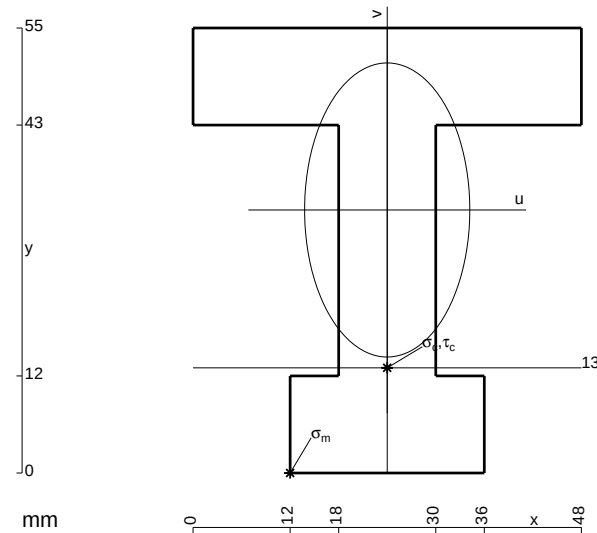
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

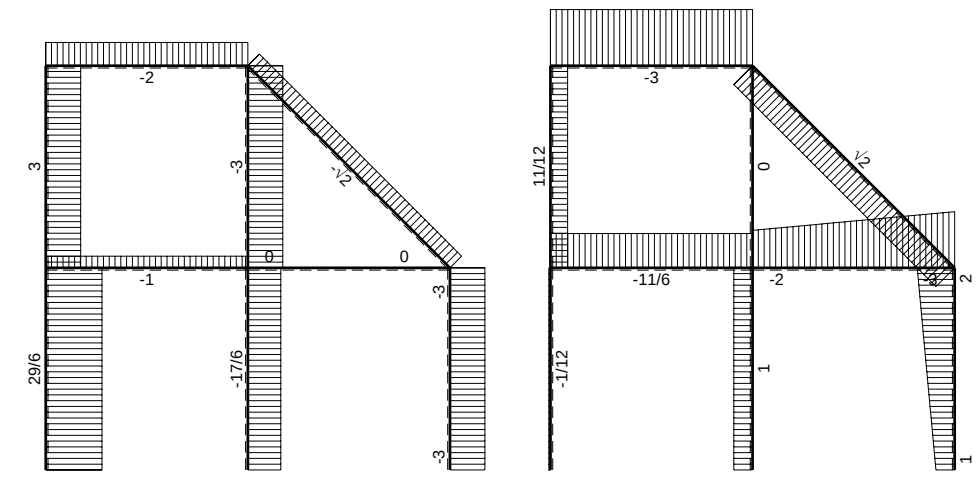
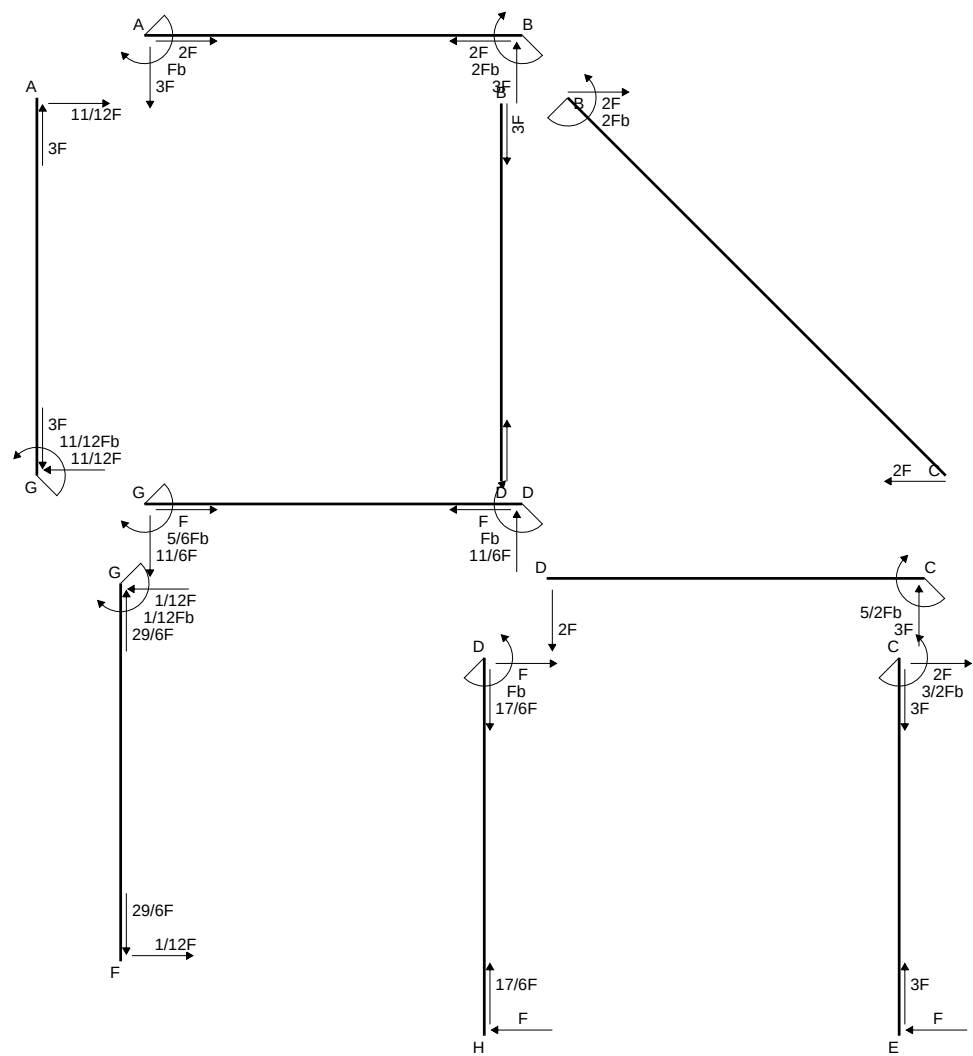
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

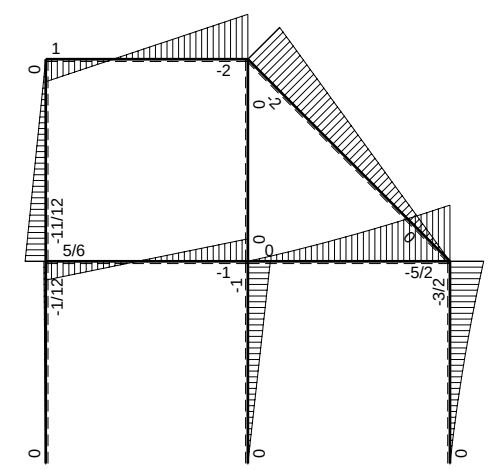


$$\begin{aligned} A &= 1236. \text{ mm}^2 \\ J_u &= 408523. \text{ mm}^4 \\ J_v &= 128880. \text{ mm}^4 \\ y_g &= 32.51 \text{ mm} \\ T_y &= -3950. \text{ N} \\ M_x &= -2622800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.51 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -19.51 \text{ mm} \\ \sigma_c &= -Mv/J_u = -125.3 \text{ N/mm}^2 \\ \tau_c &= 6.345 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 125.7 \text{ N/mm}^2 \\ S &= 7875. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3Fx$	0	0	0	0	0+0	0
BA b	0	$2Fb-3Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-3Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

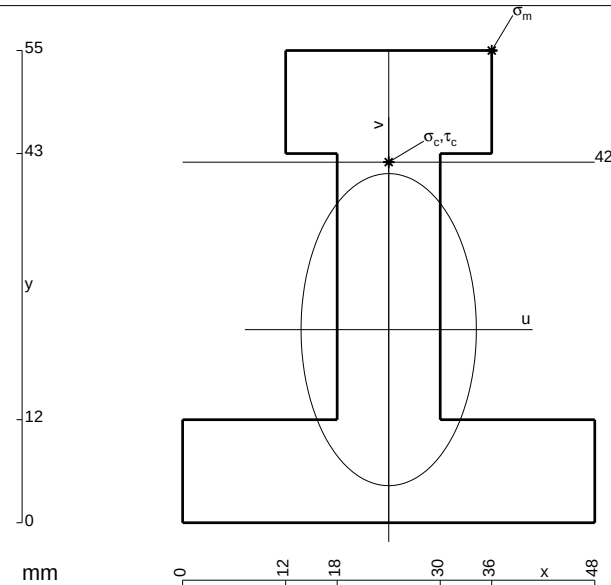
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

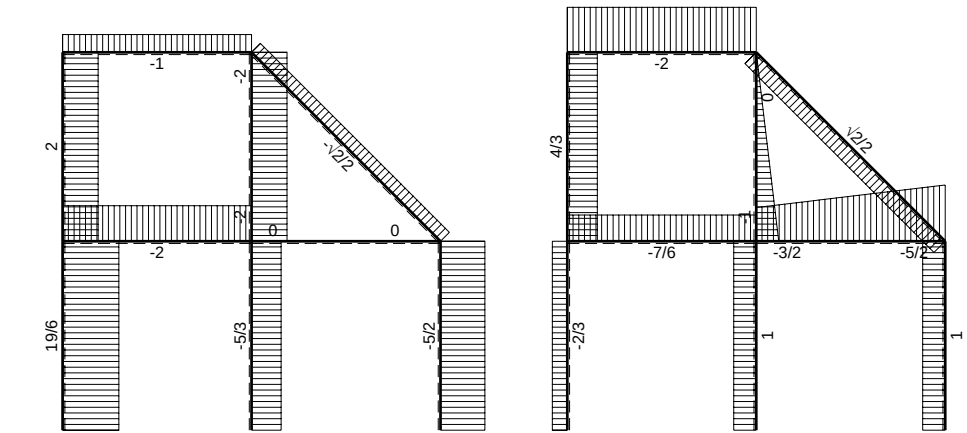
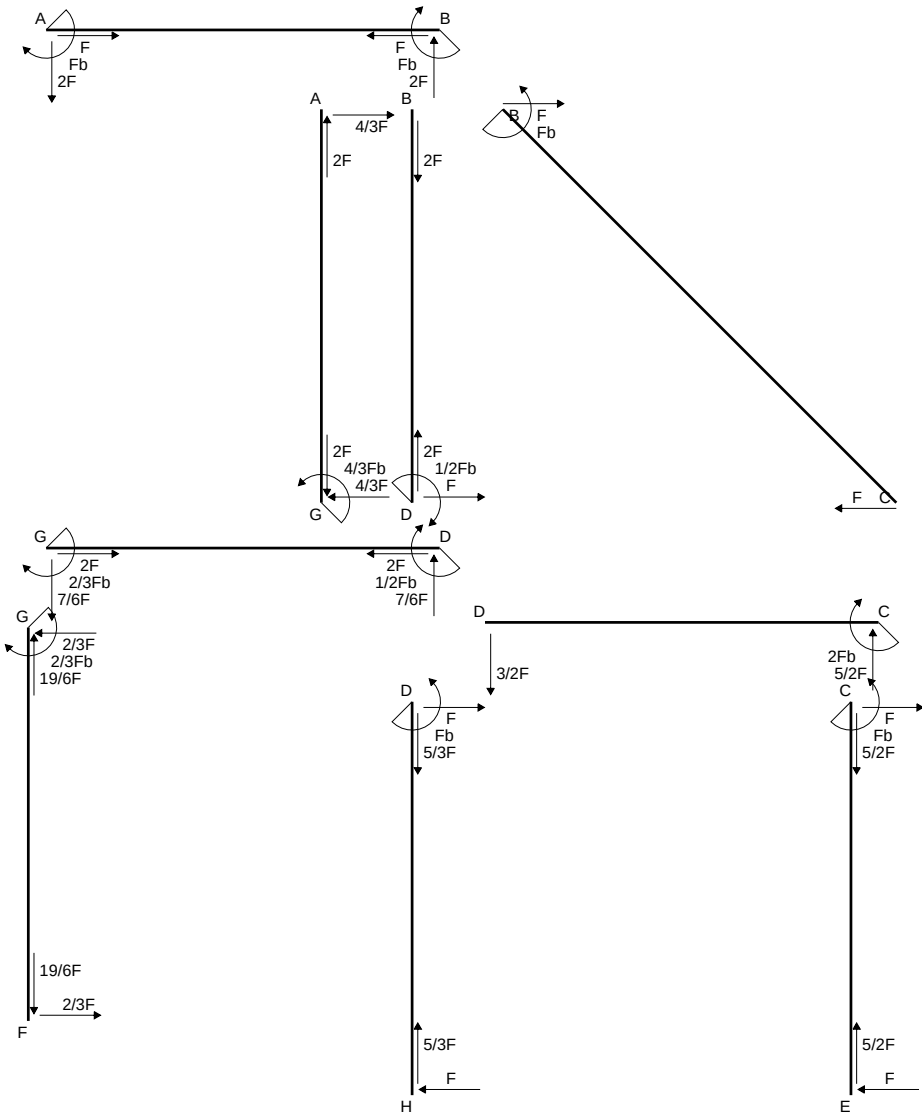
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

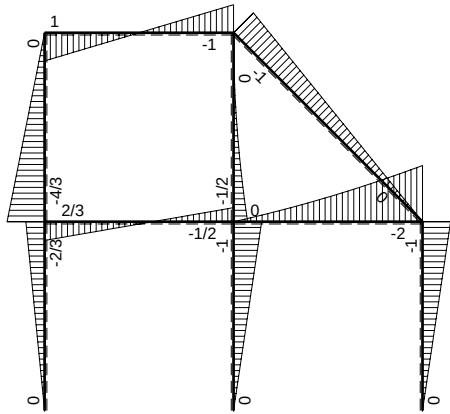


$$\begin{aligned} A &= 1236. \text{ mm}^2 \\ J_u &= 408523. \text{ mm}^4 \\ J_v &= 128880. \text{ mm}^4 \\ y_g &= 22.49 \text{ mm} \\ T_y &= -3750. \text{ N} \\ M_x &= -2750000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 32.51 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 19.51 \text{ mm} \\ \sigma_c &= -Mv/J_u = 131.3 \text{ N/mm}^2 \\ \tau_c &= 6.024 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 131.7 \text{ N/mm}^2 \\ S &= 7875. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$1/2Fb-1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-2/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

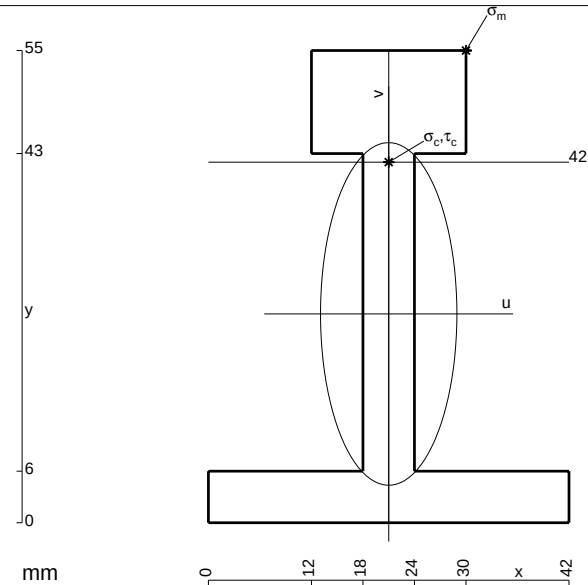
$$= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

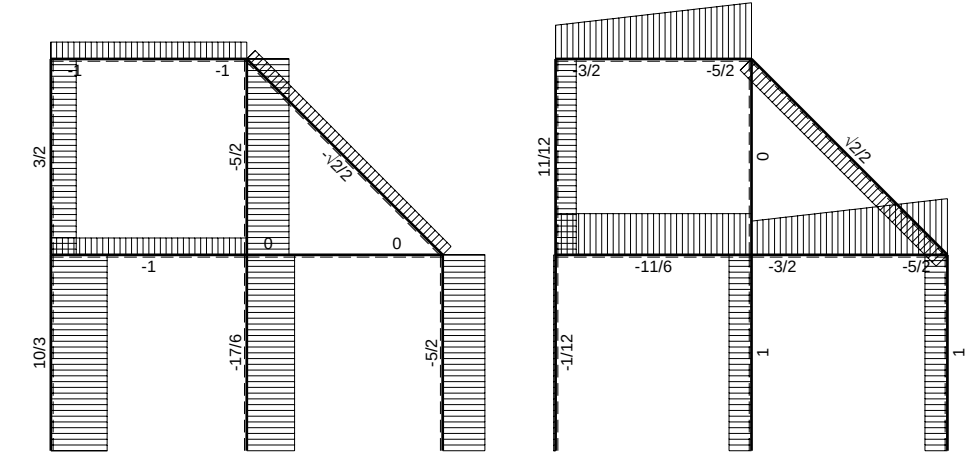
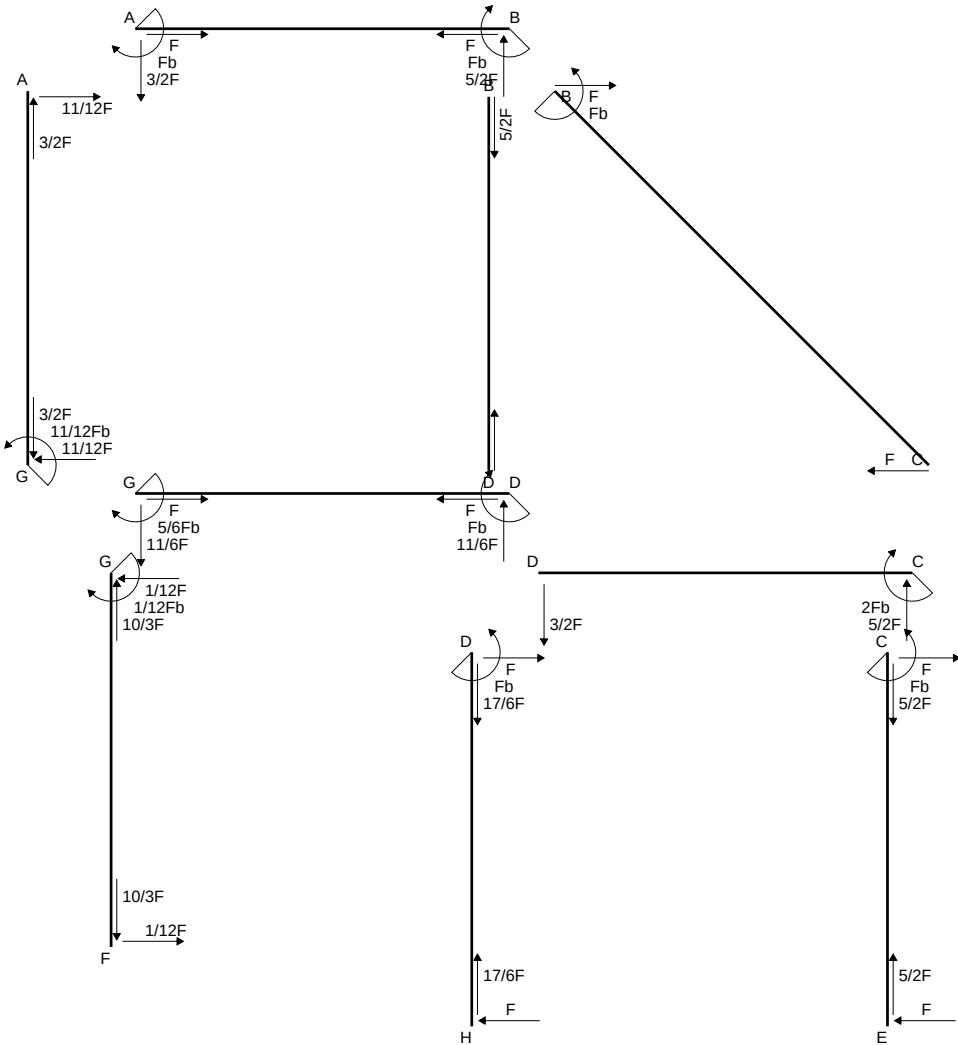
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

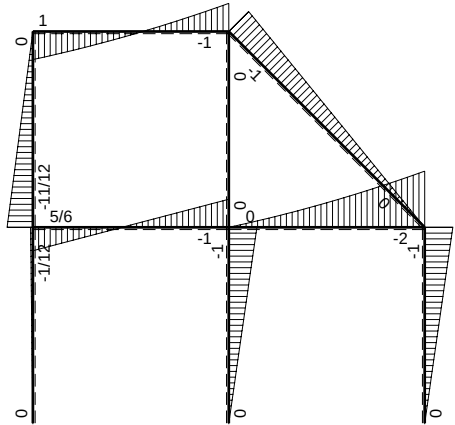


$$\begin{aligned} A &= 690. \text{ mm}^2 \\ J_u &= 274793. \text{ mm}^4 \\ J_v &= 43542. \text{ mm}^4 \\ y_g &= 24.32 \text{ mm} \\ T_y &= -2750. \text{ N} \\ M_x &= -2046000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 30.68 \text{ mm} \\ \sigma_m &= -Mv/J_u = 228.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 17.68 \text{ mm} \\ \sigma_c &= -Mv/J_u = 131.7 \text{ N/mm}^2 \\ \tau_c &= 9.074 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 132.6 \text{ N/mm}^2 \\ S &= 5441. \text{ mm}^3 \end{aligned}$$

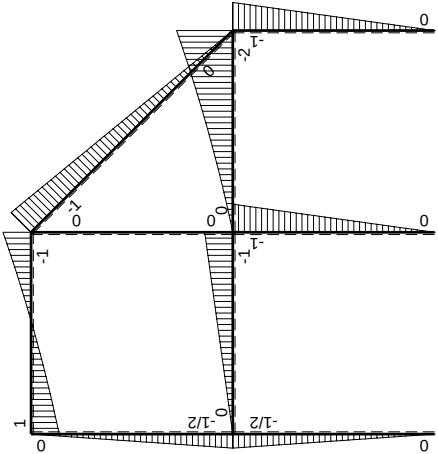
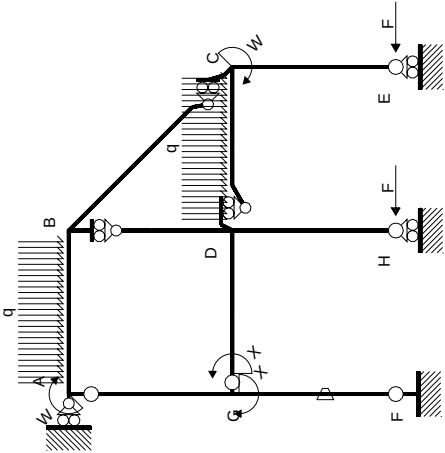


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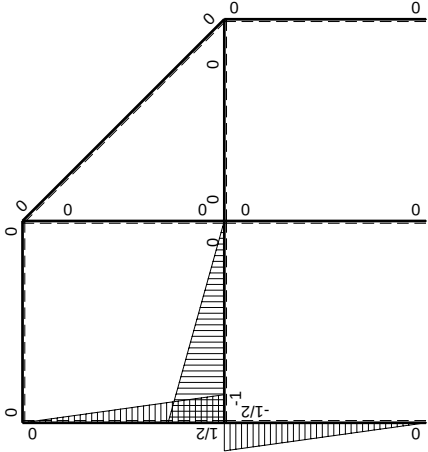


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-Fx$	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-5/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

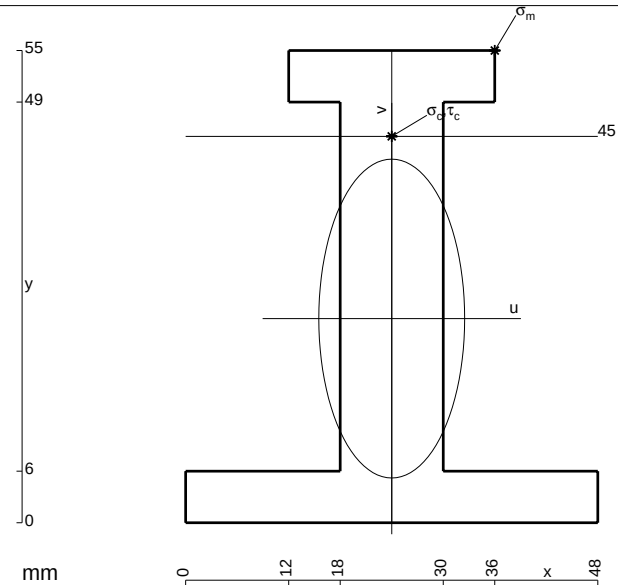
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

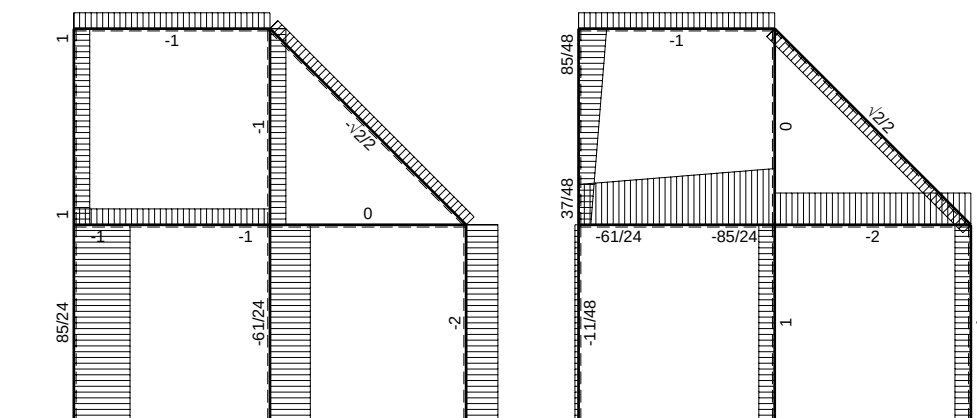
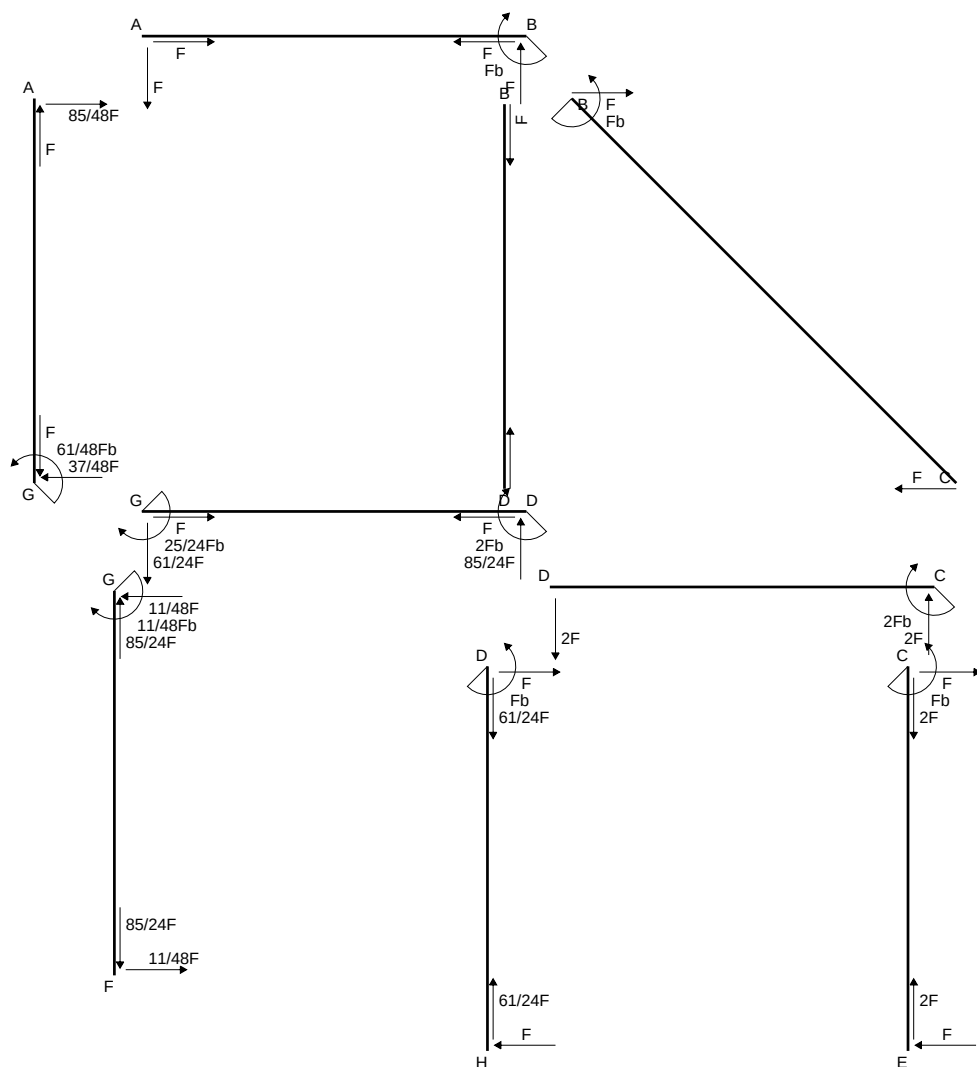
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

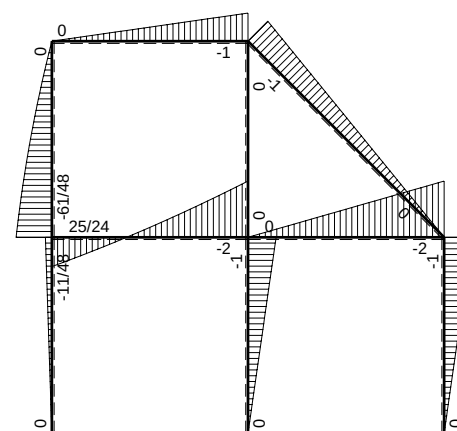
$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

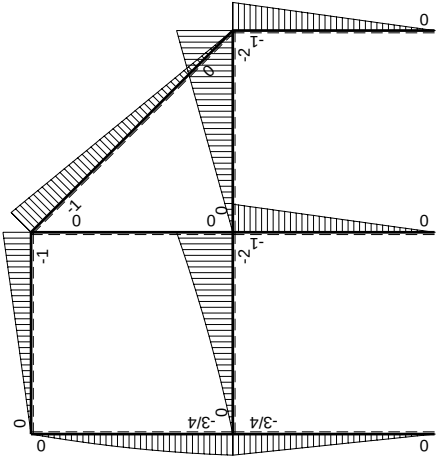
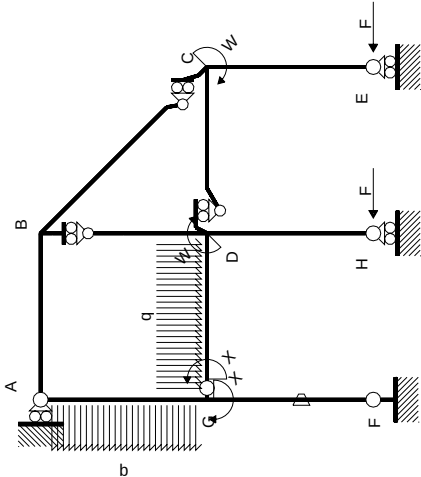


$$\begin{aligned} A &= 948. \text{ mm}^2 \\ J_u &= 326982. \text{ mm}^4 \\ J_v &= 68400. \text{ mm}^4 \\ y_g &= 23.78 \text{ mm} \\ T_y &= -3200. \text{ N} \\ M_x &= -2508800. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.22 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 21.22 \text{ mm} \\ \sigma_c &= -Mv/J_u = 162.8 \text{ N/mm}^2 \\ \tau_c &= 4.223 \text{ N/mm}^2 \\ \sigma_\varphi &= \sqrt{\sigma^2 + 3\tau^2} = 163. \text{ N/mm}^2 \\ S &= 5179. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow_F$$

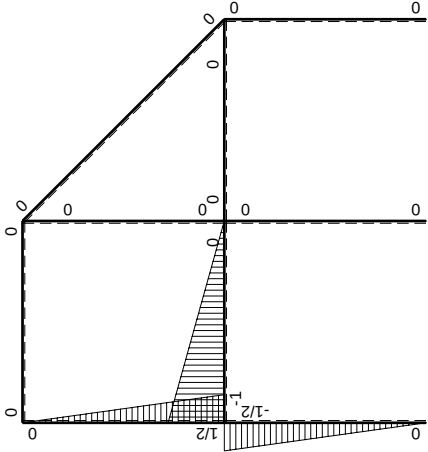
$\uparrow \boxed{+} \downarrow F$





Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	-1+x/b	$-3/2Fx-1/2qx^2$	0	$3/2Fx-Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(7/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-5/2Fx+1/2qx^2$	0	$2Fx-5/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	-1/2x/b	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$25/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-25/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(2 x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

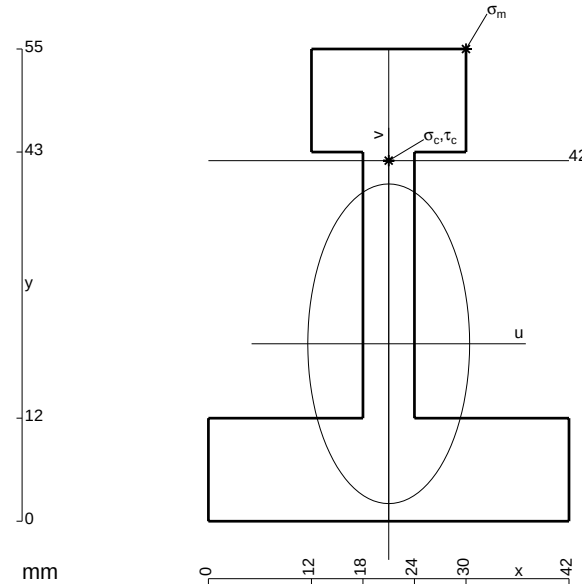
$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

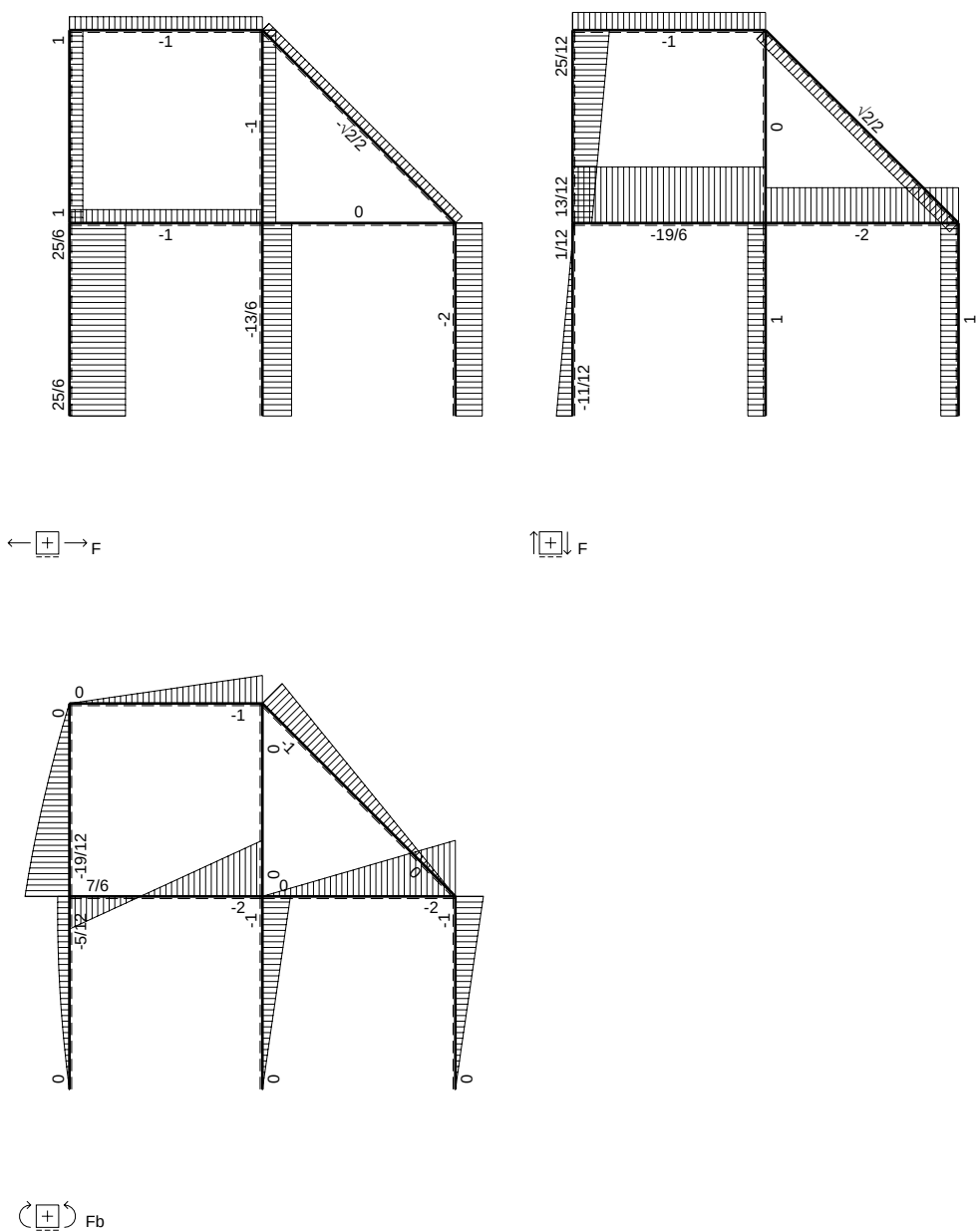
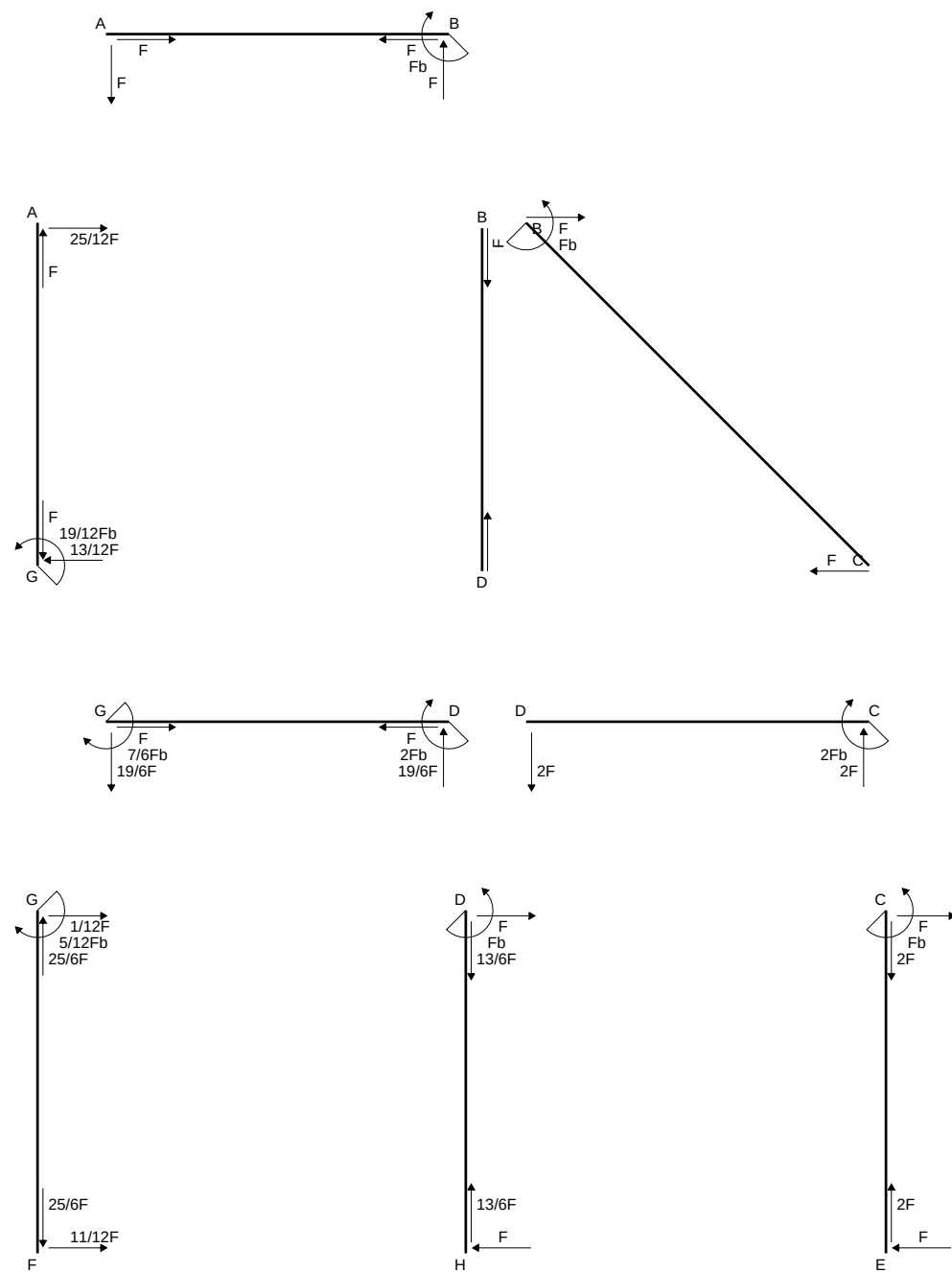
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



$$\begin{aligned} A &= 906. \text{ mm}^2 \\ J_u &= 314037. \text{ mm}^4 \\ J_v &= 80478. \text{ mm}^4 \\ y_g &= 20.67 \text{ mm} \\ T_y &= -3500. \text{ N} \\ M_x &= -1820000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 34.33 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 21.33 \text{ mm} \\ \sigma_c &= -Mv/J_u = 123.6 \text{ N/mm}^2 \\ \tau_c &= 11.61 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 125.3 \text{ N/mm}^2 \\ S &= 6251. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/2Fx+1/2qx ²	-Fb/EJ	3/4Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(3/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-1/2Fx-1/2qx ²	Fb/EJ	1/2Fb-3/4Fx+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+1/2Fx+1/2qx ²	0	-1/2Fb+3/4Fx-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-3/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx-1/2qx ²	0	-3/4Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						7/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{3}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - \frac{3}{4} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{3}{8} x^2/b + \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{3}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

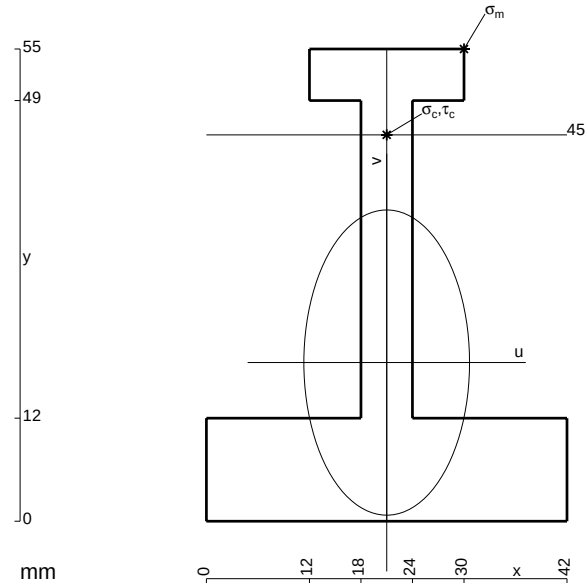
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + \frac{3}{4} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{3}{8} x^2/b - \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

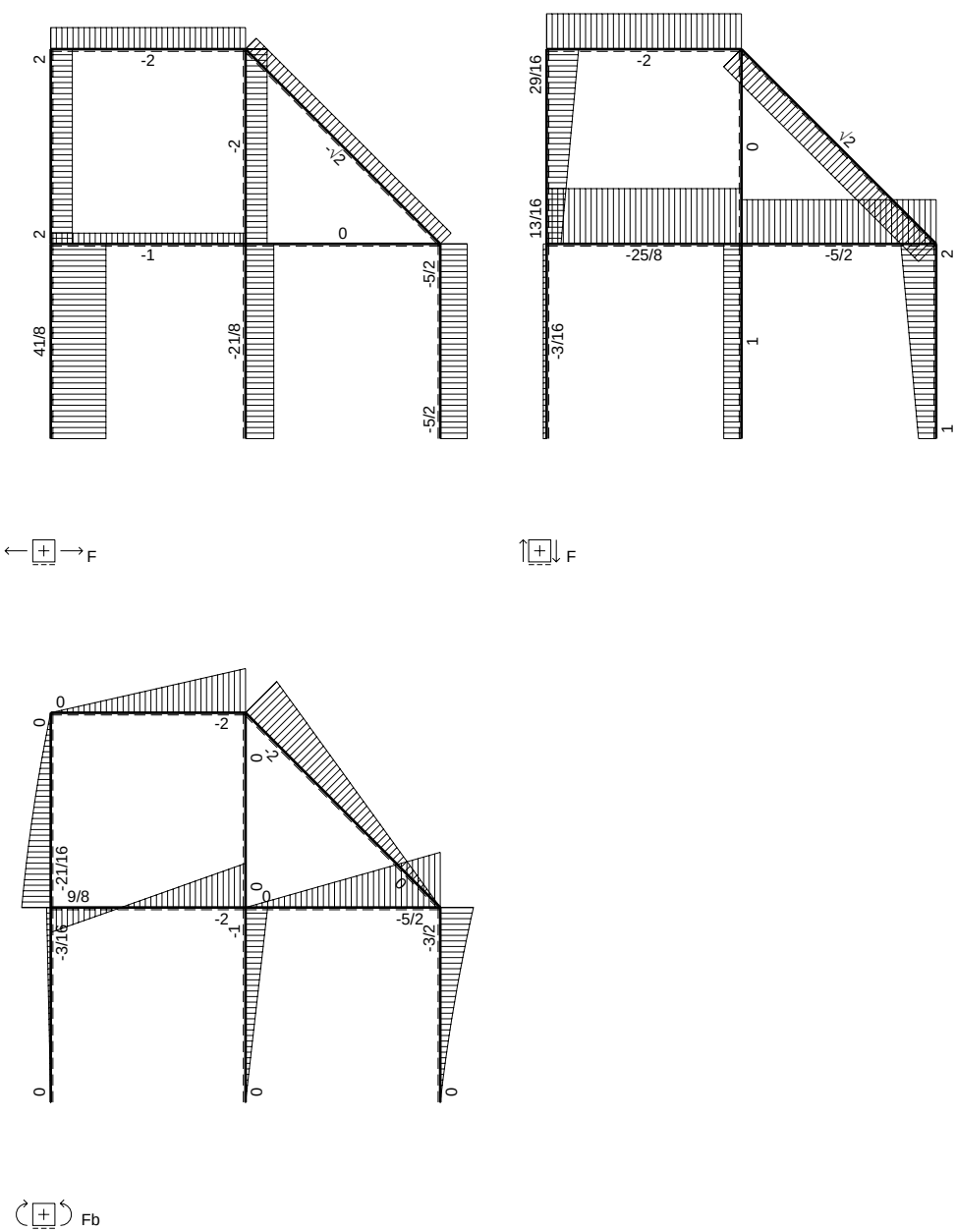
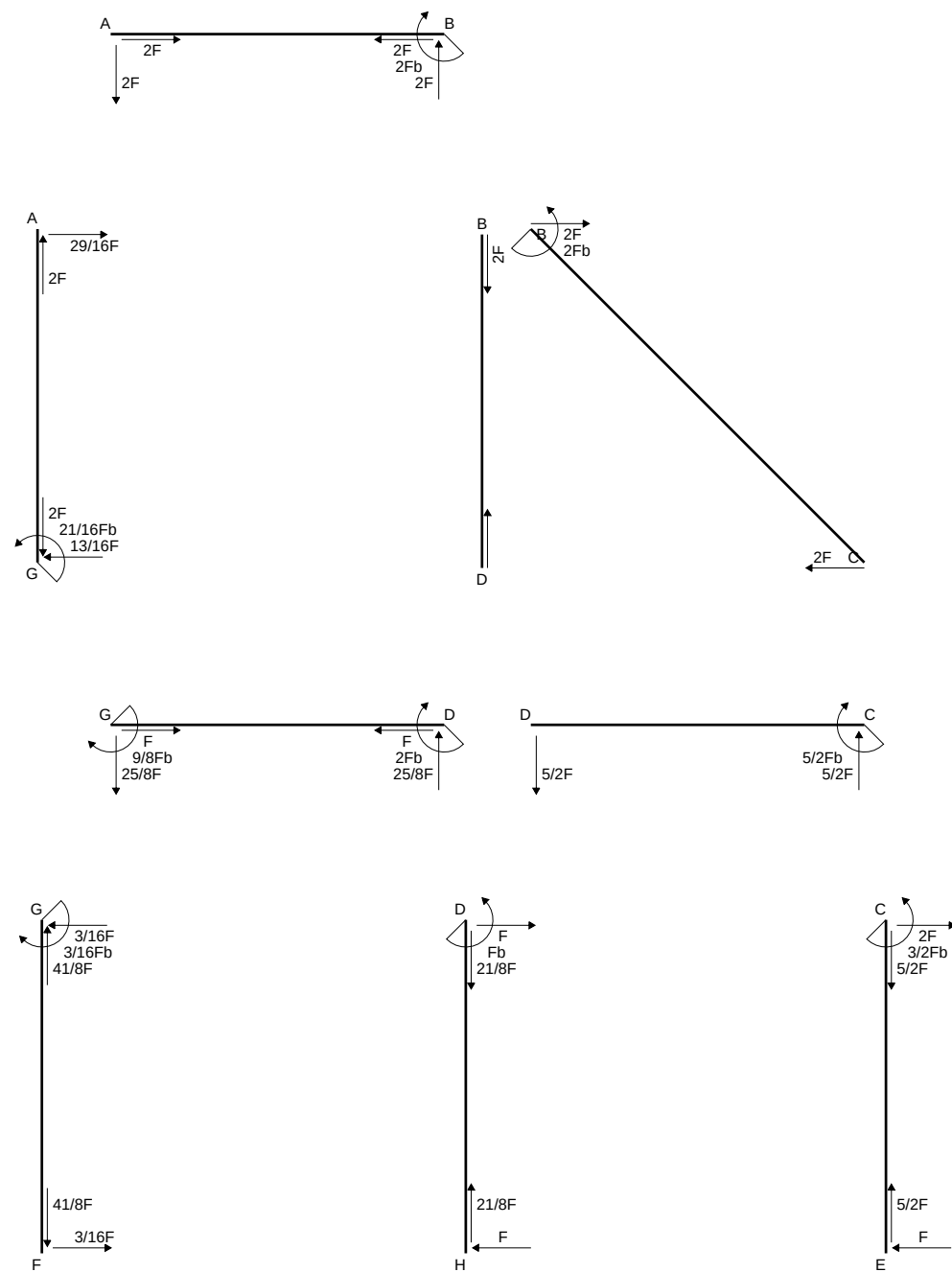
$$= \left(-\frac{1}{2} b + \frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{4} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$



$$\begin{aligned} A &= 834. \text{ mm}^2 \\ J_u &= 263619. \text{ mm}^4 \\ J_v &= 77670. \text{ mm}^4 \\ y_g &= 18.48 \text{ mm} \\ T_y &= -2640. \text{ N} \\ M_x &= -1504800. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 36.52 \text{ mm} \\ \sigma_m &= -Mv/J_u = 208.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 26.52 \text{ mm} \\ \sigma_c &= -Mv/J_u = 151.4 \text{ N/mm}^2 \\ \tau_c &= 7.185 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 151.9 \text{ N/mm}^2 \\ S &= 4305. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	3/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/8+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-3/4Fx	Fb/EJ	3/8Fb-3/4Fx+3/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx ²	0	-3/8Fb+1/2Fx+1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-7/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx ²	0	-5/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

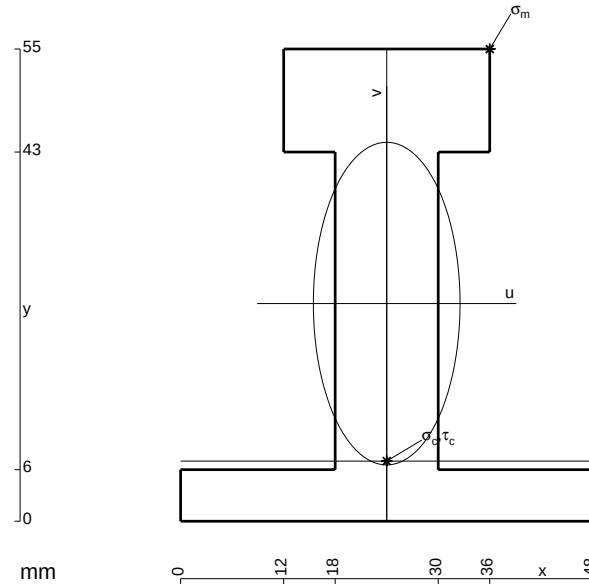
$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

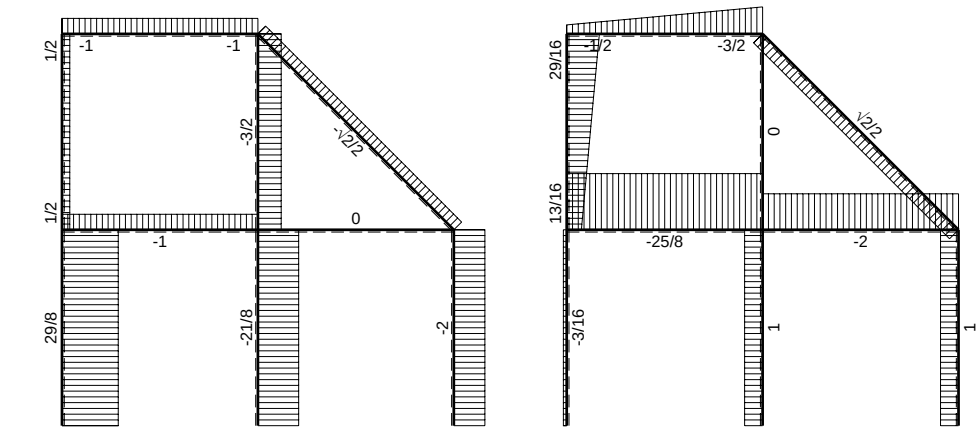
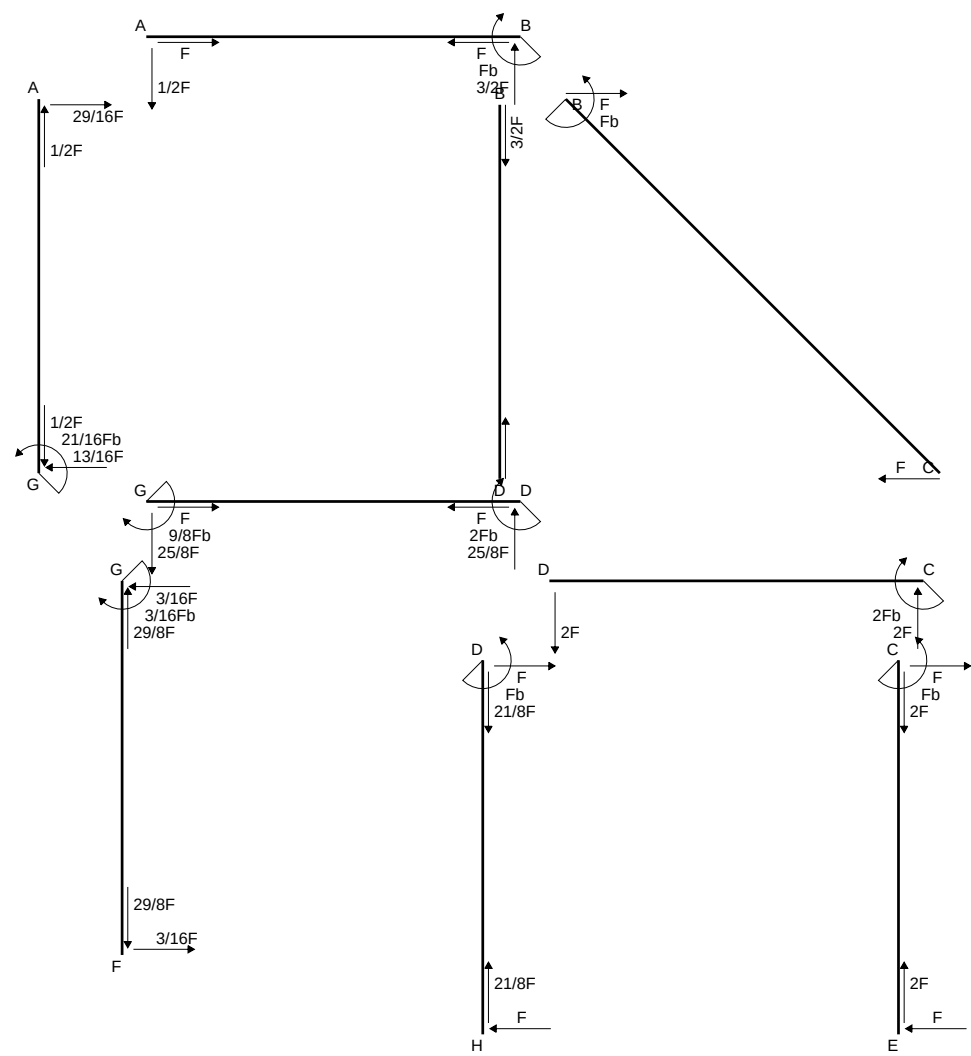
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

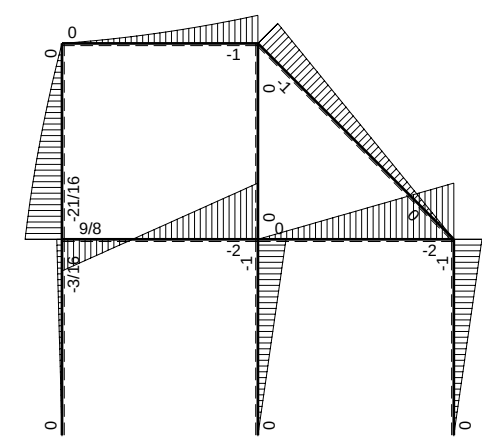


$$\begin{aligned} A &= 1020. \text{ mm}^2 \\ J_u &= 360241. \text{ mm}^4 \\ J_v &= 74448. \text{ mm}^4 \\ y_g &= 25.35 \text{ mm} \\ T_y &= -4300. \text{ N} \\ M_x &= -2666000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.65 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 7. \text{ mm} \\ v_c &= -18.35 \text{ mm} \\ \sigma_c &= -Mv/J_u = -135.8 \text{ N/mm}^2 \\ \tau_c &= 6.627 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 136.3 \text{ N/mm}^2 \\ S &= 6662. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/4Fx$	$-Fb/EJ$	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-2Fx$	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-2Fx$	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$9/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

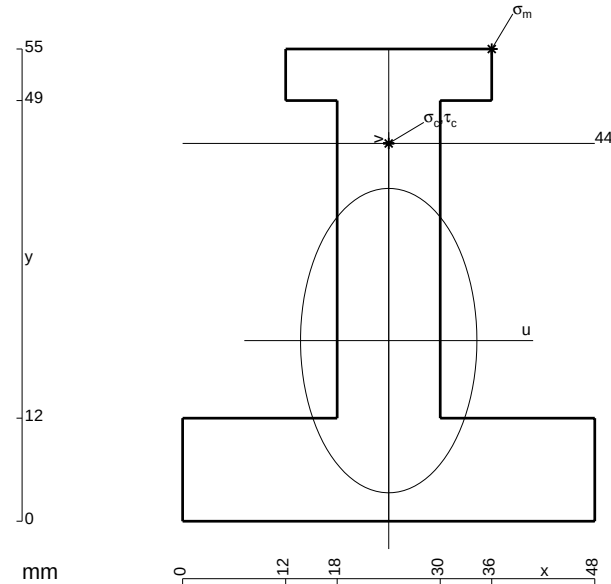
$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

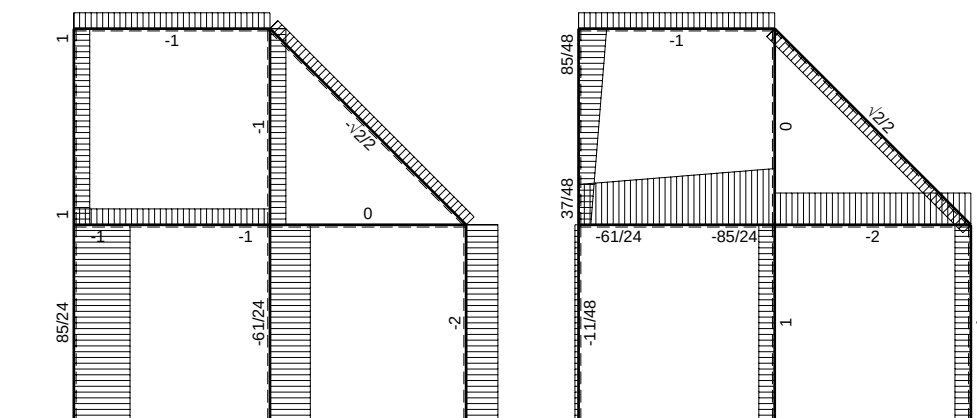
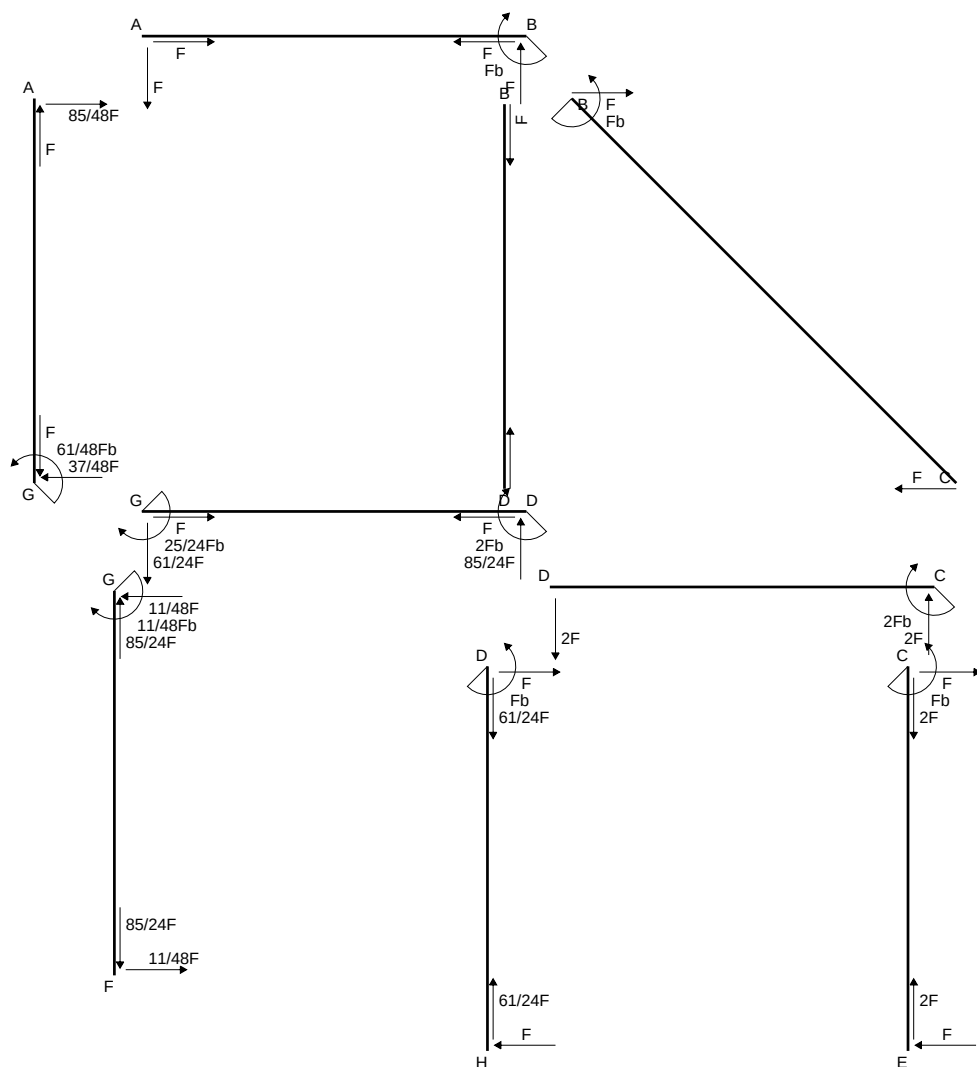
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

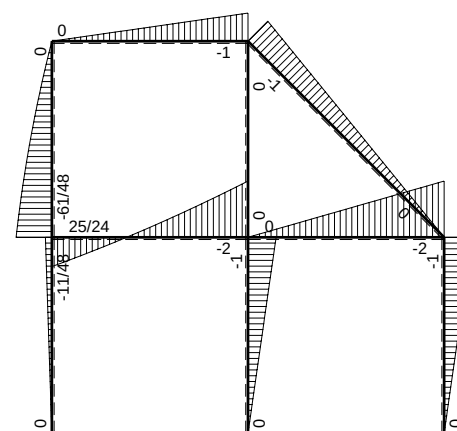
$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



$$\begin{aligned} A &= 1164. \text{ mm}^2 \\ J_u &= 366050. \text{ mm}^4 \\ J_v &= 122832. \text{ mm}^4 \\ y_g &= 21.04 \text{ mm} \\ T_y &= -3680. \text{ N} \\ M_x &= -2465600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 55. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 33.96 \text{ mm} \\ \sigma_m &= -Mv/J_u = 228.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 22.96 \text{ mm} \\ \sigma_c &= -Mv/J_u = 154.7 \text{ N/mm}^2 \\ \tau_c &= 5.015 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 154.9 \text{ N/mm}^2 \\ S &= 5987. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

$\uparrow \boxed{+} \downarrow F$

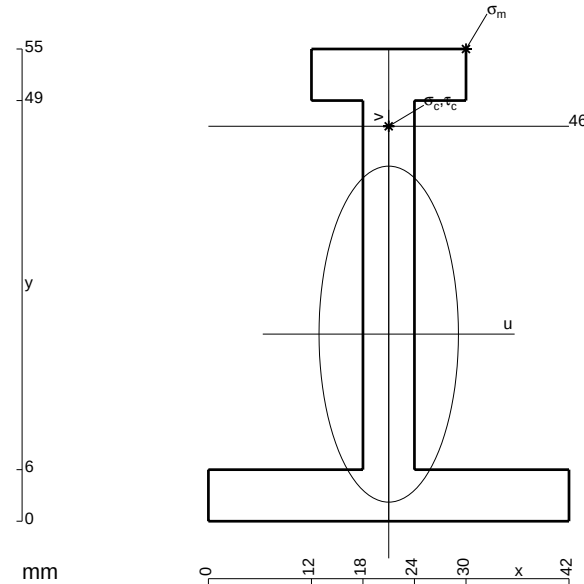


Quadro contributi PLV per iperstatica $X=W_{GD}$

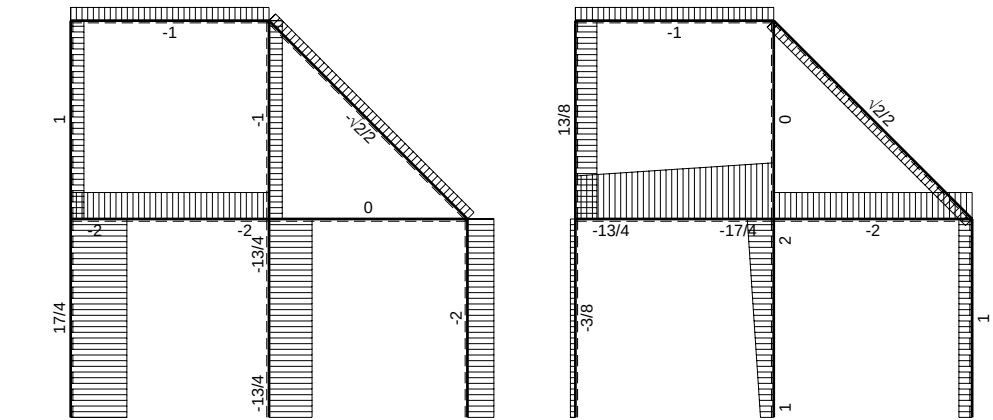
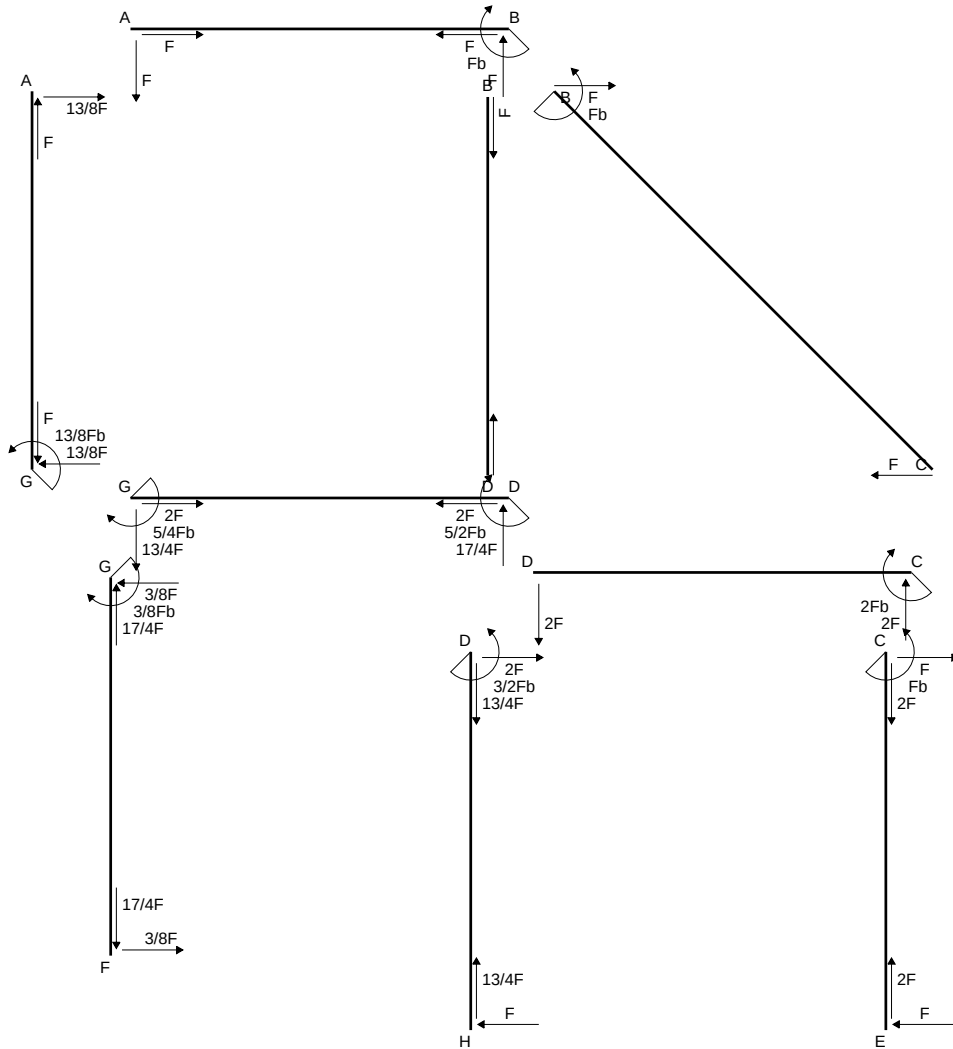
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	-1+x/b	$-3/2Fx-1/2qx^2$	0	$3/2Fx-Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(7/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-5/2Fx+1/2qx^2$	0	$2Fx-5/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	-1/2x/b	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$25/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-25/24Fb	

Sviluppi di calcolo iperstatica

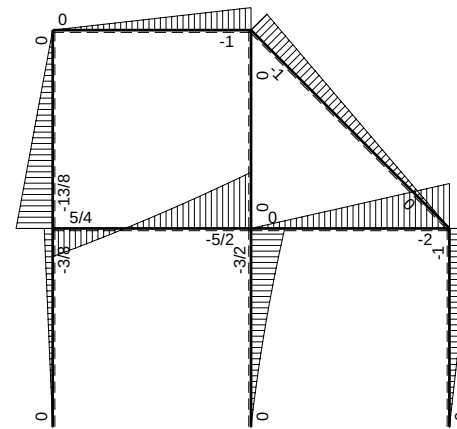
$$\begin{aligned}
L_{FG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GF}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GD}^{xx} &= \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{DG}^{xx} &= \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{GA}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{AG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{FG}^{x_0} &= \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ \\
L_{GF}^{x_0} &= \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx \\
&= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ \\
L_{GD}^{x_0} &= \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ \\
L_{DG}^{x_0} &= \int_0^b \left(2 x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ \\
L_{GA}^{x_0} &= \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx \\
&= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ \\
L_{AG}^{x_0} &= \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ
\end{aligned}$$



$$\begin{aligned}
A &= 618. \text{ mm}^2 \\
J_u &= 236783. \text{ mm}^4 \\
J_v &= 40734. \text{ mm}^4 \\
y_g &= 21.79 \text{ mm} \\
T_y &= -2360. \text{ N} \\
M_x &= -1699200. \text{ Nmm} \\
x_m &= 30. \text{ mm} \\
y_m &= 55. \text{ mm} \\
u_m &= 9. \text{ mm} \\
v_m &= 33.21 \text{ mm} \\
\sigma_m &= -Mv/J_u = 238.3 \text{ N/mm}^2 \\
x_c &= 21. \text{ mm} \\
y_c &= 46. \text{ mm} \\
v_c &= 24.21 \text{ mm} \\
\sigma_c &= -Mv/J_u = 173.7 \text{ N/mm}^2 \\
\tau_c &= 6.188 \text{ N/mm}^2 \\
\sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 174.1 \text{ N/mm}^2 \\
S &= 3725. \text{ mm}^3
\end{aligned}$$



A diagram showing a square block with a '+' sign inside. A horizontal arrow points to the right from the center of the block, labeled with the letter 'F'.



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	Fb-Fx	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	-1+x/b	$-2Fx-1/2qx^2$	0	$2Fx-3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(3/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$5/2Fb-3Fx+1/2qx^2$	0	$5/2Fx-3Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	-Fb+Fx	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	-1/2x/b	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/8Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-5/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - \frac{3}{2} x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{1}{2} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{1}{2} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{3}{8} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{5}{2} x/b - 3 x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

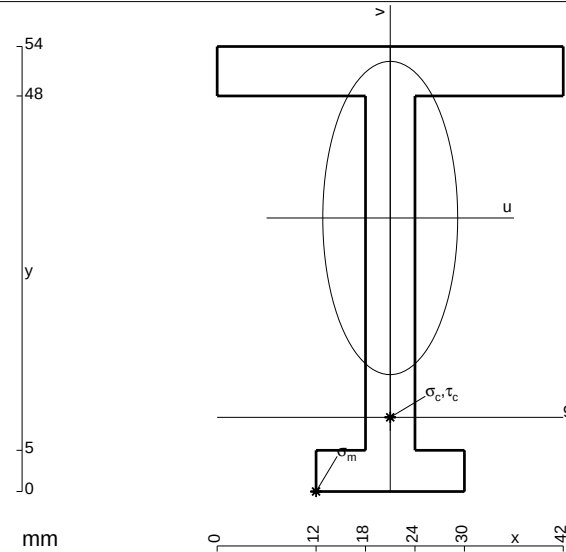
$$= \left(\frac{5}{4} b - b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{3}{8} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

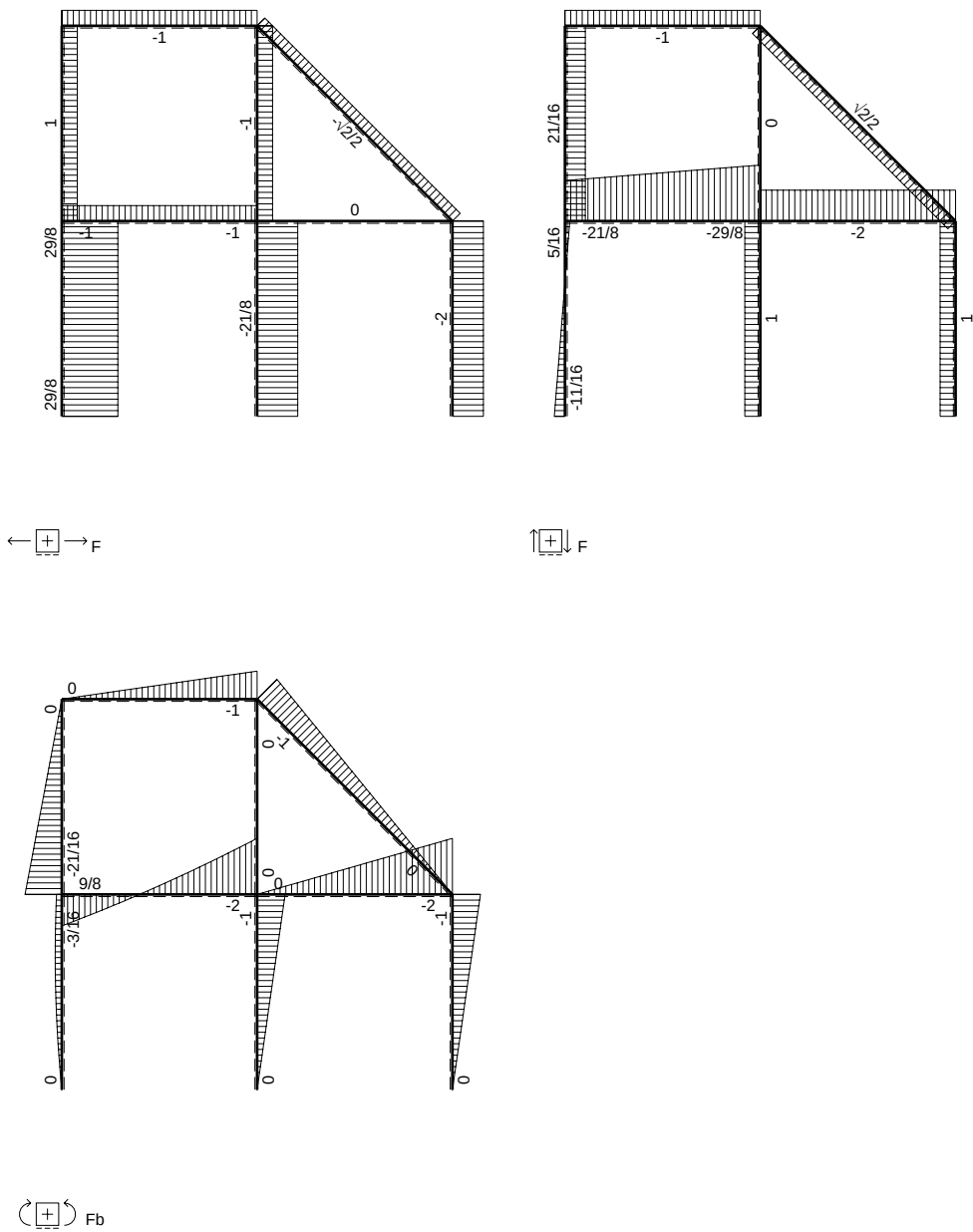
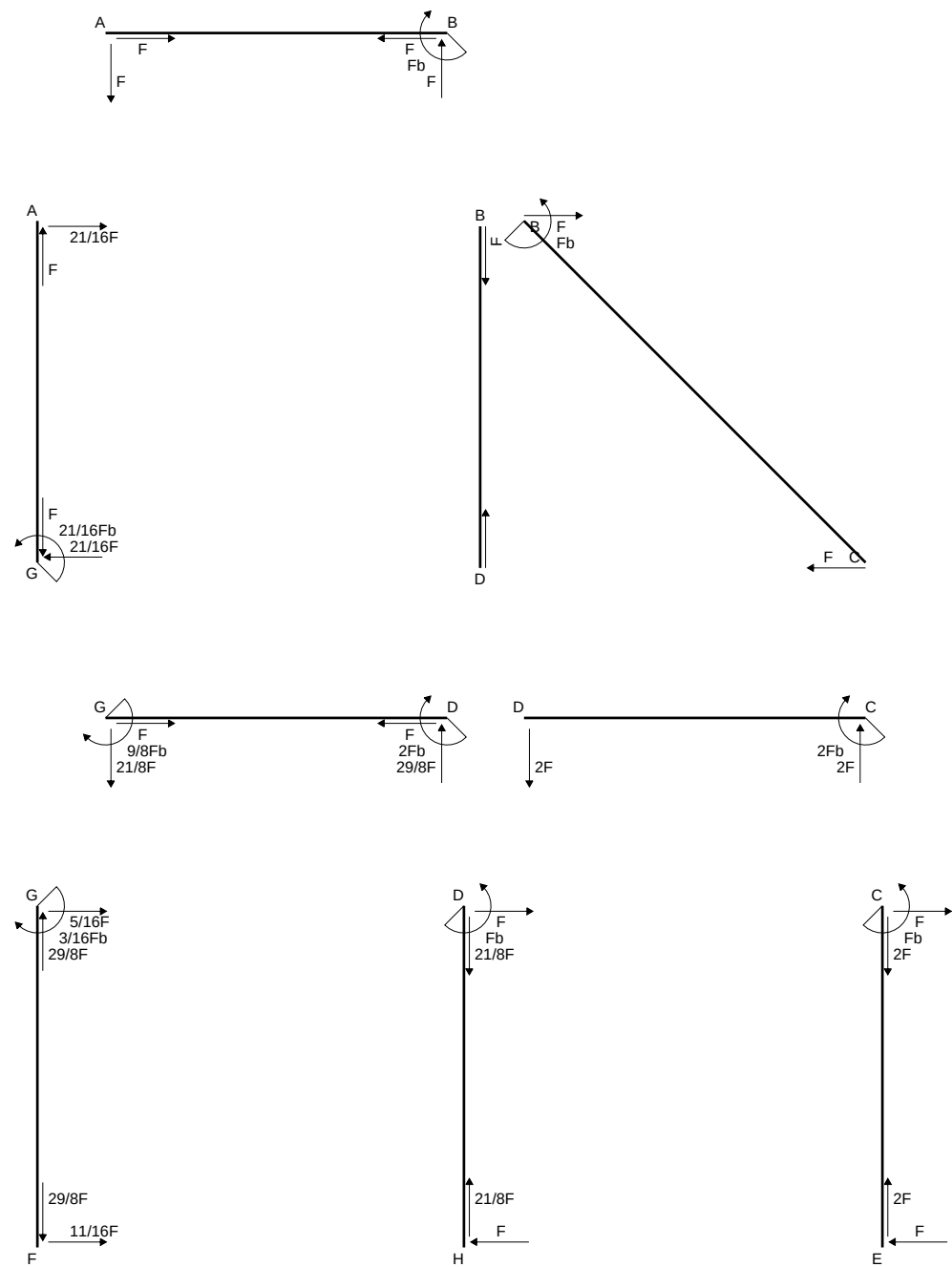
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

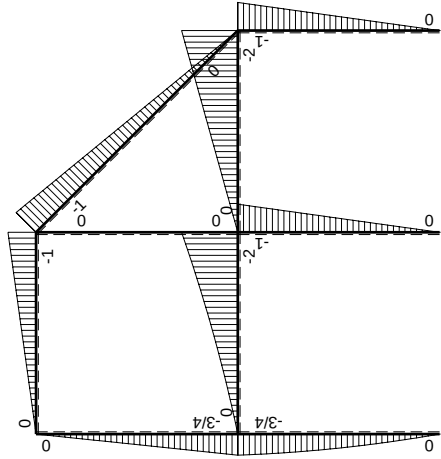
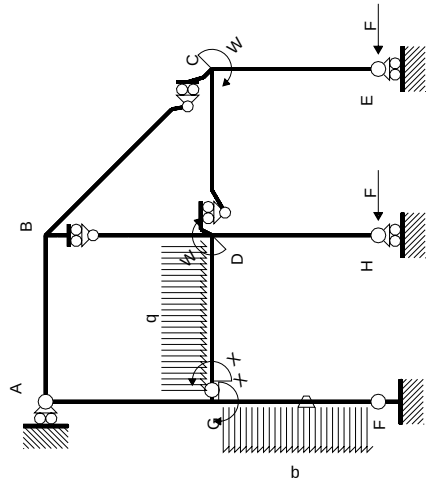
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



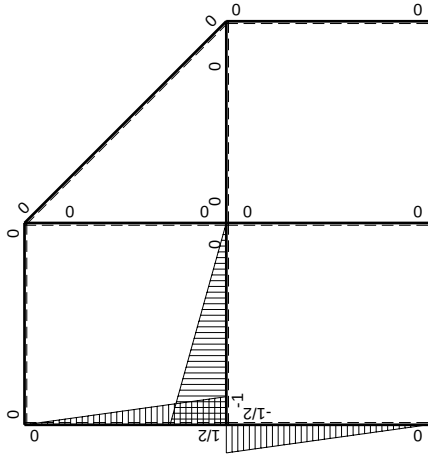
$$\begin{aligned} A &= 600. \text{ mm}^2 \\ J_u &= 216946. \text{ mm}^4 \\ J_v &= 40248. \text{ mm}^4 \\ y_g &= 33.19 \text{ mm} \\ T_y &= -1720. \text{ N} \\ M_x &= -1307200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -33.19 \text{ mm} \\ \sigma_m &= -Mv/J_u = -200. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -24.19 \text{ mm} \\ \sigma_c &= -Mv/J_u = -145.8 \text{ N/mm}^2 \\ \tau_c &= 4.48 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 146. \text{ N/mm}^2 \\ S^* &= 3391. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-5/4Fx+1/2qx ²	-Fb/EJ	5/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(7/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-1/4Fx-1/2qx ²	Fb/EJ	3/8Fb-1/2Fx-1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-3/2Fx-1/2qx ²	0	3/2Fx-Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(7/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	2Fb-5/2Fx+1/2qx ²	0	2Fx-5/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/8+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx ² /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(2 x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

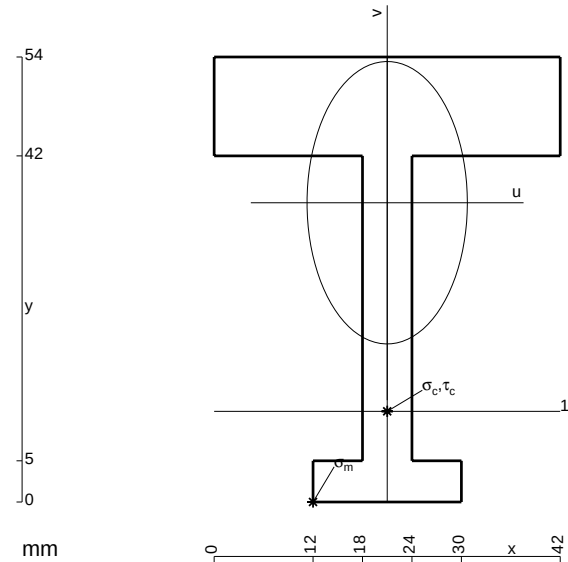
$$= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

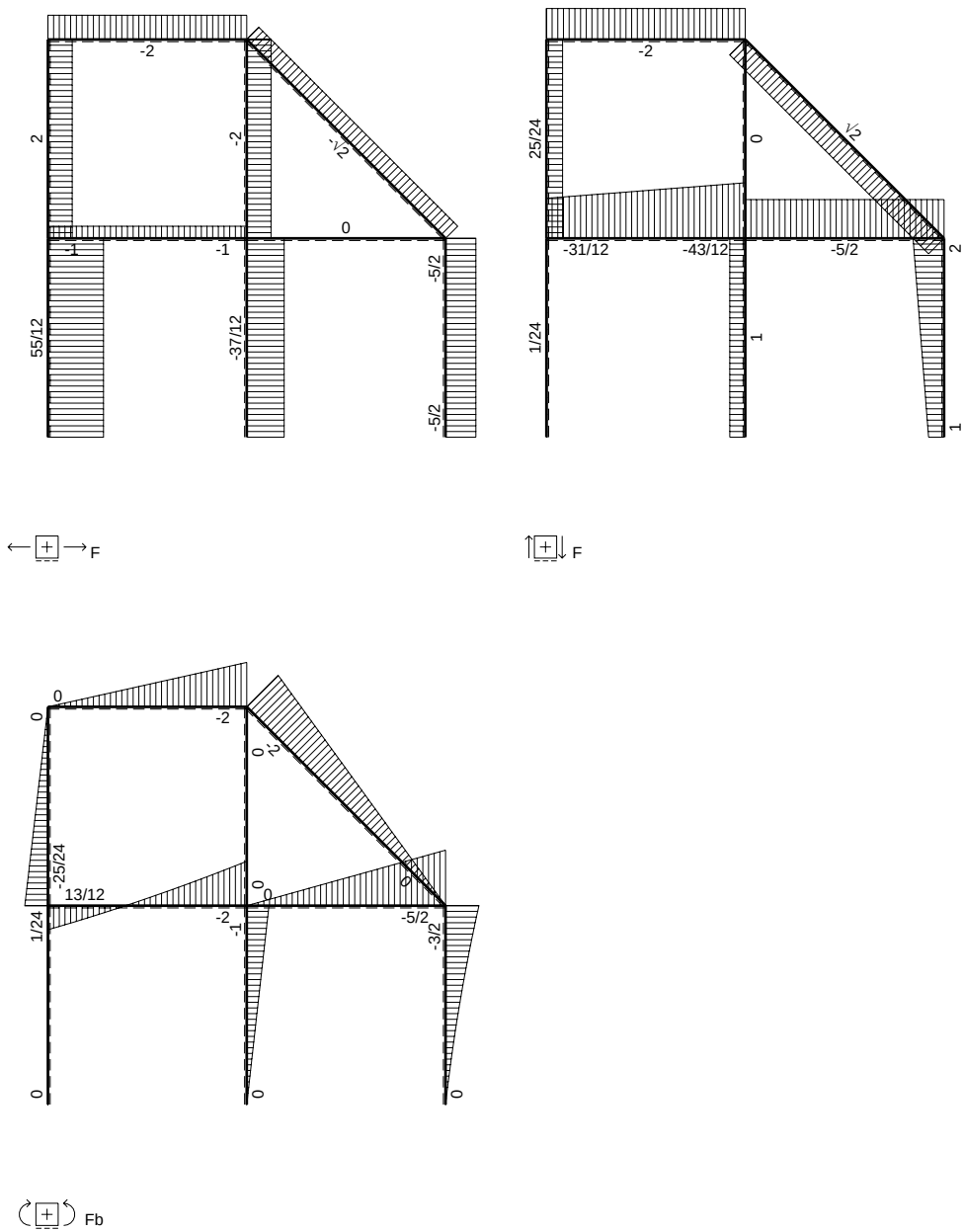
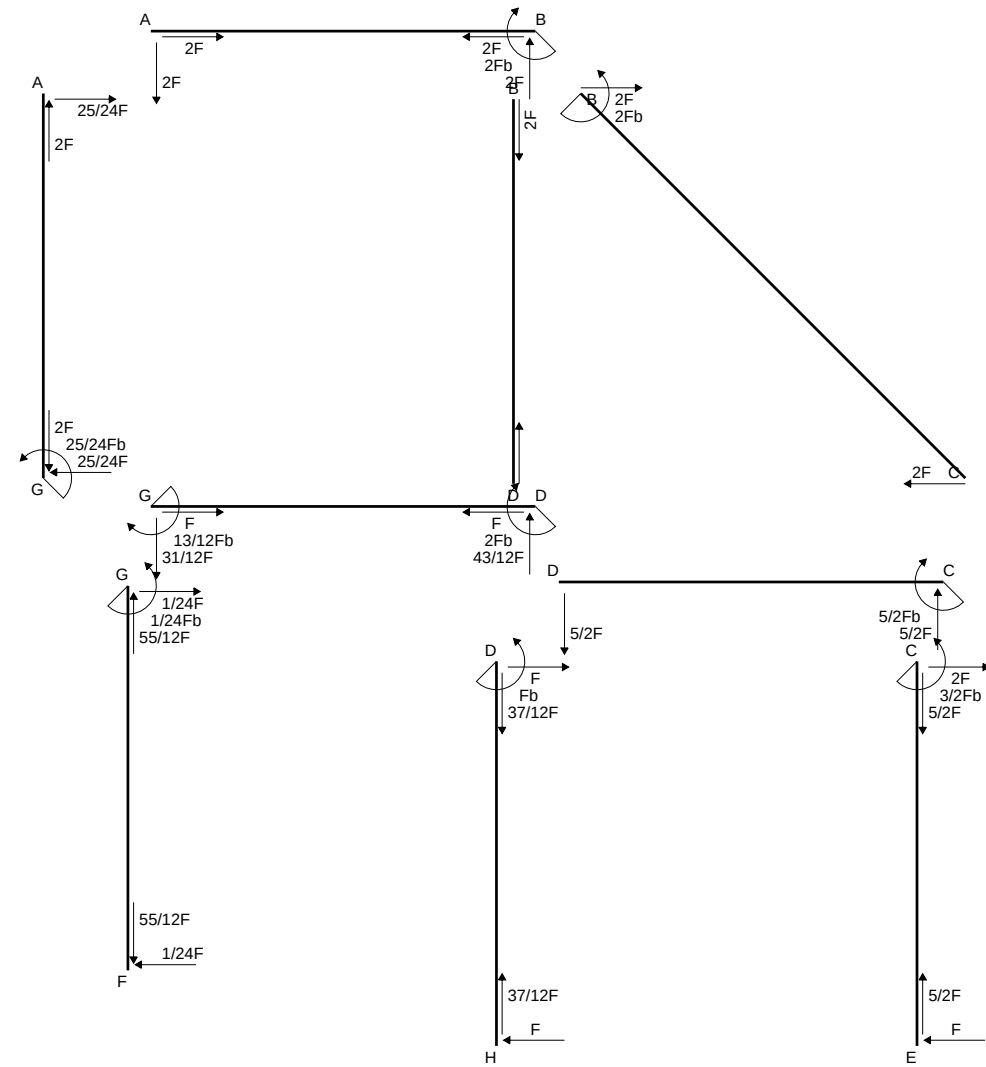
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

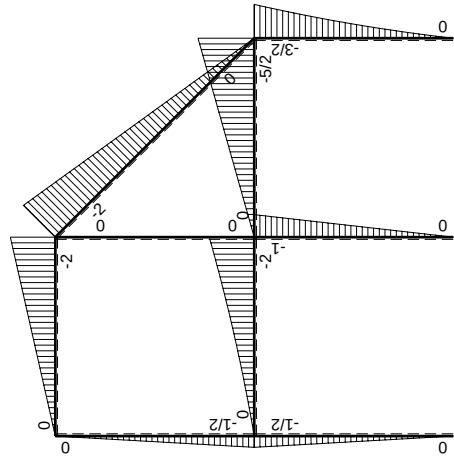
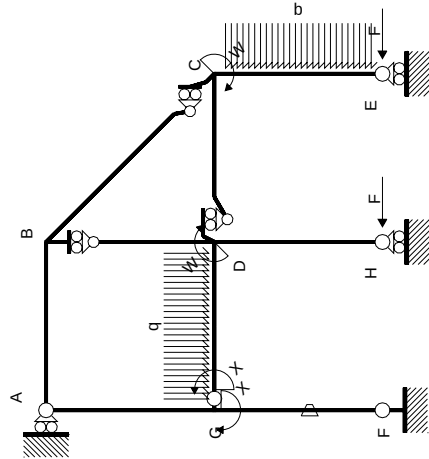
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$



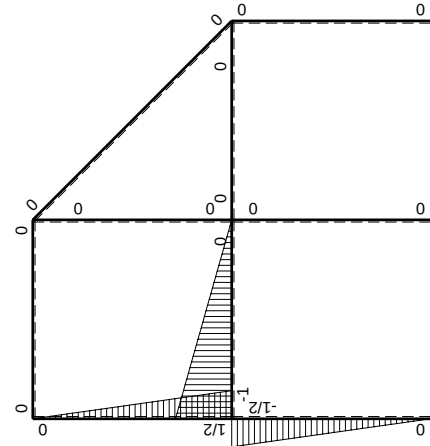
$$\begin{aligned} A &= 816. \text{ mm}^2 \\ J_u &= 239746. \text{ mm}^4 \\ J_v &= 77184. \text{ mm}^4 \\ y_g &= 36.32 \text{ mm} \\ T_y &= -1700. \text{ N} \\ M_x &= -1377000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -36.32 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.6 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -25.32 \text{ mm} \\ \sigma_c &= -Mv/J_u = -145.4 \text{ N/mm}^2 \\ \tau_c &= 4.801 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 145.6 \text{ N/mm}^2 \\ S &= 4063. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-1/2Fx	-Fb/EJ	1/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-1/2Fx	Fb/EJ	1/4Fb-1/2Fx+1/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-3/2Fx-1/2qx ²	0	3/2Fx-Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(7/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	2Fb-5/2Fx+1/2qx ²	0	2Fx-5/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						13/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

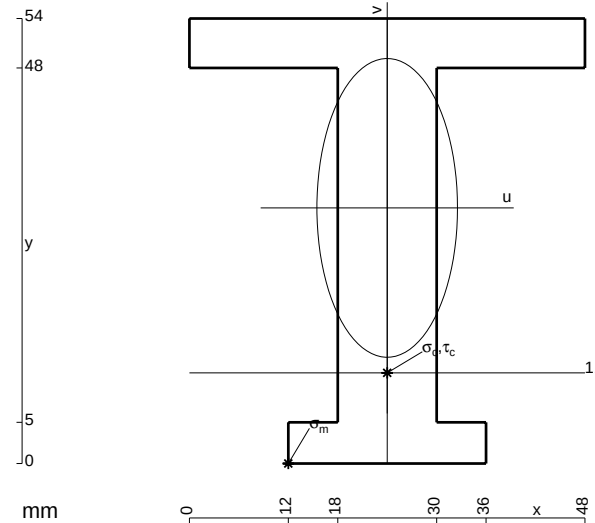
$$= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

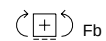
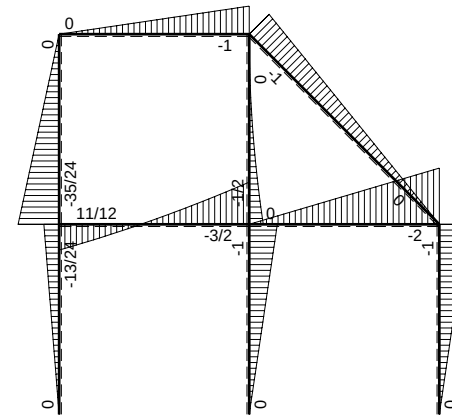
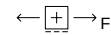
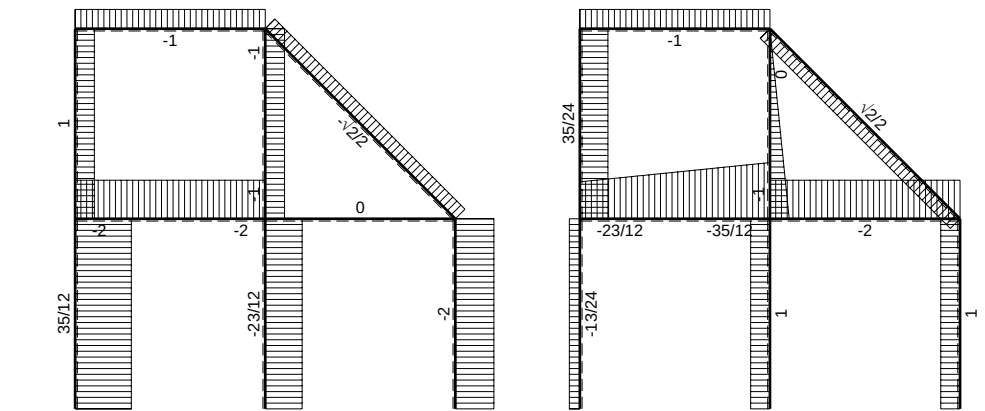
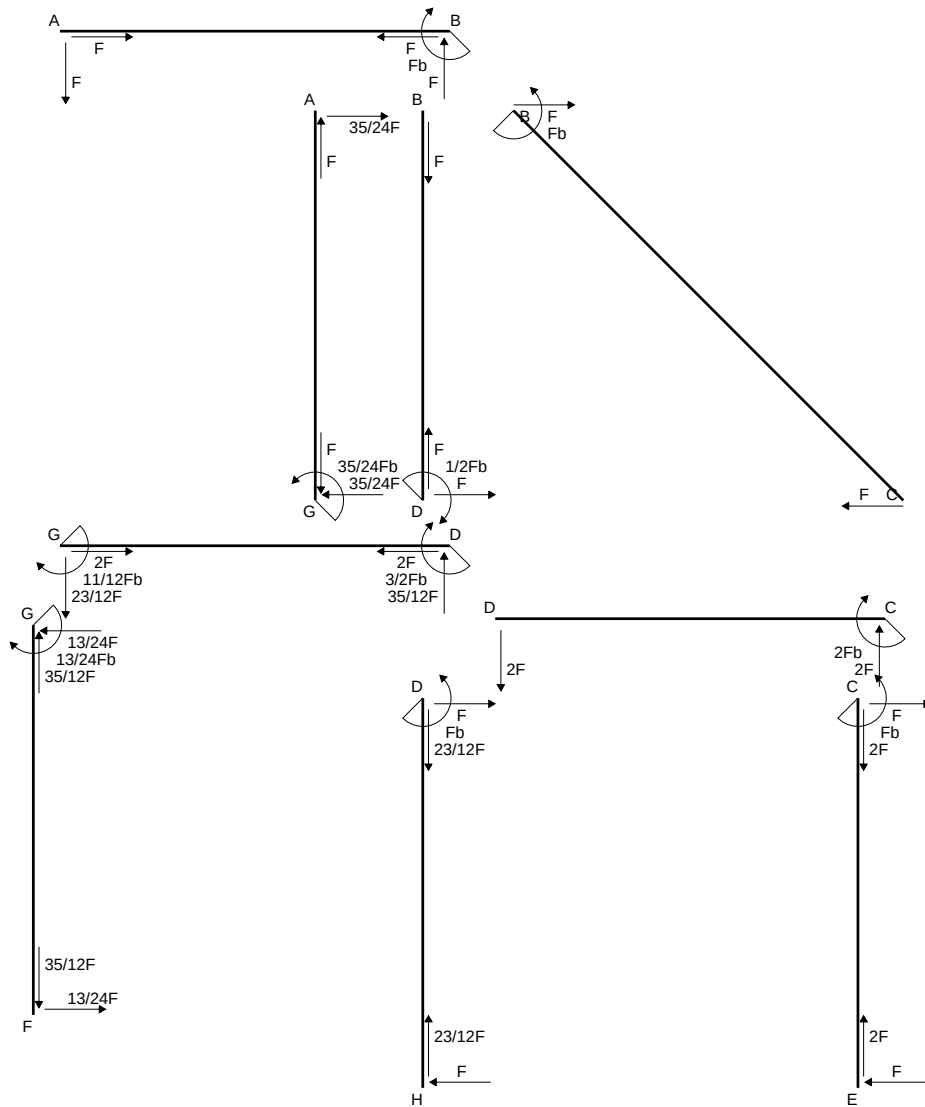
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

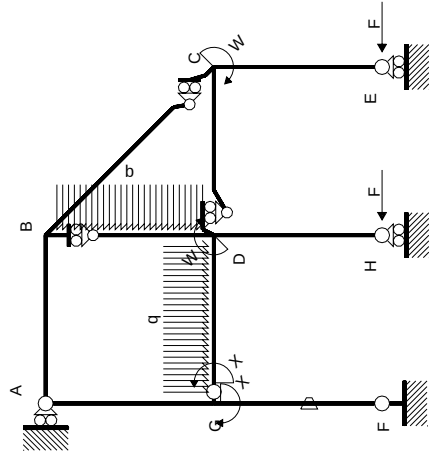
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$



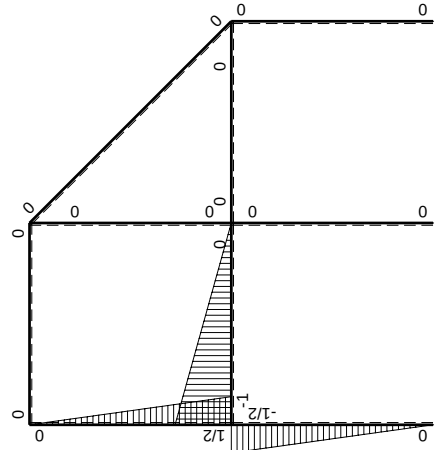
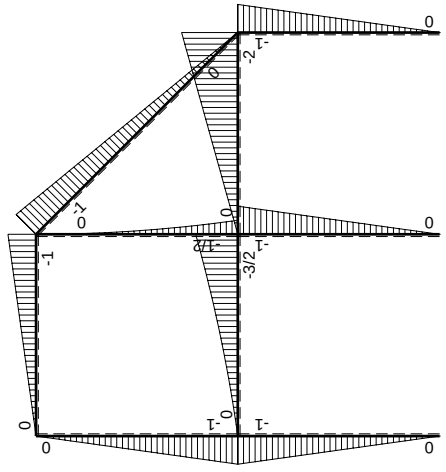
$$\begin{aligned} A &= 924. \text{ mm}^2 \\ J_u &= 303740. \text{ mm}^4 \\ J_v &= 67248. \text{ mm}^4 \\ y_g &= 31.02 \text{ mm} \\ T_y &= -2500. \text{ N} \\ M_x &= -2150000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.02 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -20.02 \text{ mm} \\ \sigma_c &= -Mv/J_u = -141.7 \text{ N/mm}^2 \\ \tau_c &= 3.484 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 141.8 \text{ N/mm}^2 \\ S &= 5080. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-Fx-1/2qx ²	0	Fx-1/2Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(5/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx ²	0	3/2Fb-2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						11/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(x/b - \frac{1}{2} x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - 2 x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{2}{3} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

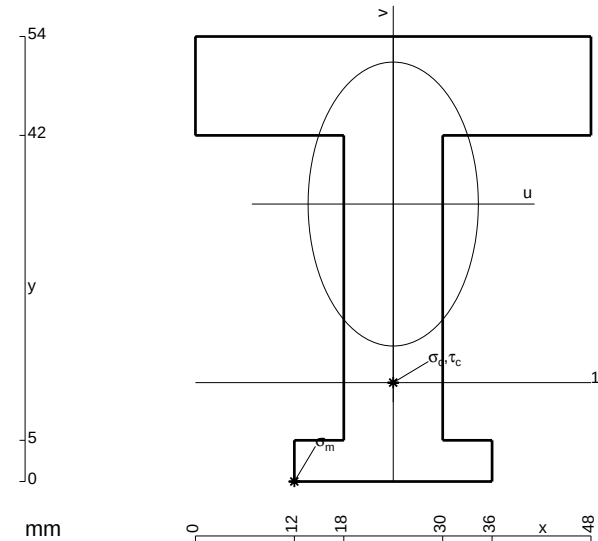
$$= \left(\frac{3}{4} b - \frac{2}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

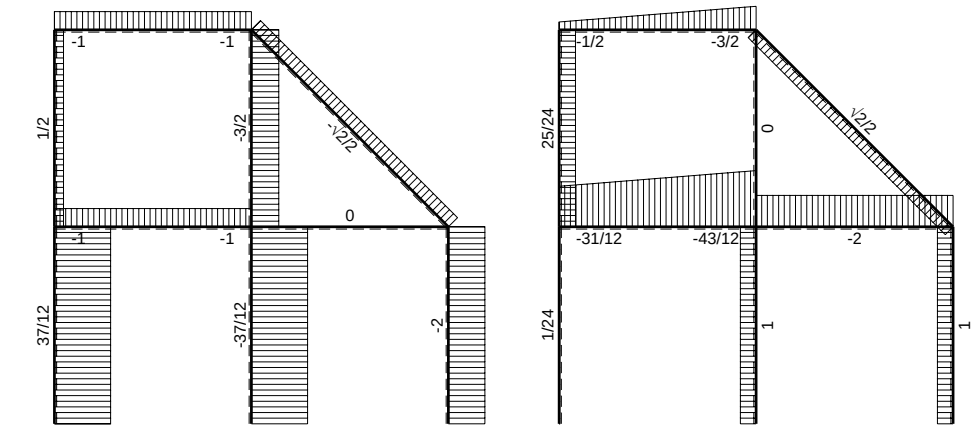
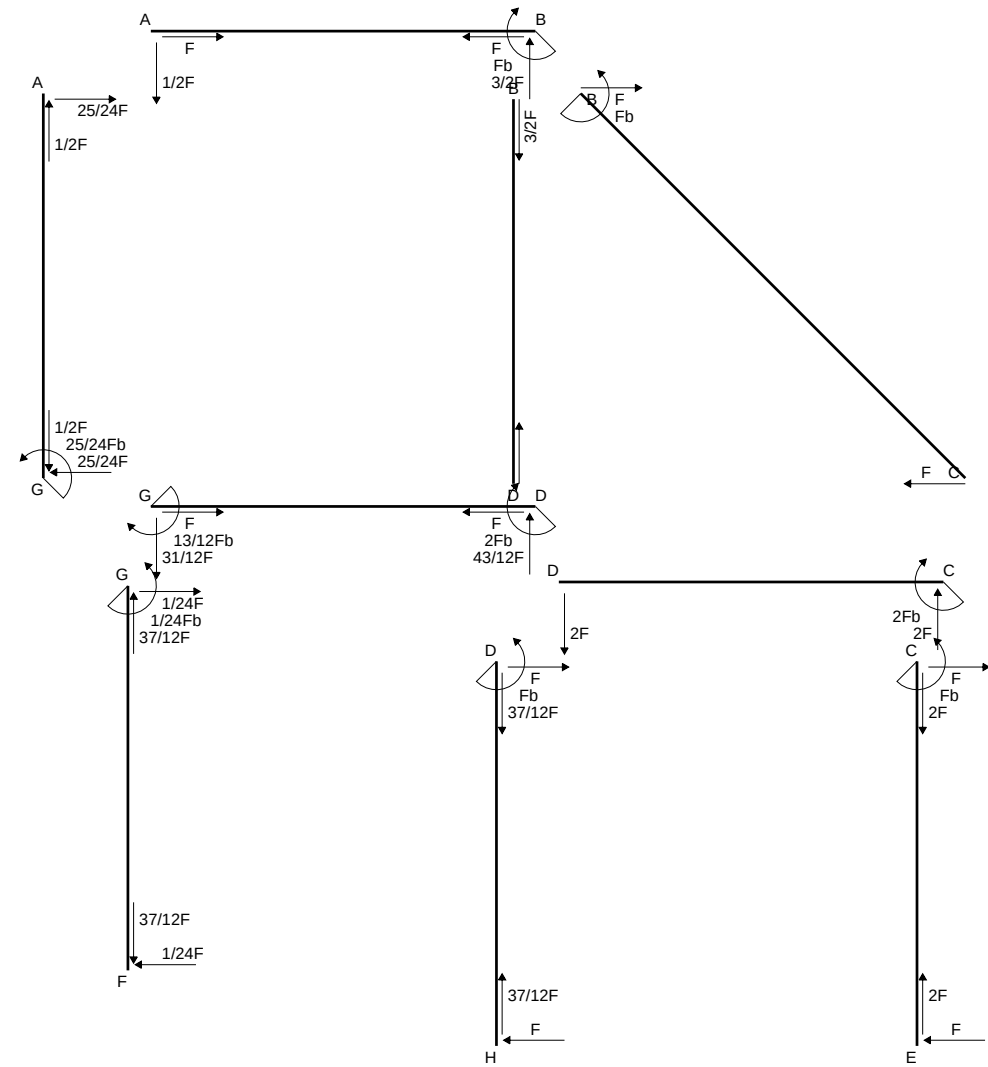
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

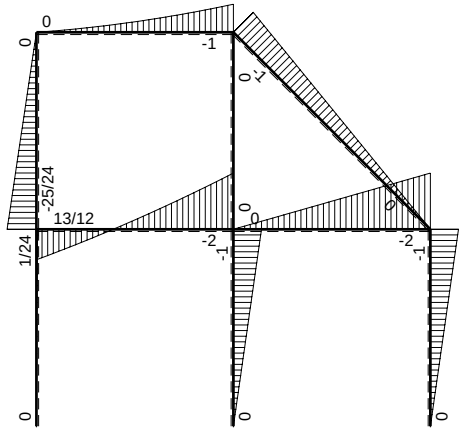


$$\begin{aligned} A &= 1140. \text{ mm}^2 \\ J_u &= 338607. \text{ mm}^4 \\ J_v &= 121680. \text{ mm}^4 \\ y_g &= 33.67 \text{ mm} \\ T_y &= -2540. \text{ N} \\ M_x &= -2311400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -33.67 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -21.67 \text{ mm} \\ \sigma_c &= -Mv/J_u = -147.9 \text{ N/mm}^2 \\ \tau_c &= 3.66 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 148. \text{ N/mm}^2 \\ S^* &= 5854. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx-1/2qx^2$	0	$3/2Fx-Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(7/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-5/2Fx+1/2qx^2$	0	$2Fx-5/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$13/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-13/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

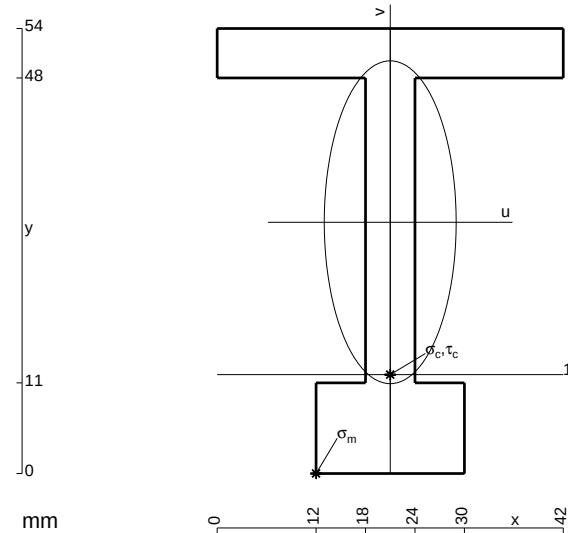
$$= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

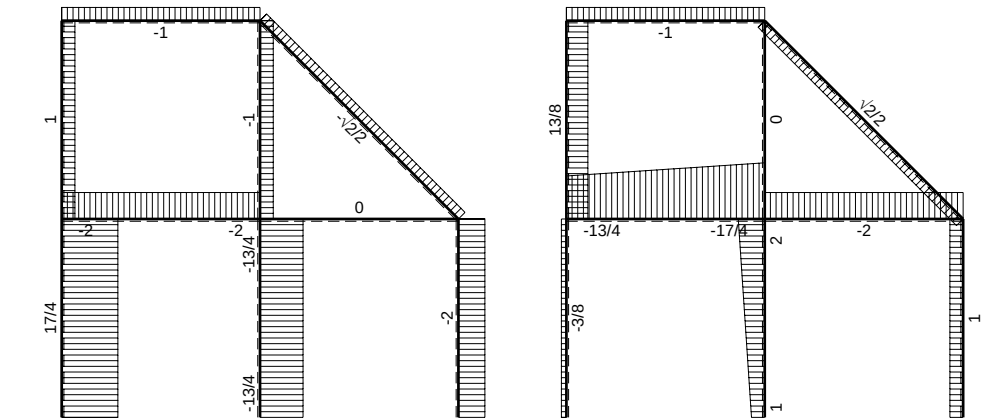
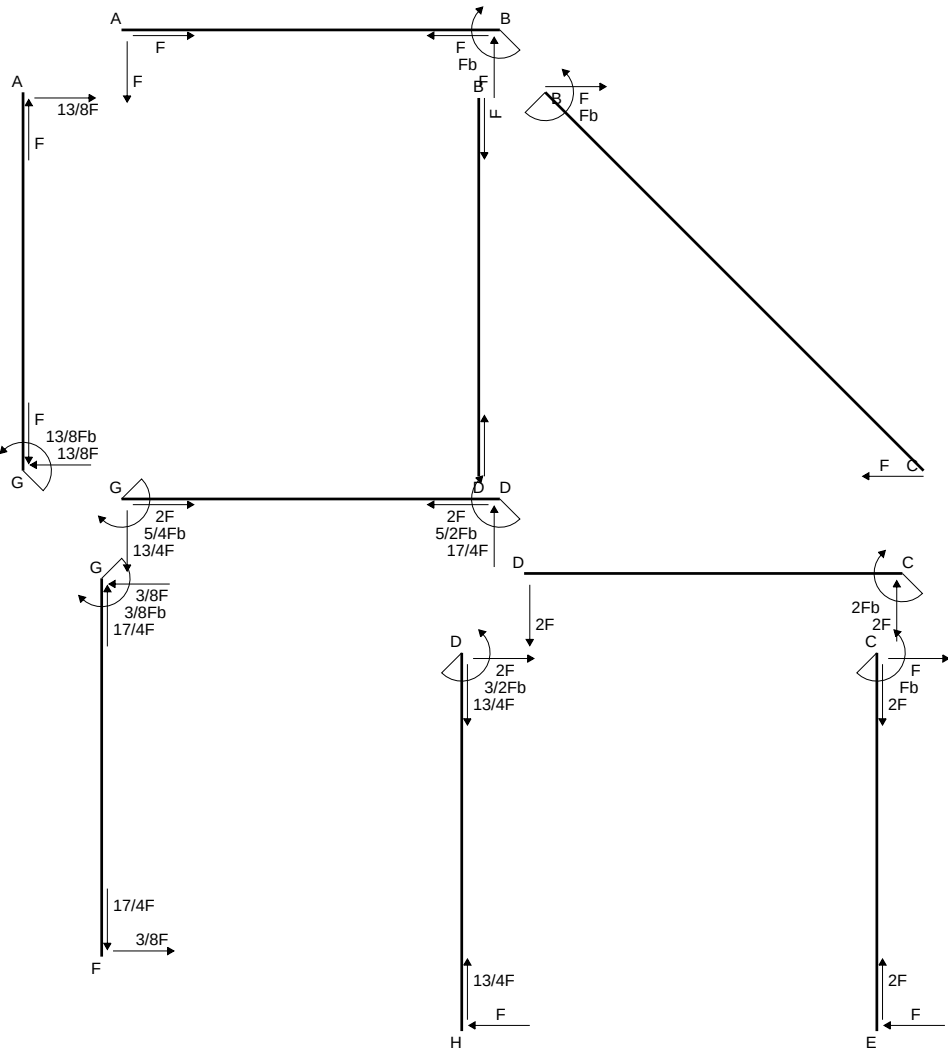
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

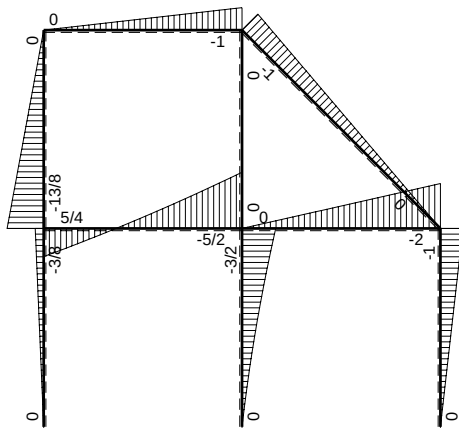


$$\begin{aligned} A &= 672. \text{ mm}^2 \\ J_u &= 257954. \text{ mm}^4 \\ J_v &= 43056. \text{ mm}^4 \\ y_g &= 30.49 \text{ mm} \\ T_y &= -2100. \text{ N} \\ M_x &= -2016000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -30.49 \text{ mm} \\ \sigma_m &= -Mv/J_u = -238.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -18.49 \text{ mm} \\ \sigma_c &= -Mv/J_u = -144.5 \text{ N/mm}^2 \\ \tau_c &= 6.869 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 145. \text{ N/mm}^2 \\ S^* &= 5062. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	Fb-Fx	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	-1+x/b	$-2Fx-1/2qx^2$	0	$2Fx-3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(3/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$5/2Fb-3Fx+1/2qx^2$	0	$5/2Fx-3Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	-Fb+Fx	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	-1/2x/b	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$5/8Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-5/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(2 x/b - \frac{3}{2} x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{1}{2} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{1}{2} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{3}{8} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{5}{2} x/b - 3 x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

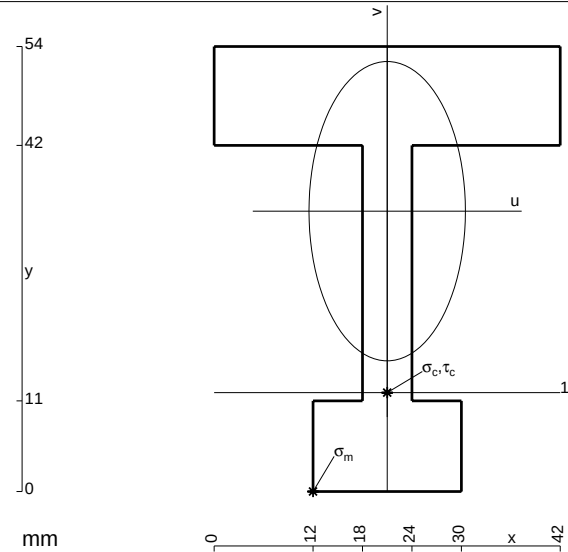
$$= \left(\frac{5}{4} b - b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{3}{8} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

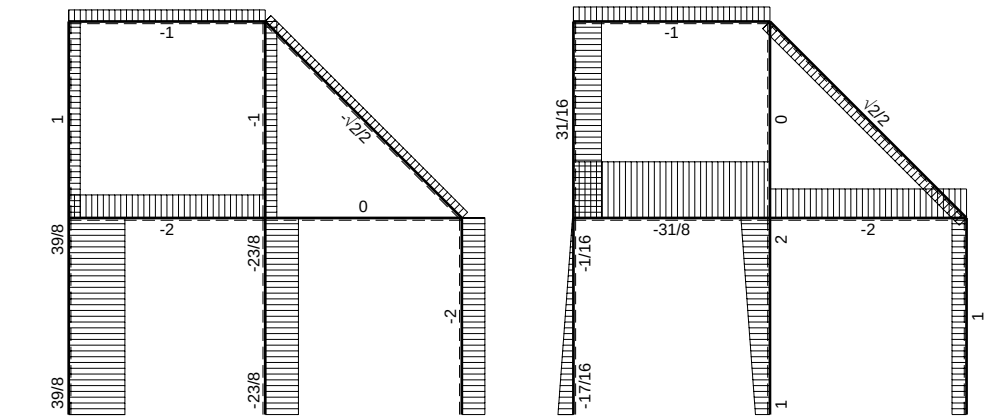
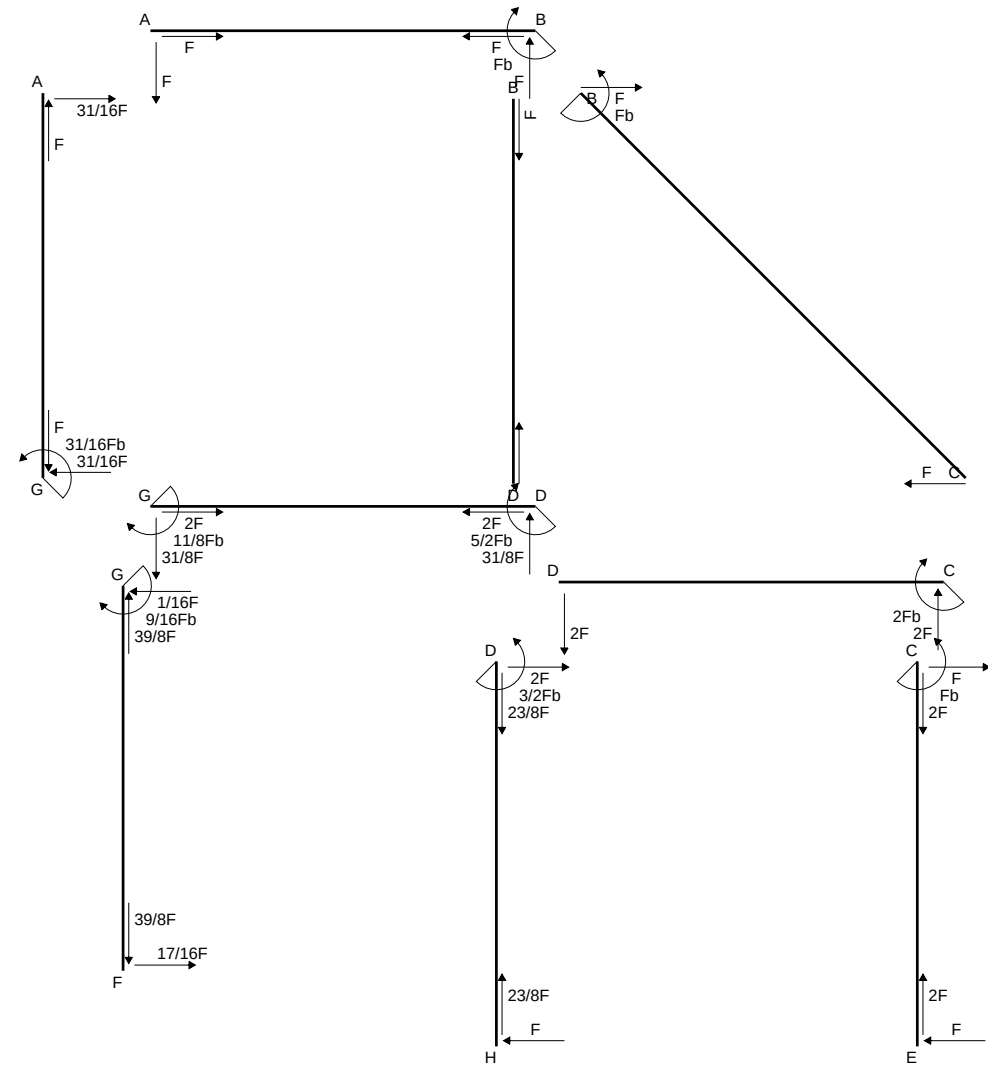
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

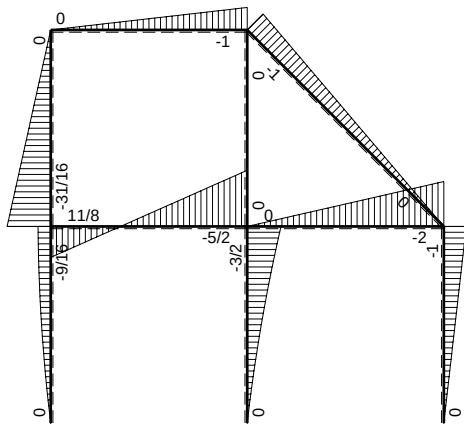


$$\begin{aligned} A &= 888. \text{ mm}^2 \\ J_u &= 293012. \text{ mm}^4 \\ J_v &= 79992. \text{ mm}^4 \\ y_g &= 34.02 \text{ mm} \\ T_y &= -3360. \text{ N} \\ M_x &= -1713600. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.02 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -22.02 \text{ mm} \\ \sigma_c &= -Mv/J_u = -128.8 \text{ N/mm}^2 \\ \tau_c &= 11.05 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 130.2 \text{ N/mm}^2 \\ S &= 5782. \text{ mm}^3 \end{aligned}$$

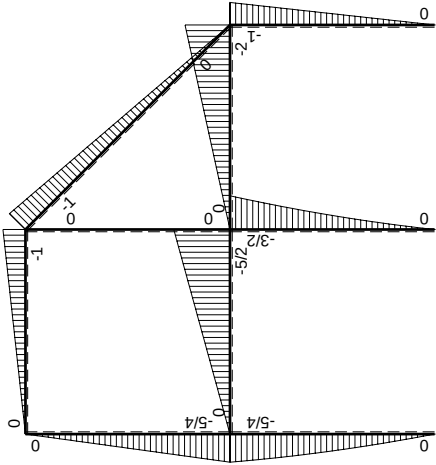
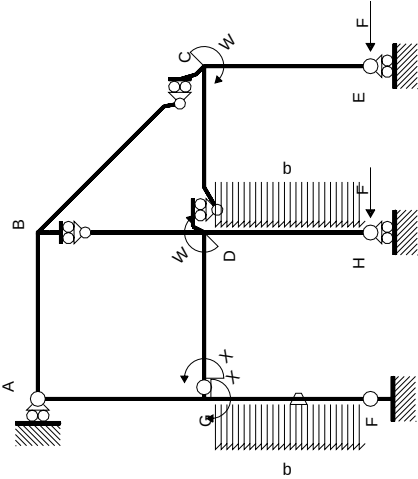


← ⊕ → F

↑ ⊕ ↓ F_b

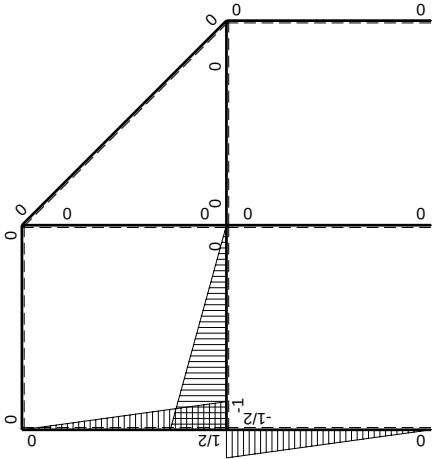


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx+1/2qx ²	-Fb/EJ	7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(11/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx ²	Fb/EJ	5/8Fb-Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-5/2Fx	0	5/2Fx-5/2Fx ² /b	0	1-2x/b+x ² /b ²	(5/12+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-5/2Fx	0	5/2Fx-5/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-5/4Fb+5/4Fx	0	-5/8Fb+5/4Fx-5/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-5/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx	0	-5/8Fx ² /b	0	1/4x ² /b ²		
	totali						11/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

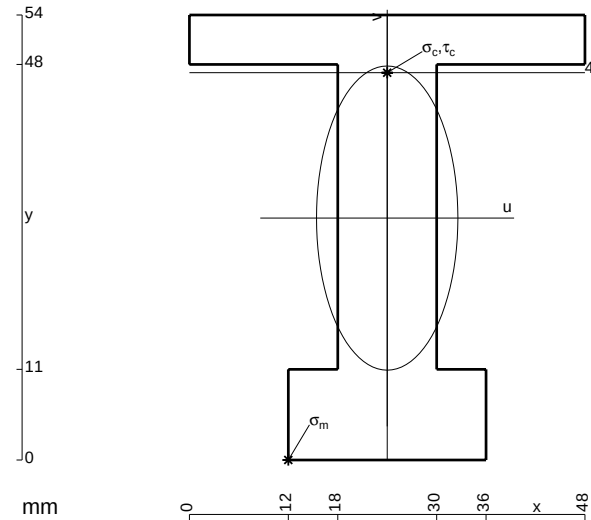
$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{5}{8} + \frac{5}{4} x/b - \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{8} x + \frac{5}{8} x^2/b - \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

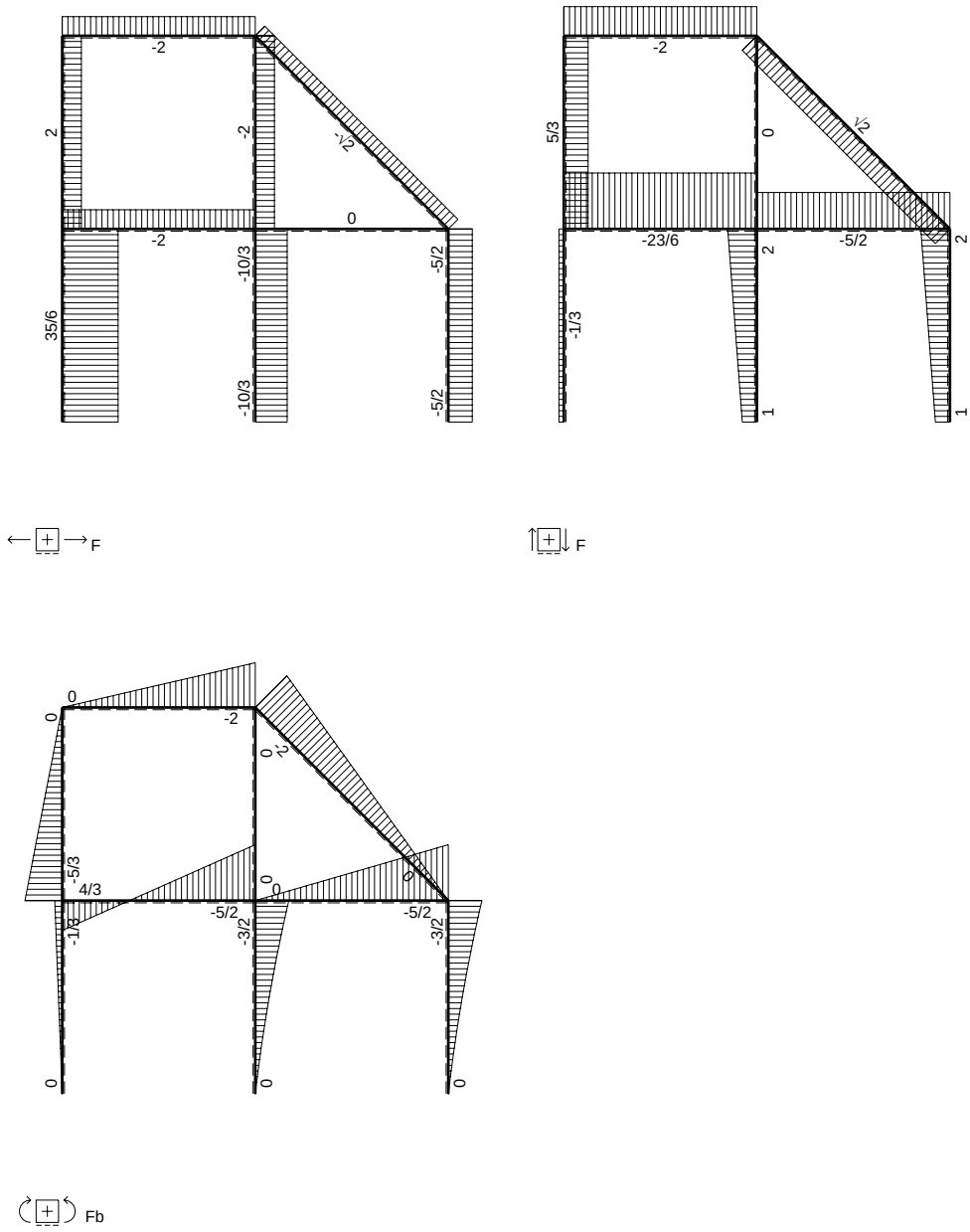
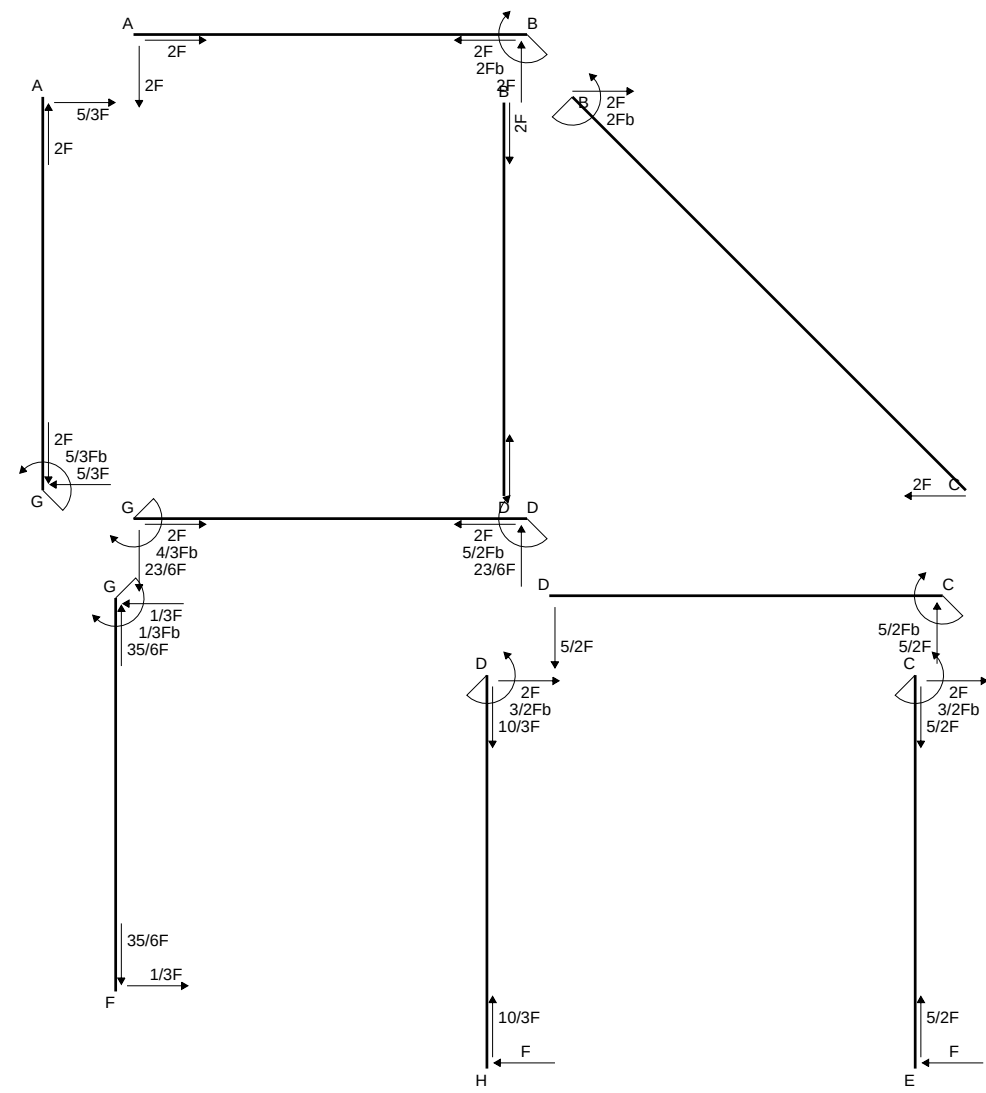
$$= \left(-\frac{5}{8} b + \frac{5}{8} b - \frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$

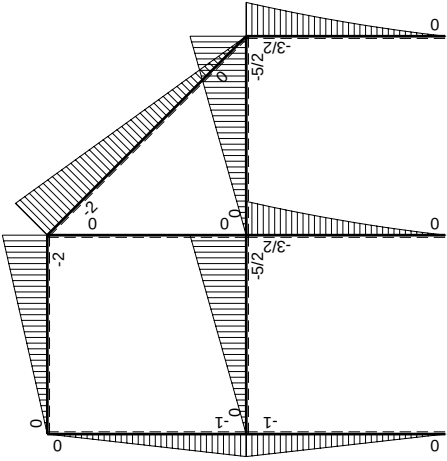
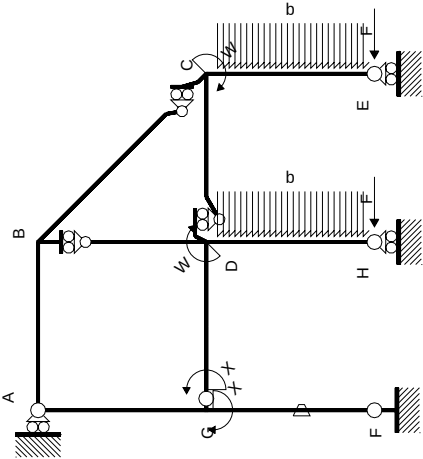
$$L_{AG}^{x_0} = \int_0^b \left(-\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$



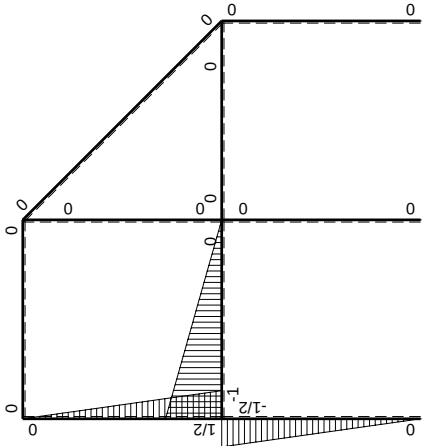
$$\begin{aligned} A &= 996. \text{ mm}^2 \\ J_u &= 339350. \text{ mm}^4 \\ J_v &= 73296. \text{ mm}^4 \\ y_g &= 29.36 \text{ mm} \\ T_y &= -4320. \text{ N} \\ M_x &= -2419200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.36 \text{ mm} \\ \sigma_m &= -Mv/J_u = -209.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 47. \text{ mm} \\ v_c &= 17.64 \text{ mm} \\ \sigma_c &= -Mv/J_u = 125.8 \text{ N/mm}^2 \\ \tau_c &= 6.844 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 126.3 \text{ N/mm}^2 \\ S &= 6451. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-5/2Fx	0	5/2Fx-5/2Fx ² /b	0	1-2x/b+x ² /b ²	(5/12+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-5/2Fx	0	5/2Fx-5/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						2/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-4/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

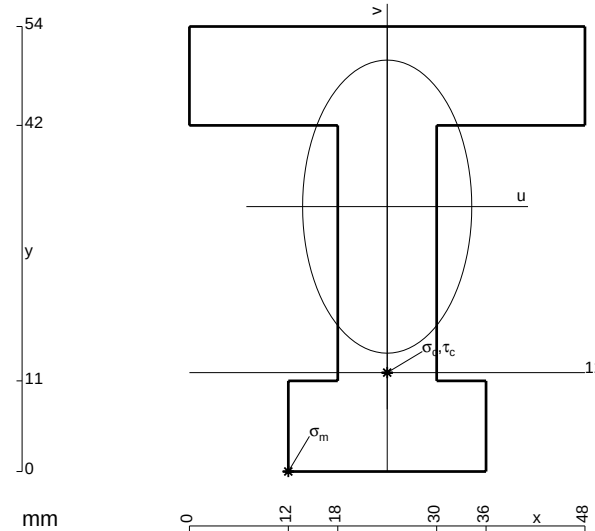
$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

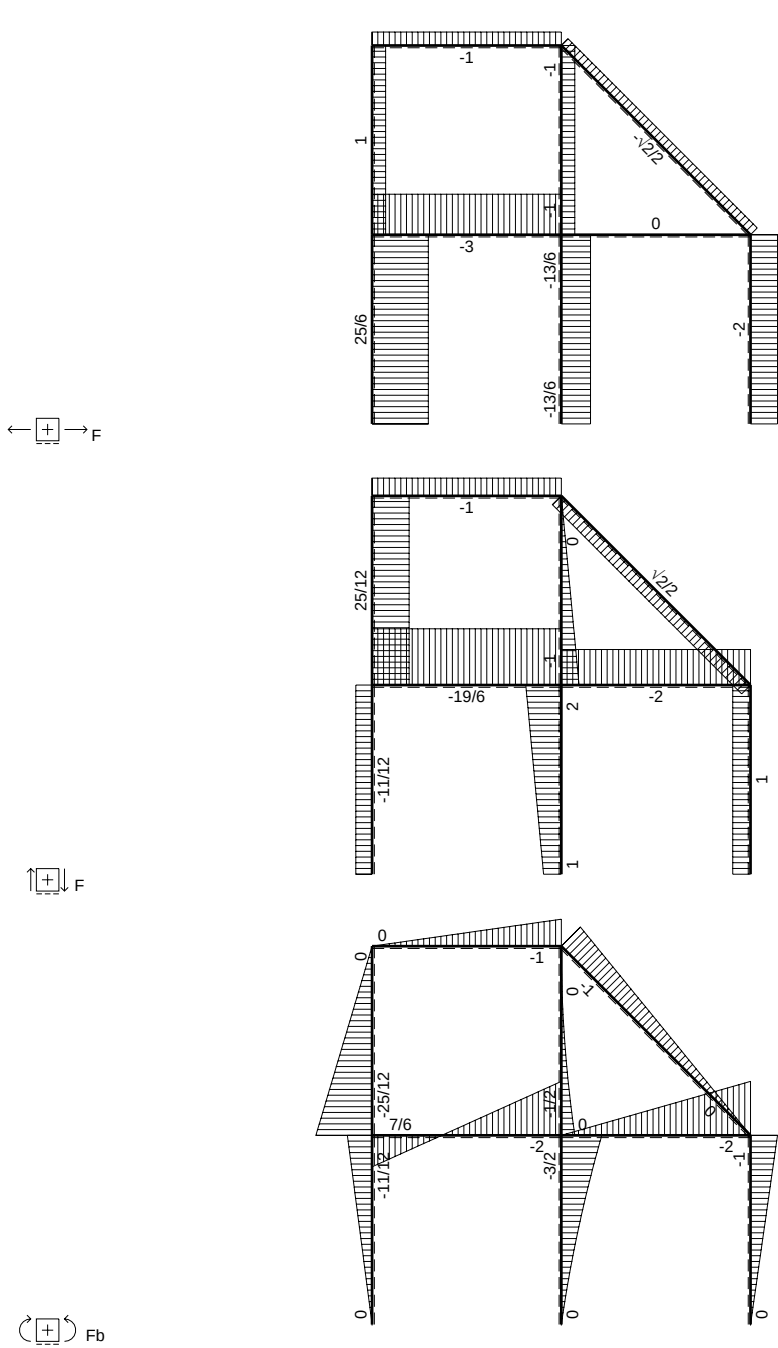
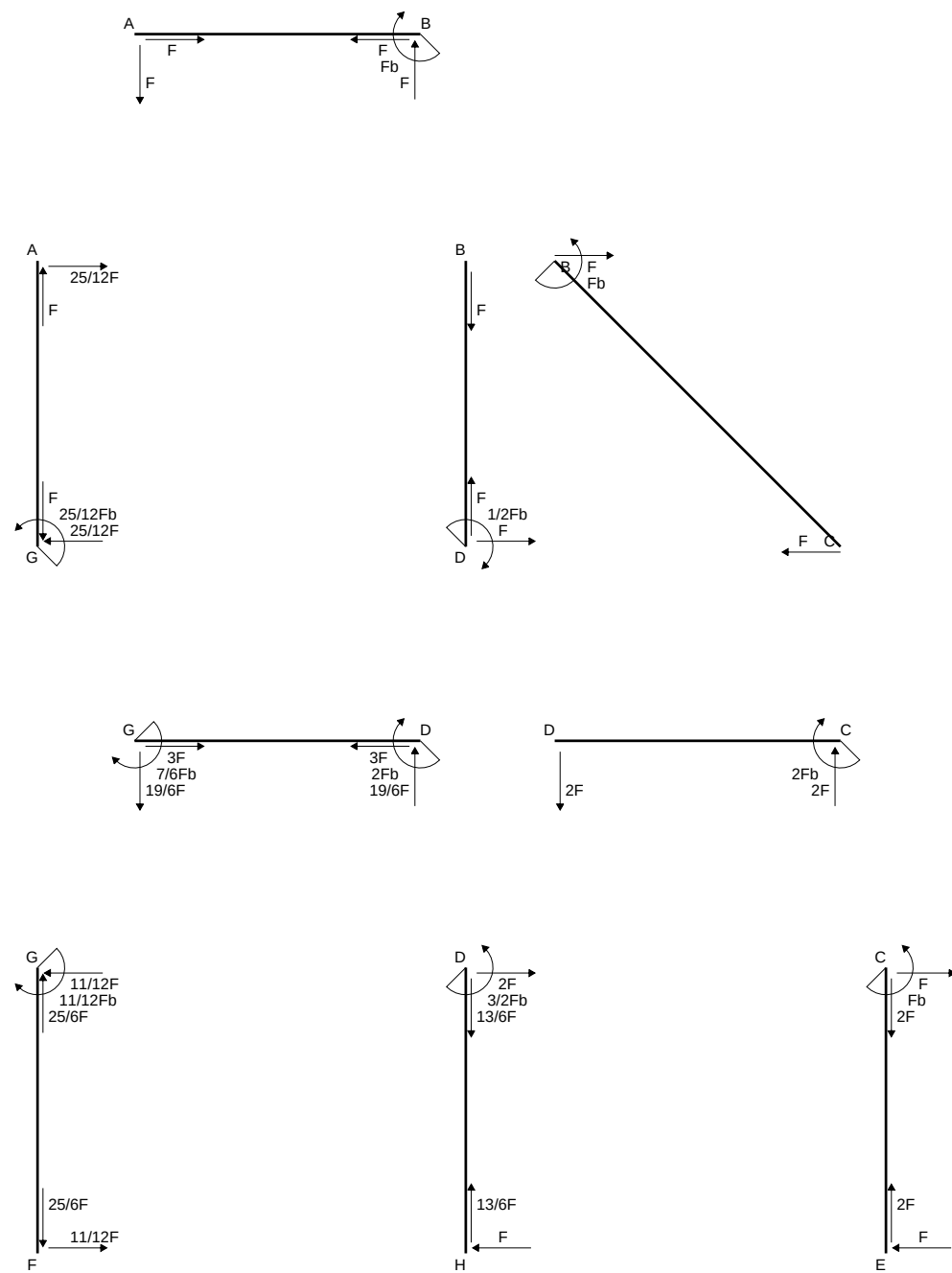
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



$$\begin{aligned} A &= 1212. \text{ mm}^2 \\ J_u &= 383443. \text{ mm}^4 \\ J_v &= 127728. \text{ mm}^4 \\ y_g &= 32.14 \text{ mm} \\ T_y &= -4300. \text{ N} \\ M_x &= -2623000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.14 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -20.14 \text{ mm} \\ \sigma_c &= -Mv/J_u = -137.8 \text{ N/mm}^2 \\ \tau_c &= 6.805 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 138.3 \text{ N/mm}^2 \\ S &= 7282. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-3/2Fb+3/2Fx	0	-3/4Fb+3/2Fx-3/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/4+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx	0	-3/4Fx ² /b	0	1/4x ² /b ²		
	totali						7/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{2} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{4} b - \frac{3}{4} b + \frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{2} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

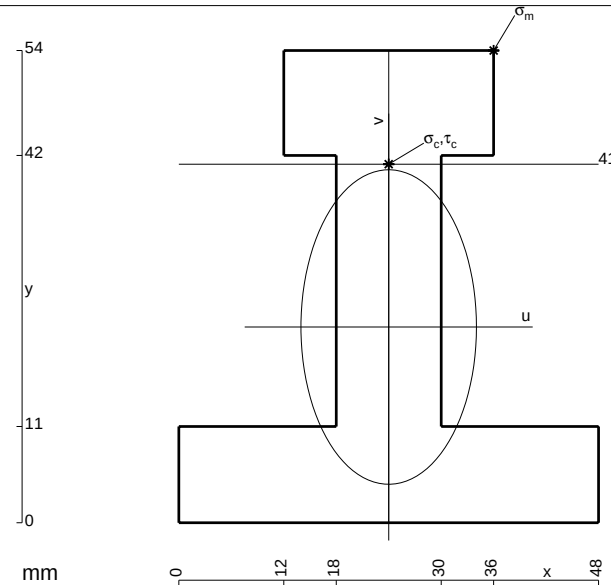
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{4} + \frac{3}{2} x/b - \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{4} x + \frac{3}{4} x^2/b - \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

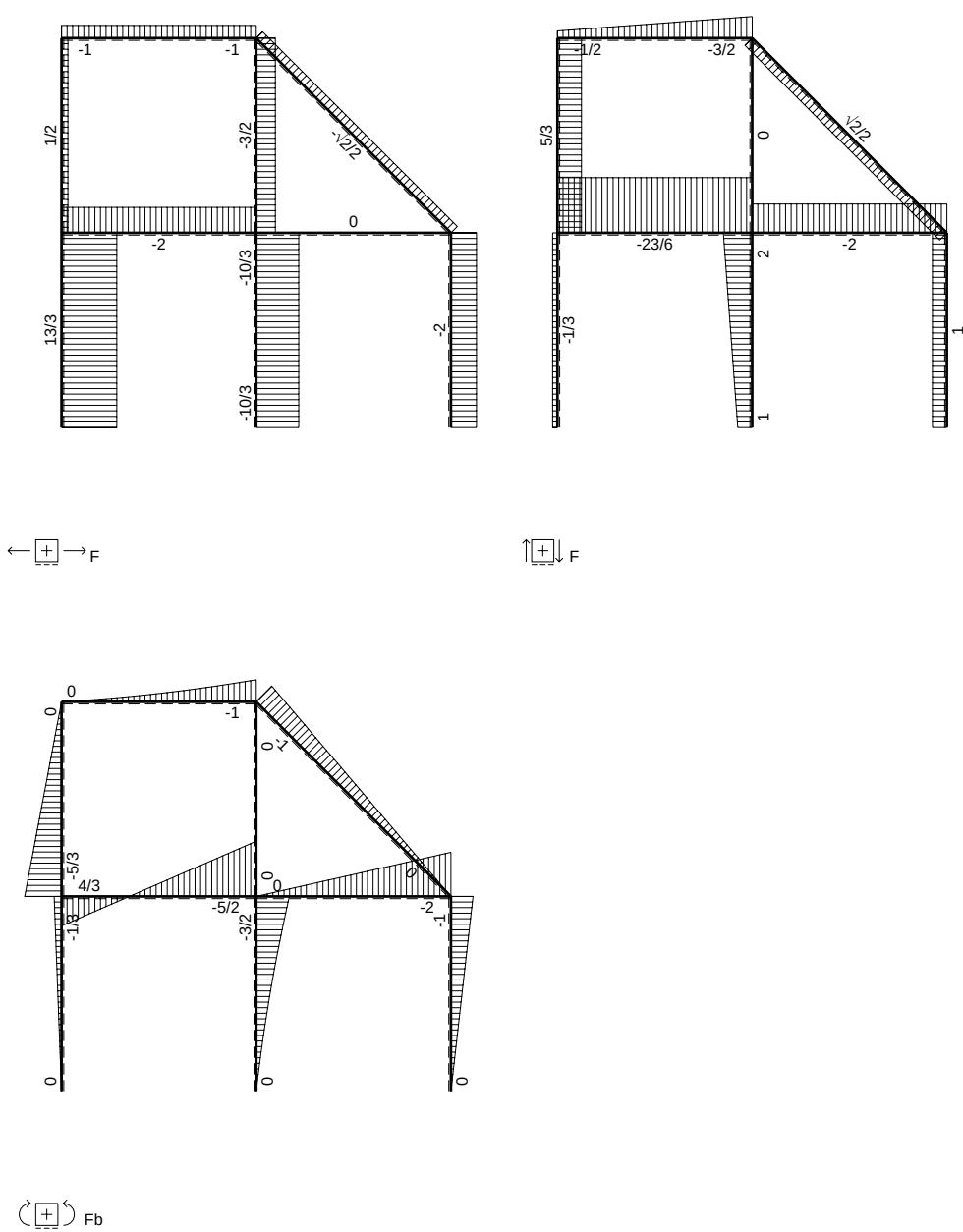
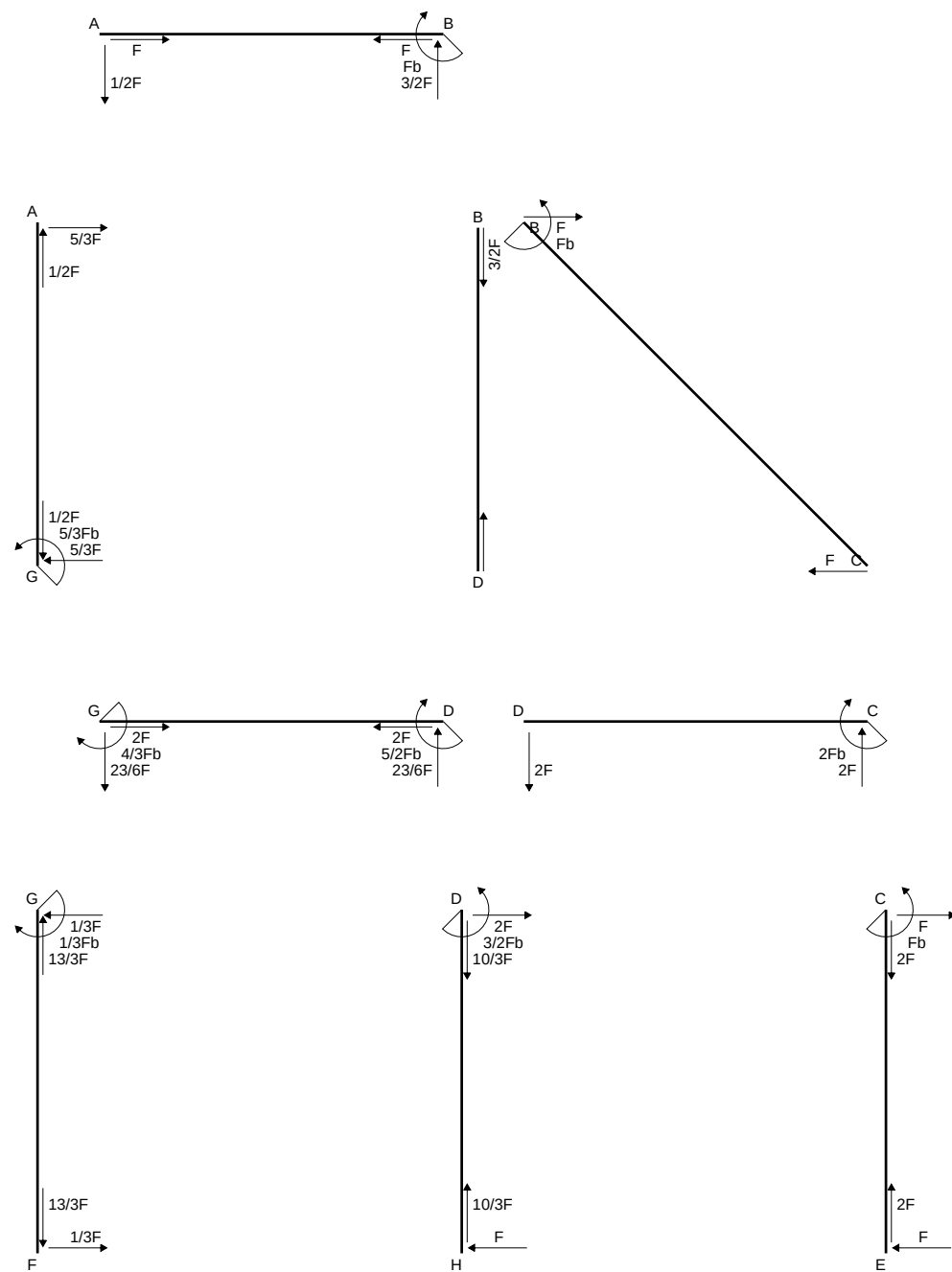
$$= \left(-\frac{3}{4} b + \frac{3}{4} b - \frac{1}{4} b \right) Fb \frac{1}{EJ} = -\frac{1}{4} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{4} b \right) Fb \frac{1}{EJ} = -\frac{1}{4} Fb^2/EJ$$



$$\begin{aligned} A &= 1188. \text{ mm}^2 \\ J_u &= 384370. \text{ mm}^4 \\ J_v &= 119664. \text{ mm}^4 \\ y_g &= 22.38 \text{ mm} \\ T_y &= -4220. \text{ N} \\ M_x &= -2785200. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.62 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.1 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 18.62 \text{ mm} \\ \sigma_c &= -Mv/J_u = 134.9 \text{ N/mm}^2 \\ \tau_c &= 6.961 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 135.5 \text{ N/mm}^2 \\ S &= 7608. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-5/2Fx$	0	$5/2Fx-5/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$5/2Fb-5/2Fx$	0	$5/2Fx-5/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$2/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-4/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

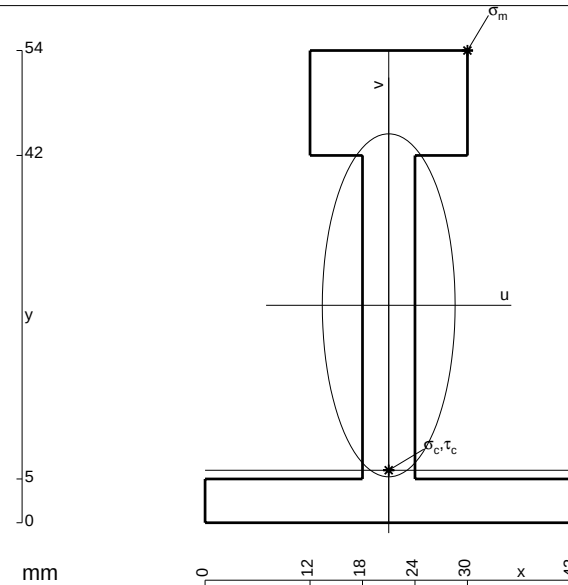
$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

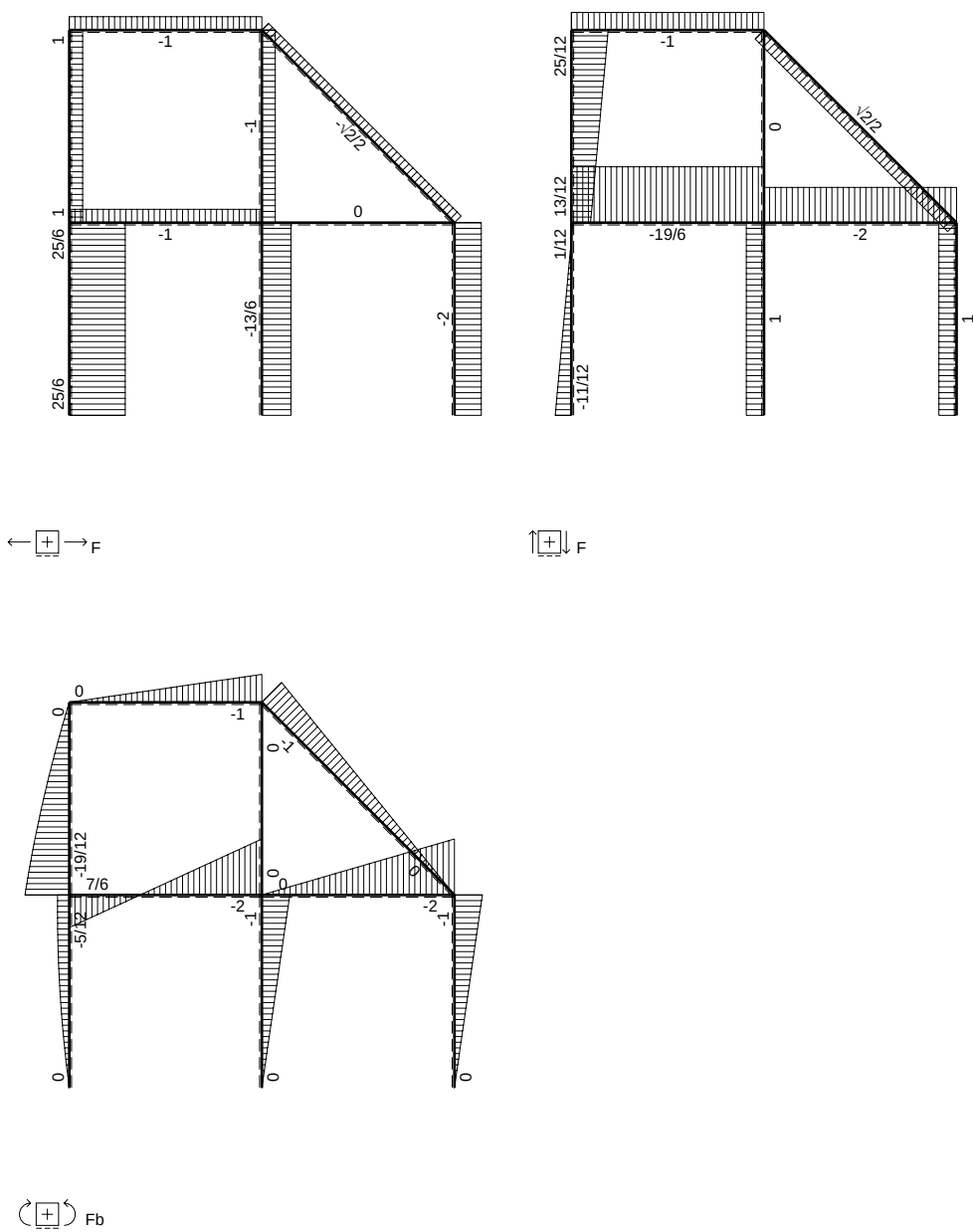
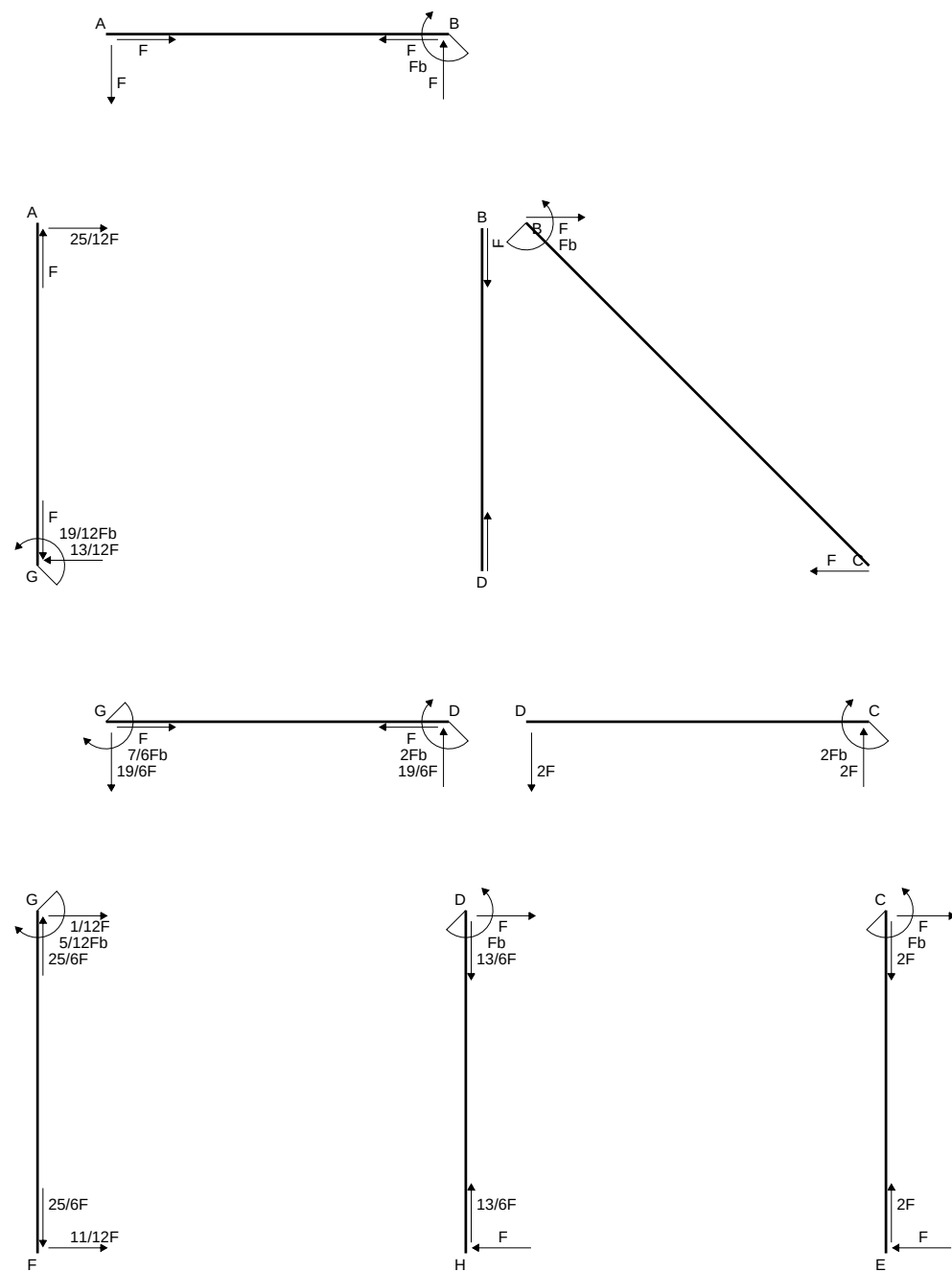
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

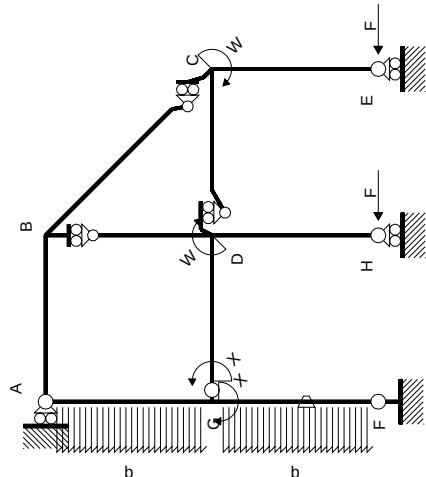
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



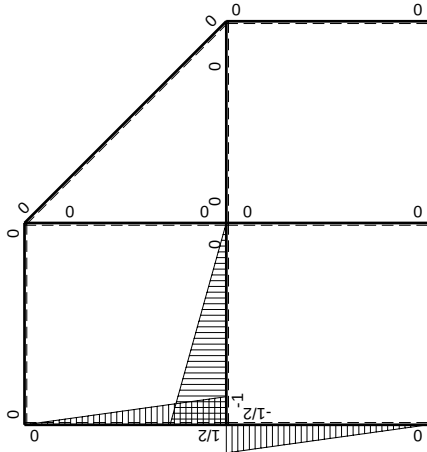
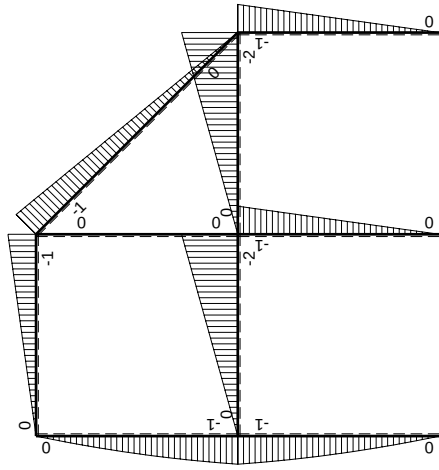
$$\begin{aligned} A &= 648. \text{ mm}^2 \\ J_u &= 249420. \text{ mm}^4 \\ J_v &= 37368. \text{ mm}^4 \\ y_g &= 24.86 \text{ mm} \\ T_y &= -2880. \text{ N} \\ M_x &= -2044800. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 29.14 \text{ mm} \\ \sigma_m &= -Mv/J_u = 238.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 6. \text{ mm} \\ v_c &= -18.86 \text{ mm} \\ \sigma_c &= -Mv/J_u = -154.6 \text{ N/mm}^2 \\ \tau_c &= 9.261 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 155.5 \text{ N/mm}^2 \\ S &= 4812. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/2Fx+1/2qx ²	-Fb/EJ	3/4Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(3/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-1/2Fx-1/2qx ²	Fb/EJ	1/2Fb-3/4Fx+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+1/2Fx+1/2qx ²	0	-1/2Fb+3/4Fx-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-3/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx-1/2qx ²	0	-3/4Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						7/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{3}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - \frac{3}{4} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{3}{8} x^2/b + \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{3}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

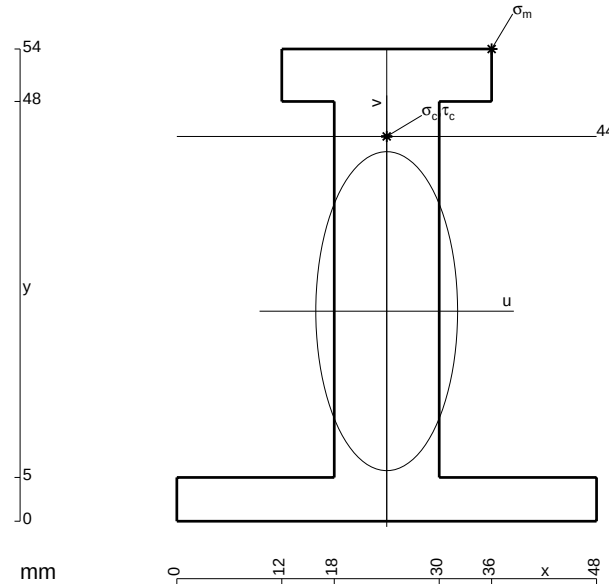
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + \frac{3}{4} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{3}{8} x^2/b - \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

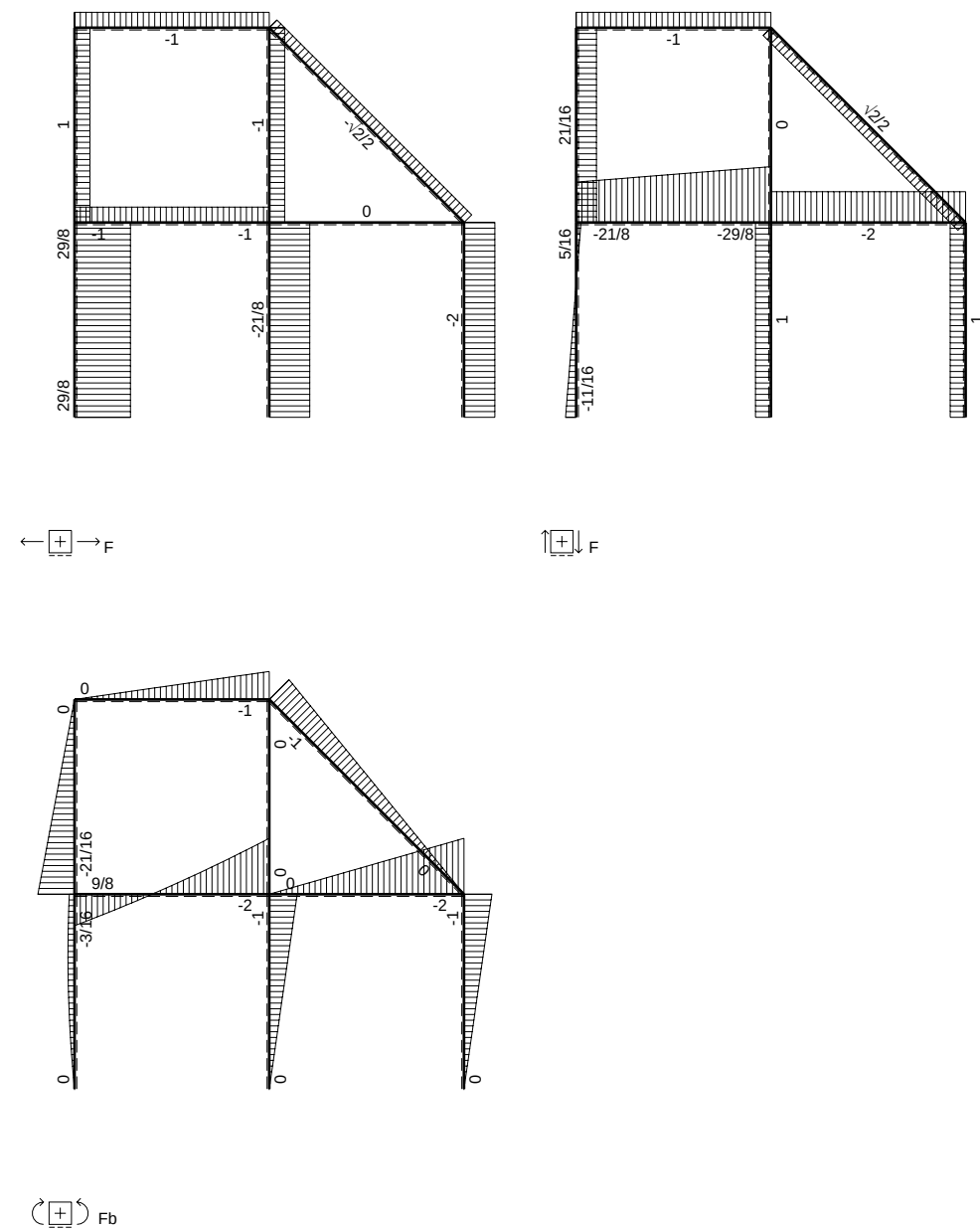
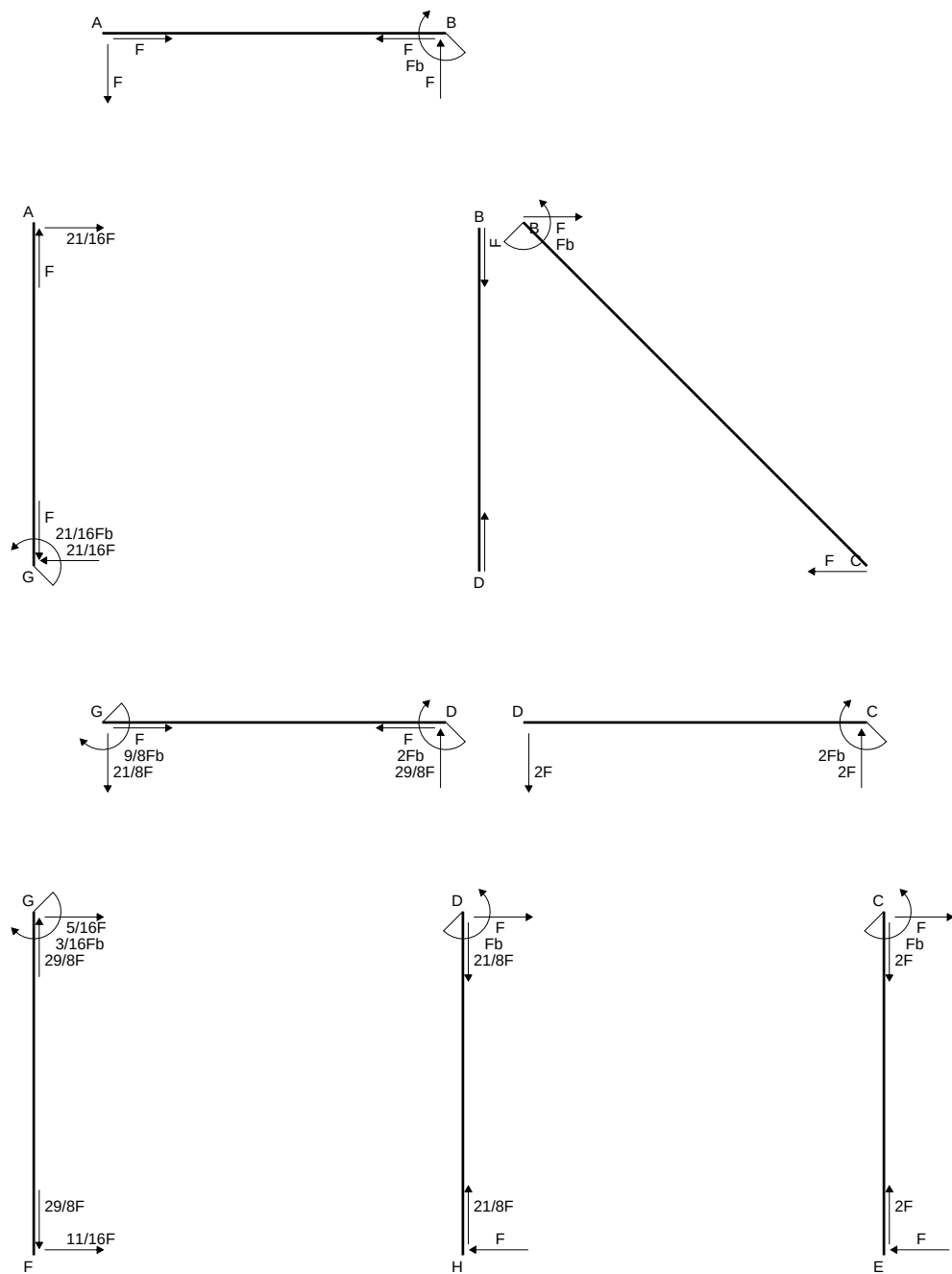
$$= \left(-\frac{1}{2} b + \frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{4} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$



$$\begin{aligned} A &= 900. \text{ mm}^2 \\ J_u &= 299580. \text{ mm}^4 \\ J_v &= 59184. \text{ mm}^4 \\ y_g &= 24.02 \text{ mm} \\ T_y &= -2620. \text{ N} \\ M_x &= -1991200. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.98 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 19.98 \text{ mm} \\ \sigma_c &= -Mv/J_u = 132.8 \text{ N/mm}^2 \\ \tau_c &= 3.6 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 132.9 \text{ N/mm}^2 \\ S &= 4940. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-5/4Fx+1/2qx ²	-Fb/EJ	5/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(7/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-1/4Fx-1/2qx ²	Fb/EJ	3/8Fb-1/2Fx-1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-3/2Fx-1/2qx ²	0	3/2Fx-Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(7/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	2Fb-5/2Fx+1/2qx ²	0	2Fx-5/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/8+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx ² /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

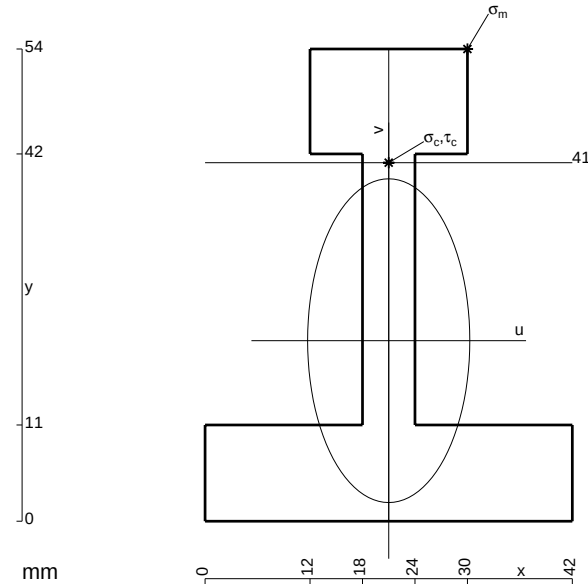
$$= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

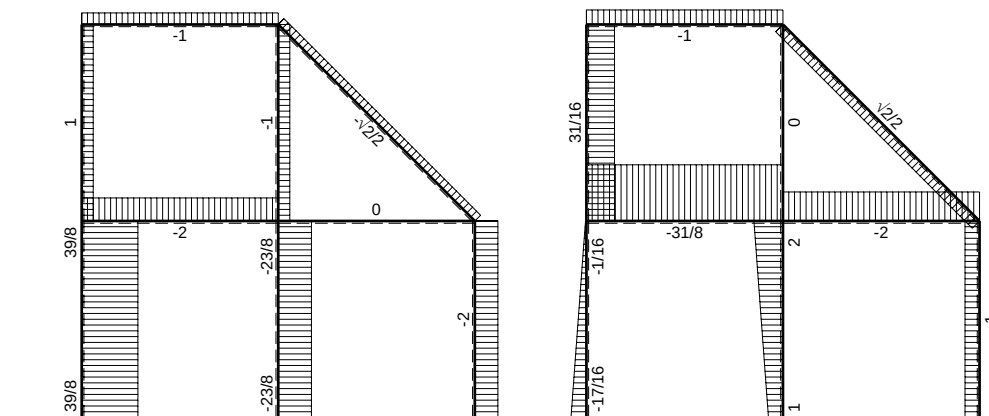
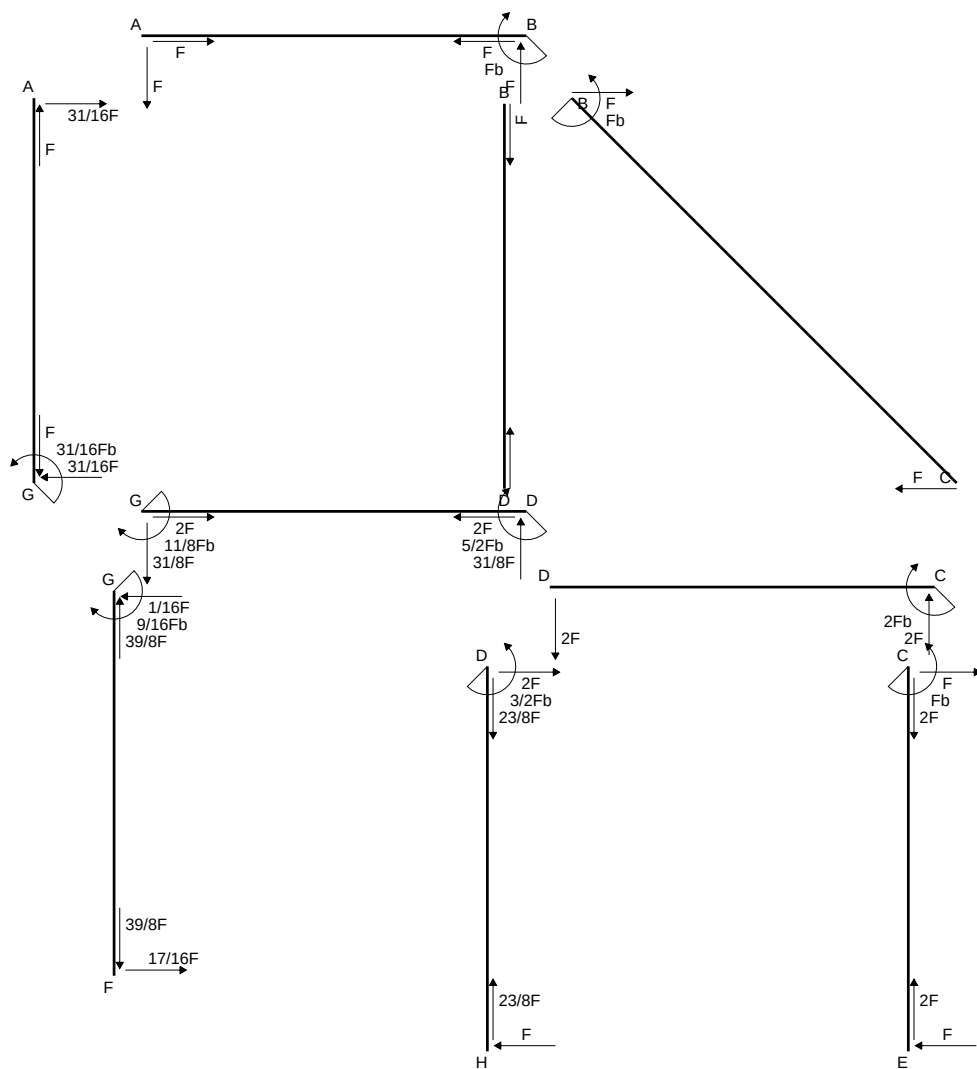
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

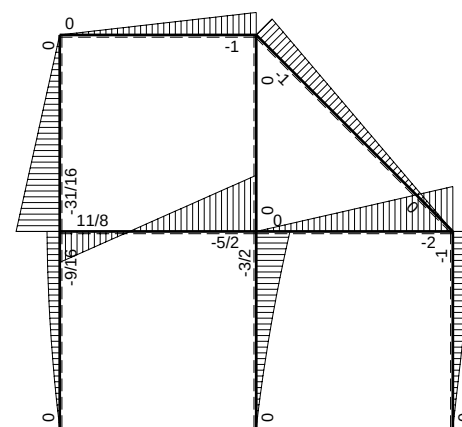
$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$



$$\begin{aligned} A &= 864. \text{ mm}^2 \\ J_u &= 296124. \text{ mm}^4 \\ J_v &= 74304. \text{ mm}^4 \\ y_g &= 20.65 \text{ mm} \\ T_y &= -2300. \text{ N} \\ M_x &= -1863000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.35 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 20.35 \text{ mm} \\ \sigma_c &= -Mv/J_v = 128.1 \text{ N/mm}^2 \\ \tau_c &= 7.811 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 128.8 \text{ N/mm}^2 \\ S &= 6034. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

$\uparrow \boxed{+} \downarrow F$



 F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx+1/2qx ²	-Fb/EJ	7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(11/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx ²	Fb/EJ	5/8Fb-Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-5/2Fx	0	5/2Fx-5/2Fx ² /b	0	1-2x/b+x ² /b ²	(5/12+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-5/2Fx	0	5/2Fx-5/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-5/4Fb+5/4Fx	0	-5/8Fb+5/4Fx-5/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-5/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx	0	-5/8Fx ² /b	0	1/4x ² /b ²		
	totali						11/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

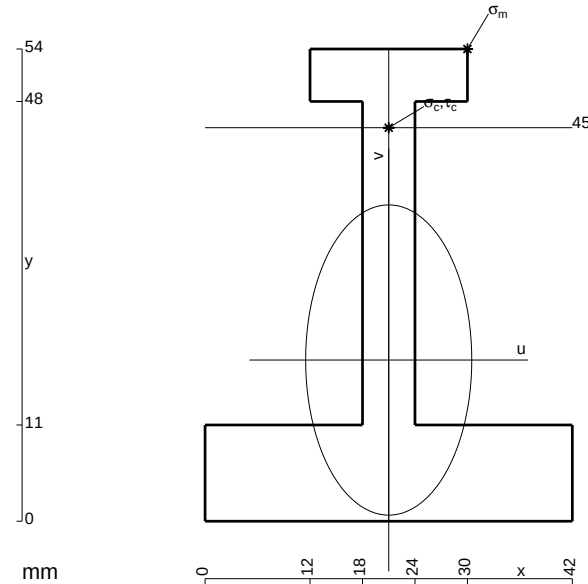
$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{5}{8} + \frac{5}{4} x/b - \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{8} x + \frac{5}{8} x^2/b - \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

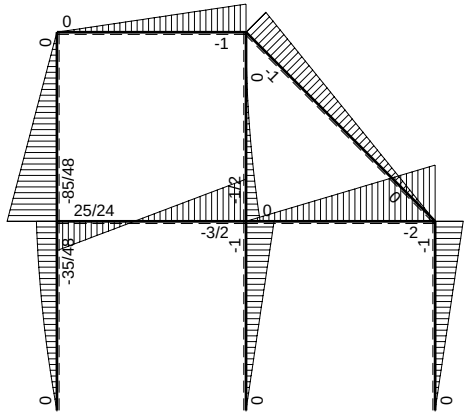
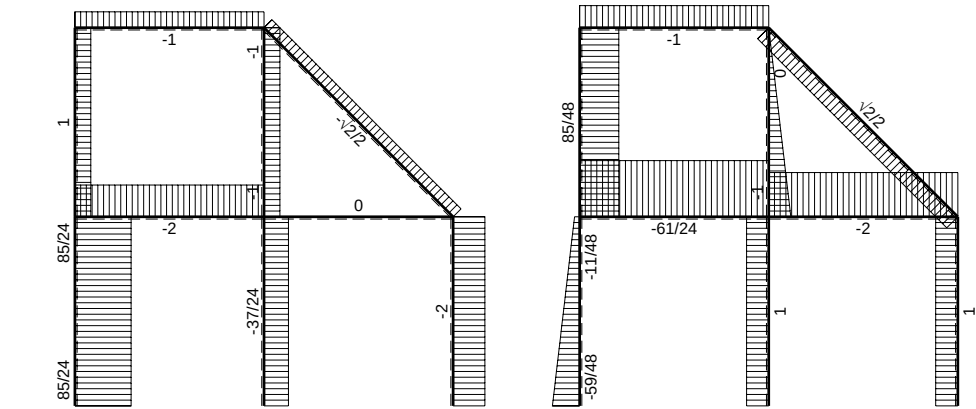
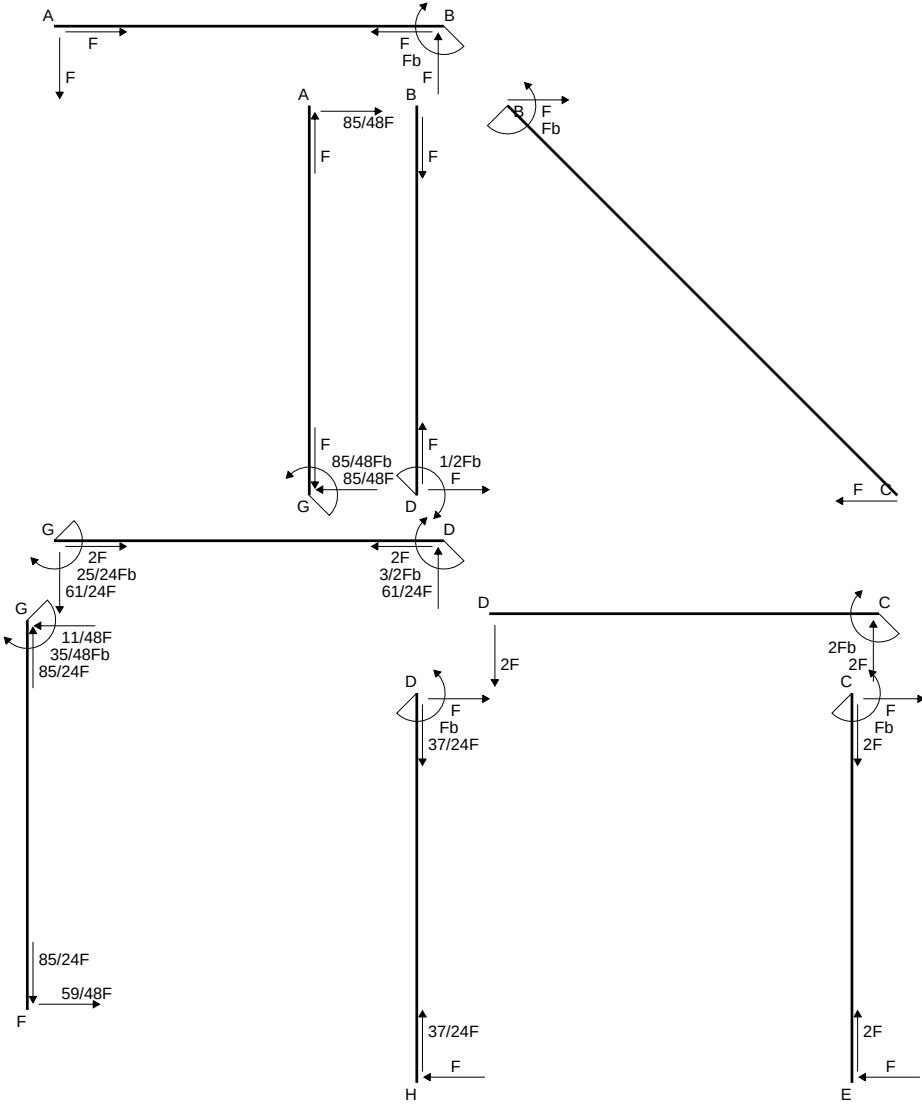
$$= \left(-\frac{5}{8} b + \frac{5}{8} b - \frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$

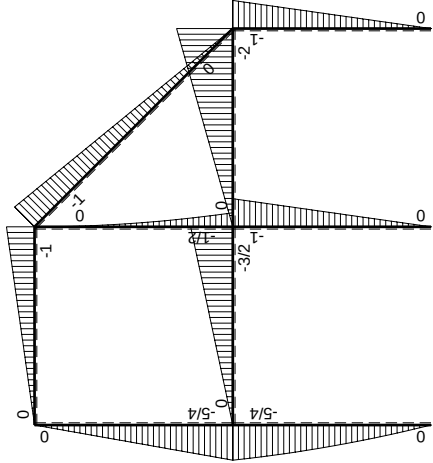
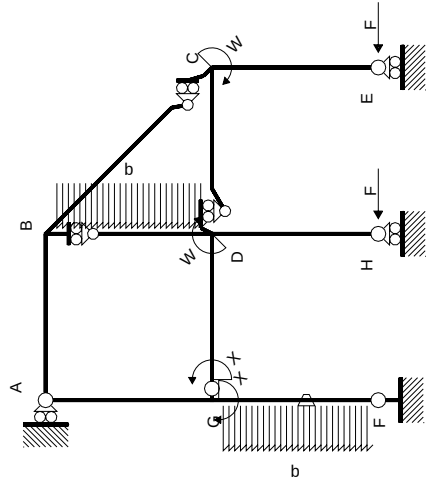
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$



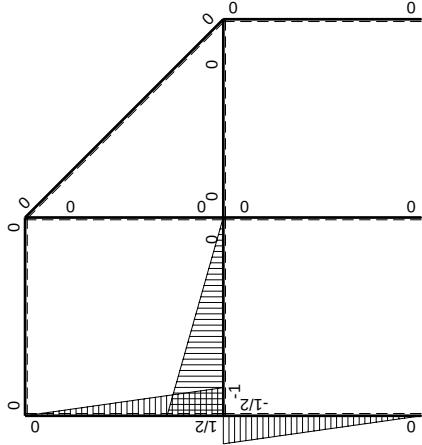
$$\begin{aligned} A &= 792. \text{ mm}^2 \\ J_u &= 249320. \text{ mm}^4 \\ J_v &= 71496. \text{ mm}^4 \\ y_g &= 18.43 \text{ mm} \\ T_y &= -1780. \text{ N} \\ M_x &= -1530800. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 35.57 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 26.57 \text{ mm} \\ \sigma_c &= -Mv/J_u = 163.1 \text{ N/mm}^2 \\ \tau_c &= 4.786 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 163.3 \text{ N/mm}^2 \\ S &= 4023. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-7/4Fx+1/2qx^2$	$-Fb/EJ$	$7/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(11/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$5/4Fb-3/4Fx-1/2qx^2$	Fb/EJ	$5/8Fb-Fx+1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-5/4Fb+5/4Fx$	0	$-5/8Fb+5/4Fx-5/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-5/24+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx$	0	$-5/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$25/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-25/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{23}{48} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

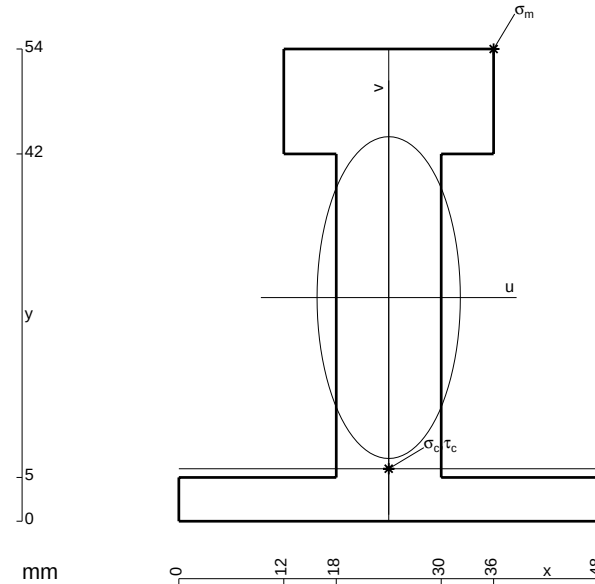
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{5}{8} + \frac{5}{4} x/b - \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{8} x + \frac{5}{8} x^2/b - \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

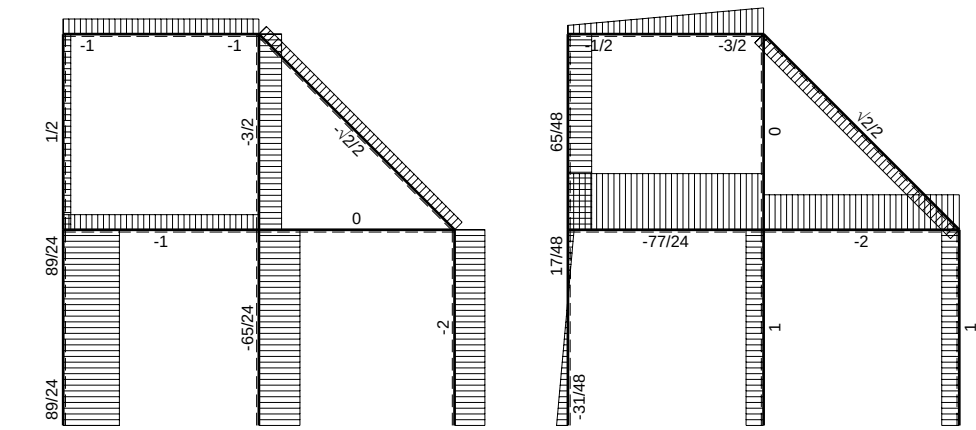
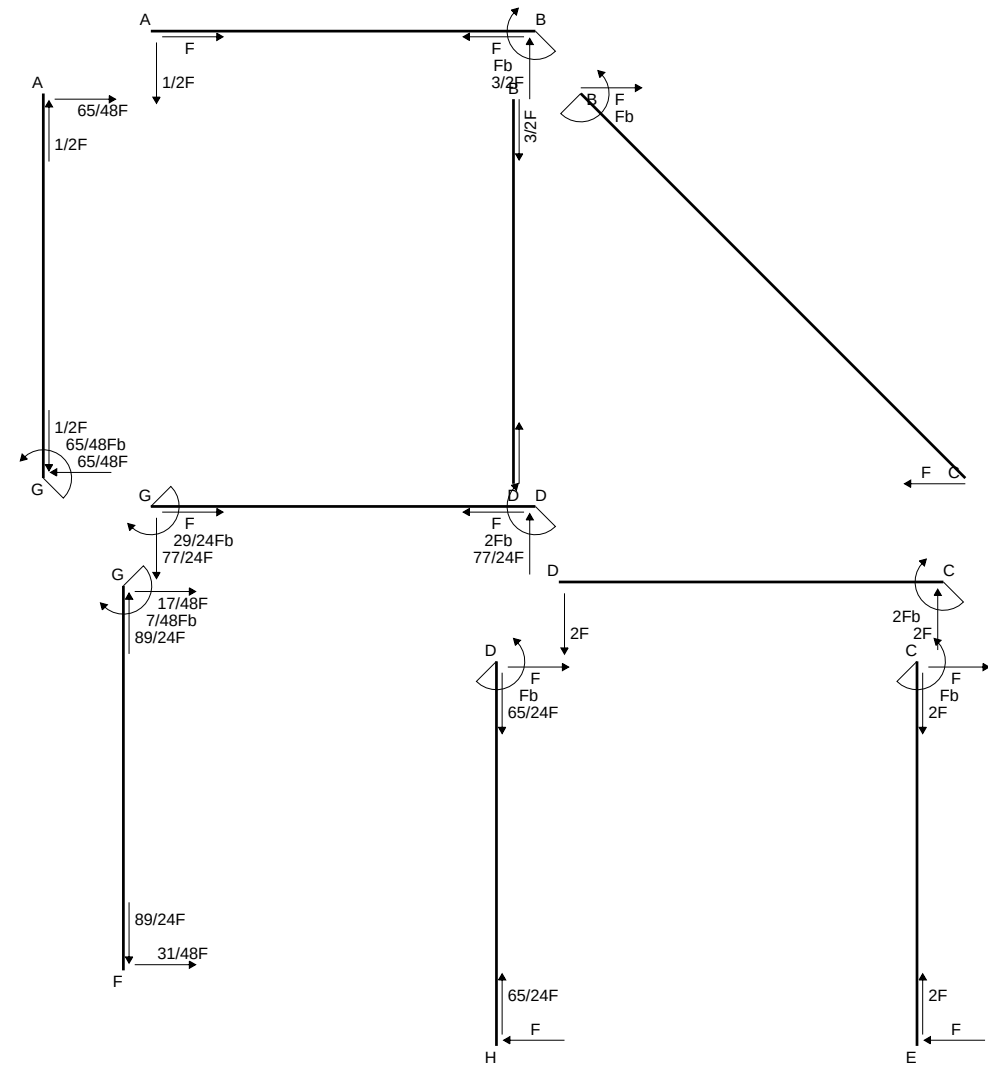
$$= \left(-\frac{5}{8} b + \frac{5}{8} b - \frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b \right) Fb \frac{1}{EJ} = -\frac{5}{24} Fb^2/EJ$$

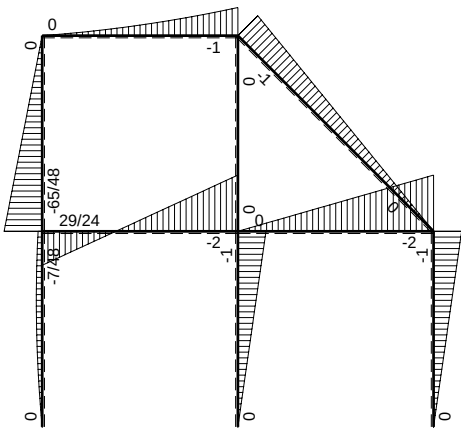


$$\begin{aligned} A &= 972. \text{ mm}^2 \\ J_u &= 329140. \text{ mm}^4 \\ J_v &= 65232. \text{ mm}^4 \\ y_g &= 25.57 \text{ mm} \\ T_y &= -2920. \text{ N} \\ M_x &= -2657200. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.43 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 6. \text{ mm} \\ v_c &= -19.57 \text{ mm} \\ \sigma_c &= -Mv/J_u = -158. \text{ N/mm}^2 \\ \tau_c &= 4.272 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 158.2 \text{ N/mm}^2 \\ S &= 5779. \text{ mm}^3 \end{aligned}$$

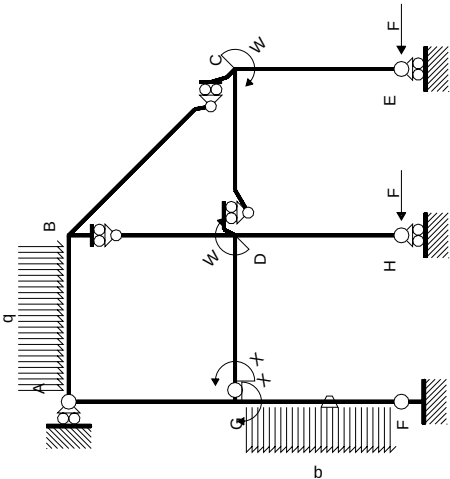


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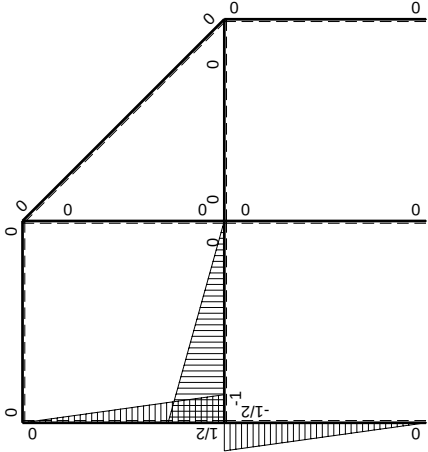
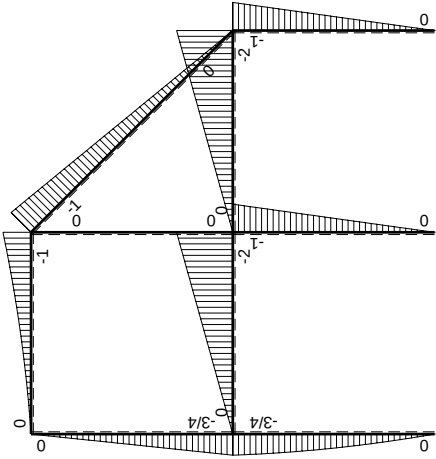


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-2Fx$	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-2Fx$	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$29/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-29/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

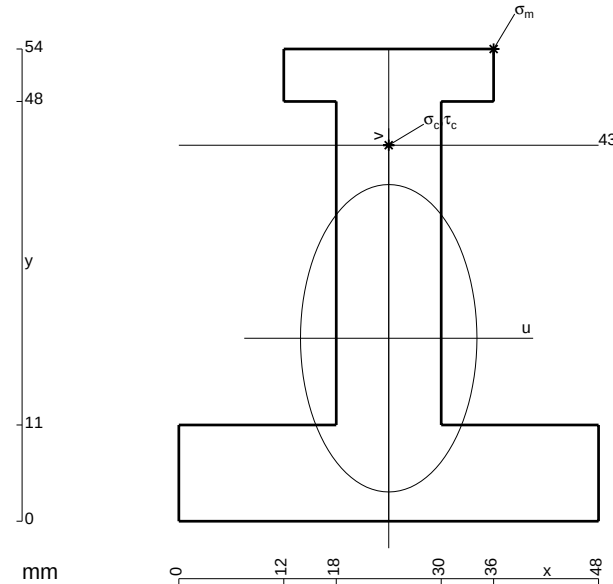
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

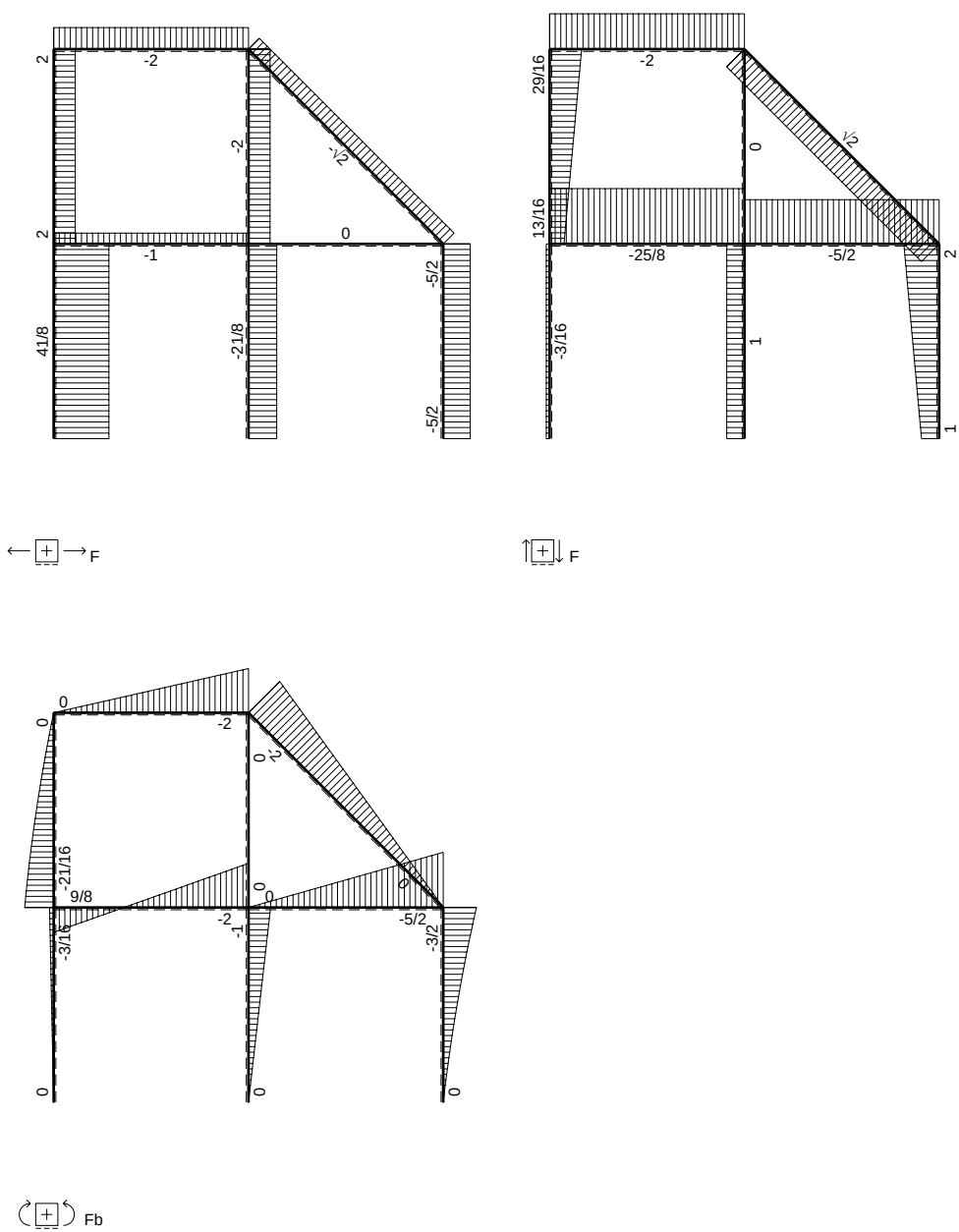
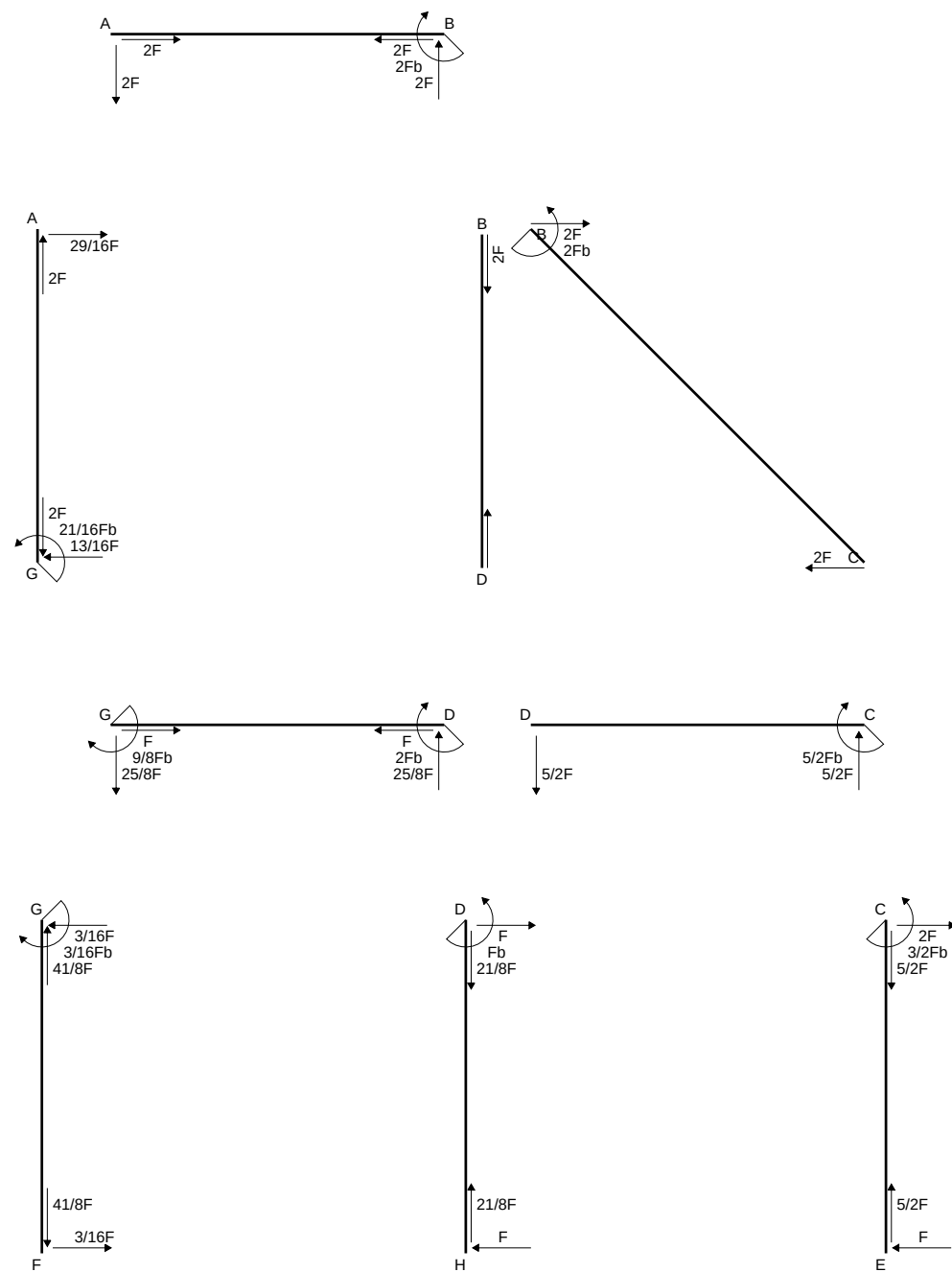
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$



$$\begin{aligned} A &= 1116. \text{ mm}^2 \\ J_u &= 344933. \text{ mm}^4 \\ J_v &= 113616. \text{ mm}^4 \\ y_g &= 20.92 \text{ mm} \\ T_y &= -2600. \text{ N} \\ M_x &= -2496000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 33.08 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 22.08 \text{ mm} \\ \sigma_c &= -Mv/J_u = 159.8 \text{ N/mm}^2 \\ \tau_c &= 3.647 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 159.9 \text{ N/mm}^2 \\ S &= 5806. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	3/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/8+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-3/4Fx	Fb/EJ	3/8Fb-3/4Fx+3/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx ²	0	-3/8Fb+1/2Fx+1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-7/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx ²	0	-5/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						9/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

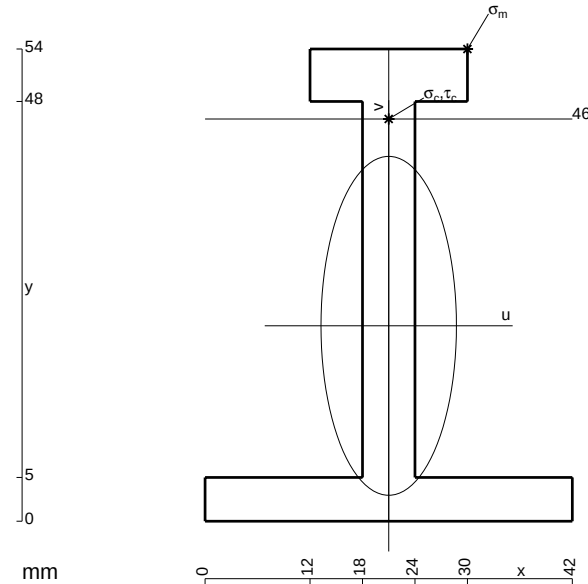
$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

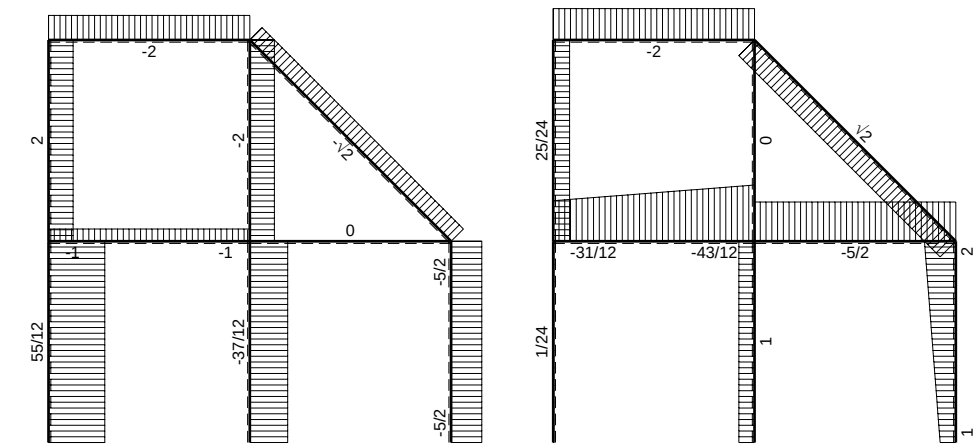
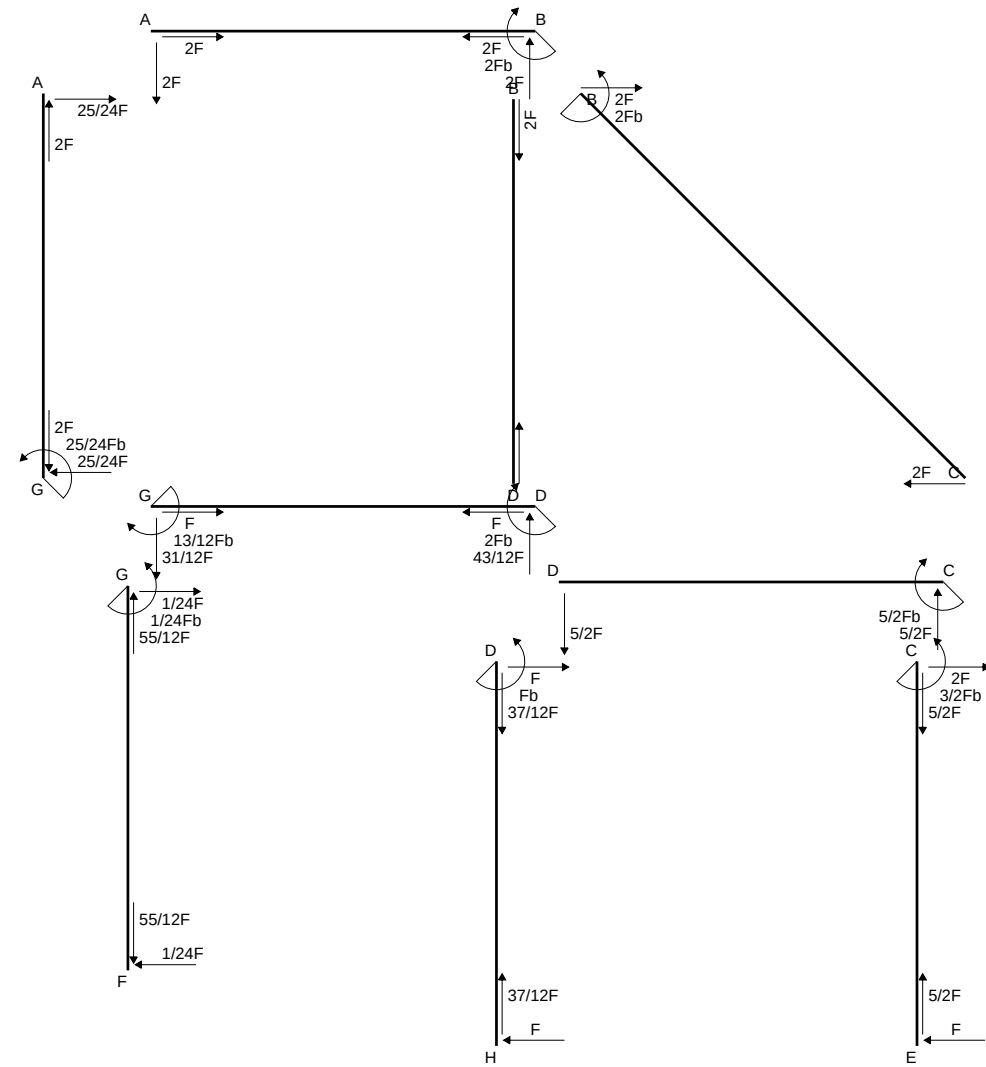
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

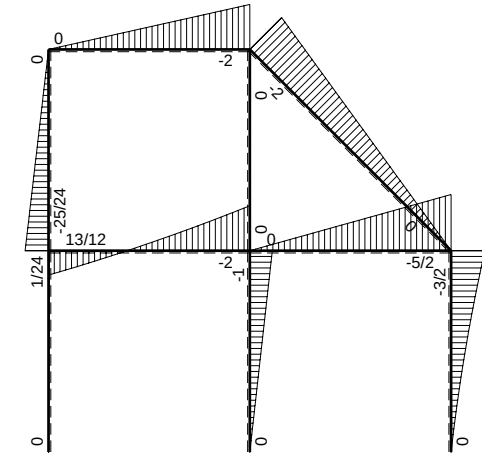


$$\begin{aligned} A &= 576. \text{ mm}^2 \\ J_u &= 216352. \text{ mm}^4 \\ J_v &= 34560. \text{ mm}^4 \\ y_g &= 22.34 \text{ mm} \\ T_y &= -2675. \text{ N} \\ M_x &= -1364250. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 31.66 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.6 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 23.66 \text{ mm} \\ \sigma_c &= -Mv/J_u = 149.2 \text{ N/mm}^2 \\ \tau_c &= 6.987 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 149.7 \text{ N/mm}^2 \\ S &= 3391. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-1/2Fx	-Fb/EJ	1/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-1/2Fx	Fb/EJ	1/4Fb-1/2Fx+1/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-3/2Fx-1/2qx ²	0	3/2Fx-Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(7/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	2Fb-5/2Fx+1/2qx ²	0	2Fx-5/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						13/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

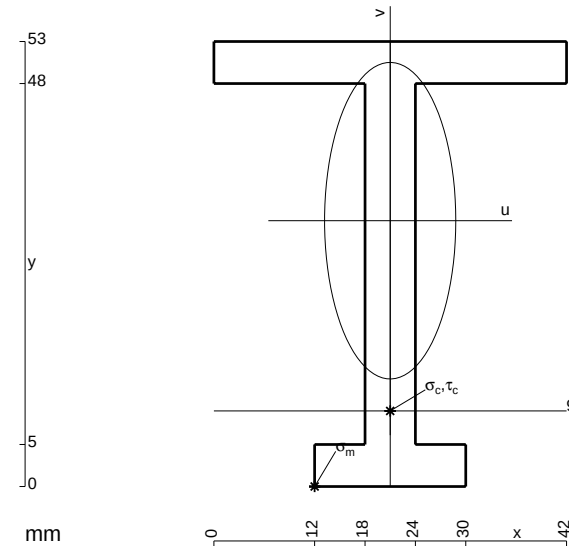
$$= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

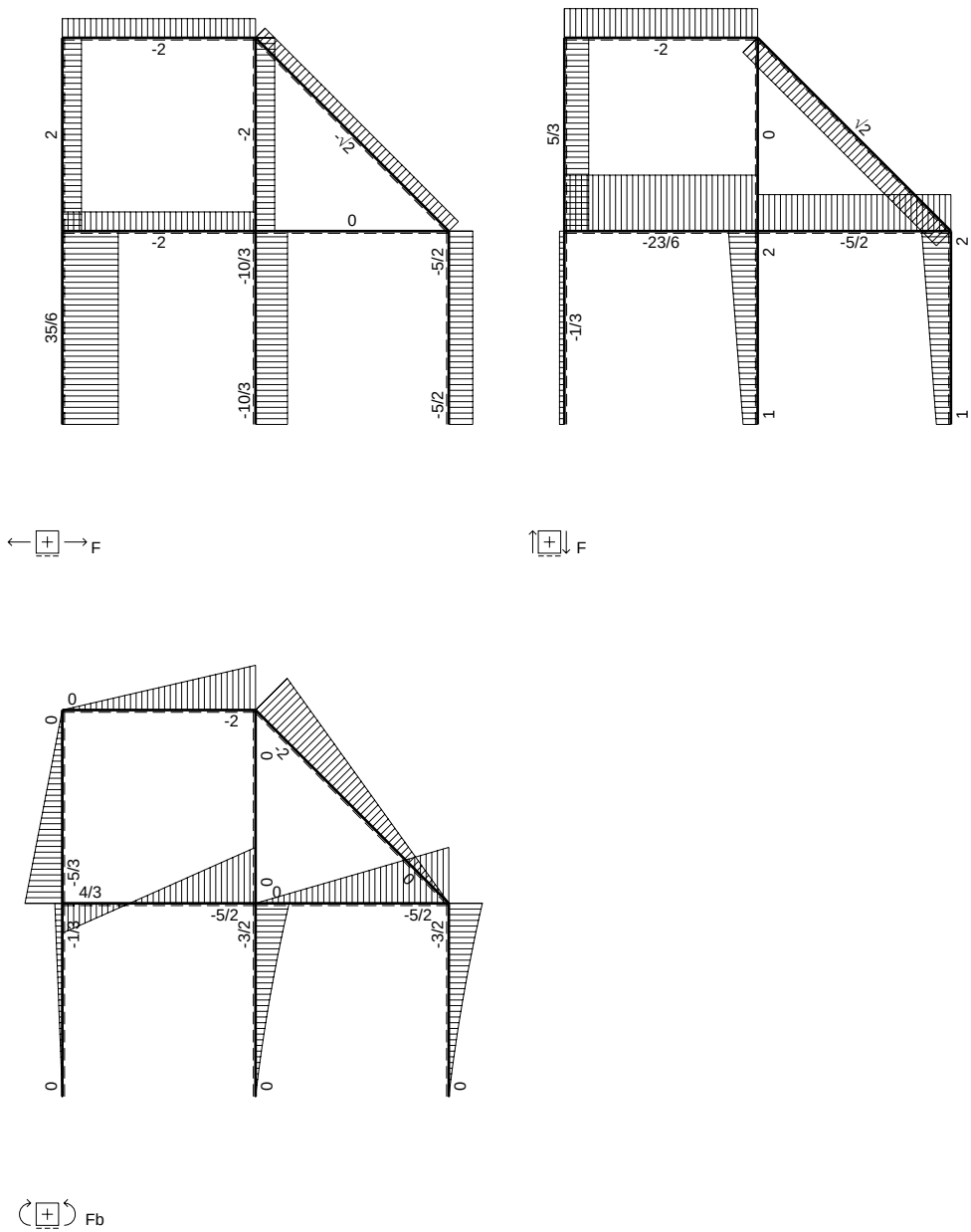
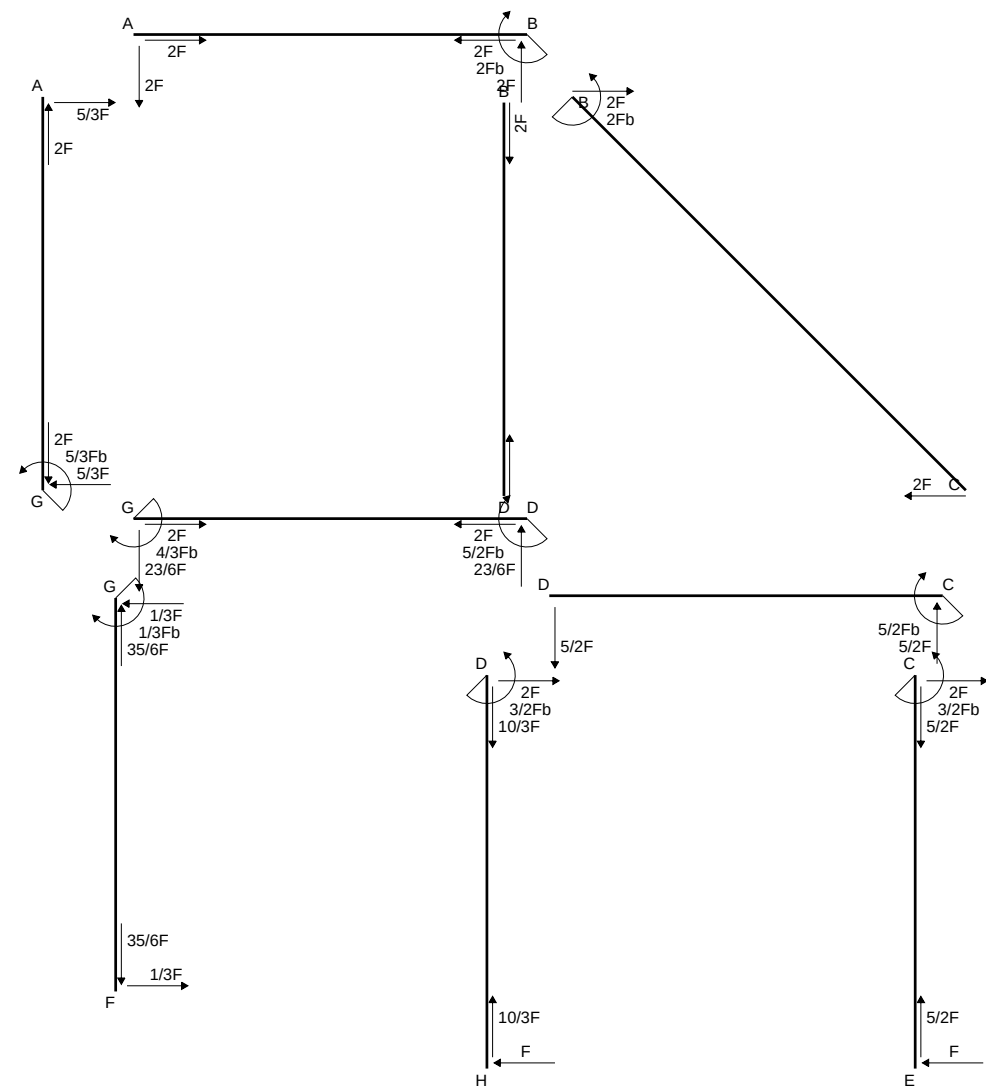
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$



$$\begin{aligned} A &= 558. \text{ mm}^2 \\ J_u &= 198314. \text{ mm}^4 \\ J_v &= 34074. \text{ mm}^4 \\ y_g &= 31.66 \text{ mm} \\ T_y &= -2375. \text{ N} \\ M_x &= -1306250. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -31.66 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -22.66 \text{ mm} \\ \sigma_c &= -Mv/J_u = -149.3 \text{ N/mm}^2 \\ \tau_c &= 6.42 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 149.7 \text{ N/mm}^2 \\ S &= 3216. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-5/2Fx	0	5/2Fx-5/2Fx ² /b	0	1-2x/b+x ² /b ²	(5/12+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-5/2Fx	0	5/2Fx-5/2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						2/3Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-4/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

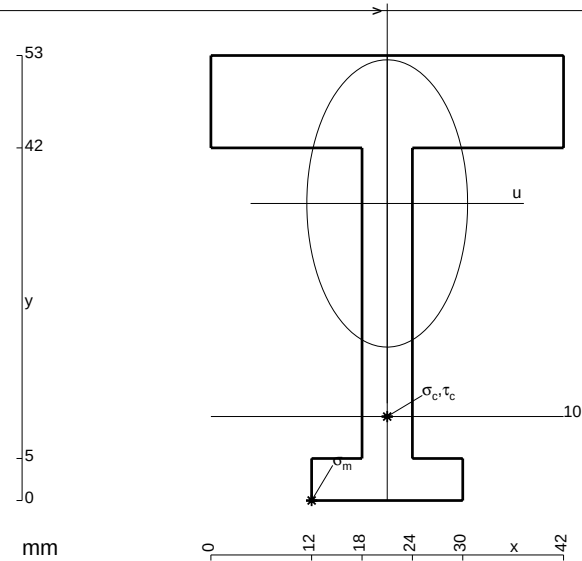
$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

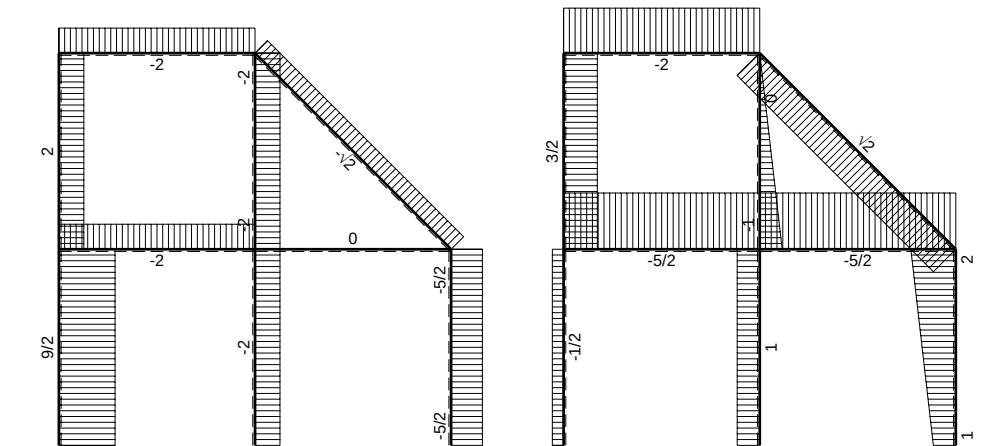
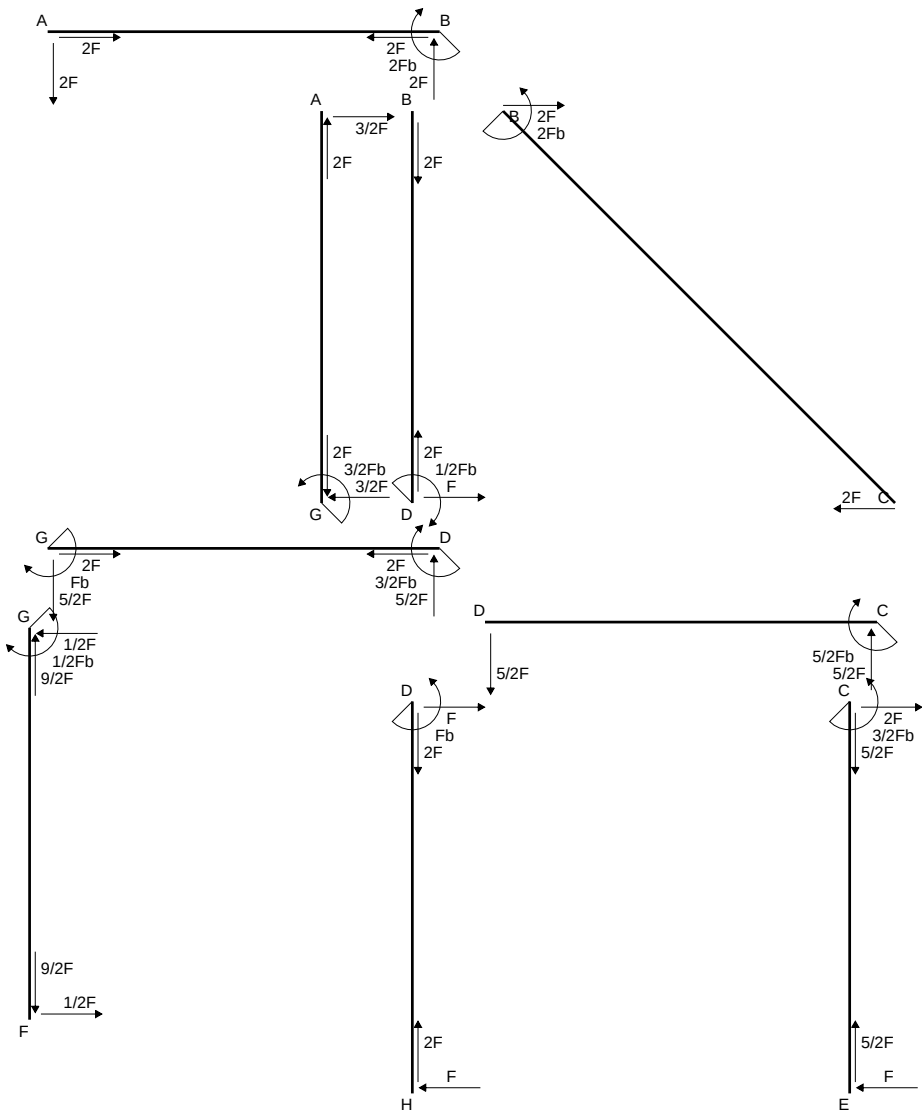
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

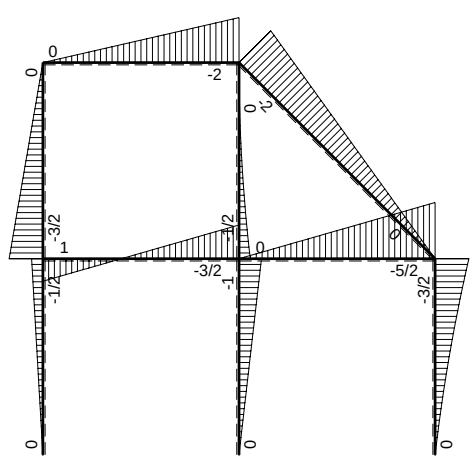


$$\begin{aligned} A &= 774. \text{ mm}^2 \\ J_u &= 226668. \text{ mm}^4 \\ J_v &= 71010. \text{ mm}^4 \\ y_g &= 35.38 \text{ mm} \\ T_y &= -2325. \text{ N} \\ M_x &= -1395000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -35.38 \text{ mm} \\ \sigma_m &= -Mv/J_u = -217.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -25.38 \text{ mm} \\ \sigma_c &= -Mv/J_u = -156.2 \text{ N/mm}^2 \\ \tau_c &= 6.49 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 156.6 \text{ N/mm}^2 \\ S &= 3796. \text{ mm}^3 \end{aligned}$$

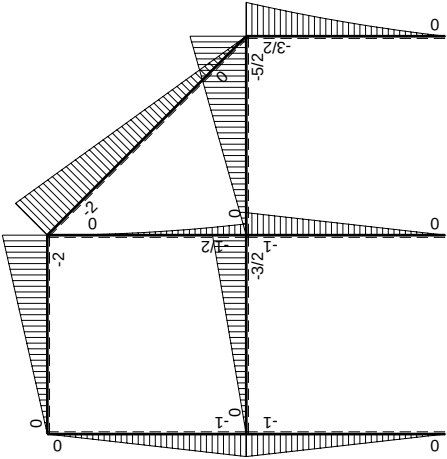
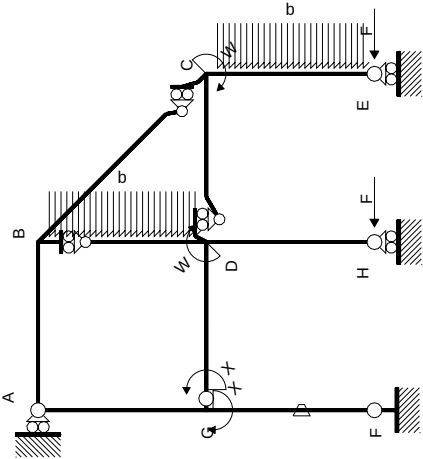


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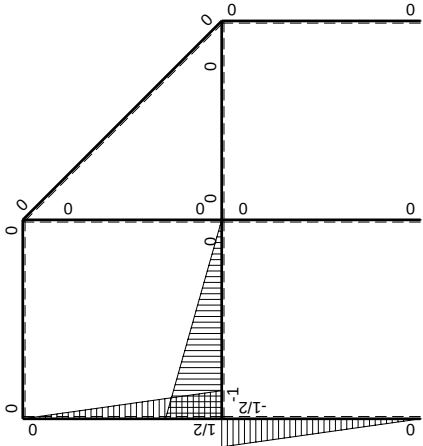


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						1/2Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

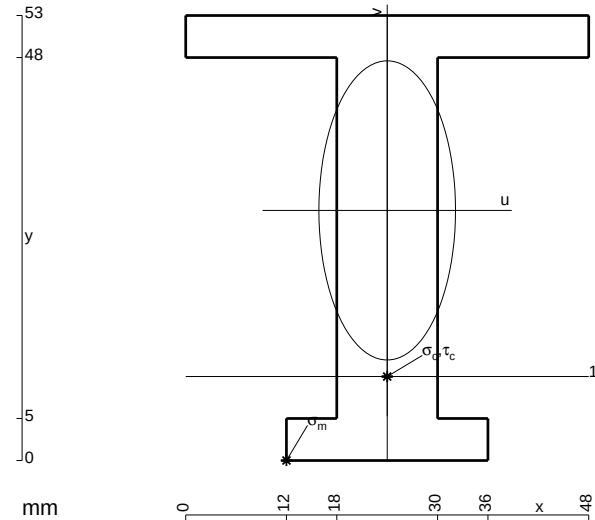
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

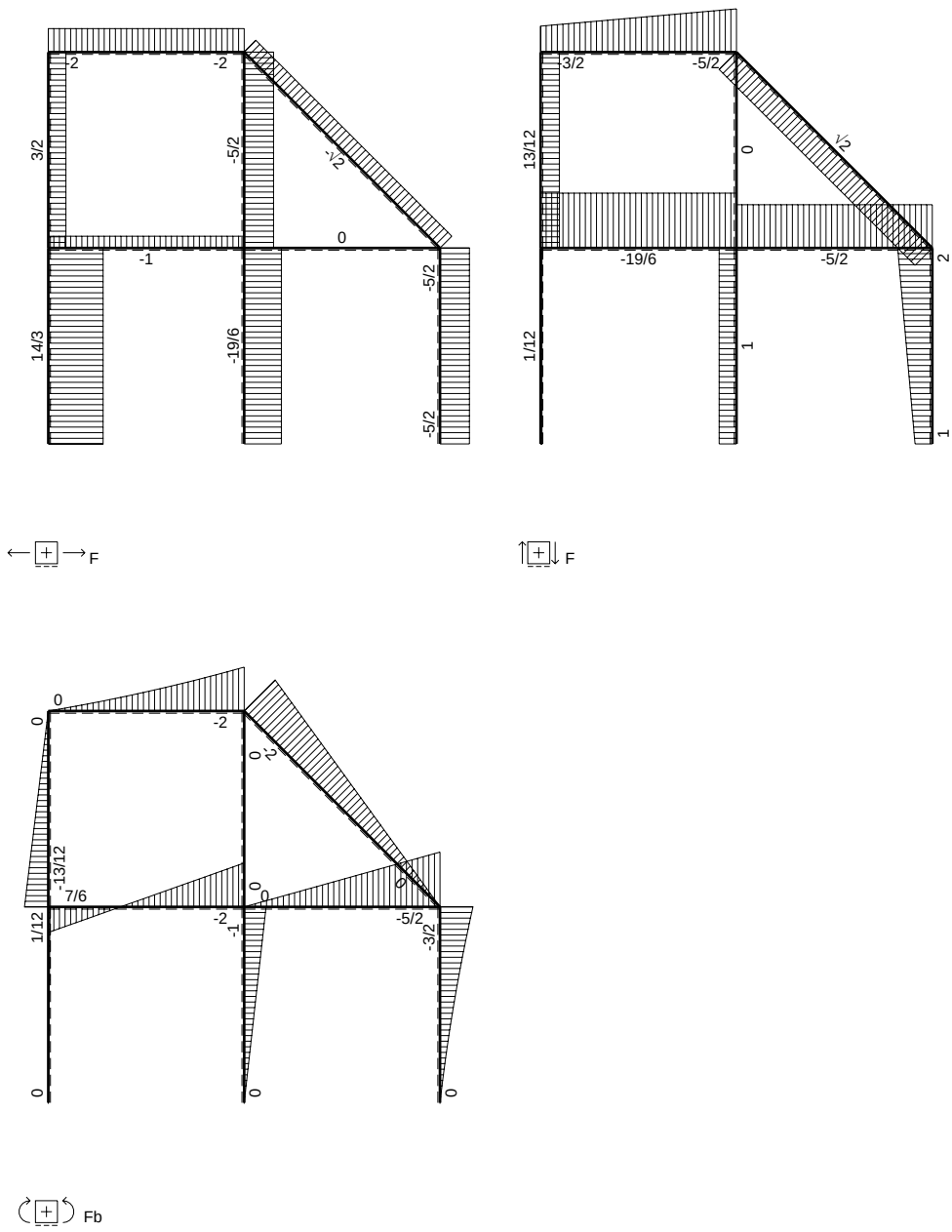
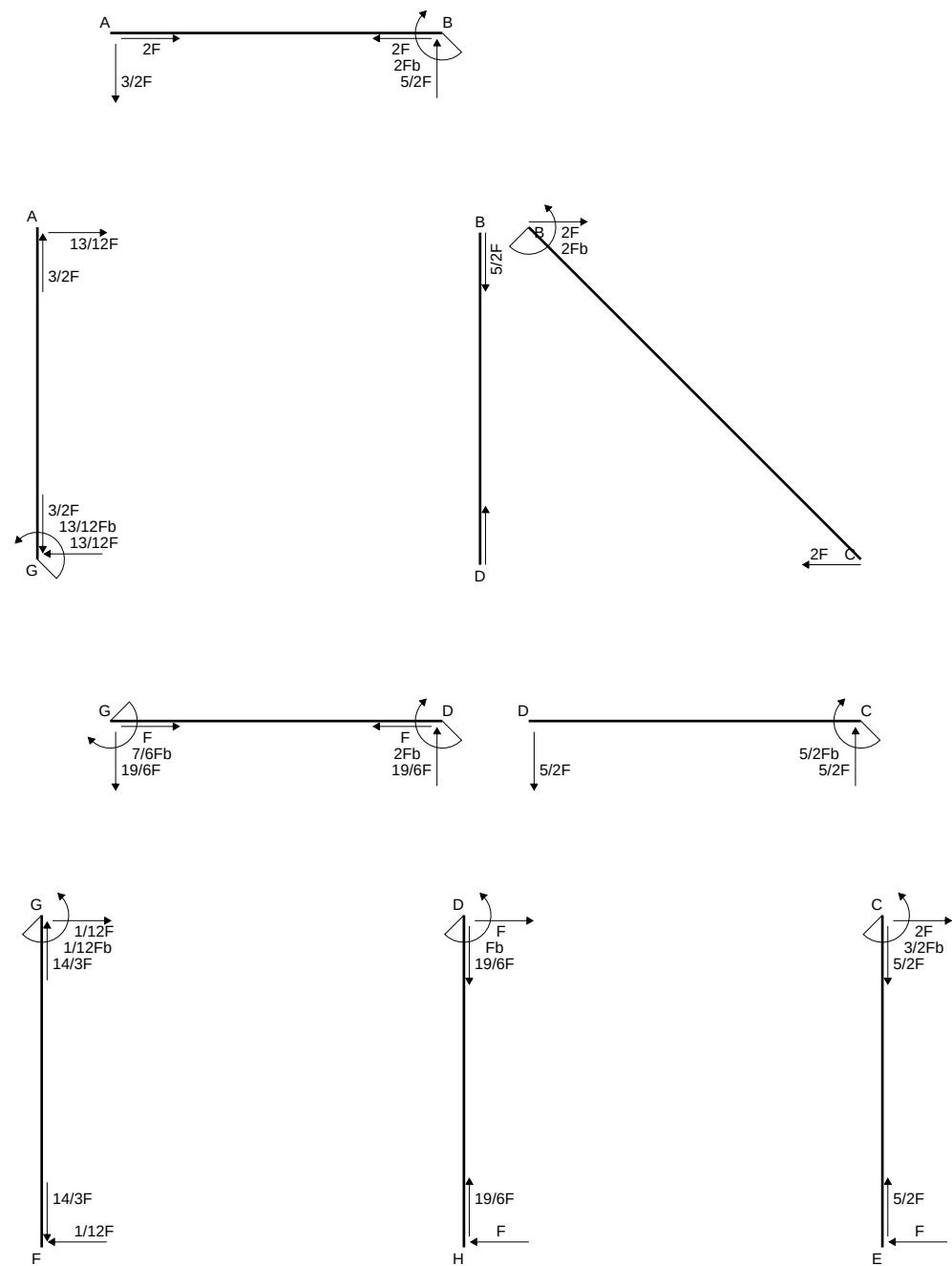
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

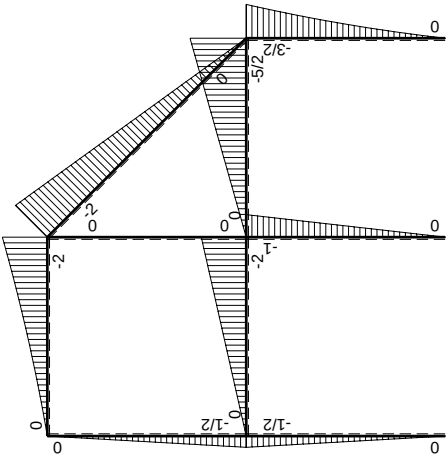
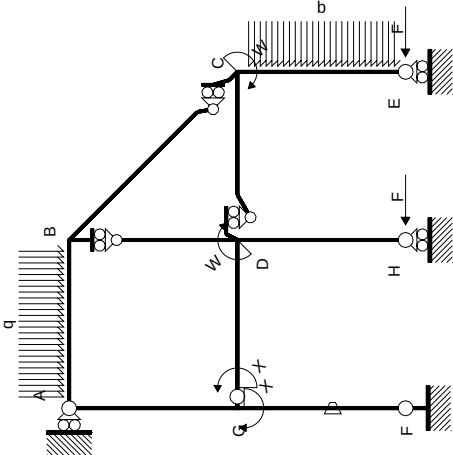
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



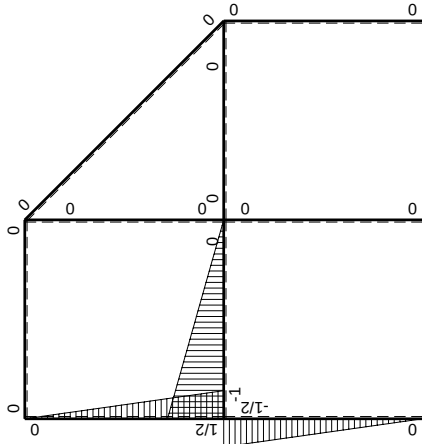
$$\begin{aligned} A &= 876. \text{ mm}^2 \\ J_u &= 278148. \text{ mm}^4 \\ J_v &= 58032. \text{ mm}^4 \\ y_g &= 29.79 \text{ mm} \\ T_y &= -3300. \text{ N} \\ M_x &= -2145000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.79 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -19.79 \text{ mm} \\ \sigma_c &= -Mv/J_u = -152.6 \text{ N/mm}^2 \\ \tau_c &= 4.56 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 152.8 \text{ N/mm}^2 \\ S &= 4612. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-2Fx$	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-2Fx$	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

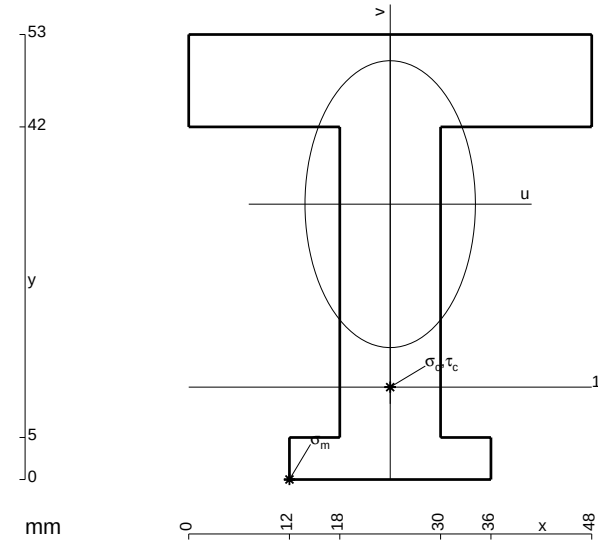
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

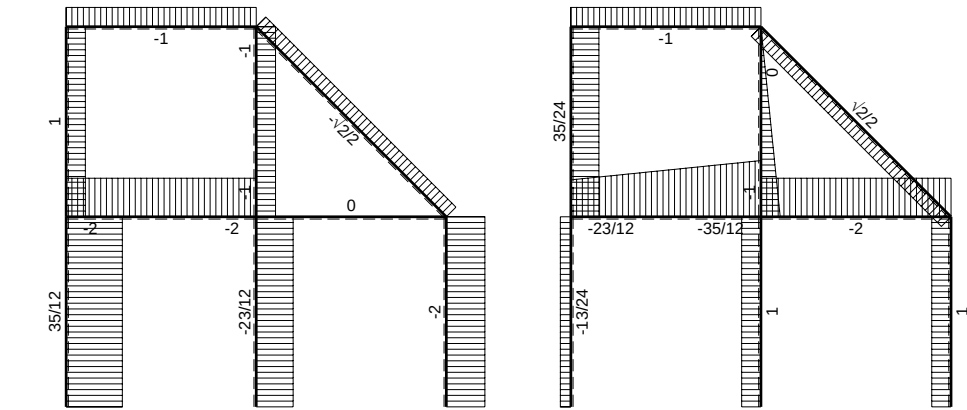
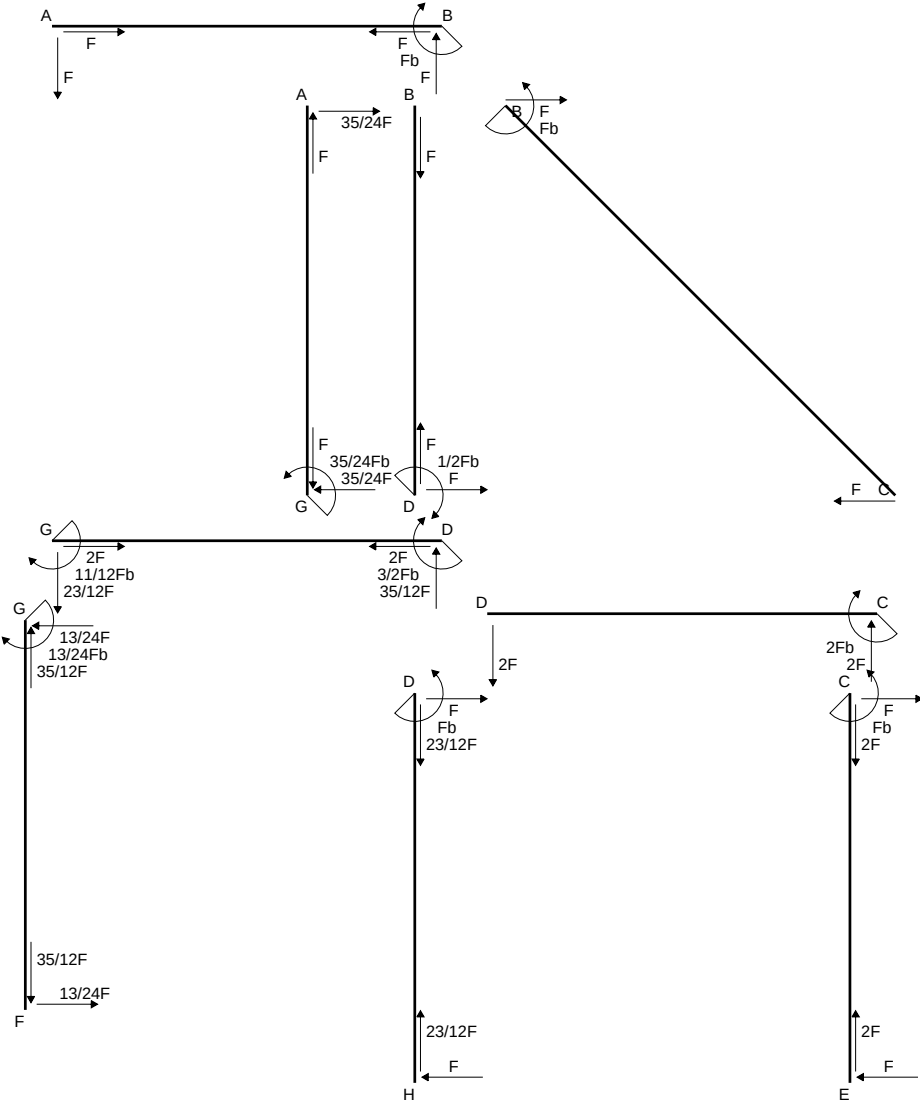
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

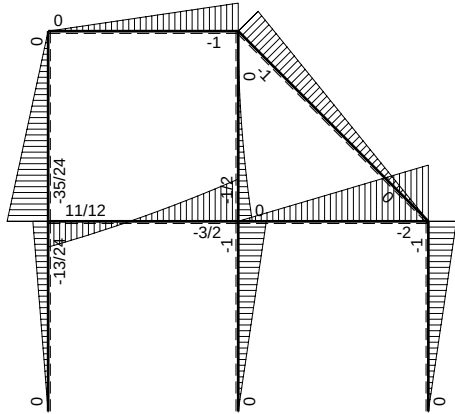


$$\begin{aligned} A &= 1092. \text{ mm}^2 \\ J_u &= 318895. \text{ mm}^4 \\ J_v &= 112464. \text{ mm}^4 \\ y_g &= 32.8 \text{ mm} \\ T_y &= -3325. \text{ N} \\ M_x &= -2327500. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.8 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -21.8 \text{ mm} \\ \sigma_c &= -Mv/J_u = -159.1 \text{ N/mm}^2 \\ \tau_c &= 4.71 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 159.3 \text{ N/mm}^2 \\ S &= 5421. \text{ mm}^3 \end{aligned}$$

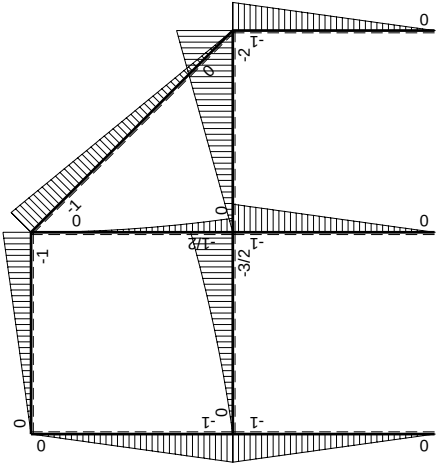
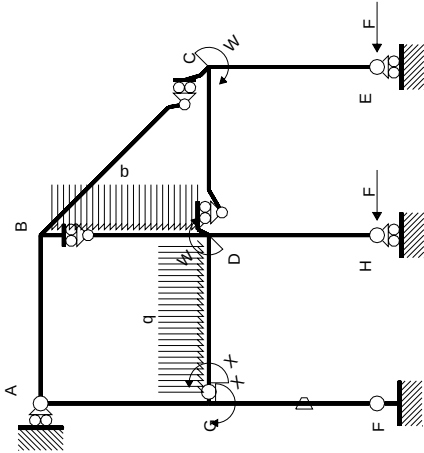


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

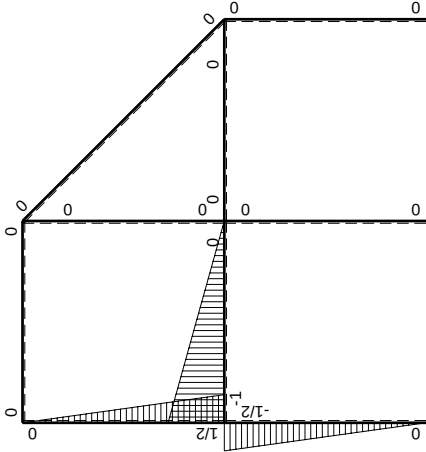


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-Fx-1/2qx ²	0	Fx-1/2Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(5/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx ²	0	3/2Fb-2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						11/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(x/b - \frac{1}{2} x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{6} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - 2 x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{2}{3} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

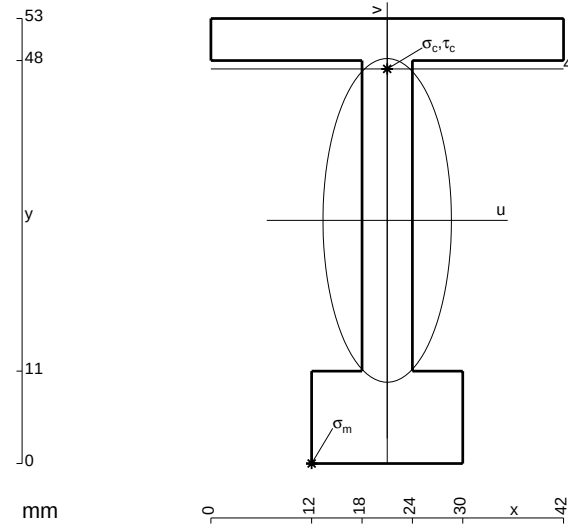
$$= \left(\frac{3}{4} b - \frac{2}{3} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{5}{24} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

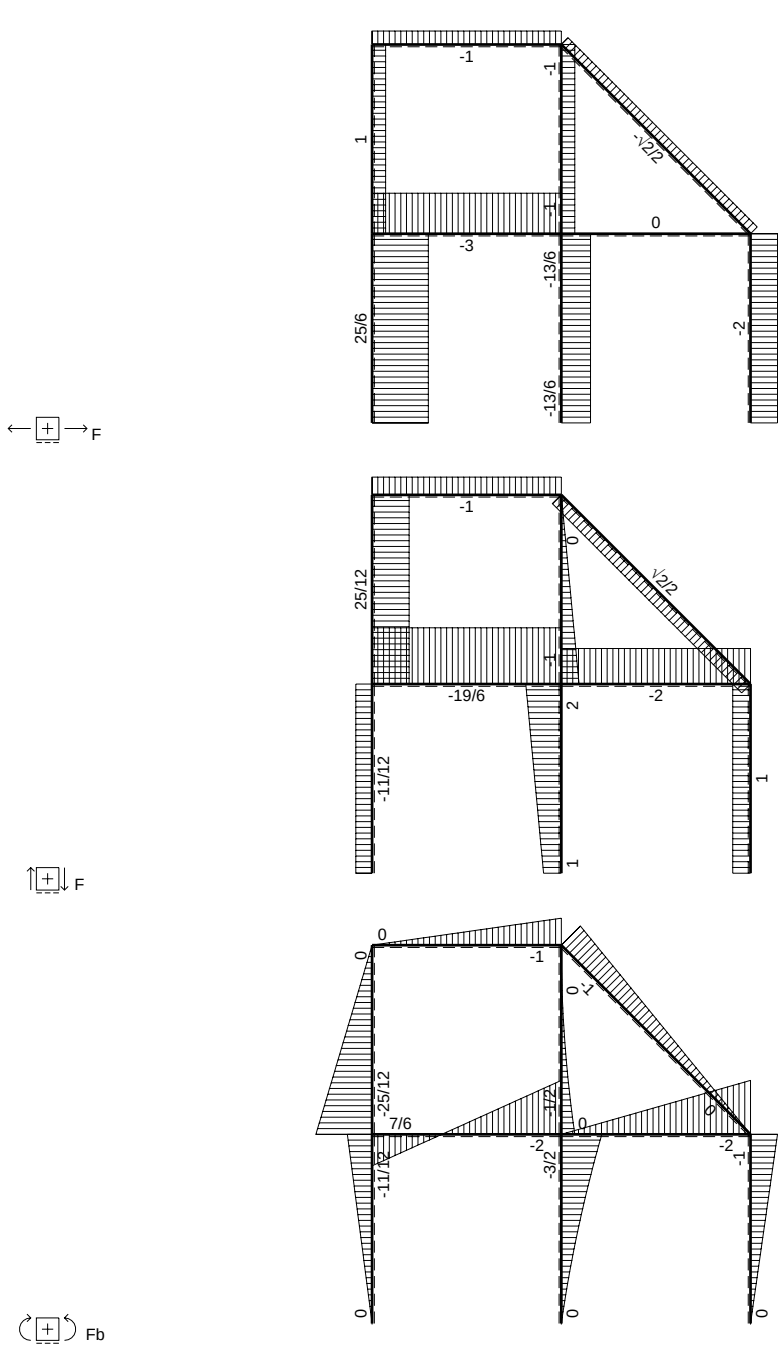
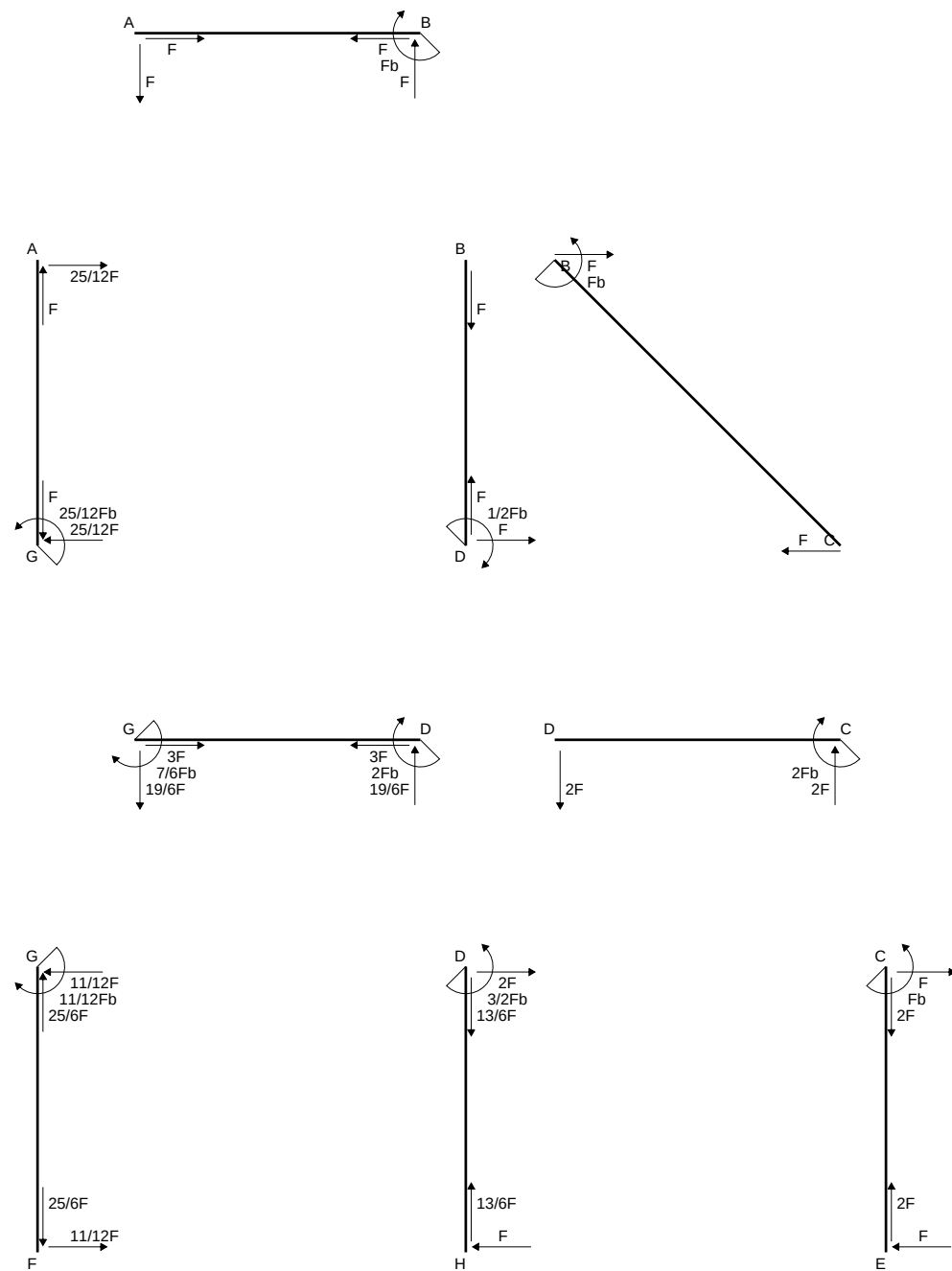
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



$$\begin{aligned} A &= 630. \text{ mm}^2 \\ J_u &= 234233. \text{ mm}^4 \\ J_v &= 36882. \text{ mm}^4 \\ y_g &= 28.96 \text{ mm} \\ T_y &= -2140. \text{ N} \\ M_x &= -1605000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -28.96 \text{ mm} \\ \sigma_m &= -Mv/J_u = -198.4 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 47. \text{ mm} \\ v_c &= 18.04 \text{ mm} \\ \sigma_c &= -Mv/J_u = 123.6 \text{ N/mm}^2 \\ \tau_c &= 7.058 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 124.2 \text{ N/mm}^2 \\ S &= 4635. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/4+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx ² /b	0	x ² /b ²		
DH b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx ²	0	0	0	0		
GA b	1/2-1/2x/b	-3/2Fb+3/2Fx	0	-3/4Fb+3/2Fx-3/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/4+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx	0	-3/4Fx ² /b	0	1/4x ² /b ²		
	totali						7/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{2} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{4} - \frac{3}{2} x/b + \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{4} x - \frac{3}{4} x^2/b + \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{4} b - \frac{3}{4} b + \frac{1}{4} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{2} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

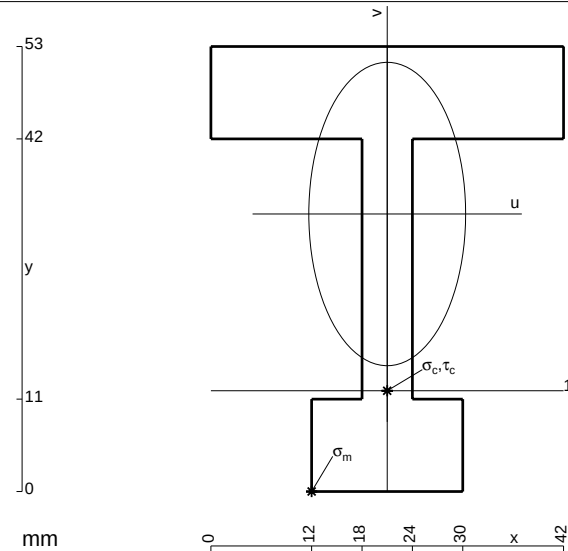
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{4} + \frac{3}{2} x/b - \frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{4} x + \frac{3}{4} x^2/b - \frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

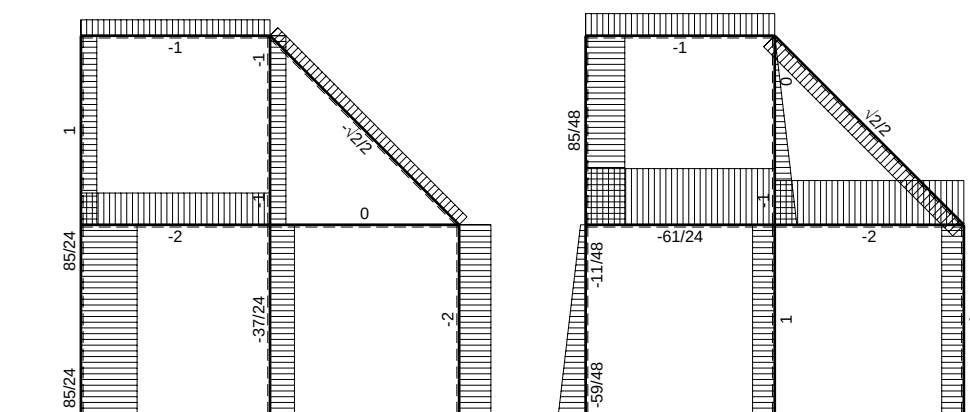
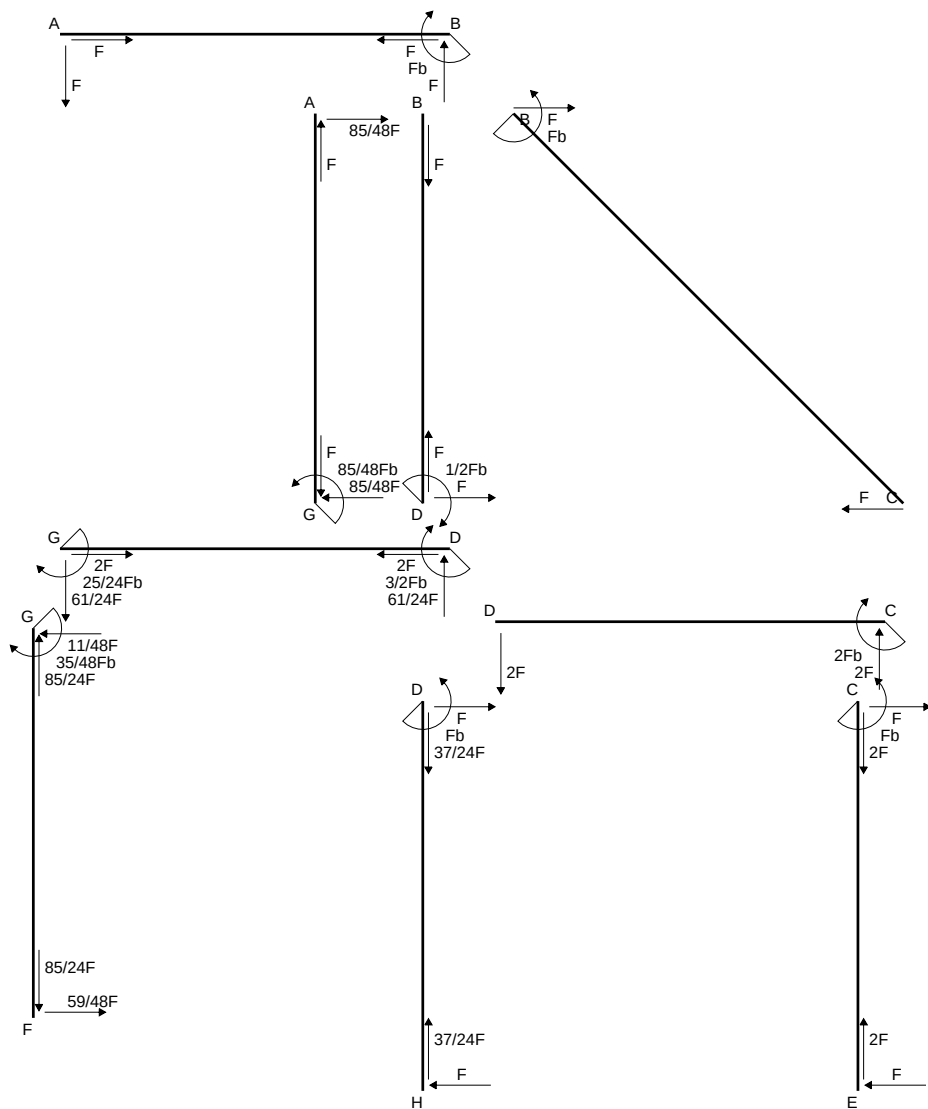
$$= \left(-\frac{3}{4} b + \frac{3}{4} b - \frac{1}{4} b \right) Fb \frac{1}{EJ} = -\frac{1}{4} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{3}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

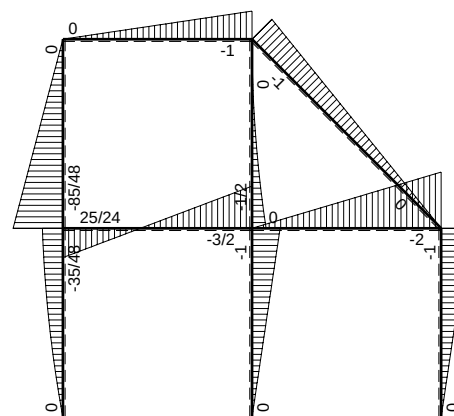
$$= \left(-\frac{1}{4} b \right) Fb \frac{1}{EJ} = -\frac{1}{4} Fb^2/EJ$$



$$\begin{aligned} A &= 846. \text{ mm}^2 \\ J_u &= 276280. \text{ mm}^4 \\ J_v &= 73818. \text{ mm}^4 \\ y_g &= 33.05 \text{ mm} \\ T_y &= -2180. \text{ N} \\ M_x &= -1744000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -33.05 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.6 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -21.05 \text{ mm} \\ \sigma_c &= -Mv/J_u = -132.9 \text{ N/mm}^2 \\ \tau_c &= 7.345 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 133.5 \text{ N/mm}^2 \\ S &= 5585. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

↑ + ↓ F



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-7/4Fx+1/2qx ²	-Fb/EJ	7/8Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(11/48+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx ²	Fb/EJ	5/8Fb-Fx+1/8Fx ² /b+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-5/4Fb+5/4Fx	0	-5/8Fb+5/4Fx-5/8Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-5/24+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx	0	-5/8Fx ² /b	0	1/4x ² /b ²		
	totali						25/48Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-25/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) 1/EJ \, dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(b - b + \frac{1}{3} b \right) 1/EJ = 1/3 \, b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{3} b \right) 1/EJ = 1/3 \, b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) 1/EJ \, dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{12} b \right) 1/EJ = 1/12 \, b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{7}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb 1/EJ \, dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[\frac{7}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb 1/EJ + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{7}{24} b - \frac{1}{16} b \right) Fb 1/EJ + \left(\frac{1}{4} b \right) \theta = 23/48 \, Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{5}{8} - x/b + \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb 1/EJ \, dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta \, dx$$

$$= \left[\frac{5}{8} x - \frac{1}{2} x^2/b + \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb 1/EJ + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{8} b - \frac{1}{2} b + \frac{1}{24} b + \frac{1}{16} b \right) Fb 1/EJ + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = 23/48 \, Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb 1/EJ \, dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb 1/EJ$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb 1/EJ = 1/4 \, Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb 1/EJ \, dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb 1/EJ$$

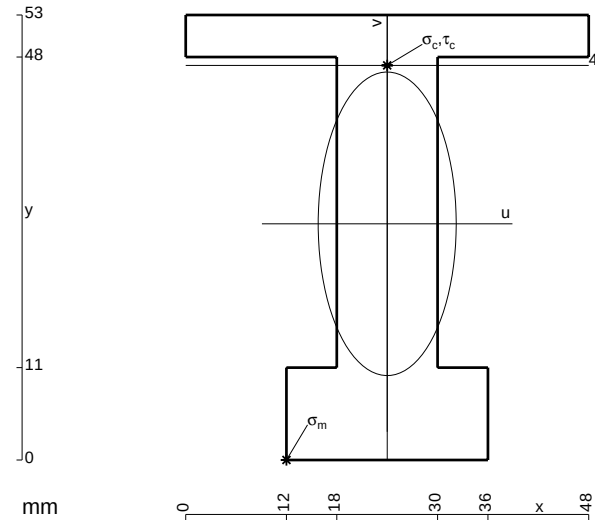
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb 1/EJ = 1/4 \, Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{5}{8} + \frac{5}{4} x/b - \frac{5}{8} x^2/b^2 \right) Fb 1/EJ \, dx = \left[-\frac{5}{8} x + \frac{5}{8} x^2/b - \frac{5}{24} x^3/b^2 \right]_0^b Fb 1/EJ$$

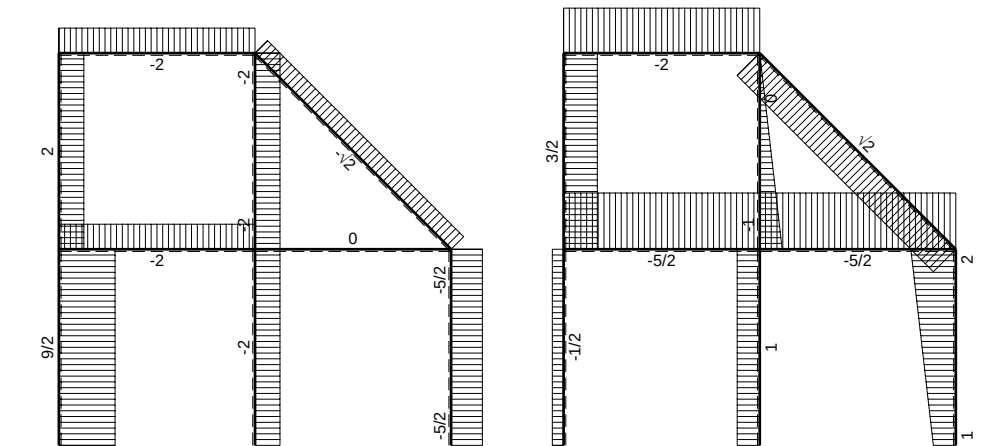
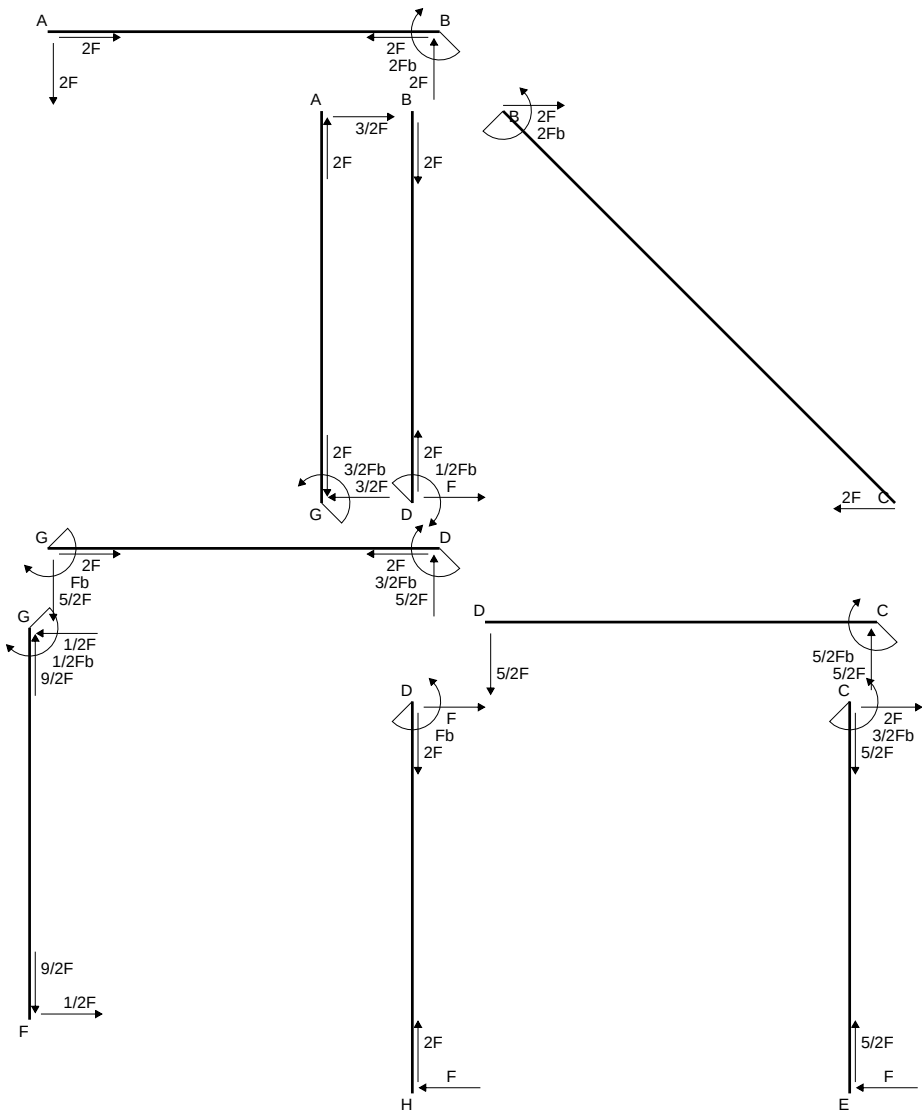
$$= \left(-\frac{5}{8} b + \frac{5}{8} b - \frac{5}{24} b \right) Fb 1/EJ = -5/24 \, Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 \right) Fb 1/EJ \, dx = \left[-\frac{5}{24} x^3/b^2 \right]_0^b Fb 1/EJ$$

$$= \left(-\frac{5}{24} b \right) Fb 1/EJ = -5/24 \, Fb^2/EJ$$

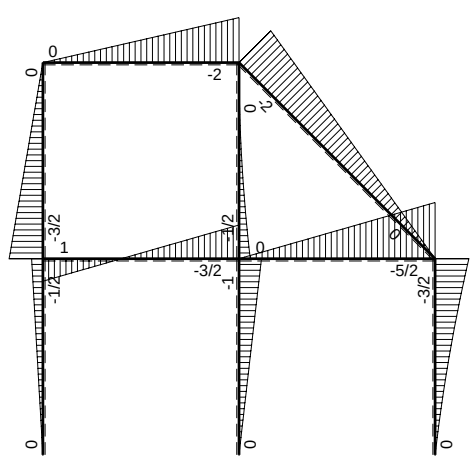


$$\begin{aligned} A &= 948. \text{ mm}^2 \\ J_u &= 309947. \text{ mm}^4 \\ J_v &= 64080. \text{ mm}^4 \\ y_g &= 28.13 \text{ mm} \\ T_y &= -2840. \text{ N} \\ M_x &= -2414000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -28.13 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.1 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 47. \text{ mm} \\ v_c &= 18.87 \text{ mm} \\ \sigma_c &= -Mv/J_u = 146.9 \text{ N/mm}^2 \\ \tau_c &= 4.276 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 147.1 \text{ N/mm}^2 \\ S &= 5601. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-5/2Fx	0	0	0	0	0+0	0
CD b	0	5/2Fb-5/2Fx	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx ²	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx ²	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						1/2Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

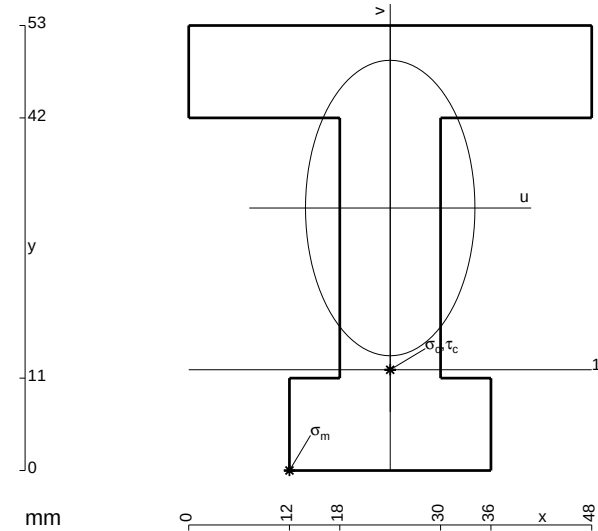
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

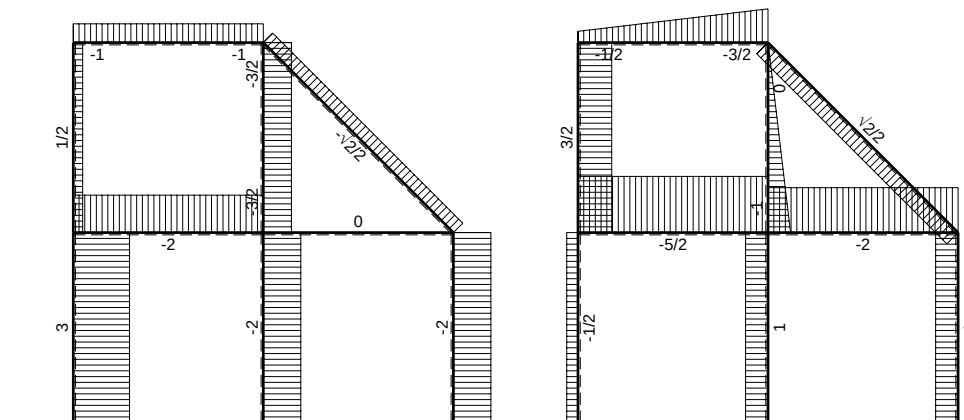
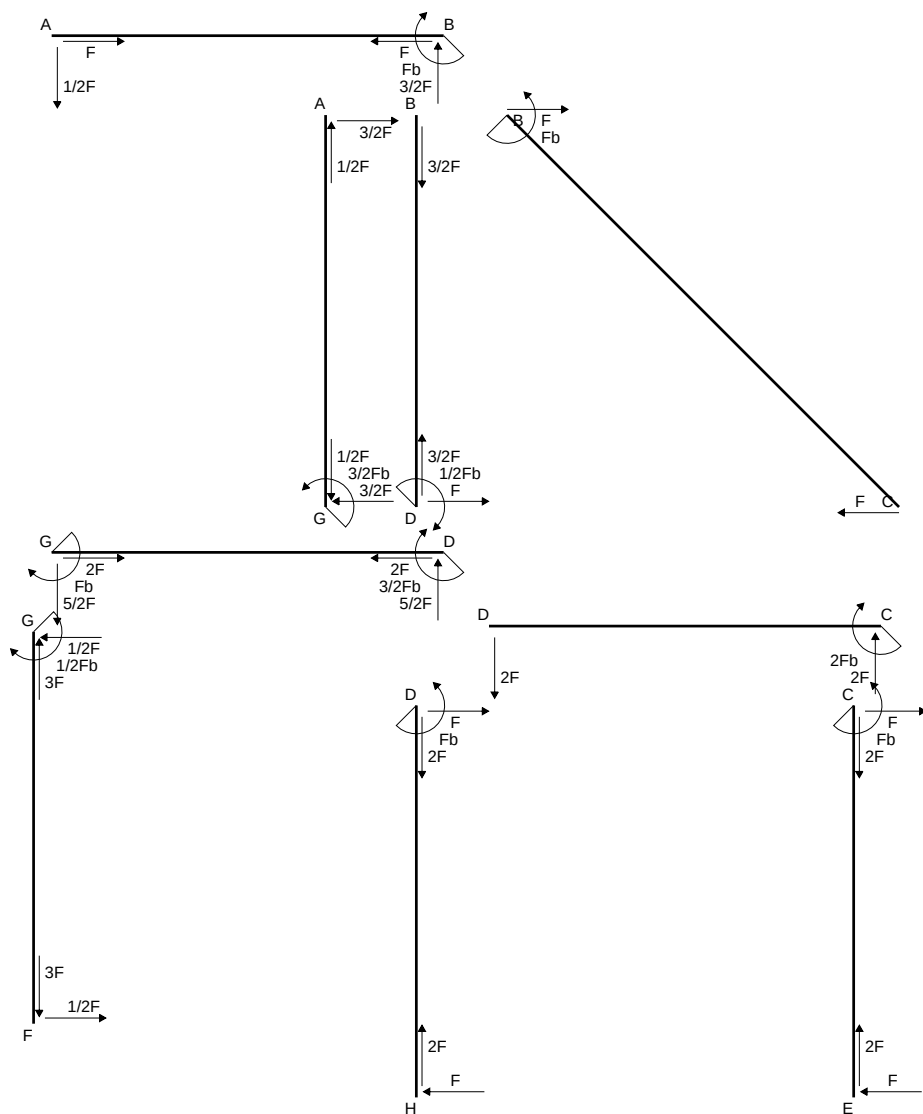
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

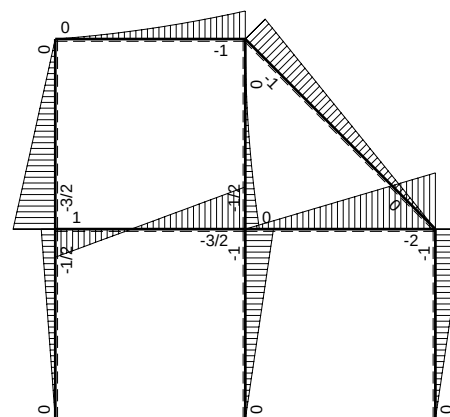
$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



$$\begin{aligned} A &= 1164. \text{ mm}^2 \\ J_u &= 360644. \text{ mm}^4 \\ J_v &= 118512. \text{ mm}^4 \\ y_g &= 31.26 \text{ mm} \\ T_y &= -2925. \text{ N} \\ M_x &= -2632500. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.26 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.2 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -19.26 \text{ mm} \\ \sigma_c &= -Mv/J_u = -140.6 \text{ N/mm}^2 \\ \tau_c &= 4.757 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 140.9 \text{ N/mm}^2 \\ S &= 7039. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

$\uparrow \boxed{+} \downarrow F$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

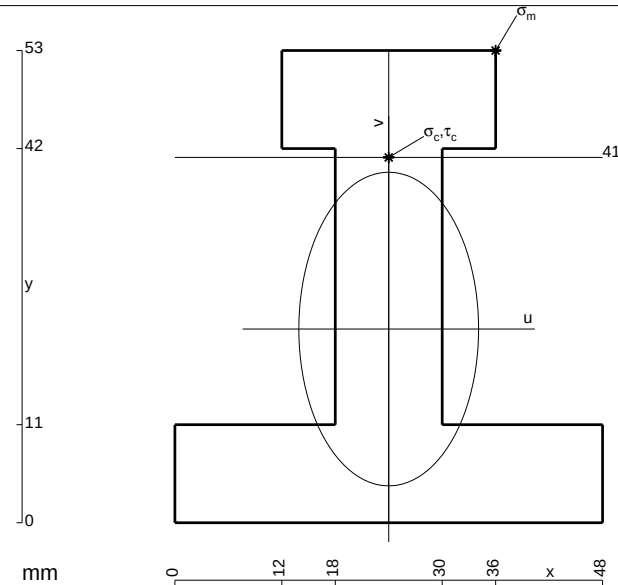
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

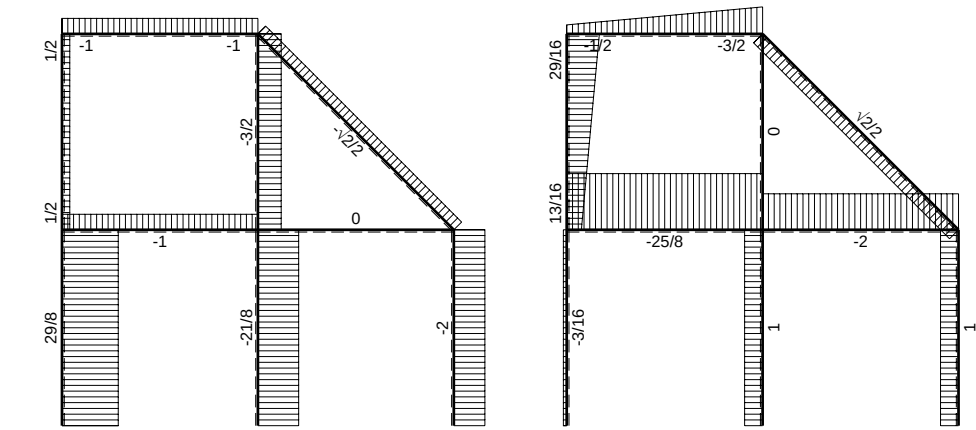
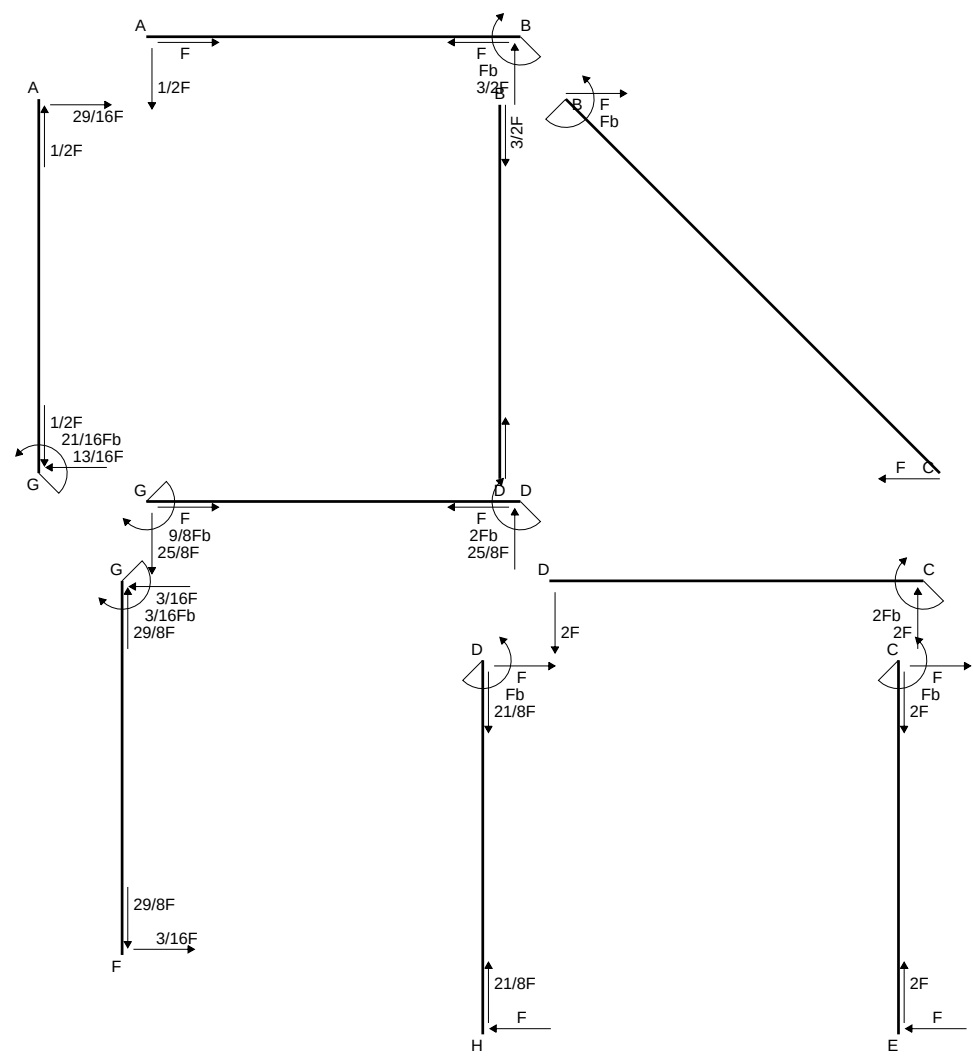
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

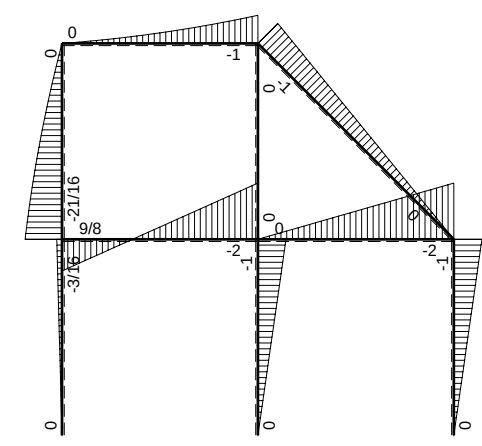


$$\begin{aligned} A &= 1164. \text{ mm}^2 \\ J_u &= 360644. \text{ mm}^4 \\ J_v &= 118512. \text{ mm}^4 \\ y_g &= 21.74 \text{ mm} \\ T_y &= -2900. \text{ N} \\ M_x &= -2755000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.26 \text{ mm} \\ \sigma_m &= -Mv/J_u = 238.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 19.26 \text{ mm} \\ \sigma_c &= -Mv/J_u = 147.2 \text{ N/mm}^2 \\ \tau_c &= 4.717 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 147.4 \text{ N/mm}^2 \\ S &= 7039. \text{ mm}^3 \end{aligned}$$

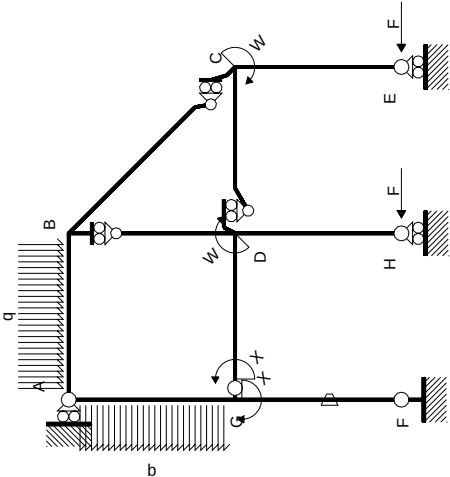


← ⊕ → F

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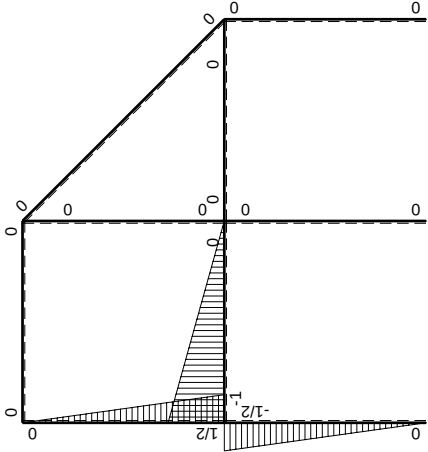
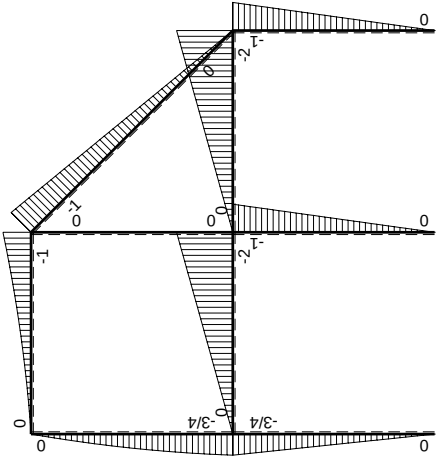


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



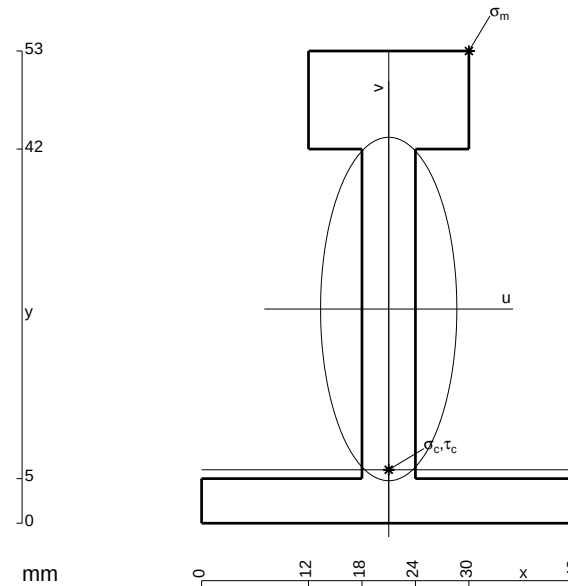
M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

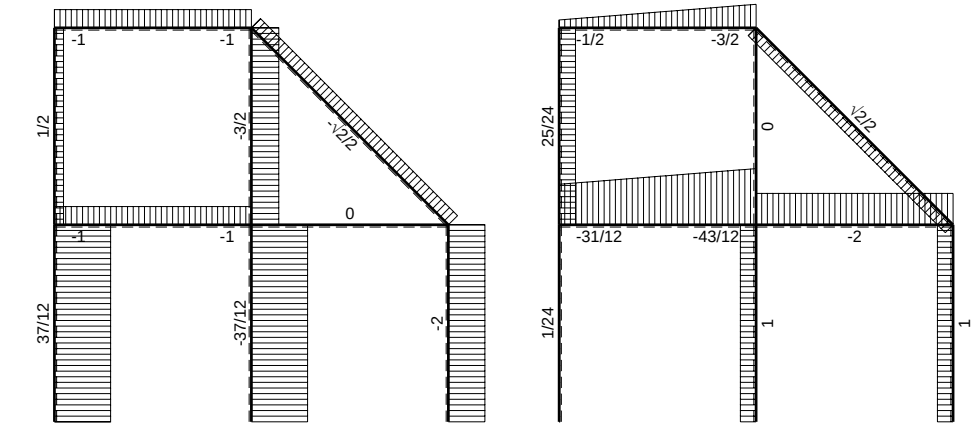
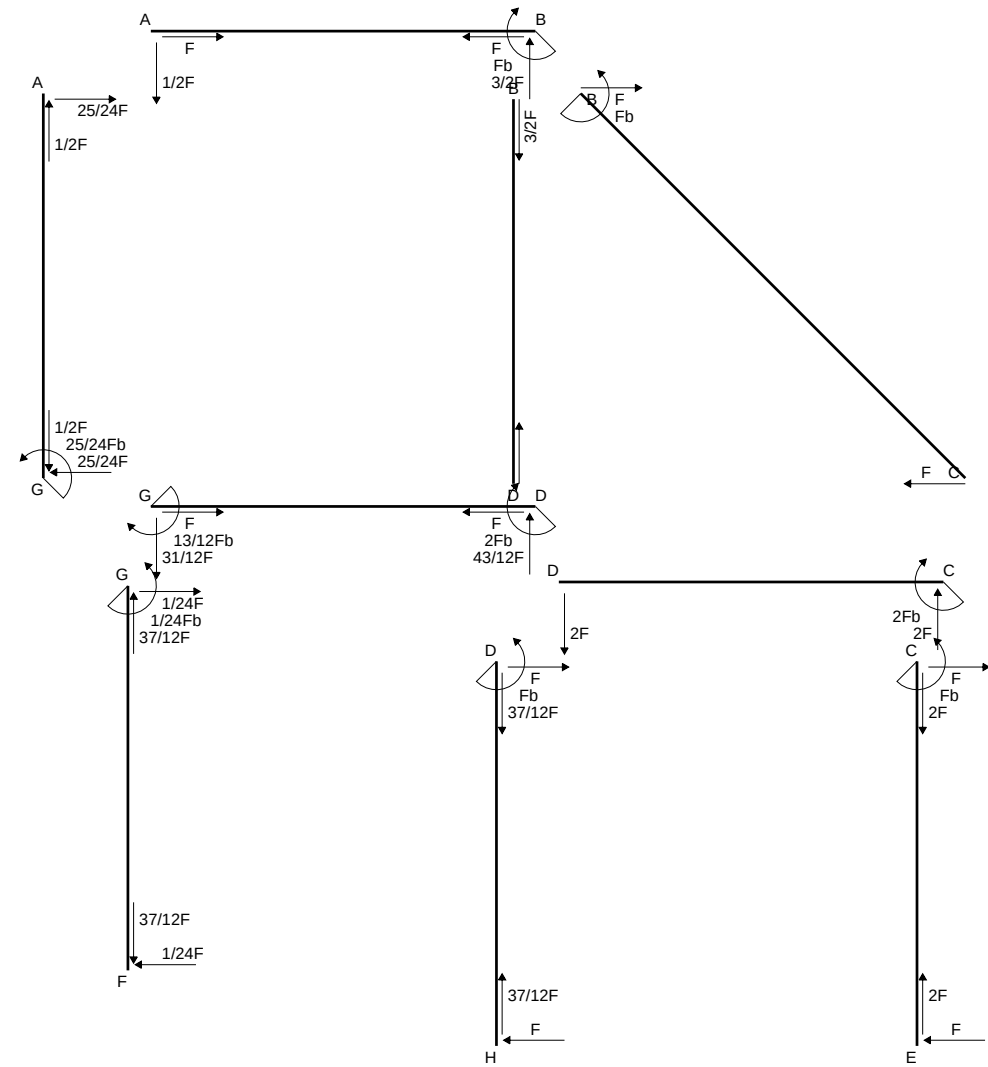
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/4Fx$	$-Fb/EJ$	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-2Fx$	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-2Fx$	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$9/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-9/8Fb$	

Sviluppi di calcolo iperstatica

$$\begin{aligned}
L_{FG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GF}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GD}^{xx} &= \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{DG}^{xx} &= \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{GA}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{AG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{FG}^{x_0} &= \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ \\
L_{GF}^{x_0} &= \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx \\
&= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ \\
L_{GD}^{x_0} &= \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ \\
L_{DG}^{x_0} &= \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ \\
L_{GA}^{x_0} &= \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx \\
&= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ \\
L_{AG}^{x_0} &= \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ
\end{aligned}$$

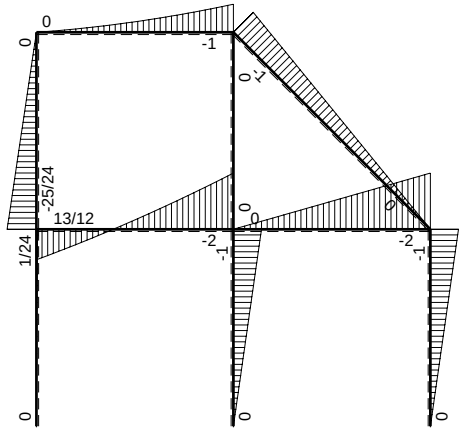


$$\begin{aligned}
A &= 630. \text{ mm}^2 \\
J_u &= 234233. \text{ mm}^4 \\
J_v &= 36882. \text{ mm}^4 \\
y_g &= 24.04 \text{ mm} \\
T_y &= -3220. \text{ N} \\
M_x &= -1610000. \text{ Nmm} \\
x_m &= 30. \text{ mm} \\
y_m &= 53. \text{ mm} \\
u_m &= 9. \text{ mm} \\
v_m &= 28.96 \text{ mm} \\
\sigma_m &= -Mv/J_u = 199. \text{ N/mm}^2 \\
x_c &= 21. \text{ mm} \\
y_c &= 6. \text{ mm} \\
v_c &= -18.04 \text{ mm} \\
\sigma_c &= -Mv/J_u = -124. \text{ N/mm}^2 \\
\tau_c &= 10.62 \text{ N/mm}^2 \\
\sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 125.4 \text{ N/mm}^2 \\
S &= 4635. \text{ mm}^3
\end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx-1/2qx^2$	0	$3/2Fx-Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(7/24+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-5/2Fx+1/2qx^2$	0	$2Fx-5/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$13/24Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-13/12Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

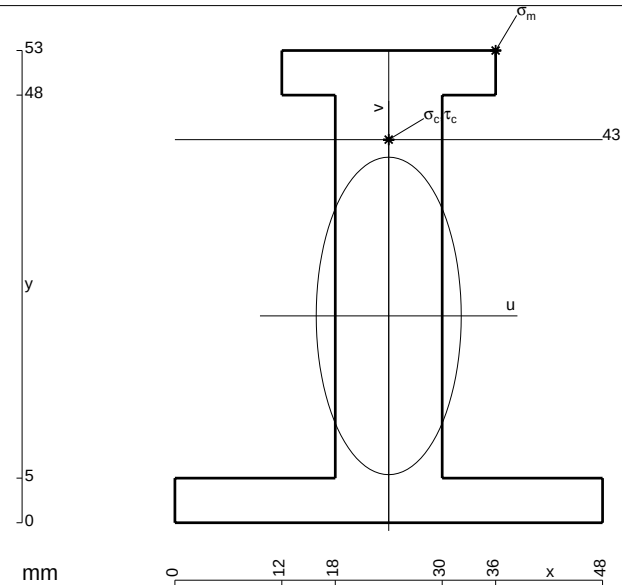
$$= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

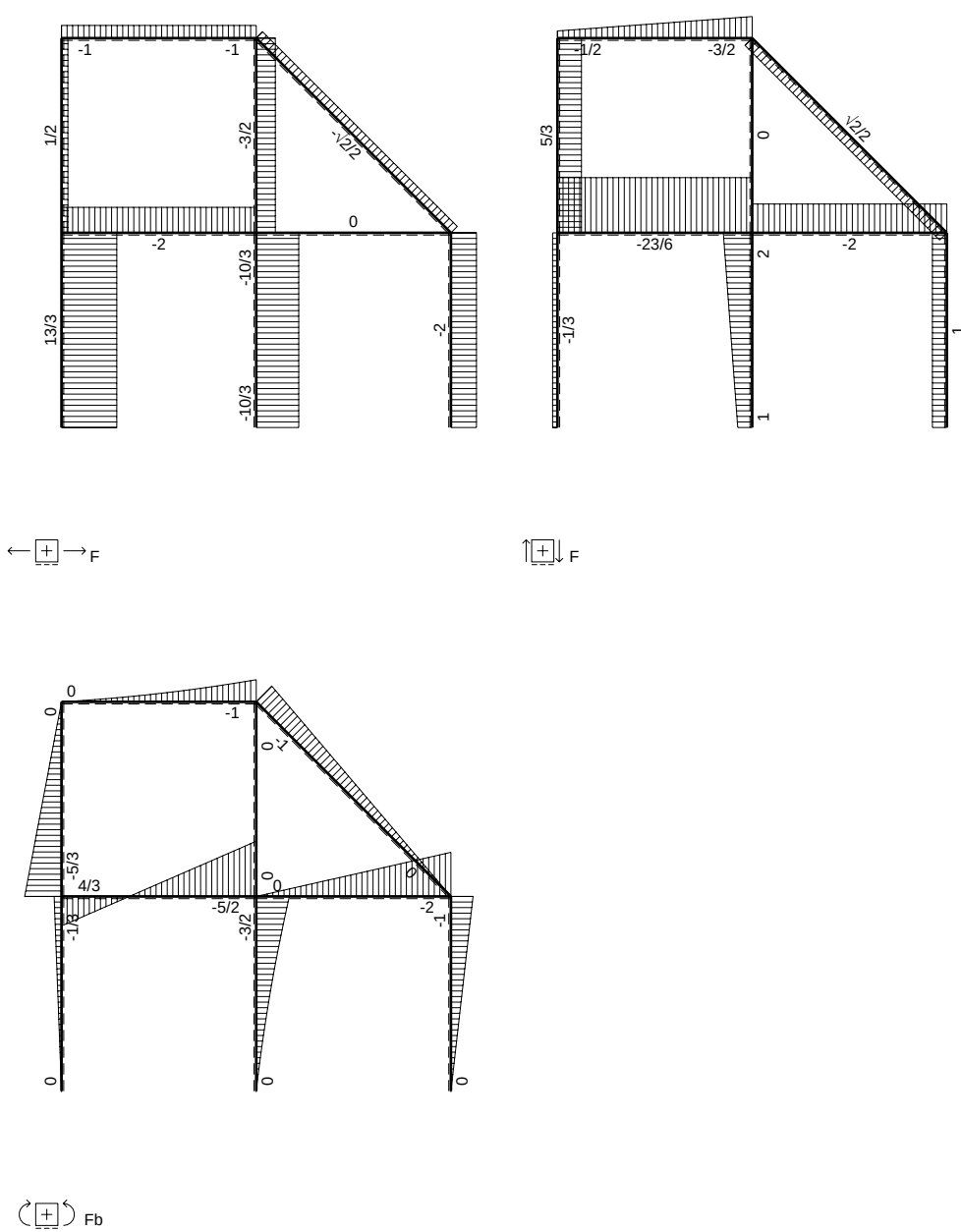
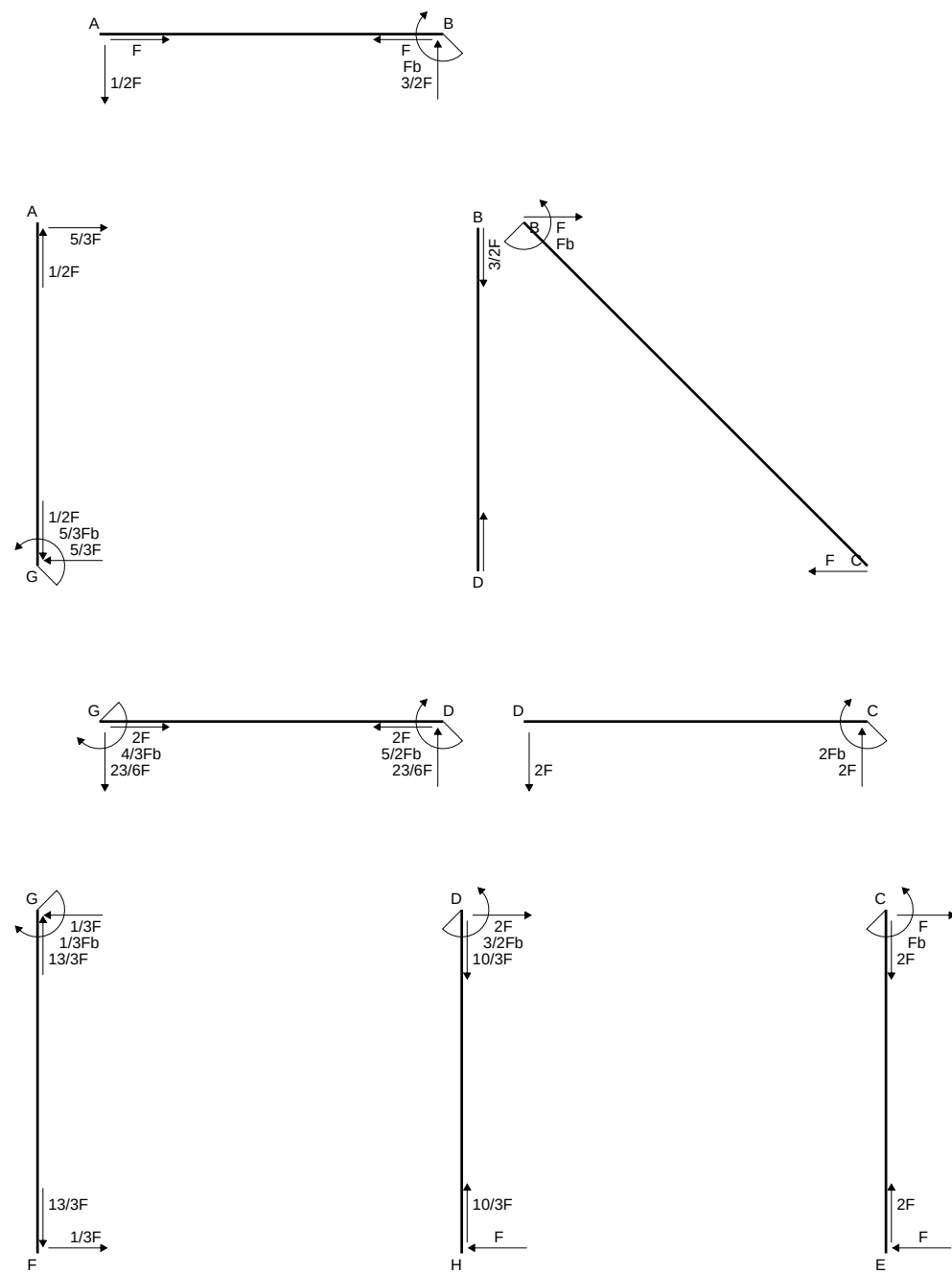
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

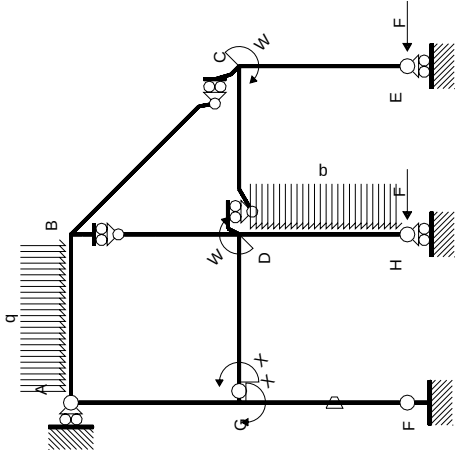
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$



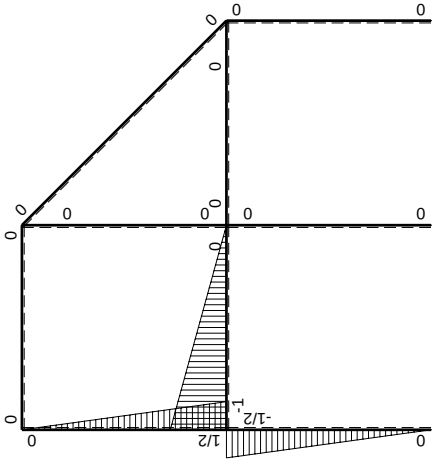
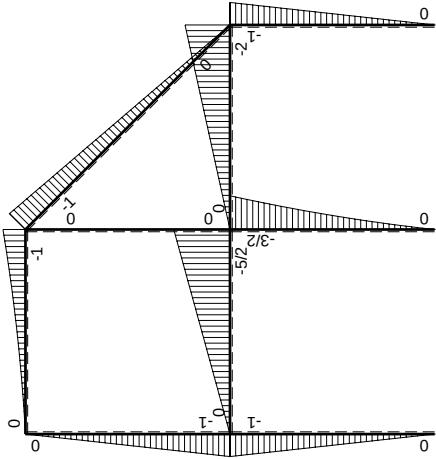
$$\begin{aligned} A &= 876. \text{ mm}^2 \\ J_u &= 278149. \text{ mm}^4 \\ J_v &= 58032. \text{ mm}^4 \\ y_g &= 23.21 \text{ mm} \\ T_y &= -3560. \text{ N} \\ M_x &= -1958000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.79 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 19.79 \text{ mm} \\ \sigma_c &= -Mv/J_u = 139.3 \text{ N/mm}^2 \\ \tau_c &= 4.919 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 139.6 \text{ N/mm}^2 \\ S &= 4612. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-5/2Fx$	0	$5/2Fx-5/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$5/2Fb-5/2Fx$	0	$5/2Fx-5/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$2/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-4/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

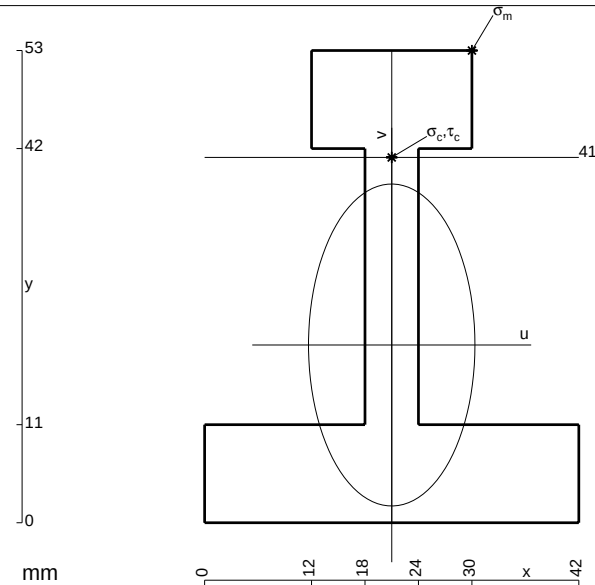
$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

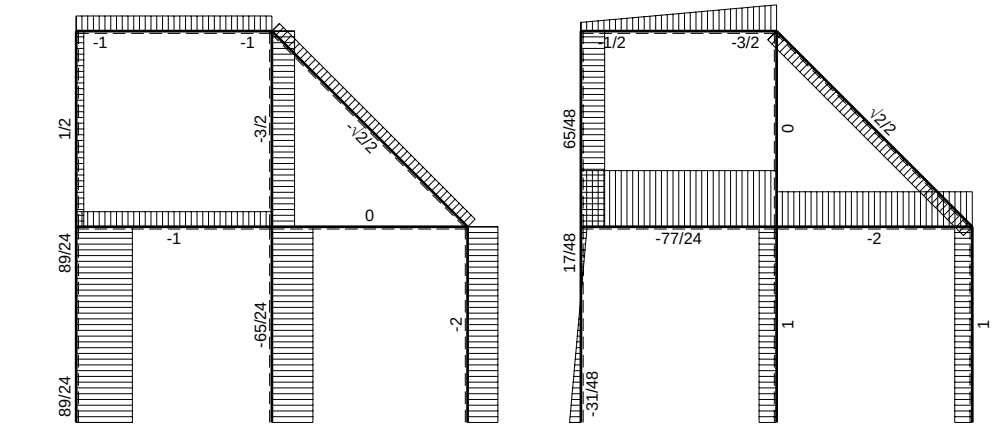
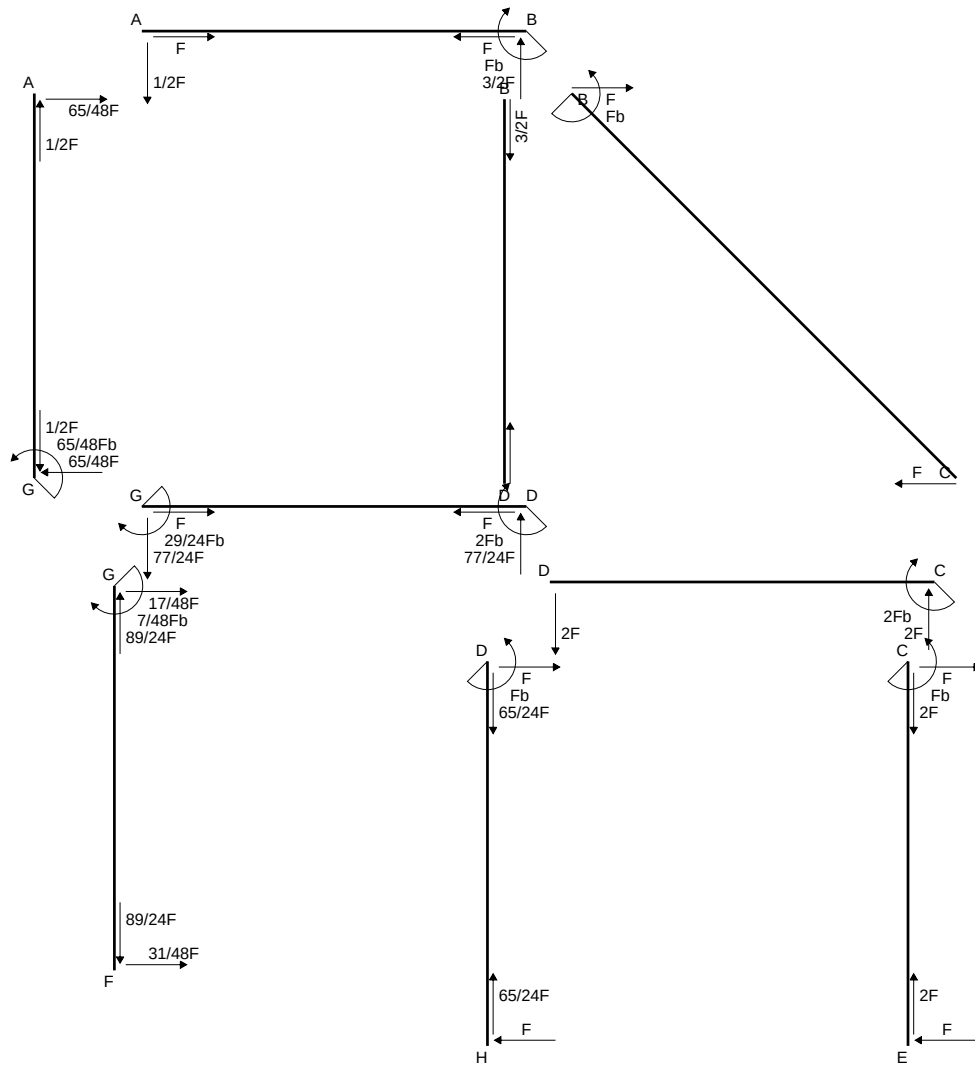
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

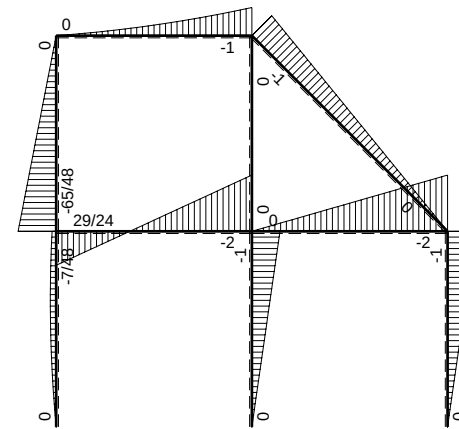
$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

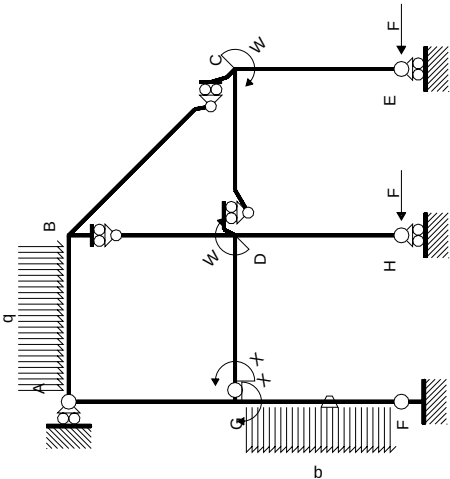


$$\begin{aligned} A &= 846. \text{ mm}^2 \\ J_u &= 276280. \text{ mm}^4 \\ J_v &= 73818. \text{ mm}^4 \\ y_g &= 19.95 \text{ mm} \\ T_y &= -3060. \text{ N} \\ M_x &= -1836000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.05 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219.7 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 21.05 \text{ mm} \\ \sigma_c &= -Mv/J_u = 139.9 \text{ N/mm}^2 \\ \tau_c &= 10.31 \text{ N/mm}^2 \\ \sigma_\varphi &= \sqrt{\sigma^2 + 3\tau^2} = 141. \text{ N/mm}^2 \\ S &= 5585. \text{ mm}^3 \end{aligned}$$



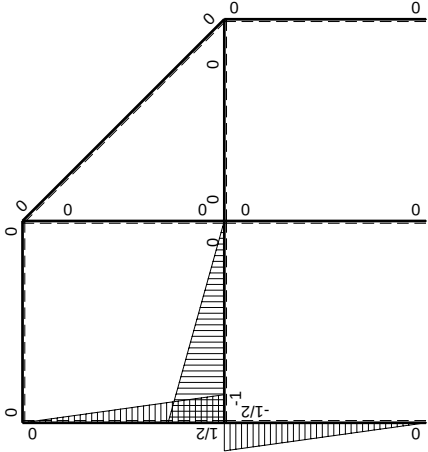
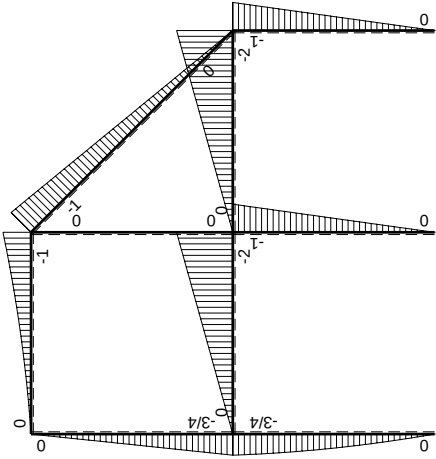
A diagram showing a square block with a '+' sign inside. A horizontal arrow points to the right from the block, labeled with the letter 'F'.





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-5/4Fx+1/2qx^2$	$-Fb/EJ$	$5/8Fx^2/b-1/4qx^3/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(7/48+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-1/4Fx-1/2qx^2$	Fb/EJ	$3/8Fb-1/2Fx-1/8Fx^2/b+1/4qx^3/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-2Fx$	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-2Fx$	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+3/4Fx$	0	$-3/8Fb+3/4Fx-3/8Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$3/4Fx$	0	$-3/8Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$29/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-29/24Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{5}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{5}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{5}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{3}{8} - \frac{1}{2} x/b - \frac{1}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{1}{4} x^2/b - \frac{1}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{1}{4} b - \frac{1}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{19}{48} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

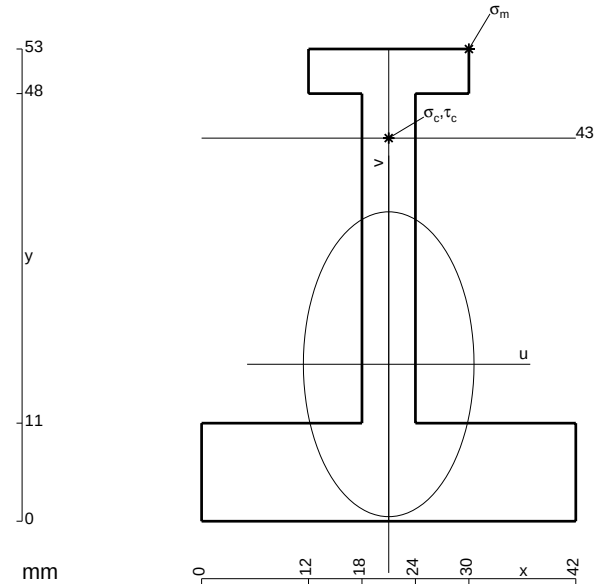
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{3}{8} + \frac{3}{4} x/b - \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{3}{8} x + \frac{3}{8} x^2/b - \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

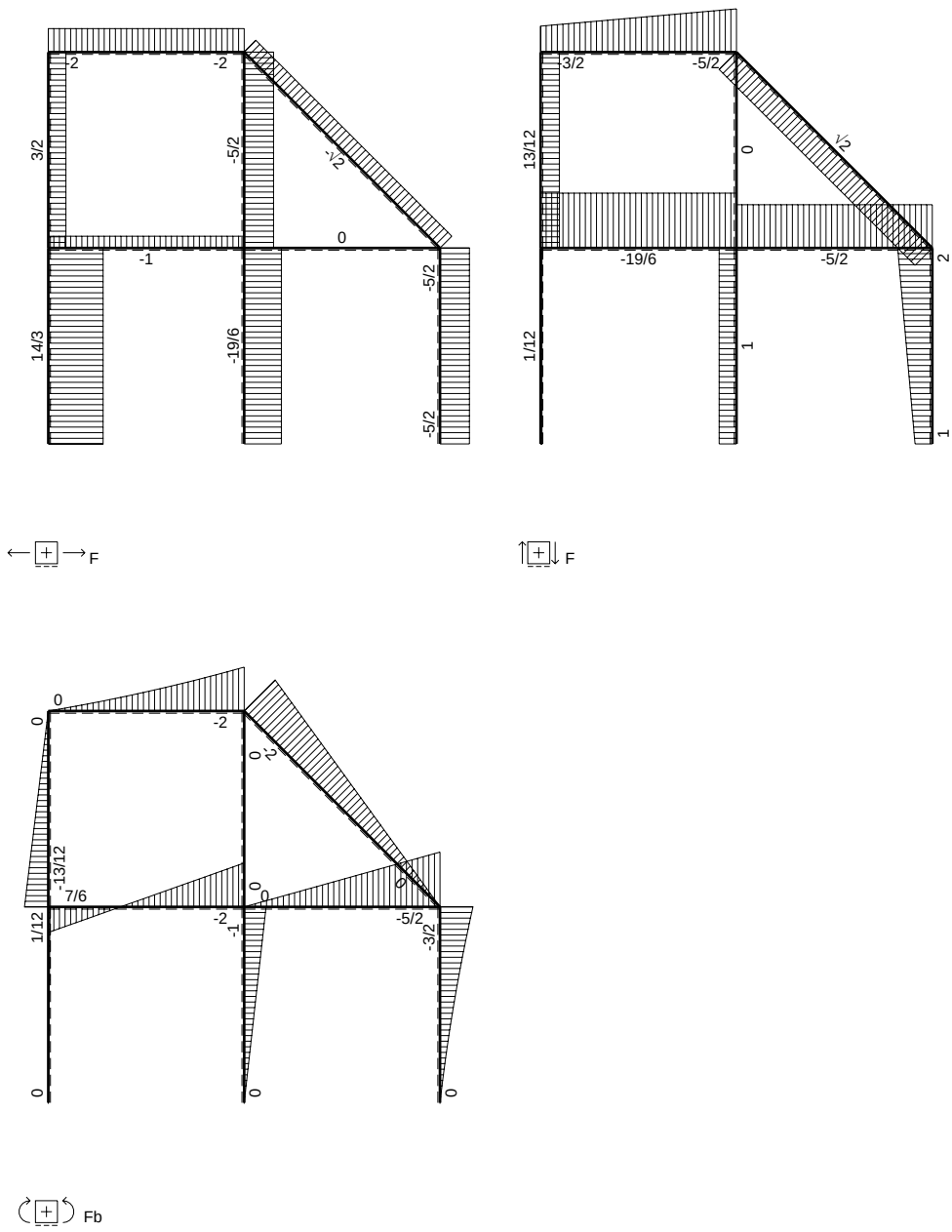
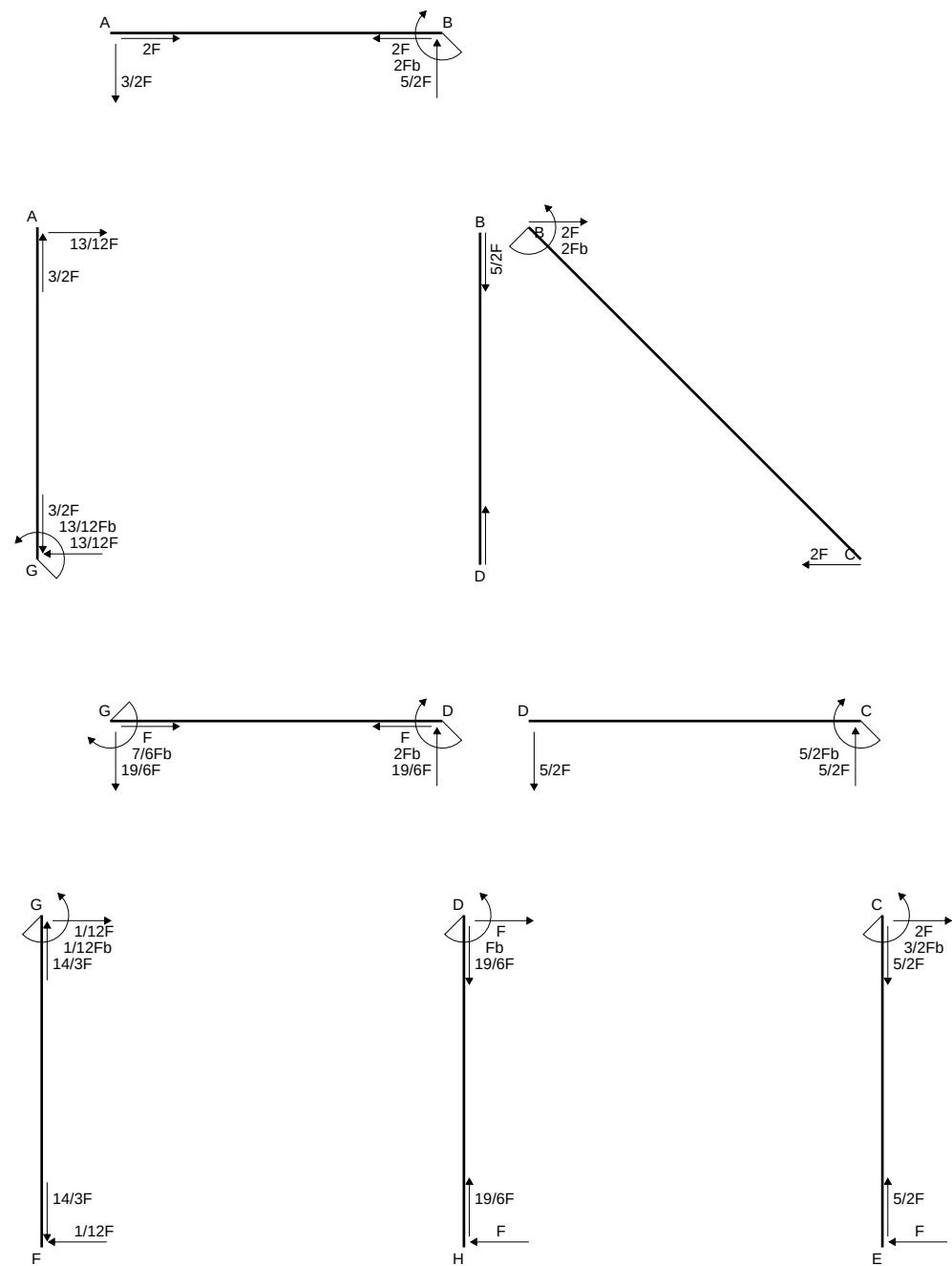
$$= \left(-\frac{3}{8} b + \frac{3}{8} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$

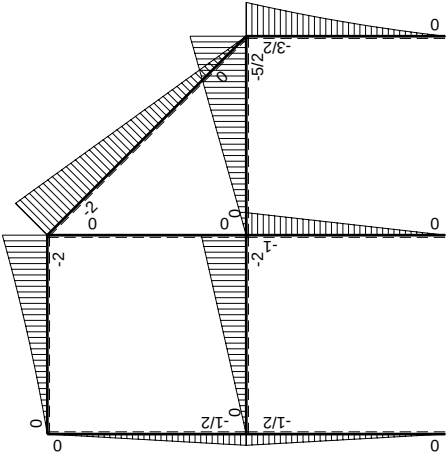
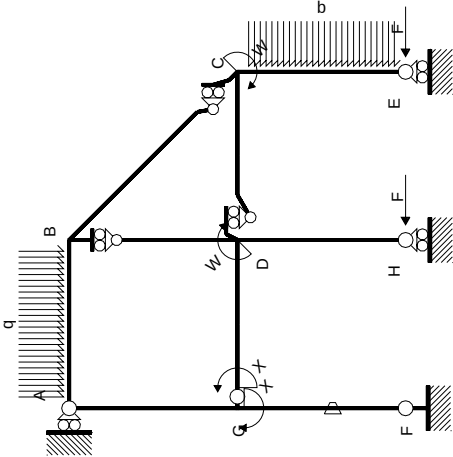
$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{8} b \right) Fb \frac{1}{EJ} = -\frac{1}{8} Fb^2/EJ$$



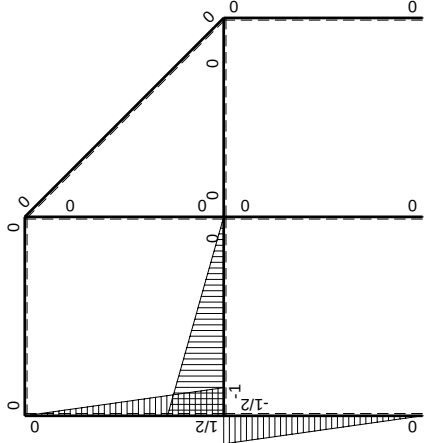
$$\begin{aligned} A &= 774. \text{ mm}^2 \\ J_u &= 226668. \text{ mm}^4 \\ J_v &= 71010. \text{ mm}^4 \\ y_g &= 17.62 \text{ mm} \\ T_y &= -2260. \text{ N} \\ M_x &= -1469000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 35.38 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.3 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 25.38 \text{ mm} \\ \sigma_c &= -Mv/J_u = 164.5 \text{ N/mm}^2 \\ \tau_c &= 6.308 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 164.9 \text{ N/mm}^2 \\ S &= 3796. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-2Fb+\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-5/2Fx$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-5/2Fx$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-2Fx$	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-2Fx$	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2x/b - 2x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2x/b - 2x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

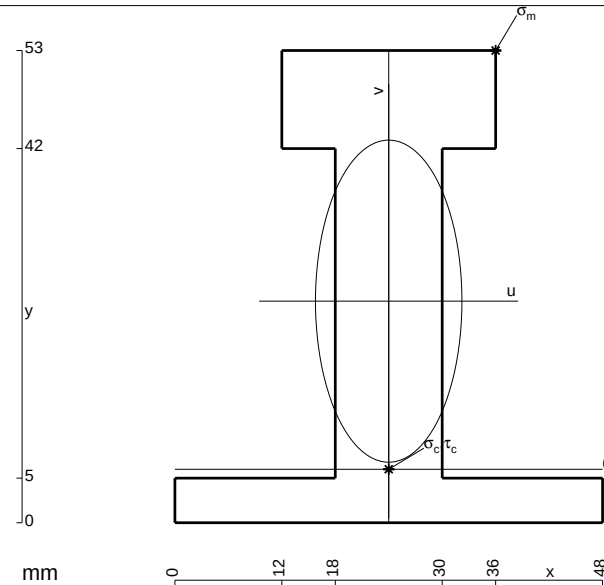
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

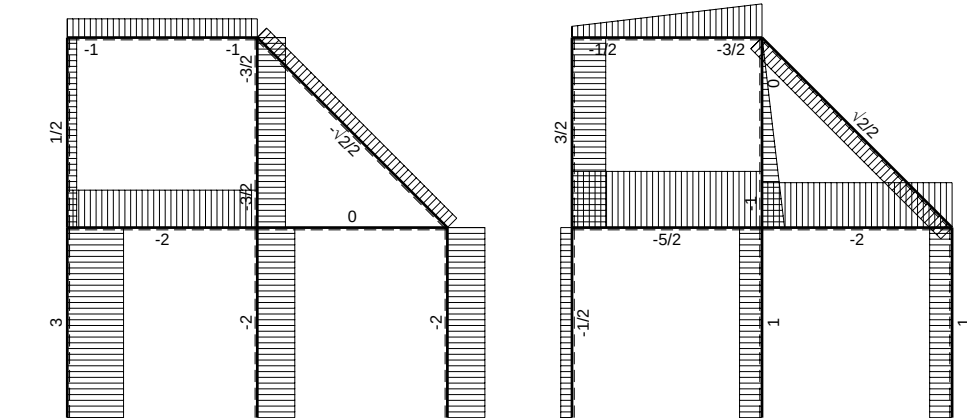
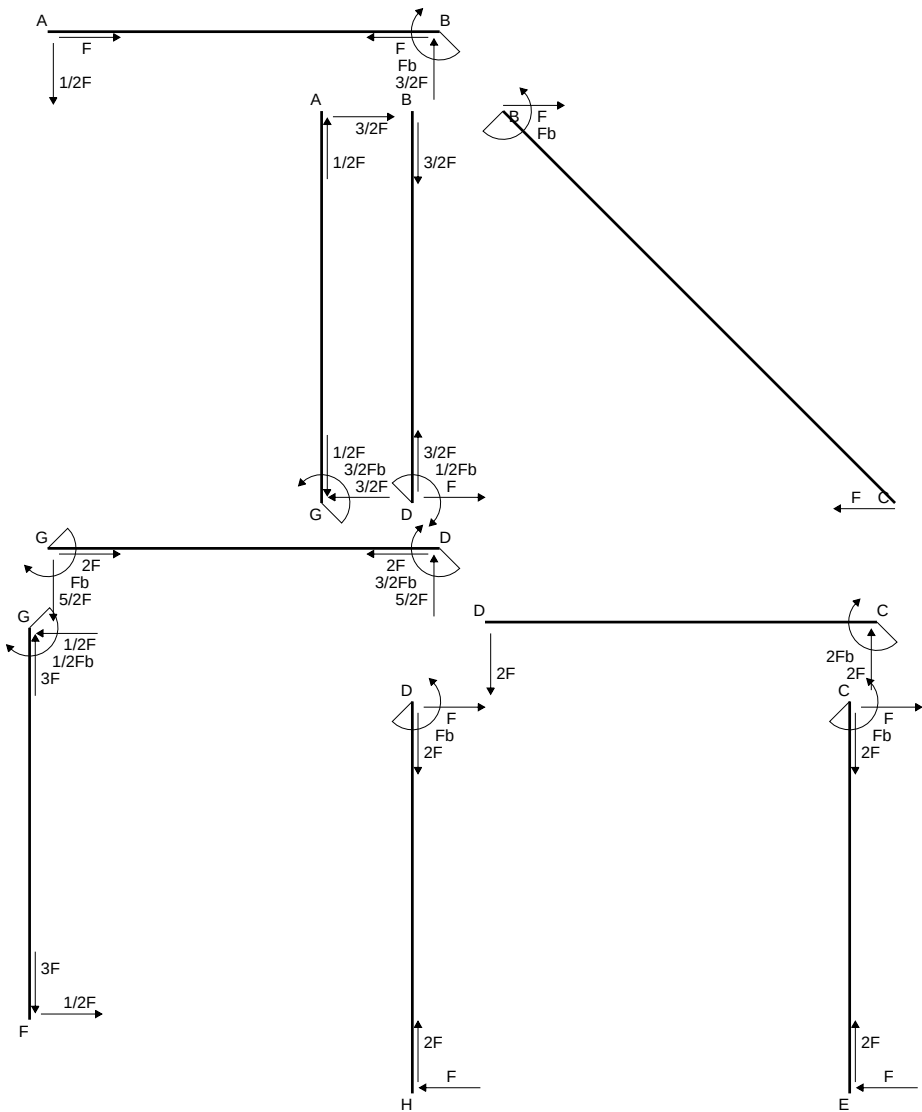
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

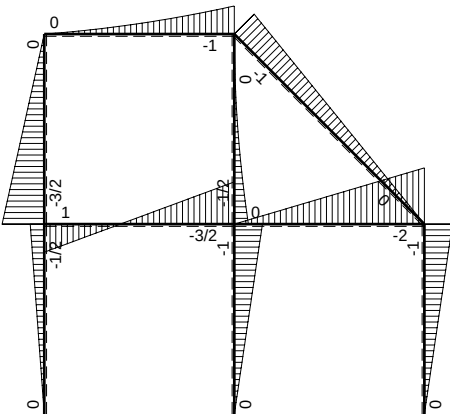


$$\begin{aligned} A &= 948. \text{ mm}^2 \\ J_u &= 309947. \text{ mm}^4 \\ J_v &= 64080. \text{ mm}^4 \\ y_g &= 24.87 \text{ mm} \\ T_y &= -3775. \text{ N} \\ M_x &= -2642500. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.13 \text{ mm} \\ \sigma_m &= -Mv/J_u = 239.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 6. \text{ mm} \\ v_c &= -18.87 \text{ mm} \\ \sigma_c &= -Mv/J_u = -160.9 \text{ N/mm}^2 \\ \tau_c &= 5.684 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 161.2 \text{ N/mm}^2 \\ S &= 5601. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ F_b

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	$-1/2qx^2$	0	0	0	0	0+0	0
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0		
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-Fx$	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$Fb-Fx$	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$3/2Fb-3/2Fx$	0	$3/2Fx-3/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-Fb+Fx$	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$1/2Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

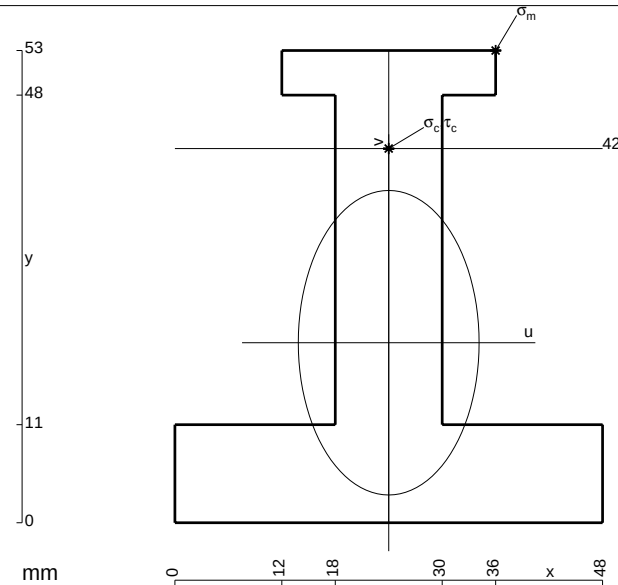
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

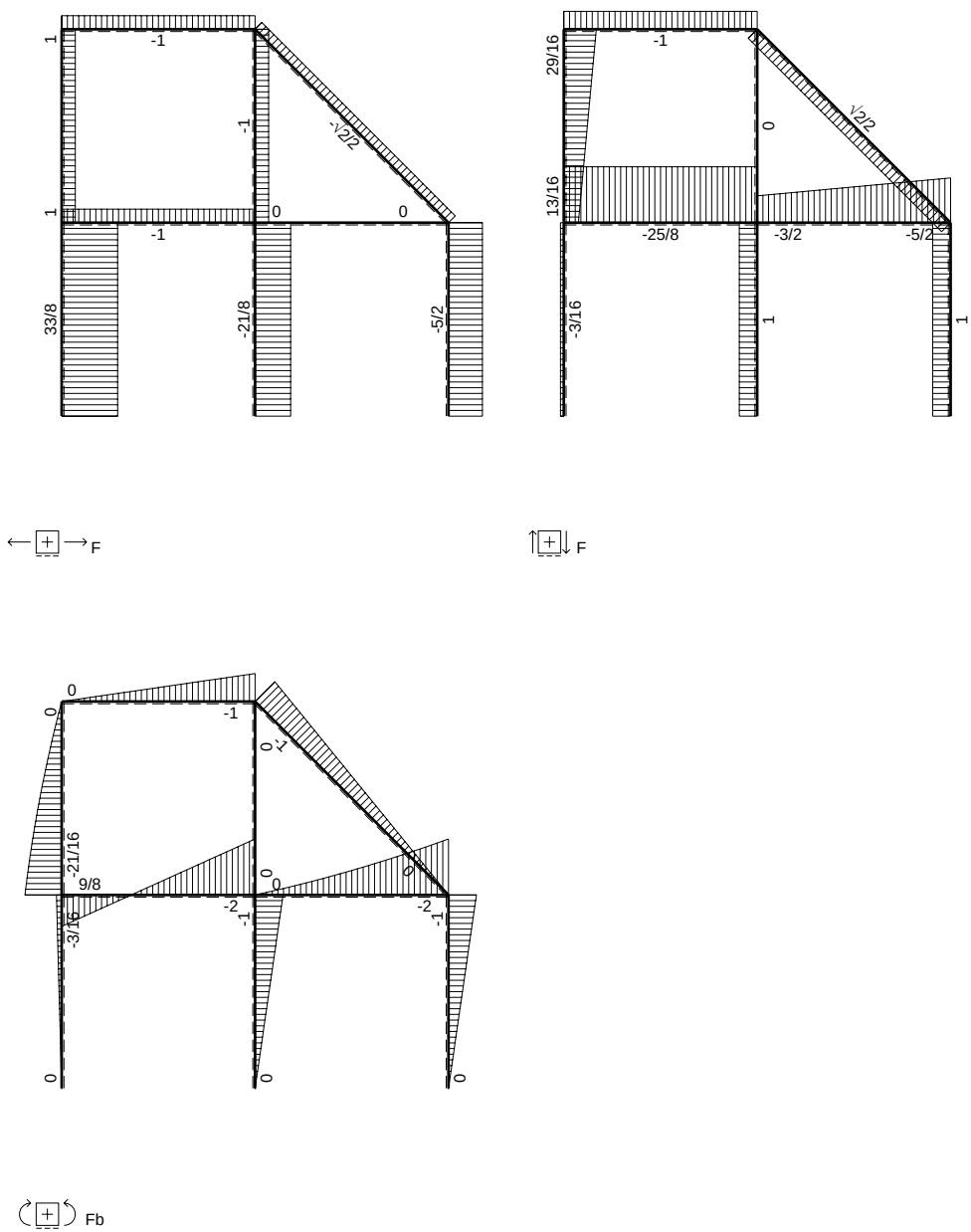
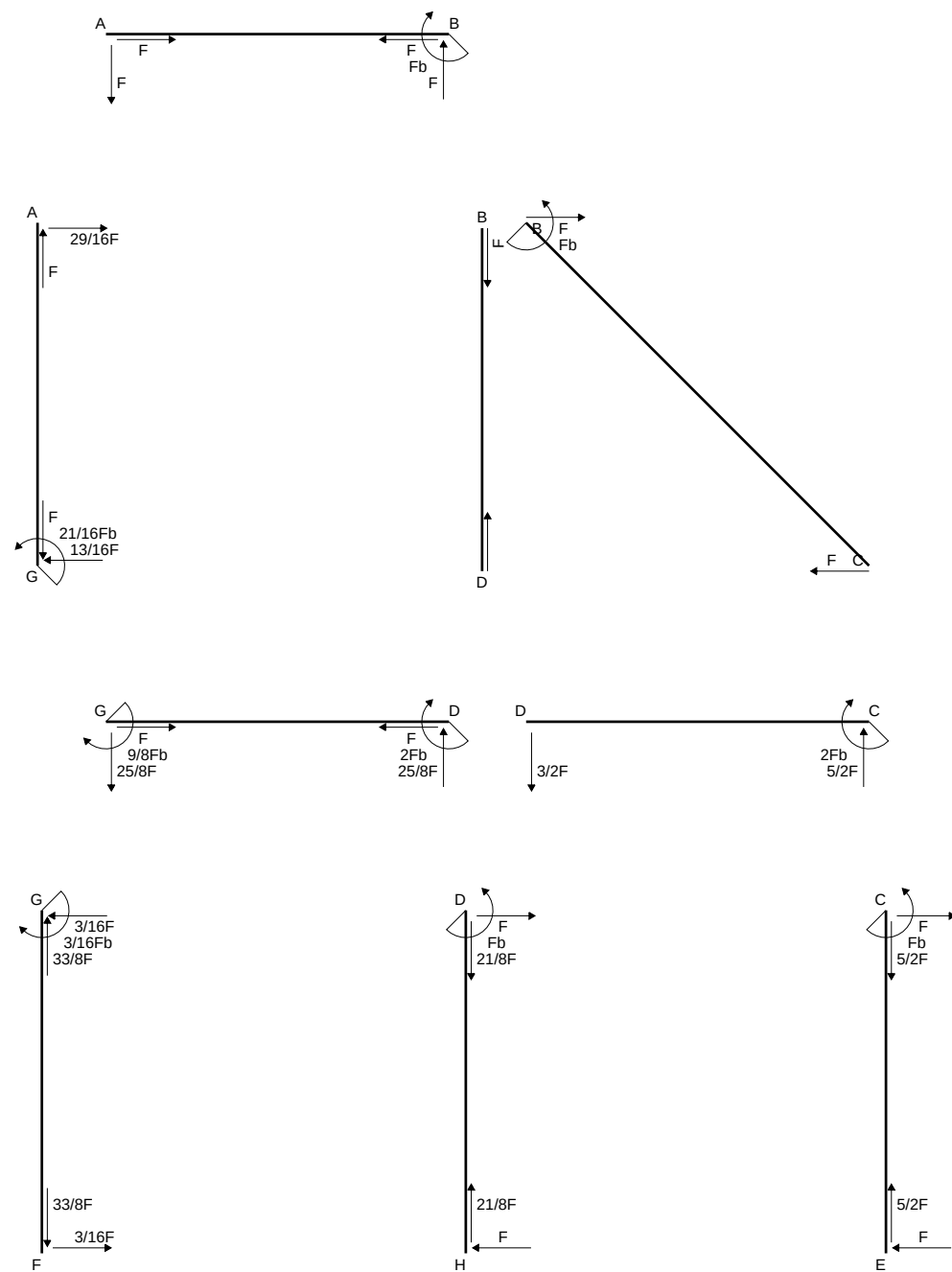
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

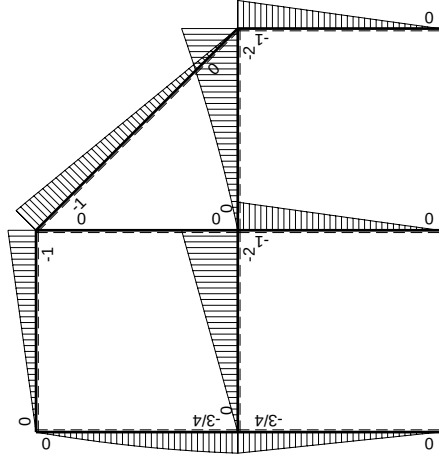
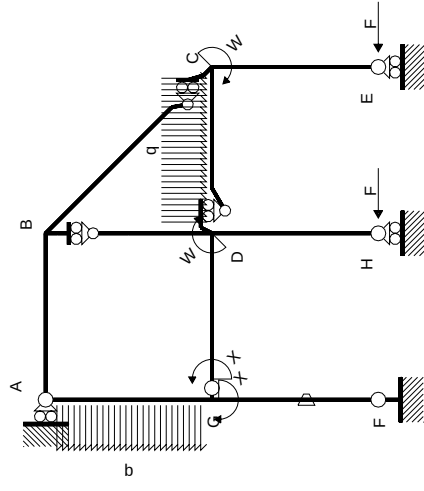
$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

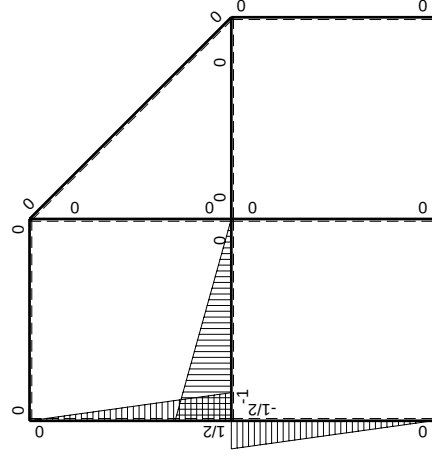


$$\begin{aligned} A &= 1092. \text{ mm}^2 \\ J_u &= 318895. \text{ mm}^4 \\ J_v &= 112464. \text{ mm}^4 \\ y_g &= 20.2 \text{ mm} \\ T_y &= -2580. \text{ N} \\ M_x &= -1935000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 32.8 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 21.8 \text{ mm} \\ \sigma_c &= -Mv/J_u = 132.3 \text{ N/mm}^2 \\ \tau_c &= 3.655 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 132.4 \text{ N/mm}^2 \\ S &= 5421. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-3/4Fx$	$-Fb/EJ$	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-2Fx$	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-2Fx$	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$9/16Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

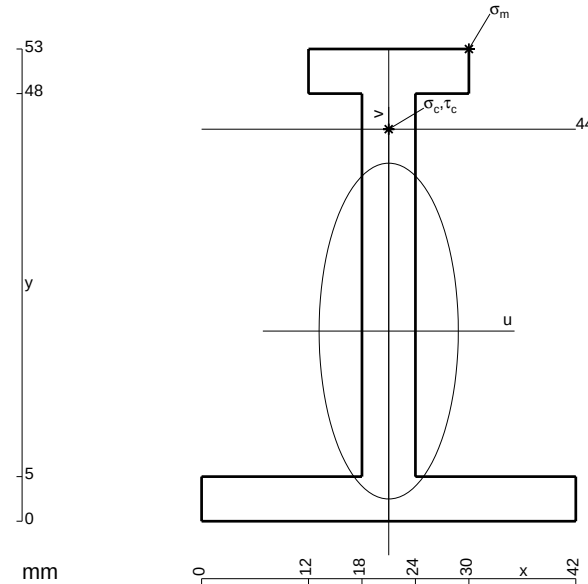
$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

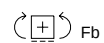
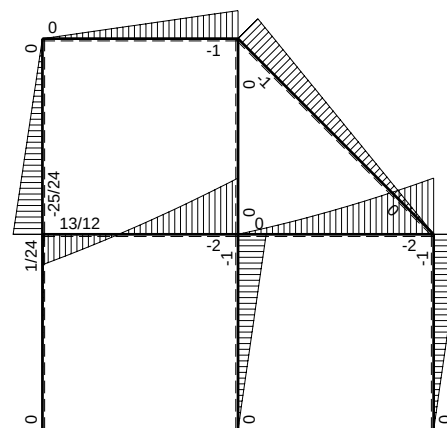
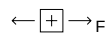
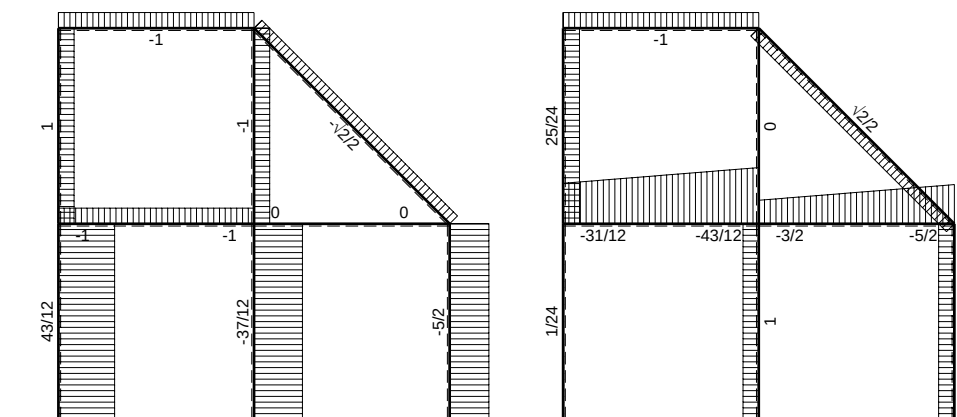
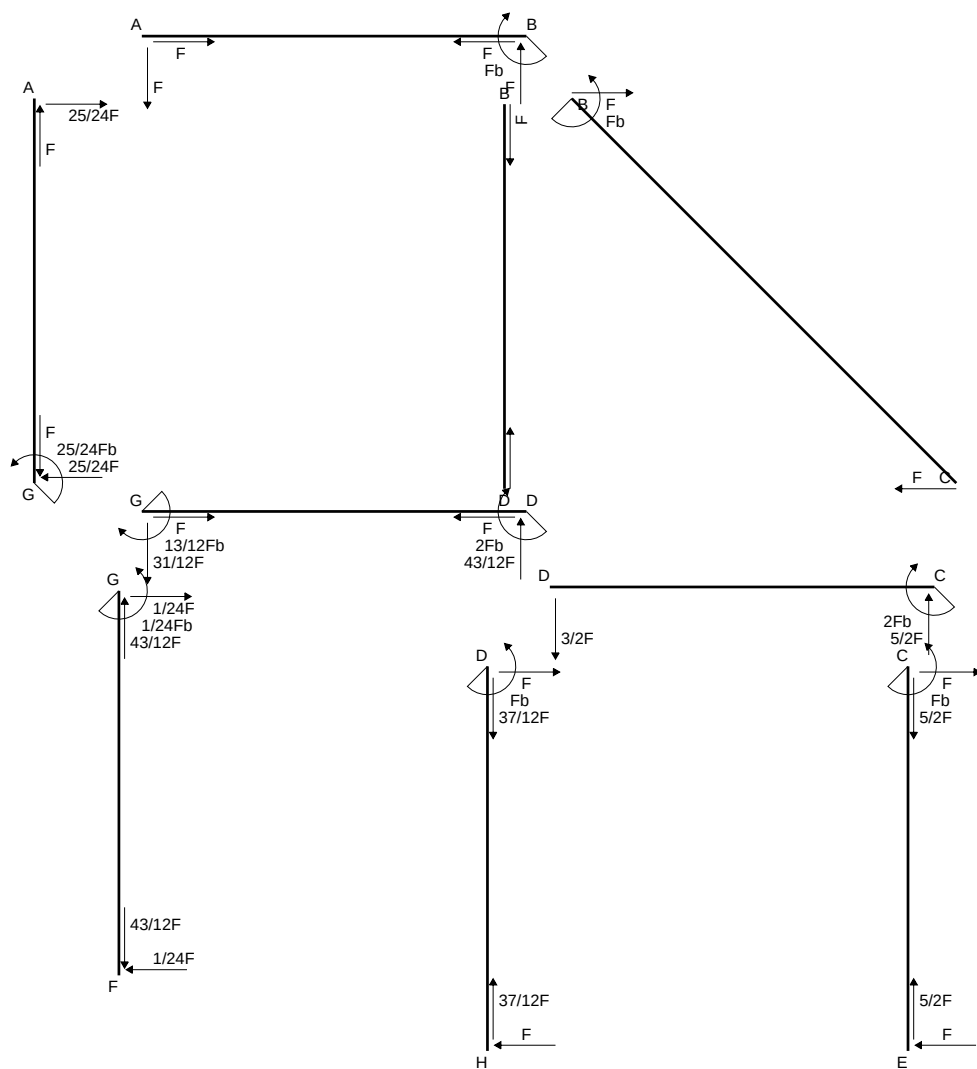
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

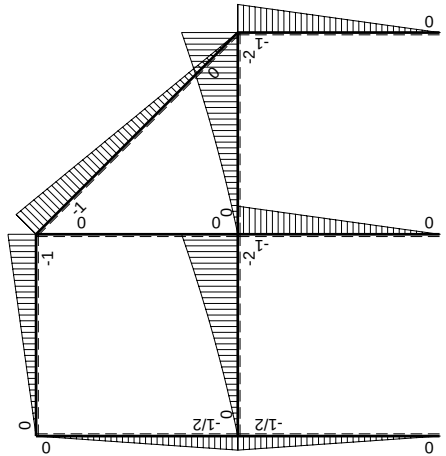
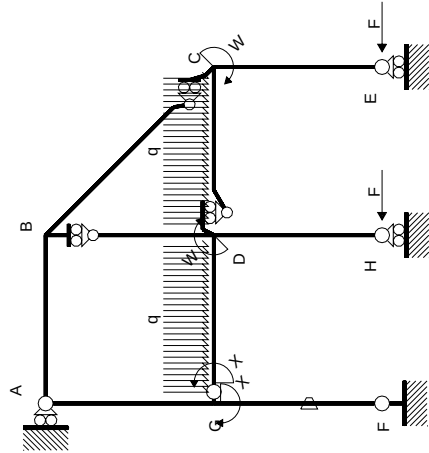
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



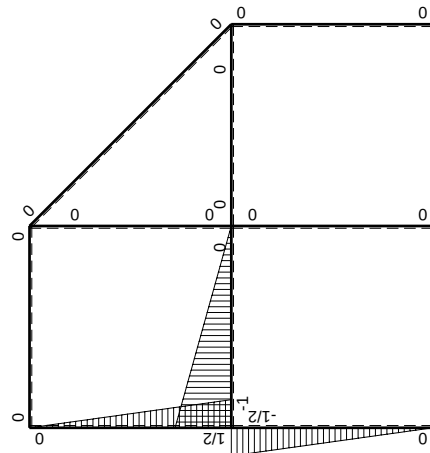
$$\begin{aligned} A &= 558. \text{ mm}^2 \\ J_u &= 198314. \text{ mm}^4 \\ J_v &= 34074. \text{ mm}^4 \\ y_g &= 21.34 \text{ mm} \\ T_y &= -2050. \text{ N} \\ M_x &= -1312000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 31.66 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.5 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 22.66 \text{ mm} \\ \sigma_c &= -Mv/J_u = 149.9 \text{ N/mm}^2 \\ \tau_c &= 5.541 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 150.2 \text{ N/mm}^2 \\ S &= 3216. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-3/2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx ²	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-1/2Fx	-Fb/EJ	1/4Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/12+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-1/2Fx	Fb/EJ	1/4Fb-1/2Fx+1/4Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD b	-1+x/b	-3/2Fx-1/2qx ²	0	3/2Fx-Fx ² /b-1/2qx ³ /b	0	1-2x/b+x ² /b ²	(7/24+0)Fb ² /EJ	1/3Xb/EJ
DG b	x/b	2Fb-5/2Fx+1/2qx ²	0	2Fx-5/2Fx ² /b+1/2qx ³ /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/12+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx ² /b	0	1/4x ² /b ²		
	totali						13/24Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{3}{2} x/b - x^2/b^2 - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{3} x^3/b^2 - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{3} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(2 x/b - \frac{5}{2} x^2/b^2 + \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{5}{6} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

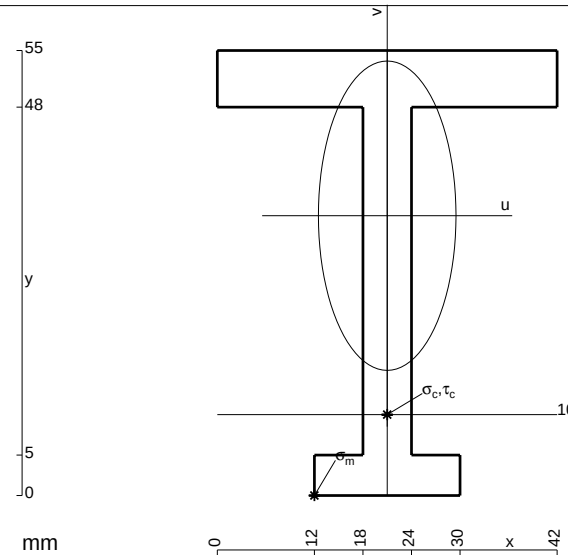
$$= \left(b - \frac{5}{6} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{7}{24} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

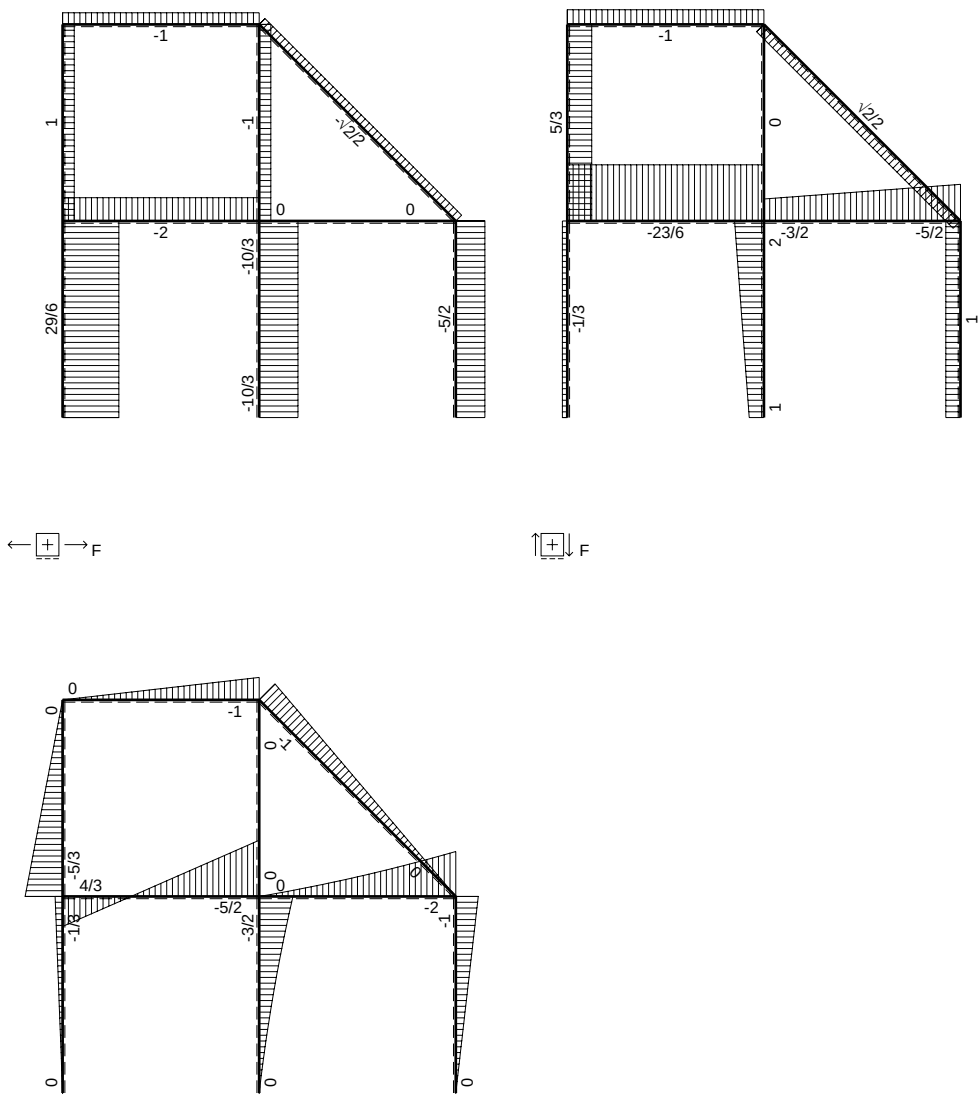
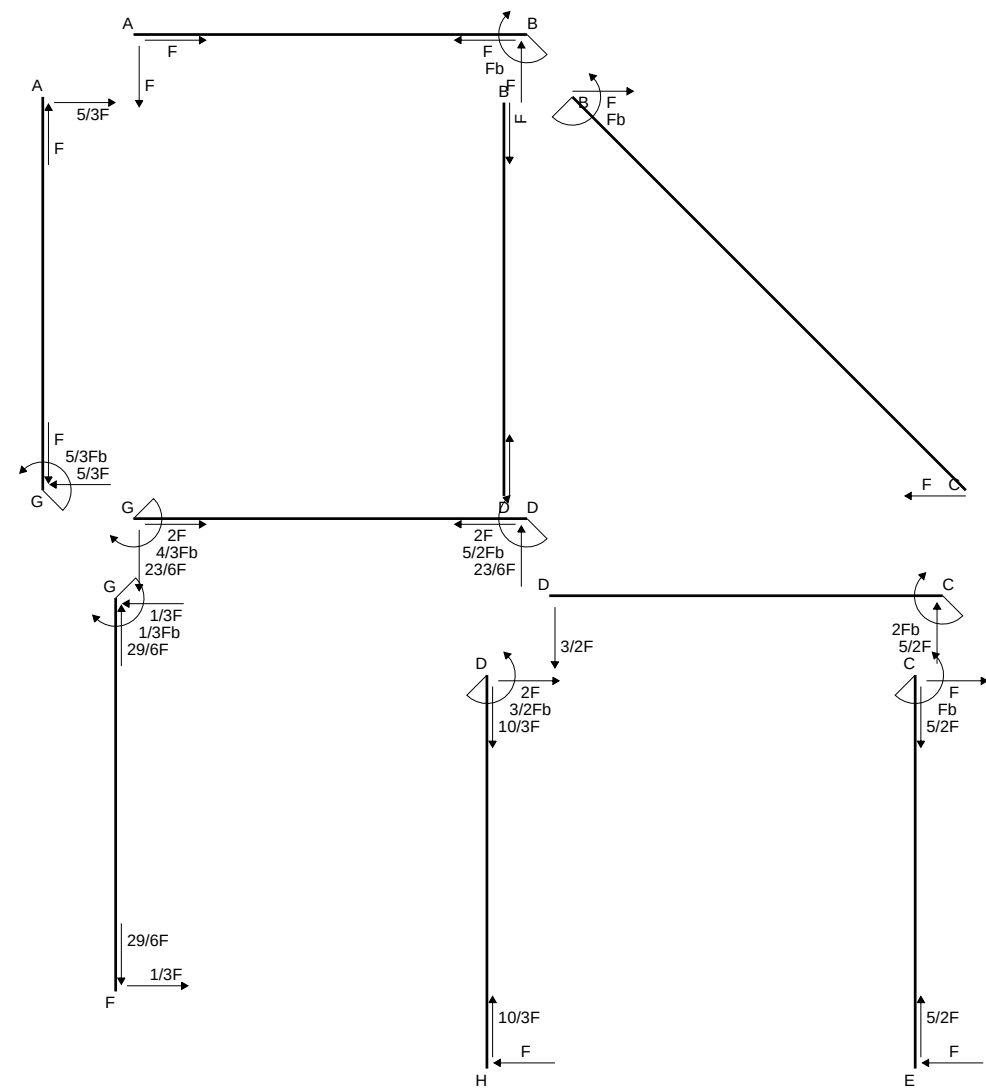
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

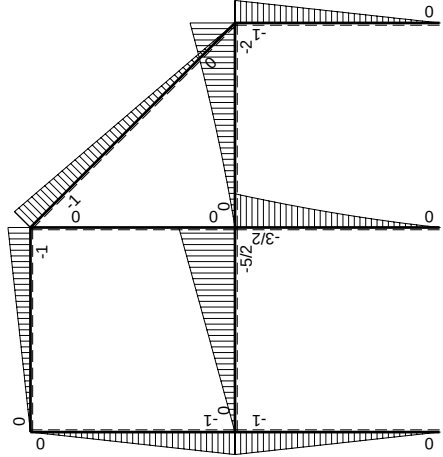
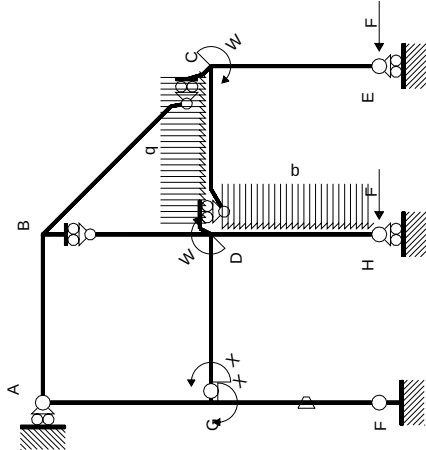
$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$



$$\begin{aligned} A &= 642. \text{ mm}^2 \\ J_u &= 234775. \text{ mm}^4 \\ J_v &= 46422. \text{ mm}^4 \\ y_g &= 34.58 \text{ mm} \\ T_y &= -2100. \text{ N} \\ M_x &= -1478400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.58 \text{ mm} \\ \sigma_m &= -Mv/J_u = -217.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -24.58 \text{ mm} \\ \sigma_c &= -Mv/J_u = -154.8 \text{ N/mm}^2 \\ \tau_c &= 5.516 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 155.1 \text{ N/mm}^2 \\ S &= 3700. \text{ mm}^3 \end{aligned}$$

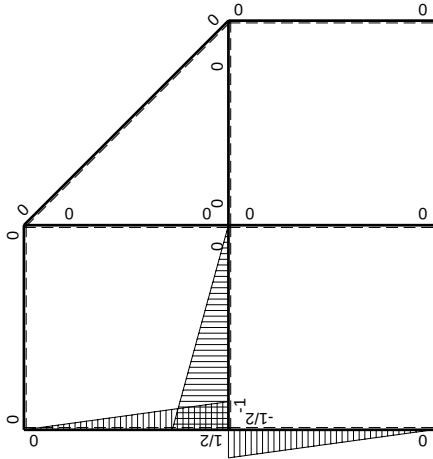


$\left[\begin{smallmatrix} + \\ + \end{smallmatrix} \right] F_b$



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	-Fx	$-Fb/EJ$	$1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/6+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	Fb-Fx	Fb/EJ	$1/2Fb-Fx+1/2Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-5/2Fx$	0	$5/2Fx-5/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$5/2Fb-5/2Fx$	0	$5/2Fx-5/2Fx^2/b$	0	x^2/b^2		
DH b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
HD b	0	$Fx+1/2qx^2$	0	0	0	0		
GA b	$1/2-1/2x/b$	-Fb+Fx	0	$-1/2Fb+Fx-1/2Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	Fx	0	$-1/2Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$2/3Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-4/3Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{5}{2} x/b - \frac{5}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{5}{4} x^2/b - \frac{5}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

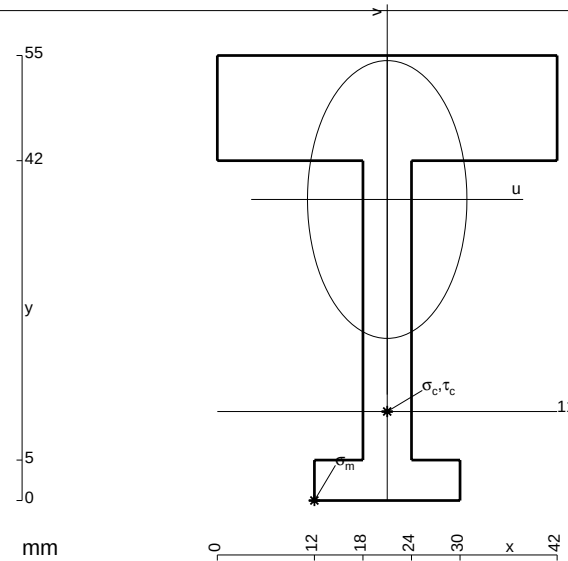
$$= \left(\frac{5}{4} b - \frac{5}{6} b \right) Fb \frac{1}{EJ} = \frac{5}{12} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

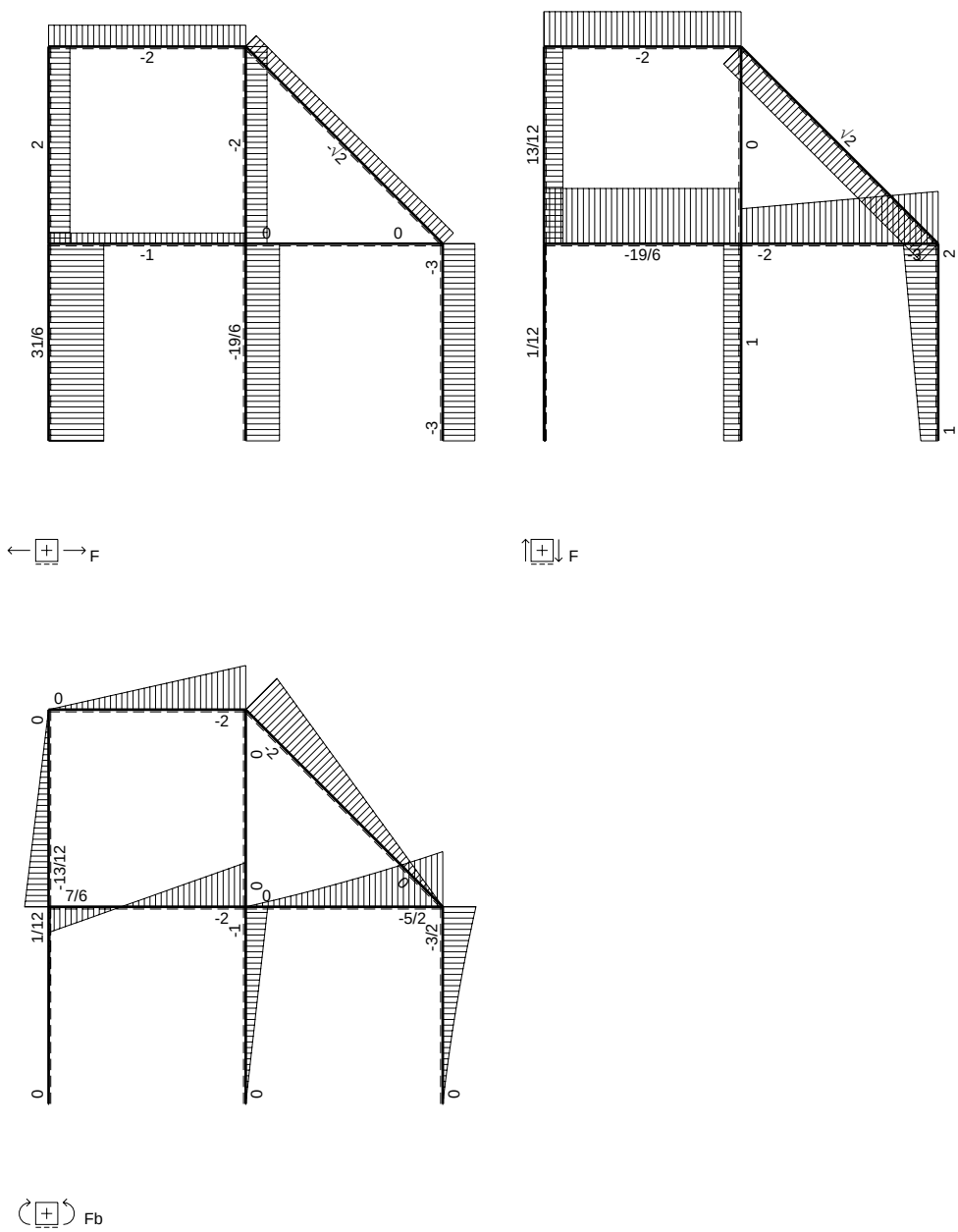
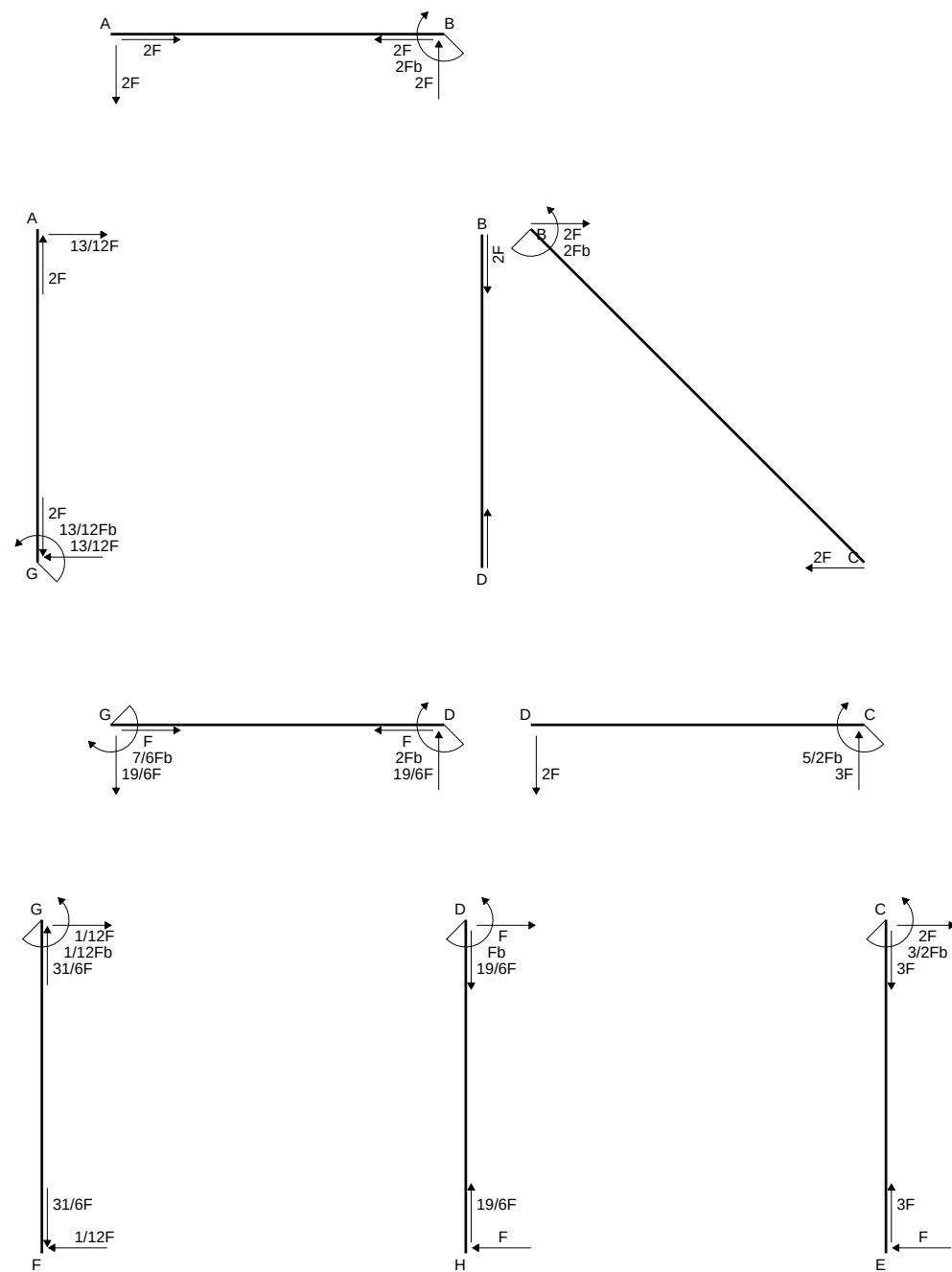
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$



$$\begin{aligned} A &= 858. \text{ mm}^2 \\ J_u &= 252957. \text{ mm}^4 \\ J_v &= 83358. \text{ mm}^4 \\ y_g &= 37.21 \text{ mm} \\ T_y &= -2100. \text{ N} \\ M_x &= -1562400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -37.21 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.8 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -26.21 \text{ mm} \\ \sigma_c &= -Mv/J_u = -161.9 \text{ N/mm}^2 \\ \tau_c &= 5.777 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 162.2 \text{ N/mm}^2 \\ S &= 4175. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx- $1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$5/2Fb-3Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-3/2Fb+2Fx-1/2qx^2$	0	0	0	0	0+0	0
EC b	0	$Fx+1/2qx^2$	0	0	0	0		
FG b	- $1/2x/b$	- $1/2Fx$	-Fb/EJ	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	- $1+x/b$	-2Fx	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	2Fb-2Fx	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	- $1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	- $1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

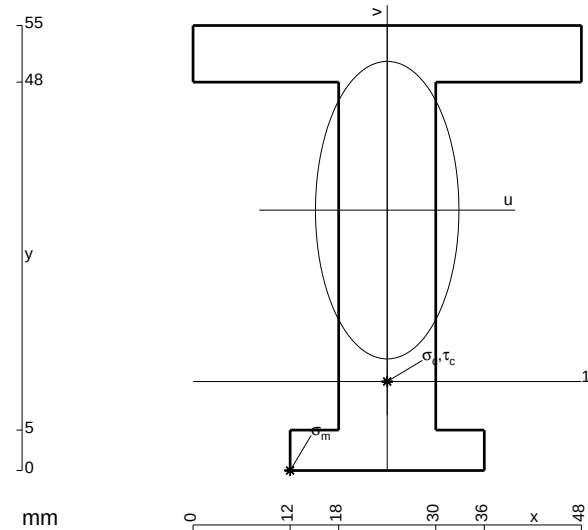
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

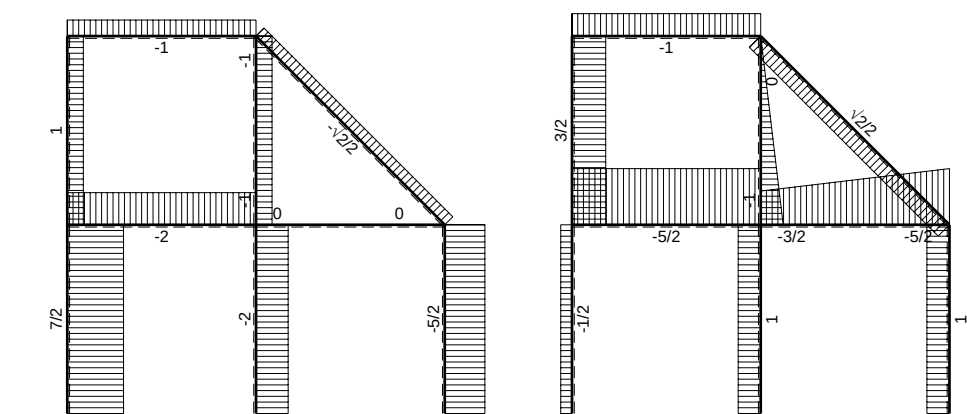
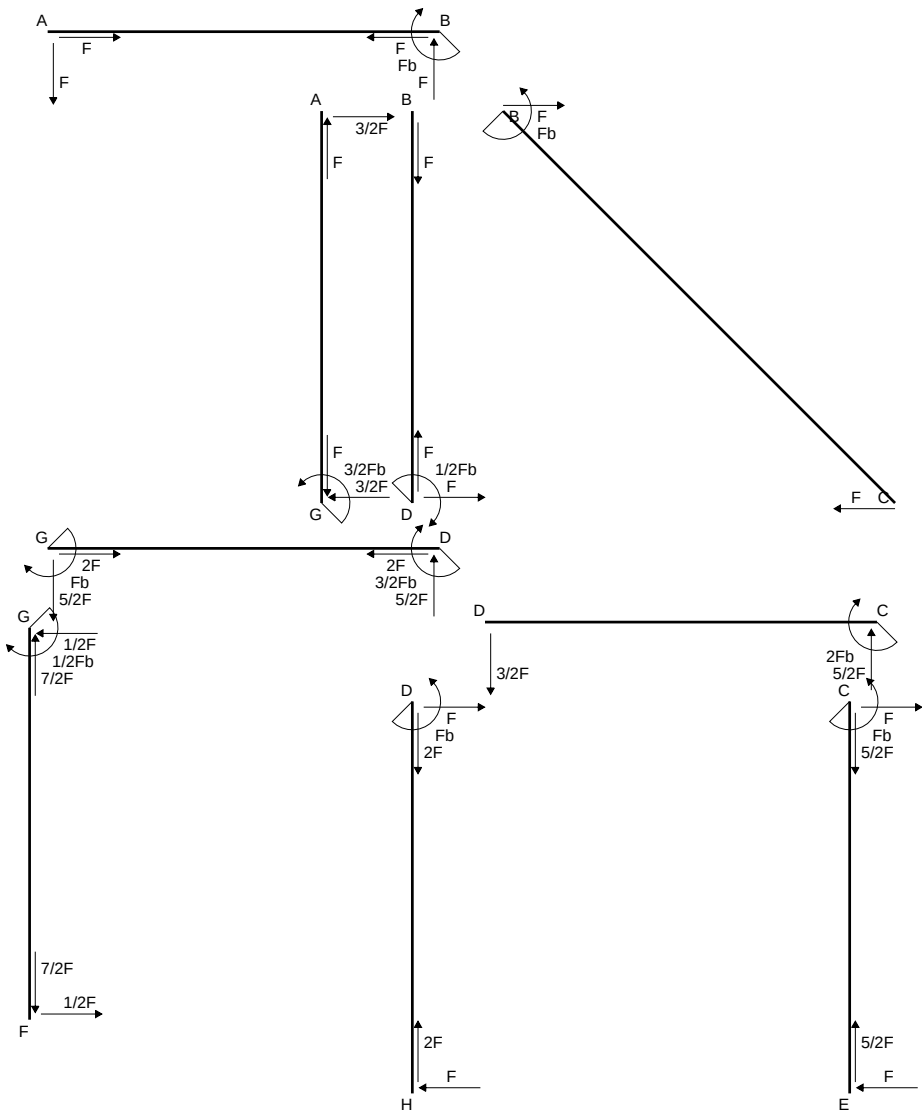
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

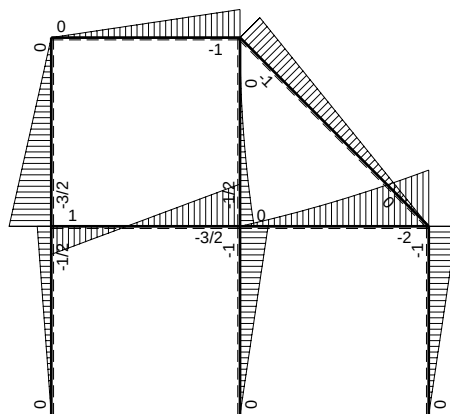


$$\begin{aligned} A &= 972. \text{ mm}^2 \\ J_u &= 328901. \text{ mm}^4 \\ J_v &= 76464. \text{ mm}^4 \\ y_g &= 32.18 \text{ mm} \\ T_y &= -3000. \text{ N} \\ M_x &= -2450000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -32.18 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -21.18 \text{ mm} \\ \sigma_c &= -Mv/J_u = -157.8 \text{ N/mm}^2 \\ \tau_c &= 4.03 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 157.9 \text{ N/mm}^2 \\ S &= 5302. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-3/2Fx-1/2qx ²	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx ²	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(1/6+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx ² /b	0	1/4-1/2x/b+1/4x ² /b ²	(-1/6+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx ² /b	0	1/4x ² /b ²		
	totali						1/2Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x_0} = \int_0^b \left(\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b \left(\frac{1}{2} - x/b + \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{1}{2} x^2/b + \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{6} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{5}{12} Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b \left(\frac{3}{2} x/b - \frac{3}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{3}{4} x^2/b - \frac{1}{2} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

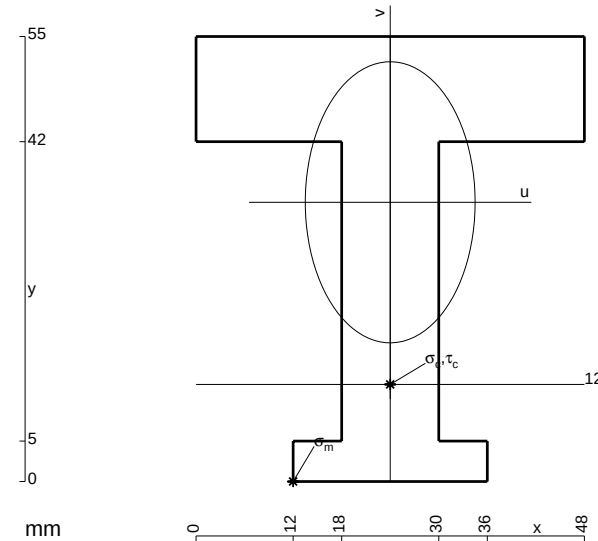
$$= \left(\frac{3}{4} b - \frac{1}{2} b \right) Fb \frac{1}{EJ} = \frac{1}{4} Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b \left(-\frac{1}{2} + x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{1}{2} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

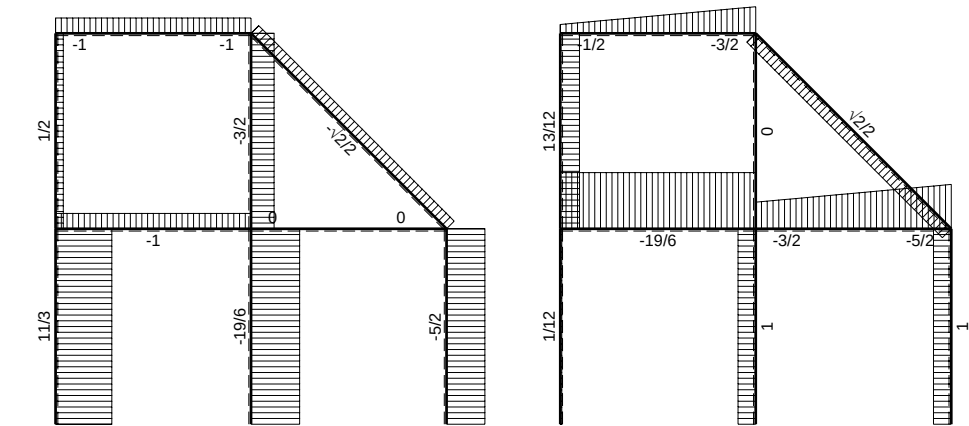
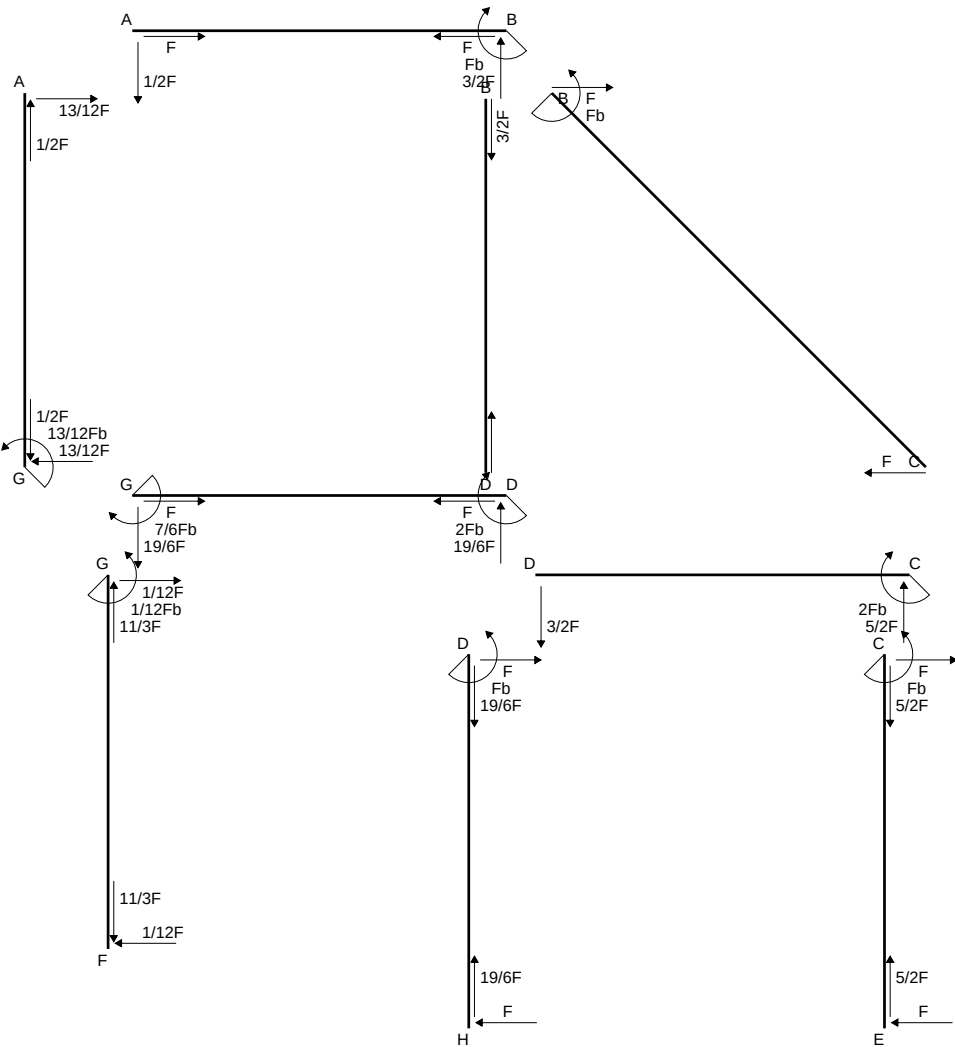
$$= \left(-\frac{1}{2} b + \frac{1}{2} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b \left(-\frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{6} b \right) Fb \frac{1}{EJ} = -\frac{1}{6} Fb^2/EJ$$

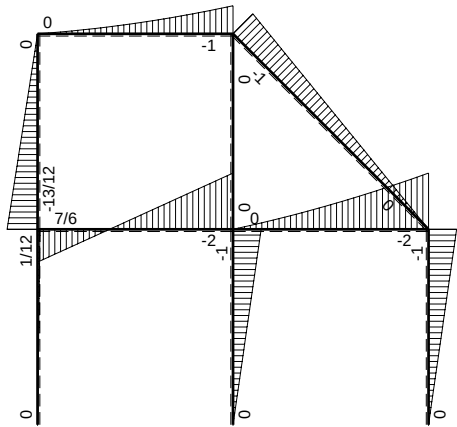


$$\begin{aligned} A &= 1188. \text{ mm}^2 \\ J_u &= 358599. \text{ mm}^4 \\ J_v &= 130896. \text{ mm}^4 \\ y_g &= 34.51 \text{ mm} \\ T_y &= -4975. \text{ N} \\ M_x &= -2069600. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -34.51 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199.2 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -22.51 \text{ mm} \\ \sigma_c &= -Mv/J_u = -129.9 \text{ N/mm}^2 \\ \tau_c &= 6.967 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 130.5 \text{ N/mm}^2 \\ S &= 6026. \text{ mm}^3 \end{aligned}$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0		
BC $\sqrt{2}b$	0	$-Fb+\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	$-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
CD b	0	$2Fb-5/2Fx+1/2qx^2$	0	0	0	0		
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	$-1/2x/b$	$-1/2Fx$	$-Fb/EJ$	$1/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$1/2Fb-1/2Fx$	Fb/EJ	$1/4Fb-1/2Fx+1/4Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	$-1+x/b$	$-2Fx$	0	$2Fx-2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$2Fb-2Fx$	0	$2Fx-2Fx^2/b$	0	x^2/b^2		
DH b	0	$-Fb+Fx$	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-1/2Fb+1/2Fx$	0	$-1/4Fb+1/2Fx-1/4Fx^2/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	$-1/2x/b$	$1/2Fx$	0	$-1/4Fx^2/b$	0	$1/4x^2/b^2$		
	totali						$7/12Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						$-7/6Fb$	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{1}{3} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(2 x/b - 2 x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[x^2/b - \frac{2}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

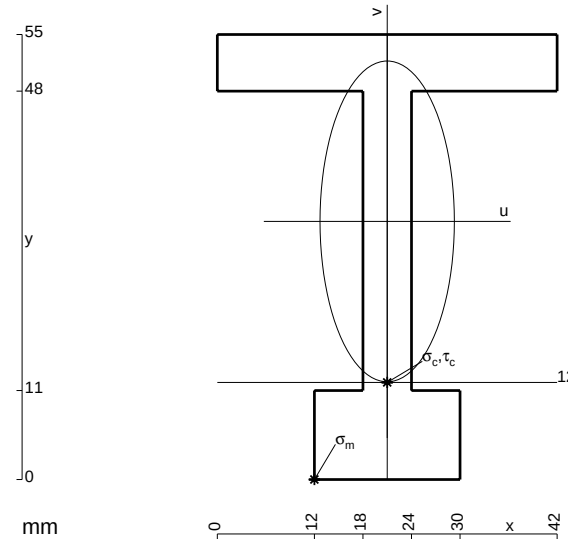
$$= \left(b - \frac{2}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{3} Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{1}{4} + \frac{1}{2} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x + \frac{1}{4} x^2/b - \frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

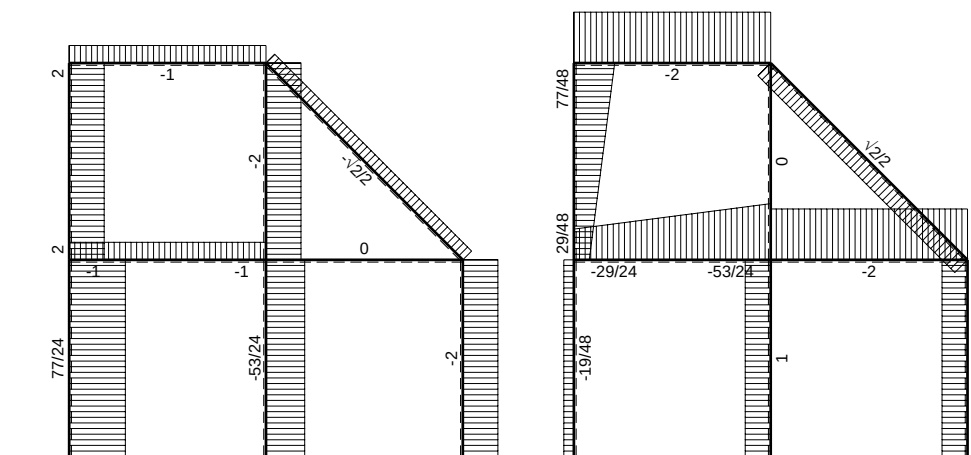
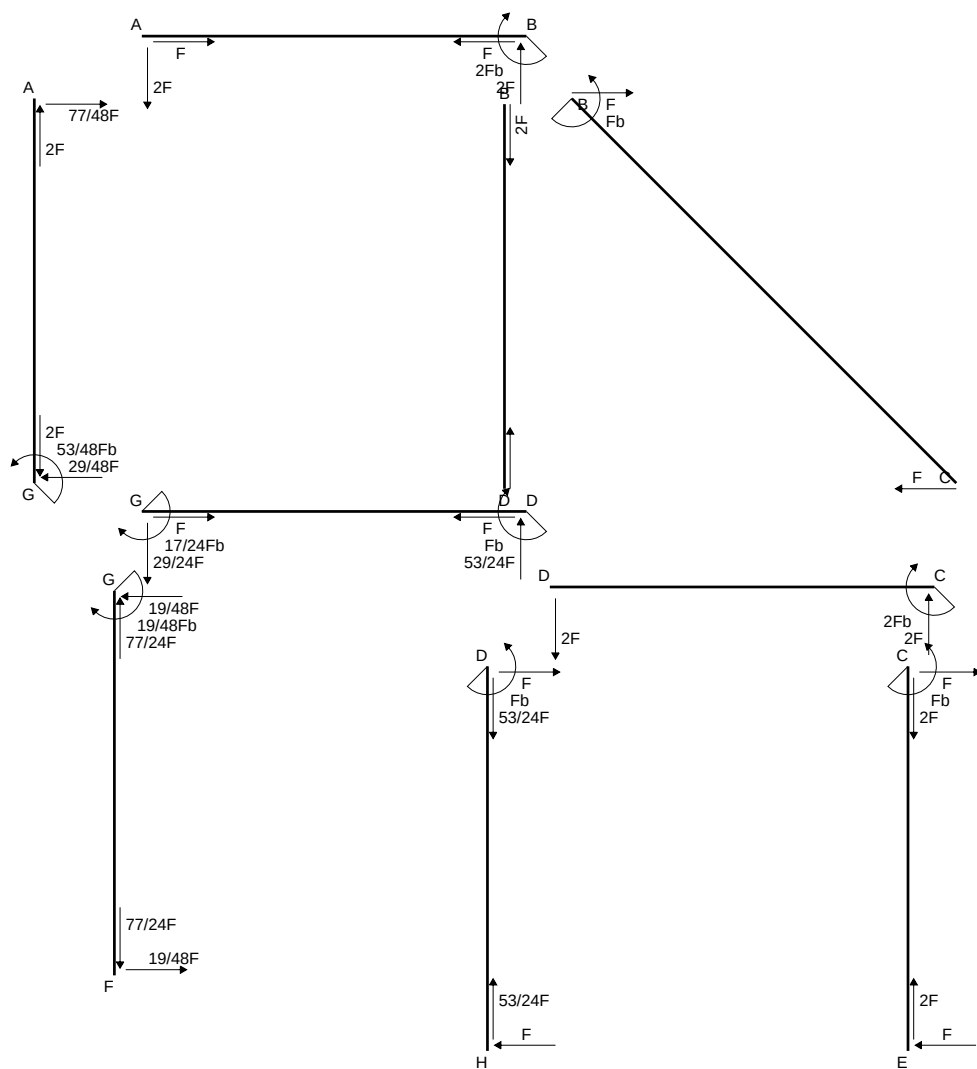
$$= \left(-\frac{1}{4} b + \frac{1}{4} b - \frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{12} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

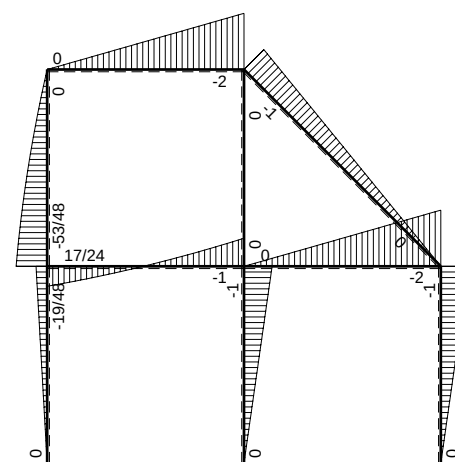
$$= \left(-\frac{1}{12} b \right) Fb \frac{1}{EJ} = -\frac{1}{12} Fb^2/EJ$$

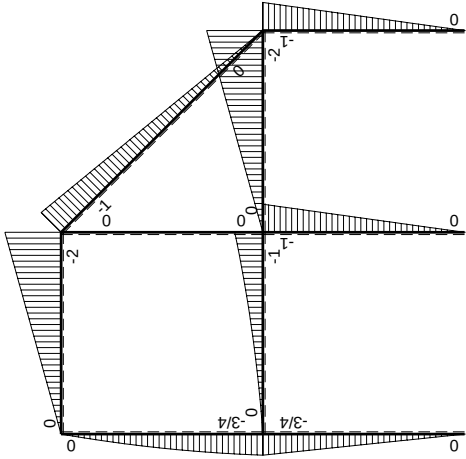
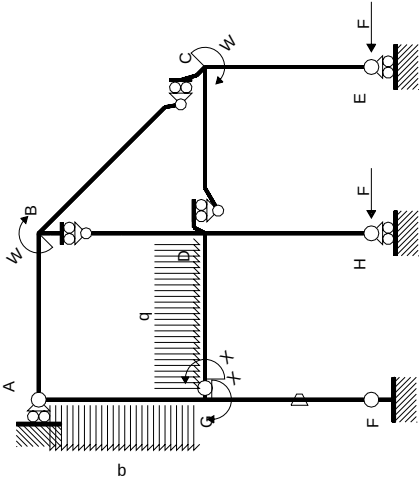


$$\begin{aligned} A &= 714. \text{ mm}^2 \\ J_u &= 280743. \text{ mm}^4 \\ J_v &= 49230. \text{ mm}^4 \\ y_g &= 31.9 \text{ mm} \\ T_y &= -4050. \text{ N} \\ M_x &= -1846800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -31.9 \text{ mm} \\ \sigma_m &= -Mv/J_u = -209.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -19.9 \text{ mm} \\ \sigma_c &= -Mv/J_u = -130.9 \text{ N/mm}^2 \\ \tau_c &= 12.86 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 132.8 \text{ N/mm}^2 \\ S &= 5350. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

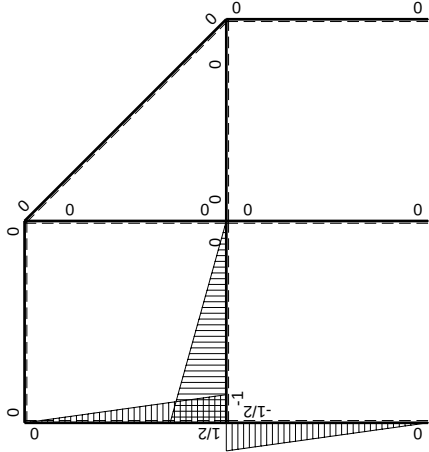
$\uparrow \boxed{+} \downarrow F$





 M_0 flessione da carichi assegnati

Schema di calcolo iperstatico



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	$3/8Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/8+1/4)Fb^2/EJ$	$1/12Xb/EJ$
GF b	$1/2-1/2x/b$	$3/4Fb-3/4Fx$	Fb/EJ	$3/8Fb-3/4Fx+3/8Fx^2/b$	$1/2Fb/EJ-1/2Fx/EJ$	$1/4-1/2x/b+1/4x^2/b^2$		
GD b	-1+x/b	-1/2Fx-1/2qx ²	0	$1/2Fx-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
DG b	x/b	$Fb-3/2Fx+1/2qx^2$	0	$Fx-3/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	$1/2-1/2x/b$	$-3/4Fb+1/4Fx+1/2qx^2$	0	$-3/8Fb+1/2Fx+1/8Fx^2/b-1/4qx^3/b$	0	$1/4-1/2x/b+1/4x^2/b^2$	$(-7/48+0)Fb^2/EJ$	$1/12Xb/EJ$
AG b	-1/2x/b	$5/4Fx-1/2qx^2$	0	$-5/8Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$		
	totali						$17/48Fb^2/EJ$	$1/2Xb/EJ$
	iperstatica $X=W_{GD}$						-17/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b \left(\frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b \left(\frac{3}{8} - \frac{3}{4} x/b + \frac{3}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{3}{8} x - \frac{3}{8} x^2/b + \frac{1}{8} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{3}{8} b - \frac{3}{8} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{3}{8} Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b \left(x/b - \frac{3}{2} x^2/b^2 + \frac{1}{2} x^3/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{2} x^3/b^2 + \frac{1}{8} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{2} b + \frac{1}{8} b \right) Fb \frac{1}{EJ} = \frac{1}{8} Fb^2/EJ$$

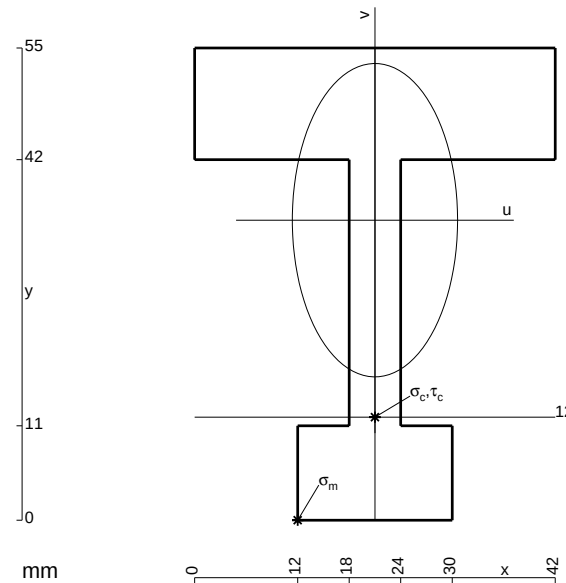
$$L_{GA}^{x\theta} = \int_0^b \left(-\frac{3}{8} + \frac{1}{2} x/b + \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx$$

$$= \left[-\frac{3}{8} x + \frac{1}{4} x^2/b + \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

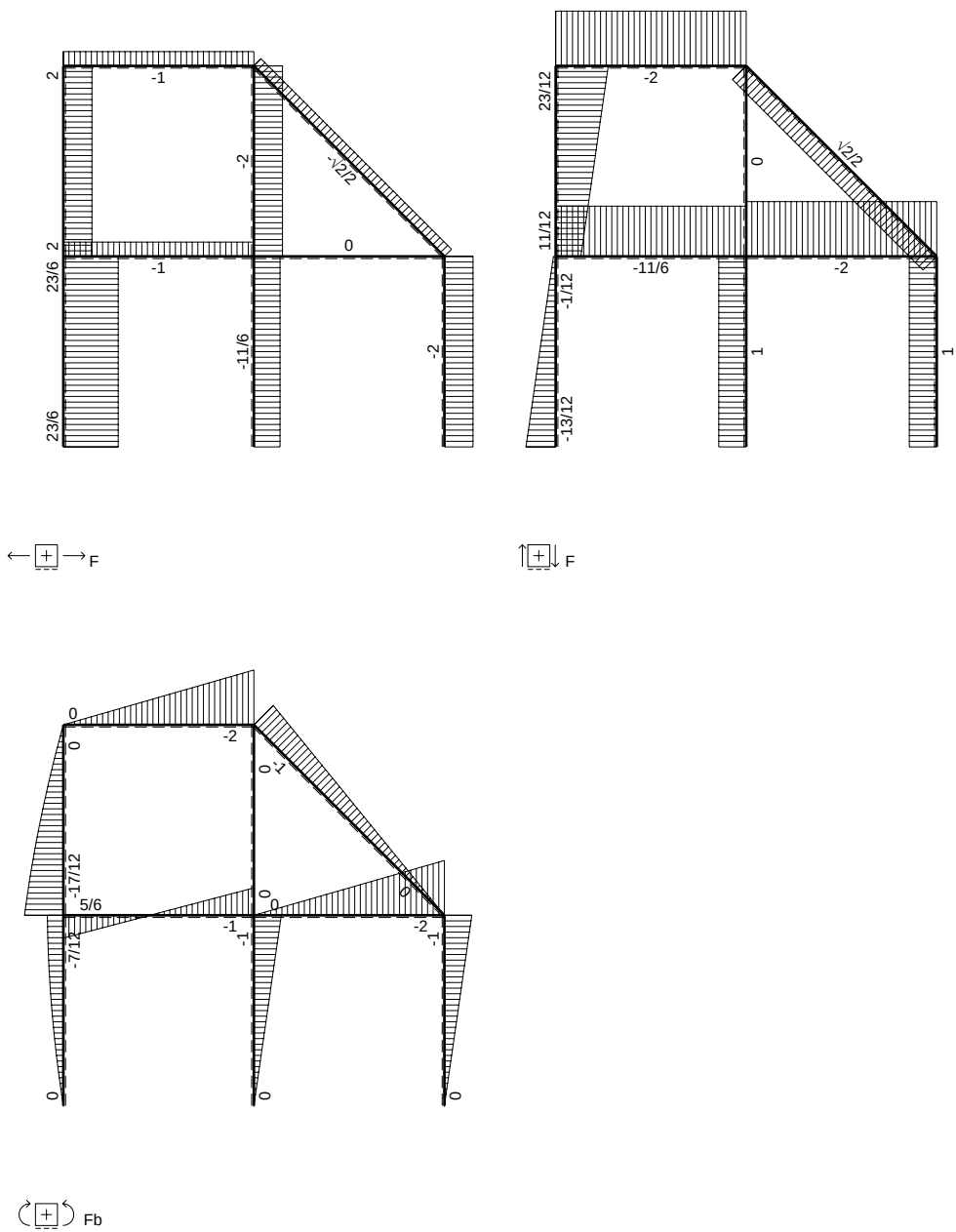
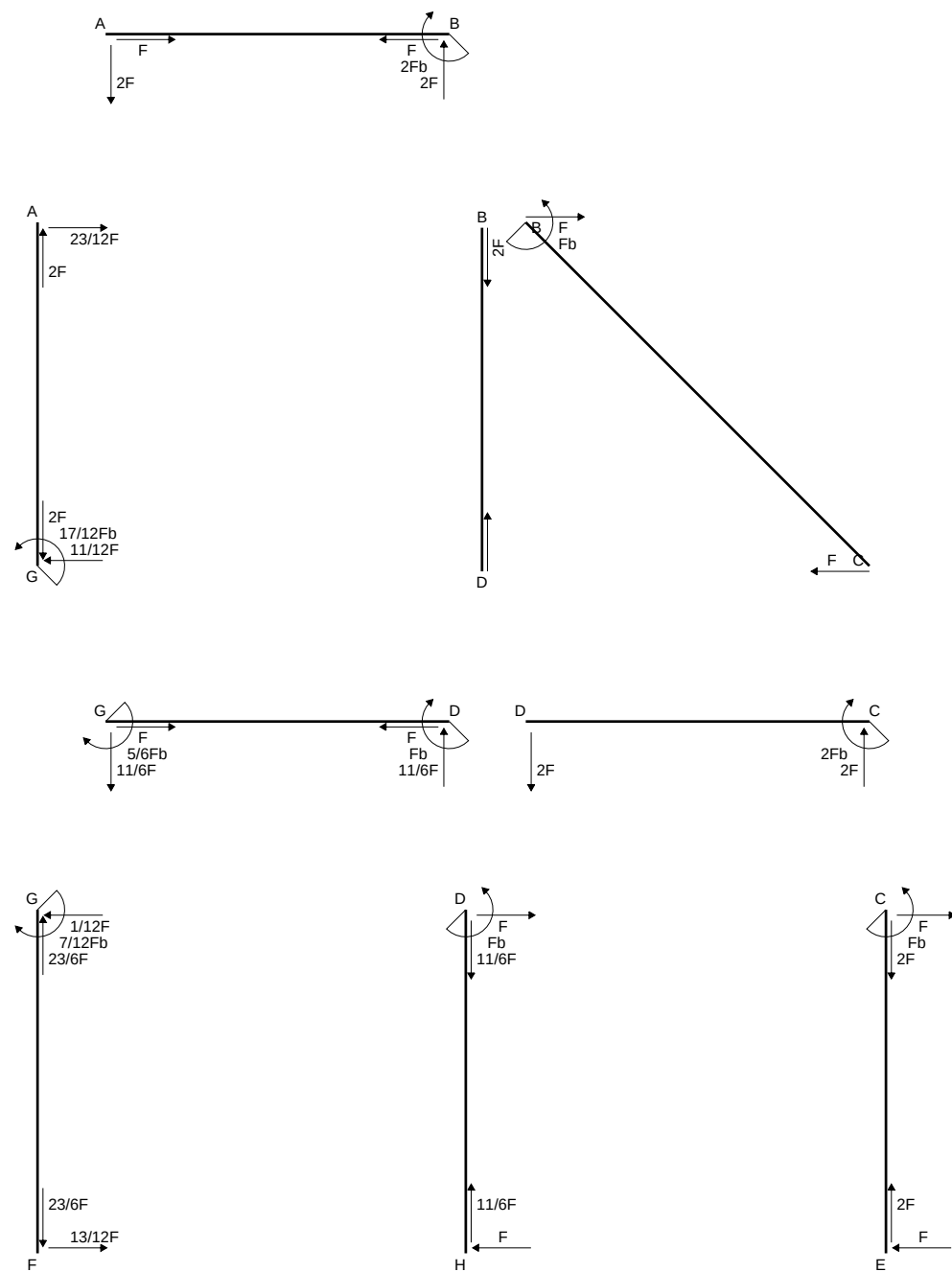
$$= \left(-\frac{3}{8} b + \frac{1}{4} b + \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$

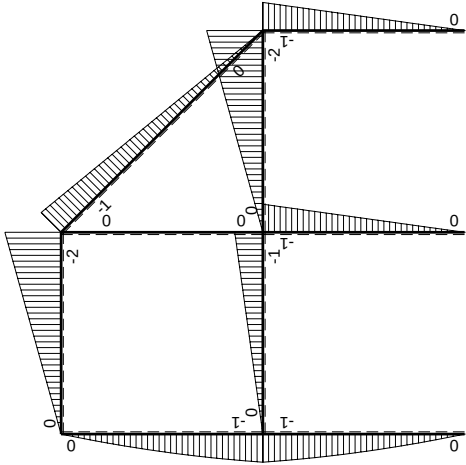
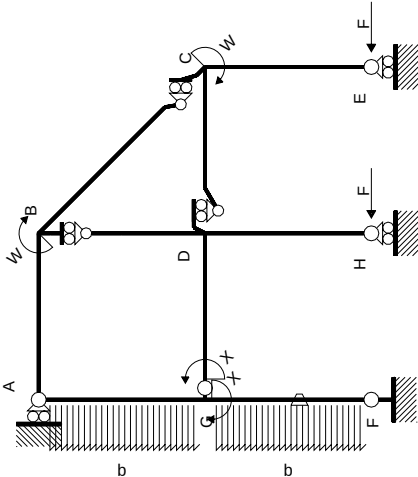
$$L_{AG}^{x\theta} = \int_0^b \left(-\frac{5}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{5}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{5}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{7}{48} Fb^2/EJ$$



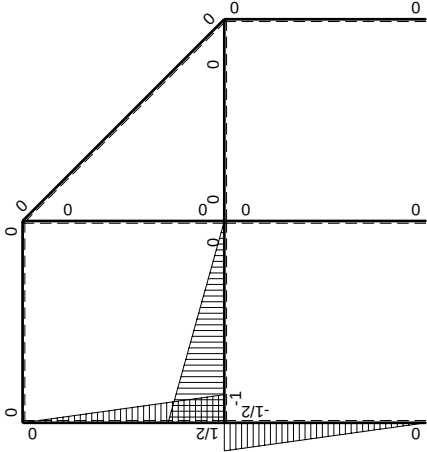
$$\begin{aligned} A &= 930. \text{ mm}^2 \\ J_u &= 309835. \text{ mm}^4 \\ J_v &= 86166. \text{ mm}^4 \\ y_g &= 34.95 \text{ mm} \\ N &= -1560. \text{ N} \\ T_y &= -3120. \text{ N} \\ M_x &= -1934400. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.95 \text{ mm} \\ \sigma_m &= N/A - Mv/J_u = -219.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -22.95 \text{ mm} \\ \sigma_c &= N/A - Mv/J_u = -144.9 \text{ N/mm}^2 \\ \tau_c &= 10.02 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 146. \text{ N/mm}^2 \\ S &= 5971. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	0	0	0	0	0	0+0	0
DB b	0	0	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-3/2Fx+1/2qx ²	-Fb/EJ	3/4Fx ² /b-1/4qx ³ /b	1/2Fx/EJ	1/4x ² /b ²	(3/16+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-1/2Fx-1/2qx ²	Fb/EJ	1/2Fb-3/4Fx+1/4qx ³ /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	Fb-Fx	0	Fx-Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+1/2Fx+1/2qx ²	0	-1/2Fb+3/4Fx-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-3/16+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx-1/2qx ²	0	-3/4Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						5/12Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GF}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{GD}^{xx} = \int_0^b \left(1 - 2x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{DG}^{xx} = \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ$$

$$L_{GA}^{xx} = \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{AG}^{xx} = \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ$$

$$L_{FG}^{xo} = \int_0^b \left(\frac{3}{4} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{4} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{4} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b \left(\frac{1}{2} - \frac{3}{4} x/b + \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx$$

$$= \left[\frac{1}{2} x - \frac{3}{8} x^2/b + \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta$$

$$= \left(\frac{1}{2} b - \frac{3}{8} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{7}{16} Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b \left(x/b - x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{2} x^2/b - \frac{1}{3} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

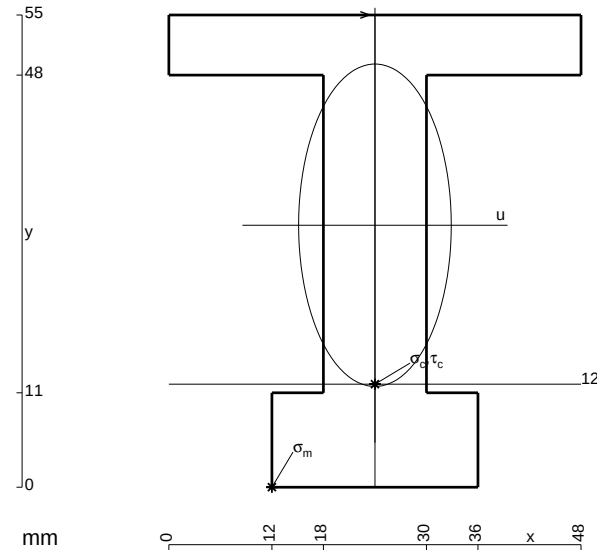
$$= \left(\frac{1}{2} b - \frac{1}{3} b \right) Fb \frac{1}{EJ} = \frac{1}{6} Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b \left(-\frac{1}{2} + \frac{3}{4} x/b - \frac{1}{4} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{2} x + \frac{3}{8} x^2/b - \frac{1}{16} x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

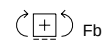
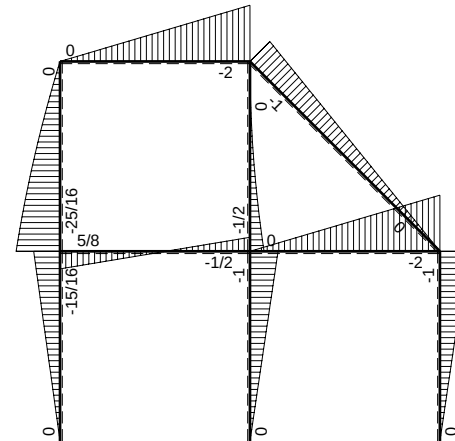
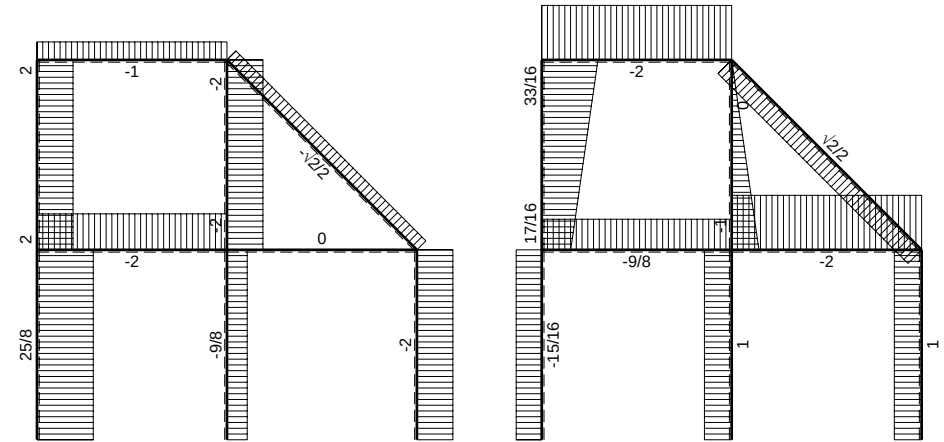
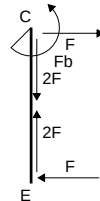
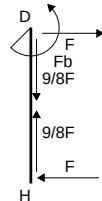
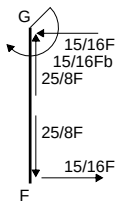
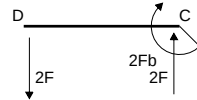
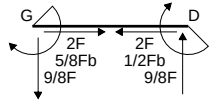
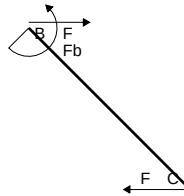
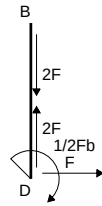
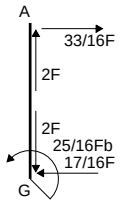
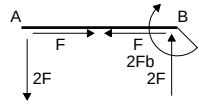
$$= \left(-\frac{1}{2} b + \frac{3}{8} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b \left(-\frac{3}{4} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{1}{4} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= \left(-\frac{1}{4} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{3}{16} Fb^2/EJ$$



$$\begin{aligned} A &= 1044. \text{ mm}^2 \\ J_u &= 368307. \text{ mm}^4 \\ J_v &= 82512. \text{ mm}^4 \\ y_g &= 30.51 \text{ mm} \\ N &= -2050. \text{ N} \\ T_y &= -4100. \text{ N} \\ M_x &= -2747000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.51 \text{ mm} \\ \sigma_m &= N/A - Mv/J_u = -229.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -18.51 \text{ mm} \\ \sigma_c &= N/A - Mv/J_u = -140. \text{ N/mm}^2 \\ \tau_c &= 6.337 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 140.5 \text{ N/mm}^2 \\ S &= 6831. \text{ mm}^3 \end{aligned}$$

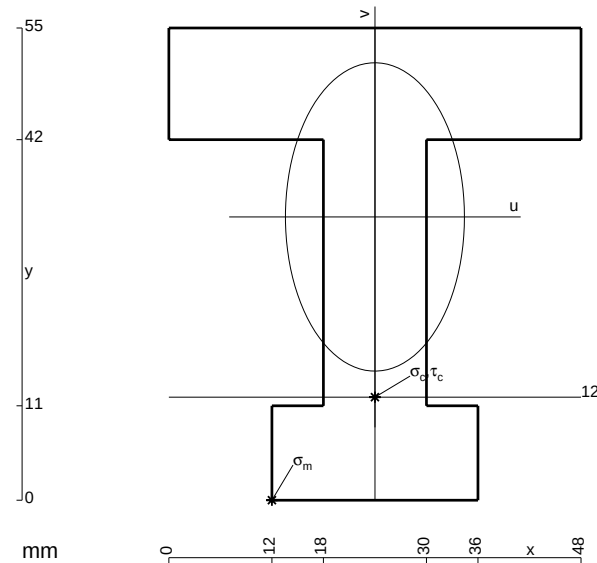


Quadro contributi PLV per iperstatica $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	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	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0		
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx ²	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx ²	0	0	0	0		
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0		
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0		
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx ² /b	1/2Fx/EJ	1/4x ² /b ²	(5/24+1/4)Fb ² /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx ² /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x ² /b ²		
GD 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
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx ² /b	0	x ² /b ²		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0		
GA b	1/2-1/2x/b	-5/4Fb+3/4Fx+1/2qx ²	0	-5/8Fb+Fx-1/8Fx ² /b-1/4qx ³ /b	0	1/4-1/2x/b+1/4x ² /b ²	(-11/48+0)Fb ² /EJ	1/12Xb/EJ
AG b	-1/2x/b	7/4Fx-1/2qx ²	0	-7/8Fx ² /b+1/4qx ³ /b	0	1/4x ² /b ²		
	totali						5/16Fb ² /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$\begin{aligned}
L_{FG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GF}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{GD}^{xx} &= \int_0^b \left(1 - 2 x/b + x^2/b^2 \right) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(b - b + \frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{DG}^{xx} &= \int_0^b \left(x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} b/EJ \\
L_{GA}^{xx} &= \int_0^b \left(\frac{1}{4} - \frac{1}{2} x/b + \frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{4} x - \frac{1}{4} x^2/b + \frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{4} b + \frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{AG}^{xx} &= \int_0^b \left(\frac{1}{4} x^2/b^2 \right) \frac{1}{EJ} dx = \left[\frac{1}{12} x^3/b^2 \right]_0^b \frac{1}{EJ} \\
&= \left(\frac{1}{12} b \right) \frac{1}{EJ} = \frac{1}{12} b/EJ \\
L_{FG}^{xo} &= \int_0^b \left(\frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(\frac{1}{2} x/b \right) \theta dx = \left[\frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[\frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(\frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ \\
L_{GF}^{xo} &= \int_0^b \left(\frac{5}{8} - \frac{5}{4} x/b + \frac{5}{8} x^2/b^2 \right) Fb \frac{1}{EJ} dx + \int_0^b \left(-\frac{1}{2} + \frac{1}{2} x/b \right) \theta dx \\
&= \left[\frac{5}{8} x - \frac{5}{8} x^2/b + \frac{5}{24} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-\frac{1}{2} x + \frac{1}{4} x^2/b \right]_0^b \theta \\
&= \left(\frac{5}{8} b - \frac{5}{8} b + \frac{5}{24} b \right) Fb \frac{1}{EJ} + \left(-\frac{1}{2} b + \frac{1}{4} b \right) \theta = \frac{11}{24} Fb^2/EJ \\
L_{GD}^{xo} &= \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ \\
L_{DG}^{xo} &= \int_0^b \left(\frac{1}{2} x/b - \frac{1}{2} x^2/b^2 \right) Fb \frac{1}{EJ} dx = \left[\frac{1}{4} x^2/b - \frac{1}{6} x^3/b^2 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(\frac{1}{4} b - \frac{1}{6} b \right) Fb \frac{1}{EJ} = \frac{1}{12} Fb^2/EJ \\
L_{GA}^{xo} &= \int_0^b \left(-\frac{5}{8} + x/b - \frac{1}{8} x^2/b^2 - \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx \\
&= \left[-\frac{5}{8} x + \frac{1}{2} x^2/b - \frac{1}{24} x^3/b^2 - \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{5}{8} b + \frac{1}{2} b - \frac{1}{24} b - \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{11}{48} Fb^2/EJ \\
L_{AG}^{xo} &= \int_0^b \left(-\frac{7}{8} x^2/b^2 + \frac{1}{4} x^3/b^3 \right) Fb \frac{1}{EJ} dx = \left[-\frac{7}{24} x^3/b^2 + \frac{1}{16} x^4/b^3 \right]_0^b Fb \frac{1}{EJ} \\
&= \left(-\frac{7}{24} b + \frac{1}{16} b \right) Fb \frac{1}{EJ} = -\frac{11}{48} Fb^2/EJ
\end{aligned}$$



$$\begin{aligned}
A &= 1260. \text{ mm}^2 \\
J_u &= 406524. \text{ mm}^4 \\
J_v &= 136944. \text{ mm}^4 \\
y_g &= 33. \text{ mm} \\
N &= -2030. \text{ N} \\
T_y &= -4060. \text{ N} \\
M_x &= -2923200. \text{ Nmm} \\
x_m &= 12. \text{ mm} \\
u_m &= -12. \text{ mm} \\
v_m &= -33. \text{ mm} \\
\sigma_m &= N/A - Mv/J_u = -238.9 \text{ N/mm}^2 \\
x_c &= 24. \text{ mm} \\
y_c &= 12. \text{ mm} \\
v_c &= -21. \text{ mm} \\
\sigma_c &= N/A - Mv/J_u = -152.6 \text{ N/mm}^2 \\
\tau_c &= 6.256 \text{ N/mm}^2 \\
\sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 153. \text{ N/mm}^2 \\
S &= 7517. \text{ mm}^3
\end{aligned}$$