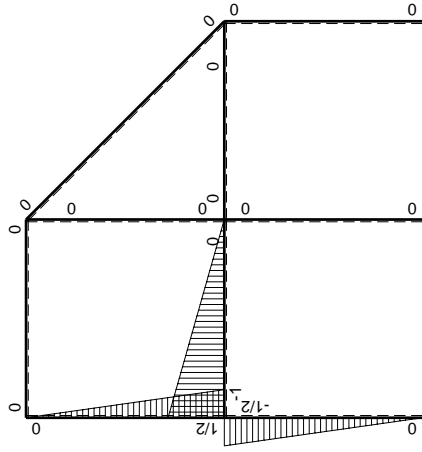


Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

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

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

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

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

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

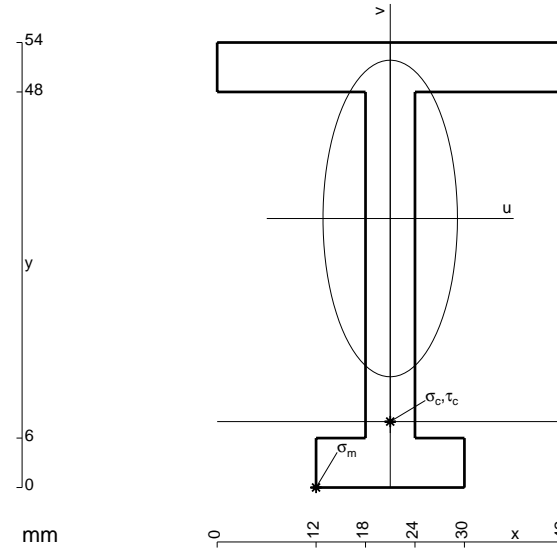
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

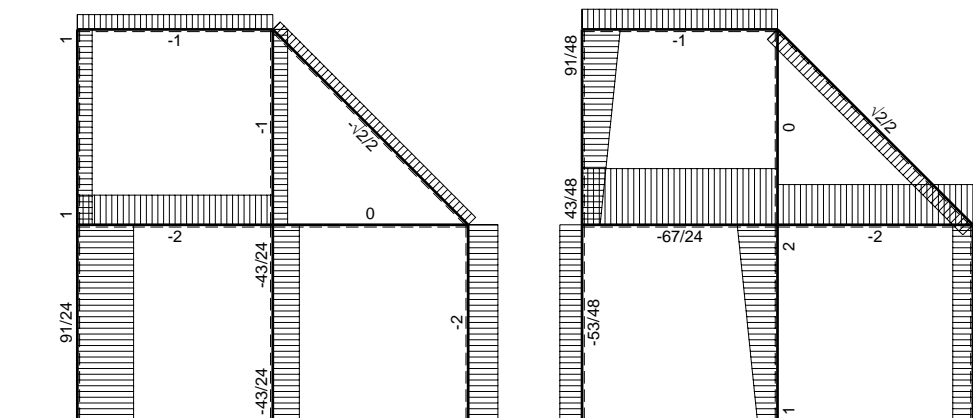
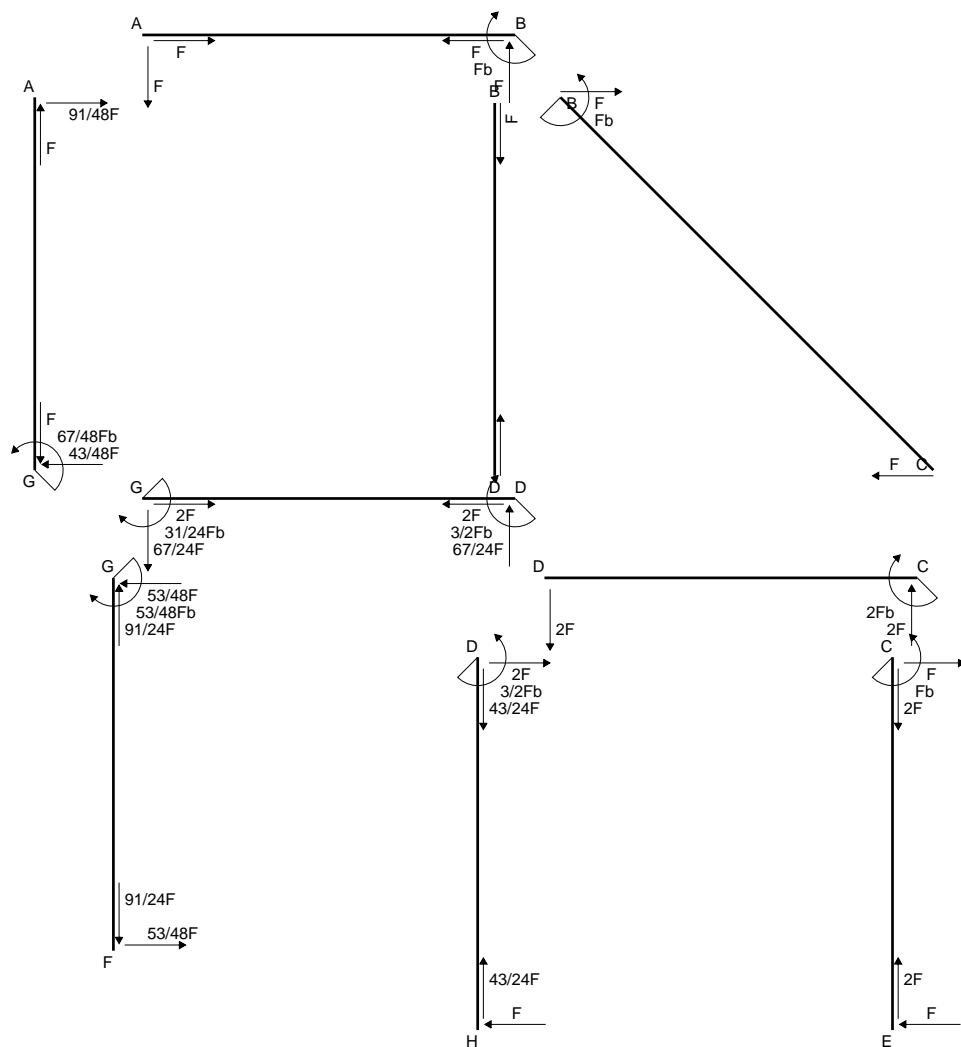
$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

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

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

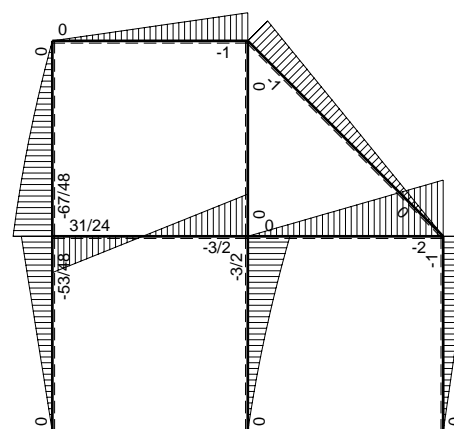


- A = 612. mm<sup>2</sup>
- J<sub>u</sub> = 225968. mm<sup>4</sup>
- J<sub>v</sub> = 40716. mm<sup>4</sup>
- y<sub>g</sub> = 32.65 mm
- T<sub>y</sub> = -2580. N
- M<sub>x</sub> = -1444800. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -32.65 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -208.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 8. mm
- v<sub>c</sub> = -24.65 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -157.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.679 N/mm<sup>2</sup>
- σ<sub>q</sub> = √(σ<sup>2</sup>+3τ<sup>2</sup>) = 158. N/mm<sup>2</sup>
- S = 3510. mm<sup>3</sup>

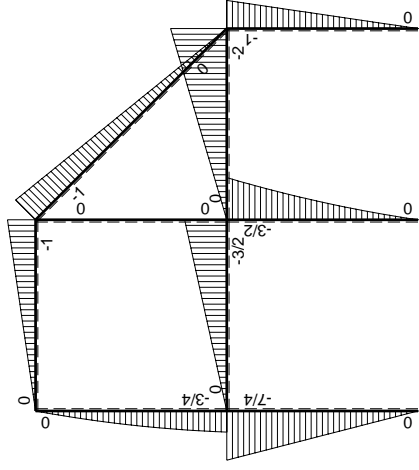
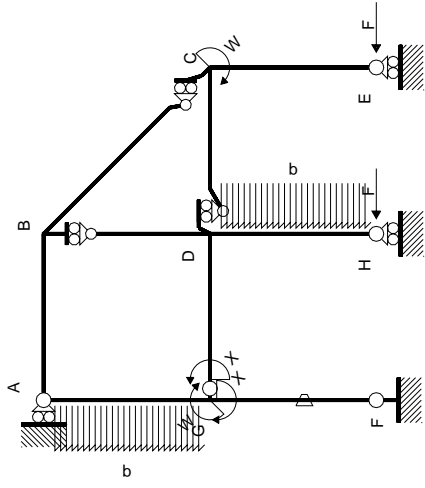


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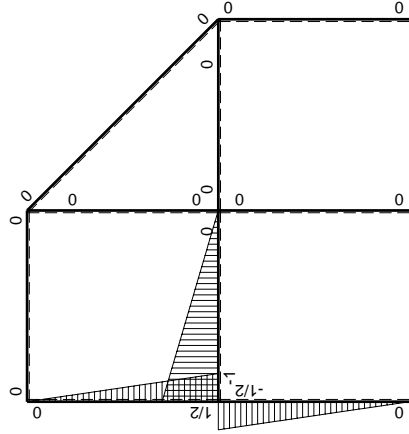


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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (7/24 b) Fb 1/EJ + (1/4 b) \theta = 13/24 Fb^2/EJ$$

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

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

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

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

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

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

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

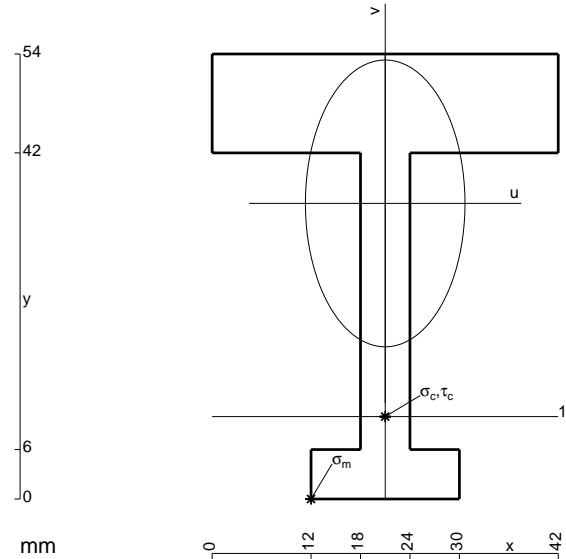
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

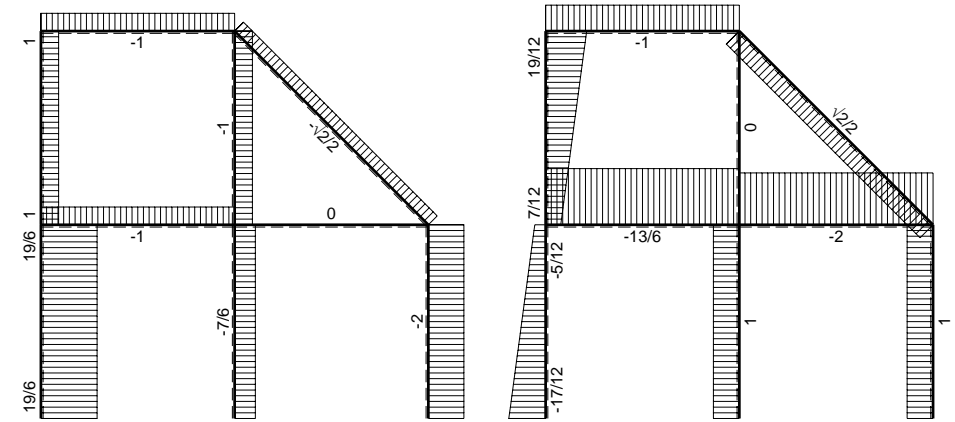
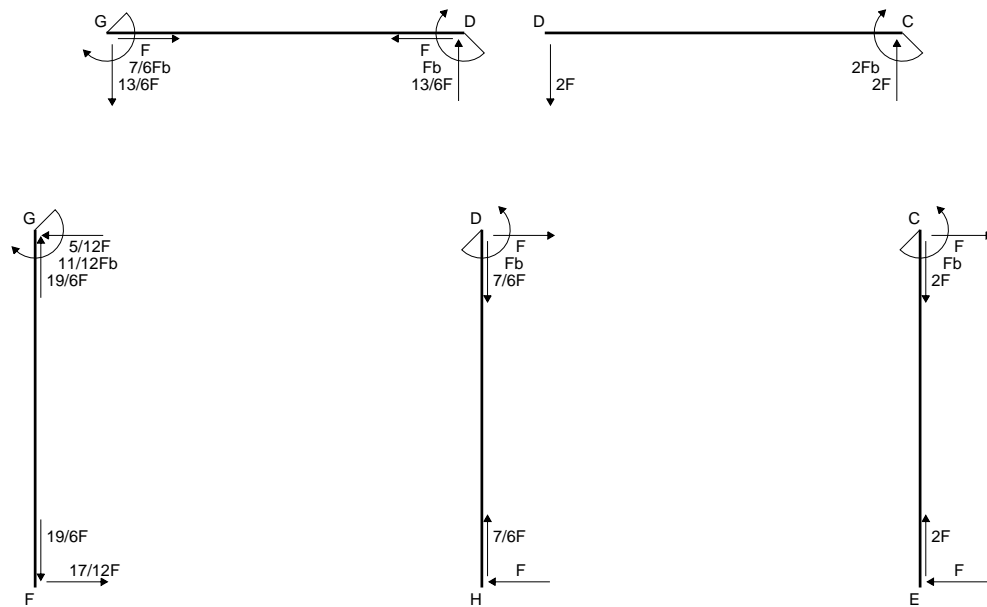
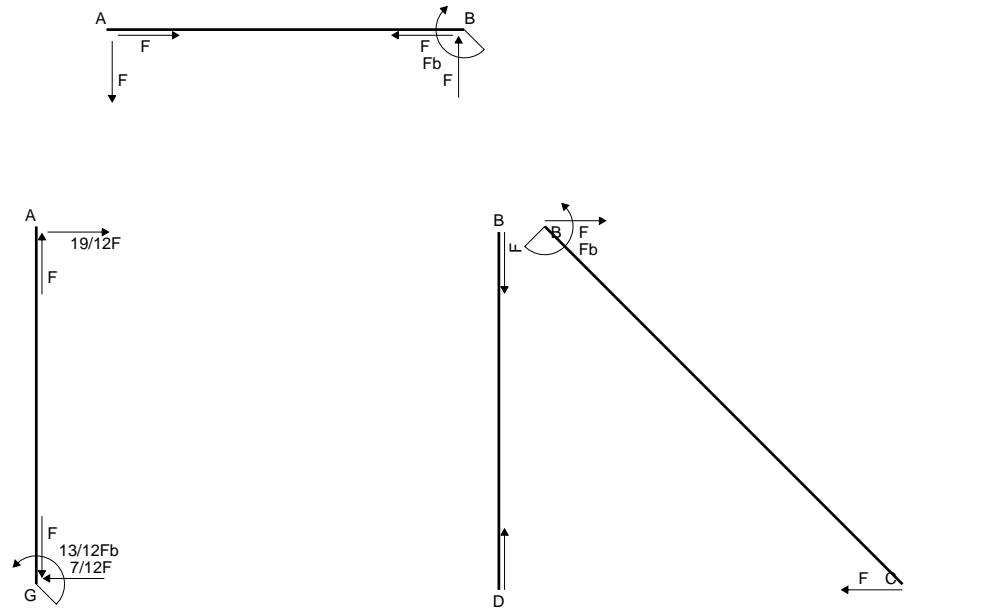
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



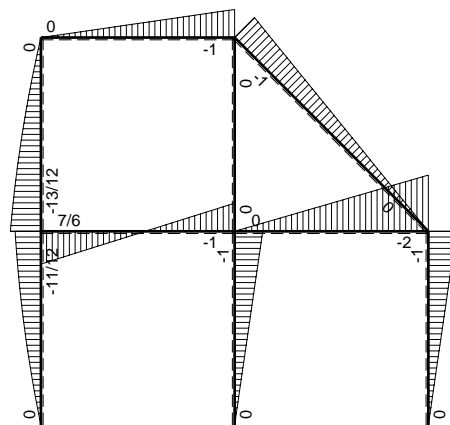
- A = 828. mm<sup>2</sup>
- J<sub>u</sub> = 250978. mm<sup>4</sup>
- J<sub>v</sub> = 77652. mm<sup>4</sup>
- y<sub>g</sub> = 35.87 mm
- T<sub>y</sub> = -2520. N
- M<sub>x</sub> = -1537200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -35.87 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -25.87 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -158.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.06 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 158.9 N/mm<sup>2</sup>
- S = 4219. mm<sup>3</sup>



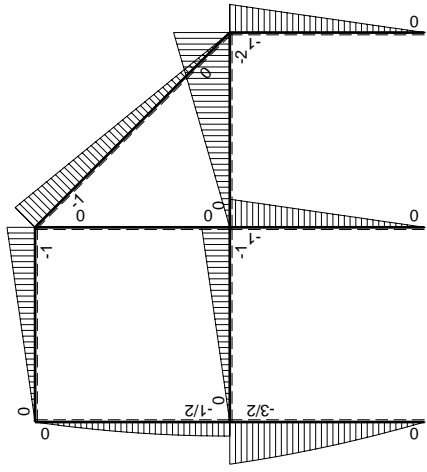
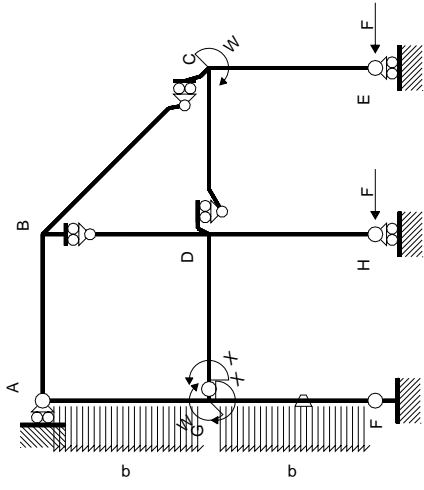


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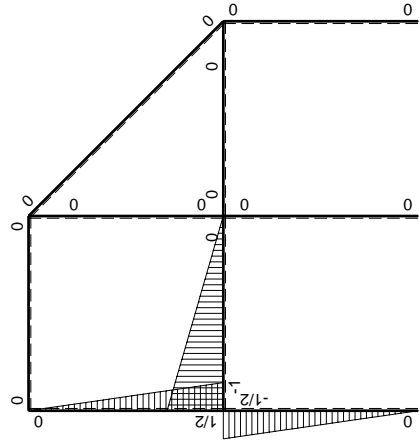


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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 <sup>2</sup>	-Fb/EJ	Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(13/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/2Fb-Fx-1/2qx <sup>2</sup>	Fb/EJ	3/4Fb-5/4Fx+1/4Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup>	0	-1/4Fb+1/4Fx+1/4Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-5/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	Fx-1/2qx <sup>2</sup>	0	-1/2Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							7/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-7/6Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

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

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

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

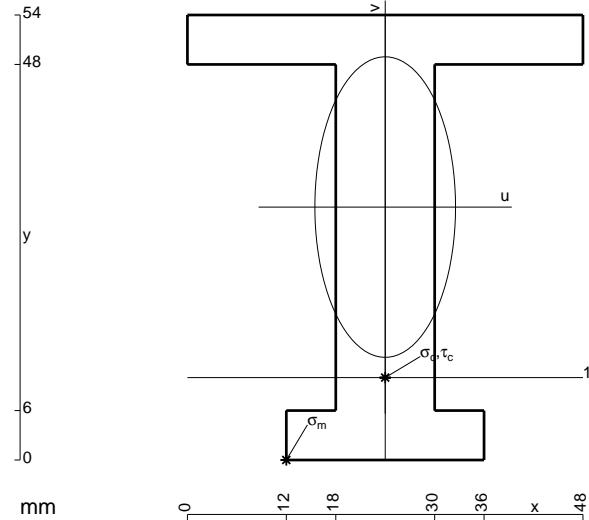
$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/4 x/b + 1/4 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-1/4 x + 1/8 x^2/b + 1/12 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

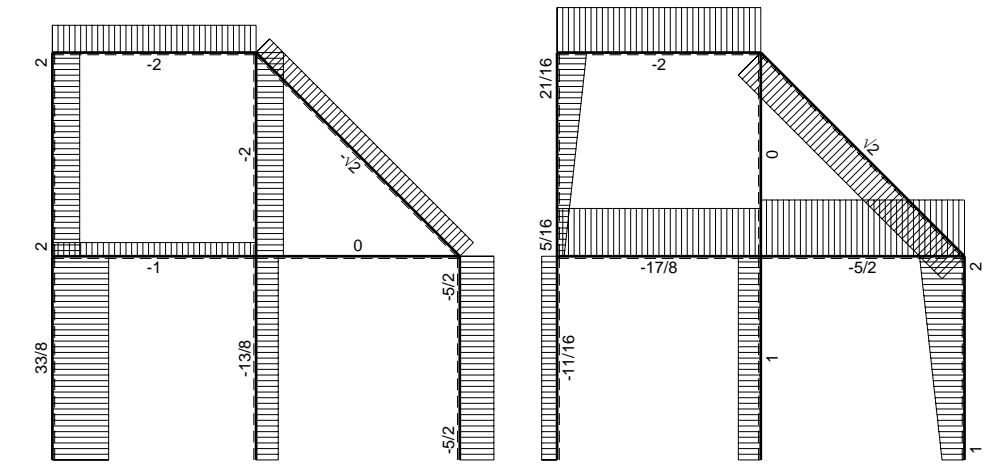
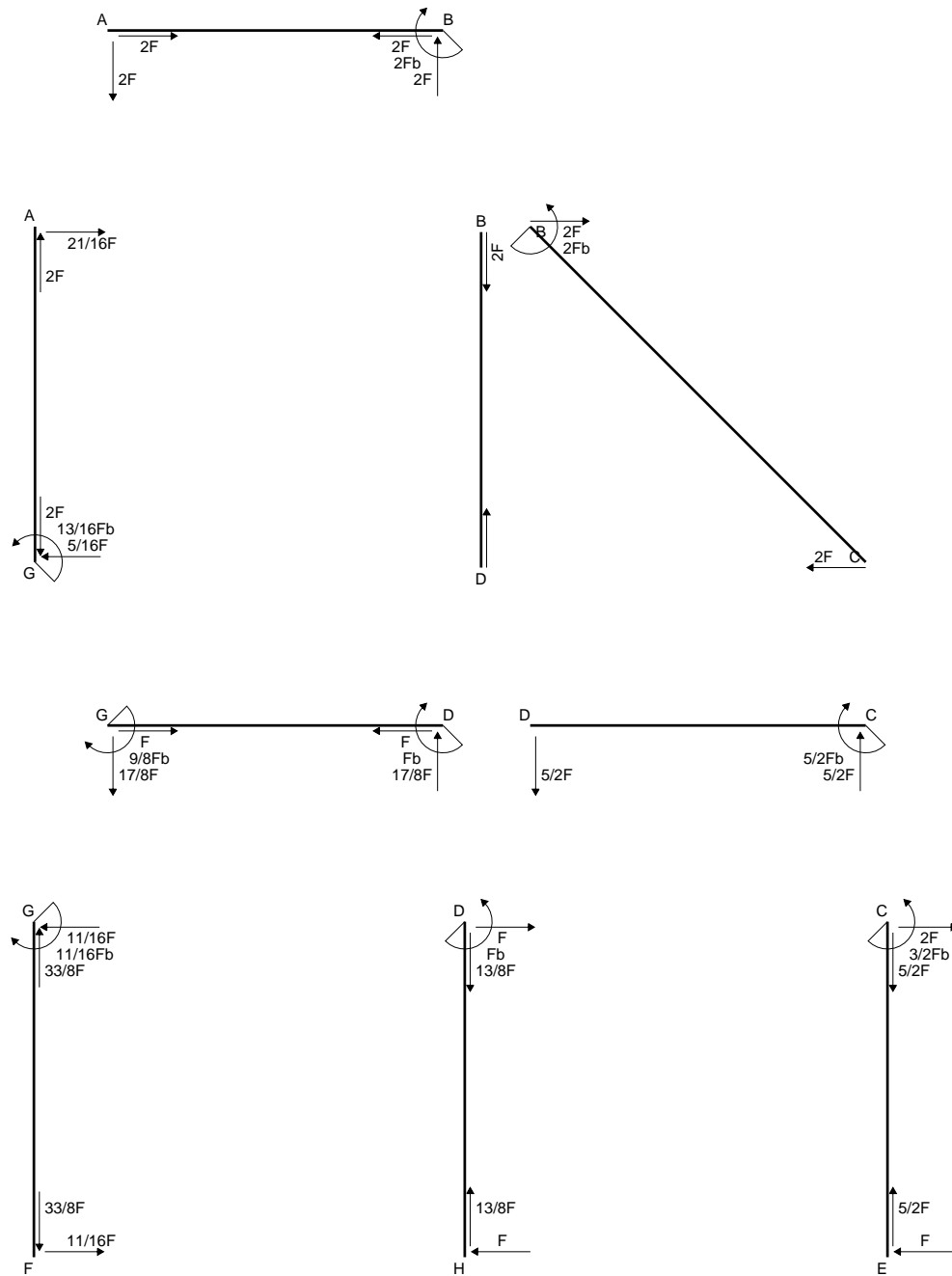
$$= (-1/4 b + 1/8 b + 1/12 b - 1/16 b) Fb 1/EJ = -5/48 Fb^2/EJ$$

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

$$= (-1/6 b + 1/16 b) Fb 1/EJ = -5/48 Fb^2/EJ$$

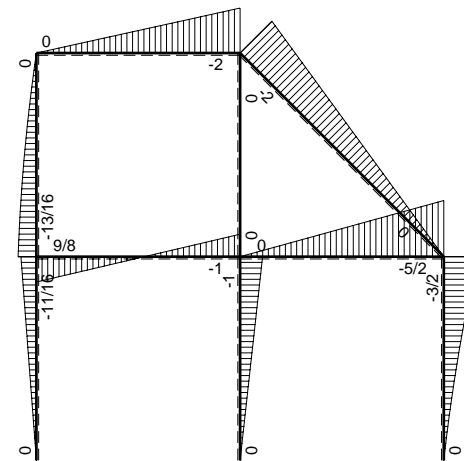


- A = 936. mm<sup>2</sup>
- J<sub>u</sub> = 311455. mm<sup>4</sup>
- J<sub>v</sub> = 68256. mm<sup>4</sup>
- y<sub>g</sub> = 30.69 mm
- T<sub>y</sub> = -3520. N
- M<sub>x</sub> = -2323200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -30.69 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -228.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -20.69 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -154.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.782 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 154.6 N/mm<sup>2</sup>
- S = 5077. mm<sup>3</sup>

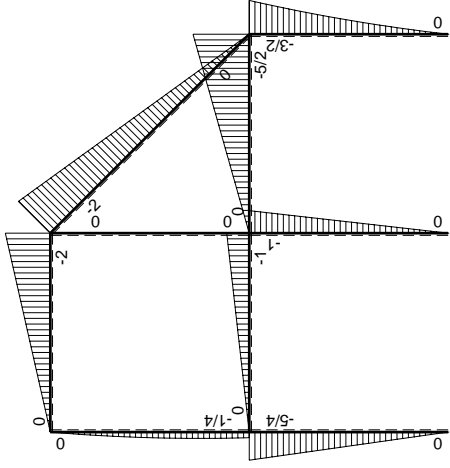
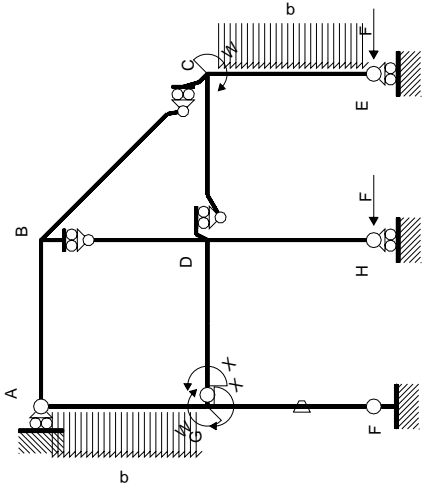


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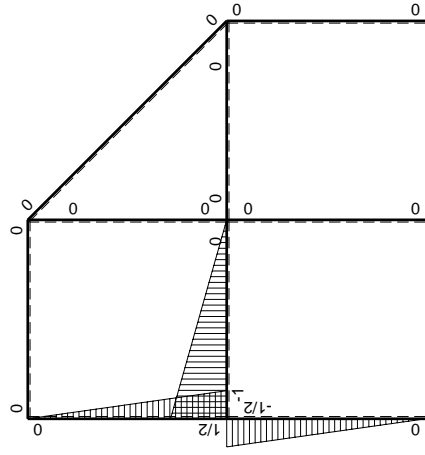


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

M<sub>0</sub> flessione da carichi assegnati



M<sub>x</sub> flessione da iperstatica X=1

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(5/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx <sup>2</sup>	0	-1/8Fb+3/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx <sup>2</sup>	0	-3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						9/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

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

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

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

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

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

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

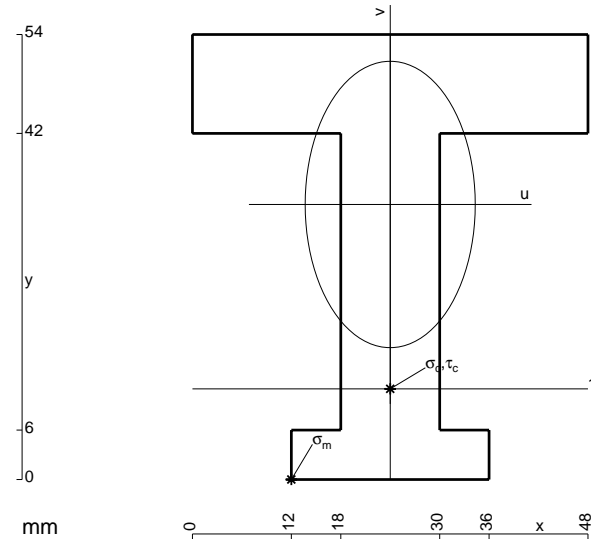
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

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

$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

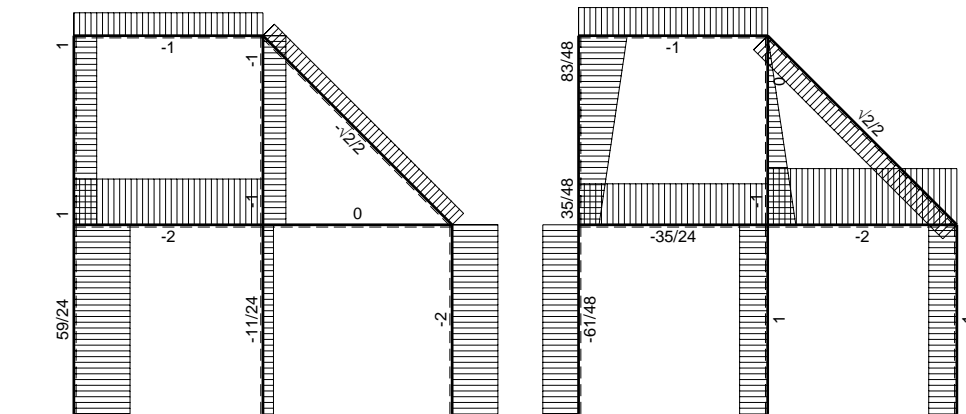
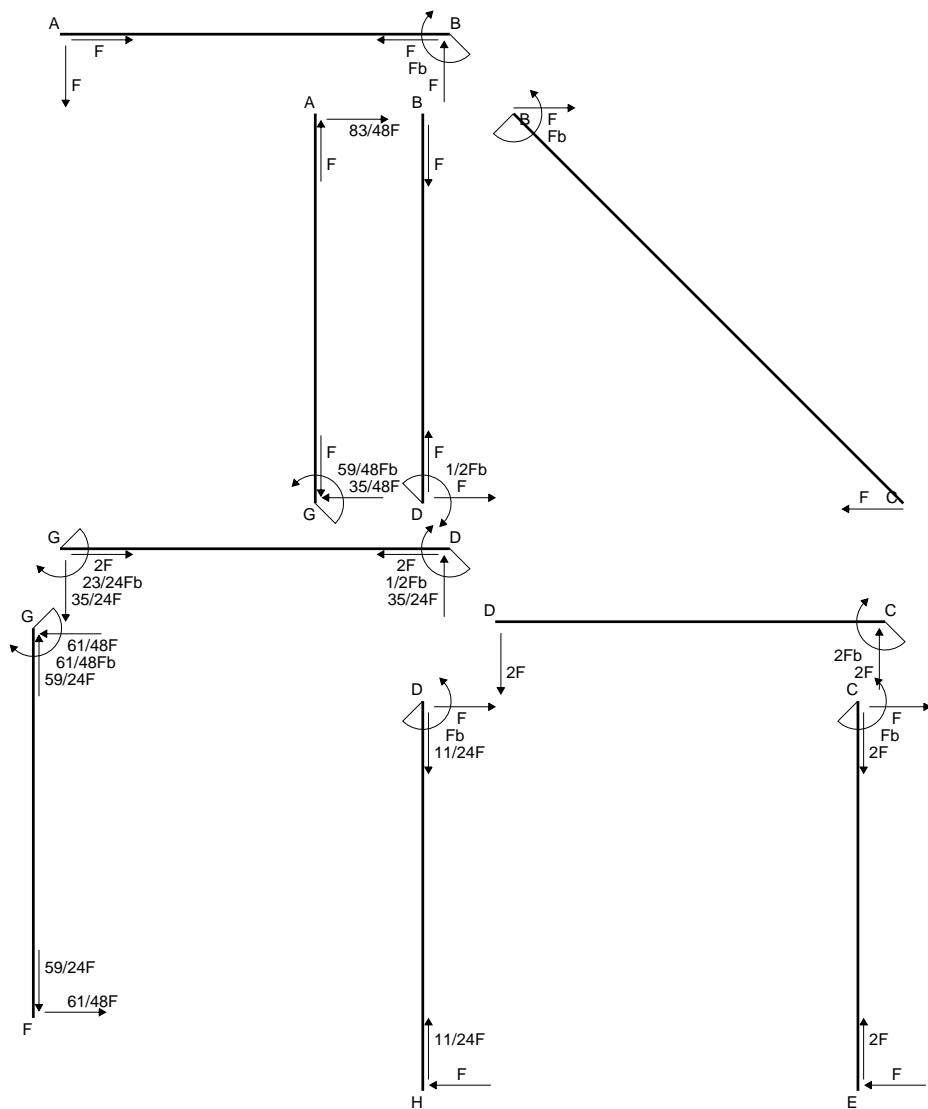
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



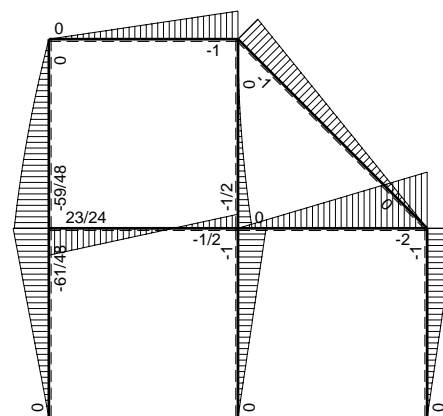
- A = 1152. mm<sup>2</sup>
- J<sub>u</sub> = 348030. mm<sup>4</sup>
- J<sub>v</sub> = 122688. mm<sup>4</sup>
- y<sub>g</sub> = 33.38 mm
- T<sub>y</sub> = -3500. N
- M<sub>x</sub> = -2485000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -33.38 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -238.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -22.38 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -159.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.916 N/mm<sup>2</sup>
- σ<sub>ρ</sub> = √(σ<sup>2</sup> + 3τ<sup>2</sup>) = 160. N/mm<sup>2</sup>
- S = 5867. mm<sup>3</sup>



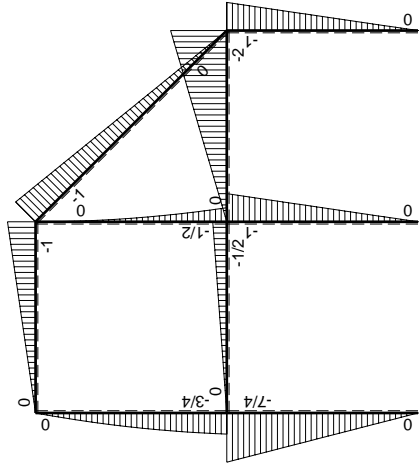
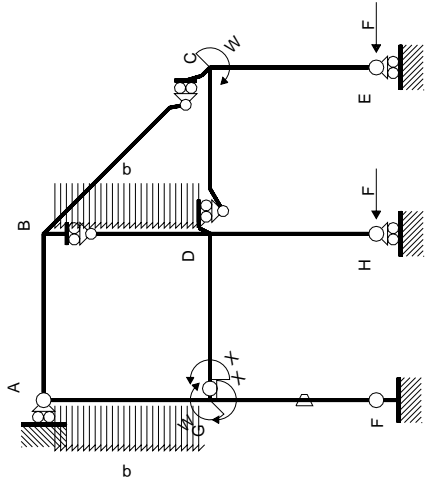


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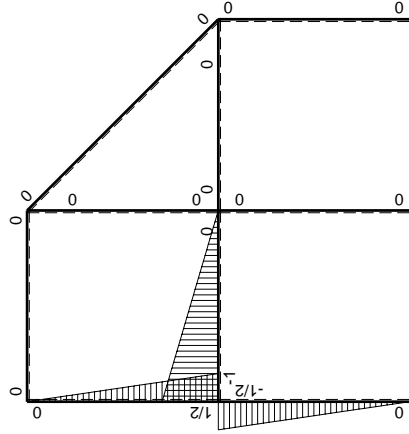


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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 <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(7/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	7/4Fb-7/4Fx	Fb/EJ	7/8Fb-7/4Fx+7/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							23/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-23/24Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (7/24 b) Fb 1/EJ + (1/4 b) \theta = 13/24 Fb^2/EJ$$

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

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

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

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

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

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

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

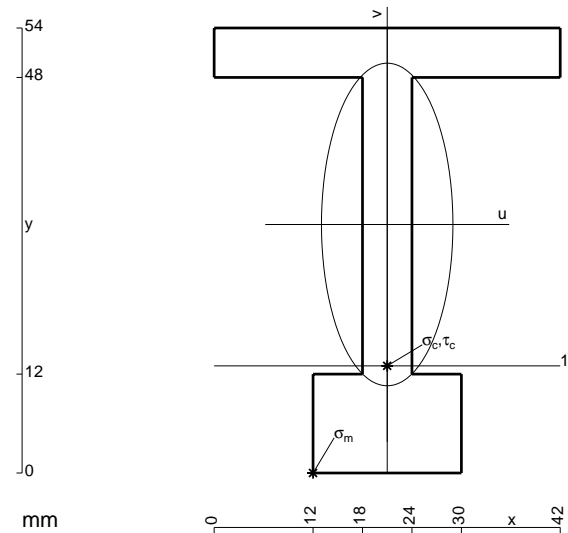
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

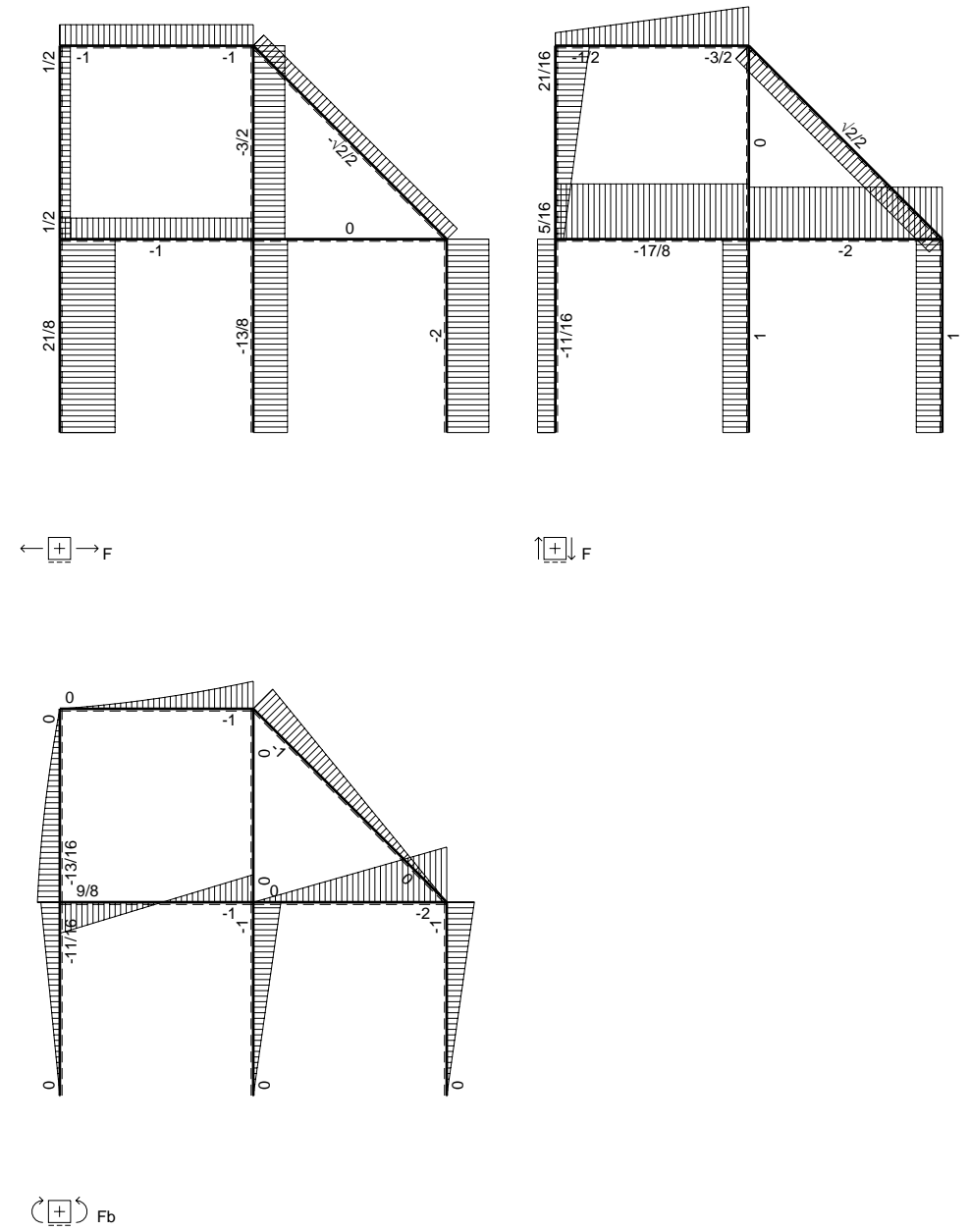
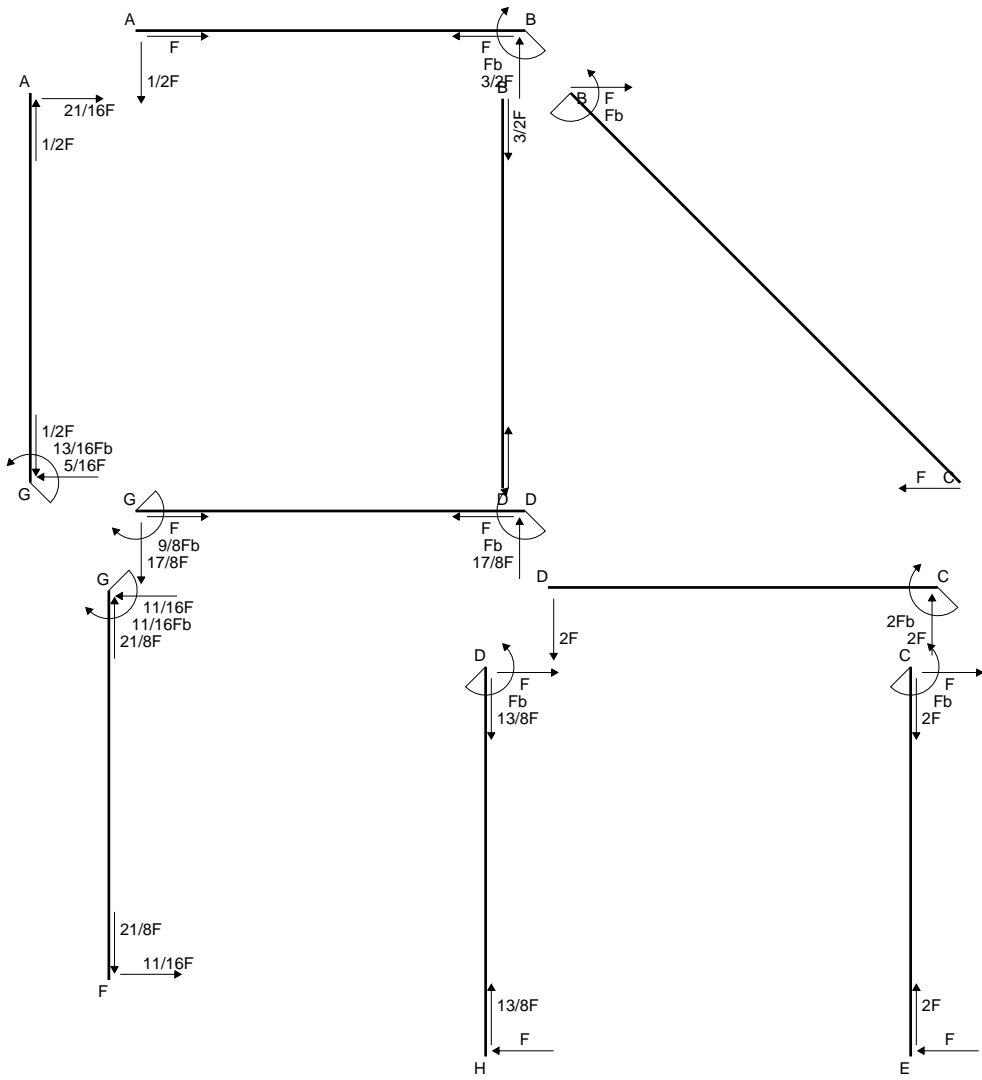
$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

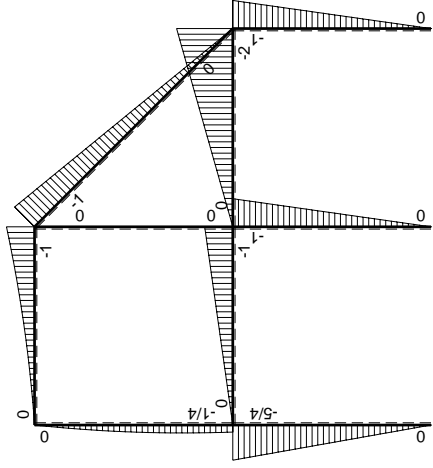
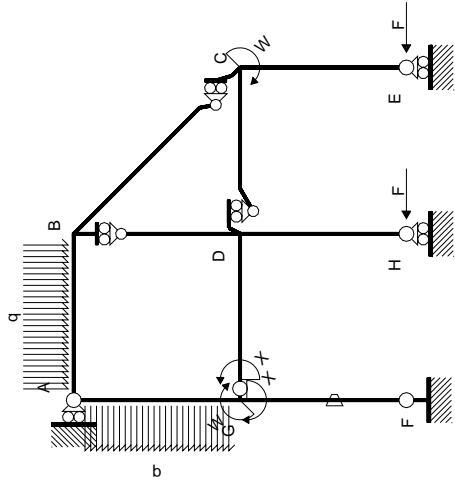
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



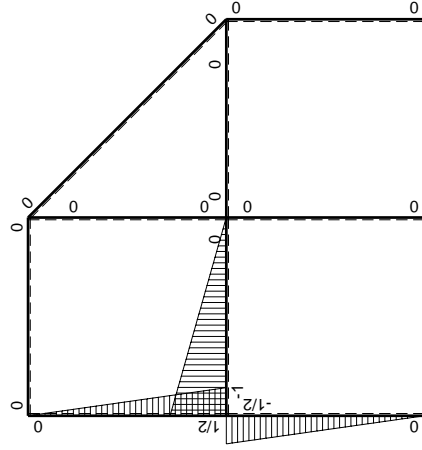
$A = 684. \text{ mm}^2$   
 $J_u = 262207. \text{ mm}^4$   
 $J_v = 43524. \text{ mm}^4$   
 $y_g = 30.16 \text{ mm}$   
 $T_y = -2280. \text{ N}$   
 $M_x = -1732800. \text{ Nmm}$   
 $x_m = 12. \text{ mm}$   
 $u_m = -9. \text{ mm}$   
 $v_m = -30.16 \text{ mm}$   
 $\sigma_m = -Mv/J_u = -199.3 \text{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





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_0(x)$	$\theta$	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$	
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	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

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

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

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

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

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

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

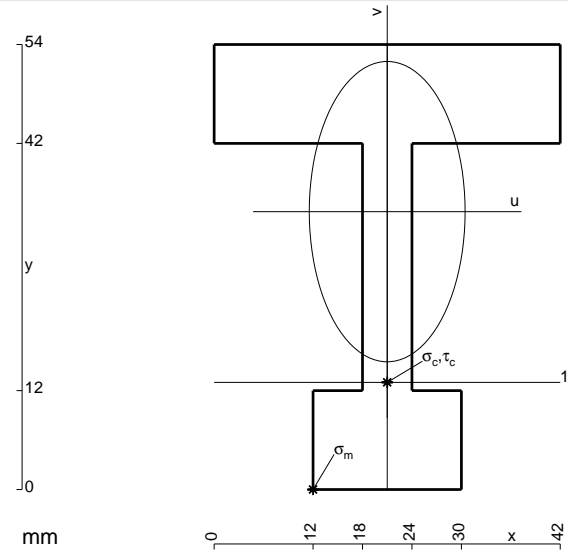
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

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

$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

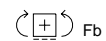
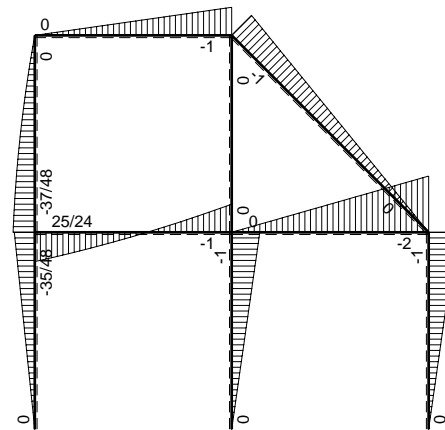
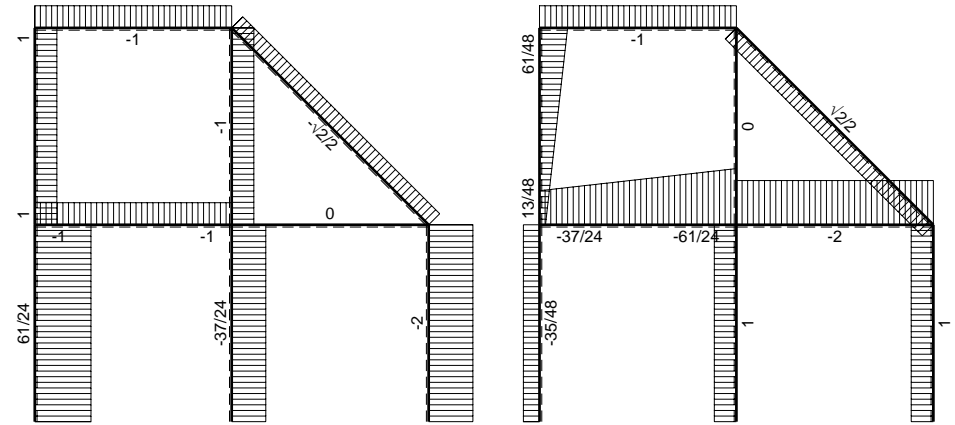
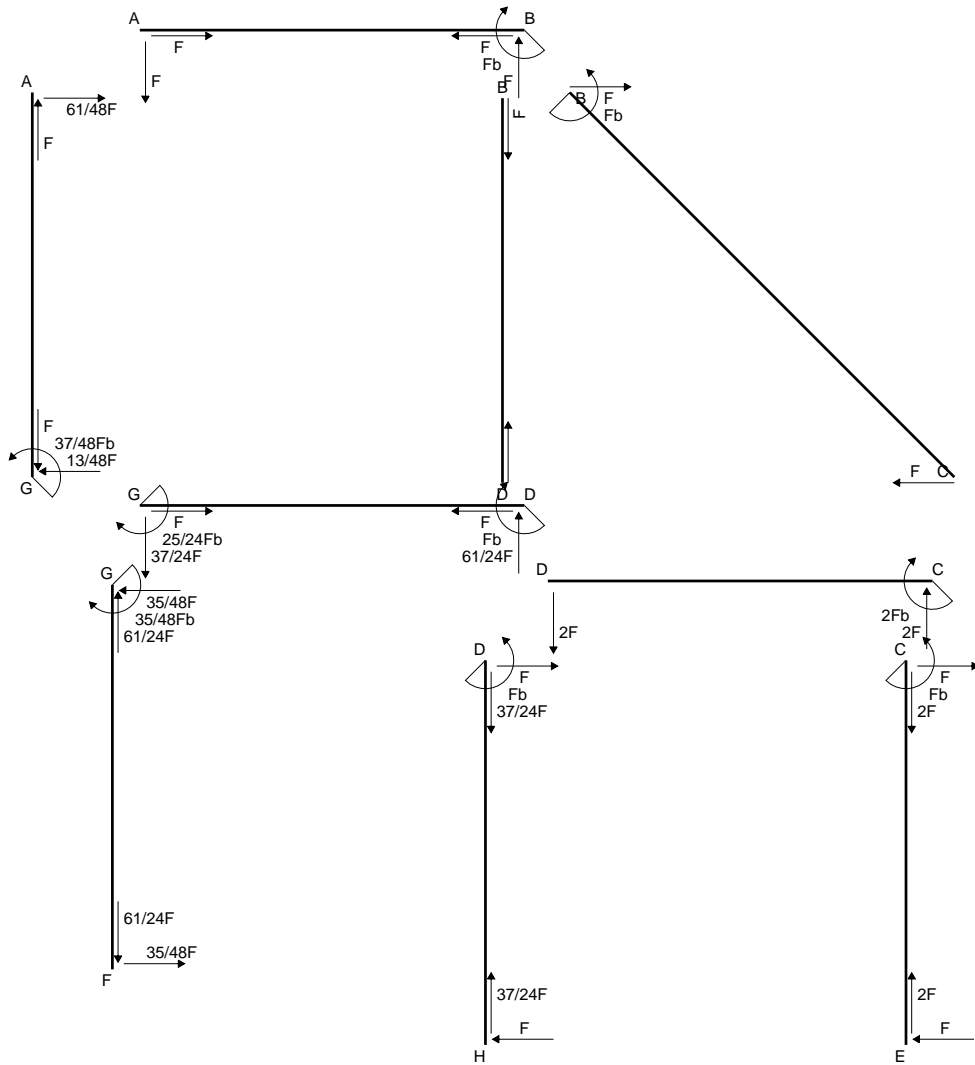
$$L_{AG}^{x\theta} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

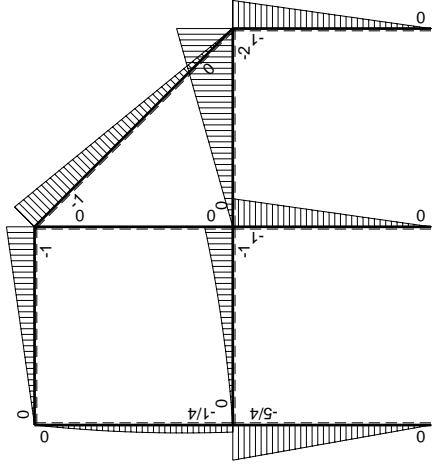
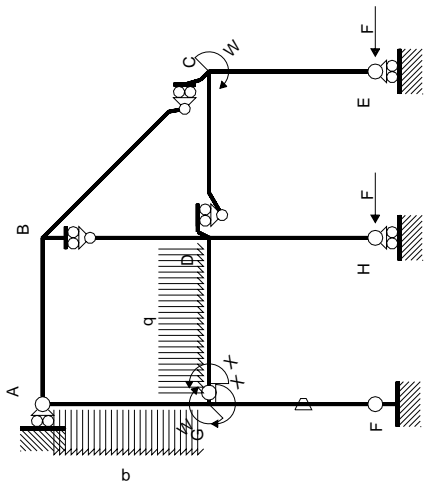
$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



- A = 900. mm<sup>2</sup>
- J<sub>u</sub> = 299017. mm<sup>4</sup>
- J<sub>v</sub> = 80460. mm<sup>4</sup>
- y<sub>g</sub> = 33.72 mm
- T<sub>y</sub> = -2280. N
- M<sub>x</sub> = -1846800. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -33.72 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -208.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -20.72 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -128. N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.771 N/mm<sup>2</sup>
- σ<sub>ρ</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 128.7 N/mm<sup>2</sup>
- S = 6115. mm<sup>3</sup>

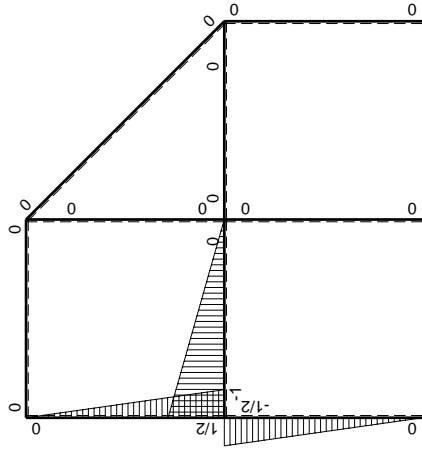






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

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

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

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

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

$$= (1/4 b -1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

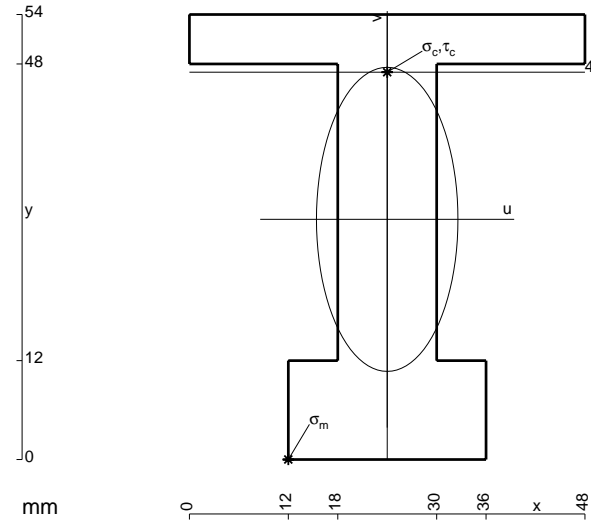
$$= (1/2 b -1/2 b +1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

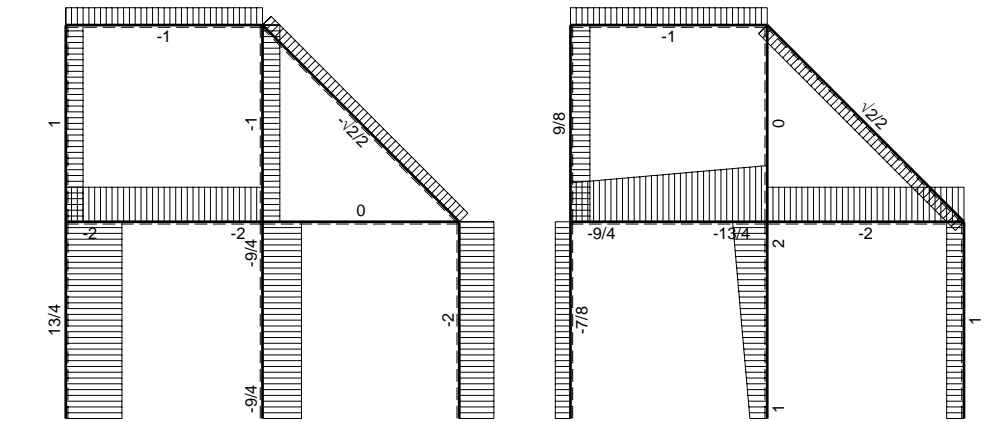
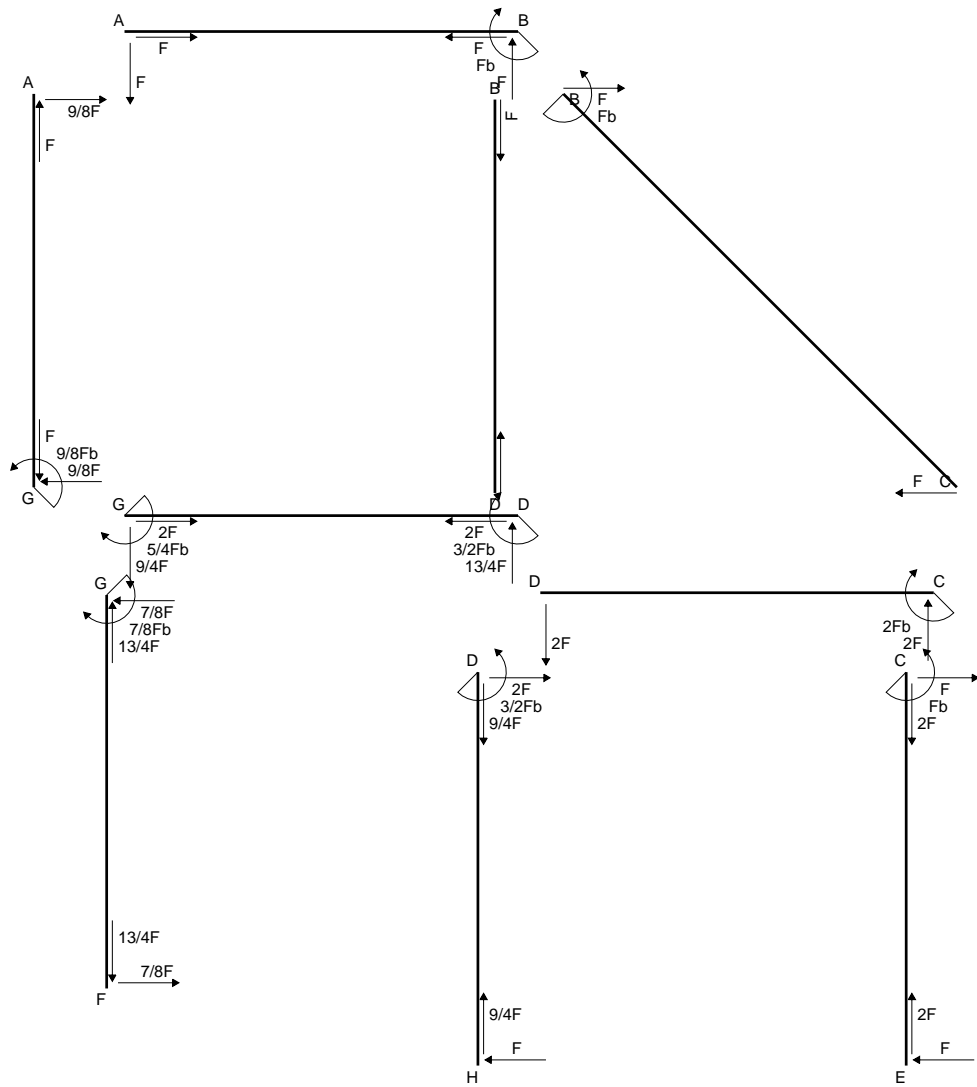
$$= (-1/8 b +1/8 b -1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

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

$$= (-1/8 b +1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

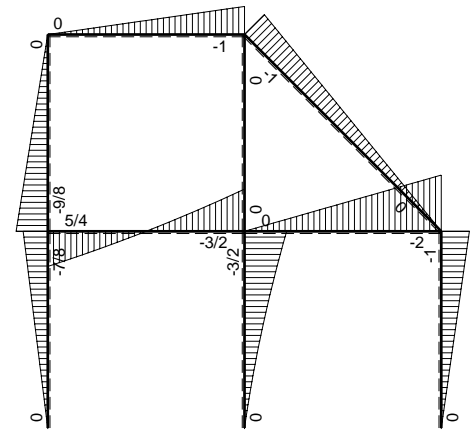


- A = 1008. mm<sup>2</sup>
- J<sub>u</sub> = 343131. mm<sup>4</sup>
- J<sub>v</sub> = 74304. mm<sup>4</sup>
- y<sub>g</sub> = 29.14 mm
- T<sub>y</sub> = -3000. N
- M<sub>x</sub> = -2580000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -29.14 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219.1 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 47. mm
- v<sub>c</sub> = 17.86 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 134.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.747 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 134.5 N/mm<sup>2</sup>
- S = 6515. mm<sup>3</sup>

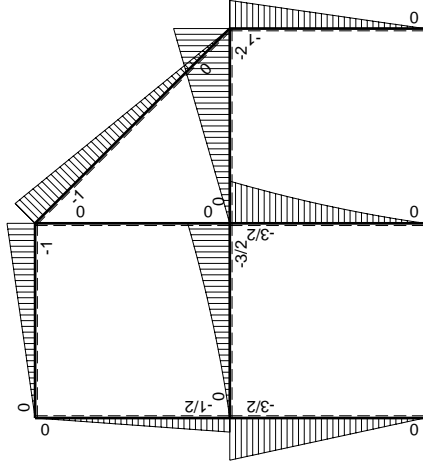
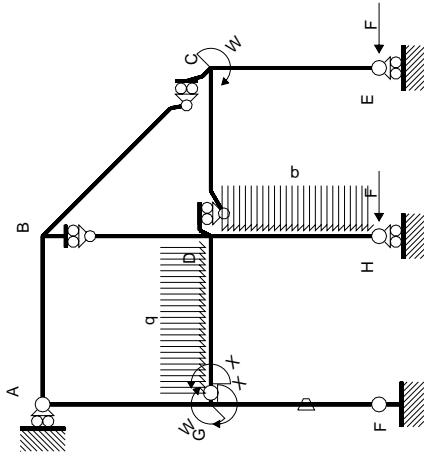


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↑ ⊕ ↓ F

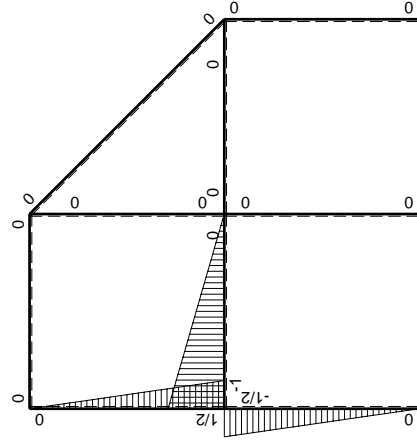


⊕ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	-Fb/EJ	3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx-1/2qx <sup>2</sup>	0	Fx-1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	3/2Fb-2Fx+1/2qx <sup>2</sup>	0	3/2Fx-2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							5/8Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-5/4Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

$$= (1/2 b - 1/6 b - 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

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

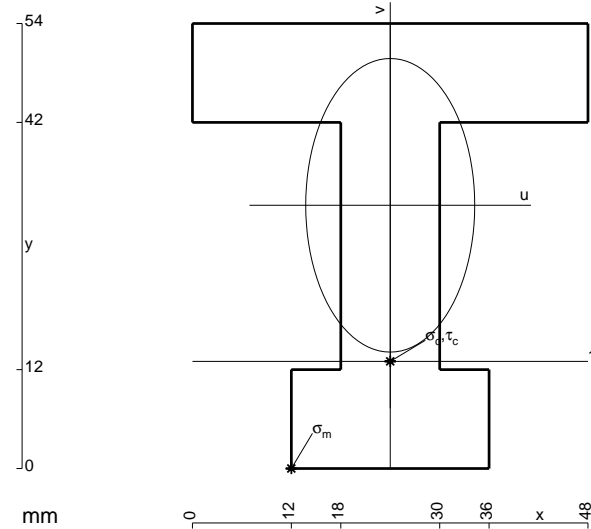
$$= (3/4 b - 2/3 b + 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

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

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

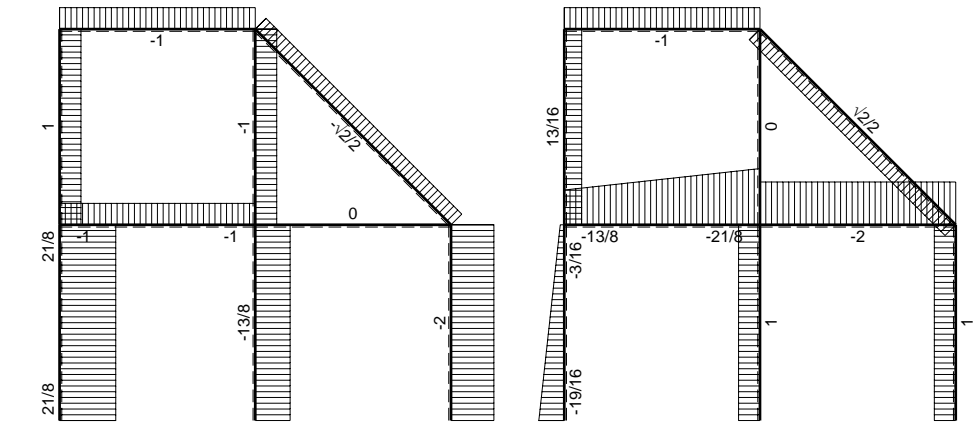
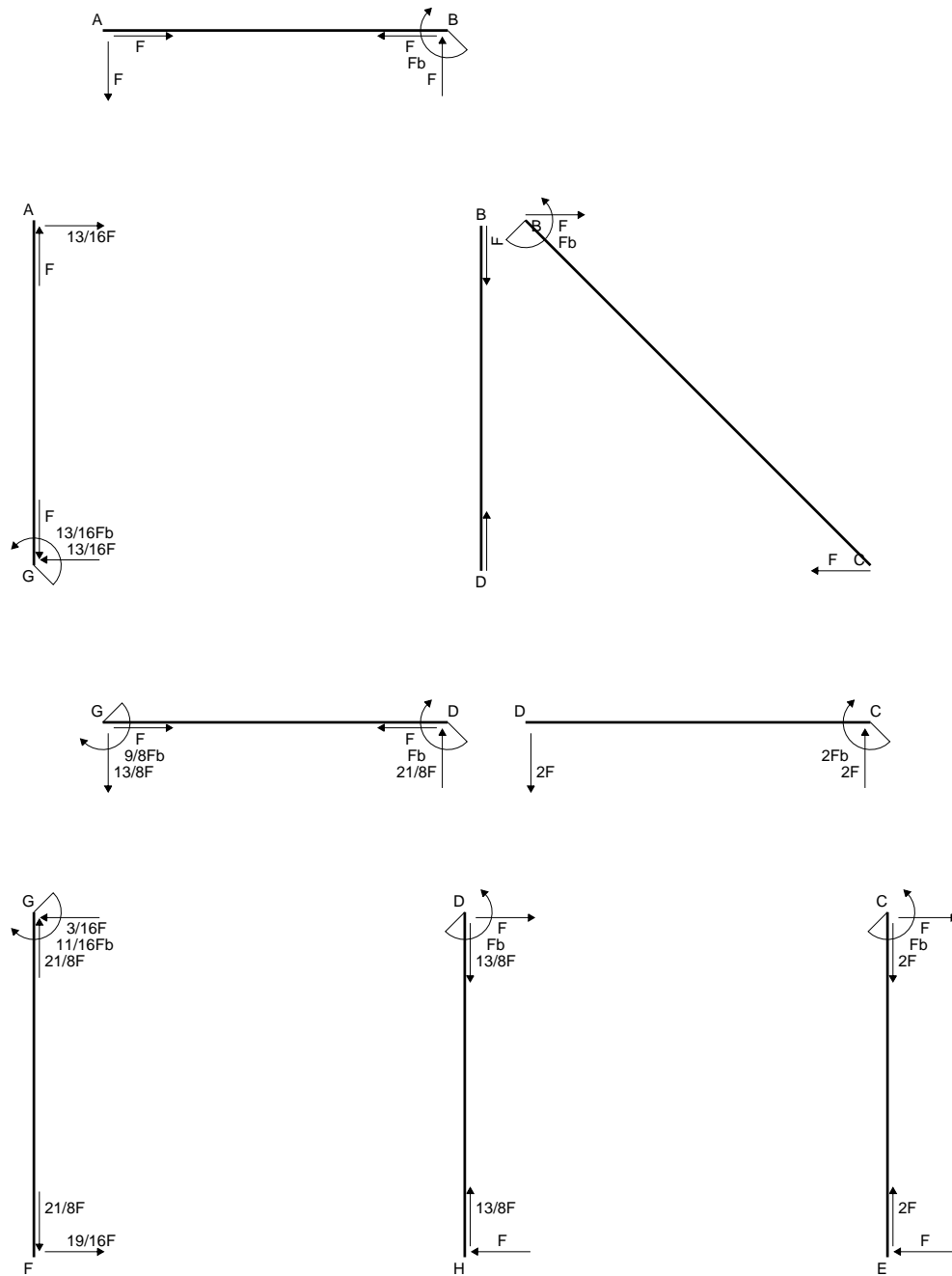
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

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



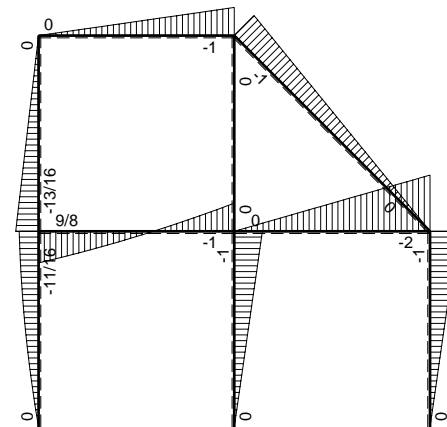
- A = 1224. mm<sup>2</sup>
- J<sub>u</sub> = 388508. mm<sup>4</sup>
- J<sub>v</sub> = 128736. mm<sup>4</sup>
- y<sub>g</sub> = 31.94 mm
- T<sub>y</sub> = -3060. N
- M<sub>x</sub> = -2784600. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -31.94 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -228.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -18.94 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -135.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.057 N/mm<sup>2</sup>
- σ<sub>q</sub> = √(σ<sup>2</sup> + 3τ<sup>2</sup>) = 136. N/mm<sup>2</sup>
- S = 7704. mm<sup>3</sup>



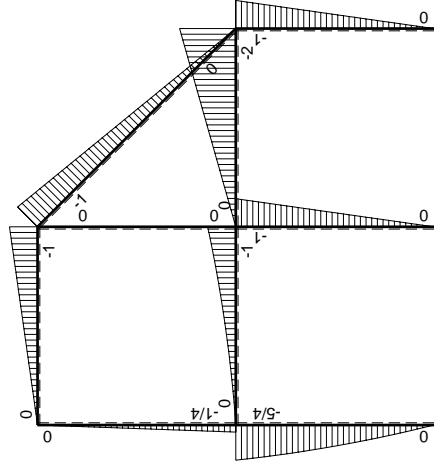
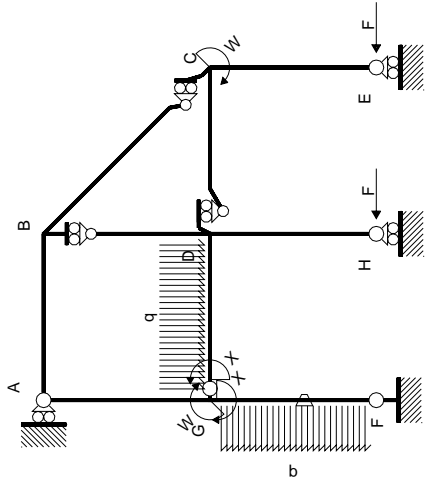


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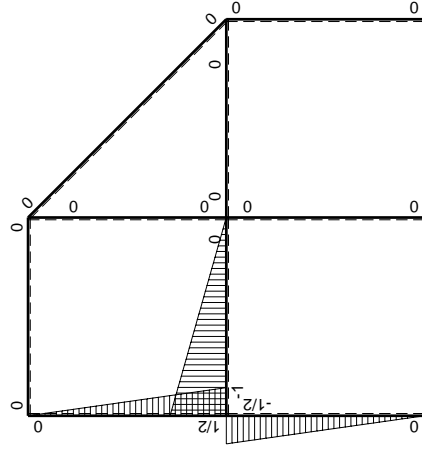


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

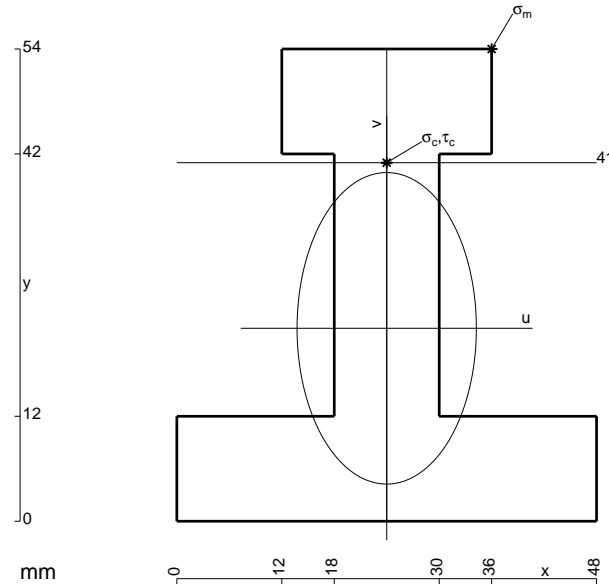
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

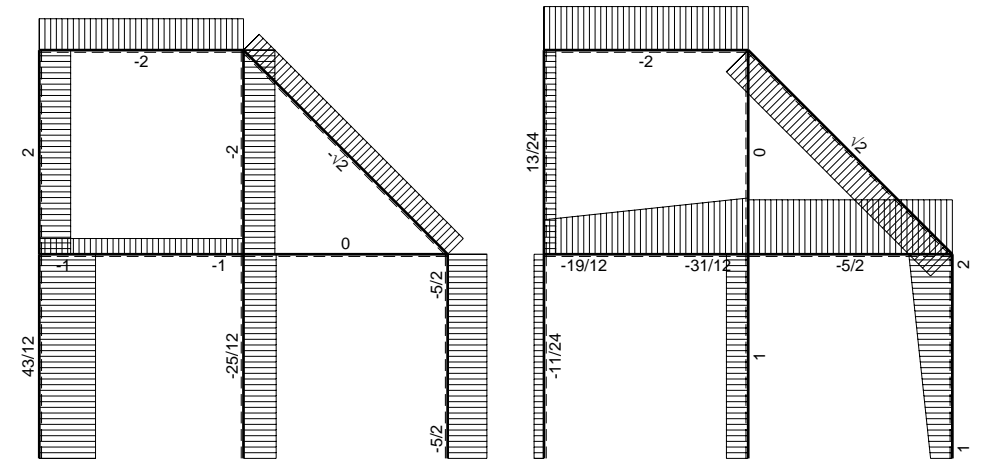
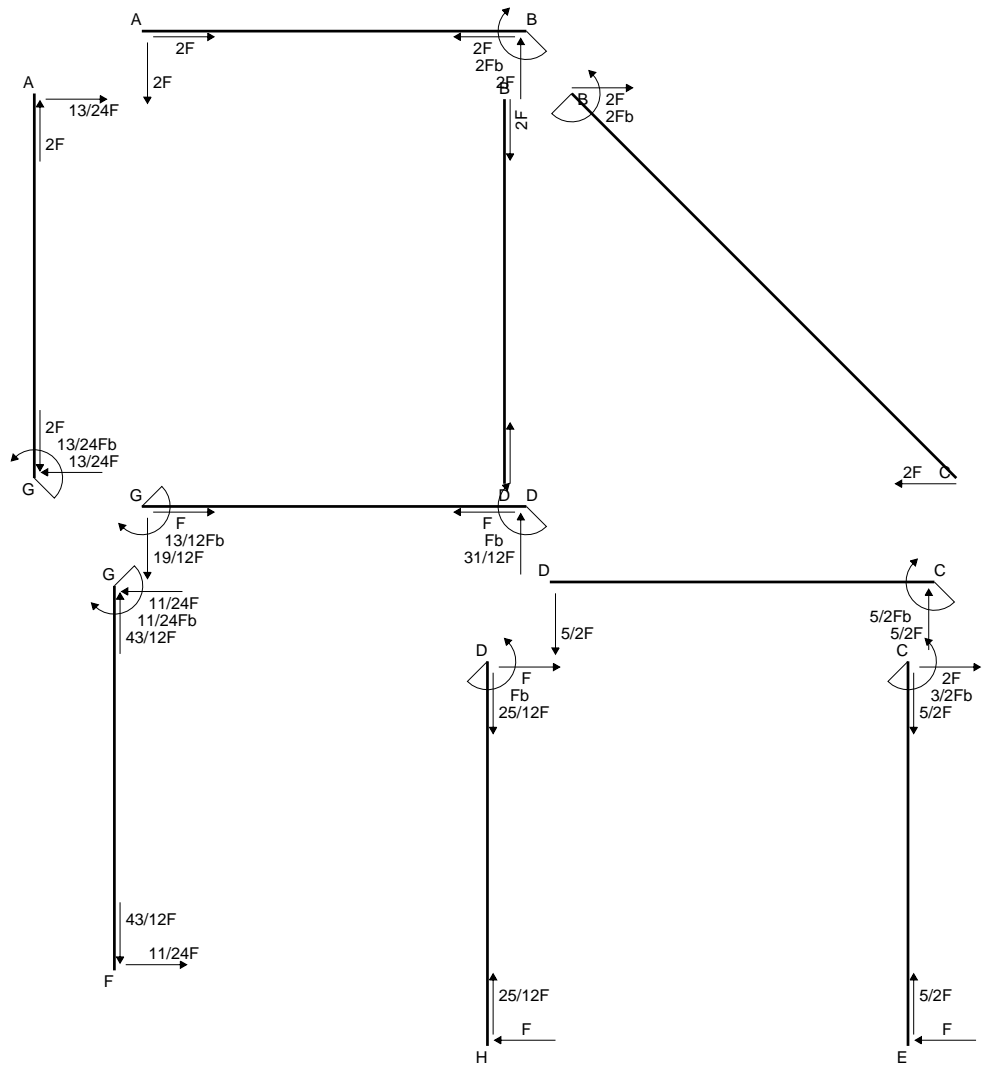
$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

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

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

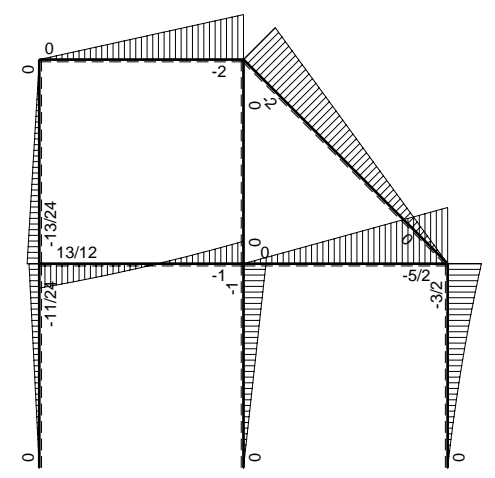


- A = 1224. mm<sup>2</sup>
- J<sub>u</sub> = 388508. mm<sup>4</sup>
- J<sub>v</sub> = 128736. mm<sup>4</sup>
- y<sub>g</sub> = 22.06 mm
- T<sub>y</sub> = -3040. N
- M<sub>x</sub> = -2918400. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 31.94 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 239.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 18.94 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 142.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.024 N/mm<sup>2</sup>
- σ<sub>σ</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 142.5 N/mm<sup>2</sup>
- S = 7704. mm<sup>3</sup>

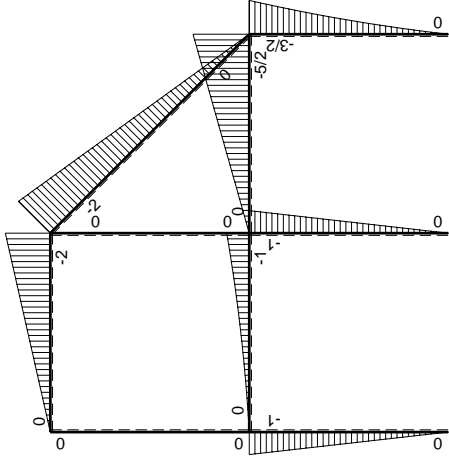
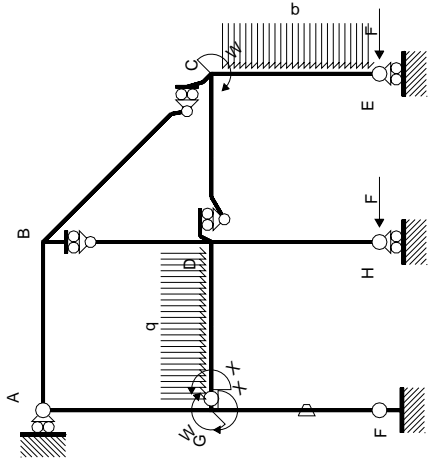


← ⊕ →  $F$

↑ ⊕ ↓  $F_b$

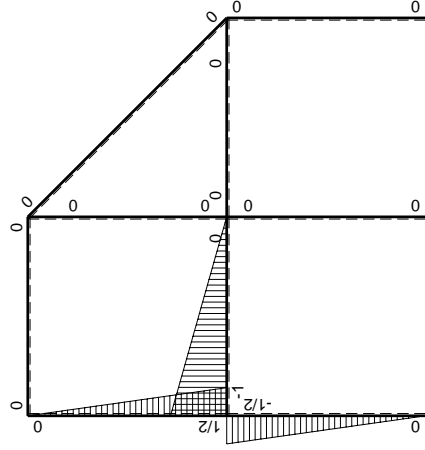


⊕ ⊖  $M_b$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-2Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	0+0	1/12Xb/EJ	
AG b	-1/2x/b	0	0	0	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							13/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-13/12Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

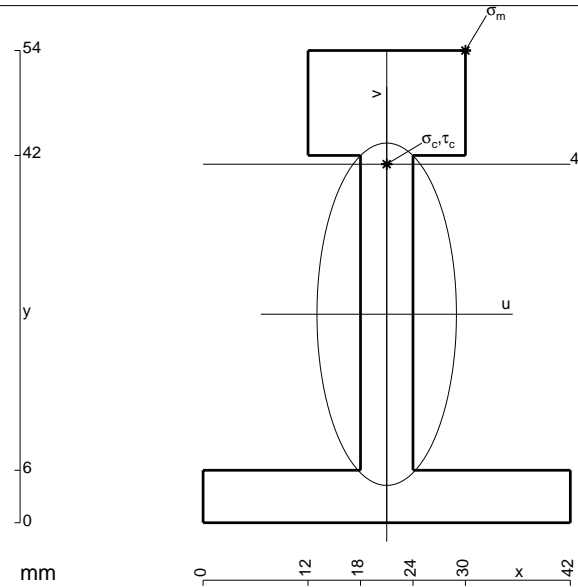
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

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

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

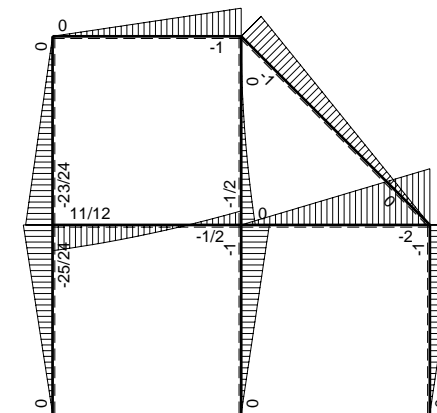
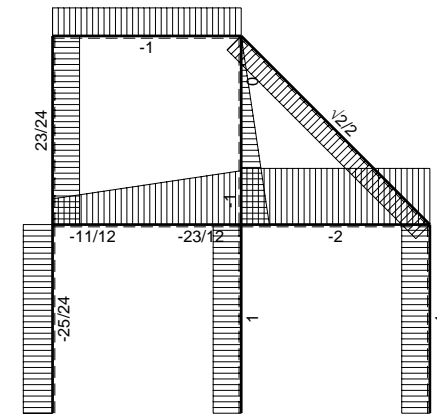
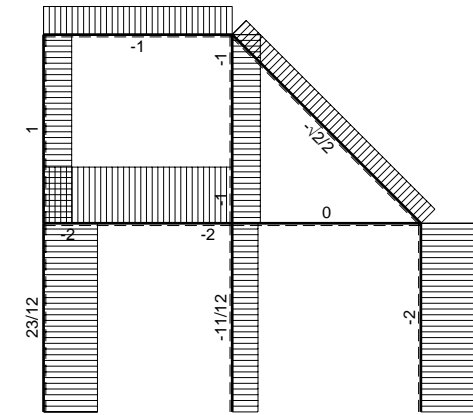
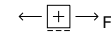
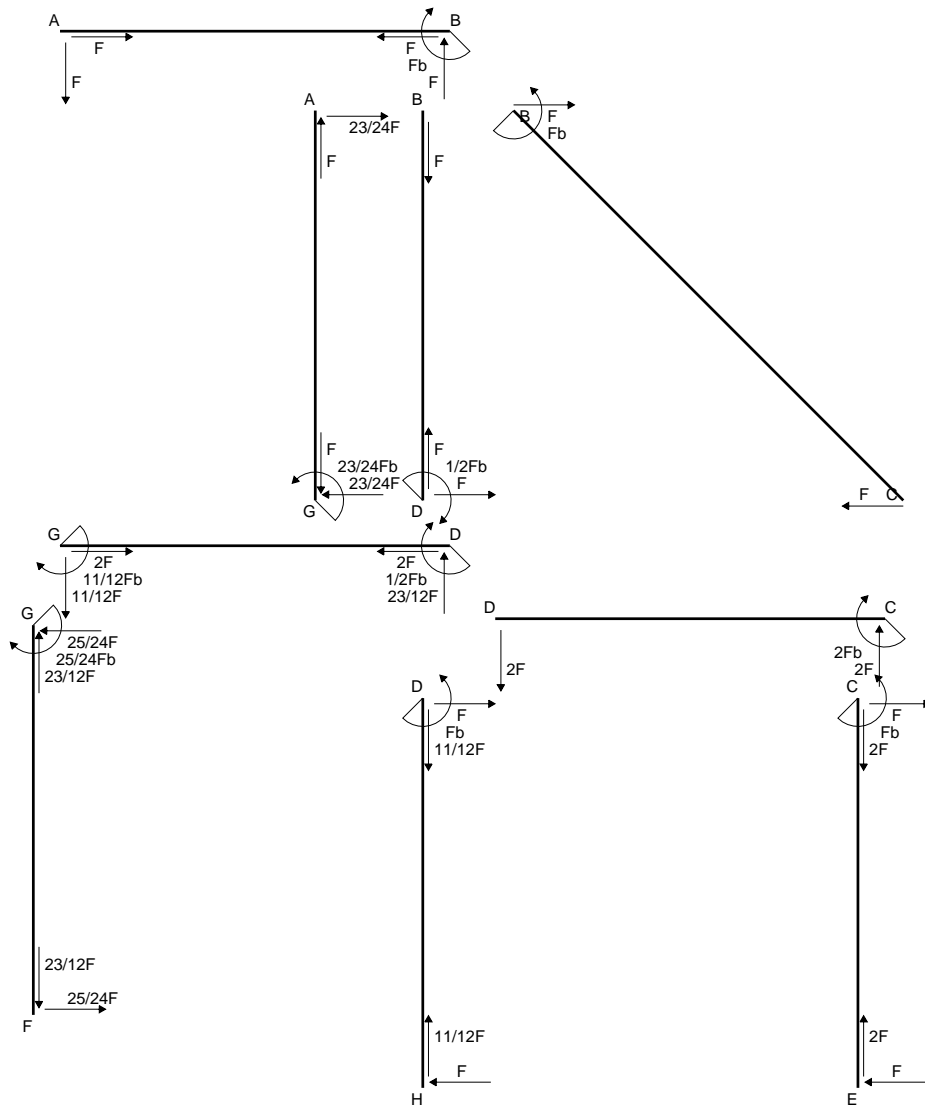
$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

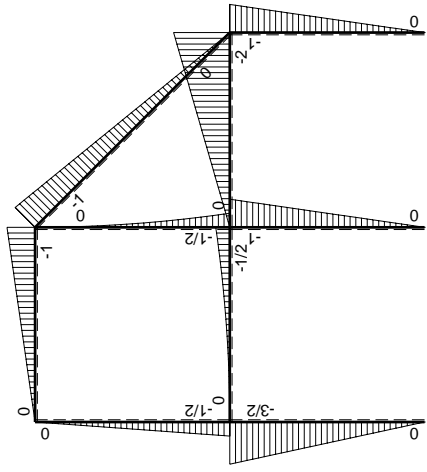
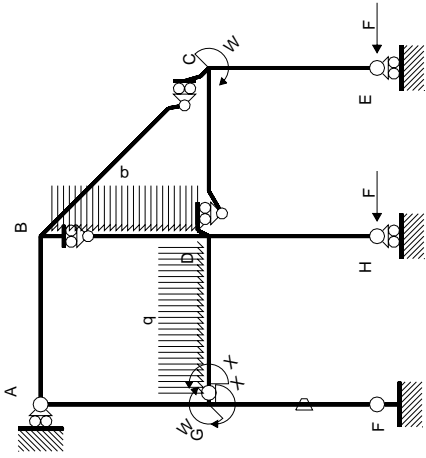
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$



- A = 684. mm<sup>2</sup>
- J<sub>u</sub> = 262207. mm<sup>4</sup>
- J<sub>v</sub> = 43524. mm<sup>4</sup>
- y<sub>g</sub> = 23.84 mm
- T<sub>y</sub> = -3400. N
- M<sub>x</sub> = -1734000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 30.16 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 17.16 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 113.5 N/mm<sup>2</sup>
- τ<sub>c</sub> = 11.51 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 115.2 N/mm<sup>2</sup>
- S = 5324. mm<sup>3</sup>

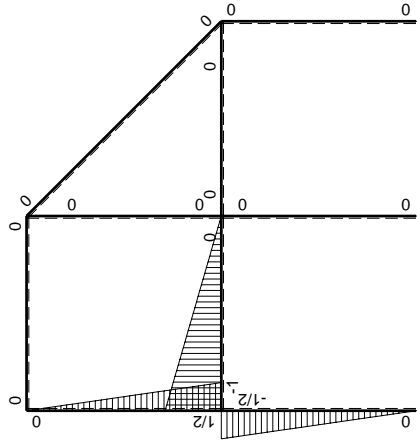






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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 <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2qx <sup>2</sup>	0	1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-Fx+1/2qx <sup>2</sup>	0	1/2Fx-Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						11/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/12Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

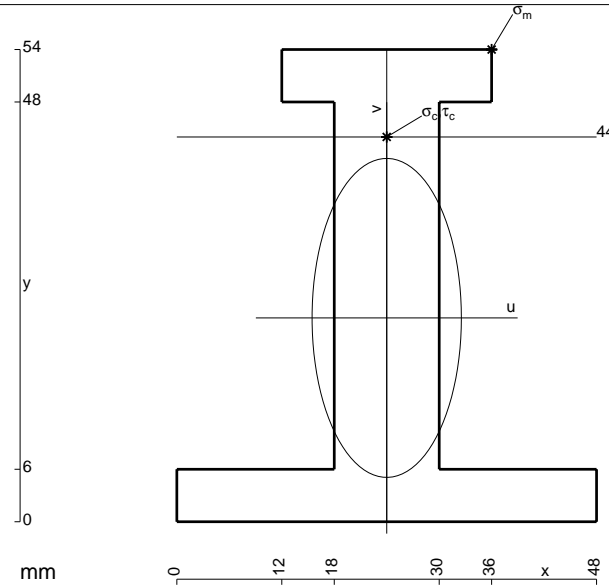
$$= (1/4 b - 1/3 b + 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

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

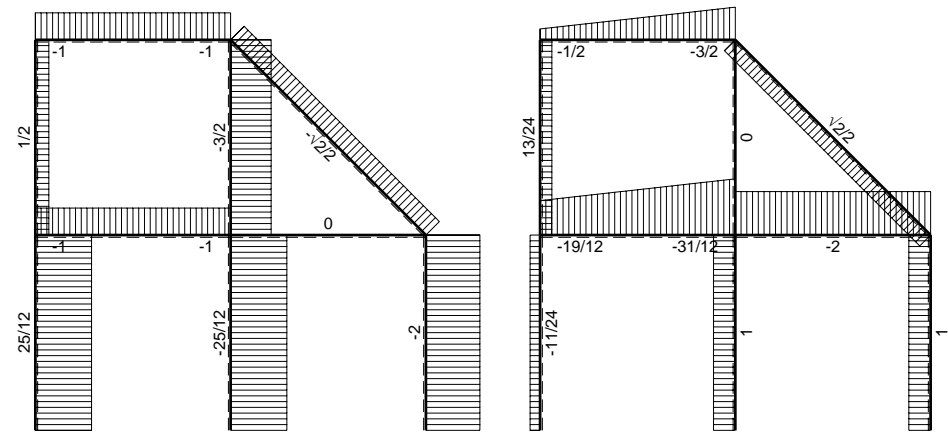
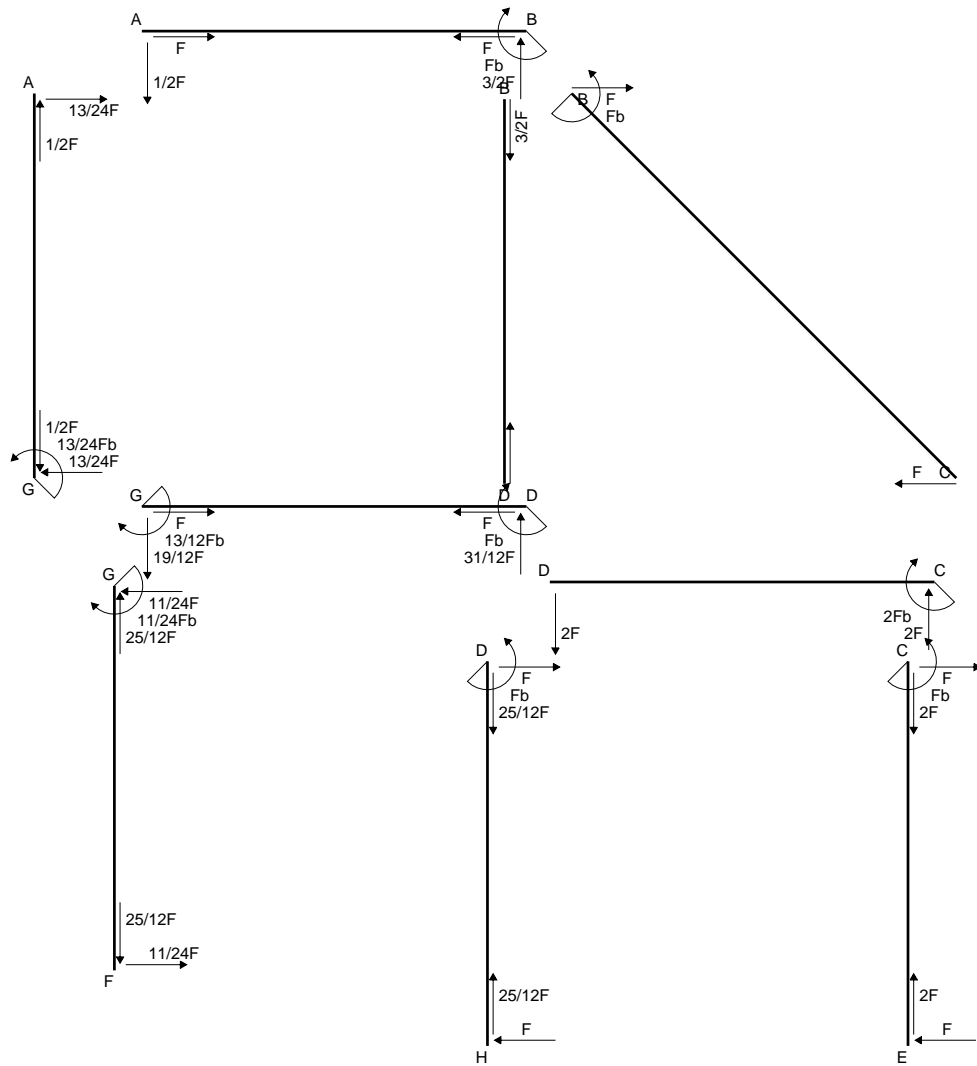
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

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

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

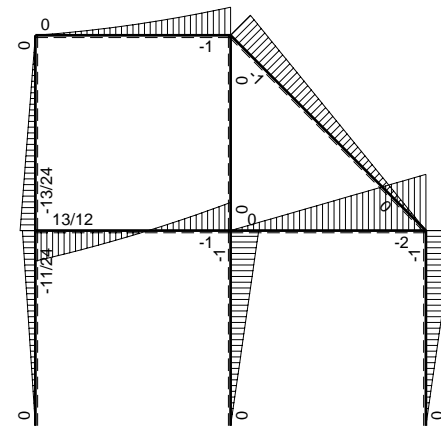


- A = 936. mm<sup>2</sup>
- J<sub>u</sub> = 311455. mm<sup>4</sup>
- J<sub>v</sub> = 68256. mm<sup>4</sup>
- y<sub>g</sub> = 23.31 mm
- T<sub>y</sub> = -3800. N
- M<sub>x</sub> = -2128000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 30.69 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 44. mm
- v<sub>c</sub> = 20.69 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 141.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.162 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 141.7 N/mm<sup>2</sup>
- S = 5077. mm<sup>3</sup>

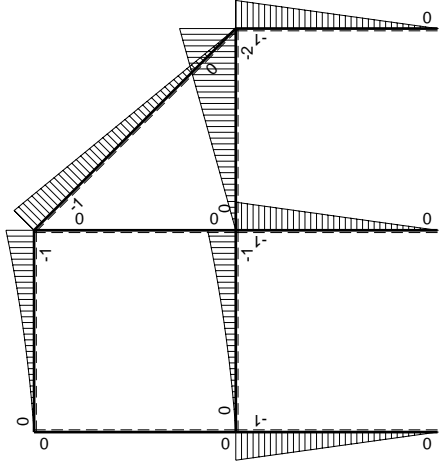
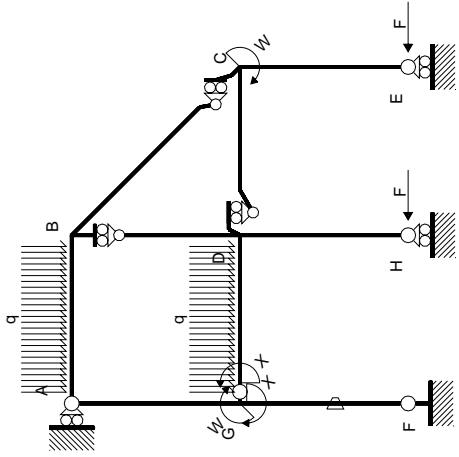


← ⊕ → F

↑ ⊕ ↓ F

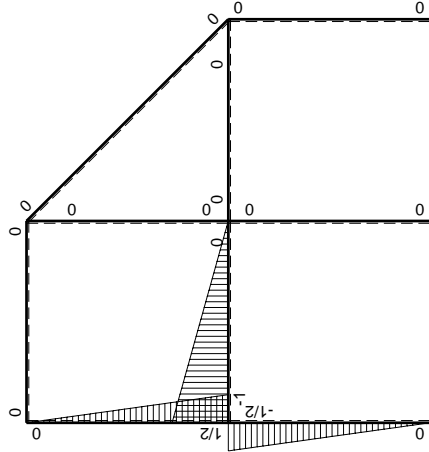


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

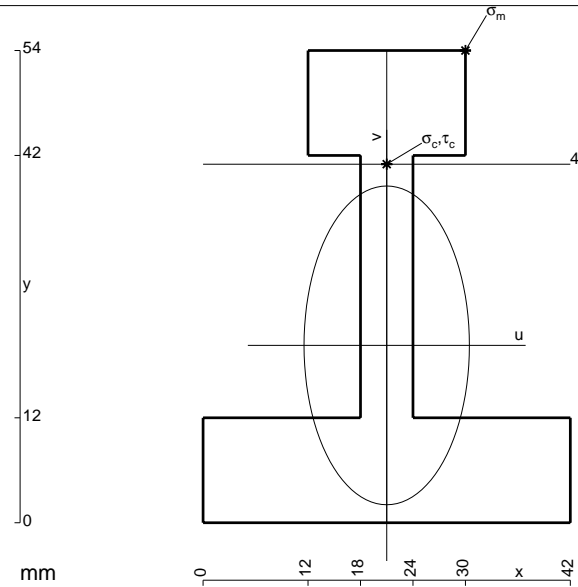
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

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

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

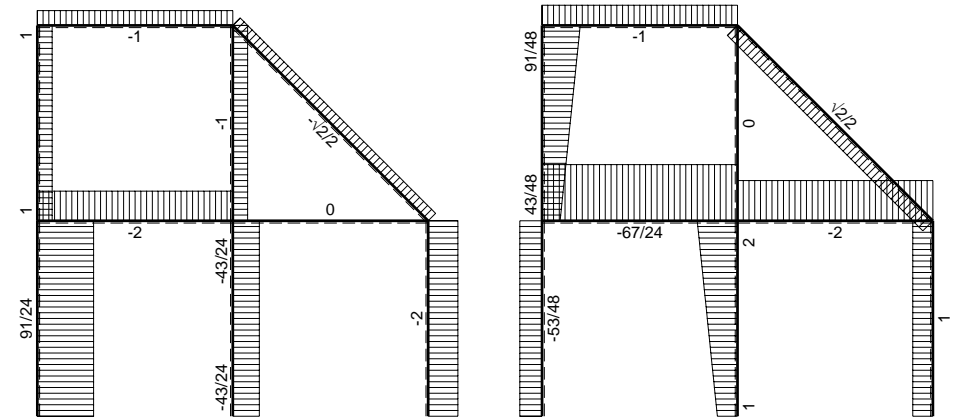
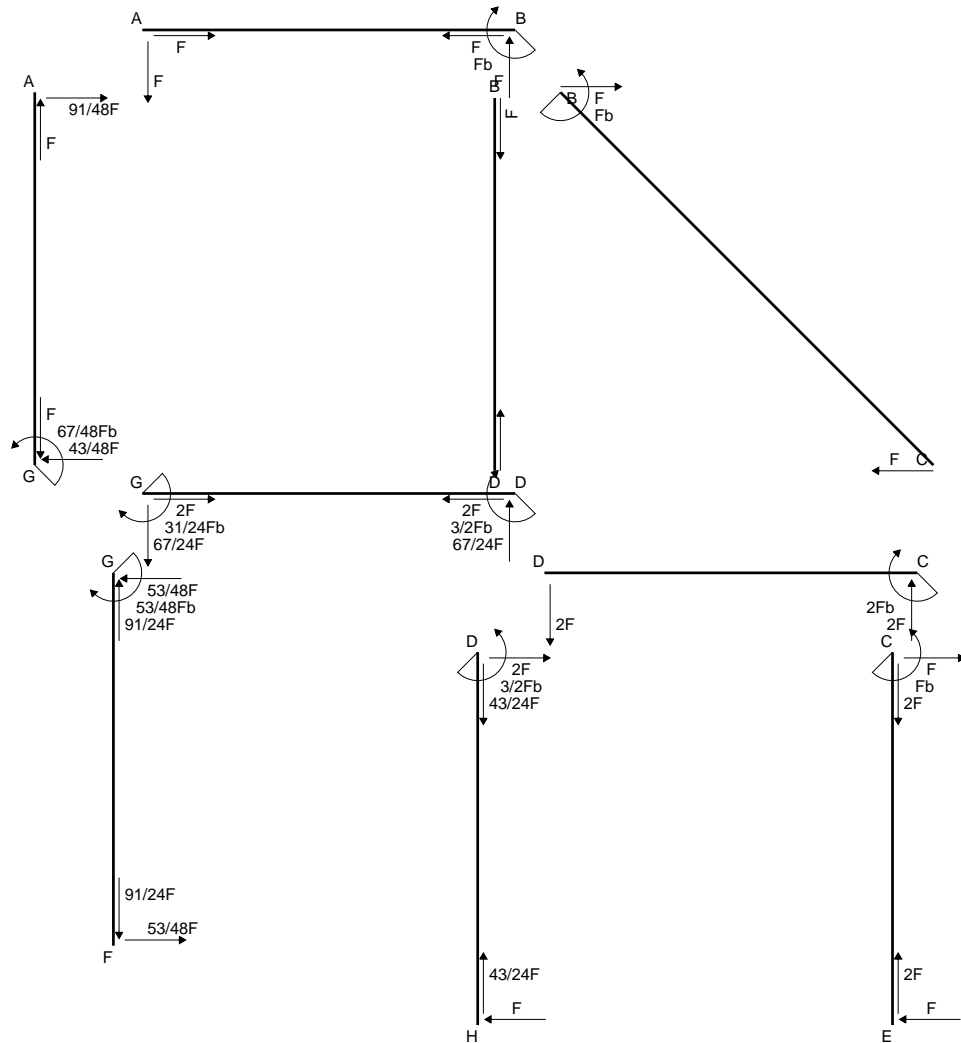
$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

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



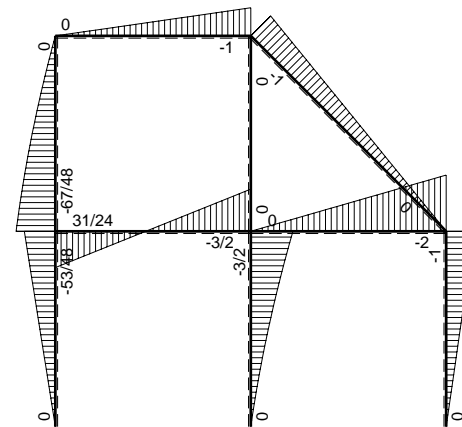
- A = 900. mm<sup>2</sup>
- J<sub>u</sub> = 299017. mm<sup>4</sup>
- J<sub>v</sub> = 80460. mm<sup>4</sup>
- y<sub>g</sub> = 20.28 mm
- T<sub>y</sub> = -3180. N
- M<sub>x</sub> = -1939800. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.72 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 218.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 20.72 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 134.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 10.84 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 135.7 N/mm<sup>2</sup>
- S = 6115. mm<sup>3</sup>



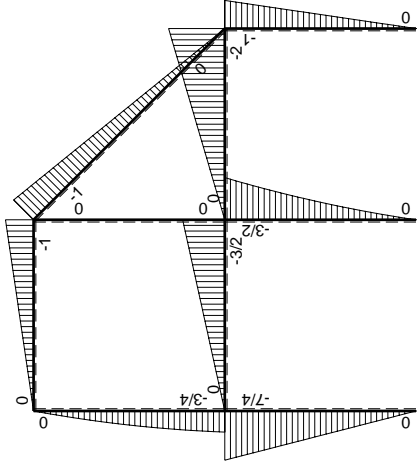
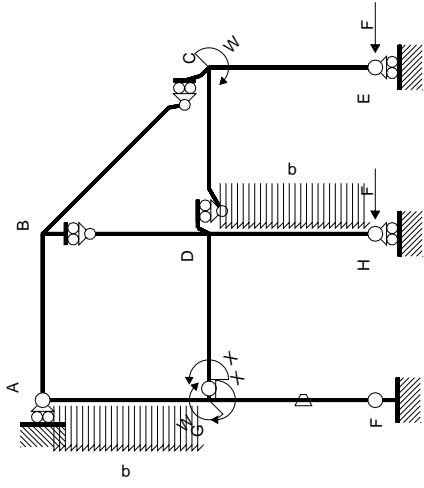


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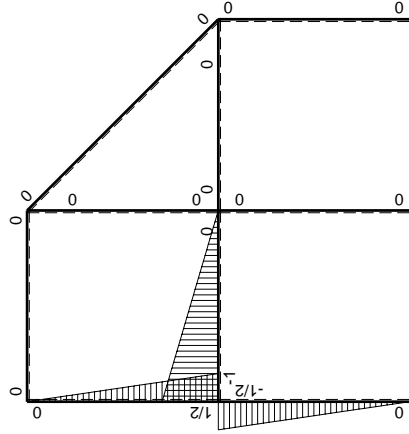


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (7/24 b) Fb 1/EJ + (1/4 b) \theta = 13/24 Fb^2/EJ$$

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

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

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

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

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

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

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

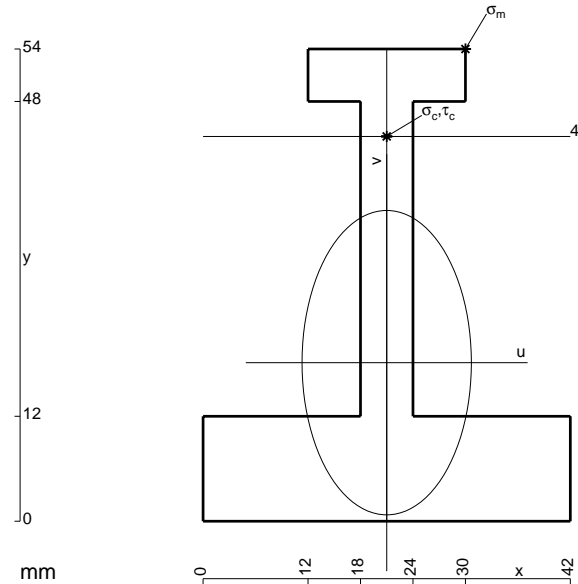
$$L_{GA}^{xo} = \int_0^b (-3/8 +1/2 x/b +1/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x +1/4 x^2/b +1/24 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ$$

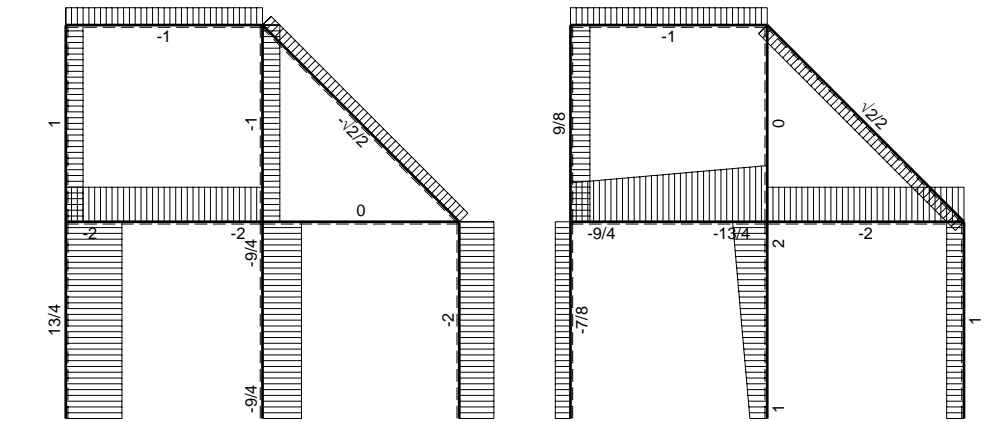
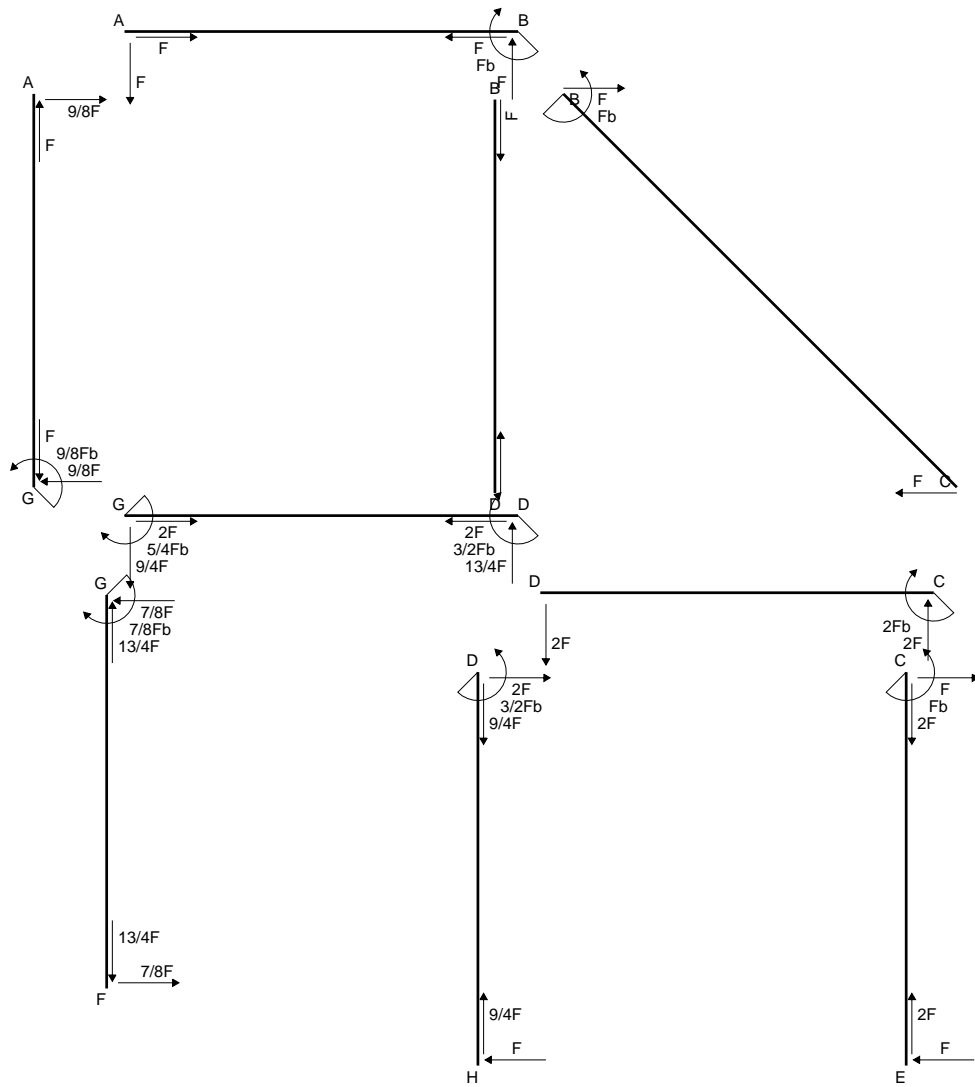
$$= (-3/8 b +1/4 b +1/24 b -1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

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

$$= (-5/24 b +1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

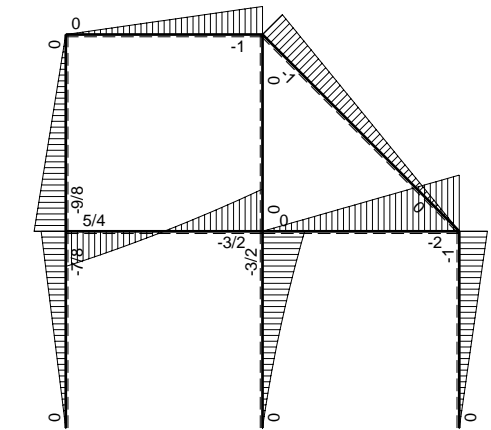


- A = 828. mm<sup>2</sup>
- J<sub>u</sub> = 250978. mm<sup>4</sup>
- J<sub>v</sub> = 77652. mm<sup>4</sup>
- y<sub>g</sub> = 18.13 mm
- T<sub>y</sub> = -2420. N
- M<sub>x</sub> = -1597200. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 35.87 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 228.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 44. mm
- v<sub>c</sub> = 25.87 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 164.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.78 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 165.1 N/mm<sup>2</sup>
- S = 4219. mm<sup>3</sup>

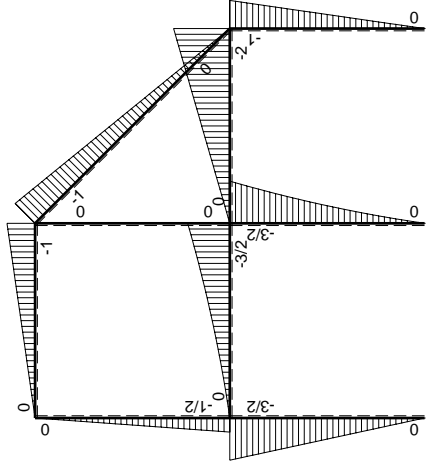
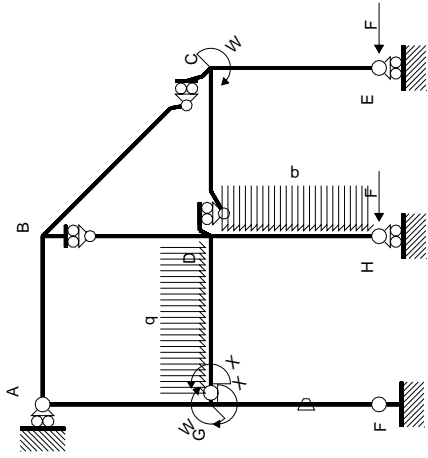


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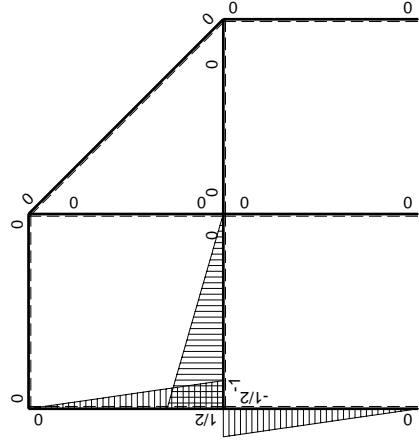


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx-1/2qx <sup>2</sup>	0	Fx-1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx <sup>2</sup>	0	3/2Fx-2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/8Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/4Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

$$= (1/2 b - 1/6 b - 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

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

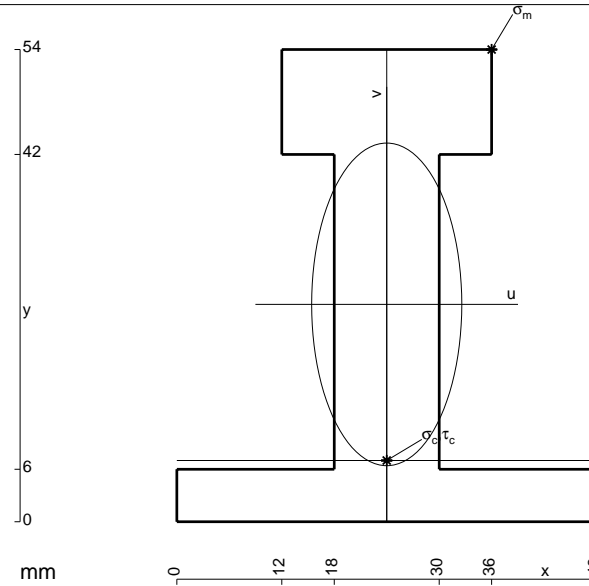
$$= (3/4 b - 2/3 b + 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

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

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

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

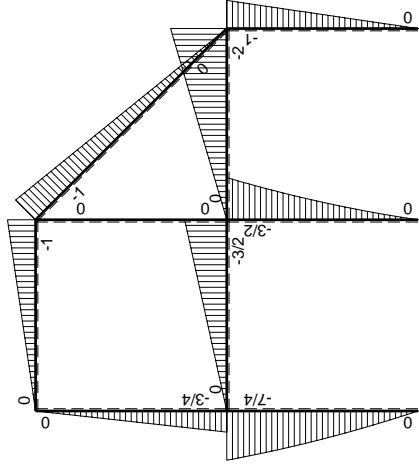
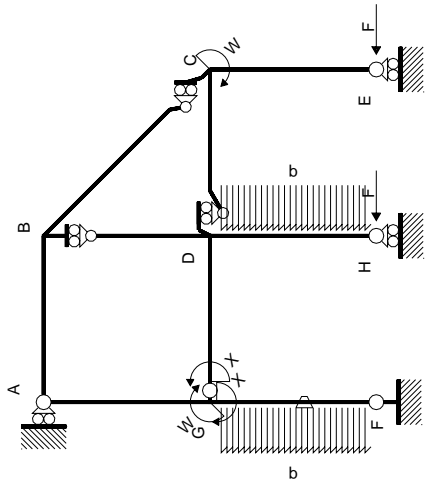
$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



- A = 1008. mm<sup>2</sup>
- J<sub>u</sub> = 343131. mm<sup>4</sup>
- J<sub>v</sub> = 74304. mm<sup>4</sup>
- y<sub>g</sub> = 24.86 mm
- T<sub>y</sub> = -3960. N
- M<sub>x</sub> = -2811600. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 29.14 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 238.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -17.86 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -146.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.266 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 146.7 N/mm<sup>2</sup>
- S = 6515. mm<sup>3</sup>

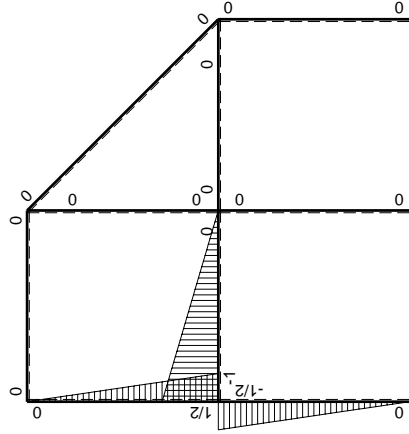






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

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

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

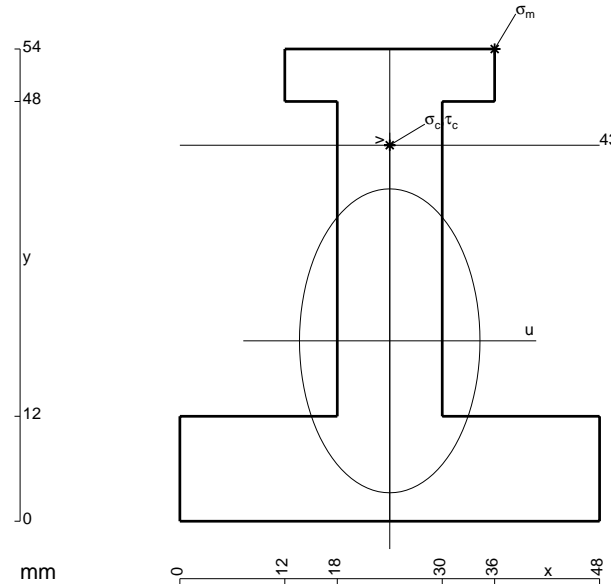
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

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

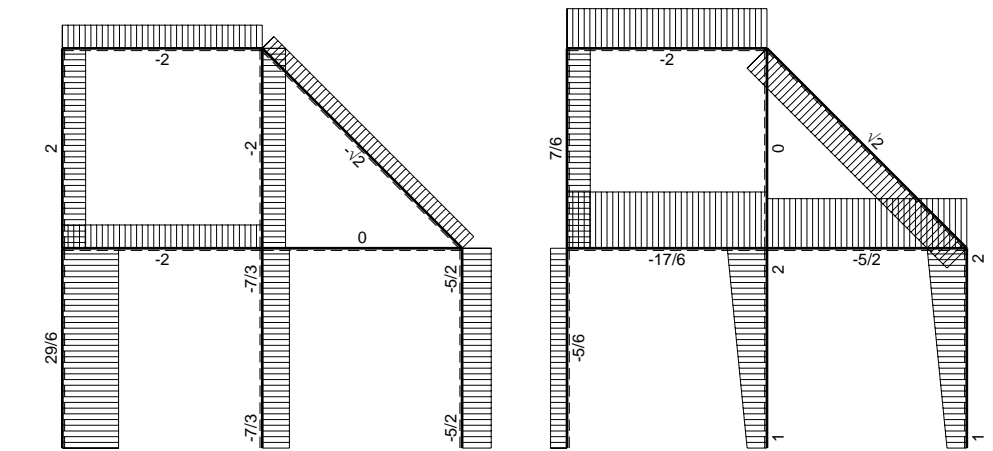
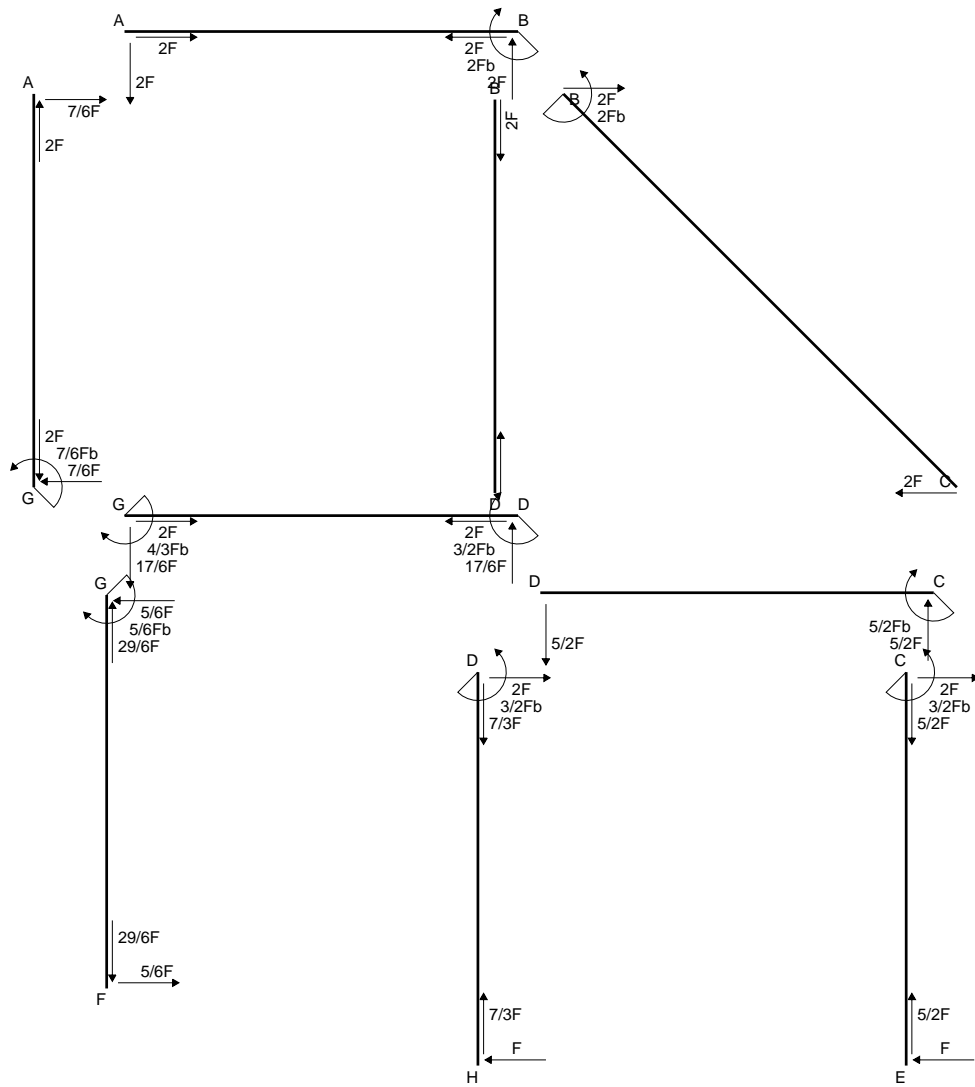
$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

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

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

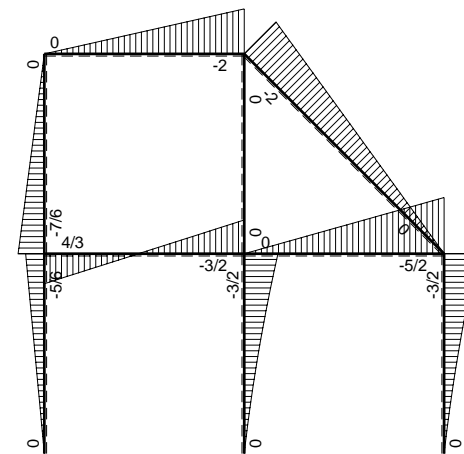


- A = 1152. mm<sup>2</sup>
- J<sub>u</sub> = 348030. mm<sup>4</sup>
- J<sub>v</sub> = 122688. mm<sup>4</sup>
- y<sub>g</sub> = 20.63 mm
- T<sub>y</sub> = -2740. N
- M<sub>x</sub> = -2082400. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.38 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 43. mm
- v<sub>c</sub> = 22.38 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 133.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.849 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 134. N/mm<sup>2</sup>
- S = 5867. mm<sup>3</sup>

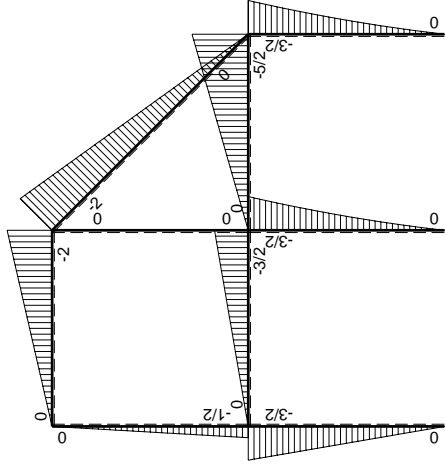
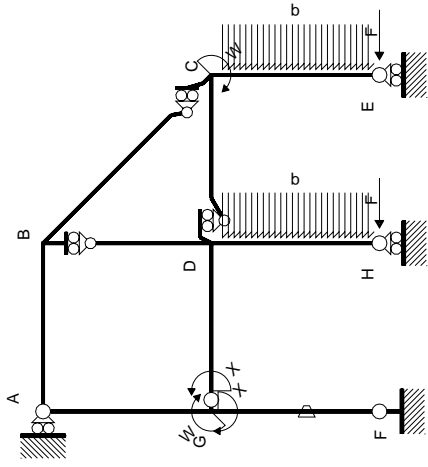


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↑ ⊕ ↓ F

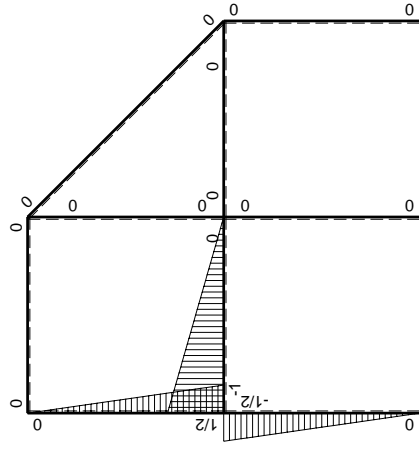


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x -3/4 x^2/b +1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

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

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

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

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

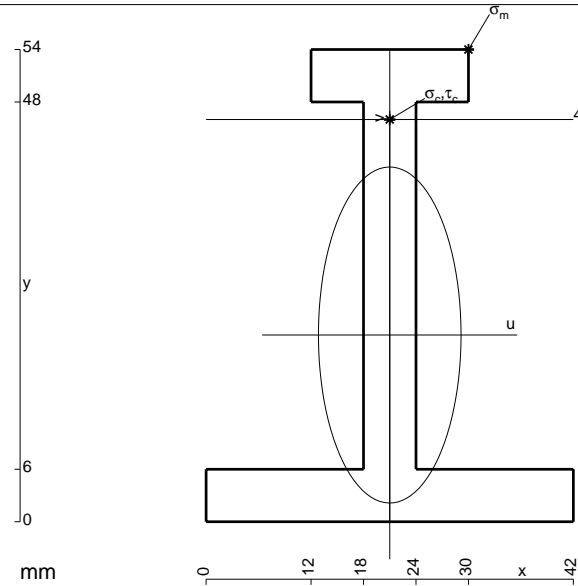
$$= (3/4 b -1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

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

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

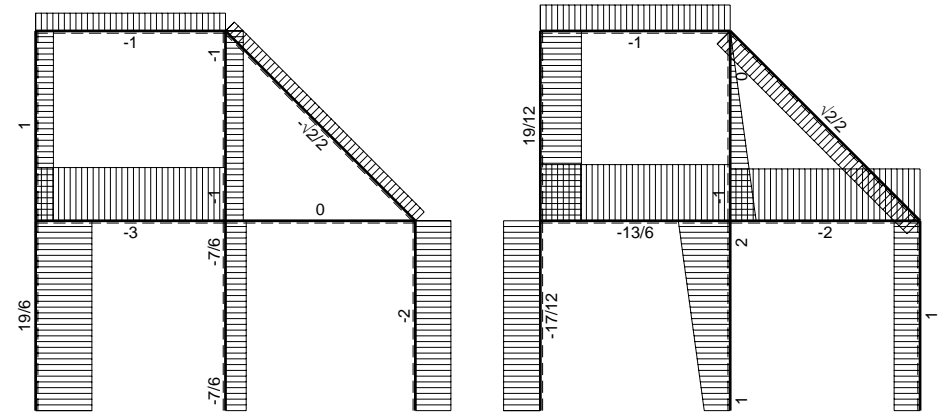
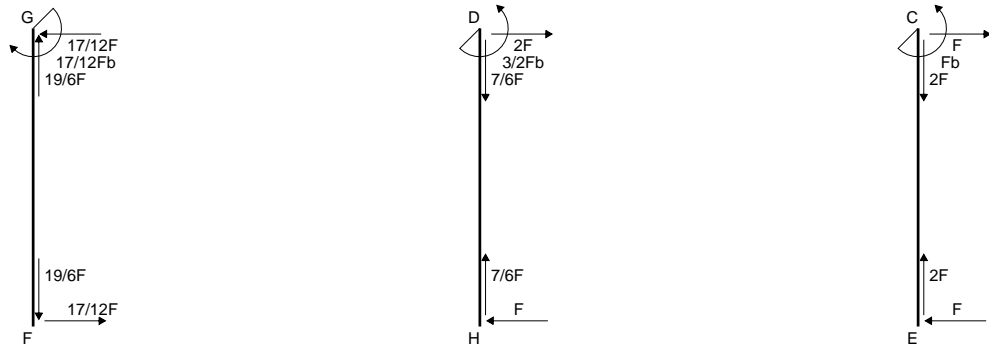
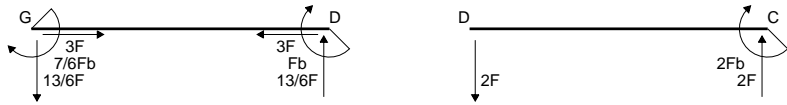
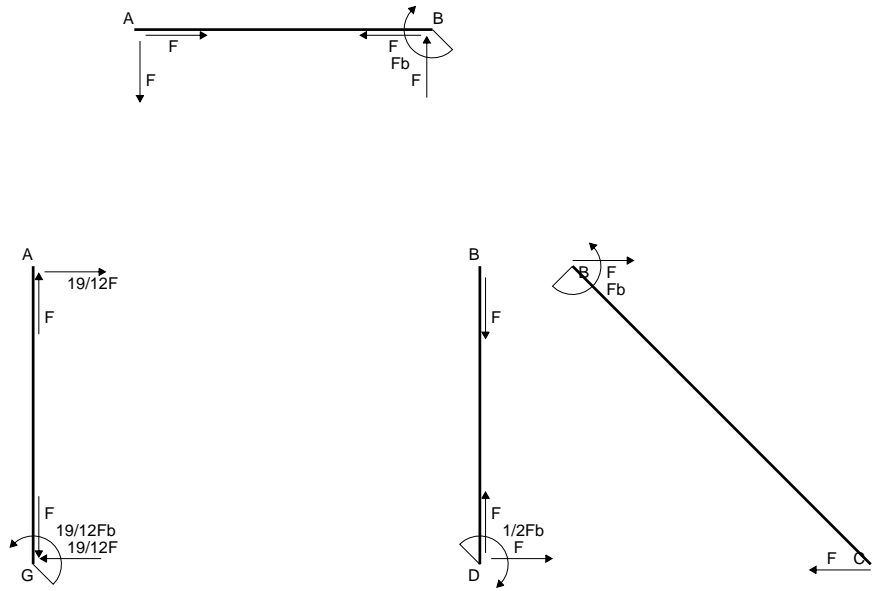
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

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



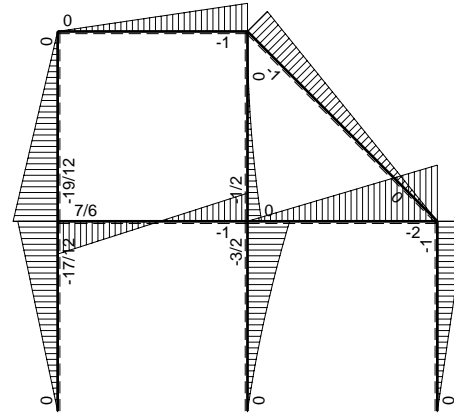
- A = 612. mm<sup>2</sup>
- J<sub>u</sub> = 225968. mm<sup>4</sup>
- J<sub>v</sub> = 40716. mm<sup>4</sup>
- y<sub>g</sub> = 21.35 mm
- T<sub>y</sub> = -1775. N
- M<sub>x</sub> = -1437750. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 32.65 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 207.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 46. mm
- v<sub>c</sub> = 24.65 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 156.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.595 N/mm<sup>2</sup>
- σ<sub>ρ</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 157. N/mm<sup>2</sup>
- S = 3510. mm<sup>3</sup>



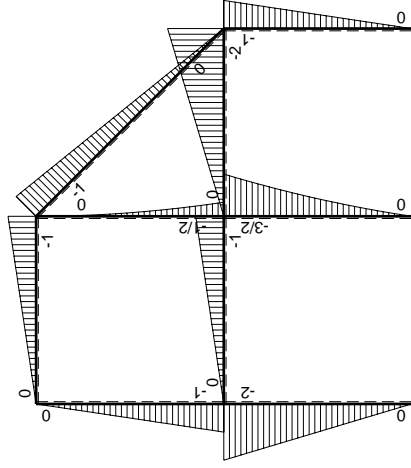
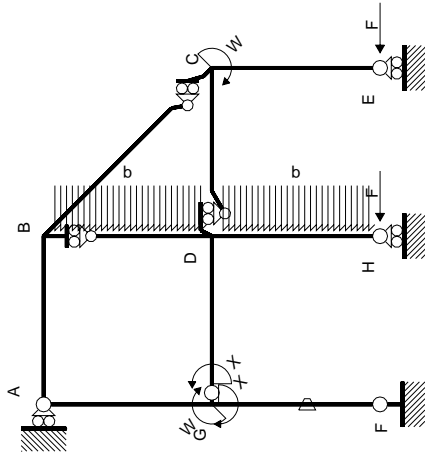


← (+) → F

↑ (+) ↓ F

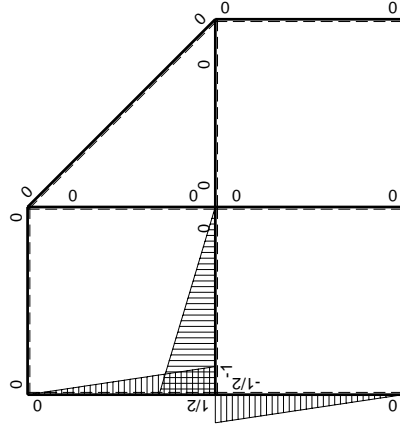


↺ (+) ↻ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

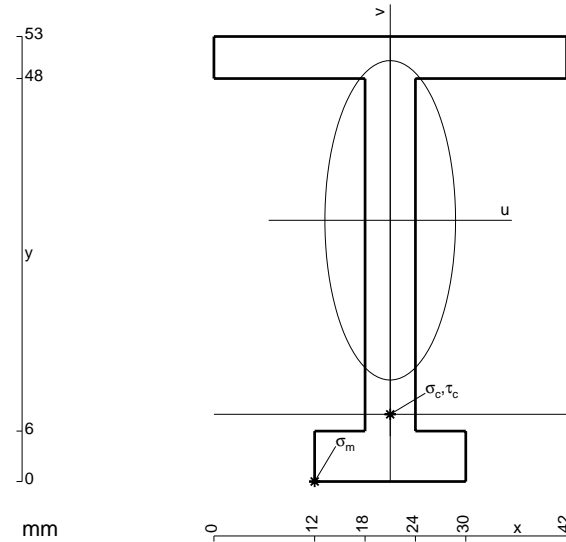
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

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

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

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

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



$$A = 570. \text{ mm}^2$$

$$J_u = 206355. \text{ mm}^4$$

$$J_v = 34542. \text{ mm}^4$$

$$y_g = 31.11 \text{ mm}$$

$$T_y = -1700. \text{ N}$$

$$M_x = -1445000. \text{ Nmm}$$

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

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

$$v_m = -31.11 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -217.9 \text{ N/mm}^2$$

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

$$y_c = 8. \text{ mm}$$

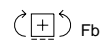
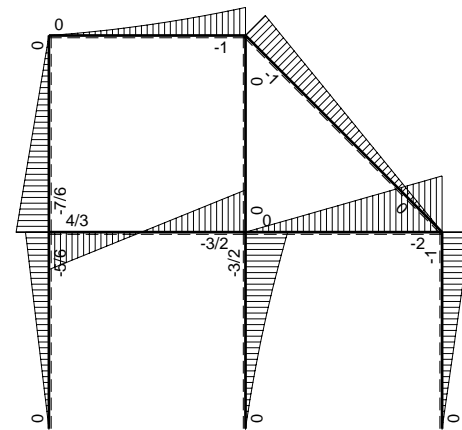
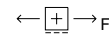
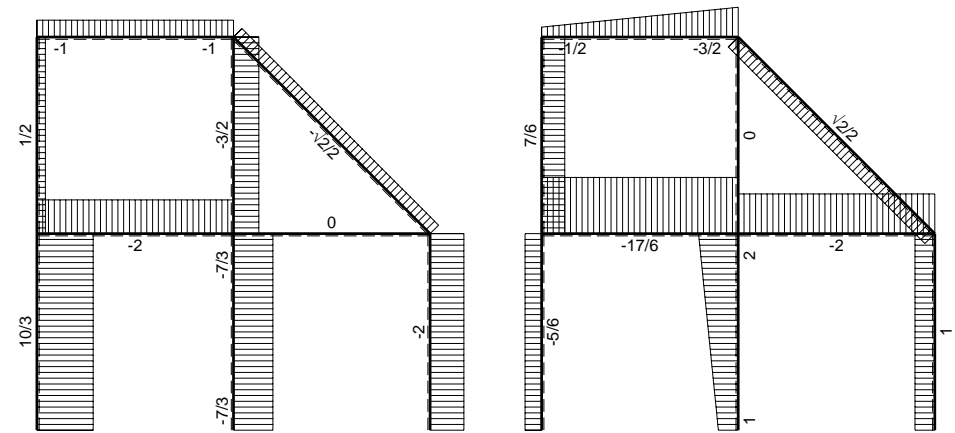
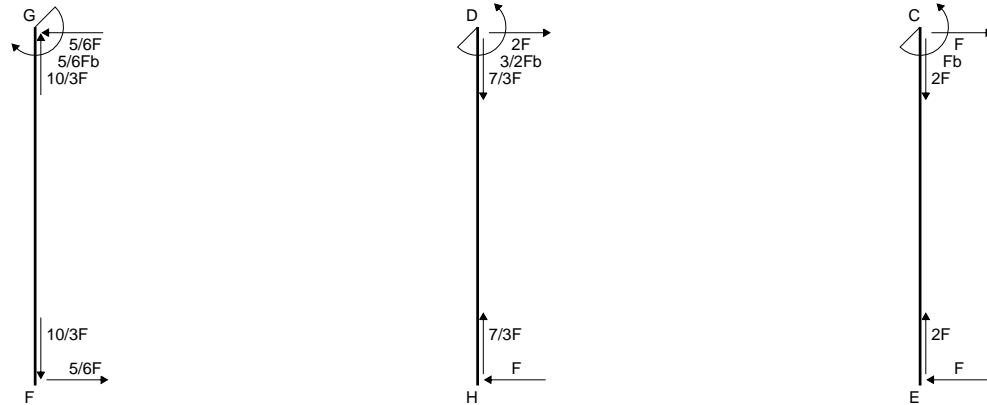
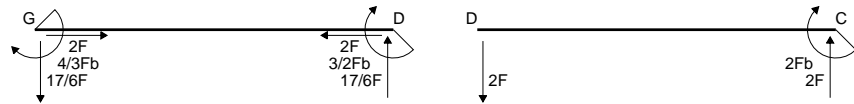
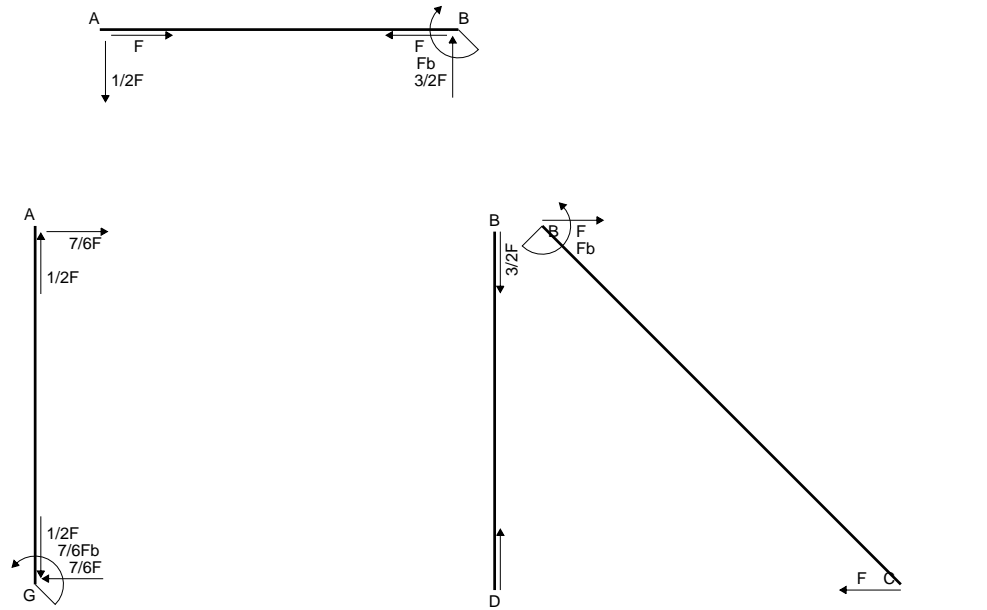
$$v_c = -23.11 \text{ mm}$$

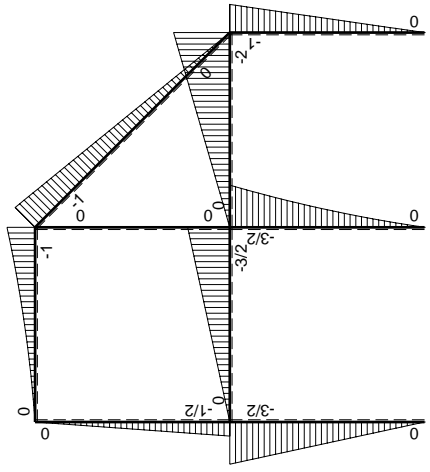
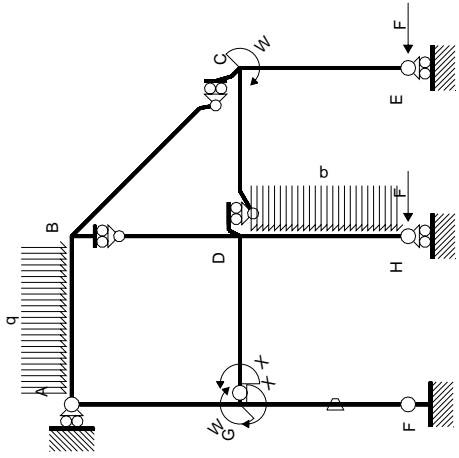
$$\sigma_c = -Mv/J_u = -161.8 \text{ N/mm}^2$$

$$\tau_c = 4.566 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 162. \text{ N/mm}^2$$

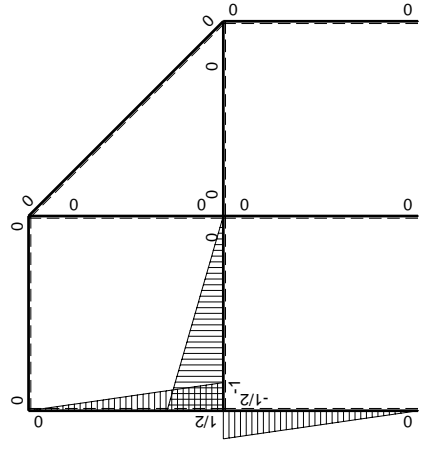
$$S = 3325. \text{ mm}^3$$





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

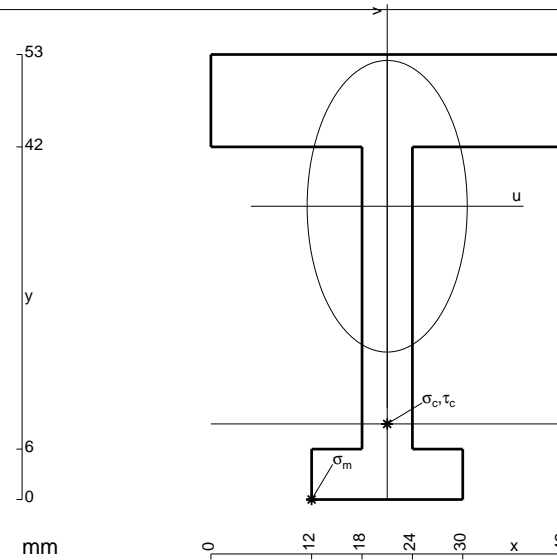
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

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

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

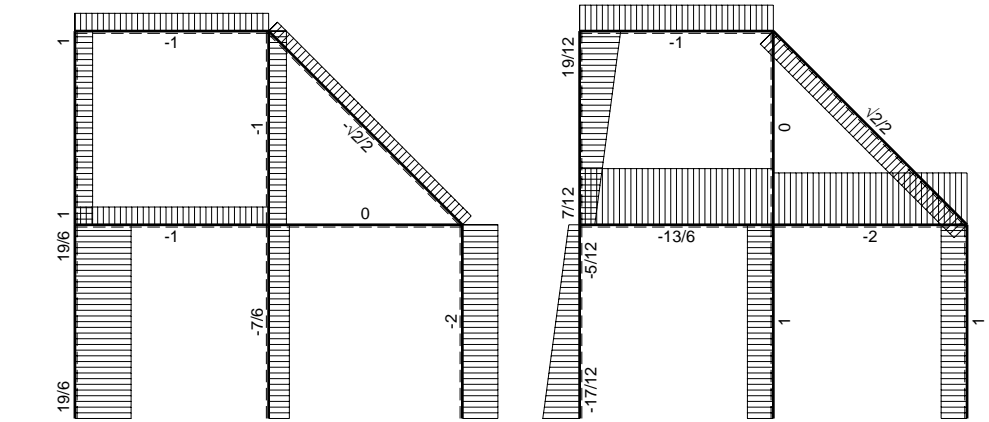
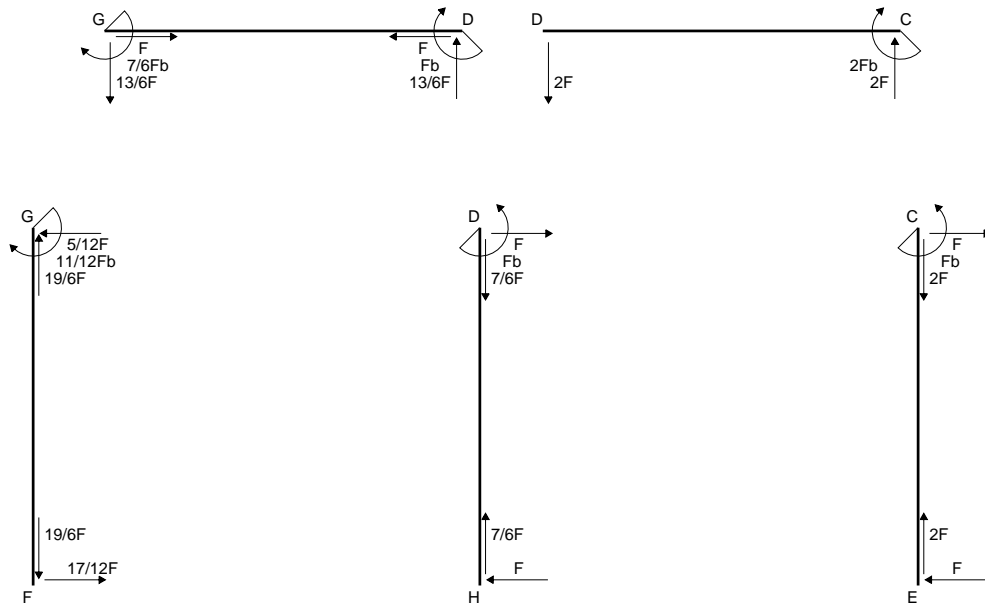
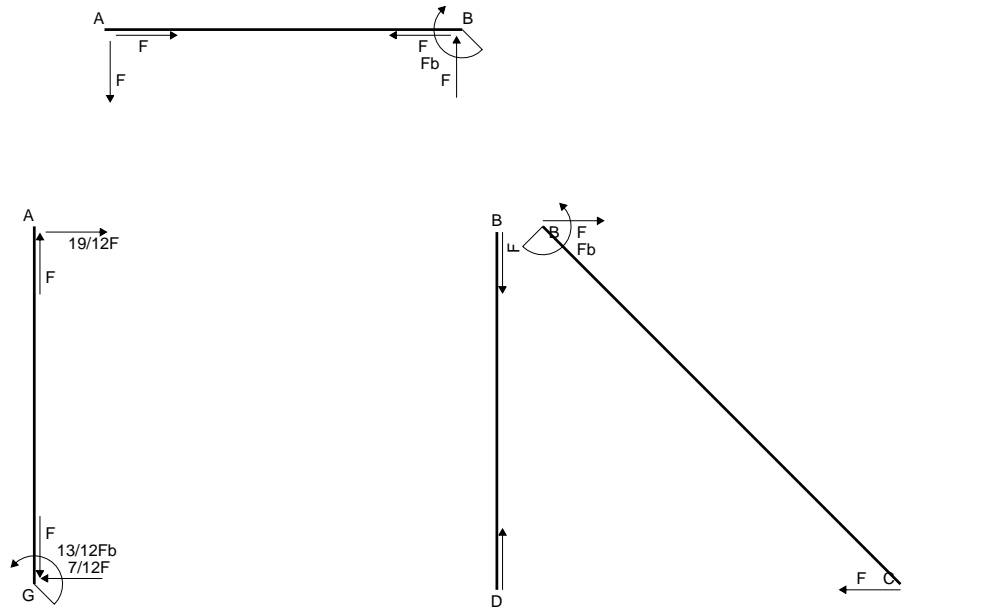
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

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



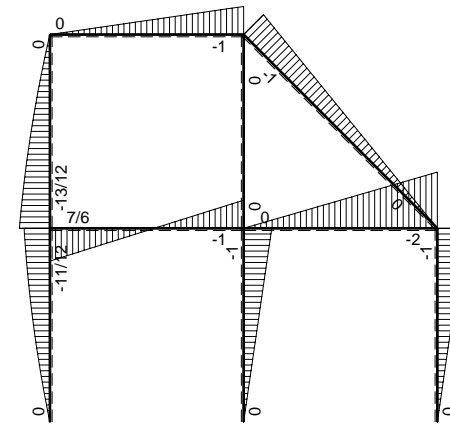
- A = 786. mm<sup>2</sup>
- J<sub>u</sub> = 237222. mm<sup>4</sup>
- J<sub>v</sub> = 71478. mm<sup>4</sup>
- y<sub>g</sub> = 34.93 mm
- T<sub>y</sub> = -1720. N
- M<sub>x</sub> = -1548000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -34.93 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -227.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -25.93 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -169.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.763 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 169.4 N/mm<sup>2</sup>
- S = 3942. mm<sup>3</sup>



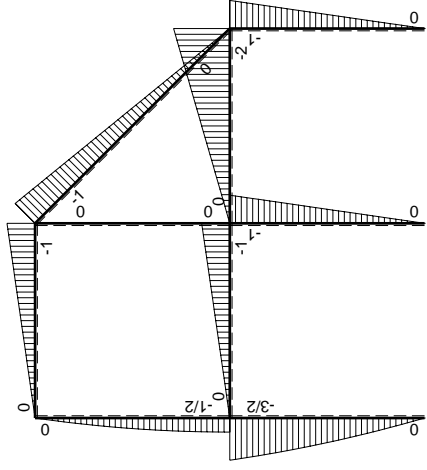
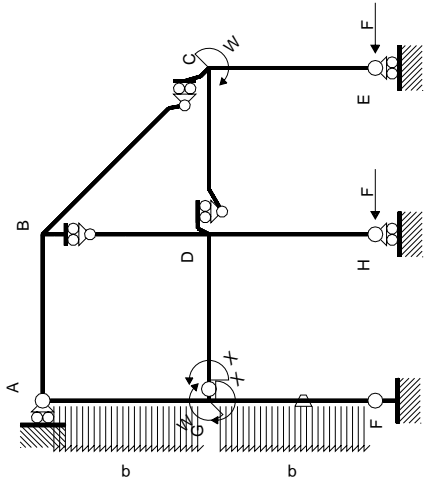


← ⊕ → F

↑ ⊕ ↓ F

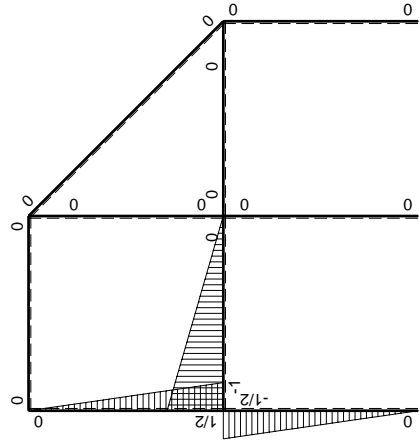


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	-2Fx+1/2qx <sup>2</sup>	-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 <sup>2</sup>	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 <sup>2</sup>	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 <sup>2</sup>	0	$-1/2Fx^2/b+1/4qx^3/b$	0	$1/4x^2/b^2$			
	totali							7/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-7/6Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

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

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

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

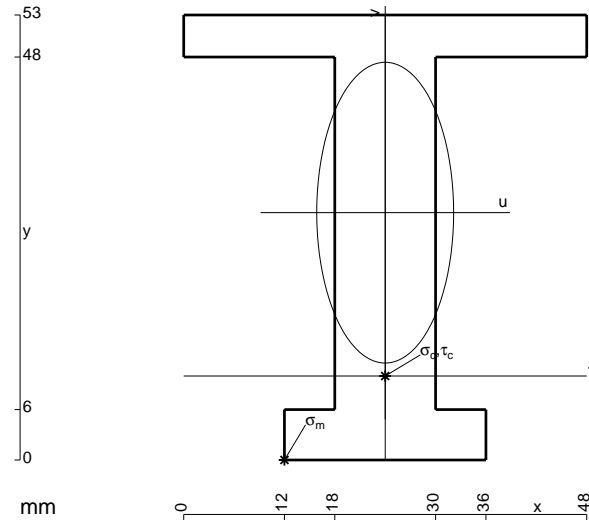
$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/4 x/b + 1/4 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-1/4 x + 1/8 x^2/b + 1/12 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

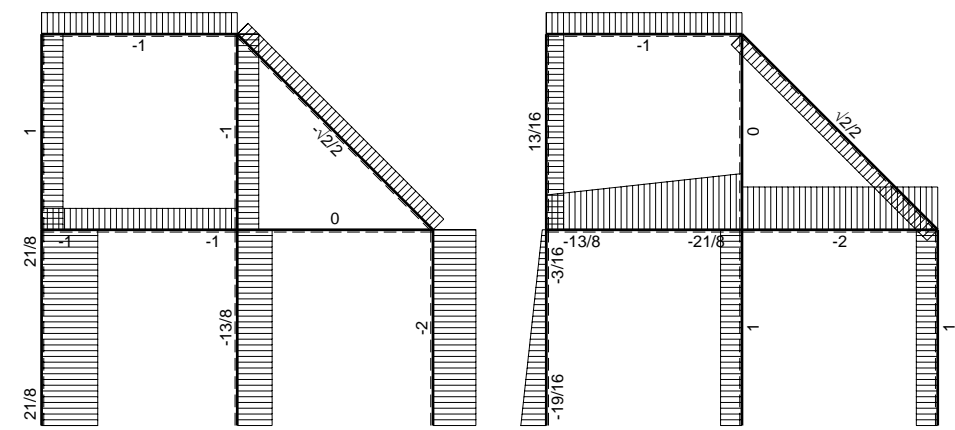
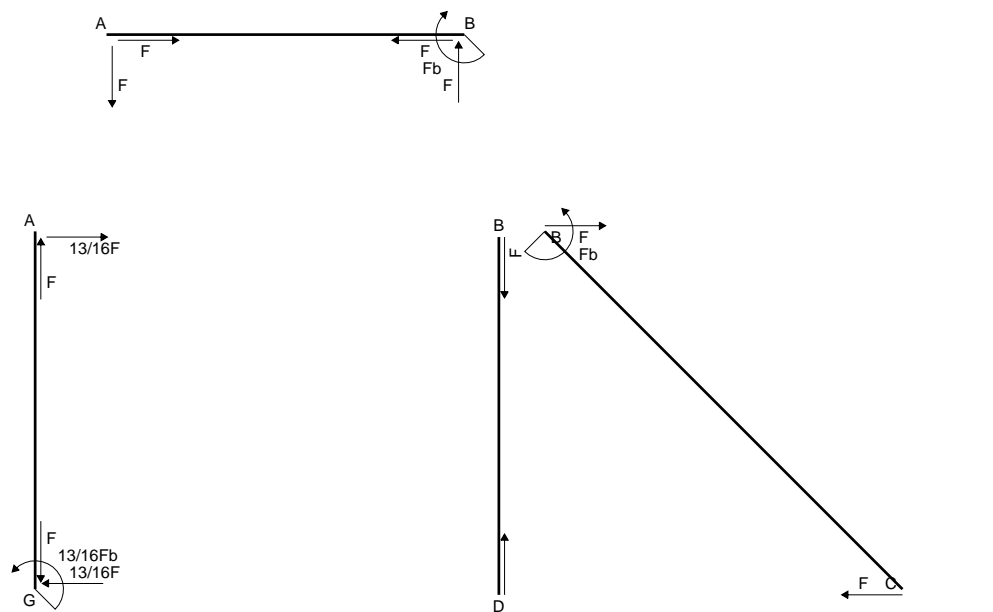
$$= (-1/4 b + 1/8 b + 1/12 b - 1/16 b) Fb 1/EJ = -5/48 Fb^2/EJ$$

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

$$= (-1/6 b + 1/16 b) Fb 1/EJ = -5/48 Fb^2/EJ$$

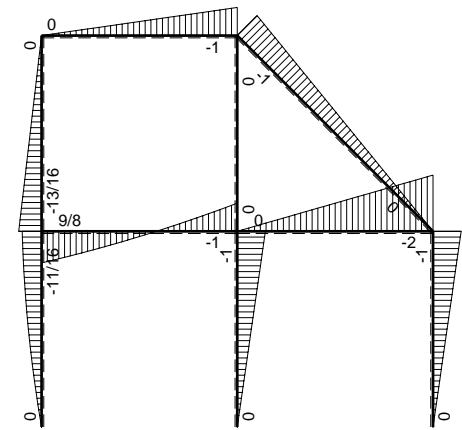
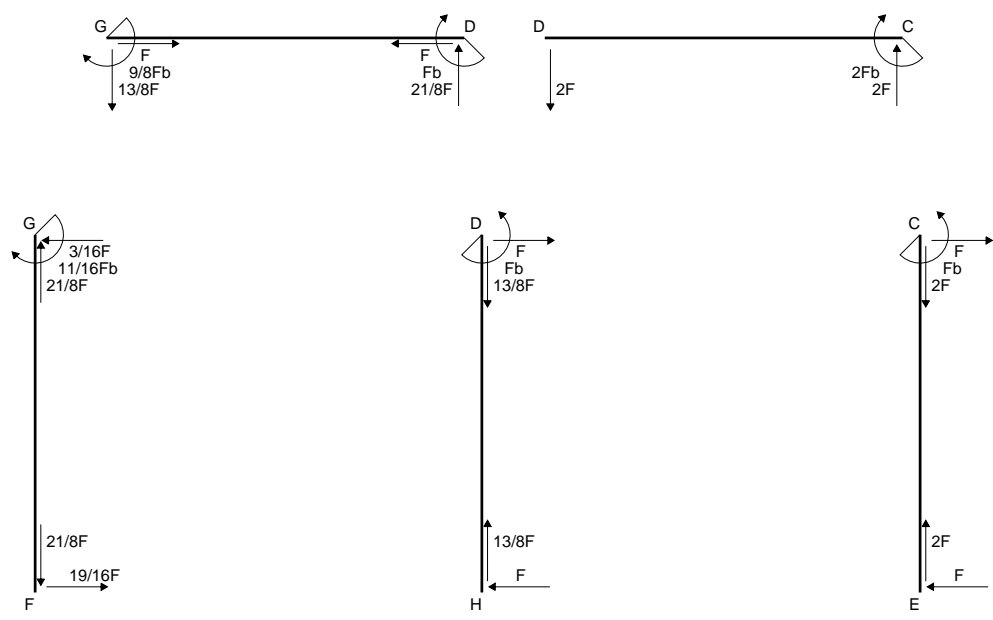


- A = 888. mm<sup>2</sup>
- J<sub>u</sub> = 285133. mm<sup>4</sup>
- J<sub>v</sub> = 59040. mm<sup>4</sup>
- y<sub>g</sub> = 29.46 mm
- T<sub>y</sub> = -2440. N
- M<sub>x</sub> = -2318000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -29.46 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -19.46 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -158.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.452 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup> + 3τ<sup>2</sup> = 158.3 N/mm<sup>2</sup>
- S = 4840. mm<sup>3</sup>

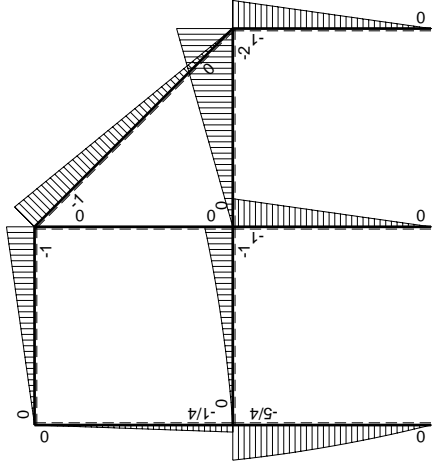
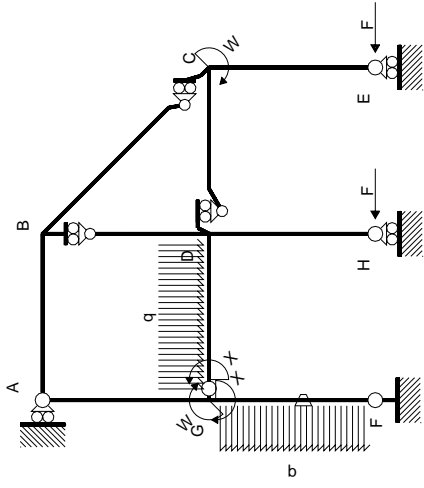


← ⊕ →  $F$

↑ ⊕ ↓  $F$

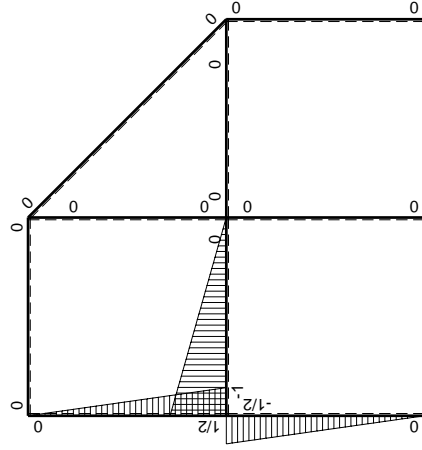


⊕ ↺  $F_b$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

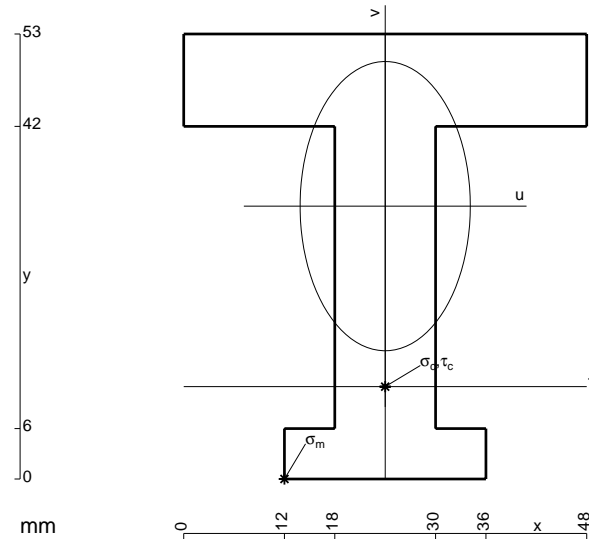
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

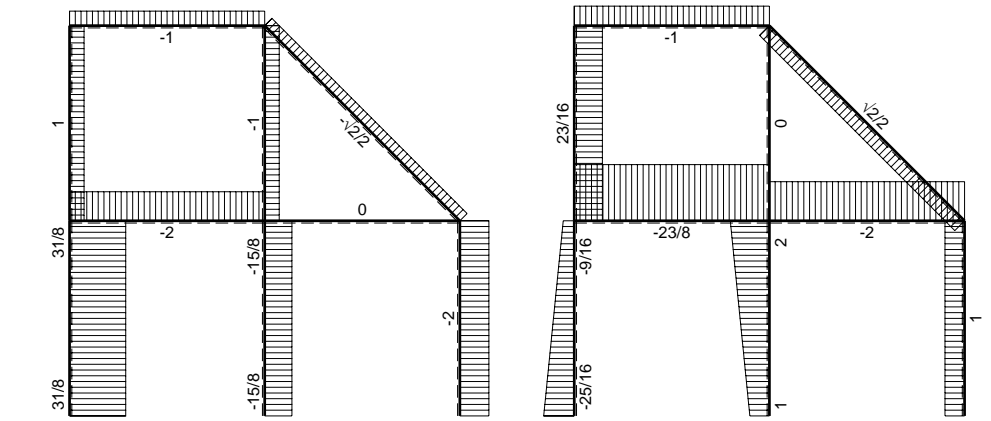
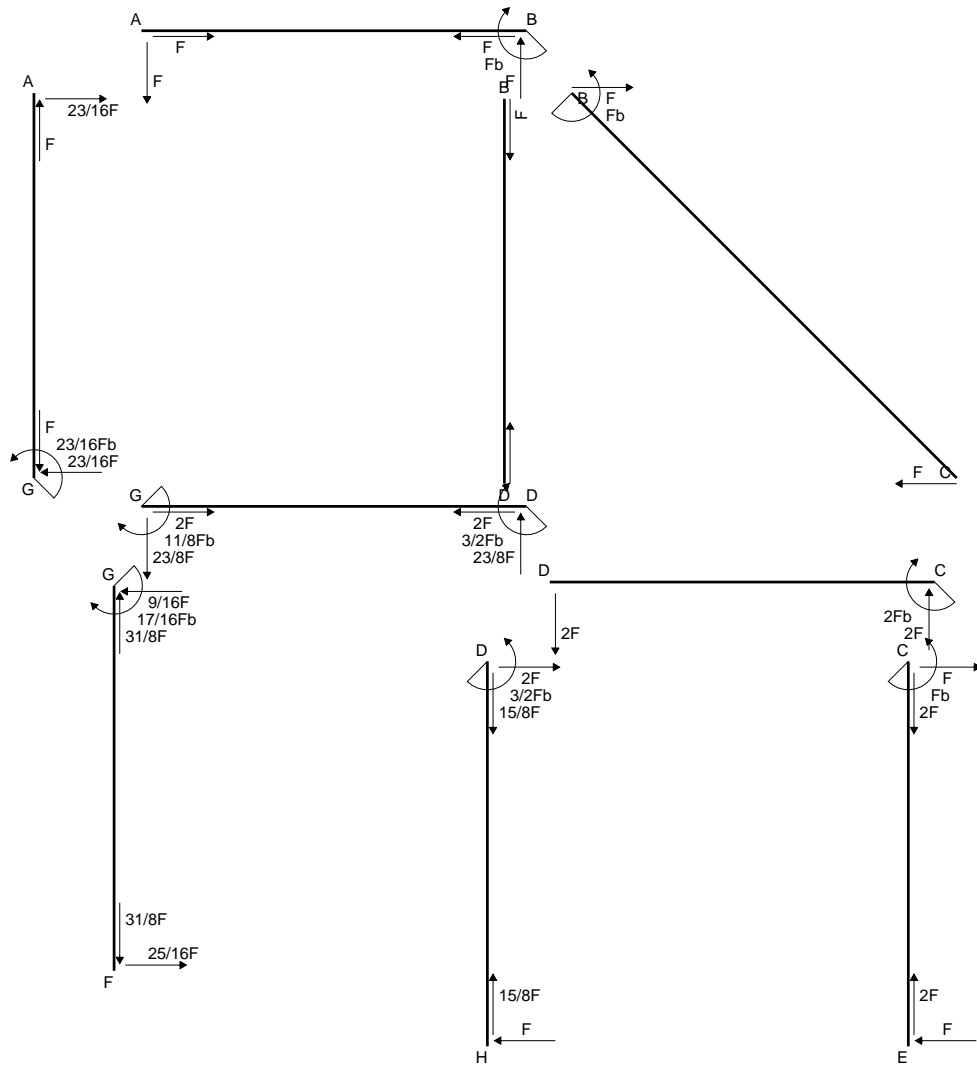
$$L_{AG}^{xo} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$



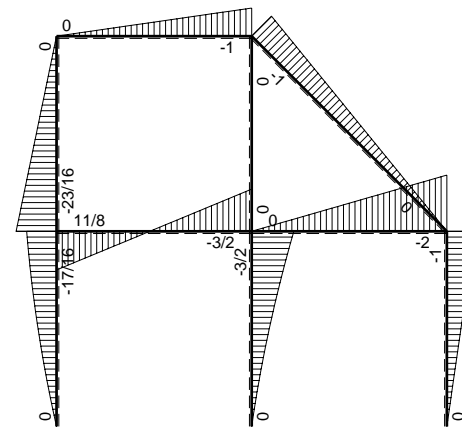
- A = 1104. mm<sup>2</sup>
- J<sub>u</sub> = 327740. mm<sup>4</sup>
- J<sub>v</sub> = 113472. mm<sup>4</sup>
- y<sub>g</sub> = 32.5 mm
- T<sub>y</sub> = -4020. N
- M<sub>x</sub> = -2010000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -32.5 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -199.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -21.5 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -131.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.814 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 132.2 N/mm<sup>2</sup>
- S = 5688. mm<sup>3</sup>



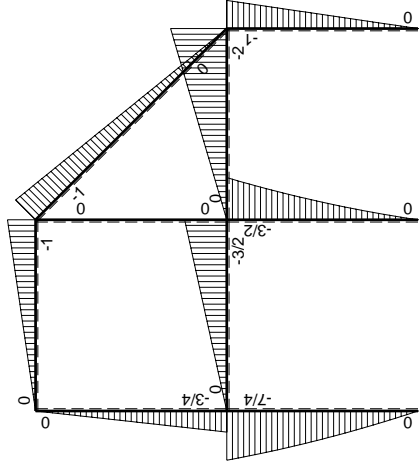
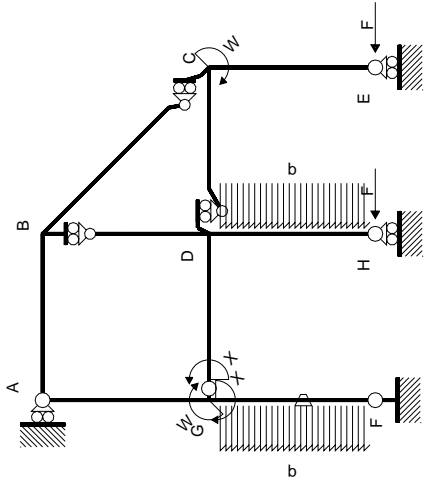


← ⊕ → F

↑ ⊕ ↓ F

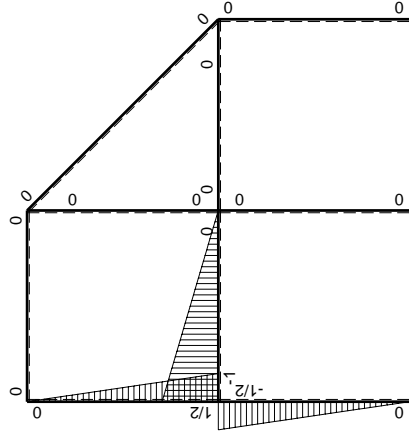


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

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

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

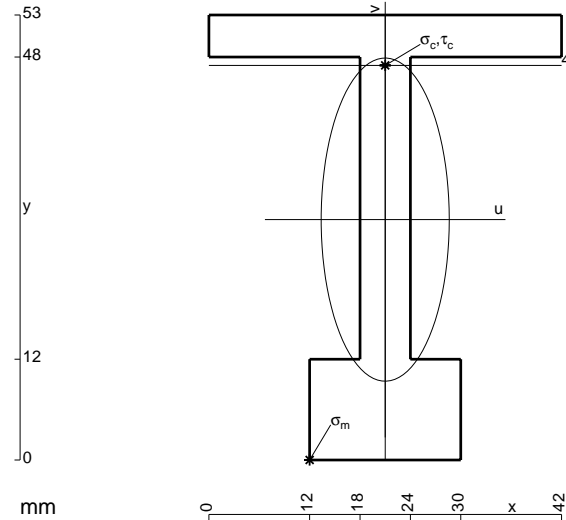
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

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

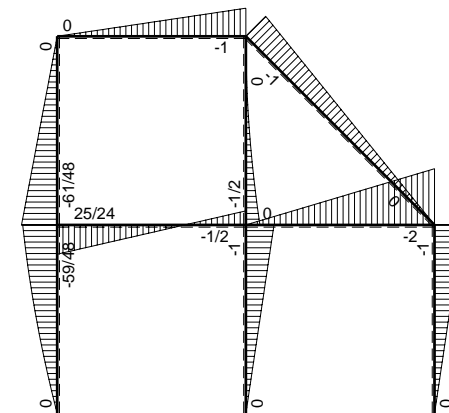
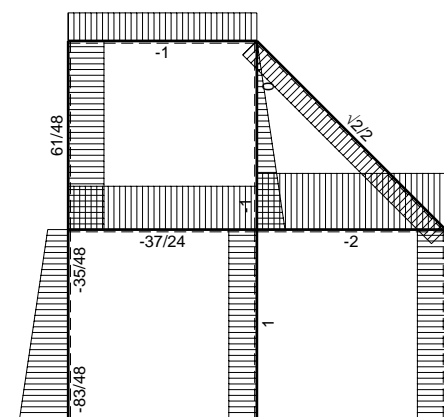
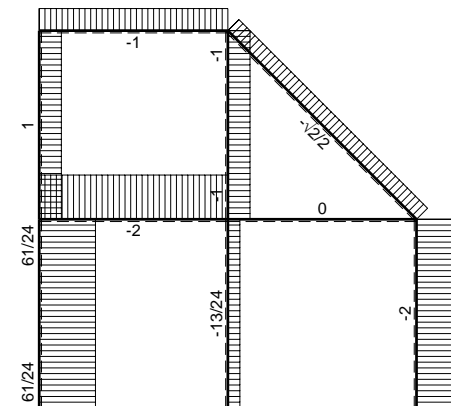
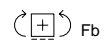
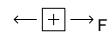
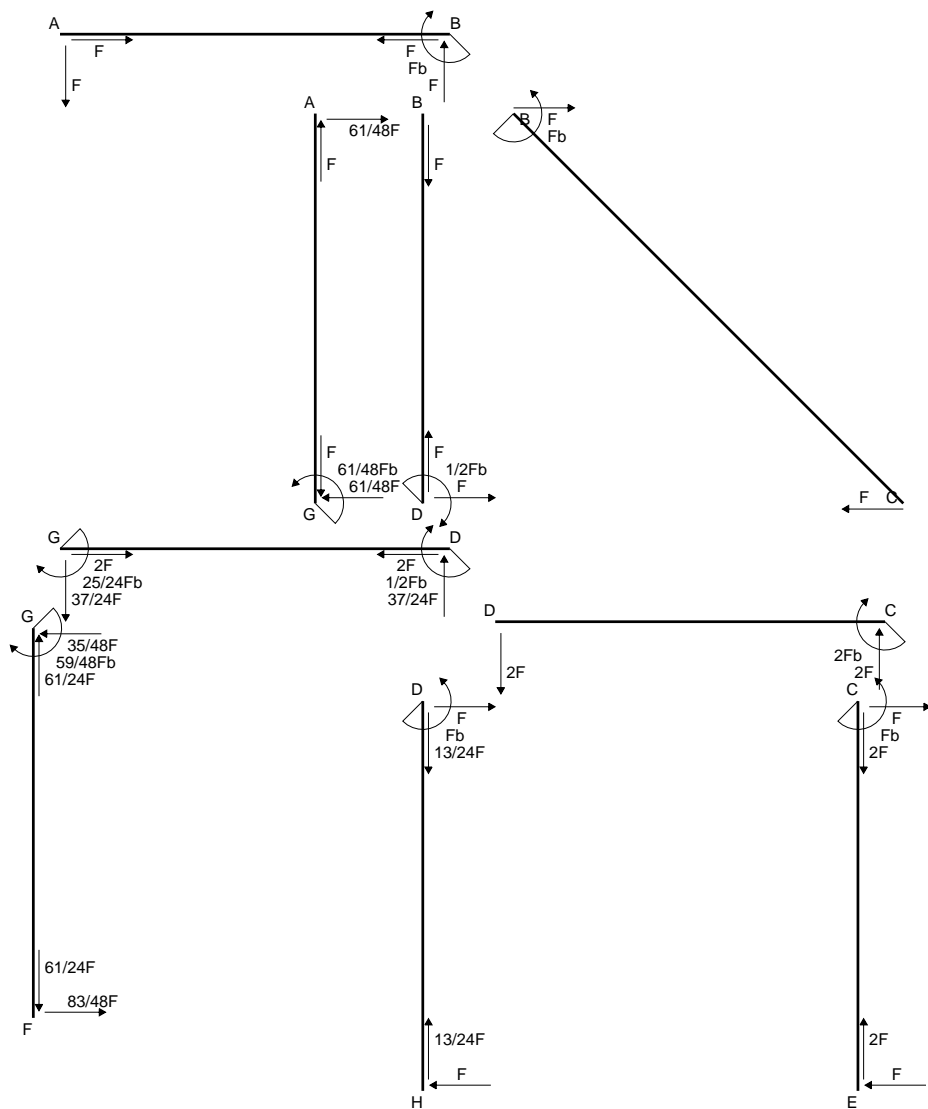
$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

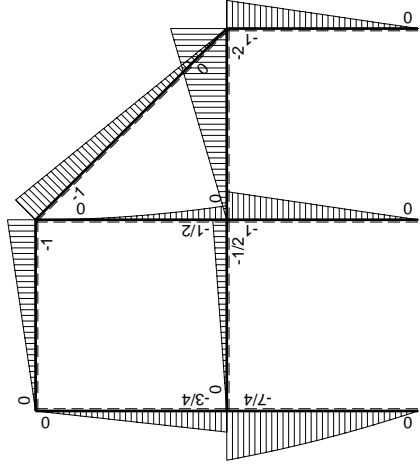
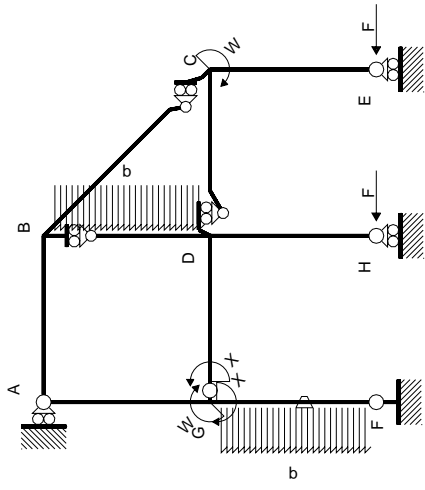
$$L_{AG}^{x_0} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

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



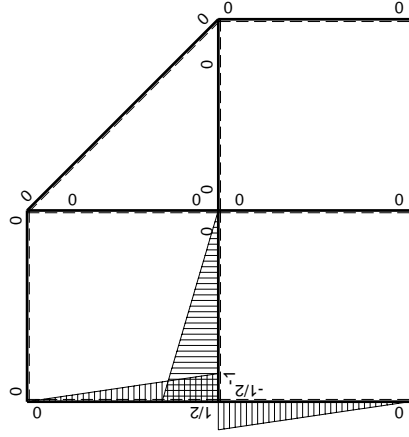
- A = 642. mm<sup>2</sup>
- J<sub>u</sub> = 237823. mm<sup>4</sup>
- J<sub>v</sub> = 37350. mm<sup>4</sup>
- y<sub>g</sub> = 28.63 mm
- T<sub>y</sub> = -3160. N
- M<sub>x</sub> = -1738000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -28.63 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -209.2 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 47. mm
- v<sub>c</sub> = 18.37 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 134.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 10.42 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 135.4 N/mm<sup>2</sup>
- S = 4706. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

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

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

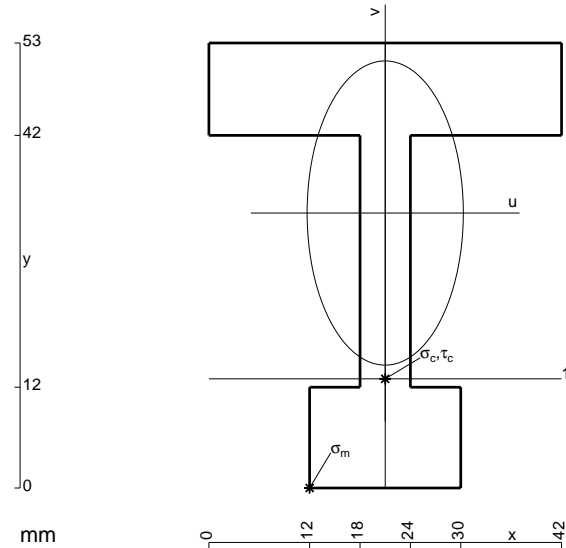
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

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

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

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

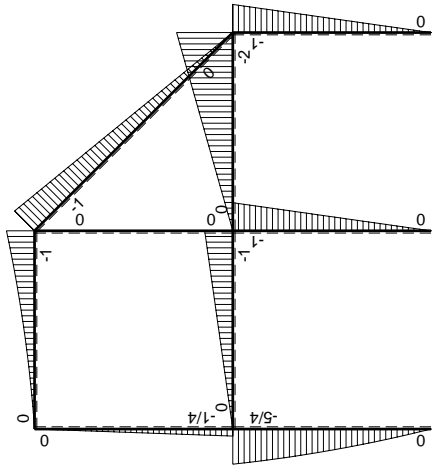
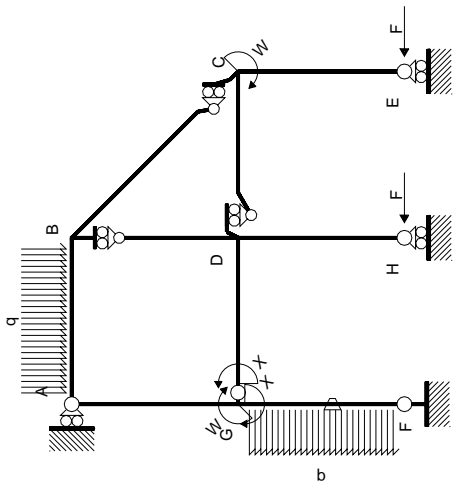
$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



- A = 858. mm<sup>2</sup>
- J<sub>u</sub> = 281777. mm<sup>4</sup>
- J<sub>v</sub> = 74286. mm<sup>4</sup>
- y<sub>g</sub> = 32.75 mm
- T<sub>y</sub> = -3140. N
- M<sub>x</sub> = -1884000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -32.75 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -19.75 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -132.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 10.96 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 133.4 N/mm<sup>2</sup>
- S = 5900. mm<sup>3</sup>

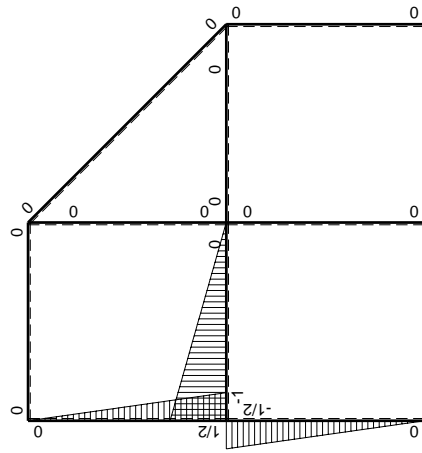






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

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

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

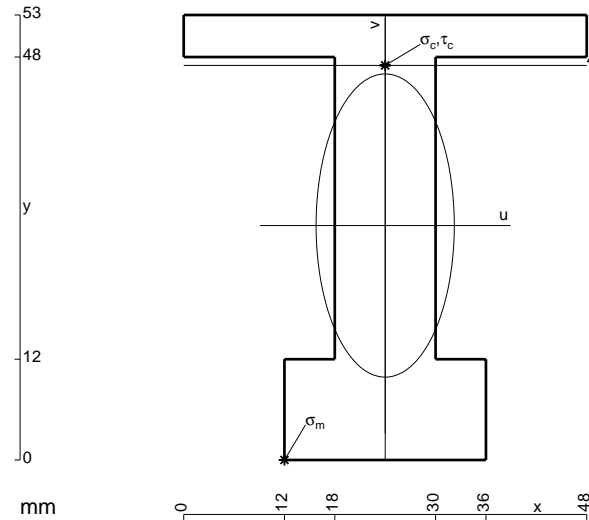
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

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

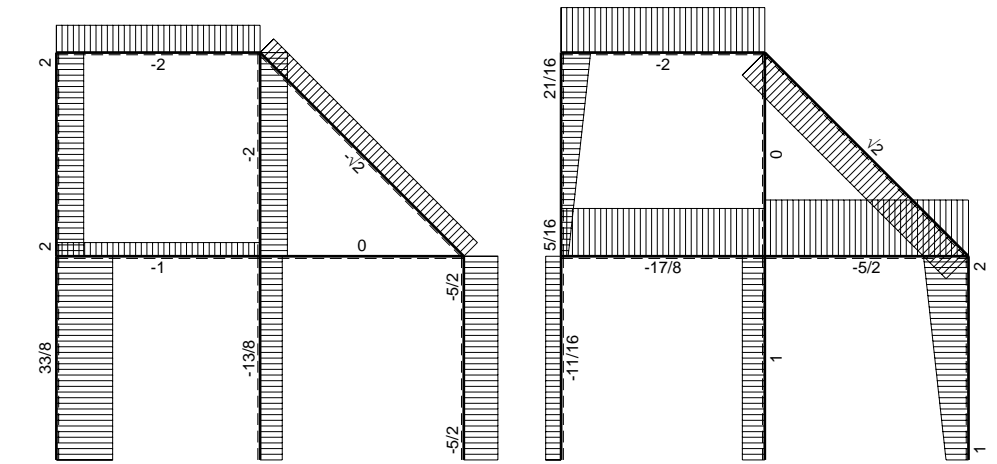
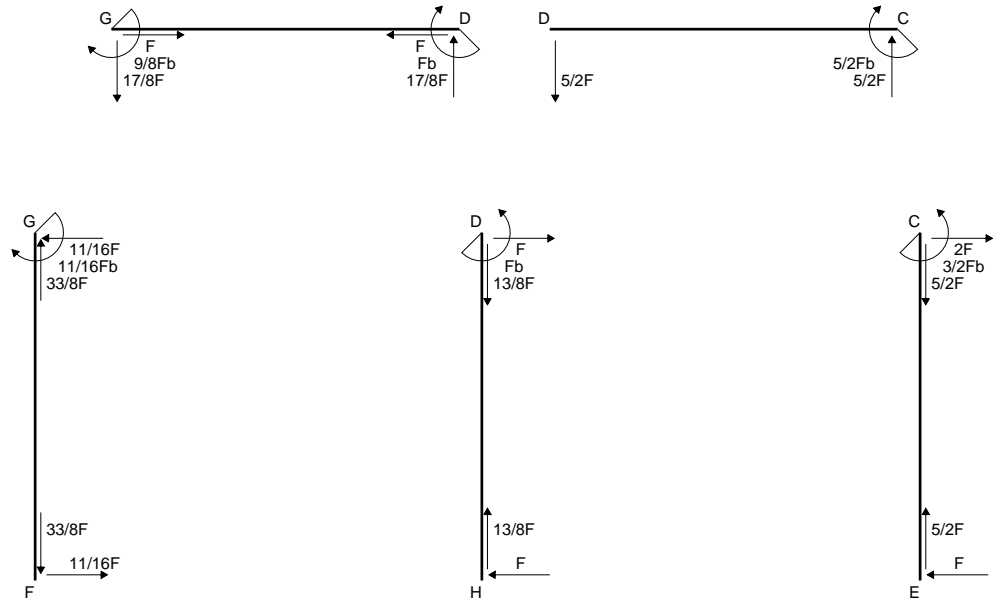
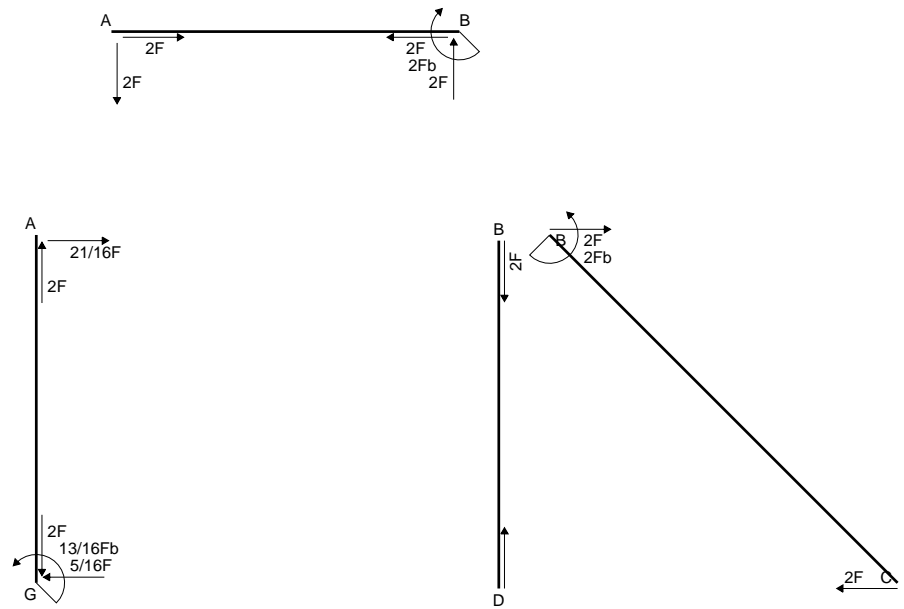
$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

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

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

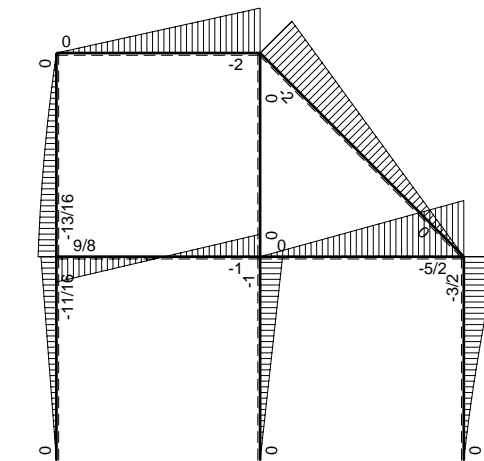


- A = 960. mm<sup>2</sup>
- J<sub>u</sub> = 313227. mm<sup>4</sup>
- J<sub>v</sub> = 65088. mm<sup>4</sup>
- y<sub>g</sub> = 27.92 mm
- T<sub>y</sub> = -3960. N
- M<sub>x</sub> = -2574000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -27.92 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -229.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 47. mm
- v<sub>c</sub> = 19.08 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 156.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.956 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 157.1 N/mm<sup>2</sup>
- S = 5653. mm<sup>3</sup>

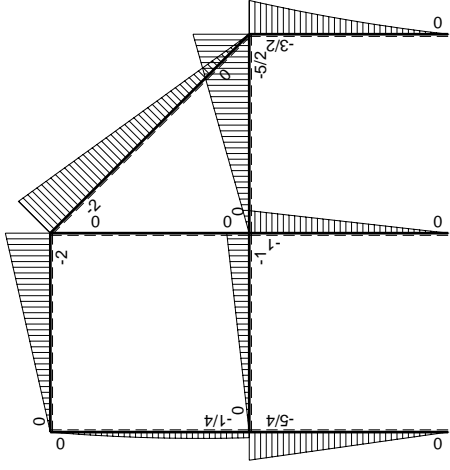
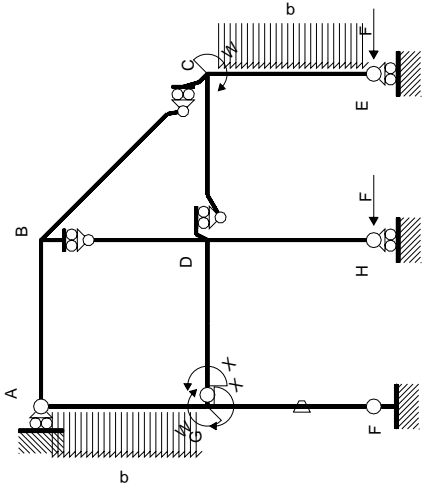


← ⊕ → F

↑ ⊕ ↓ F

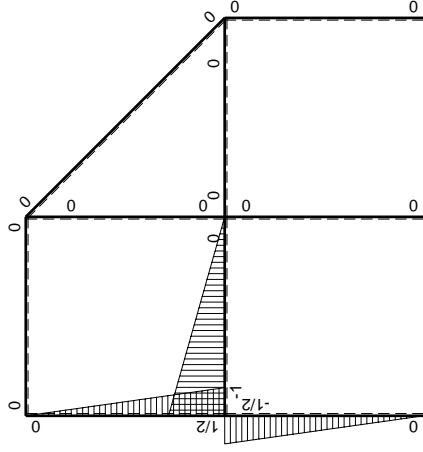


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	-2Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(5/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx <sup>2</sup>	0	-1/8Fb+3/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	3/4Fx-1/2qx <sup>2</sup>	0	-3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							9/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-9/8Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

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

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

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

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

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

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

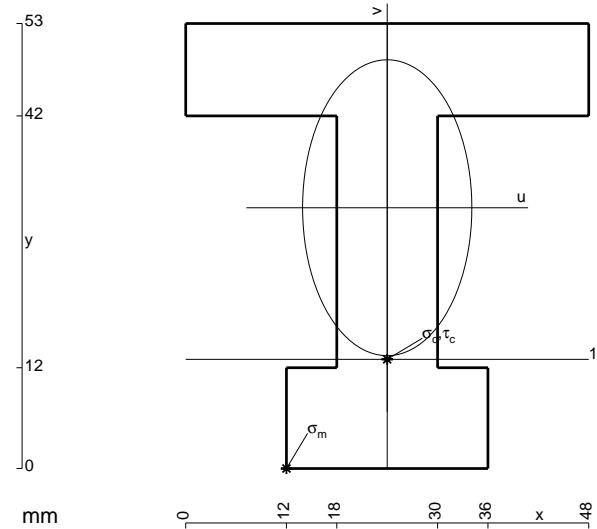
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

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

$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

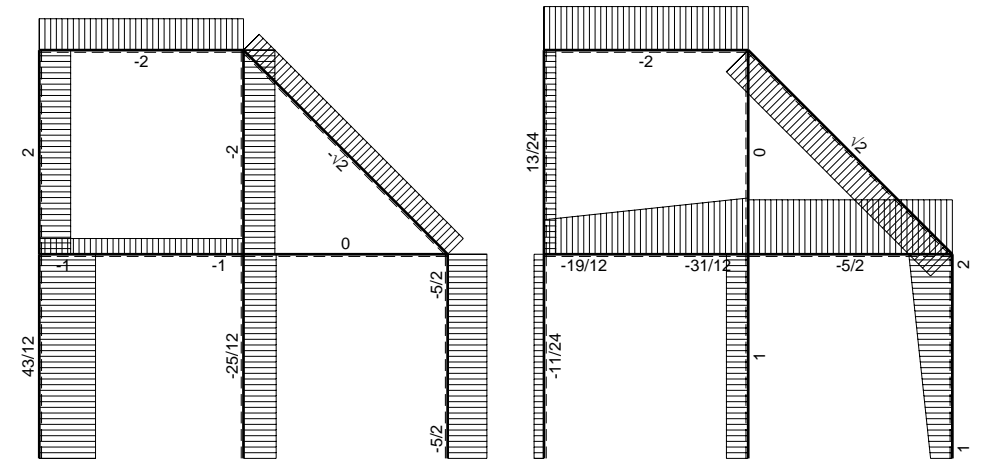
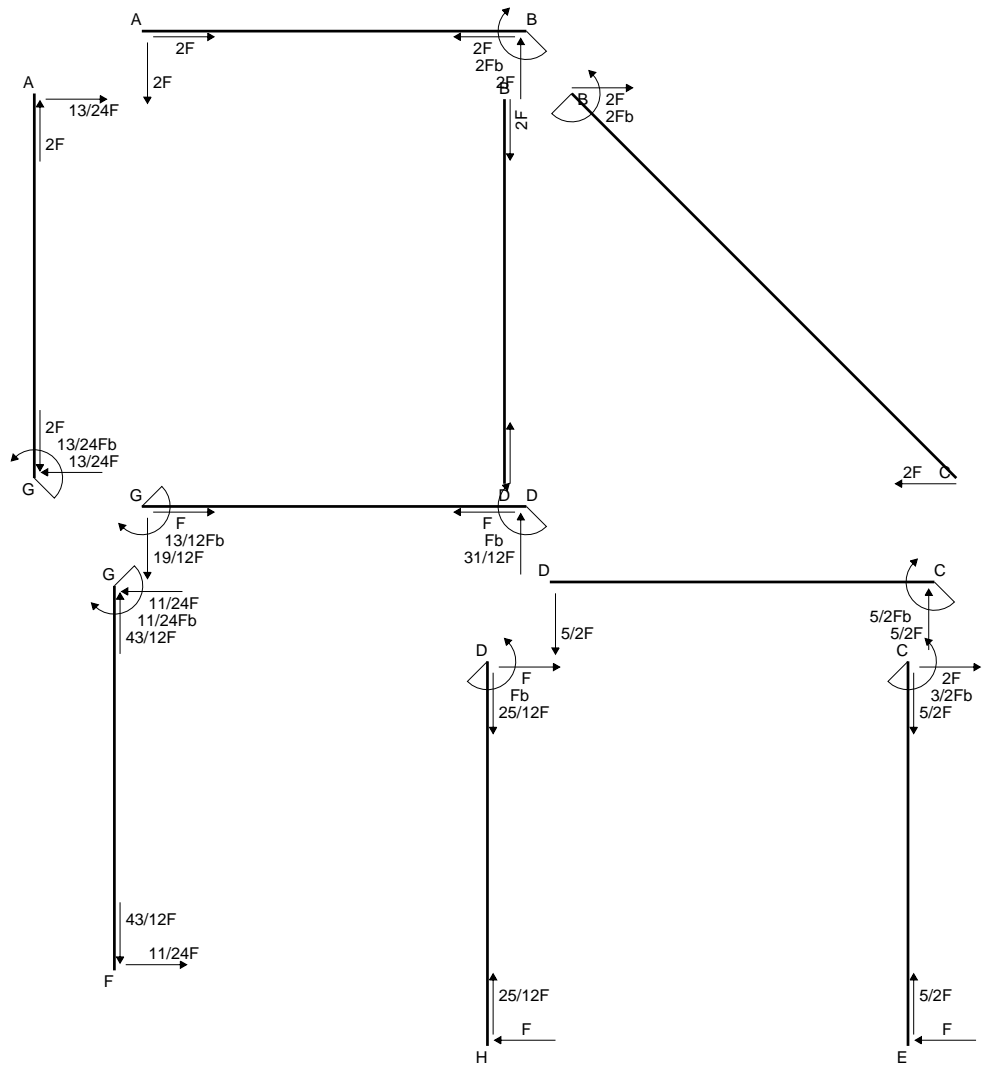
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



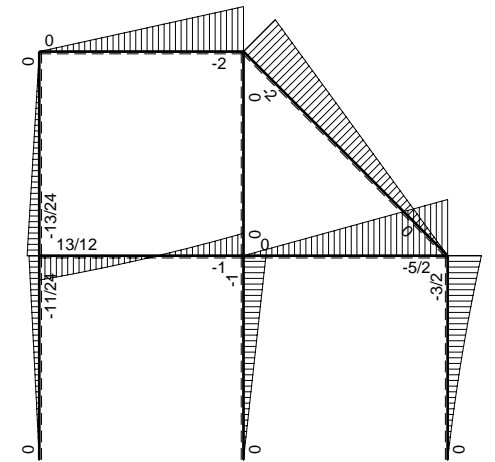
- A = 1176. mm<sup>2</sup>
- J<sub>u</sub> = 365284. mm<sup>4</sup>
- J<sub>v</sub> = 119520. mm<sup>4</sup>
- y<sub>g</sub> = 31.06 mm
- T<sub>y</sub> = -4025. N
- M<sub>x</sub> = -2817500. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -31.06 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -18.06 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -139.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.832 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 139.8 N/mm<sup>2</sup>
- S = 7440. mm<sup>3</sup>



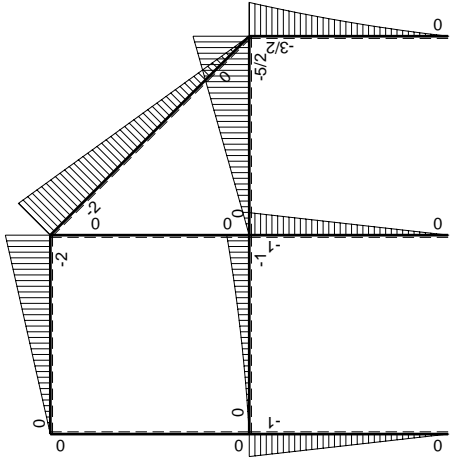
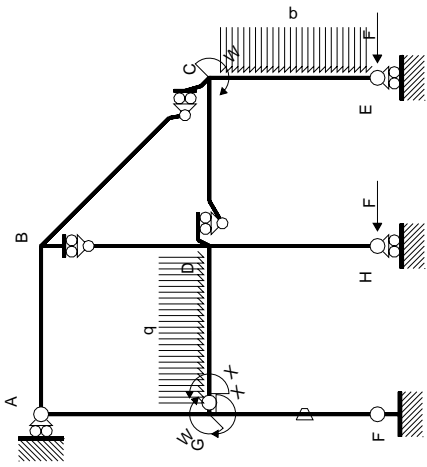


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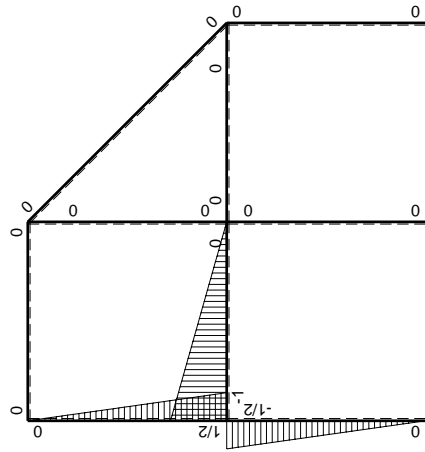


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-2Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	0+0	1/12Xb/EJ	
AG b	-1/2x/b	0	0	0	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							13/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-13/12Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

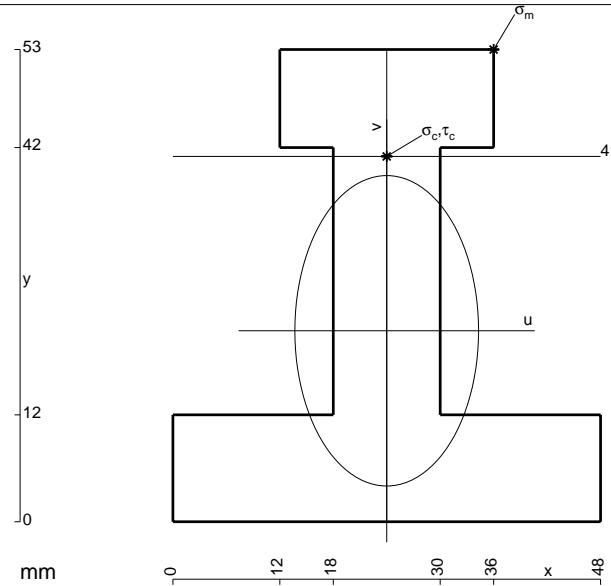
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

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

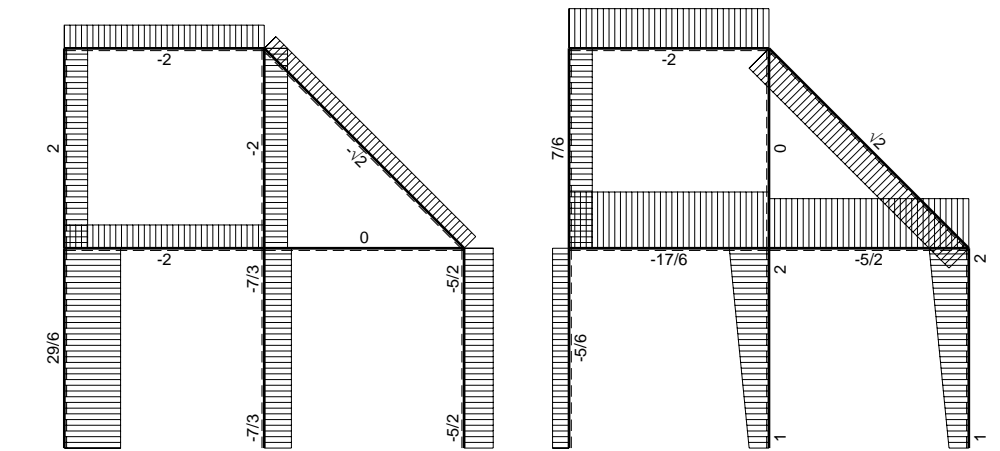
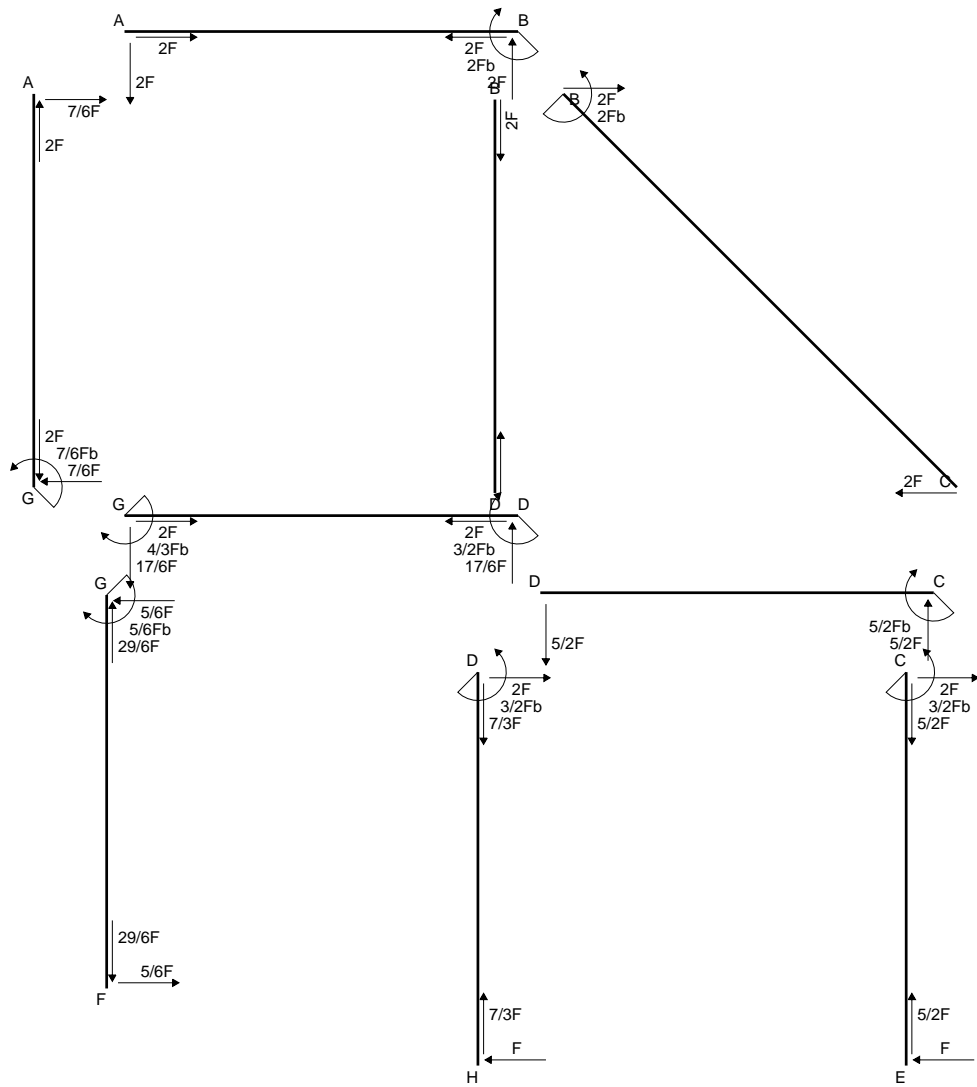
$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

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

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

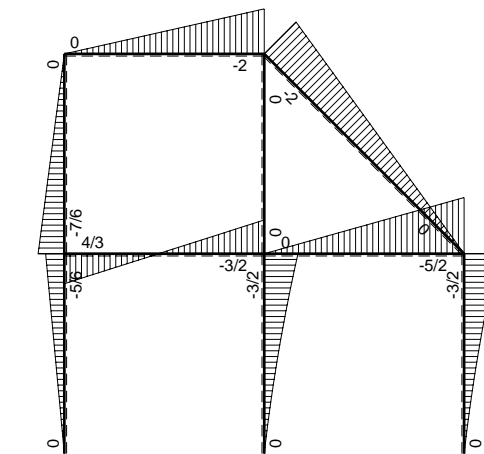


- A = 1200. mm<sup>2</sup>
- J<sub>u</sub> = 364306. mm<sup>4</sup>
- J<sub>v</sub> = 127584. mm<sup>4</sup>
- y<sub>g</sub> = 21.43 mm
- T<sub>y</sub> = -3075. N
- M<sub>x</sub> = -2306250. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 31.57 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 19.57 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 123.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.01 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 124.2 N/mm<sup>2</sup>
- S = 7123. mm<sup>3</sup>

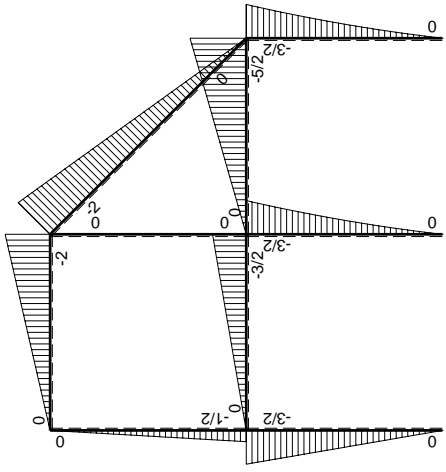
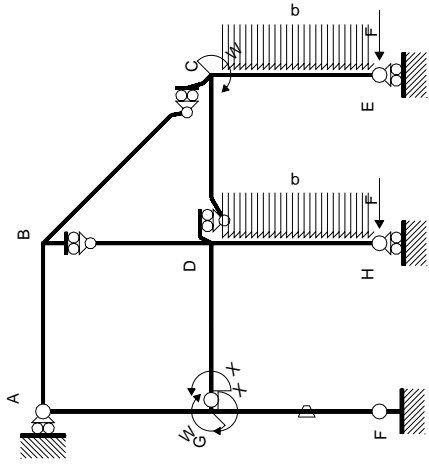


← ⊕ →  $F$

↑ ⊕ ↓  $F$

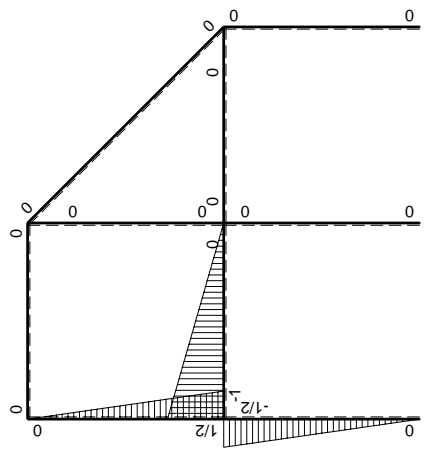


⊕ ⊖  $F_b$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

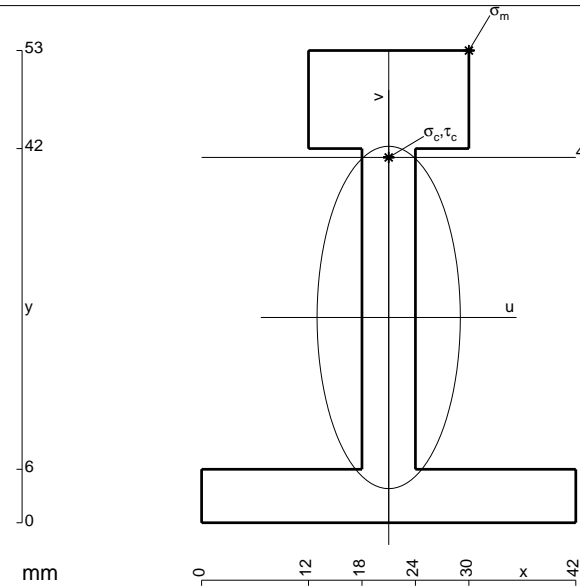
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

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

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

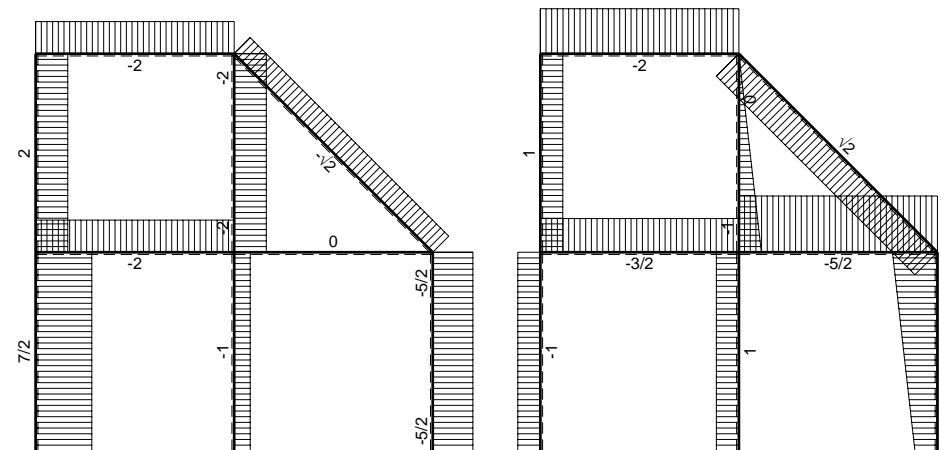
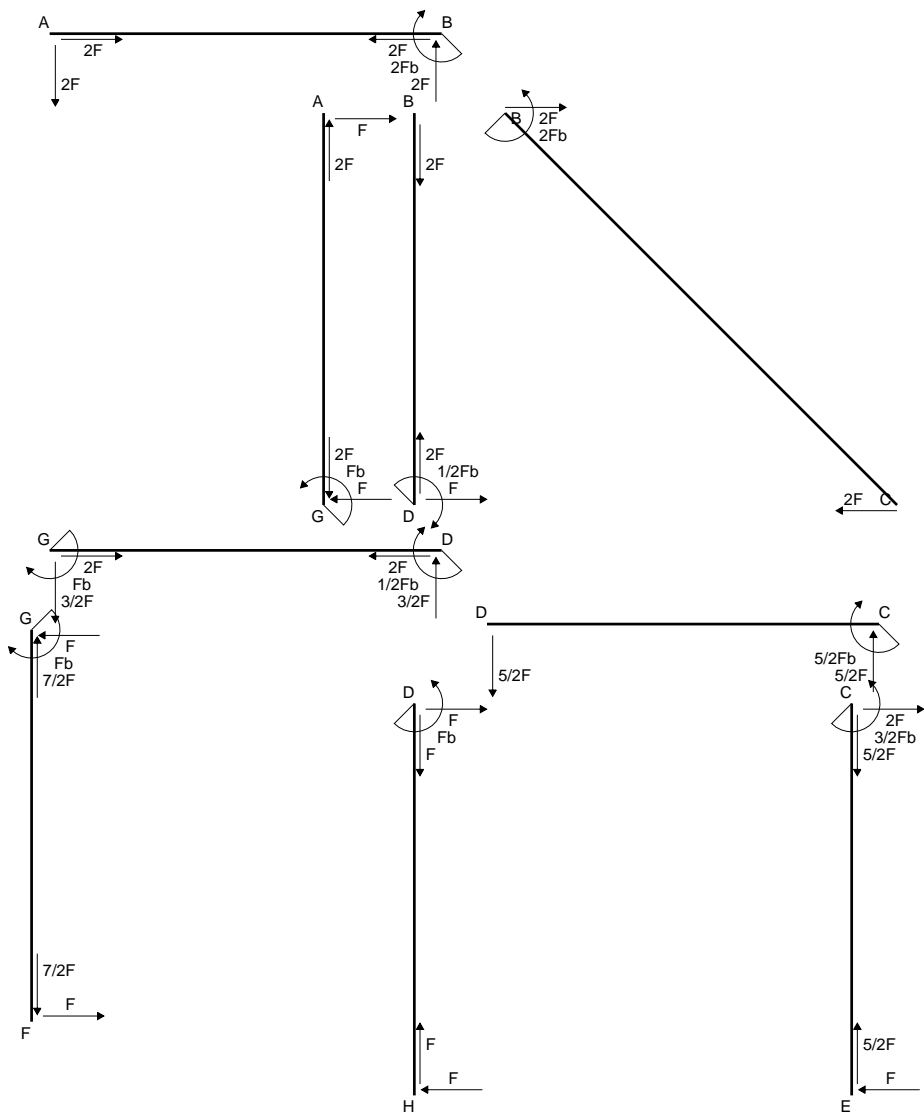
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

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



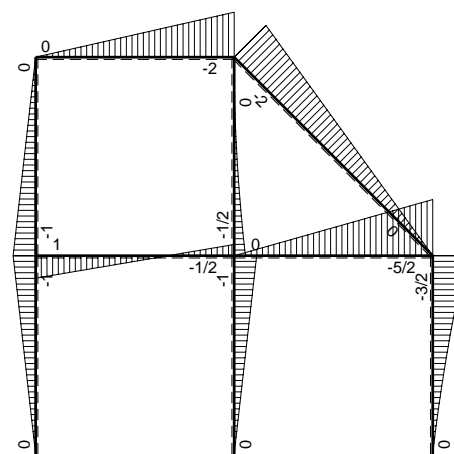
- A = 666. mm<sup>2</sup>
- J<sub>u</sub> = 245945. mm<sup>4</sup>
- J<sub>v</sub> = 43038. mm<sup>4</sup>
- y<sub>g</sub> = 23.04 mm
- T<sub>y</sub> = -2150. N
- M<sub>x</sub> = -1720000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 29.96 mm
- σ<sub>m</sub> = -M<sub>v</sub>/J<sub>u</sub> = 209.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 17.96 mm
- σ<sub>c</sub> = -M<sub>v</sub>/J<sub>u</sub> = 125.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.217 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 126.2 N/mm<sup>2</sup>
- S = 4954. mm<sup>3</sup>



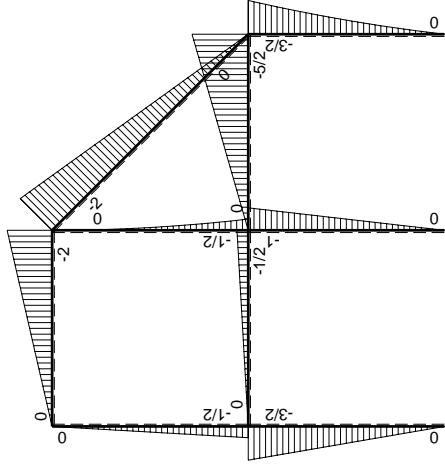
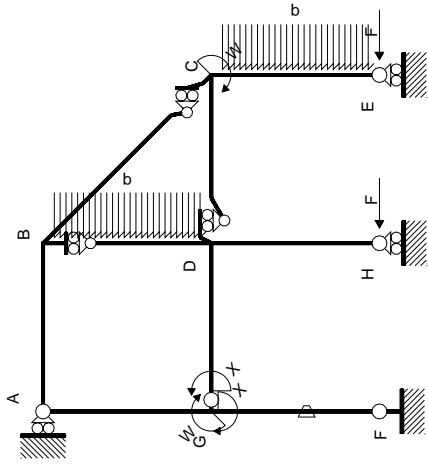


← + → F

↑ + ↓ F

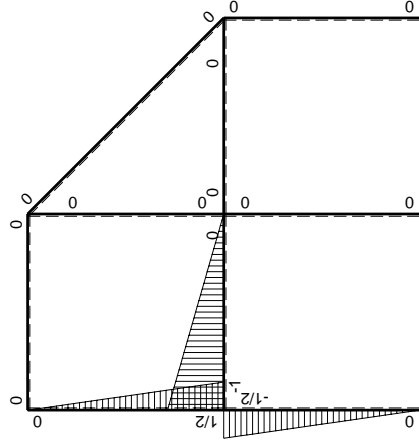


↺ + ↻ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0	
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							1/2Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

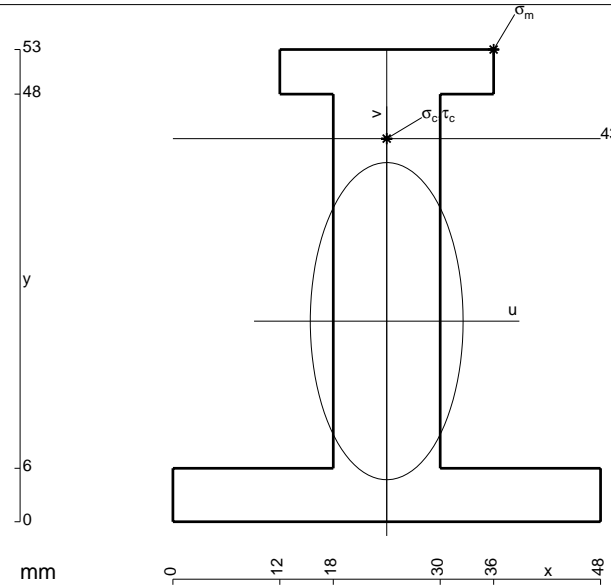
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

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

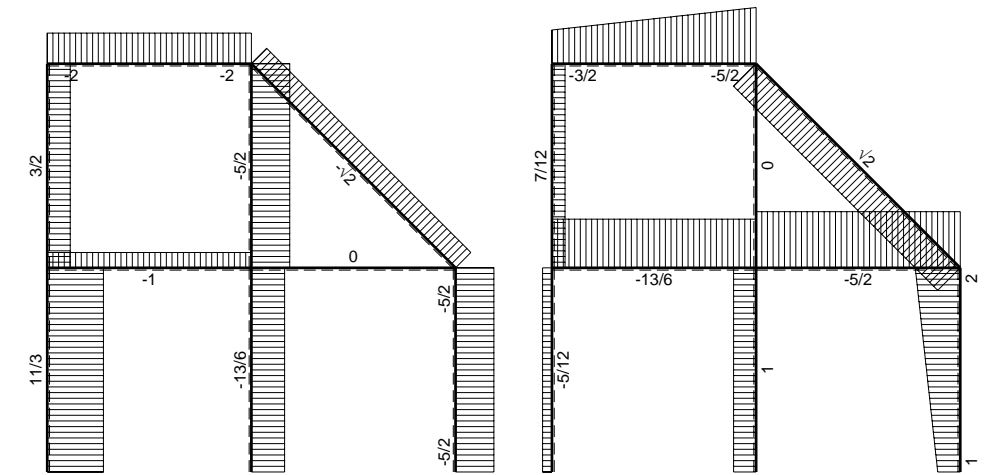
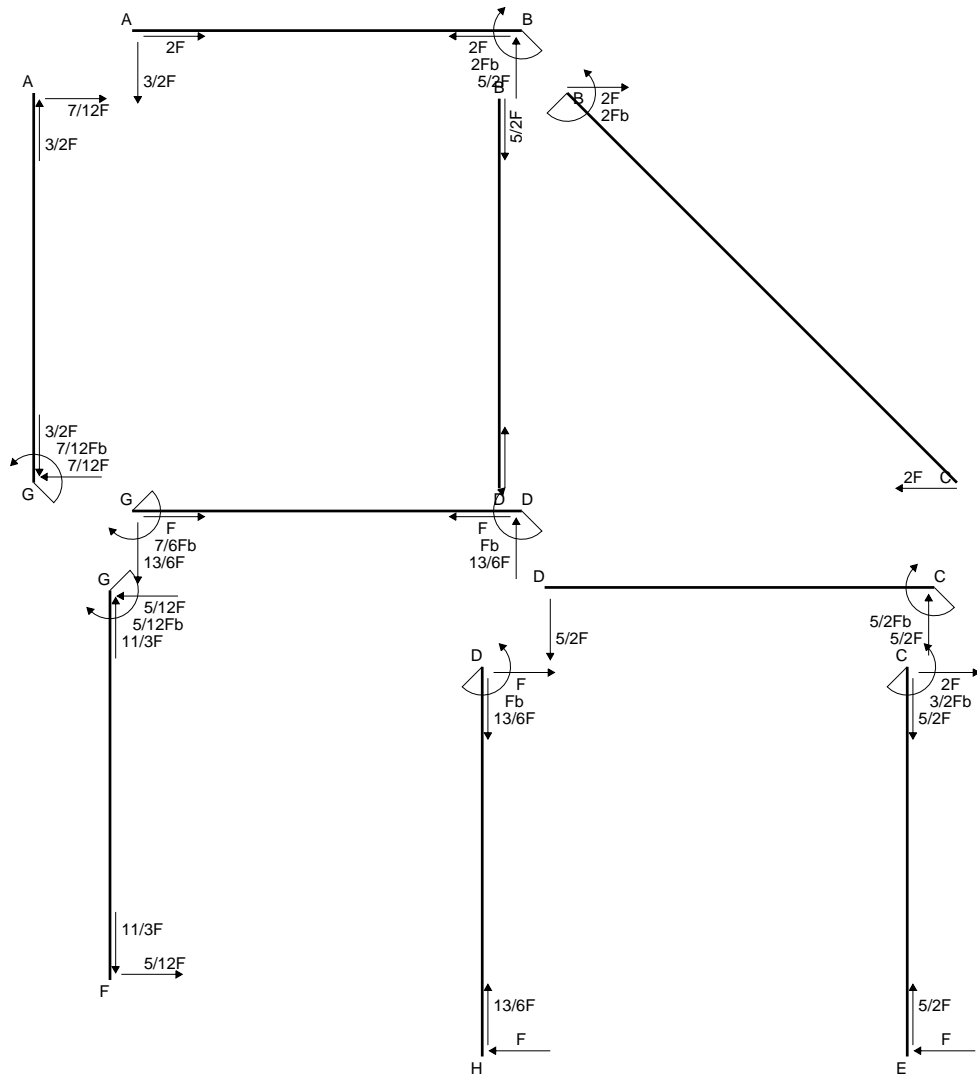
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

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

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

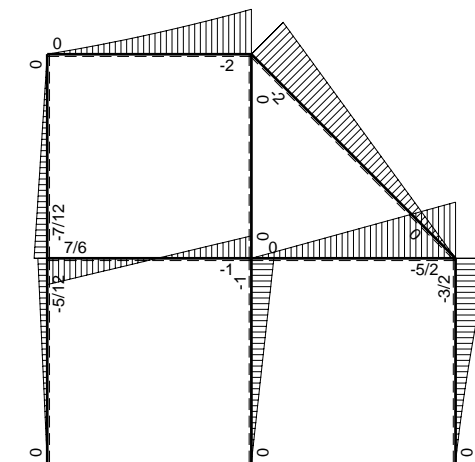


- A = 912. mm<sup>2</sup>
- J<sub>u</sub> = 289000. mm<sup>4</sup>
- J<sub>v</sub> = 67104. mm<sup>4</sup>
- y<sub>g</sub> = 22.51 mm
- T<sub>y</sub> = -2450. N
- M<sub>x</sub> = -2082500. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 30.49 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 219.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 43. mm
- v<sub>c</sub> = 20.49 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 147.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.347 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 147.7 N/mm<sup>2</sup>
- S = 4738. mm<sup>3</sup>

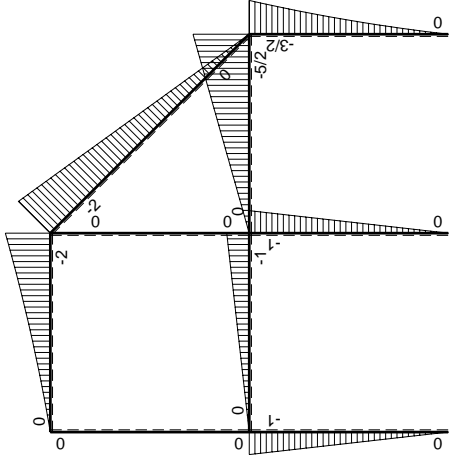
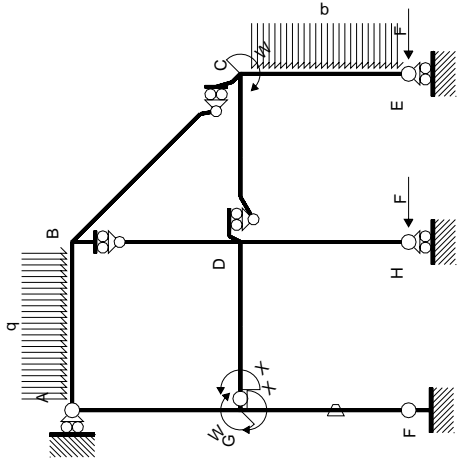


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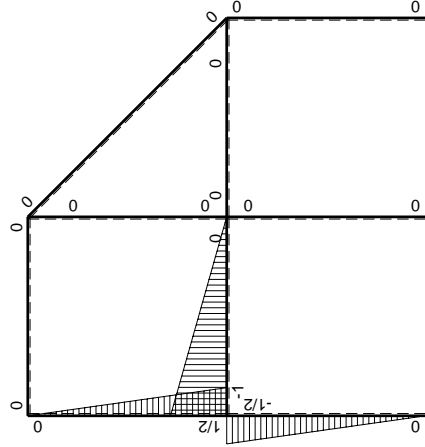


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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	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	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	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	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	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

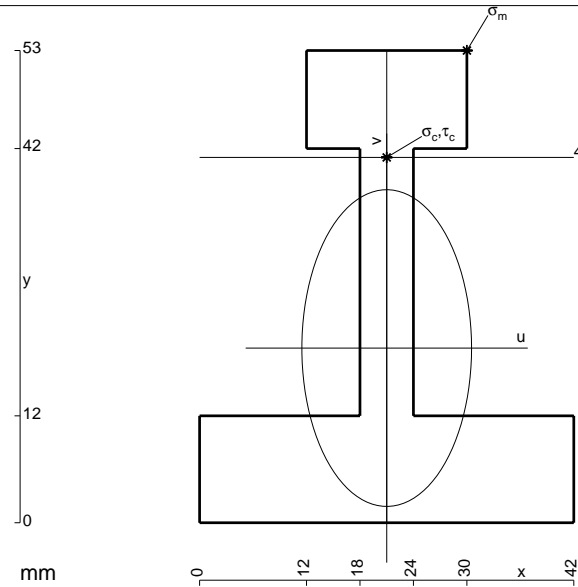
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

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

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

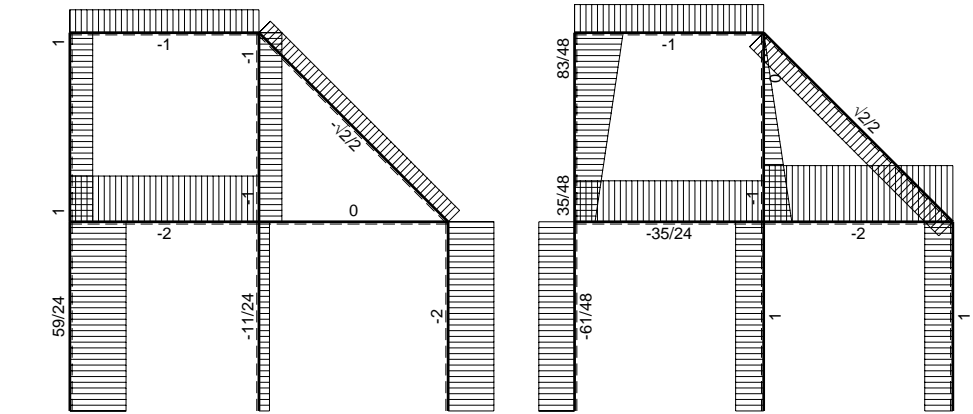
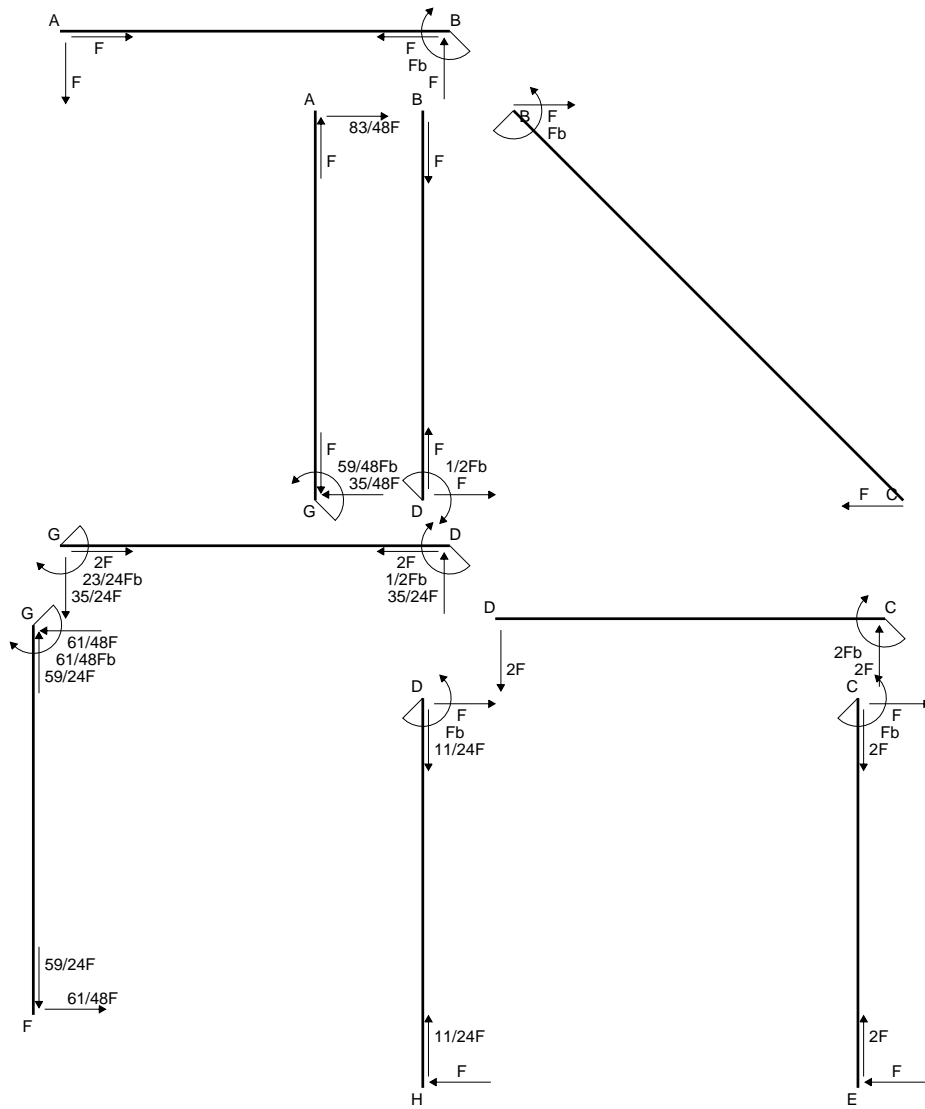
$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

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



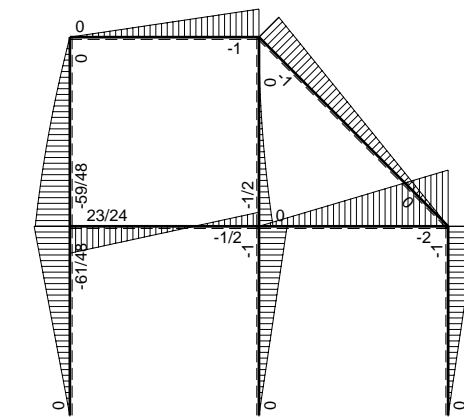
- A = 882. mm<sup>2</sup>
- J<sub>u</sub> = 278746. mm<sup>4</sup>
- J<sub>v</sub> = 79974. mm<sup>4</sup>
- y<sub>g</sub> = 19.6 mm
- T<sub>y</sub> = -2125. N
- M<sub>x</sub> = -1912500. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.4 mm
- σ<sub>m</sub> = -M<sub>v</sub>/J<sub>u</sub> = 229.1 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 21.4 mm
- σ<sub>c</sub> = -M<sub>v</sub>/J<sub>u</sub> = 146.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.185 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 147.3 N/mm<sup>2</sup>
- S = 5655. mm<sup>3</sup>



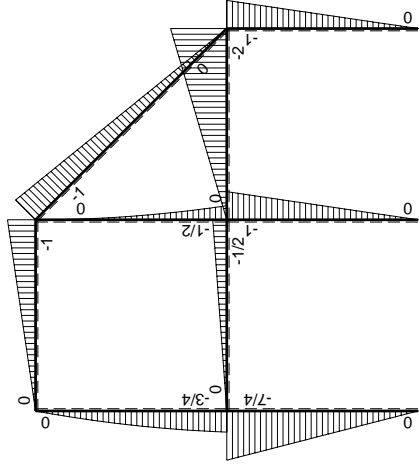
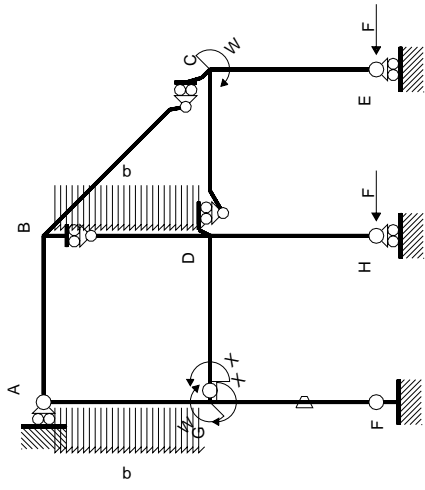


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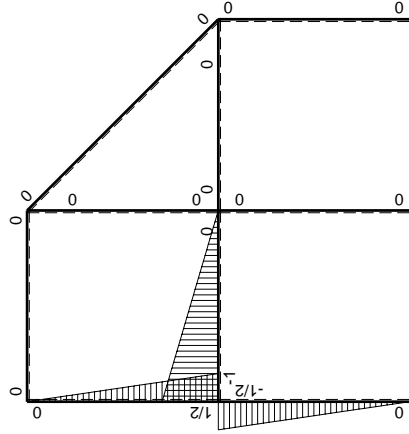


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (7/24 b) Fb 1/EJ + (1/4 b) \theta = 13/24 Fb^2/EJ$$

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

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

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

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

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

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

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

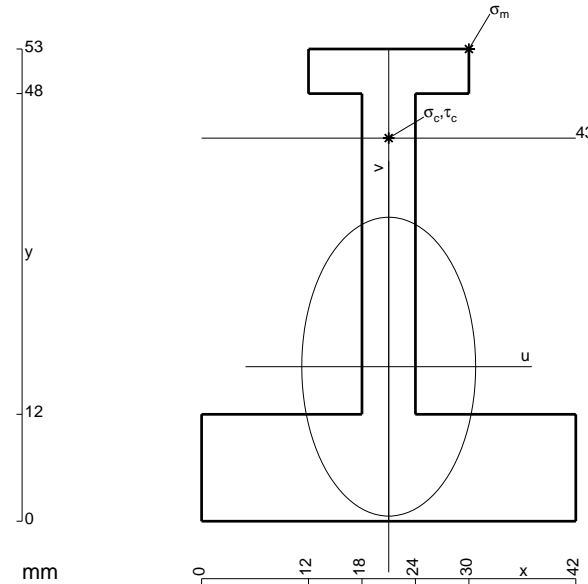
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

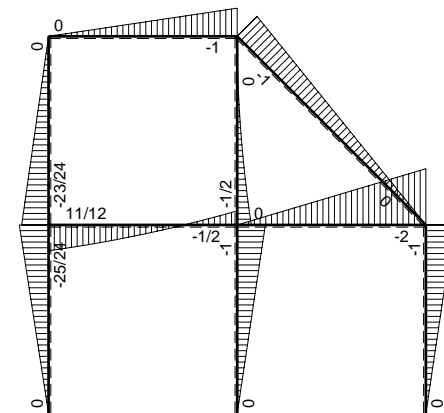
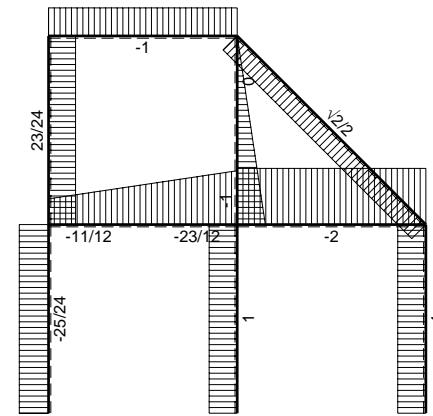
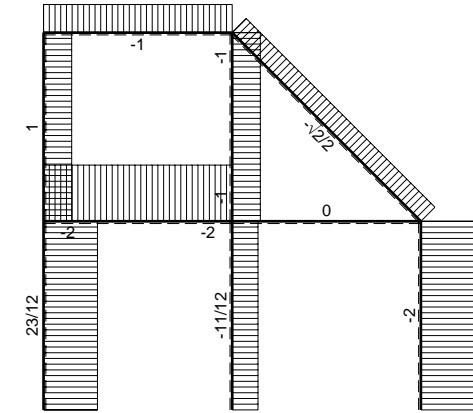
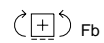
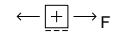
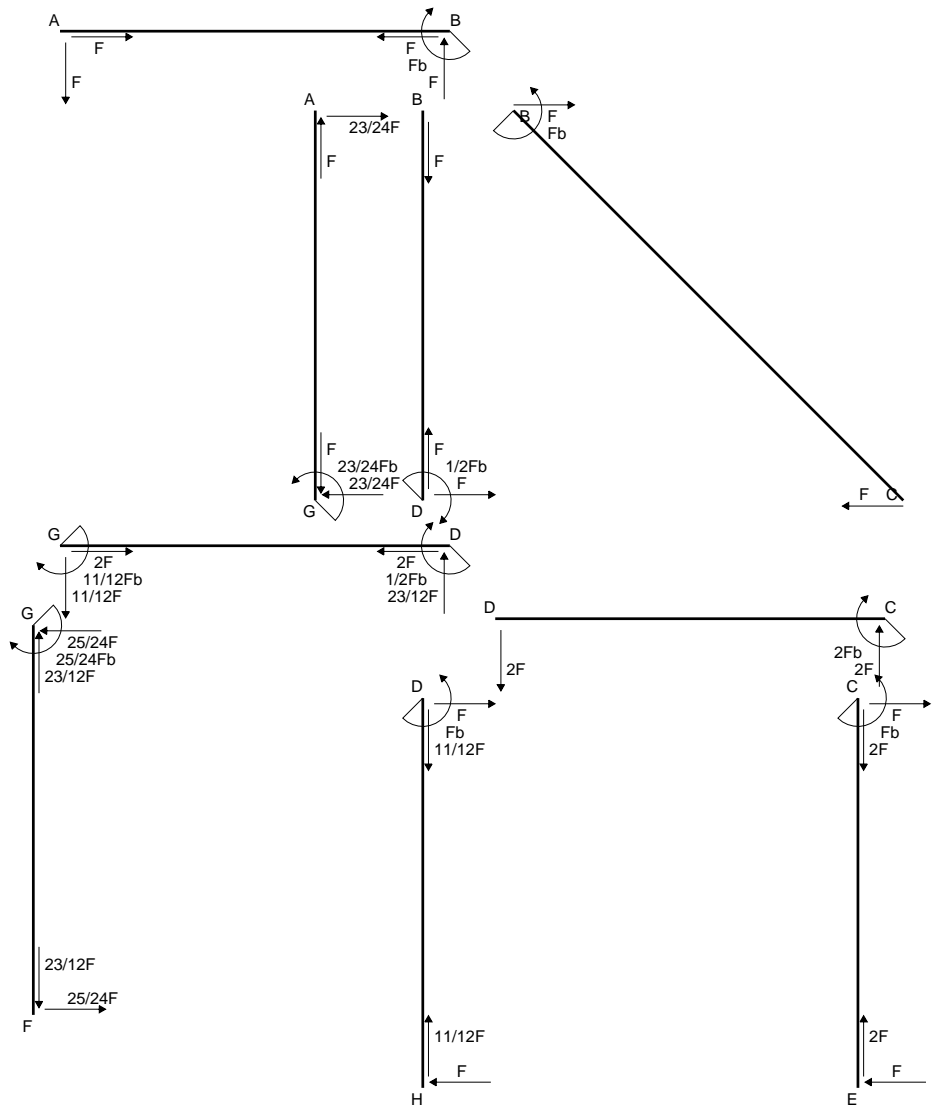
$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

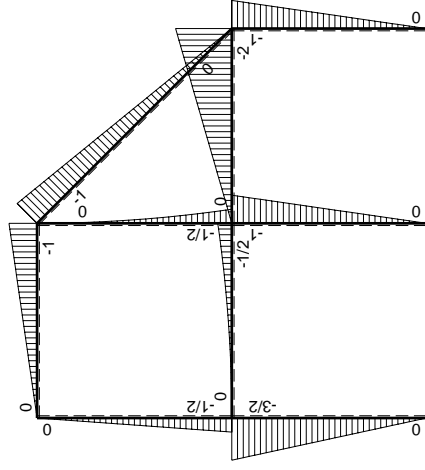
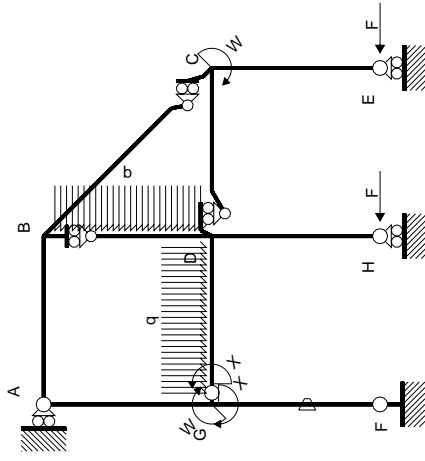
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



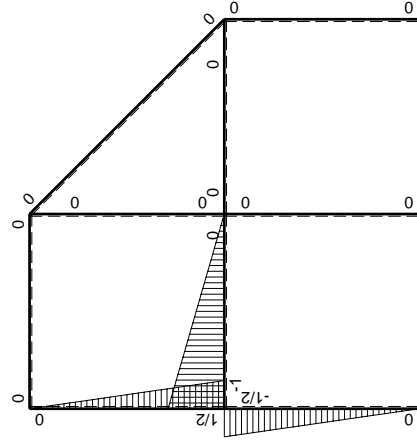
$A = 810. \text{ mm}^2$   
 $J_u = 227958. \text{ mm}^4$   
 $J_v = 77166. \text{ mm}^4$   
 $y_g = 17.34 \text{ mm}$   
 $T_y = -1600. \text{ N}$   
 $M_x = -1520000. \text{ Nmm}$   
 $x_m = 30. \text{ mm}$   
 $y_m = 53. \text{ mm}$   
 $u_m = 9. \text{ mm}$   
 $v_m = 35.66 \text{ mm}$   
 $\sigma_m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





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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 <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2qx <sup>2</sup>	0	1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-Fx+1/2qx <sup>2</sup>	0	1/2Fx-Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						11/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/12Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

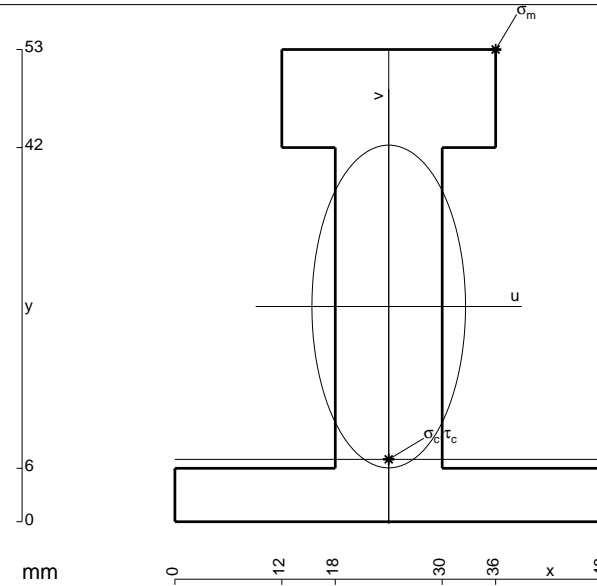
$$= (1/4 b - 1/3 b + 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

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

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

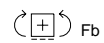
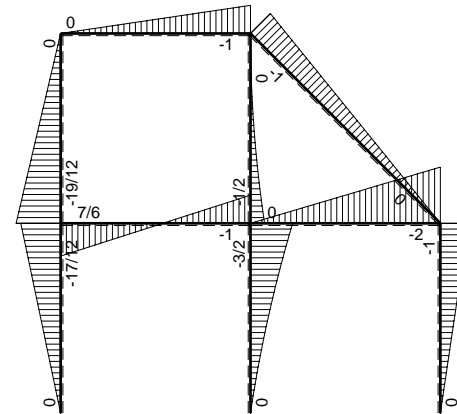
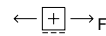
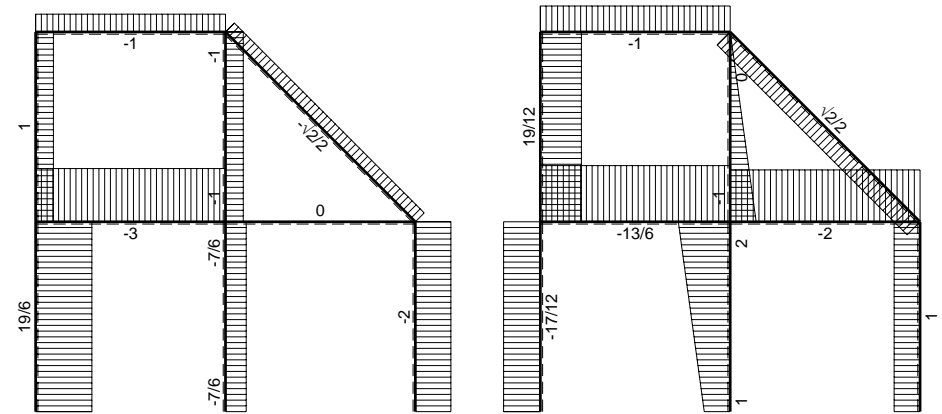
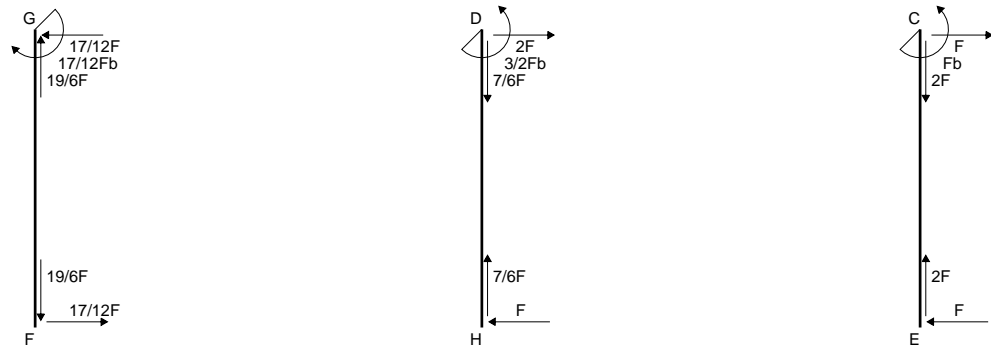
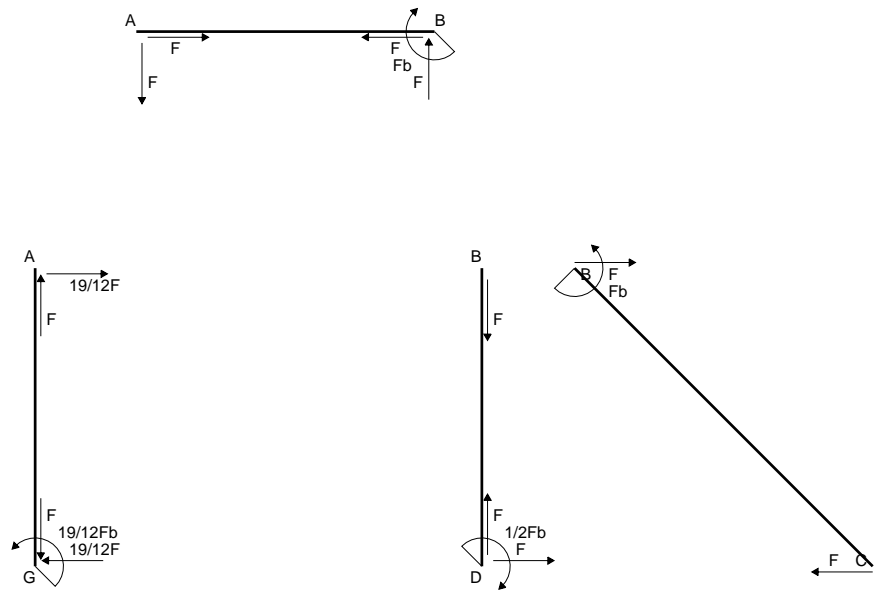
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

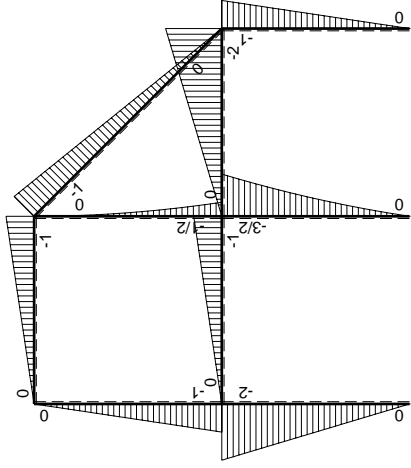
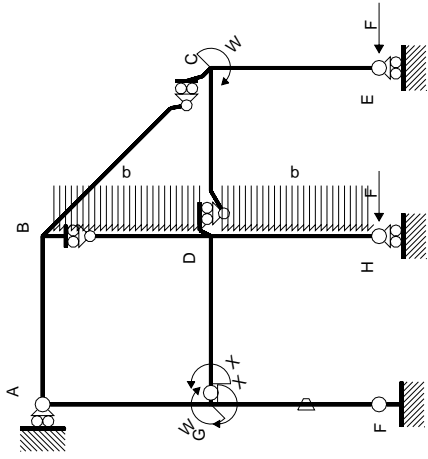
$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



- A = 984. mm<sup>2</sup>
- J<sub>u</sub> = 322959. mm<sup>4</sup>
- J<sub>v</sub> = 73152. mm<sup>4</sup>
- y<sub>g</sub> = 24.16 mm
- T<sub>y</sub> = -4460. N
- M<sub>x</sub> = -2230000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 28.84 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.1 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -17.16 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -118.5 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.257 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 119.1 N/mm<sup>2</sup>
- S = 6306. mm<sup>3</sup>

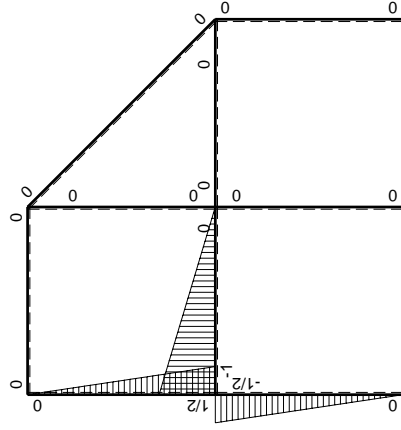






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [x - x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

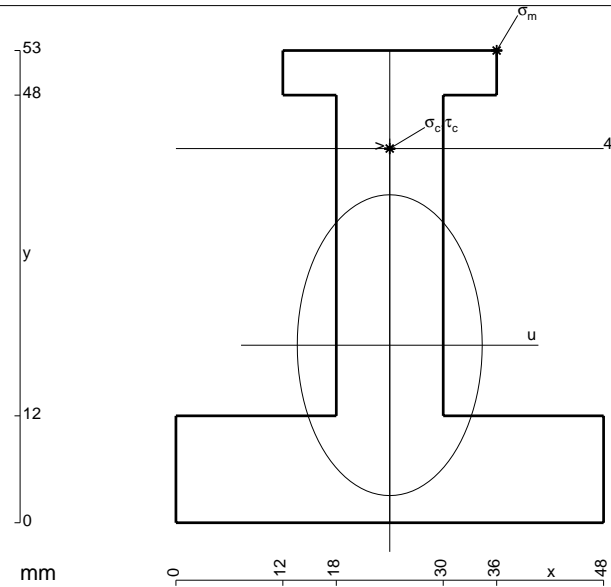
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

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

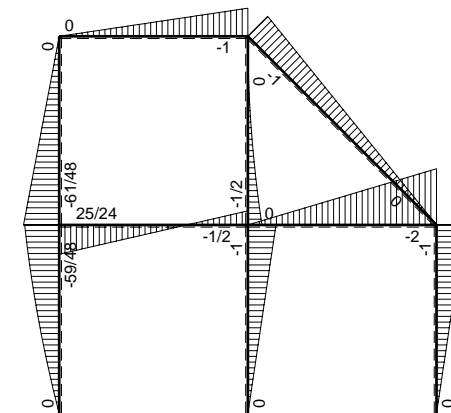
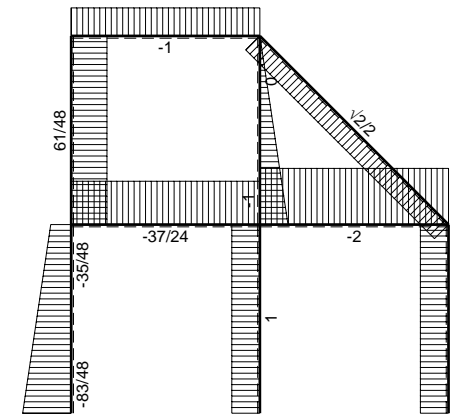
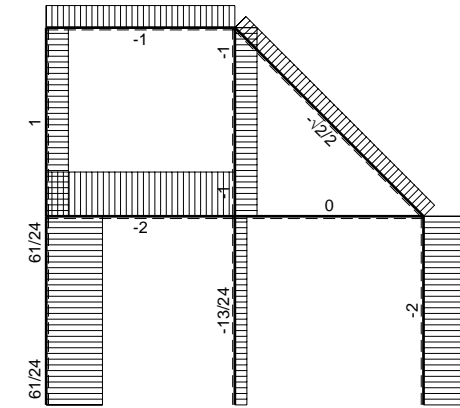
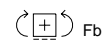
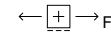
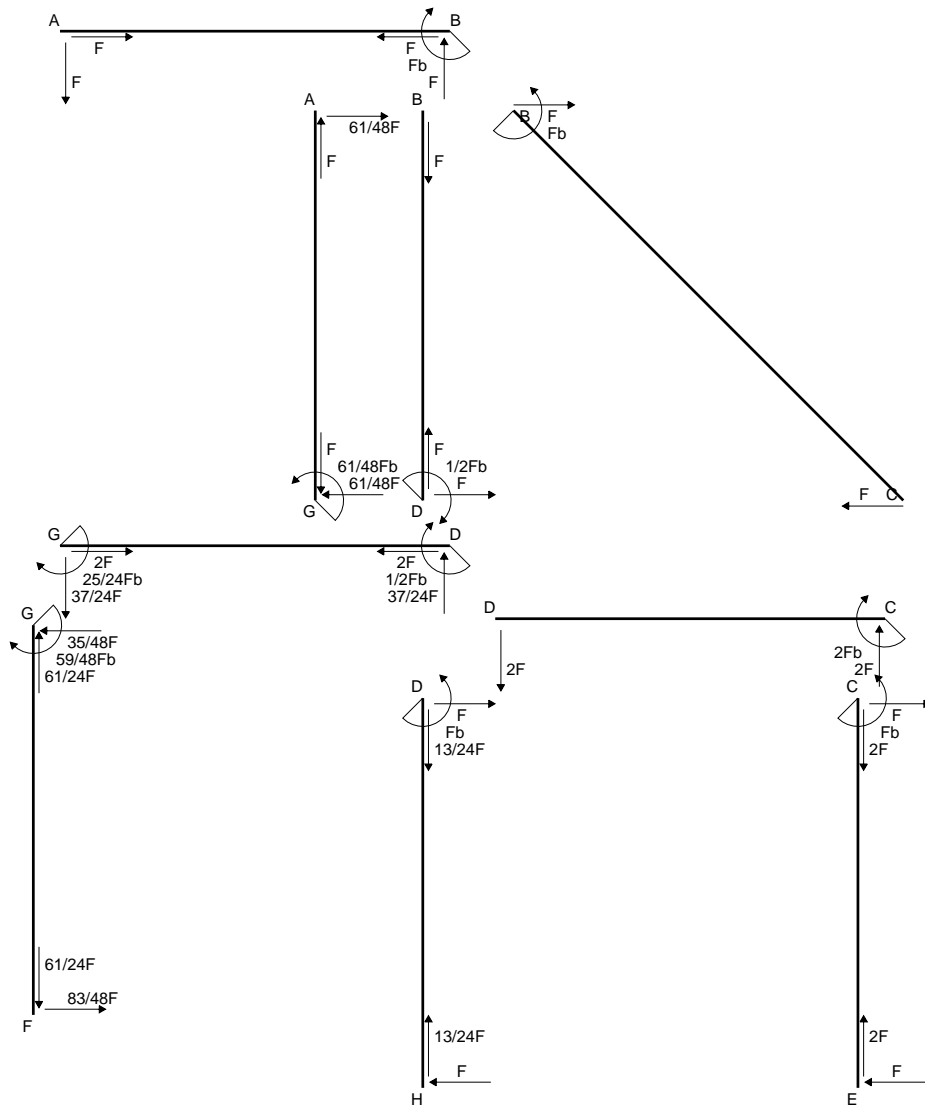
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

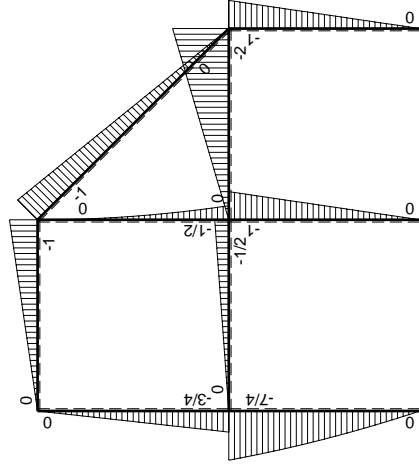
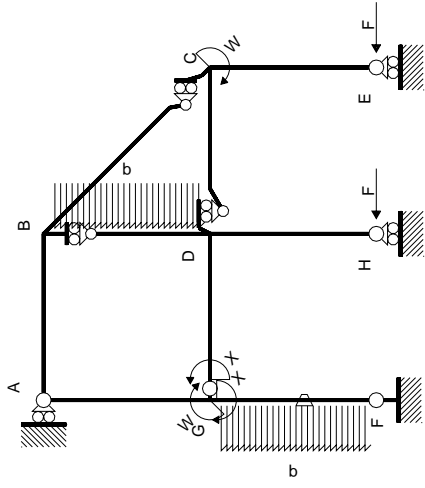
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

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



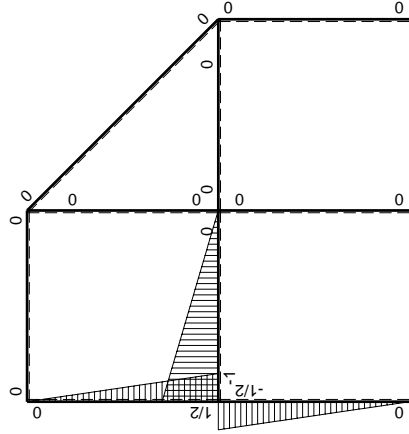
- A = 1128. mm<sup>2</sup>
- J<sub>u</sub> = 321538. mm<sup>4</sup>
- J<sub>v</sub> = 121536. mm<sup>4</sup>
- y<sub>g</sub> = 19.93 mm
- T<sub>y</sub> = -3700. N
- M<sub>x</sub> = -2035000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.07 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 22.07 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 139.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.249 N/mm<sup>2</sup>
- σ<sub>ρ</sub> = √(σ<sup>2</sup>+3τ<sup>2</sup>) = 140. N/mm<sup>2</sup>
- S = 5474. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

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

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

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

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

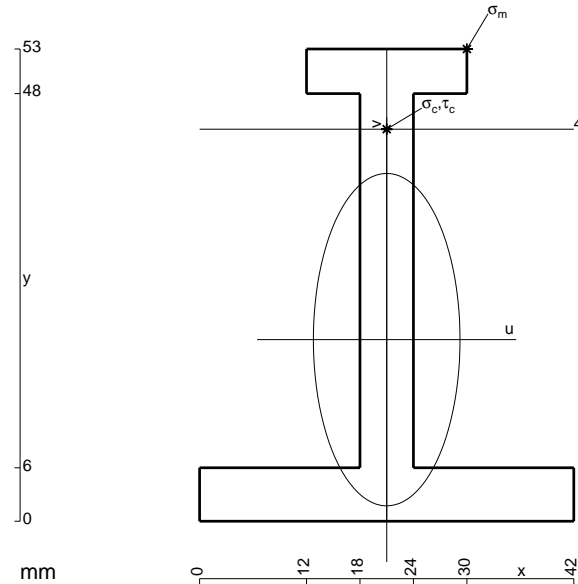
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

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

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

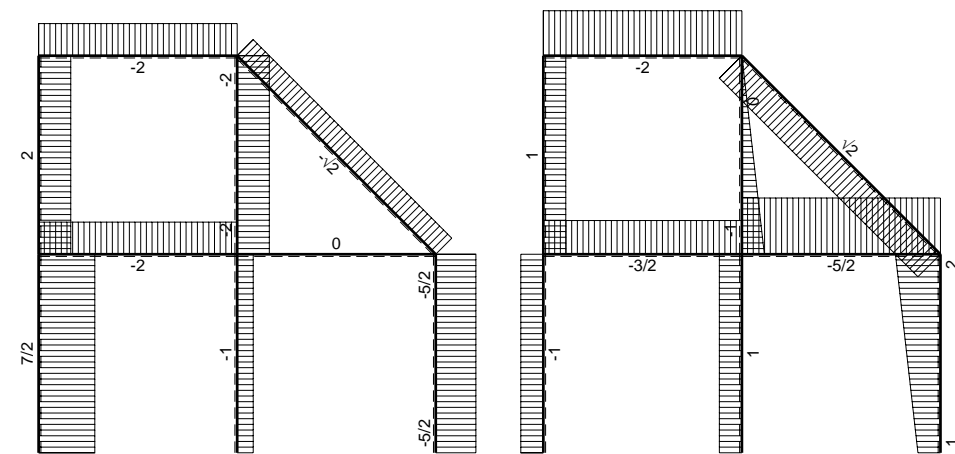
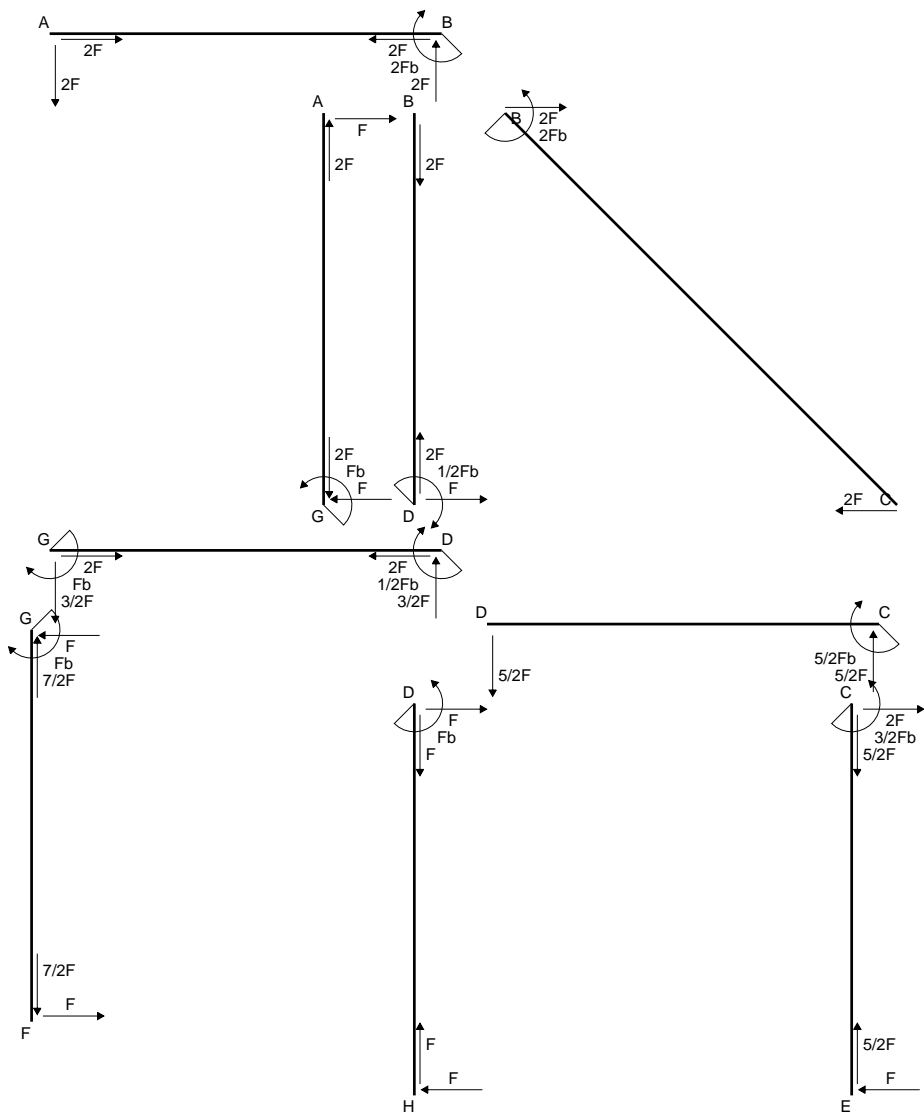
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

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



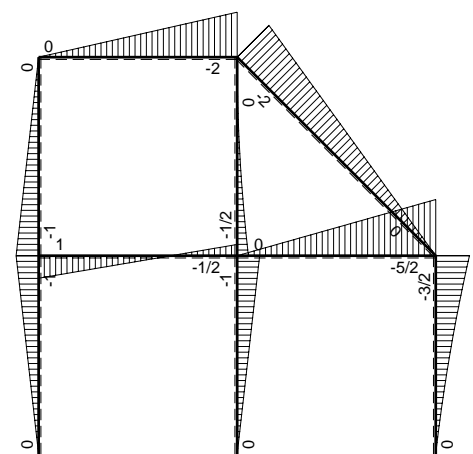
- A = 594. mm<sup>2</sup>
- J<sub>u</sub> = 206801. mm<sup>4</sup>
- J<sub>v</sub> = 40230. mm<sup>4</sup>
- y<sub>g</sub> = 20.38 mm
- T<sub>y</sub> = -2320. N
- M<sub>x</sub> = -1392000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 32.62 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 219.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 44. mm
- v<sub>c</sub> = 23.62 mm
- σ<sub>c</sub> = -Mv/J<sub>v</sub> = 159. N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.218 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 159.4 N/mm<sup>2</sup>
- S = 3326. mm<sup>3</sup>



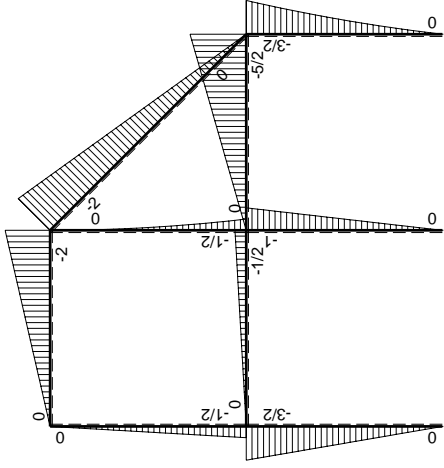
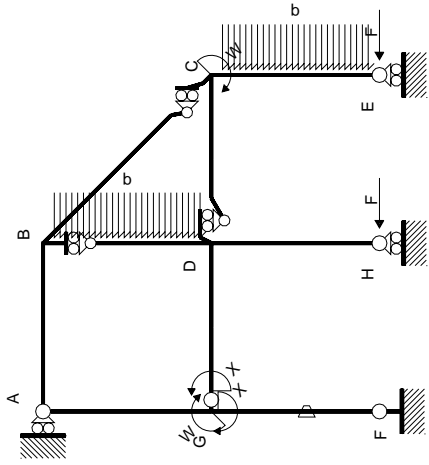


← ⊕ → F

↑ ⊕ ↓ F

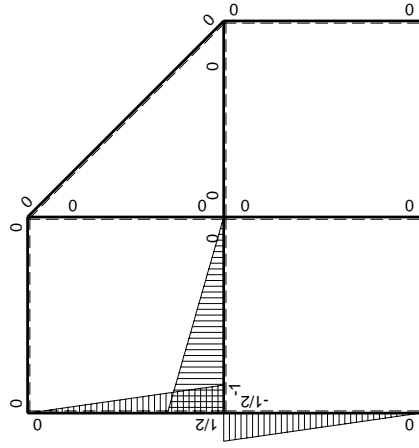


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0	
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							1/2Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-Fb	

Sviluppi di calcolo iperstatica

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

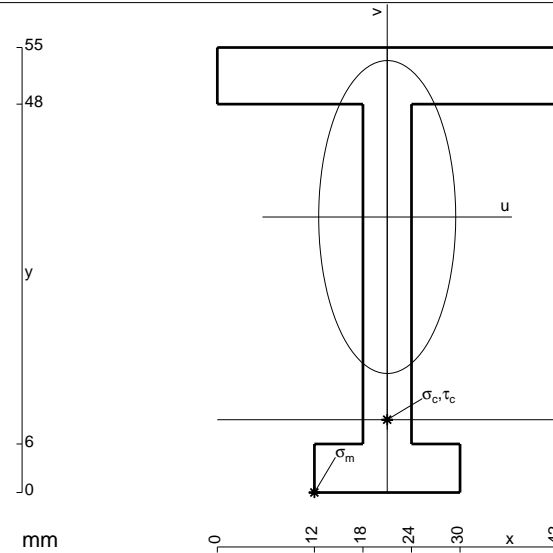
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

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

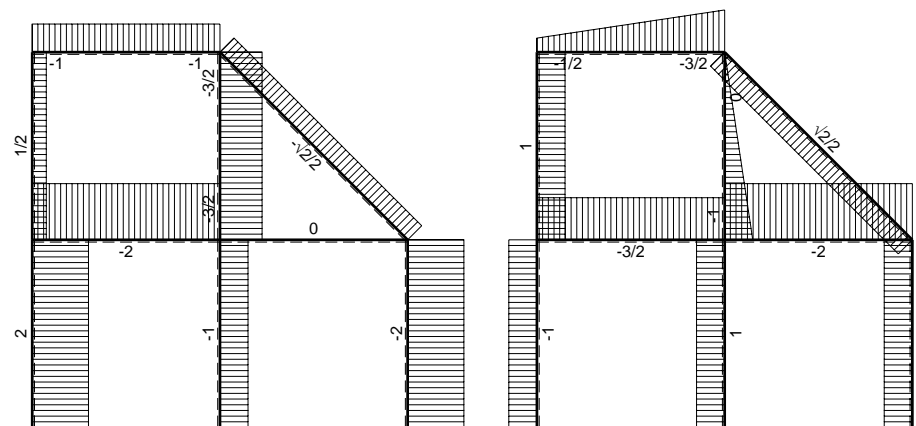
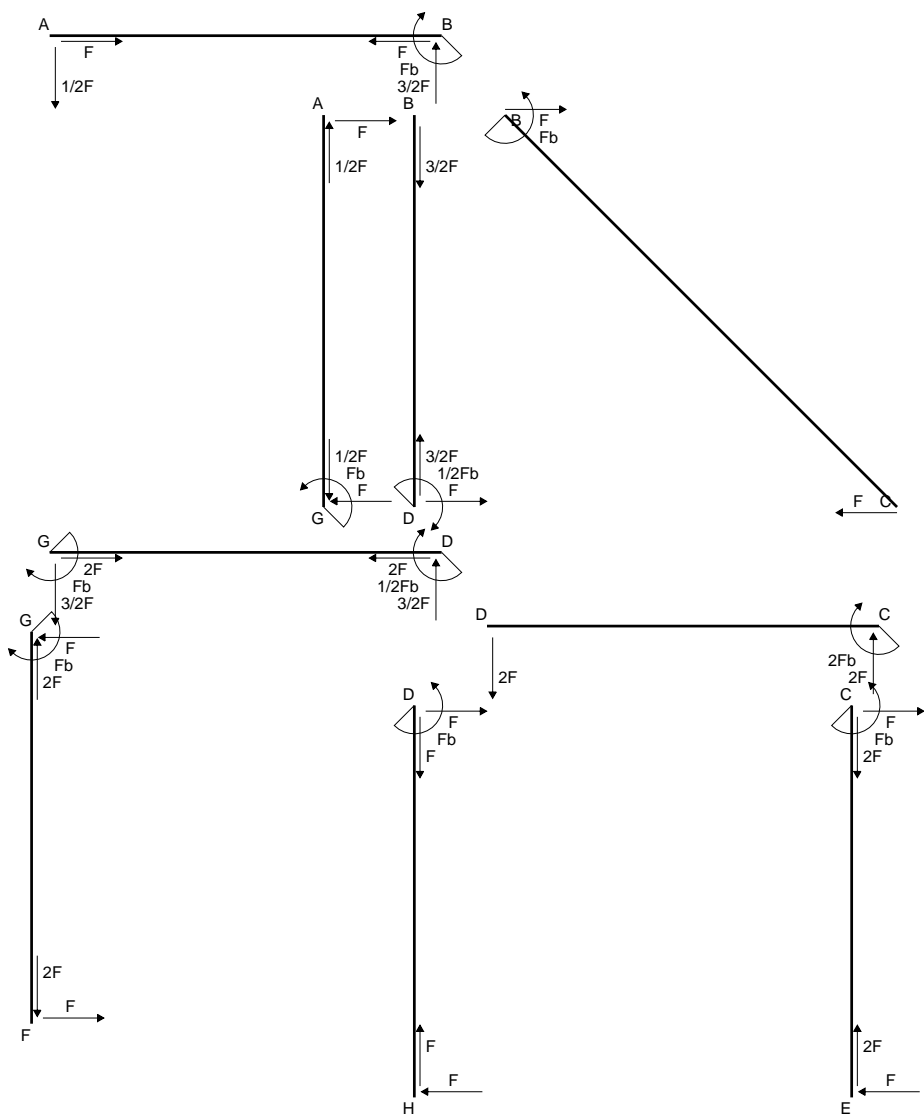
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

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

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

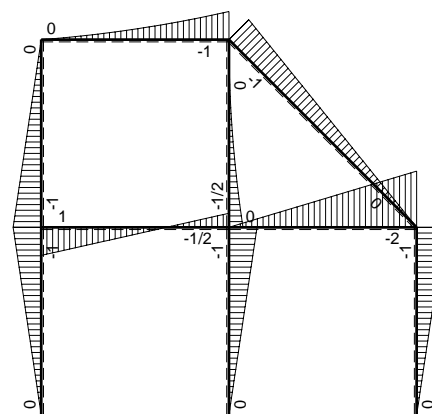


- A = 654. mm<sup>2</sup>
- J<sub>u</sub> = 244740. mm<sup>4</sup>
- J<sub>v</sub> = 46890. mm<sup>4</sup>
- y<sub>g</sub> = 34.05 mm
- T<sub>y</sub> = -2450. N
- M<sub>x</sub> = -1641500. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -34.05 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -228.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -25.05 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -168. N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.392 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 168.4 N/mm<sup>2</sup>
- S = 3831. mm<sup>3</sup>

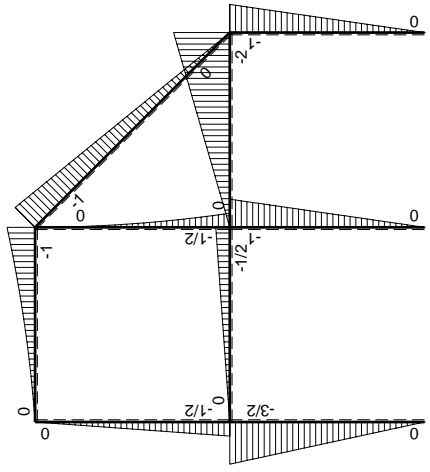
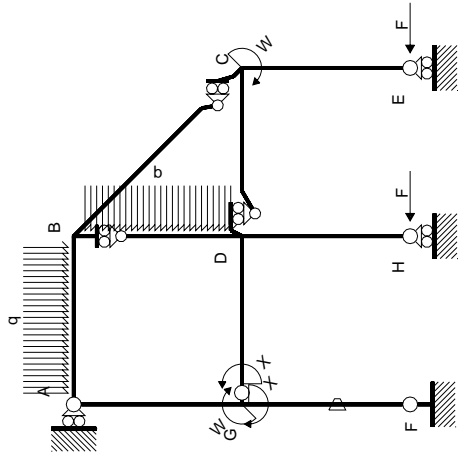


← (+) → F

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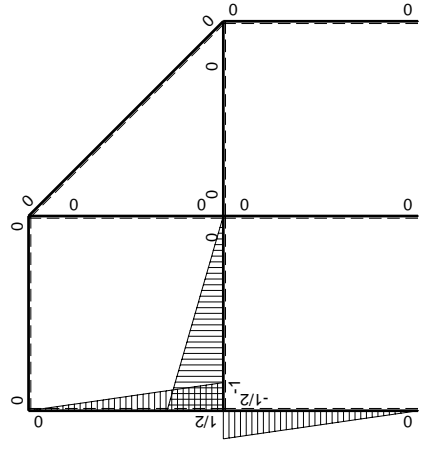


⤵ (+) ⤵ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

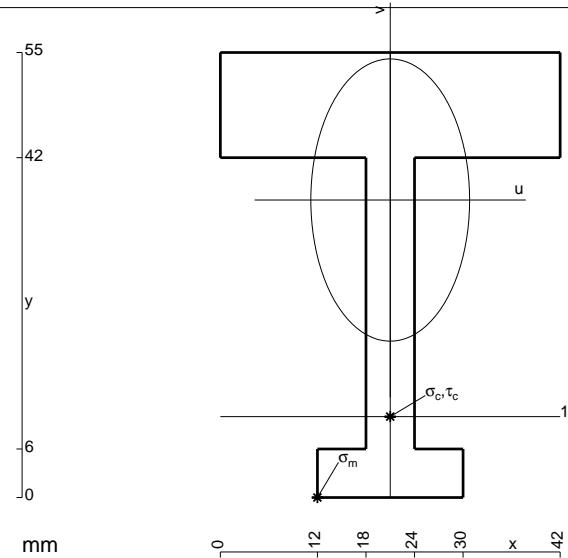
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

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

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

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

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



$$A = 870. \text{ mm}^2$$

$$J_u = 264856. \text{ mm}^4$$

$$J_v = 83826. \text{ mm}^4$$

$$y_g = 36.77 \text{ mm}$$

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

$$M_x = -1728000. \text{ Nmm}$$

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

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

$$v_m = -36.77 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.9 \text{ N/mm}^2$$

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

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

$$v_c = -26.77 \text{ mm}$$

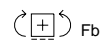
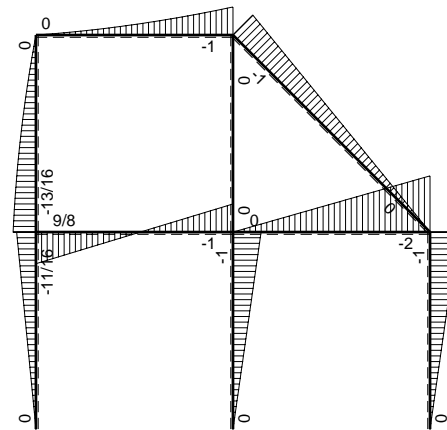
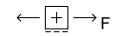
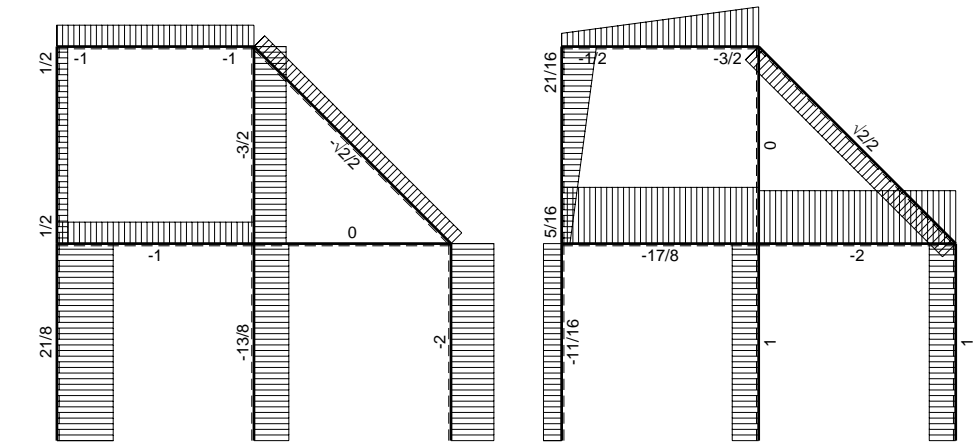
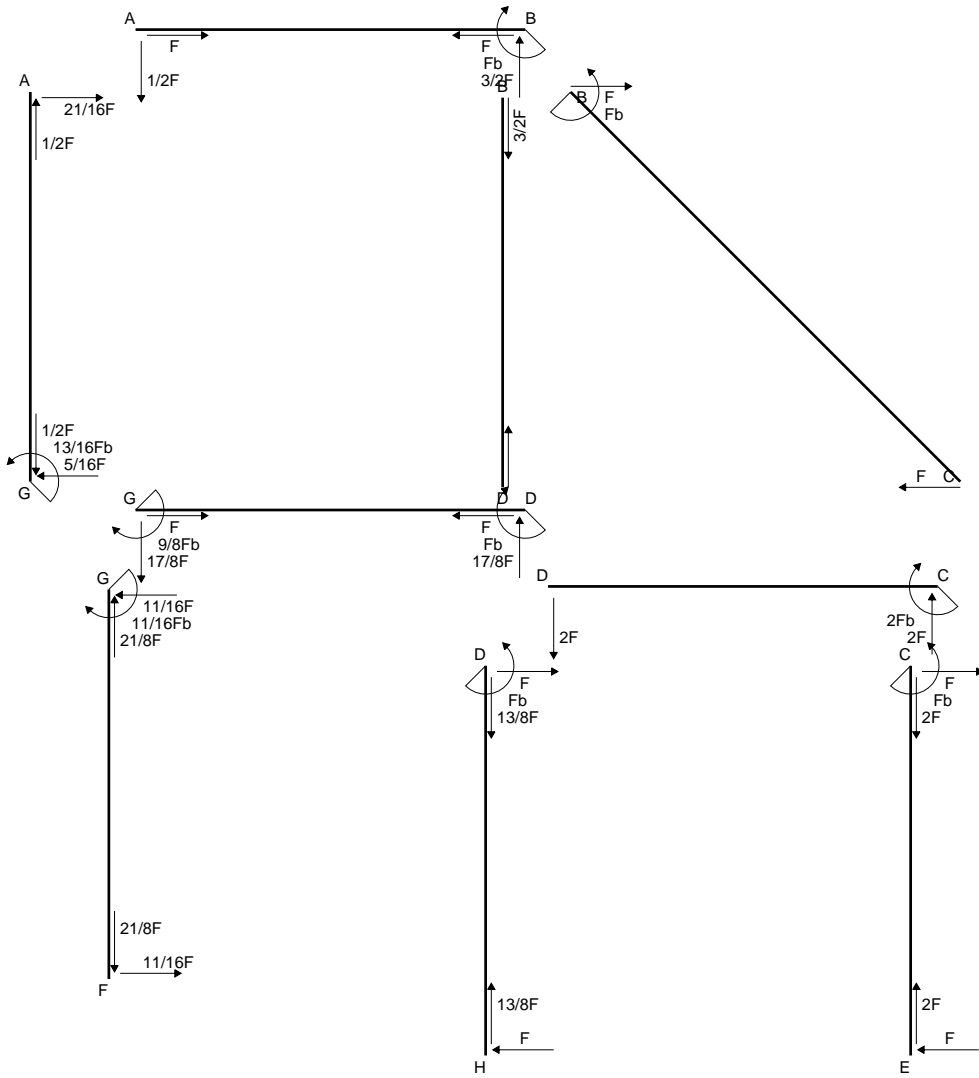
$$\sigma_c = -Mv/J_u = -174.6 \text{ N/mm}^2$$

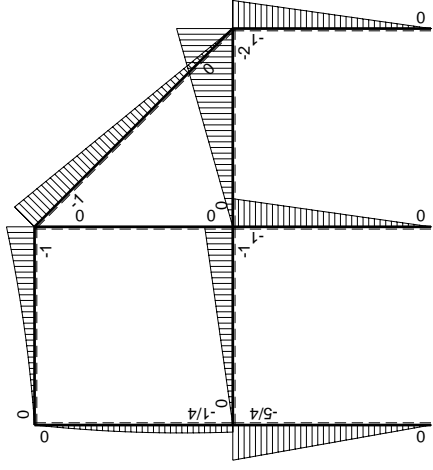
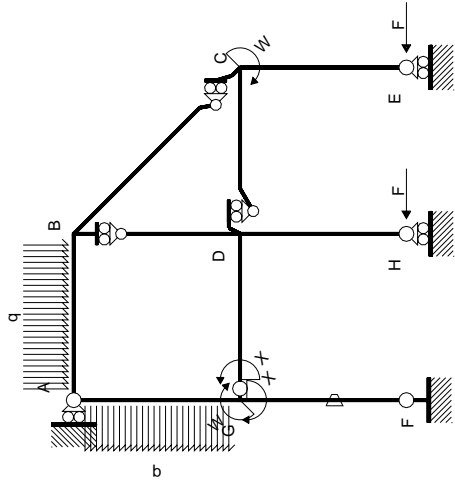
$$\tau_c = 6.551 \text{ N/mm}^2$$

$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 175. \text{ N/mm}^2$$

$$S = 4338. \text{ mm}^3$$

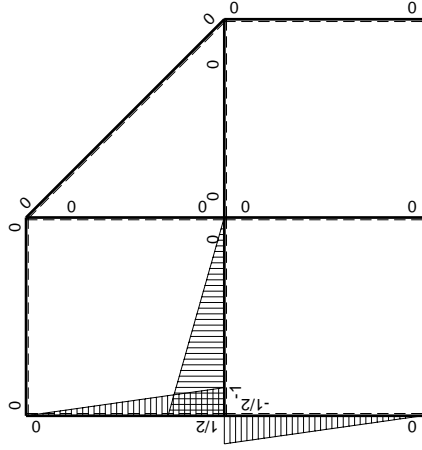






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_X$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

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

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

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

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

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

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

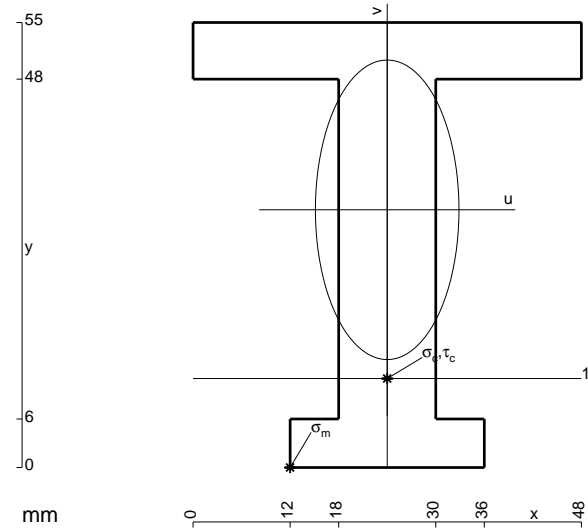
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

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

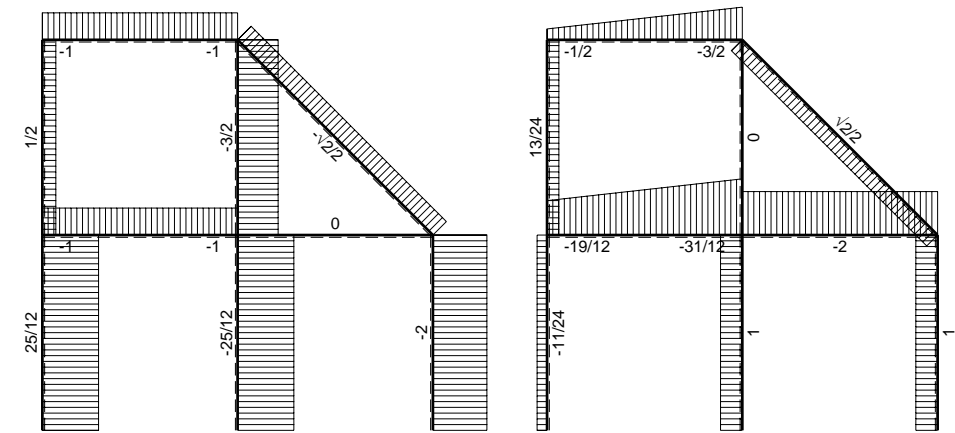
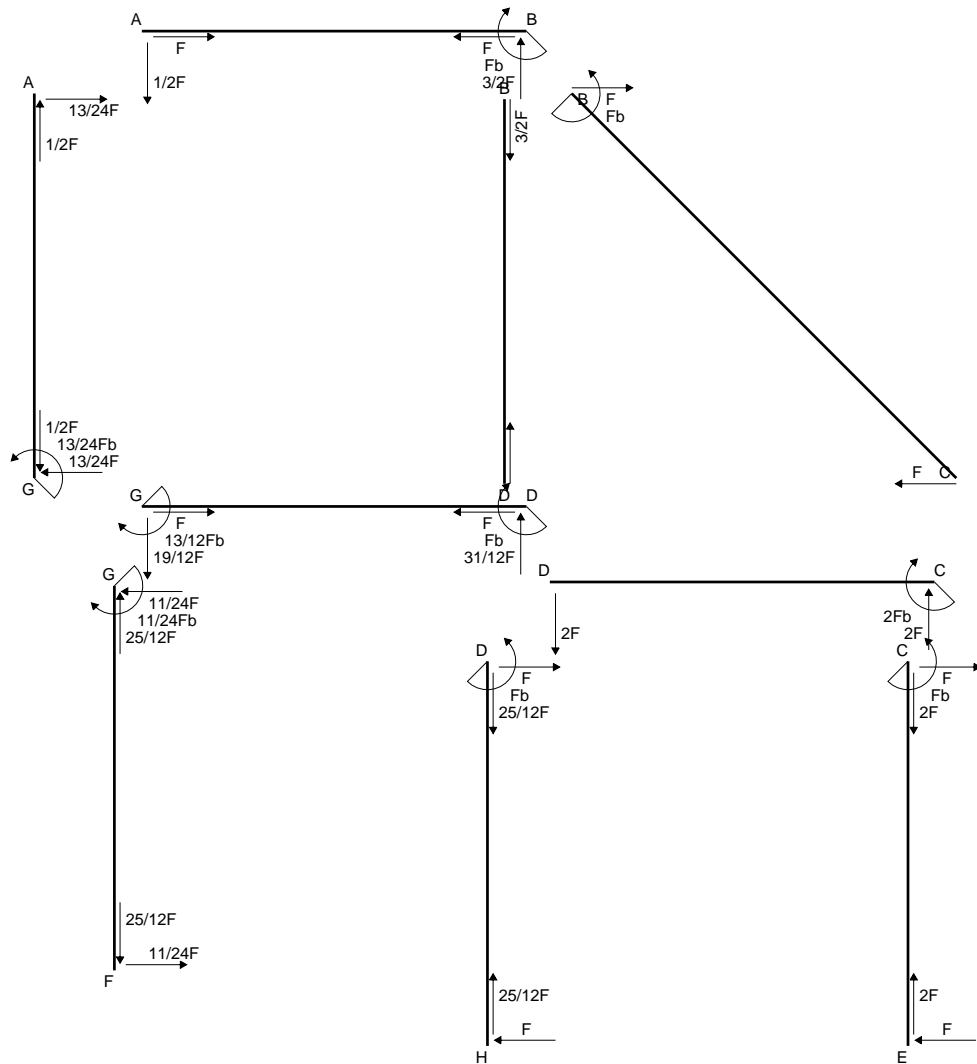
$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

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

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

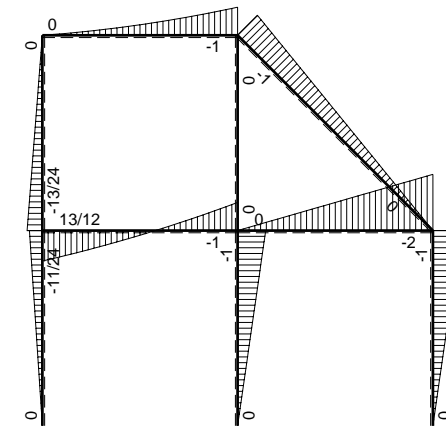


- A = 984. mm<sup>2</sup>
- J<sub>u</sub> = 337339. mm<sup>4</sup>
- J<sub>v</sub> = 77472. mm<sup>4</sup>
- y<sub>g</sub> = 31.85 mm
- T<sub>y</sub> = -2700. N
- M<sub>x</sub> = -2106000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -31.85 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -198.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -20.85 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -130.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.706 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 130.3 N/mm<sup>2</sup>
- S = 5556. mm<sup>3</sup>

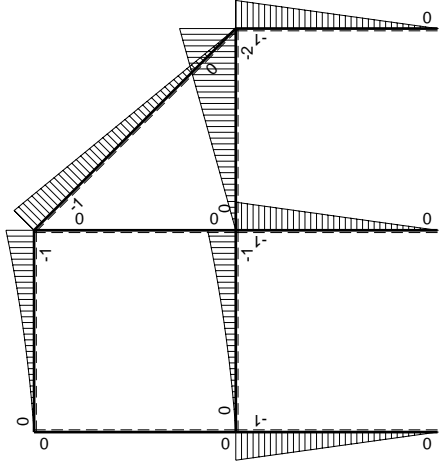
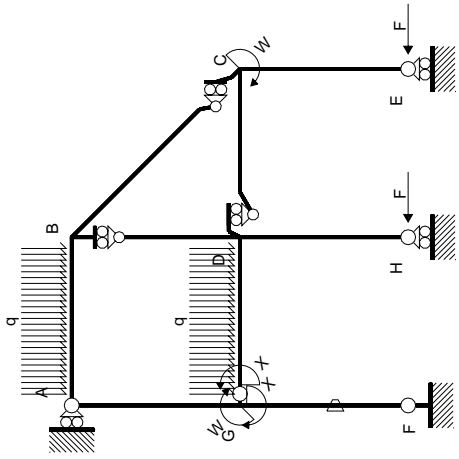


← ⊕ → F

↑ ⊕ ↓ F

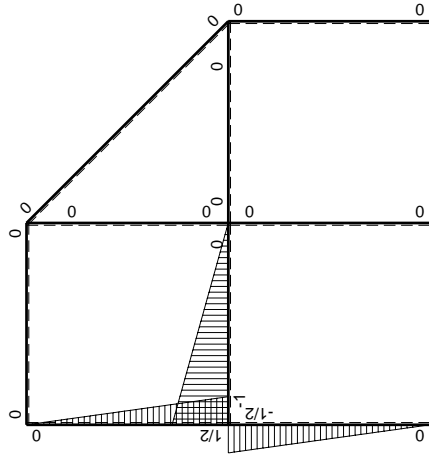


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

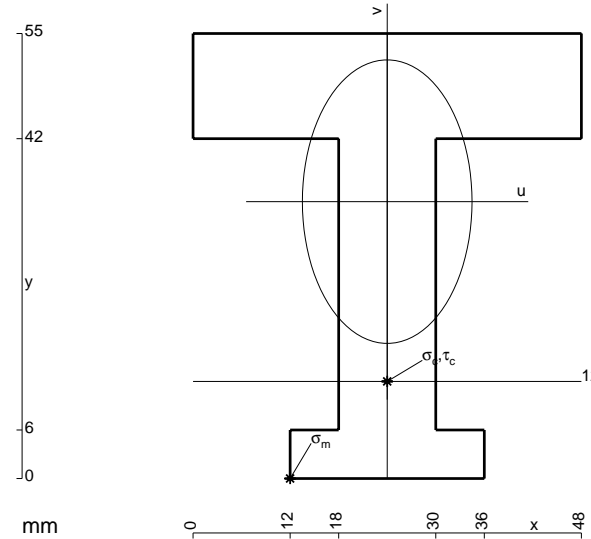
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

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

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

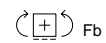
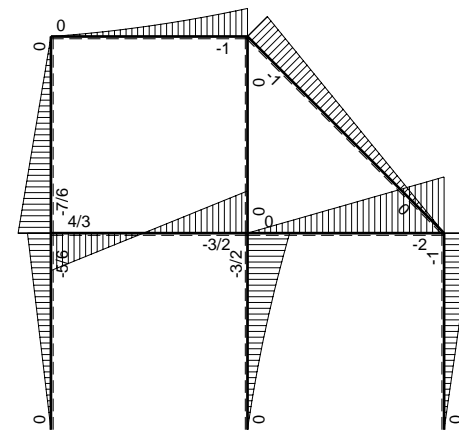
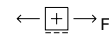
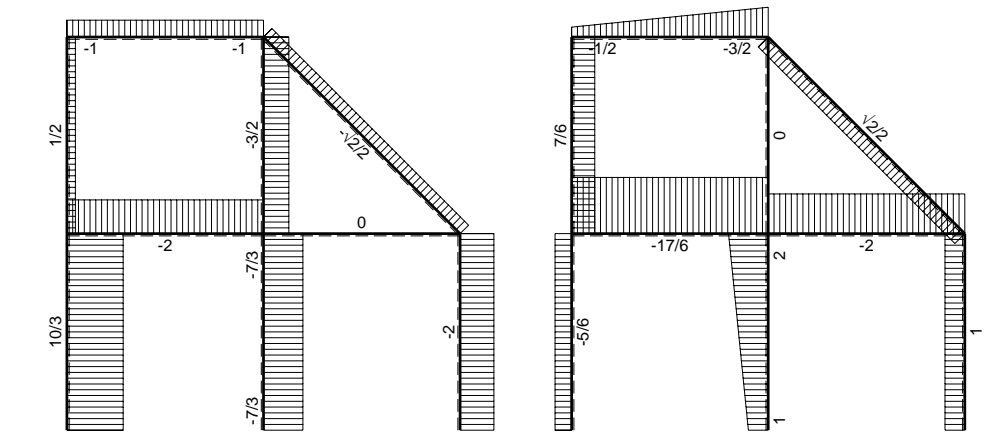
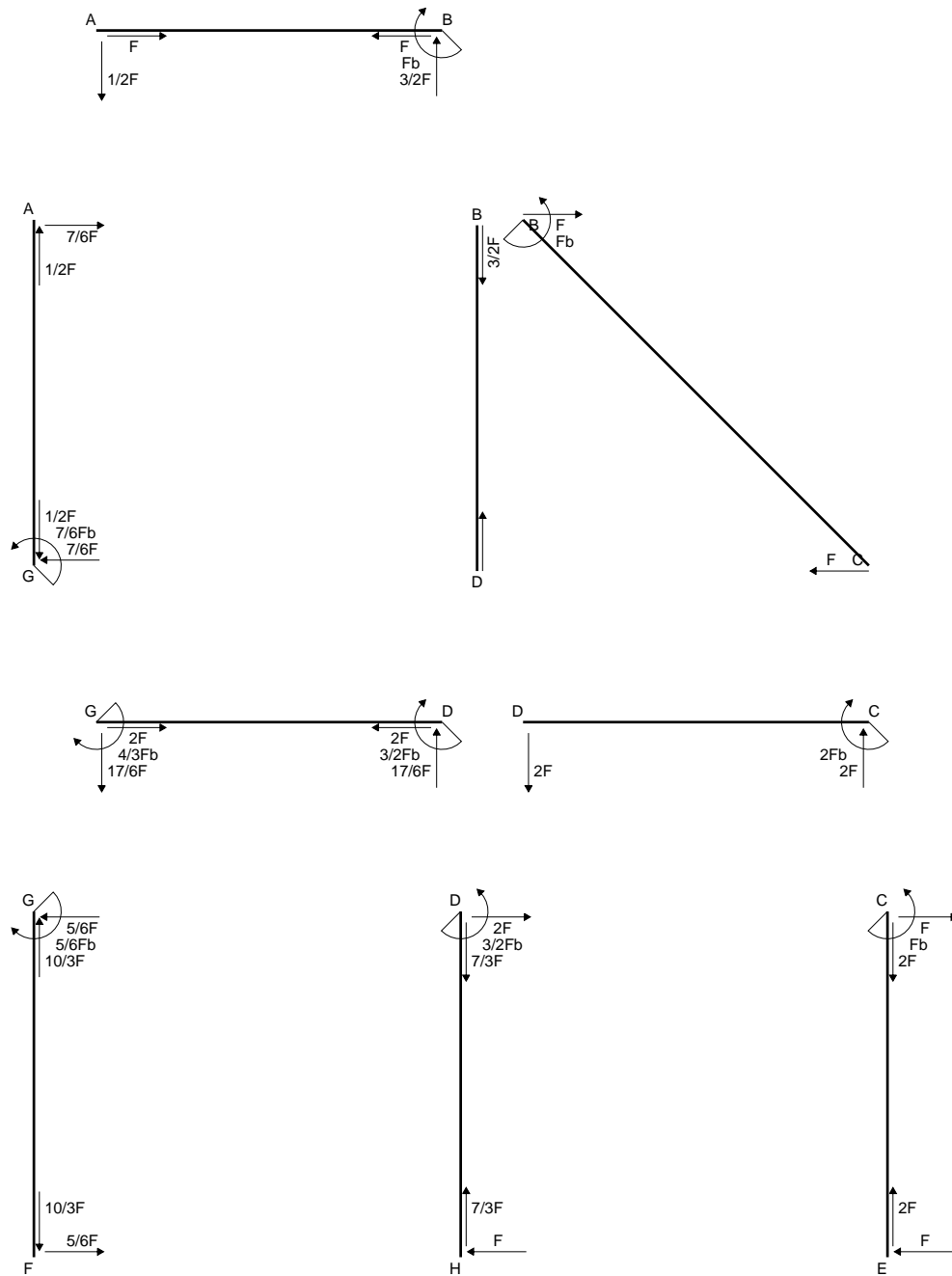
$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

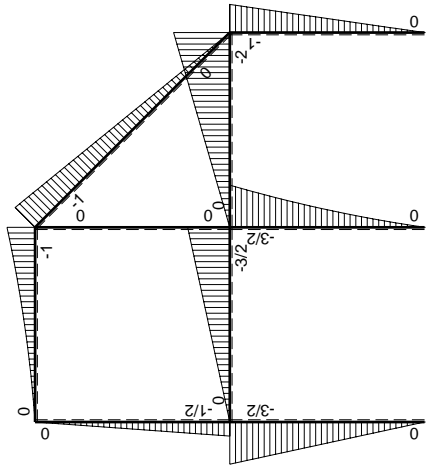
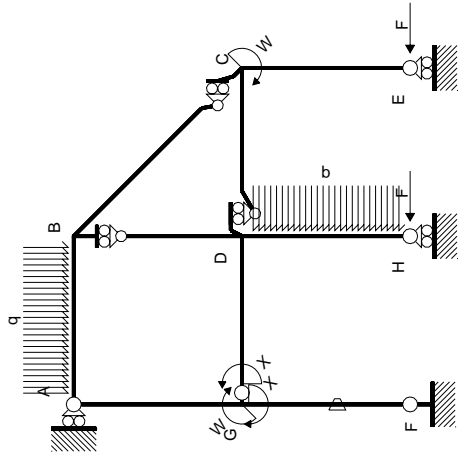
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$



- A = 1200. mm<sup>2</sup>
- J<sub>u</sub> = 368598. mm<sup>4</sup>
- J<sub>v</sub> = 131904. mm<sup>4</sup>
- y<sub>g</sub> = 34.22 mm
- T<sub>y</sub> = -2720. N
- M<sub>x</sub> = -2257600. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -34.22 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -209.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 12. mm
- v<sub>c</sub> = -22.22 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -136.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.881 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 136.3 N/mm<sup>2</sup>
- S = 6312. mm<sup>3</sup>

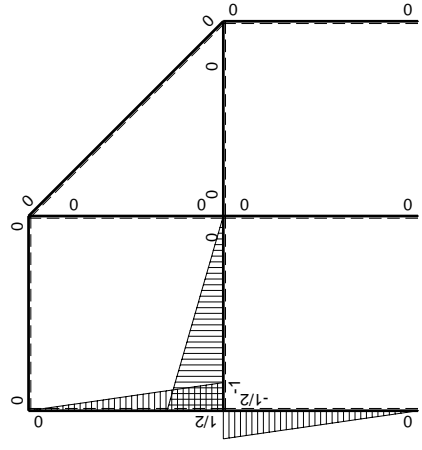






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	$-1/2x/b$	$-3/2Fx$	$-Fb/EJ$	$3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(1/4+1/4)Fb^2/EJ$	$1/12Xb/EJ$	
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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

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

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

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

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

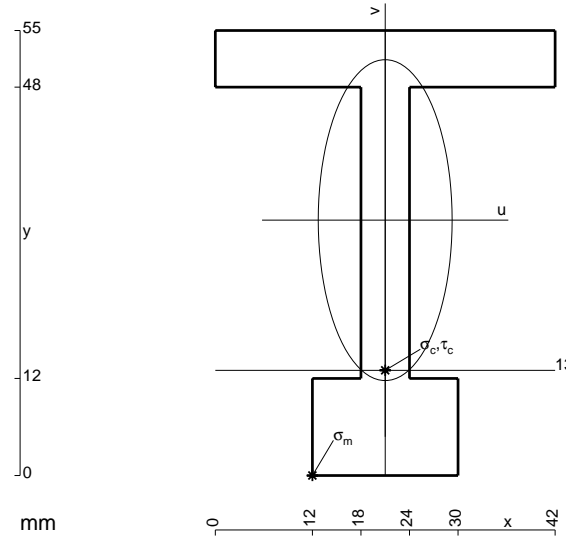
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

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

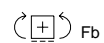
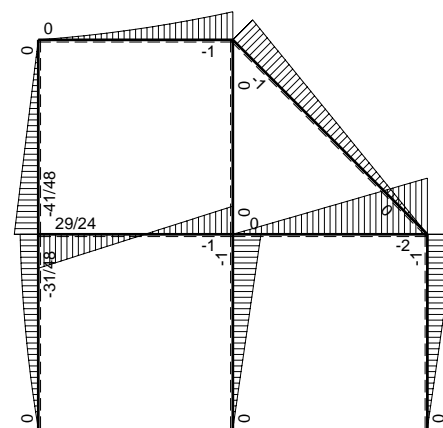
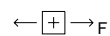
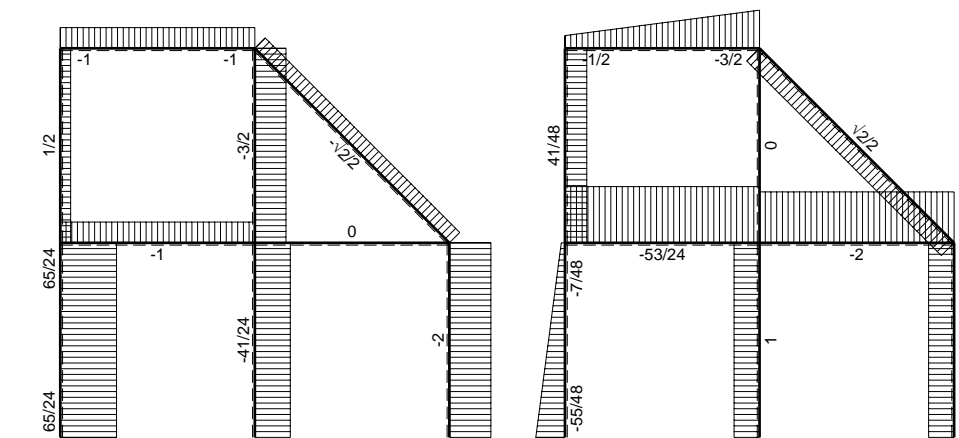
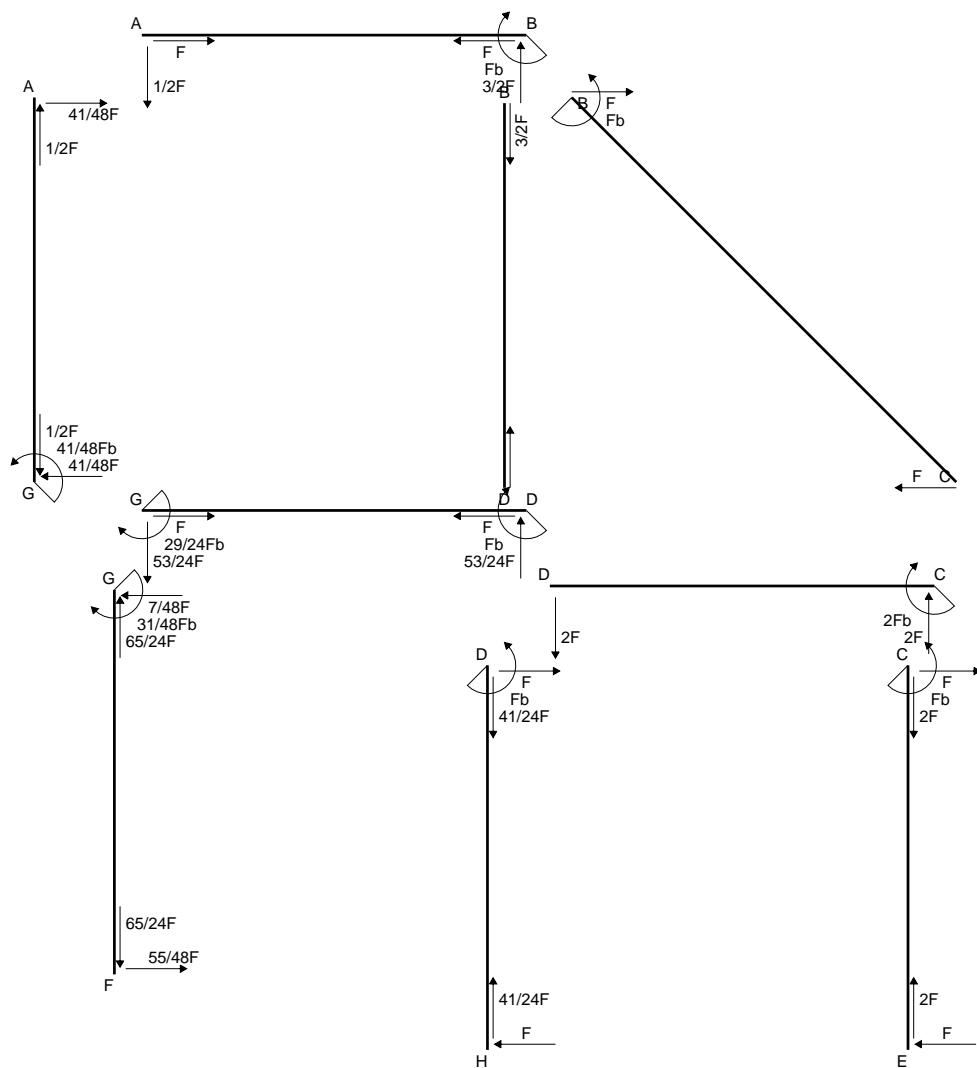
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

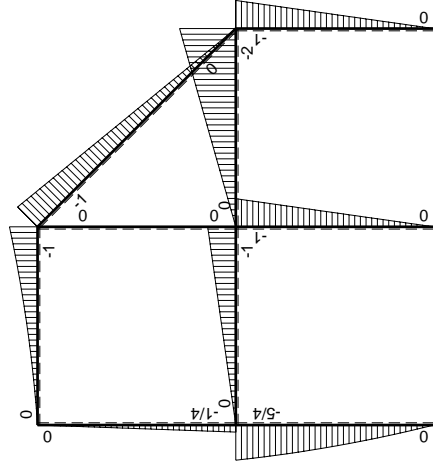
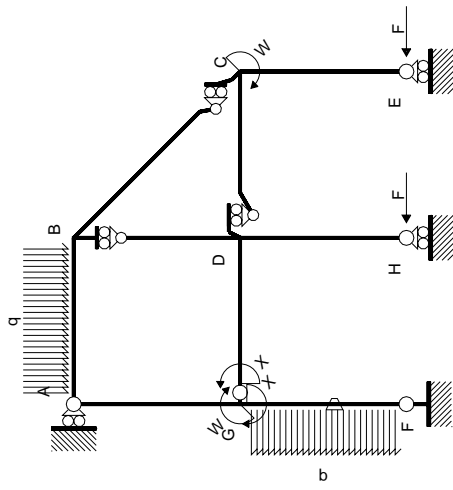
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

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



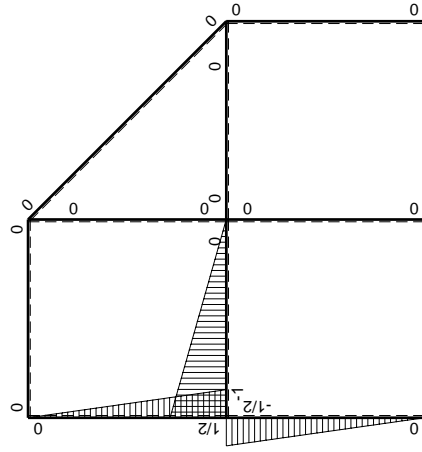
$A = 726. \text{ mm}^2$   
 $J_u = 285657. \text{ mm}^4$   
 $J_v = 49698. \text{ mm}^4$   
 $y_g = 31.57 \text{ mm}$   
 $T_y = -2260. \text{ N}$   
 $M_x = -1988800. \text{ Nmm}$   
 $x_m = 12. \text{ mm}$   
 $u_m = -9. \text{ mm}$   
 $v_m = -31.57 \text{ mm}$   
 $\sigma_m = -Mv/J_u = -219.8 \text{ N/mm}^2$   
 $x_c = 21. \text{ mm}$   
 $y_c = 13. \text{ mm}$   
 $v_c = -18.57 \text{ mm}$   
 $\sigma_c = -Mv/J_u = -129.3 \text{ N/mm}^2$   
 $\tau_c = 7.432 \text{ N/mm}^2$   
 $\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 129.9 \text{ N/mm}^2$   
 $S = 5637. \text{ mm}^3$





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

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

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

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

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

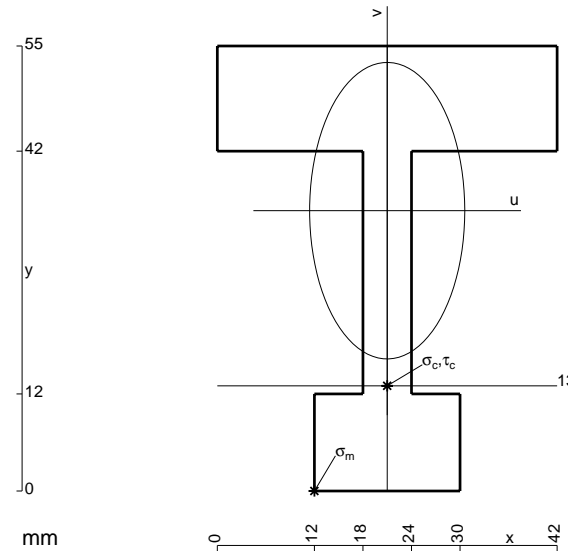
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

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

$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

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

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$



$$A = 942. \text{ mm}^2$$

$$J_u = 316348. \text{ mm}^4$$

$$J_v = 86634. \text{ mm}^4$$

$$y_g = 34.65 \text{ mm}$$

$$T_y = -2240. \text{ N}$$

$$M_x = -2083200. \text{ Nmm}$$

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

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

$$v_m = -34.65 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -228.2 \text{ N/mm}^2$$

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

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

$$v_c = -21.65 \text{ mm}$$

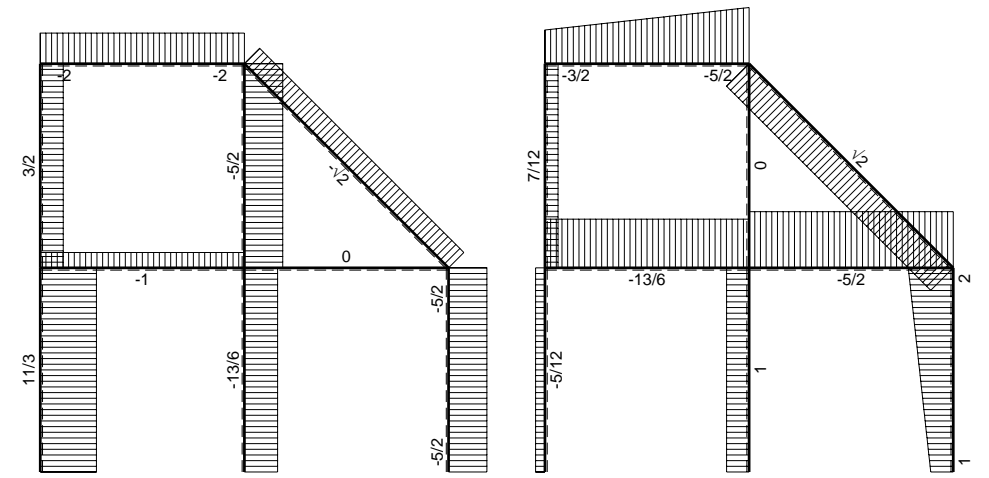
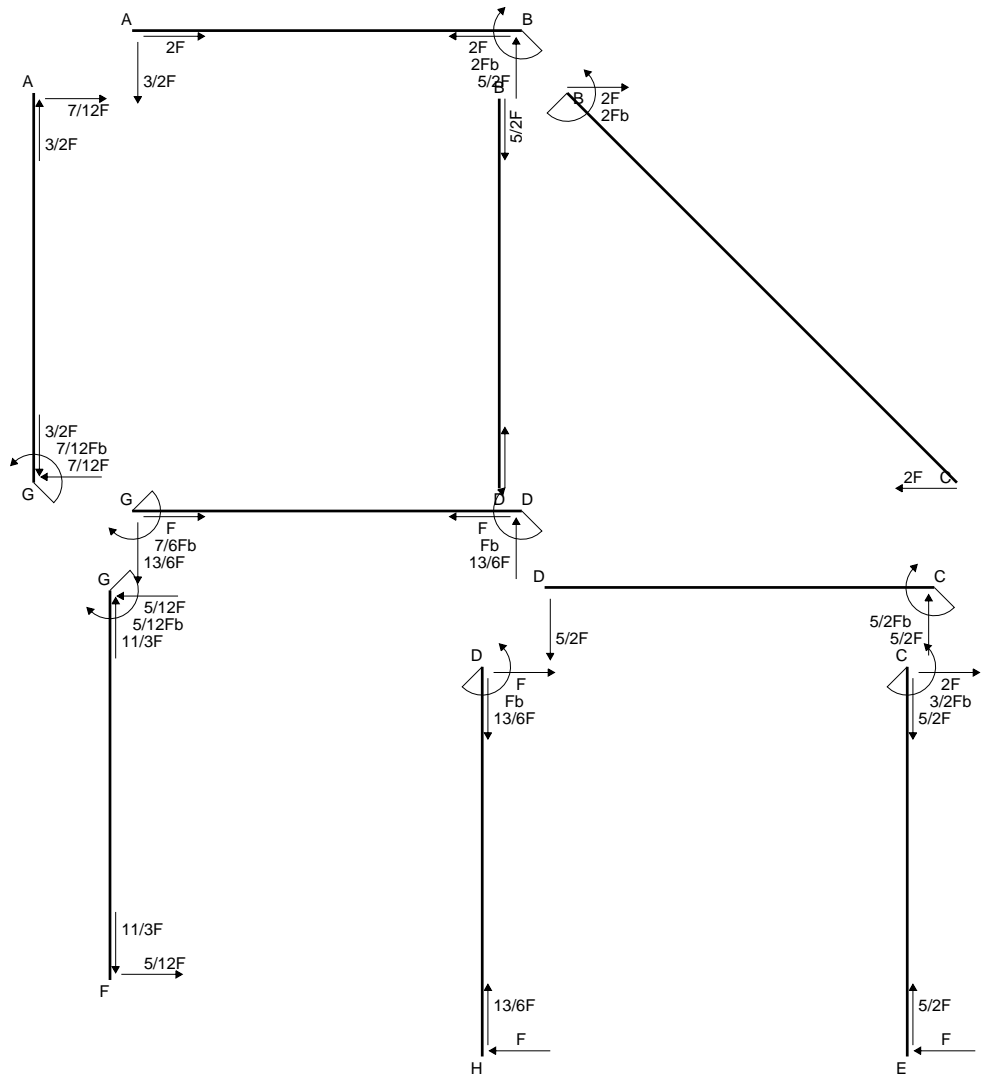
$$\sigma_c = -Mv/J_u = -142.5 \text{ N/mm}^2$$

$$\tau_c = 7.459 \text{ N/mm}^2$$

$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 143.1 \text{ N/mm}^2$$

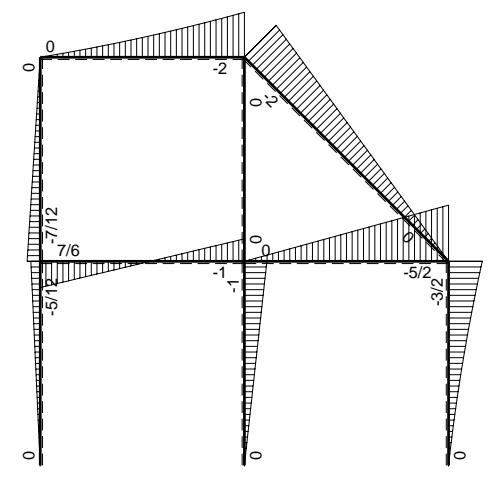
$$S = 6321. \text{ mm}^3$$



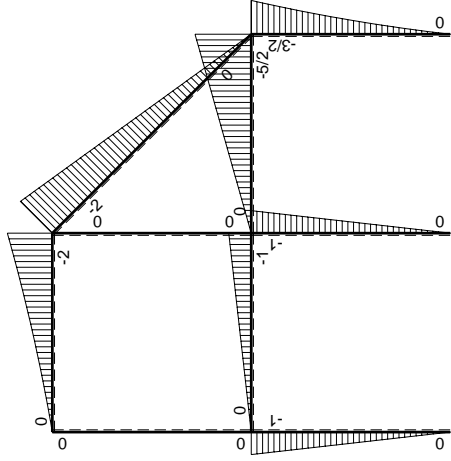
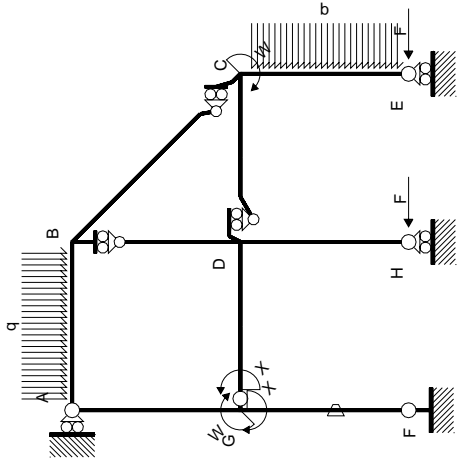


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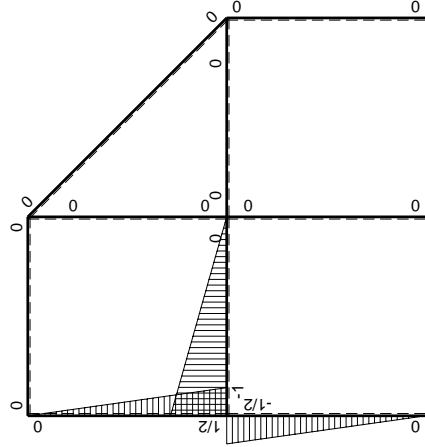


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica X=1

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

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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	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	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	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	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	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

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

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

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

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

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

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

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

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

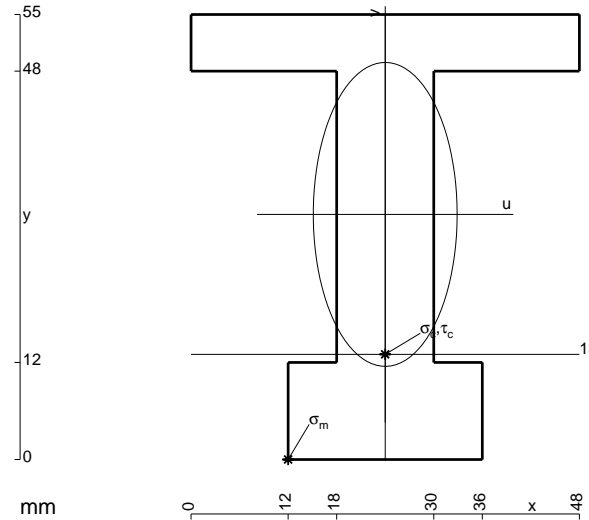
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

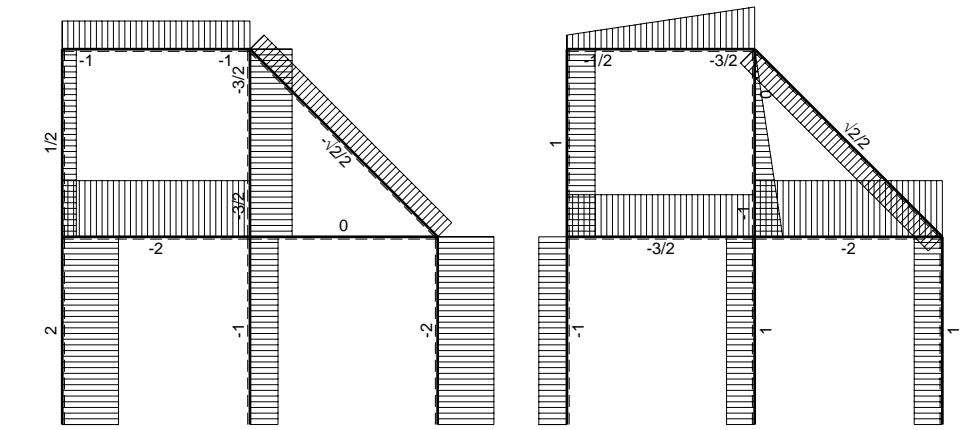
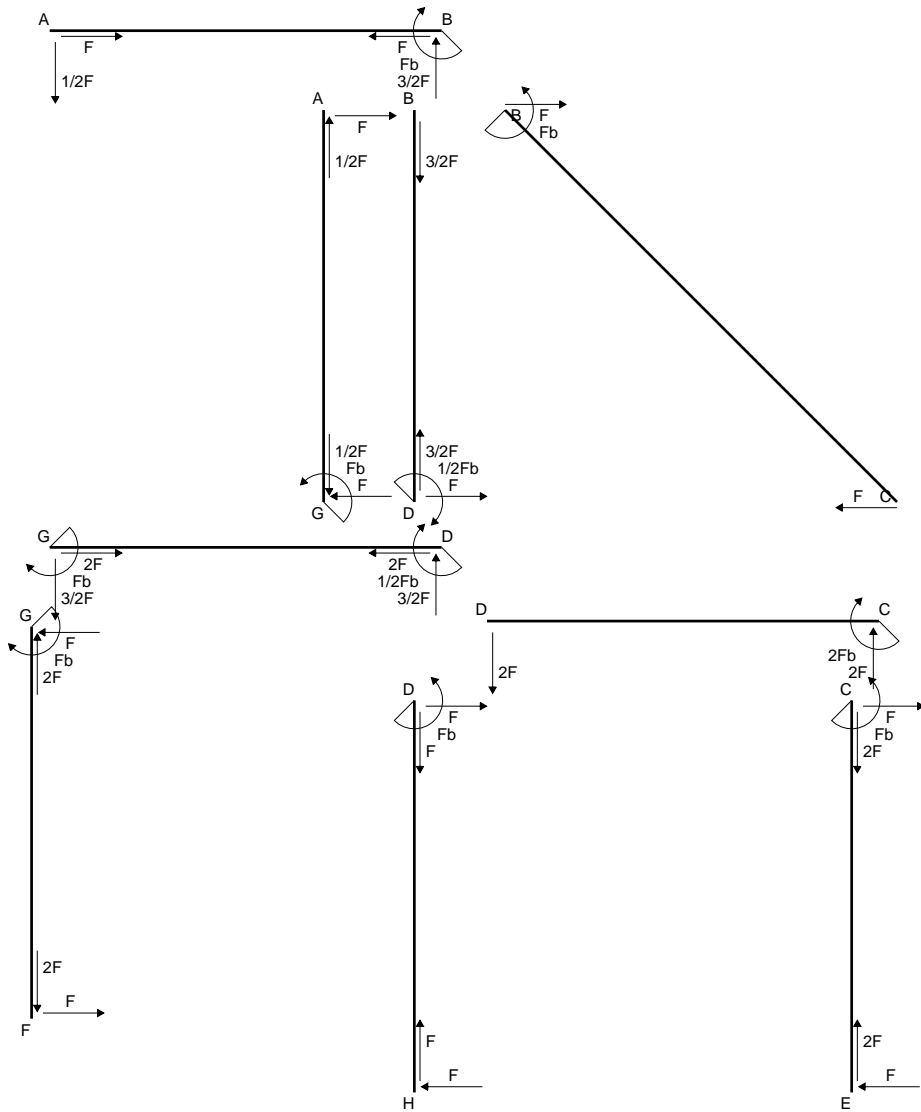
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

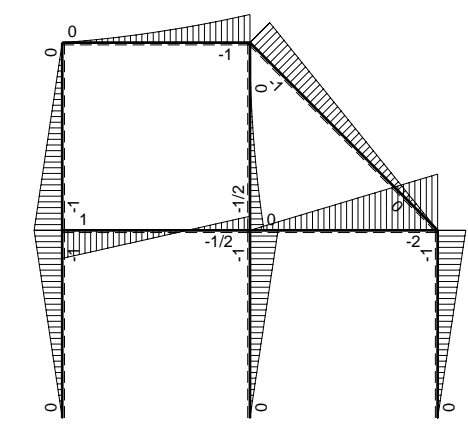


- A = 1056. mm<sup>2</sup>
- J<sub>u</sub> = 372596. mm<sup>4</sup>
- J<sub>v</sub> = 83520. mm<sup>4</sup>
- y<sub>g</sub> = 30.3 mm
- T<sub>y</sub> = -3000. N
- M<sub>x</sub> = -2940000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -30.3 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239. N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -17.3 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -136.5 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.838 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 136.7 N/mm<sup>2</sup>
- S = 7211. mm<sup>3</sup>

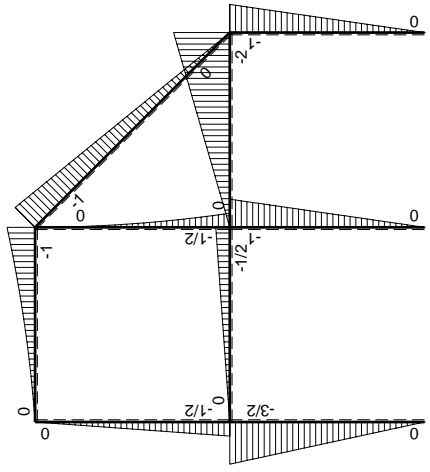
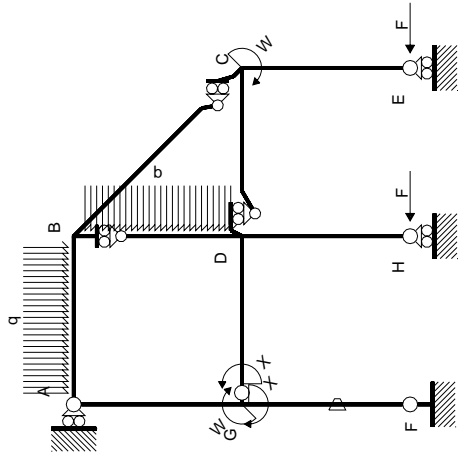


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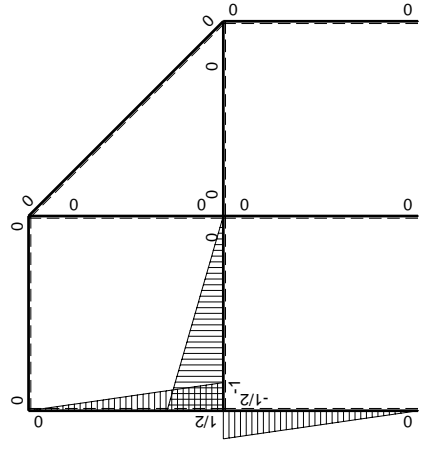


⊕ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/4 - 3/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/4 b - 3/4 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

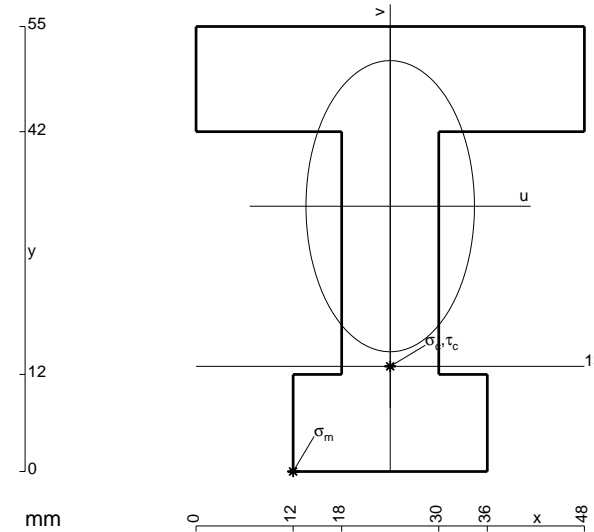
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

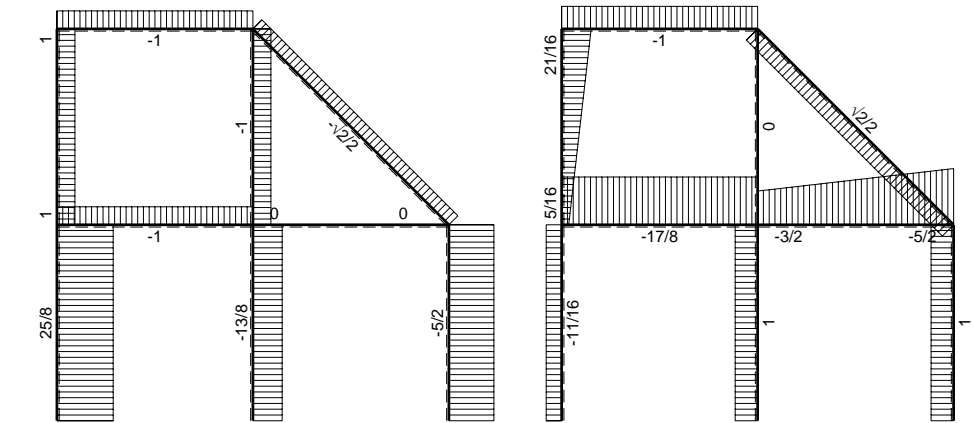
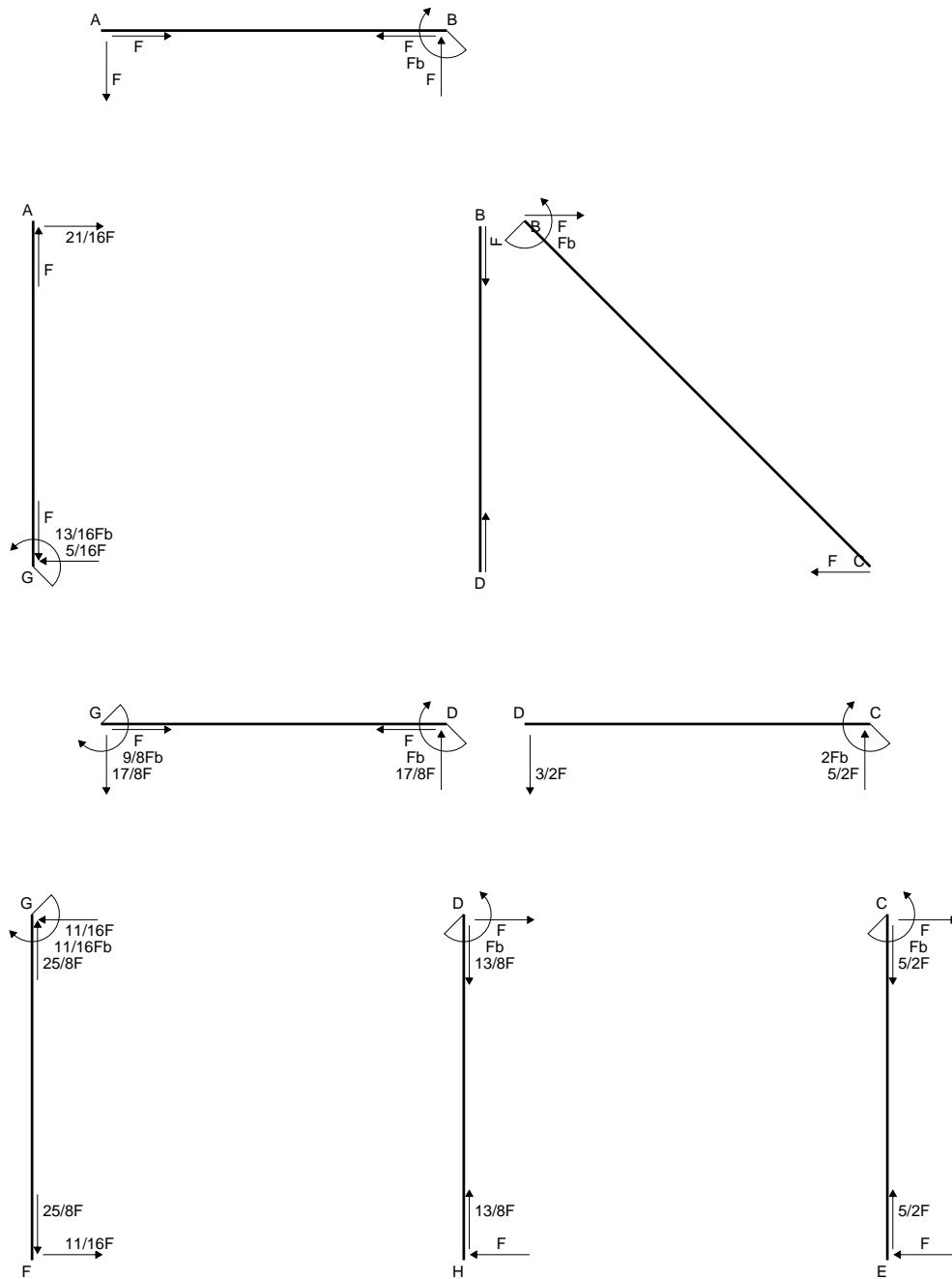
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



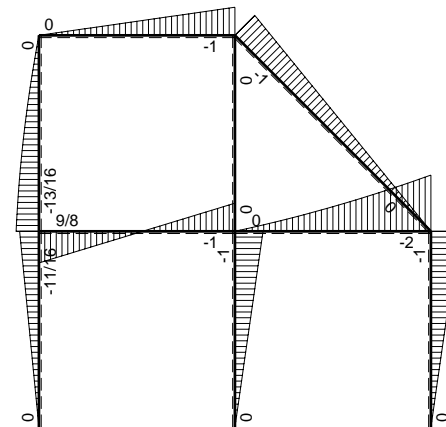
- A = 1272. mm<sup>2</sup>
- J<sub>u</sub> = 412017. mm<sup>4</sup>
- J<sub>v</sub> = 137952. mm<sup>4</sup>
- y<sub>g</sub> = 32.79 mm
- T<sub>y</sub> = -4820. N
- M<sub>x</sub> = -2506400. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -32.79 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -199.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -19.79 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -120.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.76 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 121.2 N/mm<sup>2</sup>
- S = 7960. mm<sup>3</sup>



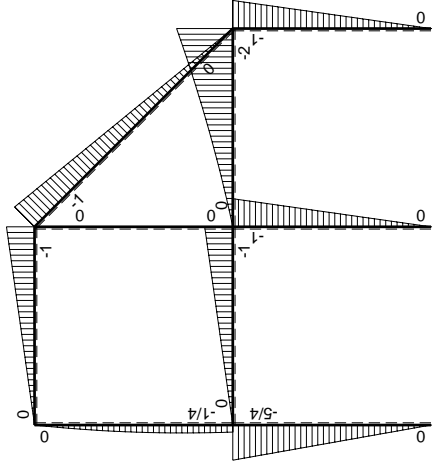
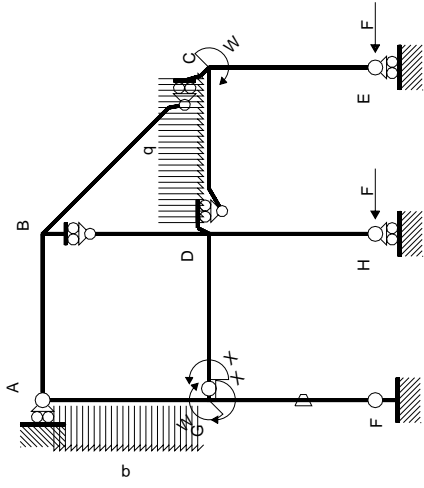


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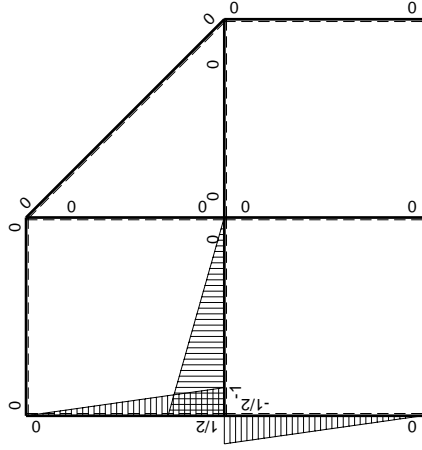


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(5/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx <sup>2</sup>	0	-1/8Fb+3/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx <sup>2</sup>	0	-3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						9/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (5/8 - 5/4 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [5/8 x - 5/8 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (5/8 b - 5/8 b + 5/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 11/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

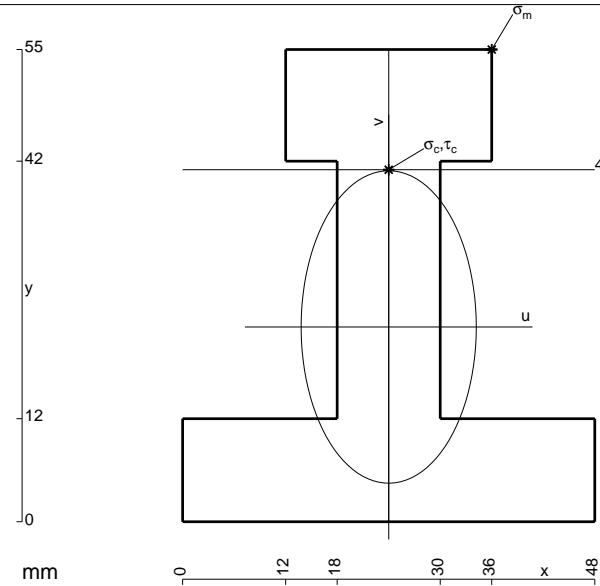
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 3/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x + 1/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



$$A = 1248. \text{ mm}^2$$

$$J_u = 413282. \text{ mm}^4$$

$$J_v = 129888. \text{ mm}^4$$

$$y_g = 22.68 \text{ mm}$$

$$T_y = -5875. \text{ N}$$

$$M_x = -2679000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 32.32 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.5 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

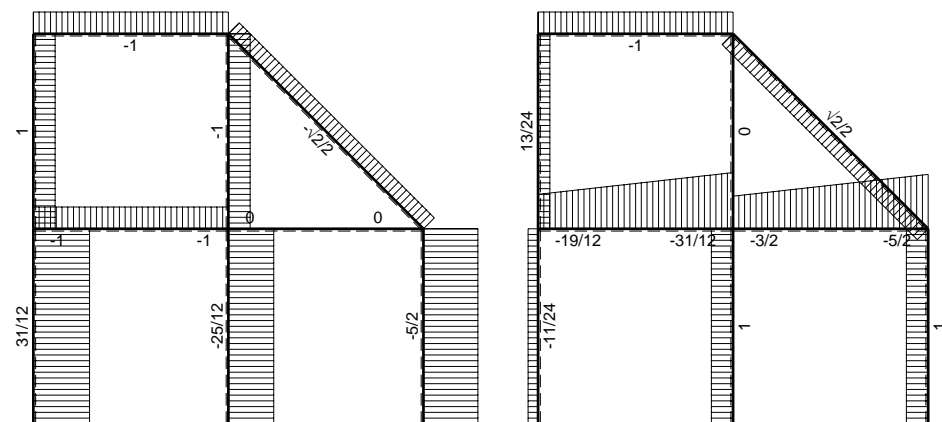
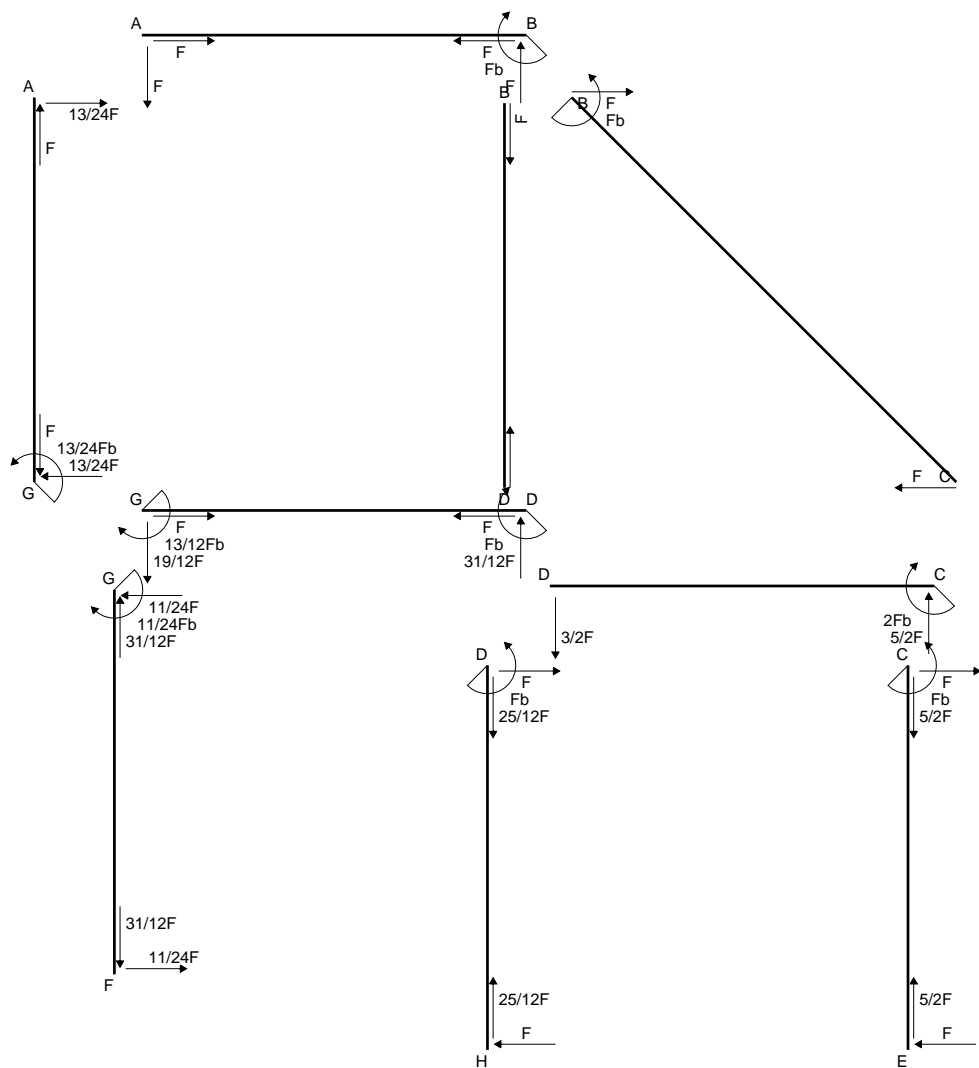
$$v_c = 18.32 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 118.7 \text{ N/mm}^2$$

$$\tau_c = 9.81 \text{ N/mm}^2$$

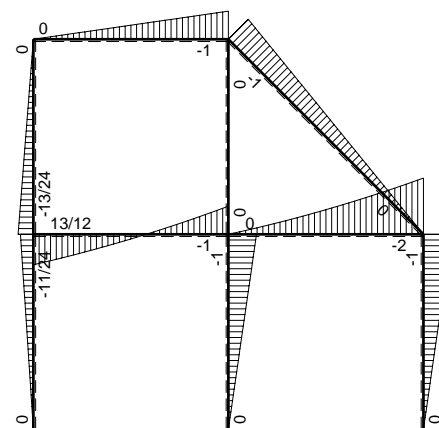
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 119.9 \text{ N/mm}^2$$

$$S = 8281. \text{ mm}^3$$

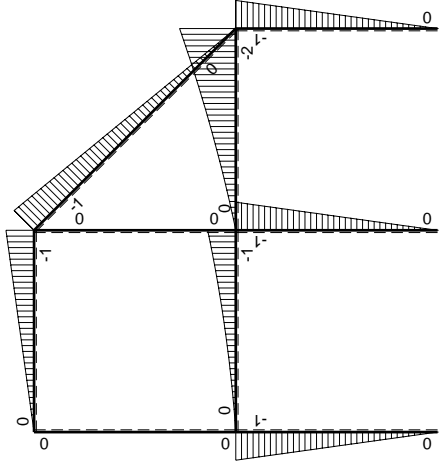
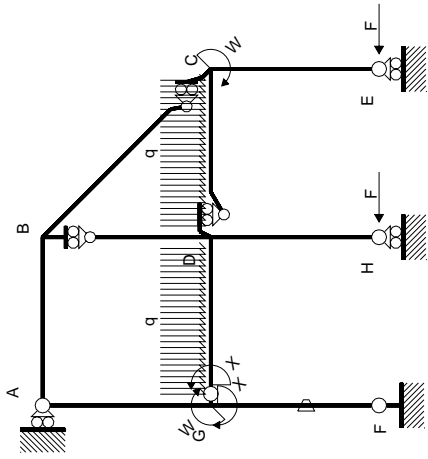


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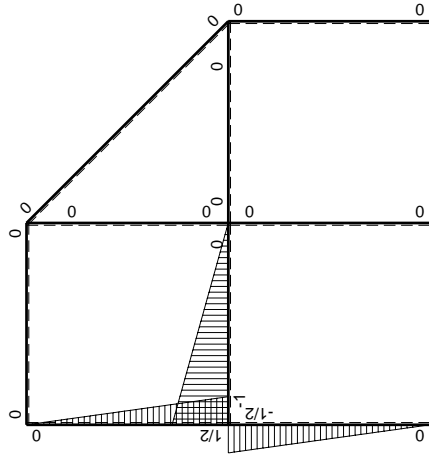


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	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 <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b <sup>2</sup>	0+0	1/12Xb/EJ	
AG b	-1/2x/b	0	0	0	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							13/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

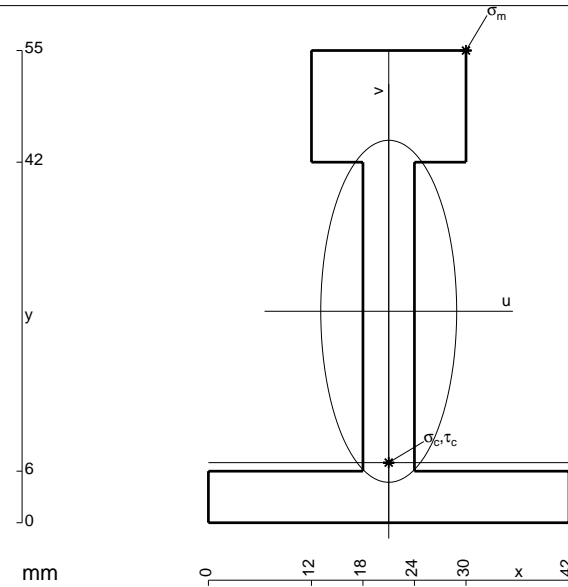
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

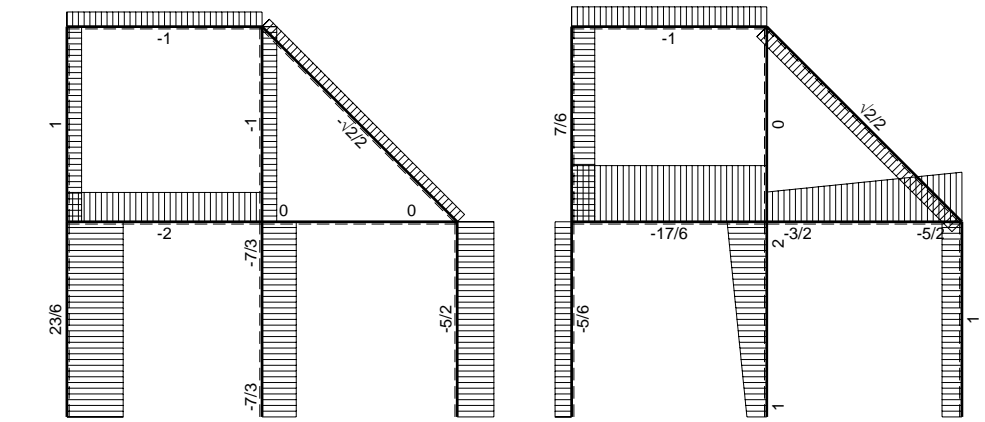
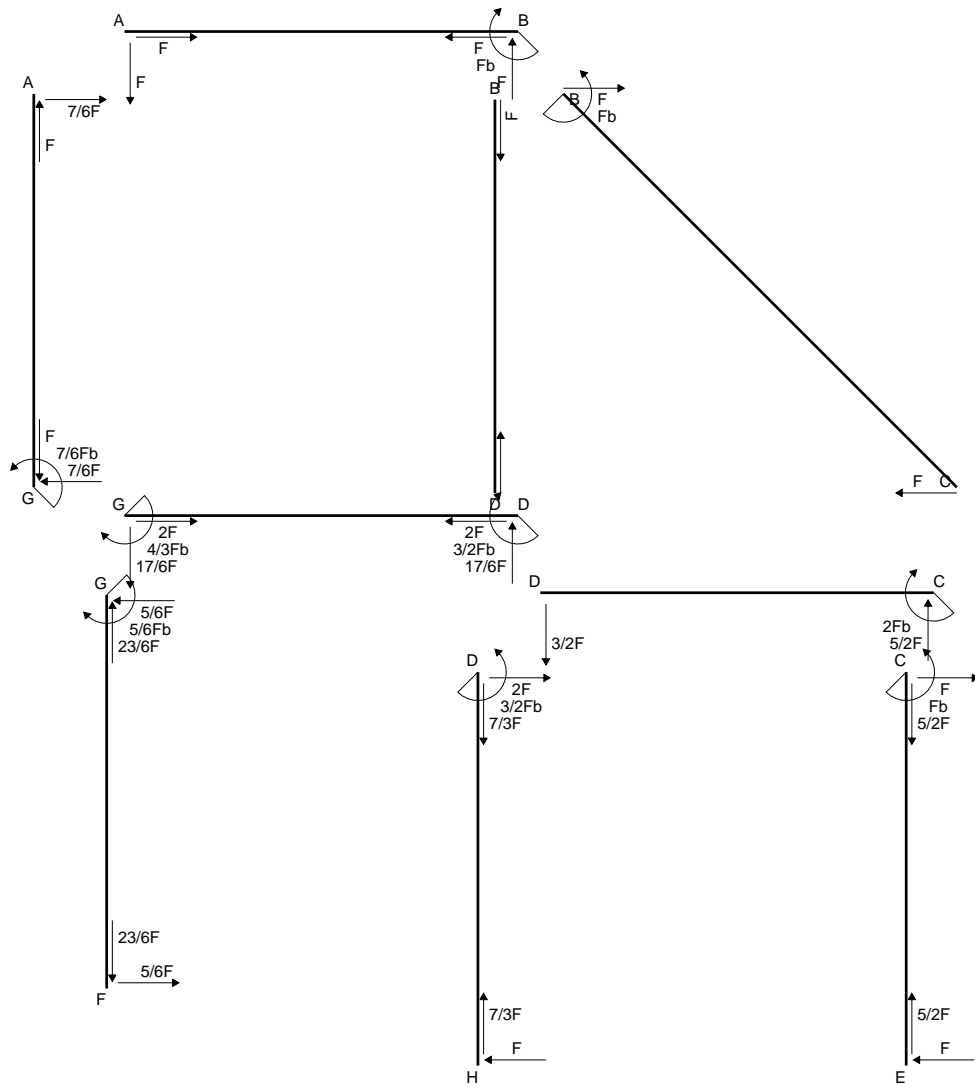
$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$



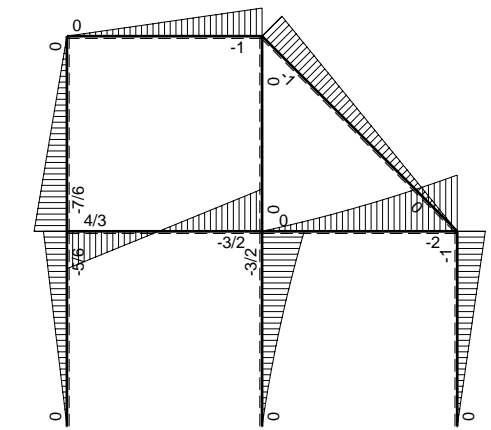
- A = 702. mm<sup>2</sup>
- J<sub>u</sub> = 278693. mm<sup>4</sup>
- J<sub>v</sub> = 44010. mm<sup>4</sup>
- y<sub>g</sub> = 24.63 mm
- T<sub>y</sub> = -4050. N
- M<sub>x</sub> = -2008800. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 30.37 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 218.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -17.63 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -127.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 13.46 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 129.2 N/mm<sup>2</sup>
- S = 5559. mm<sup>3</sup>



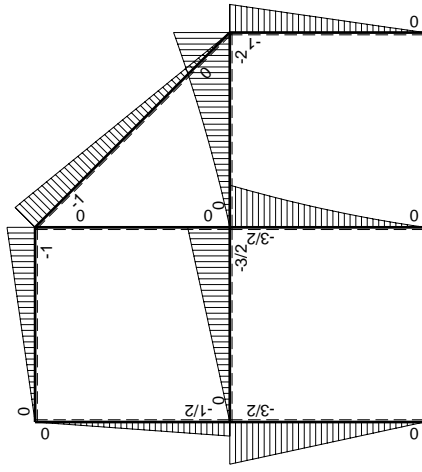
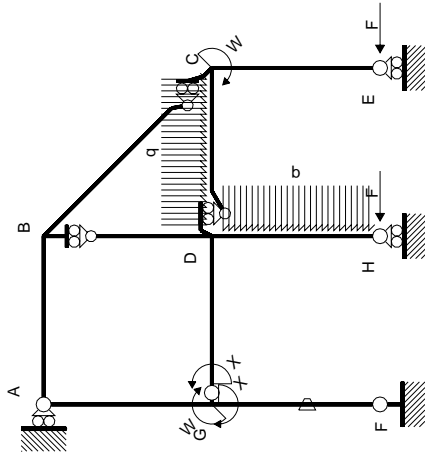


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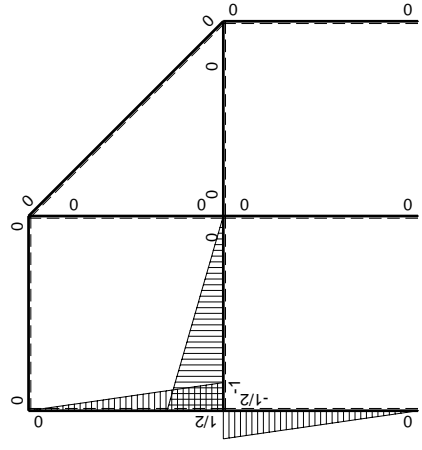


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							2/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-4/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/4 - 3/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/4 b - 3/4 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

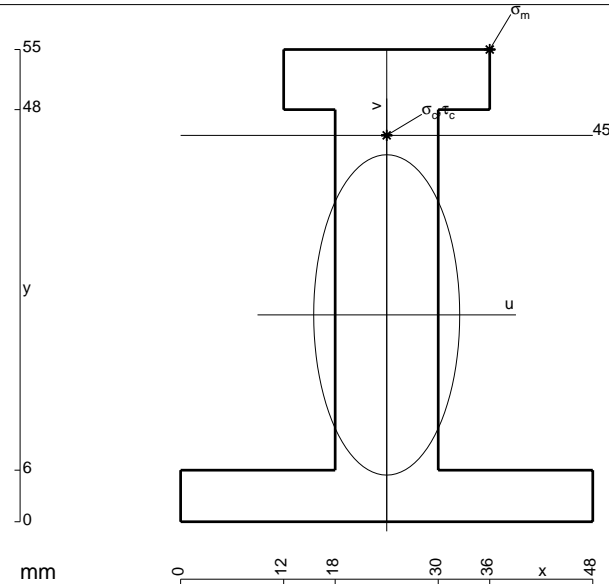
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

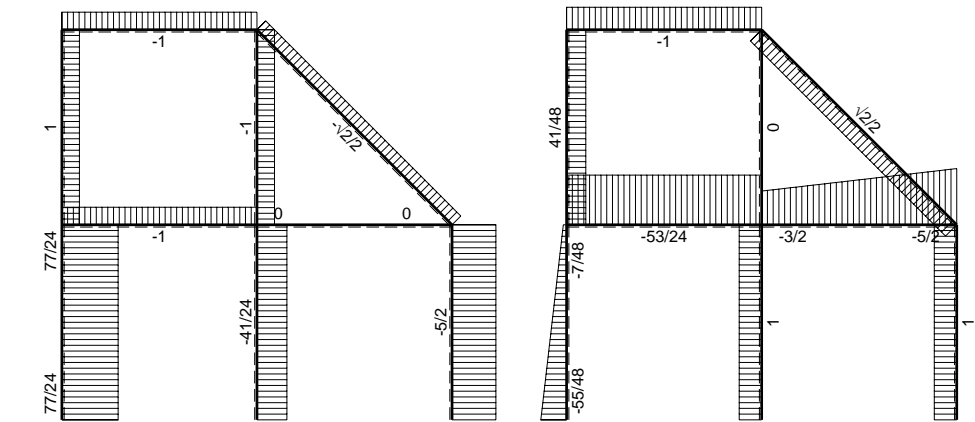
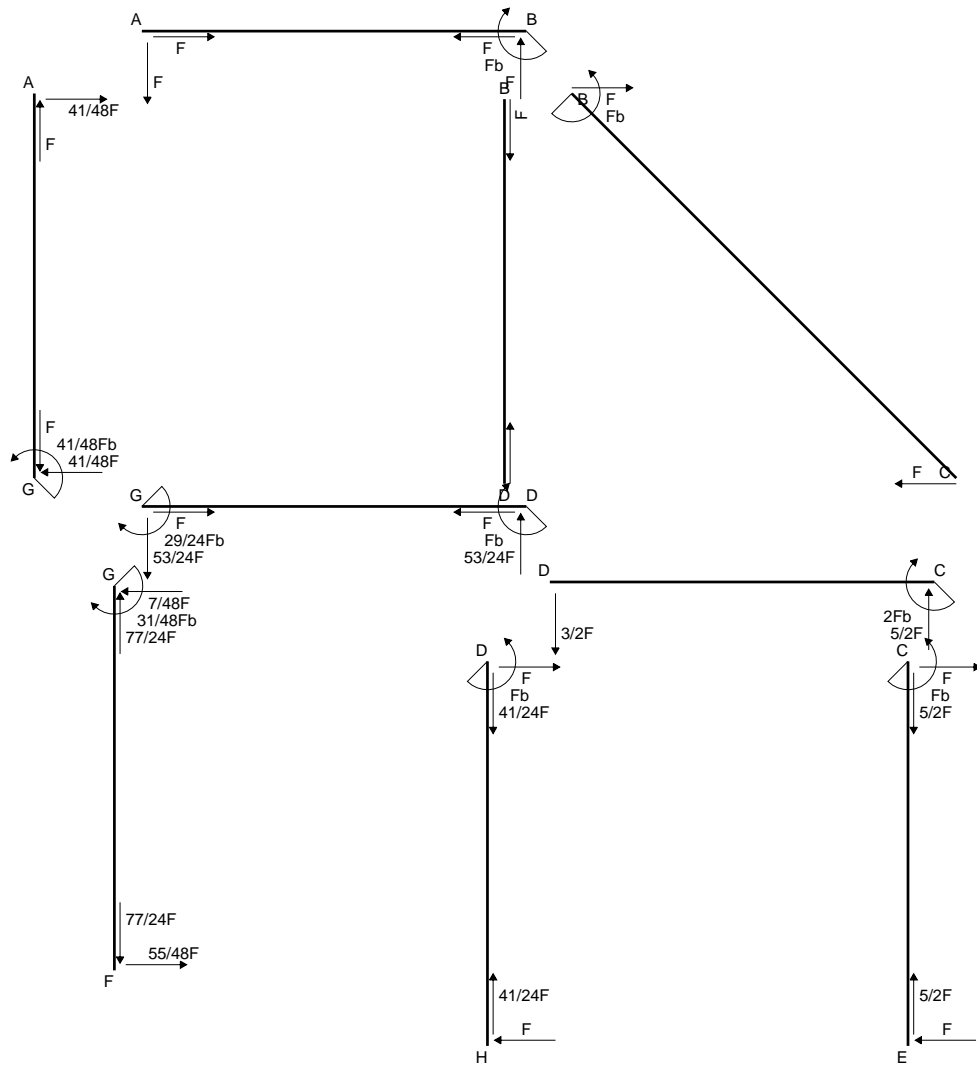
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

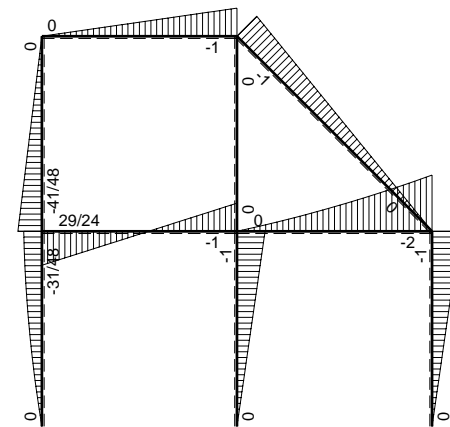


- A = 960. mm<sup>2</sup>
- J<sub>u</sub> = 334225. mm<sup>4</sup>
- J<sub>v</sub> = 69408. mm<sup>4</sup>
- y<sub>g</sub> = 24.09 mm
- T<sub>y</sub> = -4625. N
- M<sub>x</sub> = -2479000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 30.91 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 229.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 45. mm
- v<sub>c</sub> = 20.91 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 155.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.241 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 155.5 N/mm<sup>2</sup>
- S = 5412. mm<sup>3</sup>

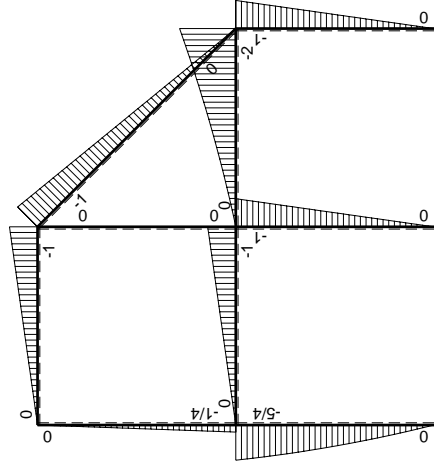
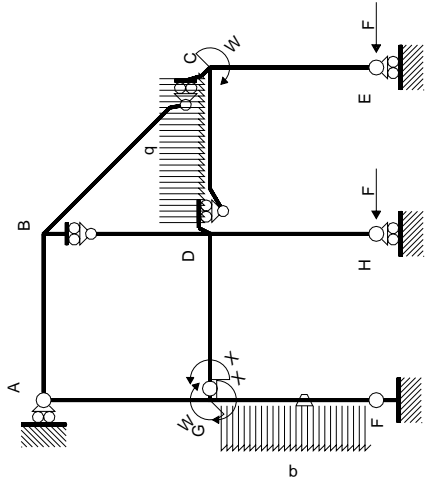


← ⊕ → F

↑ ⊕ ↓ F

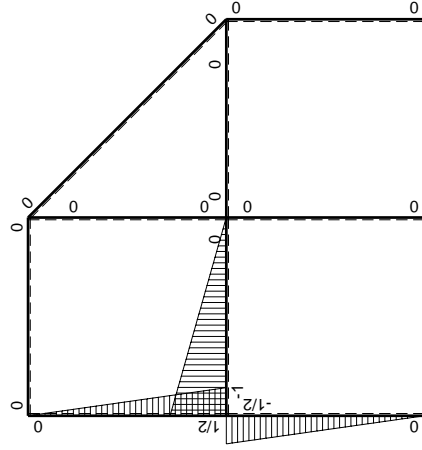


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(11/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	5/8Fb-Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						29/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-29/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (5/8 - x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [5/8 x - 1/2 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (5/8 b - 1/2 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

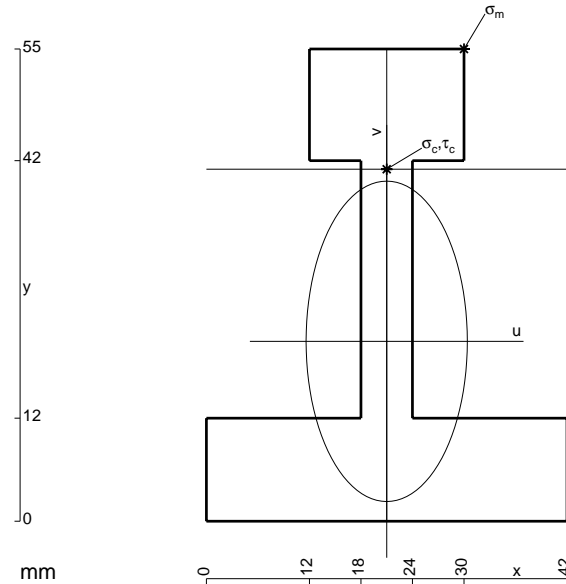
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 1/4 x/b - 1/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x + 1/8 x^2/b - 1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

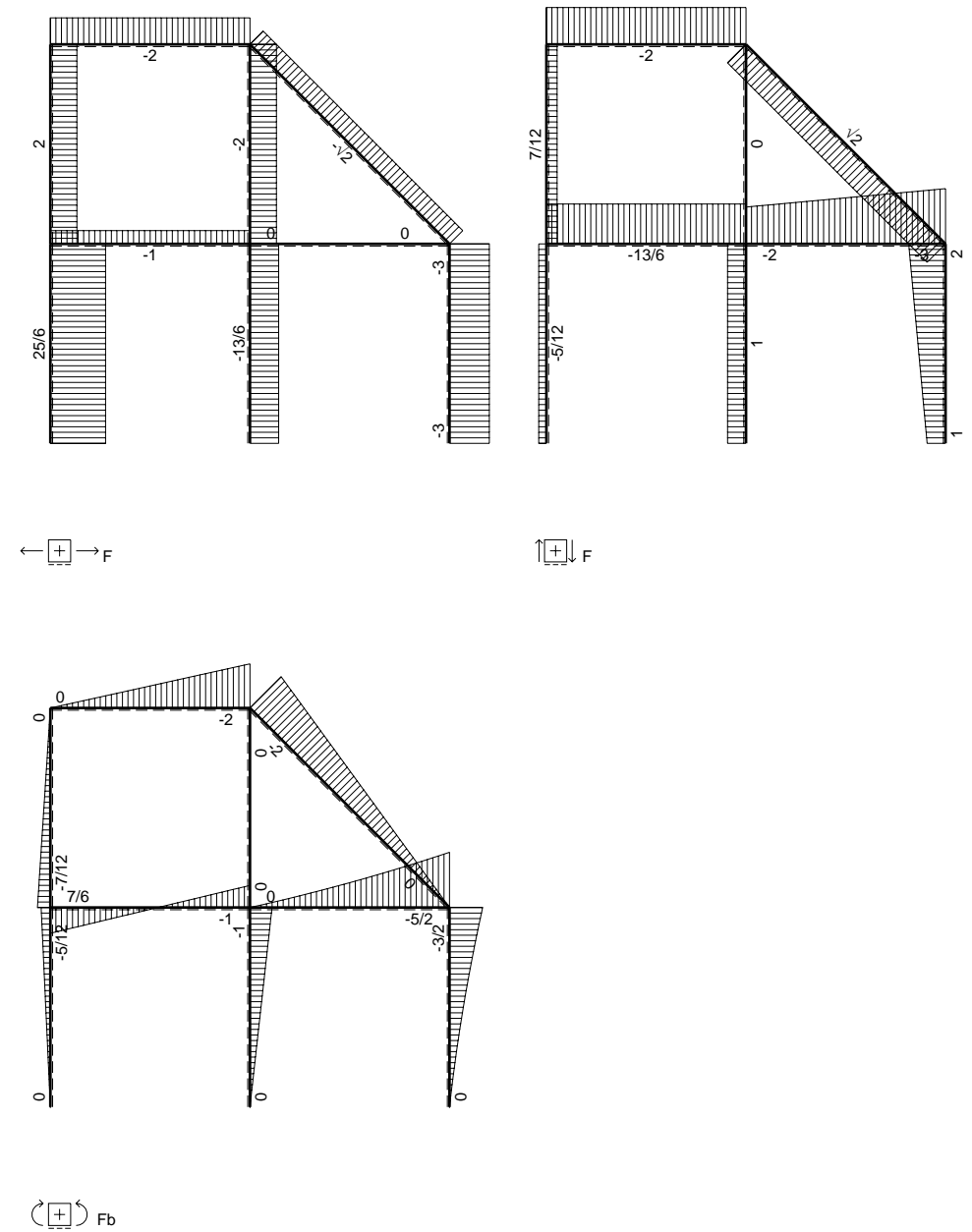
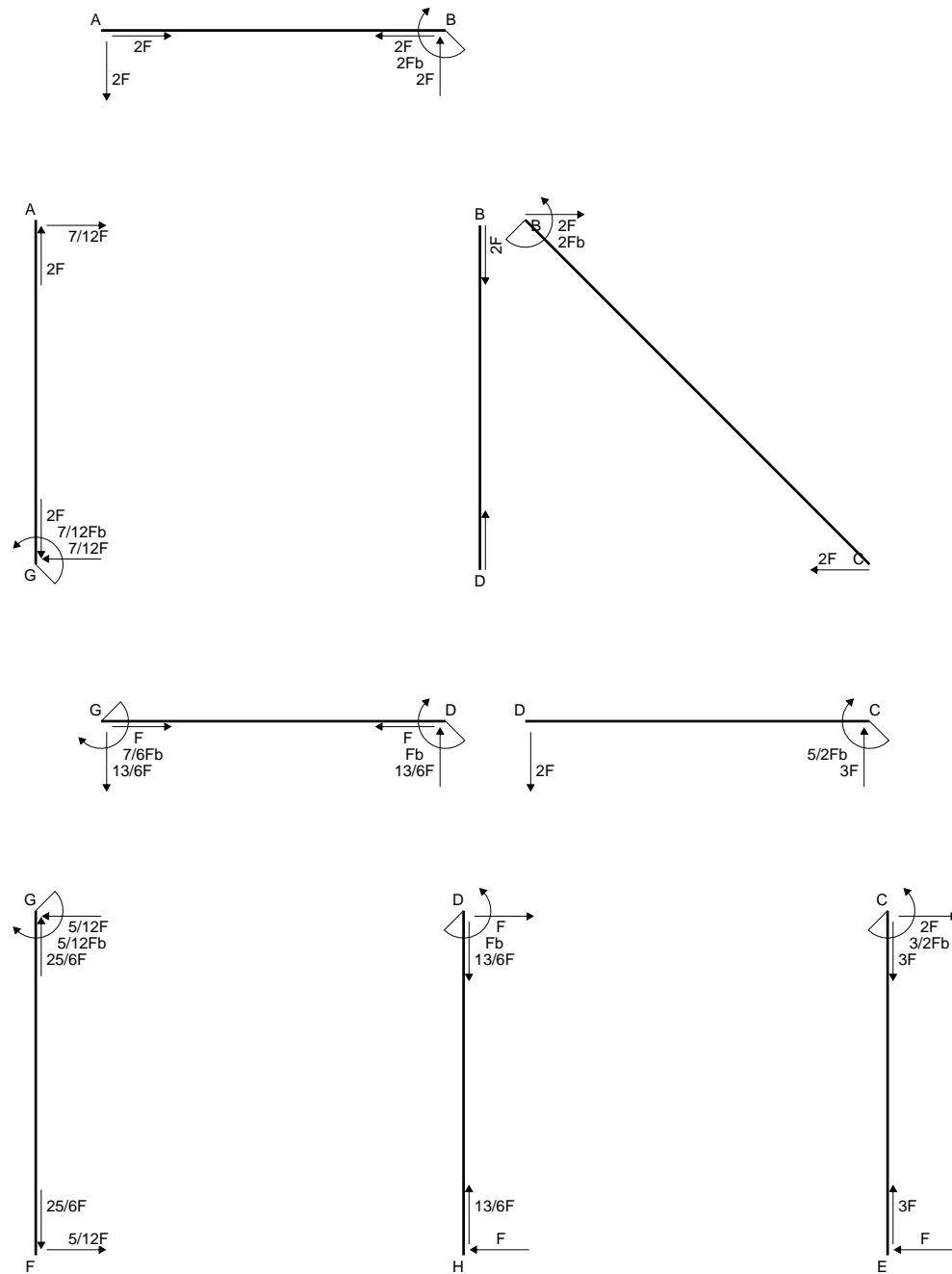
$$L_{AG}^{xo} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

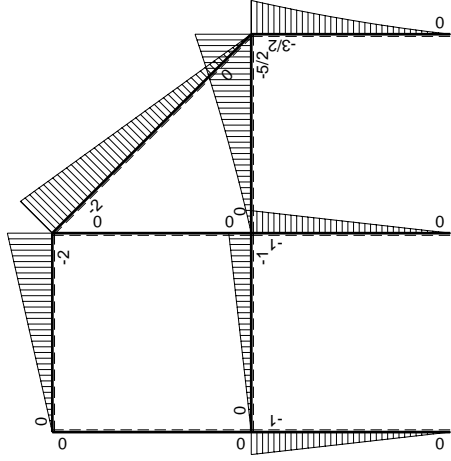
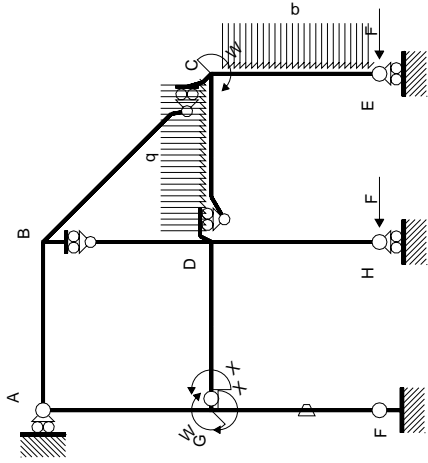
$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$



- A = 918. mm<sup>2</sup>
- J<sub>u</sub> = 319684. mm<sup>4</sup>
- J<sub>v</sub> = 80946. mm<sup>4</sup>
- y<sub>g</sub> = 20.95 mm
- T<sub>y</sub> = -3900. N
- M<sub>x</sub> = -2246400. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 34.05 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 239.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 20.05 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 140.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 13.36 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 142.8 N/mm<sup>2</sup>
- S = 6570. mm<sup>3</sup>

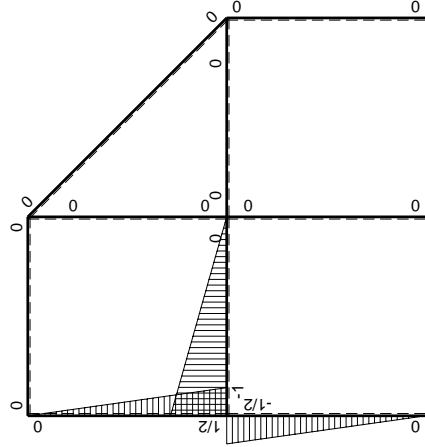






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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 <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	5/2Fb-3Fx+1/2qx <sup>2</sup>	0	0	0	0		
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b <sup>2</sup>	0+0	1/12Xb/EJ
AG b	-1/2x/b	0	0	0	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

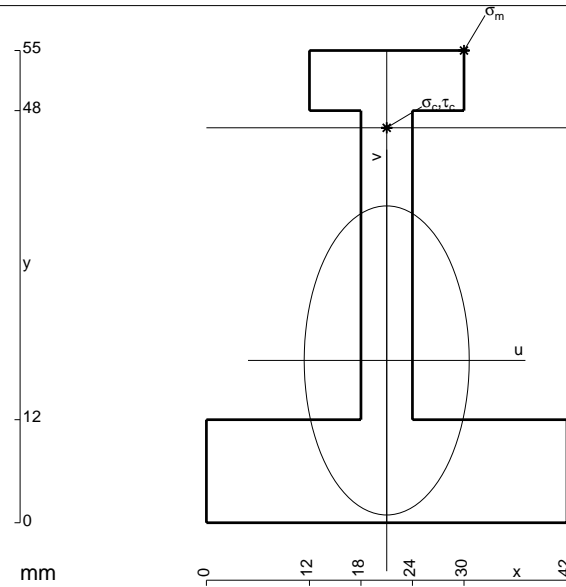
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

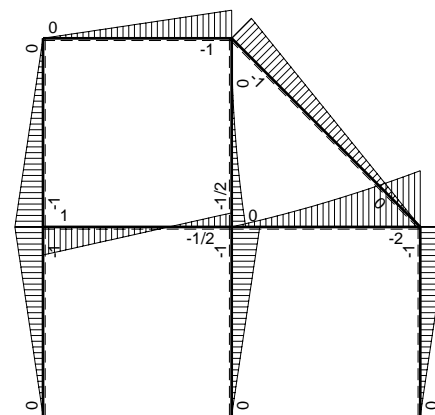
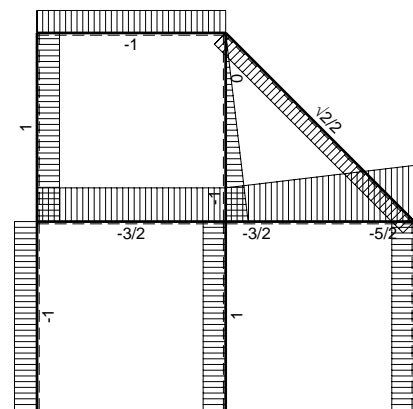
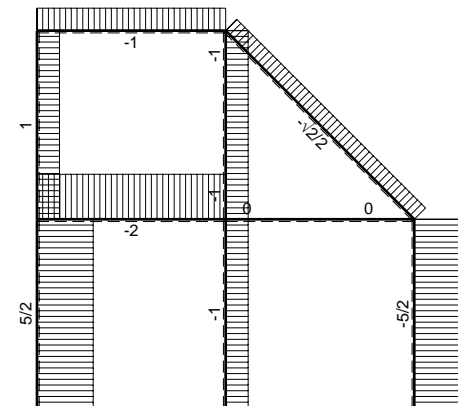
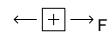
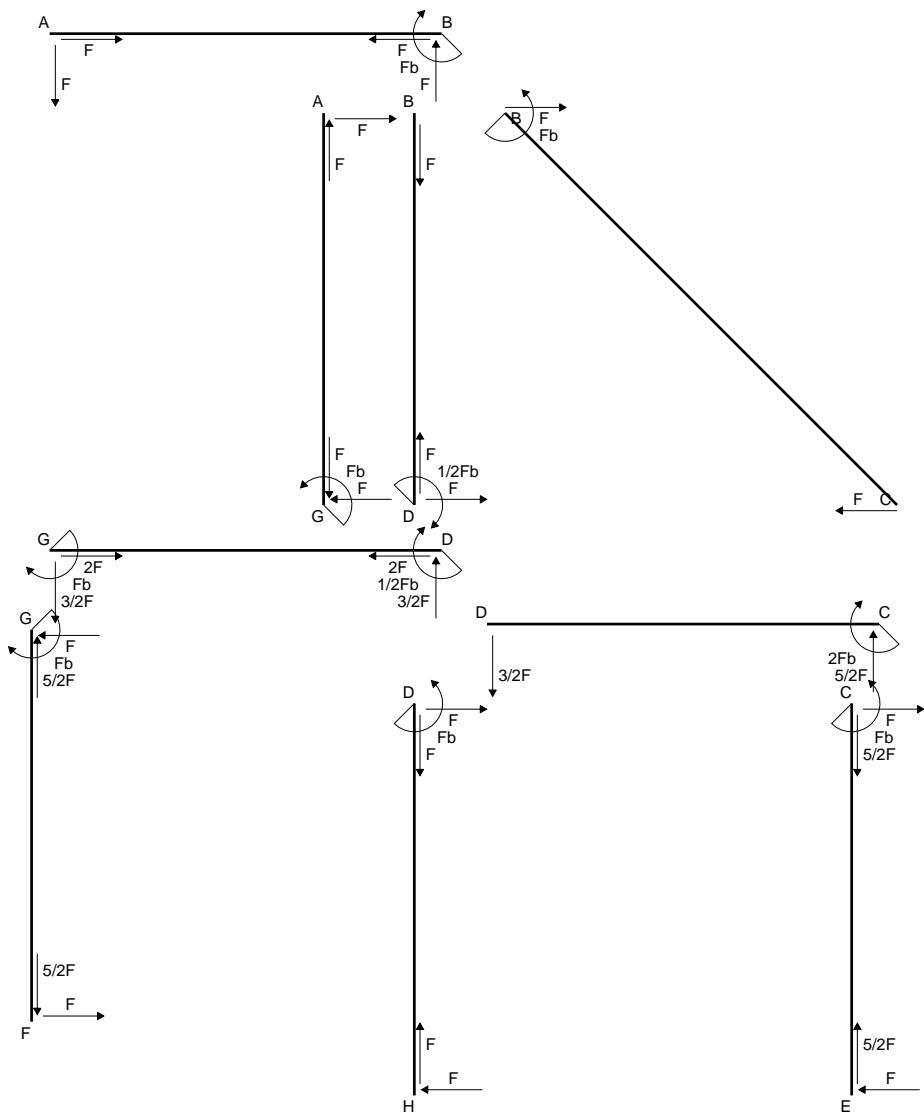
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

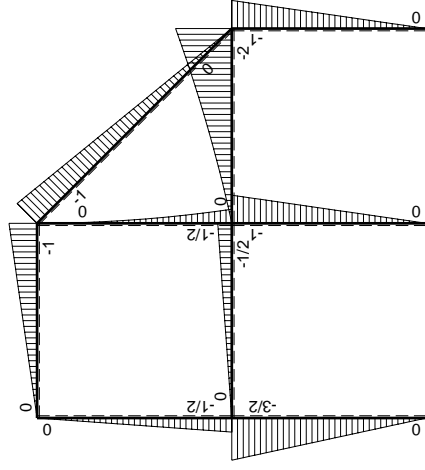
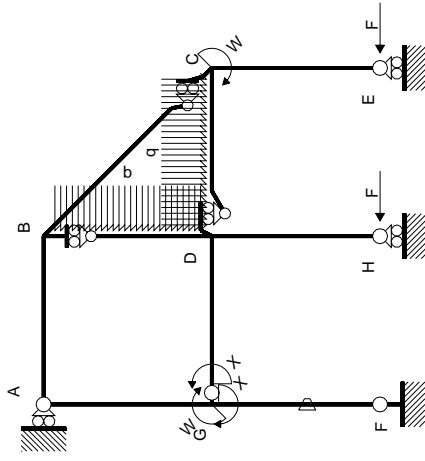
$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$



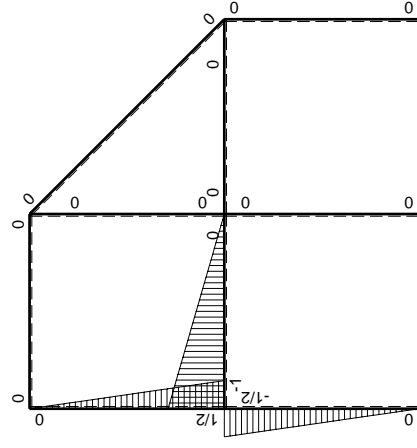
- A = 846. mm<sup>2</sup>
- J<sub>u</sub> = 274282. mm<sup>4</sup>
- J<sub>v</sub> = 78138. mm<sup>4</sup>
- y<sub>g</sub> = 18.9 mm
- T<sub>y</sub> = -2310. N
- M<sub>x</sub> = -1501500. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 36.1 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 197.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 46. mm
- v<sub>c</sub> = 27.1 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 148.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.238 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 148.7 N/mm<sup>2</sup>
- S = 4444. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0+0	0
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0+0	0
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
	totali						1/2Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/4 - 3/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/4 b - 3/4 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

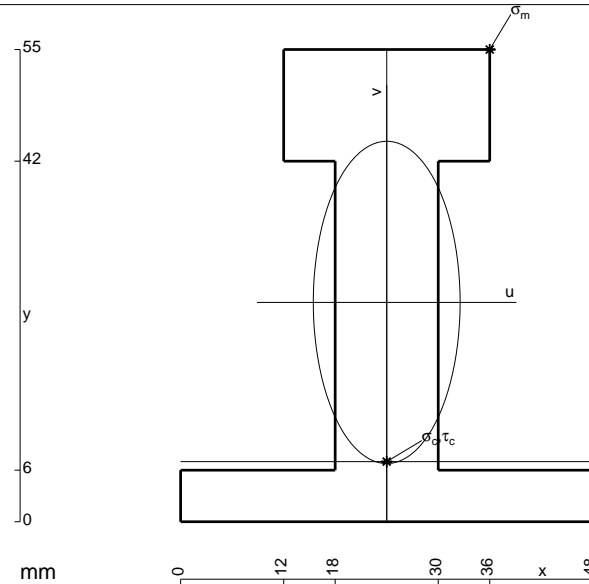
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

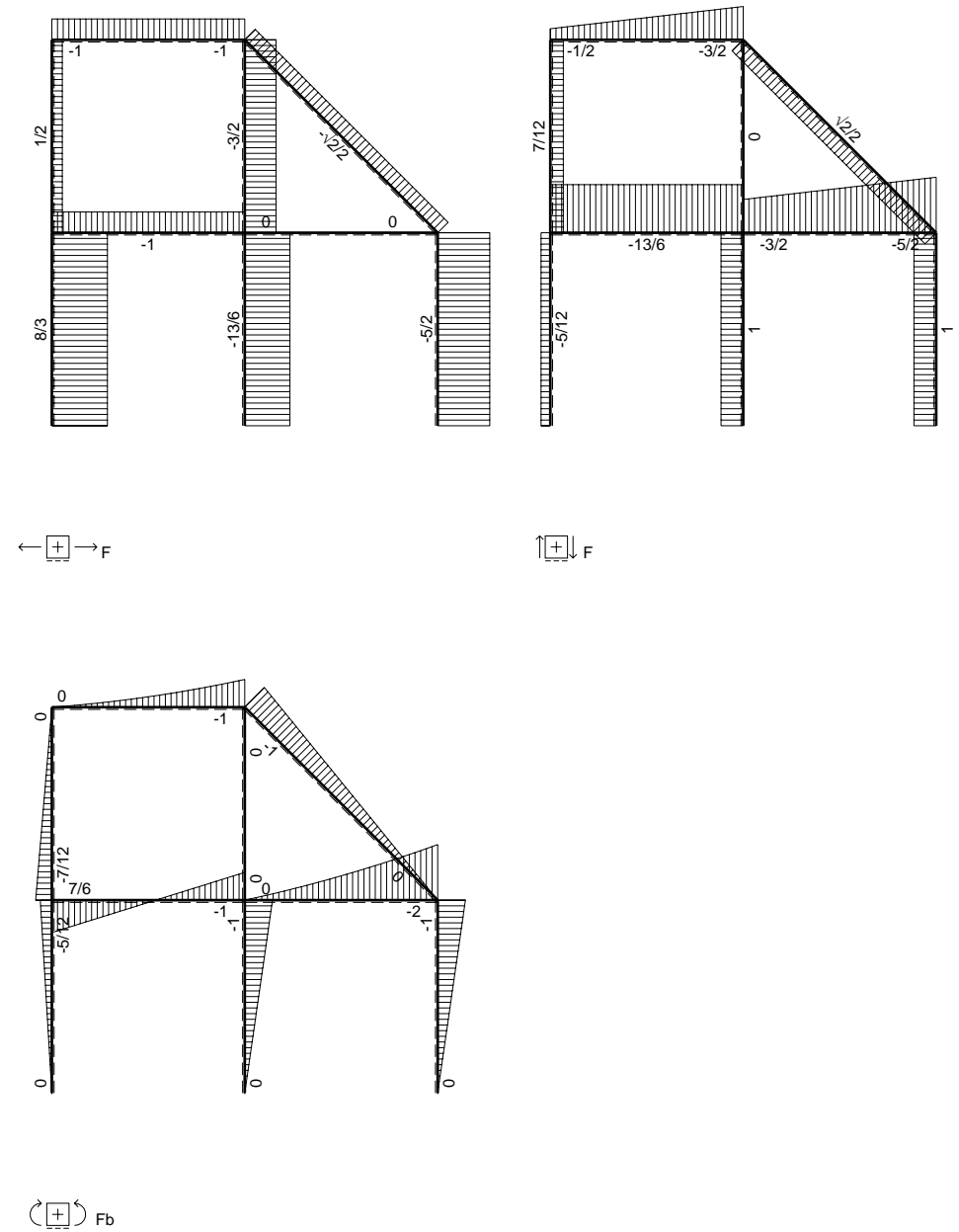
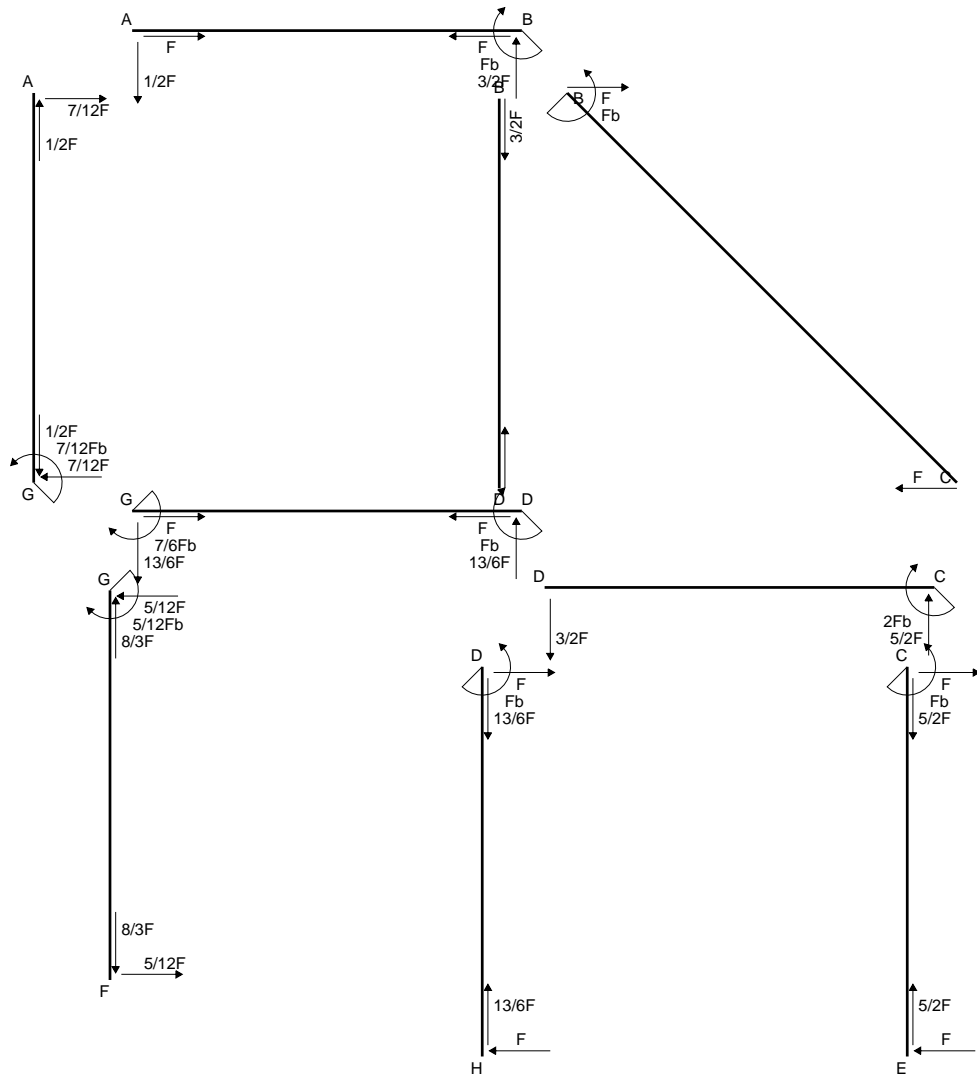
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

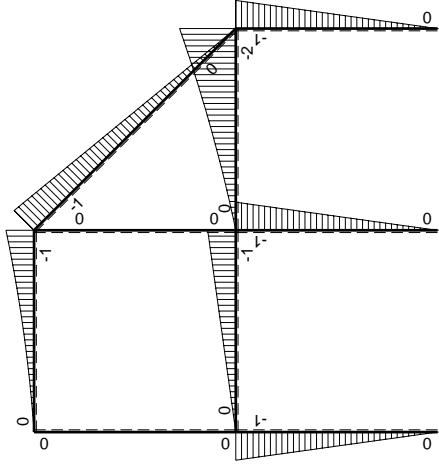
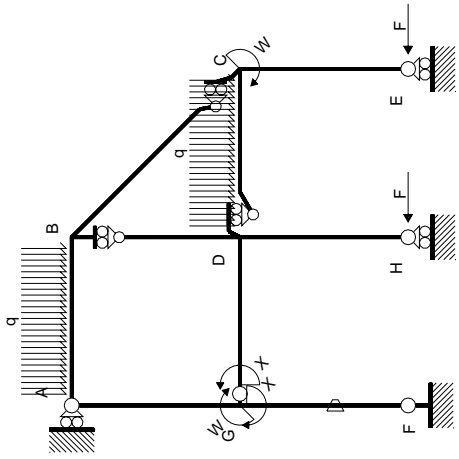
$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



- A = 1032. mm<sup>2</sup>
- J<sub>u</sub> = 363732. mm<sup>4</sup>
- J<sub>v</sub> = 75456. mm<sup>4</sup>
- y<sub>g</sub> = 25.55 mm
- T<sub>y</sub> = -3900. N
- M<sub>x</sub> = -2589600. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 29.45 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -18.55 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -132. N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.006 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 132.5 N/mm<sup>2</sup>
- S = 6722. mm<sup>3</sup>

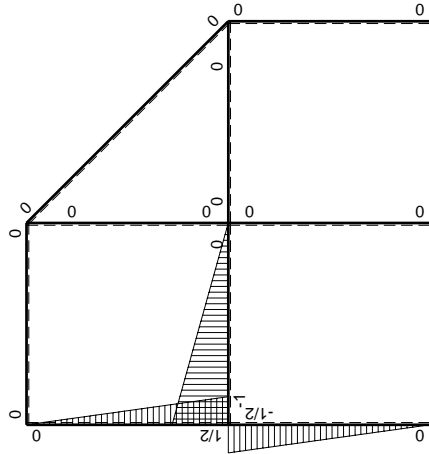






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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	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	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	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

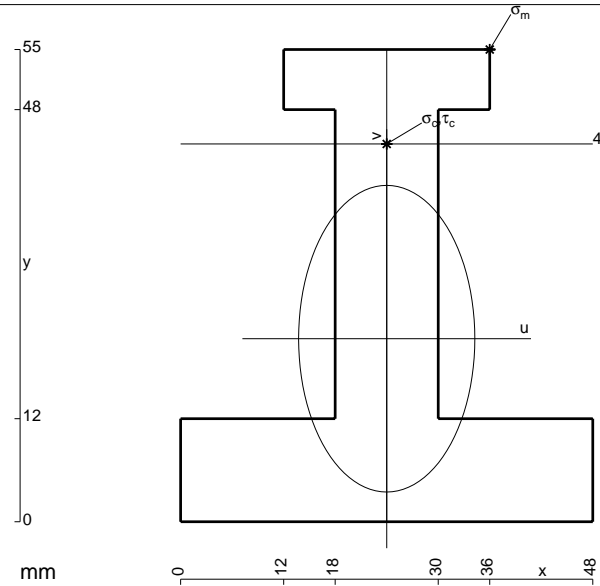
$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

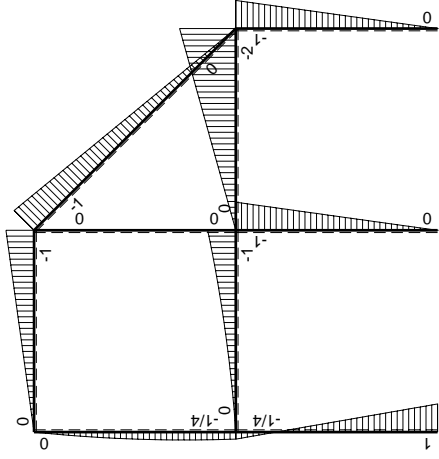
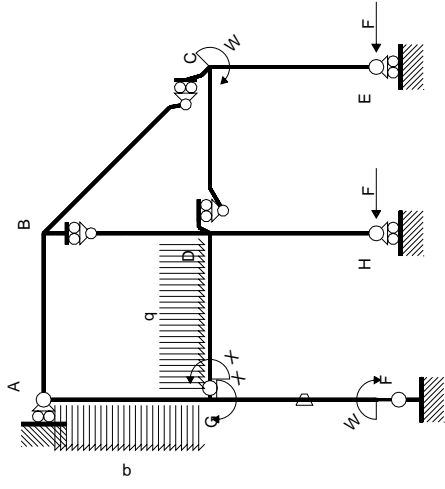
$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$



- A = 1176. mm<sup>2</sup>
- J<sub>u</sub> = 375010. mm<sup>4</sup>
- J<sub>v</sub> = 123840. mm<sup>4</sup>
- y<sub>g</sub> = 21.32 mm
- T<sub>y</sub> = -3475. N
- M<sub>x</sub> = -2446400. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.68 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 219.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 44. mm
- v<sub>c</sub> = 22.68 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 148. N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.831 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 148.2 N/mm<sup>2</sup>
- S = 6256. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx <sup>2</sup>	0	-1/8Fb+3/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	3/4Fx-1/2qx <sup>2</sup>	0	-3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							13/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-13/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 5/24 b) Fb 1/EJ + (1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 3/4 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 3/8 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 3/8 b + 5/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

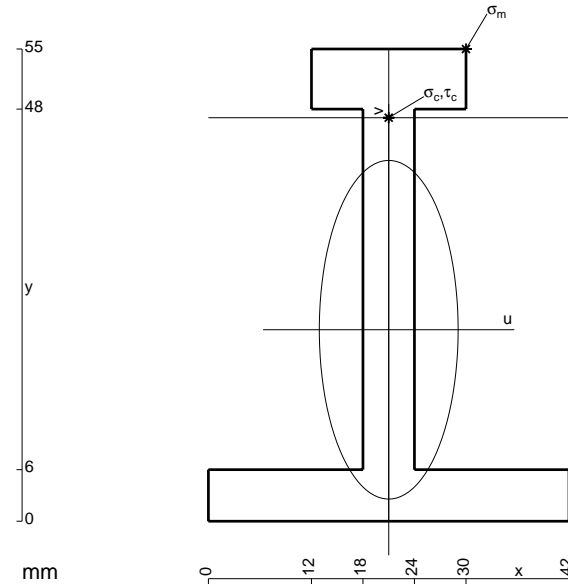
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 3/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x + 1/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

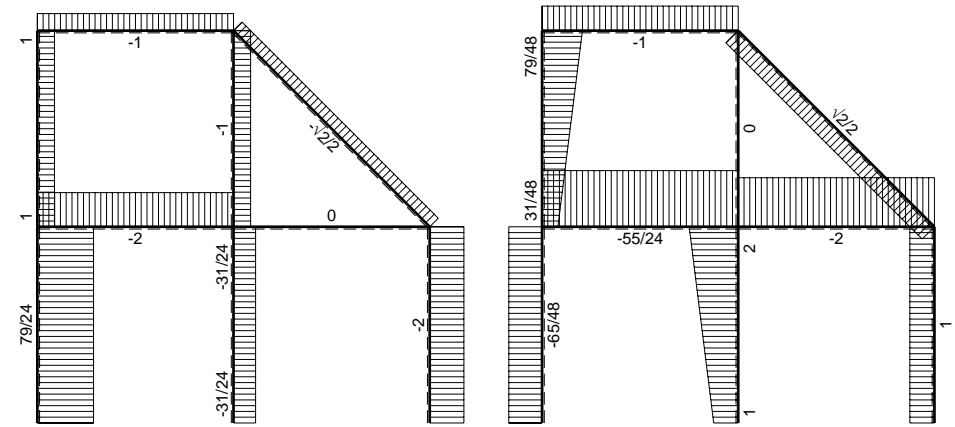
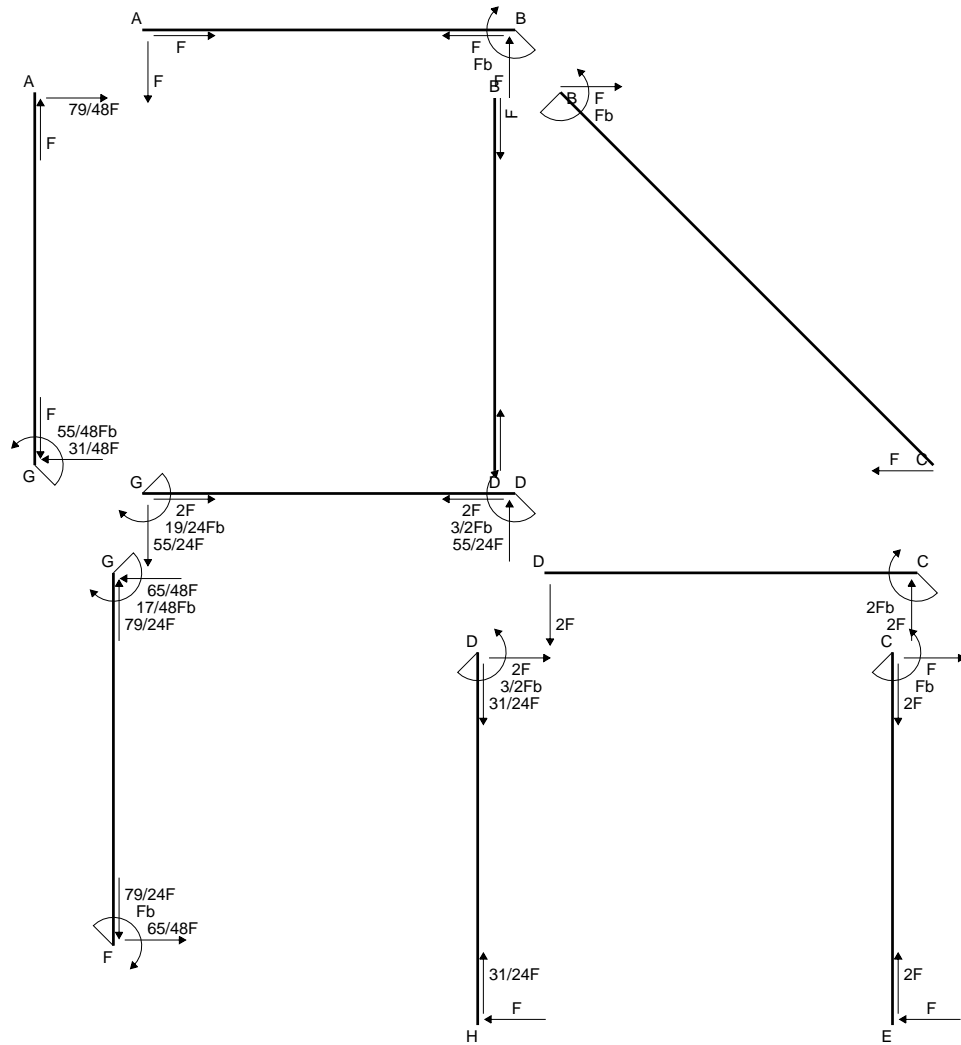
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



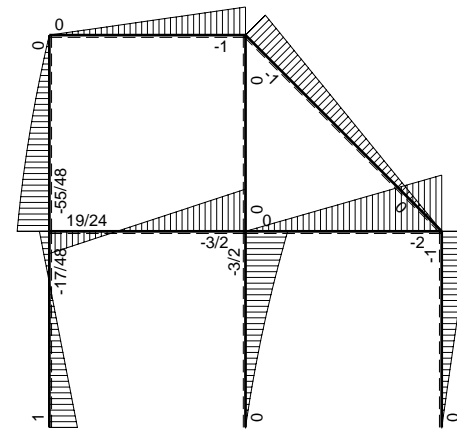
- A = 630. mm<sup>2</sup>
- J<sub>u</sub> = 245181. mm<sup>4</sup>
- J<sub>v</sub> = 41202. mm<sup>4</sup>
- y<sub>g</sub> = 22.3 mm
- T<sub>y</sub> = -1840. N
- M<sub>x</sub> = -1711200. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 32.7 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 228.2 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 47. mm
- v<sub>c</sub> = 24.7 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 172.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.791 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 172.6 N/mm<sup>2</sup>
- S = 3830. mm<sup>3</sup>



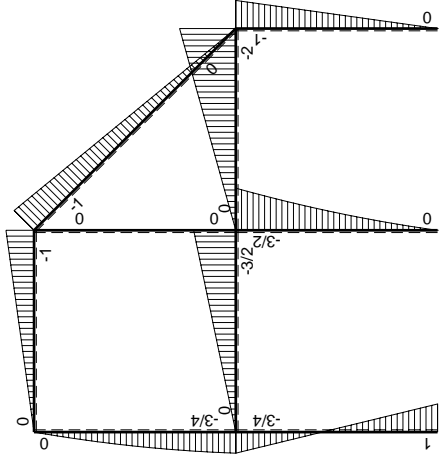
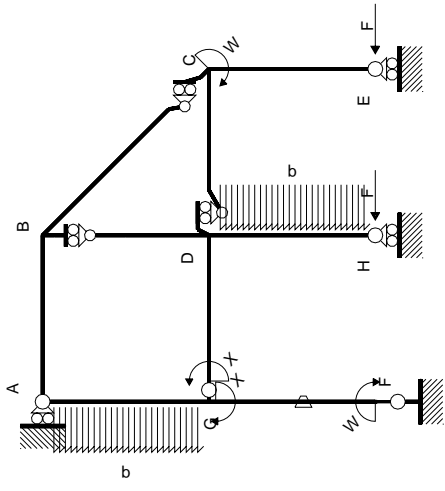


← ⊕ → F

↑ ⊕ ↓ F

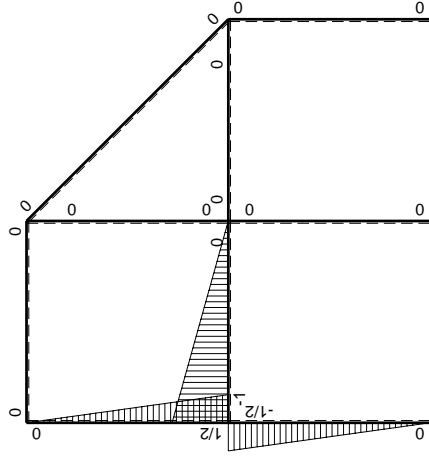


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-7/4Fx	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-7/4Fx	Fb/EJ	3/8Fb-5/4Fx+7/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						19/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-19/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b) Fb 1/EJ + (1/4 b) \theta = 7/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 5/4 x/b + 7/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 5/8 x^2/b + 7/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 5/8 b + 7/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 7/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

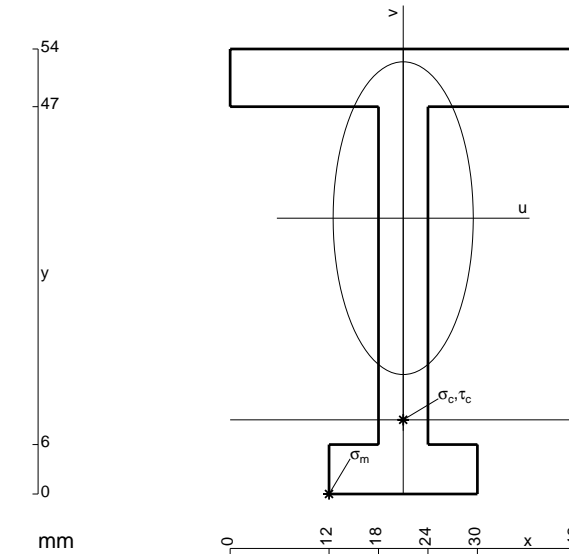
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

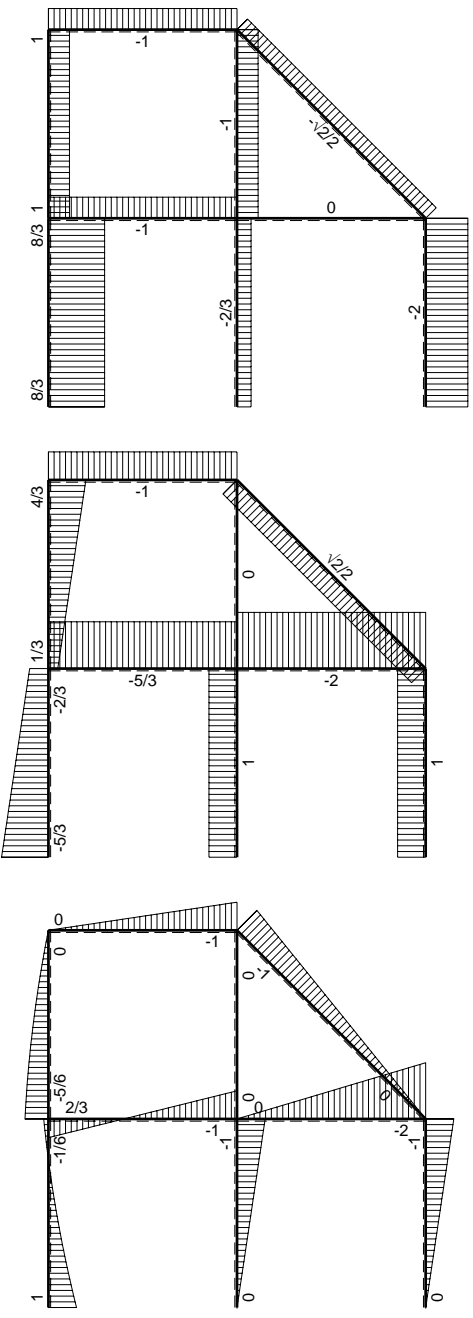
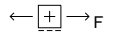
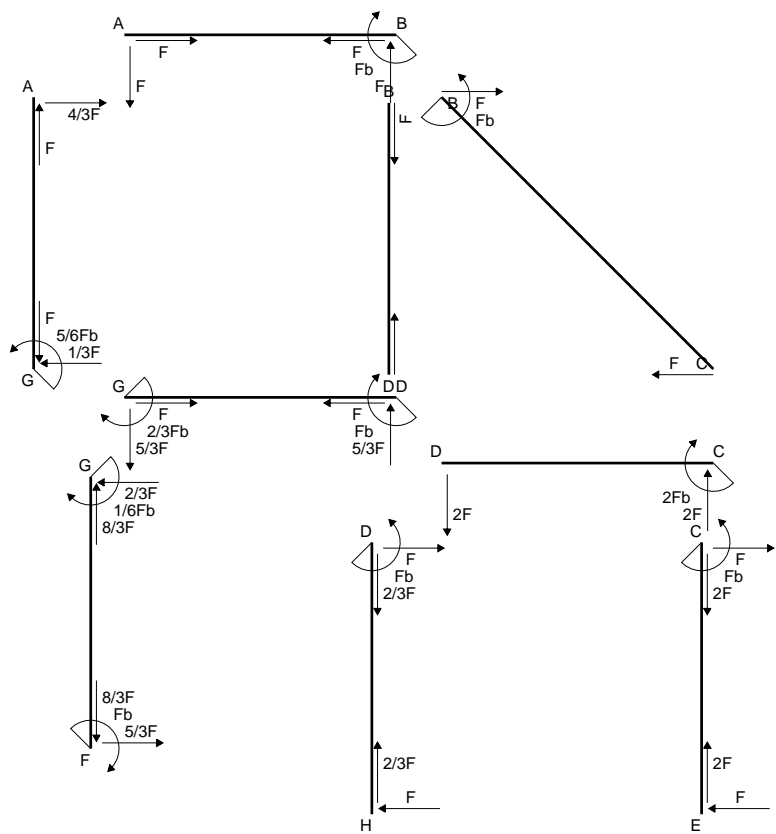
$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

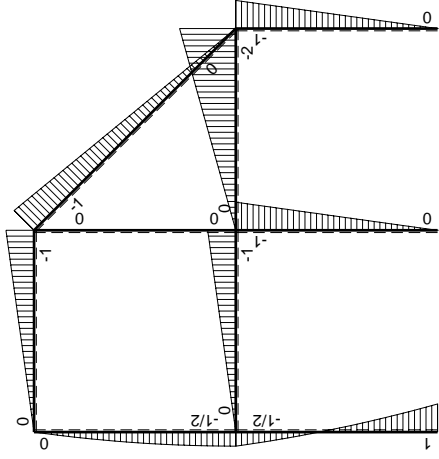
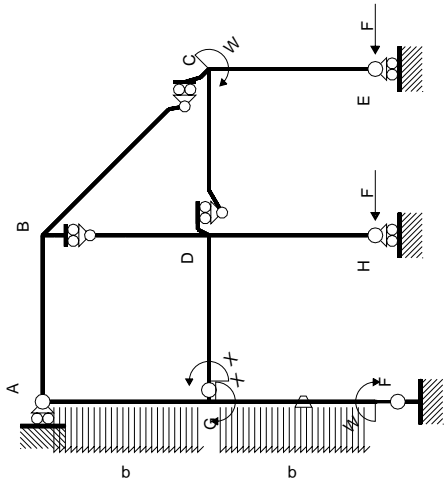
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



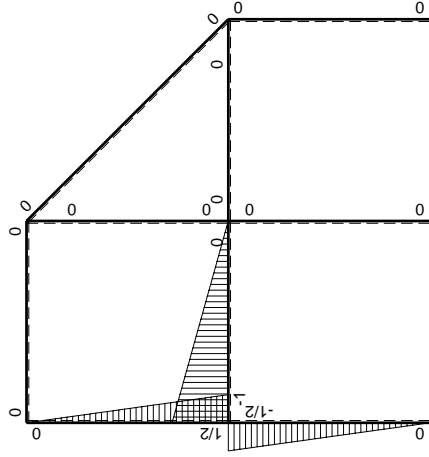
- A = 648. mm<sup>2</sup>
- J<sub>u</sub> = 233472. mm<sup>4</sup>
- J<sub>v</sub> = 46872. mm<sup>4</sup>
- y<sub>g</sub> = 33.47 mm
- T<sub>y</sub> = -1740. N
- M<sub>x</sub> = -1670400. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -33.47 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -24.47 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -175.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.669 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 175.3 N/mm<sup>2</sup>
- S = 3759. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-2Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-Fx-1/2qx <sup>2</sup>	Fb/EJ	1/4Fb-3/4Fx+1/4Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/2Fb+1/2qx <sup>2</sup>	0	-1/4Fb+1/4Fx+1/4Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-5/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx-1/2qx <sup>2</sup>	0	-1/2Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						1/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/3 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/3 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 13/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 3/4 x/b + 1/4 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 3/8 x^2/b + 1/12 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 3/8 b + 1/12 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 13/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

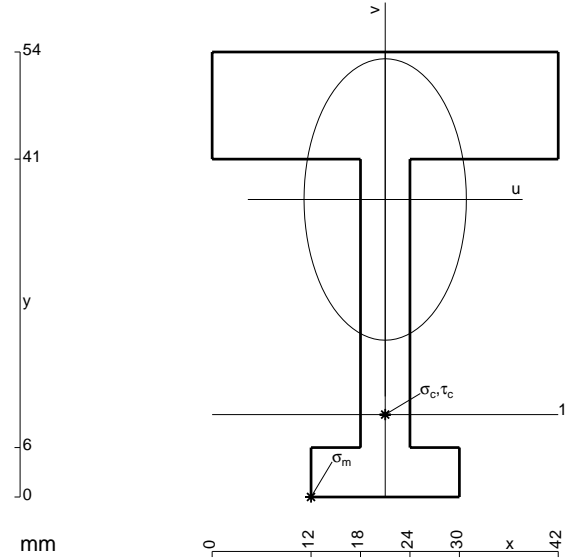
$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/4 x/b + 1/4 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-1/4 x + 1/8 x^2/b + 1/12 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/8 b + 1/12 b - 1/16 b) Fb 1/EJ = -5/48 Fb^2/EJ$$

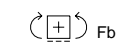
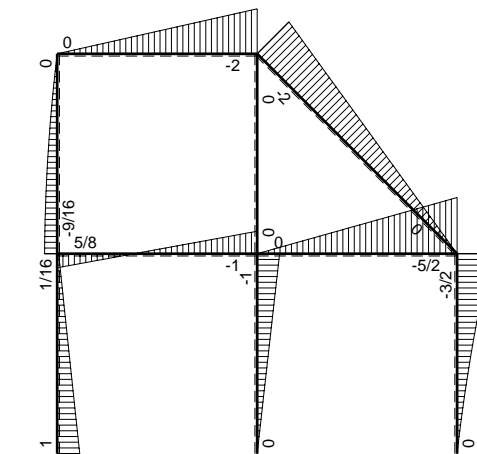
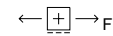
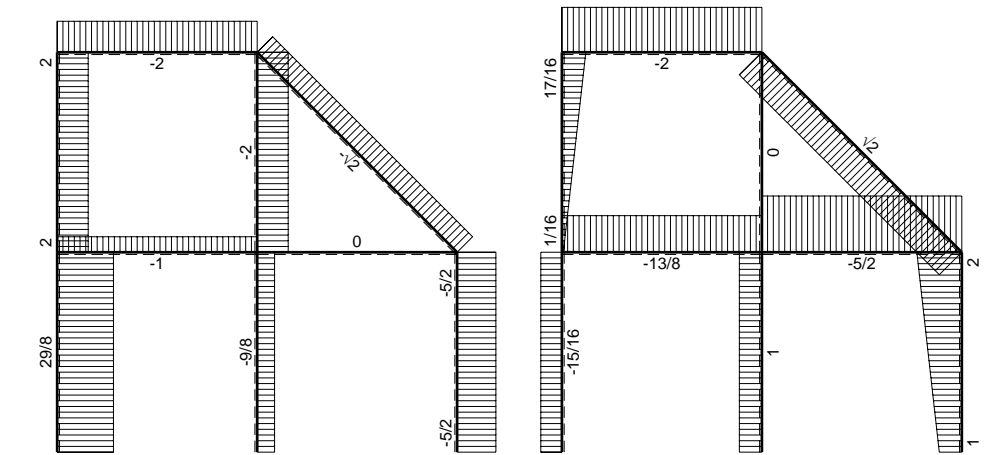
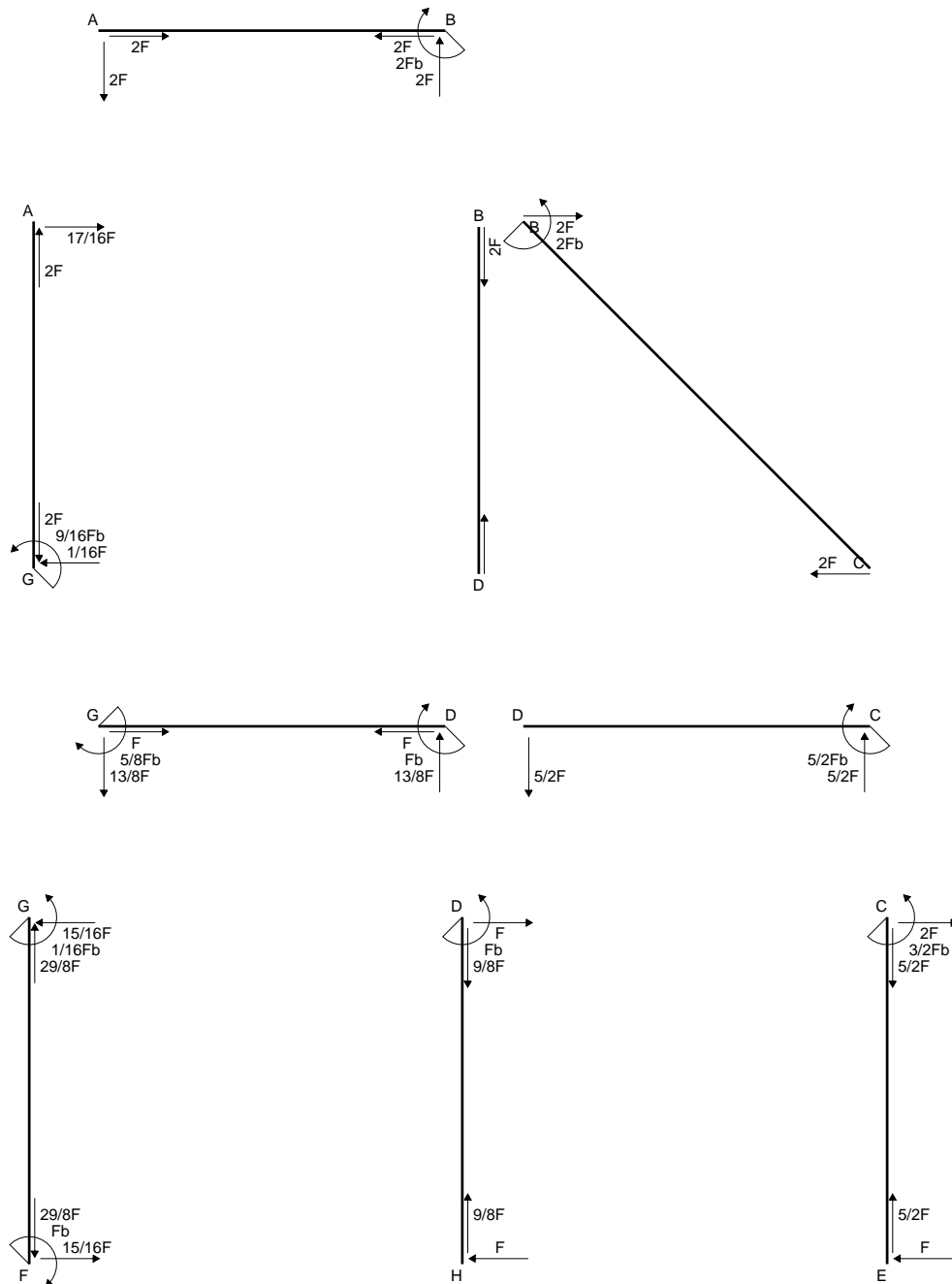
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/6 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/6 b + 1/16 b) Fb 1/EJ = -5/48 Fb^2/EJ$$



- A = 864. mm<sup>2</sup>
- J<sub>u</sub> = 252075. mm<sup>4</sup>
- J<sub>v</sub> = 83808. mm<sup>4</sup>
- y<sub>g</sub> = 36.1 mm
- T<sub>y</sub> = -2720. N
- M<sub>x</sub> = -1387200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -36.1 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -198.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -26.1 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -143.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.643 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 144.3 N/mm<sup>2</sup>
- S = 4250. mm<sup>3</sup>







Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-2Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx <sup>2</sup>	0	-1/8Fb+3/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	3/4Fx-1/2qx <sup>2</sup>	0	-3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							5/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 5/24 b) Fb 1/EJ + (1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 3/4 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 3/8 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 3/8 b + 5/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

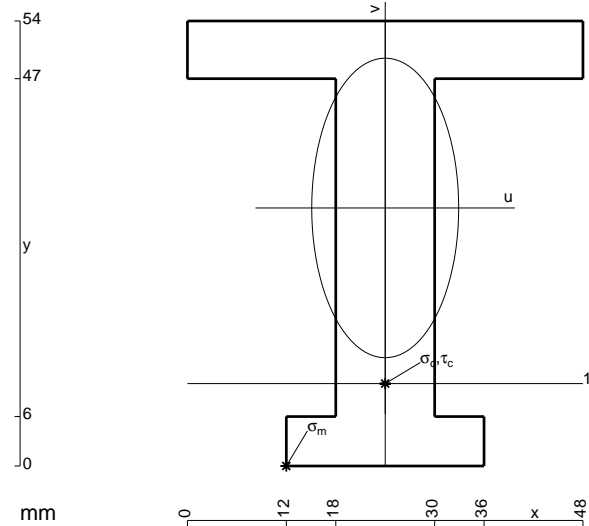
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 3/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x + 1/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

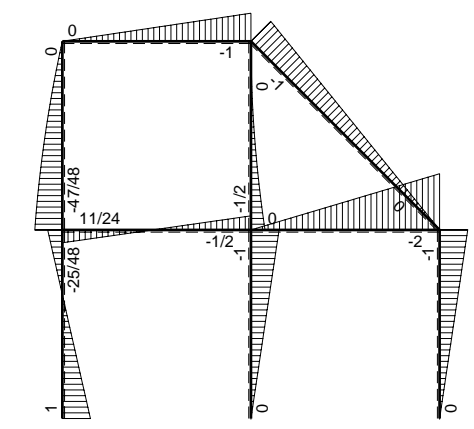
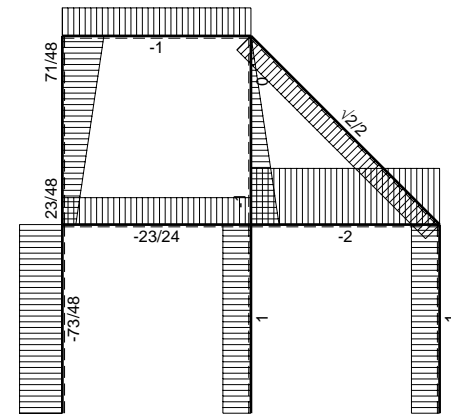
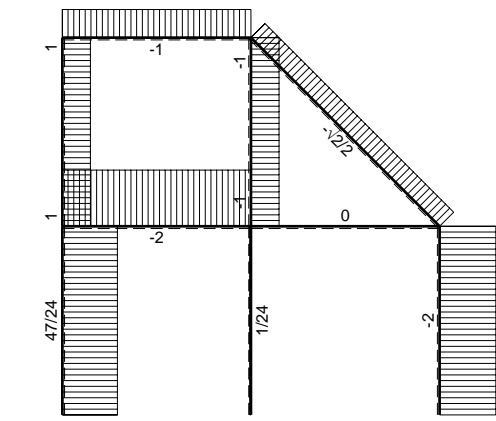
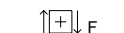
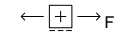
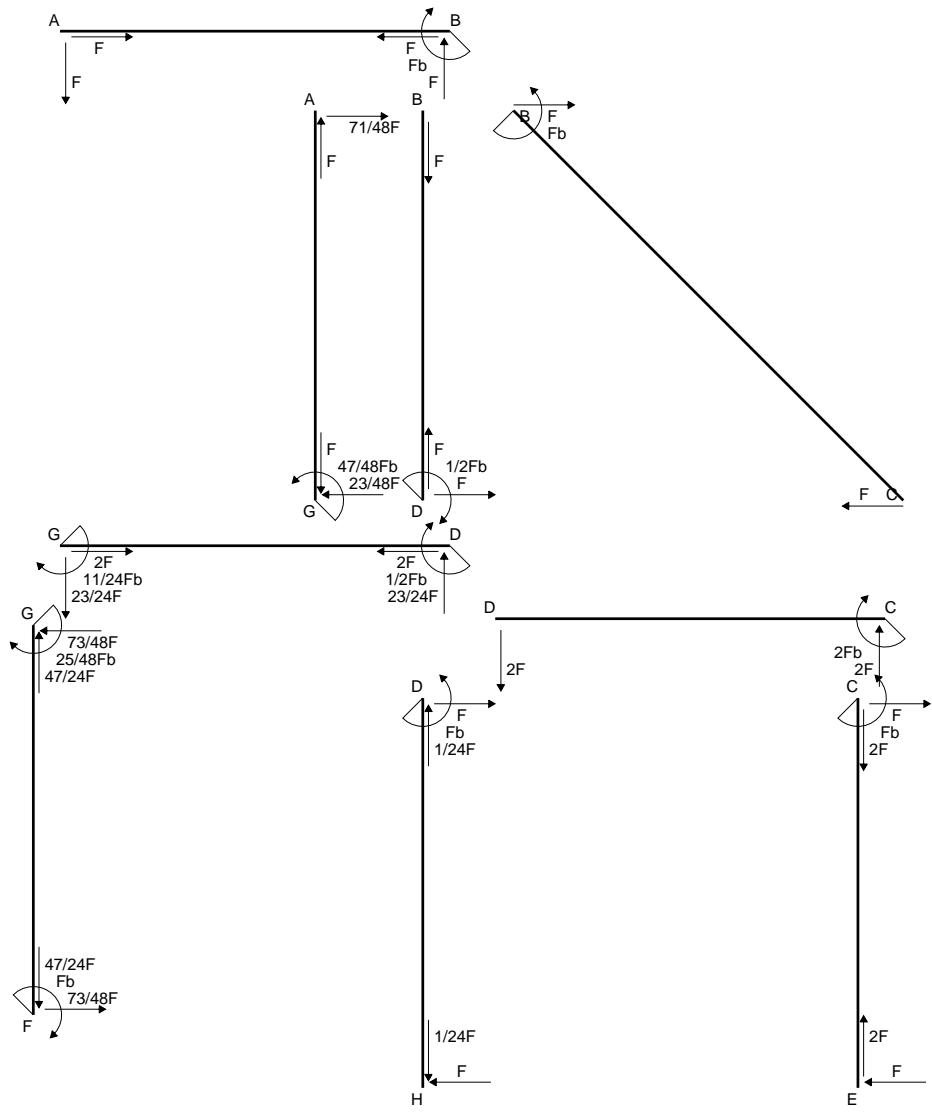
$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

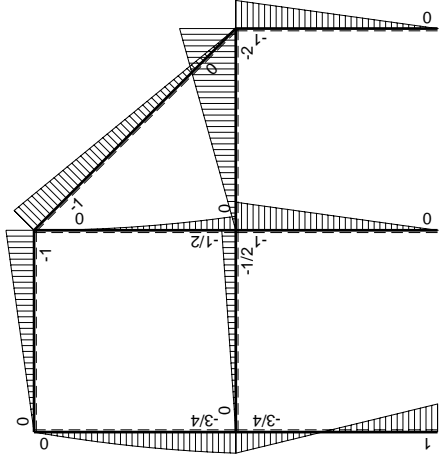
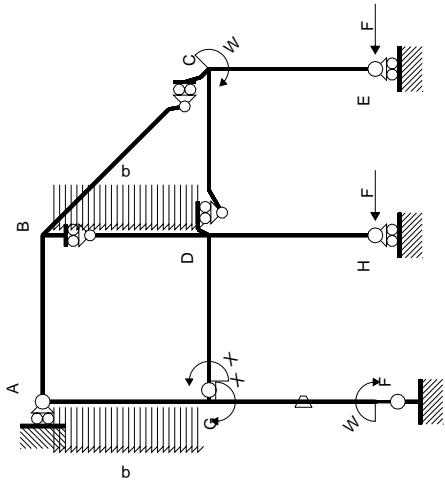
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



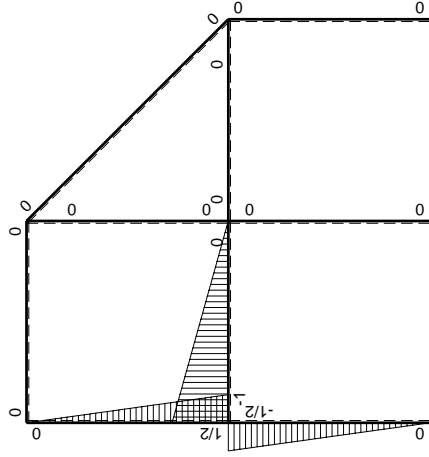
- A = 972. mm<sup>2</sup>
- J<sub>u</sub> = 321252. mm<sup>4</sup>
- J<sub>v</sub> = 77328. mm<sup>4</sup>
- y<sub>g</sub> = 31.31 mm
- T<sub>y</sub> = -3825. N
- M<sub>x</sub> = -2142000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -31.31 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -208.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -21.31 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -142.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.156 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 142.4 N/mm<sup>2</sup>
- S = 5196. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-7/4Fx	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-7/4Fx	Fb/EJ	3/8Fb-5/4Fx+7/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						11/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b) Fb 1/EJ + (1/4 b) \theta = 7/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 5/4 x/b + 7/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 5/8 x^2/b + 7/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 5/8 b + 7/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 7/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

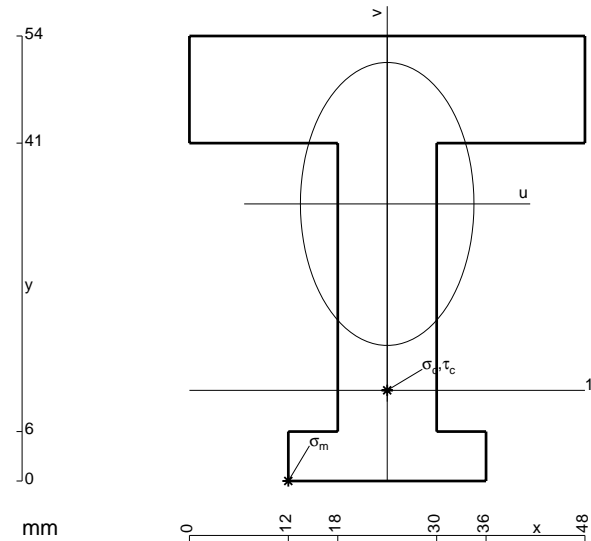
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

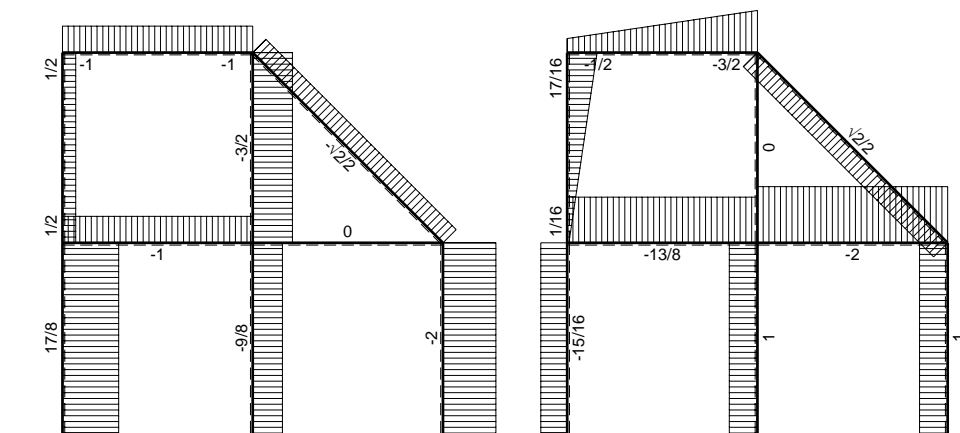
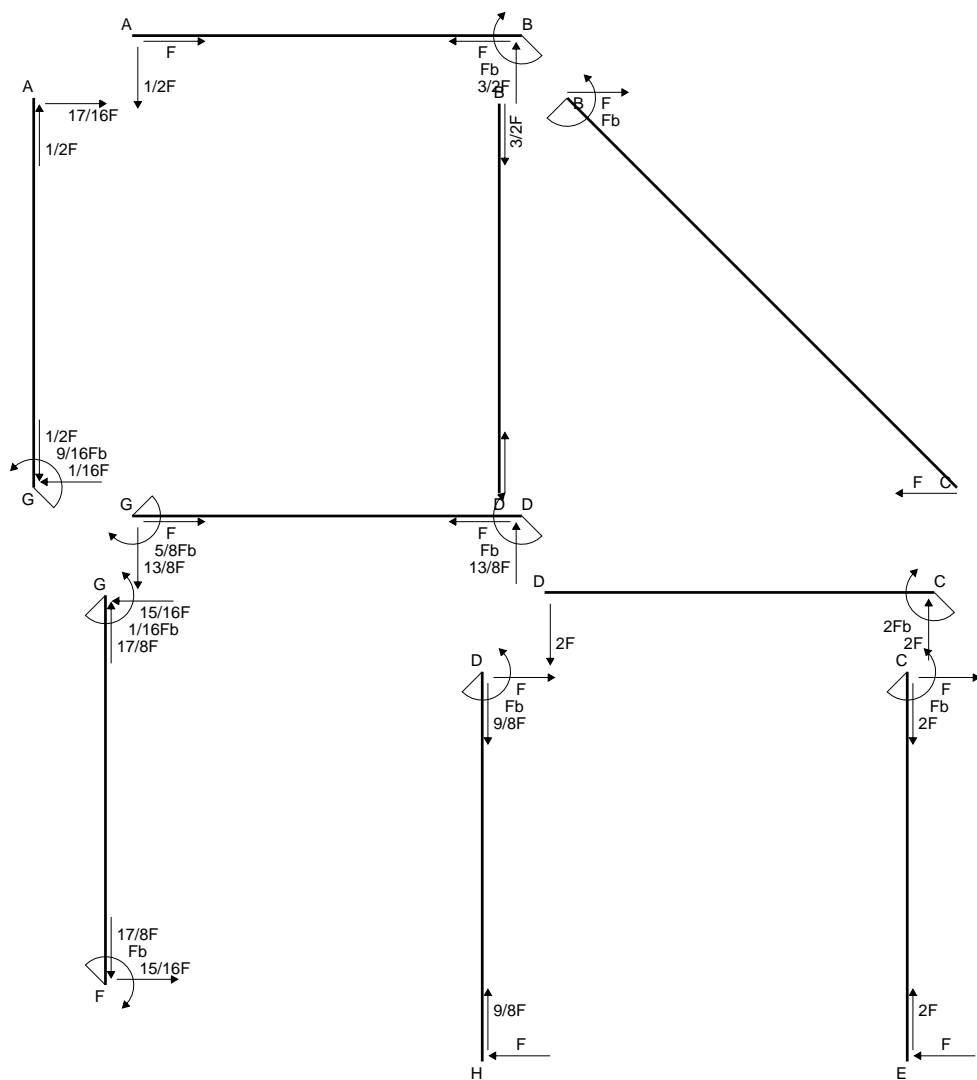
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



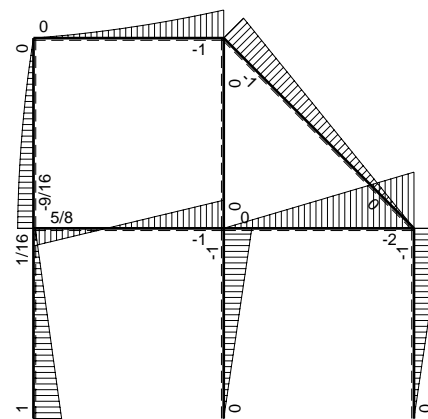
- A = 1188. mm<sup>2</sup>
- J<sub>u</sub> = 350338. mm<sup>4</sup>
- J<sub>v</sub> = 131760. mm<sup>4</sup>
- y<sub>g</sub> = 33.62 mm
- T<sub>y</sub> = -3740. N
- M<sub>x</sub> = -2281400. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -33.62 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -218.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -22.62 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -147.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.264 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup> + 3τ<sup>2</sup> = 147.6 N/mm<sup>2</sup>
- S = 5917. mm<sup>3</sup>



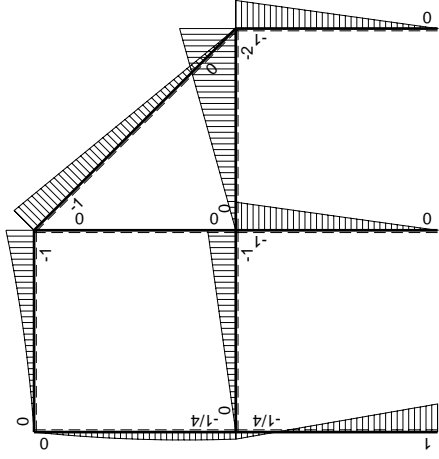
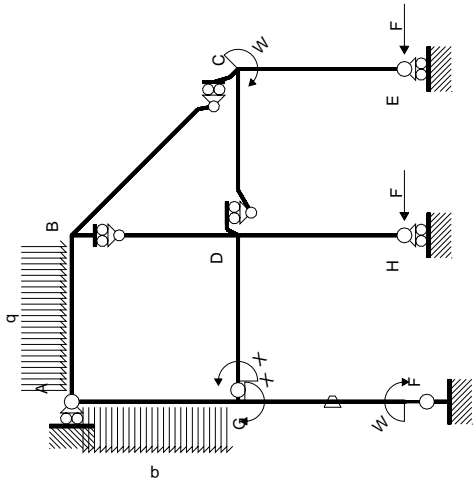


← ⊕ →  $F$

↑ ⊕ ↓  $F$

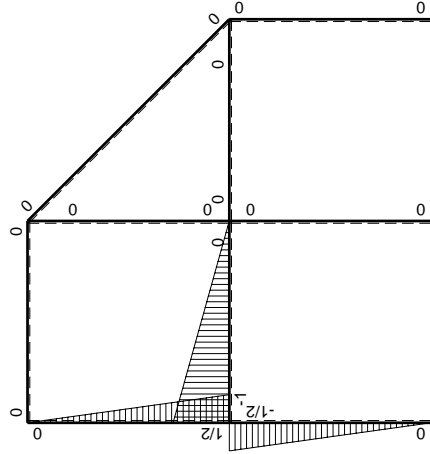


⊕ ⊖  $F_b$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 5/24 b) Fb 1/EJ + (1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 3/4 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 3/8 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 3/8 b + 5/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

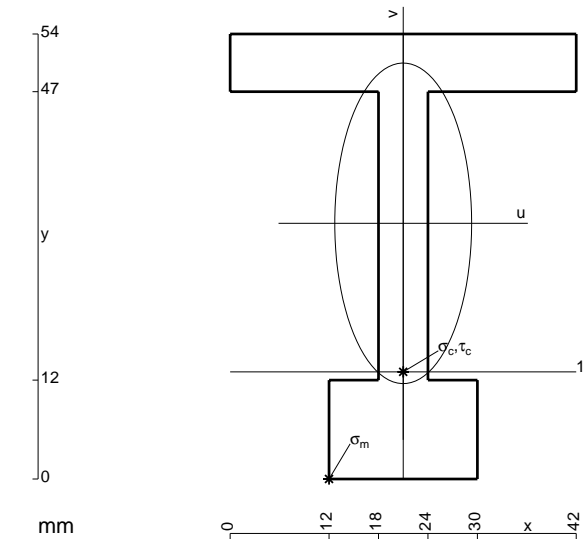
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 3/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x + 1/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

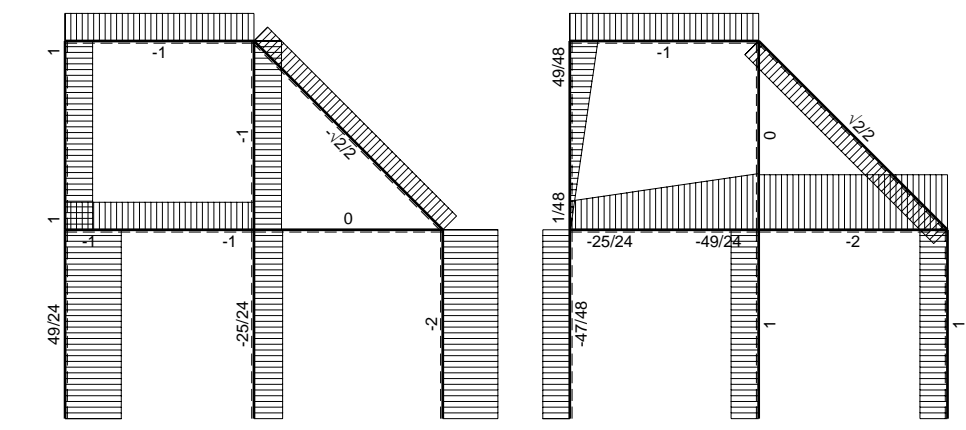
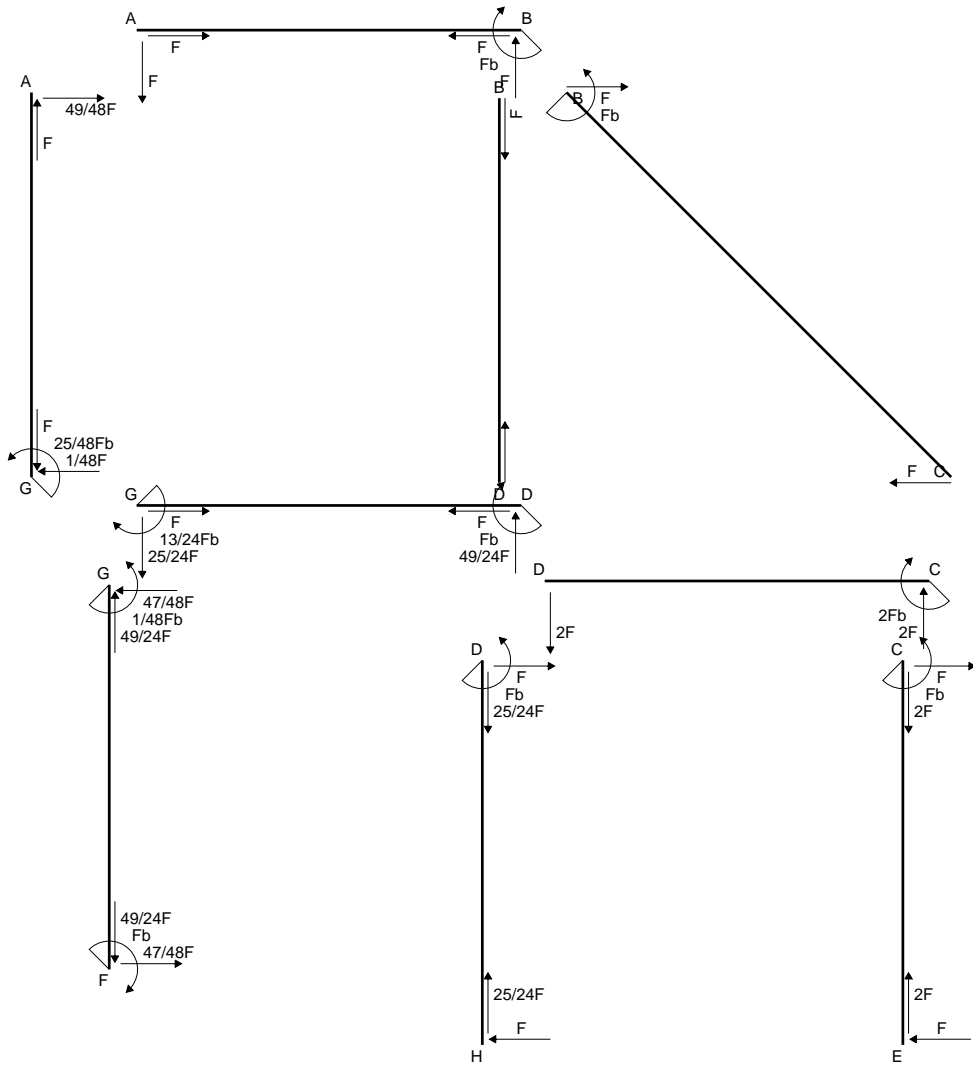
$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

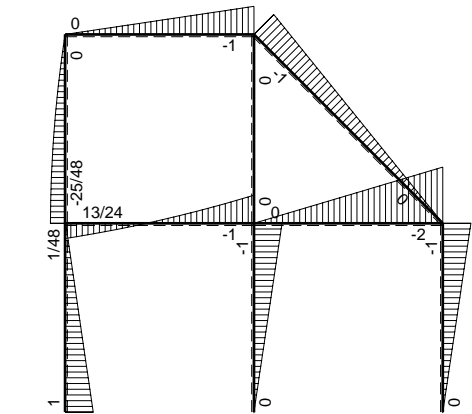


- A = 720. mm<sup>2</sup>
- J<sub>u</sub> = 272496. mm<sup>4</sup>
- J<sub>v</sub> = 49680. mm<sup>4</sup>
- y<sub>g</sub> = 31.02 mm
- T<sub>y</sub> = -3060. N
- M<sub>x</sub> = -2019600. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -31.02 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -229.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -18.02 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -133.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 10.32 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 134.8 N/mm<sup>2</sup>
- S = 5517. mm<sup>3</sup>

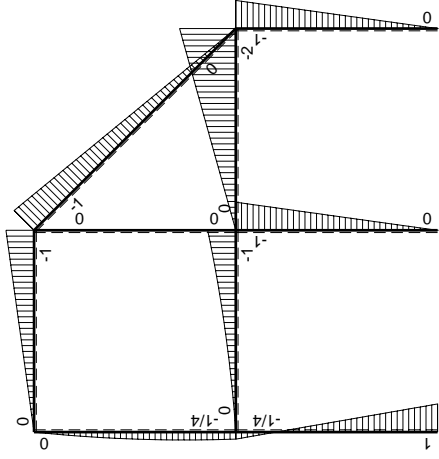
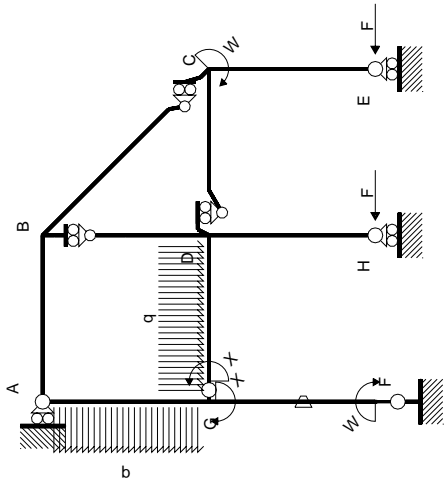


← ⊕ → F

↑ ⊕ ↓ F<sub>b</sub>

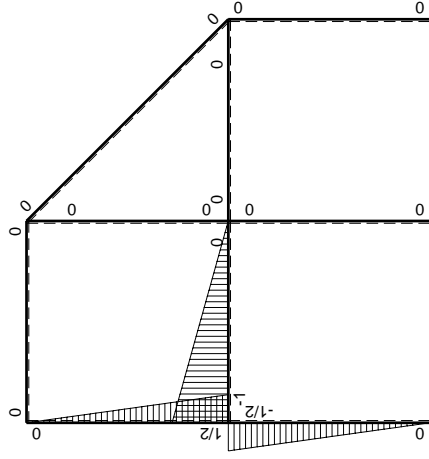


⊕ ⊗ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx <sup>2</sup>	0	-1/8Fb+3/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	3/4Fx-1/2qx <sup>2</sup>	0	-3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							13/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-13/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x_0} = \int_0^b (-1/2 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 5/24 b) Fb 1/EJ + (1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b (1/8 - 3/4 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 3/8 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 3/8 b + 5/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

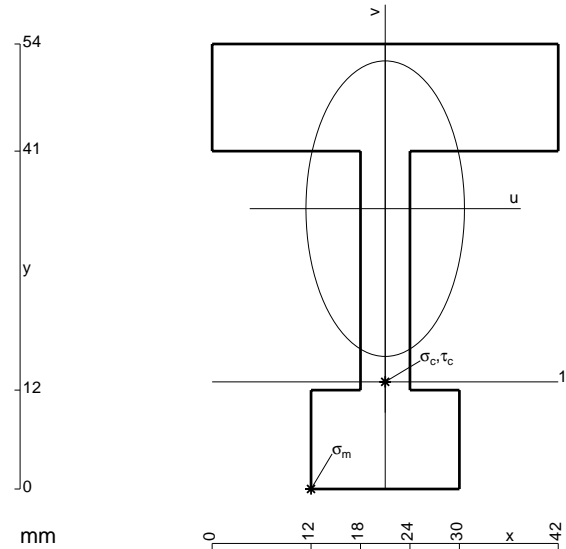
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b (-1/8 + 3/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x + 1/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

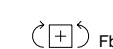
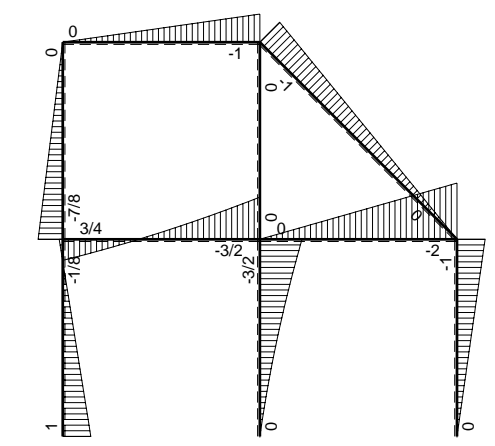
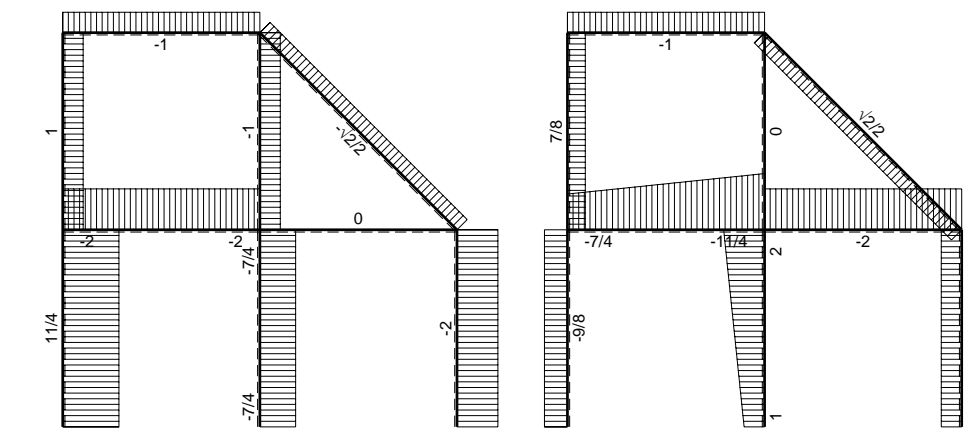
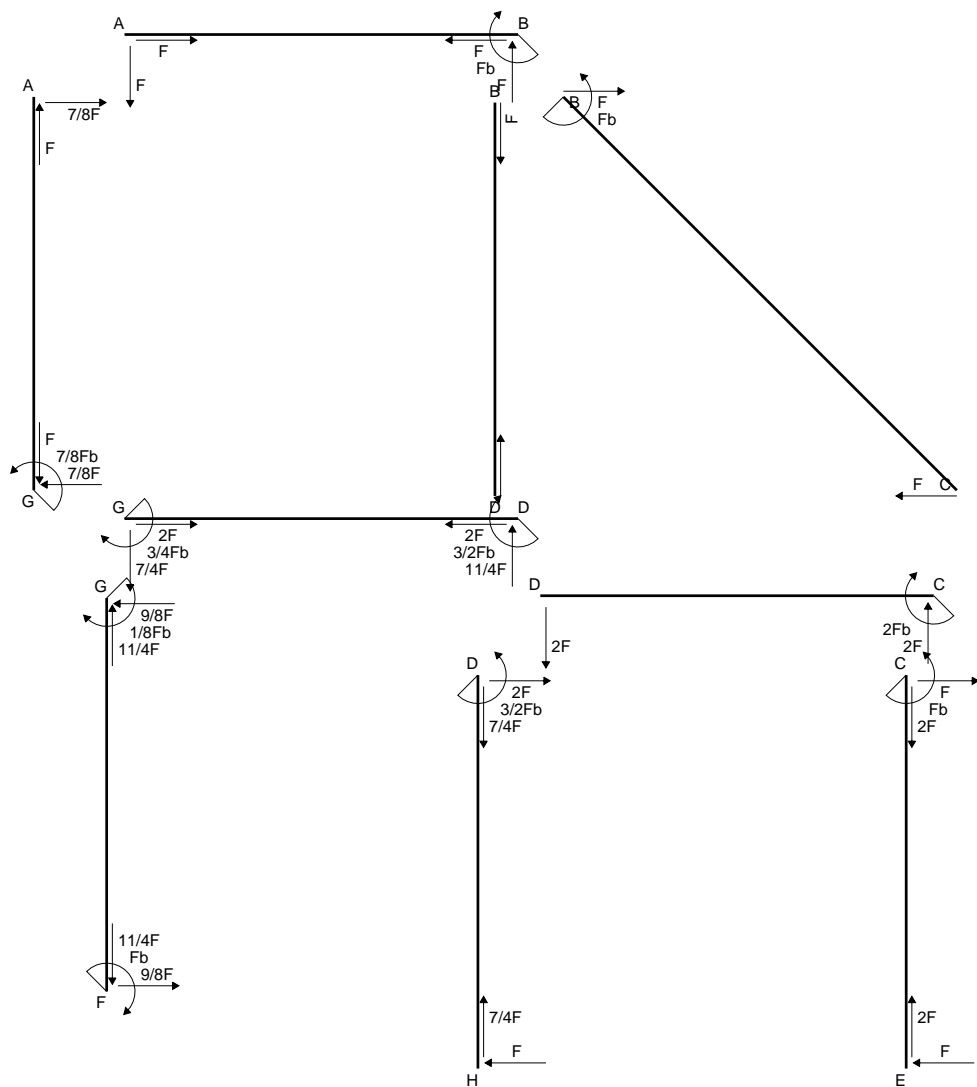
$$L_{AG}^{x_0} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

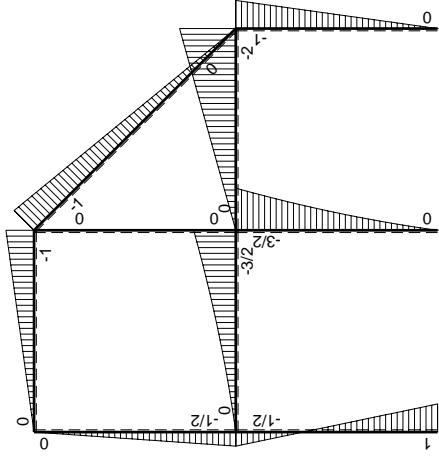
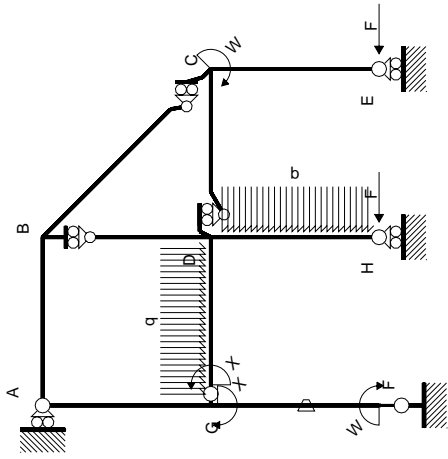
$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



- A = 936. mm<sup>2</sup>
- J<sub>u</sub> = 301116. mm<sup>4</sup>
- J<sub>v</sub> = 86616. mm<sup>4</sup>
- y<sub>g</sub> = 34.02 mm
- T<sub>y</sub> = -2980. N
- M<sub>x</sub> = -2115800. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -34.02 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -21.02 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -147.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 10.2 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 148.7 N/mm<sup>2</sup>
- S = 6181. mm<sup>3</sup>

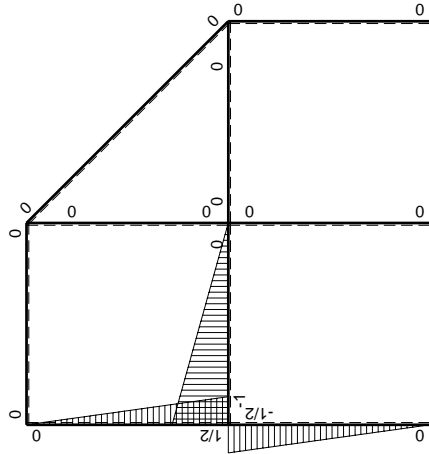






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx-1/2qx <sup>2</sup>	0	Fx-1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	3/2Fb-2Fx+1/2qx <sup>2</sup>	0	3/2Fx-2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							3/8Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-3/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - 1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/6 b - 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 2/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

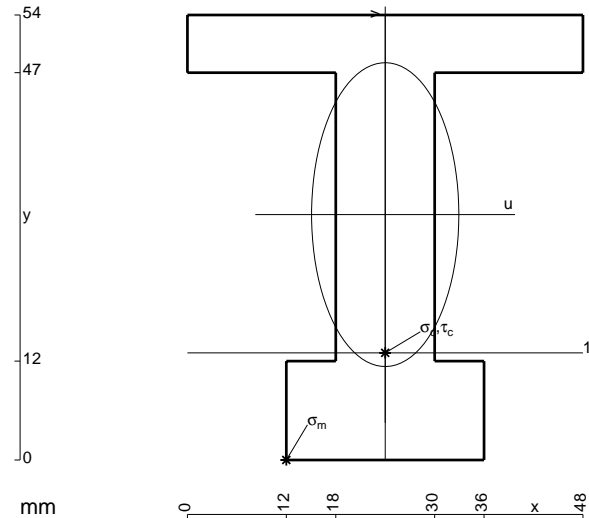
$$= (3/4 b - 2/3 b + 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

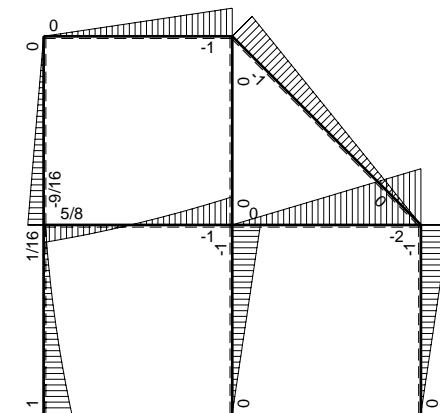
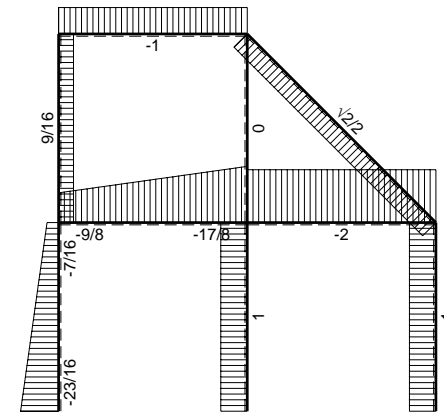
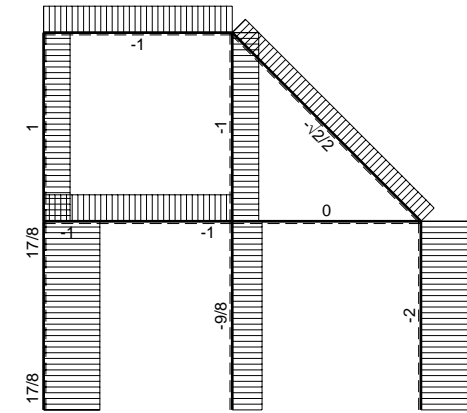
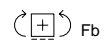
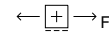
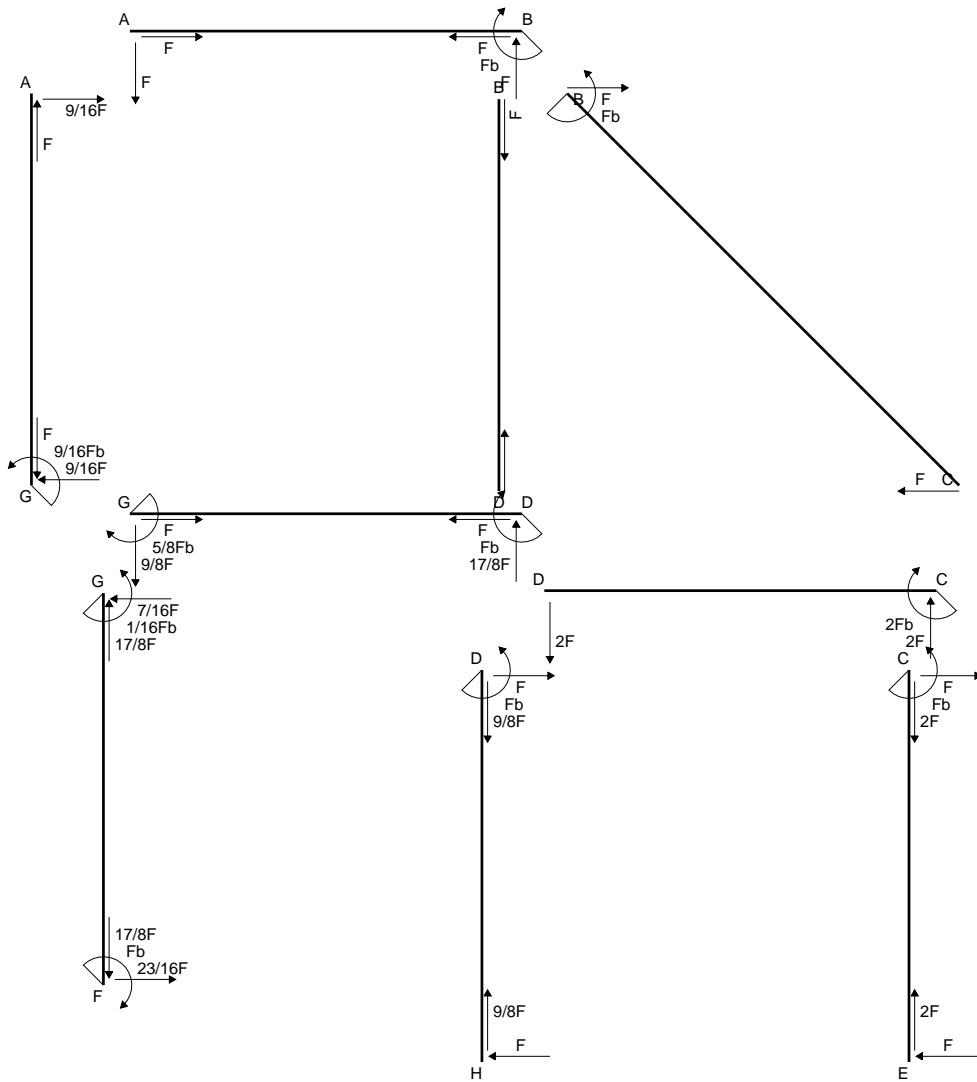
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

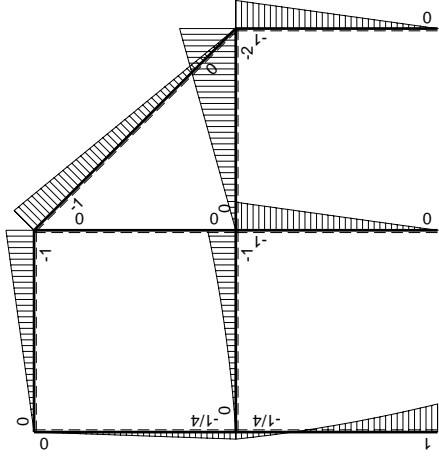
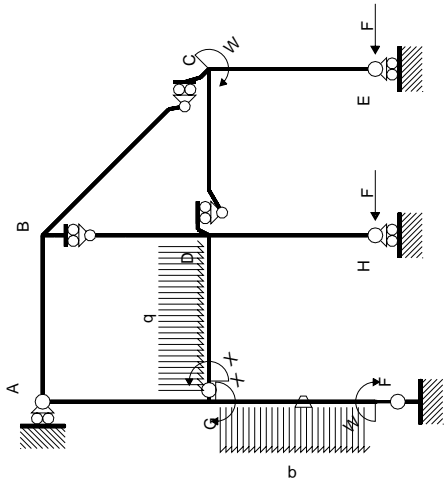
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



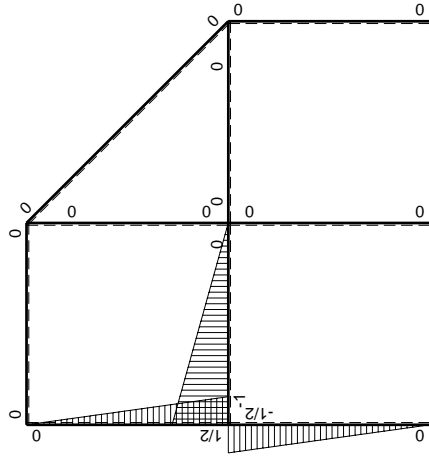
- A = 1044. mm<sup>2</sup>
- J<sub>u</sub> = 354848. mm<sup>4</sup>
- J<sub>v</sub> = 83376. mm<sup>4</sup>
- y<sub>g</sub> = 29.78 mm
- T<sub>y</sub> = -3120. N
- M<sub>x</sub> = -2371200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -29.78 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -199. N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -16.78 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -112.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.169 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 112.5 N/mm<sup>2</sup>
- S = 7055. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	1/8Fb-1/2Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/4Fx	0	-1/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							5/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 1/2 x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 1/4 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 1/4 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

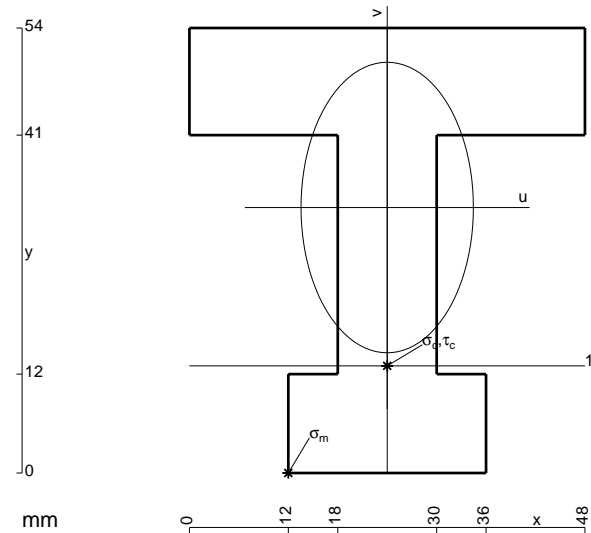
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 1/4 x/b - 1/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x + 1/8 x^2/b - 1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

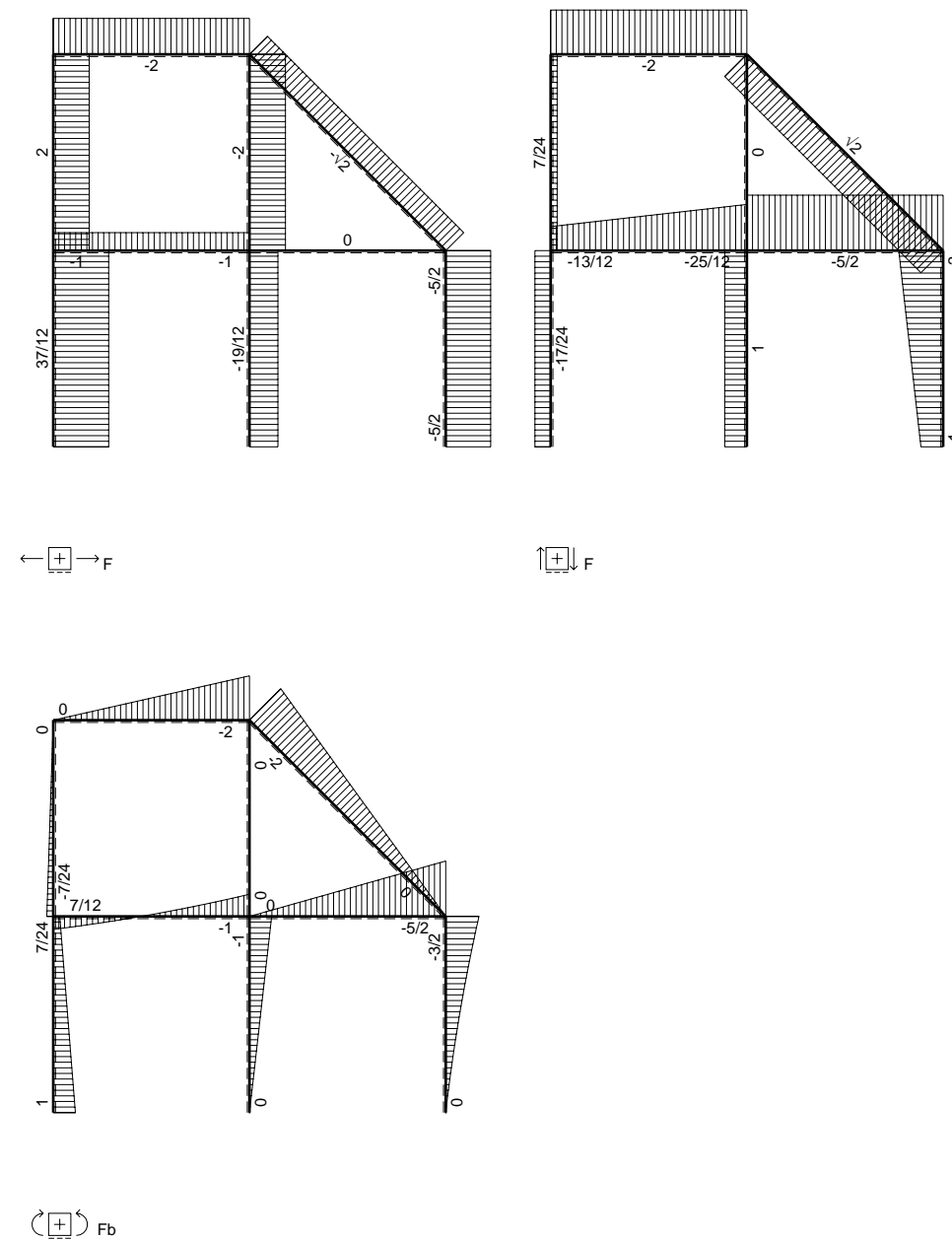
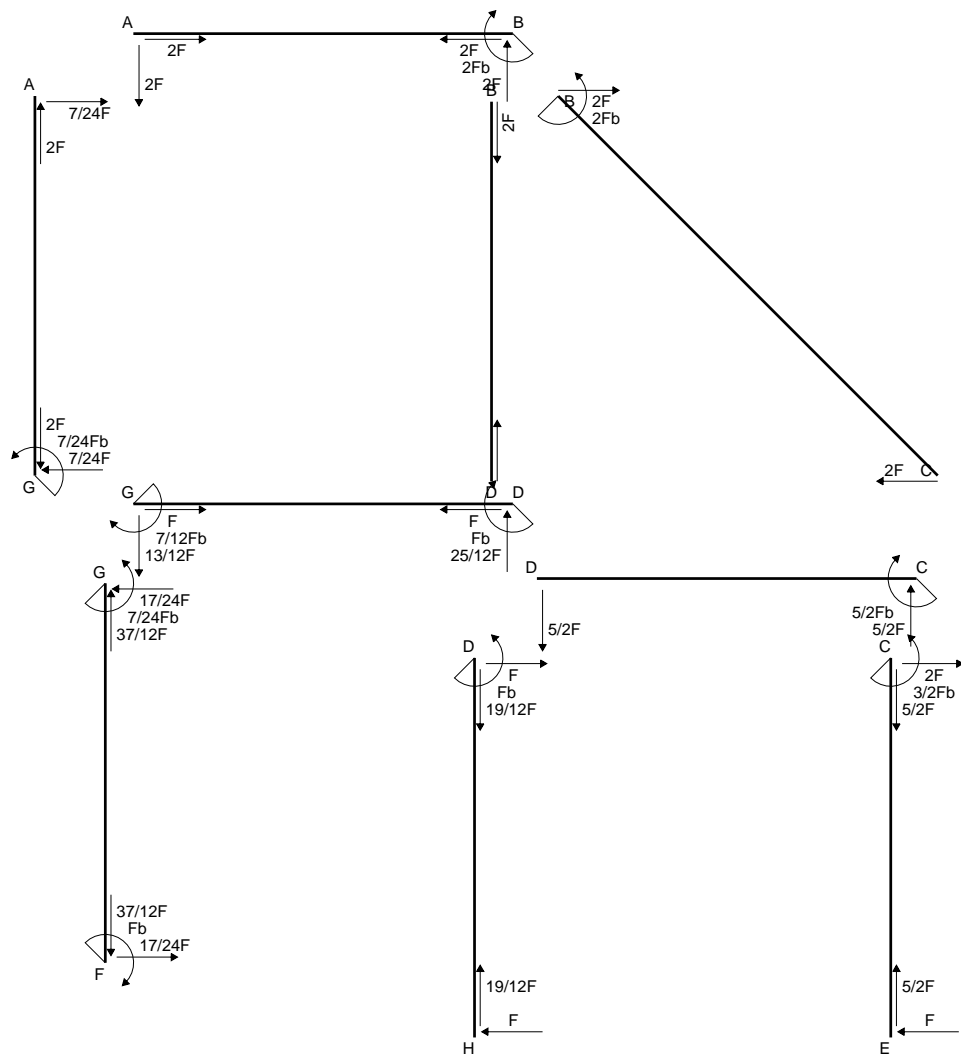
$$L_{AG}^{xo} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$



- A = 1260. mm<sup>2</sup>
- J<sub>u</sub> = 391706. mm<sup>4</sup>
- J<sub>v</sub> = 137808. mm<sup>4</sup>
- y<sub>g</sub> = 32.21 mm
- T<sub>y</sub> = -3140. N
- M<sub>x</sub> = -2543400. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -32.21 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -209.2 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -19.21 mm
- σ<sub>c</sub> = -Mv/J<sub>v</sub> = -124.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.201 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 125.1 N/mm<sup>2</sup>
- S = 7786. mm<sup>3</sup>







Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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 <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	Fb-Fx	-Fb/EJ	-1/2Fx+1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	-Fx	Fb/EJ	-1/2Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b <sup>2</sup>	0+0	1/12Xb/EJ	
AG b	-1/2x/b	0	0	0	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							7/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-7/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

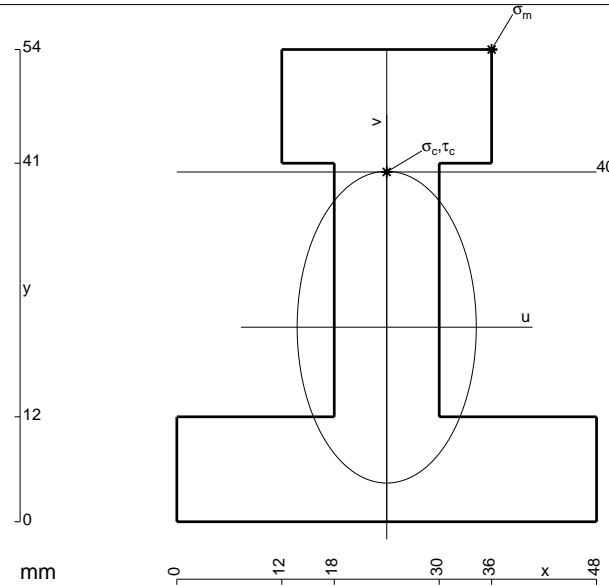
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

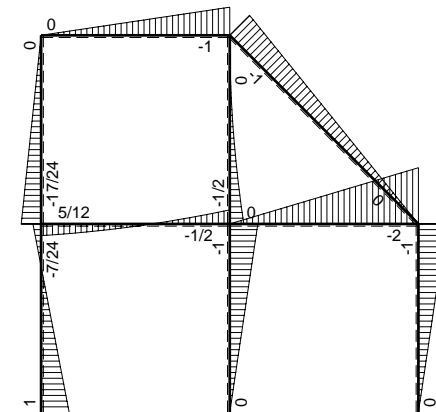
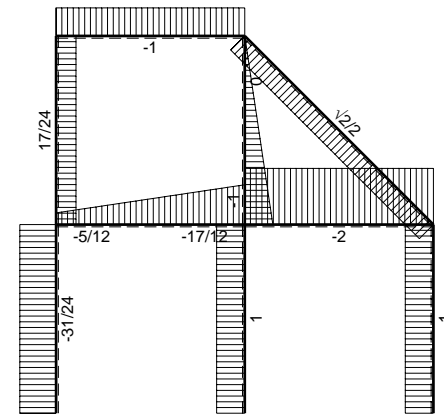
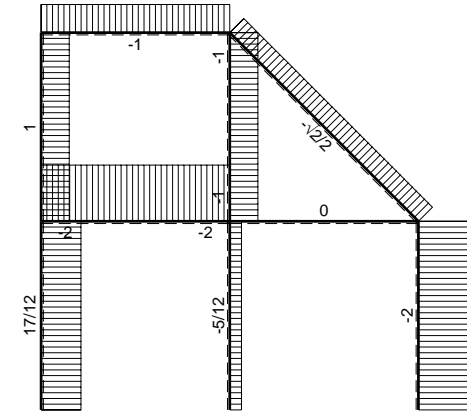
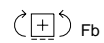
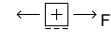
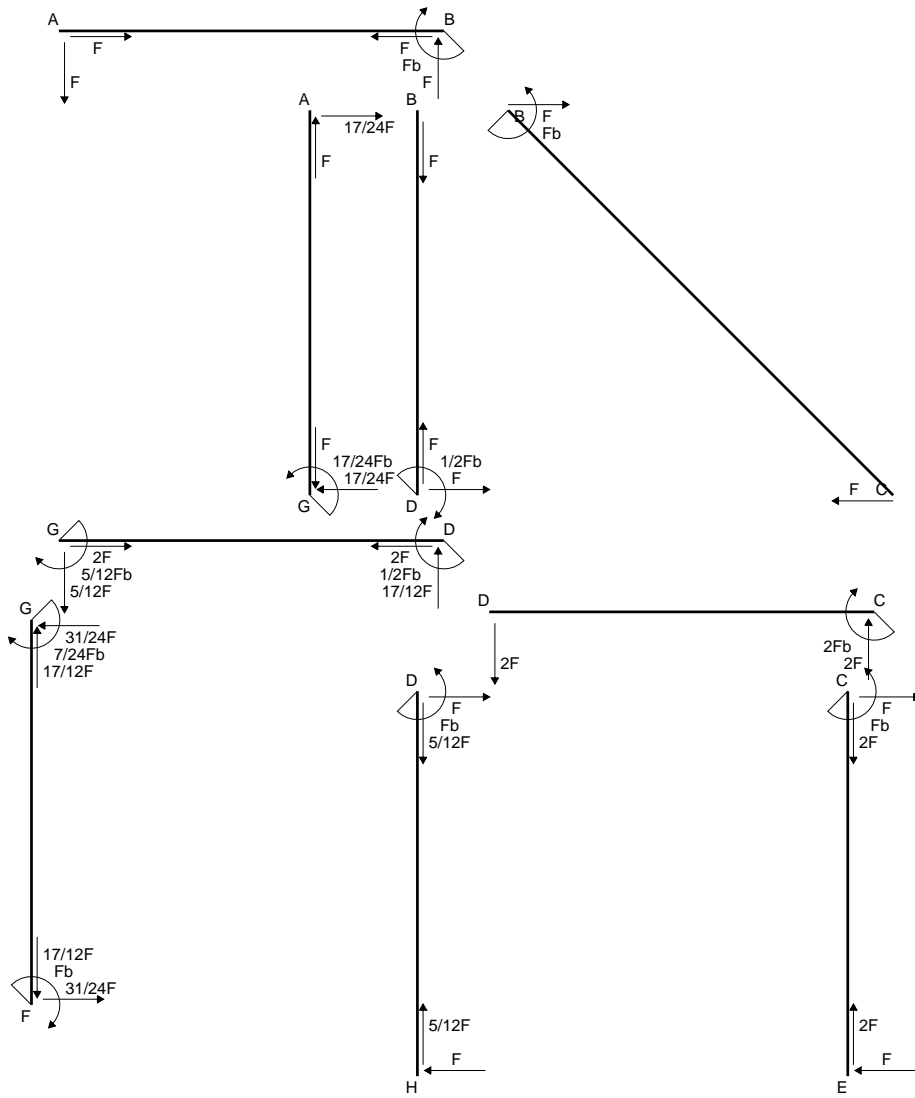
$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

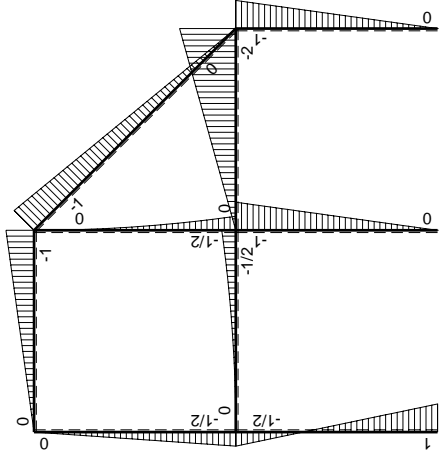
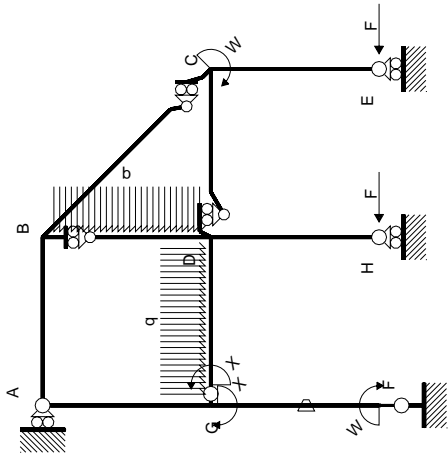
$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$



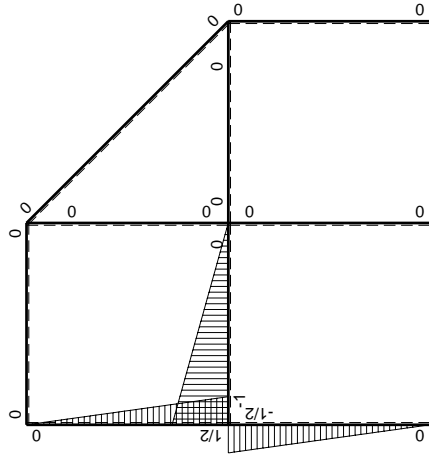
- A = 1236. mm<sup>2</sup>
- J<sub>u</sub> = 393000. mm<sup>4</sup>
- J<sub>v</sub> = 129744. mm<sup>4</sup>
- y<sub>g</sub> = 22.25 mm
- T<sub>y</sub> = -3150. N
- M<sub>x</sub> = -2709000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 31.75 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 218.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 40. mm
- v<sub>c</sub> = 17.75 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 122.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.409 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 122.7 N/mm<sup>2</sup>
- S = 8098. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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 <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2qx <sup>2</sup>	0	1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	1/2Fb-Fx+1/2qx <sup>2</sup>	0	1/2Fx-Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							5/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-5/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/6 b - 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

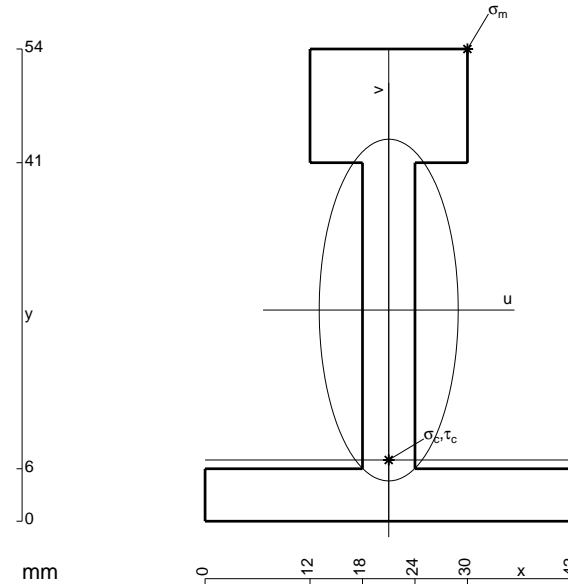
$$= (1/4 b - 1/3 b + 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

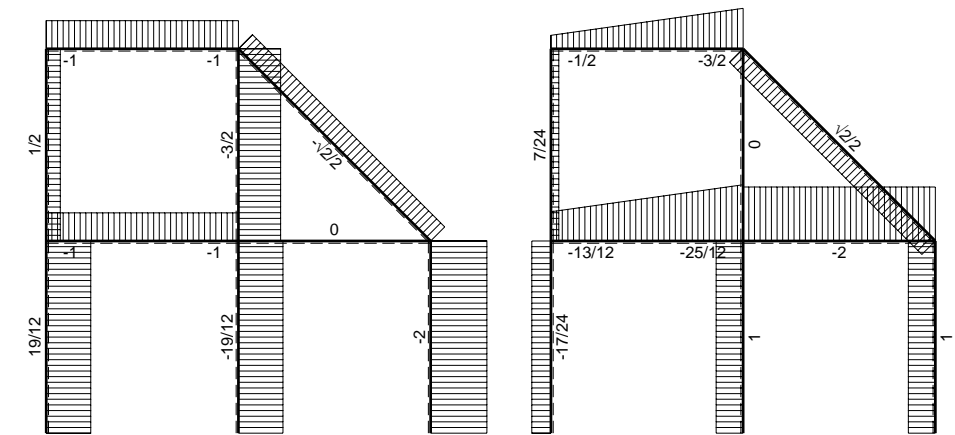
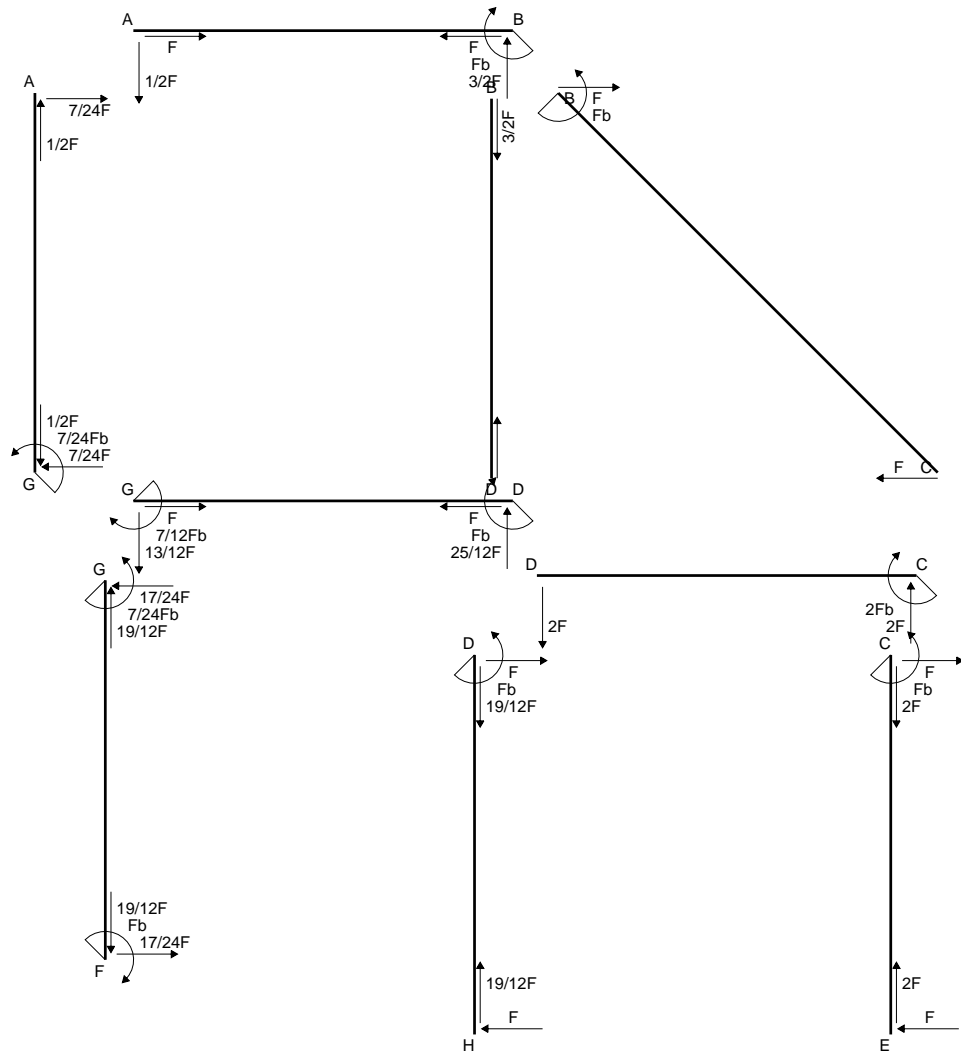
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



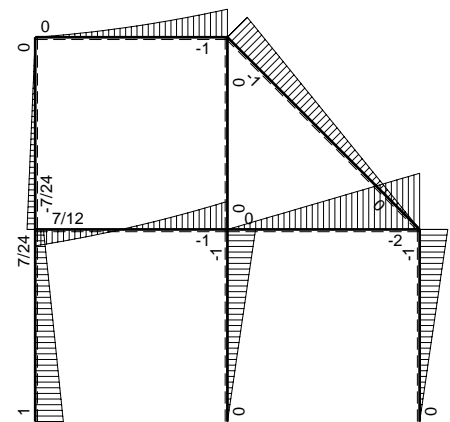
- A = 696. mm<sup>2</sup>
- J<sub>u</sub> = 265885. mm<sup>4</sup>
- J<sub>v</sub> = 43992. mm<sup>4</sup>
- y<sub>g</sub> = 24.15 mm
- T<sub>y</sub> = -2240. N
- M<sub>x</sub> = -2038400. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 29.85 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 228.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -17.15 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -131.5 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.631 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 132.1 N/mm<sup>2</sup>
- S = 5435. mm<sup>3</sup>



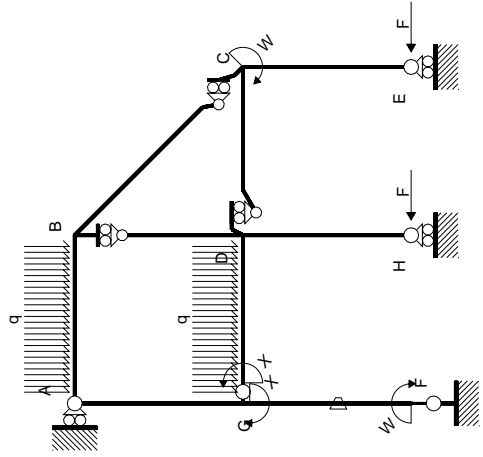


← ⊕ → F

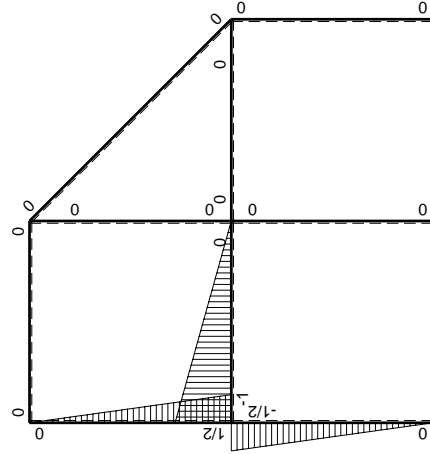
↑ ⊕ ↓ F\_b



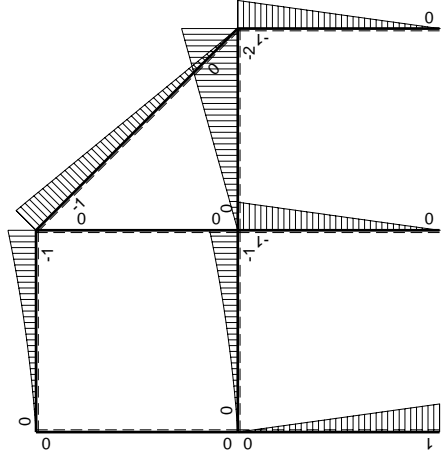
⊕ F\_b



Schema di calcolo iperstatico



$M_x$  flessione da iperstatica  $X=1$



$M_0$  flessione da carichi assegnati

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	$-1/2x/b$	$Fb-Fx$	$-Fb/EJ$	$-1/2Fx+1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$	
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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

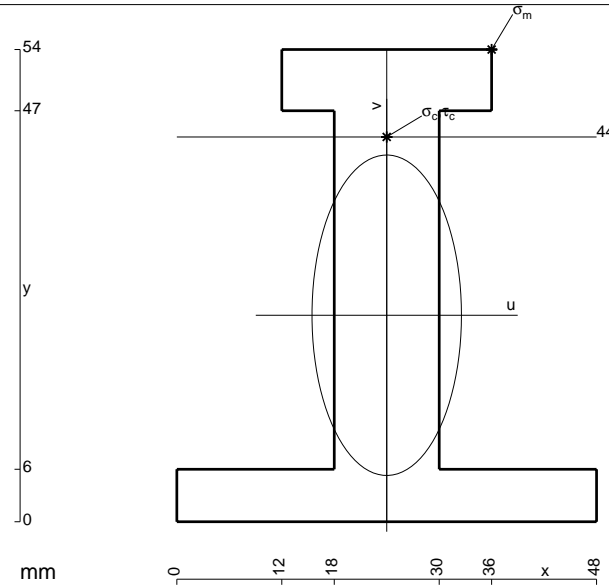
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

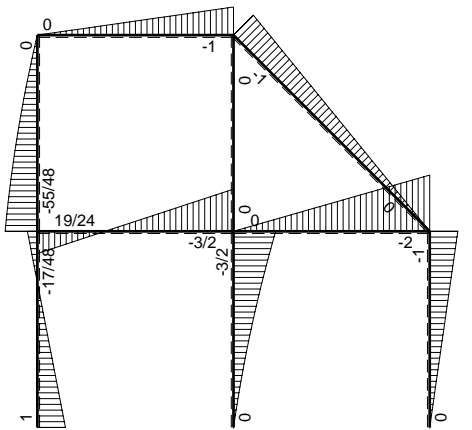
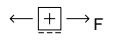
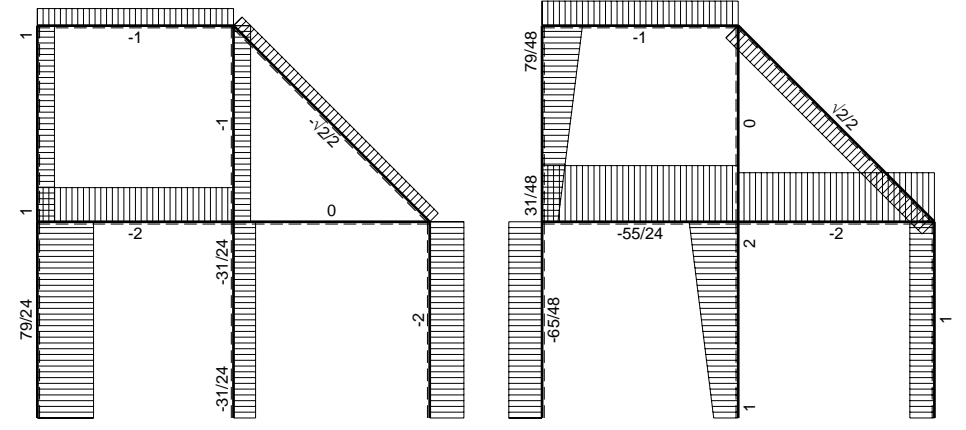
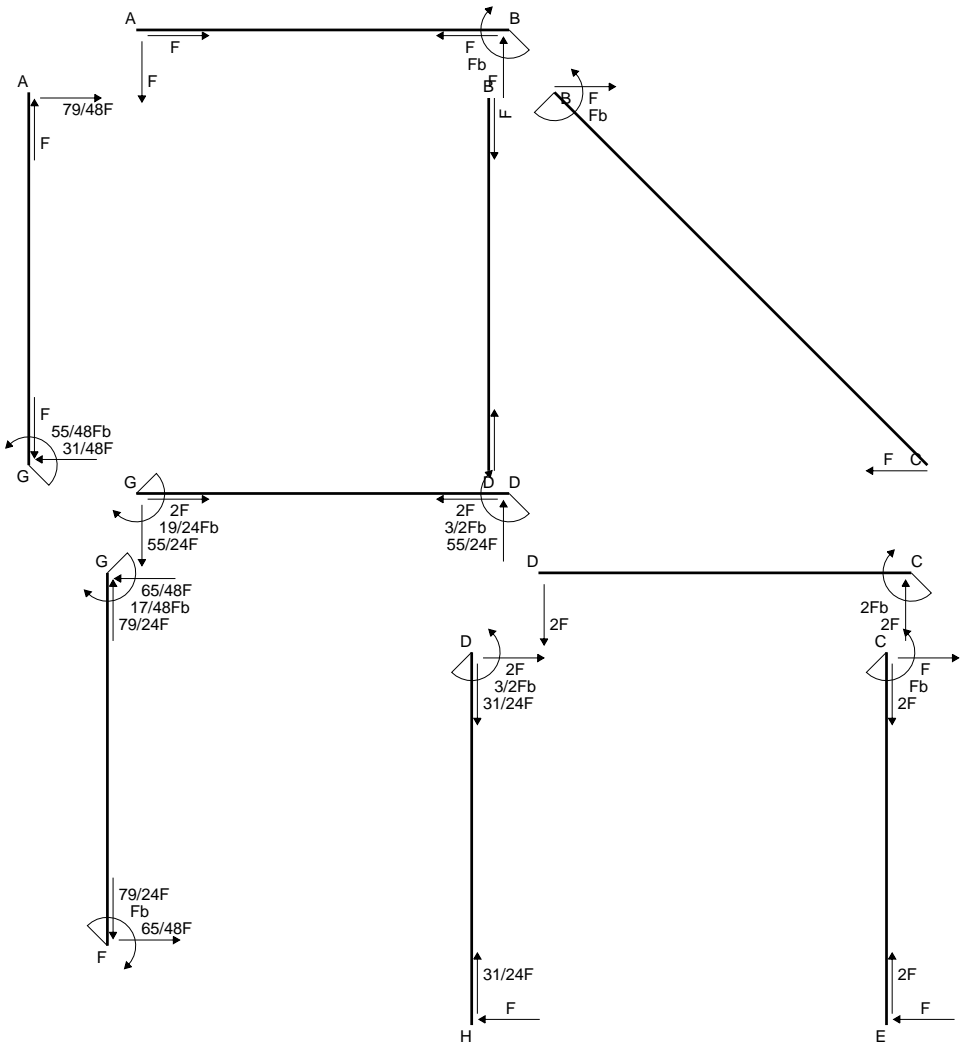
$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

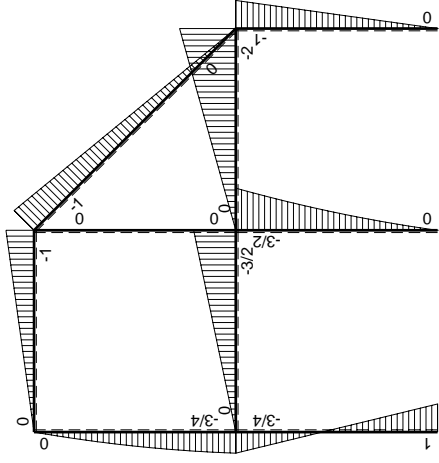
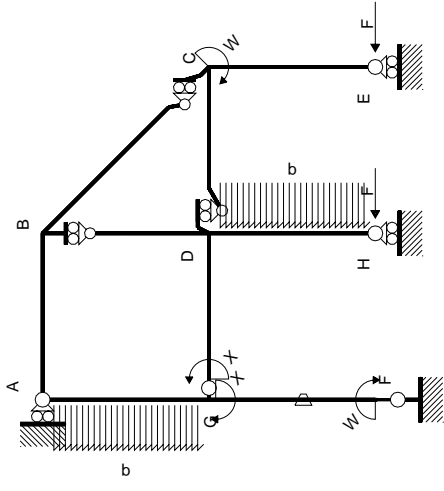
$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$



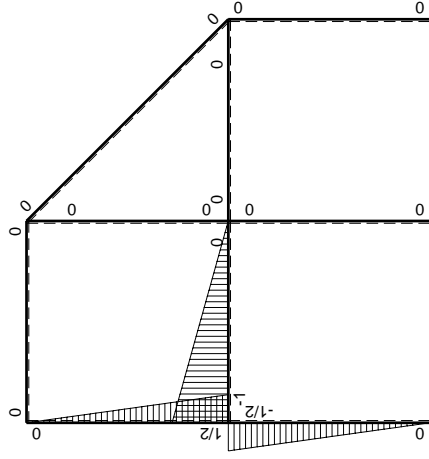
- A = 948. mm<sup>2</sup>
- J<sub>u</sub> = 318391. mm<sup>4</sup>
- J<sub>v</sub> = 69264. mm<sup>4</sup>
- y<sub>g</sub> = 23.61 mm
- T<sub>y</sub> = -2600. N
- M<sub>x</sub> = -2496000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 30.39 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 238.2 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 44. mm
- v<sub>c</sub> = 20.39 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 159.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.61 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 159.9 N/mm<sup>2</sup>
- S = 5305. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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	Fb-7/4Fx	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-7/4Fx	Fb/EJ	3/8Fb-5/4Fx+7/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						19/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-19/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b) Fb 1/EJ + (1/4 b) \theta = 7/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 5/4 x/b + 7/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 5/8 x^2/b + 7/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 5/8 b + 7/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 7/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

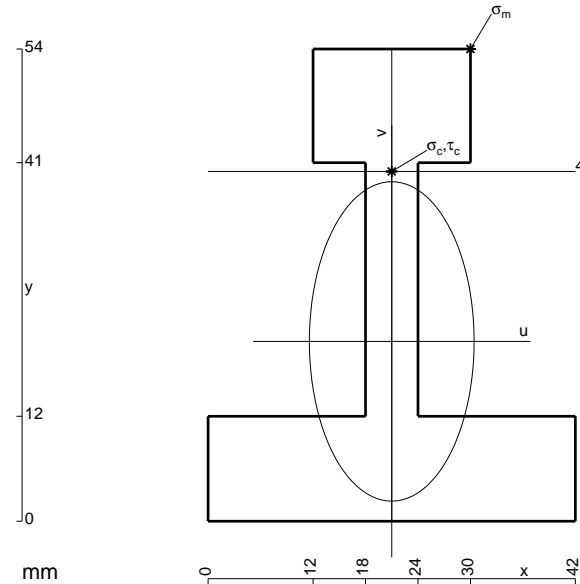
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

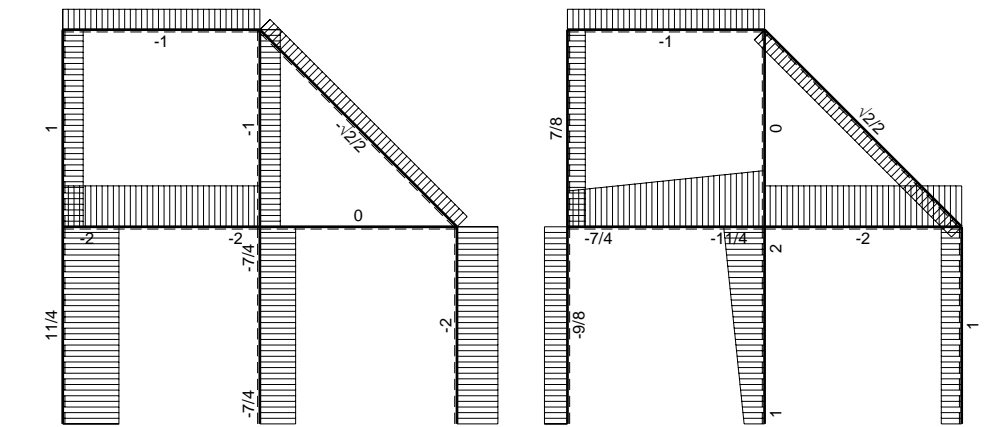
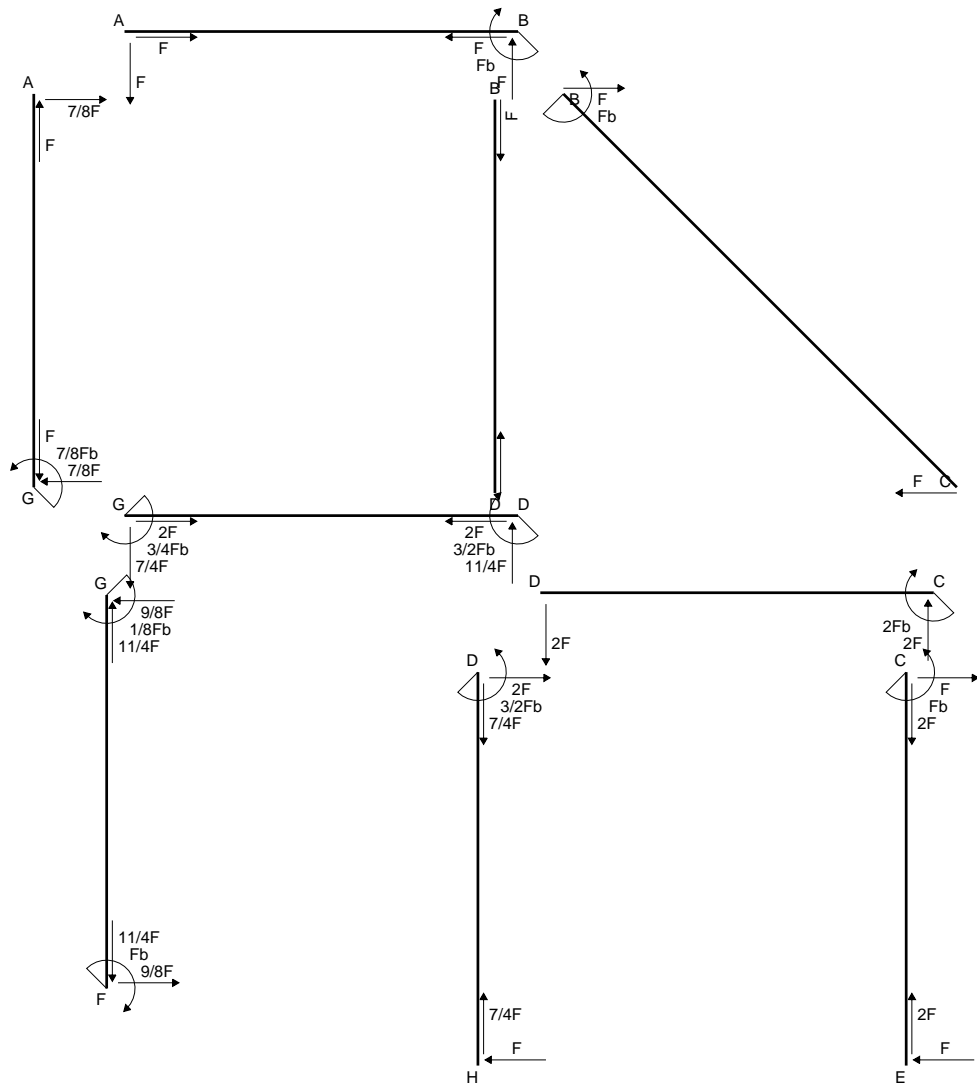
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



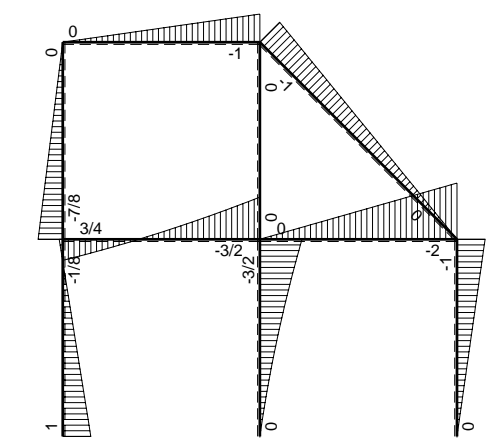
- A = 912. mm<sup>2</sup>
- J<sub>u</sub> = 304351. mm<sup>4</sup>
- J<sub>v</sub> = 80928. mm<sup>4</sup>
- y<sub>g</sub> = 20.56 mm
- T<sub>y</sub> = -3560. N
- M<sub>x</sub> = -1815600. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.44 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 40. mm
- v<sub>c</sub> = 19.44 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 116. N/mm<sup>2</sup>
- τ<sub>c</sub> = 12.52 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 118. N/mm<sup>2</sup>
- S = 6424. mm<sup>3</sup>



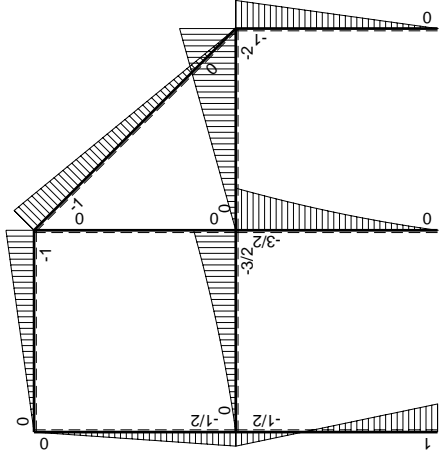
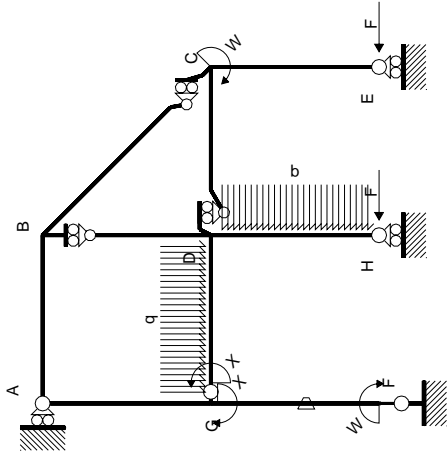


← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx-1/2qx <sup>2</sup>	0	Fx-1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	3/2Fb-2Fx+1/2qx <sup>2</sup>	0	3/2Fx-2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							3/8Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-3/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - 1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/6 b - 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 2/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

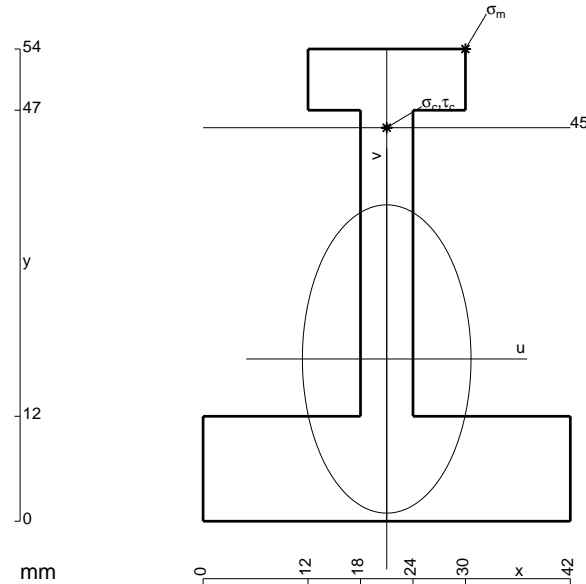
$$= (3/4 b - 2/3 b + 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

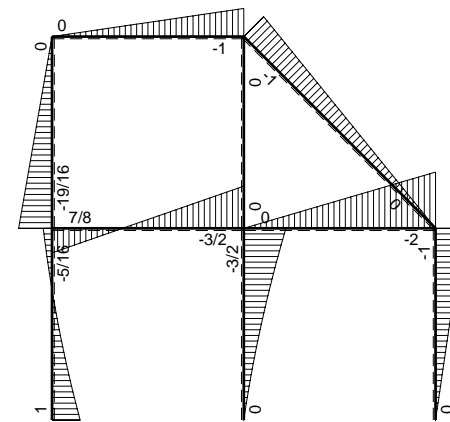
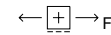
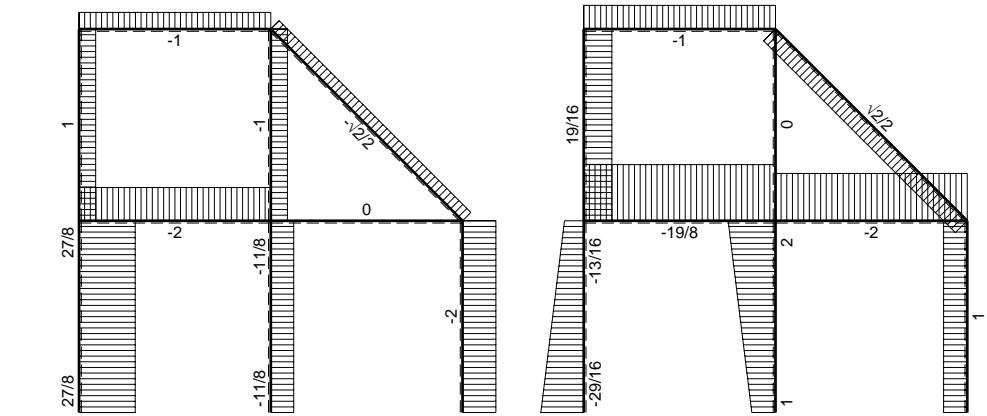
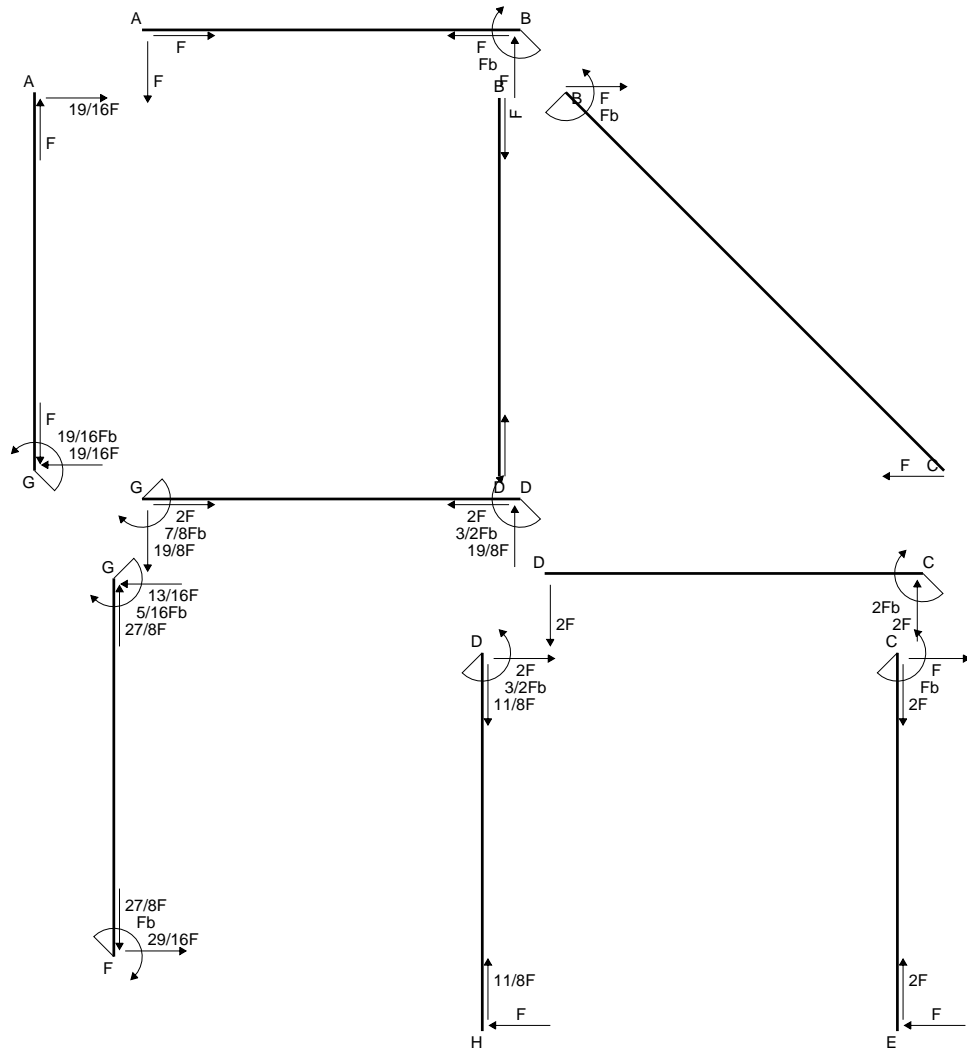
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

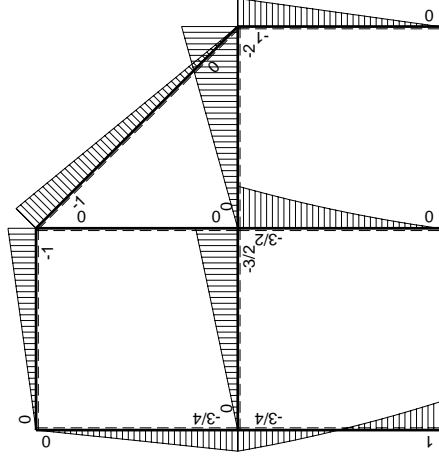
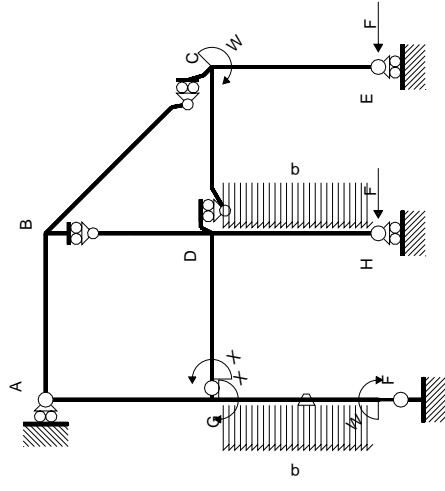
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



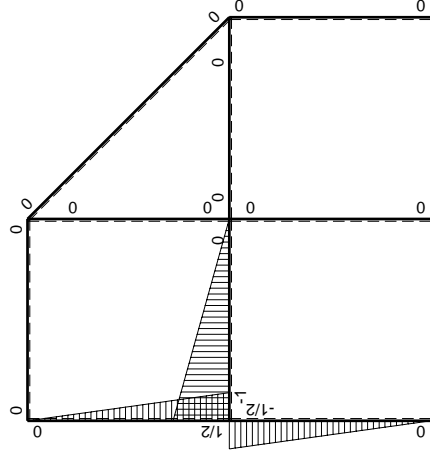
- A = 840. mm<sup>2</sup>
- J<sub>u</sub> = 261182. mm<sup>4</sup>
- J<sub>v</sub> = 78120. mm<sup>4</sup>
- y<sub>g</sub> = 18.55 mm
- T<sub>y</sub> = -2760. N
- M<sub>x</sub> = -1545600. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 35.45 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 45. mm
- v<sub>c</sub> = 26.45 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 156.5 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.67 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 157.1 N/mm<sup>2</sup>
- S = 4355. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-9/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+9/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/16+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-5/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-Fx+3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 -2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b +1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b +1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b +9/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b +3/8 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b +3/8 b -1/16 b) Fb 1/EJ + (1/4 b) \theta = 5/16 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - x/b +3/8 x^2/b^2 +1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 +1/2 x/b) \theta dx$$

$$= [3/8 x -1/2 x^2/b +1/8 x^3/b^2 +1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

$$= (3/8 b -1/2 b +1/8 b +1/16 b) Fb 1/EJ + (-1/2 b +1/4 b) \theta = 5/16 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b -3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b -1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b -1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b -3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b -1/2 x^3/b^2]_0^b Fb 1/EJ$$

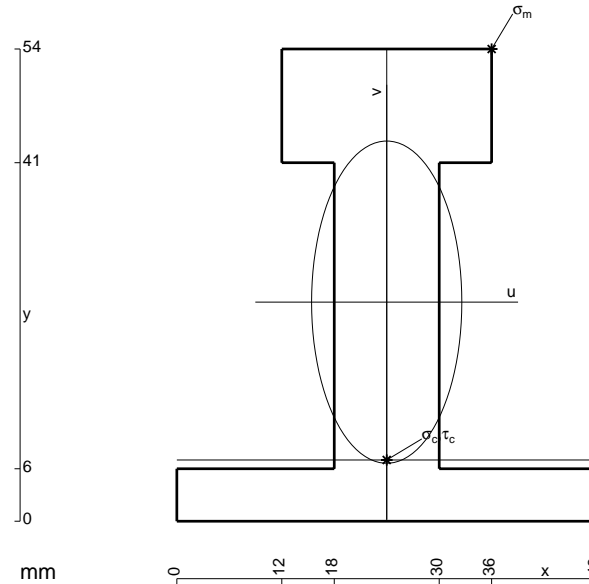
$$= (3/4 b -1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 +3/4 x/b -3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x +3/8 x^2/b -1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b +3/8 b -1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

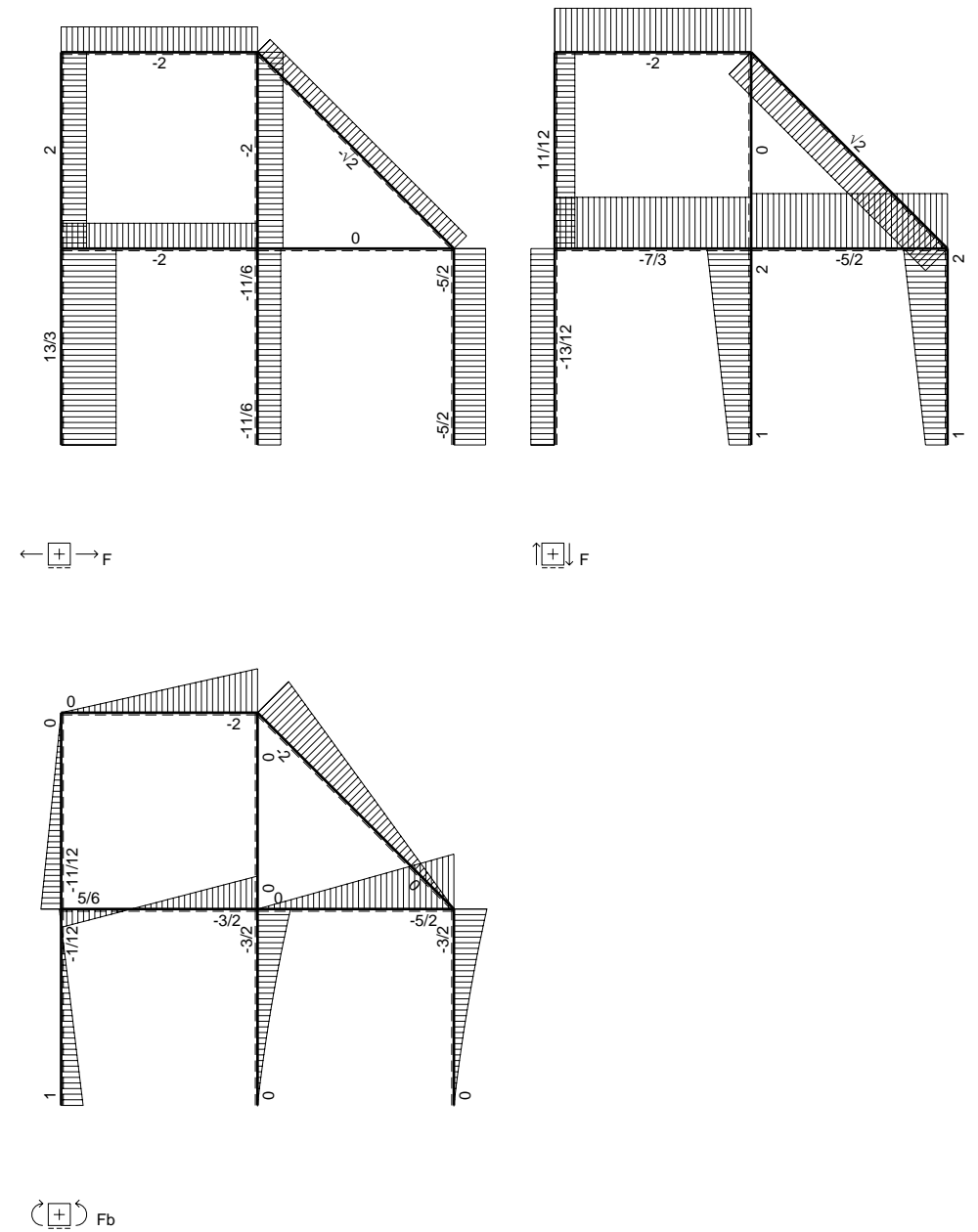
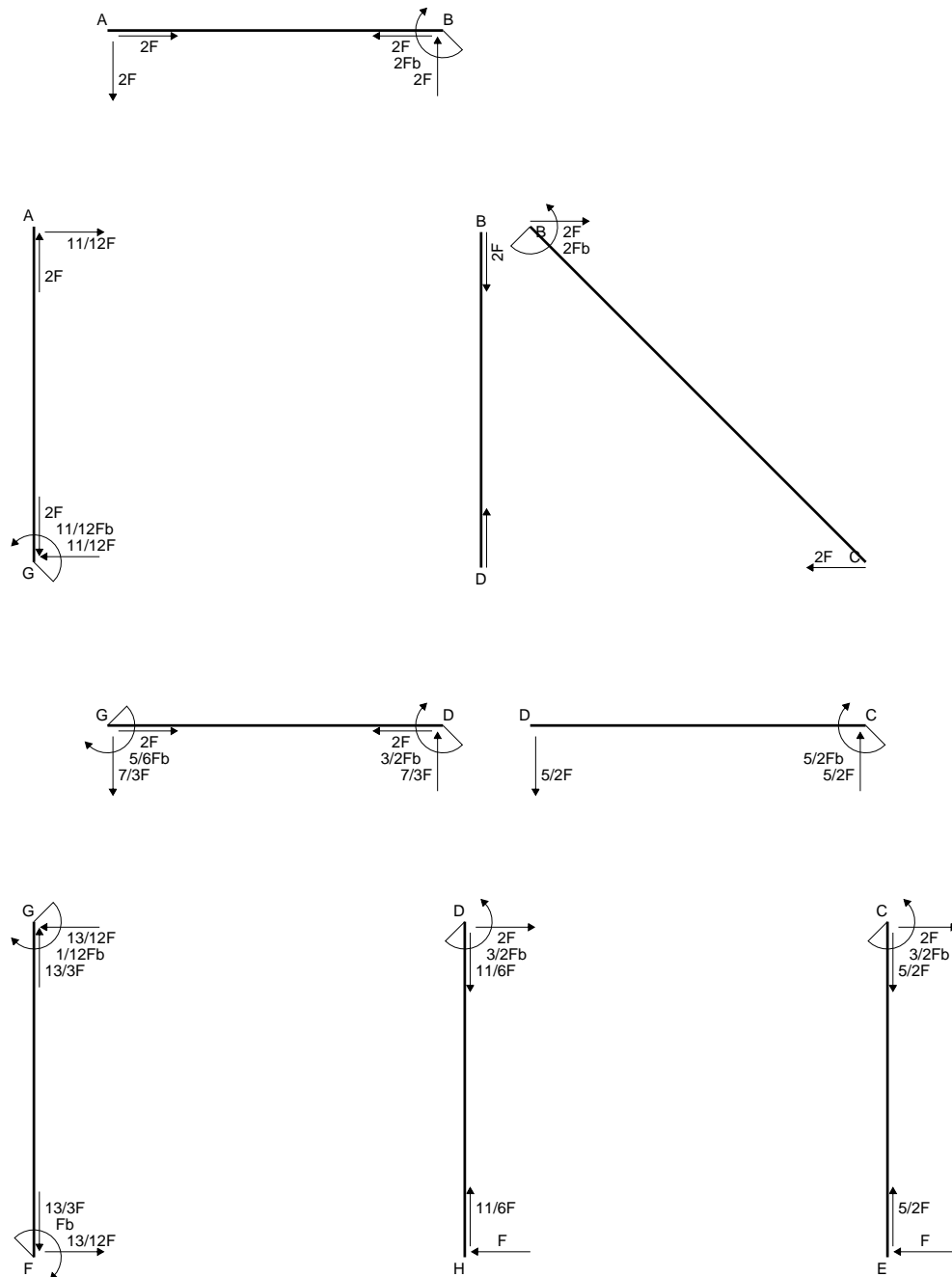
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

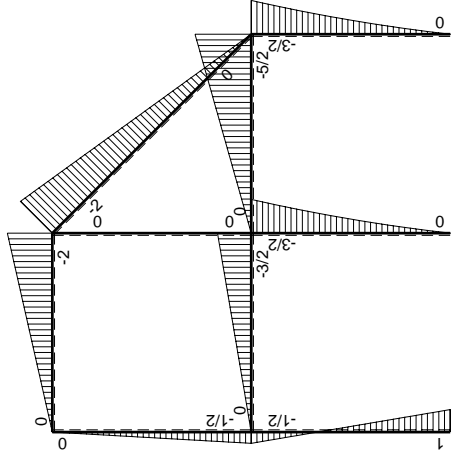
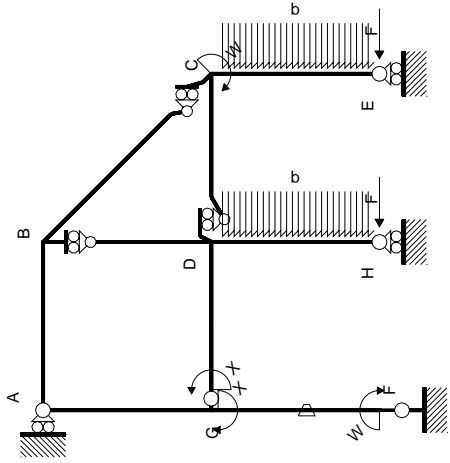
$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



- A = 1020. mm<sup>2</sup>
- J<sub>u</sub> = 346417. mm<sup>4</sup>
- J<sub>v</sub> = 75312. mm<sup>4</sup>
- y<sub>g</sub> = 25.05 mm
- T<sub>y</sub> = -4300. N
- M<sub>x</sub> = -2623000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 28.95 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 219.2 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -18.05 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -136.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.8 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 137.2 N/mm<sup>2</sup>
- S = 6574. mm<sup>3</sup>

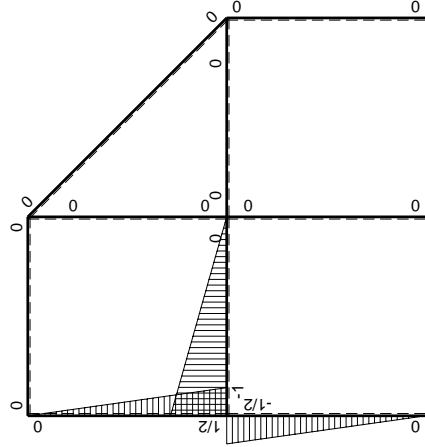






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

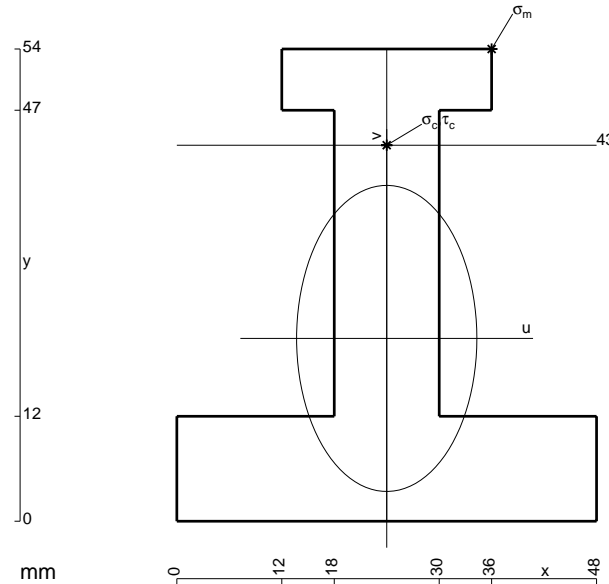
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

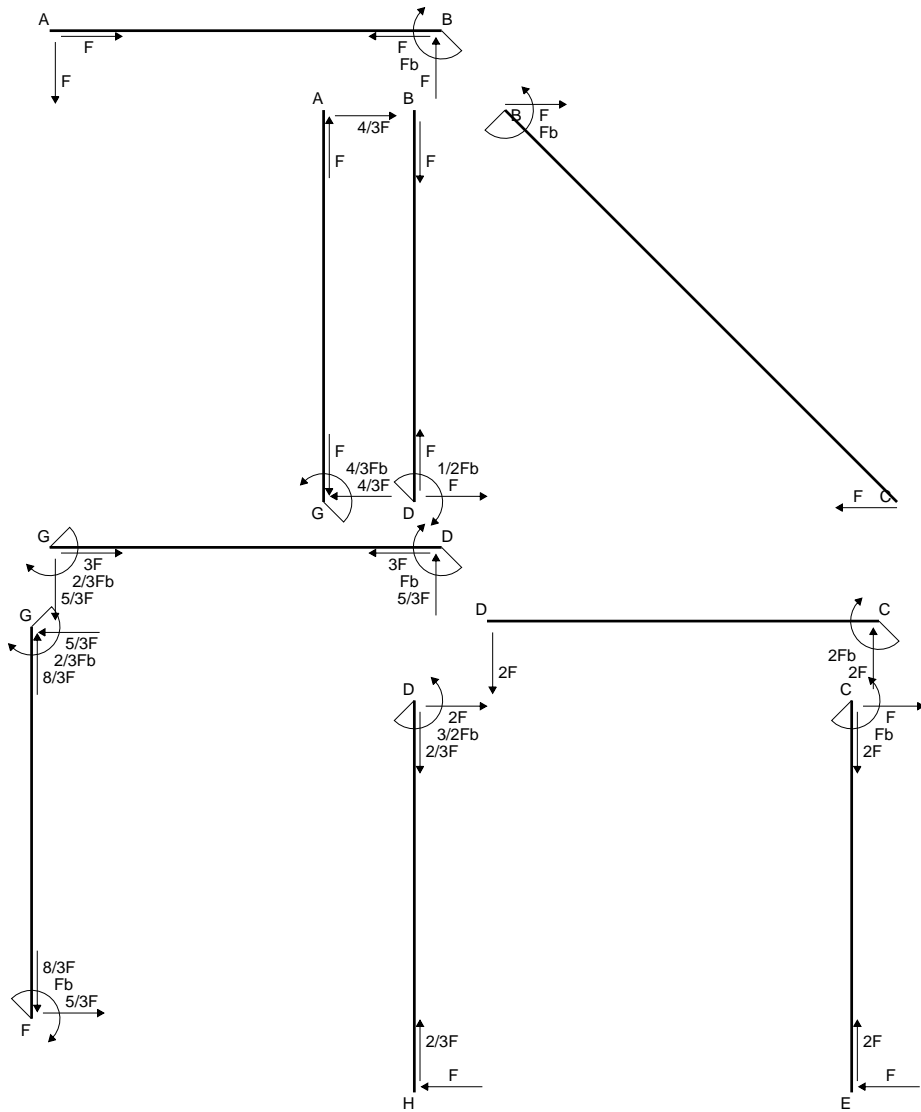
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



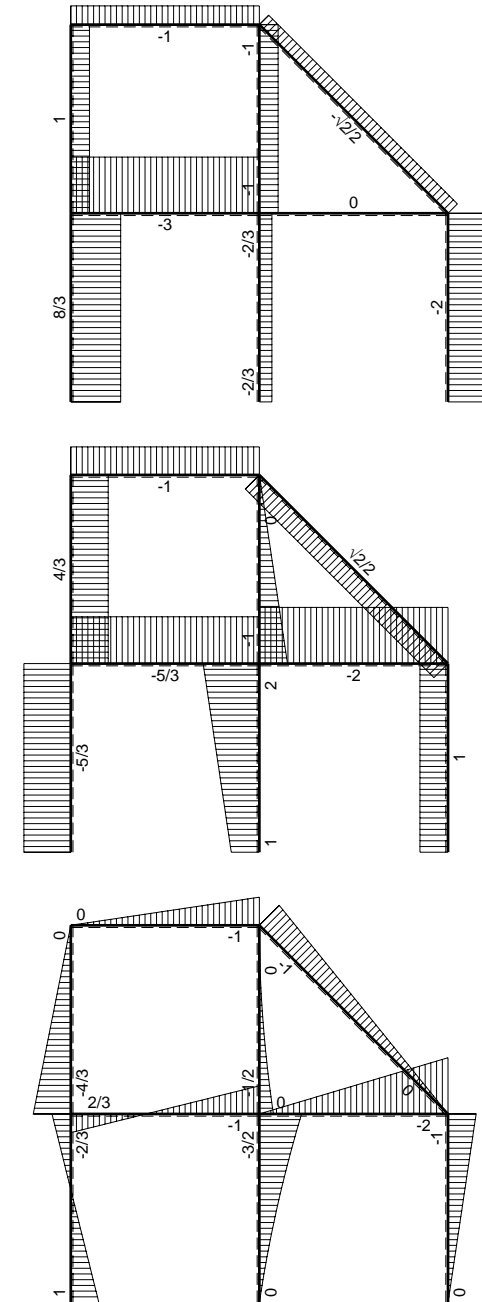
- A = 1164. mm<sup>2</sup>
- J<sub>u</sub> = 356609. mm<sup>4</sup>
- J<sub>v</sub> = 123696. mm<sup>4</sup>
- y<sub>g</sub> = 20.9 mm
- T<sub>y</sub> = -3750. N
- M<sub>x</sub> = -2475000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.1 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 229.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 43. mm
- v<sub>c</sub> = 22.1 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 153.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.371 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 153.6 N/mm<sup>2</sup>
- S = 6129. mm<sup>3</sup>

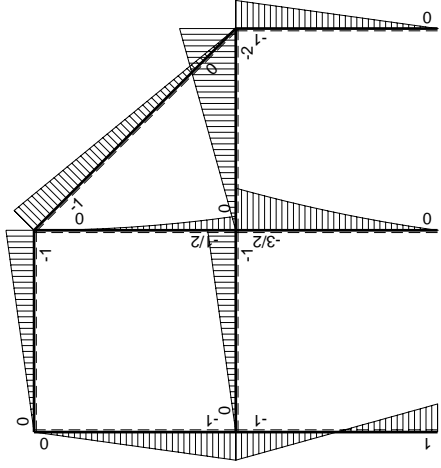
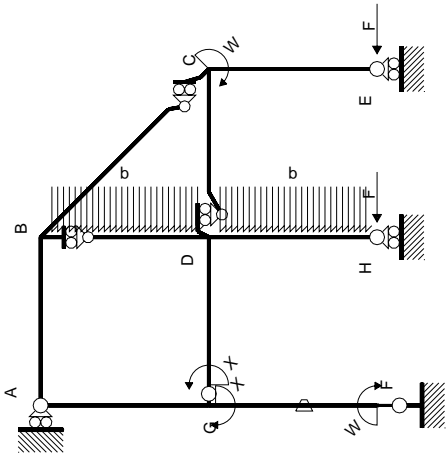


$$\leftarrow \boxed{+} \rightarrow F$$

$$\uparrow \boxed{+} \downarrow F$$

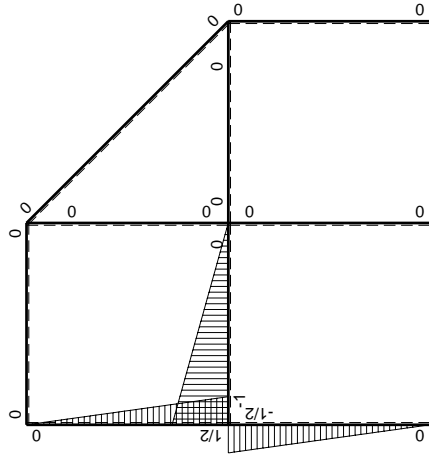
$$\circlearrowleft \boxed{+} \circlearrowright F_b$$





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	0	0	
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0	
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-2Fx	-Fb/EJ	-1/2Fx+Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-2Fx	Fb/EJ	1/2Fb-3/2Fx+Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							1/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/3 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - 3/2 x/b + x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 3/4 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 3/4 b + 1/3 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

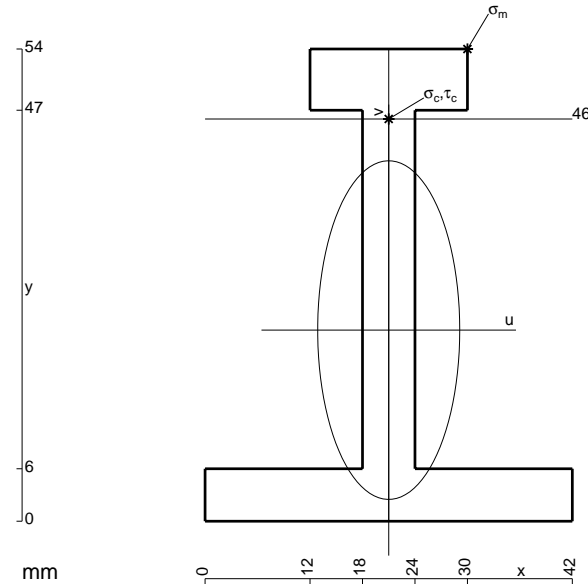
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



$$A = 624. \text{ mm}^2$$

$$J_u = 234015. \text{ mm}^4$$

$$J_v = 41184. \text{ mm}^4$$

$$y_g = 21.86 \text{ mm}$$

$$T_y = -2460. \text{ N}$$

$$M_x = -1746600. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 32.14 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

$$v_c = 24.14 \text{ mm}$$

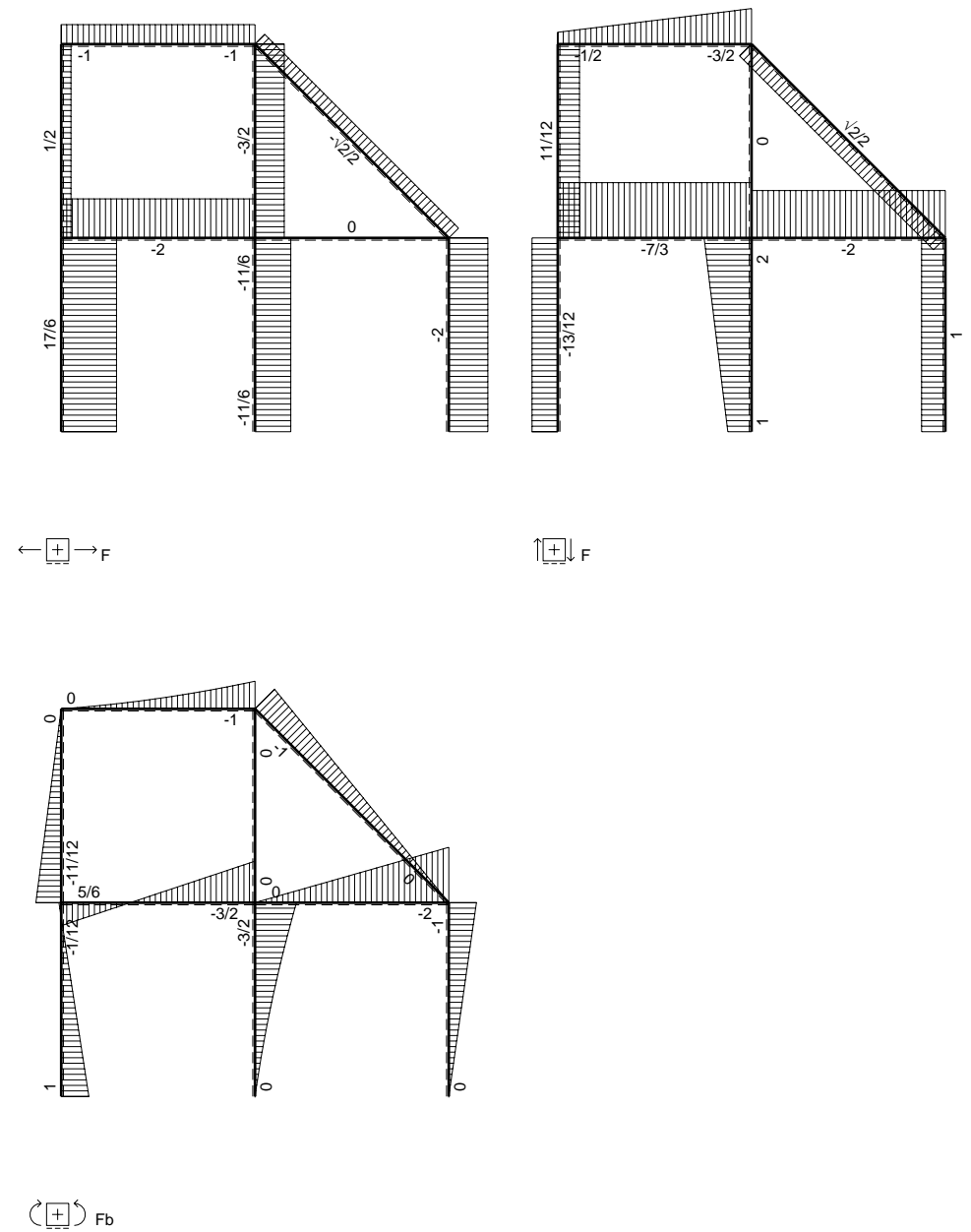
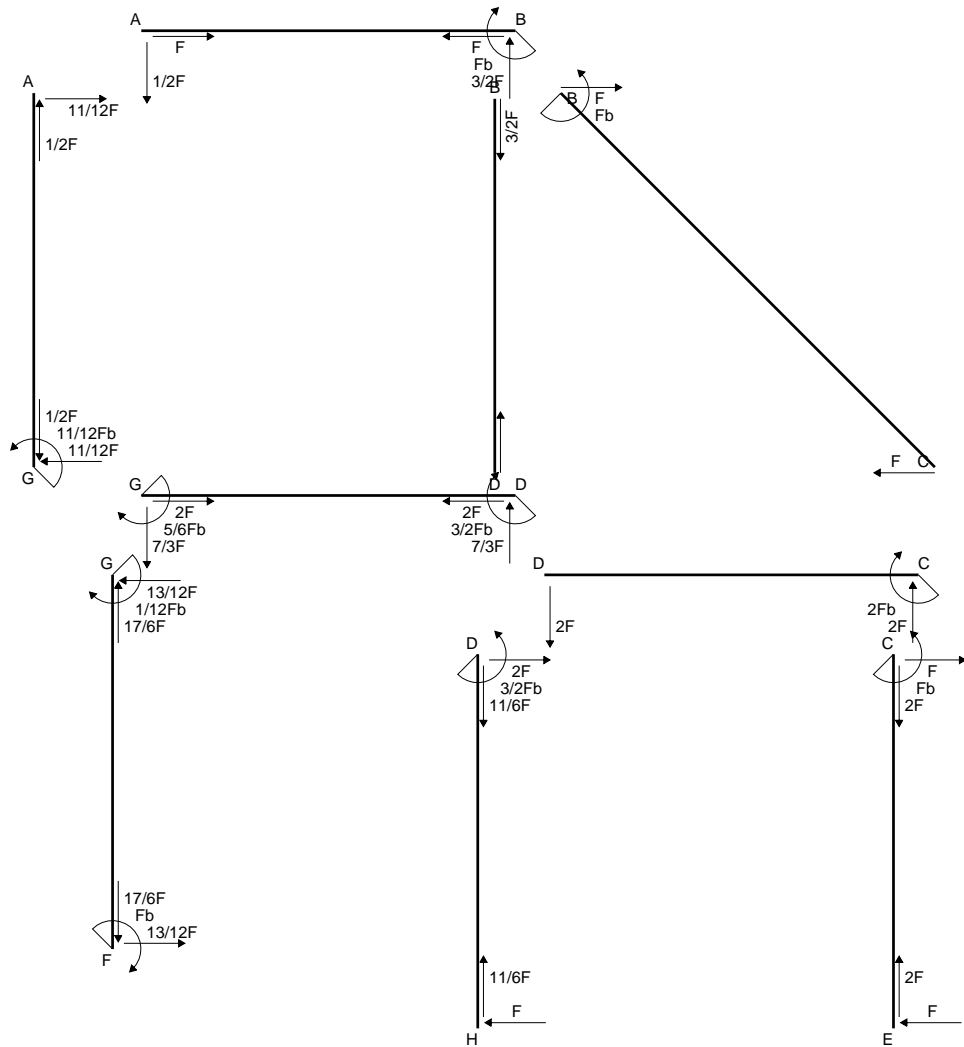
$$\sigma_c = -Mv/J_u = 180.2 \text{ N/mm}^2$$

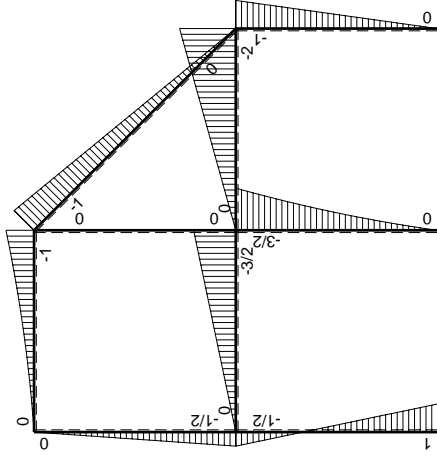
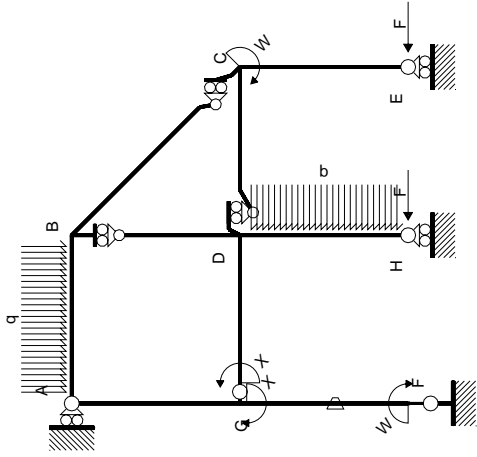
$$\tau_c = 6.582 \text{ N/mm}^2$$

$$\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 180.6 \text{ N/mm}^2$$

$$S = 3757. \text{ mm}^3$$

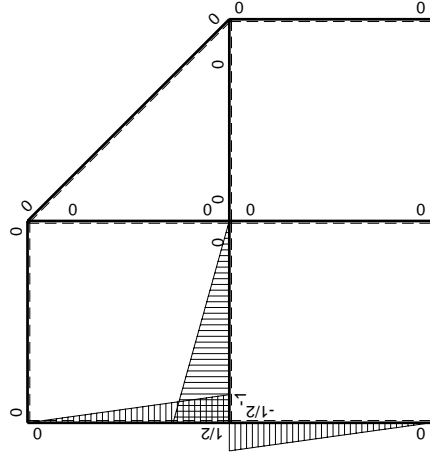






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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	$-1/2x/b$	$Fb-3/2Fx$	$-Fb/EJ$	$-1/2Fx+3/4Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(0+1/4)Fb^2/EJ$	$1/12Xb/EJ$
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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

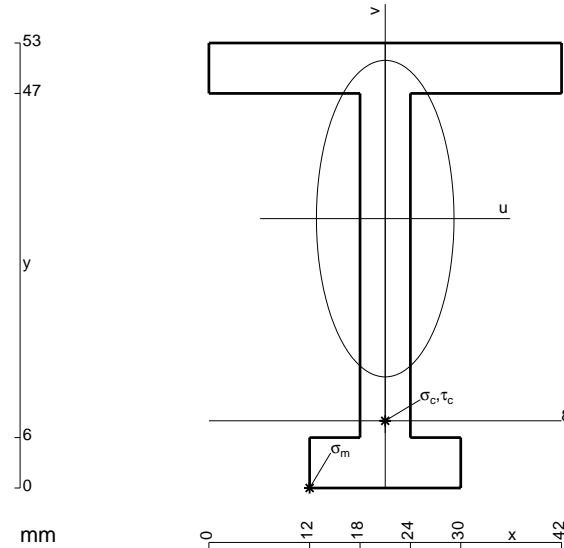
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

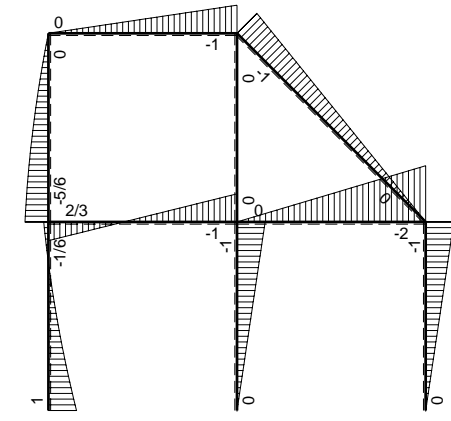
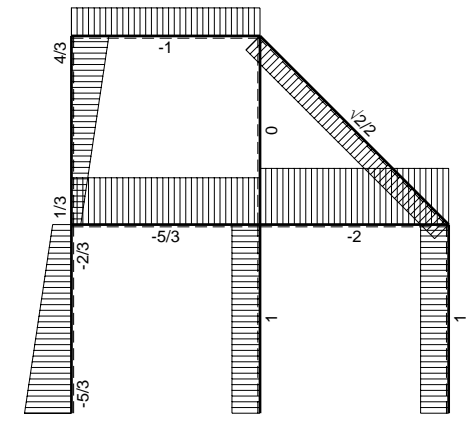
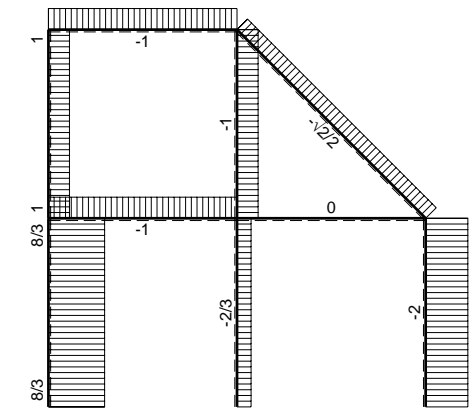
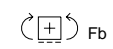
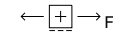
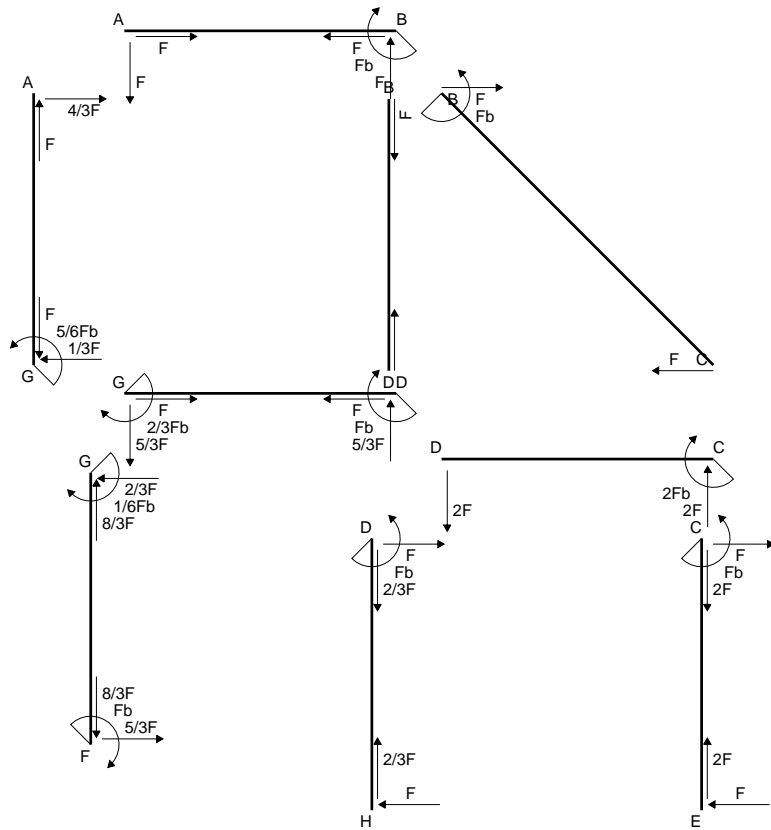
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

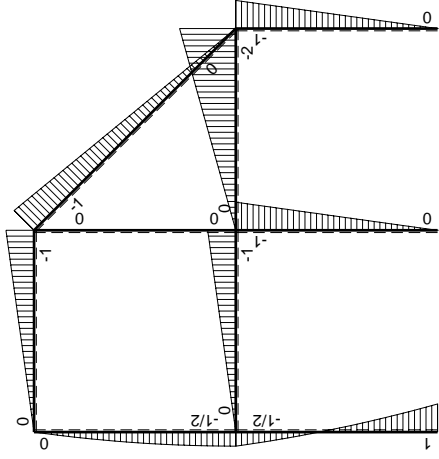
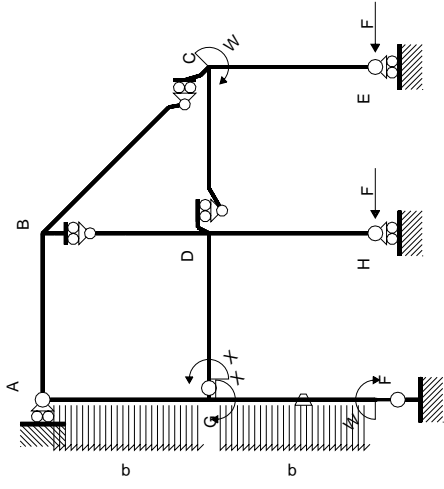
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



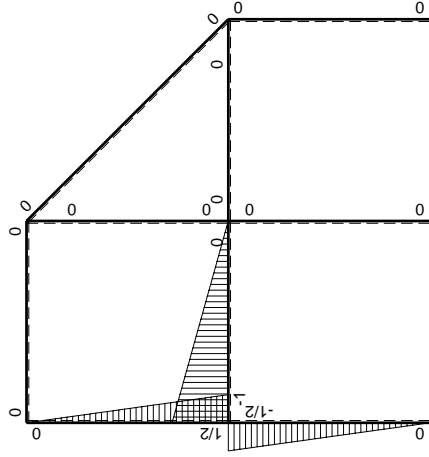
- A = 606. mm<sup>2</sup>
- J<sub>u</sub> = 215454. mm<sup>4</sup>
- J<sub>v</sub> = 40698. mm<sup>4</sup>
- y<sub>g</sub> = 32.08 mm
- T<sub>y</sub> = -1780. N
- M<sub>x</sub> = -1335000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -32.08 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -198.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 8. mm
- v<sub>c</sub> = -24.08 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -149.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.74 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 149.5 N/mm<sup>2</sup>
- S = 3442. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-2Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-Fx-1/2qx <sup>2</sup>	Fb/EJ	1/4Fb-3/4Fx+1/4Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/2Fb+1/2qx <sup>2</sup>	0	-1/4Fb+1/4Fx+1/4Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-5/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx-1/2qx <sup>2</sup>	0	-1/2Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						1/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1/2 - x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/3 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/3 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 13/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 3/4 x/b + 1/4 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 3/8 x^2/b + 1/12 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 3/8 b + 1/12 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 13/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

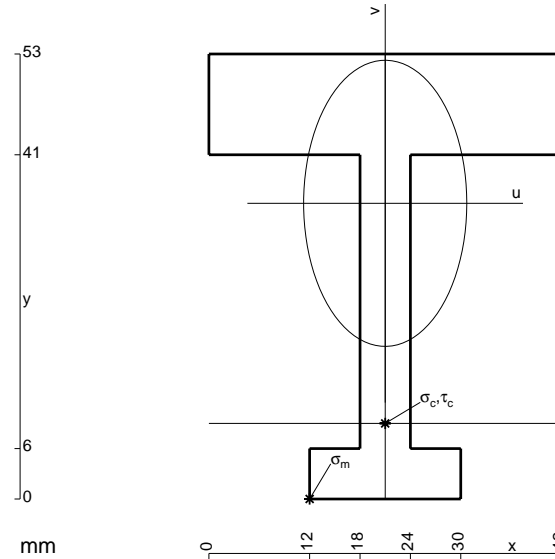
$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/4 x/b + 1/4 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-1/4 x + 1/8 x^2/b + 1/12 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/8 b + 1/12 b - 1/16 b) Fb 1/EJ = -5/48 Fb^2/EJ$$

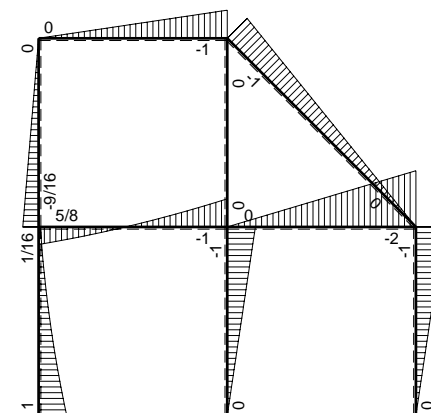
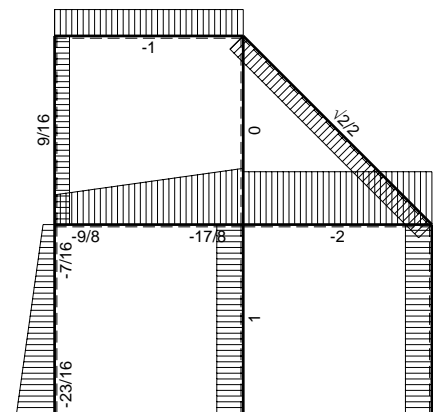
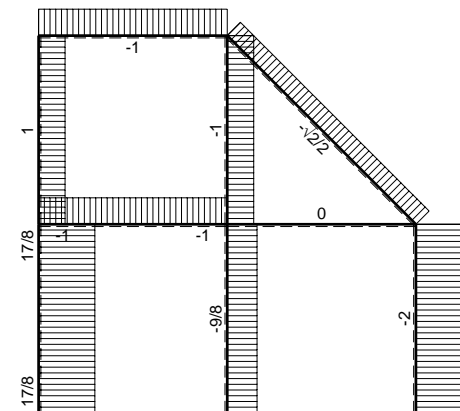
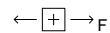
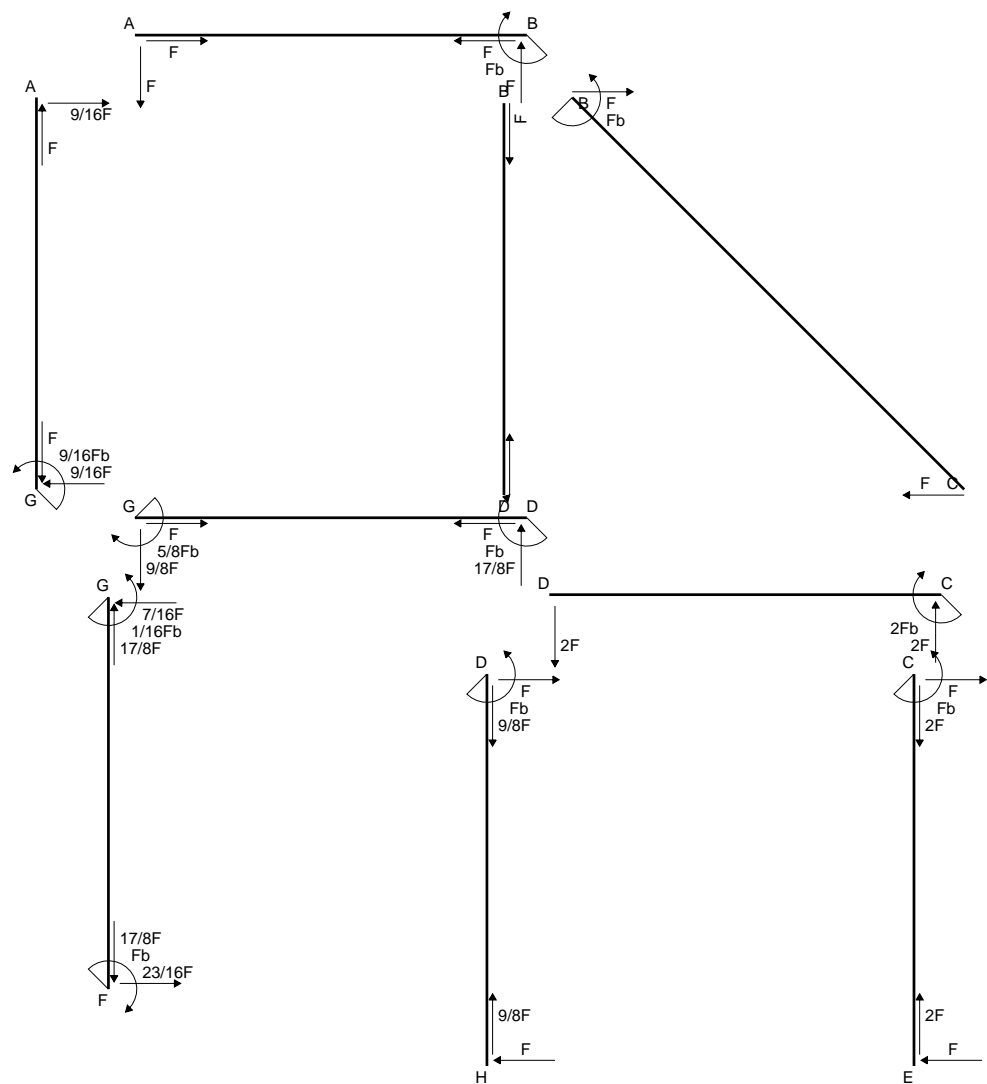
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/6 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

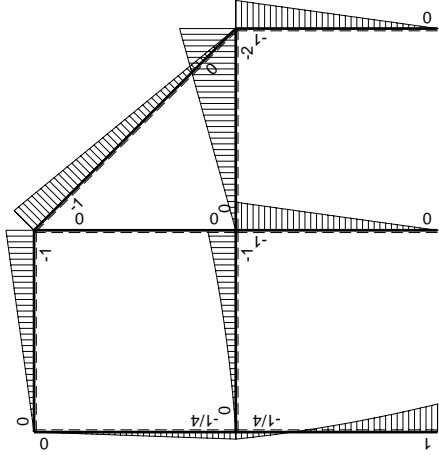
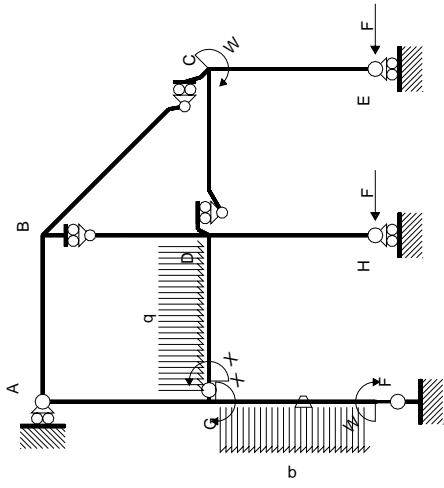
$$= (-1/6 b + 1/16 b) Fb 1/EJ = -5/48 Fb^2/EJ$$



- A = 822. mm<sup>2</sup>
- J<sub>u</sub> = 238712. mm<sup>4</sup>
- J<sub>v</sub> = 77634. mm<sup>4</sup>
- y<sub>g</sub> = 35.22 mm
- T<sub>y</sub> = -1760. N
- M<sub>x</sub> = -1408000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -35.22 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -207.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -26.22 mm
- σ<sub>c</sub> = -Mv/J<sub>v</sub> = -154.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.888 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 154.9 N/mm<sup>2</sup>
- S = 3978. mm<sup>3</sup>

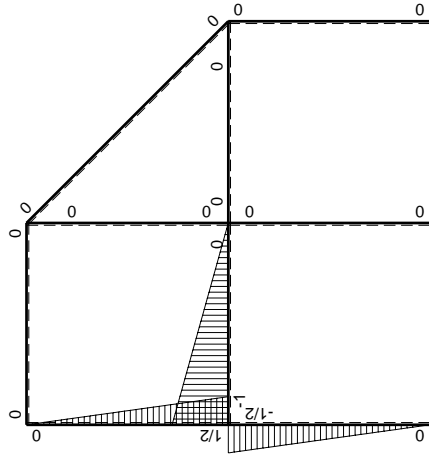






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	1/8Fb-1/2Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x_0} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b (1/8 - 1/2 x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 1/4 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 1/4 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

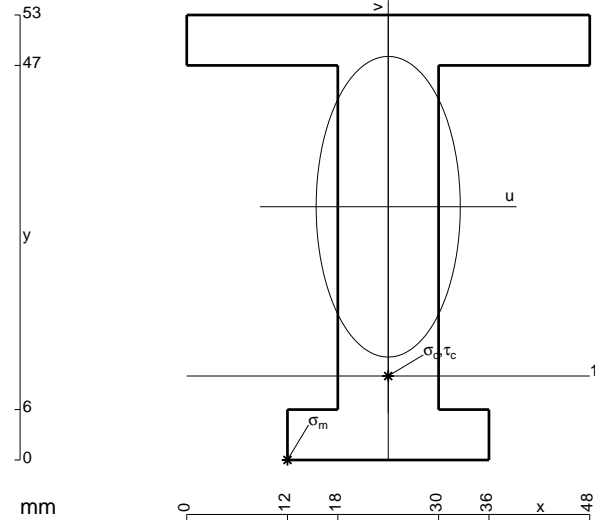
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b (-1/8 + 1/4 x/b - 1/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x + 1/8 x^2/b - 1/24 x^3/b^2]_0^b Fb 1/EJ$$

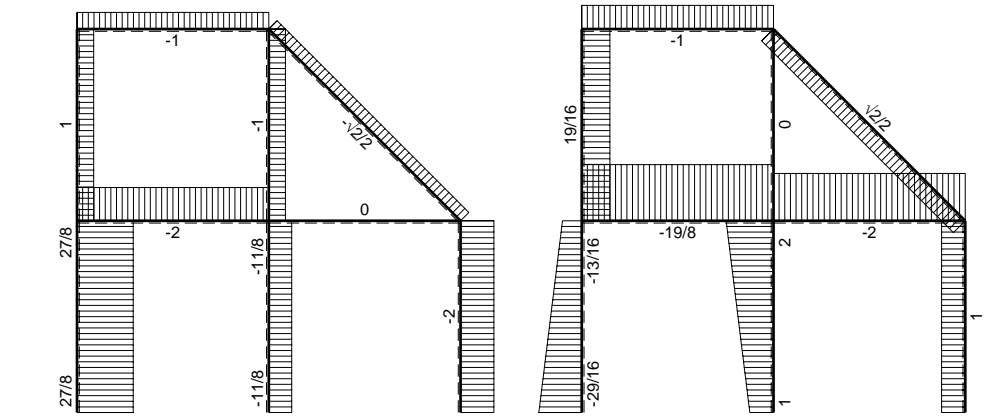
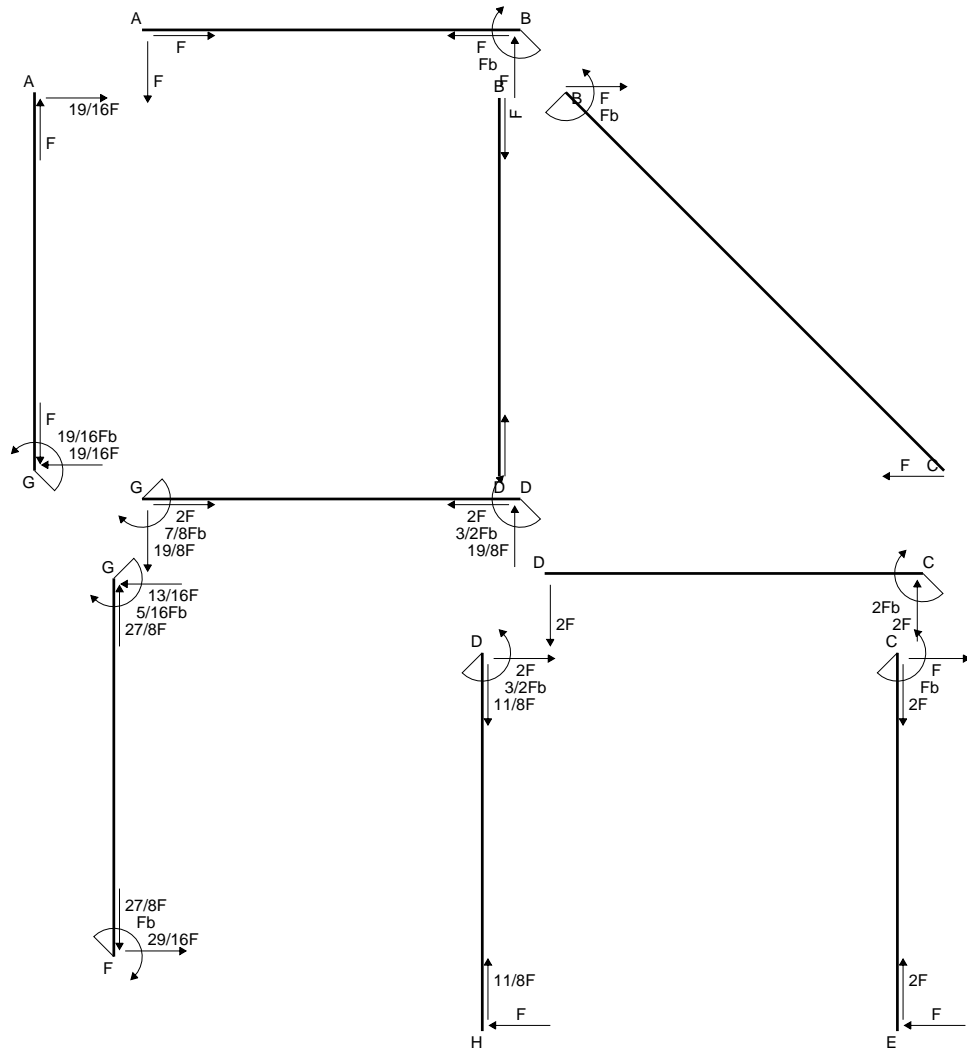
$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

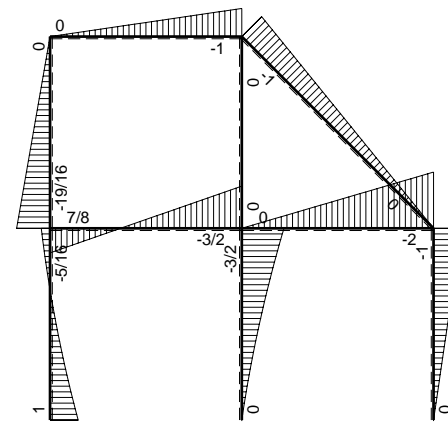


- A = 924. mm<sup>2</sup>
- J<sub>u</sub> = 296396. mm<sup>4</sup>
- J<sub>v</sub> = 68112. mm<sup>4</sup>
- y<sub>g</sub> = 30.16 mm
- T<sub>y</sub> = -2540. N
- M<sub>x</sub> = -2159000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -30.16 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -20.16 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -146.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.553 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 147. N/mm<sup>2</sup>
- S = 4975. mm<sup>3</sup>

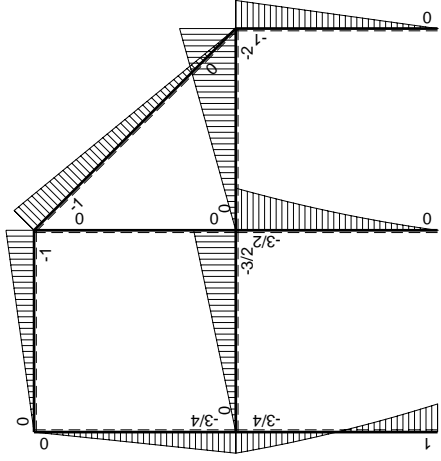
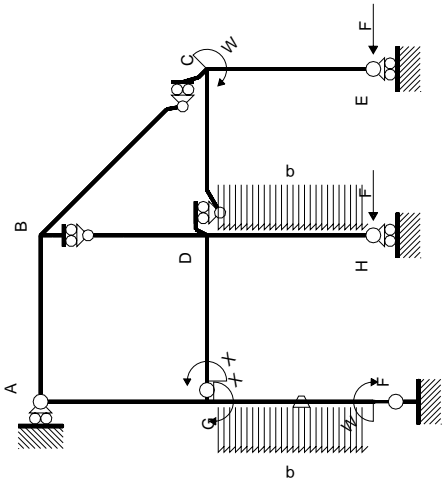


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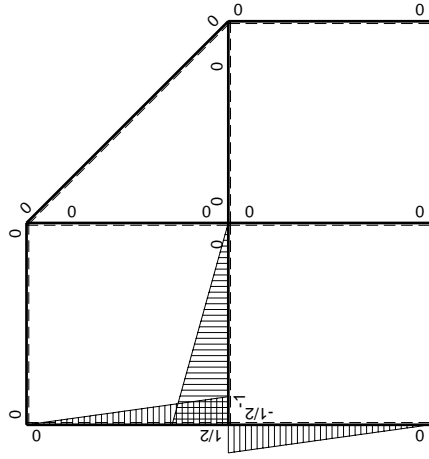


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-9/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+9/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/16+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-5/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-Fx+3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 9/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 3/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 3/8 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 5/16 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - x/b + 3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/2 x^2/b + 1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/2 b + 1/8 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/16 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

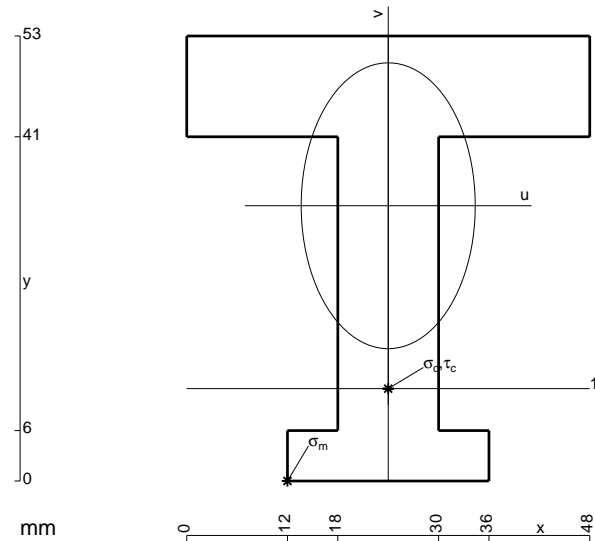
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

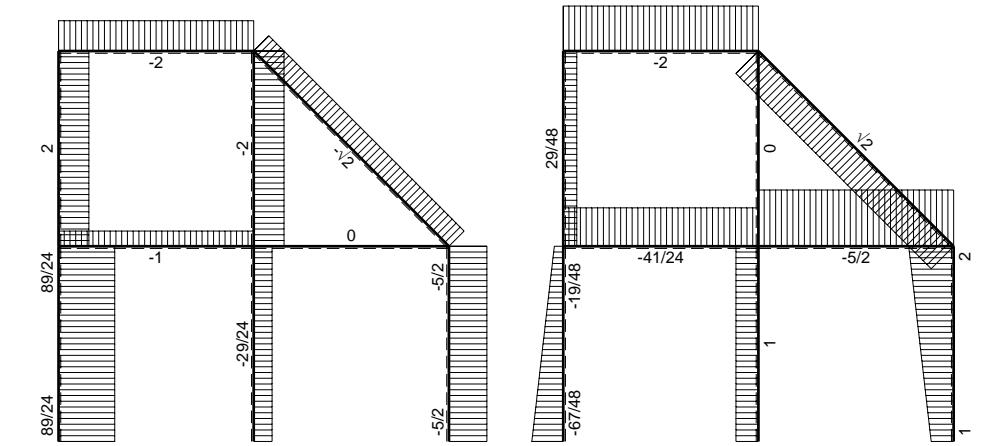
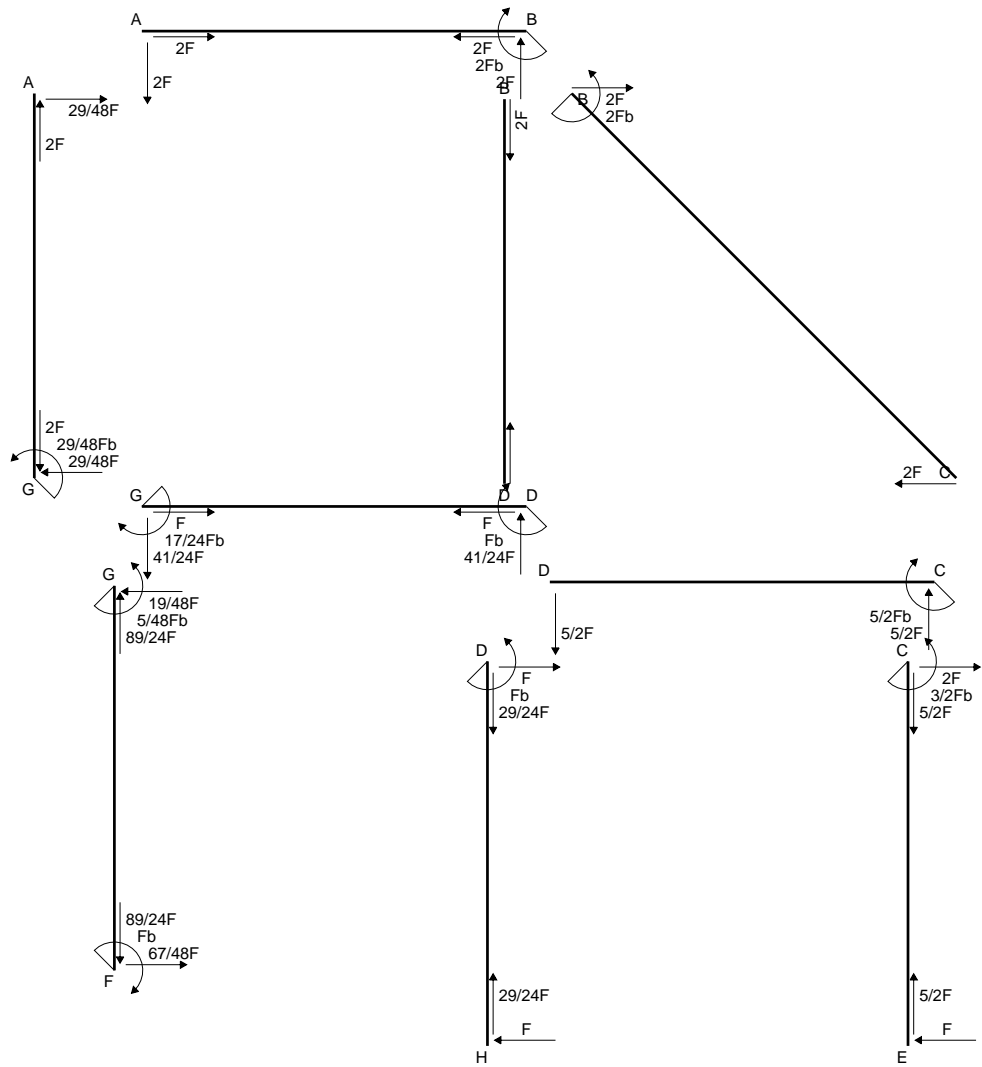
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



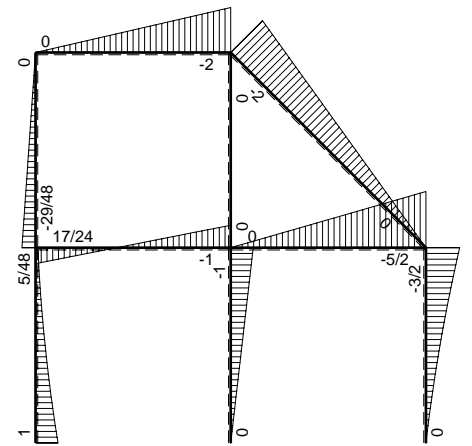
- A = 1140. mm<sup>2</sup>
- J<sub>u</sub> = 330567. mm<sup>4</sup>
- J<sub>v</sub> = 122544. mm<sup>4</sup>
- y<sub>g</sub> = 32.78 mm
- T<sub>y</sub> = -2560. N
- M<sub>x</sub> = -2304000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -32.78 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -228.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -21.78 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -151.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.708 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup> + 3τ<sup>2</sup> = 152. N/mm<sup>2</sup>
- S = 5746. mm<sup>3</sup>



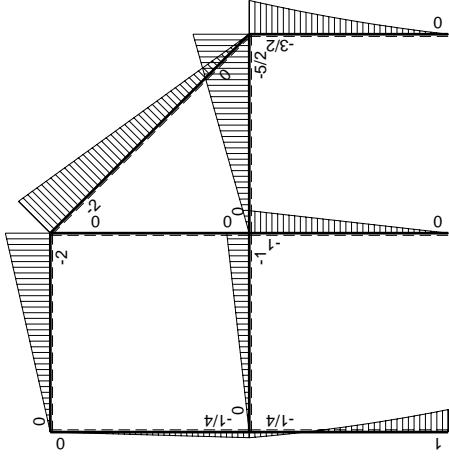
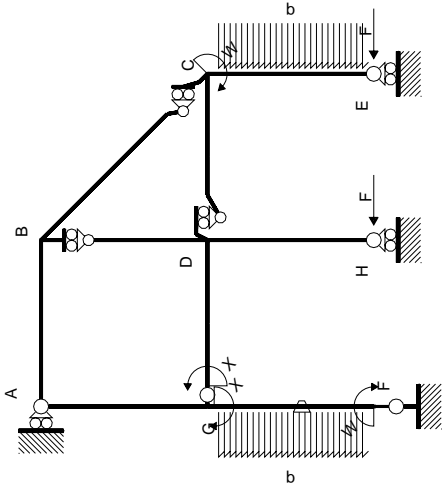


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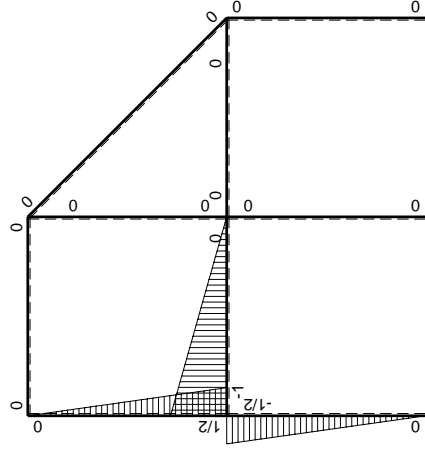


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	Fb-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	1/8Fb-1/2Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						17/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-17/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b (1/8 - 1/2 x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 1/4 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 1/4 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

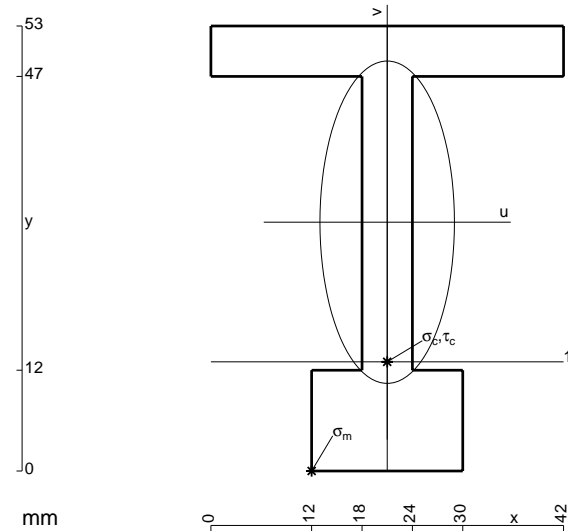
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b (-1/8 + 1/4 x/b - 1/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x + 1/8 x^2/b - 1/24 x^3/b^2]_0^b Fb 1/EJ$$

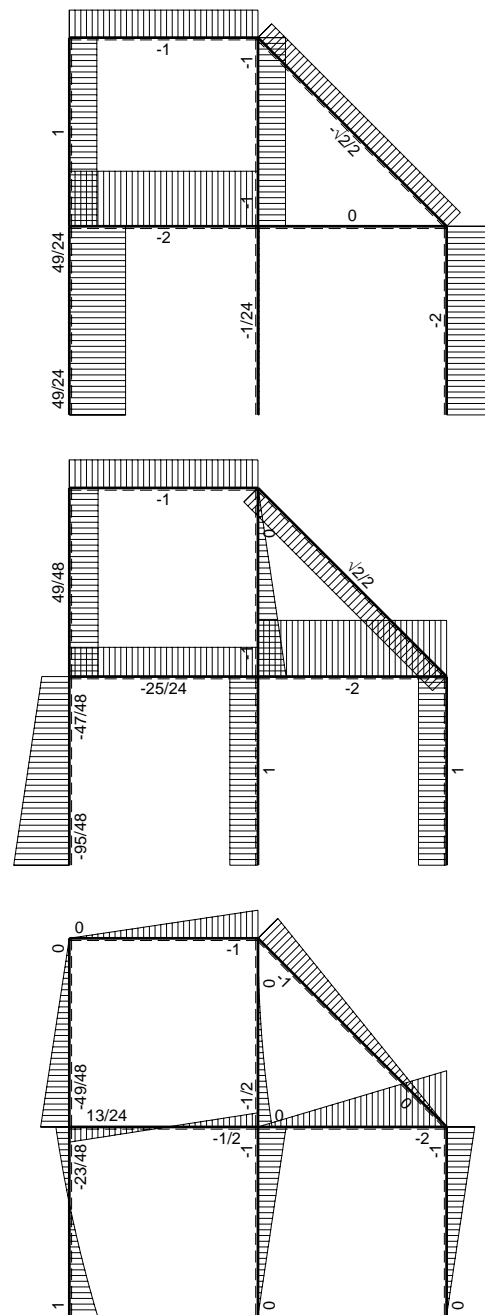
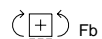
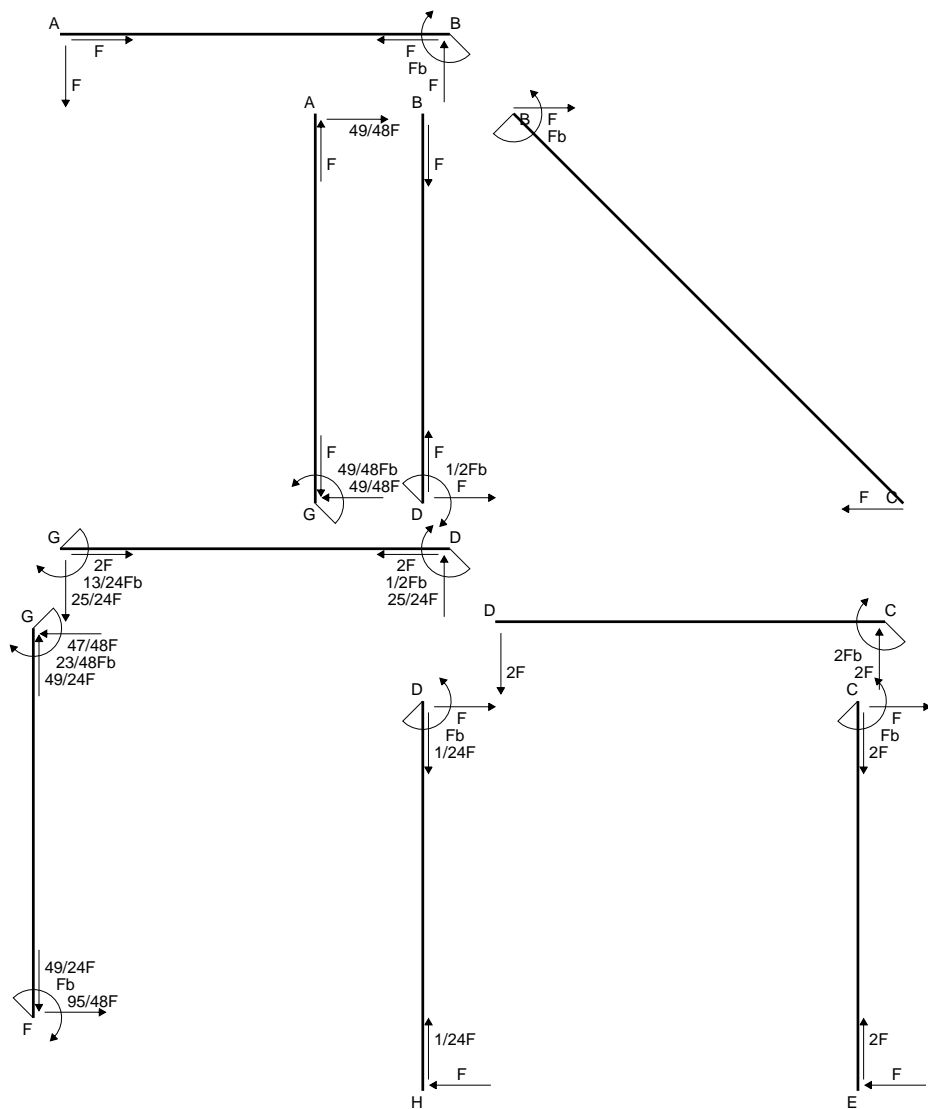
$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

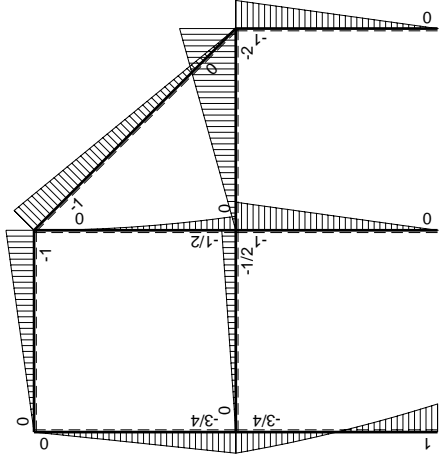
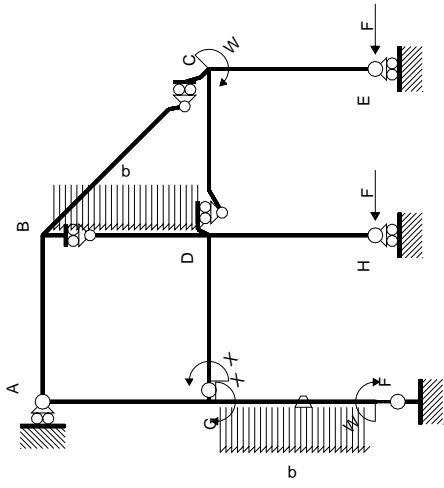
$$L_{AG}^{x\theta} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$



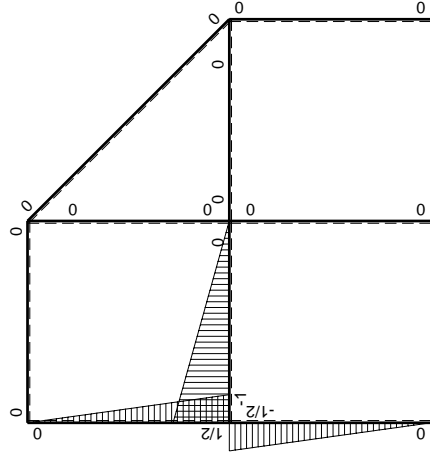
- A = 678. mm<sup>2</sup>
- J<sub>u</sub> = 249963. mm<sup>4</sup>
- J<sub>v</sub> = 43506. mm<sup>4</sup>
- y<sub>g</sub> = 29.63 mm
- T<sub>y</sub> = -2125. N
- M<sub>x</sub> = -2018750. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -29.63 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -16.63 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -134.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.378 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 134.9 N/mm<sup>2</sup>
- S = 5207. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-9/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+9/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/16+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-5/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-Fx+3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						13/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 9/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 3/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 3/8 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 5/16 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - x/b + 3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/2 x^2/b + 1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/2 b + 1/8 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/16 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

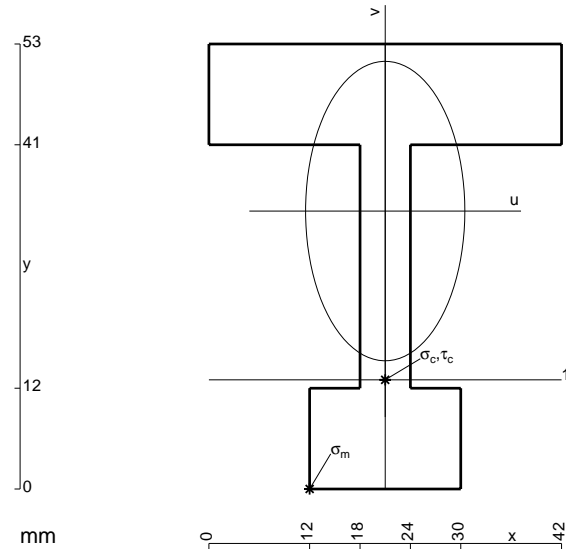
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

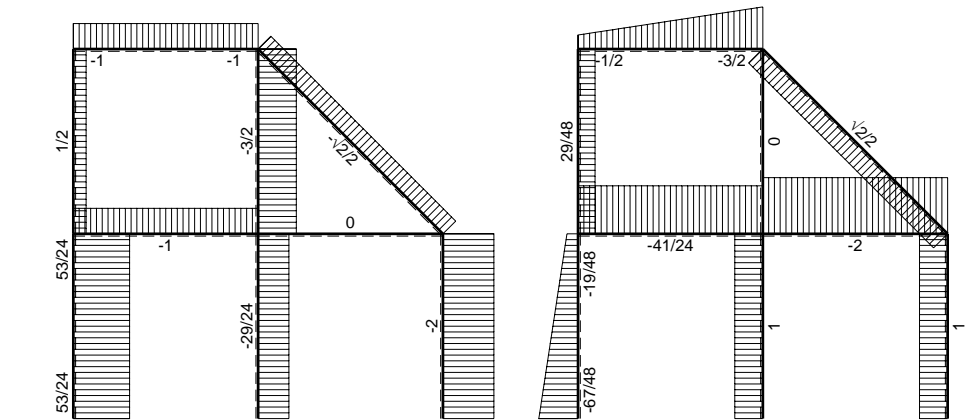
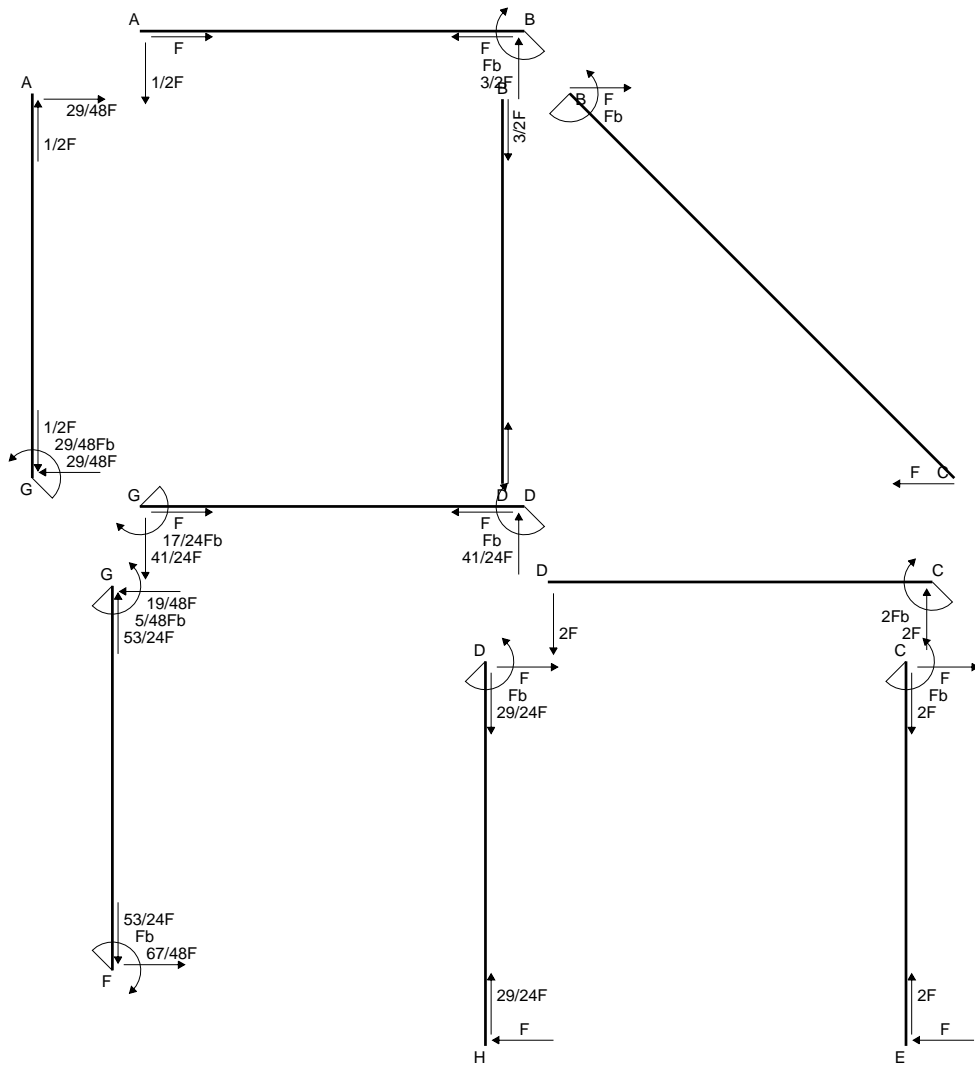
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



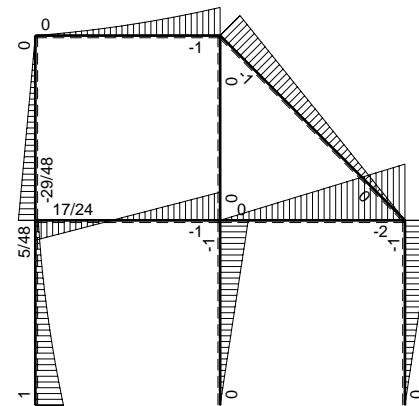
- A = 894. mm<sup>2</sup>
- J<sub>u</sub> = 284424. mm<sup>4</sup>
- J<sub>v</sub> = 80442. mm<sup>4</sup>
- y<sub>g</sub> = 33.1 mm
- T<sub>y</sub> = -3420. N
- M<sub>x</sub> = -1710000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -33.1 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -199. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -20.1 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -120.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 11.98 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 122.6 N/mm<sup>2</sup>
- S = 5978. mm<sup>3</sup>



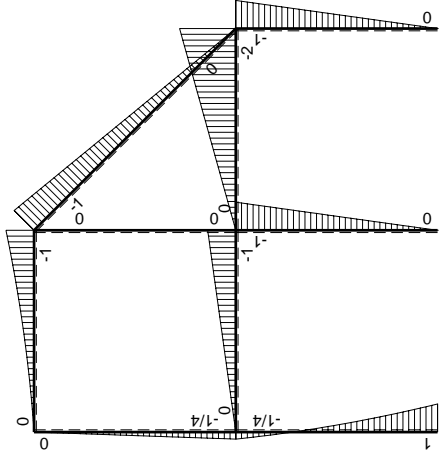
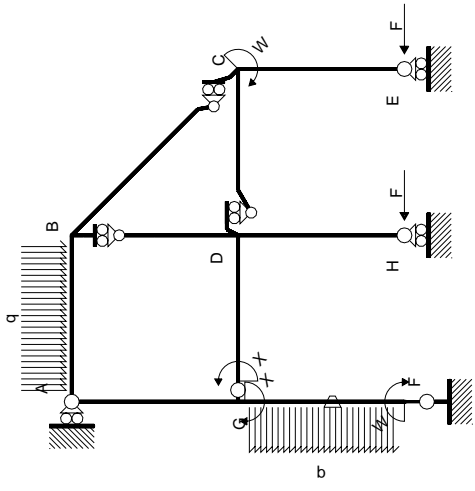


← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 1/2 x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 1/4 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 1/4 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

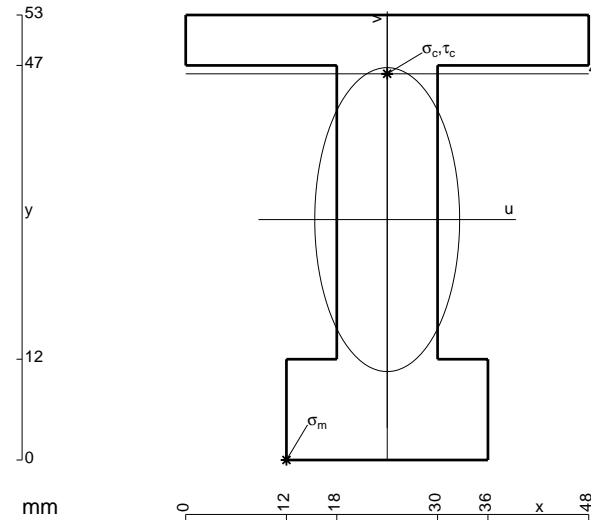
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 1/4 x/b - 1/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x + 1/8 x^2/b - 1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$



$$A = 996. \text{ mm}^2$$

$$J_u = 326526. \text{ mm}^4$$

$$J_v = 74160. \text{ mm}^4$$

$$y_g = 28.63 \text{ mm}$$

$$T_y = -4340. \text{ N}$$

$$M_x = -2387000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.63 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.3 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

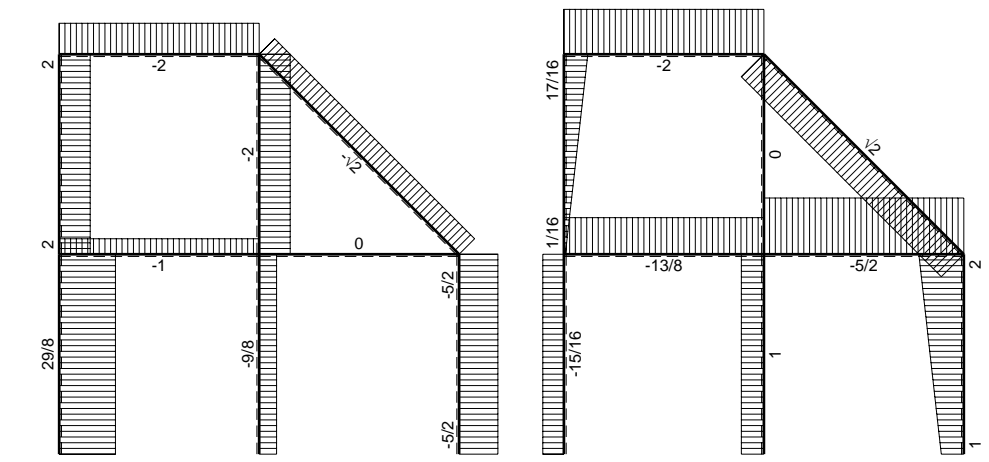
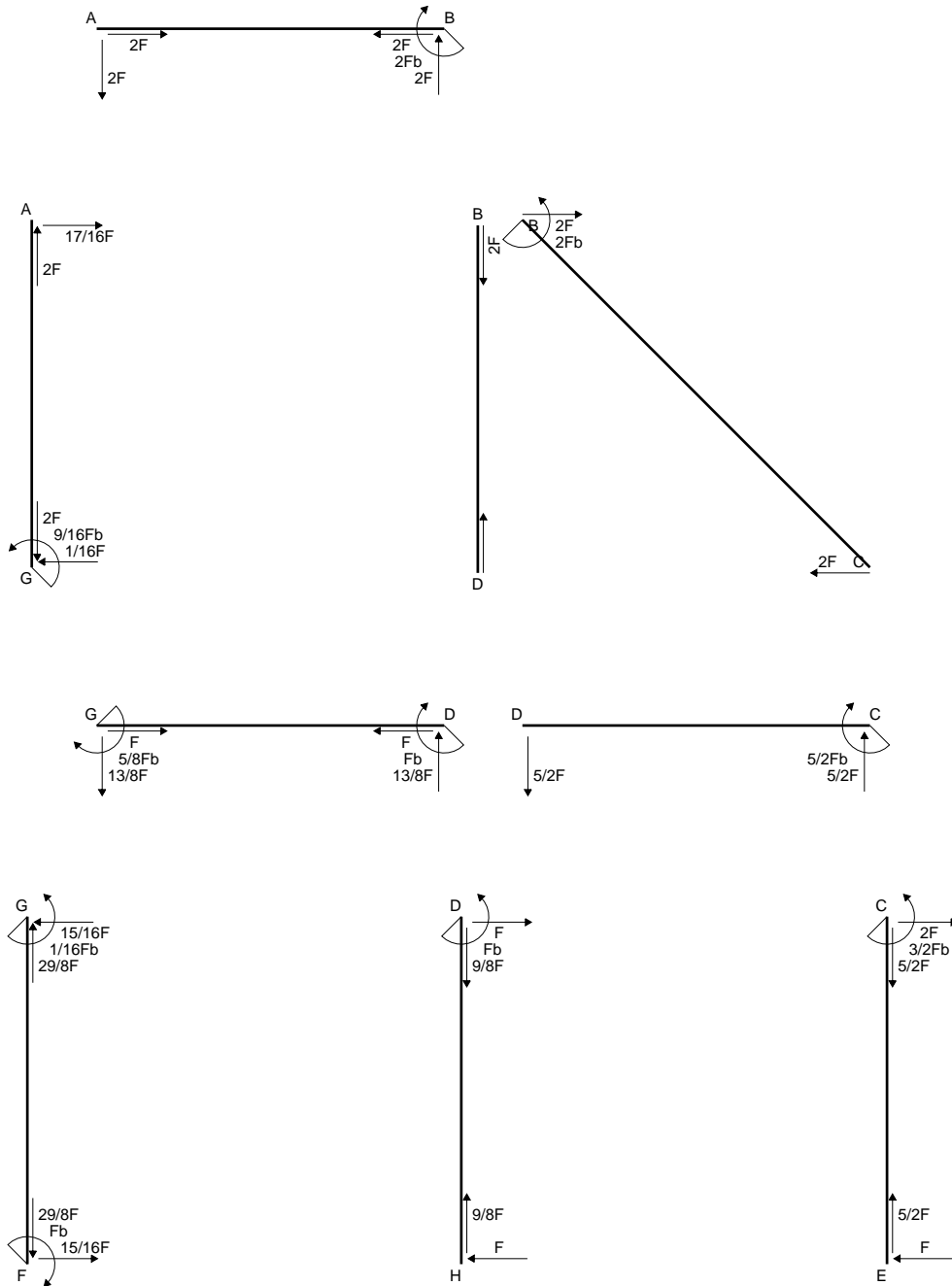
$$v_c = 17.37 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 127. \text{ N/mm}^2$$

$$\tau_c = 7.054 \text{ N/mm}^2$$

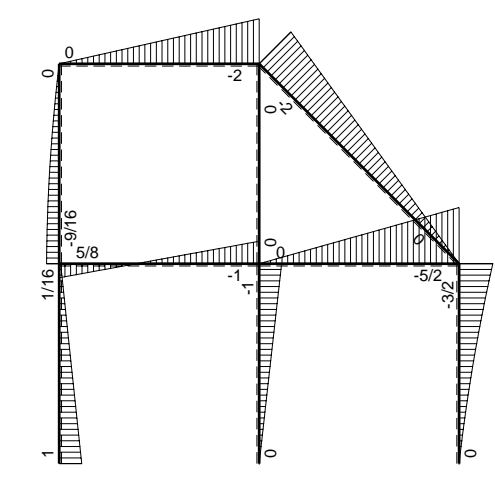
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 127.5 \text{ N/mm}^2$$

$$S = 6368. \text{ mm}^3$$

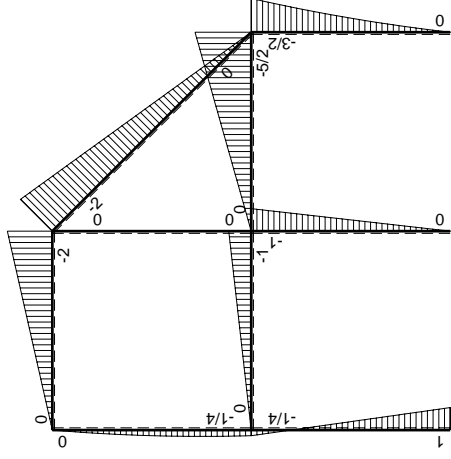
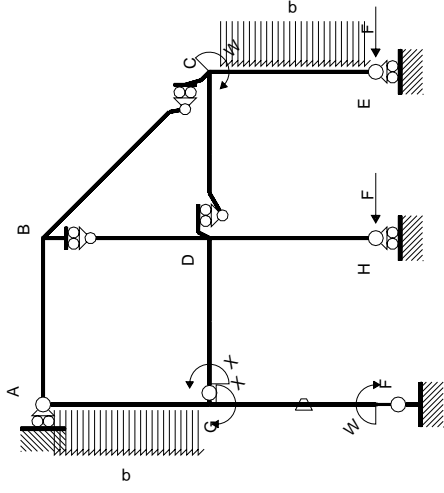


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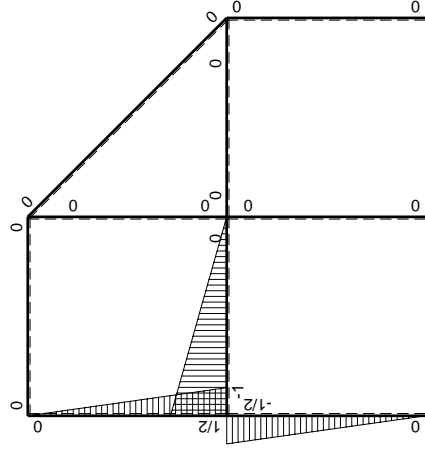


⊕ ⊕ Fb



Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-2Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx <sup>2</sup>	0	-1/8Fb+3/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	3/4Fx-1/2qx <sup>2</sup>	0	-3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							5/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 5/24 b) Fb 1/EJ + (1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 3/4 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 3/8 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 3/8 b + 5/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

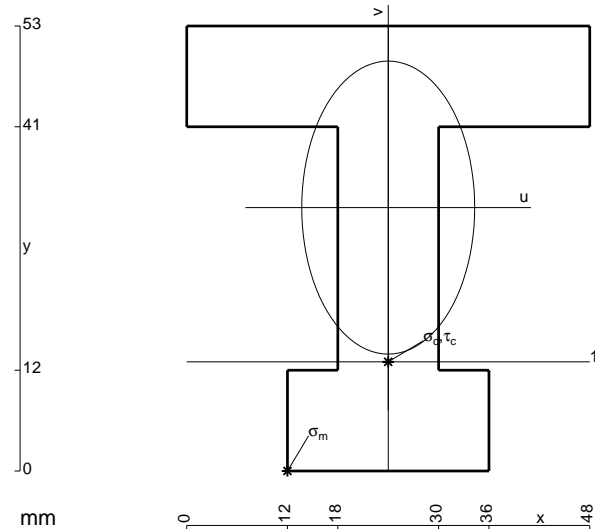
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 3/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x + 1/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

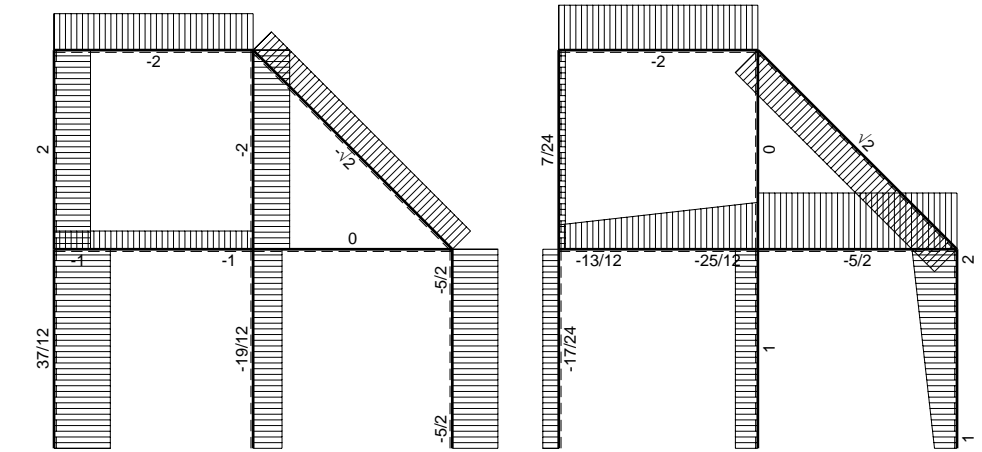
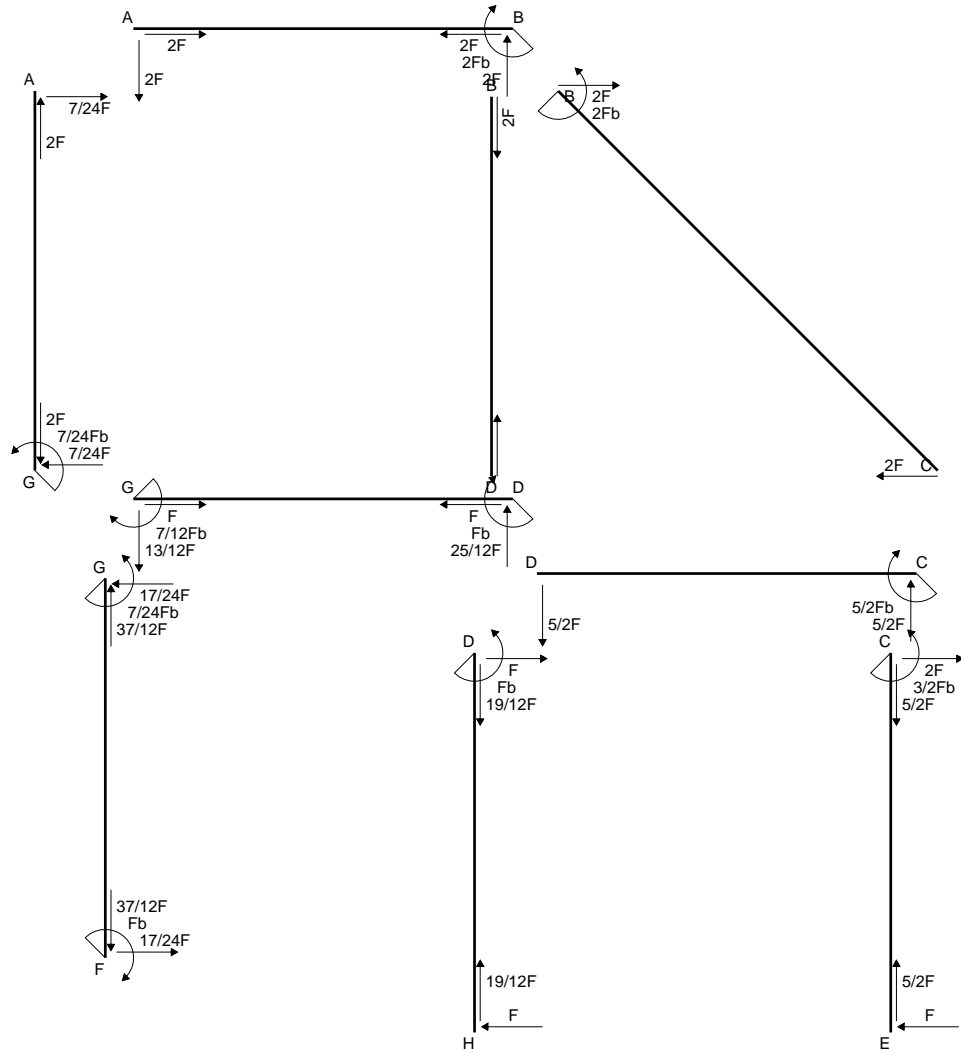
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



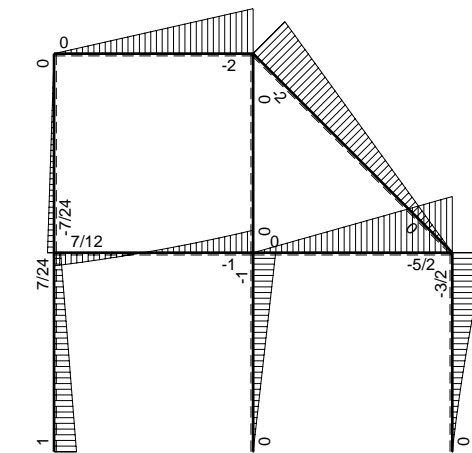
- A = 1212. mm<sup>2</sup>
- J<sub>u</sub> = 369093. mm<sup>4</sup>
- J<sub>v</sub> = 128592. mm<sup>4</sup>
- y<sub>g</sub> = 31.37 mm
- T<sub>y</sub> = -4300. N
- M<sub>x</sub> = -2580000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -31.37 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -18.37 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -128.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.314 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 129. N/mm<sup>2</sup>
- S = 7533. mm<sup>3</sup>



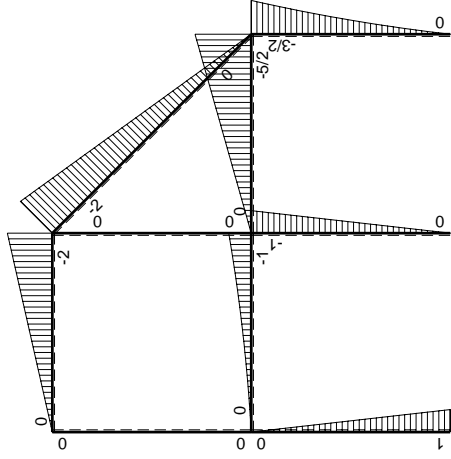
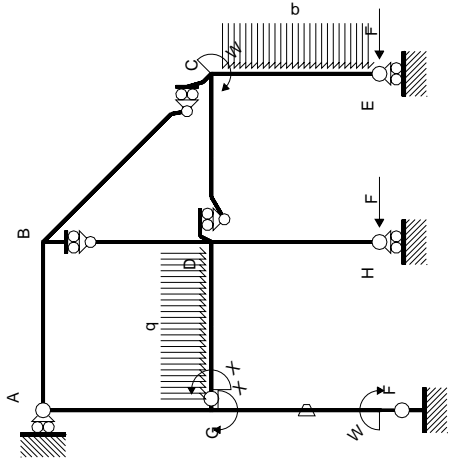


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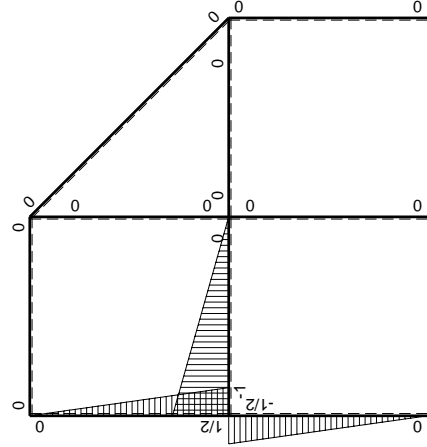


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	-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 <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	Fb-Fx	-Fb/EJ	-1/2Fx+1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	-Fx	Fb/EJ	-1/2Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b <sup>2</sup>	0+0	1/12Xb/EJ	
AG b	-1/2x/b	0	0	0	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							7/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-7/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

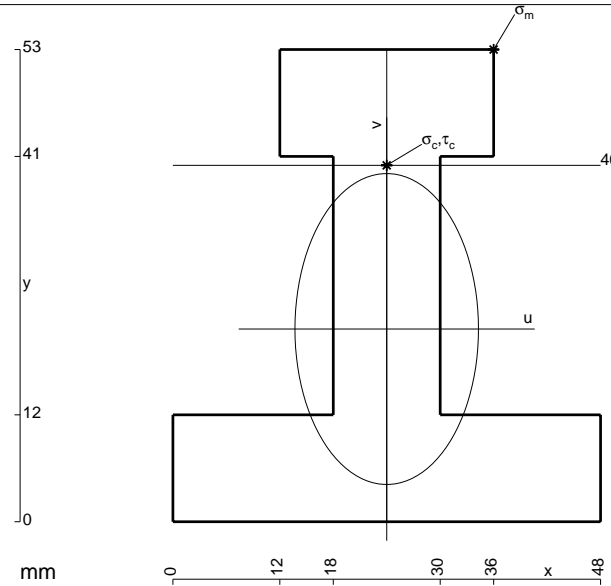
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

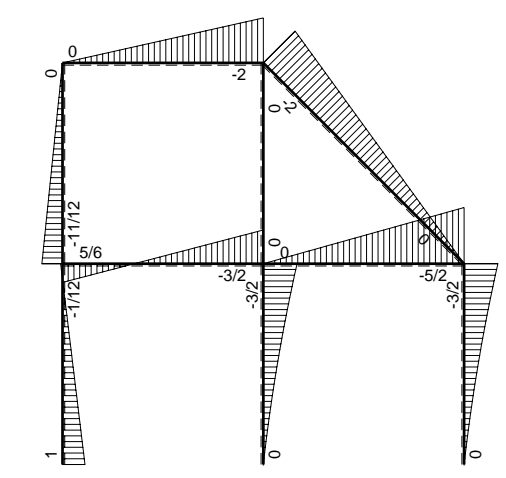
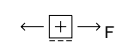
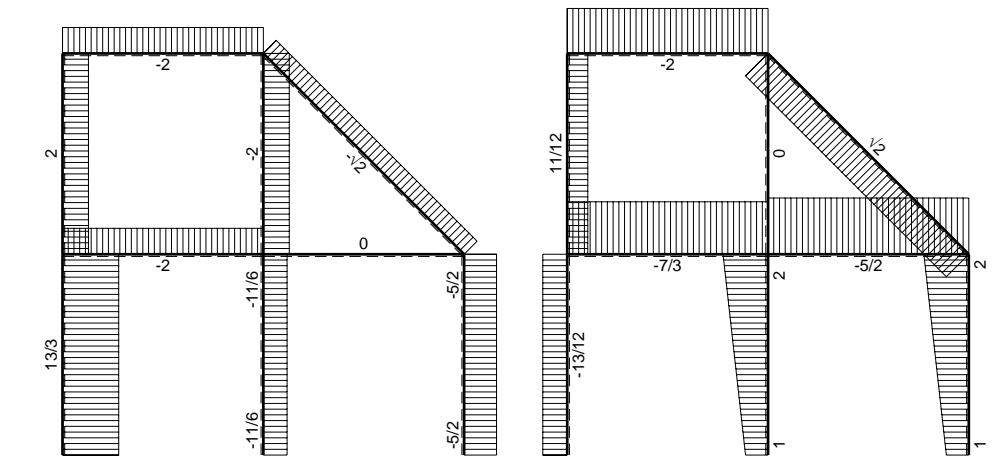
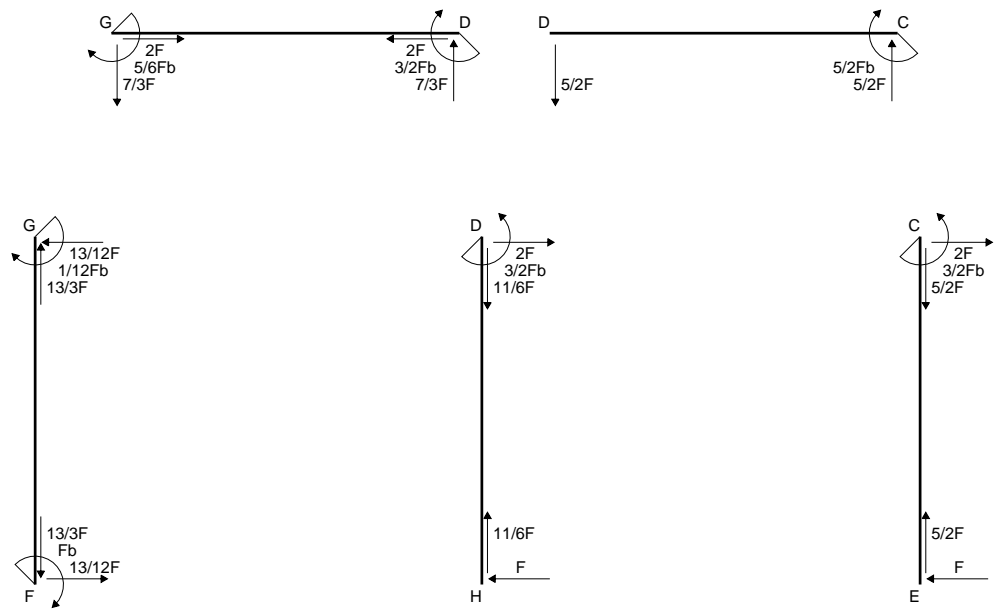
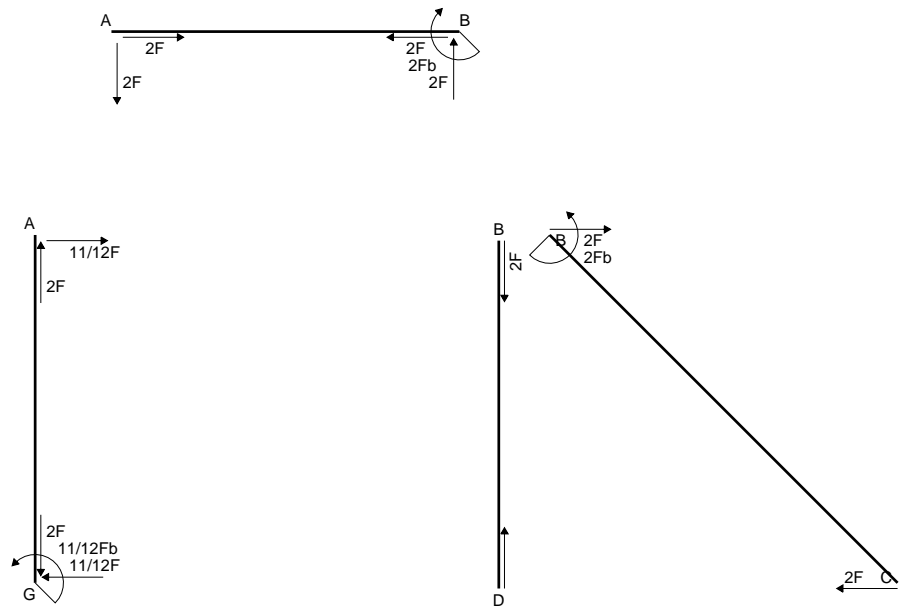
$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

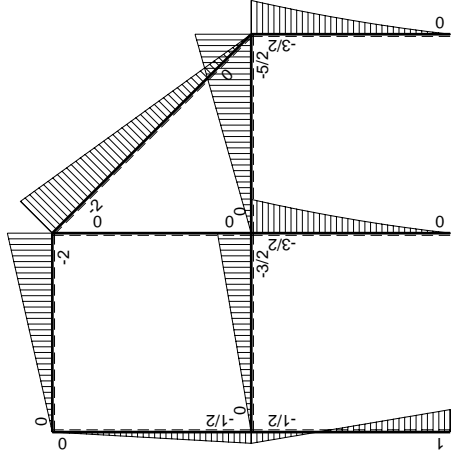
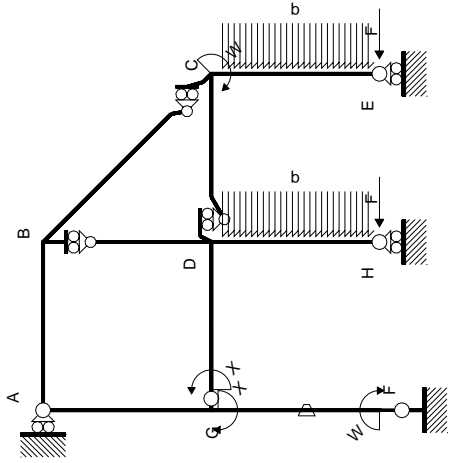
$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$



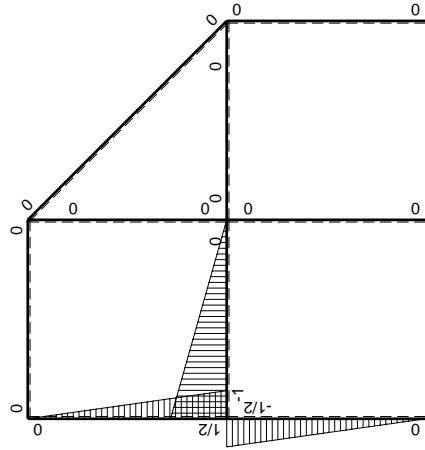
- A = 1212. mm<sup>2</sup>
- J<sub>u</sub> = 369093. mm<sup>4</sup>
- J<sub>v</sub> = 128592. mm<sup>4</sup>
- y<sub>g</sub> = 21.63 mm
- T<sub>y</sub> = -4150. N
- M<sub>x</sub> = -2697500. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 31.37 mm
- σ<sub>m</sub> = -M<sub>v</sub>/J<sub>u</sub> = 229.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 40. mm
- v<sub>c</sub> = 18.37 mm
- σ<sub>c</sub> = -M<sub>v</sub>/J<sub>u</sub> = 134.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.059 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 134.8 N/mm<sup>2</sup>
- S = 7533. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

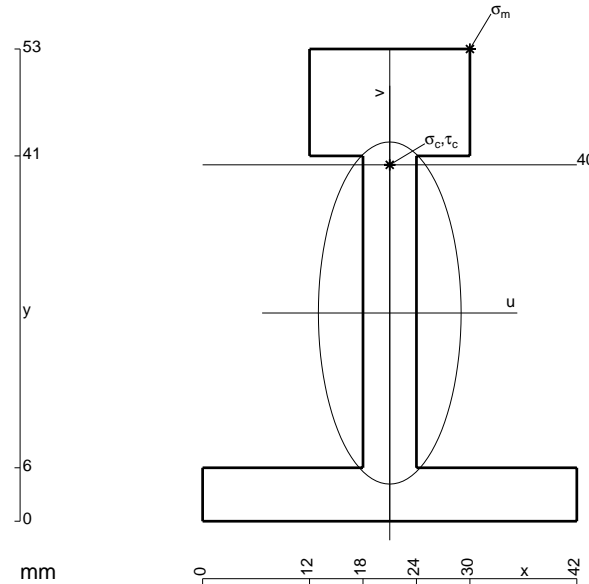
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

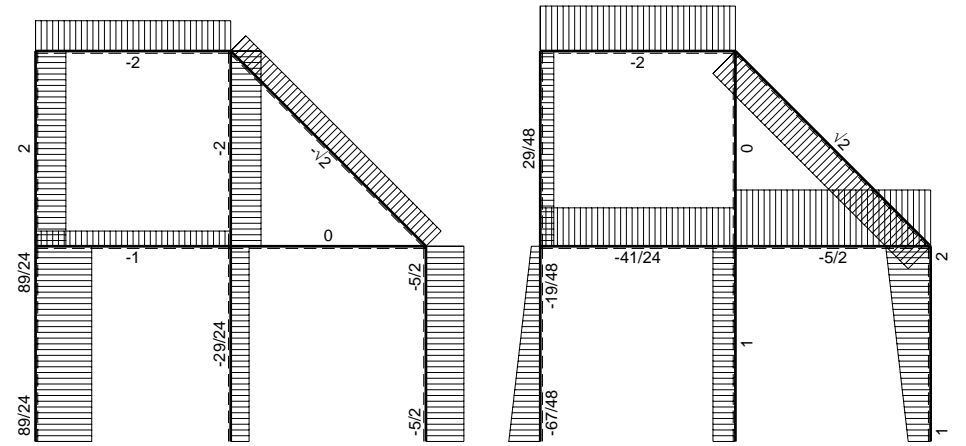
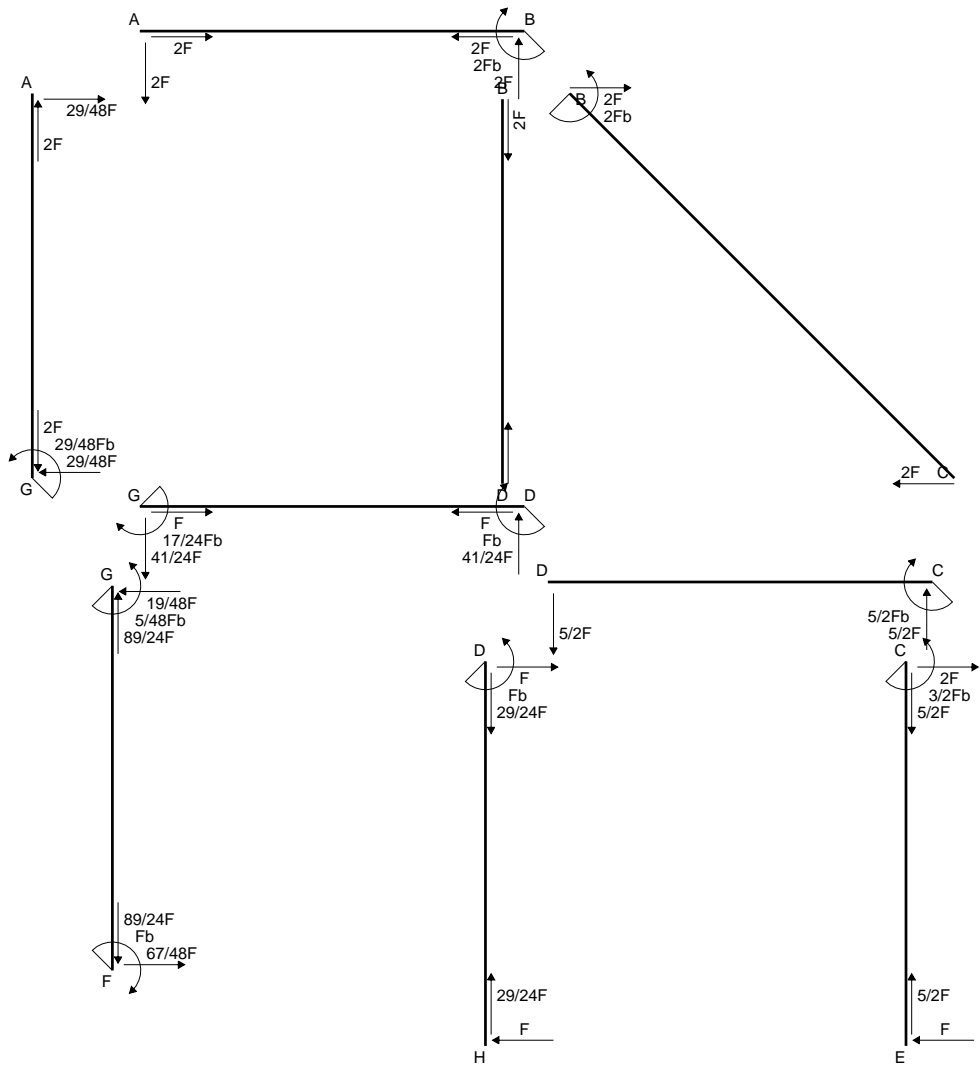
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



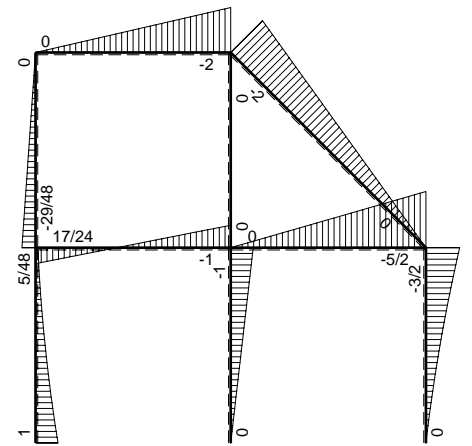
- A = 678. mm<sup>2</sup>
- J<sub>u</sub> = 249963. mm<sup>4</sup>
- J<sub>v</sub> = 43506. mm<sup>4</sup>
- y<sub>g</sub> = 23.37 mm
- T<sub>y</sub> = -2875. N
- M<sub>x</sub> = -2012500. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 29.63 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 238.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 40. mm
- v<sub>c</sub> = 16.63 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 133.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 9.982 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 135. N/mm<sup>2</sup>
- S = 5207. mm<sup>3</sup>



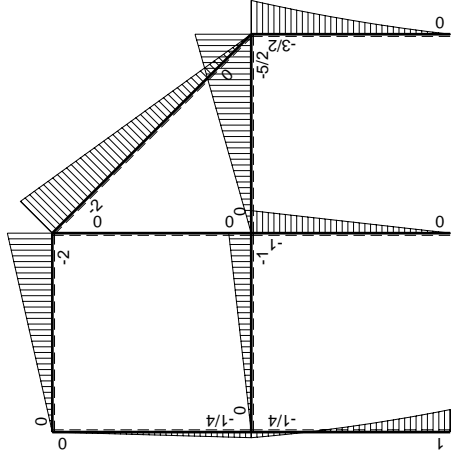
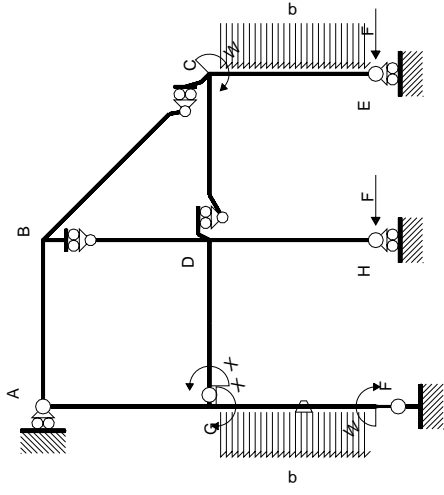


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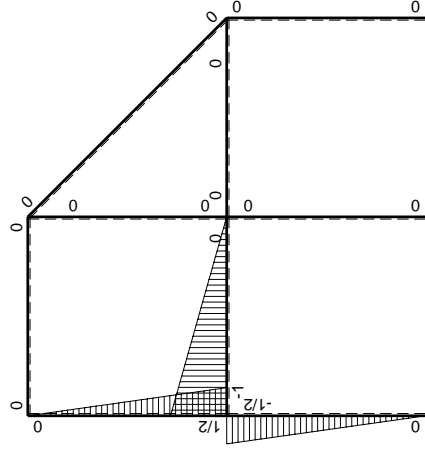


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	Fb-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	1/8Fb-1/2Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						17/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-17/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 1/2 x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 1/4 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 1/4 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

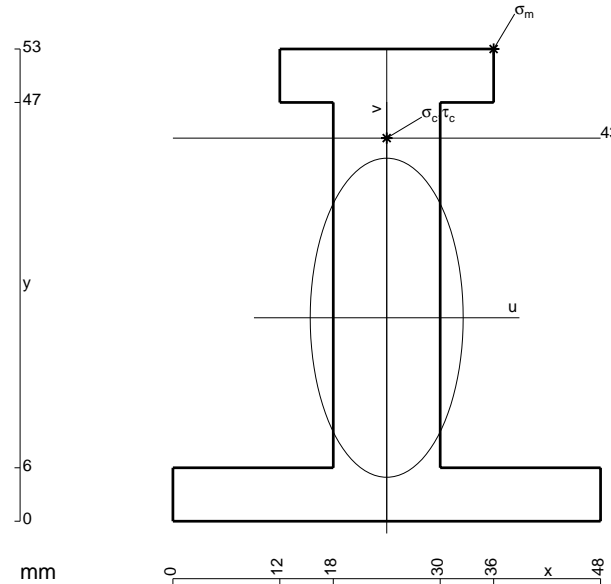
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 1/4 x/b - 1/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x + 1/8 x^2/b - 1/24 x^3/b^2]_0^b Fb 1/EJ$$

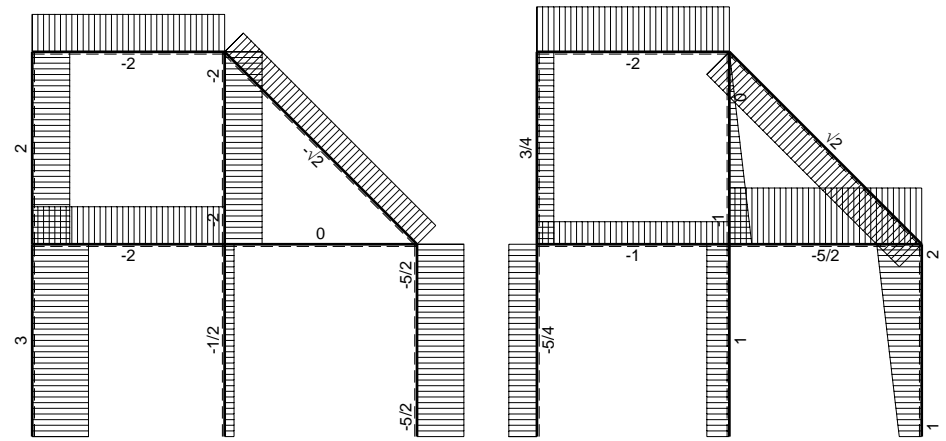
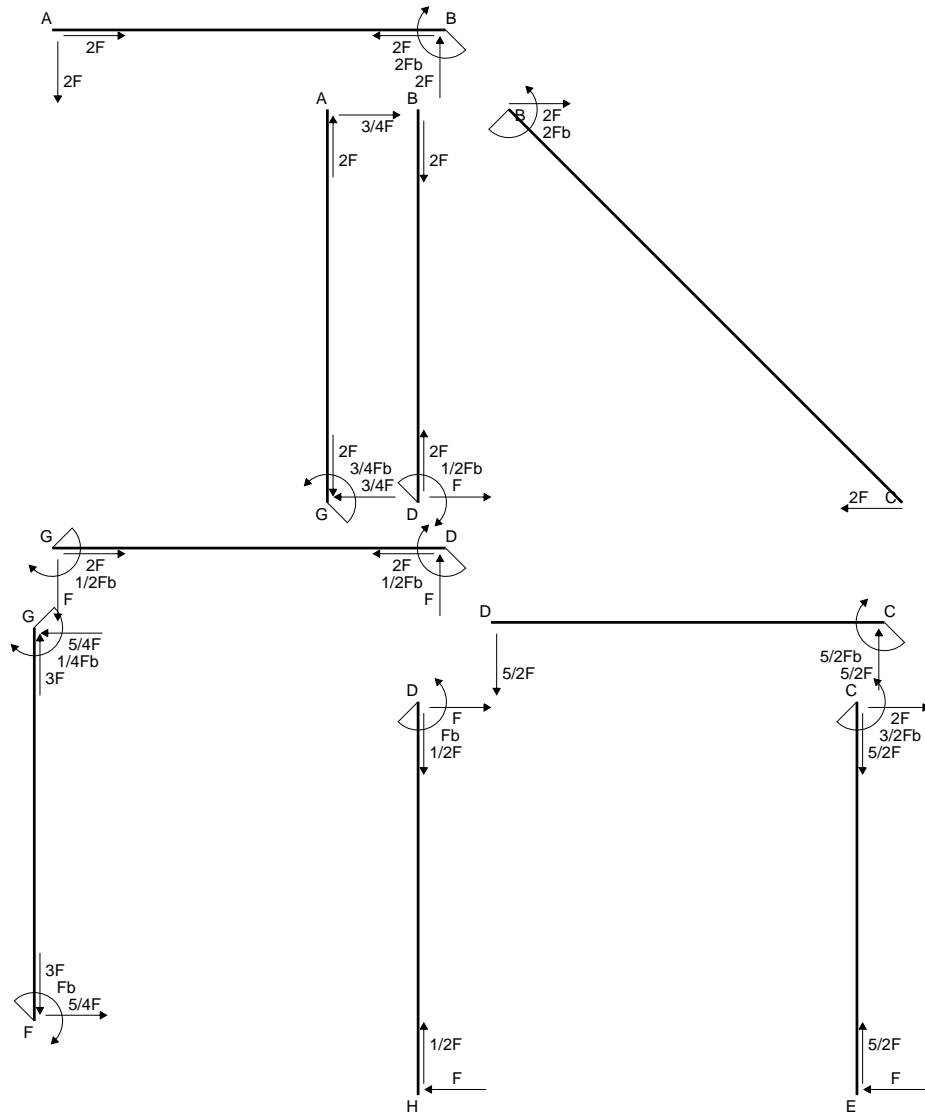
$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

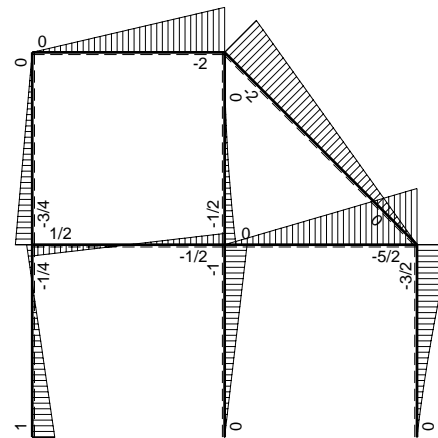


- A = 924. mm<sup>2</sup>
- J<sub>u</sub> = 296396. mm<sup>4</sup>
- J<sub>v</sub> = 68112. mm<sup>4</sup>
- y<sub>g</sub> = 22.84 mm
- T<sub>y</sub> = -2600. N
- M<sub>x</sub> = -1950000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 30.16 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 198.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 43. mm
- v<sub>c</sub> = 20.16 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 132.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.637 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 132.8 N/mm<sup>2</sup>
- S = 4975. mm<sup>3</sup>

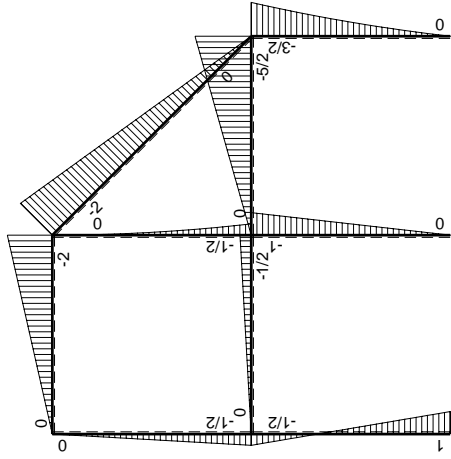
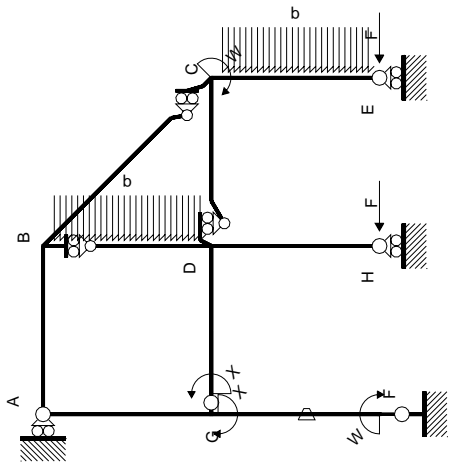


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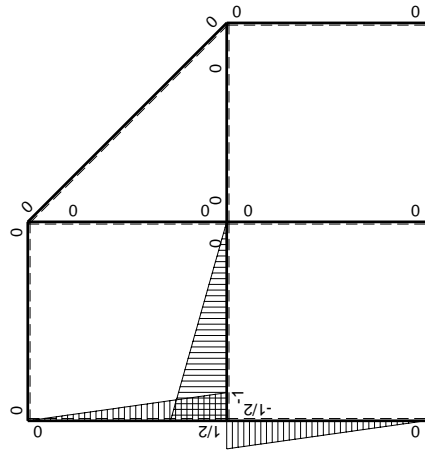


↺ + ↻ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						1/4Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-1/2Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

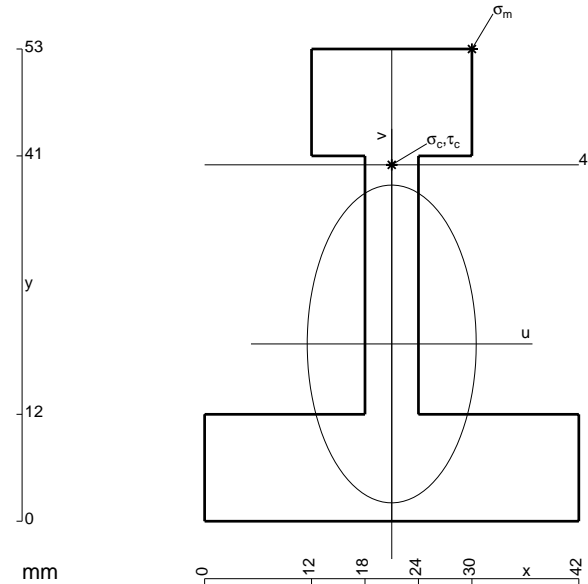
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

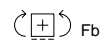
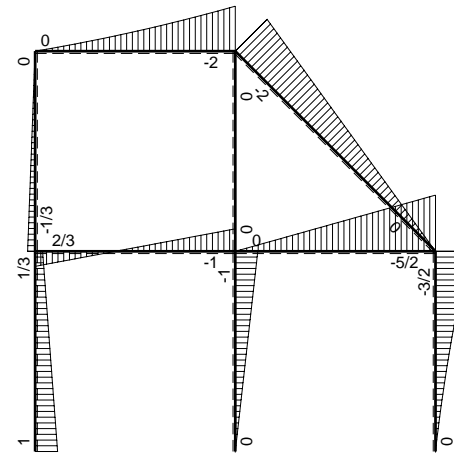
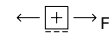
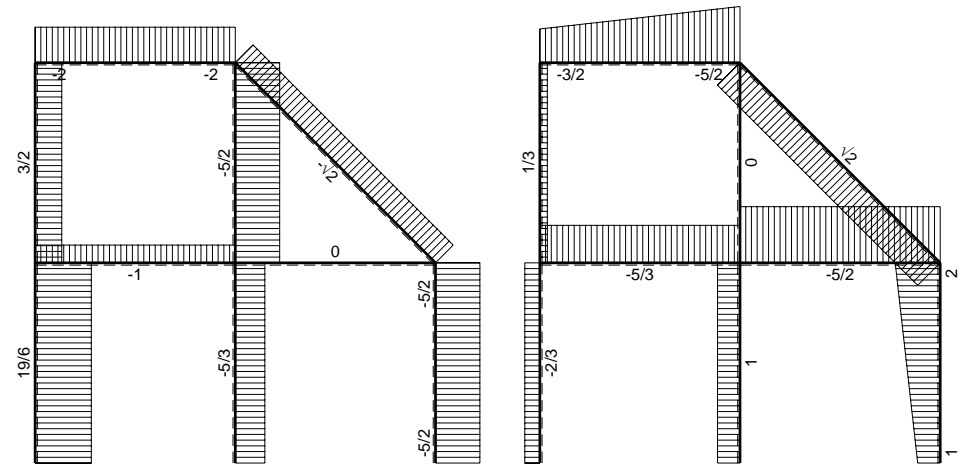
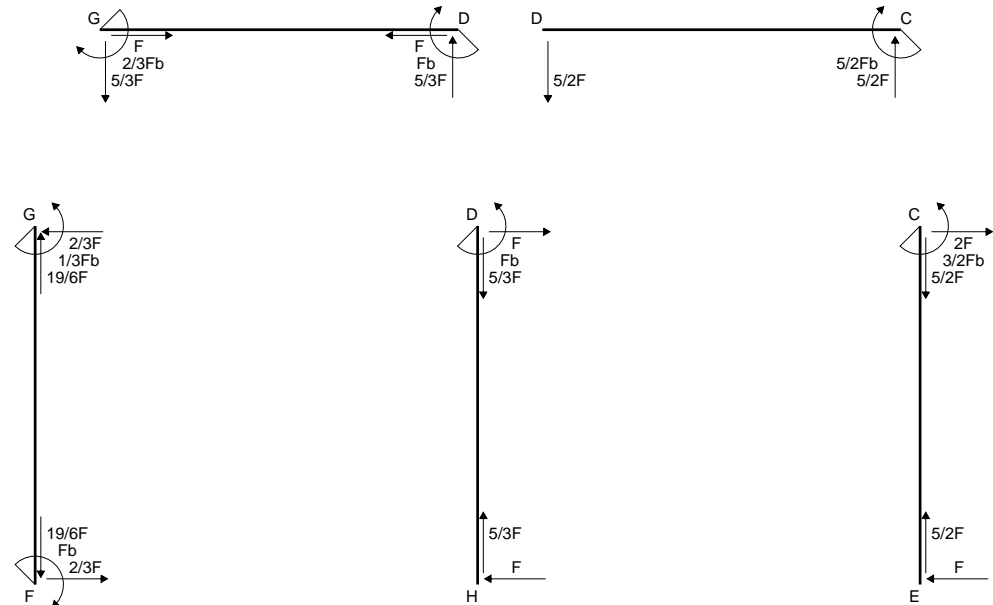
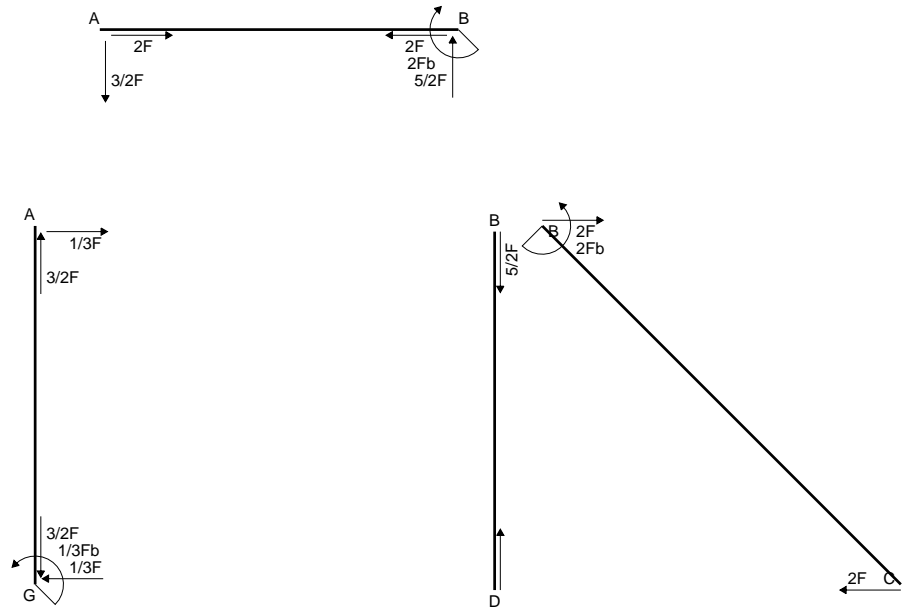
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

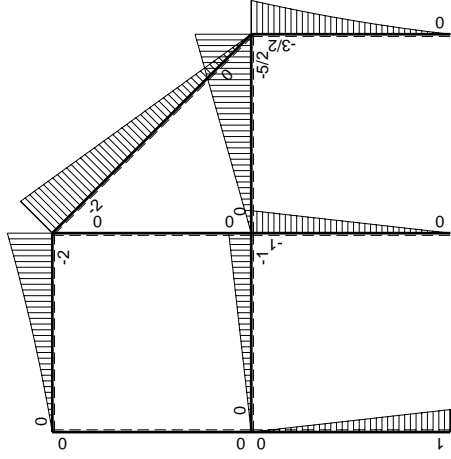
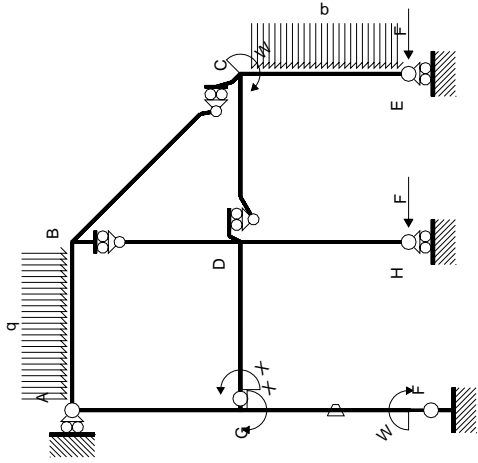
$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



- A = 894. mm<sup>2</sup>
- J<sub>u</sub> = 284424. mm<sup>4</sup>
- J<sub>v</sub> = 80442. mm<sup>4</sup>
- y<sub>g</sub> = 19.9 mm
- T<sub>y</sub> = -2250. N
- M<sub>x</sub> = -1800000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.1 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 40. mm
- v<sub>c</sub> = 20.1 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 127.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.882 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 128. N/mm<sup>2</sup>
- S = 5978. mm<sup>3</sup>

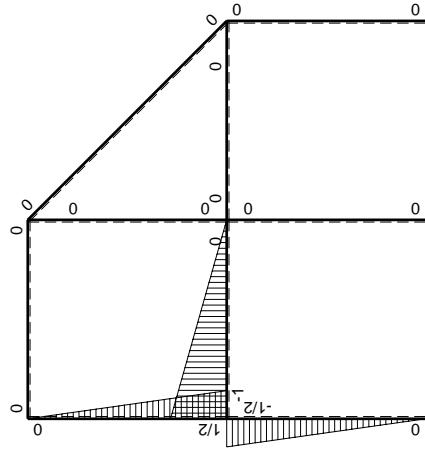






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	$-3/2Fx-1/2qx^2$	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

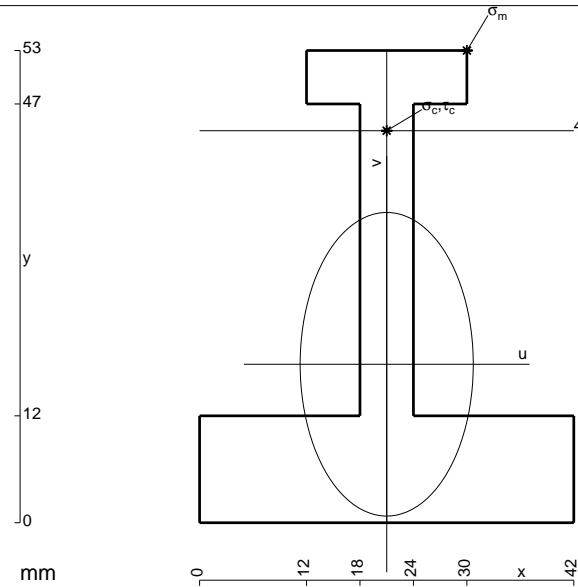
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

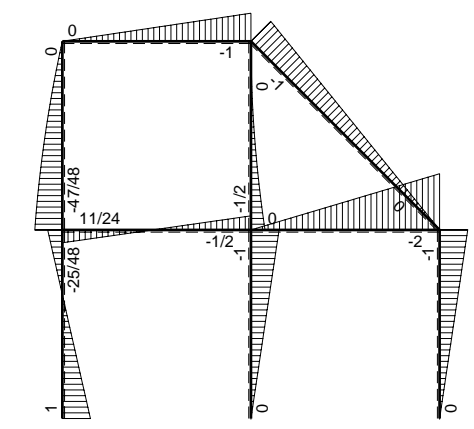
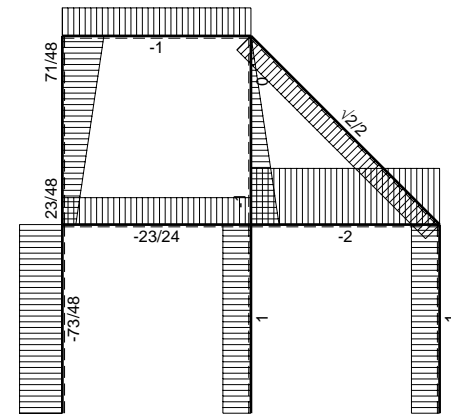
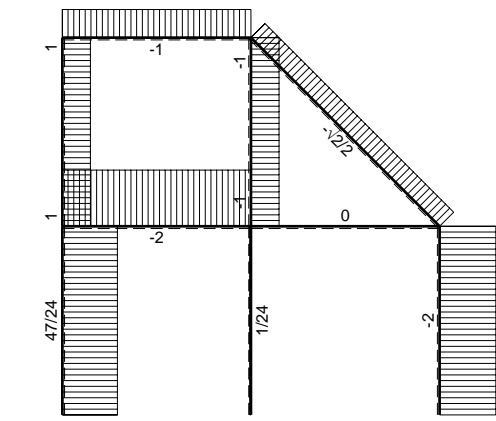
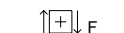
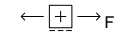
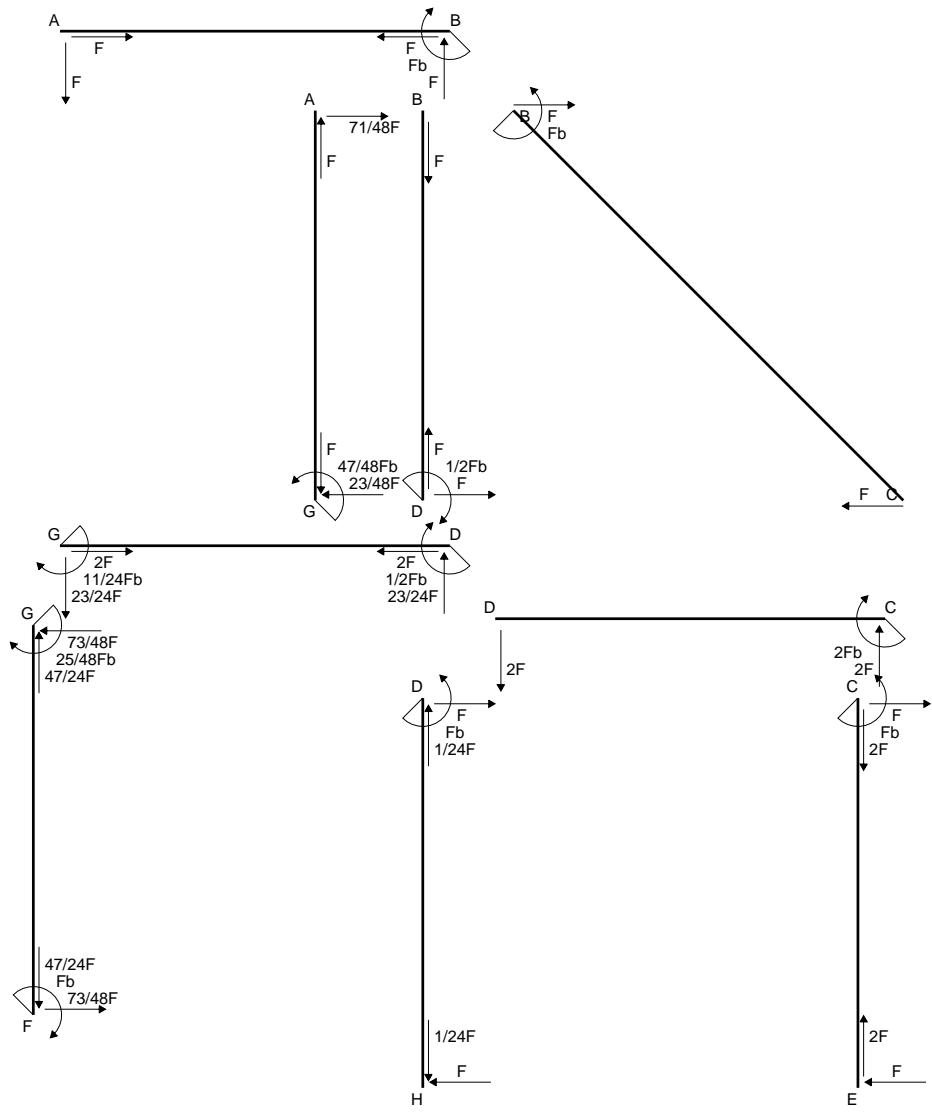
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

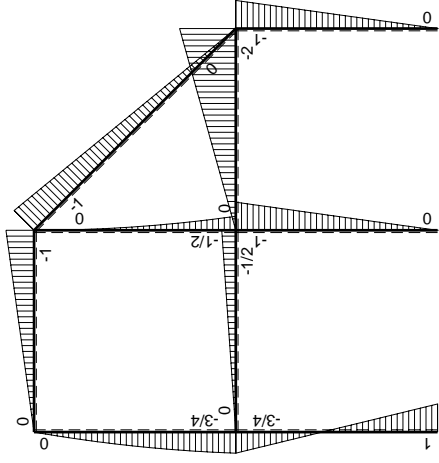
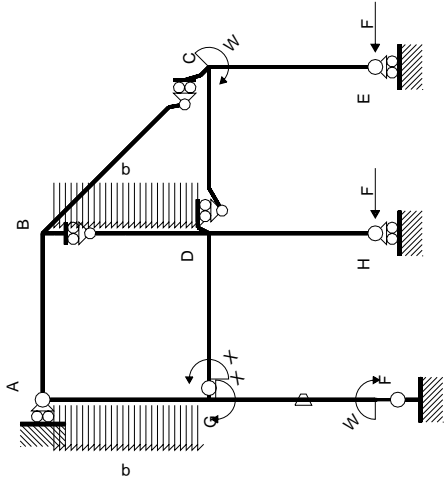
$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$



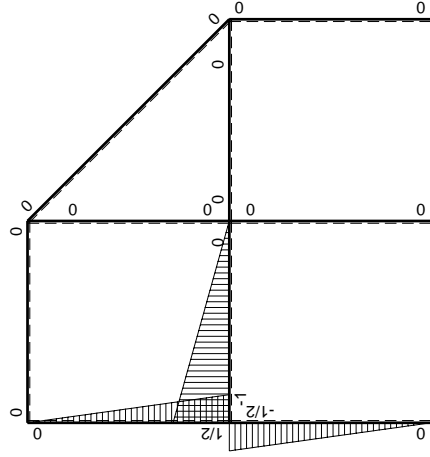
- A = 822. mm<sup>2</sup>
- J<sub>u</sub> = 238712. mm<sup>4</sup>
- J<sub>v</sub> = 77634. mm<sup>4</sup>
- y<sub>g</sub> = 17.78 mm
- T<sub>y</sub> = -1750. N
- M<sub>x</sub> = -1487500. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 35.22 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 219.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 44. mm
- v<sub>c</sub> = 26.22 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 163.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.861 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 163.6 N/mm<sup>2</sup>
- S = 3978. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	0	0	
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0	
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-7/4Fx	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/4Fb-7/4Fx	Fb/EJ	3/8Fb-5/4Fx+7/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							11/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-11/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b) Fb 1/EJ + (1/4 b) \theta = 7/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 5/4 x/b + 7/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 5/8 x^2/b + 7/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 5/8 b + 7/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 7/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

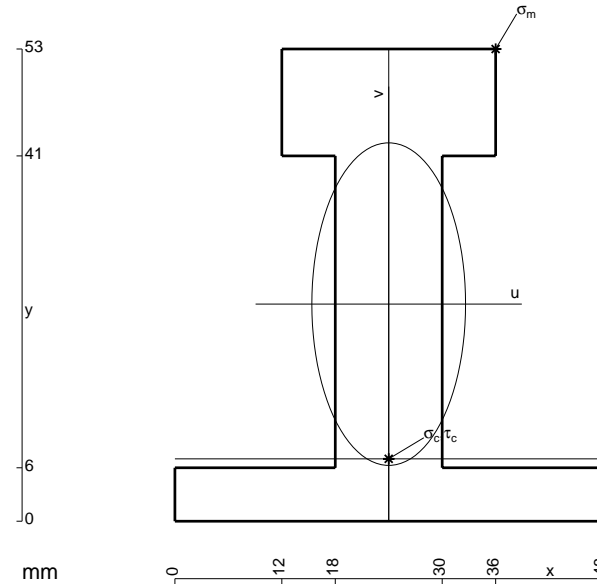
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

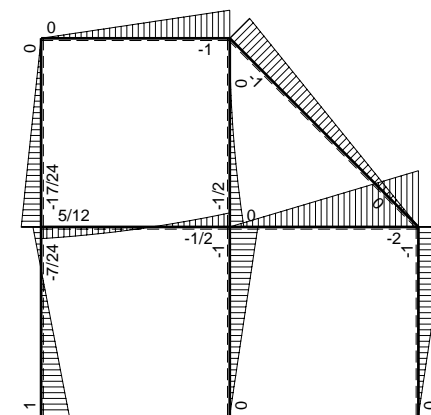
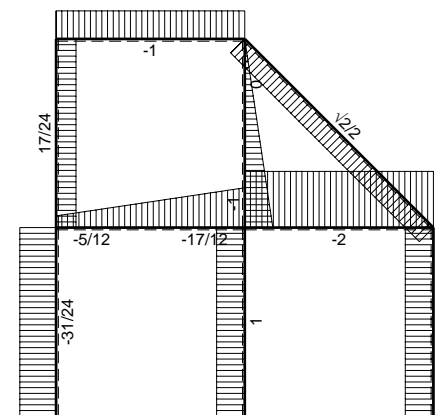
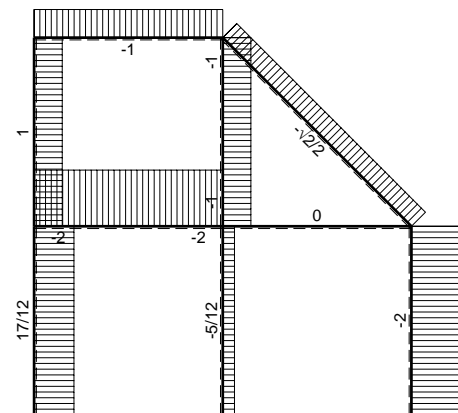
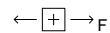
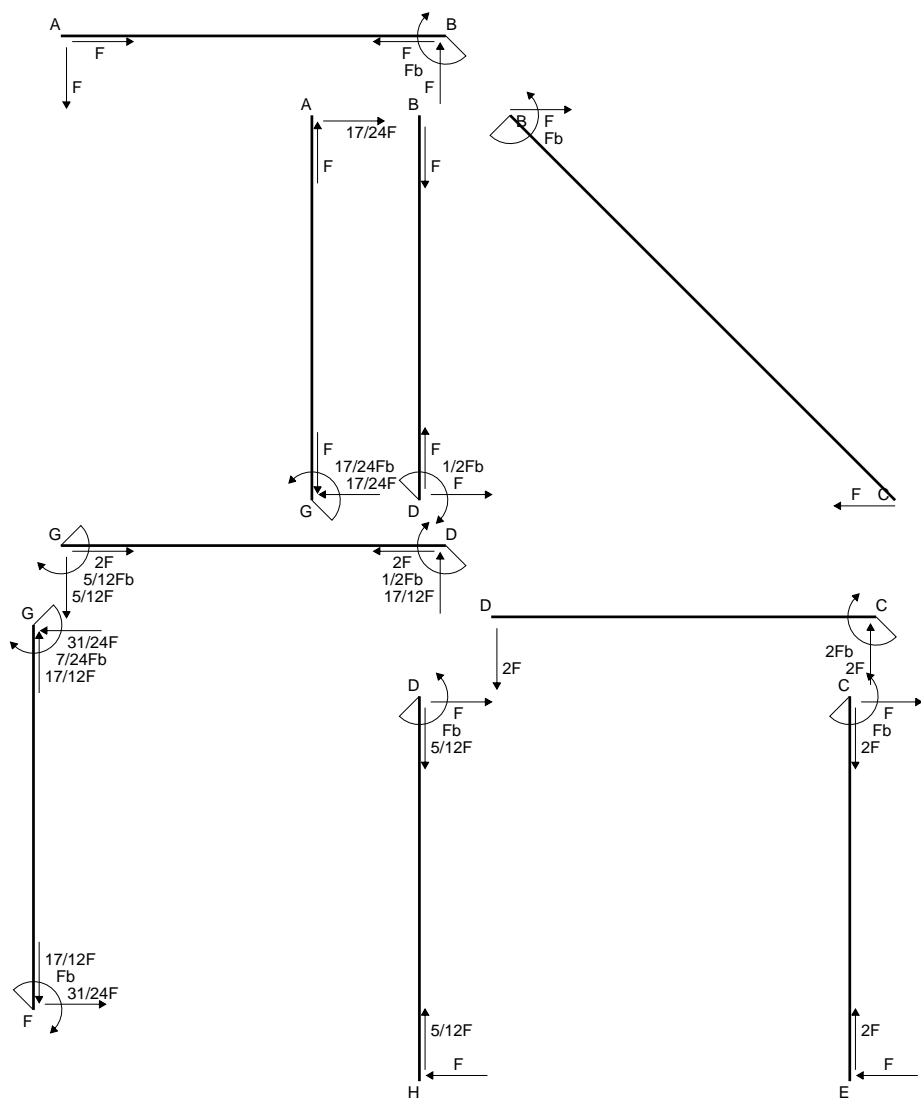
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

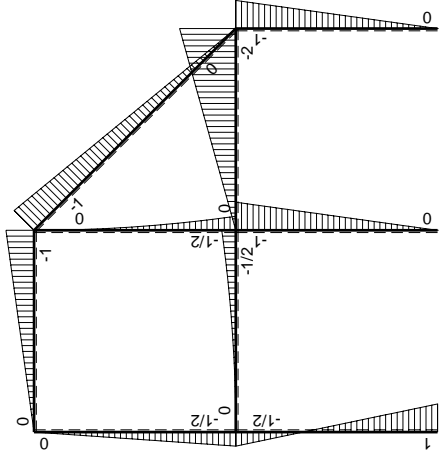
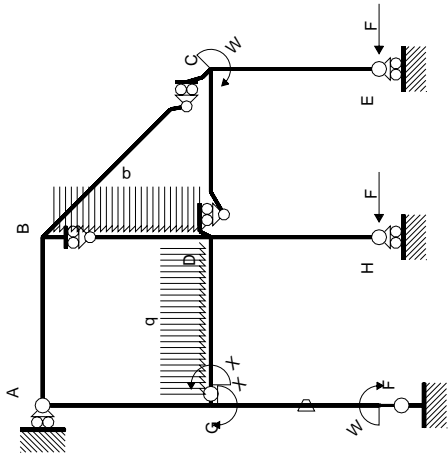
$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



- A = 996. mm<sup>2</sup>
- J<sub>u</sub> = 326526. mm<sup>4</sup>
- J<sub>v</sub> = 74160. mm<sup>4</sup>
- y<sub>g</sub> = 24.37 mm
- T<sub>y</sub> = -2900. N
- M<sub>x</sub> = -2610000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 28.63 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 228.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -17.37 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -138.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.713 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 139.1 N/mm<sup>2</sup>
- S = 6368. mm<sup>3</sup>

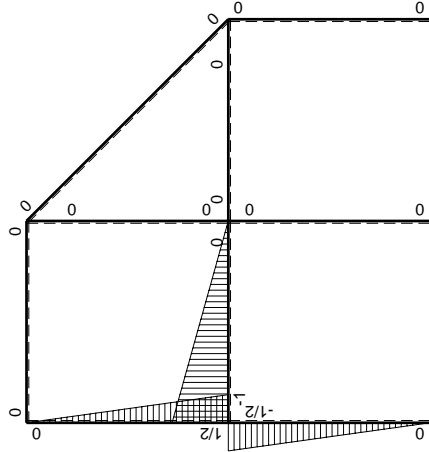






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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 <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2qx <sup>2</sup>	0	1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-Fx+1/2qx <sup>2</sup>	0	1/2Fx-Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/6 b - 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

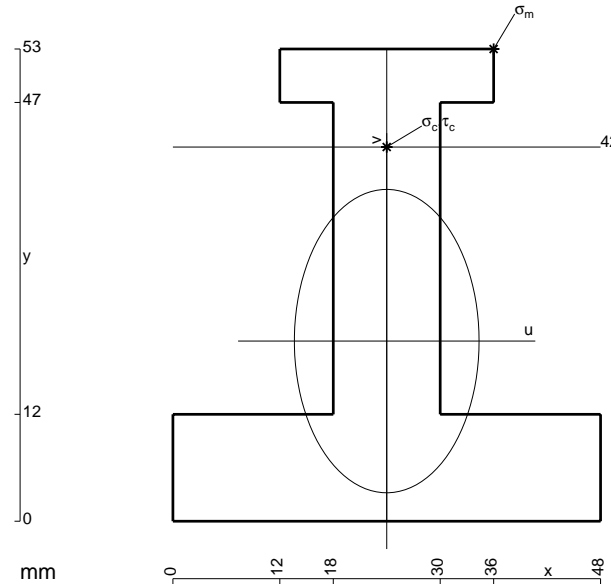
$$= (1/4 b - 1/3 b + 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

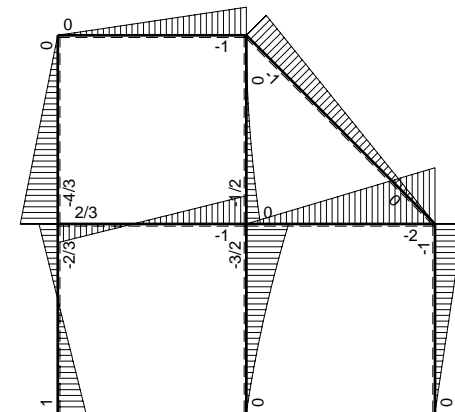
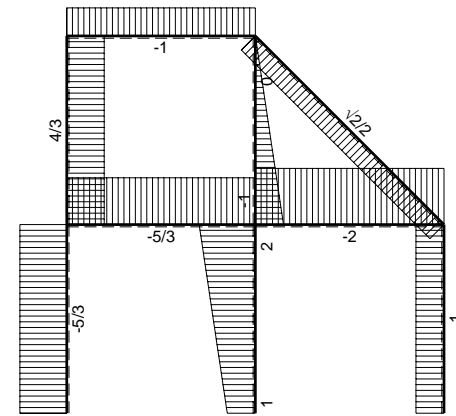
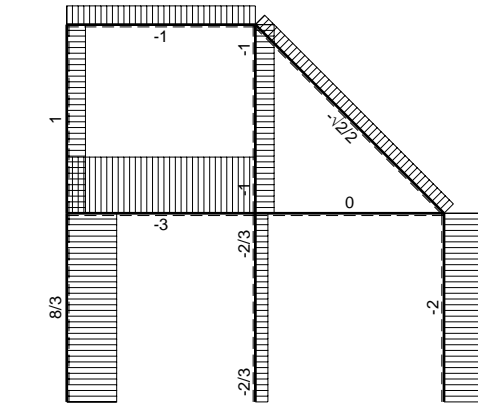
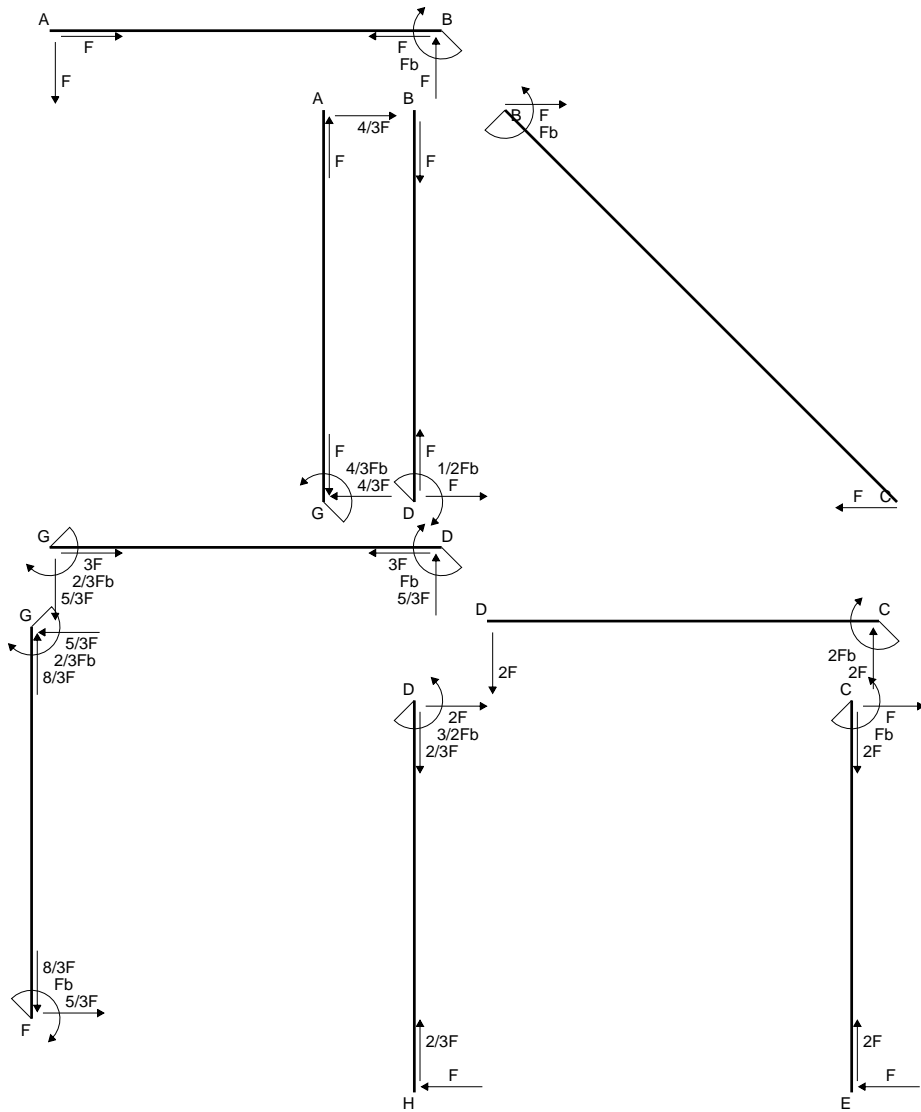
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

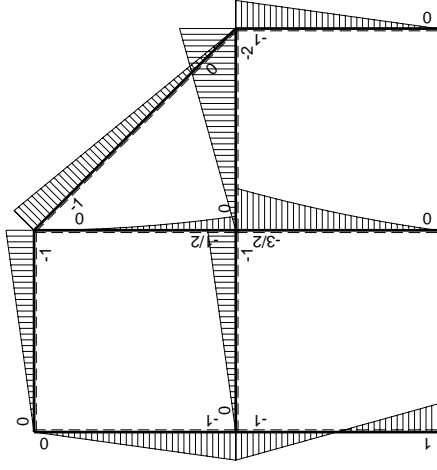
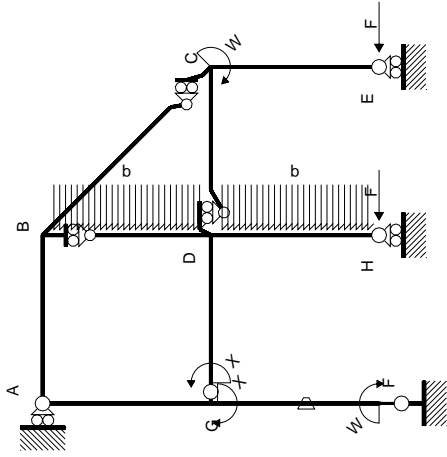
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



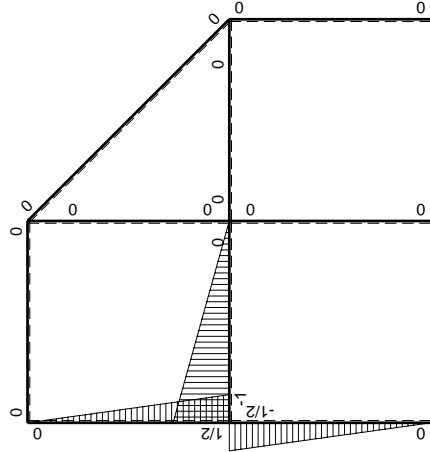
- A = 1140. mm<sup>2</sup>
- J<sub>u</sub> = 330567. mm<sup>4</sup>
- J<sub>v</sub> = 122544. mm<sup>4</sup>
- y<sub>g</sub> = 20.22 mm
- T<sub>y</sub> = -2540. N
- M<sub>x</sub> = -2413000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 32.78 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 239.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 21.78 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 159. N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.679 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 159.1 N/mm<sup>2</sup>
- S = 5746. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	0	0	
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0	
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-2Fx	-Fb/EJ	-1/2Fx+Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-2Fx	Fb/EJ	1/2Fb-3/2Fx+Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							1/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/3 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - 3/2 x/b + x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 3/4 x^2/b + 1/3 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 3/4 b + 1/3 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

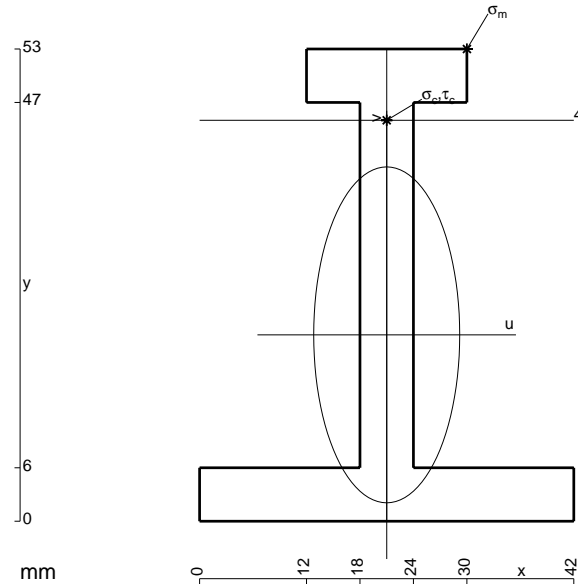
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

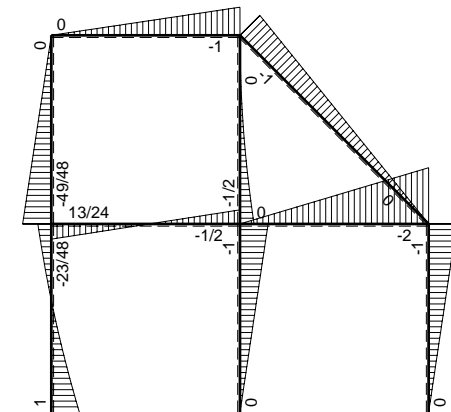
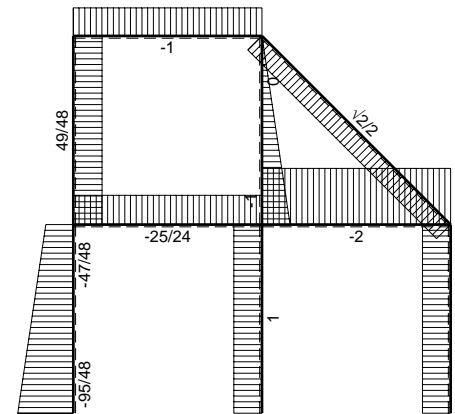
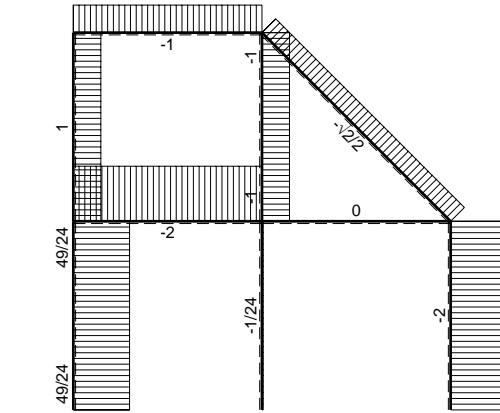
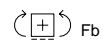
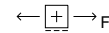
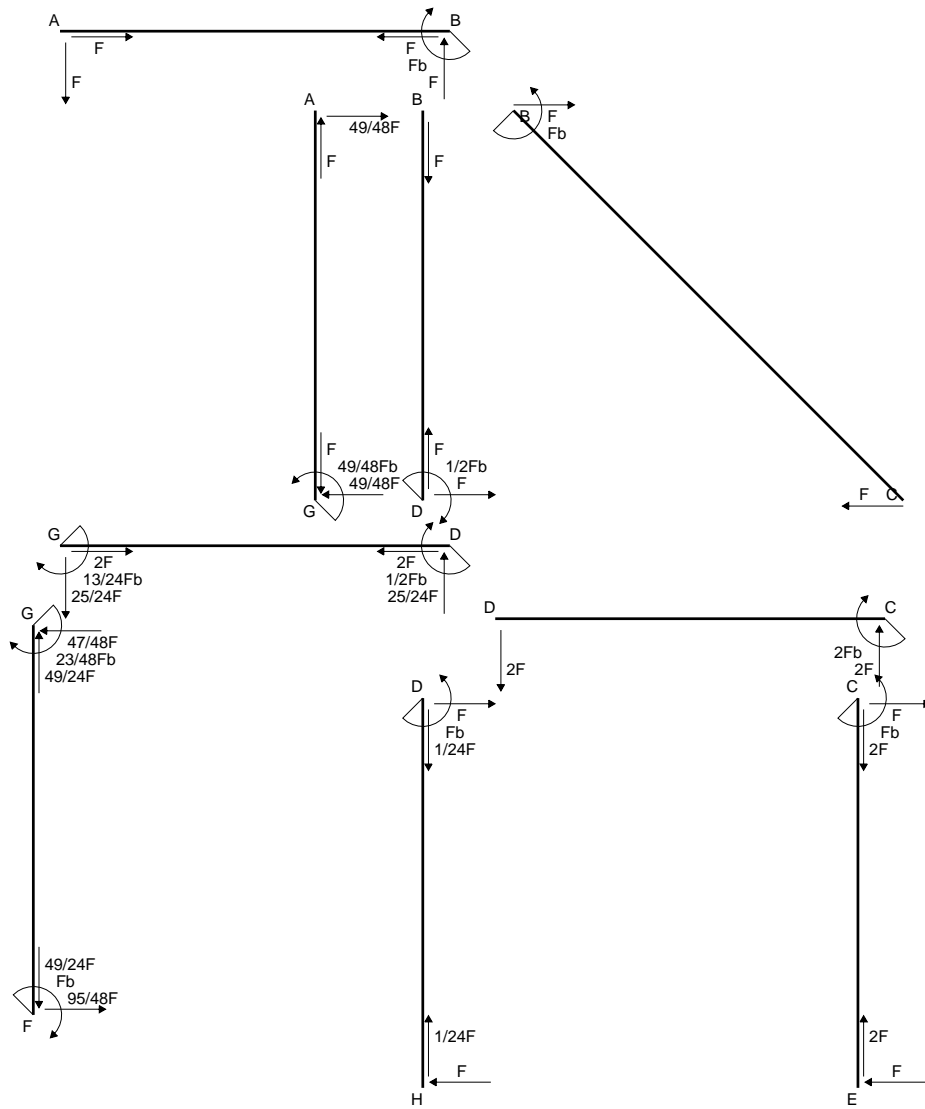
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

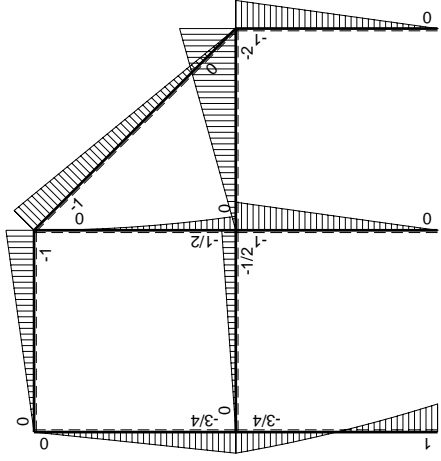
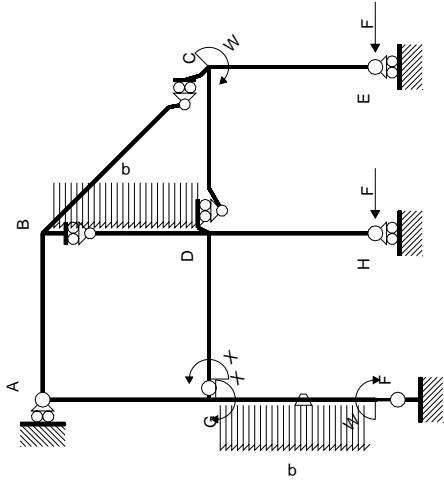
$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



- A = 606. mm<sup>2</sup>
- J<sub>u</sub> = 215454. mm<sup>4</sup>
- J<sub>v</sub> = 40698. mm<sup>4</sup>
- y<sub>g</sub> = 20.92 mm
- T<sub>y</sub> = -2680. N
- M<sub>x</sub> = -1340000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 32.08 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 45. mm
- v<sub>c</sub> = 24.08 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 149.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.136 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 150.3 N/mm<sup>2</sup>
- S = 3442. mm<sup>3</sup>

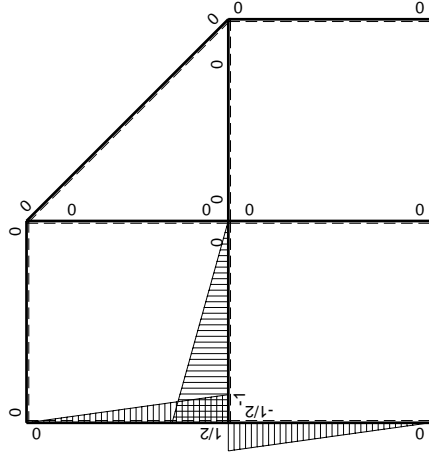






Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-9/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+9/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/16+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-5/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-Fx+3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						13/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-13/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 9/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 3/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 3/8 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 5/16 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - x/b + 3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/2 x^2/b + 1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/2 b + 1/8 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/16 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

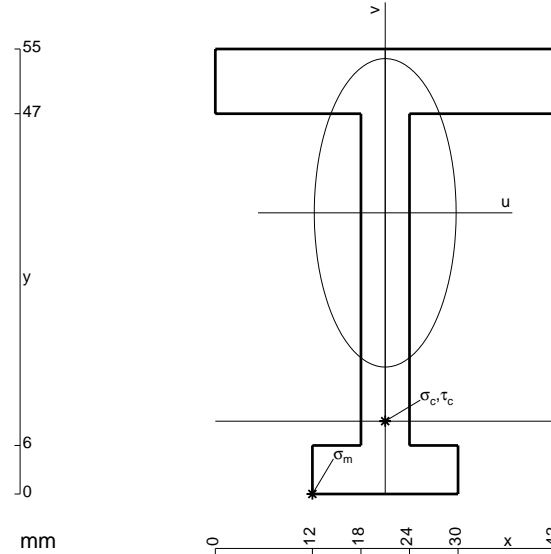
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

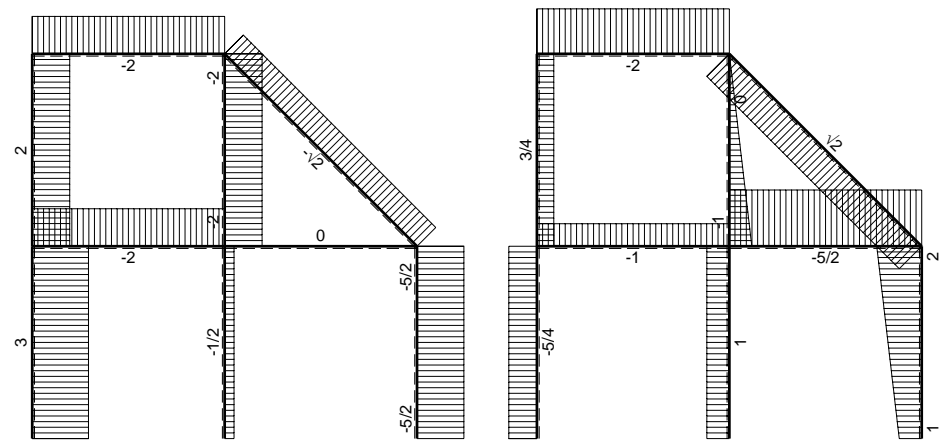
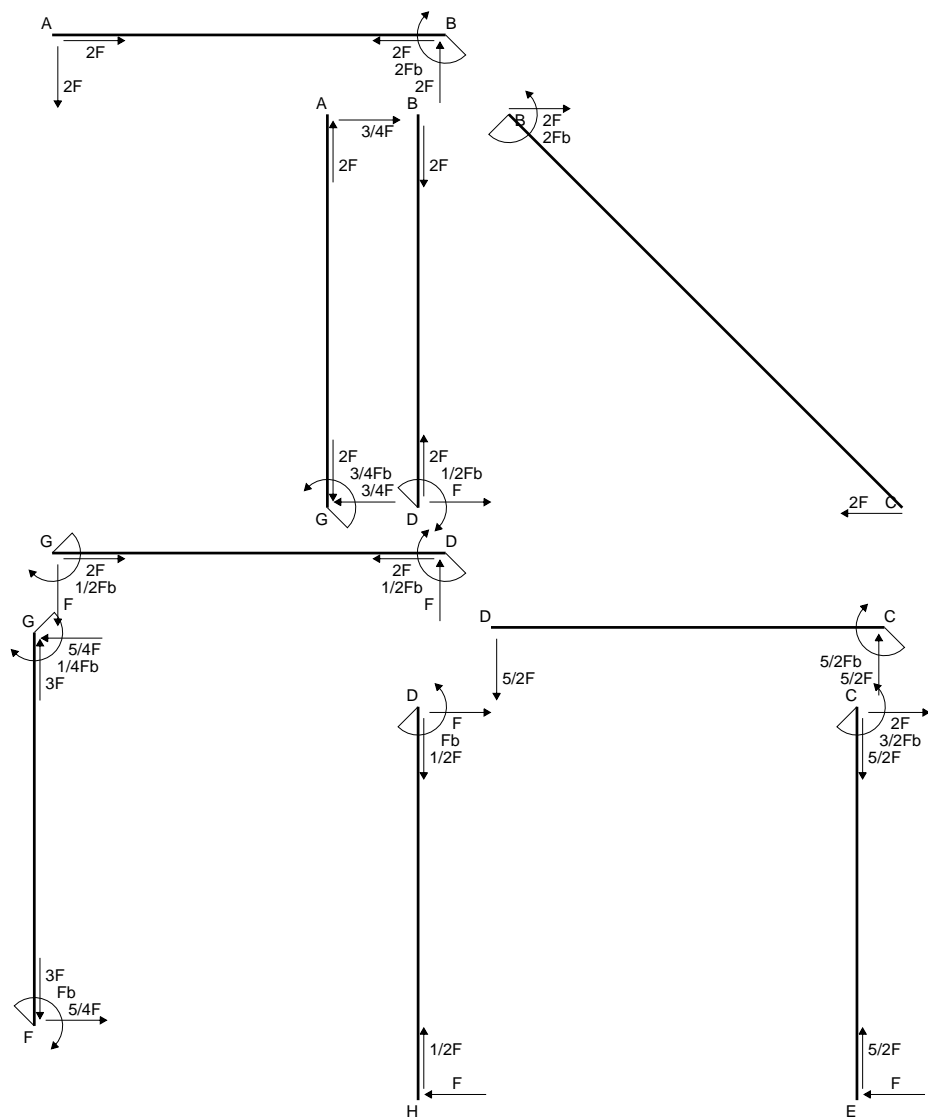
$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

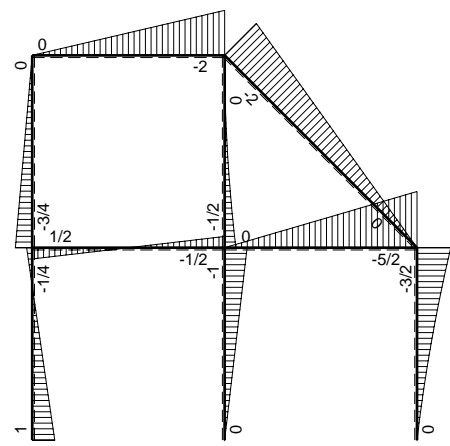


- A = 690. mm<sup>2</sup>
- J<sub>u</sub> = 250916. mm<sup>4</sup>
- J<sub>v</sub> = 53046. mm<sup>4</sup>
- y<sub>g</sub> = 34.75 mm
- T<sub>y</sub> = -2660. N
- M<sub>x</sub> = -1516200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -34.75 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -210. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -25.75 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -155.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.926 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 156.1 N/mm<sup>2</sup>
- S = 3920. mm<sup>3</sup>

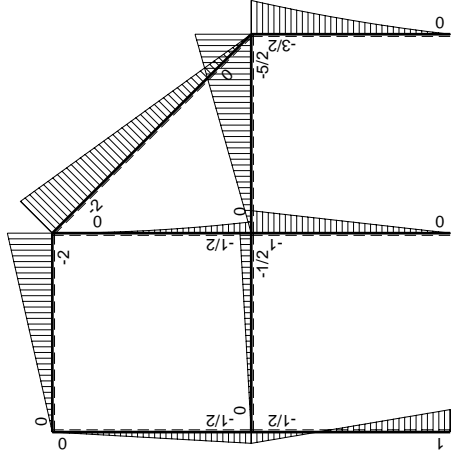
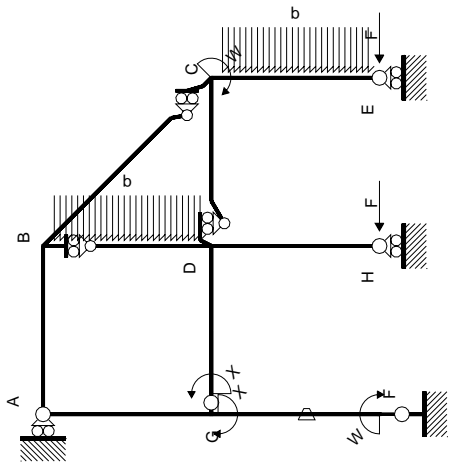


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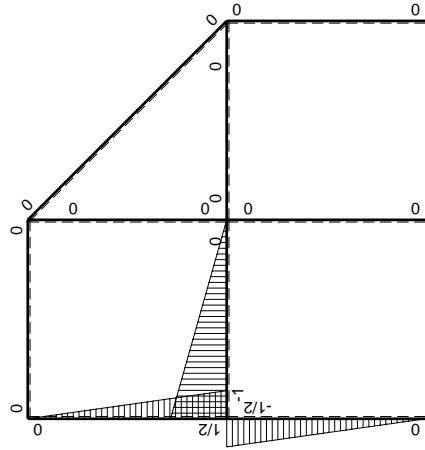


⊕ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0	
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							1/4Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-1/2Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

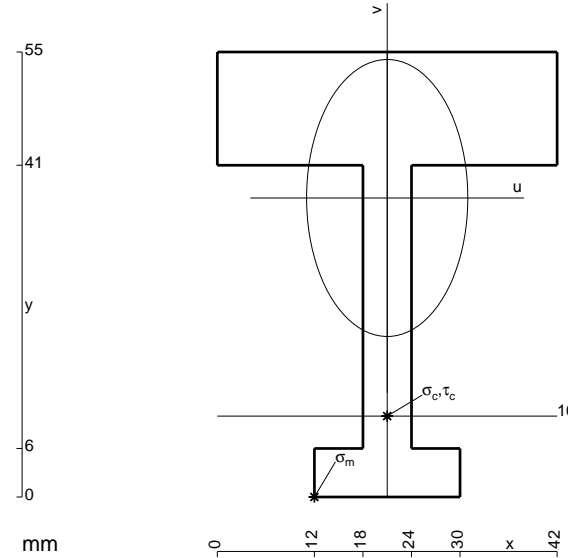
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

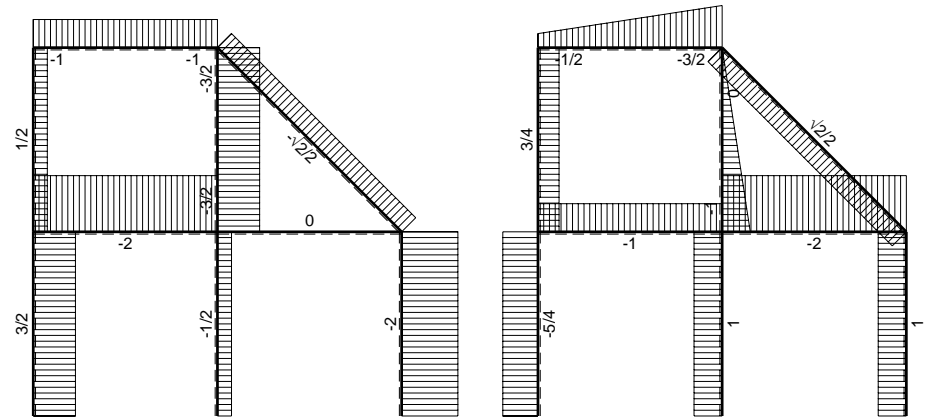
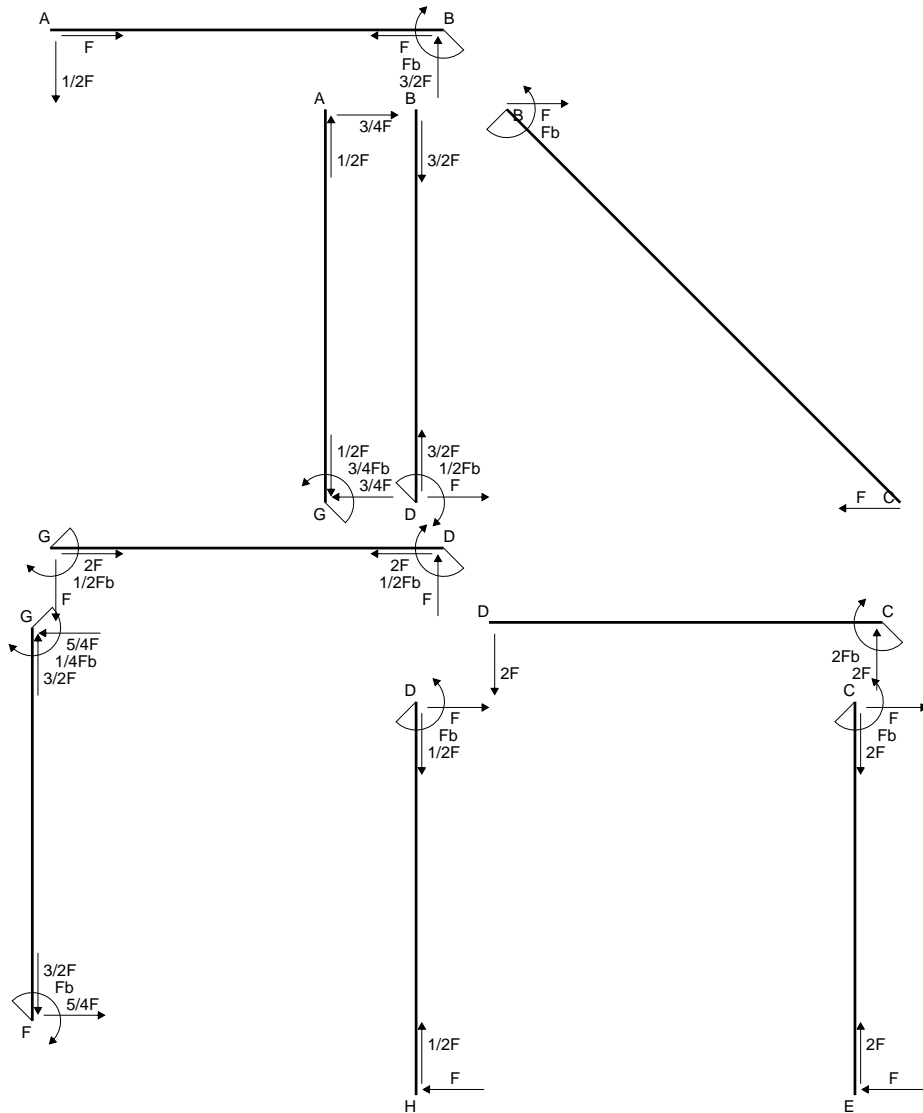
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



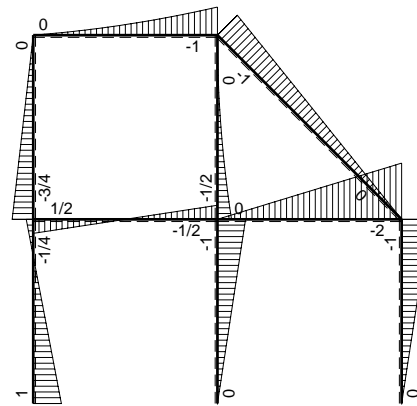
- A = 906. mm<sup>2</sup>
- J<sub>u</sub> = 265632. mm<sup>4</sup>
- J<sub>v</sub> = 89982. mm<sup>4</sup>
- y<sub>g</sub> = 36.96 mm
- T<sub>y</sub> = -2550. N
- M<sub>x</sub> = -1581000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -36.96 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -220. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -26.96 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -160.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.98 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 160.9 N/mm<sup>2</sup>
- S = 4362. mm<sup>3</sup>



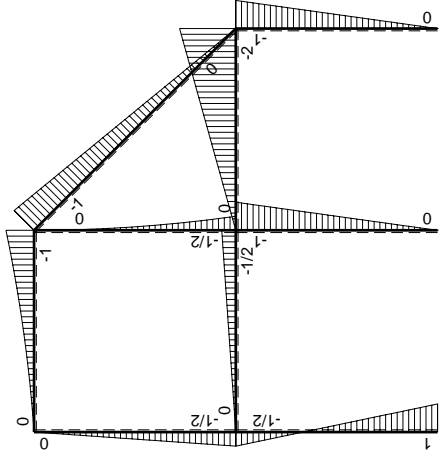
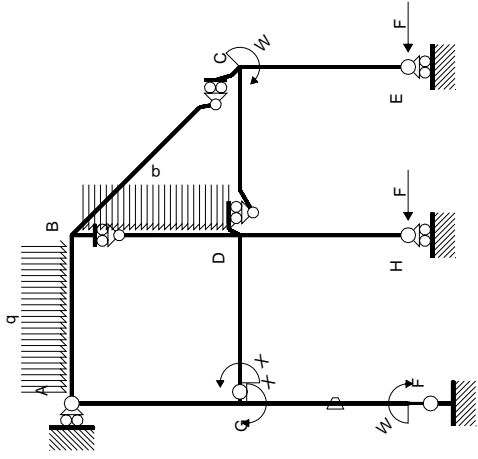


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⊕ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

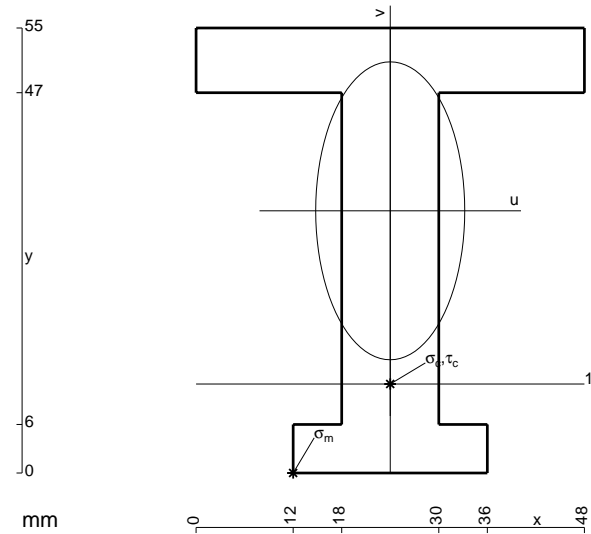
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

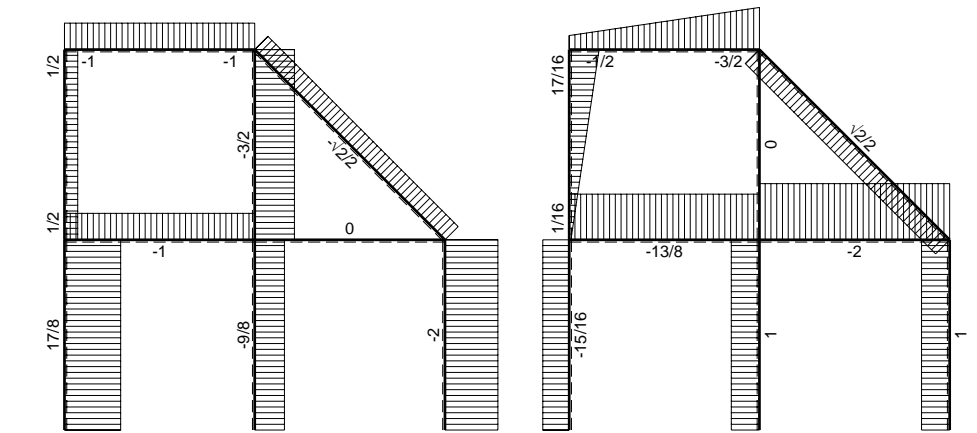
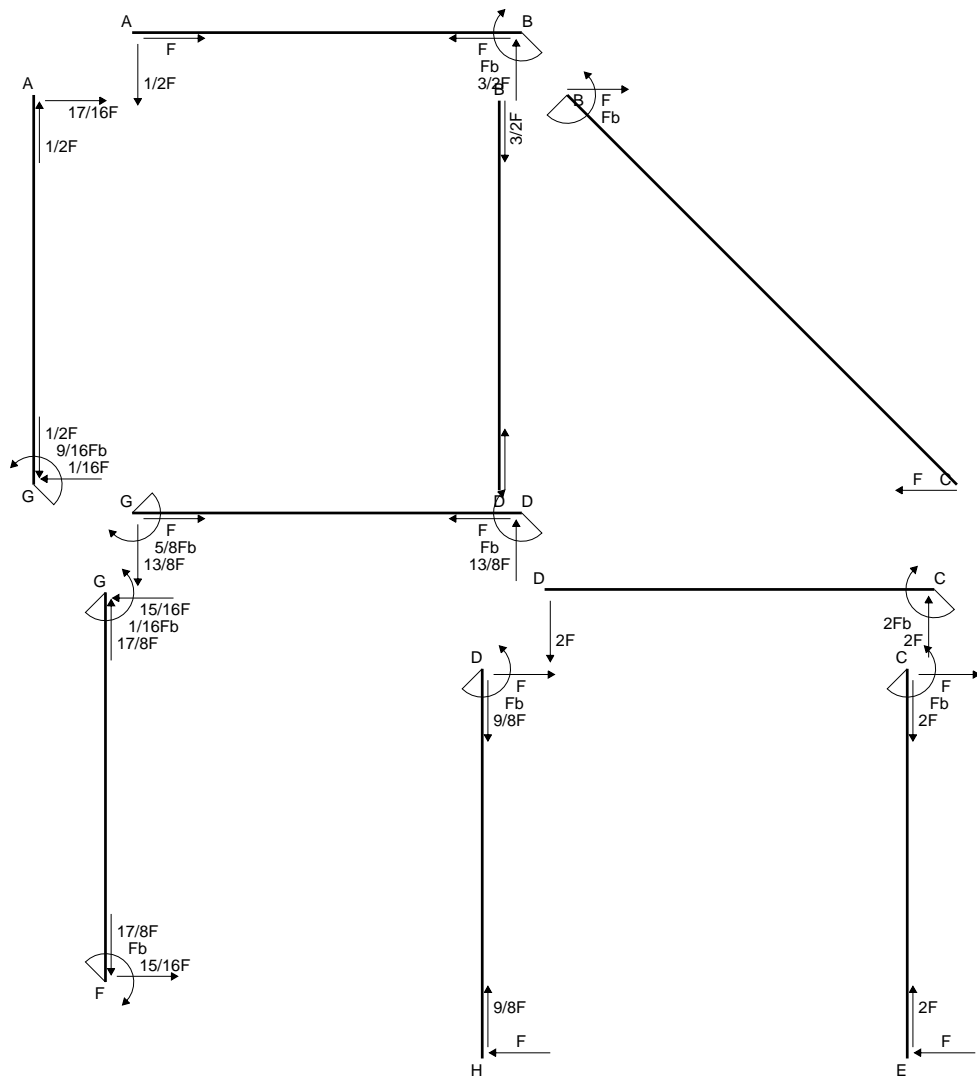
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

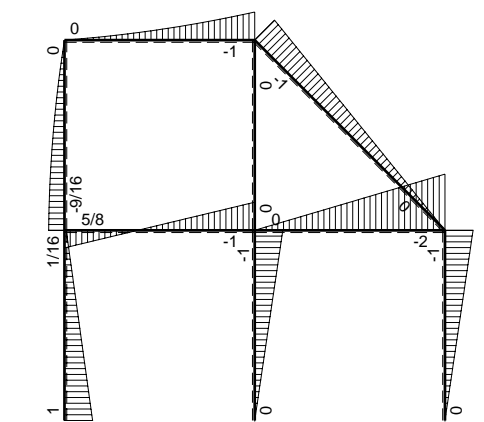


- A = 1020. mm<sup>2</sup>
- J<sub>u</sub> = 345844. mm<sup>4</sup>
- J<sub>v</sub> = 86544. mm<sup>4</sup>
- y<sub>g</sub> = 32.41 mm
- T<sub>y</sub> = -3660. N
- M<sub>x</sub> = -2452200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -32.41 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -229.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -21.41 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -151.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.999 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 152. N/mm<sup>2</sup>
- S = 5669. mm<sup>3</sup>

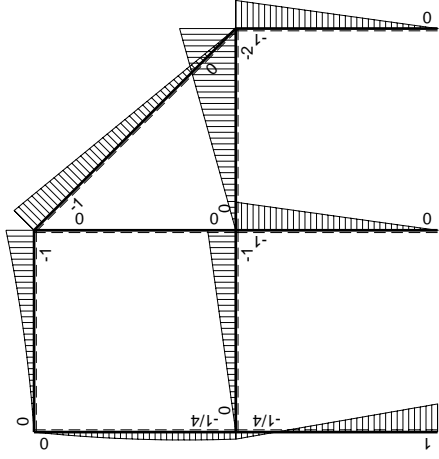
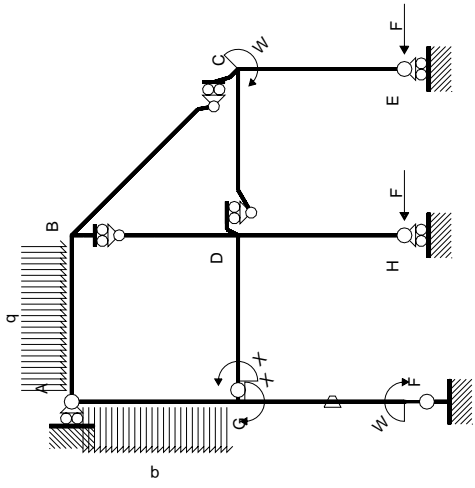


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⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 5/24 b) Fb 1/EJ + (1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 3/4 x/b + 5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 3/8 x^2/b + 5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 3/8 b + 5/24 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

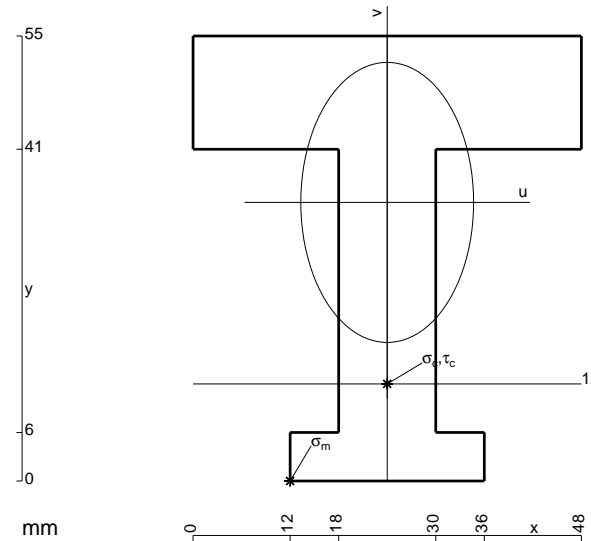
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 3/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x + 1/8 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/8 b - 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

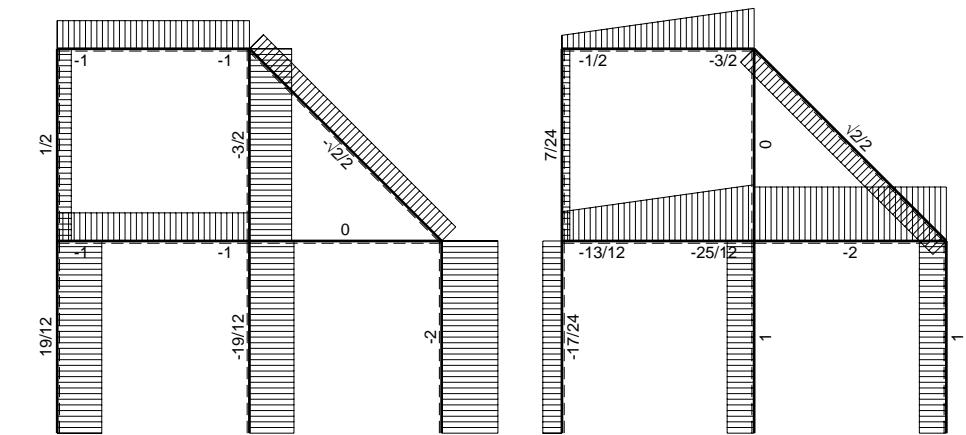
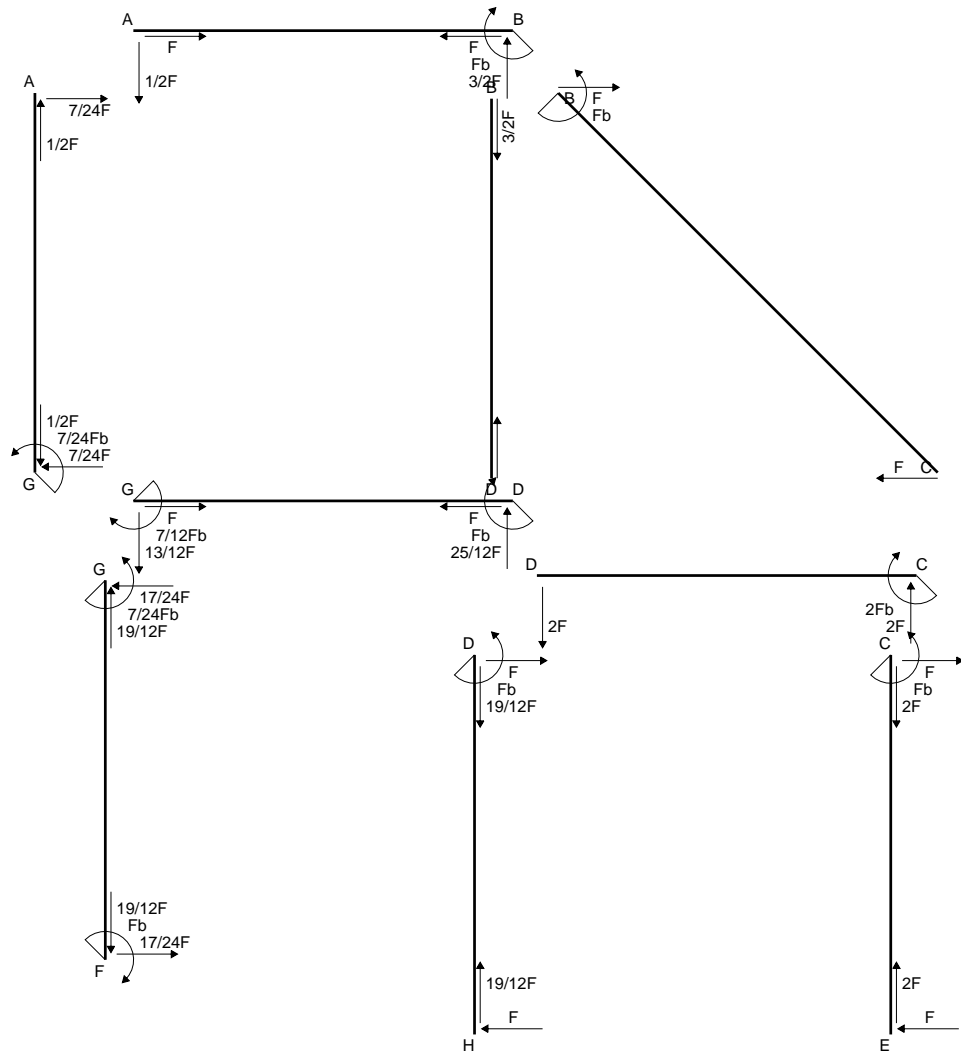
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b + 1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



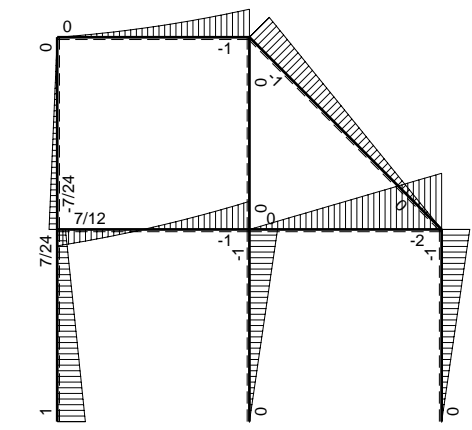
- A = 1236. mm<sup>2</sup>
- J<sub>u</sub> = 370453. mm<sup>4</sup>
- J<sub>v</sub> = 140976. mm<sup>4</sup>
- y<sub>g</sub> = 34.43 mm
- T<sub>y</sub> = -3580. N
- M<sub>x</sub> = -2577600. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -34.43 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 12. mm
- v<sub>c</sub> = -22.43 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -156.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.12 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 156.3 N/mm<sup>2</sup>
- S = 6357. mm<sup>3</sup>



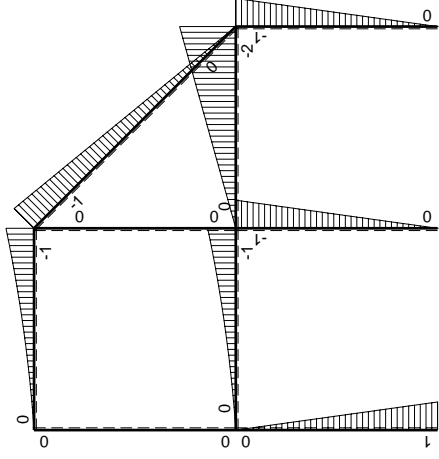
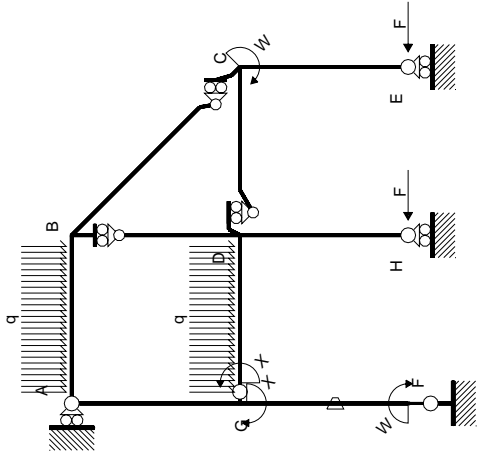


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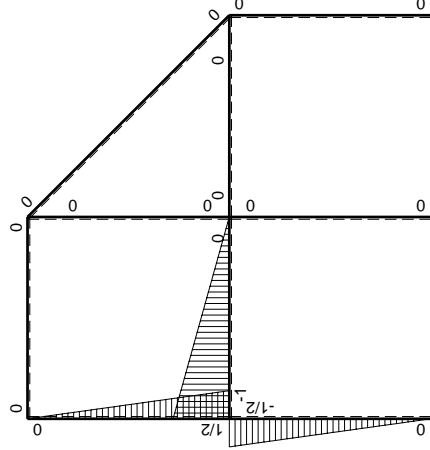


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	$-1/2x/b$	$Fb-Fx$	$-Fb/EJ$	$-1/2Fx+1/2Fx^2/b$	$1/2Fx/EJ$	$1/4x^2/b^2$	$(-1/12+1/4)Fb^2/EJ$	$1/12Xb/EJ$	
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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

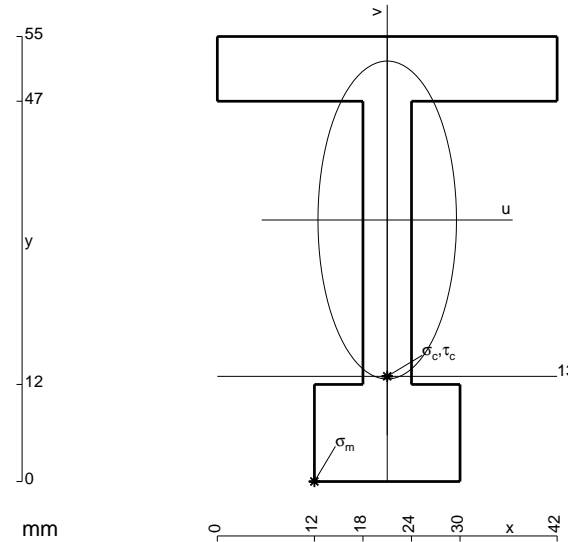
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

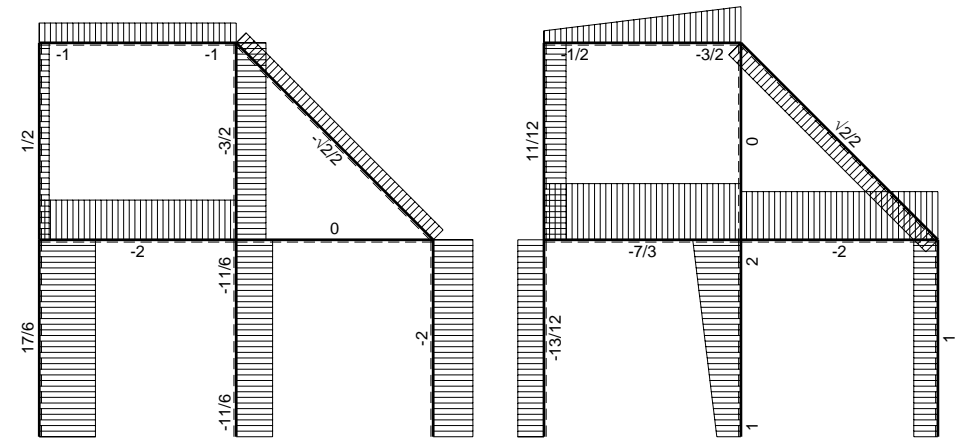
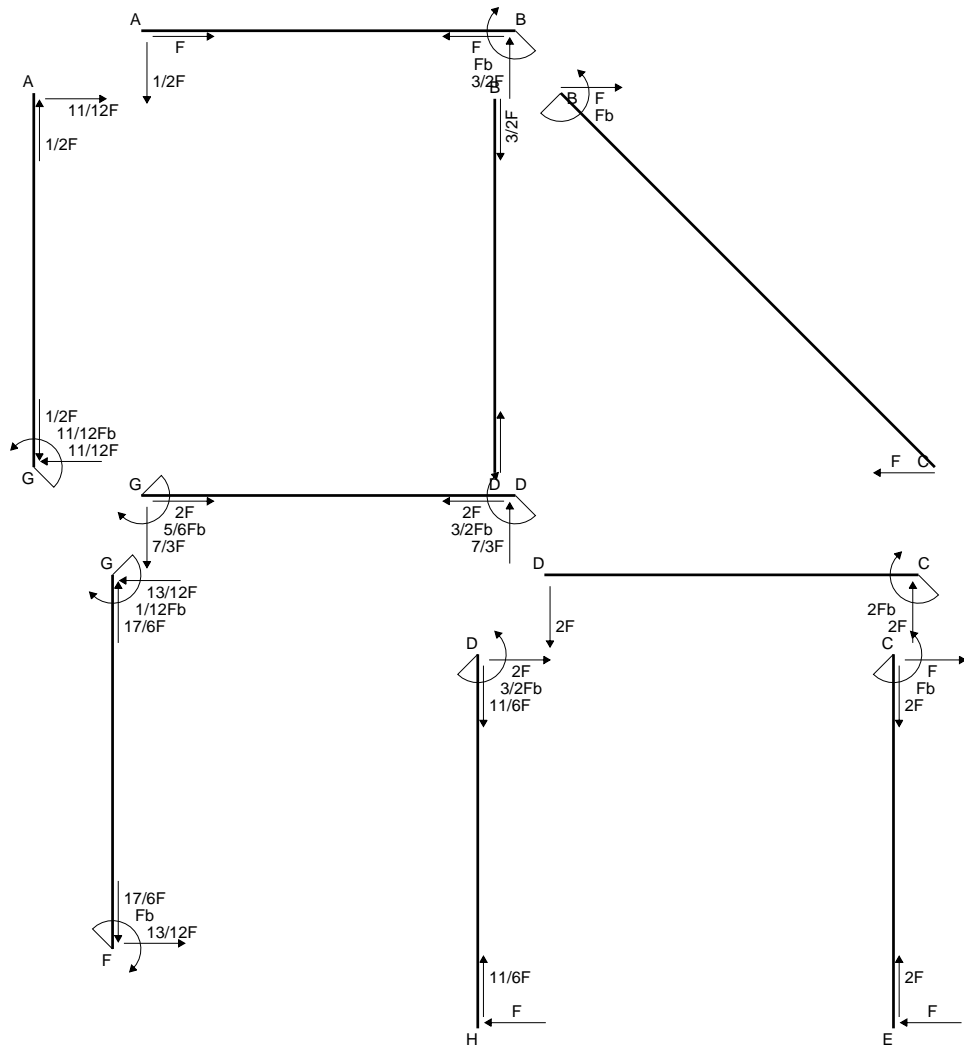
$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

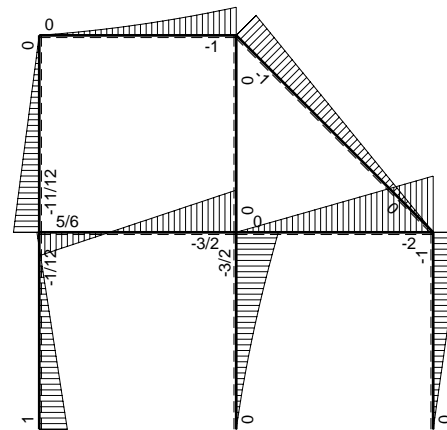


- A = 762. mm<sup>2</sup>
- J<sub>u</sub> = 294369. mm<sup>4</sup>
- J<sub>v</sub> = 55854. mm<sup>4</sup>
- y<sub>g</sub> = 32.32 mm
- T<sub>y</sub> = -2320. N
- M<sub>x</sub> = -1809600. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -32.32 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -198.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -19.32 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -118.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.624 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 119.5 N/mm<sup>2</sup>
- S = 5804. mm<sup>3</sup>

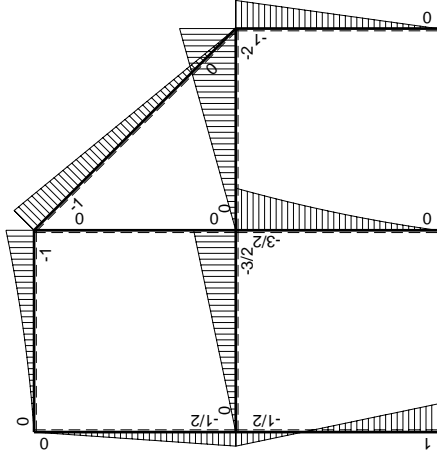
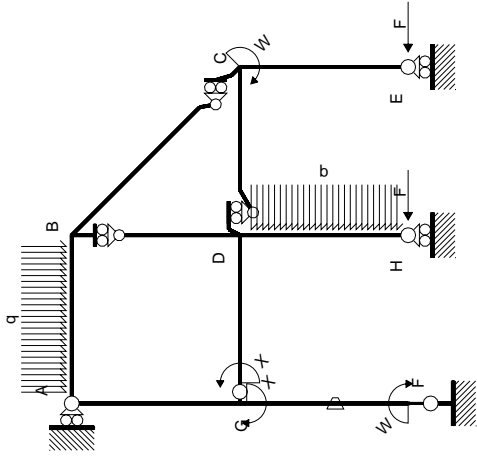


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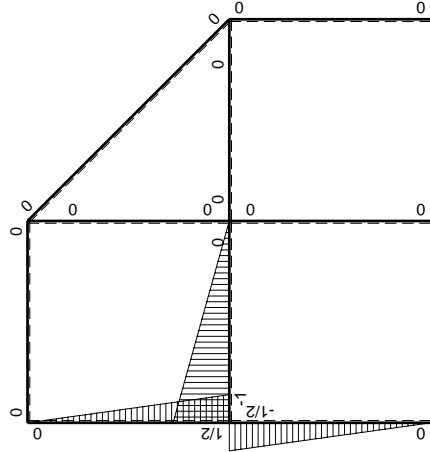


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

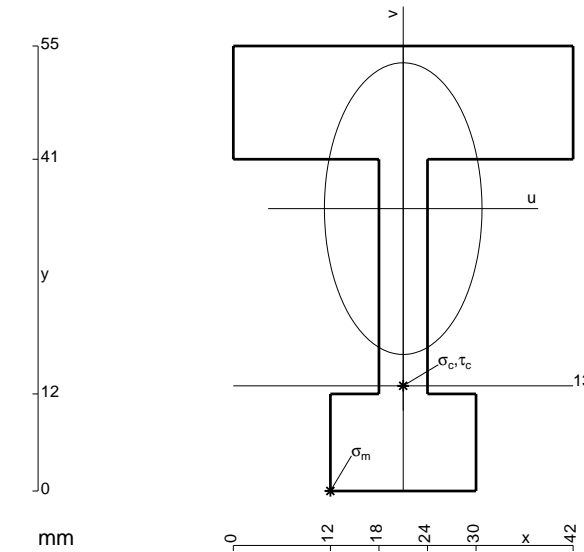
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

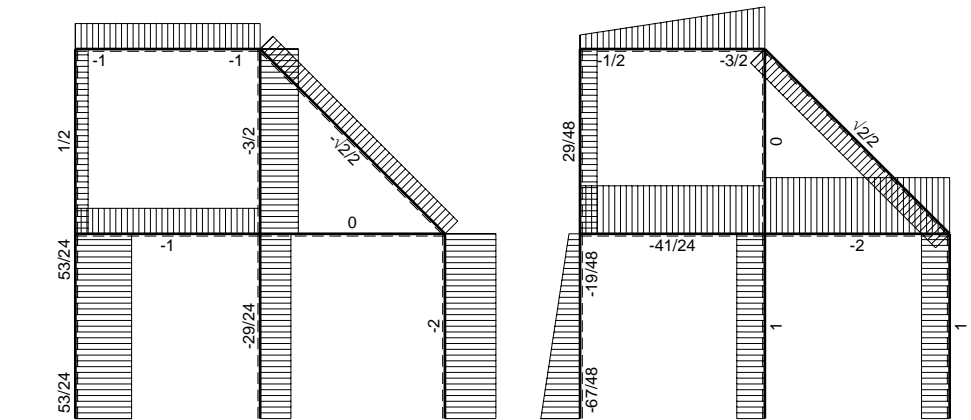
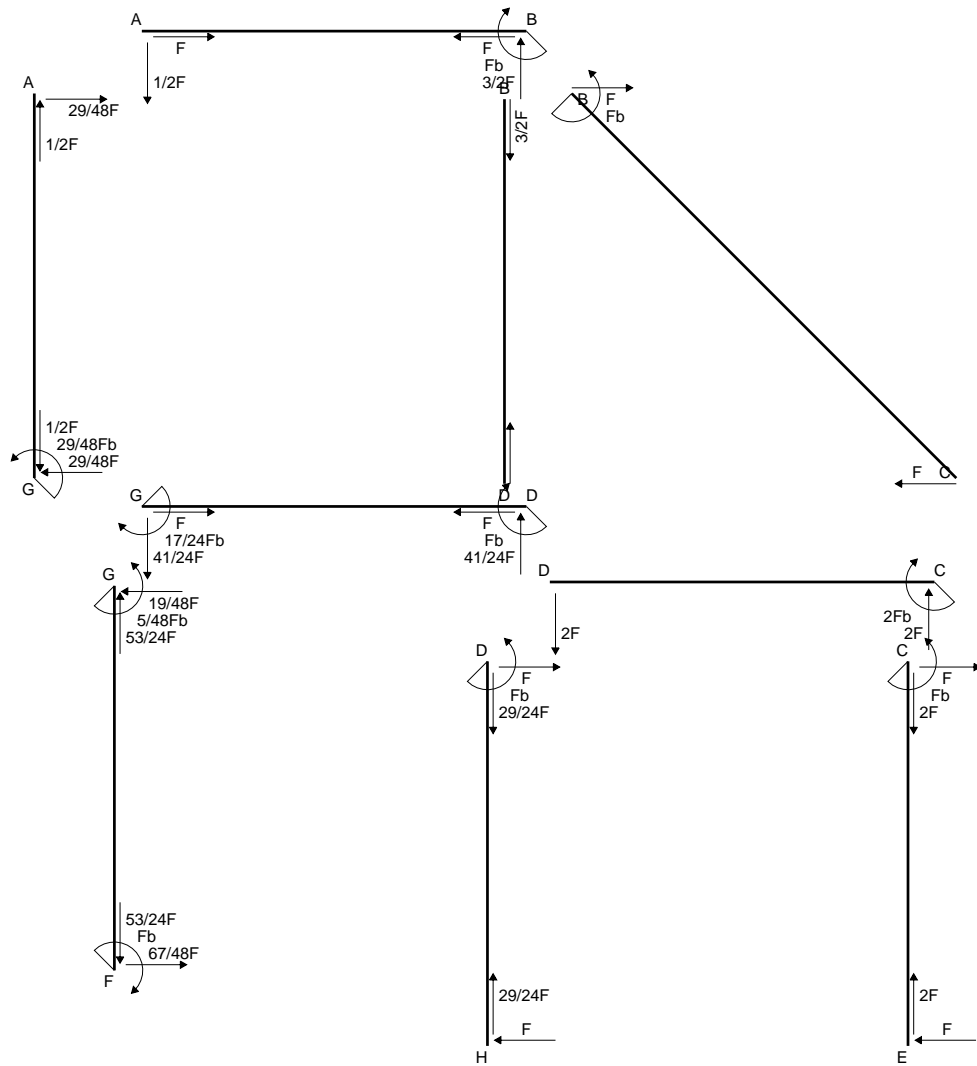
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



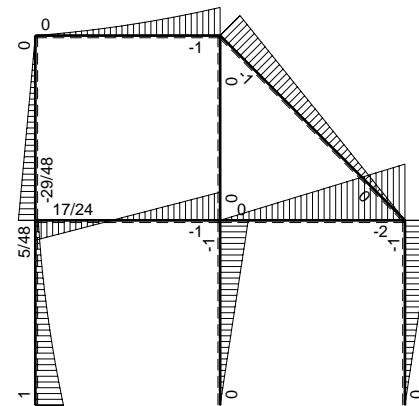
- A = 978. mm<sup>2</sup>
- J<sub>u</sub> = 317980. mm<sup>4</sup>
- J<sub>v</sub> = 92790. mm<sup>4</sup>
- y<sub>g</sub> = 34.9 mm
- T<sub>y</sub> = -2300. N
- M<sub>x</sub> = -1909000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -34.9 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -209.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -21.9 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -131.5 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.687 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 132.1 N/mm<sup>2</sup>
- S = 6377. mm<sup>3</sup>



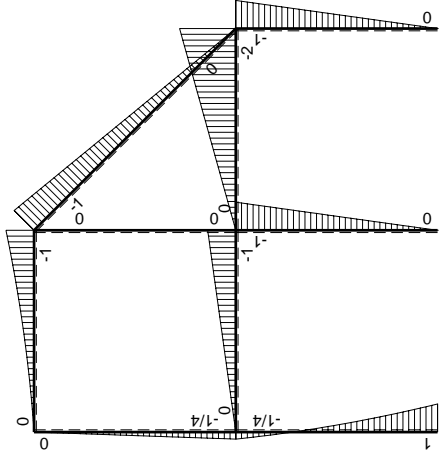
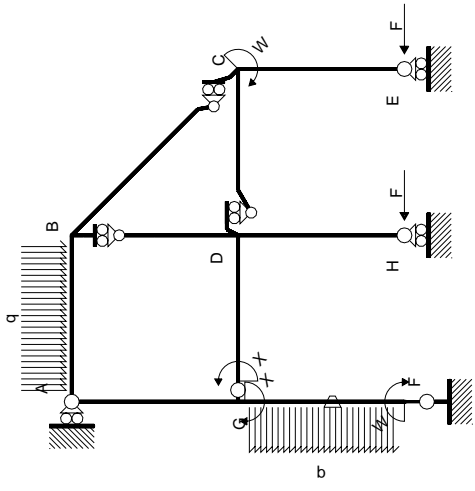


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⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 1/2 x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 1/4 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 1/4 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

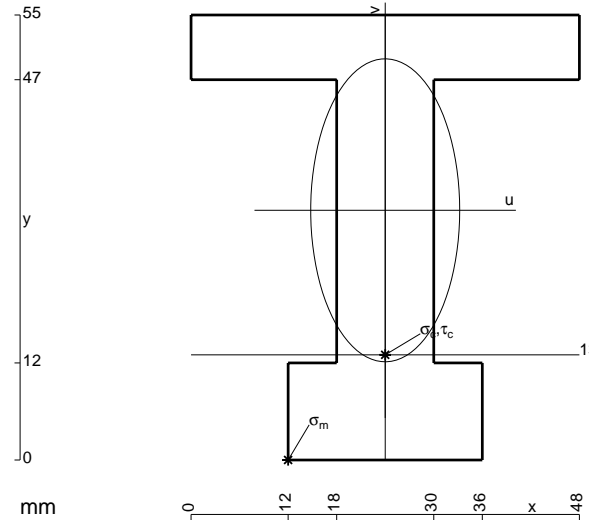
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 1/4 x/b - 1/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x + 1/8 x^2/b - 1/24 x^3/b^2]_0^b Fb 1/EJ$$

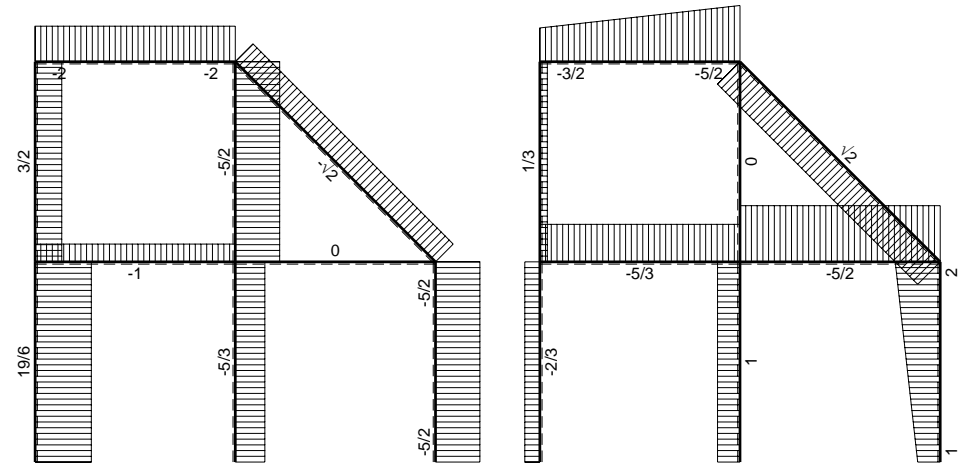
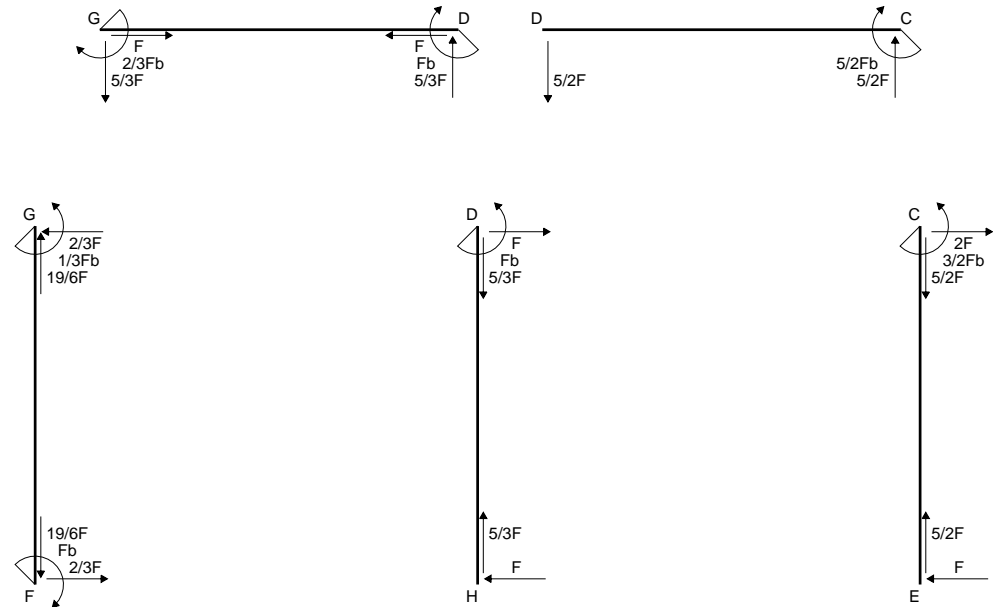
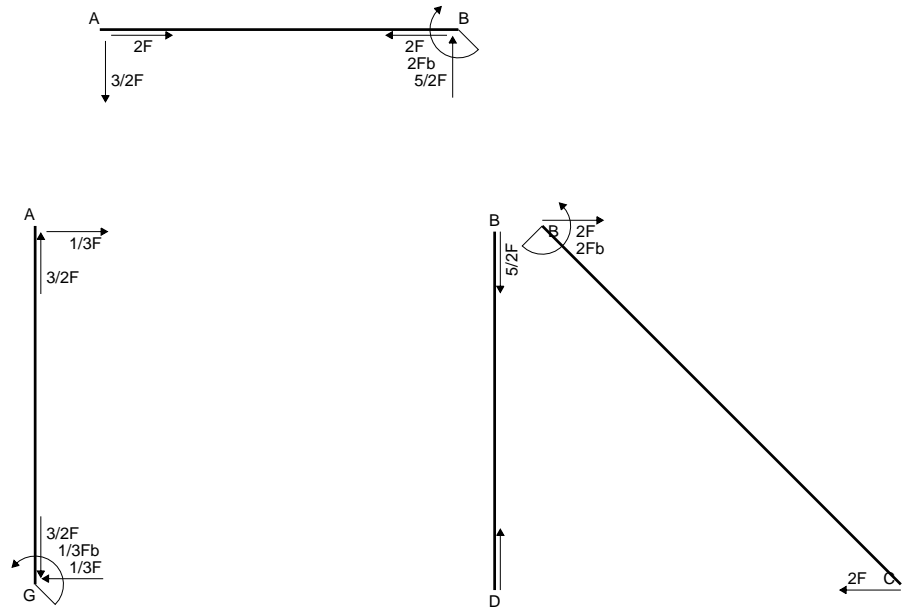
$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

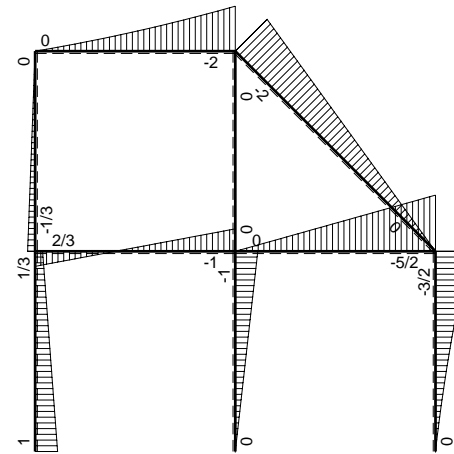


- A = 1092. mm<sup>2</sup>
- J<sub>u</sub> = 382903. mm<sup>4</sup>
- J<sub>v</sub> = 92592. mm<sup>4</sup>
- y<sub>g</sub> = 30.86 mm
- T<sub>y</sub> = -3100. N
- M<sub>x</sub> = -2728000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -30.86 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -17.86 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -127.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.98 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 127.6 N/mm<sup>2</sup>
- S = 7381. mm<sup>3</sup>

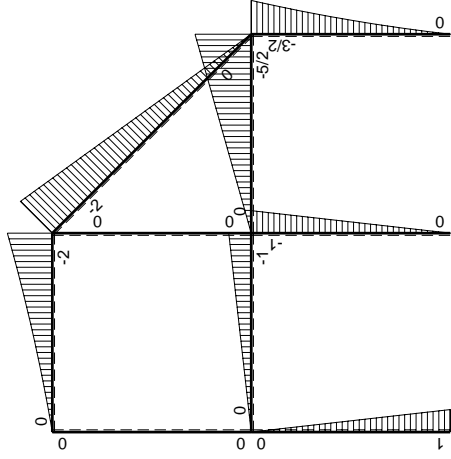
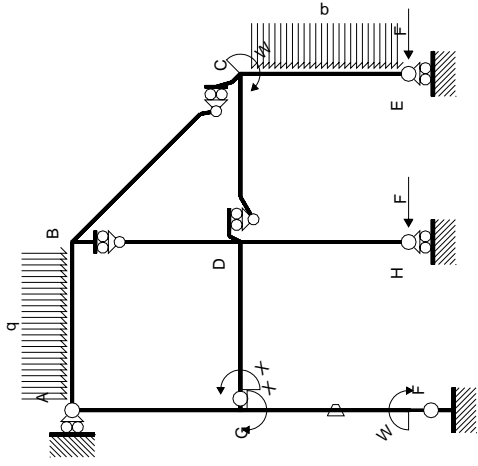


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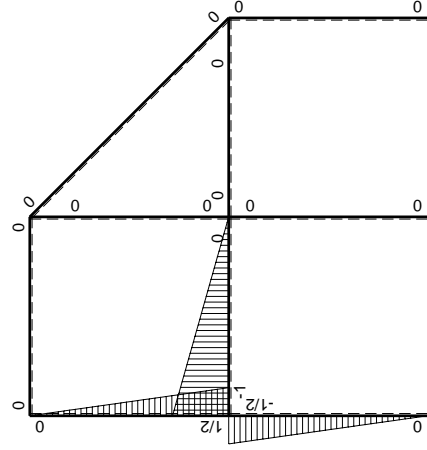


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	$-3/2Fx-1/2qx^2$	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

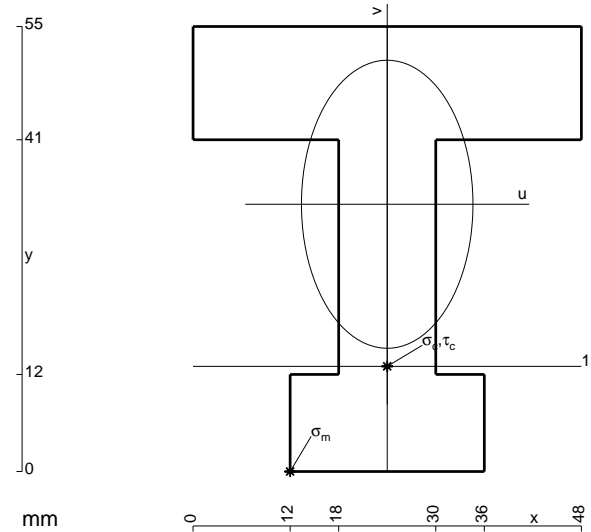
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

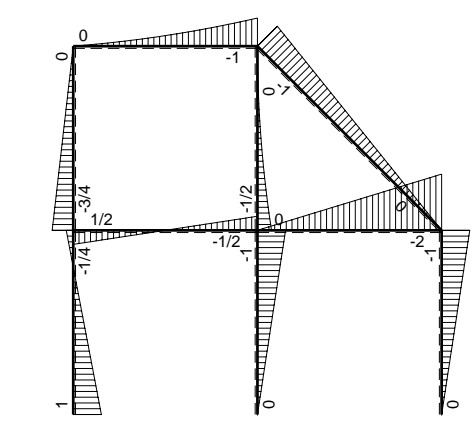
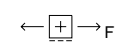
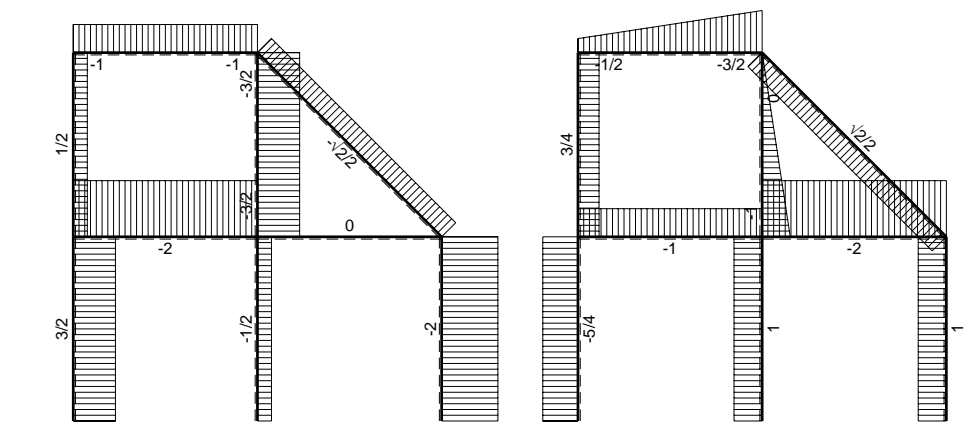
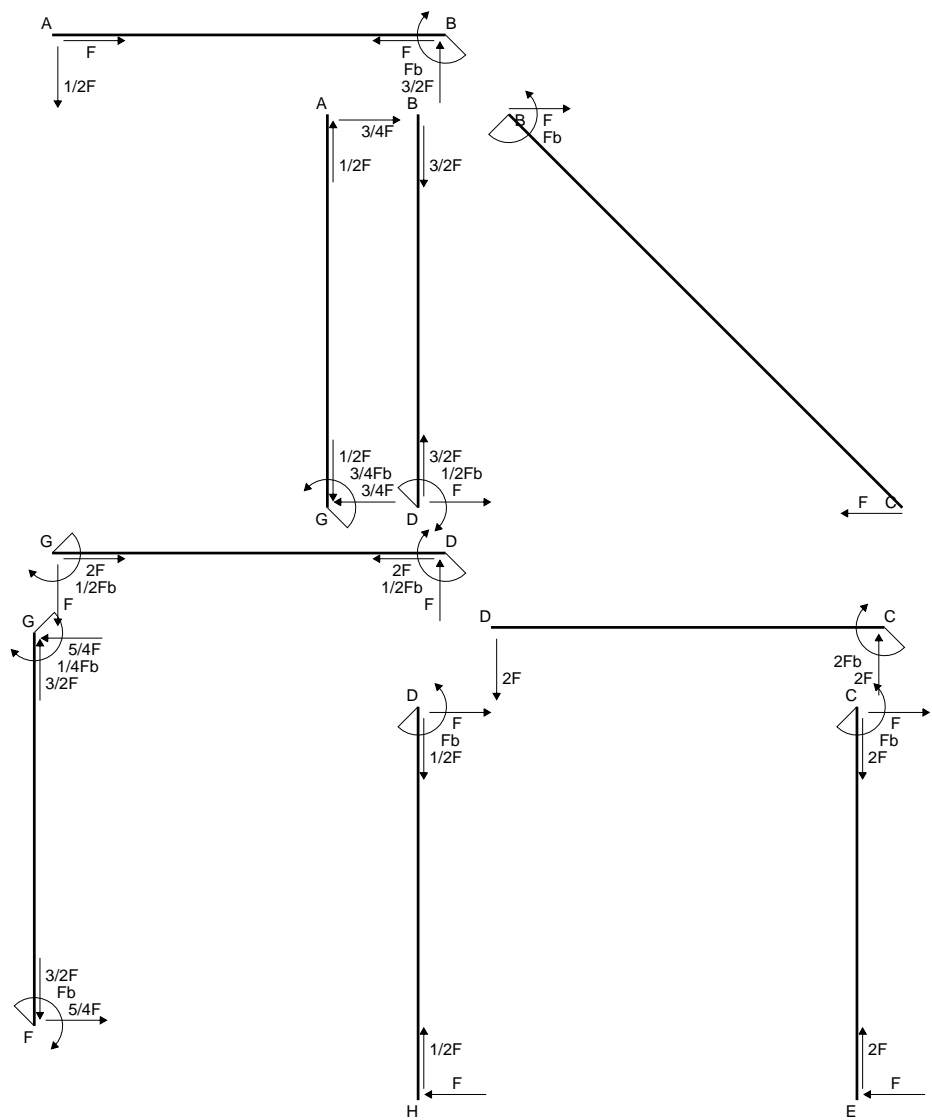
$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

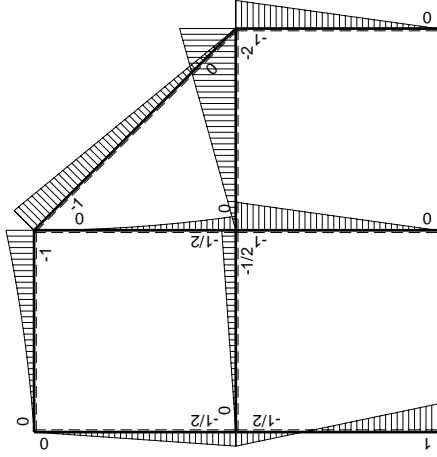
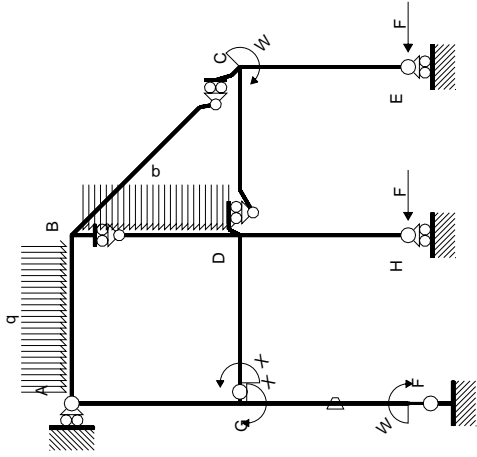
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$



- A = 1308. mm<sup>2</sup>
- J<sub>u</sub> = 414675. mm<sup>4</sup>
- J<sub>v</sub> = 147024. mm<sup>4</sup>
- y<sub>g</sub> = 33.03 mm
- T<sub>y</sub> = -3100. N
- M<sub>x</sub> = -2883000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -33.03 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -229.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -20.03 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -139.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.004 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 139.5 N/mm<sup>2</sup>
- S = 8032. mm<sup>3</sup>

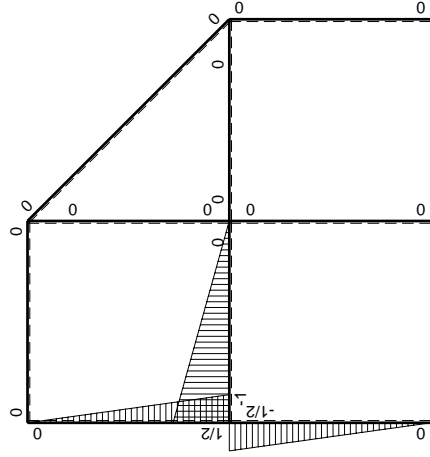






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

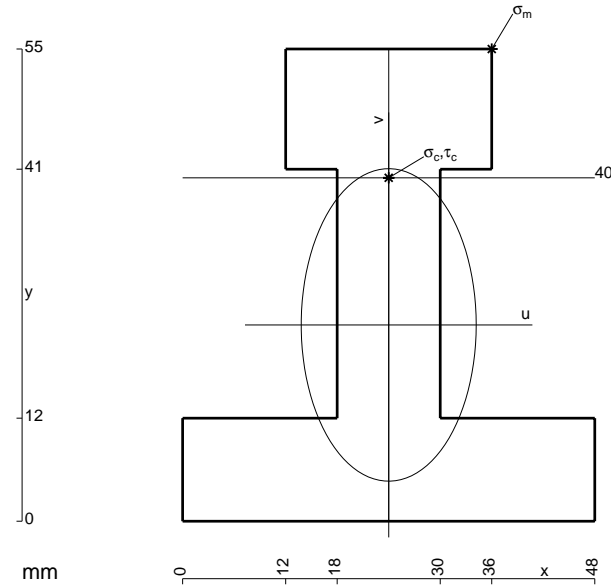
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

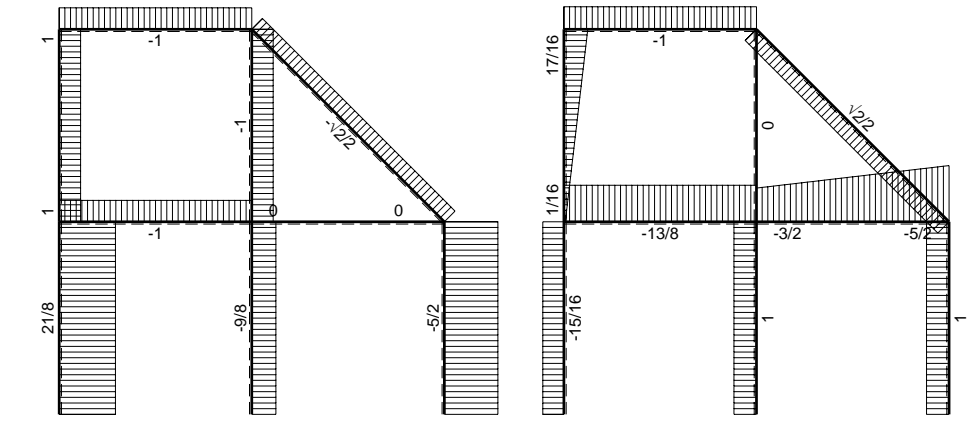
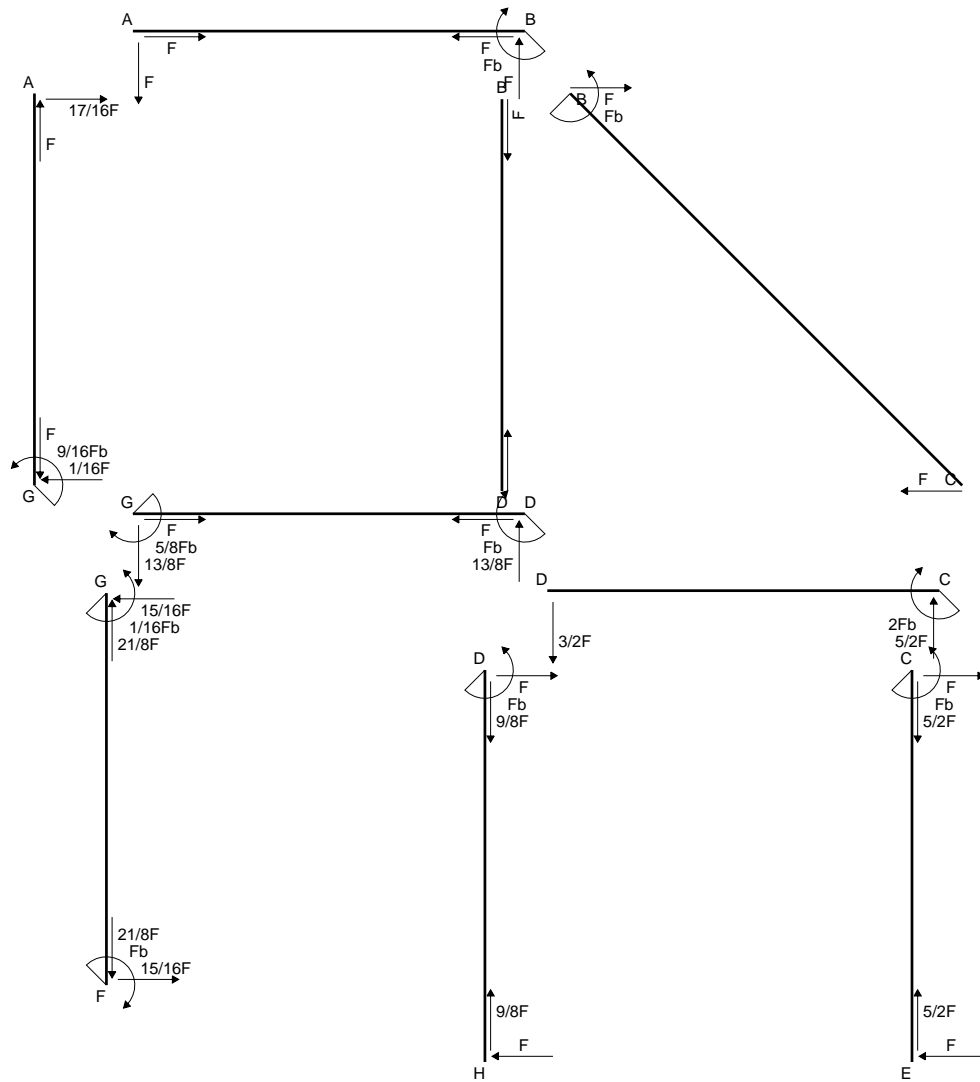
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

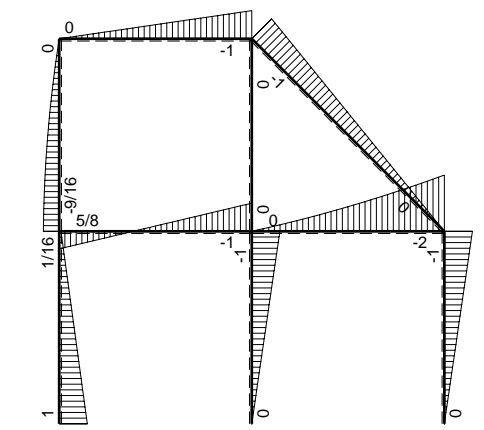


- A = 1260. mm<sup>2</sup>
- J<sub>u</sub> = 417492. mm<sup>4</sup>
- J<sub>v</sub> = 130896. mm<sup>4</sup>
- y<sub>g</sub> = 22.86 mm
- T<sub>y</sub> = -3180. N
- M<sub>x</sub> = -3116400. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 32.14 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 239.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 40. mm
- v<sub>c</sub> = 17.14 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 127.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.496 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 128.3 N/mm<sup>2</sup>
- S = 8658. mm<sup>3</sup>

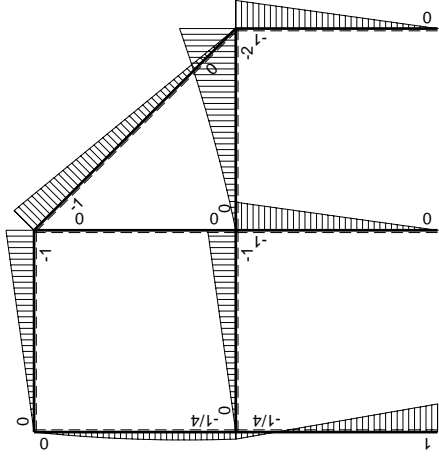
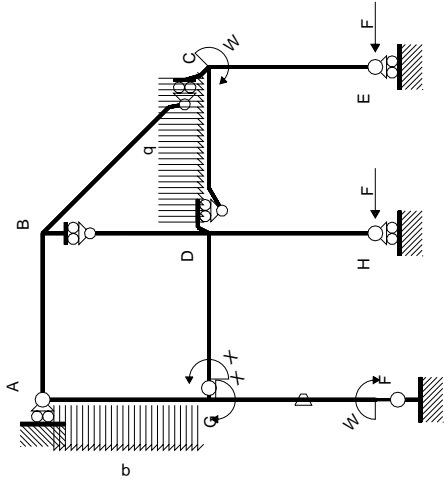


← ⊕ → F

↑ ⊕ ↓ F<sub>b</sub>

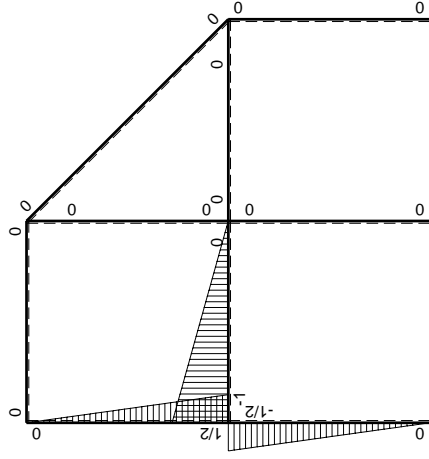


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-5/4Fx	-Fb/EJ	-1/2Fx+5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-5/4Fx	Fb/EJ	1/8Fb-3/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/4Fb-1/4Fx+1/2qx <sup>2</sup>	0	-1/8Fb+3/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx-1/2qx <sup>2</sup>	0	-3/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 -2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b +1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b +1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b +5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b +5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b +5/24 b) Fb 1/EJ + (1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 -3/4 x/b +5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 +1/2 x/b) \theta dx$$

$$= [1/8 x -3/8 x^2/b +5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

$$= (1/8 b -3/8 b +5/24 b) Fb 1/EJ + (-1/2 b +1/4 b) \theta = 5/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b -1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b -1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b -1/3 x^3/b^2]_0^b Fb 1/EJ$$

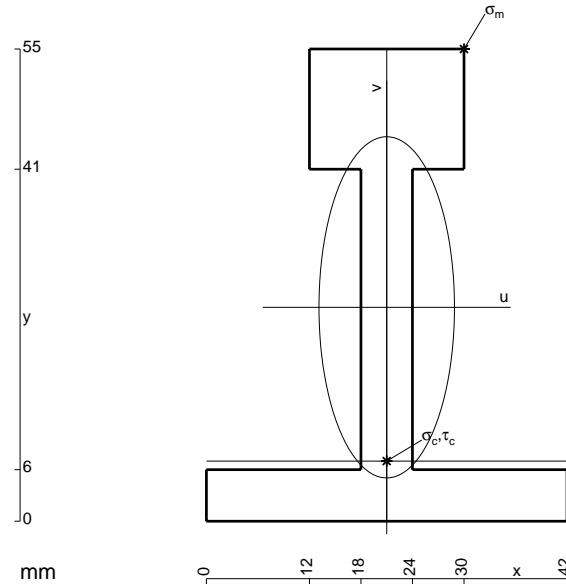
$$= (1/2 b -1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 +3/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x +1/8 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/8 b +1/8 b -1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$

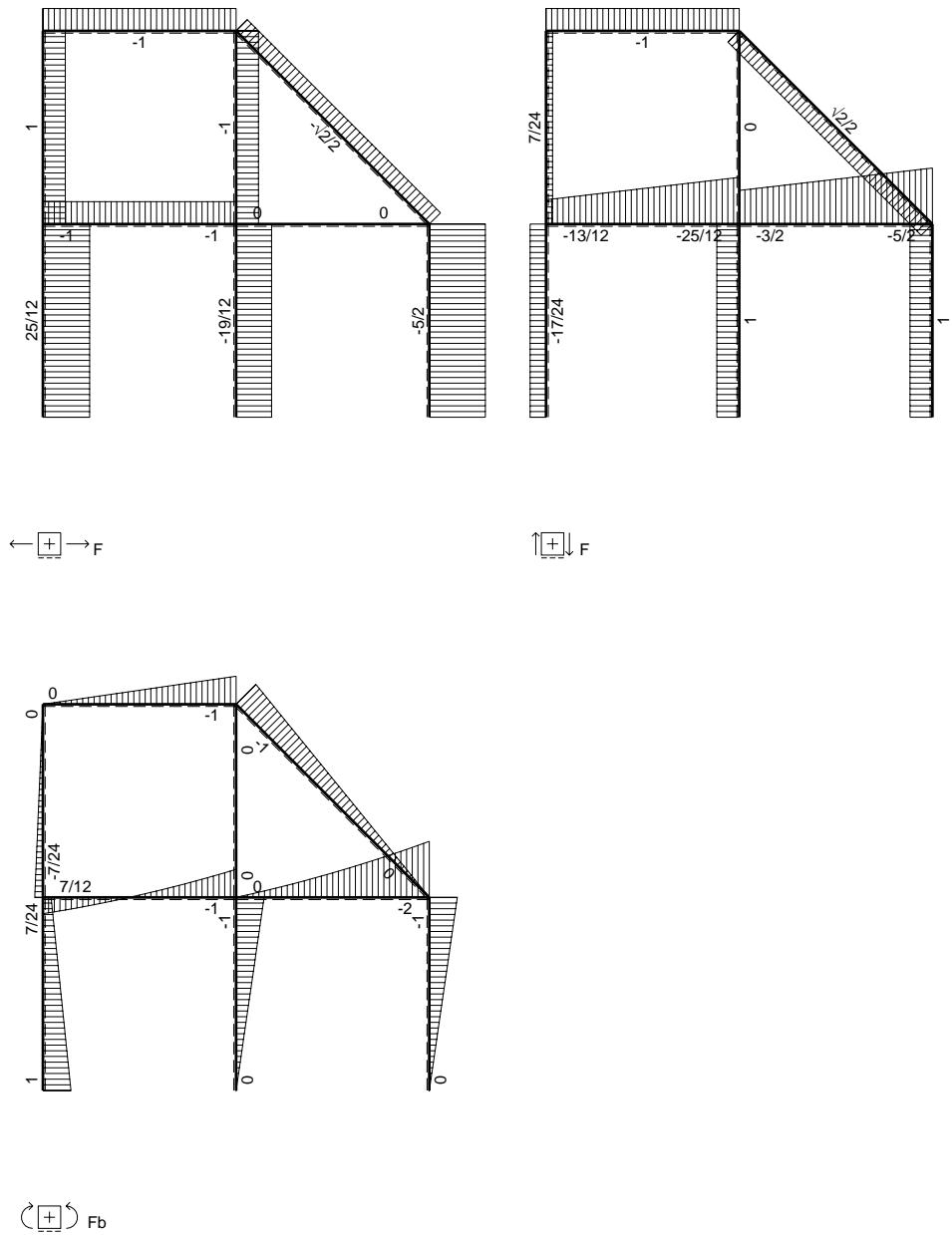
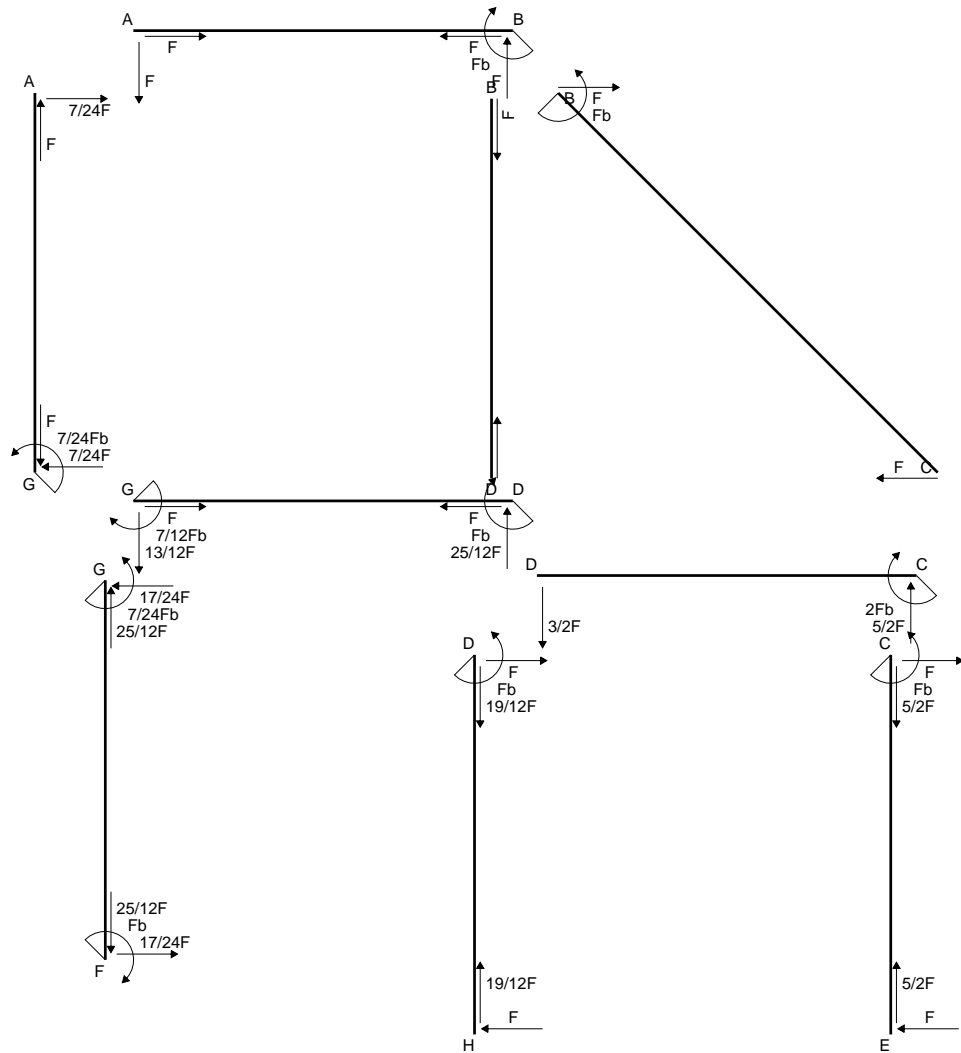
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2 +1/4 x^3/b^3) Fb 1/EJ dx = [-1/8 x^3/b^2 +1/16 x^4/b^3]_0^b Fb 1/EJ$$

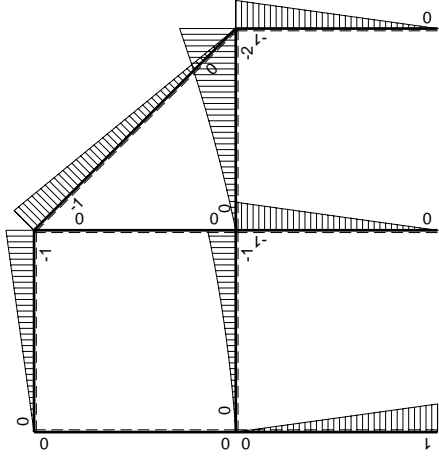
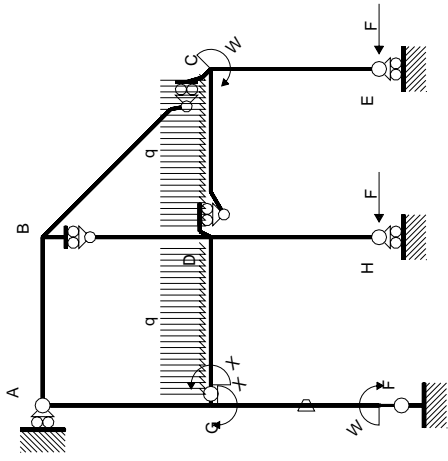
$$= (-1/8 b +1/16 b) Fb 1/EJ = -1/16 Fb^2/EJ$$



- A = 714. mm<sup>2</sup>
- J<sub>u</sub> = 282052. mm<sup>4</sup>
- J<sub>v</sub> = 44478. mm<sup>4</sup>
- y<sub>g</sub> = 24.91 mm
- T<sub>y</sub> = -4500. N
- M<sub>x</sub> = -1872000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 30.09 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -17.91 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -118.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 14.98 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 121.7 N/mm<sup>2</sup>
- S = 5632. mm<sup>3</sup>







Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-Fx	-Fb/EJ	-1/2Fx+1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	-Fx	Fb/EJ	-1/2Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	0	0	0	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	0+0	1/12Xb/EJ	
AG b	-1/2x/b	0	0	0	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							7/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-7/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

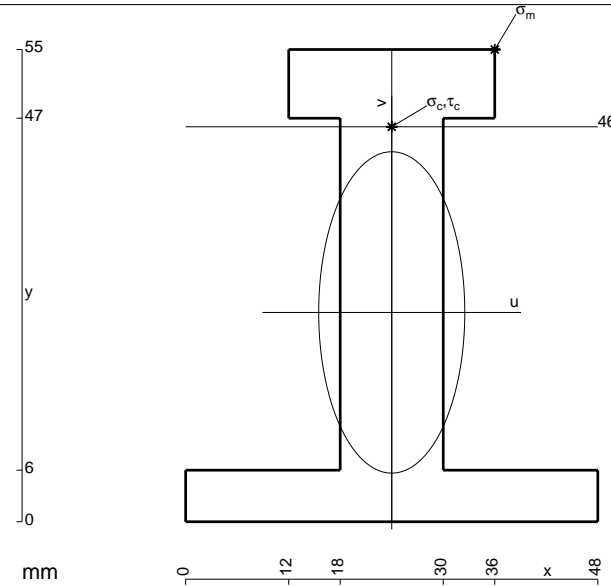
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

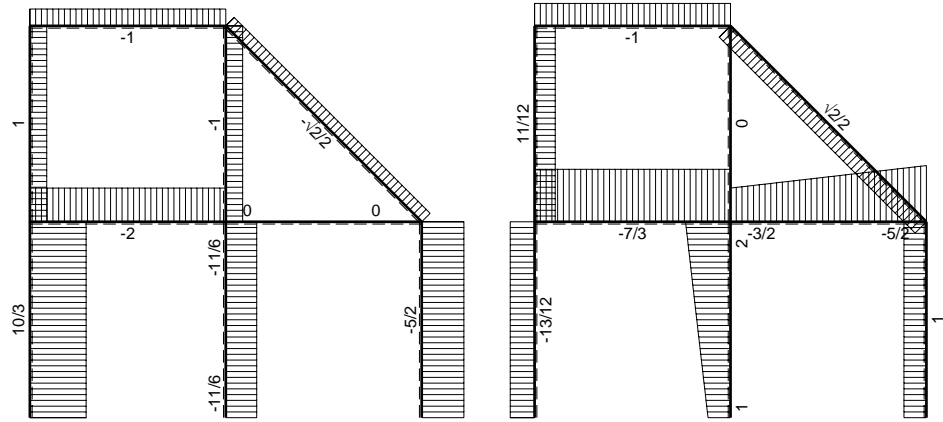
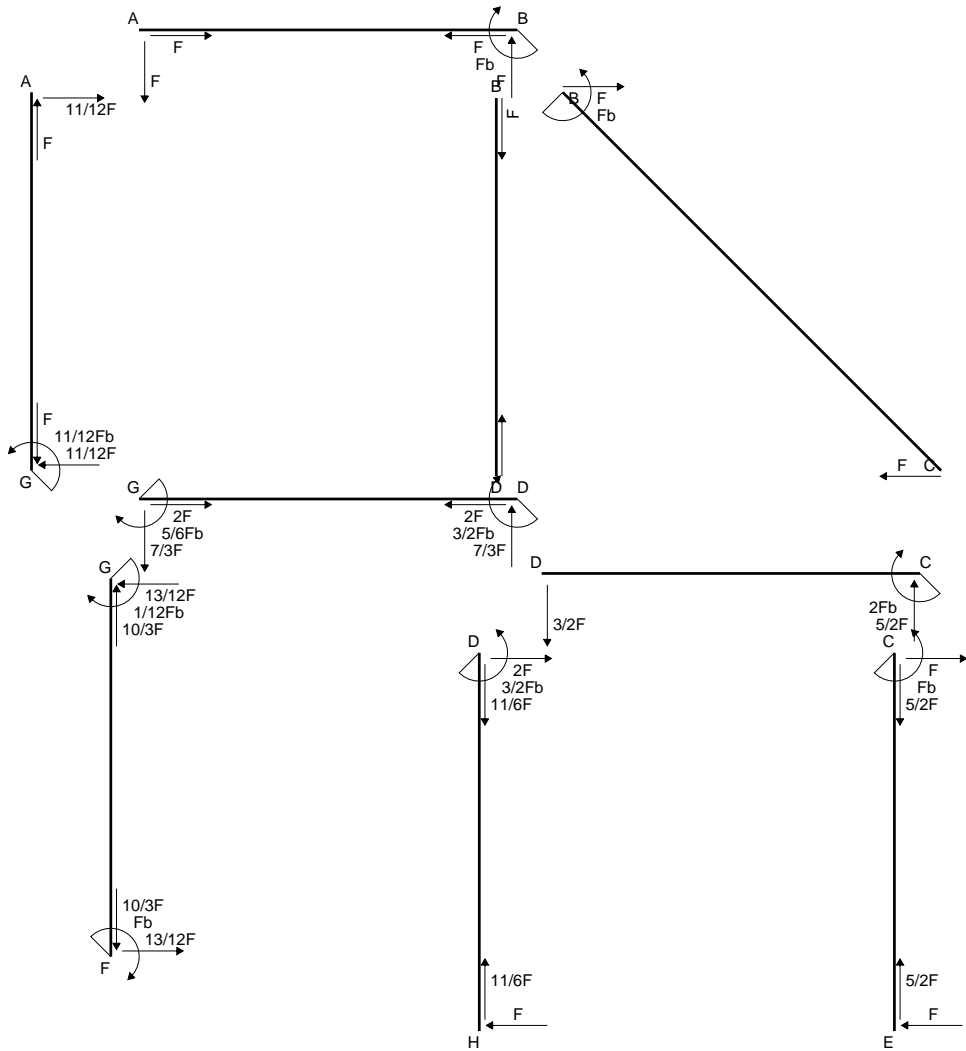
$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

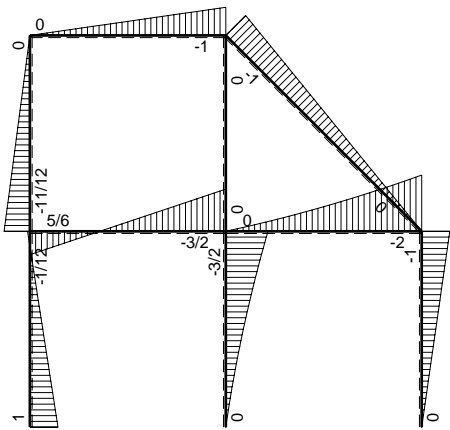


- A = 972. mm<sup>2</sup>
- J<sub>u</sub> = 340722. mm<sup>4</sup>
- J<sub>v</sub> = 70416. mm<sup>4</sup>
- y<sub>g</sub> = 24.38 mm
- T<sub>y</sub> = -5100. N
- M<sub>x</sub> = -2325600. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 30.62 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209. N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 46. mm
- v<sub>c</sub> = 21.62 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 147.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.707 N/mm<sup>2</sup>
- σ<sub>φ</sub> = √(σ<sup>2</sup>+3τ<sup>2</sup>) = 148. N/mm<sup>2</sup>
- S = 5377. mm<sup>3</sup>

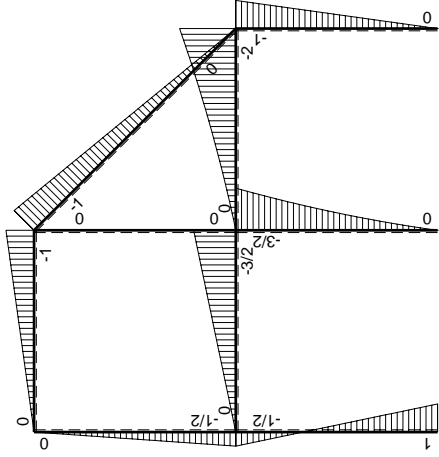
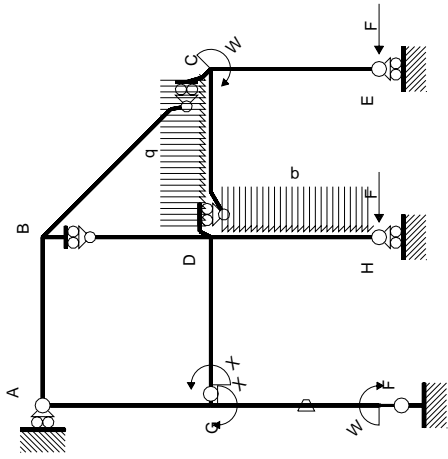


← ⊕ → F

↑ ⊕ ↓ F

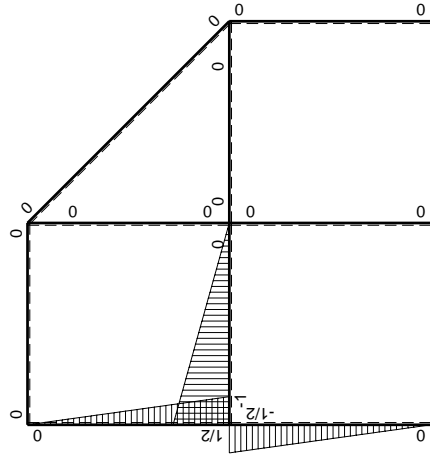


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							5/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

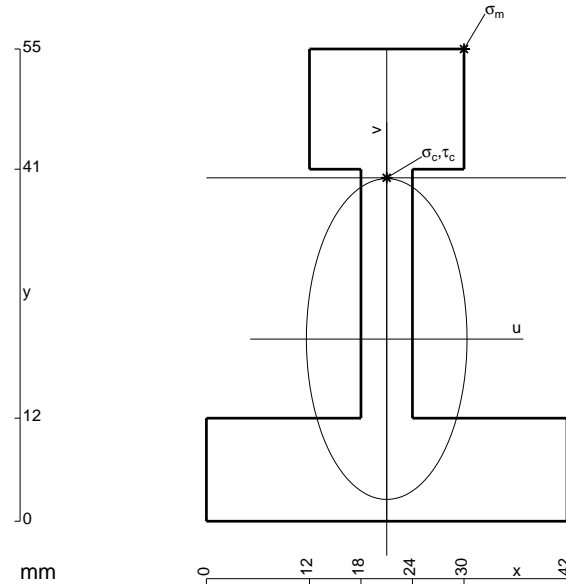
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

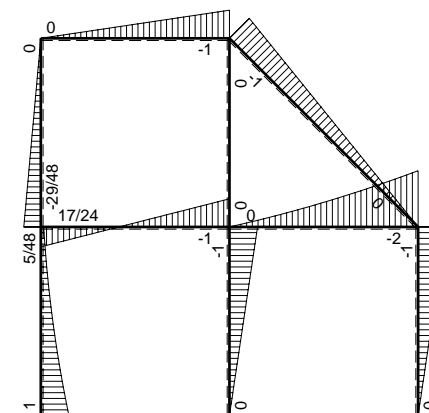
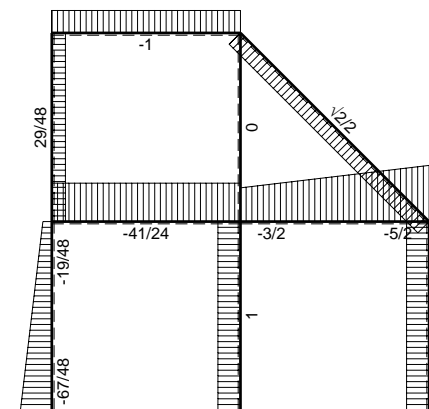
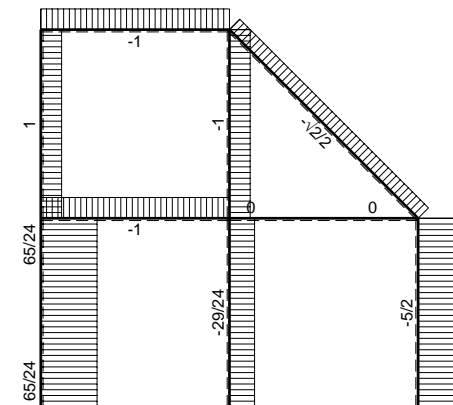
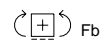
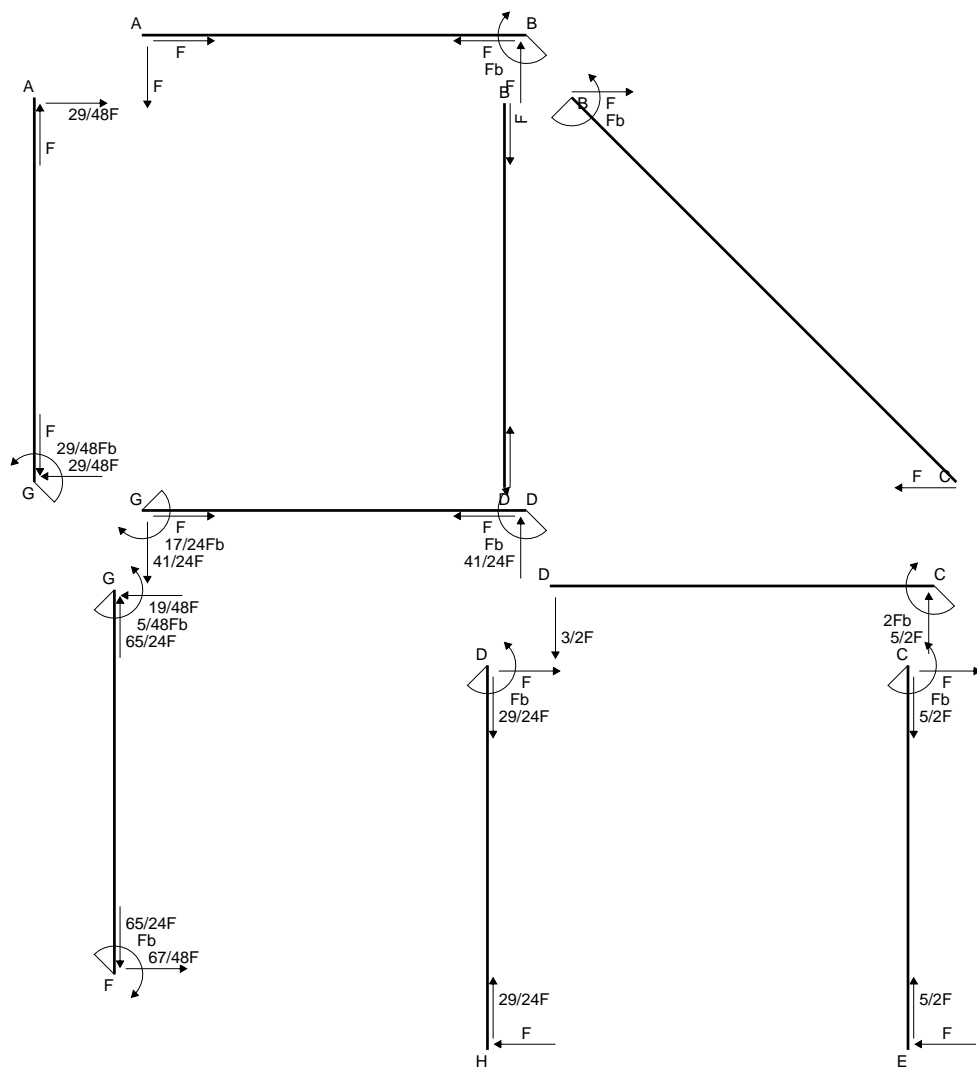
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

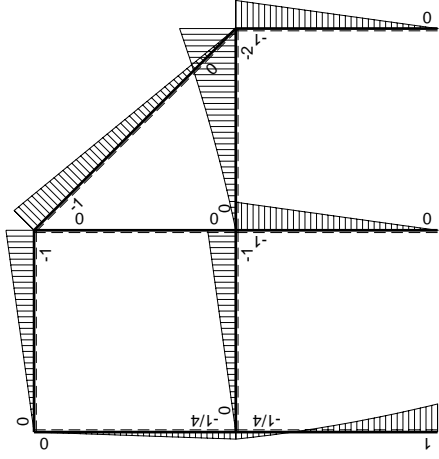
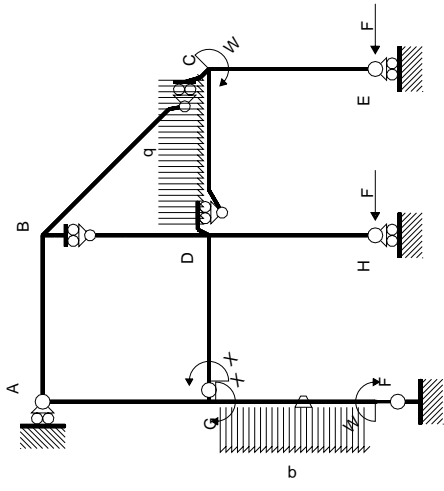
$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



- A = 930. mm<sup>2</sup>
- J<sub>u</sub> = 324687. mm<sup>4</sup>
- J<sub>v</sub> = 81414. mm<sup>4</sup>
- y<sub>g</sub> = 21.22 mm
- T<sub>y</sub> = -4250. N
- M<sub>x</sub> = -2108000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.78 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 219.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 40. mm
- v<sub>c</sub> = 18.78 mm
- σ<sub>c</sub> = -Mv/J<sub>v</sub> = 122. N/mm<sup>2</sup>
- τ<sub>c</sub> = 14.98 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 124.7 N/mm<sup>2</sup>
- S = 6865. mm<sup>3</sup>







Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	-1/2Fx+7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	1/8Fb-1/2Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/4Fb+1/4Fx	0	-1/8Fb+1/4Fx-1/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/4Fx	0	-1/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						17/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-17/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/8 - 1/2 x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/8 x - 1/4 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/8 b - 1/4 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 11/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

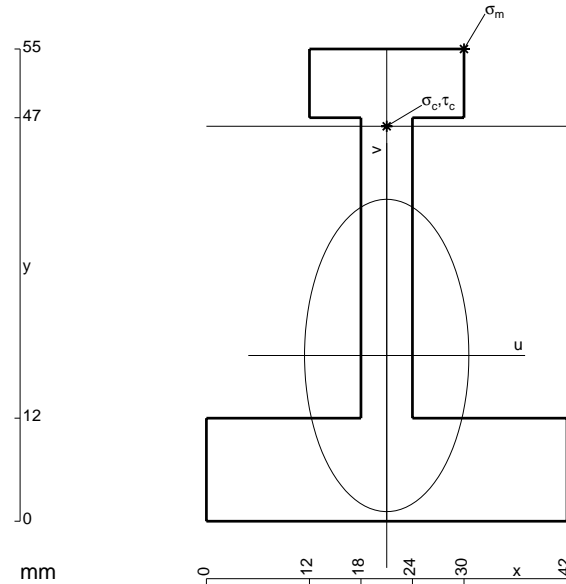
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/8 + 1/4 x/b - 1/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x + 1/8 x^2/b - 1/24 x^3/b^2]_0^b Fb 1/EJ$$

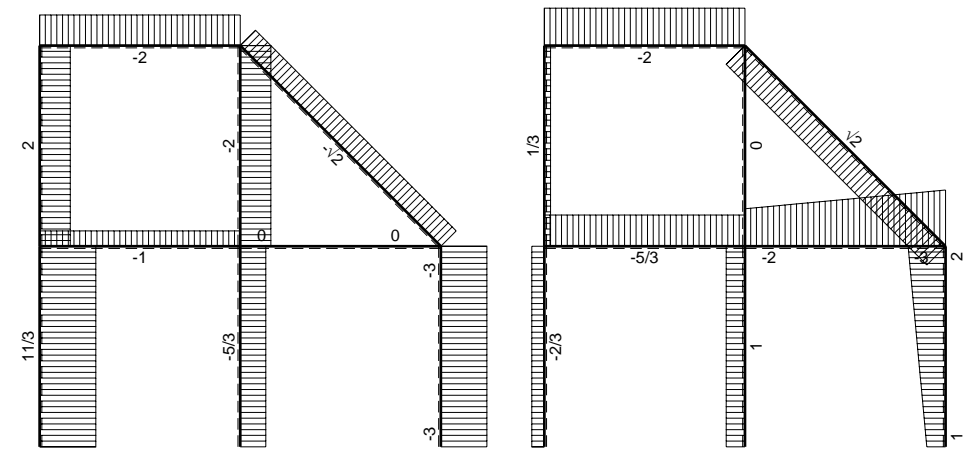
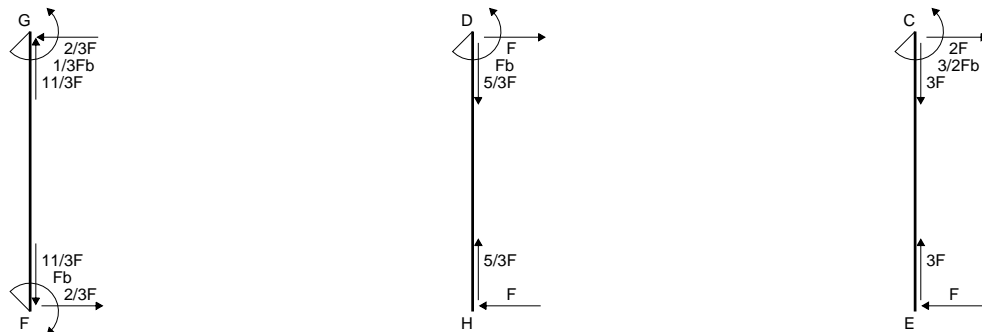
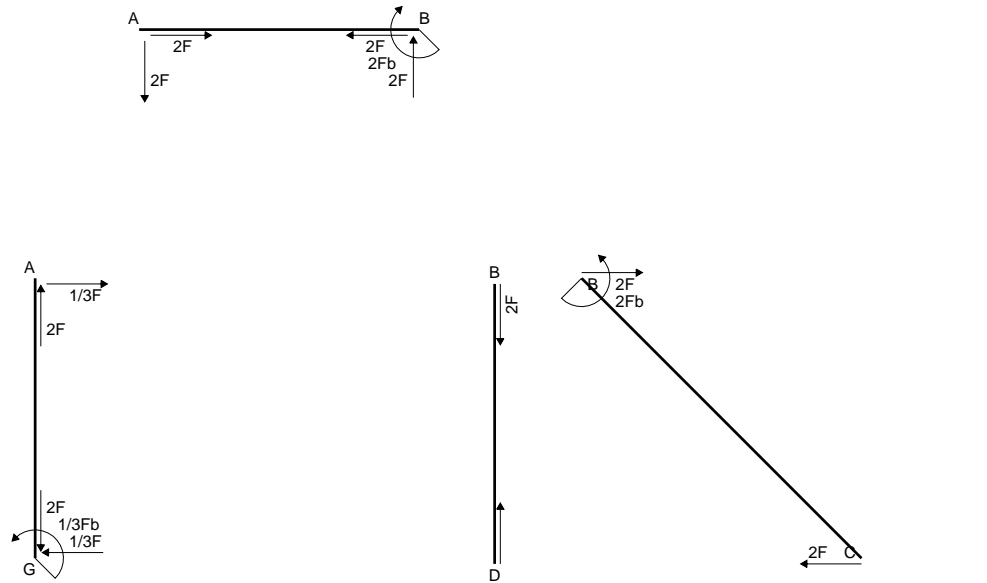
$$= (-1/8 b + 1/8 b - 1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/8 x^2/b^2) Fb 1/EJ dx = [-1/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/24 b) Fb 1/EJ = -1/24 Fb^2/EJ$$

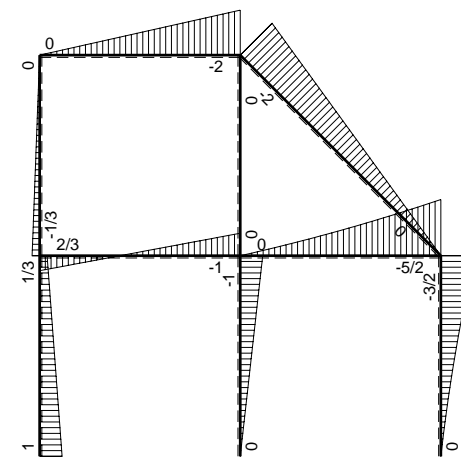


- A = 858. mm<sup>2</sup>
- J<sub>u</sub> = 283959. mm<sup>4</sup>
- J<sub>v</sub> = 78606. mm<sup>4</sup>
- y<sub>g</sub> = 19.3 mm
- T<sub>y</sub> = -3400. N
- M<sub>x</sub> = -1822400. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 35.7 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 229.1 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 46. mm
- v<sub>c</sub> = 26.7 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 171.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 9.434 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 172.1 N/mm<sup>2</sup>
- S = 4727. mm<sup>3</sup>

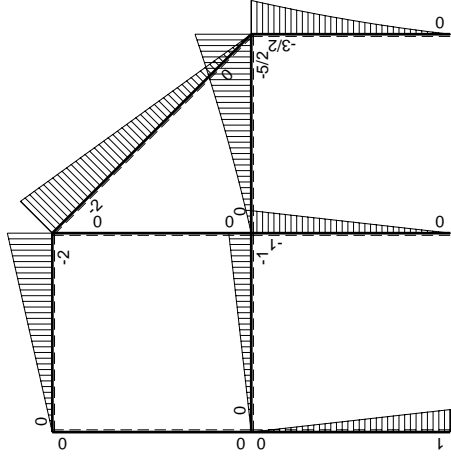
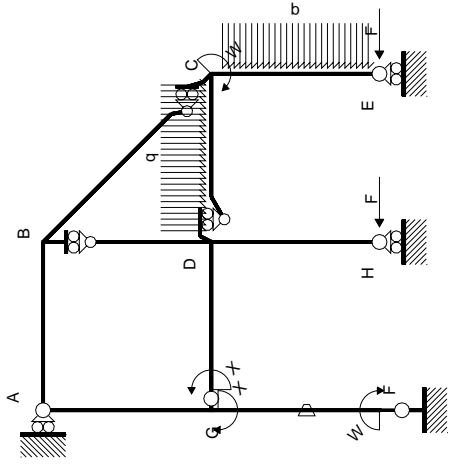


← ⊕ → F

↑ ⊕ ↓ F

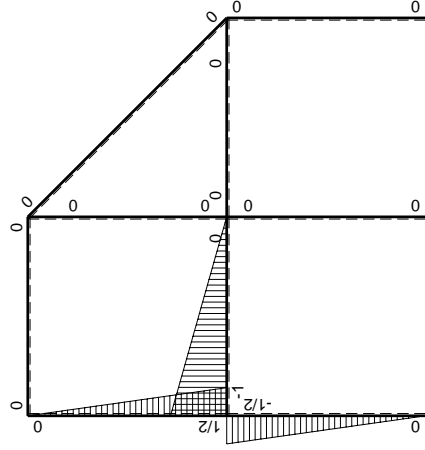


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	-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 <sup>2</sup>	0	0	0	0	0+0	0	
CD b	0	5/2Fb-3Fx+1/2qx <sup>2</sup>	0	0	0	0			
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	Fb-Fx	-Fb/EJ	-1/2Fx+1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	-Fx	Fb/EJ	-1/2Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b <sup>2</sup>	0+0	1/12Xb/EJ	
AG b	-1/2x/b	0	0	0	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							1/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

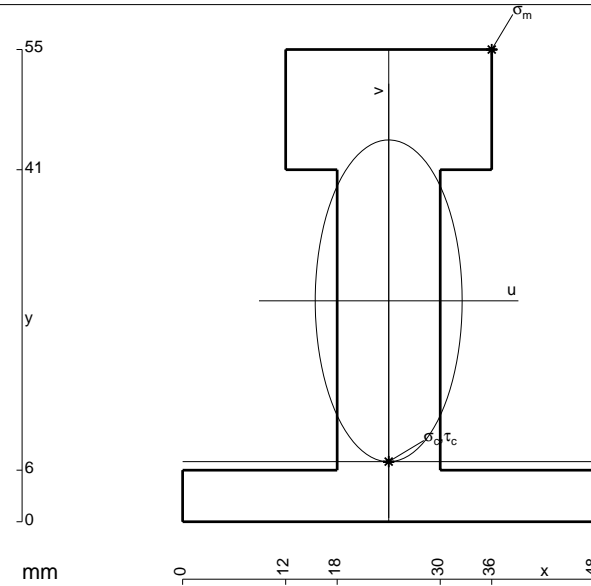
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

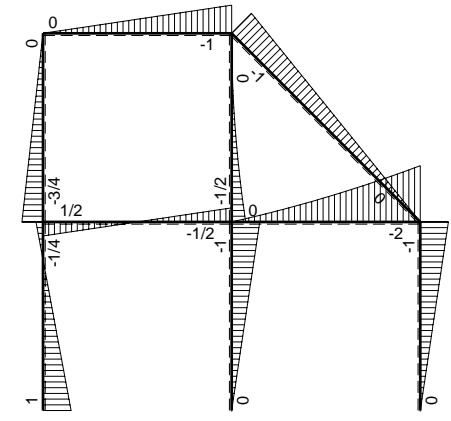
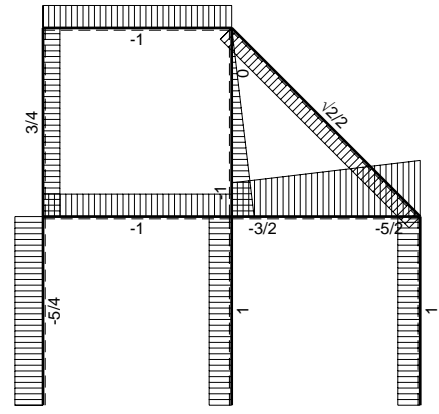
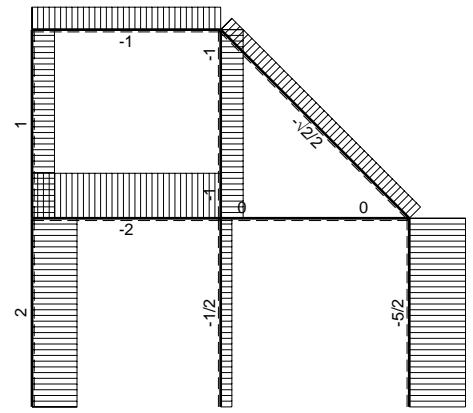
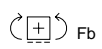
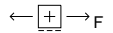
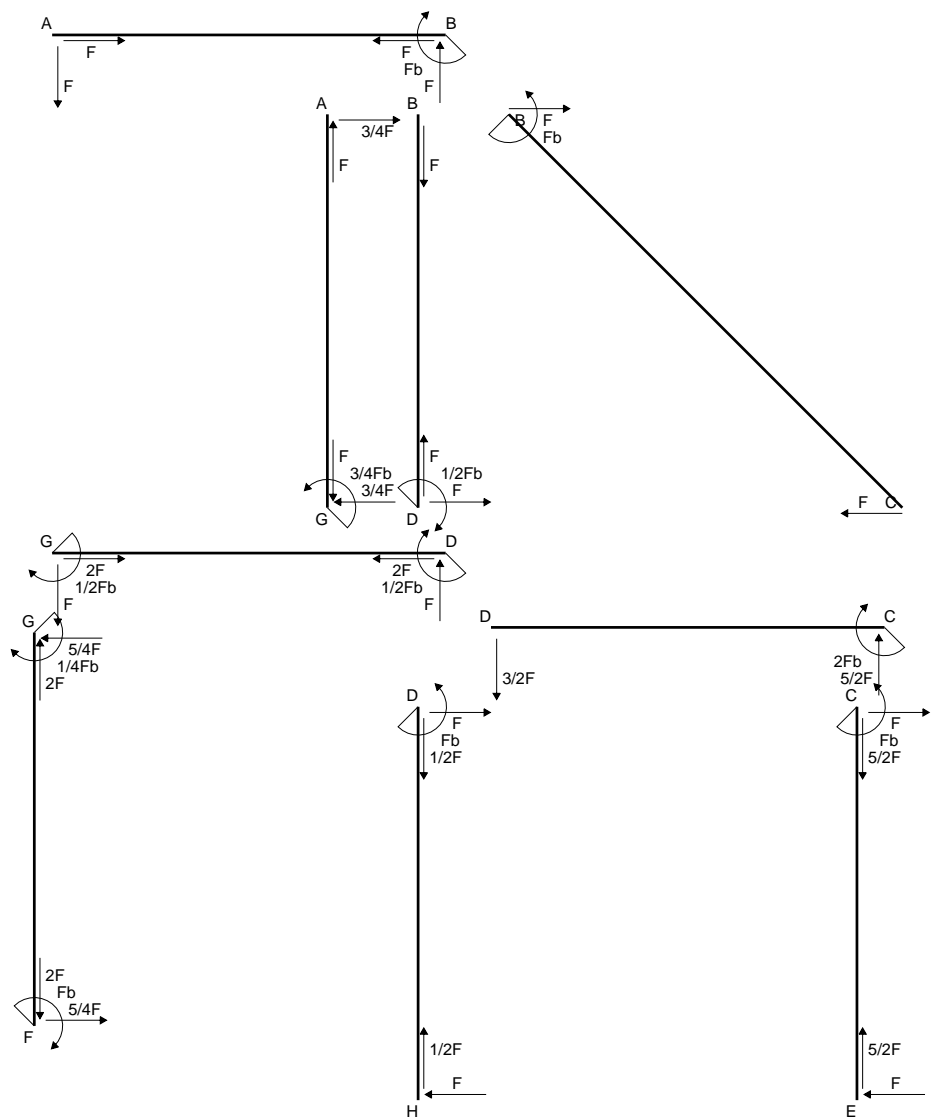
$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

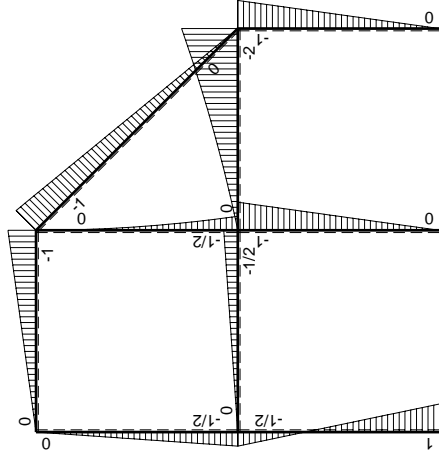
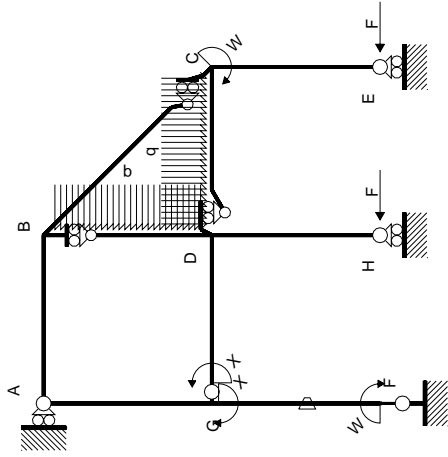
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$



- A = 1044. mm<sup>2</sup>
- J<sub>u</sub> = 366752. mm<sup>4</sup>
- J<sub>v</sub> = 76464. mm<sup>4</sup>
- y<sub>g</sub> = 25.73 mm
- T<sub>y</sub> = -5010. N
- M<sub>x</sub> = -3006000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 29.27 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 239.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -18.73 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -153.5 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.715 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 154.1 N/mm<sup>2</sup>
- S = 6777. mm<sup>3</sup>

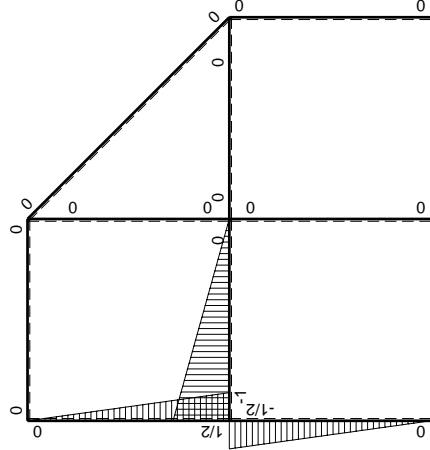






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	Fb-3/2Fx	-Fb/EJ	-1/2Fx+3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(0+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-3/2Fx	Fb/EJ	1/4Fb-Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						1/4Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-1/2Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/2 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/2 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/4 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

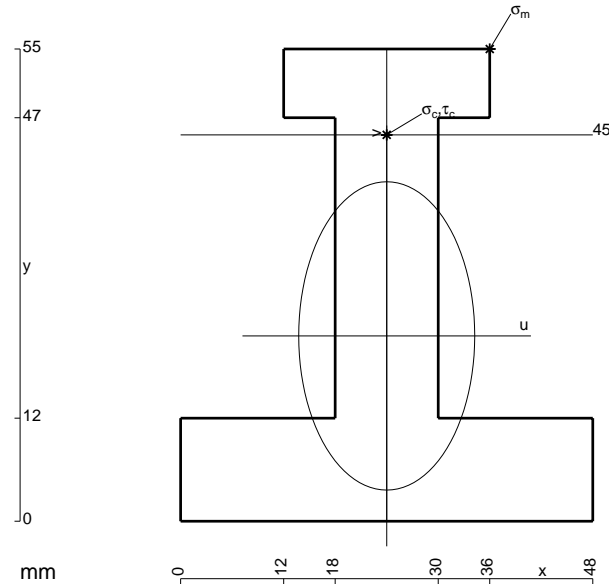
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

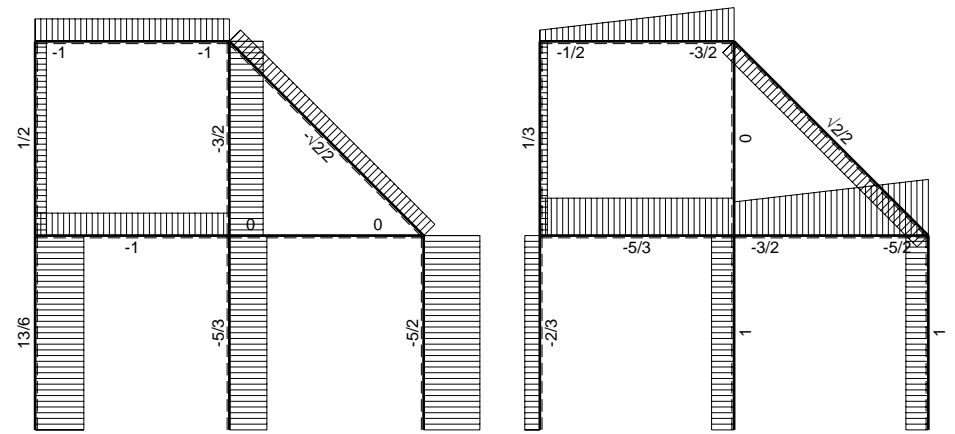
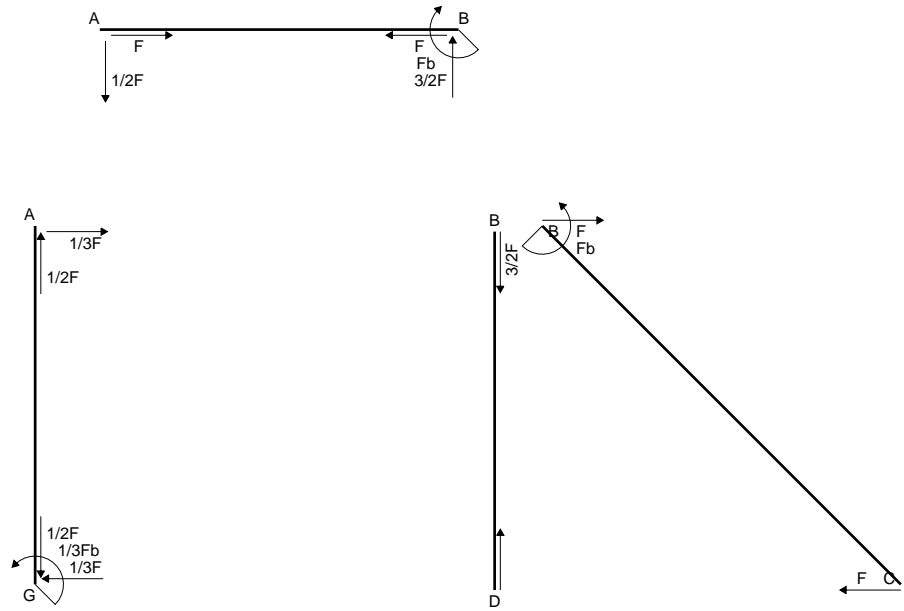
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

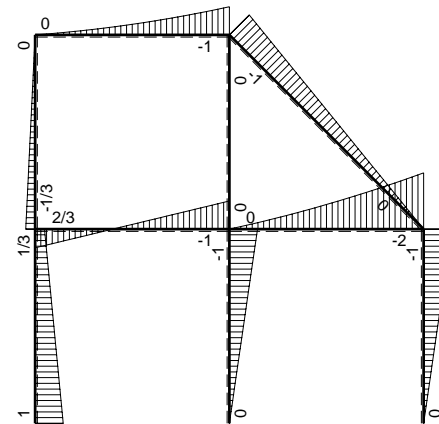


- A = 1188. mm<sup>2</sup>
- J<sub>u</sub> = 383155. mm<sup>4</sup>
- J<sub>v</sub> = 124848. mm<sup>4</sup>
- y<sub>g</sub> = 21.58 mm
- T<sub>y</sub> = -3650. N
- M<sub>x</sub> = -2277600. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.42 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 198.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 45. mm
- v<sub>c</sub> = 23.42 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 139.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.949 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 139.5 N/mm<sup>2</sup>
- S = 6235. mm<sup>3</sup>

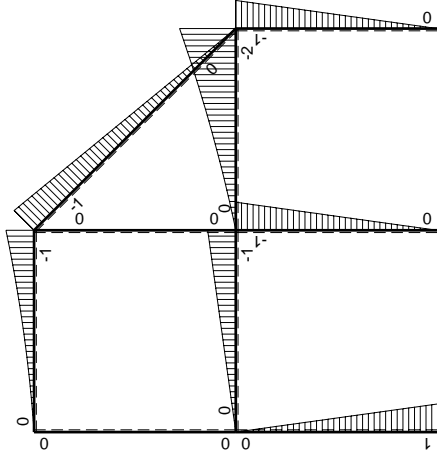
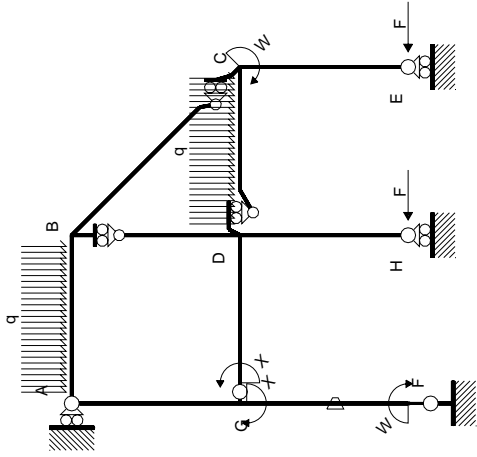


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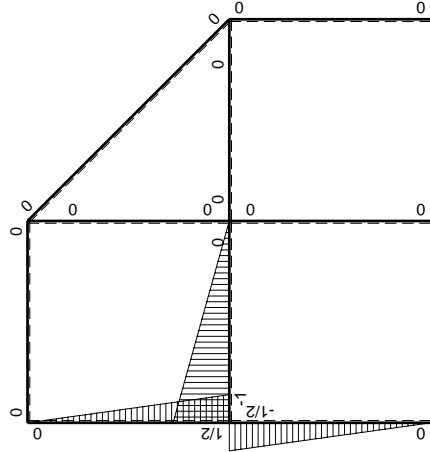


↺ (+) ↻ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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	$-3/2Fx-1/2qx^2$	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (-1/4 b + 1/6 b) Fb 1/EJ + (1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [-1/4 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

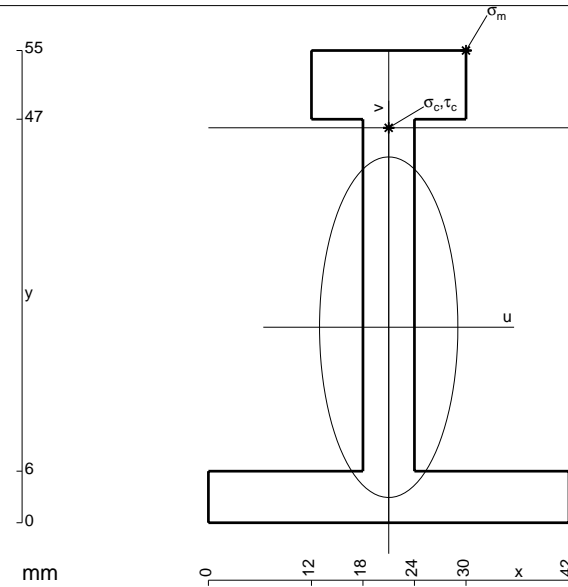
$$= (-1/4 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/6 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

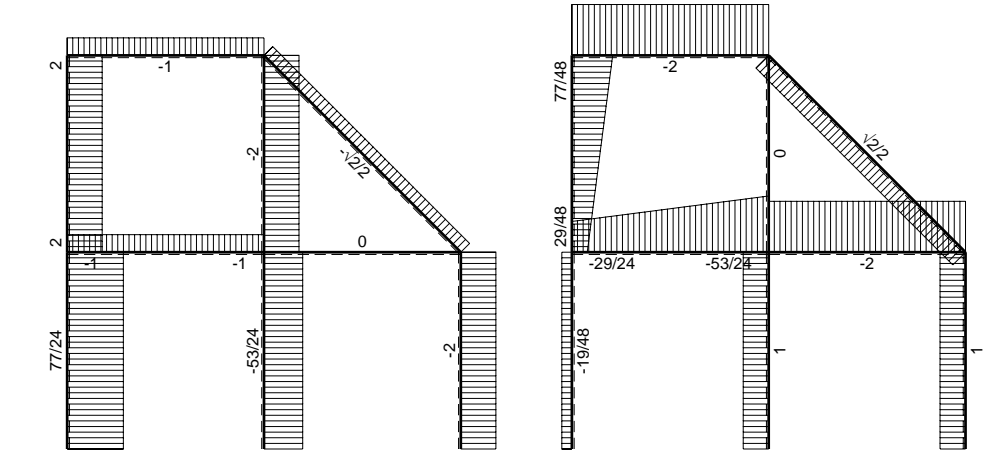
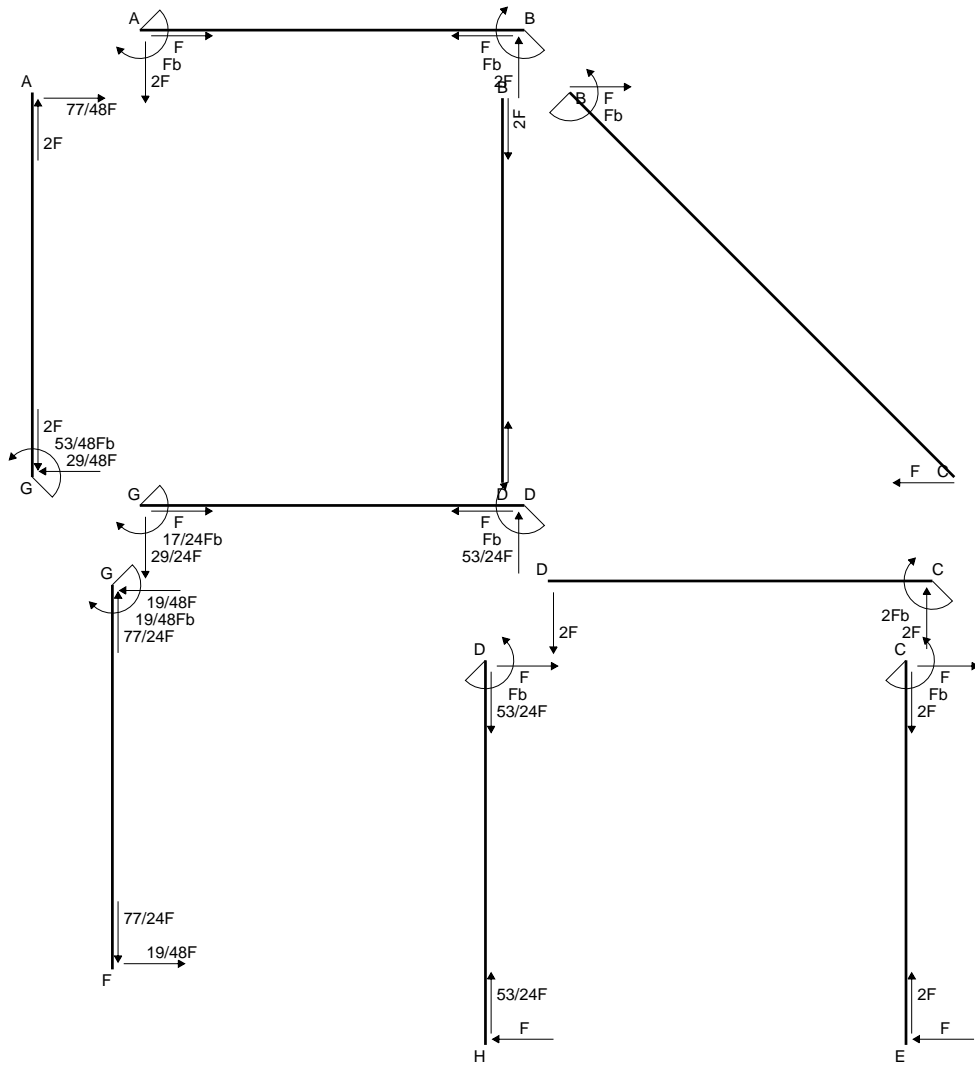
$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$



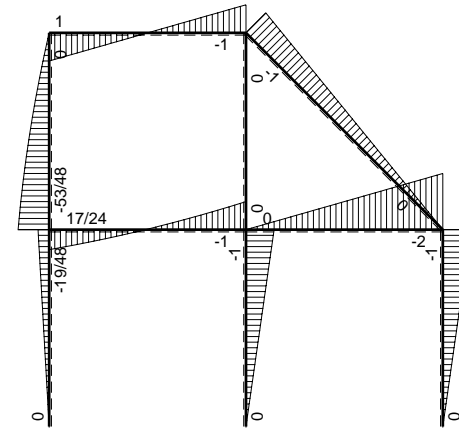
- A = 642. mm<sup>2</sup>
- J<sub>u</sub> = 252660. mm<sup>4</sup>
- J<sub>v</sub> = 41670. mm<sup>4</sup>
- y<sub>g</sub> = 22.77 mm
- T<sub>y</sub> = -2475. N
- M<sub>x</sub> = -1643400. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 32.23 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 46. mm
- v<sub>c</sub> = 23.23 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 151.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.869 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 151.6 N/mm<sup>2</sup>
- S = 4207. mm<sup>3</sup>



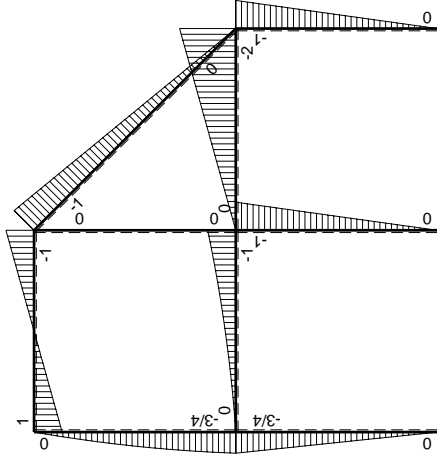
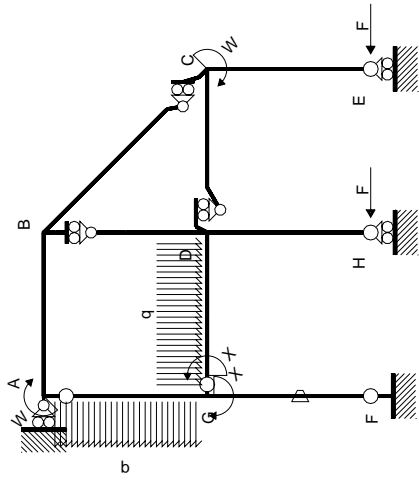


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↑ ⊕ ↓ F

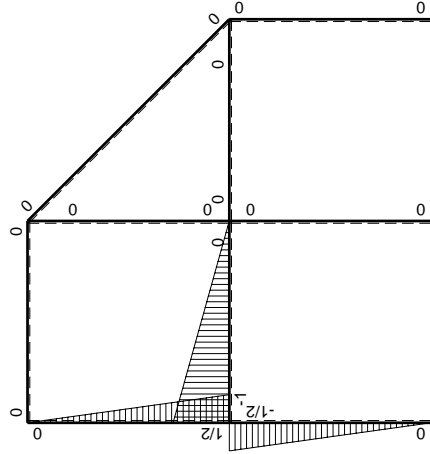


⊕ Fb



Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	Fb-2Fx	0	0	0	0	0+0	0	
BA b	0	Fb-2Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	3/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/8+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/4Fb-3/4Fx	Fb/EJ	3/8Fb-3/4Fx+3/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							17/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-17/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 3/4 x/b + 3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 3/8 x^2/b + 1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 3/8 b + 1/8 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

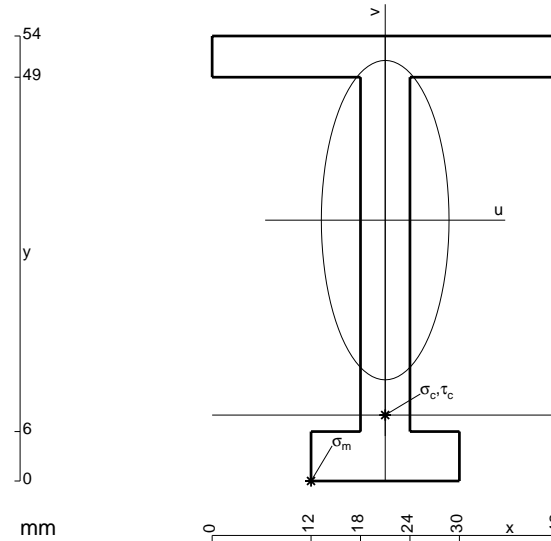
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

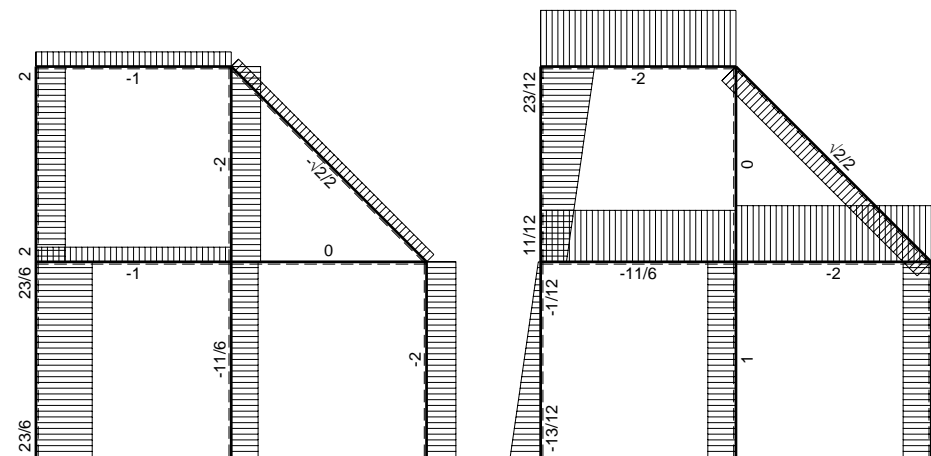
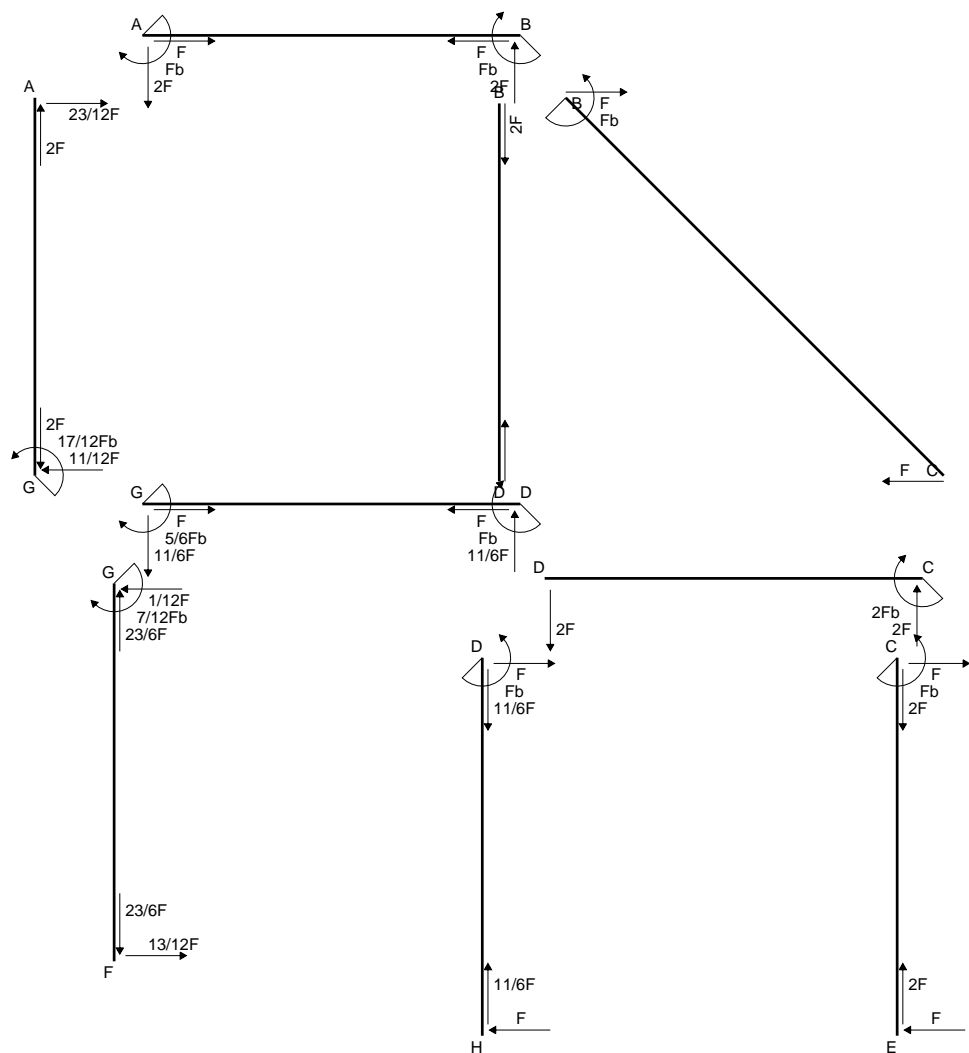
$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

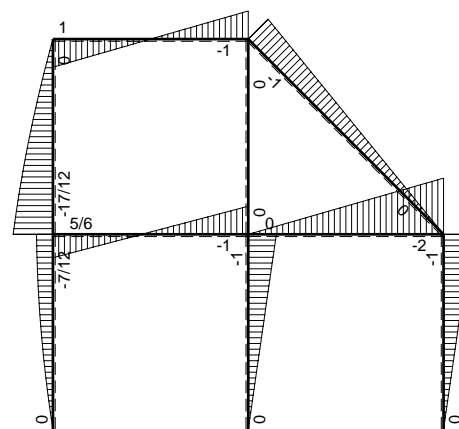


- A = 576. mm<sup>2</sup>
- J<sub>u</sub> = 216352. mm<sup>4</sup>
- J<sub>v</sub> = 34560. mm<sup>4</sup>
- y<sub>g</sub> = 31.66 mm
- T<sub>y</sub> = -1740. N
- M<sub>x</sub> = -1496400. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -31.66 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 8. mm
- v<sub>c</sub> = -23.66 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -163.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.545 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 163.8 N/mm<sup>2</sup>
- S = 3391. mm<sup>3</sup>

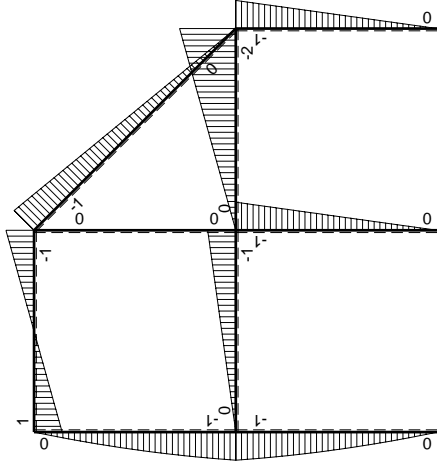
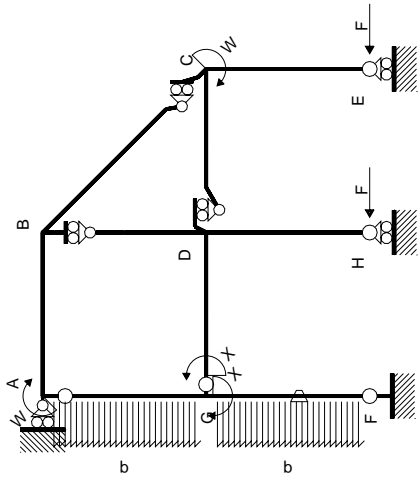


← ⊕ → F

↑ ⊕ ↓ F

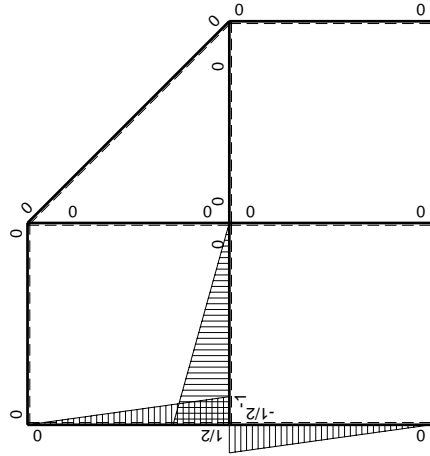


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
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 <sup>2</sup>	-Fb/EJ	3/4Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(3/16+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-1/2Fx-1/2qx <sup>2</sup>	Fb/EJ	1/2Fb-3/4Fx+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup>	0	-1/2Fb+3/4Fx-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-3/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx-1/2qx <sup>2</sup>	0	-3/4Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/4 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [1/4 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 7/16 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - 3/4 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 3/8 x^2/b + 1/16 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 3/8 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 7/16 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

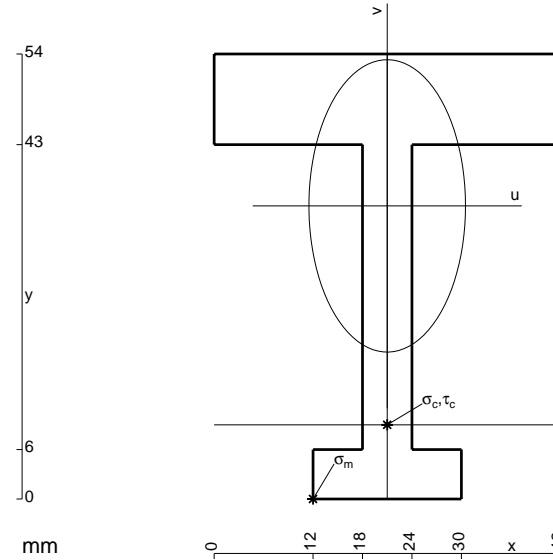
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + 3/4 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 3/8 x^2/b - 1/16 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 3/8 b - 1/16 b) Fb 1/EJ = -3/16 Fb^2/EJ$$

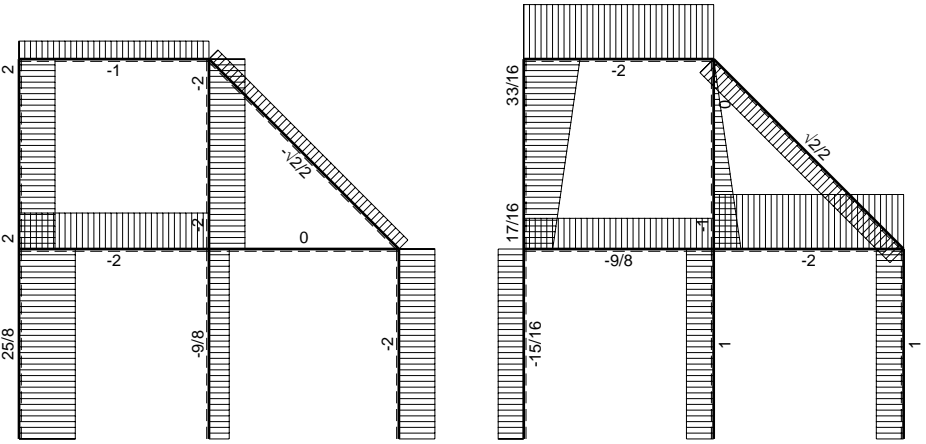
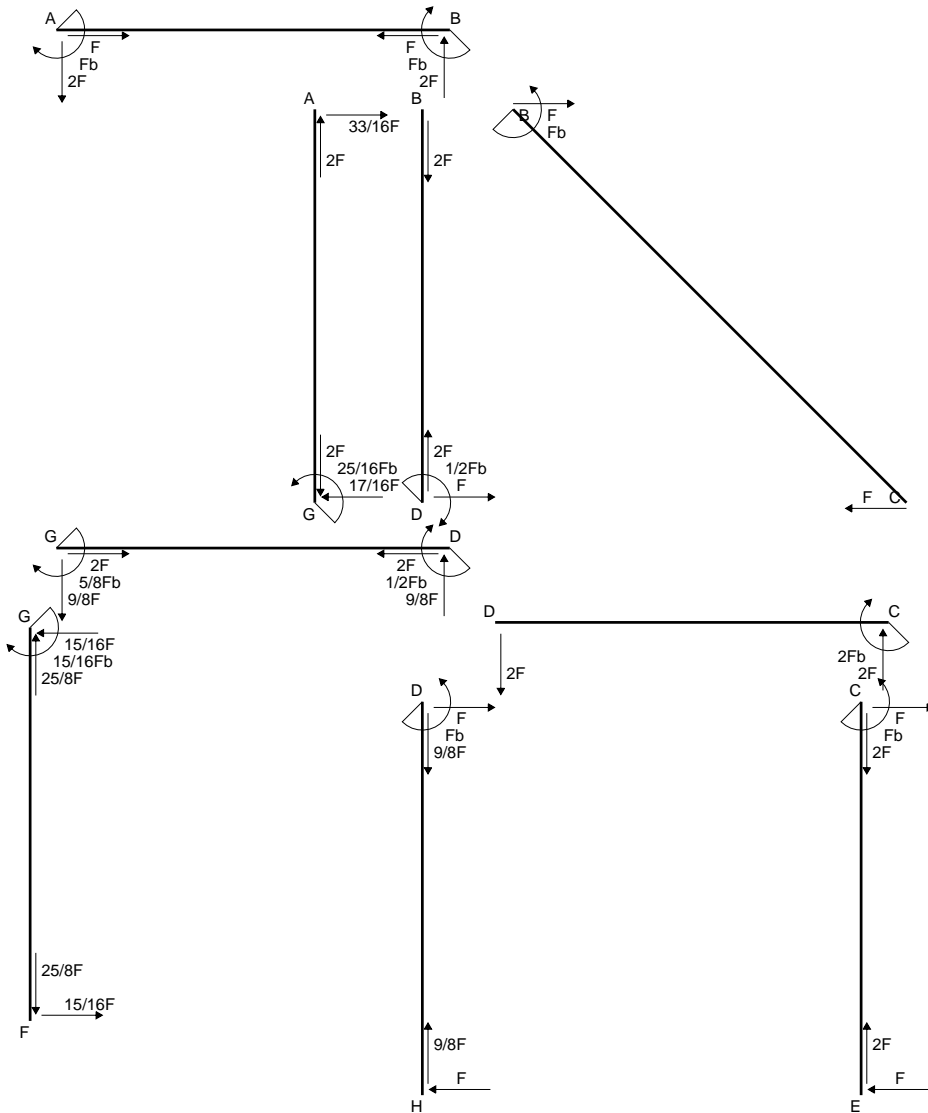
$$L_{AG}^{xo} = \int_0^b (-3/4 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/4 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/16 b) Fb 1/EJ = -3/16 Fb^2/EJ$$



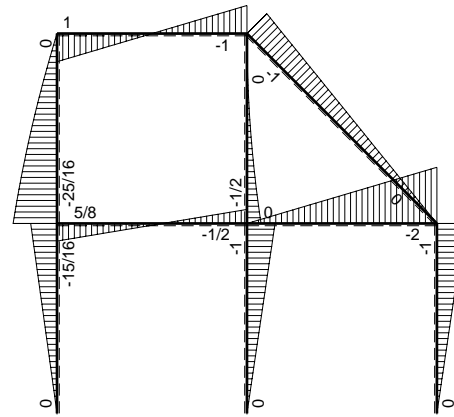
- A = 792. mm<sup>2</sup>
- J<sub>u</sub> = 249320. mm<sup>4</sup>
- J<sub>v</sub> = 71496. mm<sup>4</sup>
- y<sub>g</sub> = 35.57 mm
- T<sub>y</sub> = -1760. N
- M<sub>x</sub> = -1601600. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -35.57 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -228.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -26.57 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -170.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.733 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 170.9 N/mm<sup>2</sup>
- S = 4023. mm<sup>3</sup>



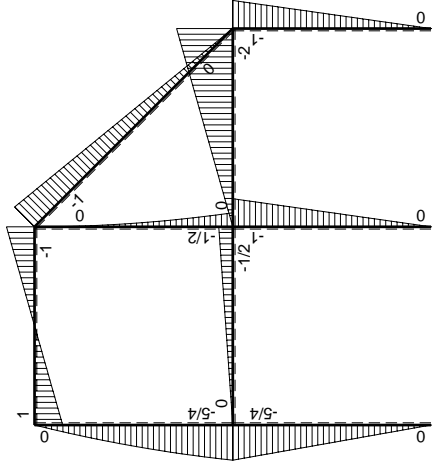
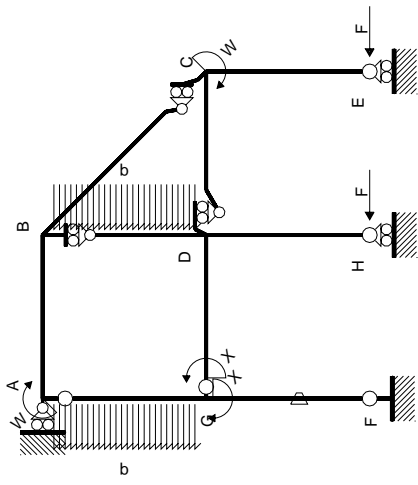


$\leftarrow \boxed{+} \rightarrow F$

$\uparrow \boxed{+} \downarrow F$

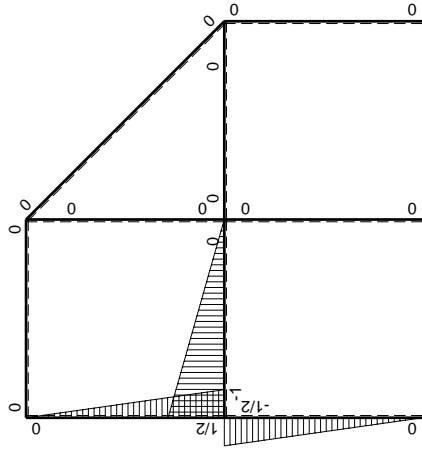


$\curvearrowright \boxed{+} \curvearrowleft F_b$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 -2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b +1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b +1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (5/8 -5/4 x/b +5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 +1/2 x/b) \theta dx$$

$$= [5/8 x -5/8 x^2/b +5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

$$= (5/8 b -5/8 b +5/24 b) Fb 1/EJ + (-1/2 b +1/4 b) \theta = 11/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b -1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b -1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b -1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b -1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b -1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b -1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

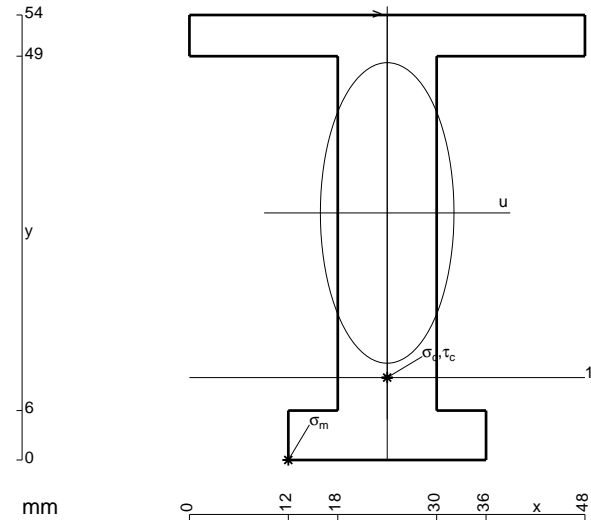
$$L_{GA}^{xo} = \int_0^b (-5/8 + x/b -1/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-5/8 x +1/2 x^2/b -1/24 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ$$

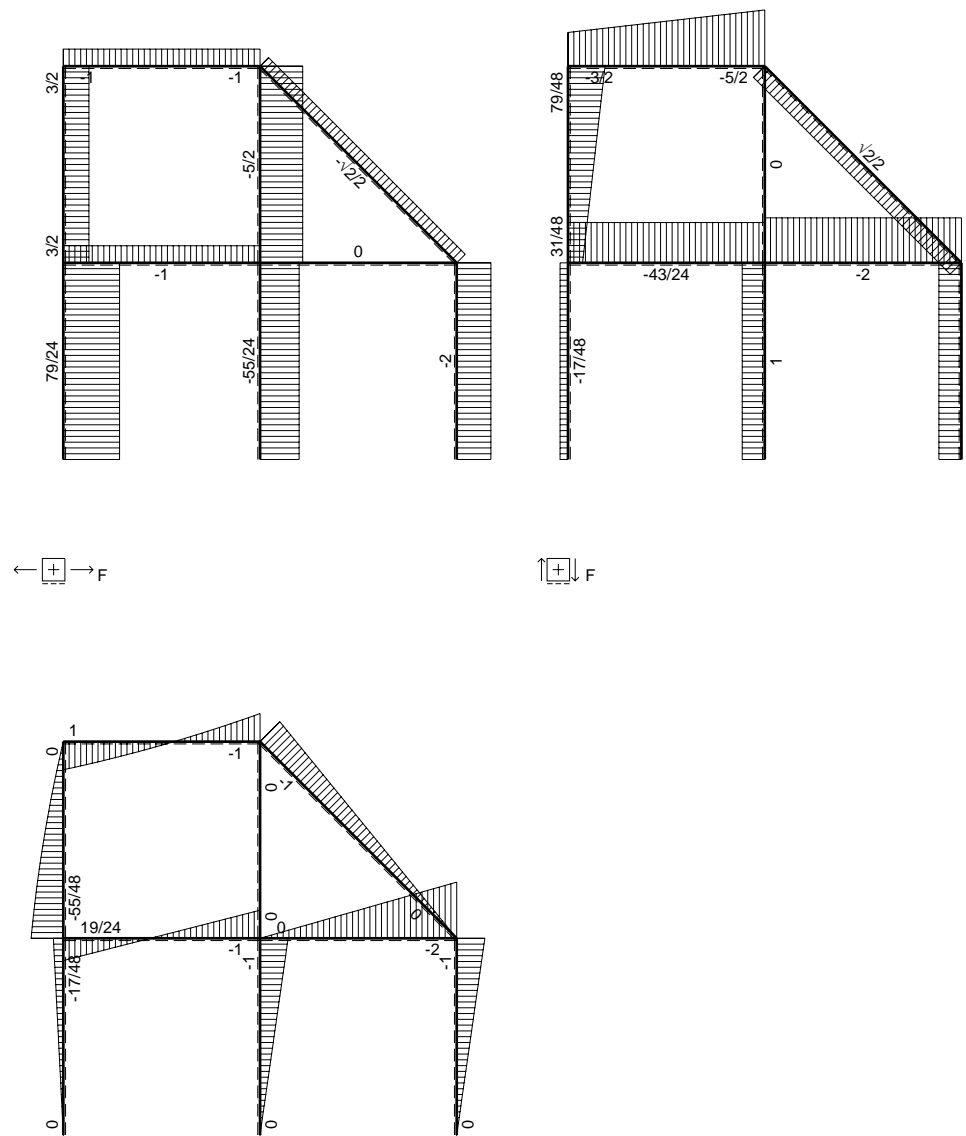
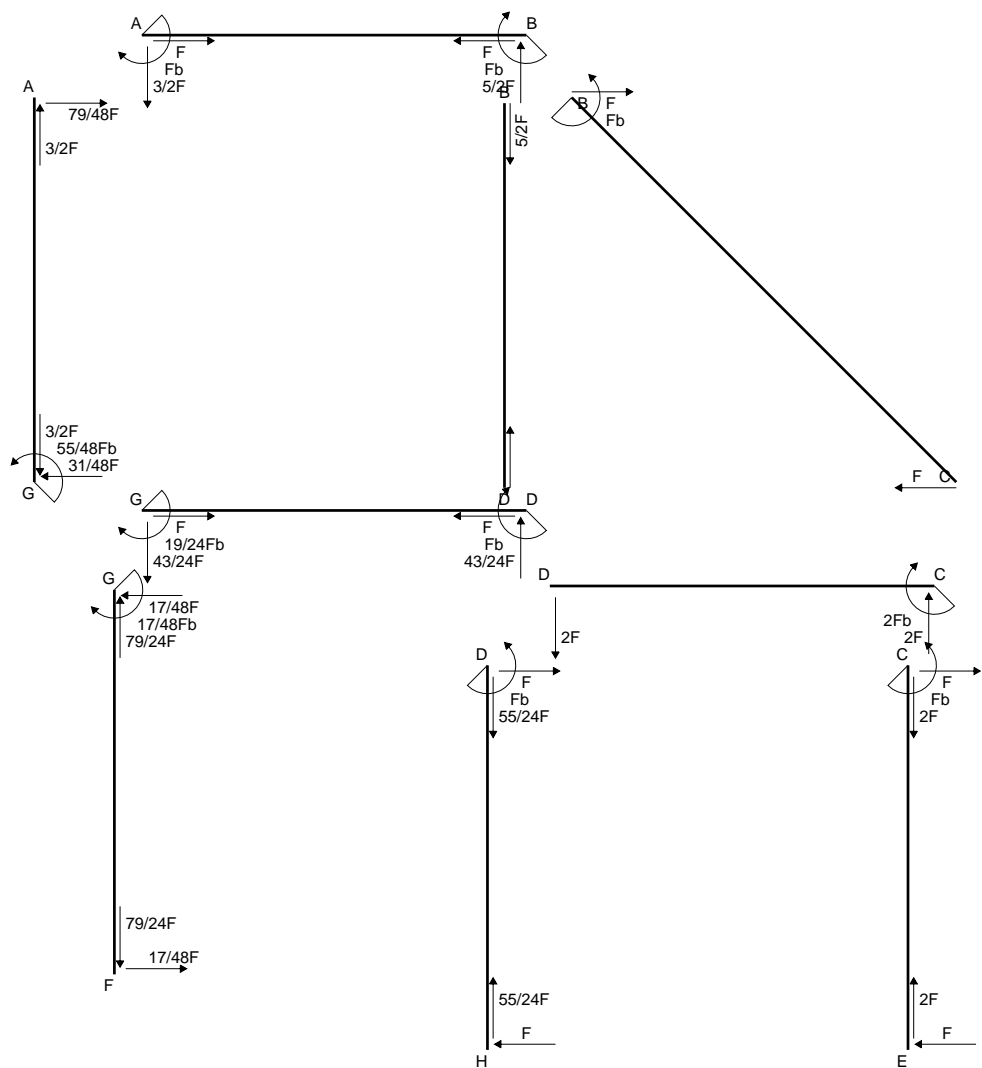
$$= (-5/8 b +1/2 b -1/24 b -1/16 b) Fb 1/EJ = -11/48 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-7/8 x^2/b^2 +1/4 x^3/b^3) Fb 1/EJ dx = [-7/24 x^3/b^2 +1/16 x^4/b^3]_0^b Fb 1/EJ$$

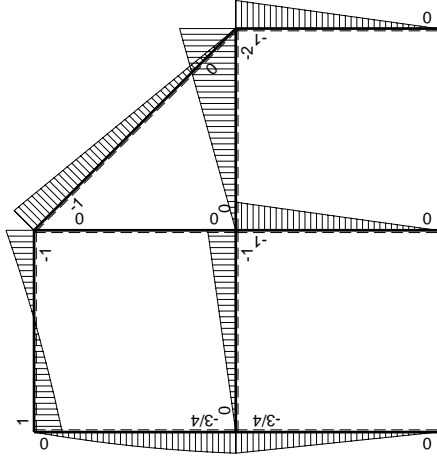
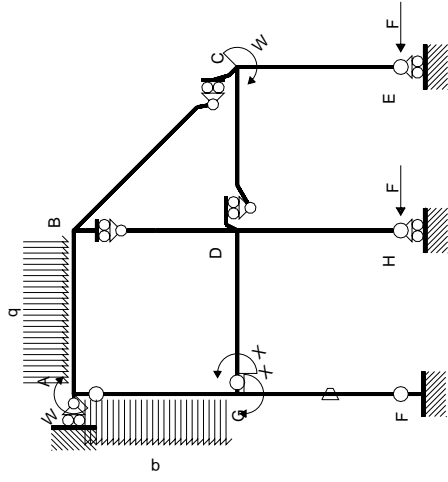
$$= (-7/24 b +1/16 b) Fb 1/EJ = -11/48 Fb^2/EJ$$



- A = 900. mm<sup>2</sup>
- J<sub>u</sub> = 299580. mm<sup>4</sup>
- J<sub>v</sub> = 59184. mm<sup>4</sup>
- y<sub>g</sub> = 29.98 mm
- T<sub>y</sub> = -2480. N
- M<sub>x</sub> = -2380800. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -29.98 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -238.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -19.98 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -158.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.408 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 158.9 N/mm<sup>2</sup>
- S = 4940. mm<sup>3</sup>



$\curvearrowright (+)$   $F_b$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 3/4 x/b + 3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 3/8 x^2/b + 1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 3/8 b + 1/8 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

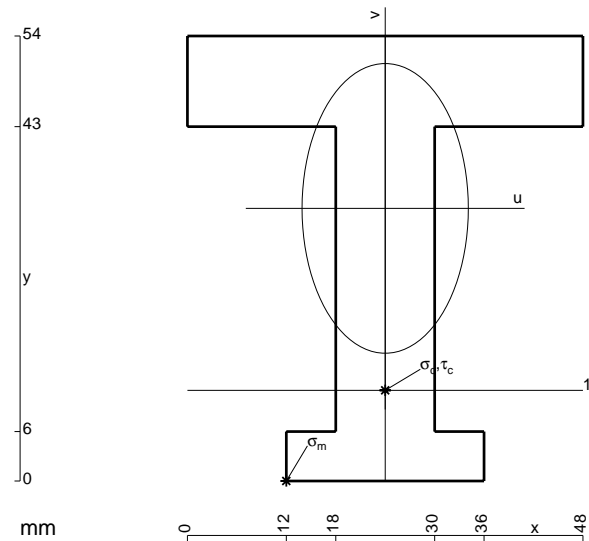
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

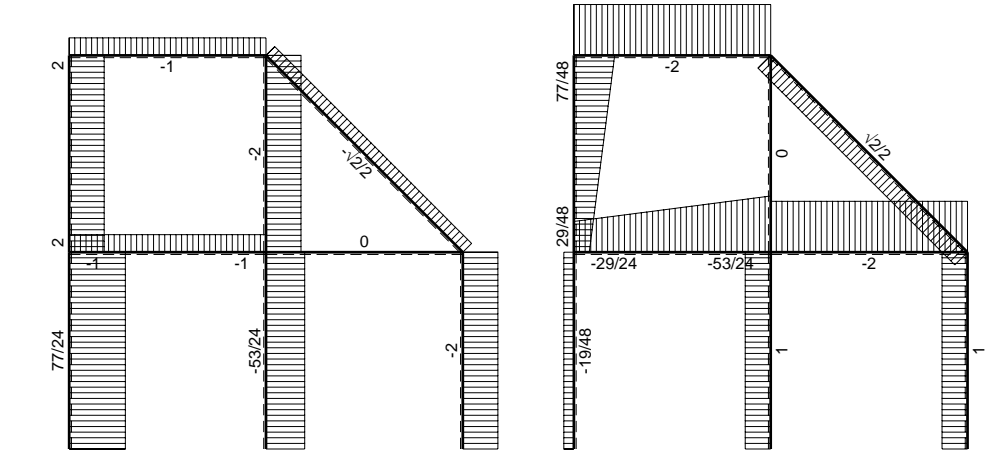
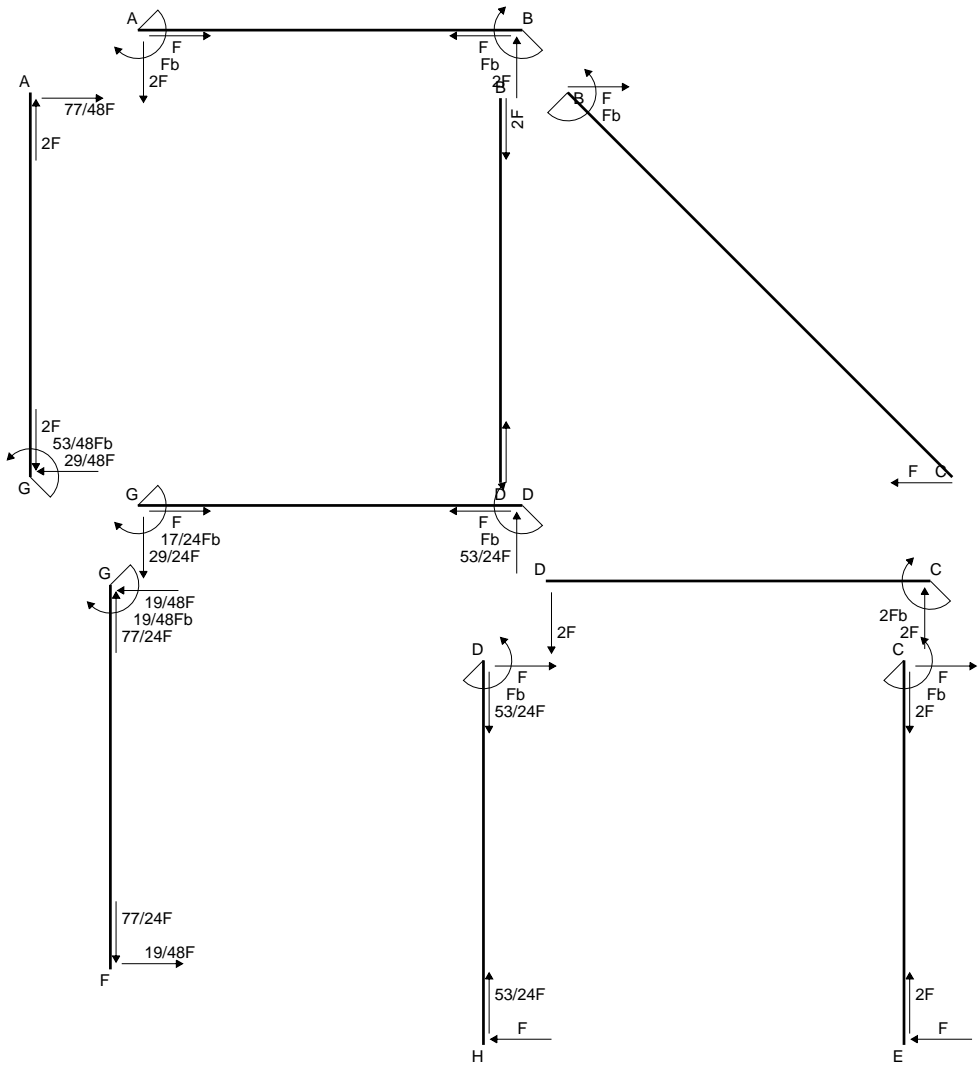
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



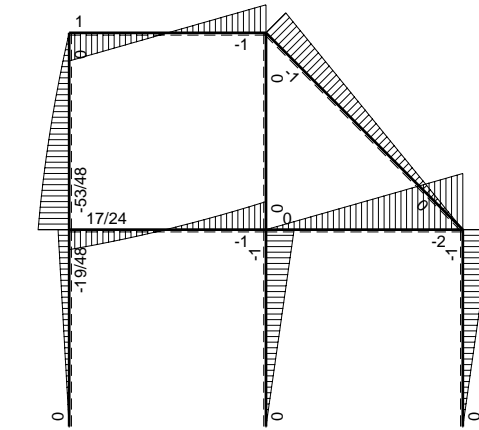
- A = 1116. mm<sup>2</sup>
- J<sub>u</sub> = 344933. mm<sup>4</sup>
- J<sub>v</sub> = 113616. mm<sup>4</sup>
- y<sub>g</sub> = 33.08 mm
- T<sub>y</sub> = -4080. N
- M<sub>x</sub> = -2080800. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -33.08 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -199.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -22.08 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -133.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.723 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup> + 3τ<sup>2</sup> = 133.6 N/mm<sup>2</sup>
- S = 5806. mm<sup>3</sup>



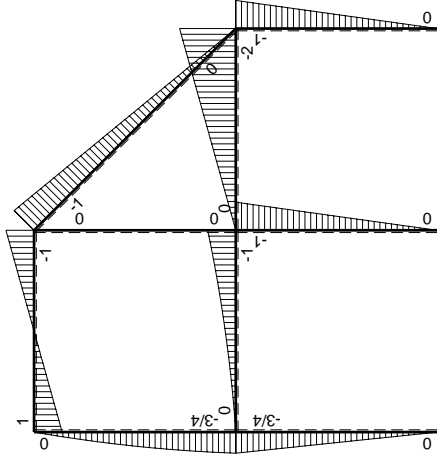
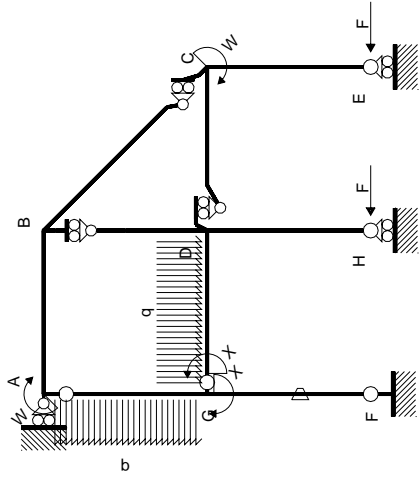


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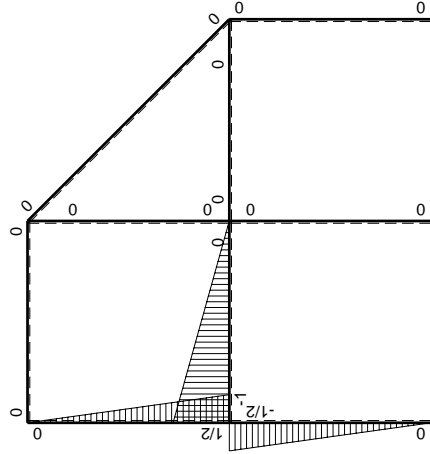


⊕ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	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 <sup>2</sup>	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 <sup>2</sup>	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x_0} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b (3/8 - 3/4 x/b + 3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 3/8 x^2/b + 1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 3/8 b + 1/8 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

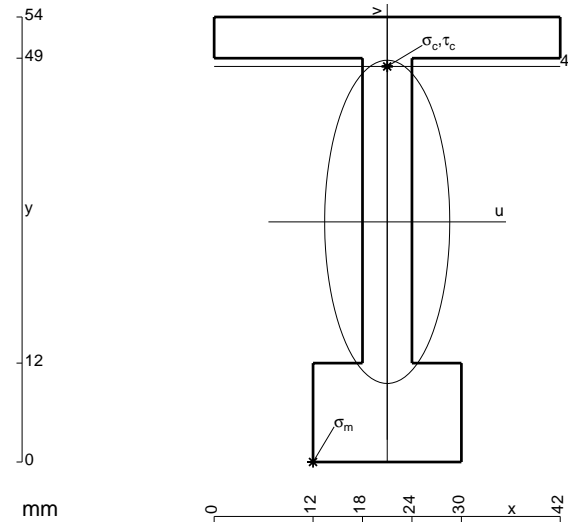
$$L_{GA}^{x_0} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



$$A = 648. \text{ mm}^2$$

$$J_u = 249419. \text{ mm}^4$$

$$J_v = 37368. \text{ mm}^4$$

$$y_g = 29.14 \text{ mm}$$

$$T_y = -3200. \text{ N}$$

$$M_x = -1792000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -29.14 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 48. \text{ mm}$$

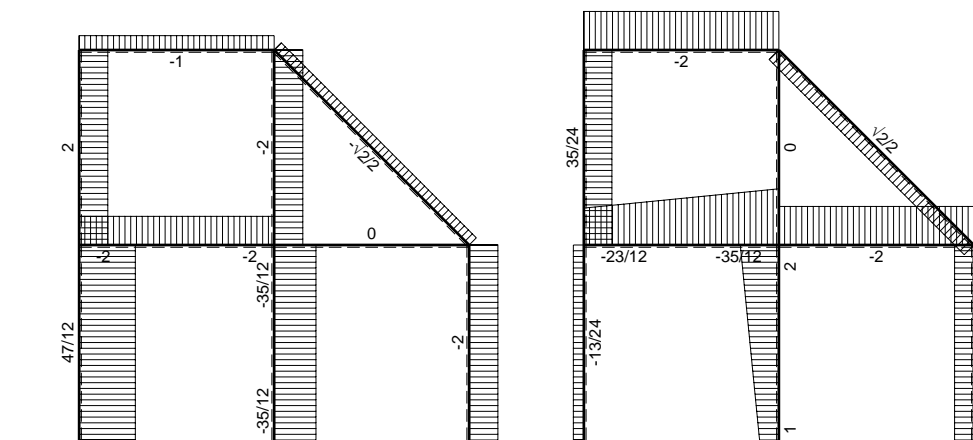
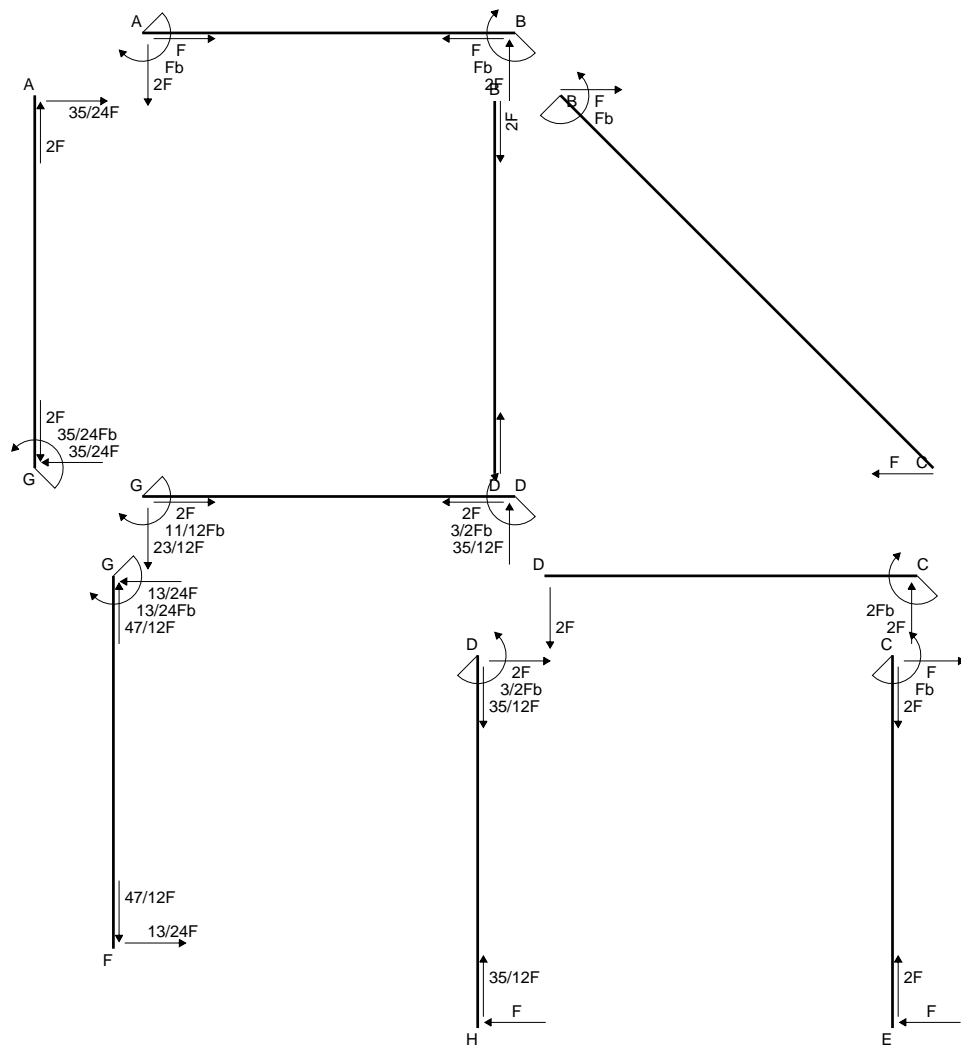
$$v_c = 18.86 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 135.5 \text{ N/mm}^2$$

$$\tau_c = 10.29 \text{ N/mm}^2$$

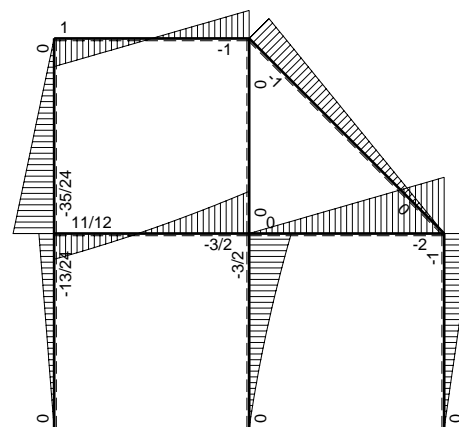
$$\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 136.7 \text{ N/mm}^2$$

$$S = 4812. \text{ mm}^3$$

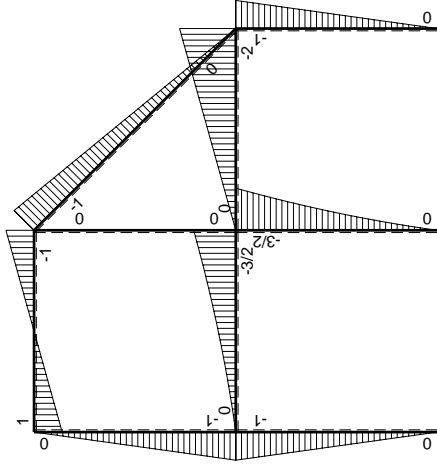
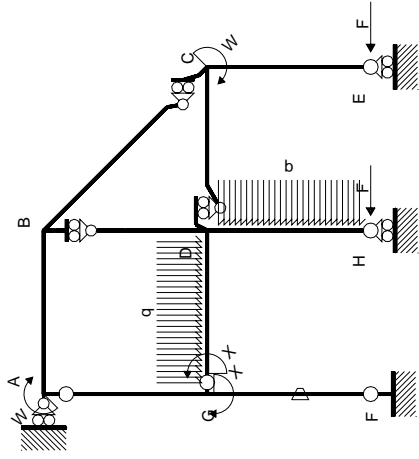


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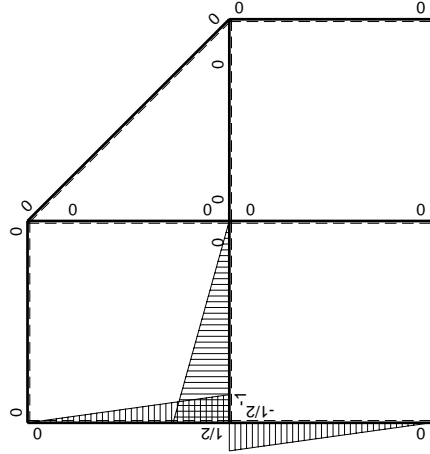


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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$	
AB b	0	Fb-2Fx	0	0	0	0	0+0	0	
BA b	0	Fb-2Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	0	0	0	0	
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx-1/2qx <sup>2</sup>	0	Fx-1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	3/2Fb-2Fx+1/2qx <sup>2</sup>	0	3/2Fx-2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							11/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-11/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - 1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/6 b - 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 2/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

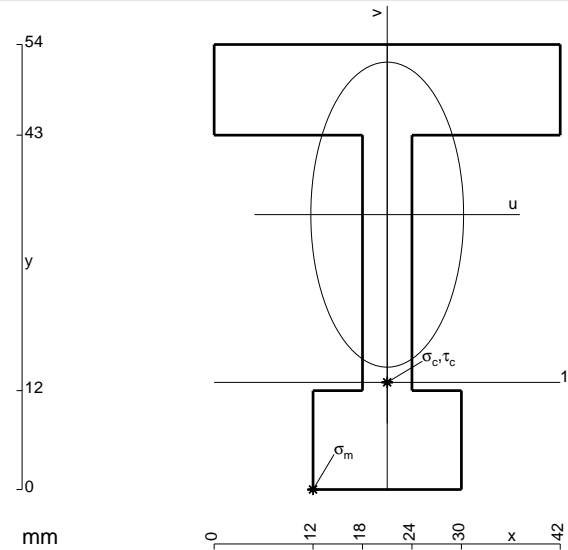
$$= (3/4 b - 2/3 b + 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

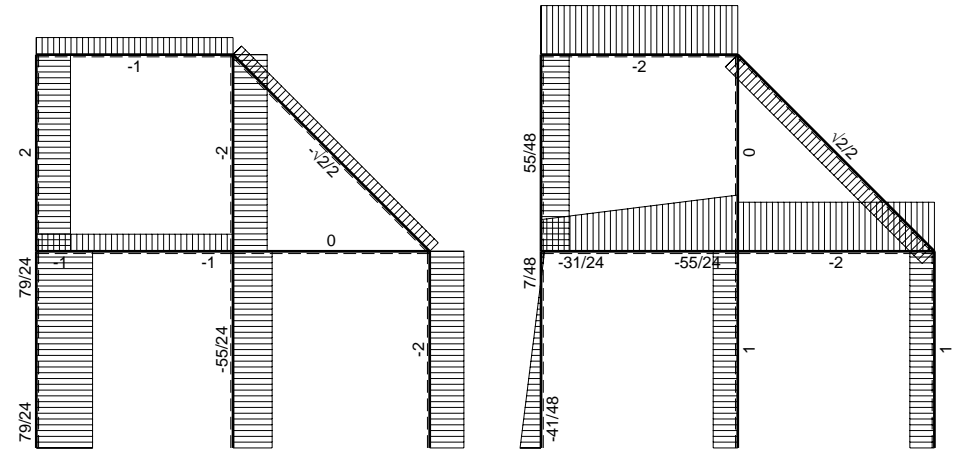
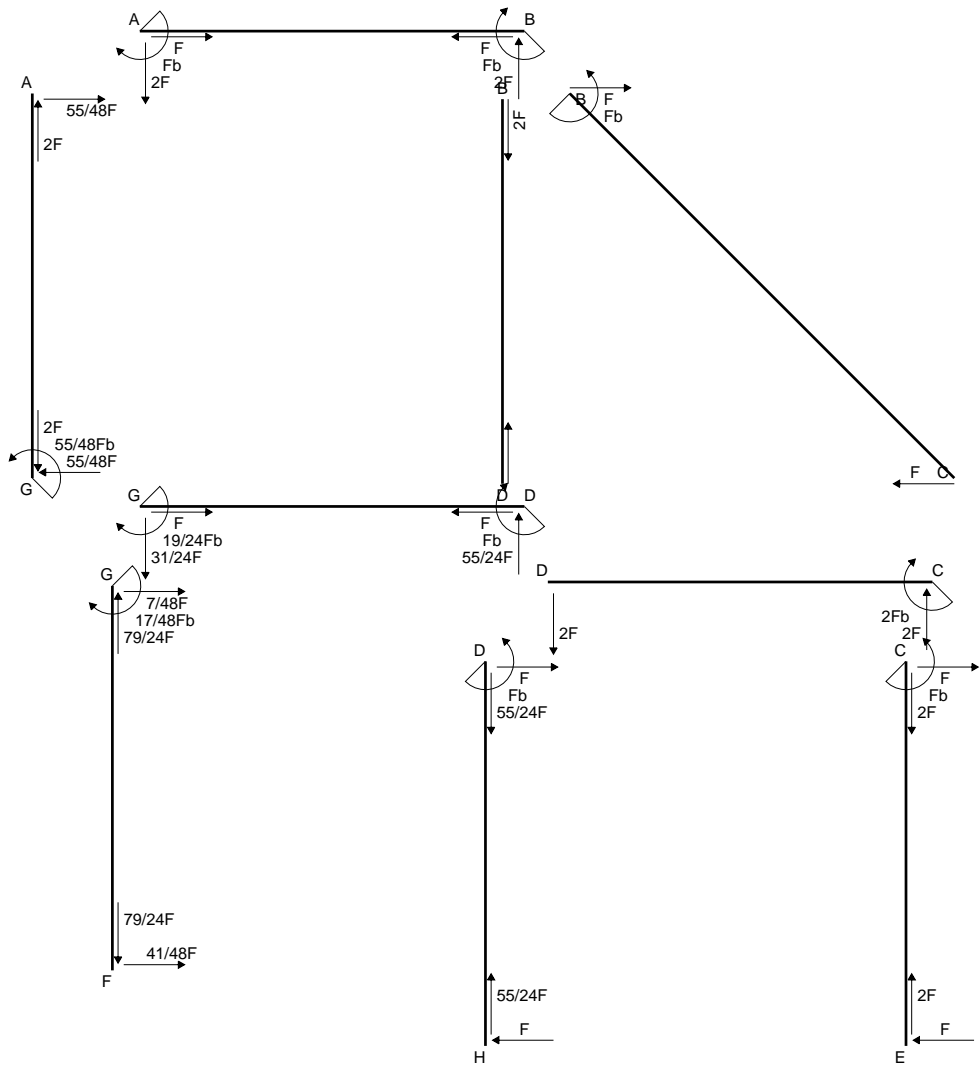
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



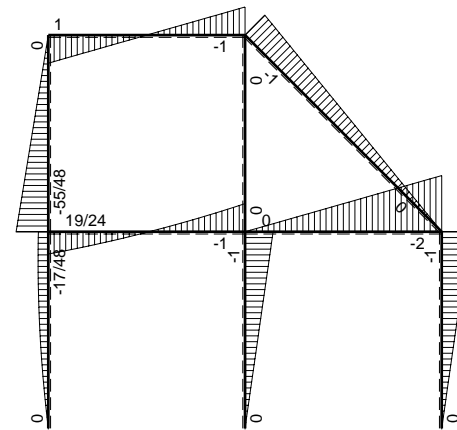
- A = 864. mm<sup>2</sup>
- J<sub>u</sub> = 296124. mm<sup>4</sup>
- J<sub>v</sub> = 74304. mm<sup>4</sup>
- y<sub>g</sub> = 33.35 mm
- T<sub>y</sub> = -3200. N
- M<sub>x</sub> = -1952000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -33.35 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -20.35 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -134.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 10.87 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 135.5 N/mm<sup>2</sup>
- S = 6034. mm<sup>3</sup>

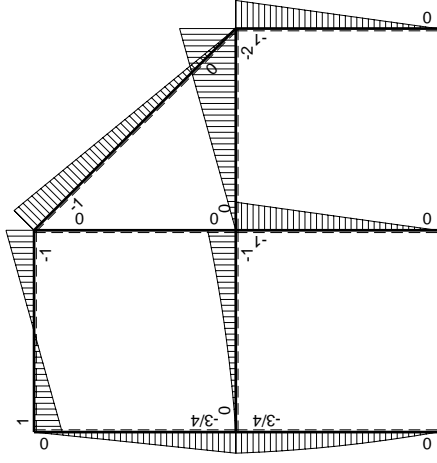
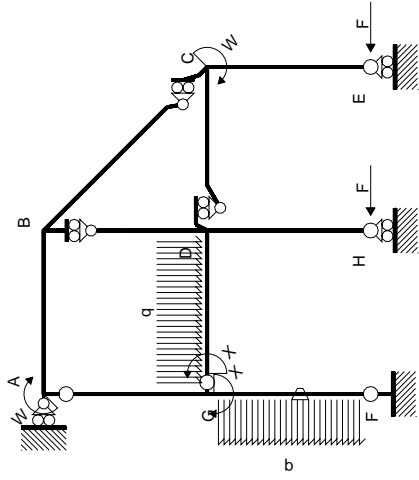




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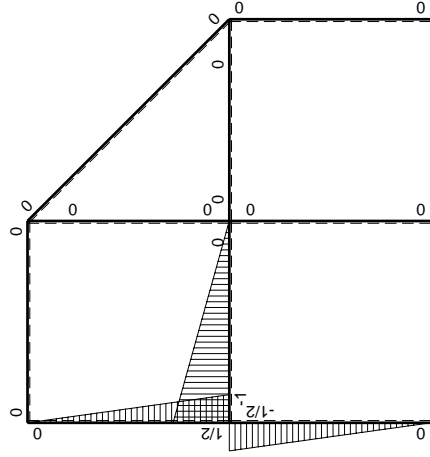
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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-5/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	5/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(7/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-1/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-1/2Fx-1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						19/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-19/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x_0} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

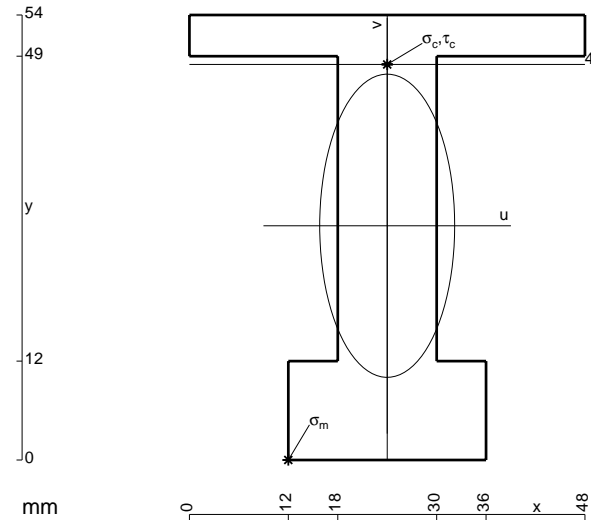
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

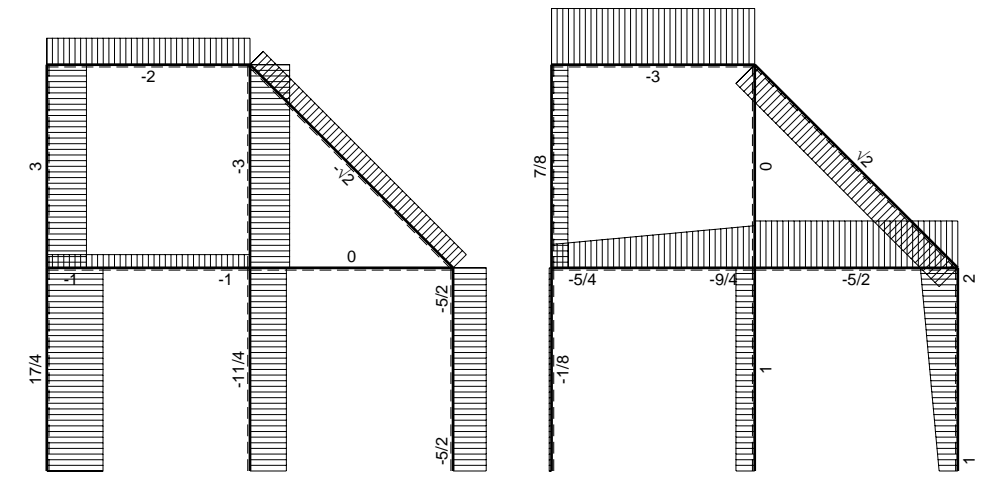
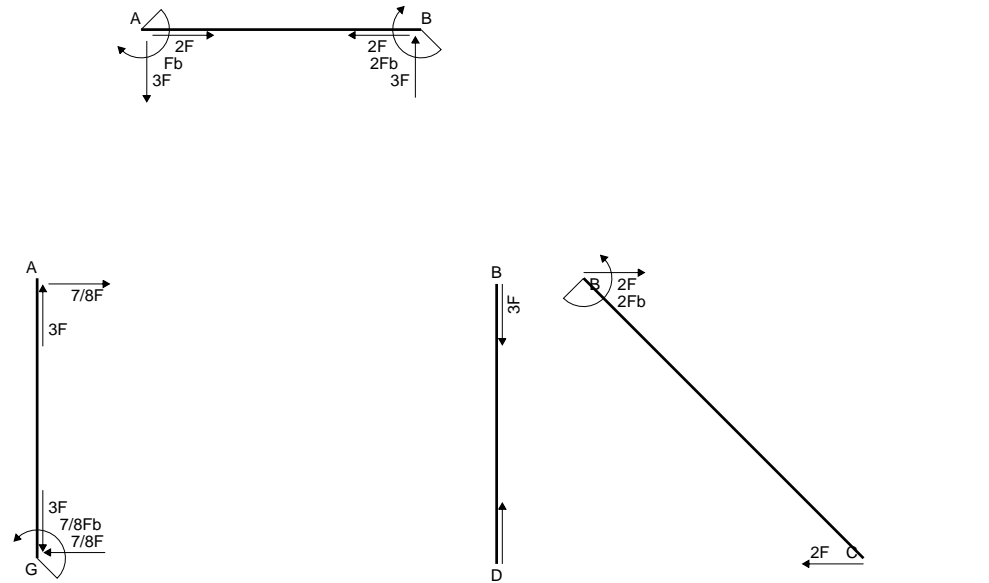
$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

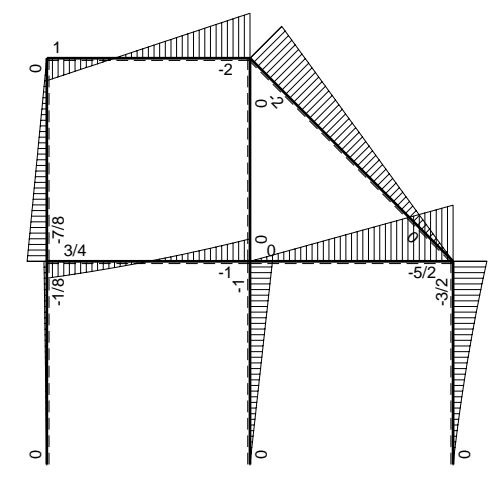
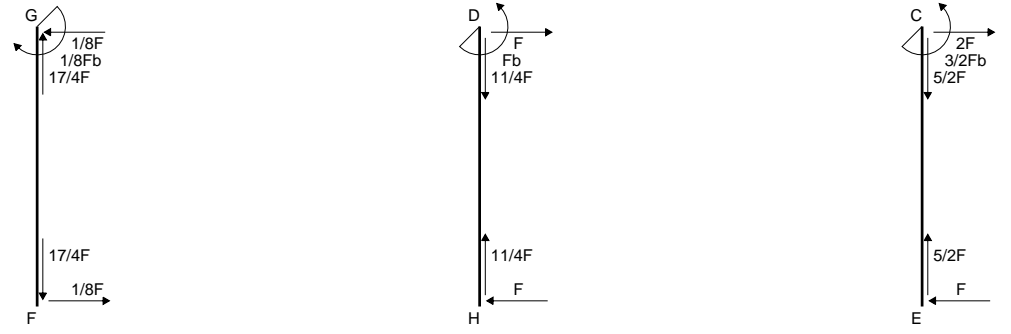


- A = 972. mm<sup>2</sup>
- J<sub>u</sub> = 329140. mm<sup>4</sup>
- J<sub>v</sub> = 65232. mm<sup>4</sup>
- y<sub>g</sub> = 28.43 mm
- T<sub>y</sub> = -4020. N
- M<sub>x</sub> = -2653200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -28.43 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -229.1 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 48. mm
- v<sub>c</sub> = 19.57 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 157.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.882 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 158.1 N/mm<sup>2</sup>
- S = 5779. mm<sup>3</sup>

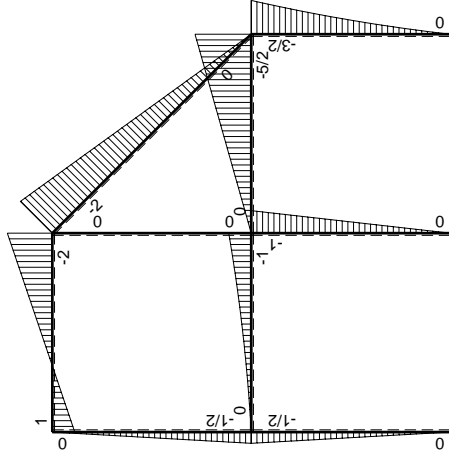
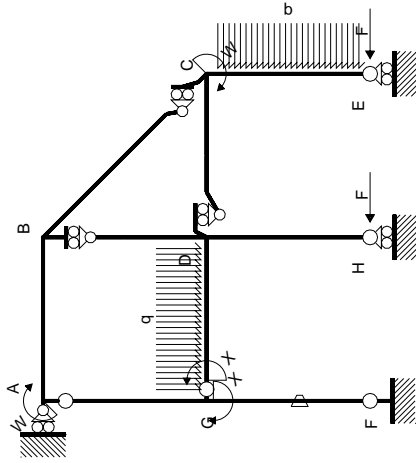


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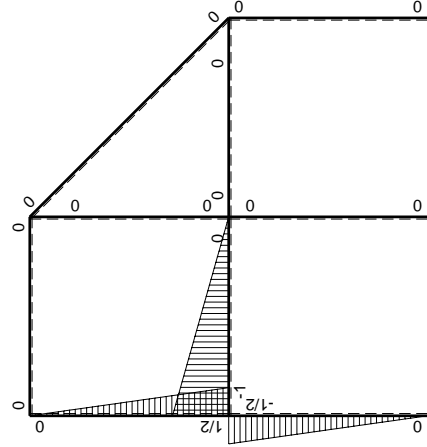


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

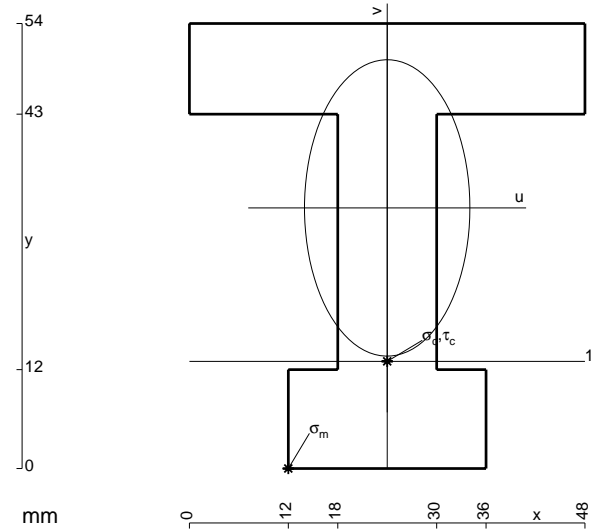
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

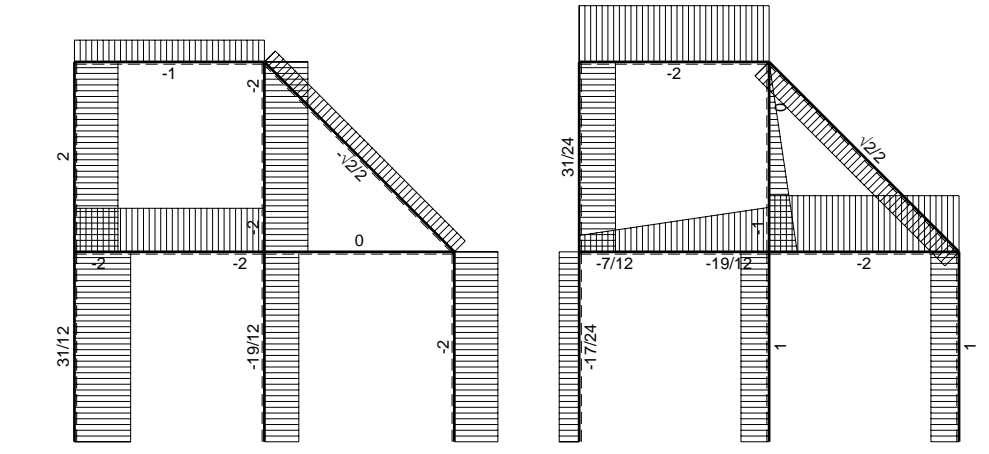
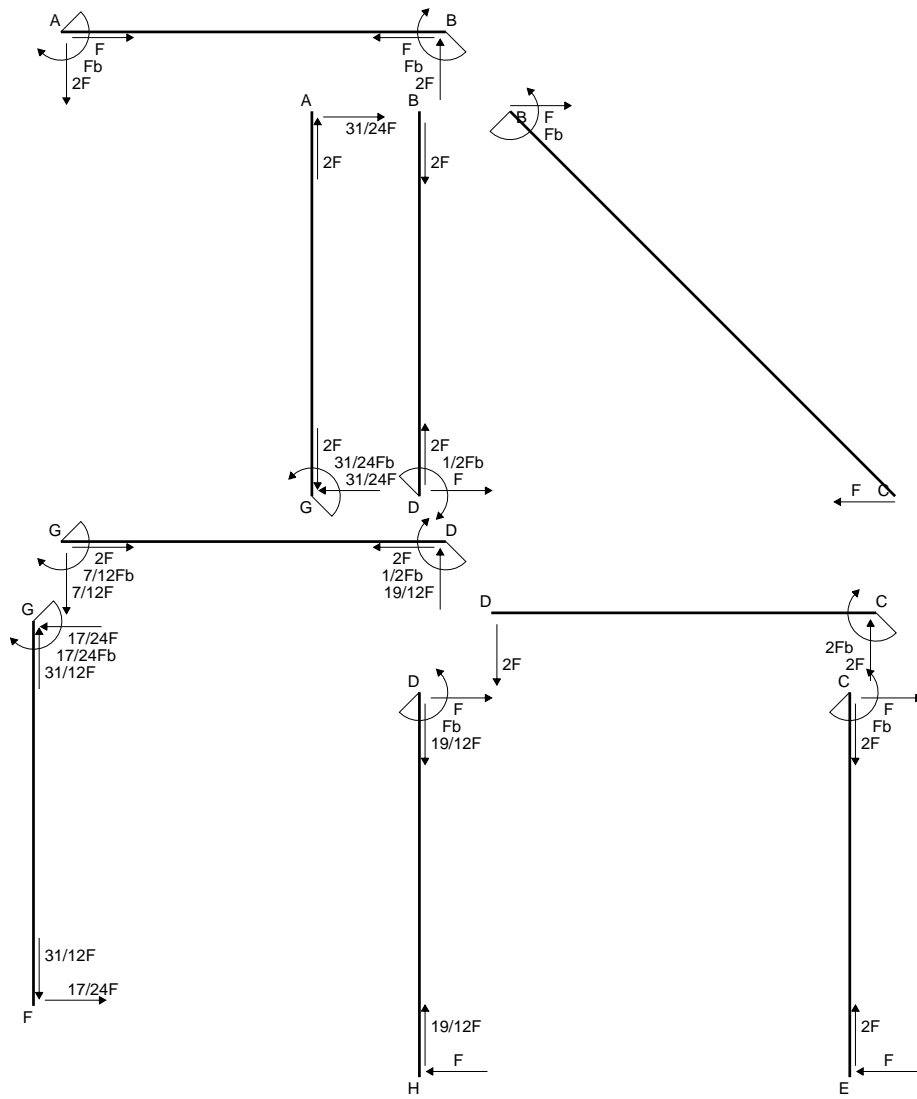
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



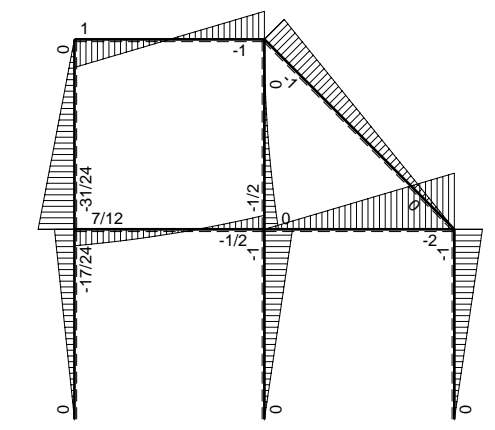
- A = 1188. mm<sup>2</sup>
- J<sub>u</sub> = 384370. mm<sup>4</sup>
- J<sub>v</sub> = 119664. mm<sup>4</sup>
- y<sub>g</sub> = 31.62 mm
- T<sub>y</sub> = -4100. N
- M<sub>x</sub> = -2911000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -31.62 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -18.62 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -141. N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.763 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 141.5 N/mm<sup>2</sup>
- S = 7608. mm<sup>3</sup>



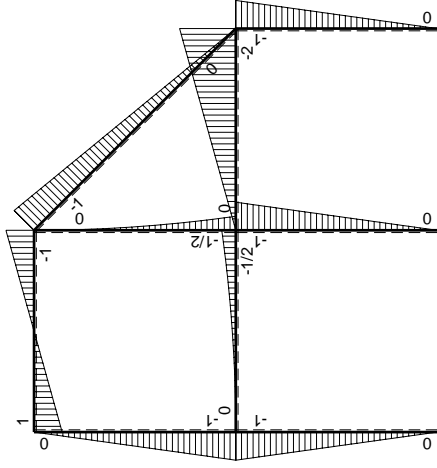
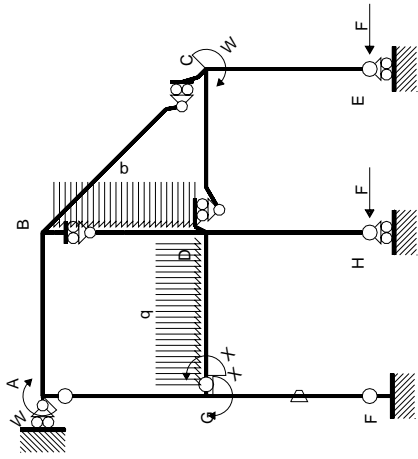


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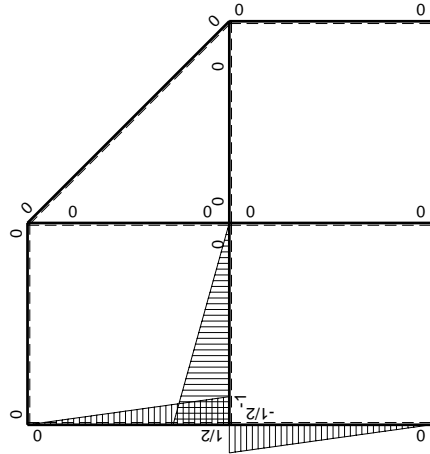


⊕ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2qx <sup>2</sup>	0	1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-Fx+1/2qx <sup>2</sup>	0	1/2Fx-Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/6 b - 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

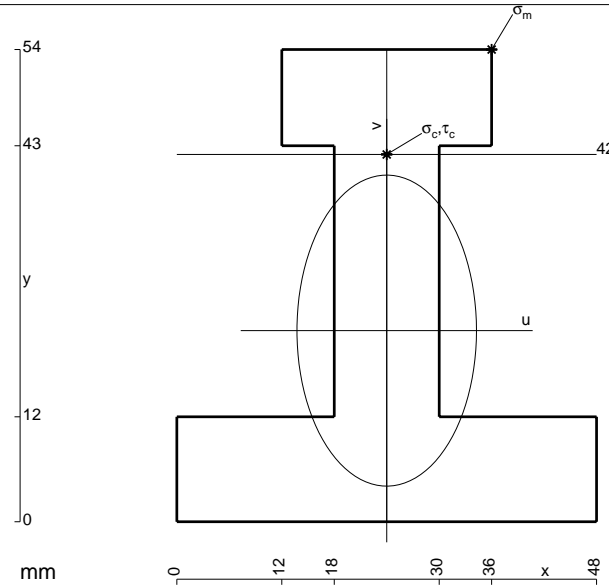
$$= (1/4 b - 1/3 b + 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

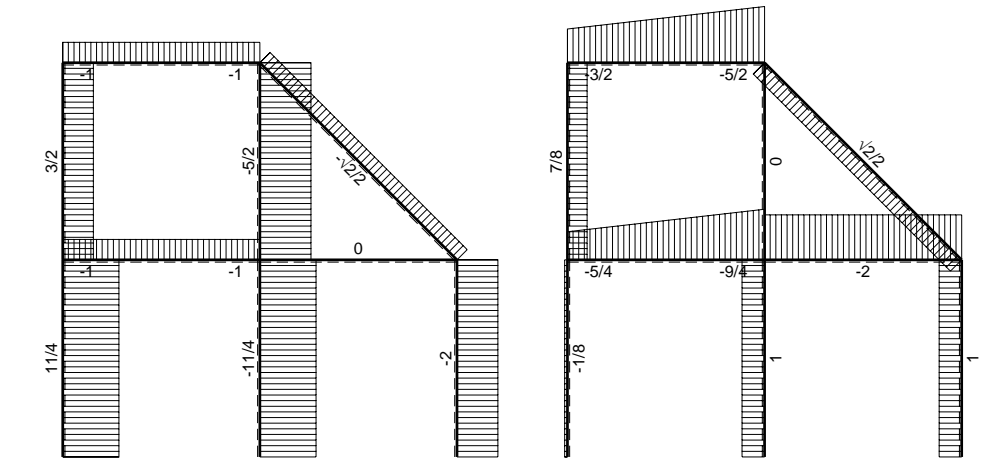
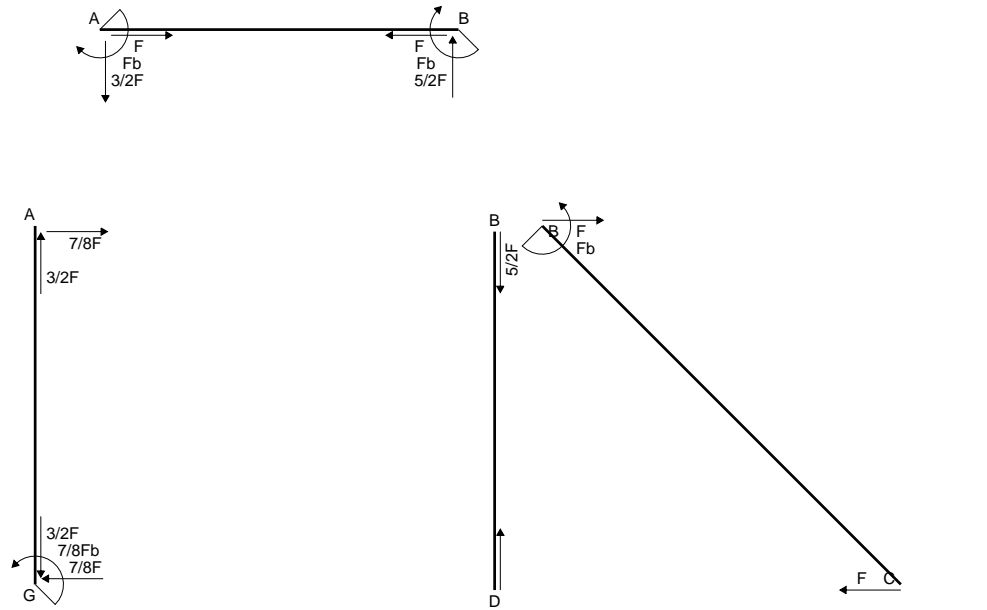
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

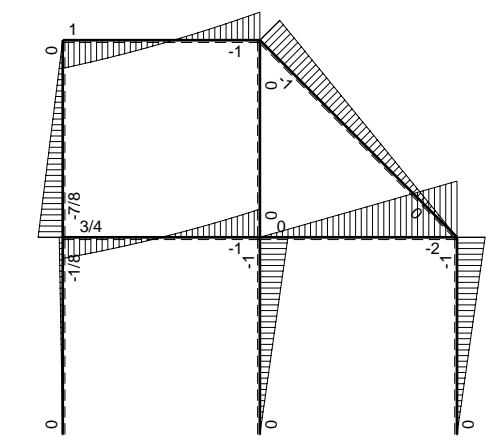
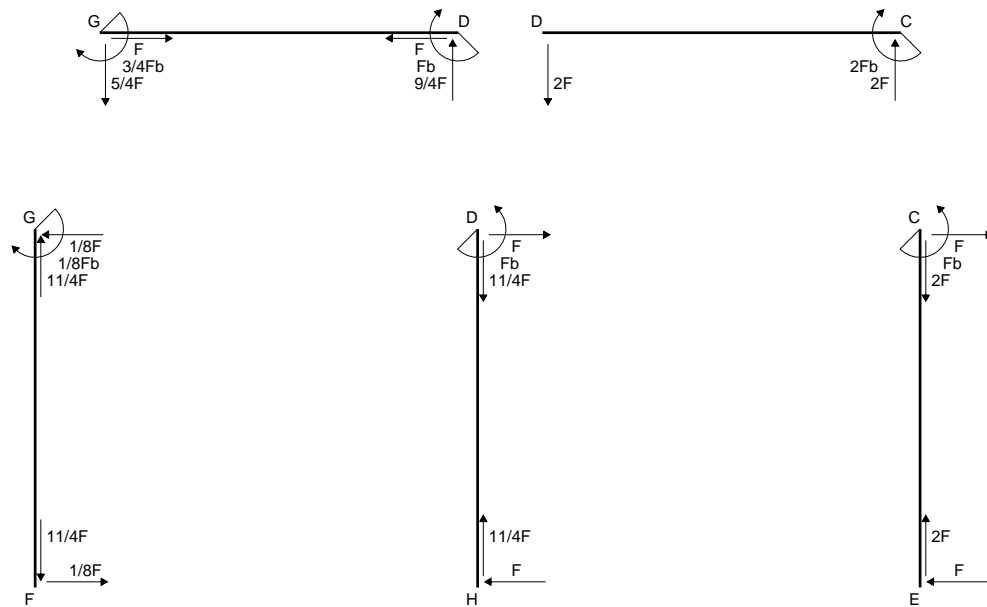


- A = 1212. mm<sup>2</sup>
- J<sub>u</sub> = 383443. mm<sup>4</sup>
- J<sub>v</sub> = 127728. mm<sup>4</sup>
- y<sub>g</sub> = 21.86 mm
- T<sub>y</sub> = -3120. N
- M<sub>x</sub> = -2371200. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 32.14 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 198.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 20.14 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 124.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.937 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 124.9 N/mm<sup>2</sup>
- S = 7282. mm<sup>3</sup>

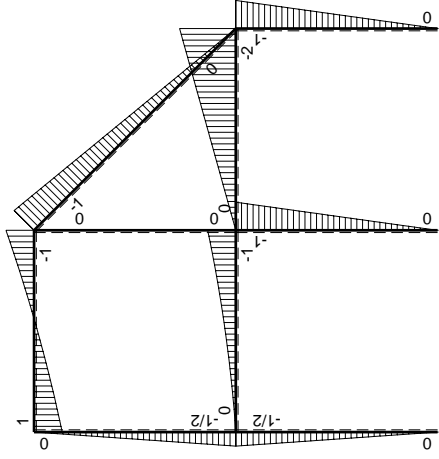
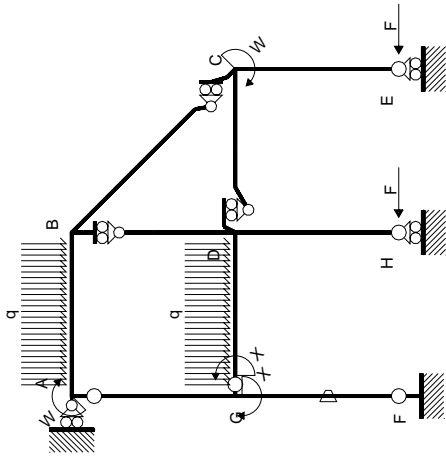


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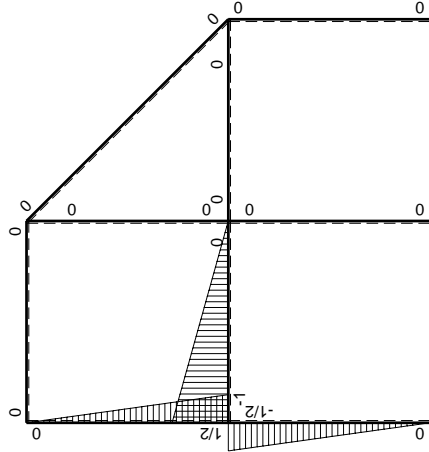


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_X$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

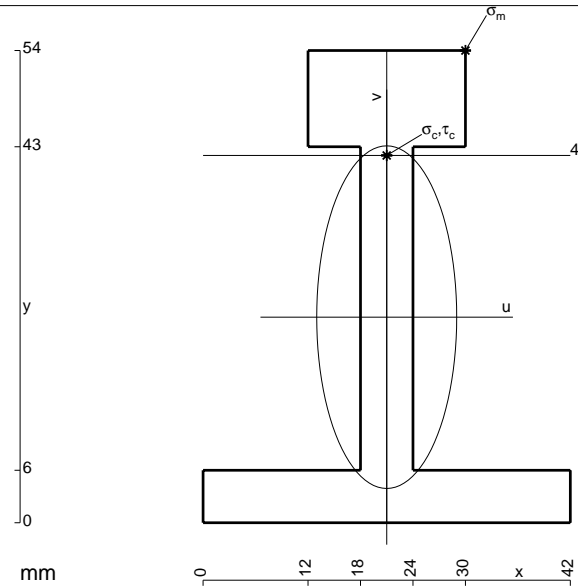
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

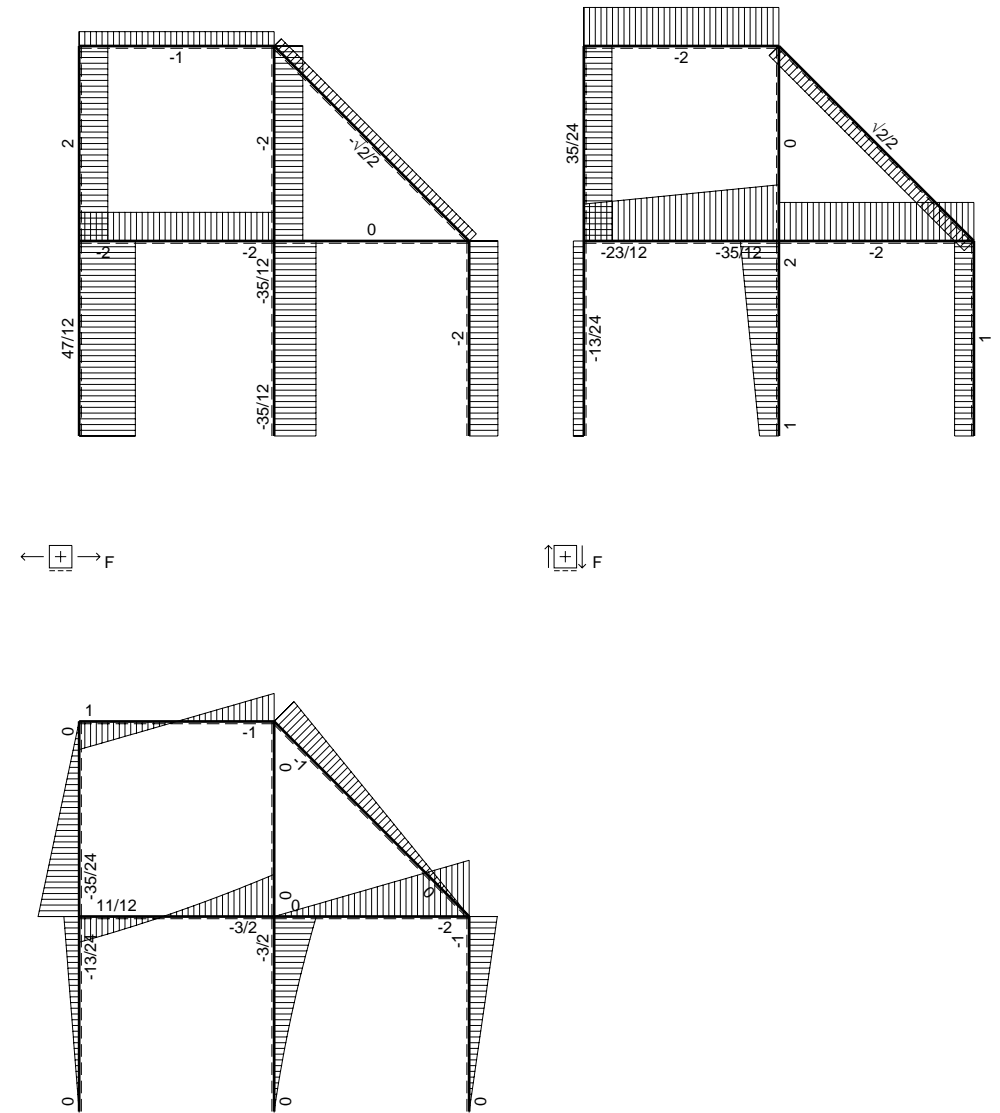
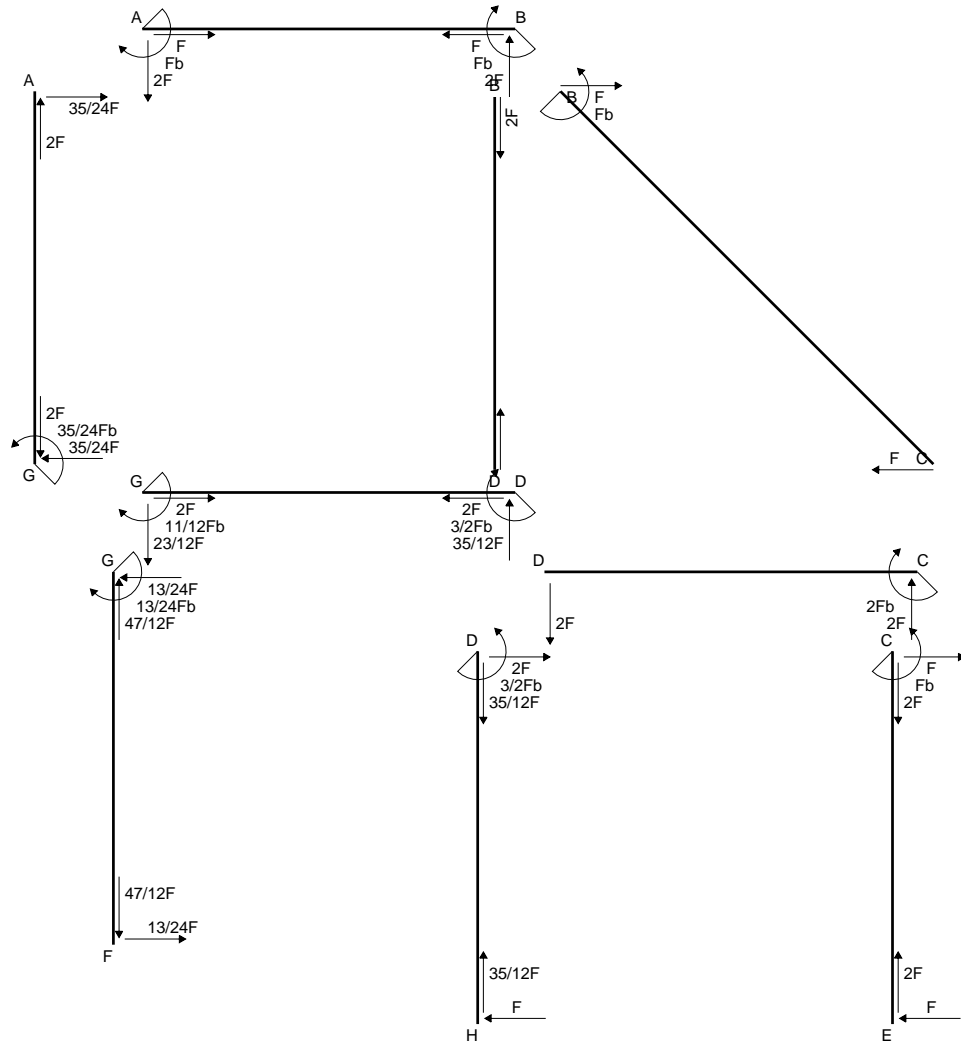
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

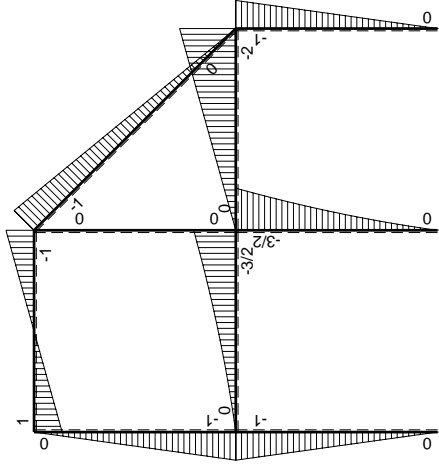
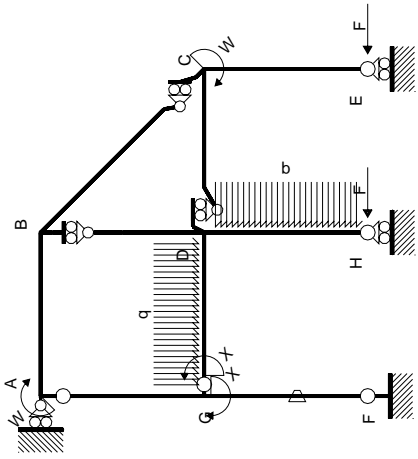


- A = 672. mm<sup>2</sup>
- J<sub>u</sub> = 257954. mm<sup>4</sup>
- J<sub>v</sub> = 43056. mm<sup>4</sup>
- y<sub>g</sub> = 23.51 mm
- T<sub>y</sub> = -2180. N
- M<sub>x</sub> = -1765800. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 30.49 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 208.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 18.49 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 126.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.13 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 127.2 N/mm<sup>2</sup>
- S = 5062. mm<sup>3</sup>



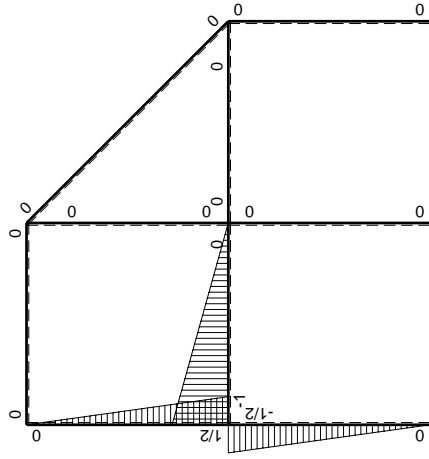


$\curvearrowright (+)$   $F_b$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx-1/2qx <sup>2</sup>	0	Fx-1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx <sup>2</sup>	0	3/2Fx-2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						11/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - 1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/6 b - 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 2/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

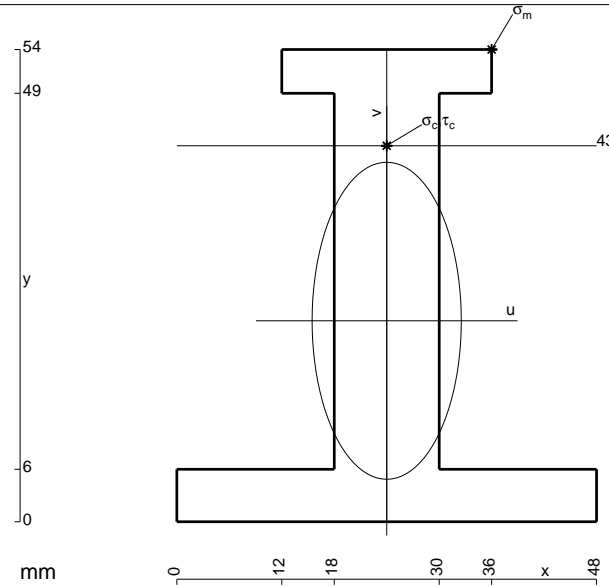
$$= (3/4 b - 2/3 b + 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

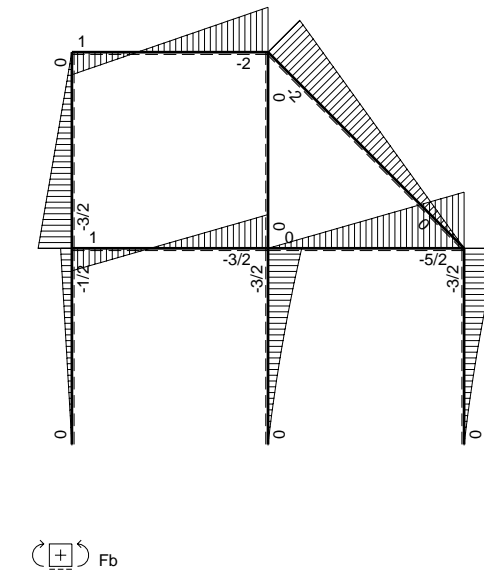
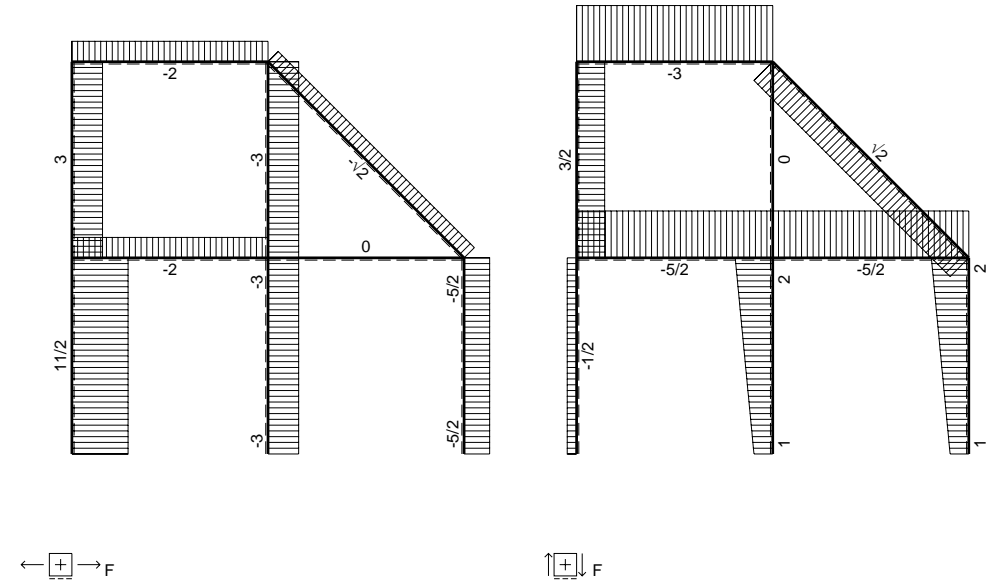
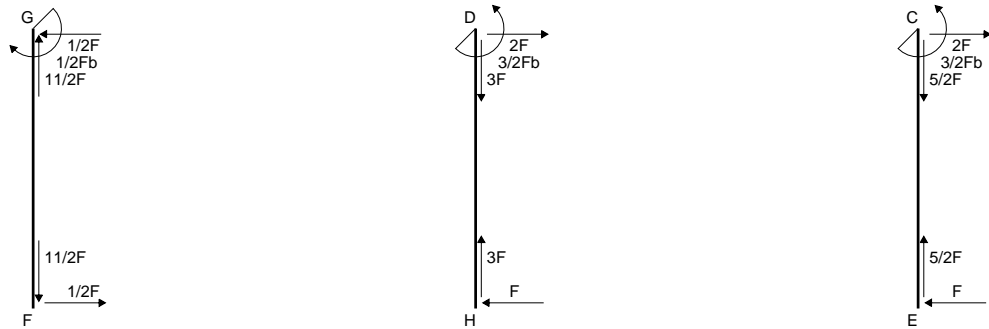
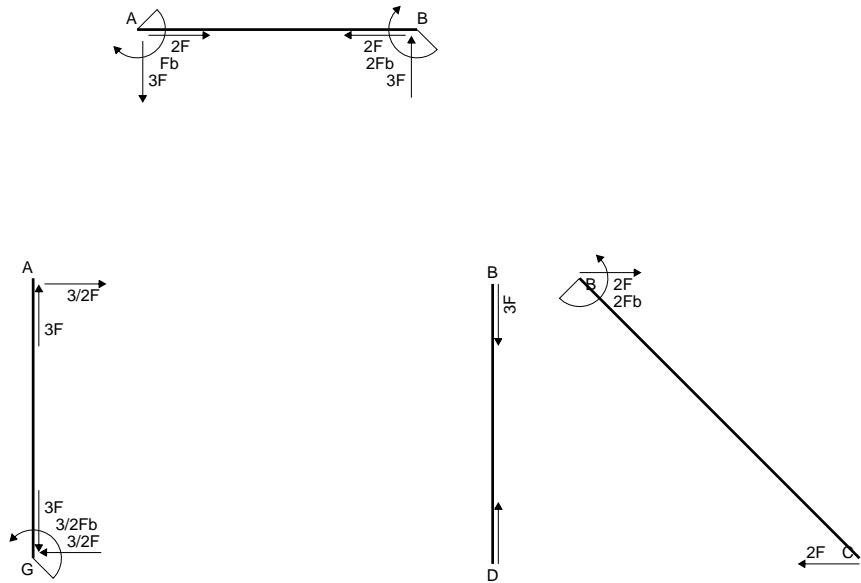
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

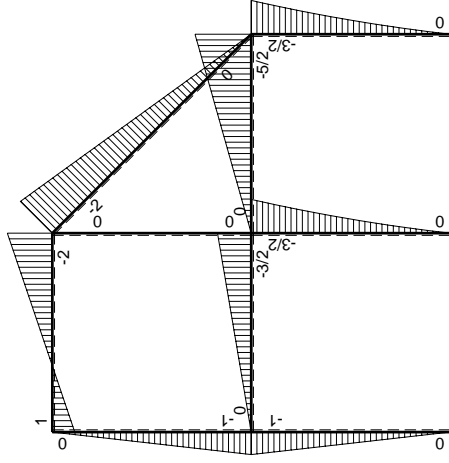
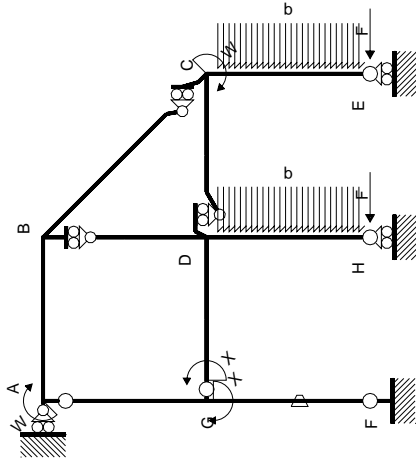
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



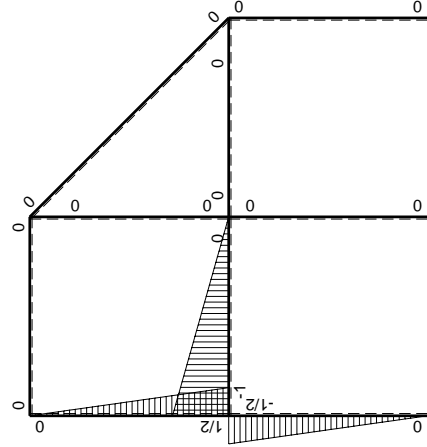
- A = 924. mm<sup>2</sup>
- J<sub>u</sub> = 303740. mm<sup>4</sup>
- J<sub>v</sub> = 67248. mm<sup>4</sup>
- y<sub>g</sub> = 22.98 mm
- T<sub>y</sub> = -2500. N
- M<sub>x</sub> = -2150000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 31.02 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 219.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 43. mm
- v<sub>c</sub> = 20.02 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 141.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.484 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 141.8 N/mm<sup>2</sup>
- S = 5080. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$	
AB b	0	Fb-3Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-3Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							1/2Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

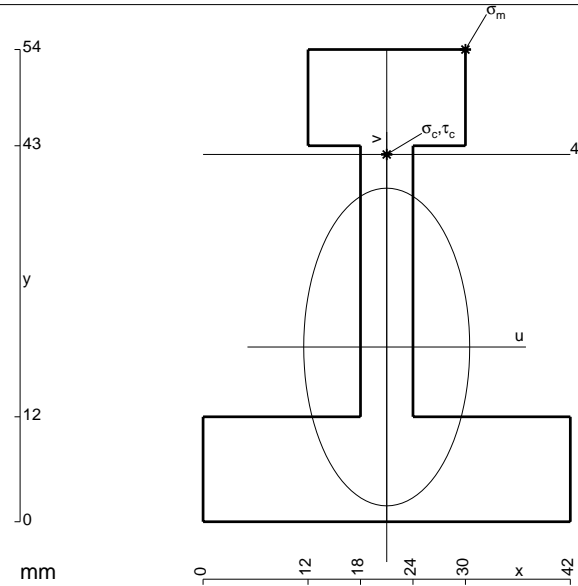
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

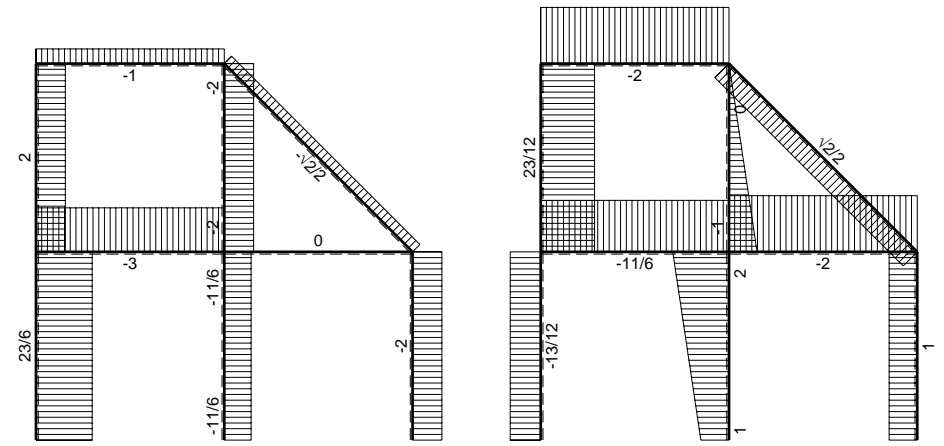
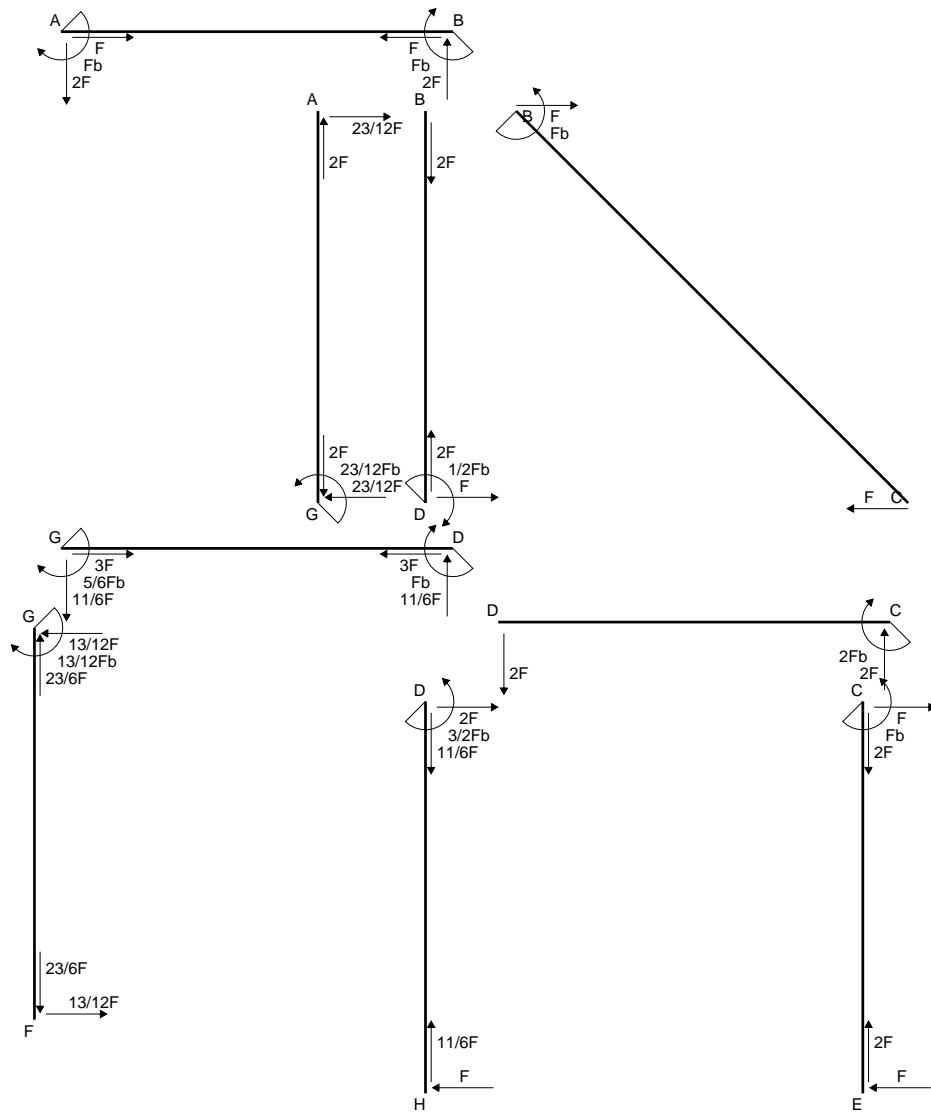
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



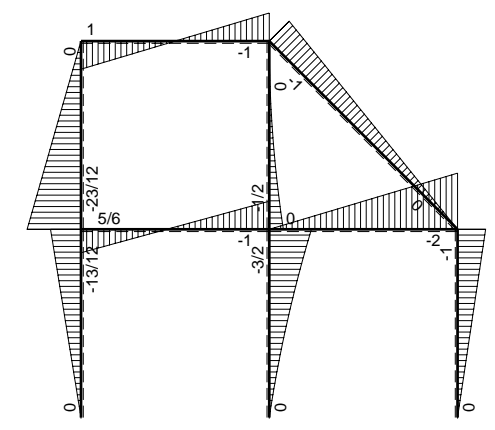
- A = 888. mm<sup>2</sup>
- J<sub>u</sub> = 293012. mm<sup>4</sup>
- J<sub>v</sub> = 79992. mm<sup>4</sup>
- y<sub>g</sub> = 19.98 mm
- T<sub>y</sub> = -2175. N
- M<sub>x</sub> = -1979250. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 34.02 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 229.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 22.02 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 148.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.153 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 149.3 N/mm<sup>2</sup>
- S = 5782. mm<sup>3</sup>

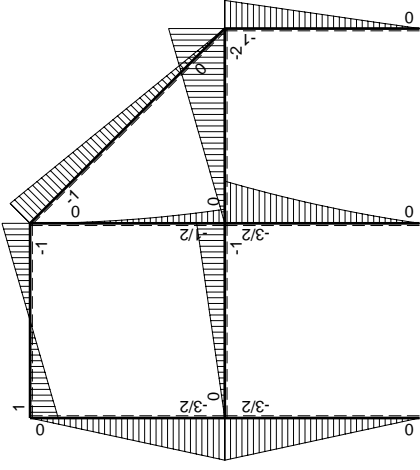
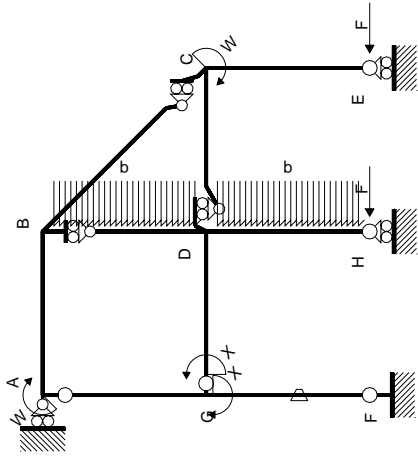




← ⊕ → F

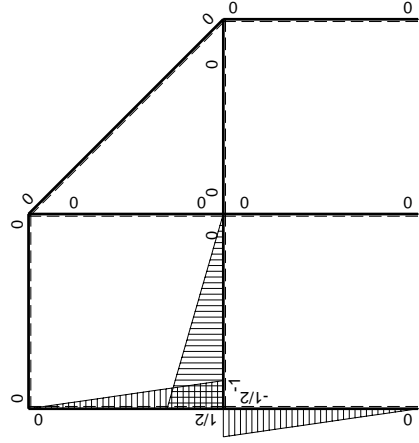
↑ ⊕ ↓ F





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/2Fb+3/2Fx	0	-3/4Fb+3/2Fx-3/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/4+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx	0	-3/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/4 - 3/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/4 b - 3/4 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

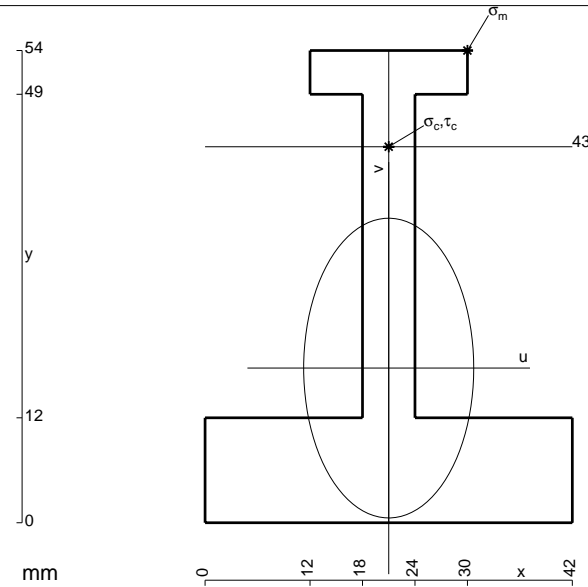
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/4 + 3/2 x/b - 3/4 x^2/b^2) Fb 1/EJ dx = [-3/4 x + 3/4 x^2/b - 1/4 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/4 b + 3/4 b - 1/4 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-3/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b) Fb 1/EJ = -1/4 Fb^2/EJ$$



$$A = 816. \text{ mm}^2$$

$$J_u = 239746. \text{ mm}^4$$

$$J_v = 77184. \text{ mm}^4$$

$$y_g = 17.68 \text{ mm}$$

$$T_y = -1640. \text{ N}$$

$$M_x = -1574400. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 36.32 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

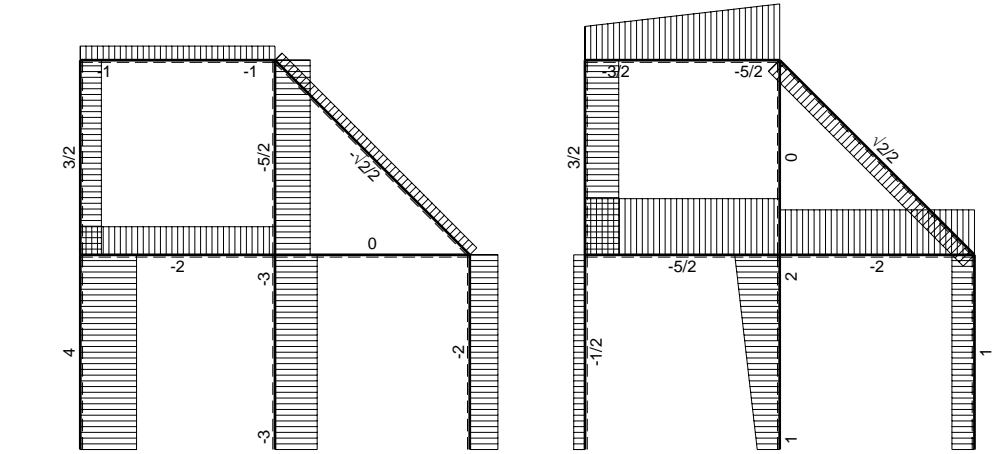
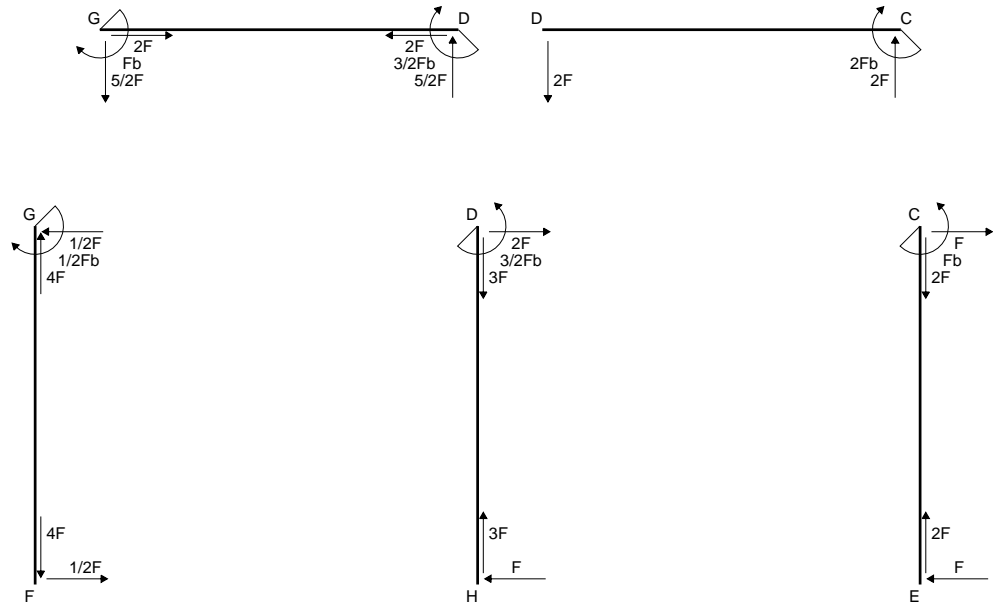
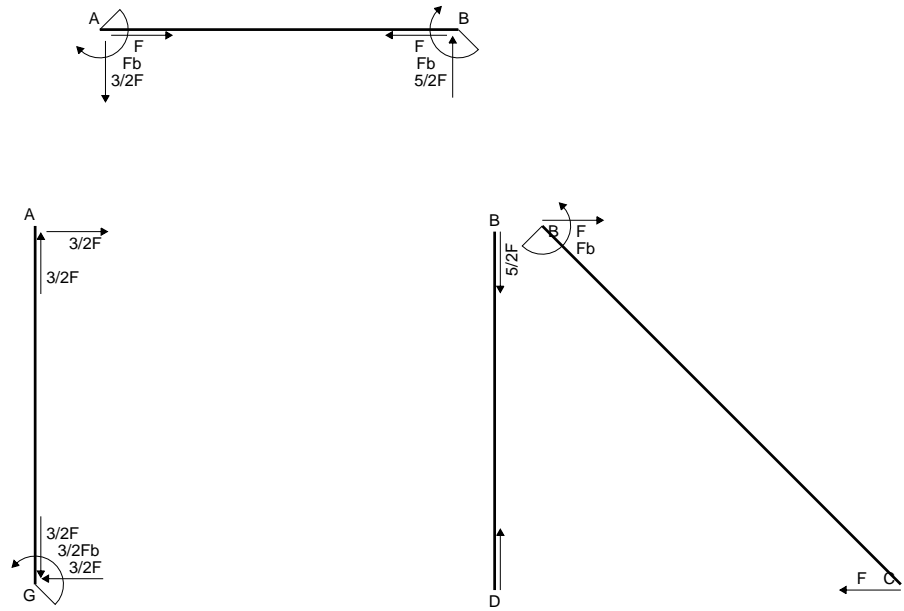
$$v_c = 25.32 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 166.3 \text{ N/mm}^2$$

$$\tau_c = 4.632 \text{ N/mm}^2$$

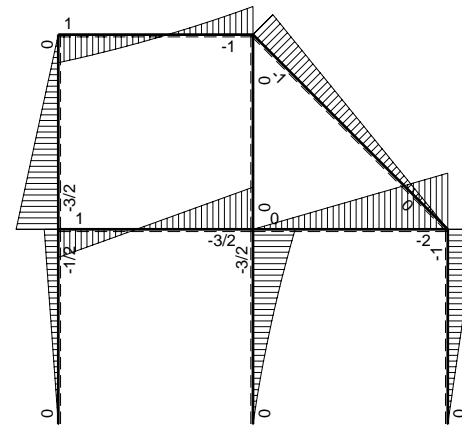
$$\sigma_\varphi = \sqrt{\sigma^2 + 3\tau^2} = 166.4 \text{ N/mm}^2$$

$$S = 4063. \text{ mm}^3$$

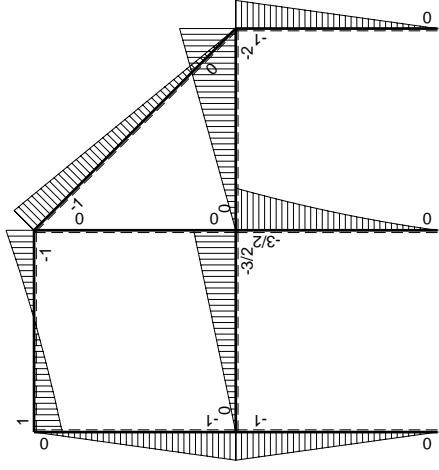
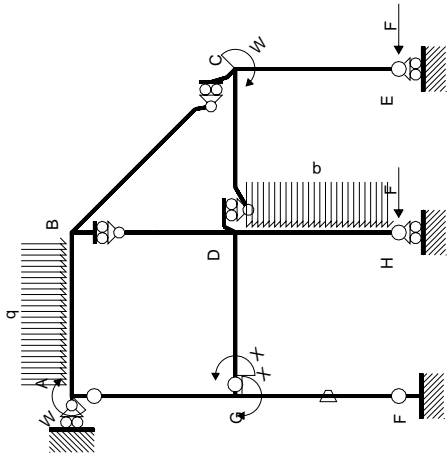


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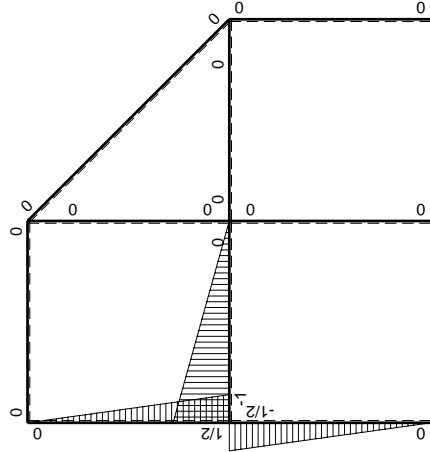


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_1$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

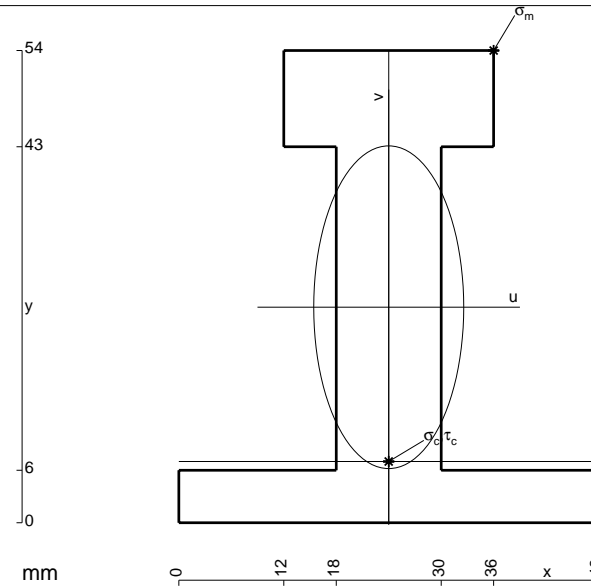
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

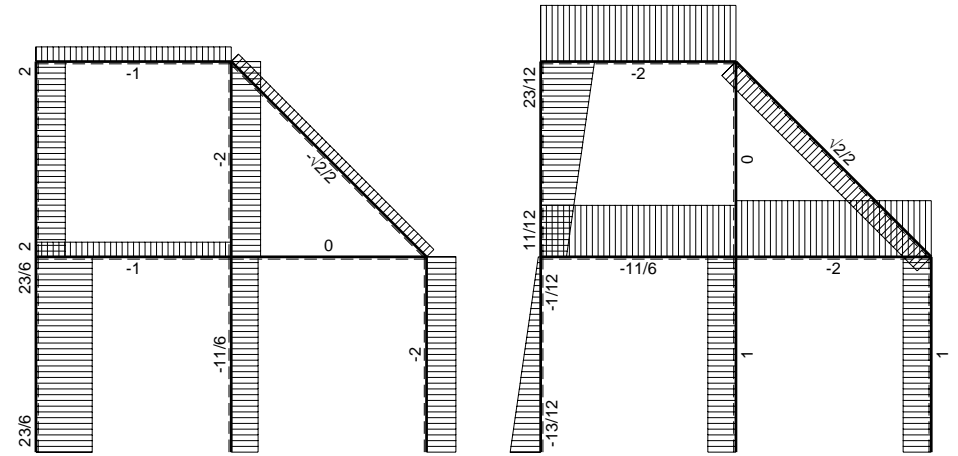
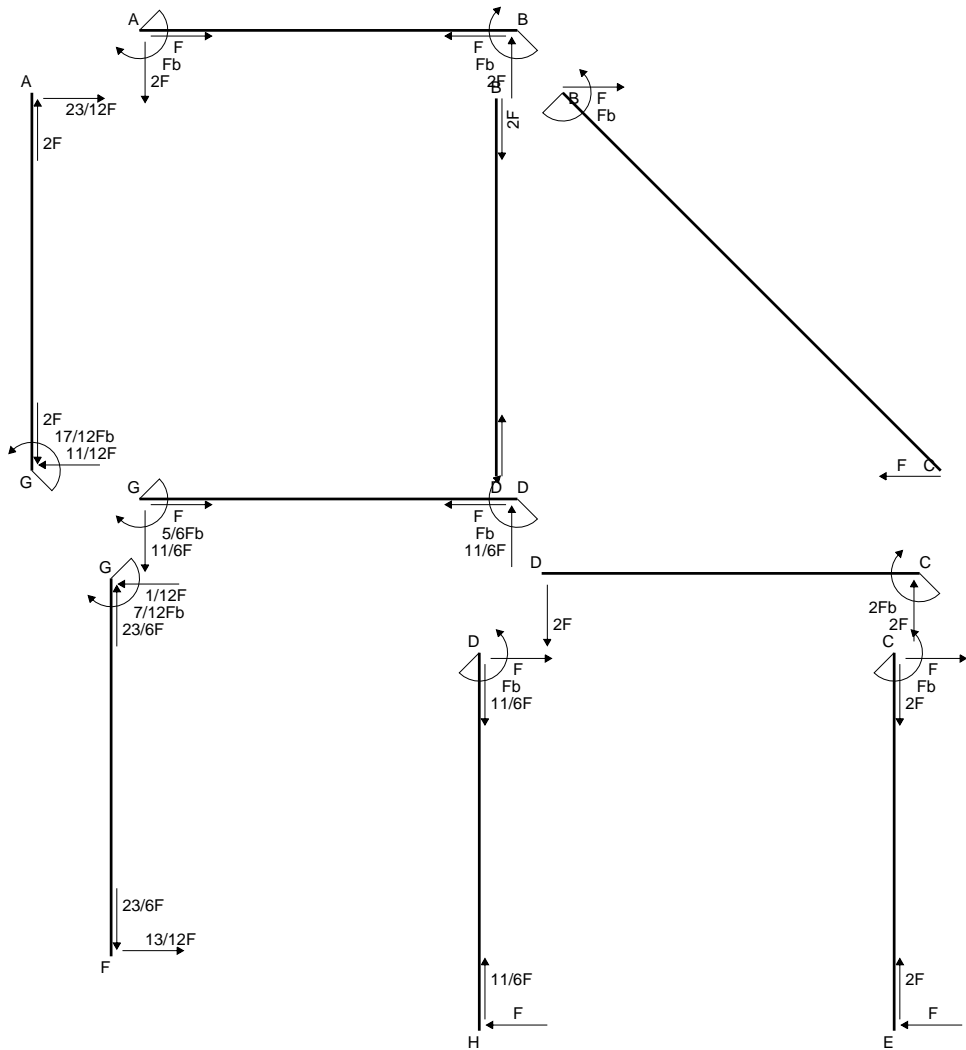
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



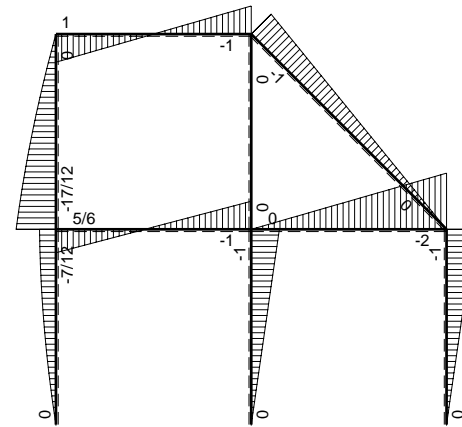
- A = 996. mm<sup>2</sup>
- J<sub>u</sub> = 339350. mm<sup>4</sup>
- J<sub>v</sub> = 73296. mm<sup>4</sup>
- y<sub>g</sub> = 24.64 mm
- T<sub>y</sub> = -4520. N
- M<sub>x</sub> = -2305200. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 29.36 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -17.64 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -119.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.161 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 120.5 N/mm<sup>2</sup>
- S = 6451. mm<sup>3</sup>



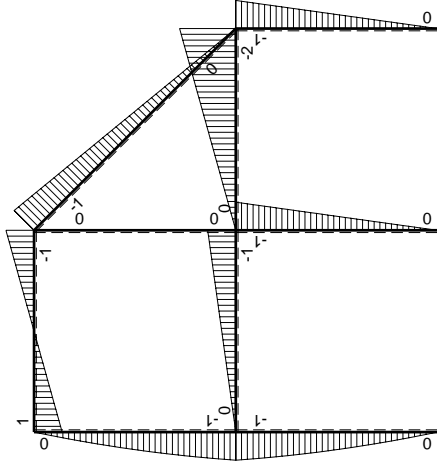
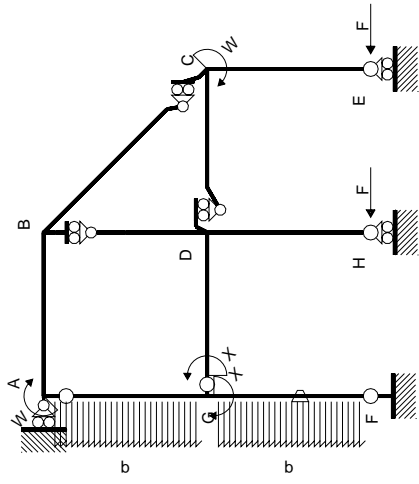


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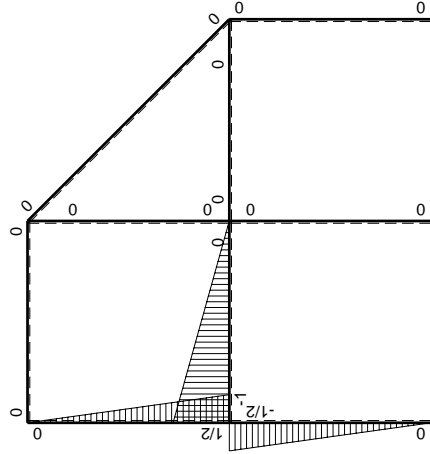


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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	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 <sup>2</sup>	-Fb/EJ	3/4Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(3/16+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-1/2Fx-1/2qx <sup>2</sup>	Fb/EJ	1/2Fb-3/4Fx+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup>	0	-1/2Fb+3/4Fx-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-3/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx-1/2qx <sup>2</sup>	0	-3/4Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b (3/4 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [1/4 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 7/16 Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b (1/2 - 3/4 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 3/8 x^2/b + 1/16 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 3/8 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 7/16 Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

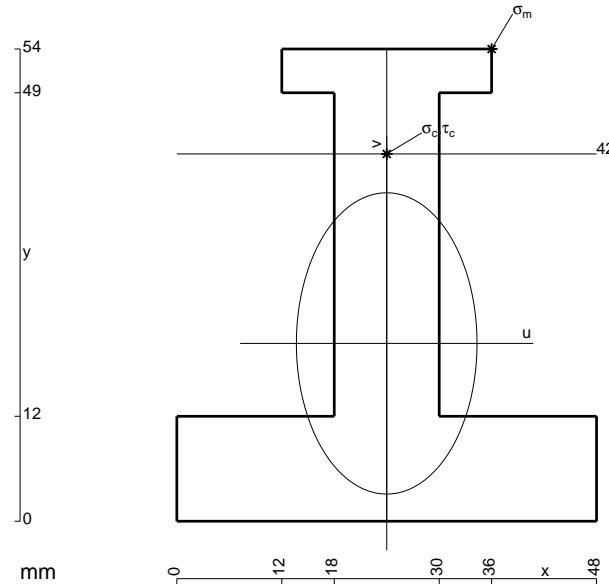
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b (-1/2 + 3/4 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 3/8 x^2/b - 1/16 x^3/b^2]_0^b Fb 1/EJ$$

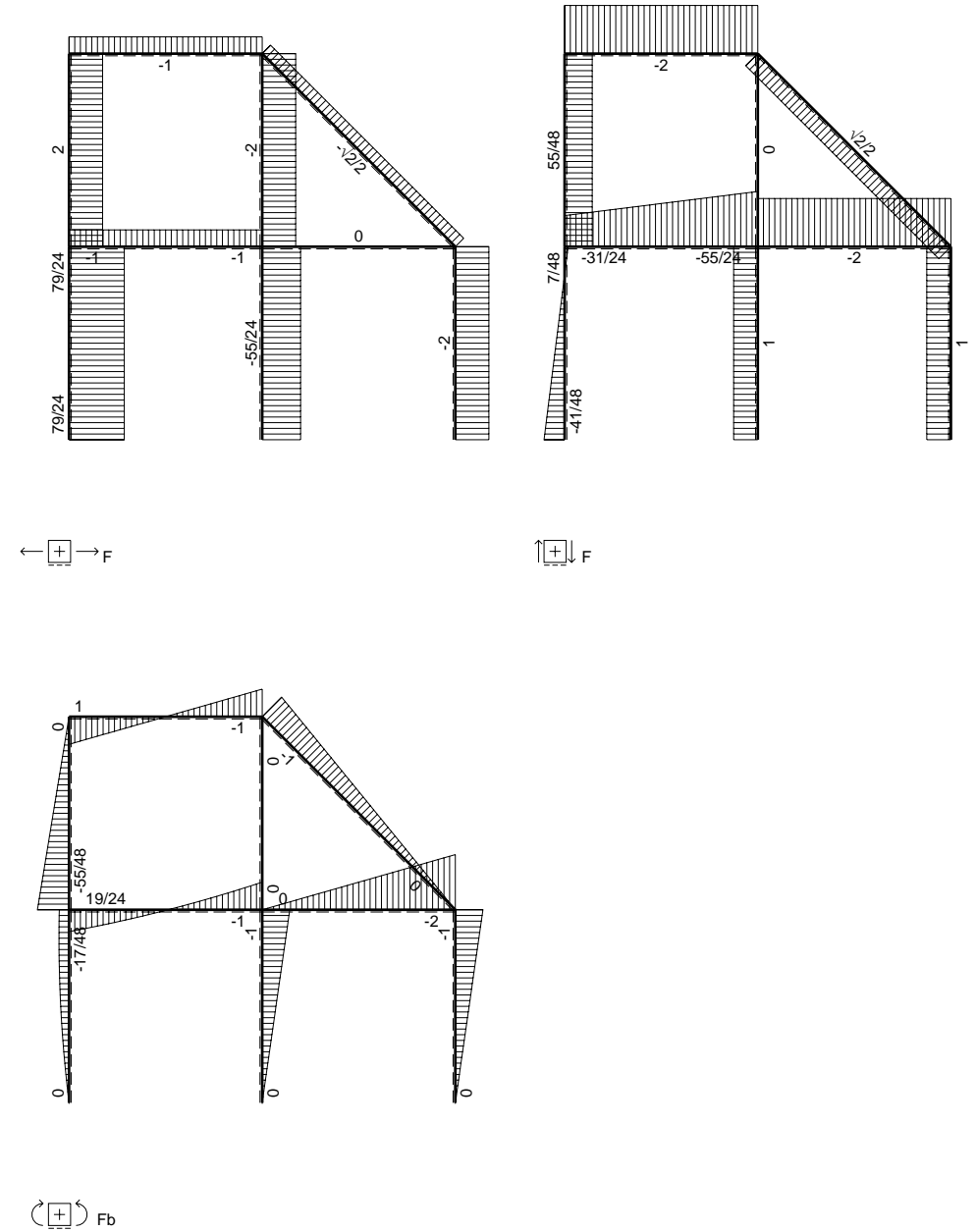
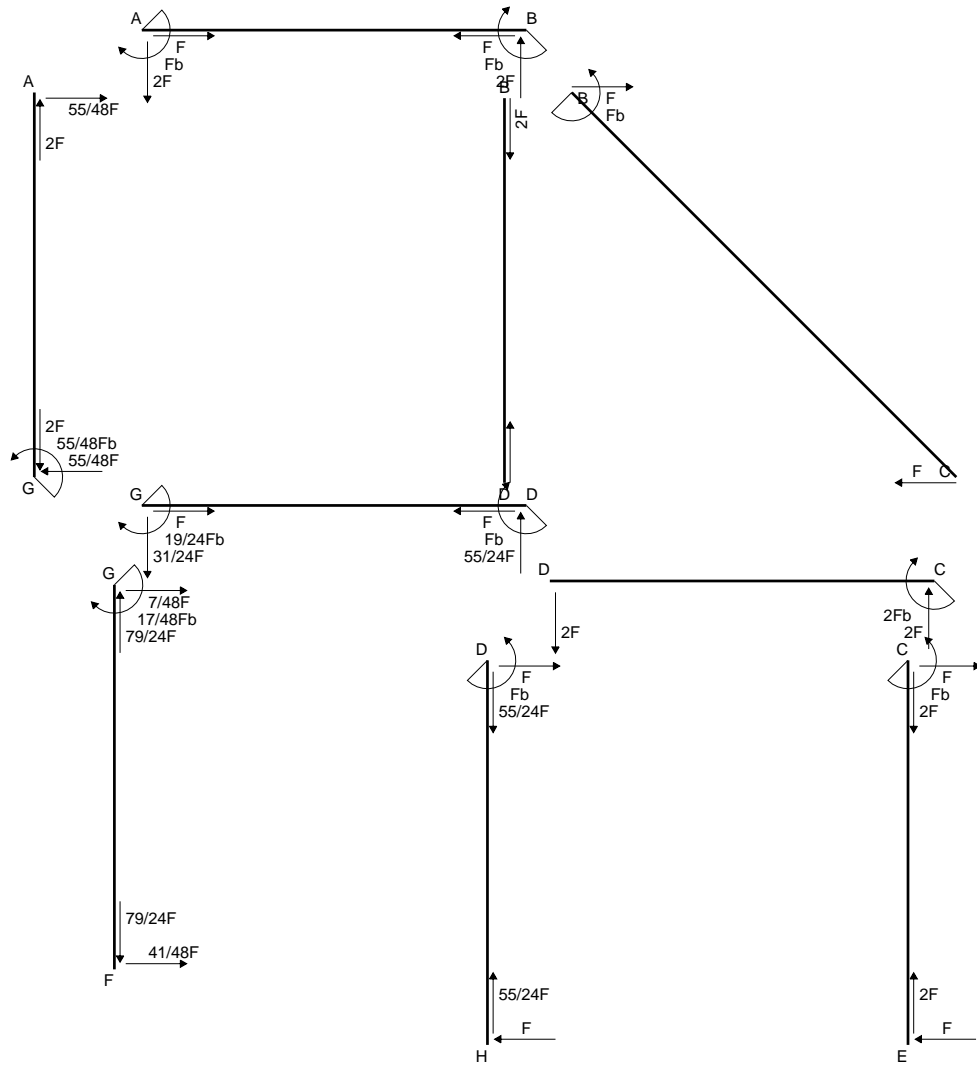
$$= (-1/2 b + 3/8 b - 1/16 b) Fb 1/EJ = -3/16 Fb^2/EJ$$

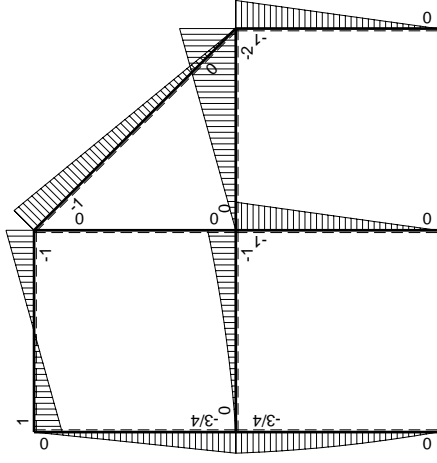
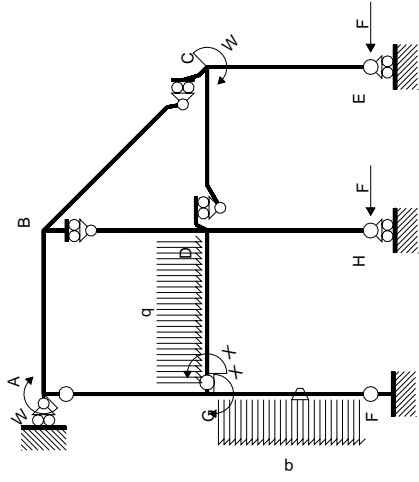
$$L_{AG}^{x\theta} = \int_0^b (-3/4 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/4 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/16 b) Fb 1/EJ = -3/16 Fb^2/EJ$$



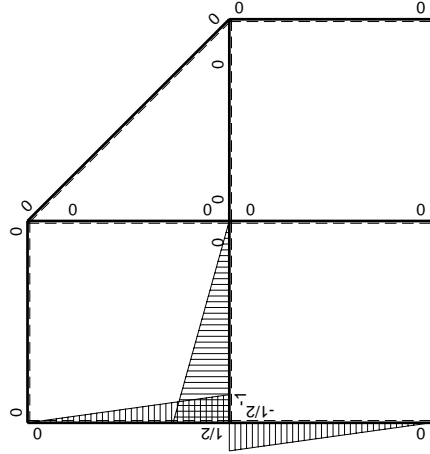
- A = 1140. mm<sup>2</sup>
- J<sub>u</sub> = 338607. mm<sup>4</sup>
- J<sub>v</sub> = 121680. mm<sup>4</sup>
- y<sub>g</sub> = 20.33 mm
- T<sub>y</sub> = -3760. N
- M<sub>x</sub> = -2105600. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.67 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 21.67 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 134.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.417 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 135.1 N/mm<sup>2</sup>
- S = 5854. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-5/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	5/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(7/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-1/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-1/2Fx-1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						19/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-19/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

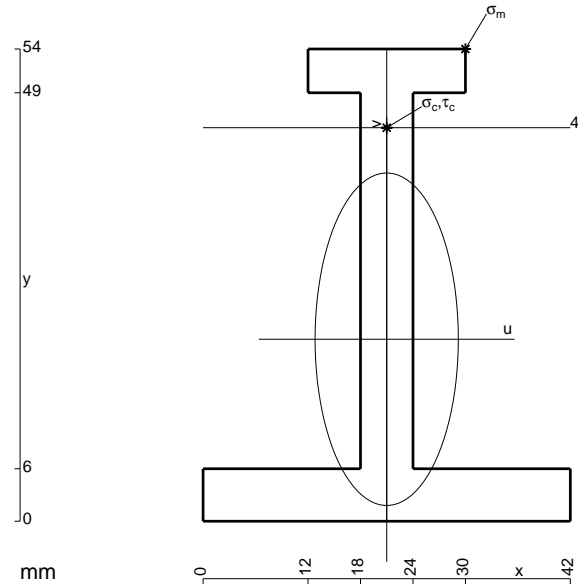
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

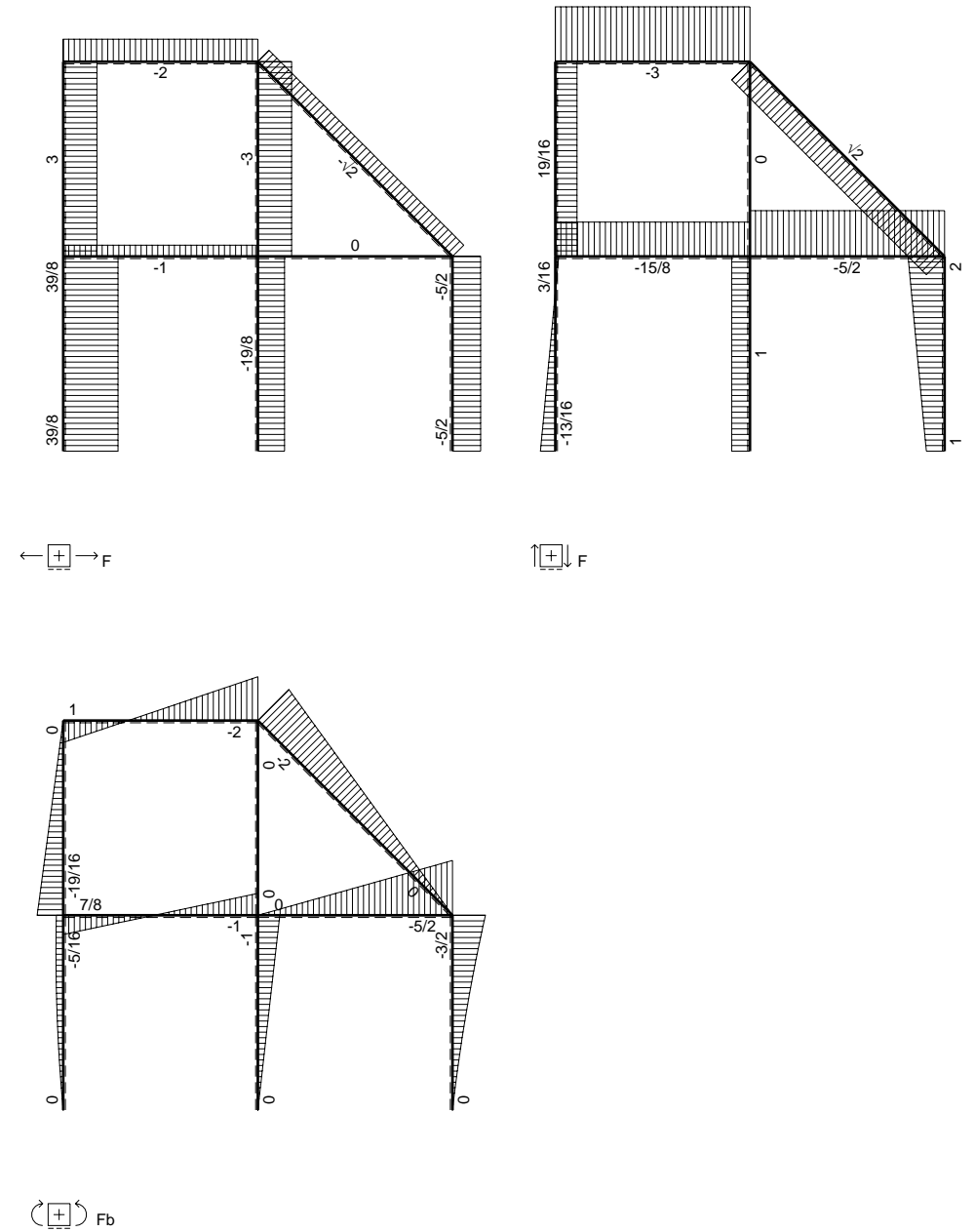
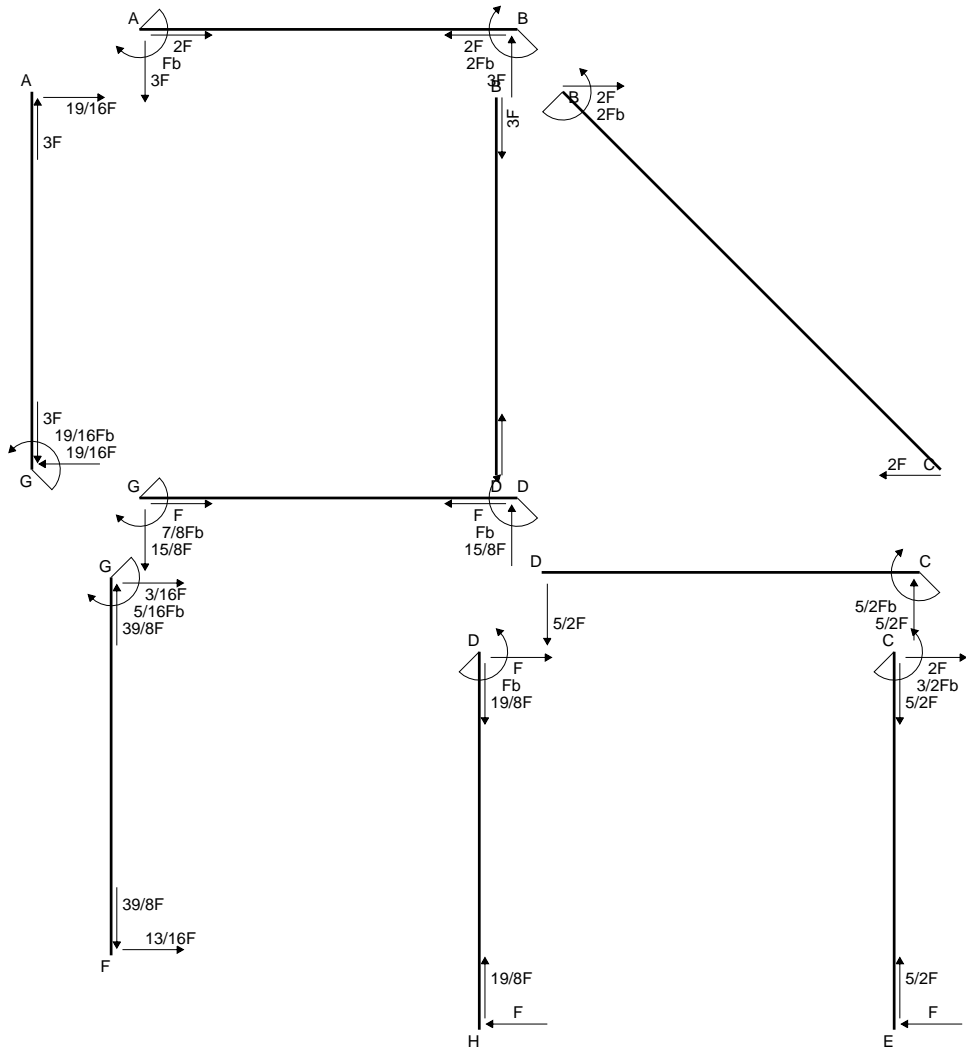
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

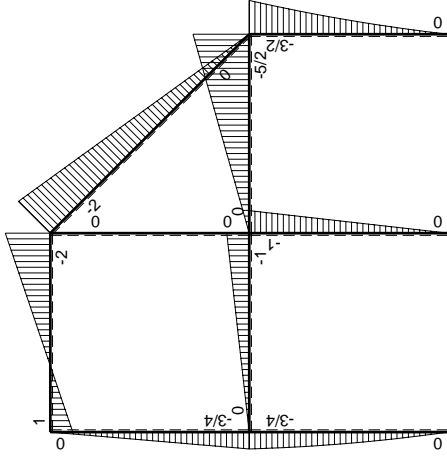
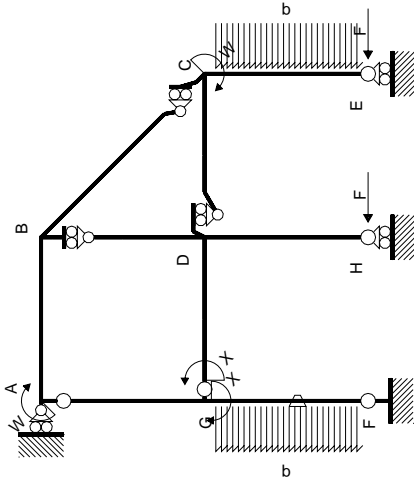
$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



- A = 600. mm<sup>2</sup>
- J<sub>u</sub> = 216946. mm<sup>4</sup>
- J<sub>v</sub> = 40248. mm<sup>4</sup>
- y<sub>g</sub> = 20.81 mm
- T<sub>y</sub> = -2340. N
- M<sub>x</sub> = -1427400. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.19 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 218.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 45. mm
- v<sub>c</sub> = 24.19 mm
- σ<sub>c</sub> = -Mv/J<sub>v</sub> = 159.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.095 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 159.5 N/mm<sup>2</sup>
- S = 3391. mm<sup>3</sup>

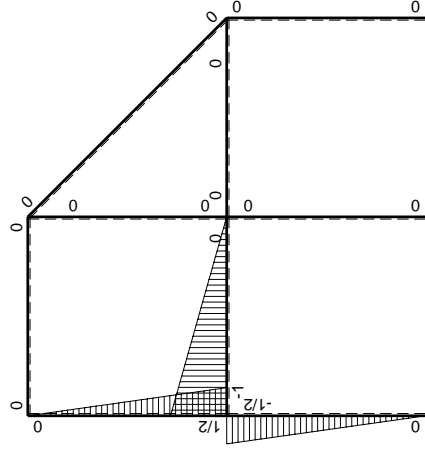






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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 <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
FG b	-1/2x/b	-5/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	5/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(7/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-1/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-1/2Fx-1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

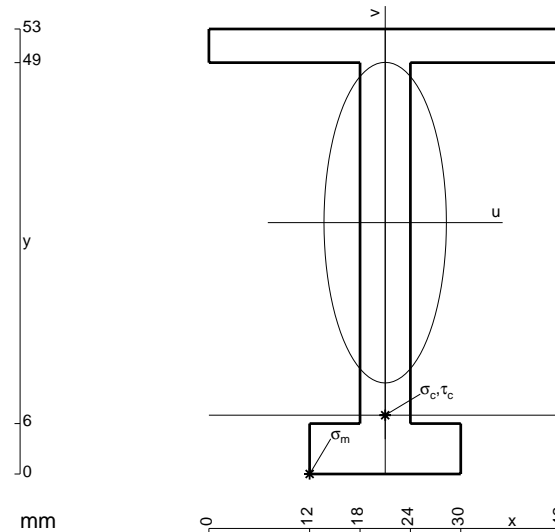
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

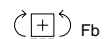
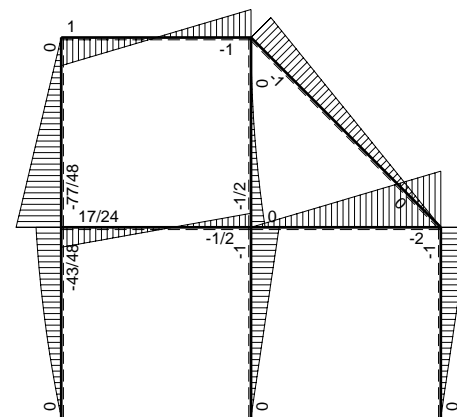
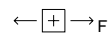
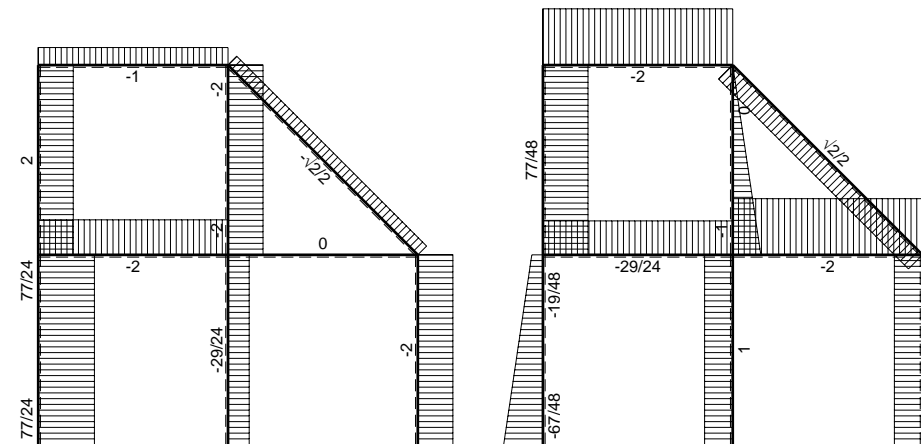
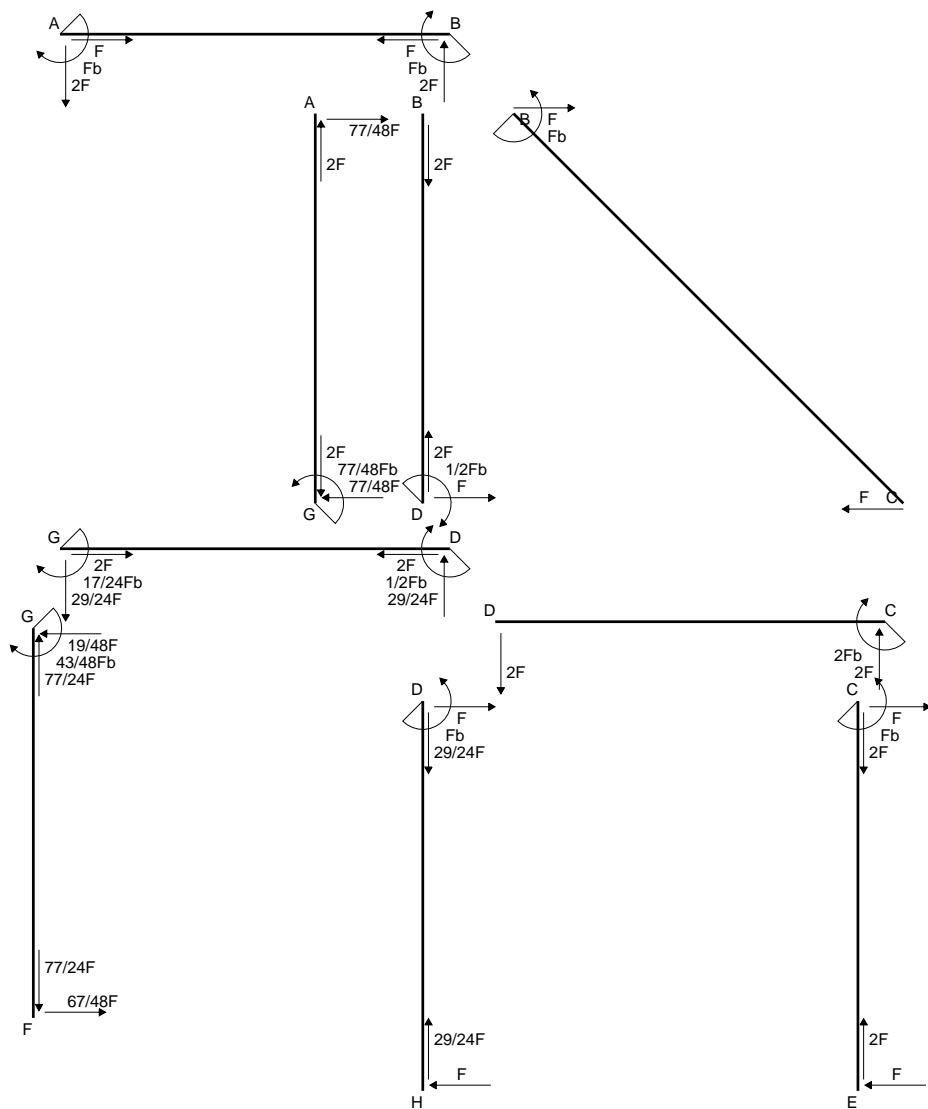
$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

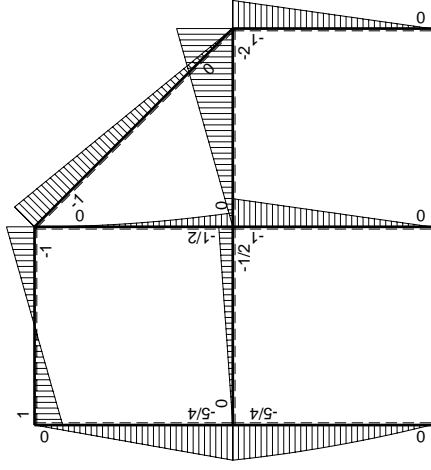
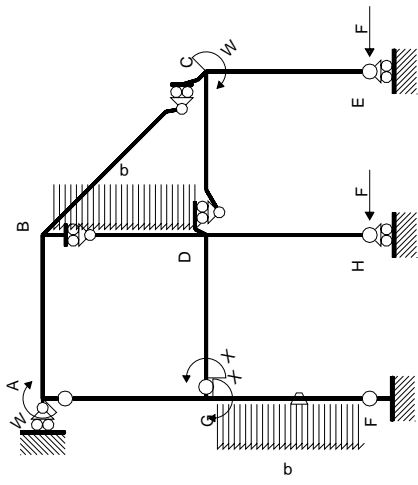
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



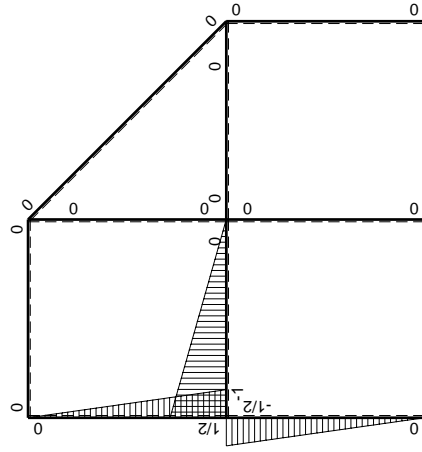
- A = 534. mm<sup>2</sup>
- J<sub>u</sub> = 194732. mm<sup>4</sup>
- J<sub>v</sub> = 28386. mm<sup>4</sup>
- y<sub>g</sub> = 29.94 mm
- T<sub>y</sub> = -2300. N
- M<sub>x</sub> = -1495000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -29.94 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -229.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 7. mm
- v<sub>c</sub> = -22.94 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -176.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.004 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup> + 3τ<sup>2</sup> = 176.4 N/mm<sup>2</sup>
- S = 3050. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	$Fb-2Fx$	0	0	0	0	0+0	0
BA b	0	$Fb-2Fx$	0	0	0	0	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (5/8 - x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [5/8 x - 1/2 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (5/8 b - 1/2 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

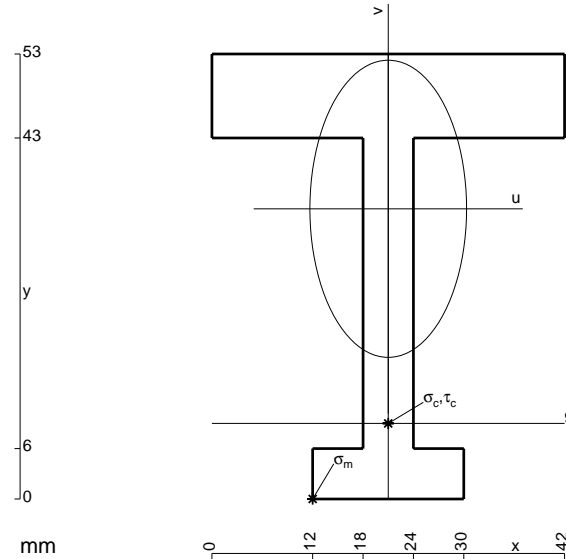
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-5/8 + 5/4 x/b - 5/8 x^2/b^2) Fb 1/EJ dx = [-5/8 x + 5/8 x^2/b - 5/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/8 b + 5/8 b - 5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$

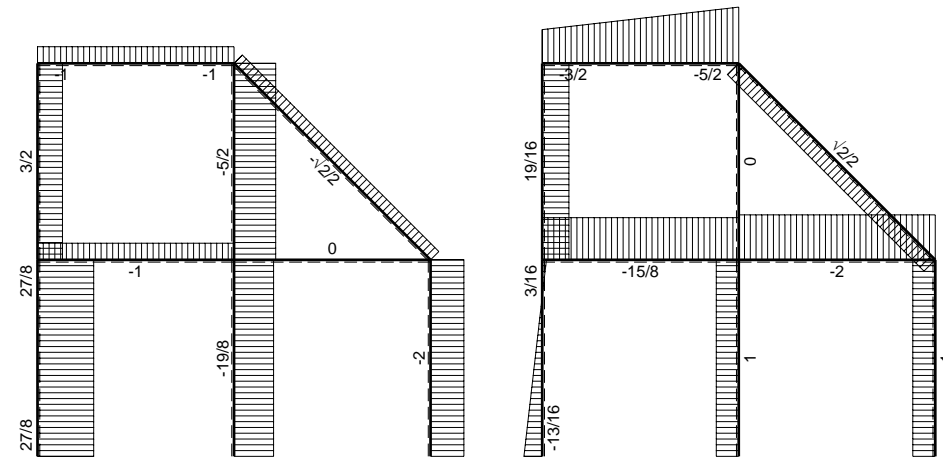
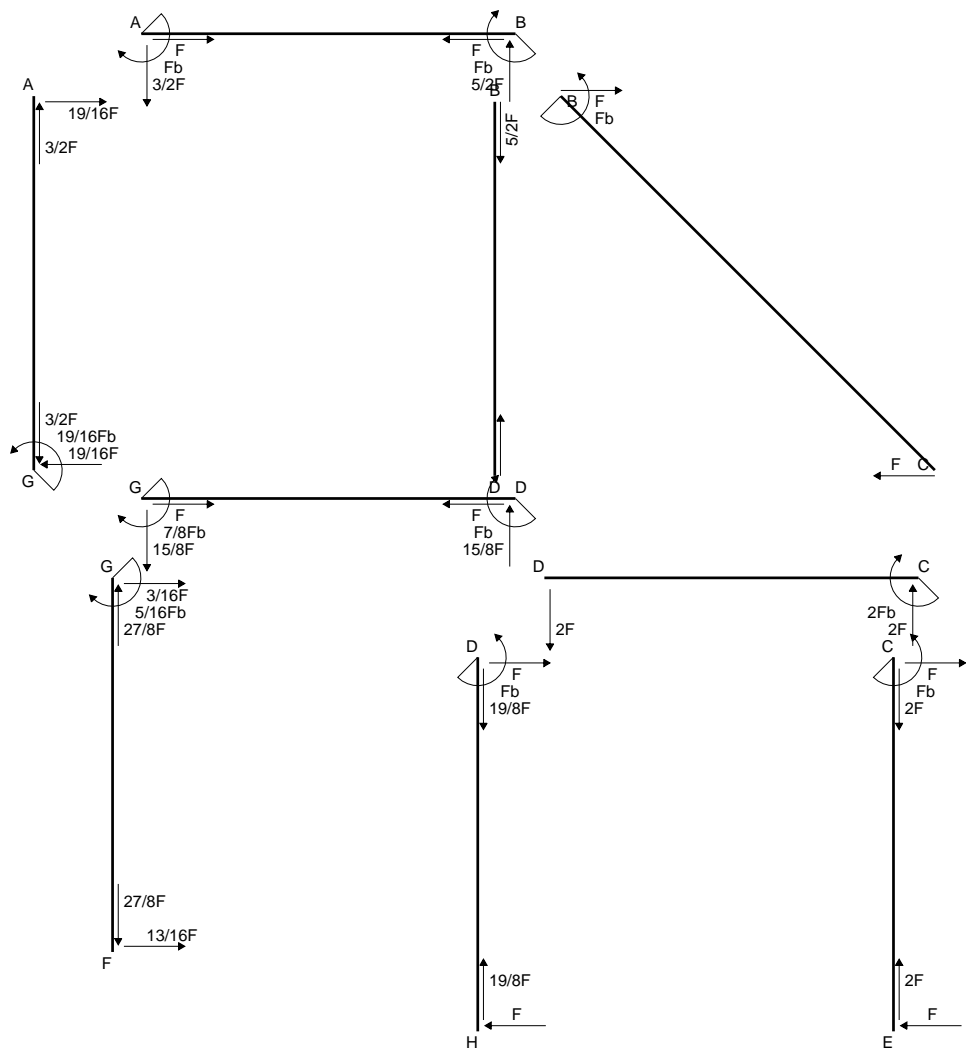
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2) Fb 1/EJ dx = [-5/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$



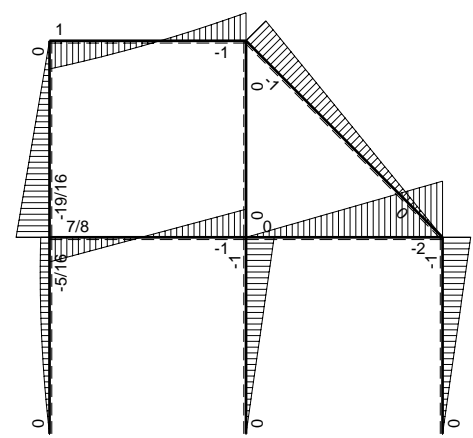
- A = 750. mm<sup>2</sup>
- J<sub>u</sub> = 235055. mm<sup>4</sup>
- J<sub>v</sub> = 65322. mm<sup>4</sup>
- y<sub>g</sub> = 34.56 mm
- T<sub>y</sub> = -2320. N
- M<sub>x</sub> = -1624000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -34.56 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -238.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -25.56 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -176.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.409 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 177. N/mm<sup>2</sup>
- S = 3896. mm<sup>3</sup>



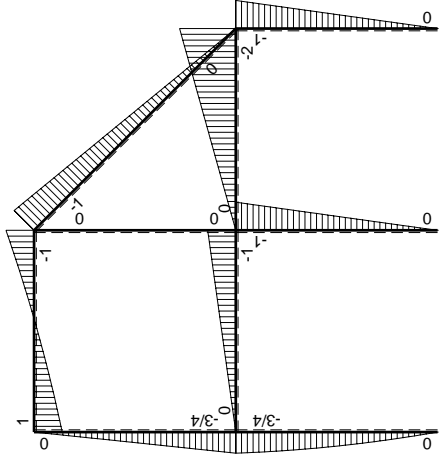
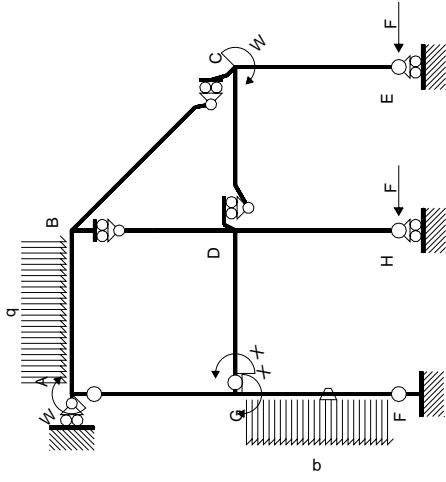


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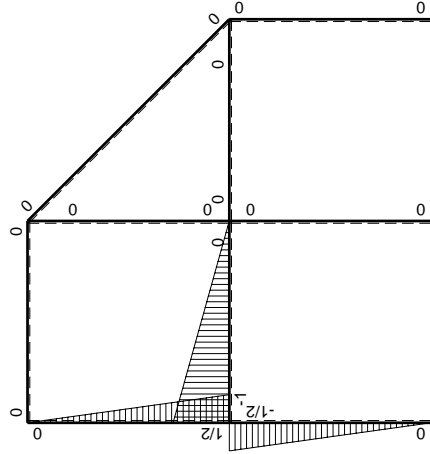


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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	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	0+0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0+0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

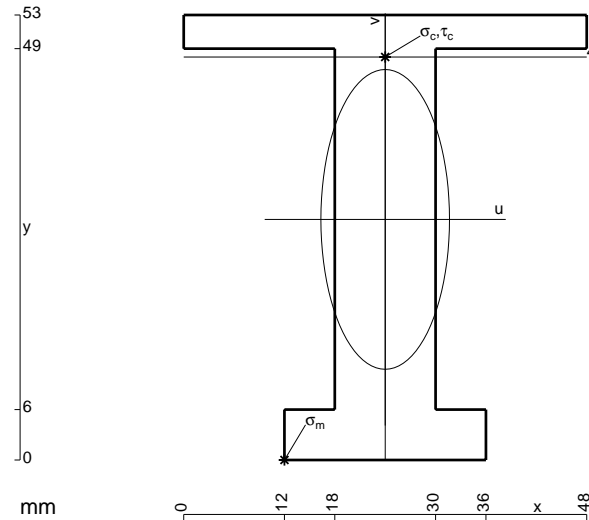
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

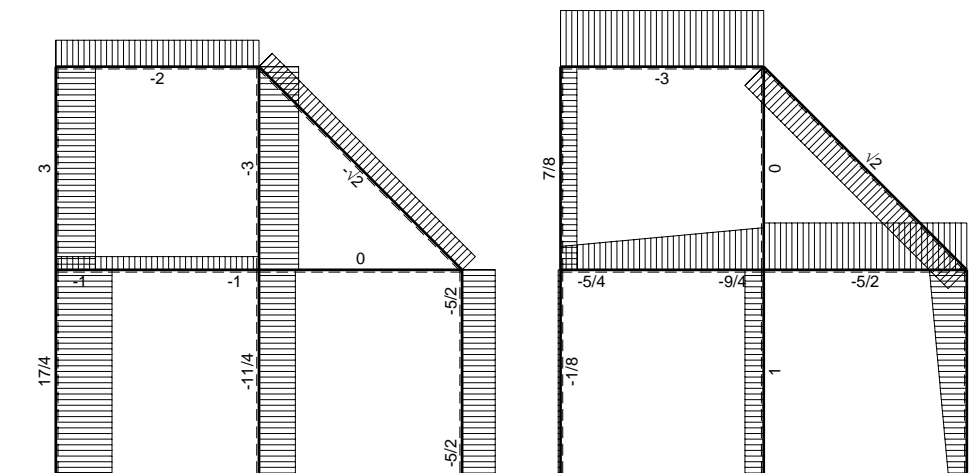
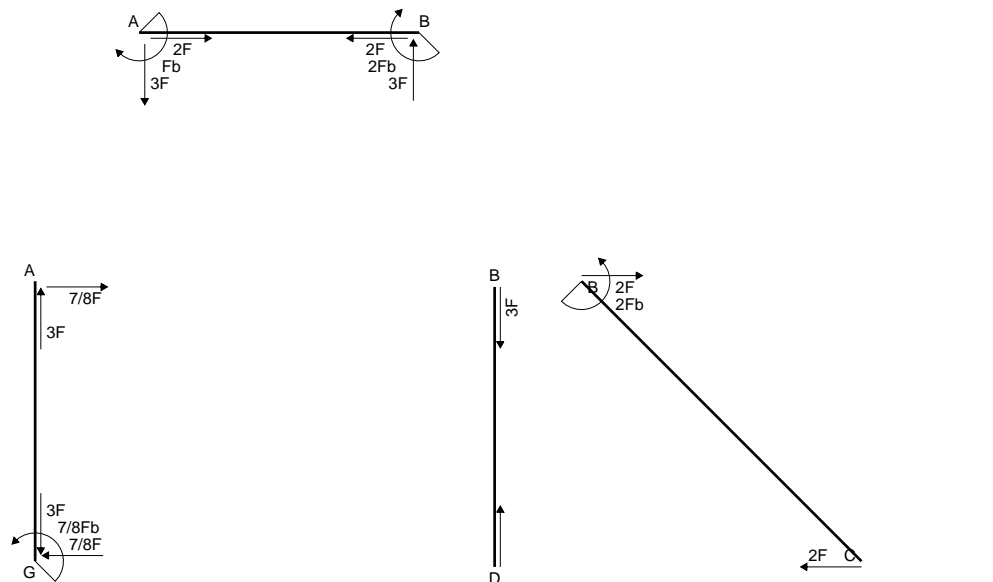
$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

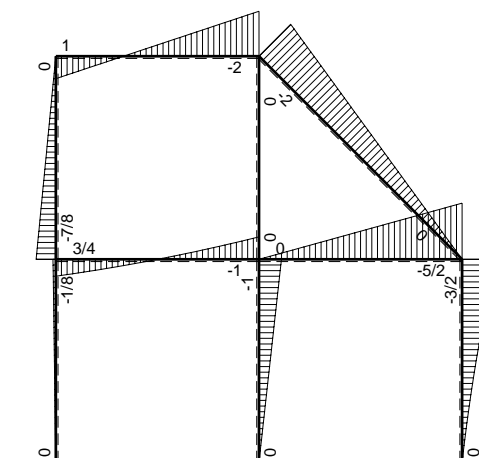
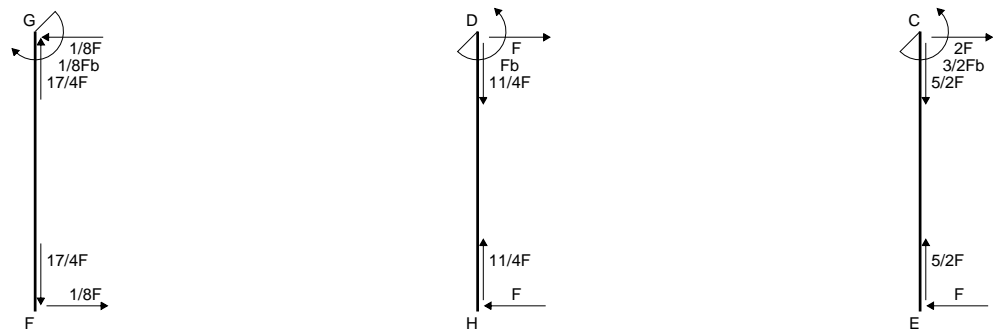
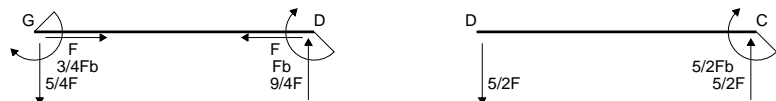


- A = 852. mm<sup>2</sup>
- J<sub>u</sub> = 271527. mm<sup>4</sup>
- J<sub>v</sub> = 49968. mm<sup>4</sup>
- y<sub>g</sub> = 28.65 mm
- T<sub>y</sub> = -2520. N
- M<sub>x</sub> = -1890000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -28.65 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -199.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 48. mm
- v<sub>c</sub> = 19.35 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 134.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.502 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 134.8 N/mm<sup>2</sup>
- S = 4528. mm<sup>3</sup>

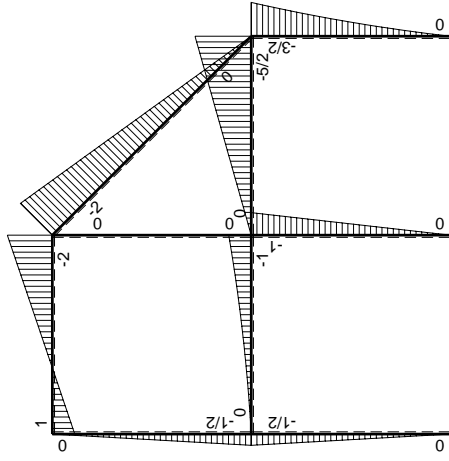
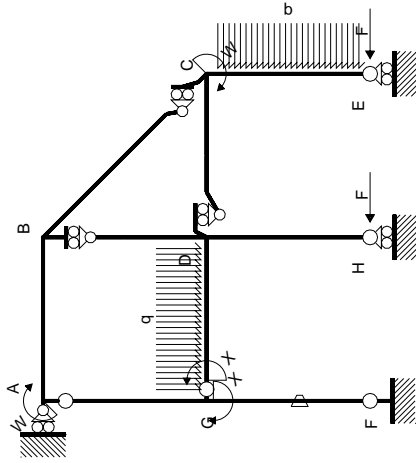


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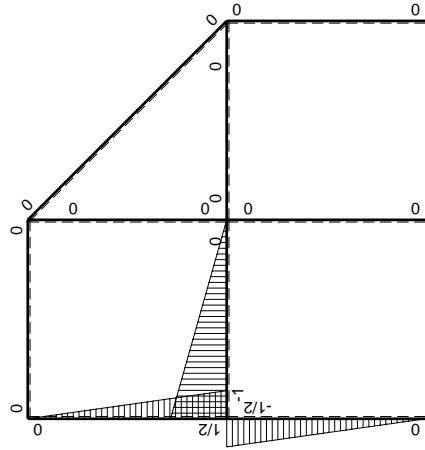


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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 <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	-1/2Fx	-Fb/EJ	1/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-1/2Fx	Fb/EJ	1/4Fb-1/2Fx+1/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							3/8Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-3/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

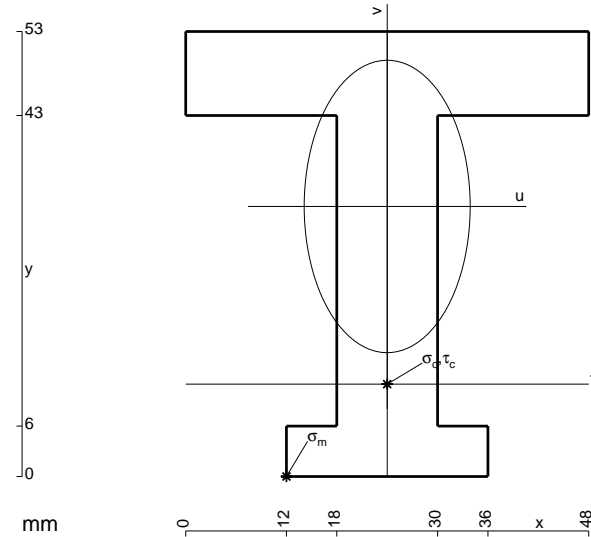
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



$$A = 1068. \text{ mm}^2$$

$$J_u = 324016. \text{ mm}^4$$

$$J_v = 104400. \text{ mm}^4$$

$$y_g = 32.16 \text{ mm}$$

$$T_y = -2625. \text{ N}$$

$$M_x = -2100000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -32.16 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.5 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

$$v_c = -21.16 \text{ mm}$$

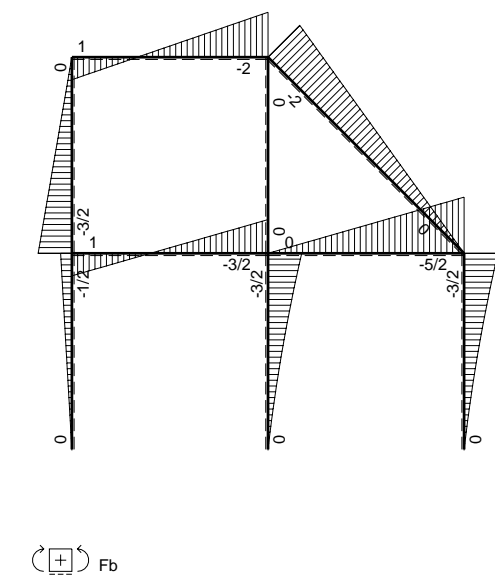
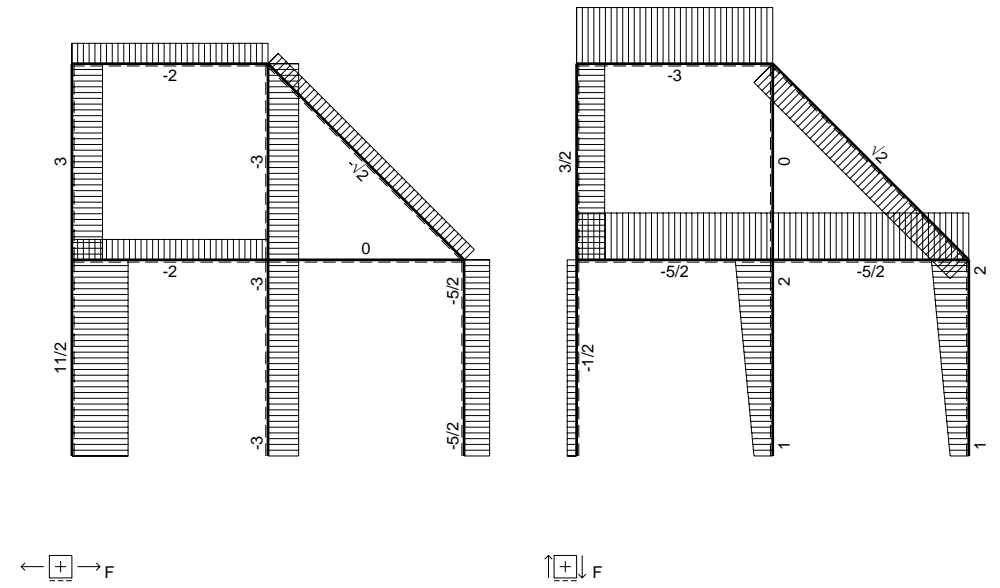
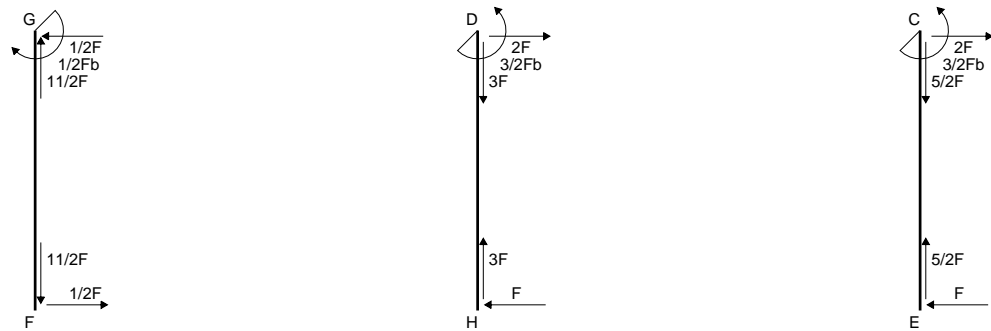
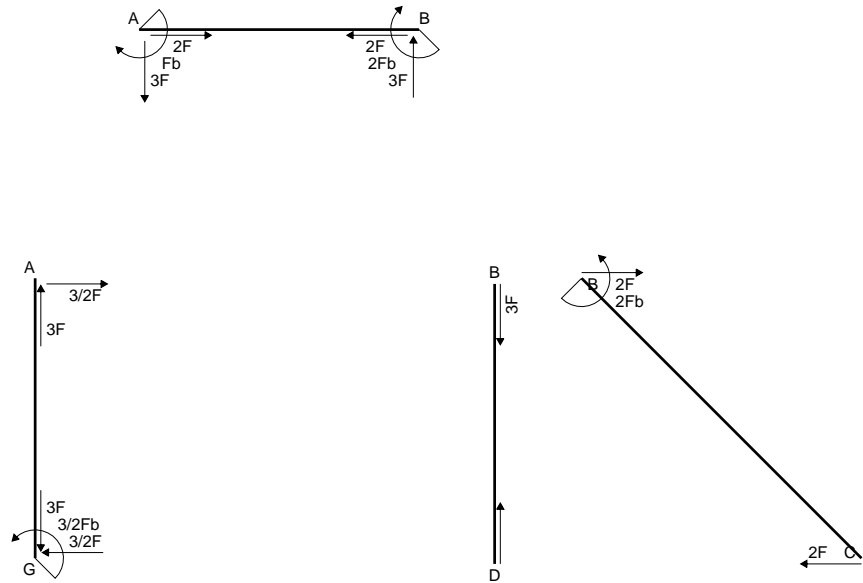
$$\sigma_c = -Mv/J_u = -137.2 \text{ N/mm}^2$$

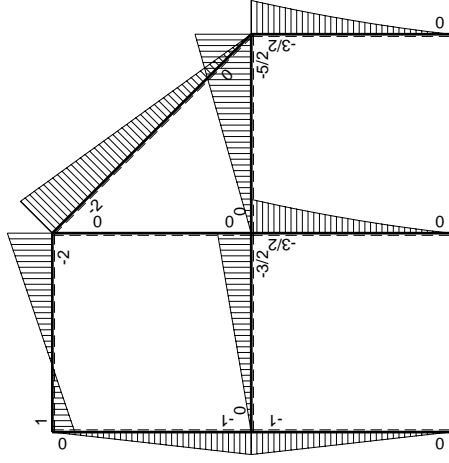
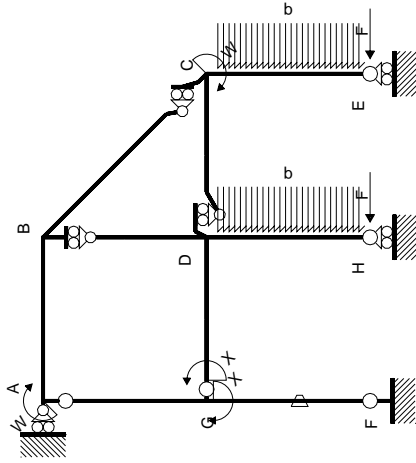
$$\tau_c = 3.794 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 137.3 \text{ N/mm}^2$$

$$S = 5619. \text{ mm}^3$$

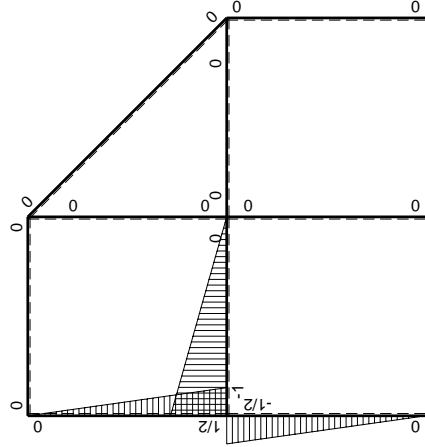






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	Fb-3Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-3Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							1/2Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

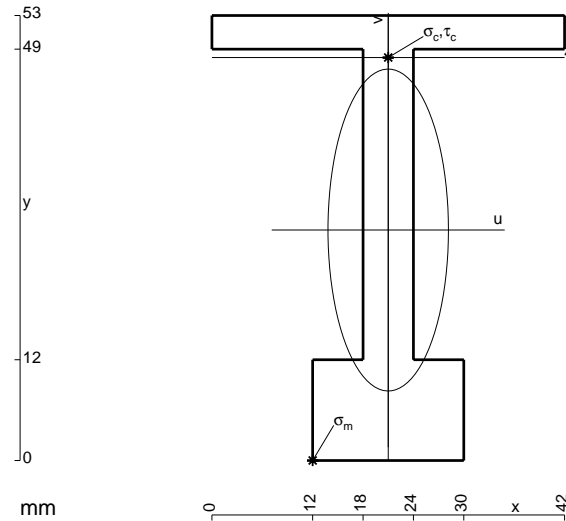
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

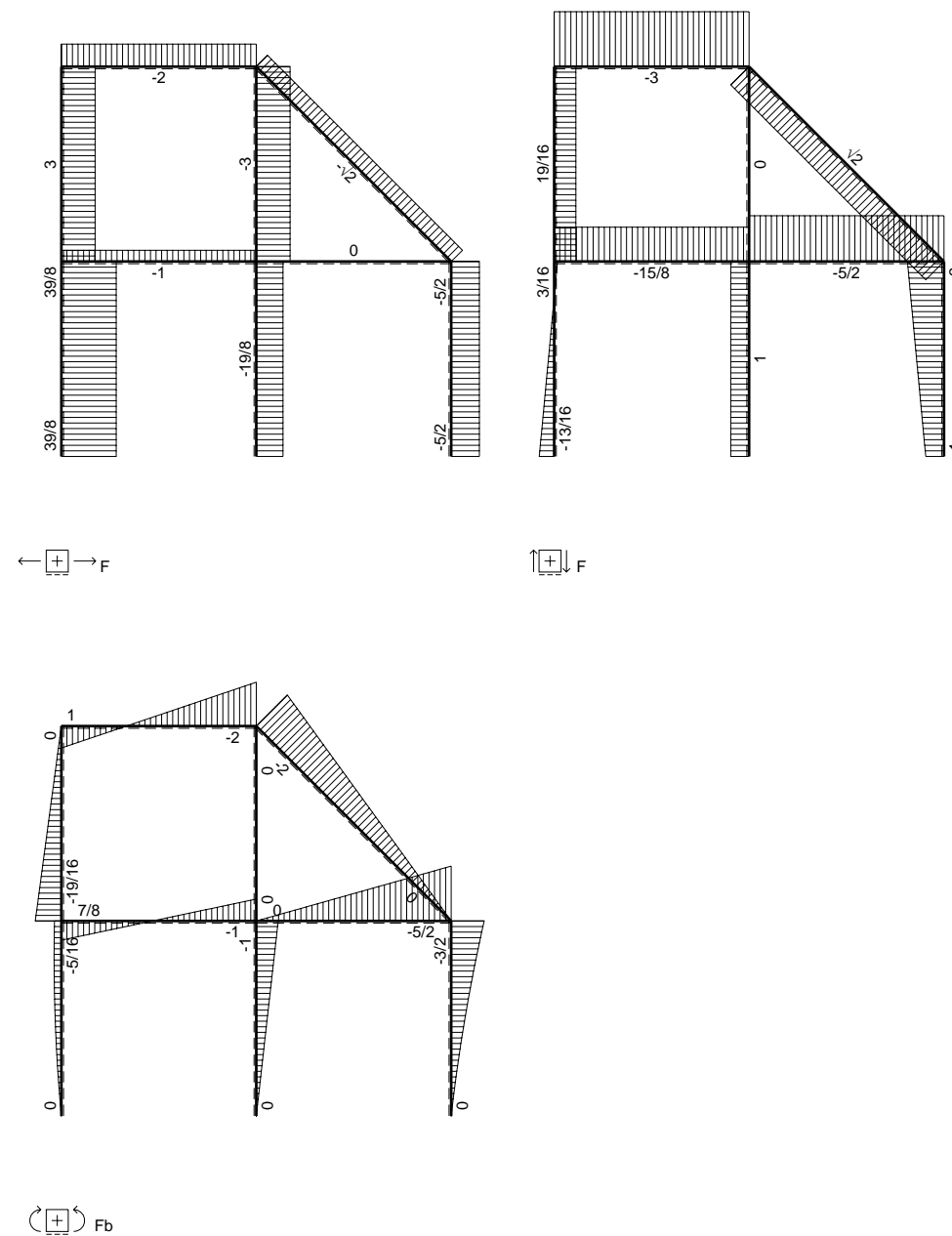
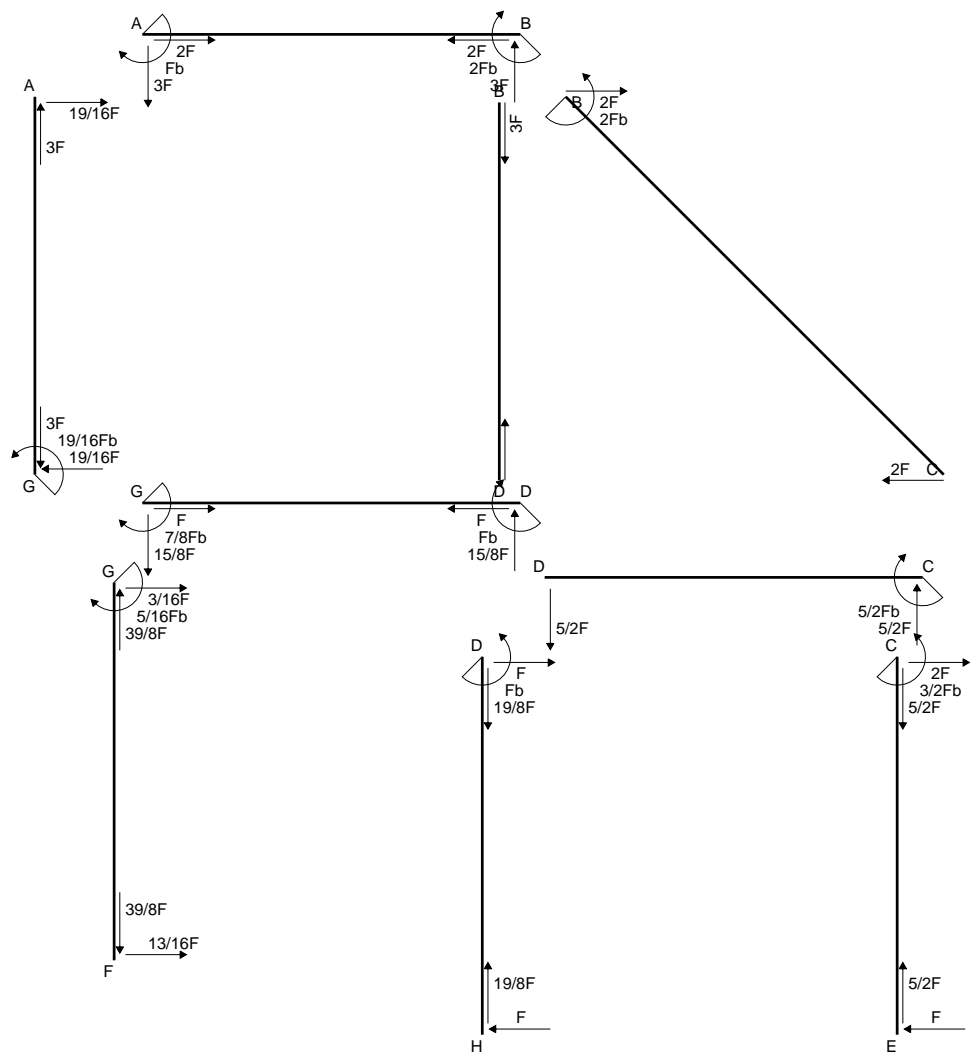
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

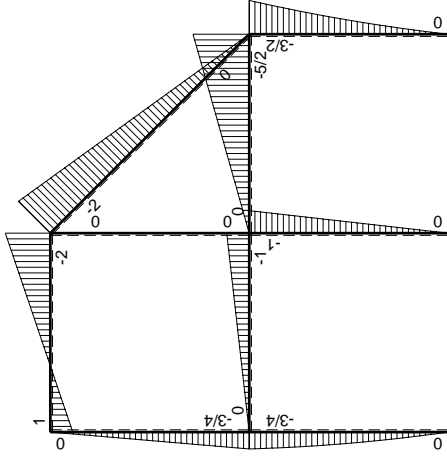
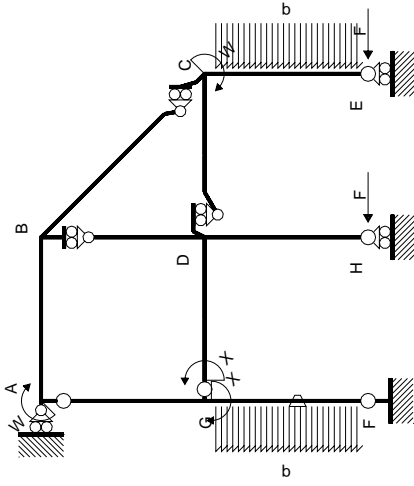
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



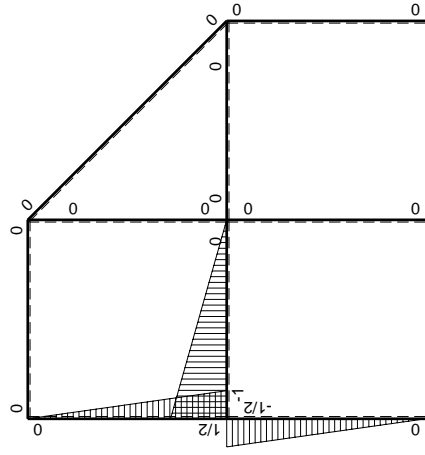
- A = 606. mm<sup>2</sup>
- J<sub>u</sub> = 222763. mm<sup>4</sup>
- J<sub>v</sub> = 31194. mm<sup>4</sup>
- y<sub>g</sub> = 27.45 mm
- T<sub>y</sub> = -2100. N
- M<sub>x</sub> = -1785000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -27.45 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -220. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 48. mm
- v<sub>c</sub> = 20.55 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 164.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.415 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 165. N/mm<sup>2</sup>
- S = 4083. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

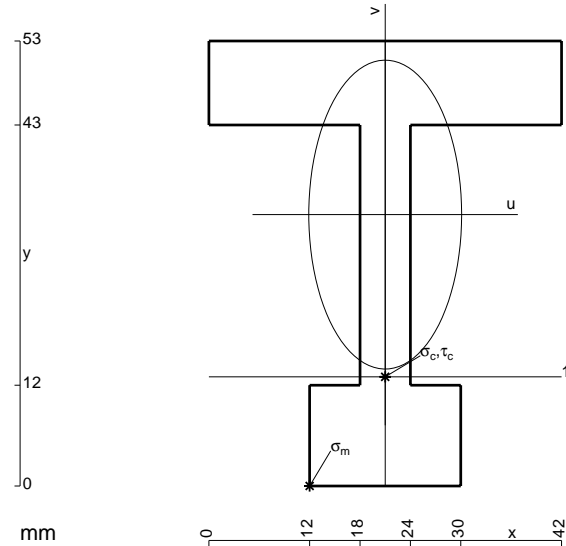
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

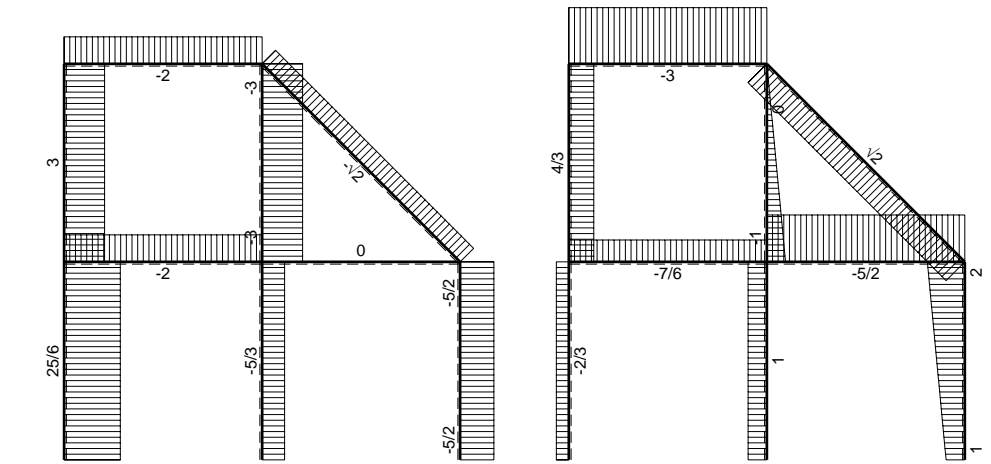
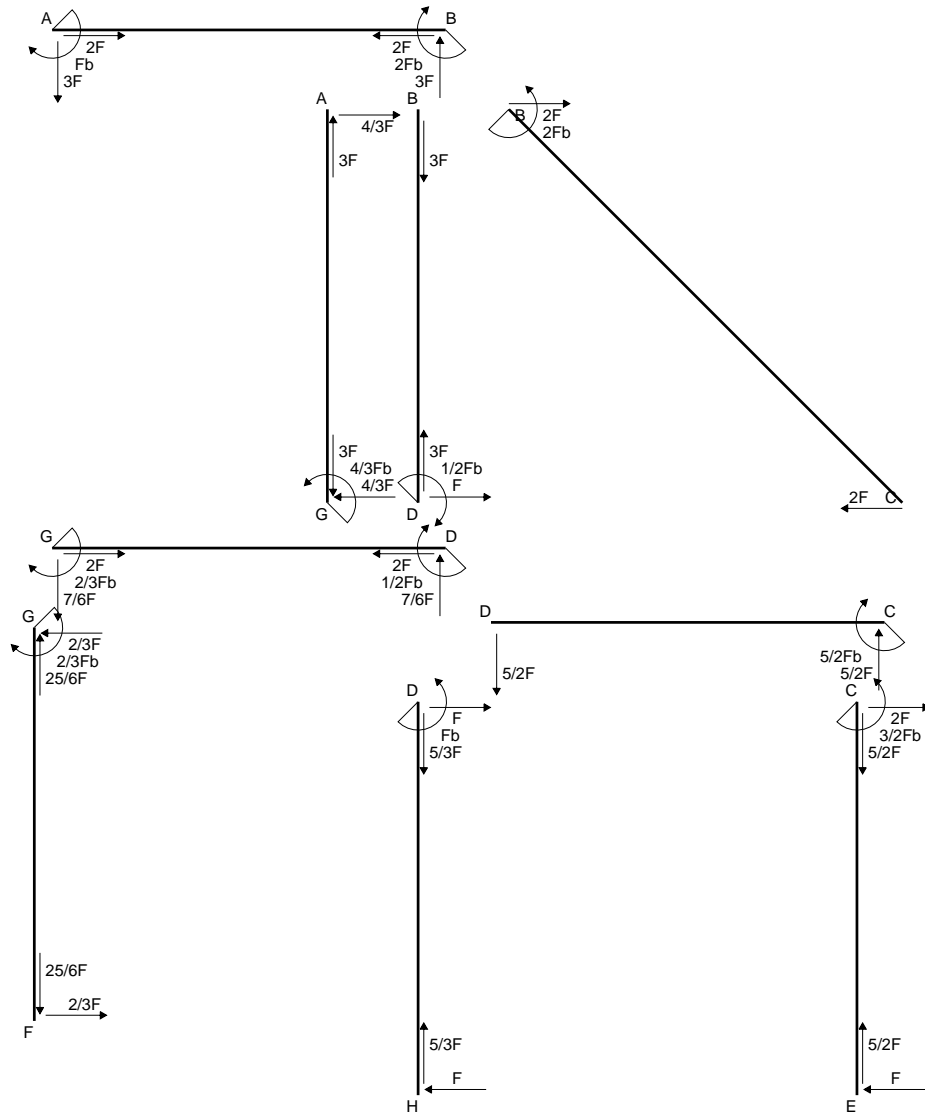
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



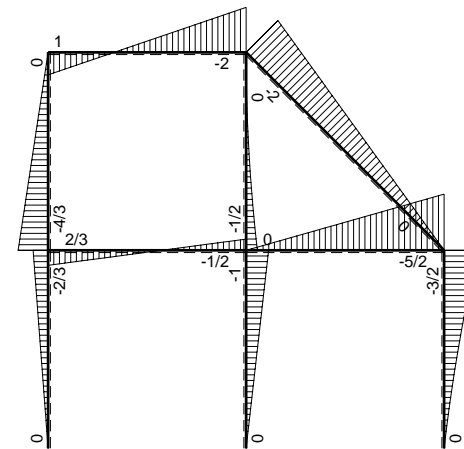
- A = 822. mm<sup>2</sup>
- J<sub>u</sub> = 278203. mm<sup>4</sup>
- J<sub>v</sub> = 68130. mm<sup>4</sup>
- y<sub>g</sub> = 32.32 mm
- T<sub>y</sub> = -2175. N
- M<sub>x</sub> = -1957500. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -32.32 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -227.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -19.32 mm
- σ<sub>c</sub> = -Mv/J<sub>v</sub> = -136. N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.564 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 136.6 N/mm<sup>2</sup>
- S = 5805. mm<sup>3</sup>



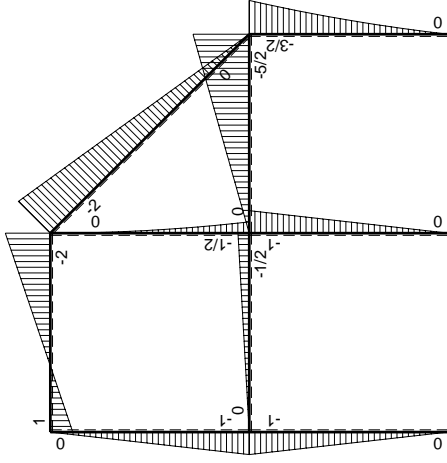
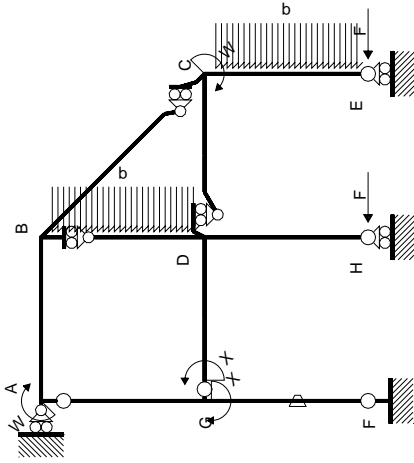


← (+) → F

↑ (+) ↓ F

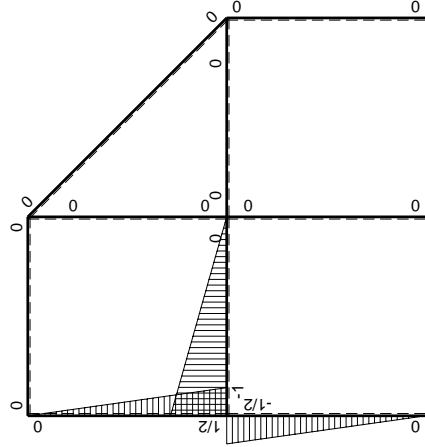


⤵ (+) ⤴ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	Fb-3Fx	0	0	0	0	0+0	0
BA b	0	2Fb-3Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						1/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

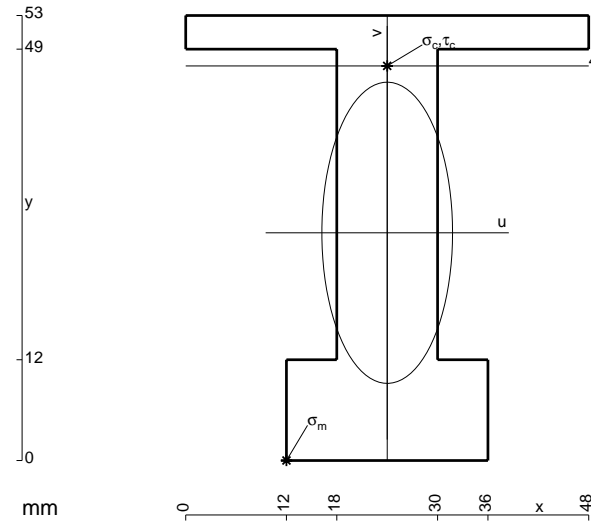
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

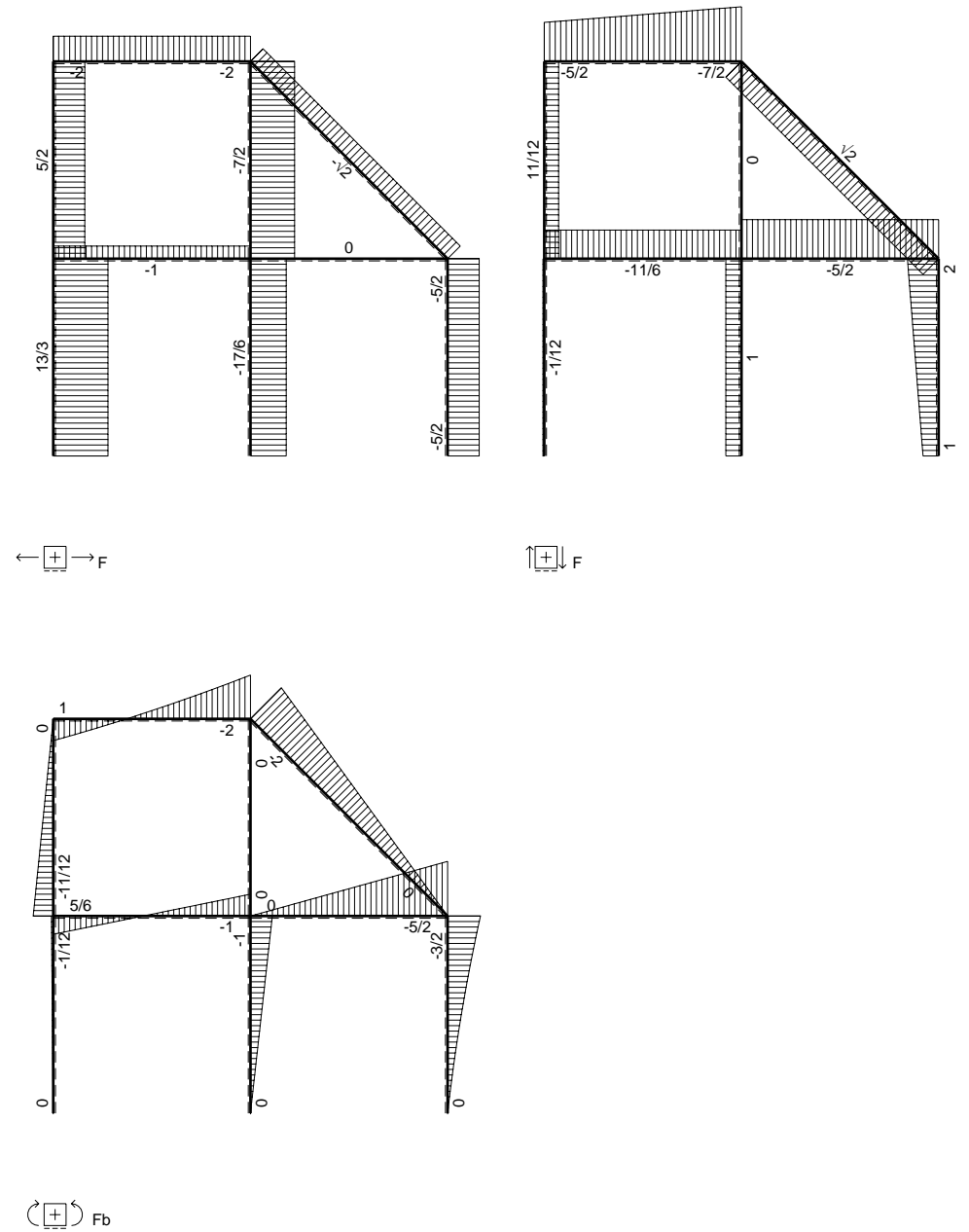
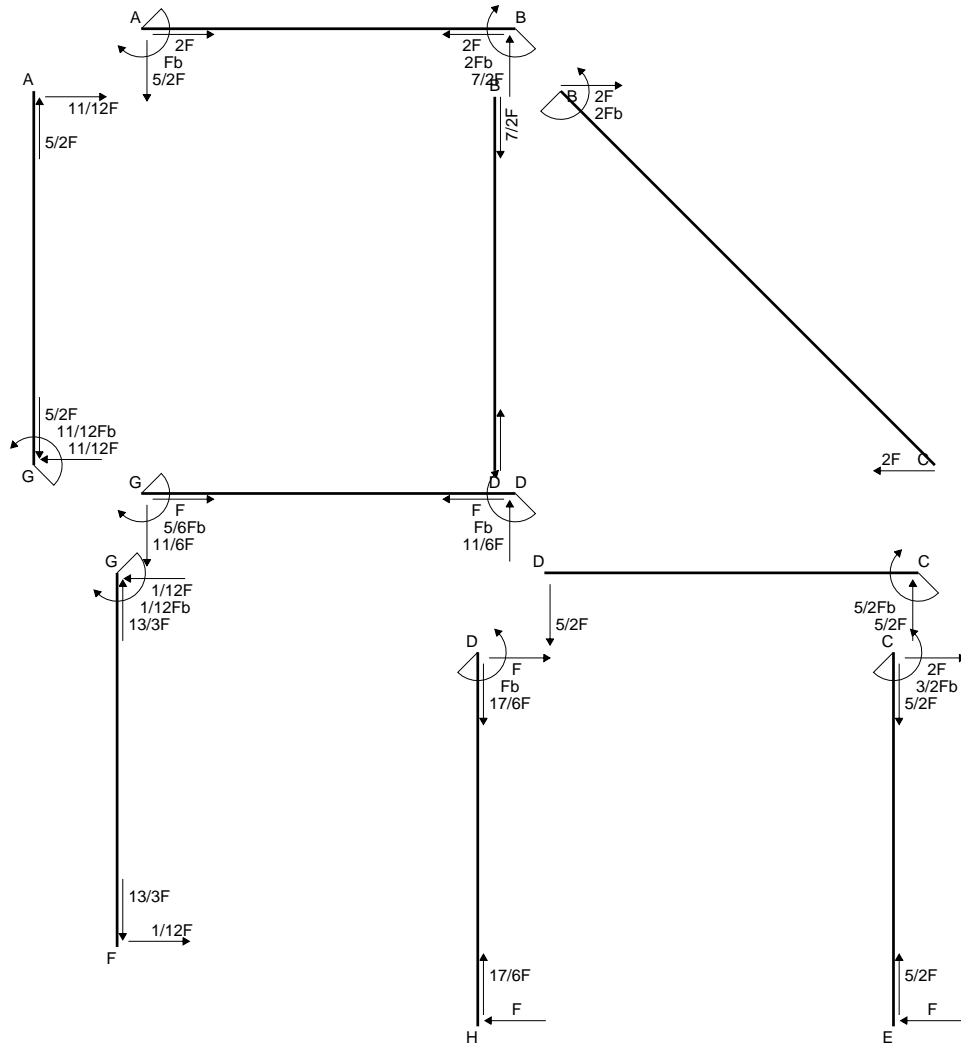
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

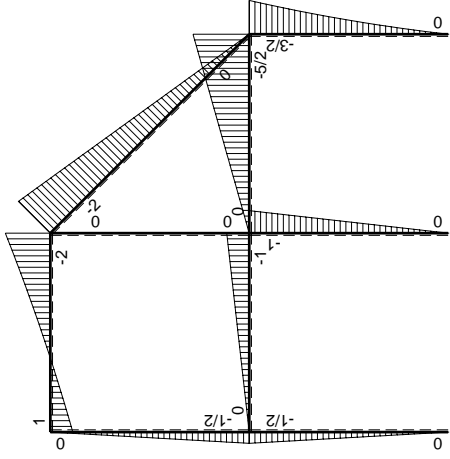
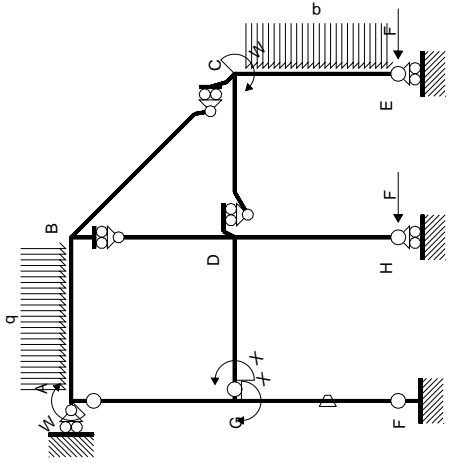
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



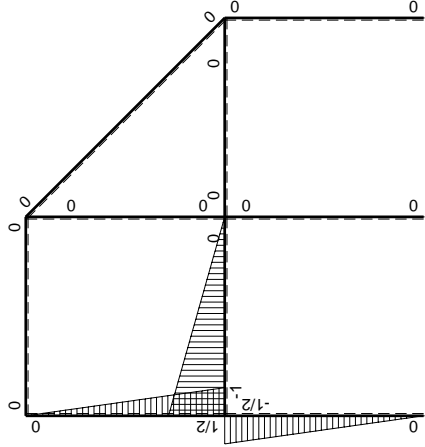
- A = 924. mm<sup>2</sup>
- J<sub>u</sub> = 297390. mm<sup>4</sup>
- J<sub>v</sub> = 56016. mm<sup>4</sup>
- y<sub>g</sub> = 27.12 mm
- T<sub>y</sub> = -2750. N
- M<sub>x</sub> = -2612500. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -27.12 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -238.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 47. mm
- v<sub>c</sub> = 19.88 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 174.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.919 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 174.7 N/mm<sup>2</sup>
- S = 5085. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

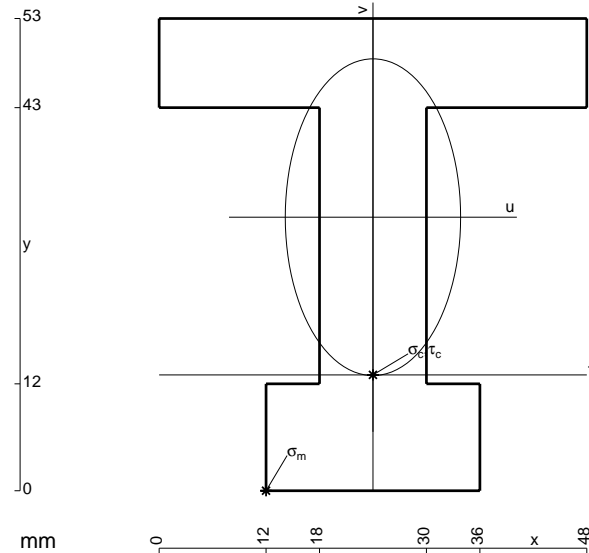
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

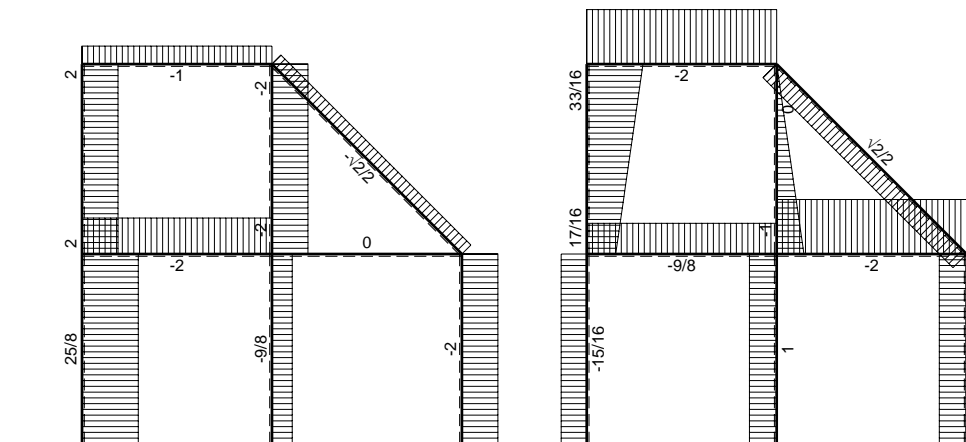
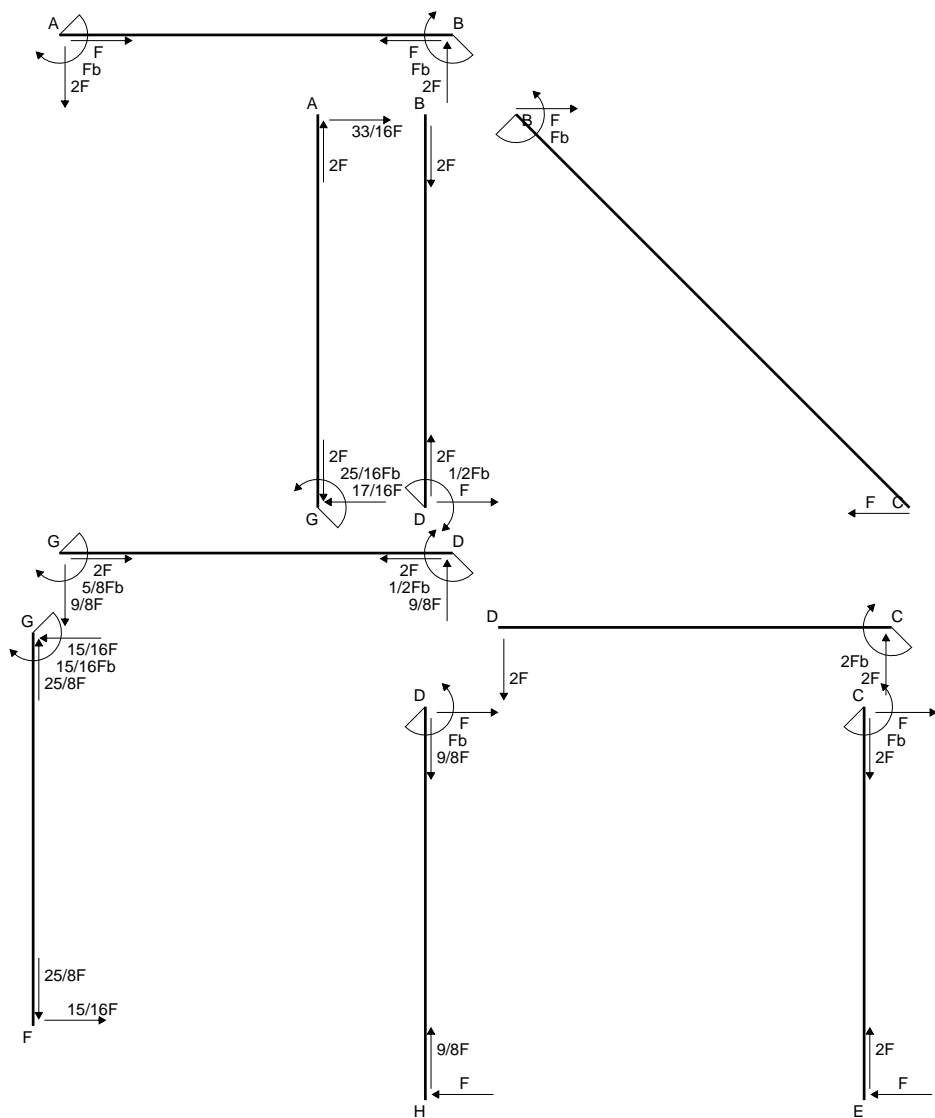
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



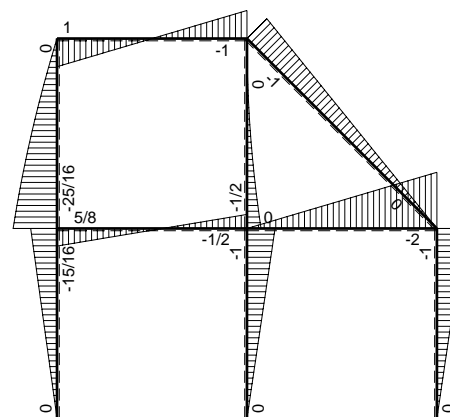
- A = 1140. mm<sup>2</sup>
- J<sub>u</sub> = 360421. mm<sup>4</sup>
- J<sub>v</sub> = 110448. mm<sup>4</sup>
- y<sub>g</sub> = 30.7 mm
- N = -4600. N
- T<sub>y</sub> = -8050. N
- M<sub>x</sub> = -2300000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -30.7 mm
- σ<sub>m</sub> = N/A-Mv/J<sub>u</sub> = -199.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -17.7 mm
- σ<sub>c</sub> = N/A-Mv/J<sub>u</sub> = -117. N/mm<sup>2</sup>
- τ<sub>c</sub> = 13.65 N/mm<sup>2</sup>
- σ<sub>q</sub> = √(σ<sup>2</sup>+3τ<sup>2</sup>) = 119.3 N/mm<sup>2</sup>
- S = 7332. mm<sup>3</sup>



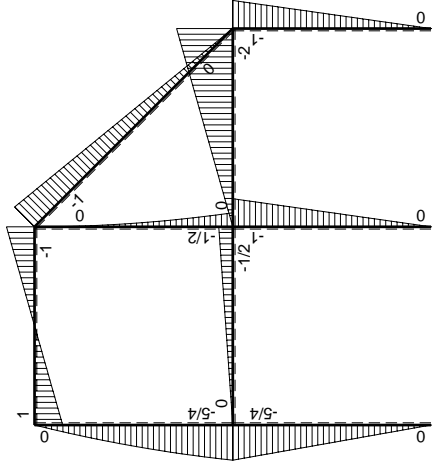
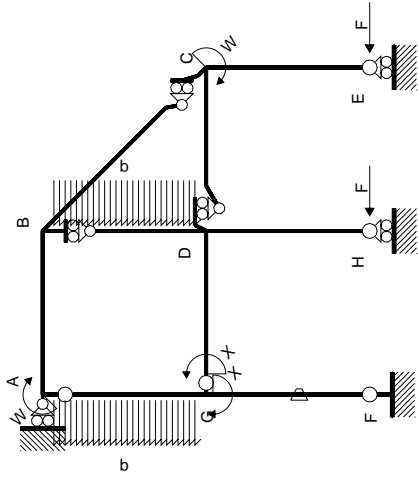


← ⊕ → F

↑ ⊕ ↓ F

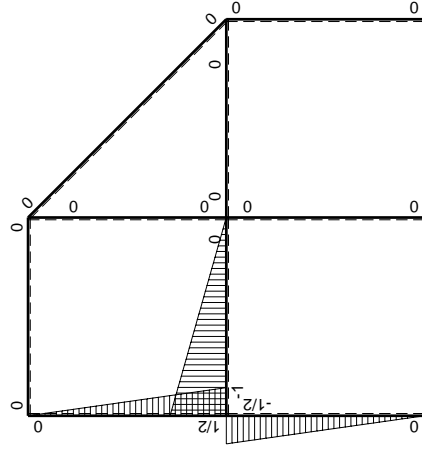


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-5/4Fx	-Fb/EJ	5/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(5/24+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-5/4Fx	Fb/EJ	5/8Fb-5/4Fx+5/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-5/4Fb+3/4Fx+1/2qx <sup>2</sup>	0	-5/8Fb+Fx-1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-11/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	7/4Fx-1/2qx <sup>2</sup>	0	-7/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 -2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b +1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b +1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [5/24 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b) Fb 1/EJ + (1/4 b) \theta = 11/24 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (5/8 -5/4 x/b +5/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 +1/2 x/b) \theta dx$$

$$= [5/8 x -5/8 x^2/b +5/24 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

$$= (5/8 b -5/8 b +5/24 b) Fb 1/EJ + (-1/2 b +1/4 b) \theta = 11/24 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b -1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b -1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b -1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b -1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b -1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b -1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

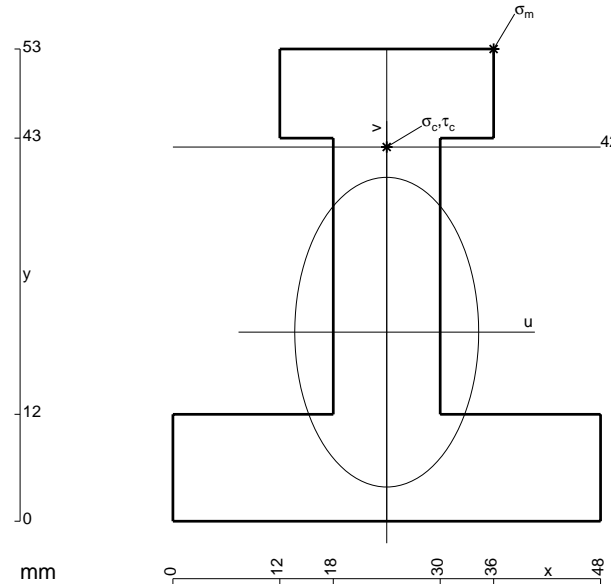
$$L_{GA}^{xo} = \int_0^b (-5/8 + x/b -1/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-5/8 x +1/2 x^2/b -1/24 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ$$

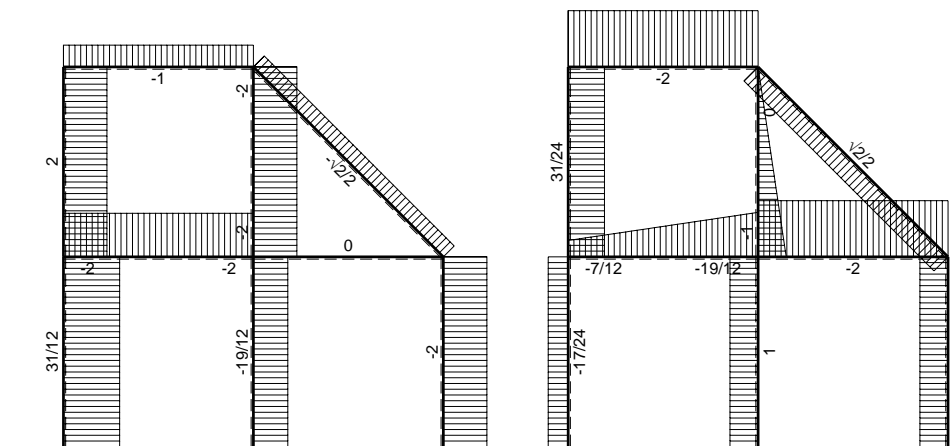
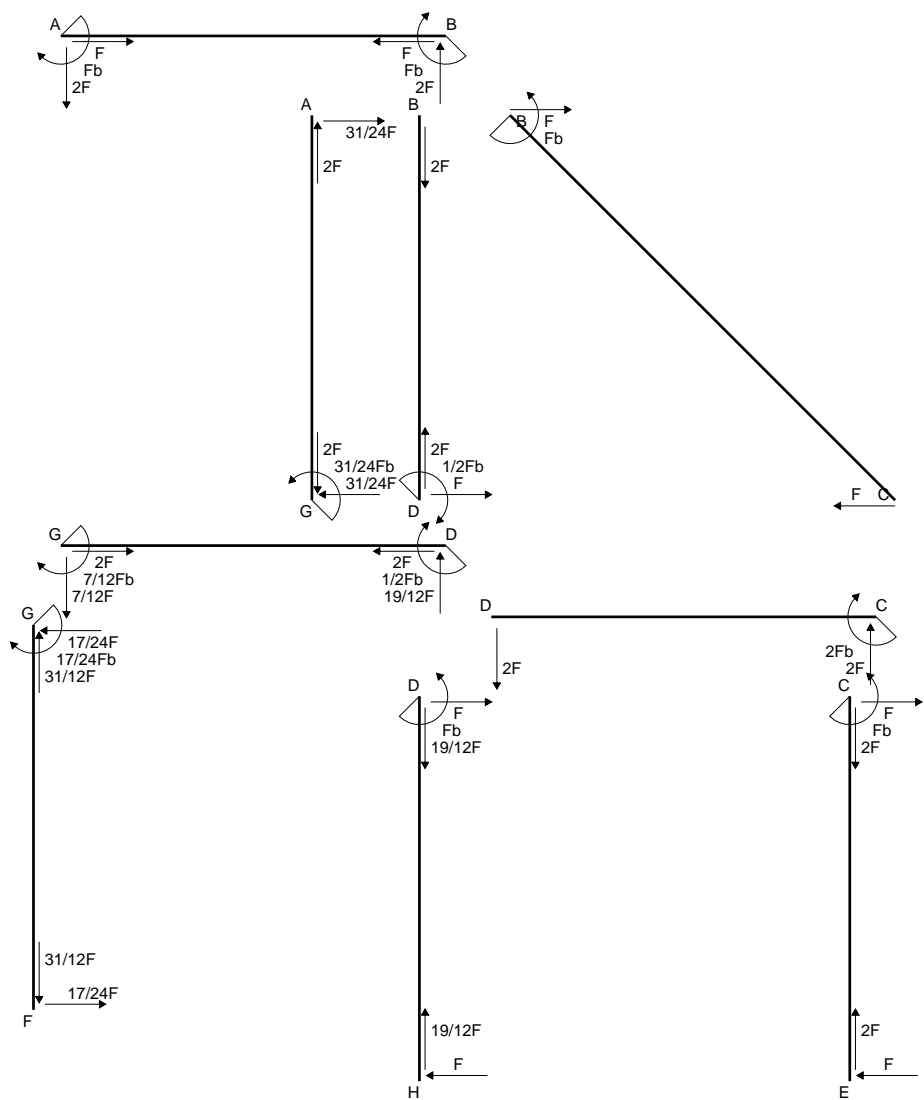
$$= (-5/8 b +1/2 b -1/24 b -1/16 b) Fb 1/EJ = -11/48 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-7/8 x^2/b^2 +1/4 x^3/b^3) Fb 1/EJ dx = [-7/24 x^3/b^2 +1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-7/24 b +1/16 b) Fb 1/EJ = -11/48 Fb^2/EJ$$

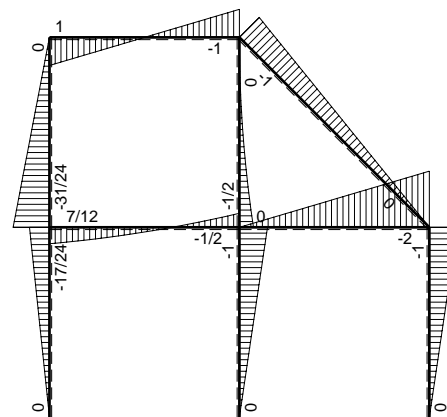


- A = 1188. mm<sup>2</sup>
- J<sub>u</sub> = 358924. mm<sup>4</sup>
- J<sub>v</sub> = 126576. mm<sup>4</sup>
- y<sub>g</sub> = 21.22 mm
- T<sub>y</sub> = -4300. N
- M<sub>x</sub> = -2365000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 31.78 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 20.78 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 136.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.672 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 137.4 N/mm<sup>2</sup>
- S = 6683. mm<sup>3</sup>

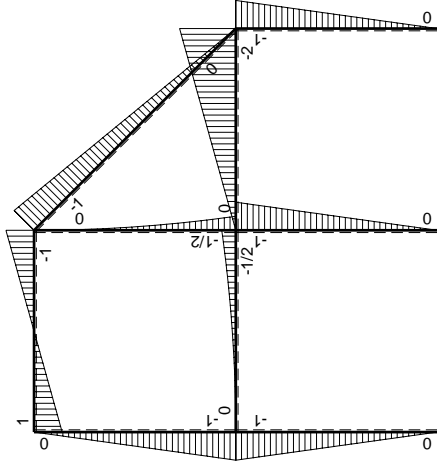
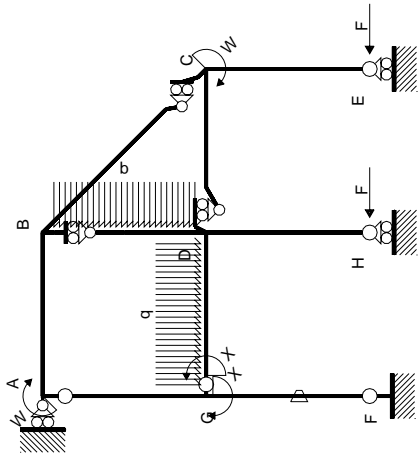


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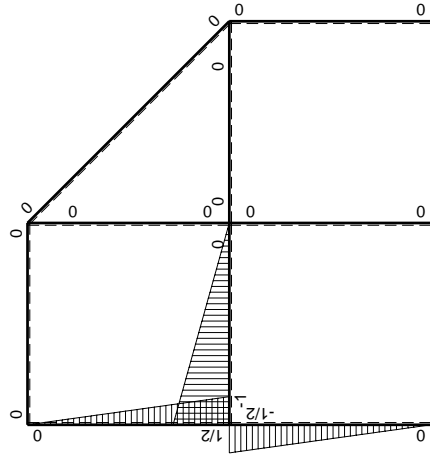


⤴ (+) ⤵ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2qx <sup>2</sup>	0	1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-Fx+1/2qx <sup>2</sup>	0	1/2Fx-Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/6 b - 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

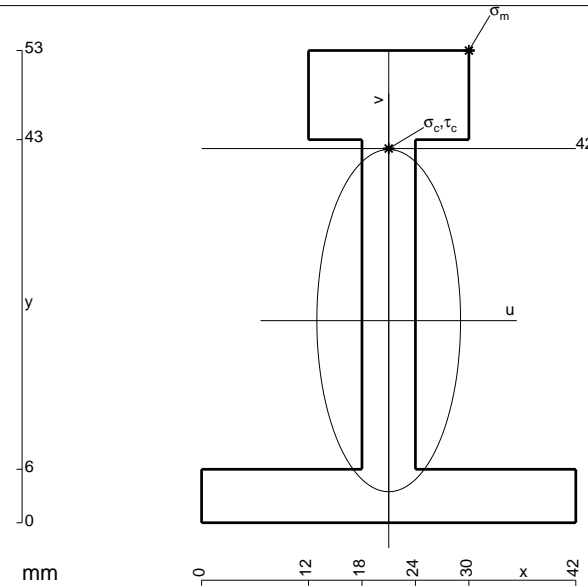
$$= (1/4 b - 1/3 b + 1/8 b) Fb 1/EJ = 1/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

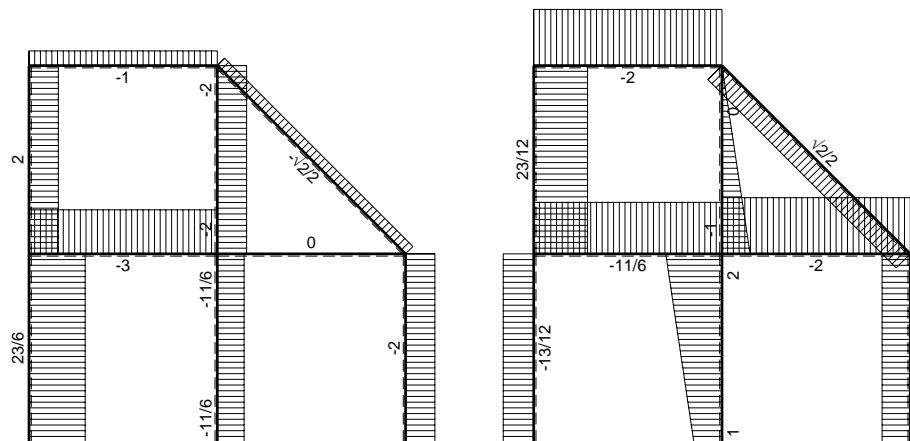
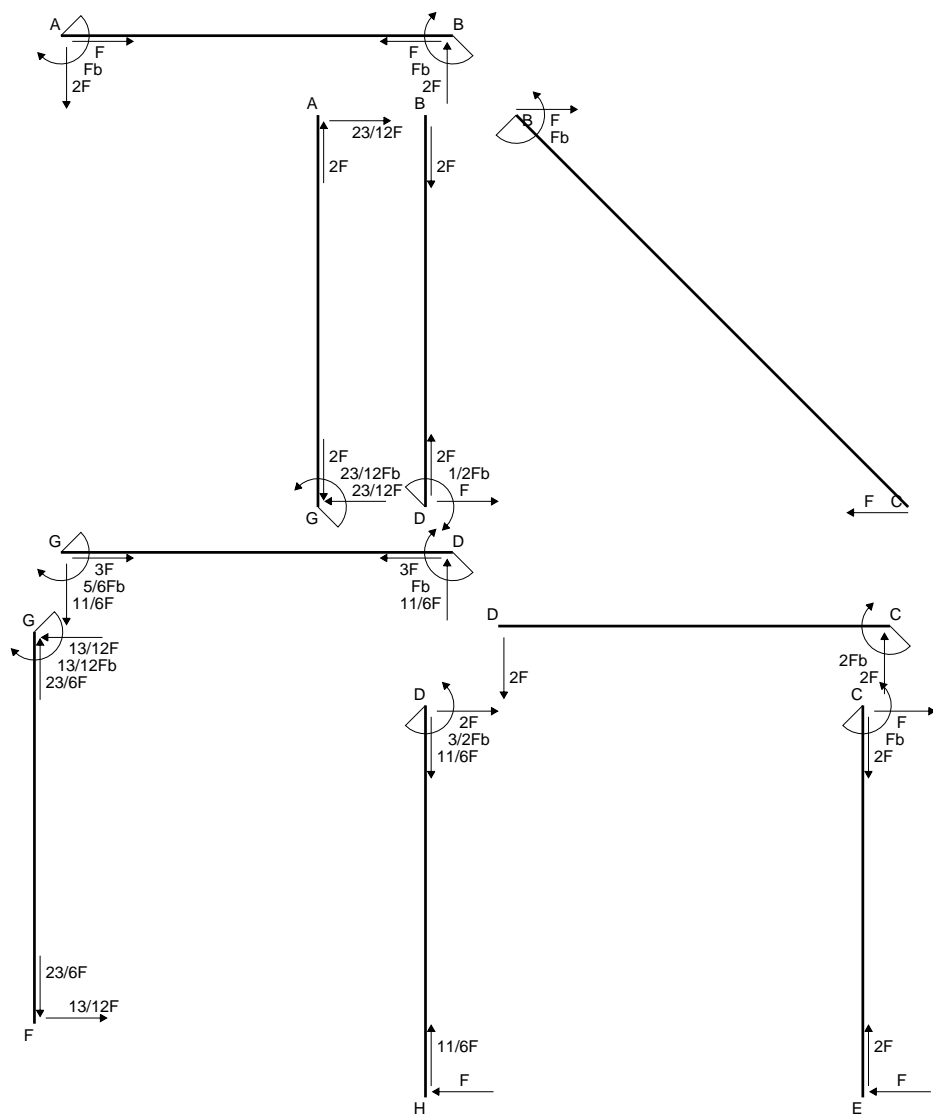
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



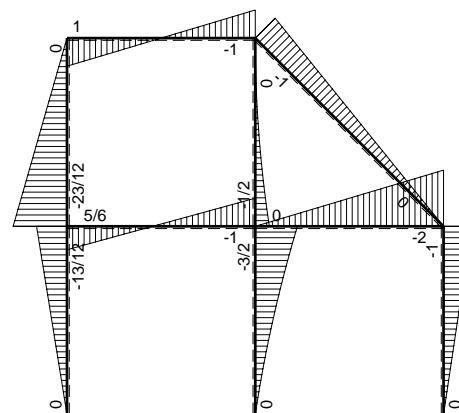
- A = 654. mm<sup>2</sup>
- J<sub>u</sub> = 241316. mm<sup>4</sup>
- J<sub>v</sub> = 42570. mm<sup>4</sup>
- y<sub>g</sub> = 22.68 mm
- T<sub>y</sub> = -2900. N
- M<sub>x</sub> = -1740000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 30.32 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 218.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 19.32 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 139.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 9.365 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 140.2 N/mm<sup>2</sup>
- S = 4676. mm<sup>3</sup>



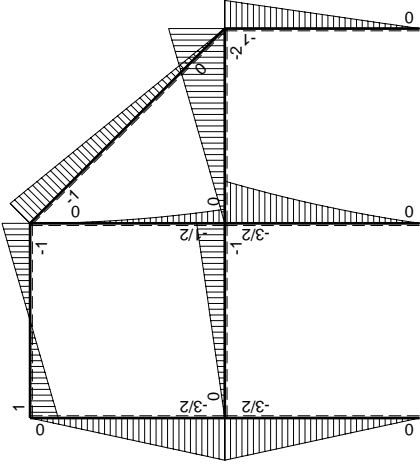
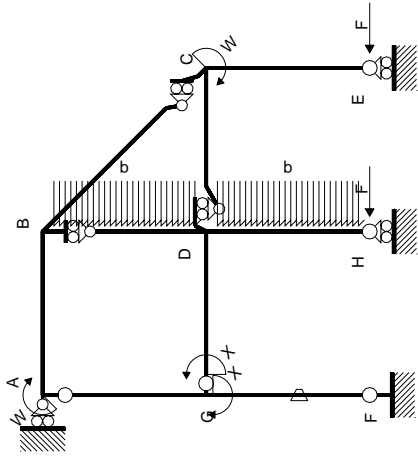


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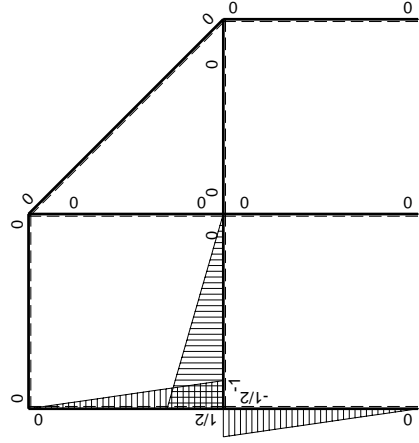


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
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 <sup>2</sup>	0	0	0	0	0+0	0	
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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 <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
GA b	1/2-1/2x/b	-3/2Fb+3/2Fx	0	-3/4Fb+3/2Fx-3/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/4+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	3/2Fx	0	-3/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							5/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/4 - 3/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/4 b - 3/4 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

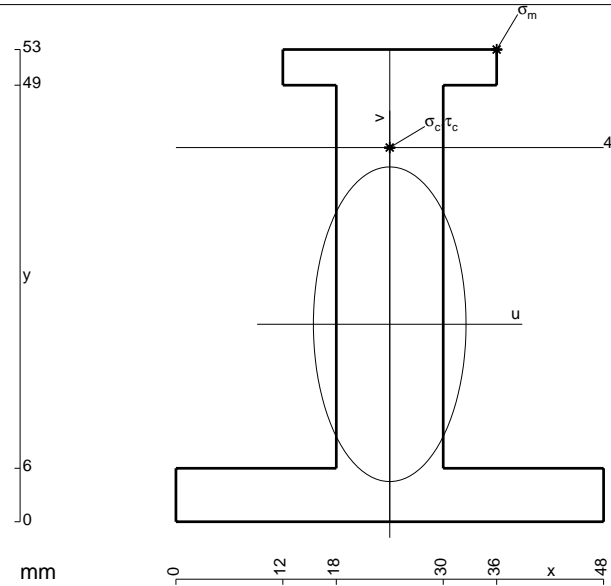
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/4 + 3/2 x/b - 3/4 x^2/b^2) Fb 1/EJ dx = [-3/4 x + 3/4 x^2/b - 1/4 x^3/b^2]_0^b Fb 1/EJ$$

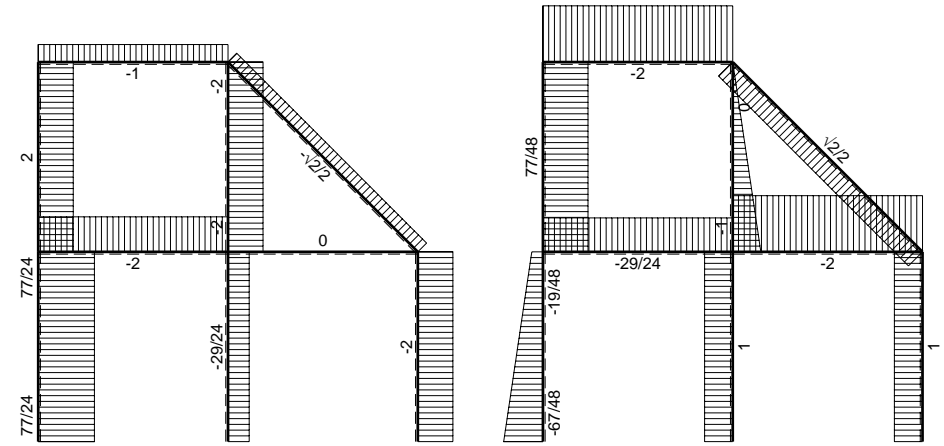
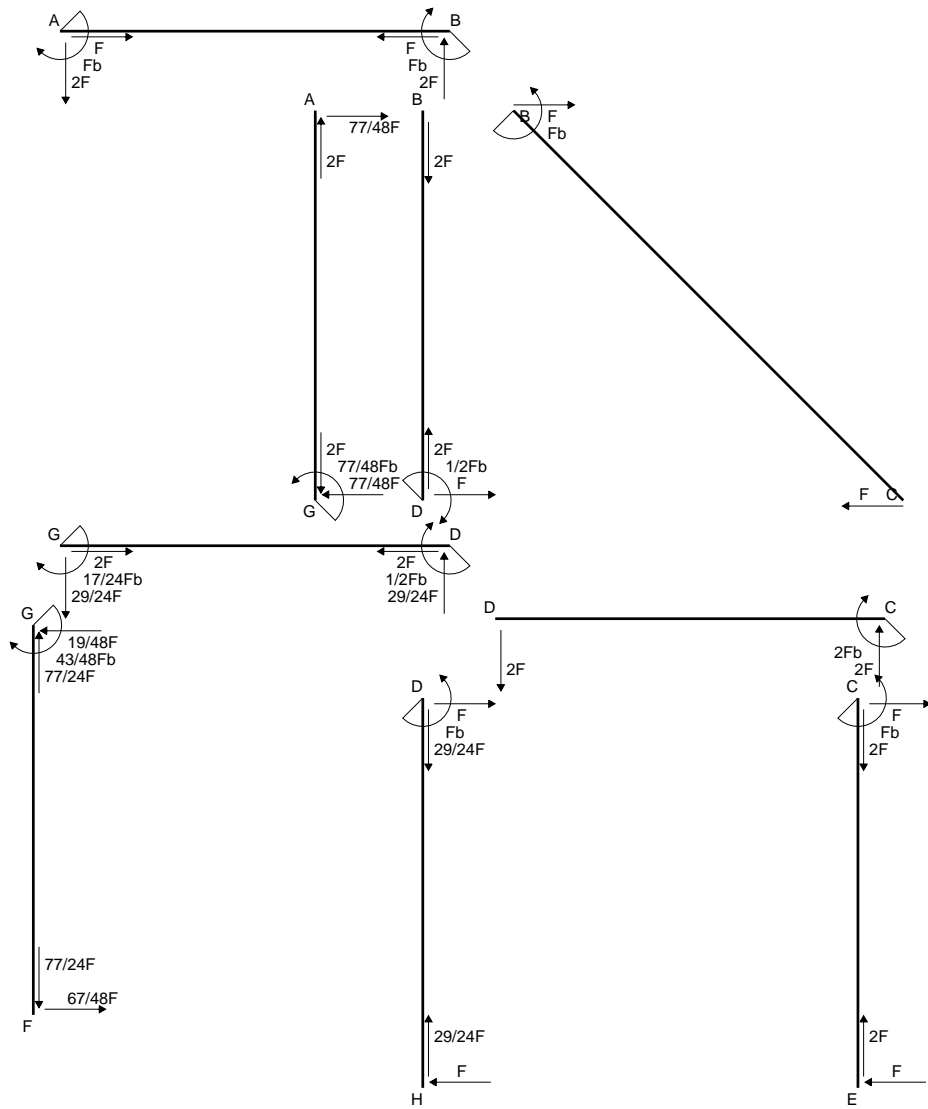
$$= (-3/4 b + 3/4 b - 1/4 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-3/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

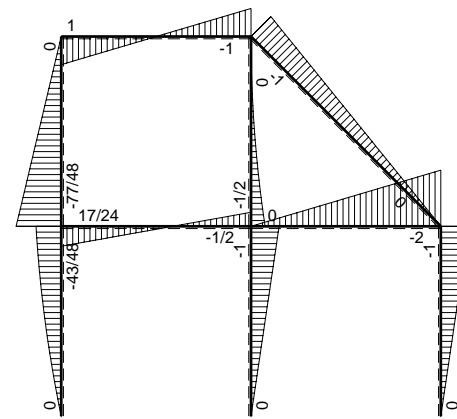


- A = 900. mm<sup>2</sup>
- J<sub>u</sub> = 280787. mm<sup>4</sup>
- J<sub>v</sub> = 66096. mm<sup>4</sup>
- y<sub>g</sub> = 22.17 mm
- T<sub>y</sub> = -3220. N
- M<sub>x</sub> = -2093000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 30.83 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 229.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 19.83 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 147.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.518 N/mm<sup>2</sup>
- σ<sub>φ</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 148. N/mm<sup>2</sup>
- S = 4728. mm<sup>3</sup>

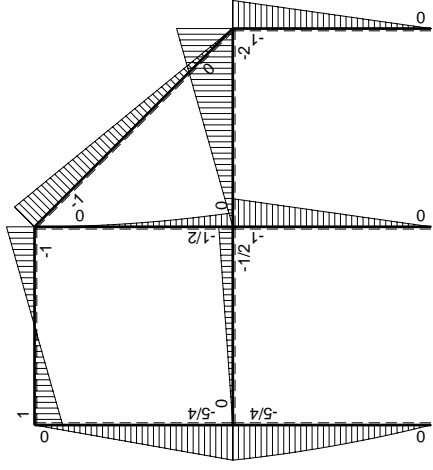
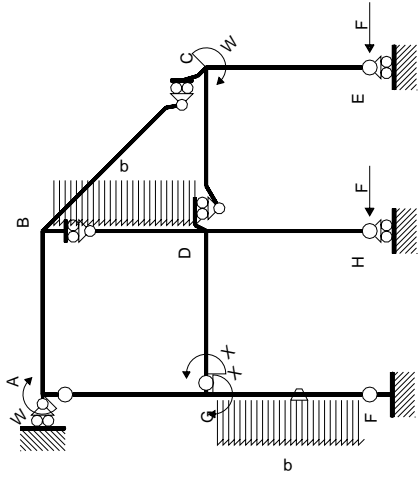


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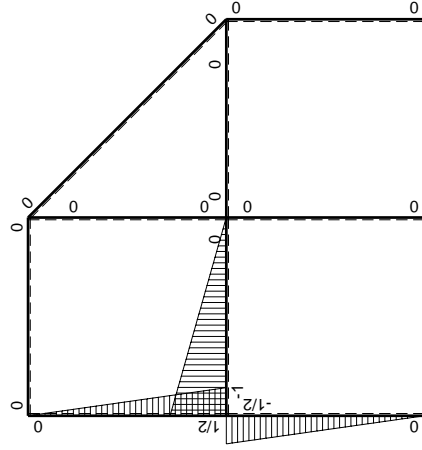


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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(11/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	5/8Fb-Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-5/4Fb+5/4Fx	0	-5/8Fb+5/4Fx-5/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-5/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx	0	-5/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						17/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-17/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (5/8 - x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [5/8 x - 1/2 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (5/8 b - 1/2 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

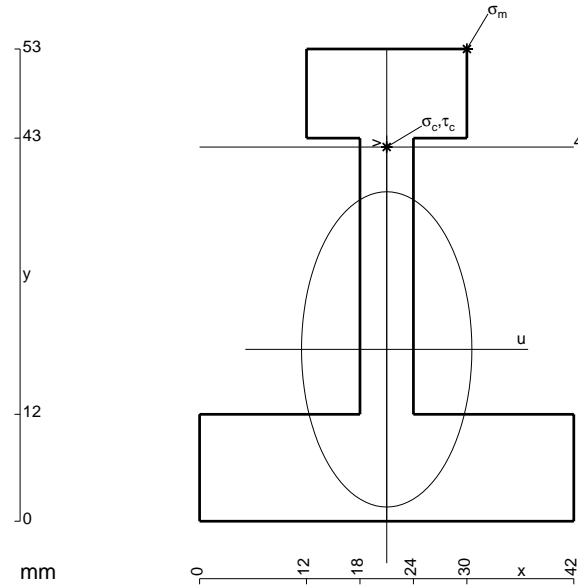
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-5/8 + 5/4 x/b - 5/8 x^2/b^2) Fb 1/EJ dx = [-5/8 x + 5/8 x^2/b - 5/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/8 b + 5/8 b - 5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$

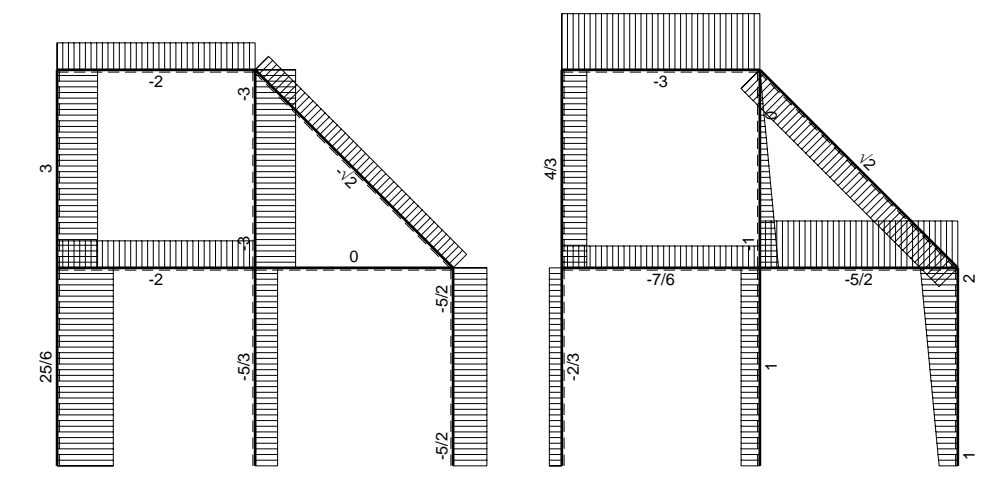
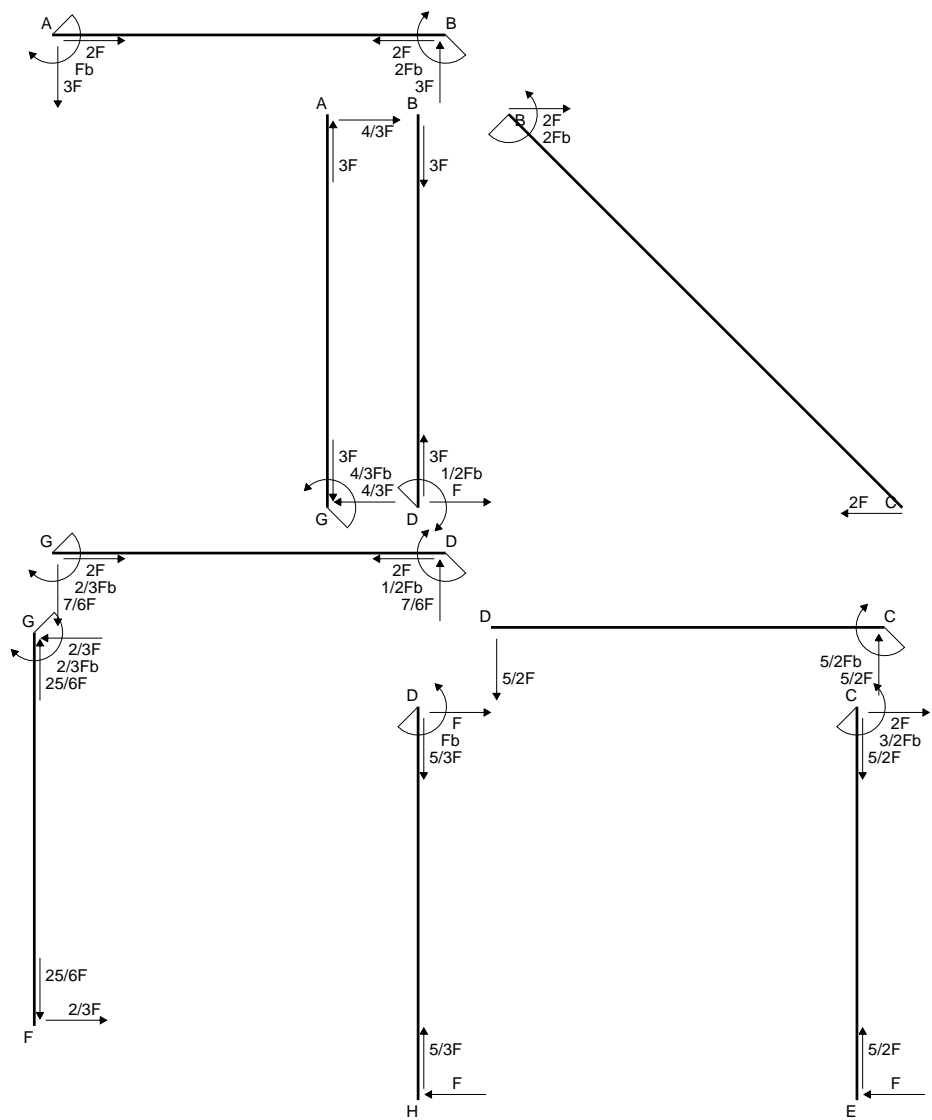
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2) Fb 1/EJ dx = [-5/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$



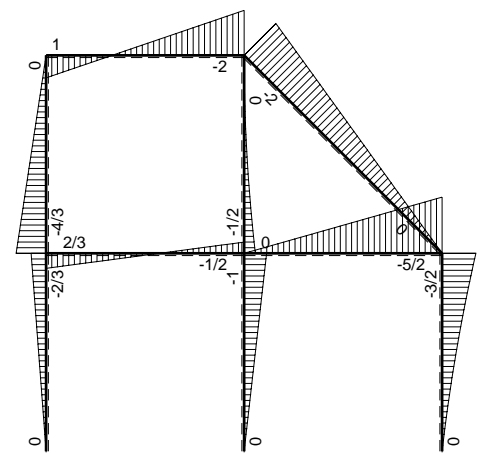
- A = 870. mm<sup>2</sup>
- J<sub>u</sub> = 272367. mm<sup>4</sup>
- J<sub>v</sub> = 79506. mm<sup>4</sup>
- y<sub>g</sub> = 19.29 mm
- T<sub>y</sub> = -2760. N
- M<sub>x</sub> = -1932000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.71 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 239.1 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 22.71 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 161.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 8.964 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 161.9 N/mm<sup>2</sup>
- S = 5308. mm<sup>3</sup>



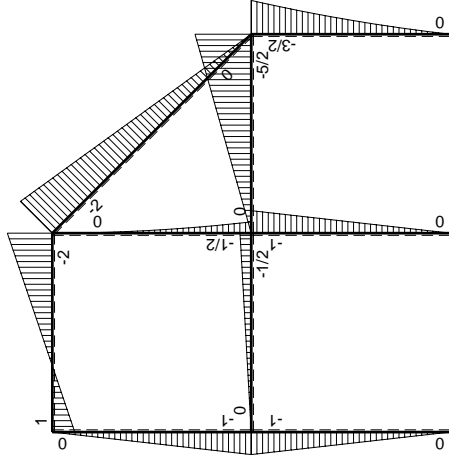
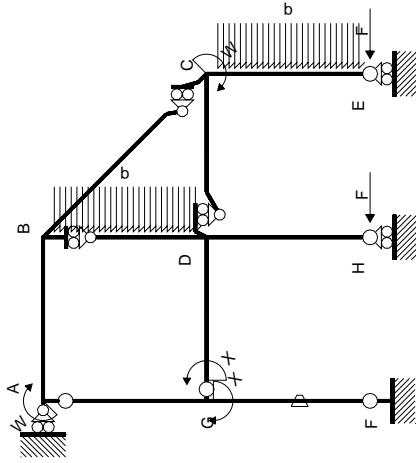


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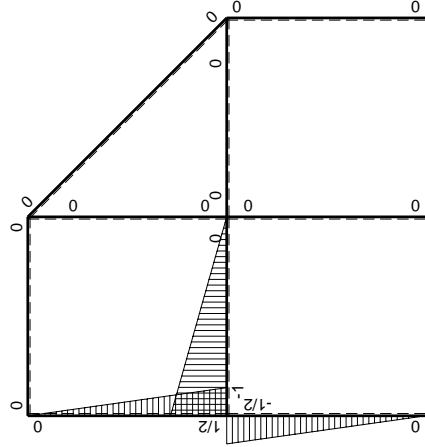


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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	$Fb-3Fx$	0	0	0	0	0+0	0	
BA b	0	$2Fb-3Fx$	0	0	0	0	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	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	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	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

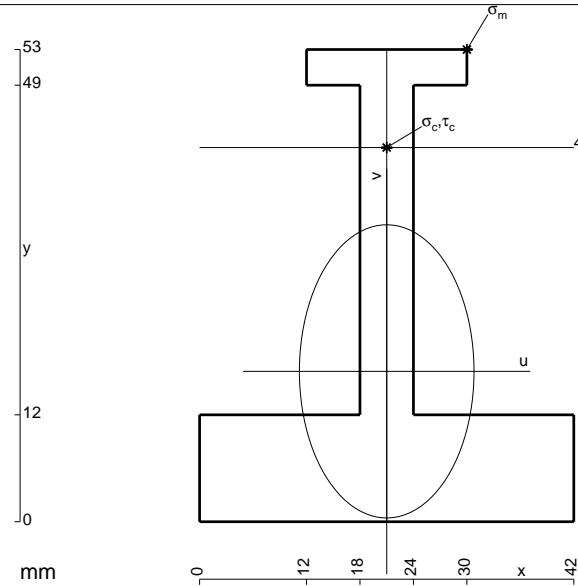
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

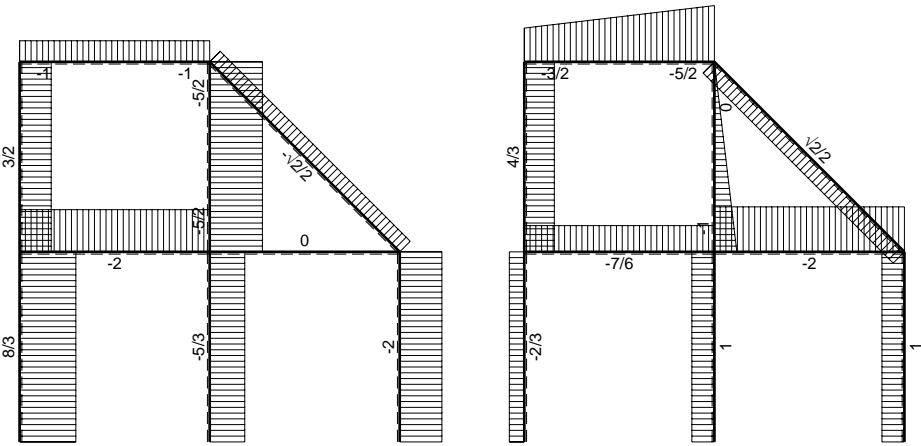
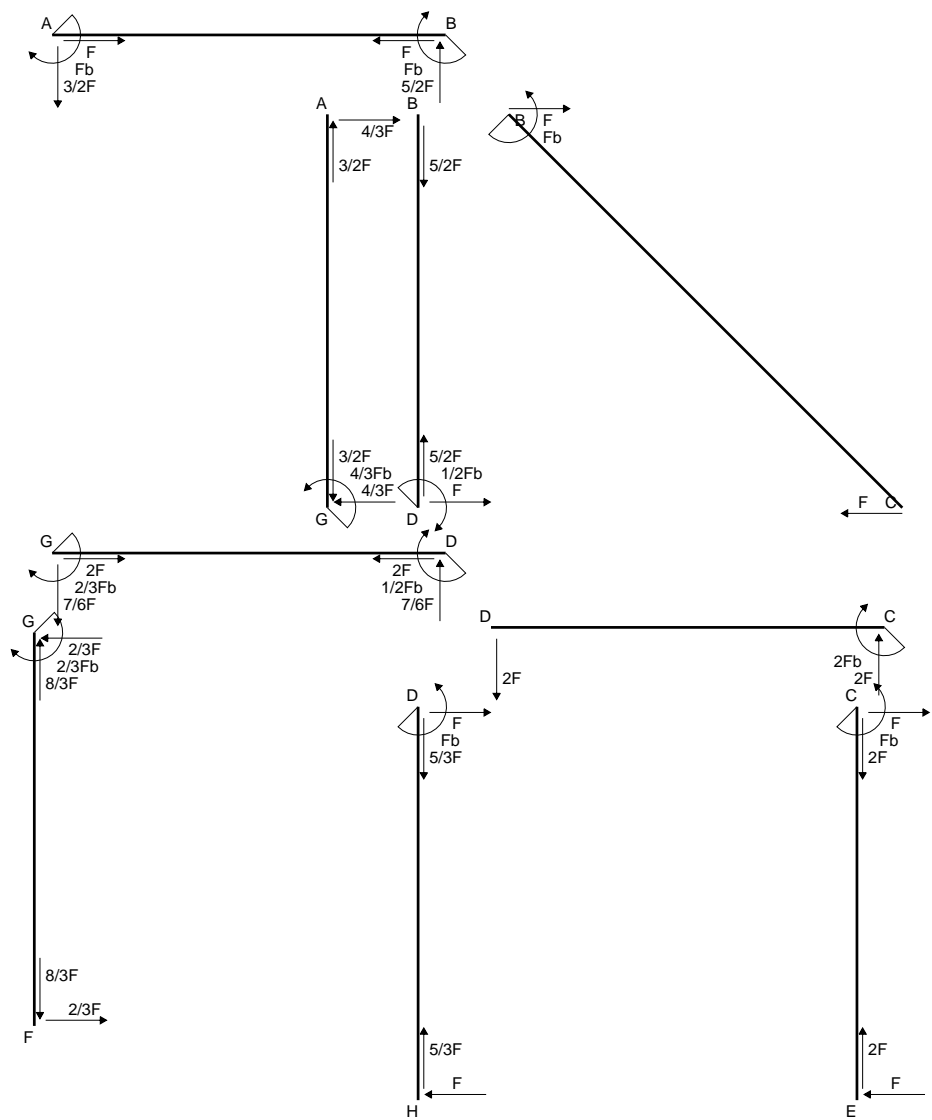
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

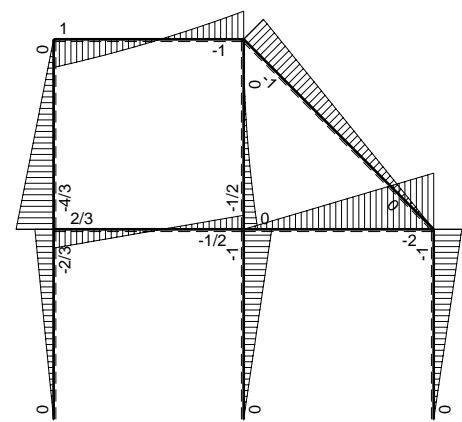


- A = 798. mm<sup>2</sup>
- J<sub>u</sub> = 216134. mm<sup>4</sup>
- J<sub>v</sub> = 76698. mm<sup>4</sup>
- y<sub>g</sub> = 16.88 mm
- T<sub>y</sub> = -1575. N
- M<sub>x</sub> = -1181250. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 36.12 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 197.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 25.12 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 137.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.444 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 137.5 N/mm<sup>2</sup>
- S = 3659. mm<sup>3</sup>

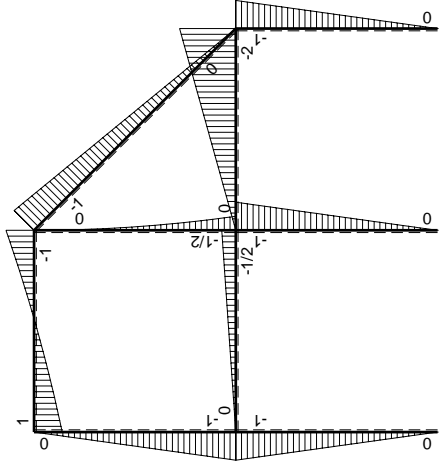
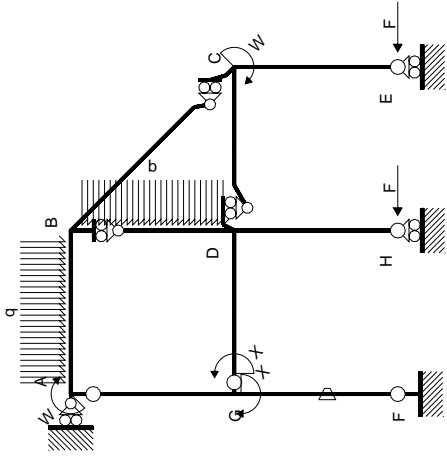


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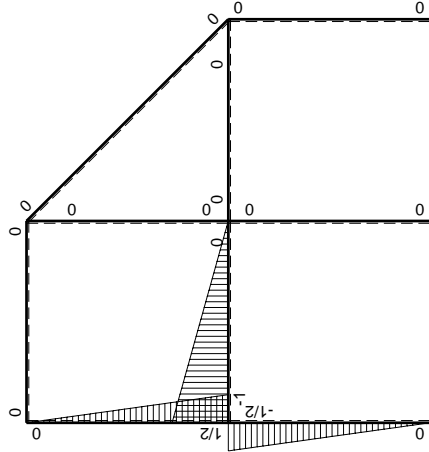


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica X=1

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$Fb-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-5/2Fx+1/2qx^2$	0	0	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

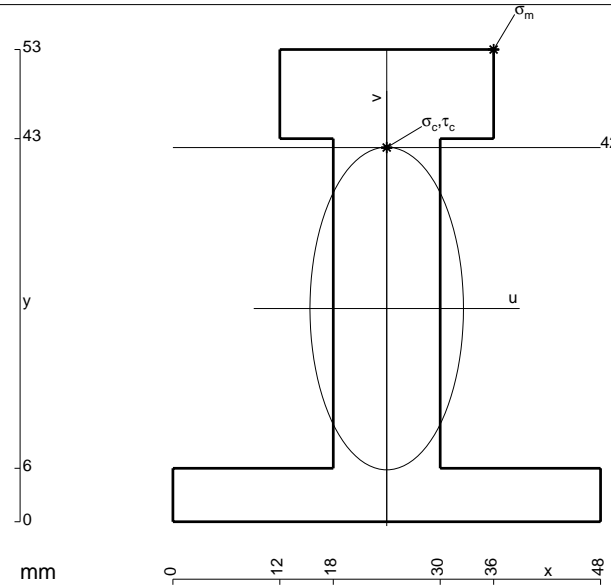
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

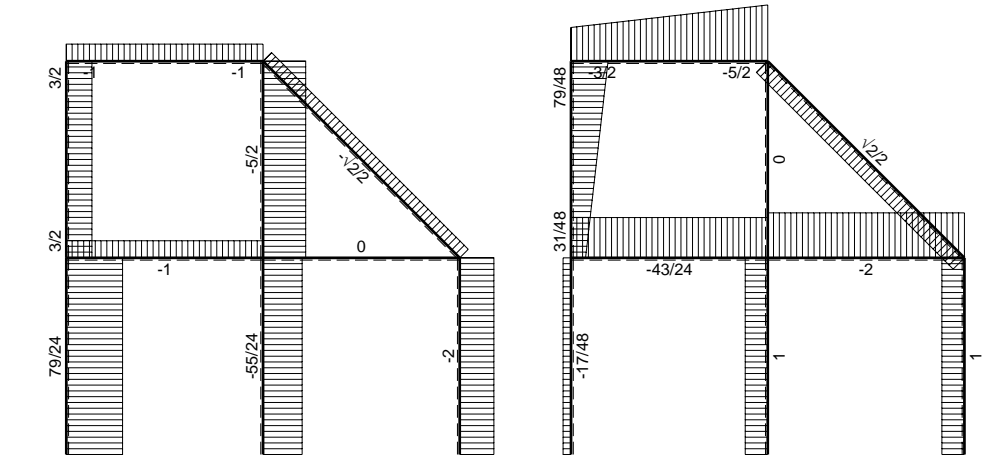
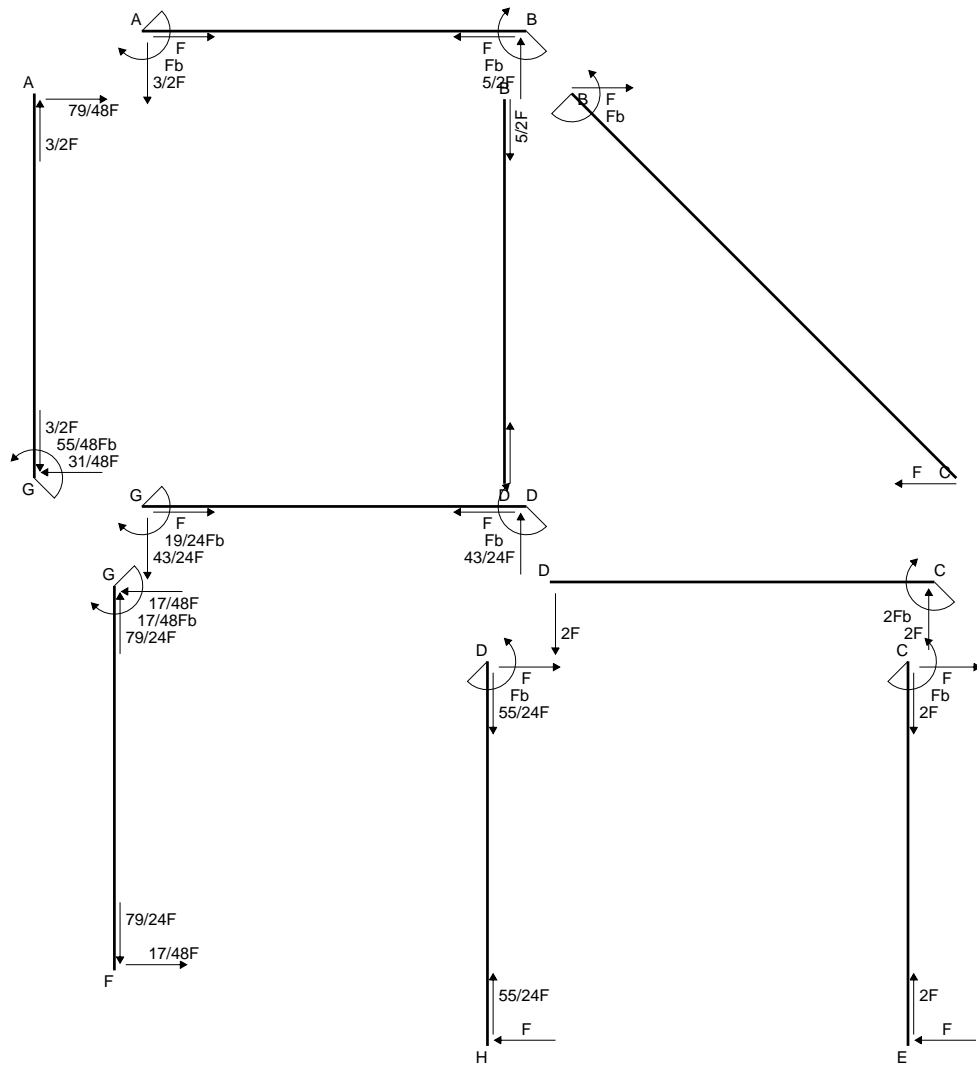
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



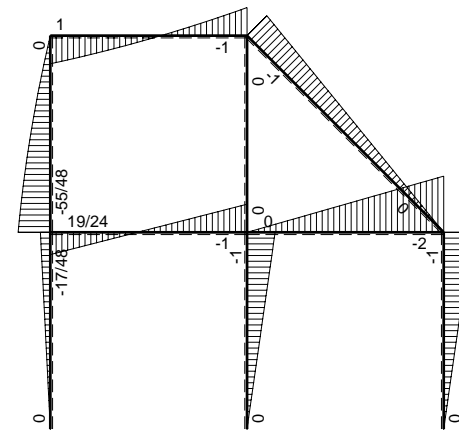
- A = 972. mm<sup>2</sup>
- J<sub>u</sub> = 318872. mm<sup>4</sup>
- J<sub>v</sub> = 72144. mm<sup>4</sup>
- y<sub>g</sub> = 23.93 mm
- T<sub>y</sub> = -2860. N
- M<sub>x</sub> = -2288000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 29.07 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 208.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 18.07 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 129.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.484 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 129.9 N/mm<sup>2</sup>
- S = 5999. mm<sup>3</sup>



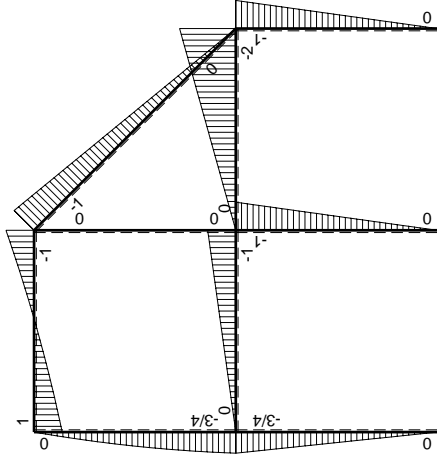
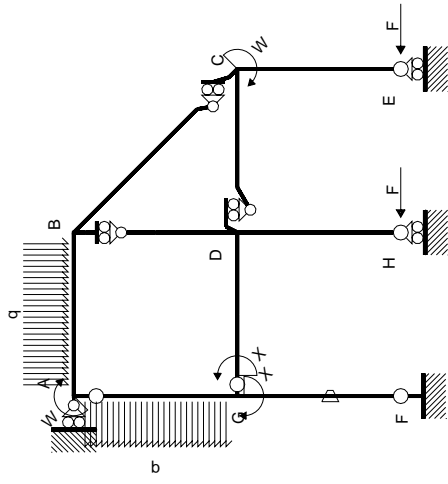


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⊕ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$	
AB b	0	$Fb-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0	
BA b	0	$Fb-5/2Fx+1/2qx^2$	0	0	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 -2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b +1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b +1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 -3/4 x/b +3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 +1/2 x/b) \theta dx$$

$$= [3/8 x -3/8 x^2/b +1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

$$= (3/8 b -3/8 b +1/8 b) Fb 1/EJ + (-1/2 b +1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b -1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b -1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b -1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b -1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

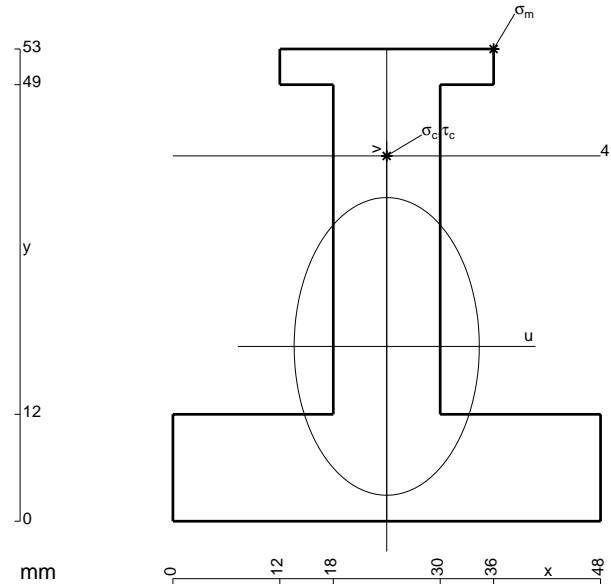
$$L_{GA}^{xo} = \int_0^b (-3/8 +1/2 x/b +1/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x +1/4 x^2/b +1/24 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ$$

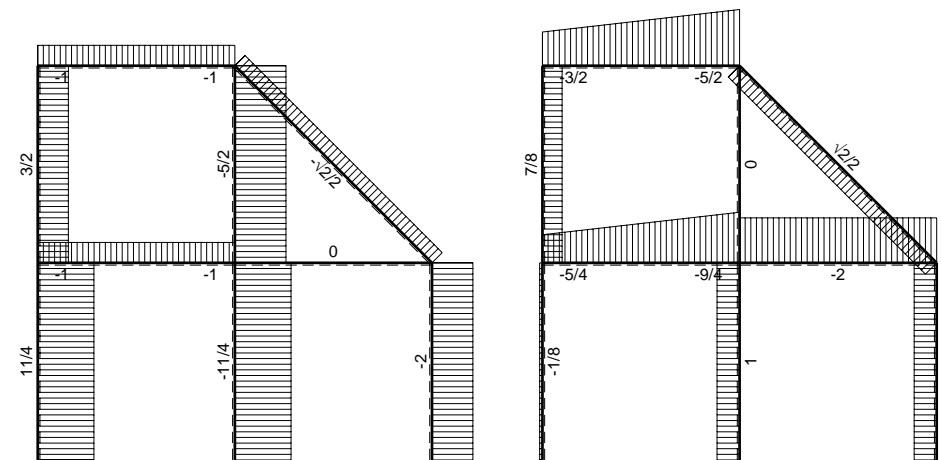
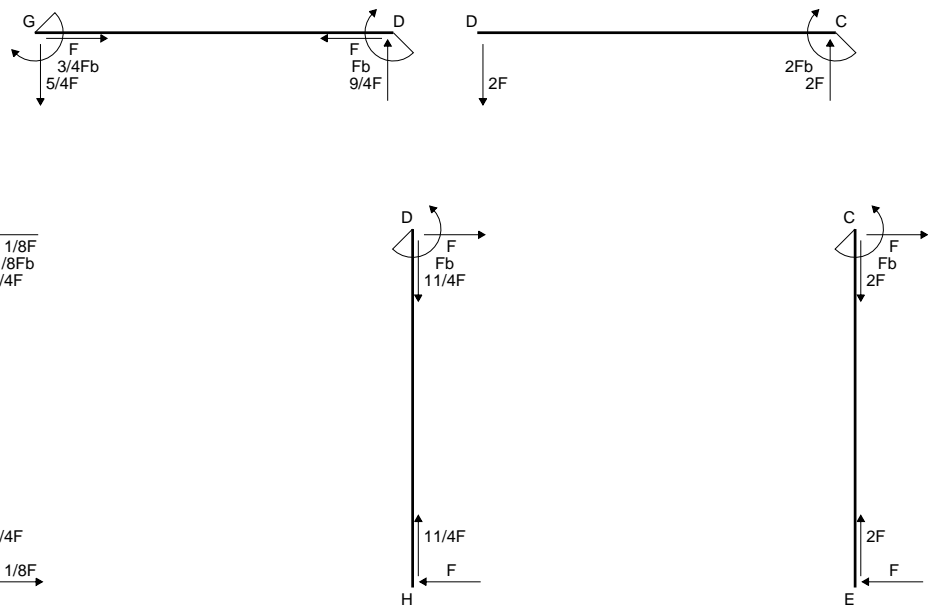
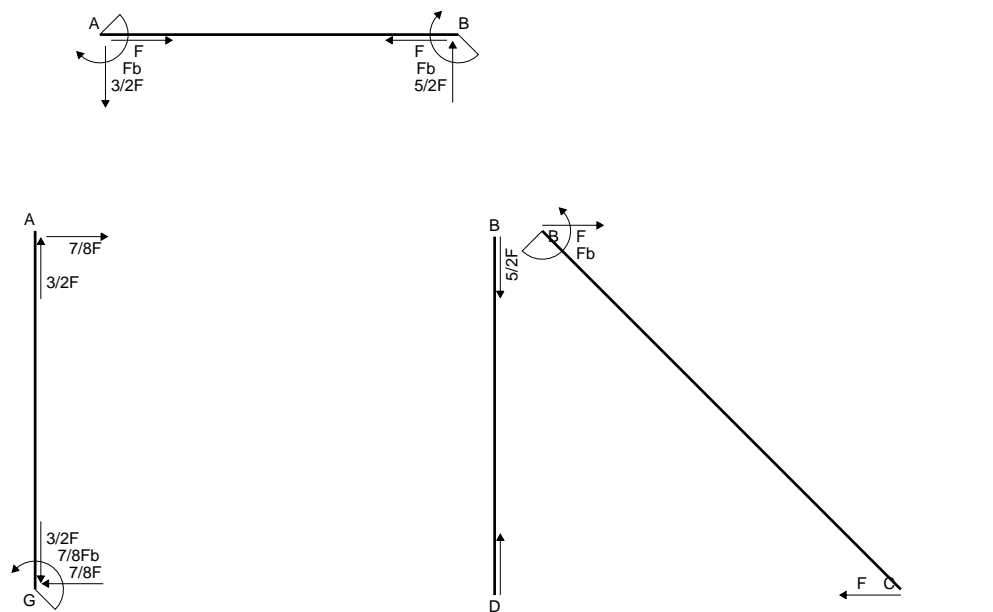
$$= (-3/8 b +1/4 b +1/24 b -1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 +1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 +1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b +1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

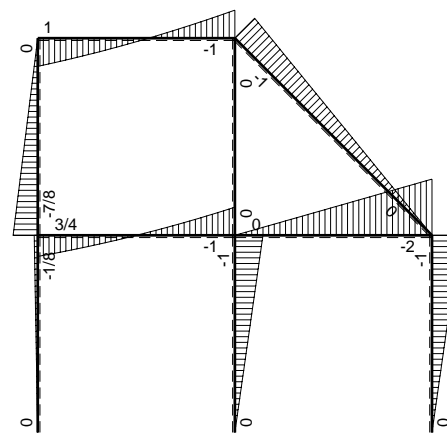


- A = 1116. mm<sup>2</sup>
- J<sub>u</sub> = 311633. mm<sup>4</sup>
- J<sub>v</sub> = 120528. mm<sup>4</sup>
- y<sub>g</sub> = 19.62 mm
- T<sub>y</sub> = -2400. N
- M<sub>x</sub> = -2040000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.38 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 218.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 21.38 mm
- σ<sub>c</sub> = -Mv/J<sub>v</sub> = 140. N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.497 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 140.1 N/mm<sup>2</sup>
- S = 5449. mm<sup>3</sup>

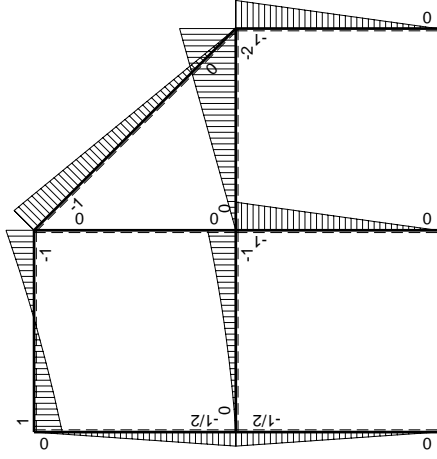
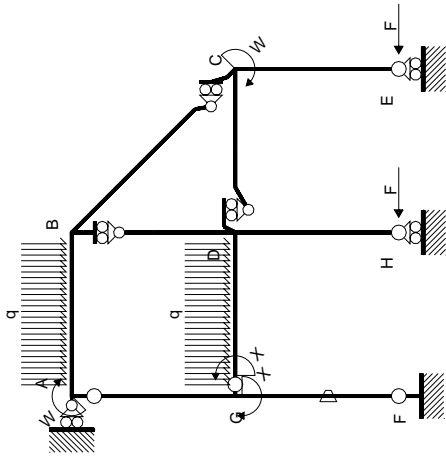


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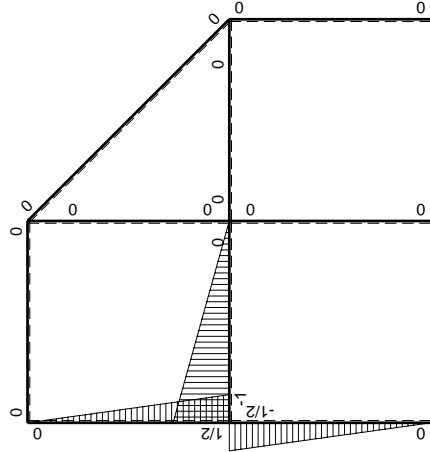


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

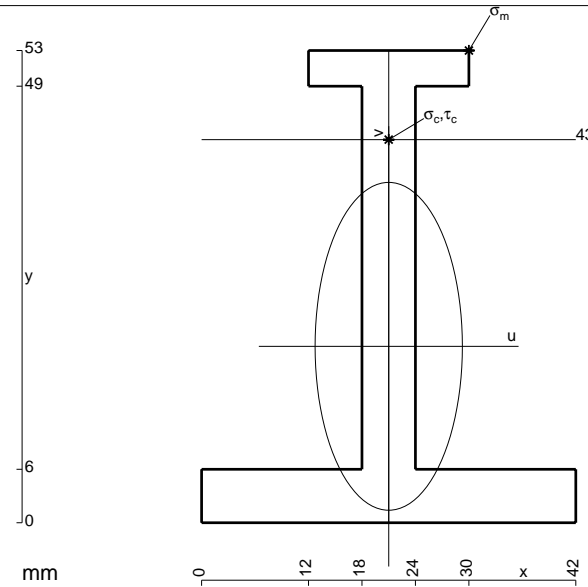
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

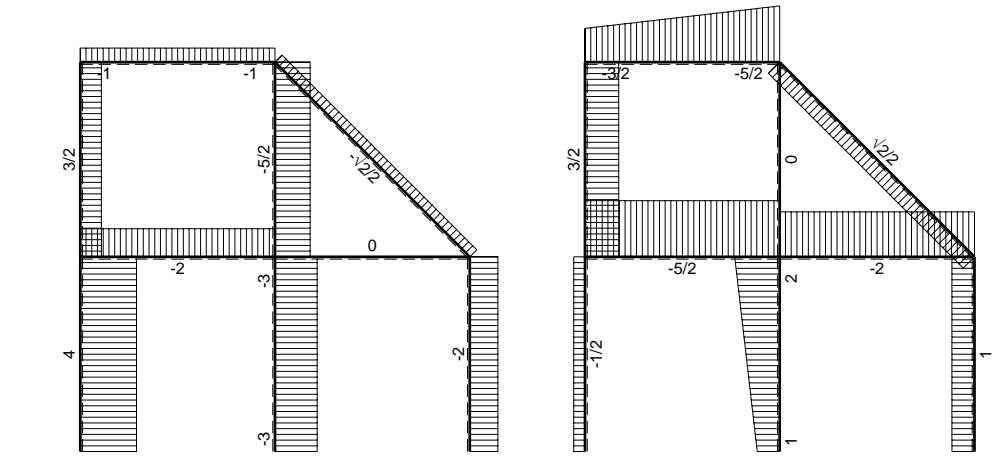
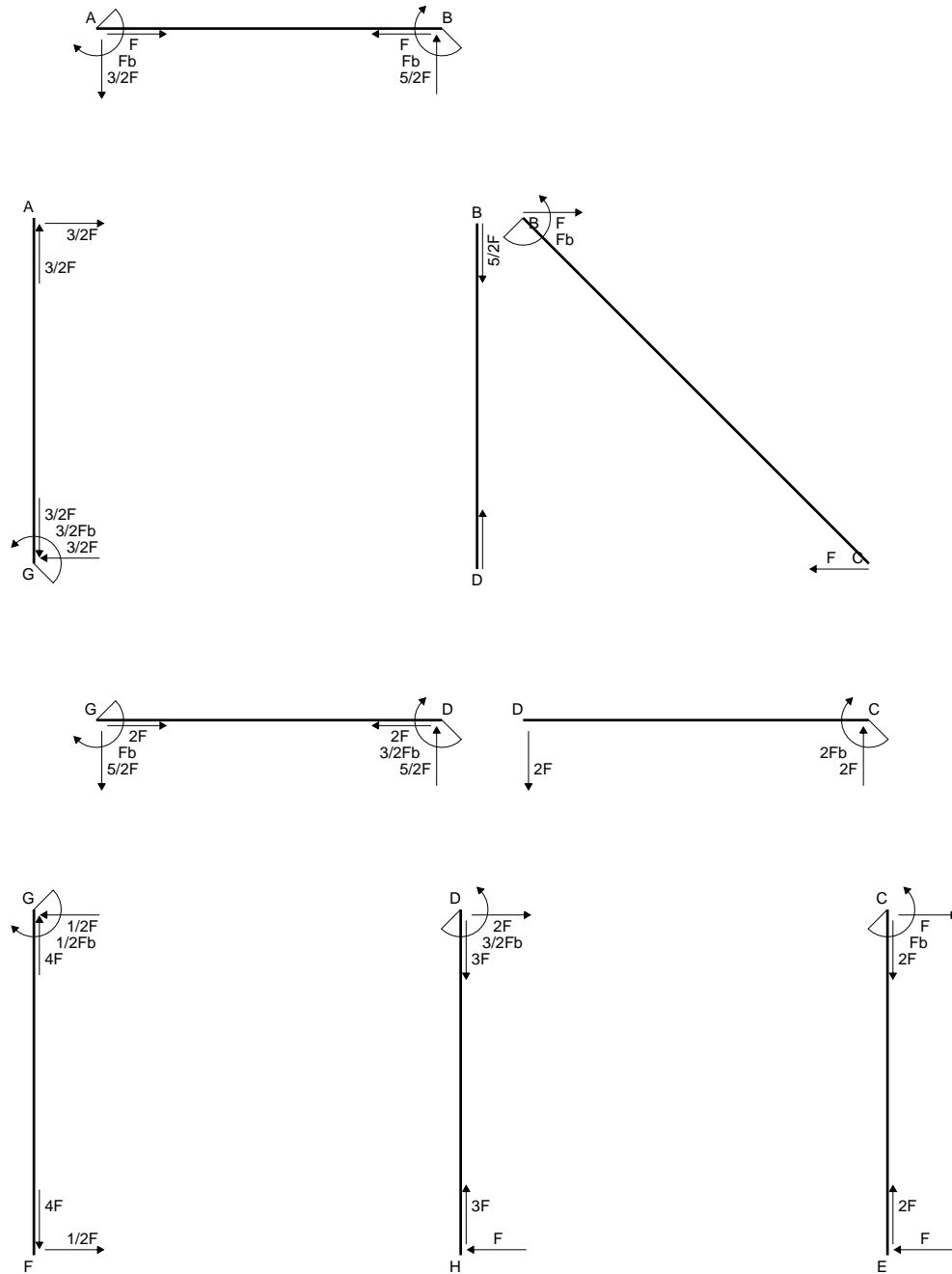
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



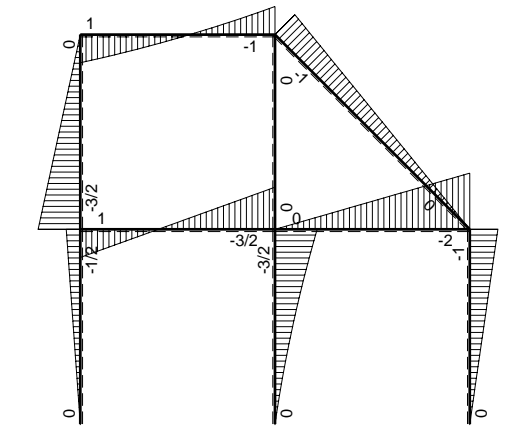
- A = 582. mm<sup>2</sup>
- J<sub>u</sub> = 197114. mm<sup>4</sup>
- J<sub>v</sub> = 39762. mm<sup>4</sup>
- y<sub>g</sub> = 19.8 mm
- T<sub>y</sub> = -1500. N
- M<sub>x</sub> = -1350000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 53. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.2 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 227.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 43. mm
- v<sub>c</sub> = 23.2 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 158.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.046 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 159.1 N/mm<sup>2</sup>
- S = 3190. mm<sup>3</sup>



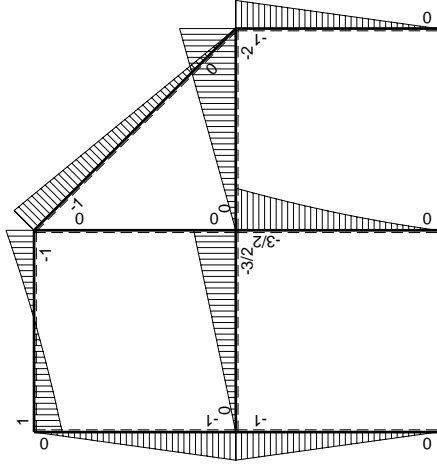
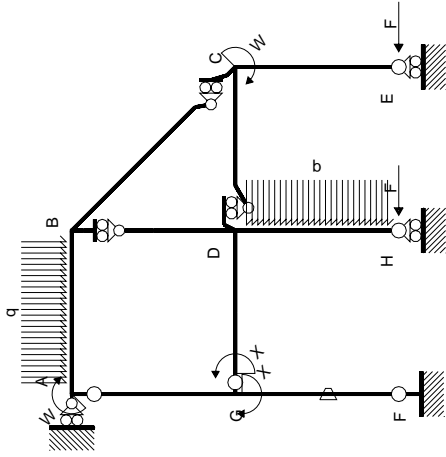


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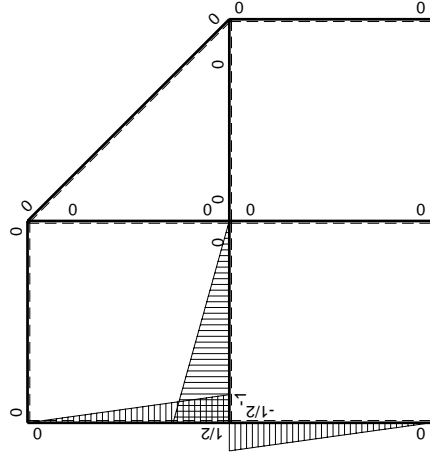


⊕ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_X$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

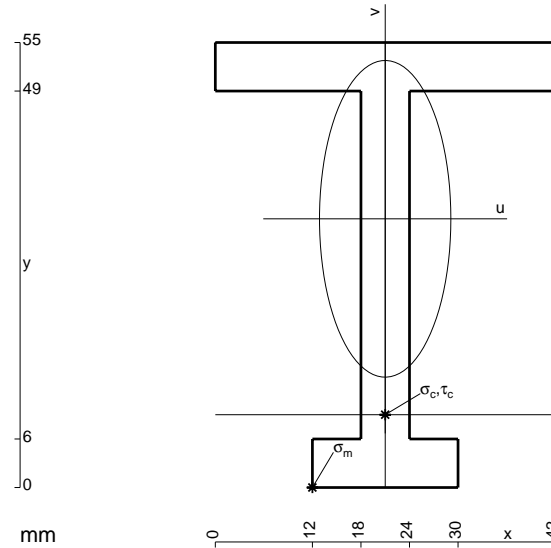
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

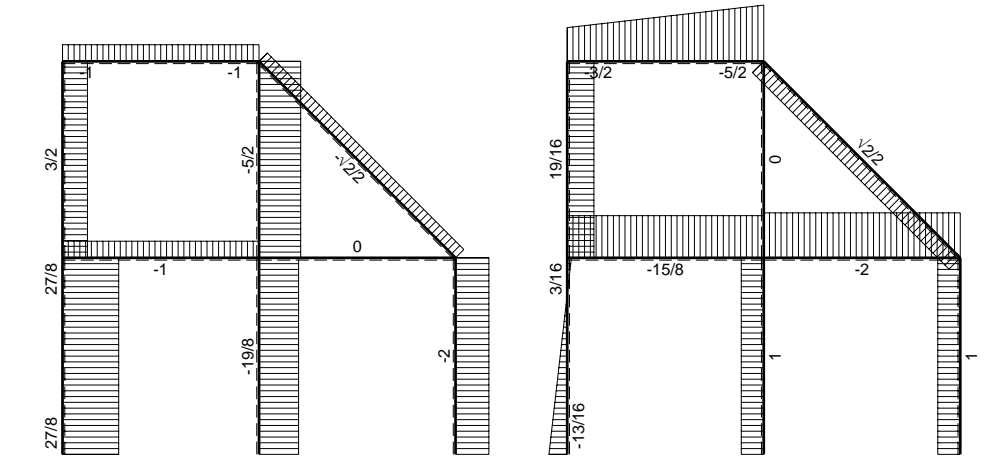
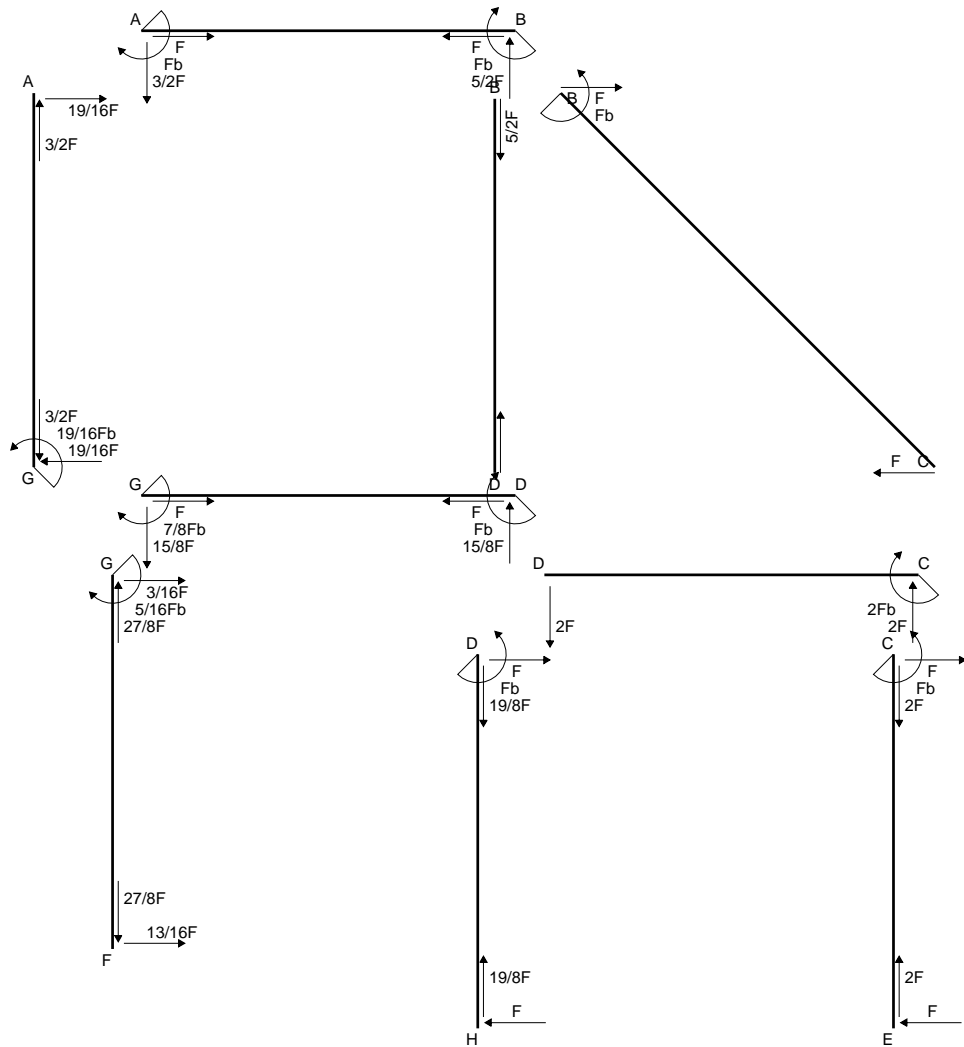
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

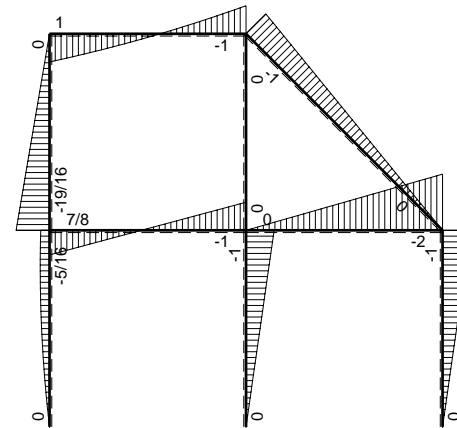


- A = 618. mm<sup>2</sup>
- J<sub>u</sub> = 236783. mm<sup>4</sup>
- J<sub>v</sub> = 40734. mm<sup>4</sup>
- y<sub>g</sub> = 33.21 mm
- T<sub>y</sub> = -1740. N
- M<sub>x</sub> = -1705200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -33.21 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239.2 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -24.21 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -174.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.563 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 174.5 N/mm<sup>2</sup>
- S = 3725. mm<sup>3</sup>

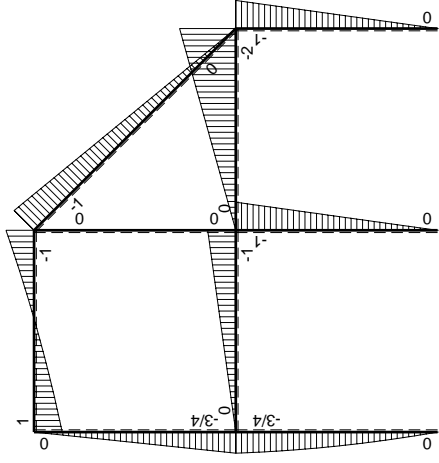
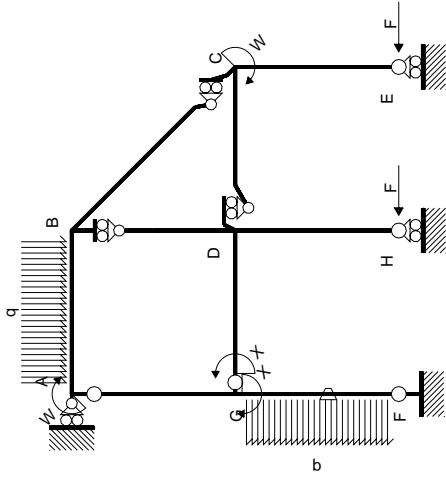


← ⊕ → F

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⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

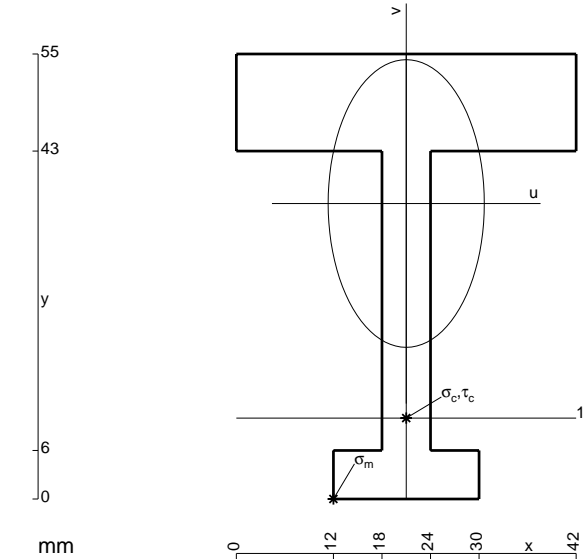
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

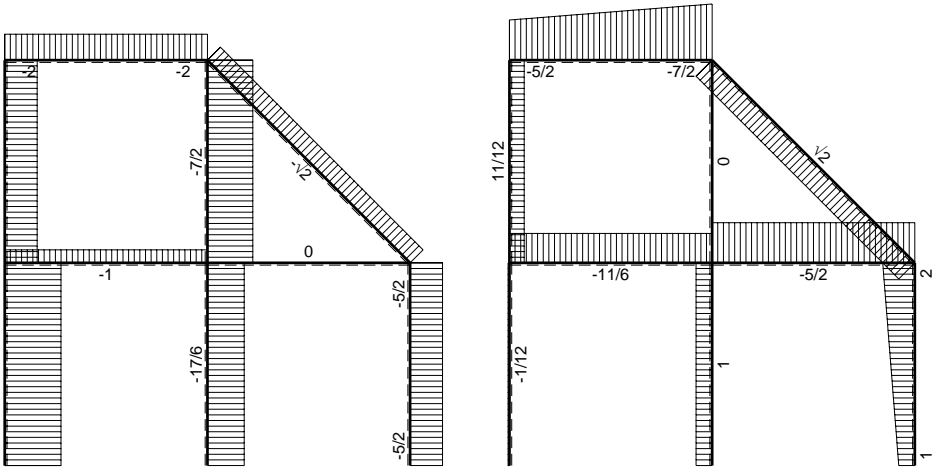
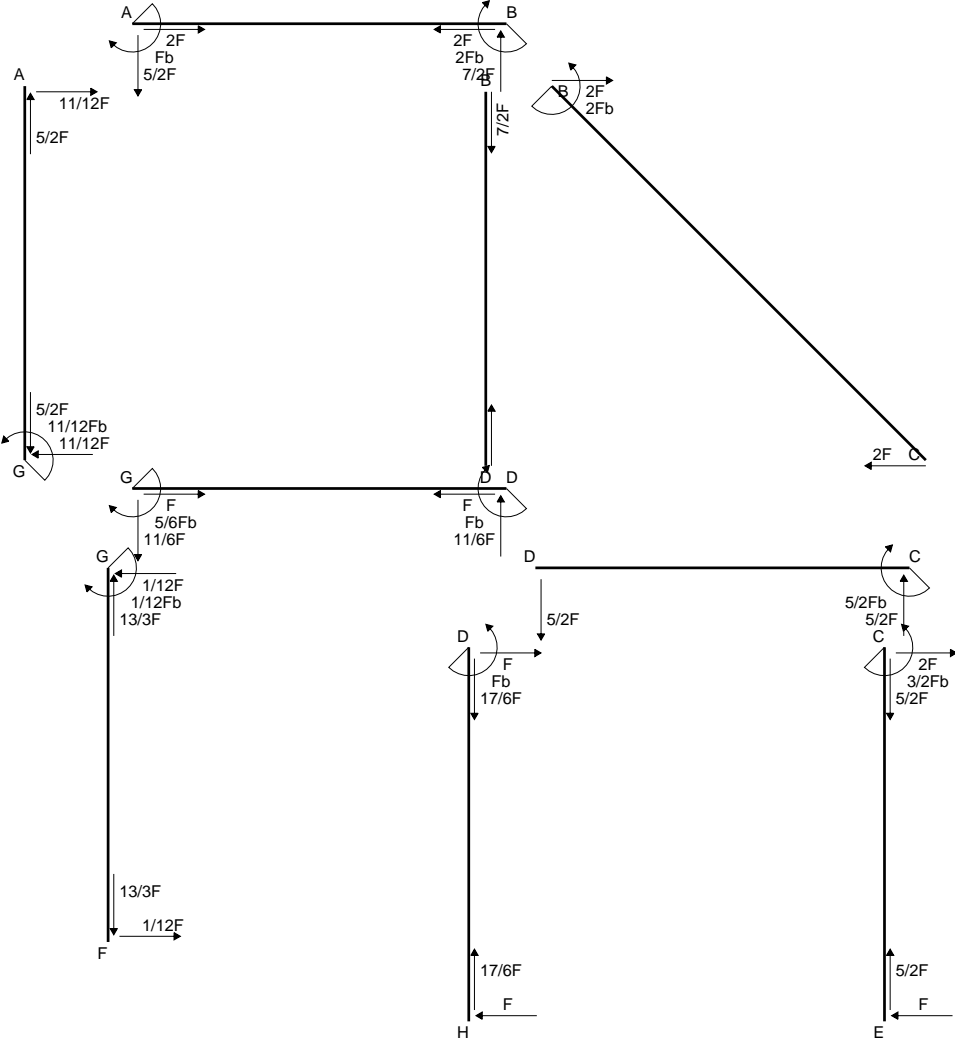
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



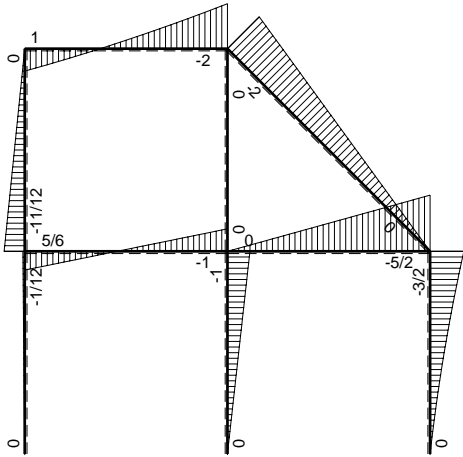
- A = 834. mm<sup>2</sup>
- J<sub>u</sub> = 263619. mm<sup>4</sup>
- J<sub>v</sub> = 77670. mm<sup>4</sup>
- y<sub>g</sub> = 36.52 mm
- T<sub>y</sub> = -2760. N
- M<sub>x</sub> = -1435200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -36.52 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -198.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -26.52 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -144.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.512 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 145. N/mm<sup>2</sup>
- S = 4305. mm<sup>3</sup>



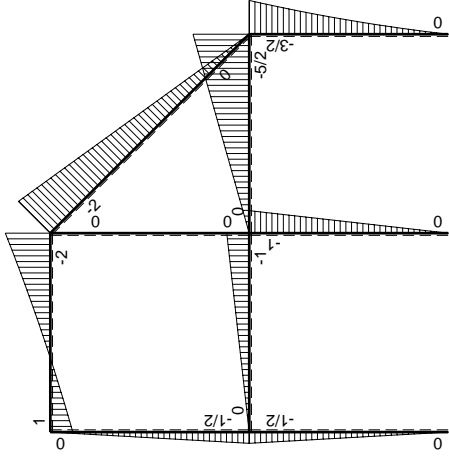
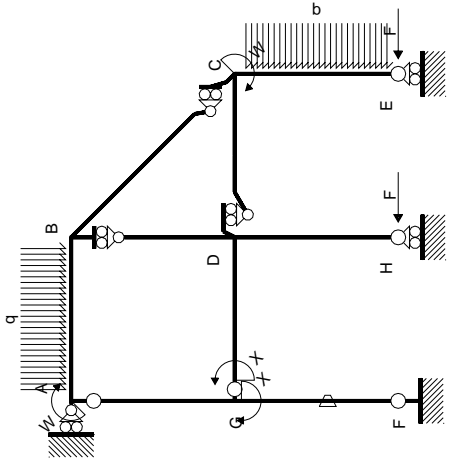


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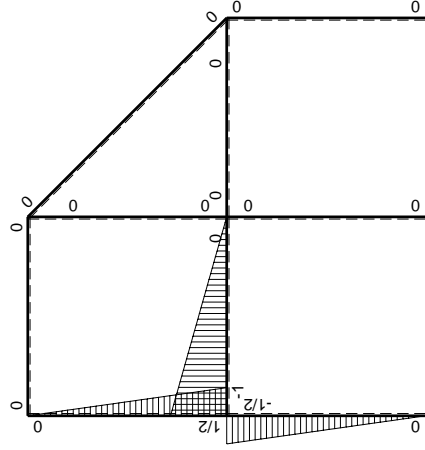


⤵ + ⤶ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

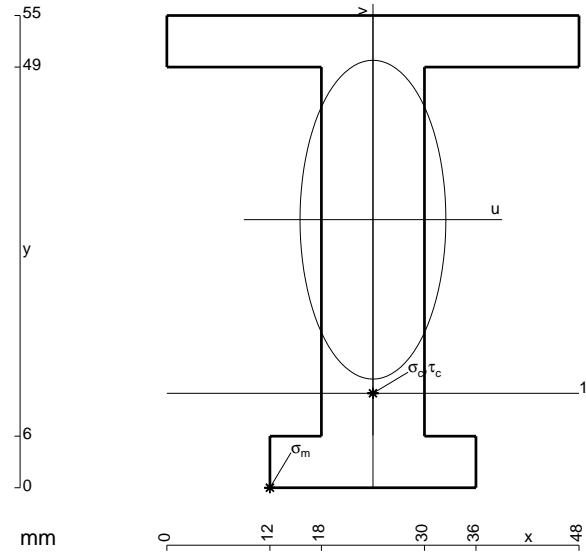
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

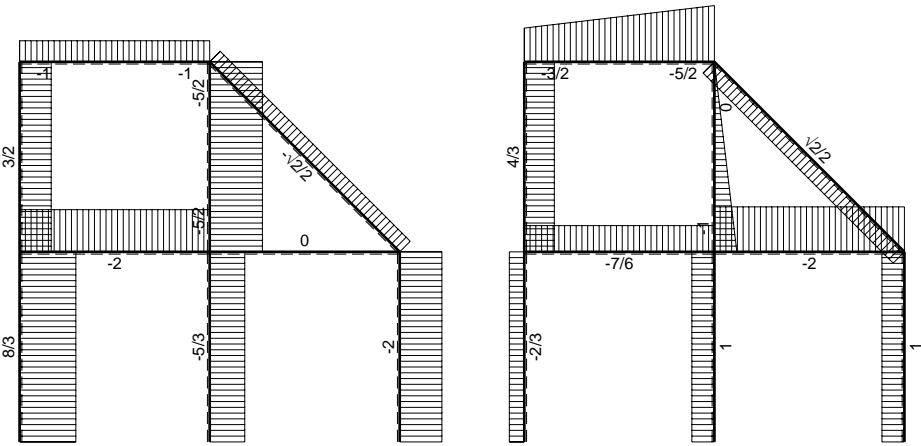
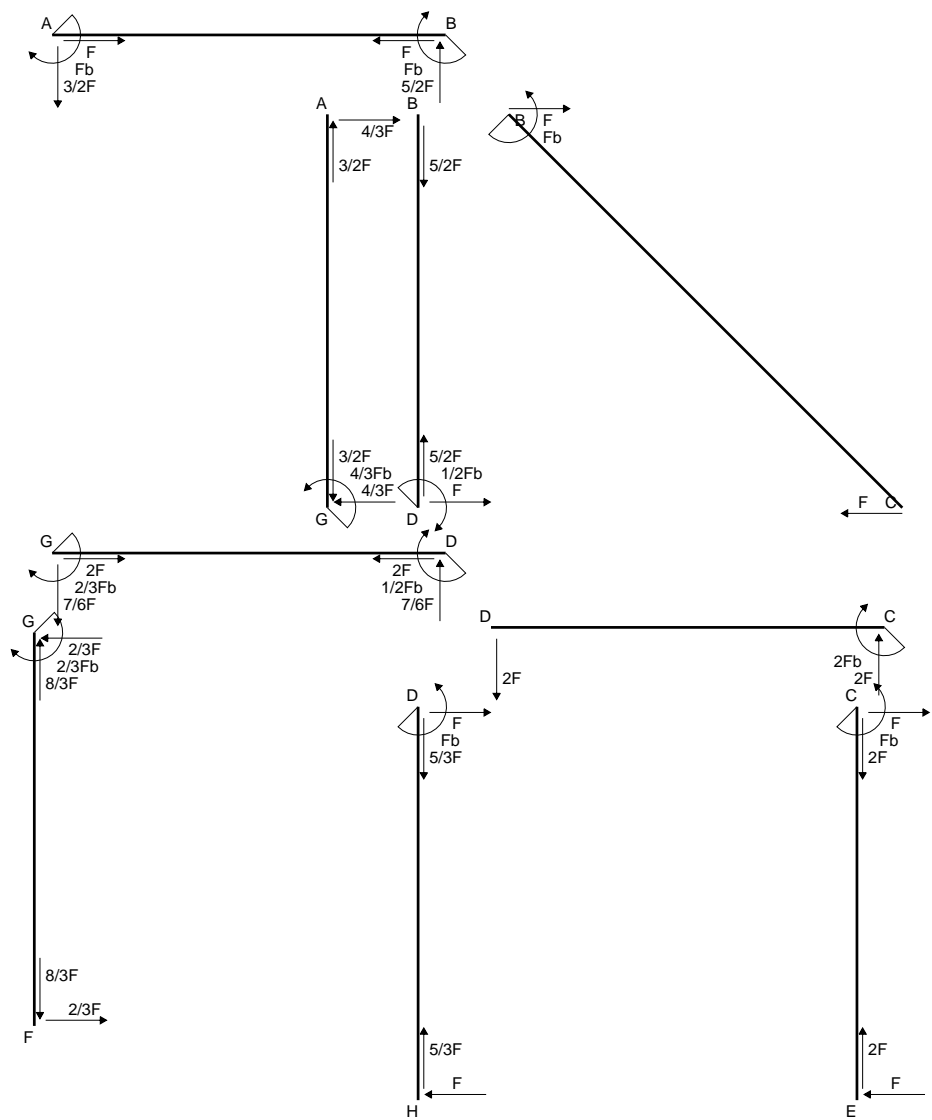
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

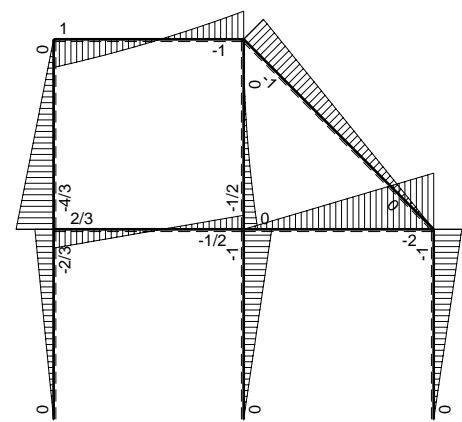


- A = 948. mm<sup>2</sup>
- J<sub>u</sub> = 326981. mm<sup>4</sup>
- J<sub>v</sub> = 68400. mm<sup>4</sup>
- y<sub>g</sub> = 31.22 mm
- N = -3780. N
- T<sub>y</sub> = -6615. N
- M<sub>x</sub> = -2154600. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -31.22 mm
- σ<sub>m</sub> = N/A-Mv/J<sub>u</sub> = -209.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -20.22 mm
- σ<sub>c</sub> = N/A-Mv/J<sub>u</sub> = -137.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 9.15 N/mm<sup>2</sup>
- σ<sub>q</sub> = √(σ<sup>2</sup>+3τ<sup>2</sup>) = 138.1 N/mm<sup>2</sup>
- S = 5427. mm<sup>3</sup>

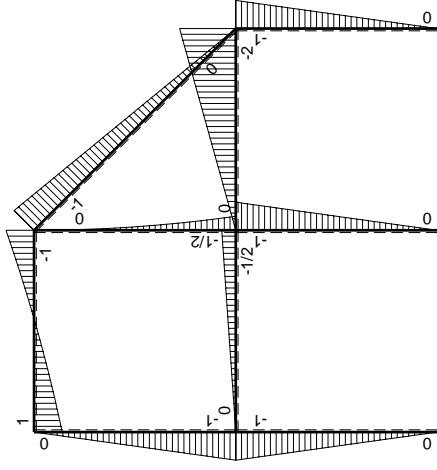
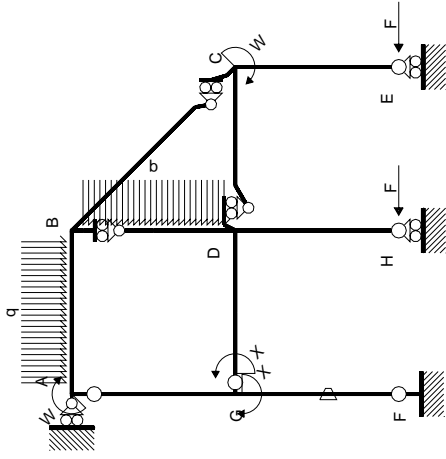


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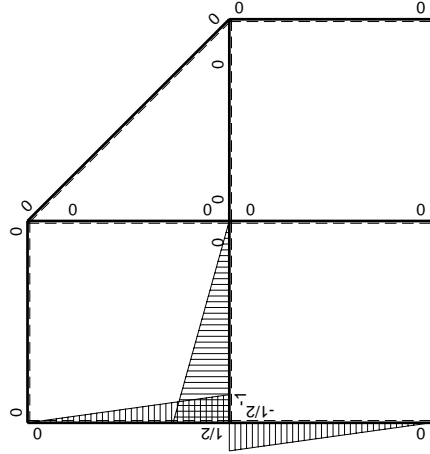


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$Fb-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-5/2Fx+1/2qx^2$	0	0	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

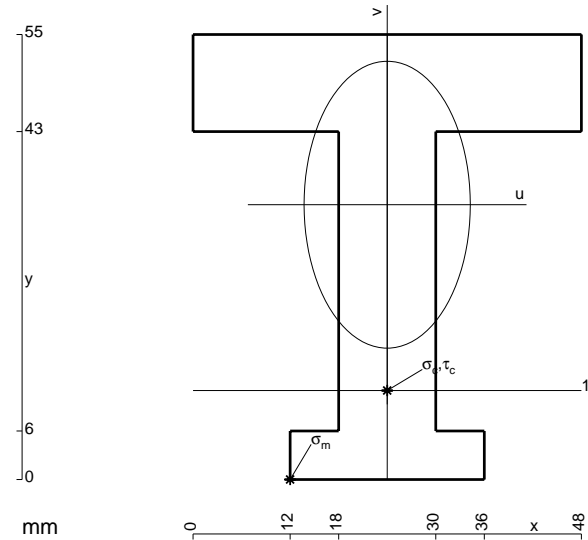
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



$$A = 1164. \text{ mm}^2$$

$$J_u = 366051. \text{ mm}^4$$

$$J_v = 122832. \text{ mm}^4$$

$$y_g = 33.96 \text{ mm}$$

$$T_y = -3820. \text{ N}$$

$$M_x = -2368400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -33.96 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 11. \text{ mm}$$

$$v_c = -22.96 \text{ mm}$$

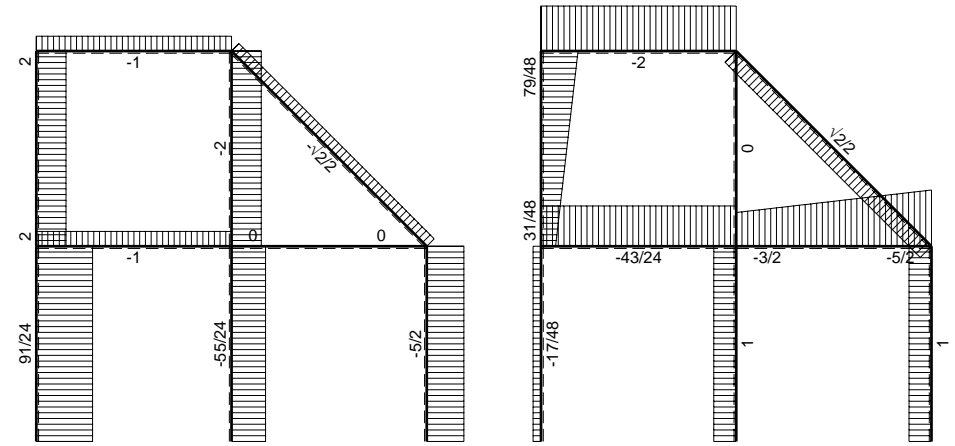
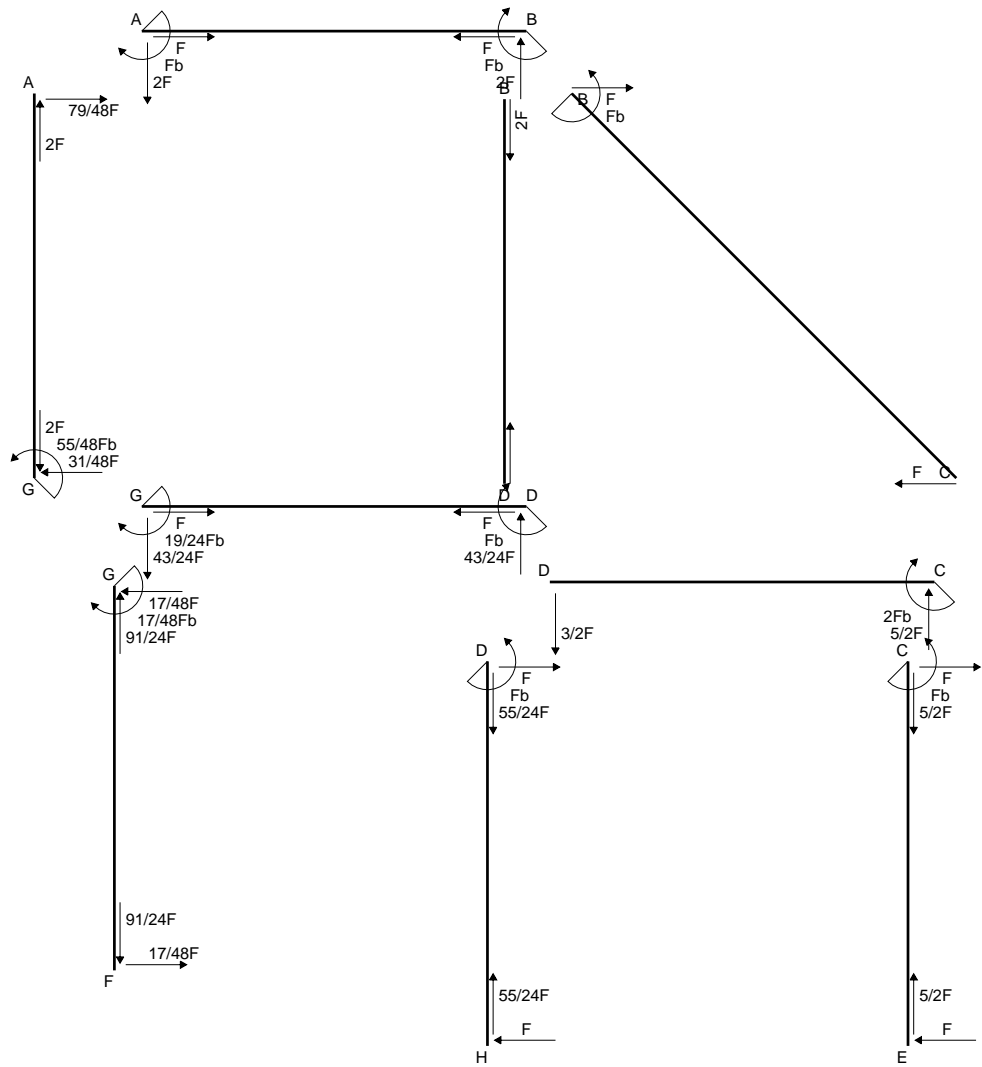
$$\sigma_c = -Mv/J_u = -148.6 \text{ N/mm}^2$$

$$\tau_c = 5.206 \text{ N/mm}^2$$

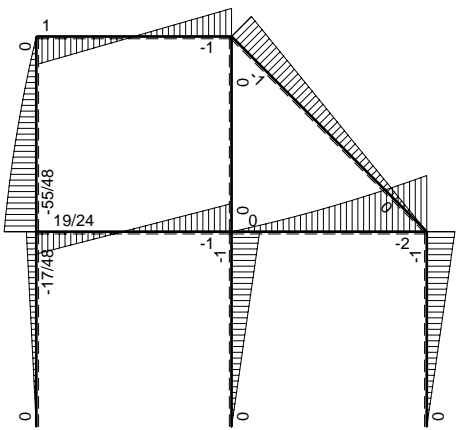
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 148.9 \text{ N/mm}^2$$

$$S = 5987. \text{ mm}^3$$

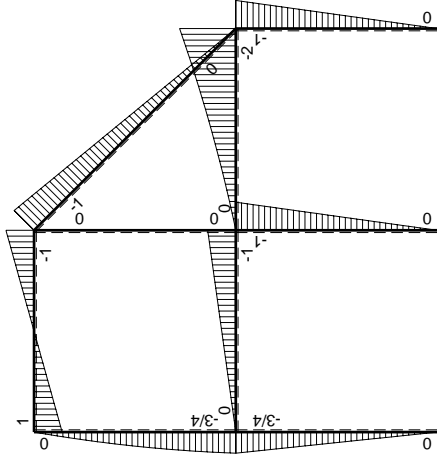
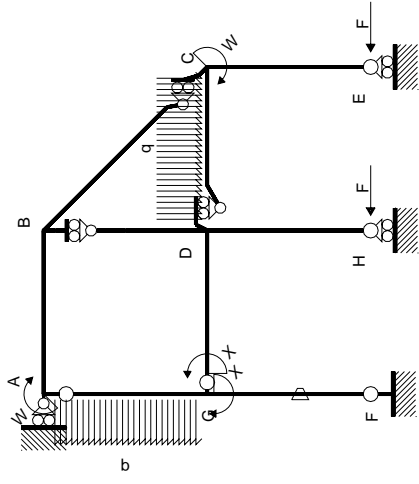




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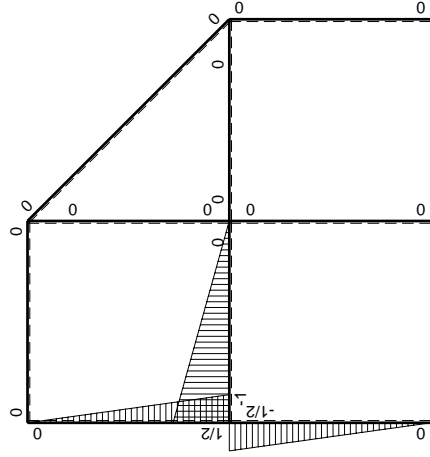


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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	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	0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	3/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/8+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-3/4Fx	Fb/EJ	3/8Fb-3/4Fx+3/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						19/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-19/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 3/4 x/b + 3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 3/8 x^2/b + 1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 3/8 b + 1/8 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

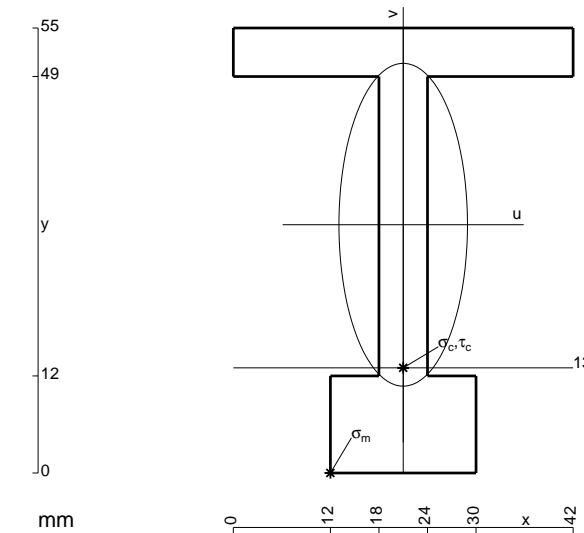
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

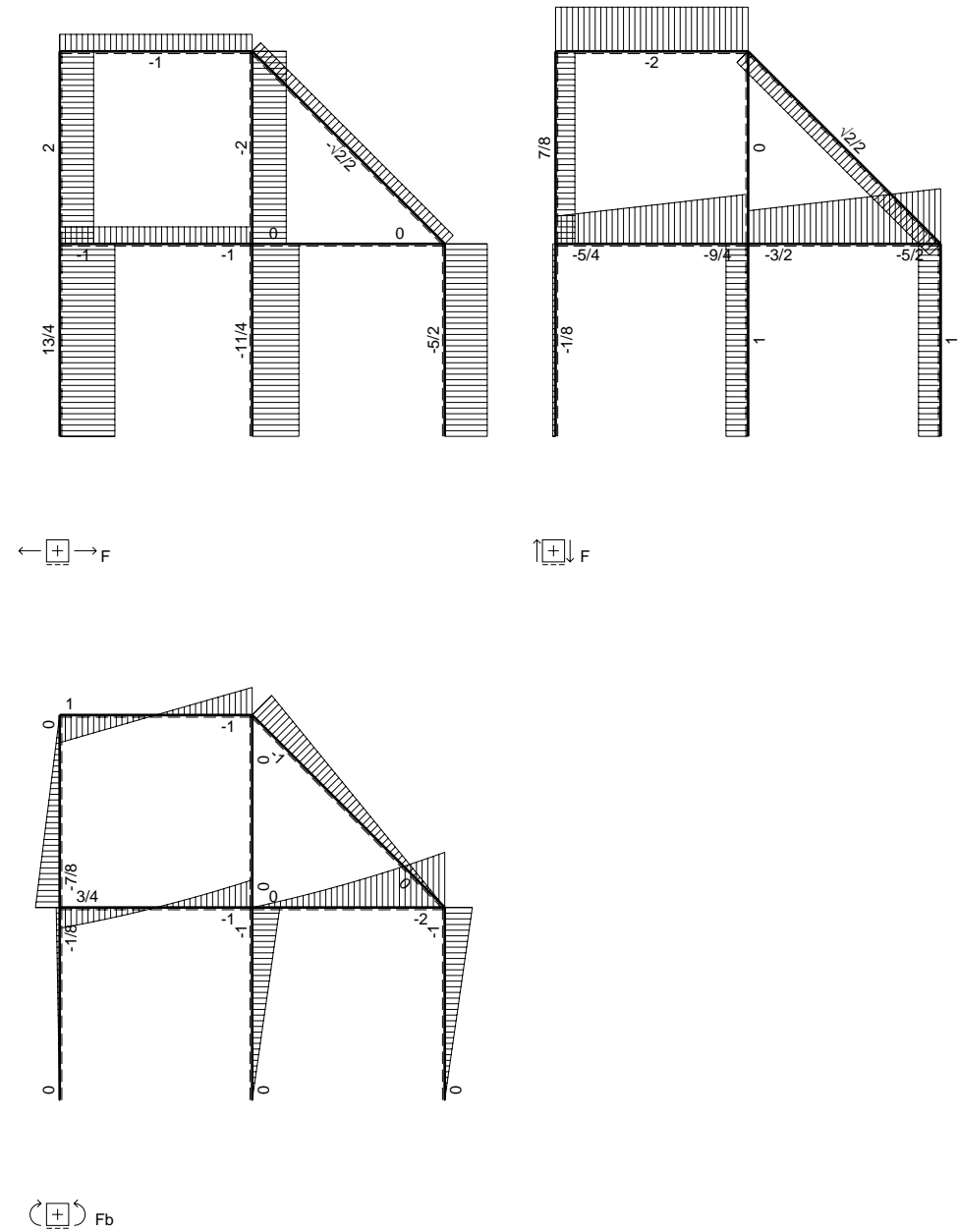
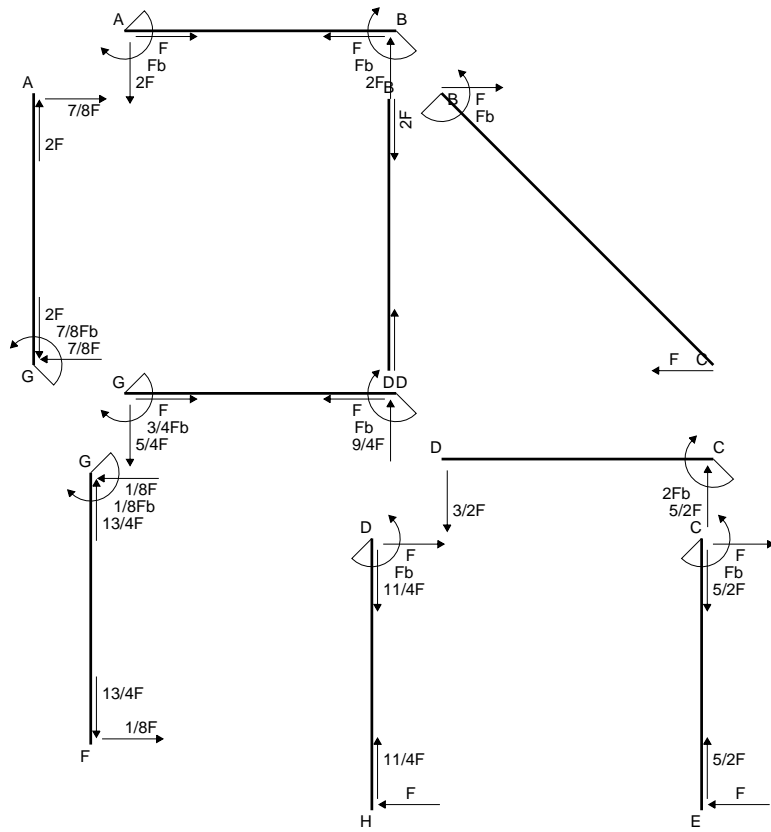
$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

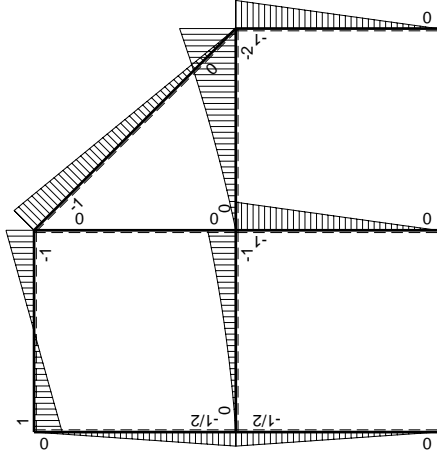
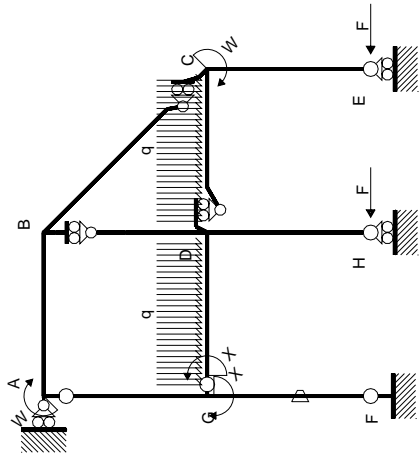
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



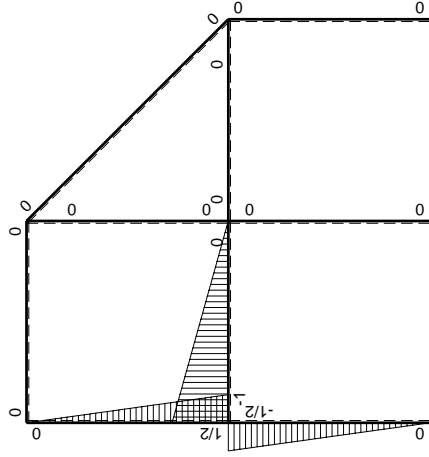
$A = 690. \text{ mm}^2$   
 $J_u = 274792. \text{ mm}^4$   
 $J_v = 43542. \text{ mm}^4$   
 $y_g = 30.68 \text{ mm}$   
 $T_y = -3825. \text{ N}$   
 $M_x = -2050200. \text{ Nmm}$   
 $x_m = 12. \text{ mm}$   
 $u_m = -9. \text{ mm}$   
 $v_m = -30.68 \text{ mm}$   
 $\sigma_m = -Mv/J_u = -228.9 \text{ N/mm}^2$   
 $x_c = 21. \text{ mm}$   
 $y_c = 13. \text{ mm}$   
 $v_c = -17.68 \text{ mm}$   
 $\sigma_c = -Mv/J_u = -131.9 \text{ N/mm}^2$   
 $\tau_c = 12.62 \text{ N/mm}^2$   
 $\sigma_q = \sqrt{\sigma^2 + 3\tau^2} = 133.7 \text{ N/mm}^2$   
 $S = 5441. \text{ mm}^3$





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
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 <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	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 <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	1/2Fb-1/2Fx	Fb/EJ	1/4Fb-1/2Fx+1/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-1/2Fx-1/2qx <sup>2</sup>	0	1/2Fx-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-3/2Fx+1/2qx <sup>2</sup>	0	Fx-3/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						3/8Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-3/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^3/b^3) Fb 1/EJ dx = [1/4 x^2/b - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - 3/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/2 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

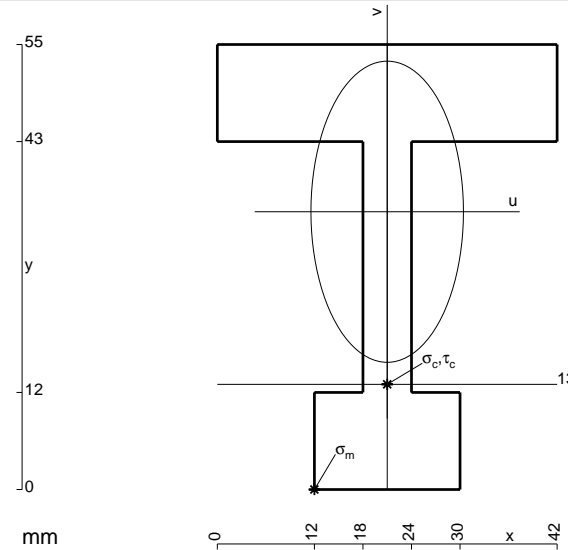
$$= (1/2 b - 1/2 b + 1/8 b) Fb 1/EJ = 1/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

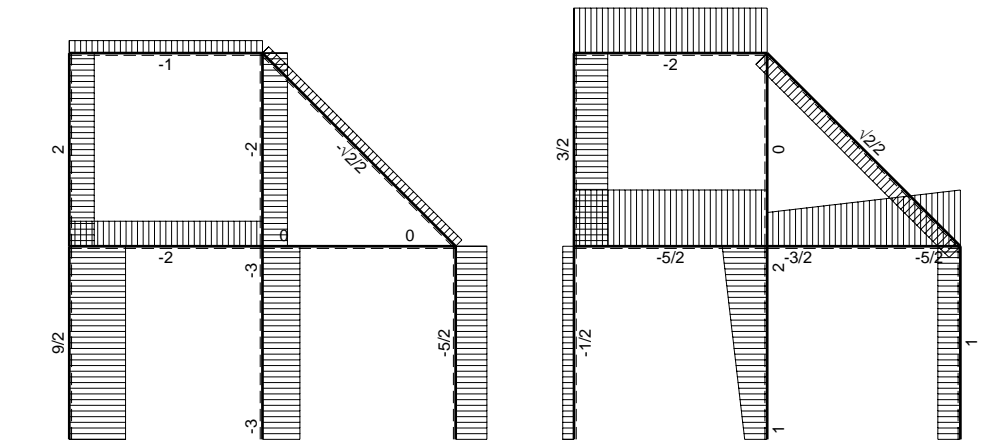
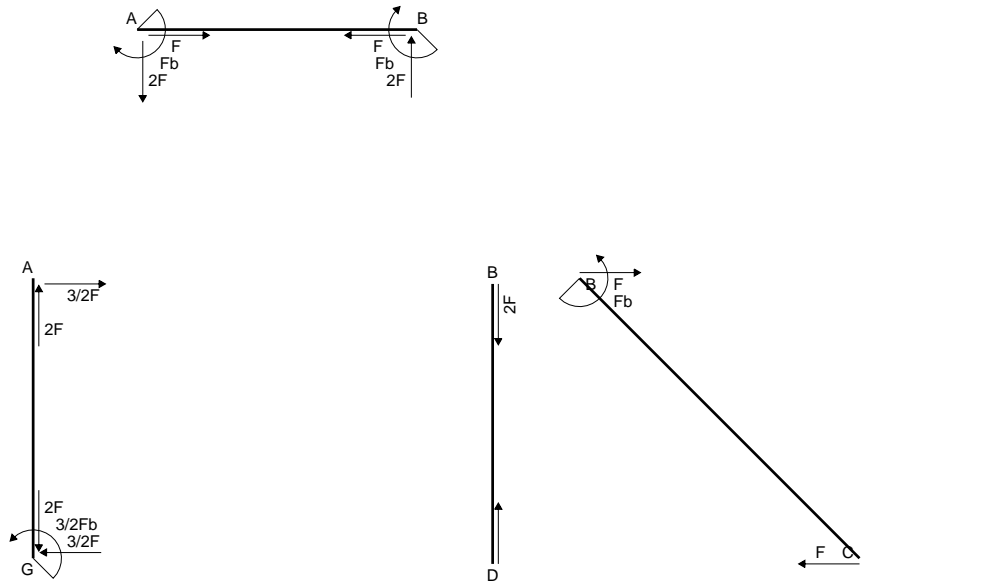
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



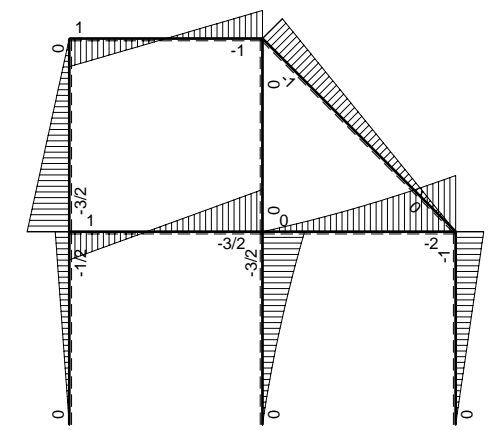
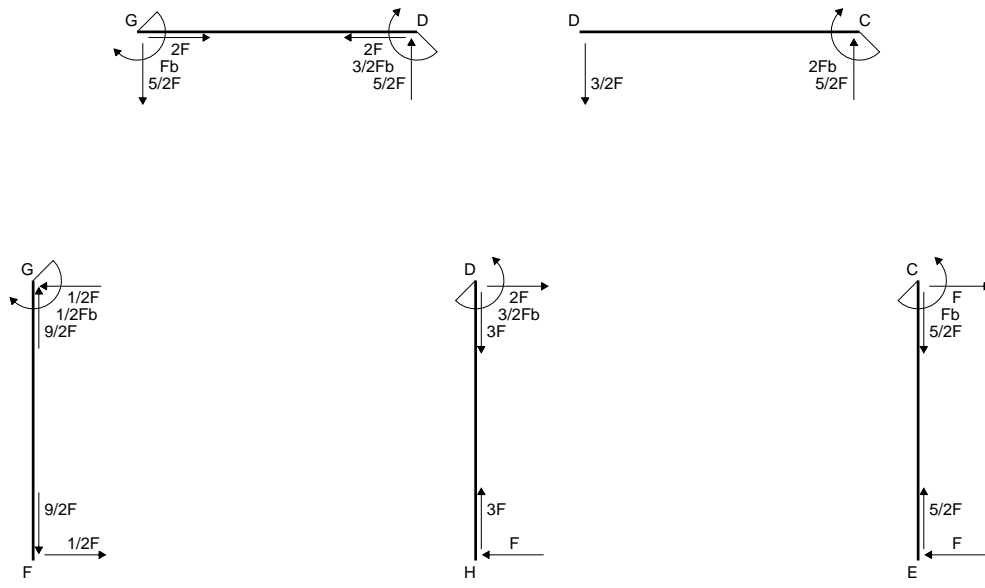
- A = 906. mm<sup>2</sup>
- J<sub>u</sub> = 314037. mm<sup>4</sup>
- J<sub>v</sub> = 80478. mm<sup>4</sup>
- y<sub>g</sub> = 34.33 mm
- T<sub>y</sub> = -3800. N
- M<sub>x</sub> = -2188800. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -34.33 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -239.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 13. mm
- v<sub>c</sub> = -21.33 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -148.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 12.61 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 150.3 N/mm<sup>2</sup>
- S = 6251. mm<sup>3</sup>



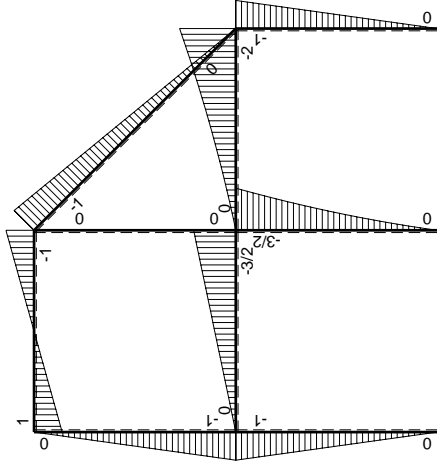
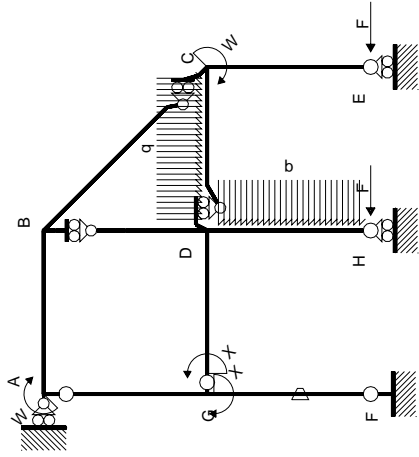


← ⊕ → F

↑ ⊕ ↓ F

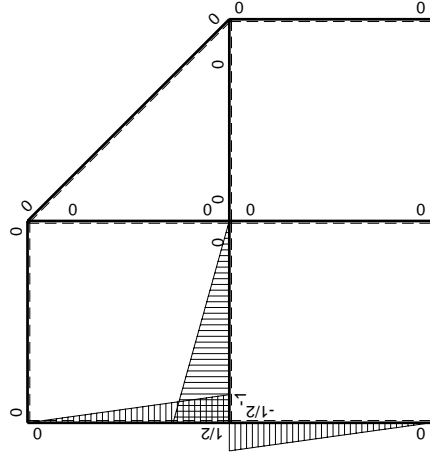


⊕ ↺ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	Fb-2Fx	0	0	0	0	0+0	0	
BA b	0	Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

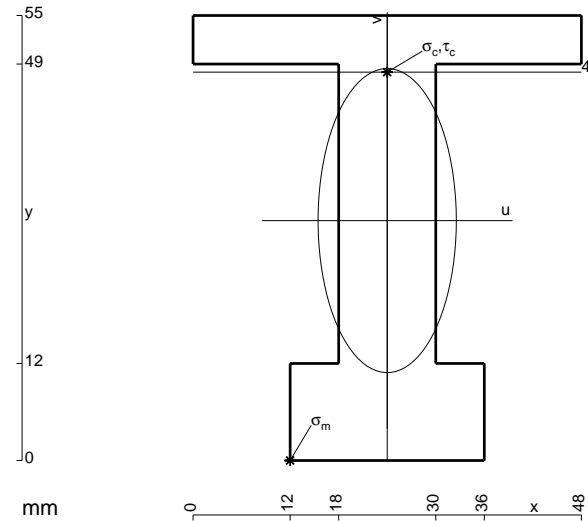
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{x\theta} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



$$A = 1020. \text{ mm}^2$$

$$J_u = 360241. \text{ mm}^4$$

$$J_v = 74448. \text{ mm}^4$$

$$y_g = 29.65 \text{ mm}$$

$$T_y = -3875. \text{ N}$$

$$M_x = -2418000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.65 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 48. \text{ mm}$$

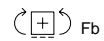
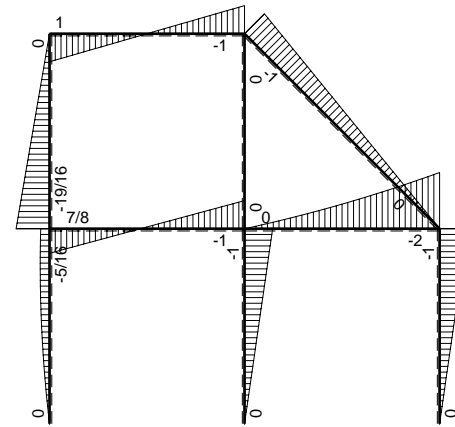
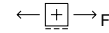
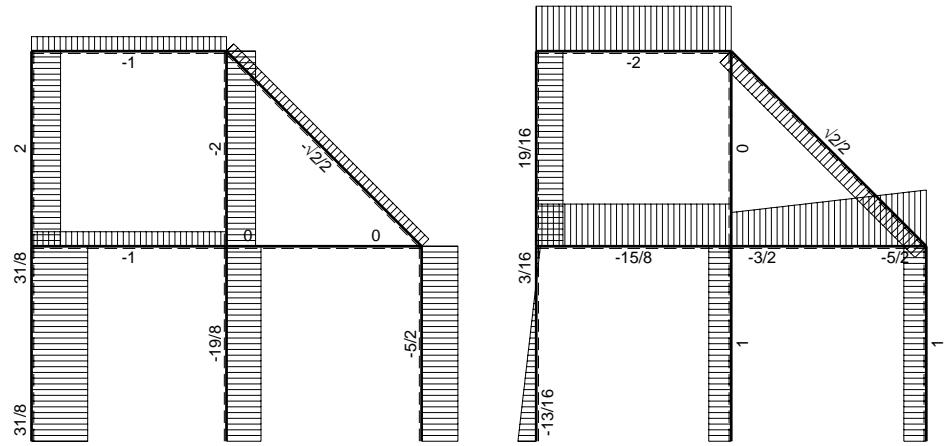
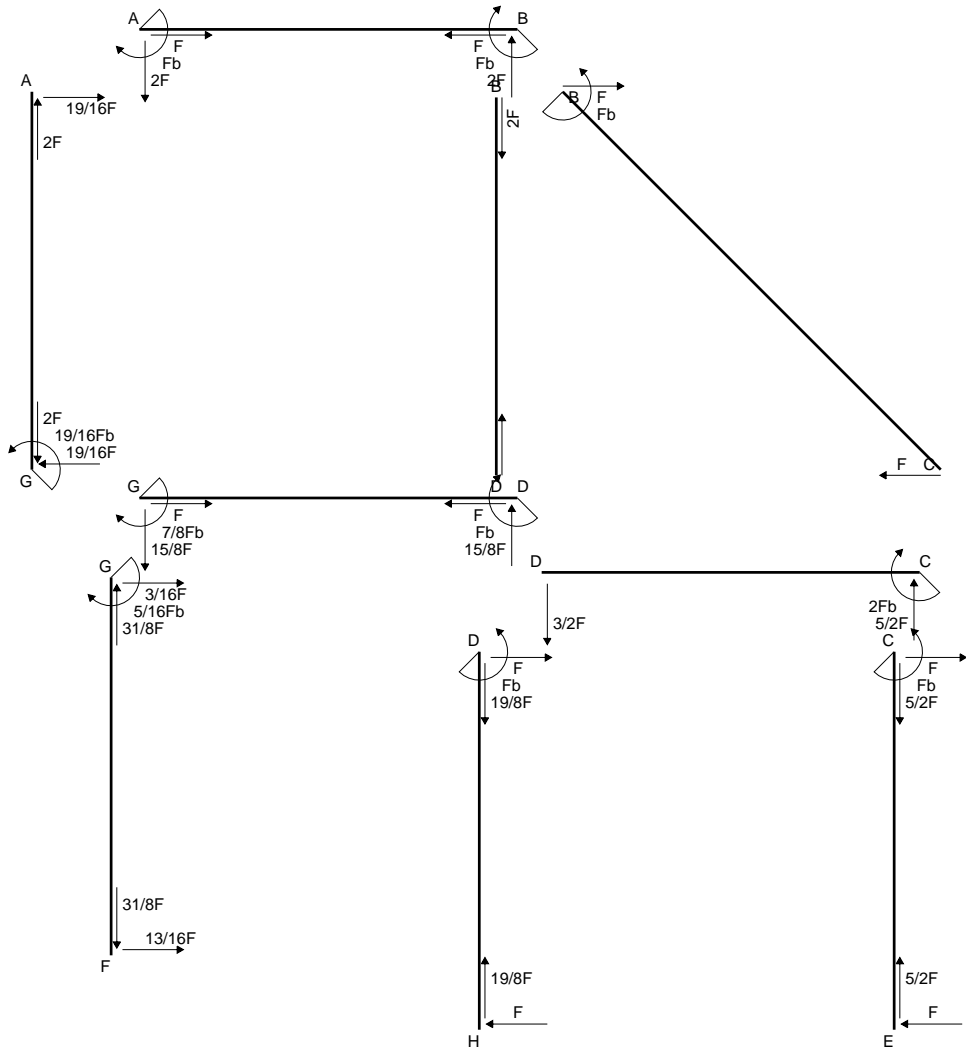
$$v_c = 18.35 \text{ mm}$$

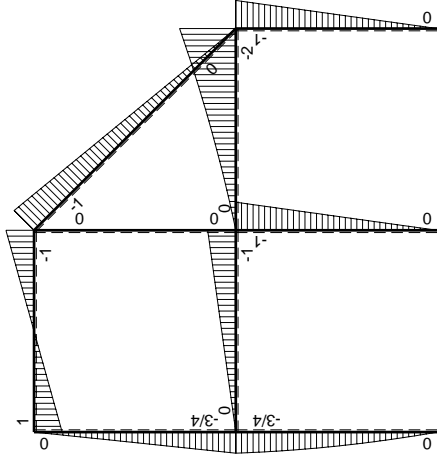
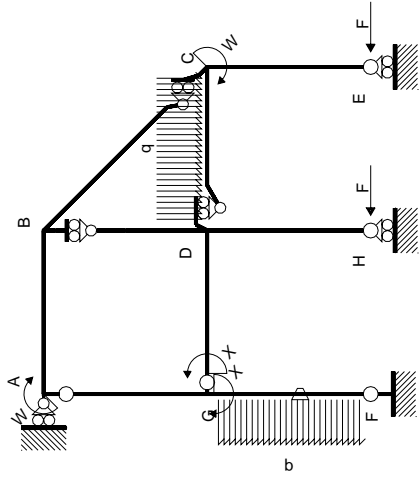
$$\sigma_c = -Mv/J_u = 123.1 \text{ N/mm}^2$$

$$\tau_c = 5.972 \text{ N/mm}^2$$

$$\sigma_\rho = \sqrt{\sigma^2 + 3\tau^2} = 123.6 \text{ N/mm}^2$$

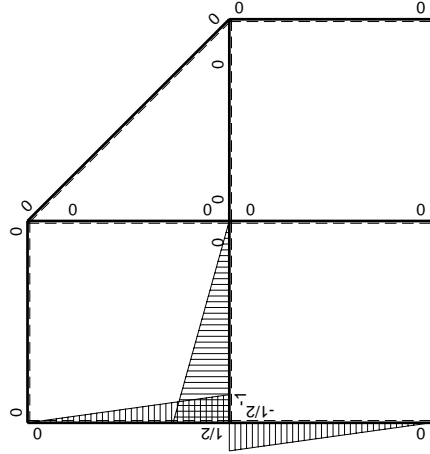
$$S = 6662. \text{ mm}^3$$





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	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	0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-5/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	5/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(7/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-1/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-1/2Fx-1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+3/4Fx	0	-3/8Fb+3/4Fx-3/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

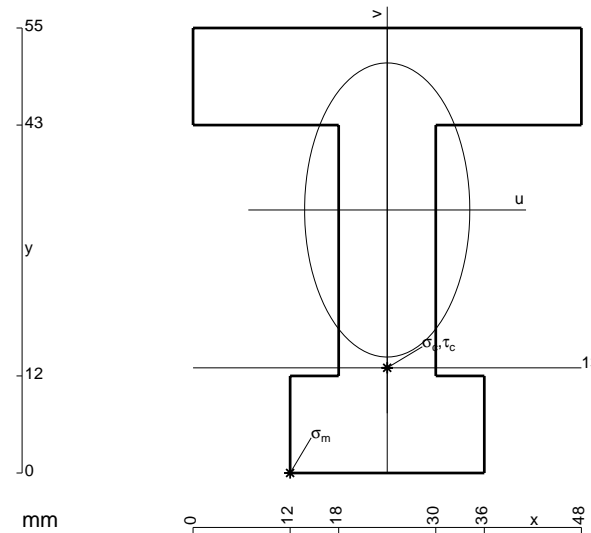
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



$$A = 1236. \text{ mm}^2$$

$$J_u = 408523. \text{ mm}^4$$

$$J_v = 128880. \text{ mm}^4$$

$$y_g = 32.51 \text{ mm}$$

$$T_y = -3950. \text{ N}$$

$$M_x = -2622800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -32.51 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.7 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

$$v_c = -19.51 \text{ mm}$$

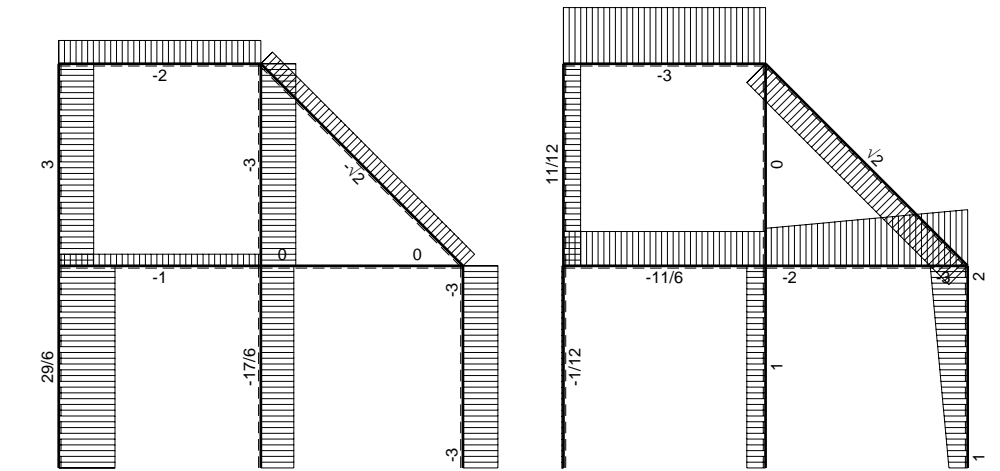
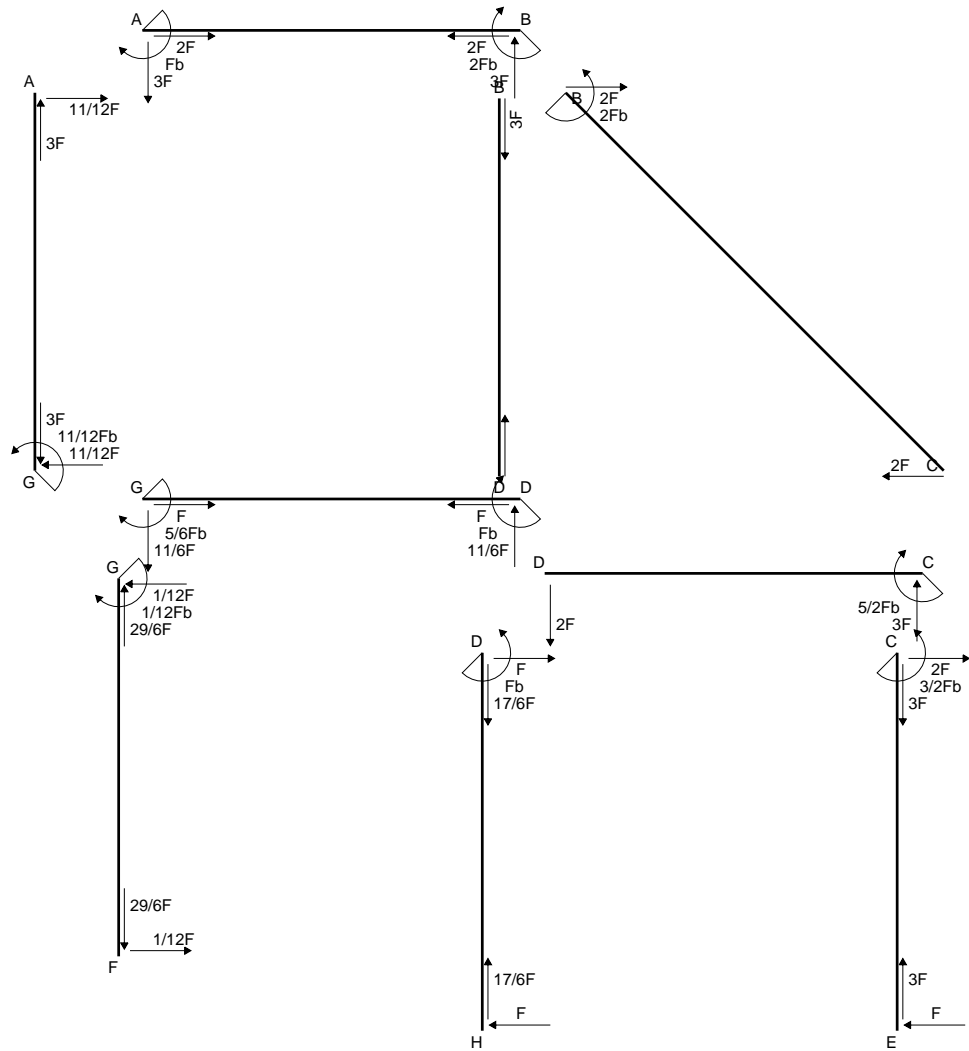
$$\sigma_c = -Mv/J_u = -125.3 \text{ N/mm}^2$$

$$\tau_c = 6.345 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 125.7 \text{ N/mm}^2$$

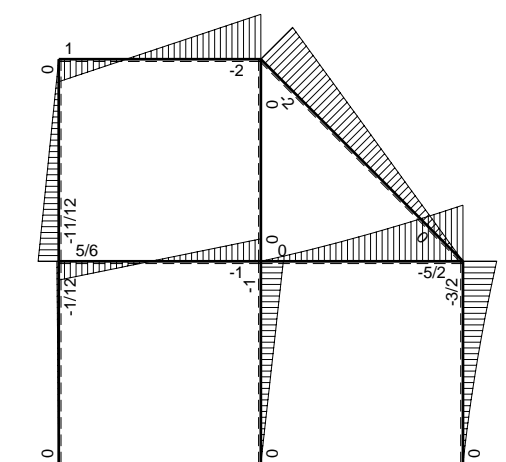
$$S = 7875. \text{ mm}^3$$



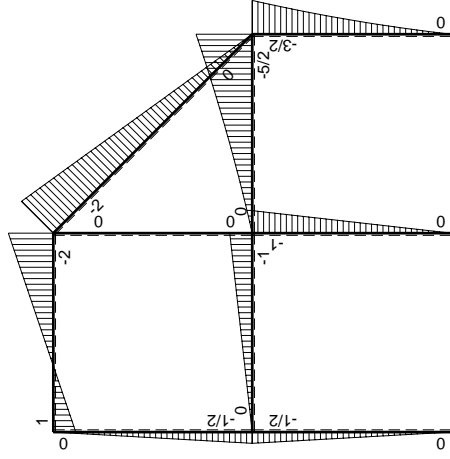
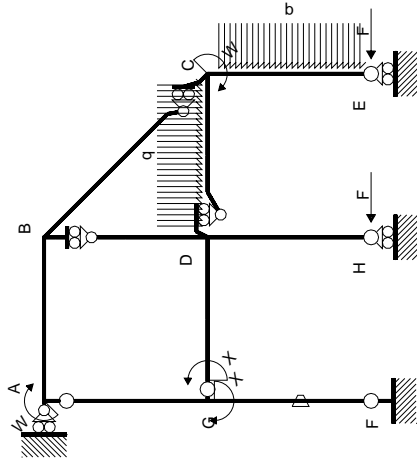


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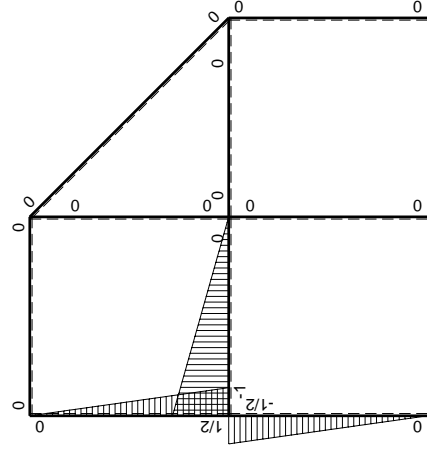


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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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 <sup>2</sup>	0	0	0	0	0+0	0	
CD b	0	5/2Fb-3Fx+1/2qx <sup>2</sup>	0	0	0	0			
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	-1/2Fx	-Fb/EJ	1/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-1/2Fx	Fb/EJ	1/4Fb-1/2Fx+1/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-Fx	0	Fx-Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/6+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	Fb-Fx	0	Fx-Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							5/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-5/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

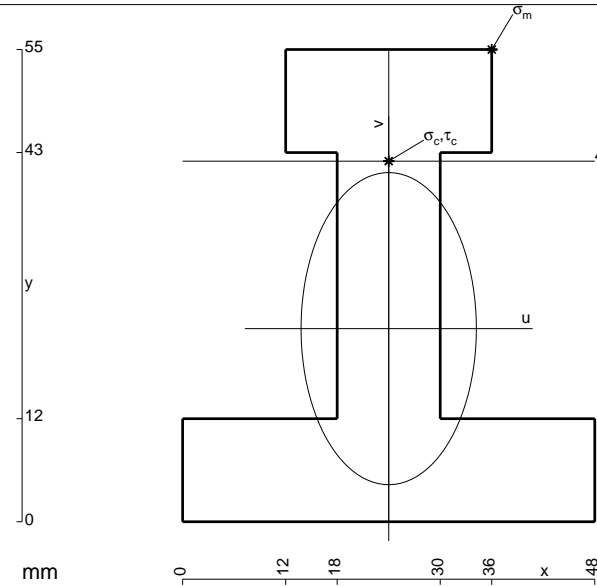
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

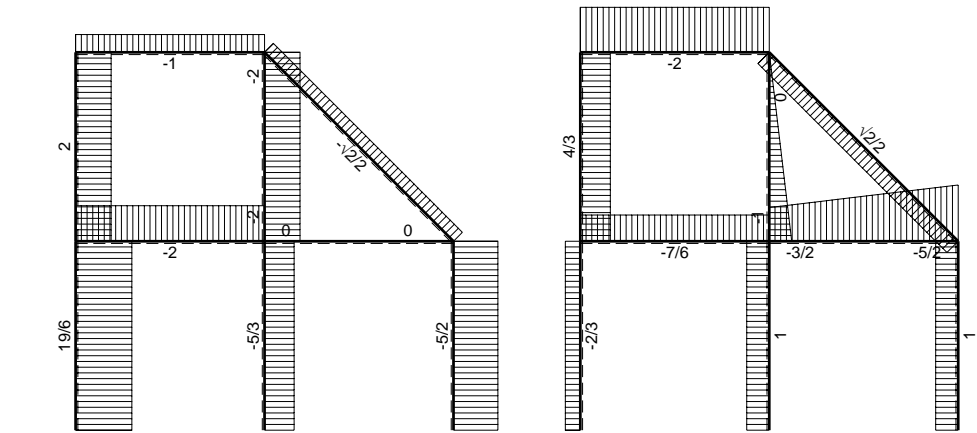
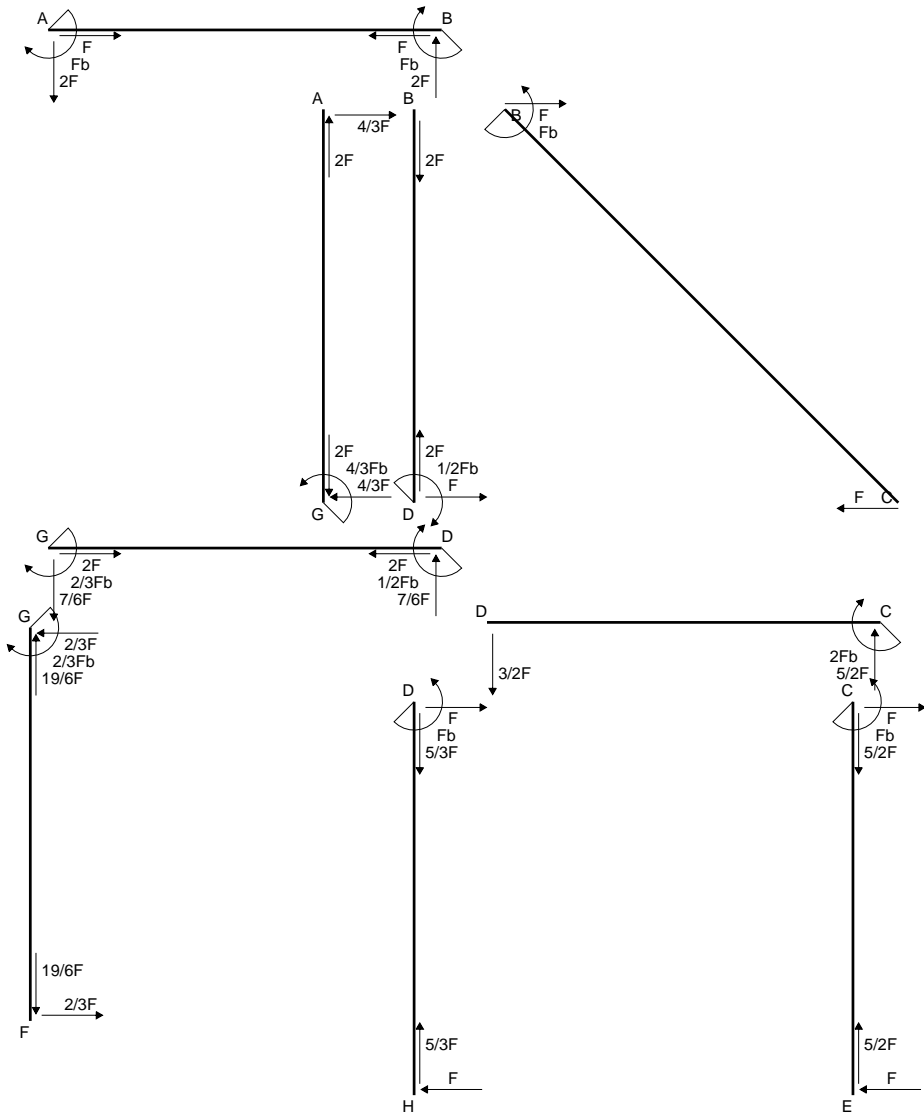
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

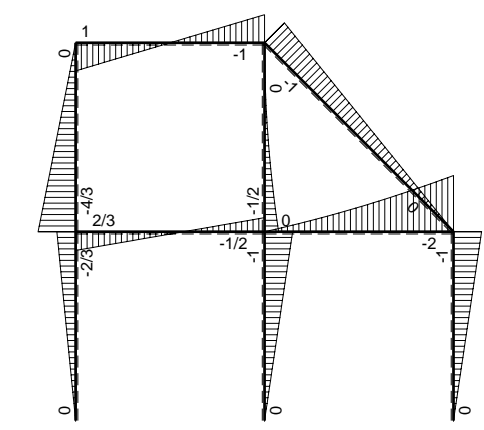


- A = 1236. mm<sup>2</sup>
- J<sub>u</sub> = 408523. mm<sup>4</sup>
- J<sub>v</sub> = 128880. mm<sup>4</sup>
- y<sub>g</sub> = 22.49 mm
- T<sub>y</sub> = -3750. N
- M<sub>x</sub> = -2750000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 32.51 mm
- σ<sub>m</sub> = -M<sub>v</sub>/J<sub>u</sub> = 218.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 19.51 mm
- σ<sub>c</sub> = -M<sub>v</sub>/J<sub>u</sub> = 131.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.024 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 131.7 N/mm<sup>2</sup>
- S = 7875. mm<sup>3</sup>

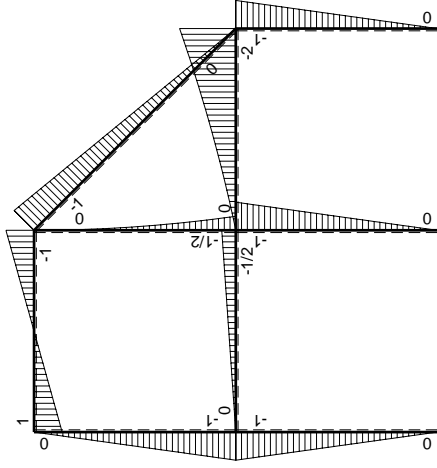
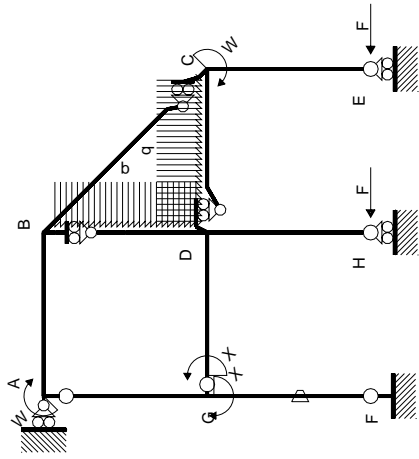


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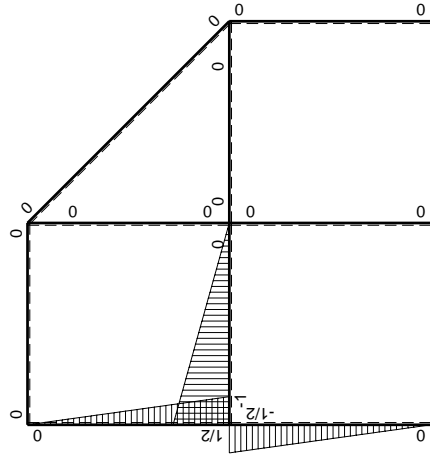


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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	Fb-2Fx	0	0	0	0	0+0	0
BA b	0	Fb-2Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DC b	0	-3/2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CD b	0	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	0	0	0	0+0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0+0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GD b	-1+x/b	-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	1/2Fb-1/2Fx	0	1/2Fx-1/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>	(1/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0+0	0
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
	totali						1/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-2/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [1/4 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

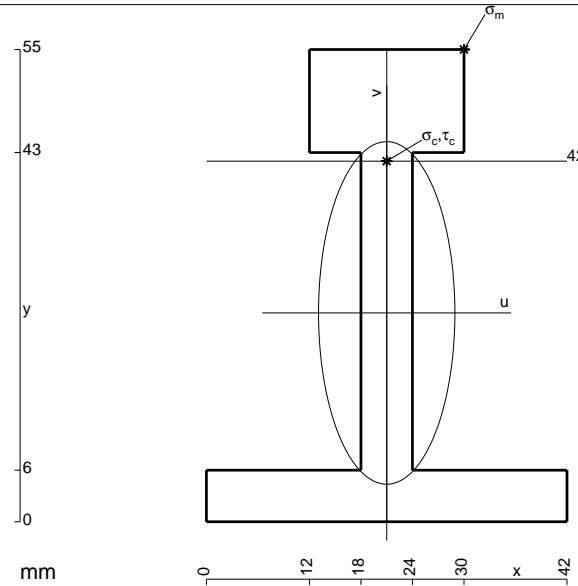
$$= (1/4 b - 1/6 b) Fb 1/EJ = 1/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

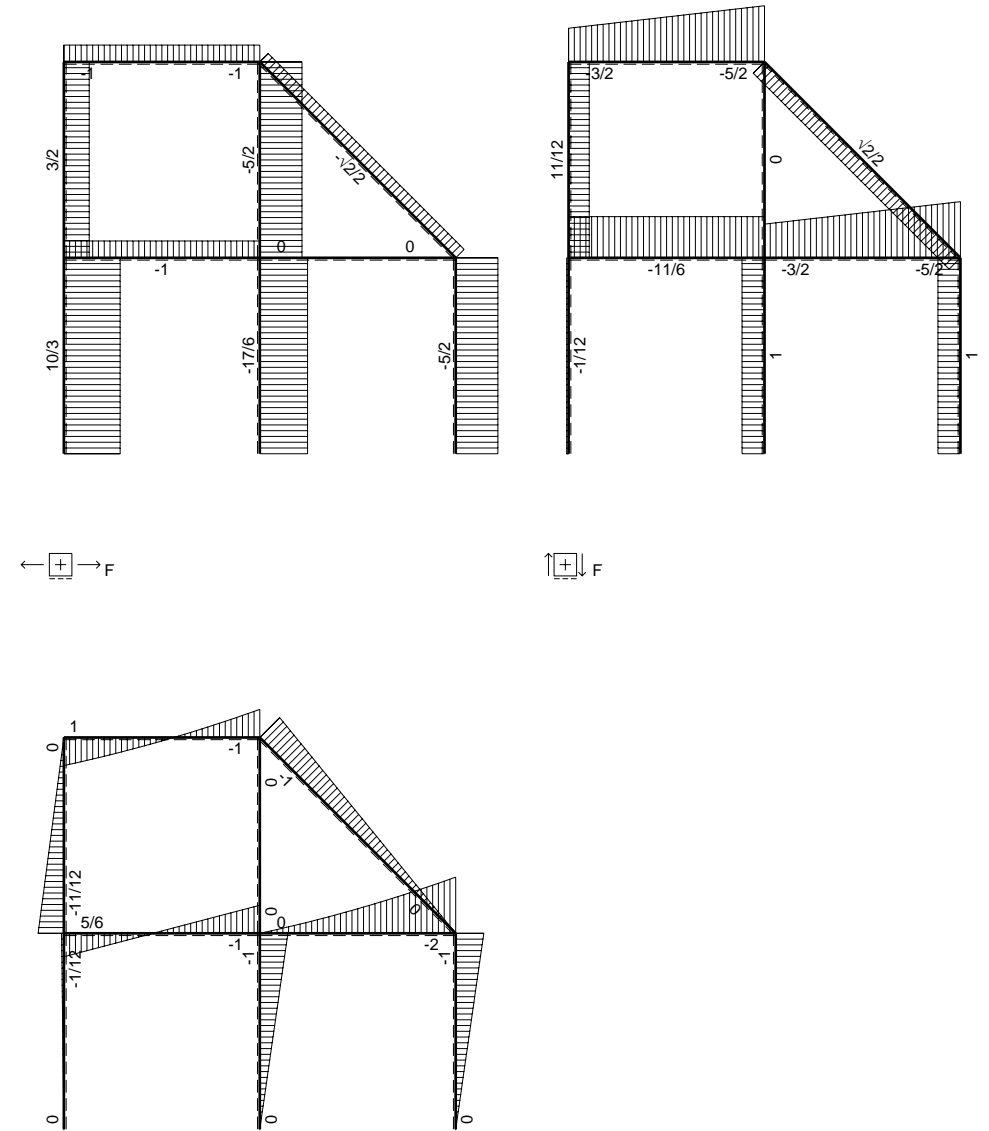
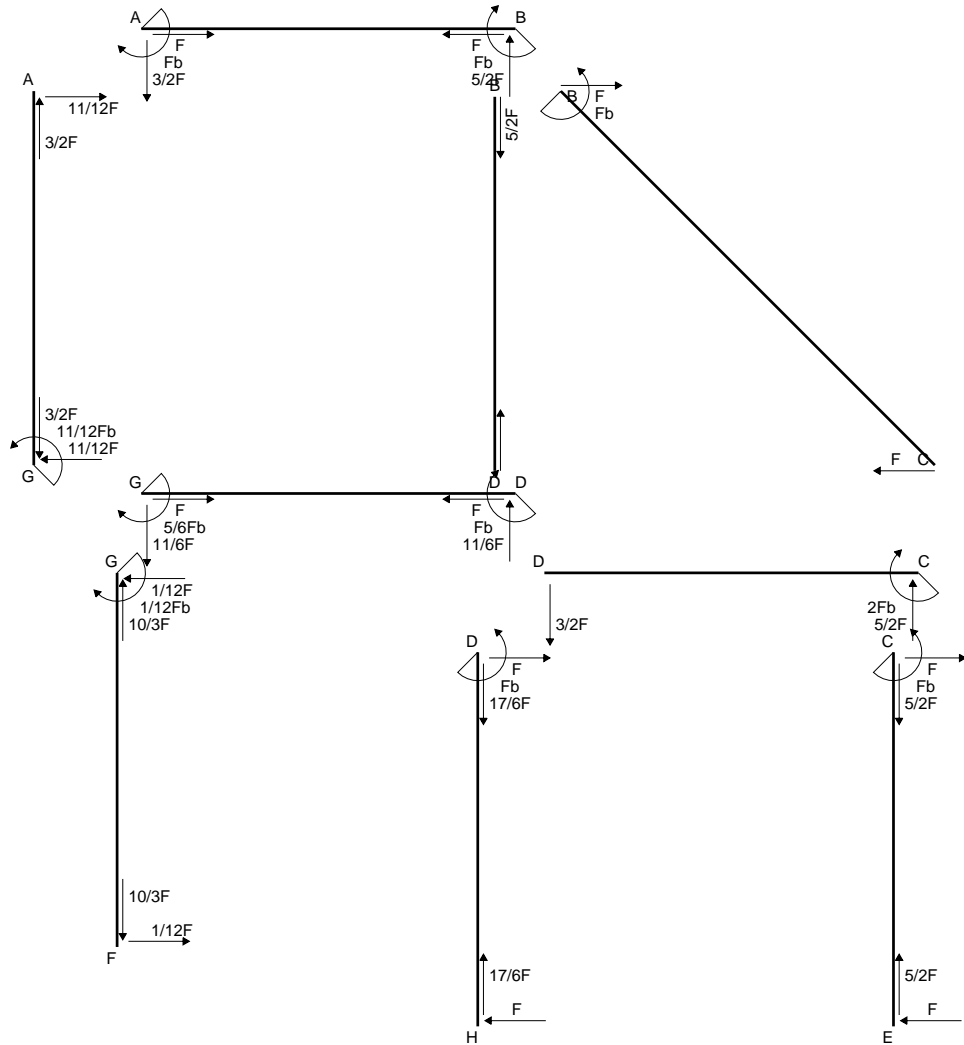
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

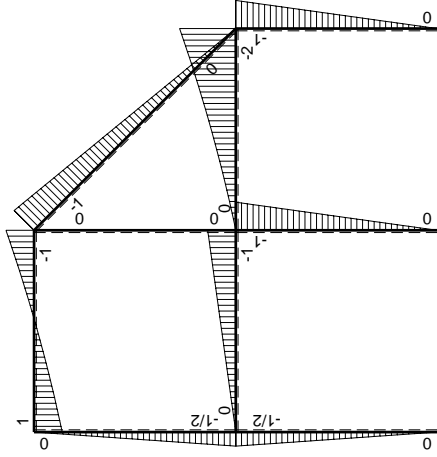
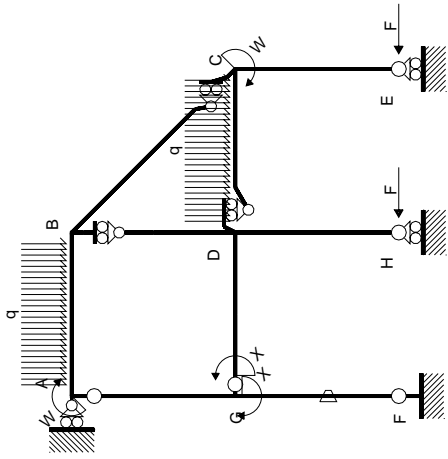


- A = 690. mm<sup>2</sup>
- J<sub>u</sub> = 274793. mm<sup>4</sup>
- J<sub>v</sub> = 43542. mm<sup>4</sup>
- y<sub>g</sub> = 24.32 mm
- T<sub>y</sub> = -2750. N
- M<sub>x</sub> = -2046000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 30.68 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 228.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 42. mm
- v<sub>c</sub> = 17.68 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 131.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 9.074 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 132.6 N/mm<sup>2</sup>
- S = 5441. mm<sup>3</sup>



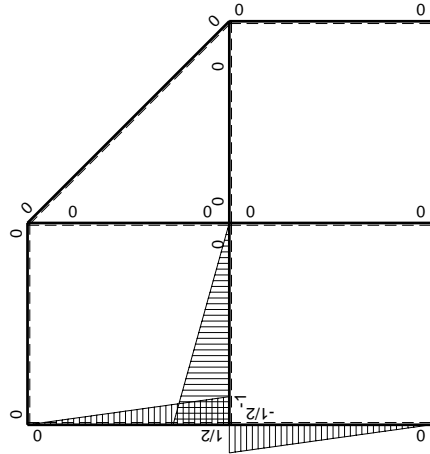


$\curvearrowright (+) Fb$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	$Fb-3/2Fx-1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fb-5/2Fx+1/2qx^2$	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (x/b - x^2/b^2) Fb 1/EJ dx = [1/2 x^2/b - 1/3 x^3/b^2]_0^b Fb 1/EJ$$

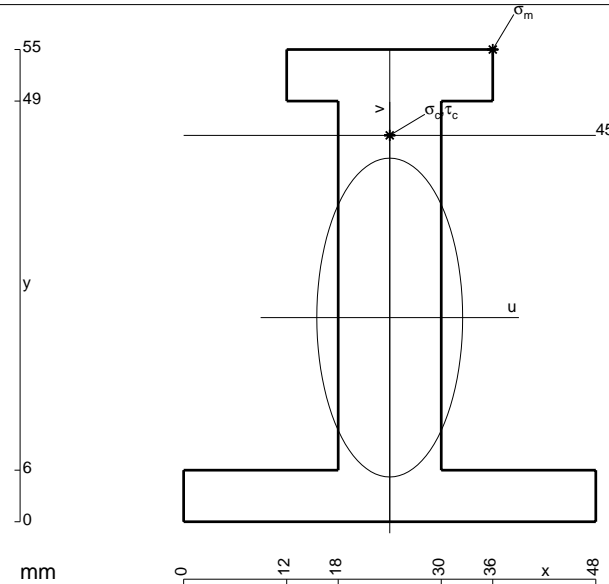
$$= (1/2 b - 1/3 b) Fb 1/EJ = 1/6 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

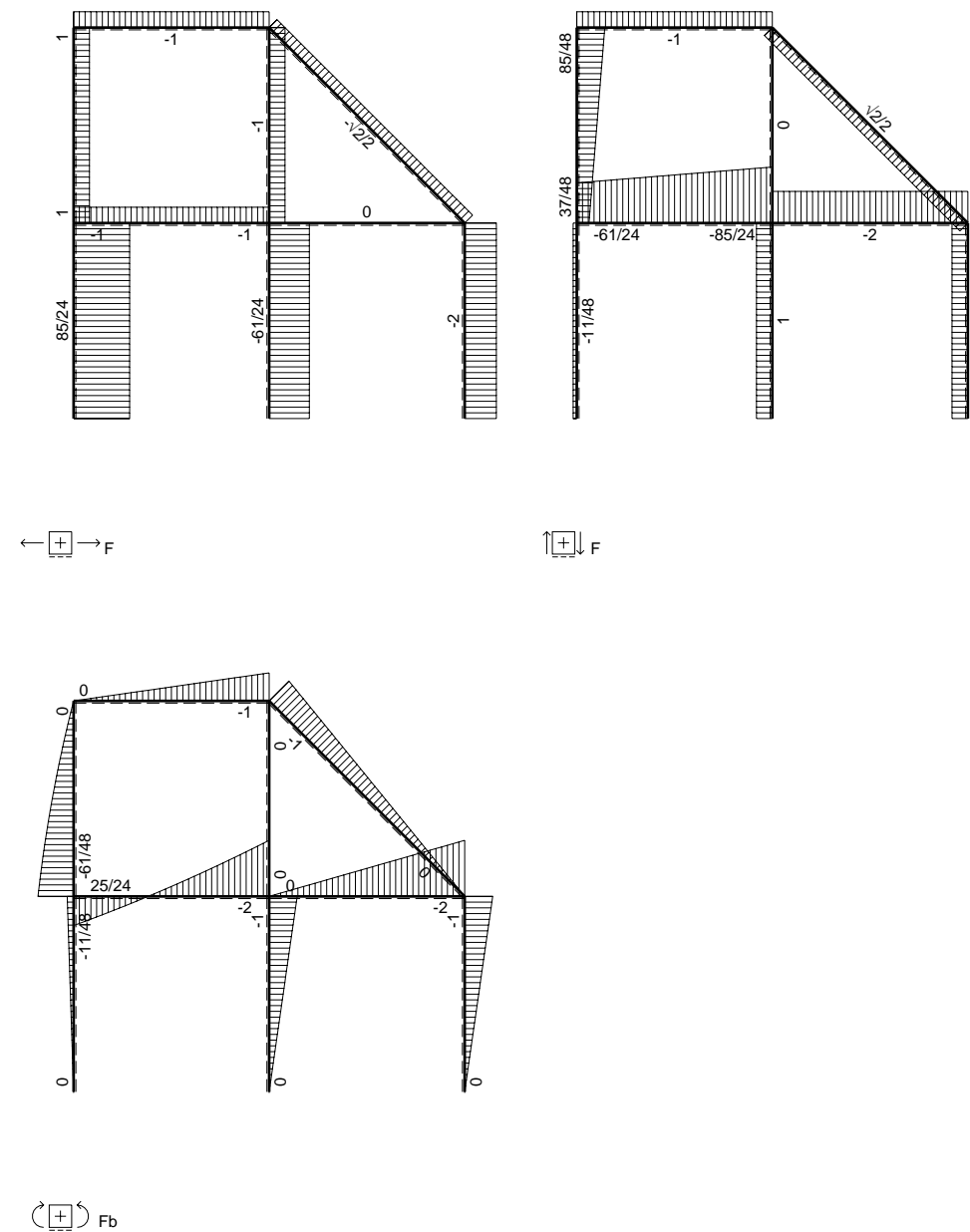
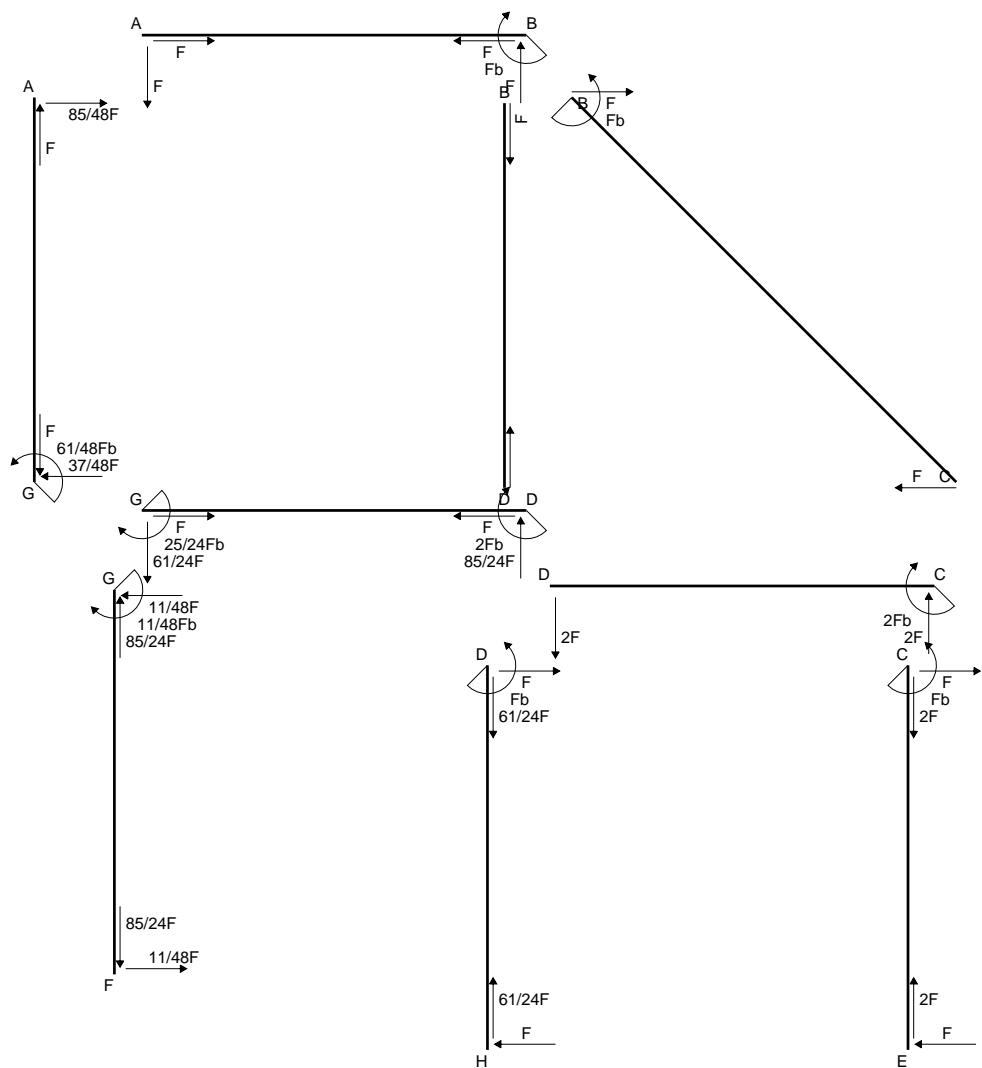
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

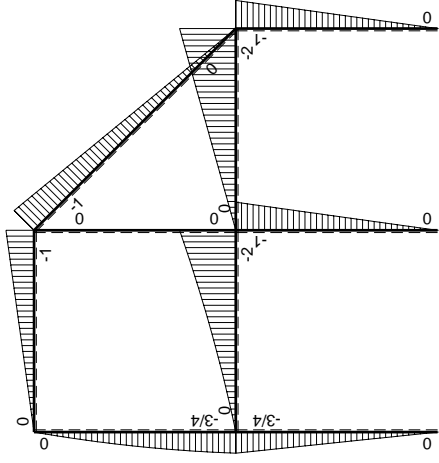
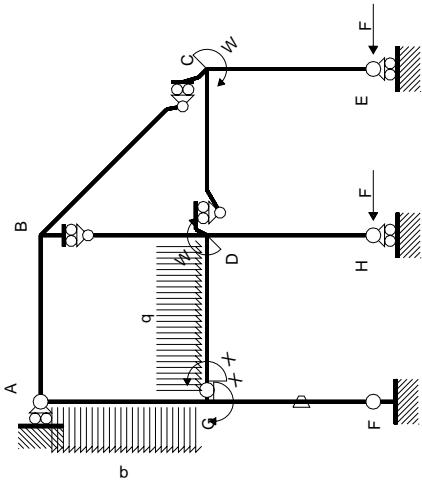
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



- A = 948. mm<sup>2</sup>
- J<sub>u</sub> = 326982. mm<sup>4</sup>
- J<sub>v</sub> = 68400. mm<sup>4</sup>
- y<sub>g</sub> = 23.78 mm
- T<sub>y</sub> = -3200. N
- M<sub>x</sub> = -2508800. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 31.22 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 239.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 45. mm
- v<sub>c</sub> = 21.22 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 162.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.223 N/mm<sup>2</sup>
- σ<sub>ρ</sub> = √(σ<sup>2</sup> + 3τ<sup>2</sup>) = 163. N/mm<sup>2</sup>
- S = 5179. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-Fx	0	0	0	0	0+0	0	
BA b	0	Fb-Fx	0	0	0	0	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	0	0	
DC b	0	-2Fx	0	0	0	0	0+0	0	
CD b	0	2Fb-2Fx	0	0	0	0	0	0	
CE b	0	-Fb+Fx	0	0	0	0	0+0	0	
EC b	0	Fx	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 3/4 x/b + 3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 3/8 x^2/b + 1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 3/8 b + 1/8 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 1/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/3 b - 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 5/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b - 5/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (b - 5/6 b + 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

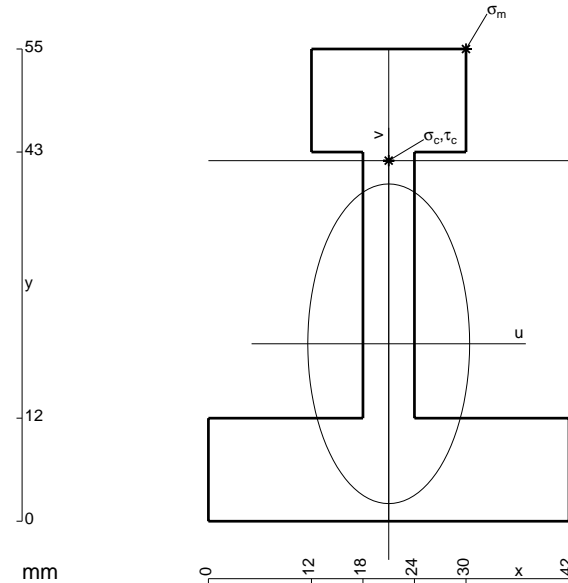
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



$$A = 906. \text{ mm}^2$$

$$J_u = 314037. \text{ mm}^4$$

$$J_v = 80478. \text{ mm}^4$$

$$y_g = 20.67 \text{ mm}$$

$$T_y = -3500. \text{ N}$$

$$M_x = -1820000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 55. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 34.33 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199. \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 42. \text{ mm}$$

$$v_c = 21.33 \text{ mm}$$

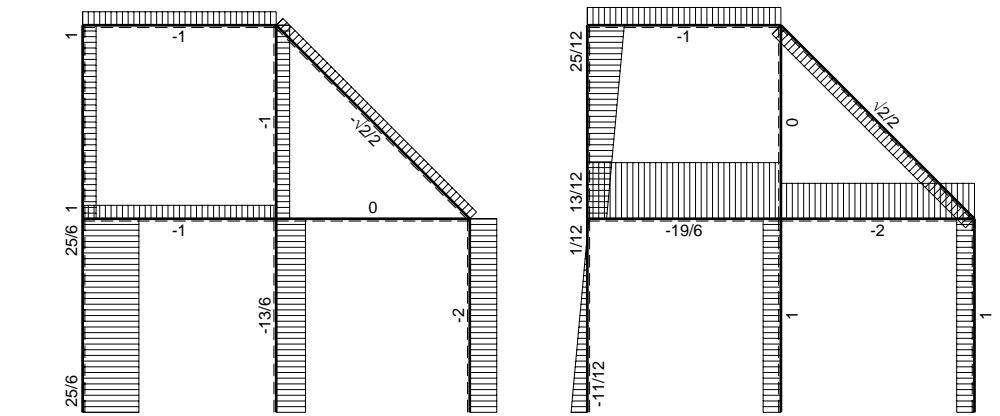
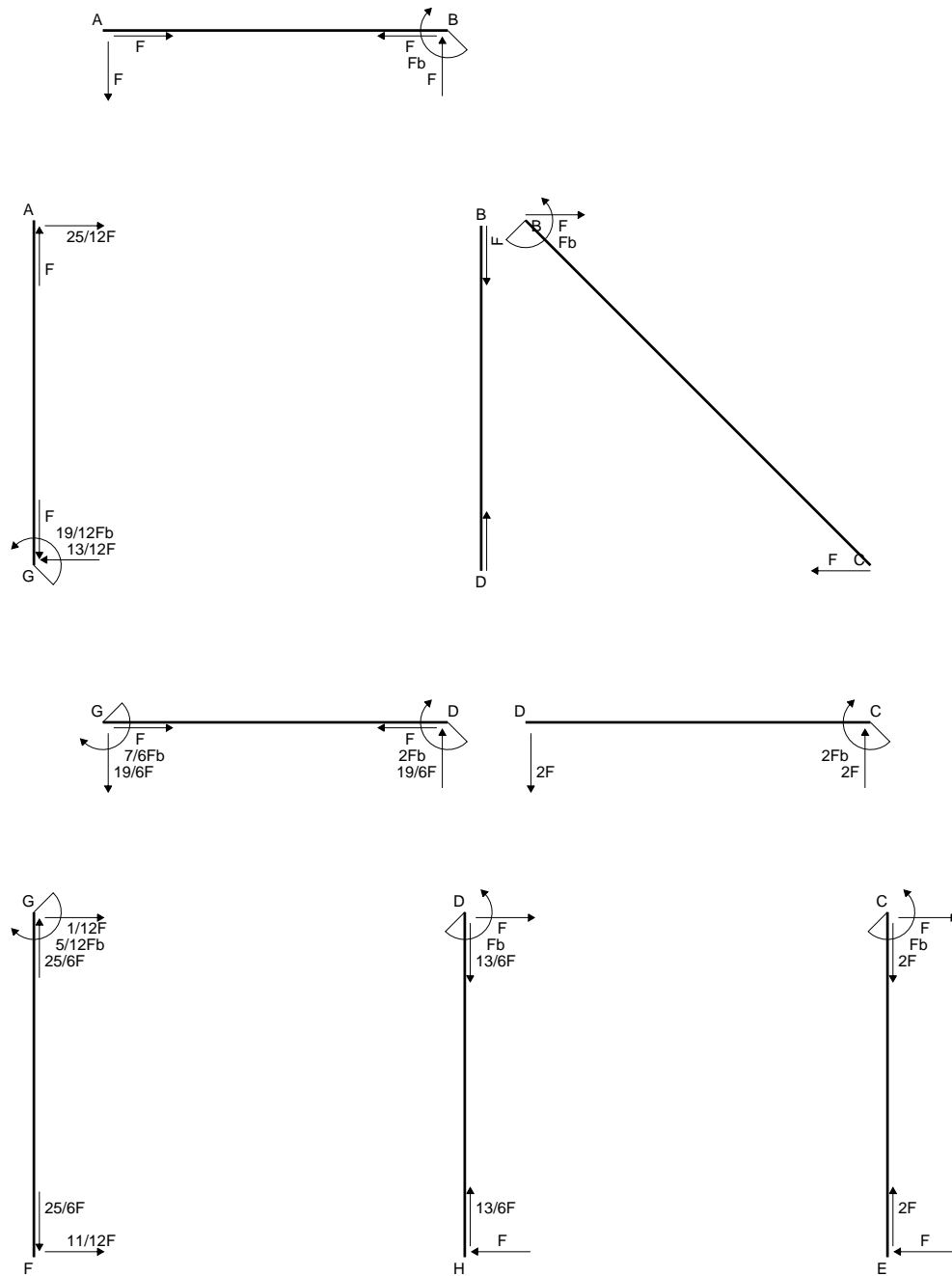
$$\sigma_c = -Mv/J_u = 123.6 \text{ N/mm}^2$$

$$\tau_c = 11.61 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 125.3 \text{ N/mm}^2$$

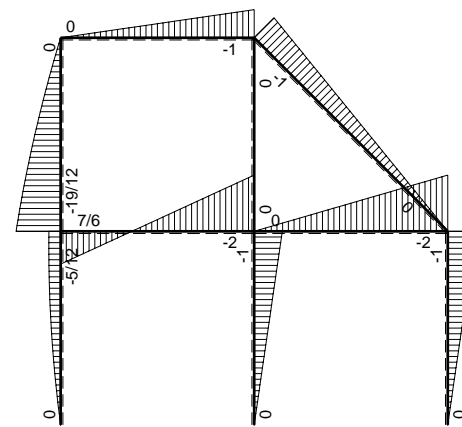
$$S = 6251. \text{ mm}^3$$



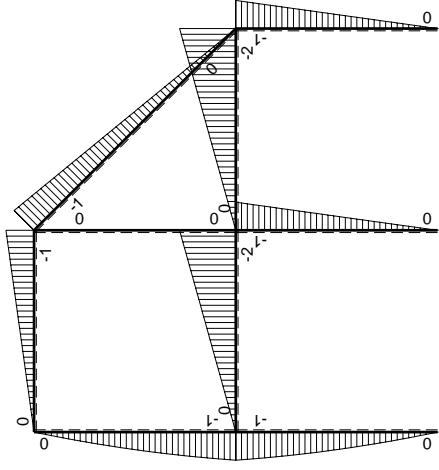
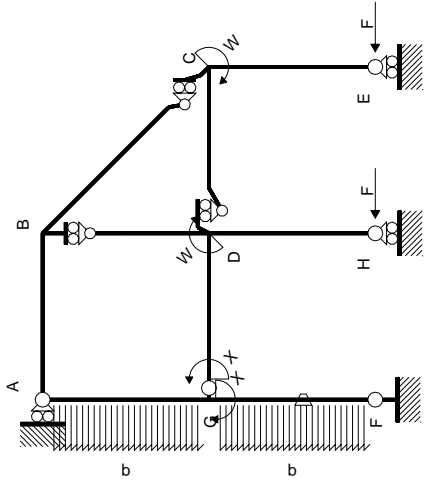


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⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
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 <sup>2</sup>	-Fb/EJ	3/4Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(3/16+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-1/2Fx-1/2qx <sup>2</sup>	Fb/EJ	1/2Fb-3/4Fx+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/3+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup>	0	-1/2Fb+3/4Fx-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-3/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx-1/2qx <sup>2</sup>	0	-3/4Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x_0} = \int_0^b (3/4 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [1/4 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 7/16 Fb^2/EJ$$

$$L_{GF}^{x_0} = \int_0^b (1/2 - 3/4 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 3/8 x^2/b + 1/16 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 3/8 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 7/16 Fb^2/EJ$$

$$L_{GD}^{x_0} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{DG}^{x_0} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

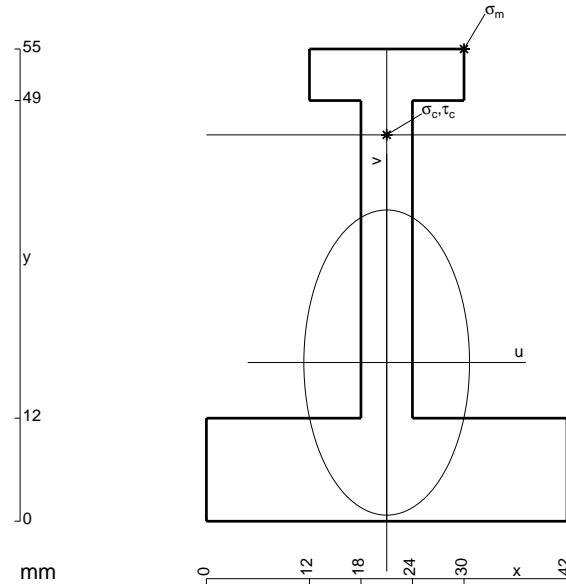
$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{GA}^{x_0} = \int_0^b (-1/2 + 3/4 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 3/8 x^2/b - 1/16 x^3/b^2]_0^b Fb 1/EJ$$

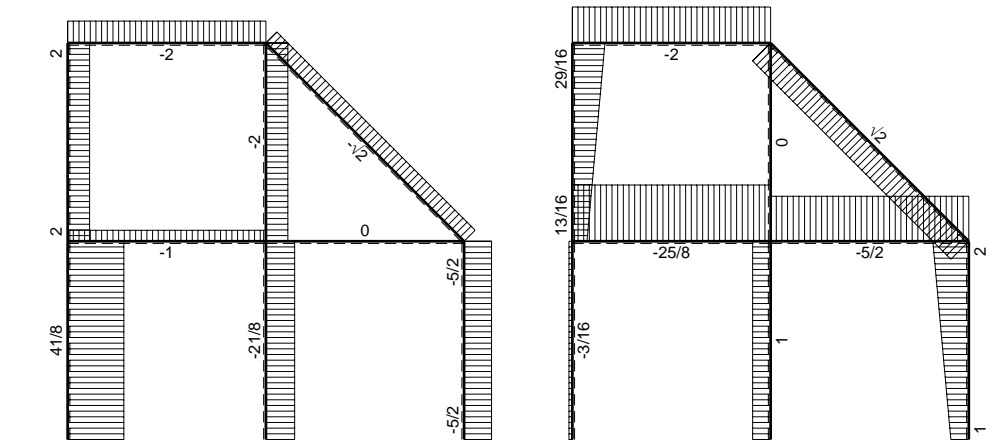
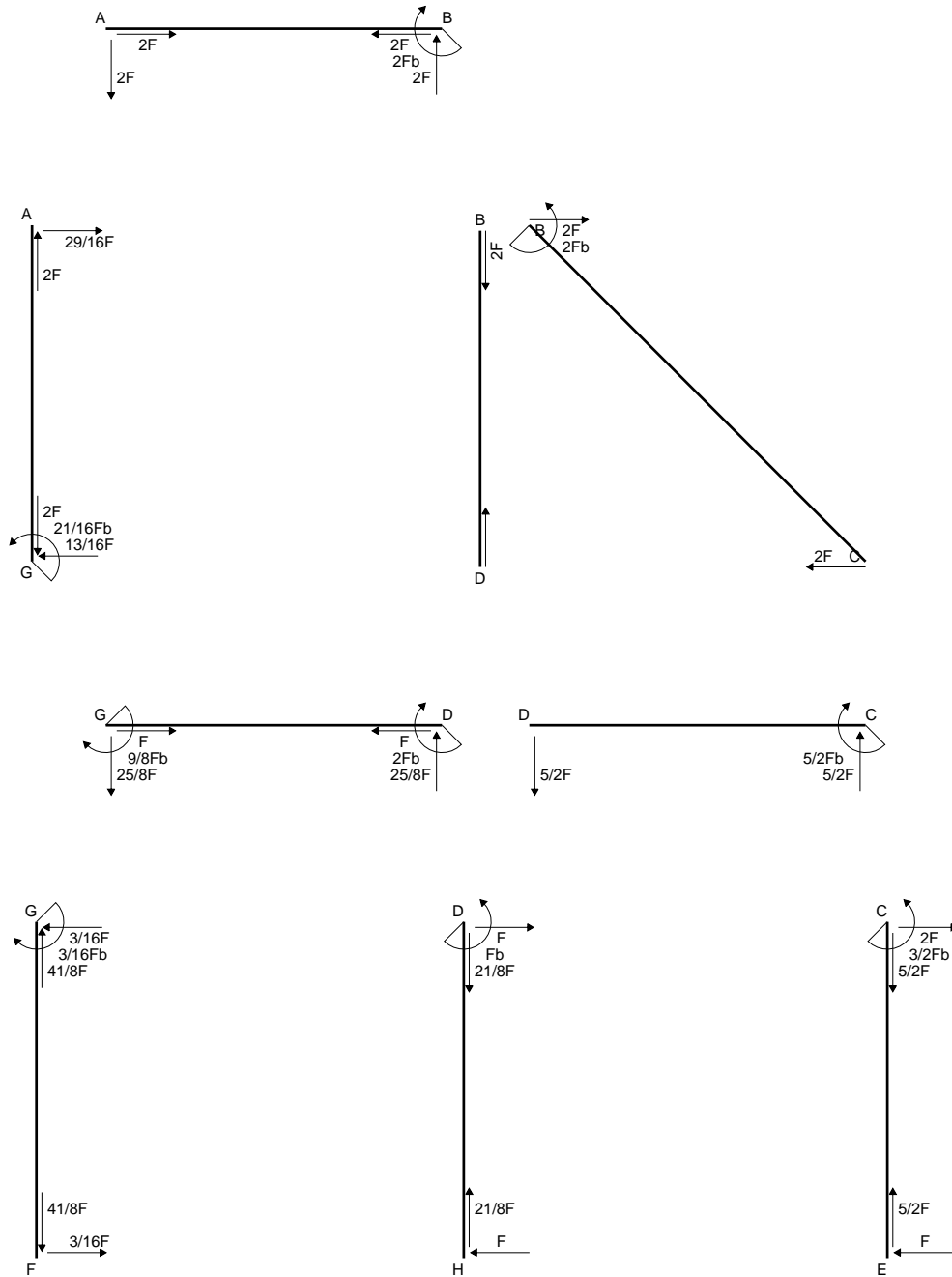
$$= (-1/2 b + 3/8 b - 1/16 b) Fb 1/EJ = -3/16 Fb^2/EJ$$

$$L_{AG}^{x_0} = \int_0^b (-3/4 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/4 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/16 b) Fb 1/EJ = -3/16 Fb^2/EJ$$

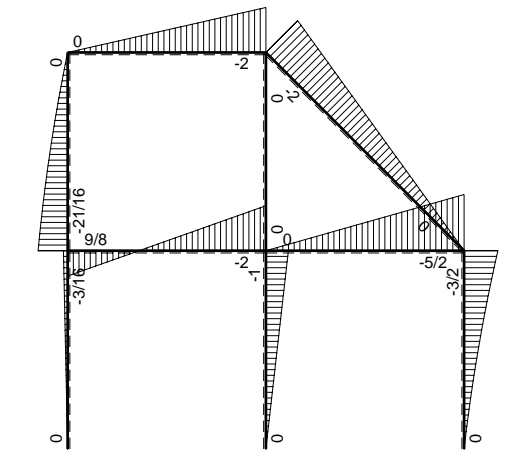


- A = 834. mm<sup>2</sup>
- J<sub>u</sub> = 263619. mm<sup>4</sup>
- J<sub>v</sub> = 77670. mm<sup>4</sup>
- y<sub>g</sub> = 18.48 mm
- T<sub>y</sub> = -2640. N
- M<sub>x</sub> = -1504800. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 36.52 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 208.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 45. mm
- v<sub>c</sub> = 26.52 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 151.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.185 N/mm<sup>2</sup>
- σ<sub>σ</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 151.9 N/mm<sup>2</sup>
- S = 4305. mm<sup>3</sup>

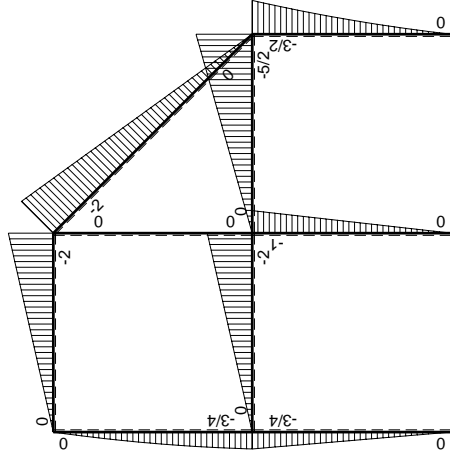
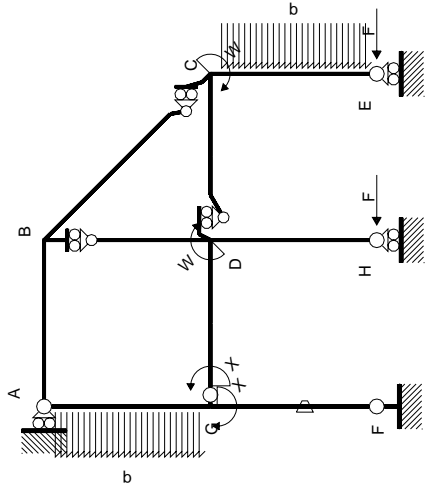


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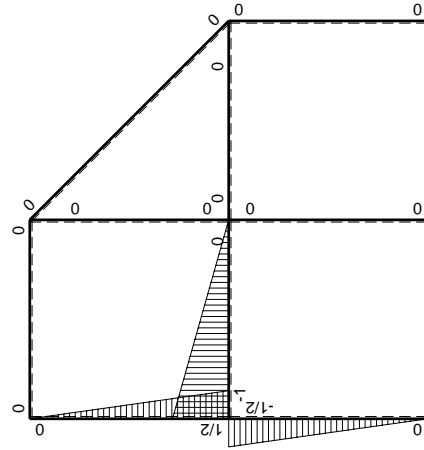
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Schema di calcolo iperstatico



$M_0$  flessione da carichi assegnati

$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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 <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0			
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	3/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/8+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	3/4Fb-3/4Fx	Fb/EJ	3/8Fb-3/4Fx+3/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/3+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
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 <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							9/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-9/8Fb	

Svilupi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 -2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b +1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b +1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 -3/4 x/b +3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 +1/2 x/b) \theta dx$$

$$= [3/8 x -3/8 x^2/b +1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

$$= (3/8 b -3/8 b +1/8 b) Fb 1/EJ + (-1/2 b +1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b -2 x^2/b^2) Fb 1/EJ dx = [x^2/b -2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b -2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b -2 x^2/b^2) Fb 1/EJ dx = [x^2/b -2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b -2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

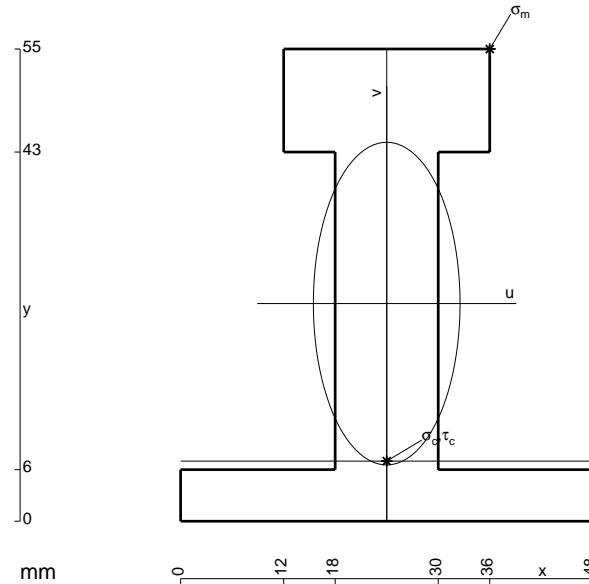
$$L_{GA}^{xo} = \int_0^b (-3/8 +1/2 x/b +1/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x +1/4 x^2/b +1/24 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b +1/4 b +1/24 b -1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

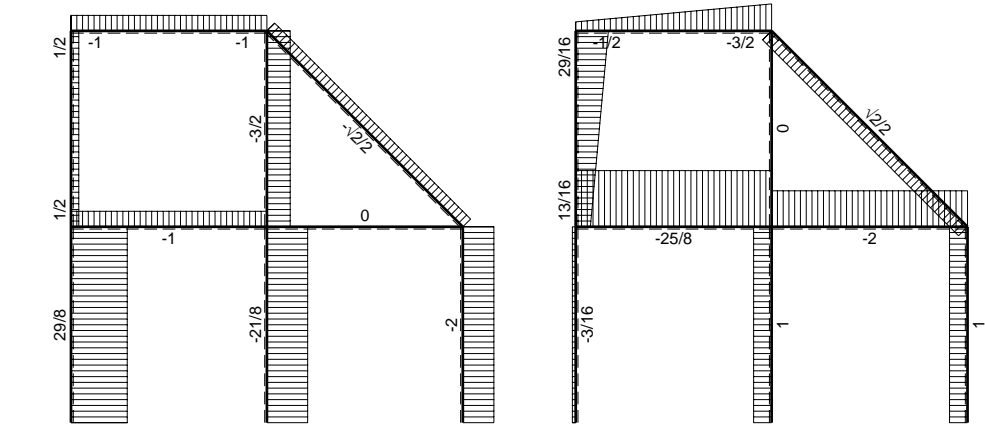
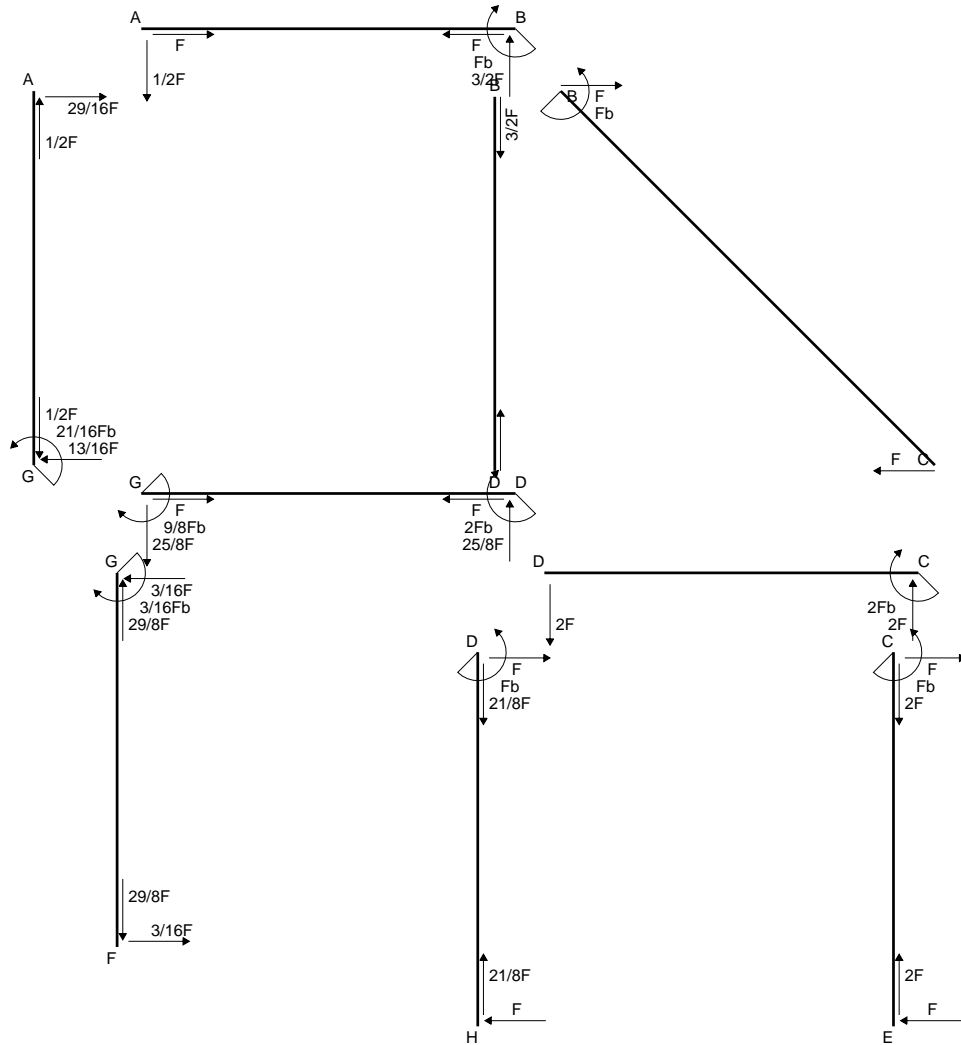
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 +1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 +1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b +1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



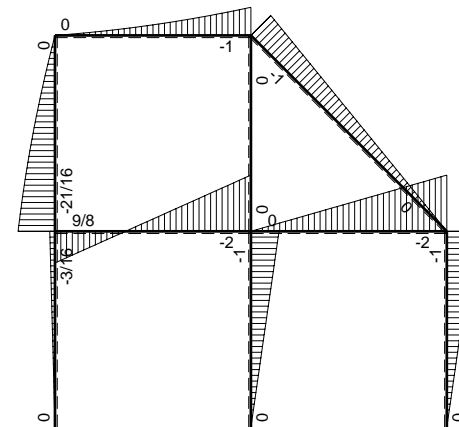
$A = 1020. \text{ mm}^2$   
 $J_u = 360241. \text{ mm}^4$   
 $J_v = 74448. \text{ mm}^4$   
 $y_g = 25.35 \text{ mm}$   
 $T_y = -4300. \text{ N}$   
 $M_x = -2666000. \text{ Nmm}$   
 $x_m = 36. \text{ mm}$   
 $y_m = 55. \text{ mm}$   
 $u_m = 12. \text{ mm}$   
 $v_m = 29.65 \text{ mm}$   
 $\sigma_m = -Mv/J_u = 219.4 \text{ N/mm}^2$   
 $x_c = 24. \text{ mm}$   
 $y_c = 7. \text{ mm}$   
 $v_c = -18.35 \text{ mm}$   
 $\sigma_c = -Mv/J_u = -135.8 \text{ N/mm}^2$   
 $\tau_c = 6.627 \text{ N/mm}^2$   
 $\sigma_\varrho = \sqrt{\sigma^2 + 3\tau^2} = 136.3 \text{ N/mm}^2$   
 $S = 6662. \text{ mm}^3$



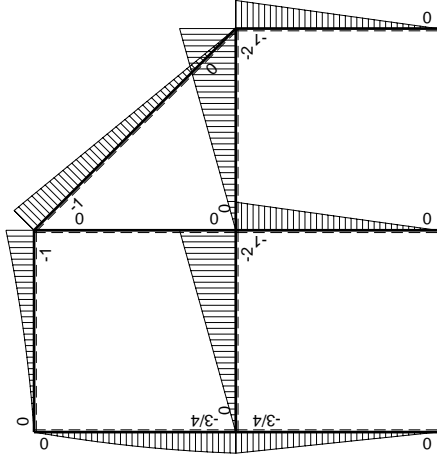
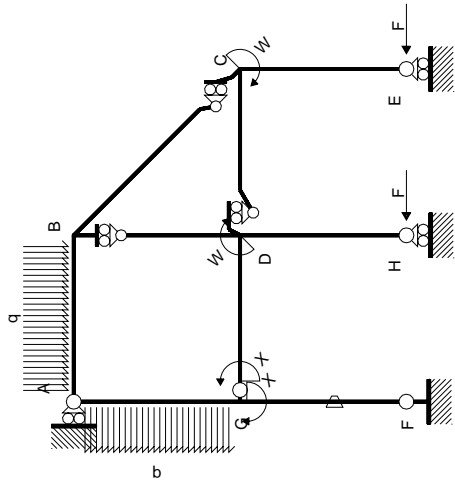


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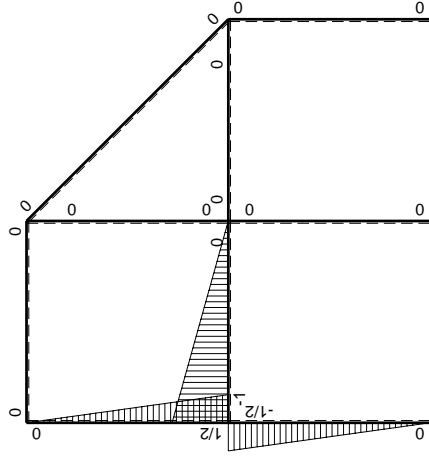


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
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	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	0	0	
DC b	0	$-2Fx$	0	0	0	0	0+0	0	
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0	
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0	
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 3/4 x/b + 3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 3/8 x^2/b + 1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 3/8 b + 1/8 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

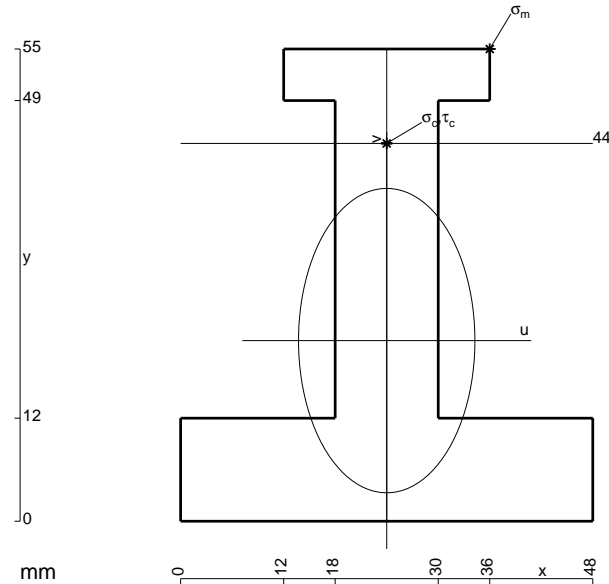
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

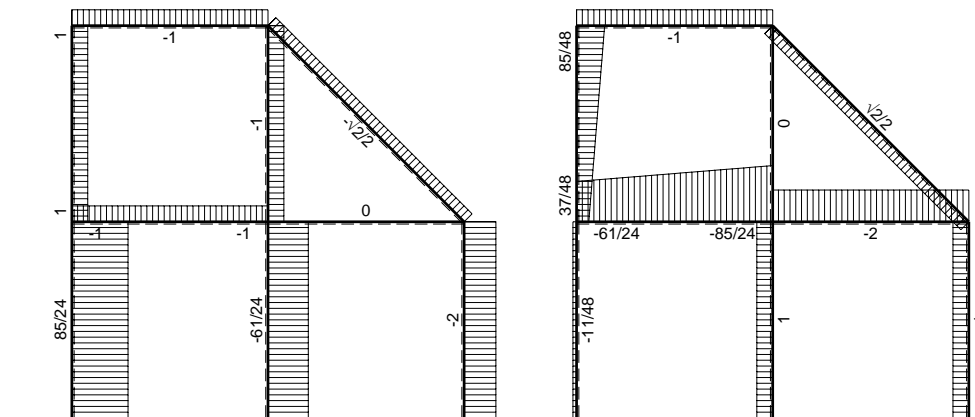
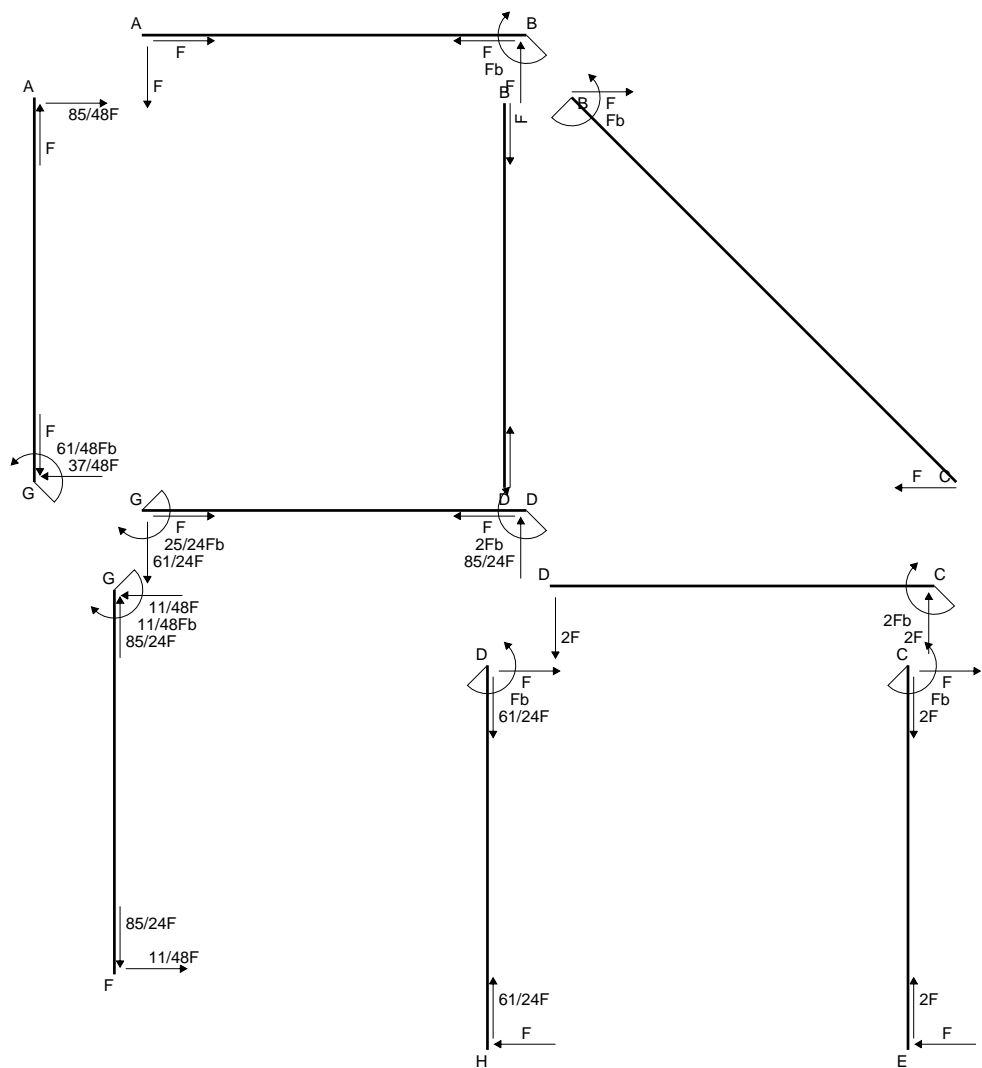
$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

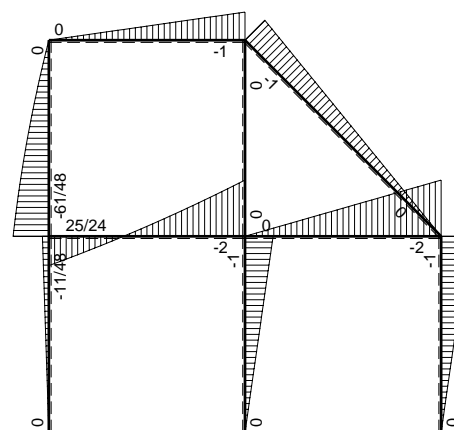


- A = 1164. mm<sup>2</sup>
- J<sub>u</sub> = 366050. mm<sup>4</sup>
- J<sub>v</sub> = 122832. mm<sup>4</sup>
- y<sub>g</sub> = 21.04 mm
- T<sub>y</sub> = -3680. N
- M<sub>x</sub> = -2465600. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.96 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 228.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 44. mm
- v<sub>c</sub> = 22.96 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 154.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 5.015 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 154.9 N/mm<sup>2</sup>
- S = 5987. mm<sup>3</sup>

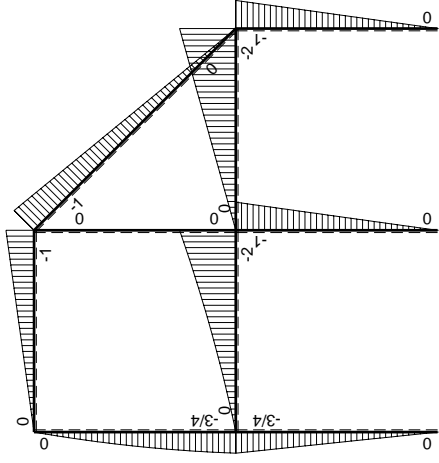
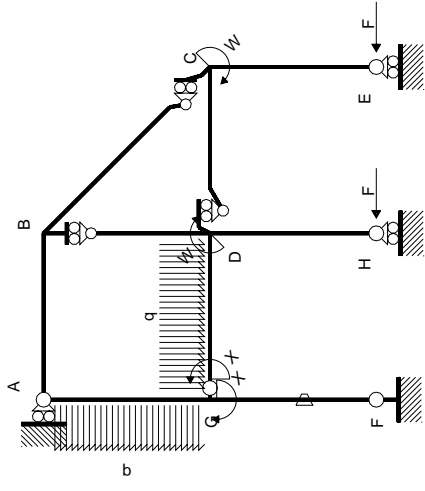


← ⊕ → F

↑ ⊕ ↓ Fb

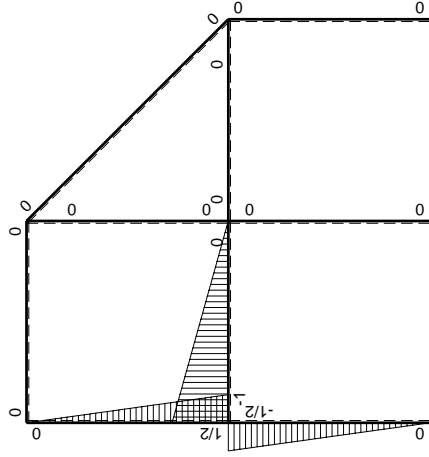


⊕ ⊕ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	3/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/8+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-3/4Fx	Fb/EJ	3/8Fb-3/4Fx+3/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx-1/2qx <sup>2</sup>	0	3/2Fx-Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(7/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	2Fx-5/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/4Fb+1/4Fx+1/2qx <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						25/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-25/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 3/4 x/b + 3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 3/8 x^2/b + 1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 3/8 b + 1/8 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 1/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/3 b - 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 5/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b - 5/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (b - 5/6 b + 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

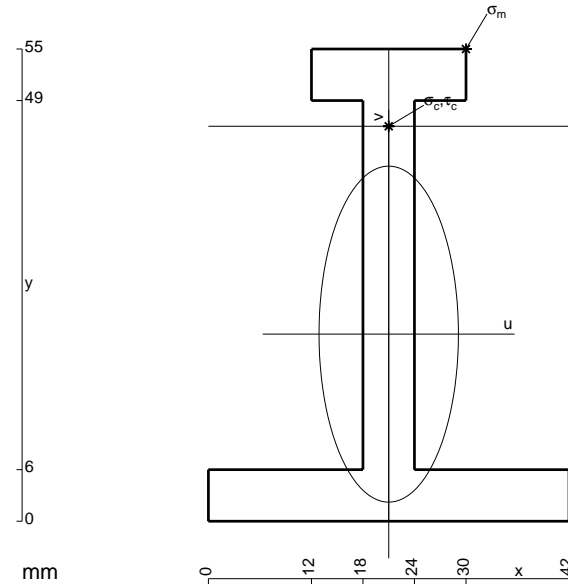
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

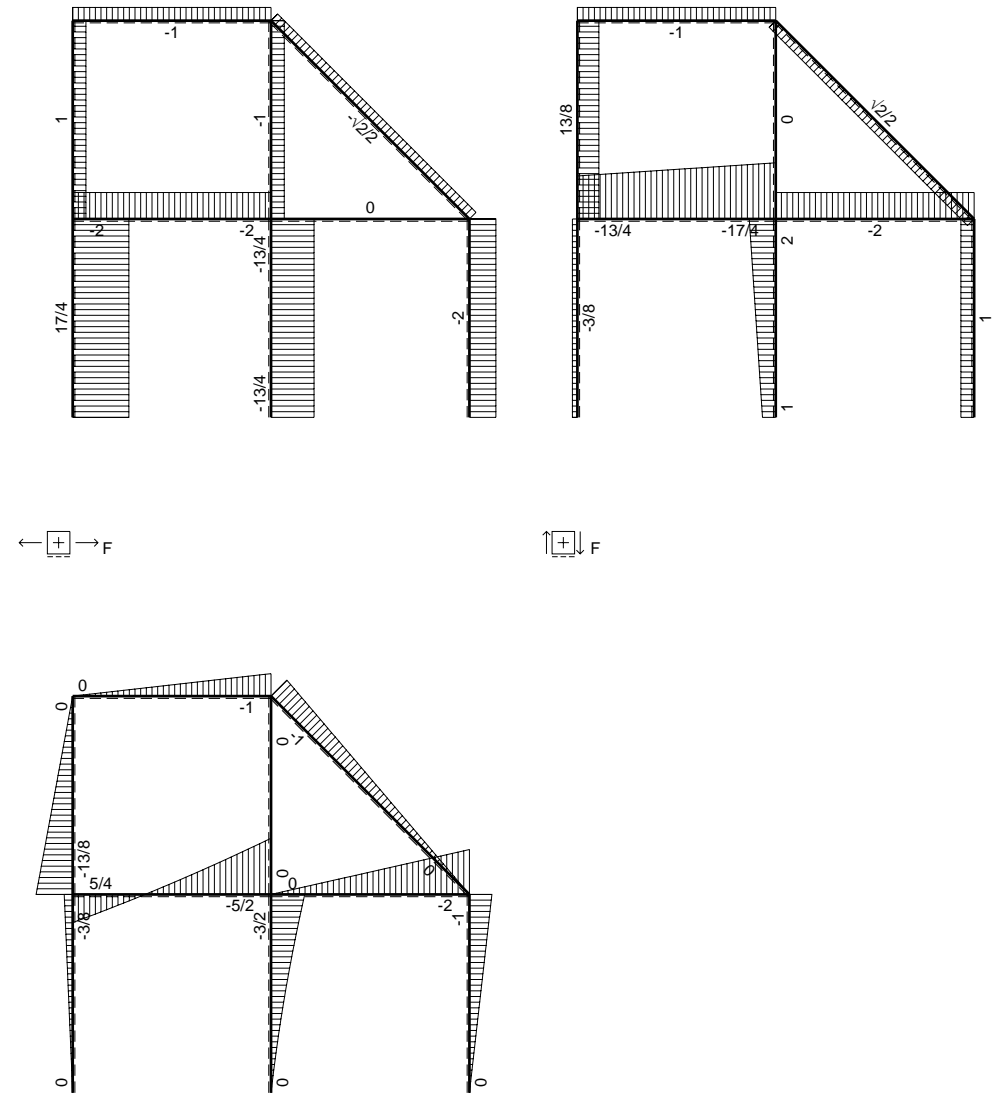
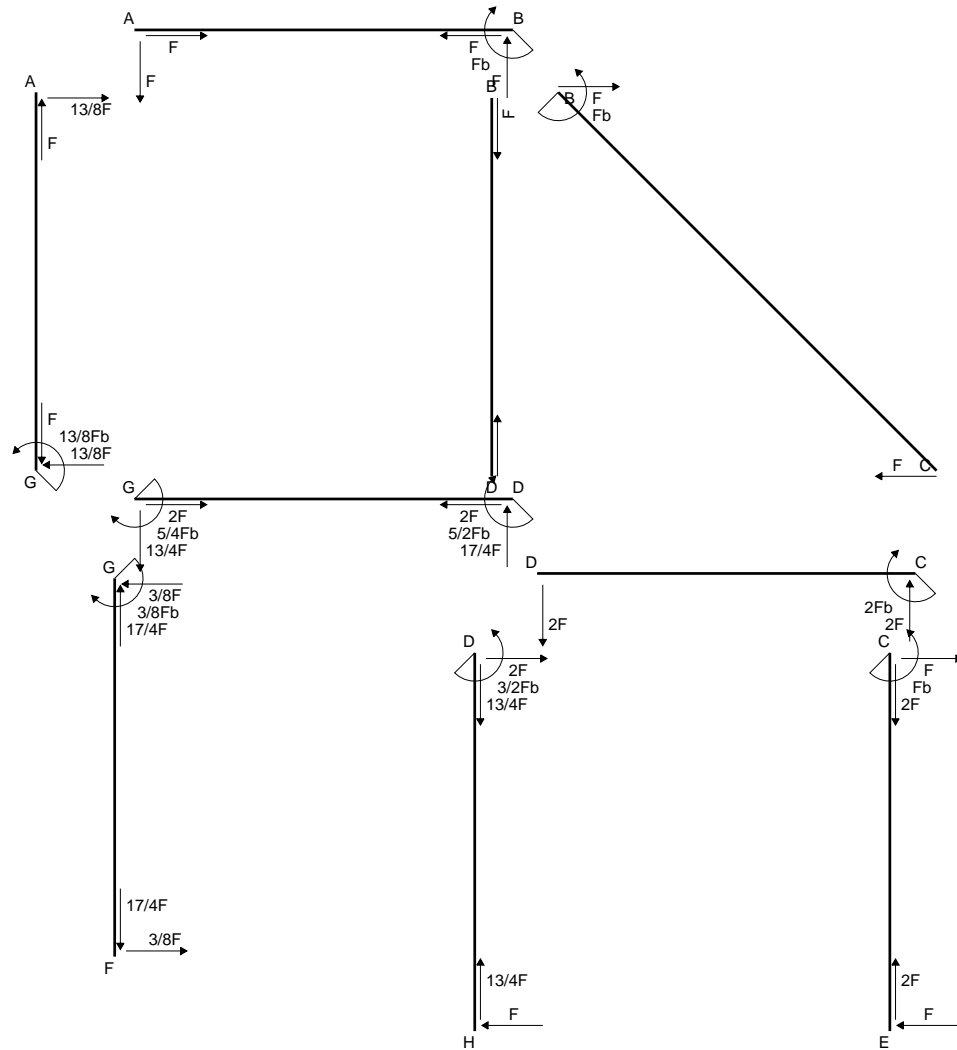
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

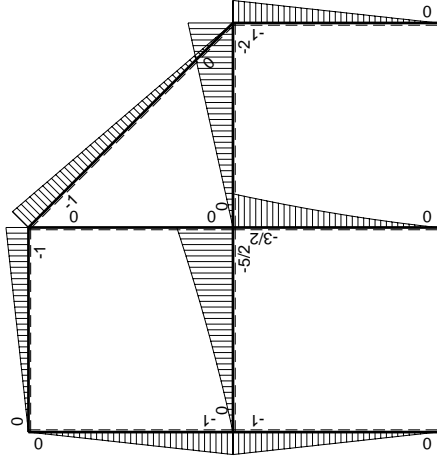
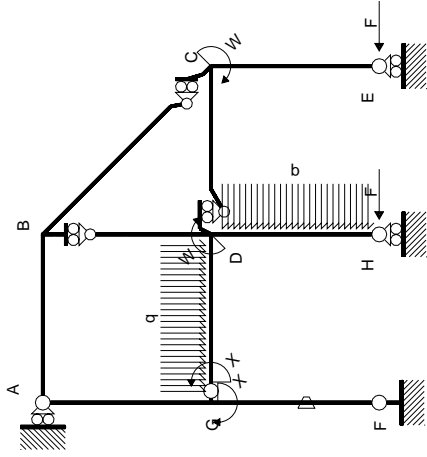
$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



- A = 618. mm<sup>2</sup>
- J<sub>u</sub> = 236783. mm<sup>4</sup>
- J<sub>v</sub> = 40734. mm<sup>4</sup>
- y<sub>g</sub> = 21.79 mm
- T<sub>y</sub> = -2360. N
- M<sub>x</sub> = -1699200. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 55. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.21 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 238.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 46. mm
- v<sub>c</sub> = 24.21 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 173.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.188 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 174.1 N/mm<sup>2</sup>
- S = 3725. mm<sup>3</sup>

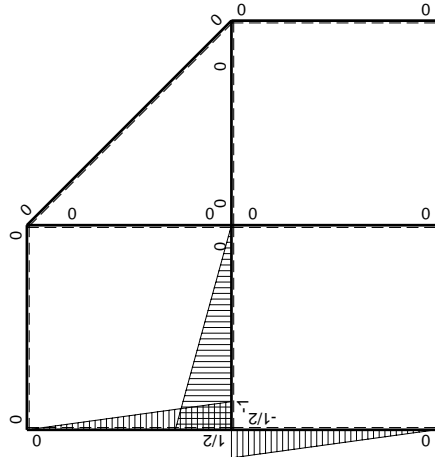






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-2Fx-1/2qx <sup>2</sup>	0	2Fx-3/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(3/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-3Fx+1/2qx <sup>2</sup>	0	5/2Fx-3Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/8Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b - 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b - 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (b - 1/2 b - 1/8 b) Fb 1/EJ = 3/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (5/2 x/b - 3 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [5/4 x^2/b - x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

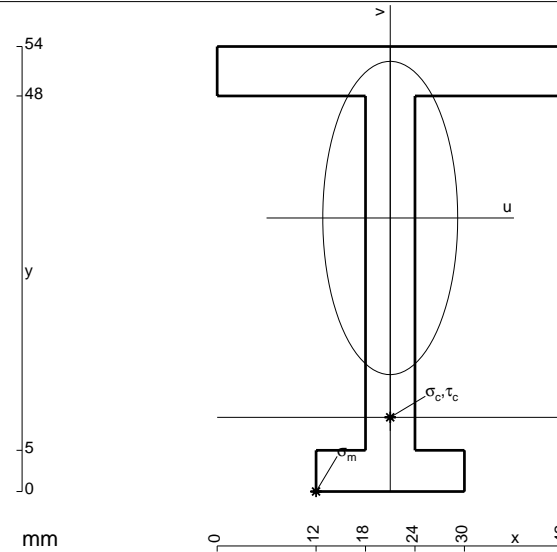
$$= (5/4 b - b + 1/8 b) Fb 1/EJ = 3/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

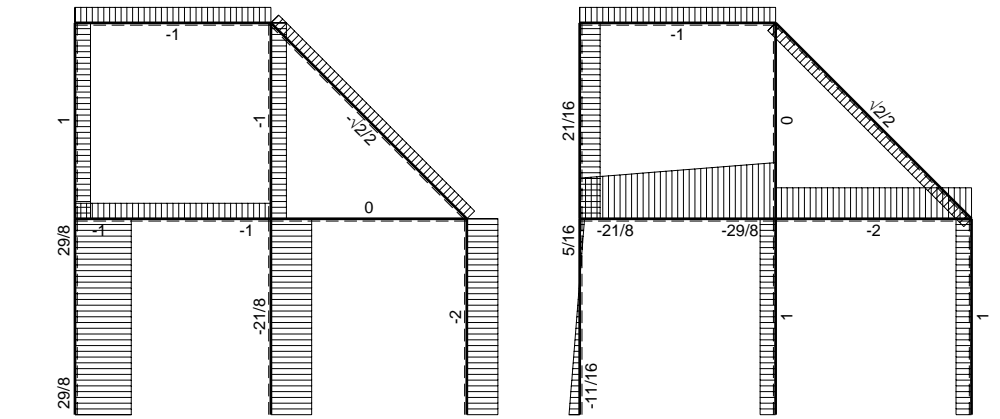
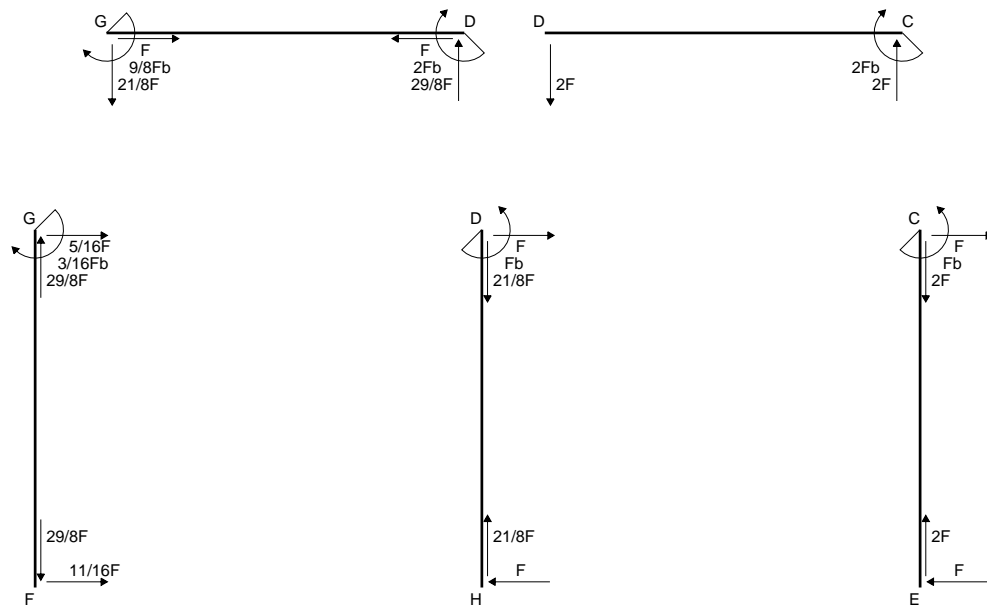
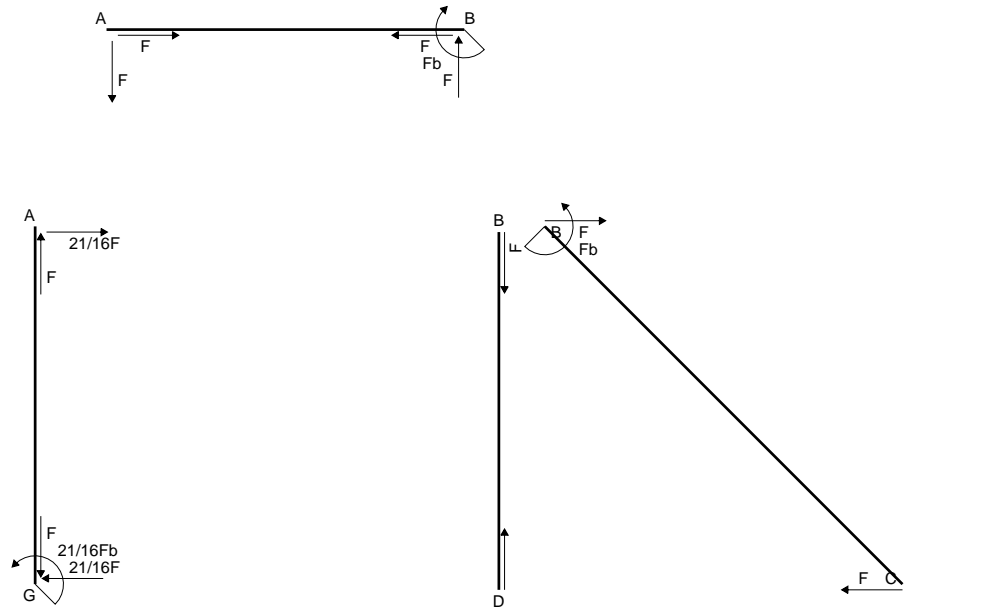
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

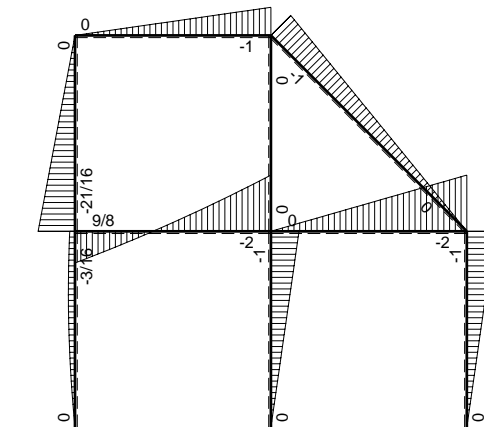


- A = 600. mm<sup>2</sup>
- J<sub>u</sub> = 216946. mm<sup>4</sup>
- J<sub>v</sub> = 40248. mm<sup>4</sup>
- y<sub>g</sub> = 33.19 mm
- T<sub>y</sub> = -1720. N
- M<sub>x</sub> = -1307200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -33.19 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -200. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -24.19 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -145.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.48 N/mm<sup>2</sup>
- σ<sub>q</sub> = √(σ<sup>2</sup>+3τ<sup>2</sup>) = 146. N/mm<sup>2</sup>
- S = 3391. mm<sup>3</sup>

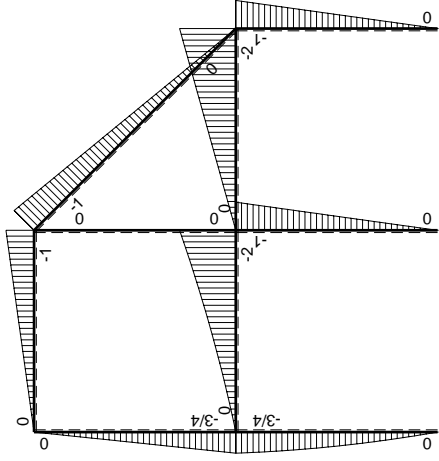
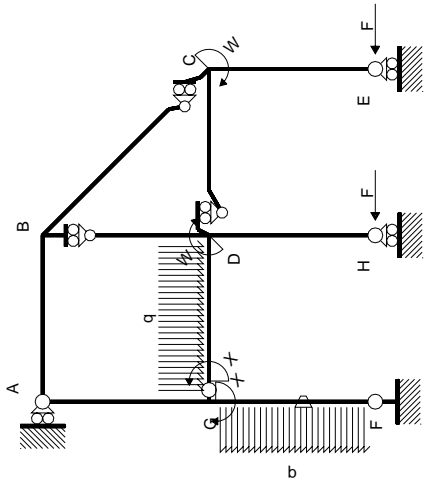


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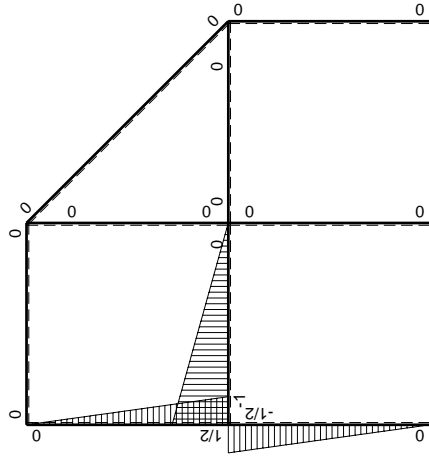


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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 <sup>2</sup>	-Fb/EJ	5/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(7/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-1/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-1/2Fx-1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx-1/2qx <sup>2</sup>	0	3/2Fx-Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(7/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	2Fx-5/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						9/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 1/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/3 b - 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 5/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b - 5/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

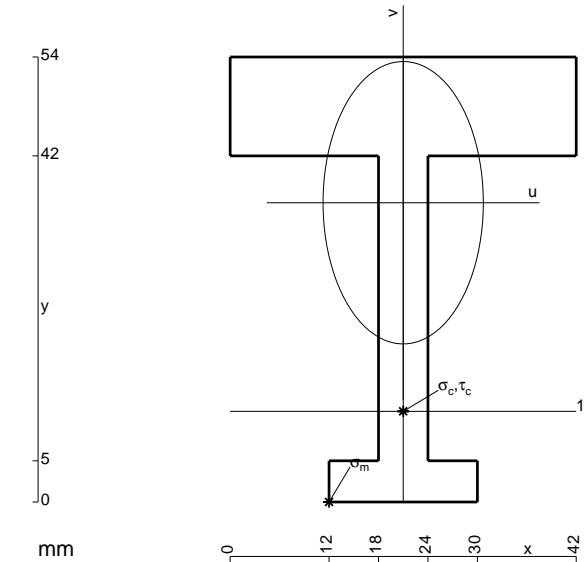
$$= (b - 5/6 b + 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

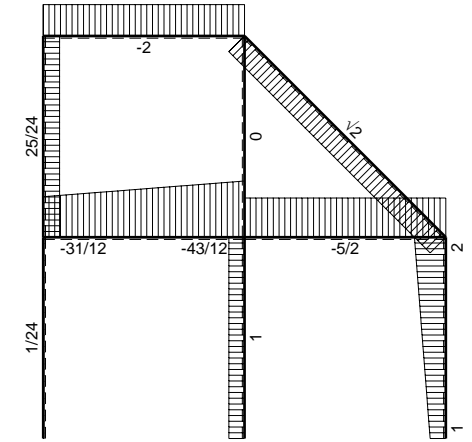
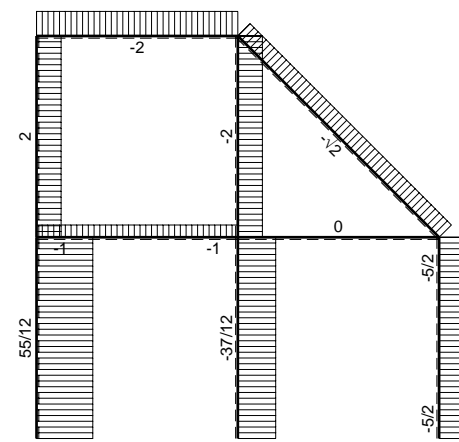
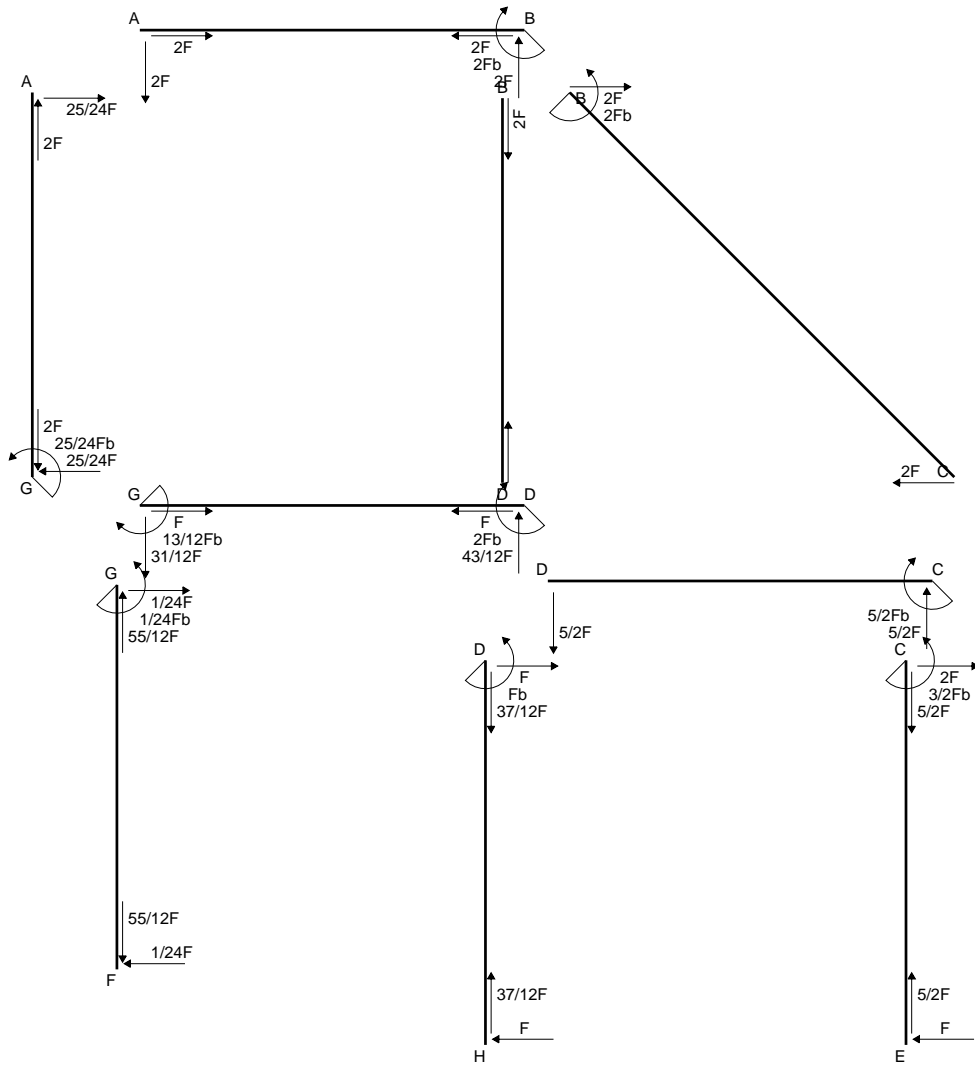
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



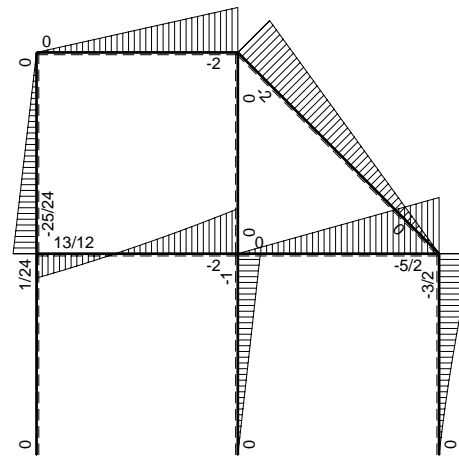
- A = 816. mm<sup>2</sup>
- J<sub>u</sub> = 239746. mm<sup>4</sup>
- J<sub>v</sub> = 77184. mm<sup>4</sup>
- y<sub>g</sub> = 36.32 mm
- T<sub>y</sub> = -1700. N
- M<sub>x</sub> = -1377000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -36.32 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -208.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -25.32 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -145.4 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.801 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 145.6 N/mm<sup>2</sup>
- S = 4063. mm<sup>3</sup>



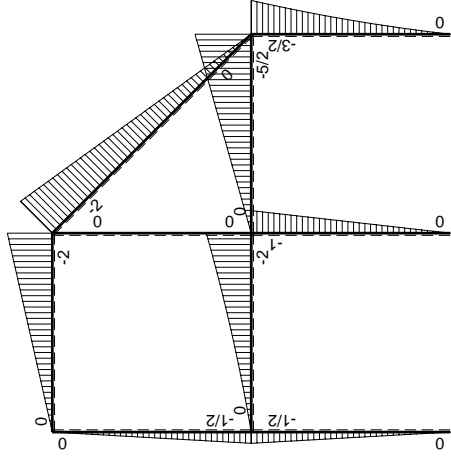
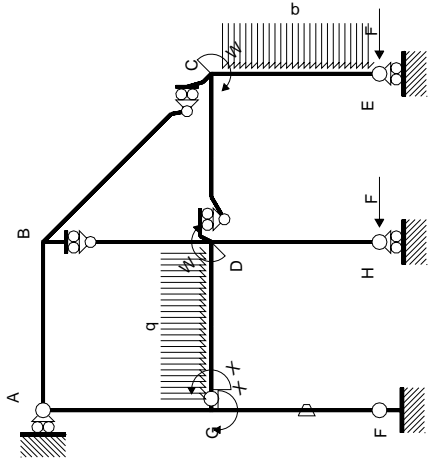


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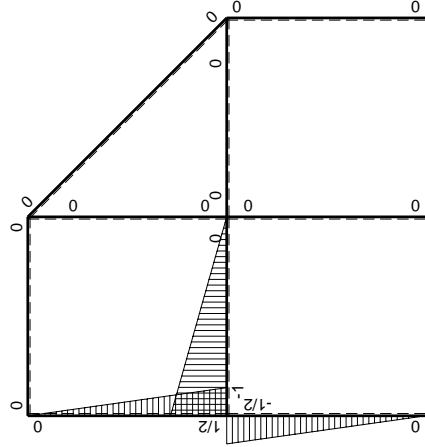


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-2Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	-1/2Fx	-Fb/EJ	1/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-1/2Fx	Fb/EJ	1/4Fb-1/2Fx+1/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-3/2Fx-1/2qx <sup>2</sup>	0	3/2Fx-Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(7/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	2Fx-5/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							13/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 1/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/3 b - 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 5/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b - 5/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

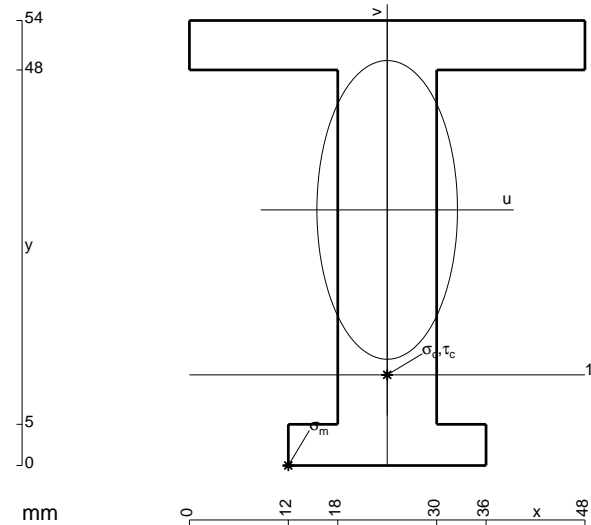
$$= (b - 5/6 b + 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

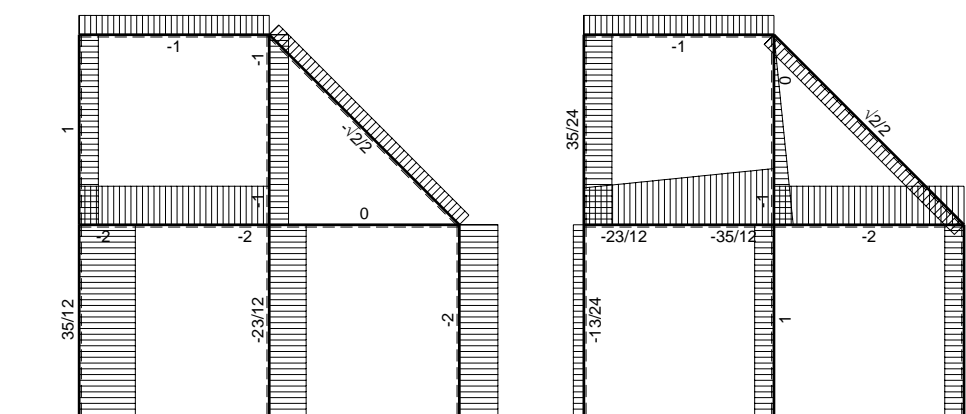
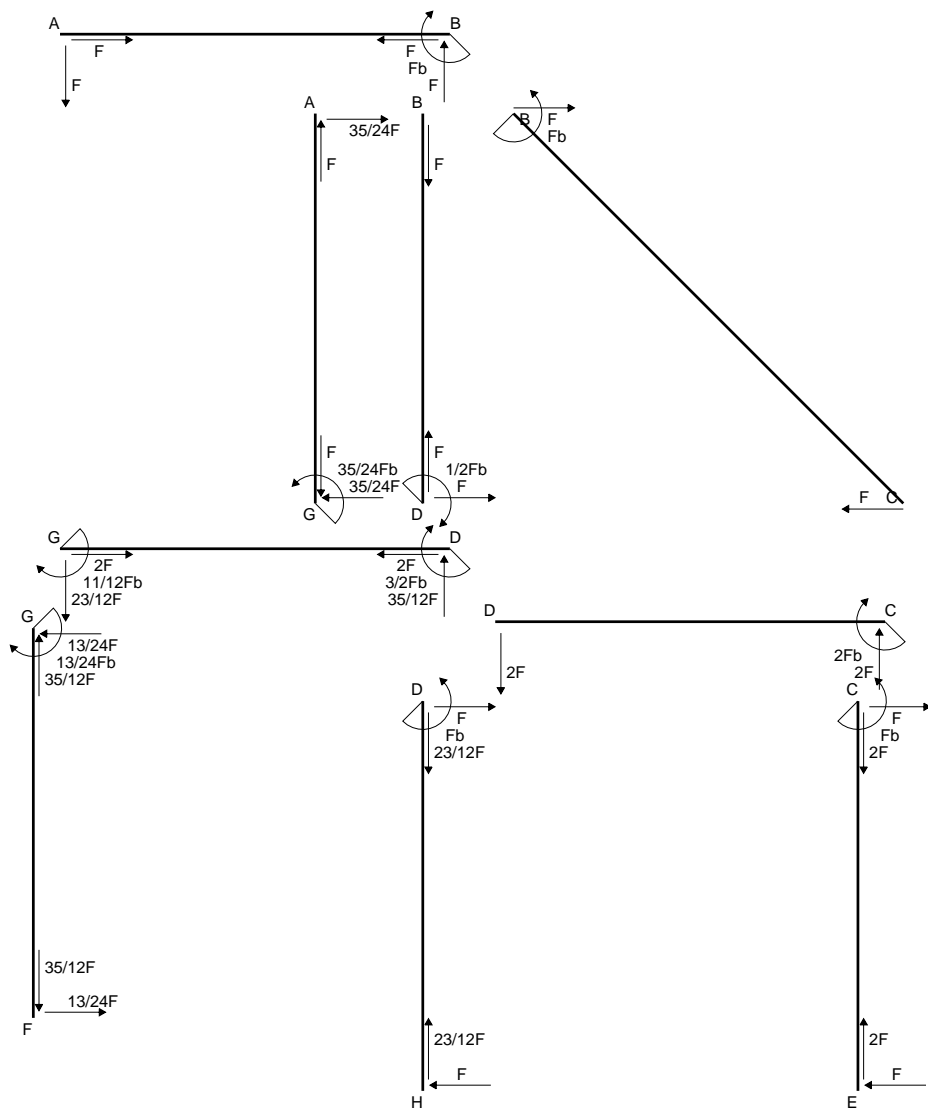
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

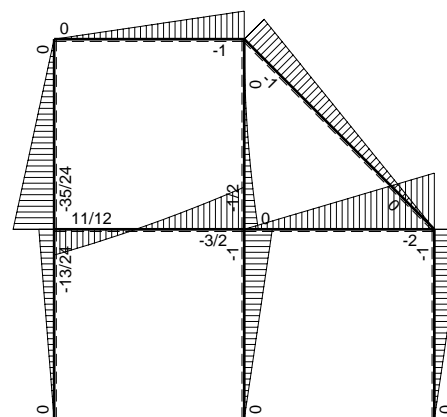


- A = 924. mm<sup>2</sup>
- J<sub>u</sub> = 303740. mm<sup>4</sup>
- J<sub>v</sub> = 67248. mm<sup>4</sup>
- y<sub>g</sub> = 31.02 mm
- T<sub>y</sub> = -2500. N
- M<sub>x</sub> = -2150000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -31.02 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 11. mm
- v<sub>c</sub> = -20.02 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -141.7 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.484 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 141.8 N/mm<sup>2</sup>
- S = 5080. mm<sup>3</sup>

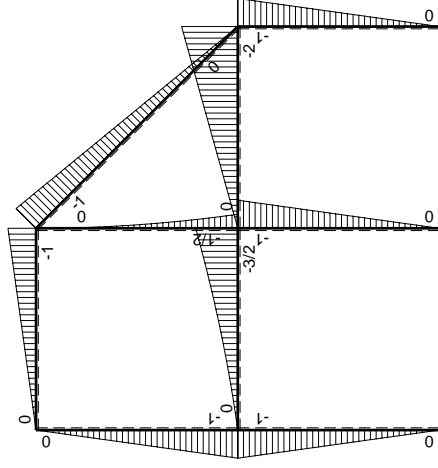
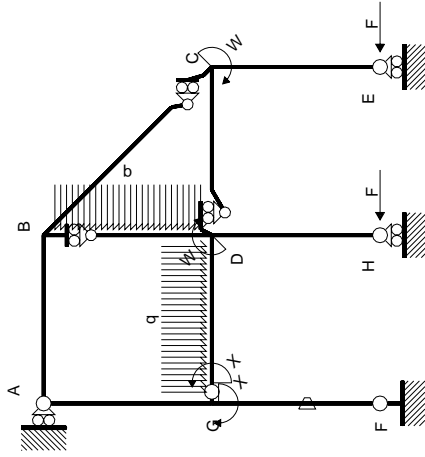


← ⊕ →  $F$

↑ ⊕ ↓  $F$

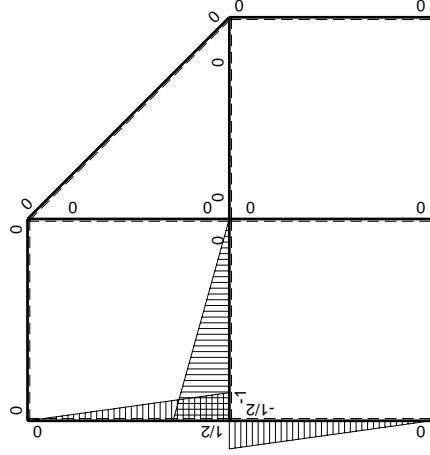


⊕  $F_b$



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-Fx-1/2qx <sup>2</sup>	0	Fx-1/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-2Fx+1/2qx <sup>2</sup>	0	3/2Fx-2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						11/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (x/b - 1/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [1/2 x^2/b - 1/6 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (1/2 b - 1/6 b - 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 2/3 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

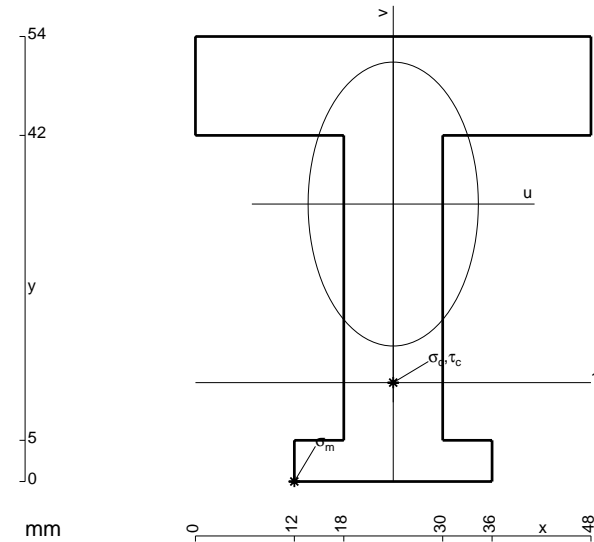
$$= (3/4 b - 2/3 b + 1/8 b) Fb 1/EJ = 5/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

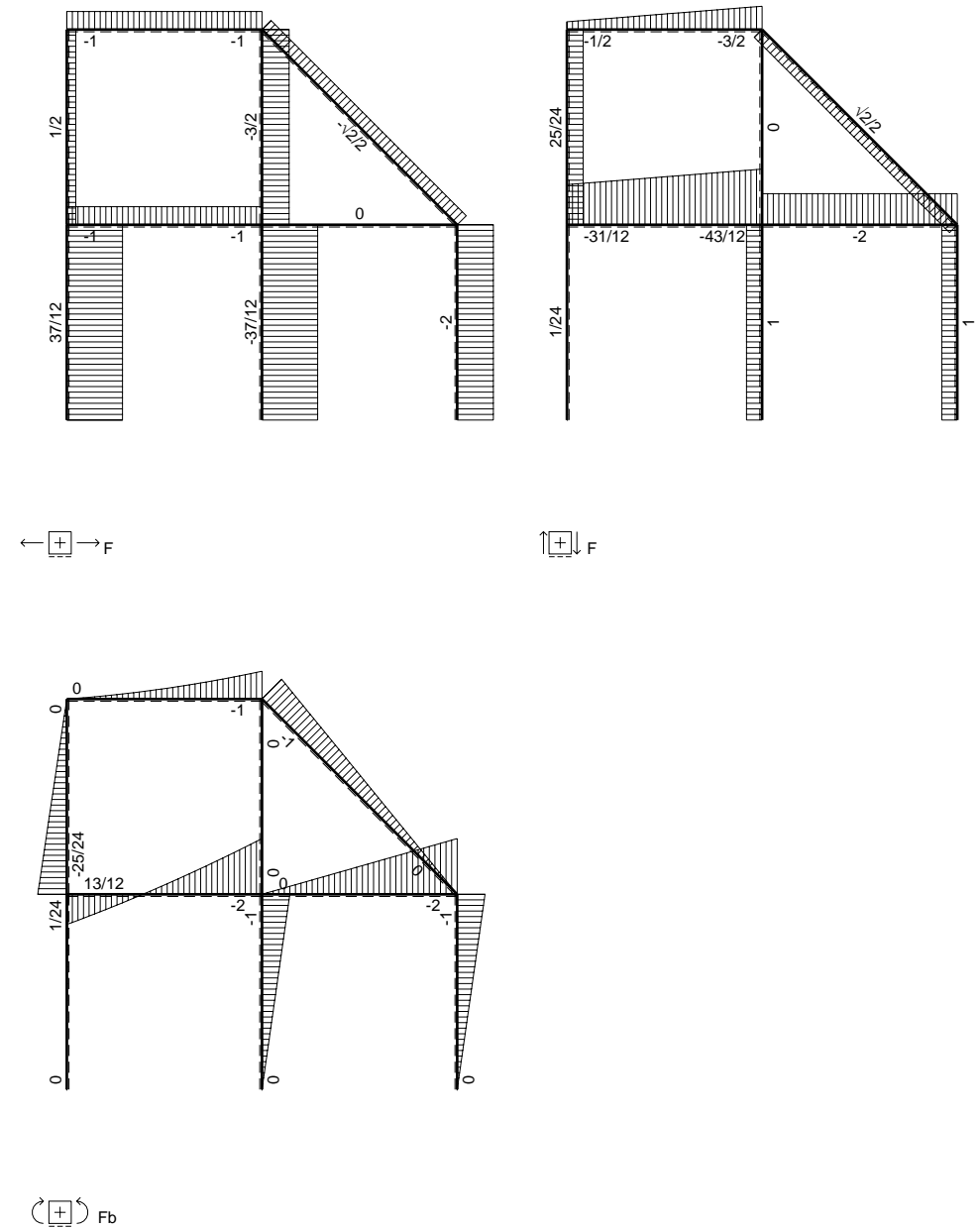
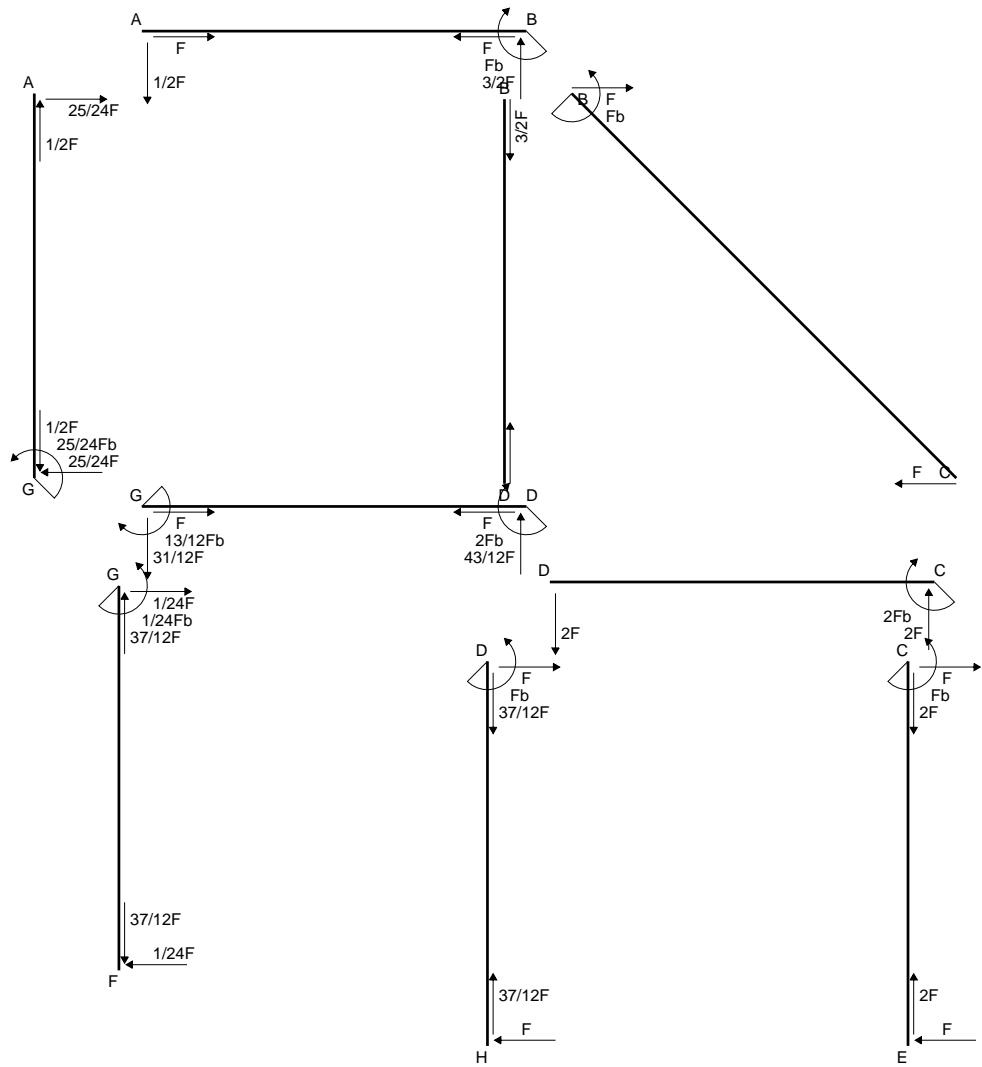
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

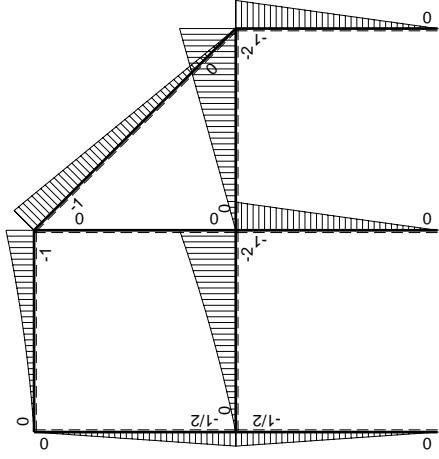
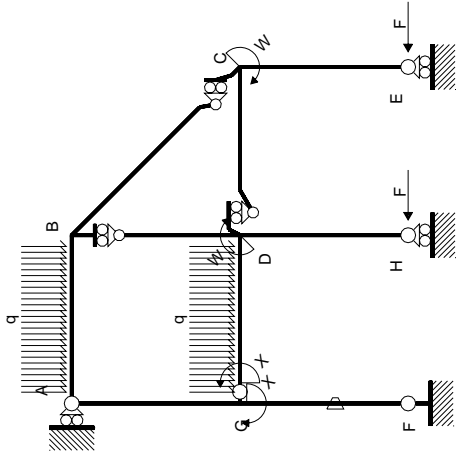
$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



- A = 1140. mm<sup>2</sup>
- J<sub>u</sub> = 338607. mm<sup>4</sup>
- J<sub>v</sub> = 121680. mm<sup>4</sup>
- y<sub>g</sub> = 33.67 mm
- T<sub>y</sub> = -2540. N
- M<sub>x</sub> = -2311400. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -33.67 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -229.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 12. mm
- v<sub>c</sub> = -21.67 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -147.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.66 N/mm<sup>2</sup>
- σ<sub>q</sub> = √(σ<sup>2</sup>+3τ<sup>2</sup>) = 148. N/mm<sup>2</sup>
- S = 5854. mm<sup>3</sup>

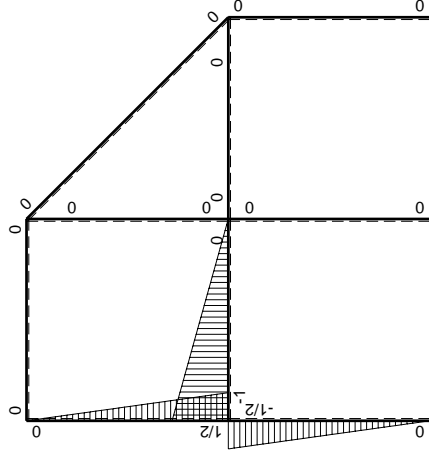






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 1/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/3 b - 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 5/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b - 5/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

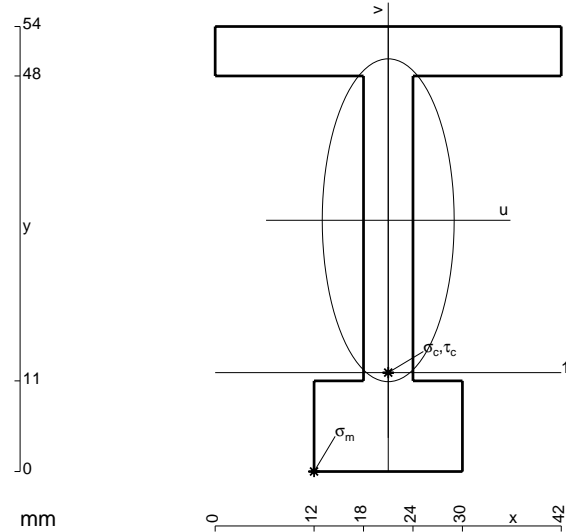
$$= (b - 5/6 b + 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

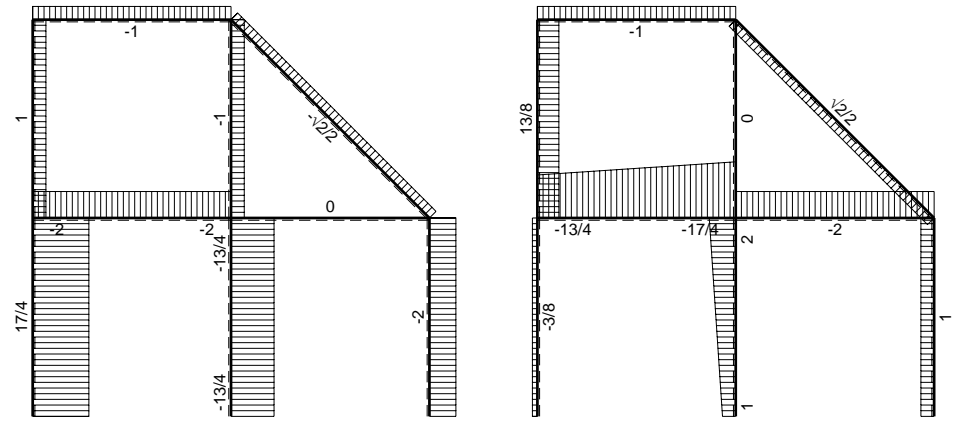
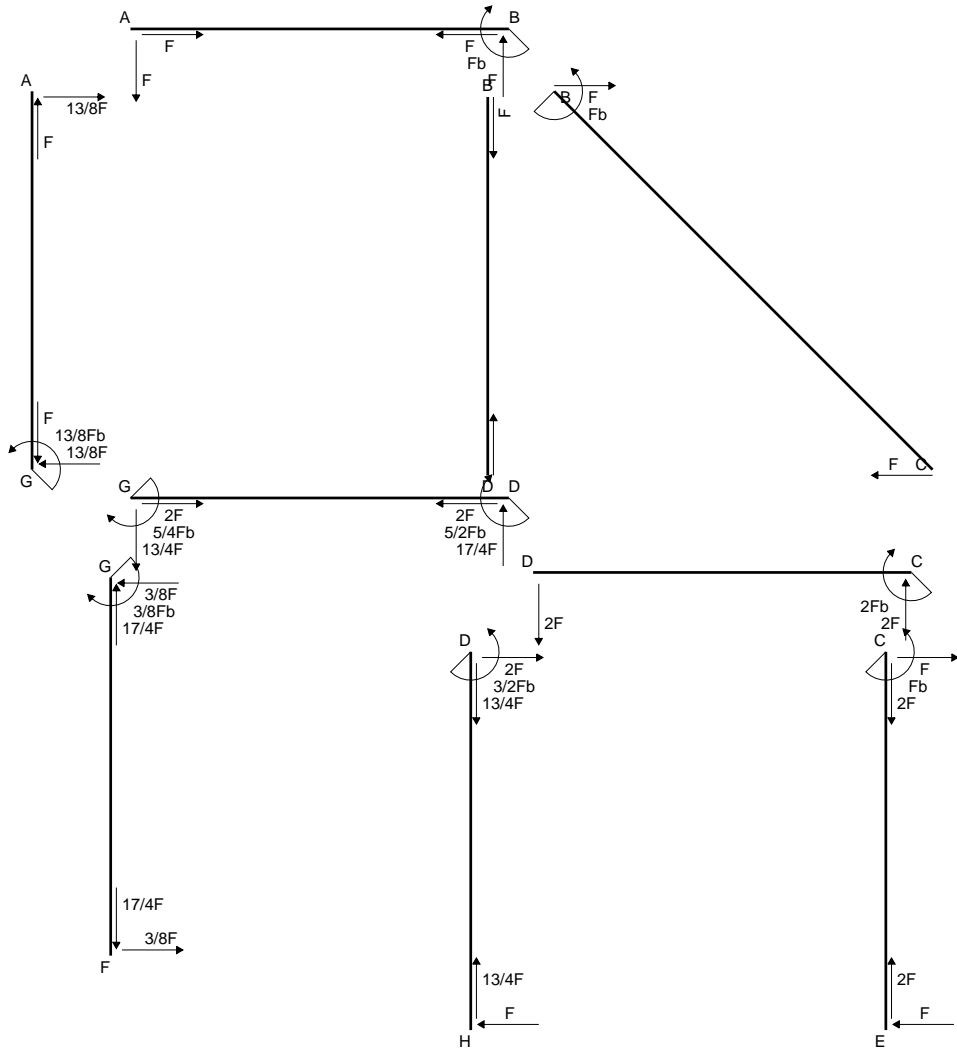
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

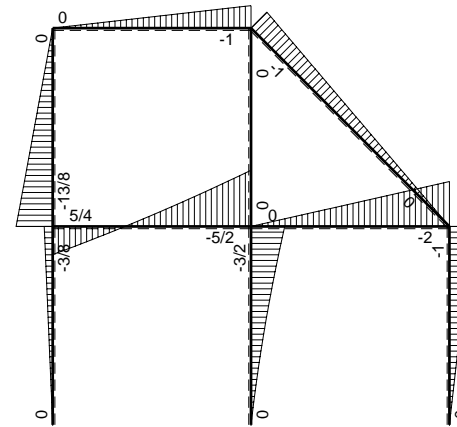


- A = 672. mm<sup>2</sup>
- J<sub>u</sub> = 257954. mm<sup>4</sup>
- J<sub>v</sub> = 43056. mm<sup>4</sup>
- y<sub>g</sub> = 30.49 mm
- T<sub>y</sub> = -2100. N
- M<sub>x</sub> = -2016000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -30.49 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -238.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 12. mm
- v<sub>c</sub> = -18.49 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -144.5 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.869 N/mm<sup>2</sup>
- σ<sub>q</sub> = √(σ<sup>2</sup>+3τ<sup>2</sup>) = 145. N/mm<sup>2</sup>
- S = 5062. mm<sup>3</sup>

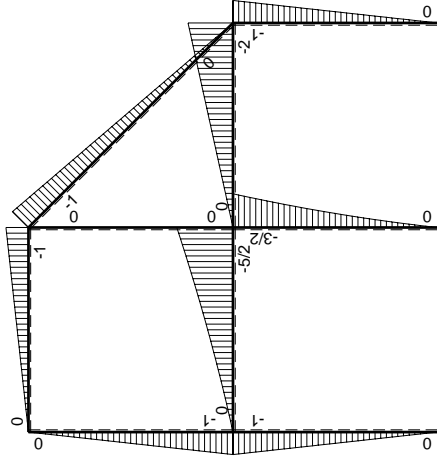
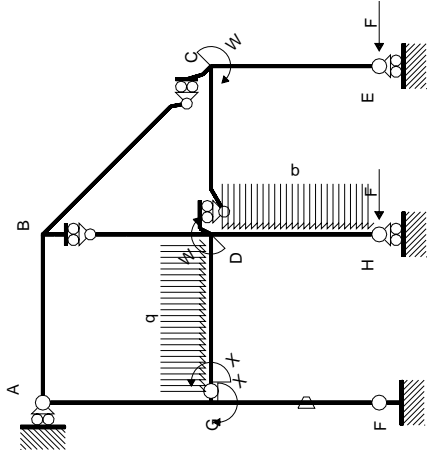


← ⊕ → F

↑ ⊕ ↓ F

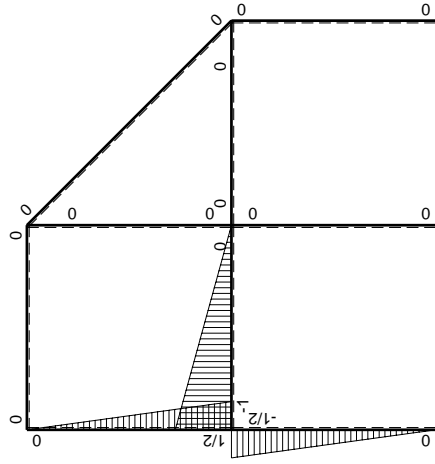


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-2Fx-1/2qx <sup>2</sup>	0	2Fx-3/2Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(3/8+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-3Fx+1/2qx <sup>2</sup>	0	5/2Fx-3Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						5/8Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-5/4Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b - 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b - 1/2 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (b - 1/2 b - 1/8 b) Fb 1/EJ = 3/8 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (5/2 x/b - 3 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [5/4 x^2/b - x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

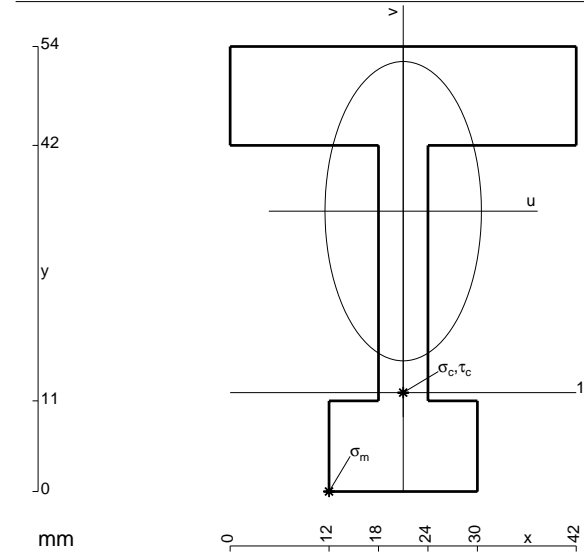
$$= (5/4 b - b + 1/8 b) Fb 1/EJ = 3/8 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

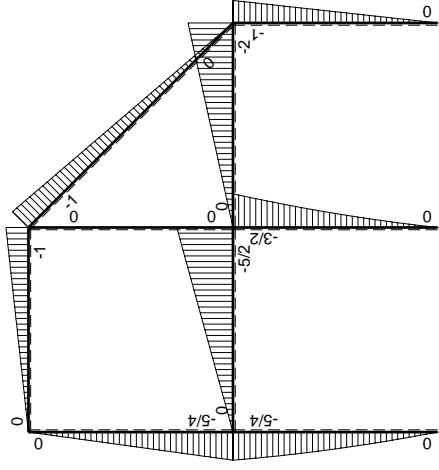
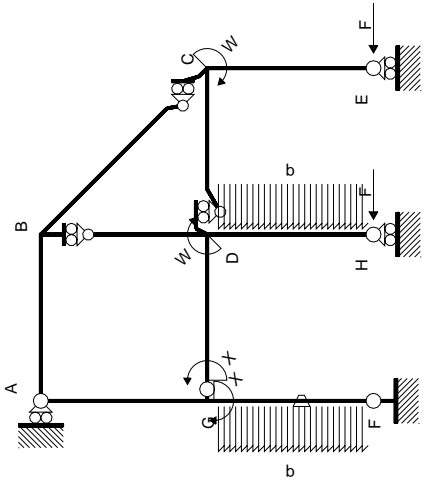
$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



- A = 888. mm<sup>2</sup>
- J<sub>u</sub> = 293012. mm<sup>4</sup>
- J<sub>v</sub> = 79992. mm<sup>4</sup>
- y<sub>g</sub> = 34.02 mm
- T<sub>y</sub> = -3360. N
- M<sub>x</sub> = -1713600. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -34.02 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -199. N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 12. mm
- v<sub>c</sub> = -22.02 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -128.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 11.05 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 130.2 N/mm<sup>2</sup>
- S = 5782. mm<sup>3</sup>

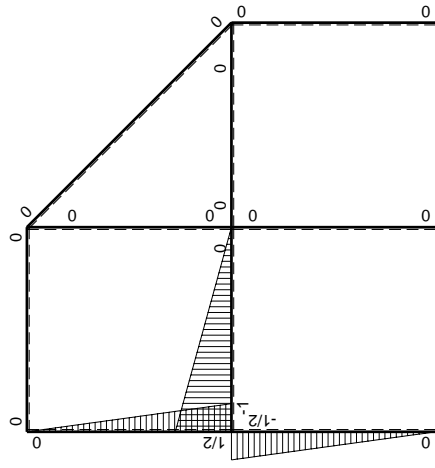






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(11/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	5/8Fb-Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-5/2Fx	0	5/2Fx-5/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-5/2Fx	0	5/2Fx-5/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
GA b	1/2-1/2x/b	-5/4Fb+5/4Fx	0	-5/8Fb+5/4Fx-5/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-5/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx	0	-5/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						11/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (5/8 - x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [5/8 x - 1/2 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (5/8 b - 1/2 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

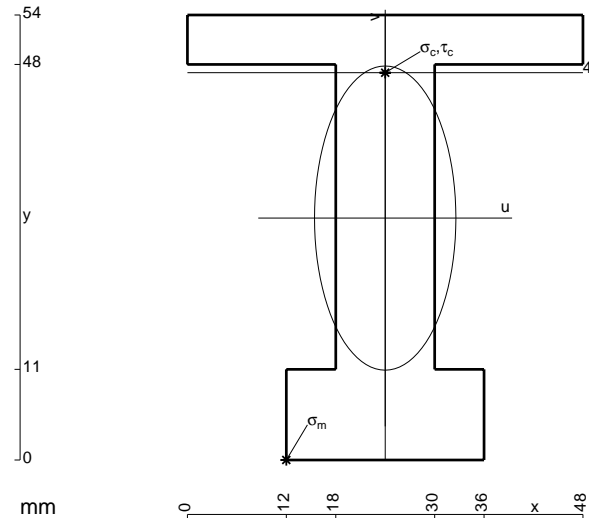
$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-5/8 + 5/4 x/b - 5/8 x^2/b^2) Fb 1/EJ dx = [-5/8 x + 5/8 x^2/b - 5/24 x^3/b^2]_0^b Fb 1/EJ$$

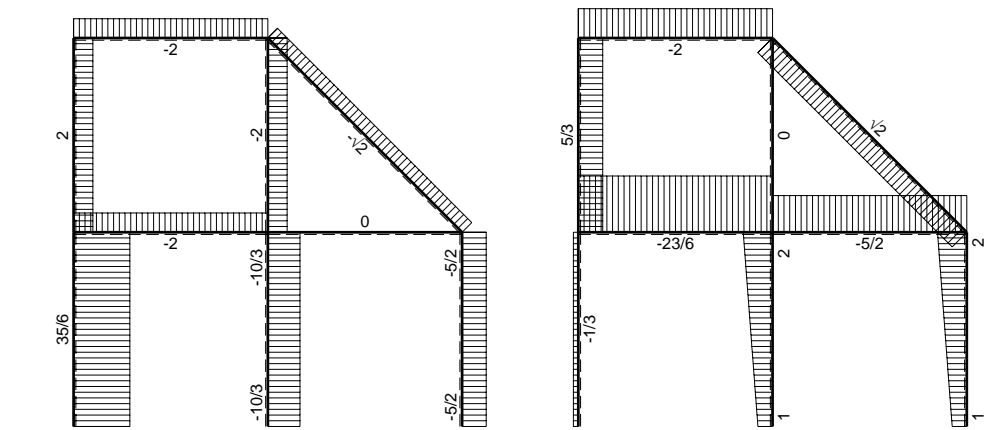
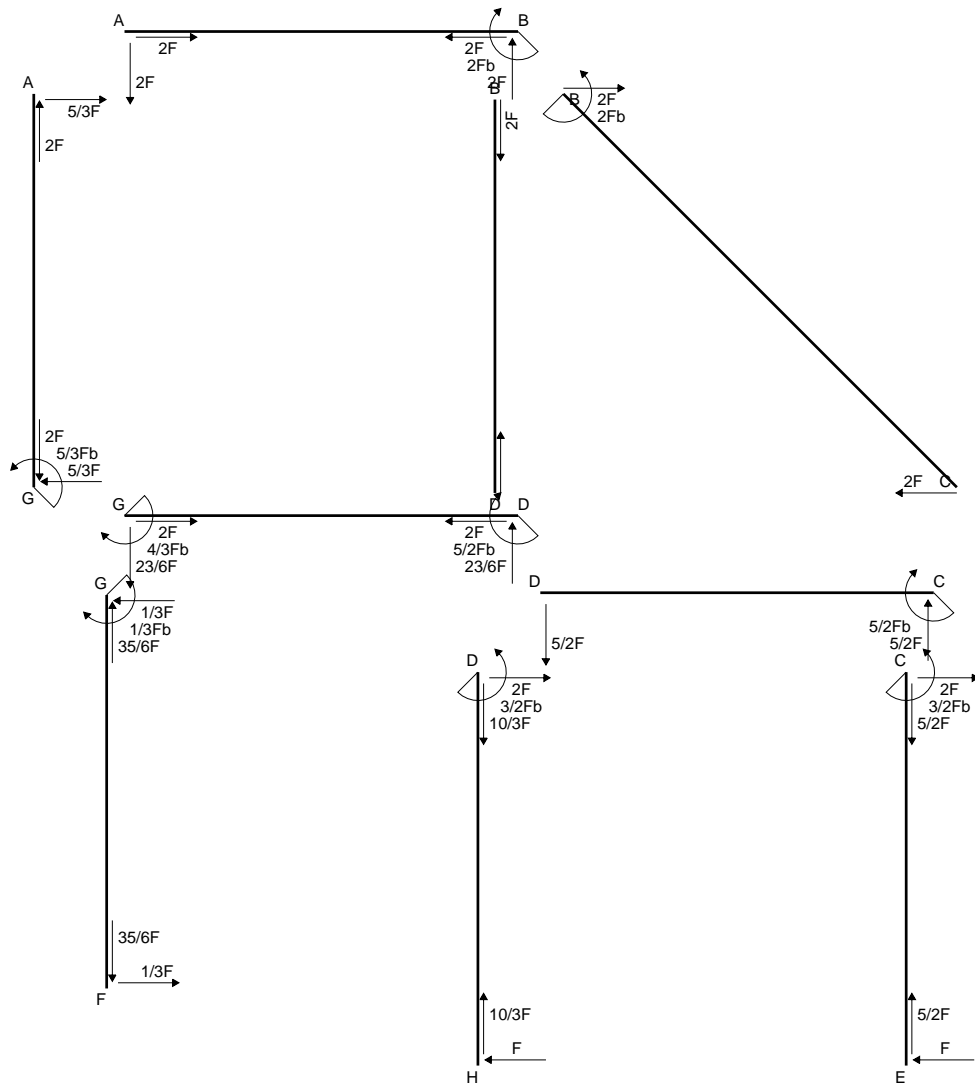
$$= (-5/8 b + 5/8 b - 5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2) Fb 1/EJ dx = [-5/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$

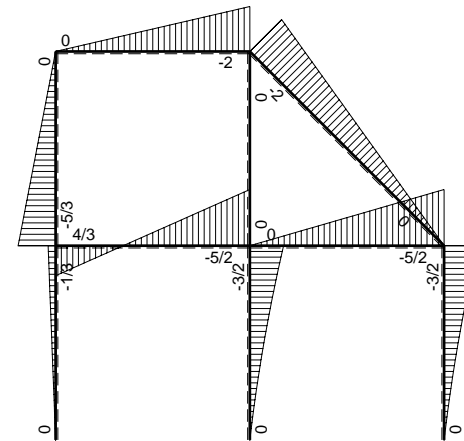


- A = 996. mm<sup>2</sup>
- J<sub>u</sub> = 339350. mm<sup>4</sup>
- J<sub>v</sub> = 73296. mm<sup>4</sup>
- y<sub>g</sub> = 29.36 mm
- T<sub>y</sub> = -4320. N
- M<sub>x</sub> = -2419200. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -29.36 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -209.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 47. mm
- v<sub>c</sub> = 17.64 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 125.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.844 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 126.3 N/mm<sup>2</sup>
- S = 6451. mm<sup>3</sup>

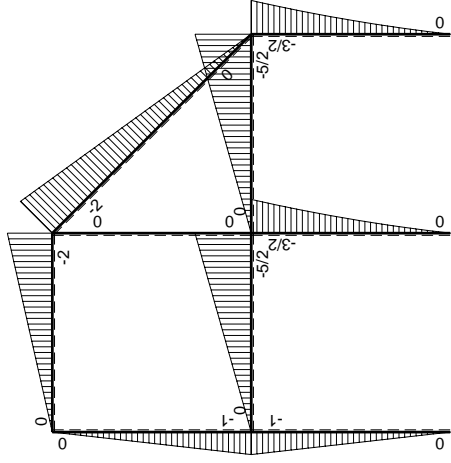
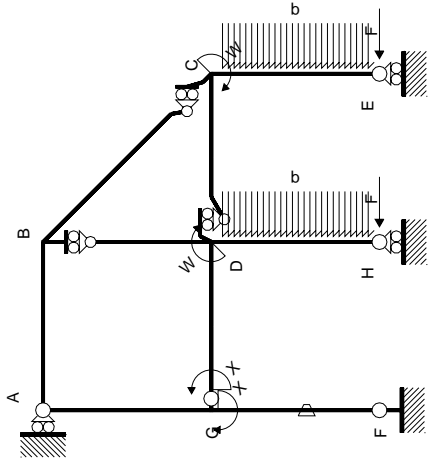


← ⊕ → F

↑ ⊕ ↓ Fb

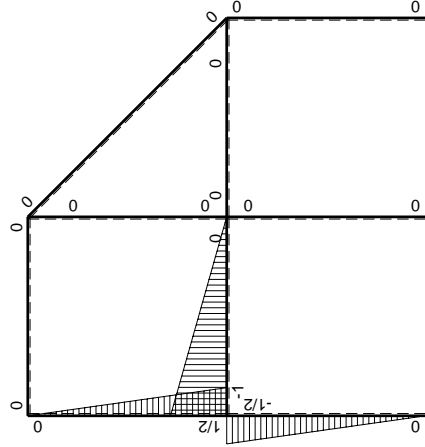


⊕ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$	
AB b	0	-2Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-5/2Fx	0	5/2Fx-5/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	5/2Fb-5/2Fx	0	5/2Fx-5/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							2/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-4/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

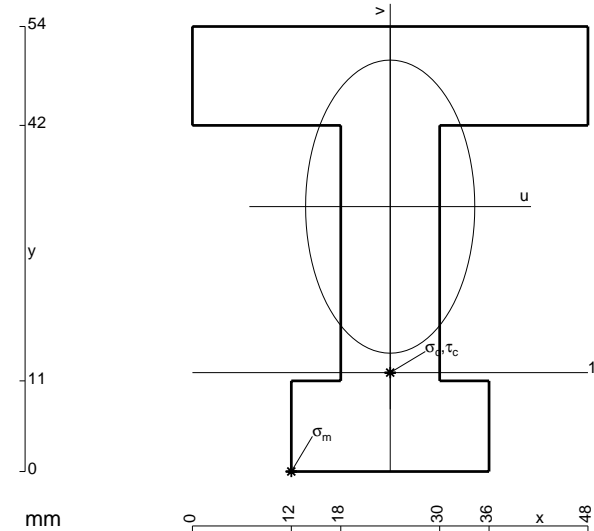
$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

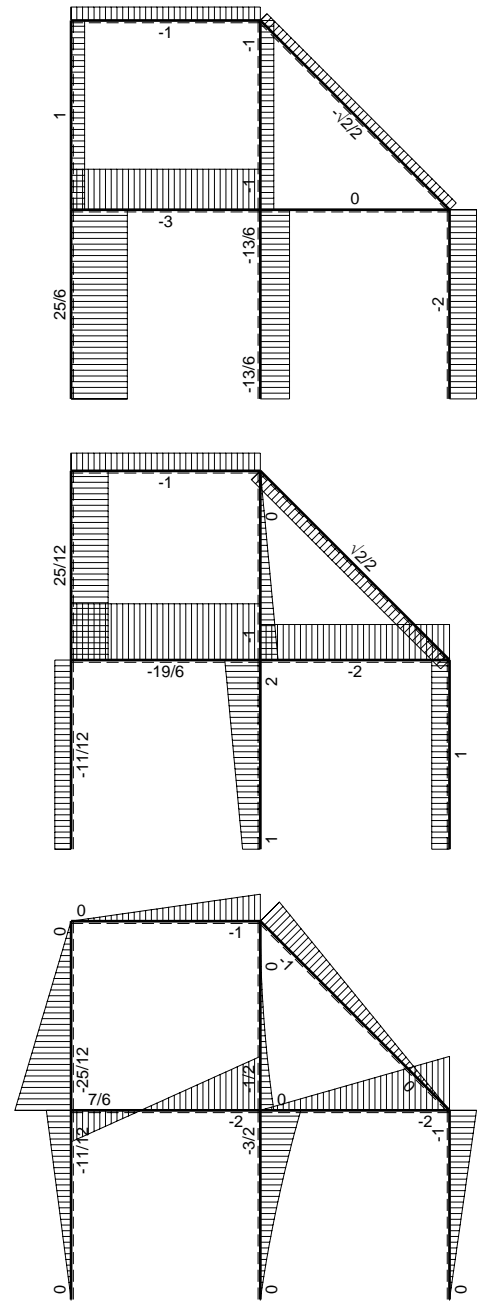
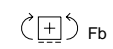
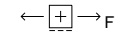
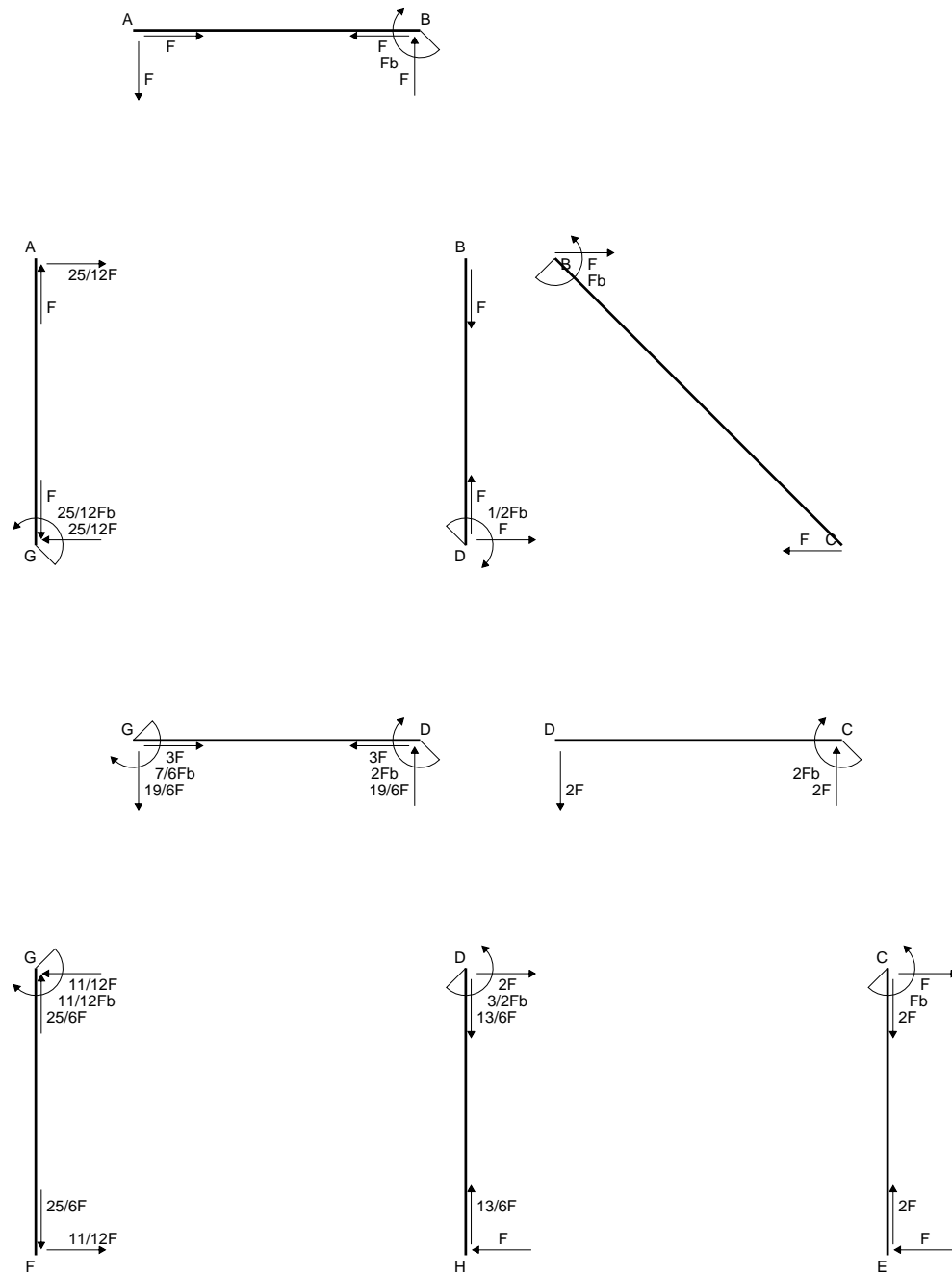
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

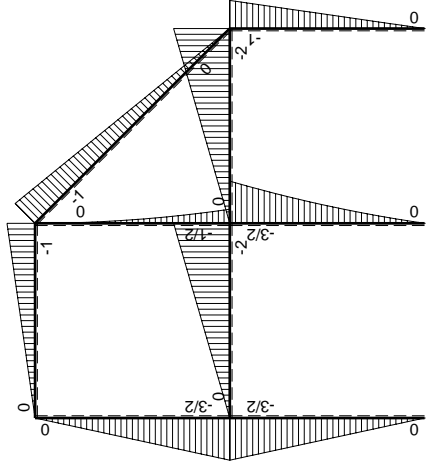
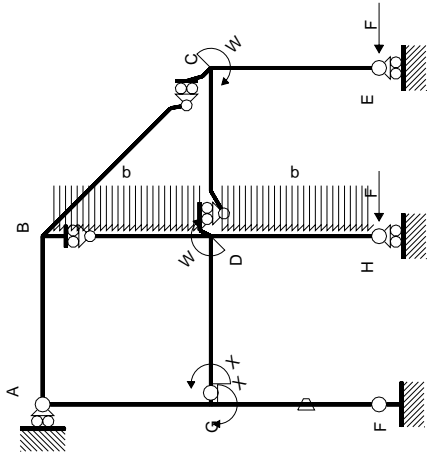
$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



- A = 1212. mm<sup>2</sup>
- J<sub>u</sub> = 383443. mm<sup>4</sup>
- J<sub>v</sub> = 127728. mm<sup>4</sup>
- y<sub>g</sub> = 32.14 mm
- T<sub>y</sub> = -4300. N
- M<sub>x</sub> = -2623000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -32.14 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -219.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 12. mm
- v<sub>c</sub> = -20.14 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -137.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.805 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 138.3 N/mm<sup>2</sup>
- S = 7282. mm<sup>3</sup>

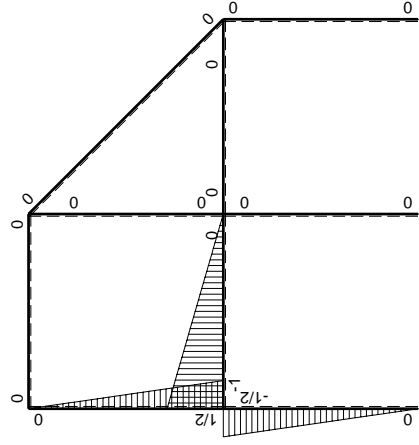






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJdx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-3/2Fx	-Fb/EJ	3/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/4+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/2Fb-3/2Fx	Fb/EJ	3/4Fb-3/2Fx+3/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/3+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
GA b	1/2-1/2x/b	-3/2Fb+3/2Fx	0	-3/4Fb+3/2Fx-3/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/4+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx	0	-3/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/4 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b) Fb 1/EJ + (1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/4 - 3/2 x/b + 3/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/4 x - 3/4 x^2/b + 1/4 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/4 b - 3/4 b + 1/4 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/2 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

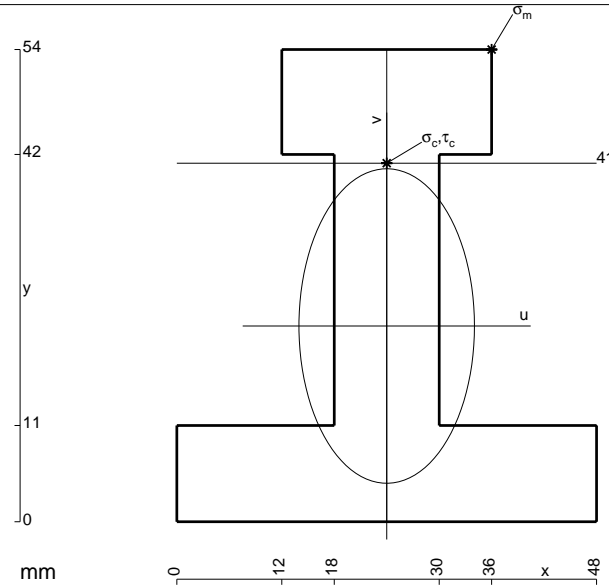
$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/4 + 3/2 x/b - 3/4 x^2/b^2) Fb 1/EJ dx = [-3/4 x + 3/4 x^2/b - 1/4 x^3/b^2]_0^b Fb 1/EJ$$

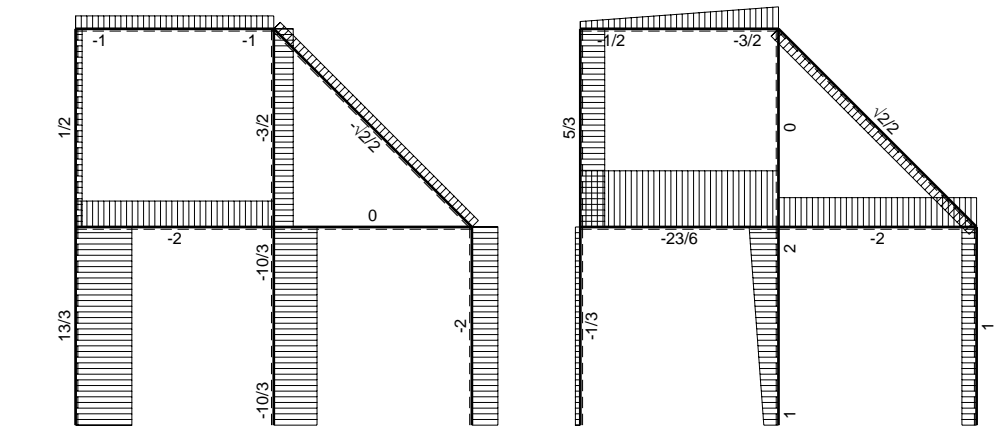
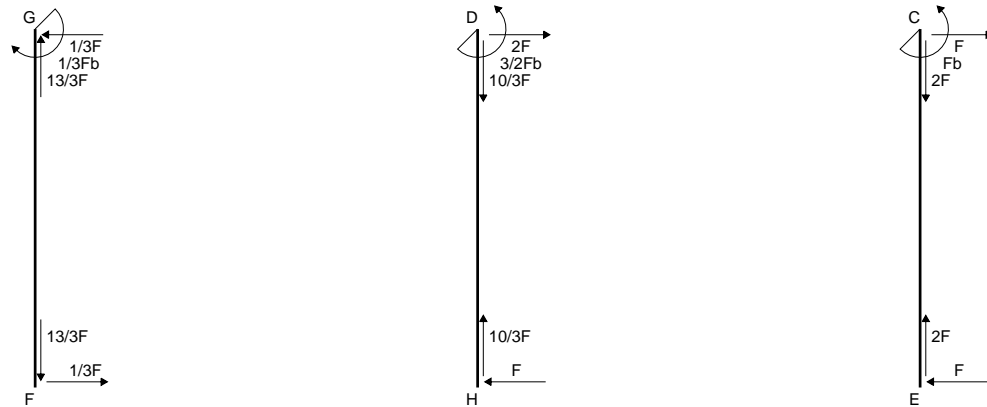
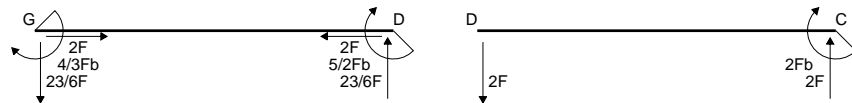
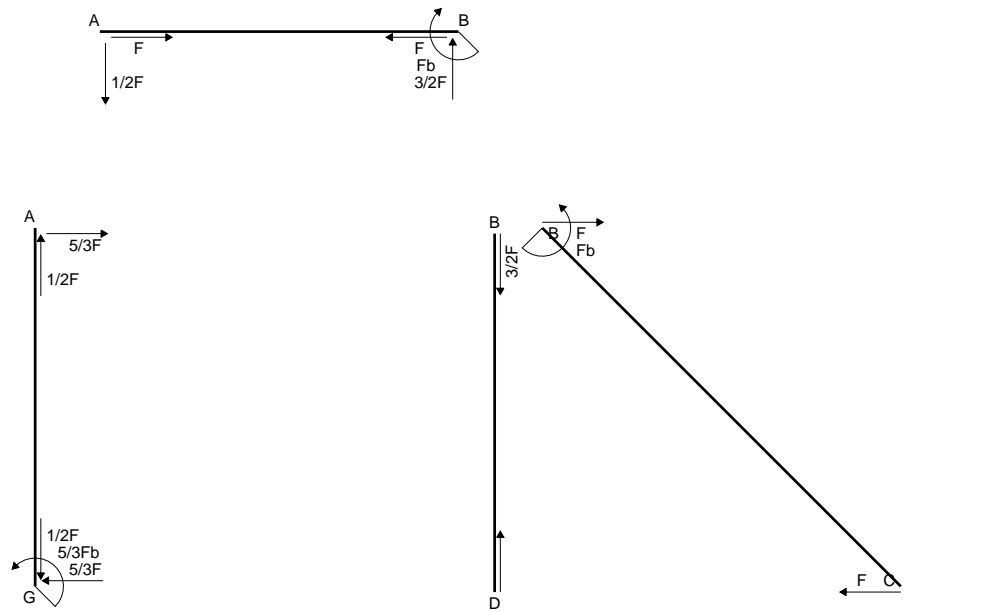
$$= (-3/4 b + 3/4 b - 1/4 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-3/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b) Fb 1/EJ = -1/4 Fb^2/EJ$$

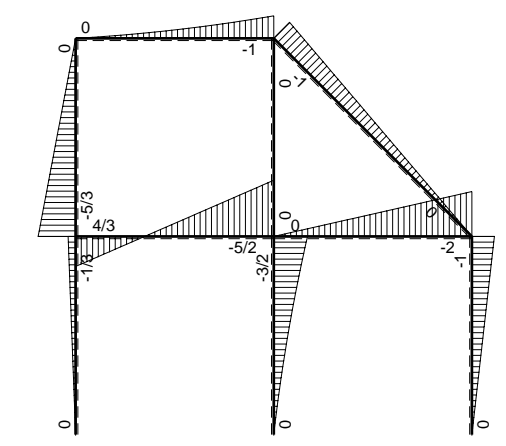


- A = 1188. mm<sup>2</sup>
- J<sub>u</sub> = 384370. mm<sup>4</sup>
- J<sub>v</sub> = 119664. mm<sup>4</sup>
- y<sub>g</sub> = 22.38 mm
- T<sub>y</sub> = -4220. N
- M<sub>x</sub> = -2785200. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 31.62 mm
- σ<sub>m</sub> = -M<sub>v</sub>/J<sub>u</sub> = 229.1 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 18.62 mm
- σ<sub>c</sub> = -M<sub>v</sub>/J<sub>u</sub> = 134.9 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.961 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 135.5 N/mm<sup>2</sup>
- S = 7608. mm<sup>3</sup>

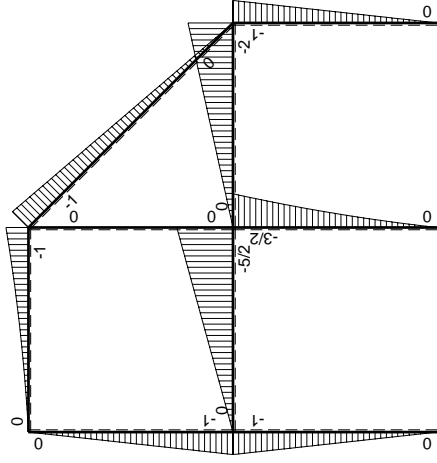
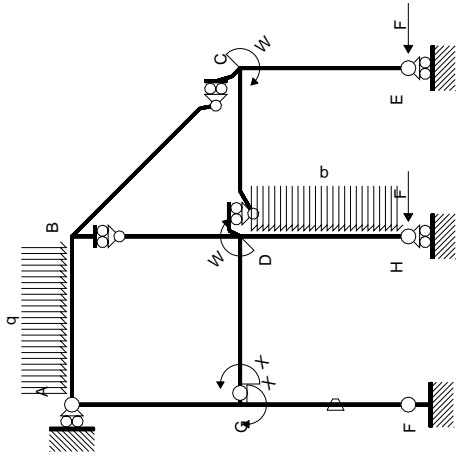


← ⊕ → F

↑ ⊕ ↓ F

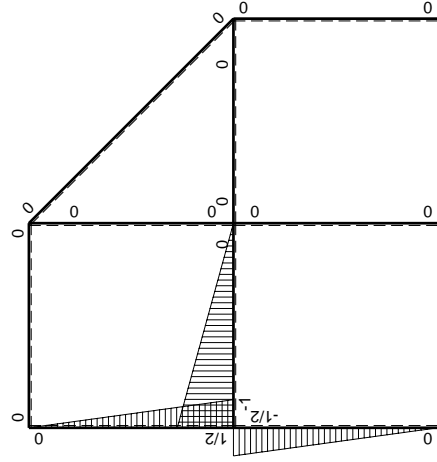


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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	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	0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

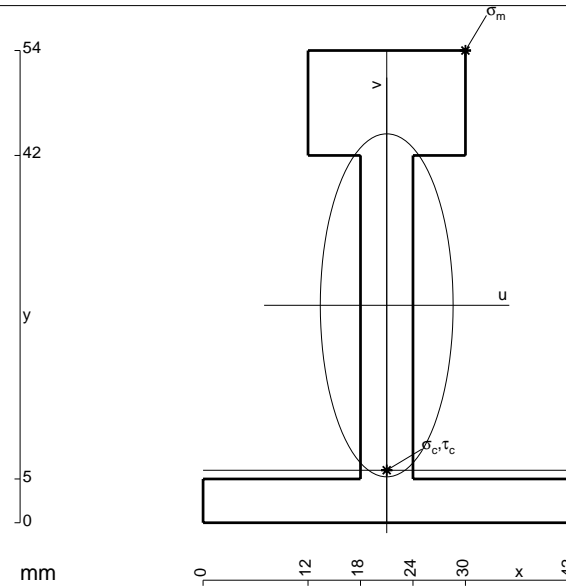
$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

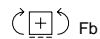
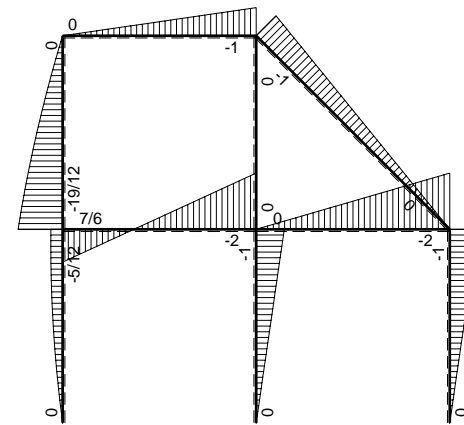
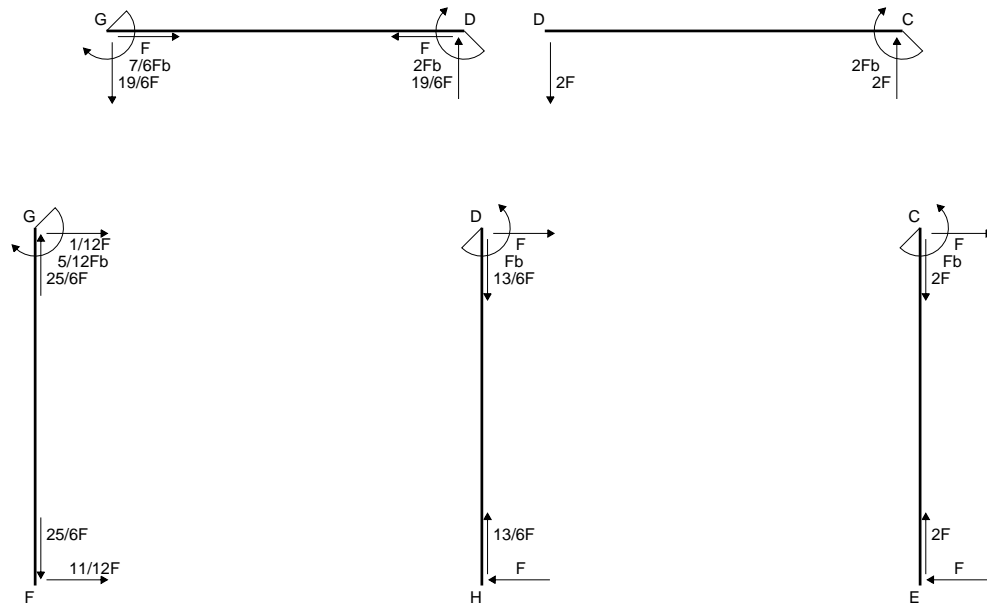
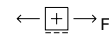
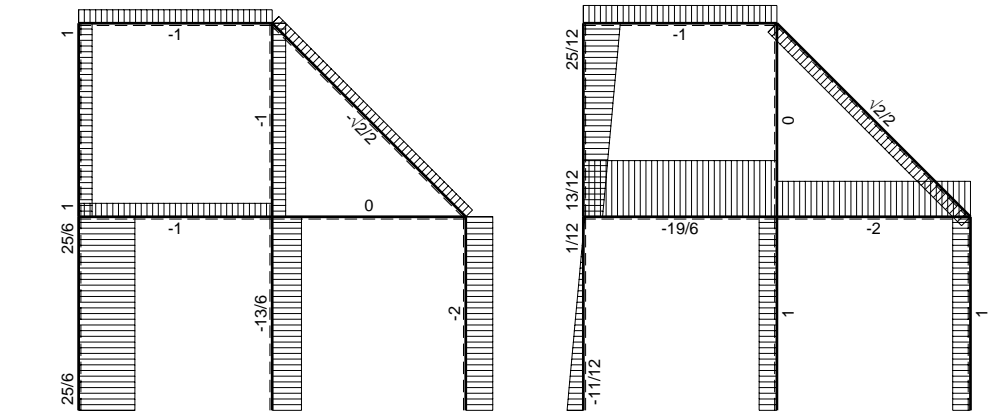
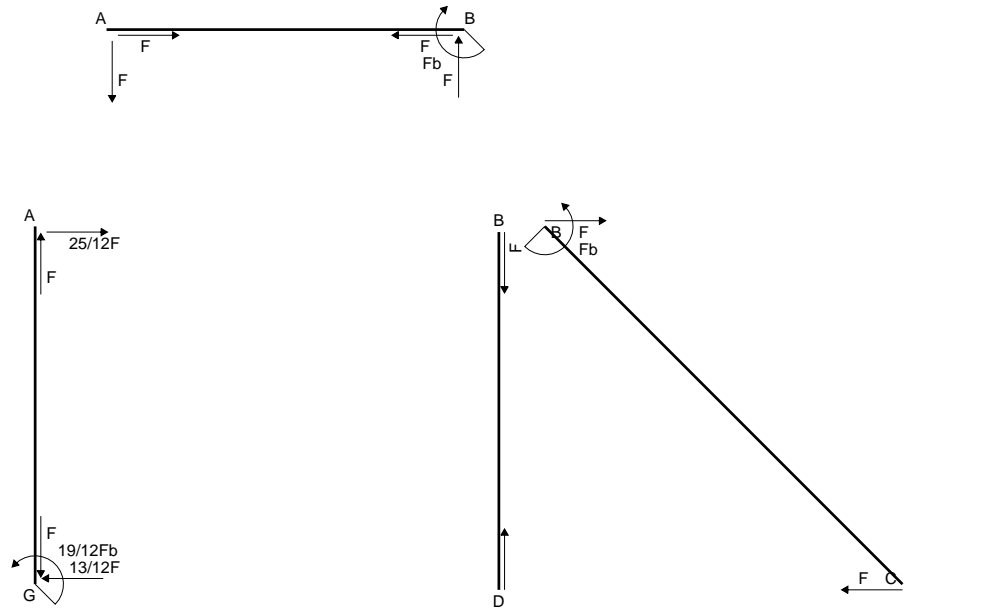
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

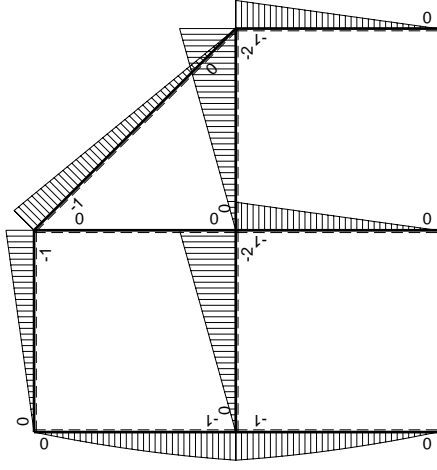
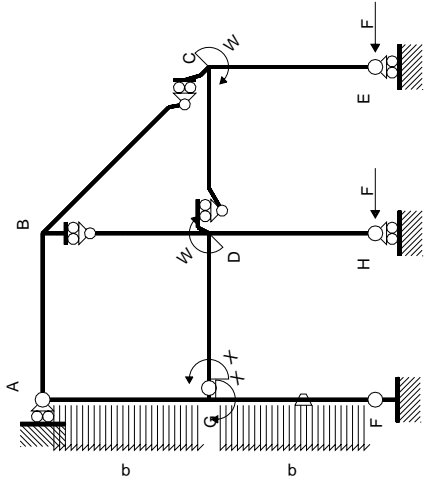
$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



- A = 648. mm<sup>2</sup>
- J<sub>u</sub> = 249420. mm<sup>4</sup>
- J<sub>v</sub> = 37368. mm<sup>4</sup>
- y<sub>g</sub> = 24.86 mm
- T<sub>y</sub> = -2880. N
- M<sub>x</sub> = -2044800. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 29.14 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 238.9 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 6. mm
- v<sub>c</sub> = -18.86 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -154.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 9.261 N/mm<sup>2</sup>
- σ<sub>q</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 155.5 N/mm<sup>2</sup>
- S = 4812. mm<sup>3</sup>

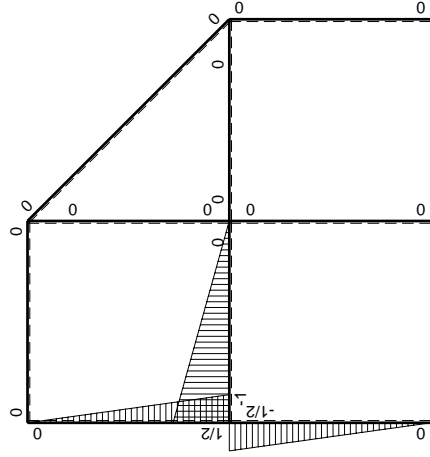






Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_X$  flessione da iperstatica X=1

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
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+1/2qx <sup>2</sup>	-Fb/EJ	3/4Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(3/16+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-1/2Fx-1/2qx <sup>2</sup>	Fb/EJ	1/2Fb-3/4Fx+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/3+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup>	0	-1/2Fb+3/4Fx-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-3/16+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/2Fx-1/2qx <sup>2</sup>	0	-3/4Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						7/12Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-7/6Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/4 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [1/4 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 7/16 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - 3/4 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 3/8 x^2/b + 1/16 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 3/8 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 7/16 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

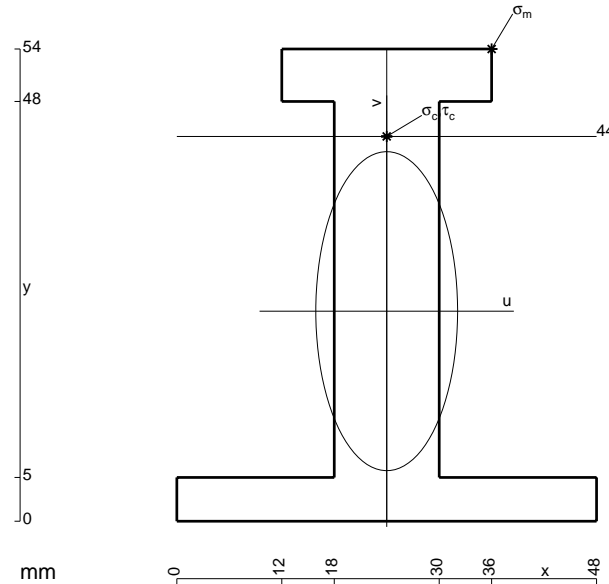
$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + 3/4 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 3/8 x^2/b - 1/16 x^3/b^2]_0^b Fb 1/EJ$$

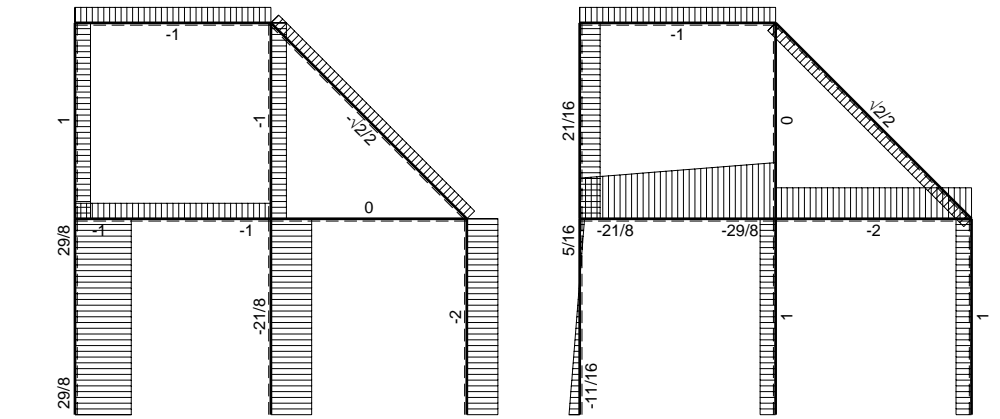
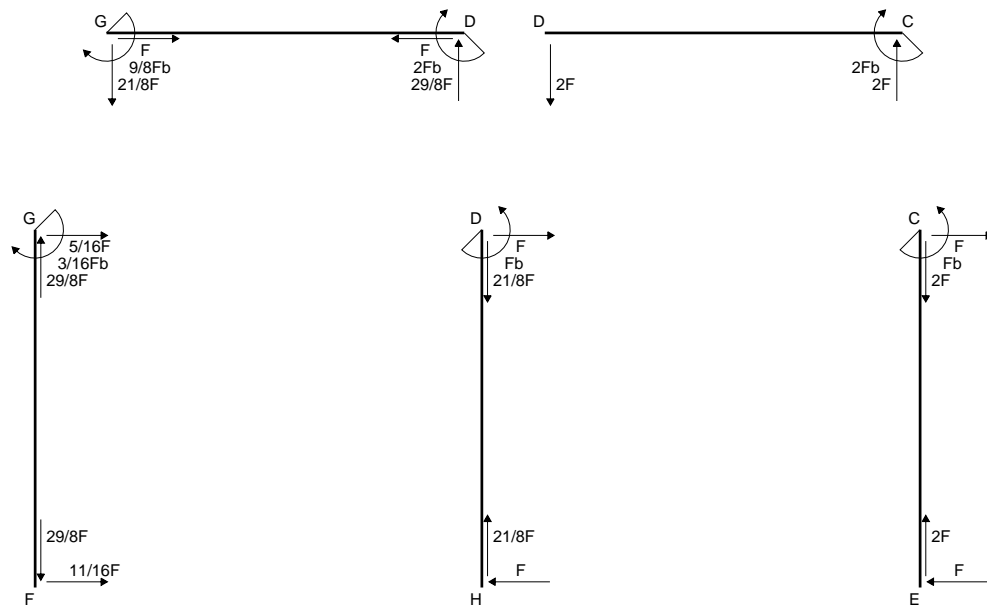
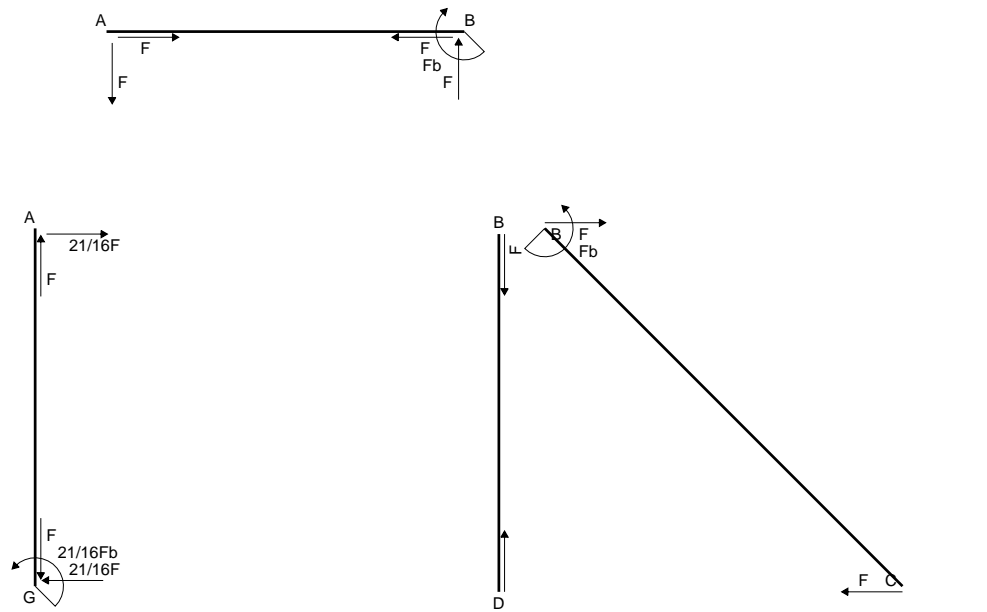
$$= (-1/2 b + 3/8 b - 1/16 b) Fb 1/EJ = -3/16 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-3/4 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-1/4 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/16 b) Fb 1/EJ = -3/16 Fb^2/EJ$$

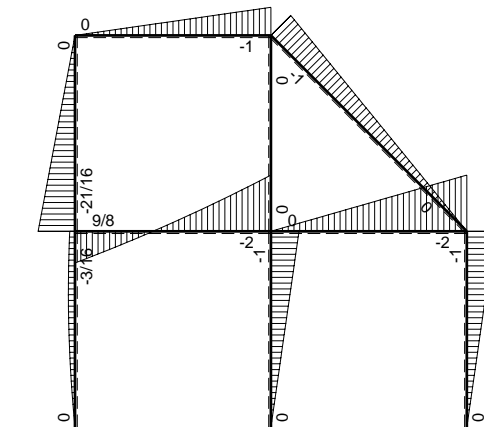


- A = 900. mm<sup>2</sup>
- J<sub>u</sub> = 299580. mm<sup>4</sup>
- J<sub>v</sub> = 59184. mm<sup>4</sup>
- y<sub>g</sub> = 24.02 mm
- T<sub>y</sub> = -2620. N
- M<sub>x</sub> = -1991200. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 29.98 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.3 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 44. mm
- v<sub>c</sub> = 19.98 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 132.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.6 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 132.9 N/mm<sup>2</sup>
- S = 4940. mm<sup>3</sup>

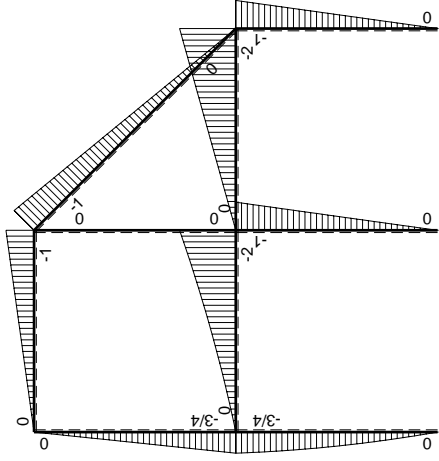
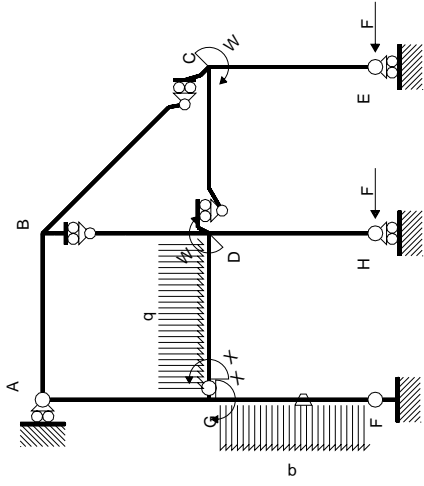


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↑ ⊕ ↓ F<sub>b</sub>



⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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 <sup>2</sup>	-Fb/EJ	5/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(7/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-1/4Fx-1/2qx <sup>2</sup>	Fb/EJ	3/8Fb-1/2Fx-1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx-1/2qx <sup>2</sup>	0	3/2Fx-Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(7/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	2Fx-5/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/8+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	3/4Fx	0	-3/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						9/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 -2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b +1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b +1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b (5/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b -1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b (3/8 -1/2 x/b -1/8 x^2/b^2 +1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 +1/2 x/b) \theta dx$$

$$= [3/8 x -1/4 x^2/b -1/24 x^3/b^2 +1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

$$= (3/8 b -1/4 b -1/24 b +1/16 b) Fb 1/EJ + (-1/2 b +1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b (3/2 x/b - x^2/b^2 -1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b -1/3 x^3/b^2 -1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (3/4 b -1/3 b -1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b (2 x/b -5/2 x^2/b^2 +1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b -5/6 x^3/b^2 +1/8 x^4/b^3]_0^b Fb 1/EJ$$

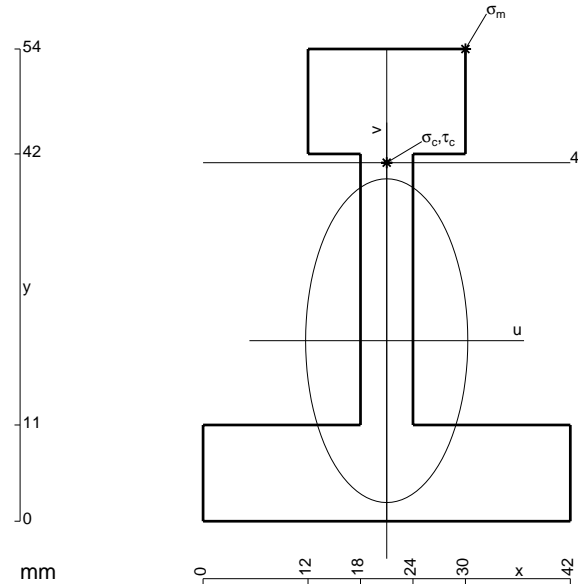
$$= (b -5/6 b +1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b (-3/8 +3/4 x/b -3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x +3/8 x^2/b -1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-3/8 b +3/8 b -1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

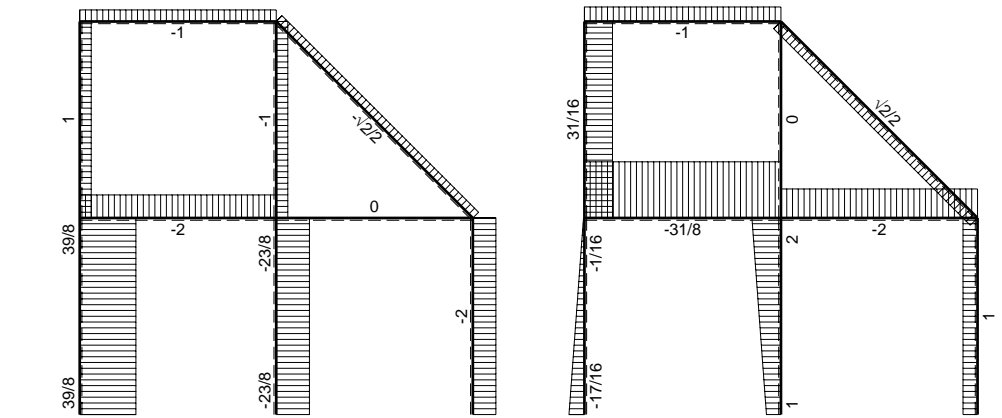
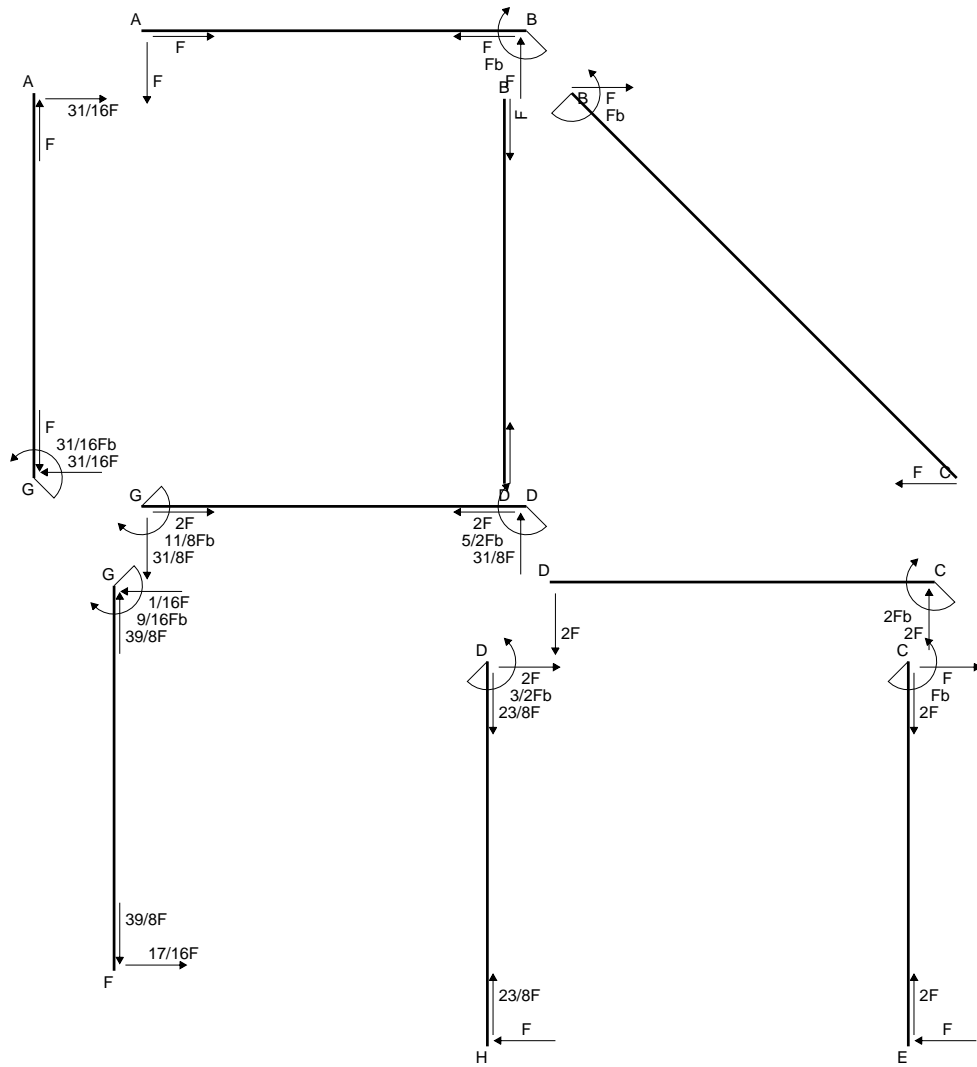
$$L_{AG}^{x\theta} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



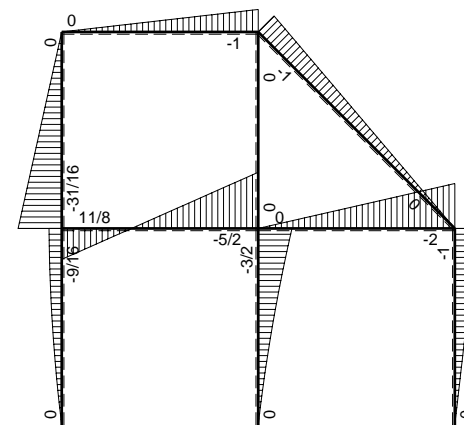
- A = 864. mm<sup>2</sup>
- J<sub>u</sub> = 296124. mm<sup>4</sup>
- J<sub>v</sub> = 74304. mm<sup>4</sup>
- y<sub>g</sub> = 20.65 mm
- T<sub>y</sub> = -2300. N
- M<sub>x</sub> = -1863000. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 33.35 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 209.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 41. mm
- v<sub>c</sub> = 20.35 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 128.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 7.811 N/mm<sup>2</sup>
- σ<sub>σ</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 128.8 N/mm<sup>2</sup>
- S = 6034. mm<sup>3</sup>



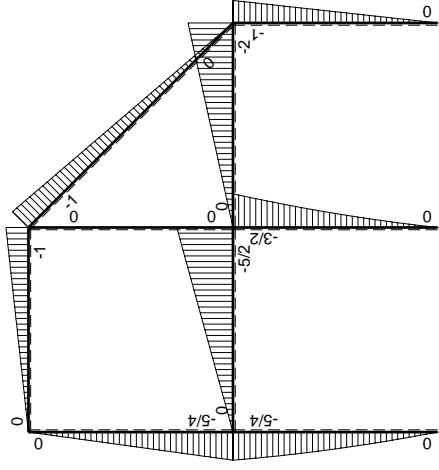
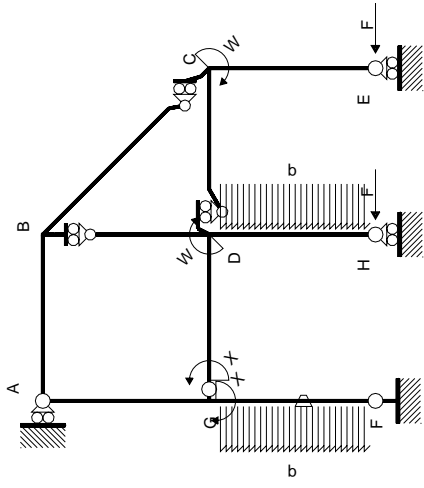


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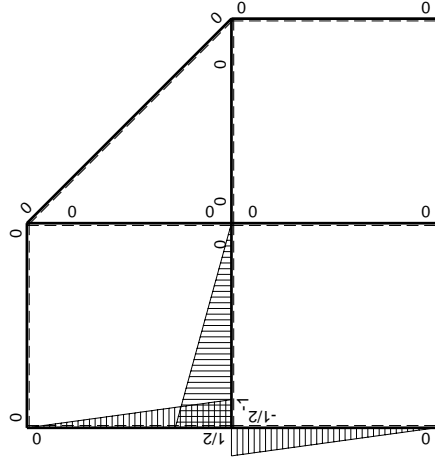


⊕ Fb



Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	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	0	0
DC b	0	-2Fx	0	0	0	0	0+0	0
CD b	0	2Fb-2Fx	0	0	0	0	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(11/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	5/8Fb-Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-5/2Fx	0	5/2Fx-5/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-5/2Fx	0	5/2Fx-5/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0		
GA b	1/2-1/2x/b	-5/4Fb+5/4Fx	0	-5/8Fb+5/4Fx-5/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-5/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx	0	-5/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						11/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-11/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (7/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [7/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (7/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (5/8 - x/b + 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [5/8 x - 1/2 x^2/b + 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (5/8 b - 1/2 b + 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

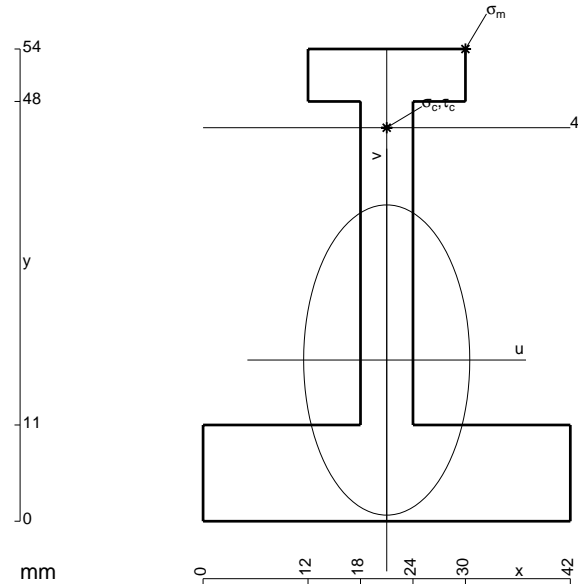
$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-5/8 + 5/4 x/b - 5/8 x^2/b^2) Fb 1/EJ dx = [-5/8 x + 5/8 x^2/b - 5/24 x^3/b^2]_0^b Fb 1/EJ$$

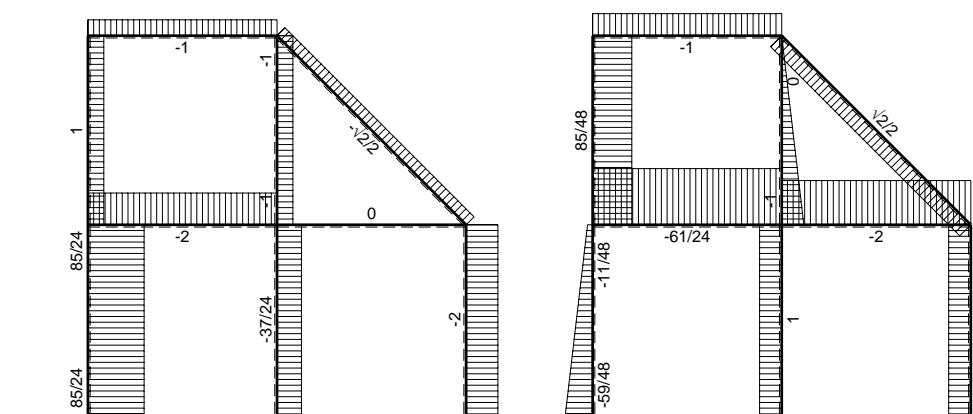
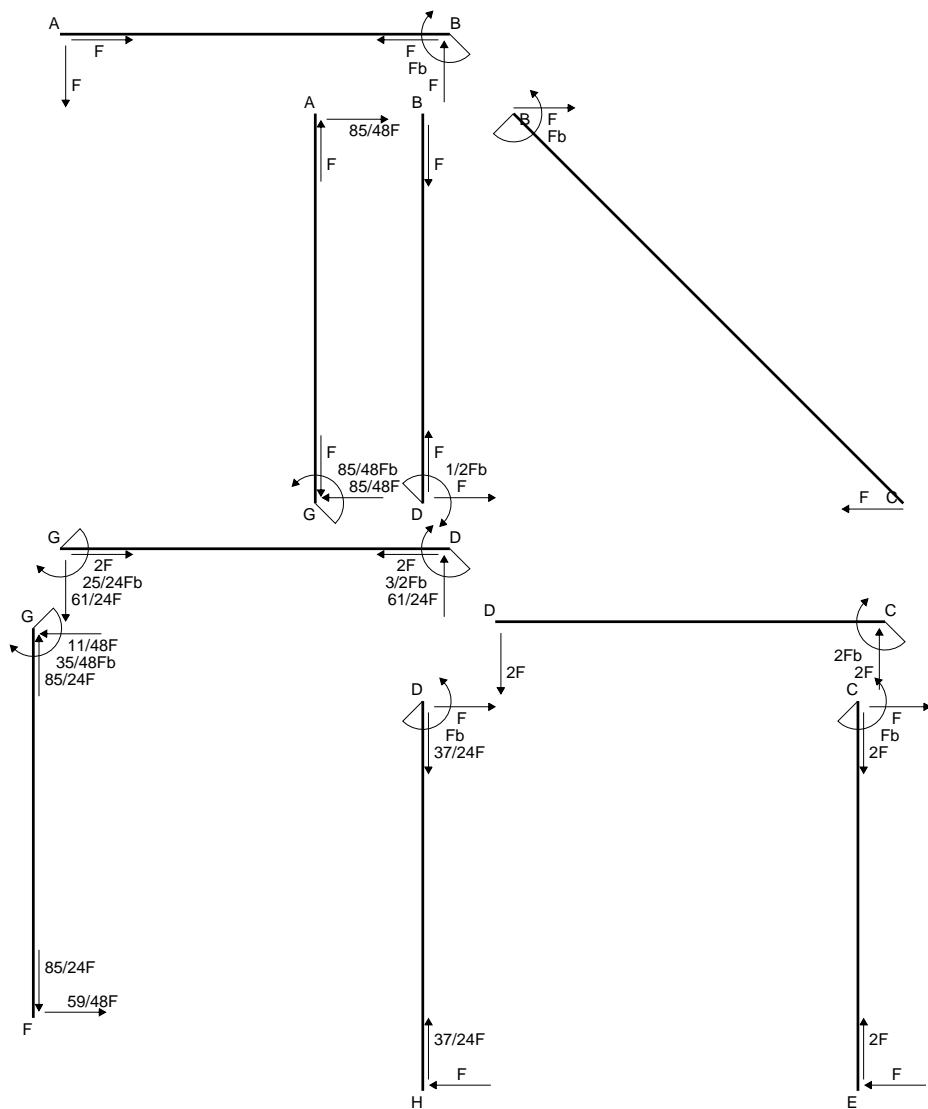
$$= (-5/8 b + 5/8 b - 5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2) Fb 1/EJ dx = [-5/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$

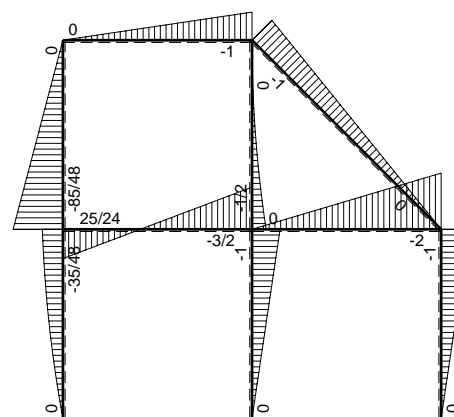


- A = 792. mm<sup>2</sup>
- J<sub>u</sub> = 249320. mm<sup>4</sup>
- J<sub>v</sub> = 71496. mm<sup>4</sup>
- y<sub>g</sub> = 18.43 mm
- T<sub>y</sub> = -1780. N
- M<sub>x</sub> = -1530800. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 35.57 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 218.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 45. mm
- v<sub>c</sub> = 26.57 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 163.1 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.786 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 163.3 N/mm<sup>2</sup>
- S = 4023. mm<sup>3</sup>

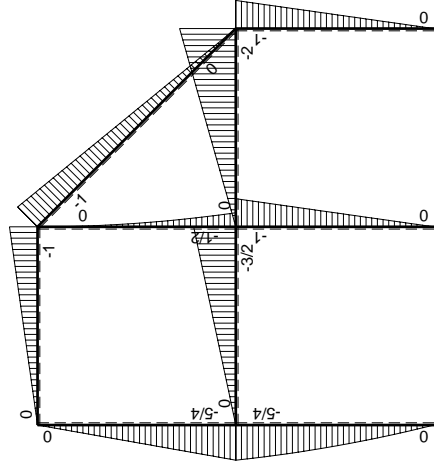
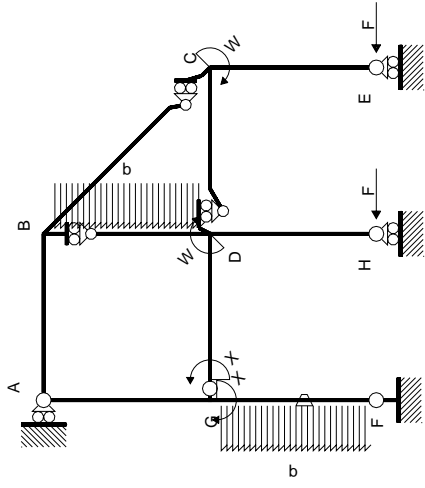


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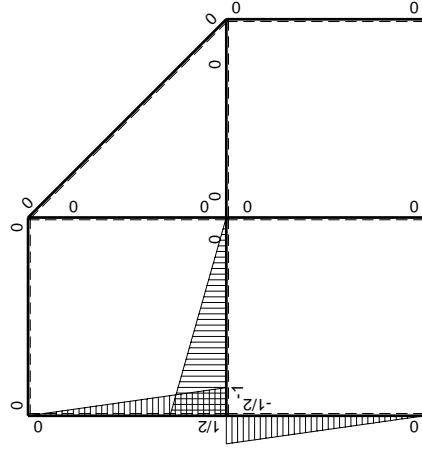


⊕ ⊖ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	-Fx	0	0	0	0	0+0	0
BA b	0	Fb-Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-Fb+ $\sqrt{2}/2Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-Fb+Fx	0	0	0	0	0+0	0
EC b	0	Fx	0	0	0	0	0	0
FG b	-1/2x/b	-7/4Fx+1/2qx <sup>2</sup>	-Fb/EJ	7/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(11/48+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	5/4Fb-3/4Fx-1/2qx <sup>2</sup>	Fb/EJ	5/8Fb-Fx+1/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-5/4Fb+5/4Fx	0	-5/8Fb+5/4Fx-5/8Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-5/24+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx	0	-5/8Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						25/48Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-25/24Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 -2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b +1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b +1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 -1/2 x/b +1/4 x^2/b^2) 1/EJ dx = [1/4 x -1/4 x^2/b +1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b -1/4 b +1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{x\theta} = \int_0^b (7/8 x^2/b^2 -1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [7/24 x^3/b^2 -1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (7/24 b -1/16 b) Fb 1/EJ + (1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GF}^{x\theta} = \int_0^b (5/8 - x/b +1/8 x^2/b^2 +1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 +1/2 x/b) \theta dx$$

$$= [5/8 x -1/2 x^2/b +1/24 x^3/b^2 +1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x +1/4 x^2/b]_0^b \theta$$

$$= (5/8 b -1/2 b +1/24 b +1/16 b) Fb 1/EJ + (-1/2 b +1/4 b) \theta = 23/48 Fb^2/EJ$$

$$L_{GD}^{x\theta} = \int_0^b (3/2 x/b -3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b -1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b -1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{x\theta} = \int_0^b (3/2 x/b -3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b -1/2 x^3/b^2]_0^b Fb 1/EJ$$

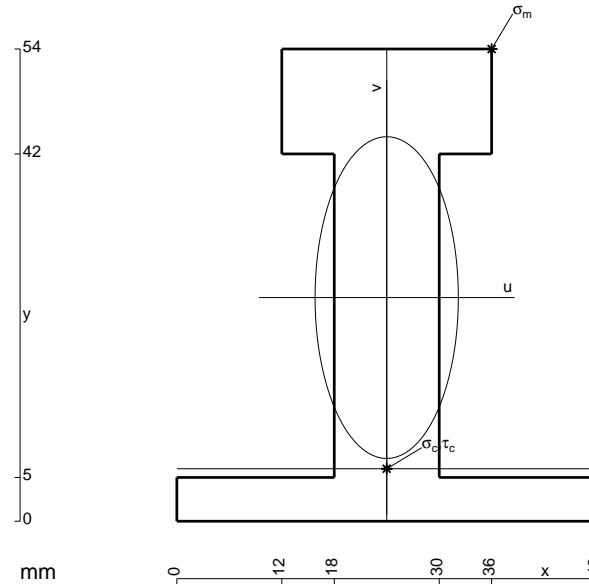
$$= (3/4 b -1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{x\theta} = \int_0^b (-5/8 +5/4 x/b -5/8 x^2/b^2) Fb 1/EJ dx = [-5/8 x +5/8 x^2/b -5/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/8 b +5/8 b -5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$

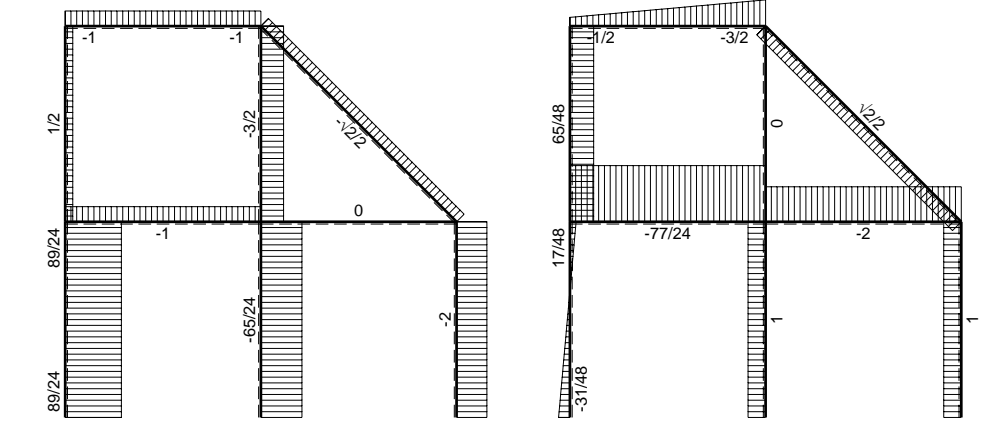
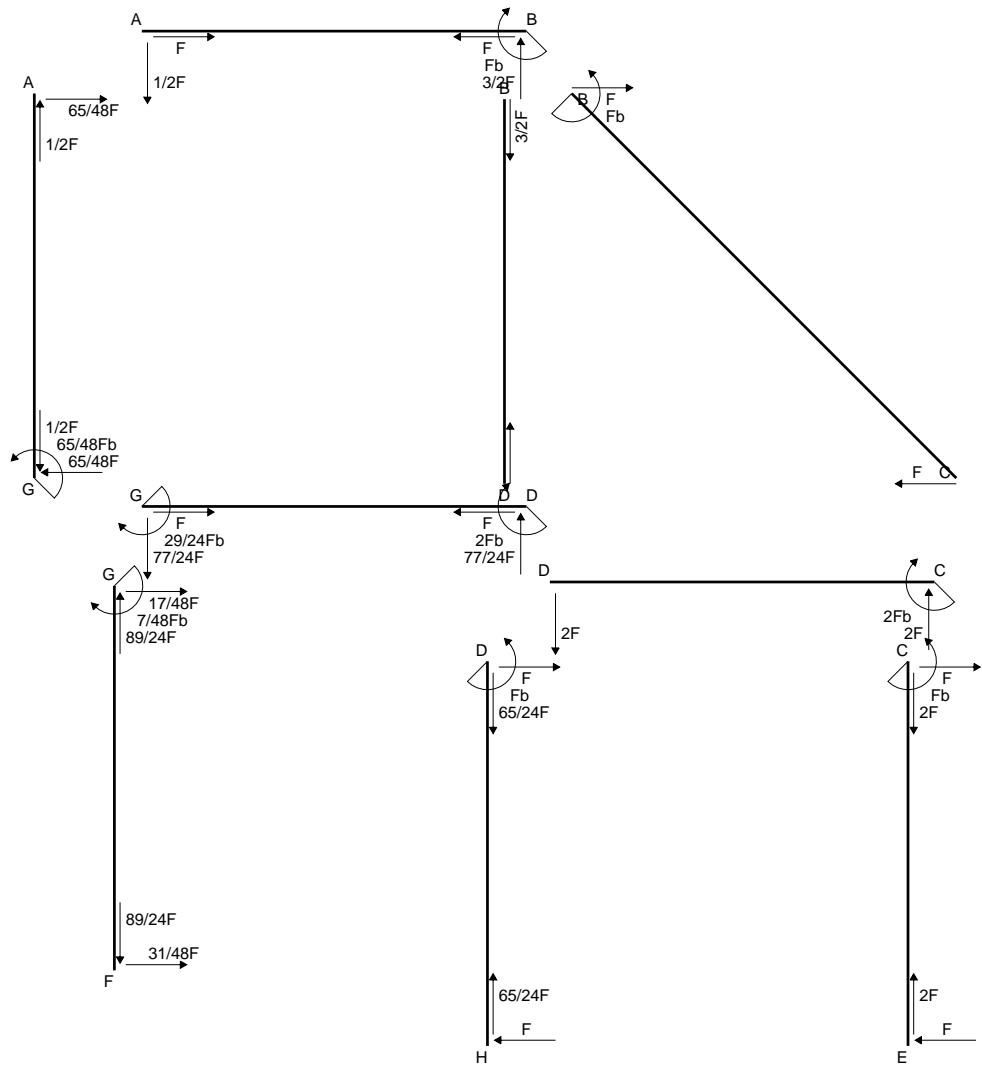
$$L_{AG}^{x\theta} = \int_0^b (-5/8 x^2/b^2) Fb 1/EJ dx = [-5/24 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-5/24 b) Fb 1/EJ = -5/24 Fb^2/EJ$$



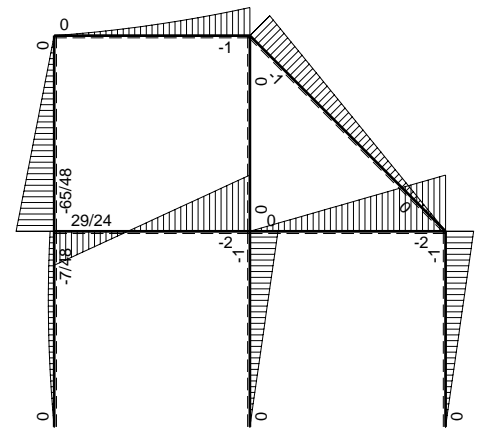
- A = 972. mm<sup>2</sup>
- J<sub>u</sub> = 329140. mm<sup>4</sup>
- J<sub>v</sub> = 65232. mm<sup>4</sup>
- y<sub>g</sub> = 25.57 mm
- T<sub>y</sub> = -2920. N
- M<sub>x</sub> = -2657200. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 28.43 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 229.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 6. mm
- v<sub>c</sub> = -19.57 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -158. N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.272 N/mm<sup>2</sup>
- σ<sub>σ</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 158.2 N/mm<sup>2</sup>
- S = 5779. mm<sup>3</sup>



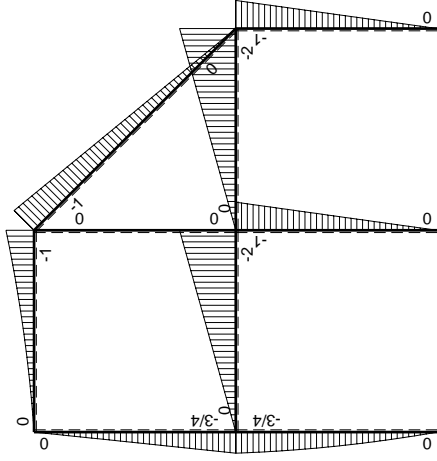
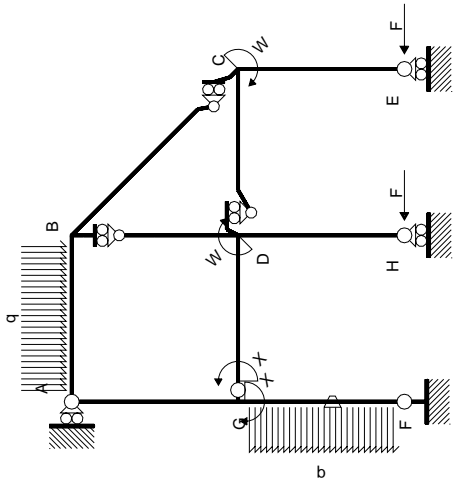


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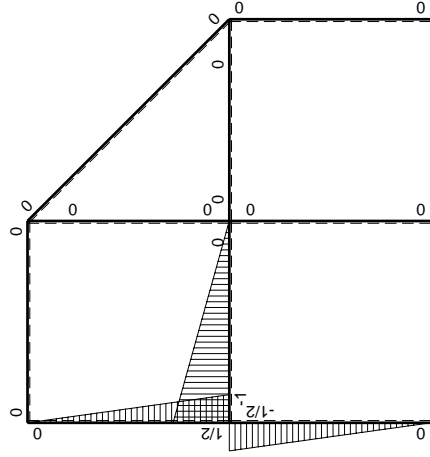


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Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
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	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	0+0	0
DC b	0	$-2Fx$	0	0	0	0	0+0	0
CD b	0	$2Fb-2Fx$	0	0	0	0	0+0	0
CE b	0	$-Fb+Fx$	0	0	0	0	0+0	0
EC b	0	$Fx$	0	0	0	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	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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (5/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx$$

$$= [5/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (5/24 b - 1/16 b) Fb 1/EJ + (1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 1/2 x/b - 1/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 1/4 x^2/b - 1/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 1/4 b - 1/24 b + 1/16 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 19/48 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

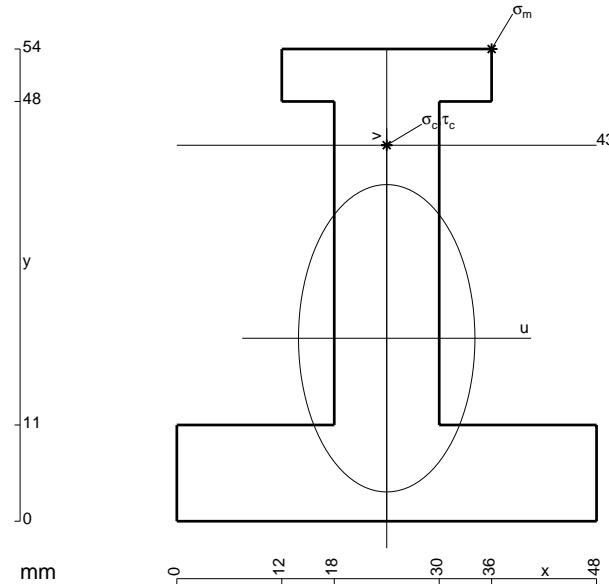
$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-3/8 + 3/4 x/b - 3/8 x^2/b^2) Fb 1/EJ dx = [-3/8 x + 3/8 x^2/b - 1/8 x^3/b^2]_0^b Fb 1/EJ$$

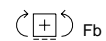
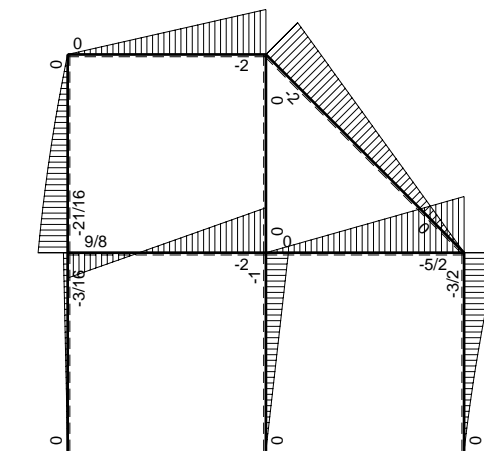
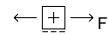
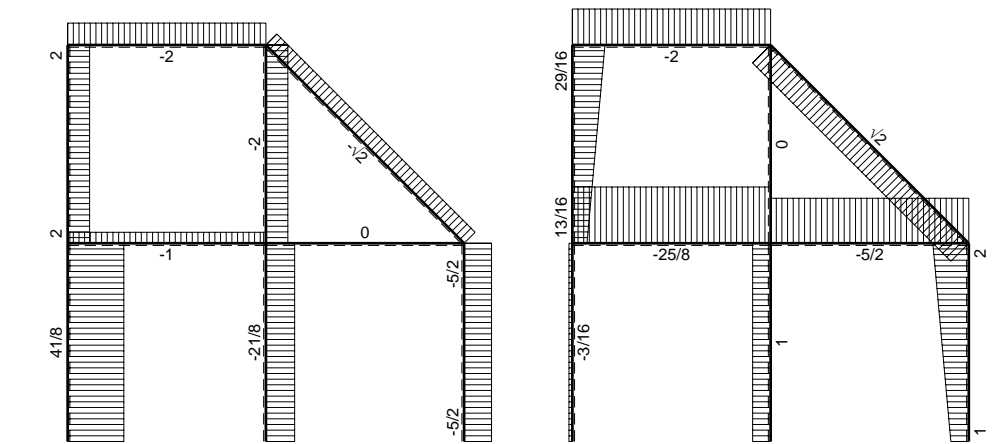
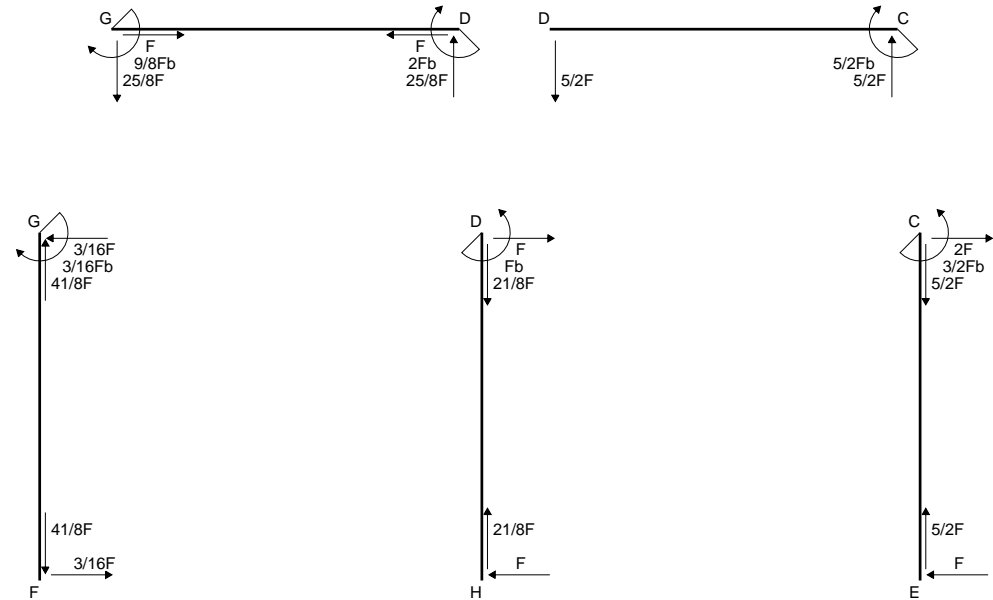
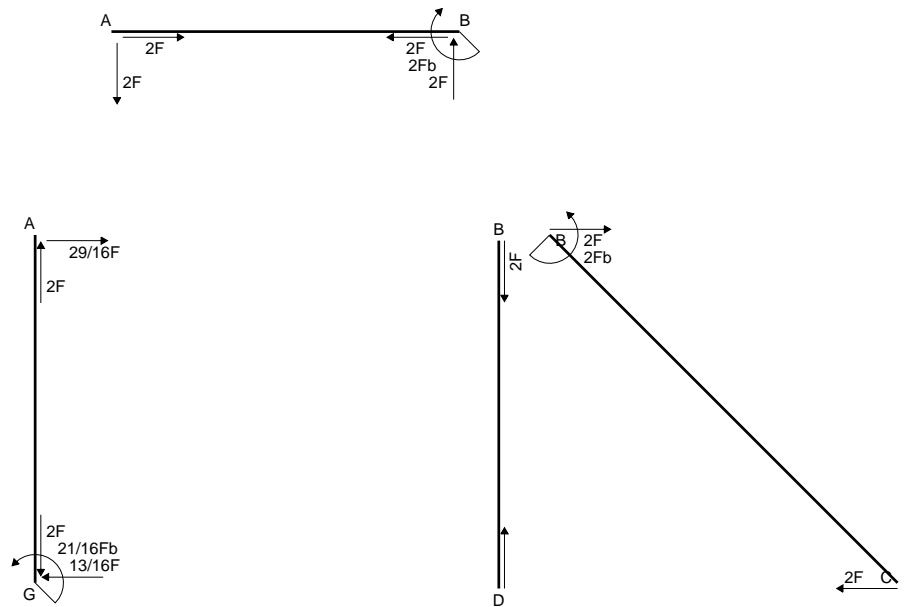
$$= (-3/8 b + 3/8 b - 1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$

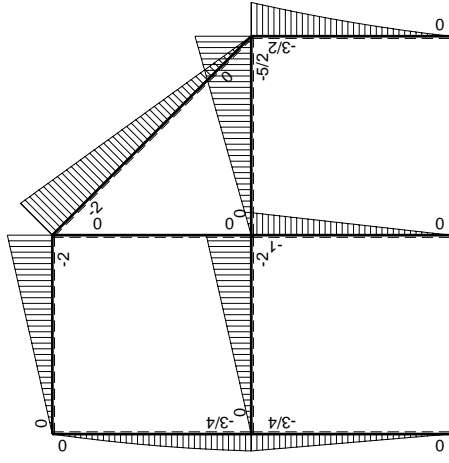
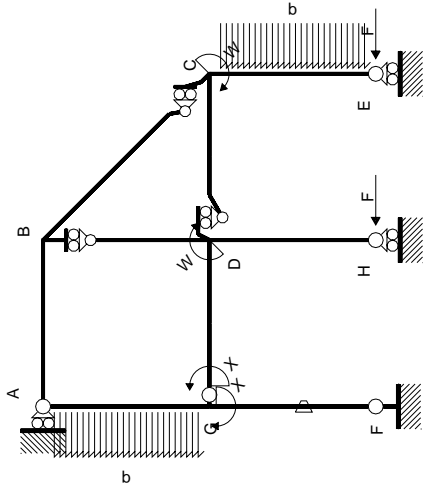
$$L_{AG}^{xo} = \int_0^b (-3/8 x^2/b^2) Fb 1/EJ dx = [-1/8 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/8 b) Fb 1/EJ = -1/8 Fb^2/EJ$$



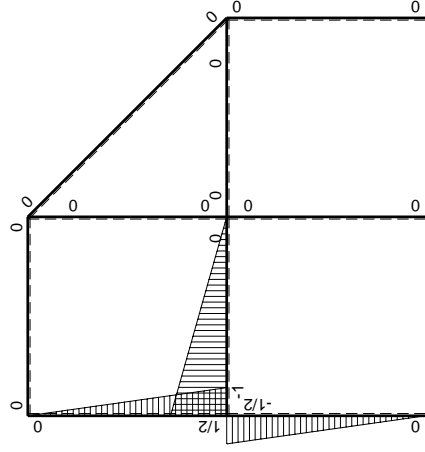
- A = 1116. mm<sup>2</sup>
- J<sub>u</sub> = 344933. mm<sup>4</sup>
- J<sub>v</sub> = 113616. mm<sup>4</sup>
- y<sub>g</sub> = 20.92 mm
- T<sub>y</sub> = -2600. N
- M<sub>x</sub> = -2496000. Nmm
- x<sub>m</sub> = 36. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 12. mm
- v<sub>m</sub> = 33.08 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 239.4 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 43. mm
- v<sub>c</sub> = 22.08 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = 159.8 N/mm<sup>2</sup>
- τ<sub>c</sub> = 3.647 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 159.9 N/mm<sup>2</sup>
- S = 5806. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	-3/4Fx	-Fb/EJ	3/8Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/8+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	3/4Fb-3/4Fx	Fb/EJ	3/8Fb-3/4Fx+3/8Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/3+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	2Fb-2Fx	0	2Fx-2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
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 <sup>2</sup>	0	-3/8Fb+1/2Fx+1/8Fx <sup>2</sup> /b-1/4qx <sup>3</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-7/48+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	5/4Fx-1/2qx <sup>2</sup>	0	-5/8Fx <sup>2</sup> /b+1/4qx <sup>3</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						9/16Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-9/8Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/8 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/8 b) Fb 1/EJ + (1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (3/8 - 3/4 x/b + 3/8 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [3/8 x - 3/8 x^2/b + 1/8 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (3/8 b - 3/8 b + 1/8 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 3/8 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

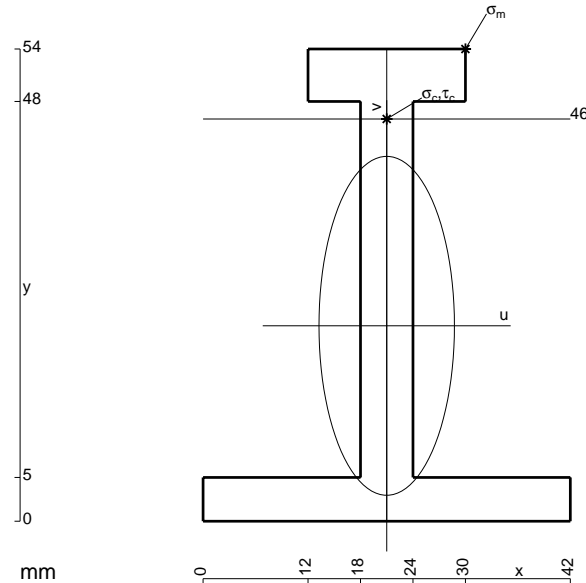
$$L_{GA}^{xo} = \int_0^b (-3/8 + 1/2 x/b + 1/8 x^2/b^2 - 1/4 x^3/b^3) Fb 1/EJ dx$$

$$= [-3/8 x + 1/4 x^2/b + 1/24 x^3/b^2 - 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-3/8 b + 1/4 b + 1/24 b - 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$

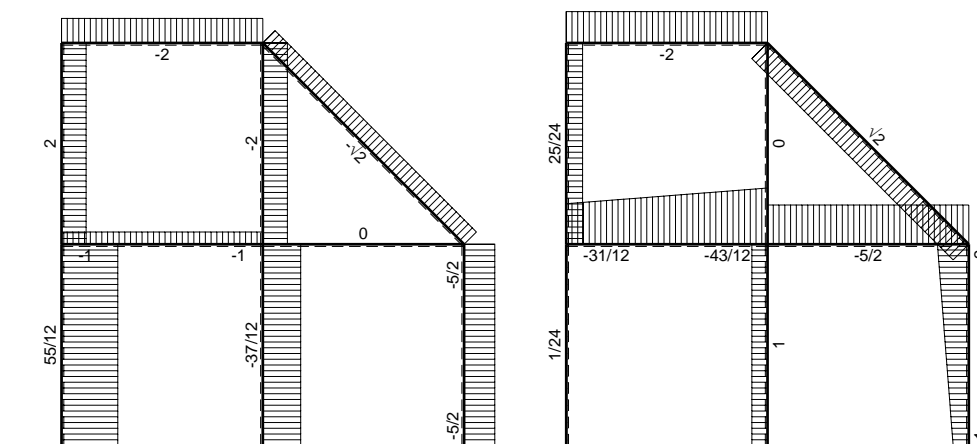
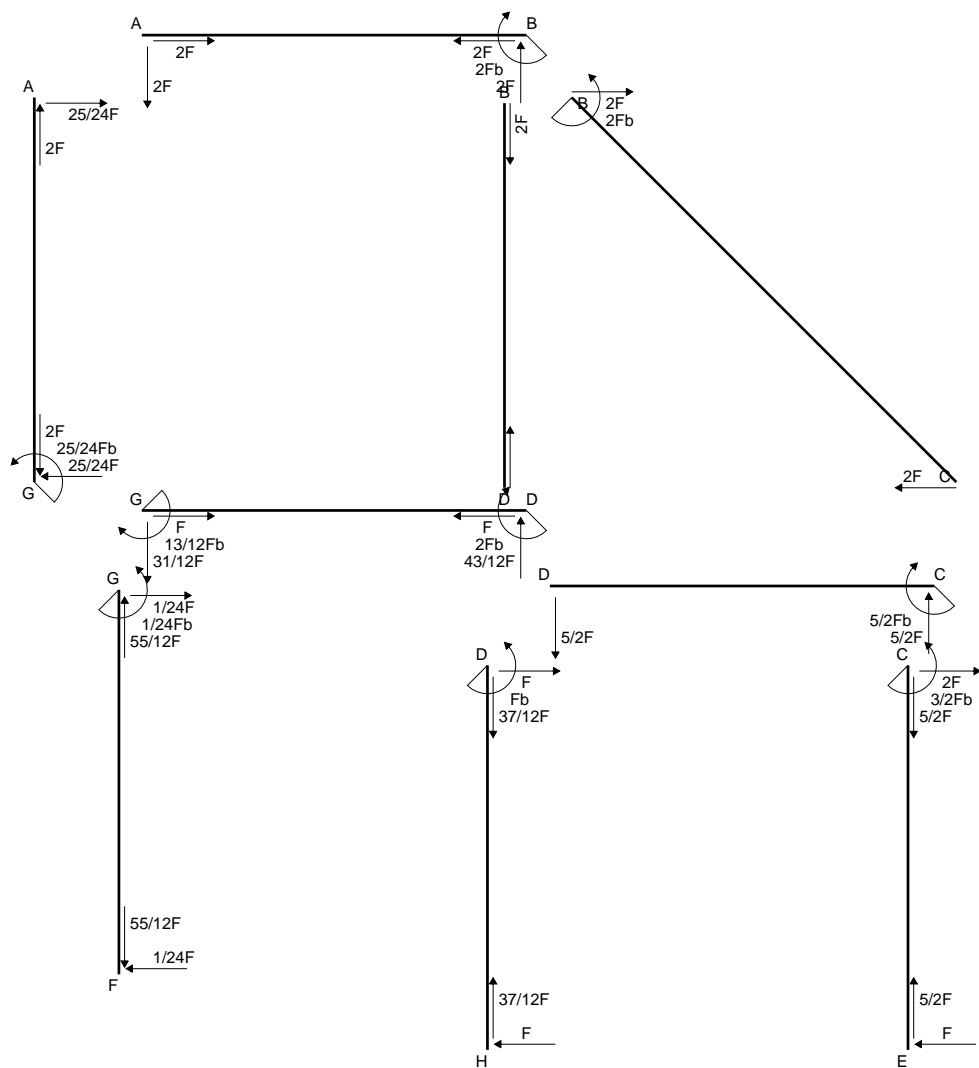
$$L_{AG}^{xo} = \int_0^b (-5/8 x^2/b^2 + 1/4 x^3/b^3) Fb 1/EJ dx = [-5/24 x^3/b^2 + 1/16 x^4/b^3]_0^b Fb 1/EJ$$

$$= (-5/24 b + 1/16 b) Fb 1/EJ = -7/48 Fb^2/EJ$$



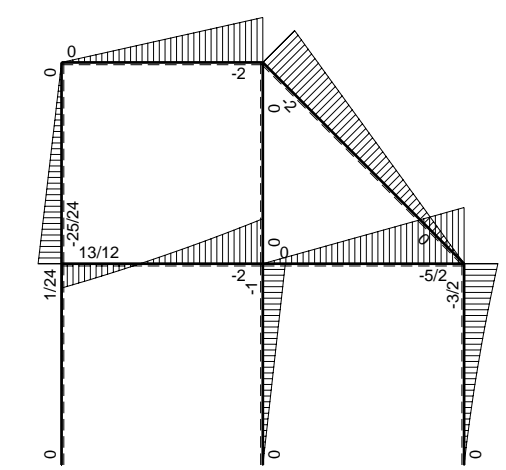
- A = 576. mm<sup>2</sup>
- J<sub>u</sub> = 216352. mm<sup>4</sup>
- J<sub>v</sub> = 34560. mm<sup>4</sup>
- y<sub>g</sub> = 22.34 mm
- T<sub>y</sub> = -2675. N
- M<sub>x</sub> = -1364250. Nmm
- x<sub>m</sub> = 30. mm
- y<sub>m</sub> = 54. mm
- u<sub>m</sub> = 9. mm
- v<sub>m</sub> = 31.66 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = 199.6 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 46. mm
- v<sub>c</sub> = 23.66 mm
- σ<sub>c</sub> = -Mv/J<sub>v</sub> = 149.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.987 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 149.7 N/mm<sup>2</sup>
- S = 3391. mm<sup>3</sup>



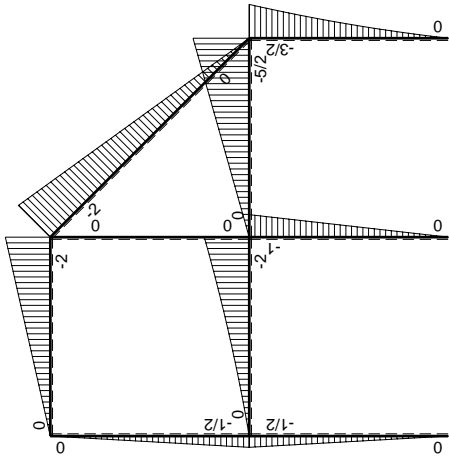
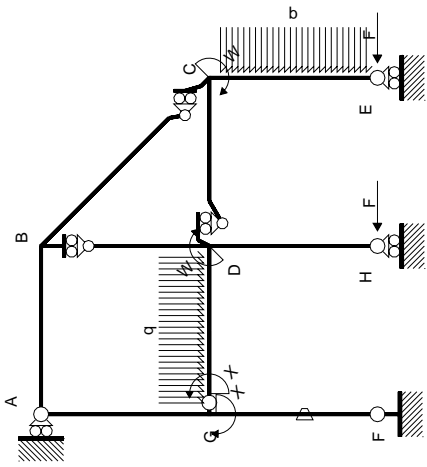


← ⊕ → F

↑ ⊕ ↓ F

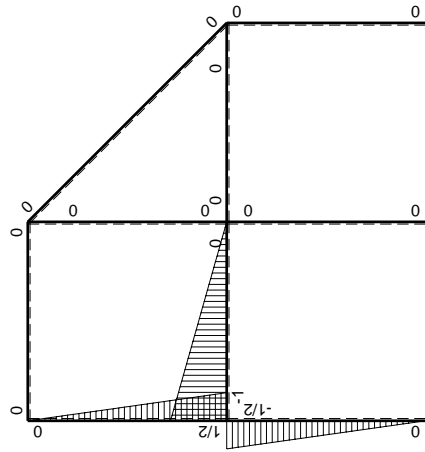


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$	
AB b	0	-2Fx	0	0	0	0	0+0	0	
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0	
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0	
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0	
FG b	-1/2x/b	-1/2Fx	-Fb/EJ	1/4Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/12+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
GF b	1/2-1/2x/b	1/2Fb-1/2Fx	Fb/EJ	1/4Fb-1/2Fx+1/4Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>			
GD b	-1+x/b	-3/2Fx-1/2qx <sup>2</sup>	0	3/2Fx-Fx <sup>2</sup> /b-1/2qx <sup>3</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(7/24+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ	
DG b	x/b	2Fb-5/2Fx+1/2qx <sup>2</sup>	0	2Fx-5/2Fx <sup>2</sup> /b+1/2qx <sup>3</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>			
DH b	0	-Fb+Fx	0	0	0	0	0+0	0	
HD b	0	Fx	0	0	0	0	0	0	
GA b	1/2-1/2x/b	-1/2Fb+1/2Fx	0	-1/4Fb+1/2Fx-1/4Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/12+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ	
AG b	-1/2x/b	1/2Fx	0	-1/4Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>			
	totali							13/24Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$							-13/12Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - x^2/b^2 - 1/2 x^3/b^3) Fb 1/EJ dx = [3/4 x^2/b - 1/3 x^3/b^2 - 1/8 x^4/b^3]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/3 b - 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 5/2 x^2/b^2 + 1/2 x^3/b^3) Fb 1/EJ dx = [x^2/b - 5/6 x^3/b^2 + 1/8 x^4/b^3]_0^b Fb 1/EJ$$

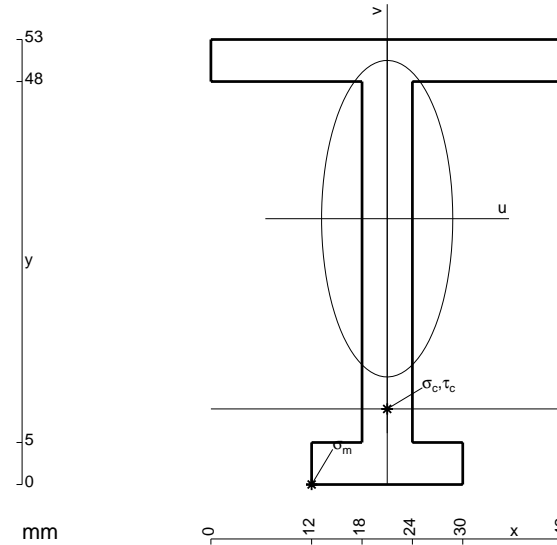
$$= (b - 5/6 b + 1/8 b) Fb 1/EJ = 7/24 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

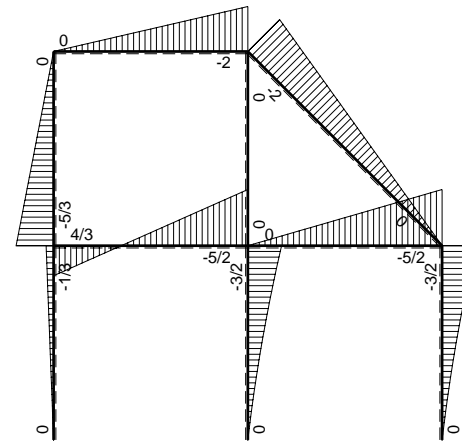
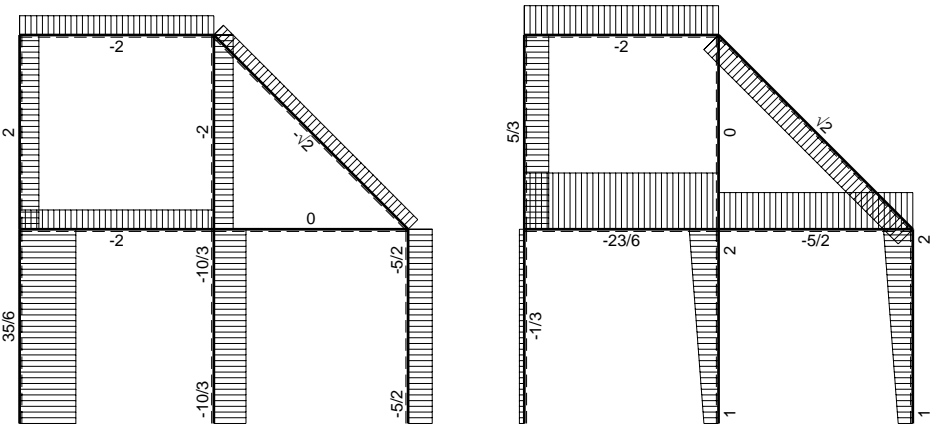
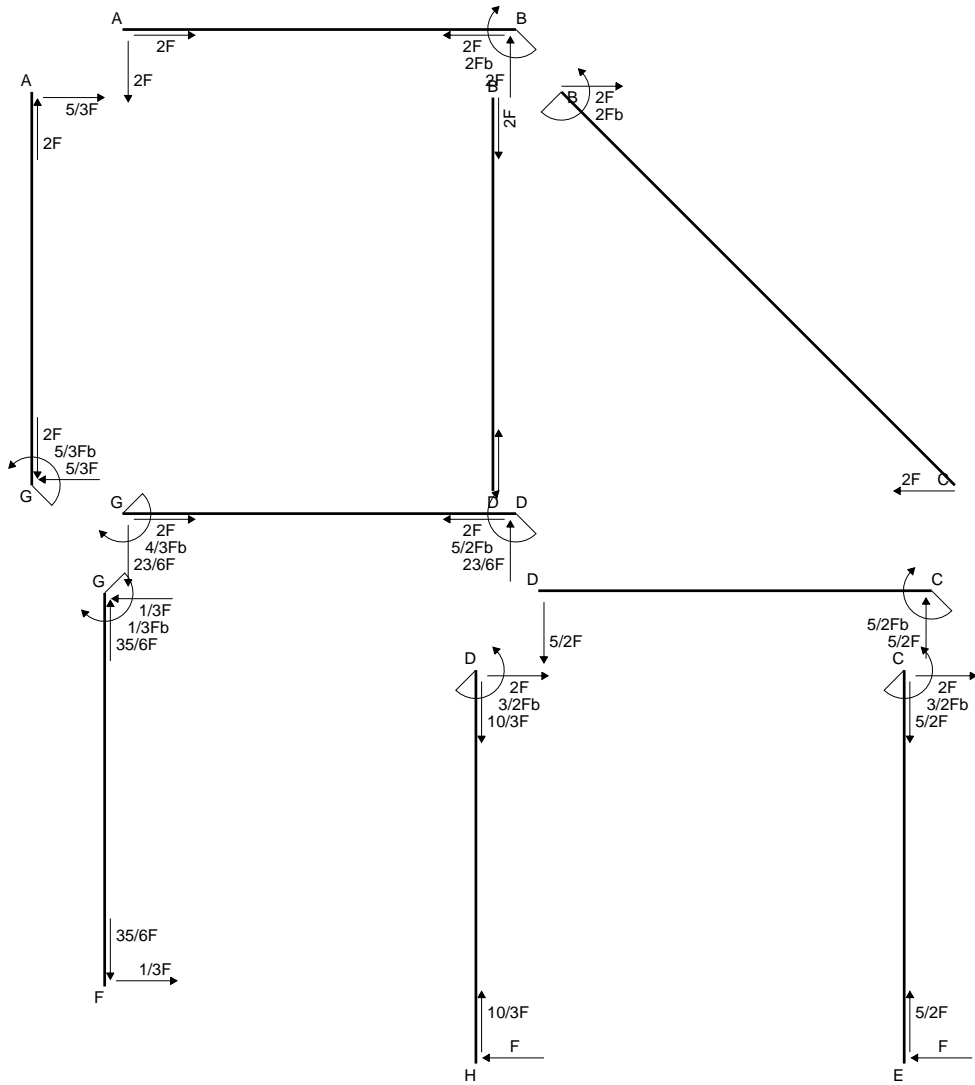
$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

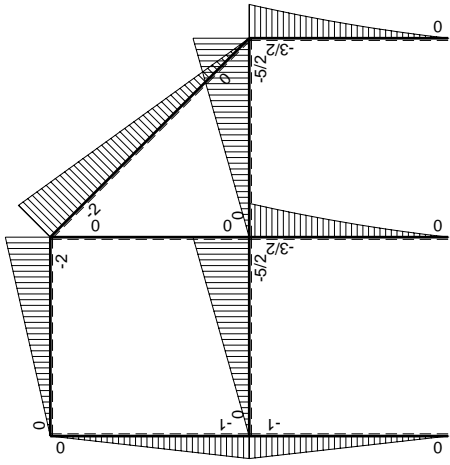
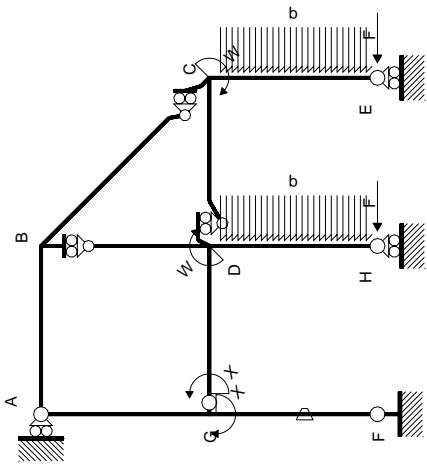
$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



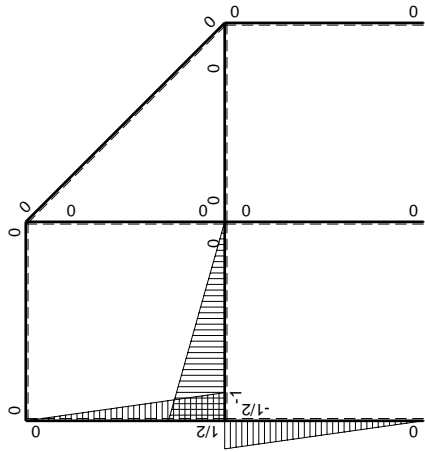
- A = 558. mm<sup>2</sup>
- J<sub>u</sub> = 198314. mm<sup>4</sup>
- J<sub>v</sub> = 34074. mm<sup>4</sup>
- y<sub>g</sub> = 31.66 mm
- T<sub>y</sub> = -2375. N
- M<sub>x</sub> = -1306250. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -31.66 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -208.5 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 9. mm
- v<sub>c</sub> = -22.66 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -149.3 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.42 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 149.7 N/mm<sup>2</sup>
- S = 3216. mm<sup>3</sup>





Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_x$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x / EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	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	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-5/2Fx	0	5/2Fx-5/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(5/12+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	5/2Fb-5/2Fx	0	5/2Fx-5/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
HD b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						2/3Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-4/3Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (5/2 x/b - 5/2 x^2/b^2) Fb 1/EJ dx = [5/4 x^2/b - 5/6 x^3/b^2]_0^b Fb 1/EJ$$

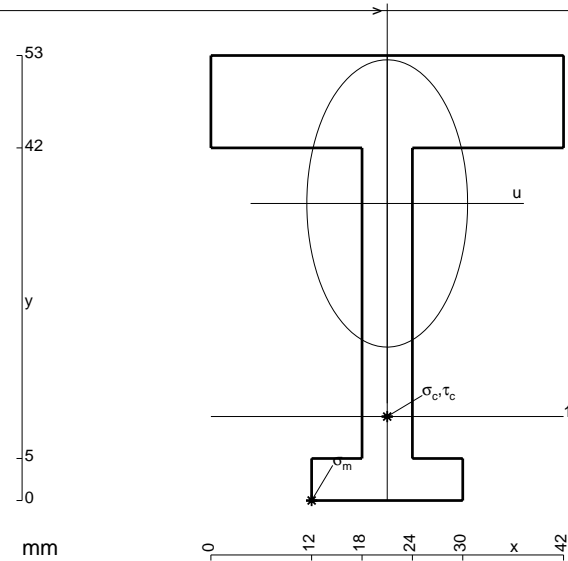
$$= (5/4 b - 5/6 b) Fb 1/EJ = 5/12 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

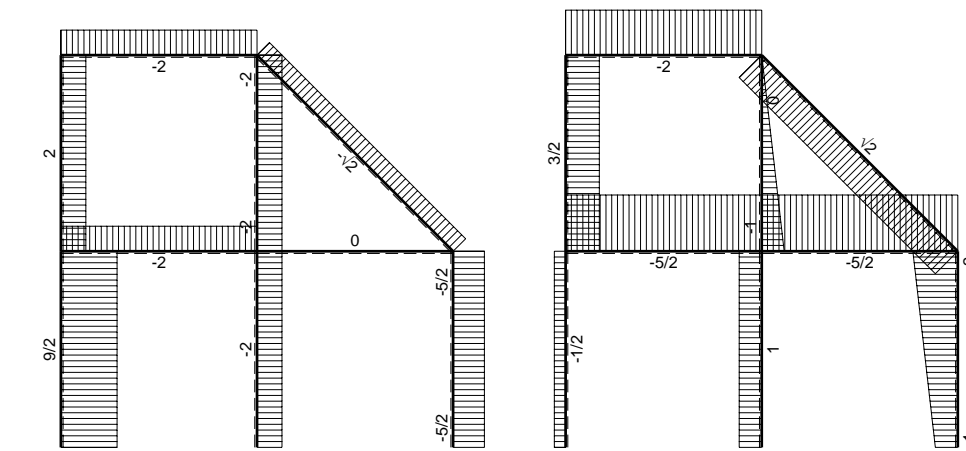
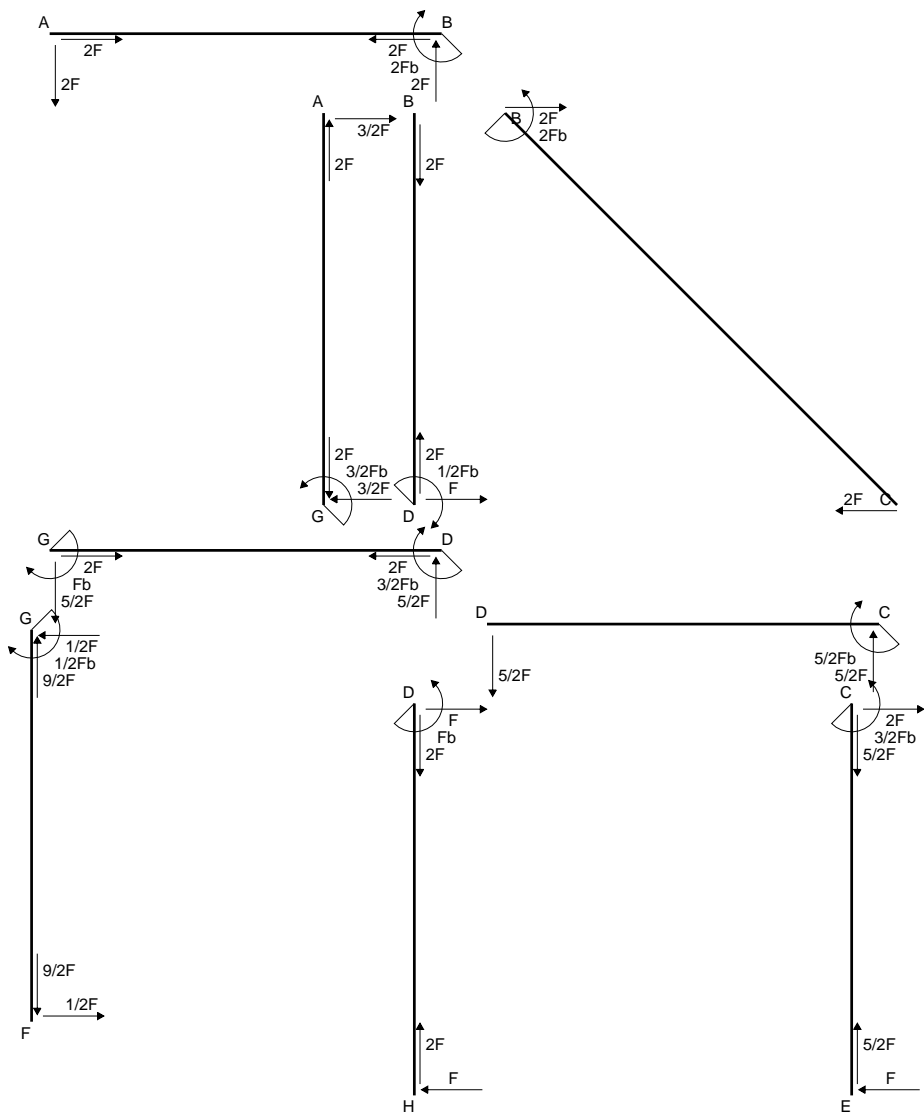
$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$



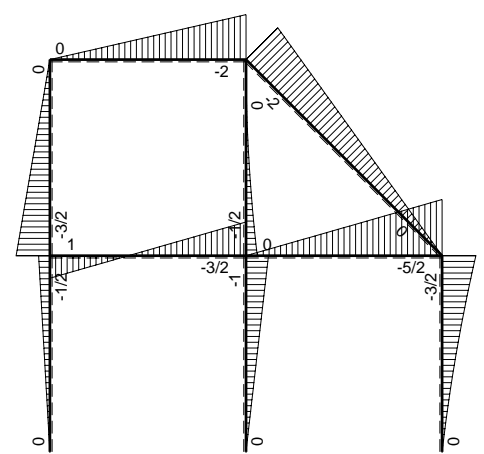
- A = 774. mm<sup>2</sup>
- J<sub>u</sub> = 226668. mm<sup>4</sup>
- J<sub>v</sub> = 71010. mm<sup>4</sup>
- y<sub>g</sub> = 35.38 mm
- T<sub>y</sub> = -2325. N
- M<sub>x</sub> = -1395000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -9. mm
- v<sub>m</sub> = -35.38 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -217.8 N/mm<sup>2</sup>
- x<sub>c</sub> = 21. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -25.38 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -156.2 N/mm<sup>2</sup>
- τ<sub>c</sub> = 6.49 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 156.6 N/mm<sup>2</sup>
- S = 3796. mm<sup>3</sup>



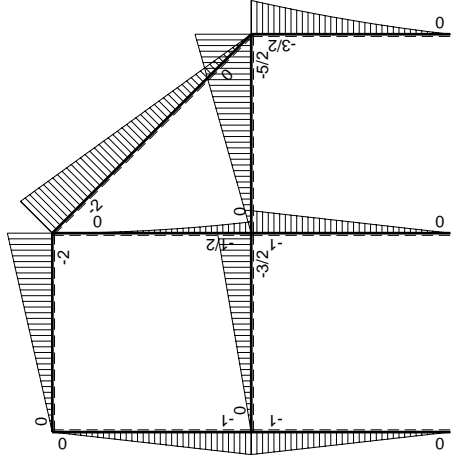
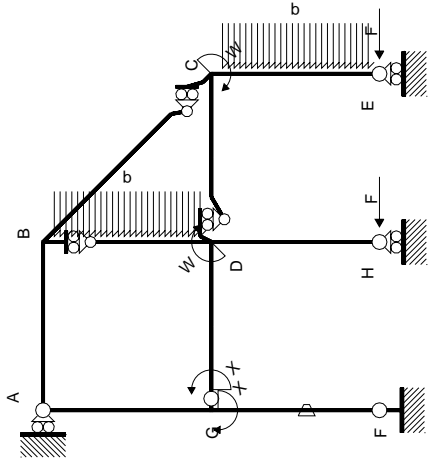


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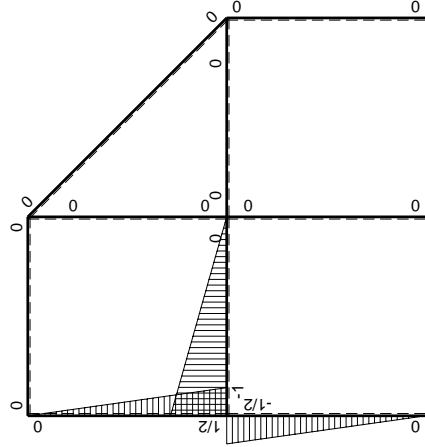


⊕ Fb



Schema di calcolo iperstatico

$M_0$  flessione da carichi assegnati



$M_1$  flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-2Fx	0	0	0	0	0+0	0
BA b	0	2Fb-2Fx	0	0	0	0	0	0
BC $\sqrt{2}b$	0	-2Fb+ $\sqrt{2}Fx$	0	0	0	0	0	0
BD b	0	-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
DB b	0	1/2Fb-Fx+1/2qx <sup>2</sup>	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	0	0
CE b	0	-3/2Fb+2Fx-1/2qx <sup>2</sup>	0	0	0	0	0+0	0
EC b	0	Fx+1/2qx <sup>2</sup>	0	0	0	0	0	0
FG b	-1/2x/b	-Fx	-Fb/EJ	1/2Fx <sup>2</sup> /b	1/2Fx/EJ	1/4x <sup>2</sup> /b <sup>2</sup>	(1/6+1/4)Fb <sup>2</sup> /EJ	1/12Xb/EJ
GF b	1/2-1/2x/b	Fb-Fx	Fb/EJ	1/2Fb-Fx+1/2Fx <sup>2</sup> /b	1/2Fb/EJ-1/2Fx/EJ	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>		
GD b	-1+x/b	-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	1-2x/b+x <sup>2</sup> /b <sup>2</sup>	(1/4+0)Fb <sup>2</sup> /EJ	1/3Xb/EJ
DG b	x/b	3/2Fb-3/2Fx	0	3/2Fx-3/2Fx <sup>2</sup> /b	0	x <sup>2</sup> /b <sup>2</sup>		
DH b	0	-Fb+Fx	0	0	0	0	0+0	0
HD b	0	Fx	0	0	0	0	0	0
GA b	1/2-1/2x/b	-Fb+Fx	0	-1/2Fb+Fx-1/2Fx <sup>2</sup> /b	0	1/4-1/2x/b+1/4x <sup>2</sup> /b <sup>2</sup>	(-1/6+0)Fb <sup>2</sup> /EJ	1/12Xb/EJ
AG b	-1/2x/b	Fx	0	-1/2Fx <sup>2</sup> /b	0	1/4x <sup>2</sup> /b <sup>2</sup>		
	totali						1/2Fb <sup>2</sup> /EJ	1/2Xb/EJ
	iperstatica $X=W_{GD}$						-Fb	

Sviluppi di calcolo iperstatica

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/6 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/6 b) Fb 1/EJ + (1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/2 - x/b + 1/2 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/2 x - 1/2 x^2/b + 1/6 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/2 b - 1/2 b + 1/6 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 5/12 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (3/2 x/b - 3/2 x^2/b^2) Fb 1/EJ dx = [3/4 x^2/b - 1/2 x^3/b^2]_0^b Fb 1/EJ$$

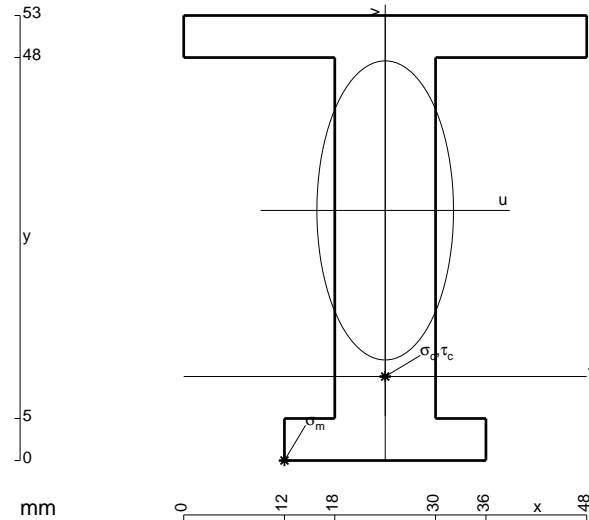
$$= (3/4 b - 1/2 b) Fb 1/EJ = 1/4 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/2 + x/b - 1/2 x^2/b^2) Fb 1/EJ dx = [-1/2 x + 1/2 x^2/b - 1/6 x^3/b^2]_0^b Fb 1/EJ$$

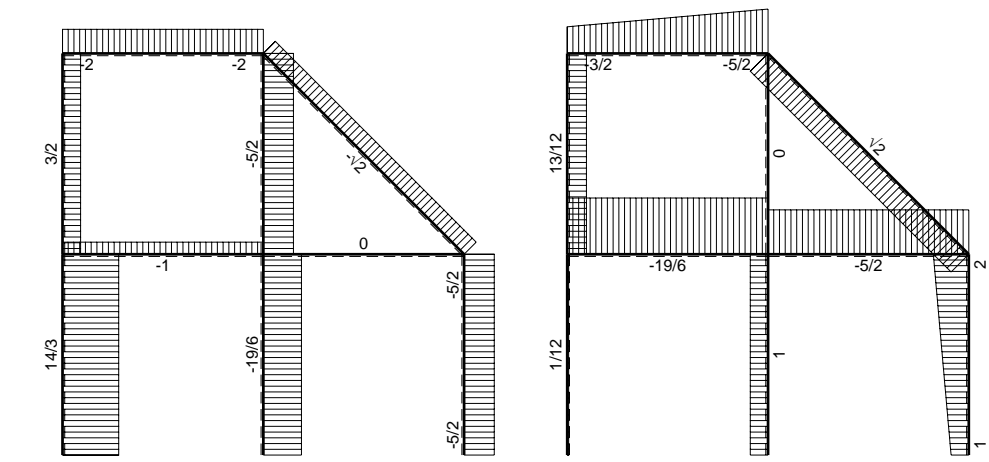
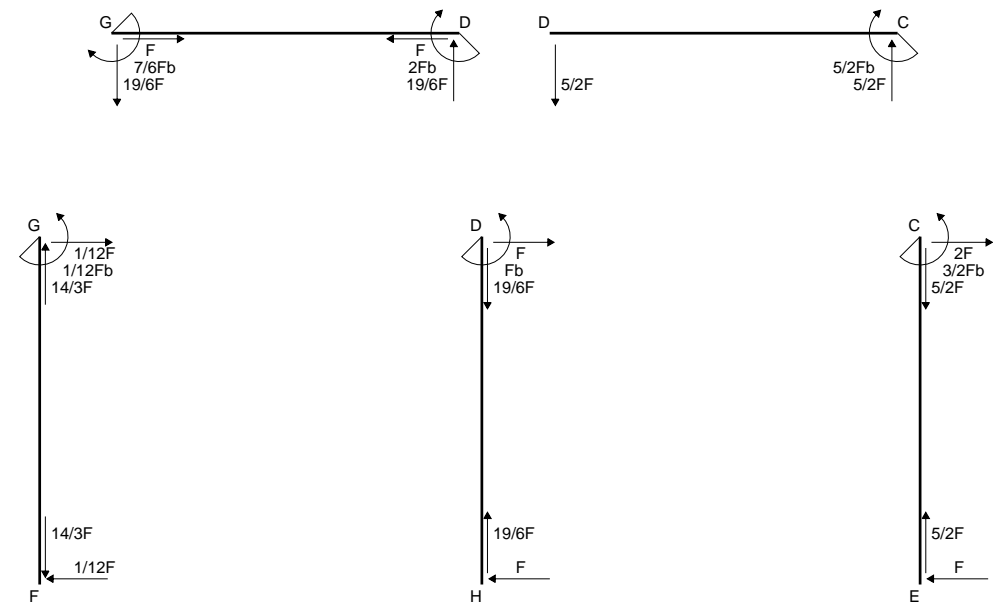
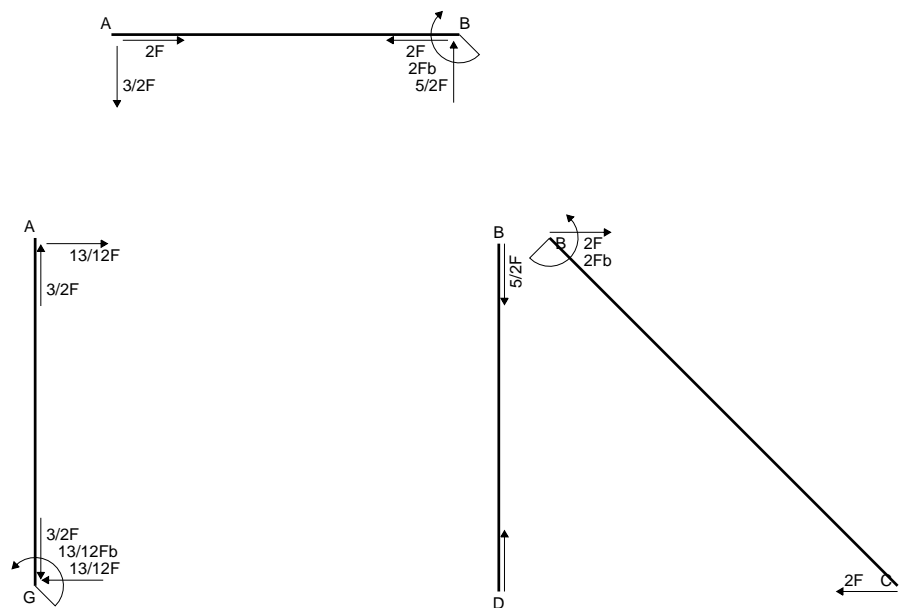
$$= (-1/2 b + 1/2 b - 1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/2 x^2/b^2) Fb 1/EJ dx = [-1/6 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/6 b) Fb 1/EJ = -1/6 Fb^2/EJ$$

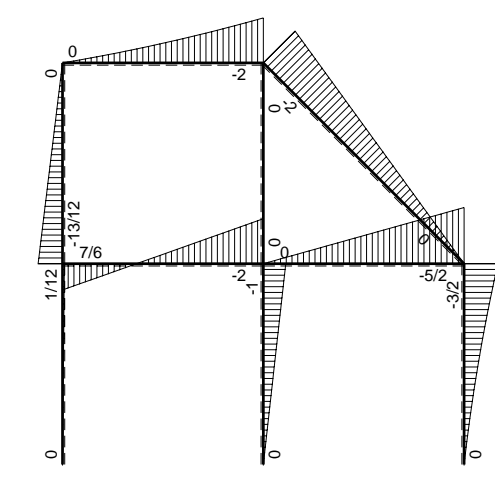


- A = 876. mm<sup>2</sup>
- J<sub>u</sub> = 278148. mm<sup>4</sup>
- J<sub>v</sub> = 58032. mm<sup>4</sup>
- y<sub>g</sub> = 29.79 mm
- T<sub>y</sub> = -3300. N
- M<sub>x</sub> = -2145000. Nmm
- x<sub>m</sub> = 12. mm
- u<sub>m</sub> = -12. mm
- v<sub>m</sub> = -29.79 mm
- σ<sub>m</sub> = -Mv/J<sub>u</sub> = -229.7 N/mm<sup>2</sup>
- x<sub>c</sub> = 24. mm
- y<sub>c</sub> = 10. mm
- v<sub>c</sub> = -19.79 mm
- σ<sub>c</sub> = -Mv/J<sub>u</sub> = -152.6 N/mm<sup>2</sup>
- τ<sub>c</sub> = 4.56 N/mm<sup>2</sup>
- σ<sub>o</sub> = √σ<sup>2</sup>+3τ<sup>2</sup> = 152.8 N/mm<sup>2</sup>
- S = 4612. mm<sup>3</sup>

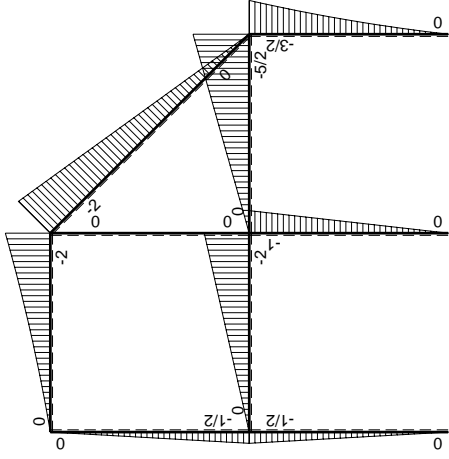
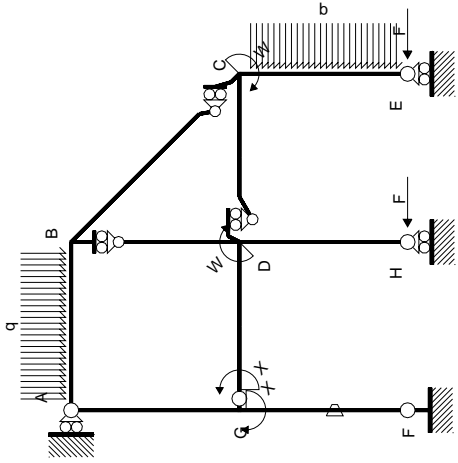


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↑ ⊕ ↓ F<sub>b</sub>

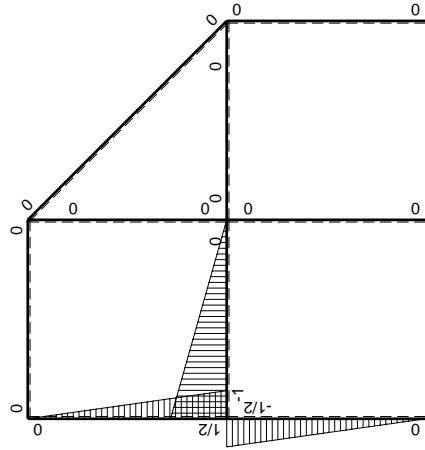


⊕ ⊖ F<sub>b</sub>



Schema di calcolo iperstatico

$M_0$ , flessione da carichi assegnati



$M_x$ , flessione da iperstatica  $X=1$

Quadro contributi PLV per iperstatica  $X=W_{GD}$ 

→	$M_x(x)$	$M_o(x)$	$\theta$	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
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

$$L_{FG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GF}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{GD}^{xx} = \int_0^b (1 - 2 x/b + x^2/b^2) 1/EJ dx = [x - x^2/b + 1/3 x^3/b^2]_0^b 1/EJ$$

$$= (b - b + 1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{DG}^{xx} = \int_0^b (x^2/b^2) 1/EJ dx = [1/3 x^3/b^2]_0^b 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{GA}^{xx} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) 1/EJ dx = [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/4 b - 1/4 b + 1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{AG}^{xx} = \int_0^b (1/4 x^2/b^2) 1/EJ dx = [1/12 x^3/b^2]_0^b 1/EJ$$

$$= (1/12 b) 1/EJ = 1/12 b/EJ$$

$$L_{FG}^{xo} = \int_0^b (1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (1/2 x/b) \theta dx = [1/12 x^3/b^2]_0^b Fb 1/EJ + [1/4 x^2/b]_0^b \theta$$

$$= (1/12 b) Fb 1/EJ + (1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GF}^{xo} = \int_0^b (1/4 - 1/2 x/b + 1/4 x^2/b^2) Fb 1/EJ dx + \int_0^b (-1/2 + 1/2 x/b) \theta dx$$

$$= [1/4 x - 1/4 x^2/b + 1/12 x^3/b^2]_0^b Fb 1/EJ + [-1/2 x + 1/4 x^2/b]_0^b \theta$$

$$= (1/4 b - 1/4 b + 1/12 b) Fb 1/EJ + (-1/2 b + 1/4 b) \theta = 1/3 Fb^2/EJ$$

$$L_{GD}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{DG}^{xo} = \int_0^b (2 x/b - 2 x^2/b^2) Fb 1/EJ dx = [x^2/b - 2/3 x^3/b^2]_0^b Fb 1/EJ$$

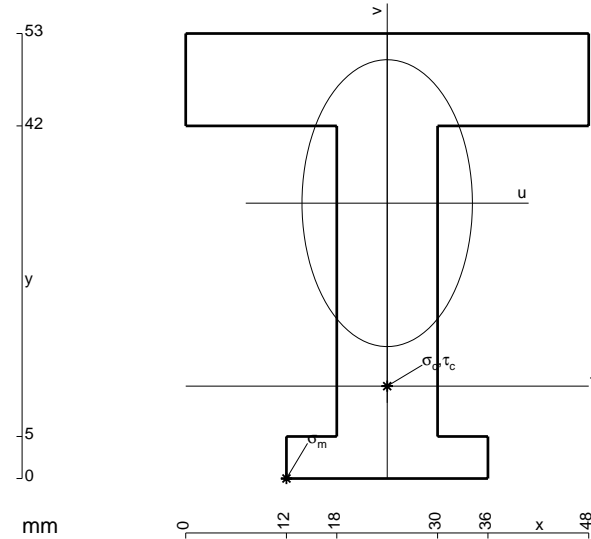
$$= (b - 2/3 b) Fb 1/EJ = 1/3 Fb^2/EJ$$

$$L_{GA}^{xo} = \int_0^b (-1/4 + 1/2 x/b - 1/4 x^2/b^2) Fb 1/EJ dx = [-1/4 x + 1/4 x^2/b - 1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/4 b + 1/4 b - 1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$

$$L_{AG}^{xo} = \int_0^b (-1/4 x^2/b^2) Fb 1/EJ dx = [-1/12 x^3/b^2]_0^b Fb 1/EJ$$

$$= (-1/12 b) Fb 1/EJ = -1/12 Fb^2/EJ$$



$A = 1092. \text{ mm}^2$   
 $J_u = 318895. \text{ mm}^4$   
 $J_v = 112464. \text{ mm}^4$   
 $y_g = 32.8 \text{ mm}$   
 $T_y = -3325. \text{ N}$   
 $M_x = -2327500. \text{ Nmm}$   
 $x_m = 12. \text{ mm}$   
 $u_m = -12. \text{ mm}$   
 $v_m = -32.8 \text{ mm}$   
 $\sigma_m = -Mv/J_u = -239.4 \text{ N/mm}^2$   
 $x_c = 24. \text{ mm}$   
 $y_c = 11. \text{ mm}$   
 $v_c = -21.8 \text{ mm}$   
 $\sigma_c = -Mv/J_u = -159.1 \text{ N/mm}^2$   
 $\tau_c = 4.71 \text{ N/mm}^2$   
 $\sigma_o = \sqrt{\sigma_c^2 + 3\tau_c^2} = 159.3 \text{ N/mm}^2$   
 $S = 5421. \text{ mm}^3$