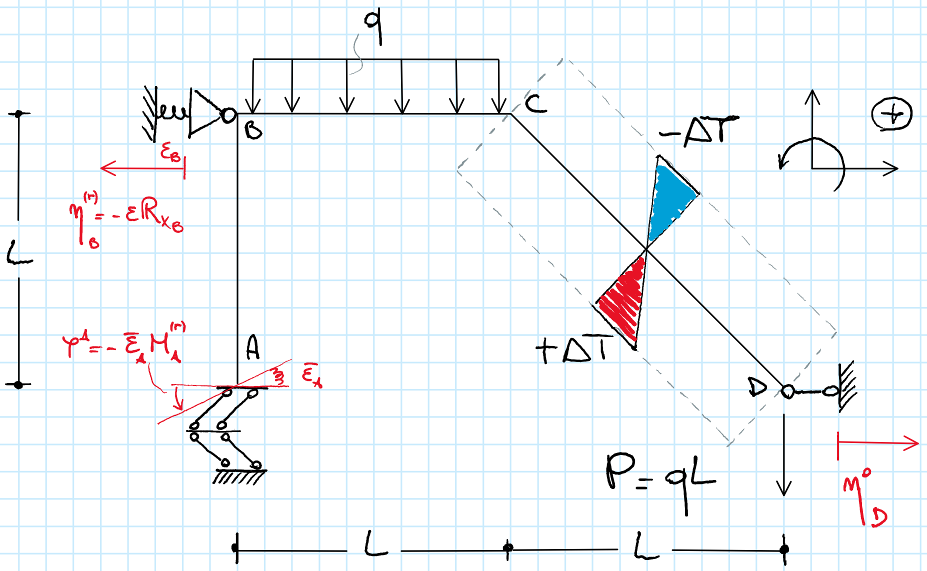
IPER 15

martedì 21 gennaio 2025 18:22

RISOLVERE LA STRUTTURA UNA VOLTA IPERSTATICA DETERMINANDO IL DIAGRAMMA DEI MOMENTI



POSIZIONI

$$|P| = qL$$

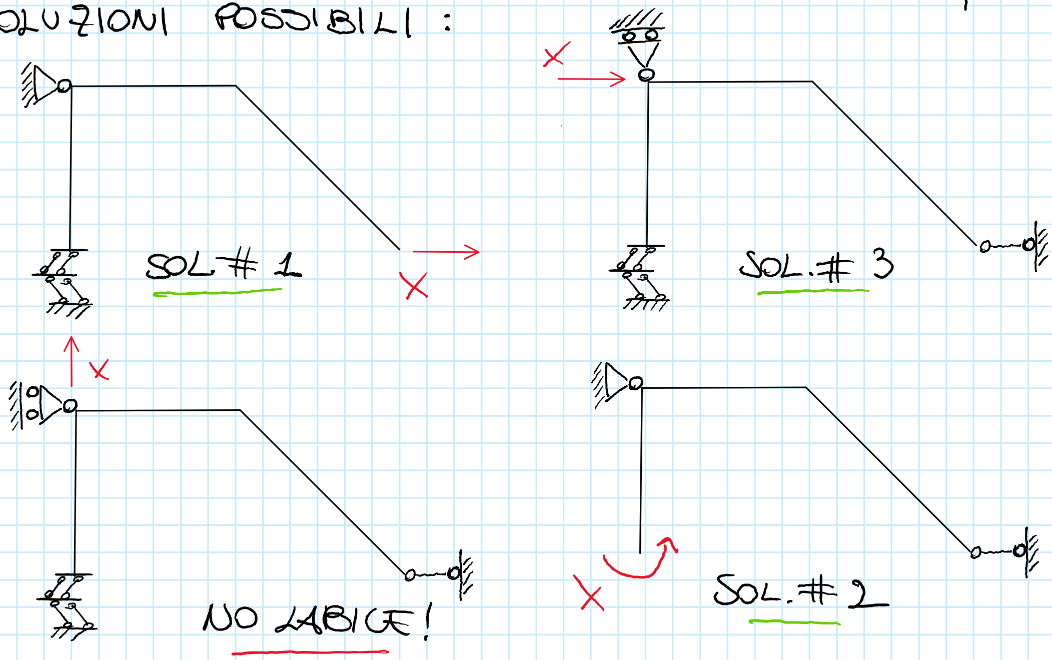
$$|\bar{\varepsilon}| = \frac{2}{5}\frac{L}{EI}$$

$$|\varepsilon_B| = \frac{3}{5}\frac{L^3}{EI}$$

$$|\eta_D^\circ| = \frac{qL^4}{EI}\left[\frac{\sqrt{2}}{3} + 2\right]$$

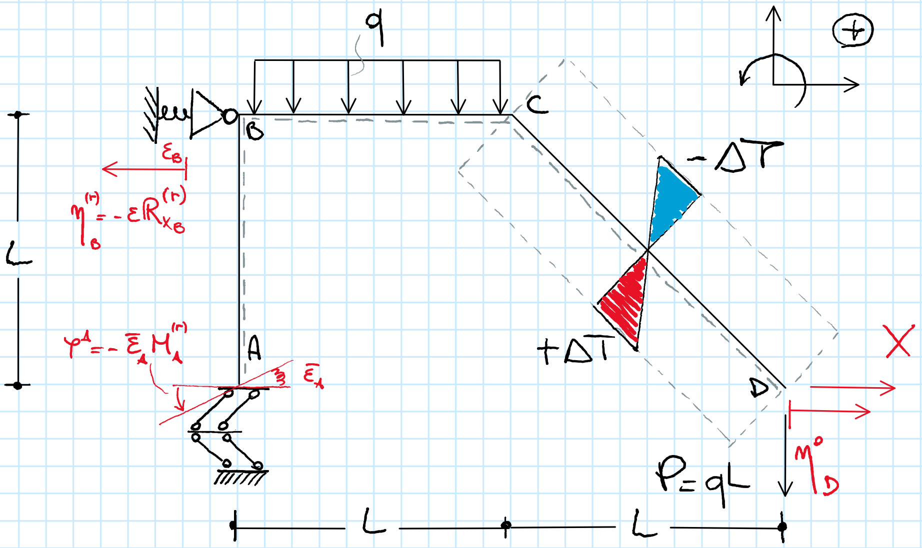
$$\left|\frac{\alpha \Delta T}{h}\right| = \frac{qL^2\sqrt{2}}{EI}\left[\frac{25}{6} + \frac{\sqrt{2}}{3}\right]$$

SOLUZIONI POSSIBILI :

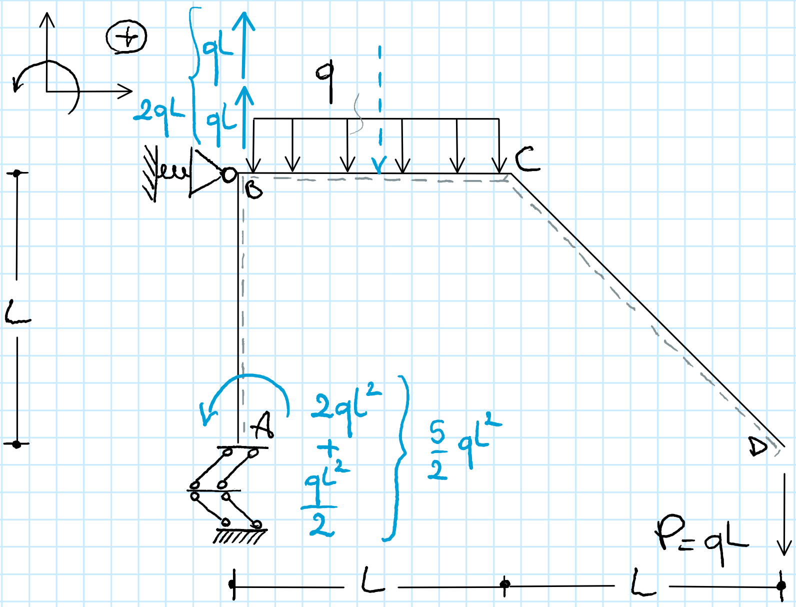


SOLUZIONE # 1

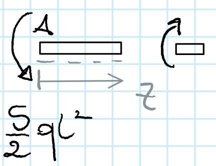
- **SISTEMA PRINCIPALE ISOSTATICO**



SCHEMA [0] SOLO CARICHI ESTERNI



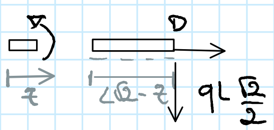
TRATTO AB $\quad 0 \leq z \leq L$



$$\boxed{M^{(0)}(z) = -\frac{5}{2}qL^2}$$

$$\begin{cases} M_A = -\frac{5}{2}qL^2 \\ M_B = -\frac{5}{2}qL^2 \end{cases}$$

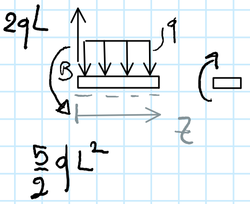
TRATTO CD $\quad 0 \leq z \leq L\sqrt{2}$



$$\boxed{M^{(0)}(z) = -qL\frac{\sqrt{2}}{2}\left(L\sqrt{2} - z\right)}$$

$$\begin{cases} M_C = -qL^2 \\ M_D = \emptyset \end{cases}$$

TRATTO BC $0 \le z \le L$



$$\boxed{M^{(0)}(z) = -\frac{5}{2}qL^2 + 2qLz - \frac{qz^2}{2}}$$

$$\begin{cases} M_B = -\frac{5}{2}qL^2 \\ M_C = -qL^2 \end{cases}$$

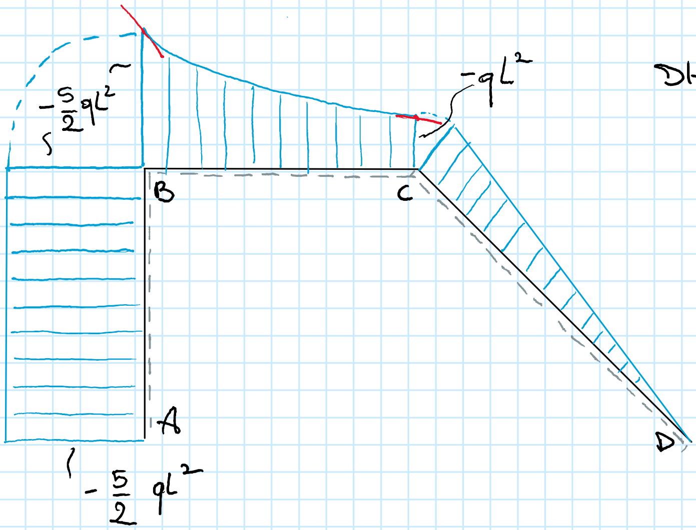
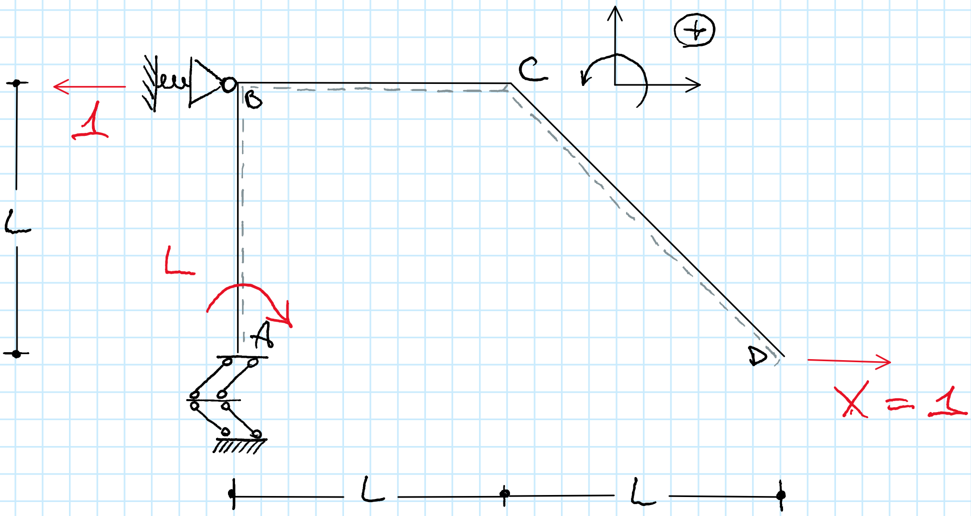
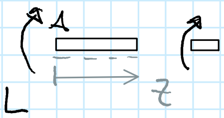


DIAGRAMMA $M^{(0)}(z)$

• SCHEMA [1] SOLO $X = 1$

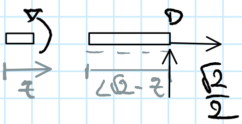


TRATTO AB $0 \le z \le L$



$$\boxed{M^{(1)}(z) = L}$$ cost.

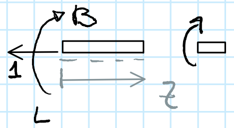
TRATTO CD $0 \le z \le L\sqrt{2}$



$$\boxed{M^{(1)}(z) = \frac{\sqrt{2}}{2}\left[L\sqrt{2} - z\right]}$$

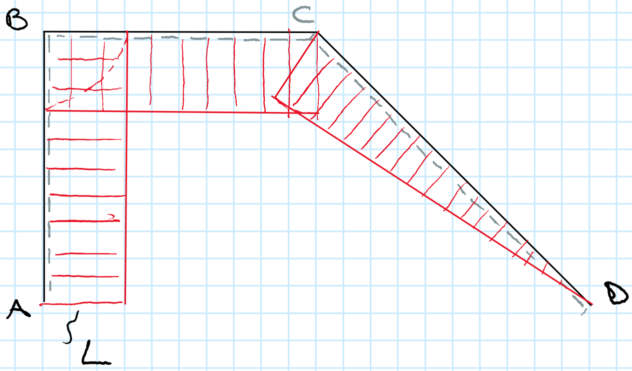
$$\begin{cases} M_C = L \\ M_D = 0 \end{cases}$$

TRATTO BC $0 \le z \le L$



$$\boxed{M^{(1)}(z) = L} \quad \text{cost.}$$

DIAGRAMMA $M^{(1)}(z)$



$$\underbrace{\mathcal{L}_{ve}} = 1 \cdot \eta_i^{(r)} + \sum_j R_j^{(1)} \cdot \eta_j^{(r)} = 1 \cdot \eta_D^{o} + M_A^{(1)} \cdot \varphi_A^{(r)} + R_{X_B}^{(1)} \cdot \eta_B^{(r)} =$$

$$= \eta_D^{o} - L\left[-\bar{\varepsilon}\, \underbrace{M_A^{(r)}}\right] - 1\left[-\varepsilon_B \underbrace{R_{X_B}^{(r)}}\right] =$$

$$\hookrightarrow \underbrace{M_A^{(0)}}_{\frac{5}{2}ql^2} + X_1 \underbrace{M_A^{(1)}}_{-L} \qquad \hookrightarrow \underbrace{R_{X_B}^{(0)}}_{\emptyset} + X \underbrace{R_{X_B}^{(1)}}_{-1}$$

$$= \underbrace{\eta_D^{o} + \bar{\varepsilon}\left[\frac{5}{2}qL^3 - XL^2\right] - \varepsilon_B X}$$

$$\underbrace{\mathcal{L}_{Vi}} = \int_{Str} M^{(1)} \frac{M^{(r)}}{EI} dStr + \int_{Str} M^{(1)} \frac{\alpha \overline{\Delta T}}{h} dStr =$$

$$M^{(r)} \rightarrow M^{(0)} + M^{(1)} X$$

$$= \frac{1}{EI}\int_{Str} M^{(1)} M^{(0)} dStr + \frac{X}{EI}\int_{Str} \left[M^{(1)}\right]^2 dStr + \int_{Str} M^{(1)} \frac{\alpha \overline{\Delta T}}{h} dStr =$$

$$= \frac{1}{EI}\left\{\int_{\overline{AB}} M^{(1)} M^{(0)} dz + \int_{\overline{BC}} M^{(1)} M^{(0)} dz + \int_{\overline{CD}} M^{(1)} M^{(0)} dz\right\} +$$

$$+ \frac{X}{EI}\left\{\int_{\overline{AB}} \left[M^{(1)}\right]^2 dz + \int_{\overline{BC}} \left[M^{(1)}\right]^2 dz + \int_{\overline{CD}} \left[M^{(1)}\right]^2 dz\right\} + \int_{\overline{CD}} M^{(1)} \frac{\alpha \overline{\Delta T}}{h} dz =$$

$$= \frac{1}{EI}\left\{\int_0^L L\left[-\frac{5}{2}qL^2\right]dz + \int_0^L L\left[-\frac{5}{2}qL^2 + 2qLz - q\frac{z^2}{2}\right] +\right.$$

$$\left. + \int_0^{L\sqrt{2}} \frac{\sqrt{2}}{2}\left[L\sqrt{2} - z\right]\left[-qL\frac{\sqrt{2}}{2}\left(L\sqrt{2}-z\right)\right]dz\right\} + \frac{X}{EI}\left\{\int_0^L L^2 dz + \right.$$

$$\left. + \int_0^L L^2 dz + \int_0^{L\sqrt{2}} \frac{2}{4}\left[L\sqrt{2}-z\right]^2 dz\right\} + \alpha\frac{\Delta T}{h}\int_0^{L\sqrt{2}} \frac{\sqrt{2}}{2}\left[L\sqrt{2}-z\right]dz =$$

$$+ \frac{1}{EI}\left\{-\frac{5}{2}qL^3\left[z\right]_0^L - \frac{5}{2}qL^3\left[z\right]_0^L + 2qL^2\left[\frac{z^2}{2}\right]_0^L - \frac{qL}{2}\left[\frac{z^3}{3}\right]_0^L - qL^3\left[z\right]_0^{L\sqrt{2}} + \right.$$

$$\left. + qL^2\frac{\sqrt{2}}{2}\left[\frac{z^2}{2}\right]_0^{L\sqrt{2}} + qL^2\frac{\sqrt{2}}{2}\left[\frac{z^2}{2}\right]_0^{L\sqrt{2}} - \frac{qL}{2}\left[\frac{z^3}{3}\right]_0^{L\sqrt{2}}\right\} + \frac{X}{EI}\left\{L^2\left[z\right]_0^L + \right.$$

$$\left. + L^2\left[z\right]_0^L + L^2\left[z\right]_0^{L\sqrt{2}} + \frac{1}{2}\left[\frac{z^3}{3}\right]_0^{L\sqrt{2}} - L\sqrt{2}\left[\frac{z^2}{2}\right]_0^{L\sqrt{2}}\right\} +$$

$$+ \alpha\frac{\Delta T}{h}\left\{L\left[z\right]_0^{L\sqrt{2}} - \frac{\sqrt{2}}{2}\left[\frac{z^2}{2}\right]_0^{L\sqrt{2}}\right\} =$$

$$= \frac{1}{EI}\left\{-5qL^4 + qL^4 - \frac{qL^4}{6} - qL^4\sqrt{2} + \frac{qL^2\sqrt{2}}{4}(2L^2) + qL^2\frac{\sqrt{2}}{4}2L^2 - \frac{qL}{6}L^3 2\sqrt{2}\right\} +$$

$$+ \frac{X}{EI}\left\{2L^3 + L^3\sqrt{2} + \frac{1}{6}L^3 \cdot 2\sqrt{2} - L\frac{\sqrt{2}}{2}\cdot 2L^2\right\} + \alpha\frac{\Delta T}{h}\left\{L^2\sqrt{2} - \frac{\sqrt{2}}{4}L^2 2\right\} =$$

$$= \frac{1}{EI}\left\{-4qL^4 - \frac{1}{6}qL^4 - \frac{qL^4}{3}\sqrt{2}\right\} + \frac{X}{EI}\left\{2L^3 + \frac{L^3\sqrt{2}}{3}\right\} + \frac{\alpha\Delta T}{h}\frac{L^2\sqrt{2}}{2} =$$

$$= \frac{1}{EI}\left\{-\frac{25}{6}qL^4 - \frac{qL^4}{3}\sqrt{2}\right\} + \frac{X}{EI}\left\{2L^3 + \frac{L^3\sqrt{2}}{3}\right\} + \frac{\alpha\Delta T}{h}\frac{L^2\sqrt{2}}{2}$$

$\mathcal{L}_{ve} = \mathcal{L}_{vi}$ fornisce

$$\eta_B^\circ + \bar{\varepsilon} \cdot \frac{5}{2} qL^3 - \bar{\varepsilon} L^2 X - \varepsilon_B X = -\frac{qL^4}{EI}\left[+\frac{25}{6}+\frac{\sqrt{2}}{3}\right] + \frac{XL^3}{EI}\left[2+\frac{\sqrt{2}}{3}\right] + \frac{\alpha \Delta T}{h} \frac{L^2\sqrt{2}}{2}$$

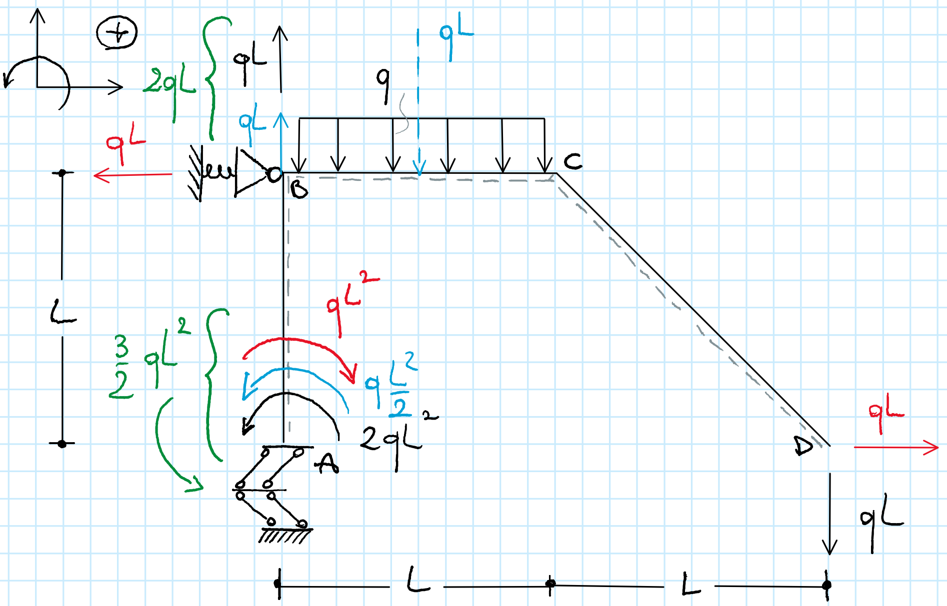
$$X\left\{\frac{L^3}{EI}\left(2+\frac{\sqrt{2}}{3}\right) + \underbrace{\bar{\varepsilon} L^2}_{\frac{2}{3}\frac{L}{EI}} + \underbrace{\varepsilon_B}_{\frac{3}{5}\frac{L^3}{EI}}\right\} = \underbrace{\eta_B^\circ}_{\frac{qL^4}{EI}\left[\frac{\sqrt{2}}{3}+2\right]} + \bar{\varepsilon}\,\frac{5}{2} qL^3 + \cancel{\frac{qL^4}{EI}\left[\frac{25}{6}+\frac{\sqrt{2}}{3}\right]} - \cancel{\underbrace{\frac{\alpha \Delta T}{h}}_{\frac{qL^2}{EI}\frac{\sqrt{2}}{3}\left[\frac{25}{6}+\frac{\sqrt{2}}{3}\right]} \frac{L^2\sqrt{2}}{2}}$$

$$X\left\{\frac{L^3}{EI}\left(2+\frac{\sqrt{2}}{3}\right) + \frac{L^3}{EI}\right\} = \frac{qL^4}{EI}\left\{\frac{\sqrt{2}}{3}+2\right\} + \frac{2}{5}\frac{L}{EI}\frac{5}{2}qL^3$$

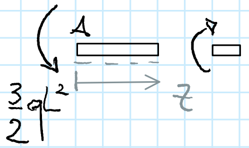
$$X\cancel{\left\{\frac{L^3}{EI}\left(2+\frac{\sqrt{2}}{3}\right) + \frac{L^3}{EI}\right\}} = qL\cancel{\left\{\frac{L^3}{EI}\left(2+\frac{\sqrt{2}}{3}\right) + \frac{L^3}{EI}\right\}}$$

$X = qL$ POSITIVA

SOLUZIONE SISTEMA PRINCIPALE ISOSTATICO

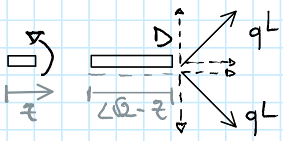


TRATTO AB $0 \le z \le L$



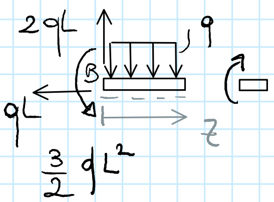
$$\boxed{M^{(r)}(z) = -\frac{3}{2} qL^2}$$ cost.

TRATTO CD $0 \le z \le L\sqrt{2}$



$$\boxed{M^{(r)}(z) = \emptyset}$$

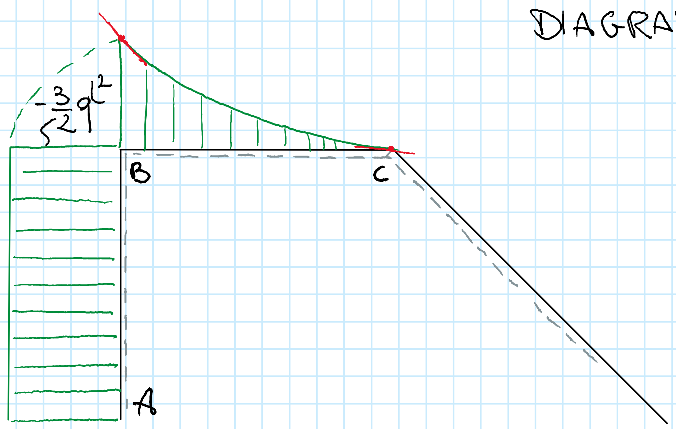
TRATTO BC $0 \le z \le L$



$$\boxed{M^{(r)}(z) = 2qLz - \frac{qz^2}{2} - \frac{3}{2} qL^2}$$

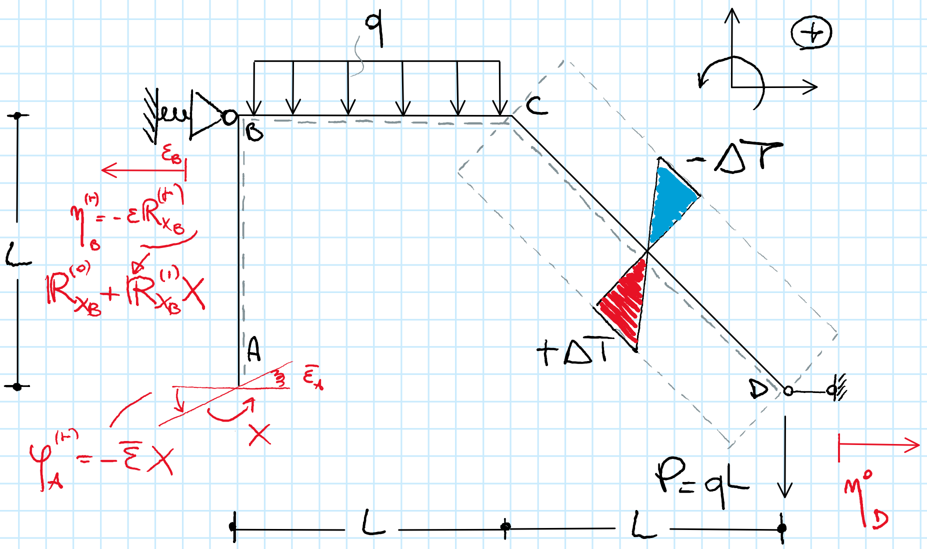
$$\begin{cases} M_B = -\frac{3}{2} qL^2 \\ M_C = \emptyset \end{cases}$$

DIAGRAMMA FINALE $M^{(r)}(z)$

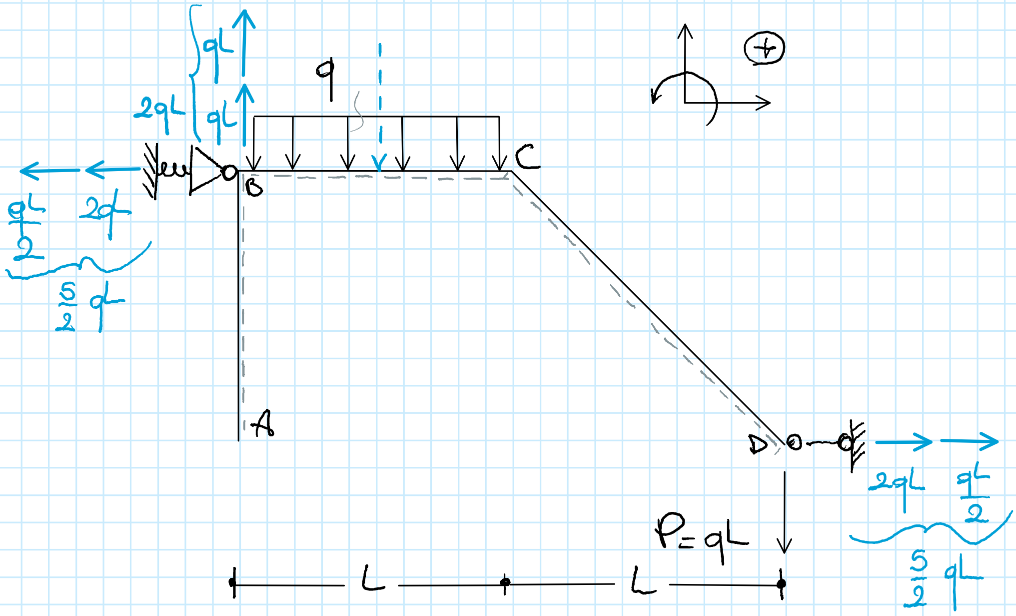


SOLUZIONE #2

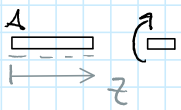
• SISTEMA PRINCIPALE ISOSTATICO



SCHEMA [0] SOLO CARICHI ESTERNI



TRATTO AB $0 \le z \le L$



$$\boxed{M^{(0)}(z) = \emptyset}$$

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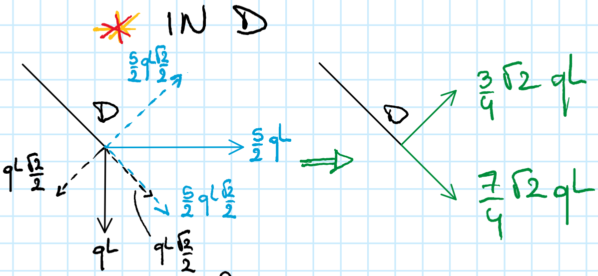
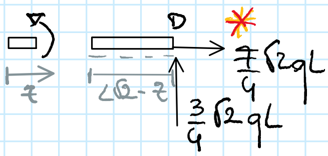


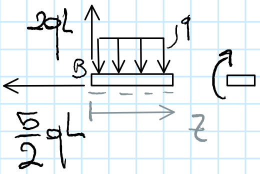
TRATTO CD $0 \le z \le L\sqrt{2}$



$$\boxed{M^{(0)}(z) = \frac{3}{4}\sqrt{2}\,qL\,(\sqrt{2}L - z)}$$

$$\begin{cases} M_C = \frac{3}{2}qL^2 \\ M_D = \emptyset \end{cases}$$

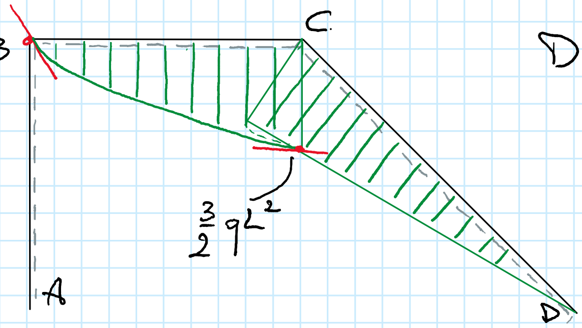
TRATTO BC $0 \leq z \leq L$



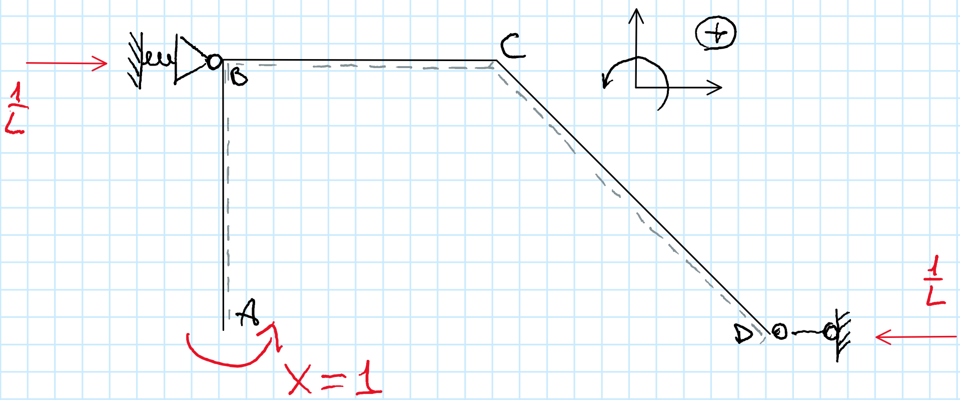
$$\boxed{M^{(0)}(z) = 2qLz - q\frac{z^2}{2}}$$

$$\begin{cases} M_B = 0 \\ M_C = \frac{3}{2}qL^2 \end{cases}$$

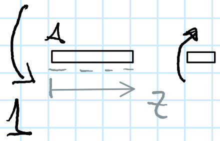
DIAGRAMMA $M^{(0)}(z)$



- SCHEMA [1] SOLO $X = 1$

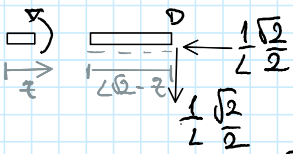


TRATTO AB $0 \leq z \leq L$



$$\boxed{M^{(1)}(z) = -1} \quad \text{cost.}$$

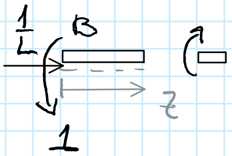
TRATTO CD $0 \leq z \leq L\sqrt{2}$



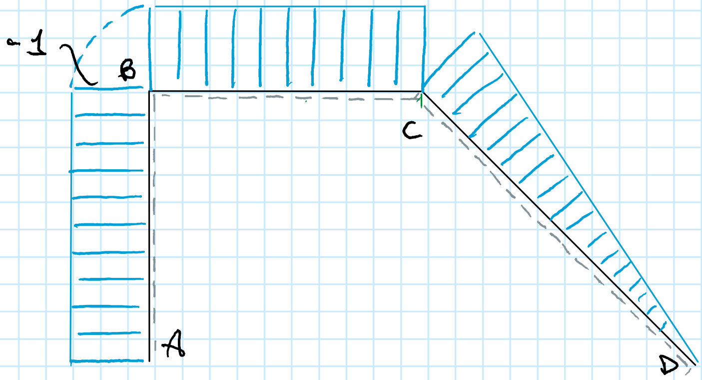
$$\boxed{M^{(1)}(z) = -\frac{\sqrt{2}}{2L}(\sqrt{2}L - z)}$$

$$\begin{cases} M_C = -1 \\ M_D = \emptyset \end{cases}$$

TRATTO BC $0 \leq z \leq L$



$$\boxed{M^{(1)}(z) = -1} \quad \text{cost.}$$



$$\underline{d_{ve}} = 1\cdot\left(-\bar{\varepsilon}X\right) + \frac{1}{L}\left(-\varepsilon\left(-\frac{5}{2}qL+\frac{1}{L}X\right)\right) + \left(-\frac{1}{L}M_D^{0}\right) =$$

$$= \underbrace{-\bar{\varepsilon}X - \frac{\varepsilon}{L}\left[\frac{X}{L}-\frac{5}{2}qL\right] - \frac{M_D^{0}}{L}}$$

$$\underline{d_{vi}} = \int_{Str} M^{(1)}\frac{\overbrace{M^{(r)}}^{M^{(0)}+M^{(1)}X}}{EI}\,dStr + \int_{Str} M^{(1)}\,\alpha\frac{\overline{\Delta T}}{h}\,dStr =$$

$$= \frac{1}{EI}\left\{\int_{\overline{AB}} M^{(1)}M^{(0)}\,dz + \int_{\overline{BC}} M^{(1)}M^{(0)}\,dz + \int_{\overline{CD}} M^{(1)}M^{(0)}\,dz\right\} +$$

$$+\frac{X}{EI}\left\{\int_{\overline{AB}}\left[M^{(1)}\right]^2 dz + \int_{\overline{BC}}\left[M^{(1)}\right]^2 dz + \int_{\overline{CD}}\left[M^{(1)}\right]^2 dz\right\} + \int_{CD} M^{(1)}\frac{\alpha\overline{\Delta T}}{h}\,dz =$$

$$= \frac{1}{EI}\left\{\int_0^L (-1)\cdot 0\,dz + \int_0^L (-1)\left(2qLz - q\frac{z^2}{2}\right)dz + \int_0^{\sqrt{2}L}\left(-\frac{\sqrt{2}}{2L}\left(\sqrt{2}L-z\right)\right)\left(\frac{3}{4}\sqrt{2}qL\left(\sqrt{2}L-z\right)\right)dz\right\} +$$

$$+\frac{X}{EI}\left\{\int_0^L (-1)^2\,dz + \int_0^L (-1)^2\,dz + \int_0^{\sqrt{2}L}\Big[\underbrace{-\frac{\sqrt{2}}{2L}\left(\sqrt{2}L-z\right)}_{+1+\frac{z^2}{2L^2}-\frac{\sqrt{2}}{L}z}\Big]^2 dz\right\} + \int_0^{\sqrt{2}L}\underbrace{\left(-\frac{\sqrt{2}}{2L}\left(\sqrt{2}L-z\right)\right)}_{-1+\frac{\sqrt{2}}{2L}z}\cdot\frac{\alpha\overline{\Delta T}}{h}\,dz =$$

$$= \frac{1}{EI}\left\{\int_0^L -2qLz + q\frac{z^2}{2} + \int_0^{\sqrt{2}L}\left(-1+\frac{\sqrt{2}}{2L}z\right)\left(\frac{3}{2}qL^2 - \frac{3}{4}\sqrt{2}qLz\right)dz\right. +$$

$$\left.+\frac{X}{EI}\left\{\left[z\right]_0^L + \left[z\right]_0^L + \left[z\right]_0^{\sqrt{2}L} + \frac{1}{2L^2}\left[\frac{z^3}{3}\right] - \frac{\sqrt{2}}{L}\left[\frac{z^2}{2}\right]^{\sqrt{2}L}\right\} + \frac{\alpha\overline{\Delta T}}{h}\left\{-\left[z\right]_0^{\sqrt{2}L} + \frac{\sqrt{2}}{2L}\left[\frac{z^2}{2}\right]_0^{\sqrt{2}L}\right\} =$$

$$= \frac{1}{EI}\left\{-2qL\left[\frac{z^2}{2}\right]_0^L + \frac{q}{2}\left[\frac{z^3}{3}\right]_0^L - \frac{3}{2}qL^2\left[z\right]_0^{\sqrt{2}L} + \frac{3}{4}\sqrt{2}qL\left[\frac{z^2}{2}\right]_0^{\sqrt{2}L} + \frac{3}{4}\sqrt{2}qL\left[\frac{z^2}{2}\right]_0^{\sqrt{2}L} +\right.$$

$$-\frac{3}{4}q\left[\frac{z^3}{3}\right]_0^{\sqrt{2}L}\Bigg\} + \frac{X}{EI}\Bigg\{L+L+\sqrt{2}L+\frac{\sqrt{2}L}{3}-\sqrt{2}L\Bigg\} + \frac{\alpha\overline{\Delta T}}{h}\Bigg\{-\sqrt{2}L+\frac{\sqrt{2}}{2}L\Bigg\} =$$

$$= \frac{1}{EI}\Bigg\{-qL^3+\frac{qL^3}{6}-\frac{3}{2}\sqrt{2}qL^3+\frac{3}{4}\sqrt{2}qL^3+\frac{3}{4}\sqrt{2}qL^3-\frac{\sqrt{2}}{2}qL^3\Bigg\}+$$

$$+\frac{X}{EI}\Bigg\{2L+\frac{\sqrt{2}L}{3}\Bigg\}+\frac{\alpha\overline{\Delta T}}{h}\Bigg\{-\frac{\sqrt{2}}{2}L\Bigg\}=$$

$$=\underbrace{\frac{1}{EI}\left[-\frac{5}{6}qL^3-\frac{\sqrt{2}}{2}qL^3\right]+\frac{X}{EI}\left[2L+\frac{\sqrt{2}L}{3}\right]-\frac{\sqrt{2}L}{2}\frac{\alpha\overline{\Delta T}}{h}}$$

$\mathcal{L}_{ve} = \mathcal{L}_{vi}$ fornisce

$$-\varepsilon X - \frac{\varepsilon}{L^2}X + \frac{5}{2}\varepsilon q - \frac{M_D^0}{L} = \frac{2XL}{EI} - \frac{5}{6}\frac{qL^3}{EI} - \frac{\sqrt{2}}{2}\frac{qL^3}{EI} + \frac{X}{EI}\frac{\sqrt{2}L}{3} - \frac{\sqrt{2}L}{2}\frac{\alpha\overline{\Delta T}}{h}$$

$$-\frac{2}{5}\frac{L}{EI}X - \frac{3}{5}\frac{L^{\cancel{3}}}{EI}\frac{X}{\cancel{L^2}} + \frac{\cancel{5}q}{2}\frac{3}{\cancel{5}}\frac{L^3}{EI} - \frac{qL^3}{EI}\left[\frac{\sqrt{2}}{3}+2\right] = \frac{2XL}{EI} - \frac{5}{6}\frac{qL^3}{EI} - \frac{\sqrt{2}}{2}\frac{qL^3}{EI} +$$

$$+\frac{X}{EI}\frac{\sqrt{2}L}{3} - \frac{\cancel{\sqrt{2}}L}{\cancel{2}}\, qL^2\frac{\sqrt{2}}{EI}\left[\frac{25}{6}+\frac{\sqrt{2}}{3}\right]$$

$$-\frac{XL}{EI}\left(3+\frac{\sqrt{2}}{3}\right) = -\frac{3}{2}\frac{qL^3}{EI} + \frac{qL^3}{EI}\left(\frac{\sqrt{2}}{3}+2\right) - \frac{5}{6}\frac{qL^3}{EI} - \frac{\sqrt{2}}{2}\frac{qL^3}{EI} - \frac{qL^3}{EI}\left(\frac{25}{6}+\frac{\sqrt{2}}{3}\right)$$

$$\frac{-9+12-5-25}{6} = \frac{-\cancel{27}^{\,9}}{\cancel{6}_{\,2}}$$

$$-\frac{XL}{EI}\left(3+\frac{\sqrt{2}}{3}\right) = -\frac{9}{2}\frac{qL^3}{EI} - \frac{\sqrt{2}}{2}\frac{qL^3}{EI}$$

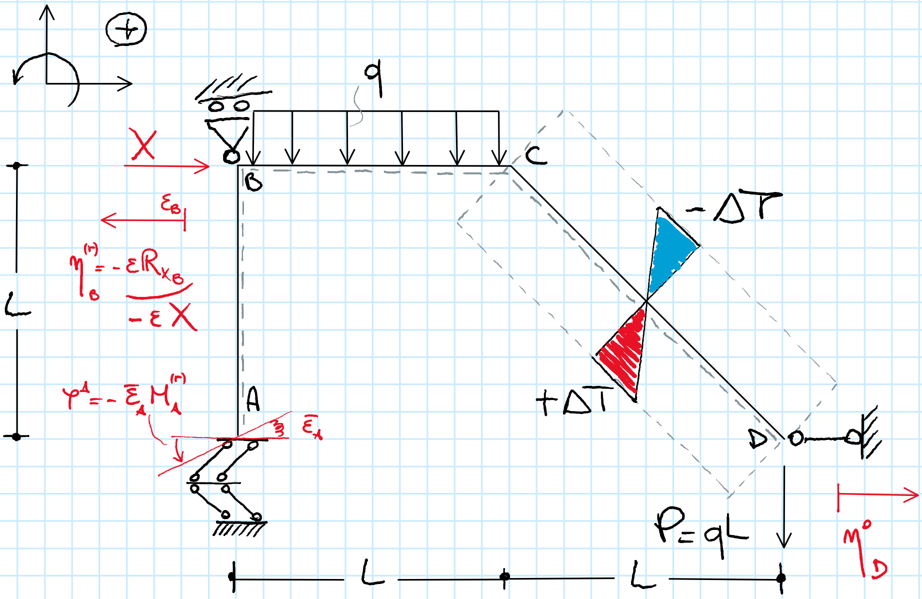
$$+X\left(3+\frac{\sqrt{2}}{3}\right) = \frac{qL^2}{2}\left(9+\sqrt{2}\right)$$

$$+\frac{X}{3}\left(9+\sqrt{2}\right) = \frac{qL^2}{2}\left(9+\sqrt{2}\right)$$

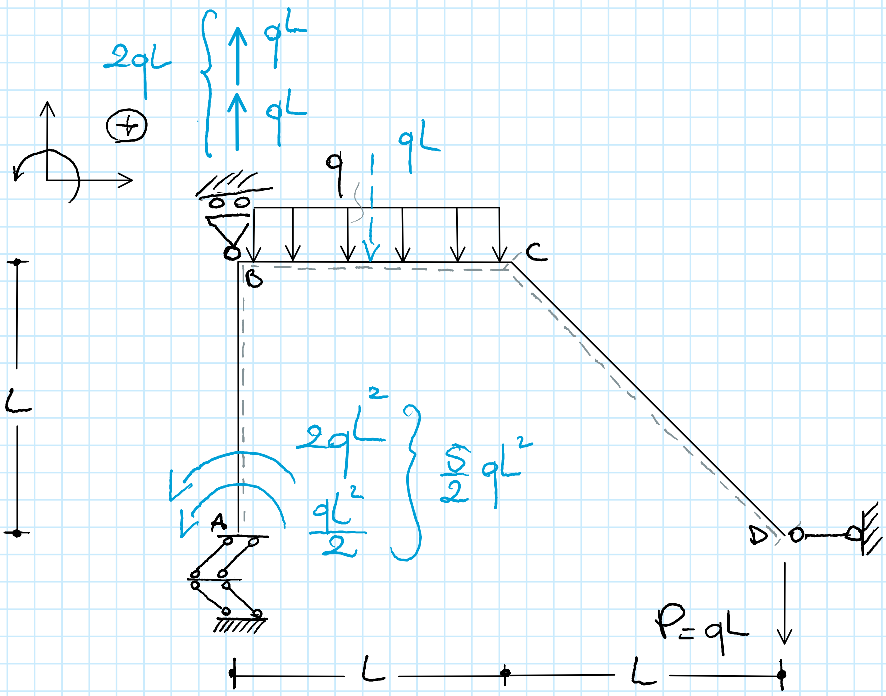
$$X = \frac{3}{2}qL^2$$

SOLUZIONE # 3

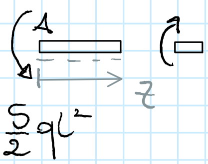
- SISTEMA PRINCIPALE ISOSTATICO



SCHEMA [0] SOLO CARICHI ESTERNI



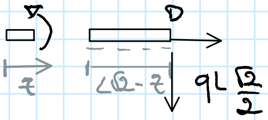
TRATTO AB $0 \leq z \leq L$



$$\boxed{M^{(0)}(z) = -\frac{5}{2}qL^2}$$

$$\begin{cases} M_A = -\frac{5}{2}qL^2 \\ M_B = -\frac{5}{2}qL^2 \end{cases}$$

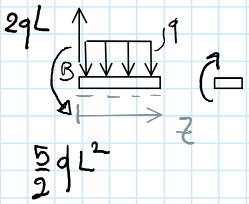
TRATTO CD $0 \le z \le L\sqrt{2}$



$$\boxed{M^{(0)}(z) = -qL\frac{\sqrt{2}}{2}\left(L\sqrt{2}-z\right)}$$

$$\begin{cases} M_C = -qL^2 \\ M_D = \emptyset \end{cases}$$

TRATTO BC $0 \le z \le L$



$$\boxed{M^{(0)}(z) = -\frac{5}{2}qL^2 + 2qLz - \frac{qz^2}{2}}$$

$$\begin{cases} M_B = -\frac{5}{2}qL^2 \\ M_C = -qL^2 \end{cases}$$

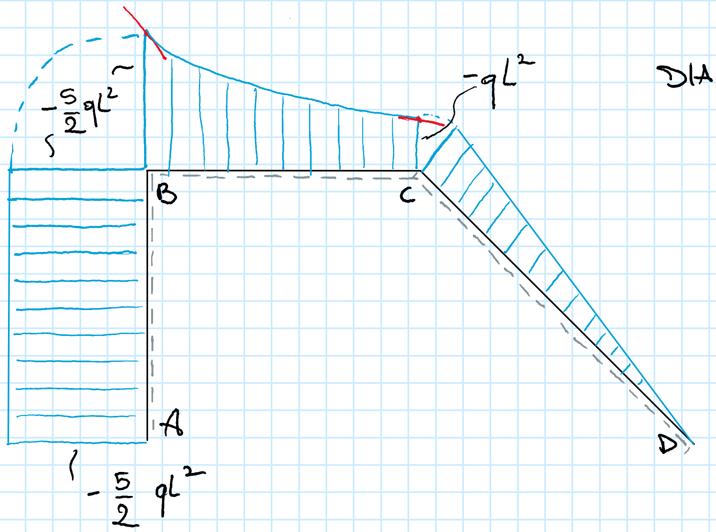
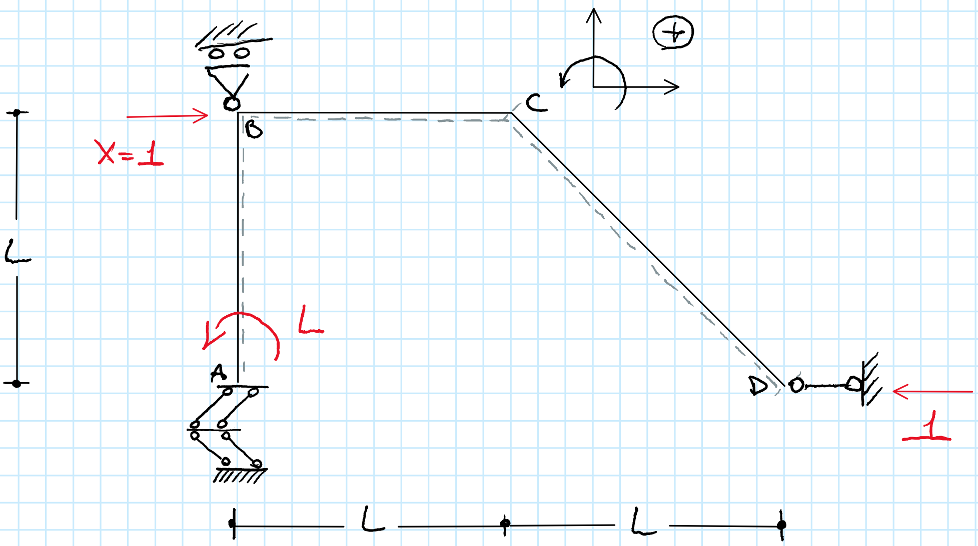
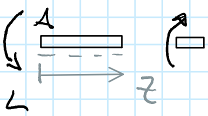


DIAGRAMMA $M^{(0)}(z)$

• SCHEMA [1] SOLO $X=1$

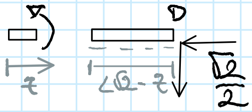


TRATTO AB $0 \le z \le L$



$$\boxed{M^{(1)}(z) = -L}$$ cost.

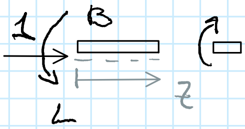
TRATTO CD $0 \le z \le L\sqrt{2}$



$$\boxed{M^{(1)}(z) = -\frac{\sqrt{2}}{2}\left[L\sqrt{2} - z\right]}$$

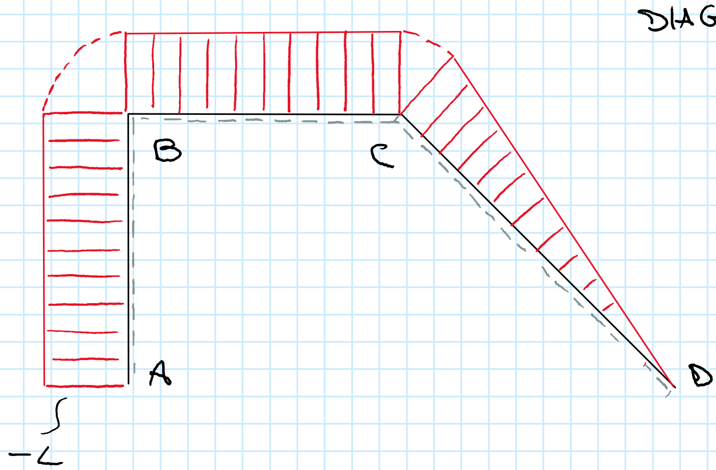
$$\begin{cases} M_C = -L \\ M_D = \emptyset \end{cases}$$

TRATTO BC $0 \le z \le L$



$$\boxed{M^{(1)}(z) = -L} \quad \text{cost.}$$

DIAGRAMMA $M^{(1)}(z)$



$$\underset{\smile}{L_{ve}} = 1 \cdot \eta_i^{(r)} + \sum_j R_j^{(1)} \cdot \eta_j^{(r)} = 1 \cdot \eta_B^{(r)} + M_A^{(1)} \cdot \varphi_A^{(r)} + R_{X_D}^{(1)} \cdot \eta_D^{\circ} =$$

$$= 1 \cdot -\varepsilon X + L\left[-\varepsilon M_A^{(r)}\right] - 1 \cdot \eta_D^{\circ} =$$

$$M_A^{(r)} \rightarrow \underbrace{M_A^{(0)}}_{\frac{5}{2}qL^2} + X \underbrace{M_A^{(1)}}_{L}$$

$$= \underbrace{-\varepsilon X - \varepsilon L\left[\frac{5}{2}qL^2 + XL\right] - \eta_D^{\circ}}\, =$$

$$\underset{\smile}{L_{vi}} = \int_{Str} M^{(1)} \frac{M^{(r)}}{EI}\, dStr + \int_{Str} M^{(1)} \frac{\alpha \Delta T}{h}\, dStr =$$

$$M^{(r)} \rightarrow M^{(0)} + M^{(1)} X$$

$$= \frac{1}{EI}\int_{Str} M^{(1)} M^{(0)}\, dStr + \frac{X}{EI}\int_{Str} \left[M^{(1)}\right]^2 dStr + \int_{Str} M^{(1)} \frac{\alpha \Delta T}{h}\, dStr =$$

$$= \frac{1}{EI}\left\{\int_{\overline{AB}} M^{(1)} M^{(0)}\, dz + \int_{\overline{BC}} M^{(1)} M^{(0)}\, dz + \int_{\overline{CD}} M^{(1)} M^{(0)}\, dz\right\} +$$

$$+\frac{X}{EI}\left\{\int_{\overline{AB}}\left[\tilde{M}^{(1)}\right]^2 dz+\int_{\overline{BC}}\left[\tilde{M}^{(1)}\right]^2 dz+\int_{\overline{CD}}\left[\tilde{M}^{(1)}\right]^2 dz\right\}+\int_{\overline{CD}} \tilde{M}^{(1)}\frac{\alpha\overline{\Delta T}}{h}\,dz=$$

$$=\frac{1}{EI}\left\{\int_0^L -L\left[-\frac{5}{2}qL^2\right]dz+\int_0^L -L\left[-\frac{5}{2}qL^2+2qLz-\frac{qz^2}{2}\right]+\right.$$

$$\left.+\int_0^{\sqrt{2}L}-\frac{\sqrt{2}}{2}\left[L\sqrt{2}-z\right]\left[-qL\frac{\sqrt{2}}{2}\left(L\sqrt{2}-z\right)\right]dz\right\}+\frac{X}{EI}\left\{\int_0^L L^2\,dz+\right.$$

$$-L+\frac{\sqrt{2}}{2}z \qquad -qL^2+\frac{qL\sqrt{2}}{2}z$$

$$\left.+\int_0^L L^2\,dz+\int_0^{\sqrt{2}L}\frac{\cancel{2}}{\cancel{4}_{\,2}}\left[L\sqrt{2}-z\right]^2 dz\right\}+\frac{\alpha\overline{\Delta T}}{h}\int_0^{\sqrt{2}L}-\frac{\sqrt{2}}{2}\left[L\sqrt{2}-z\right]dz=$$

$$=\frac{1}{EI}\left\{+\frac{5}{2}qL^3\left[z\right]_0^L+\frac{5}{2}qL^3\left[z\right]_0^L-2qL^2\left[\frac{z^2}{2}\right]_0^L+\frac{qL}{2}\left[\frac{z^3}{3}\right]_0^L+\right.$$

$$\left.+qL^3\left[z\right]_0^{\sqrt{2}L}-qL^2\frac{\sqrt{2}}{2}\left[\frac{z^2}{2}\right]_0^{\sqrt{2}L}-qL^2\frac{\sqrt{2}}{2}\left[\frac{z^2}{2}\right]_0^{\sqrt{2}L}+\frac{qL}{2}\left[\frac{z^3}{3}\right]_0^{\sqrt{2}L}\right\}+\frac{X}{EI}\left\{L^2\left[z\right]_0^L+\right.$$

$$\left.+L^2\left[z\right]_0^L+L^2\left[z\right]_0^{\sqrt{2}L}+\frac{1}{2}\left[\frac{z^3}{3}\right]_0^{\sqrt{2}L}-L\sqrt{2}\left[\frac{z^2}{2}\right]_0^{\sqrt{2}L}\right\}+\frac{\alpha\overline{\Delta T}}{h}\left\{-L\left[z\right]_0^{\sqrt{2}L}+\frac{\sqrt{2}}{2}\left[\frac{z^2}{2}\right]_0^{\sqrt{2}L}\right\}=$$

$$=\frac{1}{EI}\left\{+\frac{5}{2}qL^4+\frac{5}{2}qL^4-qL^4+\frac{qL^4}{6}+\cancel{\sqrt{2}qL^4}-\cancel{\frac{\sqrt{2}}{2}qL^4}-\cancel{\frac{\sqrt{2}}{2}qL^4}+\right.$$

$$\left.+\frac{\sqrt{2}}{3}qL^4\right\}+\frac{X}{EI}\left\{L^3+L^3+\cancel{\sqrt{2}L^3}+\frac{\sqrt{2}}{3}L^3-\cancel{\sqrt{2}L^3}\right\}+\frac{\alpha\overline{\Delta T}}{h}\left\{-\sqrt{2}L^2+\frac{\sqrt{2}}{2}L^2\right\}=$$

$$\underbrace{=\frac{1}{EI}\left\{+\frac{25}{6}qL^4+\frac{\sqrt{2}}{3}qL^4\right\}+\frac{X}{EI}\left\{2L^3+\frac{\sqrt{2}}{3}L^3\right\}+\frac{\alpha\overline{\Delta T}}{h}\left\{-\frac{1}{2}\sqrt{2}L^2\right\}}$$

$L_{ve} = L_{vi}$ $\underline{\text{fornisce}}$

$$-\varepsilon X - \bar{\varepsilon} L\left[\frac{5}{2} q L^2 + X L\right] - \eta_D^\circ = +\frac{1}{EI}\left[+\frac{25}{6} q L^4 + \frac{\sqrt{2}}{3} q L^4\right] +$$

$$+\frac{X}{EI}\left[2L^3 + \frac{\sqrt{2}}{3} L^3\right] + \frac{\alpha \Delta T}{h}\left[-\frac{1}{2}\sqrt{2} L^2\right]$$

$$-\frac{3}{5}\frac{XL^3}{EI} - \frac{2}{5}\frac{L^2}{EI}\left[\frac{5}{2} q L^2 + X L\right] - \frac{qL^4}{EI}\left[\frac{\sqrt{2}}{3} + 2\right] =$$

$$= +\frac{1}{EI}\left[+\frac{25}{6} q L^4 + \frac{\sqrt{2}}{3} q L^4\right] + \frac{X}{EI}\left[2L^3 + \frac{\sqrt{2}}{3} L^3\right] - \frac{qL^4}{EI}\left[\frac{25}{6} + \frac{\sqrt{2}}{3}\right]$$

$$\frac{X L^{\cancel{3}}}{\cancel{EI}}\left[-\frac{3}{5} - \frac{2}{5} - 2 - \frac{\sqrt{2}}{3}\right] = \frac{q L^{\cancel{4}}}{\cancel{EI}}\left[+\cancel{\frac{25}{6}} + \cancel{\frac{\sqrt{2}}{3}} - \cancel{\frac{25}{6}} - \cancel{\frac{\sqrt{2}}{3}} + \frac{\sqrt{2}}{3} + 2 + 1\right]$$

$$X\left[-3 - \frac{\sqrt{2}}{3}\right] = qL\left[\frac{\sqrt{2}}{3} + 3\right]$$

$X = -qL$ NEGATIVO