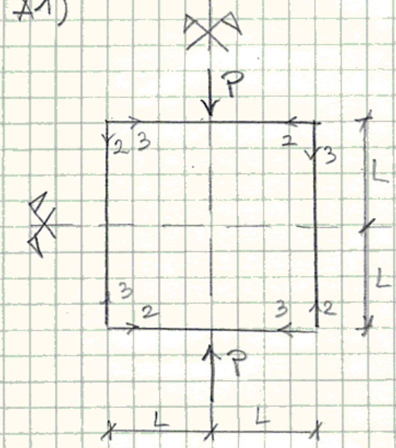
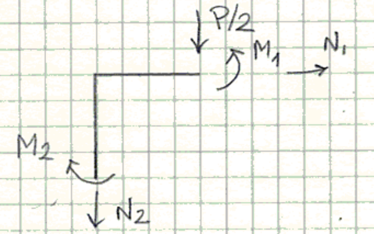
A1)



La struttura, labile nel piano, presenta due assi di simmetria. Se ne considera un quarto.



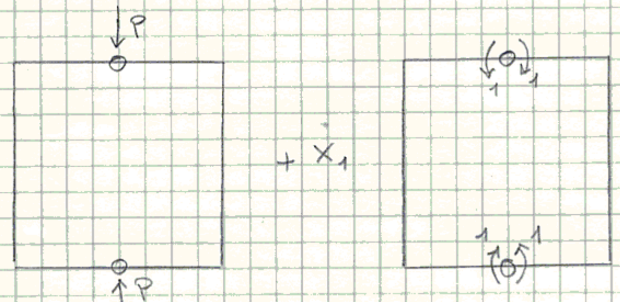
$$N_1 = 0$$

$$N_2 = -P/2$$

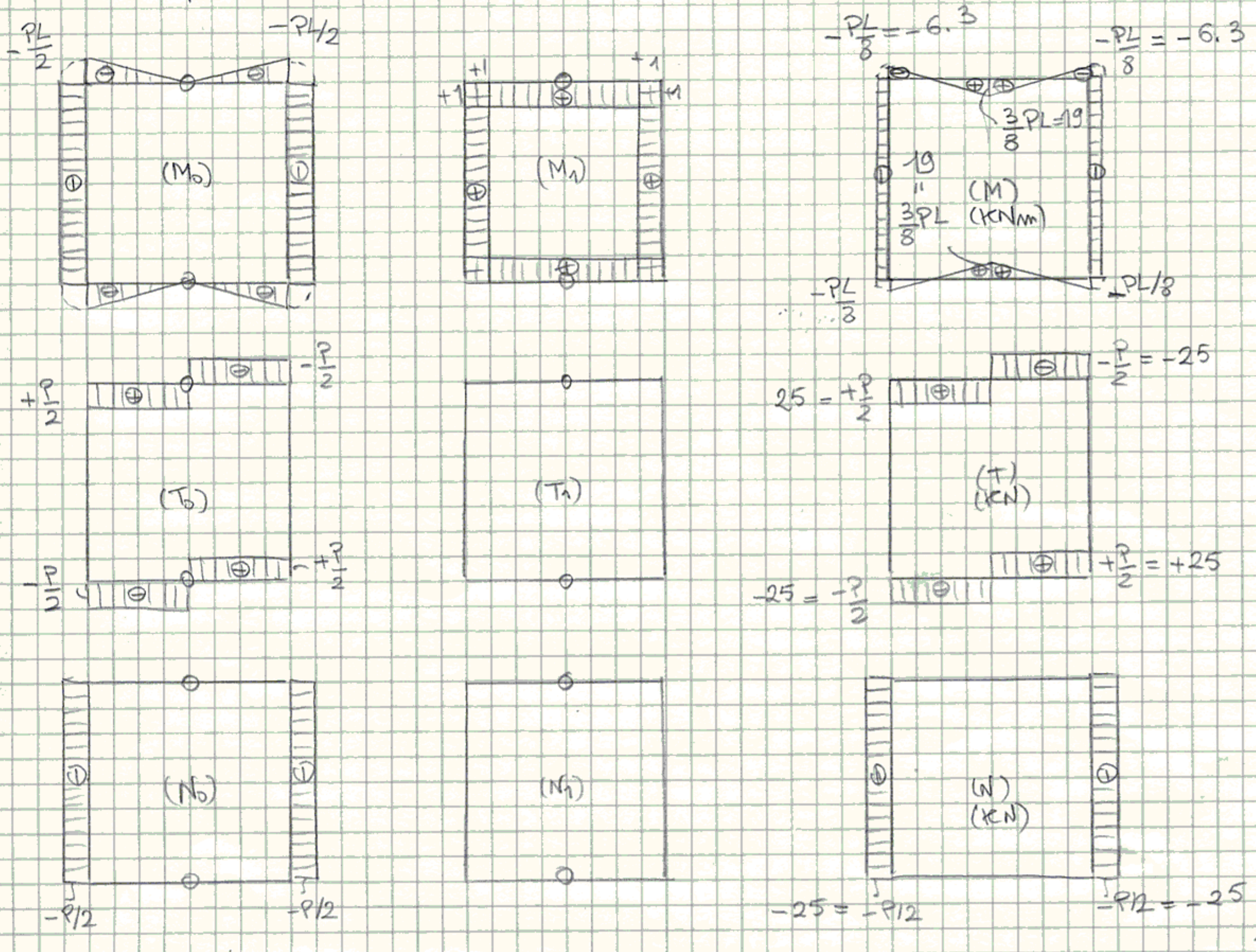
$$M_2 - M_1 + \frac{P}{2} L = 0$$

La struttura è una volta staticamente indeterminata (internamente).

Incognita iperstatica: $X_1 = M_1$.



DIAGRAMMI FINALI
(SOLO P)



$$EI_1\,\eta_{10} = -\cancel{4}\,\frac{PL}{\cancel{4}}\,\frac{L}{\cancel{4}} + 2\,\frac{PL}{\cancel{4}}\,\cancel{4}L = -3PL^2$$

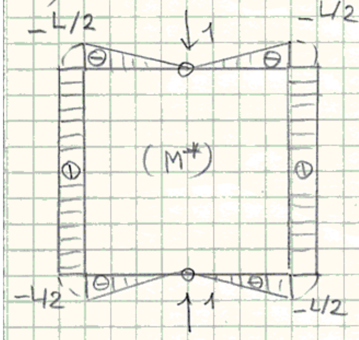
$$EI_1\,\eta_{11} = 8L$$

$$X_1 = -\frac{\eta_{10}}{\eta_{11}} = \frac{3}{8}PL$$

$$-\frac{4PL}{4\,2} + \frac{3}{8}PL = -\frac{PL}{8}$$

A2) $W_1 \geq \dfrac{3/8\,PL}{\sigma_{amm}} = \dfrac{19 \cdot 10^3 \cdot \cancel{10^6}}{240 \cdot \cancel{10^6}}\ cm^3 = 79{,}17\ cm^3$ IPE 160 $\begin{cases} W_1 = 108{,}7\ cm^3 \\ I_1 = 869{,}3\ cm^4 \\ H = 160\ mm \end{cases}$

A3)



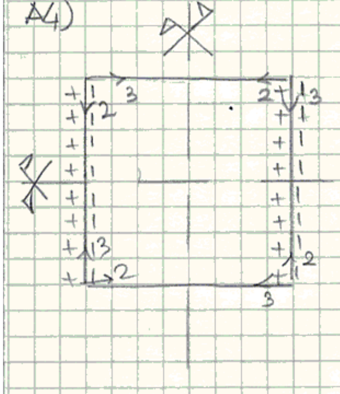
$$1 \cdot \Delta\varphi = \frac{\cancel{2}}{EI_1}\left(-\frac{L}{\cancel{2}}\right)\left(-\frac{PL}{8_4}\right)2L + \frac{4}{EI_1}\int_0^L \left(\frac{-x}{\cancel{2}}\right)\left(\frac{3}{8_4}PL - \frac{P}{\cancel{2}}x\right)dx$$

$$= \frac{PL^3}{4EI_1} + \frac{P}{4EI_1}\int_0^L \left(4x^2 - 3Lx\right)dx$$

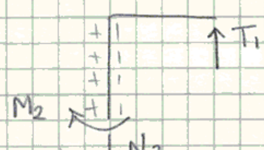
$$= \frac{PL^3}{4EI_1} + \frac{P}{4EI_1}\left[\frac{4}{3}L^3 - \frac{3}{2}L^3\right]$$

$$= \frac{PL^3}{4EI_1}\left[1 - \frac{1}{6}\right] = \frac{5}{24}\,\frac{PL^3}{EI_1}$$

A4)



La struttura ora presenta un asse di simmetria orizzontale e un asse di antisimmetria verticale.

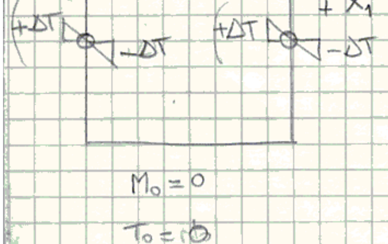


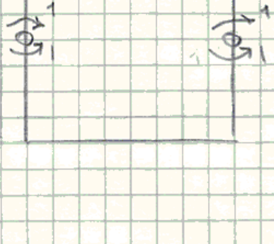
$N_2 = T_1$

$M_2 = T_1 L$

La struttura è ancora una volta staticamente determinata.

Incognita iperstatica: $X_1 = M_2$

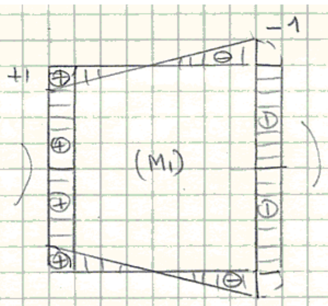


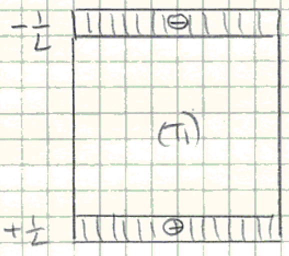


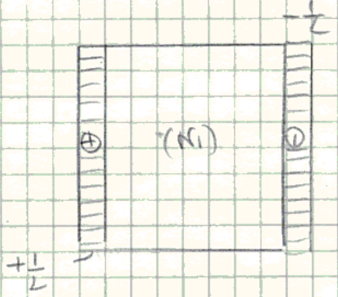
$M_0 = 0$

$T_0 = 0$

$N_0 = 0$





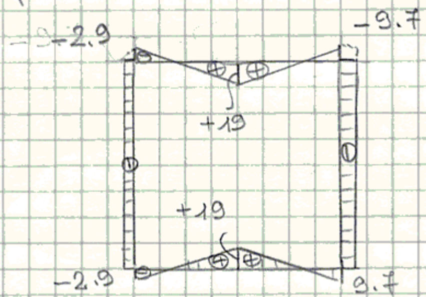


$$\eta_{1t} = -\,\chi_t\,4L = -\frac{2\alpha\Delta T}{H}\,4L = -\frac{8\alpha\Delta T L}{H}$$

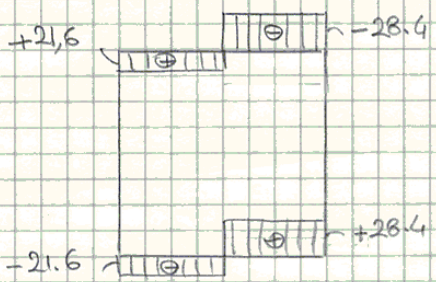
$$EI_1\,\eta_{11} = 4L + 4\,\frac{L}{3} = 4\cdot\frac{4}{3}\,L = \frac{16}{3}\,L$$

$$X_1^t = -\frac{\eta_{1t}}{\eta_{11}} = \frac{\cancel{8}\,\alpha\Delta T \cancel{L}}{H}\,\frac{3EI_1}{\cancel{16}_2 \cancel{L}} = \frac{3\alpha\Delta T EI_1}{2H} = \frac{3\cdot10^{-5}\cdot\cancel{20}\cdot 21\cancel{0}\cdot 1\cancel{0}^{\cancel{6}}\cdot 869\cdot\cancel{10}^{-8}}{\cancel{2}\cdot 0,16} = \frac{3\cdot21\cdot869}{10^5\cdot0,16} = 3,4 \text{ kNm}$$

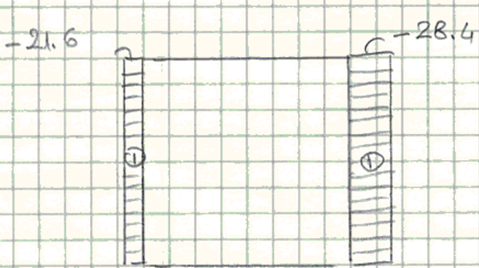
Diagrammi finali (P e ΔT):



(M)
(kNm)

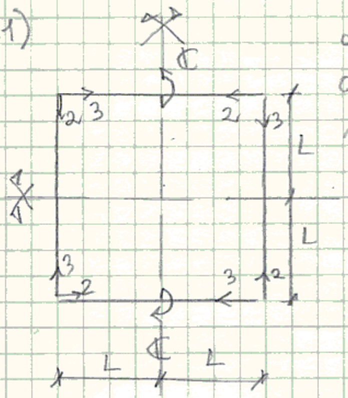


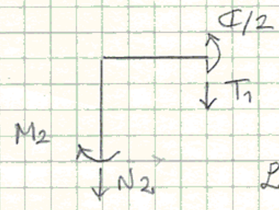
(T)
(kN)



(N)
(kN)

B1) La struttura, labile nel piano, presenta un asse di simmetria orizzontale e un asse di antisimmetria verticale. Si considera un quarto di struttura:



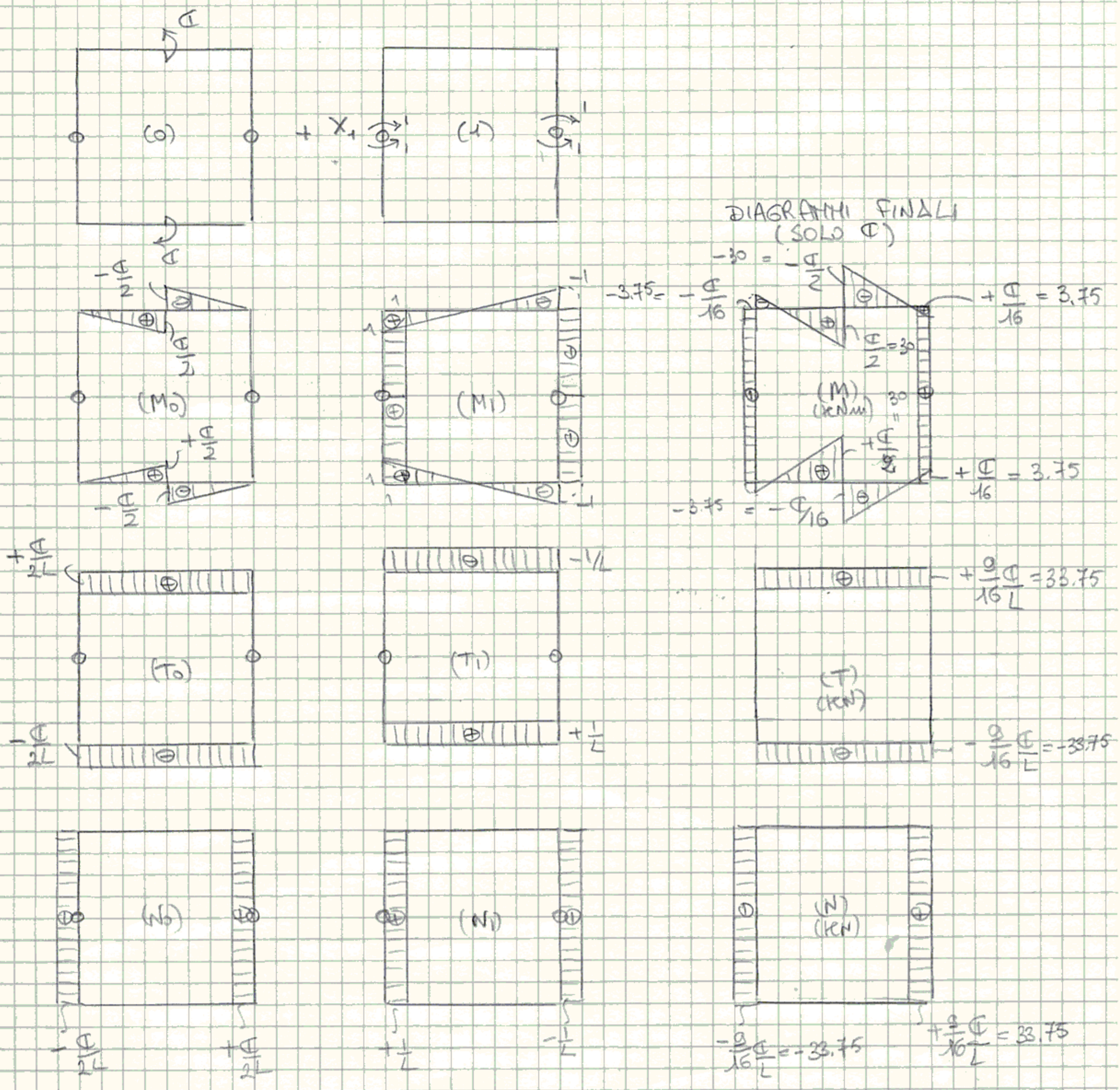


$$N_2 = -T_1$$

$$M_2 - \frac{\mathfrak{C}}{2} + T_1 L = 0$$

La travatura è una volta staticamente indeterminata (internamente).

Incognita iperstatica: $X_1 = M_2$.



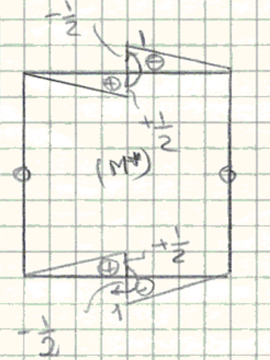
$$EI_1\eta_{10} = 4L\,\frac{1}{6}\,\frac{\mathbb{C}}{2} = \frac{\mathbb{C}L}{3}$$

$$EI_1\eta_{11} = 4L + \frac{4}{3}L = \frac{16}{3}L$$

$$X_1 = -\frac{\eta_{10}}{\eta_{11}} = -\frac{\mathbb{C}\cancel{L}}{\cancel{3}}\,\frac{\cancel{3}}{16\cancel{L}} = -\frac{\mathbb{C}}{16}$$

B2) $W_1 \geq \frac{\mathbb{C}}{\sigma_{AMM}} = \frac{3\cancel{0}\cdot 10^3\cdot \cancel{10^6}}{24\cancel{0}\cdot\cancel{10^6}}\ cm^3 = 125\ cm^3$ IPE 180 $\begin{cases} W_1 = 146.3\ cm^3 \\ I_1 = 1317\ cm^4 \\ H = 180\ mm \end{cases}$

B3)



$$2\cdot\varphi = \frac{4}{EI_1}\int_0^L \left(\frac{x}{2L}\right)\left(-\frac{\mathbb{C}}{\cancel{16}_4} + \frac{9}{\cancel{16}_4}\frac{\mathbb{C}}{L}x\right)dx$$

$$= \frac{\mathbb{C}}{8L^2EI_1}\int_0^L \left(9x^2 - Lx\right)dx$$

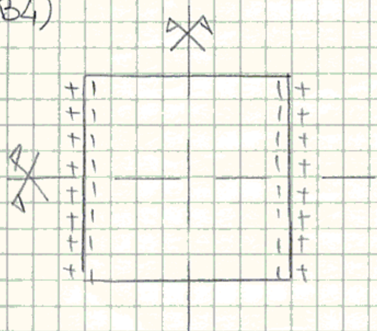
$$= \frac{\mathbb{C}}{8EI_1L^2}\,L^3\left[3 - \frac{1}{2}\right] = \frac{5}{16}\,\frac{\mathbb{C}L}{EI_1}$$

$$= \frac{5\cdot 6\cancel{0}\cdot 10^3\cdot 1}{16\cdot 21\cancel{0}\cdot\cancel{10^3}\cdot 1317\cdot\cancel{10^3}}$$

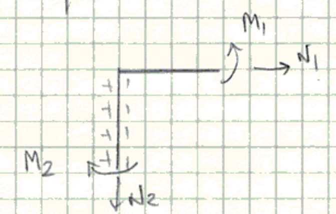
$$= \frac{3\cancel{0}\cdot 10^3}{16\cdot 21\cancel{0}\cdot 1317} = 0{,}00678$$

$$= 0{,}38^\circ$$

B4)



La struttura presenta due assi di simmetria. Se ne studia un quarto.



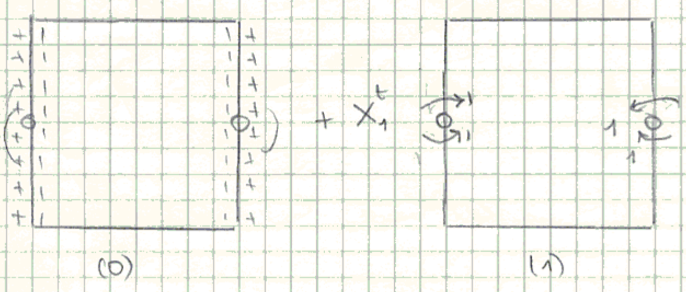
$M_1 = M_2$

$N_1 = 0$

$N_2 = 0$

La struttura è una volta staticamente indeterminata

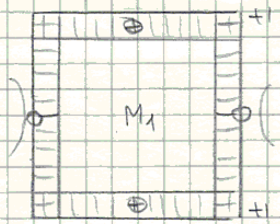
Incognita iperstatica: $X_1 = M_1$



$M_0 = 0$

$T_0 = 0$

$N_0 = 0$



$T_1 = 0$

$N_1 = 0$

$$\eta_{1t} = 2L\chi_t = 4L\,\frac{2\alpha\Delta T}{H} = 8\alpha\Delta T\,\frac{L}{H}$$

$$\eta_{11} = \frac{8L}{EI_1}$$

$$X_1^t = \cancel{8}\alpha\Delta T\,\frac{\cancel{L}}{H}\,\frac{EI_1}{\cancel{8}\cancel{L}} = \frac{20\cdot 10^{-5}\cdot 210\cdot 10^{6}\cdot 1317\cdot 10^{-8}}{0,18}\,\frac{1}{10^{3}}\ kNm = \frac{2\cdot 2{,}1\cdot 1{,}317}{1{,}8}\ kNm = 3{,}07\ kNm$$

Diagrammi finali (C e ΔT):