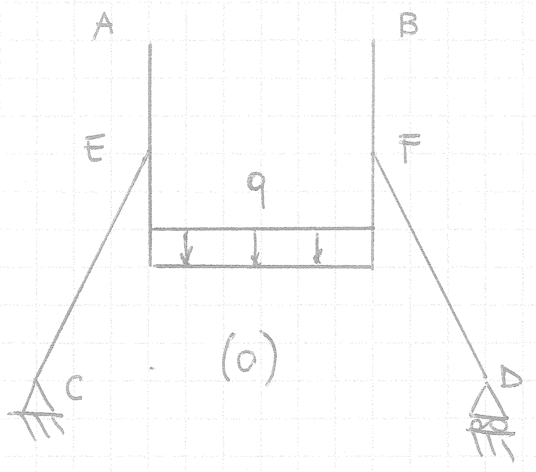
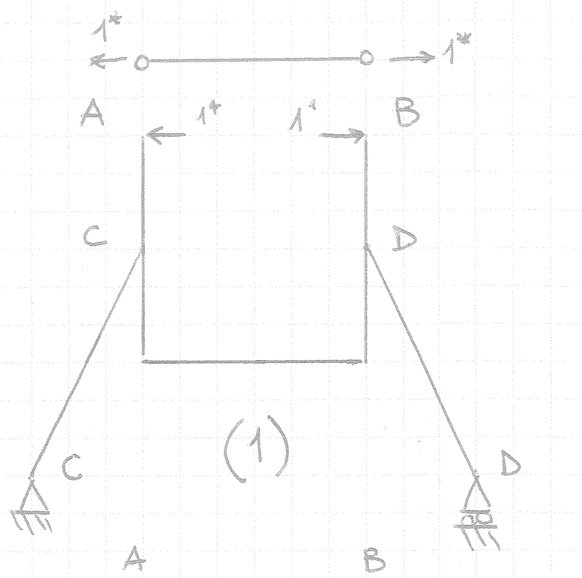
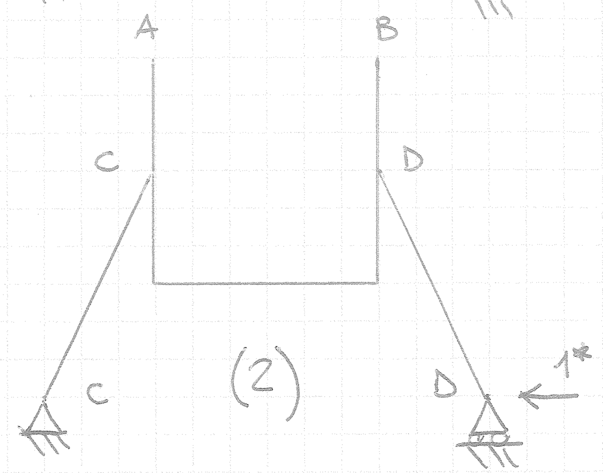


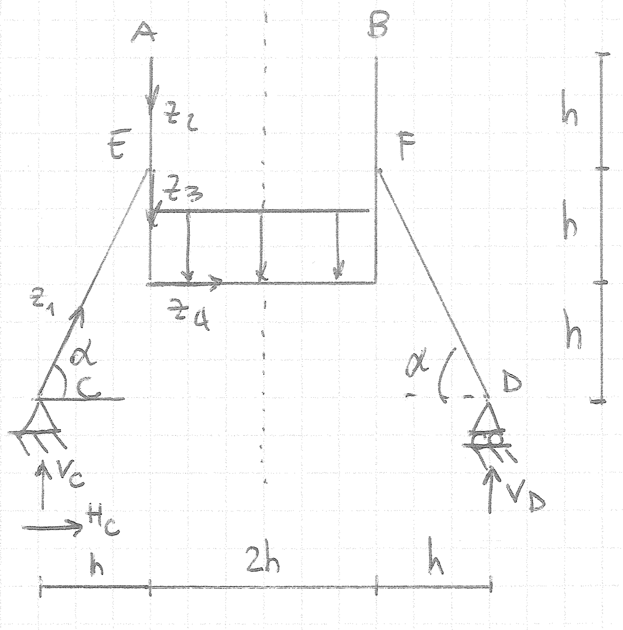
$+ \quad X_1$



$+ \quad X_2$



SISTEMA 0



$h = 2\,m \qquad q = 1000\ N/m$

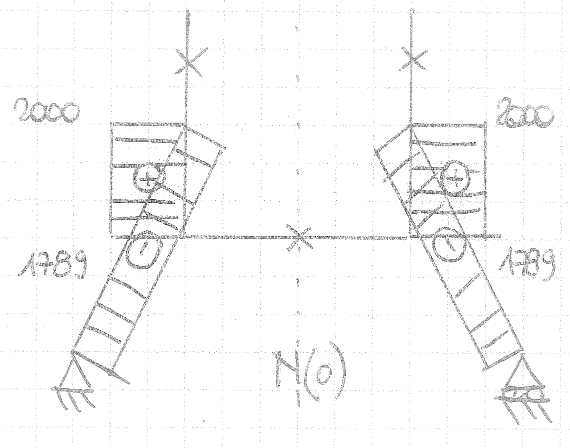
$\rightarrow)\ H_C = 0$

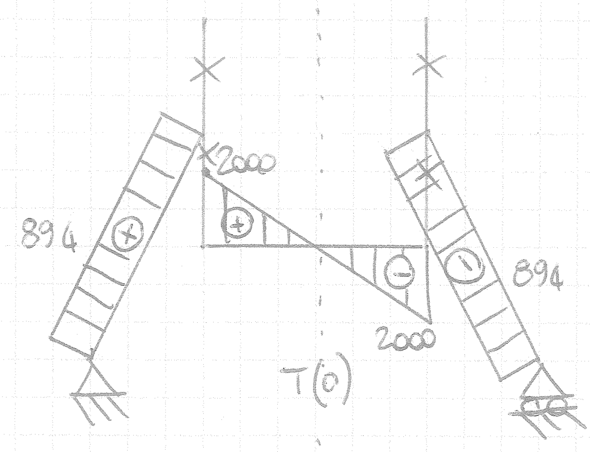
$V_D = V_B$ per simmetria

$\uparrow)\ 2V_C - 2qh = 0 \qquad V_C = V_D = qh$

$\alpha = \arctan\left(\frac{2h}{h}\right)$

$\simeq 63{,}4°$





$M(z_1) = V_c \cdot z \cos\alpha$

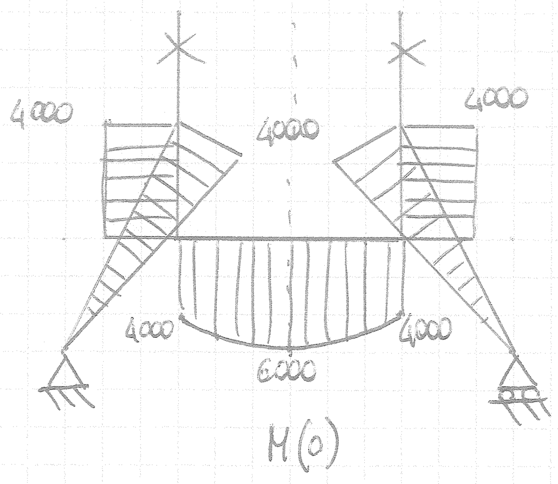
$M(z_2) = 0$

$M(z_3) = + V_c \cdot h = q h^2$

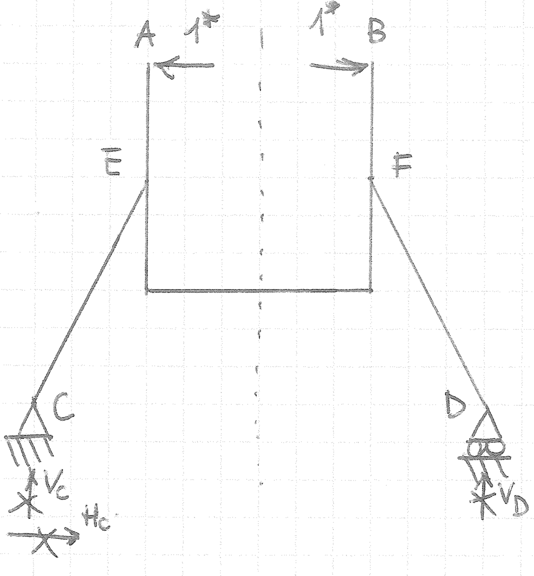
$M(z_4) = V_c \cdot (h+z) - \frac{q z^2}{2}$

$N(z_1) = - V_c \cdot \operatorname{sen}\alpha$

$T(z_1) = V_c \cdot \cos\alpha$



SISTEMA (1)

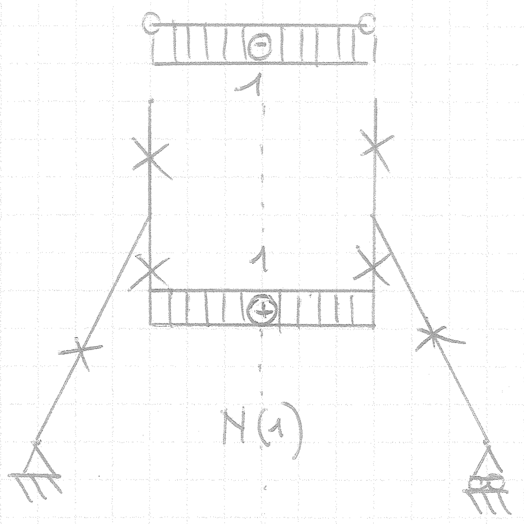


$\rightarrow)$ $H_C = 0$

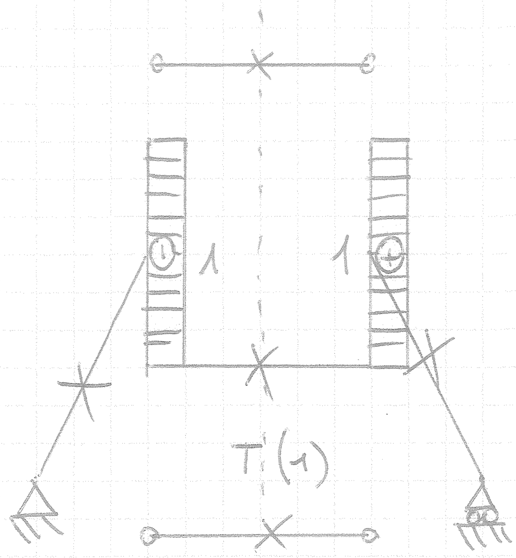
$V_C = V_D$ per simmetria

$C \circlearrowright)$ $V_D \cdot 4h = 0$ $\quad V_D = 0$

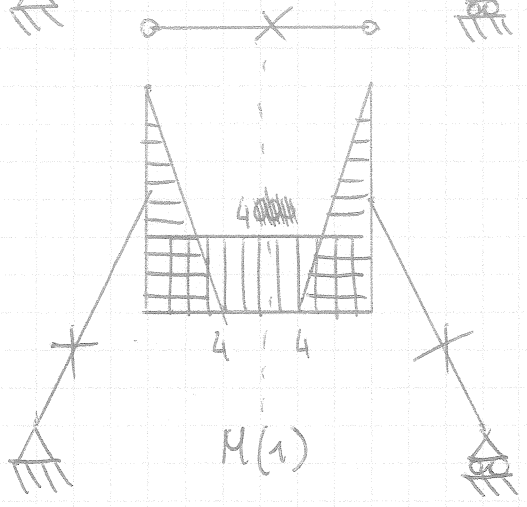
$V_C = V_D = 0$



N(1)



T(1)



M(1)

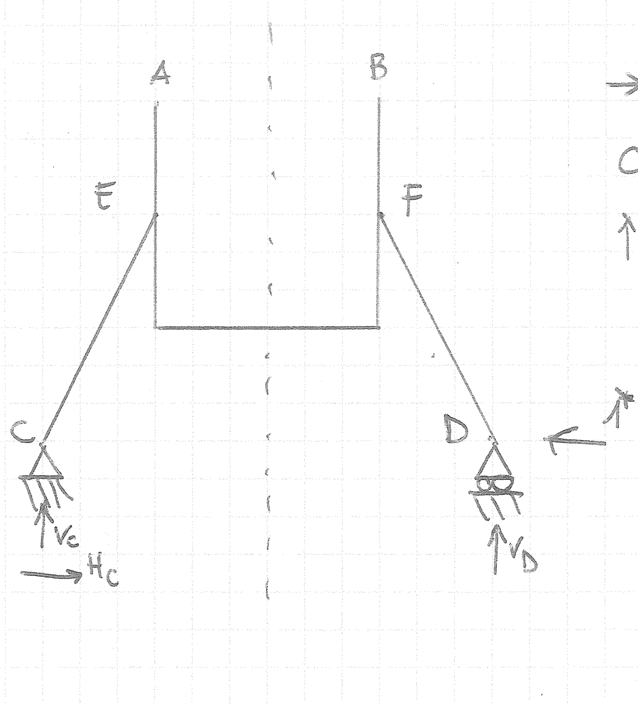
$M(z_1) = 0$

$M(z_2) = -z$

$M(z_3) = -(h + z)$

$M(z_4) = -(2h)$

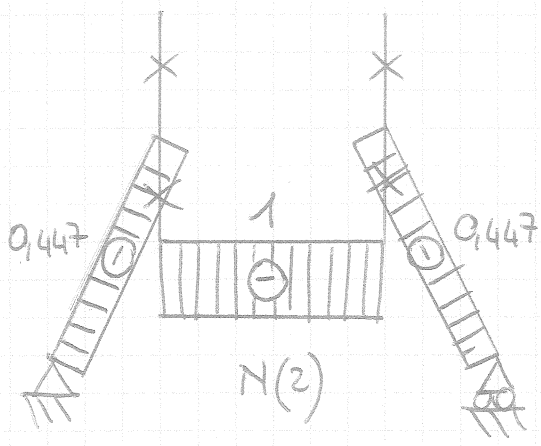
SISTEMA 2

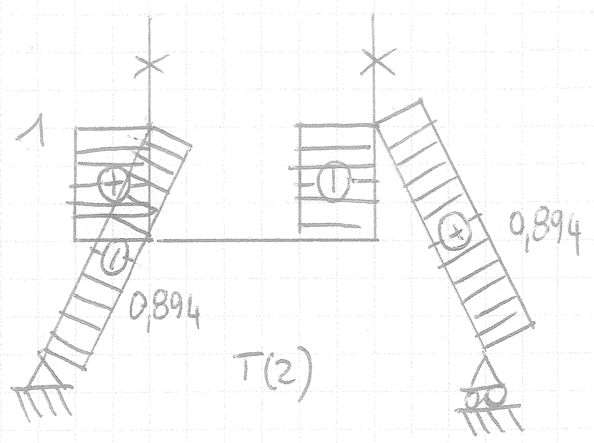


$\rightarrow)\ H_C - 1 = 0 \qquad H_C = 1$

$C \circlearrowright)\ V_D \cdot 4h = 0$

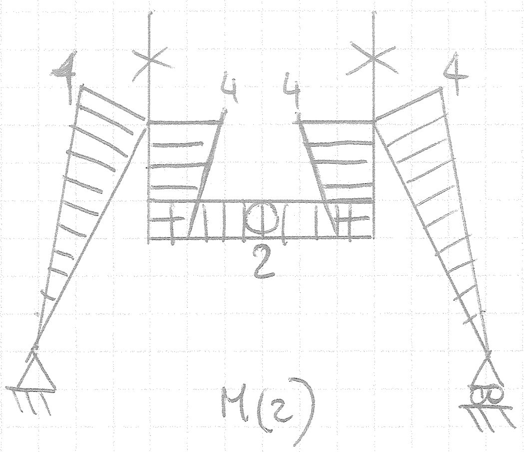
$\uparrow)\ V_C = 0$





$N(z_1) = -H_C \cos\alpha$

$T(z_1) = -H_C \cdot \sin\alpha$



$M(z_1) = -H_C \cdot z \sin\alpha$

$M(z_2) = 0$

$M(z_3) = -H_C \cdot (2h - z)$

$M(z_4) = -H_C \cdot h$

$$\eta_{10} = \frac{1}{EJ} \cdot \left[2\int_0^h (qh^2)\left(-(h+z)\right) dz + 2\int_0^h \left(-\frac{qz^2}{2} + qhz + qh^2\right)(-2h)\, dz \right]$$

$$= -133333/EJ$$

$$\eta_{20} = \frac{1}{EJ} \left[2\int_0^{h/\cos\alpha} (qhz\cos\alpha)(-z\sin\alpha)\, dz + 2\int_0^h (qh^2)\left(-(2h-z)\right) dz + 2\int_0^h \left(-\frac{qz^2}{2} + qhz + qh^2\right)(-h) \right]$$

$$= -138369/EJ$$

$$\eta_{11} = \frac{1}{EJ}\left[2\int_0^{2h} z^2\, dz + 2\int_0^h 4h^2\, dz \right] = 106,67/EJ$$

$$\eta_{22} = \frac{1}{EJ}\left[2\int_0^{h/\cos\alpha} (z^2 \sin^2\alpha)\, dz + 2\int_0^h (2h-z)^2\, dz + 2\int_0^h h^2\, dz \right] =$$

$$= 101,04/EJ$$

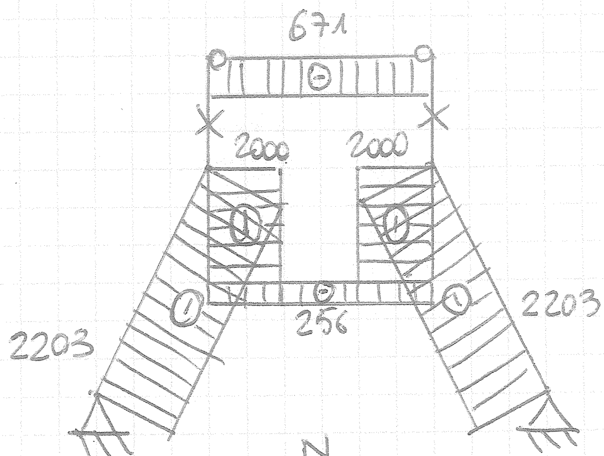
$$M_{12} = \frac{1}{EJ}\left[2\int_0^{h}\left(-(h+z)\right)\left(-(2h-z)\right)dz + 2\int_0^{h}(-2h)(-h)\,dz = \right.$$

$$= 66{,}67/EJ$$

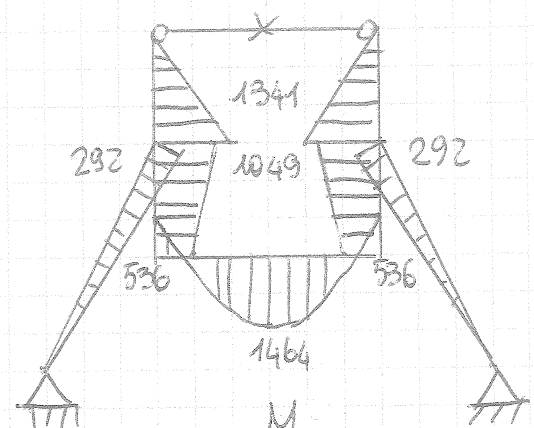
$$\begin{aligned}(1) &\rightarrow \\ (2) &\rightarrow\end{aligned}\quad \begin{cases} M_{11}\cdot X_1 + M_{12}\cdot X_2 = -M_{10} \\ M_{12}\cdot X_1 + M_{22}\cdot X_2 = -M_{20}\end{cases}$$

$X_1 = 670{,}6\ N$

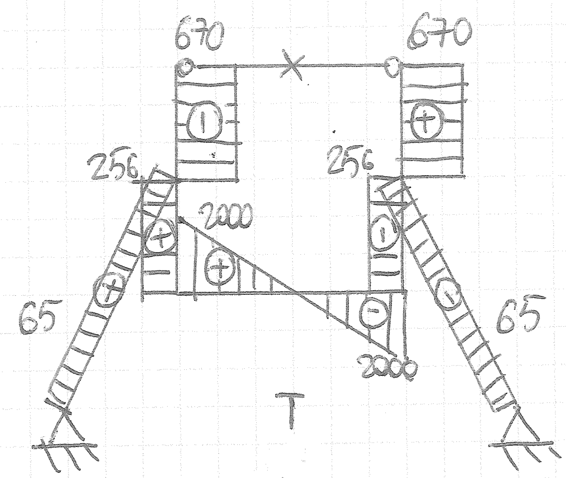
$X_2 = 927\ N$



N



M



T

) PROGETTO

$\sigma_{am} = 390$ MPa

$M_{max} = 1464$ ~~MPa~~ Nm

$W_{min} = \frac{M_{max}}{\sigma_{am}} = \frac{1464 \cdot 10^3}{390} = 3753,9\ mm^3 \rightarrow 3,8\ cm^3$

Combinazioni

$N_1 = 256$ N $\quad N_2 = 2000$ N

$M_1 = 1464$ Nm $\quad M_2 = 1341$ Nm

Adotto IPE 80

$W_x = 20,03\ cm^3$

$J_x = 80,14\ cm^3$

$A = 7,64\ cm^2$

VERIFICA

$\sigma_{max} = \frac{N}{A} + \frac{M}{W_x} =$

Combinazione 1 $\quad \frac{256}{764} + \frac{1464 \cdot \cancel{10^3}}{20,03 \cdot \cancel{10^3}} = 73,4$ ok

Combinazion 2 $\quad \frac{2000}{764} + \frac{1341 \cdot \cancel{10^3}}{20,03 \cdot \cancel{10^3}} = 70$ ok

3) $\Delta t = 20°$

$\alpha = 1,2 \cdot 10^{-5}\ C^{-1}$

$E = 210\,000$ MPa

$\varepsilon^T = \alpha \Delta t$

1) $\rightarrow \quad L_{ve} = 0 = L_{vi} = \eta_{10} + \eta_{11} \cdot X_1 + \eta_{12} \cdot X_2 + \underbrace{2\int_0^h \varepsilon^t \cdot N^*_{AB}\, dz}_{\text{Contributo termico}}$

$\Longrightarrow \eta_{10}^{\Delta t} = \eta_{10} + 2\int_0^h \alpha \Delta t \cdot (-1)\, dz = \eta_{10} - 2h\alpha\Delta t$

Per tener conto della deformabilità assiale di AB

$\eta_{11}^N = \eta_{11} + \frac{2}{EA}\int_0^h (-1)^2\, dz = \eta_{11} + \frac{2h}{EA}$

$\begin{cases} \eta_{11}^N \cdot X_1 + \eta_{12} \cdot X_2 = -\eta_{10}^{\Delta t} \\ \eta_{12} \cdot X_1 + \eta_{22} \cdot X_2 = -\eta_{20} \end{cases}$

$X_1 = 673$ N

$X_2 = 925,4$ N

I grafici rimangono sostanzialmente invariati