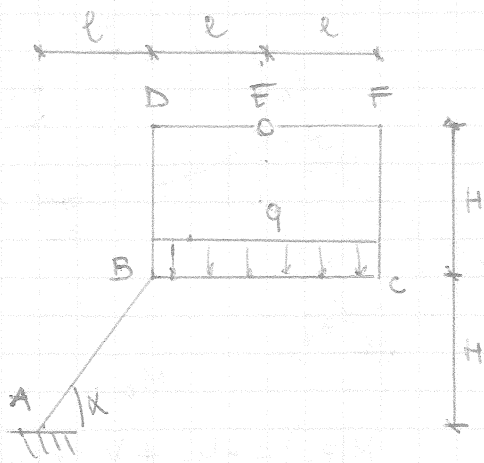


10/02/2017

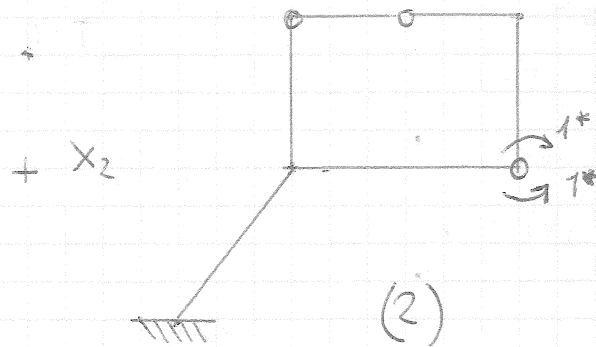
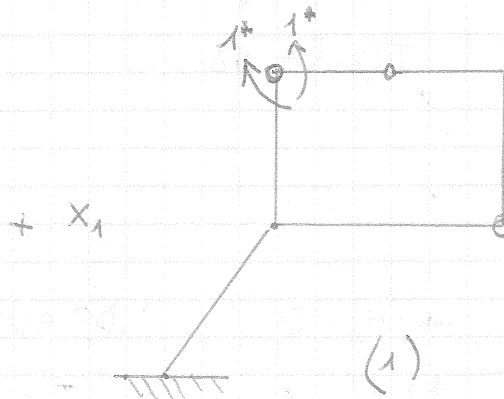
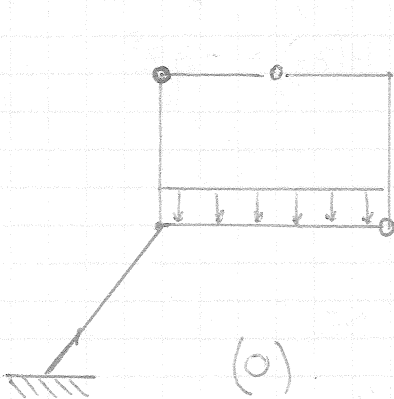


$q = 1000 \text{ N/m}$

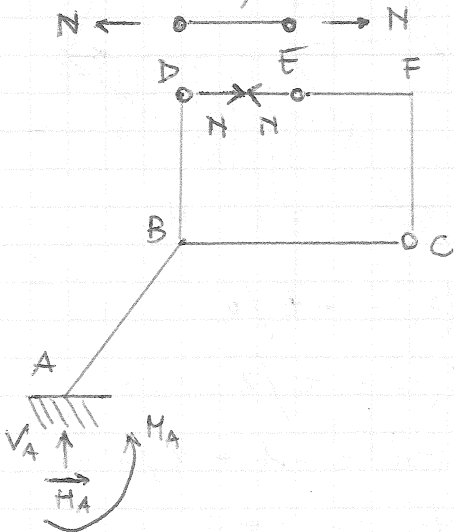
$e = 2 \text{ m}$

$h = 4 \text{ m}$

$\alpha = \arctan(h/e) \approx 63,4^\circ$



SISTEMA (0)

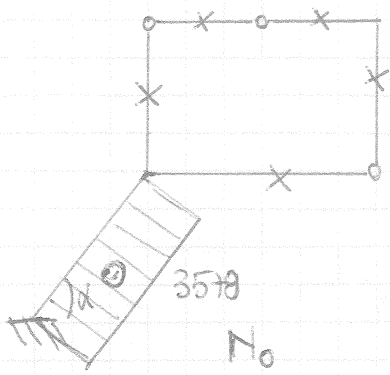


$\rightarrow) H_A = 0$

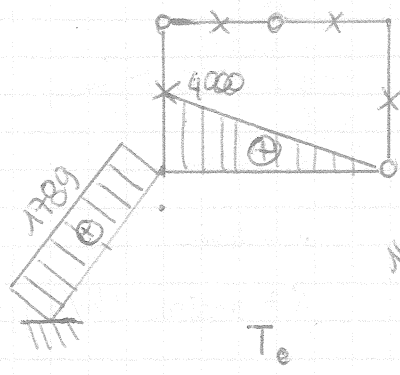
$\uparrow) V_A = 2ql$

$A) M_A = 4ql^2$

$C) \text{ AUS. CFE } N = 0$

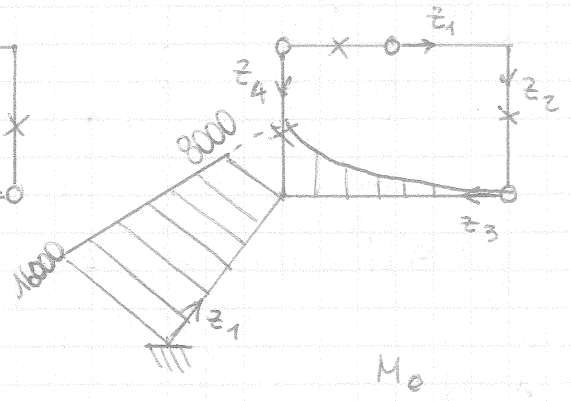


$$N(z_1) = -V_A \cdot \cos \alpha$$



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

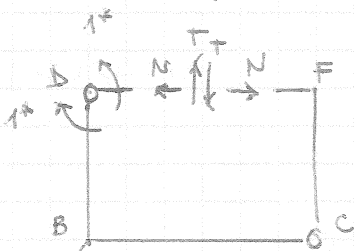
$$T(z_3) = qz$$



$$M(z_1) = -M_A + V_A \cdot z \cos \alpha$$

$$M(z_3) = -\frac{qz^2}{2}$$

SISTEMA (1)



$$\rightarrow H_A = 0$$

$$D \uparrow \text{AUS. DE}$$

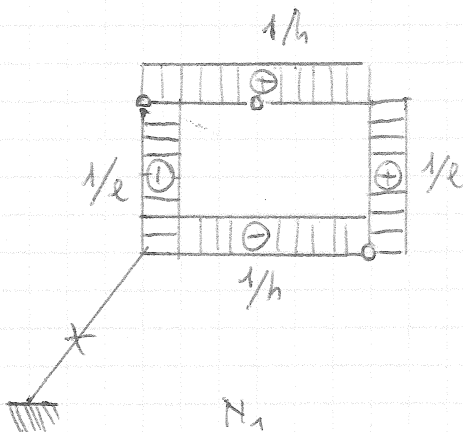
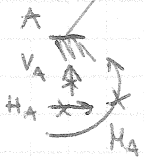
$$\uparrow V_A = 0$$

$$T = -1/e$$

$$A \uparrow M_A = 0$$

$$C \uparrow \text{AUS. CFE}$$

$$T \cdot e - N \cdot h = 0 \quad N = -1/h$$

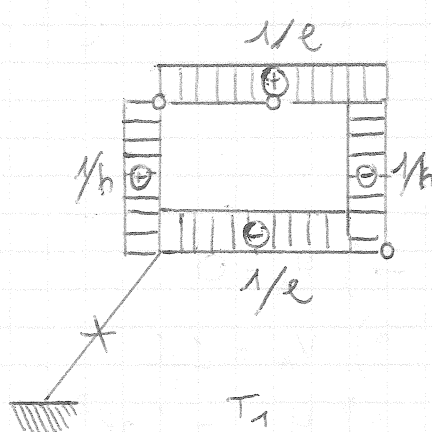


$$N(z_1) = N(z_2) = +1/h$$

$$N(z_3) = 1/e$$

$$N(z_4) = -1/e$$

$$N(z_5) = -1/h$$



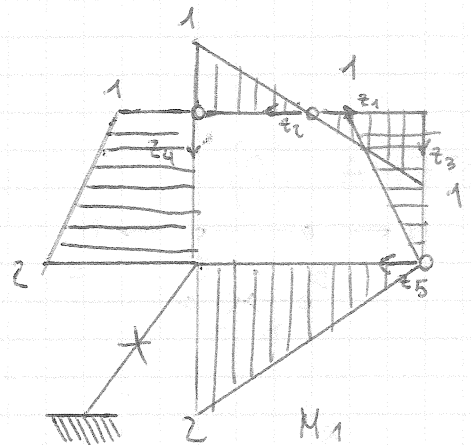
$$T(z_1) = 1/e$$

$$T(z_2) = 1/e$$

$$T(z_3) = -1/h$$

$$T(z_4) = 1/h$$

$$T(z_5) = -1/e$$



$$M(z_1) = -z/e$$

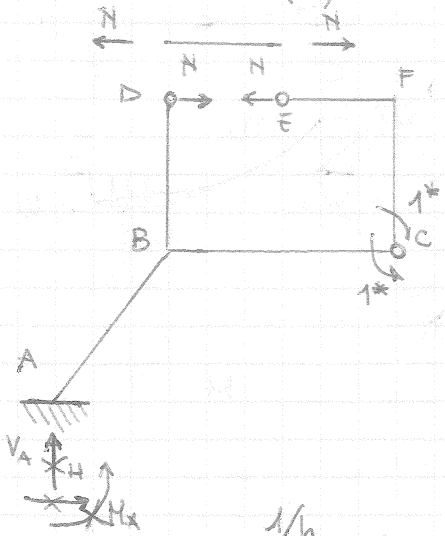
$$M(z_2) = z/e$$

$$M(z_3) = -1 + z/h$$

$$M(z_4) = 1 + z/h$$

$$M(z_5) = z/e$$

SISTEMA (2)



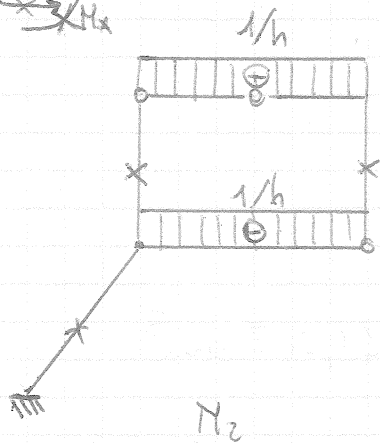
$$\rightarrow) H_A = 0$$

C) AVS. OFE

$$\uparrow) V_A = 0$$

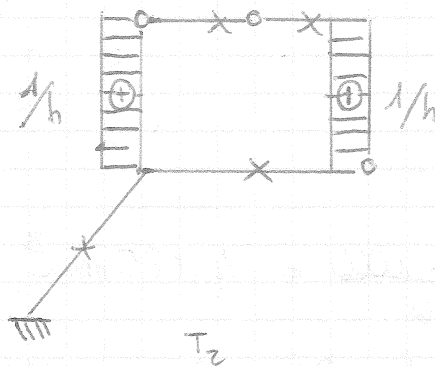
$$N \cdot h - 1^* = 0 \quad N = 1/h$$

$$A) M_A = 0$$



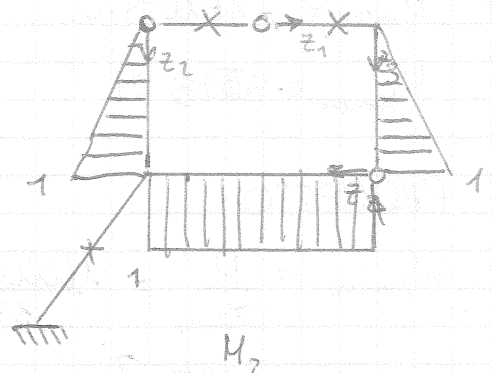
$$N(z_1) = 1/h$$

$$N(z_4) = -1/h$$



$$T(z_2) = -1/h$$

$$T(z_3) = 1/h$$



$$M(z_2) = l/h$$

$$M(z_3) = z/h$$

$$M(z_4) = 1$$

$$M_{10} = \frac{1}{EJ} \left[\int_0^{2l} \left(-\frac{qz^2}{2} \right) \left(\frac{z}{l} \right) dz \right] = -\frac{ql^3}{EJ}$$

$$M_{20} = \frac{1}{EJ} \left[\int_0^{2l} \left(-\frac{qz^2}{2} \right) (1) dz \right] = -\frac{4}{3} \frac{ql^3}{EJ}$$

$$M_{11} = \frac{1}{EJ} \left[\int_0^l \frac{z^2}{l^2} dz + \int_0^h \left(1 + \frac{z}{h} \right)^2 dz + \int_0^h \left(-1 + \frac{z}{h} \right)^2 dz + \int_0^{2l} \frac{z^2}{l^2} dz \right] = \left(\frac{8}{3} h + \frac{10l}{3} \right) \frac{1}{EJ}$$

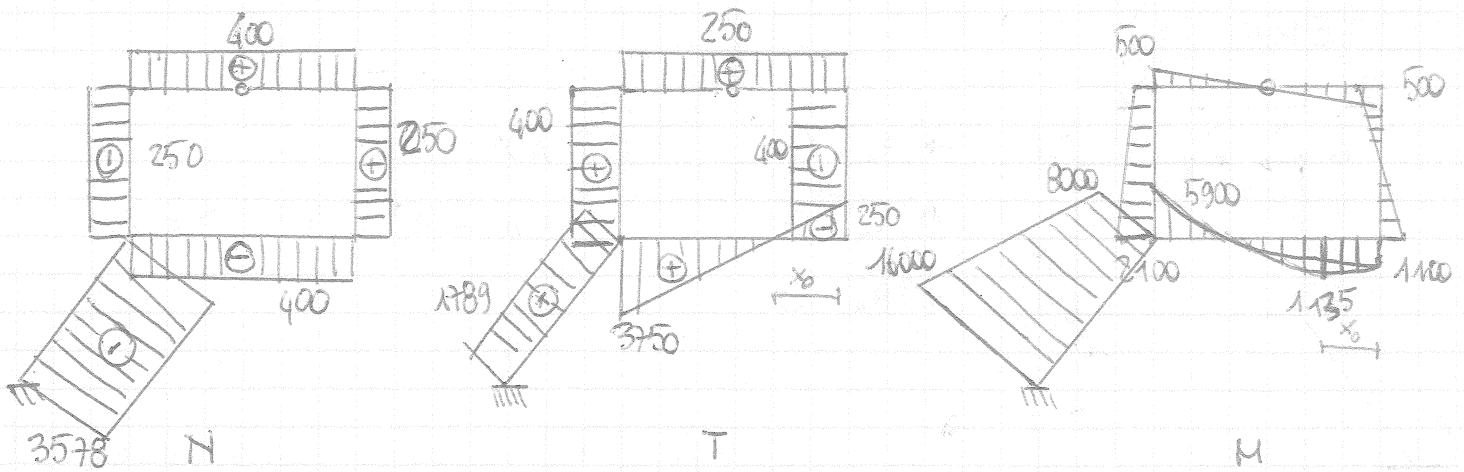
$$M_{22} = \frac{1}{EJ} \left[2 \int_0^h \frac{z^2}{h^2} dz + \int_0^l 1 dz \right] = \frac{2h}{3EJ} + \frac{2l}{EJ}$$

$$M_{12} = \frac{1}{EJ} \left[\int_0^h \left(\frac{z}{h} \right) \left(1 + \frac{z}{h} \right) dz + \int_0^h \left(\frac{z}{h} \right) \left(-1 + \frac{z}{h} \right) dz + \int_0^{2l} (1) \left(\frac{z}{l} \right) dz \right] = \frac{2h}{3EJ} + \frac{2l}{EJ}$$

$$\begin{cases} M_{11} \cdot x_1 + M_{12} \cdot x_2 = -M_{10} \\ M_{12} \cdot x_1 + M_{22} \cdot x_2 = -M_{20} \end{cases}$$

$$x_1 = 500 \text{ Nm}$$

$$x_2 = 1100 \text{ Nm}$$



$$x_0 = (4 \cdot 250) / (3750 + 250) = 0,250 \text{ m}$$

$$2) \quad M_{\max} = -16000 \text{ Nm}$$

$$N_{\max} = -3578 \text{ N}$$

PROGETTO

$$W_{\min} = \frac{M}{\sigma_{\text{amm}}} = \frac{16000 \cdot 1000}{390} = 41025 \text{ mm}^3 \rightarrow 41,025 \text{ cm}^3$$

ADOTTO IPE 120 $W_y = 52,96 \text{ cm}^3$ $I_y = 317,8 \text{ cm}^4$ $A = 13,21 \text{ cm}^2$

VERIFICA

$$\sigma_{\max} = \frac{N}{A} + \frac{M}{W_y} = \frac{3578}{13,21 \cdot 100} + \frac{16000 \cdot 1000}{52,96 \cdot 1000} = 304,8 < 390 \text{ ok!}$$

$$3) \quad x_t = \frac{\alpha \cdot \Delta t}{h_s} \quad h_s = \text{altezza sezione} = 120 \text{ mm}$$

$$\Delta t = 40^\circ \text{C} \quad \alpha = 1,2 \cdot 10^{-5} \text{ } ^\circ \text{C}^{-1}$$

$$M_{11}^T = \int_0^h \left(1 + \frac{z}{h}\right) x^T dz = \frac{3}{2} \frac{h \alpha \Delta t}{h_s}$$

$$M_{22}^T = \int_0^h \left(\frac{z}{h}\right) x^T dz = \frac{h}{2} \frac{\alpha \Delta t}{h_s}$$

$$M_{10}^T = \int_0^h (0) \cdot x^T dz = 0$$

$$M_{10}^N = 0 \quad M_{20}^N = 0$$

$$M_{11}^N = \frac{1}{EA} \left[2 \int_0^{2l} \frac{1}{h^2} dz + 2 \int_0^h \frac{1}{h^2} dz \right] = \frac{4l}{EA h^2} + \frac{2h}{EA h^2}$$

$$M_{22}^N = \frac{1}{EA} \left[2 \int_0^{2l} \left(1/h^2 \right) dz \right] = \frac{4l}{EA h^2}$$

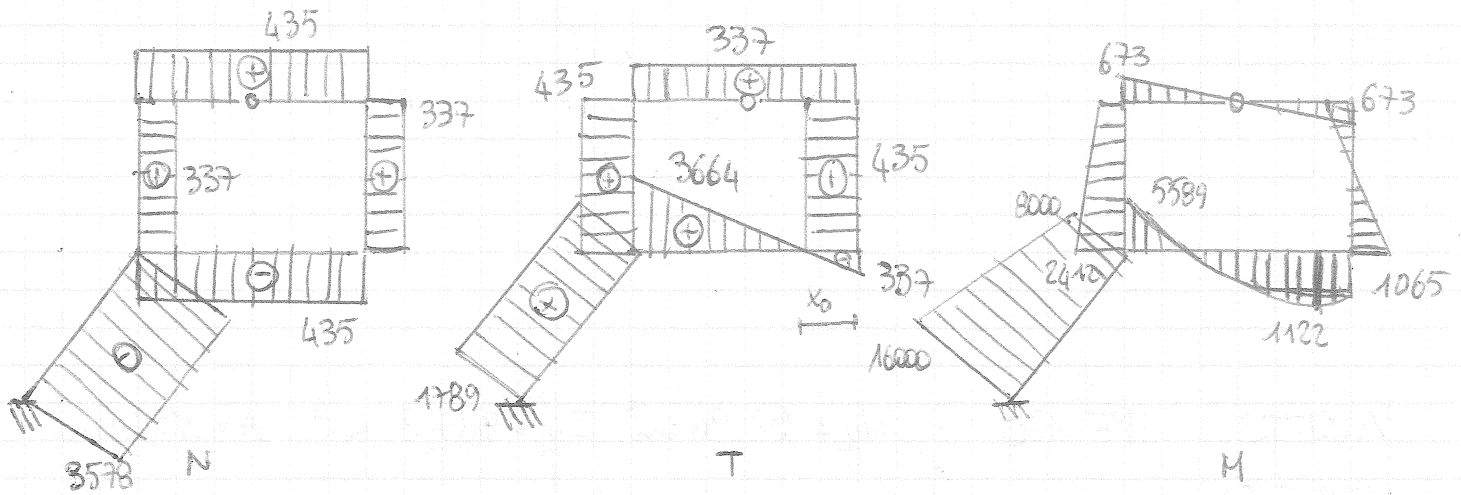
$$M_{12}^N = \frac{1}{EA} \left[2 \int_0^{2l} 1/h^2 dz \right] = \frac{4l}{EA h^2}$$

$$M_{ik}^{TOT} = M_{ik}^T + M_{ik}^N$$

$$\begin{cases} M_{11}^{TOT} \cdot X_1 + M_{12}^{TOT} \cdot X_2 = -M_{10}^{TOT} \\ M_{12}^{TOT} \cdot X_1 + M_{22}^{TOT} \cdot X_2 = -M_{20}^{TOT} \end{cases}$$

$$X_1^{TOT} = 673 \text{ Nm}$$

$$X_2^{TOT} = 1065 \text{ Nm}$$



$$x_0 = \frac{337}{(3664 + 337)} \cdot (4) = 0,337 \text{ m}$$