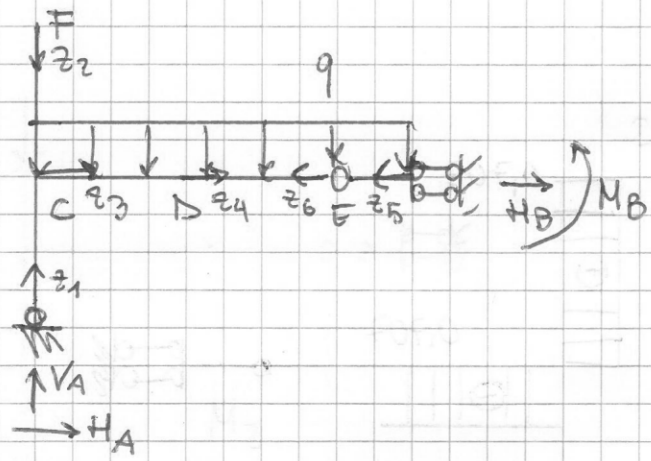


1) SISTEMA (0)



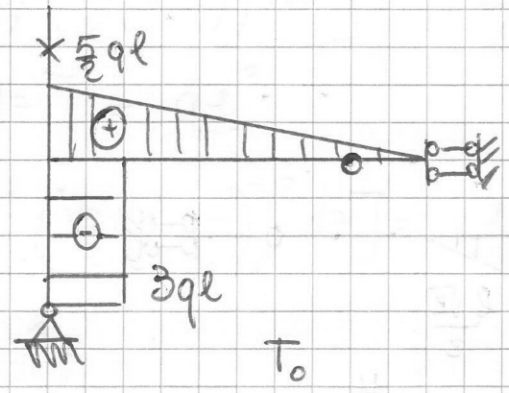
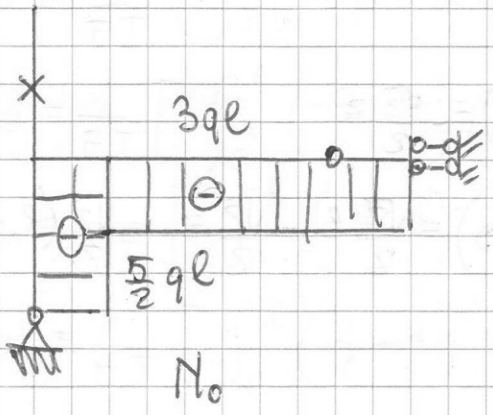
$\uparrow) V_A = \frac{5}{2} ql$

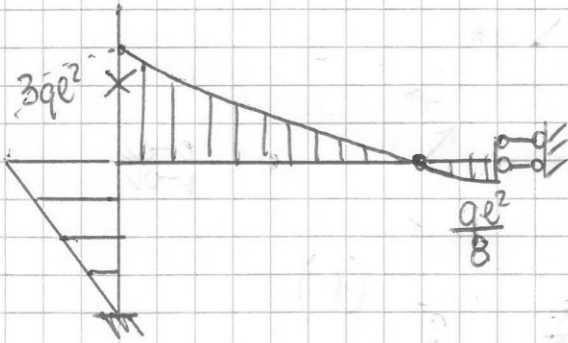
$E \curvearrowright) M_B = \frac{ql^2}{8}$

$E \curvearrowright) -V_A \cdot 2l + H_A \cdot l + 2ql^2 = 0$

$H_A = 3ql$

$\rightarrow) H_B = -3ql$





$$M_0(z_1) = -3qlz$$

$$M_0(z_2) = 0$$

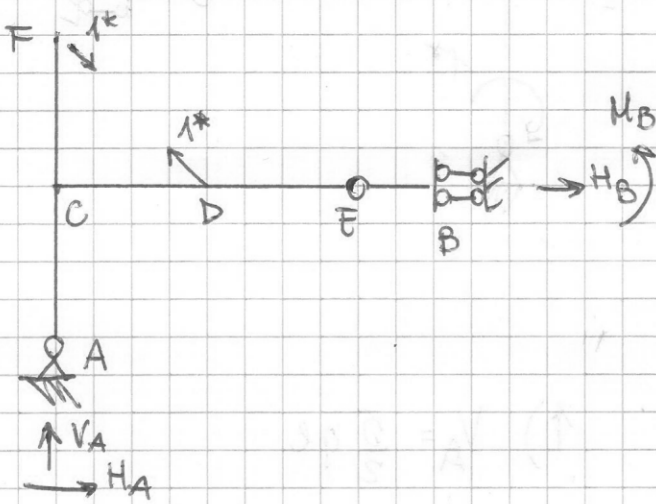
$$M_0(z_3) = -3ql^2 + \frac{5}{2}qlz - \frac{qz^2}{2}$$

$$M_0(z_4) = -ql^2 + \frac{5}{2}qlz - \frac{qz^2}{2}$$

$$M_0(z_5) = \frac{ql^2}{8} - \frac{qz^2}{2}$$

$$M_0(z_6) = -\frac{qz}{2}(z+l)$$

SISTEMA (1)

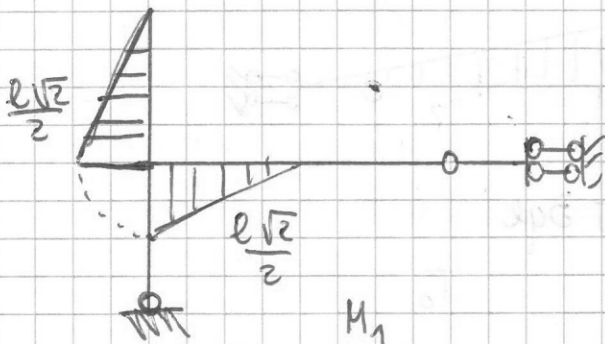
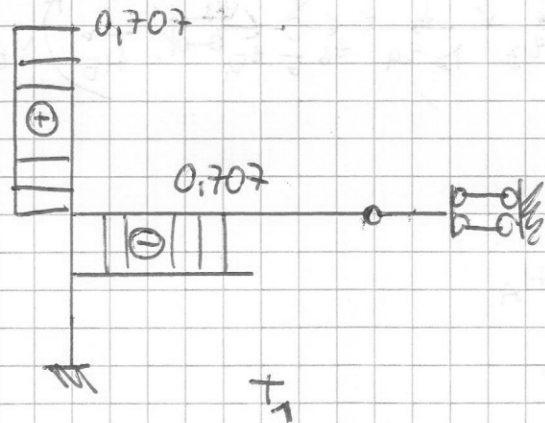
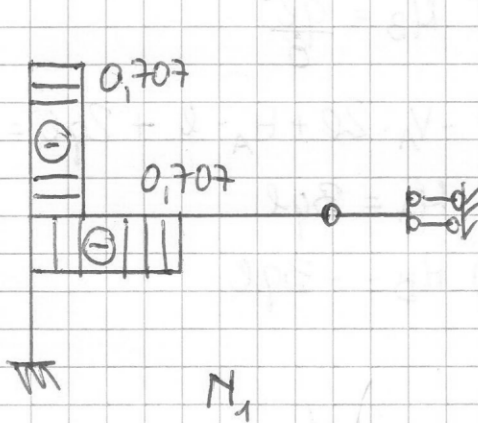


$$\uparrow) V_A = 0$$

$$\rightarrow) M_B = 0$$

$$\rightarrow) H_A = 0$$

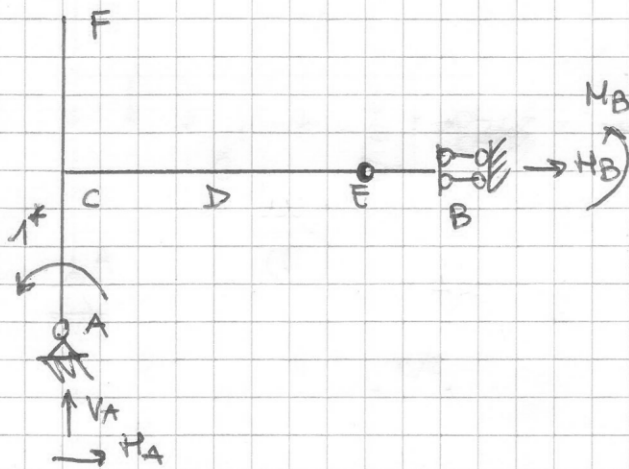
$$\rightarrow) H_B = 0$$



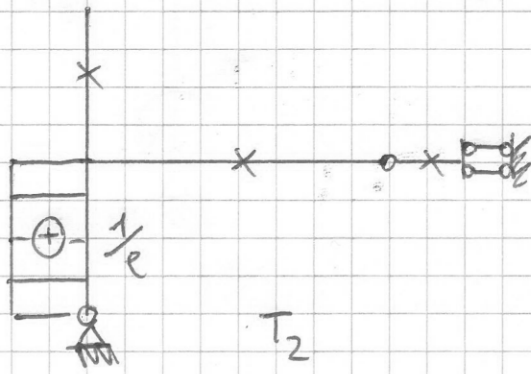
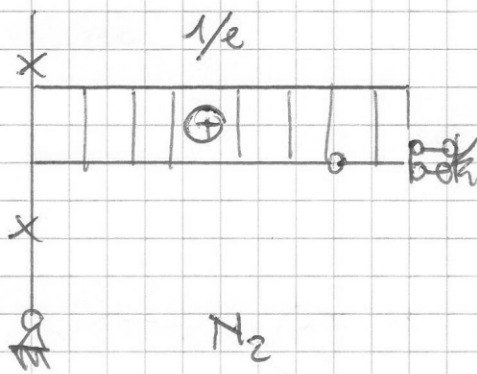
$$M_1(z_2) = -\frac{\sqrt{2}}{2}z$$

$$M_1(z_3) = \frac{\sqrt{2}}{2}l - \frac{\sqrt{2}}{2}z = \frac{\sqrt{2}}{2}(l-z)$$

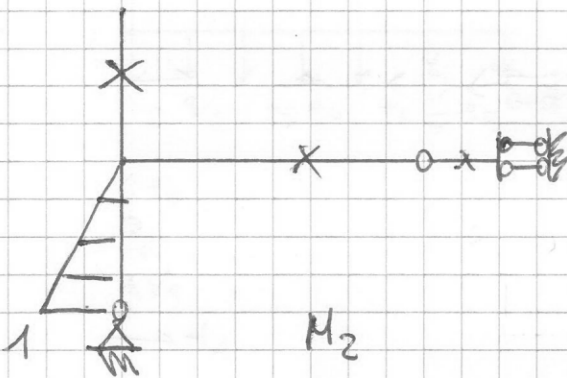
SISTEMA 2



$$\begin{aligned} \uparrow) V_A &= 0 \\ \rightarrow) H_B &= 0 \\ \uparrow) 1 + H_A \cdot l &= 0 \\ H_A &= -\frac{1}{l} \\ \rightarrow) H_B &= \frac{1}{l} \end{aligned}$$



$$M_2(z_1) = -1 + \frac{z}{l}$$



$$M_{10} = \frac{1}{EJ} \left[\int_0^l \left(-3ql^2 + \frac{\sqrt{2}}{2} qlz - \frac{qz^2}{2} \right) \left(\frac{\sqrt{2}}{2} (l-z) \right) dz \right] = -\frac{9\sqrt{2}ql^4}{16EJ}$$

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

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

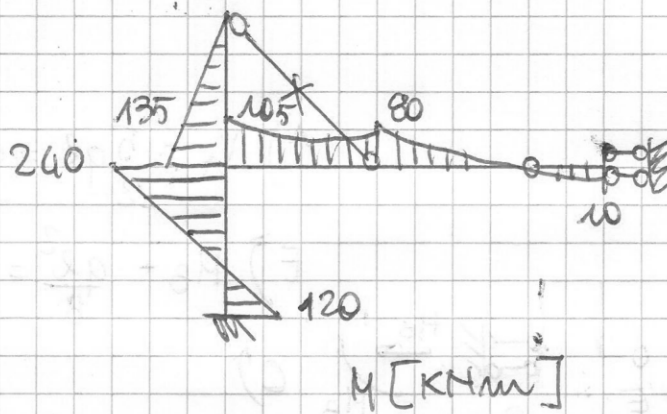
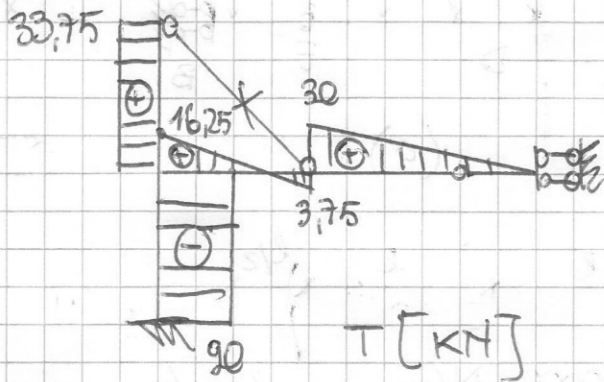
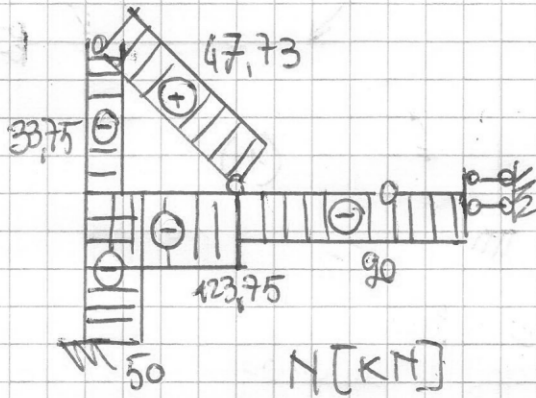
$$M_{22} = \frac{1}{EJ} \left[\int_0^l \left(\frac{z}{l} - 1 \right)^2 dz \right] = \frac{l}{3EJ}$$

$$M_{12} = 0$$

$$(1) \rightarrow \begin{cases} X_1 M_{11} + M_{10} = 0 \\ (2) \rightarrow \begin{cases} X_2 M_{22} + M_{20} = 0 \end{cases} \end{cases}$$

$$X_1 = \frac{27}{16} ql = 47,73 \text{ KN}$$

$$X_2 = -\frac{3}{2} ql^2 = 120 \text{ kNm}$$



$$2) M_c = 240 \text{ kNm}$$

$$N_c = -50 \text{ KN}$$

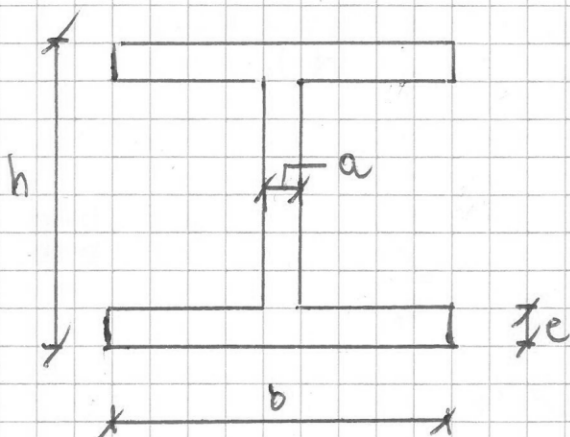
$$T_c = -90 \text{ KN}$$

$$\sigma_{adm} = 190 \text{ MPa}$$

$$E = 210000 \text{ MPa}$$

$$W_{min} = \frac{240 \cdot 10^6}{190} = 1263 \text{ cm}^3$$

ADATTO IPE 450



$$h = 450 \text{ mm}$$

$$b = 190 \text{ mm}$$

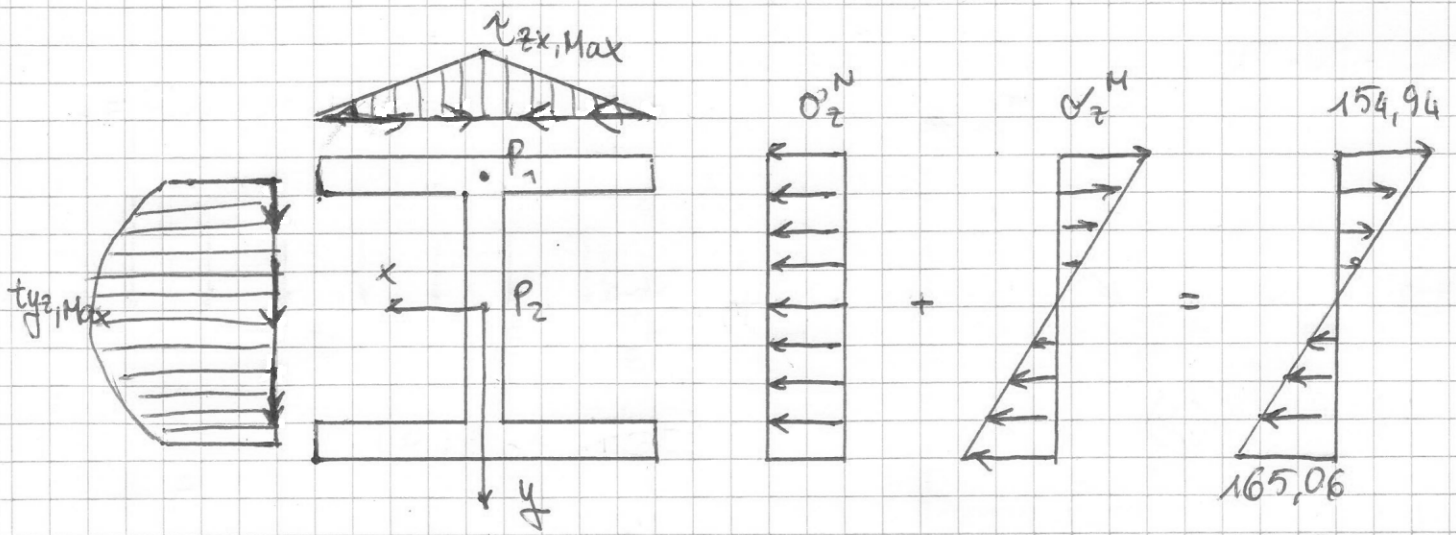
$$e = 14,6 \text{ mm}$$

$$a = 9,4$$

$$A = 98,82 \text{ cm}^2$$

$$W_x = 1500 \text{ cm}^3$$

$$J_x = 33740 \text{ cm}^4$$



$$\sigma_{z, max} = \sigma_z^N + \sigma_z^M = \frac{N}{A} + \frac{M}{W_x} = \frac{-50 \cdot 10^3}{9882} + \frac{240 \cdot 10^6}{1500 \cdot 10^3} = 154,94 - 165,06$$

$$\tau_{zs} = -\frac{T_y \cdot S_x^*}{I_y \cdot J_x}$$

$$\tau_{zx, Max} = -\frac{90000}{8} \cdot \frac{(8 \cdot (-190) \cdot 0,5^2 (450 - 8))}{33740 \cdot 10000} = 5,6 \text{ N/mm}^2$$

$$\tau_{zy, Max} = -\frac{90000}{14,6 \cdot 33740 \cdot 10000} \cdot (8 \cdot (-190) \cdot (450 - 8) \cdot 0,5 + 14,6 \cdot (450 - 16) \cdot 0,5 \cdot (-1)) = 37,4 \text{ N/mm}^2$$

$$\sigma_{id, P_1} = \sqrt{\sigma_{z, P_1}^2 + 3 \tau_{z, P_1}^2} = \sqrt{165,06^2 + 3 \cdot 5,6^2} = 165,3 < 190 \text{ MPa}$$

$$\sigma_{id, P_2} = \sqrt{\sigma_{z, P_2}^2 + 3 \tau_{z, P_2}^2} = \sqrt{2,53^2 + 3 \cdot 37,4^2} = 64,8 < 190 \text{ MPa}$$

$$3) \quad M_{11}^{TOT} = M_{11}^M + M_{11}^N = \frac{l}{3EJ} + \int_0^{l\sqrt{2}} \frac{1^2}{EA} dz = \frac{l}{3EJ} + \frac{l\sqrt{2}}{EA}$$

$$(1) \rightarrow \left\{ \begin{array}{l} X_1 \cdot M_{11}^{TOT} + M_{10} + \int_0^{l\sqrt{2}} (1) \alpha \Delta t dz = 0 \\ X_2 \cdot M_{22} + M_{20} = 0 \end{array} \right.$$

$$\Delta t = -30^\circ \quad \begin{array}{l} X_1 = 540 \text{ kN} \\ X_2 = 120 \text{ kNm} \end{array}$$

