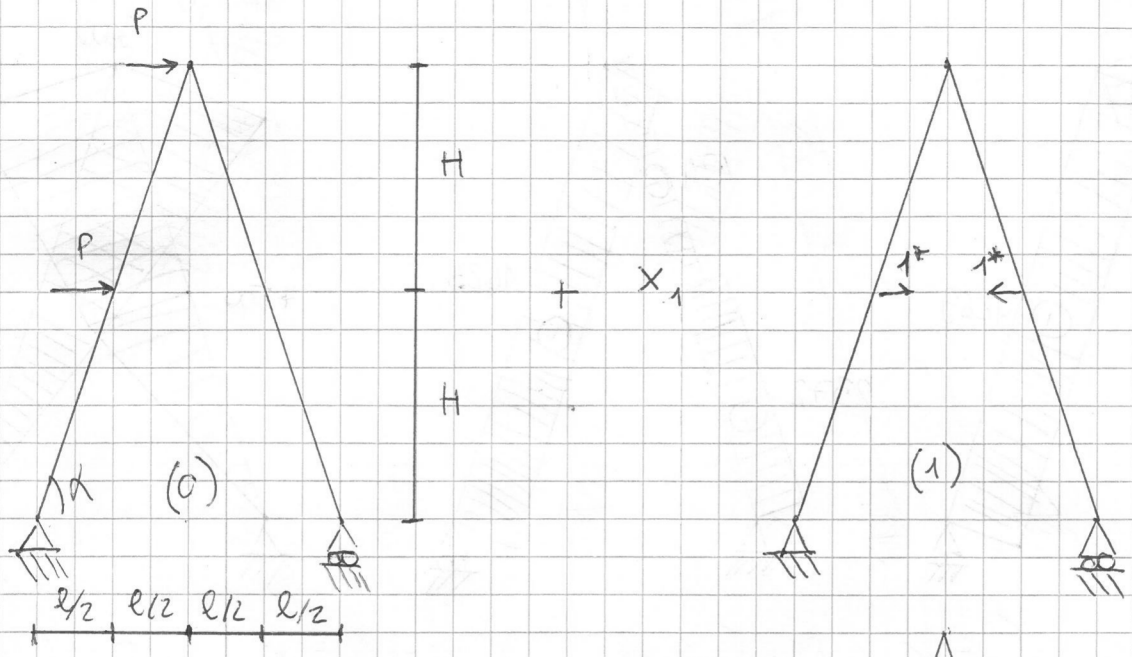
30/05/18



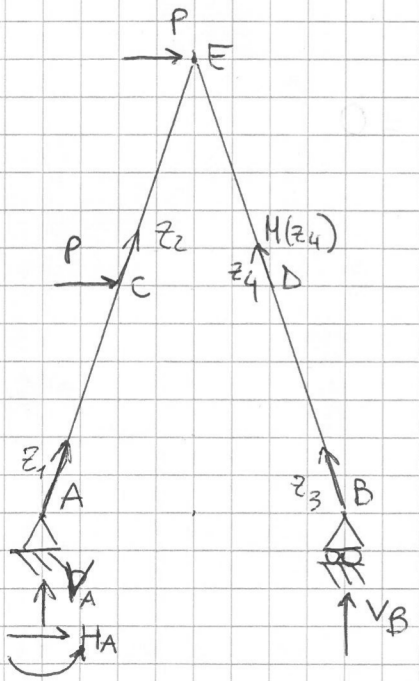

$\ell = 2\,m$

$h = \frac{3}{2}\ell$

$P = 2000\,N$

$\alpha = \arctan\left(\frac{3\ell}{\ell}\right) \approx 71,57°$

1) SISTEMA (0)

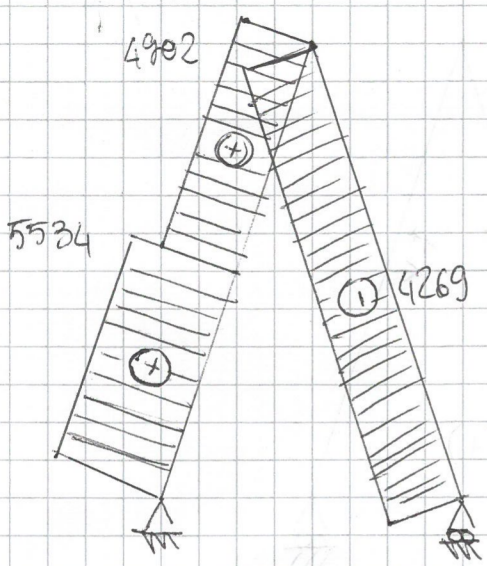


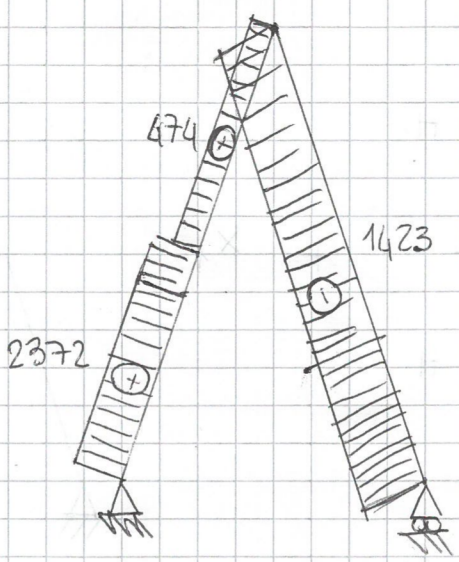

$\rightarrow) H_A = -2P$

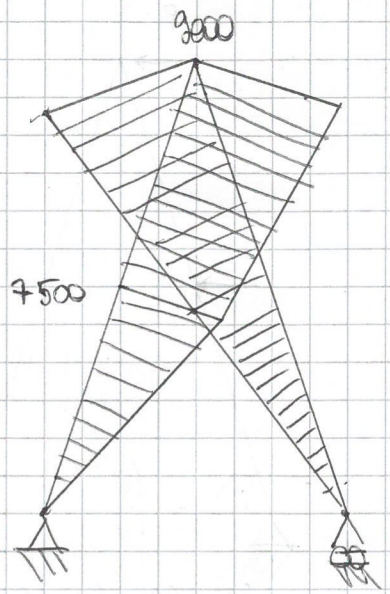
$A\circlearrowleft) \; P\frac{3}{2}\ell + P \cdot 3\ell - V_B \cdot 2\ell = 0$

$V_B = \frac{9}{4}P$

$\uparrow) \; V_A = -\frac{9}{4}P$




$$N_0(z_1) = 2P\cdot\cos\alpha + \frac{9}{4}P\cdot\operatorname{sen}\alpha \qquad T_0(z_1) = 2P\operatorname{sen}\alpha - \frac{9}{4}P\cos\alpha$$

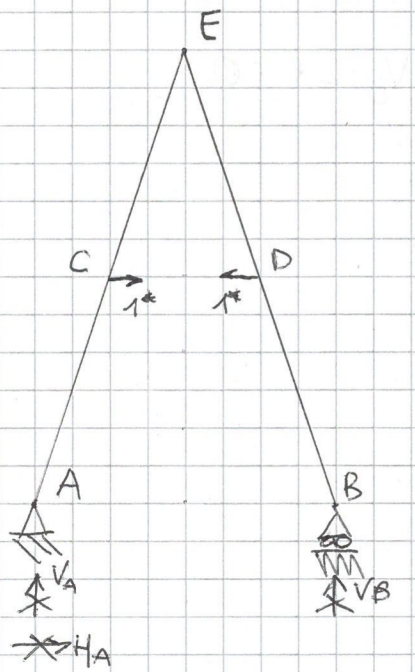
$$N_0(z_2) = 2P\cos\alpha + \frac{9}{4}P\operatorname{sen}\alpha - P\cos\alpha \qquad T_0(z_2) = 2P\operatorname{sen}\alpha - \frac{9}{4}P\cos\alpha - P\operatorname{sen}\alpha$$

$$N_0(z_3) = -\frac{9}{4}P\operatorname{sen}\alpha = N_0(z_4) \qquad T_0(z_3) = -\frac{9}{4}P\cdot\cos\alpha = T_0(z_4)$$

$$M_0(z_1) = 2P\operatorname{sen}\alpha\, z - \frac{9}{4}P\cos\alpha\, z \qquad M_0(z_2) = \frac{15}{8}Pl + P\operatorname{sen}\alpha\, z - \frac{9}{4}P\cos\alpha\, z$$

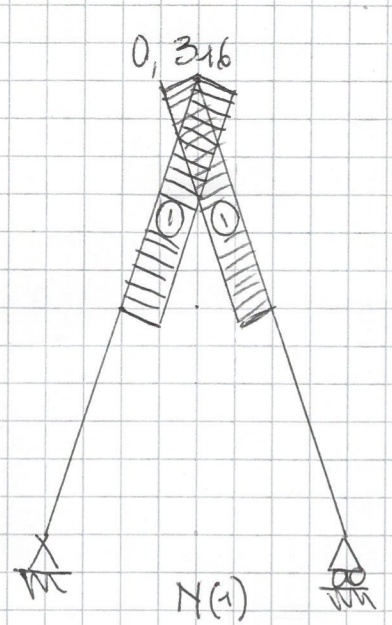
$$M_0(z_3) = \frac{9}{4}P\cos\alpha\, z \qquad M_0(z_4) = \frac{9}{8}Pl + \frac{9}{4}P\cos\alpha\, z$$

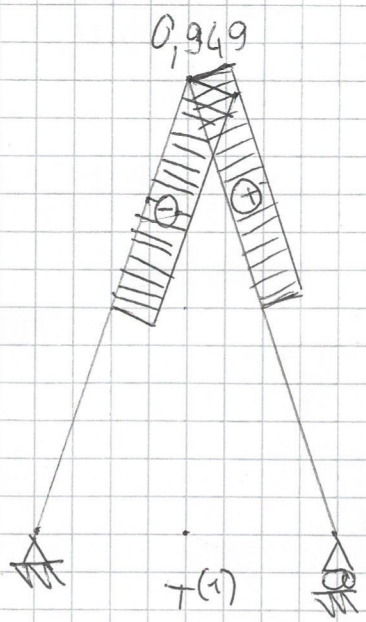
SISTEMA (1)

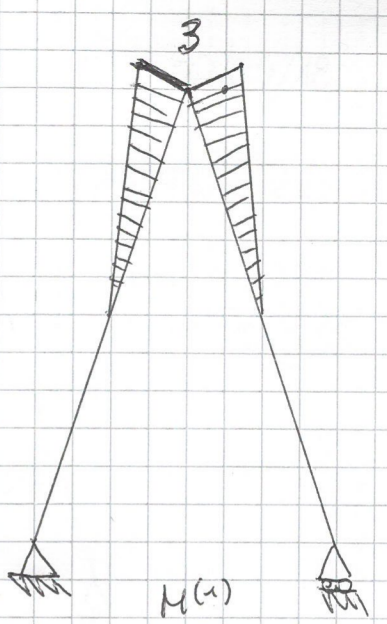



$\rightarrow) H_A = 0$

A) $V_B = 0$ $\qquad \uparrow) V_A = 0$



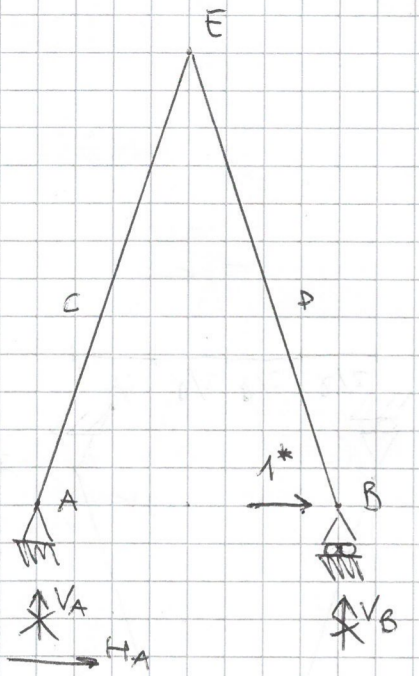




$N_1(z_1) = 0$ $\quad N(z_2) = -\cos\alpha$ $\quad N_1(z_3) = 0$ $\quad N_1(z_4) = -\cos\alpha$

$T_1(z_1) = 0$ $\quad T_1(z_2) = -\operatorname{sen}\alpha$ $\quad T_1(z_3) = 0$ $\quad T_1(z_4) = \operatorname{sen}\alpha$

$M_1(z_1) = 0$ $\quad M_1(z_2) = -\operatorname{sen}\alpha z$ $\quad M_1(z_3) = 0$ $\quad M_1(z_4) = -\operatorname{sen}\alpha z$

SISTEMA (2)



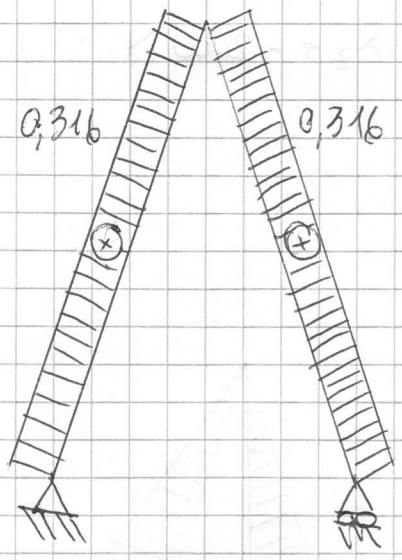

$\rightarrow) \; H_A = -1$

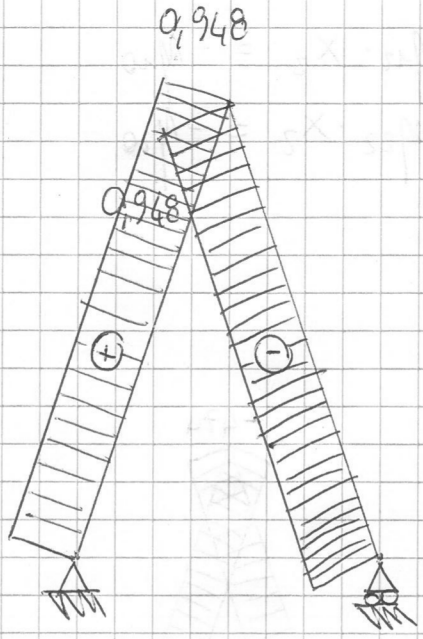
$A\uparrow) \; V_B = 0$

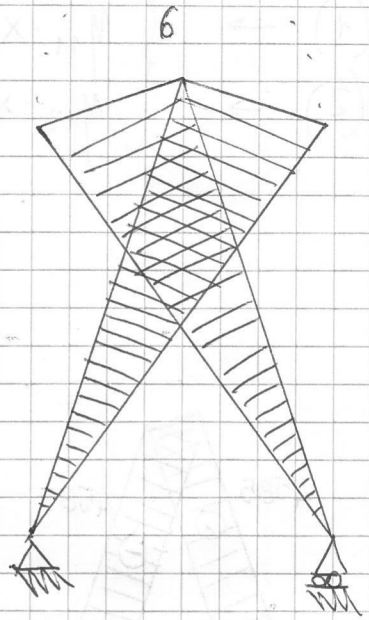
$\uparrow) \; V_A = 0$

$N_2(z_1) = N_2(z_2) = \cos\alpha$ $\quad N_2(z_3) = N_2(z_4) = \cos\alpha$

$T_2(z_1) = T_2(z_2) = \operatorname{sen}\alpha$ $\quad T_2(z_3) = T_2(z_4) = -\operatorname{sen}\alpha$




$$M_2(z_1) = \operatorname{sen}\alpha z \qquad M_2(z_2) = \frac{3}{2}\ell + \operatorname{sen}\alpha z \qquad M_2(z_3) = \operatorname{sen}\alpha z$$

$$M_2(z_4) = \frac{3}{2}\ell + \operatorname{sen}\alpha z$$

$$\eta_{10} = \frac{1}{EJ}\left[\int_0^{\frac{\ell}{2\cos\alpha}} (-\operatorname{sen}\alpha z)\left(\frac{15}{8}P\ell + P\operatorname{sen}\alpha z - \frac{9}{4}P\cos\alpha z\right) + \right.$$

$$\left. + \int_0^{\frac{\ell}{2\cos\alpha}} (-\operatorname{sen}\alpha z)\left(\frac{9}{8}P\ell + \frac{9}{4}P\cos\alpha z\right) dz\right] = -\frac{3\sqrt{10}\,P\ell^3}{2EJ}$$

$$\eta_{20} = \frac{1}{EJ}\left[\int_0^{\frac{\ell}{2\cos\alpha}} (\operatorname{sen}\alpha z)\left(2P\operatorname{sen}\alpha z - \frac{9}{4}P\cos\alpha z\right) dz + \int_0^{\frac{\ell}{2\cos\alpha}} (\operatorname{sen}\alpha z)\left(\frac{9}{4}P\cos\alpha z\right) + \right.$$

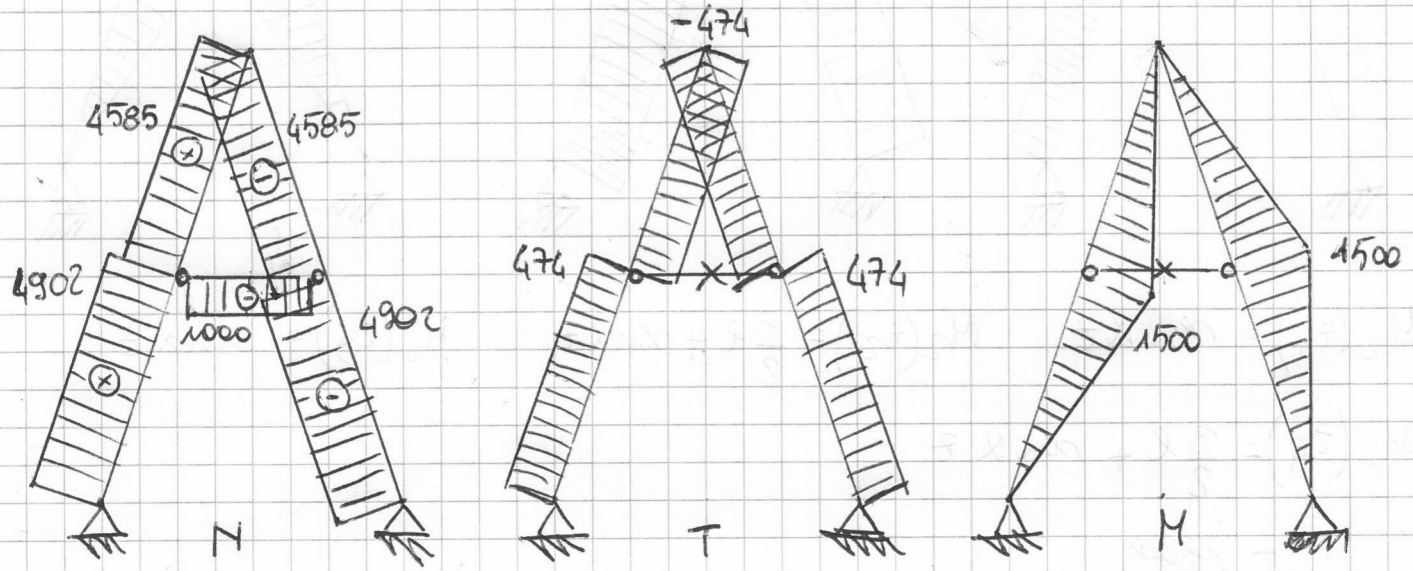
$$\left. + \int_0^{\frac{\ell}{2\cos\alpha}} \left(\frac{3}{2}\ell + \operatorname{sen}\alpha z\right)\left(\frac{15}{8}P\ell + P\operatorname{sen}\alpha z - \frac{9}{4}P\cos\alpha z\right) dz\right] = \frac{81\sqrt{10}\,P\ell^3}{16EJ}$$

$$\eta_{11} = \frac{1}{EJ}\left[2\int_0^{\frac{\ell}{2\cos\alpha}} (-\operatorname{sen}\alpha z)^2\, dz\right] = \frac{3\sqrt{10}\,\ell^3}{4EJ}$$

$$\eta_{22} = \frac{1}{EJ}\left[2\int_0^{\frac{\ell}{\cos\alpha}} (\operatorname{sen}\alpha z)^2 dz\right] = \frac{6\sqrt{10}\,\ell^3}{EJ}$$

$$\eta_{12} = \frac{1}{EJ}\left[2\int_0^{\frac{\ell}{2\cos\alpha}} (-\operatorname{sen}\alpha z)\left(\frac{3}{2}\ell + \operatorname{sen}\alpha z\right) dz\right] = -\frac{15\sqrt{10}\,\ell^3}{8EJ}$$

$$(1) \rightarrow \begin{cases} \eta_{11} \cdot X_1 + \eta_{12} \cdot X_2 = -\eta_{10} \\ (2) \rightarrow \\ \eta_{12} \cdot X_1 + \eta_{22} \cdot X_2 = -\eta_{20} \end{cases} \qquad X_1 = -1000\ N \qquad X_2 = -2000\ N$$




2) IPE 200 $A = 28{,}48\ cm^2$ $I_x = 1943\ cm^4$ $E = 210\,000\ MPa$

$\Delta_u^A = -1\ cm = -0{,}01\ m$

$$\eta_{11}^{TOT} = \frac{3\sqrt{10}\,\ell^3}{4EJ} + \frac{1}{EA}\int_0^\ell (1)^2\,dz = \frac{3\sqrt{10}\,\ell^3}{4EJ} + \frac{\ell}{EA}$$

$$1) \rightarrow L_{VE} = V_A^{(1)} \cdot \Delta_{u_i}^A = 0 \cdot (-0{,}01) = L_{V_i} = \eta_{11}^{TOT} \cdot X_1 + \eta_{12} \cdot X_2 + \eta_{10} = 0$$

$$2) \rightarrow L_{VE} = V_A^{(2)} \cdot \Delta_u^A = 0 \cdot (-0{,}01) = L_{V_i} = \eta_{12} \cdot X_1 + \eta_{22} \cdot X_2 + \eta_{20} = 0$$

$X_1 = -999{,}98\ N \qquad X_2 = -2000\ N$

La deformabilità assiale della biella e il cedimento in A non influiscono significativamente sulle sollecitazioni della struttura