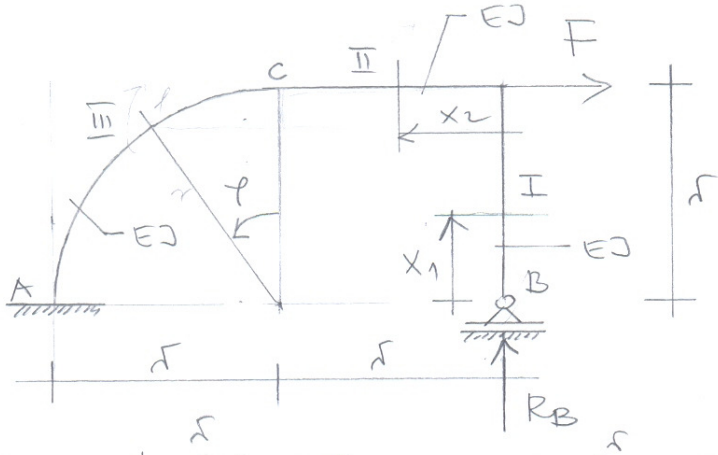
2. A) $EJ = \text{const}$ $\quad M, T, N = ?$

$F = 50\ kN$

$r = 2\ m$



$$E_p = E_p^{I} + E_p^{II} + E_p^{III}$$

$$\frac{\partial E_p}{\partial R_B} = 0$$

$$\frac{\partial E_p}{\partial R_B} = \frac{1}{EJ}\int_0^r M_{x_1}\frac{\partial M_{x_1}}{\partial R_B}dx + \frac{1}{EJ}\int_0^r M_{x_2}\frac{\partial M_{x_2}}{\partial R_B}dx + \frac{1}{EJ}\int_0^{\pi/2} M_\varphi \frac{\partial M_\varphi}{\partial R_B} r\,d\varphi = 0$$

$M_{x_1} = 0 \qquad M_{x_2} = R_B \cdot x_2 \qquad M_\varphi = R_B \cdot r(1+\sin\varphi) - F \cdot r(1-\cos\varphi)$

$\frac{\partial M_{x_1}}{\partial R_B} = 0 \qquad \frac{\partial M_{x_2}}{\partial R_B} = x_2 \qquad \frac{\partial M_\varphi}{\partial R_B} = r(1+\sin\varphi)$

$$\int_0^r R_B x_2^2\,dx + \int_0^{\pi/2}\left[R_B \cdot r(1+\sin\varphi) - F \cdot r(1-\cos\varphi)\right] r(1+\sin\varphi)\, r\,d\varphi = 0$$

$$R_B \cdot \frac{r^3}{3} + R_B \cdot r^3 \int_0^{\pi/2}(1+2\sin\varphi+\sin^2\varphi)\,d\varphi - F \cdot r^3 \int_0^{\pi/2}(1+\sin\varphi-\cos\varphi-\sin\varphi\cos\varphi)\,d\varphi = 0$$

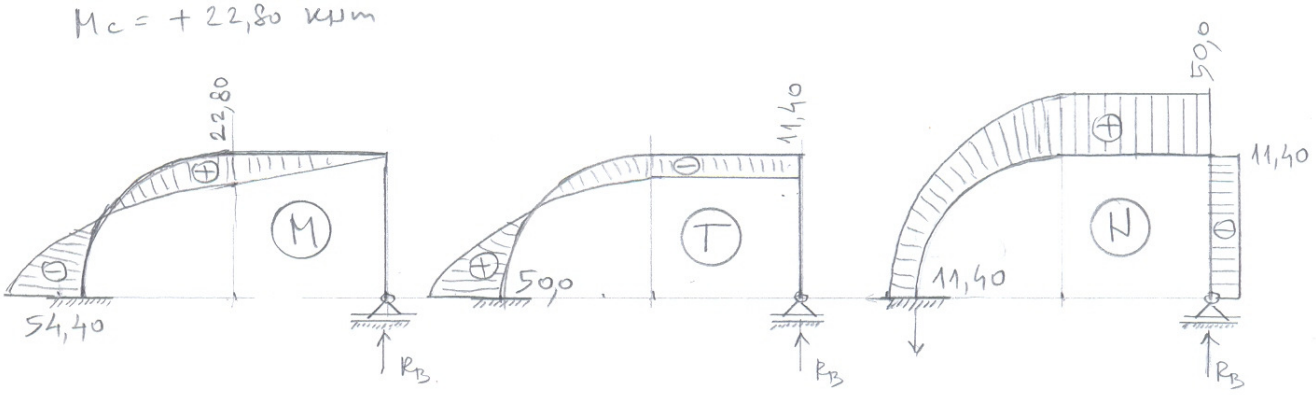
$$\frac{R_B}{3} + R_B\left(\frac{\pi}{2} + 2\cdot 1 + \pi/4\right) = F\left(\frac{\pi}{2} + 1 - 1 - \frac{1}{2}\right)$$

$$4{,}6895 \cdot R_B = 1{,}0708 \cdot F \rightarrow R_B = 0{,}228 \cdot F$$

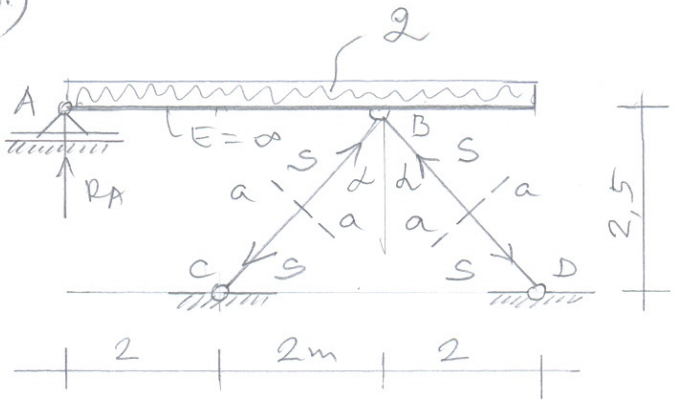
$$R_B = \underline{11{,}40\ kN}$$

$M_A = -54{,}40\ kNm$

$M_C = +22{,}80\ kNm$



3.)



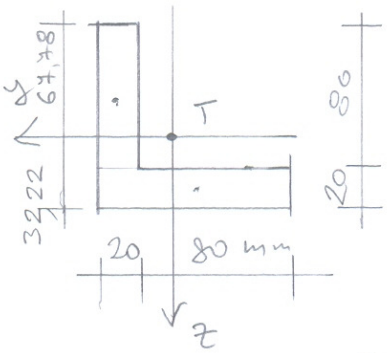
$q = 7\ kN/m'$ $k_i = ?$

$\sigma_p = 210\ MPa$

$E = 2 \cdot 10^5\ MPa$

$\alpha = 38,66°$

$R_A = 10,5\ kN$



$A = 3600\ mm^2$

$z_T = y_T = 32,22\ mm$

$$J_y = J_z = \frac{100 \cdot 20^3}{12} + 100 \cdot 20 \cdot 22,22^2 + \frac{20 \cdot 80^3}{12} + 20 \cdot 80 \cdot 27,78^2 = 3,142 \cdot 10^6\ mm^4$$

$$J_{yz} = 100 \cdot 20\,(+22,22)(-17,78) + 80 \cdot 20\,(-27,78)(+22,22)$$

$$J_{yz} = -1,778 \cdot 10^6\ mm^4$$

$$J_{min} = J_y - |J_{yz}| = 1,364 \cdot 10^6\ mm^4$$

$$S_{kritT} = \frac{\pi^2 \cdot E \cdot J_{min}}{l_i^2} = \underline{\underline{262,67\ kN}}$$

$$l_i = l = \sqrt{2^2 + 2,5^2} = 3,2016\ m$$

$$\Sigma M_A = 0 \qquad q \cdot 6 \cdot 3 = S \cdot \cos\alpha \cdot 2 \cdot 4 \rightarrow \underline{\underline{S = 20,17\ kN}}$$

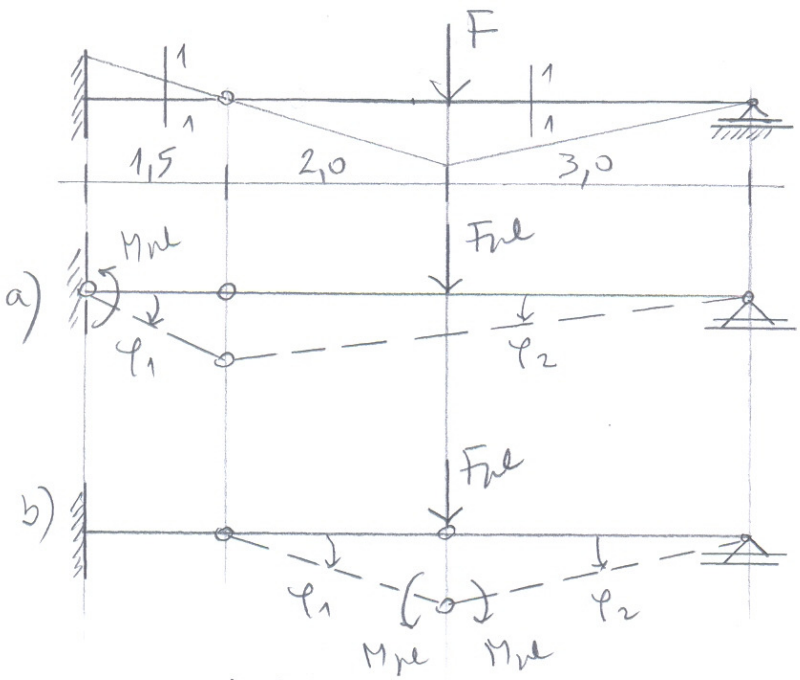
$$k_i = \frac{S_{kritT}}{S} = \underline{\underline{13,02}}$$

$$i_{min} = \sqrt{\frac{J_{min}}{A}} = 19,46\ mm \qquad \lambda = \frac{l_i}{i_{min}} = 164,5$$

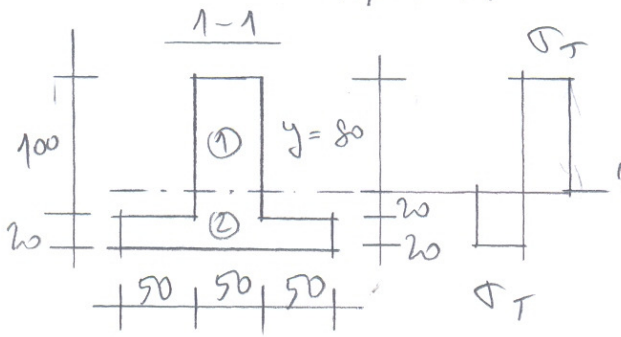
$$\lambda_p = \sqrt{\frac{\pi^2 \cdot E}{\sigma_p}} = 97 \qquad \lambda > \lambda_p$$

5.) $\sigma_T = 250\ MPa$ $F_{dop} = ?$

$k = 1,6$



$$F_{dop} = \frac{F_{plmin}}{k} = \underline{\underline{33,85\ kN}}$$



$A = 8000\ mm^2$

$M.O.\ \ y = 80\ mm$

$W_{pl} = S_1 + S_2 = 80 \cdot 50 \cdot 40 + 20 \cdot 50 \cdot 10 + 150 \cdot 20 \cdot 30 =$

$W_{pl} = 26 \cdot 10^4\ mm^3$

$M_{pl} = W_{pl} \cdot \sigma_T = 65\ kNm$

a) $\sum A = F_{pl} \cdot \varphi_2 \cdot 3 - M_{pl} \cdot \varphi_1 = \emptyset$ $\quad \varphi_1 \cdot 1,5 = \varphi_2 \cdot 5$

$F_{pl} \cdot 0,3 \cdot 3 = M_{pl}$ $\quad \varphi_2 = 0,3 \cdot \varphi_1$

$$F_{pl} = \frac{M_{pl}}{0,9} = \underline{\underline{72,22\ kN}}$$

b) $\sum A = F_{pl} \cdot \varphi_1 \cdot 2 - M_{pl} \cdot \varphi_1 - M_{pl} \cdot \varphi_2 = \emptyset$ $\quad \varphi_1 \cdot 2 = \varphi_2 \cdot 3$

$F_{pl}\ 2 = M_{pl} + M_{pl} \frac{2}{3}$ $\quad \varphi_2 = \frac{2}{3} \varphi_1$

$$F_{pl} = \frac{1,667 \cdot M_{pl}}{2} = \frac{M_{pl}}{1,2} = \underline{\underline{54,17\ kN}} = F_{plmin}$$