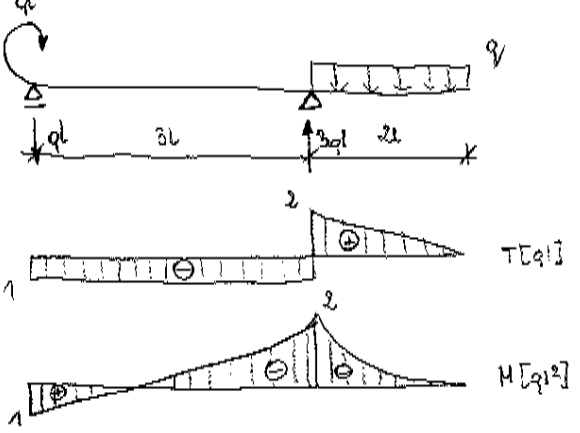


$T_{max} = 2ql$ $\quad R = 175\ MPa$

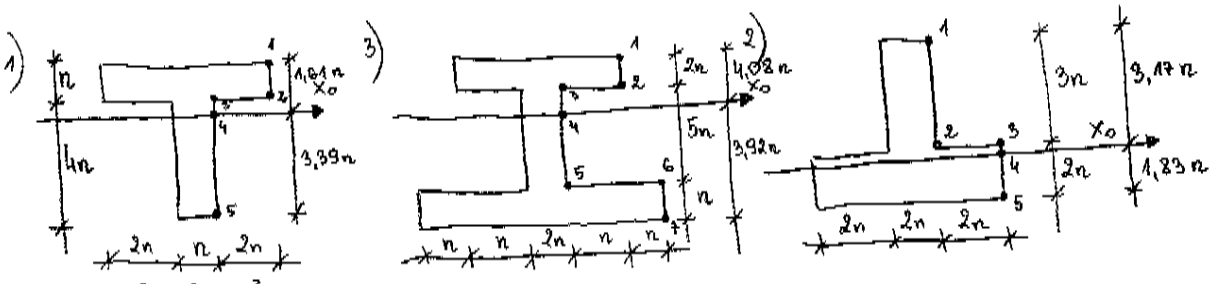
$M_{max} = 2ql^2$ $\quad R_t = 105\ MPa$

$q = 3\ kN/m$

$l = 4\ m$

$T_{max} = 2ql = 2 \cdot 3\ kN/m \cdot 4m = 24\ kN$

$M_{max} = 2ql^2 = 2 \cdot 3\ kN/m \cdot (4m)^2 = 96\ kNm$



$A = 4n^2 + 5n^2 = 9n^2$

1) $S_x = 4n^2 \cdot 2n + 5n^2 \cdot 4,5n = 30,5\,n^3$

$y_0 = 3,39\,n$

$J_{x_0} = \left(\frac{n \cdot (4n)^3}{12} + (2n - 3,39n)^2 \cdot 4n^2\right) + \left(\frac{5n \cdot n^3}{12} + (4,5n - 3,39n)^2 \cdot 5n^2\right) = 19,64\,n^4$

$W_x^g = \frac{J_{x_0}}{y^g} = 12,2\,n^3$

$W_x^d = \frac{J_{x_0}}{y^d} = 5,79\,n^3 = W_{x\,min}$

$\sigma_{max} = \frac{M_{max}}{W_{x\,min}} \leq R$

$\frac{96\ kNm}{5,79\,n^3} \leq 175\ MPa \Rightarrow \frac{9600\ kNcm}{5,79\,n^3} \leq 17,5\ \frac{kN}{cm^2} \Rightarrow 5,79\,n^3 \geq \frac{9600\ kNcm}{17,5\ kN/cm^2} \Rightarrow n^3 \geq 94,74\ cm^3$

$n \geq 4,56\ cm$ $\qquad n = 4,6\ cm$

$\tau_{max} = \frac{T_{max} \cdot \bar{S}_x}{J_{x_0} \cdot b} \leq R_t$

$\tau_{max} = \tau_4 = \frac{24\ kN \cdot (5n^2 \cdot 1,11n + 0,61n^2 \cdot 0,305n)}{19,64\,n^4 \cdot n} = \frac{137,66\ kN \cdot n^3}{19,64\,n^5} = \frac{137,66\ kN}{19,64\,n^2} \leq 105\ MPa$

$\frac{137,66\ kN}{19,64\,n^2} \leq 10,5\ \frac{kN}{cm^2} \Rightarrow 19,64\,n^2 \geq \frac{137,66\ kN}{10,5\ kN/cm^2} \Rightarrow n^2 \geq 0,667\ cm^2 \Rightarrow n \geq 0,82\ cm$

$\sigma^g = \frac{M_{max}}{W_x^g} = \frac{96\ kNm}{12,2\,n^3} = \frac{9600\ kNcm}{12,2 \cdot (4,6\ cm)^3} = 8,084\ kN/cm^2 = 80,84\ MPa$

$\sigma^d = \frac{M_{max}}{W_x^d} = \frac{96\ kNm}{5,79\,n^3} = \frac{9600\ kNcm}{5,79 \cdot (4,6\ cm)^3} = 17,034\ kN/cm^2 = 170,34\ MPa$

$\tau_1 = 0$

$\tau_2 = \frac{24\ kN \cdot (5n^2 \cdot 1,11n)}{5n \cdot 19,64\,n^4} = 0,064\ kN/cm^2 = 0,64\ MPa$

$\tau_3 = \frac{24\ kN \cdot (5n^2 \cdot 1,11n)}{n \cdot 19,64\,n^4} = 0,32\ kN/cm^2 = 3,2\ MPa$

$\tau_4 = \tau_{max} = 0,331\ kN/cm^2 = 3,31\ MPa$

2) $A = 12n^2 + 6n^2 = 18n^2$

$S_x = 12n^2 \cdot n + 6n^2 \cdot 3{,}5n = 33n^3$

$y_o = 1{,}83n$

$J_{x_o} = \left(\frac{6n \cdot (2n)^3}{12} + (n - 1{,}83n)^2 \cdot 12n^2\right) + \left(\frac{2n \cdot (3n)^3}{12} + (3{,}5n - 1{,}83n)^2 \cdot 6n^2\right) = 33{,}5n^4$

$W_x^s = \frac{J_{x_o}}{y^s} = \frac{33{,}5n^4}{3{,}17n} = 10{,}57n^3$

$W_x^d = \frac{J_{x_o}}{y^d} = \frac{33{,}5n^4}{1{,}83n} = 18{,}31n^3$

$\sigma_{max} = \frac{M_{max}}{W_{x_{min}}} \leq R$

$\frac{96\,kNm}{10{,}57n^3} \leq 17{,}5\,\frac{kN}{cm^2}$ $\quad n^3 \geq 51{,}9\,cm^3$ $\quad n \geq 3{,}73\,cm$

$\tau_{max} = \tau_2 = \frac{T_{max} \cdot S_x}{b \cdot J_{x_o}} \leq R_t$

$\frac{24\,kN \cdot (6n^2 \cdot 1{,}67n)}{2n \cdot 33{,}5n^4} \leq 10{,}5\,\frac{kN}{cm^2}$ $\quad n^2 \geq 0{,}34\,cm^2$ $\quad n \geq 0{,}58\,cm$

$n = 3{,}8\,cm$

$\sigma^s = \frac{M_{max}}{W_x^s} = \frac{96\,kNm}{10{,}57 \cdot (3{,}8cm)^3} = 16{,}552\ kN/cm^2 = 165{,}52\ MPa$

$\sigma^d = \frac{M_{max}}{W_x^d} = \frac{96\,kNm}{18{,}31 \cdot (3{,}8cm)^3} = 9{,}555\ kN/cm^2 = 95{,}55\ MPa$

$\tau_1 = 0$

$\tau_2 = \tau_{max} = 0{,}248\ kN/cm^2 \cong 2{,}48\ MPa$

$\tau_3 = \frac{24\,kN \cdot (6n^2 \cdot 1{,}67n)}{6n \cdot 33{,}5n^4} = 0{,}082\ kN/cm^2 = 0{,}82\ MPa$

$\tau_4 = \frac{24\,kN \cdot (6n \cdot 1{,}83n \cdot 0{,}915n)}{6n \cdot 33{,}5n^4} = 0{,}083\ kN/cm^2 = 0{,}83\ MPa$

3) $A = 6n^2 + 10n^2 + 8n^2 = 24n^2$

$S_x = 6n^2 \cdot 0{,}5n + 10n^2 \cdot 3{,}5n + 8n^2 \cdot 7n = 94n^3$

$y_o = 3{,}92n$

$J_{x_o} = \left(\frac{6n \cdot n^3}{12} + (0{,}5n - 3{,}92n)^2 \cdot 6n^2\right) + \left(\frac{2n \cdot (5n)^3}{12} + (3{,}5n - 3{,}92n)^2 \cdot 10n^2\right) + \left(\frac{4n \cdot (2n)^3}{12} + (7n - 3{,}92n)^2 \cdot 8n^2\right) = 171{,}83n^4$

$W_x^s = \frac{J_{x_o}}{y^s} = 42{,}11n^3$

$W_x^d = \frac{J_{x_o}}{y^d} = 43{,}83n^3$

$\sigma_{max} = \frac{96\,kNm}{42{,}11n^3} \leq 17{,}5\,\frac{kN}{cm^2} \Rightarrow n^3 \geq 13{,}03\,cm^3$ $\quad n \geq 2{,}35\,cm$

$\tau_{max} = \frac{24\,kN \cdot (8n^2 \cdot 3{,}08n + 2n \cdot 2{,}08n \cdot 1{,}04n)}{2n \cdot 171{,}83n^4} = \frac{695{,}19\,kNn^3}{343{,}66n^5} \leq 10{,}5\,\frac{kN}{cm^2} \Rightarrow \frac{2{,}023\,kN}{n^2} \leq 10{,}5\,\frac{kN}{cm^2} \Rightarrow n^2 \geq 0{,}19cm^2$

$n \geq 0{,}44\,cm$ $\quad n = 2{,}4\,cm$

$\sigma^s = 164{,}91\ MPa$ $\quad \sigma^d = 158{,}44\ MPa$

$\tau_2 = 1{,}49\ MPa$ $\quad \tau_5 = 2{,}49\ MPa$

$\tau_3 = 2{,}99\ MPa$ $\quad \tau_6 = 0{,}83\ MPa$