Remarks: See §4.4, pages 168 till 170
See §4.5.4, pages 179 till 182

Answers:

a. $F_\mathrm{p} = 2000\ \mathrm{kN}$

b. $\sigma_\mathrm{t} = -8{,}88\ \mathrm{N/mm^2}$ and $\sigma_b = 0$

Explanation:

$$A = 450\times10^3\ \mathrm{mm^2} \text{ and } I_{zz} = 30{,}375\times10^9\ \mathrm{mm^4}$$

a. mid-span cross-section:

due to q: $M = \frac{1}{8}(100\ \mathrm{kN/m})(8\ \mathrm{m})^2 = 800\ \mathrm{kNm}$

due to F_p $M = -F_\mathrm{p} e_\mathrm{p} = -F_\mathrm{p}(0{,}25\ \mathrm{m})$

further: $N = -F_\mathrm{p}$

$$\sigma_\mathrm{b} = \frac{-F_\mathrm{p}}{450\times10^{-3}\ \mathrm{m^2}} + \frac{\big((800\ \mathrm{kNm}) - F_\mathrm{p}(0{,}25\ \mathrm{m})\big)(0{,}45\ \mathrm{m})}{30{,}375\times10^{-3}\ \mathrm{m^4}} \le 0$$

$$\Rightarrow F_\mathrm{p} \ge 2000\ \mathrm{kN}$$

b. As a result of pre-stress force:

$$N = -2\times10^6\ \mathrm{N} \text{ and } M = (-2\times10^6\ \mathrm{N})(250\ \mathrm{mm}) = -500\times10^6\ \mathrm{Nmm}$$

$$\sigma^{(\mathrm{N})} = \frac{-2\times10^6\ \mathrm{N}}{450\times10^3\ \mathrm{mm^2}} = -4{,}44\ \mathrm{N/mm^2}$$

$$\sigma_\mathrm{t}^{(\mathrm{M})} = \frac{(-500\times10^6\ \mathrm{Nmm})(-450\ \mathrm{mm})}{3{,}0375\times10^{10}\ \mathrm{mm^2}} = +7{,}41\ \mathrm{N/mm^2}$$

$$\sigma_\mathrm{b}^{(\mathrm{M})} = \frac{(-500\times10^6\ \mathrm{Nmm})(+450\ \mathrm{mm})}{3{,}0375\times10^{10}\ \mathrm{mm^2}} = -7{,}41\ \mathrm{N/mm^2}$$

As a result of the distributed load:

$$M = +800\times10^6\ \mathrm{Nmm}$$

$$\sigma_\mathrm{t}^{(\mathrm{M})} = \frac{(+800\times10^6\ \mathrm{Nmm})(-450\ \mathrm{mm})}{3{,}0375\times10^{10}\ \mathrm{mm^2}} = -11{,}85\ \mathrm{N/mm^2}$$

$$\sigma_\mathrm{b}^{(\mathrm{M})} = \frac{(+800\times10^6\ \mathrm{Nmm})(+450\ \mathrm{mm})}{3{,}0375\times10^{10}\ \mathrm{mm^2}} = +11{,}85\ \mathrm{N/mm^2}$$