Remarks: See §4.4, pages 168 till 170
See §4.5.4, pages 179 till 182
See §4.6, pages 184 till 186

Answers:

a. $F_\text{p} = 432 \text{ kN}$

b. $\sigma_\text{t} = -10 \text{ N/mm}^2$

$\sigma_b = 0 \text{ N/mm}^2$

c. $\sigma_t = +3,33 \text{ N/mm}^2$

$\sigma_b = -13,33 \text{ N/mm}^2$

Explanation:

Cross-sectional properties:
$A = 86,4 \times 10^3 \text{ mm}^2$ and $W = 5,184 \times 10^6 \text{ mm}^3$

a. In C: due to the distributed load: $M_z = +69,12 \text{ kNm}$

Due to the pre-stressed load: $N = -N_\text{p}$ and $M_z = -(0,1 \text{ m}) \times F_\text{p}$

Total C:

$N = -N_\text{p}$ and $M_z = (+69,12 \text{ kNm}) - (0,1 \text{ m}) \times F_\text{p}$

The bottom-most fibers have the most chance of being in tension

$$\sigma_b = \frac{-F_\text{p}}{86,4 \times 10^{-3} \text{ m}^2} + \frac{(+69,12 \text{ kNm}) - (0,1 \text{ m}) \times F_\text{p}}{5,184 \times 10^{-6} \text{ m}^3} \leq 0$$

Therefore: $F_\text{p} \geq 432 \text{ kN}$

b. In cross-section C: $N = -432 \text{ kN}$ en $M_z = +25,92 \text{ kNm}$.

$$\sigma^{(N)} = \frac{-432 \times 10^3 \text{ kN}}{86,4 \times 10^3 \text{ mm}^2} = -5 \text{ N/mm}^2$$

$$\sigma_t^{(M)} = \frac{(+25,92 \times 10^6 \text{ Nmm})}{-5,184 \times 10^6 \text{ mm}^3} = -5 \text{ N/mm}^2 \text{ and } \sigma_b^{(M)} = +5 \text{ N/mm}^2$$

c. In cross-section C: $N = -432 \text{ kN}$ en $M_z = -43,2 \text{ kNm}$.

$$\sigma^{(N)} = \frac{-432 \times 10^3 \text{ kN}}{86,4 \times 10^3 \text{ mm}^2} = -5 \text{ N/mm}^2$$

$$\sigma_t^{(M)} = \frac{-43,2 \times 10^6 \text{ Nmm}}{-5,184 \times 10^6 \text{ mm}^3} = +8,33 \text{ N/mm}^2 \text{ and } \sigma_b^{(M)} = -8,33 \text{ N/mm}^2$$

d. In reality, the normal stress at the ends of the beam is zero except at the point where the cable is anchored. The calculated normal stress diagram is statically equivalent with the eccentric force due to the cable, but is valid only at a distance in order of the size of the beam height.