Opmerkingen: Zie §4.4, blz. 150 t/m 153
Zie §4.5.4, blz. 160 t/m 163
Zie §4.6, blz. 165 t/m 166

Antwoorden:

a. $F_p = 210$ kN
$c = 83{,}33$ mm
b. $\Delta\ell_p = 315$ mm
c. $\Delta\ell_b = -1{,}37$ mm
d. $\Delta\ell_{\text{vijzel}} = 316{,}37$ mm
e. $q = 3{,}89$ kN/m
f. $\Delta\ell_{b;\,\text{tgv}\,q} = 0{,}69$ mm
g. $\Delta F_p = 0{,}46$ kN

Toelichting:

$A = 35\times10^3$ mm^2 en $W = \dfrac{I}{\frac{1}{2}h} = 1{,}458\times10^6$ mm^3

a. $N = \sigma_{NC}A_b = (-6\text{ N/mm}^2)(35\times10^3\text{ mm}^2) = 210\times10^3$ N
$F_p = -N = 210$ kN
Maximum buigspanning: $\sigma = 6$ N/mm^2. Hieruit volgt:
$M = W\sigma = (1{,}458\times10^6\text{ mm}^3)(6\text{ N/mm}^2) = 8{,}75\times10^6$ Nmm $(\frown)$
$e_{z;p} = \dfrac{M_z}{N} = \dfrac{-8{,}75\times10^6\text{ Nmm}}{-210\times10^3\text{ N}} = 41{,}67$ mm
$c = \frac{1}{2}h - e = 83{,}33$ mm

b. $(EA)_p = (200\times10^2\text{ N/mm}^2)(200\text{ mm}^2) = 4\times10^6$ N
$\Delta\ell_p = \dfrac{F_p\ell}{(EA)_p} = \dfrac{(210\times10^3\text{ N})(6000\text{ mm})}{4\times10^6\text{ N}} = 315$ mm

c. Ter hoogte van de voorspanstaaf geldt: $\sigma = -8$ N/mm^2
$\Delta\ell_b = \dfrac{\sigma}{E_b}\ell = \dfrac{-8\text{ N/mm}^2}{35\times10^3\text{ N/mm}^2}\times(6000\text{ mm}) = -1{,}37$ mm

d. $\Delta\ell_{\text{vijzel}} = \Delta\ell_p - \Delta\ell_b = (315\text{ mm}) - (-1{,}37\text{ mm}) = 316{,}37$ mm

e. Voor de maximum buigspanning t.g.v. q moet gelden:
$\sigma^{(M)}_{\text{max;}\,\text{tgv}\,q} = \dfrac{\frac{1}{8}q\ell^2}{W} \le 12$ N/mm^2
$q \le \dfrac{8\times(12\text{ N/mm}^2)(1{,}458\times10^6\text{ mm}^3)M_q}{(6000\text{ mm})^2} = 3{,}89$ N/mm

f. Ter hoogte van de voorspanstaaf is de betonspanning t.g.v. q:
$\sigma_{\text{tgv}\,q} = \dfrac{41{,}67\text{ mm}}{125\text{ mm}}\times(12\text{ N/mm}^2) = 4\text{ N/mm}^2$; hieruit volgt:
$\Delta\ell_{b;\,\text{tgv}\,q} = \dfrac{\sigma_{\text{tgv}\,q}}{E_b}\ell = \dfrac{4\text{ N/mm}^2}{35\times10^3\text{ N/mm}^2}\times(6000\text{ mm}) = 0{,}69$ mm

g. $\Delta F_p = (EA)_p\dfrac{\Delta\ell_{b;\,\text{tgv}\,q}}{\ell} = (4\times10^3\text{ kN})\dfrac{0{,}69\text{ mm}}{6000\text{ mm}} = 0{,}46$ kN (0,22%)