B beton EC

afleiding wapening A_s

$$M_{Ed} = A_s \cdot f_{yd} \cdot \left(d - \underbrace{\frac{\beta \cdot A_s \cdot f_{yd}}{b \cdot f_{cd} \cdot \alpha}}_{x_u} \right)$$

$$M_{Ed} = A_s \cdot f_{yd} \cdot d - \frac{\beta \cdot A_s^2 \cdot f_{yd}^2}{b \cdot f_{cd} \cdot \alpha}$$

$$\frac{\beta \cdot f_{yd}^2}{b \cdot f_{cd} \cdot \alpha} \cdot A_s^2 - f_{yd} \cdot d \cdot A_s + M_{Ed} = 0$$

$$A_s = \frac{f_{yd} \cdot d - \sqrt{(f_{yd} \cdot d)^2 - 4 \cdot \frac{\beta \cdot f_{yd}^2}{b \cdot f_{cd} \cdot \alpha} \cdot M_{Ed}}}{2 \cdot \frac{\beta \cdot f_{yd}^2}{b \cdot f_{cd} \cdot \alpha}}$$

afleiding x_u CB2 blz 52 B beton

$$M_{Ed} = \alpha b x_u f_{cd} (d - \beta x_u)$$

$$M_{Ed} = \alpha b x_u f_{cd} \cdot d - \alpha b x_u \cdot f_{cd} \cdot \beta x_u$$

$$\underbrace{\alpha b f_{cd} \cdot \beta}_{a} \cdot x_u^2 + \underbrace{-\alpha b f_{cd} \cdot d}_{b}\, x_u + \underbrace{M_{Ed}}_{c}$$

$$x_u = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$$ (oplossen vierkants vergelijking)

$$x_u = \frac{\alpha b f_{cd} \cdot d - \sqrt{(-\alpha b f_{cd} d)^2 - 4 \cdot \alpha b f_{cd} \beta M_{Ed}}}{2 \cdot \alpha b f_{cd} \beta}$$

$$x_u = \frac{\alpha b f_{cd}\, d}{2\alpha b f_{cd} \beta} - \sqrt{\frac{\alpha^2 b^2 f_{cd}^2 d^2}{4 \cdot \alpha^2 b^2 f_{cd}^2 \beta^2} - \frac{4\alpha b f_{cd} \beta . M_{Ed}}{4\alpha^2 b^2 f_{cd}^2 \beta^2}}$$

$$x_u = \frac{d}{2\beta} - \sqrt{\frac{d^2}{(2\beta)^2} - \frac{M_{Ed}}{\alpha b f_{cd} \beta} \times \frac{4\beta}{4\beta}}$$

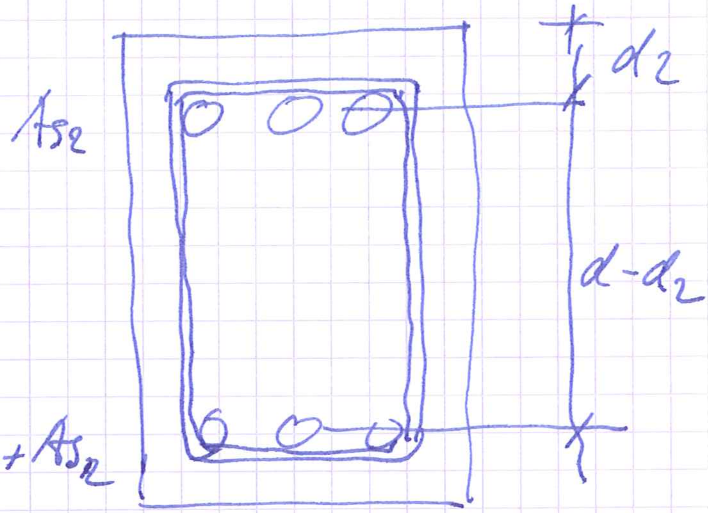
$$x_u = \frac{d}{2\beta} - \sqrt{\frac{d^2}{(2\beta)^2} - \frac{4\beta\, M_{Ed}}{\alpha b f_{cd} \cdot (2\beta)^2}}$$

$$x_u = \frac{d - \sqrt{d^2 - \frac{4\beta M_{Ed}}{\alpha b f_{cd}}}}{2\beta}$$

Rekenwaarde M_{Ed}.

Opneembaar M_{Rd}

Drukwapening. Po beton EC



Trek+ drukwapening

$$M_{Ed,totaal} = M_{Ed1} + M_{Ed2}$$

$$M_{Ed1} = A_{s1} \cdot f_{yd} \cdot z$$

$$= \rho_{max}\, bd \cdot f_{yd} \cdot z$$

$$M_{Ed2} \Rightarrow M_{Ed,totaal} - M_{Ed1}$$

$$A_{s1} = \rho_{max} \cdot bd.$$

$$A_{s2} = \frac{M_{Ed2}}{f_{yd}(d - d_2)}$$

$$d_2 = d - c_{druk} - d_{bgl} - \tfrac{1}{2}\, d_{gem,druk}.$$

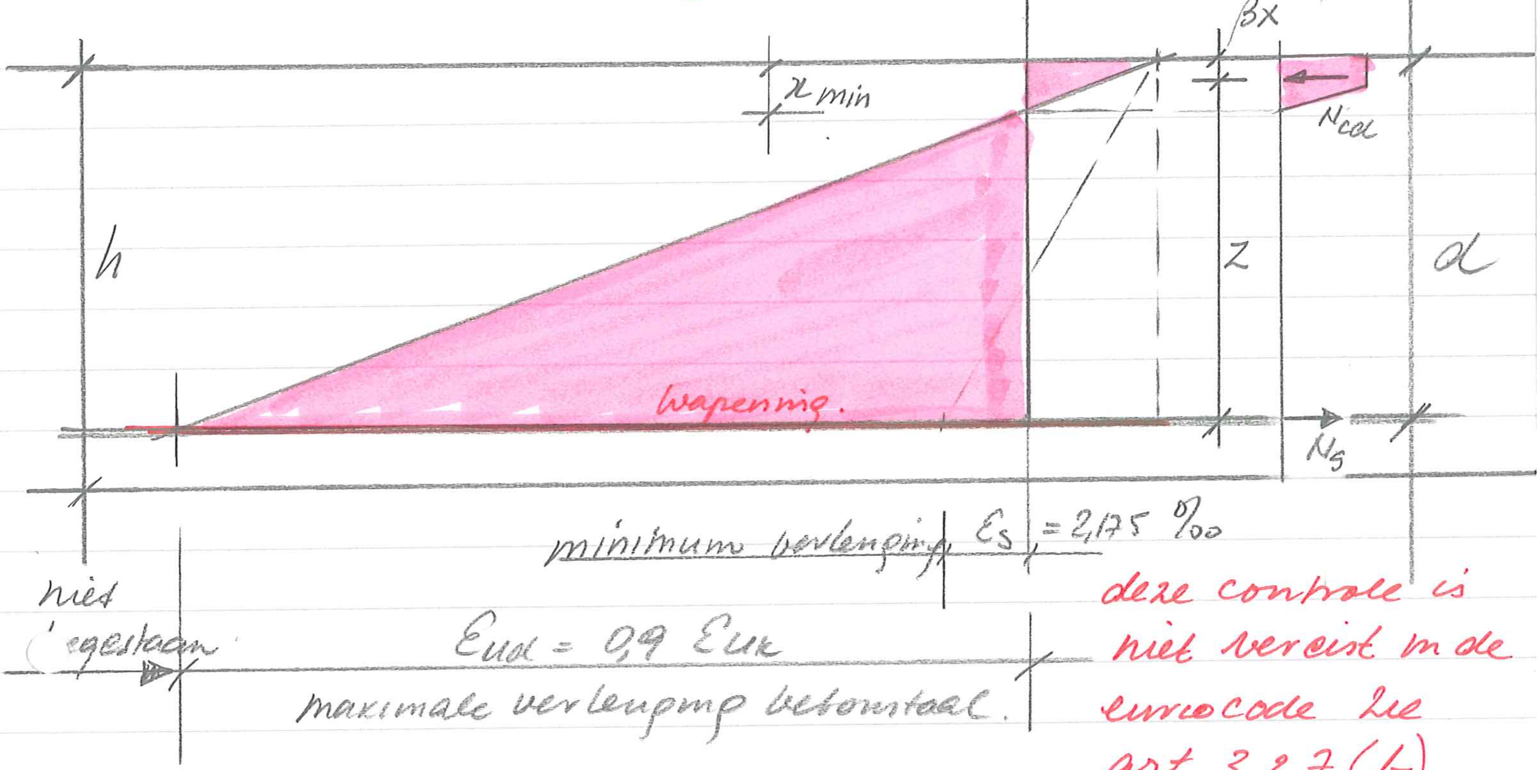
Trekwapening: $A_{s,totaal} = A_{s1} + A_{s2}$

drukwapening : A_{s2}

Zie voorbeeld blz 61 CB 2

Beton buigwapening

B. beton EC



deze controle is niet vereist in de eurocode zie art 3.2.7 (b)

$$\frac{x_{min}}{\varepsilon_{cu3}} = \frac{d}{\varepsilon_{ud} + \varepsilon_{cu3}} \Rightarrow x_{min} = \frac{\varepsilon_{cu3}}{\varepsilon_{ud} + \varepsilon_{cu3}} \cdot d$$

$N_{cd} = \alpha \cdot b \cdot x \cdot f_{cd}$ $\qquad A_s = N_{cd} / f_{yd}$

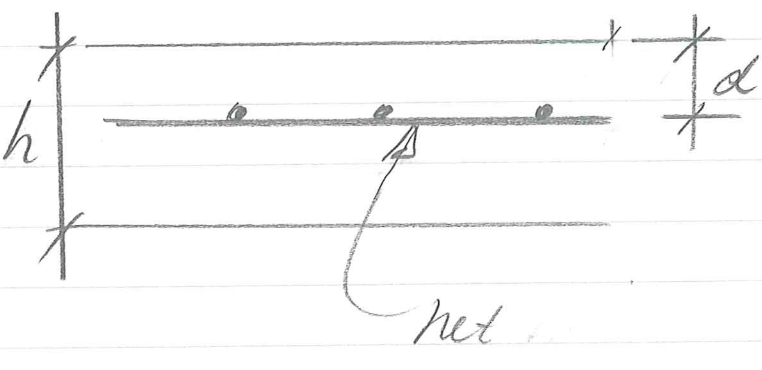
$z = d - \beta x$ $\qquad M_{ud} = N_{cd} \cdot z$

ongescheurde doorsnede $W_c = 1/6 \cdot b h^2$

trekspanning in beton $f_{ctm} \times \left(1{,}6 - \frac{h}{1000}\right)$. $h \leq 600$

Scheurmoment $M_{Rd,c} = W_c \cdot f_{ctm}$

dus van de totale betondoorsnede.



B beton EC

SCHEURMOMENT: $M_r = W_c \cdot f_{ctm} \times \left(1{,}6 - \frac{h}{1000}\right)$

$$A_{min} = \frac{M_r}{z \cdot f_{yk}} = \frac{\frac{1}{6} b h^2 \cdot f_{ctm}}{z \cdot f_{yk}}$$

uitgangspunt: $0{,}81h$ $\quad z = 0{,}9d$

$d = 0{,}9h$

$$= \frac{\frac{1}{6} \cdot b h^2 \cdot f_{ctm}}{0{,}81 h \cdot f_{yk}}$$

$$= \frac{b \cdot d}{6 \cdot 0{,}81 \cdot 0{,}9} \cdot \frac{f_{ctm}}{f_{yk}}$$

$$= 0{,}23\, bd.$$

$\boxed{\text{Ter berekening minimum wapening.}}$

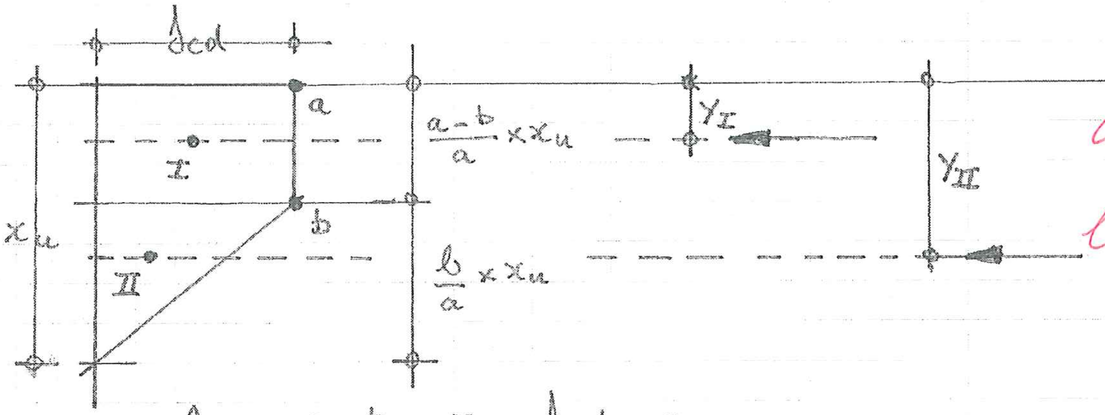
Afleiding minimum wapening in CB2

= benaderingsformule!

$z = 0{,}81\, h$

B beton EC

Doorsnedeberekening beton - bepaling α en β - Eurocode 2



$a = \varepsilon_{cu3}$

$b = \varepsilon_{c3}$

$$\left.\begin{aligned} A_I &= \frac{a-b}{a} \times x_u \times f_{cd} \\ A_{II} &= \tfrac{1}{2} \times \frac{b}{a} \times x_u \times f_{cd} \end{aligned}\right\} \Sigma A = \left[\frac{a-b}{a} + \frac{b}{2a}\right] \times x_u \times f_{cd}$$

$$= \frac{2a-b}{2a} \times x_u \times f_{cd}$$

$$\Longrightarrow \boxed{\alpha = \frac{2a-b}{2a}}$$

$$y_I = \tfrac{1}{2} \times \frac{a-b}{a} \times x_u = \frac{a-b}{2a} \times x_u$$

$$y_{II} = \left[\frac{a-b}{a} + \tfrac{1}{3}\frac{b}{a}\right] \times x_u = \frac{a - \tfrac{2}{3}b}{a} \times x_u$$

$$\alpha = \frac{a - b/2}{a}$$

$$A_I \times y_I = \frac{a-b}{a} \times \frac{a-b}{2a} \times x_u^2 \times f_{cd} = \frac{(a-b)^2}{2a^2} \times x_u^2 \times f_{cd}$$

$$A_{II} \times y_{II} = \frac{b}{2a} \times \frac{a - \tfrac{2}{3}b}{a} \times x_u^2 \times f_{cd} = \frac{ab - \tfrac{2}{3}b^2}{2a^2} \times x_u^2 \times f_{cd}$$

$$\Sigma (A \times y) = \frac{(a-b)^2}{2a^2} + \frac{ab - \tfrac{2}{3}b^2}{2a^2} = \frac{a^2 - 2ab + b^2 + ab - \tfrac{2}{3}b^2}{2a^2} \times x_u^2 \times f_{cd}$$

$$= \frac{a^2 - ab + \tfrac{1}{3}b^2}{2a^2} \times x_u^2 \times f_{cd}$$

$$\frac{\Sigma (A \times y)}{\Sigma A} = \frac{\dfrac{a^2 - ab + \tfrac{1}{3}b^2}{2a^{\cancel{2}}} \times x_u^{\cancel{2}} \times \cancel{f_{cd}}}{\dfrac{2a-b}{\cancel{2a}} \times \cancel{x_u} \times \cancel{f_{cd}}} = \frac{a^2 - ab + \tfrac{1}{3}b^2}{2a^2 - ab} \times x_u$$

$$\Longrightarrow \boxed{\beta = \frac{a^2 - ab + \tfrac{1}{3}b^2}{2a^2 - ab}}$$

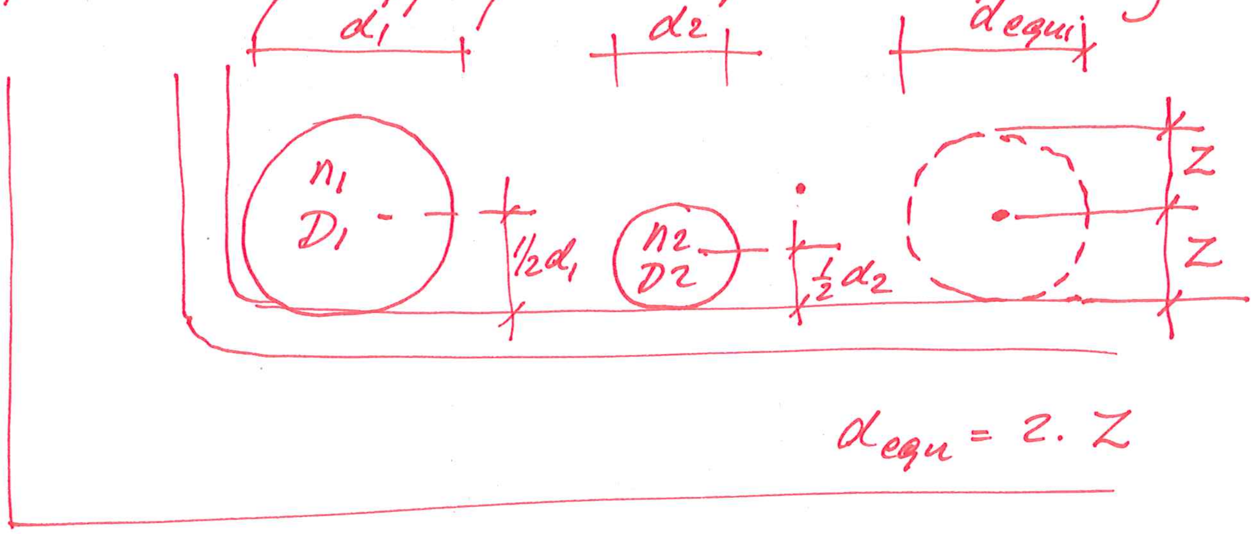
R. JENSE / 19-10-2000

$a = \varepsilon_{cu3}$

$b = \varepsilon_{c3}$

B beton EC

Berekening ligging zwaartepunt wapening



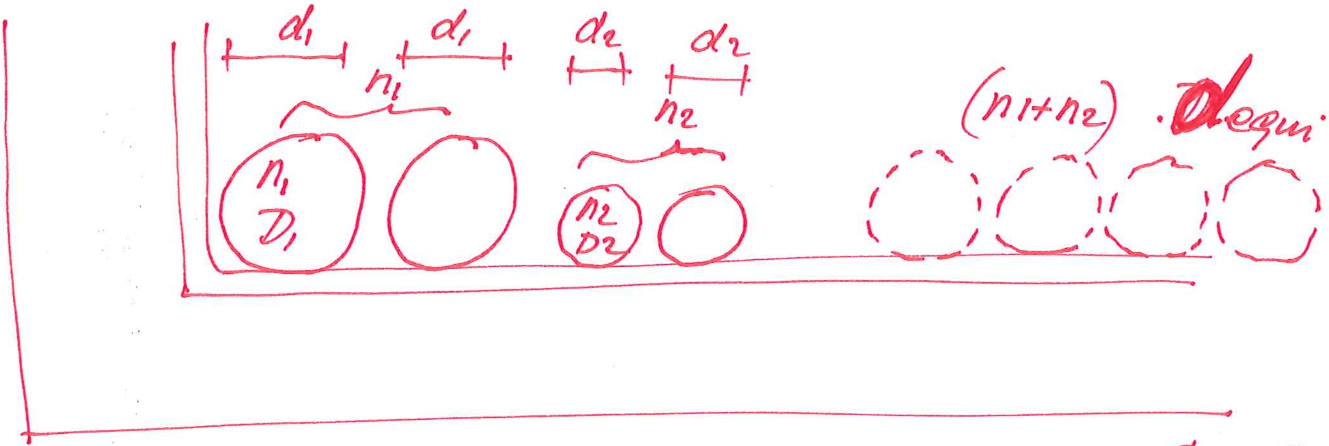
$d_{equ} = 2 . Z$

$$Z = \frac{n_1 D_1 \cdot \frac{1}{2} d_1 + n_2 D_2 \cdot \frac{1}{2} d_2}{n_1 D_1 + n_2 D_2}$$

te gebruiken voor berekening nuttige hoogte.

Berekening equivalente diameter voor bijvoorbeeld verankering, scheurwijdte e.d.

wordt verder niet gebruikt:



$$n_1 D_1 + n_2 D_2 = (n_1 + n_2) . D_{equi} \Rightarrow D_{equ} = \frac{n_1 D_1 + n_2 D_2}{n_1 + n_2}$$

$$D_{equ} = \frac{1}{4} \cdot \pi \, d_{equ}^2 \qquad d_{equi} = \sqrt{\frac{4 . D_{equ} .}{\pi}}$$

$$d_{equi} = \sqrt{\frac{4 . (n_1 D_1 + n_2 D_2)}{\pi . (n_1 + n_2)}}$$

echter

verankeringslengte : enkele staaf: geen equivalent.

scheurwijdte : gemiddelde diameter;