Steel Properties (For steel reinforcement, ASTM A615M Grade 420 MPa)

$f_y := 420\ MPa = 60.916\ ksi$ $E_s := 2 \cdot 10^5\ MPa$

Concrete Properties

$\gamma_{concrete} := 25\ \frac{kN}{m^3} = (2.549 \cdot 10^3)\ \frac{kgf}{m^3}$

$f'_c := 32 \cdot MPa$ $\lambda := 1.0$

$E_c := 4700 \cdot \sqrt{f'_c \cdot MPa} = (2.659 \cdot 10^7)\ kPa$ $n := \frac{E_s}{E_c} = 7.522$

$f_r := 0.62 \cdot \lambda \cdot \sqrt{f'_c \cdot MPa} = 3.507\ MPa$: modulus of rupture of concrete (ACI 318-08, eq. 9-10)

Geometric Properties

$b := 1000\ mm$ $h := 900\ mm$ $c_c := 75\ mm$ $w_{limit} := 0.1\ mm$

$Dia := [10\ mm \quad 12\ mm \quad 16\ mm \quad 20\ mm \quad 25\ mm \quad 32\ mm]^T$

$Area := [0.7854\ cm^2 \quad 1.131\ cm^2 \quad 2.011\ cm^2 \quad 3.142\ cm^2 \quad 4.909\ cm^2 \quad 8.042\ cm^2]^T$

$Dn := 6$: Rebar Selection D10=1, D12=2, D16=3, D20=4, D25=5, D32=6

$s := 150\ mm$ $d_s := Dia_{Dn} = 32\ mm$ $A_s := Area_{Dn} \cdot \frac{b}{s} = (5.361 \cdot 10^3)\ mm^2$

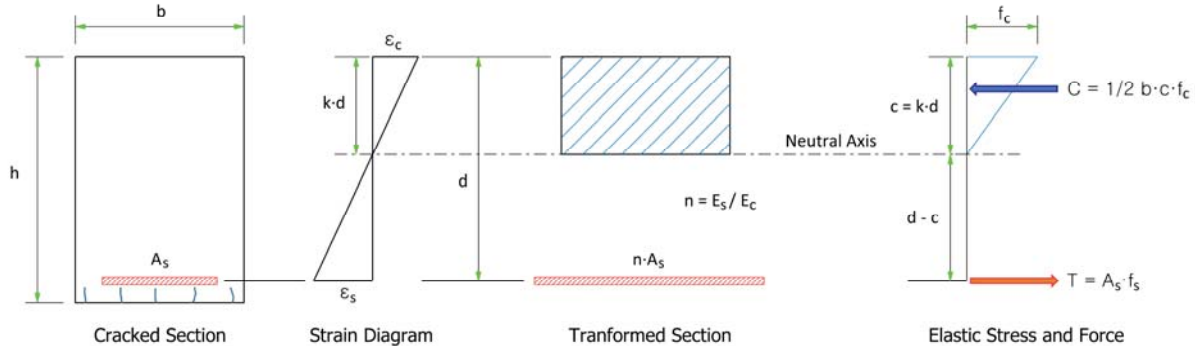
$I_g := \frac{b \cdot h^3}{12} = 0.061\ m^4$ $y_t := \frac{h}{2} = 0.45\ m$ $d := h - c_c = 0.825\ m$ $d_c := c_c + \frac{d_s}{2} = 91\ mm$

$d := 809\ mm$

Cracking Moment and Moment at Service Loads

$M_{srv} := 250\ kN \cdot m$ $M_{cr} := \frac{f_r \cdot I_g}{y_t} = 473.479\ kN \cdot m$: cracking moment (ACI 318-08, eq. 9-9)

Calculation of Tensile Stress in Reinforcement at Service Loads



$B := \frac{b}{n \cdot A_s} = 0.025\ mm^{-1}$ $c := \frac{\sqrt{2 \cdot B \cdot d + 1} - 1}{B} = 218.283\ mm$: neutral axis depth

$I_{cr} := \frac{b \cdot c^3}{3} + n \cdot A_s \cdot (d - c)^2 = (1.754 \cdot 10^{10})\ mm^4$: moment of inertia of cracked section transformed to concrete

$f_s := \frac{M_{srv}}{A_s \cdot \left(d - \frac{c}{3}\right)} = 63.336\ MPa$ $f_s := \frac{M_{srv}}{I_{cr}} n \cdot (d - c) = 63.336\ MPa$: steel stress

$f_c := \frac{M_{srv}}{I_{cr}} c = 3.111\ MPa$: concrete stress

- verificaton -

$T := A_s \cdot f_s = 339.564\ kN$ $C := 0.5 \cdot b \cdot c \cdot f_c = 339.564\ kN$: internal couple $T = C$

$M := T \cdot \left(d - \frac{c}{3}\right) = 250\ kN \cdot m$ $M_{srv} = 250\ kN \cdot m$: internal couple mement $M = M_{srv}$

- if there is a compression axial force, the tensile stress minus compress can be applied to calcua lte the crack width.

$P := 0\ kN$ $A_c := b \cdot h - A_s$

$\sigma_s := \frac{P \cdot E_s}{E_s \cdot A_s + E_c \cdot A_c} = 0\ MPa$ $\sigma_s := \frac{P}{A_s + \frac{1}{n} \cdot A_c} = 0\ MPa$

$f_s := f_s - \sigma_s = (6.334 \cdot 10^4)\ kPa$: steel stress considering compression

1. Calculation of Crack Width (ACI)

Step 1. Calculation of Spacing and Crack Width (ACI 318-08)

$s_{max} := 380 \cdot \frac{280}{f_s} \cdot MPa \cdot mm - 2.5 \cdot c_c = (1.492 \cdot 10^3)\ mm$: maxium spacing (ACI 318-08, eq. 10-4)

$Judge := \text{if}\ (s_{max} > s\ ,\ \text{“OK”}\ ,\ \text{“NG”}) = \text{“OK”}$

Step 2. Comparison of Cracking Moment and Moment at Service Loads

$M_{cr} = 473.479\ kN \cdot m$ $M_{srv} = 250\ kN \cdot m$ $Judge := \text{if}\ (M_{cr} > M_{srv}\ ,\ \text{“OK”}\ ,\ \text{“NG”}) = \text{“OK”}$

Step 3. Calculation of Crack Width (ACI 224.1R)

$\beta := \frac{h - c}{d - c} = 1.154$ $d_c = 91\ mm$ $A := 2\ d_c \cdot s = (2.73 \cdot 10^4)\ mm^2$

$w := 2 \cdot \frac{f_s}{E_s} \cdot \beta \cdot \sqrt{{d_c}^2 + \left(\frac{s}{2}\right)^2} = 0.086\ mm$: crack width (ACI 224.1R-07, eq. 1-1)

$w :=$ if $c_c > 50\ mm$; $c_c \leftarrow 50\ mm$; $d_c \leftarrow c_c + 0.5 \cdot d_s$; $w \leftarrow 2 \cdot \frac{f_s}{E_s} \cdot \beta \cdot \sqrt{{d_c}^2 + \left(\frac{s}{2}\right)^2}$; $w = 0.073\ mm$

: crack width calculated with reduced cover depth, 50 mm (ACI 350-06, Clause 10.6.4)

$Judge :=$ if $M_{srv} \le M_{cr}$ “Not cracked” else if $w \le w_{limit}$ “Lower than limit” else “NG” $=$ “Not cracked”