Crack width limitation acc. to DIN 1045-1: 2008-08

Requirements

Permissible crack width w_k = 0,15 mm.

Materials, geometry

Rectangular cross section with height = 80,0 cm; width = 100,0 cm
Concrete quality: C20/25
Concrete cover c_{nom}: 3,5 cm
Bar diameter: $d_{s,exist.}$ = 16,0 mm (Reinforcing steel)

Check of the minimum reinforcement

Action: Centrical tension
A_s is computed for one layer $\Rightarrow$ Tensile zone height = component height / 2
Location of restraint: inside of the component
Concrete age at time of cracking: 6 to 28 days

Height of the effective area of the reinforcement as per Pict. 53 d): h_{eff} = 16,60 cm

Section 11.2.2 (8): For thick components under centrical tension, the minimum reinforcement can be calculated considering the effective edge zone $A_{c,eff}$ where $A_{c,eff} = h_{eff} \cdot b$ and $A_{ct} = 0.5\ h \cdot b$.

$$A_{s,min} = f_{ct,eff} \cdot A_{c,eff} / \sigma_s \geq k \cdot f_{ct,eff} \cdot A_{ct} / f_{yk} \qquad (130\,a,b)$$

with k = 0,50 $f_{ct,eff}$ = 2,20 N/mm² $A_{c,eff}$ = 1075,0 cm²
A_{ct} = 4000,0 cm² f_{yk} = 500 N/mm² σ_s = see following calculation

The limiting of crack width can be proved by limiting of the bar diameter.

$\phi_s = \phi_s^* \cdot f_{ct,eff} / 3.0$
$\Rightarrow$ $\phi_s = \phi_s^* \cdot 0,73$ $\Rightarrow$ $\phi_s^* = 16,0\ mm / 0,73 = 21,82\ mm$
$\Rightarrow$ σ_s = 160,00 N/mm² as per Table 20
$\Rightarrow$ $A_{s,min}$ = 22,83 cm² $\geq$ 8,80 cm²

$A_{s,min}$ = 22,83 cm² per layer

Check of crack width limitation by direct calculation

Concrete age at time of cracking: > 28 days
$A_{s,exist.}$ = 24,00 cm² in the layer to be proved
Steel stress σ_s = 180,00 N/mm²
Component: Beam

Difference of the average strain of concrete and reinforcement:

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - 0{,}4 \cdot \frac{f_{ct,eff}}{eff\rho} \cdot (1 + \alpha_e \cdot eff\rho)}{E_s} \geq 0{,}6 \cdot \frac{\sigma_s}{E_s} \qquad (136)$$

with effρ = 0,0223 E_s = 200000 N/mm² E_{cm} = 24900 N/mm²
$f_{ct,eff}$ = 2,20 N/mm² $\alpha_e = E_s / E_{cm}$ = 8,0

$\varepsilon_{sm} - \varepsilon_{cm} = 0{,}00067 \geq 0{,}00054 \Rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0{,}00067$

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Maximum crack distance:

$$s_{r,max} = \frac{d_s}{3{,}6 \cdot \text{eff}\rho} \leq \frac{\sigma_s \cdot d_s}{3{,}6 \cdot f_{ct,eff}} \qquad (137)$$

$s_{r,max} = 199{,}1 \leq 363{,}6 \Rightarrow s_{r,max} = 199{,}1$ mm

Crack width:

$$w_k = s_{r,max} \cdot (\varepsilon_{sm} - \varepsilon_{cm}) \qquad (135)$$

$w_k = 0{,}13$ mm $\leq w_{k,zul} = 0{,}15$ mm The check is OK!