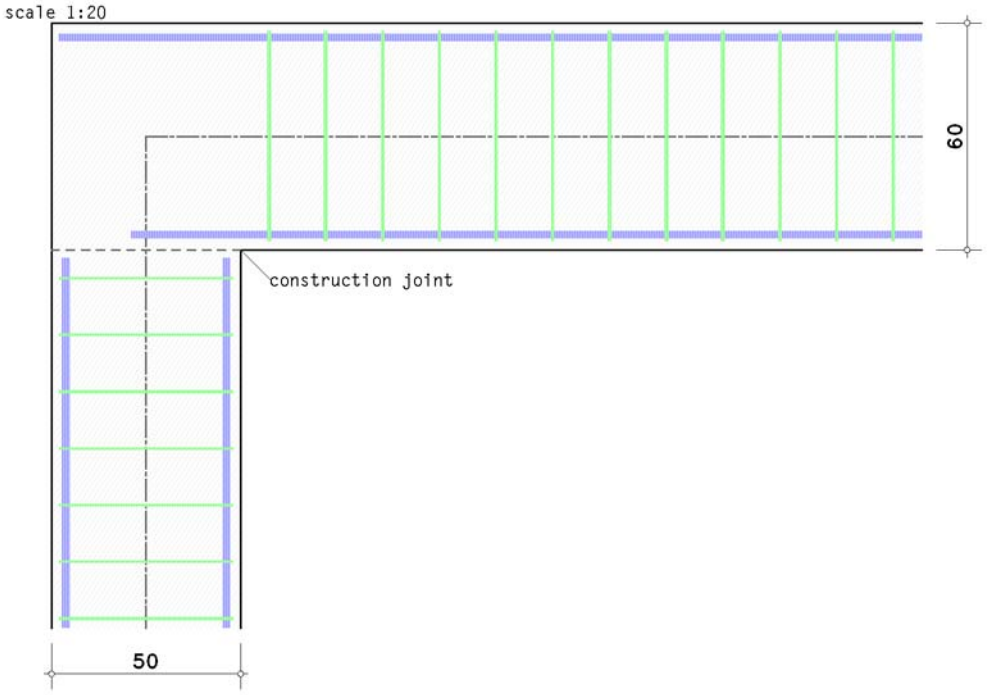
dimensioning a frame corner EC 2 (1.11), NA: Deutschland

# 1. input protocol




**system**
beam: height $h_b$ = 60.0 cm, axis distances (design calculation) $d_{1,bo}$ = 5.0 cm, $d_{1,bu}$ = 4.0 cm
column: height $h_c$ = 50.0 cm, axis distances (design calculation) $d_{1,cl}$ = 5.0 cm, $d_{1,cr}$ = 4.0 cm
opening angle $\alpha$ = 90.00°, width beam/column $b_b = b_c$ = 40.0 cm
**material properties**
concrete acc. to EC 2, 3.1.7(1): C30/37, reinforcement acc. to EC 2, 3.2.7(2a): B500A
**material safety factors**
design situation: basic combination
design resistance: concrete $\gamma_c$ = 1.50, reinforcement $\gamma_s$ = 1.15
**parameters**
dimensioning a frame corner with a negative moment
req. reinforcement at the cut:
beam: $A_{s,bo}$ = 10.00 cm², $A_{s,bu}$ = 0.00 cm², $a_{sb,b}$ = 0.00 cm²($F_{t,b}$ = 0.0 kN, $z_b$ = 0.0 cm)
column: $A_{s,cl}$ = 12.00 cm², $A_{s,cr}$ = 0.00 cm², $a_{sb,c}$ = 0.00 cm²/m($F_{t,c}$ = 0.0 kN, $z_c$ = 0.0 cm)
calculation of the required anchorage lengths: calculate bonding conditions
calculate the diameter of mandrel depending on the edge distance of concrete
the tension reinforcement of beam is bent when the moment close.
**beam-/column reinforcement from an external structural analysis**
beam: above 4Ø20, bottom 2Ø20, stirrup Ø8/15.0 cm
column: left 4Ø20, right 2Ø20, stirrup Ø8/15.0 cm

## 1.1. durability and concrete cover

schließendes Moment (Zug external):
beam: minimum strength class, concrete cover
due to reinforcement corrosion XC1 ⇒ C16/20, $c_{nom}$ = 20 mm, $c_{nom,b}$ = 18 mm, $c_{nom,l}$ = 12 mm
⇒ $c_{nom}$ = 20 mm ≤ $c_v$ = 20 mm ok
minimum concrete quality C16/20 with $f_{ck}$ = 16.0 N/mm² < exst $f_{ck}$ = 30.0 N/mm² ok
column: minimum strength class, concrete cover
due to reinforcement corrosion XC1 ⇒ C16/20, $c_{nom}$ = 20 mm, $c_{nom,b}$ = 18 mm, $c_{nom,l}$ = 12 mm
⇒ $c_{nom}$ = 20 mm ≤ $c_v$ = 20 mm ok
minimum concrete quality C16/20 with $f_{ck}$ = 16.0 N/mm² < exst $f_{ck}$ = 30.0 N/mm² ok

# 2. note

general reinforcement rules are not taken into account.

# 3. design calculation

## 3.1. results table

**required reinforcement**

| lc | $A_{s,bo}$ cm² | $F_{t,b}$ kN | $A_{s,cl}$ cm² | $F_{t,c}$ kN | $\Delta F_t$ kN |
|---|---|---|---|---|---|
| | 10.00 | 434.8 | 12.00 | 521.7 | 87.0 |

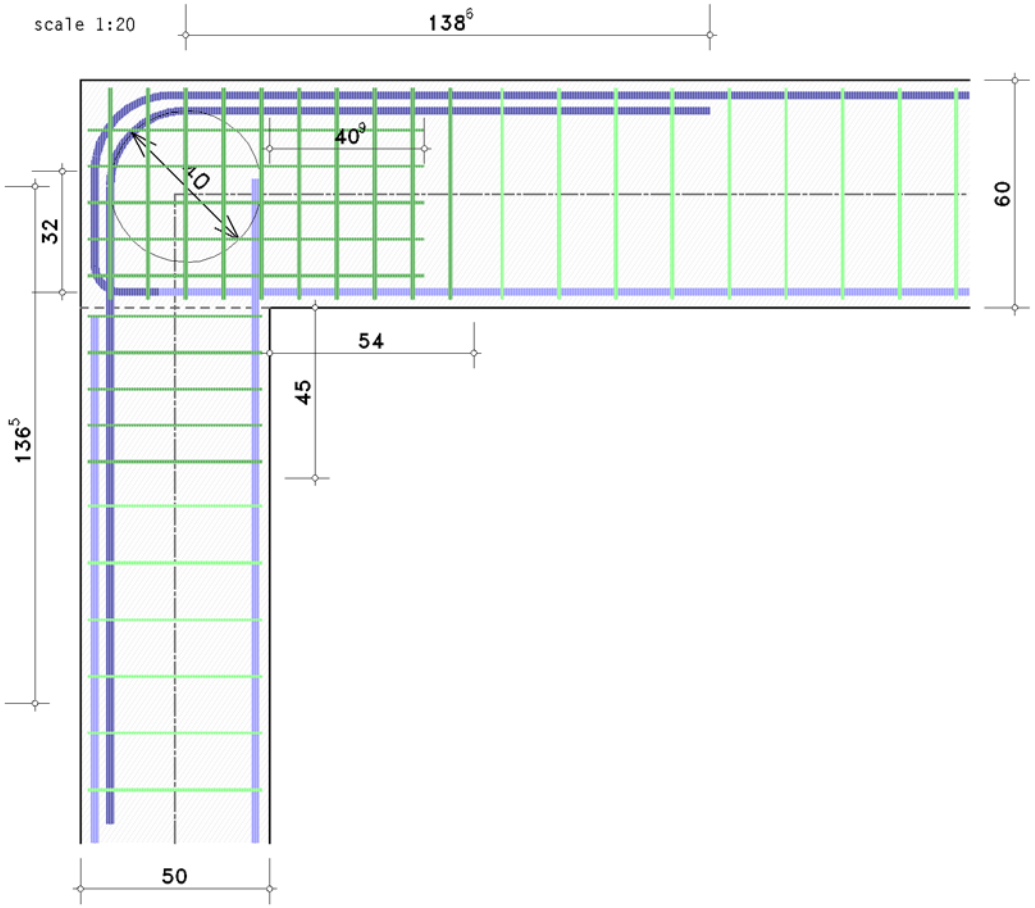
$A_{s,bo}$: req. reinforcement in beam; $A_{s,cl}$: req. reinforcement in column
$F_{t,b}$, $F_{t,c}$: Zugkraft in of beam-/column reinforcement$\Delta F_t$: difference in tensile force $\Delta F_t = |F_{t,b}-F_{t,c}|$

# 4. final result

anchorage reinforcement: req $A_{s,z} = \max(F_{t,c},F_{t,b}) / f_{yd} = 12.00$ cm²
tensile splitting reinforcement horiz.: req $a_{s,sh} = \Delta F_t / (f_{yd}\cdot(h_b+\Delta h_c)) = 9.52$ cm²/m, $\Delta h_c = 0.9\cdot h_c = 45.0$ cm
tensile splitting reinforcement vert.: req $a_{s,sv} = \Sigma A_{s,b} / (h_c+\Delta h_b) = 9.62$ cm²/m, $\Delta h_b = 0.9\cdot h_b = 54.0$ cm

maximum reinforcement: $A_{s,bo} = 10.00$ cm² ($F_{t,b} = 434.8$ kN), $A_{s,cl} = 12.00$ cm² ($F_{t,c} = 521.7$ kN), $A_{s,z} = 12.00$ cm²
$a_{s,sh} = 9.52$ cm²/m ($\Delta F_t = 87.0$ kN), $a_{s,sv} = 9.62$ cm²/m

# 5. selected reinforcement




lap lengthn of anchorage reinforcement
column:
reduction factor for $\rho_1$ = req $A_{s,z}$ / exst $A_{s,cl} = 0.955$, $\varnothing_{s,z} = 20$ mm, $\varnothing_{s,cl} = 20$ mm:
$\alpha_i = \alpha_1\cdot\alpha_6 = 2.00$, $\alpha_1 = 1$, $\alpha_6 = 2.00$
bond area good
design value of bond strength for $f_{ck} = 30.0$ N/mm², $\varnothing_s = 20.0$ mm: $f_{bd} = 3.04$ N/mm²
basic value of anchorage length for $f_{yd} = 434.8$ N/mm²: $l_{b,rqd} = 0.25\cdot\varnothing_s\cdot f_{yd}/f_{bd} = 71.48$ cm
minimum anchorage length for $\alpha_i = 2.00$: $l_{b,min} = \min(0.3\cdot\alpha_i\cdot l_{b,rqd}, 15\cdot\varnothing_s, 20\text{ cm}) = 42.89$ cm
design value of anchorage length for $\alpha_i = 2.00$, $A_{s,req} = 12.00$ cm², $A_{s,exst} = 12.57$ cm²:
$l_b = A_{s,req}/A_{s,exst}\cdot\alpha_i\cdot l_{b,rqd} = 136.52$ cm
beam:
reduction factor for $\rho_1$ = req $A_{s,z}$ / exst $A_{s,bo} = 0.955$, $\varnothing_{s,z} = 20$ mm, $\varnothing_{s,bo} = 20$ mm:
$\alpha_i = \alpha_1\cdot\alpha_6 = 2.00$, $\alpha_1 = 1$, $\alpha_6 = 2.00$
bond area for h = 60.0 cm, $h_z = 7.00$ cm: moderate
design value of bond strength for $f_{ck} = 30.0$ N/mm², $\varnothing_s = 20.0$ mm: $f_{bd} = 2.13$ N/mm²
basic value of anchorage length for $f_{yd} = 434.8$ N/mm²: $l_{b,rqd} = 0.25\cdot\varnothing_s\cdot f_{yd}/f_{bd} = 102.11$ cm
minimum anchorage length for $\alpha_i = 2.00$: $l_{b,min} = \min(0.3\cdot\alpha_i\cdot l_{b,rqd}, 15\cdot\varnothing_s, 20\text{ cm}) = 61.27$ cm
design value of anchorage length for $\alpha_i = 2.00$, $A_{s,req} = 12.00$ cm², $A_{s,exst} = 12.57$ cm²:
$l_b = A_{s,req}/A_{s,exst}\cdot\alpha_i\cdot l_{b,rqd} = 195.02$ cm
diameter of mandrel of anchorage reinforcement
diameter of mandrel of bars: $D = 20\cdot\varnothing_s = 40.0$ cm for min c = 28.0 mm < 50 mm and < $3\cdot\varnothing_s = 60$ mm

reduzierte lap length of anchorage reinforcement in beam
$l_{b,red} = l_b - \Delta l_b = 138.6$ cm with $\Delta l_b = 56.4$ cm
anchorage length of horizontaln tensile splitting reinforcement
bond area for h = 60.0 cm, $h_z = 11.00$ cm: moderate
design value of bond strength for $f_{ck} = 30.0$ N/mm², $\varnothing_s = 8.0$ mm: $f_{bd} = 2.13$ N/mm²
basic value of anchorage length for $f_{yd} = 434.8$ N/mm²: $l_{b,rqd} = 0.25 \cdot \varnothing_s \cdot f_{yd}/f_{bd} = 40.85$ cm
minimum anchorage length for $\alpha_i = 1.00$: $l_{b,min} = \min(0.3 \cdot \alpha_i \cdot l_{b,rqd}, 10 \cdot \varnothing_s) = 12.25$ cm
design value of anchorage length for $\alpha_i = 1.00$: $l_b = \alpha_i \cdot l_{b,rqd} = 40.85$ cm
diameter of mandrel of horizontaln tensile splitting reinforcement
diameter of mandrel for stirrup/U-bents: $D = 4 \cdot \varnothing_s = 3.2$ cm for $\varnothing_s = 8$ mm < 20 mm
diameter of mandrel of vertical tensile splitting reinforcement
diameter of mandrel for stirrup/U-bents: $D = 4 \cdot \varnothing_s = 4.0$ cm for $\varnothing_s = 10$ mm < 20 mm
**verification of reinforcement**
concrete cover $c_v = 2.0$ cm = $c_{nom} = 2.00$ cm ok
beam reinforcement:
above bar reinforcement, 4Ø20, exst $A_{s,bo} = 12.57$ cm² > req $A_{s,bo} = 10.00$ cm² ok
bar distance $s_{bo} = 10.7$ cm > min $s_{bo} = 4.0$ cm ok
bottom bar reinforcement, 2Ø20, exst $A_{s,bu} = 6.28$ cm², req $A_{s,bu} = 0$
bar distance $s_{bu} = 32.0$ cm > min $s_{bu} = 4.0$ cm ok
transverse stirrup, Ø8/15.0 cm (2-shear), exst $a_{s,bb} = 6.70$ cm²/m, req $a_{s,bb} = 0$
column reinforcement:
left bar reinforcement, 4Ø20, exst $A_{s,cl} = 12.57$ cm² > req $A_{s,cl} = 12.00$ cm² ok
bar distance $s_{cl} = 10.8$ cm > min $s_{cl} = 4.0$ cm ok
right bar reinforcement, 2Ø20, exst $A_{s,cr} = 6.28$ cm², req $A_{s,cr} = 0$
bar distance $s_{cr} = 32.4$ cm > min $s_{cr} = 4.0$ cm ok
transverse stirrup, Ø8/15.0 cm (2-shear), exst $a_{s,bc} = 6.70$ cm²/m, req $a_{s,bc} = 0$
anchorage reinforcement:
bar reinforcement, 4Ø20, exst $A_{s,z} = 12.57$ cm² > req $A_{s,z} = 12.00$ cm² ok
bar distance $s_z = 10.1$ cm > min $s_z = 4.0$ cm ok
lap length beam $l_{b,Zb} = 138.6$ cm = req $l_{b,Zb} = 138.6$ cm ok
column $l_{b,Zc} = 136.5$ cm = req $l_{b,Zc} = 136.5$ cm ok
diameter of mandrel $D_z = 40.0$ cm = req $D_z = 40.0$ cm ok
tensile splitting reinforcement:
horiz. U-bents/stirrup, Ø8/9.6 cm (2-shear), exst $a_{s,sh} = 10.47$ cm²/m > req $a_{s,sh} = 9.52$ cm²/m ok
anchorage length $l_{b,sh} = 40.9$ cm = req $l_{b,sh} = 40.9$ cm ok
diameter of mandrel min $D_{sh} = 3.2$ cm
U-bent length $l_{sh} = h_c - c_v + l_{b,sh} = 88.9$ cm (anchoring from the beam cut)
vertical stirrup, Ø10/10.0 cm (2-shear), exst $a_{s,sv} = 15.71$ cm²/m > req $a_{s,sv} = 9.62$ cm²/m ok
diameter of mandrel min $D_{sv} = 4.0$ cm

## design resistance ensured

# 6. regulations

EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
EN 1990/NA, Nationaler Anhang zur EN 1990, Ausgabe Dezember 2010

EN 1992-1-1, Eurocode 2: Bemessung und Konstruktion von Stahlbeton- und Spannbetonbauteilen -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln for den Hochbau;
Deutsche Fassung EN 1992-1-1:2004 + AC:2010, Ausgabe Januar 2011
EN 1992-1-1/NA, Nationaler Anhang zur EN 1992-1-1, Ausgabe April 2013