POS. 10: HEFT 599, 4.4.3, BSP.2

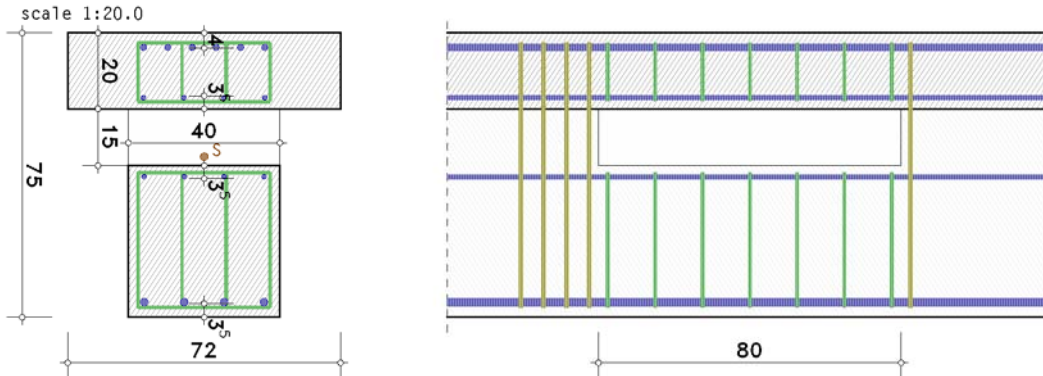dimensioning of a beam recess EC 2 (1.11), NA: Deutschland

1. input protocol

visualisation of the selected reinforcement

cross section

T-beam: h = 75.0 cm, b = 40.0 cm, h_p = 20.0 cm, b_p = 72.0 cm
recess: e_o = 20.0 cm, e_u = 40.0 cm, I_A = 80.0 cm
axis distances (calculation): $d_{o,o}$ = 4.0 cm, $d_{u,o}$ = 3.4 cm, $d_{o,u}$ = 3.4 cm, $d_{u,u}$ = 3.6 cm

material properties

concrete acc. to EC 2, 3.1.7(1): C30/37, ε_{c2} = -2.00‰, ε_{cu2} = -3.50‰, f_{cd} = 17.00 N/mm²
reinforcement acc. to EC 2, 3.2.7(2a): B500A, ε_{ud} = 25.0‰, f_{yd} = 434.78 N/mm², f_{td} = 456.52 N/mm², E_s = 200000.0 N/mm²

parameters

design method acc. to Heft 599, DAfStb
moment zero crossing in the centre of recess
shear force distribution determined from the effective belt stiffnesses
shear design: compression strut angle minimum

1.1. design calculation values

lc 1: $M_{y,Ed}$ = -294.00 kNm, $V_{z,Ed}$ = 252.00 kN

1.2. durability and concrete cover

<u>bottom</u>: minimum strength class, concrete cover
due to reinforcement corrosion XC1 $\Rightarrow$ C16/20, c_{nom} = 20 mm, $c_{nom,b}$ = 20 mm, $c_{nom,l}$ = 10 mm
$\Rightarrow$ c_{nom} = 20 mm ≤ c_v = 20 mm ok
minimum concrete quality C16/20 with f_{ck} = 16.0 N/mm² < 30.0 N/mm² ok
<u>above</u>: minimum strength class, concrete cover
due to reinforcement corrosion XC1 $\Rightarrow$ C16/20, c_{nom} = 20 mm, $c_{nom,b}$ = 20 mm, $c_{nom,l}$ = 8 mm
$\Rightarrow$ c_{nom} = 20 mm ≤ c_v = 20 mm ok
minimum concrete quality C16/20 with f_{ck} = 16.0 N/mm² < 30.0 N/mm² ok

2. note

general reinforcement rules are not taken into account.

3. recess

3.1. lc 1

design calculation values in centre cut: N_{Ed} = 0.00 kN, M_{Ed} = -294.00 kNm, V_{Ed} = 252.00 kN
shear force distribution: 6.5% of shear force acts in the compression chord (= bottom chord)
<u>above the recess</u>
design calculation values in top chord: $N_{Ed,o}$ = 434.3 kN, $V_{Ed,o}$ = 16.3 kN, $M_{Ed,ol}$ = -32.6 kNm, $M_{Ed,or}$ = -19.5 kNm
longitudinal reinforcement in top chord: $A_{so,o}$ = 10.42 cm², $A_{su,o}$ = 1.14 cm²
shear design:
design resistance without shear reinforcement V_{Rdc} = 24.44 kN, max. design resistance of compression strut $V_{Rd,mx}$ = 578.34 kN
$|V_{Ed,o}|$ < V_{Rdc} $\Rightarrow$ minimum reinforcement: $a_{sb,o}$ = 6.67 cm²/m
<u>below the recess</u>
design calculation values in bottom chord: $N_{Ed,u}$ = -434.3 kN, $V_{Ed,u}$ = 235.7 kN, $M_{Ed,u}$ = ±94.3 kNm
longitudinal reinforcement in bottom chord: $A_{so,u}$ = 1.66 cm², $A_{su,u}$ = 1.67 cm²
shear design:
design resistance without shear reinforcement V_{Rdc} = 111.56 kN, max. design resistance of compression strut $V_{Rd,mx}$ = 637.87 kN
V_{Rdc} < $|V_{Ed,u}|$ < $V_{Rd,mx}$ $\Rightarrow$ shear reinforcement in bottom chord $a_{sb,u}$ = 7.80 cm²/m
<u>suspended reinforcement</u>: $T_{v,l}$ = 419.3 kN $\Rightarrow$ $A_{s,l}$ = 9.64 cm², $T_{v,r}$ = 40.0 kN $\Rightarrow$ $A_{s,r}$ = 0.92 cm², distribution width 22.5 cm
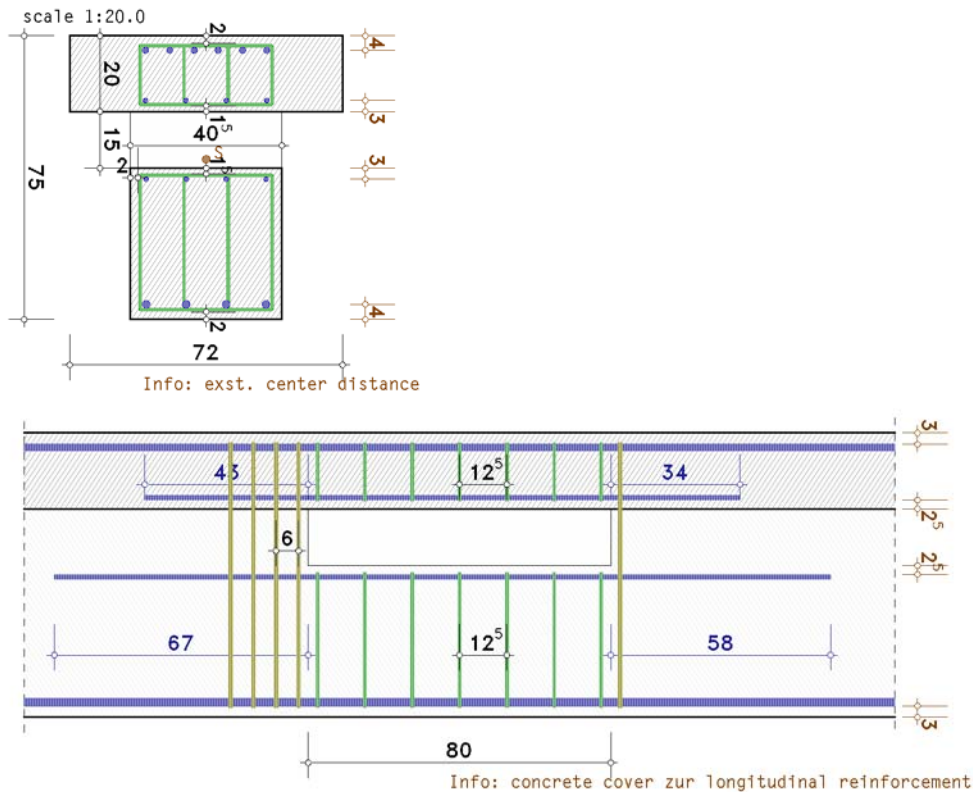<u>total</u>: $A_{so,o}$ = 10.42 cm², $A_{su,o}$ = 1.14 cm², $a_{sb,o}$ = 6.67 cm²/m, $A_{so,u}$ = 1.66 cm², $A_{su,u}$ = 1.67 cm²
        $a_{sb,u}$ = 7.80 cm²/m, $A_{s,l}$ = 9.64 cm², $A_{s,r}$ = 0.92 cm², ρ = 0.41%

4. final result

maximum reinforcement: $A_{so,o} = 10.42$ cm², $A_{su,o} = 1.14$ cm², $a_{sb,o} = 6.67$ cm²/m, $A_{so,u} = 1.66$ cm²
$A_{su,u} = 1.67$ cm², $a_{sb,u} = 7.80$ cm²/m, $A_{s,l} = 9.64$ cm², $A_{s,r} = 0.92$ cm², $\rho = 0.41\%$

5. selected reinforcement

Info: exst. center distance

Info: concrete cover zur longitudinal reinforcement

<u>above the recess</u>
concrete cover to stirrup reinforcement:
         above $c_{vo} = 2.0$ cm > $c_{nom} = 2.00$ cm **ok**
         bottom (to recess) $c_{vi} = 1.5$ cm, lateral $c_{vr} = 2.0$ cm
longitudinal reinforcement above 6Ø16, exst $A_s = 12.06$ cm²
         exst $A_s = 12.06$ cm² > req $A_s = 10.42$ cm² **ok**
         bottom 4Ø12, exst $A_s = 4.52$ cm²
         exst $A_s = 4.52$ cm² > req $A_s = 1.14$ cm² **ok**
         anchorage length from recess edge left/right 43.2/34.2 cm
stirrup reinforcement   Ø8/12.5 cm (4-cut), exst $a_{sb} = 16.08$ cm²/m > req $a_{sb} = 6.67$ cm²/m **ok**
center distance   above exst $d_1 = 3.80$ cm < clc $d_1 = 4.0$ cm **ok**
                    bottom exst $d_1 = 2.90$ cm < clc $d_1 = 3.4$ cm **ok**
<u>below the recess</u>
concrete cover to stirrup reinforcement:
         above (to recess) $c_{vi} = 1.5$ cm, lateral $c_{vr} = 2.0$ cm
         bottom $c_{vu} = 2.0$ cm > $c_{nom} = 2.00$ cm **ok**
longitudinal reinforcement above 4Ø12, exst $A_s = 4.52$ cm²
         exst $A_s = 4.52$ cm² > req $A_s = 1.66$ cm² **ok**
         anchorage length from recess edge left/right 67.1/58.1 cm
         bottom 4Ø20, exst $A_s = 12.57$ cm²
         exst $A_s = 12.57$ cm² > req $A_s = 1.67$ cm² **ok**
stirrup reinforcement   Ø8/12.5 cm (4-cut), exst $a_{sb} = 16.08$ cm²/m > req $a_{sb} = 7.80$ cm²/m **ok**
center distance   above $d_v = 3.00$ cm $\Rightarrow$ exst $d_1 = 2.90$ cm < clc $d_1 = 3.4$ cm **ok**
                    bottom $d_v = 4.00$ cm $\Rightarrow$ exst $d_1 = 4.00$ cm > clc $d_1 = 3.6$ cm **not ok !!**
<u>suspended reinforcement</u>
Bügel left   4Ø10/6.0 cm (4-cut), exst $A_s = 12.57$ cm² > req $A_s = 9.64$ cm² **ok**
Bügel right   1Ø10/6.0 cm (2-cut), exst $A_s = 1.57$ cm² > req $A_s = 0.92$ cm² **ok**

design resistance not guaranteed !!
s. selected reinforcement

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

Josef Hegger et. al.: Bewehren nach Eurocode 2
Deutscher Ausschuss für Stahlbeton, Heft 599, Beuth Verlag GmbH, 2013