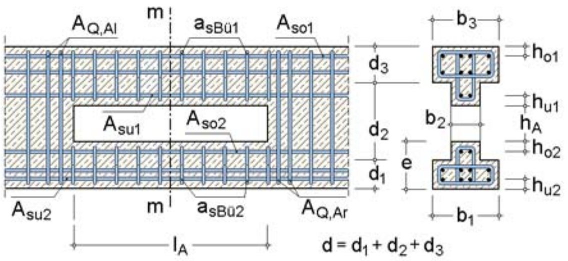
POS. 3: OPENING I-SECTION

girder opening

design calculation acc. to DIN EN 1992-1-1 (EC 2) / NA: Deutschland (4H-BETON version: 11/2007-4l)



reinforcem.BSt 500 (A)
concrete C30/37
material safety $\gamma_s = 1.15$, $\gamma_c = 1.50$

method acc. to Heft 399, DAfStb

I-section

width b_1 = 30.0 cm   height d_1 = 20.0 cm
width b_2 = 15.0 cm   height d_2 = 50.0 cm
width b_3 = 30.0 cm   height d_3 = 20.0 cm

reinforcement edge distance

top : h_{o1} = 3.0 cm h_{u1} = 2.0 cm
bottom: h_{o2} = 2.0 cm h_{u2} = 3.0 cm

opening

l_A = 75.0 cm h_A = 20.0 cm   e = 30.0 cm

design calculation values - design loads

$N_{Ed,m}$ = 100.0 kN $V_{Ed,m}$ = 50.0 kN $M_{Ed,m}$ = 312.5 kNm

design calculation (distr. factor from flange stiffn.)

design method for large openings
general rules for detailing reinforcement not considered !
zero crossing of moments at -0.20 lA = -15.0 cm from left opening edge

top :

$N_{Ed,o}$ = -464.9 kN $V_{Ed,o}$ = 34.8 kN
$M_{Ed,ol}$ = 5.2 kNm $M_{Ed,or}$ = 36.5 kN
reinforcement non-structurally reinforced
$|V_{Ed,o}| < V_{Rd,ct}$ = 50.1 kN
minimum reinforcement: $a_{sBül}$ = 1.39 cm²/m

bottom:

$N_{Ed,u}$ = 564.9 kN $V_{Ed,u}$ = 15.2 kN
$M_{Ed,ul}$ = 2.3 kNm $M_{Ed,ur}$ = 16.0 kN
A_{so2} = 4.7 cm² A_{su2} = 8.8 cm²
$V_{Rd,ct}$ = 0.0 kN < $|V_{Ed,u}|$ < $V_{Rd,max}$ = 239.1 kN
totally in tensile zone: θ = 45.0° ⇒ $a_{sBü2}$ = 1.40 cm²/m

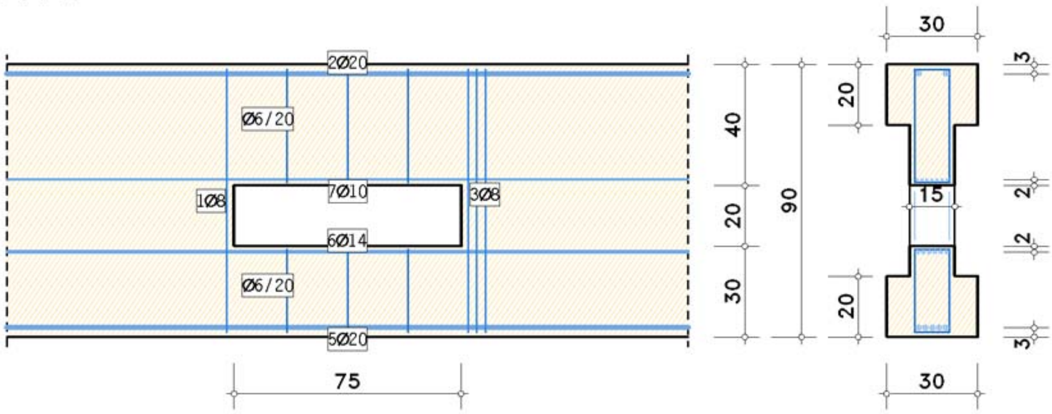
supporting reinf.: $A_{Q,Al}$ = 1.0 cm² $A_{Q,Ar}$ = 1.7 cm²

selected:

upper flange,	A_{so1} :	2 Ø 20 = 6.3 cm² > 0.0 cm²
	A_{su1} :	7 Ø 10 = 5.5 cm² > 0.0 cm²
	$a_{sBü1}$:	Ø 6 / 20 cm (2-shear) = 2.83 cm²/m > 1.39 cm²/m
lower flange,	A_{so2} :	6 Ø 14 = 9.2 cm² > 4.7 cm²
	A_{su2} :	5 Ø 20 = 15.7 cm² > 8.8 cm²
	$a_{sBü2}$:	Ø 6 / 20 cm (2-shear) = 2.83 cm²/m > 1.40 cm²/m
left hang.sh.,	$A_{Q,Al}$:	1 Ø 8 = 1.0 cm² ≥ 1.0 cm²
(2-shear)	$A_{Q,Ar}$:	3 Ø 8 = 3.0 cm² > 1.7 cm²

reinforcement drawing:

scale 1 : 25



material properties

concrete	f_{ck}	α	ε_{c2}	ε_{c2u}	n_c	E_{cm}	f_{ctm}
	MN/m²	-	‰	‰	-	MN/m²	MN/m²
C30/37	30.0	0.850	-2.00	-3.50	2.00	32836.6	2.896

design value of compression strength $f_{cd} = \alpha_c f_{ck} / \gamma_c$
strain at reaching the maximum strength ε_{c2}, ult. compr. strain ε_{c2u}
concr. comp. stress $\sigma_c = f_{cd} (1-(1-\varepsilon_c/\varepsilon_{c2})^n)$ for $0 \geq \varepsilon_c > \varepsilon_{c2}$ and $\sigma_c = f_{cd}$ for $\varepsilon_{c2} \geq \varepsilon_c > \varepsilon_{c2u}$
modulus of elasticity E_{cm}, mean value of axial tensil strength f_{ctm}

reinforcem.	f_{yk}	f_{tk}	ε_{su}	E_s
	MN/m²	MN/m²	‰	MN/m²
BSt 500 (A)	500.0	525.0	25.00	200000.0

design yield strength $f_{yd} = f_{yk} / \gamma_s$
design tensile strength $f_{td} = f_{tk} / \gamma_s$
ult. tensile strain ε_{su}, modulus of elasticity E_s