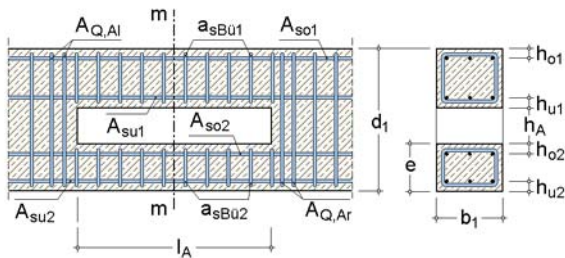


POS. 1: OPENING RECTANGLE

girder opening

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



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

method acc. to Heft 399, DAFStb

rectangular section

width $b_1 = 30.0$ cm height $d_1 = 50.0$ 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 $e = 10.0$ 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 $-0.10 l_A = -7.6$ cm from left opening edge

top:

$N_{Ed,o} = -835.7$ kN $V_{Ed,o} = 44.4$ kN

$M_{Ed,o1} = 3.4$ kNm $M_{Ed,or} = 43.4$ kN

$A_{so1} = 5.5$ cm² $A_{su1} = 5.5$ cm²

$|V_{Ed,o}| < V_{Rd,ct} = 57.0$ kN

minimum reinforcement: $a_{sBü1} = 2.78$ cm²/m

bottom:

$N_{Ed,u} = 935.7$ kN $V_{Ed,u} = 5.6$ kN

$M_{Ed,u1} = 0.4$ kNm $M_{Ed,ur} = 5.4$ kN

$A_{so2} = 8.0$ cm² $A_{su2} = 14.7$ cm²

$V_{Rd,ct} = 0.0$ kN $< |V_{Ed,u}| < V_{Rd,max} = 95.6$ kN

totally in tensile zone: $\theta = 45.0^\circ$ (not decisive)

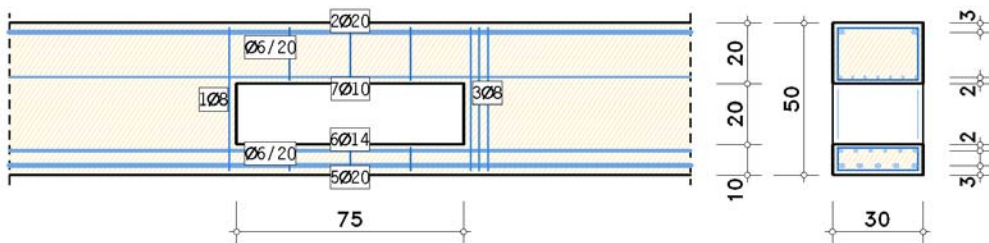
minimum reinforcement: $a_{sBü2} = 2.78$ cm²/m

supporting reinf.: $A_{Q,A1} = 0.7$ cm² $A_{Q,Ar} = 2.9$ cm²

selected:	upper flange,	$A_{so1} : 2 \text{ } \varnothing 20 = 6.3 \text{ cm}^2 > 5.5 \text{ cm}^2$
		$A_{su1} : 7 \text{ } \varnothing 10 = 5.5 \text{ cm}^2 \geq 5.5 \text{ cm}^2$
		$a_{sBü1} : \varnothing 6 / 20 \text{ cm (2-shear)} = 2.83 \text{ cm}^2/\text{m} > 2.78 \text{ cm}^2/\text{m}$
lower flange,	$A_{so2} : 6 \text{ } \varnothing 14 = 9.2 \text{ cm}^2 > 8.0 \text{ cm}^2$	
	$A_{su2} : 5 \text{ } \varnothing 20 = 15.7 \text{ cm}^2 > 14.7 \text{ cm}^2$	
	$a_{sBü2} : \varnothing 6 / 20 \text{ cm (2-shear)} = 2.83 \text{ cm}^2/\text{m} > 2.78 \text{ cm}^2/\text{m}$	
left hang.sh.,	$A_{Q,A1} : 1 \text{ } \varnothing 8 = 1.0 \text{ cm}^2 > 0.7 \text{ cm}^2$	
	(2-shear) $A_{Q,Ar} : 3 \text{ } \varnothing 8 = 3.0 \text{ cm}^2 > 2.9 \text{ cm}^2$	

reinforcement drawing:

scale 1 : 25



material properties

concrete	f_{ck}	α	ϵ_{c2}	ϵ_{c2u}	n_c	E_{cm}	f_{ctm}
	MN/m ²	-	‰	‰	-	MN/m ²	MN/m ²
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 $\sigma_c = f_{cd} (1 - (\epsilon_c / \epsilon_{c2})^n)$ for $0 \leq \epsilon_c < \epsilon_{c2}$ and $\sigma_c = f_{cd}$ for $\epsilon_c \geq \epsilon_{c2}$
 modulus of elasticity E_{cm} , mean value of axial tensile strength f_{ctm}

reinforcem.	f_{yk}	f_{tk}	ϵ_{su}	E_s
	MN/m ²	MN/m ²	‰	MN/m ²
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