

HALFEN Stud Connector HSC

Design resistance, construction detailing determination of internal forces and verification according to EC2-1-1 with EC2-1-1/NA and national technical approval No. Z-21.8-1973

General parameters

material of HSC anchor	Bst	B500B
Nominal diameter of the HSC anchor		20
Total number of HSC layers		1
orientation of the anchor head		Horizontal
concrete strength class		C30/37
exposure class		XC3
bond conditions		good
nominal size of concrete cover	C _{nom}	35.0 [mm]
reduced ΔCdev		No

column dimensions

column width	b _{col}	595 [mm]
column height	h _{col}	300 [mm]
Column longitudinal reinforcement Ø	d _{sL}	25 [mm]
shear reinforcement Ø	d _{sw,col}	8 [mm]
spacing of stirrups	s _{w,col}	100 [mm]
spacing of stirrups in the joint	s _{w,KS}	50 [mm]

Corbel dimensions

Corbel width	b _c	595 [mm]
corbel length	l _c	300 [mm]
corbel height	h _c	350 [mm]
Detailing of construction joint		without construction joint
separate stirrups in corbel and column		No
double side corbel		Yes
Distance from the edge of column to load application	a _c	100 [mm]
length of base plate	a _L	50 [mm]
Width of base plate	b _L	495 [mm]
thickness of base plate	d _L	10 [mm]

Actions

Design value of vertical load	F _{Ed}	495.0 [kN]
Design value of horizontal load	H _{Ed}	100.0 [kN]
approach H _{Ed} = 0.2 * V _{Ed}		Yes

Steel schedule

HSC-Anchor

	Quantity	HSC-Anchor type	L [mm]	orientation of the anchor head
1. HSC-layer	3	HSC-HD-20	830	H

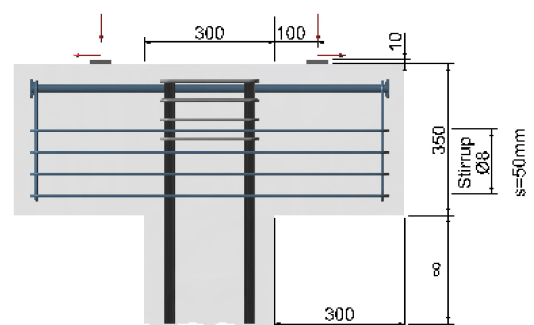
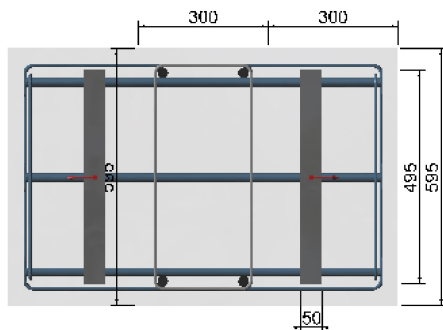
Stirrup reinforcement

The above mentioned dimensions of stirrups are proposals just to explain the system. As part of the installation planning, the final dimensions must be defined.

vertical stirrup at stud head					
	Quantity	Ø[mm]	L ₁ [mm]	L ₂ [mm]	sw[mm]
1. HSC-layer	2	8	475	276	-

closed horizontal stirrups enveloping corbel and column					
	Quantity	Ø[mm]	L ₁ [mm]	L ₂ [mm]	sw[mm]
Horizontal	4	8	525	830	64

Required stirrups in the column across hight of corbel					
	Quantity	Ø[mm]	L ₁ [mm]	L ₂ [mm]	sw[mm]
as per reinforcement of column	4	8	525	230	44
as per reinforcement of corbel	4	8	525	230	44

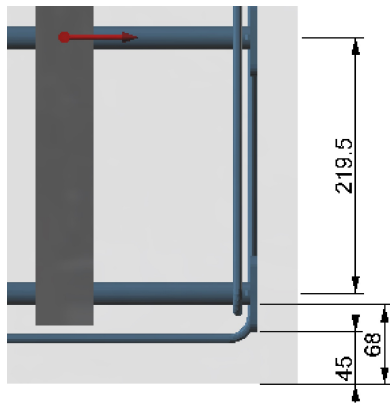


Column stirrup reinforcement outside the corbel connection is not shown.

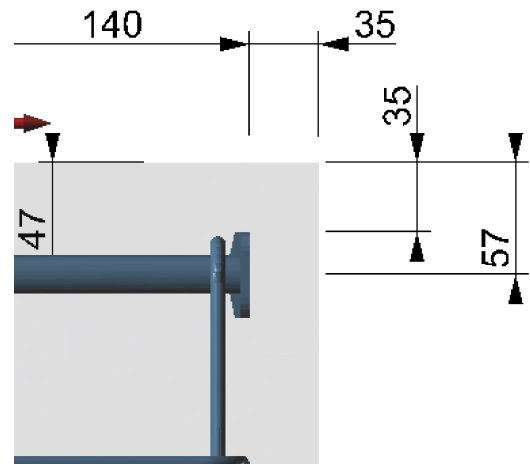
Concrete cover of HSC

C_v [mm]	$C_{nom,HSC,side}$ [mm]	$C_{nom,HSC,Head,side}$ [mm]	$C_{nom,HSC,top}$ [mm]	C_1 [mm]
35.0	68.0	45.0	47.0	35.0
d_1 [mm]	\dot{U}_{prov} [mm]	$S_{HSC,La1}$ [mm]	$S_{HSC,La2}$ [mm]	
57.0	140.0	219.5	-	

plan view



view



Important hints

The calculation - including the static values - apply only for the illustrated HALFEN building product. Load capacities of seemingly identical third-party products may differ. The provider of this software cannot assume liability for alternative building products.

The proper functioning of bearing shall be ensured by reinforcement in adjacent members, limitation of bearing stress and measures to account for movement, restraint and production and assembling deviations according to DIN EN 1992-1-1, Section 10.9.5.

Calculation and design of HSC anchor in Corbel according to EC2-1-1 with EC2-1-1/NA and approval Z-21.8-1973

verification of shear resistance in the corbel (Annex 4, Section 3)

$$\begin{aligned}
 V_{Ed} &= F_{Ed} &&= 495.0 \text{ kN} \\
 V_{Rd,max} &= 0.5 \cdot v \cdot b_c \cdot z \cdot f_{ck} / \gamma_c &&= 0.5 \cdot 0.55 \cdot 595 \cdot 264 \cdot 3.0 / 1.5 &&= 863.0 \text{ kN} \\
 v &= \max [0.7 - f_{ck} / 200; 0.5] &&= \max [0.7 - 30.0 / 200; 0.5] &&= 0.55 \\
 z &= 0.9 \cdot d &&= 0.9 \cdot 293.0 &&= 263.7 \text{ mm} \\
 d &= h_c - d_1 &&= 350 - 57 &&= 293 \text{ mm} \\
 d_1 &&&&&= 57.0 \text{ mm} \\
 V_{Ed} / V_{Rd,max} &&&= 495.0 / 863.0 &&= 57.36 \%
 \end{aligned}$$

Calculation of the beam tie force (Annex 4, Section 4)

$$\begin{aligned}
 Z_{Ed} &= F_{Ed} \cdot a_c / z_0 + H_{Ed} \cdot (a_H + z_0) / z_0 &&= 495.0 \cdot 0.4 + 100.0 \cdot (67 + 226) / 226 &&= 348.9 \text{ kN} \\
 a_c / z_0 &\geq 0.4 &&= 100 / 226 &&= 0.44 \geq 0.4 \\
 z_0 &= d \cdot (1 - 0.4 \cdot F_{Ed} / V_{Rd,max}) &&= 293 \cdot (1 - 0.4 \cdot 495.0 / 863.0) &&= 226 \text{ mm} \\
 a_H &= d_1 + d_L &&= 57.0 + 10 &&= 67.0 \text{ mm}
 \end{aligned}$$

Calculation of required cross section area of the HSC anchors (Annex 4, Section 5)

$$\begin{aligned}
 A_{s,HSC,rqd} &= Z_{Ed} / f_{yd} \geq A_{s,min} &&= 348.9 / 43.48 \geq 4.65 &&= 8.03 \text{ cm}^2 \\
 n_{HSC,rqd} &= A_{HSC,rqd} / A &&= 8.03 / 3.14 &&= 2.6 \\
 A_{s,min} &= (f_{ctm} \cdot W_c + Z_{Ed} \cdot (z_0 - z_{s1} - W_c / (h_c \cdot b_c))) / (z_0 \cdot f_{yk}) &&&&= 4.65 \text{ cm}^2 \\
 A_{s,max} &= 0.08 \cdot h_c \cdot b_c &&= 0.08 \cdot 35.0 \cdot 59.5 &&= 166.60 \text{ cm}^2 \\
 A_{s,HSC,prov} &= n_{HSC,prov} \cdot A &&= 3 \cdot 3.14 &&= 9.42 \text{ cm}^2 \\
 \beta_{As} &= A_{s,HSC,rqd} / A_{s,HSC,prov} &&= 8.03 / 9.42 &&= 85.15 \% \\
 \beta_{As,min} &= A_{s,min} / A_{s,HSC,prov} &&= 4.65 / 9.42 &&= 49.29 \% \\
 \beta_{As,max} &= A_{s,HSC,prov} / A_{s,max} &&= 9.42 / 166.60 &&= 5.66 \% \\
 n_{HSC,prov} &&&&&= 3 \\
 n_{HSC,L a1} &&&&&= 3 \\
 n_{HSC,L a2} &&&&&= 0
 \end{aligned}$$

Verification of bearing stress under the base plate (Annex 4, Section 7)

$$\begin{aligned}
 F_{Rd,LP} &= A_{c0,LP} \cdot f_{cd} \cdot (A_{c1,LP} / A_{c0,LP})^{0.5} \leq A_{c0,LP} \cdot f_{cd} \cdot 3.0 &&= 799.0 \text{ kN} \\
 f_{cd} &&&&&= 1.70 \text{ kN/cm}^2 \\
 A_{c0,LP} &&&&&= 247.5 \text{ cm}^2 \\
 A_{c1,LP} &&&&&= 892.5 \text{ cm}^2 \\
 F_{Ed} / F_{Rd,LP} &&&= 495.0 / 799.0 &&= 61.95 \%
 \end{aligned}$$

Verification of the anchorage of HSC-anchors in the corbel (Annex 4, Section 8)

The verification of a single row HSC-anchors in the corbel is considered verified if detailing rules a) - c) in accordance to Annex 4, Section 1 have been observed.

$$\begin{aligned}
 \ddot{u}_{min} &= \max [c_1 / 2 + h_{HSC}; d_1 / 2 + h_{HSC} - a_L / 2] &&= \max [3.5 / 2 + 1.2; 5.7 / 2 + 1.2 - 5.0 / 2] &&= 3.0 \text{ cm} \\
 \ddot{u}_{prov} &= a_{d2} - c_v &&= 17.5 - 3.5 &&= 14.0 \text{ cm} \\
 \ddot{u}_{min} / \ddot{u}_{prov} &&&= 3.0 / 14.0 &&= 21.07 \%
 \end{aligned}$$

Detailing of closed stirrups in the corbel (Annex 4, Section 9)

$$\begin{aligned} a_c / h_c &= 100.0 / 350.0 &= 0.29 &\leq 0.5 \\ V_{Ed} / V_{Rd,max} &= 495.0 / 863.0 &= 0.57 &> 0.3 \end{aligned}$$

1) For each row of HSC-anchors at least one vertical stirrups in the near of the anchor head is required

$$n_{sw,v,La1} = 1$$

2) Horizontal stirrups to prevent splitting forces

$$\begin{aligned} A_{sw,h,rqd} &= 0.5 * A_{s,HSC,rqd} &= 0.5 * 8.03 &= 4.01 \text{ cm}^2 \\ A_{sw,h,prov} &= 2 * n_{sw,h,prov} * \pi * d_{sw,h}^2 / 4 &= 4.02 \text{ cm}^2 \\ n_{sw,h,prov} &= 4 \end{aligned}$$

stirrups enclose corbel and column

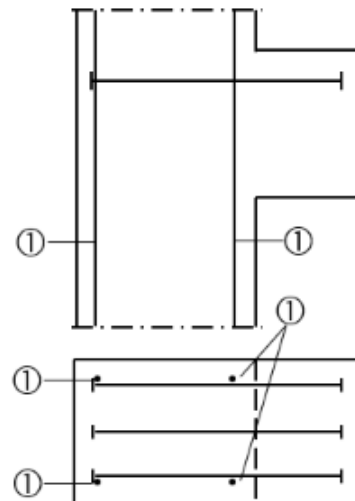
Anchorage of HSC-Anchors in the subsequented column (Annex 4, Section 10)

The verification of the anchorage of HSC-anchors in the column is completely fulfilled if the detailing rules a) - e) according to Annex 4, Section 10 have been observed.

Transverse Reinforcement in the column above the height of the corbel

$$\begin{aligned} \emptyset_{sw,col} &= 8 \text{ mm} &&\geq 8 \text{ mm} \\ n_{sw,col,rqd} &= h_c / s_{sw,shear} + 1 &= 350 / 50 + 1 &= 8 \\ n_{sw,col,prov} &= h_c / s_{sw,col} + 1 &= 350 / 100 + 1 &= 4 \\ n_{sw,col,h} &= (\text{as per reinforcement of corbel}) &&= 4 \end{aligned}$$

The on-site column longitudinal reinforcement ① shall be arranged according to the adjacent outline sketch.



Summary of design loads / design resistances and degree of utilisation

	$F_{Ed}[\text{kN}]$	$V_{Rd,max}[\text{kN}]$	Utilisation
Shear resistance of corbel	495.0	863.0	57.36 %
	$Z_{Ed}[\text{kN}]$	$Z_{Rd}[\text{kN}]$	Utilisation
Resistance of tension strut	348.9	409.8	85.15 %
	$F_{Ed}[\text{kN}]$	$F_{Rd,LP}[\text{kN}]$	Utilisation
Bearing stress under the base plate	495.0	799.0	61.95 %
Anchorage of HSC-anchors in the corbel	verified		
Anchorage of HSC-anchors in the column	verified		

All verifications are fulfilled