

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 ΔC_{dev} | | No |

column dimensions

| | | |
|---|--------------|----------|
| column width | b_{col} | 595 [mm] |
| column height | h_{col} | 300 [mm] |
| Column longitudinal reinforcement \emptyset | d_{sL} | 25 [mm] |
| shear reinforcement \emptyset | $d_{sw,col}$ | 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 |

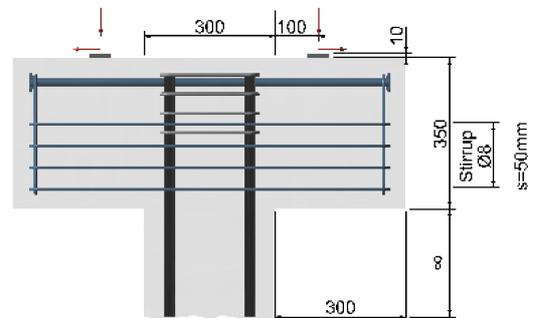
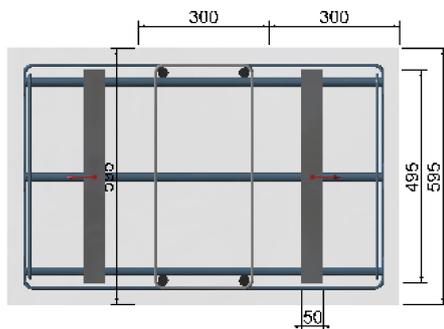
Stirrup reinforcement

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 |

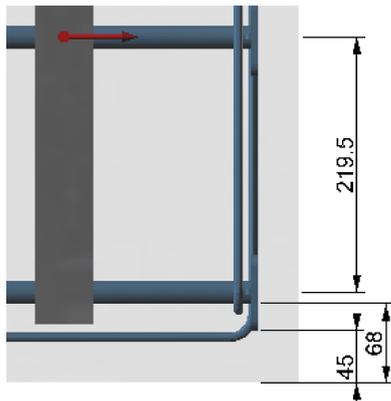


Column stirrup reinforcement outside the corbel connection is not shown.

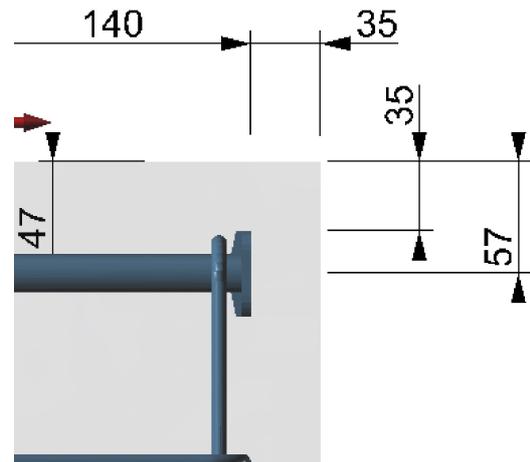
Concrete cover of HSC

| 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)

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

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

$$\begin{aligned}
 Z_{Ed} &= F_{Ed} * a_c / Z_0 + H_{Ed} * (a_H + z_0) / Z_0 &&= 495.0 * 0.4 + 100.0 * (67 + 226) / 226 &&= 348.9 \text{ kN} \\
 a_c / Z_0 &\geq 0.4 &&= 100 / 226 &&= 0.44 \geq 0.4 \\
 Z_0 &= d * (1 - 0.4 * F_{Ed} / V_{Rd,max}) &&= 293 * (1 - 0.4 * 495.0 / 863.0) &&= 226 \text{ mm} \\
 a_H &= d_1 + d_L &&= 57.0 + 10 &&= 67.0 \text{ mm}
 \end{aligned}$$

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

$$\begin{aligned}
 A_{s,HSC,rqd} &= Z_{Ed} / f_{yd} \geq A_{s,min} &&= 348.9 / 43.48 \geq 4.65 &&= 8.03 \text{ cm}^2 \\
 n_{HSC,rqd} &= A_{HSC,rqd} / A &&= 8.03 / 3.14 &&= 2.6 \\
 A_{s,min} &= (f_{ctm} * W_c + Z_{Ed} * (z_0 - z_{s1} - W_c / (h_c * b_c))) / (z_0 * f_{yk}) &&&&= 4.65 \text{ cm}^2 \\
 A_{s,max} &= 0.08 * h_c * b_c &&= 0.08 * 35.0 * 59.5 &&= 166.60 \text{ cm}^2 \\
 A_{s,HSC,prov} &= n_{HSC,prov} * A &&= 3 * 3.14 &&= 9.42 \text{ cm}^2 \\
 \beta_{As} &= A_{s,HSC,rqd} / A_{s,HSC,prov} &&= 8.03 / 9.42 &&= 85.15 \% \\
 \beta_{As,min} &= A_{s,min} / A_{s,HSC,prov} &&= 4.65 / 9.42 &&= 49.29 \% \\
 \beta_{As,max} &= A_{s,HSC,prov} / A_{s,max} &&= 9.42 / 166.60 &&= 5.66 \% \\
 n_{HSC,prov} &&&&&= 3 \\
 n_{HSC,La1} &&&&&= 3 \\
 n_{HSC,La2} &&&&&= 0
 \end{aligned}$$

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

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

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)

| | | | |
|-----------------------|-----------------|--------|-------|
| a_c / h_c | = 100.0 / 350.0 | = 0.29 | ≤ 0.5 |
| $V_{Ed} / V_{Rd,max}$ | = 495.0 / 863.0 | = 0.57 | > 0.3 |

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

| | | | |
|----------------|-------------------------|--------------|------------------------|
| $A_{sw,h,rqd}$ | = 0.5 * $A_{s,HSC,rqd}$ | = 0.5 * 8.03 | = 4.01 cm ² |
|----------------|-------------------------|--------------|------------------------|

| | | | |
|-----------------|--|--|------------------------|
| $A_{sw,h,prov}$ | = 2 * $n_{sw,h,prov}$ * π * $d_{sw,h}^2 / 4$ | | = 4.02 cm ² |
|-----------------|--|--|------------------------|

| | | | |
|-----------------|--|--|-----|
| $n_{sw,h,prov}$ | | | = 4 |
|-----------------|--|--|-----|

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

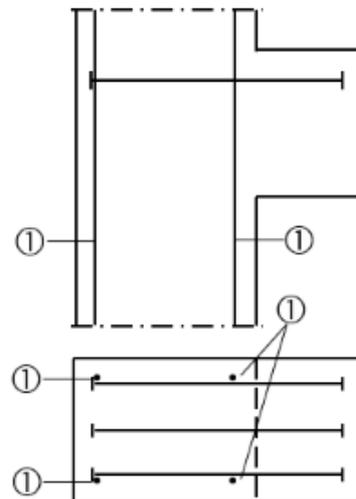
| | | | |
|------------------------|--------|--|--------|
| $\varnothing_{sw,col}$ | = 8 mm | | ≥ 8 mm |
|------------------------|--------|--|--------|

| | | | |
|------------------|-----------------------------|----------------|-----|
| $n_{sw,col,rqd}$ | = $h_c / s_{sw, shear} + 1$ | = 350 / 50 + 1 | = 8 |
|------------------|-----------------------------|----------------|-----|

| | | | |
|-------------------|--------------------------|-----------------|-----|
| $n_{sw,col,prov}$ | = $h_c / s_{sw,col} + 1$ | = 350 / 100 + 1 | = 4 |
|-------------------|--------------------------|-----------------|-----|

| | | | |
|--------------|------------------------------------|--|-----|
| $n_{sw, ch}$ | = (as per reinforcement of corbel) | | = 4 |
|--------------|------------------------------------|--|-----|

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} [kN] | $V_{Rd,max}$ [kN] | Utilisation |
|--|---------------|-------------------|-------------|
| Shear resistance of corbel | 495.0 | 863.0 | 57.36 % |
| | Z_{Ed} [kN] | Z_{Rd} [kN] | Utilisation |
| Resistance of tension strut | 348.9 | 409.8 | 85.15 % |
| | F_{Ed} [kN] | $F_{Rd,LP}$ [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