PRODUCT TECHNICAL DATASHEET

HIT-PUNCHING SHEAR STRENGTHENING SYSTEM

Update: Nov 25

HIT-Punching Shear with HIT-RE 500 V4 injection mortar, HAS/HAS-U threaded rods, Filling Set

for strengthening concrete in shear (DIBt aBG Z-15.5-387, based on DIN EN 1992-1-1/NA)

HIT-Punching Shear Strengthening system

Hilti HIT-RE 500 V4 (in 330 / 500 / 1400 ml foil pack)

HAS 8.8
HAS-A4
(M12 – M24)

HAS-U 8.8
HAS-U A4
(M12-M24)

Filling Set and Locking Nut accessory

Benefits

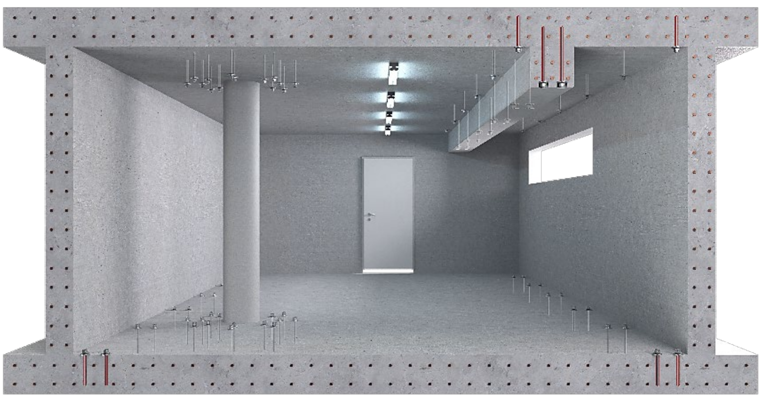
- Suitable in concrete strength classes C20/25-C50/60.
- Suitable for dry and water-saturated concrete, and water-filled holes.
- Suitable for either Hilti hollow drill bit for Hammer Drilling or Diamond Coring with Roughening tool
- Working temperature range of the base material: -5°C to +40°C
- Sufficiently long working time at elevated temperatures
- HAS-U anchor rods have engraved marking on the head for easy verification of steel grade and bar length even after installation

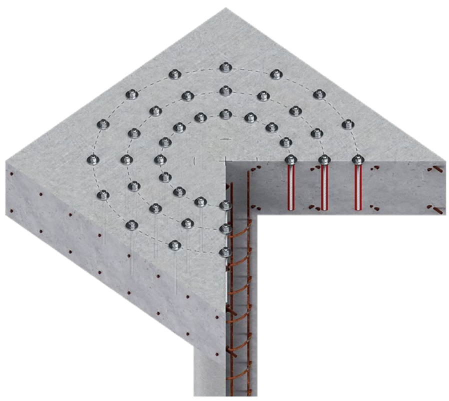
Application: Punching shear strengthening of concrete members

Increasing loads on structures may result in the existing reinforced concrete members that have insufficient resistance in bending, shear, compression, or torsion, thus needing strengthening. HIT-Punching Shear offers a minimally invasive strengthening solution that increases the punching shear resistance of concrete slabs and foundations by increasing available cross-sectional steel when installed from one side, resulting in the strengthened member safely resisting additional loads and preventing the need to demolish and rebuild.

Design of the verification and strengthening scheme is possible:

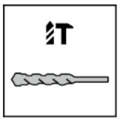
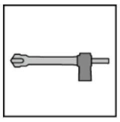
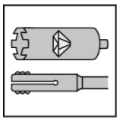
- Based on DIN EN 1992 with the German National Approval (aBG),
- Integrated in the PROFIS Engineering suite





Application conditions

Base material	Load conditions
 Concrete	Static/ Quasi-static

Drilling, cleaning, setting			Other information	
 Hammer drilled holes	 Hollow drill bit drilled holes	 Diamond cored holes with roughening tool	 PROFIS Engineering design Software	 Whitepaper

Linked Approvals/Certificates and Instructions for use

Approval no.	Application / loading condition	Authority / Laboratory	Date of issue	Date of expiry
aBG Z-15.5-387	Punching Shear Strengthening Static quasi-static	DIBt, Berlin	23-04-2025	23-04-2030

The instructions for use can be viewed using the link in the instructions for use table or the QR code/link in the Hilti webpage table.

Instructions for use (IFU)

Material and Application				
Application	IFU- HIT-Punching Shear one-sided installation			
Injection mortar	IFU Hilti HIT-RE 500 V4 (330/500 ml)			IFU Hilti HIT-RE 500 V4 (1400 ml)
Dispenser	IFU HDM	IFU HDE 500-A12	IFU HDE-500 22	IFU HIT-P8000D

Link to Hilti Webpage

Injection mortars / Dispenser / Accessories					
Hilti HIT-RE 500 V4	HDE 500-22	HDE 500-A12	Hilti HIT-P8000D	Filling set	PS 300

Strengthening Elements	
HAS-U	HAS

Specific properties of the Strengthening Elements

Mechanical properties of the Hilti HAS and HAS-U strengthening element and Hilti Filling Set

Designation	Material
Steel elements made of carbon steel	
HAS 8.8, HAS-U 8.8	Strength class 8.8, $f_{uk} = 800\ N/mm^2$, $f_{yk} = 640\ N/mm^2$, Elongation at fracture $(l_0 = 5d) > 12\%$ ductile Electroplated zinc coated $\geq 5\ \mu m$
Nut	Strength class 8.8, $f_{uk} = 800\ N/mm^2$, $f_{yk} = 640\ N/mm^2$, Electroplated zinc coated $\geq 5\ \mu m$
Hilti Filling Set	Filling washer: Electroplated zinc coated $\geq 5\ \mu m$ Spherical washer: Electroplated zinc coated $\geq 5\ \mu m$ Lock nut: Electroplated zinc coated $\geq 5\ \mu m$
Steel elements made of stainless steel with corrosion resistance class (CRC) III according to DIN EN 1993-1-4:2015-10	
HAS A4, HAS-U A4	Strength class 70, $f_{uk} = 700\ N/mm^2$, $f_{yk} = 450\ N/mm^2$, Elongation at fracture $(l_0 = 5d) > 12\%$ d ductile Stainless steel according to DIN EN 10088-1:2014-12
Nut	Strength class 70, $f_{uk} = 700\ N/mm^2$, $f_{yk} = 450\ N/mm^2$, Stainless steel 1.4401, 1.4404, 1.4578, 1.4571, 1.4362 according to DIN EN 10088-1:2014-12
Hilti Filling Set A4	Filling washer: Stainless steel according to DIN EN 10088-1:2024-04 Spherical washer: Stainless steel according to DIN EN 10088-1:2024-04 Lock nut: Stainless steel according to DIN EN 10088-1:2024-04

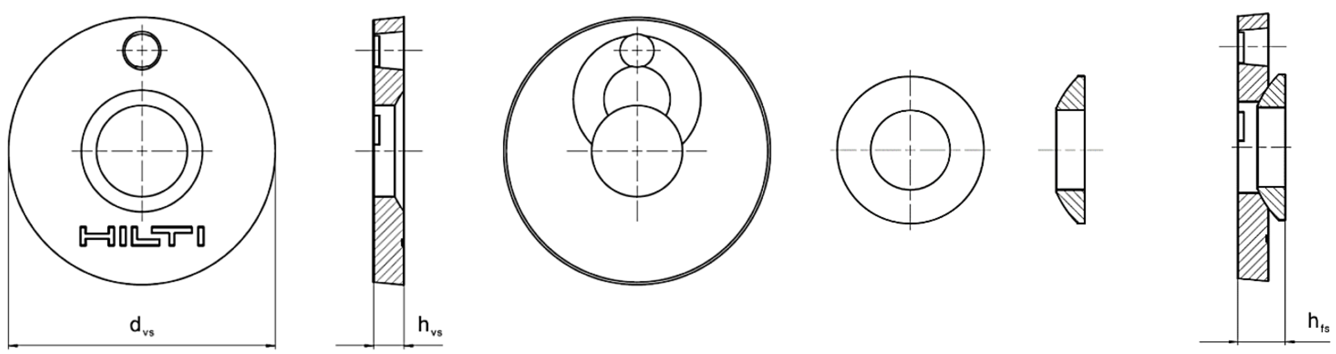
Dimensions of the filling washer for use with standard nut

Mechanical properties of Filling Set are standardized and can be taken from the link given in Approvals / Certificates.

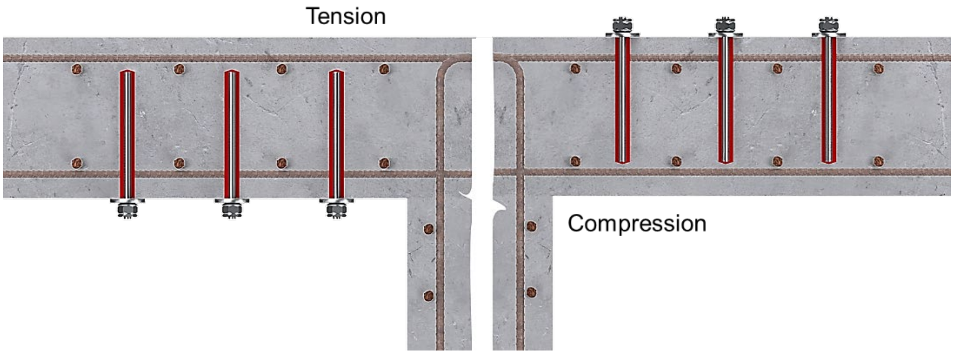
Dimensions filling washer

Anchor size			M12	M16	M20	M24
Diameter	d_{vs}	[mm]	44	52	60	70
Height of filling washer	h_{vs}	[mm]	5	6	6	6
Height of filling washer and spherical washer	h_{fs}	[mm]	10	11	13	15

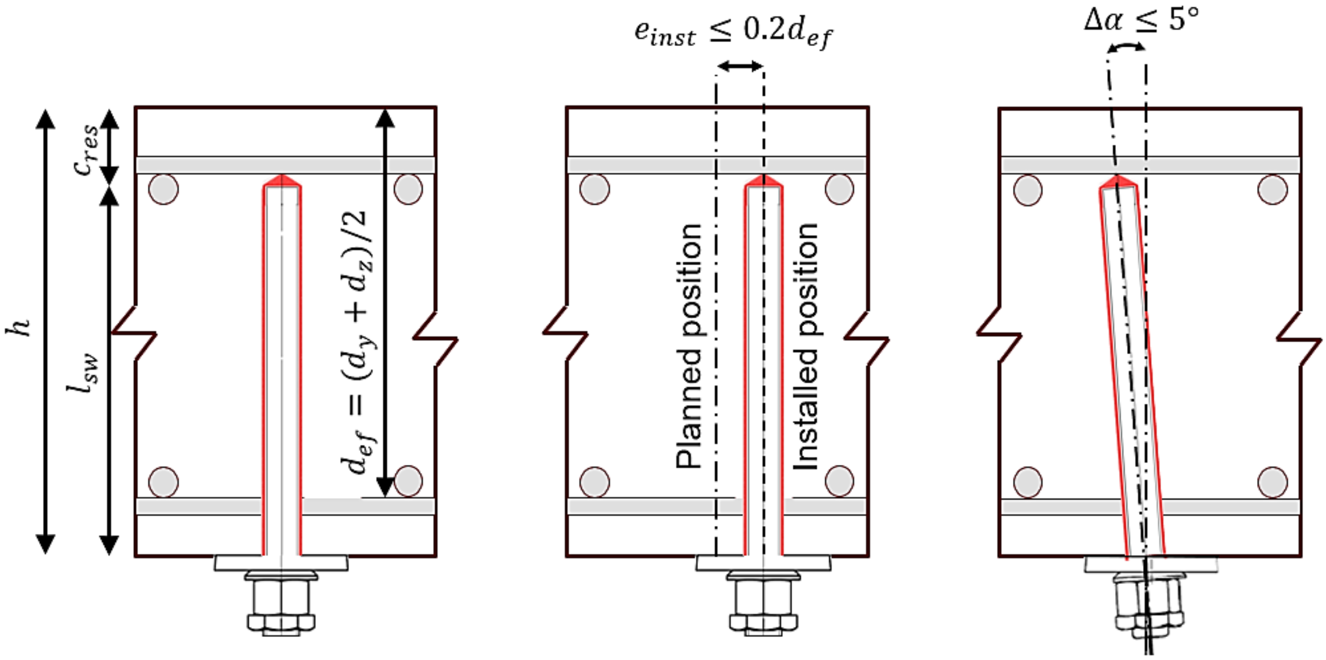
Sealing washer Spherical washer Filling Set



Cross-section of HIT-Punching Shear installed from either the top or bottom of a concrete member



Installation Parameters and Permitted Tolerances



Member cross-section **Installation tolerance** **Angular deviation**

$\boldsymbol{h}$	: height of the concrete member
$\boldsymbol{c_{res}}$	: defined residual concrete cover above the end of the threaded rod to the concrete surface
$\boldsymbol{l_{sw}}$	: $\boldsymbol{h - c_{res}}$ = embedment depth of the threaded rod
$\boldsymbol{e_{inst}}$	: eccentricity of the threaded rods
$\boldsymbol{e_{inst,max}}$	: maximum installation tolerance of the threaded rods in all directions: $\leq 0.2d_{ef}$
$\boldsymbol{\Delta\alpha_{max}}$	: maximum permissible angle of inclination (= 5°) of the threaded rods with respect to the line of action of the shear force (perpendicular to the longitudinal axis of the concrete member)

Design according to *aBG Z-15.5-387* for static conditions

Based on DIN EN 1992-1-1/NA and DIN EN 1992-2/NA, the **static** verification must fulfil:

$\boldsymbol{\tau_{Ed}} \leq \boldsymbol{k_d k_{max} \tau_{Rd,c}}$, when $\boldsymbol{\tau_{Ed}} > \boldsymbol{\tau_{Rd,c}}$ (in N/mm²) Eq. (1)

Where,

$$\boldsymbol{\tau_{Ed}} = \frac{\boldsymbol{\beta \cdot V_{Ed}}}{\boldsymbol{u_{crit} \cdot d_{ef}}} \quad \text{Eq. (2)}$$

- V_{Ed}: design punching shear force at the Ultimate Limit State
- β: load eccentricity parameter ≥ 1.1
- u_{crit}: critical control perimeter, set at $2.0d_{ef}$ from the face of the loaded area
- k_d: coefficient for the mean effective depth, d_{ef}, and the diameter of the threaded rod, see Table 2
- $k_{max} = 1{,}4$

$\boldsymbol{\tau_{Rd,c}} = \boldsymbol{max}\left[\boldsymbol{C_{Rd,c} k (100 \rho_l f_{ck})^{\frac{1}{3}}}, \boldsymbol{\tau_{min}}\right] + \boldsymbol{k_1 \sigma_{cp}}$ (in N/mm²) Eq. (3)

- For inner columns and other columns with $\frac{u_0}{d_{ef}} \geq 4$, $C_{Rd,c} = \frac{0{,}18}{\gamma_c}$ Eq. (4a)
- For inner columns with $\frac{u_0}{d} < 4$, $C_{Rd,c} = \frac{0{,}18}{\gamma_c} \cdot \left(0{,}1 \cdot \frac{u_0}{d_{ef}} + 0{,}6\right) \geq \frac{0{,}15}{\gamma_c}$ Eq. (4b)
- $k = 1 + \sqrt{\frac{200}{d_{ef}}} \leq 2{,}0$ Eq. (5)
- Mean longitudinal reinforcement, $\rho_l = \sqrt{\rho_{l,x} \cdot \rho_{l,y}} \leq \min\,(0.02\,, 0.5\frac{f_{cd}}{f_{yd}})$ Eq. (6)
- $\tau_{min} = \begin{cases} \frac{0{,}0525}{\gamma_c} k^{3/2} f_{ck}^{1/2} \; for\ d_{ef} \leq 600\ mm \\ \frac{0{,}0325}{\gamma_c} k^{3/2} f_{ck}^{1/2} \; for\ d_{ef} > 800\ mm \end{cases}$ Eq. (7)
  - Linear interpolation permitted for $600\ mm < d_{ef} \leq 800\ mm$
- $\sigma_{cp} = (\sigma_{cx} + \sigma_{cy})/2$: Mean axial prestress, negative for tension
- $k_1 = 0{,}10$
- γ_c: Partial safety factor for concrete; $\gamma_c = 1{,}5$ for persistent & transient design scenarios, $\gamma_c = 1{,}2$ for accidental scenarios.

If $\boldsymbol{\tau_{Rd,c}} \leq \boldsymbol{\tau_{Ed}} \leq \boldsymbol{k_d k_{max} \tau_{Rd,c}}$, strengthening is required and is possible.

For floor slabs, strengthening must satisfy the condition:

$\boldsymbol{\beta \cdot V_{Ed}} \leq \boldsymbol{V_{Rd,cs}} = \boldsymbol{k_d (0.75 \tau_{Rd,c} u_{crit} d_{ef})} + \boldsymbol{k_{pi}} \left(\boldsymbol{1.5 f_{ywd,ef} A_{sw,crit}} \frac{d_{ef}}{s_r}\right)$ (in kN) Eq. (8)

- k_d: see Table 2
- k_{pi}: Coefficient of efficiency of the post-installed punching shear strengthening elements, see Table 2
- $f_{ywd,ef} = 250 + 0{,}25 \cdot d_{ef} \leq f_{ywd}$, with f_{ywd} from Table 1
- s_r: Spacing between first and second reinforcing perimeters, also followed for all subsequent reinforcing perimeters
  - $s_{min} \leq s_r \leq 1{,}5d_{ef}$ if the reinforcing perimeter is located within u_{crit}
  - $s_{min} \leq s_r \leq 2{,}0d_{ef}$ if the reinforcing perimeter is located beyond u_{crit}

The punching reinforcement required at the critical perimeter, u_{crit}, is evaluated by:

$$A_{sw,crit} = \frac{\tau_{Ed} - 0{,}75 k_d \tau_{Rd,c}}{1{,}5 k_{pi} f_{ywd,ef}} s_r u_{crit} \quad \text{Eq. (9)}$$

To evaluate the total reinforcement required in the first and second reinforcing perimeters, $A_{sw,i} \geq \boldsymbol{\kappa_i} A_{sw,crit}$, $(i \leq 2)$ where:

- $\kappa_1 = 2{,}5$ for the **first** reinforcing perimeter, according to DIN EN 1992-1-1/NA, NCI to 6.4.5 (1)

- $\kappa_2 = 1{,}4$ for the **second** reinforcing perimeter, according to DIN EN 1992-1-1/NA, NCI to 6.4.5 (1)

Alternatively, κ_i may be evaluated by:

$$\kappa_i = \frac{\beta V_{Ed} - 0.75 k_d \tau_{Rd,c} u_i d_{ef}}{\beta V_{Ed} - 0.75 k_d \tau_{Rd,c} u_{crit} d_{ef}} \qquad \text{Eq. (10)}$$

- u_i: length of the first or second reinforcing perimeter, set from the face of the loaded area at $[s_0]$ or $[s_0 + s_r]$, respectively.

For foundations, strengthening also must satisfy the condition: $\boldsymbol{\tau_{Rd,c} \leq \tau_{Ed} \leq k_d k_{max} \tau_{Rd,c}}$

$$\boldsymbol{\tau_{Ed} = \frac{\beta \cdot V_{Ed,red}}{u_{crit} d_{ef}}} \qquad \text{Eq. (11)}$$

- $V_{Ed,red} = V_{Ed} - \Delta V_{Ed}$ Eq. (12)
- ΔV_{Ed}: net upwards force acting within the area bound by u_{crit}, A_{crit}, and is evaluated by subtracting the self-weight of the foundation from the upwards pressure generated by the soil.

For foundations, $\boldsymbol{\tau_{Rd,c}}$ may be evaluated by:

$$\boldsymbol{\tau_{Rd,c} = max\left[C_{Rd,c} k (100 \rho_l f_{ck})^{\frac{1}{3}}, \tau_{min}\right] \cdot \frac{2d_{ef}}{a_{crit}}} \qquad \text{Eq. (13)}$$

- a_{crit}: distance from the face of the loaded area to the critical control perimeter, $\leq 2d_{ef}$.

If $\boldsymbol{\tau_{Rd,c} \leq \tau_{Ed} \leq k_d k_{max} \tau_{Rd,c}}$, strengthening is required and is possible.

For foundations, strengthening must satisfy the condition:

$$\boldsymbol{\beta \cdot V_{Ed,red} \leq V_{Rd,s} = k_{pi}\left(f_{ywd,ef} A_{sw,1+2}\right)} \qquad \text{Eq. (14)}$$

- $A_{sw,1+2}$: cross-sectional area of steel of the first two rows of reinforcement positioned between within a distance $s_0 \geq 0{,}3 d_{ef}$ and $s_0 + s_r \leq 0{,}8 d_{ef}$

For both floor slabs and foundations, the outer perimeter where punching shear reinforcement is not required, is evaluated by:

$$\boldsymbol{u_{out} = \frac{\beta V_{Ed}}{\tau_{Rd,c} d_{ef}}} \qquad \text{Eq. (15)}$$

- $\tau_{Rd,c}$ is evaluated per Eq. (3), but with $C_{Rd,c} = \frac{0{,}15}{\gamma_c}$ and $k_1 = 0{,}12$
- The distance between the outermost reinforcing perimeter and u_{out} must be $\leq 1{,}5 d_{ef}$.

Table (1)

Strengthening element	**Element diameter**	**Design value of yield Strength of the elements in Eq. (8)** f_{ywd} **[N/mm²]**	**Cross-sectional area of strengthening element in Eq. (3)** A_{sw} **[mm²]**
HAS 8.8, HAS-U 8.8, HAS A4, HAS-U A4	M12	390	84,3
	M16		157,0
	M20		245,0
	M24		353,0

Table (2)

Parameters for punching shear strengthening	Element diameter	Mean effective depth to reinforcement, d_{ef} [mm]	Installation from above or from below
Coefficient of efficiency of the post-installed punching shear strengthening: $\boldsymbol{k_{pi}}$ **[-]**	M12	≥ 160 mm	0,82
	M16	160 mm ≤ d_{ef} < 280 mm	0,59
		≥ 280 mm	0,82
	M20	≥ 350 mm	
	M24	≥ 420 mm	
Coefficient between d_{ef} and the diameter of the threaded rod: $\boldsymbol{k_d}$ **[-]**	M12	≥ 160 mm	1,0
	M16	160 mm ≤ d_{ef} < 280 mm	0,95
		≥ 280 mm	1,0
	M20	≥ 350 mm	
	M24	≥ 420 mm	

For specific design cases, refer to PROFIS Engineering.

Detailing rules according to *aBG Z-15.5-387*

Table (3): Minimum and maximum spacing

Element diameter	Minimum longitudinal spacing, s_{min} [mm]	Maximum tangential spacing, $s_{t,max}$, for perimeters within u_{crit} [mm]	Maximum tangential spacing, $s_{t,max}$, for perimeters beyond u_{crit} [mm]
M12	72	$1{,}5d_{ef}$	$2{,}0d_{ef}$
M16	96		
M20	120		
M24	144		

Note 1: For floor slabs, the maximum spacing between the reinforcing perimeters, s_r, is $0{,}75d_{ef}$. This does not apply to the first reinforcing perimeter, whose distance from the column face must be within $0{,}3d_{ef} \leq s_0 \leq 0{,}5d_{ef}$.

Note 2: For foundations, the maximum spacing between the reinforcing perimeters, s_r, is $0{,}5d_{ef}$ or $0{,}75d_{ef}$, depending on the ratio α_λ / d_{ef}.

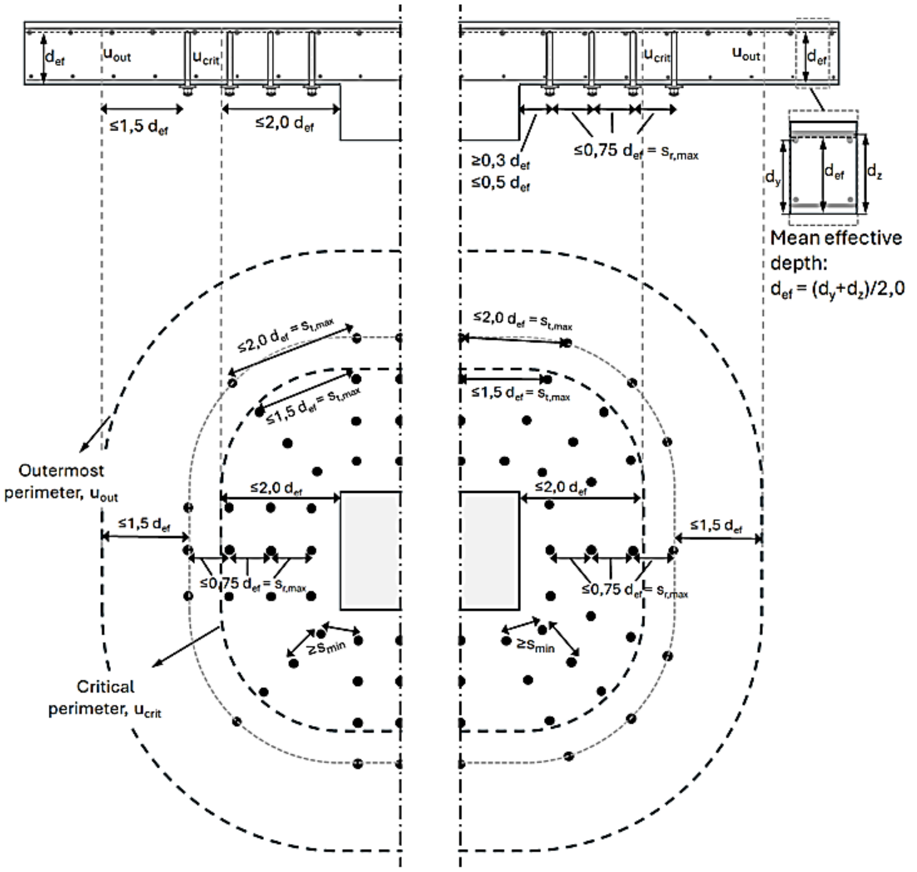
- α_λ: Distance from the compression member (column or wall) to the edge of the foundation.

Table (4): Maximum edge distance

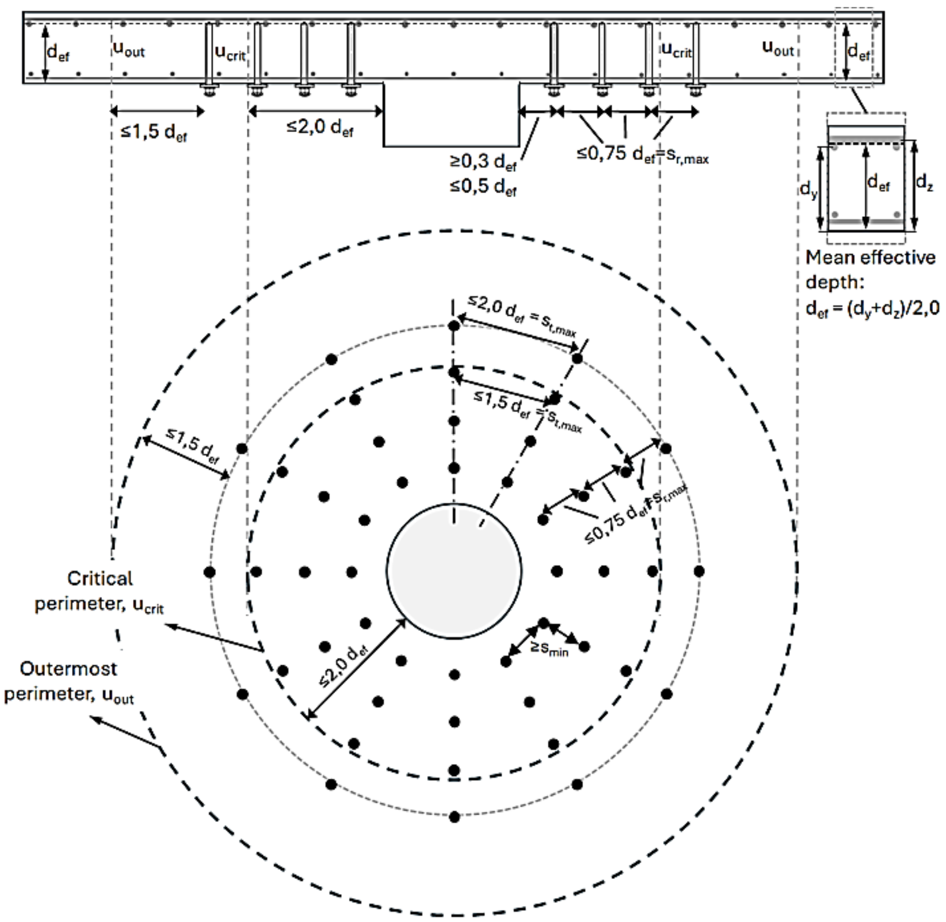
Drilling system	Rod size	Minimum edge distance, c_{min}	
		Without Drilling Aid	With Drilling Aid
Hammer drilling (HD), Hammer drilling with Hilti hollow drill bits (HDB) (1) and Diamond coring with Roughening tool (RT)	M12	$45\ mm + 0{,}06l_{sw}$	$45\ mm + 0{,}02l_{sw}$
	M16	$50\ mm + 0{,}06l_{sw}$	$50\ mm + 0{,}02l_{sw}$
	M20	$55\ mm + 0{,}06l_{sw}$	$55\ mm + 0{,}02l_{sw}$
	M24	$60\ mm + 0{,}06l_{sw}$	$60\ mm + 0{,}02l_{sw}$
Pneumatic drilling (CA)	M12	$50\ mm + 0{,}08l_{sw}$	$50\ mm + 0{,}02l_{sw}$
	M16		
	M20	$55\ mm + 0{,}08l_{sw}$	$55\ mm + 0{,}02l_{sw}$
	M24	$60\ mm + 0{,}08l_{sw}$	$60\ mm + 0{,}02l_{sw}$

Note: The minimum concrete cover according to DIN EN 1992-1-1 must be observed.

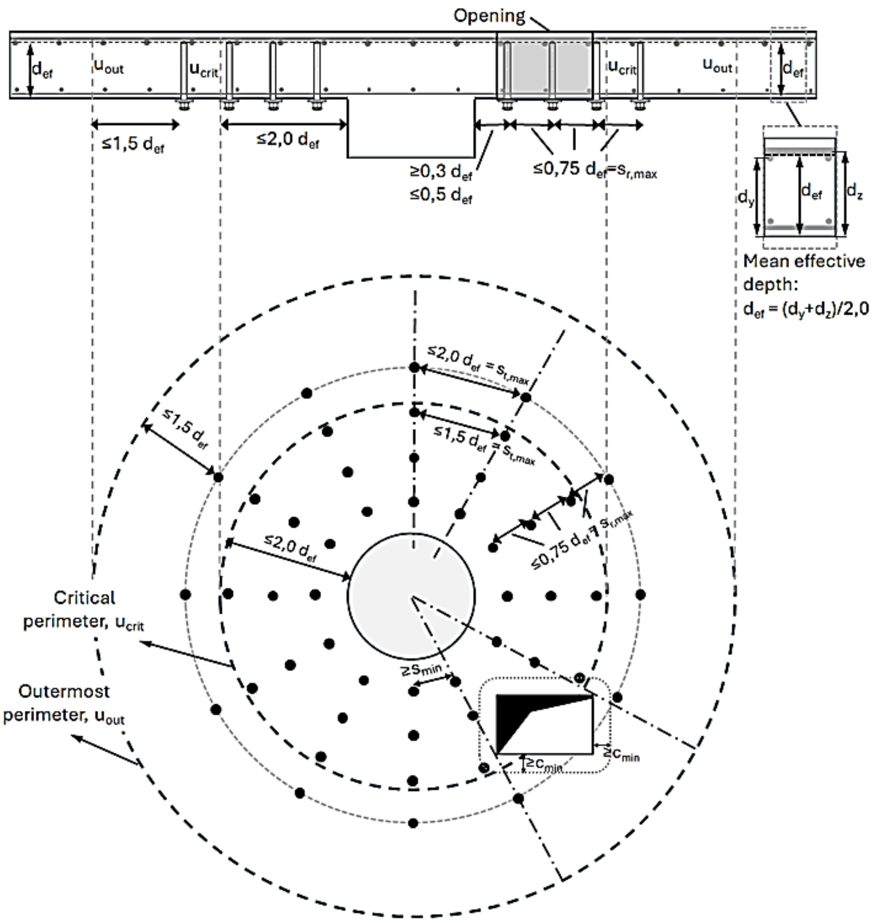
Example of a punching shear reinforcement layout for floor slabs supported by rectangular columns



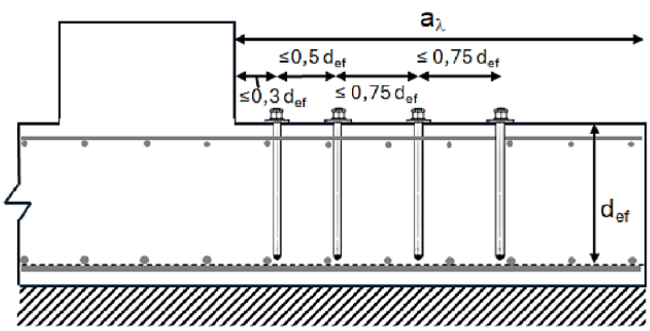
Example of a punching shear reinforcement layout for floor slabs supported by circular columns



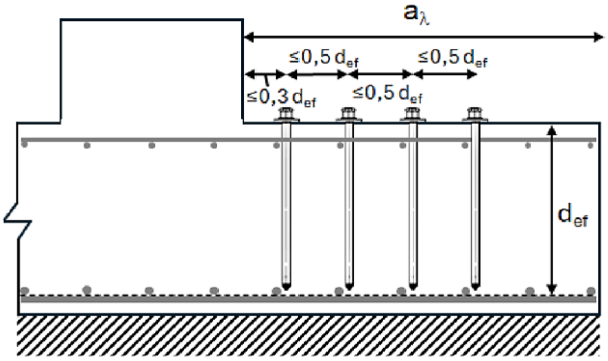
Example of a punching shear reinforcement layout for floor slabs supported by circular columns with an opening



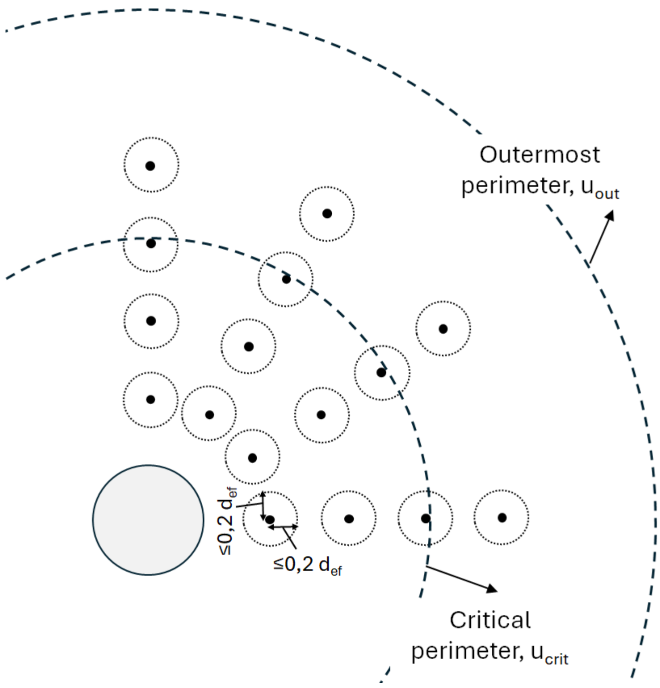
Example of a punching shear reinforcement layout for foundations with $\alpha_\lambda/d_{ef} > 2$



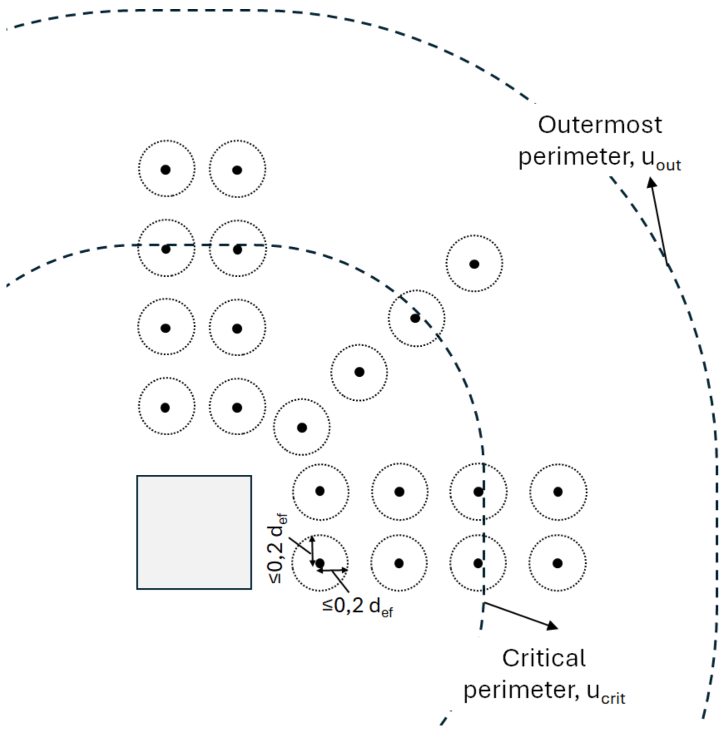
Example of a punching shear reinforcement layout for foundations with $\alpha_\lambda/d_{ef} \leq 2$



Example of the permitted tolerances when installation of the HIT-Punching system coincides with existing longitudinal reinforcement (for circular columns)



Example of the permitted tolerances when installation of the HIT-Punching system coincides with existing longitudinal reinforcement (for rectangular columns)



Setting information

Installation temperature
-5 °C to +40 °C

Service temperature range
Hilti HIT-RE 500 V4 injection mortar with strengthening element HAS / HAS-U may be applied in the temperature ranges given below. An elevated base material temperature may lead to a reduction of the design bond resistance.

Temperature range	Base material temperature	Maximum long term base material temperature	Maximum short term base material temperature
Temperature range	-40 °C to +40 °C	+24 °C	+40 °C

Maximum short term base material temperature
Short-term elevated base material temperatures are those that occur over brief intervals, e.g., from diurnal cycling.

Maximum long term base material temperature
Long-term elevated base material temperatures are roughly constant over significant periods of time.

Table (5): Working time and curing time [(1)] [(2)]

Temperature of the base material, T	Maximum working time, t_{work}	Minimum curing time, t_{cure}
-5 °C to -1 °C	2 h	168 h
0 °C to 4 °C	2 h	48 h
5 °C to 9 °C	2 h	24 h
10 °C to 14 °C	1,5 h	16 h
15 °C to 19 °C	1 h	12 h
20 °C to 24 °C	30 min	7 h
25 °C to 29 °C	20 min	6 h
30 °C to 34 °C	15 min	5 h
35 °C to 39 °C	12 min	4,5 h
40 °C	10 min	4 h

1) The curing time data are valid for dry base material only. In wet base material, the curing times must be doubled.
2) The minimum temperature of the foil pack is +5° C.

Table (6): Installation parameters for the HIT-Punching Shear strengthening system

Installation parameters			M12	M16	M20	M24
Element diameter	d	[mm]	12	16	20	24
Nominal drill bit diameter	d_0	[mm]	14	18	22	28
Minimum mean effective depth to longitudinal reinforcement [1)]	$d_{ef,min}$	[mm]	160	160	350	420
Maximum concrete cross-section depth [2)]	h_{max}	[mm]	1100			
Embedment depth	l_{sw}	[mm]	$h - c_{res}$			
Residual concrete cover at the position of the drill hole	c_{res}	[mm]	35	40	45 [3)]	60 [3)]
Maximum installation torque	$T_{inst} \leq$	[Nm]	40	80	150	200

1) Slab thickness, h, is based on the mean effective depth
2) Conditions regarding the maximum anchorage length, $l_{sw,max}$, according to Table 7 and the IFU must be observed.
3) If $l_{sw} < d_{ef}$, then anchorage length, l_{sw}, must be increased to reach the centre of gravity of the longitudinal reinforcement; as an approximation, this may be taken as $l_{sw} = d_{ef}$.

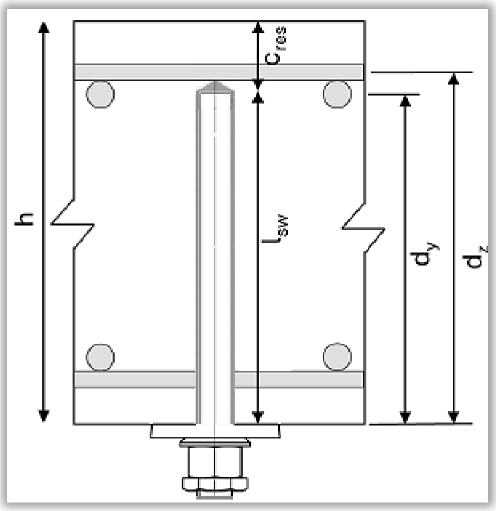


Table (7): Maximum embedment depth, $l_{sw,max}$, depending on threaded rod diameter and mortar dispenser [1)]

Threaded rod diameter	Injection mortar dispenser		
	HDM 330, HDM 500	HDE 500	HIT-P8000D
	$l_{sw,max}$ [mm]	$l_{sw,max}$ [mm]	$l_{sw,max}$ [mm]
M12	1000	1000	1000
M16		1060	1060
M20	700	1055	1055
M24	500	1040	1040

[1)] The embedment depth depends on the drilling methods, please see the IFU for further details.

Drilling and Installation equipment

For detailed setting information on installation see instructions for use given with the product.

Scanning		PS 300 Ferroscan system
Rotary Hammers (Corded and Cordless)		TE 2 - TE 70
Diamond Coring Machines		DD EC-1, DD 100 … DD 160
Dispenser		HDE HDM PE-8000D
Other tools	 	Compressed air gun, Set of cleaning brushes
		Hammer drill bit TE-CX, TE-YX, TE-C, TE-Y
		Hollow drill bit TE-CD, TE-YD
		Diamond core bit SP-L, SP-HX, SP-H, P-U
		Roughening tools TE-YRT
		Piston plug