Deutsches Institut für Bautechnik

DIBt

Public-law institution jointly founded by the federal states and the Federation

Technical authority granting approvals and permits for construction products and construction techniques

General construction technique permit

Date: 21 Oct 2024

Reference number: I 25-1.15.5-32/24

Number:
Z-15.5-383

Validity
from: **21 October 2024**
to: **8 May 2029**

Applicant:
Hilti Deutschland AG
Hiltistraße 2
86916 Kaufering

Subject of decision:
Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4

The subject named above is herewith granted a general construction technique permit (*allgemeine Bauartgenehmigung*).
This decision contains seven pages and 20 annexes.
This general construction technique permit replaces general construction technique permit no. Z-15.5-383 of 8 May 2024. The subject concerned was granted approval for the first time on 8 May 2024.

Translation authorised by DIBt

I GENERAL PROVISIONS

1 The general construction technique permit confirms the fitness for application of the subject concerned within the meaning of the Building Codes of the federal states (*Landesbauordnungen*).

2 This decision does not replace the permits, approvals and certificates required by law for carrying out construction projects.

3 This decision is granted without prejudice to the rights of third parties, in particular private property rights.

4 Notwithstanding further provisions in the 'Special Provisions', copies of this decision shall be made available to the installer of the subject concerned. Furthermore, the installer of the subject concerned shall be made aware of the fact that this decision must be made available at the place of application. Upon request, copies of the decision shall be provided to the authorities involved.

5 This decision shall be reproduced in full only. Partial publication requires the consent of DIBt. Texts and drawings in promotional material shall not contradict this decision. In the event of a discrepancy between the German original and this authorised translation, the German version shall prevail.

6 This decision may be revoked. The provisions contained herein may subsequently be supplemented and amended, in particular if this is required by new technical findings.

7 This decision is based on the information and documents provided by the applicant on the subject concerned during the permit procedure. Alterations to the information on which this general construction technique permit was based are not covered by this decision and shall be notified to DIBt without delay.

II SPECIAL PROVISIONS

1 Subject concerned and field of application

The subject concerned is the Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4. The Hilti shear strengthening system consists of the Hilti HIT-RE 500 V4 injection mortar, the Hilti HAS(-U) threaded rod, the Hilti filling set (filling washer, spherical washer, lock nut) and a nut. The lock nut (to be used optionally) is covered by the European Technical Assessments ETA-23/0277 of 8 February 2024 and ETA-18/0974 of 30 November 2020. All other components are covered by ETA-20/0541 of 9 June 9 2023.

The Hilti HAS(-U) threaded rods, Hilti filling sets and nuts are made of carbon steel or stainless steel.

The threaded rods are installed in concrete in a borehole previously filled with the injection mortar.

The Hilti shear strengthening system may be used as a post-installed shear reinforcement in reinforced and prestressed concrete members.

The subject of the permit is the planning, design and execution of the post-installed shear reinforcement in reinforced and prestressed concrete members.

The field of application of the post-installed shear reinforcement is specified as follows:

- reinforced and prestressed concrete members in accordance with DIN EN 1992-1-1 in conjunction with DIN EN 1992-1-1/NA made of normal weight concrete of strength class C20/25 up to C50/60 in accordance with DIN EN 206-1;
- minimum member thickness h_{min} = 200 mm;
- static and quasi-static loading as well as fatigue related loads;
- in members subject to dry interior conditions (steel members of all types of steel); in members subject to other conditions in accordance with DIN EN 1993-1-4 corresponding to corrosion resistance class CRC III (only steel members made of stainless steel).
- temperature in the anchorage zone of the shear reinforcement (threaded rod): -40°C up to +60°C (with a maximum short-term temperature of +60°C and a maximum long-term temperature of +43°C).

2 Provisions for planning, design and execution

2.1 Planning

The Hilti shear strengthening system using Hilti HIT-RE 500 V4 shall be planned by an engineer experienced in the field of reinforced and prestressed concrete structures.

Unless otherwise specified below, DIN EN 1992-1-1 in conjunction with DIN EN 1992-1-1/NA or DIN EN 1992-2 in conjunction with DIN EN 1992-2/NA shall apply to the detailing of the reinforced concrete and prestressed concrete structures.

The post-installed threaded rods shall be installed perpendicular to the longitudinal axis of the member as a shear reinforcement in the areas of beams and slabs made of reinforced concrete subjected to shear forces and shall strengthen them evenly.

The post-installed threaded rods shall not be used together with other forms of shear reinforcement (e.g., cast-in stirrups/ties/links, bent-up longitudinal rebars, double-head anchors, etc.) for the purpose of calculating the shear resistance. The acting shear force shall be fully covered by the post-installed threaded rods.

The shear reinforcement resulting from the post-installed threaded rods shall not be used in the calculation of torsional stress. The torsion and shear reinforcement shall be designed separately.

The minimum and maximum spacing between individual threaded rods as well as their minimum distances to free edges of the beams and slabs in accordance with Annexes 12 to 14 shall be observed.

The installation parameters (borehole depth, minimum and maximum embedment depth) in accordance with Annex 6 shall be observed.

The full load capacity of the post-installed threaded rods shall not be deemed achieved until the curing times specified in Annex 10 have been observed.

If fire resistance requirements need to be met, suitable fire protection cladding or fire protection coatings shall be provided in the area of the exposed post-installed threaded rods to ensure that the load-bearing capacity under cold conditions is also maintained in case of fire.

2.2 Design

2.2.1 General

The post-installed shear reinforcements (threaded rods), which form part of the Hilti shear strengthening system using Hilti HIT-RE 500 V4, shall be designed on the basis of DIN EN 1992-1-1 in conjunction with DIN EN 1992-1-1/NA or DIN EN 1992-2 in conjunction with DIN EN 1992-2/NA by an engineer experienced in the field of reinforced and prestressed concrete structures.

Unless otherwise specified below, DIN EN 1992-1-1 in conjunction with DIN EN 1992-1-1/NA or DIN EN 1992-2 in conjunction with DIN EN 1992-2/NA shall apply to the determination of the internal forces and the flexural reinforcement of the reinforced and prestressed concrete members.

Verifications shall be carried out in the ultimate limit state and the serviceability limit state in accordance with DIN EN 1992-1-1 in conjunction with DIN EN 1992-1-1/NA or DIN EN 1992-2 in conjunction with DIN EN 1992-2/NA.

The following verification shall be fulfilled: $V_{Ed} \leq V_{Rd} = \min(V_{Rd,max}, V_{Rd,s})$

The resistances $V_{Rd,max}$ and $V_{Rd,s}$ shall be determined in accordance with Sections 2.2.2 and 2.2.3.

The angle α between the threaded rods and the longitudinal axis of the member in accordance with DIN EN 1992-1-1, Figure 6.5, in conjunction with DIN EN 1992-1 1/NA shall be $\alpha = 90°$. Tolerances for α with respect to the line of action are given in Annex 2, Figure 2(c) of this decision.

The angle θ between the compression strut and the longitudinal axis of the member in accordance with DIN EN 1992-1-1, Figure 6.5, in conjunction with DIN EN 1992-1-1/NA shall be determined within the limits given in Section 2.2.2.

For fatigue-relevant loads, the verification shall be carried out in accordance with DIN EN 1992-1-1, Clause 6.8.6, in conjunction with DIN EN 1992-1-1/NA. The fatigue strength of the threaded rods as shear force reinforcement may be applied with $\Delta\sigma_s = 60$ N/mm² for up to 5×10^6 load cycles. This verification may be omitted if the fatigue-relevant loads for up to 5×10^6 load cycles do not represent more than 33 % of the total load.

If shear loads (e.g., due to biaxial bending) arise in the anchorage zone of the post-installed threaded rods, links or an adequately anchored transverse reinforcement shall be present in the anchorage zone of the post-installed threaded rods to prevent splitting.

In the serviceability limit state, it shall be verified that the crack width w_k is limited to 0.3 mm under the quasi-continuous load combination unless a requirement for more restrictive limit values arises.

2.2.2 Verification of the concrete compression strut

In accordance with the regulations of DIN EN 1992-1-1 in conjunction with DIN EN 1992-1-1/NA, the resistance of the concrete compression strut for example for α = 90° shall be determined using the following equation:

$$V_{Rd,max} = \frac{b_{w,eff} \cdot z \cdot \nu_1 \cdot f_{cd}}{\cot(\theta) + \tan(\theta)} \quad (2.1)$$

where:

z = inner lever arm with $z = 0.9 \cdot d \leq \max (d - 2 \cdot c_{V,1}\,;\, d - c_{V,1} - 30\ mm)$,

with d being the effective depth of section

and $c_{V,1}$ being the allowance on the concrete cover of the longitudinal reinforcement in the compression zone in accordance with DIN EN 1992-1-1/NA, NDP to 6.2.3 (1);

v_1 = 0.75 (reduction factor for concrete strength in case of shear cracks in accordance with DIN EN 1992-1-1/NA, NDP to 6.2.3(3));

f_{cd} = design value of concrete compressive strength;

$b_{w,eff}$ = effective cross-sectional width of the strengthened cross-section;

$$b_{w,eff} = b_w - e_{inst} \quad (2.2)$$

with b_w being the cross-sectional width

and e_{inst} being the transversal eccentricity of the post-installed threaded rods with respect to the longitudinal axis of the concrete cross-section.

The angle θ shall be limited. The limit values in accordance with DIN EN 1992-1-1, Eq. (6.7N) and DIN EN 1992-1-1/NA, NDP to Clause 6.2.3 (2) or the limit values of the NDP to Clause 6.2.3 (2) in accordance with DIN EN 1992-2/NA shall apply. In Equation (6.7bDE) given in DIN EN 1992-1-1/NA, $b_{w,eff}$ shall be used instead of b_w.

For beams to be strengthened with a just one line of post-installed threaded rods (see Annex 14, Figure 4(a)), the transversal eccentricity shall be less than the upper-bound limit $e_{inst,max}$ = min(50 mm, b_w/6), as shown in Annex 2, Figure 2(b).
For beams and slabs with two or more lines of post-installed threaded rods (see e.g. Annex 14, Figures 4(b) and 4(c)), the effect of any eccentricity may be neglected, i.e. e_{inst} = 0 if all limits for edge distances and spacings are satisfied.

2.2.3 Verification of the threaded rod

In accordance with the regulations of DIN EN 1992-1-1 in conjunction with

DIN EN 1992-1-1/NA, the required post-installed shear reinforcement by threaded rods shall be determined using the following equation:

$$V_{Rd,s} = k_{pi} \cdot k_s \cdot a_{sw} \cdot z \cdot f_{ywd} \cdot \cot(\theta) \quad (2.3)$$

where:

k_{pi} = post-installed shear reinforcement coefficient that depends on the installation configuration (see Annex 1, Figure 1) in accordance with Annex 11, Table14;

k_s = size-dependent coefficient, defined in Annex 11, Table 14, as a function of the inner lever arm z;

f_{ywd} = design yield strength of the threaded rods in accordance with Annex 11, Table 13.

a_{sw} = cross-sectional area of post-installed threaded rods per unit length of the concrete member, to be calculated as $a_{sw} = n_{swt} \cdot A_{sw} / s_{wl}$

with n_{swt} being the number of post-installed threaded rods per transverse line

and A_{sw} being the cross-sectional area of the post-installed threaded rods in accordance with Annex 11, Table 13

and s_{wl} being the longitudinal spacing of the post-installed threaded rods (see Annex 12).

For members with a concentrated load applied on the upper side within the range of $0.5\ d \le a_v \le 2.0\ d$ from the support edge (see DIN EN 1992-1-1, Figure 6.6), the acting shear load V_{Ed} may be reduced by a factor $\beta = a_v / (2.0\ d)$. This reduction may be applied in accordance with DIN EN 1992-1-1, Clause 6.2.3 (8), in conjunction with DIN EN 1992-1-1/NA by replacing A_{sw} with $(k_{pi} \cdot k_s \cdot A_{sw})$ in Equation (6.19). The anchorage of the longitudinal reinforcement shall be verified for the entire shear force V_{Ed} acting above the support.

The number of the threaded rods per transverse line n_{swt}, the cross-sectional area A_{sw} and the longitudinal spacing of the threaded rods (s_{wl}) may generally be determined iteratively. If individual parameters are adjusted, the resistances $V_{Rd,s}$ and $V_{Rd,max}$ shall be determined again and the verifications shall be carried out once more.

2.3 Execution

The executing company shall provide a declaration of conformity in accordance with Sections 16a(5) and 21(2) of the Model Building Code to confirm the conformity of the construction technique with the general construction technique permit included in this decision. The post-installed shear reinforcements in the form of post-installed threaded rods may only be carried out by companies that have a certificate of suitability for post-installed reinforcement connections (see Model Administrative Provisions – Technical Building Rules (*MVV TB*), Annex 1). This certificate of suitability shall include same-system installation steps and comparable installation conditions in accordance with Annexes 7 to 10 and 15 to 20.

The post-installed threaded rods shall be installed in accordance with the planning and construction drawings.

The installation parameters (nominal drill bit diameter, maximum tightening torque) in accordance with Annex 6 shall be observed.

The full load capacity of the post-installed threaded rods shall not be deemed achieved until the curing times specified in Annex 10 have been observed.

The installation instructions in Annexes 15 to 20 and all the manufacturer's additional instructions for users shall be observed.

The boreholes shall be drilled perpendicular to the concrete member. Deviations up to a maximum value of $\Delta\alpha_{max} = 5°$ from the perpendicular line to the longitudinal axis in accordance with Annex 2, Figure 2(c) shall be permitted.

Drilling into existing reinforcements in the member to be strengthened shall be avoided when creating the boreholes. However, should the load-bearing reinforcements such as the flexural reinforcements be drilled through during the drilling process, the remaining load-bearing capacity shall be checked.
If reinforcements are hit during drilling, the borehole shall be properly sealed with a high-strength mortar.

Reference to design standards:

DIN EN 1992-1-1:2011-01 + DIN EN 1992-1-1/A1:2015-03	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for building; German Version EN 1992-1-1:2004+AC:2010 and EN 1992-1-1:2004/A1:2014
DIN EN 1992-1-1/NA:2013-04 + DIN EN 1992-1-1/NA/A1:2015-12	National Annex - Nationally determined parameters - Eurocode 2: Design of concrete structures - Part 1-1: General design rules and rules for building + Amendment A1
DIN EN 1992-2:2010-12	Eurocode 2: Design of concrete structures - Part 2: Concrete bridges - Design and detailing rules; German version EN 1992 2:2005 + AC:2008
DIN EN 1992-2/NA:2013-04	National Annex - Nationally determined parameters - Eurocode 2: Design of concrete structures - Part 2: Concrete bridges - Design and detailing rules

Beatrix Wittstock
Head of Section

Drawn up by
Tempel

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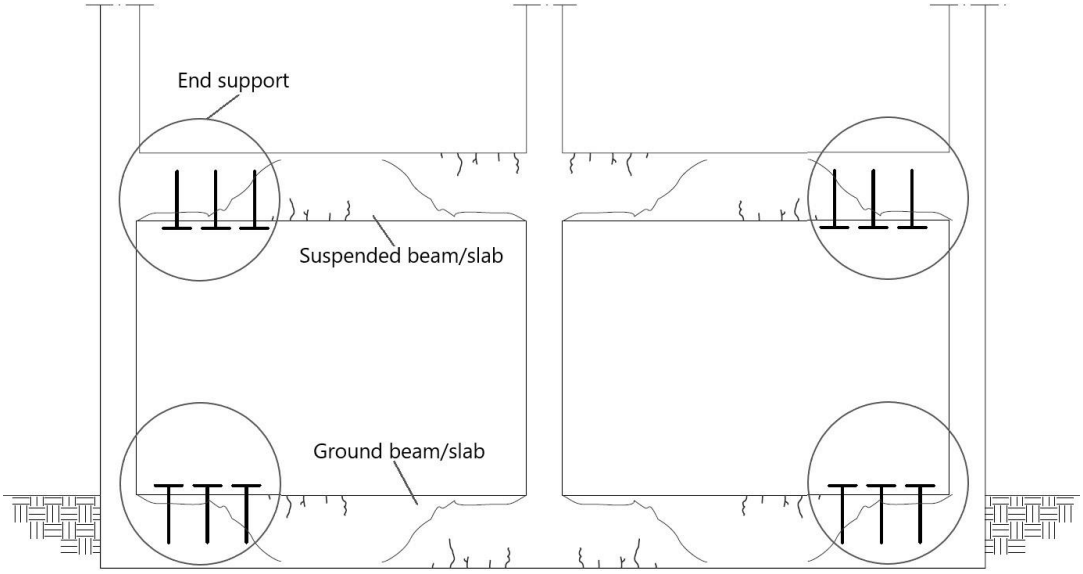
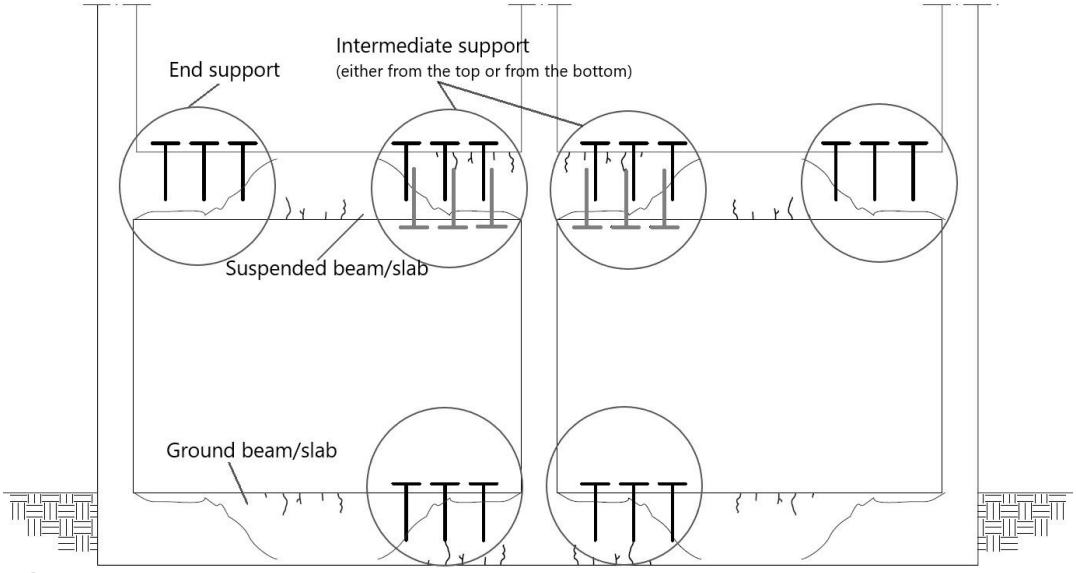
Representation of a concrete structure to be strengthened under shear



Configuration A:

Shear reinforcement installed from the tension side of the member at the position of a simply supported end.

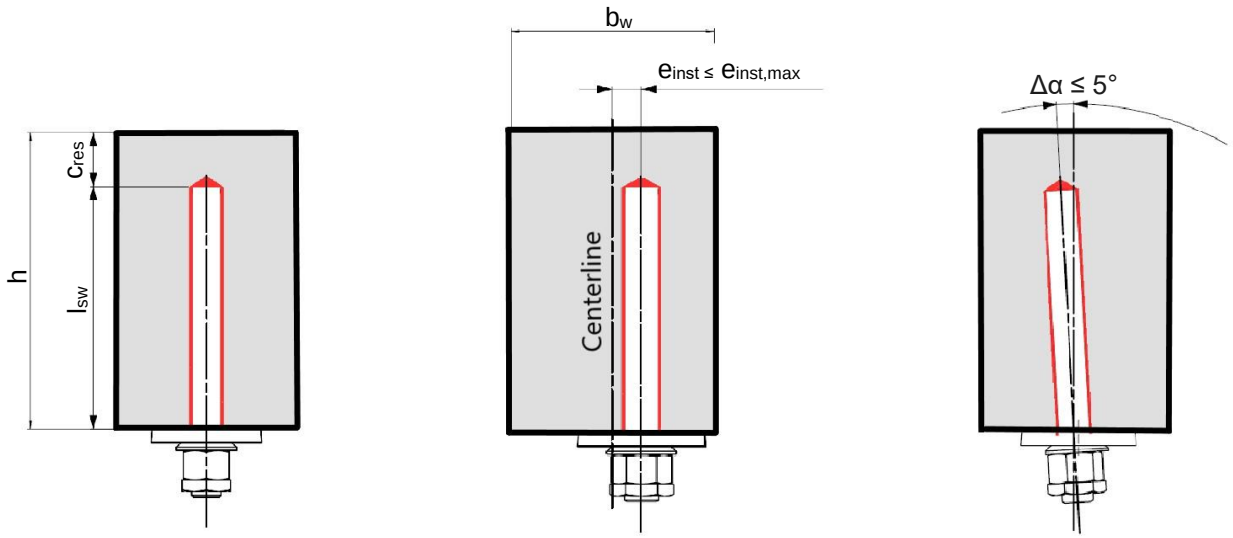


Configuration B:

Shear reinforcement installed on one side of the compression side of the member at the position of a simply supported end or on the intermediate support from both sides (either compression side or tension side).

Figure 1: Schematic representation of locations on a reinforced concrete frame where shear reinforcement might be required (either from the top or bottom of a concrete element).
Note: Connections between columns and flat slabs and related punching shear verification are not covered by this decision.

Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4	**Annex 1**
Installed condition	



(a) Member cross section (b) Eccentricity (c) Angular deviation

Figure 2: Installation conditions with dimensions and permissible installation tolerances, where:

- b_w = cross-sectional width,
- h = height of the concrete member to be strengthened,
- c_{res} = residual concrete cover at the position of the borehole,
- $l_{sw} = h - c_{res}$ = embedment depth of the threaded rod,
- e_{inst} = eccentricity of the threaded rod,
- $e_{inst,max}$ = min(50 mm, $b_w / 6$) = maximum eccentricity of the threaded rods,
- $\Delta\alpha_{max}$ = maximum permissible angle of inclination of the threaded rod with respect to the line of action of the shear force (perpendicular to the longitudinal axis of the concrete member).

Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4	**Annex 2**
Installed condition	

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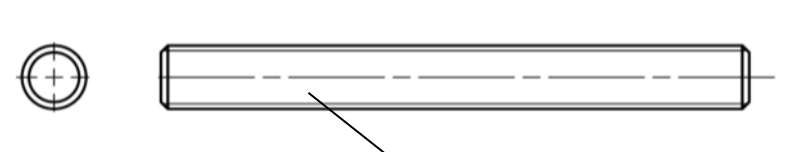
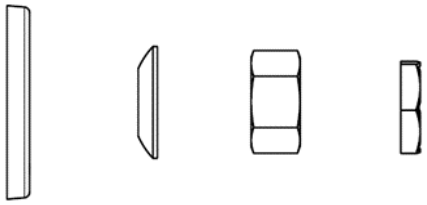
Steel elements

Hilti HAS, HAS-U threaded rods made of stainless steel A4 and galvanized steel 8.8



HAS colour code marking:
5.8 = RAL 5010 (blue)
8.8 = RAL 1023 (yellow)
A4 = RAL 3000 (red)

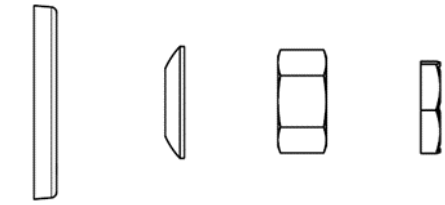
Hilti HAS…: M12 to M24



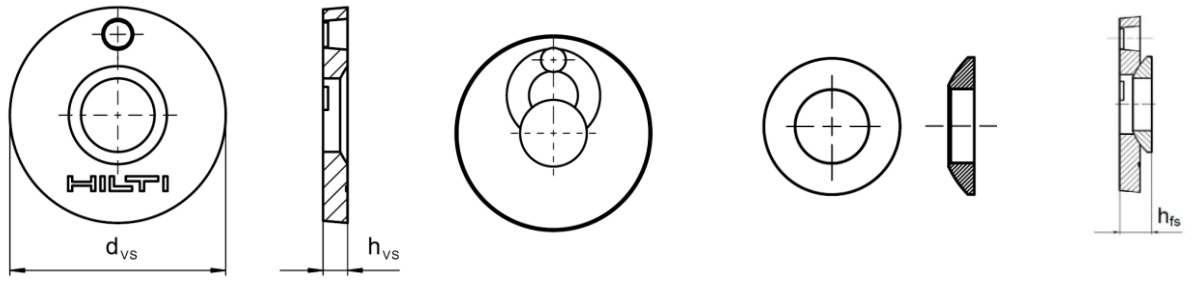
Sealing washer | Spherical washer | Nut | Lock nut (optional)

Marking:
Steel grade number and length identification letter: e.g. 8L

Hilti HAS-U-…: M12 to M24



Sealing washer | Spherical washer | Nut | Lock nut (optional)



Sealing washer | Spherical washer | Filling set

Hilti filling set

Table 1: Dimensions of the Hilti filling set

Hilti filling set			**M12**	**M16**	**M20**	**M24**
Diameter of sealing washer	d_{vs}	[mm]	44	52	60	70
Height of sealing washer	h_{vs}	[mm]	5	6		
Height of filling set	h_{fs}	[mm]	10	11	13	15

Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4	**Annex 3**
Steel elements and filling set	

Injection mortar Hilti HIT-RE 500 V4: epoxy resin system with aggregate

330 ml, 500 ml and 1400 ml

Marking:
Hilti-HIT
Batch number and
production line
Expiry date mm/yyyy

Product name: 'Hilti HIT-RE 500 V4'

Static mixer Hilti HIT-RE-M

Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4	**Annex 4**
Injection mortar and static mixer	

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Table 2: Materials

Designation	Material
Steel elements made of galvanized steel	
HAS 8.8, HAS-U 8.8	Strength class 8.8, f_{uk} = 800 N/mm², f_{yk} = 640 N/mm², elongation at fracture (l_0=5d) > 12% ductile galvanized ≥ 5 µm
Nut	Strength class 8.8, f_{uk} = 800 N/mm², f_{yk} = 640 N/mm², galvanized ≥ 5 µm
Hilti filling set	Sealing washer: galvanized ≥ 5 µm Spherical washer: galvanized ≥ 5 µm Lock nut: galvanized ≥ 5 µm
Steel elements made of stainless steel of corrosion resistance class (CRC) III in accordance with DIN EN 1993-1-4:2015-10	
HAS A4, HAS-U A4	Strength class 70, f_{uk} = 700 N/mm², f_{yk} = 450 N/mm² elongation at fracture (l_0=5d) > 12% ductile stainless steel in accordance with DIN EN 10088-1:2014-12
Nut	Strength class 70, f_{uk} = 700 N/mm², f_{yk} = 450 N/mm² stainless steel 1.4401, 1.4404, 1.4578, 1.4571,1.4439, 1.4362 in accordance with DIN EN 10088-1:2014-12
Hilti filling set A4	Sealing washer: stainless steel in accordance with DIN EN 10088-1:2014-12 spherical washer: stainless steel in accordance with DIN EN 10088-1:2014-12 Lock nut: stainless steel in accordance with DIN EN 10088-1:2014-12

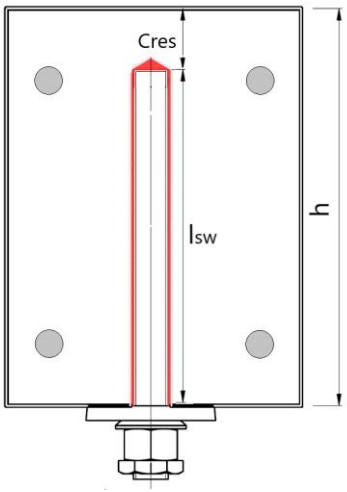

Figure 3: Simplified schematic representation of installation parameters

Table 3: Installation parameters of threaded rods

Installation parameters			**M12**	**M16**		**M20**	**M24**
Threaded rod diameter	d	[mm]	12	16		20	24
Nominal drill bit diameter	d_0	[mm]	14	18		22	28
Minimum concrete cross-section depth	h_{min}	[mm]	200	200	400	600	
Maximum concrete cross-section depth [1)]	h_{max}	[mm]	2200				
Embedment depth	l_{sw}		h - c_{res}				
Residual concrete cover at the position of the borehole	c_{res}	[mm]	35	35	40	45	60
Maximum tightening torque	$T_{inst} \leq$	[Nm]	40	80		150	200

[1)] In addition, the conditions regarding the maximum embedment depth $l_{sw,max}$ in accordance with Tables 4, 5, 6 and 8 shall be met.

Table 4: Maximum embedment depth $l_{sw,max}$ depending on threaded rod diameter and mortar dispenser

Threaded rod diameter	**Injection mortar dispenser**		
	HDM 330, HDM 500 $l_{sw,max}$ [mm]	**HDE 500** $l_{sw,max}$ [mm]	**HIT-P8000D** $l_{sw,max}$ [mm]
M12	1000	1000	1000
M16		1400	1400
M20	700	1800	1800
M24	500		2140

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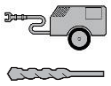
Table 5: Parameters of drilling, cleaning and setting tools for hammer drilling (HD)

Reinforcement element	Drilling and cleaning					Installation		
	Hammer drilling (HD)	Compressed air (CA)	Brush HIT-RB	Air nozzle HIT-DL	Extension for air nozzle	Piston plug HIT-SZ	Extension for piston plug	Maximum embedment depth
							 [1)]	-
Size	d_0 [mm]	d_0 [mm]	Size	Size	[-]	Size	[-]	$l_{sw,max}$ [mm]
M12	14	-	14	14	HIT-DL 10/0.8 or HIT-DL V10/1	14	HIT-VL 11/1.0	1000
M16	18	-	18	18		18		1400
M20	22	22	22	22	HIT-DL 16/0.8 or HIT-DL B and/or HIT-VL 16/0.7 and/or HIT-VL 16	22	HIT-VL 16/0.7 and/or HIT-VL 16	1800
M24	28	28	28	28		28		2140

[1)] Assemble extension HIT-VL 16/0.7 with coupler HIT-VL K for deeper boreholes.

Table 6: Parameters of drilling and setting tools for hammer drilling with hollow drill bit (HDB)

Reinforcement element	**Drill** (no cleaning required)				**Installation**		
	Hammer drilling, hollow drill bit [(1)] (HDB)	Brush HIT-RB	Air nozzle HIT-DL	Extension for air nozzle	Piston plug HIT-SZ	Extension for piston plug	Maximum embedment depth
						 [(2)]	-
Size	d_0 [mm]	Size	Size	[-]	Size	[-]	$l_{sw,max}$ [mm]
M12	14	-			14	HIT-VL 11/1.0	400
M16	18				18		1000
M20	22				22	HIT-VL 16/0.7 and/or HIT-VL 16	1000
M24	28				28		1000

[1)] With vacuum cleaner Hilti VC 10/20/40 (automatic filter cleaning activated, ECO mode off) or a vacuum cleaner providing equivalent cleaning performance in combination with the specified Hilti hollow drill bit TE-CD or TE-YD.

[2)] Assemble extension HIT-VL 16/0.7 with coupler HIT-VL K for deeper boreholes.

Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4	**Annex 7**
Cleaning and setting tools / cleaning alternatives	

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Table 7: Cleaning alternatives

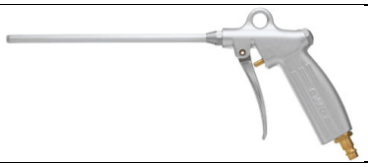
Compressed Air Cleaning (CAC): Air nozzle with an orifice opening of at least 3.5 mm in diameter.	
Automatic Cleaning (AC): Cleaning is performed during drilling with Hilti TE-CD and TE-YD drilling system including vacuum cleaner.	

Table 8: Parameters of drilling and setting tools for diamond drilling with roughening tool (RT)

Reinforcement element	**Drilling and cleaning**					**Installation**		
	Diamond coring	Roughening tool (RT)	Brush HIT-RB	Air nozzle HIT-DL	Extension for air nozzle	Piston plug HIT-SZ	Extension for piston plug	Maximum embedment depth
							 1)	-
Size	d_0 [mm]	d_0 [mm]	Size	Size	[-]	Size	[-]	$l_{sw,max}$ [mm]
M12	-	-	-	-	-	-	-	-
M16	18	18	18	18	HIT-DL 10/0.8 or HIT-DL V10/1	18	HIT-VL 11/1,0	900
M20	22	22	22	22	HIT-DL 16/0.8 or HIT-DL B and/or HIT-VL 16/0.7 and/or HIT-VL 16	22	HIT-VL 16/0.7 and/or HIT-VL 16	1200
M24	28	28	28	28		28		1400

1) Assemble extension HIT-VL 16/0.7 with coupler HIT-VL K for deeper boreholes.

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Table 9: Hilti roughening tool TE-YRT – tool parameters

Related components			
Diamond coring		Roughening tool TE-YRT	Wear gauge RTG…
			
d_0 [mm]		d_0 [mm]	size
Nominal	Measured		
14	-	-	-
18	17.9 to 18.2	18	18
22	21.9 to 22.2	22	22
28	27.9 to 28.2	28	28

Table 10: Hilti roughening tool TE-YRT – roughening and blowing times

	Roughening time $t_{roughen}$	**Minimum blowing time $t_{blowing}$**
l_{sw} [mm]	$t_{roughen}$ [sec] = l_{sw} [mm] / 10	$t_{blowing}$ [sec] = $t_{roughen}$ [sec] + 20
101 to 200	20	40
201 to 300	30	50
301 to 400	40	60
401 to 500	50	70
501 to 600	60	80

Table 11: Hilti roughening tool TE-YRT and wear gauge RTG

Hilti roughening tool TE-YRT	
Wear gauge RTG	

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Table 12: Maximum working time and minimum curing time (1) (2)

Temperature in the base material T	Maximum working time t_{work}	Minimum curing time t_{cure}
-5°C to 0°C	2 hours	168 hours
0°C to 5°C	2 hours	48 hours
5°C to 10°C	2 hours	24 hours
10°C to 15°C	1.5 hours	16 hours
15°C to 20°C	1 hour	16 hours
20°C to 25°C	30 min	7 hours
25°C to 30°C	20 min	6 hours
30°C to 35°C	15 min	5 hours
35°C to 39°C	12 min	4.5 hours
40°C	10 min	4 hours

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 must not be less than +5°C.

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Parameters for determining the resistances in accordance with Section 2.2.3

Table 13: Geometric and material parameters for design equation (2.3)

Material	**Size**	**Design yield strength** f_{ywd} [MPa]	**Cross-sectional area of a threaded rod** 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 14: Performance parameters for design equation (2.3)

Hilti shear strengthening rods		**Size**		**One-sided installation configuration A** (1)	**One-sided installation configuration B** (1)
Coefficient for post-installed shear reinforcement	k_{pi} [-]	**M12**		0,735	0.588
		M16	**h ≥ 400mm**		
			200 mm ≤ h < 400 mm	0.529	0.423
		M20		0.735	0.588
		M24			
Size-dependent coefficient	k_s [-]	**M12**		$\begin{cases} 1.0 & , \text{ if } z \le 0.75 \text{ m} ; \\ 1.15 - 0.20\ z & , \text{ if } z > 0.75 \text{ m} \end{cases}$ (2)	
		M16			
		M20			
		M24			

(1) See Figure 1 of Annex 1

(2) z [m] = inner lever arm in accordance with DIN EN 1992-1-1, Clause 6.2.3

Table 15: Minimum spacing between the threaded rods and maximum shear strengthening ratio

Threaded rod diameter	Minimum longitudinal spacing $s_{wl,min}$ [mm]	Minimum tranverse spacing $s_{wt,min}$ [mm]	Maximum shear strengthening ratio (1) $\rho_{sw,max}$ [%]
M12	120	120	0.8
M16	160	160	
M20	200	200	
M24	240	240	

(1) The shear strengthening ratio must be calculated as $\rho_{sw} = a_{sw} / b_w$, where a_{sw} is the stressed area of post-installed threaded rods per unit length of the concrete member and b_w is the minimum concrete cross-sectional width between tension and compression chords.

Table 16: Maximum spacing in beams in accordance with DIN EN 1992-1-1 and DIN EN 1992-1-1/NA

Shear force utilization (1)	Maximum longitudinal spacing $s_{wl,max}$	Maximum transverse spacing $s_{wt,max}$
$V_{Ed} / V_{Rd,max} \leq 0.3$	min(0.7 h, 300 mm)	min(h, 800 mm)
$0.3 < V_{Ed} / V_{Rd,max} \leq 0.6$	min(0.5 h, 300 mm)	min(h, 600 mm)
$V_{Ed} / V_{Rd,max} > 0.6$	min(0.25 h, 200 mm)	

(1) $V_{Rd,max}$ calculated in accordance with design equation (2.1)

Table 17: Maximum distances in slabs in accordance with DIN EN 1992-1-1 and DIN EN 1992-1-1/NA

Shear force utilization (1)	Maximum longitudinal spacing $s_{wl,max}$	Maximum transverse spacing $s_{wt,max}$
$V_{Ed} / V_{Rd,max} \leq 0.3$	0.7 h	h
$0.3 < V_{Ed} / V_{Rd,max} \leq 0.6$	0.5 h	
$V_{Ed} / V_{Rd,max} > 0.6$	0.25 h	

(1) $V_{Rd,max}$ calculated in accordance with design equation (2.1)

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Table 18: Minimum and maximum edge distances to the free edges of beams and slabs depending on drilling method and associated drilling tolerance

Drilling system	Size	Minimum edge distance $c_{wt,min}$		Maximum edge distance $c_{wt,max}$	
		Without Drilling Aid	With Drilling Aid	Beams	Slabs
Hammer drilling (HD), hammer drilling with Hilti hollow drill bits (HDB) (1) and diamond coring (DD) with roughening tool (RT)	**M12**	45 mm + 0.06 l_{sw}	45 mm + 0.02 l_{sw}	175 mm	max(175 mm, 0.5 h)
	M16	50 mm + 0.06 l_{sw}	50 mm + 0.02 l_{sw}		
	M20	55 mm + 0.06 l_{sw}	55 mm + 0.02 l_{sw}	250 mm	max(250 mm, 0.5 h)
	M24	60 mm + 0.06 l_{sw}	60 mm + 0.02 l_{sw}		
Pneumatic drilling (CA)	**M12**	50 mm + 0.08 l_{sw}	50 mm + 0.02 l_{sw}	175 mm	max(175 mm, 0.5 h)
	M16				
	M20	55 mm + 0.08 l_{sw}	55 mm + 0.02 l_{sw}	250 mm	max(250 mm, 0.5 h)
	M24	60 mm + 0.08 l_{sw}	60 mm + 0.02 l_{sw}		

(1) HDB = Hollow Drill Bit Hilti TE-CD and TE-YD

Note: The minimum concrete cover in accordance with DIN EN 1992-1-1 must be observed.

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Spacing and edge distances of the threaded rods

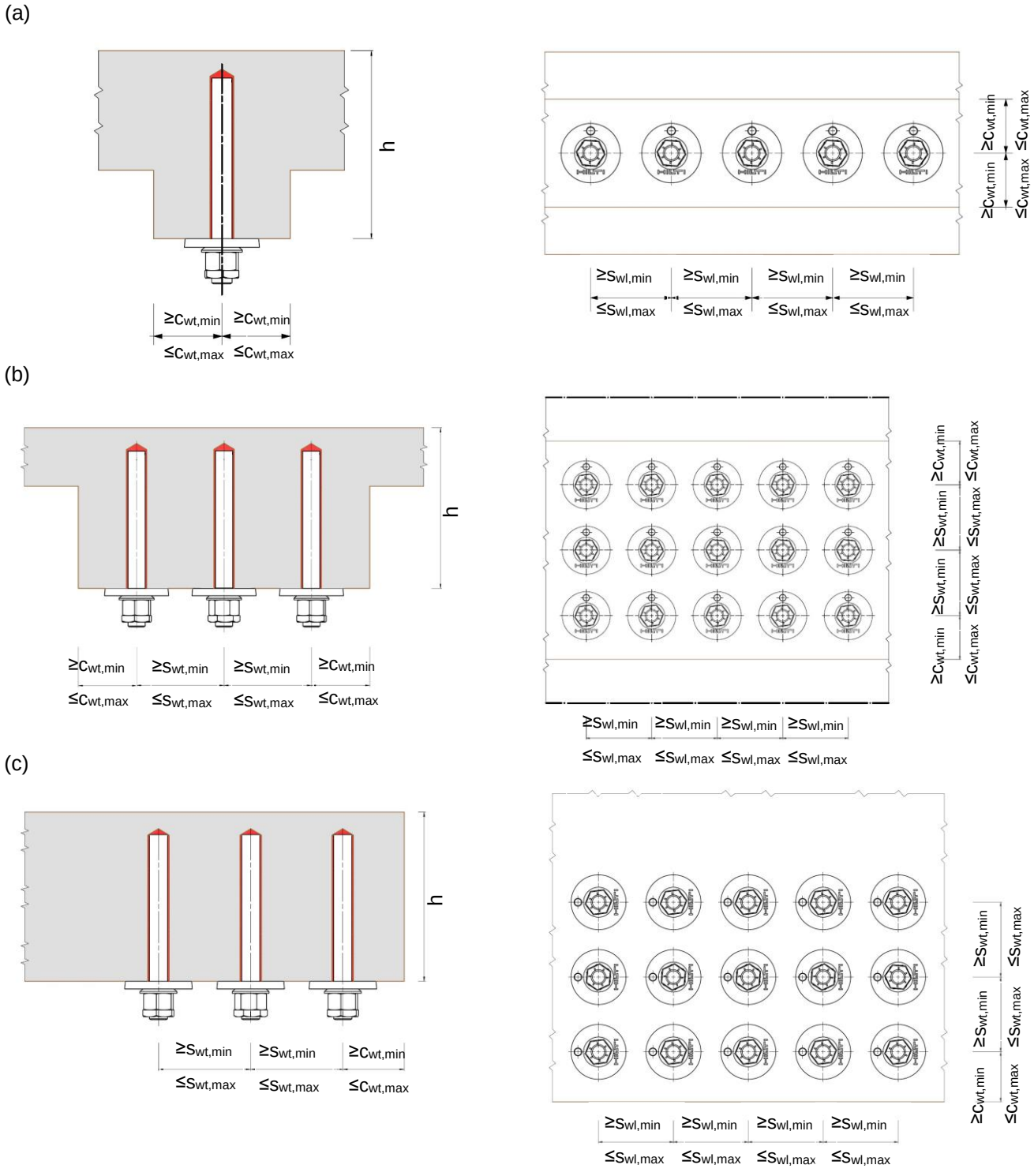

Figure 4: Edge distances and spacing of the threaded rods installed in: beams with one row (a) or more (b) rows of threaded rods; slabs (c).

Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4	**Annex 14**
Graphic representation of the spacing and edge distances in beams and slabs	

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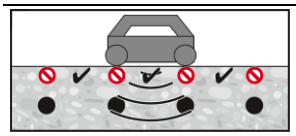
Installation instructions

Safety Regulations

Review the Material Safety Data Sheet (MSDS) before use for proper and safe handling!
Wear well-fitting protective clothing, protective goggles and protective gloves when working with Hilti HIT-RE 500 V4.
Important: Observe the installation instructions of the manufacturer provided with each foil pack.

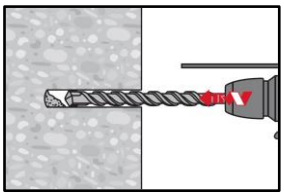


Detect the position of existing reinforcement (e.g. with the Hilti Ferroscan System PS 300/PS 1000) and mark borehole positions.

Hole drilling

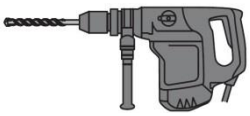
In case of aborted borehole, the borehole shall be filled with mortar. All figures given in this section are to be understood as vertical upwards or vertical downwards.

a) Hammer drilling

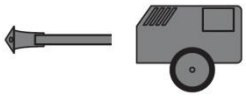


Drill hole to the required embedment depth with a hammer drill set in rotation-hammer mode or a compressed air drill using an appropriately sized carbide drill bit.

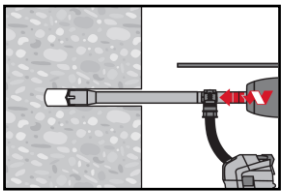
Hammer drill (HD)



Compressed air drill (CA)

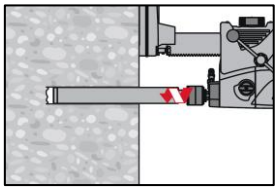


b) Hammer drilling with Hilti hollow drill bit TE-CD, TE-YD



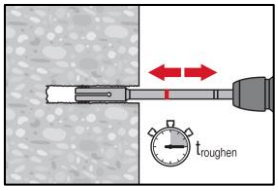
Drill hole to the required embedment depth with an appropriately sized Hilti TE-CD or TE-YD hollow drill bit with vacuum attached to Hilti vacuum cleaner VC 10/20/40 (automatic filter cleaning activated, eco mode off) or a vacuum cleaner providing equivalent performance in combination with the specified Hilti hollow drill bit TE-CD or TE-YD. This drilling system removes the dust and cleans the borehole during drilling when used in accordance with the user's manual. After drilling is completed, proceed to the 'injection preparation' step in the installation instruction.

c) Diamond coring with roughening using Hilti roughening tool TE-YRT



Diamond coring is permitted when suitable diamond core drilling machines and the corresponding core bits are used.

For the use in combination with Hilti roughening tool TE-YRT, see parameters in Table 8 of Annex 8 and Table 9 of Annex 9.



Before roughening, water needs to be removed from the borehole.

Check usability of the roughening tool using the wear gauge RTG.

Roughen the borehole over the whole depth to the required embedment depth l_{sw}.

For roughening time see Table 10 of Annex 9.

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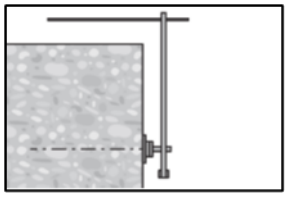
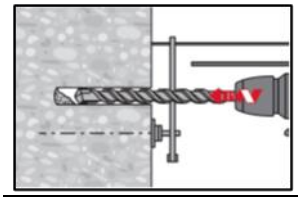
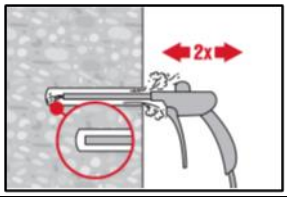
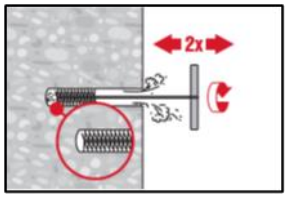
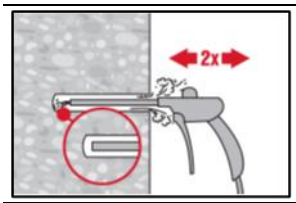
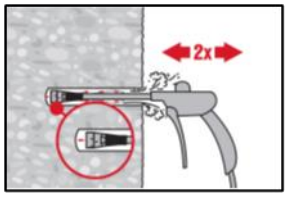
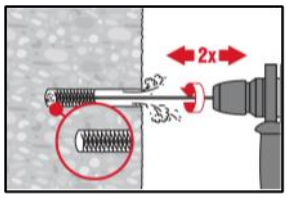
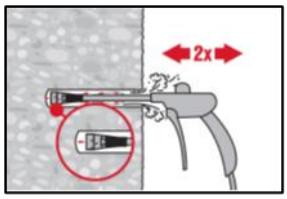
Drilling aid	For borehole depths > 20 cm, a drilling aid should be used.
	Ensure that the borehole is orthogonal to the longitudinal axis of the concrete member to be strengthened. Various options are possible, e.g.: • Hilti drilling aid HIT-BH • Lath or spirit level • Visual check
	Hole drilling with Hilti drilling aid HIT-BH
Borehole cleaning	Just before setting the bar, the borehole must be free of dust and debris. Inadequate hole cleaning = poor load values.
Compressed Air Cleaning (CAC)	For borehole diameter d = 12 mm and borehole depths ≤ 250 mm, or borehole diameter d > 12 mm and borehole depths ≤ 20 · d.
	Blow 2 times from the back of the hole (if needed with nozzle extension) over the whole length with oil-free compressed air (min. 6 bar at 6 m³/h) until return air stream is free of dust. Safety tip: Do not inhale concrete dust.
	Brush 2 times with the specified brush (see Table 5 of Annex 7) by inserting the Hilti HIT-RB steel brush to the back of the hole (if needed with extension) in a twisting motion and removing it. The brush must produce natural resistance when entering the borehole (brush Ø ≥ borehole Ø) - if not, the brush is too small and must be replaced by a larger one.
	Blow again 2 times from the back of the hole over the whole length with compressed air until return air stream is free of dust.
Compressed Air Cleaning (CAC)	For borehole diameter d = 12 mm and borehole depths > 250 mm, or borehole diameter d > 12 mm and borehole depths > 20 · d.
	Use the appropriate Hilti HIT-DL air nozzle (see Table 5 of Annex 7). Blow 2 times from the back of the hole over the whole length with oil-free compressed air until return air stream is free of dust. Safety tip: Do not inhale concrete dust.

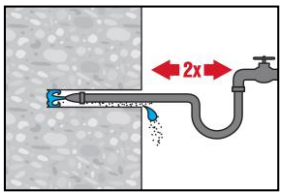


Screw the HIT-RB round steel brush in one end of the HIT-RBS brush extension(s), so that the overall length of the brush is sufficient to reach the base of the borehole. Attach the other end of the extension to the TE-C/TE-Y chuck. Brush 2 times with the specified brush (see Table 5 of Annex 7) by inserting the Hilti HIT-RB the steel brush to the back of the hole (if needed with extension) and removing it.
Safety tip:
Start machine brushing operation slowly.
Start brushing operation only after the brush has been inserted into the borehole.

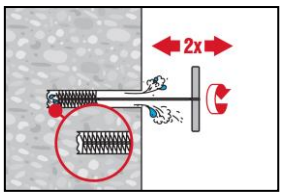


Use the appropriate Hilti HIT-DL air nozzle (see Table 5 of Annex 7).
Blow 2 times from the back of the hole over the whole length with oil-free compressed air until return air stream is free of dust.

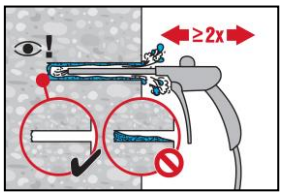
Cleaning of diamond cored holes roughened by the TE-YRT Hilti roughening tool



Flush 2 times by inserting a water hose (normal water-line pressure is sufficient) to the back of the hole until water runs clear.



Brush 2 times with the specified brush (see Table 8 of Annex 8) by inserting the Hilti HIT-RB steel brush to the back of the hole (if needed with extension) in a twisting motion and removing it. The brush must produce natural resistance when entering the borehole (brush Ø ≥ borehole Ø) - if not, the brush is too small and must be replaced by a smaller one.



Blow 2 times from the back of the hole (if needed with nozzle extension) over the whole length with oil-free compressed air (min. 6 bar at 6 m³/h) until return air stream is free of dust and the borehole dry. Remove all water from the borehole until borehole is completely dried before mortar injection ($t_{blowing}$ see Table 10 of Annex 9).

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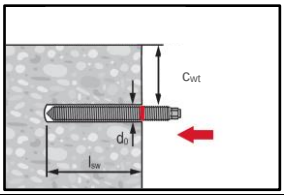
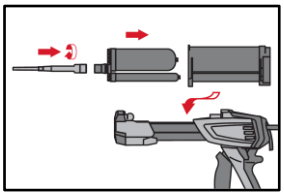
Threaded rod preparation

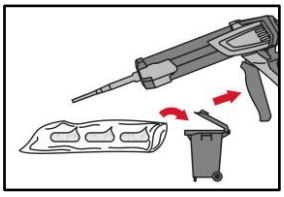


Before use, make sure the threaded rod is dry and free of oil or other residues.
Mark the embedment depth on the threaded rod (e.g. with a tape) → l_{sw}.
Insert the threaded rod into the borehole to ensure ease of movement and setting depth l_{sw}.

Injection preparation



Tightly attach the HIT-RE-M Hilti mixing nozzle to the foil pack. Do not modify the mixing nozzle in any way whatsoever.
Observe the instruction for use of the dispenser.
Check foil pack holder and foil pack for proper functioning. Insert foil pack into foil pack holder and put holder into dispenser.



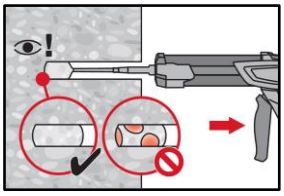
The foil pack opens automatically when dispensing is initiated. Depending on the size of the foil pack, an initial amount of mortar has to be discarded. Quantities to be discarded are

2 strokes	for 330 ml foil pack,
3 strokes	for 500 ml foil pack,
65 ml	for 1400 ml foil pack.

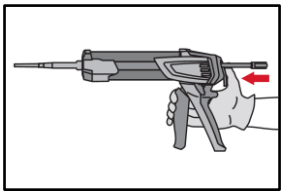
The minimum foil pack temperature is 5°C.

Inject mortar from the back of the borehole without forming air voids.

Injection method for borehole depth ≤ 250 mm (without overhead applications)

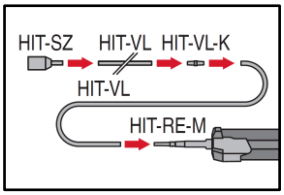


Inject the mortar starting at the back of the hole, slowly withdrawing the mixer with each trigger pull.
Fill approximately 2/3 of the borehole to ensure that the annular gap between the steel element and the concrete is completely filled with mortar along the embedment depth.



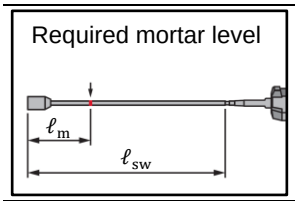
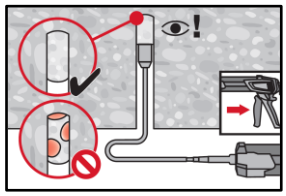
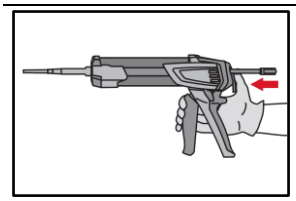
After injection is completed, depressurize the dispenser by pressing the release trigger. This will prevent the mortar from being further discharged from the mixer.

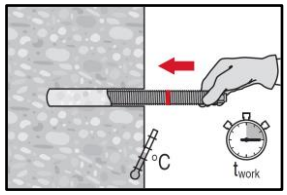
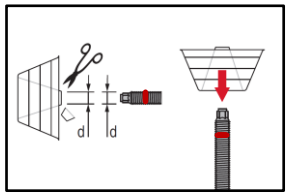
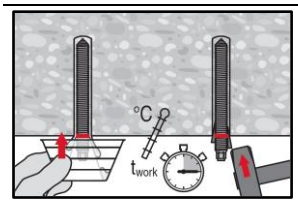
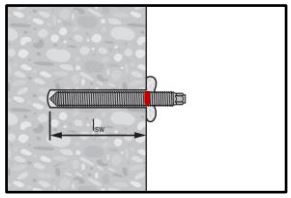
Injection method for borehole depth > 250 mm or overhead applications

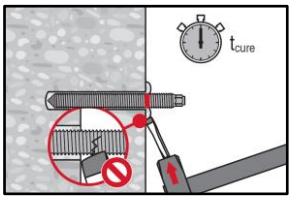
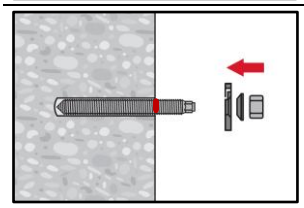
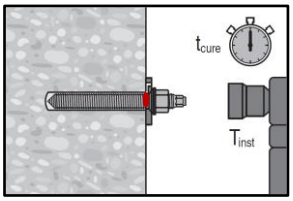
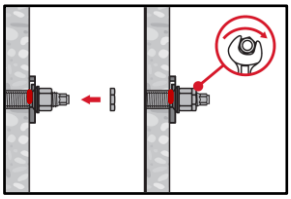
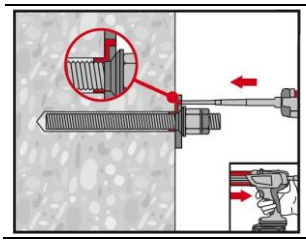


Assemble HIT-RE-M mixing nozzle, extension(s) and HIT-SZ piston plugs (see Table 5 and Table 6 of Annex 7).
For combinations of several injection extensions, HIT-VL-K coupler are to be used.
The substitution of the injection extension by a plastic hose or a combination of both is permitted.
The combination of HIT-SZ piston plugs with a HIT-VL 16 pipe and HIT-VL 16 tube facilitates the proper injection process.

Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4	**Annex 18**
Installation instructions	

	Mark the required mortar level l_m and embedment depth l_{sw} (e.g. with an adhesive tape or a pen). Estimation: $l_m = l_{sw} / 3$ Precise formula for optimum mortar volume: $l_m = l_{sw}$ (1.2 (d^2 / d_0^2) - 0.2)
	For overhead installation, the injection is only possible with the aid of extensions and piston plugs. Assemble HIT-RE-M mixer, extension(s) and appropriately sized piston plug (see Table 5 and Table 6 of Annex 7). Insert piston plug to back of the hole and inject mortar. During injection, the piston plug will be naturally extruded out of the borehole by the mortar pressure.
	After injection is completed, depressurize the dispenser by pressing the release trigger. This will prevent the mortar from being further discharged from the mixer.

Setting the threaded rod	Before use, verify that the threaded rod is dry and free of oil and other contaminants.
	For easy installation, insert the threaded rod into the borehole while slowly twisting until the embedment mark reaches the concrete surface level. Observe the working time t_{work} (see Table 12 of Annex 10), which varies according to the temperature of the base material. Minor adjustments to the threaded rod position may be performed during the working time. For larger setting depths, the Hilti TE-HAS-C/Y M… setting adapter is recommended in combination with the Hilti hammer drill.
	During insertion of the threaded rod, mortar might flow out of the borehole. For collection of the flowing mortar the HIT-OHC overhead dripping cup may be used.
	Support the threaded rod and prevent it from falling until mortar has started to harden e.g. by using HIT-OHW wedges. Observe the curing time t_{cure} (see Table 12 of Annex 10), which varies according to the temperature of the base material. Minor adjustments to the threaded rod position may be performed during the working time.
	After installing the threaded rod, the annular gap must be completely filled with mortar. Proper installation: • The desired embedment depth l_{sw} is reached when the embedment mark reaches the concrete surface level. • Excess mortar flows out of the borehole after the threaded rod has been fully inserted until the embedment mark reaches the concrete surface level.

	At the end of the curing time t_{cure} (see Table 12 of Annex 10), remove the excess mortar.
	Ensure that the concrete surface is level so that an even transmission of force between the anchor plate and the concrete is ensured. Use the Hilti filling set with a standard nut. Observe the correct orientation of the sealing washer and the spherical washer.
	After required curing time t_{cure} (see Table 12 of Annex 10), the post-installed threaded rod contributes to the shear resistance of the element with the performance given in Annex 11. The tightening torque to be applied must not exceed the maximum values T_{inst} given in Table 3 of Annex 6.
	Optional: Installation of lock nut. Tighten with a ¼ to ½ turn.
	Optional: Fill the annular gap between steel element and fixture with 1-3 strokes of a Hilti HIT injection mortar.

Hilti HIT-Shear strengthening system using Hilti HIT-RE 500 V4	**Annex 20**
Installation instructions	