POST-INSTALLED REBAR DESIGN MANUAL

Issue 2019

Basics, design and installation of post installed rebars

Content

1 Basics of post installed rebar connections 2
1.1 Definition of rebar 2
1.2 Advantages of post-installed rebar connections 2
1.3 Post-installed reinforcing bars and their application in construction 3
1.4 Application range 4
1.5 Bond of cast-in ribbed bars 8
1.6 Specifics of post-installed reinforcing bars 9

2 Design of Post-Installed Reinforcement 10
2.1 Loads on reinforcing bars 10
2.2 Design requirements 11
2.3 Jobsite constraints 11
2.4 Required anchorage length 11
2.5 Connection detailing 11
2.6 System specification 12
2.7 Establishment of required system performance (qualification) 12

3 Design Concepts 14
3.1 Establishing the required bar anchorage length 14
3.2 Overview of Eurocode2 [1] anchorage length provisions for straight reinforcing bars 14
3.3 Cracked concrete vs. uncracked concrete 18
3.4 Approval based ETA/EC2 design method 19
3.5 Design examples 21
3.6 Load case fire 25
3.7 Corrosion behaviour 26

4 References 27

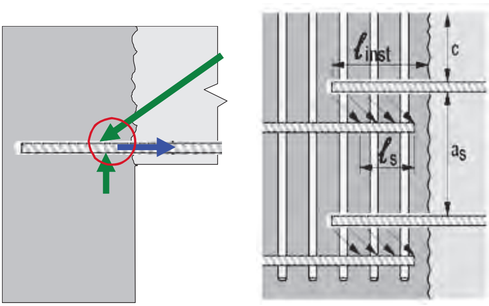
5 Installation of Post-Installed Reinforcement 32
5.1 Joint to be roughened 32
5.2 Drilling 32
5.3 Hole cleaning 33
5.4 Injection and bar installation 33
5.5 Installation instruction 34
5.6 Mortar consumption estimation for post installed rebars 40

6 How do I decide which system to use? 44
6.1 System selection considerations 44
6.2 HIT-HY 200 46
6.3 HIT-RE 500 60
6.4 HIT-RE 500V3 66
6.5 HIT-RE 100 74

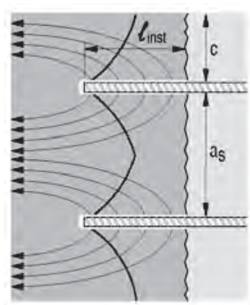
1 Basics of post installed rebar connections

1.1 Definition of rebar

Reinforcement anchorages or splices that are fixed into already cured concrete by Hilti HIT injection adhesives in drilled holes are called “Post-installed rebar connections” as opposed to normal, so called “cast-in” reinforcement. Many connections of rebars installed for good detailing practice will not require specific design considerations. But post-installed rebars which become part of the structural system have to be designed as carefully as the entire structure. While European Technical Approvals prove that in basic load situations, post-installed rebars behave like cast-in bars, a number of differences needs to be considered in special design situations such as fire or load cases where hooks or bends would be required for cast-in anchorages. The following chapters are intended to give the necessary information to safely design and specify post-installed reinforcement connections.



structural rebar situations: “anchorage node in equilibrium” and “splice”



anchor situation

This section of the Fastening Technology Manual deals with reinforcement connections designed according to structural reinforced concrete design principles. The task of structural rebars is to take tensile loads and since concrete failure is always brittle, reinforced concrete design assumes that concrete has no tensile strength. Therefore structural rebars can end / be anchored in only two situations:

- the bar is not needed anymore (the anchorage is a node in equilibrium without tensile stress in concrete)
- another bar takes over the tensile load (overlap splice)

Situations where the concrete needs to take up tensile load from the anchorage or where rebars are designed to carry shear loads should be considered as “rebar used as anchors” and designed according to anchor design principles as given e.g. in the guidelines of EOTA [3]

Unlike in anchor applications, reinforcement design is normally done for yielding of the steel in order to obtain ductile behaviour of the structure with a good serviceability. The deformations are rather small in correlation to the loads and the crack width limitation is around w_k ~0.3mm. This is an important factor when considering resistance to the environment, mainly corrosion of the reinforcement.

In case of correct design and installation the structure can be assumed as monolithic which allows us to look at the situation as if the concrete was poured in one. Due to the allowed high loads the required embedment depth can be up to 80d (diameter of rebar).

1.2 Advantages of post-installed rebar connections

With the use of the Hilti HIT injection systems it is possible to connect new reinforcement to existing structures with maximum confidence and flexibility.

- **design flexibility**
- **form work simplification**
- **reliable like cast in**
- **defined load characteristics**
- **horizontal, vertical and overhead**
- **simple, high confidence application**

1.3 Post-installed reinforcing bars and their application in construction

A common and long-standing application of anchoring adhesives is the installation of deformed reinforcing bars (rebar) in holes drilled in concrete to emulate the behavior of cast-in-place reinforcing bars (Figure 2). These are commonly referred to as post-installed reinforcing bars. This application can be characterized as follow:

a. Post-installed reinforcing bars are embedded in adhesive in a hole drilled in existing concrete on one side of the interface and are usually cast into new concrete on the other side of the interface (Figure 1). The bars may be equipped with hooks or heads on the cast-in end, but necessity straight on the post-installed end;

b. Post-installed reinforcing bars, in contrast to adhesive anchors, are often installed with small concrete cover ($3\phi > c > 2\phi$, where ϕ is the reinforcement bar diameter and c is the concrete cover). In such cases, the strength under tension loading of the post-installed reinforcing bar connection is typically limited by the splitting strength of the concrete (as characterized by splitting cracks forming along the length of the bar);

c. Post-installed reinforcing bars are typically not designed to resist direct shear loading in the manner of an anchor bolt and

d. Post-installed reinforcing bars are generally embedded as required to “develop” their design stress σ_{sd} using the basic required anchorage length, design anchorage length and splice length provisions of Eurocode2 [1]. In order to achieve ductility of the structure the design stress will often be close to the design yield strength.

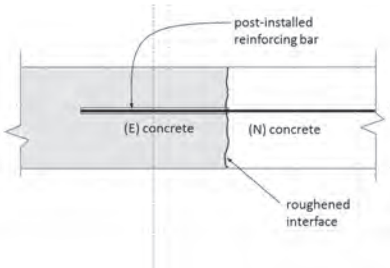


Figure 1– Post-installed reinforcing bar.

In some specific cases the tensile stress in post-installed reinforcing bars must be directly transferred into the concrete. In such cases they are designed as anchors taking account of the Concrete Capacity Design (CCD)-Method. The two design theories rebar theory and anchor theory, have peculiar differences which are summarized in Table 1 [12].

This Guide provides information regarding the design, detailing and installation of post-installed reinforcing bars. It does not address the design of adhesive anchors as governed by ETAG 001, part5 [4], CEN/TS 1992-4 [13] and TR 029 [3] anchor qualification and design provisions.

Table 1 – Main differences between anchor theory and rebar theory

Key differences	Anchor theory	Rebar theory
Design standard	EN 1992-4	EN 1992-1
Load direction	Tension, shear, combination of both	Tension
Load transfer mechanism	Utilization of tensile concrete strength	Equilibrium with local or global concrete struts
Failure modes	Steel failure, pull-out, splitting, concrete cone	Steel failure, pull-out, splitting
Design results	Capacity	Anchorage length
Minimum concrete cover	According to ETA	According to Eurocode2
Allowable anchorage length	$20\phi \geq l_b \geq 4\phi$	$60\phi \geq l_b \geq \max(0.3l_{brqd}; 10\phi; 100\text{mm})$

1.4 Application range

As noted above, post-installed reinforcing bars are typically used to develop a monolithic connection between new and existing concrete elements or structures. Post-installed reinforcing bars are used in both retrofit work and in new construction and are suitable for a wide range of applications.

Figure 2– Injecting Hilti HIT adhesive in a drilled hole with Hilti dispenser HDM / HDE to simplify installation of post-installed reinforcing bars.

One of the most common classes of applications for post-installed reinforcing bars is the extension of existing reinforced concrete (R/C) structural elements such as slabs, walls, and columns (Figure 3), either to facilitate expansion of floor space or to address other functional changes in the use of the structure. Such applications usually involve the placement of large numbers of bars with close spacing. In some cases the post-installed reinforcing bars are installed close to the surface of the concrete (e.g., using the minimum concrete cover according to Eurocode2 provisions, whereby the presence of existing reinforcing must be taken into account). Where applicable, such as in a column, slab, or wall extension, it is generally preferable to place the post-installed reinforcing bars inside of the existing reinforcing bar cage, both to minimize spall during drilling and to ensure adequate cover. Avoidance of existing reinforcing is facilitated by the use of reinforcing detection equipment, such as the Hilti PS 300 or Hilti PS 1000 scanning systems (Figure 4).

a. Column extension

b. Slab-to-slab connection

c. Slab-to-wall connection

d. Wall extension

e. Steel column encasement extending from wall

f. Slab extension

Figure 3– Applications involving extension of existing construction with new elements using Hilti HIT-RE 500 and Hilti HIT-HY 200

Since the required embedment to satisfy anchorage length provisions of the building code (typically 40 to 60 bar diameters) often greatly exceeds typical anchoring embedment (generally limited to 20 bar diameters), special precautions may be necessary to ensure that the holes are drilled straight, the drilling process does not spall or otherwise damage the existing concrete or the existing reinforcing or other embedment. These may include the use of specialized tools such as the Hilti drilling alignment system and Hilti ferric- and GPR-based detection systems.
Another class of applications includes the strengthening of existing concrete structures, often to improve performance e.g. due to refurbishment (Figure 5).

Figure 4– Scanning for reinforcing bars and other embedded items with a Hilti GPR scanner.

a. Slab-to-wall connection

b. Wall-to-wall connection

c. Onlay shotcrete wall

d. Slab-to-column connection strengthening

Figure 5– Structural strengthening applications using Hilti HIT-RE 500

A third application class with unique requirements is the extension, rehabilitation, and strengthening of existing concrete bridges and other civil engineering structures (Figure 6). These applications are often distinguished by the need for enhanced resistance to corrosion and temperature extremes. Hilti has developed unique shear-friction solutions for bridge deck overlays[1] and offers hybrid adhesives (e.g., Hilti HIT-HY 200) with superior resistance to elevated temperatures [12].

[1] Contact Hilti for further information

a. Bridge widening

b. Bridge deck rehabilitation

c. Bridge deck augmentation

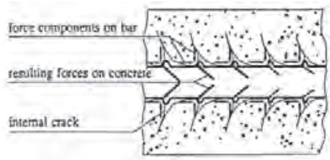
Figure 6– Applications in bridge rehabilitation with post-installed reinforcing bars

1.5 Bond of cast-in ribbed bars

General Behaviour

For ribbed bars, the load transfer in concrete is governed by the bearing of the ribs against the concrete. The reacting force within the concrete is assumed to be a compressive strut with an angle of 45°.

For higher bond stress values, the concentrated bearing forces in front of the ribs cause the formation of cone-shaped cracks starting at the crest of the ribs. The resulting concrete keyed between the ribs transfer the bearing forces into the surrounding concrete, but the wedging action of the ribs remains limited. In this stage the displacement of the bar with respect to the concrete (slip) consists of bending of the keys and crushing of the concrete in front of the ribs.

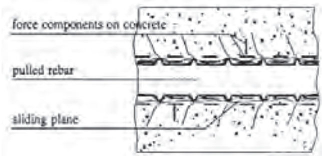


Load transfer from ribbed bars into concrete

The bearing forces, which are inclined with respect to the bar axis, can be decomposed into directions parallel and perpendicular to the bar axis. The sum of the parallel components equals the bond force, whereas the radial components induce circumferential tensile stresses in the surrounding concrete, which may result in longitudinal radial (splitting / spalling) cracks. Two failure modes can be considered:

Bond Failure

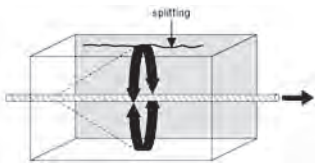
Bond failure is caused by pull-out of the bar if the confinement (concrete cover, transverse reinforcement) is sufficient to prevent splitting of the concrete cover. In that case the concrete keys are sheared off and a sliding plane around the bar is created. Thus, the force transfer mechanism changes from rib bearing to friction. The shear resistance of the keys can be considered as a criterion for this transition. It is attended by a considerable reduction of the bond stress. Under continued loading, the sliding surface is smoothed due to wear and compaction, which will result in a further decrease of the bond stress, similar to the case of plain bars.



Bond failure of ribbed bars

Splitting failure:

Bond splitting failure is decisive if the radial cracks propagate through the entire cover. In that case the maximum bond stress follows from the maximum concrete confinement, which is reached when the radial cracks have penetrated the cover for about 70%. Further crack propagation results in a decrease of the confining stresses. At reaching the outer surface these stresses are strongly reduced, which results in a sudden drop of the bond stress.

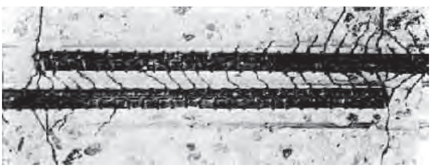


Splitting

Influence of spacing and cover on splitting and spalling of concrete

In most cases the reinforcement bars are placed close to the surface of the concrete member to achieve good crack distribution and economical bending capacity. For splices at wide spacing (normally in slabs, left part of figure left), the bearing capacity of the concrete depends only on the thickness of the concrete cover. At narrow spacing (normally in beams, right part of figure above) the bearing capacity depends on the spacing and on the thickness of the cover. In the design codes the reduction of bearing capacity of the cover is taken into account by means of multiplying factors for the splice length.

Load Transfer in Overlap Splices


Load transfer at lap splices

The load transfer between bars is performed by means of compressive struts in the concrete, see figure left. A 45° truss model is assumed. The resulting perpendicular forces act as splitting forces. The splitting forces are normally taken up by the transverse reinforcement. Small splitting forces are attributed to the tensile capacity of the concrete. The amount of the transverse or tie reinforcement necessary is specified in the design codes.

1.Specifics of post-installed reinforcing bars

General Behaviour

The load transfer for post-installed bars is similar to cast in bars if the stiffness of the overall load transfer mechanism is similar to the cast-in system. The efficiency depends on the strength of the adhesive mortar against the concentrated load near the ribs and on the capacity of load transfer at the interface of the drilled hole.

In many cases the bond values of post-installed bars are higher compared to cast in bars due to better performance of the adhesive mortar. But for small edge distance and/or narrow spacing, splitting or spalling forces become decisive due to the low tensile capacity of the concrete.

Post-Installed Reinforcement Approvals

There are European Technical Approvals for post-installed rebar connections. Systems getting such approvals have to be assessed according to the EOTA technical guideline TR023 [2] (available in the EOTA website). Requirements for a positive assessment are an installation system providing high installation quality for deep holes and an adhesive fulfilling the test requirements of the guideline TR023. Obtaining the approval is basically the proof that the post-installed rebars work at least as well as cast-in rebars (with respect to bond strength and displacement); consequently, the design of the rebar anchorage is performed according to structural concrete design codes, in the case of Europe this is Eurocode 2 [1].

High Quality Adhesives Required

Assessment criteria

EOTA TR023 [2] specifies a number of tests in order to qualify products for post-installed rebar applications. These are the performance areas checked by the tests:

1. bond strength in different strengths of concrete
2. substandard hole cleaning
3. Wet concrete
4. Sustained load and temperature influence
5. Freeze-thaw conditions
6. Installation directions
7. Maximum embedment depth
8. Avoidance of air bubbles during injection
9. Durability (corrosion, chemical attack)

Approvals with or without exceptions

If an adhesive fulfills all assessment criteria of EOTA TR023, rebar connections carried out with this adhesive can be designed with the bond strength and minimum anchorage length according to Eurocode 2 [1] as outlined in section 2.2 of this document.

Adhesives which do not fully comply with all assessment criteria can still obtain an “approval with exceptions”.

- If the bond strength obtained in tests does not fulfil the specified requirements, then bond strengths lower than those given by Eurocode 2 shall be applied. These values are given in the respective ETA.
- If it cannot be shown that the bond strength of rebars post-installed with a selected product and cast-in rebars in cracked concrete (w=0.3mm) is similar, then the minimum anchorage length $\ell_{b,min}$ and the minimum overlap length $\ell_{0,min}$ shall be increased by a factor 1.5.

2 Design of post-installed reinforcement

Based on the approval (ETA) for the mortar system qualified according to EOTA TR023 [2] which allows to use the accepted structural code Eurocode 2 EN 1992-1-1:2011 [1], chapters 8.4: "anchorage of longitudinal reinforcement" and 8.7 "Laps and mechanical couplers" taking into account some adhesive specific parameters. This method is called

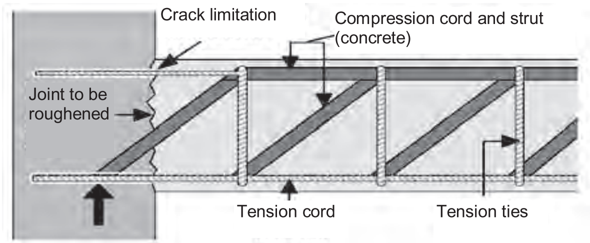
"ETA/EC2 Design Method"

paragraph 3.5 gives an overview of the design approach and design examples, technical data from the rebar approvals can be found in section 6.

2.1 Lords on reinforcing bars

Strut and Tie Model

Strut-and-tie models are used to calculate the load path in reinforced concrete members. Where a non-linear strain distribution exists (e.g. supports) strut-and-tie models may be used {Clause 6.5.1(1), EC2: EN 1992-1-1:2011}.



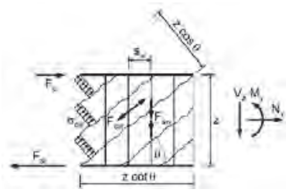
Strut-and-tie-model

Strut-and-tie models consist of struts representing compressive stress fields, of ties representing the reinforcement and of the connecting nodes. The forces in the elements of a strut-and-tie model should be determined by maintaining the equilibrium with the applied loads in ultimate limit state. The ties of a strut-and-tie model should coincide in position and direction with the corresponding reinforcement {Clause 5.6.4, EC2: EN 1992-1-1:2011 Analysis with strut and tie models}.

In modern concrete design codes the strut angle θ can be selected within certain limits, roughly between 30° and 60°. Many modern concrete design codes show a figure similar to the following:

The equilibrium equations in horizontal direction gives the force in the reinforcement:

$$F_{sl} = \frac{M_y}{z} + \frac{N_x}{2} + \frac{V_z \cdot \cot\theta}{2}$$


truss model in modern codes

2.2 Design requirements

Design of post-installed reinforcing bar connections requires that the type, size, spacing and quantity and anchorage / splice length be established for the connection. This is typically based on either direct calculation of section forces, or a requirement to match existing reinforcement.

Additional design considerations may include:

- loading type (sustained, seismic, shock)
- fire requirements
- corrosion resistance
- detailing requirements based on element type (integrity reinforcement, etc.)

2.3 Jobsite constraints

Prior to designing a post-installed reinforcing bar connection, identification of the jobsite constraints is vital. Key parameters that should be accounted for in the design may include:

- existing reinforcement layout as given in drawings and confirmed on site using detection equipment
- required proximity of new to existing reinforcing to satisfy conditions for non-contact lap splices, etc.
- required drilling method (hammer drill, core drill, Hilti Hollow Drill Bit)
- orientation of connection (downward, overhead, etc.)
- ambient air and concrete temperatures at time of installation
- type and condition of the concrete e.g. cracked, carbonized
- access and geometrical constraints

2.4 Required anchorage length

In general, the required bar embedment is based on the design anchorage length provisions of the code. Where geometrical or other practical constraints dictate, alternate procedures may be appropriate to establish bond length. The size of the bar and required anchorage length may also influence the type of adhesive system to be used. Adhesives with longer working time (e.g., Hilti HIT-RE 500-V3) are usually more appropriate for large diameter bars in combination with deep holes, whereby for small to medium bar diameters and shorter holes, systems with accelerated cure (e.g., Hilti hybrid adhesive HIT-HY 200) can increase installation efficiency. These considerations may be affected by the anticipated job site conditions (e.g., access and ambient air and concrete temperatures).

2.5 Connection detailing

The location of post-installed re inforcing bars with respect to existing reinforcement should be clearly indicated in the project documentation. In addition, the specifications and details should include:

- adhesive system
- bar type and size
- required design/splice anchorage length
- hole diameters and drilling method(s)
- requirements for preparation/roughening of existing concrete surface
- instruction on inviolability of existing reinforcement and embedded items as required
- requirements on training/certification of installers as required
- inspection/proof loading requirements

2.6 System specification

Specifications should correlate to the design assumptions and the specific job site requirements addressed in the project documentation. Substitutions based on a simple specification of bond stress may not be sufficient to ensure proper execution of the work.

2.7 Establishment of required system performance (qualification)

The suitability of an adhesive system for post-installed reinforcing bar applications is dependent on many factors. Systems that may be otherwise appropriate for anchoring applications will not necessarily fulfill the requirements for safe and reliable reinforcing bar installations.

Figure 31 lists the full range of tests required to qualify adhesive anchor systems for post-installed reinforcing bar applications as provided in TR023 [2] which can be summarized as:

1. The ability of the adhesive to develop the required bond resistance from concrete strength class C20/25 to C50/60;

2. The sensitivity of the bond resistance to hole cleaning, freezing and thawing conditions, concrete temperature extremes in service, installation orientation, and alkalinity/sulfurexposure;

3. The ability of the system to successfully execute long bar installations (up to 60 bar diameters) without substantial voids in the adhesive around the post-installed reinforcing bar;

4. The corrosion resistance of the post-installed reinforcing bar;

   While it is generally the case that modern structural-grade adhesives are capable of developing bond resistances in excess of those shown by cast-in rebar, the effects of job-site installation conditions, temperature, and other factors included in the assessment can reduce bond resistance substantially. Therefore, system performance is critical for qualification, not just adhesive bond strength as determined under optimum conditions.

	Purpose of test	Concrete (1)	Rebar (2) size	Rebar (2) length (9)	Minimum number of tests	Criteria req. α (3)	Test procedure
1	Bond resistance in C20/25	C20/25	12mm 25mm d_{max}	$10d_s$ $10d_s$ $10d_s$	5 5 (4) 5	see 3.3.2	2.2
2	Bond resistance in C50/60	C50/60	d_{max}	$7d_s$	5	see 3.3.2	2.3
3	Installation safety dry concrete	C20/25	d_{max} (5)	$10d_s$	5	≥ 0.8 (6)	2.4
4	Installation safety wet concrete	C20/25	d_{max} (5)	$10d_s$	5	≥ 0.75 (6)	2.5
5	Functioning under sustained loads	C20/25	12mm	$10d_s$	5	≥ 0.9	2.6
6	Functioning under freeze/thaw conditions	C50/60 (7)	12mm	$7d_s$	5	≥ 0.9	2.7
7	Functioning with installation direction	C20/25	d_{max}	$10d_s$	5	≥ 0.9	2.8
8	Installation at maximum embedment depth	C20/25	d_{max}	max l_v	5	see 3.2.3	2.9
9	Correct injection		d_{max}	max l_v	5	see 3.2.4	2.10
10	Checking durability of mortar (8)	C20/25	12mm	$10d_s$	3 x 10	see 3.3.3	2.11
11	Corrosion resistance of rebar (10)	C20/25	12mm	70mm	3	see 3.3.4.3	3.3.4.2

Notes to Table 2.1

(1) All tests performed in non-cracked concrete

(2) size: diameter of the rebar; d_{max}: max. diameter of the rebar specified by the manufacturer; length: embedment length of the bar in the concrete

(3) see 3.3.1

(4) Tests are necessary only, if tests according to line 3 and 4 are done with d_s = 25mm < d_{max}

(5) Tests shall be done with d_s = 25mm, if comparison tests according to line 1 are carried out with d_s = 25mm instead of d_{max}

(6) The required α shall not be changed, because the concept of installation safety factor γ_2 is not supported by EC2

(7) The test result shall be normalised to C20/25 by using a factor reflecting the influence of concrete strength or bond resistance as established by tests according to line 1 and 2

(8) Tests are not required for mortars based on cement only

(9) 10 d_s and 7 d_s shall be reduced in case of steel failure mode. It is the objective of these tests to determine bond resistance.

(10) No prove of the corrosion resistance of the rebar is needed if post-installed rebars are used in building components in dry surroundings according to exposure class X0 and XC1 of EC2. Also no prove is needed when only corrosion resistant rebars are specified for all applications; see 3.3.4.1.

Figure 7 – Test Program for Evaluating Reinforcing Bars for Use in Post-installed Reinforcing Bar Connections (EOTA TR 023) [2].

3 Design concepts

3.1 Establishing the required bar anchorage length

Systems qualified under EOTA TR 023 [2] are required to demonstrate bond resistance and stiffness characteristics that are compatible with cast-in reinforcement. Therefore, post-installed reinforcing bars installed with qualified systems can be designed and detailed using the same provisions that are applicable to the development of straight cast-in-place bars.

3.2 Overview of Eurocode2 [1] anchorage length provisions for straight reinforcing bars

The Eurocode2 [1] concept of anchorage length is based on the attainable average bond stress over the length of embedment of the reinforcement. Anchorage length can be defined as the shortest length in which the bar stress increases from zero to the design steel stress σ_{sd} acting at the point where the anchorage or splice starts. The bar stress is the force per unit area of the bar cross-section.

Structural reinforced concrete design is in practice based on the assumption that the reinforcing bar will develop its nominal yield strength before premature failure occurs due to inadequate bond. Basic required anchorage length, design anchorage length and splice length is intended to ensure that the nominal yield strength (the minimum bar stress at which permanent (inelastic) deformation occurs) of the bar can be developed under structure loading.

In the following a summary of Eurocode2 [1] provisions for cast-in is given as far as it concerns the design of post-installed reinforcing bars.

The anchorage length is closely associated to the design bond strength, f_{bd}, which is given as follows:

$f_{bd} = 2{,}25 \cdot \eta_1 \cdot \eta_2 \cdot f_{ctd}$ (N/mm²)

Where:

2,25 = basic value of the design bond strength (N/mm²)

η_1 = coefficient related to the quality of the bond condition and the position of the bar during concrete pouring.
η_1 = 1.0 stands for good bond conditions and η_1=0.7 is taken for all other cases. Note for post-installed rebar
η_1 = 1.0 should be taken (-)

η_2 = coefficient related to the rebar diameter: η_2 = (132-ϕ)/100 ≤ 1.0 where ϕ is the nominal rebar diameter [mm] while η_2 = 1,0 for ϕ ≤ 32mm (-)

f_{ctd} = the design tensile strength of the concrete

The basic required anchorage length $l_{b,rqd}$ is given as follows:

$l_{b,rqd} = (\phi/4) / (\sigma_{sd}/f_{bd})$ (mm)

Where:

ϕ = the reinforcing bar diameter (mm)

σ_{sd} = design steel stress at the beginning of the anchorage (N/mm²)

f_{bd} = design value of the ultimate bond stress (N/mm²)

The design anchorage length l_{bd} is calculated from the basic required anchorage length $l_{b,rqd}$ taking into account the influence of five parameters (α_1 to α_5) and it should not be less than a minimum anchorage length $l_{b,min}$. The design anchorage length lbd is given as follows:

Rebar under tension:	$l_{bd} = \alpha_1\, \alpha_2\, \alpha_3\, \alpha_4\, \alpha_5\, l_{b,rqd} \geq l_{b,min}$	(mm)
Rebar under compression:	$l_{bd} = \alpha_4 l_{b,rqd} \geq l_{b,min}$	(mm)

Where:

α_1 considers the form of the bar (for straight bar ends α_1=1.0, for other shapes in certain conditions α_1=0.7) (-)

α_2 takes into account the concrete cover: $0,7 \leq \alpha_2 = 1-0,15(c_d-k\phi)/\phi \leq 1.0$ where cd is the smallest of (a) the concrete cover and (b) half of the clear spacing of bars and k= 1 for bars without hook and k=3 for bars with hook (-).
α_2 takes account of passive confinement provided by the surrounded concrete.

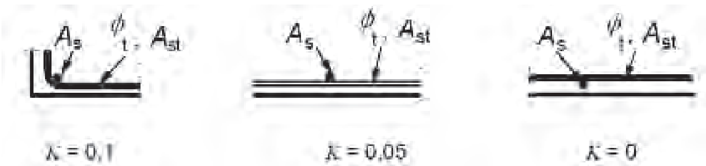
For simplification α_2 =1.0 maybe assumed.

α_3 takes account for the effect of transverse reinforcement where $0,7 \leq \alpha_3 = 1-K\lambda \leq 1.0$ with $\lambda = (\Sigma A_{st} - \Sigma A_{st,min})/A_s$. (-)

ΣA_{st} = cross-sectional area of the minimum transverse reinforcement along the design anchorage length l_{bd} (mm²)

$\Sigma A_{st,min}$= 0.25A_s for beams and $\Sigma A_{st,min}$=0 for slabs with A_s = area of a single anchored bar with maximum bar diameter (mm²)

K: coefficient related to the position of the post-installed rebar



α_3 takes account of passive confinement provided by the lateral reinforcement.Concrete structural members that are confined react to the Poisson type lateral expansion and generate side pressures. With the increase in lateral steel, the ductility of the concrete increases (its ability of sustaining large permanent changesin shape without breaking). For simplification α_3 =1.0 maybe assumed.

α_4 = 0.7 if transverse reinforcement is welded to the reinforcement to be anchored, otherwise α_4= 1.0 (-)

α_5 = takes account of transverse pressure while $\alpha_5 = 1-0.04p \geq 0.7$ where p is the transverse pressure along the anchorage length (active confinement).
The confining pressure which is applied to pre-stress the concrete element laterally prior to loading exerts an initial volumetric strain due to compaction. In order to overcome this, additional axial strain and stress are needed, and the load capacity of the concrete is increased compared to the passively confined concrete.

The cumulating of the influences is limited by $\alpha_2 \cdot \alpha_3 \cdot \alpha_5 \geq 0.7$

The minimum anchorage length $l_{b,min}$ is given as follows:

$l_{b,min}$ = max(0.3$l_{b,rqd}$; 10ϕ; 100mm) for bars under tension (mm)
$l_{b,min}$ = max(0.6$l_{b,rqd}$; 10ϕ; 100mm) for bars under compression (mm)

The design splice length lo is also calculated from the basic required anchorage length $l_{b,rqd}$ with:
$l_0 = \alpha_1\, \alpha_2\, \alpha_3\, \alpha_5\, \alpha_6 \cdot l_{b,rqd} \geq l_{0,min}$ (mm)

For bars in compression (usually considered only in highly loaded columns), all α-factors except α_6 are the same as for anchorage, see above. For bars in tension (and α_4 also in compression) the factors are defined as follows:

α_6 =1.5 if all bars are spliced in the same area (i.e. the splices are not staggered)
which is usually the case with post-installed splices (-)
Note: If the clear distance between lapped bars e exceeds four times the bar diameter ϕ or 50mm, then the overlap length shall be increased by a length equal to e-4ϕ or e-50mm.

The minimum splice length lo,min can be calculated as follows:
$l_{0,min}$ = max(0.3$\cdot\alpha_6\cdot l_{b,rqd}$; 15$\phi$; 200mm)

Special provisions for post-installed rebars

To prevent damage of the concrete during drilling the following requirements have to be met:

- Minimum concrete cover:
  $c_{min} = 30 + 0.06\, l_v \geq 2d_s$ (mm) for hammer drilled holes
  $c_{min} = 50 + 0.08\, l_v \geq 2d_s$ (mm) for compressed air drilled holes

  The factors 0.06 and 0.08 take into account the possible deviations during drilling. However, if special drilling aid devices are used, this value could be smaller.
- Minimum clear spacing between two post-installed bars should be 4ϕ ≥ 40mm.

Note that the Eurocode2 [1] limits the extent to which bond stresses in the concrete may be utilized via a 0.7 cap on the value of the quotient $0.7 \leq \alpha_2 = 1\text{-}0.15(c_d\text{-}k\phi)/\phi \leq 1.0$ in the basic anchorage length equation. Figure 8 provides a schematic representation of this limit, whereby for bars with a high value of concrete cover ($c_d/\phi \geq 3$), it is assumed that splitting no longer controls the behavior at ultimate load.
Hilti anchoring adhesives can generate bond stresses that far exceed this limit represented by the “actual design bond capacity” line plotted below.

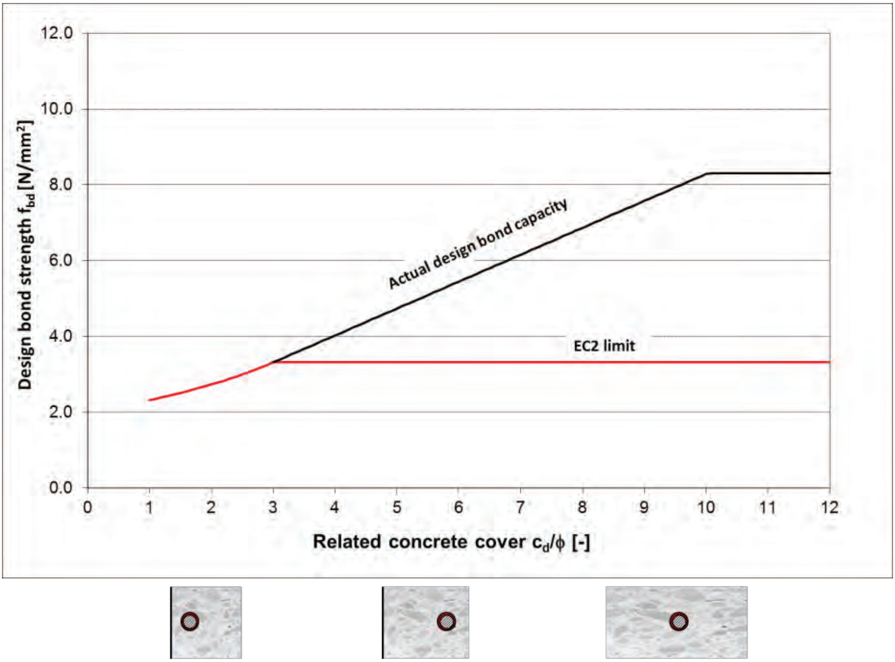


Figure 8 – Effective limit on bond stress for post-installed rebar using Hilti mortar systems represented by the “actual design bond capacity” and design bond strength values as provided by Eurocode2 [1]

3.3 Cracked concrete vs. uncracked concrete

According to TR023, to account for a possible different behavior of a post-installed rebar and cast-in rebar in cracked concrete, the minimum anchorage length should be amplified by a factor of 1.5. This increase is omitted if tests show that the bond strength of post-installed rebar and cast-in rebar in cracked concrete is similar [2]. In addition, in most of post-installed rebar applications, cracks are located perpendicular to the reinforcement axis without affecting the bond loading capacity of the system connection. In the related ETA for post-installed rebar of each product, values of bond strengths and amplification factors for minimum anchorage lengths are reported.

3.4 Approval based ETA/EC2 design method

3.4.1 Application Range

The principle that rebars are anchored “where they are not needed any more” (anchorage) or where the force is taken over by another bar (splice) and the fact that only straight rebars can be post-installed lead to the application range shown by the figures taken from EOTA TR023 [2]:

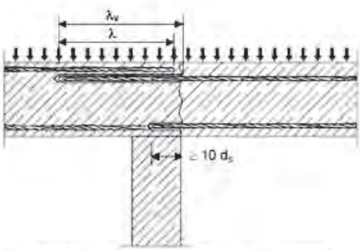


Figure 1.1: Overlap joint for rebar connections of slabs and beams

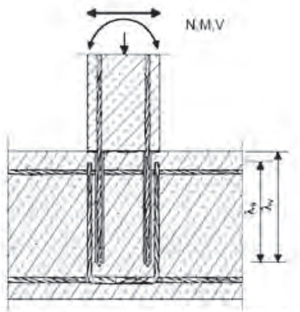


Figure 1.2: Overlap joint at a foundation of a column or wall where the rebars are stressed in tension

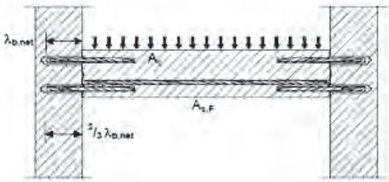


Figure 1.3: End anchoring of slabs or beams, designed as simply supported

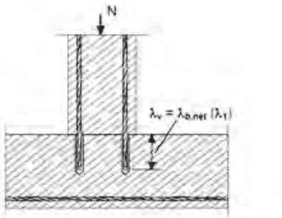


Figure 1.4: Rebar connection for components stressed primarily in compression. The rebars are stressed in compression

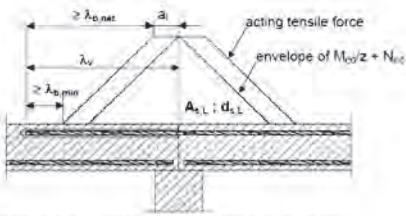


Figure 1.5: Anchoring of reinforcement to cover the line of acting tensile force

Note to Figure 1.1 to 1.5:

In the Figures no transverse reinforcement is plotted, the transverse reinforcement as required by EC 2 shall be present.

The shear transfer between old and new concrete shall be designed according to EC 2.

Application range according to EOTA TR023

All other applications lead to tensile stress in the concrete. Therefore, the principle “works like cast-in” would not be true any more. Such cases must be considered with specific models exceeding the approval based approach to post-installed rebar connections.

3.4.2 Design of Development and Overlap Length with Eurocode 2

The following reflect the design relevant sections from EOTA TR023, chapter 4 “Assumptions under which the fitness of use is to be assessed” and from the specific European Technical Approvals:

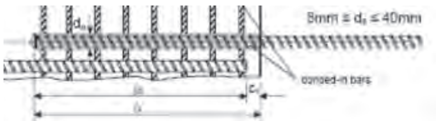
Design method for post-installed rebar connections

- The post-installed rebar connections assessed according to this Technical Report shall be designed as straight cast-in-place rebars according to EC2 using the values of the design bond resistance f_{bd} for deformed bars as given in the relevant approval.
- Overlap joint for rebars: For calculation of the effective embedment depth of overlap joints the concrete cover at end-face of the post-installed rebar c_1 shall be considered:

  $\ell_v \geq \ell_0 + c_1$

  with: ℓ_0 = required lap length

  c_1 = concrete cover at end-face of bonded-in rebar



front cover c_1

- The definition of the bond region in EC2 is valid also for post-installed rebars.
- The conditions in EC2 concerning detailing (e.g. concrete cover in respect to bond and corrosion resistance, bar spacing, transverse reinforcement) shall be complied with.
- The transfer of shear forces between new and old concrete shall be designed according to EC2 [1].

Additional provisions

- To prevent damage of the concrete during drilling the following requirements have to be met:

  • Minimum concrete cover:

  $c_{min} = 30 + 0{,}06\ l_v \geq 2d_s$ (mm) ϕ<25mm, $C_{min} = 40 + 0.06 l_v \geq 2d_s$, $\phi \geq$ 25mm for hammer drilled holes

  $c_{min} = 50 + 0{,}08\ l_v \geq 2d_s$ (mm) for compressed air drilled holes

  The factors 0,06 and 0,08 should take into account the possible deviations during the drilling process. This value might be smaller if special drilling aid devices are used.

  Furthermore the minimum concrete cover given in clause 4.4.1.2, EC2: EN 1992-1-1: 2004 shall be observed.

  • Minimum clear spacing between two post-installed bars a = 40 mm ≥ $4d_s$

- To account for potentially different behaviour of post-installed and cast-in-place rebars in cracked concrete,

  • in general, the minimum lengths $l_{b,min}$ and $l_{o,min}$ given in the EC 2 for anchorages and overlap splices shall be increased by a factor of 1.5. This increase may be neglected under certain conditions. The relevant approval states under which conditions the factor can be neglected for a specific adhesive.

Preparation of the joints

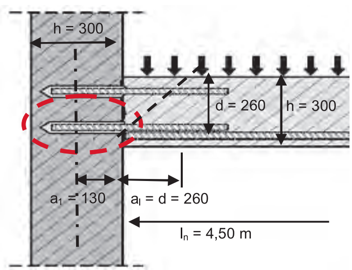
- The surface of the joint between new and existing concrete should be prepared (roughing, keying) according to the envisaged intended use according to EC2.
- In case of a connection being made between new and existing concrete where the surface layer of the existing concrete is carbonated, the layer should be removed in the area of the new reinforcing bar (with a diameter d_s+60mm) prior to the installation of the new bar.

Transverse reinforcement

The requirements of transverse reinforcement in the area of the post-installed rebar connection shall comply with clause 8.7.4, EC2: EN 1992-1-1:2011.

3.5 Design examples

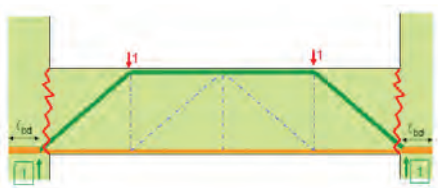
a) End support of slab, simply supported



Wall: h = 300 mm

Concrete strength class: C20/25, dry concrete

Reinforcement: f_{yk} = 500 N/mm2, γ_s = 1,15



Bottom reinforcement at support:

Steel area required: = 231 mm²/m

$\varnothing$12, s = 200 mm $\Rightarrow$ $A_{s,prov}$ = 565 mm²/m;
Installation by wet diamond core drilling: Hilti HIT-RE 500 is suitable adhesive (see Tech data, sect. 2.2.3)

Basic anchorage length {EC2: EN 1992-1-1:2004, section 8.4.3}:
$\ell_{b,rqd} = (d_s / 4) \times (\sigma_{sd} / f_{bd})$
with: d_s = diameter of the rebar = 12 mm
σ_{sd} = calculated design stress of the rebar = $(A_{s,rqd} / A_{s,prov}) \cdot (f_{yk}/\gamma_s)$ = (231 / 565) · (500 / 1,15) = 177 N/mm²
f_{bd} = design value of bond strength according to corresponding ETA (= 2,3 N/mm²)
$\ell_{b,rqd}$ = (12 / 4) x (177 / 2,3) = 231 mm

Design anchorage length {EC2: EN 1992-1-1:2004, section 8.4.4}:
$\ell_{bd} = \alpha_1\ \alpha_2\ \alpha_3\ \alpha_4\ \alpha_5\ \ell_{b,rqd} \geq \ell_{b,min}$
with: $\ell_{b,rqd}$ as above
α_1 = 1,0 for straight bars
$\alpha_2 = 1 - 0{,}15(c_d - ø)/ø$ $(0{,}7 \leq \alpha_2 \leq 1{,}0)$
α_2 is for the effect of concrete cover, in this case half the clear spacing: c_d=(200-12)/2=94mm
α_2 = 0,7 Straight bars, c_d = min (a/2, c_1, c)
α_3 = 1,0 because of no transverse reinforcement
α_4 = 1,0 because of no welded transverse reinforcement
α_5 = 1,0 influence of transverse pressure is neglected in this example

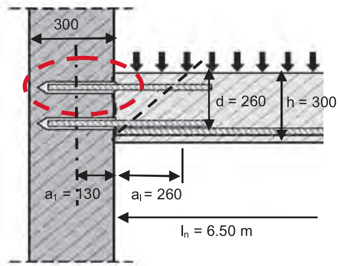
ℓ_{bd} = 0,7 · 231 = 162 mm

minimum anchorage length {Clause 8.4.4(1), EC2: EN 1992-1-1:2004}:

$\ell_{b,min}$ = max {0,3$\ell_{b,rqd}$; 10ϕ; 100mm} = 120 mm

ℓ_{bd} controls → drill hole length **l_{ef} = 162 mm**

Top reinforcement at support:



As the design stress is 0, the minimum anchorage length applies for the upper reinforcement. As in the above calculation for bottom reinforcement:

$\ell_{b,min}$ = max {0,3$\ell_{b,rqd}$; 10ϕ; 100mm} = 120 mm

Therefore, drill hole length **l_{ef} = 120mm**

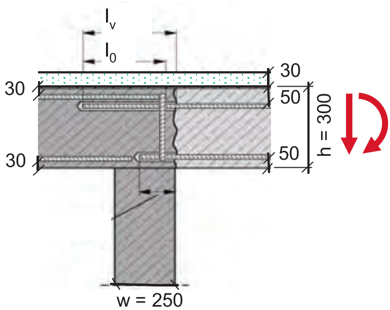
If wet diamond core drilling is used {Clause 8.4.4(1), EC2: EN 1992-1-1:2004}:

$\ell_{b,min}$ = max {0,3$\ell_{b,rqd}$; 10ϕ; 100mm} · 1,5 = 180 mm (as wet diamond core drilling is used, the minimum values according do EC2 have to be multiplied by 1,5, see tech data)

-> in this case the minimum length will control, drill hole length **l_{ef} = 180mm** for upper and lower layers

b) splice on support

General information for design example



- Slab: cover cast-in bars c_c = 30 mm (top, bottom); cover new bars: c_n = 50mm h = 300 mm;
- Top reinforcement (new and existing): ϕ16, s = 200 mm; $A_{s,prov}$ = 1005 mm^2/m; cover to face c_1 = 30 mm
- Bottom reinforcement: ϕ10, s=200 mm; $A_{s,prov}$=393 mm^2/m
- Concrete strength class: C25/30
- Properties of reinforcement: f_{yk} = 500 N/mm^2
- Fire resistance: R60 (1 hour), Light weight plaster for fire protection: t_p=30 mm; maximum steel stress in fire $\sigma_{Rd,fi}$ = 322 N/mm^2
- Hilti HIT-RE 500

Post-installed reinforcement top

The required design lap length l_0 shall be determined in accordance with EC2: EN 1992-1-1:2004, section 8.7.3:

$l_{0,pi} = \alpha_1\ \alpha_2\ \alpha_3\ \alpha_5\ \alpha_6\ l_{b,rqd,pi} \geq l_{0,min}$

$A_{s,req}$=	807	mm^2/m	
σ_{sd} = $(A_{s,rqd} / A_{s,prov}) \cdot (f_{yk}/\gamma_s)$ = (807 / 1005) · (500 / 1,15) =	349	N/mm^2	
f_{bd} = design value of bond strength according to 2.2.3 =	2,7	N/mm^2	(ETA-08/0105)

$l_{b,rqd,pi}$ = $(\phi / 4) \cdot (\sigma_{sd} / f_{bd})$ = (16 / 4) · (349 / 2,7) = 516 mm

α_1 = 1,0 for straight bars

α_2 = $(1 - 0{,}15(c_d - ø)/ø \geq 0.7)$ = 1-0,15(50-16)/16 = 0,7

α_3 = 1,0 no transverse reinforcement

α_5 = 1,0 no transverse pressure

α_6 = 1,5 splice factor

$l_{0,min}$ = max{0,3·1,5·515; 15·16; 200} = 240 mm

$l_{0,pi}$ = 0,7·1,5·530 = 542 mm

<u>Fire resistance post-installed reinforcement top:</u>

$\sigma_{sd,fi}$ = 249 N/mm^2 $< \sigma_{Rd,fi} \rightarrow$ ok

c_{fi} = $c_n + t_p$ = 30 + 50 = 80 mm cover effective against fire

$f_{bd,fi}$ = (sect. 2.4.1, table fire parallel) 1.42/1.43 = 0.993 N/mm^2 FAHY200-2016-S, Table 5

$l_{0,pi,fi}$ = $(\phi/4)\cdot(\sigma_{sd,fi}/f_{bd,fi})$ = (16/4)·(249/0.993) = 1003 mm

<u>Embedment depth for post-installed rebars top:</u>

e = $[\,(s/2)^2 + (c_n\text{-}c_c)^2\,]^{0,5} - \phi = [\,100^2 + (50\text{-}30)^2\,]^{0,.5}$ -16 = 86 mm clear spacing between spliced bars

Δl_0 = e-4ϕ = 86 - 4·16 = 22 mm Reference to ETA-12/0083 Annex B2& EC2 Cl. 8.7.2(3)

l_0 = max($l_{0,pi}$; $l_{0,pi,fi}$; $l_{0,ci}$; $l_{0,min}$) + Δl_0 = 1003 + 22 = 1025 mm

c_f = 30 mm

w/2 = 125 mm

l_v = l_0 + max(w/2; c_f) = 1025 + 125 = 1150 mm

the anchorage is taken from the line of between beam and support, EC2. The detailing could be considered in accordance with local standard and practice

<u>Embedment depth for post-installed rebars bottom:</u>

Concrete in compression, no force on bars → anchorage with minimum embedment length.

f_{min} = 1,0 mm (ETA-08/0105)

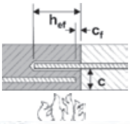
$l_{b,min}$ = f_{min}·max(10ϕ; 100mm) = 1.0·max(10·10; 100) = 100 mm

w/2 = 125 mm

l_v = $l_{b,min}$ + w/2 = 100 +125 = 225 mm

3.6 Load case fire

There are two types of design tables corresponding to the basic fire situations “parallel” and “anchorage”.
An additional fire condition analysis in accordance with Hong Kong requirements is provided for local analysis



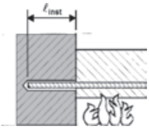
In the fire situation “**parallel**” the only parameter is the clear distance from the fire exposed concrete surface to the perimeter of the bar (“clear concrete cover c”). From this parameter, one can directly read the bond strength of the adhesive for specific fire durations.

Clear concrete cover c	Max. bond stress, τ_c [N/			
[mm]	F30	F60	F90	F120
10	0			
20	0,494	0		
30	0,665		0	0
40	0,897	0,481		
50	1,200	0,623		
60	1,630	0,806	0,513	
70	2,197	1,043	0,655	0,487
80	2,962	1,351	0,835	0,614
90	3,992	1,748	1,065	0,775
100	5,382	2,263	1,358	0,977
110	7,255	2,930	1,733	1,233
120	9,780	3,792	2,210	1,556
130		4,909	2,818	1,963
140	11,00	6,355	3,594	2,477
150		8,226	4,584	3,125

$$F_{fire} = f_{bd,fi} * \phi * \pi * h_{ef}$$

In fire design, it is not necessary to re-calculate influences like bond condition or alpha factors. It is sufficient to prove that the calculated splice or anchorage length is sufficient to transmit the load under fire with the given bond strength in case of fire $\tau_{Rd,fi}$.

Fire design table for situation “parallel”



In the fire situation “**anchorage**” the tables directly show the fire resistance as a force [kN] for given diameters, embedment depths and fire durations.

The tables mention a maximum steel force in fire. It is important to know that this value is derived for a specific assumed value of $f_{yk,fi}$ (see sect. 2.1.2) and will be different for other values of $f_{yk,fi}$. In the published tables (Hong Kong report) $f_{yk,fi}$=500N/mm^2 was normally assumed

Bar ∅ [mm]	Drill hole ∅ [mm]	Max. $F_{s,T}$ [kN]	ℓ_{inst} [mm]	F30 [kN]	F60 [kN]	F90 [kN]
8	12	16,2	80	2,18	0,73	0,24
			120	8,21	2,90	1,44
			170	16,2	9,95	5,99
			210		16,2	13,01
			230			16,2
			250			
			300			
10	14	25,3	100	5,87	1,95	0,84
			150	16,86	8,06	4,45
			190	25,3	16,83	11,86
			230		25,3	20,66
			260			25,3
			280			
			320			
			120	12,32	4,35	2,16
			180	28,15	17,56	11,59

$$R_{fire} = \phi \cdot \pi \cdot \sum_{i=1}^{n} \tau_{crit,\theta i} \cdot \ell_i$$

Intermediate values between those given in the fire design tables may be interpolated linearly. Extrapolating is not permitted.

Fire design table for situation “anchorage”

3.7 Corrosion behaviour

The Swiss Association for Protection against Corrosion (SGK) was given the assignment of evaluating the corrosion behaviour of fastenings post-installed in concrete using the Hilti HIT-HY 200, HIT-RE 500, HIT-RE 500V3 injection systems.

Corrosion tests were carried out. The behaviour of the two systems had to be evaluated in relation to their use in field practice and compared with the behaviour of cast-in reinforcement. The SGK can look back on extensive experience in this field, especially on expertise in the field of repair and maintenance work.
The result can be summarized as follows:

Hilti HIT-HY 200

- The Hilti HIT-HY 200 systems in combination with reinforcing bars can be considered resistant to corrosion when they are used in sound, alkaline concrete. The alkalinity of the adhesive mortar safeguards the initial passivation of the steel. Owing to the porosity of the adhesive mortar, an exchange takes place with the alkaline pore solution of the concrete.
- If rebars are bonded-in into chloride-free concrete using this system, in the event of later chloride exposure, the rates of corrosion are about half those of rebars that are cast-in.
- In concrete containing chlorides, the corrosion behaviour of the system corresponds to that of cast-in rebars. Consequently, the use of unprotected steel in concrete exposed to chlorides in the past or possibly in the future is not recommended because corrosion must be expected after only short exposure times.

Hilti HIT-RE 500

- If the Hilti HIT-RE 500 system is used in corrosive surroundings, a sufficiently thick coat of adhesive significantly increases the time before corrosion starts to attack the bonded-in steel.
- The HIT-RE 500 system may be described as resistant to corrosion, even in concrete that is carbonated and contains chlorides, if a coat thickness of at least 1 mm can be ensured. In this case, the unprotected steel in the concrete joint and in the new concrete is critical.
- If the coat thickness is not ensured, the HIT-RE 500 system may be used only in sound concrete. A rebar may then also be in contact with the wall of the drilled hole. At these points, the steel behaves as though it has a thin coating of epoxy resin.
- In none of the cases investigated did previously rusted steel (without chlorides) show signs of an attack by corrosion, even in concrete containing chlorides.
- Neither during this study an acceleration of corrosion was found at defective points in the adhesive nor was there any reference to this in literature. Even if a macro-element forms, the high resistance to it spreading inhibits a locally increased rate of corrosion.
- Information in reference data corresponds with the results of this study.

4 References

[1] EN 1992-1-1:2011 Part 1-1: General rules and rules for buildings (Eurocode 2); January 2011

[2] EOTA: Technical Report TR 023, Assessment of post- installed rebar connections, Edition Nov. 2006

[3] EOTA: Technical Report TR 029, Design of Anchors, Edition Sept. 2010

[4] EOTA: ETAG 001, part 5. bonded anchors. Brussels, 2008.

[5] Kunz, J., Muenger F.: Splitting and Bond Failure of Post-Installed Rebar Splices and Anchorings. Bond in Concrete. fib, Budapest, 20 to 22 November 2002

[6] Hamad, B.S., Al-Hammoud, R., Kunz, J.: Evaluation of Bond Strength of Bonded-In or Post-Installed Reinforcement. ACI Structural Journal, V. 103, No. 2, March – April 2006.

[7] Kupfer, H., Münger, F., Kunz, J., Jähring, A.: Nachträglich verankerte gerade Bewehrungsstäbe bei Rahmenknoten. Bauingenieur: Sonderdruck, Springer Verlag,

[8] HIT-Rebar – Design of bonded-in reinforcement using Hilti HIT-HY 150 or Hilti HIT-RE 500 for predominantly cyclic (fatigue) loading. Hilti Corporate Research, TWU-TPF-06a/02-d, Schaan 2002

[9] Randl, N: Expertise zu Sonderfällen der Bemessung nachträglich eingemörtelter Bewehrungsstäbe; Teile A, B, C. University of Applied Science of Carinthia. Spittal (Austria), 2011.

[10] CSTB: Document Technique d'Application 3/10-649 Relevant de l'Agrément Technique Europeen ATE 09/0295. Marne la Valée (France), June 2010.

[11] Eurocode 8: Auslegung von Bauwerken gegen Erdbeben – Teil 1: Grundlagen, Erdbebeneinwirkungen und Regeln für Hochbauten; Deutsche Fassung EN 1998-1:2004. April 2006

[12] Mahrenholtz, C., Eligehausen, R., Reinhardt, HW. (2015). "Design of post-installed reinforcing bars as end anchorage or as bonded anchow, "Engineering Structure, V.100, p.645-655.

[13] CEN/TS 1992-4-1:2009, Design of fastenings for use in concrete-Part 4-1

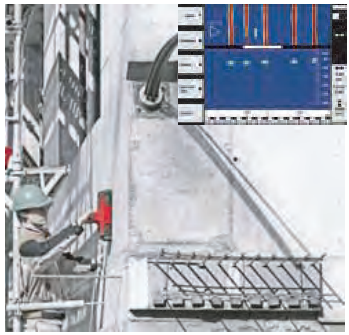
SCAN BEFORE DRILL

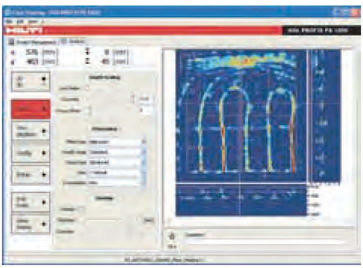
Hilti Dectection system


9
10
11
12
13
14
15
16
[mm]
HILTI
PS 1000
HILTI
PSA 14
[mm]

PS 1000 Radar Scanning
Gives you the real inside insight

Three different scanning modes for different scanning needs:





Advanced software with comprehensive analysis features

System Functions
Locating reinforcing bars
Locating pre-and post-tensioning tendons
Locating cavities
Locating plastic pipes and electric cables
Detecting objects in multiple layers
Estimating wall and slab thickness

PS 300 Ferroscan
Quick detection on rebar structures

Imagescan | **Quick scan** | **Quickscan Recording**

System Functions
Locating reinforcing bars
Measuring depth of concrete cover
Determining rebar diameter
Detecting objects in first layers

Ferroscan MAP combines
multiple scans
in a large-area view

5 Installation of Post-Installed Reinforcement

5.1 Joint to be roughened

The model of inclined compressive struts is used to transfer the shear forces through the construction joint at the interface between concrete cast at different times. Therefore a rough interface is required to provide sufficient cohesion in the construction joint {Clause 6.2.5(2), EC2: EN 1992-1-1:2004}.

5.2 Drilling

Injection anchor systems are used to fix reinforcement bars into concrete. Fast cure products are generally used with rebar diameters up to 25mm and moderate hole depths of up to about 1.5m, depending on the ambient temperature. Slow cure systems can be used with larger bar diameters and deep holes: The deepest rebar fixing to our knowledge so far was 12m. As rebar embedment lengths are usually much longer than with standard anchor applications, there are a number of additional system components helping to provide high quality of installation:

Drilling aid: Rebars are usually situated close to the concrete surface. If a long drill hole is not parallel to the surface, the inner lever arm of the structure will decrease along the hole if the deviation is away from the surface and even worse, the hole may penetrate the concrete surface or result in insufficient cover if the deviation is towards the surface. According to the rebar approvals, the deviations to be taken into account are 0.08 times the hole length (4.6°) for compressed air drilling, 0.0 6 times the hole length (3.4°) with hammer drilling and 0.02 times the hole length (1.1°) if a drilling aid is used (optical help or drilling rig, see fig. 9).

Figure 9: drilling aids

5.3 Hole cleaning

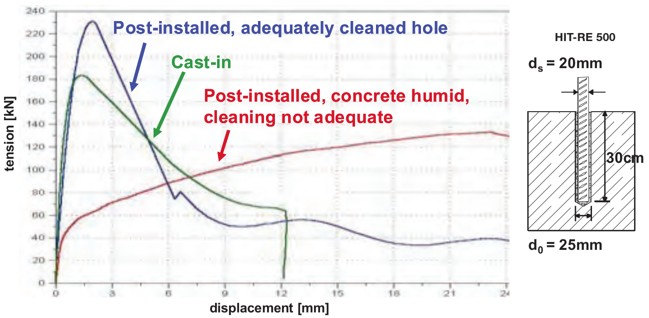
The holes should be blown out using compressed, oil free air. Extension tubes and air nozzles directing the air to the hole walls should be used, if holes are deeper than 250mm.

Deeper holes than 250mm should as well be brushed by machine brushing using steel brushes and brush extensions:

Screw the round steel brush HIT-RB to the end of the brush extension(s) HIT-RBS, 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.

The rebar approvals (ETA) give detailed information on the cleaning procedure for each product.

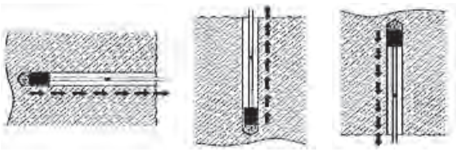
The following figure underlines the importance of adequate hole cleaning: For drilled holes cleaned according to the instruction, the post-installed bar (blue line) shows higher stiffness and higher resistance than the equivalent cast-in bar. With substandard cleaning (red line), however, stiffness and resistance are clearly below those of the cast-in bar.



5.4 Injection and bar installation

It is important that air bubbles are avoided during the injection of the adhesive: when the bar is installed later, the air will be compressed and may eject part of the adhesive from the hole when the pressure exceeds the resistance of the liquid adhesive, thus endangering the installer. Moreover, the presence of air may prevent proper curing of the adhesive.

In order to reach the bottom of the drilled holes, mixer extensions shall be used. The holes should be filled with HIT to about 2/3. Marking the extension tubes at 1/3 of the hole length from the tip will help to dispense the correct amount of adhesive. Piston plugs ensure filling of the holes without air bubbles.



After injecting the HIT, the rebars should be inserted into the hole with a slight rotating movement. When rebars are installed overhead, dripping cups OHC can be used to prevent excess HIT from falling downward in an uncontrolled manner.

5.5 Installation instruction

For correct installation and the linked products, please refer to the detailed “Hilti HIT Installation guide for fastenings in concrete”, Hilti Corp., Schaan W3362 1007 as well as to the product specific rebar approvals.

Setting instruction

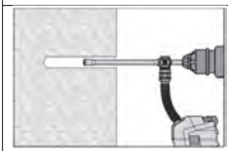
Review the Material Safety Data Sheet (MSDS) before use for proper and safe handling!
Wear well-fitting protective goggles and protective gloves when working with Hilti HIT-HY 200, HIT-RE 500 and HIT-RE 500 SD.
Important: Observe the installation instruction of the manufacturer provided with each foil pack.

1. Scan before drill

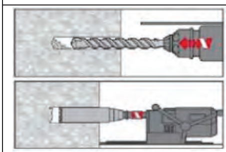
Clean up the scanning surface to avoid small stones on the surface affect the movement of the wheel or damage the scanner body. Scan the surface by using quick scan or imagescan. Analyze the image and mark the safe drilling spot

2. Drill hole

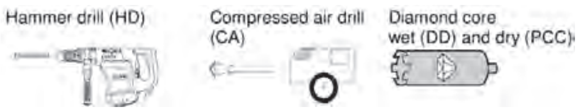
Note: Before drilling, remove carbonized concrete; clean contact areas (see Annex B1)
In case of aborted drill hole the drill hole shall be filled with mortar.



Drill hole to the required embedment depth with an appropriately sized Hilti TE-CD or TE-YD hollow drill bit with Hilti vacuum attachment.
This drilling system removes the dust and cleans the bore hole during drilling when used in accordance with the user’s manual.
After drilling is complete, proceed to the “injection preparation” step in the instructions for use.



Drill the hole to the required embedment depth using a hammer-drill with carbid drill bit set in rotation hammer mode, a compressed air drill or a diamond core machine.

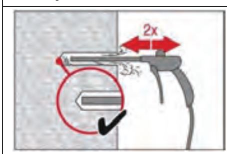


3. Bore hole cleaning

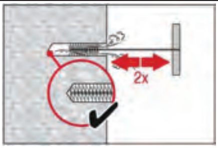
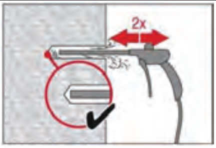
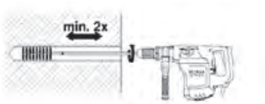
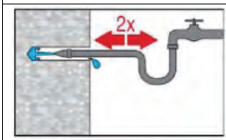
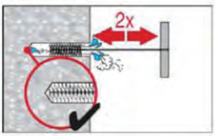
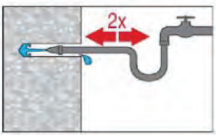
(Not needed with Hilti TE-CD and Hilti TE-YD drill bit)
The borehole must be free of dust, debris, water, ice, oil, grease and other contaminants prior to mortar injection.

Just before setting an anchor, the bore hole must be free of dust and debris by one of two cleaning methods described below

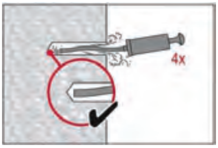
Compressed air cleaning (CAC)



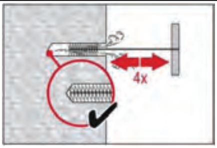
Blowing
2 times from the back of the hole with oil-free compressed air (min. 6 bar at 100 litres per minute (LPM)) until return air stream is free of noticeable dust. Bore hole diameter ≥ 32 mm the compressor must supply a minimum air flow of 140 m³/hour.
If required use additional accessories and extensions for air nozzle and brush to reach back of hole.

	Brushing 2 times with the specified brush HIT-RB size (brush Ø ≥ borehole Ø) by inserting the round steel brush to the back of the hole in a twisting motion. The brush shall produce natural resistance as it enters the anchor hole. If this is not the case, please use a new brush or a brush with a larger diameter.
	Blowing 2 times again with compressed air until return air stream is free of noticeable dust. If required use additional accessories and extensions for air nozzle and brush to reach back of hole.
	Deep boreholes – Blowing For boreholes deeper than 250mm (for Ø=8mm – 12mm) or deeper than 20 Ø (for Ø>12mm) use the appropriate air nozzle Hilti HIT-DL Safety tip: Do not inhale concrete dust. The application of the dust collector Hilti HIT-DRS is recommended.
	Deep boreholes – Brushing For boreholes deeper than 250 mm (for Ø=8mm – 12mm) or deeper than 20 Ø (for Ø>12mm) use machine brushing and brush extensions HIT-RBS. Screw the round steel brush HIT-RB in one end of the brush extension(s) HIT-RBS, 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. Safety tip: - Start machine brushing operational slowly. - Start brushing operation once brush is inserted in borehole.
  	In addition for wet diamond coring (DD), for HIT-RE 500 and HIT-RE 500SD only: For wet diamond coring please observe the following steps in addition **prior to** compressed air cleaning: Remove all core fragments from the anchor hole. Flush the anchor hole with clear running water until water runs clear. Brush the anchor hole again 2 times with the appropriate sized brush over the entire depth of the anchor hole. Repeat the flushing process until water runs out of the anchor hole.

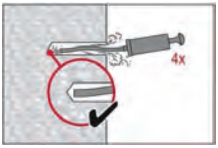
Manual Cleaning (MC) Manual cleaning is permitted for hammer drilled boreholes up to hole diameters $d_0 \leq$ 20mm and depths ℓ_v resp. $\ell_{e,ges.}$ ≤ 160mm.



Blowing
4 strokes with Hilti blow-out pump from the back of the hole until return air stream is free of noticeable dust.



Brushing
4 times with the specified brush HIT_RB size (brush Ø ≥ borehole Ø) by inserting the round steel wire brush to the back of the hole with a twisting motion. The brush shall produce natural resistance as it enters the anchor hole. If this is not the case, please use a new brush or a brush with a larger diameter.

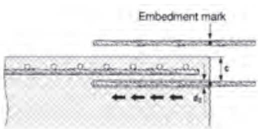


Blowing
4 strokes with Hilti blow-out pump from the back of the hole until return air stream is free of noticeable dust.

Manual Cleaning (MC)

Hilti hand pump recommended for blowing out bore hole with diameters d<20mm and bore hole depth h_0<160mm

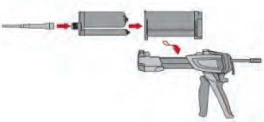
3.Rebar preparation and foil pack preparation



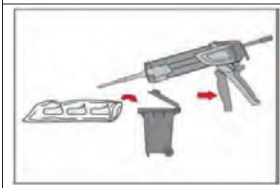
Before use, make sure the rebar is dry and free of oil or other residue.

Mark the embedment depth on the rebar. (e.g. with tapte) , ℓ_v

Insert rebar in borehole, to verify hole and setting depth ℓ_v resp. $\ell_{e,ges}$



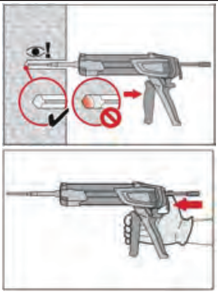
- Observe the Instruction for Use of the dispenser and the mortar.
- Tightly attach Hilti HIT-RE-M mixing nozzle to foil pack manifold.
- Insert foil pack into foil pack holder and swing holder into the dispenser.



Discard initial mortar. The foil pack opens automatically as dispensing is initiated. Depending on the size of the foil pack an initial amount of adhesive has to be discarded.
After changing a mixing nozzle, the first few trigger pulls must be discarded as decribed above. For each new foil pack a new mixing nozzle must be used.
Discard quantities for RE500 or RE500-SD are
3 strokes for 330 ml foil pack,
4 strokes for 500 ml foil pack,
65 ml for 1400 ml foil pack,
Discard quantities for HY200 are
2 strokes for 330 ml foil pack,
3 strokes for 500 ml foil pack,
4 strokes for 500 ml foil pack ≤ 5°C

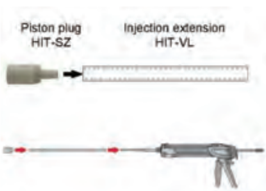
4.Inject mortar into borehole Forming air pockets be avoided

4.1 Injection method for borehole depth ≤ 250 mm

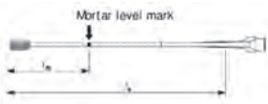


Inject the mortar from the back of the hole towards the front and slowly withdraw the mixing nozzle step by step after each trigger pull.
Fill holes approximately 2/3 full, or as required to ensure that the annular gap between the rebar and the concrete is completely filled with adhesive over the embedment length.
After injecting, depressurize the dispenser by pressing the release trigger. This will prevent further mortar discharge from the mixing nozzle.

4.2 Injection method for borehole depth > 250 mm or overhead application

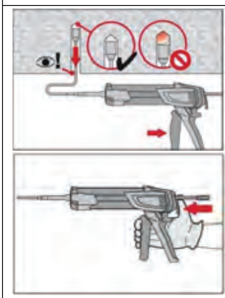


Assemble mixing nozzle HIT-RE-M, extension(s) and piston plug HIT-SZ.
For combinations of several injection extansions use coupler HIT-VL K. A substitution of the injection extansion for a plastic hose or a combination of both is permitted.
The combination of HIT-SZ piston plug with HIT-VL 16 pipe and then HIT-VL 16 tube support proper injection.



Mark the required mortar level ℓ_m and embedment depth ℓ_b resp.

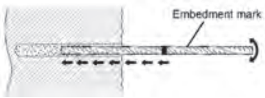
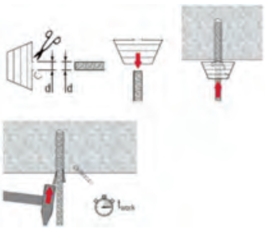
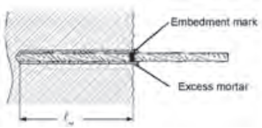
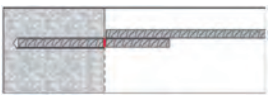
$\ell_{e,ges}$ with tape or marker on the injection extension.



Insert piston plug to back of the hole. Begin injection allowing the pressure of the injected adhesive mortar to push the piston plug towards the front of the hole.
Fill holes approximately 2/3 full, or as required to ensure that the annular gap between the rebar and the concrete is completely filled with adhesive over the embedment length.

Injection until the morat level mark ℓ_m becomes visible.

After injecting, depressurize the dispenser by pressing the release trigger. This will prevent further mortar discharge from the mixing nozzle.

5.Insert rebar	
	For easy installation insert the rebar slowly twisted into the boreholeuntil the embedment mark is at the concrete surface level.
	Overhead application: During insertion of the rebar, mortar might flow out of the borehole. For collection of the flowing mortar, HIT-OHC may be used. Support the rebar and secure it from falling till mortar started to harden, e.g. using wedges HIT-OHW.
	After installing the rebar the annular gap must be completely filled with mortar.
	After installing the rebar the annular gap must be completely filled with mortar. Proper installation can be verified when: Desired anchoring embedment is reached ℓ_v: embedment mark at concrete surface. Excess mortar flows out of the borehole after the rebar has been fully inserted until the embedment mark.
	Full load may be applied only after the curing time "t_{cure}" has elapsed.

5.6 Mortar consumption estimation for post installed rebars

Rebar Ø d_s [mm]	10	12	16	20	25	32	40
Drill bit Ø d_0 [mm]	14	16	20	25	32	40	55
Hole depth [mm]							
100	10.3	13.4	20.9	32.7	53.6	83.8	158.4
120	12.3	16.1	25.1	39.3	64.3	100.5	190.1
140	14.4	18.8	29.3	45.8	75.1	117.3	221.7
160	16.4	21.4	33.5	52.4	85.8	134.0	253.4
180	18.5	24.1	37.7	58.9	96.5	150.8	285.1
200	20.5	26.8	41.9	65.5	107.2	167.6	316.8
220	22.6	29.5	46.1	72.0	118.0	184.3	348.5
240	24.6	32.2	50.3	78.5	128.7	201.1	380.1
260	26.7	34.9	54.5	85.1	139.4	217.8	411.8
280	28.7	37.5	58.6	91.6	150.1	234.6	443.5
300	30.8	40.2	62.8	98.2	160.8	251.3	475.2
320	32.8	42.9	67.0	104.7	171.6	268.1	506.8
340	34.9	45.6	71.2	111.3	182.3	284.8	538.5
360	36.9	48.3	75.4	117.8	193.0	301.6	570.2
380	39.0	50.9	79.6	124.4	203.7	318.3	601.9
400	41.1	53.6	83.8	130.9	214.5	335.1	633.6
450	46.2	60.3	94.2	147.3	241.3	377.0	712.8
500	51.3	67.0	104.7	163.6	268.1	418.9	791.9
550	56.4	73.7	115.2	180.0	294.9	460.8	871.1
600	61.6	80.4	125.7	196.4	321.7	502.7	950.3
650	66.7	87.1	136.1	212.7	348.5	544.5	1029.5
700	71.8	93.8	146.6	229.1	375.3	586.4	1108.7
750	77.0	100.5	157.1	245.4	402.1	628.3	1187.9
800	82.1	107.2	167.6	261.8	428.9	670.2	1267.1
850	87.2	113.9	178.0	278.2	455.7	712.1	1346.3
900	92.4	120.6	188.5	294.5	482.5	754.0	1425.5
950	97.5	127.3	199.0	310.9	509.4	795.9	1504.7
1000	102.6	134.0	209.4	327.3	536.2	837.8	1583.9
1200	123.2	160.8	251.3	392.7	643.4	1005.3	1900.7
1400	143.7	187.7	293.2	458.2	750.6	1172.9	2217.4
1600	164.2	214.5	335.1	523.6	857.9	1340.4	2534.2
1800	184.7	241.3	377.0	589.1	965.1	1508.0	2851.0
2000	205.3	268.1	418.9	654.5	1072.3	1675.5	3167.8
2500	256.6	335.1	523.6	818.1	1340.4	2094.4	3959.7
3000	307.9	402.1	628.3	981.8	1608.5	2513.3	4751.7
3200	328.4	428.9	670.2	1047.2	1715.7	2680.8	5068.4

1. In the above table please find the quantity of mortar required for one fastening point, in ml. In this estimation, we consider 80% of the mortar is used for fastening, the rest being used for the first pull outs and waste.
2. The greyed area should not be used since it is not in accordance with the design codes requiring a depth of at least 10 drilling diameters.

IMPROVE WORKMANSHIP BY SAFESET SYSTEM

Now you can design post-installed rebar connections with more confidence. Inadequately cleaning holes during installation can reduce the performance of conventional chemical anchor systems significantly. Hilti SAFESET technology eliminates this factor almost entirely - in both cracked or uncracked concrete.

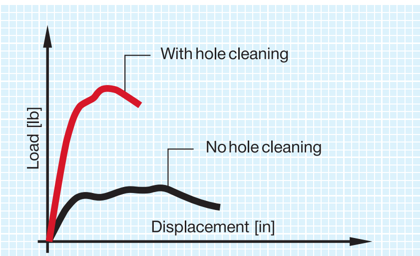
Cleaning while drilling.

Hollow drill bits + HIT-HY 200-R / HIT-RE 500 / HIT-RE 500-V3

Hilti TE-CD and TE-YD hollow drill bits, in conjunction with HIT-HY 200-R, HIT-RE 500 or HIT-RE 500-V3, make subsequent hole cleaning completely unnecessary. Dust is removed by the Hilti vacuum system while drilling is in progress for faster drilling and a virtually dustless working environment.

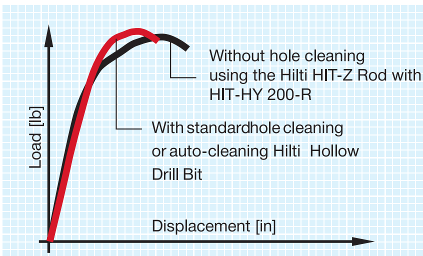
Hilti SAFEset Technology
Up to 60% faster!

Potential effects of no hole cleaning



The loading performance of a threaded rod or rebar with conventional injection adhesive may be very low if the hole is inadequately cleaned after drilling. The Hilti SAFESET system eliminates a cleaning step while still providing excellent load values.

Hilti adhesive with SAFESET Technology



The new SAFESET system featuring HIT-HY 200-R allows a fastening point to take high loads, as if the hole were cleaned using standard hole cleaning methods.

HIT-HY 200-R

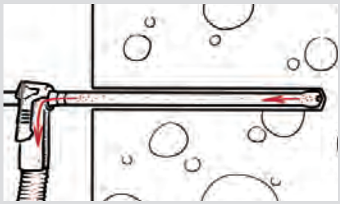
HIT-RE 100

HIT-RE 500

HIT-RE 500-V3

Technical data

Rebar diameter range	Y8 to Y25
Threaded rod diameters	M10 to M30
Embedment depth	Up to 1000mm
Concrete compressive strengths	C20/25 to C50/60
Installation temperature range	-10 °C to 40 °C



Hollow Drill Bit
TE-CD / TE-YD

6. How do I decide which system to use?

Options for the installation of post-installed reinforcing bars include cementitious grouts, polymer adhesives, and hybrid systems that combine cementitious components with polymers. The use of cementitious (e.g., baseplate) grouts is typically limited to down-hole applications and is not discussed further in this Guide. Adhesives (sometimes referred to as thixotropic adhesives) that have the correct viscosity to provide a void-free bond layer in the annular space between the bar and the concrete while still resisting unrestricted flow have been developed specifically for anchoring and bar embedment. These systems permit installation at all orientations with superior bond strength under a variety of use conditions. The proper selection of the system is dependent on a number of job-specific parameters.

6.1 System selection considerations

Jobsite constraints impact both design values (bond strength) as well as installation effectiveness. Typical parameters for Hilti adhesive systems are shown in Table 2.

Table 2 – Typical parameters for HIT-HY 200-R and HIT-RE 500 V3

Jobsite constraints	HIT-HY 200-R[1]	HIT-RE 500 V3
Typical reinforcing bar diameter range	8mm-32mm	8mm-40mm[(2)]
Embedment range	Up to 2m[(3),(5)]	Up to 3,2m[(3),(5)]
Temperature of base material (installation)	-10°C to 40°C	-5°C to 40°C
Working time[3]	6 min. to 3 hrs.	10 min. to 2 hrs.
Cure time[3]	1 hrs. to 20 hrs.	4 hrs. to 168 hrs.
Holes drilled in dry and water-saturated concrete	Yes	Yes
Water-filled holes and underwater applications	No	Yes
Hammer-drilled holes	Yes	Yes
Core drilled holes	No	Yes
Hilti SafeSet™ technology using Hilti roughening tool	No	Yes
Hilti SafeSet™ technology using Hilti HDB and VC vacuum	Yes	Yes[4]

[1] HIT-HY 200-A (accelerated cure) available. Not suitable for larger bar diameters due to short gel time.
[2] For larger bar sizes contact Hilti.
[3] Temperature dependent.
[4] Contact Hilti.
[5] Dispenser dependent.

System selection is therefore dependent on the combination of design requirements and jobsite constraints. Note also that each system is offered with a variety of options for injection in terms of cartridge size and injection equipment (manual vs. battery or pneumatic drive). Additionally, Hilti offers specialized drilling systems that substantially reduce hole cleaning requirements.

An aspect of system selection that is sometimes overlooked is the absolute volume of adhesive that must be placed in the hole. Large diameter and very deep holes may require a greater volume of adhesive than can be reasonably placed even with pneumatic delivery equipment. Furthermore, injection of large quantities of adhesive can result in excessive heat generation due to the exothermic nature of polymerization. These issues should be carefully considered for cases outside of the normal range of post-installed reinforcing bar applications.

NOTE: Hilti technical staff can provide assistance with unique or non-standard applications.

Hilti HIT-HY 200 post-installed rebars

Injection mortar system		Benefits
	Hilti HIT-HY 200-R 500 ml foil pack (also available as 330 ml foil pack)	- **SAFEset** technology: drilling and borehole cleaning in one step with Hilti hollow drill bit - HY 200-R version is formulated for best handling and cure time specifically for rebar applications - Suitable for concrete C 12/15 to C 50/60 - Suitable for dry and water saturated concrete - For rebar diameters up to 32 mm - Non corrosive to rebar elements - Good load capacity at elevated temperatures - Suitable for embedment length up to 1000 mm - Suitable for applications down to -10 °C
	Static mixer	
	Rebar (Ø8-Ø32)	

Concrete	Fire resistance (HK)	European Technical Approval	Corrosion tested	Seismic	PROFIS Rebar design software	Hilti SAFEset technology with hollow drill bit	Drinking water appoved

Service temperature range

Temperature range: -40°C to +80°C (max. long term t emperature +50°C, max. short term temperature +80°C) .

Approvals / certificates

Description	Authority / Laboratory	No. / date of issue
European Technical Assessment HIT-HY 200-R for seismic post-installed rebar	DIBt, Berlin	ETA-12/0083 (HIT-HY 200-R)
Fire test report	CSTB, Paris	26033756

a) All data given in this section according ETA-12/0083, issued 2013-06-05 and ETA-11/0492, issued 2014-05-13.

Materials

Reinforcement bars according to EC2 Annex C Table C.1 and C.2N.

Properties of reinforcement

Product form		**Bars and de-coiled rods**	
Class		B	C
Characteristic yield strength f_{yk} or $f_{0,2k}$ (MPa)		400 to 600	
Minimum value of $k = (f_t/f_y)_k$		≥ 1,08	≥ 1,15 < 1,35
Characteristic strain at maximum force, ε_{uk} (%)		≥ 5,0	≥ 7,5
Bendability		Bend / Rebend test	
Maximum deviation from nominal mass (individual bar) (%)	Nominal bar size (mm) ≤ 8 > 8	± 6,0 ± 4,5	
Bond: Minimum relative rib area, $f_{R,min}$	Nominal bar size (mm) 8 to 12 > 12	0,040 0,056	

Setting details

For detailed information on installation see instruction for use given with the package of the product.

Table B3: Working time t_{work} and minimum curing time t_{cure}

Temperature in the anchorage base [°C]	Maximum working time t_{work} [1)]	Minimum curing time t_{cure}
-10 to -5	3 hour	20 hour
-4 to +0	2 hour	8 hour
+1 to +5	1 hour	4 hour
+6 to +10	40 min	2,5 hour
+11 to +20	15 min	1,5 hour
+21 to +30	9 min	1 hour
+31 to +40	6 min	1 hour

Resistance to chemical substances

Chemical	Resistance		Chemical	Resistance
Air	+		Gasoline	+
Acetic acid 10%	+		Glycole	o
Acetone	o		Hydrogen peroxide 10%	o
Ammonia 5%	+		Lactic acid 10%	+
Benzyl alcohol	-		Maschinery oil	+
Chloric acid 10%	o		Methylethylketon	o
Chlorinated lime 10%	+		Nitric acid 10%	o
Citric acid 10%	+		Phosphoric acid 10%	+
Concrete plasticizer	+		Potassium Hydroxide pH 13,2	+
De-icing salt (Calcium chloride)	+		Sea water	+
Demineralized water	+		Sewage sludge	+
Diesel fuel	+		Sodium carbonate 10%	+
Drilling dust suspension pH 13,2	+		Sodium hypochlorite 2%	+
Ethanol 96%	-		Sulfuric acid 10%	+
Ethylacetate	-		Sulfuric acid 30%	+
Formic acid 10%	+		Toluene	o
Formwork oil	+		Xylene	o

+ resistant
o resistant in short term (max. 48h) contact
- not resistant

Electrical Conductivity

HIT-HY 200 in the hardened state **is not conductive electrically**. Its electric resistivity is $15{,}5 \cdot 10^{9}\ \Omega \cdot cm$ (DIN IEC 93 – 12.93). It is adapted well to realize electrically insulating anchorings (ex: railway applications, subway).

Drilling diameters

Rebar (mm)	Drill bit diameters d_0 [mm]	
	Hammer drill (HD)	Compressed air drill (CA)
8	12 (10 [a)])	-
10	14 (12 [a)])	-
12	16 (14 [a)])	17
16	20	20
20	25	26
25	32	32
32	40	40

a) Max. installation length l = 250 mm.

Basic design data for rebar design according to ETA-12/0083

Bond strength

Bond strength in N/mm² according to ETA for good bond conditions

Rebar (mm)	Concrete class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
8 - 32	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,3

Pullout design bond strength for HIT Rebar design

Design bond strength in N/mm² according to ETA 12/0084

Hammer, compressed air drilling Dry or water saturated hole. Concrete strength C20/25.									
temperature range	**Bar diameter**								
	8	10	12	14	16	20	25	28	32
I: 40ºC/24ºC	8,0								
II: 58ºC/35ºC	6,7								
III: 70ºC/43ºC	5,7								

Maximum anchorage length

Please refer to EC2 clause 8.4.4 for anchorage length design

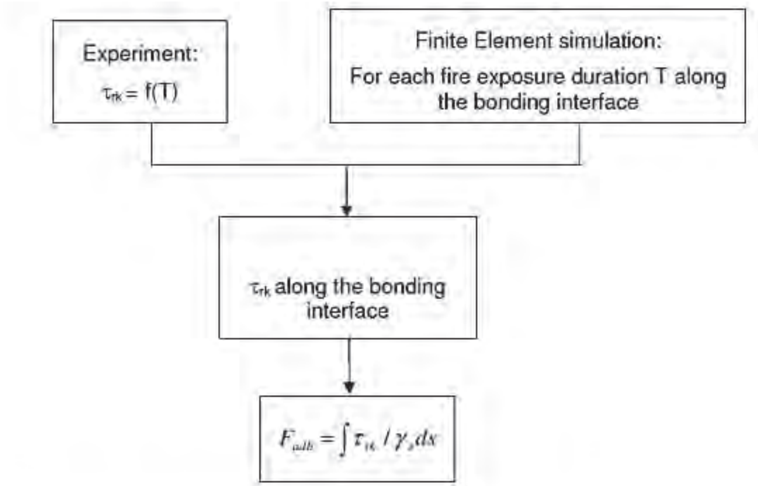
Rebar		Concrete temp. ≥ -10°C	Concrete temp. ≥ 0°C
Diameter d_s [mm]	$f_{y,k}$ [N/mm²]	l_{max} [mm]	l_{max} [mm]
8	500	700	1000
10	500	700	1000
12	500	700	1000
14	500	700	1000
16	500	700	1000
18	500	700	1000
20	500	700	1000
22	500	700	1000
24	500	700	1000
25	500	700	1000
26	500	700	1000
28	500	700	1000
30	500	700	1000
32	500	700	1000

HY200 Fire Assessment

When the Hilti injection resin system for the post-installed rebar concrete-to-concrete connection application subjected to fire exposure, the system performance would undergo certain degree of reduction due to the effect of elevated temperature. An evaluation of the performance behavior under fire condition (in accordance with Code of Practice for Fire Safety in Buildings 2011 or other related standards) of injection resin used in post-installed concrete connection with rebar (Size Ø8 to 32 mm type 2 deformed bar for HY-200) is studied using Finite Element simulation method for supporting engineering design.

The maximum loads applicable through a rebar in concrete connection with Hilti injection resin as a function of both fire duration and anchorage length need to be assessed for the slab to slab connections, wall to slab connections, beam to beam connections and wall to beam connections.

The evaluation of the above characteristics need three steps procedure:



Where:

τ_{rk} is the characteristic bonding stress

T is the temperature

F_{adh} is the maximum load applicable to the rebar.

γ_S is the appropriate safety factor.

Figure 1 Evaluation Procedure

Step 1: Hilti resin with rebar subject to fire exposure experiments in different anchorage depth and fire rating and development the relationship for the bonding strength and the temperature.

Step 2: Consists in the finite element modeling of the temperature profiles at the bonding interface of the four considered connection types.

Step 3: Determination of the bonding stress along the bonding interface using step 1 and 2. The maximum load applicable through a rebar anchored with Hilti resin is then calculated by integrating this bonding stress over the interface area.

Step 1 experiments were carried out by the European laboratories and the related data are provided by Hilti for step **2** and step **3** for analysis. The bonding relations between the temperature and the critical bond stress are given as below:

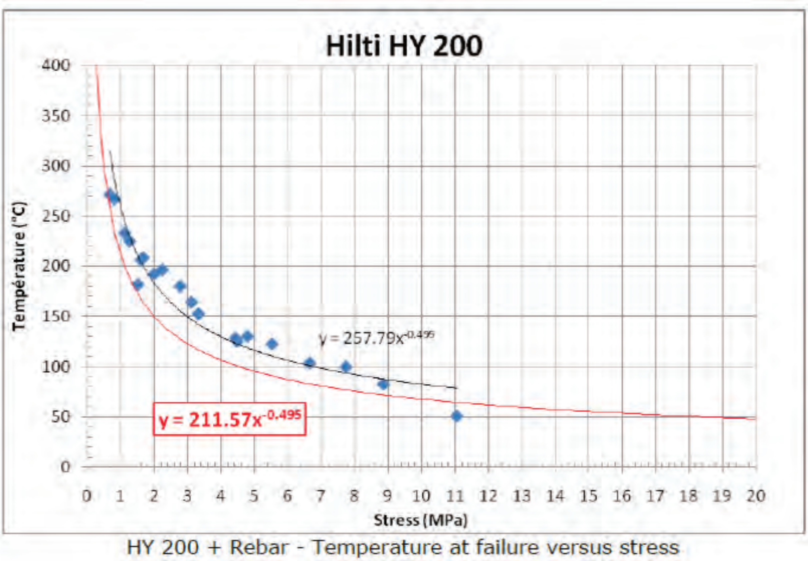


Figure 10 HILTI HIT-HY 200-A&R Characteristic bonding stress-temperature relationship
(blue points are experimental results; red points are the corresponding characteristic values)

More details about the experimental program can be found in the test report as "No EEM 11 26033756 on Fire Testing of Post installed rebar, threaded rod and HIT-Z connections with HY200 injection mortar".

In this report, the following four types of connections (see **Figure 1** to **Figure 14**) are studied, and the related design tables are given for practical engineering usages.

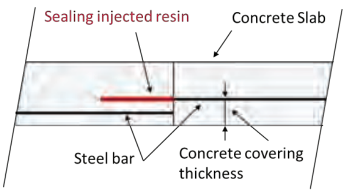


Figure 11 Slab to slab connection

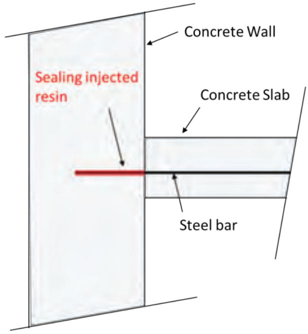


Figure 12 Wall to slab connection

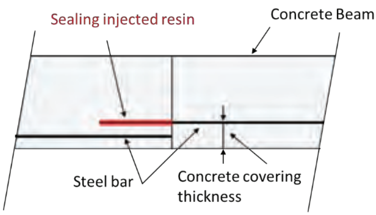


Figure 13 Beam to beam connection

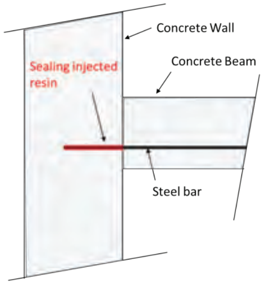
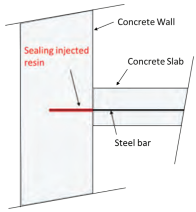


Figure 14 Wall to beam connection

Wall to slab connection



The maximum force in the rebar (resin adhesion strength) is given by:

$$F_{adh} = \int_{0}^{L_s} \frac{1}{\gamma_g} \pi * \emptyset * \tau_{rk}(x) dx$$

Where

- F_{adh} is the maximum force in the rebar;
- $\emptyset$ is the rebar diameter;
- $\tau_{rk}(x)$ is the characteristic bonding stress at a depth of x;
- L_s is the anchorage length;
- γ_g is the global safety factor, $\gamma_g = 1.43$;

			Maximum Force in the Rebar (kN)			
			R60	R120	R180	R240
Rebar Diameter (mm)	Rebar Maximum Load (kN)	Anchorage Depth (mm)	Cover = 25mm	Cover = 35mm	Cover = 45mm	Cover = 60mm
10	39.27	100	5.55	1.39	0.83	0.66
		120	12.28	2.64	1.37	1.01
		140	19.58	5.03	2.30	1.56
		160	26.87	9.60	3.88	2.42
		180	34.16	16.82	6.58	3.79
		200	39.27	24.11	11.15	5.97
		220		31.40	18.10	9.42
		240		38.70	25.39	14.82
		260		39.27	32.69	22.12
		280			39.27	29.41
		300				36.71
		320				39.27
12	56.55	120	14.74	3.16	1.65	1.22
		140	23.49	6.04	2.76	1.87
		160	32.24	11.52	4.65	2.91
		180	41.00	20.20	7.91	4.55
		200	49.75	28.95	13.42	7.16
		220	56.55	37.70	21.79	11.31
		240		46.45	30.55	17.79
		260		55.21	39.30	26.54
		280		56.55	48.05	35.29
		300			56.55	44.05
		320				52.80
		340				56.55
16	100.53	160	42.99	15.36	6.21	3.88
		180	54.66	26.93	10.54	6.06
		200	66.33	38.60	17.89	9.55
		220	78.00	50.27	29.06	15.10
		240	89.67	61.94	40.73	23.79
		260	100.53	73.61	52.40	35.46
		280		85.28	64.07	47.13
		300		96.95	75.74	58.80
		320		100.53	87.41	70.47
		340			99.08	82.14
		360			100.53	93.81
		380				100.53

			Maximum Force in the Rebar (kN)			
			R60	R120	R180	R240
Rebar Diameter (mm)	Rebar Maximum Load (kN)	Anchorage Depth (mm)	Cover = 25mm	Cover = 35mm	Cover = 45mm	Cover = 60mm
20	157.08	200	82.91	48.22	22.37	11.94
		220	97.50	62.81	36.33	18.87
		240	112.09	77.40	50.92	29.75
		260	126.68	91.99	65.50	44.34
		280	141.26	106.57	80.09	58.92
		300	155.85	121.16	94.68	73.51
		320	157.08	135.75	109.27	88.10
		340		150.34	123.85	102.69
		360		157.08	138.44	117.27
		380			153.03	131.86
		400			157.08	146.45
		420				157.08
25	245.44	250	149.23	105.82	72.76	46.30
		270	167.46	124.06	91.00	64.54
		290	185.70	142.29	109.23	82.77
		310	203.93	160.53	127.47	101.01
		330	222.17	178.76	145.70	119.24
		350	240.40	197.00	163.93	137.48
		370	245.44	215.23	182.17	155.71
		390		233.46	200.40	173.94
		410		245.44	218.64	192.18
		430			236.87	210.41
		450			245.44	228.65
		470				245.44
32	402.12	320	272.70	219.65	174.83	140.96
		340	296.04	242.99	198.17	164.30
		360	319.38	266.33	221.51	187.64
		380	342.72	289.67	244.85	210.98
		400	366.06	313.01	268.19	234.32
		420	389.40	336.35	291.53	257.66
		440	402.12	359.69	314.87	281.00
		460		383.03	338.21	304.34
		480		402.12	361.55	327.68
		500			384.89	351.02
		520			402.12	374.36
		540				397.70
		560				402.12

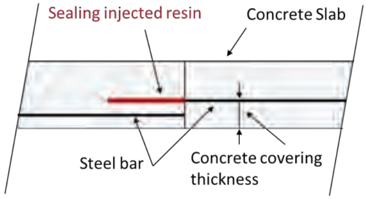
Slab to slab connection

The experimental temperature – bonding stress relationship is given by:

$$\tau = \left(\frac{\theta}{211.57}\right)^{-2.02}$$

Where:

- θ is the temperature in °C
- τ is the bonding stress in MPa



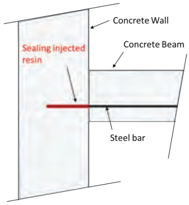
Maximum Bonding Stress for a Slab to Slab Connection

	Bonding Stress (MPa)					
Concrete Depth (mm)	**R30**	**R60**	**R90**	**R120**	**R180**	**R240**
10	0.13					
20	0.23	0.11				
30	0.42	0.16	0.10			
40	0.80	0.23	0.14	0.11		
50	1.57	0.35	0.19	0.14		
60	3.17	0.55	0.27	0.18	0.11	
70	6.40	0.87	0.38	0.24	0.14	0.10
80	12.57	1.42	0.55	0.32	0.18	0.12
90		2.33	0.80	0.44	0.22	0.15
100		3.86	1.19	0.61	0.28	0.18
110		6.39	1.78	0.85	0.36	0.23
120		10.44	2.69	1.19	0.47	0.28
130			4.08	1.69	0.62	0.35
140			6.17	2.42	0.81	0.43
150			9.26	3.47	1.07	0.55
160			13.68	4.98	1.43	0.69
170				7.12	1.91	0.88
180				10.10	2.56	1.13
190	16.60			14.15	3.45	1.44
200					4.64	1.86
210		16.60			6.23	2.40
220					8.32	3.10
230			16.60		11.05	4.02
240					14.54	5.20
250				16.60		6.70
260						8.62
270					16.60	11.03
280						14.00
290						16.60
300 or above						

*Global safety factor (1.43) need to be apply to the bond stress

Wall to beam connection

The maximum force in the rebar (resin adhesion strength) is given by:



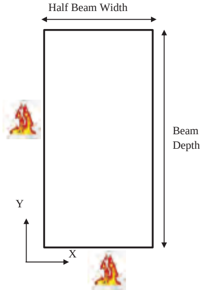
$$F_{adh} = \int_{0}^{L_s} \frac{1}{\gamma_g} \pi * \emptyset * \tau_{rk}(x) dx$$

Where

- F_{adh} is the maximum force in the rebar;
- $\emptyset$ is the rebar diameter;
- $\tau_{rk}(x)$ is the characteristic bonding stress at a depth of x;
- L_s is the anchorage length;
- γ_g is the global safety factor, $\gamma_g = 1.43$;

		Rebar Anchorage Depth (mm)				
Rebar Diameter (mm)	Rebar Maximum Load (kN)	Cover (mm)	R60 (Beam Width = 300mm)	R120 (Beam Width = 300mm)	R180 (Beam Width = 400mm)	R240 (Beam Width = 400mm)
10	39.27	30	204			
		35	202			
		40	199	253		
		45	197	252		
		50	194	250		
		55	191	248		
		60	187	246	289	323
12	56.55	30	225			
		35	223			
		40	221	275		
		45	218	273		
		50	216	272		
		55	212	270		
		60	209	268	310	345
16	100.53	30	268			
		35	266			
		40	264	318		
		45	262	317		
		50	259	315		
		55	255	313		
		60	252	311	353	387
20	100.53	30	313			
		35	310			
		40	308	362		
		45	305	361		
		50	303	359		
		55	300	357		
		60	296	355	397	432
25	245.44	30	366			
		35	364			
		40	361	416		
		45	359	414		
		50	356	413		
		55	353	411		
		60	349	409	452	486
32	402.12	30	442			
		35	440			
		40	437	493		
		45	435	491		
		50	432	489		
		55	429	488		
		60	425	485	528	563

Beam to beam connection



The experimental temperature – bonding stress relationship is given by:

$$\tau = \left(\frac{\theta}{211.57}\right)^{-2.02}$$

Where:

- θ is the temperature in °C
- τ is the bonding stress in MPa

Beam Width = 300mm, Fire Duration = 120 min								
Bond Stress (MPa)		**X-Dir (mm)**						
		40	**50**	**70**	**90**	**110**	**130**	**150**
Y-Dir (mm)	300	0.10	0.13	0.22	0.38	0.62	0.89	1.02
	250	0.10	0.13	0.22	0.37	0.60	0.86	0.98
	200	0.10	0.13	0.21	0.35	0.54	0.75	0.84
	150		0.12	0.18	0.27	0.40	0.51	0.56
	100			0.13	0.17	0.22	0.25	0.27
	50					0.10	0.10	0.10

Beam Width = 400mm, Fire Duration = 240 min								
Bond Stress (MPa)		**X-Dir (mm)**						
		80	**100**	**120**	**140**	**160**	**180**	**200**
Y-Dir (mm)	400	0.12	0.16	0.23	0.31	0.40	0.48	0.51
	350	0.12	0.16	0.23	0.31	0.40	0.47	0.50
	300	0.11	0.16	0.22	0.29	0.37	0.44	0.46
	250	0.11	0.15	0.20	0.26	0.32	0.37	0.39
	200	0.10	0.13	0.17	0.21	0.25	0.28	0.29
	150		0.10	0.12	0.15	0.17	0.18	0.19
	100					0.10	0.11	0.11

*Global safety factor (1.43) need to be apply to the bond stress

Hilti HIT-RE 500 post-installed rebars

Injection mortar system		Benefits
	Hilti HIT-RE 500 550 ml foil pack	- suitable for concrete C 12/15 to C 50/60 - high loading capacity - suitable for dry and water saturated concrete - under water application - large diameter applications - high corrosion resistant - long working time at elevated temperatures - odourless epoxy
	Static mixer	
	Rebar (Ø8-Ø40)	

Concrete

Diamond drilled holes

European Technical Approval

Hilti
Z-21.8-1790

DIBt approval

NSF

Drinking water appoved

SGK

Corossion tested

PROFIS Rebar design software

SAFEset

Hilti SAFEset technology with hollow drill bit

Service temperature range

Temperature range: -40°C to +80°C (max. long term temperature +50°C, max. short term temperature +80°C).

Approvals / certificates

Description	Authority / Laboratory	No. of issue
European technical approval	DIBt, Berlin	ETA-0810105
European technical approval	DIBt, Berlin	ETA-0410027
DIBt approval	DIBt, Berlin	2-21.8-1790
Fire test report	IBMB Braunschweig	335710550-5
Assessment report (fire)	Warringtonfire	WF327804/B

Materials

Reinforcmenent bars according to EC2 Annex C Table C.1 and C.2N.

Properties of reinforcement

Product form		Bars and de-coiled rods	
Class		B	C
Characteristic yield strength f_{yk} or $f_{0,2k}$ (MPa)		400 to 600	
Minimum value of k = $(f_t/f_y)_k$		≥ 1,08	≥ 1,15 < 1,35
Characteristic strain at maximum force, ε_{uk} (%)		≥ 5,0	≥ 7,5
Bendability		Bend / Rebend test	
Maximum deviation from nominal mass (individual bar) (%)	Nominal bar size (mm) ≤ 8 > 8	 ± 6,0 ± 4,5	
Bond: Minimum relative rib area, $f_{R,min}$	Nominal bar size (mm) 8 to 12 > 12	 0,040 0,056	

Setting details

For detailed information on installation see instruction for use given with the package of the product.

Curing time for general conditions

Data according to ETA-08/0105, issue 30 April 2014			
Temperature in the anchorage base [°C]	Maximum working time t_{work} 1)	Initial curing time $t_{cure,\ ini}$ 2)	Minimum curing time t_{cure}
+5 to +9	120 min	18 hour	72 hour
+10 to +14	90 min	12 hour	48 hour
+15 to +19	30 min	8 hour	24 hour
+20 to +24	25 min	6 hour	12 hour
+25 to +29	20 min	5 hour	10 hour
+30 to +39	12 min	4 hour	8 hour
+40	12 min	2 hour	4 hour

1) The temperature of the foil pack must be between +5 °C and +40 °C during use.
2) After $t_{cure,\ ini}$ has elapsed preparation work may continue please change highlighted to same format as the table.

For dry concrete curing times may be reduced according to the following table. For installation temperatures below +5 °C all load values have to be reduced according to the load reduction factors given below.

Curing time for dry concrete

Additional Hilti technical data				
Temperature of the base material	Working time in which rebar can be inserted and adjusted t_{gel}	Initial curing time $t_{cure,ini}$	Reduced curing time before rebar can be fully loaded t_{cure}	Load reduction factor
T_{BM} = -5 °C	4 h	36 h	72 h	0,6
T_{BM} = 0 °C	3 h	25 h	50 h	0,7
T_{BM} = 5 °C	2 ½ h	18 h	36 h	1
T_{BM} = 10 °C	2 h	12 h	24 h	1
T_{BM} = 15 °C	1 ½ h	9 h	18 h	1
T_{BM} = 20 °C	30 min	6 h	12 h	1
T_{BM} = 30 °C	20 min	4 h	8 h	1
T_{BM} = 40 °C	12 min	2 h	4 h	1

Fitness for use

Some creep tests have been conducted in accordance with ETAG guideline 001 part 5 and TR 023 in the following conditions : in dry environnement at 50 ℃ during 90 days.
These tests show an excellent behaviour of the post-installed connection made with HIT-RE 500: low displacements with long term stability, failure load after exposure above reference load.

Resistance to chemical substances

Categories	Chemical substances	resistant	Non resistant
Alkaline products	Drilling dust slurry pH = 12,6	+	
	Potassium hydroxide solution (10%) pH = 14	+	
Acids	Acetic acid (10%)		+
	Nitric acid (10%)		+
	Hydrochloric acid (10%)		+
	Sulfuric acid (10%)		+
Solvents	Benzyl alcohol		+
	Ethanol		+
	Ethyl acetate		+
	Methyl ethyl keton (MEK)		+
	Trichlor ethylene		+
	Xylol (mixture)	+	
Products from job site	Concrete plasticizer	+	
	Diesel	+	
	Engine oil	+	
	Petrol	+	
	Oil for form work	+	
Environnement	Salt water	+	
	De-mineralised water	+	
	Sulphurous atmosphere (80 cycles)	+	

Electrical Conductivity

HIT-RE 500 in the hardened state **does not conduct electrically**. Its electric resistivity is $66 \cdot 10^{12}\ \Omega.m$ (DIN IEC 93 – 12.93). It is adapted well to realize electrically insulating anchorings (ex: railway applications, subway).

Drilling diameters

Rebar (mm)	Drill bit diameters d_0 [mm]			
	Hammer drill (HD)	Compressed air drill (CA)	Diamond coring	
			Wet (DD)	Dry (PCC)
8	12 (10 [a)])	-	12 (10 [a)])	-
10	14 (12 [a)])	-	14 (12 [a)])	-
12	16 (14 [a)])	17	16 (14 [a)])	-
16	20	20	20	-
20	25	26	25	-
25	32	32	32	35
32	40	40	40	47
40	55	57	52	52

a) Max. installation length l = 250 mm.

Basic design data for rebar design according to rebar ETA

Bond strength in N/mm² according to ETA 08/0105 for good bond conditions for hammer drilling, compressed air drilling, dry diamond core drilling

Rebar (mm)	Concrete class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
8 - 32	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,3
34	1,6	2,0	2,3	2,6	2,9	3,3	3,6	3,9	4,2
36	1,5	1,9	2,2	2,6	2,9	3,3	3,6	3,8	4,1
40	1,5	1,8	2,1	2,5	2,8	3,1	3,4	3,7	4,0

Bond strength in N/mm² according to ETA 08/0105 for good bond conditions for wet diamond core drilling

Rebar (mm)	Concrete class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
8 - 25	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,3
26 - 32	1,6	2,0	2,3	2,7	2,7	2,7	2,7	2,7	2,7
34	1,6	2,0	2,3	2,6	2,6	2,6	2,6	2,6	2,6
36	1,5	1,9	2,2	2,6	2,6	2,6	2,6	2,6	2,6
40	1,5	1,8	2,1	2,5	2,5	2,5	2,5	2,5	2,5

Pullout design bond strength

Design bond strength in N/mm² according to ETA 04/0027

<table>
<tr><td colspan="14">Hammer or compressed air drilling.
Water saturated, water filled or submerged hole.
Concrete Strength C20/25.</td></tr>
<tr><td rowspan="3">temperature range</td><td colspan="13">Bar diameter</td></tr>
<tr><td colspan="13">Data according to ETA 04/0027</td></tr>
<tr><td>8</td><td>10</td><td>12</td><td>14</td><td>16</td><td>20</td><td>22</td><td>24</td><td>25</td><td>26</td><td>28</td><td>30</td><td>32</td></tr>
<tr><td>I: 40℃/24℃</td><td colspan="3">7,1</td><td colspan="3">6,7</td><td colspan="7">6,2</td></tr>
<tr><td>II: 58℃/35℃</td><td colspan="4">5,7</td><td colspan="6">5,2</td><td colspan="3">4,8</td></tr>
<tr><td>III: 70℃/43℃</td><td colspan="5">3,3</td><td colspan="5">3,1</td><td colspan="3">2,9</td></tr>
</table>

Increasing factor in non-cracked concrete: $f_{B,p}=(f_{cck}/25)^{0,1}$ (f_{cck}: characteristic compressive strength on cube)

Maximum anchorage length

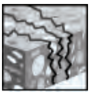
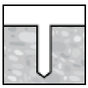
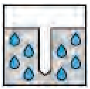
According to ETA-08/0105, the minimum anchorage length shall be increased by factor 1,5 for wet diamond core drilling. For all the other given drilling methods the factor is 1,0.

Actual anchorage length should base on the design condition

Rebar		l_{max} [mm]
Diameter d_s [mm]	**$f_{y,k}$ [N/mm²]**	
8	500	1000
10	500	1000
12	500	1200
16	500	1600
20	500	2000
25	500	2500
32	500	3200
40	500	3200

HIT-RE 500 V3 post-installed rebars

Injection mortar system		Benefits
	Foil pack: HIT-RE 500 V3 (available in 330 and 500 ml cartridges)	- **SafeSet** technology: Simplified method of borehole preparation using either Hilti hollow drill bit for hammer drilling or Roughening tool for diamond cored applications - Suitable for concrete C 12/15 to C 50/60 - High loading capacity - Suitable for dry and water saturated concrete - Non-corrosive to rebar elements - Long working time at elevated temperatures - Cures down to -5°C - Odourless epoxy - Fire time exposure up to 4h
	Rebar (Ø8-Ø40)	

Base material				Load conditions		
						
Concrete (non-cracked)	Concrete (cracked)	Dry concrete	Wet concrete	Static/ quasi-static	Seismic, ETA-C1	Fire resistance

Installation conditions			Other informations		
		SAFESET		CE	
Hammer drilling	Diamond coring	Hilti **SafeSet** technology	European Technical Assessment	CE conformity	PROFIS Rebar design Software

Approvals / certificates

Description	Authority / Laboratory	No. / date of issue
European technical assessment [a]	CSTB, Marne la Vallée	ETA-16/0142 / 2016-07-11
Fire evaluation	CSTB, Marne la Vallée	MRF 1526054277/B

b) All data given in this section according to ETA-16/0142 issue 2016-07-11.

Static and quasi-static loading

Static EC2 design, small concrete cover (see section 3.2.1)

Design bond strength in N/mm² according to ETA 16/0142 for good bond conditions

Rebar - size	Concrete class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
All allowed hammer drilling methods									
φ8 - φ40	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,3
Diamond coring wet									
φ8 - φ12	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,0
φ14 - φ16	1,6	2,0	2,3	2,7	3,0	3,4	3,7	3,7	3,7
φ20 - φ36	1,6	2,0	2,3	2,7	3,0	3,4	3,4	3,4	3,4
φ40	1,6	2,0	2,3	2,7	3,0	3,0	3,0	3,0	3,0

For poor bond conditions multiply thevalues by 0,7.

Materials

Properties of reinforcement

Designation	Material
Reinforcing bars (rebars)	
Rebar EN 1992-1-1	Bars and de-coiled rods class B or C with f_{yk} and k according to NDP or NCL of EN 1992-1-1 $f_{uk} = f_{tk} = k \cdot f_{yk}$

Fitness for use

Some creep tests have been conducted in accordance with ETAG guideline 001 part 5 and TR 023 in the following conditions: **in dry environment at 50 °C during 90 days**.
These tests show an excellent behaviour of the post-installed connection made with HIT-RE 500 V3: low displacements with long term stability, failure load after exposure above reference load.

Resistance to chemical substances

Chemicals tested	Content (%)	Resistance
Toluene	47,5	+
Iso-octane	30,4	+
Heptane	17,1	+
Methanol	3	+
Butanol	2	+
Toluene	60	+
Xylene	30	+
Methylnaphthalene	10	+
Diesel	100	+
Petrol	100	+
Methanol	100	-
Dichloromethane	100	-
Mono-chlorobenzene	100	o
Ethylacetat	50	-
Methylisobutylketone	50	-
Salicylic acid-	50	+
Acetophenon	50	+
Acetic acid	50	-
Propionic acid	50	-
Sulfuric acid	100	-
Nitric acid	100	-
Hydrochloric acid	36	-
Potassium hydroxide	100	-

Chemical tested	Content (%)	Resistance
Sodium hydroxide 20%	100	-
Triethanolamine	50	-
Butylamine	50	-
Benzyl alcohol	100	-
Ethanol	100	-
Ethyl acetate	100	-
Methyl ethyl ketone (MEK)	100	-
Trichlorethylene	100	-
Lutensit TC KLC 50	3	+
Marlophen NP 9,5	2	+
Water	95	+
Tetrahydrofurane	100	-
Demineralized water	100	+
Salt water	saturated	+
Salt spray testing	-	+
SO_2	-	+
Enviroment/wheather	-	+
Oil for formwork (forming oil)	100	+
Concentrate plasticizer	-	+
Concrete potash solution	-	+
Concrete potash solution	-	+
Saturated suspension of borehole cuttings	-	+

\+ **Resistant**
\- **Not resistant**
o **Partially Resistant**

Electrical Conductivity
HIT-RE 500 V3 in the hardened state **is not conductive electrically.** Its electric resistivity is 66Ω10^{12} Ω.m (DIN IEC 93 – 12.93). It is adapted well to realize electrically insulating anchorings (ex: railway applications, subway).

Installation temperature range
-5°C to +40°C

Service temperature range

Hilti HIT-RE 500 V3 injection mortar 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 I	-40 °C to +80 °C	+50 °C	+80 °C

Max short term base material temperature

Short-term elevated base material temperatures are those that occur over brief intervals, e.g. as result of diurnal cycling.

Max long term base material temperature

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

Working time and curing time [1)]

Temperature of the base material	Working time in which rebar can be inserted and adjusted t_{gel}	Initial curing time $t_{cure,ini}$	Curing time before rebar can be fully loaded t_{cure}
5 °C ≤ T_{BM} ≤ -1 °C	2 h	48 h	168 h
0 °C ≤ T_{BM} ≤ 4 °C	2 h	24 h	48 h
5 °C ≤ T_{BM} ≤ 9 °C	2 h	16 h	24 h
10 °C ≤ T_{BM} ≤ 14 °C	1,5 h	12 h	16 h
15 °C ≤ T_{BM} ≤ 19 °C	1 h	8 h	16 h
20 °C ≤ T_{BM} ≤ 24 °C	30 min	4 h	7 h
25 °C ≤ T_{BM} ≤ 29 °C	20 min	3,5 h	6 h
30 °C ≤ T_{BM} ≤ 34 °C	15 min	3 h	5 h
35 °C ≤ T_{BM} ≤ 39 °C	12 min	2 h	4,5 h
T_{BM} = 40 °C	10 min	2 h	4 h

1) The curing time data are valid for dry base material only. In wet base material the curing times must be doubled.

Setting information

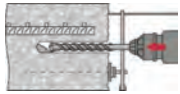
Installation equipment

Rebar – size	φ8	φ10	φ12	φ14	φ16	φ18	φ20	φ25	φ28	φ32	φ34	φ36	φ40
Rotary hammer	TE 2 (-A)– TE 40(-A)					TE40 – TE80							
Other tools	Blow out pump (h_{ef} ≤ 10·d)					-							
	Compressed air gun[a)] Set of cleaning brushes[b)], dispenser, piston plug Roughening tools												

a) Compressed air gun with extension hose for all drill holes deeper than 250 mm(for φ 8 to φ 12) or deeper than 20·φ (for φ > 12 mm)

b) Automatic brushing with round brushfor all drill holes deeper than 250 mm (for φ 8 to φ 12) or deeper than 20·φ (for φ > 12 mm.

Minimum concrete cover c_{min} of the post-installed rebar

Drilling method	Bar diameter [mm]	Minimum concrete cover c_{min} [mm]		
		Without drilling aid	With drilling aid	
Hammer drilling **(HD)** and **(HDB)**	**$\phi < 25$**	$30 + 0{,}06 \cdot l_v \geq 2 \cdot \phi$	$30 + 0{,}02 \cdot l_v \geq 2 \cdot \phi$	
	$\phi \geq 25$	$40 + 0{,}06 \cdot l_v \geq 2 \cdot \phi$	$40 + 0{,}02 \cdot l_v \geq 2 \cdot \phi$	
Compressed air drilling **(CA)**	**$\phi < 25$**	$50 + 0{,}08 \cdot l_v$	$50 + 0{,}02 \cdot l_v$	
	$\phi \geq 25$	$60 + 0{,}08 \cdot l_v \geq 2 \cdot \phi$	$60 + 0{,}02 \cdot l_v \geq 2 \cdot \phi$	
Diamond coring in wet **(PCC)** dry **(DD)**	**$\phi < 25$**	Drill stand works like a drilling aid	$30 + 0{,}02 \cdot l_v \geq 2 \cdot \phi$	
	$\phi \geq 25$		$40 + 0{,}02 \cdot l_v \geq 2 \cdot \phi$	
Diamond coring with Roughening too	**$\phi < 25$**	$30 + 0{,}06 \cdot l_v \geq 2 \cdot \phi$	$30 + 0{,}02 \cdot l_v \geq 2 \cdot \phi$	
	$\phi \geq 25$	$40 + 0{,}06 \cdot l_v \geq 2 \cdot \phi$	$40 + 0{,}02 \cdot l_v \geq 2 \cdot \phi$	

Drilling diameters

Rebar - size	Hammer drill (HD)	Hollow Drill Bit (HDB)[b)]	Compressed air drill (CA)	Diamond coring		
				Dry (PCC)[b)]	Wet (DD)	With roughening tool (RT)[b)]
	d_0 [mm]					
						
ϕ8	12 (10 [a)])	-	-	-	12 (10 [a)])	-
ϕ10	14 (12 [a)])	14 (12 [a)])	-	-	14 (12 [a)])	-
ϕ12	16 (14 [a)])	16 (14 [a)])	17	-	16 (14 [a)])	-
ϕ14	18	18	17	-	18	18
ϕ16	20	20	20	-	20	20
ϕ18	22	22	22	-	22	22
ϕ20	25	25	26	-	25	25
ϕ22	28	28	28	-	28	28
ϕ24	32 (30 [a)])	32 (30 [a)])	32	-	32	32
ϕ25	32 (30 [a)])	32 (30 [a)])	32	-	32	32
ϕ26	35	35	35	35	35	35
ϕ28	35	35	35	35	35	35
ϕ30	37	-	37	35	37	-
ϕ32	40	-	40	47	40	-
ϕ34	45	-	42	47	45	-
ϕ36	45	-	45	47	47	-
ϕ40	55	-	57	52	52	-

c) Each of two given values can be used.
d) No cleaning required

Associated components for the use of Hilti Roughening tool TE -YRT

Diamond coring		Roughening tool TE-YRT	Wear gauge RTG...
			
d_0 [mm]		d_0 [mm]	size
Nominal	measured		
18	17,9 to 18,2	18	18
20	19,9 to 20,2	20	20
22	21,9 to 22,2	22	22
25	24,9 to 25,2	25	25
28	27,9 to 28,2	28	28
30	29,9 to 30,2	30	30
32	31,9 to 32,2	32	32
35	34,9 to 35,2	35	35

Minimum roughening time $t_{roughen}$ ($t_{roughen}$ [sec] = h_{ef} [mm] /10)

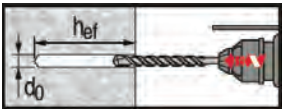
h_{ef} [mm]	$t_{roughen}$ [sec]
0 to 100	10
101 to 200	20
201 to 300	30
301 to 400	40
401 to 500	50
501 to 600	60

Setting instructions

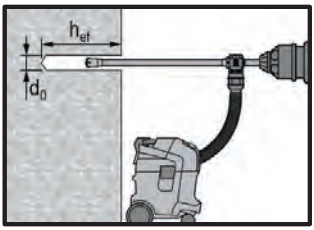
***For detailed information on installation see instruction for use given with the package of the product.**

Safety regulations.

Review the Material Safety Data Sheet (MSDS) before use for proper and safe handling! Wear well-fitting protective goggles and protective gloves when working with Hilti HIT-RE 500 V3.

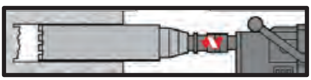


Hammer drilled hole (HD)

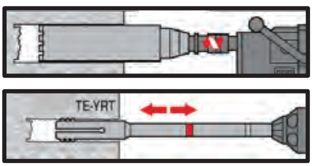


Hammer drilled hole with Hollow Drilled Bit (HDB)

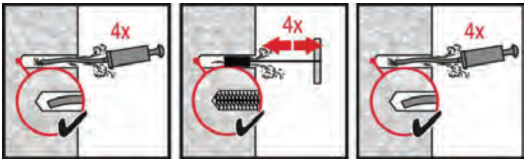
No cleaning required



Diamond Drilling (DD)



Diamond Drilling + Roughening Tool (DD+RT)

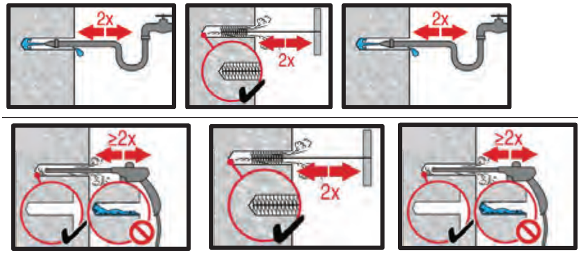


Hammer Drilling:

Manual cleaning (MC)
for drill diameters $d_0 \leq 20$ mm and drill hole depth $h_0 \leq 10 \cdot d$.

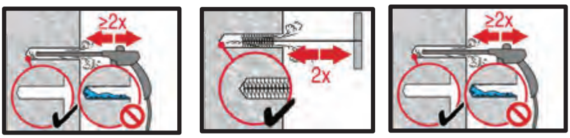
Hammer Drilling:

Compressed air cleaning (CAC)
for all drill hole diameters d_0 and drill hole depths $h_0 \leq 20 \cdot d$.



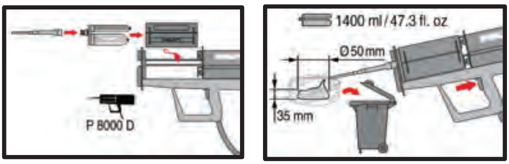
Diamond cored holes:

Compressed air cleaning (CAC)
for all drill hole diameters d_0 and drill hole depths h_0 .

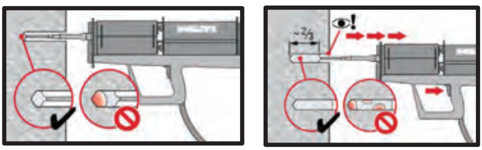


Diamond cored holes with Hilti roughening tool:

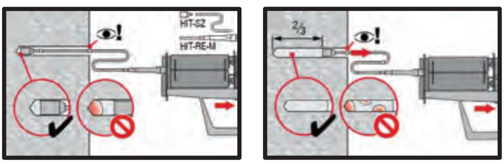
Compressed air cleaning (CAC)
for all drill hole diameters d_0 and drill hole depths h_0 .



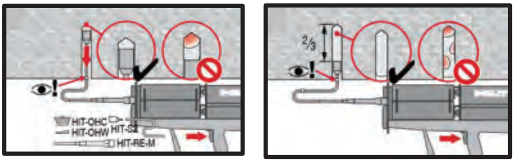
Injection system preparation.



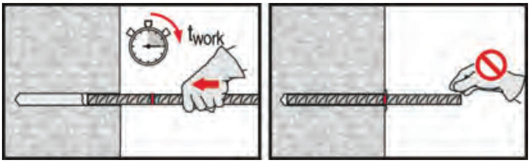
Injection method for drill hole depth $h_{ef} \leq 250$ mm.



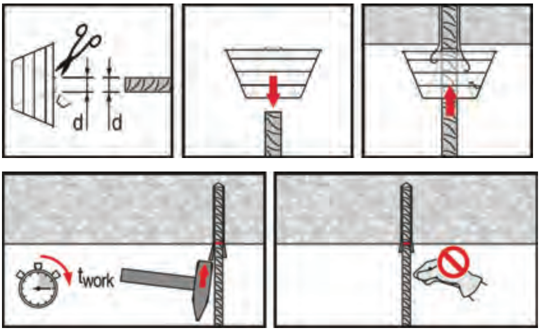
Injection method for drill hole depth $h_{ef} > 250$mm.



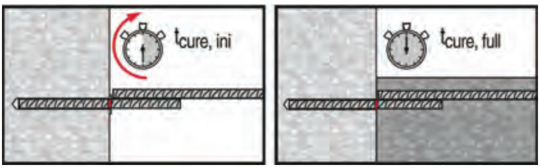
Injection method for overhead application.



Setting element, observe working time “t_{work}”.



Setting element for overhead applications, observe working time “t_{work}”.

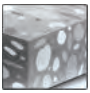


Apply full load only after curing time “t_{cure}“.

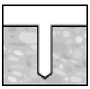
HIT-RE 100 post-installed rebar

Injection mortar system		Benefits
	Hilti HIT-RE 100 500 ml foil pack	- Suitable for concrete C12/15 to C 50/60 - High loading capacity - Suitable for dry and water saturated concrete - For rebar diameters up to 40 mm Non corrosive to rebar elements - Long working time at elevated temperatures - Suitable for embedment length till 3200 mm
	Rebar (Ø8-Ø40)	

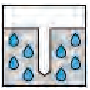
Base material



Concrete (non-cracked)



Dry concrete



Wet concrete

Load conditions

Static/ quasi-static

Installation conditions

Hammer drilling

Diamond coring

Other information

European Technical Assessment

CE conformity

Approvals / certificates

Description	Authority / Laboratory	No. / date of issue
European technical assessment [a)]	DIBt, Berlin	ETA – 15/0883 / 2016-04-21

Basic design data

Static EC2 design

Design bond strength in N/mm² according to ETA 15/0883 for good bond conditions

Rebar-size	Concrete class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
All allowed hammer drilling methods									
ϕ8 - ϕ32	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,3
ϕ34	1,6	2,0	2,3	2,6	2,9	3,3	3,6	3,9	4,2
ϕ36	1,5	1,9	2,2	2,6	2,9	3,3	3,6	3,8	4,1
ϕ40	1,5	1,8	2,1	2,5	2,8	3,1	3,4	3,7	4,0
Diamond coring wet									
ϕ8 - ϕ32	1,6	2,0	2,3	2,7					
ϕ34	1,6	2,0	2,3	2,6					
ϕ36	1,5	1,9	2,2	2,6					
ϕ40	1,5	1,8	2,1	2,5					

For poor bond conditions multiply the values by 0,7. Values valid for non-cracked and cracked concrete

Minimum anchorage length and minimum lap length

The minimum anchorage length $\ell_{b,min}$ and the minimum overlap length $\ell_{0,min}$ according to EN 1992-1-1 shall be multiplied by the relevant **Amplification factor** in the table below.

Amplification factor α_{lb} for the min. anchorage length and min. lap length according to EN 1992-1-1 for:

Rebar - size	Concrete class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
All allowed hammer drilling methods									
ϕ8 -ϕ40	1,0								
Diamond coring dry and wet									
ϕ8 -ϕ40	1,5								

Fitness for use

Some creep tests have been conducted in accordance with ETAG guideline 001 part 5 and TR 023 in the following conditions: **in dry environment at 50 °C during 90 days.**
These tests show an excellent behaviour of the post-installed connection made with HIT-RE 100: low displacements with long term stability, failure load after exposure above reference load.

Resistance to chemical substances

Chemical	Resistance
Acetic acid 100%	o
Acetic acid 10%	+
Hydrochloric Acid 20%	+
Nitric Acid 40%	-
Phosphoric Acid 40%	+
Sulphuric acid 40%	+
Ethyl acetate 100%	o
Acetone 100%	-
Ammoniac 5%	o
Diesel 100%	+
Gasoline 100%	+
Ethanol 96%	o
Machine oils 100%	+

Chemical	Resistance
Methanol 100%	o
Peroxide of hydrogen 30%	o
Solution of phenol (sat.)	-
Sodium hydroxide pH=14	+
Solution of chlorine (sat.)	+
Solution of hydrocarbons (60 % vol Toluene, 30 % vol Xylene,10 % vol Methyl naphtalene)	+
Salted solution 10%	+
sodium chloride	
Suspension of concrete (sat.)	+
Chloroform 100%	+
Xylene 100%	+

+ resistant
o resistant in short term (max. 48h) contact
- not resistant

Electrical Conductivity

HIT-RE 100 in the hardened state **is not conductive electrically**. Its electric resistivity is $1{,}4 \cdot 10^{10}\ \Omega \cdot m$ (DIN IEC 93 – 12.93). It is adapted well to realize electrically insulating anchorings (ex: railway applications, subway).

Installation temperature range:
+5°C to +40°C

Service temperature range
Hilti HIT-RE 100 injection mortar 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 I	-40 °C to +80 °C	+50 °C	+80 °C

Max short term base material temperature
Short-term elevated base material temperatures are those that occur over brief intervals, e.g. as a result of diurnal cycling.
Max long term base material temperature
Long-term elevated base material temperatures are roughly constant over significant periods of time.

Working time and curing time[a)]

Temperature IN the base material T_{BM}	Maximum working time t_{work}	Initial curing time $t_{cure,ini}$[b)]	Minimum curing time t_{cure}
-5 °C ≤ T_{BM} < 9 °C	2 hours	18 hours	72 hours
10 °C ≤ T_{BM} < 14 °C	1,5 hours	12 hours	48 hours
15 °C ≤ T_{BM} < 19 °C	30 min	8 hours	24 hours
20 °C ≤ T_{BM} < 24 °C	25 min	6 hours	12 hours
25 °C ≤ T_{BM} < 29 °C	20 min	5 hours	10 hours
30 °C ≤ T_{BM} ≤ 39 °C	12 min	4 hours	8 hours
40 °C	12 min	2 hours	4 hours

a) The curing time data are valid for dry base material only. In wet base material the curing times must be doubled.
b) After $t_{cure,ini}$ has elapsed preparation work may continue

Setting information

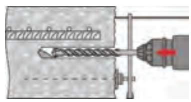
Installation equipment

Rebar – size	ϕ8-ϕ16	ϕ18-ϕ40
Rotary hammer	TE2(-A) – TE30(-A)	TE40 – TE80
Other tools	Blow out pump (h_{ef} ≤ 10·d)	-
	Compressed air gun[a)] Set of cleaning brushes[b)], dispenser, piston plug	

a) Compressed air gun with extension hose for all drill holes deeper than 250 mm (for ϕ 8 to ϕ 12) or deeper than 20·ϕ (for ϕ > 12 mm)
b) Automatic brushing with round brush for all drill holes deeper than 250 mm (for ϕ 8 to ϕ 12) or deeper than 20·ϕ (for ϕ > 12 mm)

Minimum concrete cover c_{min} of the post-installed rebar

Drilling method	Rebar – size [mm]	Minimum concrete cover c_{min} [mm]	
		Without drilling aid	With drilling aid
Hammer drilling **(HD)**	ϕ < 25	30 + 0,06 · l_v ≥ 2 · ϕ	30 + 0,02 · l_v ≥ 2 · ϕ
	ϕ ≥ 25	40 + 0,06 · l_v ≥ 2 · ϕ	40 + 0,02 · l_v ≥ 2 · ϕ
Compressed air drilling **(CA)**	ϕ < 25	50 + 0,08 · l_v	50 + 0,02 · l_v
	ϕ ≥ 25	60 + 0,08 · l_v ≥ 2 · ϕ	60 + 0,02 · l_v ≥ 2 · ϕ
Diamond coring dry **(PCC)** or wet **(DD)**	ϕ < 25	Drill stand is used as drilling aid	30 + 0,02 · l_v ≥ 2 · ϕ
	ϕ ≥ 25		40 + 0,02 · l_v ≥ 2 · ϕ



Drilling and cleaning diameters

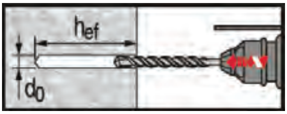
Rebar [mm]	Hammer drill (HD)	Compressed air drill (CA)	Diamond core		Brush HIT-RB	Air nozzle HIT-RB
			Wet (DD)	Dry (PCC)[b)]		
	d₀ [mm]				size	
ϕ8	12 (10[a)])	-	12 (10[a)])	-	12 (10[a)])	12 (10[a)])
ϕ10	14 (12[a)])	-	14 (12[a)])	-	14 (12[a)])	14 (12[a)])
ϕ12	16 (14[a)])	-	16 (14[a)])	-	16 (14[a)])	16 (14[a)])
	-	17	-	-	18	16
ϕ14	18	17	18	-	18	18
ϕ16	20	-	20	-	20	20
	-	20	-	-	22	20
ϕ18	22	22	22	-	22	22
ϕ20	25 (24[a)])	-	25	-	25 (24[a)])	25 (24[a)])
	-	26	-	-	28	25
ϕ22	28	28	28	-	28	28
ϕ24	32	32	32	35	32	32
ϕ25	32 (30[a)])	32 (30[a)])	32 (30[a)])	35	32 (30[a)])	
ϕ26	35	35	35	35	35	
ϕ28	35	35	35	35	35	
ϕ30	-	35	35	35	35	
	37	-	-		37	
ϕ32	40	40	40	47	40	
ϕ34	-	42	42	47	42	
	45	-	-		45	
ϕ36	45	45	-	47	45	
	-	-	47		47	
ϕ40	-	-	52	52	52	
	55	57	-		55	

a) Both of a given values can be used.
b) No cleaning required.

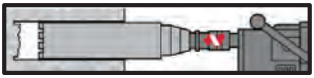
Setting instructions
***For detailed information on installation see instruction for use given with the package of the product.**

Safety regulations.

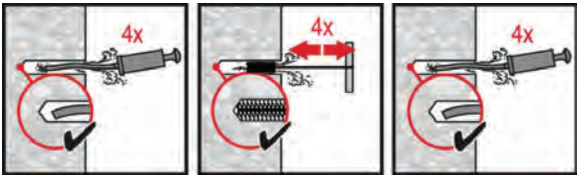
Review the Material Safety Data Sheet (MSDS) before use for proper and safe handling! Wear well-fitting protective goggles and protective gloves when working with Hilti HIT-RE 100.



Hammer drilled hole (HD)



Diamond Drilling (DD)

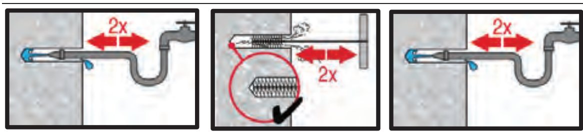


Hammer Drilling:

Manual cleaning (MC)
for drill diameters $d_0 \leq 20$ mm and drill hole depth $h_0 \leq 10 \cdot d$.

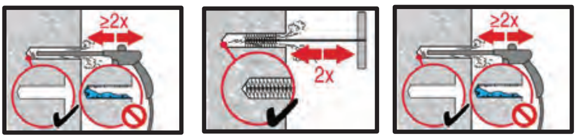
Hammer Drilling:

Compressed air cleaning (CAC)
for all drill hole diameters d_0 and drill hole depths $h_0 \leq 20 \cdot d$.



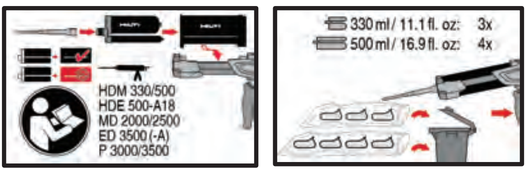
Wet diamond coring:

Compressed air cleaning (CAC)
for all drill hole diameters d_0 and drill hole depths h_0 .

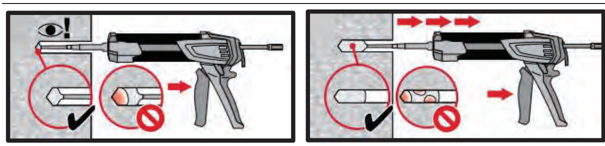


Dry diamond coring:

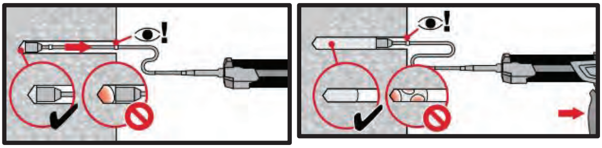
Compressed air cleaning (CAC)
for all drill hole diameters d_0 and drill hole depths h_0 .



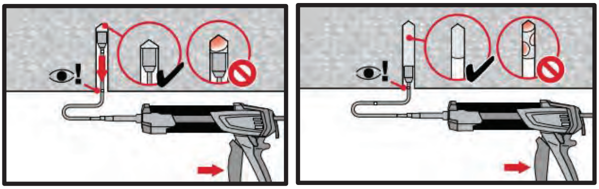
Injection system preparation.



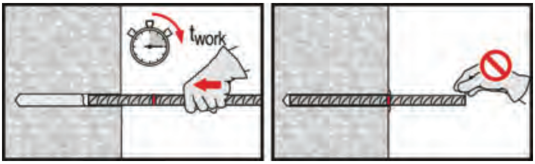
Injection method for drill hole depth $h_{ef} \leq 250$ mm.



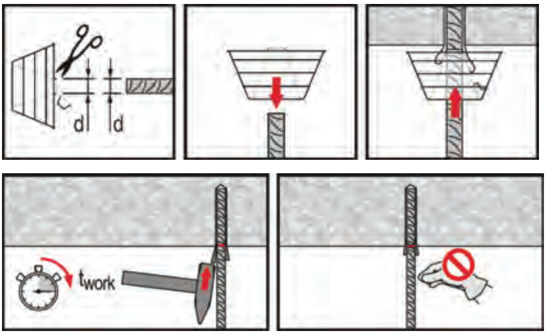
Injection method for drill hole depth h_{ef} > 250mm.



Injection method for overhead application.



Setting element, observe working time “t_{work}”.



Setting element for overhead applications, observe working time “t_{work}”.

Apply full load only after curing time “t_{cure}“.

Hilti worldwide

Afghanistan
Ansary Engineering Products & Services (AEP), Hilti Division, Kabul
Phone +93 799 481 935

Algeria
BFIX SARL, Algiers
Phone+213 216 013 60
Fax+213 216 055 03

Angola
Agrinsul S.A.R.L, Luanda
Phone+244 222 395 884
Fax+244 222 397 935

Argentina
Hilti Argentina, S.R.L., Buenos Aires
Phone+54 11 4721 4400
Fax+54 11 4721 4410

Aruba
Carfast Holding N.V, Oranjestad
Phone +297-5-828-449
Fax +297-5-832-582

Australia
Hilti (Aust.) Pty. Ltd., Rhodes
Phone+61 2 8748 1000
Fax+61 2 8748 1190

Austria
Hilti Austria Ges.m.b.H., Wien
Phone+43 1 66101
Fax+43 1 66101 257

Azerbaijan
HCA Ltd., Baku
Phone+994 12 598 0955
Fax+994 12 598 0957

Bahrain
Hilti Bahrain W.L.L., Manama
Phone +973 17 702 101
Fax +973 17 702 151

Bangladesh
Aziz & Company Ltd., Hilti Division,
Dhaka
Phone+8802 881 4461
Fax+8802 8827028

Barbados
Williams Equipment, Ltd., St.Michel
Phone+1 246 425 5000
Fax+1 246 417 9140

Belgium
Hilti Belgium S.A., Asse (Zellik)
Phone+32 2 4677911
Fax+32 2 4665802

Belize
Benny's Homecenter Ltd., Belize City,
Phone+501 227 2126
Fax+501 227 4340

Benin
La Roche S.A.R.L., Cotonou
Phone+229 21330775
Fax+229 21331920

Bhutan
Hilti Regional Office
Middle East & South Asia Region, Dubai
Phone+9714 8060300
Fax+9718 4480485

Bolivia
Genex, S.A., Santa Cruz
Phone+591 3 343 1819
Fax+591 3 343 1819

Bosnia and Herzegovina
Hilti Systems BH d.o.o. Sarajevo, Sarajevo-Ilidža
Phone +387 33 761 100
Fax +387 33 761 101

Botswana
Turbo Agencies, Gaborone
Phone+267 312288
Fax+267 352925

Brazil
Hilti do Brasil Comercial Ltda., Barueri
Phone+55 11 4134 9000
Fax+55 11 4134 9021

Bulgaria
Hilti (Bulgaria) GmbH, Sofia
Phone +359 2976 00 11
Fax +359 2974 01 23

Canada
Hilti (Canada) Ltd., Mississauga, Ontario
Phone 1-800-363-4458
Fax 1-800-363-4459

Cayman Islands
Active Traders Ltd., Georgetown
Phone +345-769-4458
Fax +345-769-5886

Chile
Hilti Chile, Ltda.,Santiago
Phone+562 655 3000
Fax+562 365 0505

China
Hilti (China) Ltd., Shanghai
Phone+86 21 6485 3158
Fax+86 21 6485 0311

Colombia
Hilti Colombia, Bogotá
Phone+571 3810121/3810134
Fax+571 3810131

Costa Rica
Superba S.A., La Uruca, San José
Phone+506 255 1044
Fax+506 255 1110

Croatia
Hilti Croatia d.o.o., Sesvete-Zagreb
Phone+385 1 2030 777
Fax+385 1 2030 766

Cyprus
Cyprus Trading Corp. Ltd., Nicosia
Phone+357 22 740340
Fax+357 22 482892

Czech Republik
Hilti CR spol. s r.o, Prag-Pruhonice
Phone+420 2 611 95 611
Fax+420 2 726 80 440

Denmark
Hilti Danmark A/S, Rødovre
Phone +45 88 8000
Fax +45 44 88 8084

Dominican Republik
Dalsan C por A, Santo Domingo
Phone+1 809 565 4431
Fax+1 809 541 7313

Ecuador
Quifatex S.A., Quito
Phone+593 2 247 7400
Fax+593 2 247 8600

Egypt
M.A.P.S.O. for Marine Propulsion & Supply S.A.E., Cairo
Phone +202 2 698 47 77
Fax+202 2 698 82 60

El Salvador
Electrama, S.A. de C.V., San Salvador
Phone+503 274 9745
Fax+503 274 9747

Estonia
Hilti Eesti OÜ, Tallinn
Phone+372 6 550 900
Fax+372 6 550 901

Ethiopia
A. Sarafian Industrial Accessories & Tools, Addis Ababa
Phone+251 115512408
Fax+251 115519068

Fiji
Central Pacific Agencies, Suva
Phone+ 679 336 2580

Finland
Hilti (Suomi) OY, Vantaa
Phone+358 9 47870 0
Fax+358 9 47870 100

France
Hilti France S.A., Magny-les-Hameaux
Phone+33 1 3012 5000
Fax+331 3012 5012

Gabon
CECA-GADIS, Libreville
Phone+241 740747
Fax+241 720416

Georgia
ICT Georgia Ltd., Tbilisi
Phone+995 32 25 38 42

Germany
Hilti Deutschland GmbH, Kaufering
Phone+49 8191/90-0
Fax+49 8191/90-1122

Ghana
Auto Parts Limited, Accra
Phone+233 21225924
Fax+233 21224899

Great Britain
Hilti (Gt. Britain) Ltd., Manchester
Phone+44 161 886 1000
Fax+44 161 872 1240

Greece
Hilti Hellas SA, Likovrisi
Phone+30210 288 0600
Fax+30210 288 0607

Guatemala
Equipos y Fijaciones, S.A., Guatemala City
Phone+502 339 3583
Fax+502 339 3585

Guyana
Agostini's Fastening Systems Ltd., Port of Spain
Phone +1 868 623 2236
Fax+1 868 624 6751

Honduras
Lazarus & Lazarus, S.A., San Pedro Sula
Phone+504 565 8882
Fax+504 565 8624

Hong Kong
Hilti (Hong Kong) Ltd., Kwun Tung, Kowloon
Phone+852 8228 8118
Fax+852 2764 3234 (main)

Hungary
Hilti (Hungária), Budapest
Phone+36 1 4366 300
Fax+36 1 4366 390

Iceland
HAGI ehf HILTI Iceland, Reykjavik
Phone+354 4143700
Fax+354 4143720

India
Hilti India Pvt Ltd., New Dehli
Phone +91 11 4270 1111
Fax+91 11 2637 1634

Indonesia
P.T. Hilti Nusantara, Jakarta
Phone+62 21 / 789-0850
Fax+62 21 / 789-0845

Iran
Madavi Company, Hilti Division, Tehran
Phone+98 21 81 721
Fax+98 21 887 61 523

Iraq
Systems Engineering Services Co. (SESCO), Hilti Division, Baghdad
Phone+964 1 778 8933
Phone+964 7901 309592

Ireland
Hilti (Fastening Systems) Ltd., Dublin
Phone+353 1 886
Fax+353 1 886 3569

Israel
Hilti (Israel) Ltd., Petach Tikva
Phone+972 3 930 4499
Fax+972 3 930 2095

Italy
Hilti Italia S.p.A., Milano
Phone+3902 212721
Fax+3902 25902189

Jamaica
Evans Safety Ltd., Kingston
Phone+1 876 929 5546
Fax+1 876 926 2069

Japan
Hilti (Japan) Ltd., Yokohama
Phone+81 45 943 6211
Fax+81 45 943 6231

Jordan
Newport Trading Agency Division, Amman
Phone +962 6 4026829
Fax+962 6 4026794

Kazakhstan
EATC Ltd., Almaty
Phone +7327 298 01 80
Fax+7 3272 50 39 57

Korea
Hilti (Korea) Ltd., Seoul,
Phone +82 2 2007 2802
Fax +82 2 2007 2809

Kuwait
Works & Building Co, Hilt Safat
Phone+965 844 855
Fax+965 4831379

Latvia
Hilti Services Limited, Riga
Phone+371 762 8822
Fax+371 762 8821

Lebanon
Chehab Brothers S.A.L., Hilti Division, Beirut
Phone+9611 244435
Fax+9611 243623

Libya
Wemco Workshop & Maintenance Equipments Co., Tripoli
Phone+ 218 21 4801213
Fax+ 218 21 4802810

Liechtenstein
Hilti Aktiengesellschaft, Schaan Liechtenstein
Phone+423 234 2111
Fax+423 234 2965

Lithuania
UAB Hilti Complete Systems
Phone+370 6 872 7898
Fax+370 5 271 5341

Luxembourg
Hilti G.D. Luxembourg, Bertrange
Phone+352 310 705
Fax+352 310 751

Macedonia
Famaki-ve doel, Skopje
Phone+389 2 246 96
Fax+389 2 246 99 97

Madagascar
Société F. Bonnet Et Fils,
Antananarivo
Phone+261 202220326
Fax+261 202222253

Malaysia
Hilti (Malaysia) Sdn. Bhd.,
Petaling Jaya
Phone+60 3 563 38583
Fax+60 3 563 37100

Maldives
Aima Con. Co. Pvt. Ltd,
Hilti Division, Malé
Phone +960 3330909
Fax+960 3313366

Malta
Panta Marketing & Services Ltd.,
Msida
Phone+356 21 441 361
Fax+356 21 440 000

Mauritius
Ireland Blyth Limited, Port Louis
Phone+230 207 05 00
Fax+230 207 04 41

Mexico
Hilti Mexicana, S.A. de C.V.,
Mexico City
Phone+5255 5387-1600
Fax+5255 5281-5967

Moldova
Sculcom Grup SRL, Chisinau
Phone+373 22 212488
Fax+373 22 238196

Mongolia
PSC CO. LTD., Hilti Division,
Ulaan Baatar
Phone+976 +50 88 45 84
Fax+976 50 88 45 85

Morocco
Mafix SA, Casablanca
Phone+2122 257301
Fax+2122 257364

Mozambique
Diatecnica Lda., Maputo
Phone+2581 303816
Fax+2581 303804

Namibia
A. Huester Machinetool Company
(Pty) Ltd., Windhoek
Phone+26461 237083
Fax+26461 227696

Nepal
INCO (P) Ltd., Kathmandu
Phone+9771 4431 992
Fax+9771 4432 728

Netherlands
Hilti Nederland B.V.,
Berkel en Rodenrijs
Phone+3110 5191111
Fax+3110 5191199

Netherlands Antilles
Fabory Carribbean Fasteners N.V.,
Davelaar
Phone+599 9 737 6288
Fax+599 9 737 6225

New Zealand
Hilti (New Zealand) Ltd., Auckland
Phone +64 9 571 9995
Fax +64 9 571 9942

Nicaragua
Fijaciones de Nicaragua, Managua
Phone+505 270 4567
Fax+505 278 5331

Nigeria
Top Brands Import Ltd., Hilti
Division
Ikeja
Phone +234 1 817 97 601
Fax+234 1 496 22 00

Norway
Motek AS, Oslo
Phone+47 230 52 500
Fax+47 22 640 063

Oman
Bin Salim Enterprices LLC,
Hilti Division, Muscat
Phone+968 245 63078
Fax+968 245 61193

Pakistan
Hilti Pakistan (Pvt) Ltd
Lahore
Phone +9242 111144584
Fax +9242 37500521

Palestine
Shaer United Co. for Modern
Technology, Beit Jala
Phone+970 2 276 5840
Fax+970 2 274 7355

Panama
Cardoze & Lindo,
Ciudad de Panamá
Phone+507 274 9300
Fax+507 267 1122

Peru
Química Suiza SA, Lima
Phone+511 211 4000
Fax+511 211 4050

Philippines
Hilti (Philippines) Inc., Makati City
Phone+632 784 7100
Fax+632 784 7101

Poland
Hilti (Poland) Sp. z o.o., Warsaw
Phone +48 320 5500
Fax +48 22 320 5500

Portugal
Hilti (Portugal), Produtos e Servicos,
Lda., Matosinhos – Senhora Da Hora,
Phone +351 229 568 100
Fax+35122 9568190

Puerto Rico
Hilti Caribe, Inc., Hato Rey,
Phone+1-787 281 6160
Fax+1 787 281 6155

Qatar
Hilti Qatar
Doha
Phone+974 4425022
Fax+974 435 6098

Romania
Hilti Romania S.R.L., Otopeni
Phone+40 213523000

Russia
Hilti Distribution Ltd., Moscow
Phone+7 495 792 52 52
Fax+7 495 792 52 53

République de Djibouti
Les Etablissements TANI, Djibouti
Phone +235 35 03 37
Fax+235 35 23 33

Saudi Arabia
TFT Ltd
Jeddah
Phone +9662 6983660
Fax +9662 6974696

Senegal
Senegal-Bois, Dakar
Phone+2218 323527
Fax+2218 321189

Serbia Montenegro
Hilti SMN d.o.o., Belgrade
Phone +381-11-2379-515
Fax+381-11-2379-514

Singapore
Hilti Far East Private
Ltd., Singapore
Phone+65 6777 7887,
Fax+65 6777 3057

Slovakia
Hilti Slovakia spol. s r.o., Bratislava
Phone+421 248 221 211
Fax+421 248 221 255

Slovenja
Hilti Slovenija d.o.o., Trzin
Phone+386 1 56809 33
Fax+386 1 56371 12

South Africa
Hilti (South Africa) (Pty) Ltd.,
Midrand
Phone+2711 2373000
Fax+2711 2373111

Spain
Hilti Española S.A., Madrid
Phone+3491 3342200
Fax+3491 3580446

Sri Lanka
Hunter & Company Ltd.,Hilti
Division
Phone+94 114713352
Fax +94 114723208

St. Lucia
Williams Equipment Ltd, Castries
Phone +1 758 450-3272
Fax+1 758-450-4206

St.Maarten, N.A.
Carfast Holding N.V., Cole Bay
Phone +599 544 4760
Fax +599-544-4763

Sudan
PEMECO INDUSTRIAL
SUPPLIES CO. LTD. Khartoum
Phone+249 15 517 5031
Fax+249 15 517 5032

Sweden
Hilti Svenska AB, Arlöv
Phone+46 40 539 300
Fax+46 40 435 196

Switzerland
Hilti (Schweiz) AG, Adliswil
Phone+41 844 84 84 85
Fax+41 844 84 84 86

Syria
Al-Safadi Brothers Co., Hilti
Division
Damascus
Phone+96311 6134211
Fax+96311 6123818

Taiwan
Hilti Taiwan Co., Ltd., Taipei
Phone+886 2 2357 9090
Fax+886 2 2397 3730

Tanzania
Coastal Steel Industrial Limited,
Hilti Division, Dar es Salaam
Phone+255 222865662
Fax+255 222865692

Thailand
Hilti (Thailand) Ltd.,
Bangkok Metropolis
Phone+66 2 751 4123
Phone-2-751 4127
Fax+66 2 751 4116

Trinidad and Tobago
Agostini's Fastening Systems Ltd.,
TT- Port of Spain
Phone+1 868 623 2236
Fax+1 868 624 6751

Tunisia
Permetal SA, Tunis C.U.N
Phone+216 71 766 911
Fax+216 71 766 807

Turkey
Hilti Insaat Malzemeleri Tic .A.S.,
Umraniye/Istanbul
Phone+90 216 528 6800
Fax+90 216 528 6898

Turkmenistan
Zemmer Legal, Ashgabat

Uganda
Casements (Africa) Ltd., Kampala
Phone+25641 234000
Fax+25641 234301

Ukraine
HILTI (Ukraine) Ltd., Kyiv
Phone +380 44 390 5566
Fax+380 44 390 5565

United Arab Emirates
Hilti Emirates L.L.C.
Phone+9714 8854445
Fax+9714 8854405

USA
Hilti, Inc.,Tulsa
Phone (866) 445-8827
Fax 1-800-879-7000

Uruguay
Seler Parrado, S.A., Montevideo
Phone+598 2 902 3515
Fax+598 2 902 0880

Uzbekistan
BNZ Industrial Support, Tashkent
Phone +998 90 186 2792
Fax +99871 361

Venezuela
Inversiones Hilti de Venezuela, S.A.,
Caracas
Phone+58 -212-2034200
Fax+58-212-2034310

Vietnam
Hilti AG Representative Office,
Ho Chi Minh City
Phone+84 8 930 4091
Fax+84 8 930 4090

Yemen
Nasser Ziad Establishment, Hilti
Division, Sana'a
Phone+9671 275238
Fax+9671 272854

Zambia
BML Electrical Limited, Kitwe
Phone+260 (2) 226644

Zimbabwe
Glynn's Bolts (Pvt.) Ltd., Harare
Phone+2634 754042-48
Fax+2634 754049