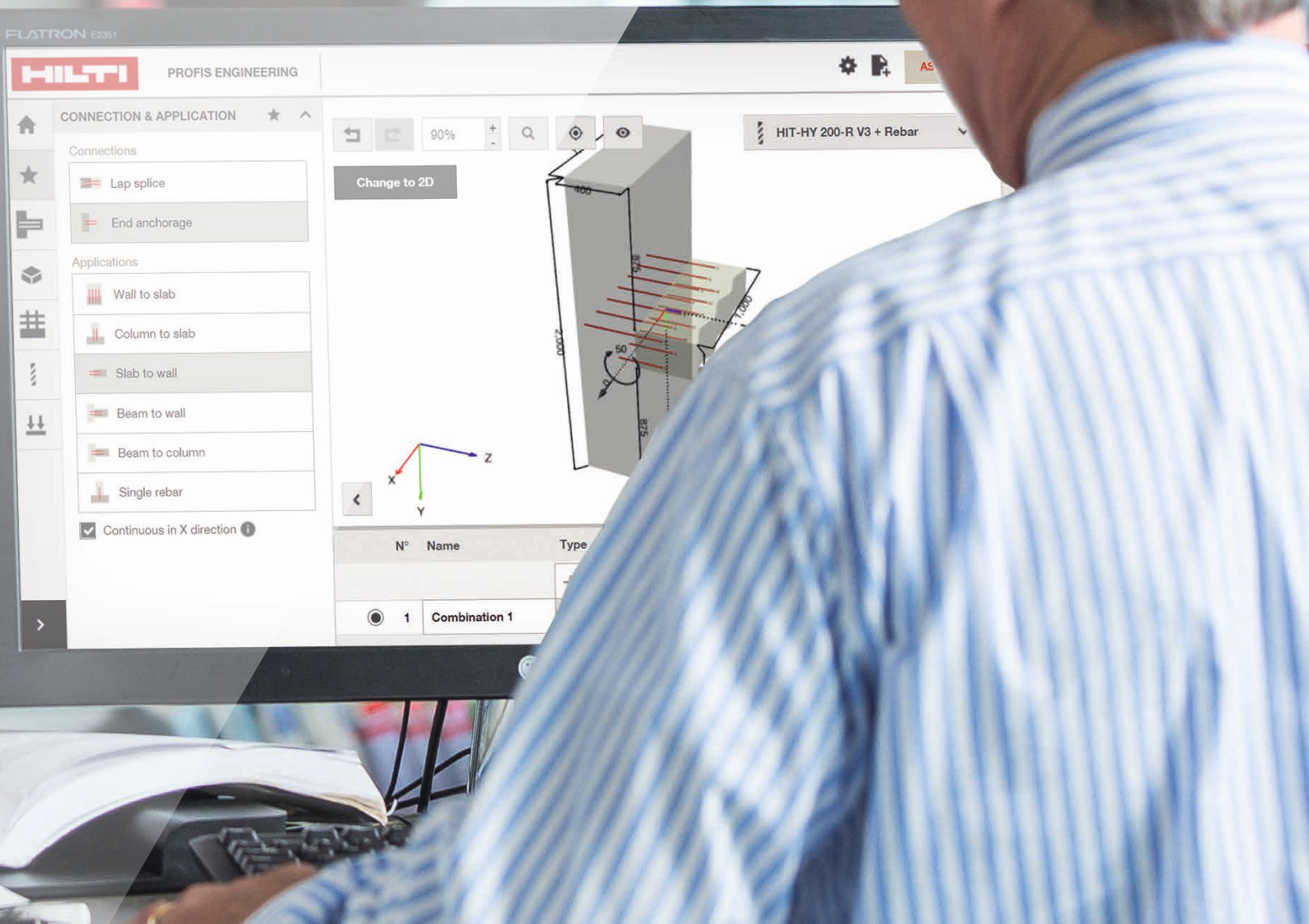
THE (R)EVOLUTION IN POST-INSTALLED REBAR

Hilti HIT-RE 500 V4, HIT-HY 200-R V3 and TR 069: More applications in post-installed rebar connections



UNTIL NOW WITH LIMITATIONS

Up to now, Eurocode 2 limited the application range of post-installed rebar connections

THE (R)EVOLUTION

Post-installed rebar connections have become a trusted, everyday solution in recent years. They are used in both retrofit work and in new construction – for a wide range of applications like slab-to-wall connections, anchoring of stair landings, connecting cantilever slabs with slabs or anchoring columns in existing foundations.

When strengthening existing concrete structures – e. g. to improve performance due to refurbishment – post-installed rebar is used to widen cantilever slabs, to rehabilitate edges of slabs and to close breakthroughs.

Until as recently as 2018, post-installed rebar was assessed through the EAD 330087. However, this EAD does not cover design.

After several years of intense research and testing, TR 069 has broadened the scope of post-installed rebar applications since 2019. In 2022 the TR 069 has been updated to include, 100 year design working life and seismic loading. Hilti can now offer you a revolutionary system for post-installed rebar connections, consisting of:

- The design method – TR 069, as published by EOTA that takes into account the product dependent bond performance
- New products – Hilti HIT-RE 500 V4 and HIT-HY 200-R V3 injectable mortars, with strong ETAs with a working life up to 100 years
- New software – PROFIS Engineering, for convenient calculation and creation of all necessary documentation
- The HIT-RE 500 V4 is now assessed to be used to resist seismic action as well

»The updated TR 069 covers the design of reinforced concrete connections, with a working life up to 100 years to resist static as well as seismic actions.«

STATUS QUO

Post-installed rebar connections

The design of post-installed rebar connections in combination with products assessed based on EAD 330087 can be carried out following the provisions of the valid European reinforced concrete standard (EN 1992-1-1). The assessment process is intended to verify the equivalency of the load-displacement behavior between cast-in and post-installed rebar.

Obviously, only applications which can be designed with straight deformed cast-in bars in accordance with EN 1992-1-1 can be designed and executed with post-installed rebar. Typically, moment-resisting reinforced concrete connections must be designed and executed as lap splicing. This, however, is not feasible in many cases where advance planning and detailing of existing reinforcement is required.

EXTENDED POSSIBILITIES

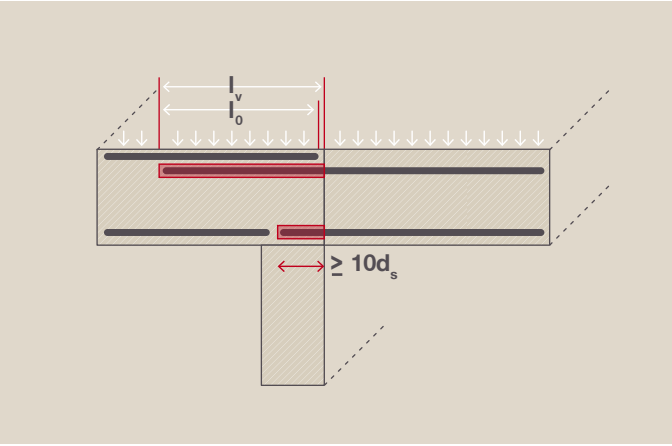
On the way to a broader application range

RIGID CONNECTIONS

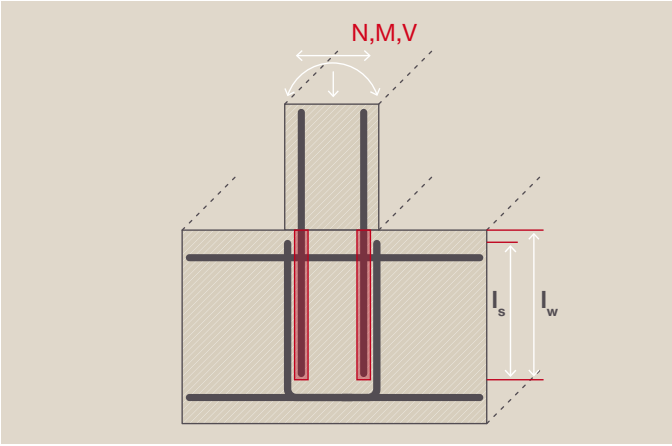
Until now, only with splice

To this day, post-installed rebar connections according to EAD 330087 can only be executed with straight rebar, which are permitted in accordance with EN 1992-1-1 (for static loading) or EN 1998-1 (for seismic action). This means that the moment-resisting connections need to be executed with splices. Alternative Strut and Tie methods applicable in some situations for static loading are not valid, if the connection has to resist seismic actions.

Execution of a post-installed, moment-resisting concrete rebar connection by splicing, as required by EAD 330087:



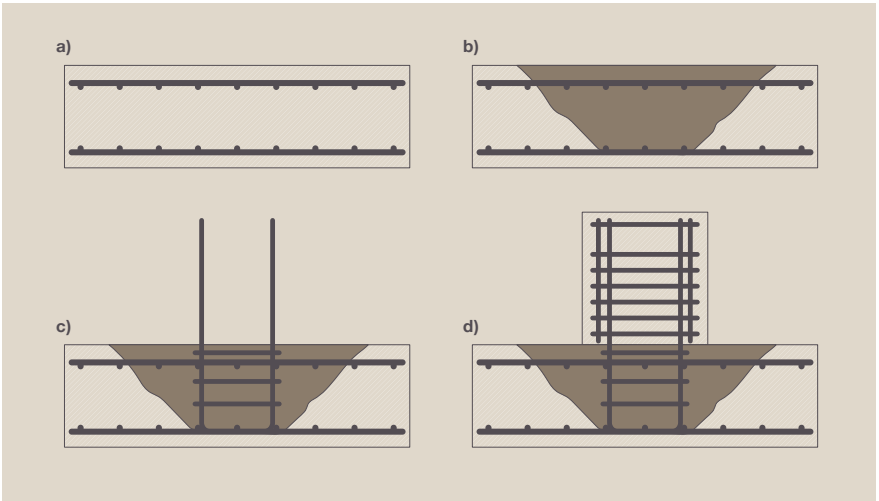
Slab-to-slab connection using splice (schematic drawing)



Column or wall connection using splice with load-bearing rebar (schematic drawing)

This requirement to construct moment-resisting rebar connections using a splice can have a crucial impact on the construction workflow, economics and safety:

- A splice (planned overlap of a cast-in rebar with a post-installed rebar) in new construction needs to be planned and be in place. This is not always the case.
- As concrete-pouring is carried out stepwise, rebar can be exposed, which can lead to different issues: Influencing logistics, damaged rebar and also safety hazards in congested construction sites.
- The load-bearing capacity of a splice consisting of two rebar with different properties is dependent of the capacity of the rebar with the lower bond strength, i. e. the one that is cast-in. This is why the potential of the used mortar can usually not be fully leveraged. This can lead to overlap lengths that can be uneconomical and often unfeasible to geometrical limitations.
- In renovation, a rebar connection with splice needs to be executed by partial demolition to expose the existing rebar, fix the new rebar onto it and then close the connection with concrete again, all of which is very time- and thus cost-intensive.



Schematic description of executing a rebar connection with partial demolition

A MILESTONE

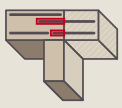
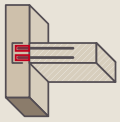
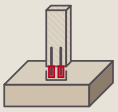
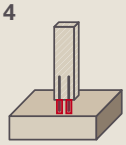
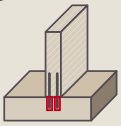
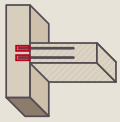
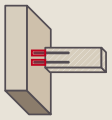
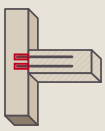
New design method for post-installed rebar connections

THE NEW DESIGN CONCEPT

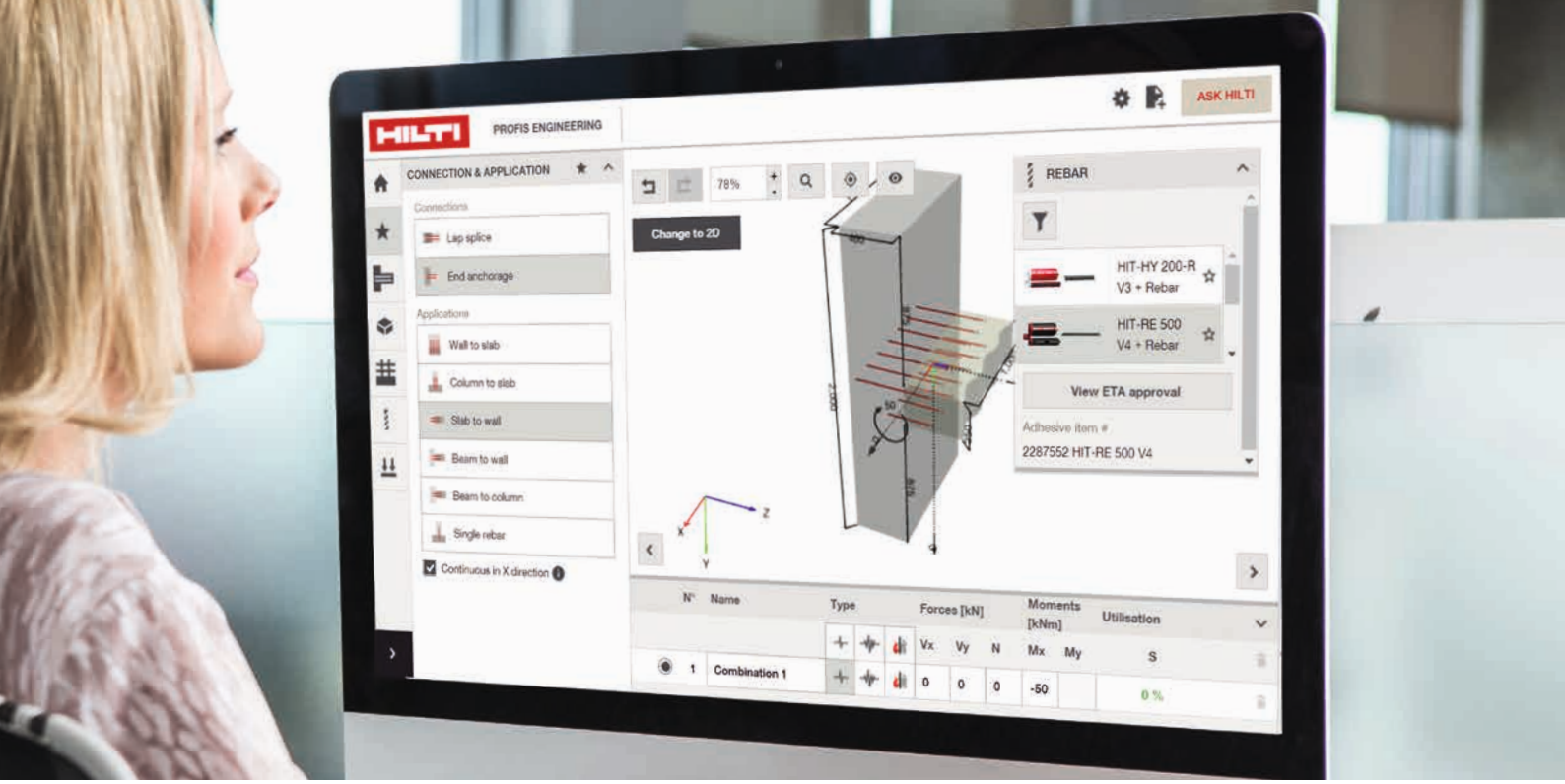
Technical Report TR 069 covers the design of post-installed, moment resisting concrete connections

The new Technical Report TR 069, published in 2019 “Design method for anchorages of post-installed reinforcing bars (rebar) with improved bond-splitting behavior as compared to EN 1992-1-1” allows for the design of post-installed, moment-resisting reinforced concrete connections under static and seismic loading conditions without using a splice configuration. To do so, the product used for post-installed rebar must be assessed following the EAD 332402 “Post-Installed Reinforcing Bar (Rebar) Connections with Improved Bond-Splitting Behavior Under Static Loading and Seismic Action”. The latter includes methods and criteria to assess the real bond-splitting behavior rebar systems, which, depending on the product characteristics, can be significantly higher than for cast-in rebar in accordance to EN 1992-1-1.

TR 069

Connection type	Rigid connection with splice			Rigid connection without splice				
Element	1  Slab to wall	2  Beam to wall	3  Column to slab	4  Column to foundation	5  Wall to foundation	6  Slab to wall	7  Beam to wall	8  Beam to column
Design method	EN 1992-1-1 & EN 1998-1 (Eurocodes 2, Part 1-1 & 8 Part 1)			TR 069 / EN 1992-1-1 & EN 1998-1				

Typical applications of rebar connections covered by EAD 330087 No. 1-3 (EN1992-1-1 & EN 1998-1) and EAD 334202 No. 4-8 (TR 069)



HILTI HIT-RE 500 V4 AND HIT-HY 200-R V3: QUALIFIED THROUGH EAD 332402

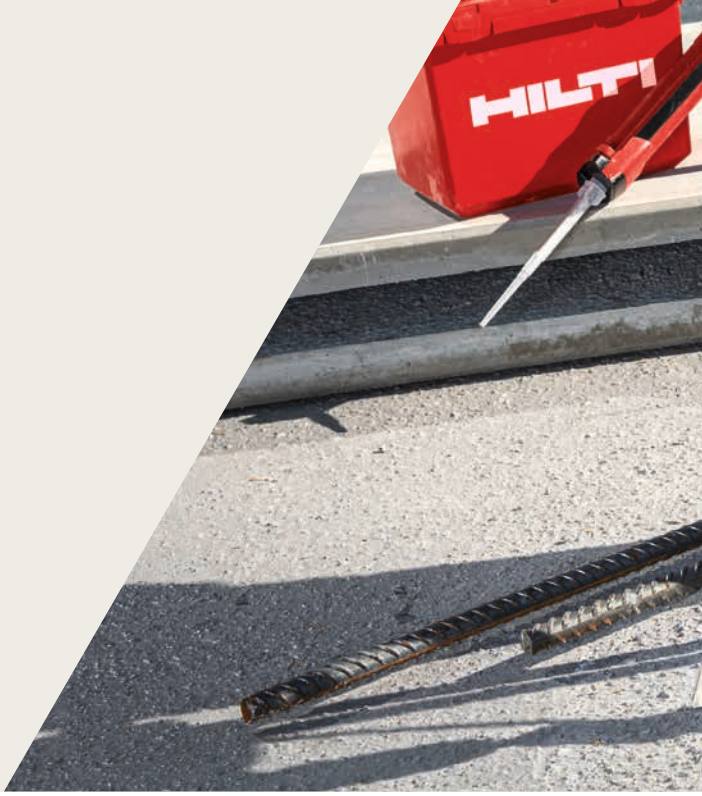
Significant advantages in planning

Hilti HIT-RE 500 V4 and HIT-HY 200-R V3 injectable mortars are qualified through EAD 332402 and can thus be designed and executed by TR 069. This offers you the following advantages:

- Significant increase of application range for post-installed rebar connections
- Flexibility during planning and detailing of moment-resisting reinforced concrete connections
- Less interruption of the construction process due to partial demolition
- Less health and safety risks related to cast-in rebar sticking out of the concrete
- Use the performance of the injection mortar to its fullest extent, optimizing the design solution
- Much longer-lasting, safer post-installed rebar connections that hold true for up to 100 years for tunnels and bridges, or up to 50 years for buildings – their entire estimated life cycle
- Project planning, design and documentation of the calculation process for post-installed rebar using the Hilti PROFIS Engineering design software

CLARITY

TR 069 combines standards and guidelines in concrete construction



DESIGN BY REQUIREMENTS OF REINFORCED CONCRETE

In TR 069, anchor theory meets reinforced concrete design

The new TR 069 combines reinforced concrete design principles (EN 1992-1-1) with anchoring to concrete principles (EN 1992-4). Design following TR 069 is only possible if injection systems are assessed according to EAD 332402. An assessment according to EAD 330087 or EAD 330499 is not sufficient. Within TR 069 the individual failure modes of the system connection are explained in detail. They are:

- Rebar steel yielding
- Concrete cone failure
- Bond splitting failure

The design is based on the hierarchy strength design principle, i. e., the lowest resistance of the individual failure modes is decisive. Yielding of the steel, concrete cone failure and bond-splitting failure of the post-installed rebar connection must be verified. In addition, the requirements of EN 1992-1-1 in terms of minimum anchorage length must be fulfilled. In addition, TR 069 works within the following framework:

- The TR 069 provides a design of the post-installed rebar's anchorage length. The load transfer between new and existing concrete members shall be verified in accordance with EN 1992-1-1 (e. g., shear transfer at the interface and shear resistance of connecting member).

- This technical report covers post-installed rebar connections in reinforced or unreinforced, normal weight, without fibres, non-carbonated C20/25 to C50/60 concrete.

- During the assessment process, the bond-slip behavior for different concrete cover is tested. The product dependent resistance corresponding to bond-splitting failure, and its relevant parameters, are provided in the product ETA and obtained following the qualification process of EAD 332402.

- The safety concept (i. e. partial safety factors) adopted in TR 069 is the same as in the applicable Eurocodes: EN 1992-1-1 (for steel yielding) and EN 1992-4 (for concrete cone and bond-splitting failure modes), which ensure a high level of compatibility of the design output in accordance with TR 069 with the EN 1992-1-1.

FITTING PERFECTLY

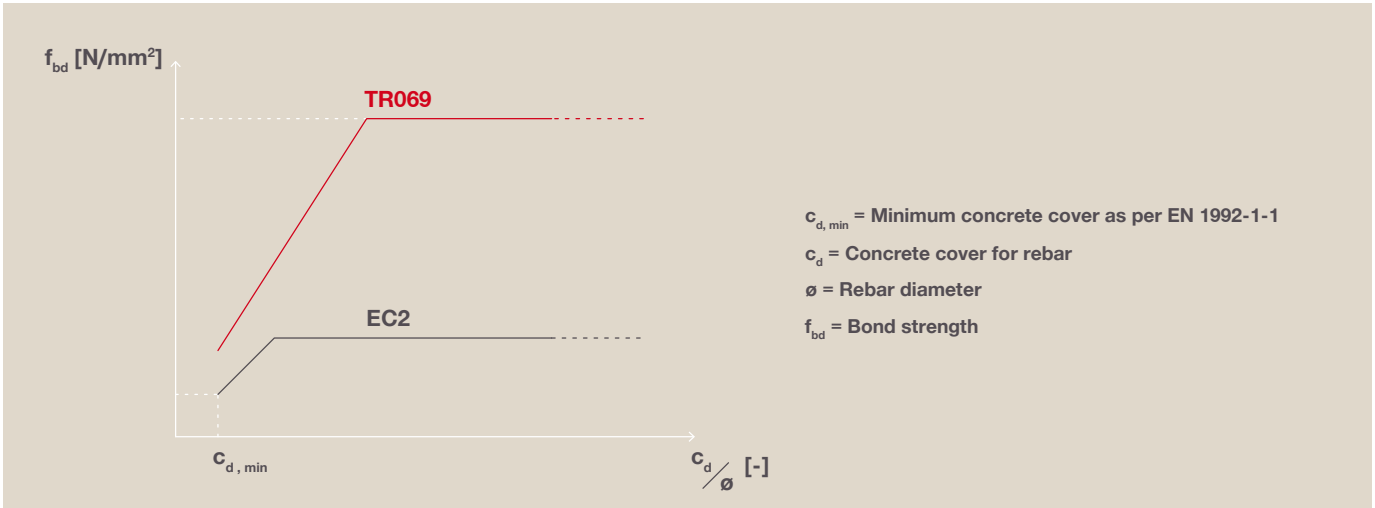
HIT-RE 500 V4 and HIT-HY 200-R V3 injection mortars for post-installed rebar

A PERFECT COMBINATION

Optimized design through better bond strength

It is well known that the thicknes of the concrete cover (or spacing to adjacent rebars) is the key influencing parameter for the bond strength of a rebar. When the concrete cover is thinner, the resulting bond strength is relatively small compared to the bond strength values with increased concrete cover. Post-installed rebar with thinner concrete cover may fail via splitting, while post-installed rebar with thicker cover can fail via pull-out.

In the graph below, the bond curves of cast-in rebar and post-installed rebar using HIT-RE 500 V4 and HIT-HY 200-R V3 for different thickness of concrete covers are qualitatively shown. The test results with HIT-RE 500 V4 and HIT-HY 200-R V3 show a significantly higher bond strength compared to cast-in rebar under the same conditions. This product-related behavior assessed according to EAD 332402 is reflected in the bond/splitting design in accordance with TR 069 and provides the possibility of utilizing this performance in post-installed reinforced concrete connections. As a result, the connection design of the anchorage length can be optimized.



Bond strength vs. concrete cover/diameter for post-installed rebar connection for a certain installation length and concrete strength, based on Eurocode 2 and TR 069 splitting model

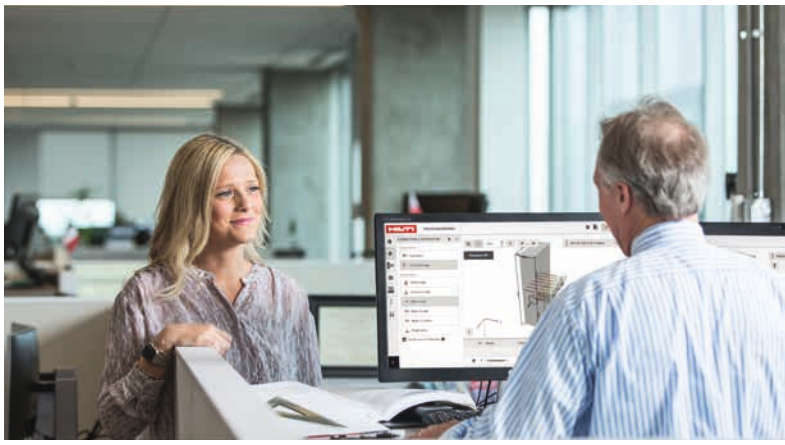
Application conditions of the Hilti HIT-RE 500 V4 and HIT-HY 200-R V3 injection system for post-installed rebar connections

Application conditions	HIT-RE 500 V4	HIT-HY 200-R V3
Connection type	Anchorage, splice, moment resisting connection	Anchorage, splice, moment resisting connection
Load Type/Design Method/EAD	Static, Seismic, Fire/EN 1992-1-1/ EAD 330087-01-0601 Static, Seismic/TR 069/ EAD 332402-00-0601-v2	Static, Seismic, Fire/EN 1992-1-1/ EAD 330087-01-0601 Static/TR 069/ EAD 332402-00-0601-v1
Service life	50 y/100 y	50 y/100 y
Rebar diameter	8 mm – 40 mm	8 mm – 40 mm (up to 40 mm for EN 1992-1-1 design)
Maximum embedment depth	≤ 3.2 m	≤ 1 m
In-service temperature range	–5 °C up to 40 °C	–10 °C up to 40 °C
Working time	10 min – 2 h	6 min – 3 h
Curing time	4 h – 168 h	1 h – 20 h
Dry and wet drilled hole	Yes	Yes
Water-filled drilled hole	Yes (only TR069 design)	No
Hammer drilled hole	Yes	Yes
Diamond drilled hole	Yes	Yes (14 mm – 28 mm rebar diameter)
Hilti SafeSet technology with roughening tool	Yes	Yes
Hilti SafeSet technology with hollow drill bit HDB and Hilti vacuum	Yes	Yes

SAFETY IN DESIGN AND EXECUTION

PROFIS Engineering: Planning, designing and documenting in one tool

Using the free Hilti PROFIS Engineering design software you can resolve every type of post-installed reinforced concrete connection: from simply supported to moment-resisting to splice. PROFIS Engineering offers you flexibility and efficiency, always according to the latest regulations and standards (TR 069, EC2). In addition, it generates an easy-to-use design report for your project documentation.



Tender templates

Design according to TR 069 (without splice) **Post-installed rebar connection Hilti HIT-RE 500 V4 and HIT-HY 200-R V3 with B500B according to TR 069**	**Design according to EN 1992-1-1 (with splice)** **Post-installed rebar connection Hilti HIT-RE 500 V4 and HIT-HY 200-R V3 with B500B**
Post-installed rebar connection with Hilti HIT-HY 200-R V3 fast-curing injection mortar (or equivalent) and rebar (B500B)	Post-installed rebar connection with Hilti HIT-HY 200-R V3 fast-curing injection mortar (or equivalent) and rebar (B500B)
Rebar diameter: ... mm	Rebar diameter: ... mm
Embedment depth in concrete: ... mm	Embedment depth in concrete: ... mm
Total length rebar: ... mm	Total length rebar: ... mm
Quantity and position of rebar are to be taken from execution planning or static attestation and to be observed	Quantity and position of rebar are to be taken from execution planning or static attestation and to be observed
Installation according to ETA-20/0539 or ETA-19/0665 & EAD 332402-00-0601 for design in accordance with TR 069 in concrete C20/25 to C50/60	**Installation according to ETA-20/0540 or ETA-19/0600 & EAD 330087 in concrete C12/15 to C50/60**
An assessment according to EAD 330499 or EAD 330087 or both is NOT sufficient.	

SafeSet: Consistent safety during installation

The load-bearing capacity of post-installed rebar connections can be influenced significantly by the installation process. The appropriate cleaning of the drilled hole and a void-free installation can be achieved following the Instruction For Use (IFU) of the post-installed rebar system. Inserting the rebar up to the required anchorage length within the working time of the mortar is another crucial factor in your installation process.

To minimize installation errors, HIT-RE 500 V4 and HIT-HY 200-R V3 injection mortars are compatible with the SafeSet system.

When hammer drilling, the Hilti SafeSet system relies on hollow drill bits (HDB) connected to a vacuum cleaner (e. g. Hilti VC 40-U or VC 20-U vacuums) to drill and clean the hole in one step. Hilti HDBs utilize the same state-of-the-art carbide drilling technology as Hilti TE-CX and Hilti TE-YX bits. The Hilti SafeSet system performs equally well in dry and wet concrete and eliminates the most load-affecting and time-consuming step in the installation process: cleaning the hole before injecting the adhesive.

When diamond coring with roughening, Hilti SafeSet uses the TE-Y RT “Flex fork” roughening tool. This creates a rough surface within the diamond-cored hole – helping to increase the mechanical interlock between mortar and concrete. The result is much higher bond strength values with fewer, simpler cleaning steps.

Hilti SafeSet helps to minimize installation errors, contributing to a design which performs as you need it to on the jobsite.

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