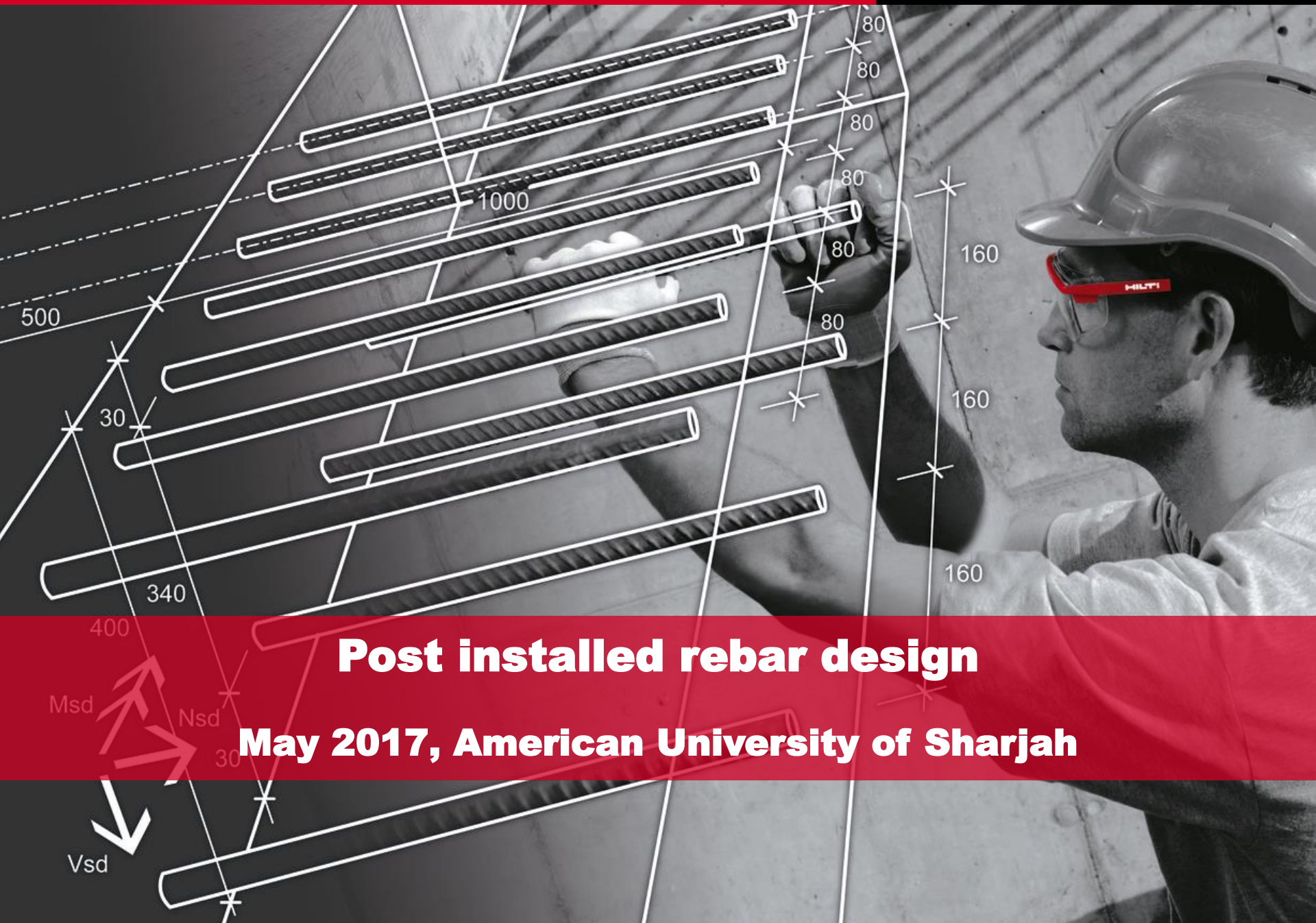
Hilti. Outperform. Outlast.



Post installed rebar design

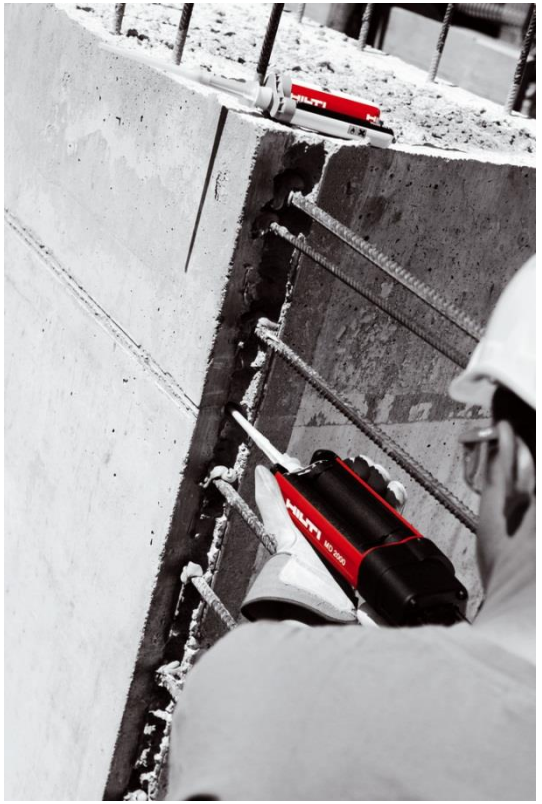
May 2017, American University of Sharjah

Agenda

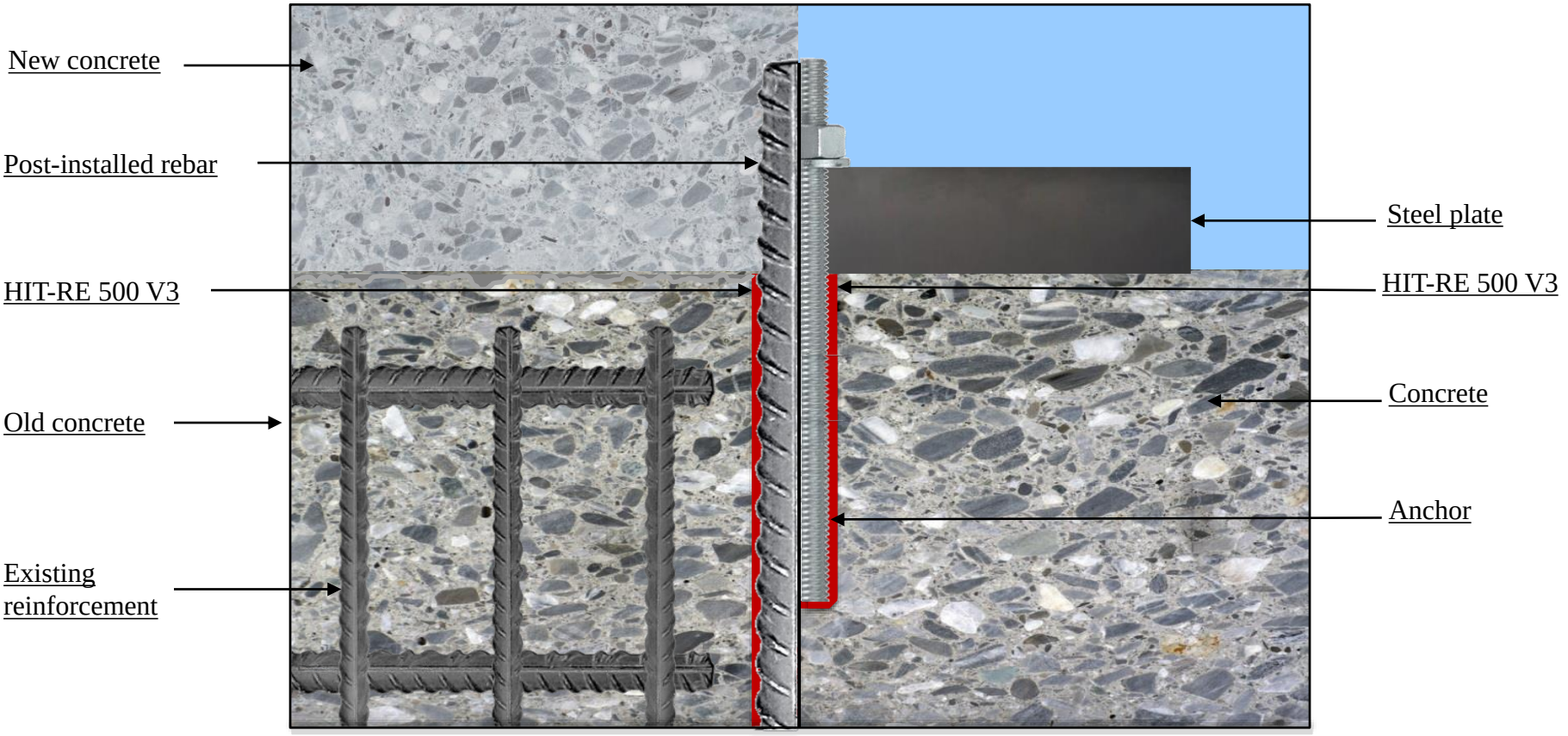
- **Scope and applications**
- **Available design methods**
- **How to transfer moments to an existing slab?**

  Frame node design
- **How to optimize the design?**

  Take the maximum power of the chemical
- **Questions**



The same product has different features if used for anchor applications or for post-installed rebar applications



Post-installation scope and applications

3 Main needs for post-installation of rebars:

Missing or misplaced rebars

Necessary for:

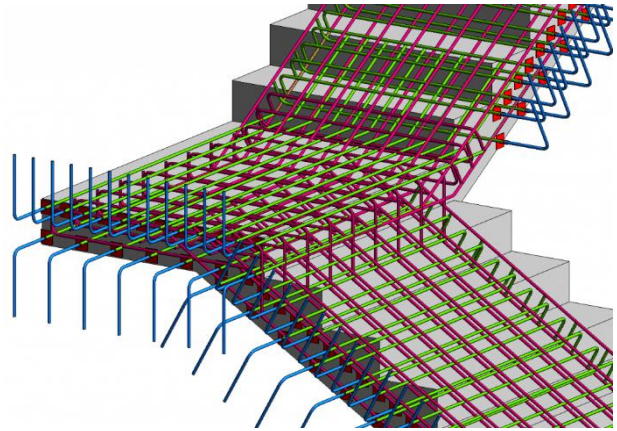
- Missing bars due to mistakes on the jobsite
- Change in the design of the structure

Additional rebars

Necessary for:

- Correction of the general architecture
- Required additional bars for additional strength

Alternative construction method



Necessary for:

- Fixing of Staircases
- Stiffner Columns
- Replacing couplers and other time consuming applications

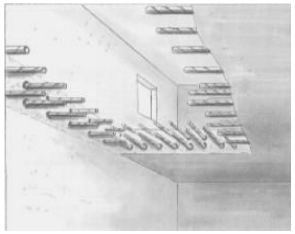
Example of applications

Extension of slabs, balconies & stairs

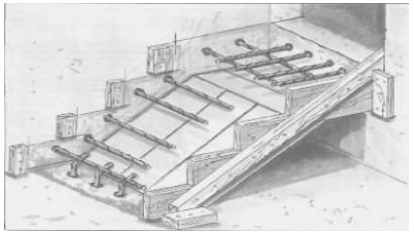
Connections of new slabs

Balcony extension

Close openings / slab enlargement



Staircase connection



Post installed rebars gives the flexibility required for new constructions and allow easier renovation

Example of applications

Extension of columns, beams & walls

Connections of new columns


Reservoirs extension

Connection of beams


Wall extension

Post installed rebars gives the flexibility required for new constructions and allow easier renovation

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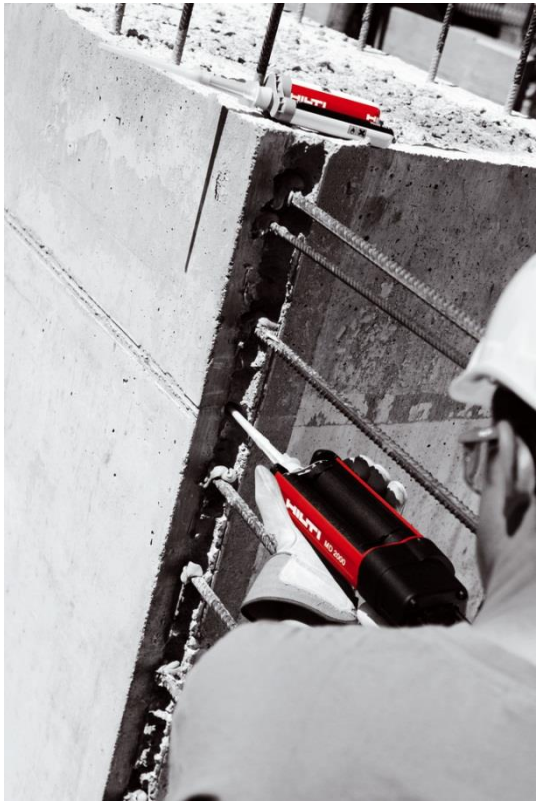
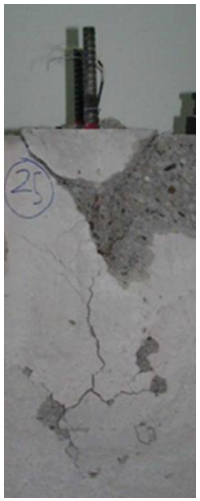


Design method that should be avoided (safety risk)

1. 10/12/15… x diameter embedment

- Basic / Simplistic design method
- Small concrete covers are not considered
- Splitting and concrete cone failure modes are ignored
- Simultaneous behavior of rebars is not taken into consideration

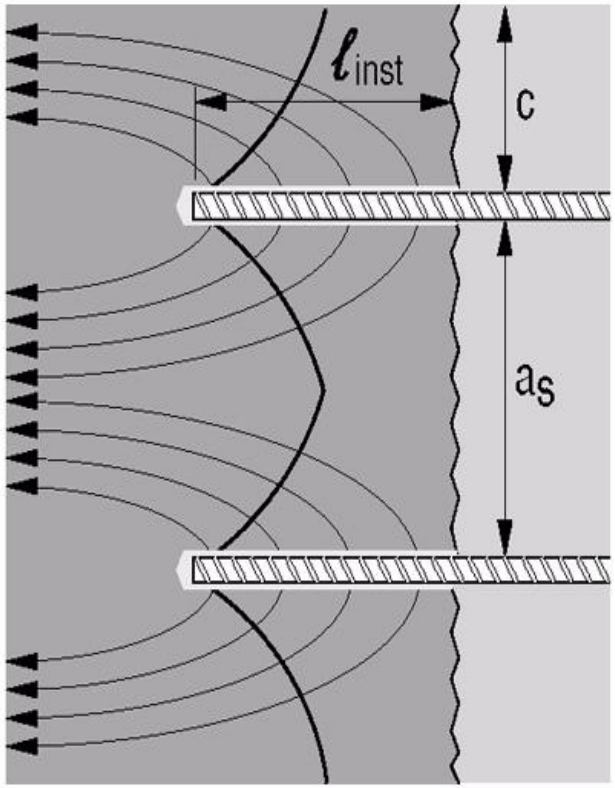


Datasheets and tables should be avoided in all post-installation fixings

Design method that can be used (not recommended)

2. Design of Rebar as an Anchor (ETAG 001 – Annex C)

- Load acting on rebar is transferred to the concrete
- Rebar resists both Shear and Tension forces
- Takes into account the concrete cone failure
- Spacing and edge distance will often make anchor design impossible for rebars (As per ETA values of Spacing and Edge Distances on Anchor Theory)



The correct design method for post-installed rebars

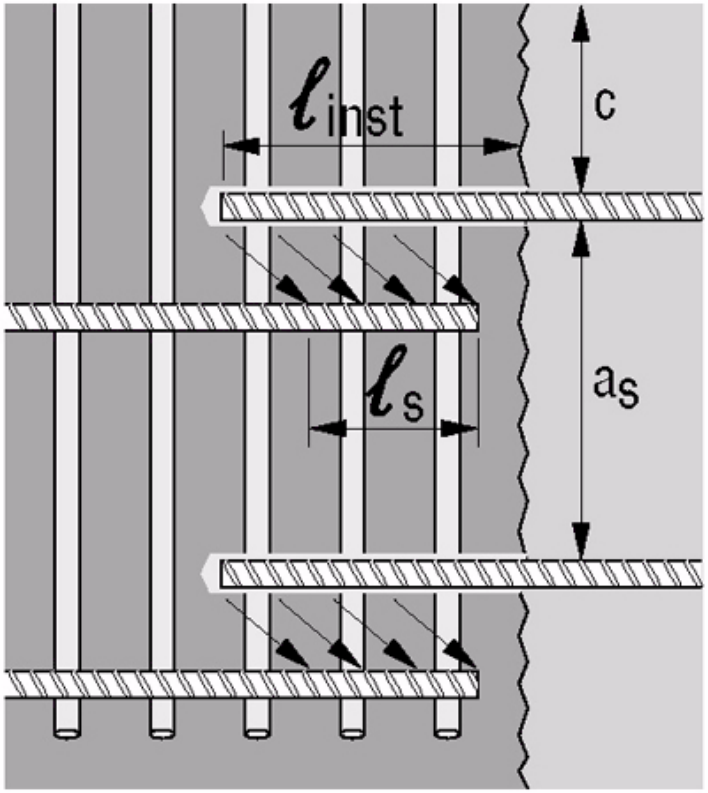
3. Eurocode 2 Part 1 (EN 1992 – 1)

- The logic is that post-installed rebars will work the same way as a straight cast-in bar.
- The requirements to be able to design according to EC2 is to have a rebar ETA TR023.
- The failure modes possible to occur are all ductile, concrete cone is impossible to occur.

We can calculate as per EC2 the embedment length using the following:

$$l_{b,rqd} = \frac{\emptyset}{4} \cdot \frac{\sigma_{sd}}{f_{bd}} \qquad l_{bd} = l_{b,rqd} \cdot \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_4 \cdot \alpha_5$$

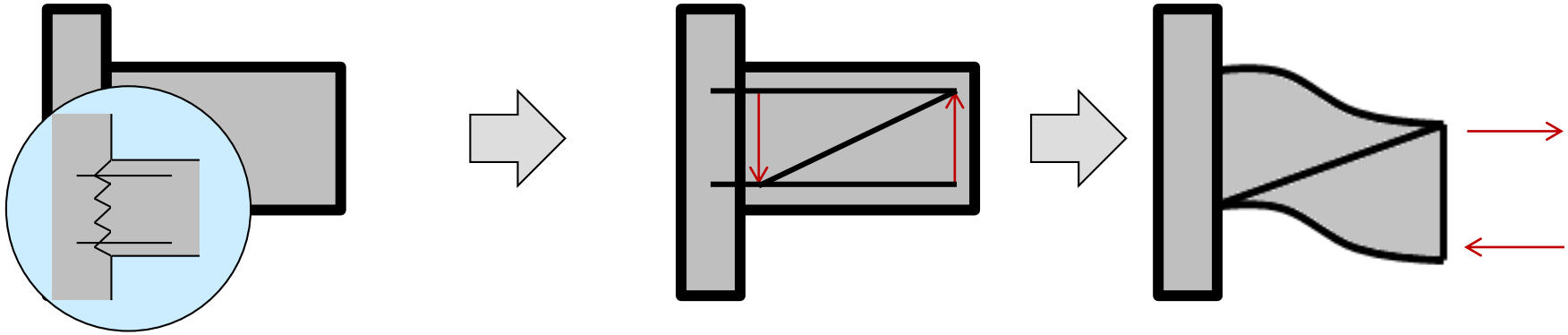
Load is transferred from the post installed rebar to the existing rebars



Unlike the Anchor Theory, the load is transferred from the new rebars to the existing rebars through the concrete

The rebar is designed only to take pure tension

If we have a shear loading on a concrete member fastened on a roughened surface, using a strut-and-tie model allows us to see the shear load into a pure tension.



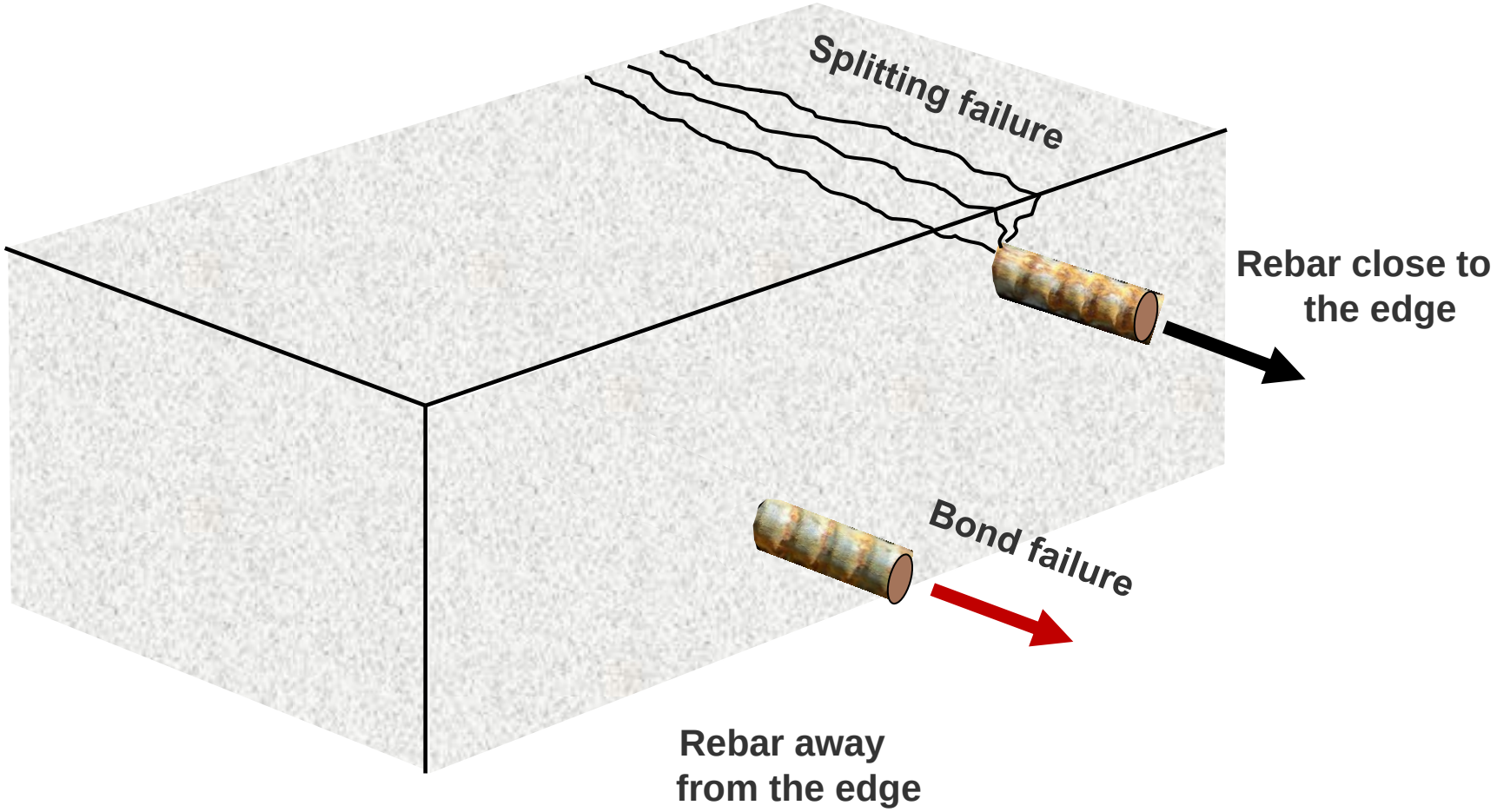
Roughened surface

Pure shear application

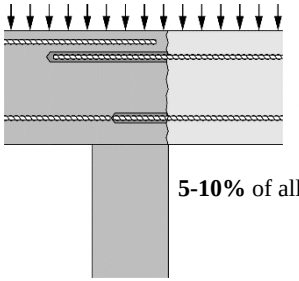
Only tension is acting on the rebars !

This is coming from Eurocode 2 (as per EN 1992-1-1:2004) and is required for any rebar application (cast-in as well as post-installed)

Two failure possibilities are considered by EC2 formulation



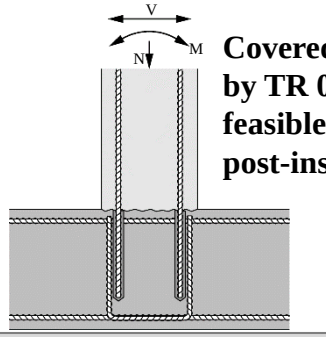
Moment resisting nodes are in practice not possible according to EC2/TR023 approach



Covered by TR 023

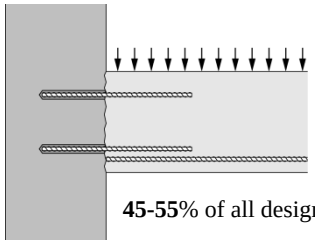
5-10% of all design cases

Overlap joint for rebar connections of slabs and beams



Covered by TR 023, but not feasible with post-installed rebars

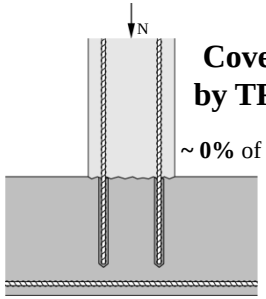
Overlap joint at a foundation of a column or wall



Covered by TR 023

45-55% of all design cases

End anchoring of slabs or beams (simply supported)

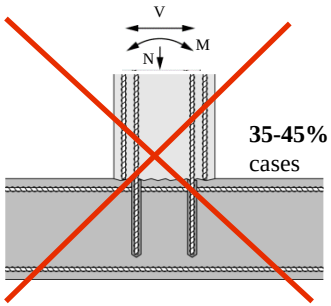


Covered by TR 023

~ 0% of all design cases

Components stressed primarily in compression

NOT covered by TR 023 but highly requested by specifiers



35-45% of all design cases

Components subjected to bending moment and compression

In 35-45% of all design cases EC2/TR023 does not provide a solution

Hilti provides a solution following the philosophy of EC2

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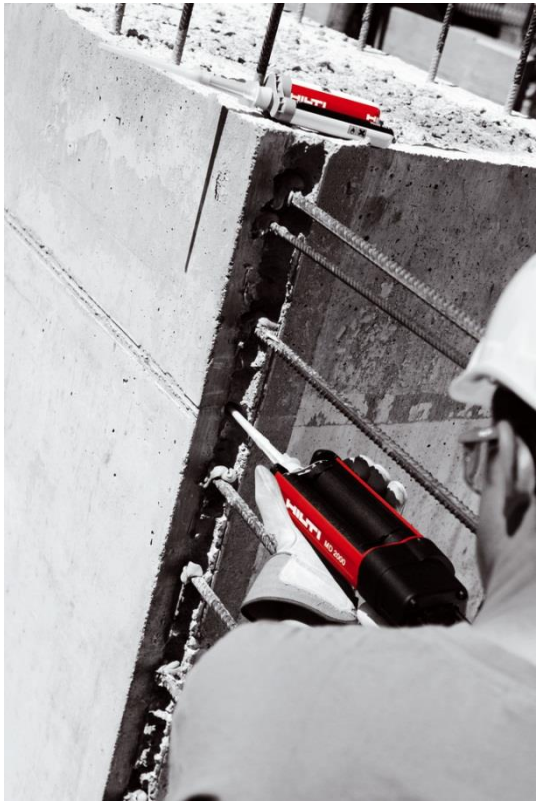
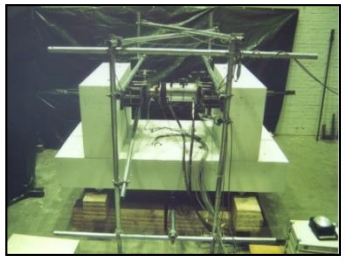
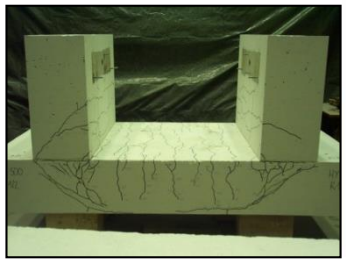


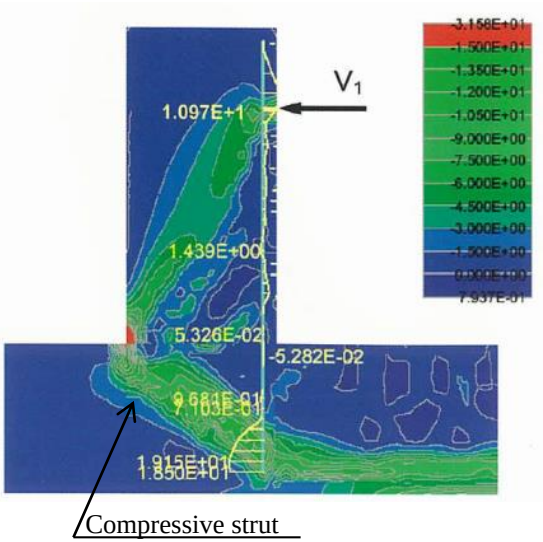
For some applications, moment transfer is required for post-installed rebars

Tests





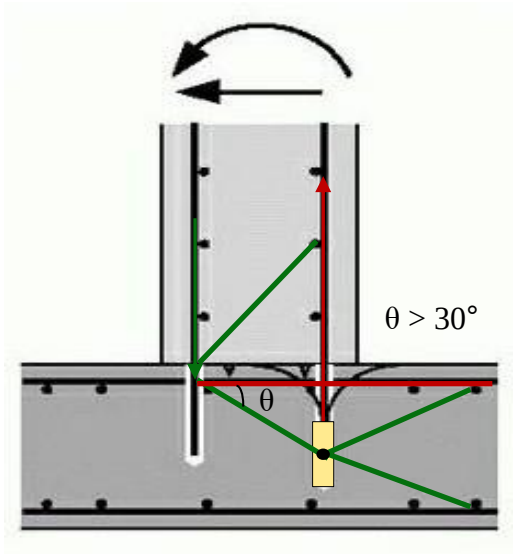
Finite Element Analysis



Only the main struts are shown

The force flow in the frame node
(Hilti research with Technical University of Munich and the American University of Beirut).

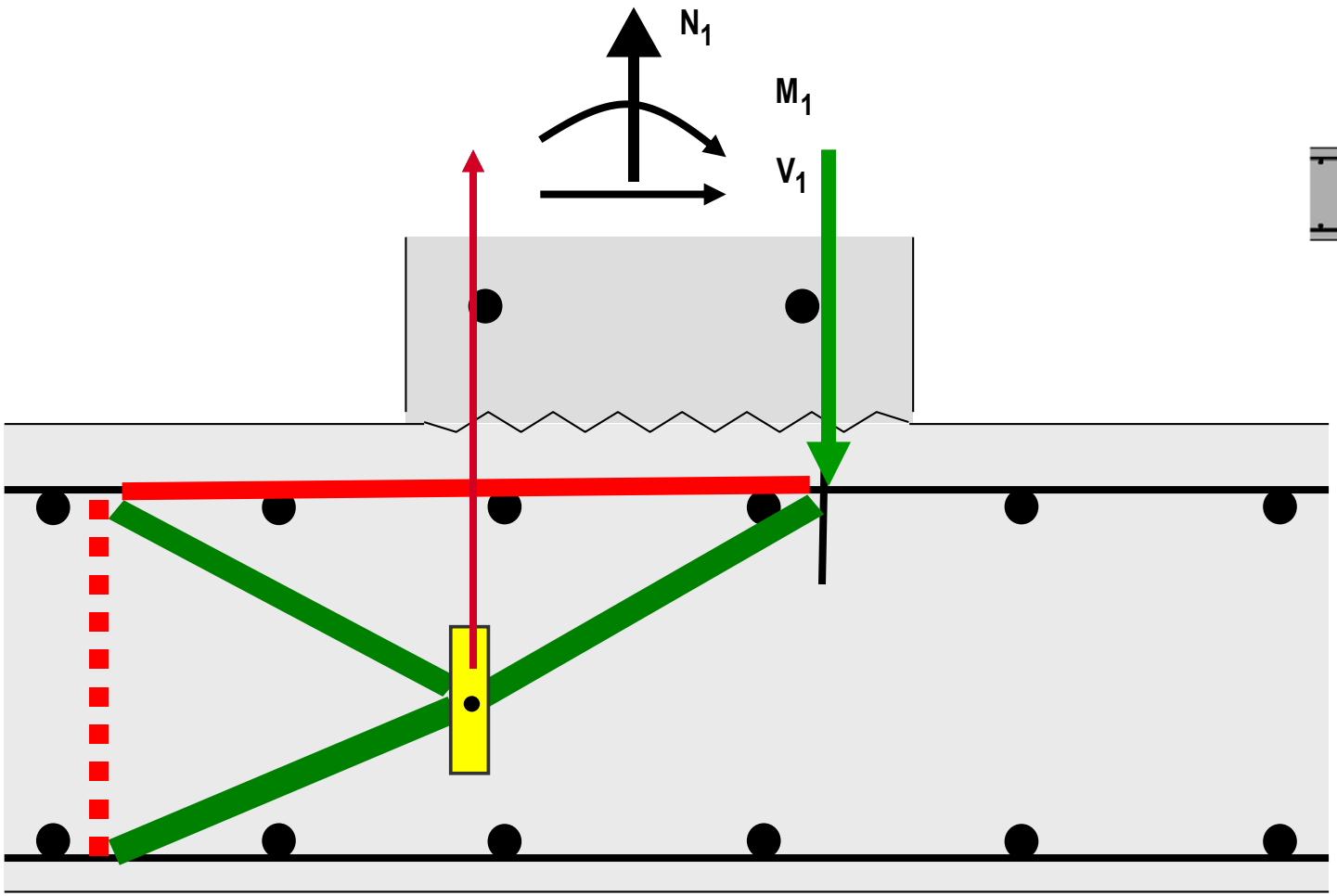
Strut and tie model

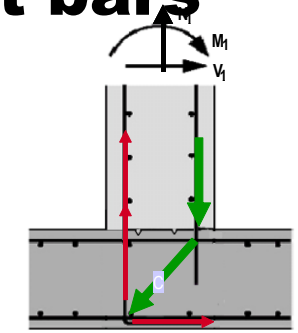


The strut and tie model is developed for straight bars (Hilti research), showing that this application can also be designed according to EC2 approach.

Hilti provides a strut and tie model for moment resisting node with straight bars

Together with TU Munich and AUB, Hilti has developed strut and tie model for straight bars





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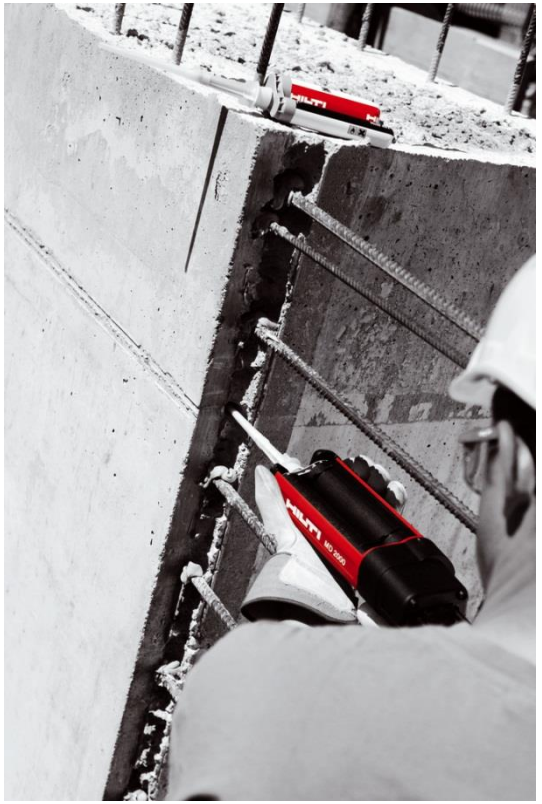
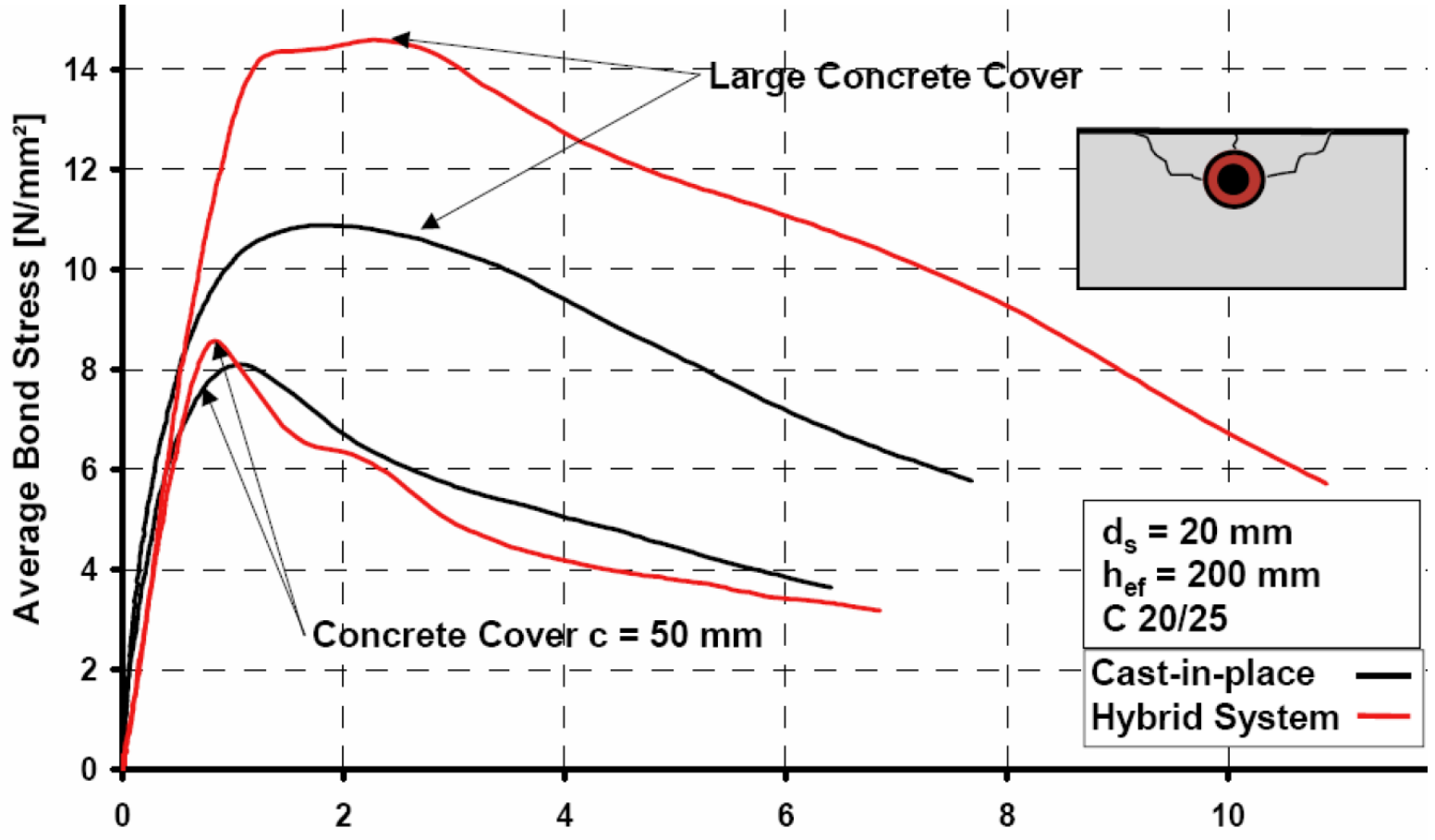
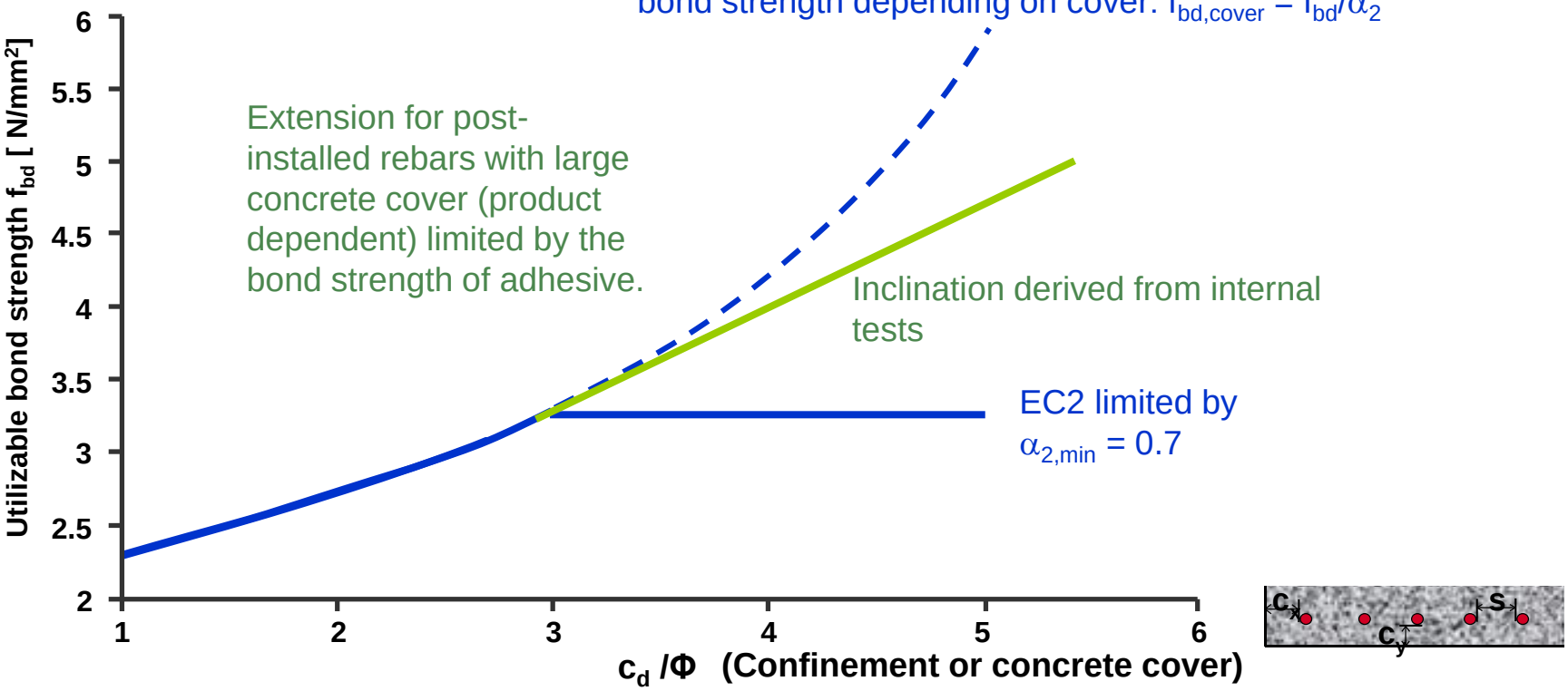


With large concrete cover post-installed rebar is stronger than cast-in



We know from our 30 years anchoring experience that our chemicals have a higher bond strength than concrete

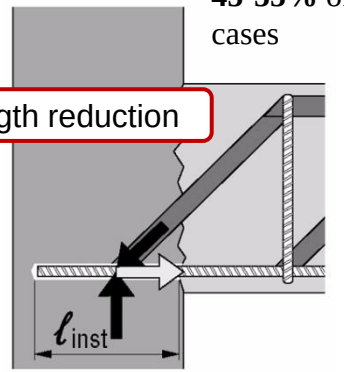


We are able to use more of the capacity of the mortars as soon as we are above c_d/Ø > 3

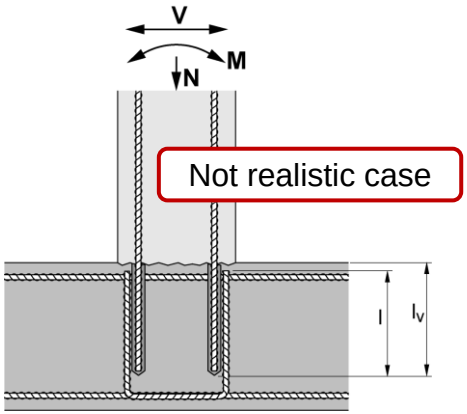
By doing these internal tests we were able to provide and optimize a solution for all cases on the jobsite

45-55% of all design cases

Length reduction

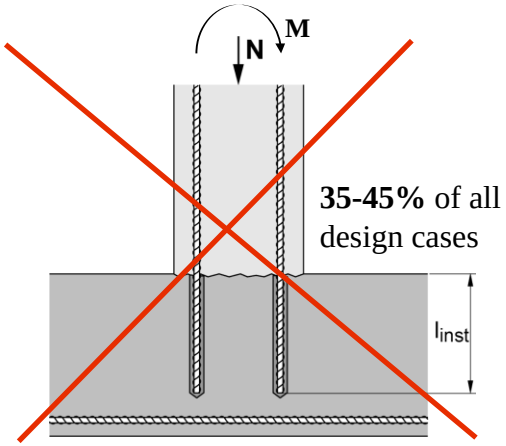


End anchoring of slabs or beams, designed as simply supported



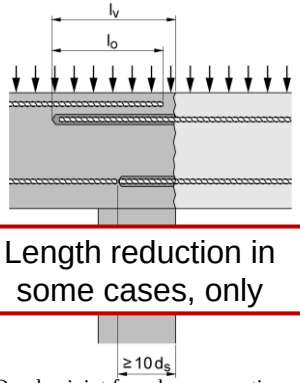
Not realistic case

Overlap joint at a foundation of a column or wall



35-45% of all design cases

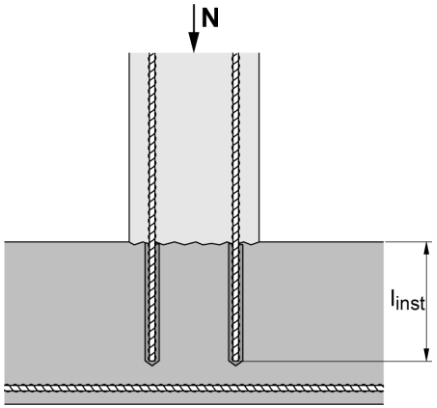
Rebar connection for components subjected to bending moment



5-10% of all design cases

Length reduction in some cases, only

Overlap joint for rebar connections of slabs and beams



Rebar connection for components stressed primarly in compression

No solution according to EC2!

Hilti provides:

- Design solution
- Length reduction

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