HRC-products and EN 1992-1-1 (Eurocode 2)

HRC-products:

T-headed reinforcement (HRC 100 Series)

Use of T-heads is a method for mechanical anchorage of reinforcing steel bars.

HRC T-headed reinforcement anchors the full tensile capacity of the rebar in the head alone. This saves space and material compared to anchorage by hooks, bends or anchorage length. Additionally, headed rebar is easier to handle than bend rebar. T-headed bars are thus a contribution to a more efficient reinforcement.

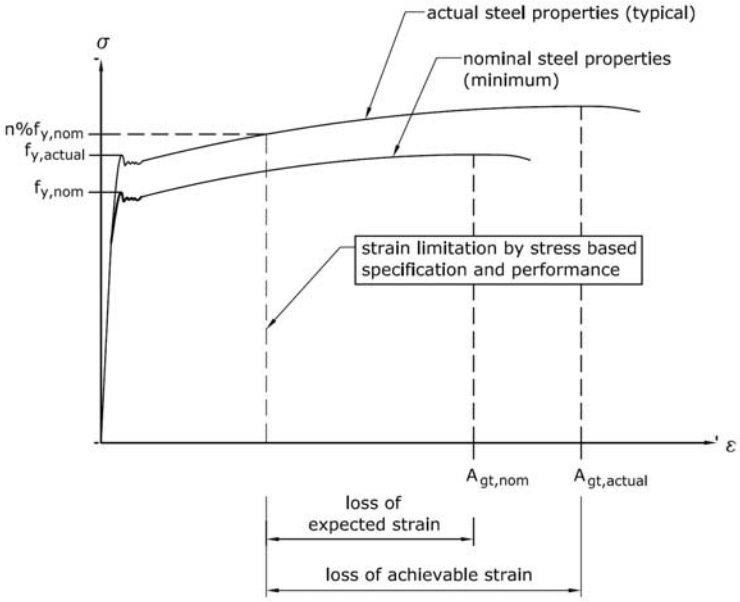
One possibility when using T-headed bars is to replace rebar of a certain diameter by fewer rebar with larger diameter. In this way congested areas will be relieved, resulting in less working hours needed for placing of the reinforcement, more precise execution and improved casting conditions. Improved casting conditions have positive effects for the durability of the construction.

Mechanical couplers (HRC 400 Series)

Rebar couplers of HRC 400 Series transfer the full actual tensile capacity of the reinforcing steel. This means that the couplers do not present a weak link for a coupled rebar and the full actual ductility of the reinforcing steel (strength and strain) can be utilized. HRC 400 couplers have small slip values (plastic deformation after loading). The high capacity and the small slip values allow the splicing of all rebar in one section.

HRC 400 series couplers have coarse tapered threads, which are robust and easy to install.

The diagram to the right illustrates how a reinforcement coupler with insufficient capacity will hinder the utilization of the full ductility of the reinforcing steel (strength **and** strain): The stress- and strain properties of most rebar steel heats exceed the minimum requirements of the standards as $f_{y,spec}$ ($f_{y,nom}$) and $A_{gt,nom}$. If the prescribed capacity of the coupler (n%* $f_{y,spec}$) is too low, the prescribed strength will be achieved, but the usable elongation will be limited considerably. This reduces the robustness of the structure and might be harmful for design which makes use of the full ductility of the reinforcement.



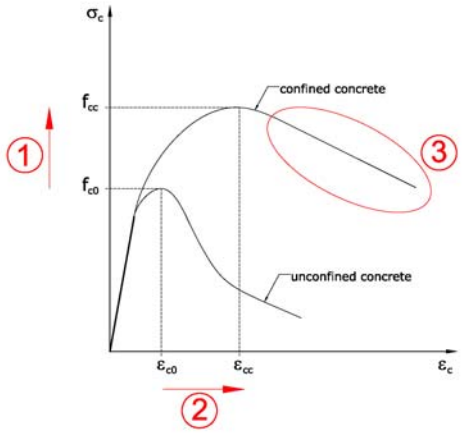
Comments to some clauses of EN 1992-1-1:2004

3.1.9 Confined concrete

"... Confinement can be generated by adequately closed links or cross-ties, which reach plastic conditions due to lateral extension of the concrete."

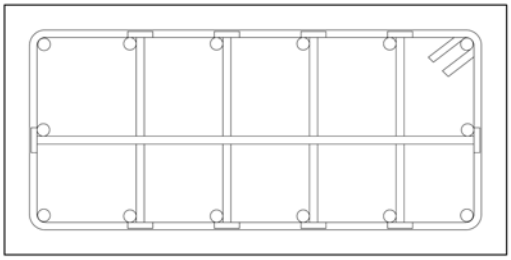
Comment:

The diagram to the right shows the effects of confinement: (1) increase of concrete strength, (2) increase in compression strain and (3) slower strength decrease after the onset of crushing (ductile failure). The effectiveness of the confining reinforcement depends on its stiffness as a system, i.e. both stiffness of the rebar (adjustable with rebar diameter) and stiffness of the anchorage of the rebar.



HRC T-heads are designed to anchor the full actual tensile strength of the reinforcing bar without crushing the concrete underneath the head in concrete of at least 30MPa compressive strength. Contrary to that anchoring by hook or bend will lead to some crushing of concrete because of the large contact pressure in the rebar bend and thus to some slip of the rebar. Anchorage by a T-head is therefore stiffer than anchorage by hook or bend. The confining effect becomes operative in the very moment the concrete starts to expand in lateral direction.

Use of T-headed bars for confinement has some practical advantages as well: the installation of T-headed bars is easy and quick and the rebar diameter can easily be adapted to the real need, because the rebar don't need to be bent. This will avoid congestion and improve the casting conditions



Possible applications are at the anchorage of post tensioning cables and confining reinforcement in columns and shear walls.

T-headed reinforcement at anchorage of post tensioning cables

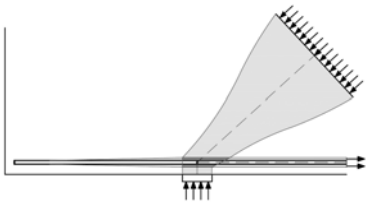
... and in a shear wall

6.5 Design with strut and tie models
6.5.3 Ties
(2) "Reinforcement should be adequately anchored in the nodes."

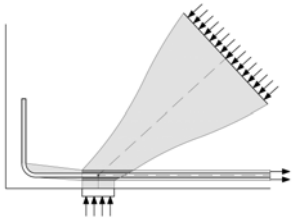
Comment:

HRC T-heads anchor the full actual tensile capacity of the rebar in the head alone. This is a space-saving and safe anchorage just in one point and creates good conformity between the model and reality.

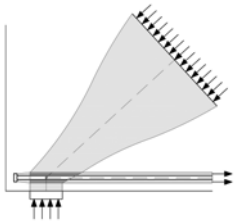
Additionally, avoiding anchorage bends and hooks saves material and gives more flexibility in the choice of the rebar diameter (there is no bending radius dictating the size of the applicable rebar diameter).



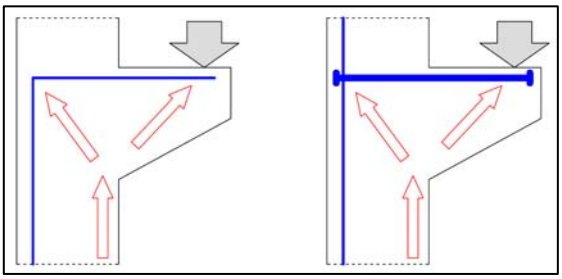
Different anchorage lengths by using straight bar…

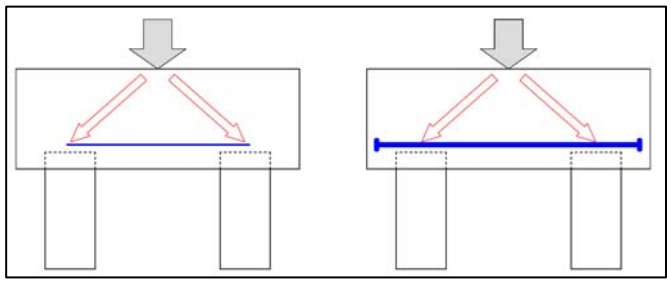


standard bend…

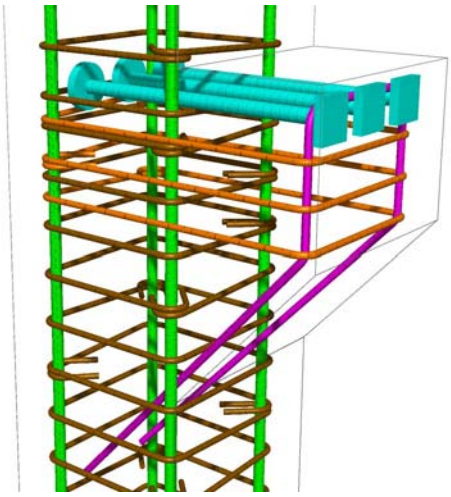


…and T-head

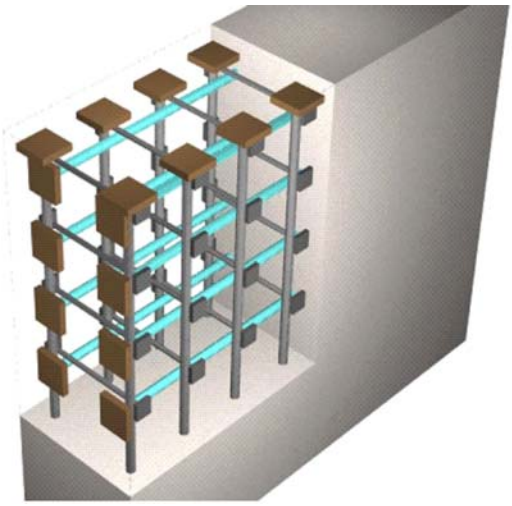




Strut-and-tie-models and the use of T-headed bars in design



Reinforcement of a Corbel



Reinforcement of a corner (note the small T-headed bars providing confinement)

8.4 Anchorage of longitudinal reinforcement

8.4.1 General

(5) "Where mechanical devices are used the test requirements should be in accordance with the relevant products standard or a European Technical Approval."

Comment:

HRC 100 Series T-headed bars are covered by an European Technical Approval (ETA -08/0035) and bear the CE-marking.

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Authorised and notified according to Article 10 of the Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products

MEMBER OF EOTA

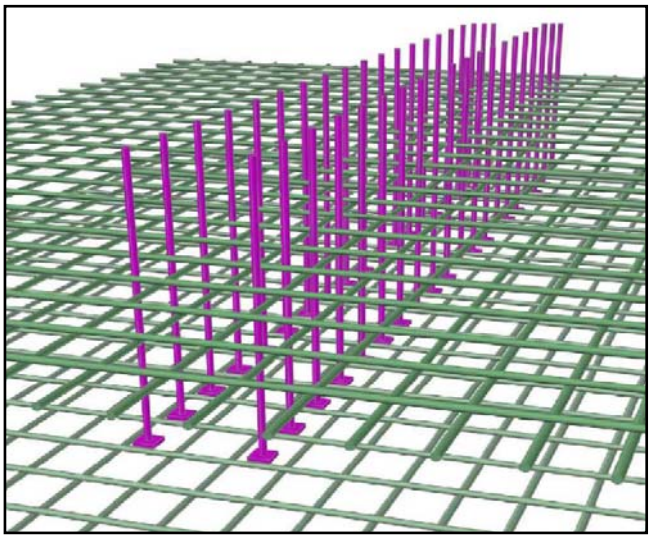
European Technical Approval ETA-08/0035

This ETA replaces ETA-08/0035 with validity from 31.01.2008 till 31.01.2013

Trade name:	HRC 100 Series T-headed bars
Holder of approval:	Metalock Industrier AS Lierstranda 107 N-3400 Lier Norway
Generic type and use of construction product:	T-headed reinforcement steel bars
Valid from: to:	08.10.2009 31.01.2013
Manufacturing plant:	Metalock Industrier AS Lierstranda 107 N-3400 Lier Norway
This European Technical Approval contains:	7 pages including 1 Annex which forms an integral part of the document

EOTA European Organisation for Technical Approvals

ETA for HRC 100 Series



Anchorage of wall reinforcement in a slab, where reinforcement carpets were used (T-headed bars are placed after all layers of the slab reinforcement are installed).

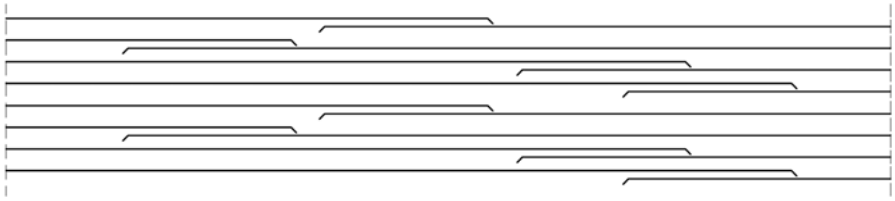
Additional T-headed reinforcement to cover peak bending moments in a slab: no anchorage length

8.7.3 Lap lenght

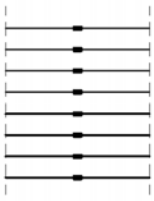
Comment:

Calculating lap lengths according to EC 2 is quite complex. Additionally, there is a demand to a systematic offset (staggering) of the lap splices in order to avoid to get ”punished” with increased lap length (factor α_6). The result are many different rebar lengths for staggering, alternatively the use of longer lap lengths (more material) for the splice of all bars in one section. Many bar lengths are a challenge to logistics on site and may lead to a possible increase in installation time. The consequences depend much on the rebar diameter.

HRC 400 rebar couplers transfer the full real tensile capacity of the reinforcing bar and have small slip values. All rebar can be spliced in one section, avoiding completely lap lengths and many different bar lengths which have to be handled – saving time and material.



Outline of a lap splice according to EN 1992-1-1 in order to avoid increased lap length



Alternative: use of mechanical couplers

8.7.4.1 Transverse reinforcement for bars in tension

(3)”… If more than 50% of he reinforcement is lapped at one point and the distance, a, between adjacent laps at a section is ≤ 10ø (see Figure 8.7) transverse reinforcement should be formed by links or U bars anchored into the body of the section.”

Comment:

In order to avoid the mentioned extra reinforcement the laps have to be staggered considerably and spliced bars need to have a certain distance. This means many different bar lengths and more work at the site. This situation may be difficult to avoid anyway, for example in beams.

HRC rebar couplers transfer the full real tensile capacity of the rebar and have little slip. All rebar can be spliced in one section, avoiding both lap length and additional reinforcement. This saves material and installation time.

8.8 Additional rules for large diameter bars

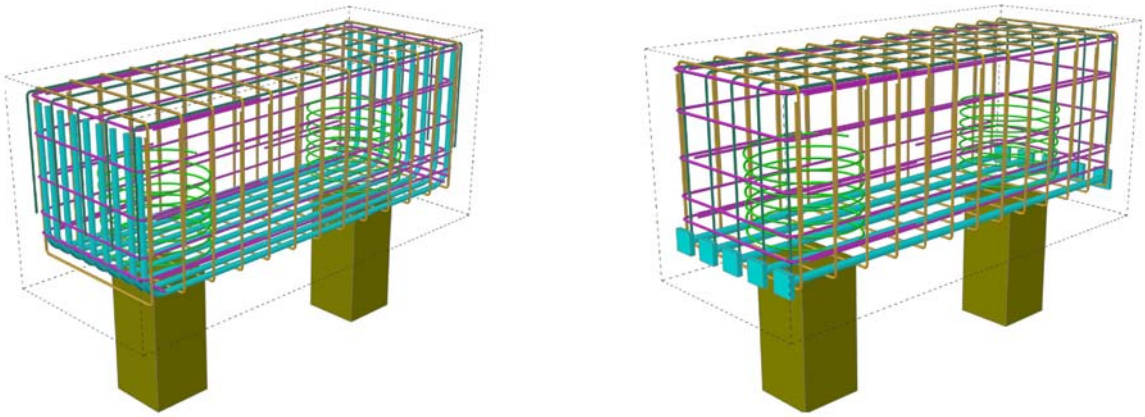
(3) "Such bars should be anchored with mechanical devices."

(4) "Generally large diameter bars should not be lapped."

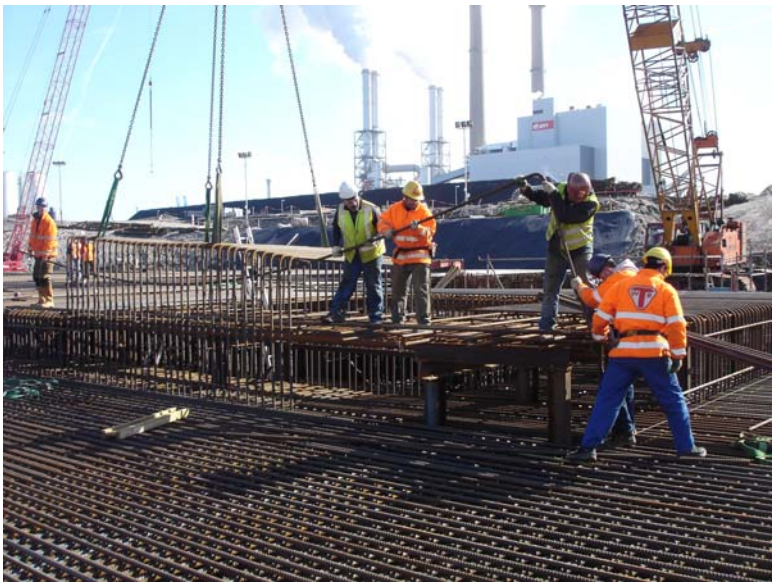
Comment:

Anchorage and lap splicing of large diameter bars need much space and rebar material, because of long anchorage- and lap lengths and large bending radius. This is valid not just for "large diameters" according to the code, but for all rebar with larger diameter.

HRC T-heads and - couplers anchor and splice reinforcing bars in a safe way, regardless of the rebar diameter. This allows for possible reduction of the geometry of the structure and saves material. Additionally, straight bars (with T-head) are considerably easier to ship and to install on site, compared to bend bars.



Rebar amount in the right hand picture is reduced by 26%, just by replacing the bend main rebar in the bottom with T-headed bars with larger diameter.



Labor-intensive and inconvenient placing of long bend rebar

Frame corner with T-headed bars

9.2 Beams

9.2.2 Shear reinforcement

(2) "The shear reinforcement may consist of a combination of: links; … cages, ladders etc. Which are cast in without enclosing the longitudinal reinforcement but are properly anchored in the compression and tension zones."

(4) "At least β_3 of the necessary shear reinforcement should be in the form of links."

Note: The value of β_3 *for use in a Country may be found in its National Annex. The recommended value is 0,5."*

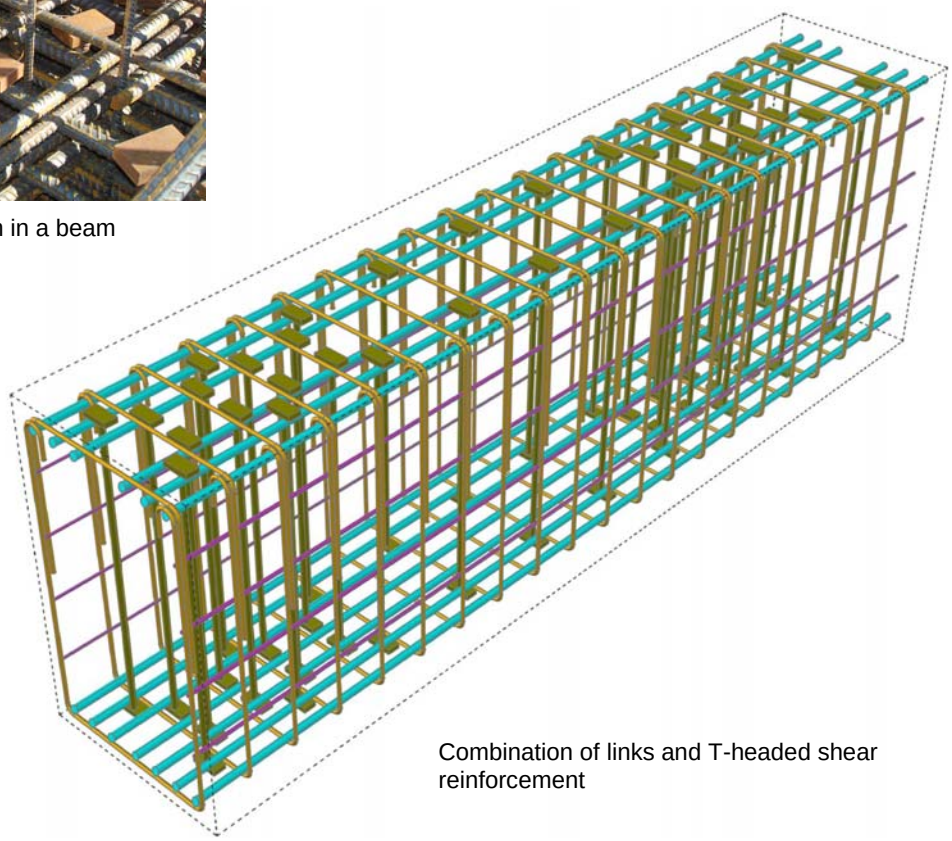
Comment:

The clause says that only a part of the total amount of the shear reinforcement must be in form of links, enclosing the longitudinal rebar. Recommended amount is 50% formed as links. This can be simplified by using just one rebar diameter and constant spacing for the links. Afterwards one can "fill up" with T-headed shear reinforcement to cover the actual need. T-headed shear reinforcement is placed after the installation of the longitudinal rebar. The T-heads assure full anchorage at both ends. T-headed shear reinforcement as alternative to rebar with hooks allows more flexibility when choosing rebar diameter, because the bar does not need to be bent. Thus one can achieve large reinforcement percentages without the danger of congestion (use of few large diameter bars instead of many thin bars). Applications may be areas with large shear forces as supports or lifting points. T-headed shear reinforcement is easy and quick to install and straightforward in control. This saves material and time.

T-headed shear reinforcement Ø32mm in a beam

T-headed shear reinforcement can be fixed with wire or by welding. EN 13670 "Execution of concrete structures" allows principally the assembly of reinforcement by spot welding. Exceptions might be structures prone to fatigue loads. This must be stated in the execution specifications.

Fixing of T-headed bars by tie wire



Combination of links and T-headed shear reinforcement

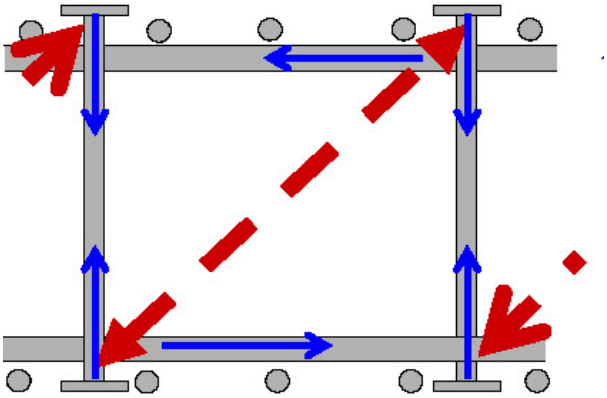
Shear reinforcement in slabs

Compared to beams, shear reinforcement in slabs are not links enclosing all longitudinal reinforcement. Shear reinforcement in slabs are single units with specific distance, which have to be fully anchored at both ends.

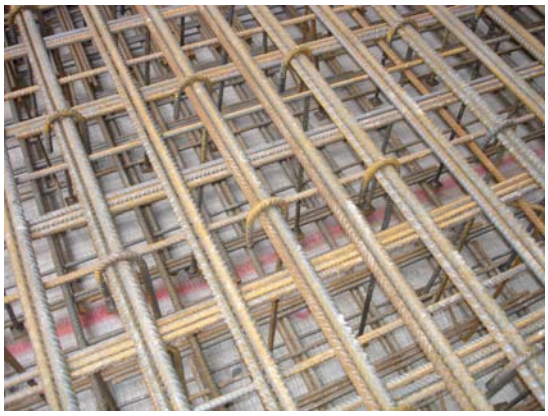
According to strut-and-tie modeling the load transfer from the diagonal compression struts to the horizontal- and vertical components takes place in nodes. Because there is not enough space for an anchorage length, the longitudinal reinforcement is exposed to a vertical component, trying to push the rebar outwards. To avoid this, conventional vertical shear reinforcement in slabs should enclose the longitudinal rebar.

However, T-headed shear reinforcement is fully anchored in the node. Thus it is able to accommodate the complete vertical component from the diagonal compression strut. The longitudinal reinforcement will therefore not experience the “push-out effect” of this component and need not to be “tied inn” by the shear reinforcement. Thus T-headed shear reinforcement does not need to enclose the longitudinal rebar.

T-headed shear reinforcement is an alternative especially for large slabs and foundations, leading to a considerably decrease in the number of units which have to be installed and speeding up the placing.



Strut and tie model with T-headed shear reinforcement



Shear reinforcement with one hook and one T-head as alternative to rebar with T-head at both ends

Easy and quick installation of T-headed shear reinforcement in a slab