T-headed reinforcement -
A tool for design and construction of robust structures

Robustness – the importance of design, detailing and construction

"Robustness is the property of systems that enables them to survive unforeseen or unusual circumstances."
(F.Knoll, T.Vogel: Design for Robustness; IABSE Structural Engineering Documents no. 11)

For a civil structure unforeseen or unusual circumstances can occur not just during its lifetime (as overloading, accidents, natural disasters), but also in all stages of the planning and construction.

A structure is not robust until it is
- **planned**
- **detailed** and
- **built** for robustness.

The designer should in his work not just take into consideration estimated and possible load scenarios, but also prepare for an unsophisticated construction process. Structures which are straightforward to build are commonly built in good quality too. Complicated detailing leads to difficult and cumbersome construction, increasing the risk of errors (incorrect placement, missing bars) and creating congested areas. The latter jeopardizes good concrete consolidation, which may negatively affect the bearing capacity and ductility of the structure and reduce its durability.
Details which are not conforming to the planned design and detailing of a structure represent a potential weak spot in the entire construction. Such weak spots make the structure vulnerable, even for the expected load cases – the structure is not robust! Therefore designers and detailers must make it possible for the construction workers to achieve the planned design – also under the varying conditions on site.

Further is it important for the use of special rebar components, as anchorages and mechanical splices, that these have sufficient capacity. Otherwise the actual ductility of the rebar will not be utilized, creating weak links – even if the rebar itself is strong and ductile.

T-headed bars

T-headed bars (also "headed rebar") are common reinforcing steel bars, with mechanical end-anchorage in the form of a small plate – the T-head.

Large structures shall be robust. T-headed rebar can be regarded as a tool to achieve this – especially in the case of large loads, combined with limited space and geometry.
T-headed rebar contribute to robustness in two phases of the construction process: planning/detailing and execution (the actual construction). These two phases are closely connected to each other.
Some examples are given on the next pages…

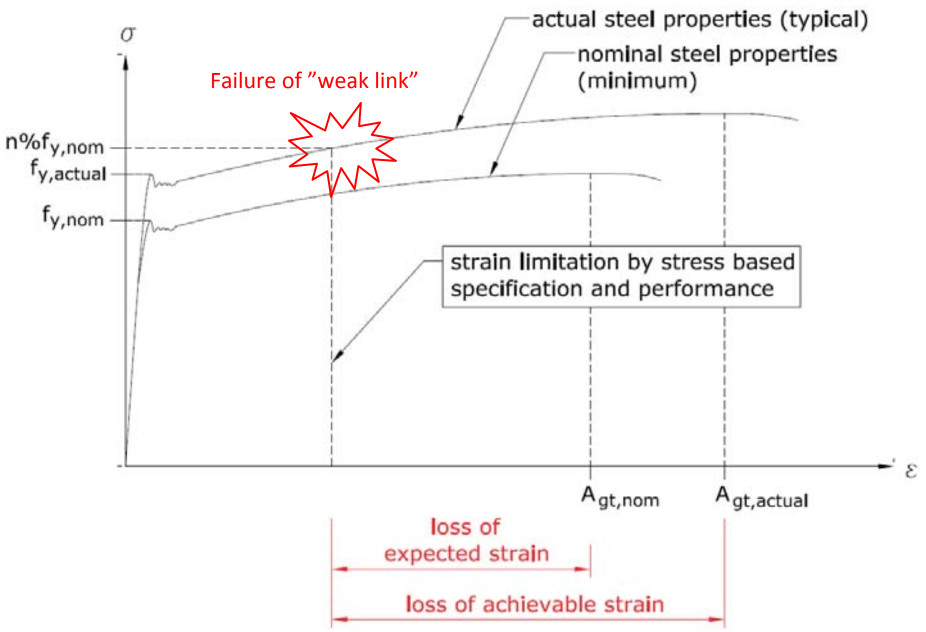
In order to fully utilize the advantages of T-headed bars three main characteristics need to be fulfilled:
1. The heads need to have sufficient area and stiffness to anchor the ***actual*** tensile strength of the rebar.
2. The strength of the head-to-bar connection must be at least the same as the ***actual*** strength of the rebar (not just the nominal).
3. There must be consistently high quality throughout the production.

Ductility, capacity reserves:

HRC T-headed bars develop the actual tensile properties (stress and strain) of the reinforcing steel (i.e. up to rupture of the rebar) it is possible to utilize the real ductility of the material and thus extraordinary capacity reserves. This is very important for unusual load cases (e.g. accidental loading) in order to avoid total collapse, even for local failure of parts of the structure.

Why is capacity so important?

Almost every rebar heat exceeds the minimum stress and strain requirements, which are specified in the codes. Anchorages and splices with insufficient capacity will in reality fail before the possible or even the specified strain is reached. This limits the ductility of the reinforcement (weak link) and reduces the robustness of the entire structure.



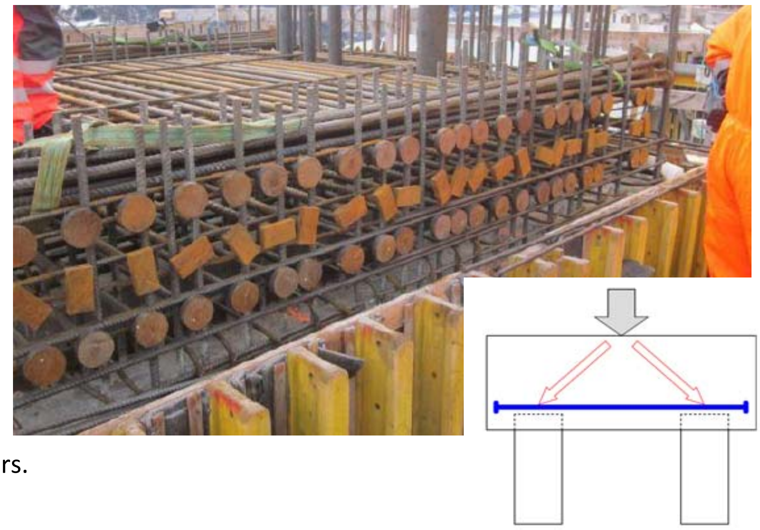
Structural advantages

HRC T-headed bars anchor the actual tensile strength of the rebar used just via the T-head. This has two basic effects:

- The rebar is anchored immediately beneath the head and the full length of the bar is effective. This is important where the reinforcement goes to the edges of a structure, as in beams and corbels, discontinuity regions, transverse ties etc.
- Anchorage with T-heads replaces hooks and bends. The limitation of the usable reinforcement diameter by a certain bending radius is removed. This allows the use of larger rebar diameters and less congested reinforcement (including improved casting conditions). Accessibility, safety on site and speed of construction is improved.

The space saving anchorage makes T-headed bars well suited for design with strut-and-tie models. Such models are among others based on nodes. The tension ties, representing the reinforcement, shall be sufficiently anchored in the nodes. For an anchorage length or a bend, the anchorage is spread over a certain length, not corresponding with the ideal models and consuming much space.

T-headed bars provide a larger effective core (see confinement), increasing the bearing capacity and often allowing for slimmer detailing solutions. Because of the self-anchoring T-head, HRC T-headed rebar offer larger placing tolerances compared to bent or hooked bars.



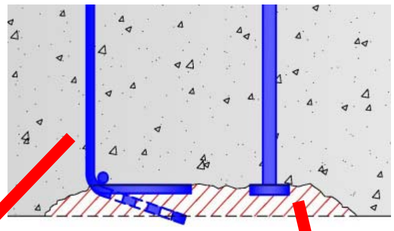
Confinement

The high capacity of the head-to-bar connection allows HRC-T-headed bars to be loaded up to the ultimate strength of the reinforcing steel ("bar break"). Additionally, compressive stresses in the transverse direction (the confinement effect) are delivered effectively by the head plate. This prevents buckling of longitudinal bars. Anchorage by T-heads is stiffer than anchorage by hooks or bends, resulting in immediate confining action. The stiffness and high capacity of the anchorage, combined with the flexibility in the choice of the rebar diameter and easy construction make HRC T-headed bars very effective cross-ties in shear walls, large columns, boundary elements, anchorage of PT-cables etc.

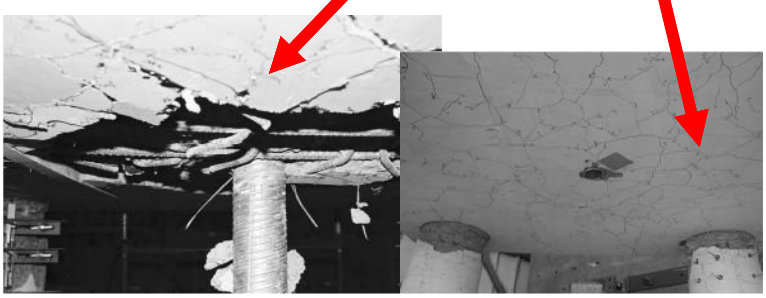
Robust structures…

…even under extraordinary load situations

The use of T-heads avoids the risk of straightening rebar bends pushing out the concrete cover. In cases of lost cover the T-heads still develop the full tensile strength of the rebar. If bond is degraded in addition to a lost concrete cover (e.g. plastic cyclic loading), the advantages of HRC T-heads can make a fundamental difference to the overall structural performance.



The pictures to the right show the same structural member, tested with the same load. The only difference is the detailing of the shear reinforcement.



Additional benefits:

- **Material savings** (no anchorage lengths, no hooks or bends)
- **Reduced construction time** (easy handling and placing, possibility to reduce number of bars).

HRC 100 Series T-headed bars

- Concentrated transfer of the actual full tensile capacity of the rebar
- Very stiff connection between steel and concrete → zero slip connection between bar and head
- Material- and space saving rebar anchorage
- Easier transport and handling of straight bars with T-head → Improved safety on site
- Fast and precise installation (e.g. headed shear reinforcement is installed up to five times as fast as common stirrups)
- Better control of rebar works

some certifications (for updated list check HRC's websites):

- ✓ ETA-08/0035 (incl. CE-marking)
- ✓ ICC ES: ER-5292
- ✓ CalTrans approved
- ✓ City of LA

HRC 400 Series Mechanical Couplers:

- Fast, simple and self-locking installation
- Visual quality control of installation
- No cross-threading
- Capacity of over 700MPa exceeds the actual stress and strain capacity of most rebar grades
- Fulfills and exceeds all international known requirements for rebar couplers, including for seismic events

some certifications (for updated list check HRC's websites):

- ✓ ISO 15835 (all categories, incl. fatigue and both seismic)
- ✓ UK Cares: TA1-B (tension and compression) and TA1-C (type A)
- ✓ CalTrans approved as ultimate splice

Contact:

Europe: **HRC Europe – Metalock Industrier AS**

Postboks 591,
N-3412 Lierstranda,
Norway

Tel: +(47) 32 24 04 70
Fax: +(47) 32 84 00 56
info@hrc-europe.com; www.hrc-europe.com

USA: **Headed Reinforcement Corp.**

11200 Condor Avenue
Fountain Valley, CA 92708,
USA

Tel: 1-800-HRC-6775
Fax: (714) 557-4460
sales@hrc-usa.com; www.hrc-usa.com

Canada: **Headed Reinforcement Canada Inc.**

PO Box 37015
RPO Water Street W,
St. John's NL A1E 5Y2

info@hrc-canada.com; www.hrc-canada.com