HIGH PERFORMANCE REINFORCEMENT PRODUCTS

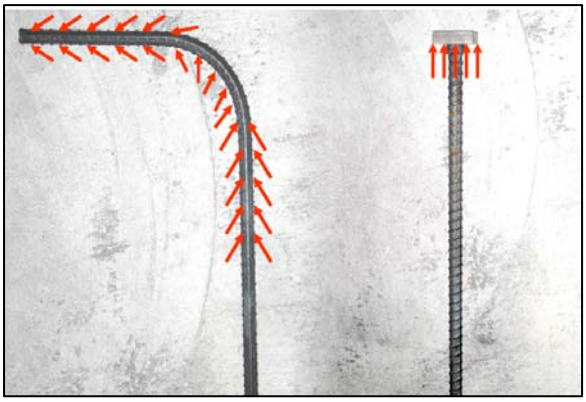
HRC T-Headed Bars
Advantages for the user

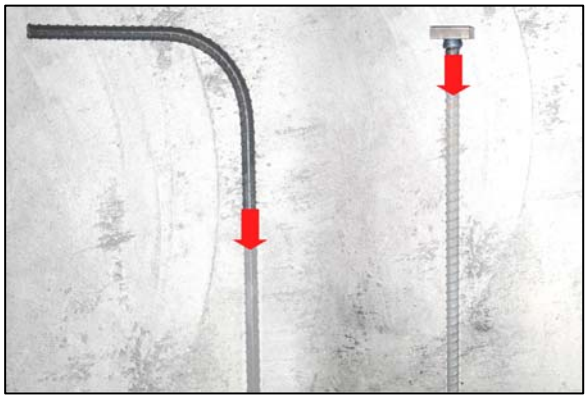
HRC T-headed bars have some special characteristics which distinguish them from conventional reinforcement. HRC T-heads anchor the full actual tensile capacity of the rebar. Thus the reinforcement stays fully anchored beyond yielding up to bar break. That makes it possible to use the real stress- and strain capacity of the reinforcing steel, i.e. the ductility of the rebar.

The advantages of designing with headed reinforcement are acknowledged by engineers all over the world. An increasing number of contractors are choosing headed reinforcement because of the benefits of their use, especially the increased speed of installation.

What are the special characteristics of a HRC T-headed bar?

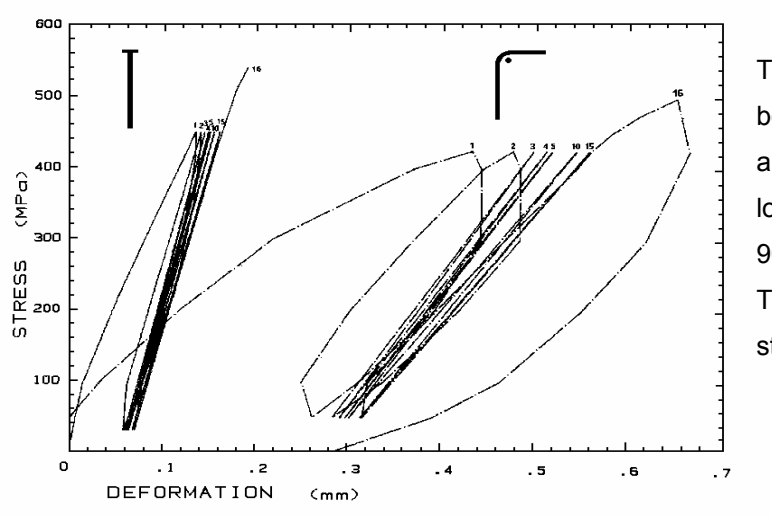
1. Concentrated transfer of the full tensile capacity of the rebar





HRC 100 and 200 Series T-heads are designed to develop the tensile strength of the rebar without crushing normal strength concrete beneath the head. That makes the full capacity of the rebar available from its end. The anchorage is not dependent on bond between reinforcing steel and surrounding concrete or a crossing bar. Anchorage of the full tensile capacity of the rebar prevents premature pullout failure.

2. Stiff anchorage of the rebar – minimizing slip



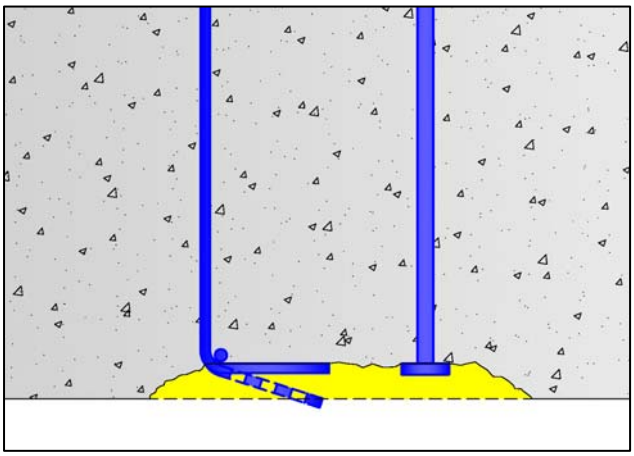
The diagram compares the stress-strain behaviour of anchorage by a HRC T-head and anchorage by bend under repeated loading and unloading between 6% and 90% R_{eH}.
The T-head anchors the rebar much stiffer than a bend.

(Source: test report STF65 F86083; “T-Headed Bars, SP1: Static Pullout Tests” SINTEF Norway, 1986)

Stiff anchorage does not mean stiffer reinforcement. The stiff anchorage by HRC T-heads reduces slip to a minimum, enabling the ductility of the reinforcing steel to be developed. Stiff anchorage of transverse reinforcement has a positive effect on the shear capacity (see page 3) and confinement (see page 5).

The special characteristics result in advantages both in design and practical use

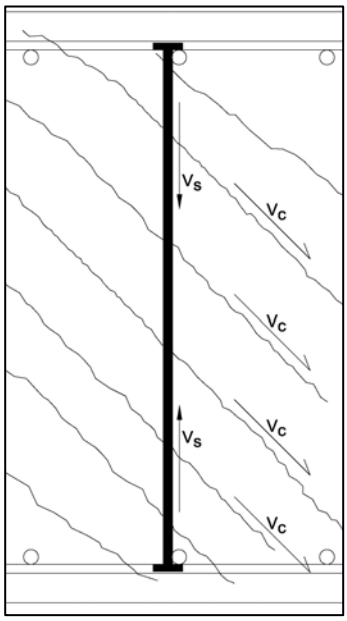
- Space saving anchorage (no development length, no hooks or bends)
- Safe anchorage, regardless of the bar diameter
- Safe anchorage even under loss of concrete cover
- Independent of bond between rebar and surrounding concrete, thus possible to use plain high-strength steel and beneficial in concrete with low bond properties (as lightweight aggregate concrete)
- Increased shear capacity
- Increased ductility of the construction



When using T-headed bars there is no danger of spalling of the concrete cover by straightening bends. In cases of lost cover the T-head can still develop the full tensile strength of the rebar. If bond is degraded in addition to spalling of the concrete cover (ex: plastic cyclic loading), the advantages of HRC T-heads can make a fundamental difference to the overall structural integrity.

T-heads give a stiff anchorage to the rebar.
Stiff anchorage of shear reinforcement leads to:
→ decreased crack width
→ increased friction in the cracks (aggregate interlock)
→ increased concrete contribution to shear capacity

(acknowledged among others by the Canadian Standard CAN/CSA-A23.3-04 “Design of concrete structures” and ACI 421.1.R-99 “Shear reinforcement for slabs”)



Increased ductility of a reinforced concrete structure by using T-headed bars

Why ductility?

In the design of any structure the following types of loads have to be considered:

- likely loads (dead loads, live loads)
- unlikely loads (extreme environmental loads, accidents)
- failure of a local structural part (e.g. a column or a wall panel)

Often is it unpractical or even impossible to design a structure to behave in the elastic state under extreme loads (which magnitude might be unknown). The solution in such cases is to give the structure sufficient ***ductility***. Ductility is then a criterion of resistance equivalent to strength.

Ductility is the ability to displace inelastically without significant loss of strength or stiffness. In other words: a ductile structure is capable to sustain a certain level of deformation without failure. Thus the structure exposed to extreme loads or events can absorb energy without collapse and even might be reparable without weakening the load capacity or disabling its function.

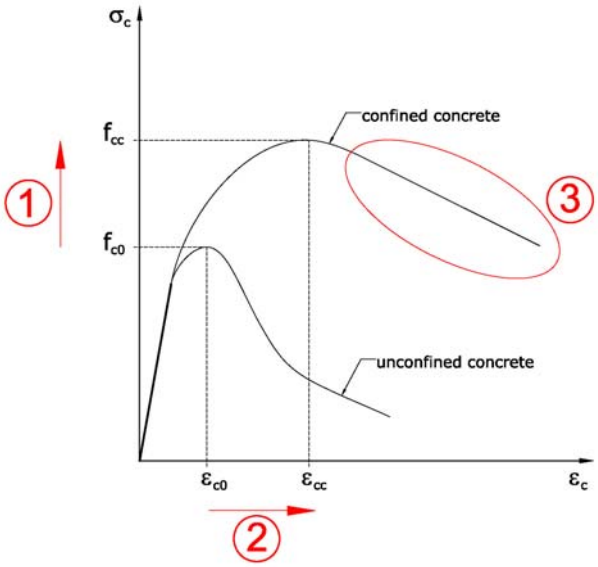
How to make a structure more ductile with help of T-headed bars?

Reinforced concrete

	Compression	Tension	
Ductility:	Confinement of compression members by stiff transverse reinforcement → ***see page 5***	Prevention of buckling of the reinforcement at yield stress by stiff anchored headed cross ties or links	Utilization of the ductility properties of the reinforcing steel by: - adequate anchorage - adequate connection (splicing) It is very important that anchorage and rebar splice have sufficient stress - AND STRAIN capacity. → ***see page 6***

The effects of confinement:

(1) increase in concrete strength
(2) increase in compression strain (possibility of absorbing energy by plastification)
(3) slower strength decrease after crushing of the concrete (ductile behaviour)



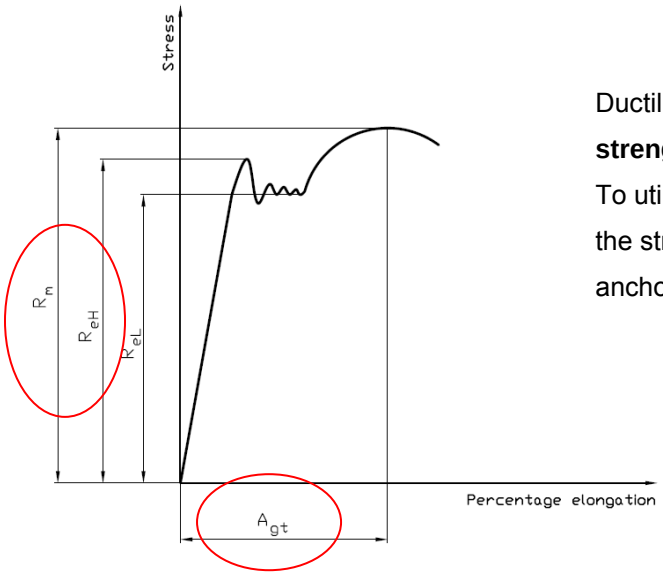
Stress-strain curve for confined and unconfined concrete

The stiffer the transverse reinforcement performs, the larger is the confining effect.

The stiffness of the transverse reinforcement is not only depending on the amount of the steel cross section area (reinforcement ratio), but on the stiffness of the tie **anchorage** as well. By using T-headed bars not only is a high reinforcement ratio possible without congesting the cross section, but the head ensures a stiffer anchorage than a bend or hook as well (see page 2).

Headed cross-ties in a wall of a nuclear waste containment structure

Utilization of the real ductility properties of the reinforcing steel



Ductility of reinforcing steel is not just described in terms of **strength** but by **deformation** as well.
To utilize the ductility of the reinforcing steel bars, the stress and strain capacity of rebar splices and anchorages is essential.

T-heads (HRC 100 and 200 series)

HRC T-heads anchor the actual tensile capacity of the rebar. That means that the reinforcement stays fully anchored beyond yielding, up to bar break. Thus it is possible to use the **real stress- and strain capacity** of the reinforcing steel while avoiding premature pull-out failure of the rebar. Transverse reinforcement is anchored stiff by T-heads and will add confinement to the structure.

Rebar with HRC 100 series T-heads at both ends

Mechanical splices (HRC 400 series)

HRC 400 mechanical splices are dimensioned to exceed the **actual stress- and strain capacity** of the reinforcing steel. Lap splices with additional reinforcement can be avoided. HRC 400 mechanical couplers provide real continuity of the rebar even under extreme loads. The splice will not be the weak link!

HRC 400 mechanical coupler

Improved productivity at the construction site with T-headed bars

Effective construction process by efficient reinforcement:

T-headed bars are easy and fast to place. In many cases fewer bars with larger diameter can be used. The absence of hooks or bends for anchorage allows often the use of straight bars.

→ reduced construction time

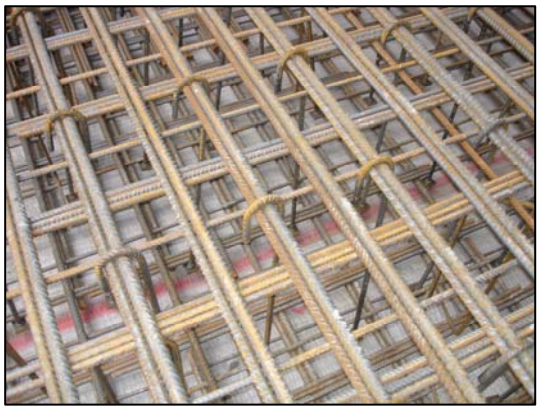
→ increased predictability of delivery

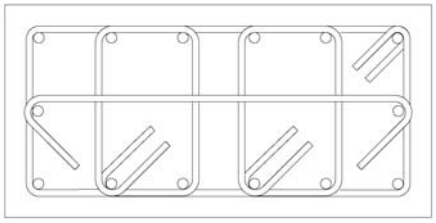
→ reduced defects and errors

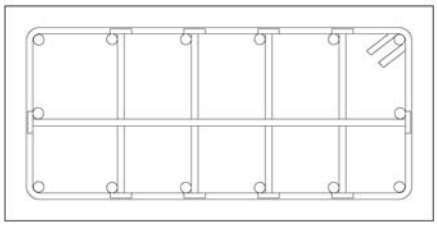
→ reduced accidents.

Common problems:

Solutions with headed reinforcement:







Examples for the use of T-headed reinforcement:

Summary: Anchorage by HRC T-Heads is…

- **Safe**
  (HRC T-heads anchor the full actual tensile capacity of the rebar – "bar break")

- **Structural Performance**
  (superior anchorage, improved ductility)

- **Concrete Quality**
  (reduce congestion of reinforcement, better pouring conditions)

- **Possible Material saving**
  (No hooks or bends, no development length,
  effective anchorage may lead to reduced member dimensions)

- **Easy and fast to place**
  (Increased speed of construction, better placement tolerances)

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