B.T. innovation GmbH, 39116 Magdeburg, Germany

Increase in the shear force capacity of head bolt sleeve anchors in concrete construction by up to 60 %

Anchorage points in concrete are usually subjected to tensile as well as shear loads. The edge distances play a special role with shear loads. The goal of all planning is to introduce the highest possible forces into the concrete via the anchoring point. In all anchor solutions, the applied shear force is introduced into the concrete via the sleeve. Based on the load introduction position, the concrete prefers to break with a classic 60° concrete breakout cone. A new type of shear force anchor, the BT Q-Anchor, allows a very efficient utilisation of the concrete with experimentally determined load increases of up to 60 % due to its geometry.

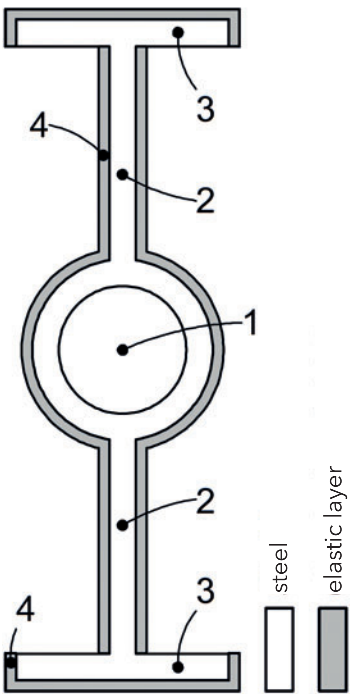
Types of failure and derivation of a new anchor geometry

As a rule, an interaction of tensile and shear forces must be taken into account for anchoring, which are ideally absorbed by the anchor or the concrete. In the event of an overload, a number of possible failures are known with sleeve anchors. In addition to the rather rare steel failure of the fastener or the screw with or without lever arm, pulling the fastener out of the concrete is an important failure criterion. The failure patterns are reflected in cone-shaped concrete breakout cones, splitting of the concrete or local concrete breakouts. In the case of a classical breakout cone, the size of the sectional surface of the broken-out concrete is decisive for the forces to be applied. The approach was to increase the size of this sectional surface and thereby increase the required failure forces.

Fig. 1.a shows the load-bearing behaviour of a rope. The load, in this case the dead load of the screw, suspends upwards by the rope. In tension, the lower part of the rope fails under pressure. This basic operating principle of the rope statics was transferred to a head bolt sleeve anchor within a concrete body (Fig. 1.c). This anchor consists of a screw-in sleeve (1) on which webs (2) with load introduction elements (3) are arranged. All areas that should not transfer any compressive

a)

b)



c)

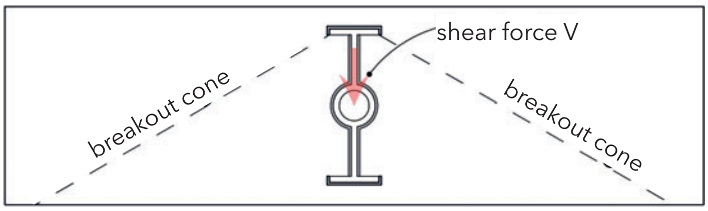


Fig. 1:
a) Illustration of the load-bearing behaviour of a rope,
b) Plan view of shear force anchor
c) Desired breakout behaviour of the newly developed shear force anchor

Fig. 2: Prototype of a newly developed, manually manufactured BT Q-Anchor before concreting. The test specimen was 16 cm thick. The anchor was embedded in the centre of the concrete. The visible reinforcement was incorporated to suppress bending failure of the test specimen.

force into the concrete under the action of a force were provided with an elastic layer (4). If this operating principle works, the anchor enables thinner-walled construction and consequently minimises the use of raw materials, transport costs, etc.

Experiments and evaluations

During the development of the anchor, a large number of prototypes were produced by hand. Tests carried out with the largest anchors, with an M24 thread, are described below. For the experimental investigation of the anchors, the prototypes were cast in the middle of 16 cm thick concrete bodies (Fig. 2). The test specimens themselves were reinforced at the sides and bottom in order to prevent bending cracks in the test specimens when the load was applied and to obtain the largest possible breakout cone. The concrete in the immediate vicinity of the anchors was always unreinforced.

In the test arrangement shown in Fig. 3, for example, a shear force V at 90° to the longitudinal axis of the component is introduced into a concrete body via a tension strap. Starting from the head bolt sleeve anchor, a breakout cone formed. The angle of load distribution in the force direction is approx. 60°. With the newly developed anchors, the load could be suspended back against its direction of action by the elastic layer and corresponding load introduction surfaces. Thus, it is geometrically possible to generate a larger breakout cone and introduce higher loads into the structural element.

The tests carried out on some anchor types with M24 threads are described and evaluated below. For each test series, commercially available anchors approved as permanent fixings were embedded in concrete, stored and tested under the same conditions. Meaningful values were always available within a test series. The test specimens were clamped in a specially manufactured tensile testing device and the force was determined as a function of the travel. The maximum failure values were determined.

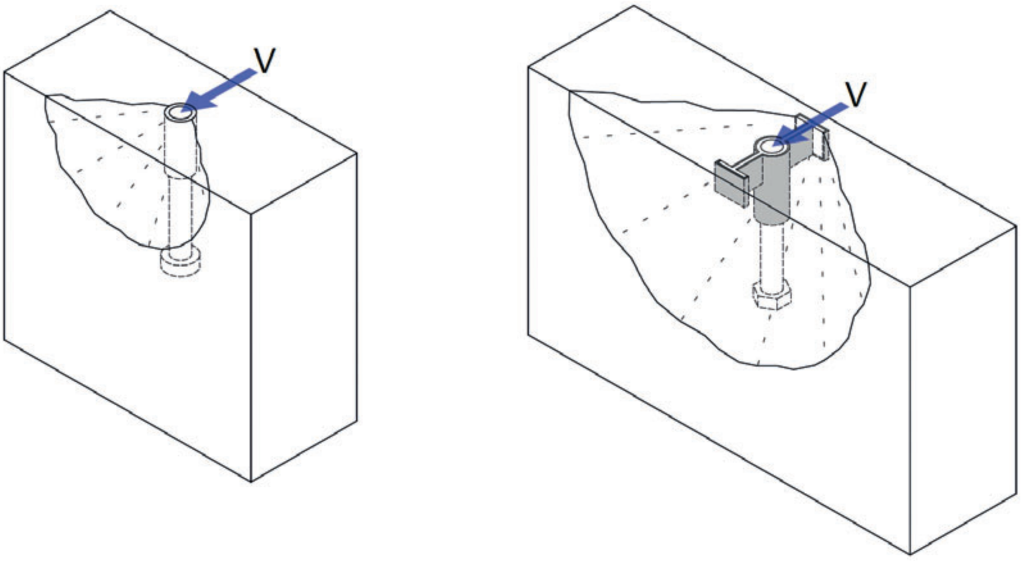


Fig. 3: Comparison of the experimentally determined breakout cones of approved head bolt sleeve anchors and one of the newly developed "winged" head bolt sleeve anchors with a load introduction V at 90° to the structural element axis. The concrete breakout cone and thus the cross-sectional area of the newly developed anchor is considerably larger.

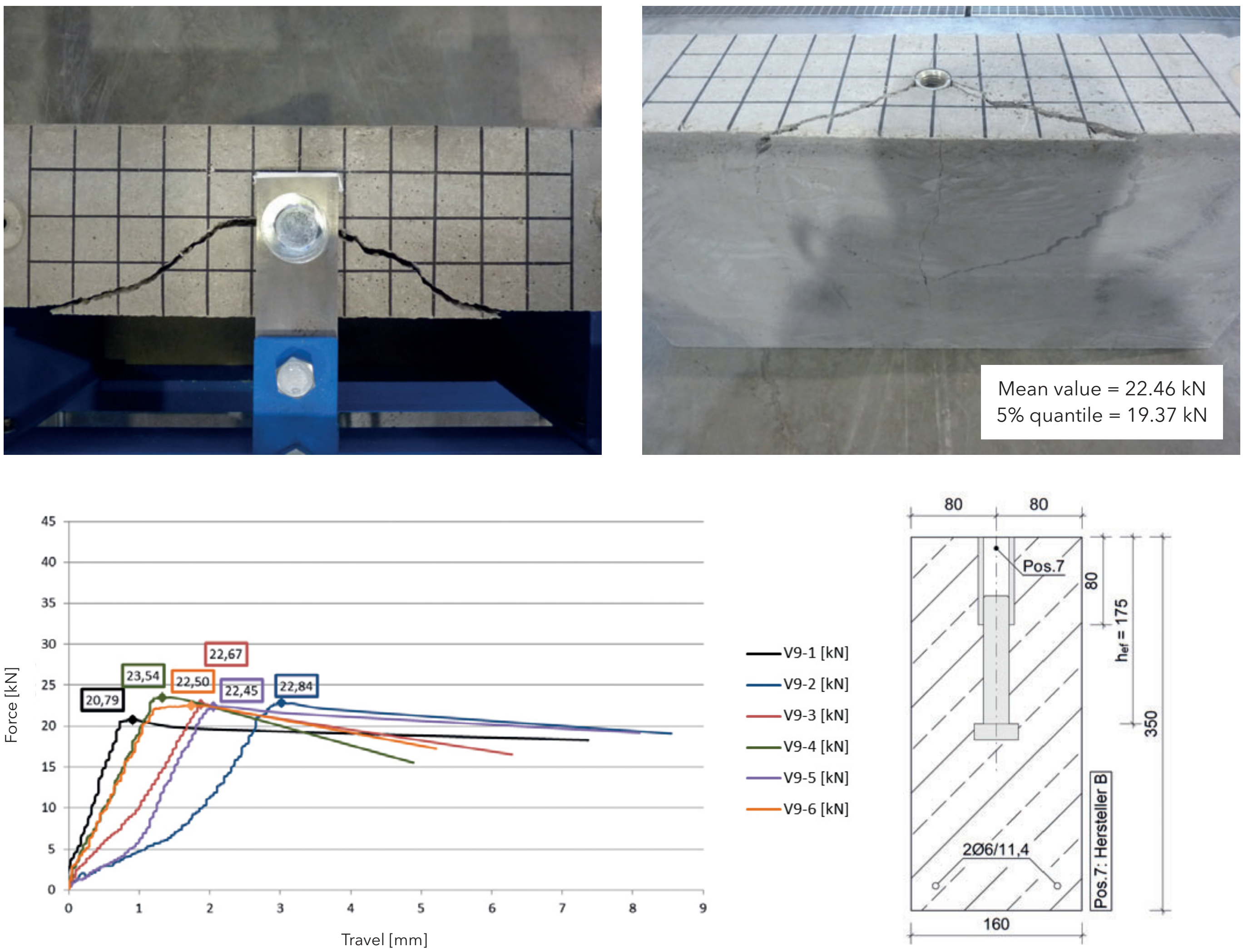


Fig. 4: Testing of a commercially available head bolt sleeve anchor. The mean value of the failure load of the test specimens was determined experimentally for the given geometry to be 22.46 kN and the 5 % quantile value to be 19.37 kN.

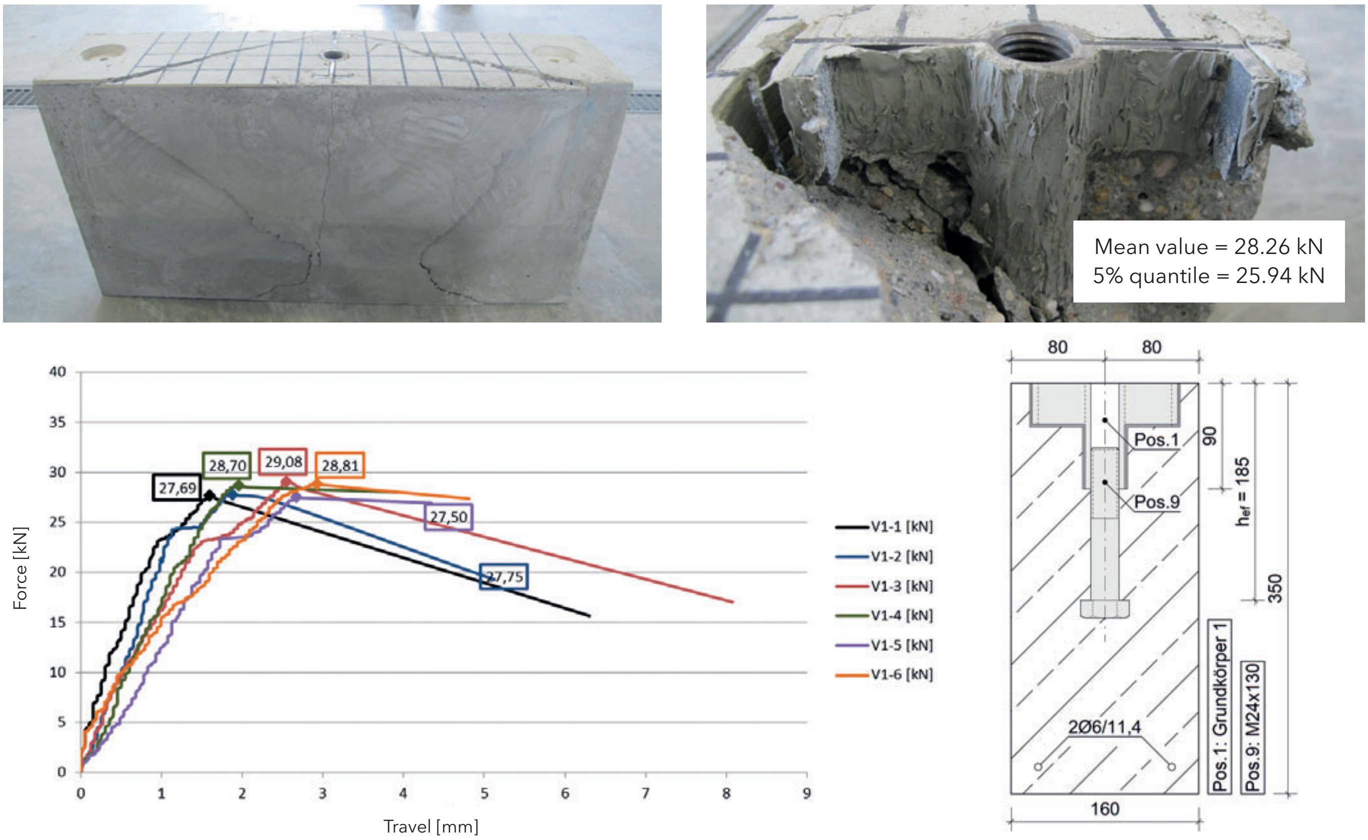


Fig. 5: Testing of a "winged" head bolt sleeve anchor with load introduction surfaces welded to the top of the central sleeve. The mean value of the failure load of the test specimens was determined experimentally for the given geometry to be 28.26 kN and the 5 % quantile value to be 25.94 kN.

The commercially available head bolt sleeve anchors always showed the expected failure pattern with a 60° concrete breakout cone. The failure occurred at a mean value of 22.46 kN with a standard deviation of 0.91 kN. The values are close together. The 5 % quantile value is 19.37 kN (Fig. 4).

One of the newly developed head bolt sleeve anchors has two webs at the top of the sleeve to which rectangular plates, collectively referred to as "wings", are welded (Fig. 5). These anchors were also subjected to shear force and showed the hoped-for damage pattern with a significantly enlarged

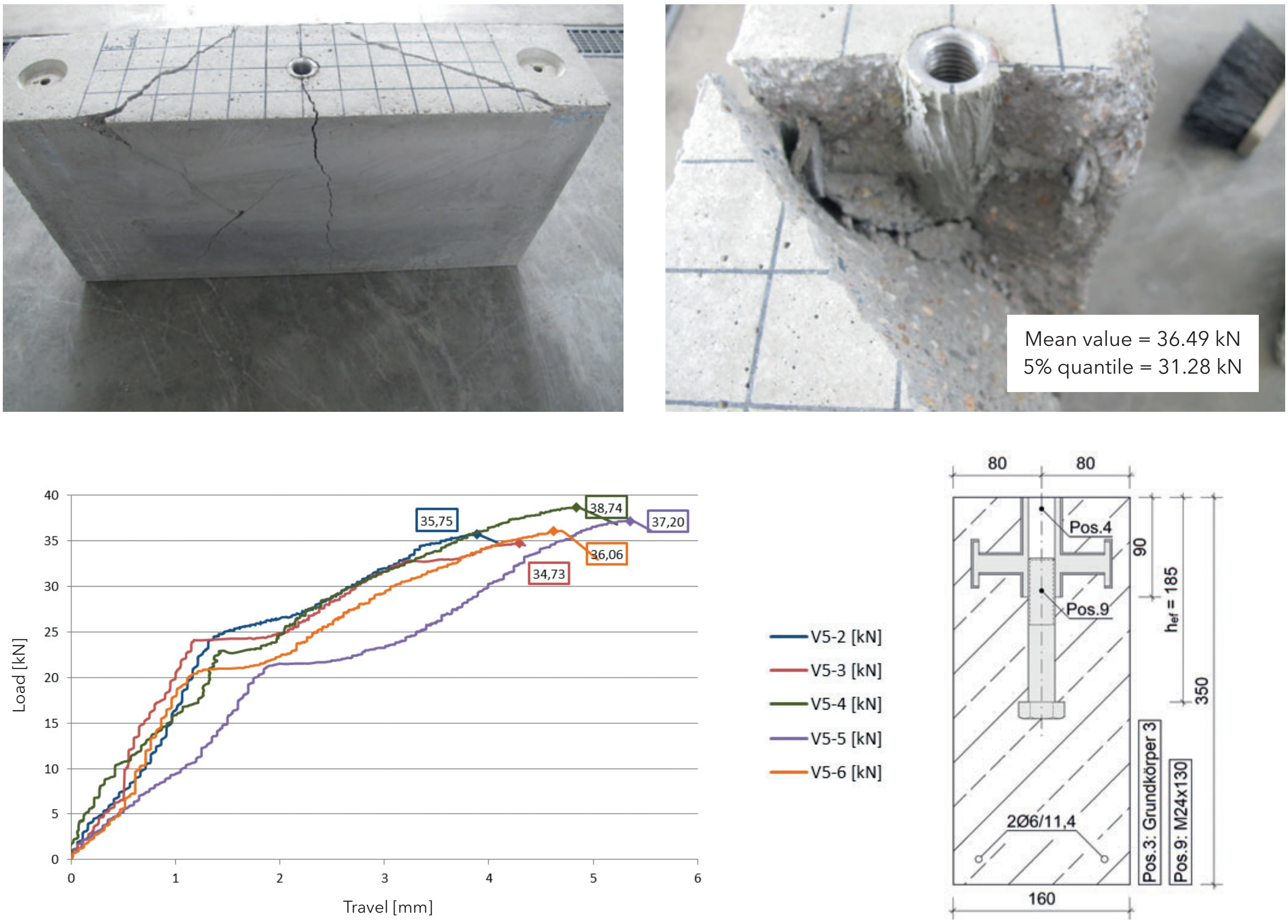


Fig. 6: Testing of a "winged" head bolt sleeve anchor with load introduction surfaces welded on the bottom of the central sleeve. The mean value of the failure load of the test specimens was determined experimentally for the given geometry to be 36.49 kN and the 5 % quantile value to be 31.82 kN.

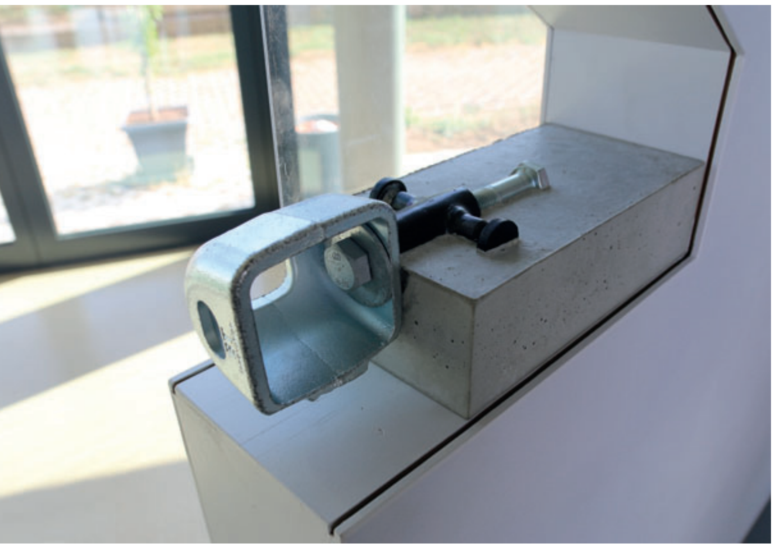


Fig. 7: The new BT Q-Anchor fits very well with the BT-Spannschloss® (turnbuckle).

Fig. 8: Design sizes of the BT Q-Anchor – M12, M16, M20, M24

concrete breakout cone. The concrete failure occurred at a mean value of 28.94 kN with a small standard deviation of 0.70 kN. The values vary slightly and are close to each other. The 5 % quantile value is 25.94 kN. In a comparison of the 5 % quantile values, this anchor type already shows a considerable load increase of about 30 %.

In further tests, anchors with back anchoring points welded deep to the sleeve were embedded in concrete and tested (Fig. 6). These anchors were also subjected to shear force and showed a damage pattern with an even larger concrete breakout cone. The concrete failure occurred at a mean value of 36.49 kN with a standard deviation of 1.53 kN. The values vary more than the values of the head bolt anchors described above, but are still quite close to each other. The 5 % quantile value is 31.28 kN. In comparison to the 5 % quantile values, this anchor type already shows an enormous load increase of over 60 % compared to the commercially available permanent fasteners.

Prospects

B.T. innovation GmbH and IAB Weimar developed the product as part of a cooperative research project. After completion of the product development, the BT Q-Anchor is currently being converted into a series product and is in the approval process. B.T. innovation GmbH intends to launch a finished product on the market in 2020. ■

FURTHER INFORMATION

BT innovation

B.T. innovation GmbH
Sudenburger Wuhne 60, 39116 Magdeburg, Germany
T +49 391 73520, F +49 391 735252
info@bt-innovation.de, www.bt-innovation.de

IAB Institut für Angewandte Bauforschung Weimar

IAB Weimar gGmbH
Über der Nonnenwiese 1
99428 Weimar, Germany
kontakt@iab-weimar.de
www.iab-weimar.de