

ADHESIVE ANCHORS ON CONCRETE SURFACES

KLEBEN AUF BETON

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SUMMARY

Adhesives can be used today to bond any materials together. The quality of the joint depends on the parts to be joined, the adhesive used and the bonding process. The bonding process is not only limited to the application and curing of the adhesive, but also deals with all influencing factors and requires great care. This is the only way to achieve sufficient process reliability and long-term stability, which is particularly important in the construction industry with regard to approval criteria and durability over very long periods of time. Adhesive anchorages on component surfaces are one of the latest developments in the field of fastening technology. The load-bearing capacity of these joints on concrete depends largely on the surface tensile strength of the concrete, as it represents the weakest link in the chain of parts to be joined, adhesives and fasteners. For this reason, the tensile strength of constituent components must first be determined by means of tests in order to be able to assess the bondability.

ZUSAMMENFASSUNG

Mit Klebstoffen können heute beliebige Werkstoffe miteinander verbunden werden. Die Qualität der Fügeverbindung hängt vom Fügeteil, vom verwendeten Klebstoff, und dem Klebprozess ab. Der Klebprozess beschränkt sich nicht nur auf das Auftragen und Aushärten des Klebstoffs, sondern setzt sich mit allen Einflussfaktoren auseinander und erfordert eine hohe Sorgfalt. Nur so kann eine ausreichende Prozesssicherheit und Langzeitstabilität erreicht werden, die insbesondere im Bauwesen hinsichtlich der Zulassungskriterien und der Beständigkeit über sehr lange Zeiträume gefordert ist. Klebeverankerungen an Bauteiloberflächen sind eine der neuesten Entwicklungen im Bereich der Befestigungstechnik. Die Tragfähigkeit dieser Verbindungen auf Beton hängen maßgeblich von der Oberflächenzugfestigkeit des Betons ab, da er das schwächste Glied in der Kette Fügeteil, Klebstoff und Befestiger darstellt. Deshalb muss an Bestandsbauteilen

vorab die Abreißfestigkeit mit Versuchen ermittelt werden, um die Klebbarkeit beurteilen zu können.

KEYWORDS: Concrete, tensile strength, surface tensile strength

1. EVALUATION CRITERIA FOR THE CONCRETE SUBSTRATE

The strength of the concrete edge zone is the decisive criterion for bonded fastenings. The concrete surface must be free of separating substances and sufficiently strong so that the loads or compound stresses can be absorbed by the concrete. Tests are necessary to assess the strength of the concrete edge zone. The determination of the mechanical condition of the concrete surface can be carried out with the tear-off test, which provides the surface tensile strength as a result. These values are a measure of cohesion and the basis for assessing the bondability [1].

2. CONCRETE

Concrete is an artificial material and is produced today from cement, aggregates (aggregates), water and mostly still with concrete additives and admixtures. Both fresh and hardened concrete is a two-phase system consisting of cement paste and aggregates. The aggregate is round or broken and normally occupies about 70% of the concrete volume. The grain sizes of aggregates can range from a tenth of a millimetre to several centimetres and, in normal concrete, influence not so much the strength as the stiffness, since it is usually stronger and denser than the cement stone. The particle size distribution determines the amount of water in a concrete mix, the cement content and the workability of the fresh concrete [2].

Concrete is divided into concrete strength classes according to compressive strength at the age of 28 days. The compressive strength is determined on cylinders $f_{ck, cyl}$ or on cubes $f_{ck, cube}$. The strength class is designated by the capital letter C and the strength data for cylinder and cube compressive strength in N/mm², e.g. C 25/30. Concrete has a high compressive strength and a low tensile strength. In addition, the concrete tensile strength is a highly scattering and unsafe parameter.



Fig. 1: Concrete

The tensile strength of the concrete must therefore not be calculated according to plan, but must be covered by reinforcement in the corresponding areas. The tensile strength can be roughly estimated with one tenth of the compressive strength [3].

3. TENSILE STRENGTH

The tensile strength of the concrete depends on the properties of the cement paste and the adhesion between the cement paste and the aggregate. The tensile strength increases with decreasing water-cement ratio and increasing degree of hydration, but significantly lower than the compressive strength of the concrete. Tensile strength and compressive strength are therefore not proportional to each other. Concretes with crushed aggregate have a 10 - 20% higher tensile strength than gravel sand concretes, as the adhesion and interlocking between cement stone and rough aggregate is better. Of particular importance for the tensile strength is the drying out of the concrete and the associated shrinkage, which causes residual stresses and microcracks [2].

In the unloaded state, normal concrete has microcracks between cement paste and aggregate as a result of the low bond strength in the contact zone and the obstruction of early shrinkage of the cement paste by the stiffer, volume-stable concrete aggregates. The microcracks are the starting point for crack development under (compressive and) tensile stress and grow at right angles to the external load as tensile stress increases. If the crack development reaches a critical extent, the microcracks combine to form a single, continuous crack and sudden concrete failure occurs [4].

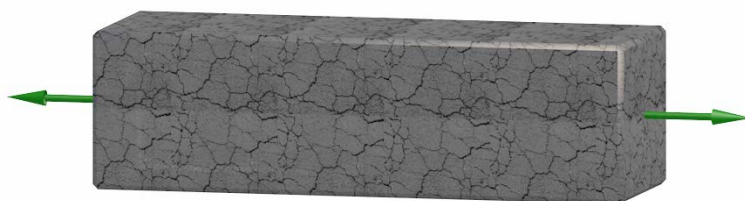


Fig. 2: Cracked concrete

4. SURFACE TENSILE STRENGTH

The surface tensile strength is the maximum tensile force that can be applied perpendicular to the concrete surface and creates cohesion fracture in the concrete edge zone. Surface tensile testing is the most important test method for assessing the mechanical properties of near-surface concrete layers. For this purpose, a test stamp is affixed and loaded with centric tension until failure. The adhesive tensile strength test tests the adhesion or the adhesion of coatings or paints to the concrete surface. However, the test equipment and the test procedure are the same for both tests [1].

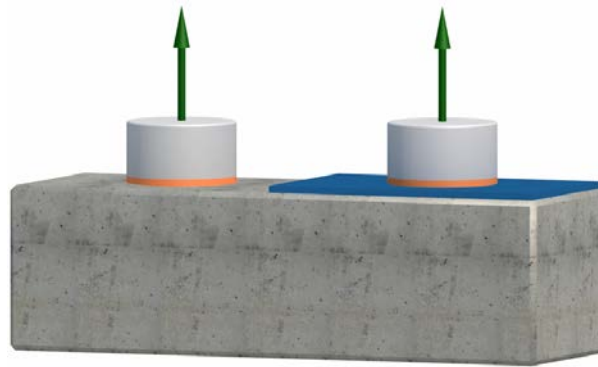


Fig. 3: Testing of surface tensile strength and adhesive tensile strength

5. TEST SPECIFICATIONS FOR THE DETERMINATION OF SURFACE TENSILE STRENGTH / ADHESIVE TENSILE STRENGTH

According to DIN EN 1542, the tensile strength test on concrete surfaces must be carried out as follows, among other things:

- Round test stamp with a diameter of 50 ± 0.5 mm
- Minimum thickness of test punch in steel: 20 mm
- Minimum thickness of the inspection stamp in aluminium: 30 mm
- Flatness of the adhesive surface of the test stamp: $e \leq 0.1$ mm / 50 mm
- No load by bending or shear forces in tensile test
- Bonding with two components - Epoxy resin adhesive
- Excess adhesive leaking from the side must be removed
- Measuring device with maximum value memory
- Accuracy of the tester $\pm 2\%$.

- Vertical alignment of the device above the punch ($90 \pm 1\%$)
- Test speed / load increase of 0.05 ± 0.01 MPa / s
- At least 5 tensile strength tests on one test piece

The scope of the surface tensile strength test according to DAfStb guideline carries at least 3 tests. If individual values below the required smallest individual value are achieved, at least two individual tests must be carried out in the local vicinity to determine whether it is an outlier. If the additional test results are above the required value, the outlier may be discarded. For protection and repair measures or coatings, the required individual values are at least 1 N/mm^2 and the mean value of the test results is 1.5 N/mm^2 [1].

6. REPRODUCIBILITY OF RESULTS

The surface tensile strength of concrete scatters more than the compressive strength. This is caused by cracks, shrinkage, sanding, unevenness, release agents, etc., which have a greater effect under tensile stress than under compressive stress. Defects or areas with a lower tensile strength are randomly distributed and occur in the manufacturing process as a result of the concrete composition, processing, formwork, curing and post-treatment. For this reason, the surface tensile strength test should be performed with a corresponding scope of testing. Using the diagram in Fig. 4, the required number of tests can be estimated as a function of the required confidence interval q . The number of tests can be determined from the number of tests required. The standard deviation s is to be determined in preliminary tests or is known from experience [1].

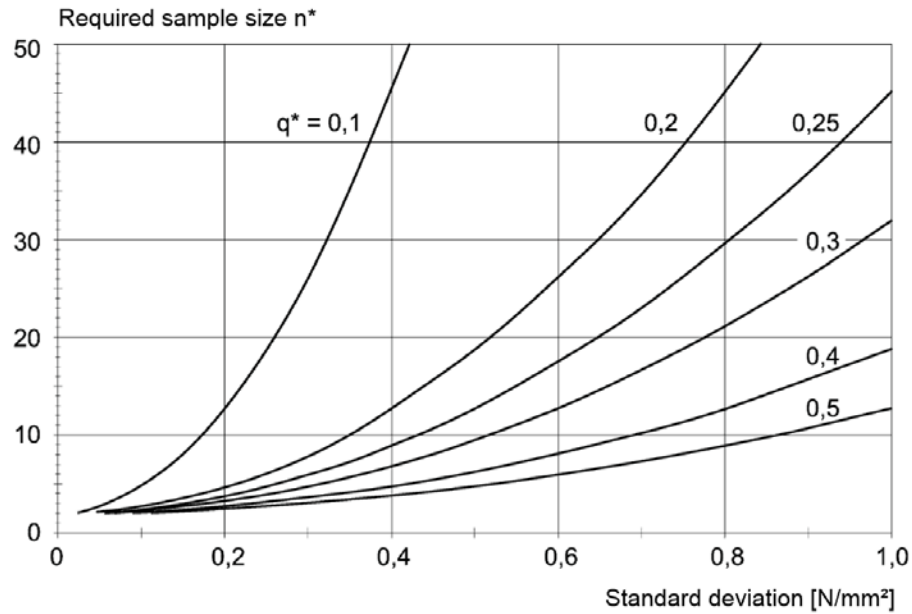


Fig. 4: Determination of the required sample size n as a function of the standard deviation of the sample and the required confidence interval q in N/mm^2 [1]

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