Conducting Pull-Off Tests

Instruction Manual

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Content

Application

Determining the pull-off strength of concrete substrates and their coatings helps in assessing the quality of a surface. It can be carried out on horizontal, slanted and vertical surfaces.

2. Definitions

Surface tensile strength

Determining the surface tensile strength of concrete:
A cylindrical, bending resistant dolly that has been glued to the surface is pulled off using a controlled loading rate increase. The force needed for this plus the surface size of the dolly determines the surface tensile strength.
The fracture patterns resulting from this test may provide information as to the quality of the surface tested.

Adhesive failure
Fracture between two layers

Cohesion failure
Fracture within one layer

3.1 Avoiding canting effects

Spot drilling of the concrete

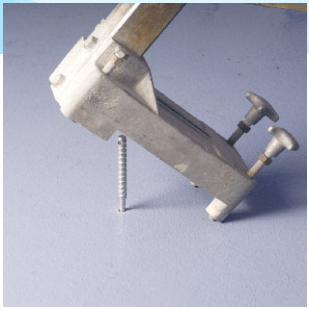
Spot drilling the concrete free-hand is not permissible. To enable a vibration-free loading without canting effects, fixing a support frame secured with dowels must be done at all costs on horizontal, vertical and overhead surfaces.

Inserting the dowel

Fixing the dowel in place

Inserting the drill core anchorage

Tightening the drill core anchorage

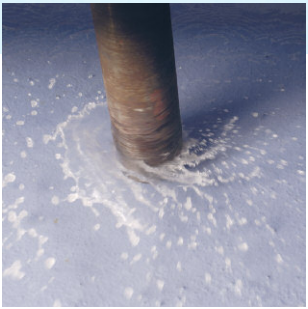


Erecting the support frame

Fixing the support frame in place

Spot drilling the test area

3.2 Wet or dry drilling?



Wet or dry drilling?

Dry drilling is not permitted according to ZTV-ING. Especially in thermoplastic surface protection layers dry drilling is unsuitable as peak temperatures can be expected during drilling.

3.3 Core drilling

Core drilling

The drill device should not produce heavy vibrations and any lateral movement of the drill bit ought to be avoided. The drilling must be performed using a diamond drill bit with a cylinder of 50 mm ø (± 1 mm), applied at an axis angle of 90 (± 1°) to the surface. The cut of the groove must be made 15 mm (± 5 mm) deep into the concrete substrate. The diamond drill bit is then removed from the test sample without causing any damage. After drilling the drill sludge produced must be removed with water until it is completely gone.

IMPORTANT. PLEASE NOTE!

It is not permissible to use an artificial heat source such as a hot air blower.

4. Dolly

To test the tensile strength circular dollies with a diameter of 50 mm (± 0.5 mm) made from steel (2 cm thick) are used.

For the purpose of the pull-off test dollies must be fitted with a fixture to attach the test device that ensures that the load can be exerted per pendicular to the test surface and that no bending or shear forces are exerted on it.

5. Preparing the dolly

The dollies are roughened up using a sander or sand paper and are then cleaned with a lint-free cloth.
The dollies must be dry and free from any grease.

5.1 Cleaning the test area

Concrete surfaces must be prepared in accordance with ZTV-ING (e.g. grit blasting). Coating systems are roughened up with coarse sandpaper or with a steel brush. The sanding dust is removed using a lint-free cloth or oil-free compressed air.

6. Inserting the adhesive

Adhesives on an epoxy basis (EP), polymethyl-metacrylate resin (PMMA) and polyurethane resin (PU) basis are frequently used in practice.

6.1 Tensile strength adhesive on epoxy resin basis (EP)

The bonding properties are in particular dependent on resin type, additives and filler materials used. Low-viscosity EP resins strengthen the concrete surface and therefore distort measuring results. EP resins must be set to a paste-like consistency by adding thixotropic agents. At room temperature EP based adhesives require several hours to cure.
Because of these long curing times the dollies bonded on vertical and slanted surfaces must be fixed in place with a support frame. In practice this is often difficult to achieve on site. In addition, EP resins have very low moisture compatibility.

6.2 Tensile strength adhesive on polymethyl-metacrylate basis (PMMA)

PMMA adhesives are two-component products. They consist of a powdered hardener and a liquid, monomer mixture with accelerator (main component). Application is possible even in temperatures below zero. Reaction time is very short - only a few minutes. Thanks to these short reaction times PMMA adhesives would be ideal, however, on PCC mortars they only achieve limited adhesion, so that no meaningful results can be drawn with regard to pull-off testing. In addition, PMMA adhesives typically produce bad odours. If the test area has a high residual moisture level, PMMA adhesives are not suitable.

6.3 Tensile strength adhesive on polyurethane basis (PU)

PU adhesives are also two-component products. They consist of a paste-like main component and a hardener component.
The reaction time is very short. PU tensile strength adhesives are solvent-free, hence there's no unpleasant odour. Reliable results are achieved in pull-off tests with PU tensile strength adhesives.

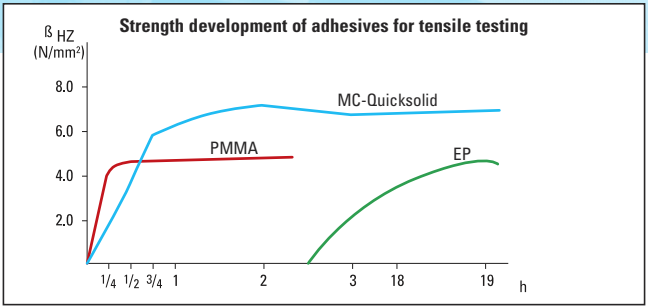
6.4 MC-Quicksolid

Based on the aforementioned advantages the **MC-Quicksolid Toolbox** comes with a polyurethane adhesive. In addition to three double-chambered cartridges of **MC-Quicksolid** (PU tensile strength adhesive) the set also contains nine static mixers, a discharger, gloves and goggles.

The actual mixing process takes place in the static mixer. Compared to other adhesives its handling is significantly easier. The curing time of MC-Quicksolid is very short indeed. There is no unpleasant odour. MC-Quicksolid reaches its final strength roughly after just 45 minutes at a room temperature of 20 °C.

Applying the adhesive MC-Quicksolid

A 50 ml double-chambered cartridge can bond approx. 15 dollies.



MC-Quicksolid has properties that lie within the limits of the loading capacity of many commercial pull-off testers.

Literaturhinweise

Heidrich, G.: »Einflüsse auf das Ergebnis von Haftzugprüfungen«, Dissertation at the Fachhochschule Hildesheim-Holzminden, 1989
[Factors influencing the results of tensile strength testing]

7. Test appliance

A portable tensile tester of at least class 2 quality in accordance with DIN 51220 or with DIN EN ISO 4624:2003-08 must be used. The tensile tester must include the electronic force controls for the linear force increase with the electronic power amplification for the servo drive, the measurement data storage, a serial interface to transmit the measurement data and the batteries to allow cable-less operation (e.g. ConsurTest made by FORM+TEST, Riedlingen).

8. Attaching the dolly

Apply a thin (approx. 1 mm thick) adhesive layer to the surface of the dolly in such a way that the adhesive can form an even, homogenous layer between dolly and substrate.

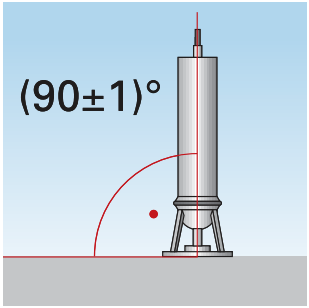
Apply enough pressure onto the dolly to ensure that any air contained in and between the contact surfaces and the adhesive is pressed out.
The dollies must be centrally aligned and bonded; protrusions into the groove are not permissible.

IMPORTANT. PLEASE NOTE!

No adhesive must enter the drill groove.

9. Setting up the test appliance

The test appliance for the pull-off test must be concentrically aligned above the dolly at an (90 ± 1)° degree angle above the drilled surface. The test appliance must be positioned in such a way that it cannot change its position during testing.



10. Applying the load

Force increase speed:

- On concrete substrates and hard layers: 100 N/s*
- On elastic and hard thermoplastic layers: 300 N/s

IMPORTANT. PLEASE NOTE!

*) The load must be increased continually and evenly with a speed of (0.05 ± 0.01) MPa/s until fracture.

11. Determining the failure type/evaluation

The failure type of the test sample is to be determined through visual inspection/evidence.

The following types of failure exist:
A: Cohesion failure of the concrete substrate
A/B: Adhesion failure between substrate and first layer (e.g. primer, bonding slurry or repair mortar)
B: Cohesion failure in the first layer
B/C: Adhesion failure between the first and the second layer
C: Cohesion failure between the second layer (as defined by the product or system to be tested)
-/Y: Adhesion failure between the last layer and the adhesive layer (e.g. C/Y at a two-layer repair system)
Y: Cohesion failure in the adhesive layer
Y/Z: Adhesion failure between adhesive layer and dolly (which is Z).

12. Number of pull-off tests

On horizontal surfaces for every 1,000 m^2 started nine pull-off tests must be performed after substrate preparation in accordance with ZTV-ING. If preparation is done by way of chiselling off, for each 250 m^2 area six pull-off tests have to be performed.

On other concrete substrates, after preparation of the substrate, for each 500 m^2 individual surface six pull-off tests have to be carried out. Pull-off strength testing is not necessary for total installation surfaces not exceeding 50 m^2, for coatings of no more than 250 m^2 and for impregnation works.

The pull-off strengths of the concrete substrate must comply with the values in the table:

Pull-off strengths required of concrete substrates (minimum value)

System			Median (N/mm^2)	Smallest permissible individual value (N/mm^2)
1		Concrete replacement systems	1,5	1,0
2a	Surface protection systems	OS-B (OS 2)	0,8	0,5
2b		OS-D (OS 5) (system without fine filler)	1,0	0,6
2c		OS-C (OS 4), OS-D (OS 5), OS-E (OS 9) (system with fine filler)	1,3	0,8
2d		OS 8	2,0	1,5
2e		OS-F (OS 11 / OS 13)	1,5	1,0

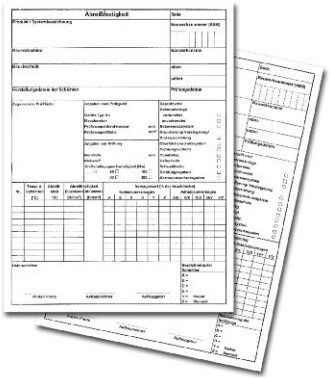
In the event of individual values falling below the smallest permissible individual value, at least two individual tests near the site (distance radius 1 m) need to establish whether these are runaway values or not.

13. Documentation

In the event of a combination of these failure types a visual inspection/evidencing of the failure surfaces must be carried out in order to determine the percentage share of surface per failure type and to state it as a share ratio, e.g.: A : A/B : B = 40% : 10% : 50%.

TIP

Each pull-off test should be recorded in a log (e.g. form B 1.3.2 issued by ZTV-ING).



Important Notice: The information given in this manual is based on our experience and is made to the best of our knowledge following the style of the ZTV-ING, but is nonetheless non-binding. All instructions must be adapted to suit the individual building projects, the application purpose and the specific local conditions. Given these preconditions, we shall be liable for the accuracy of the information given as outlined in our sales and delivery terms and conditions with respect to the technical properties of our products, but not for the execution of any pull-off strength tests. In any case, the generally accepted technical rules must be adhered to.

Conducting Pull-Off Tests MC-Quicksolid

Pull-off strength is a very important aspect when assessing the surface quality of concrete substrates and their coatings. Gathering meaningful and reliable data depends primarily on the adhesive layer between dolly and substrate. The tensile strength adhesive MC-Quicksolid lets you determine reliable pull-off strengths – quickly and competently.

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