GI BOND-TEST

Purpose

The **BOND-TEST** is used to conduct a pull-off test in accordance with ASTM C1583, "Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)." The obtained **pull-off strength** can be used for the following purposes:

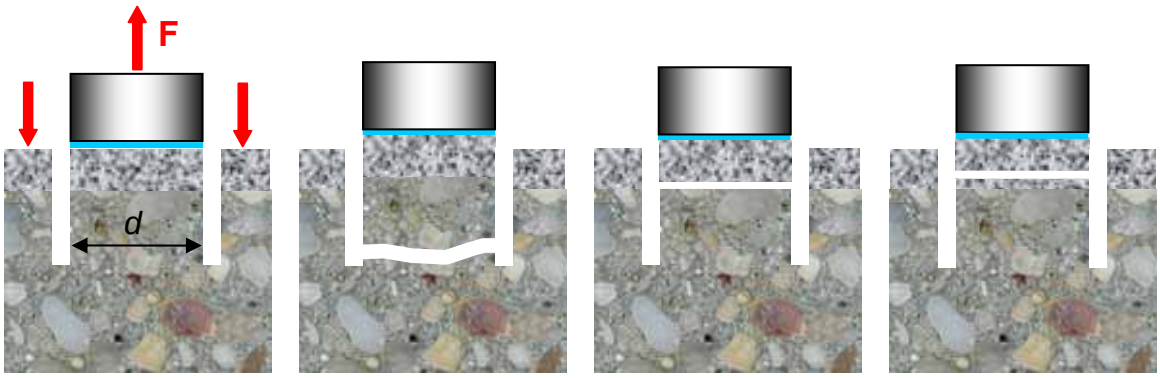
- To evaluate the in-place bond strength between a repair overlay and the substrate
- To evaluate the in-place tensile strength of concrete or other materials
- To evaluate the effect of surface preparation procedures on the tensile strength of the substrate before applying a repair material or overlay

Principle

In the **BOND-TEST,** a disc is bonded to a prepared testing surface and the disc is pulled off after a partial core has been cut around the disc (extreme left in following figure). The pull-off force, *F,* is divided by the cross-sectional area of the partial core to obtain the pull-off strength f_p:

$$f_p = \frac{4F}{\pi d^2}$$

where d is the diameter of the partial core.



BOND-TEST *(a) Failure in substrate* *(b) Bond failure* *(c) Failure in overlay*

The types of failures that can occur in a **BOND-TEST** are illustrated above: (a) failure in the substrate indicates that the bond strength is greater than the tensile strength of the substrate; (b) failure at the interface provides a measure of the tensile bond strength between the overlay and the substrate; and (c) failure in the overlay indicates that the bond strength is greater than the tensile strength of the overlay. During a test, it is very important that **negligible bending** is introduced to the disc by the loading system. Otherwise, low and erratic test results will be obtained.

Failure type (a) is preferred because it shows that the bond strength of the overlay is greater than the tensile strength of the substrate. Note that failure occurs at the weakest link of the composite system, and one cannot predict which type of failure will occur. Only tests results with the same type of failure should be averaged in calculating the average pull-off strength.

The nature of the **BOND-TEST** has been investigated by finite element analyses (see Petersen, C.G., Dahlblom, O. and Worters, P., "Bond-Test of Concrete and Overlays," *Proceedings*, International Conference on NDT in Civil Engineering, University of Liverpool, U.K., 1997; Bungey, J.H. and Madandoust, R., Factors influencing pull-off tests on concrete," *Mag. of Concr. Res.*, 1992, 44, No. 158)). Failure in the **BOND-TEST** using a 75-mm disc was predicted to occur at a displacement of 0.02 mm to 0.03 mm and the nominal stress in the partial core before rupture is about 3 % lower than the uniaxial tensile strength of the substrate concrete.

Variability

For 75-mm discs, the coefficient of variation of replicate test results is about 8 to 10 % on concrete with a maximum aggregate size of 38 mm. For 50-mm discs, the coefficient of variation is 14 to 16 %.

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The BOND-TEST procedure

1. Surface planing

The surface is ground with a diamond studded planing tool to expose the aggregates and to obtain a plane surface. The center knob that remains is removed with a separate wheel grinder. The dry surface is steel brushed and any dust or powder is blown away. The suction plate is used to stabilize the planing tool. Note that this operation is done without using cooling water.

2. Bonding the disc

A clean disc is bonded to the prepared surface using a rapid-curing adhesive (GRA). The GRA adhesive has a tensile strength of 10 MPa when fully cured, which takes 2 to 5 minutes at normal temperatures. The progress of hardening is observed in the small cup in which the two-component GRA was mixed. In cold weather conditions, the concrete surface and the disc are heated with a heat gun to accelerate curing of the adhesive.

3. Partial coring

A partial core is cut perpendicular to the surface using cooling water; the bonded disc serves as a drill guide (the inner diameter of the coring bit is slightly larger than the disc diameter). The partial core is cut with the **CORECASE** (page 39). For tests to measure bond strength, the core is cut to a depth of 25 mm into the substrate or one-half of the core diameter, whichever is greater; for tensile strength of the substrate, cut to a depth of 25 mm.

4. Pull-off

The disc is loaded in direct tension at a controlled rate using a calibrated hydraulic pull machine. The machine, which is the same as used for pullout tests (pgs. 28 and 87), bears against a circular counter pressure ring positioned centrally on the planed surface. The peak force in kN is recorded and used to obtain the pull-off strength by dividing by the cross-sectional area of the partial core. The type of failure, (a), (b) or (c), as shown on the previous page, is recorded.

The procedure and special equipment used for the **BOND-TEST** ensure that the disc is loaded in direct tension without bending. Bending may lower results by 20 to 50 %. The discs have sufficient stiffness to avoid distortion during testing. By bonding a clean disc on a planed, dry surface with the GRA adhesive, failure should not occur at the disc/overlay interface. Failure at the disc/overlay interface is an inconclusive test and must be repeated if the bond strength is to be evaluated.

Testing Examples

BOND-TEST *being performed for quality control of the bond between a wear resistant overlay and a concrete slab; coring after bonding the 75- mm disc is shown (left), application of pull-off load (middle), and the bond failure, type (b), between the overlay and the substrate (right) at 1.8 MPa*

BOND-TEST *being performed on granite tiles in a subway station*

The bond of a repair on a balcony being evaluated with **BOND-TEST**

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The BOND-TEST Equipment and Ordering Numbers

B-10000 DSV-Kit: For surface planing, bonding the disc, and attaching the coring rig to produce the partial core without anchoring.

Item	Order #
Diamond planing wheel unit	B-10010
Suction plate with valve and gauge	B-10020
Two adjustable clamping pliers	B-10030
Centering plate for 75 mm disc *Optionally*, centering plate for 50 mm disc	B-10040 B-10050
Vacuum pump with hose	B-10060
Wrench, 17 mm	B-10070
Small screwdriver	B-10080
Attaché case	B-10090

B-11000 BOND-TEST Preparation Kit: For removing the center knob after surface planing, cleaning the surface, bonding the discs, and heating the discs in cold weather conditions

Item	Order #
Grinder with cup stone	B-11010
Heat gun	B-11020
Steel brush	B-11030
75 mm discs, 6 pcs *Optionally*, 50 mm discs, 6 pcs	B-11040 B-11050
GRA glue, box	B-11060
Putty knife	B-11070
Araldite epoxy (for acrylic-based materials)	B-11080
Attaché case	B-11090

Optionally:

GRA glue, can with ½ kg powder	B-11100
GRA liquid, bottle with 200 mL	B11110

CORECASE CS-75: For producing the partial core.

Item	Order #
Coring rig with coupling	CC-10
Handles for coring rig, 3 pcs	CC-20
Coring bit, 75 mm x 110 mm	CCB-75/110
Water pump with 2 hoses	CC-30
Clamping pliers, adjustable, 2 pcs	CC-40
Set of anchoring tools, 8 mm	CC-50
8 mm expansion anchors, 20	CC-60
Chisel	CC-70
Hammer	CC-80
Corelifter, 75 mm diameter	CC-90
Wrench, 14 mm	CC-100
Measuring tape	CC-110
Set of spare bearings for coring rig	CC-120
Reinforcement locator	CC-130
Manual	CC-140
Attaché case	CC-150

B-13000 BOND-TEST Pull Machine Kit

The hydraulic pull machine has a 0 to100 kN precision electronic gauge with memory for storage of test results (peak-value, time and date of testing). The peak-value is shown after a test has been completed. The internal accuracy of the gauge is 0.01 kN. The display shows the pull force in 0.1 kN digital increments. The pull machine needs to be re-calibrated once a year, or sooner, if serviced or damaged.

Item	Order #
Hydraulic pull machine with electronic gauge	B-13025
AMIGAS printout software	L-13
Cable for printout	L-14
Strength conversion table (to 25 kN; for 50 and 75 mm discs) and manual	B-13001
Counter pressure ring	B-13002
Centering piece	B-13003
Coupling	L-16
Pull bolt	L-17
Bolt handle	L-19
Oil refilling cup	L-24
Oil refilling bottle	L-25
Large screwdriver	C-149
Small screwdriver	C-157
Attaché case	B-13004