In-Place Strength

- Evaluation of in-place strength
  - Testing cores
  - Rebound hammer
  - Pullout test
  - Case study
  - Pull-off test
  - Maturity method

Pull-off Test
ASTM C1583/C1583M

Designation: C1583/C1583M – 04$^{\varepsilon 1}$

Standard 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)[1]

This standard is issued under the fixed designation C1583/C1583M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

Measure force required to pull off a metal disc bonded to concrete surface.

1. Scope

1.1 Th ... test use to de

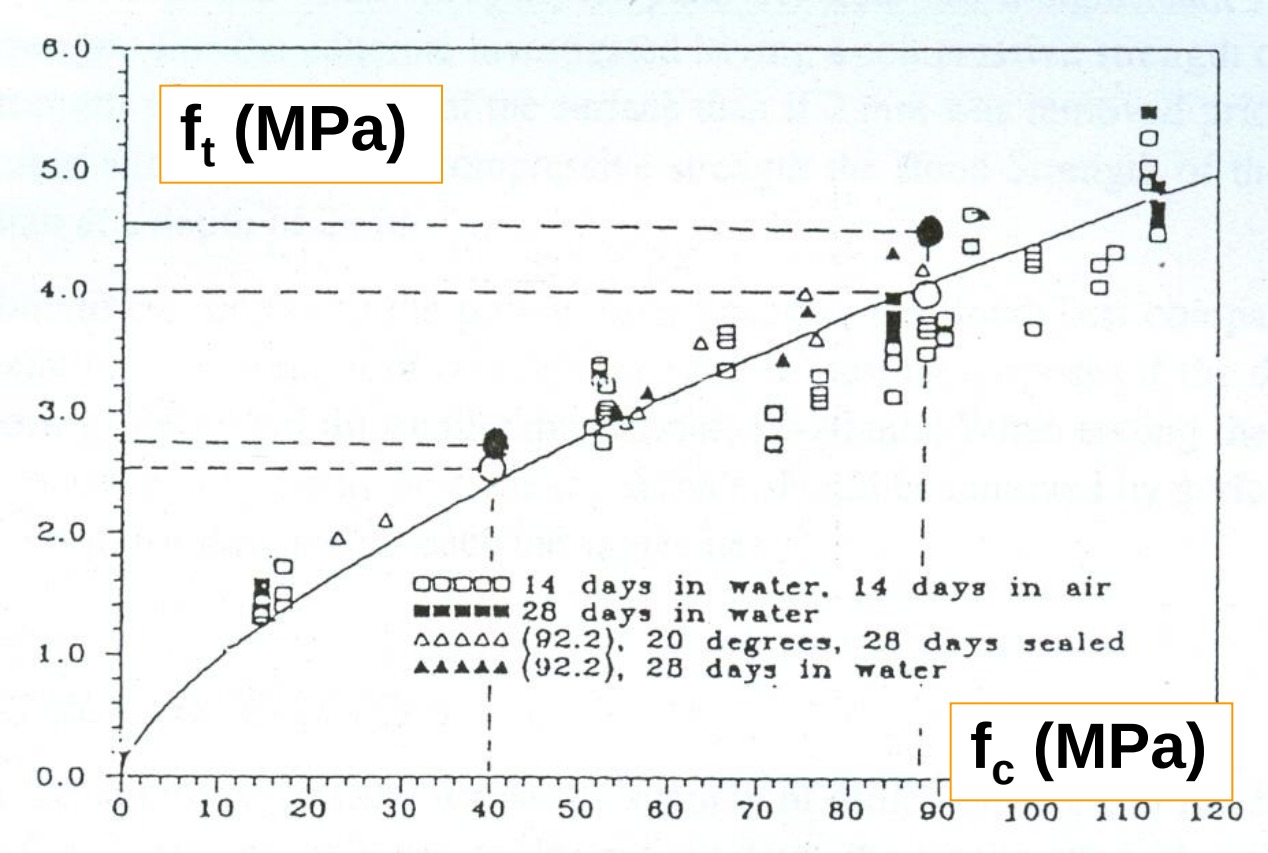
1.1.1 T ... indicator cation of a repair or overlay material.

4.1 This test is performed on the surface of a prepared

Pull-off Test

- Direct tensile strength test
- Evaluate condition of concrete surface before application of overlay or repair material
- Measure bond strength of overlay or surface repair materials

Lab testing between compressive and tensile strength



Worthers, 1994

1 MPa = 145 PSI

General Procedure

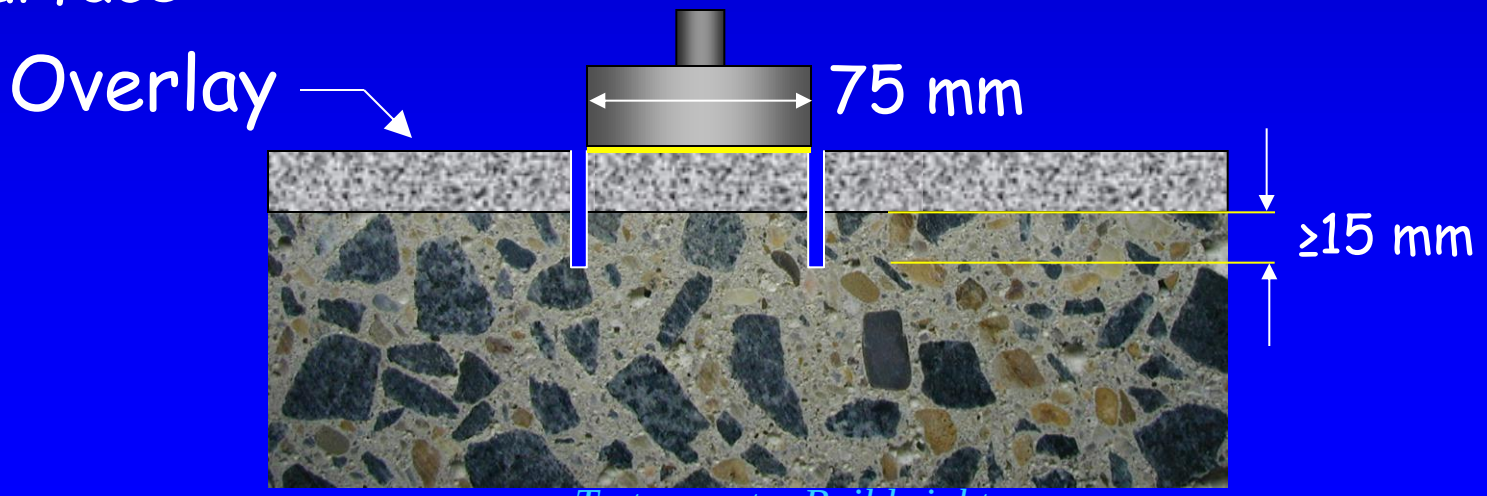
1. After the surface preparation has been made by removal of the surface concrete, the tensile strength is measured of the substrate. Drill depth of the partial core 15-20 mm.

2. If the tensile strength is acceptable (for normal values of uncracked concrete see previous slide) the testing is repeated after the new layer has been applied, making sure the partial coring is 15-20 mm below the adhesion surface.

3. For good bonding the failure has to be in the substrate at a value comparable to the tensile strength of the substrate.

BOND-TEST Test Procedure

- Use planing tool to prepare a flat/plane surface
- Bond metal disc to the dry and cleaned surface
- Drill partial core perpendicular to the planed surface using the disc as a drill master
- Apply tensile force slowly at a steady rate, centrically against a counter pressure ring resting on the planed surface



NOTE

Being a tensile test any bending forces introduced during testing will reduce the measured value considerable. In the BOND-TEST these bending forces are minimized by ensuring:

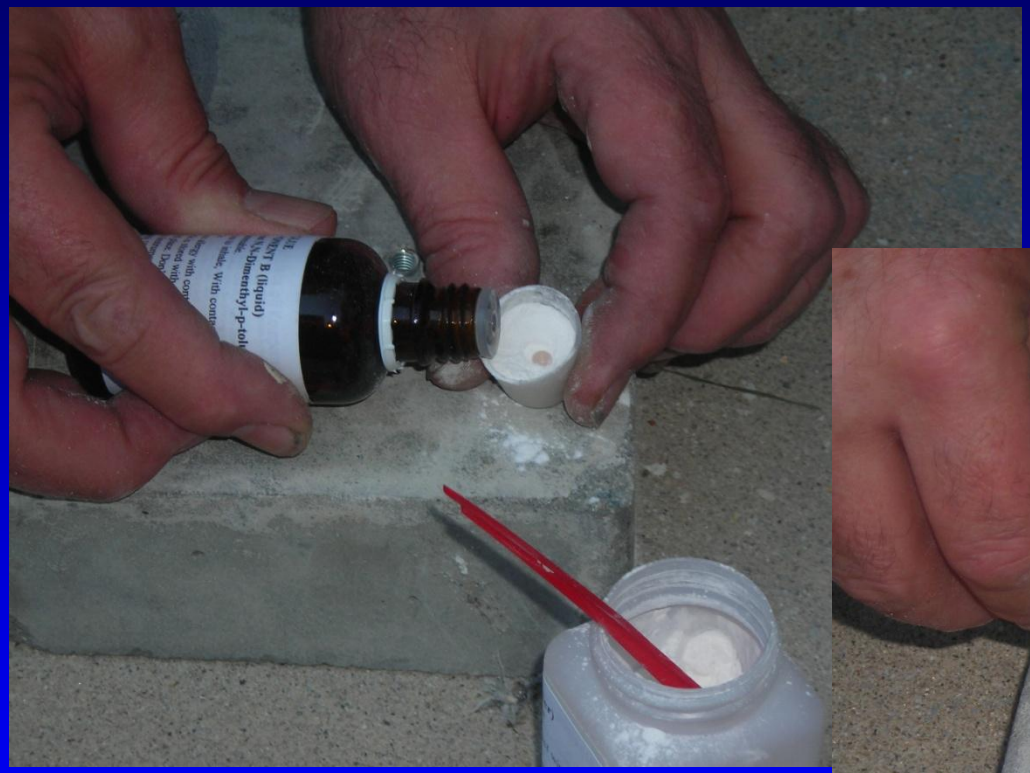
- The center line of the glued-on disc to be the centerline of the partial core.
- The CORECASE used will produce a straigth drill partial core perpendicular to the planed surface
- The counter pressure is a ring (not three points) that rest on the planed surface centric with the glued on disc

If these steps are followed, the values in slide 4 will be obtained, e.g. for 5800 PSI (40 MPa) uncracked concrete the tensile strength will be ~ 360 PSI (2.5 MPa)

Surface Planing

Grind “Button” & Brush Surface

Prepare and Apply Adhesive



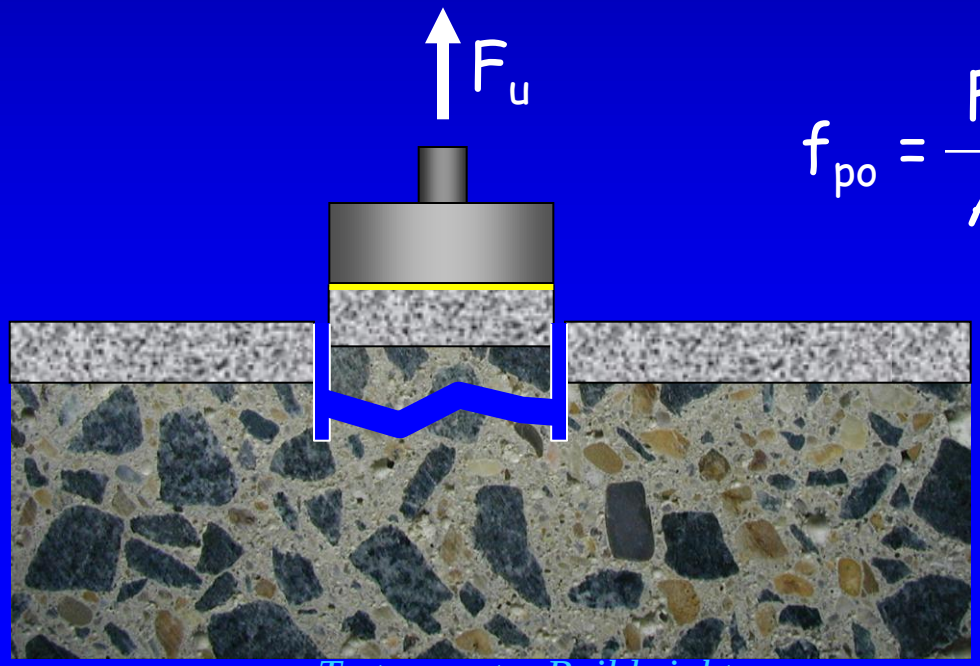
Press Disc To Surface & Clean Up

Cut Partial Depth Core

Partial coring w. Suction Plate

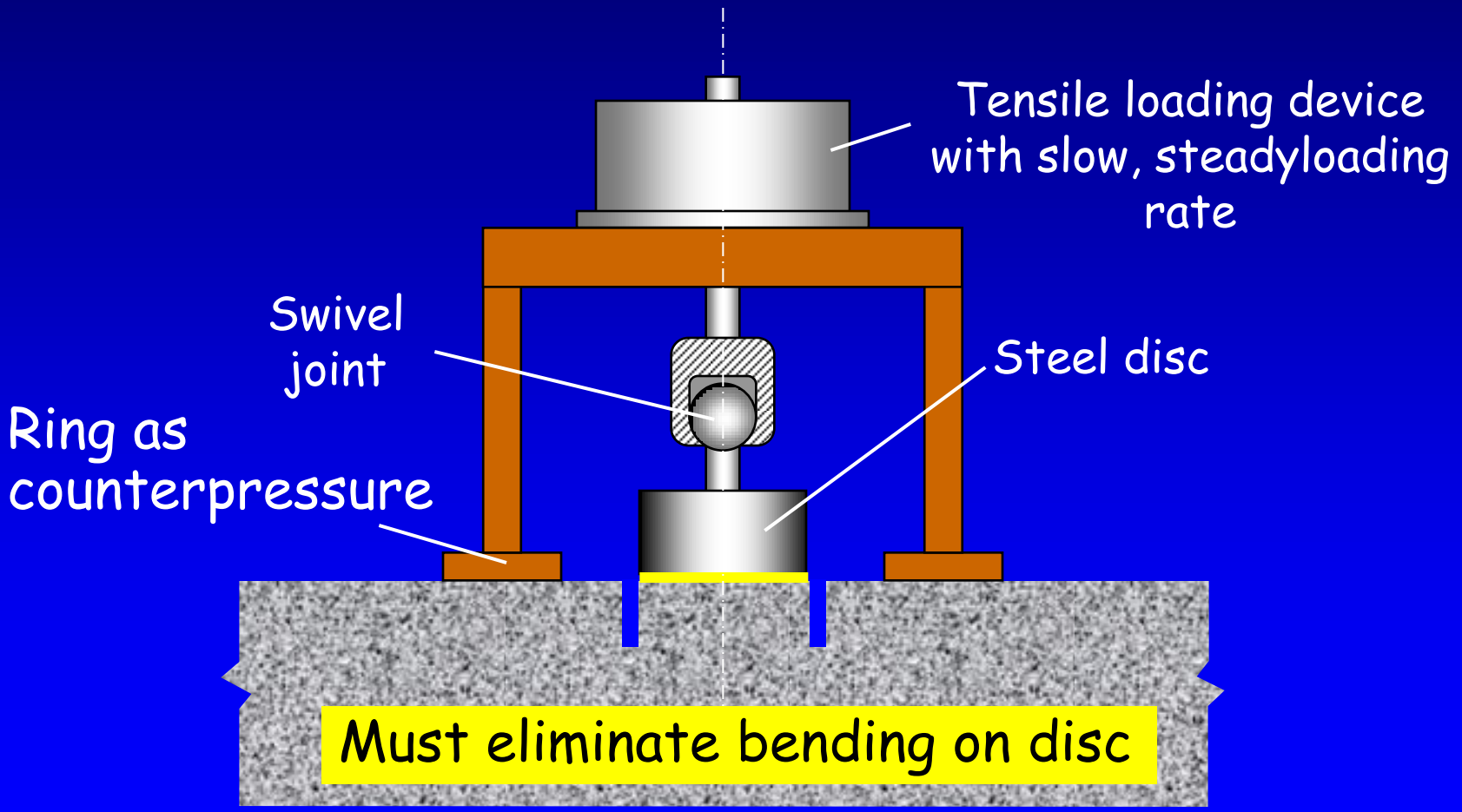
Pull-off Test Procedure

- Bond metal disc to surface
- Drill partial core
- Apply tensile force



$$f_{po} = \frac{F_u}{A}$$

Schematic of Apparatus
ASTM C1583/C1583M



Pull-off Test Apparatus

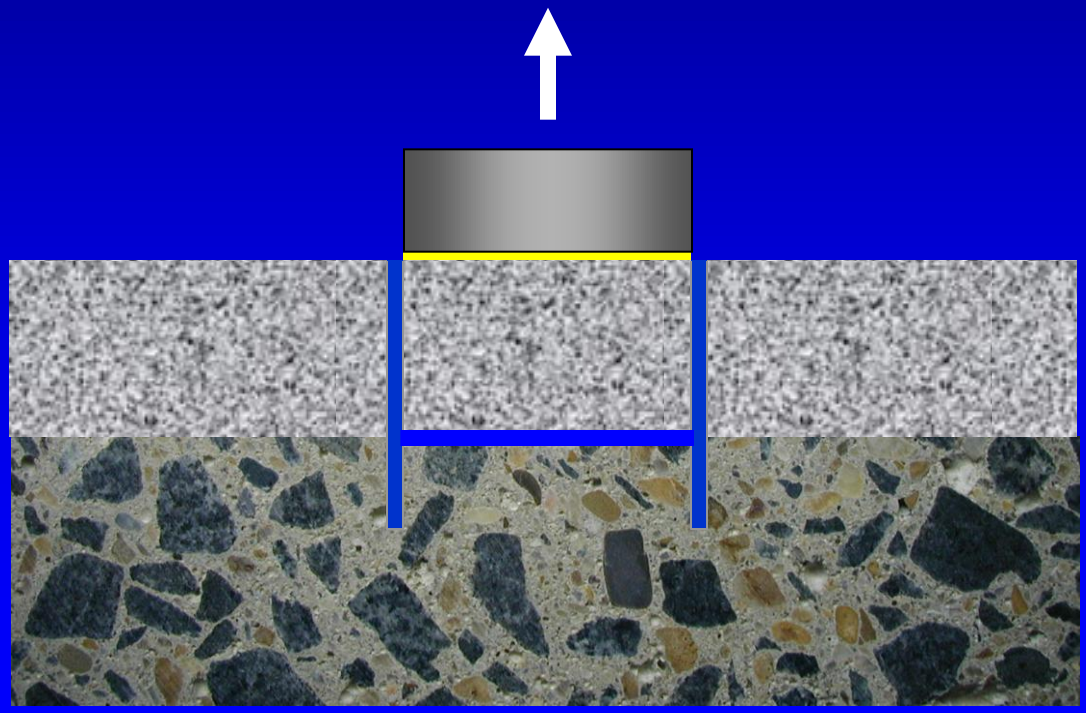
Adhesion testing of tiles

Adhesion testing of overlay

Successful Test!

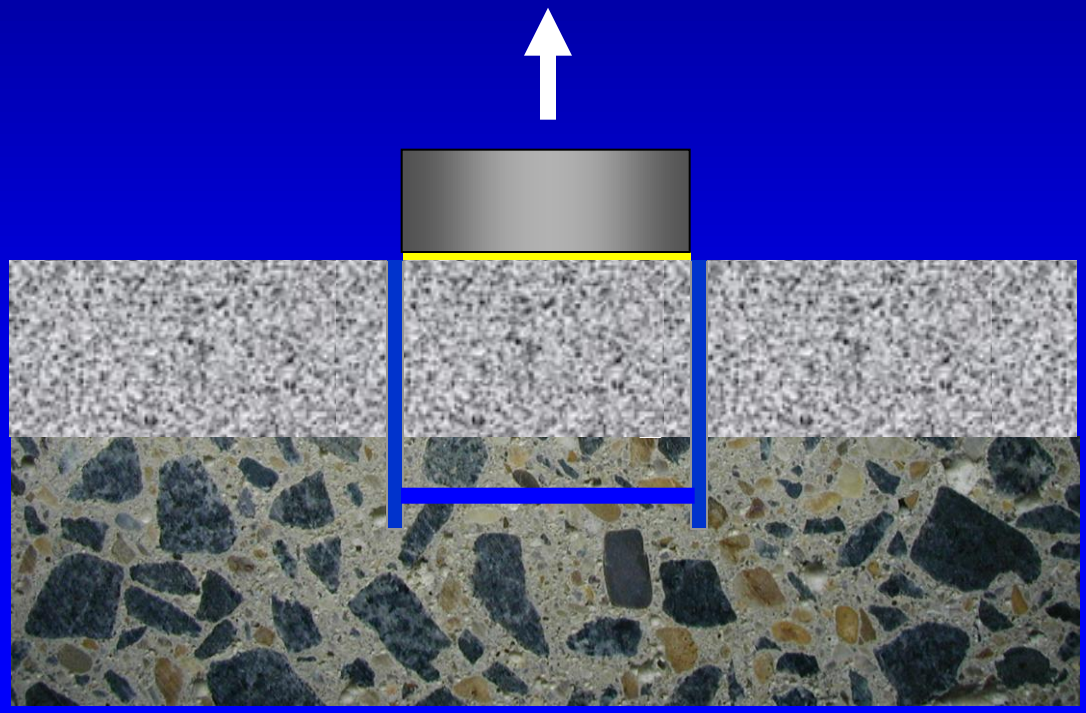
Pull-off Test Failure Locations

- Interfacial bond failure (bond strength)



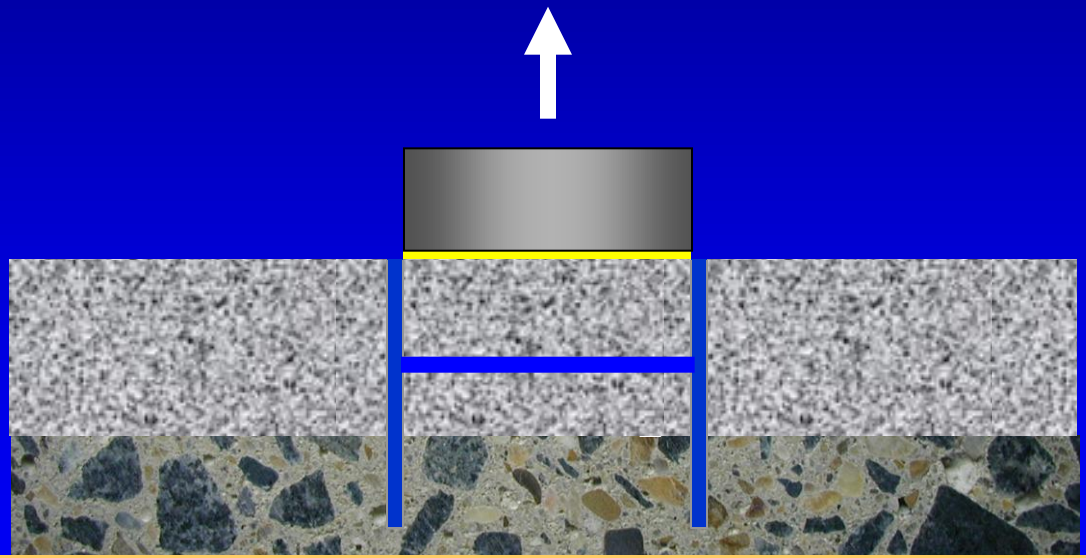
Pull-off Test Failure Locations

- Cohesive failure in the existing concrete (substrate strength)



Pull-off Test Failure Locations

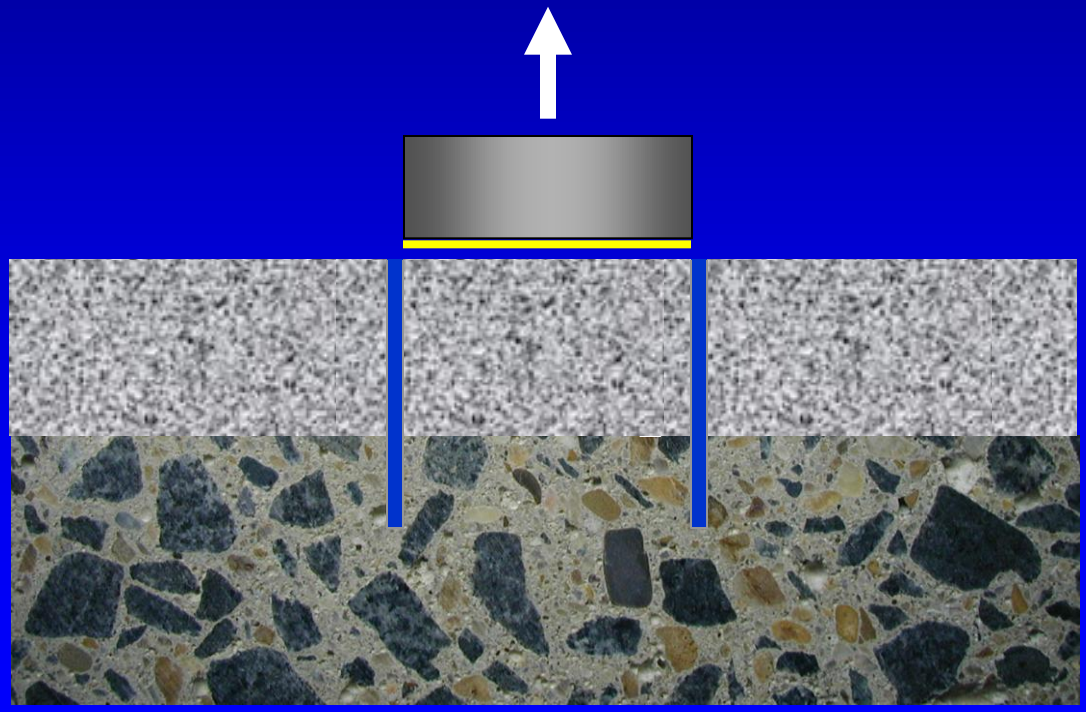
- Cohesive failure in the repair material



- Can not predict failure location
- Average the results for same failure locations

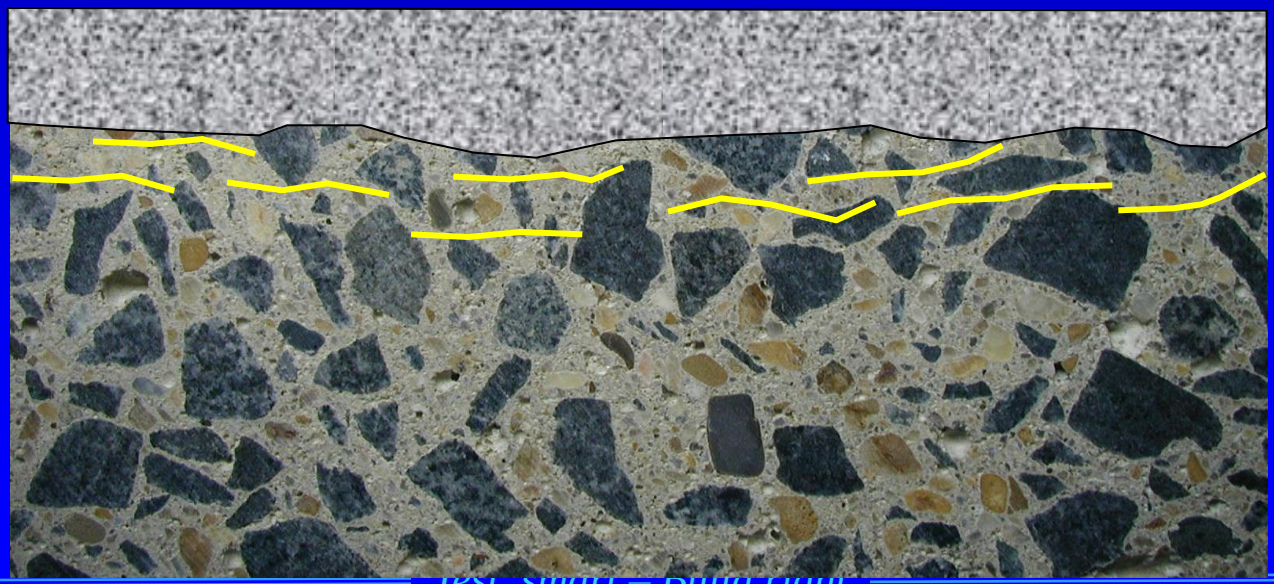
Pull-off Test Failure Locations

- Bond failure at the epoxy
- Inconclusive test



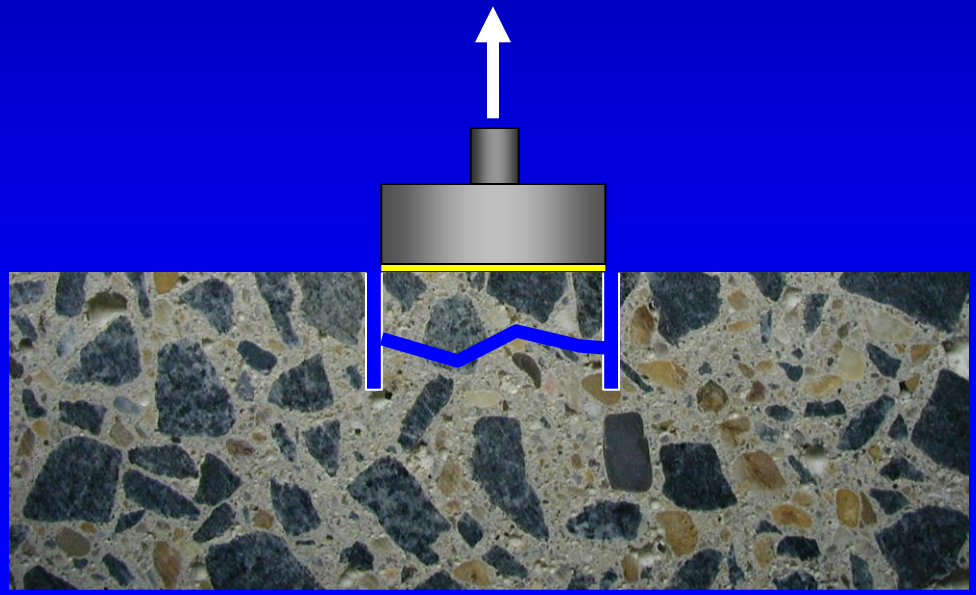
Evaluation of Surface Preparation Methods

- Surfaces to receive overlay or repair material are usually prepared to ensure good bonding
- Some repair methods can damage concrete and reduce the "apparent" bond strength



Evaluation of Surface Preparation Methods

- Test substrate before applying overlay
  - ACI 503R (Use of Epoxy Compounds with Concrete) recommends substrate pull-off strength > 175 psi (1.2 MPa)



Summary

- Pull-off test can be used to evaluate surface before applying repair materials or overlays
- Evaluate bond strength of repair materials
- Need to eliminate bending on the disk when it is being pulled off
- Good adhesive needed to provide strong bond and allow rapid testing
- Failure will occur in "weakest link"