

A Repair Technician's Guide to the ACI 562-16

Rick Edelson, Edelson Consulting Group, LLC

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 1

Copyright Material

This presentation is protected by US and International copyright laws. Reproduction, distribution, display and use of the presentation without permission of the speaker is prohibited.

© Edelson Consulting Group LLC 2016

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 2

The Big Picture

Let's go to the end first, then back to the beginning

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 3

Chapter 10 – Quality Assurance

- 10.2.2 The construction documents shall include testing and inspection requirements applicable to the project.
- 10.2.2C ...Repair inspector qualifications for inspection of concrete repairs should be demonstrated by **certification...An individual who has been certified an ICRI Concrete Surface Repair Testing Technician (ICRI Concrete Surface Repair Technician)**

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 4

Who is a Repair Technician?

- The Repair Technician is NOT the Licensed Design Professional (LDP)
- the engineer or architect, licensed as described, who is responsible for the structural design of a particular project (**also historically engineer of record**)
- The 562 Code is specifically written for the LDP

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 5

Who is a Repair Technician?

The very first statement of the Code:

- *ACI 562-16, "Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures" was developed to provide design professionals involved in the assessment of existing concrete structures a code for the assessment of the damage and deterioration, and the design of appropriate repair and rehabilitation strategies.*
- **1.5 – Responsibilities of the licensed design professional**

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 6

1.5 Responsibilities of the licensed design professional

- 1.5.1 The licensed design professional for the project is responsible for 1) assessing; 2) designing, detailing, and specifying the work proposed and material requirements; 3) establishing requirements to maintain load paths for the work proposed; and 4) preparing construction documents of the work proposed and specifying a quality assurance program.



2016 Fall Convention | November 9-11 | Cleveland, Ohio

7

Who is a Repair Technician?

- 10.2.1C The quality of concrete repairs is largely dependent upon the workmanship during construction. Inspection is necessary to verify repairs and rehabilitation work are completed in accordance with construction documents.



2016 Fall Convention | November 9-11 | Cleveland, Ohio

8

Who is a Repair Technician?

- 10.2.1C The quality of concrete repairs is largely dependent upon the workmanship during construction. Inspection is necessary to verify repairs and rehabilitation work are completed in accordance with construction documents.



2016 Fall Convention | November 9-11 | Cleveland, Ohio

9

Who is a Repair Technician?

- 10.2.1C The quality of concrete repairs is largely dependent upon the workmanship during construction. Inspection is necessary to verify repairs and rehabilitation work are completed in accordance with construction documents.



2016 Fall Convention | November 9-11 | Cleveland, Ohio

10

Who is a Repair Technician?

- 10.2.1C The quality of concrete repairs is largely dependent upon the workmanship during construction. Inspection is necessary to verify repairs and rehabilitation work are completed in accordance with construction documents.
- 10.2.2C Repair construction should be inspected to verify the quality of materials, quality of workmanship, and for compliance with the intent of the construction documents.



2016 Fall Convention | November 9-11 | Cleveland, Ohio

11

Who is a Repair Technician?

The Repair Technician is the person qualified to inspect the quality of the work.

- From the Ownership side: This is the Quality Assurance Inspector.
- From the Contractor side: This is the person responsible to control the quality of work, i.e. Quality Control.
- From the ACI 562 side: An individual who has been certified as qualified to perform testing and inspection on concrete repairs, i.e. either of the above two individuals.




2016 Fall Convention | November 9-11 | Cleveland, Ohio

12

What knowledge must the Repair Technician possess?

Let's take a look at a few examples




INTERNATIONAL CONCRETE REPAIR INSTITUTE

2016 Fall Convention | November 9-11 | Cleveland, Ohio 13

Condition Assessment

- **Methods of assessment**
 - ASTM D4580 sounding
 - Exploratory removal
 - Impact-echo
 - Impulse-response
 - Thermography
 - ASTM C1583
- 10.4.1C A primary purpose of construction observation of rehabilitation work is to verify that the exposed existing construction is as assumed in the design and that the work detailed in the contract documents will fulfill the design intent.
- 7.4.1.2 (Bond) Testing requirements shall be in accordance with Table 7.4.1.2.



INTERNATIONAL CONCRETE REPAIR INSTITUTE


2016 Fall Convention | November 9-11 | Cleveland, Ohio 14

Causes of concrete deterioration

- Embedded metal corrosion
- Freeze-thaw
- Erosion/abrasion
- Disintegration

- 1.7.4 The in-place strength of the existing structure shall be determined considering in-place geometric dimensions and material properties including effects of material deterioration and other deficiencies.

The knowledge of why a repair is being performed is imperative for understanding what is to be repaired. And therefore having the ability to observe if a repair has been completed.




INTERNATIONAL CONCRETE REPAIR INSTITUTE

2016 Fall Convention | November 9-11 | Cleveland, Ohio 15

Carbonation and Chloride contamination

- Corrosion of reinforcing steel can be initiated by either carbonation or chloride contamination or both.
- 7.6.2 Concrete—The in-place properties of the concrete, in accordance with Chapter 6, shall be used in the repair design.
- 7.6.2C The extent and cause of deterioration and the concrete strength and quality should be assessed, including compressive strength, chlorides, carbonation, sulfate attack, alkali-silica reaction, physical damage, corrosion-induced spalling, and cracking. Chloride penetration can cause corrosion that can lead to cracking and spalling.




INTERNATIONAL CONCRETE REPAIR INSTITUTE

2016 Fall Convention | November 9-11 | Cleveland, Ohio 16

Concrete removal

- Repair area geometry
- Undercutting reinforcing steel
- 7.6.6 Repair geometry— Configuration of repairs shall consider the potential for stress concentrations and cracking in both the existing structure and the repair area.




INTERNATIONAL CONCRETE REPAIR INSTITUTE

2016 Fall Convention | November 9-11 | Cleveland, Ohio 17

Concrete removal

- 7.6.6C Repair shapes with sharp reentrant corners can cause stress concentrations that may result in cracking. Long, slender (high aspect ratio) repair areas also may result in cracking. The shape of the repair should be considered to reduce stress concentrations and possible cracking.
- Methods discussed in ICRI No. 310.1R provide guidance to reduce cracking in concrete repairs including providing a uniform depth of edges and substrate, repair geometry, surface preparation, concrete removal below reinforcement (undercutting) and elimination of feather edge repairs.



INTERNATIONAL CONCRETE REPAIR INSTITUTE

2016 Fall Convention | November 9-11 | Cleveland, Ohio 18

Concrete removal

- **Methods of removal**
 - Jack Hammer
 - Chipping
 - Hydrodemolition
 - Saw cutting perimeter
 - Surface roughness (ICRI CSP chips)
 - Bruising (microfractures)
- 10.2.2C Required testing and inspections may include (a) through (j):
 - a) Delivery, placement, and testing reports documenting the identity, quantity, location of placement, repair materials tests, and other tests as required
 - b) Construction and removal of forms and reshoring
 - c) **Concrete removal and surface preparation of the concrete and reinforcement...**

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 19

Concrete surface preparation

- Bruising
- Cleanliness
- Temperature
- Moisture
- d) Placing of reinforcement and anchors
- e) **Mixing, placing, and curing of repair materials**
- f) Sequence of erection and connection of new members
- g) Tensioning of tendons
- h) Review and reporting of construction loads on floors, beams, columns, and walls
- i) General progress of work
- j) Installation and testing of post-installed anchors

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 20

Concrete surface preparation

- Bruising
- Cleanliness
- Temperature
- Moisture
- 7.4.2C
... A properly prepared substrate is achieved by removing existing deteriorated, damaged, or contaminated concrete. The exposed sound concrete is then roughened and cleaned to allow for adequate bond of a repair material.

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 21

Cementitious replacement material

- Material selection
- Compatibility
- 7.5.1 Design of the repair system shall consider the properties and installation of the repair materials and systems. These include, but are not limited to:
 - **physical properties of the repair materials, type of application, adhesion, volume stability, thermal movement, durability, corrosion resistance, installation methods, curing requirements, and environmental conditions.**

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 22

Cementitious replacement material

- **Methods of placement**
 - Dry-packing
 - Trowel applied
 - Poured flatwork
 - Form and pour
 - Form and pump
 - Preplaced aggregate
 - Shotcrete
- 10.2.2C Required testing and inspections may include (a) through (j):
 - a) **Delivery, placement,** and testing reports documenting the **identity, quantity, location of placement,** repair materials tests, and other tests as required...
 - e) **Mixing, placing, and curing of repair materials**

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 23

Concrete curing

- **Methods of curing**
 - Curing compounds
 - Evaporation retarders
 - Burlap
 - Polyethylene sheeting
 - Wet cure
- 10.2.2C Required testing and inspections may include (a) through (j):
 - e) **Mixing, placing, and curing of repair materials**

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 24

Bond

- Mechanisms affecting bond
 - Surface roughness (ICRI CSP chips)
 - Bruising (microfractures)
- ASTM D4580 sounding (integrity)
- Bond pull-off testing (quantitative)

f_{cr}	Reference	Testing requirements
Less than 30 psi	7.42	Bond-integrity testing
Between 30 and 60 psi	7.43	Quantitative bond strength testing
Greater than 60 psi	7.44	Quantitative bond strength testing

- 7.4.2C ... Bond integrity testing can consist of various qualitative test methods such as sounding in accordance with ASTM D4580

2016 Fall Convention | November 9-11 | Cleveland, Ohio 25

Bond

- Bond pull-off testing
- 7.4.3C ... Bond capacity has primarily been evaluated using direct tension pull-off tests, as defined in **ASTM C1583 and as described in ICRI No. 210.3.**

2016 Fall Convention | November 9-11 | Cleveland, Ohio 26

Reinforcing steel corrosion

- Acceptable corrosion
- Unacceptable corrosion
- Damaged reinforcing

- 8.4.1 The corrosion and deterioration of reinforcement and embedded components shall be considered in the durability design.

2016 Fall Convention | November 9-11 | Cleveland, Ohio 27

Reinforcing steel corrosion

- Acceptable corrosion
- Unacceptable corrosion
- Damaged reinforcing

- 8.4.1C Untreated reinforcement corrosion limits the life expectancy of repair areas, repair materials, and repaired structures. **ICRI No. 310.1R provides guidelines on removal of damaged concrete and cleaning of reinforcing steel.** Repairs that do not address reinforcement corrosion may negatively impact the design service life and require more intensive monitoring.

2016 Fall Convention | November 9-11 | Cleveland, Ohio 28

Reinforcing steel

- Calculation of lost cross sectional area

- 7.6.3.1 **Reinforcement that is damaged or corroded shall be permitted to remain.** The effective cross-sectional area of remaining reinforcement shall be permitted to be used in the repair design in accordance with the design basis code.
- 7.6.3.1C ... **The effective area is calculated using the remaining effective diameter of the reinforcing bar accounting for the loss of section due to corrosion.**

2016 Fall Convention | November 9-11 | Cleveland, Ohio 29

Reinforcing steel

- Corrosion removal

- 8.4.1 The corrosion and deterioration of reinforcement and embedded components shall be considered in the durability design.
- 8.4.1C **Untreated reinforcement corrosion limits the life expectancy** of repair areas, repair materials, and repaired structures. **ICRI No. 310.1R provides guidelines on removal of damaged concrete and cleaning of reinforcing steel.**

2016 Fall Convention | November 9-11 | Cleveland, Ohio 30

Reinforcing steel

- Concrete cover
- 8.2.2 Corrosion—Where concrete cover for existing reinforcement is insufficient to provide corrosion protection for the design service life of the structure, additional concrete cover or an alternate means of corrosion protection shall be provided to mitigate corrosion of reinforcement within the repair area.

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 31

Reinforcing steel replacement

- Development length
- Lap length
- Bar size and f_y
- Alternative splicing methods
- 1.6.1C As necessary, the construction documents should indicate:
 - ...(d) Details, locations and notes indicating the size, configuration, reinforcement, anchors, repair materials, preparation requirements, and other pertinent information to implement
 - ...(g) Development length of reinforcement and length of lap splices
 - (h) Type and location of mechanical or welded splices of reinforcement

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 32

Testing

- Bond pull-off (ASTM C1583)
- Slump (ASTM C143)
- Self consolidating concrete testing (ASTM C1611)
- Concrete Test Specimens (ASTM C31)
- 10.2.2C ...Repair construction should be inspected to verify the quality of materials, quality of workmanship, and for compliance with the intent of the construction documents.
- 10.3.1C Tests of repair materials should comply with testing and test frequency of new concrete construction, unless otherwise specified in the contract documents and approved by the jurisdictional authority.

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 33

The Big Picture

As I said in the beginning:
Let's go to the end first, then back to the beginning

We're not at the end

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 34

Chapter 10 – Quality Assurance

- 10.2.2 The construction documents shall include testing and inspection requirements applicable to the project.
- 10.2.2C ...Repair inspector qualifications for inspection of concrete repairs should be demonstrated by certification...An individual who has been certified an ICRI Concrete Surface Repair Testing Technician (ICRI Concrete Surface Repair Technician)


INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 35




The linked image cannot be displayed. The file may have been moved, renamed, or deleted. Verify that the link points to the correct file and location.


We have just defined the ICRI Concrete Surface Repair Technician Certification Program

INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 36

 The linked image cannot be displayed. The file may have been moved, renamed, or deleted. Verify that the link points to the correct file and location.


Tier 1: ICRI Concrete Surface Repair Technician Educational Program, consists of five (5) online training modules. Those who successfully complete this portion of the program, including passing all five (5) online training modules, will be awarded a Certificate of Achievement from ICRI.


 INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 37

 The linked image cannot be displayed. The file may have been moved, renamed, or deleted. Verify that the link points to the correct file and location.


Tier 1 Modules:


- Module 1: What is Reinforced Concrete? / Deterioration of Reinforced Concrete
- Module 2: Quality Requirements
- Module 3: Repair Methods and Materials
- Module 4: Pre-placement Inspection
- Module 5: Post-placement Inspection

 INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 38

 The linked image cannot be displayed. The file may have been moved, renamed, or deleted. Verify that the link points to the correct file and location.


- Tier 2: **The full certification program**, ICRI Concrete Surface Repair Technician—Grade 1, consists of the same five (5) online training modules in Tier 1, an online knowledge exam, and a performance exam (video submission or live recorded). By passing the five (5) online training modules, the online knowledge exam, and performance exam, an ICRI Concrete Surface Repair Technician—Grade 1 certification will be issued by ICRI.


 INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 39

 The linked image cannot be displayed. The file may have been moved, renamed, or deleted. Verify that the link points to the correct file and location.


Tier 2 Modules:

- Knowledge Exam
- Performance Exam (live or video recorded)

 INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 40

 The linked image cannot be displayed. The file may have been moved, renamed, or deleted. Verify that the link points to the correct file and location.


- The **Tier 2** knowledge and performance exams are based on the Educational Program (**Tier 1**) and the following four (4) ASTM Standards, including all Annexes and Appendices, and ICRI Guideline:
- **C143**, Standard Test Method for Slump of Hydraulic-Cement Concrete;
- **C1611**, Standard Test Method for Slump Flow of Self-Consolidating Concrete;
- **C31**, Standard Practice for Making and Curing Concrete Test Specimens in the Field;
- **C1583**, Standard Test Method for Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method);
- **ICRI Guideline No. 210.3R**, Guide for Using In-Situ Tensile Pulloff Tests to Evaluate Bond of Concrete Surface Materials

 INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 41

Who is a Repair Technician?

- The Repair Technician is **NOT** the Licensed Design Professional (LDP)
- The ICRI Certified Concrete Surface Repair Technician

 INTERNATIONAL CONCRETE REPAIR INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 42



A Repair Technician's Guide to the ACI 562-16
Rick Edelson, Edelson Consulting Group, LLC

INTERNATIONAL
CONCRETE REPAIR
INSTITUTE 2016 Fall Convention | November 9-11 | Cleveland, Ohio 43