

ACI 503.7-07

Specification for Crack Repair by Epoxy Injection

An ACI Standard

Reported by ACI Committee 503



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Specification for Crack Repair by Epoxy Injection

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An ACI Standard

Reported by ACI Committee 503

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This Specification gives requirements for repairing cracks in concrete by injection of two-component epoxy-resin adhesive.

Keywords: adhesive; concrete; crack; epoxy; repair injection; sealer.

NOTES TO SPECIFIER

This Specification is incorporated by reference in the Project Specification using the wording in Section P3 of the Preface and including information from the Mandatory Requirements, Optional Requirements, and Submittals Checklists following this Specification.

PREFACE

P1. ACI Specification 503.7 is intended to be used by reference or incorporation in its entirety in the Project Specification. Do not copy individual Sections, Parts, Articles, or Paragraphs into the Project Specification, because taking them out of context may change their meaning.

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Reference to this document shall not be made in contract documents. If items found in this document are desired by the Architect/Engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the Architect/Engineer.

P2. If Sections or Parts of ACI Specification 503.7 are copied into the Project Specification or any other document, do not refer to them as an ACI Specification, because the Specification has been altered.

P3. A statement such as the following will serve to make ACI Specification 503.7 a part of the Project Specification:

“Work on (Project Title) shall conform to all requirements of ACI Specification 503.7-07, “Specification for Crack Repair by Epoxy Injection,” published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these Contract Documents.”

P4. Each technical Section of ACI Specification 503.7 is written in the three-part Section format of the Construction Specifications Institute, as adapted for ACI requirements. The language is imperative and terse.

P5. The Specification is written to the Contractor. When a provision of this Specification requires action by the Contractor, the verb “shall” is used. If the Contractor is allowed to exercise an option when limited alternatives are available, the phrasing “either...or...” is used. Statements provided in the Specification as information to the Contractor use the verbs “may” or “will.” Informational statements typically identify activities or options that “will be taken” or “may be taken” by the Owner or Architect/Engineer.

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SECTION 1—GENERAL

1.1—Scope

This Specification covers the repair of cracks in concrete by pressure-injecting epoxy into cracks that intersect at least one accessible surface of the concrete or masonry member. It does not cover the repair of delaminations where the intersection of the cracked concrete with the surface of the concrete member is not accessible nor can be made accessible.

1.2—Definitions

accepted—determined to be satisfactory by the Architect/Engineer.

Architect/Engineer—the architect, engineer, architectural firm, or engineering firm issuing Contract Documents or administering the Work under Contract Documents, or both.

bond line—the layer of adhesive that attaches two opposing faces of a crack.

continuous metering and mixing—the process in which two adhesive components are continuously metered into and discharged from a mixing chamber.

Contract Documents—a set of documents supplied by the Owner to the Contractor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

crack face—the exposed intersection of a crack and the surface of the concrete member.

crack repair—the work performed to permit the transfer of tensile stress across the crack.

injection adhesive—the material that is injected into a crack for the purpose of repair.

injection port—a device or passageway in the surface seal through which the injection adhesive is introduced into a crack.

Project Specification—the written document that details requirements for the Work in accordance with service parameters and other specific criteria.

surface seal—the material that is applied to the crack face to contain the adhesive during the injection process.

Work—the entire construction or separately identifiable parts thereof required to be furnished under Contract Documents.

1.3—Reference standards

- C 42/C 42M-04 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- C 496/C 496M-04 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
- C 881/C 881M-02 Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
- D 695-02a Standard Test Method for Compressive Properties of Rigid Plastics

These standards may be obtained from the following organization:

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
www.astm.org

1.4—Submittals

1.4.1 Injection adhesives

1.4.1.1 Qualification testing—Submit an independent laboratory test report, including all test results, certifying that the injection adhesive meets all the requirements specified in Section 2.2.

1.4.1.2 Manufacturer's certification—Submit the manufacturer's certification verifying conformance to the requirements of Section 2.2 of each lot of injection adhesive to be used in the Work.

1.4.1.3 Additional testing—Submit additional test results when required.

1.5—Quality assurance

1.5.1 Metering accuracy—Use equipment or tools for continuous (metering) or batch proportioning for the two components of the injection adhesive that are able to establish and maintain a ratio of the components within the tolerance specified by the manufacturer of the injection adhesive over the full range of operating pressures and temperatures. If the manufacturer of the adhesive does not specify a tolerance for the mixture ratio, maintain a mixture ratio within $\pm 3\%$ of the nominal mixture ratio specified by the manufacturer of the adhesive.

1.5.2 Qualification test for metering accuracy

1.5.2.1 When a continuous metering and mixing pump is required, test the metering accuracy of equipment before the start of the Work to demonstrate that the pump is capable of

maintaining the ratio within the tolerances required in Section 1.5.1.

1.5.2.1.a Conduct the test using a pump discharge pressure that ranges from the lowest to the highest discharge pressure at which the equipment is expected to be operated during the injection process.

1.5.2.1.b The device used to measure metering accuracy shall be capable of controlling the discharge pressure of each of the components separately as they are simultaneously discharged into separate containers.

1.5.2.1.c Conduct one test by discharging both adhesive components simultaneously into separate containers while maintaining a discharge pressure on both components equal to the lowest operating discharge pressure. Conduct a second test at the highest operating discharge pressure.

1.5.2.1.d Measure injection pressure with a gauge mounted upstream of and within 300 mm (12 in.) of the mixing chamber.

1.5.2.1.e Discharge a minimum of 200 g (7 oz) of each component into separate graduated containers or into containers that can be weighed. If the ratio determination is made by mass, the volumetric ratio may be determined by calculation using the specific gravity of each component. (The volumetric ratio is determined by multiplying the mass ratio by the inverse of the ratio of the specific gravities of the components.)

1.5.2.2 Demonstrate that the injection equipment does not have more than a 35 kPa (5 psi) drop in pressure in either of the two component lines after operating with no flow for 3 minutes with at least 80% or more of the operating pressure.

1.5.3 *Qualification tests for mixing effectiveness of equipment*—Before the start of the test injection Work specified in Section 1.5.4, conduct the bond strength 2-day cure and compressive yield and compressive modulus tests in ASTM C 881/C 881M on the specified injection adhesive processed with the equipment and tools to be used to meter, and mix the injection adhesive in the Work. If the test results do not meet the requirements of ASTM C 881/C 881M, modify or replace the equipment.

1.5.4 *Qualification of injection procedures*

1.5.4.1 *Test injection*—As the first item of Work, repair a test crack selected by the Architect/Engineer not less than 3.0 m (10 ft) in total length. If there are no cracks at least 3.0 m (10 ft) in length, the Architect/Engineer will select a number of shorter cracks whose total length will approximately equal 3.0 m (10 ft). Inject the test crack(s) using the specified injection adhesive. Use the same surface seal, equipment, and application methods that are to be used in executing the Work. Meet the requirements of Section 1.5.7. Do not begin the remaining injection work until the equipment and application methods are accepted.

1.5.5 *Quality control*

1.5.5.1 *Metering accuracy tests for continuous mixing*—The first time any piece of two-component continuous metering and mixing equipment is used in the Work and any time each piece of equipment is used after a 4-hour or longer shutdown period, test two-component continuous metering and mixing equipment to demonstrate that the equipment is

operating as required in Sections 1.5.1 and 1.5.2. If the ratio of the two components is not within the specified tolerance, stop injection work until the equipment is brought into compliance with Section 1.5.1. Maintain a record of all such tests, including date, time, results of the tests required in Section 1.5.5.1, temperature of each adhesive component, and location of the last crack injected before the test performed to comply with Section 1.5.5.1. Submit the record to the Architect/Engineer at the end of each workday.

1.5.5.2 *Metering accuracy test for batch mixing*—For every batch of adhesive mixed, record the amount of each component and the total amount of mixed adhesive within $\pm 3\%$. Maintain a record of all batches, including date, time, and mixture ratio.

1.5.5.3 *Injection adhesive*—When the results of splitting tensile core testing, as specified in Section 1.5.7.2, do not meet the requirements of Section 1.5.7.1, make three compressive strength specimens to verify that the adhesive and injection equipment meet the requirements of this Specification. Make the specimens with injection adhesive that has been metered and mixed with the equipment used in the Work. Fabricate these test specimens by injecting the injection adhesive into metal molds with dimensions consistent with the requirements of Section 6.2 of ASTM D 695. Use an accelerated cure schedule provided by the manufacturer to cure the specimens. If the manufacturer does not provide an accelerated cure schedule, cure the specimens for 24 ± 1 hour at 52 ± 1 °C (125 ± 2 °F). Tests results shall meet the compressive strength requirement of ASTM C 881/C 881M. If the compressive strength requirement is not met, stop injection work until the equipment and materials comply with this Specification. If the tests indicate the adhesive and equipment comply with the specification, stop work and notify the Architect/Engineer.

1.5.6 *Daily log*—Maintain a written daily log for each day of injection work that includes:

- Ambient temperatures at the start and end of the workday and 4 hours after the end of the workday;
- Weather conditions, such as rain, snow, and wind, including changes during the shift;
- Crack cleaning methods, if any, including locations;
- Record of injection adhesive, including manufacturer, product and batch number, and amount used each day; and
- Signature and printed name of person responsible for record keeping.

Submit the log to the Architect/Engineer each workday.

1.5.7 *Acceptance*

1.5.7.1 *Acceptance criteria*—Injection work is acceptable if core testing, as specified in Section 1.5.7.2, demonstrates that:

- At least 90% of the depth of the crack in each core is filled with adhesive, and the splitting tensile strength of the core taken from that location is at least 90% of the splitting tensile strength of a core taken from an uncracked area within 300 mm (12 in.) of the repaired crack; or
- A splitting tensile test of the core indicates that no more than 10% of the bonded area of the crack in each core

exhibits combined areas of separation of the adhesive from the concrete or cohesive failure within the adhesive.

If adhesive penetration or bond strength are not acceptable, stop injection work until the areas represented by the testing are accepted, and changes in procedures or materials for continued injection work have been accepted. Reinject adhesive in the locations where injection has not been acceptable. If partial injection has blocked all access to the cracks on surfaces that can be reached, drill injection holes into the concrete to intersect the crack in their void areas.

1.5.7.2 Core testing—Obtain core samples in accordance with ASTM C 42/C 42M at the time and specific locations designated by the Architect/Engineer. Obtain cores in a manner that includes as much of the bond line of the repaired concrete as possible, unless otherwise accepted by the Architect/Engineer. Replace cores that do not intersect the crack for at least 75% of the length of the core with cores that meet this criterion. Examine core samples to evaluate the degree of injection adhesive penetration. Cores used for evaluation of splitting tensile strength shall be tested in accordance with ASTM C 496/C 496M. Allow 24 hours after injection before coring and 72 hours after injection before beginning splitting tensile tests. If cores would sever reinforcing steel or other embedded items, do not core, and notify the Architect/Engineer so that an alternative location can be chosen.

Obtain cores at the following frequency:

Inspection test	Frequency
Visual inspection for depth of penetration	Three cores from first 30 m (100 ft), and one core for each 30 m (100 ft) thereafter
Splitting tensile strength per ASTM C 496/C 496M	One core for first 30 m (100 ft), and one core for each 75 m (250 ft) thereafter

Obtain minimum 100 mm (4 in.) diameter cores for splitting tensile tests. It is permitted to obtain nominal 50 mm (2 in.) cores if they are only used to verify adhesive penetration, provided that these cores are wide enough to intersect cracks that may not be perpendicular to the surface where the core is drilled. Mark each core with a unique number and provide a list identifying the location where each numbered core was taken. Mark each of the cores with a "T" for top or "B" for bottom for cores taken vertically, or "H" for cores taken horizontally. Mark the respective end of the core with the letters "IS" (injection side) to indicate the side from which the injection was performed. Adjust the length of cores for testing so that the ratio of core length to diameter is not greater than 2.0 for cores longer than 200 mm (8 in.). The portion of the core furthest from the side from which the injection was performed shall be included in the length of core to be tested. Transfer identification marks on the core ends as necessary to maintain their identity up to the time of test. When testing, align the core so that the crack is in a plane as close to vertical as possible.

Fill core holes as required by the Project Specification.

1.6—Delivery and storage of materials

1.6.1 Delivery—Deliver all injection adhesives to the job site in sealed containers with labels intact.

1.6.2 Storage—Store all injection adhesives between 4 and 32 °C (40 and 90 °F) unless otherwise specified by the manufacturer.

1.7—Safety and environmental precautions

1.7.1 Use goggles and chemical-resistant gloves with adequate ventilation because injection adhesives can cause skin or eye irritation. Follow the manufacturer's Material Safety Data Sheet before using or disposing of material.

SECTION 2—MATERIALS

2.1—Surface seal

Use the materials to seal the crack faces that have the strength and adhesion to contain the injection adhesive in the crack during the injection process and while the injection adhesive cures, and, if required to be removed, shall not leave a residue or damage the surfaces.

2.2—Injection adhesives

2.2.1 Injection adhesives for cracks that can be sealed on all faces—Use an adhesive that conforms to the requirements of ASTM C 881/C 881M, Type IV, Grade 1, and any additional requirements as defined in the Project Specifications.

2.2.2 Injection adhesives for cracks that cannot be sealed on all faces—If all faces of the crack cannot be reached to apply a surface seal, use an injection adhesive that conforms to the requirements ASTM C 881/C 881M, Type IV, Grades 1, 2, or 3, and has a viscosity that will allow it to achieve and maintain the penetration requirements specified in Section 1.5.7.1.

SECTION 3—EXECUTION

3.1—Evaluation and preparation

3.1.1 Crack width—Inspect all cracks to determine if they are within the scope described in the Project Specifications. When required, measure the width of the crack to make this determination, and make the measurement at the time of day when the cracks are at their widest as measured at the surface of the concrete member.

3.1.2 Crack movement—If the width of a crack changes because of daily temperature cycles or other external loading of the structure, inject the crack when it is at its widest.

3.1.3 Crack preparation

3.1.3.1 Remove foreign material, such as dirt, oil, grease, or other chemicals, from the cracks before injection.

3.1.3.2 Water in cracks—Unless the crack is in submerged concrete, remove any water that can be seen by visual inspection from the cracks before the injection process, and remove water that appears during the injection process.

3.1.3.3 Ice in cracks—Do not inject cracks when the temperature of the concrete is below freezing and moisture conditions indicate the possibility of ice on the internal surfaces of the crack.

3.1.3.4 Temperature of the concrete—Do not inject adhesive if the temperature of the concrete is not within the range of application temperatures recommended by the manufacturer of the adhesive.

3.2—Test injection

After the test crack(s) has (have) been prepared, conduct the test injection specified in Section 1.5.4.1. If results do not meet the requirements of Section 1.5.7.1, modify crack preparation and grouting procedures, as approved, until satisfactory results can be obtained.

3.3—Surface sealing

3.3.1 Surface seals—Apply a surface seal over all exterior faces of the crack that can be reached to contain the injection adhesive in the crack.

3.4—Injection

3.4.1 Degree of filling—Inject cracks so that the requirements of Section 1.5.7.1 are met.

3.5—Cleanup

3.5.1 Surface seal and ports—Remove surface seal and any installed injection ports that protrude from the surface of the concrete.

3.5.2 Spills and leaks—Clean and remove all spills and leaks of injection adhesive and stains caused by the injection adhesives.

FOREWORD TO CHECKLISTS

F1. This Foreword is included for explanatory purposes only; it does not form a part of ACI Specification 503.7.

F2. ACI Specification 503.7 may be referenced by the Specifier in the Project Specification for any building project, together with supplementary requirements for the specific project. Responsibilities for project participants must be defined in the Project Specification. The ACI Specification cannot and does not address responsibilities for any project participant other than the Contractor.

F3. Checklists do not form a part of ACI Specification 503.7. Checklists assist the Specifier in selecting and specifying project requirements in the Project Specification.

F4. The Specifier shall make adjustments to the needs of a particular project by reviewing each of the items in the checklists and including the items the Specifier selects as mandatory requirements in the Project Specification.

F5. The Mandatory Requirements Checklist indicates work requirements regarding specific qualities, procedures, materials, and performance criteria that are not defined in ACI Specification 503.7.

F6. The Optional Requirements Checklist identifies Specifier choices and alternatives. The checklists identify the Sections, Parts, and Articles of the reference specification and the action required or available to the Specifier.

F7. The Submittal Checklist identifies Specifier choices for information or data to be provided by the Contractor before, during, or after construction.

F8. Recommended references—Documents and publications that are referenced in the Checklists of ACI Specification 503.7 are listed. These references provide guidance to the Specifier and are not considered to be part of ACI Specification 503.7.

American Concrete Institute

228.2R Nondestructive Test Methods for Evaluation of Concrete in Structures

This publication may be obtained from this organization:

American Concrete Institute
P.O. Box 9094
Farmington Hills, MI 48333-9094
www.concrete.org

MANDATORY REQUIREMENTS CHECKLIST

Section/Part/Article	Notes to Specifier
1.1	<p>Specify any cracks that are not within the scope of the Work and who identifies those cracks—Contractor or Specifier.</p> <ul style="list-style-type: none"> Generally, cracks larger than 0.13 mm (0.005 in.) in width are reparable using the liquid adhesives specified in Section 2.2.1. A statement, such as “Do not repair any crack that is less than 0.13 mm (0.005 in.) at its widest point,” can be used. If the cracks contain concrete fines that have resulted from the grinding action of concrete movement or densely packed dirt, removal that would render the crack reparable may not be possible. In many cases, these contaminants can be successfully removed with compressed air, water injected under pressure, or a combination of both. If the contamination is only near the surface, it may be possible to drill holes to intersect the crack below the contamination. Injection can then be accomplished through these holes. Contamination with oil, grease, or other chemicals may also make achievement of a satisfactory bond impossible unless removal efforts are successful. If it is expected that any of these conditions exist after removal attempts, exploratory injection and core testing may be required to determine whether certain cracks should be excluded from the scope of work or whether the acceptance criteria should be modified.
1.5.7.2	Specify requirements for repairing core holes.
3.4.1	Specify removal of metal ports where there is a possibility of corrosion.

OPTIONAL REQUIREMENTS CHECKLIST

Section/Part/Article	Notes to Specifier
1.5.5.1	Indicate when records should be submitted.
1.5.5.2	Indicate when records should be submitted.
1.5.5.3	Indicate when an accelerated cure is permitted.
1.5.7.1	<p>When contaminants are present in a crack, exploratory injection and core testing may demonstrate that the requirements of Section 1.5.7.1 cannot be achieved even after all reasonable efforts to remove contaminants have been exhausted. If project requirements allow a lower strength than the required “90% of splitting tensile strength,” replace the “90%” with the percent of splitting tensile strength that the project requirements will allow.</p> <p>In some circumstances, nondestructive evaluation (NDE) can be used as an alternative to core testing to establish the degree of crack filling. NDE minimizes damage to the concrete. No standards exist, however, for using NDE to determine the quality of crack repair by epoxy injection. To safeguard the Owner, NDE should be used only after verifiable testing has been presented to demonstrate that the method is reliable. Even if NDE is permitted on a project, side-by-side coring and NDE tests should be required to demonstrate that NDE and coring produce the same results on that project. See 228.2R.</p>
1.5.7.2	Specify locations where cores should not be taken because of the presence of reinforcing steel, other embedments, or other sensitive areas.
3.3.1	<p>If core testing and nondestructive evaluation are not possible, quality assurance is difficult. Method requirements can greatly increase the likelihood of adequate penetration. Liquid adhesives, when introduced into a crack, usually self-level by flowing or draining to the lowest elevation in the void. The injection of a liquid adhesive into a crack can be visualized as filling a void with a liquid from the bottom. Injecting from the lowest elevation to the highest provides the most assurance that the crack has been completely filled.</p> <p>The following port-to-port flow methods can be specified:</p> <ol style="list-style-type: none"> For cracks generally in an inclined or vertical plane, start injecting at the lowest elevation of the crack. If, starting at the port of lowest elevation, flow from port to successive ports spaced at a distance equal to the thickness of the concrete member cannot be achieved, report to the Architect/Engineer. Ten minutes after initial injection has been completed at the highest elevation port, reinject at that port until no additional adhesive can be injected. Repeat the reinjection procedure until all ports refuse injection adhesive 10 minutes after previous injection resulted in the port accepting adhesive; and For cracks generally in a horizontal plane, start injecting at the lowest end of the crack. If, starting at one end of the crack, flow from port to successive ports spaced at a distance equal to the thickness of the concrete member cannot be achieved, report to the Specifier. Ten minutes after initial injection has been completed, reinject all ports. Repeat injection procedure until all ports refuse injection adhesive 10 minutes after repeating the injection procedure.
3.5.1	Specify if there is no requirement to remove surface seals and ports. Allowing seals and ports to remain in place can result in a lower job cost.
3.5.2	Specify if there is no requirement to remove spills and stains from the concrete. Not requiring spills and leaks to be removed can result in a lower job cost.

SUBMITTAL CHECKLIST

Section/Part/Article	Notes to Specifier
1.4.1	In addition to the manufacturer's certification on each lot of adhesive, and independent test report including all or some of the requirements of the adhesive specification is advisable. If the adhesive is known to the Specifier to be suitable for the application, the requirement for independent test reports may be waived.
1.5	Submit qualification testing results.
1.5.6	Submit installation records when required.



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The AMERICAN CONCRETE INSTITUTE

was founded in 1904 as a nonprofit membership organization dedicated to public service and representing the user interest in the field of concrete. ACI gathers and distributes information on the improvement of design, construction and maintenance of concrete products and structures. The work of ACI is conducted by individual ACI members and through volunteer committees composed of both members and non-members.

The committees, as well as ACI as a whole, operate under a consensus format, which assures all participants the right to have their views considered. Committee activities include the development of building codes and specifications; analysis of research and development results; presentation of construction and repair techniques; and education.

Individuals interested in the activities of ACI are encouraged to become a member. There are no educational or employment requirements. ACI's membership is composed of engineers, architects, scientists, contractors, educators, and representatives from a variety of companies and organizations.

Members are encouraged to participate in committee activities that relate to their specific areas of interest. For more information, contact ACI.

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