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Guideline Specification for the Repair of Cracks and Delaminations in Concrete and Wood Structures by Injection of Liquid Epoxy Adhesives

Purpose

This guideline specification is provided to engineers, specifiers and architects to aid them in establishing the requirements for the repair of cracks and delaminations in concrete and wooden structures, for steel plate bonding and for bolt grouting by injection of liquid epoxy adhesives. The specification also establishes the minimum requirements for such repairs by approved applicator/licensees of ChemCo Systems, Inc., who use the KEMKO[®] Injection Process and KEMKO epoxy injection products, techniques and equipment.

A separate guideline specification is available for repairs with epoxy adhesive pastes which are generally used to fill wide cracks and delaminations, in overhead applications, in steel plate bonding and wherever back side seal application is not possible or exceedingly difficult.

Scope

This specification establishes standards for materials and equipment, execution of work, field quality control, applicator and workman's qualifications and provides information for measurement and payment. The procedures for work execution described herein are considered to be "typical" and may have to be modified for specific job conditions.

1.0

General

The Contractor or his sub-contractor, subject to certain pre-qualification conditions, shall furnish all materials, injection and auxiliary equipment, tools, labor and supervision necessary to repair cracks and delamination or fill voids in concrete or wood structures and conduct tests confirming the success of the repair performed by him.

2.0

Materials and Equipment

- 2.1 Injection Resins
- 2.1.1 The injection resin shall be a two component epoxy adhesives which has the capability to bond to concrete, wood or steel surfaces.
- 2.1.2 For injection of cracks up to 1/4 inch, cold joints, delaminations and holes above 60 F, the two component epoxy adhesive shall have a mixed viscosity from 300 to 600 cps at 73 F. For use below 60 F and for fine cracks (10 mil or less), the adhesive shall have a mixed viscosity at 73 F of 150 to 225 cps. For all load bearing uses the adhesive shall have a HDT of at least 130 F. For repair of structures whose internal mass temperature during service exceeds 105 F, the HDT of the adhesive to be used shall be 25 F higher than the maximum service temperature. All other physical properties shall comply with the provisions of ASTM C881-90, Type IV. Adhesives used in non-load bearing applications shall comply with the provisions of ASTM C881-90, Type I.
- 2.1 Injection Resins, Cont'd
- 2.1.3. For void filling applications and the repair of wide gaps and delaminations a liquid two component epoxy adhesive with long potlife (1.5 hours, min.) shall be used. The product shall have physical properties which meet the provisions of ASTM C881-90, Type I with the exception that a cure time of 14 days is allowed for all tests.

- 2.2 Surface Seal
- 2.2.1 The application of sealing material shall fully contain the liquid adhesive to be injected. If necessary, the seal shall be applied on both sides of a wall, floor or ceiling to be repaired.
- 2.2.2 The sealing material shall have adequate strength to hold injection ports in place and the capability of withstanding the pressure during adhesive injection and cure. Removal of seal shall be possible without undue alteration of the surface.
- 2.3 Equipment
- 2.3.1 General.
Portable equipment shall be used employing positive displacement metering pumps which are interlocked to provide resin delivery in proportions required by the composition of the two component injection adhesive. Mixing of the adhesive shall be accomplished in line with a static mixer. The equipment shall be driven by air or electric power.
- 2.3.2 Specific Equipment Requirements.
- (a) Ratio tolerance.
The injection equipment shall be capable of maintaining the volume ratio of the specified adhesive components during uninterrupted flow within a tolerance of +/- 5%.
- (b) Pressure Control.
The injection equipment shall have an automatic pressure control device that allows operation at any preset pressure within its operating range.
- (c) Automatic Shut-Off.
The injection equipment shall have an automatic shut-off feature to prevent delivery of one adhesive component only, when the other component supply is exhausted.
- 3.0
- ### Execution of Work
- 3.1 Pre-Production Qualification
- 3.1.1 The contractor/sub-contractor shall demonstrate to the satisfaction of the Engineer his ability to perform the work by repairing a section of the crack or a crack of at least 8 feet in length selected by the Engineer employing the methods outlined below.
- 3.1.2 The contractor/sub-contractor shall be paid for the demonstration work on the same basis as for the entire of the contract work.
- 3.1.3 Contractor/sub-contractor's ability to perform the work shall be confirmed by testing two test cores in a manner outlined in 3.5.1.6 to 3.5.1.8. which are to be taken from locations determined by the Engineer.
- 3.1.4 Acceptance of the demonstration test core results by the Engineer shall be in writing, giving the contractor/sub-contractor permission to proceed and complete the work subject to periodic tests as outlined in 3.5.1.2.
- 3.2 SurfacePreparation, Placement of Injection Ports
- 3.2.1. Surfaces adjacent to cracks or other areas of application shall be cleaned of dirt, dust, oil, efflorescence, paint or other foreign material which may be detrimental to establishing a bond of the sealing material prior to epoxy injection.
- 3.2.2 The entry ports shall be located either on the crack surface or in a drilled hole intersecting the crack. Port setting shall be done in such a manner as not to plug the crack at that location and prevent subsequent adhesive injection.
- 3.2.3 For the repair of through-cracks entry ports shall be placed along a crack in intervals not less than the thickness structure at that location.
- 3.2.4 The entry port spacing for the repair of cracks which do not entirely penetrate the structure shall be no less than the measured depth of the crack.
- 3.2.5 The surface seal material shall be applied to the face of the crack between and around the entry ports. For through cracks the surface seal shall be applied on both faces.
- 3.2.6 Adhesive injection shall not be started before the seal material has had adequate time to acquire sufficient strength to withstand injection pressures.

3.3 Injection

3.3.1 Injection of the epoxy adhesive shall begin at the lowest entry port and continue until there the adhesive emerges from the next adjacent (higher) port.

3.3.2 As soon as the adhesive emerges from the adjacent port, injection shall be stopped, the port sealed and the injection transferred to the adjacent port.

3.3.3 The process of injection, waiting for emergence of adhesive from the next adjacent port, sealing of the injection port and continuation of injection in the adjacent port shall continue until the crack is filled.

3.3.4 The process of injection described in 3.3.1 to 3.3.3 may be modified to the extent that injection at the original port may be continued after emergence of adhesive from the adjacent port by sealing that port and waiting for emergence at at the next higher port or ports. This modification of the regular injection procedure may be used if the injection pressure does not substantially increase, the port seals remain in place and no leaks become apparent.

3.3.5 If port to port travel of the injection adhesive is not indicated, the work shall be stopped and remedial action shall be taken which may require resetting of surface ports or drilling holes which intersect with the crack from a different angle. Such work shall only be done after authorization from the Engineer.

3.4 Finishing

3.4.1 After the crack has been completely filled, the injection adhesive shall be given sufficient time to cure to a state which allows removal of the seal without any adhesive run-out or smearing of the adjacent surface.

3.4.2 All surface seal material and injection adhesive runs or spills shall be carefully removed from the surface, if so directed by the Engineer.

3.4.3 The face of the repaired crack shall be finished flush with the adjacent surface and indentations or protrusions caused by the placement of entry ports shall be removed, if so directed by the Engineer.

3.4.4 After the work has been accepted by the Engineer, test core holes shall be filled using a two component epoxy grout mix, applied by hand trowel and thoroughly rodded and tamped in place. The surface finish shall match the color and texture of the adjacent surface to the satisfaction of the Engineer. Materials and procedures for filling test core hole shall be submitted to and approved by the Engineer before proceeding with this work.

3.4.5 Seal removal (3.4.1) and surface finishing (3.4.3) shall be specific bid items or factors in negotiated work, while removal of runs or spills (3.4.2) is included in the contract price. Filling and finishing of test cores holes (3.3.4) shall be paid for by the owner (see also 3.5.1.4).

3.5

Field Quality Control

3.5.1 Core testing to verify adhesive penetration and bond strength.

Note: It is imperative that the location of tendons in structures be known and none are cut in the coring process.

3.5.1.1 The contractor/subcontractor shall obtain test core samples adequate in diameter to intersect the crack to the full depth of the core, if possible.

3.5.1.2 In addition to the two demonstration test cores (3.1.3), two test cores samples shall be taken in the first one hundred lineal feet of repaired crack and one test core for each one hundred lineal feet thereafter. The test cores shall be taken from locations as selected by the Engineer.

3.5.1.3. At the direction of and at locations identified by the Engineer, contractor/subcontractor shall take two core samples of sound concrete (wood), if its strength is not known or is subject of disagreement. The cores shall be tested in accordance with the method specified in 3.5.1.6 to 3.5.1.8 and their average compressive strength shall establish the minimum bond strength required for test cores to be acceptable.

3.5.1.4 All core sampling and testing, including demonstration and verification core sampling and testing shall be performed at the owner's expense.

3.5.1.5 The contractor/subcontractor shall provide all following labor, materials and services for core sampling and testing as directed by the Engineer, including and not limited to:

- (a) Preparation, handling, storage and transportation of epoxy injection test core specimens.
- (b) Providing suitable containers for the storage, curing and transportation of test specimens.
- (c) Providing a suitable storage area for test equipment, supplies and other items required for sampling and space for testing, if field tests are conducted.
- (d) Making arrangements for core testing be an independent testing facility.

3.5.1.6 Methods of Test Core Testing.

(a) Adhesive Penetration:

Visual Inspection

(b) Bond Strength/Compression Test:

ASTM C 42-87

3.5.1.7 Test Requirements.

(a) Adhesive penetration:

A minimum of 90 % of the crack shall be filled with injection adhesive, as visible by inspection the core surfaces.

(b) Bond Strength:

Concrete - Failure primarily in concrete before adhesive failure becomes apparent at 90% of the concrete or the sound concrete(see 3.5.1.3) sample (average) compressive strength. For concrete with a compressive strength of 6,500 psi or greater, the test cores shall not fail below 90 % of the actual compressive strength or at 6,500 psi, whichever is lower. Wood - Failure in the wood grain.

3.5.1.8 Test Evaluation and Acceptance.

(a) Cores taken from work area pass tests:

Work is accepted as performed.

(b) Cores taken from work area fail in tests

due to lack of adhesive penetration:

The work in this area shall be stopped until the crack area represented by the failing test core has been re-injected, re-cored (verification cores), as directed by the Engineer and satisfactorily re-tested.

(c) Cores taken from work area fail due to lack of bond strength:

The work shall be stopped in that area. Two additional test cores (verification cores) shall be taken at the direction of the Engineer and tested. Compliance of the verification cores with the test requirements of 3.5.1.7 shall constitute permission to resume work. Upon failure of the verification cores to meet the test requirements of 3.5.1.7, the Engineer may authorize continuation of the work in the area, if in his judgment the actual bond strength of the verification cores is adequate, or he may order additional verification cores, both in the sound concrete and the work area or he may reject this work.

3.5.2 Injection Equipment Tests.

3.5.2.1 To verify the performance of the injection equipment, pressure and ratio test shall be conducted by the method, in a frequency and with the results as set forth below.

3.5.2.2 Pressure/Ratio Test Equipment.

The test equipment shall be a device with two independent sections, identical in design and function, one for each adhesive component, complete with proper fittings, pressure gauges (250 psi max. rating), in-line filters and needle valves with appropriate discharge nozzles. The device shall be capable of controlling flow rate and pressure of each adhesive component independently by opening or closing the needle valves.

3.5.2.3 Pressure Test.

(a) Test Method.

The mix-head of the injection equipment, in the off-position for this purpose, shall be disconnected from the two adhesive component delivery hoses which are then re-connected to the appropriate section of the pressure/ratio test device. The valves of the test device shall be closed. The injection equipment shall then be started and allowed to operate until the pressure in the test device reaches and exceeds 160, but not more than 200 psi in both sections. The injection equipment shall then be turned off and the pressure shall be let down to 160 psi by slightly opening each valve. After reaching 160 psi, the valves shall be closed and the pressure in the system observed for 5 minutes.

(b) Test Result.

During the two minute waiting period the pressure in each section of the pressure/ratio test device shall not fall to below 150 psi.

(c) Frequency of Test.

The pressure test shall be performed on the injection equipment at the beginning and the middle of each work shift it is used.

3.5.2.4 Ratio Test.

(a) Test Method.

Employing the test device described in 3.5.2.2 and connecting it in the same manner as described in 3.5.2.3 to the injection equipment, the injection equipment is in operation and the adhesive components are being simultaneously discharged and collected in separate preweighed or calibrated containers. At least 100 g or 3 fluid ounces of the of the lesser volume component of the two component adhesive shall be collected. For greater accuracy of the test, samples shall be obtained by simultaneously collecting the adhesive components while the equipment is running. To accomplish this the sample containers shall be quickly and simultaneously moved into the stream of the adhesive components and removed when sufficient sample was collected.

(b) Test Requirements.

The test shall be conducted at atmospheric pressure and at 160 psi at the prevailing job site temperature and employing the adhesive to be used in the repair.

(c) Test Results.

The average error of at least three individual tests in the ratio of the two adhesive components collected shall not exceed +/- 5%.

(d) Test Frequency.

The ratio test shall be conducted at the beginning and the middle of each shift the injection equipment is in use. The Engineer may direct the contractor/subcontractor to conduct additional ratio tests, if there is reason to believe that the equipment does not deliver the adhesive in the proper proportions.

4.0

Contractor/Subcontractor Pre-Qualification

4.1 Contractor/Subcontractor's Pre-Qualification.

The epoxy injection work shall be performed by an approved/licensed applicator of the KEMKO Injection Process, who has received training in the use of ChemCo Systems' injection equipment, KEMKO materials and has been familiarized with the techniques used in their application in crack repair.

4.2. Workman's Qualification.

Contractor/Subcontractor workmen engaged in epoxy injection work shall have satisfactorily completed a program of instruction in the methods of repairing concrete structures, wooden timbers and beams utilizing the KEMKO Injection Process and KEMKO adhesives. These instructions shall familiarize the workmen with the causes of cracking in concrete, proper material selection, planning and execution of epoxy injection work and the operation, trouble shooting and maintenance of ChemCo Systems' equipment.

5.0

Measurement and Payment

5.1 Measurement.

Crack repair by epoxy adhesive injection shall be measured per lineal foot, or per location, or per crew day, or on a lump sum, or time and material basis.

5.2 Payment.

Payment for crack repair by epoxy adhesive injection shall be made at the contract price in units as determined in 5.1.

End of Guideline Specification