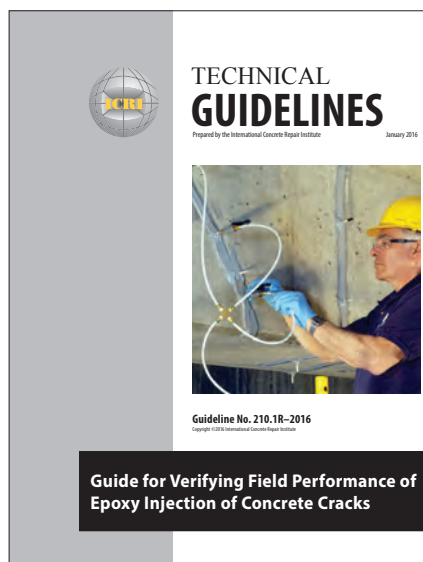


GUIDE FOR VERIFYING FIELD PERFORMANCE OF EPOXY INJECTION OF CONCRETE CRACKS

BY DENNIS WIPF



ICRI Technical Guideline No. 210.1R – 2016, “**Guide for Verifying Field Performance of Epoxy Injection of Concrete Cracks**” has been recently revised and updated. The guideline, originally produced in 1998, provides a detailed description of various methods for verifying the quality and effectiveness of materials, equipment and procedures. The guideline’s primary purpose is to provide contractors, inspectors, and design professionals methodology and criteria for field quality control and quality

assurance verification of the epoxy injection process.

Various sections of the guideline have been revised to provide new or updated information reflecting current recommended industry standard practice and state-of-the-art technology.

The use of epoxy injection to repair cracks in concrete has been a standard practice for many years. However, because the results cannot be verified easily by direct observation, the process and the effectiveness has been somewhat of a mystery. A great deal of contractor expertise is required in making judgments on different variables during the injection process. As such, epoxy injection has been referred to as “more of an art than a science,” meaning that contractor expertise is critical, and scientific evaluation of the effectiveness is difficult. This guideline provides information on injection equipment, workmanship methodology, and various nondestructive testing methods that can be

used to verify the effectiveness of the injection process. This document is not intended to be a guide for the selection of materials or methods of performing the work.

Generally, the performance of epoxy injection is measured according to whether the epoxy adhesive has adequately filled the crack and has cured in place. In many instances, a significant quantity of injection work may take place before the quality assurance testing is initiated. This document includes process-control methods to assess if satisfactory injection work is being performed during the project.

The guideline establishes five different quality assurance/quality control methods:

- Visual observations of the injection process;
- Materials laboratory testing;
- Materials field testing;
- Removal and evaluation of cores; and
- Nondestructive testing (NDT) methods.

Visual Observations: The section on visual observations of the injection process discusses “port-to-port flow,” the verification of epoxy resin flowing out of the next adjacent port (Fig. 1). However, simply achieving port-to-port flow does not guarantee that the crack is completely filled. The guideline provides a methodology for injecting cracks that are sloping or vertical, allowing gravity to help the material completely fill the crack. Most importantly, the document defines the critical concept of epoxy injection, that the cracks should be filled until “refusal,” the point at which the crack will not accept additional epoxy material when injected under pressure.



Fig. 1: Injection showing port-to-port adhesive travel



Fig. 2: Injection showing adhesive travel beyond the cap seal



Fig. 3: Injection using a manifold system

The guideline also includes new photographs demonstrating methods of verifying that the cracks have been completely filled (Fig. 2), and manifold systems, which can inject several ports simultaneously (Fig. 3). Different criteria for evaluating visual observations of the injection process are presented in a table at the end of the guideline.

Materials Laboratory Testing: Laboratory tests can be used to determine if an epoxy adhesive is properly proportioned and mixed. Laboratory testing can be expensive and impact the construction schedule. Therefore, it is usually only applicable to large projects.

The compressive strength test (ASTM D695¹) can be used to evaluate the strength of an epoxy resin control sample at the beginning of the project with samples obtained during the injection process. Confirming that resin samples are fully cured, and the field material matched the submittal, can be established by differential scanning calorimetry (ASTM E2160²).

Other less used laboratory tests are identified in the guideline, as well as a summary of acceptability standards presented in the table at the end of the guideline.

Materials Field Testing: Field testing provides critical information to verify that materials and equipment are performing properly, and is useful in identifying deficiencies or equipment malfunctions before completion of substantial amounts of the work.



Fig. 4: Gel time test (ASTM C88/C881M)

The gel time test (ASTM C88/C881M³) is the simplest of the field tests and confirms that the injected resin will harden (Fig. 4). At the beginning of the project, a small sample of epoxy resin is hand-mixed, establishing a control sample for gel time and color, which can be used as a comparison for

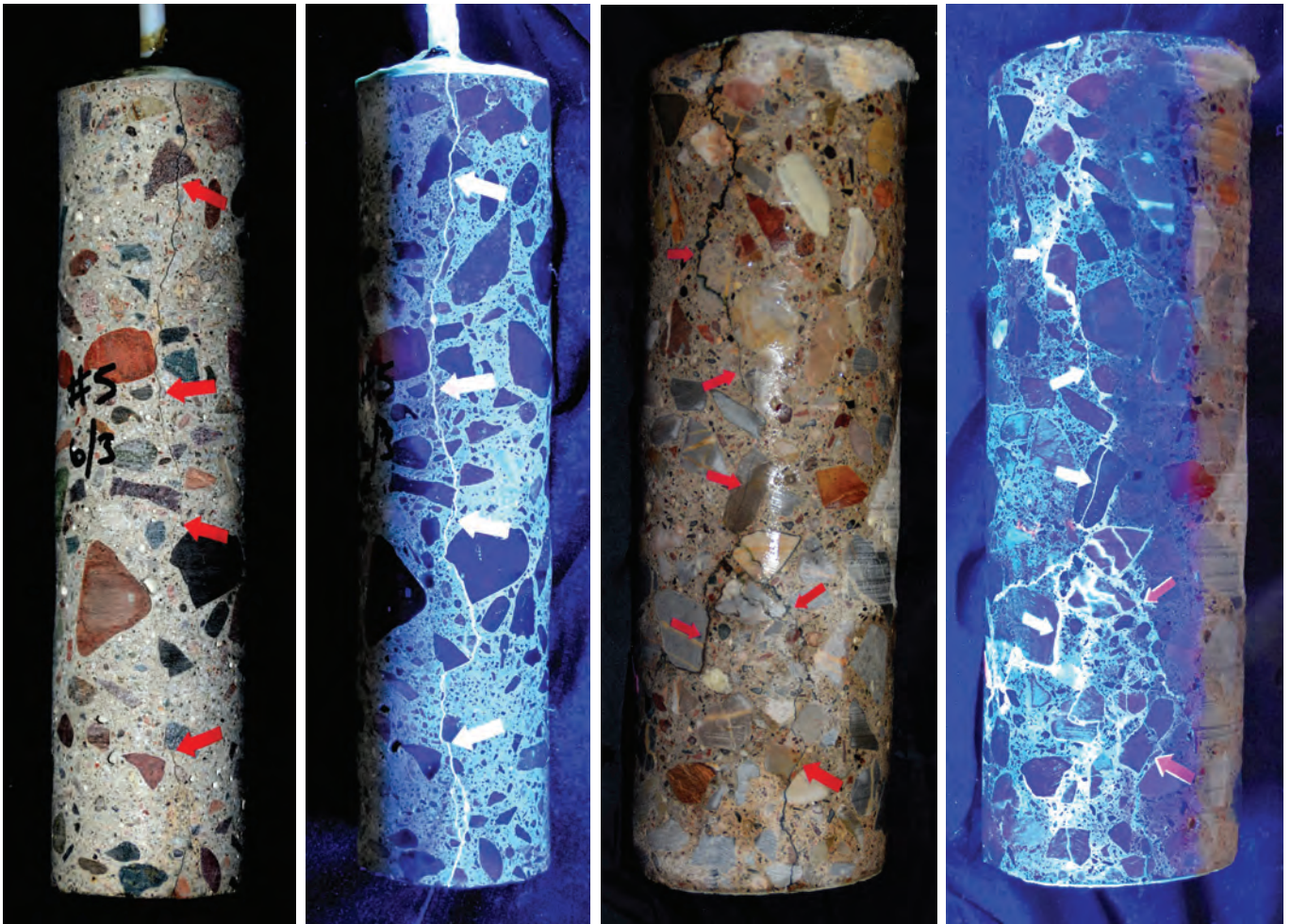


Fig. 5: Cores showing epoxy penetration⁶ (second and fourth images shown under ultraviolet illumination)

additional samples obtained during the work. Resin samples should be obtained at least daily from the end of the injection nozzle to compare with the control sample.

Two field tests can be performed to verify that the injection equipment is operating properly: the ratio and pressure tests. The ratio test is performed by dispensing a small amount of each component of the resin into a separate container, such that the volume or weight of each component can be verified to ensure that proper ratio proportioning is occurring. The pressure test is used to verify that the injection pumps are capable of maintaining adequate and equal pressure on each component, without internal leakage of the equipment. Each of these tests can be performed in a short time and are recommended at the beginning of each shift as a minimum.

Removal and Evaluation of Cores: Since the end result of epoxy injection is hidden within the concrete, coring to verify success of the injection process is critical. Cores are obtained by wet or dry core drilling using diamond tipped bits along

the length of the crack. Cores are visually evaluated to determine penetration of the epoxy resin. Although 100% penetration is desired, generally, penetration is considered adequate if 90% of the crack is filled with epoxy adhesive, as viewed from the exposed length of the crack on the sides of the core.⁴

Since many epoxies are naturally fluorescent under ultraviolet illumination, it can be helpful to examine the core using a "black light" ultraviolet light source to highlight the injection resin and verify penetration. The new guideline provides photographs of this process (Fig. 5).

Cores may also be evaluated in the laboratory or in the field by testing the bond line between the epoxy and the concrete within the core. The splitting tension laboratory test (ASTM C496⁵) quantitatively establishes splitting tension strengths. The simple field test of manually applying a sharp blow with a hammer to the side of the core can qualitatively evaluate incomplete filling, poor bond or improper mixing.

NDT Methods: Coring may not be possible in some locations without compromising structural integrity because of reinforcement, or additional quality assurance may be desired. Three NDT methods are described in the guideline, which are appropriate for epoxy injection: Ultrasonic Pulse Velocity, Impact Echo, and Spectral Analysis of Surface Waves. Each of these methods is described in more detail in the guideline, which includes NDT result data plots of both filled and unfilled cracks (Fig. 6).

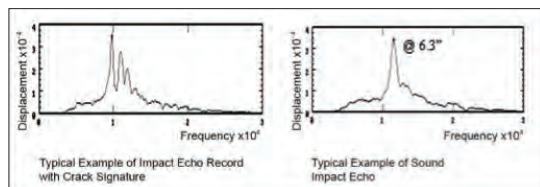


Fig. 6: Example of IE test results on a filled (right) and partially filled (left) crack (After Promboon, Y. et al. 2002)⁶

CONCLUSION

The revised and updated Guide for Verifying Field Performance of Epoxy Injection of Concrete Cracks contains new material and photographs to help eliminate some of the mystery in the epoxy injection process. The document provides quality assurance and quality control methodology that can be performed in the laboratory and repeatedly in the field. Contractors, inspectors and design professionals involved in concrete repairs incorporating epoxy injection of cracks will find the new guideline very useful.

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