

Is epoxy injection the best method for repairing cracks?

We don't actually want concrete to crack. But we certainly expect it to, and all good designs plan for it. Indeed, the reinforcement in concrete doesn't even begin to work until it cracks. We even put in lines of weakness and beg the cracks to follow, which of course they sometimes don't.

Unfortunately, it is all too common for concrete to develop cracks that the designer failed to anticipate. Cracks can be due to drying shrinkage, expansion, and contraction from temperature changes, flexure, settlement, or overloading of the structure. Some cracks are benign and have no adverse impact on the structure other than to mar its appearance. Some, however, leak or even threaten the building's structural integrity. But there is not always agreement on just which cracks should be repaired and how they should be repaired. Several years ago, in the pages of the International Concrete Repair Institute's *Concrete Repair Bulletin* (May/June, July/August, and September/October 1993), James Warner and John Trout "agreed to disagree" on this topic. We asked them if they had changed their minds (definitely not) and excerpted much of what follows from that exchange. James Warner is a concrete repair consultant in Mariposa, Calif., and a regular contributor to ICRI's *Concrete Repair Bulletin*. John Trout is with the Lily Corporation, Aurora, Ill.; he speaks on epoxy injection at the World of Concrete and has published a book on the subject (*Epoxy Injection in Construction*) that is

available from the Hanley-Wood Bookstore (800-323-3550 or www.worldofconcrete.com).

CC: Should all cracks be repaired?

Warner: Most cracks are not of structural significance, that is, their existence does not adversely affect the capacity or stability of the structure. Before considering whether to repair a crack, one should determine the cause of the crack, the rationale of repair, and whether effective repair is possible (excessive debris in a crack may preclude effective filling). Because most cracks are subject to continued movement, any fix made should provide for future activity and, in many instances, the best repair will be no repair.

There are many reasons why repair is desired. Although cosmetic and aesthetic cures are frequently requested, it is almost impossible to fix a crack so that it will not remain visible, and in many cases a crack will actually stand out and be more visible once repaired. Obviously, crack repair to improve aesthetics must be carefully considered, and in a great many instances, no repair will be the best treatment.

Often outright repair of all cracks in a structure is not rational. The true repair professional will carefully consider the cause, the potential for continued movement, and future effects of any crack repair.

Trout: Poor



A permanent fix, with injection of epoxy resin, should be made only to cracks that are not subject to further movement, or for which proper movement joints have been provided as part of the repair.

— James Warner

candidates for repair are cracks that are not structural faults, do not threaten the reinforcement via exposure to corrosive elements, are not leakers, and are not leaching objectionable stains onto architectural surfaces. To repair such faults is to squander an owner's resources. Given the cost of repairing concrete, the likelihood that the repair will fail, and the knowledge that many problems result from entry of the elements through neglected cracks, wisdom calls for a permanent fix—injection. Certainly an injection repair is not invisible, but it has a much lower profile than any other repair.

CC: What is the best way to repair cracks that are moving?

Warner: A common objective of crack repair is to prevent or stop leakage. Because most cracks are subject to at least some movement at some time, the best repair for leakage is one that will allow some movement. Thus routing and filling with an elastomer, or covering with an appropriate elastomeric membrane, is probably the best strategy.

Trout: Repair with an elastomer or an elastomeric membrane is not a good strategy. Elastomers or any other treatment that merely bridges an active fault is a temporary repair. After several years (manufacturer claims vary from 1 to 30 years), the crack is likely to reflect through the

Most cracks in need of repair should be injected with an epoxy. It is not obvious to me that a permanent fix should only be made to cracks that are not experiencing movement. — John Trout



seal as a result of embrittlement (especially if exposed to ultraviolet light) and fatigue.

This fatigue factor cannot be overemphasized. The movement experienced at most faults is not merely the reasonable adjustment resulting in a single annual cycle but is repeated daily. Though the mass of the concrete may not change dimension during such a brief cycle, the surface of the concrete will shrink away from the fault as it cools, resulting in a yawning at the mouth of the fault. This frequent movement, though slight, fatigues surface repairs. Most injection folk know all about this, having experienced the frustration of their high modulus cap seal cracking overnight due to this movement.

Besides all of the above, elastomeric surface repairs do not discourage elongation of a crack and are frequently vulnerable to damage due to traffic and vandalism. There are cases where it may be the preferred fix, such as a densely cracked parking garage slab that is kept at a constant temperature year-round.

CC: But what about cracks that we want to prevent from moving?

Warner: There are those rare cases where “welding” of the crack in order to return the concrete to a monolithic mass for structural purposes is desired. Such repair requires injection of a resin, usually epoxy. Obviously, such a permanent fix should be made only to cracks that are not subject to further movement, or for which proper movement joints have been provided as part of the repair. Engineers have a good understanding of concrete cracking and know which cracks are tolerable. Above all, they understand that the way concrete relieves stress is to crack and that prior to the mobilization of the reinforcement, cracks are to be expected.

Trout: Warner has correctly observed that most cracks are subject to continued movement and has stated, regarding epoxy injection, that “obviously, such a permanent fix should be made only to cracks that are not subject to further movement.” This implies that most cracks should

not be injected with an epoxy. This is wrong—most cracks in need of repair should be injected with an epoxy. It is not “obvious” to me that a permanent fix should be made only to cracks that are not experiencing further movement.

I suspect that Warner is presuming that the movement that occurs at cracks must necessarily be accommodated, or a structural fault is likely to be induced elsewhere with dire consequences. I have personally been involved with the injection of tens of thousands of feet of cracks over 25 years and never once have seen an instance of structural damage induced as a result of proper injection of a “moving” crack. Without a doubt, there have been frequent instances of a member re-cracking adjacent to an injected fault, but core inspection invariably reveals that the crack was improperly injected.

In fact, instances of “necessary movement” are rare. In cases where relief is essential at cracks, it is usually due to flawed design. If relief is required at a particular location, it is the responsibility of the design engineer to provide for it. Movement occurs at cracks induced by drying shrinkage or flexure simply because it can. If the cracks are permanently fixed, the structure will be obligated simply to behave as designed.

CC: How clean does a crack have to be for epoxy injection?

Warner: Injection of epoxy resin can work only if the crack is reasonably clean.

Trout: Worrying about how clean the crack is presumes that bond is essential to the success of the process. This is seldom the case, since with or without bond, compressive strength is restored since there is hard stuff in the void. Shear strength is back for the same reason. I have seen many instances where the resin saturated the debris and yielded excellent full-depth cores that broke away from the glue line. If the fault is completely filled with hard debris, then there is obviously no void to accept resin, but these cases are rare.

CC: Are there cases where epoxy

injection is not appropriate?

Warner: Although Trout is apparently in disagreement, criteria that advise against epoxy injection of moving cracks are well established and widely accepted. For example, the U.S. Army Corps of Engineers Manual EM-1110-2-2002, *Evaluation and Repair of Concrete Structures*, states that “unless the crack is dormant (or the cause of cracking is removed, thereby making the crack dormant) cracking probably will recur, possibly somewhere else in the structure. If the cracks are active, ... it is necessary to use a sealant or other material that allows the cracks to function as joints.” Epoxy injection is only one of many crack repair methods. Although epoxy is a fine tool, it is not rational to fill every crack with epoxy.

Trout: As I stated earlier, most cracks in need of repair should be injected with an epoxy. I am clearly not suggesting that it is rational to fill every crack. However, epoxy injection is a permanent fix since the resin penetrates deeply into the fault where it is not exposed to ultraviolet light or other elements, the high tensile and bond strengths of the epoxy resin discourages elongation of the crack, compressive and shear strengths are restored, reinforcement is protected from corrosion, and the repair is not vulnerable to vandalism or traffic. ■

Publication #C01C070

*Copyright © 2001 Hanley-Wood, LLC
All rights reserved*