Resin Injection: A Permanent Fix

by John Trout

Epoxy injection has the reputation of being a structural repair procedure, and it is. However the vast majority of concrete crack injection applications (over 70% by the author's reckoning) are structural preservation rather than repair; that is, instances where resin is injected into faults in order to keep good concrete good rather than to restore design strengths. The sealing of cracks to protect exposed reinforcement is the most common example.

A brief look at the applications and the technology explains this wide and increasing popularity of injection for concrete preservation.

To begin with, most crack repair techniques other than injection have proven to be temporary fixes. They have included scrubbing with cementitious grouts, coating with various epoxy and textured formulations, the application of liquid membranes, the sandwiching of fiberglass membranes between coatings and even between liquid membranes themselves, sealants of all sorts installed over the fault or in a routed groove, the use of mastic and epoxy pastes to cap the faults, and the list continues.

After one to twenty years, failure of all of the above has been virtually assured. In many cases the surface repair materials embrittled with aging; in others, they curled away from the surface due to exposure to ultraviolet. Often the cracks elongated, especially in instances of live loads or significant temperature changes. Traffic and vandalism took a toll as well, but the most common failure has been due to fatigue of the repair material. This fatigue factor needs to be understood to fully appreciate the probability of failure of those repair procedures which merely bridge a void.

Cracks in concrete which are exposed to seasonal temperature changes open and close in their entirety as the volume of the concrete annually changes in its entire mass. However cracks open and close at their mouth with much greater frequency as the surface of the concrete creeps back and forth in response to daily changes in temperature; and in many areas with greater frequency due to alternating exposure to warming sunlight and cooling shade throughout the day.

Though the amount of movement is very slight and the crack quite narrow, failure is nevertheless inevitable as the aging repair material is repeatedly strained by this yawning at the mouth of the fault. It may take years, but as many injection contractors can attest, this phenomenon is often observed overnight when a high modulus epoxy capping material is applied over a crack and temperatures drop significantly. Their high modulus cap seal is cracked along the line of the fault by morning.

By comparison, an injected epoxy is a permanent fix for these reasons: the resin fills the void rather than bridging it, preventing the entry of atmospheric elements, and coating exposed reinforcing steel to starve the corrosion process; the high bond and tensile strengths of the epoxies prevent yawning and elongation of the crack; and injected resin is not vulnerable to ultra violet rays, weathering, traffic or vandalism.

Though recognizing that injection is probably a better fix, many specifiers are nevertheless reluctant to inject a rigid epoxy into faults where there is evidence of movement (and move they all do since they yawn) for fear the crack will simply reappear nearby. The use of a sealant or flexible membrane seems more sensible. However, whether or not there is movement at a fault is not important; but rather whether the movement must be accommodated is the consideration. More often than not movement occurs at a crack simply because it is permitted to, not because it must be accommodated there. In instances where restraint of movement at a random crack is likely to result in fracturing of a member, design or construction is obviously flawed. If provision for movement was required at the location, it should have been specified by the engineer and put into place by the builder.

If the design or construction is not flawed, inject the moving crack; the structure will then simply behave as designed, resisting the stresses or relieving them elsewhere.

The permanent fix is the most economical repair for permanent structures not only because the process does not have to be repeated, but also because as temporary repairs fail, they are seldom restored immediately since inspections and budgets and priorities must first fall into place. Such delays prove costly as further corrosion of reinforcement occurs, autos are damaged by calcium deposits, interior finishes are marred, etc.

When the cost and disruption of spall repair generated by corrosion is considered, the case for the permanent injection fix of cracks is overwhelming.

Another advantage of the injection selection is appearance. No repair has a lower profile. This was not always so when it was once necessary to drill holes and use an epoxy paste to cap the crack to contain the injected resins. But today holes are seldom needed and low pressure injection technology has made it possible to seal cracks with strippable, nonstaining silicone sealants leaving only an amber glue line.

Though cracks less than .30 mm are normally not a threat to reinforcement unless in a severe environment such as a water retaining structure, cracks of only .05 mm commonly cause coating failures as a result of the yawning phenomenon. In California for example, where the use of coatings on exterior concrete is common, the appearance of many otherwise elegant structures is severely marred by coating failures along very fine cracks. Once the crack has reflected through a coating, the coating has a tendency to curl away from the surface, greatly exaggerating the width of the fault in the coating and accumulating dirt.

As the combination of high tensile and bond strengths of an injected epoxy resin discourage elongation of a crack, it also stops the yawning at its mouth. A surface can then be painted without fear of the crack reflecting through. Elastomeric coatings anticipate the movement of yawning and are less vulnerable for the first few years, but aging embrittles all coatings. If the cracks are injected, relatively inexpensive coatings without elastomeric properties can be confidently specified.

An often overlooked application of injection is the resurfacing of floor slabs, whether on grade or suspended. While no expense is spared in the preparation of the surface for an epoxy overlay for example, cracks and cold joints in slabs are typically treated with layers of sandwiched fiberglass: a treatment which is not permanent and is usually unsightly. Only the injection of a fault can assure the permanent integrity of the overlay. Though a bond may not be available due to contamination from oil or other substances, injection is nevertheless reduced to an impenetrable seam.

Further regarding slabs, costly flexible membranes are often specified for parking structures in order to bridge cracks and seal the concrete against the penetration of chlorides or other detrimental elements. The injection of the cracks followed by resurfacing with a relatively inexpensive product may yield a less costly yet permanent solution.

We receive inquiries from contractors almost daily regarding injection equipment. The most common reason we hear for getting into injection is: "Well, I ran into this spec..." There are also better reasons.

American Concrete Institute Committee 224-R-72 guideline for concern with cracks in concrete:

Exposure Condition	Maximum Allowable Crack Width
Dry Air	.41 min
Humidity, moist air, soil	.30 mm
Deicing chemicals	.18 mm
Seawater or spray	.15 mm
Water retaining structures	.10 mm