Epoxy Concrete Repair

When properly injected, epoxy forms a permanent bond that no cement patch can match

by Wendy Talarico

Unless they've worked with it a few times, contractors are often nervous about using epoxy to repair concrete foundation cracks. Epoxy involves unfamiliar chemical components that must be precisely measured, mixed, and installed. Any mistakes and the material may never set up. Even properly mixed, epoxy can set up too fast on warm days, so you have to work quickly. And once the epoxy is in the wall, it's there for good: You can't go back and dig it out without taking the adjoining wall sections out with it.

In the last few years, manufacturers have taken some of the worry out of epoxy injection by selling the material in premeasured cartridges, many of which can be used with a caulking gun. Some companies offer kits that include everything you need for filling a crack. These are often accompanied by explicit instructions (one company includes a training video), and toll-free phone numbers for technical support.

This article focuses on these newer injection products and techniques for sealing cracks in poured concrete foundation walls. Epoxy can be used for some types of block foundation repairs as well, but don't try pumping it into a cracked block: The material will flow like water into all the voids. Epoxy also works well on surface defects such as spalling, but application techniques differ from crack injection.

Epoxy or Cement?

Concrete repair specialists wouldn't even consider using cement to patch a crack. But because of the higher labor and material costs that go with the injection process, remodelers are less likely to dismiss cement patches. They're quick and easy to apply, they're inexpensive, and, under stable conditions, cement patches can hold for years. But introduce water, movement, vibration, or pressure, and the cement patch will pull away from the crack and crumble out. Since all concrete walls expand and contract to some degree, repair specialists would rather use epoxy than risk being called back to the site to apply another batch of cement.

In many situations epoxy is clearly the material of choice. For example, if a foundation wall is fractured only partway down, chances are the crack will continue to move until it reaches the bottom of the wall. In many cases, injecting the crack with epoxy will provide enough strength and adhesion to keep the crack from progressing further.

Similarly, settlement cracks in load-bearing walls often continue to grow as the house bears down on the foundation. Injecting epoxy "welds" the wall together, creating a monolithic structure that provides better support to the house above.

Epoxy also works well when a crack is damp or leaking. Hydraulic cement will stand up to small amounts of water, but if the wall moves, hydraulic cement will lose its hold. Epoxy bonds to the crack's surfaces, even when they are wet, and displaces any water that's residing inside the crack. This is good to know when the wall is subjected to freeze/thaw cycles.

Plus, some epoxies are flexible and create, in effect, an expansion joint at the crack. While this may not provide the structural strength of rigid epoxy, it will allow for expansion and contraction and still provide a permanent seal.

Still, epoxy is not a cure for a poorly designed or substandard foundation. Nor will the material prevent external forces, like hydrostatic pressure or poor grading, from taking their toll on the foundation (see "Diagnosing the Crack"). But in most cases, epoxy will stand up to the kinds of pressures that make cement patches fail.

Epoxy is a good choice for repairing leaking foundation cracks. Here, a Jaco contractor installs a flexible epoxy that allows for expansion and contraction.

Chemistry Class

Developed in the 1940s, epoxy is a petroleum-based resin that, when mixed with an alkaline hardener, sets up quickly and has strong adhesive properties. The epoxy you purchase for crack injection should contain 100% solids — that is, it should not be diluted with water, alcohol, or other solvents that evaporate, causing the material to shrink.

Epoxy used for residential concrete repair is surprisingly watery. More viscous solutions are available for the wider cracks found on bridges, dams, and other large concrete structures. But for ordinary 1/8-inch-wide residential foundation cracks, a lower viscosity epoxy is easier to pump and will seep further into the crack. With the proper, high-pressure equipment, manufacturers claim epoxy will fill voids as narrow as .002 inches.

Epoxy is thermosetting. In other words, it creates heat as it reacts. Large batches of epoxy will smoke and sputter like a science experiment gone wrong. That's why working with great quantities can be dangerous, although even small amounts will generate a lot of heat. But once it sets up, epoxy is inert. Noth-

Figure 1. *Several manufacturers offer injection kits that include everything you need to repair a crack, including surface seal, injection epoxy, ports, and an injection gun.*

THERMAL-CHEM

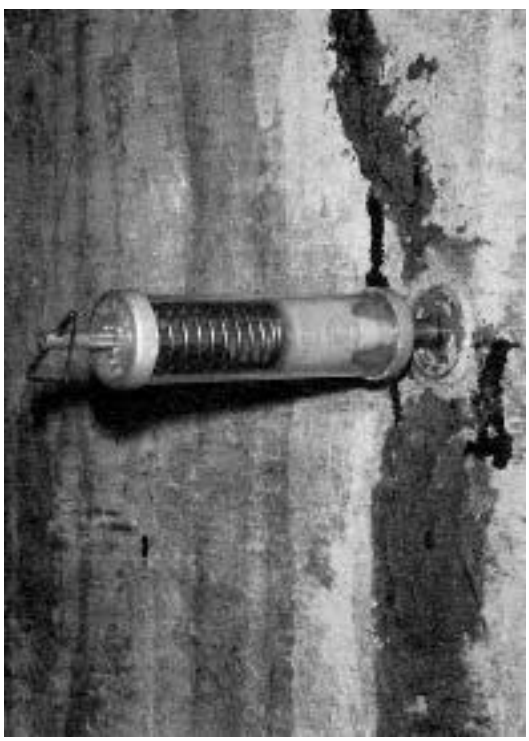

Figure 2. *Spring-loaded, low-pressure injection cartridges from Micro Capsule Engineering automatically inject epoxy into hairline cracks, which typically take longer to fill than larger cracks.*

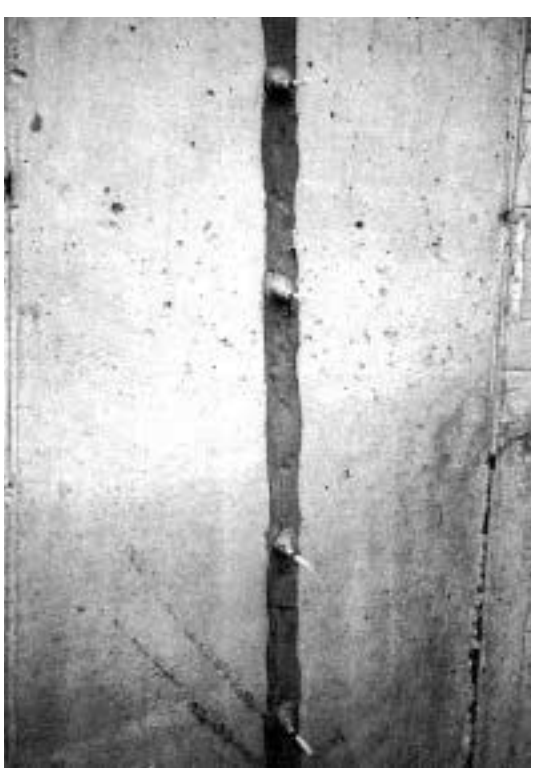

Figure 3. *Place injection ports at intervals equal to the thickness of the wall — usually every 8 to 12 inches. To keep each T-port in place, mound the surface-seal material over the port's base.*

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ing short of a chlorinated solvent will break it down.

To set up, epoxy requires a minimum temperature of about 50˚F. While warmer temperatures will accelerate setting times, cold weather necessitates special formulations since any material allowed to freeze will not set up at all.

Safety. Since epoxy contains hazardous chemicals and has been known to blow back, or shoot out the back of the cartridge, you should wear heavy-duty gloves and good eye protection. It's also a good idea to apply a barrier cream to exposed skin. Provide adequate ventilation to avoid inhaling the fumes. Empty cartridges are considered hazardous waste in some parts of the country. Check with local authorities for the best way to dispose of them. One manufacturer, Polygem, recycles used cartridges.

The Right Equipment

If you live near a large city, there are probably stores nearby that specialize in concrete repair products. Occasionally the local ready-mix suppliers handle epoxy. But if you're in a small town, chances are you'll end up ordering epoxy through the mail, which means you can't run back to the store to pick up another container. It also means there's no one on the other side of the counter to answer questions.

Unless you have some experience with crack injection, invest in one of the complete kits offered by several manufacturers (see "For More Information," at the end of this article). These normally include several cartridges of epoxy, injection ports, surface-seal epoxy, and an injection gun. Some companies include extras like brushes and a trowel for smoothing the surface seal (see Figure 1).

Once you become adept at epoxy injection, you can purchase the components in bulk and do your own mixing. Buying epoxy this way is less expensive, but you'll need expensive metering/mixing/dispensing equipment (up to $20,000). This automatically takes the resin and the hardener from two separate containers, mixes them, and injects the epoxy. But for the beginner or those who don't intend to make crack repair a business mainstay, cartridges are the way to go.

Surface-seal epoxy. This is a two-part epoxy troweled over the outside of the crack to create a barrier that keeps the injection resin from escaping. The paste seals cracks up to about 3 inches wide without sagging or slipping. It adheres to steel, wood, and damp surfaces. Quick-setting surface seal allows injection to start 30 minutes after it has been applied, while the slower-setting variety should cure overnight.

Injection epoxy. This is the material that actually gets pumped into the crack. It's available in at least three types of cartridges ranging in size from 6 to 24 ounces:

- Biaxial, or side-by-side, cartridges house the hardener and resin separately in adjoining containers. A special injection gun pushes the plungers on both containers, forcing the material through a static mixing tube and out a long nozzle. Because the components are housed separately, any epoxy remaining in the cartridge can be saved for another job. The major disadvantage of this type of cartridge is the need to invest in a special gun costing around $250.
- Concentric cartridges house the hardener inside a thin tube lodged within the resin tube. Again, a special gun is needed to push each of the materials into a static mixing tube and out the nozzle. As with biaxial cartridges, any leftover material can be used on another job.
- Single-barrel, sealed cartridges are the only type used with a standard caulking gun. The hardener and the resin are separated by a foil seal. A plunger breaks the seal and pushes it to the end of the casing. The plunger is then rotated to mix the two components. Disadvantages include the fact that any leftover material cannot be saved for the next application (since it will have hardened). Also, the container needs to be carefully handled since the seal can be dislodged.
- Other configurations: One company, Micro Capsule Engineering (12245 N.E. Whitaker Way, Portland, OR 97230; 503/256-3455), offers a spring-loaded, low-pressure injection system that doesn't require a gun. Instead the company uses small cartridges resembling syringes (see Figure 2). Releasing the plunger activates a spring that slowly forces the epoxy into the crack. The company advises using the system only on hairline cracks.

Injection ports. These tubes are set into the surface seal to provide a conduit for getting the injection resin from the gun into the crack. While there are all kinds of configurations and materials used for ports, many kits include surface-mounted T-ports. The flared portion of the port is held onto the crack by the surface-seal epoxy while the other end, through which the epoxy is injected, projects about 1½ inches from the wall. Once the material is injected, the port is crimped or plugged with a small plastic cap. Most companies recommend spacing the ports at intervals equal to the thickness of the wall, usually 8 to 12 inches (see Figure 3).

Injection gun. There are all kinds of systems for getting the epoxy

Figure 4. *To repair a through-wall crack, like the one in this stem wall (right), first excavate and thoroughly clean the crack. Next, apply the surface-seal epoxy and install the injection ports. Then, working from the bottom port, pump the epoxy into the crack (below) until the material begins to ooze from the port above. As you finish with each port, cap it off and move to the one above.*

from the container into the crack. These range from relatively small handguns to pneumatic pump systems that look like bazookas. Some of the stronger guns can deliver the epoxy at pressures of 300 psi or more.

The system you choose depends on how much crack injection you intend to do and what type of cartridges you prefer. Novices should stick with sealed cartridges that can be used with caulking guns. Injection equipment for other types of cartridges starts at about $250.

Injecting a Crack

Injecting epoxy is a three-step process:

- Clean and prepare the surfaces
- Create a casing to contain the injection epoxy by covering the crack with a surface-seal epoxy
- Inject the crack

Getting to work. Because an epoxy repair is only as strong as the surface to which it adheres, the first step in the injection process is to thoroughly clean the crack and remove any dust and crumbly concrete with a wire brush. If the crack has been previously patched, take out the patch and get down to the original crack. Some manufacturers recommend flushing the crack with sulphamic acid and rinsing it with water if the area is particularly dirty and dusty (see Figure 4).

The next step is to measure and mark the locations of your injection ports. If you're using T-ports, the flared portion at the base should be placed perpendicular to the crack.

Now you're ready to mix a batch of surface seal. Because this two-part material has the same consistency as peanut butter, you'll get best results by mixing it in a metal or plastic container with a paddle on a slow-speed drill (400 to 600 rpm). Some manufacturers make one part of the surface seal white and the other part black. You'll know it's adequately mixed when there are no streaks and the material is uniformly gray.

Using a trowel or your hands (you should wear rubber gloves), spread a thin film evenly over the crack. At the port locations, hold the bottom of the T-port in place and liberally mound the surface seal over the base. The material is thick enough to hold the ports in place. Finally, brush out the surface seal to smooth it and eliminate pinholes.

If the crack runs the width of the wall and the outside of the foundation is above grade, you must also seal the other side of the crack. For critical structural repairs or for leaking cracks, it may be necessary to excavate and seal sections of the crack below grade as well. While most manufacturers say the backfill is a sufficient stopper, epoxy repair contractors have found that backfill, particularly if it is loose or sandy, can absorb a great deal of injection epoxy.

If you can't excavate, repair specialists recommend pumping in the injection epoxy slowly and gently. If necessary, pump a small amount into each of the ports and give the material a few hours to thicken and form a barrier. Then finish the injection process as usual. You will have to use more injection epoxy than if both sides of the crack are sealed.

Once you've mixed the cartridge and loaded it into the gun, slip the gun nozzle into the open end of the bottom port and start injecting the epoxy. When the material begins to ooze from the next port up, disengage the gun crank and remove the nozzle from the port. Depending on the type of port you're using, you can either crimp the end or cap it. Move up the crack, repeating this procedure at each port.

Depending on the size and shape of the crack, it may take anywhere from 30 seconds to 30 minutes or more before the epoxy begins to ooze from the next port. Hairline cracks typically take longer to fill than wide open cracks since there is greater resistance. Trying to rush the process by applying more pressure may keep the crack from filling to capacity. Extreme pressure can pop the ports right off the wall.

After you have pumped all the ports, give the epoxy about 12 hours to harden. If your clients are concerned about the appearance of the crack, you can cut or grind off the ends of the ports and paint over the crack. Some manufacturers sell pro-

Diagnosing the Crack

All concrete cracks; it's just the nature of the material. Common sources of cracks include shrinkage, improper curing, settlement, poor quality concrete, stress (as from earthquakes or improper backfilling), and impact damage, such as when a backhoe slams into the foundation wall. The tremendous force exerted against a foundation by wet soil can also cause cracks.

Judging when a crack must be repaired and when it can be left alone is something of an art. Certainly if a crack is leaking it should be fixed. This is especially true in cold climates where water in the crack can freeze and create an even larger crack. Most shrinkage cracks, however, cause no structural problems and can be left. Other kinds of cracks may or may not need repair, depending on their severity. In general, it's a good idea to repair cracks that go all the way through the wall to restore the foundation's structural integrity. For cracks that seem to undermine the foundation's strength, it's worthwhile to call in an engineer.

There are other reasons for repairing cracks, even where leaks and strength are not at issue. For instance, if a house is being sold, a home inspector may recommend to the buyer that all the foundation cracks be repaired with epoxy. Or the homeowners may order the repairs to make the foundation look better.

Determining the cause of the crack takes some detective work. While most foundation cracks occur within the first year after the house is built, other cracks develop as the house settles. A good indication of settlement cracking is cracked walls and uneven floors throughout the home.

For leaking cracks, excavate around the crack to check for drainage problems or poor fill. If the crack is dry but there's efflorescence, it probably leaks occasionally. In either case, take care of the drainage problem before repairing the crack. Otherwise, it's likely that another crack will develop, often alongside the one that's been repaired.

To determine if the crack is moving, some concrete repair specialists recommend using a monitor, such as a thin slip of glass. Wedge the glass into the crack or glue it across the crack. If the monitor slips or breaks within a few days, the crack is moving.

In investigating the crack, don't forget to interview the homeowners. They may be able to tell you if the crack leaks and whether it moves or is getting larger.

— W. T.

prietary solvents to clean spattered epoxy from the floor and walls. But a strong solvent like toluene will also work.

When the Crack Leaks

If the crack is damp or weeping, first try to determine the source of the water. Often this is fairly straightforward. For instance, if a crack leaks only during heavy rains, take a look at the drainage around the house. Sometimes a downspout will funnel water directly into the basement. Once the downspout has been redirected, you are no longer working with an actively leaking crack. Similarly, improper grading will direct water toward the house, causing basement leaks. However, if the water is actively flowing, as in the case of an underground spring, you may have to call in a waterproofing specialist — unless you have the pumps and other equipment necessary to temporarily stem the flow.

Many waterproofers prefer to inject polyurethane into an actively leaking crack. This material forms a dense foam upon contact with water. But polyurethane does not provide structural strength. For a load-bearing wall, epoxy is used for its additional strength.

For leaking cracks the epoxy repair process is only slightly different than for dry cracks. Since surface-seal epoxy will not set up with water running against it, you first seal the crack on both sides with fast-setting hydraulic cement. Next, on the dry side of the crack, you apply a film of surface-seal epoxy overlapping the hydraulic cement. This provides additional strength to keep the ports from blowing off during injection.

Injection is basically the same as for dry cracks, except that the crack may have some water in it. Once you start injecting, the epoxy will displace the water and force it out through the ports above. Don't cap a port until pure epoxy is flowing out the port above.

Business Matters

Epoxy is not cheap. Two gallons of surface seal cost about $100 while a single 18-ounce cartridge of injection epoxy will run from $15 to $25. Estimating how much you'll need is not easy since the epoxy can migrate several feet away from the crack through adjacent voids. With experience, you'll get a feel for how much you'll need. As a rule of thumb, a gallon (128 ounces) of injection epoxy will fill 231 cubic inches.

The labor involved to fill a crack can also be costly. Not only does the actual process take longer than slapping on a cement patch, it also requires two or three trips to the site. Excavation is an additional expense.

These factors add up to a more expensive repair than the standard cement patch. Epoxy repair costs start at about $200. This can be a problem if you're bidding against other contractors who don't intend to use epoxy. But if the homeowners have experienced cement patches that repeatedly crumble, they may be willing to spend the extra money to do the repair with epoxy. ■

Wendy Talarico is an associate editor at The Journal of Light Construction.

For More Information

For information on epoxy injection or a list of manufacturers, contact:
International Association of Concrete Repair Specialists
P.O. Box 17402
Dulles International Airport
Washington, DC 20041
703/450-0116

Selected Epoxy Manufacturers:

Bulk only
Euclid Chemical Co.
19218 Redwood Rd.
Cleveland, Ohio 44110
216/531-9222

Fosroc Inc.
55 Skyline Dr.
Plainview, NY 11803
800/645-3954

Sika Corp.
201 Polito Ave.
Lyndhurst, NJ 07071
800/933-7452

Kits, cartridges, and bulk
Abatron Inc.
33 Center Dr.
Gilberts, IL 60136
708/426-2200

Armitage Industries Inc.
Thermal-Chem Division
1650 Carmen Dr.
Elk Grove Village, IL 60007
800/635-3773

E-Poxy
14 West Shore St.
Ravena, NY 12143
800/833-3400

Jaco Coatings
1894 Old Oxford Rd.
Hamilton, Ohio 45013
800/733-3066

Polygem Inc.
1105 Carolina Dr.
West Chicago, IL 60185
708/231-5600

Prime Resins
2381 Rockaway Industrial Blvd.
Conyers, GA 30207
800/321-7212