

CRACK and JOINT REPAIRS on INDUSTRIAL CONCRETE FLOORS, PAVEMENTS and SECONDARY CONTAINMENT AREAS

Introduction

Defects that affect the structural integrity, water and chemical proofing, ride and walking quality of industrial concrete slabs and pavements involve untreated cracks and joints. Repair of these defects are critical to achieving a long lasting protective polymer overlay life cycle for chemical containment areas and industrial floors.

There are many methods and options that can be selected in the repair of cracks and joints. These methods and options are governed by where the defect has occurred; on exterior or interior locations, degree of chemical exposure, vehicular traffic conditions, vibration or movement from loading and unloading of tanks and vessels, and thermal change movements.

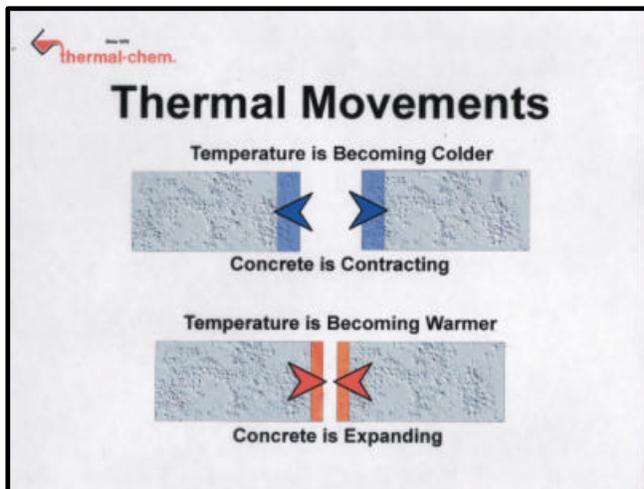


Figure 1

Typically, all cracks and joints move when the temperature changes; this is referred to as thermal movement. When the temperature becomes colder, the concrete contracts and the cracks and joints open wider. When the temperature becomes warmer, the concrete expands and the cracks and joints close as shown in Fig. 1. Closing of the crack or joint does not mean that the defect will stop water or chemicals from passing through the opening, it just slows the process down until the defect opens wider when the concrete temperature becomes colder.

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Cracks

Surface Observation

Cracks are one of the major contributors causing concrete industrial floor and slab-on-grade pavement defects. Cracks are defined as a partial or full depth separation of the concrete into two or more parts. Cracks may travel longitudinally or transverse in nearly straight lines; wander aimlessly across the pavement or floor, be spaced in neatly parallel patterns from 3 in. to 10 ft. (75mm to 3m) apart, form closely irregular shapes over an entire surface looking like a map, form diagonal paths at slab corners, extend from joint or other cracks to the concrete edge, or follow parallel to a non-working joint. For information on the causes of cracking in portland cement concrete (PCC) consult the many documents from ACI committees 201 and 503 ⁽¹⁾.

Crack Evaluation

Cracks are separated into two categories: MOVING CRACKS and NON-MOVING CRACKS. These terms refer to the crack opening and closing during thermal movements or during loading or unloading of tanks or vessels, which results in the placement or removal of heavy loads onto or off of the concrete.

Moving Cracks

All exterior concrete construction cracks will move. Cracks that are on the interior portion of a structure and exposed to a doorway opening, or in the direct line of window exposure that allows the sun to shine through will also move because of thermal changes. Cracks that are near equipment or ovens that heat up and cool down will move. Cracks that are near vibrating equipment, or in elevated floor panels that flex when heavy loads travel across them will also move.

The question often asked is: after repairing a crack with the injection welding process, will they re-crack in the same location or break parallel to the repaired crack? The answer is no. Most cracks are typically caused during the curing process of the PCC and are called shrinkage cracks. Cracks can also be developed by settlement, overloading, impact and earth quakes. Moving cracks are very seldom expansion joints. Cracks that are acting as expansion or control joints will be discussed in the joint section.

Repair Method for Moving Cracks

Moving cracks on interior or exterior concrete are all repaired in the same manner by welding the two separated sections of concrete together with a structural epoxy adhesive. The process is called "Crack Injection". But before we discuss the crack injection process, let's examine what not to do.

- **DO NOT Surface Patch Moving Cracks**

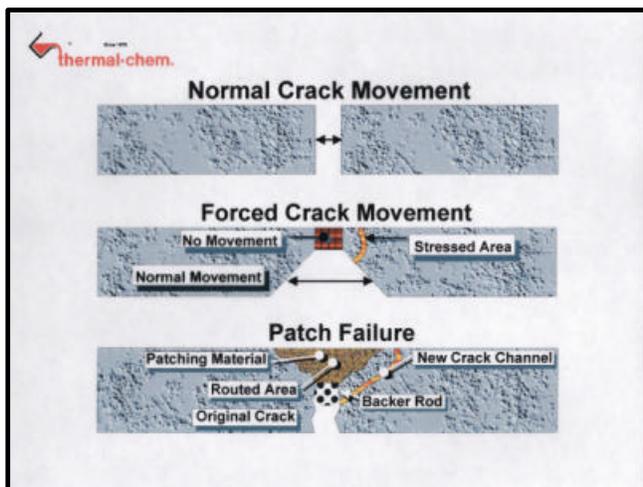


Figure 2

Figure 1 shows how the crack opens and closes during thermal-change. Figure 2 shows that if the crack is surface-patched or routed out and patched, and if thermal change, flexural movement or vibration occurs, the patch system will fail. The principal cause of failure is that the PCC has no tensile elongation property and will not stretch. Therefore, the weaker of the two materials, the PCC or the patch material, will be stressed to the point of yielding during the crack movement and break. It does not matter which material breaks, when the break occurs, the crack is reopened and the patching system has failed. Of major importance is the fact that when the crack

failure develops, the polymer overlay system also fails, because the crack will reflect upward through the polymer overlay systems, as shown in Figure 3.

- **Bridging Techniques Over Moving Cracks WILL FAIL**

Figure 3

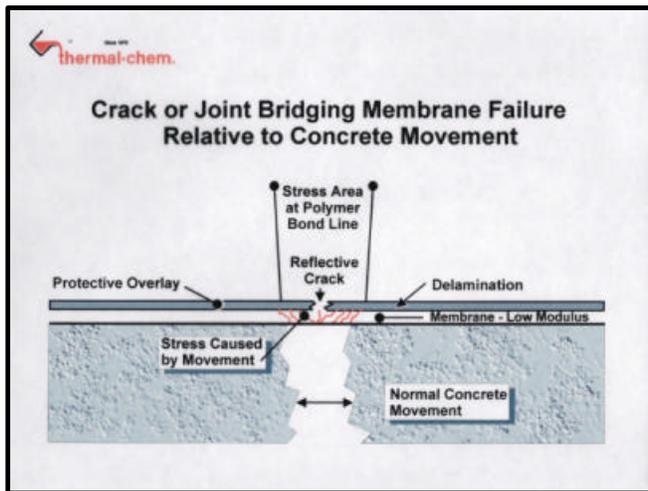


Figure 3 details the failure mode if the crack is surfaced-sealed with a flexible membrane to bridge moving cracks. The protective polymer overlay is normally a high or medium modulus polymer system. These types of systems are used because they provide the highest degree of abrasion and chemical protection for the concrete in industrial environments. However, because the tensile elongation and modulus properties are so different between the polymers, stress can cause damage to the protective system as a delaminating or reflective crack. Alternately, both defects can occur in different locations or the same location at the same time. As movement occurs in the crack, the low

modulus polymer absorbs the stresses, however, the strain at the bond line area of the low modulus polymer attachment to the higher modulus polymer becomes greater than the tear strength of the lower modulus polymer, and delamination between the two polymers often occurs. Also, if quick movements occur during colder temperature environments, the low modulus polymer's tensile elongation drops to about half of its original value. At the same time, the tensile strength property can increase two or three times its normal value and delamination may or may not occur, but the stress force will cause a reflective crack upward through the higher modulus polymer. The end result is that the broken protective top surface area of the polymer system will allow water and chemicals to enter the cracked area and the expected life cycle of the system will be shortened. If the crack did not break, the entire thickness of the low modulus membrane or filler material, it's just a matter of time before failure occurs, because low modulus materials can not provide the same protection from abrasion and chemical exposures as the high modulus polymers.

- **DO NOT Caulk Moving Cracks**

Figure 4

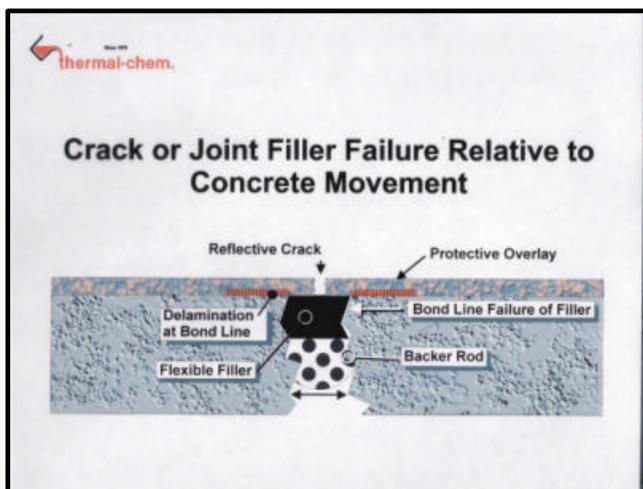


Figure 4 shows filling the crack with a flexible polymer and the protective system failure. The high modulus polymer will not elongate to accommodate the crack opening movement and will crack as stresses are developed. This type of repair will have a shorter life cycle than the flexible membrane system, but in a short time both systems will fail causing rapid deterioration to the protective system.

The crack injection process:

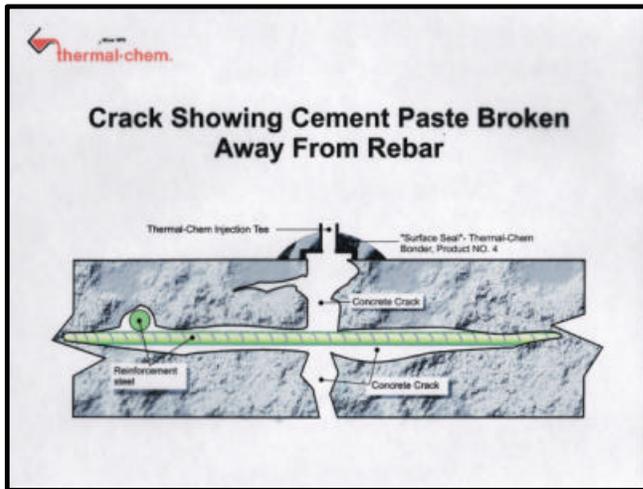
- **WELD Moving Cracks Together**

When a crack develops in concrete, the portion of the crack we see is only a small

part of the damage that was caused during the crack development. The sudden stress to the

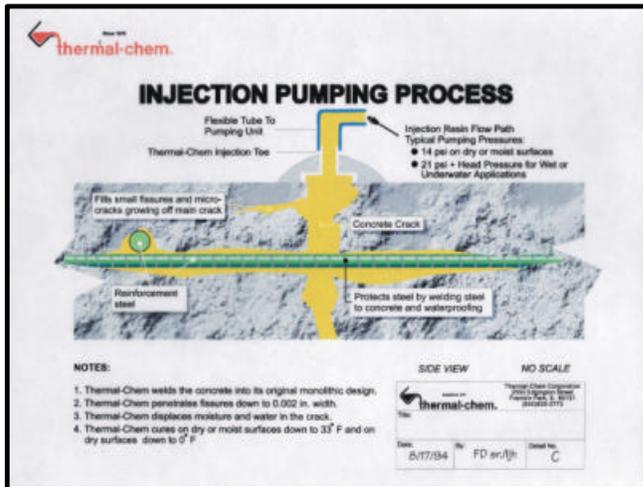
concrete simultaneously broke the concrete between the two outer surfaces. The reinforcement steel bond to the concrete crossing the crack void was damaged during the break for many feet (meters) in each direction away from the main crack void. If the reinforcement steel is too close to the outer surface of the concrete, reflective cracks will be seen. However, more common is the fact that these cracks will never be seen. The cracking occurs directly next to the reinforcement steel in the weakest portion of the concrete, the cement paste area encapsulating the reinforcement steel shown in Figure 5. The cement paste is the protecting coating for the reinforcement steel. As long as the cement paste is properly adhering to the steel, no corrosion will start on the steel's surface. However, most cracking includes the cement paste separation from the reinforcement steel.

Figure 5



Cracks that are not properly repaired and exposed to undesirable conditions will cause the normal life cycle of the PCC to be shortened. All cracks allow water, air and other contaminants to enter into the void. Water dissolves the soluble salts in the cement, smaller aggregates are loosened and the void becomes larger over a period of time. When the water and oxygen come in contact with any unprotected reinforcement steel, corrosion is accelerated. The expansion of the steel during the corrosion process often causes additional cracking to the closest outer surface of the concrete.

Figure 6



Therefore, the crack welding process must be capable of welding not only the main crack void together, but penetrate into the cavities around the reinforcement steel as shown in Figure 6. If only the main crack void is welded together corrosion will continue to accelerate because the vapor that moves through the concrete mass will turn to liquid when it comes into contact with these open voids. When water and oxygen are present, the unprotected steel will corrode and cause future damage to the slab.

The injection resin, a two-component epoxy adhesive should be pumped with low pressure (14 psi) to assure that the epoxy has time to penetrate not only the main crack void but into the cavities around the reinforcement steel and any other fissures that developed during the cracking process. If high pressure systems are used, they will typically only fill the main void by the time the epoxy has moved from the port being injected to the next adjacent port. When this happens, the epoxy sets up in the main crack void only and the lateral cavities are not filled.

Or, some of all of the epoxy bleeds off into the lateral cavities and the main crack void is starved. In either case, a failure will occur which will affect the protective polymer overlay. It's often said rightly, that the person injecting the crack should be conscientious and have lots of patience and of course use a low pressure pumping system.

Details on how to clean the concrete surface, set and space the entry ports or tees, apply the surface sealer over the crack and the entry ports, the pumping process, and entry port and surface sealer removal are located in the Crack Repair Section of your Floor or Restoration Manual.

Product Selection

- Entry Ports:**
- . Surface Setting – Thermal-Chem Tees and Plugs, Product No. P101
 - . Vacuum Drilling Holes – Thermal-Chem Ports and Plugs, Product No. P102
- Surface Sealer:**
- . Thermal-Chem Super Rapid Surface Sealer, Product No. 421, a Non-Structural Adhesive
 - . Thermal-Chem Bonder, Product No. 4, Rapid or Normal Cure, a Structural Adhesive
 - . Thermal-Chem Underwater Coating, Product No. 903, Grade 3 a Wet or Underwater Surface Adhesive
- Injection Epoxy:**
- . Thermal-Chem Injection Resin, Product No. 2, a Structural Adhesive for Dry Moist or Wet Uses in a Low-Viscosity Consistency
- Injection Epoxy:**
- . Thermal-Chem Injection Resin Gel, Product No. 201, a Structural Adhesive for Dry Moist or Wet Uses in a Gel
 - . Thermal-Chem Injection Resin High Temperature, Product No. 212, a Structural Adhesive for Exposures Up to 500° F in a Low-Viscosity Consistency
 - . Thermal-Chem Injection Resin Gel High Temperature, Product No. 213, a Structural Adhesive for Exposures up to 500° F in a Gel Consistency

Non-Moving Cracks

Concrete cracks that are located on interior areas of a structure where the temperature changes are normally less than 15°F(6°C) do not move very much and therefore typically do not need to be welded together unless there is a structural reason for the repair. When the cracks are non-moving, they may be repaired by a less expensive and faster method.

Crack Routing and Patching Method

These cracks are typically open or starting to spall on the broken concrete edges of the crack void. Cracks that have uneven adjacent surface edges caused from settling are also repaired with this

method. The cracks are routed out in a “V” shaped groove to a depth of about 1/2 in. (13mm) and a width about 3/4 in. (19mm) with light chipping hammers, a grinding tool, a power crack chasing routing tool, or a power crack chasing saw. On interior work, dust can be a major problem. Many tools have vacuum attachments and remove most if not all of the dust during the chipping process. The inner wall areas of the chipped crack surfaces must be free of dust and other contaminants before sealing.

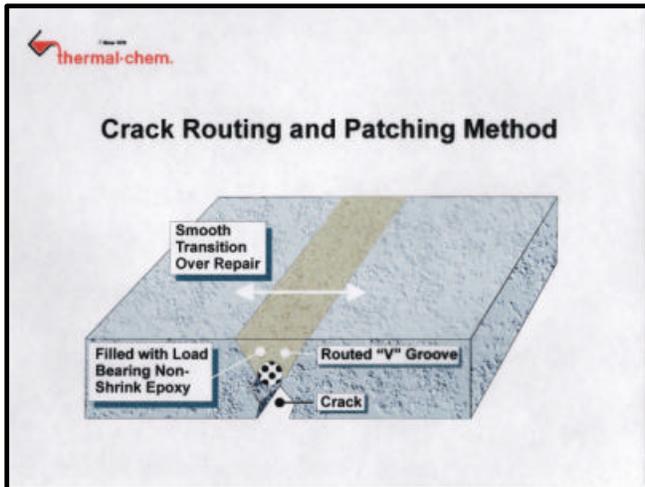


Figure 7

The grooved crack is then filled with a non-sagging Epoxy Polymer Concrete that is troweled in place; a flowable Epoxy Polymer Concrete that is self leveling; or a load-bearing Flexible Epoxy Resin that is self leveling. When self leveling products are used, the open crack area at the bottom of the “V” groove may require sealing with backer rod to prevent loss of material into the crack void as shown in Figure 7. Selection of the above products is often based on personal preference more than project changing conditions. This method is most often used because it provides a non-sagging repair with a smooth surface that will not deflect during placement of the overlay.

There is also a smooth transition from one side of the concrete crack edge to the other, that does not show the repair on thinner overlay systems.

Product Selection

- Epoxy Polymer Concrete – Trowelable or Pourable Consistencies
 - Thermal-Chem Mortar Resin, Product No. 3
 - Thermal-Chem FlexGard J Gel, Product No. 109
 - Any of Thermal-Chem’s base coat materials
- Flexible Epoxy Resins - Pourable or Pumpable Self-Leveling
 - Thermal-Chem FlexGard J, Product No. 108
 - Thermal-Chem FlexGard 125, Product No. 104

CAUTION:



Read the limitations on each Product Data Sheet for placement capabilities and cure relative to substrate temperatures.

Gravity Feed Injection

Non-moving surface and structural cracks can be repaired using a gravity injection system. This approach is economical where a large number of cracks exist and the primary concern is to prevent corrosion of the reinforcement steel from salts and water entering the concrete slab through the cracks. Typical uses occur on exterior airport runways, parking decks, bridge decks and industrial and commercial floors.

The concrete surface and cracks must be free from oils, grease, waxes, curing compounds, dust and other debris that could inhibit the epoxy from wetting the substrate. Vacuum cracks as necessary to remove debris. Freestanding water can be blown off with oil free compressed air. Apply Thermal-Chem Hairline Crack Sealer, Product 207, over the crack using a squeegee. Make several passes over the crack. Work the material into the crack using a short nap mohair roller for 5 to 15 minutes to insure penetration. Excess material can be moved to the next crack or broadcast with sand. Material temperature is critical for a successful application, warm material translates into lower viscosity and lower viscosity translates into better penetration. Coverage rates are dependent upon the width, length, depth and number of cracks as well as the porosity of the concrete.

If a coating or overlay system is to be applied over the Hairline Crack Sealer check for a greasy film that may have formed on the exposed Hairline Crack Sealer. A greasy film may occur in high humidity conditions. The film does not affect the epoxy material and may be removed with warm water and soap.

Surface Fiberglass Grid Cover Over Crack Surface

Figure 8

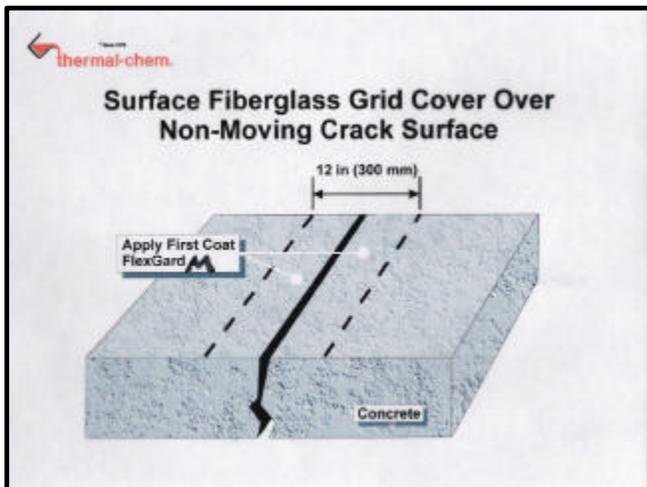
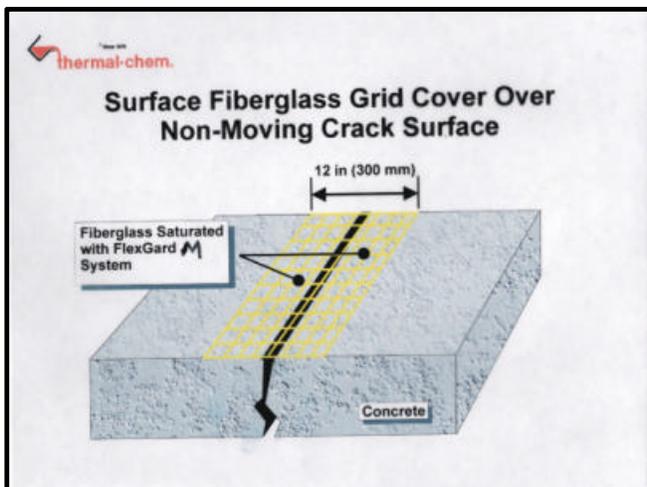


Figure 9



Many non-moving cracks are tightly closed and it's an optional choice as to rout them out or cover them with a fiberglass grid saturated with epoxy. Again, this is a personal preference in choosing the best and most expedient repair system.

The repair system is installed after the concrete surface has been cleaned as required for the polymer overlay system. Using a chalk line measure and mark a 6 in. (150 mm) distance from each side of the crack, as shown in Figure 8. Apply a 20 mils (0.5 mm) coat of Thermal-Chem FlexGard M, Product No. 739, in an even thickness between the lines. Before the epoxy becomes tacky, lay the 6 oz. wide woven fiberglass strip into the wet epoxy. Using a roller, carefully work the fiberglass into the epoxy so as not to create wrinkles. After totally saturating the fiberglass with epoxy, apply another 20 mils (0.5 mm) thickness of FlexGard M and allow to dry to touch, Figure 9. The total repair thickness is approximately 45 mils (1.1 mm).

When the epoxy is dry to the touch, the protective polymer overlay system may be applied. Thin protective systems may show the repairs through the overlay.

CAUTION:



Read the limitations on each Product Data Sheet for placement capabilities and cure relative to substrate temperatures.

Epoxy Membrane Over Cracks

When a concrete surface has many non-moving cracks that are tightly closed, often one application of a membrane over the surface is the fastest and most economical method of treatment.

After the surface preparation has been completed, apply one (1) coat of Thermal-Chem FlexGard M, Product No. 739, evenly over the concrete surface at approximately 30 mils (0.8 mm) thickness. When the membrane is dry to touch and will not mark or indent by pushing against the membrane with your thumbnail, the first application of the protective overlay may be placed.

When the membrane has become tack-free and before application of the protective overlay, check all cracks to make sure that the membrane has not drained into the crack void. If a void has developed, re-apply FlexGard M into the void until the void is filled, level with the adjacent floor surfaces. The membrane needs to be dry to touch before applying the protective overlay. Therefore, if there are wider open cracks, any of these systems explained in this document can be used in combination to speed-up the installation.

CAUTION:



Read the limitations on each Product Data Sheet for placement capabilities and cure relative to substrate temperatures.

Reference

- (1) American Concrete Institute, P.O. Box 9094, Farmington, MI 48333.

Manufacturer

Any questions or comments regarding the contents of this *Guide*, for technical questions or assistance, and/or questions with regard to specific installation procedures, contact the manufacturer:

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