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CrownTech™ - Technical Bulletin 25
Concrete Control Joints – Filling & Reinforcement

UNDERSTANGING WHY JOINTS ARE NEEDED IN CONCRETE – WITH A FOCUS ON CONTROL JOINTS – FILLING & REINFORCEMENT PRODUCTS

This Technical Bulletin focuses on the installation methods of Control (relief) Joints in concrete substrates. Other Joint Types including expansion, isolation and construction are briefly discussed in order to clarify the difference between Control Joints and other typical joints used in the placement of concrete.

Concrete moves regardless of design, cure shrinkage, dimensions, weight, loads associated with end use and environmental condition. To accommodate for structural movement, there is need for isolation of the movement and different types of joints, at varying strategic locations throughout the exterior structure must be placed and placed correctly. Additional load considerations must be incorporated, such as: seismic, or vibration stresses, or thermal, or use loads, etc. The dimension and location of joints are directly related to the anticipated tolerances required.

Concrete charges prior to cure and after cured it is subject changes in length, width, depth or volume caused by changes in its moisture content, temperature, chemical reaction with atmospheric and internal components, loads (dynamic or static), as well as other forces. Different joint types are carefully considered design elements that are required to compensate for dimensional changes and/or to allow for differential (individual) movement of one concrete element from that of another.

Demand for Joints is in response to permanent or transient dimensional changes caused by movement of the concrete substrate.

I. Control
   1. Drying Shrinkage
   2. Long Term Irreversible Creep

II. Cyclical Contraction and Expansion
   1. Thermally Induced Expansion or Contraction
   2. Mechanical Response to Dynamic and Static Physical Loads
   3. Environmental Moisture Differences

III. Abnormal Volume Changes
   1. Permanent Expansion (Sulfate Attack and/or Alkali Silica Reaction
   2. Expansive or Contractive Aggregates (Dolomite Clay or Brick)

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STRUCTURAL DESIGN REQUIRING JOINTS

I. Structures not under fluid pressure (most civil engineered projects)
II. Containers subject to fluid pressure (dams, reservoirs, tanks, pipe lining)
III. Pavement highway and airfield

TYPES OF JOINTS AND FUNCTIONS

Control: When contraction forces associated with curing shrinkage and movement associated with thermal actions or mechanical loads are restrained, then cracking will occur within the concrete when the tensile stresses exceed the strength of the concrete. Joints and cracks will open up and become wider as the concrete contracts (shrinks).

Expansion and Contraction: If expansion movement is restrained it may result in distortion and cracking within the unit or crushing of its ends and transmission of (design) anticipated and unanticipated forces to the abutting elements. Joints and cracks will be closed and the forces will cause spalling if foreign objects preclude the closing.

Deflection: When deflection (torsional, flexural, etc.) movement stress is anticipated that may exceed the materials, structural design strength limitations of the isolation joints employed.

1.0 CONTROL (RELIEF) JOINTS

Control joints are saw cut, tooled, formed or a bond breaker (plastic or metal strip) is added to provide a weakened plane. They are designed to regulate and control shrinkage crack locations, that normally occur in concrete segments. Since the joint is expected to control the location of crack, these joints are often referred to as control or (stress) relief joints. Without the control joint, tensile stress induced cracks would occur at unpredictable locations, thereby relieving the concrete of buildup internal stresses.

They are frequently used to divide large, relatively thin, structural units or sections, for example:

- Pavement
- Floor slabs
- Canal lining
- Retaining walls

Control joints form a complete break, as in the case of a floor slab, the joint is designed to go completely through the unit. Allowing each floor slab to function independent of the other.

They can also be designed to not act isolated from the adjoining floor slab. If the control joint is saw cut or tooled to one quarter of the floor slab thinness (and the joint is not wide) there may be aggregate interlock, perhaps coupled with wire mesh restraint. Where greater continuity is desired from floor slab to concrete slab dowels (usually slip bars), stepped or keyed joints may be employed. To protect the floor slab contraction joint from the deleterious effect of hammer loads (impact from small wheeled carts or vehicles) it is necessary to fill the joint with a semi-rigid stress relieving epoxy material expressly designed to reinforce joint nosings to prevent spalling and raveling.

NOTE: Semi-rigid epoxy resin systems should comply with ACI 302.1R-15 and ACI 302.2R-06.

2.0 EXPANSION (ISOLATION) JOINTS

Expansion joints (also to referred to as expansion-contraction joints) are used to isolate one structural element from another to prevent crushing and distortion, such as displacement, buckling and warping. They are sometimes called isolation joints because they are used to isolate structures that behave in different manners. Example, they are used to isolate abutting concrete structural units that might otherwise cause distress in one or both of the units due to transmission of compressive forces that develop during expansion, under applied loads or differential settlement.

Isolation joints are used primarily to isolate walls from floors or roofs, columns from floors or cladding, and pavement slabs and decks from bridge abutments – thus the name "isolation joint."

Where greater continuity is desired from one structural unit to the next (floor slab to floor slab or floor slab to stem wall) reinforcing bars or dowels, stepped or keyed joints may be employed.

To protect and fluid proof the joints (prevent egress of fluids in or out of the structure) when movement will occur requires the use of a flexible joint filler sealant or assemblage).

NOTE: Elastomeric (urethane, silicon, etc.) joint sealants should comply with
ACI 302.1R-15 and ACI 504

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3.0 INSTUCTION (INTERRUPTION or COLD) JOINTS

Construction joints may be planned or unplanned. Planned construction joints are incorporated in to the structural units for several reasons, such as precast elements length restriction or during a concrete pour due to configuration or "trick" form placement requirements. Planned construction joints can be called upon to function as expansion joints to accommodate the normal or even radical movement of a structure. Planned construction joints are usually treated in a similar fashion to Expansion joints listed above.

Unplanned construction joints usually occur due to unforeseen concrete placement difficulties or forming restrictions.

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In the case of unplanned and unwanted construction joints due to unforeseen interruption of concrete placement, an injection adhesive can be used to bond the units together. Thus, providing a monolithic structural unit as originally designed by permanently welding the unit together at the construction joint.

NOTE: Epoxy injection adhesive should comply with ACI 503 and ASTM-C 881 Type IV.

4.0 CONTROL JOINT DESIGN CONSIDERATION

Epoxy joint fillers are formulated to reduce or prevent the deterioration of industrial floor joints subjected to impact and point loading from steel and hard wheeled vehicular traffic. The semi-ridge epoxy joint grouts were designed to reduce spalling of the floor joints caused by steel or hard rubber wheeled vehicles in warehouses, manufacturing facilities and industrial plants.

4.1 Joint Fillers: Semi-ridge epoxy joint grouts were specifically developed to fill control (relief) joints and inductive loops in concrete floor slabs.

Caution: A semi-rigid epoxy joint filler, in most cases, should not be used if the joint to be repaired is an engineered expansion and/or isolation joint, or in otherwise working or moving joints. This caution may be waived by the designer or owner if the benefits of reinforcing the joint outweigh the effects of a small stress crack which may develop between the epoxy joint filler and one side of the concrete joint or as a cohesive failure within the joint filler itself.

Semi-rigid epoxy joint fillers are formulated to provide a joint grout material having a tough, resilient wearing surface capable of accommodating limited joint movement. Separation of the joint filler from either side of the joint or internal cohesive hair line cracking does not necessarily indicate failure of the semi-rigid epoxy joint filler application. Further curing shrinkage after the joint has been filled, or other contraction movement may exceed the stress-relieving capabilities of the epoxy joint filler, leading to cracking or splitting. When separation does occur, actual in-service conditions will determine whether or not further repairs are required.

Semi-rigid epoxy joint fillers subjected to “excessive movement” may be subject to cracking and spalling, thereby failing to armer or reinforce the joint, as intended. Failure to armer the joint due to excessive movement cannot be considered to be the fault of the joint material.

4.2 Temperature Changes: The upper and lower service temperature limits must be considered. If the slab will be exposed to thermal cycling, freeze-thaw or extreme seasonal variations in temperature, or if there are other special conditions (freeze rooms, etc.), consult the manufacturer.

4.3 Construction Sequence: Construction sequence or joint filler installation sequence will require

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a compromise between working and curing time. A fast-curing product has a short working time, the advantage is that the floor can be put back into service sooner than a product that is slow to cure. Corresponding longer working time products may be easier to work with, but they are slower to cure. Sufficient cure prior to exposure to traffic is necessary to insure against costly repairs and additional downtime in the future.

5.0 MATERIAL CONSIDERATION

5.1 **Application Characteristics**: All epoxy joint fillers change their handling characteristics when they are conditioned to the prevailing ambient temperature fluctuation.

At low temperature they become more viscous (less fluid) and, unless they are heated, often times more difficult to apply. High temperature causes a decrease in viscosity and a reduction in non-sag properties.

It is important to determine the application temperature range and select a product with handling characteristics suitable for that range. Use of more than one product or product modification may be required to accommodate a wide temperature range associated with year-round work.

5.2 **Curing Characteristics**: Working time and cure times are affected by the ambient and substrate temperatures.

Working Time: Pot life and open time are the two elements which make up working time.

Pot Life: Pot life is the time a predetermined quantity of mixed product is workable in the mixing vessel just prior to gel. Elevating the material's temperature and/or increasing the volume of the material mixed will decrease its pot life.

Cure Time: Cure time or cure rate accelerates with an increase in ambient and surface temperature. There is a minimum temperature below which formulations will cease to cure and/or cure at a rate that is too slow for the intended use.

5.3 **Cure Characteristics**: The bond strength of an epoxy joint filler to the concrete surface is dependent on the surface preparation, substrate durability at the interface, the bonding ability of the epoxy joint filler material itself and the sand loading, if any. An epoxy's ability to bond can be formulated to tolerate both dry and damp surface conditions, however, for best results the substrate should be clean.

5.4 **Toughness:** To maintain integrity in use, joint filling epoxies must be tough and impact resistant

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to prevent gouging, chipping and spalling from steel and hard rubber wheeled vehicular traffic and other abusive conditions.

5.5 Chemical Resistance: The resistance to chemicals is dependent on the inherent resistance of the resin and hardener formulation, the temperature and duration of exposure and the integrity of the application. If chemical resistance is an important design consideration, the installed epoxy joint filler should be free of pinholes, holidays, dishing and other defects, as well as having resistance to the specific chemical(s) that it is required to withstand (consult the material manufacturer for chemical resistance details).

6.0 SURFACE PREPARATION

6.1 General: Joints to be filled must be clean and sound, if a bond is desirable. In all cases this will require some form of surface preparation.

6.2 Contaminants: The presence of grease, wax or oil may be detected by dropping a small amount of muriatic acid onto the surface. No reaction or a little reaction indicates that the surface is contaminated. Oil penetration of the concrete surface can, also be, detected by raising the temperature of a small area to about 150 degrees Fahrenheit with a heat lamp. Oil contamination is indicated if an oil film appears or if the surface becomes greasy to the touch.

6.3 **Cleaning Procedures**:

1. Grease, wax and oil contaminants can be removed by scrubbing with an industrial grade detergent or degreasing compounds, following with mechanical cleaning. Severely contaminated joints may be saw cut with a blade slightly oversized.

2. Weak or deteriorated concrete must be removed to sound concrete by bush hammering, needle scaler, abrasive grit blasting, vacuum shotblasting, scarifying, water blasting or other suitable mechanical means.

3. Dirt, dust, laitance, form release agents and curing compounds should be removed by water cutting or abrasive grit blasting.

   Caution: Acid etching (15% solution of hydrochloric acid) is recommended only when there is no practical alternative. Etched surfaces must be thoroughly scrubbed and flushed with a large volume of potable water. A moist pH paper reading of 10 or more will indicate that the acid salts have been removed.

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4. Dust residue from mechanical cleaning may be removed by vacuuming, water jet or by clean, oil free high-pressure air.

7.0 APPLICATION TECHNIQUES

7.1 **General Installation Techniques of Epoxy Joint Fillers**: Prior to installing the epoxy joint filler the joint surface must be dry and free of all substances detrimental to the bonding of the epoxy compound. Concrete should be prepared in accordance with the procedures outlined in Section (If "cannot dry" conditions exist, contact the Manufacturer for product and/or procedural recommendations, including special installation techniques, it any.)

7.2 **Installation Contractor**: Only installation contractors who are experienced specialty contractors should install the epoxy joint filler. Epoxy joint filler contractors with control joint grouting experience and competent trained application personnel will provide installation services that meet the owner's needs.

Contractors with limited experience or no previous experience in placing epoxy joint fillers should contact the Manufacturer for application assistance or subcontract the work. Contractors with limited experience should start out in a small area, mixing only enough material to complete a few feet of joint.

The installed material should then be allowed to cure before attempting any further installation work. If the test is successful, the contractor can proceed at an increasing application rate until reaching maximum productivity. If the trial application fails for any reason, contact the Manufacturer for additional application assistance.

7.3 **Material Preconditioning**: To facilitate speed of cure, mixing and application of the epoxy joint filler, if may be preconditioned above ambient temperature. Uniform preconditioning will require approximately 24 hours (in most cases, do not exceed 90 degrees Fahrenheit).

CAUTION: While preconditioned material may facilitate ease of installation, higher material temperature accelerates gel time and shortens pot life and corresponding working life.

7.4 **Mixing**: Epoxy joint filler materials must be thoroughly mixed to disperse pigments and fillers, which may have settled during storage.

To ensure proper cure, it is important that all components of the epoxy joint filler are carefully measured and adequately mixed per the product data sheet. While the components are being mixed, the sides and bottom of the mixing vessel should be scraped with the mixing paddle.

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Thorough mixing will take from three to five minutes using a Jiffy® type impeller with a blade guard type mixer and a variable speed drill set at a low speed to avoid entraining excessive air.

CAUTION: Do not add solvents unless that procedure is specifically recommended on the product data sheet.

7.5 **Method of Application**: Epoxy joint fillers can be installed with a wide range of application tools, such as a deform or "v" bent tin can, to state-of-the-art plural component metered mixing equipment.

7.6 **Installation Procedures**: Installation procedures vary based on job conditions and equipment available.

Prepare the Joint: Prepare the joint to be epoxy grouted per the instructions listed above and per the Manufacturers recommendations.

Mixing: Mix the material with an electric variable speed drill, at low RPM's (less than 400 RPM's). A Jiffy mixing paddle or other similar paddle with a blade guard should be used.

Always thoroughly mix each component separately to ensure proper pigment and filler dispersion, before mixing the two components together. If sand is to be added as a third component, it must be added only after a complete and uniform mix of the resin and hardener has been obtained.

Epoxy joint fillers installed to armor or reinforce a control joint are normally installed without the use of "backer rods" or other foam fillers.

Joints with exceedingly wide "through cracks" at the base should be filled to 1/8" of number 70 to 90 mesh U.S. Seize Size fine aggregate poured directly into the control joint kerf prior to placement of the material to reduce epoxy joint filler material loss.

If the crack is wide enough to allow fluid outflow, a second epoxy grout pass may be required. Allow the first application to gel prior to placing the second application.

Fill the joint to the top and crown if conditions permit. All liquids, except water, will shrink as the liquid transforms to a solid. The over-filled or crowned epoxy grout will allow for shrinkage to occur and any remaining crown material will be worn flush by vehicular traffic.

Uneven or Sloped Slabs: Most epoxy joint filler materials will attempt to self-level. When a self-leveling material is not desired, a high build series of epoxy joint fillers should be specified to reduce the materials tendency to self-level. Under severe slope conditions, the use of high build

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material alone may not be sufficient to avoid excessive flow of the epoxy joint filler from the joint. Under these conditions, it may be necessary to use the high build series in conjunction with multi-pass applications to accomplish full-depth, level grouting, while avoiding excessive material loss.

8.0 OPEN TO TRAFFIC

8.1 **Open to Traffic**: Ideally, traffic should be kept off of the epoxy grout material until full cure is reached. However, access can usually be granted to moderate traffic prior to full cure. The actual time when the slab can be "opened to traffic" will vary based on reactivity of the epoxy grout installed and the temperature of the host substrate. Open to traffic time, in most cases, will run between 4 to 24 hours, depending on the material selected.

8.2 **Early Access**: If access must be granted to the owner or operator prior to the epoxy joint filler reaching a tack free state, broadcast a 70 to 90 mesh aggregate, to excess, on the exposed epoxy joint filler to reduce tracking of the material. In most cases, premature access will, however, void the warranties and guarantees offered by the manufacturer for that area where the access is required.

9.0 PHYSICAL PROPERTIES

9.1 **Semi-Rigid Epoxy Joint Filler**: A semi-rigid epoxy joint filler should possess the physical properties listed in the Technical Data Sheets of the following Crown Polymers' products:

8502 CrownFlex™ Semi-Rigid Membrane and Joint Crack Filler
8503 CrownFlex™ Semi-Rigid Thixotropic Cove Base Joint and Crack Filler
8504 CrownFlex™ Semi-Rigid Non-Sag Paste Joint and Crack Filler

APPROXIMATE YIELD per GALLON (No Wastage)

Width Per Inch	Depth Per Inch	Linear Feet Per Gal		Width Per Inch	Depth Per Inch	Linear Feet Per Gal
1/8	1/8	1200		1/2	1/8	300
1/8	1/4	600		1/2	1/4	150
1/8	1/2	300		1/2	1/2	75
1/8	3/4	200		1/2	3/4	50
1/8	1	150		1/2	1	37
1/4	1/8	600		1	1/8	150
1/4	1/4	300		1	1/4	75
1/4	1/2	150		1	1/2	37
1/4	3/4	100		1	3/4	25

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1/4	1	75		1	1	19

9.2 Semi-Rigid Epoxy Benefits:

1. Long term adhesion to the faces of the joint
3. Resistance to creep, slump or cold flow
4. Resistance to undue shrinkage
5. Non-bleeding and non-staining properties
6. Adequate elastic properties to accommodate movement without splitting
7. Resistance to aging
8. Compatibility with floor and overlay design
9. Resistance to specified chemicals
10. Adequate hardness and abrasion resistance
11. Retention of physical properties
12. Stability in storage
13. Ease of mixing
14. Ease of installation

9.3 Elastomeric Polyurea Joint Sealant: A polyurea joint sealant should possess the physical properties listed in the Technical Data Sheets of the following Crown Polymers' products:

7126 CrownCaulk™ Polyurea HA Self-Leveling Control Joint & Crack Caulk
7136 CrownCaulk™ 82A Polyurea Self-Leveling Control Joint & Crack Caulk

9.4 Elastomeric Joint Fillers:

Elastomeric joint fillers do not reinforce the concrete edges of Portland Cement Concrete. Elastomeric joint fillers are used to:

1. Used to seal joints
2. Waterproofing or Fluid Proofing the Control Joint
3. Filling joints to block contaminants intrusion
4. Movement of concrete inducted by changes in weather

10. Reasons for Failure:

10.1 Prior to replacing a semi-rigid epoxy joint filler or elastomeric joint sealer the reason for failure should be determined.

1. Unsuitable joint filler specified and installed

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2. Joint dimensions that do not match specification and/or product capability
4. Joint movement is greater than anticipated
5. Incorrect mixing of multi-component material
6. Improper application of material
7. Lack of chemical resistance

TECHNICAL SUPPORT

For questions, contact a Crown Polymers' representative.

DISCLAIMER

LIMITED WARRANTY

Crown Polymers warrants its products to be free of manufacturing defects and meets all Crown Polymers current published physical properties. Crown Polymers' sole responsibility shall be to replace the portion of any product proved to be defective. There are no other warranties by Crown Polymers of any nature whatsoever expressed or implied, including any warranty of merchantability or fitness for a particular purpose in connection with this product. Crown Polymers shall not be liable for damages of any sort, including remote or consequential damages resulting from any claimed breach of any warranty whether expressed or implied. Crown Polymers shall not be responsible for the use of this product in a manner to infringe on any patent held by others. In addition, no warranty or guarantee pertaining to appearance, color, fading, chalking, staining, shrinkage, peeling, normal wear and tear or improper application by the applicator will be issued. Damage caused by abuse, neglect and lack of proper maintenance, acts of nature and/or physical movement of the substrate or structural defects are also excluded from the limited warranty. Crown Polymers reserves the right to conduct performance tests on any material claimed to be defective prior to any repairs by owner, general contractor, or applicator.

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