

# Concrete Repair Alternatives

Techniques, Economic Feasibility,  
Limitations, and Application

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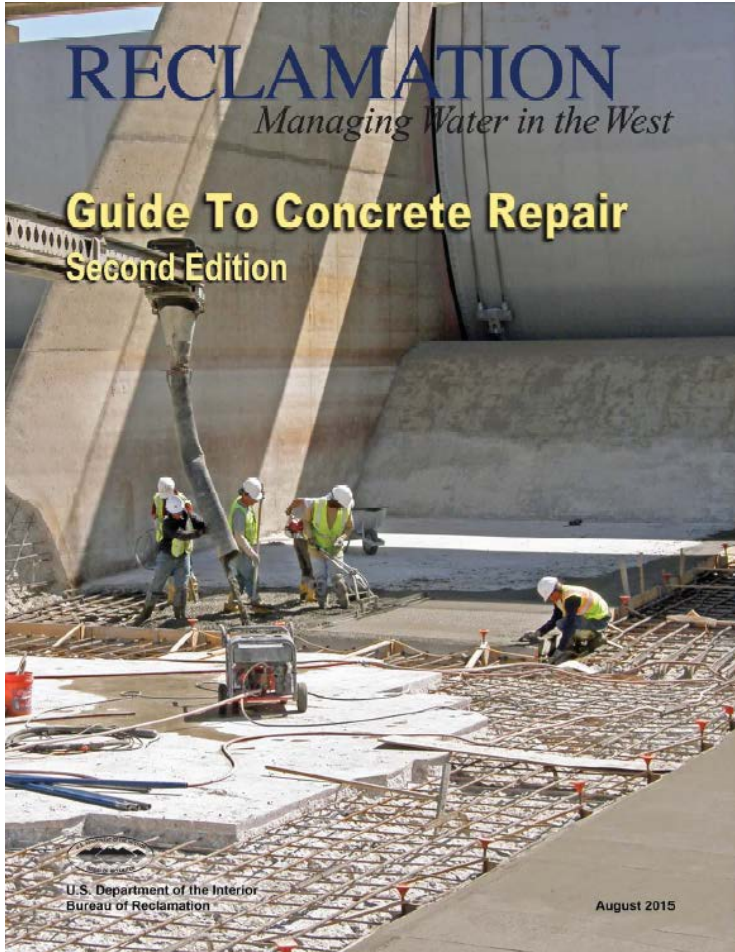
Construction Engineers

USDA NRCS NDCSMC

Fort Worth, Texas

May 16, 2017

# References



CECW-EG  Engineer Manual 1110-2-2002	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	EM 1110-2-2002  30 June 1995
	Engineering and Design  EVALUATION AND REPAIR OF CONCRETE STRUCTURES	
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# The Concrete Repair Process

- Investigate the problem.
- Develop a repair or replace plan.
- Remove all unsound material.
- Clean all steel and concrete.
- Ensure good cavity geometry.
- Provide 3/4" clearance under all steel.
- Apply bonding agent to old concrete.
- Use a properly proportioned repair mix, compatible with old concrete.
- Properly place, consolidate, and cure the repair mixture.

# Investigate The Problem





# Repair Plan

- How will unsound concrete be removed?
- How will good cavity geometry be attained?
- How will bonding surface be cleaned?
- What type of bonding agent will be used?
- How will bonding agent be applied?
- What repair material will be used?
- How will repair material be installed?
- How will repair material be cured?
- What finishing technique will be used?

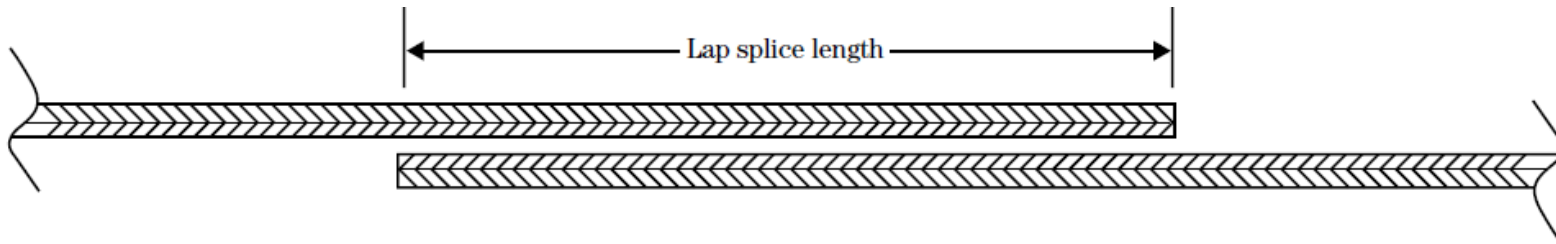


# Remove all unsound material and clean steel and concrete

- Saw
- Wire brush
- Sandblast
- Shot-blast
- Chipping hammer
- Jackhammer
- Hydro jet
- Scarify
- Acid etch

# Cleaning of Reinforcing Steel

- If the rebar has lost more than 25% of its original section, then splice on a new bar.



- Sandblast rebar that has heavy oxidation.

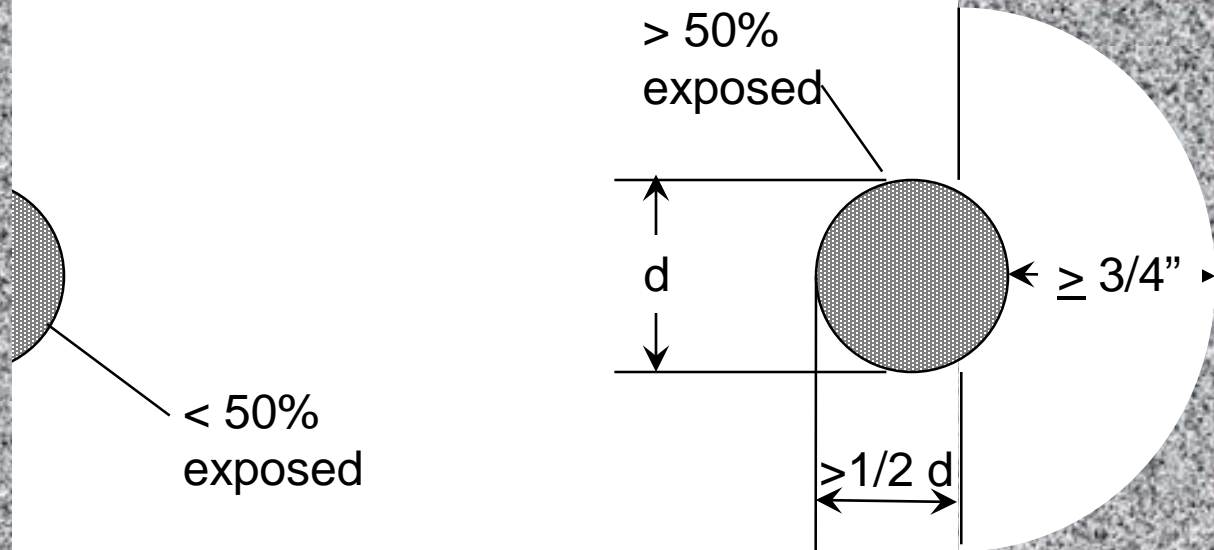
# Good Cavity Geometry

Edges sawed or chipped to a depth of 1"



# Concrete Removal and Exposed Rebar

3/4" clearance under steel that is >50% exposed  
No clearance required under rebar <50% exposed





# Surface Preparation

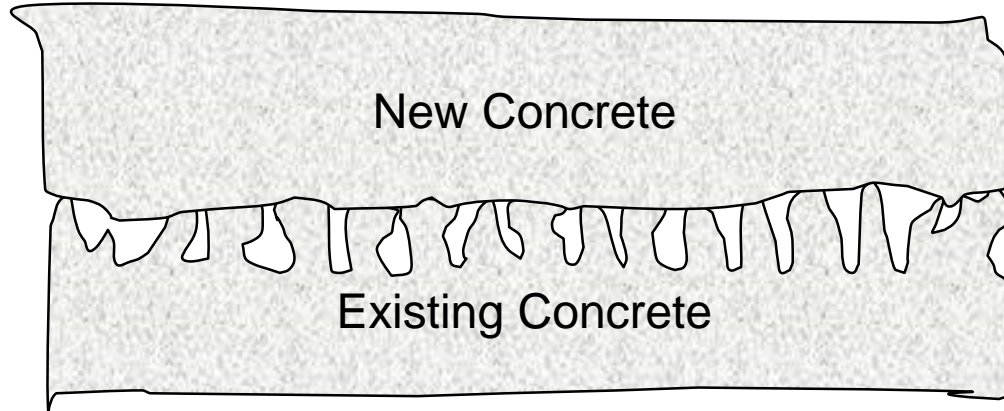
- Remove laitance and weathered surface concrete to a sound bonding surface
- Thoroughly clean the bonding surface
- If the bonding agent requires a moist surface, moisten the surface prior to applying bonding agent
- Remove any standing water



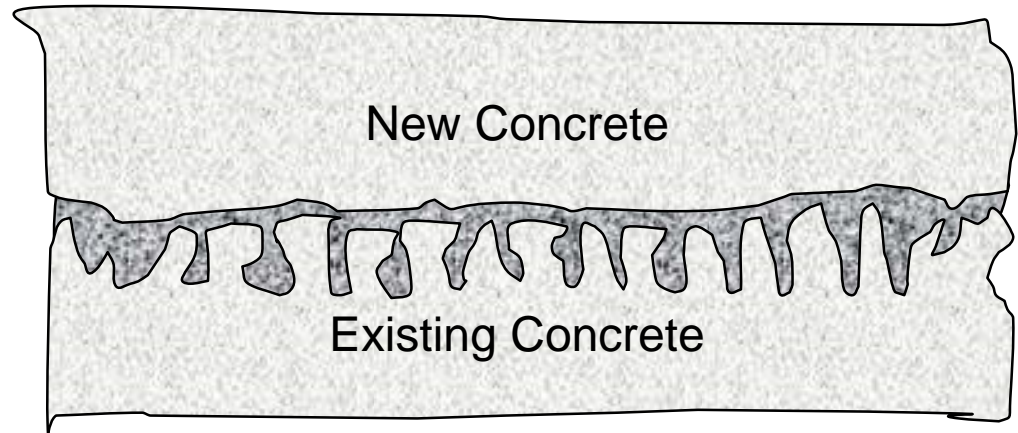
# Apply Bonding Agent

- Portland cement
- Polymers
  - Latex
  - Epoxy
  - Others

# Why Bonding Agents Are Needed



Bonding Agent





# Latex Bonding Agents and Additives



Property/ test method	Acrylic	Polyvinyl- acetate (non- re-emulsifiable)	Butadiene- styrene	Polyvinylacetate (re-emulsifiable)
Appearance	Milky white	Milky white	Milky white	Milky white or clear
Solids Content	45%	55%	48%	50%
Primary Use	Bonding fresh concrete to old concrete	Bonding fresh concrete to old concrete, thin layer toppings	Bonding fresh concrete to old concrete, concrete admixture, thin layer toppings	Bonding to plaster
Application Methods	Brush, broom, spray, roller as adhesive, trowel as topping	Brush, broom, spray, roller as adhesive, trowel as topping	Brush, spray, roller as adhesive, trowel as topping.	Brush, spray, roller
Applications	<—Underlayments, stucco, grouting-mortar, terrazzo, crack fillers—>			
Cleaning, Surface Preparation	Remove oil, grease; wet surface	Remove oil, grease	Remove oil, grease	
Comp. Strength (MPa) 2 in. (50 mm) cubes ASTM C109	22.0 28.27	23.45 24.82	22.75 27.58	22.0 (air) 20.68 (wet)
Tensile Strength (MPa) 1 in. (25 mm) thick briquettes ASTM C190	4.0 4.24	2.41 3.10	3.10 4.0	2.06 (air) 2.83 (wet)
Flexural Strength Bar (MPa) ASTM C-348-61T	6.55 9.65	6.90 8.62	8.62 11.38	6.38 (air) 5.17 (wet)
Where to Use	Indoor and out- door exposures; on concrete, steel, wood; guniting; thin section topping. May be used as a plaster bond within 45-60 min.	Indoor and out- door exposures; on concrete, steel, wood; guniting; thin section topping. May be used as a plaster bond within 45-60 min.	Indoor and out- door exposures; on concrete, steel, wood; guniting; thin section topping. May be used as a plaster bond within 45-60 min.	Indoor ceilings primarily, limited use as concrete bonding agent
Where Not to Use	Not for extreme chemical exposure, not for conditions of high hydrostatic pressure	Not for extreme chemical exposure, not for conditions of high hydrostatic pressure	Not for extreme accelerators, not for extreme chemical exposure, not for constant water	Do not use as an admixture. Do not use under wet or humid conditions. Do not use at temperatures below 10°C.

From P. Maslow, *Chemical Materials for Construction* (with permission).

SikaLatex R Pro Select Concrete Bonding Agent & Acrylic Fortifier A general-purpose acrylic latex bonding agent and admixture for mortar and concrete. Use as a bonding agent for bonding new concrete to old, or as an additive for SikaRepair mortars to increase the adhesion and performance, and create a tougher surface. Add SikaLatex R in place of water, and mix to a desired consistency. Color: Milky white. Follow concrete and or mortar instructions to correct proportions. No. 471643: Container Size: 1 qt, Shelf Life: 12 mo, Pkg Qty: 1, Package Type: Bottle No. 187782: Container Size: 1 gal, Shelf Life: 12 mo, Pkg Qty: 1, Package Type: Bottle





# SikaLatex®

## Acrylic latex bonding agent and admixture for portland-cement mortar and concrete

<b>Description</b>	SikaLatex® is an acrylic-polymer latex. It is a non-reemulsifiable, general-purpose bonding agent and an admixture to produce polymer-modified concrete and mortar.
<b>Where to Use</b>	<ul style="list-style-type: none"><li>■ An admixture in mortar and concrete to improve adhesion, and achieve a denser surface.</li><li>■ Use in patching and parge or leveling coats. Use with stucco and terrazzo.</li><li>■ As a bonding adhesive in an undiluted form or as a bonding grout when mixed with sand and portland cement.</li></ul>
<b>Advantages</b>	<ul style="list-style-type: none"><li>■ Mortar and concrete containing SikaLatex® exhibit improved adhesion to prepared substrates.</li><li>■ Increased adhesive strength of mortar/concrete when used as a bonding agent or as a bonding grout.</li><li>■ Increases resistance to freeze/thaw cycling.</li><li>■ Does not produce a vapor barrier.</li><li>■ USDA certifiable for incidental food contact</li></ul>



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## How to Use

### Surface Preparation

Surface must be clean and sound. Remove dust, laitance, grease, curing compounds, impregnations, waxes, foreign particles and disintegrated materials. Preparation work should be done by mechanical means such as chipping or sandblasting to a CSP-3 or greater. Dampen surface with clean water. Substrate should be saturated surface dry (SSD) with no standing water during applications.

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### Mixing Procedure

**As an admixture** - With mixer running, add materials in the following order: SikaLatex® solution, aggregate, cement. Add more SikaLatex® solution if required.

**As a primer for acrylic coatings** - Dilute 1:1 with water.

**As a bonding agent** - Add 1 part cement, 2 parts sand, and a sufficient amount of undiluted SikaLatex® to produce a creamy paint consistency. Maximum 4 gals./sack of cement.

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### Application

**Primer (for acrylic coatings only)** - Apply diluted SikaLatex® to prepared concrete substrate using brushes, rollers, soft brooms, or spray. SikaLatex® must be tack-free (film formation) prior to coating. Estimated coverage on a CSP-3 prepared surface is 300 sq. ft./gal. SikaLatex® primer may be applied up to 24 hours ahead providing the area is kept dry and clean. Very porous concrete may require a second coat of SikaLatex® to seal the surface.

**Bonding Agent** - Brush slurry into area to be resurfaced with stiff-bristled broom or scrub brush. Be sure entire surface and all edges are coated. Apply topping immediately over scrub coat before the bonding slurry dries.

**Admixture** - Immediately trowel SikaLatex® mortar or concrete mixes applied in areas to be patched. Do not over-finish. As soon as finish will resist damage, cure with damp burlap and/or white pigmented polyethylene film. Curing should continue for 24 hours. Pre-testing is recommended when adding SikaLatex® to a specific mix design to assure proper results are obtained.




# SikaLatex Limitations

- Minimum application temperature 40°F.
  - Toppings must be applied immediately over SikaLatex® bonding grout.
  - Discard material if frozen.
  - Avoid over-working or over-finishing surface.
  - Do not apply solvents or solvent-based curing compounds to SikaLatex® mortar/concrete.
  - Do not use air-entraining cements when used as an admixture.
  - Do not use for overlays.
  - As with all cement based materials, avoid contact with aluminum to prevent adverse chemical reaction and possible product failure. Insulate potential areas of contact by coating aluminum bars, rails, posts etc. with an appropriate epoxy such as Sikadur® Hi-Mod 32.
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# Epoxy Repair Products

Shop for epoxy concrete products on Google

Sponsored 



PC Products  
PC Concrete 9  
**\$20.06**  
Home Depot  
★★★★★ (51)



Loctite  
Fixmaster® ...  
**\$38.28**  
All-Spec



RadonSeal  
Plus Deep...  
**\$169.00**  
RadonSeal W...  
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Concrete ...  
**\$129.00**  
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3M DP190  
Epoxy ...  
**\$27.00**  
ULINE



3M - Chemicals  
**\$16.93**  
Mouser Electr...



Rock and  
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AeroMarine P...



WEST System  
Epoxy Kit ...  
**\$153.33**  
Jamestown D...  
★★★★★ (19)



Bar Top Epoxy  
& Table Top ...  
**\$79.95**  
BestBarTopE...  
Free shipping



loctite 29309  
adhesive, epo...  
**\$11.80**  
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Special offer



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Epoxy Kit w/...  
**\$89.00**  
Polished Con...



FASTPATCH  
DPR ...  
**\$99.00**  
www.pavepat...



# Epoxy Bonding Agents

- ASTM C881- Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete





## **BONDING ADHESIVE**

Multi-Purpose Epoxy Adhesive

### **PRODUCT DESCRIPTION**

Five Star® Bonding Adhesive is a multi-purpose, two component, 100% solids, moisture insensitive structural epoxy adhesive. Five Star® Bonding Adhesive is excellent for bonding fresh concrete or repair materials to cured concrete, steel, and as a coating for corrosion protection of steel. Five Star® Bonding Adhesive meets ASTM C 881 Type I, II, IV and V, Grade 2, Classes B and C; and also meets USDA specifications for use in food processing areas.

### **ADVANTAGES**

- High strength bonding adhesive
- Moisture insensitive before, during and after cure
- Excellent adhesion to masonry, concrete, wood, steel and most structural materials
- Convenient 1:1 mixing ratio
- Low odor
- Easy to use

### **USES**

- Bonding fresh concrete to hardened concrete or steel
- Corrosion protection for steel
- Structural adhesive
- Gravity fill cracks in horizontal concrete and masonry



## PLACEMENT GUIDELINES

- SURFACE PREPARATION:** Surface must be clean and sound. For best results, surfaces should be dry. Remove dust, laitance, grease, curing compounds, impregnations and waxes. Concrete may be sandblasted or prepared by other approved mechanical means. Steel should be sandblasted to an SSPC-SP6 commercial finish.
- MIXING:** For best results, material should be preconditioned to between 65°F and 85°F (18°C and 29°C). Pre-mix each component thoroughly. Place one part by volume of Component A and one part by volume of Component B into a clean pail. Mix thoroughly for three minutes with a low speed drill (400-600 rpm) to avoid air entrapment. Do not mix more material than can be placed in 25 minutes at 70°F (21°C).
- METHODS OF PLACEMENT:**

**To bond fresh concrete or repair material to hardened concrete:** Five Star® Bonding Adhesive may be sprayed, brushed or rolled, approximately 80 sq. ft. per gallon. Place fresh concrete or repair material while Five Star® Bonding Adhesive is still tacky which can range from one to four hours depending on job site conditions. If coating becomes glossy and loses tackiness, remove any surface contaminants then recoat with additional Five Star® Bonding Adhesive and proceed.

**Gravity Fill:** Pour over V-notched cracks on horizontal surfaces. Continue placement until cracks are completely filled. Prior to filling, seal underside of cracks with Five Star® RS Anchor Gel or Five Star® Injection Gel where required.

**Epoxy Mortar:** Add 1.5 parts oven dried sand to 1 part mixed Five Star® Bonding Adhesive. Mix until uniform consistency is achieved and apply into repair area.

**Corrosion protection for steel:** Clean steel to an SSPC-SP6 commercial finish. Spray or brush Five Star® Bonding Adhesive on steel to a 20 mil thickness, leaving no voids, pinholes or uncoated areas. Allow to cure. Where bond to steel is required, reapply prior to concrete placement. **Complete placement of concrete while Five Star® Bonding Adhesive is still tacky.**
- CLEAN-UP:** Use an appropriate solvent to clean uncured material. Cured material can only be removed mechanically.

**NOTE: PRIOR TO APPLICATION, READ ALL PRODUCT PACKAGING THOROUGHLY.** For more detailed placement procedures, refer to Design-A-Spec™ installation guidelines or call Five Star Products' Engineering and Technical Service Center at 1-800-243-2206.



# Portland Cement Based Bonding Agents

- Neat-cement grout
- Sanded grout
- Latex modified grout






# Properly Proportioned Repair Materials

- Modulus of elasticity
- Coefficient of thermal expansion
- Permeability
- Skid resistance
- Freeze-thaw durability
- Resistance to chemicals
- Setting time
- Strength gain
- Compressive strength



# Properly Proportioned Repair Mix

- Tensile and bond strength
- Ease of placement
- Curing time
- Placement temperature
- Ventilation
- Patch thickness
- Color
- Cost



# Types of Repair Materials (Portland Cement Products)

- Portland Cement Concrete (PCC)
- Portland Cement Mortar (PCM)
- Low Slump PCC
- Superplasticized PCC
- Fiber reinforced PCC
- Dry Pack Mortar
- Shotcrete



# Types of Repair Materials

- Polymer modified products
  - Latex modified PCM and PCC
  - Epoxy modified PCM and PCC
- Epoxy Concrete
- Others



# Quality PC Products

- PCM – Portland Cement Mortar
- PCC - Portland Cement Concrete
- PMM – Polymer-Modified Mortar
- PMC – Polymer-Modified Concrete



# PCM, PCC, PMM, and PMC

- Low water cement ratio: 0.40 or less
- Minimum strength
- Well graded and proportioned aggregate
- ASTM C33 quality aggregates
- Aggregate size  $\frac{1}{3}$  or less repair thickness
- Install quickly after mixing



# Mix Design Continued:

- Air entrained 5 – 7 %
- Water reducing admixture
- Superplasticizer



# Dry Pack Mortar

- 1 part cement and 2 parts fine sand
- Enough moisture to create a ball
- Place the zero slump mortar into the confined space in  $\frac{1}{2}$ -inch thick layers and compact it with a wooden stick
- Great for filling snap-tie cone holes and small cavities





# EPOXY RESIN

- Two component mix
- Many mixes are sensitive to moisture
- Will bond to waterstops
- Has high thermal expansion
- Shrinks very little



# EPOXY RESIN SAFETY

- Avoid contact with skin
- Gloves and glasses
- Adequate ventilation



# EPOXY RESIN MORTAR

- Epoxy mortar for 1.5 to 2 inch deep
- Use epoxy concrete for deeper repairs
- 3/8 inch maximum aggregate size
- Bonding surface should be dry
- Can be tamped or poured



# EPOXY CONCRETE

- Coarse aggregate and epoxy resin binder
- Placed in 2 inch lifts
- Hand tamp to compact into cavity



# EPOXY MORTAR AND CONCRETE

- Don't use a thinner to help finish.
- Proper mix ratio
- Proper mixing methods
- Pay attention to working (pot) life
- Lightly sand or apply cement to the surface to help the color blend better.
- Cured for 3 days, but not wet cured.



## **MP EPOXY PATCH**

Multi-Purpose, High-Strength, Non-Shrink,  
Epoxy Patching Mortar

### **PRODUCT DESCRIPTION**

Five Star® MP Epoxy Patch is a three-component, 100% solids, multi-purpose, high-strength, non-shrink epoxy patching mortar for the repair of floors, decks, trenches and ramps. Five Star® MP Epoxy Patch is specifically engineered to provide superior patching while demonstrating similar physical characteristics to the concrete substrate.

### **ADVANTAGES**

- Chemically bonds to concrete
- Excellent workability— withstands freeze / thaw cycles
- High tensile, compressive and early strengths
- Semi-rigid for shock absorption
- User-friendly
- Low modulus
- Compatible with Type III epoxy overlays
- Provides textured bonding profile

### **USES**

- Concrete repair on industrial floors, bridge and parking decks, columns, and structural beams
- Repair of spalled areas
- Quick maintenance and repair in plants and manufacturing facilities

## PLACEMENT GUIDELINES

1. **SURFACE PREPARATION:** Minimum substrate temperature should be 40°F (5°C) at time of placement. Concrete must be clean, sound, roughened, and completely dry to ensure a good bond. A perimeter edge and minimum depth of ½ inch should be provided for a durable repair. All exposed reinforcing steel should be blasted to an oxidation free condition removing all contaminants. Vacuum or blow out repair area with oil free compressed air prior to placement to remove all dust and loose particles.
2. **MIXING:** For optimum performance, all components of the Five Star® MP Epoxy Patch should be conditioned to between 65°F and 85°F (18°C and 29°C) prior to use. Pre-mix each liquid component thoroughly. Pour Components A (resin) and B (hardener) into pail and mix thoroughly for 3 minutes with a slow speed drill and paddle mixer (300 rpm) until material is of uniform consistency. Keep mixer at bottom of pail to avoid introducing air. Slowly add Component C (aggregate) to mixed liquid components. Mix thoroughly until all aggregate is wet. Working (gel) time is approximately 25 minutes when temperatures are at 70°F (21°C).
3. **METHODS OF PLACEMENT:** Prime patch area with mixed Components A and B with brush or roller. Immediately pour Five Star® MP Epoxy Patch into repair area. Float or trowel to desired level. For more detailed placement instructions call the Five Star Products, Inc. Engineering and Technical Service Center at (800) 243-2206.
4. **CLEAN UP:** Equipment — Uncured material can be removed with a suitable solvent. Cured material can only be removed mechanically. Material — Collect with absorbent material. Flush area with water. Dispose of in accordance with local, state, and federal disposal regulations.

**NOTE: PRIOR TO APPLICATION, READ ALL PRODUCT PACKAGING THOROUGHLY.** For more detailed placement procedures, refer to Design-A-Spec™ installation guidelines or call the Five Star Products, Inc. Engineering and Technical Service Center at (800) 243-2206.

## CAUTION

Component A is an irritant, and toxic. Component B is corrosive. This product causes skin irritation and is a strong sensitizer. Do not inhale vapors. Provide adequate ventilation. Protect against contact with skin and eyes. Wear rubber gloves, long sleeve shirt, goggles with side shields. Use of a NIOSH/MSHA organic vapor respirator is recommended if ventilation is inadequate. In case of contact with eyes, flush with water for at least 15 minutes and contact a physician immediately. Areas of skin contact should be promptly washed with soap and water. Do not take internally. Keep product out of reach of children. **PRIOR TO USE, REFER TO MATERIAL SAFETY DATA SHEET.**

For worldwide availability, additional product information and technical support, contact your local Five Star® distributor, local sales representative, or you may call the Five Star Products, Inc. Engineering and Technical Service Center at (800) 243-2206.

# EPOXY RESIN



# EPOXY RESIN MORTAR



# EPOXY RESIN MORTAR





# In Summary !

- Determine cause of problem
- Recognize the goal of the repair
- Develop a repair plan
- Consider the environment to which the repair material is exposed
- Prepare bonding surface
- Use a bonding and repair material compatible with the parent material
- Don't forget curing for PCM or PCC



# Texas Chain Wall Repair

June 2012

Curtesy of Shane Ice  
Assistant SCE Bismarck, ND



















