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Tips for Durable Patching & Repair

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SOMETIMES...\$#* &! HAPPENS!



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MIC Deterioration Repair



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Non Structural vs. Structural Repair

Surface Defects

- Bug holes
- Scaling
- Voids
- Honey combs
- Surface spalls
- Surface cracks
- Architectural repairs

Structural Defects

- Deep spalling
- Exposed reinforcement
- Rock pockets
- Cracking
 - Transverse
 - Full depth
- Under strength
- Capacity impaired

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Structural Definition

- Affects the concrete's performance
 - Loads
 - Protection and connection to reinforcement (significantly exposed)
- Repair area engages live or dead loads
 - Including lifting points
- Loss of structure cross section
- Weakening of constituent materials
- Necessary to reestablish structural capacity
 - Determined by structural engineer



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Repair Material Selection

This will dictate:

- Surface preparation
- Necessary application conditions
- Curing time and conditions



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Repair Material Considerations

- What materials do specifications permit?
- Compatibility of materials
- Application Conditions
- Mechanical Properties
- Surface Requirements
- Time of Set
- Color Matching



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Application Conditions

Cold Weather

- Requires protection procedures
- Consider using an accelerator
- Do repair work in a controlled environment

Hot Weather

- Keep product in cool place prior to use
- Cover mixing bucket with a wet towel and keep out of the sun



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Application Conditions

New or old concrete?

Horizontal, vertical, overhead?

Hot or cold weather?



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Mechanical Properties

Coefficient of thermal expansion

Repair material coefficient of thermal expansion should be similar to that of the existing concrete.

Thermal incompatibility could cause failure either at the interface or within the material of lower strength.



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Mechanical Properties

Drying shrinkage

Because most repairs are made on older concretes that have already experienced drying shrinkage, the repair material should have minimal shrinkage to keep from losing bond.



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Mechanical Properties

Drying shrinkage

Shrinkage of cementitious repair materials can be reduced by

- using mixtures with low w/c
- the maximum practical size and volume of coarse aggregate
- shrinkage-reducing admixtures
- using construction procedures that minimize the shrinkage potential

Proper Curing is Key!!!!





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Mechanical Properties


Permeability




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Mechanical Properties

Permeability



The diagram shows a grey rectangular slab representing a concrete surface. Six vertical, wavy blue lines are drawn across the slab, representing cracks that allow water to penetrate through the concrete. The lines are distributed across the width of the slab.




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Mechanical Properties

Permeability



The diagram shows a grey rectangular slab representing a concrete surface. A single horizontal, wavy blue line is drawn across the slab, representing a crack that allows water to penetrate through the concrete. The crack is positioned in the upper third of the slab.


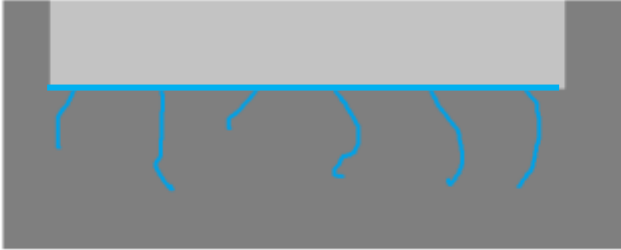


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Mechanical Properties

Permeability



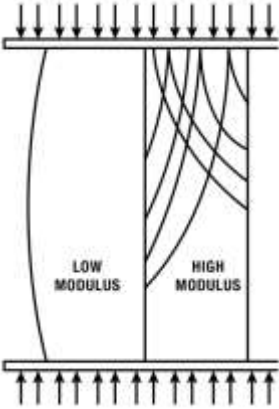
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Mechanical Properties

Modulus of Elasticity

Structural:
The modulus of elasticity of the repair material should be similar to that of the existing concrete.

Non-structural:
Lower modulus repair material helps reduce tensile stresses induced by restrained drying shrinkage.



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Repair Materials

Fast setting mortar
Polymer modified



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Repair Materials

Cementitious based materials

- Portland cement concrete
- Portland cement mortar
- Modified concretes and mortars

Grouts

Epoxy

Acrylic resins




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Repair Material

Portland Cement Concrete

<p>Advantages</p> <ul style="list-style-type: none">• Compatible with concrete• Economical• Mix with water, easy cleanup• Resist high temperatures	<p>Limitations</p> <ul style="list-style-type: none">• Critical water:cement ratio• Shrinkage, curing• Slow reactions• Low tensile, flexural, bond strengths• Surface preparation
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Repair Material

Portland Cement Mortars

- Advantages: Thinner sections (1.5-4")
- Limitations: More susceptible to drying shrinkage
- Applications: Thinner sections
- Can be applied without bonding agent
- Add water reducer and air entrainer



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Repair Material

Portland Cement Based with Mineral Additives

Advantages

- Improved adhesion
- High strengths
- Low permeability
- Abrasion, impact resistance
- Improved durability

Limitations

- Workability problems
- Finishing (sticky)
- Curing is critical
- Mixing is critical
- Higher cost



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Repair Material

Modified Blends

- Fiber Reinforced Concrete
 - Advantages: Resistant to shrinkage and cracking
 - Limitations: Workability
 - Applications: Thinner sections that may not allow conventional reinforcing.



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Repair Material

Pre-Packaged Mortars / Rapid Setting Cements

- Advantages: Convenient. Different applications. Quick Set
- Can be extended with coarse aggregate to create concrete for repairing deeper sections
- Limitations: Different mechanical properties. Limit exposure to sulfates
- Applications: Thin sections (up to 1/8")



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Repair Material

Polymer Modified Cement Based

Advantages:

- Superior bond strength without use of an admixture
- Can be used for repairs from feather edge to 1/2"
- No primer coat



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Repair Material

Polymer Modified Cement Based

Limitations:

- Mixing
- More difficult to place & finish
- Higher cost



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Repair Material

Epoxy Modified Cement Based

Advantages

- Impervious to moisture and de-icing salts
- High abrasion, skid resistance
- Minimal added dead weight
- Rapid turnaround - open to traffic in 4 - 6 hours

Limitations

- Mixing is critical
- Vapor barrier
- Thermally incompatible
- Creep
- Higher cost
- Solvents needed for cleanup



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Repair Material

Magnesium-ammonium-phosphate-cement concrete (MAPCC)

Advantages:

- Excellent bond strength,
- Low drying shrinkage
- Rapid strength gain
- Low permeability
- Great for cold weather (>freezing)



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Repair Material

Modified Blends

Microsilica Modified Portland Cement Concrete

- Advantages: Higher strengths, low permeability
- Limitations: Range of application temperature
- Applications: Patching, thicknesses over 1"



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Repair Material

Acrylic Resin

- MMA (Methylmethacrylate Concrete)
 - Advantages: Thin sections (.25 to .5") Cures quickly. Wide range of app temps. High strength
 - Limitations: Drying shrinkage
 - Applications: Repair of cracks



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Repair Material

Bonding materials

- Epoxy
- Latex
- Cements



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Patching Materials Bonding Agents

- Increase the bond between a hardened concrete and fresh mortar
- Unsanded cement paste, a commercially available latex-based material or epoxy
- Follow manufacturer’s recommendations for for bonding agents
- Bonding agents are not required but advisable if the patch surface is large and thin.



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Bonding Agents

Recommended for:

- Low slump mixes
- No slump mixes

Acceptable bonding agents

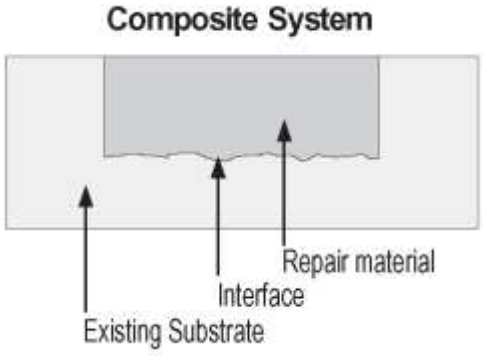
- Polymer liquids
 - Not all polymers equal, generic term
 - Basic performance
- Proper scrubcoat
 - SSD substrate, no dilution
- Epoxies
 - Wet on wet
- Epoxy cements
 - Extended open times



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3 Elements of a Repair Area

- 1. Original concrete substrate; prepared to receive repair material.
- 2. Interface between existing concrete and new repair material.
- 3. New repair material.



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Bond is Everything



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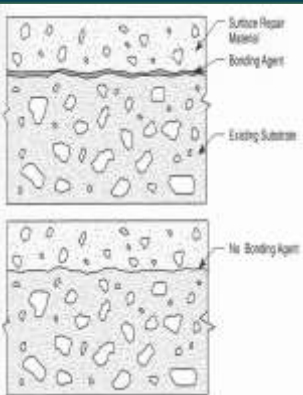
Bond is Everything

- What we are creating essentially is a cold joint.
- Use the open pore structure. It will provide capillary suction of the repair material, or bonding agents, into the substrate concrete
- Saturated, surface dry condition is generally best for achieving bond
- Substrate at proper temperature (usually 50 to 90F)
- Ensure intimate contact between new material and bond line.
- Greater than 12" or 1.5" deep, consider reinforcing (Application will dictate this)


Surface Repair Material


Bonding Agent

Existing Substrate



State	Overdry	Air dry	Saturated, surface dry	Damp or wet
Total moisture	None	Less than potential absorption	Equal to potential absorption	Greater than absorption






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Concrete Repair and Maintenance by Emmons


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Repair Processes


- Repair Area



Damaged Area



Recommended Area



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Repair Preparation

Avoid Feathered Edges



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Repair Preparation

Trowel in At Edges



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Repair Preparation

- Remove defective concrete down to sound concrete.
- Clean substrate and remove all loose material, dust, etc.
- After initial removals, surface should be sounded for delaminations and voids
- Any areas found unsound should be re-chipped



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Before we start!

Have all materials readily available including proper PPE.




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USE PROPER TOOLS

- Proper trowels
 - Mag floats for placing polymer mortars
 - Wood or sponge floats
 - May steel trowel after set
- Mixing
 - W/C ratio
 - Shear paddle
 - Mix time
 - Pot life



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Mixing Repair Materials

- ALWAYS consult manufacturer data sheets
- Specialty materials have specialty requirements (for special results!)
- Mix mechanically with low speed drill (400-600 rpm) and mixing paddle or mortar mixer if allowed
- Start mixing by adding most of liquid (3/4 – 7/8) to a clean pail
- Add powder slowly, ensuring all powder wets out
- Adjust liquid dosage if necessary to achieve desired consistency
- Mix to uniform consistency



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REPAIR PROCEDURES

- Documented repair process
- Use Mock-ups
- Training is key to getting consistency
- Make it fun



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Repair Processes

- Honeycombing



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Honeycombed Concrete

- Defective areas, such as honeycomb, must be chipped out of the solid concrete.
- The edges must be cut as straight as possible at right angles to the surface (Some recommend slightly undercut to provide a key at the edge of the patch)
- If a shallow layer of mortar is placed on top of the honeycomb concrete, moisture will form in the voids and subsequent weathering will cause the mortar to spall off.



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Repairing a Honeycombed Area

- May be cosmetic or structural
- Loose material should be removed
- If proprietary materials are used they should be done in accordance with the manufacturers instructions
- If a conventional material is used the substructure should be damp but not wet
- A cement-sand grout can be used as a bonding agent followed immediately by the application of a repair material



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Repair Processes

- Bugholes



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Bughole repair

- Open bugholes by removing and cement laitance
- Wet surface to develop even suction




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Bughole repair

- Sand/cement repair material



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Bughole repair


BUG HOLE OR SMALL COSMETIC REPAIRS

NEW TECHNOLOGY - PRE-ENGINEERED CEMENTS


- Designed specifically for filling bug holes
- Very fine aggregate filler
- High polymer loading for bond and workability
- Open set time allows for ease of placement
- Light weight product easier to work with
- Has expansive additive to reduce shrinkage
- High workability with low water/cement ratio

MIXING PROCEDURE - CRITICAL FOR SUCCESS

- Control water amount
- Requires proper mix time
- Will not set in mixing container like a patch does



1 DAY AFTER REPAIR



WEEKS AFTER REPAIR

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Repair Processes

Larger Spalls



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Repair Processes

Application of Repair Material



OVER FILL REPAIR AREA



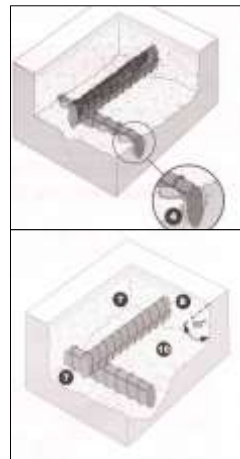
SHAVE AFTER PRODUCT SETS



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Repair Processes - Exposed Reinforcing

- Remove concrete around reinforcement
- Perimeter should be cut 90 degrees to surface
- Remove concrete a minimum of $\frac{3}{4}$ " underneath reinforcement
- Steel should be brushed to white finish to remove any corrosion
- Rebar coatings



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Repair Material

Added Reinforcing

- Rebar or dowels
- Mesh or Wire
- Fibers
- Anchors



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CURE REPAIR PROPERLY

Often most neglected
step of repair



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CURE REPAIR PROPERLY

- Accelerated materials mean accelerated need for curing!
- Wet, burlap, poly, compounds
- Complete coverage
- Consistent curing



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Remember that a Successful Repair Depends On..

- Surface Preparation
- Compatibility of Repair Materials
- Application Conditions
- Proper Application
- Curing

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Thanks & References

- **Barry Fleck – ALP**
- **Todd Spindler – SIKA**
- **ACI 546.3R-14 GUIDE TO MATERIALS SELECTION FOR CONCRETE REPAIR**
- **Peter Emmons Repair Manual**



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Questions?



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THANK YOU!

Any more questions?

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