Algonquin Hotel, New Brunswick, Canada

THE DO'S & DON'TS OF CONCRETE REPAIR – PART 2 (PREPARATION & INSTALLATION)

Certificates will be provided via email and may take up to a week to receive

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BUILDING TRUST

OBJECTIVES

- ✓ Learn the importance and options for surface preparation
- ✓ Understand how to establish successful bond
- ✓ Master the common installation techniques
  - Trowel
  - Pour
  - Form and pour
  - Form and pump
  - Spray

REPAIR PROCESS

1	**Prepare Concrete to Determined CSP**					
	HW Breaking	LW Breaking	Scabbling	Scarifying	UHP Jetting	LP Cleaning
2	**Prepare Steel Reinforcement**					
	Abrasive Blast		Abrade		Splice/Replace	
3	**Protect Steel Reinforcement**					
	Repair Material		Sacrificial Anodes		Coating	
4	**Achieve SSD Condition**					
	Ponding & Blowing		Multiple Passes of Spraying		Leave Dry-Epoxy Bond	
5	**Establish Bond**					
	Bonding Agent		Scrub Coat		Pressure/Vibration	
6	**Apply Repair Material**					
	Trowel	Pour	Form & Pour	Form & Pump	Spray LP	Spray HP
7	**Cure**					
	Mist/Soak	Burlap	Poly	Burlene	Compound	Form

CONCRETE REPAIR

- ? Trowel
- ? Pour
- ? Form and pour
- ? Form and pump
- ? Spray

BUILDING TRUST

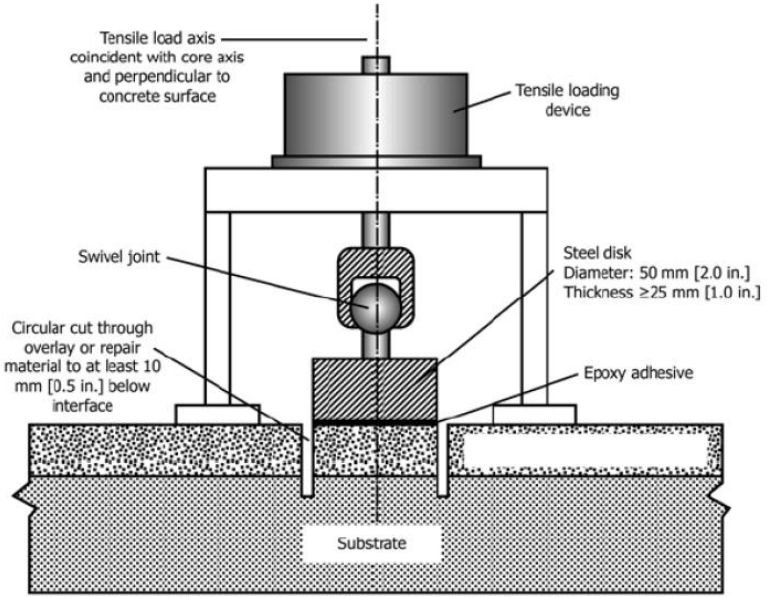
CONCRETE REPAIR

- ✓ Choose method of application
  - Major influence on cost
- ✓ Select repair materials
  - Reinforcement coating
  - Sacrificial anodes
  - Bonding agent
  - Repair mortar/concrete
- ✓ Prepare substrate and reinforcement
- ✓ Install the repair materials

SURFACE PREPARATION

SURFACE PREPARATION

- ✓ Which surface will result in higher psi direct pull adhesion test, A or B?

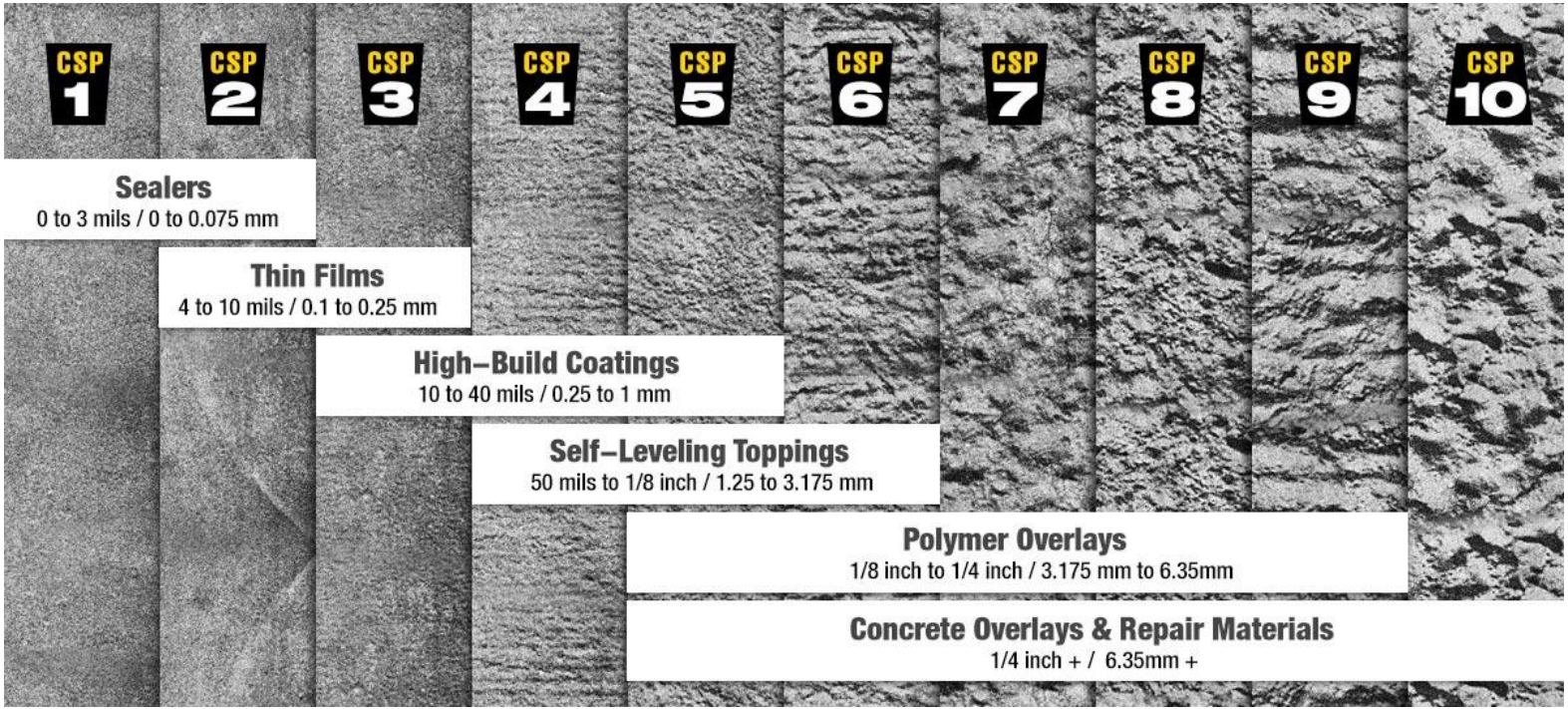


- A:

- B:

- C:

SURFACE PREPARATION – ICRI CSP 1-10



- ✓ International Concrete Repair Institute – Concrete Surface Profile
- ✓ ICRI Guideline No. 310.2R

SURFACE PREPARATION

- ✓ Saw cut perimeter
- ✓ Rectangular shape
- ✓ Fractured-aggregate profile
- ✓ Clean and sound
- ✓ Saturated, surface dry

SURFACE PREPARATION

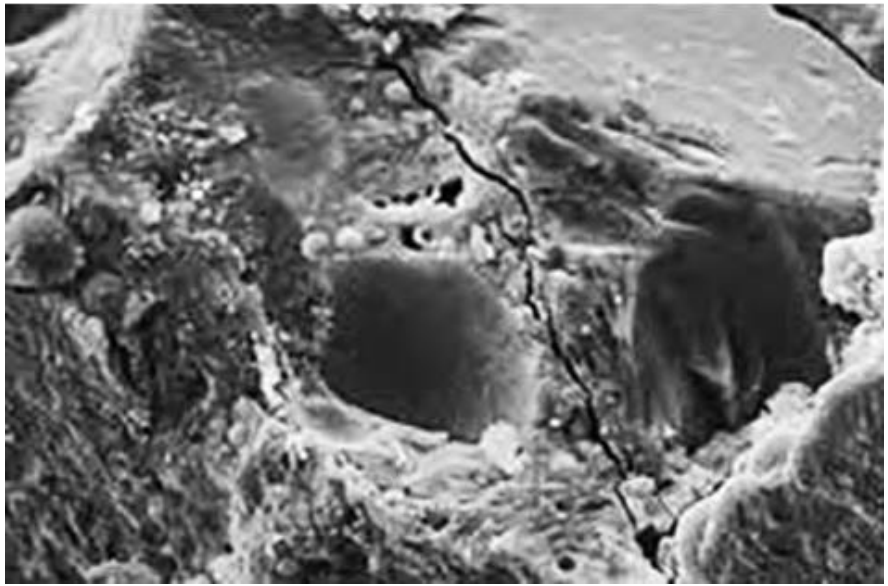
- Saw cut perimeter
- Rectangular shape
- Fractured-aggregate profile
- Clean and sound
- Saturated, surface dry

SURFACE PREPARATION METHODS

Common for Concrete Repair (≥ CSP-5)

- ✓ Handheld Concrete Breakers
  - Highly likely to cause micro-cracking
- ✓ Scabbling
  - Highly likely to cause micro-cracking
- ✓ Scarifying
  - Likely to cause micro-cracking
- ✓ High/Ultra-High Pressure Water Jetting
  - Highly unlikely to cause micro-cracking
- ✓ Low-Pressure Water Cleaning
  - Will not cause micro-cracking
  - Used subsequently to other methods

SURFACE PREPARATION METHODS



Micro-Cracking (Bruising)

- ✓ Blunt force/high impact often causing micro-cracking in the substrate
- ✓ Generally, up to 3/8” depth
- ✓ Weakens the concrete, but testing can indicate acceptability

Reduce with

- ✓ Lighter weight hammers ≤ 15 pounds
- ✓ Sharper points/chisels
- ✓ Lower angles

HANDHELD CONCRETE BREAKERS

- ✓ Jackhammer ≥ 30 pounds
- ✓ Chipping hammer ≤ 20 pounds
- ✓ Point or chisel tools
- ✓ Remove concrete/chip around reinforcement

HANDHELD CONCRETE BREAKERS

- ✓ Bush hammer
- ✓ Profile surface
- ✓ Various bits – keep sharp
- ✓ More surface area

BUILDING TRUST

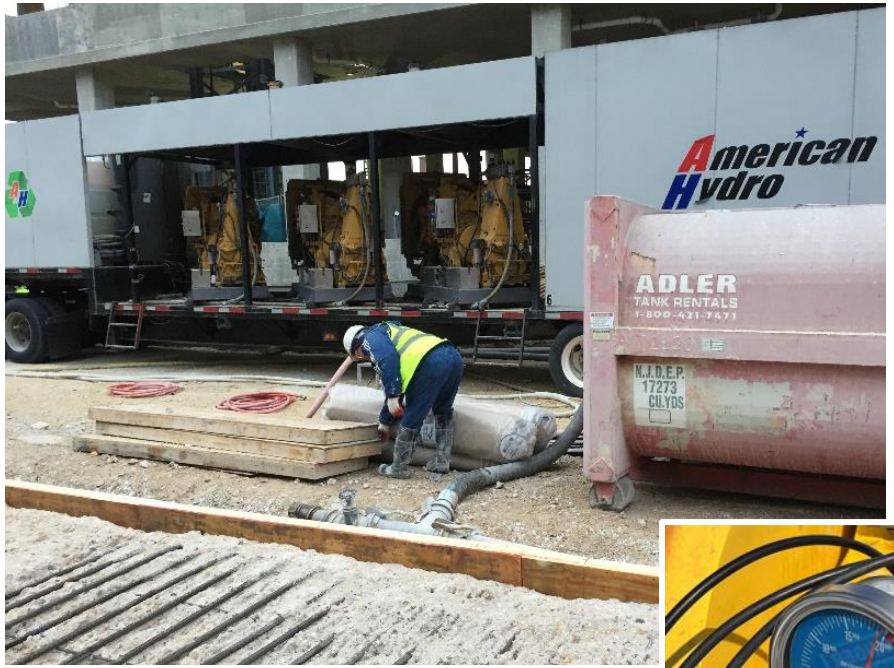
SCABBLING

- ✓ Multiple hammers
- ✓ Variety of bits – keep sharp
- ✓ High production

SCARIFYING

- ✓ Range of amplitude (1/8”, 1/4” or more)
- ✓ Variety of cutters
- ✓ Cutters float on rods

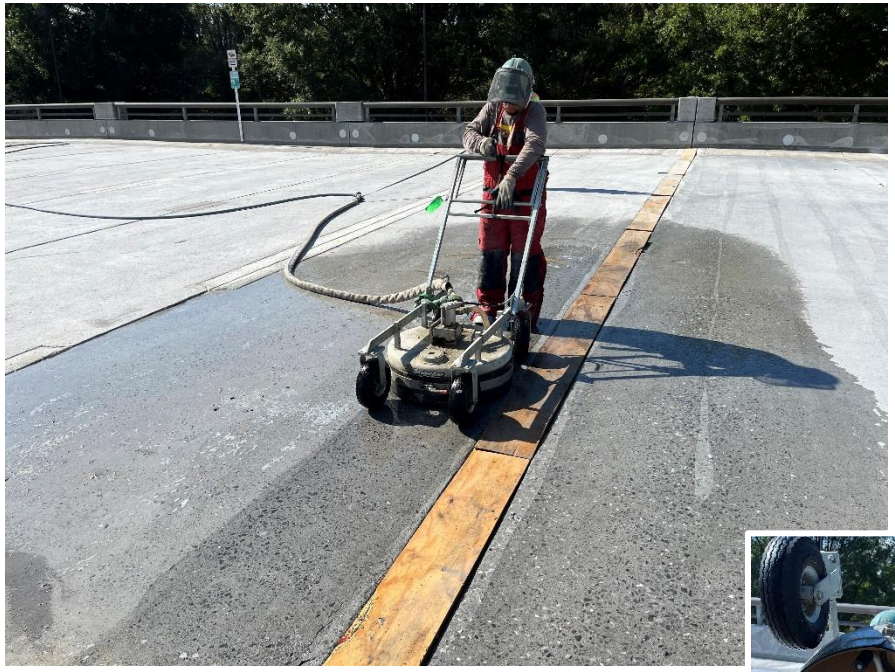
HIGH/ULTRA HIGH-PRESSURE WATER JETTING



- ✓ Pressure 5,000 – 45,000 psi
- ✓ 2 – 50 gallons/minute
- ✓ Nozzles & time

BUILDING TRUST

HIGH/ULTRA HIGH-PRESSURE WATER JETTING



- ✓ Pressure 5,000 – 45,000 psi
- ✓ 2 – 50 gallons/minute
- ✓ Nozzles & time

BUILDING TRUST

HIGH/ULTRA HIGH-PRESSURE WATER JETTING

- ✓ Robot
- ✓ Lance
- ✓ Control to profile or rapidly remove concrete

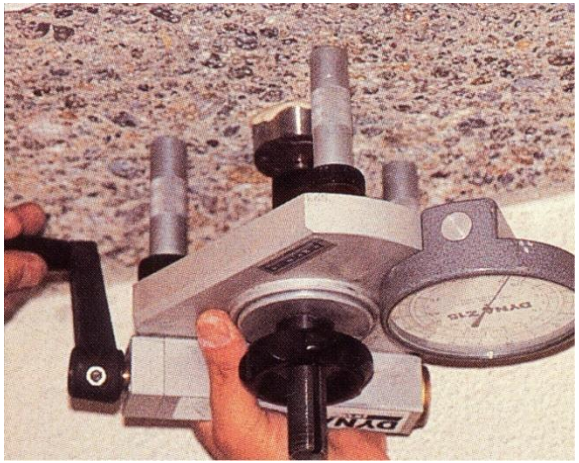
LOW-PRESSURE WATER CLEANING

- ✓ 1,000 – 5,000 psi (distance, tip)
- ✓ Negligible concrete removal
- ✓ Remove dust & clean pores after other means of preparation
- ✓ Oscillating tip most effective
- ✓ Achieve SSD condition

BUILDING TRUST

VERIFYING SURFACE PREPARATION

- ✓ Tensile/bond strength can be tested according to ASTM C1583
- ✓ This does not provide an interpretation of the results, but 250 psi or higher would generally be an accepted value
- ✓ Tensile strength of concrete typically ranges 5-10% of compressive strength



VERIFYING SURFACE PREPARATION

- ✓ Testing deep spall area, shallow resurfacing, and with repair material

VERIFYING SURFACE PREPARATION

- ✓ Test can be direct to substrate or over repair material
- ✓ Failure mode must also be observed
  - Substrate - desired
  - Bond line
  - Repair material
  - Disk adhesive

REINFORCEMENT PREPARATION

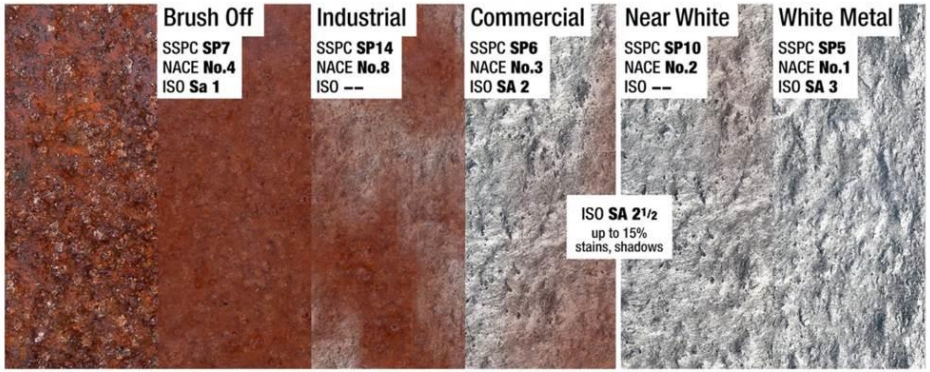
- ✓ Chip/remove concrete completely around visible rebars
- ✓ Greater of ¼” plus diameter of largest aggregate in repair material or ¾” (book)
- ✓ Enough to get fingers behind bar (field)

REINFORCEMENT PREPARATION

- ✓ Typically, if 25% or more cross-sectional loss, splice or replace with new bar
- ✓ Engineer's decision (ACI 318)

REINFORCEMENT PREPARATION

- ✓ Remove all corrosion such as by abrasive blasting or wire wheel grinding
- ✓ Prime or repair soon afterwards



Loose Material	None	None	None	None	None
Tight Material	100%	up to 10%	None	None	None
Stains, Shadows	100%	100%	up to 33%	up to 5%	None

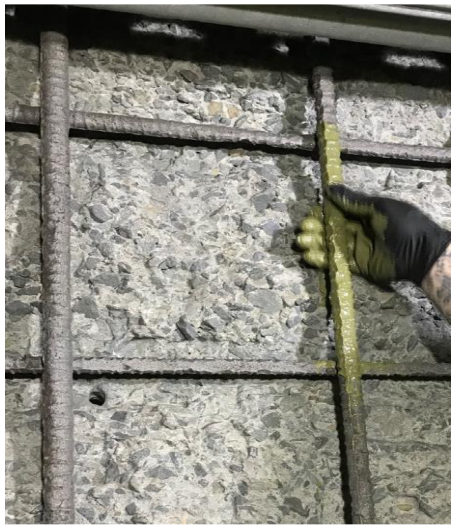
The specifications specifically mention stains, streaks and shadows, but they are practically the same: a residue showing a difference in color but of no discernible thickness. Tightly adhered material refers to anything that cannot be peeled off with a dull putty knife.

BUILDING TRUST

REINFORCEMENT COATING

Sikagard P 8100 AP

- ✓ 1-component, zinc-rich polyurethane
- ✓ Apply by brush, glove, or spray
- ✓ Allow about 1.5 hours to dry
- ✓ 1 quart covers 600 lf of #4 bar

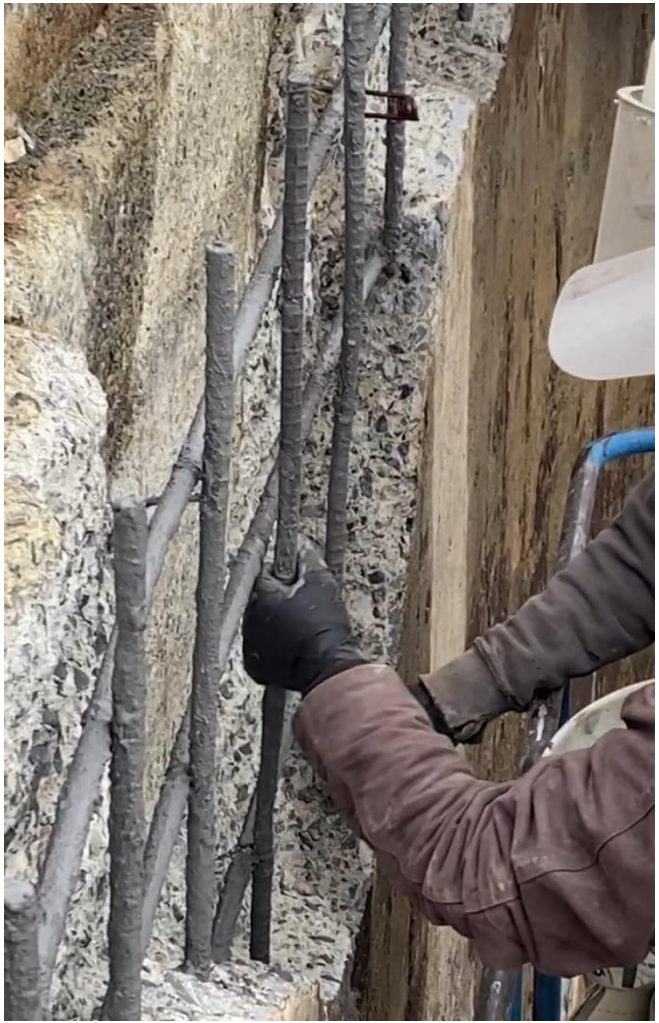


BUILDING TRUST

REINFORCEMENT COATING

Sika Armatec 110 EpoCem

- ✓ 3-component, epoxy-cement
- ✓ Apply by brush, glove, or spray
- ✓ Triples the time to corrosion
- ✓ 40% reduction of corrosion rate



BUILDING TRUST

APPLICATION METHODS

Trowel
- ✓ Smaller and/or shallower repairs

Pour
- ✓ Slabs and decks

Form and pour
- ✓ Larger volumes
- ✓ Easy to pour and enter formwork

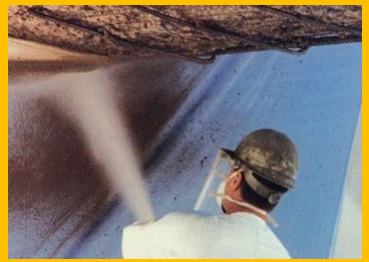
Form and pump
- ✓ When pouring is not appropriate
- ✓ Issues with access, orientation, staging

Spray **(wet/dry, high/low pressure)**
- ✓ Large volume of vertical or overhead
- ✓ Often large area but not so deep

(All methods effective when performed properly)








ESTABLISHING BOND

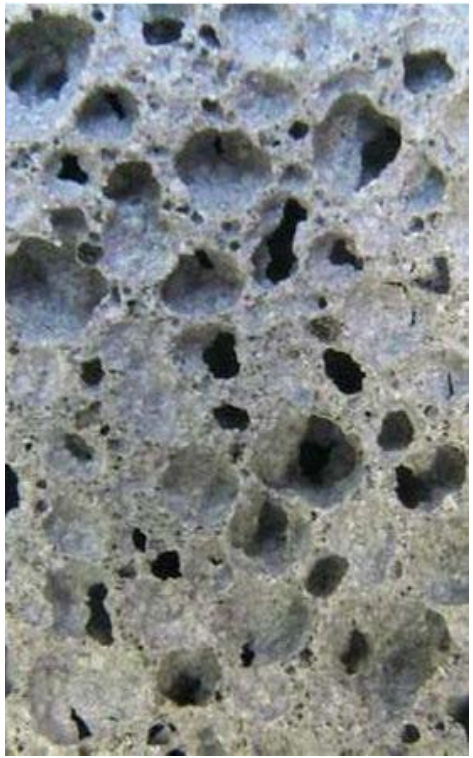
Bond Strength

1. Epoxy
2. Epoxy-cement
3. Latex-cement
4. Cement

Pore Filling

1. Liquid
2. Slurry – scrub
3. Gel – scrub harder

Just pouring a low slump mix or troweling a gel mortar on top of a well- prepared substrate may result in weak bond



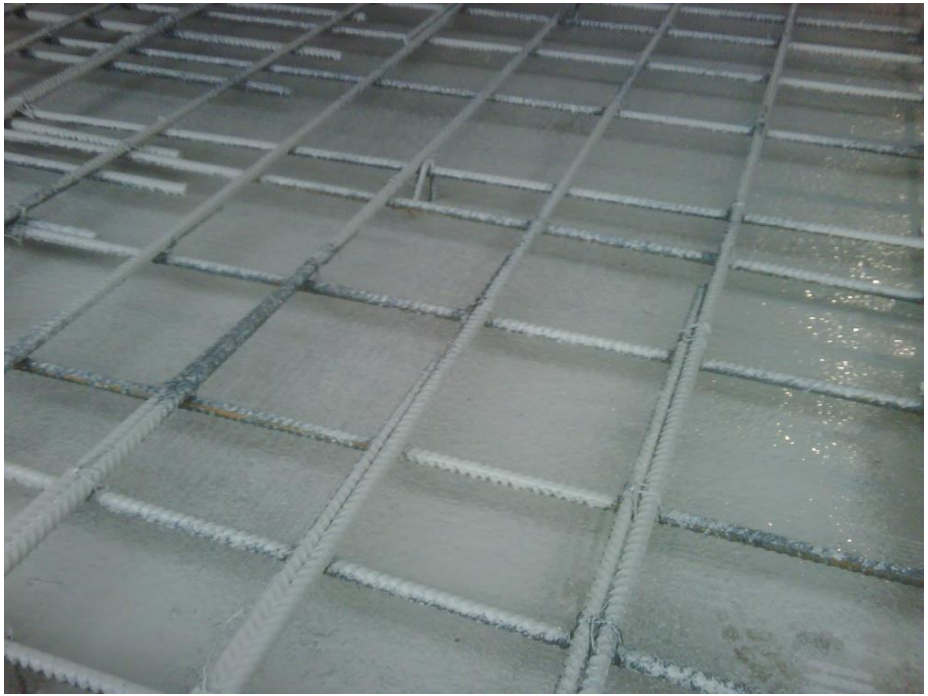
Close-up view

Side view

BONDING AGENT AND REINFORCEMENT COATING

Sikadur 32 Hi-Mod

- ✓ 100% epoxy
- ✓ Strongest bond
- ✓ Impermeable reinforcement coating

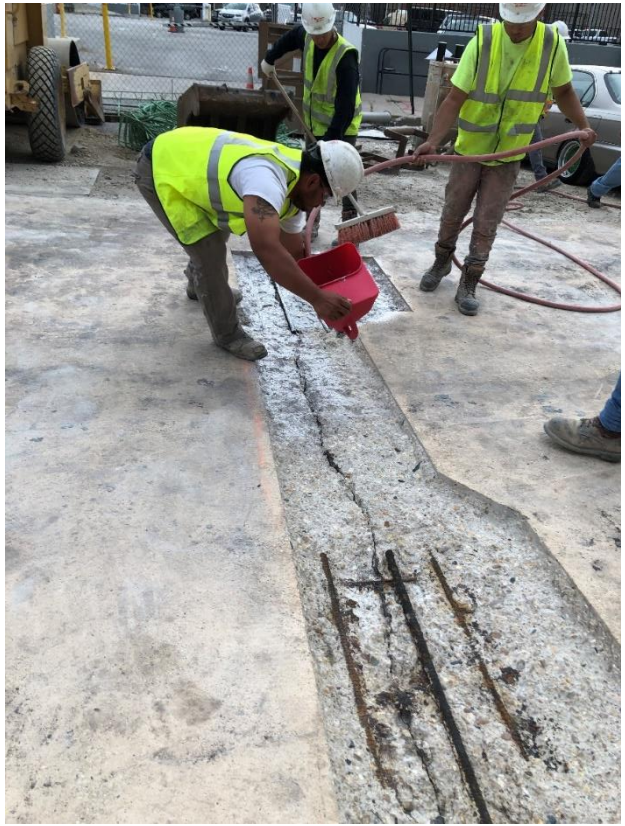


BUILDING TRUST

BONDING AGENT AND REINFORCEMENT COATING

Sikadur 32 Hi-Mod

- ✓ Brush, broom, roll, or spray apply
- ✓ Self wetting of pores
- ✓ Apply to dry or damp substrate



BONDING AGENT AND REINFORCEMENT COATING

Sikadur 32 Hi-Mod

- ✓ 0-4 hour contact time*
- ✓ Must be wet or tacky
- ✓ Adheres to saw cut perimeter

BUILDING TRUST

BONDING AGENT AND REINFORCEMENT COATING

Sika Armatec 110 EpoCem

- ✓ Epoxy-cement with slurry consistency
- ✓ Brush, broom, glove, spray apply
- ✓ Scrub into pores
- ✓ Apply to SSD substrate

BONDING AGENT AND REINFORCEMENT COATING

Sika Armatec 110 EpoCem

- ✓ 0-16 hours contact time*
- ✓ Dry in about 1 hour
- ✓ 90-minute pot life*
- ✓ Breathable
- ✓ Clean tools with water

BONDING AGENT

Scrub Coat

- ✓ Scrub repair material into substrate
- ✓ Good strength – do not wet down
- ✓ Apply to SSD substrate
- ✓ 0-15 minutes contact time is typical

REPAIR PROCESS

1	**Prepare Concrete to Determined CSP**					
	HW Breaking	LW Breaking	Scabbling	Scarifying	UHP Jetting	LP Cleaning
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6	**Apply Repair Material**					
	Trowel	Pour	Form & Pour	Form & Pump	Spray LP	Spray HP
7	**Cure**					
	Mist/Soak	Burlap	Poly	Burlene	Compound	Form

MIXING

- ✓ Know what consistency should be
  - Gel
  - 4-7” slump
  - Self-consolidating

BUILDING TRUST

MIXING

- ✓ Clean and rinse mixing container
- ✓ Add most of liquid (water/polymer)
- ✓ Mix while adding powder
- ✓ Add rest of liquid

BUILDING TRUST

MIXING

- ✓ Aggregates to be added should be SSD

MIX WATER VERSUS WATER FOR HYDRATION

Common mix water of
8 pints

Mix water of 6.5 pints
19% reduction

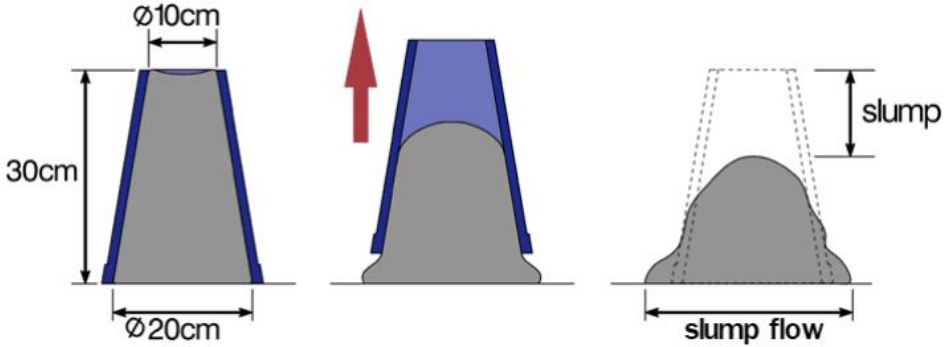
- Polycarboxylate superplasticizer replaces water used for workability

Mix water of 4.5 pints
44% reduction

MIXING

- ✓ Mix thoroughly until it looks right
- ✓ Allow time for activation of plasticizers

SLUMP TEST - ASTM C143



SLUMP FLOW TEST OF SCC - ASTM C1611

TESTING COMPRESSIVE STRENGTH

- ✓ ASTM C39 – Concrete (cylinder)
- ✓ ASTM C109 – Mortar (cube)

TESTING COMPRESSIVE STRENGTH

- ✓ ASTM C109 – Expansive Grout (cube)
  - Brass molds securely capped

TROWEL APPLIED VERTICAL/OVERHEAD REPAIRS

- ✓ Bonding agent or scrub coat
- ✓ Promptly continue to place over a scrub coat

TROWEL APPLIED VERTICAL/OVERHEAD REPAIRS

Hand Scarifier

- ✓ Work material around perimeter & force into place for good compaction
- ✓ Provide mechanical locking between lifts
- ✓ Best to apply subsequent lift as soon as prior lift has set & starting to cool

BUILDING TRUST

TROWEL APPLIED VERTICAL/OVERHEAD REPAIRS

- ✓ Finish as desired without excess water
- ✓ Finish agent allow trowel to slide and prevent crusting
- ✓ Cure

TROWEL APPLIED VERTICAL/OVERHEAD REPAIRS

- ✓ Can be applied to large surface areas
- ✓ Finish agent allow trowel to slide and prevent crusting
- ✓ Cure

BUILDING TRUST

TROWEL APPLIED VERTICAL/OVERHEAD REPAIRS

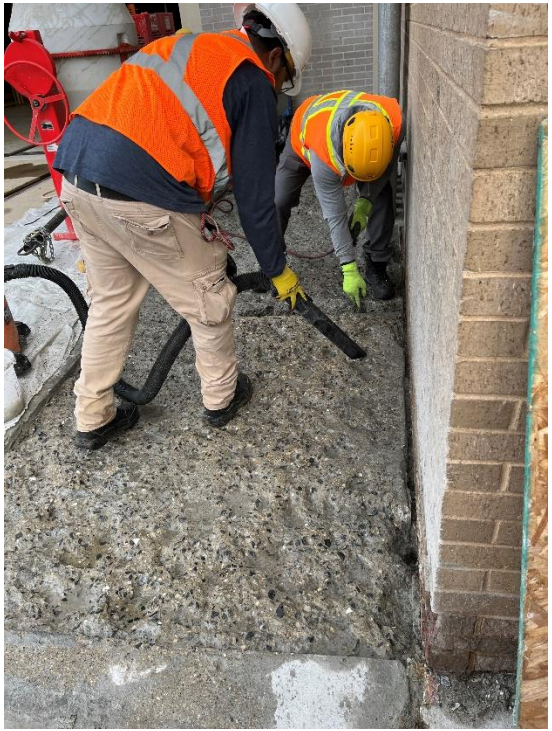
- ✓ Same process for overhead
- ✓ Slower due to worker fatigue
- ✓ Overhead lift hangs about ½” less than vertical lift

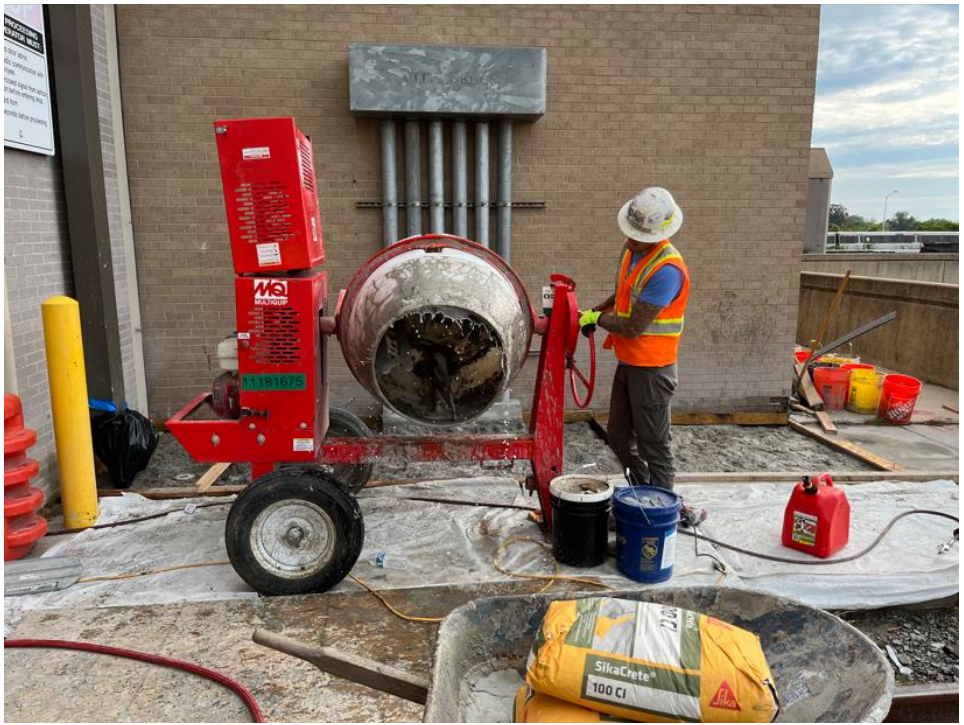
BUILDING TRUST

TROWEL APPLIED VERTICAL/OVERHEAD REPAIRS

- ✓ Same process for overhead
- ✓ Slower due to worker fatigue
- ✓ Overhead lift hangs about ½” less than vertical lift

POUR REPAIR



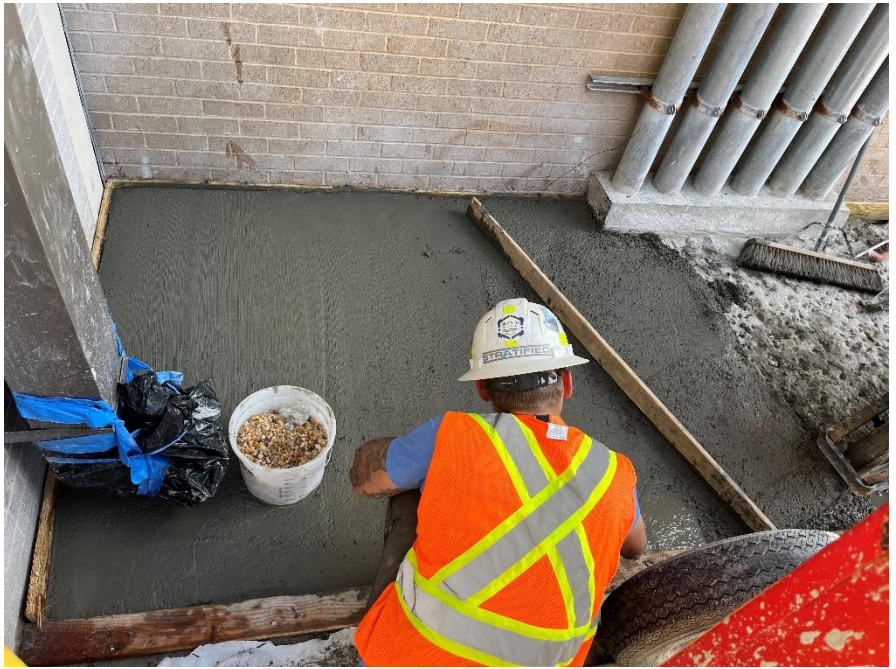


- ✓ SSD condition
- ✓ Cleaning the mixer

POUR REPAIR

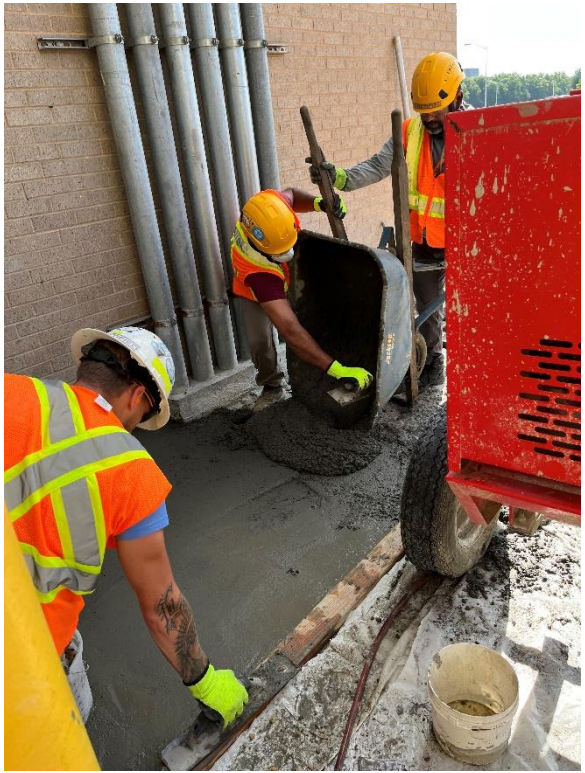
✓ Mixing, pouring, scrubbing, screeding

POUR REPAIR



- ✓ Initial finish, continue placing and screeding
- ✓ Scrub just ahead

POUR REPAIR



✓ Keep material coming to feed the screed

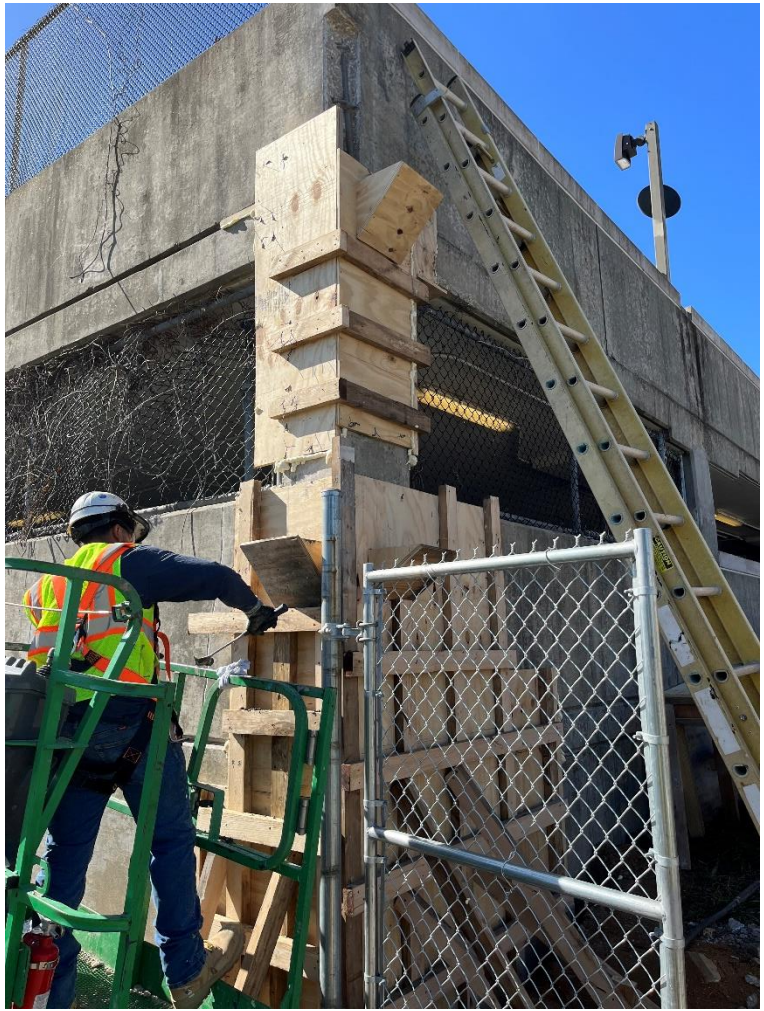
POUR REPAIR

- ✓ Final finish – broom
- ✓ Cure

FORM AND POUR

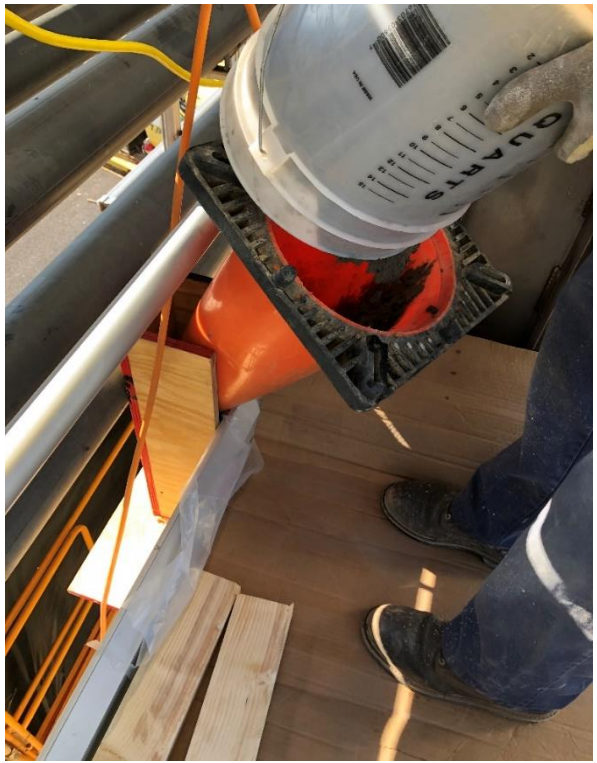
- ✓ CSP achieved and reinforcement prepared
- ✓ Underside repair

FORM AND POUR



- ✓ Underside, column, and wall repair
- ✓ SSD by filling with water and draining

FORM AND POUR



✓ Pour into form

FORM AND POUR REPAIR

Slump mix

- ✓ Flows slower
- ✓ Needs vibration
- ✓ Likely leave bug-holes
- ✓ Head/vibration for bond

SCC mix

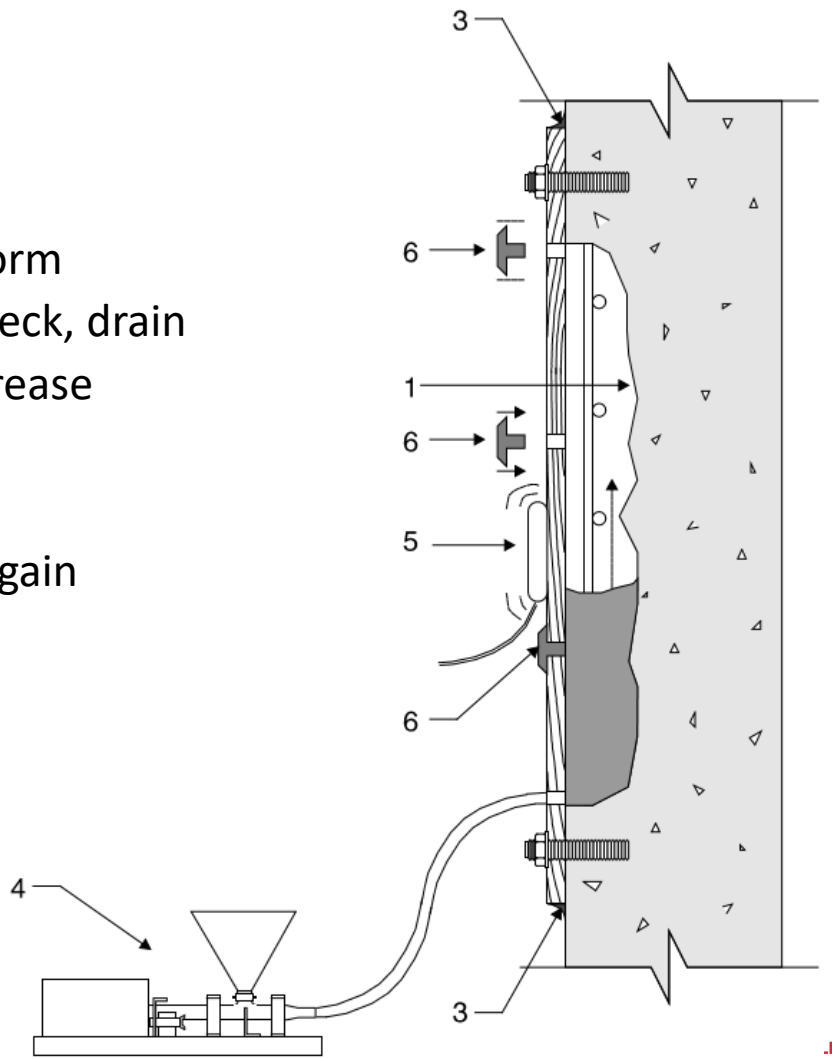
- ✓ Flows quickly
- ✓ Tapping of form
- ✓ Mitigate bug-holes
- ✓ Wets out pores for bond

FORM AND POUR

✓ Monolithic & durable

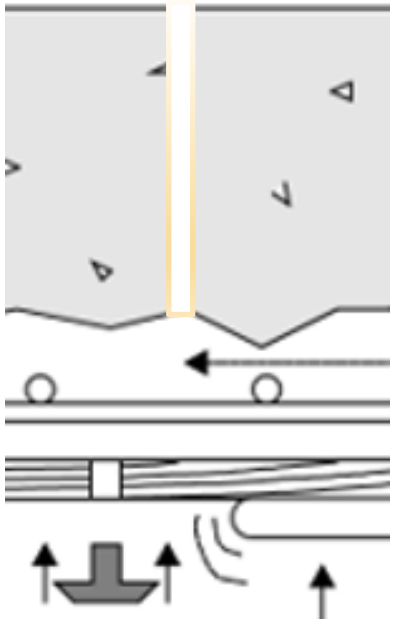
FORM AND PUMP

1. Bonding agent or SSD
2. Use release agent or plastic lined form
3. Seal perimeter, fill with water to check, drain
4. Pump full until 3-5 psi pressure increase
5. Vibrate while pumping
6. Cap vents upon fill verification
7. Strip forms after required strength gain
8. Dry pack anchor holes



VENTING OVERHEAD FORMS

- ✓ Vent through to top
- ✓ Thinner slabs
- ✓ No top side concerns



- ✓ Vent tube to be withdrawn
- ✓ Thicker slabs
- ✓ Top side concerns

PUMPS

- ✓ Hand lever grout pumps (no large aggregate)
- ✓ Power grout pumps (no large aggregate)
- ✓ Concrete pumps

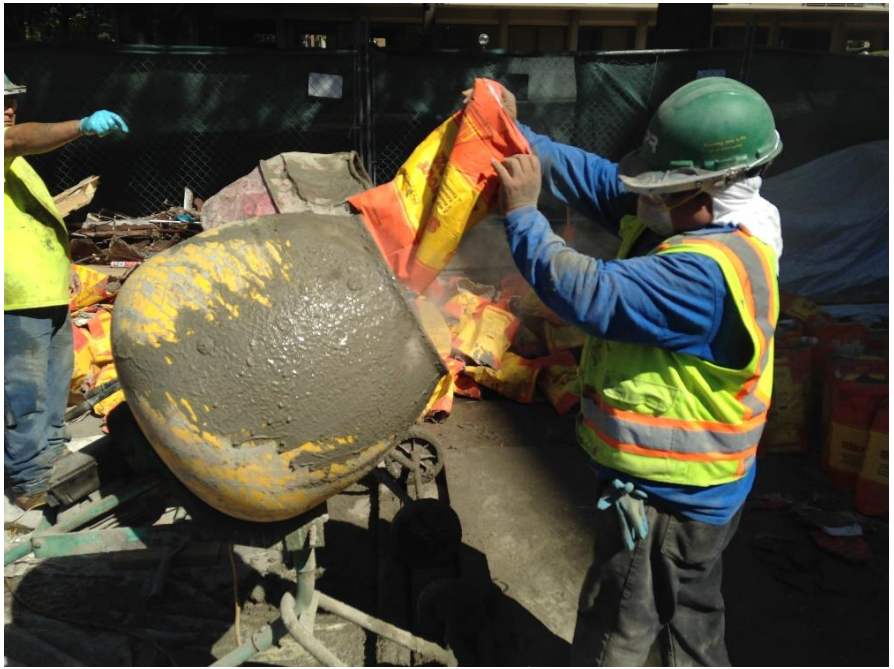
FORM AND PUMP

- ✓ Self-consolidating concrete
- ✓ Initial spread 27-33”
- ✓ 60-minute application time
- ✓ Need concrete pump

- ✓ Self-consolidating mortar
- ✓ 1/8” – 3” as mortar
- ✓ 60-minute application time
- ✓ Can use grout pump

FORM AND PUMP

- ✓ Large volume productivity
- ✓ Monolithic single application
- ✓ Unlimited shaping/molding
- ✓ Mix batches



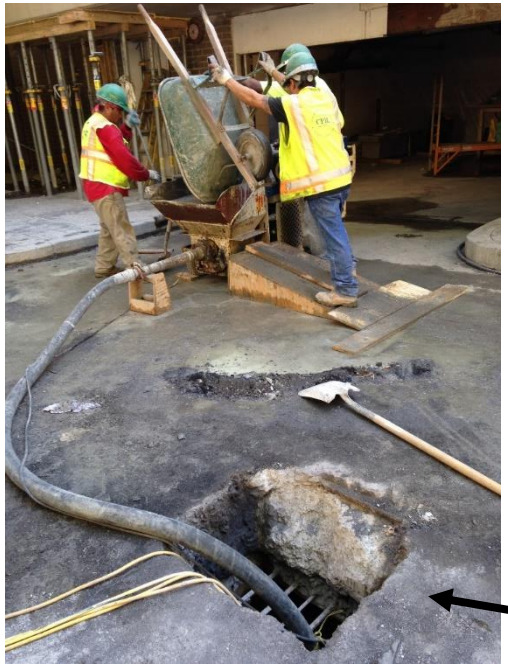
BUILDING TRUST

FORM AND PUMP

- ✓ Load the screened hopper
- ✓ Match pump and material

BUILDING TRUST

FORM AND PUMP

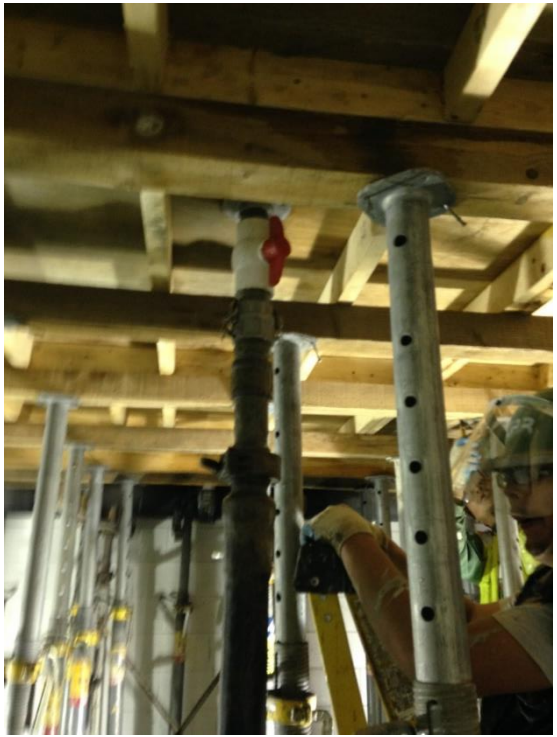


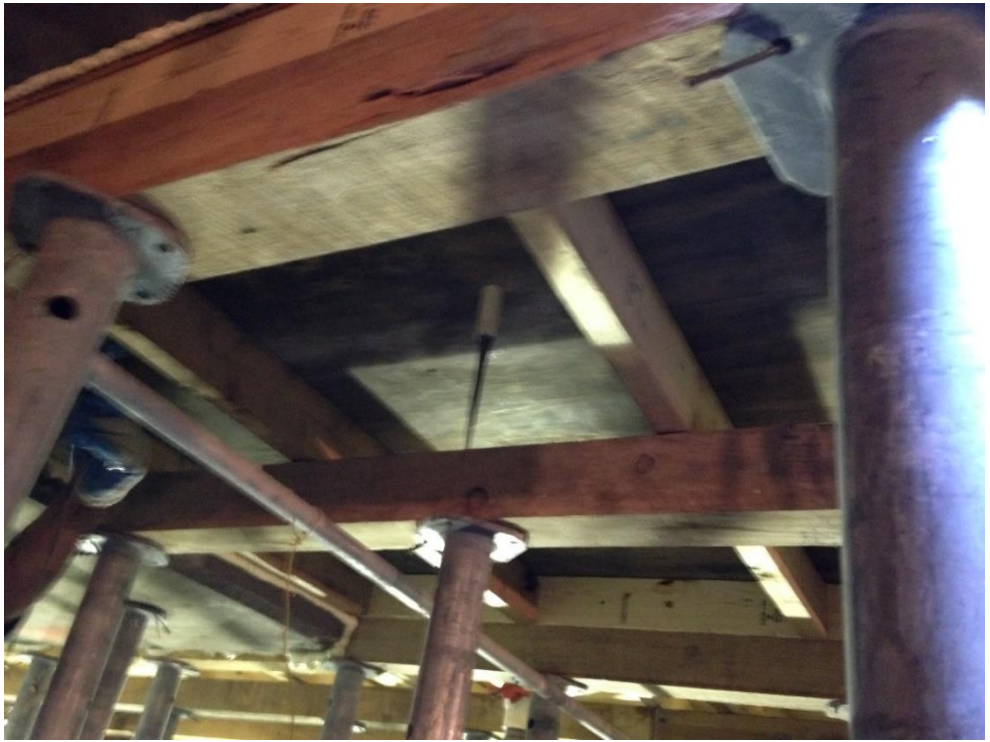
Slab too thick
for top venting

- ✓ Slick lines before starting
- ✓ Choose material for flow, working time, and line diameter and length

BUILDING TRUST

FORM AND PUMP





- ✓ Pump full checking vent tubes
- ✓ Slowly withdraw vent tube & plug

BUILDING TRUST

FORM AND PUMP

- ✓ Pump for 3-5 psi pressure increase
- ✓ Be ready to seal form leaks
- ✓ Close ports

FORM AND PUMP

- ✓ Remember to remove all vent tubes
- ✓ Fill any tube holes and grind smooth port areas

FORM AND PUMP

- ✓ Excellent flow and consolidation
- ✓ Consistency, pressure, & vibration delivers bond
- ✓ Outstanding durability

FORM AND PUMP

✓ Versatile for many types of challenging conditions

FORM AND PUMP

✓ Effective repair of columns, beams, and slabs

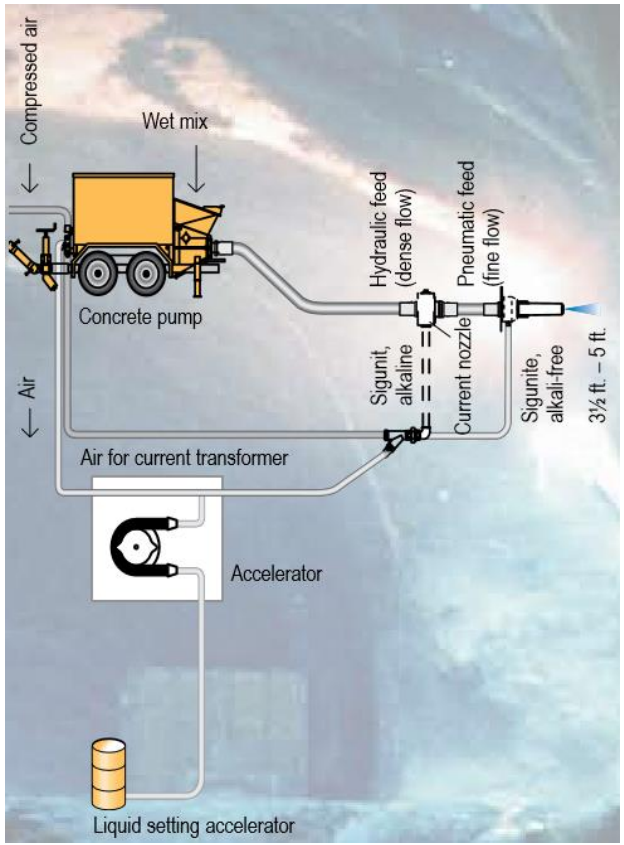
BUILDING TRUST

SPRAY APPLY

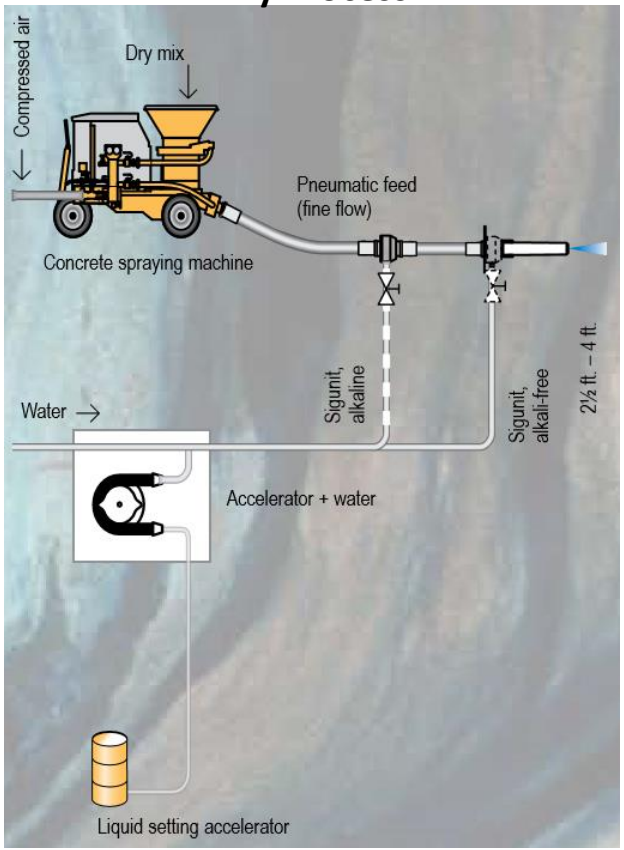
- ✓ Spray apply the repair material
- ✓ Also referred to as machine applied, shotcrete, and gunite
- ✓ Gunite infers wet process, high volume, high pressure, and large aggregate
- ✓ Shotcrete can be done as wet or dry process with high pressure
- ✓ Low pressure spraying is wet process

SPRAY APPLY

Wet Process



Dry Process



SPRAY APPLY – WET PROCESS SHOTCRETE

- ✓ Mixer
- ✓ Pump mixed material through line

SPRAY APPLY – WET PROCESS SHOTCRETE

- ✓ Slow setting material
- ✓ May use retarder and accelerator
- ✓ Can hang several inches thick at a time

SPRAY APPLY – WET PROCESS SHOTCRETE

- ✓ Larger volume applications
- ✓ Continuous areas

SPRAY APPLY – DRY PROCESS SHOTCRETE

- ✓ Larger repair areas
- ✓ Mobile and long line capable
- ✓ Simple start and stop

SPRAY APPLY – DRY PROCESS SHOTCRETE

- ✓ Mixing at nozzle
- ✓ Excellent hanging

SPRAY APPLY – DRY PROCESS SHOTCRETE

✓ Can minimize dust and rebound

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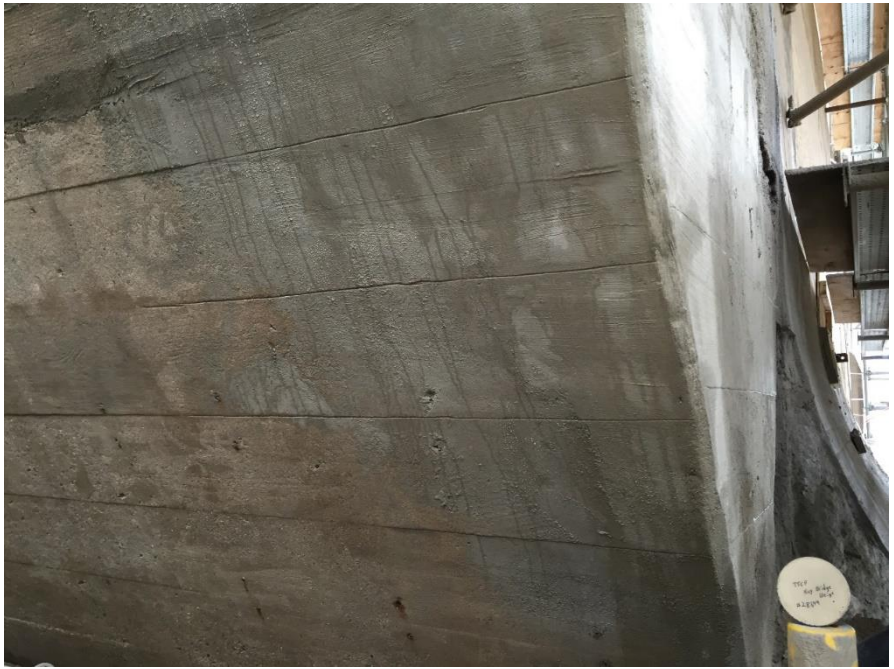
SPRAY APPLY – DRY PROCESS SHOTCRETE

- ✓ Naturally-controlled water-cement ratio to hang yet limit dust
- ✓ Paste forced into pores as aggregates initially rebound

SPRAY APPLY – DRY PROCESS SHOTCRETE



- ✓ Plenty of finishing time
- ✓ Quality repair

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SPRAY APPLY – LOW PRESSURE WET

- ✓ Economical equipment
- ✓ Material mixed then pumped through line

SPRAY APPLY – LOW PRESSURE WET

- ✓ Much faster than troweling onto surface
- ✓ Gets mixed material onto surface quickly saving time and labor
- ✓ Air pressure introduced at nozzle

SPRAY APPLY – LOW PRESSURE WET

- ✓ Bonding agent or scrub coat
- ✓ Spray, scrub, continue spraying
- ✓ Finish when ready

Light broom finish for subsequent coating

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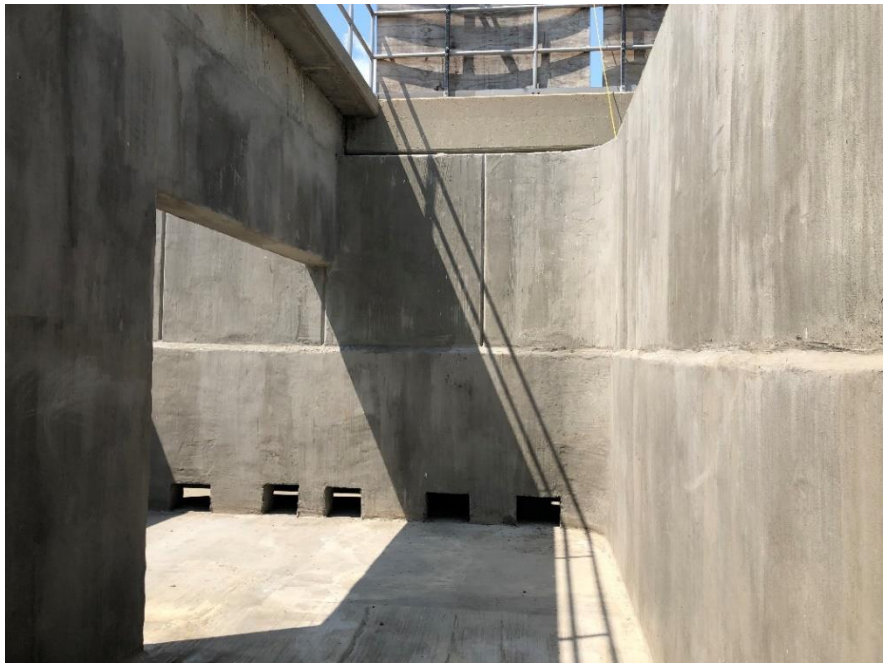
SPRAY APPLY – LOW PRESSURE WET



- ✓ Durable repairs, efficiently performed

FINISHING AID

- ✓ Use instead of finishing water
- ✓ Slickens better
- ✓ Reduces moisture loss and crusting
- ✓ Repair materials often stickier & set faster
- ✓ Very economical
- ✓ Remove before coating or sealing

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CURING

- ✓ Start curing as soon as possible after applying finish
- ✓ Objective is to prevent water loss
- ✓ Burlap needs to remain wet
- ✓ Soakers and misters can be used
- ✓ Polyethylene & burlene need to lay flat

CURING

- ✓ Keep curing until at least 75% of design strength is reached
- ✓ Hard to keep burlap in contact with vertical surfaces
- ✓ Forms can prevent moisture loss

CURING

- ✓ Curing compounds meeting ASTM C309 are effective
- ✓ Use water-based curing compounds with materials containing polymers
- ✓ Curing compounds need to be removed before applying coatings and sealants

REPAIR PROCESS

1	**Prepare Concrete to Determined CSP**					
	HW Breaking	LW Breaking	Scabbling	Scarifying	UHP Jetting	LP Cleaning
2	**Prepare/Splice/Replace Steel Reinforcement**					
	Abrasive Blast			Abrade		
3	**Protect Steel Reinforcement**					
	Repair Material		Sacrificial Anodes		Coating	
4	**Achieve SSD Condition**					
	Ponding & Blowing		Multiple Passes of Spraying		Leave Dry-Epoxy Bond	
5	**Establish Bond**					
	Bonding Agent		Scrub Coat		Pressure/Vibration	
6	**Apply Repair Material**					
	Trowel	Pour	Form & Pour	Form & Pump	Spray LP	Spray HP
7	**Cure**					
	Mist/Soak	Burlap	Poly	Burlene	Compound	Form

AVAILABLE RELATED PRESENTATIONS

- ✓ Concrete Repair (Part 1 – Material Selection)
- ✓ Concrete Repair (Part 2 – Preparation & Installation)
- ❑ Crack Repair
- ❑ Concrete Protection
- ❑ Deck Coatings

Baltimore Design School – 2014 ICRI Sustainability Award Winner

THANK YOU FOR YOUR ATTENTION!

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