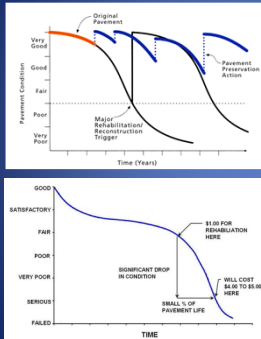


Concrete Rehab Techniques





1

Pavement Design Life and Life Cycle

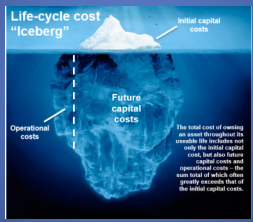



- Roadway Pavements are typically designed for 20- 30 years
- With proper construction and maintenance practices, concrete pavements commonly last 40+ years



2

Life Cycle Cost Analysis

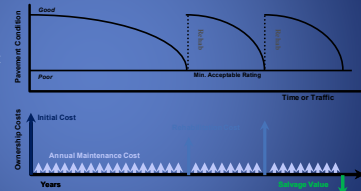





3

Life Cycle Cost Analysis (LCCA)

- Economic analysis tool that quantifies differential costs of alternative investment options for a given project
- Determines which pavement design is most cost effective over the analysis period





4

Common Pavement Distress

- Surface Defects
 - Map Cracking
 - Shrinkage Cracking
 - Scaling
 - Polishing/ Loss of skid resistance
- Joint Spalls
- Transverse Cracks
- Longitudinal Cracks
- Corner Breaks
- Shattered Slabs
- Joint Seal Damage
- Materials Related Distress
 - ASR
 - Chloride Damage



5



a. Joint faulting



b. Transverse cracking



c. Joint spalling



d. Corner break



6



7

Alkali-silica reactivity (ASR)

Reaction between the alkali hydroxides (Na, K & OH) from the cement and amorphous silica, SiO_2 , in some types of aggregate.
 The reaction produces an alkali-silica gel.
 The gel absorbs water from the surrounding paste ...
 ... and expands.
 The internal expansion eventually leads to cracking of the surrounding concrete.

Thomas et al. 2013

ACPA COLORADO/WYOMING CHAPTER

8

ASR

- Starts at the joints
- Gel causes discoloration
- Can only be diagnosed with proper testing
- New mixes are tested to prevent ASR

ACPA COLORADO/WYOMING CHAPTER

9



10

a) Presence of ASR Gel in Core

ACPA COLORADO/WYOMING CHAPTER

11

De-icer Distress Progression

Figure 1a. Initial stage of joint deterioration.

Figure 1b. Progression of joint deterioration.

Figure 2a. Further progression of joint deterioration, showing...

ACPA COLORADO/WYOMING CHAPTER

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Do all cracks need to be replaced?

- **NO!!**
- Panel replacement should be a last resort

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How Can Distresses Be Corrected?

- Partial Depth Repair
- Full Depth Repair
 - Partial Panel
 - Full Panel
- Crack Repair
 - Cross Stitch
 - Seal
 - HMWM
- Joint Resealing
- Surface Seal
- Diamond Grinding
- Concrete Overlay

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Rules of Thumb for Concrete Cracks

Width of Crack	Treatment
Up to 1/4 inch	Leave alone/ Methacrylate
1/4 to 1/2 inch	Saw and Seal
3/8 to 3/4 inch (Spalled)	Partial Depth Repair
3/4 to 1 1/2	Saw and Seal
3/4 to 1 1/2 (Spalled)	Full Depth Patching
More than 1 1/2	Full Depth Patching

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Methacrylate

- Uses:
 - Shrinkage Cracks
 - ASR
 - Hairline Cracks
 - Be careful with full depth cracks

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What is it?

- Resin Material
- 2 or 3 parts depending on brand
- Applied to surface of pavement
- Extremely low viscosity
- Bonds to the pavement and prevents movement
- Fills and seals cracks
- Can be applied to individual cracks or entire surface

18



19



20

Crack Route and Seal

- Uses:
 - Full depth cracks
 - Wide cracks in conjunction with other repairs
 - Keeps water from infiltrating

21

- Clean out cracks and remove loose material
- Try to follow same path
- Not trying to widen
- Place backer rod if wide enough
- Seal- must be recessed
- Silicone is best
- Hot pour will work

22

Type 2 Partial Depth Repairs

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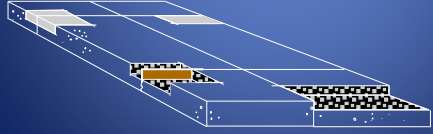

Partial Depth Repairs

- Uses:
 - Spalls
 - Large Voids
- Repairs localized distress in the top 1/3- 1/2 of the slab
- Commonly located at joints – can be placed anywhere surface defects occur or when cracks are spalling

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Partial Depth Repairs


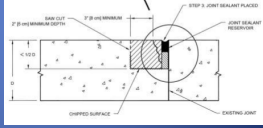

- Must be rectangular
- Surface temp 40 degrees
- Existing joints must be maintained
- Combine repairs less than 18" apart
- Minimum depth- 2"
- If greater than half of thickness-> Full depth repair

25

Method- Cutting and Chipping



1. Saw cut atleast 2 inches outside the spalled area and to a minimum depth of T/3
 1. parallel to the joint or crack.
 2. Make the cut at a slight outward angle.
2. Carefully chip out to sound concrete
 1. Max 30 lb chipping gun
 2. If reinforcement is exposed, chip by hand to prevent damage. Any epoxy coating damage should be repaired

26

Method- Cleaning and Prep


3. Clean the cavity with high pressure water followed by compressed air
 - Pavement must be clean and dry for bonding!
4. Apply bonding agent per manufacturer recommendations
 - Cement grout or Epoxy
 - Coat all surfaces (horizontal & vertical)
 - Do not allow bonding agent to set
5. If the spall abuts a joint, a bond breaker may be placed to maintain the working joint.

27

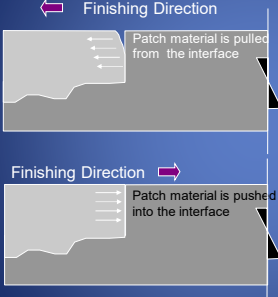
Method- Placement and Finishing

6. Mix and place the repair material
 - Follow manufacturer recommendations
 - Drill mounted mixer works well for small quantities
 - Uniform consistency- should be a thick paste
 - Extend mix as necessary- usually anything greater than 6" in any direction
7. Use a trowel to finish the surface of the repair
8. Apply texture to match surrounding area
9. Cover with curing compound.
8. If the spall abuts a working joint, the repair shall be cut with a demo saw to form the joint as soon as an appropriate cure time is achieved.
9. Re-seal all affected joints




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Partial Depth Repairs



- Match surrounding elevation
- Work tool from center toward edges
- Seal saw runouts



29




30



31

Repair Materials

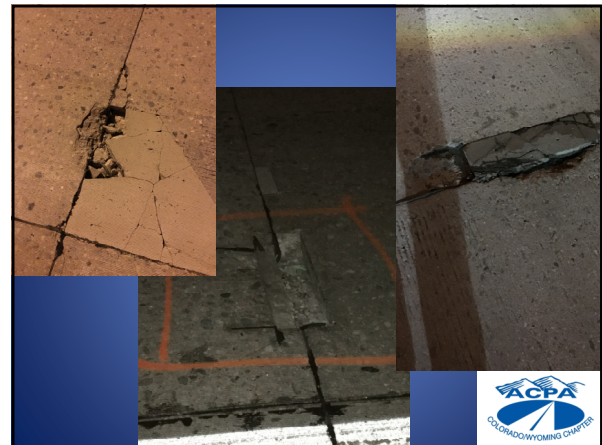
- High Strength Non Shrink Grout
- Mastic Materials
 - Hot applied
 - Flexible Material
 - Allows joints to open and close
- Do not use HMA




32



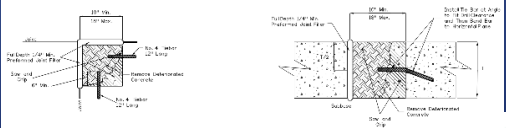

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Type 3 Repairs- Full Depth

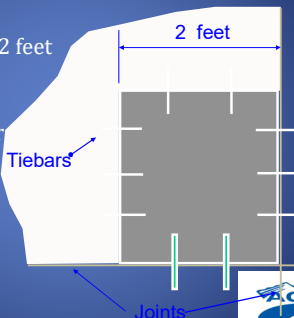

Uses:
 Corner Breaks
 Severe Spalling
 Transverse and Longitudinal Cracks
 Dependent on location in panel

35

Full Depth Repairs

- Minimum Repair 2 feet
- Full Depth Cut at existing Joints
- Must be square or rectangular
- Diamond-Blades
- Tie to Existing

36

Tie Bars

- #4- #6 depending on pavement thickness
- Deformed, epoxy coated
- Standard- 12" length, 12" spacing
- Small areas- can go down to 6" length
- Must use epoxy bonding agent

37

Dowel Bars

- Match size of existing dowels (if any)
- Place new bars centered between old bars (min 3 in. distance)
- Exposed half of bars need a bondbreaker
- Use epoxy or grout to anchor

38

Cleaning Holes (Air Blast)

39

Dowel Bar Placement for Full Depth Repairs

40


41

Concrete

- Standard Pavement Mix
- Bagged CSA mixtures can work
- Do not use:
 - HMA
 - Mastic
 - Non-shrink grout

42

- Vibrate for consolidation
- Finish as normal
- Match surrounding texture
- Place Curing Compound



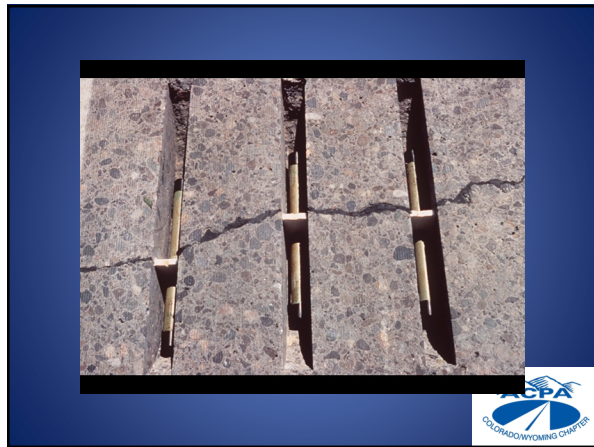
43

Retrofitting Dowel Bars

- Purpose
 - Reestablish load transfer
 - Limit future faulting
- Used for:
 - Faulted joints
 - Faulted cracks
 - Dowels that were not installed during construction



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45



46

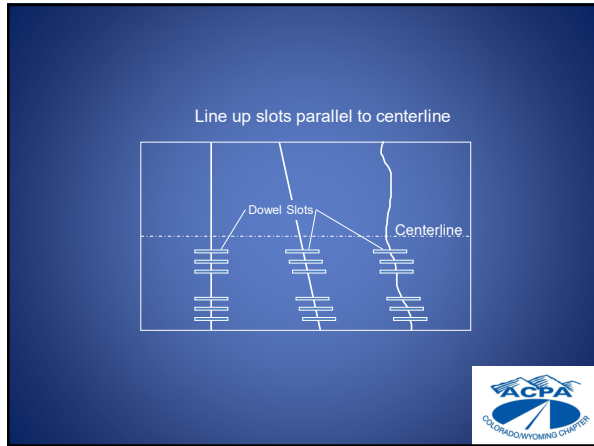
Dowel Bar Retrofit



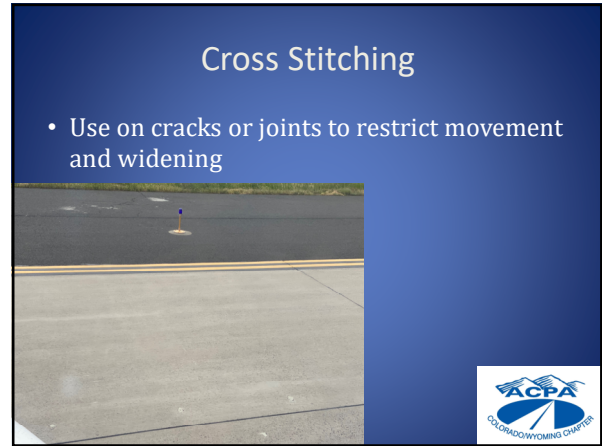
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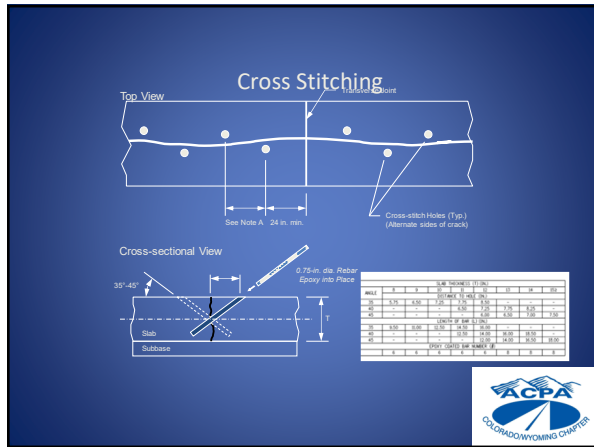
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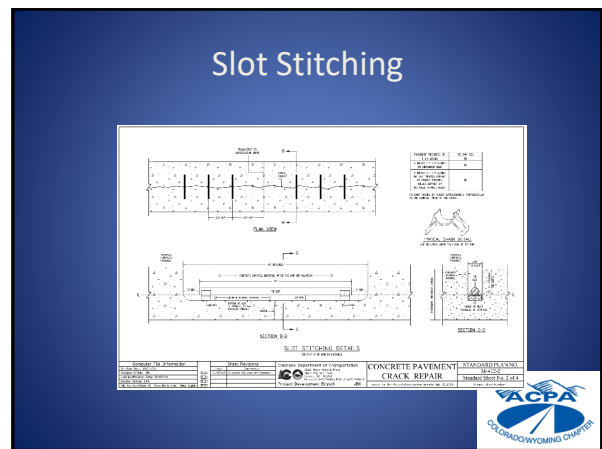
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53



54

Panel Replacement

- Shattered Slabs
- Areas where subgrade needs correction
- ASR, Deicer Distress
- Any panels that are too far deteriorated for other method



55

Why is it a last resort?

- Sometimes, does more damage than it fixes
- Lose Aggregate Interlock
- Excess stress on surrounding pavement
 - Spalling
 - Drilling Dowels
- Different types of mixes have different properties



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Panel Replacement

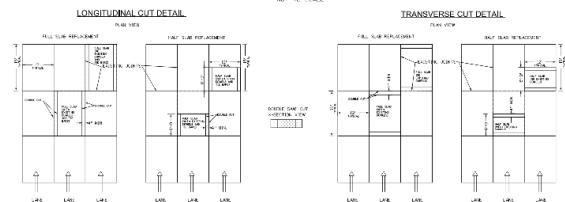
- Avoid accelerators as much as possible
- Consider rapid set materials for accelerated opening
- Include dowels in new pavements, even if existing adjacent pavement doesn't have them
 - 3 dowels per wheel path



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SLAB REMOVAL DETAILS

TYPICAL
NOT TO SCALE



NOTES:

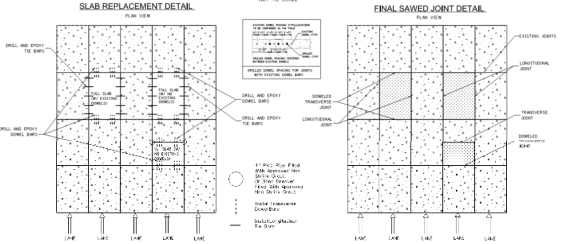
1. DAMAGE TO THE CONCRETE BEING REMOVED FROM THE CONTRACTOR'S BREAKING OPERATIONS SHALL BE REPAIRED AT THE CONTRACTOR'S EXPENSE.
2. ALL FILL AND REPAIR SHALL BE TO PERMANENT SHALL BE OBTAIN SAW CUT TO PROTECT THE REMAINING SLABS FROM DAMAGE.
3. EXPOSED SOIL SURF SHALL BE THE FULL DEPTH OF EXISTING SLAB.
4. THE EXPOSED DOUBLE SLAB CUT SHALL BE A MINIMUM 18" FROM AREA TO BE REMOVED AS SHOWN IN THE DETAIL.
5. SAWYER-BRAND AND FORWARDS DOUBLE SAW CUTS SHALL BE DONE PRIOR TO REMOVAL SLAB.
6. ALL SAW CUTS TO THE PAVEMENT SHALL BE CONFINED AND NOT ALLOWED TO ENTER ANY STORM DRAIN OR SURFACE WATER.
7. SHOULDER SHALL BE FINISHED AS TO MATCH ADJACENT TO THE SURFACE.
8. ALL EXISTING EQUIPMENT SHALL BE WITHDRAWN OR PROTECTED.
9. ALL PARTIAL SLAB ATTACHMENTS SHALL BE FULL WITHIN A DISTANCE OF 48" TO 60" FROM THE DETAIL. SLAB JOINTS SHALL BE FULL AND NOT PARTIAL.
10. REPAIRS SHALL BE MADE TO THE FULL DEPTH OF EXISTING SLAB.



58


SLAB REPLACEMENT DETAILS

TYPICAL
NOT TO SCALE



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6. THE THICKNESS OF NEW CONCRETE PAVEMENT SYSTEM SHALL MATCH EXISTING CONCRETE PAVEMENT SYSTEM. THIS SHALL INCLUDE EXISTING CONCRETE DEPTH, EXISTING REINFORCEMENT, AND EXISTING CURBS AND GUTTERS. ALL EXISTING CURBS AND GUTTERS SHALL BE REPAIRED AT THE CONTRACTOR'S EXPENSE.
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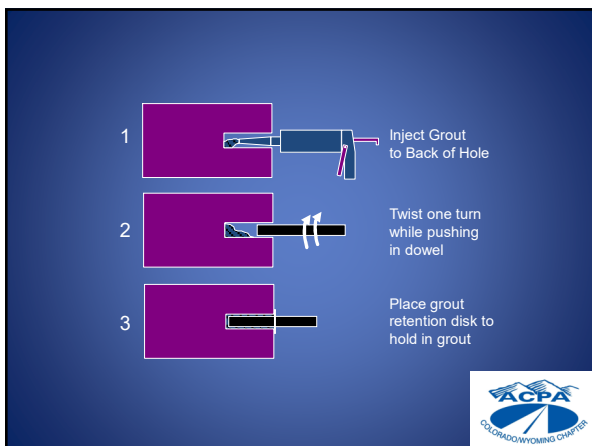
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64



65



Drill new dowels minimum 3 inches from existing

66



67



68



69



70

Concrete Placement

- Moist subgrade
- Place concrete as close to final location as possible
- Vibrate around fixtures and reinforcement- do not drag concrete
- Strikeoff
- Minimize amount of hand finishing!
- Apply Texture
- Apply curing compound
- Joint sealing


71



72

CSA Cements

- Rapid Setting Concrete
- Calcium Sulfoaluminate cement
- ASTM C1600
- 3000 psi in 1.5 hours
- Lower alkali content and shrinkage
- Not susceptible to sulfate attack
- Don't use pozzolans



73

Mobile Batcher Mixer (Volumetric)



- **Used for:** Intermittent production of concrete at jobsite, remote jobsites or small quantities
- **Advantages:**
 - Long transit times not a hurdle
 - One-person operation
- **Precautions:**
 - Good preventive maintenance program;
 - materials must be identical to those in original mix design
 - Risk of false setting due to inadequate mixing
 - feed gate calibrations



74


Diamond Grinding

- Uses:
 - Restore skid resistance
 - Eliminate Faulting
 - Remove Scaling and surface defects





75

Grinding



- Many different sizes- 3' most common, 4',6' sometimes used for rehab
- Grinders work like wood planers
- Operators can move head up and down
- Depth dependent on front wheel of machine
- Thermo-plastic striping should be removed before hand
- Existing Joint sealant can be ground through

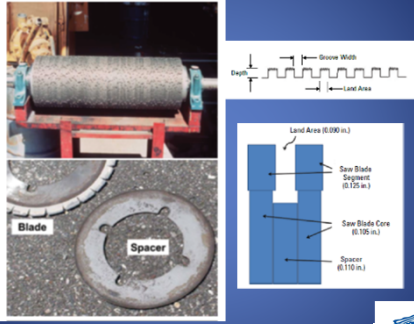


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Restoring Smoothness




77



The diagram shows a cross-section of a saw blade core and spacer. The core is labeled "Saw Blade Core (6.105 in.)" and the spacer is labeled "Spacer (6.110 in.)". The total width is labeled "Land Area (6.000 in.)". A "Blade" is shown in a separate view. A technical drawing shows the "Drive Width" and "Land Area" of the blade.



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80

Highlands Ranch, CO


- 20 year design
 - 7.5" PCCP on clay
 - No dowel bars
 - Constructed 1980's
- Design life achieved & exceeded
- Faulting & surface roughness
- Multi-year CPR program
- 2 contracts for pavement rehabilitation
 - Repairs
 - Diamond grinding



81

Surface Smoothness

- HRI \leq 150 inches/mile
 - 1/2" max. grinding depth
- HRI Percent Improvement: 50% or greater
 - If 150 in./miles requires >1/2" grinding
- HRI \leq 80 inches/mile
 - Initial HRI \leq 150 inches/mile
 - 1/2" max. grinding depth



82



83



84



Joint Resealing


- Most important aspect of concrete pavement maintenance
- Prevents spalling and joint distress
- Material should always be recessed



85

Joint Sealing Materials

- Hot-Pour
 - Field control of heating
 - Shape factor 1 ($D/W=1$) generally performs best
 - Typical life 3 - 5 yrs.
- Silicone
 - Clean and dry sidewalls!!
 - Shape factor ($\frac{D}{W} = \frac{1}{2}$)
 - Typical life 8 - 10 yrs.



86

Old Sealant Removal

- Manual Removal
- Sawing
 - Most common
 - Also shapes the reservoir
 - sticky material may clog diamond blades
- Plowing
 - Avoid "V-shaped" plows (can spall surrounding PCC)
 - Little damage with a rectangular plow
- Cutting



87

Shaping the Reservoir

- If sawing method is use – may not be necessary
- Some minor spalling may occur and is acceptable

Cleaning the Reservoir

- Most important aspect of joint sealing
- Faces require a thorough cleaning
 - No dust
 - No dirt
 - No visible traces of old sealant
- No Chemical solvent to wash reservoir



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Proper Cleaning Procedures





- Sandblast or Pressure Wash
 - Nozzle close to surface at an angle
 - Clean top 1 inch
 - Provides clean textured surface for sealant
- Air blow
 - Removes sand, dirt and dust
 - Conduct just prior to sealant pumping
 - Must filter moisture and oil from compressor
 - Minimum 120 cu.ft./min and 90 psi nozzle pressure
 - Vacuum sweeper can help



89

Backer Rod

90

Problems?



91

Surface Sealers



- Uses:
 - ASR
 - De-icer distress
 - Scaling



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- Silane Based
- Penetrate into the surface of the concrete creating a physical barrier to water and harmful chemicals
- Reapply annually
- Skid resistance must be maintained



93