Concrete Rehab Techniques

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

Life Cycle Cost Analysis
- 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

Life Cycle Cost Analysis (LCCA)

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
- Material Related Distress
  - ASR
  - Chloride Damage
Alkali-silica reactivity (ASR)

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

De-icer Distress Progression
Do all cracks need to be replaced?

• NO!!

• Panel replacement should be a last resort

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

Rules of Thumb for Concrete Cracks

<table>
<thead>
<tr>
<th>Width of Crack</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to ¼ inch</td>
<td>Leave alone/ Methacrylate</td>
</tr>
<tr>
<td>¼ to ½ inch</td>
<td>Saw and Seal</td>
</tr>
<tr>
<td>¾ to 1 ¼ inch (Spalled)</td>
<td>Partial Depth Repair</td>
</tr>
<tr>
<td>¾ to 1 ½</td>
<td>Saw and Seal</td>
</tr>
<tr>
<td>More than 1 ½</td>
<td>Full Depth Patching</td>
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</tbody>
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Methacrylate

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

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
Crack Route and Seal

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

- 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

Type 2 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
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

Method- Cutting and Chipping

1. Saw cut at least 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

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

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

10. 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

11. Re-seal all affected joints

Partial Depth Repairs

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

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

Type 3 Repairs - Full Depth

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

Full Depth Repairs

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

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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

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

Cleaning Holes (Air Blast)

Dowel Bar Placement for Full Depth Repairs

Concrete
- Standard Pavement Mix
- Bagged CSA mixtures can work
- Do not use:
  - HMA
  - Mastic
  - Non-shrink grout
• Vibrate for consolidation
• Finish as normal
• Match surrounding texture
• Place Curing Compound

Retrofitting Dowel Bars

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

Dowel Bar Retrofit
Line up slots parallel to centerline

Cross Stitching

• Use on cracks or joints to restrict movement and widening

Cross Stitching

Subbase

Slab

Top View

Cross-sectional View

See Note A

Cross Stitching

Slot Stitching
Panel Replacement

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

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

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

Panel Replacement Details

- Slab Replacement Details
- Slab Removal Details
- Dowel Anchorage Details
- Joint Detail

SLAB REPLACEMENT DETAILS

- Longitudinal Joint Detail
- Transverse Joint Detail

SLAB REMOVAL DETAILS

- Removal of Slab Section
- Preparation for New Slab

Include dowels in new pavements, even if existing adjacent pavement doesn’t have them – 3 dowels per wheel path.
Inject Grout to Back of Hole

Twist one turn while pushing in dowel

Place grout retention disk to hold in grout

Drill new dowels minimum 3 inches from existing
Concrete Placement

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

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

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

Diamond Grinding

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

Grinding

• Many different sizes- 3’ most common, 4’ 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

Restoring Smoothness
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

Surface Smoothness

- HRI ≤ 150 inches/mile
  - 1/2” max. grinding depth
- HRI Percent Improvement: 50% or greater
  - If 150 in./miles requires >1/2” grinding
- HRI ≤ 80 inches/mile
  - Initial HRI ≤ 150 inches/mile
  - 1/2” max. grinding depth
Joint Resealing

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

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.

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

Shaping the Reservoir

- If sawing method is used – 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

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

Backer Rod
Problems?

Surface Sealers

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

- 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