Concrete Pavement Preservation
About This Webinar

1. Pavement Management
2. Preventative Maintenance and Pavement Preservation Concepts
3. Strategy Selection
4. Concrete Pavement Evaluation
Service and Investment

Maintaining the Service and Investment of the Highway by Implementing Pavement Management Into Cost-Effective PAVEMENT PRESERVATION MEASURES
What is Pavement Management

- A Pavement Management System is a set of defined procedures for collecting, analyzing, maintaining, and reporting pavement data, to assist the decision makers in finding optimum strategies for maintaining pavements in serviceable condition over a given period of time for the least cost."
Use of Pavement Management Data in Preservation

• Determine if a project is a suitable candidate for preservation (e.g., acceptable faulting and IRI levels)
• Identify which treatments are feasible for a given project
• Identify the most appropriate treatment(s) in terms of cost-effectiveness and other considerations
Pavement Management

**PERFORMANCE MODEL**
- Needs Assessment
- Predict Condition
- Predict M&R

**PAVEMENT MANAGEMENT**
**PRIORITY RANKINGS**
- Needs
- Trigger Values
- Budgets

**CONCRETE PAVEMENT PRESERVATION**
- Conduct Pavement Evaluation
- Determine Causes of Distresses
- Identify Treatments

**FUNDING**
- Multiyear Work plan
- Timing funding for the right treatment
Performance Models

Typical methods for evaluating pavements

- SHRP – LTPP (Miller & Bellinger 2003) for highways
- Shahin & Walther (1990) for streets
- FAA (2003) for airports
- PCI Method (US Army Corps of Engineers)
- PASER Manual (University of Wisconsin-Madison)
Pavement Preservation and Preventive Maintenance Concepts
What is *Pavement Preservation*?

- Network level, long-term strategy for enhancing pavement performance
- Focus on extending pavement life and restoring functional condition
- Goals accomplished with a collection of preventive maintenance treatments and a few minor rehabilitation and routine maintenance treatments
What is *Preventive Maintenance*?

- Planned strategy of cost effective treatments
- Applied to structurally sound pavements with significant remaining life
- Maintain or improve functional condition
Determining Treatment Selection

• Preservation Policy- Stating what the goal is for pavement condition and/or service life.

• In order to select the right treatment, for the right pavement, at the right time, and at the right costs the following information must be compiled and analyzed:
  – Expected performance of the pavement.
  – The treatment and expected costs (initial and life-cycle), both direct (agency costs) and indirect (user costs).
  – Does it meet the goal?
What is Pavement Management
Pavement Management Concept

Pavement Condition

- 40% of life
- 70% of life
- 90% of life

Pavement Age

- $X$/mile
- $\sim 4X$/mile
- $\sim 6-10X$/mile
- $>10X$/mile
5 Core Questions

1. What is the current state of our pavements?
2. What is the level of service to be provided?
3. What level of deterioration is acceptable?
4. What are the feasible options to consider?
5. Which long-term funding option should be selected?
What Preventative Maintenance is NOT

• Worst first
• Cover up problems
Service Life

Service Life

Short-Term Pavement

Investment

Excellent

Good

Fair

Poor

Deteriorated

Years
Strategy Selection
Treatment Selection Process

- Conduct pavement evaluation
- Determine causes of distresses
- Identify treatments that address distresses
- Identify constraints, key selection factors
- Develop feasible treatment strategies
- Assess cost effectiveness of treatment strategies
- Select preferred strategy
Step 1. Pavement Evaluation

- Distress survey
- Drainage survey
- Deflection testing
- Roughness testing
- Friction testing
- Field sampling and testing
Step 2. Determine Causes of Distresses and Deficiencies

• Determine root cause(s) for observed distresses and deficiencies
  – Structural problem?
  – Functional problem?
  – Materials problem?
  – Drainage problem?
Pavement Condition Index (PCI) Concept

Distress Type ➔ PCI ➔ Distress Severity

- Excellent: 100
- Very Good: 85
- Good: 70
- Fair: 55
- Poor: 40
- Very Poor: 25
- Failed: 0

PAVEMENT CONDITION INDEX (PCI)
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<thead>
<tr>
<th>Strategy</th>
<th>Minimum RSL</th>
<th>DI</th>
<th>RQI</th>
<th>IRI</th>
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*Consists of full-depth concrete repairs, diamond grinding, and other.
RSL: Remaining service life
DI: Distress index
RQI: Ride quality index
IRI: International roughness index
Step 3. Identify Treatments That Address Deficiencies

• Preservation Treatments
  – Restore slab integrity
  – Restore functional performance

• Rehabilitation Treatments
  – Provide structural enhancement
  – Overlays

• Reconstruction
  – No remaining life
# Treatment–Distress Matrix

Table 12.3 on p. 267

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<thead>
<tr>
<th>Distress</th>
<th>Slab Stabilization</th>
<th>Slab Jacking</th>
<th>Partial-Depth Repair</th>
<th>Full-Depth Repair</th>
<th>Retrofitted Edge Drains</th>
<th>Dowel Bar Retrofit</th>
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Step 4. Identify Constraints and Key Selection Factors

• Key factors that might influence selection process
• Examples:
  – Traffic levels
  – Lane closure options
  – Future maintenance requirements
  – Geometrics
  – Funding
  – Etc. (see p. 268-269)
Step 5. Develop Feasible Treatment Strategies

• Strategy: a treatment or combination of treatments needed to address all of the deficiencies on a project

• Combination of treatments often needed to address all deficiencies (and prevent future re-development)
Treatment Sequencing for Concurrent Application

Fig. 12.1 on p. 269
Step 6. Assess Cost Effectiveness of Strategies

- Establish analysis period for comparing treatment strategies
  - 25 to 40 years (typical)
- Quantify cost-effectiveness
  - Benefit-cost ratio method
  - Life-cycle cost analysis (LCCA)
Step 7. Select Preferred Treatment Strategy

- Consider cost-effectiveness results
- Evaluate strategy in relation to key constraints and decision factors, e.g.,
  - Economics
  - Customer satisfaction
  - Construction/materials
  - Agency policy/preferences
- Use of decision matrix with weighting factors?
Concrete Pavement Evaluation
Purposes of a Pavement Evaluation

• Provides qualitative information to:
  – Determine causes of deterioration
  – Determine if pavement is not a candidate for preservation
  – Develop appropriate alternatives

• Provides quantitative information for:
  – Quantity estimates
  – Assessment of deterioration rates
  – Performing life-cycle cost analyses
Project Evaluation Approach

1. Historical data collection/records review
2. Initial site visit and assessment
3. Field testing activities
4. Laboratory materials characterization
5. Data analysis
6. Final field evaluation report
Key Pavement Evaluation Components

• Pavement Distress & Drainage Surveys
• Nondestructive Testing
• Surface Characteristics Testing
• Field Sampling and Testing
# Pavement Condition Attributes and Data Sources

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Distress Survey</th>
<th>Drainage Survey</th>
<th>Deflection Testing</th>
<th>Roughness Testing</th>
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Pavement Distress and Drainage Surveys
Pavement Distress

• Fundamental performance indicator
• Characterized by:
  – Type
    ➢ What?
  – Severity
    ➢ How Bad?
  – Extent
    ➢ How Much?
Common Concrete Pavement Distresses

- Corner Breaks
- D-Cracking or ASR
- Transverse Cracking
- Spalling
- Patch/Patch Deter.
- Joint Faulting
- Pumping
- Joint Seal Damage
- Blowup
- Map Cracking
- Punchout
- Scaling
- Longitudinal Cracking

Table 3.3 on p. 25
Saturated Concrete Pavement (Shadowing)

**Causes**
- Saturated joint
- Non drainable subbase
- Poor sealant

**Treatment**
- Drain subbase
- W/C ratio 0.40 to 0.43
- Reduce use of magnesium or calcium chlorides
Joint Spalling

**Causes**
- Saturated joints
- Freeze-thaw damage
- Slab compression (incompressibles)
- Early sawing

**Treatment**

**Preventive:** Partial-Depth Repair or Isolated Full-Depth Repair

**Rehabilitation:** Unbonded Concrete Overlay or Reconstruction
Faulting

Causes

• Load transfer loss
• Pumping
• Subgrade or subbase erosion

Treatment

Preventive:
• Dowel bar retrofit
• Full depth repair
• Diamond Grinding
• Slab stabilization

Rehabilitation: Bonded Concrete Overlay if less than 3/8” faulting or Unbonded Concrete Overlay for 3/8” to 5/8”.
Curling/Warping Roughness

Causes
• Moisture gradients through the slab thickness, daily and seasonal cycling of temperature gradients through the slab thickness, and/or permanent deformation caused by a temperature gradient in the slab during initial hardening.

Minimizes Cracks

Preventive:
• Uniform curing
• No high shrinkage mixes
• Reduce panel size
• Mid-Fault diamond grinding
• Cut pavement into smaller joints

Rehabilitation:
• Unbonded concrete overlay

\[ \Delta T = \Delta T_{Actual} + \Delta T_{Built-in} + \Delta T_{Shrinkage} \]
Transverse Cracking

**Causes**
- Foundation movement
- Excessive slab length
- Excessive curling & warping

**Treatment**

**Preventive:**
- Full depth repair
- Route & seal
- Dowel bar retrofit

**Rehabilitation:**
- Concrete overlay
Dowel Bar Distress

**Causes**
- Misalignment or corrosion

**Treatment**
- Full depth repair
Longitudinal Cracking

**Causes**
- Excessive slab width
- Shallow sawed edge joints
- Foundation movement
- Excessive tied joints

**Treatment/Repairs**
- Route & sealing
- Partial depth repairs
- Cross-stitching
Distress: Corner Breaks

**Causes**

- Fatigue damage, often in combination with slab curling and/or warping and/or erosion of support at slab corners.

**Treatment**

**Routine:** Rout & Seal

**Preventive:** Isolated Full-Depth Repair

**Rehabilitation:** Reconstruction
Bumps, Heaves, and Settlements

**Causes**

- Compressive stress buildup in the slab (due to infiltration of incompressibles, or alkali aggregate reaction) or aggregates with a high coefficient of thermal expansion.

- Foundation movement (frost heave, swelling soil) or localized consolidation, such as may occur at culverts and bridge approaches.

**Treatment**

**Preventive:** Correct the subbase/subgrade Isolated Full-Depth Repair or Mill for small lift

**Rehabilitation:** Spot Reconstruction
D-Cracking/Poor Air Content

Causes

• Entrapped moisture in coarse aggregate resulting in freeze-thaw damage

Treatment/Repair

Preventive: Sufficient tests for aggregates

Rehabilitation:

• If low term & slow acting may be able to delay reconstruction w/full depth repair
• Recycle as base and reconstruction
Alkali-Silica Distress

Causes

• Compressive stress building up in slab, due to swelling of gel produced from reaction of certain siliceous and carbonate aggregates with alkalies in cement.

Treatment

Preventive: Isolated Full-Depth Repair

Rehabilitation:

• If low term & slow acting may be able to delay reconstruction w/full depth repair

• Pressure Relief Joints, Unbonded Concrete Overlay or Reconstruction
Noise, Roughness, and Surface Friction

• Provides indicator of “functional” performance
  – Rideability
  – Safety
  – Noise

• Possible need for testing indicated by user complaints and wet-weather crashes
NDT Technologies

- Deflection testing
- Ground penetrating radar
- MIT Scan
- MIRA
Deflection Data

- Assessment of uniformity deflections along project
- Backcalculation of pavement properties
- Evaluation of joint/crack load transfer
- Void detection
- Maximum deflection (typ. 20 to 35 mils)
Ground Penetrating Radar

- Determine layer thickness
- Embedded steel location
- Presence of underlying voids

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<tr>
<th>Layer Type</th>
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<td>Granular Base</td>
<td>8 – 15%</td>
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Table 3.5 on p. 36
Magnetic Imaging Tomography

- MIT Scan-2
  - Evaluate dowel bar location and orientation
- MIT Scan T2
  - Determine concrete slab thickness

Fig. 3.13 on p. 38
Fig. 3.15 on p. 39
Surface Characteristics

- Roughness (Smoothness)
- Friction
- Noise
Roughness Surveys

- Measures actual Pavement profile.
- Widespread use in network-level pavement management.
- Relatively accurate and repeatable measurements

Non-Contact Lightweight

Portable Laser

High-Speed Profiler
Roughness Indicators

- IRI current measurement standard
- Serviceability (PSR) used in AASHTO
- General correlations:

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<th>Ride Quality</th>
<th>IRI (in/mi)</th>
<th>PSR</th>
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Table 3.6 on p. 45
Friction Surveys

• Assess overall adequacy of pavement friction as it contributes to safety
• Identify localized areas with poor friction
  – Curves
  – Intersections
  – Ramps
Assessing Surface Friction

- Measure surface friction directly with various devices (e.g., skid trailer, high speed lasers devices)
- Must also consider surface texture
  - Microtexture
  - Macrotexture
Tire/Pavement Noise Survey

• Emerging as a critical issue, especially in high-volume urban areas
• Problematic to adjacent property and business owners and the traveling public
• On-Board Sound Intensity (OBSI) method

Fig. 3.20 on p. 41
Purposes of Field Sampling and Testing

• Purposes:
  – Determine layer thicknesses
  – Characterize material properties
  – Diagnose causes (mechanisms) of distress

• Can consist of:
  – Field sampling
  – Field testing
  – Laboratory testing
Common Field Sampling and Testing Methods

- Coring
- Material sampling
- Dynamic cone penetrometer (DCP)
- Standard penetration testing (SPT)
Common Laboratory Tests

• Subgrade and granular base/subbase
  – Characterization (soil classification, moisture content)
  – California Bearing Ratio (CBR)
  – Resilient Modulus (Mr)

• Stabilized layers and PCC slab
  – Indirect Tension
  – Unconfined Compression
  – Special Materials Evaluation Tests