Integrating Preservation into Pavement Management System Decision Making and Analysis

An Implementation Case Study for New Mexico Department of Transportation

Presented by:
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KERCHER ENGINEERING, INC.
NMDOT PMS Configuration Team

- Gathered Committee of Experts from Around the Agency
  - Materials
  - Engineering
  - Maintenance
  - IT

- Brought KEI On Board to Steer Process and Provide Expert Knowledge of Pavements and Software Configuration
NMDOT PMS Configuration Tasks

- Defining Management Sections (LRS)
- Attribute and Condition Data
- Distress and Index Definitions
- Treatments and Repair Strategies
- Decision Trees and Processes
- Performance Modeling
- Optimization Analysis Criteria
NMDOT PMS Incorporating Preservation

- Committee Made it Clear that Pavement Preservation was Top Priority for Agency
- Important that PMS Incorporates Treatment Selections with Proper Timing for Preservation
- Preservation, Preventive, and Maintenance Treatments needed to Add Life to Pavements in Configuration
- Fog Seals, Patching, and Crack Sealing Had to be Included in Analysis Treatment Selections
Pavement Distresses

Collecting Appropriate Condition Data to Trigger Pavement Repairs
## Distresses Collected by Pavement Type

<table>
<thead>
<tr>
<th>Flexible Pavements*</th>
<th>Rigid Pavements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alligator Cracking</td>
<td>Corner Breaks</td>
</tr>
<tr>
<td>Transverse Cracking</td>
<td>Faulting</td>
</tr>
<tr>
<td>Edge Cracking</td>
<td>Joint Seal Damage</td>
</tr>
<tr>
<td>Longitudinal Cracking</td>
<td>Lane/Shoulder Drop-off</td>
</tr>
<tr>
<td>Block Cracking</td>
<td>Longitudinal Cracks</td>
</tr>
<tr>
<td>Patching</td>
<td>Patch Deterioration</td>
</tr>
<tr>
<td>Bleeding</td>
<td>Spalling of Joints &amp; Cracks</td>
</tr>
<tr>
<td>Weathering &amp; Raveling</td>
<td>Transverse &amp; Diagonal Cracks</td>
</tr>
</tbody>
</table>

*Reviewing Flexible setup due to time constraints
Condition Indexes

Converting Condition Data into Decision Variables for Triggering Treatments
Problem:
- Single Index Only Provides a General Indicator of Overall Health

Questions:
- What Distresses are Present?
  - Severities and Extents?
- What Repair(s) Is Required?
- Reasonable Cost of Repair?
Treatment Selection Indexes

**Individual Index**
- Alligator Cracking
- Edge Cracking
- Potholes/Patching

**Combined Index**
- Structural Index
- Environmental Index
- Functional Index

**Preservation Targeting**
- Transverse Cracking
- Block Cracking
- Oxidation/Raveling
- Skid
- Rutting
- Ride Quality

**Condition** → **Treatment**

KEI
Treatments and Repair Strategies
# Treatments & Repair Categories

<table>
<thead>
<tr>
<th>Flexible Repair Category</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - Monitor</td>
<td>0 – Monitor</td>
</tr>
</tbody>
</table>
| F1 - Preventative       | F1A - Crack Seal  
|                         | F1B - Fog Seal |
| F2 - Patch              | F2 - Patch |
| F3 - Preservation (Minor) | F3A - Scrub Seal  
|                         | F3B - Chip Seal  
|                         | F3C - Slurry Seal  
|                         | F3D - Cape Seal  
|                         | F3E - OGFC  
|                         | F3F - Micro Surfacing  
|                         | F3G - Plant Mix Wearing Course overlay – Nova Chip |
| F4 - Preservation (Major) | F4A - Pavement Resurfacing and Curb line milling Cutler (1.5” to 2.5”)  
|                         | F4B - Hot In-Place Recycling (Remixing) (1.5” to 2.5”)  
|                         | F4C - Hot In-Place Recycling (Heater Scarification) (1.5” to 2.5”)  
|                         | F4D - Cold Mill Asphalt Recycling (Warm or Cold)  
|                         | F4E - HMA/WMA Mill and Inlay (1.5” to 2.5”)  
|                         | F4F - SMA Mill and Inlay (1.5” to 2.5”) |
| F5 - Rehabilitation (Minor) | F5A - HMA/WMA Mill and Inlay 2.5” to 4”  
|                         | F5B - Hot In-Place Recycling (Remixing) (2.5” to 4”)  
|                         | F5C - Hot In-Place Recycling (Heater Scarification) (2.5” to 4”)  
|                         | F5D - Pavement Resurfacing and Curb line milling Cutler (2.5” to 4”)  
|                         | F5E - HMA/WMA Overlay 2.5” to 4”  
|                         | F5F - SMA Mill and Inlay (2.5” to 4.0”) |
| F6 - Rehabilitation (Major) | F6A - HMA/WMA Mill and Inlay greater than 4”  
|                         | F6B - Hot In-Place Recycling (Remixing) greater than 4”  
|                         | F6C - Hot In-Place Recycling (Heater Scarification) greater than 4”  
|                         | F6D - Pavement Resurfacing and Curb line milling Cutler greater than F4”  
|                         | F6E - HMA Overlay greater than 4”  
|                         | F6F - Process Place and Compact W/Overlay  
|                         | F6G - Full Depth Reclamation (FDR) |
| F7 - Reconstruction     | F7 - Reconstruction |
## Preservation Treatments

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<tr>
<th>Flexible Repair Category</th>
<th>Treatment</th>
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| **F1 - Preventative**    | F1A - Crack Seal  
                          | F1B - Fog Seal    |
| **F2 - Patch**           | F2 - Patch     |
| **F3 - Preservation (Minor)** | F3A - Scrub Seal  
                          | F3B - Chip Seal   
                          | F3C - Slurry Seal  
                          | F3D - Cape Seal     
                          | F3E - OGFC          
                          | F3F - Micro Surfacing |
                          | F3G - Plant Mix Wearing Course overlay – Nova Chip |
| **F4 - Preservation (Major)** | F4A - Pavement Resurfacing and Curb line milling Cutler (1.5” to 2.5”)  
                          | F4B - Hot In-Place Recycling (Remixing) (1.5” to 2.5”)  
                          | F4C - Hot In-Place Recycling (Heater Scarification) (1.5” to 2.5”)  
                          | F4D - Cold Mill Asphalt Recycling (Warm or Cold)  
                          | F4E - HMA/WMA Mill and Inlay (1.5” to 2.5”)  
                          | F4F - SMA Mill and Inlay (1.5” to 2.5”)  |
# Condition Index Improvements by Repair Category

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>Add 0</td>
<td>Add 10</td>
<td>Add 5</td>
<td>Add 15</td>
<td>Add 40</td>
<td>Add 60</td>
<td>Reset to 100</td>
</tr>
<tr>
<td>Environmental</td>
<td>Add 10</td>
<td>Add 0</td>
<td>Add 10</td>
<td>Add 30</td>
<td>Add 50</td>
<td>Reset to 100</td>
<td>Reset to 100</td>
</tr>
<tr>
<td>Safety</td>
<td>Add 0</td>
<td>Add 0</td>
<td>Reset to 100</td>
<td>Reset to 100</td>
<td>Reset to 100</td>
<td>Reset to 100</td>
<td>Reset to 100</td>
</tr>
<tr>
<td>Roughness</td>
<td>Add 0</td>
<td>Add 0</td>
<td>Add 5</td>
<td>Reset to 100</td>
<td>Reset to 100</td>
<td>Reset to 100</td>
<td>Reset to 100</td>
</tr>
</tbody>
</table>
Treatment Timing is Everything

There is a most Beneficial and Cost-effective Treatment for every Pavement Condition
Decision Trees

Purpose:
Right Treatment, Right Place, Right Time
Structural Decision Tree

Flexible Pavement

- Matrix Priority #1 (Interstates)
- Matrix Priority #2 (Arterials of National–Regional Significance)

- Matrix Priority #3 (Arterials of Statewide Significance)
- Matrix Priority #4 (Arterials of State Regional Significance)

- Matrix Priority #5 (Routes of Local Significance)

SI < 30  Treatment = Reconstruction
30 < SI < 45  Treatment = Rehabilitation (Major)
45 < SI < 65  Treatment = Rehabilitation (Minor)
65 < SI < 80  Treatment = Preservation (Major)
SI > 80  See Maintenance Tree Detail

SI < 25  Treatment = Reconstruction
25 < SI < 40  Treatment = Rehabilitation (Major)
40 < SI < 60  Treatment = Rehabilitation (Minor)
60 < SI < 75  Treatment = Preservation (Major)
SI > 75  See Maintenance Tree Detail

SI < 20  Treatment = Reconstruction
20 < SI < 35  Treatment = Rehabilitation (Major)
35 < SI < 55  Treatment = Rehabilitation (Minor)
55 < SI < 70  Treatment = Preservation (Major)
SI > 70  See Maintenance Tree Detail

Maintenance Tree Detail

- Alligator Cracking Index < 90  Treatment = Patch
- Alligator Cracking Index > 90
  - Patching Index < 90  Treatment = Patch
  - Patching Index > 90
    - Edge Cracking Index < 90  Treatment = Preventative
    - Edge Cracking Index > 90  Monitor
Environmental Decision Tree

Flexible Pavement

Matrix Priority #1 (Interstates) and
Matrix Priority #2 (Arterials of National-Regional Significance)

Matrix Priority #3 (Arterials of Statewide Significance) and
Matrix Priority #4 (Arterials of State Regional Significance)

Matrix Priority #5 (Routes of Local Significance)

 EI < 30 ➔ Treatment = Rehabilitation (Major)

 EI < 45 ➔ Treatment = Rehabilitation (Minor)

 EI < 65 ➔ Treatment = Preservation (Major)

 EI < 80 ➔ Treatment = Preservation (Minor)

 EI > 80 ➔ See Maintenance Tree Detail

 EI < 25 ➔ Treatment = Rehabilitation (Major)

 EI < 40 ➔ Treatment = Rehabilitation (Minor)

 EI < 60 ➔ Treatment = Preservation (Major)

 EI < 75 ➔ Treatment = Preservation (Minor)

 EI > 75 ➔ See Maintenance Tree Detail

 EI < 20 ➔ Treatment = Rehabilitation (Major)

 EI < 35 ➔ Treatment = Rehabilitation (Minor)

 EI < 55 ➔ Treatment = Preservation (Major)

 EI < 70 ➔ Treatment = Preservation (Minor)

 EI > 70 ➔ See Maintenance Tree Detail

Maintenance Tree Detail

Transverse Cracking Index < 80 ➔ Treatment = Preservation (Minor)

80 < Transverse Cracking Index < 90 ➔ Weathing/Raveling Index > 80 ➔ Treatment = Preventative
Weathing/Raveling Index < 80 ➔ Treatment = Preservation (Minor)

Transverse Cracking Index > 90 ➔ Weathing/Raveling Index > 80 ➔ Monitor
Weathing/Raveling Index < 80 ➔ Treatment = Preservation (Minor)
Functional Decision Tree

Flexible Pavement

Matrix Priority #1
(Interstates)
and
Matrix Priority #2
(Arterials of National-Regional Significance)

Roughness Index < 65

Safety Index < 50 → Treatment = Rehabilitation (Minor)
Safety Index ≥ 50 → 50 > Safety Index ≥ 75 → Treatment = Preservation (Major)

Roughness Index > 65

Safety Index > 75

Rut Depth > 2.5 Inch → Treatment = Rehabilitation (Minor)
0.75 Inch < Rut Depth < 2.5 Inch → Treatment = Preservation (Major)
0.25 Inch < Rut Depth < 0.75 Inch → Treatment = Preservation (Minor)
Rut Depth < 0.25 Inch → Monitor

Matrix Priority #3
(Arterials of Statewide Significance)
and
Matrix Priority #4
(Arterials of State Regional Significance)

Roughness Index < 60

Safety Index < 50 → Treatment = Rehabilitation (Minor)
Safety Index ≥ 50 → 50 > Safety Index ≥ 75 → Treatment = Preservation (Major)

Roughness Index > 60

Safety Index > 75

Rut Depth > 2.5 Inch → Treatment = Rehabilitation (Minor)
0.75 Inch < Rut Depth < 2.5 Inch → Treatment = Preservation (Major)
0.25 Inch < Rut Depth < 0.75 Inch → Treatment = Preservation (Minor)
Rut Depth < 0.25 Inch → Monitor

Matrix Priority #5
(Routes of Local Significance)

Roughness Index < 55

Safety Index < 50 → Treatment = Rehabilitation (Minor)
Safety Index ≥ 50 → 50 > Safety Index ≥ 75 → Treatment = Preservation (Major)

Roughness Index > 55

Safety Index > 75

Rut Depth > 2.5 Inch → Treatment = Rehabilitation (Minor)
0.75 Inch < Rut Depth < 2.5 Inch → Treatment = Preservation (Major)
0.25 Inch < Rut Depth < 0.75 Inch → Treatment = Preservation (Minor)
Rut Depth < 0.25 Inch → Monitor
Pavement Age Decision Tree

Flexible Pavement

Matrix Priority #1 (Interstates)
and Matrix Priority #2 (Arterials of National-Regional Significance)

Matrix Priority #3 (Arterials of Statewide Significance)
and Matrix Priority #4 (Arterials of State Regional Significance)

Matrix Priority #5 (Routes of Local Significance)

Last Treatment Applied was Preventive Maintenance?

Yes

Years Since Last Preventive Maintenance Treatment < 5
Monitor

Years Since Last Preventive Maintenance Treatment > 5
Treatment = Preservation (Minor)

No

Pavement Age < 4
Monitor

Pavement Age > 4
Treatment = Preservation (Minor)

Yes

Years Since Last Preventive Maintenance Treatment < 6
Monitor

Years Since Last Preventive Maintenance Treatment > 6
Treatment = Preservation (Minor)

No

Pavement Age < 5
Monitor

Pavement Age > 5
Treatment = Preservation (Minor)

Yes

Years Since Last Preventive Maintenance Treatment < 7
Monitor

Years Since Last Preventive Maintenance Treatment > 7
Treatment = Preservation (Minor)

No

Pavement Age < 6
Monitor

Pavement Age > 6
Treatment = Preservation (Minor)
Performance Models

Purpose:
Define Treatment Life and Benefit
(Reviewing Preservation Only)
Preservation (Minor) Model

- Original Deterioration Curve
- Preservation (Minor) Deterioration Curve

Overall Condition Index (OCI)

Time (Years)

Assumed End of Life Threshold

Additional Years of Pavement Life Due to Preservation Treatment: 2 Years
Patching Model

![Diagram of a Patching Model](image)

- **Deterioration Curve**
- **Meet Existing Curve**

- **Time (Years)**
- **Structural Index**

- **Add 10**
- **2 Years**
Life Cycle Treatment Rules

If Funded when Conditions Reach Threshold Values
Multi-Constraint Optimization Analysis
Objective: Maximize Benefit

Constraint: Budget

Multi-Constraint Optimization Analysis

Overall Budget

Primary Routes Budget

Maximize Condition

Secondary Budget

Maximize Condition

Interstate Budget

Maximize Condition

Reconstruction

Maximize Condition

Rehabilitation

Maximize Condition

Preservation
Optimized vs. Worst-First Analysis

Why Choosing Preservation is Critical

![Graph showing the comparison between Optimized and Worst-First Analysis over Analysis Years]

- The blue line represents the Optimized analysis, which shows a more stable and higher condition index (OCI) over the years.
- The red line represents the Worst-First analysis, which shows a more rapid decrease in the condition index (OCI) over the years.

This graph illustrates the importance of choosing the right preservation strategy to maintain the integrity of the system over time.
Thoughts on Software Calibration

- Reconstruction and Major Rehabilitation Treatments are Easy
  - Typically Indexes Reset to 100
  - Thickness of Treatments removes most if not all Distresses
  - Agency has Good Historical Data available to Support Performance Predictions

- Preservation Treatments are more Complex
  - Indexes Increase but may not Reset to Perfect
  - Typically, performance of the Treatment is dependent on the previous Treatment
  - Performance is Absolutely Dependent on Existing Condition
NMDOT Moving Forward

- Transitioning from Manual Distress Surveys to Automated Surveys
- Linking Historical Construction Records with Pavement Performance
- Also Linking Pavement Design with Pavement Performance with MEPDG Dashboard
- More Analysis Testing to Ensure Configuration is Finely Tuned to Agency Expectations
Questions???

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