Concrete Pavement Management and Preservation

Larry Scofield, IGGA/ACPA

Presentation Outline

- Defining Pavement Performance
- Beginning of Pavement Management
- Concrete Pavements Outlast the Generation That Builds Them
- Portrayal of Pavement Performance
- So What is Different Today
- ACPA Survey of State PMS Practices (Sept 2016)
- FHWA P2 ETG Survey of PMS Practices (March 2017)
- Data Rich Environment

Concrete Preservation Activities

- Diamond Grinding or Diamond Grooving
- Partial Depth or Full Depth Patching
- Dowel Bar Retrofit
- Joint Sealing or Resealing
- Slab Jacking/Stabilization
- Slab Replacement
- Longitudinal Crack Stitching
- Buried Treasure

Defining Pavement Performance

(AASHO Road Test)

- Roughness (CHLOE)
- Deflection (Benkleman Beam)
- Distress Surveys
Pavement Performance: Serviceability Concept

- “a mathematical index is derived and validated through which pavement ratings can be satisfactorily estimated from objective measurements taken on pavements.”
- Roughness was found to represent 95% of the correlation to ride panel
- Highways are for the comfort and convenience of the traveling public
- Users opinions are largely subjective
- Highway Characteristics can be objectively measured
- Serviceability can be expressed by the mean evaluation of all users
- Pavement performance can be described if the serviceability is monitored from cradle to a given point in time

Consumer Acceptability Vs Present Serviceability Rating AASHO Road Test (1958-60)

- Original Edition 1978
- Reprinted in 1982
- Pavement Asset Management 2015
- PMS Concepts Began in 1960s
- At Time of Reprint Publication (1982), only One State included Concrete in their PMS. PMS was generally developed around AC pavements.
- First State PMS was WSDOT in 1974
- First National PMS Conference was 1974
- First National PMS Conference was 1980; Only five states; AZ, CA, ID, UT, and WA had network level PMS used for project selection

1982 Concept of PMS Evolution

- New or Better Models: Stochastic Application
- Mechanistic Models
- Improve Models Through Research & Implementation
- Computerize Existing Models
- Improvement
- Time
Original Concept of Pavement Management– Circle of Life PMS Style

Concrete Pavements Out Last the Generation that Builds Them!

Design Life Vs Actual Performance

Utah I-15 Survival Analysis Results

Figure 10. Age survival curves for original ACP and JCP sections.
Portrayal of Pavement Performance

A Different Way to Think About Concrete Performance

- What about early repair of construction defects?
- Manage individual distresses/performance factors

Things to Remember About PMS and Concrete Pavement

PMS
- Pavement Management is a Lagging System—That is, damage to the pavement must occur prior to any ability to prevent or mitigate its occurrence
- Typically PMS do not respond to concrete pavement performance until it reaches a specified intervention level
- Individual performance factors are not managed separately—Composite index
- Preservation is often not included

Concrete Pavement
- Cracking in concrete may not become visible for up to 2 years
- Curl and warp and joint opening widths can change after construction
- Construction defects may not show up for many years
- Treatment life versus pavement life

So What is Different Today
Then and Now Distress Identification

1962 NASA Command Center
Dual IBM 7090
That's about .00015 gigabytes.

TxDOT 3D Automated Measurement System

Then
- Discrete Test Locations (Sampling)
- Manual Data Collection & Analysis
- Limited Computing Capacity
- Field Reviews Only
- Guestimates of Climate Data
- Little to No Ability to Evaluate Products or Test Sections
- Linear MP Location Data
- 2D Profile Measurements
- Limited to No Maintenance Data
- Questionable Traffic Data

Now
- 100% Roadway Coverage
- Automated Data Collection & Analysis
- Almost Unlimited Computing Capacity
- In-Office Visual Review of Roadways
- Accurate Environmental Data
- Ability for PMS to Test Sections and Products
- GPS Coordinates
- 3D Profile Measurements
- Exact Maintenance Locations and Costs
- Better Traffic Data?

So What is Different Today
- We Can Now Predict Distress Over Time: Transverse Cracking, Faulting, Spalling, and Roughness
- We Can Compare Predicted to Observed Distresses and Begin Addressing Design, Materials, Specification, Construction, Maintenance Improvements
- Construction Properties Used to Do Cradle to Grave PMS

Comparing Observed to Predicted

Graphs Courtesy of NCE
ACPA Survey of State PMS Practices (Sept 2016)

- Lots of Ways of Doing PMS (Triggers)
- About 60% of States Appear to be Managing Concrete Preservation with Triggers (i.e. 40% not Managing)
- No Consistent Methodology
- Most States Use Composite Statistics

FHWA Pavement Preservation ETG (March 2017)

Partial Depth Repair Survival Analysis
Data Rich Preservation Environment

Cradle to Grave Management!

Questions

Concrete Pavement Management & Preservation in Douglas County, CO

Angela Folkestad, PE
CO/WY Chapter - ACPA

Remember, We Are the Ones Who Put a Man on the Moon – We Can Do What Ever We Strive to Accomplish
Douglas County Overview

- 2019 population estimate: 358,000
- 91% lives in urban areas which is 17.5% of the County land area
- Estimated populations of incorporated towns and cities:
  - Castle Pines: 11,340
  - Castle Rock: 69,000
  - Larkspur: 195
  - Lone Tree: 15,150
  - Parker: 57,405
- Estimated population of Unincorporated Douglas County: 202,400 (includes Highlands Ranch)

Public Works Engineering manages 834 centerline miles of paved roads totaling 2,410 lane miles
- 2,040 lane miles of asphalt
- 370 lane miles of concrete
Prior to 2009 – Contracted Maintenance

- County was in a fast-paced growth
- Major infrastructure construction
- Limited funding
- Limited staff
- Slab replacement (worst first approach)

1st Concrete Grinding Project was in 2008
SB Broadway: Salford to Gateway
2009 – Changes to Contracted Maintenance Program

- Reduced Infrastructure Budget – Increased budget for Contracted Maintenance Projects
- Increased staff size
- Started to Developed a Pavement Distress Identification Manual
- Started evaluating existing pavements in-house
- Used a pavement management program to maximize funding efficiency for the greatest benefit to the network
- Change from individual area repairs to larger segments based on a Pavement Condition Index

2013 Concrete Pavement Repair Program

- Determined that faulting and settlement of the concrete pavement needed to be evaluated in more detail
- Conferences with ACPA & IGGA to determine what options were available to correct deficiencies
- On site meeting with a CDOT representative who specialized in concrete pavement repair
- Determine how concrete pavement smoothness quantified
- What is a reasonable IRI threshold?
Summary from Discussions

- Collect IRI data per lane and per segment for all concrete pavement
- Evaluate load transfer efficiency of the pavement
- Determine pavement thickness
- Perform subsurface evaluations

IRI Results for Concrete Pavement

ProVal to Predict Grinding Improvements

Load Transfer Efficiency

Pavement Thickness
<table>
<thead>
<tr>
<th>Project Cost</th>
<th>$5,033,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>SY</td>
<td>60,800</td>
</tr>
<tr>
<td>Concrete Pavement</td>
<td></td>
</tr>
</tbody>
</table>

**Douglas County - Engineering Division**

**2012 Contracted Maintenance of Condition Projects and Capital Improvements Projects**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Location</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement</td>
<td>Repair and maintenance</td>
<td>Various Areas</td>
<td>Complete</td>
</tr>
<tr>
<td>Drainage</td>
<td>Replacement</td>
<td>Various Locations</td>
<td>In Progress</td>
</tr>
<tr>
<td>Sidewalks</td>
<td>Replacement</td>
<td>Various Locations</td>
<td>Complete</td>
</tr>
</tbody>
</table>

**Map of Project Areas**

- Project Cost: $5,033,000
- 60,800 SY 9" Concrete Pavement

**Images:**
- Construction site with workers and equipment
- Close-up of freshly laid concrete pavement
- Map highlighting project areas
Diamond Grinding Specs

Focused on Improvement of Ride

- HRI ≤ 80 & max. grinding depth of 0.5”
  When initial HRI ≤ 150

- HRI ≤ 150 & max. grinding depth of 0.5”
  50% improvement over initial HRI if ≤ 150 wasn’t achievable

Pavement Management System Rebuild 2018-2019

- Assets redefined
  - “paving sector” for local streets
  - “supersegment” for arterial streets

- Automated data collection performed, shifting from manual collection of data

- Indexes and curves redefined based on current data

- Analysis was simplified
### Reformatted Inventory Tables

#### Original Inventory Table

<table>
<thead>
<tr>
<th>No.</th>
<th>Road</th>
<th>From_Description</th>
<th>To_Description</th>
<th>Length</th>
<th>ElementID</th>
<th>PCI</th>
<th>Sector_From</th>
<th>Sector_To</th>
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<tbody>
<tr>
<td>1</td>
<td>CREEKSIDE LN</td>
<td>CREEKSIDE WAY</td>
<td>0 TOWN CENTER DR</td>
<td>539.659</td>
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<td>037380</td>
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<td>LS007</td>
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<tr>
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<td>261.344</td>
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<td>0 EDINBURGH LN</td>
<td>580.193</td>
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<td>LS007</td>
<td>801.003 1381.196</td>
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<td>627.038</td>
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<td>627.038 OLD TOM MORRIS CIR</td>
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<tr>
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<td>CREEKSIDE WAY CREEKSIDE PT</td>
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<td>269.21</td>
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<tr>
<td>10</td>
<td>GREENSBOROUGH CIR</td>
<td>GREENSBOROUGH DR</td>
<td>0 GREENSBOROUGH DR</td>
<td>920.883</td>
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<td>026340</td>
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### Automated Data Collection

- **Distress**: Collected cracking, divided slabs, patches, scaling & joint spalling data in 2017
- **Ride Quality**: Collected MRI data in 2017 & 2018

### Simplified Analysis

- **Four Concrete Treatments**
  - Panel Replacement
  - Grinding
  - Joint Resealing
  - Reconstruction
- **All costs per square yard**
- **Modified Triggers**
  - Panel Replacement & Reconstruction Triggered by % of Damaged Slabs
  - Grinding Triggered by Panel Replacement in Prior Year
  - Sealing Triggered by Panel Replacement in Prior Year
Concrete Rehabilitation Strategies

**Concrete panel replacement** is used to replace damaged sections on concrete roadways – precedes concrete grinding – includes dowel bars.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Area (SY)</th>
<th>Cost</th>
<th>Cost/SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>7,420</td>
<td>$1,181,775.02</td>
<td>$159.27</td>
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<tr>
<td>2018</td>
<td>22,460</td>
<td>$2,547,339.86</td>
<td>$113.42</td>
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<tr>
<td>2016</td>
<td>20,387</td>
<td>$2,460,202.00</td>
<td>$120.68</td>
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<tr>
<td>2016</td>
<td>48,786</td>
<td>$4,375,225.70</td>
<td>$89.68</td>
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</tbody>
</table>

**Diamond Grinding** is performed on roads in good condition, but with poor ride, to restore ride quality - follows concrete panel repairs and is generally followed by joint sealing.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Area (SY)</th>
<th>Total Project Cost</th>
<th>Grinding Cost/SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>389,245</td>
<td>$2,124,049.50</td>
<td>$3.50</td>
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<tr>
<td>2014</td>
<td>285,961</td>
<td>$1,322,462.35</td>
<td>$3.53</td>
</tr>
<tr>
<td>2013</td>
<td>443,342</td>
<td>$1,953,151.46</td>
<td>$3.63</td>
</tr>
</tbody>
</table>

**Concrete Reconstruction** is utilized for complete replacement of a concrete roadway when cracked/damaged slabs > 50%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Project</th>
<th>Total Area (SY)</th>
<th>Total Project Cost</th>
<th>Concrete Cost/SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>Belford Ave.</td>
<td>12,855</td>
<td>$1,727,621</td>
<td>$59.00</td>
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<tr>
<td>2018</td>
<td>Meridian Ph. 1</td>
<td>23,454</td>
<td>$3,022,900</td>
<td>$56.51</td>
</tr>
<tr>
<td>2017</td>
<td>Oswego</td>
<td>12,634</td>
<td>$1,394,746</td>
<td>$55.74</td>
</tr>
<tr>
<td>2017</td>
<td>Lansing Circle</td>
<td>4,065</td>
<td>$369,589</td>
<td>$64.13</td>
</tr>
</tbody>
</table>

**Joint Sawing and Resealing** is used on roads in good condition and follows diamond grinding.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Length (LF)</th>
<th>Cost</th>
<th>Cost/LF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>52,731</td>
<td>$115,480.85</td>
<td>$2.19</td>
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<tr>
<td>2016</td>
<td>716,013</td>
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<tr>
<td>2015</td>
<td>57,043</td>
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<td>$3.69</td>
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<tr>
<td>2014</td>
<td>600,573</td>
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<tr>
<td>2013</td>
<td>563,744</td>
<td>$687,767.68</td>
<td>$1.22</td>
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</tbody>
</table>
Multi-Year Pavement Preservation Program in Highlands Ranch  2013-2016

<table>
<thead>
<tr>
<th>Year</th>
<th>Contract Amount</th>
<th>Lane Miles</th>
<th>Cost/Lane Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>$ 8,495,392</td>
<td>58</td>
<td>$146,472</td>
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<tr>
<td>2014</td>
<td>$ 7,199,111</td>
<td>48</td>
<td>$149,981</td>
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<tr>
<td>2015</td>
<td>$ 7,081,332</td>
<td>29</td>
<td>$244,184</td>
</tr>
<tr>
<td>2016</td>
<td>$ 3,747,829</td>
<td>20</td>
<td>$187,391</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$ 26,523,664</strong></td>
<td><strong>155</strong></td>
<td><strong>$171,120</strong></td>
</tr>
</tbody>
</table>

Overall Average: $24.31/SY

Angela Folkestad, P.E.
afolkestad@pavement.com

Thank you!