University of Nevada, Reno
Western Regional Superpave Center
Program and Research Updates

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Assistant Professor

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Personnel

– Peter E. Sebaaly, Ph.D., P.E.
  Professor, Director of WRSC
– Elie Y. Hajj, Ph.D.
  Assistant Professor
– Mena Souliman, Ph.D.
  Post-doctoral Scholar
– Murugaiyah Piratheeban, MSCE
  Research Scientist, Lab Manager
– Students
  15 Research Graduates;
  5 Undergraduates

Facility

– WRSC occupies parts of the 1st & 2nd floors of HREL building.
– Fully accredited & certified Lab by AMRL.
– Current capabilities:
  - aggregates
  - asphalt binders
  - asphalt mixtures
  - Portland cement concrete
  - Large-scale pavement testing
    (flexible and rigid pavements)
Main Areas of Research Topics

- Pavements/Materials
- Engineered Materials and Evaluation
- Pavement Maintenance and Rehab
- Pavement Performance Evaluation
- Specifications
- Pavement Design and Modeling
- Pavement Construction
Selected Research Studies

1. Implementation of AASHTO MEPDG for Flexible Pavements in Nevada (NDOT).

2. Long-Term Performance of CIR in Nevada (NDOT).

3. Development of Percent within Limit Specifications (PWL) for Nevada (NDOT).


Updates on the Implementation of AASHTO MEPDG for Flexible Pavements in Nevada
(Sponsor: Nevada DOT)
Motivation

– Why M-E Design?
  ▪ Greater emphasis on performance
  ▪ Increased emphasis on rehabilitation strategies
  ▪ Variations in Climate
  ▪ Increased Traffic
  ▪ Budgetary constraints
  ▪ Nonstandard Materials
  ▪ Darwin (AASHTO 93) no longer supported
Pavement ME Design for Flexible Pavements

- Prediction of following distresses with time:
  - Rutting
  - Fatigue cracking
  - Transverse cracking
  - Roughness (IRI)
Why Local Calibration for Nevada?

- Nevada’s use of polymer-modified asphalt binder.
- Nationally calibrated performance models are calibrated based on neat asphalt binder only.
- Using the national models will show an early failure compared to the true performance of PM binders.
- This may result in unnecessarily thick sections.
Implementation Plan

1. Sample asphalt mixtures from field projects.
2. Develop materials database.
3. Identify existing climatic weather data.
4. Identify existing traffic data.
5. Convert NDOT PMS distress data.
6. **Calibrate to Nevada’s Conditions.**
7. Validate the calibrated models.
8. Conduct trainings
Map of Sampled Contracts (2005-2010)
## Candidate Sections for Calibrations

### Fatigue Sections

<table>
<thead>
<tr>
<th>Sections</th>
<th>Traffic AADTT</th>
<th>Sampled</th>
<th>Non Sampled</th>
<th>Age(years)</th>
<th>Sampled</th>
<th>Non Sampled</th>
<th>Fatigue (%)</th>
<th>Sampled</th>
<th>Non Sampled</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG64-28NV</td>
<td>Low &lt;1000</td>
<td>0</td>
<td>1</td>
<td>0 to 3</td>
<td>0</td>
<td>1</td>
<td>3 to 10</td>
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<td>3</td>
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<tr>
<td></td>
<td>Intermediate 1000-5000</td>
<td>0</td>
<td>1</td>
<td>3 to 6</td>
<td>0</td>
<td>1</td>
<td>10 to 30</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>High &gt;5000</td>
<td>0</td>
<td>3</td>
<td>6 and up</td>
<td>0</td>
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<td>over 30</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>PG76-22NV</td>
<td>Low &lt;1000</td>
<td>0</td>
<td>6</td>
<td>0 to 3</td>
<td>0</td>
<td>0</td>
<td>3 to 10</td>
<td>1</td>
<td>8</td>
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<td>7</td>
<td>3 to 6</td>
<td>2</td>
<td>3</td>
<td>10 to 30</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>High &gt;5000</td>
<td>0</td>
<td>0</td>
<td>6 and up</td>
<td>0</td>
<td>10</td>
<td>over 30</td>
<td>0</td>
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### Rutting Sections

<table>
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<th>Non Sampled</th>
<th>Age(years)</th>
<th>Sampled</th>
<th>Non Sampled</th>
<th>Rutting Rating(in)</th>
<th>Sampled</th>
<th>Non Sampled</th>
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<tr>
<td>PG64-28NV</td>
<td>Low &lt;1000</td>
<td>3</td>
<td>4</td>
<td>0 to 3</td>
<td>6</td>
<td>1</td>
<td>0.5 to 1</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Intermediate 1000-5000</td>
<td>7</td>
<td>4</td>
<td>3 to 6</td>
<td>4</td>
<td>5</td>
<td>0.1 to 0.15</td>
<td>1</td>
<td>2</td>
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<td>High &gt;5000</td>
<td>0</td>
<td>3</td>
<td>over 6</td>
<td>0</td>
<td>5</td>
<td>0.15 and up</td>
<td>0</td>
<td>2</td>
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<tr>
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<td>Low &lt;1000</td>
<td>0</td>
<td>6</td>
<td>0 to 3</td>
<td>0</td>
<td>0</td>
<td>0.5 to 1</td>
<td>5</td>
<td>1</td>
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<tr>
<td></td>
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<td>3</td>
<td>7</td>
<td>3 to 6</td>
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<td>5</td>
<td>0.1 to 0.15</td>
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<td>14</td>
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<tr>
<td></td>
<td>High &gt;5000</td>
<td>2</td>
<td>2</td>
<td>6 and up</td>
<td>1</td>
<td>10</td>
<td>0.15 and up</td>
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### IRI Sections

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<th>Non Sampled</th>
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<th>Sampled</th>
<th>Non Sampled</th>
<th>IRI Rating (in/mile)</th>
<th>Sampled</th>
<th>Non Sampled</th>
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<td>4</td>
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<td>70 to 90</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Intermediate 1000-5000</td>
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<td>2</td>
<td>3 to 6</td>
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<td>2</td>
<td>90 to 120</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>High &gt;5000</td>
<td>0</td>
<td>0</td>
<td>6 and up</td>
<td>0</td>
<td>4</td>
<td>120 and up</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PG76-22NV</td>
<td>Low &lt;1000</td>
<td>0</td>
<td>4</td>
<td>0 to 3</td>
<td>0</td>
<td>0</td>
<td>70 to 90</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Intermediate 1000-5000</td>
<td>3</td>
<td>6</td>
<td>3 to 6</td>
<td>4</td>
<td>4</td>
<td>90 to 120</td>
<td>3</td>
<td>2</td>
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<tr>
<td></td>
<td>High &gt;5000</td>
<td>2</td>
<td>2</td>
<td>6 and up</td>
<td>1</td>
<td>8</td>
<td>120 and up</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Preliminary Calibration for Rutting Model

- Based on 7 pavement sections tested for rutting in the Repeated Load Triaxial.
Long-Term Performance of CIR Technique in Nevada
(Sponsor: Nevada DOT)
NDOT has used CIR over 1,500 centerline miles of roads over the past two decades (~25% of total system in NV).

**High Volume Roads**
- Surface Treatment
- New HMA Overlay
- CIR layer
- Existing Old HMA layer
- Crushed Aggregate Base
- Subgrade

**Low Volume Roads**
- Surface Treatment
- CIR layer
- Existing Old HMA layer
- Crushed Aggregate Base
- Subgrade
Engineered Materials
Cold In-Place Recycling in Nevada

• NDOT has long been using CMS-2s for CIR projects and recently started using Reflex and PASS emulsion.

• NDOT has observed some differences in the performance of CIR roads throughout Nevada.

• Need to assess the long-term performance of CIR roads in Nevada.
Engineered Materials

Cold In-Place Recycling in Nevada

- Total of 66 CIR projects were evaluated — Construction date 2001-2009.

- Factors Considered:

<table>
<thead>
<tr>
<th>CIR Rehab Type</th>
<th>- With Asphalt Overlay</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>- With Surface Treatment</td>
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<tr>
<td>Emulsion Type</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- CMS-2s</td>
</tr>
<tr>
<td></td>
<td>- Reflex</td>
</tr>
<tr>
<td></td>
<td>- PASS</td>
</tr>
<tr>
<td>Geographic Location</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- District</td>
</tr>
<tr>
<td></td>
<td>- County</td>
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<tr>
<td>Traffic Level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ESALs</td>
</tr>
<tr>
<td>Pre-CIR Pavement Condition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Pavement Distresses</td>
</tr>
</tbody>
</table>
Engineered Materials
Cold In-Place Recycling in Nevada

• CIR + HMA Overlay + Surface Treatment
  - CIR with CMS-2S Emulsion (37 Projects)
  - CIR with Reflex™ Emulsion (2 Projects)
  - CIR with PASS Emulsion (2 Projects)

• CIR + Surface Treatment
  - CIR with CMS-2S Emulsion (9 Projects)
  - CIR with Reflex™ Emulsion (15 Projects)
  - CIR with PASS Emulsion (2 Projects)
**Effective Life Definition**
Number of years pavement serves without a particular type of distress is defined as the effective life of the pavement for that distress.

### Average Effective Life for All Projects Combined

<table>
<thead>
<tr>
<th>Distress Type</th>
<th>CIR+Surface Treatment</th>
<th>CIR+HMA Overlay+Surface Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue Type A</td>
<td>8</td>
<td>5.5</td>
</tr>
<tr>
<td>Fatigue Type B</td>
<td>10</td>
<td>4.3</td>
</tr>
<tr>
<td>NWP</td>
<td>4</td>
<td>3.4</td>
</tr>
<tr>
<td>Trans</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Rut</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Roughness</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Block A</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

**Average Effective Life, Years**

- Fatigue Type A: 2.6, 4.3
- Fatigue Type B: 3.4, 1.8
- NWP: 2.8, 2.5
- Trans: 1.0, 5.0
- Rut: 5.5, 5.8
- Block A: 4.5

*Only one project!*
Pavement Condition Index (PCI) According to ASTM D6433

CIR + HMA Overlay + Surface Treatment

- PCI of Existing Condition
- PCI After 2 years
- PCI After 4 years
- PCI After 6 years
- PCI After 8 years

CIR + Surface Treatment

- PCI of Existing Condition
- PCI After 2 years
- PCI After 4 years
- PCI After 6 years
- PCI After 8 years

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Slide No. 20
Findings and Conclusions

• Transverse cracking & longitudinal cracking were the major type of distresses.
• CIR pavements with HMA overlay significantly reduced rutting and roughness while the other method fairly reduced it.
• Factors found insignificant on the performance of CIR pavements:
  – Variation in environmental conditions
  – CIR layer thickness between 2 and 3 inches
  – Various surface treatments
• Thickness of the overlay was crucial for the performance of CIR on high volume roads.
• CIR + HMA Overlay + Surface Treatment on high volume roads performed better than CIR + Surface Treatment on low volume roads.
• **CIR with HMA overlay:** Within the first two years, the Reflex and PASS emulsions showed slightly lower performance as compared to the CMS-2S emulsion.
• **CIR with surface treatment:** all three types of emulsions (CMS-2S, Reflex, and PASS) showed similar performances.
Pavement Construction: Percent Within Limit Specifications

(Sponsor: Nevada DOT)
Develop PWL System for NDOT
(PWL = the percent of a lot falling within set specification limits)

**Proposed Specs:**
PWL process considers both the actual value of the measured property and its associated variability

**Current Specs:**
Pass/No pass specifications

---

<table>
<thead>
<tr>
<th>Individual measurement</th>
<th>Limit</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% Violation = 28%
Develop PWL System for NDOT

Example

<table>
<thead>
<tr>
<th>Lot</th>
<th>Mean</th>
<th>STD</th>
<th>PWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.0</td>
<td>0.20</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
<td>0.40</td>
<td>67</td>
</tr>
<tr>
<td>3</td>
<td>4.8</td>
<td>0.20</td>
<td>84</td>
</tr>
</tbody>
</table>

Target Value: 5.0
Limits: ± 0.4

Asphalt Binder Content (%)
Research Phases

- **Phase I – Review of Existing PWL Specification Systems**
  - Literature review
  - General framework for the development of the PWL system was recommended for Phase II

- **Phase II – Develop the PWL Specification System**
  - PWL system was developed including several materials and mixtures properties to identify the PWLs for all sublots and lots of HMA mixtures
  - Weight factors are identified for each of the mixtures properties leading to the development of a single PWL for each lot within a construction project

- **Phase III – Implement the Specifications**
  - Implement the developed PWL system on several NDOT projects
  - Use the data to fine tune the system as needed
Weight Factors, Overall PWL, & Pay Factors

- Weight factors determined based on the findings from the NDOT study on “Impact of Construction Variability on Pavement Performance.”

  - Gradation: 25%
  - Asphalt Binder Content: 33%
  - Compaction (i.e., Mat Density): 42%

\[
PWL_{Overall} = 0.25 \cdot PWL_{Gradation} + 0.33 \cdot PWL_{AC} + 0.42 \cdot PWL_{Compaction}
\]

\[
PF = 55 + (0.5 \times PWL_{Overall})
\]

A 100% pay will be provided to the contractor at a PWL of 90%. Maximum PF will be at 105%.
**Develop PWL System for NDOT**  
**Proposed Implementation Plan**

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
<th>Pay factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 2014</td>
<td>Apply PWL system on pilot projects.</td>
<td>Pay factors will not be implemented.</td>
</tr>
<tr>
<td>Year 2015</td>
<td>The 100% pay will be provided at an overall PWL of 70.</td>
<td>The maximum pay factor is fixed at 100%.</td>
</tr>
<tr>
<td>Year 2016</td>
<td>The 100% pay will be provided at an overall PWL of 80.</td>
<td>The maximum pay factor is fixed at 100%.</td>
</tr>
<tr>
<td>Year 2017</td>
<td>The 100% pay will be provided at an overall PWL of 90.</td>
<td>The maximum pay factor is fixed at 105%.</td>
</tr>
</tbody>
</table>
Cost-Effectiveness and Optimum Application of Slurry Seal
(Sponsor: Washoe County RTC)
Effectiveness of Slurry Seal

Problem Statement and Objective

- Time of application is left to the Project Engineer judgment and practice:

- Identify the optimal timing for the application of slurry seal on asphalt pavements in the Truckee Meadows Region.
  - Phase I: *Single application* of slurry seal.
  - Phase II: *Two sequential application* of slurry seal.
Effectiveness of Slurry Seal

Research Plan

- Road Class: Arterial, Collector, Residential.
- Performance measured in terms of PCI (0-100).
  - Do-Nothing: SS was not applied to the pavement.
  - Phase I: Single Application
    - SS applied immediately after construction (referred to as 0).
    - SS applied at either: 1, 3, 5, 7, or 9 years after construction.
  - Phase II: Two sequential Application
    - First SS at either 0, 1, 3 or 5 years / Second SS at either 7 or 9 years.
Slurry Seal Applications (Example)

- **Performance Life ~ 2 yrs**
- **Extension in Pavement Service Life ~ 2 yrs**

**Graph 1:**
- Graph shows the relationship between Age in Years and Pavement Condition Index (PCI) for New Construction and Slurry Seal at year 3.

**Graph 2:**
- Graph shows the comparison of different interventions, including Do-Nothing, Slurry Seal at year 3, and New Construction, with indications for Performance Life (~2 yrs) and Extension in Pavement Service Life (~2 yrs).

**Legend:**
- Green line: New Construction
- Red line: Slurry Seal at year 3

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Phase I: Single Application of Slurry Seal
SS Effectiveness

Relative Benefit = 100 × B / B₀

Benefit Cost Ratio = B / C
Effectiveness of Slurry Seal
Summary of Findings

• Application of SS **immediately or one year after** construction is **not effective**.

• In general, the *pavement service life was not extended by application of the single slurry seal*.

• Optimum timing for sequential application:

  NC/OL  SS  SS
  
  0  1  2  3  4  5  6  7  8  9  10  11  12  13....

  ➔ Pavement service life extended by **2.0~4.0 years**
Optimum Timing for Slurry Seal Application
Overall Recommendations

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>1(^{st}) Slurry Seal Application</th>
<th>2(^{nd}) Slurry Seal Application</th>
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</thead>
<tbody>
<tr>
<td>New</td>
<td>87-90</td>
<td>86</td>
</tr>
<tr>
<td>Overlay</td>
<td>85-87</td>
<td>77</td>
</tr>
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</table>
01-50: Quantifying the Influence of Geosynthetics on Pavement Performance
(Sponsor: National Cooperative Highway Research Program)
NCHRP 01-50: Research Objective

- To develop a methodology for quantifying the *influence of geosynthetics* on pavement performance for use in pavement design & analysis.
  - Be consistent with the MEPDG framework to facilitate incorporation into the MEPDG
  - Be concerned with using geosynthetics in unbound base/subbase layers *for flexible & rigid pavements*
1. Assess vertical pressure distributions above/below geosynthetic layer;
2. Assess tensile stress/strain distribution within geosynthetic;
3. Assess deformed shape of geosynthetic;
4. Assess confinement of materials provided by geosynthetic;
5. Assess slippage condition at the geosynthetic/unbound material interface.
Subgrade Compaction

Completed Subgrade Placement
Subgrade Pressure Cell

Excavated Base Area for Instrumentation
NCHRP 01-50: Surface Instrumentation

Surface LVDT’s and Accelerometers

Loading Actuator and Plate
Thank You!

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