Pavement Renewal Solutions
Presentation Overview

• Need for more effective long-life pavement
• Pavement Renewal Solutions
  – Product Elements
  – Research
• Long-Life Approaches for 30-50 Years
• Details of Guides
• Details of rePave
• State Pavement Assessments
• Washington State Example
• Resources
Transportation Needs

• State and local transportation agencies need innovative ways to speed up the delivery of needed infrastructure improvements at lower costs.
• Incorporating existing pavement into pavement rehabilitation projects can lead to cost-effective results.
• Reusing existing pavement reduces costs, including hauling and dumping costs, and shrinks construction timelines.
• Projects can be accelerated by reusing existing pavement, alleviating the need to remove and dispose of it offsite.
Pavement Renewal Solutions

• Developed through the second Strategic Highway Research Program (SHRP2)

• Product elements:
  – Pavement Assessment Manual
  – Best Practices (design and construction)
    • Rigid Pavements
    • Flexible Pavements
  – Guide Specifications
  – Traffic Considerations
  – Life-Cycle Cost Analysis
  – Life-Cycle Assessment
  – Emerging Technologies
## Pavement Renewal Solutions

<table>
<thead>
<tr>
<th>Product</th>
<th>Benefits</th>
</tr>
</thead>
</table>
| **rePave Scoping Tool** | ✓ Will encourage longer lasting designs.  
✓ Realistic scoping assessments and easy to use.  
✓ Guides user through data gathering process. |
| **Project Assessment Manual (including Life Cycle Assessment, Traffic)** | ✓ Combines traditional rehabilitation data needs with up-to-date tools such as CA4PRS (construction productivity and work zones). |
| **Best Practices: Flexible and Rigid** | ✓ Document practices that are critical for designing and constructing long lasting pavements.  
✓ Combine key practices with specifications. |
| **Guide Specifications** | ✓ Specification elements can be incorporated in preexisting agency standard specifications. |
| **LCCA, Emerging Technologies** | ✓ Encourage use of LCCA.  
✓ Create awareness of emerging pavement technologies. |
### Pavement Renewal Systems

**How they work**

<table>
<thead>
<tr>
<th></th>
<th>Assessment</th>
<th>Scoping</th>
<th>Design</th>
<th>PS&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>rePave Scoping Tool</strong></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓ access to resources</td>
</tr>
<tr>
<td></td>
<td>Interactive decision matrix for identifying and selecting pavement renewal strategies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Assessment Manual</strong></td>
<td></td>
<td></td>
<td>Use Standard State Design Process (ie: AASHTO Pavement ME, PerRoad, etc.)</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Best Practices: Flexible and Rigid</strong></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Guide Specifications</strong></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>LCCA, Emerging Technologies</strong></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Identified and confirmed which design approaches would provide 30 to 50 years service with little structural damage

• Conducted extensive literature review.
• Queried many other countries for information on what they did and how long it lasted.
• Analyzed the LTPP Database for treatment approaches and performance.
• Where the LTPP data did not have sufficient performance history, ran numerous PerRoad and MEPDG design analyses to estimate service life for a range of LTPP sites.
Research

- Visited seven agencies to review what they did, how it performed (site visits) and worked with them to help develop the guidelines and provide feedback on the Guidelines.
- Developed test cases with each Agency and conducted a number of workshops to review and refine the guidelines.
Long-Life Approaches (30-50 years)

- Unbonded PCC overlays of flexible pavement.
- Unbonded PCC overlays of rigid pavements.
- Bonded CRCP overlays of CRCP.
- HMA overlays of rigid pavements.
  - With rubbilization of PCC pavement.
  - With crack and seating of JPCP.
  - With saw crack and seating of JRCP.
- HMA overlays of flexible pavement.
  - Provided all stripping, fatigue cracking, thermal cracking is addressed.
Long-Life Approaches (30-50 years)

For Long-Life PCCP - Snyder Rigid BP
Long Life Approaches (30-50 years)

Thickness Limits for Long Life

Smith & Peshkin

TRL – Reflection Cr HMA

LTPP Data

SHRP2 Pavement Renewal Solutions | December 2014
Long-Life Approaches (30-50 years)

Flexible design tables built using PerRoad and checked with MEPDG using limited strain criteria. The design runs were made using load spectra, and then converted to ESALs.

Thompson et al 2007
<table>
<thead>
<tr>
<th>Resources to Enhance Use of Design Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Assessment Manual</strong></td>
</tr>
<tr>
<td><strong>Guide Specifications</strong></td>
</tr>
<tr>
<td><strong>Best Practices Rigid</strong></td>
</tr>
<tr>
<td><strong>Best Practices Flexible</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SHRP2 R23</th>
<th>Using Existing Pavement in Place and Achieving Long Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft</td>
<td>March 23, 2011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SHRP2 Best Practices Rigid Guide Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft</td>
</tr>
<tr>
<td>April 17, 2011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SHRP2 Best Practices Flexible Guide Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft</td>
</tr>
<tr>
<td>April 17, 2011</td>
</tr>
</tbody>
</table>
Decision Matrix: Multiple Selection Tables

Selection tables a function of existing pavement type, distress types and levels, and subgrade support → renewal options.
Decision Matrix: Design Tables

Thirteen design tables were developed to provide an estimate of pavement thickness required for long life pavements.

Table 1. HMA Thicknesses for Remove and Replace and Overlays
(Appplies to Rules 1A, 1B, 1C, 2A, 2B, 2C, 3A, 3B)

<table>
<thead>
<tr>
<th>ESALs (millions)</th>
<th>Existing Pavement or Base Modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30,000 psi</td>
</tr>
<tr>
<td>≤10</td>
<td>10.0</td>
</tr>
<tr>
<td>10-25</td>
<td>11.0</td>
</tr>
<tr>
<td>25-50</td>
<td>12.0</td>
</tr>
<tr>
<td>50-100</td>
<td>13.0</td>
</tr>
<tr>
<td>100-200</td>
<td>14.0</td>
</tr>
</tbody>
</table>

HMA Overlay for Subgrade Mₚ = 5,000 psi.

HMA Overlay for Subgrade Mₚ = 10,000 psi.

HMA Overlay for Subgrade Mₚ = 20,000 psi.
Interactive Program rePave

A web-based application was developed to simplify the selection process and provide a platform for the background information needed to design and build long life pavements.
rePave Scoping Tool (Interactive Program)

A web-based, user-friendly means of walking through the decision making process (selection and design tables).

A user-friendly means of navigating a large amount of information (required to produce long-life pavements).
Step 1: Project Information

Interstate 5, through Seatac (Demo)

Project Information

- **Project Name**: NW Region Project 5906
- **Route**: Interstate 5
- **Location**: Washington
- **Location Description**: Interstate 5 Southbound, 2 mi. North of 5 320th to 320th. Lanes 1-3.
- **Project Description**: Cracked panel renewal
Step 2: Existing Section

Interstate 5, through SeaTac (Demo)

Existing Pavement

Number of through lanes: 5, one direction

Pavement Type: Rigid

Cross Section

<table>
<thead>
<tr>
<th>Layer</th>
<th>Type</th>
<th>Depth</th>
<th>Date Constructed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JPCP</td>
<td>7&quot;</td>
<td>1960</td>
</tr>
<tr>
<td>2</td>
<td>Granular Base</td>
<td>9&quot;</td>
<td>1960</td>
</tr>
</tbody>
</table>
**Step 3: Future Section**

**Interstate 5, through SeaTac (Demo)**

### Proposed Pavement

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Period</td>
<td>50 years</td>
</tr>
<tr>
<td>Subgrade $M_v$</td>
<td>20,000 psi CBR = 13%</td>
</tr>
<tr>
<td>ESALs</td>
<td>1.2 millions per year</td>
</tr>
<tr>
<td>Growth Rate</td>
<td>2.4%</td>
</tr>
<tr>
<td>Current ADT</td>
<td>110,000 all lanes, one direction</td>
</tr>
<tr>
<td>Number of through lanes</td>
<td>5 one direction 0 lane added</td>
</tr>
<tr>
<td>Height Restrictions</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Height: 12 above current surface (inches)
Step 4: Existing Distress

Interstate 5, through SeaTac (Demo)

Existing Pavement Condition

- **Pavement Cracking**
- **Joint Faulting**
- **Materials Distress**
- **Pumping**

% of crack panels: 25
Step 5: Renewal Options

Interstate 5, through Seatac (Demo)

1. Renewal type option: Flexible

2. Select a Recommended Action

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack and Seat existing rigid pavement and overlay with thick HMA</td>
<td>Crack and Seat existing rigid pavement to minimize reflection cracking. Refer to section on cracking and seating in the Flexible Best Practices for details.</td>
</tr>
<tr>
<td>Rubblize existing PCC pavement and overlay with HMA</td>
<td>Rubblize the existing rigid pavement to minimize or eliminate reflection cracking then place thick HMA overlay. Refer to section on rubblization in the Rigid Best Practices for rubblization details.</td>
</tr>
</tbody>
</table>

3. Select existing Base Modulus: 50,000 psi
Step 6: Summary

Interstate 5, through Seatac (Demo)

Renewal Design

<table>
<thead>
<tr>
<th>Existing</th>
<th>Proposed</th>
<th>Recommended Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New Pavement - 8.5&quot;</td>
<td>Renewal Type: Flexible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Design Period: 50 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Design ESALs: 114 million</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subgrade HR: 20,000 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pre-existing Pavement or Base Modulus: 75,000 psi</td>
</tr>
<tr>
<td>JPCP 7&quot;</td>
<td>C+S PCC - 7&quot;</td>
<td>Actions: Crack and seal existing rigid pavement to minimize reflection cracking. Refer to section on cracking and sealing in the Flexible Best Practices for details.</td>
</tr>
<tr>
<td>Granular Base 9&quot;</td>
<td>Granular Base 9&quot;</td>
<td>Renewal Removed: 0&quot;</td>
</tr>
<tr>
<td>Subgrade</td>
<td>Subgrade</td>
<td>Existing Pavement: 16&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Estimated Total Design Thickness: 8.5&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New Pavement: 8.5&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Added Elevation: 0.5&quot;</td>
</tr>
</tbody>
</table>

Flexible Best Practices

Guide Specification
Coming Enhancements:
Single Sign On
Coming enhancements:
Organize and Share
# Coming enhancements: Comparison feature

## Compare

<table>
<thead>
<tr>
<th>Name</th>
<th>Project Name #1</th>
<th>Project Name #2</th>
<th>Project Name #3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Info</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of through lanes</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Pavement Type</td>
<td>Rigid</td>
<td>Rigid</td>
<td>Rigid</td>
</tr>
<tr>
<td>Surface Type</td>
<td>JPCP</td>
<td>JPCP</td>
<td>JPCP</td>
</tr>
<tr>
<td>Cross Section</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Proposed Section** |                 |                 |                 |
| Estimated Total Design Thickness | 8.5" | 10" | 11.5" |
| New Pavement        | 8.5"           | 10"            | 13.5"           |
| Added Elevation     | 8.5"           | 10"            | 13.5"           |
| Cross Section       |                 |                 |                 |

- **Check Height**: ✔ ✔ ✔
State Pavement Assessments

• Explain the research and results identifying and analyzing long life pavement renewal systems including precast concrete and composite pavement.
  – Discuss the identified techniques.
  – Discuss the decision making guides.
  – Discuss the interactive web tool rePave.

• Review other resources to enhance use of design guidelines and what they include.

• Discuss individual use of Guideline Specifications.

• Present WSDOT early use experience.
Project Assessment Manual: Topics

- Pavement Distress Surveys
- Rut Depth and Roughness
- NDT via FWD
- Ground Penetrating Radar
- Pavement Cores
- Dynamic Cone Penetrometer
- Subgrade Sampling and Tests
- Traffic Loads for Design
- Construction Productivity and Traffic Impacts
- Life Cycle Assessment
- Material Properties
Construction Productivity and Traffic Impacts

• Construction Productivity.
• Largely built around CA4PRS (Construction Analysis for Pavement Rehabilitation Strategies).
• Typical CA4PRS input data summarized for:
  – Crack and seat followed by HMA overlay.
  – PCC overlay.
Construction Productivity and Traffic Impacts

- **PCC Overlay Scenario**

- **10-hour Night Closure (not feasible)**
- **55-hour Weekend Closure**
- **168-hour 24/7 Continuous Week-Long Closure**

**Construction Productivity Chart**

- **Y-axis**: Thickness of Pavement Constructed (inches)
- **X-axis**: Lanes-Miles Constructed in One Closure

- **Legend**:
  - Blue line: 10-hour Night Closure (not feasible)
  - Red line: 55-hour Weekend Closure
  - Green line: 168-hour 24/7 Continuous Week-Long Closure
Flexible Best Practices: Strategies

- Introduction

- HMA Renewal Strategies.
  - HMA over HMA renewal methods.
    - HMA over existing HMA pavement.
    - HMA over reclaimed HMA (recycling).
  - HMA over PCC renewal methods.
    - HMA over existing HMA-surfaced composite pavements.
    - HMA over crack and seated JPC pavements.
    - HMA over saw, crack-and-seat JRC pavements.
    - HMA over rubblized JPC pavements.
    - HMA over existing CRC pavements.
HMA Overlays over Existing HMA Pavements

- Criteria for Long Life Potential:
  - The surface condition is good and the structural capacity of the existing AC pavement is adequate for a potential long-life pavement.
  - There is no evidence of stripping in any of the existing HMA layers (determined through coring and/or GPR testing).
  - Proper repair and surface preparation is provided for the existing surface layer, and a good tack/bond coat is provided.
  - The existing drainage system is in good working condition, or adequate drainage is provided.
## Summary Tables

<table>
<thead>
<tr>
<th>Best Practice</th>
<th>Why this practice?</th>
<th>Typical Specification Requirements</th>
</tr>
</thead>
</table>
| HMA Density     | HMA density is a function of numerous variables (mix, layer thickness, weather, etc) and is crucial in constructing long-lasting HMA layers. Air void levels greater than 7 to 8% result in accelerated fatigue and increased permeability. | • The average target % of TMD should range between 93 and 94% for dense graded mixes.  
• Use of a lift thickness governed by t/NMAS ≥ 4 will aid the compaction process.  
[Refer to Elements for AASHTO Specification 401 for more details] |

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[RecommenDations for the Design and Construction of Long Life Flexible Pavement Alternatives Using Existing Pavements](image-url)
HMA Construction: Quality Control

- Density: Dense-graded mixes \( \geq 93\% \) of TMD.
- Segregation: Temperature variation is featured.

Example of segregated pavement

Thermal image during paving
Rigid Best Practices: Strategies

- Introduction

- Rigid Renewal Strategies
  - Unbonded Concrete Overlays of Concrete Pavements
  - Unbonded Concrete Overlays of HMA Pavements
  - Bonded Concrete Overlays of Concrete Pavements
Rigid Best Practices: Details

• Unbonded Concrete Overlays of Concrete Pavements
  – Criteria for Long Life Potential
  – Materials Considerations
    • Cementitious Materials
    • Aggregate
    • Chemical Admixtures
  – Separator Layers
  – Other Materials
  – Design Considerations
  – Structural Design and Joint Design Considerations
### Summary: UBO of Concrete Pavements and Specifications

#### Best Practice

- Why this Practice?
- Typical Specification Requirements

<table>
<thead>
<tr>
<th>Best Practice</th>
<th>Why this practice?</th>
<th>Typical Specification Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing pavement and pre-overlay repairs.</td>
<td>The preparation of the existing pavement is important for achieving long-life from the unbonded concrete overlay.</td>
<td><strong>Existing Pavement Condition</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Faulting ≤ 10mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Faulting &gt; 10 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Significant tending, shattered slabs, pumping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severe joint spalling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CRCP w/punchouts</td>
</tr>
</tbody>
</table>

[Refer to Elements for AASHTO Specifications SS2, SS7, SS8 for additional details]

- Overlay thickness and joint details.
  - Thickness and joint details are critical for long-life performance.
  - Overlay thickness ≥ 9 in.
  - Transverse joint spacing not to exceed 15 ft. when slab thicknesses are in excess of 9 in.
  - Joints should be doweled; dowel diameter should be a function of slab thickness. The recommended dowel bar sizes are:
    - For 9“-10”-1.25” diameter minimum
    - For > 10”-1.5” diameter minimum
  - Dowels should be corrosion resistant

[Refer to Elements for AASHTO Specifications S63 for additional details]

- Interlayer between overlay and existing pavement.
  - Interlayer thickness and conditions prior to placing the concrete overlay influence long-life performance and early temperature stress in the new slabs.
  - The interlayer material shall be a minimum of 1 in. thick new bituminous material.
  - Surface temperature of HMA interlayer shall < 90°F prior to overlay placement.

[Refer to Elements for AASHTO Specifications S63 for additional details]

- Concrete overlay materials.
  - Supplementary cementitious materials may be used to replace a maximum of 40 to 50% of the portland cement.

[Refer to Elements for AASHTO Specifications S63 for additional details]
Guide Specifications

• Introduction
• Specifications not contained in the AASHTO Guide Specifications
• Elements for AASHTO Guide Specifications
• AASHTO and State DOT Specification Summaries
# Recommended Pavement Renewal Solutions

## Specification Elements AASHTO Section 404 Tack Coat

<table>
<thead>
<tr>
<th>AASHTO Paragraph</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>404.02 Materials</td>
<td>Binding asphalt (AASHTO 404, Texas 340, Virginia 310) in accordance with local practice</td>
<td>AASHTO 404, Texas 340, Virginia 310</td>
</tr>
<tr>
<td>404.03 Construction</td>
<td>Weather Limitations</td>
<td>AASHTO 404, Michigan 501</td>
</tr>
<tr>
<td></td>
<td>Surface Preparation</td>
<td>AASHTO 404, Minnesota 2357, Missouri 407</td>
</tr>
<tr>
<td></td>
<td>Application Surfaces</td>
<td>Michigan 501, Texas 340</td>
</tr>
<tr>
<td></td>
<td>Application Rate</td>
<td>Range generally falls within most state limits</td>
</tr>
<tr>
<td></td>
<td>Application Temperatures</td>
<td>Study Team</td>
</tr>
</tbody>
</table>

Source refers to AASHTO and State Specifications.
Pavement Renewal Solutions
Early Use Case: WSDOT

• WSDOT used Pavement Renewal Solutions products on a time sensitive project on Interstate 5 to help identify the best long-term renewal approach for the agency.
  – Performed Pavement Assessment.
  – Formal designs and thicknesses were comparable to that of the Pavement Guidelines so felt confident.
  – Used the Guide Specs to help shape specs for project.
  – Final design resulted in crack, seat, overlay over existing PCC.
WSDOT used Pavement Renewal Solutions products on a time sensitive project on Interstate 5 to help identify the best long-term renewal approach for the agency.

“It helped us identify our renewal options, understand how to specify them, and define best practices for implementation, without stumbling through several weeks of analysis”

Jeff Uhlmeyer
State Pavement Engineer
Access all the products at:

www.pavementrenewal.org