



SHRP2 SOLUTIONS

TOOLS FOR THE ROAD AHEAD

Pavement Renewal Solutions

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO
The Voice of Transportation

Transportation Research Board
of the National Academies
TRB

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

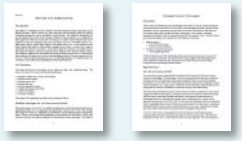
Transportation Needs

- 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

Product	Benefits
 ***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

	Assessment	Scoping	Design	PS&E
***rePave* Scoping Tool**	✓ Interactive decision matrix for identifying and selecting pavement renewal strategies		Use Standard State Design Process (ie: AASHTO Pavement ME, PerRoad, etc.)	✓ access to resources
Project Assessment Manual	✓ Guidelines for data collection, testing, etc. required for assessment and scoping			
Best Practices: Flexible and Rigid		✓		✓
Guide Specifications				✓
LCCA, Emerging Technologies		✓		

Research

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.

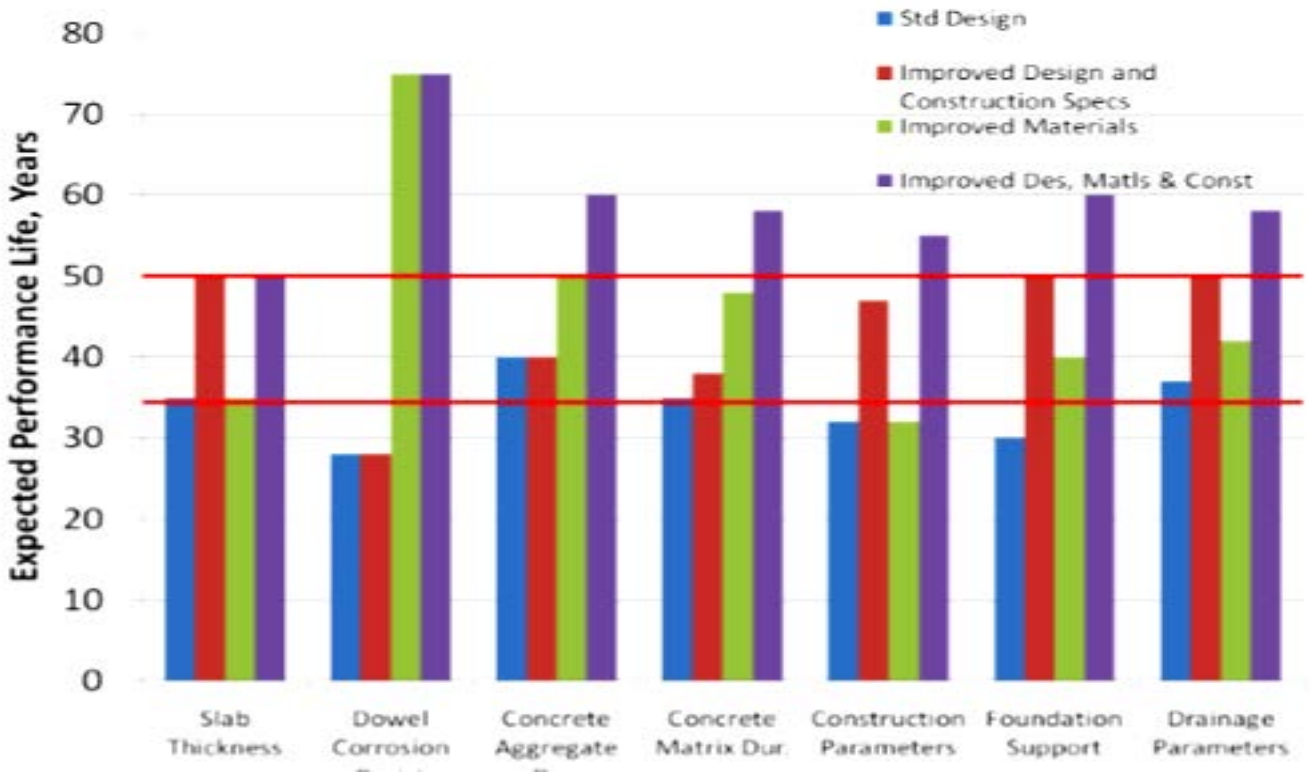


Long-Life Approaches (30-50 years)

- 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)

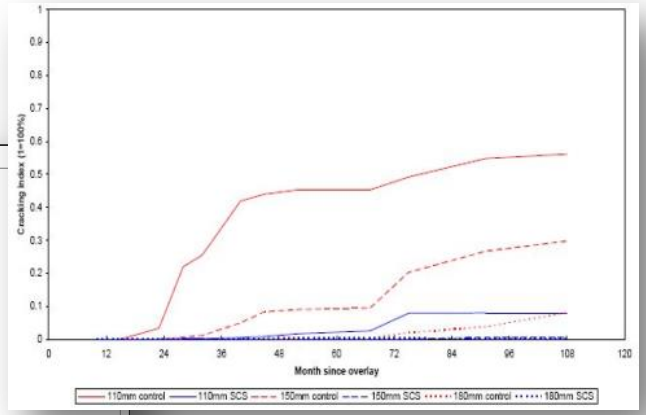
For Long-Life PCCP - Snyder Rigid BP



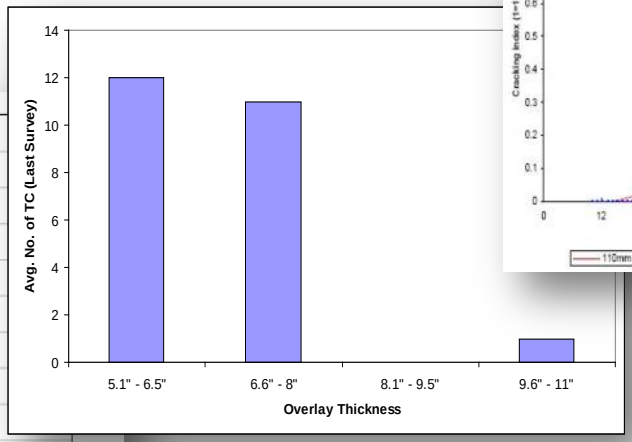
Long Life Approaches (30-50 years)

Thickness Limits for Long Life

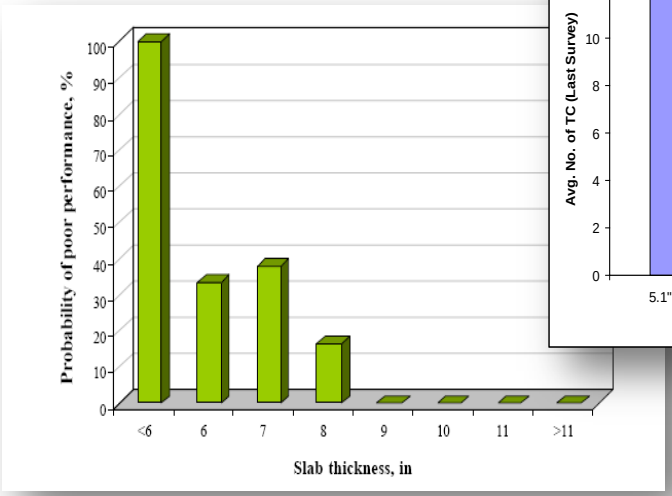
TRL – Reflection Cr HMA



LTPP Data

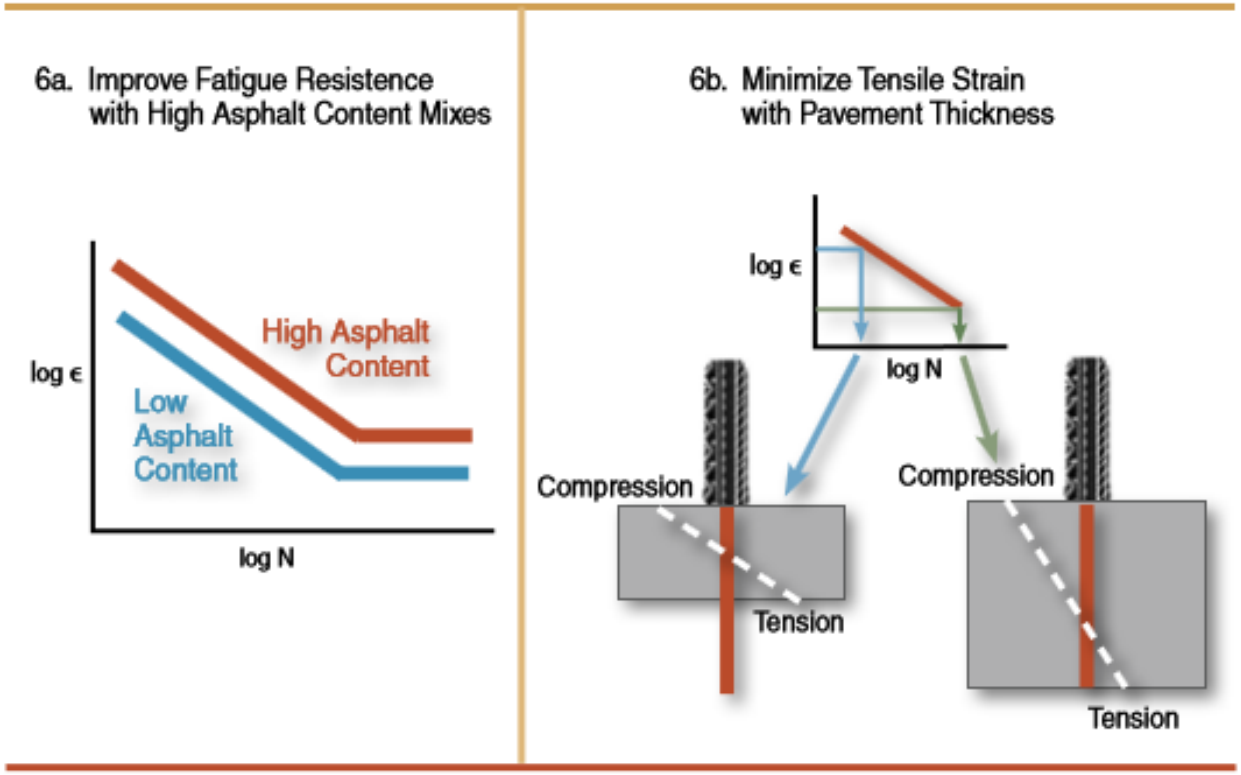


Smith & Peshkin



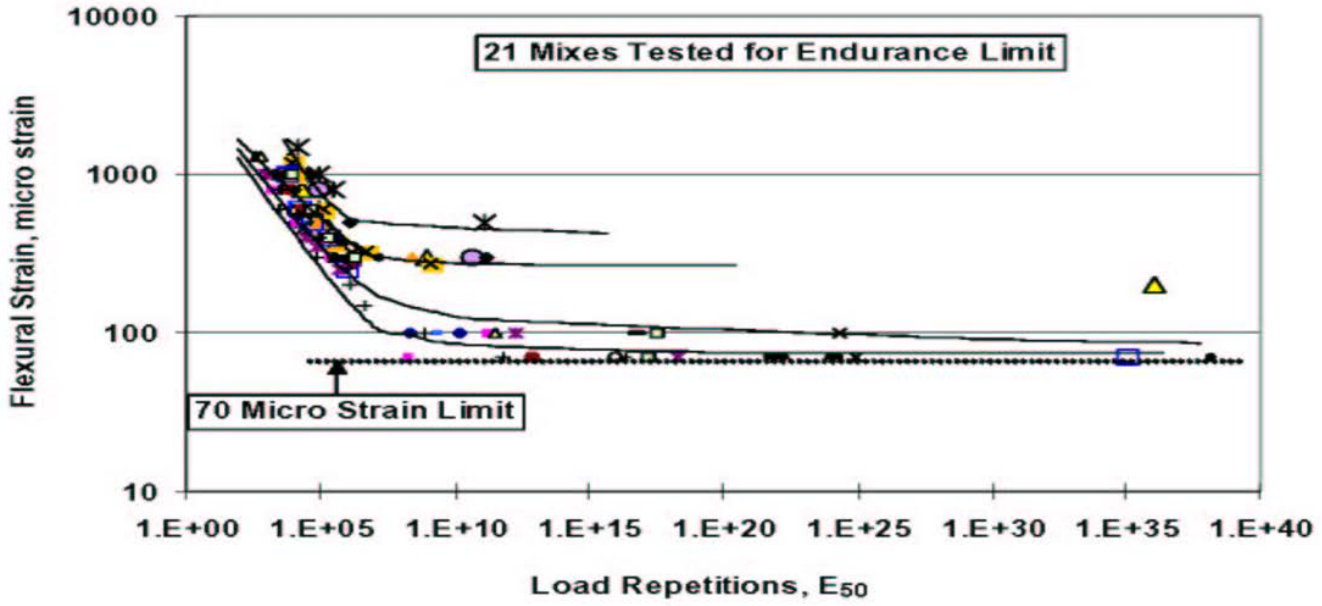
Long-Life Approaches (30-50 years)

For Long-Life HMA – Limiting Strain Criteria – APA IM-40.



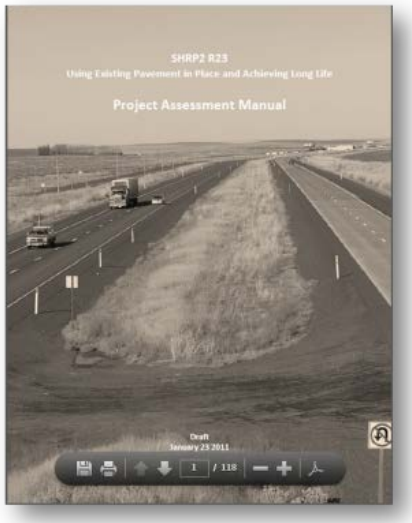
Long Life Approaches (30-50 years)

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.

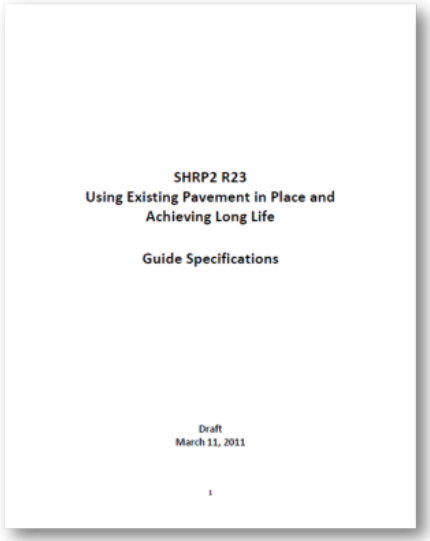


Thompson et al 2007

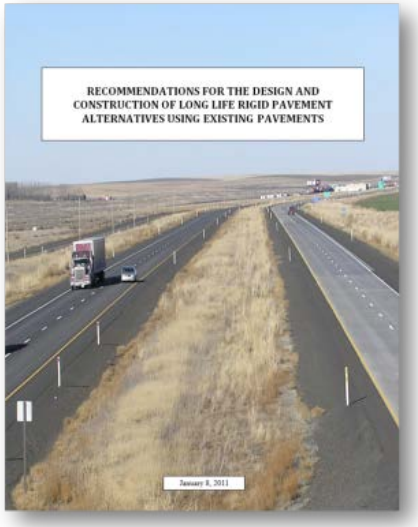
Resources to Enhance Use of Design Guidelines



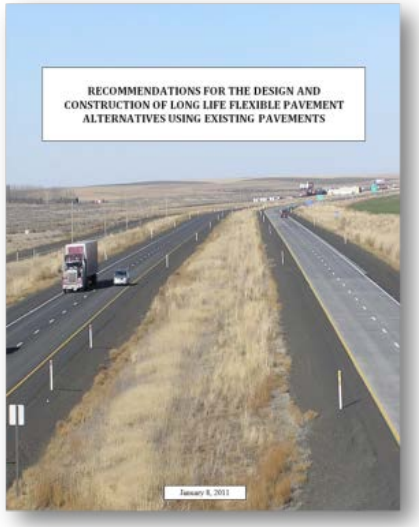
Project Assessment Manual



Guide Specifications



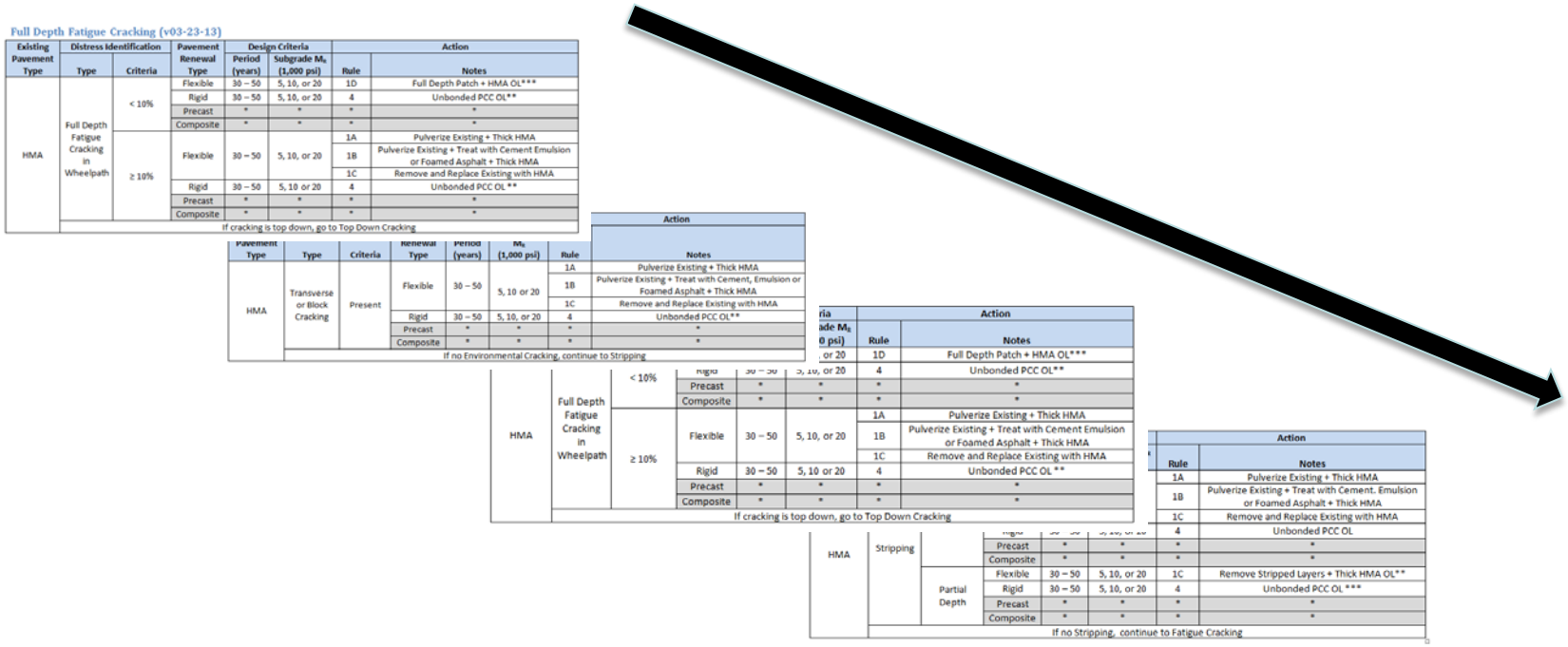
Best Practices Rigid



Best Practices Flexible

Decision Matrix: Multiple Selection Tables

Selection tables a function of existing pavement type, distress types and levels, and subgrade support → renewal options.



Full Depth Fatigue Cracking (v03-23-13)

Existing Pavement Type	Distress Identification		Pavement Renewal Type	Design Criteria		Action	
	Type	Criteria		Period (years)	Subgrade M_R (1,000 psi)	Rule	Notes
HMA	Full Depth Fatigue Cracking in Wheelpath	< 10%	Flexible	30 – 50	5, 10, or 20	1D	Full Depth Patch + HMA OL***
			Rigid	30 – 50	5, 10, or 20	4	Unbonded PCC OL**
			Precast	*	*	*	*
			Composite	*	*	*	*
		≥ 10%	Flexible	30 – 50	5, 10, or 20	1A	Pulverize Existing + Thick HMA
						1B	Pulverize Existing + Treat with Cement Emulsion or Foamed Asphalt + Thick HMA
						1C	Remove and Replace Existing with HMA
			Rigid	30 – 50	5, 10 or 20	4	Unbonded PCC OL **
			Precast	*	*	*	*
			Composite	*	*	*	*
	If cracking is top down, go to Top Down Cracking						

Pavement Type	Type	Criteria	Renewal Type	Period (years)	M_R (1,000 psi)	Action	
						Rule	Notes
HMA	Transverse or Block Cracking	Present	Flexible	30 – 50	5, 10 or 20	1A	Pulverize Existing + Thick HMA
						1B	Pulverize Existing + Treat with Cement, Emulsion or Foamed Asphalt + Thick HMA
						1C	Remove and Replace Existing with HMA
			Rigid	30 – 50	5, 10, or 20	4	Unbonded PCC OL**
			Precast	*	*	*	*
			Composite	*	*	*	*
	If no Environmental Cracking, continue to Stripping						

ria					Action	
ade M_R 0 psi)					Rule	Notes
, or 20			Rigid	30 – 50	1D	Full Depth Patch + HMA OL***
			Precast	*	4	Unbonded PCC OL**
			Composite	*	*	*
					*	*
			Flexible	30 – 50	1A	Pulverize Existing + Thick HMA
		≥ 10%			1B	Pulverize Existing + Treat with Cement Emulsion or Foamed Asphalt + Thick HMA
					1C	Remove and Replace Existing with HMA
			Rigid	30 – 50	4	Unbonded PCC OL **
			Precast	*	*	*
			Composite	*	*	*
	If cracking is top down, go to Top Down Cracking					

						Action	
						Rule	Notes
HMA	Stripping			Rigid		1A	Pulverize Existing + Thick HMA
				Precast		1B	Pulverize Existing + Treat with Cement, Emulsion or Foamed Asphalt + Thick HMA
				Composite		1C	Remove and Replace Existing with HMA
		Partial Depth		Flexible	30 – 50	4	Unbonded PCC OL
				Rigid	30 – 50	*	*
				Precast	*	*	*
				Composite	*	*	*
	If no Stripping, continue to Fatigue Cracking						

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
(Applies to Rules 1A, 1B, 1C, 2A, 2B, 2C, 3A, 3B)

HMA Overlay for Subgrade M_R = 5,000 psi.

ESALs (millions)	Existing Pavement or Base Modulus			
	30,000 psi	50,000 psi	75,000 psi	100,000 psi
≤10	10.0	9.0	8.0	6.0
10-25	11.0	10.0	8.5	6.5
25-50	12.0	11.0	9.0	7.0
50-100	13.0	11.5	9.5	7.5
100-200	14.0	12.0	10.0	7.5

HMA Overlay for Subgrade M_R = 10,000 psi.

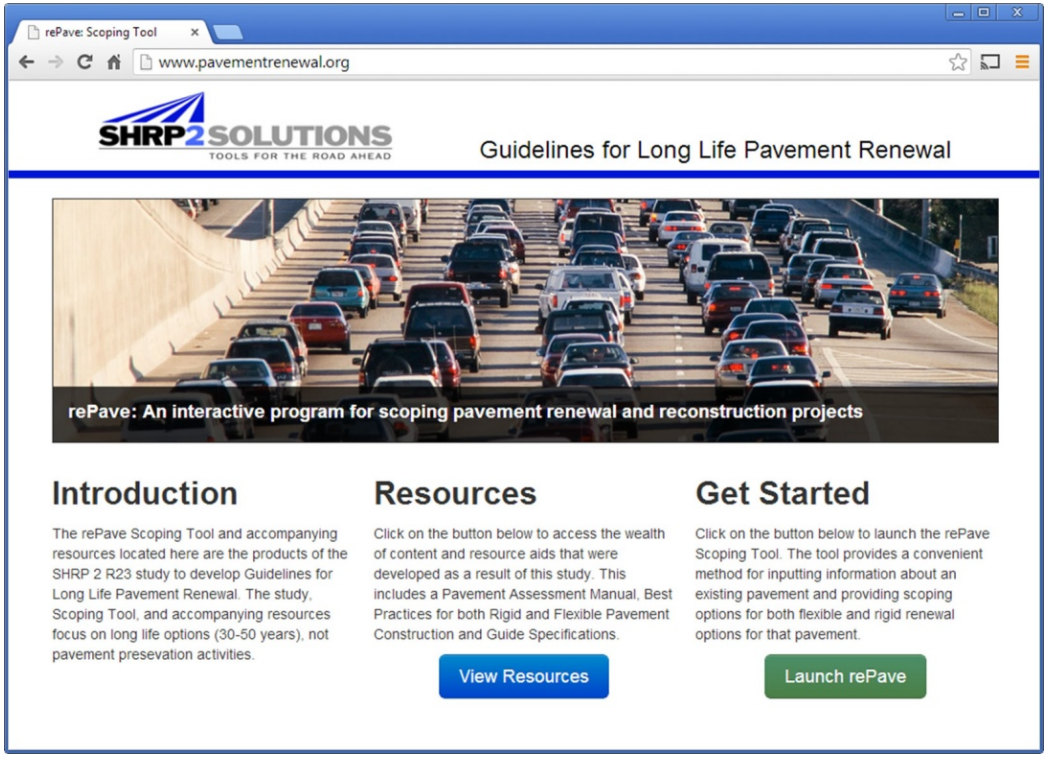
ESALs (millions)	Existing Pavement or Base Modulus			
	30,000 psi	50,000 psi	75,000 psi	100,000 psi
≤10	10.0	8.0	7.0	6.0
10-25	11.0	9.0	8.0	6.5
25-50	12.0	9.5	8.5	7.0
50-100	12.0	10.0	8.5	7.0
100-200	13.0	11.0	9.0	7.0

HMA Overlay for Subgrade M_R = 20,000 psi.

ESALs (millions)	Existing Pavement or Base Modulus			
	30,000 psi	50,000 psi	75,000 psi	100,000 psi
≤10	9.5	7.5	6.5	5.5
10-25	10.0	8.5	7.0	6.0
25-50	11.0	9.0	7.5	6.5
50-100	11.5	9.5	8.0	6.5
100-200	12.0	10.0	8.5	7.0

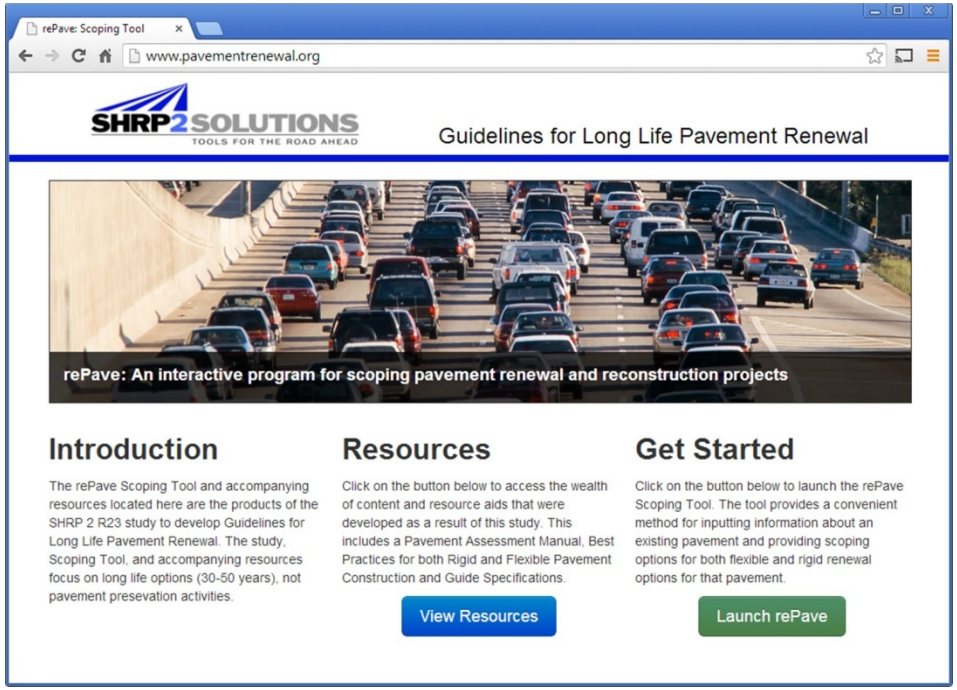
Interactive Program rePave

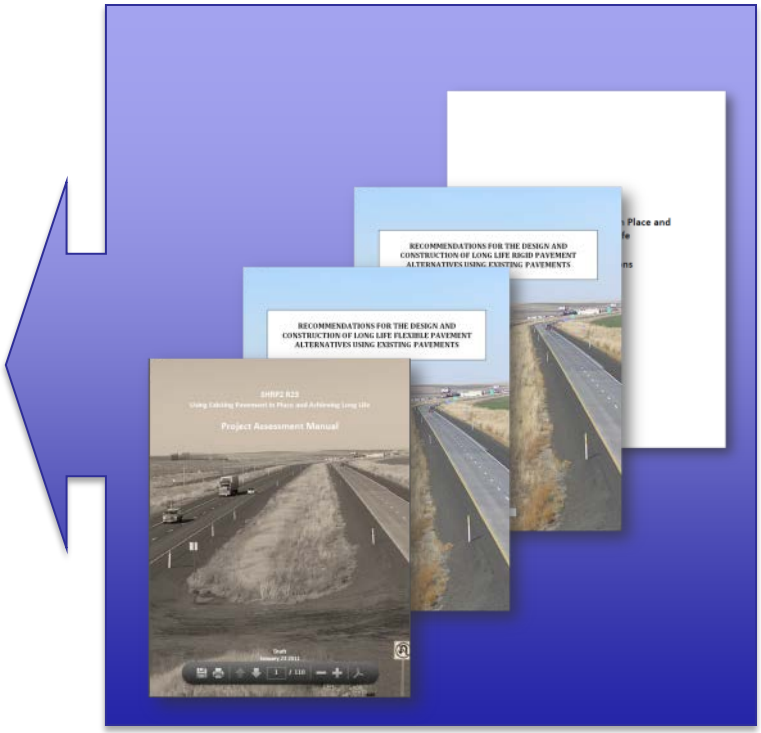
A web-based application was developed to simplify the selection process and provide a platform for the background information needed to design and build long life pavements.



rePave Scoping Tool (Interactive Program)

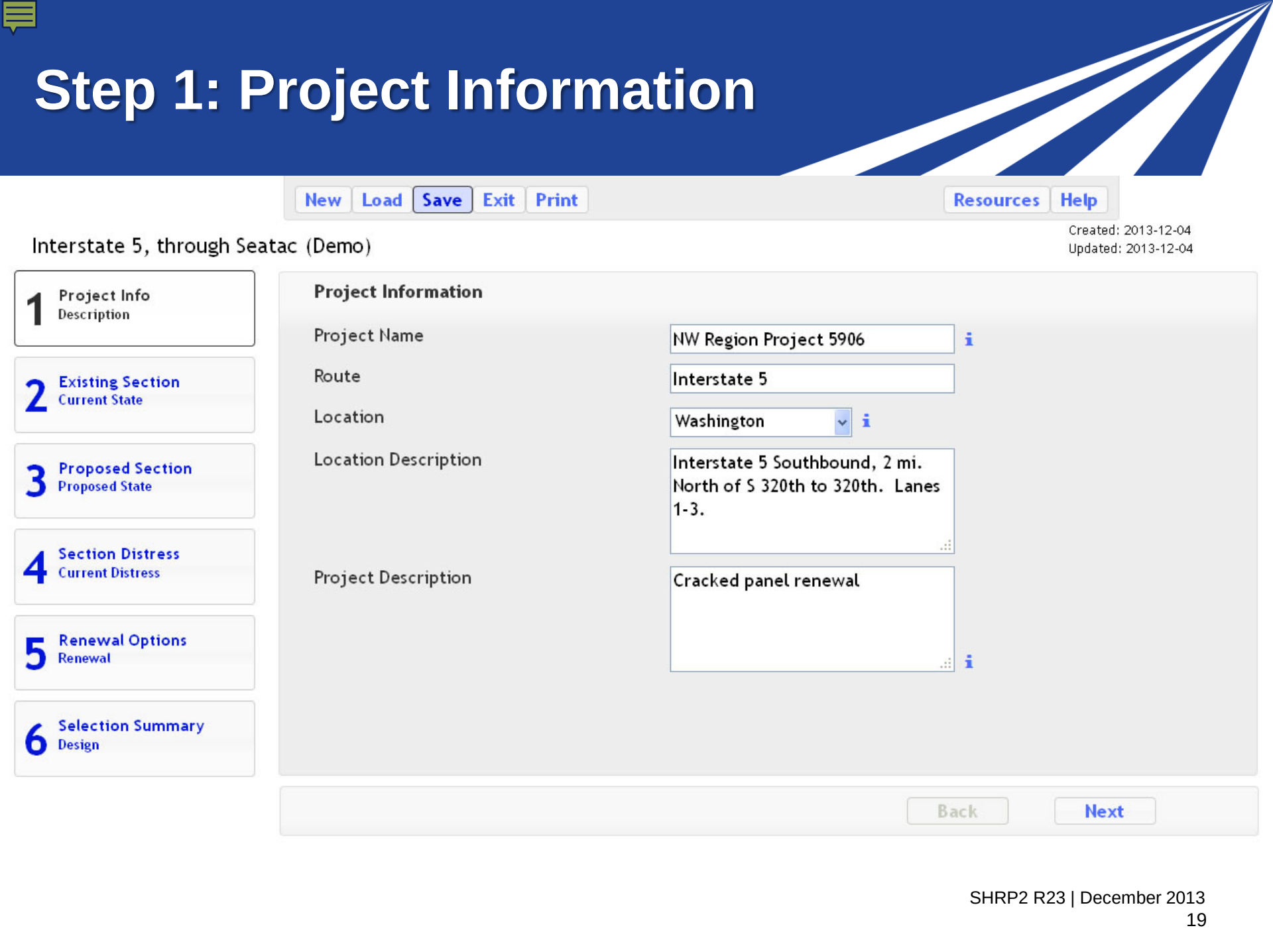
A web-based, user-friendly means of walking through the decision making process (selection and design tables).





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

Step 1: Project Information



Step 2: Existing Section

New | Load | Save | Exit | Print | Resources | Help

Interstate 5, through Seatac (Demo)

Created: 2013-12-04
Updated: 2013-12-04

1 Project Info
Description

2 Existing Section
Current State

3 Proposed Section
Proposed State

4 Section Distress
Current Distress

5 Renewal Options
Renewal

6 Selection Summary
Design

Existing Pavement

Number of through lanes: 5 one direction

Pavement Type: Rigid

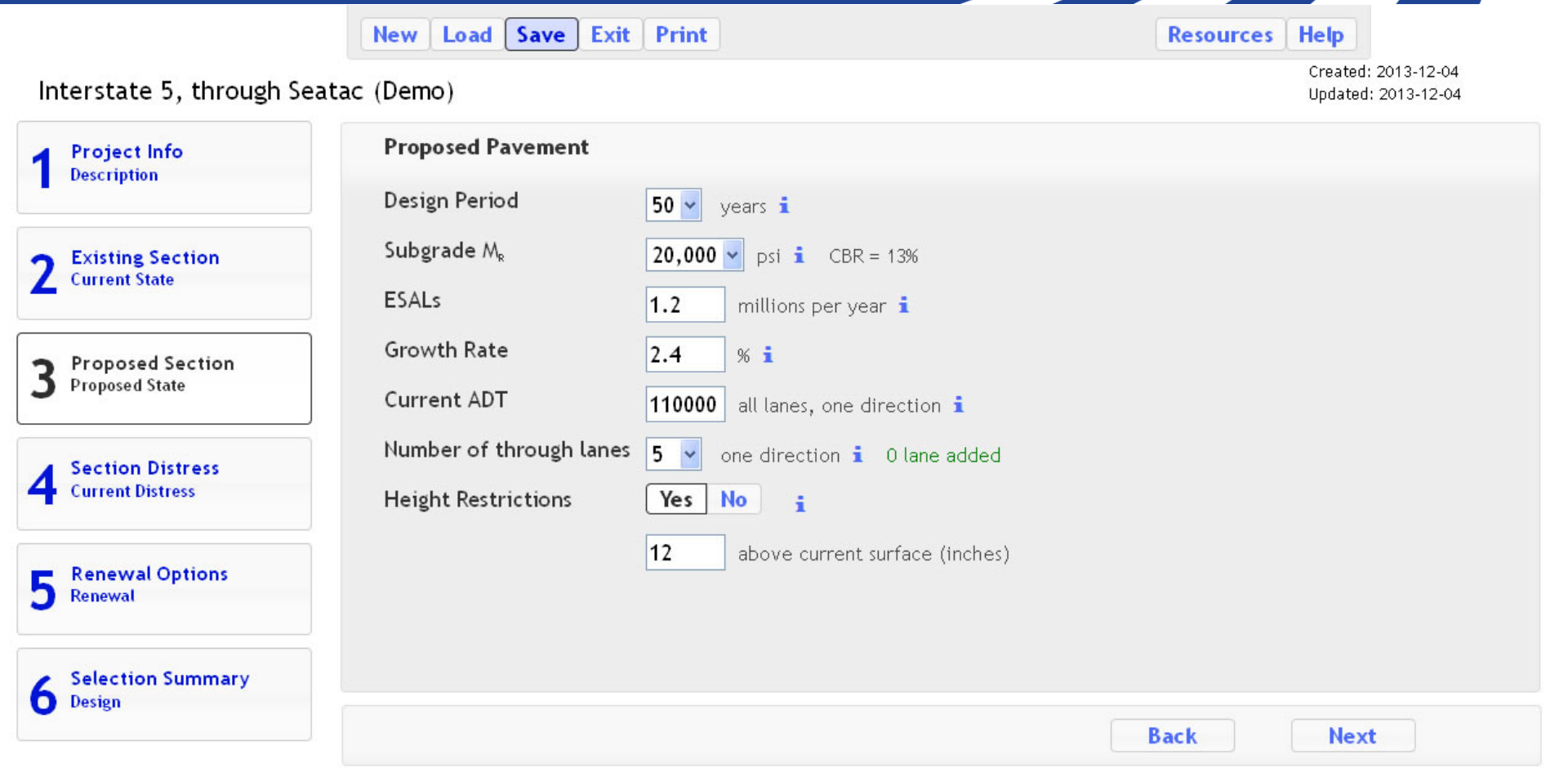
Cross Section

Layer	Type	Depth	Date Constructed
1	JPCP	7"	1960
2	Granular Base	9"	1960

Add Layer

Back | Next

Step 3: Future Section



Step 4: Existing Distress

New | Load | Save | Exit | Print | Resources | Help

Interstate 5, through Seatac (Demo)

Created: 2013-12-04
Updated: 2013-12-04

1 Project Info
Enter Description

2 Existing Section
Enter Current State

3 Proposed Section
Enter Proposed State

4 Section Distress
Enter Current Distress

5 Renewal Options
Select Renewal Strategy

6 Selection Summary
View Renewal Design

Existing Pavement Condition

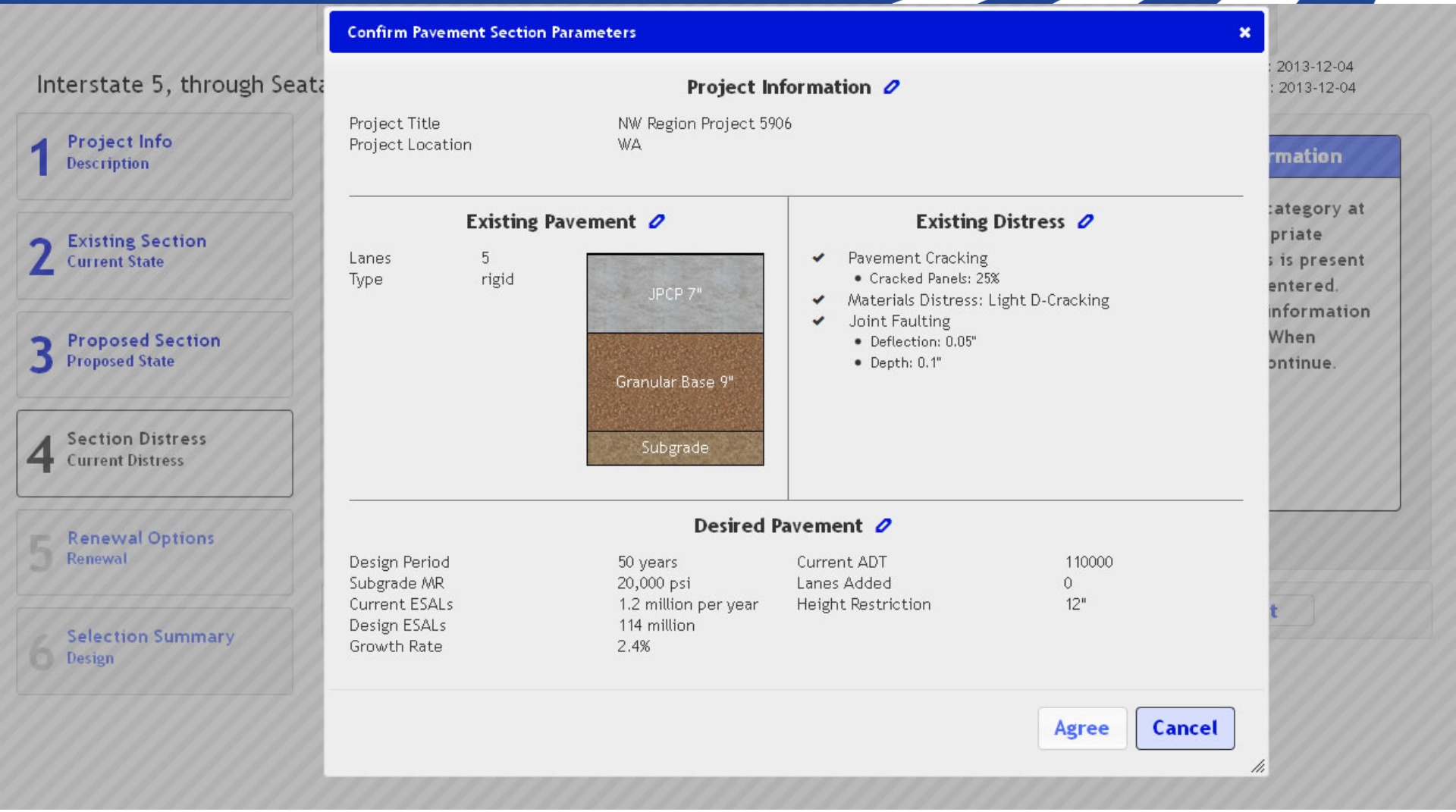
- ✔ Pavement Cracking
- ✔ Joint Faulting
- ✔ Materials Distress
- Pumping

Pavement Cracking

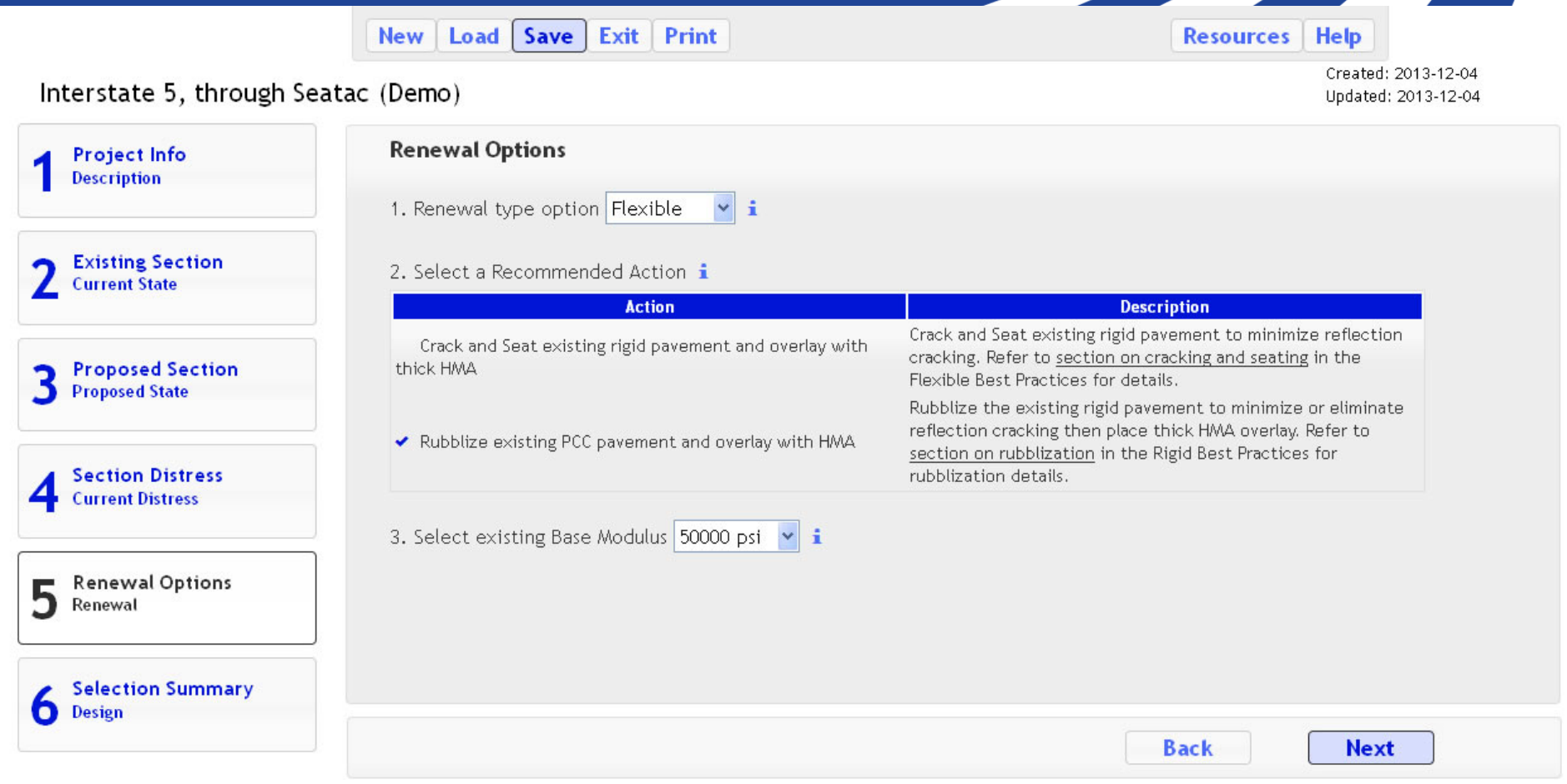
% of crack panels 25

Back | Next

Step 4a: Confirmation



Step 5: Renewal Options



Step 6: Summary

New | Load | Save | Exit | Print | Resources | Help

Interstate 5, through Seatac (Demo)

Created: 2013-12-04
Updated: 2013-12-04

1 **Project Info**
Description

2 **Existing Section**
Current State

3 **Proposed Section**
Proposed State

4 **Section Distress**
Current Distress

5 **Renewal Options**
Renewal

6 **Selection Summary**
Design

Renewal Design

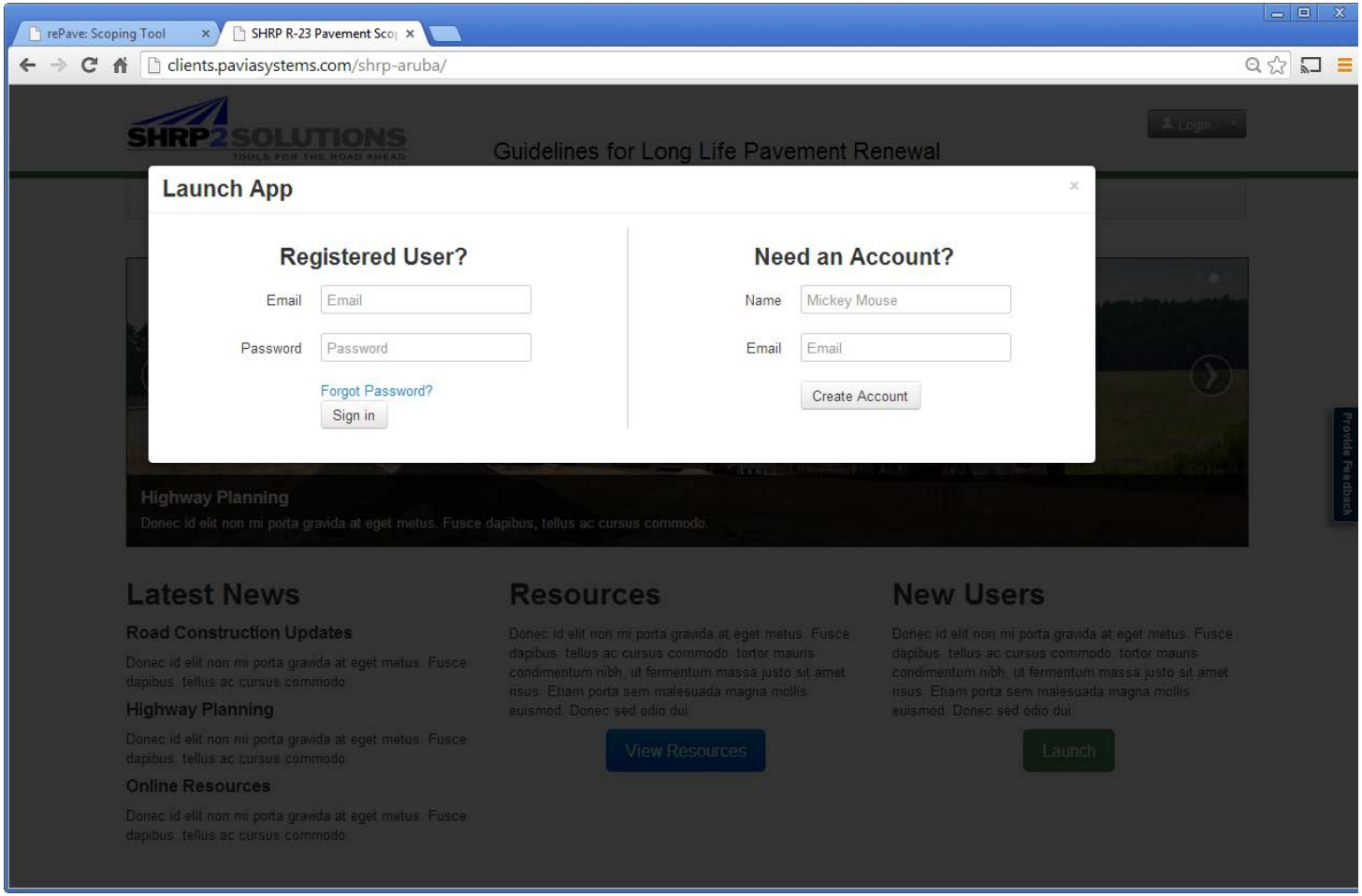
Existing | Proposed | Recommended Design

Renewal Type Flexible
Design Period 50 years
Design ESALs 114 million
Subgrade MR 20,000 psi
Pre-existing Pavement or Base Modulus 75000 psi
Actions Crack and Seat existing rigid pavement to minimize reflection cracking. Refer to section on cracking and seating in the Flexible Best Practices for details.
Pavement Removed 0"
Existing Pavement 16"
Estimated Total Design Thickness 8.5"
New Pavement 8.5"
Added Elevation 8.5"

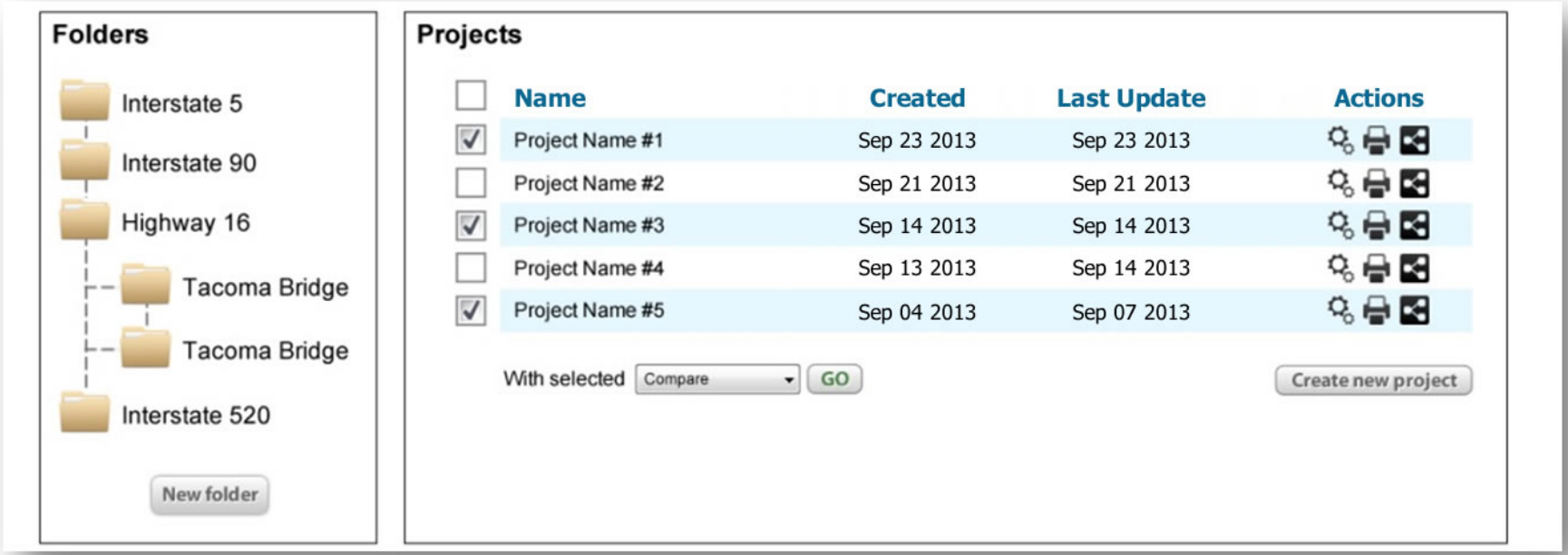
▸ Flexible Best Practices
▸ Guide Specification

Back | Save

Coming Enhancements: Single Sign On

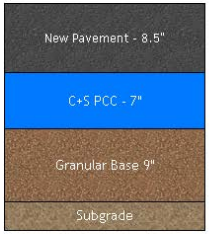


Coming enhancements: Organize and Share



Coming enhancements: Comparison feature

Compare

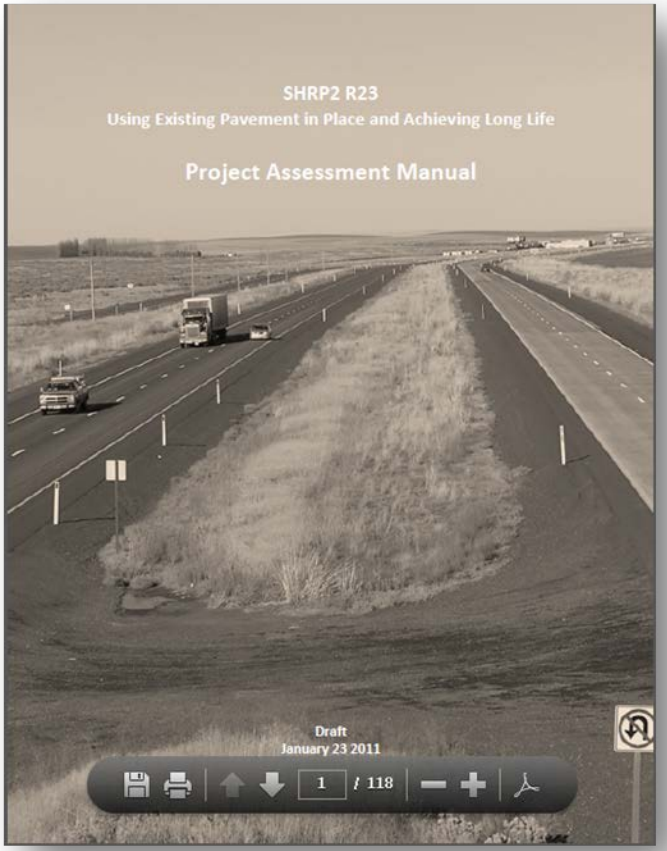
Name	Project Name #1	Project Name #2	Project Name #3
Project Info			
Existing Section			
Number of through lanes	5	5	5
Pavement Type	Rigid	Rigid	Rigid
Surface Type	JPCP	JPCP	JPCP
Cross Section			
Proposed Section			
Section Distress			
Renewal Options			
Scoping Summary			
Estimated Total Design Thickness	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

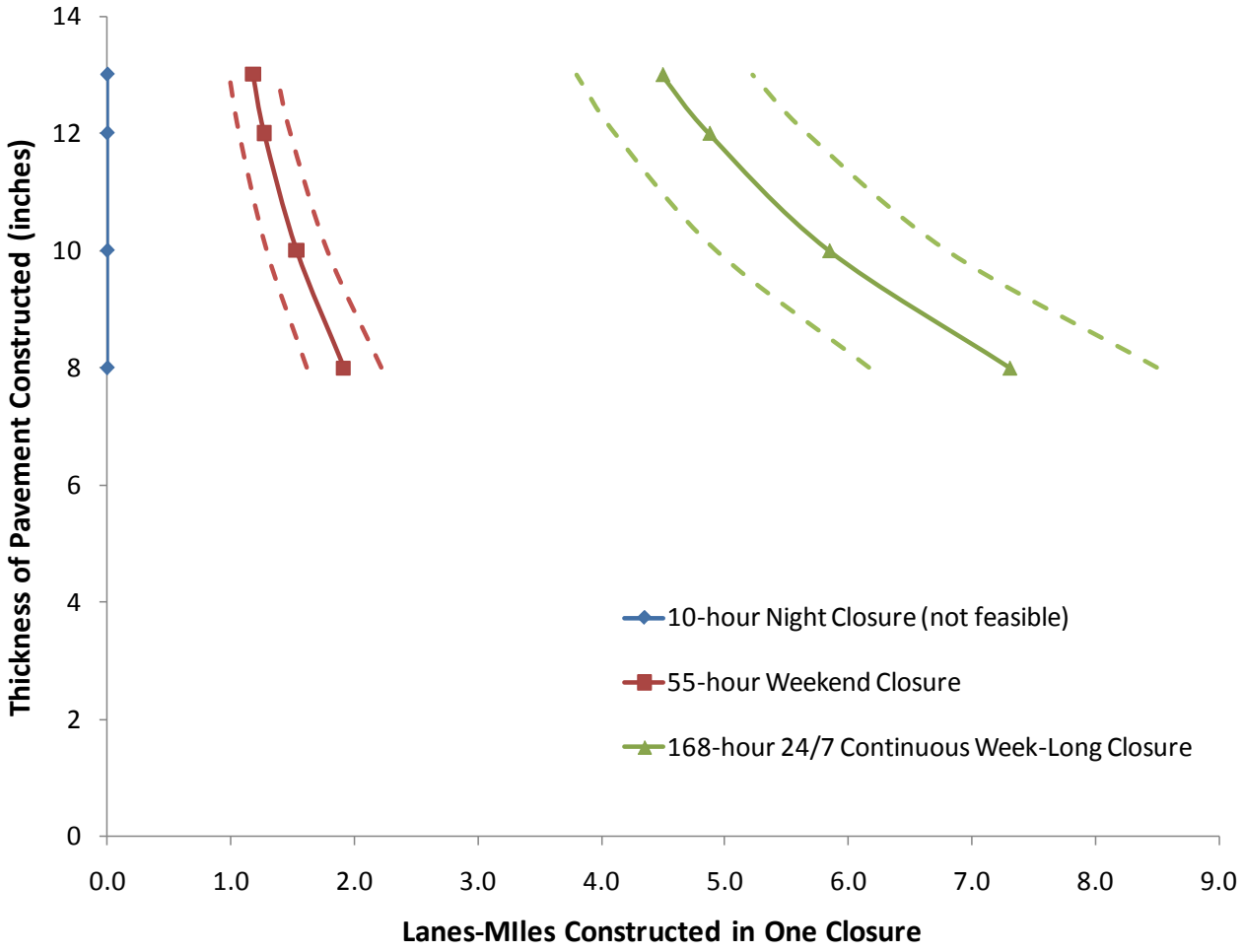
- Pavement Distress Surveys
- Rut Depth and Roughness
- NDT via FWD
- Ground Penetrating Radar
- Pavement Cores
- Dynamic Cone Penetrometer
- Subgrade Sampling and Tests
- Traffic Loads for Design
- Construction Productivity and Traffic Impacts
- Life Cycle Assessment
- Material Properties



Construction Productivity and Traffic Impacts

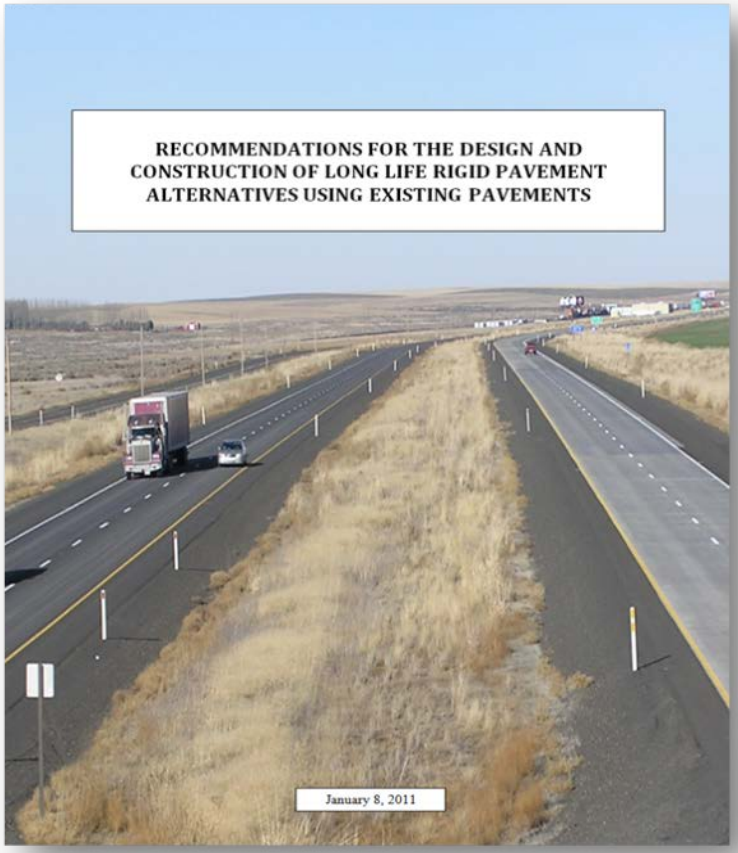
- Construction Productivity.
- Largely built around CA4PRS (Construction Analysis for Pavement Rehabilitation Strategies).
- Typical CA4PRS input data summarized for:
  - Crack and seat followed by HMA overlay.
  - PCC overlay.

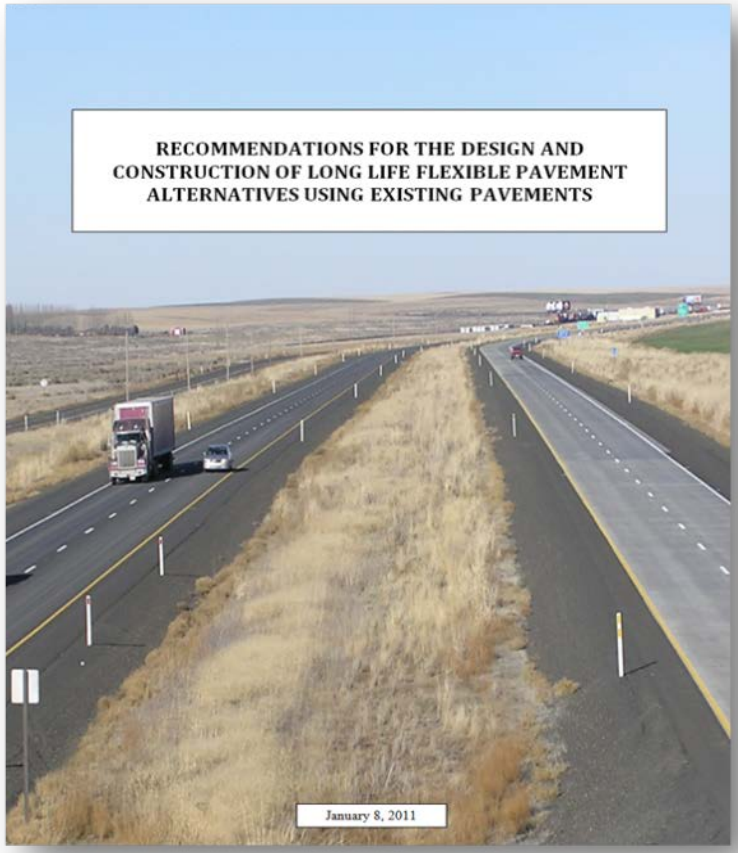
Construction Productivity and Traffic Impacts



PCC Overlay Scenario

Best Practices





Flexible Best Practices: Strategies

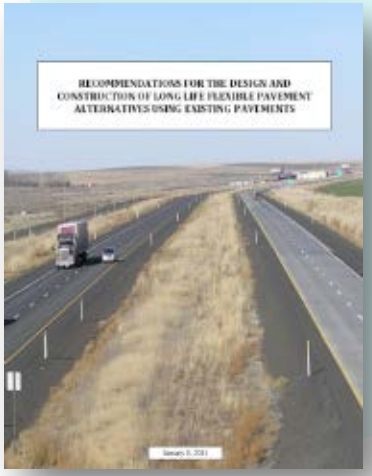
- Introduction
- HMA Renewal Strategies.
  - HMA over HMA renewal methods.
    - HMA over existing HMA pavement.
    - HMA over reclaimed HMA (recycling).
  - HMA over PCC renewal methods.
    - HMA over existing HMA-surfaced composite pavements.
    - HMA over crack and seated JPC pavements.
    - HMA 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

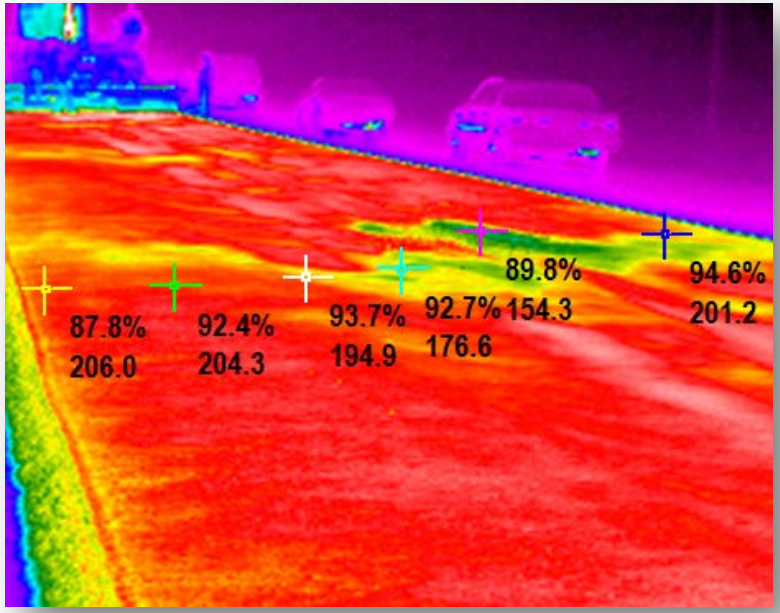
Best Practice	Why this practice?	Typical Specification Requirements
HMA Density	HMA density is a function of numerous variables (mix, layer thickness, weather, etc) and is crucial in constructing long-lasting HMA layers. Air void levels greater than 7 to 8% result in accelerated fatigue and increased 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]**



HMA Construction: Quality Control

- Density: Dense-graded mixes ≥ 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

Best Practice	Why this practice?	Typical Specification Requirements
Existing pavement and pre-overlay repairs.	The preparation of the existing pavement is important for achieving long-life from the unbonded concrete overlay.	<table><tr><th>Existing Pavement Condition</th><th>Possible Repairs</th></tr><tr><td>Faulting ≤ 10mm</td><td>No repairs needed</td></tr><tr><td>Faulting > 10 mm</td><td>Use a thicker interlayer</td></tr><tr><td>Significant tenting, shattered slabs, pumping</td><td>Full-depth repairs</td></tr><tr><td>Severe joint spalling</td><td>Clean the joints</td></tr><tr><td>CRCP w/punchouts</td><td>Full-depth repairs</td></tr></table> **[Refer to Elements for AASHTO Specifications 552, 557, 558 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 563 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 563 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 563 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

Source refers to AASHTO and State Specifications

AASHTO Paragraph		ons	Source
404.02 Materials	Bin	asphalt (AASHTO cordance with local practice	AASHTO 404 Texas 340 Virginia 310
404.03 Construction	Weather Limitations	Apply tack coat during dry weather only.	AASHTO 404 Michigan 501
	Surface Preparation	Patch, clean, and remove irregularities from all surfaces to receive tack coat. Remove loose materials.	AASHTO 404 Minnesota 2357 Missouri 407
	Application Surfaces	1. Apply the bond coat to each layer of HMA and to the vertical edge of the adjacent pavement before placing subsequent layers. 2. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and all joints.	Michigan 501 Texas 340
	Application Rate	1. Apply undiluted tack at a rate ranging from 0.05 to 0.10 gal/SY. 2. Many State DOTs allow dilution with water up to 50%.	Range generally falls within most state limits
	Application Temperatures	Use manufacturer recommendations	Study Team

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.

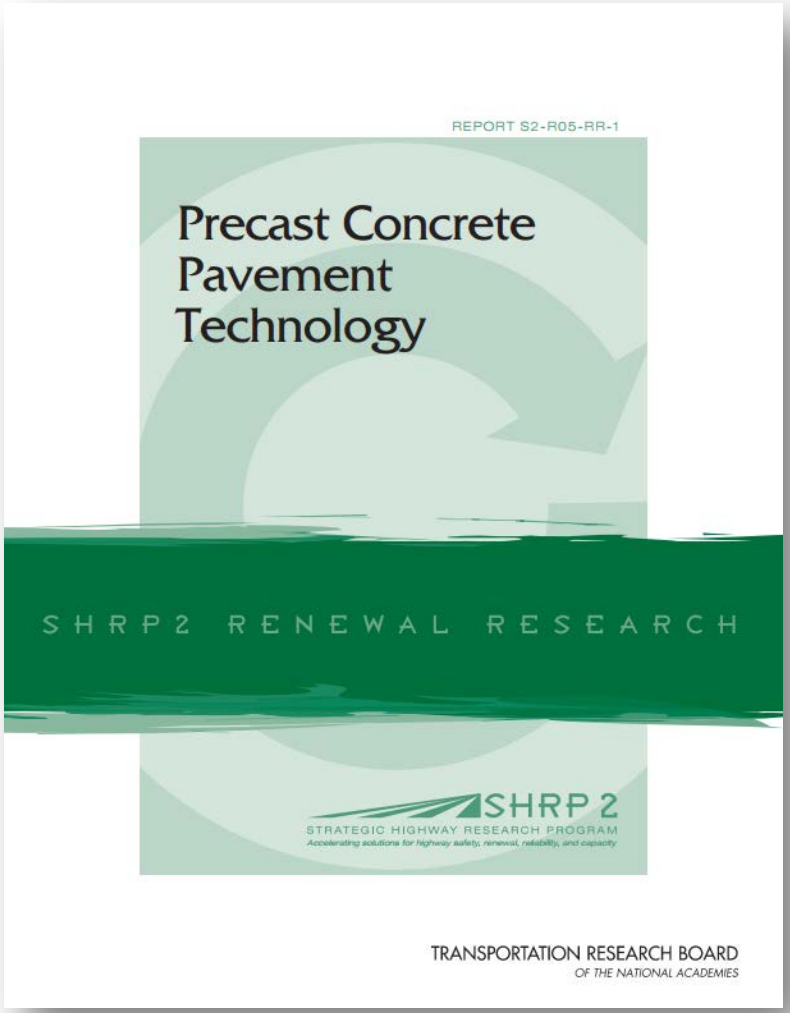
State of the Practice Value: WSDOT

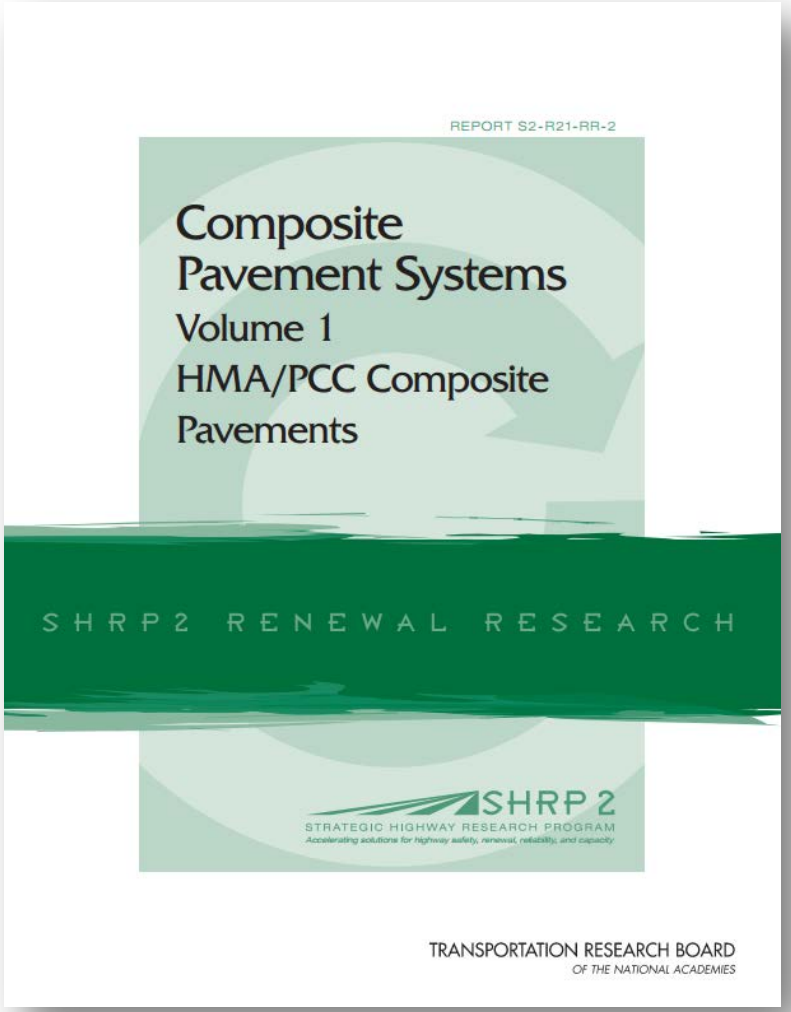
- WSDOT used Pavement Renewal Solutions products on a time sensitive project on Interstate 5 to help identify the best long-term renewal approach for the agency.

"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"

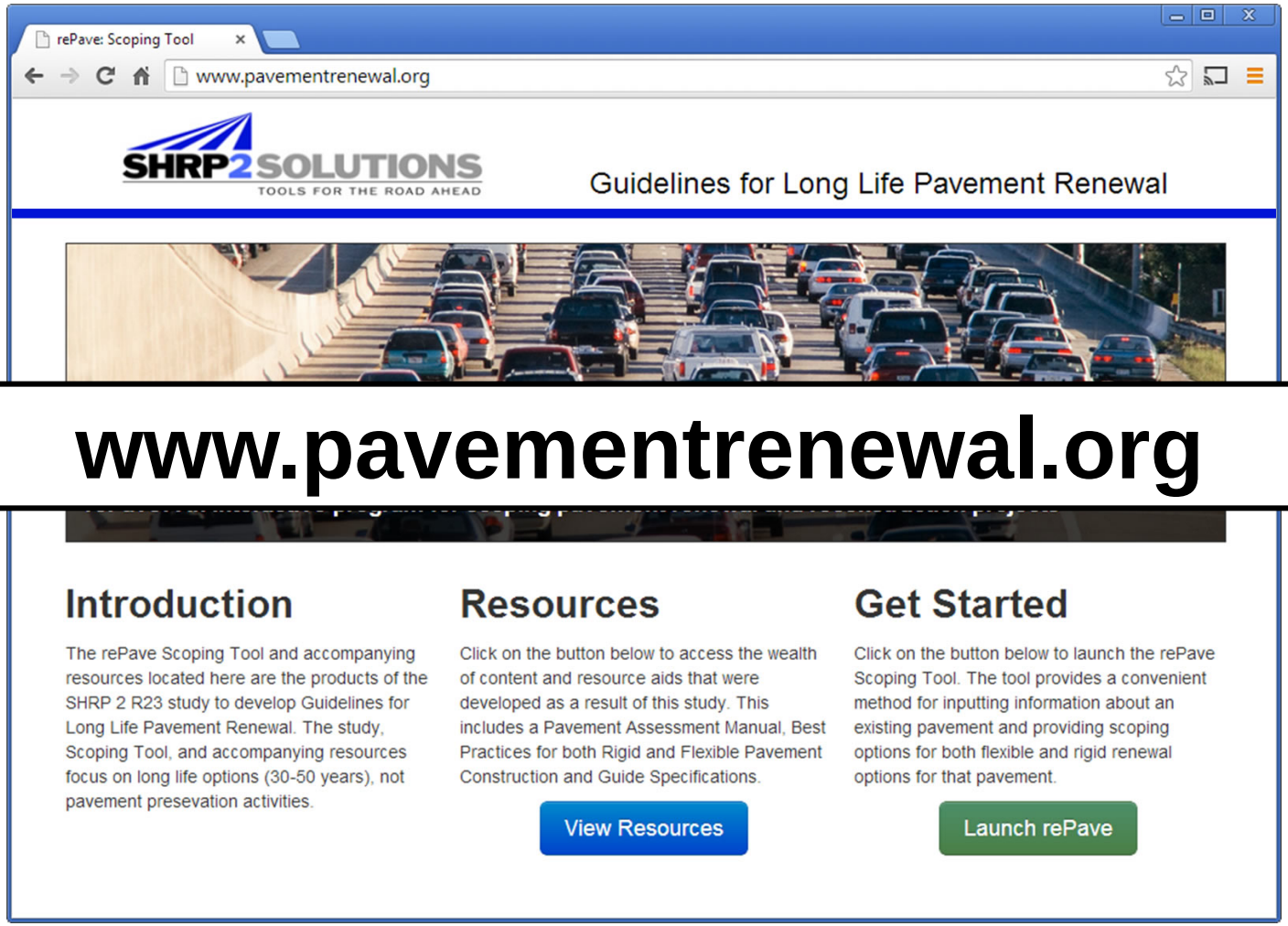
Jeff Uhlmeyer
State Pavement Engineer

Precast Concrete Pavement and New Composite Pavement Systems Options





Access all the products at:



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