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The Illinois Tollway

DRIVING THE FUTURE

Plans for Future Performance – Related Specifications (Incentives/ Disincentives)

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FHWA Tollway National Open House,

August 20, 2013

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Performance-Related Specifications

"QA specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance"

Transportation Research Circular Number E-C137
Glossary of Highway Quality Assurance Terms

Performance-Related Specifications

"…employ the quantified relationships containing the characteristics to predict as-constructed pavement performance. ***They thus provide the basis for rational acceptance/pay adjustment decisions****."*

Transportation Research Circular Number E-C137
Glossary of Highway Quality Assurance Terms

Important Definitions

- AQC Target – Acceptance Quality Characteristic Target: target average (and standard deviation) levels.
- RQL – Rejectable Quality Levels: AQC levels requiring correction or replacement.
- MQL – Maximum Quality Levels: AQC levels requiring no additional pay incentive.
- PF – Pay Adjustment Factor: Adjustment to contract payment based on the ratio of the as-built pavement Life-Cycle Costs (LCC) to the as-designed LCC.

Transportation Research Circular Number E-C137
Glossary of Highway Quality Assurance Terms

Performance-Related Specifications

Specify the target mean (and standard deviation) levels of AQC's that:

- Are measureable (more rapid the better)
- Have been found to correlate with performance (prediction models required)
- Are under contractor's control (can be varied on a project)
- Can be used to compute incentives and disincentives

PRS Benefits

- The pavement design is used directly to develop the construction performance specification
- Testing that focuses on key quality characteristics that relate to the pavement long-term performance
- Incentives and disincentives that are justified through reduction or increase in future life-cycle costs
- Allow contractors to be more innovative and more competitive
- Compared to warrantees, no long-term monitoring and management required

Shadow PRS

- Develop and Evaluate PRS like FULL implementation
- Does not impact contractor pay for the shadow project
- Learning and pre-implementation tool

Illinois Tollway

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Federal Highway Administration

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PaveSpec 4.0
Mechanistic-Empirical Models and AQCs

Input	Significantly Impact Distress			
	Transverse "Slab" Cracking	Transverse Joint Faulting	Transverse Joint Spalling	Smoothness
Initial Smoothness	X	X	X	X
PCC Strength	X			X
PCC Thickness	X	X	X	X
PCC CTE	X	X		X
Effective Dowel Diameter*		X		X
PCC air content			X	X
PCC mix w/c ratio	X	X	X	X

*Computed by measuring dowel alignment & NCHRP 10-69 procedure

PaveSpec 4.0 vs. PaveSpec 3.0

GUI
- INPUT GUIs ***(new)***
- Simulation GUIs ***(new)***

Modular
Not Linear

→

PAVESPEC 4.0 ENGINE
- Cracking.exe ***(new)***
- Faulting.exe ***(new)***
- Spalling.exe ***(new)***
- IRI.exe ***(new)***
- Simulation.exe ***(new)***
- LCC.exe ***(PaveSepc 3.0)***
- PF.exe ***(PaveSepc 3.0)***

→

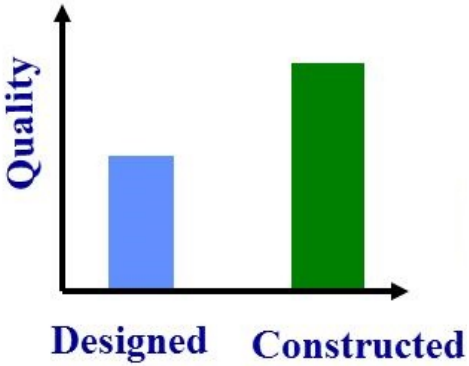
OUTPUT REPORTS
- Output GUIs ***(new)***
- Files (*.docx, *.pdf) ***(PaveSpec 3.0 revised)***

Developing PRS

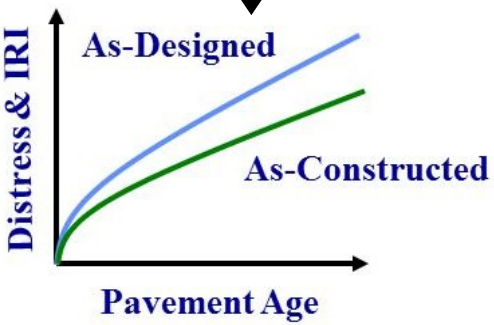
PAVESPEC

Establish Performance Criteria

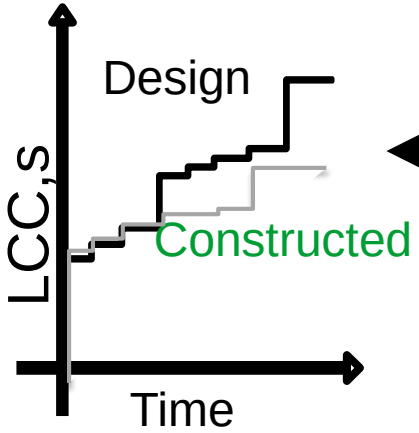
Identify AQCs and Target Values



Design AQC vs. As-Constructed AQC



Model ME Performance



Compare As-Built and As-Designed

Pay Factor f(ΔLCC)

M&R Plan

Select AQCs

- 28-day compressive strength (psi)
- Air content (%)
- PCC thickness (in)
- Profile Index / smoothness (in/mi)
- Effective dowel diameter*

Performance Criteria

- PI/IRI
- Transverse cracking
- Joint faulting
- Joint spalling

*Computed by measuring dowel alignment & NCHRP 10-69 procedure

Work Plan for Shadow I-90 Illinois Tollway

1. Conduct project coordination meetings
   - select location, gather information, develop sampling & testing plan
2. Collect and analyze historical data
   - DRAFT AQCs, M & R criteria, costs, discount rate, etc.
3. Develop PRS pay factors
   - DRAFT PaveSpec 4.0, PaveSpec 3.0
4. Prepare for PRS implementation on project
   - layout of lots & sublots, sampling & testing details

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Work Plan for Shadow I-90 Illinois Tollway

5. Conduct field sampling and testing on selected portion of project

   FHWA MCL + Illinois Tollway QC/QA data

6. Evaluate PRS results

   Incentives/disincentives for each lot; how they compare with conventional specifications

7. Prepare final report and presentation

   feedback to Tollway and FHWA on PRS

Pavement Type Selection Report

- <u>I-90 (West Section)</u>
- Traffic
- Design
- Reliability & Performance Criteria
- Support conditions
- M & R strategies
- Costs & other miscellaneous data

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Pavement Design and Pavement Type Selection for I-90 (Jane Addams Memorial Highway) from I-39 to the Kennedy Expressway

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October 1, 2012

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Project Information

- Performance criteria:
  - 172 in/mi IRI, 0.12 in faulting, 15% slabs cracked, 95% reliability
- Traffic
  - ~ 44 million trucks, 51% in design direction, 70% in design lane, 65% Class 9, 1.5% compound growth
- 30-year design
  - 12” PCC, 3” HMA, 3+9” Aggregate Base, 1.5” dowels
  - 12.5’ slab width, 15’ joint spacing
- Lots/sublots
  - 1 lot ~ 5000 lane-ft (10 sublots)
  - Consistent with Tollway lots/sublots

Maintenance and Rehabilitation Strategy

Year	Activity
0	Construct new JPCP with HMA shoulders
11	Mainline—Reseal 100% transverse joints (TJ) and 100% longitudinal joints (LJ)
	Shoulder—Rout and seal all cracks; Apply microsurface
18	Mainline—Concrete full-depth patching (3.5% of area); Reseal 100% TJ and 100% LJ
	Shoulder—Rout and seal all cracks; Apply microsurface
25	Mainline—Concrete full-depth patching (5.0% of area); Diamond grind; Reseal 100% TJ and 100% LJ
	Shoulder—Rout and seal all cracks; Apply microsurface
30	Mainline—Concrete full-depth patching (6.0% of area); Apply 4.0-in SMA overlay
	Shoulder—Apply 4.0-in HMA overlay
38	Mainline—Rout and seal all cracks
	Shoulder—Rout and seal all cracks
44	Mainline—Remove 4.0-in SMA; Concrete full-depth patching (7.0%); Apply 4.0-in SMA overlay
	Shoulder—Rout and seal all cracks; Apply microsurface

Varies
as-constructed vs. as-designed

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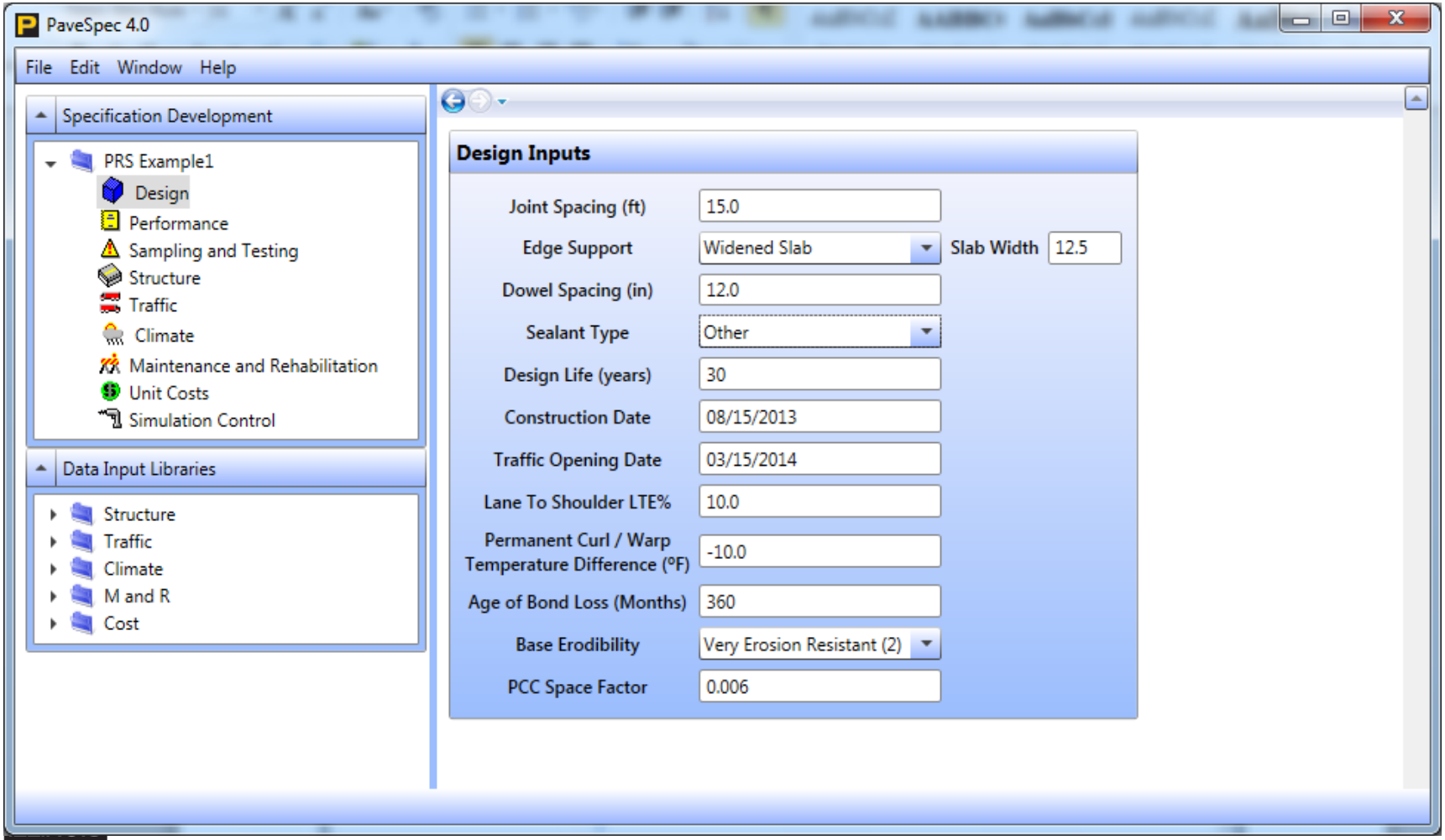
Historical AQC Data

- Means and Standard Deviations
- IMIRS (Illinois Materials Inspection and Reporting System) database
  - Compressive strength, air content
- Historical QC/QA data over last 2-5 years
  - Smoothness, thickness
- Other sources
  - National historical dowel alignment data

PaveSpec 4.0


PaveSpec 4.0
File Edit Window Help
Specification Development
PRS Example1
Design
Performance
Sampling and Testing
Structure
Traffic
Climate
Maintenance and Rehabilitation
Unit Costs
Simulation Control
Data Input Libraries
Structure
Traffic
Climate
M and R
Cost
Design Inputs
Joint Spacing (ft) 15.0
Edge Support Widened Slab
Slab Width 12.5
Dowel Spacing (in) 12.0
Sealant Type Other
Design Life (years) 30
Construction Date 08/15/2013
Traffic Opening Date 03/15/2014
Lane To Shoulder LTE% 10.0
Permanent Curl / Warp Temperature Difference (°F) -10.0
Age of Bond Loss (Months) 360
Base Erodibility Very Erosion Resistant (2)
PCC Space Factor 0.006

PaveSpec 4.0

PaveSpec 4.0

File Edit Window Help

Specification Development

- PRS Example1
  - Design
  - Performance
  - Sampling and Testing
  - Structure
  - Traffic
  - Climate
  - Maintenance and Rehabilitation
  - Unit Costs
  - Simulation Control

Data Input Libraries

- Structure
- Traffic
- Climate
- M and R
- Cost

Select distress and AQC's to be used for specification development

Performance Indicator and AQCs

Indicator	Threshold Value	AQC's that be influenced
☒ Transverse joint faulting (in)	0.12	Thickness, Coefficient of Thermal Expansion, Dowel Diameter
☒ Transverse joint spalling (%)	20	Compressive Strength, Thickness, Air Content, Water/Cement Ratio
☒ Transverse slab cracking (%)	15	Flexural Strength, Thickness, Coefficient of Thermal Expansion
☒ Smoothness (in/mile)	172	Flexural Strength, Thickness, Coefficient of Thermal Expansion, Dowel Diameter, Air Content

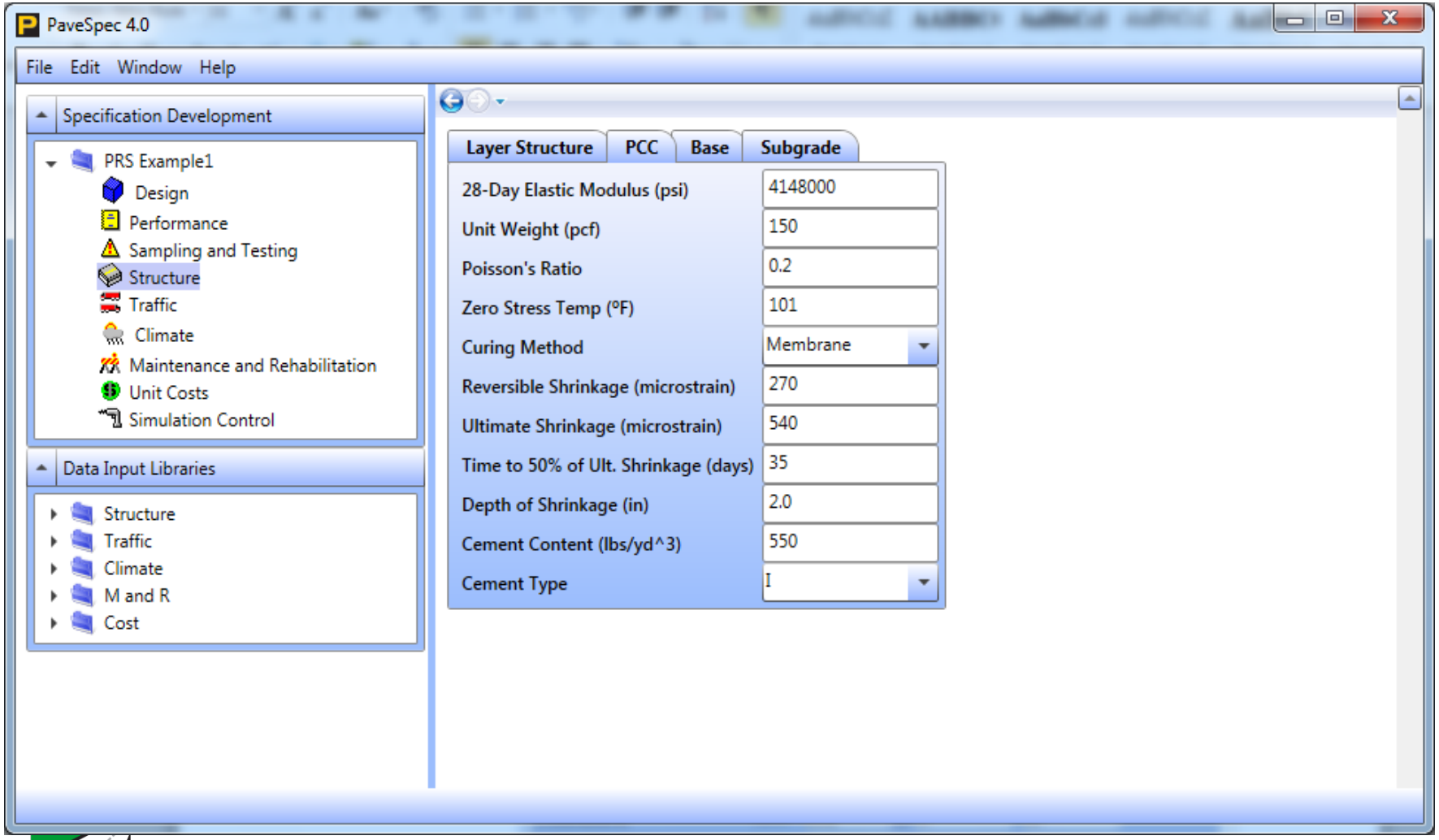
Strength AQC: Compressive

Acceptance Quality Characteristic

AQC's	Status	Sample Method	Mean	Std. Deviation
☒ PCC compressive strength (psi)	Required	Normal	5300	875
☒ PCC thickness (in)	Required	Normal	12	0.25
☐ PCC coefficient of thermal expansion (in/in/°F)	Required	Normal	0.0000055	0.0000005
☒ PCC air content (%)	Required	Normal	5	1.5
☐ PCC water cement ratio	Required	Normal	0.38	0.04
☒ Dowel Diameter (in)	Required	Normal	1.4	0.05
☒ Inital smoothness (in/mi)	Required	Normal	75	10

Note: Select AQC's to sample. Uncessary AQC's cannot be sampled. If you select not to sample a required AQC, you must specifiy an as-designed value instead.

PaveSpec 4.0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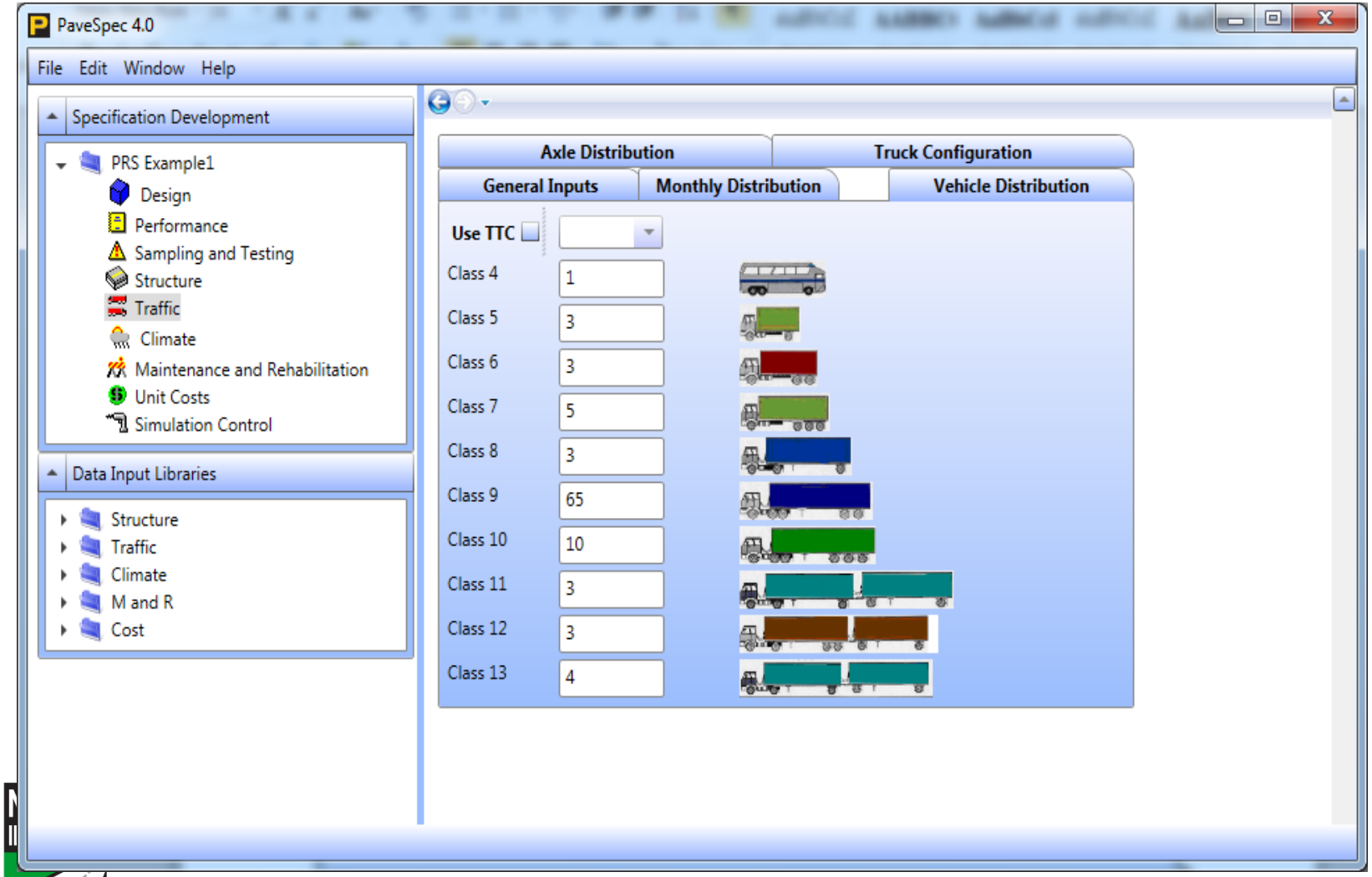
Structure
Traffic
Climate
M and R
Cost
Layer Structure
PCC
Base
Subgrade
28-Day Elastic Modulus (psi) 4148000
Unit Weight (pcf) 150
Poisson's Ratio 0.2
Zero Stress Temp (°F) 101
Curing Method Membrane
Reversible Shrinkage (microstrain) 270
Ultimate Shrinkage (microstrain) 540
Time to 50% of Ult. Shrinkage (days) 35
Depth of Shrinkage (in) 2.0
Cement Content (lbs/yd^3) 550
Cement Type I

PaveSpec 4.0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Structure
Traffic
Climate
M and R
Cost
Axle Distribution
Truck Configuration
General Inputs
Monthly Distribution
Vehicle Distribution
Use TTC
Class 4 1
Class 5 3
Class 6 3
Class 7 5
Class 8 3
Class 9 65
Class 10 10
Class 11 3
Class 12 3
Class 13 4

PaveSpec 4.0

PaveSpec 4.0

File Edit Window Help

Specification Development

- PRS Example1
  - Design
  - Performance
  - Sampling and Testing
  - Structure
  - Traffic
  - Climate
  - Maintenance and Rehabilitation
  - Unit Costs
  - Simulation Control

Data Input Libraries

- Structure
- Traffic
- Climate
- M and R
- Cost

Project Location

Latitude (degrees): 42.165439

Longitude (degrees): -88.585968

Update

Weather Station

StationID	Distance	State	City
94822	26.1	IL	Rockford
94846	36.7	IL	Chicago
14839	64.4	WI	Milwaukee
14837	77.7	WI	Madison

PaveSpec 4.0

PaveSpec 4.0

File Edit Window Help

Specification Development

- PRS Example1
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Data Input Libraries

- Structure
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Maintenance | Local Rehab | Global Rehab

Scenario 1 Scenario 2 Scenario 3

Prior to First Global Rehabilitation Application

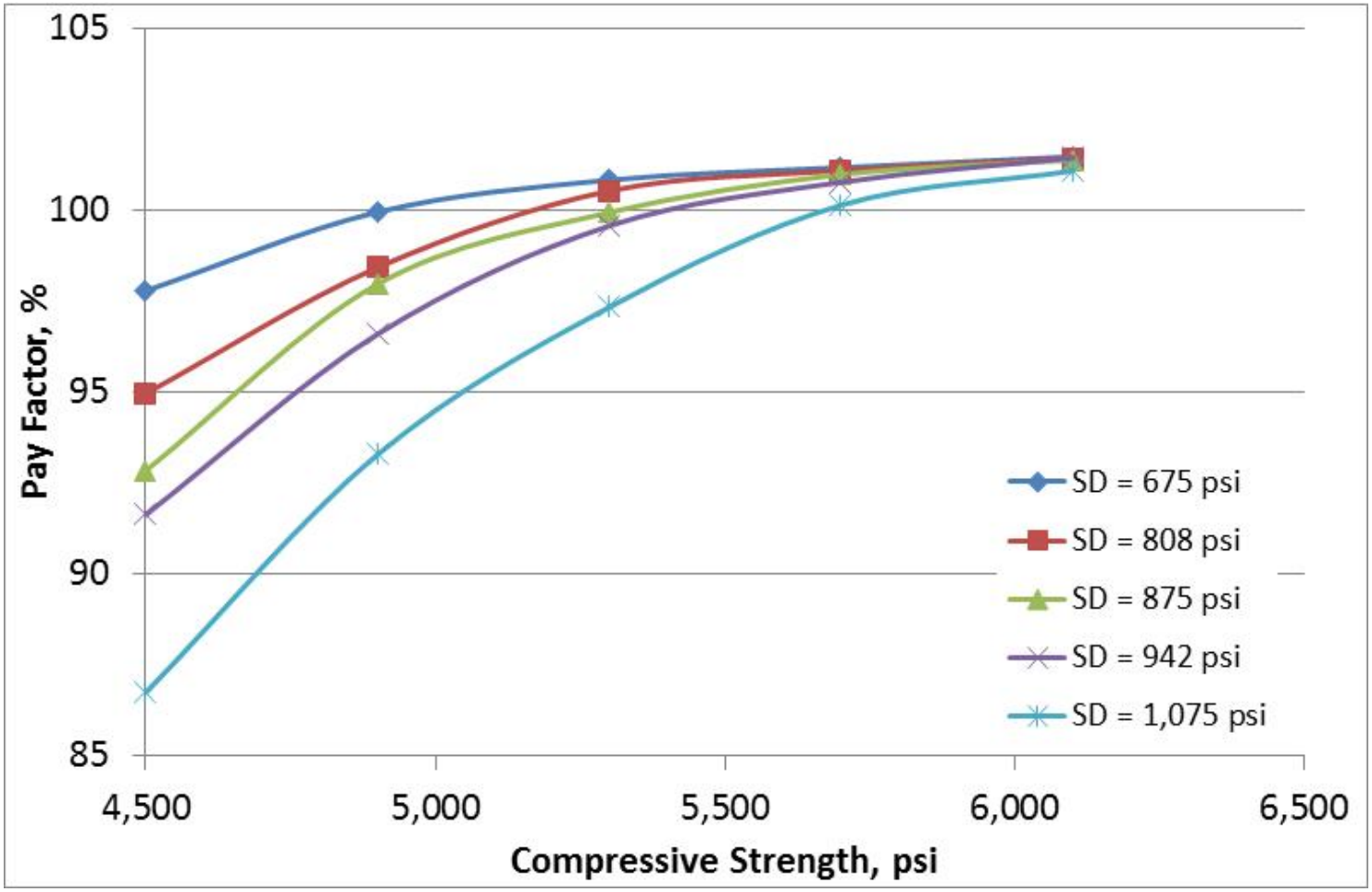
☒ Repair	100	% of spalled joints with	full-depth repairs
☒ Repair	100	% of cracked slabs with	full-depth replacement

Global Rehabilitation Sequence

	Global Rehabilitation	Assumed Life		Stat IRI		End IRI	
1st	Diamond Grinding	5	years	125	in/mile	175	in/mile
2nd	AC Overlay	14	years	70	in/mile	175	in/mile
3rd	AC Overlay	14	years	70	in/mile	175	in/mile
4th	AC Overlay	14	years	50	in/mile	175	in/mile

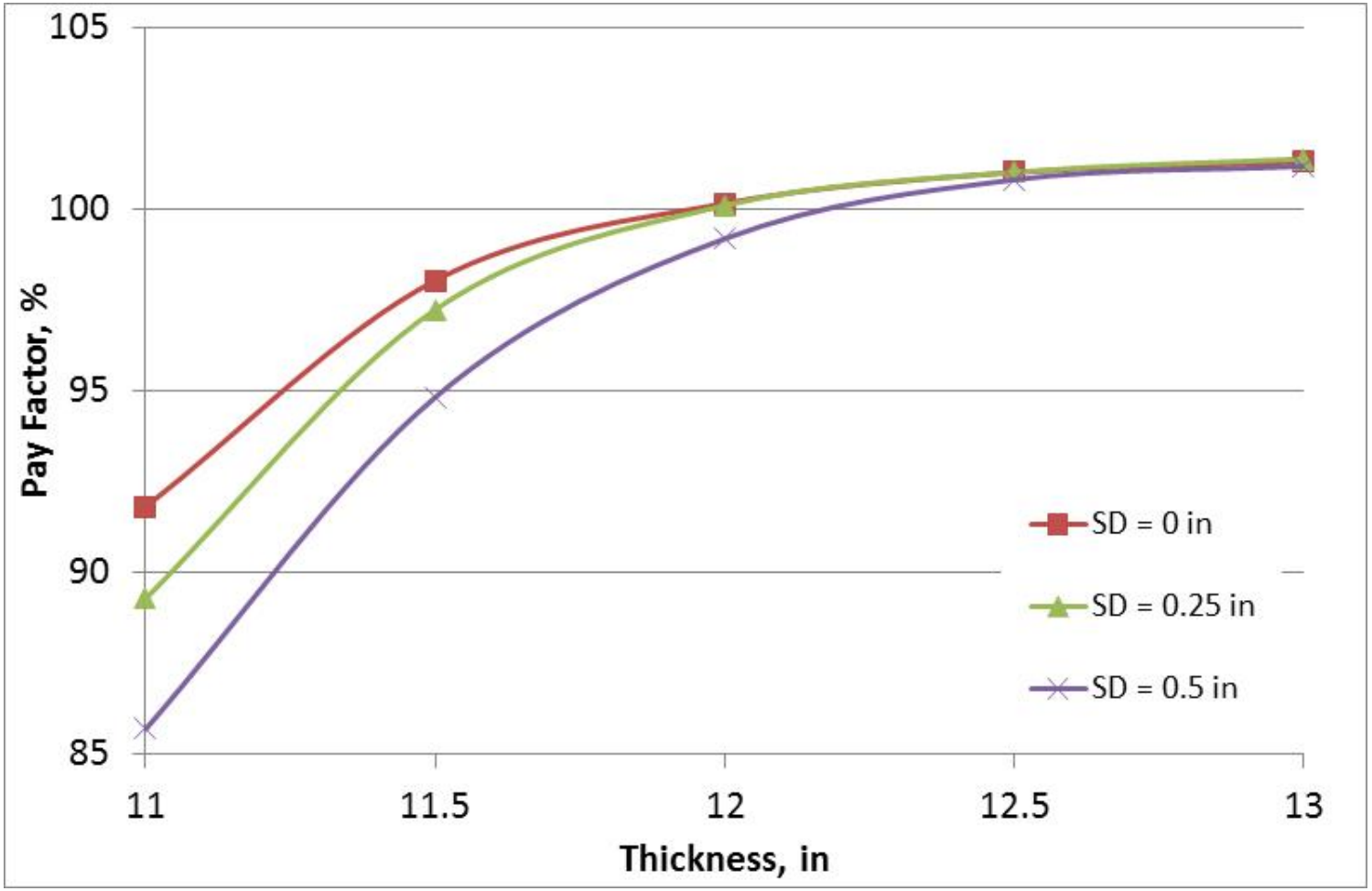
Note: If needed, 4th rehabilitation is repeated unitl end of analysis life

PaveSpec 3.0* Results (Compressive Strength)



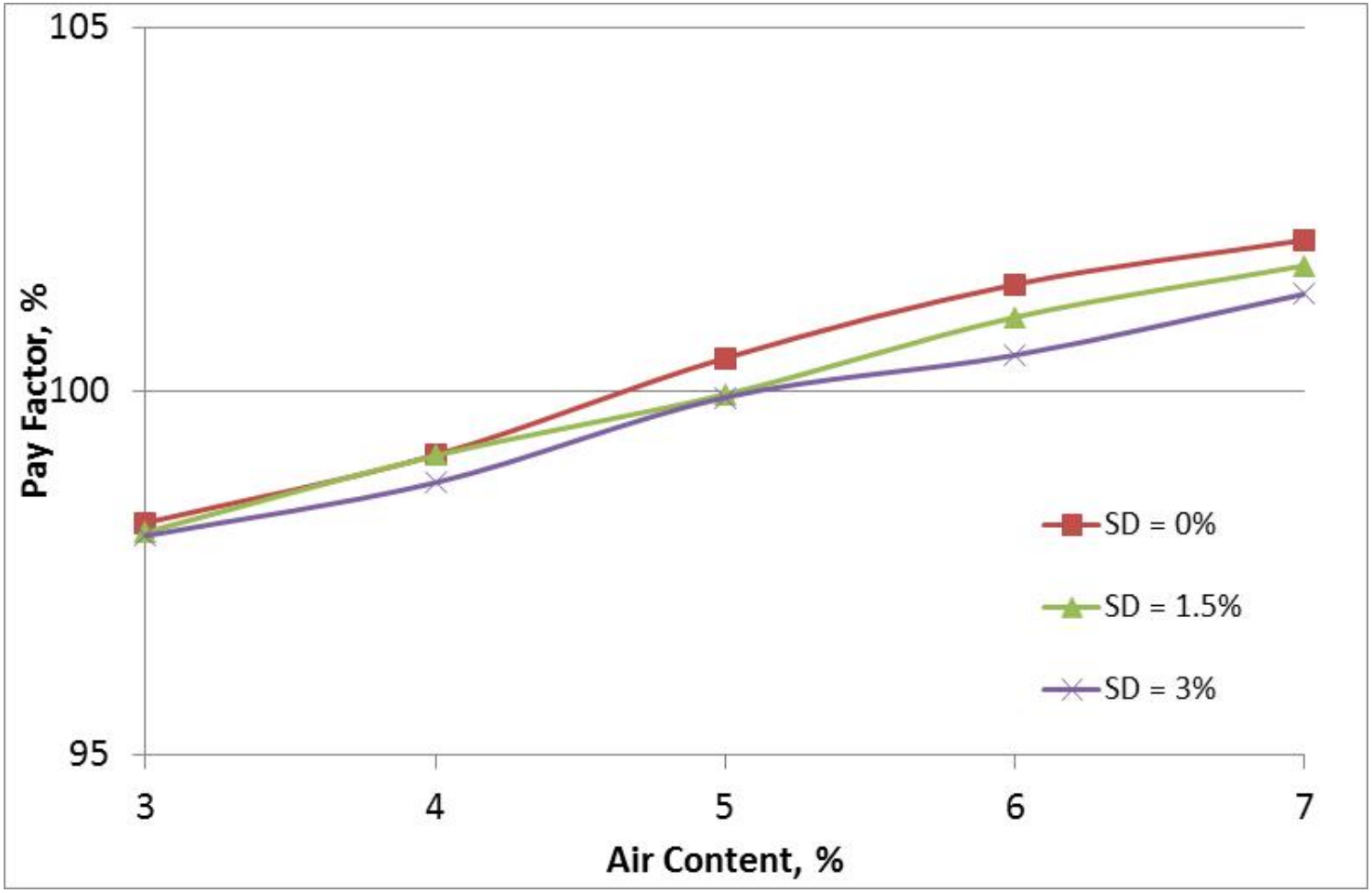
*Placeholders while PaveSpec 4.0 software is being developed and tested

PaveSpec 3.0* Results (Thickness)



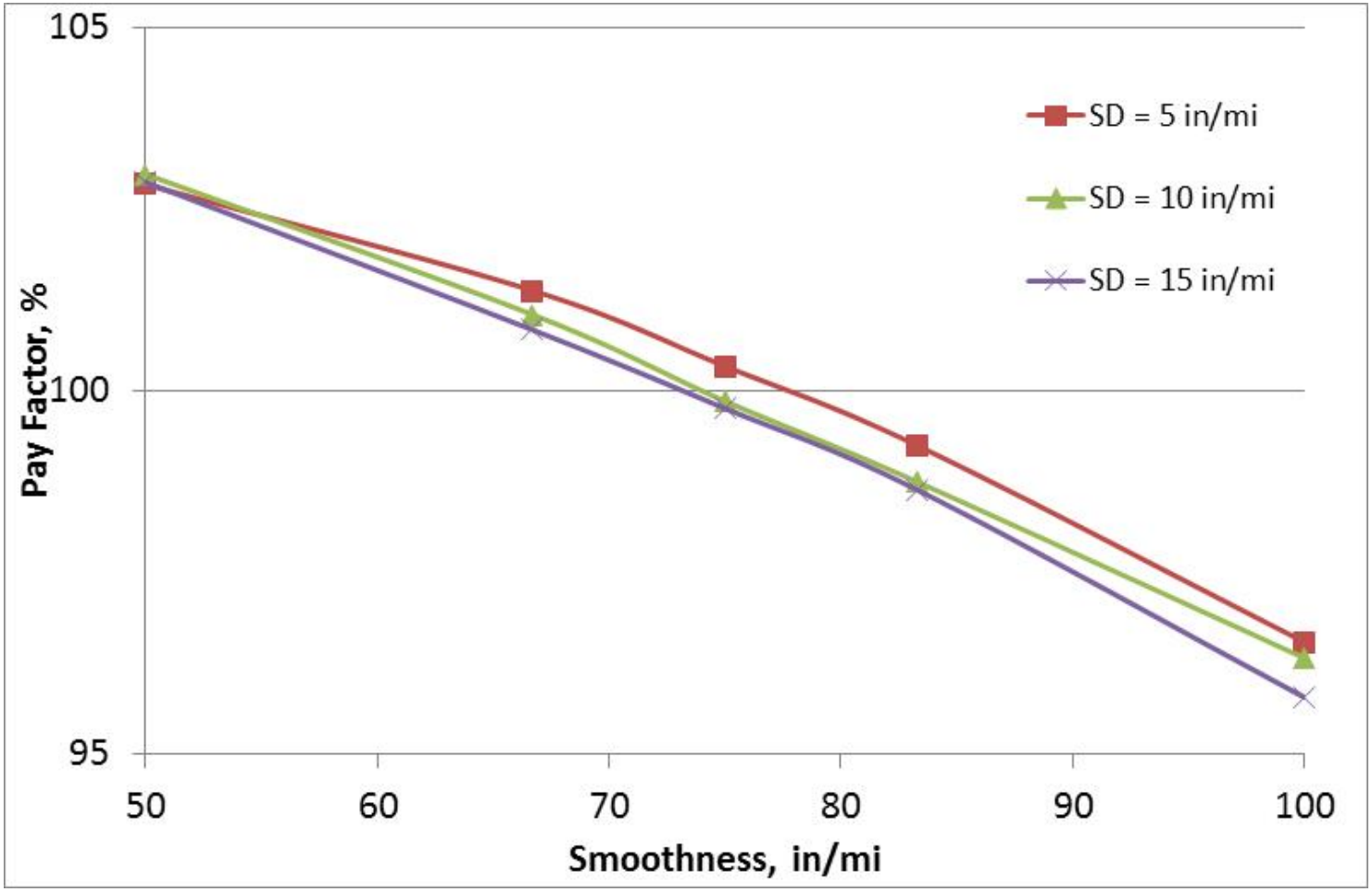
*Placeholders while PaveSpec 4.0 software is being developed and tested

PaveSpec 3.0* Results (Air Content)



*Placeholders while PaveSpec 4.0 software is being developed and tested

PaveSpec 3.0* Results (Smoothness)



*Placeholders while PaveSpec 4.0 software is being developed and tested

Lot Composite Pay Factors

$$PF_{lot} = \left(\frac{PF_{str}}{100}\right) \cdot \left(\frac{PF_{air}}{100}\right) \cdot \left(\frac{PF_{thk}}{100}\right) \cdot \left(\frac{PF_{smth}}{100}\right) \cdot \left(\frac{PF_{dowel}}{100}\right) 100$$

Maximum Composite PF: 105%

*Minimum Composite PF: 80%**

- *Provided AQCs are above the RQLs for strength, air content, dowel diameter and thickness, and below the RQL for smoothness.
- Accept or reject concrete on a sublot-by-sublot basis.
- If RQL not met for any particular AQC, all current procedures for nonconforming materials shall apply for that particular sublot.
- No incentive/disincentive for a sublot with nonconforming materials.

Where do we go from here?

- Finalize analysis of historical data
- Finalize PRS Pay Factors
- Collect AQC data for lots/sublots (FHWA MCL + Illinois Tollway QA/QC data)
- Compute means/standard deviations for each lot
- Compute incentives/disincentives for each lot
- Final report & presentation

THANK YOU

http://www.fhwa.dot.gov/publications/research/infrastructure/pavements/pccp/pavespec/