



BUILDING QUALITY PAVEMENTS

Smoothness

ASTM Definition of Roughness

“The deviations of a pavement surface from a true planar surface with characteristic dimensions that affect vehicle dynamics.....”



**Pavement Smoothness is a
lack of roughness**

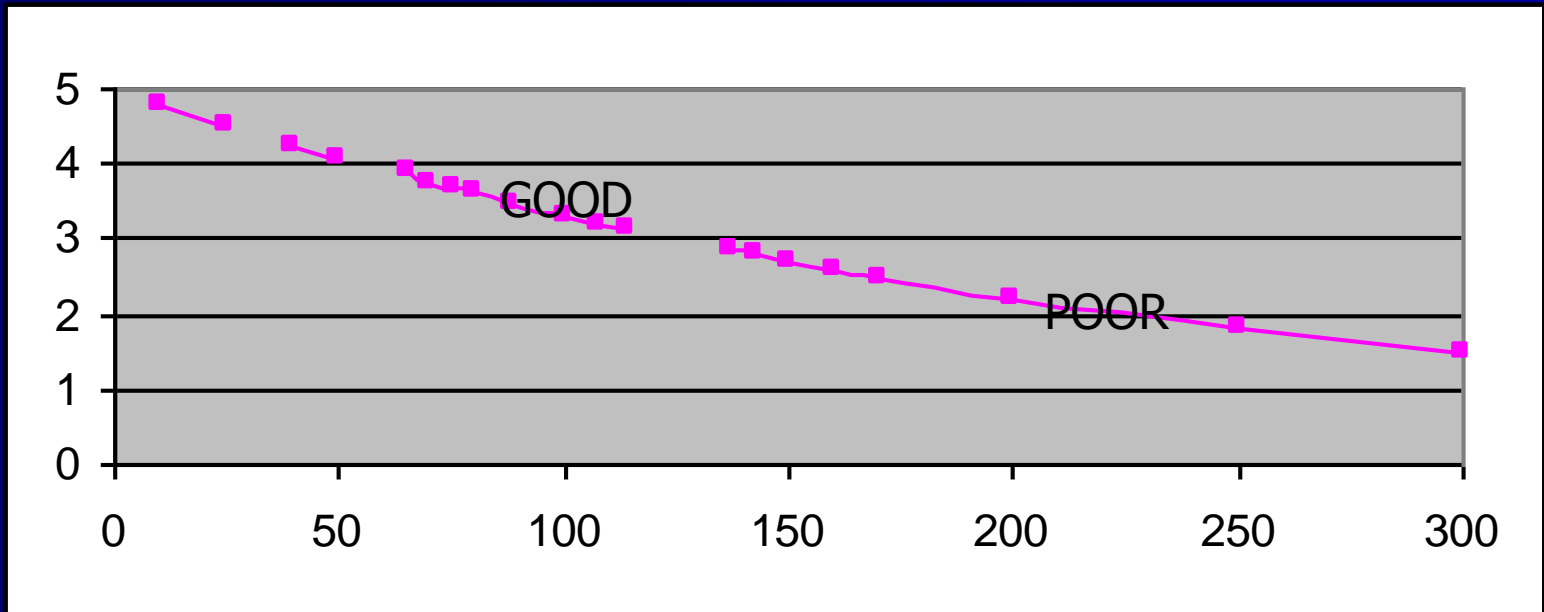
National Customer Survey

- Pavement Condition (smoothness) 36%
- Safety 22%
- Traffic Flow 16%
- Visual Appeal 11%
- Bridge Condition 6%
- Maintenance Response Time 6%
- Travel Amenities 3%

SMOOTHNESS AND PAVEMENT SERVICE RATING

NHI Model (1993 AASHTO) $PSR = K e^{-0.0041 * IRI}$

PSR

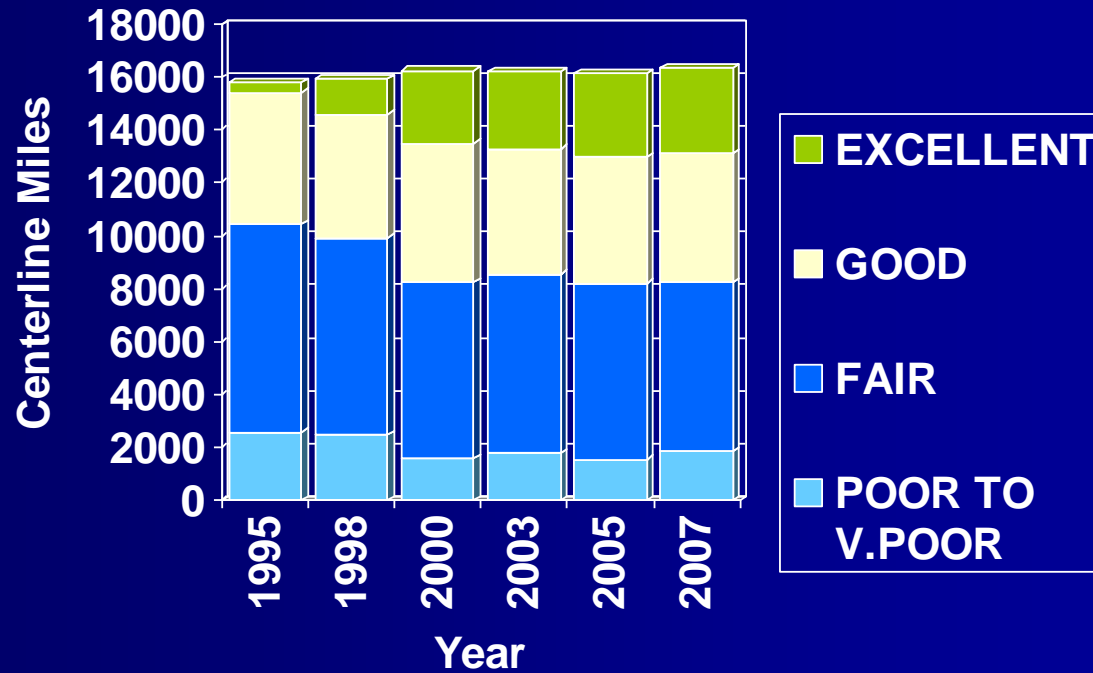


IRI

CLASSIFICATION OF HIGHWAYS BASED ON IRI

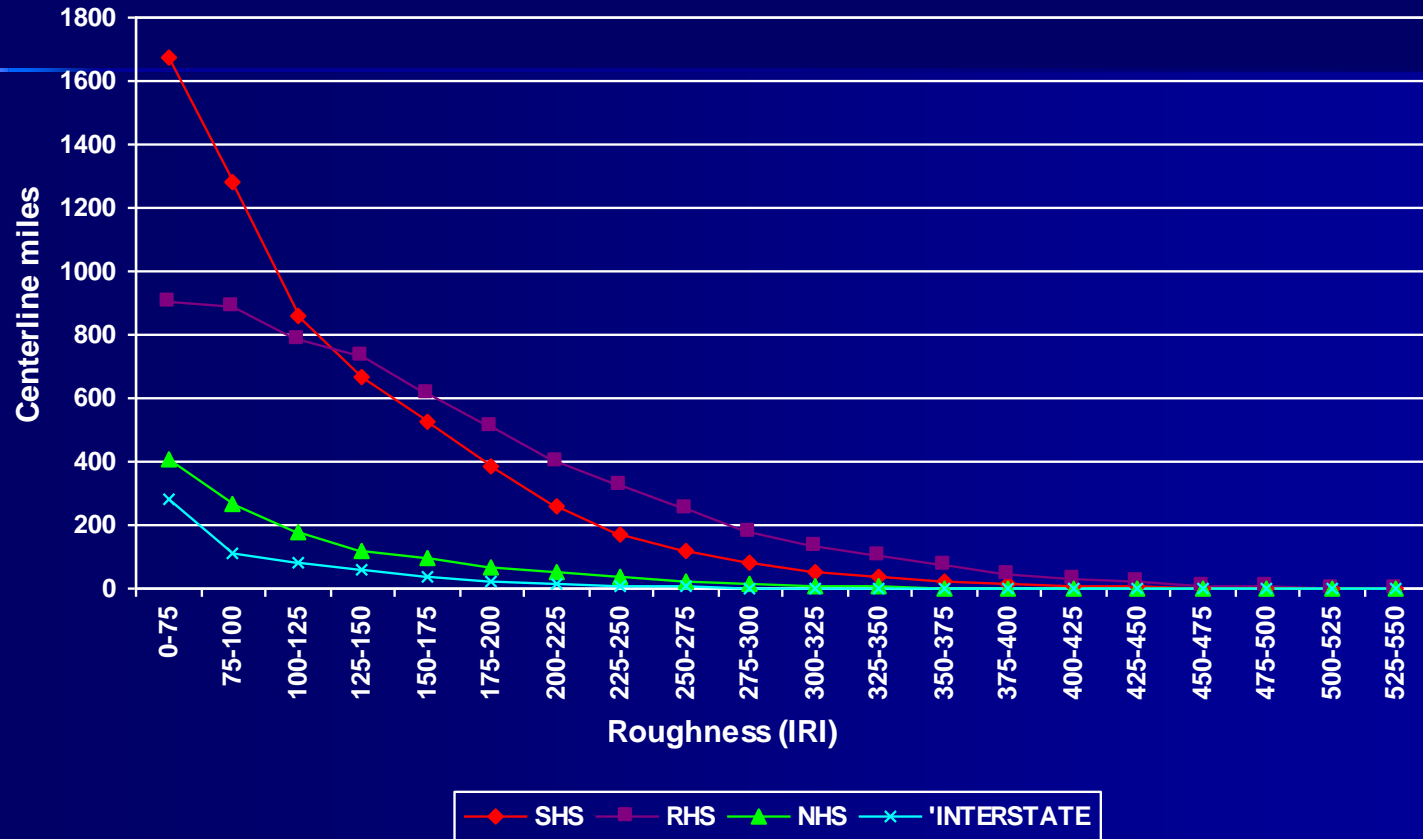
CONDITION	INTERSTATES	NHS	RHS AND SHS
Excellent	$IRI \leq 70$	$IRI \leq 75$	$IRI \leq 75$
Good	$IRI = 71 - 100$	$IRI = 76 - 110$	$IRI = 76 - 125$
Fair	$IRI = 101 - 170$	$IRI = 111 - 200$	$IRI = 126 - 225$
Poor	$IRI = 171 - 225$	$IRI = 201 - 250$	$IRI = 226 - 300$
Very Poor	$IRI \geq 226$	$IRI \geq 251$	$IRI \geq 301$

Roughness Condition Statewide From 1995 To 2007



	1995	1998	2000	2003	2005	2007
POOR TO V.	2601	2485	1600	1807	1568	1859
FAIR	7853	7451	6663	6761	6632	6377
GOOD	4952	4665	5238	4724	4780	4872
EXCELLENT	385	1335	2720	2920	3141	3240

Current ROUGHNESS DISTRIBUTION



Note: Distribution calculated from tenth of a mile records with no invalid IRI readings

Purposes for Smoothness Measurements

- Maintain construction quality
- Locating abnormal changes in the highway
 - subsurface problems, drainage, construction deficiencies
- Allocation of road maintenance resources
- Pavement serviceability performance and design

Smoothness Measurements

History

Methods

- Rolling Straightedge
- Ride Number (AASHO Road Test)
- BPR Roughometers
- Mays Ride Meter
- California Type Profiler (PI), La Specs since early eighties
- Inertial type Profilers (RN,PI, IRI)



California Type Profilograph

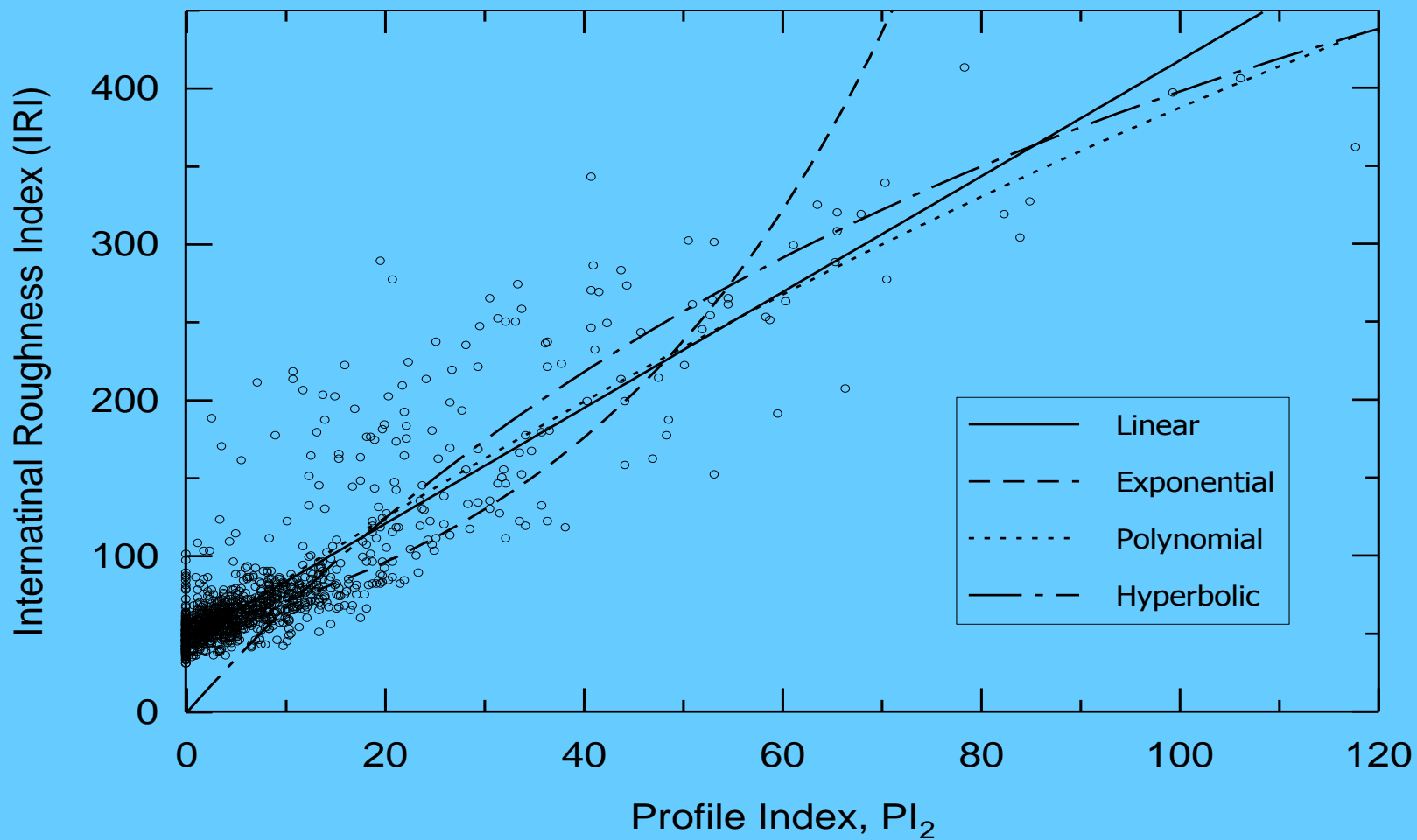


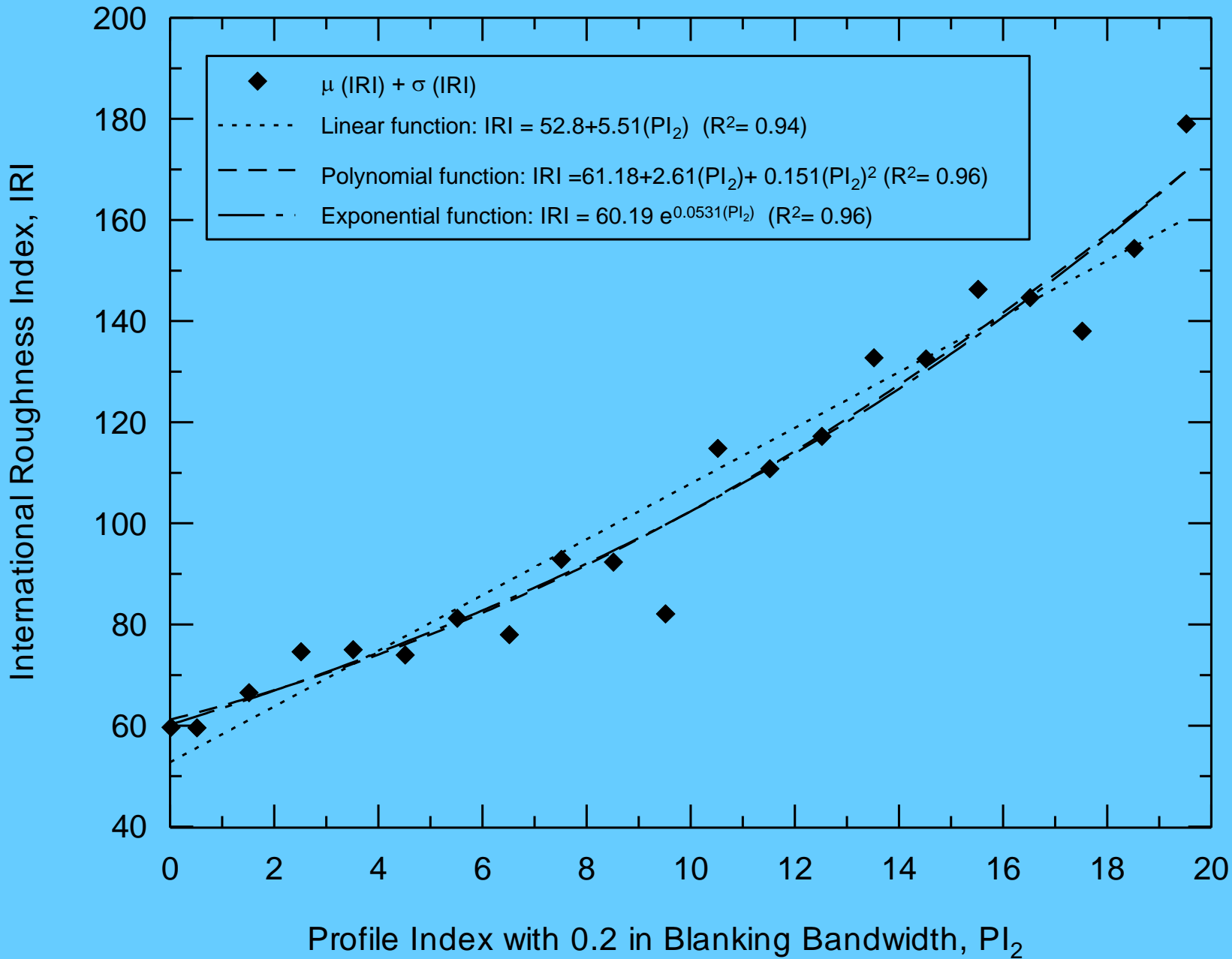


Setting up Calibration Site
w/ Walking Profiler

Smoothness Specifications

- (PI) Profile Index w/0.2" Blanking Band
- (IRI) International Roughness Index





IRI vs. PI

- Well-defined relationship between IRI and PI values of ≤ 20
- For PI values ≥ 20 , high degree of variability

EBLA28.P01 - B (24.000) - Section 1 of 1 - Seg 1 of 1 - PI2: 0.00 (in/mi)



Old Spec (PI) vs. New Spec (IRI)

Deficiencies with PI System (Manual)

- Labor Intensive, Slow, Safety?
- Blanking Band Filtering out Roughness
- PI does not represent the “ride” of the Roadway

AMES "LISA" Lightweight Inertial Profiler



```

FILE FLABLVD.P01          RP09
COUNTY                   ROUTE          D
OPERATOR DGR              DRIVER DGR    VEHICLE 2
FILE_NAME flablvd        USER_REF_2 0
DATE 05/17/2000          TIME 12:54:49 DCF
WAVELENGTH_LONG          91 m
WAVELENGTH_SHORT         0 m
  
```

METERS		ROUGH DIST	IN/MI		MM
FROM	TO		IRI 1	TEXTURE	
0	161	161	69	1.459 (R)	
161	322	161	65	1.857	
322	395	73	74	1.705	
395*	454	50	252	2.686	
=====	=====	=====	=====	=====	
0	454	445	89	1.699	

Lightweight profilers measure pavement profile (IRI), Profile index, (PI), rutting, and PCC joint faulting at 10-15 mph.

Surface Tolerance Requirements

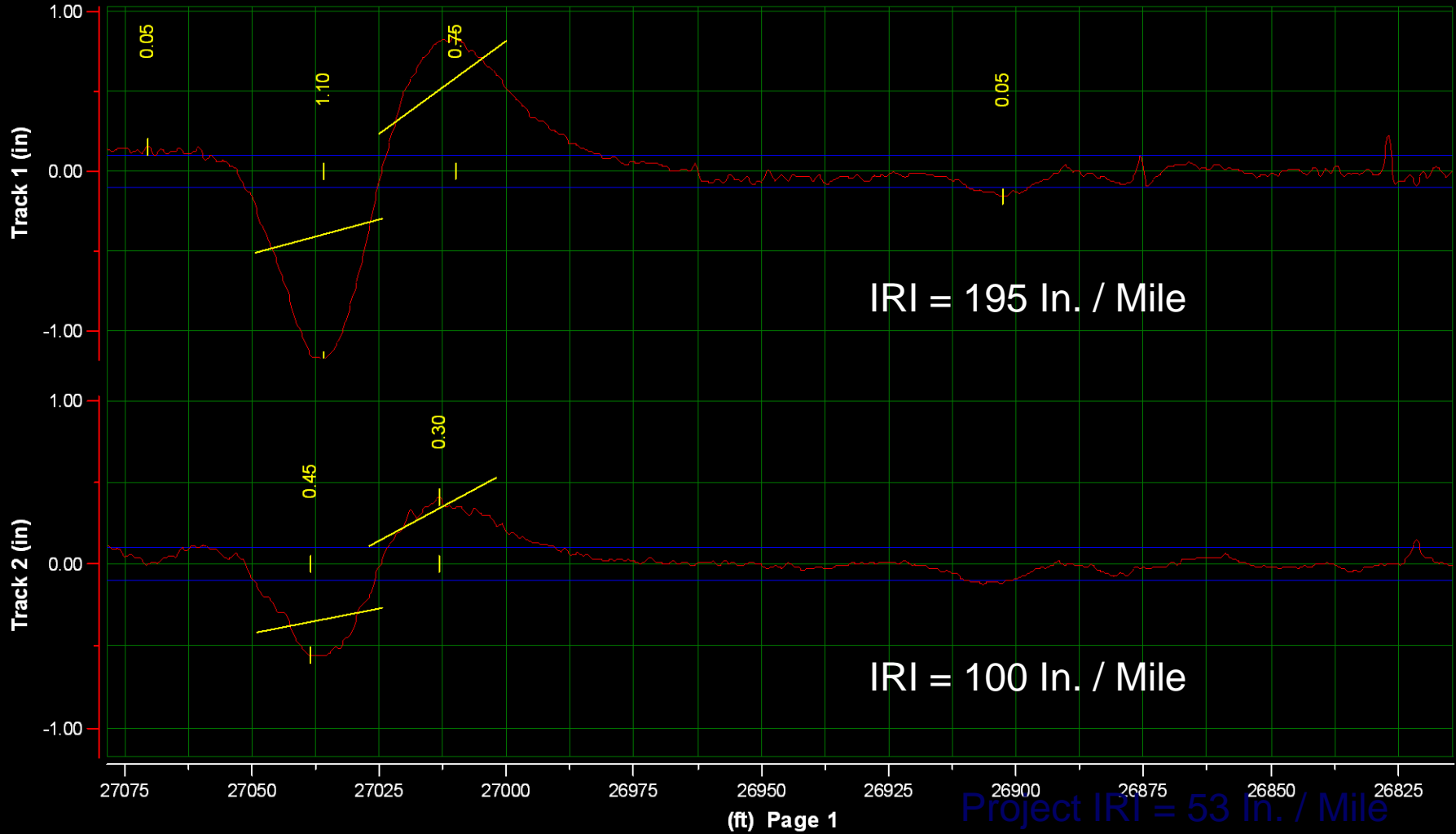
- Inertial profilers approved by Materials Engineer
- Annual certification and site calibration
- Measurement of both wheel paths
- Average every 0.05 mile intervals
- Individual wearing course wheel path readings <110 Binder Course <110 (<105 for category A)

Requirements (Cont)

- diamond grind wearing course to meet specs
- Binder course corrected (optional methods) to meet specs
- Contractor Profile may be used for acceptance



05007SBO.P01 - B (24.000) - Section 1 of 1 - Seg 64 of 102 - PI 1: 39.00 (in/mi) PI 2: 15.00 (in/mi)



Sublot IRI = 60 In. / Mile

Example of Louisiana Bump Specification

Louisiana Specifications, Flexible Pavements

Percent of Contract Unit Price (by Sublot) ¹	103% ²	100%	90%	80%	50% or Remove ³
Category A Multi-Lift New Construction and Overlays of More than two Lifts and all Interstates	<55 (<870)	<65 (<1030)	65-75 (1030-1180)	NA	>75 (>1180)
Category B One or Two Lift Overlays Over Cold Planed Surfaces, and Two-Lift Overlays Over Existing Surfaces ⁴	<65 (1030)	<75 (<1180)	75-89 (1180-1400)	NA	>89 (>1400)
Category C Single-Lift Overlays Over Existing Surfaces	<75 (<1180)	<85 (<1340)	85-95 (1340-1500)	>95-110 (>1500-1740)	>110 (>1740)
Incentive Pay, Final Completion, Average of All Travel Lanes ⁵	≤45 (≤710)				

¹or portion of sublot placed on the project.

²Maximum payment for sublots with exception areas, exclusions or grinding is 100 percent.

³At the option of the engineer.

⁴Also applies to two-lift overlays on reconstructed bases without profile grade control.

⁵Only Category A projects with no grinding are eligible for incentive.

Percent of Contract Unit Price/in/mile/sublot¹

%of Unit Price	103%	100%	90%	80%	50% or Remove
Cat. A					
Interstate and multi-lifts	<45	<65	65-75	NA	>75
Cat. B					
2-Lift Overlay	<45	<75	75-89	NA	>89
Cat. C					
Single-Lift Overlay	<45	<85	85-95	95-110	>110
Incentive Pay,		≤ 45; Final Completion, Average of All Travel Lanes (with no lot less than 100% pay); +5% of the value of the wearing course (plan			

Development of IRI Specifications for PCCP

LTRC Pavement Group

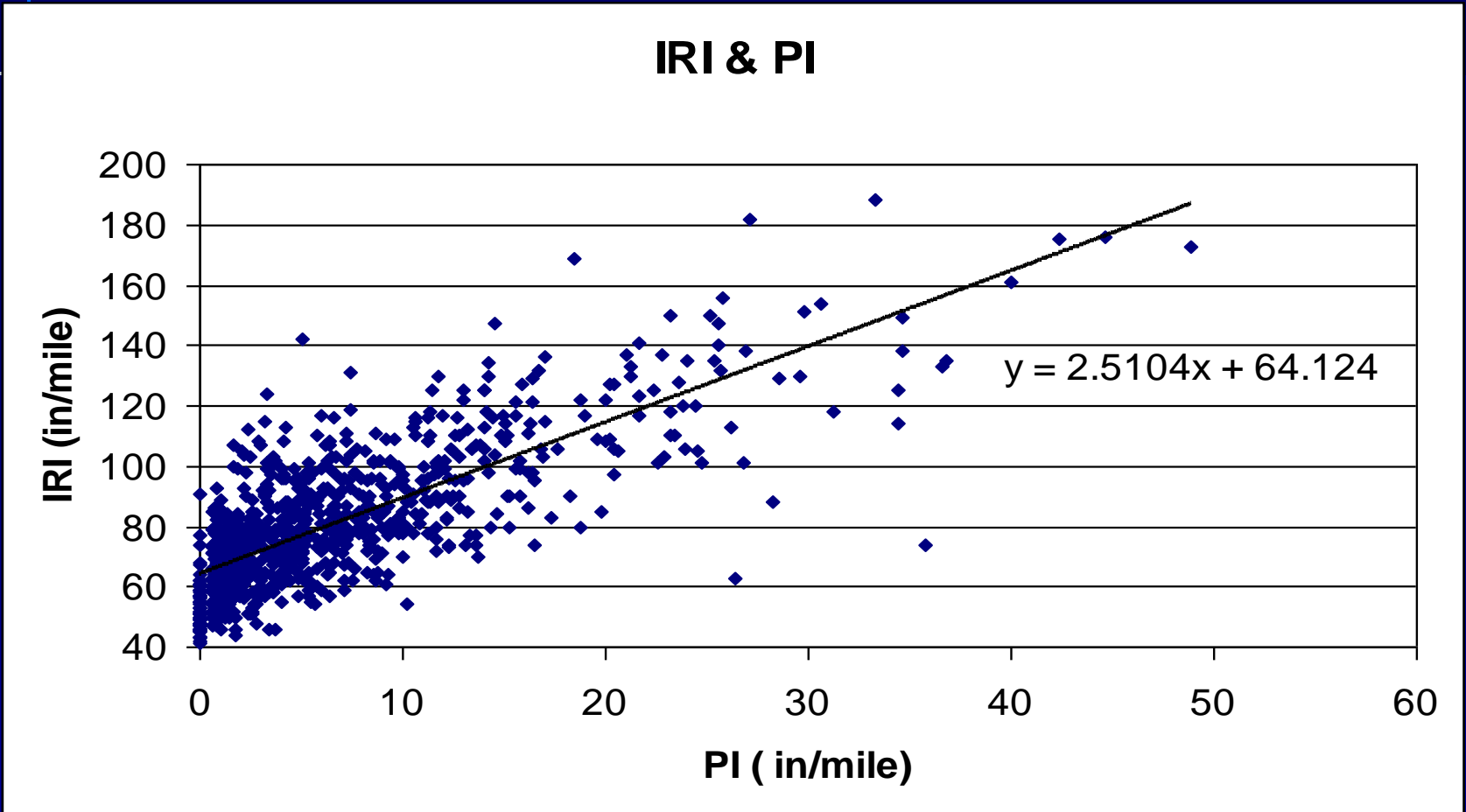
Methodology

- Collection of Profile Data on Selected PCCP jobs using LTRC ICC's High Speed Profiler
- Developing PI and IRI data from the selected Sites
- Using Linear Regression to Establish IRI values based on the Existing PI specifications (similar to what was done for flexible pavements)

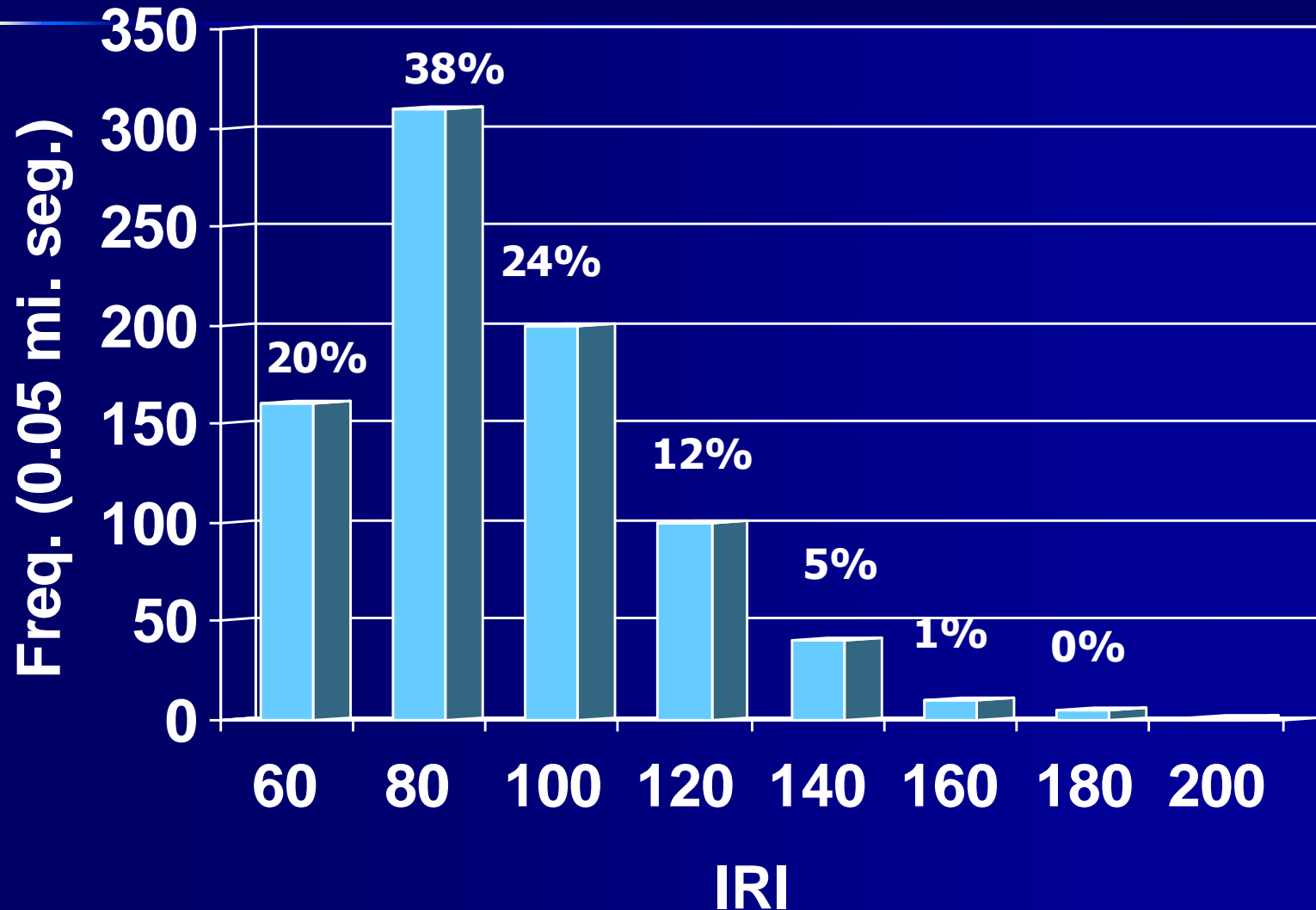
PCC Sample Projects

Project Description	IRI	PI
LA 14, ERATH-DELCAMBRE, SP# 056-06-0049	70	6
I-12, TANGIPAHOA PARISH, SP# 45403-0028 (WB-OWP)	58	1
LA 447, SP# 26801-0012, WALKER	113	18
NORTHLINE ROAD (ALF RD)	64	4

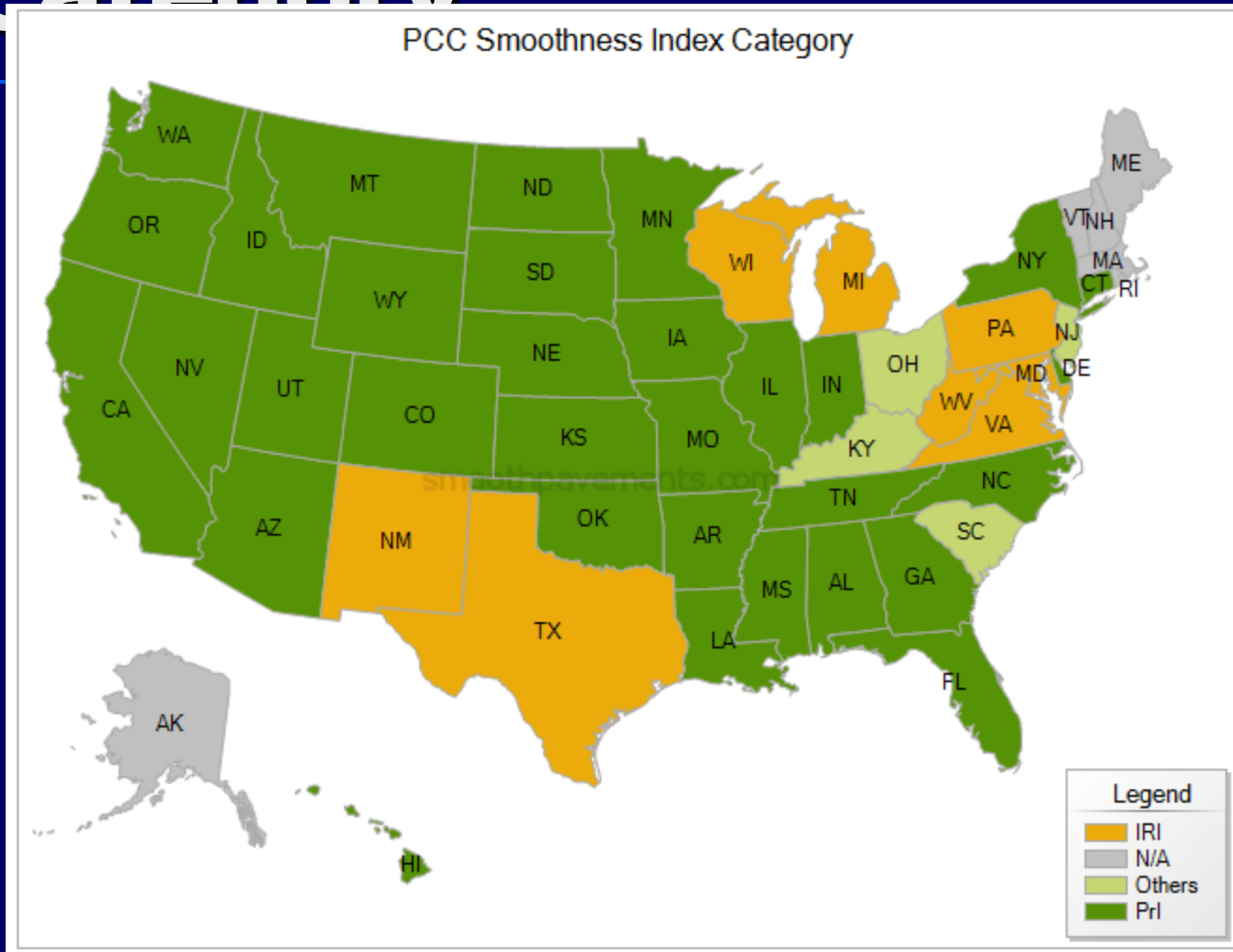
IRI & PI (each 0.05 mi. seg)



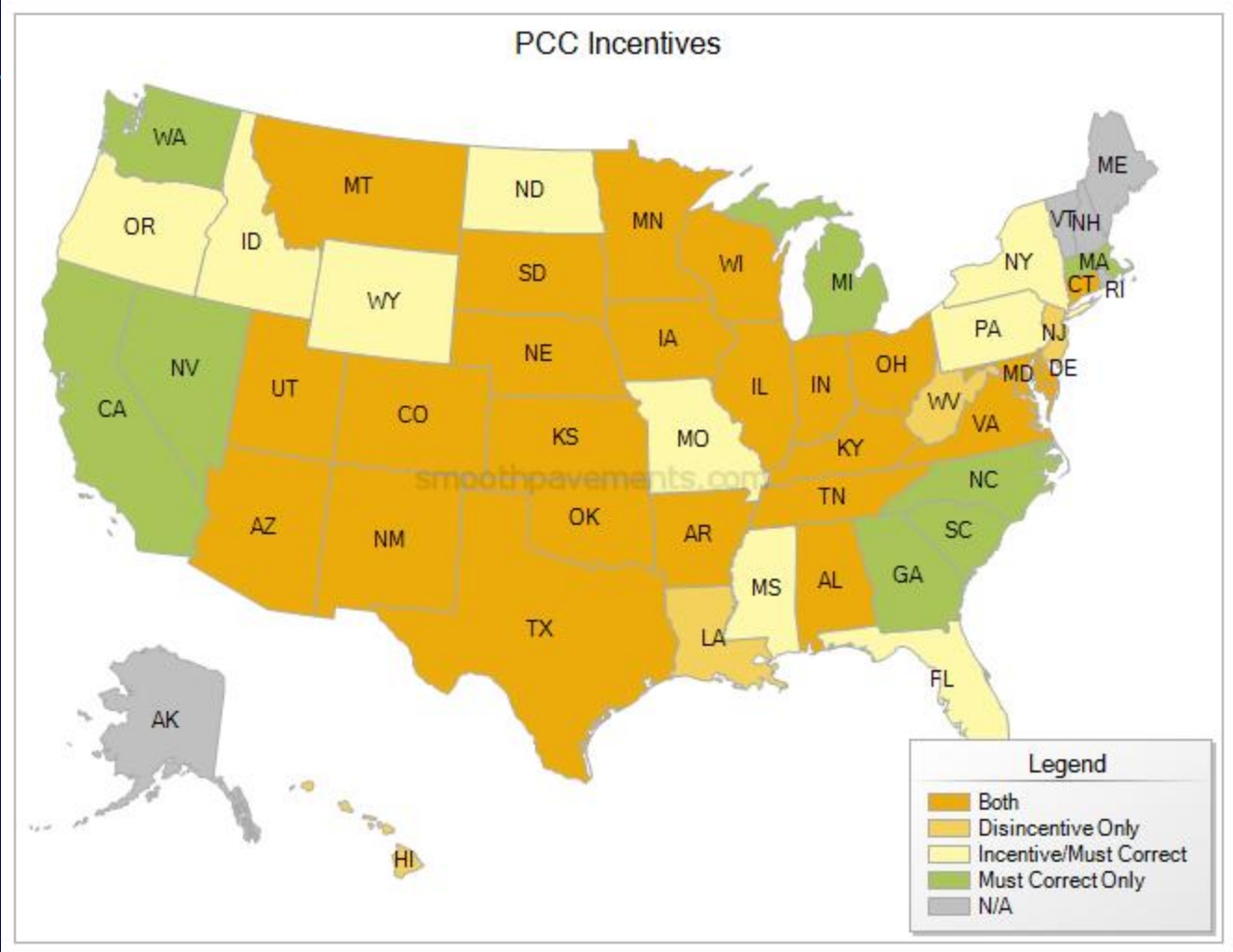
Initial JCP IRI; In/mile



PCC Smoothness Index Category



PCC Incentives



PCC IRI Specifications by State

Based from specifications
posted on
<http://www.smoothpavements.com/>

Kentucky

IRI	Pay Multiplier
< 53	+0.03
54-56	+0.02
57-60	+0.01

- Valid only if Average PI is 6 in per mile or lower
- Decentives based on PI

Maryland

Rating	Interstates	Principal Arterials
Very good	< 60	< 60
Good	60 - 94	60 - 94
Fair	95 - 119	95 - 170
Mediocre	120 - 170	171 - 220
Poor	> 170	> 220

- Pay increase and decrease based on IRI rating through multiple equations

Michigan

Speeds greater than 50 mph	Speeds 30 - 50 mph	Condition
0 - 75	0 - 125	Acceptable
> 75	> 125	Correction

New Mexico

Interstate & NH	non-NH	Pay Multiplier
< 52.2	< 49.6	110%
52.3 - 53.2	49.6 - 50.9	109%
...
60.3 - 61.3	59.9 - 61.1	101%
61.4 - 62.3	61.2 - 62.4	100%
62.4 - 63.2	62.5 - 63.8	99%
...
71.8 - 72.8	74.7 - 76	90%
> 72.8	> 76	Correction

Ohio

IRI	Thickness < 8 in	Thickness > 8in
< 45	\$375	\$875
45 - 50	\$225	\$525
50 - 55	\$150	\$350
55 - 60	\$75	\$175
60 - 70	\$0	\$0
70 - 75	-\$150	-\$350
...
90 - 95	-\$750	-\$1750
> 95	Correction	Correction

Pennsylvania

Type 1 Lots	Type 2 Lots	\$
< 35	< 45	\$1500
< 50	< 55	\$1000
< 60	< 70	\$500
< 70	< 90	0
> 70	> 90	Correction

Texas

IRI	Schedule 1*	Schedule 2*	Schedule 3*
<= 30	600	600	300
31	580	580	290
...
59	20	20	0
60	0	0	0
...
65	0	0	0
66	-20	-20	0
67	-40	-40	0
...
94	-580	-380	0
95	-600	-400	0
> 95	Correction	Correction	N/A

*Dollars per 0.1 mile

Wisconsin

Category I	\$	Category II	\$
< 25	250	< 50	250
25 - 35	$875 - (25 \times \text{IRI})$	50 - 65	$3250/3 - (50/3 \times \text{IRI})$
35 - 55	0	65 - 105	0
55 - 120	$5500/13 - (100/13 \times \text{IRI})$	105 - 120	$3500 - (100/3 \times \text{IRI})$
> 120	-500	> 120	-500

Category III	\$
< 50	250
50 - 65	$3250/3 - (50/3 \times \text{IRI})$
> 65	0

Virginia

IRI	Pay Multiplier
< 45	105%
45.1 - 55	103%
55.1 - 70	100%
70.1 - 80	90%
80.1 - 90	80%
90.1 - 100	70%
> 100	Correction

Louisiana Proposed

Category I	Category II	Category III	Pay Multiplier
speed > 45 mph	Urban Continuous, speeds < 45 mph	Urban, not continuous speeds < 45 mph	
≤ 65	≤ 80	N/A	+2%*
≤ 75	< 90	≤ 115	100%
76 - 84	91 - 99	116 - 129	98%
> 85	> 100	> 130	Correction
> 95	> 110	> 140	Min for next day continue

*Incentive Pay: average IRI in each travel lane based on the one mile (or longer) length test section is equal to or less than indicated and all IRI readings are at or below the 100% pay range.

•Grinding will not be allowed to achieve bonus; only to achieve 98% or 100% pay.

The Bottom Line

- Every phase of construction is a new opportunity to achieve a smoother and flatter road.build smoother bases.
- Roadway maintenance will decline
- Our customers get what they asked for, a smooth ride.

The Bottom Line is a Straight Line

- Every phase of construction is a new opportunity to achieve a smoother road
- Roadway maintenance will decline
- Our customers get what they asked for, a smooth ride.