IRI Update and Real-Time Smoothness Since Implementation

Fall 2019 NCC Meeting - Kalispell, MT

11 September 2019

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U.S. Department of Transportation Federal Highway Administration

National Concrete Pavement Technology Center

CP Tech Center

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IRI and Real-Time Smoothness

- Update on IRI Specifications
- Guide Specification for PCCP
- RTS Implementation Update
- Guidelines for Best Practices for Concrete Pavement Smoothness

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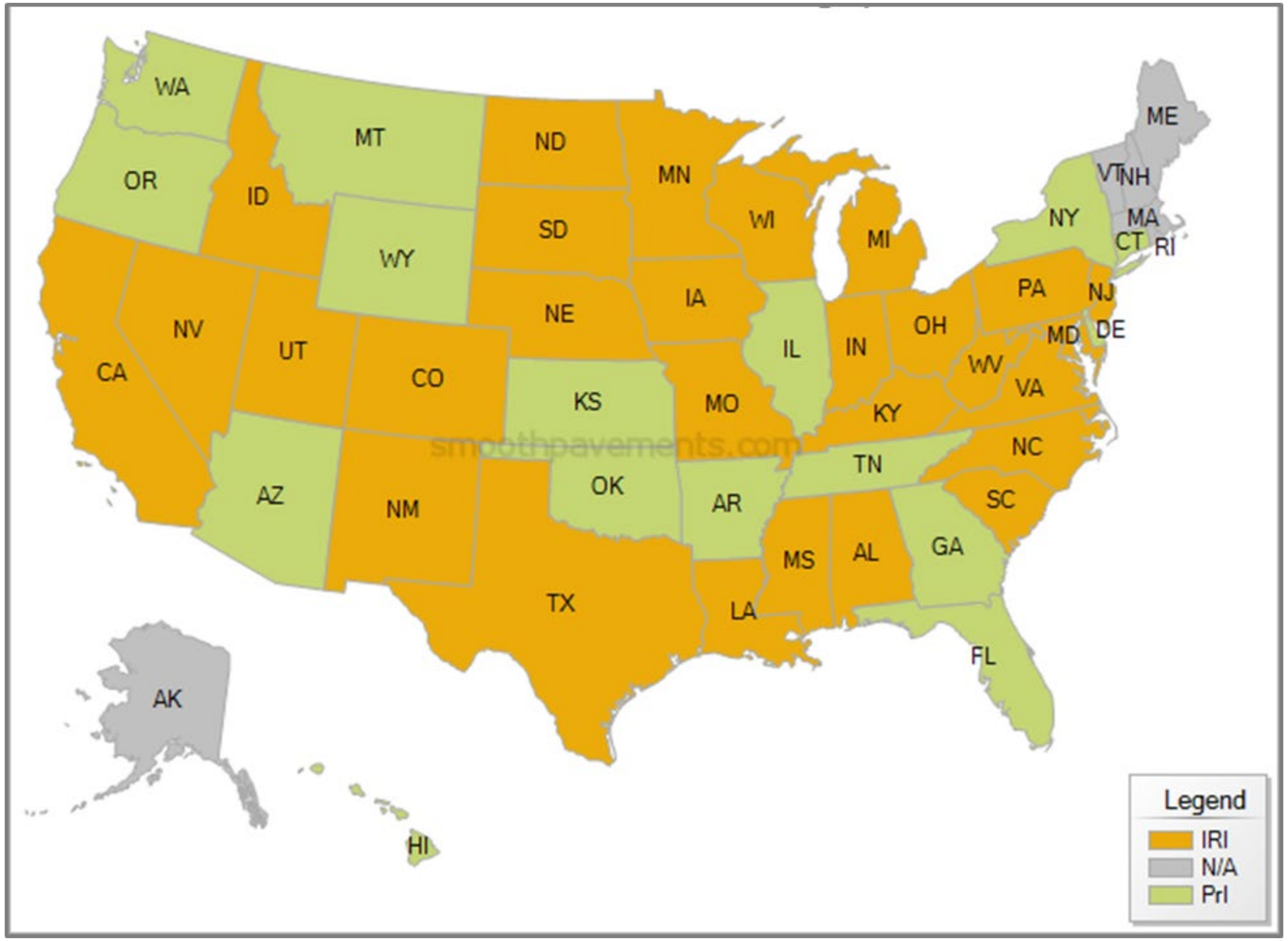
Update on IRI Specifications

- Current (2018) Specifications for PCCP: Index



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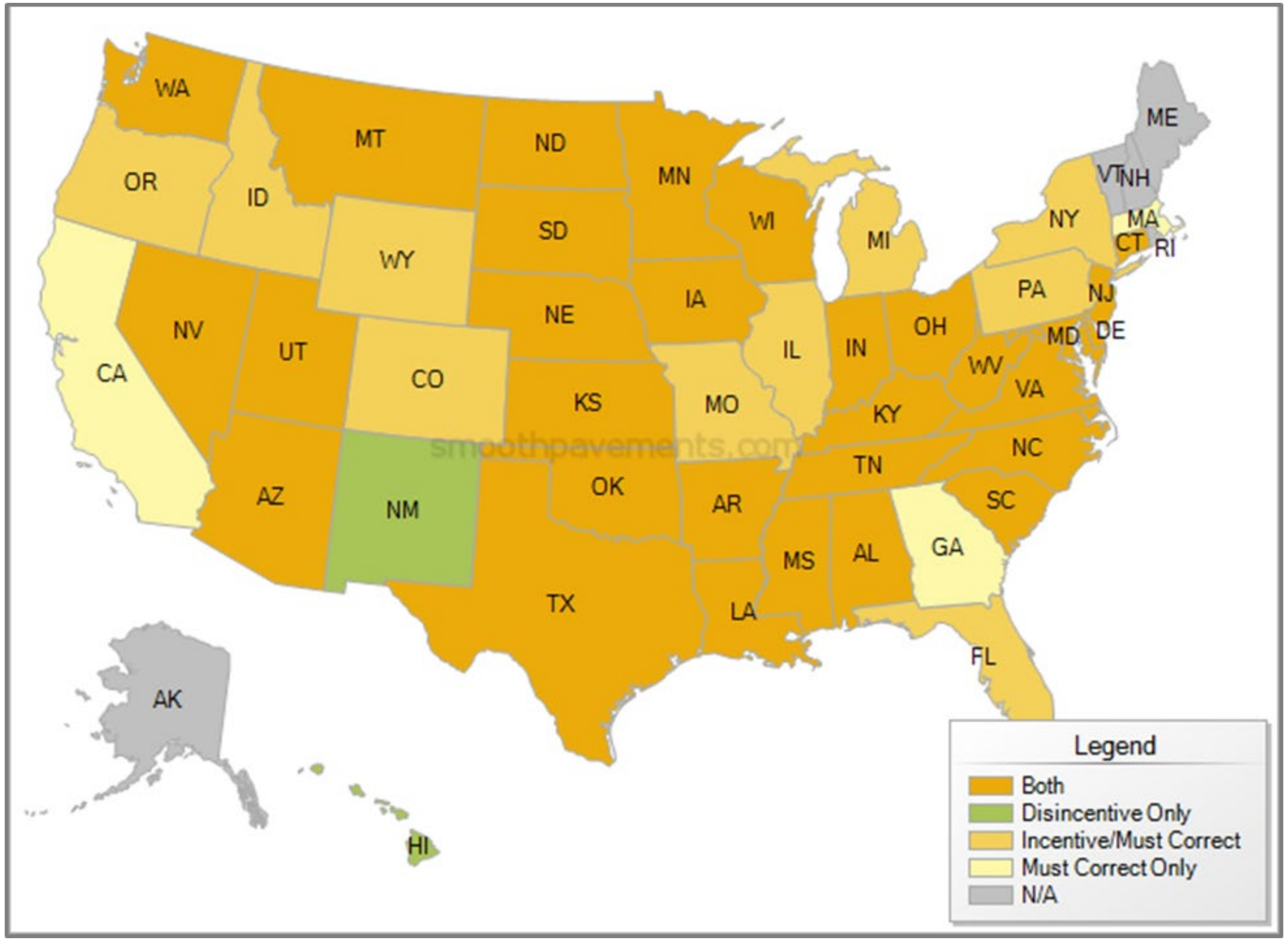
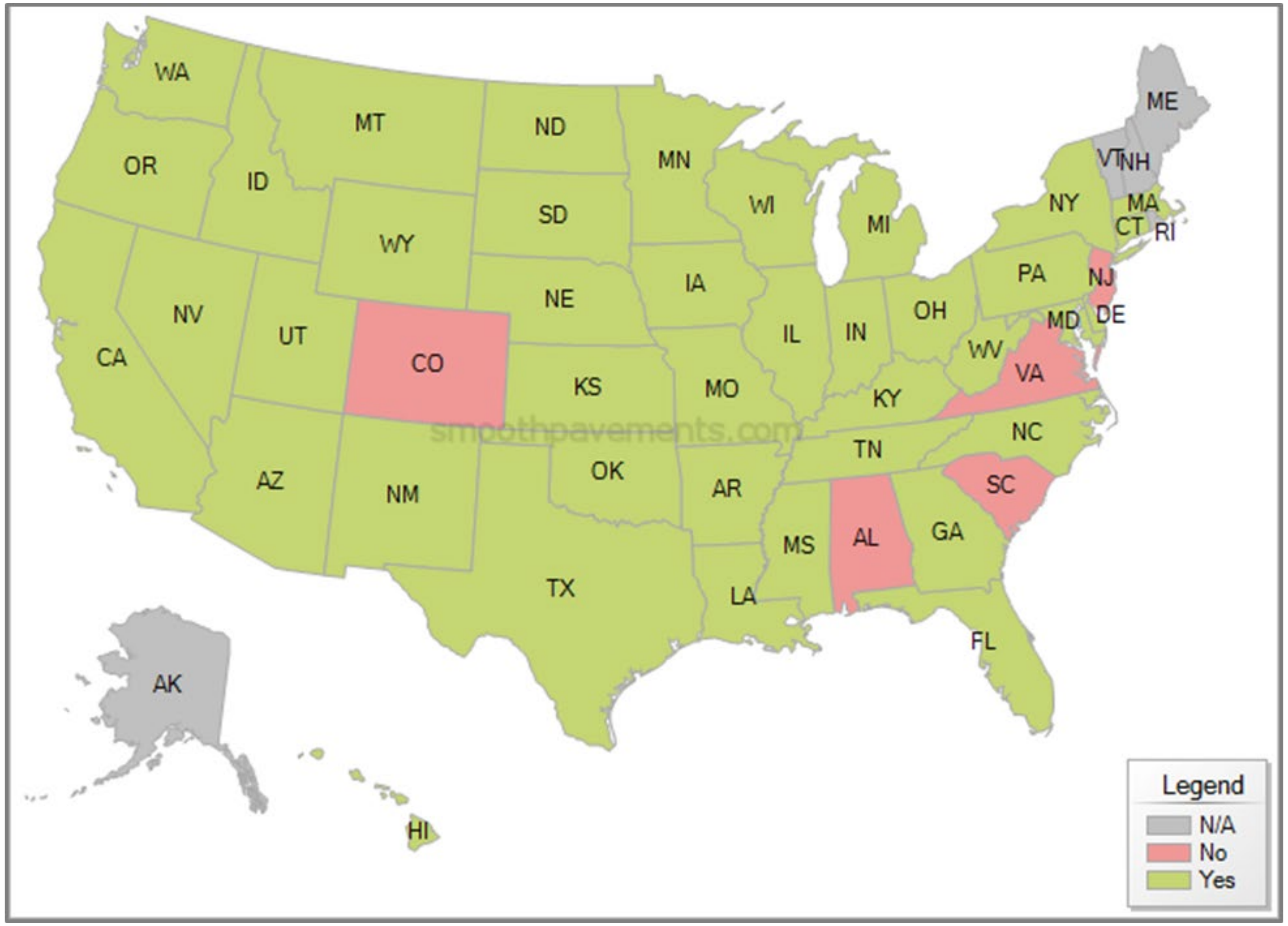
Update on IRI Specifications

- Current (2018) Specifications for PCCP: Pay Adjustment



Update on IRI Specifications

- Current (2018) Specifications for PCCP: Localized Roughness



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Update on IRI Specifications

- Summary of IRI-based specification thresholds for concrete pavement

		Incentive Upper Limit	Full Pay Lower Limit	Full Pay Upper Limit	Disincentive Lower Limit	Disincentive Upper Limit	Threshold for Correction
MRI & IRI (22 states)	*min*	39.9	40.0	54.0	54.1	67.5	60.0
	max	70.0	71.0	93.0	93.1	140.0	150.0
	avg.	56.2	56.5	71.7	72.5	95.3	96.9
HRI (CO only)		57.9	58.0	67.0	67.1	85.0	85.0

Merritt et al. 2015

Update on IRI Specifications

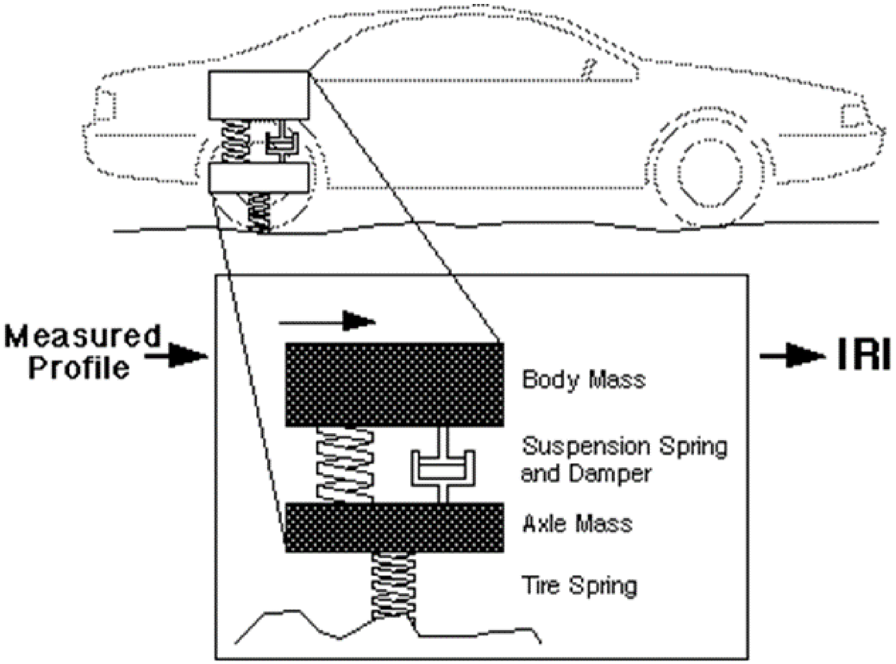
- Range of Incentives/Disincentives

Pay Adjustment Basis		Maximum Incentive	Maximum Disincentive
$ per lot (0.1 mi) ***9 states***	*min*	$200	-$250
	max	$1,600	-$1,750
	avg.	$879	-$900
$ per lot (SY) ***2 states***	*min*	$1.40	-$1.12
	max	$1.40	-$1.40
	avg.	$1.40	-$1.26
$ per lot (1.0 mi) ***1 state***		$7,350	-$7,350
$ per lot (0.01 mi) ***1 state***		$50	-$500
$ per lot (500 ft.) ***1 state***		$250	-$250
Extended Pay Adjustment **$ per lot (0.1 mi)** ***13 states (NJ excluded)***	*min*	$200	-$250
	max	$1,600	-$1,750
	avg.	$825	-$831
Percent Contract Price ***7 states***	*min*	102%	90%
	max	108%	50%
	avg.	105%	75%

Merritt et al. 2015

Update on IRI Specifications

- Why IRI?
  - Objective measure of pavement *Ride Quality*, not just *Smoothness.*
  - Uses the true profile to compute vehicle response to deviations in pavement profile (“roughness”).

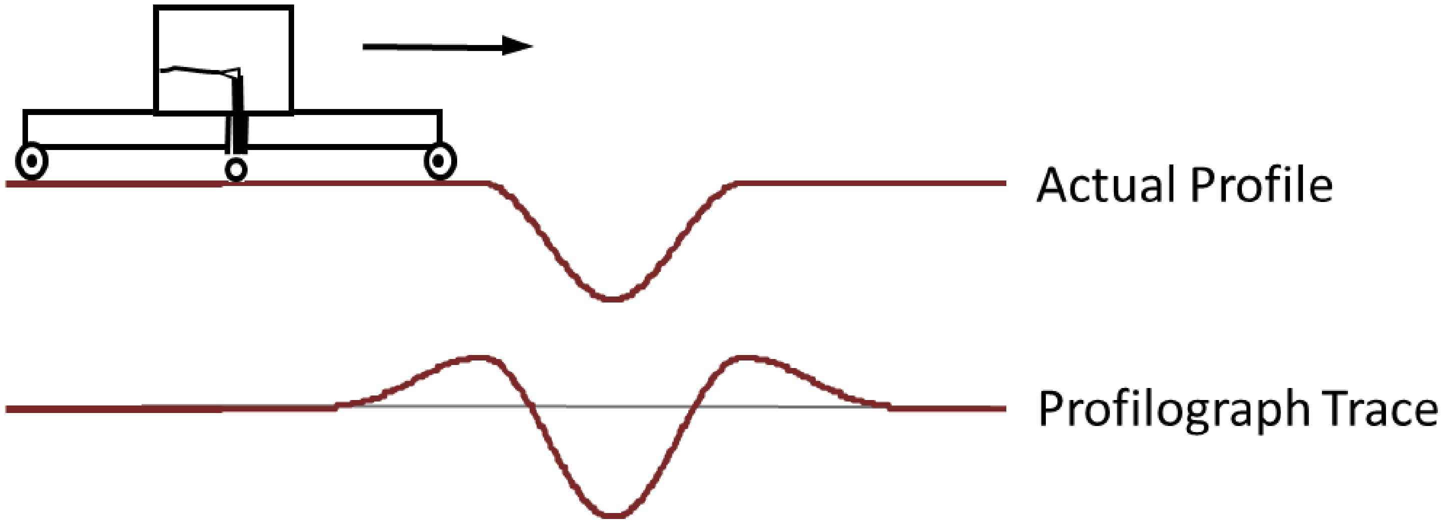


Computer Algorithm

Little Book of Profiling

Update on IRI Specifications

- Why IRI?
  - Profilograph trace is not the true pavement profile, but the profilograph's interpretation of the true profile - a "mechanical filter."



"No claim is made that the roughness or riding quality of a pavement is directly or completely reflected by the profile index." (Francis Hveem, 1960)

Update on IRI Specifications

- Why switch to IRI?
  - Inertial Profiler (IP) technology is readily available and affordable.

Update on IRI Specifications

- Why switch to IRI?
  - IP sensor issues with longitudinal tined/diamond ground surfaces have been resolved with wide footprint sensors.
  - Efficiency of data collection
  - Safety for workers
  - HPMS reporting uses IRI

IRI and Real-Time Smoothness

- Update on IRI Specifications
- Guide Specification for PCCP
- RTS Implementation Update
- Guidelines for Best Practices for Concrete Pavement Smoothness

Guide Specification for PCCP

- Incentive-based specification for new construction
- Commentary-rich guide specification
  - “Modified” version of AASHTO R 54
  - Agencies can adapt to state-specific practices/preferences
- Key issues specific to concrete pavement
  - JPCP curl/warp – diurnal changes in profile and roughness
  - Highlight importance of QC and tools such as real-time smoothness

IRI and Real-Time Smoothness

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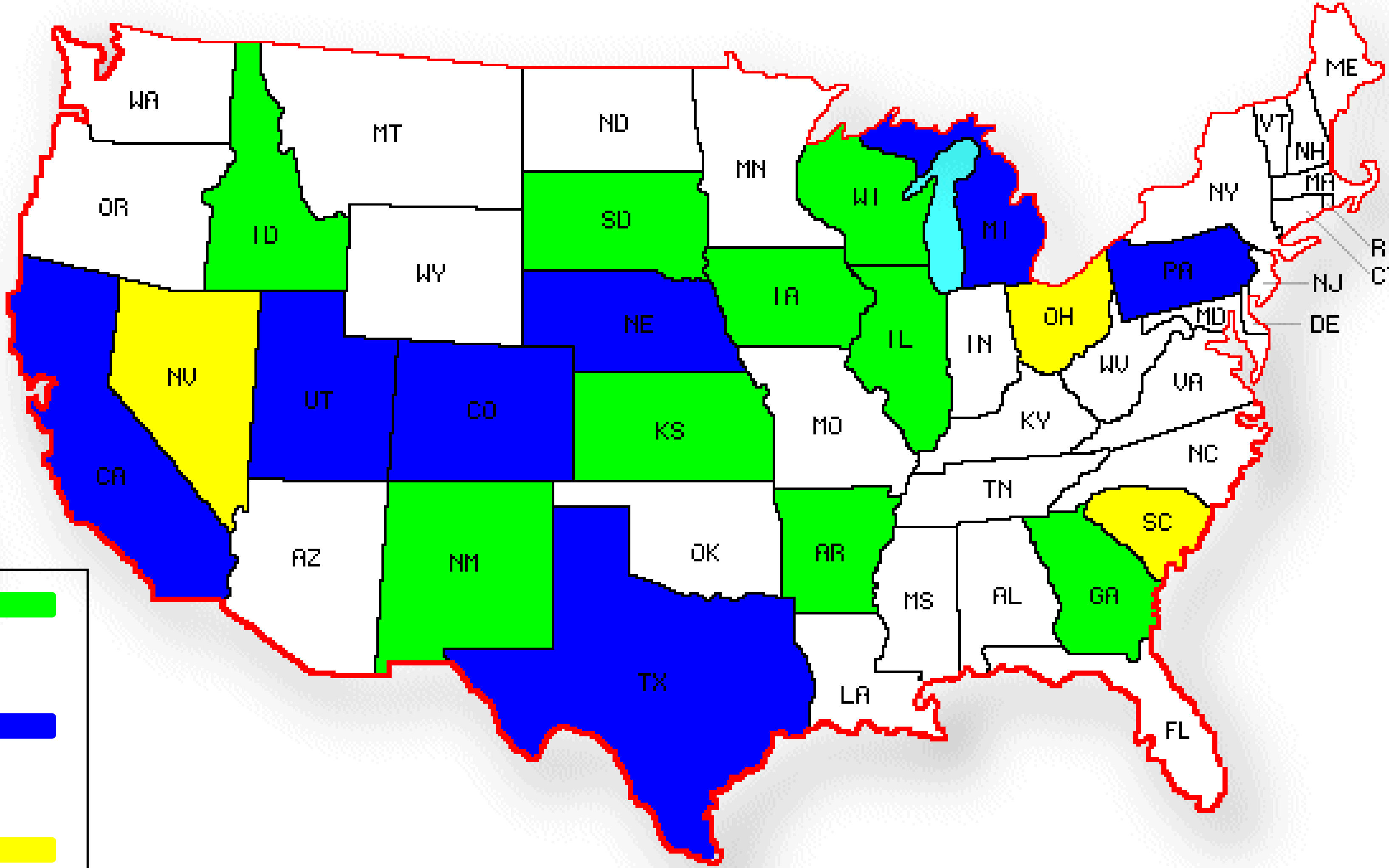
RTS Implementation Update

- 2010 – 2013: SHRP2 RTS technology evaluation
- 2014 – 2017: SHRP2 RTS technology implementation
  - 11 equipment loans
  - 8 workshops
- 2017 – 2019: FHWA RTS technology implementation
  - 10 equipment loans (7 completed)
  - On-call technical support
  - 2 webinars (1 completed)
  - Guide Specification
  - Guidelines for Best Practices

RTS Implementation Update

- Effort by state



Equipment Loans	green
Equipment Loans and Workshops	blue
Workshops	yellow

RTS Implementation Update

- Equipment
  - Ames RTP
  - Gomaco GSI (1st and 2nd Generation)

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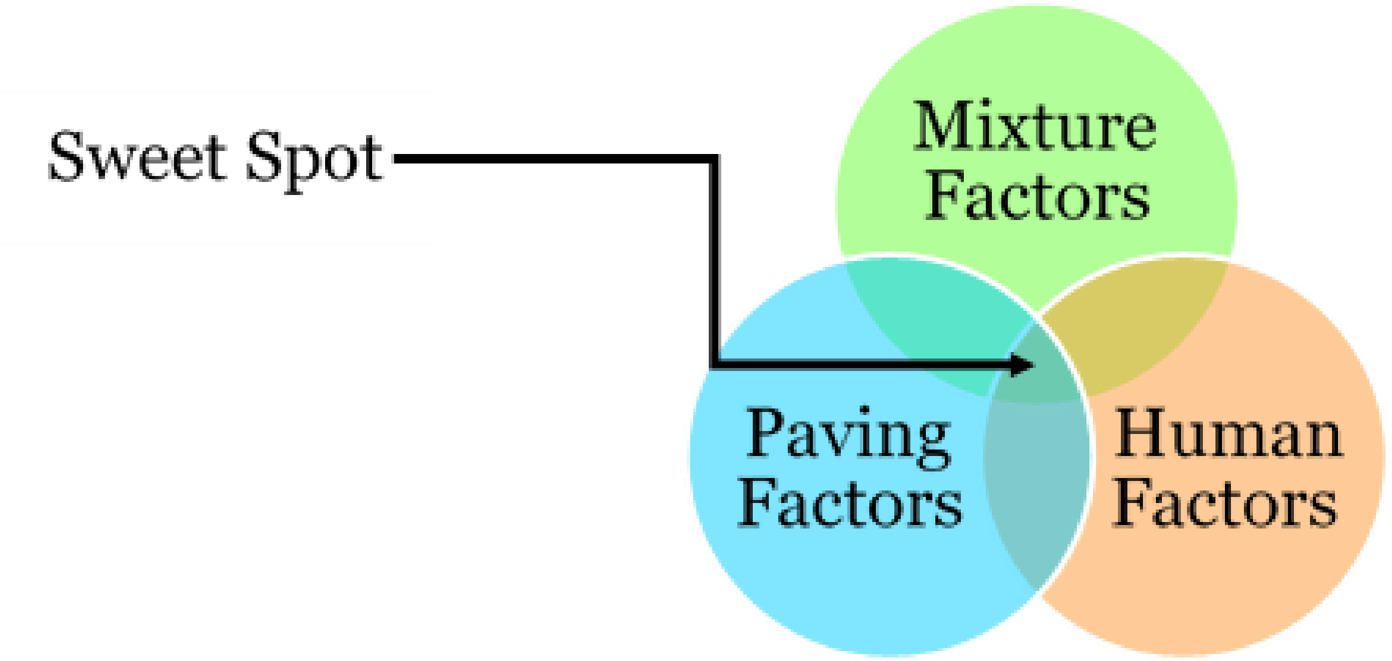
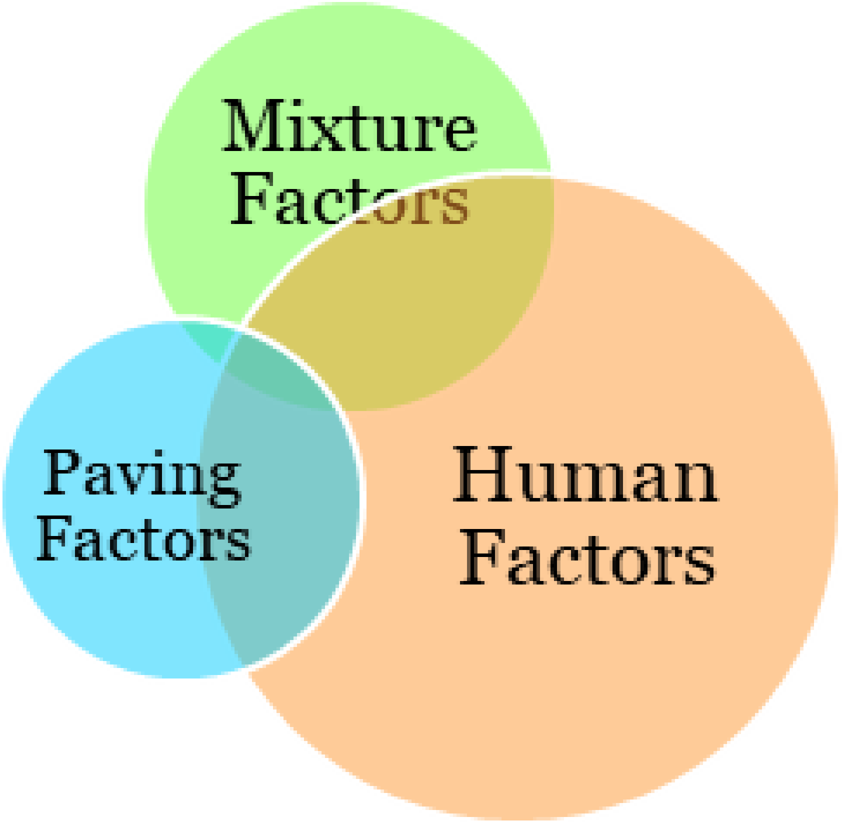
Guidelines for Best Practices for Concrete Pavement Smoothness

- Impacts on initial smoothness



Guidelines for Best Practices for Concrete Pavement Smoothness

- Paving factors includes design elements
  - Vertical curves
  - Superelevation transitions
  - Project phasing (jigsaw puzzle)
  - Blockouts (gaps)
  - Matching existing lanes
  - Equipment clearance and trackline



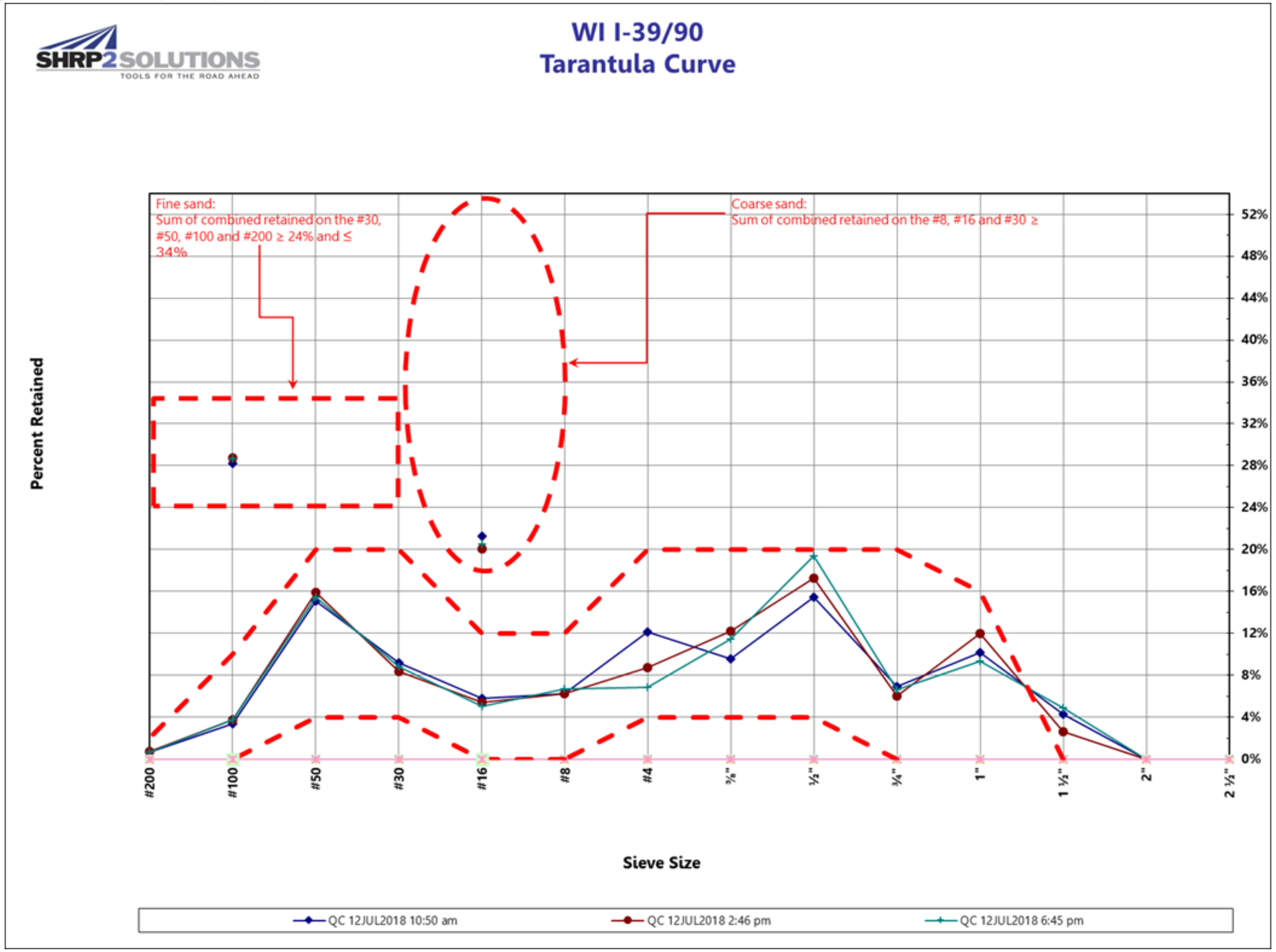
- **Specification limits should be adjusted for design elements that prohibit conformance with the specification**
- **A grinding pay item should be included when matching existing pavement**

Guidelines for Best Practices for Concrete Pavement Smoothness

- Materials and Mixtures
  - Performance engineered mixtures (PEM), optimized for:
    - Durability of the mixture
    - Economics
    - Sustainability
    - Utilization of locally available materials
    - Workability of the mixture
    - Other performance objectives

Guidelines for Best Practices for Concrete Pavement Smoothness

- Materials and Mixtures
    - Tarantula curve



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Guidelines for Best Practices for Concrete Pavement Smoothness

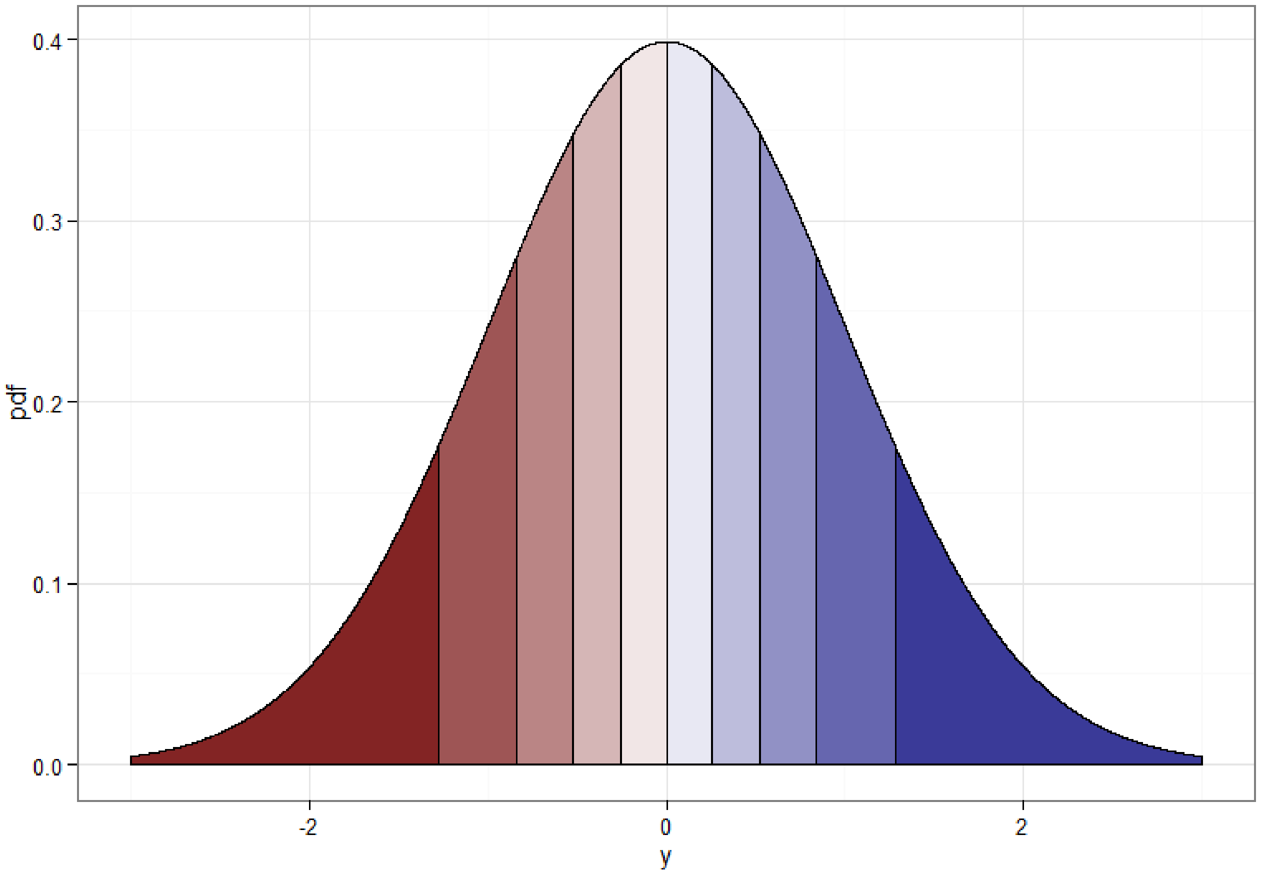
- Materials and Mixtures
- Response to vibration in the lab
    - Box test
    - Vkelly
- The paver is the field QC test

Guidelines for Best Practices for Concrete Pavement Smoothness

- Mixture Production
  1. Supply uniform concrete to the paving operation
  2. Produce and deliver the concrete at a rate that will allow the paving operations to maintain a consistent speed with minimal paver stops (consistent delivery)

Guidelines for Best Practices for Concrete Pavement Smoothness

- Mixture Production
- Uniformity, Uniformity, Uniformity
    - Within batch
    - Between batch



Guidelines for Best Practices for Concrete Pavement Smoothness

- Mixture Production
- Uniformity

Factors	Recommendations
Mixture proportions	Calibrate scales and water meters regularly to assure that mixture proportions are within specified tolerances.
Total water content	Maintain stockpiles at a moisture content above saturated surface dry (SSD).
	Draw aggregates from areas of the stockpiles that have known moisture contents.
	Update moisture compensation values in the plant control system to match the aggregate stockpile moistures. Moisture content testing of the aggregate stockpiles and adjustment of the moisture compensation value should be performed at least twice per day and more frequently if
Aggregate gradation	Reject aggregates that do not meet job mix formula tolerances.
	Observe proper stockpiling techniques to minimize segregation. Blending of individual aggregate stockpiles may improve uniformity and mitigate moisture variability.
Air content	Monitor air content at the plant and adjust admixture dosages as needed.
Segregation of the mixture during transport	Maintain the haul route in a manner that minimizes excessively rough sections which can segregate the concrete mixture in non-agitating trucks.

Guidelines for Best Practices for Concrete Pavement Smoothness

- Equipment Setup
  - Paving mold
  - Vibrators
  - Tiebar inserter(s) – centerline and/or pavement edge
  - Dowel bar inserter (DBI)
  - Steering and elevation control (stringline or 3-D machine control)
  - Dry run

Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving - Mixture adjustments
  - Subtraction/Addition of water (not to exceed the w/cm of the approved mixture design)
  - Adjustment of admixture dosages
  - Minor reproportioning of aggregates
  - Heating or cooling the mixture

Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Process Adjustments
  - Make measured and methodical adjustments one at a time
  - Be data driven
  - Keep a meticulous log of process adjustments and events that have the potential to impact pavement smoothness measurements

Guidelines for Best Practices for Concrete Pavement Smoothness

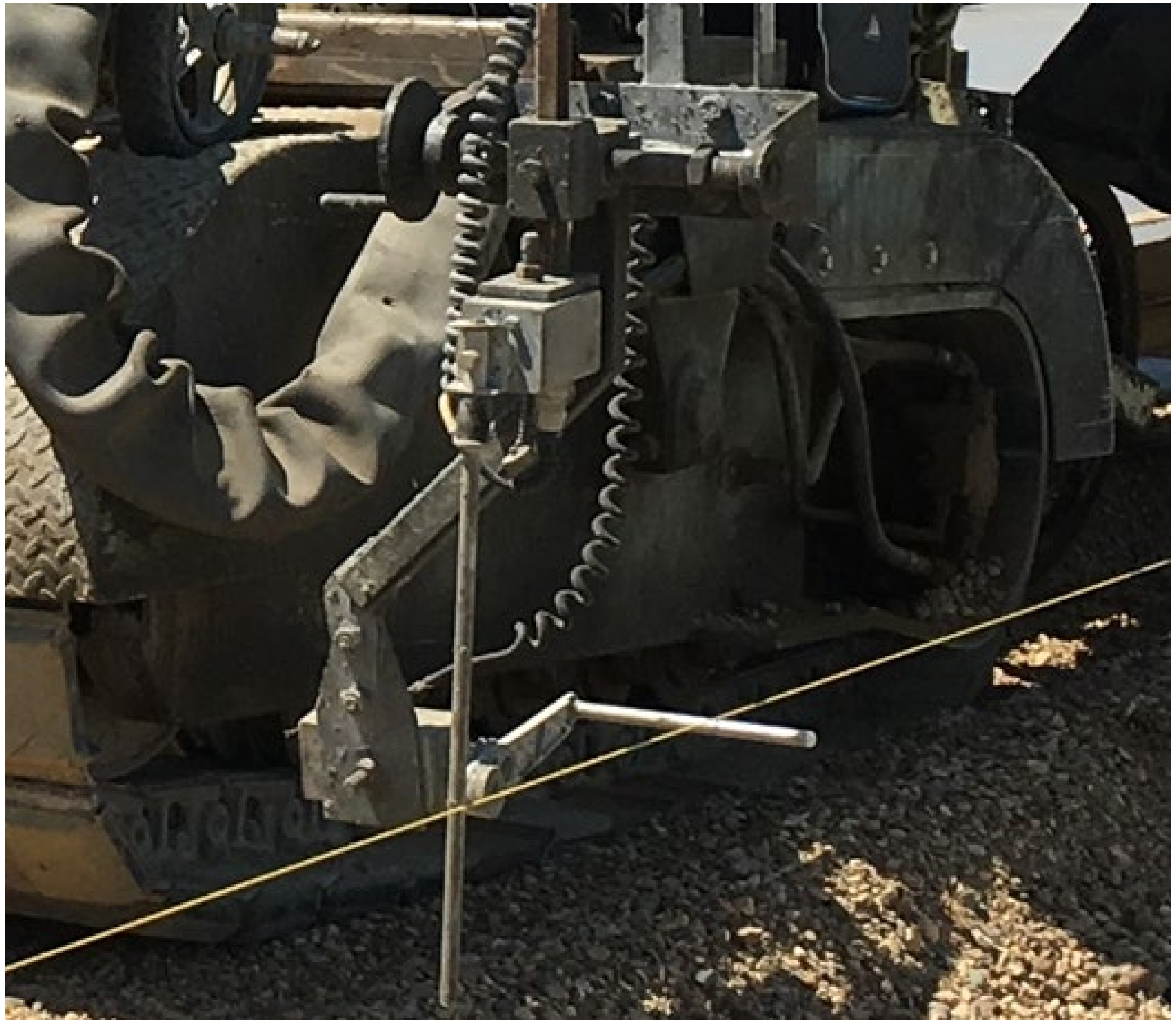
- Slipform Paving – Subbase Preparation
  - Finished to appropriate tolerance (±0.01’)
  - Maintain a uniform head of concrete

Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Trackline
  - Adequate width
  - Finished to appropriate tolerance (±0.01’)
  - Stable

Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Stringline
  - Stringline pins spaced at no greater than 25 ft. c/c
  - Tension the stringline using a winch. Check and re-tension stringline that has been in place for more than five days
  - Raise the stringline where the base course is high (less than design thickness of concrete pavement will be constructed)
  - “Eyeball” adjust the stringline for smoothness



Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – 3D Controls
  - Evaluate IRI of the model
  - Monitor the following:
    - Distance between the robotic total station and the paver
    - Line of sight issues between the robotic total station and the prism mounted on the paver
    - High winds causing movement to the robotic total station and/or the prism mounted on the paver
    - 3-D system errors (radio, software, hardware, wiring, batteries, etc.)

Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Spreading Concrete
  - React to changes in concrete head level quickly
  - Communication is key

Guidelines for Best Practices for Concrete Pavement Smoothness

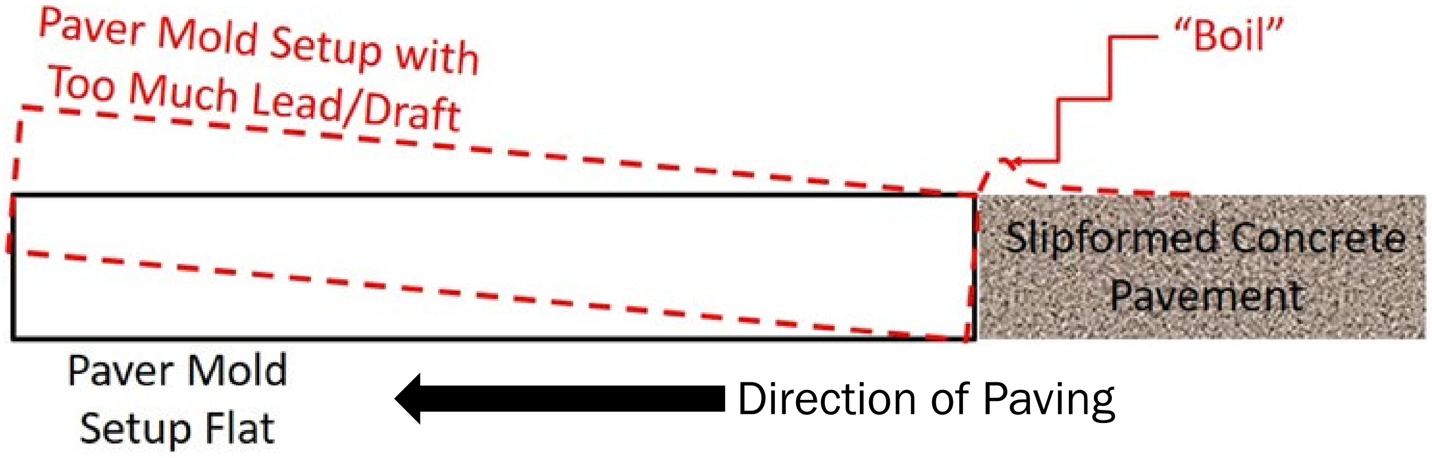
- Slipform Paving – Paver Speed
  - Minimize stops
  - Consistent speed
  - Slow down when necessary, but not too much
  - “Rhythm”

Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Vibrators
  - Frequency is speed dependent
  - Rebound from stiff base
  - Adjust height

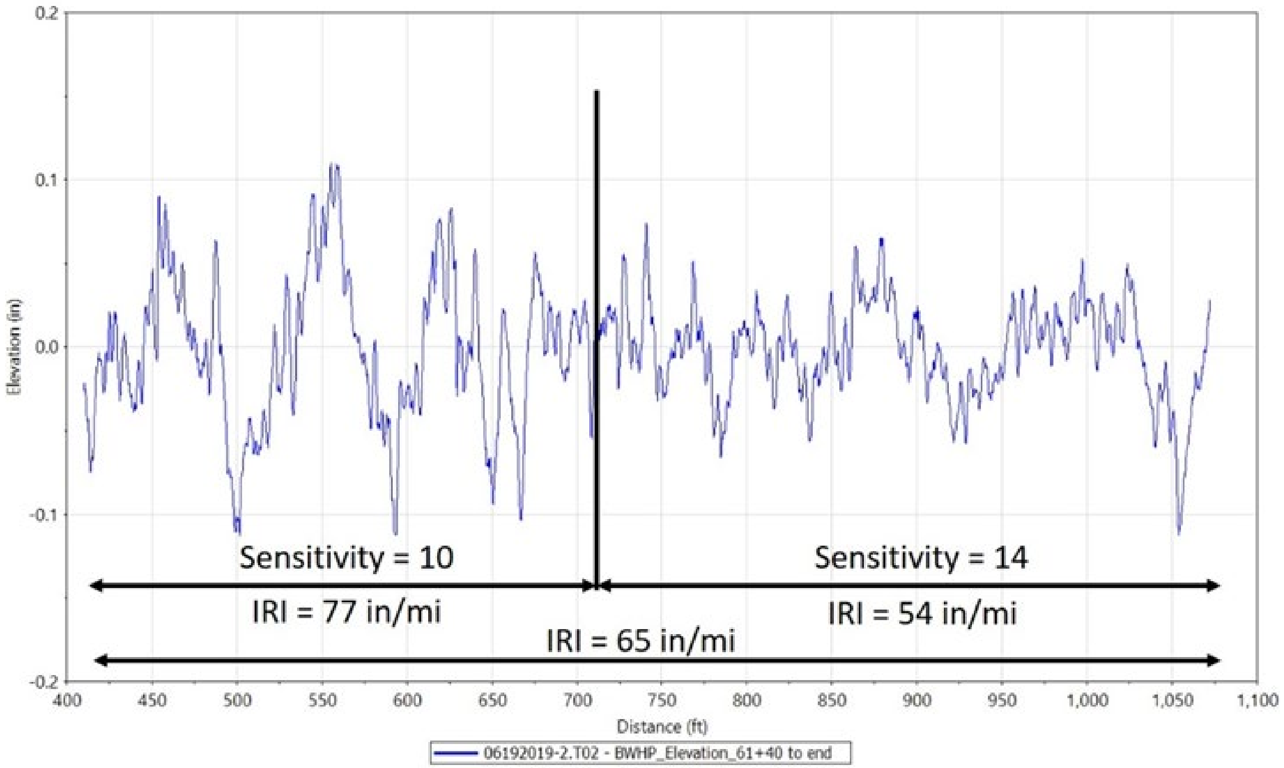
Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Paver Attitude (Lead/Draft)
  - Stay as flat as practical
  - One person responsible for adjustments
  - Reduce lead/draft when paving uphill
  - Increase lead/draft when paving downhill



Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Hydraulic Response (sensitivity)
  - Slight adjustments can have significant impacts

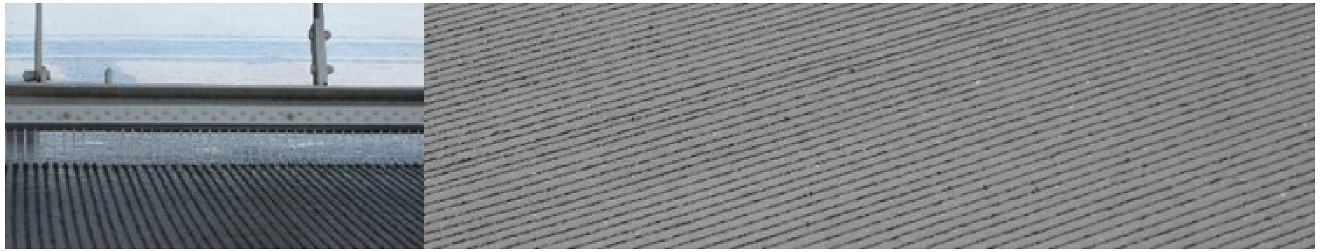


Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Hand Finishing
  - When done correctly, it improves initial smoothness
  - Many different approaches
    - Float to fill surface voids first (16’ to 12’)
    - Straightedge to cut bumps and fill dips last (16’ to 20’)

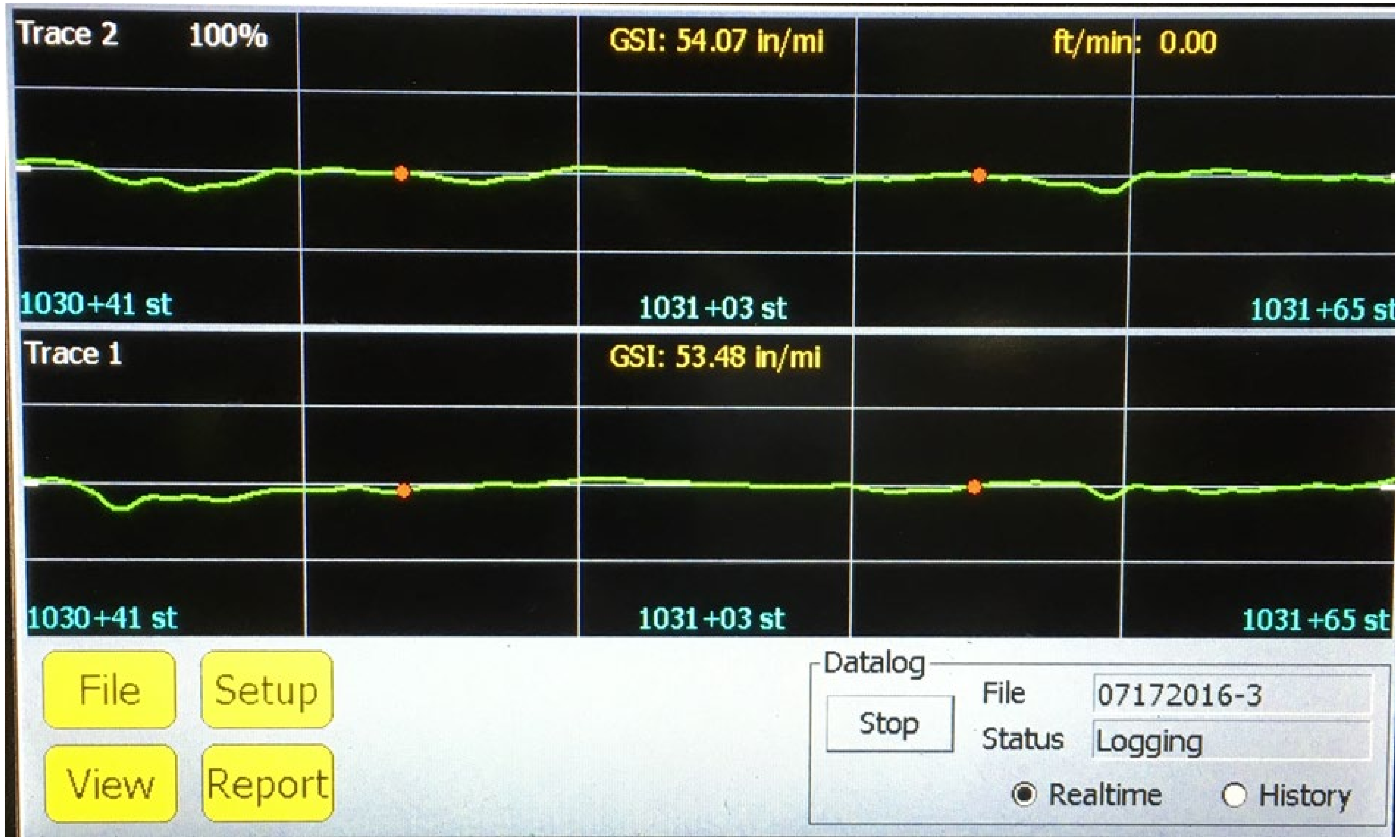
Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Texture and Cure
  - Even with line lasers, texture will influence IRI results – strive for uniformity
  - Cure completely to mitigate early age warping effects on IRI



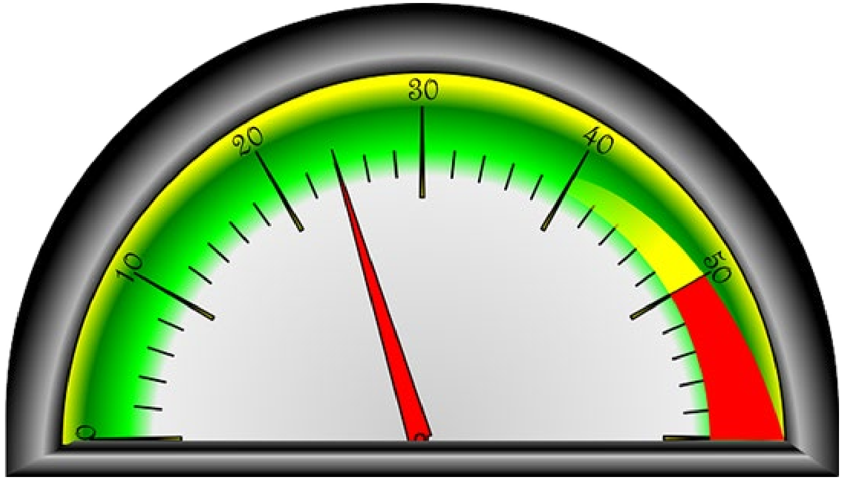
Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Real-Time Smoothness
  - QC feedback loop reduced from 18 hours to 2 hours
  - Not a replacement for conventional profiling for acceptance
  - Not a replacement for better practices to construct smoother pavements



Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Real-Time Smoothness
  - Sensor generally placed in the center of each lane
  - Systematically make changes in small increments
  - Get a minimum of 0.1 mile with consistent paving (no big events) and then evaluate if the adjustment made things smoother
  - Continue adjusting in small increments and evaluating every 0.1 mile



Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Real-Time Smoothness
  - Real-time profile parallels hardened profile

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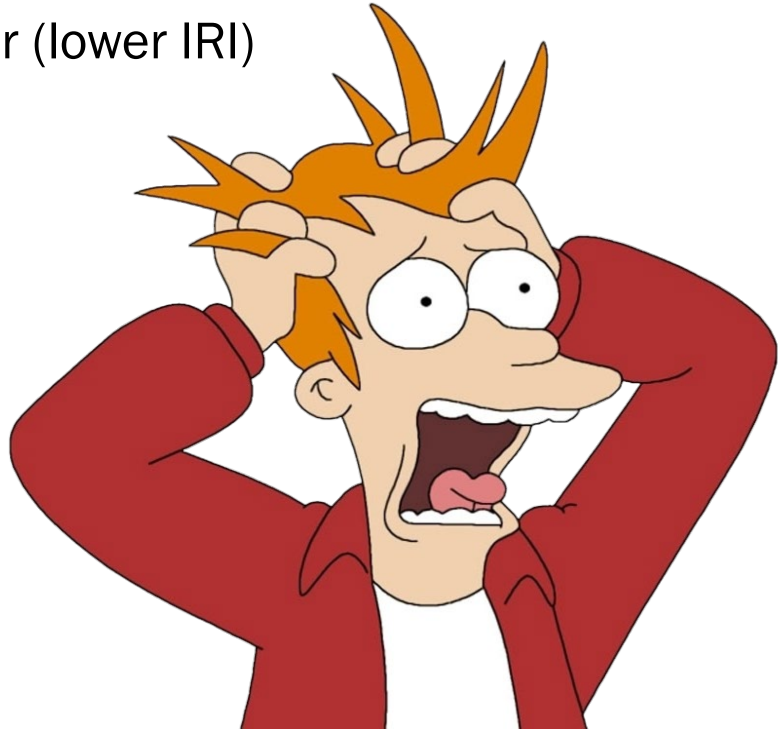
Guidelines for Best Practices for Concrete Pavement Smoothness

- Slipform Paving – Real-Time Profile
  - The RTS results are higher than the QC hardened profiles – what’s up with that?
    - Don’t panic
    - Just focus on making the RTS results better (lower IRI)
    - QC profiles will improve as well



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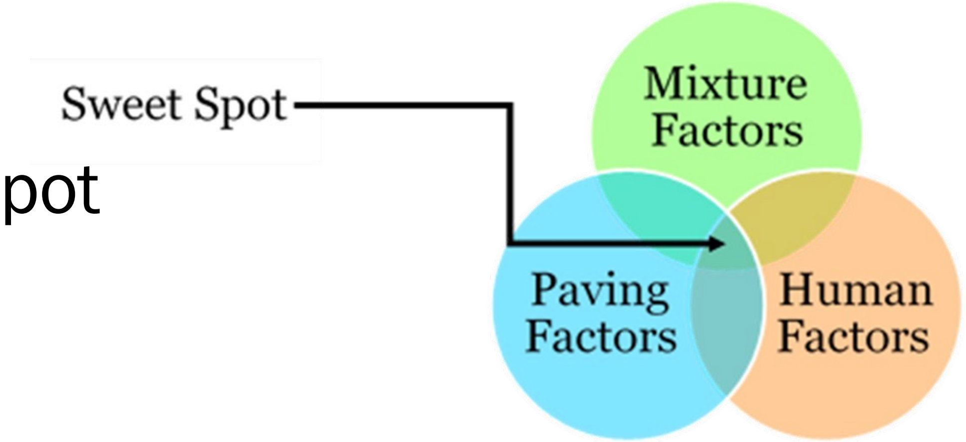
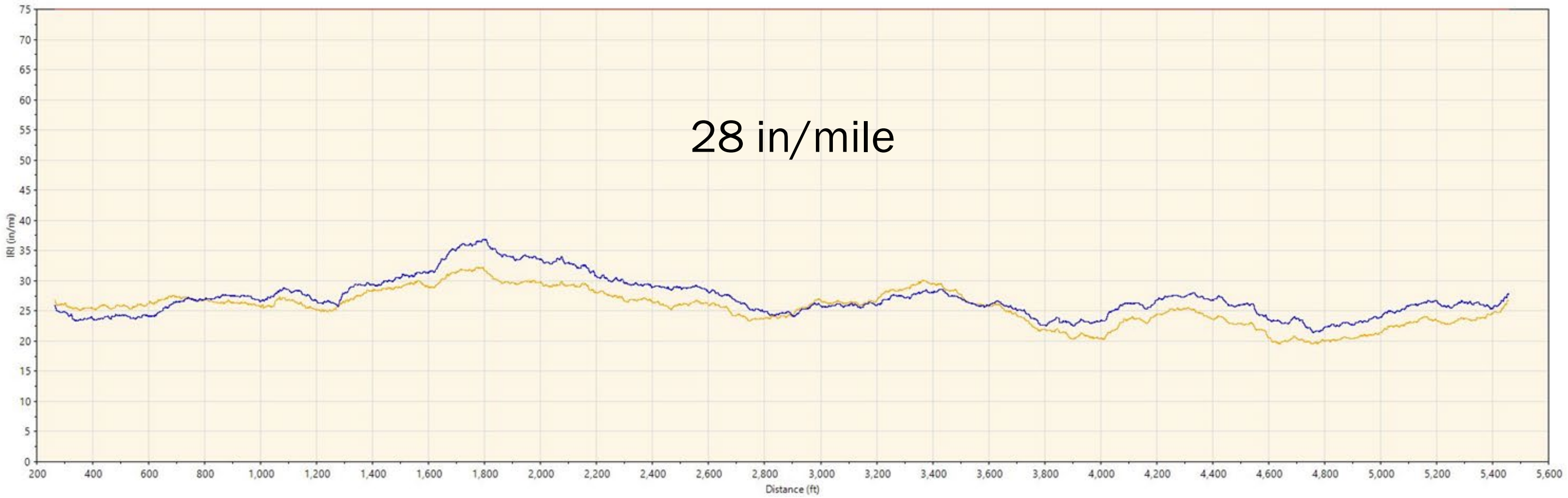


- Slipform Paving – Staying in the Sweet Spot
  - Stay focused
  - Make appropriate adjustments
  - Train the crew
  - Continuous improvement



IRI Update and Real-Time Smoothness Since Implementation

- Questions and Discussion