Matt Fonte
Principal
Fonte & Company

Building Smooth IRI Concrete Pavements

9/12/2023

About the Presenters

- **Matt Fonte** is the principal of **Fonte and Company**. A consulting company that specializes in all aspects of concrete pavements.
- Matt has 23 years of experience on the heavy civil construction platform, and 17 years in the concrete paving industry.
- Throughout these years Matt has developed an extensive knowledge of all aspects of concrete pavements to include design, phasing, bidding, mining aggregate, mix designs, batching, hauling, paving, paving smooth, evaluating final smoothness profiles, and all the steps in-between.
- Matt believes we should be good stewards of the taxpayer dollars, and one of the best ways to be a good steward of these dollars is on smooth long-lasting sustainable pavements.

WHY?

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3 Key Factors

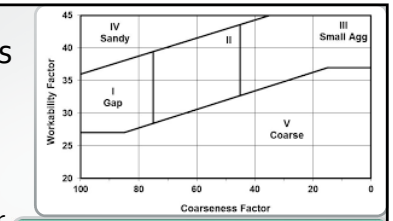
- Consistency in everything all day long
  - con·ti·nu·i·ty
  - 1. the unbroken and consistent operation of something over a period of time.
- Volatility mitigation in the operation
  - vol·a·til·i·ty
  - 1. liability to change rapidly and unpredictably, especially for the worse.
- Reduction in the Energy applied to the concrete
  - Using less energy to preform the same task

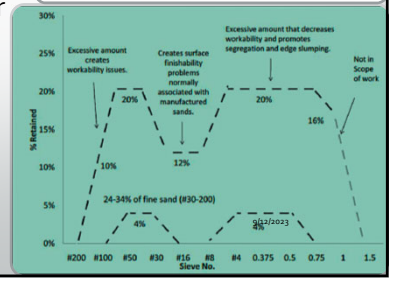
Specifications

- Ride Specification
  - Does yours reflect the importance of smoothness?
- Gradations Specification
  - Does your spec allow for a workable mix?
  - Individual gradation qualifications vs. combined dense aggregate qualifications
- Recycled Concrete Aggregate
  - Reduction in volatility of the 57/67 stone
- Strength Testing for Acceptance
  - Field strength flexural testing??
    - Are you getting good data?

Optimized Gradations

- Shilstone opened our eyes to the need for optimized gradations
- Ley took it one step further with an emphasis on workability
- Shilstone focus on the relation between 3/8 and the #8
- Tarantula focuses on all the sieves





Concrete Mix Design

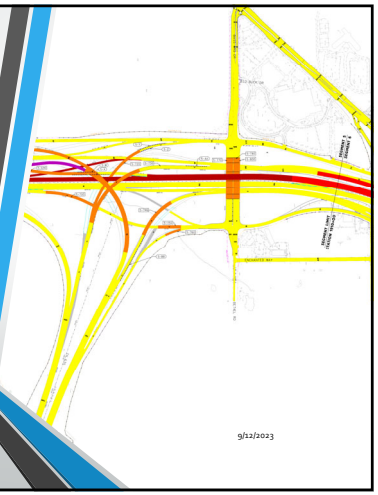
- Workability is dependent on the aggregate gradations.
- Testing for the effectiveness of the water reducers
- Not all admixtures are compatible with all SCM's
- Testing a range of water cement ratios and aggregate combinations at mix design time.

Concrete Mix Design

Concrete Mix Design

Construction Phasing

- Continuity
- Reduce Handwork
- Reduce paver changes
- Reduce paver mobilizations
- Reduce headers
- Focus on increasing larger paving areas
- Longer runs
- Wider widths??

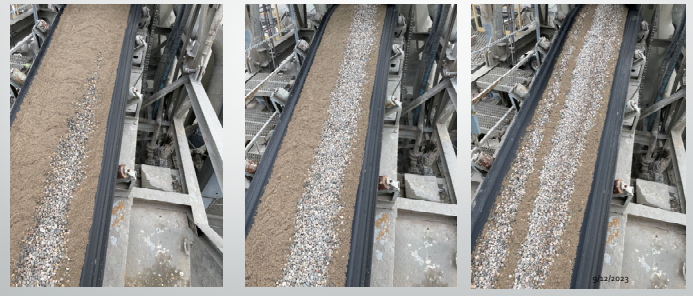


Concrete Batching

- Mixer efficiency
  - What is the condition of your drum liners?
- How is the drum loaded
  - Are all the aggregates on the charge belt from start to finish?
  - Cementitious throughout the charging of the drum
  - Water throughout the charging of the drum
  - When is each admixture introduced to the drum
- 60 second batching
  - Is the mix consistent throughout the drum in 60 seconds?
  - This is not in relation to slumping out a batch.

Uniformity – Combined Aggregates

Beginning | Middle | End



Concrete Paver Setup

- Allow enough time
- Focus on the details
- 1/32" is close enough
- Everything should be on the same plain.
  - Frame
  - Pan
  - OCB, or Screed
  - Sensor boxes

3D Modeling or Paving on WIRE?

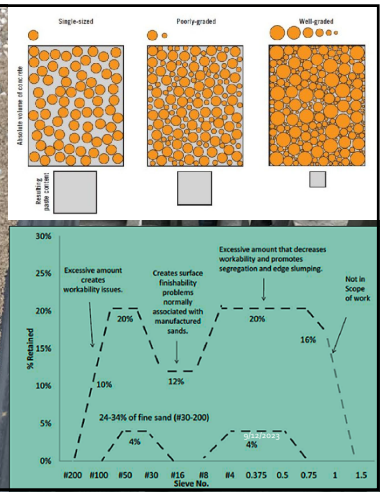
- Quality Control
- 3D – are you running your longitudinal lines through Proval?
- Wire – can you hang a 1 lbs. weight on the line with less than 3/100' deflection?

Concrete Paving

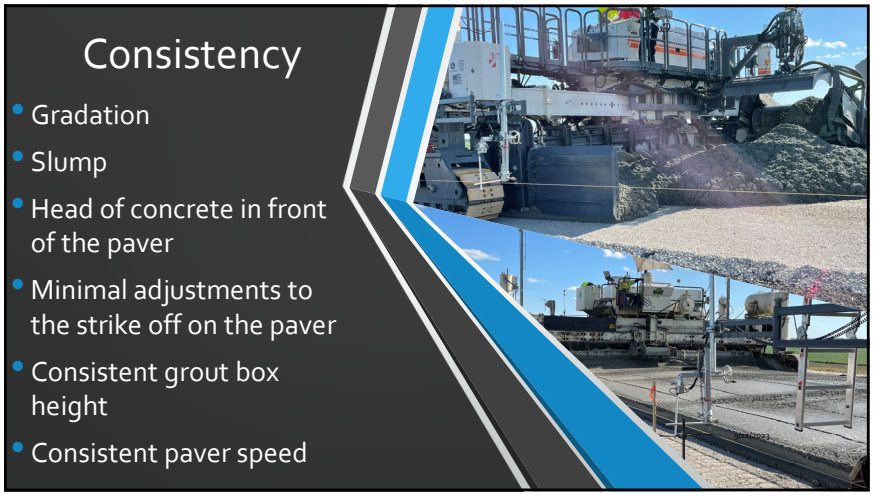
What Lever can I pull?

Gradations

- How often are you running gradations?
- How are you evaluating your gradations?
- Dense graded mixes reduce paste content.
- Dense graded mixes reduce the ability to segregate.
- 100 lbs swap in aggregates can allow 1,000 vpm reduction resulting in a 20 point reduction on IRI. This can take you from a 60 IRI to a 40 IRI.




Slump
Consistent
Water vs Water Reducer
What is your upper water cement ratio limit?


Consistency
Gradation
Slump
Head of concrete in front of the paver
Minimal adjustments to the strike off on the paver
Consistent grout box height
Consistent paver speed

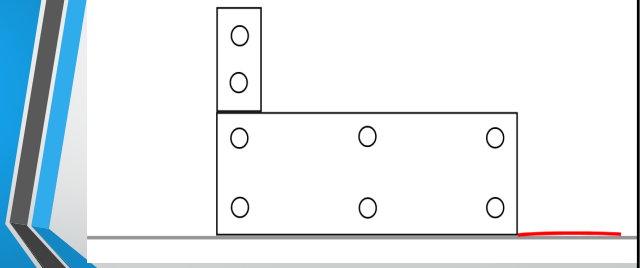

Consistent Head Pressure


Consistent Head Pressure

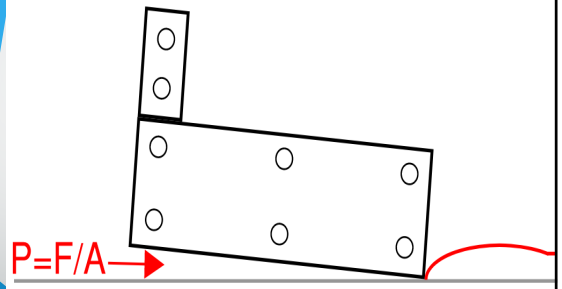
Vibration

- Reduction in energy
- Lower the better
- Relationship between consistent grout box and vibration
- Dynamite effect
- Vibrators create pressure under the pan

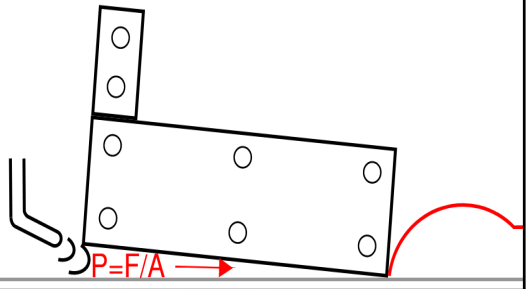
Plane of the paving pan



Plane of the paving pan



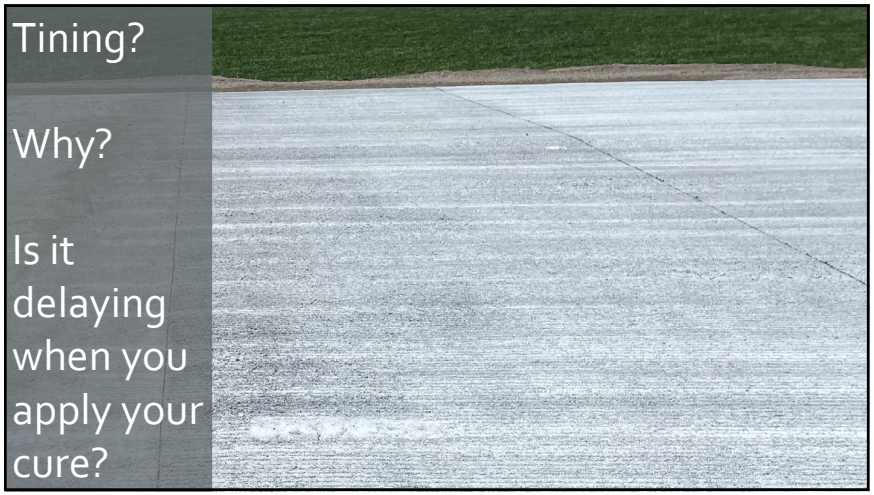
Plane of the paving pan




V Floats

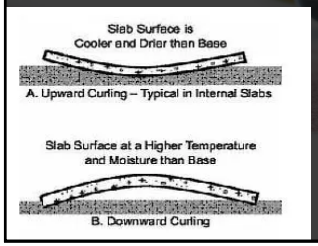

Real Time Profilers


Finishing?


Tining?
Why?
Is it delaying when you apply your cure?

Curling & Warping

- Saturate the subgrade
- Cure quickly and thoroughly
- White as a sheet of paper



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Summary

- Combined aggregate gradation (run regularly)
- Proper paver setup (Details, Details, Details)
- Consistent mix delivered to the paver
- Consistent head of concrete in front of the paver
- Consistent grout box height
- Consistent paver speed
- Low Vibration (less than 6500 VPM)
- NO plane or lead in the paver pan
- Less finishing behind the paver
- Keep the moisture in the slab during the early stages

Thank You

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CONSULTING
TRAINING
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HELPING YOU BUILD BETTER

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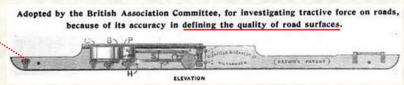
Lessons Learned on Long-Term Smoothness

A Look Back and Forward

Larry Scofield, P.E. (AZ)
IGGA/ACPA

History- A Walk Back in Time

- 1898 — Brown Viagraph



- 1900s – Present — Straight Edge (10-12 ft)

- 1940s –Present — Profilograph (California, Rainhart, Ames)

- 1940s - 1980s — Response Type (Roughometer, Mayes Meter)

- 1964 – Present — Inertial Profiler (GM Profilometer)

- 1986 & 1990 — Development of IRI (1990 PMS)
- 2000s — Development of Inclinometers, Line Lasers, Real Time Smoothness Measurement, Zero Speed Profilers, 3D profilers,

California Statewide Roughness Survey (1956)

- Tested 15 PCCP Sections
- Tested 11 AC Sections
- Jury Evaluation
- Established 7 inches/mile
- Developed 0.2" Blanking Band ← 1960 Spec (63 yrs)

A somewhat more elaborate system of deriving a numerical index will be necessary if it becomes important to assign numbers to existing highways or airfields…" **Francis Hveem 1960**, the inventor of the profilograph

FHWA Tech Briefs on Smoothness GPS-3 - 2005

TECHBRIEF

Achieving a High Level of Smoothness in Concrete Pavements without Sacrificing Long-Term Performance

FHWA Contact: Peter Kopac, HRDI-11, 202-493-3151

This document is a technical summary of the report *Achieving a High Level of Smoothness in Concrete Pavements without Sacrificing Long-Term Performance*, FHWA-HRT-05-068, that will be published by the Federal Highway Administration in summer 2005.

Introduction

For a portland cement concrete (PCC) pavement, it is important to achieve both a high level of smoothness during construction as well as a satisfactory long-term performance. It is not acceptable to construct a pavement with a high initial smoothness that will give poor long-term performance. Smoothness measurements for construction acceptance are usually performed shortly after paving is completed, using either a profilograph or a lightweight inertial profiler. However, it is unclear whether the smoothness of a pavement measured immediately after it is paved truly reflects the initial smoothness of the pavement because the smoothness can undergo changes over the short term (e.g., within 3 months) due to curling or warping effects. In other words, a pavement can have a very high smoothness immediately after construction, followed by a decrease in smoothness over a short time period because of changes in slab shape that occur with curling and warping. This research project was performed to:

- Assess whether high initial smoothness translates into better long-term performance.
- Identify design features and material properties in PCC pavements that can cause an initially smooth pavement to exhibit detrimental long-term performance.
- Provide guidance on adjustments that can be made to materials properties, design features, and construction procedures in order to avoid these detrimental effects.
- Investigate early age changes in smoothness of PCC pavements.
- Provide recommendations and guidelines regarding smoothness testing.

U.S. Department of Transportation
Federal Highway Administration
Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296
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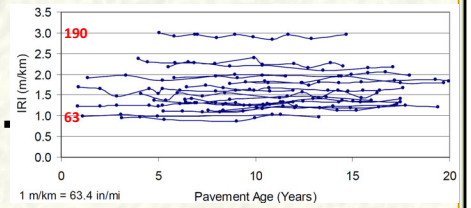
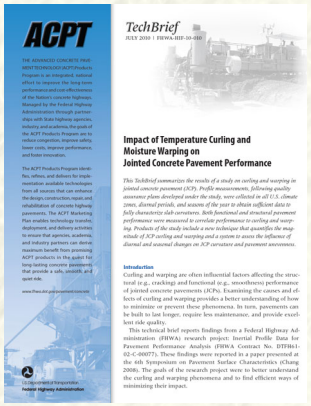
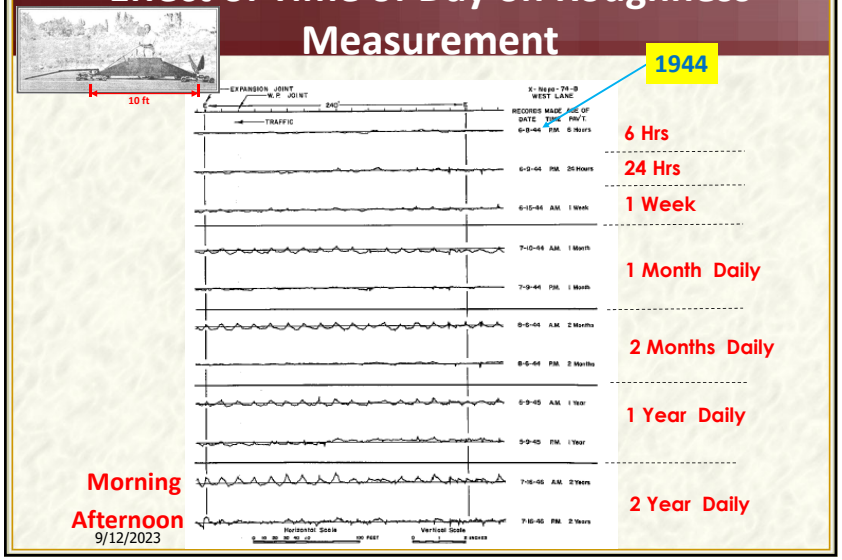


FHWA Tech Brief: Impact of Temperature Curling and Moisture Warping on JCPP- 2010



Effect of Time of Day on Roughness Measurement



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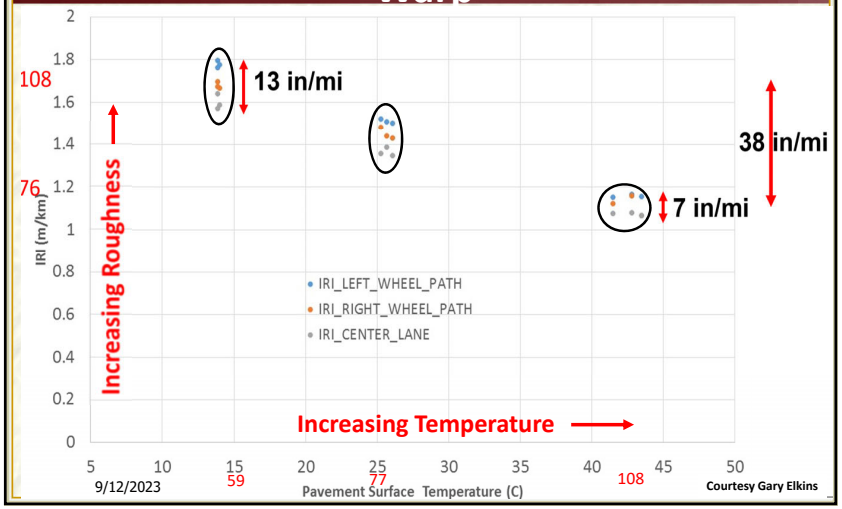
National LTPP SPS-2 Measured Curl and Warp



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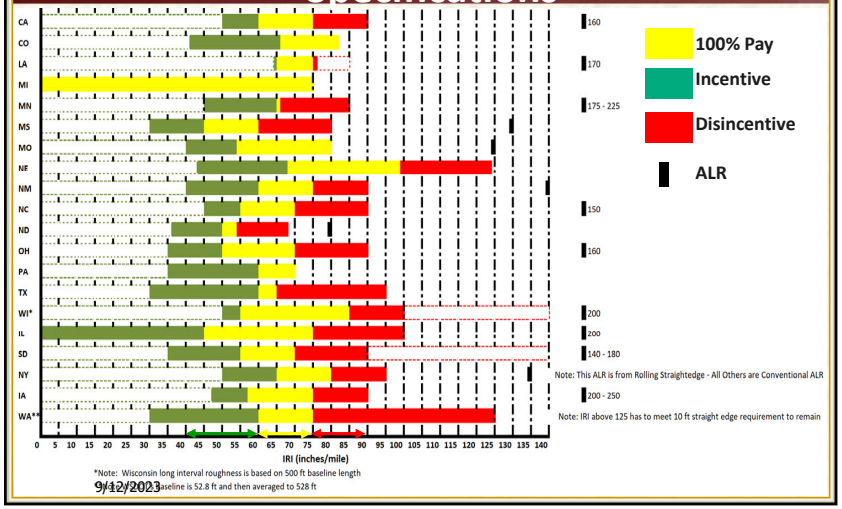
2023 IRI State Smoothness Specifications



*Note: Wisconsin long interval roughness is based on 500 ft baseline length

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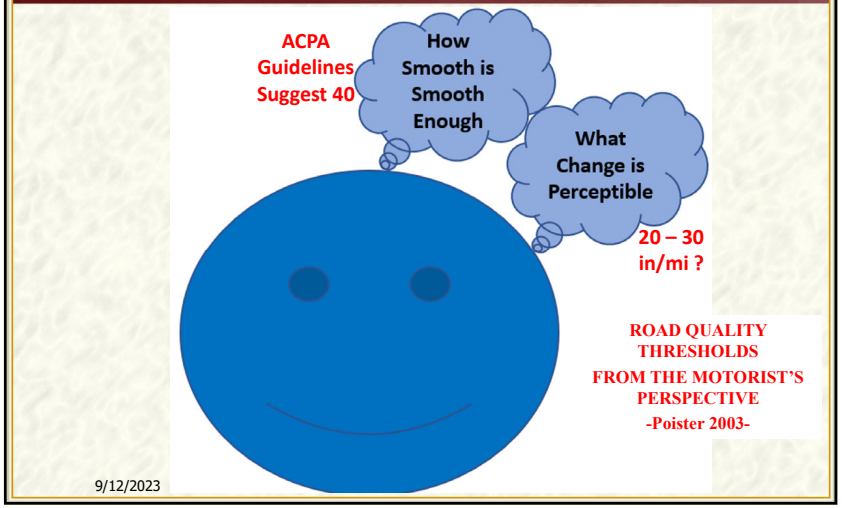
Relevance of Pavement Smoothness



Pavement Design Features Impact on Smoothness

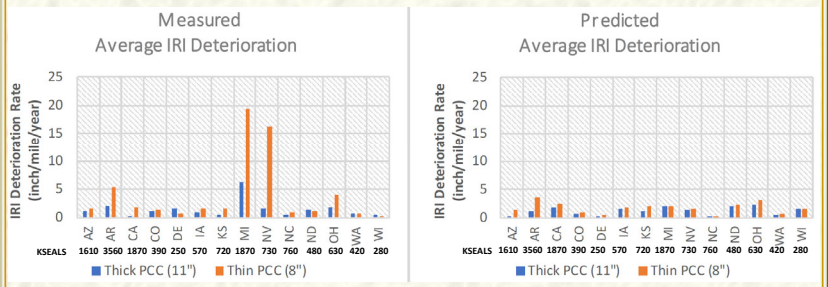
SPS-2 Design Factors

- Design Factors
  1. Strength (550 & 900)
  2. Base Type (Aggregate Base (AB), Lean Concrete Base (LCB), Permeable Asphalt Treated base (PATB/AB)
  3. Drained and Undrained
  4. Lane Width (12 ft & 14 ft)
  5. Thickness (8 in. & 11 in.)
- Site Factors
  - Coarse and Fine Grained Soils
  - Climate Zone
  - Traffic Level

Fixed Design Thicknesses

14 Times Difference in Traffic Levels

Impact of Pavement Thickness on Roughness Development



- **Average Deterioration Rate for SPS-2 Sections was 2.5 inch/mile/year**
- **Thin Sections Deteriorated 140% Higher on Average than Thick Sections**
- **Predicted IRI Indicated that thinner sections deteriorate 75% faster than thicker sections**
- **<u>Thickness Did Not Have an Impact on the Rate of Faulting</u>**

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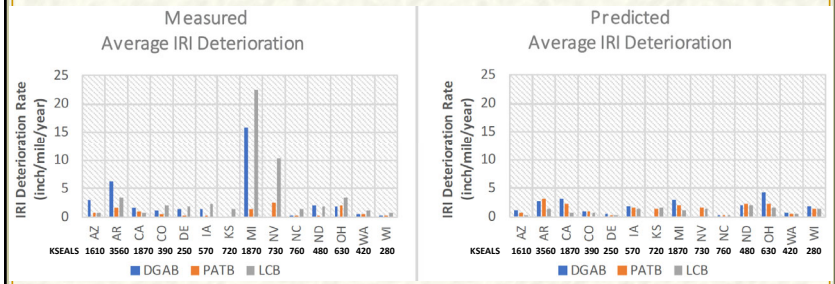
Courtesy of NCE

Impact of Base Type - (Three Base Types)



- **LCB Base Typically had the Highest Deterioration Rates for IRI**
- **<u>Predicted</u> IRI Indicated Fastest Deteriorate on PATB and Least on LCB – The <u>Opposite Occurred</u>**

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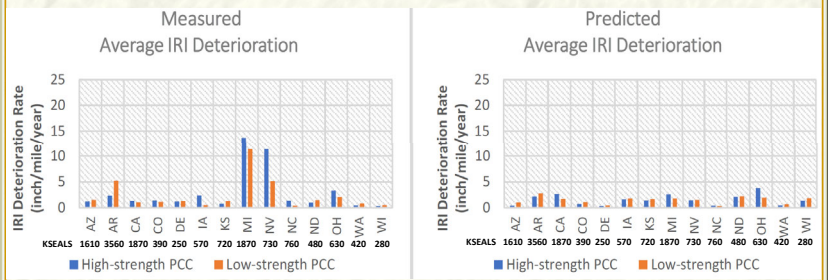
Courtesy of NCE

Impact of PCCP Strength (550 & 900 psi)



- **PCCP Strength <u>Did Not</u> Have a Definite Impact on the IRI Deterioration Rate**
- **Low-strength Sections were Predicted to Have Higher Deterioration Rates (IRI) than High Strength Sections**

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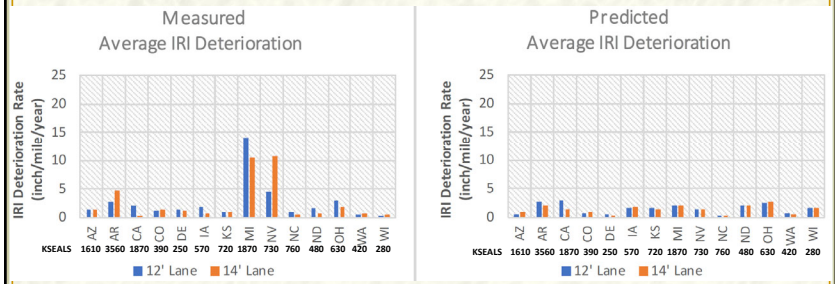
Courtesy of NCE

Impact of Lane Width (12’ & 14’)



- **There <u>Was Not</u> a Significant Performance Difference Between Test Sections of Different Lane Widths on the Same Project**
  - **On Eight Projects, 12 ft Lanes Had Higher Deterioration Rates**
  - **On Six Projects, 14 ft Lanes Had Higher Deterioration Rates**
- **Lane Width Did Not Indicate a Significant Difference in <u>Predicted IRI</u> Deterioration Rates**

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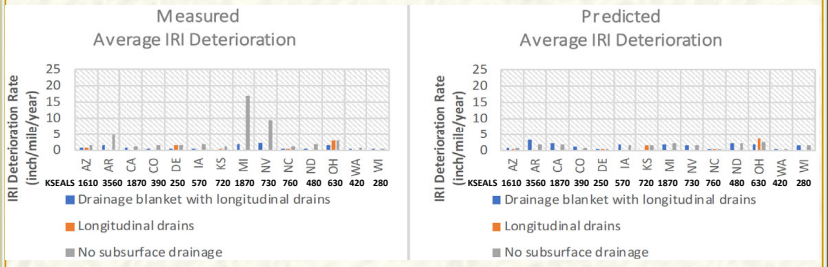
Courtesy of NCE

Impact of Drained Vs Undrained



- **In most cases, <u>only a slight difference in IRI</u> deterioration rates of drained and undrained test sections**
- **Drainage features <u>Did Not have a definite impact on the rate of faulting</u>**

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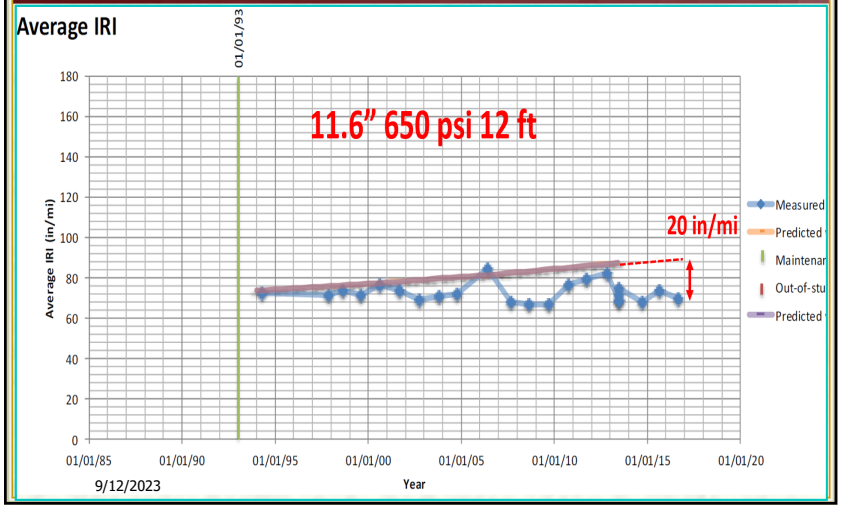
Courtesy of NCE

Colorado SPS-2 Ride Quality After 28 Years



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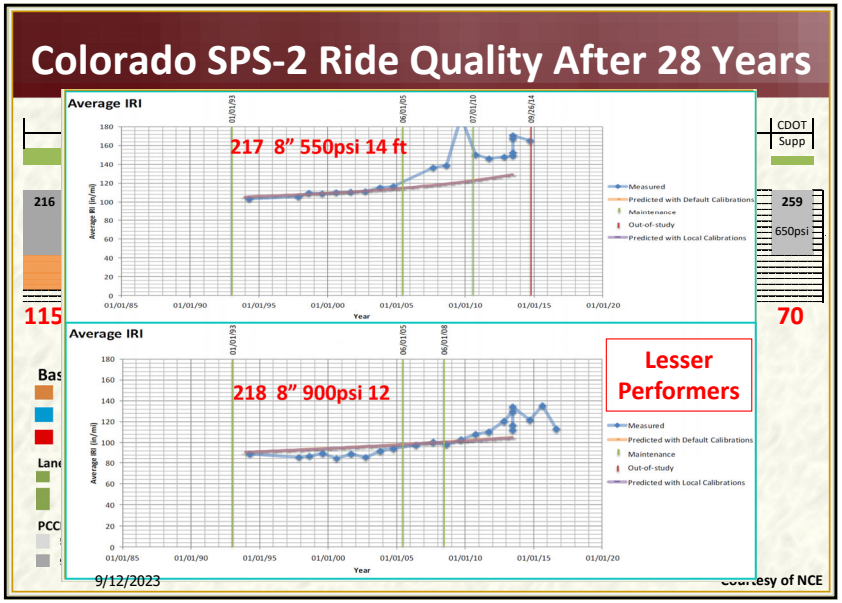
Colorado SPS-2 Ride Quality After 28 Years



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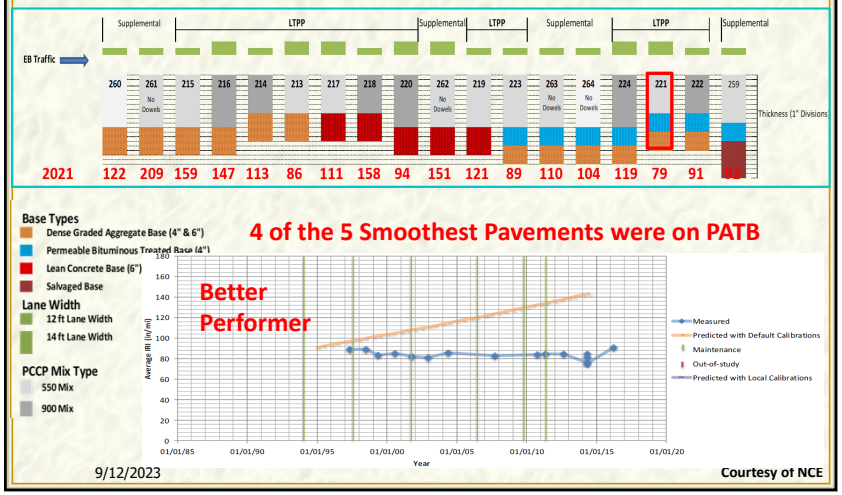
Courtesy of NCE

North Dakota SPS-2 Results (26 yrs)



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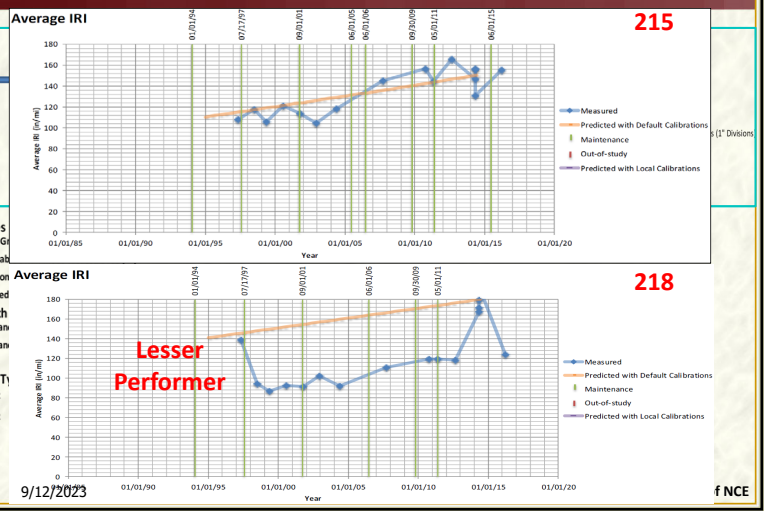
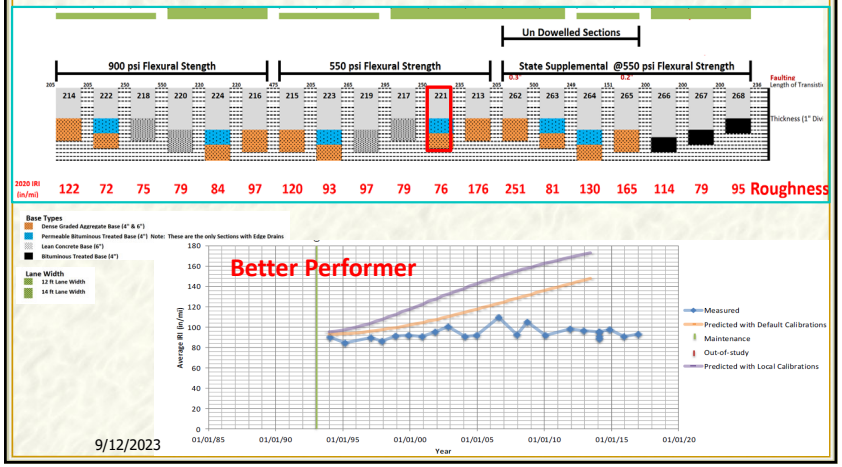


Arizona SPS-2 Results (27 yrs)



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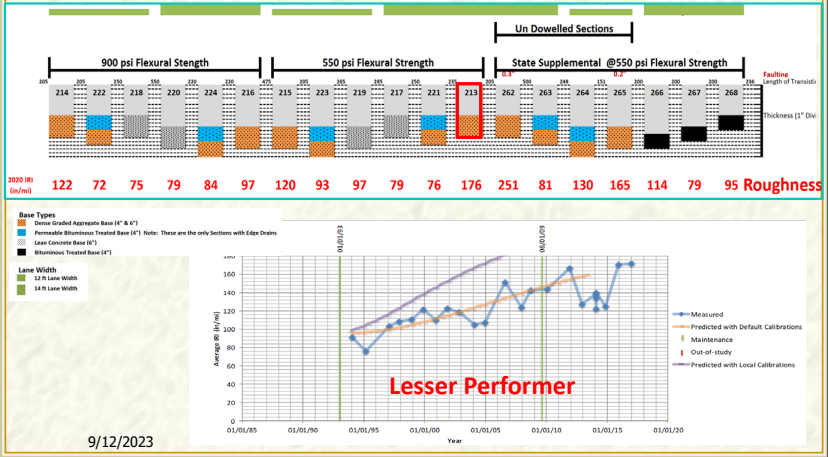

The End!

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IGGA International Grooving & Grinding Association

ACPA

QR Code for SPS-2 Preservation Pooled Fund Study Reports (Courtesy NCE)

AASHTO Has Done the Heavy Lifting

- M328-14 Standard Specification for Inertial Profiler
- R54-14 Standard Practice for Accepting Pavement Ride Quality when Measured Using Inertial Profiling Systems
- R56-14 Standard Practice for Certification of Inertial Profiling Systems
- R57 Standard Practice for Operating Inertial Profiling Systems

ASTM Standards

- E867 Standard Terminology
- E1926 Standard Practice