WHRP
Wisconsin Highway Research Program

Asphaltic Mixture New Specification Implementation –
Field Compaction and Density Validation study

Project 0092-15-09

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President
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November 29, 2016

Research Intent

<u>Study #1 – Longitudinal Joint</u>

- Use density data to evaluate various HMA longitudinal joint *types* and *methods* of construction
- Produce specification recommendations that result in the highest density longitudinal joint

<u>Study #2 – Thin Lift Overlay</u>

- Evaluate and produce a specification for Thin Lift Overlay HMA that ensures proper and consistent compaction to maximize durability
- Findings are used to validate or suggest modifications to current WisDOT specifications.

Research Intent

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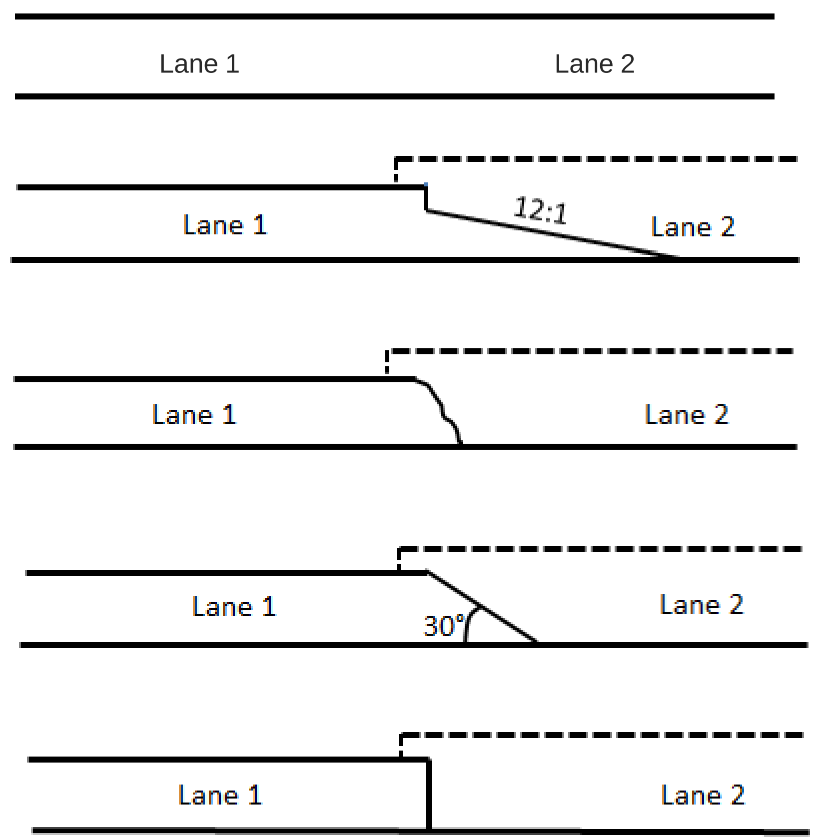
- Findings are used to validate or suggest modifications to current WisDOT specifications.

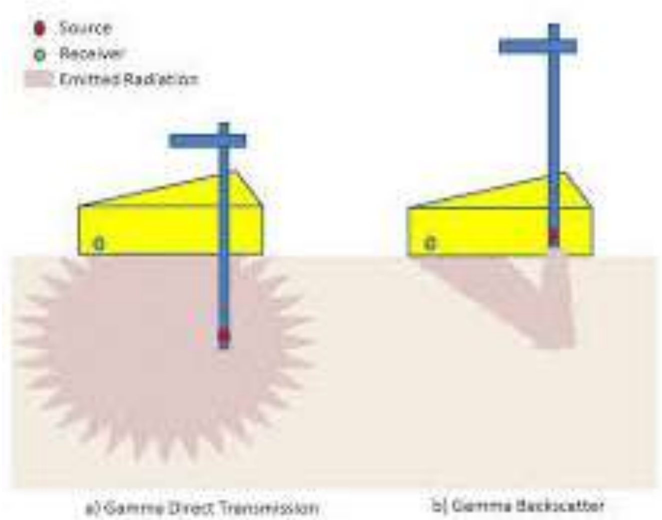
Background: Longitudinal Joint Type

- Eschelon
- Notched Wedge
- Normal Vertical
- Safety Edge
- Milled

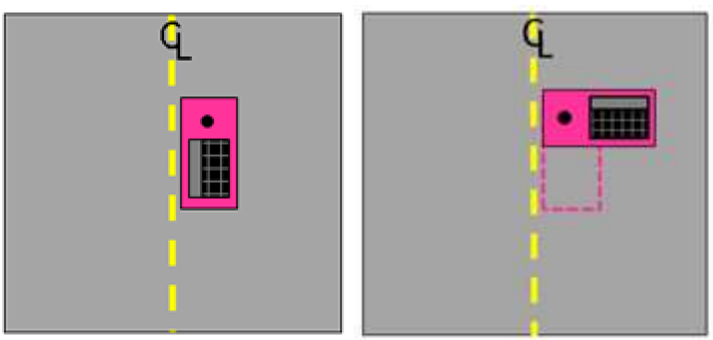


Background – Nuclear Density Gauges

- Nuclear Density Gauges – Direct Transmission vs. Backscatter



- Nuclear Density Gauges – Parallel vs. Perpendicular



Background – WisDOT Specs

- WisDOT Specs based on nuclear density readings
  - Range from 89.5 – 92.0%
- Uses maximum theoretical maximum density Gmm x 62.24
- Current FDM Guidance - Notched Wedge Longitudinal Joint

TABLE 460-3 MINIMUM REQUIRED DENSITY[1]

LOCATION	LAYER	PERCENT OF TARGET MAXIMUM DENSITY		
		MIXTURE TYPE		
		E-0.3, E-1, and E-3	E-10, E-30, and E-30x	SMA[5]
TRAFFIC LANES[2]	LOWER	91.5[3]	92.0[4]	—
	UPPER	91.5	92.0	—
SIDE ROADS, CROSSOVERS, TURN LANES, & RAMPS	LOWER	91.5[3]	92.0[4]	—
	UPPER	91.5	92.0	—
SHOULDERS & APPURTENANCES	LOWER	89.5	89.5	—
	UPPER	90.5	90.5	—

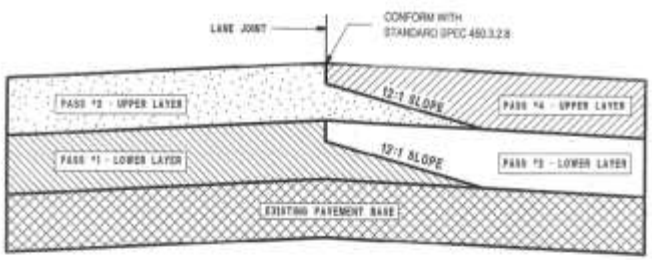
[1] The table values are for average lot density. If any individual density test result falls more than 3.0 percent below the minimum required target maximum density, the engineer may investigate the acceptability of that material.

[2] Includes parking lanes as determined by the engineer.

[3] Minimum reduced by 2.0 percent for a lower layer constructed directly on crushed aggregate or recycled base courses.

[4] Minimum reduced by 1.0 percent for lower a layer constructed directly on crushed aggregate or recycled base courses.

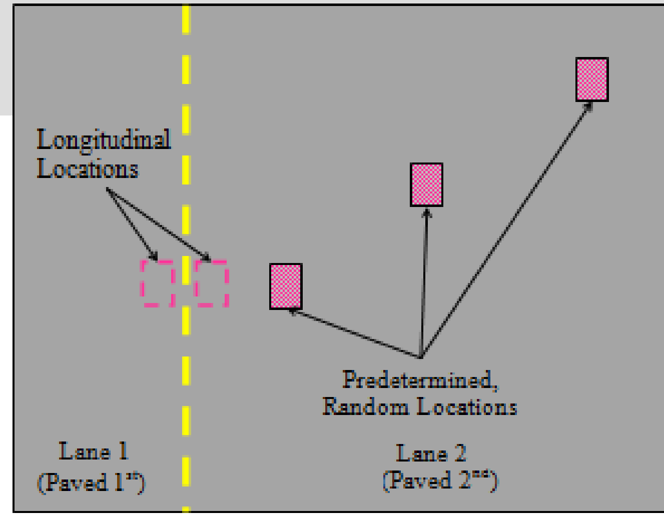
[5] The minimum required densities for SMA mixtures are determined according to CMM 8-15.



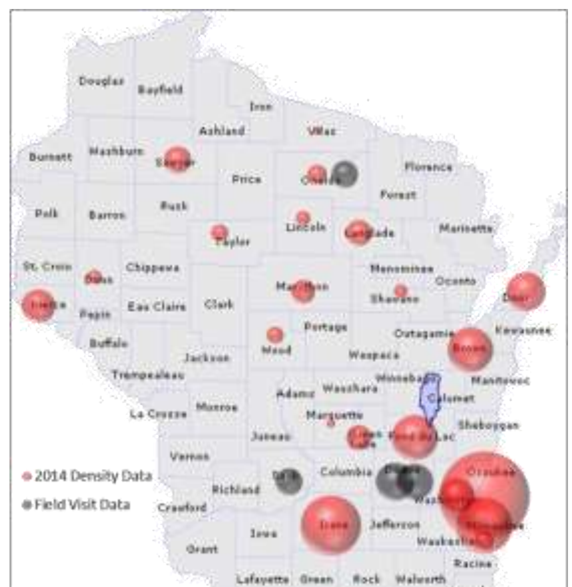
(LOWER AND UPPER LAYERS)

TYPICAL PAVEMENT CROSS SECTION
OF NOTCHED WEDGE LONGITUDINAL JOINTS

2014 Data Collection



- Contractors and DOT were asked to collect additional longitudinal joint data
- 1400 density data sets were collected on 28 different WisDOT projects



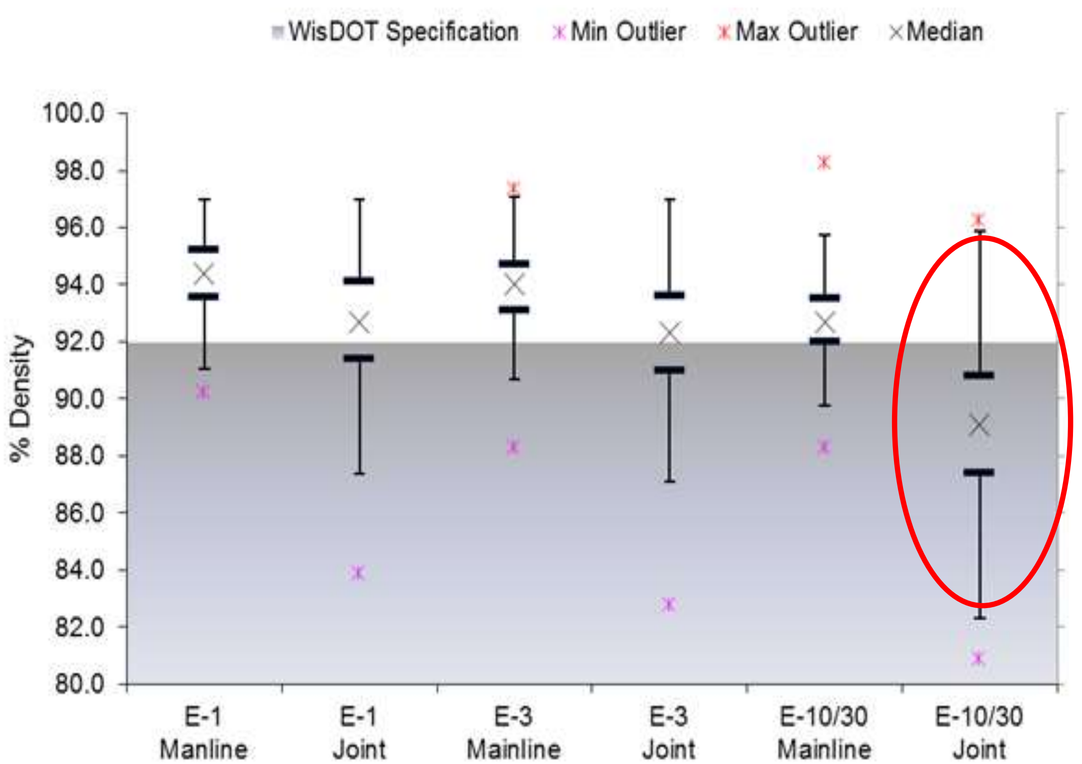
2014 Density Data Collection

- Data was separated into categories:
  - Project Information (State ID, County, ESAL, Nominal Maximum Aggregate Size (NMAS) and gauge type)
  - Layer (upper or lower)
  - Joint Type (milled, normal-vertical, notched wedge, safety edge)
  - Heated joint (yes or no)
  - Joint location (centerline or shoulder)
  - Edge of joint (confined or unconfined)
  - Gauge rotation (parallel or perpendicular)

	Upper Layer	Lower Layer	E-1	E-3	E-10/30	Notch Wedge	Normal Vertical	Milled
2014 Density Validation Study	1252 *87%*	193 *13%*	282 *17%*	460 *28%*	898 *55%*	865 *52%*	633 *38%*	176 *11%*

Initial Analysis of 2014 Density Data

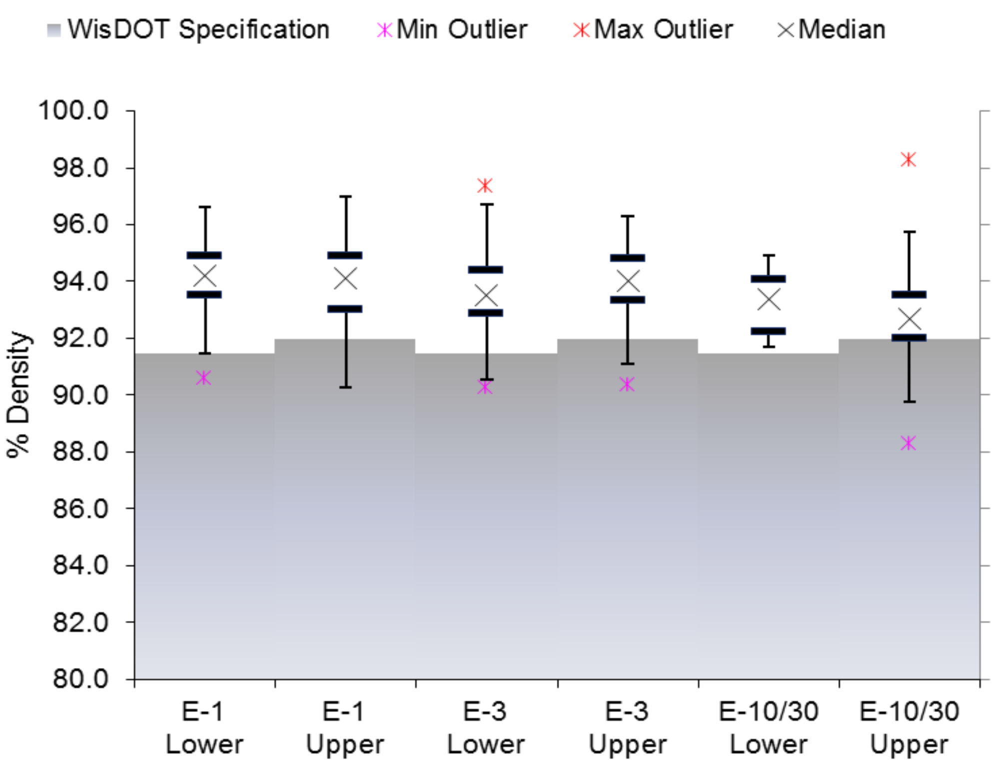
Mainline vs. Joint



- 60% Correlation between ESAL and Joint Density
  - E-1 joint – 92.7%
  - E-3 joint – 92.3%
  - E-10/30 joint – 89.1%
- Heated Joints increased densities for all types:
  - Milled – increased by 0.7%
  - Vertical – increased by 1.2%
  - Notched Wedge – increased by 1.5%

Initial Analysis of 2014 Density Data

Mainline Upper vs. Lower

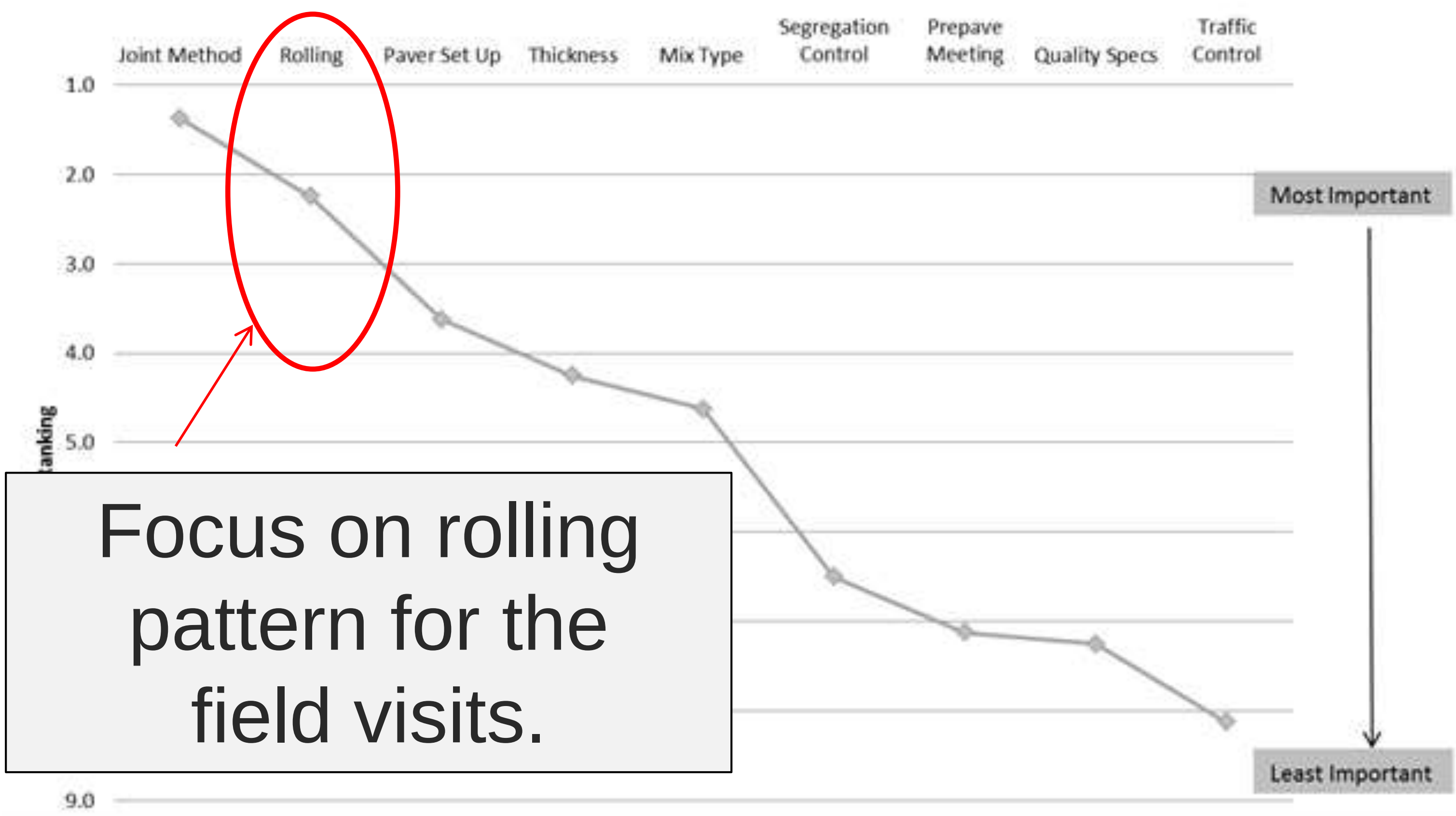


Decided to focus on the upper layer for the field visits.

Survey of Current Practices

- A survey was sent to Contractors and WisDOT personnel
- The survey asked respondents to comment on their "Best Practices" used to construct a longitudinal joint
- Results were varied

Question 6: Please rank the factors that affect the long term quality of a Longitudinal Joint.



Focus on rolling pattern for the field visits.

Project Visit Work Plan

1. Notched Wedge (testing the unconfined edge)

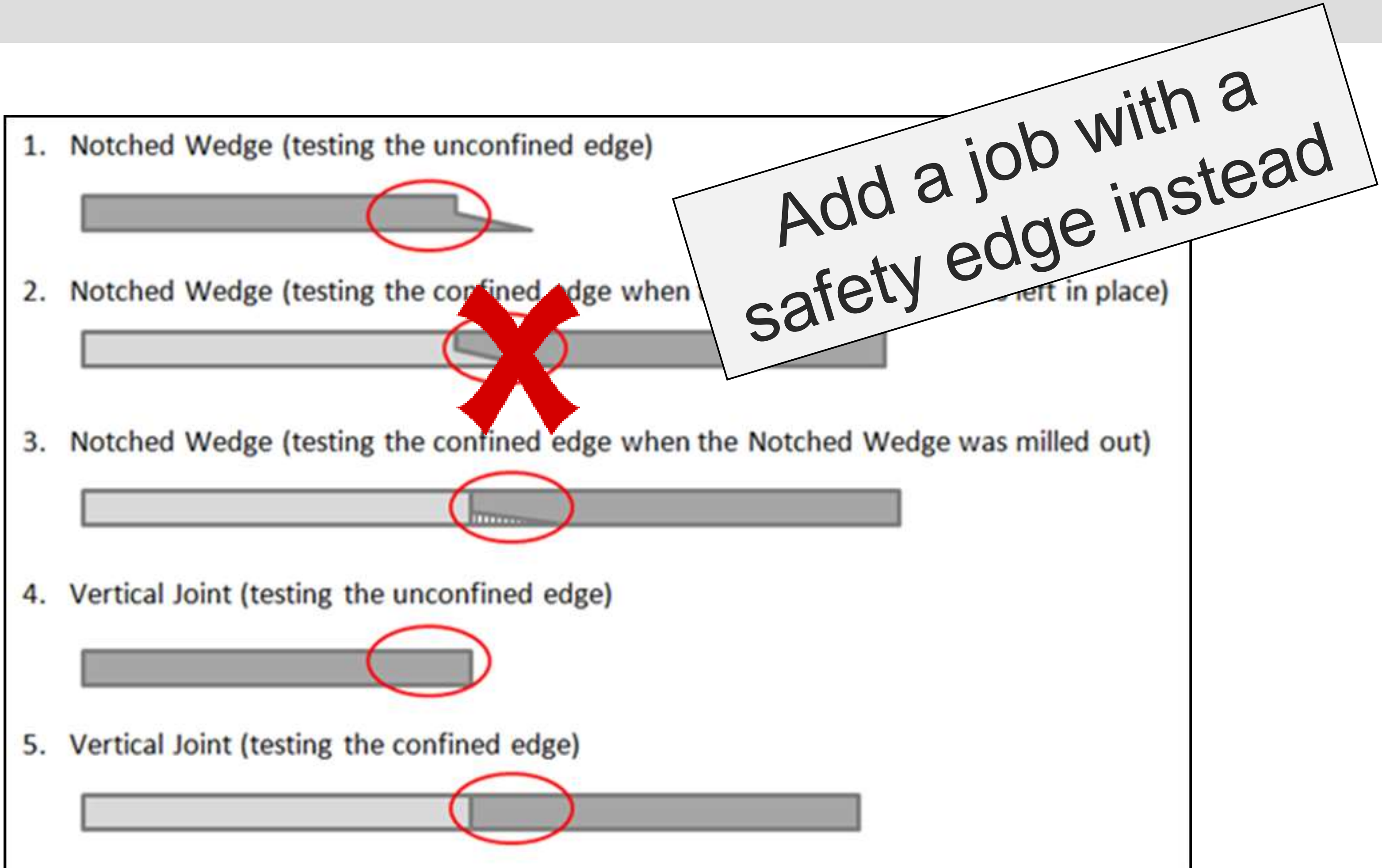
2. Notched Wedge (testing the confined edge when the Notched Wedge was left in place)

3. Notched Wedge (testing the confined edge when the Notched Wedge was milled out)

4. Vertical Joint (testing the unconfined edge)

5. Vertical Joint (testing the confined edge)

Project Visit Work Plan



Project Selections

Longitudinal Joint

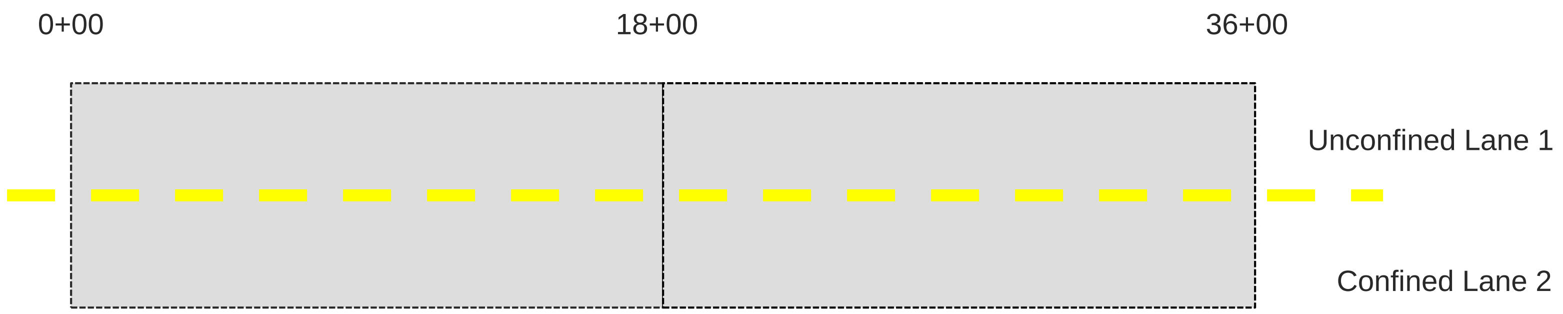
- USH 41
  - E-30 12.5mm
  - Notched wedge with milled
- STH 26
  - E-10 12.5mm
  - Vertical longitudinal joint
- CTH H
  - E-3 12.5mm
  - Safety edge longitudinal joint

Thin Lift Overlay

- USH 8
  - E-3 9.5mm
  - 1.25”

Test Sections:

- Set up 2 sections & compare rolling patterns:
  - AI / FHWA Best Practices 0+00 – 18+00
  - Contractor's Standard 18+00 – 36+00



Test Sections:

- AI / FHWA Best Practices :
  - *Unconfined* First Pass:

    Hang over 6”

    - Unless the mix pushes out

Test Sections:

- AI / FHWA Best Practices :
  - *Unconfined* First Pass:

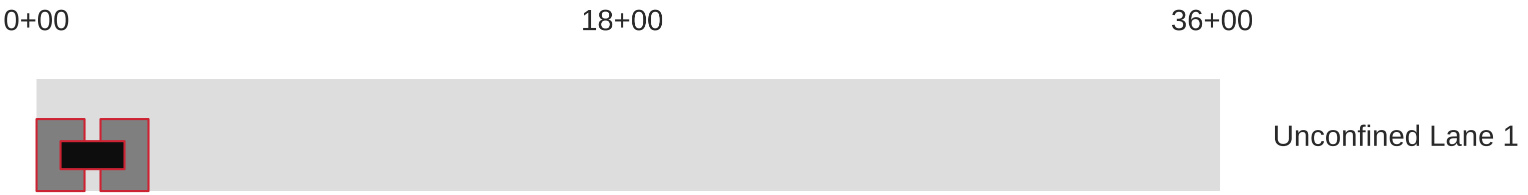
    Hang over 6”
    - Unless the mix pushes out

- Then stay back on the mat 6”
- Note: there may be a higher probability of a crack 6” off the edge

Test Sections:

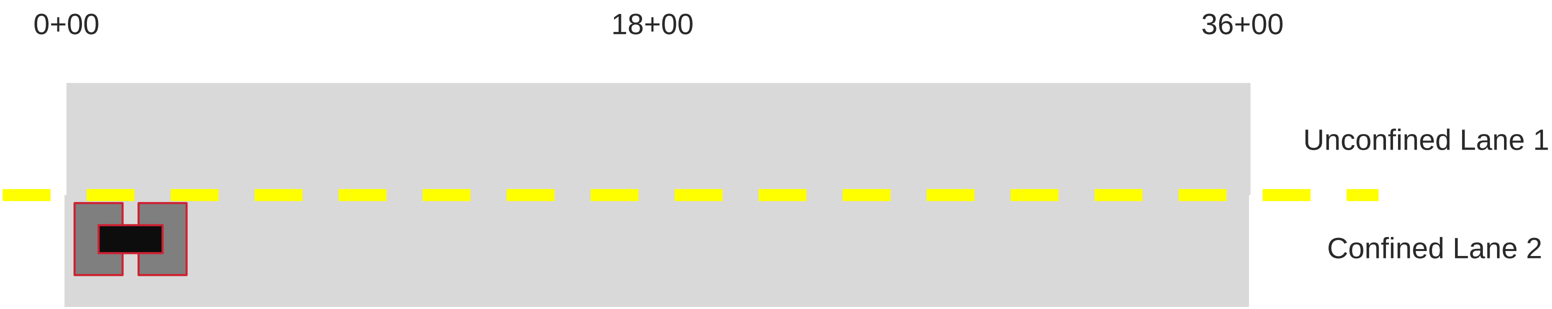
- AI / FHWA Best Practices :
  - *Unconfined* Second Pass:

    Right on the joint



Test Sections:

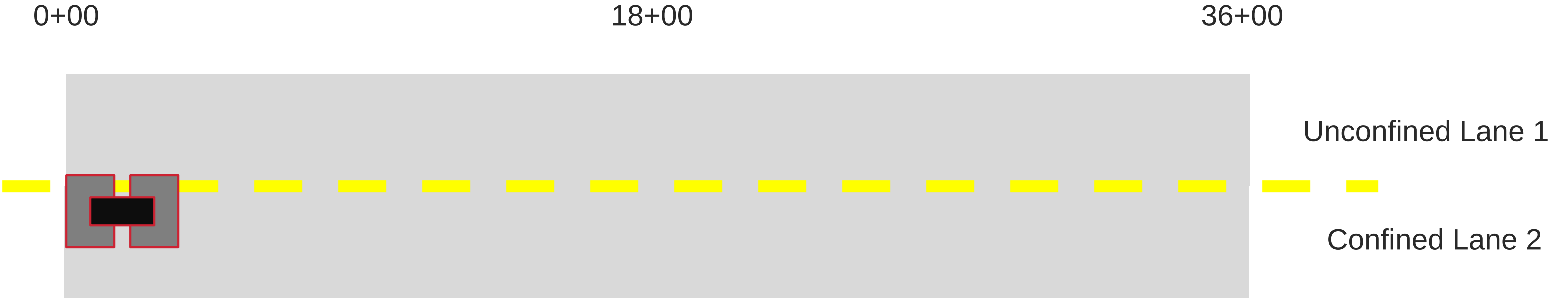
- AI / FHWA Best Practices :
  - *Confined* First Pass:
    Stay back 6-8”



Test Sections:

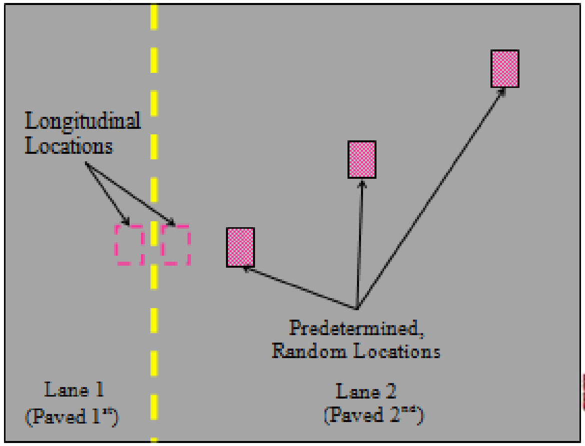
- AI / FHWA Best Practices :
  - Confined Second Pass:

    Overlap 4-6”



Work Plan:

- Nuclear Density Testing (joint & mainline)
- Cores (joint and mainline) off 2” on each side
- Cores directly on the joint
- 6 lots per section, various gauges

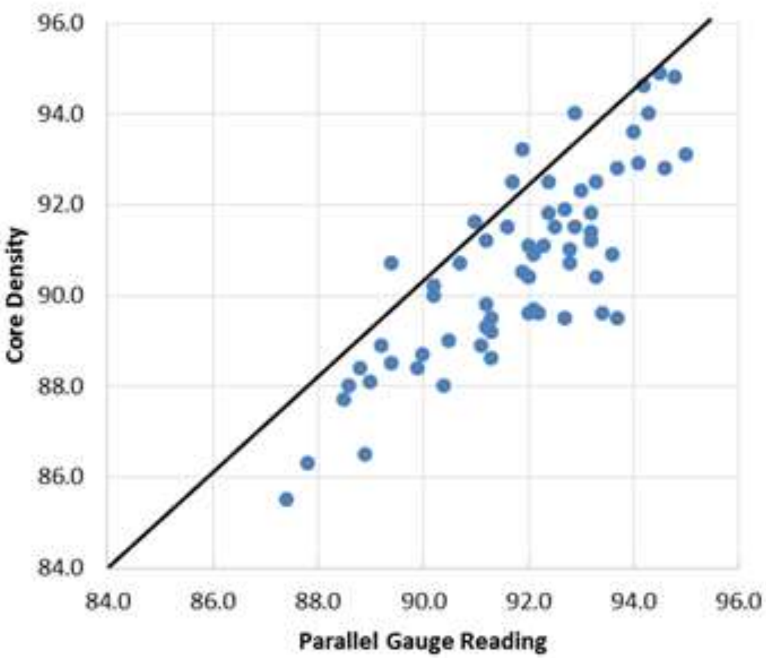


What did we find?

- Nuclear to Core correlation
- Rolling pattern
- Longitudinal Joint type
- Density directly on the joint
- Suggested density targets

Nuclear to Core correlation:

- Parallel vs. Perpendicular:
  - Parallel orientation = 82.5% correlation to core values
  - Perpendicular orientation = 67.0% correlation to core values
- How close is Parallel to cores?
  - Overestimates density 78.1% of the time
  - Underestimates density 10.9% of the time



Parallel	0.825
Perpendicular	0.670
Average of Both	0.745

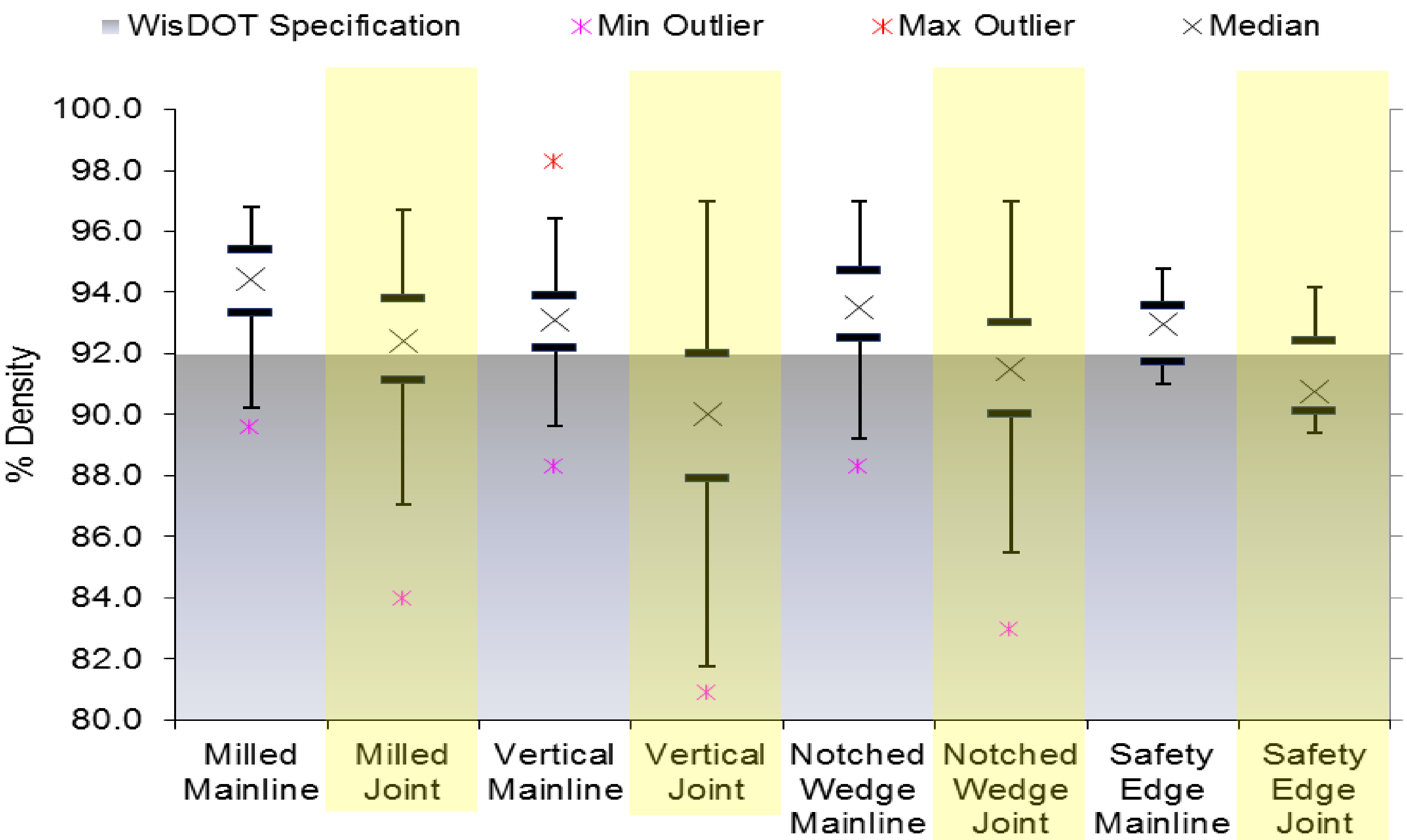
Rolling Patterns:

- Unconfined edge:
  - Vertical Joint – better to stay away on 1st pass when mix pushes out
  - Notched Wedge & Safety Edge – no significant difference
- Confined edge
  - All joints – no significant difference

Field visits vs. 2014 density data

- Vertical Joint Project –
  - Mainline Density = 2014 data
  - Joint Density > 2014 data
- Notched Wedge / Milled –
  - Mainline Density < 2014 data
  - Joint Density = 2014 data
- Safety Edge Project –
  - Mainline Density < 2014 data
  - Joint Density < 2014 data

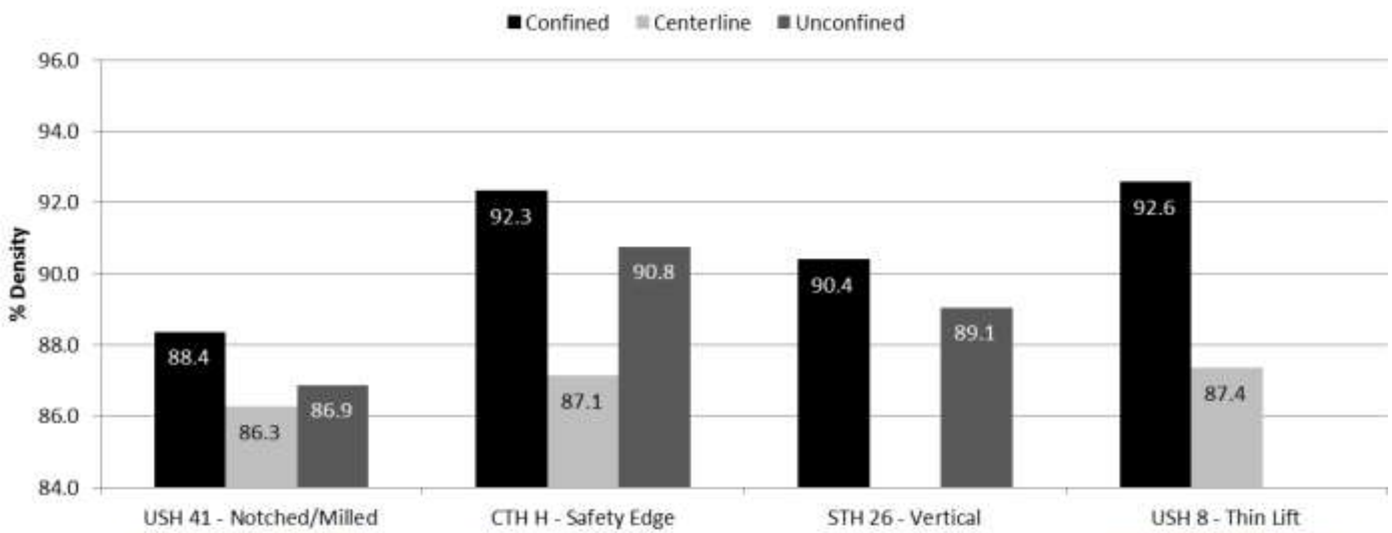
Field Visits – All Joint Types



Best Joint Types: All data

1. Milled confined (92.5%)
2. Safety Edge confined (92.4%)
3. Notched Wedge confined (92.2%)
4. Notched Wedge unconfined (91.0%)
5. Safety Edge unconfined (90.3%)
6. Vertical confined (90.7%)
7. Vertical unconfined (89.3%)

Cores on the Centerline



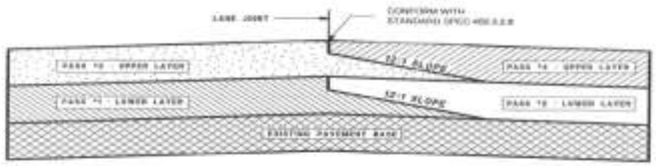
Added as additional data after STH 26

Recommendations

Density Validation:

- Continue to collect daily nuclear density data using a standard nuclear density gauge in the parallel orientation for standard thickness and thin lift over lay projects
- Use cores to establish a nuclear density / core correlation during a test strip
- Adjust the density targets to represent the core data

Recommendations



(LOWER AND UPPER LAYERS)

TYPICAL PAVEMENT CROSS SECTION OF NOTCHED WEDGE LONGITUDINAL JOINTS

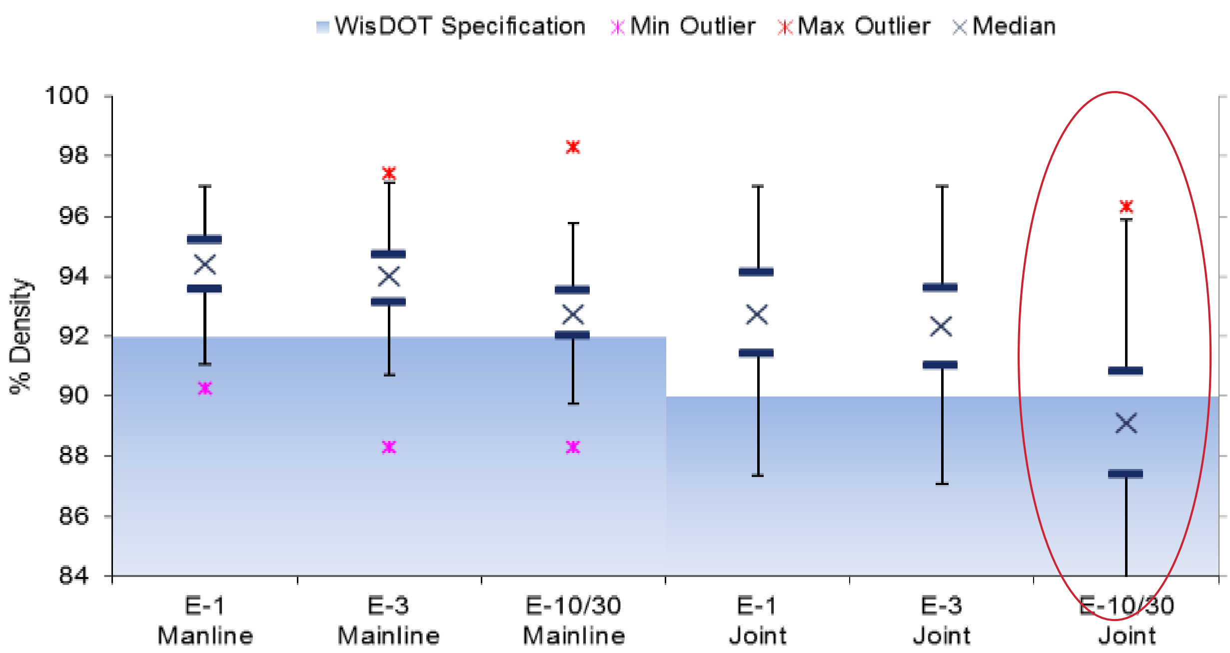
Longitudinal Joint Type

- Enforce the current standard to require the notched wedge longitudinal joint on all projects, unless echelon paving is possible
- For E-10 and E-30 mixes, additionally require milling of the unconfined notched wedge longitudinal joint when paving the adjacent lane (the data shows this is not needed to achieve density on the lower ESALs)

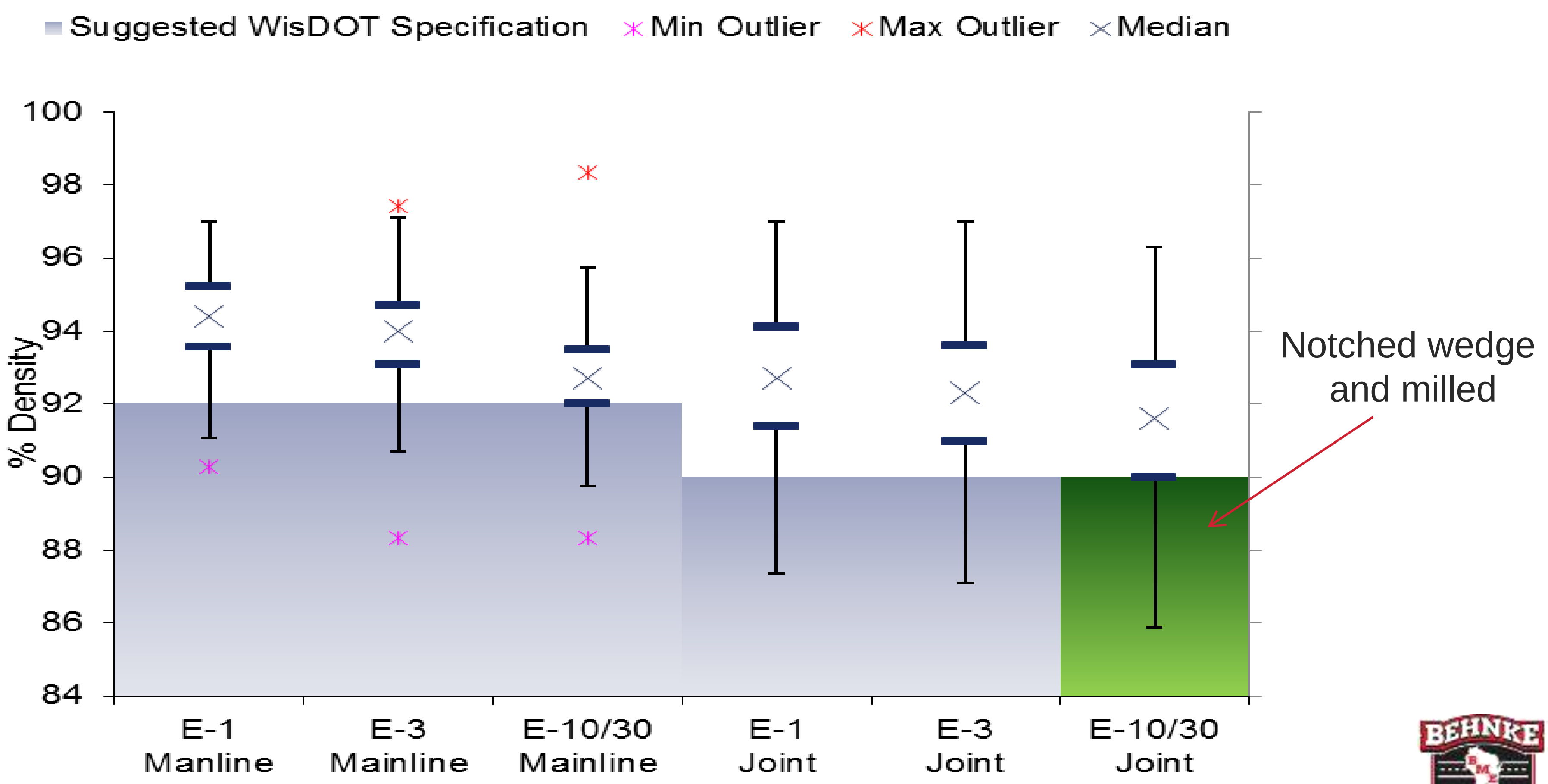
Recommendations

Density Targets

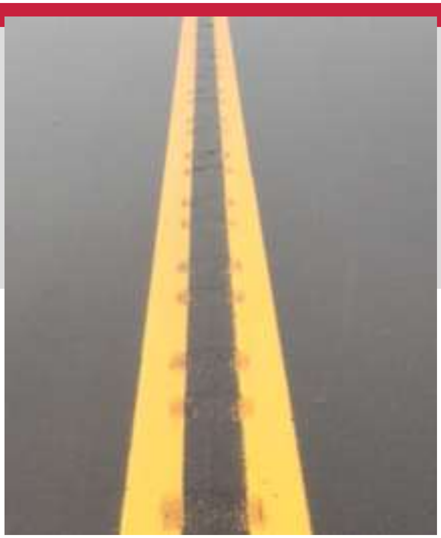
- Longitudinal Joints - min 90.0%
- All ESALS - min 92.0%
- Remove distinction between upper and lower layer



Recommendations



Recommendations



Further Recommendations Based on Observations

- Do not construct centerline rumble strips directly over the longitudinal joint, instead place them on either side of the longitudinal joint
- Look into the use of a void reducing membrane to fill the longitudinal joint from underneath
- Consider a topical joint sealer in lieu of a monetary penalty for substandard longitudinal joints
- Use a joint heater when possible, but update the online WisDOT SPV to include the current new language.

Recent Specification Changes:

- ASP 6

460.2.1 General

Replace the entire text with the following effective with the December 2016 letting:

(1) Furnish a homogeneous mixture of coarse aggregate, fine aggregate, mineral filler if required, SMA stabilizer if required, recycled material if used, warm mix asphalt additive or process if used, and asphaltic material. Design mixtures conforming to table 460-1 and table 460-2 to 4.0% air voids to establish the aggregate structure.

(2) Determine the target JMF asphalt binder content for production from the mix design data corresponding to 3.0% air voids (97% Gmm) target at the design the number of gyrations (Ndes). Add liquid asphalt to achieve the required air voids at Ndes.

(3) For SMA, determine the target JMF asphalt binder content for production from the mix design data corresponding to 4.0% air voids (96% Gmm) target at Ndes.

Recent Specification Changes:

- ASP 6

460.3.3.1 Minimum Required Density

Replace paragraph one with the following effective with the December 2016 letting:

(1) Compact all layers of HMA mixture to the density table 460-3 shows for the applicable mixture, location, and layer.

TABLE 460-3 MINIMUM REQUIRED DENSITY[1]

LOCATION	LAYER	PERCENT OF TARGET MAXIMUM DENSITY		
		MIXTURE TYPE		
		LT and MT	HT	SMA[5]
TRAFFIC LANES[2]	LOWER	93.0[3]	93.0[4]	—
	UPPER	93.0	93.0	—
SIDE ROADS, CROSSOVERS, TURN LANES, & RAMPS	LOWER	93.0[3]	93.0[4]	—
	UPPER	93.0	93.0	—
SHOULDERS & APPURTENANCES	LOWER	91.0	91.0	—
	UPPER	92.0	92.0	—

[1] The table values are for average lot density. If any individual density test result falls more than 3.0 percent below the minimum required target maximum density, the engineer may investigate the acceptability of that material.

[2] Includes parking lanes as determined by the engineer.

[3] Minimum reduced by 2.0 percent for a lower layer constructed directly on crushed aggregate or recycled base courses.

[4] Minimum reduced by 1.0 percent for a lower layer constructed directly on crushed aggregate or recycled base courses.

[5] The minimum required densities for SMA mixtures are determined according to CMM 8-15.

Recent Specification Changes:

- PWL Test Strip Spec
  - Based on <u>Cores</u>

LAYER	MIXTURE TYPE LT & MT	HT
LOWER	91.5[1]	92.0[2]
UPPER	91.5	92.0

[1] Minimum reduced by 2.0 percent for a lower layer constructed directly on crushed aggregate or recycled base courses.

[2] Minimum reduced by 1.0 percent for lower layer constructed directly on crushed aggregate or recycled base courses.

Thank you to....

- WisDOT and WHRP
- Aaron Coenen, PE, PhD
- S.T.A.T.E. Testing, LLC
- Payne and Dolan, Inc
- Northeast Asphalt, Inc
- DL Gasser Construction

Questions?