BMD Overview for Beginners

MAPA Spring Training - February 7th, 2024

Adam J. Taylor, P.E.

National Center for Asphalt Technology (NCAT)

Motivations for Implementing BMD



- Reasons vary from Agency to Agency
- Dissatisfaction with performance of current mix designs
- Limitations of current volumetric-based system

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Why Change?

- The key properties in Superpave mix design are air voids and volume of effective binder (V_{be})
- Volumetric properties do not tell us anything about the **quality** of the binder, or about the interactions of different binder components and additives
- V_{be} is dependent on the aggregate bulk specific gravity (G_{sb}), which is not a reliable property
  - G_{sb} are subject to change over time, but not often verified
  - G_{sb} has a low level of precision
  - G_{sb} of RAP aggregate is questionable
- *Volumetrics tell us about the <u>quantity</u> of binder, but not about the <u>quality</u> of binder*

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With the current volumetric mix design system…

Performance Testing (20+ years ago)

- Performance tests were supposed to be included in Superpave Level II & III
  - Superpave Shear Tester (SST)
  - Superpave IDT

- Tests were too complicated and cost too much to implement for routine use

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Rutting

- In the early years of Superpave implementation, most attention was focused on rutting


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Rutting

- Mix design strategies to mitigate rutting
  - Use of more angular aggregates
  - Binder grade adjustments
  - Polymer modification
  - Increased compactive efforts
  - Implementation of mixture rutting test (APA, HWTT)
- No longer a concern for many highway agencies

Cracking

- A decade after Superpave implementation, we realized we needed to evaluate cracking susceptibility
- Fragmented research on cracking tests
- Numerous tweaks to volumetrics, but failed to address underlying flaws



“Asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate and location within the pavement structure”

Balanced Mix Design BMD

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AASHTO Standards on BMD

- AASHTO PP 105-20 (2022)
  - *Standard Practice for Balanced Mix Design of Asphalt Mixtures*
- AASHTO MP 46-20
  - *Standard Specification for Balanced Mix Design*

Anticipated Benefits of BMD

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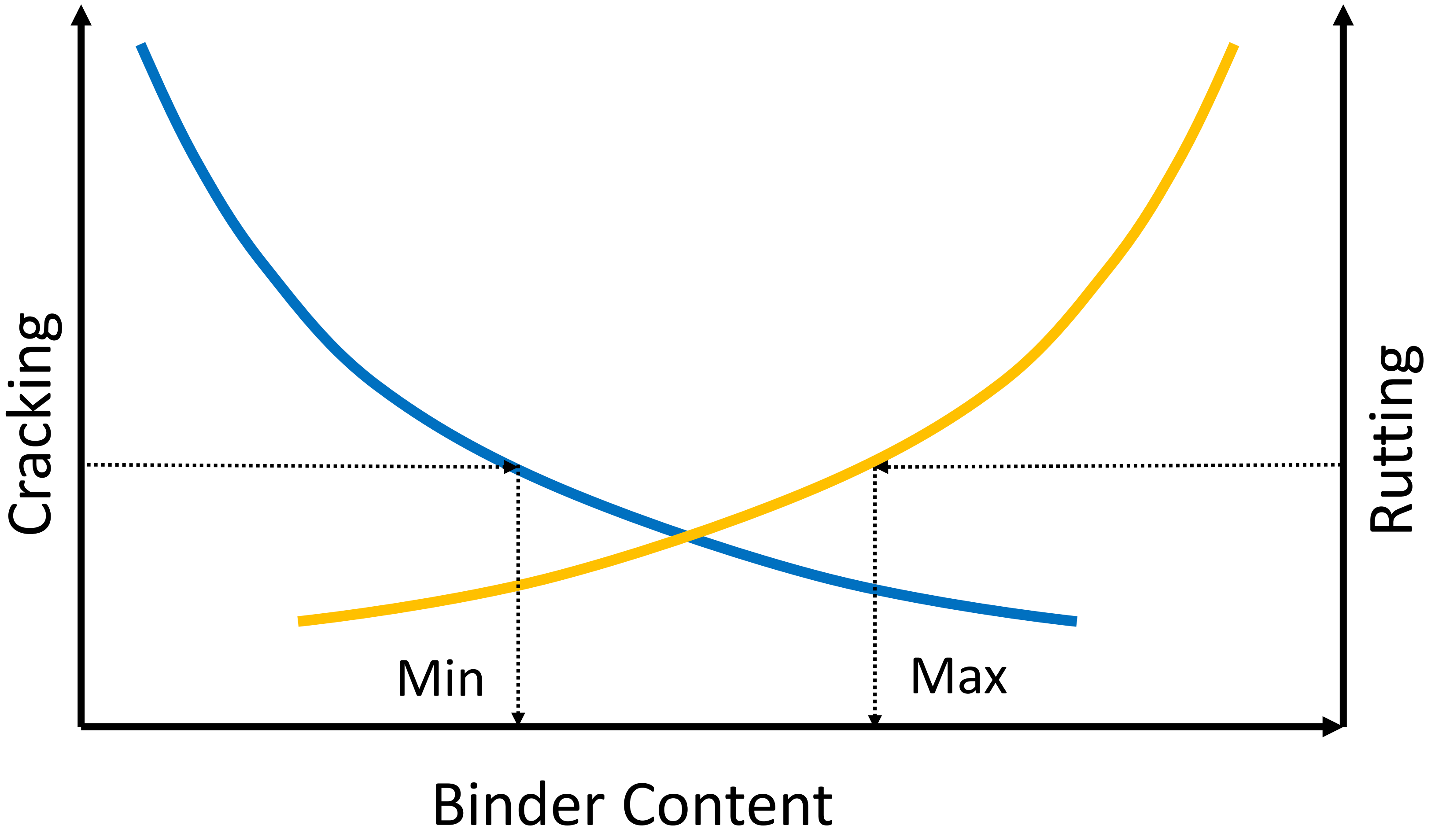
Ensure Performance

Enable Innovation

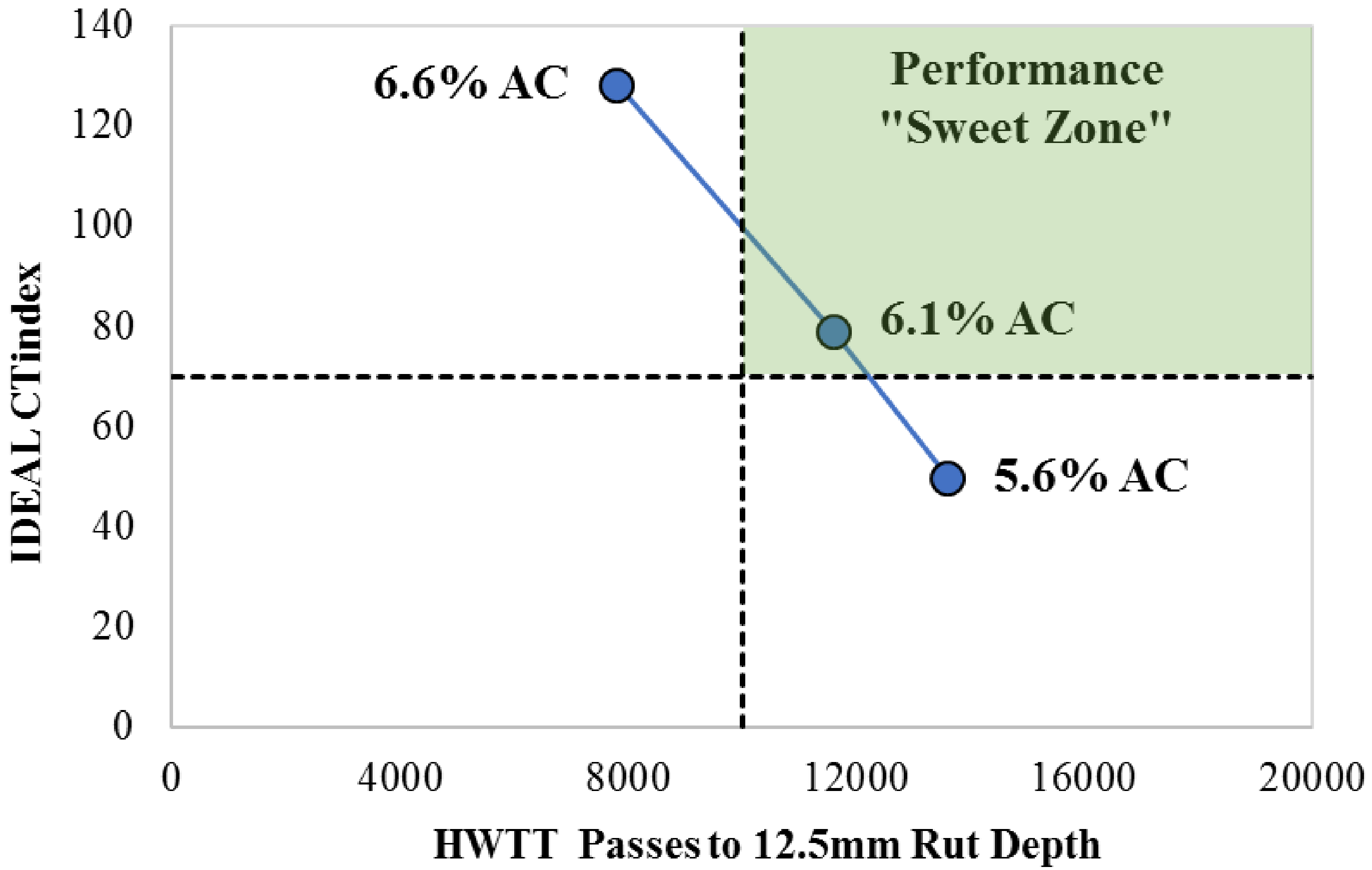
Optimize Cost

Acceptable Cracking and Rutting



Acceptable Rutting and Cracking

- Example
  - Balance IDEAL-CT and Hamburg (HWTT)
  - Balancing AC Content in this example
  - BMD isn't just about AC content, however



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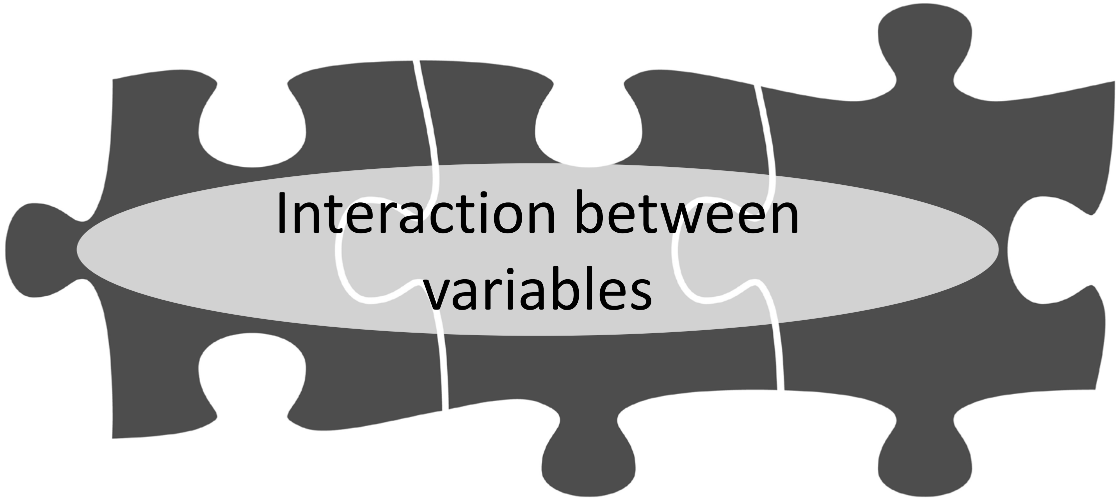
What mix design variables affect performance?

Binder
- Binder content
- Binder grade
- Crude source
- Anti-strip
- Additives

Aggregate
- Gradation
- Angularity
- Strength
- Dust

Recycled
- RAP content
- RAS content
- Binder grade
- Plastics
- Rubber
- Fibers



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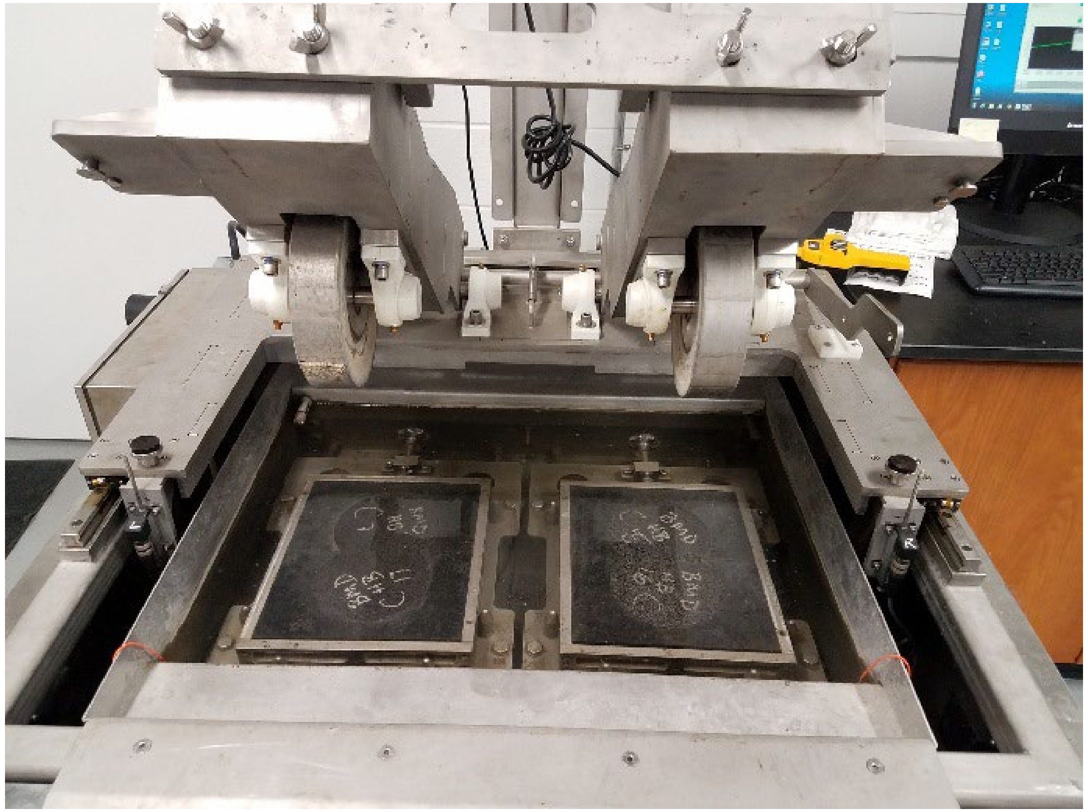
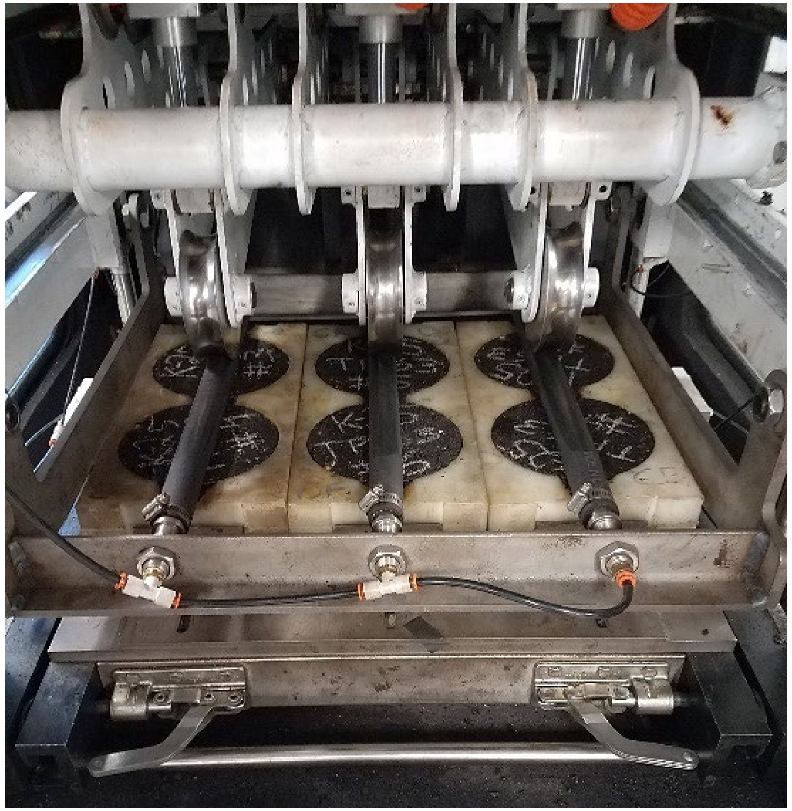
Common BMD Rutting Tests – Wheel Tracking



Hamburg Wheel Tracking Test (HWTT)
AASHTO T324-23



Asphalt Pavement Analyzer (APA)
AASHTO T340-23

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Common BMD Rutting Tests – Rapid Rutting

HT-IDT (Draft ASTM)

IDEAL-RT (ASTM D8360-22)

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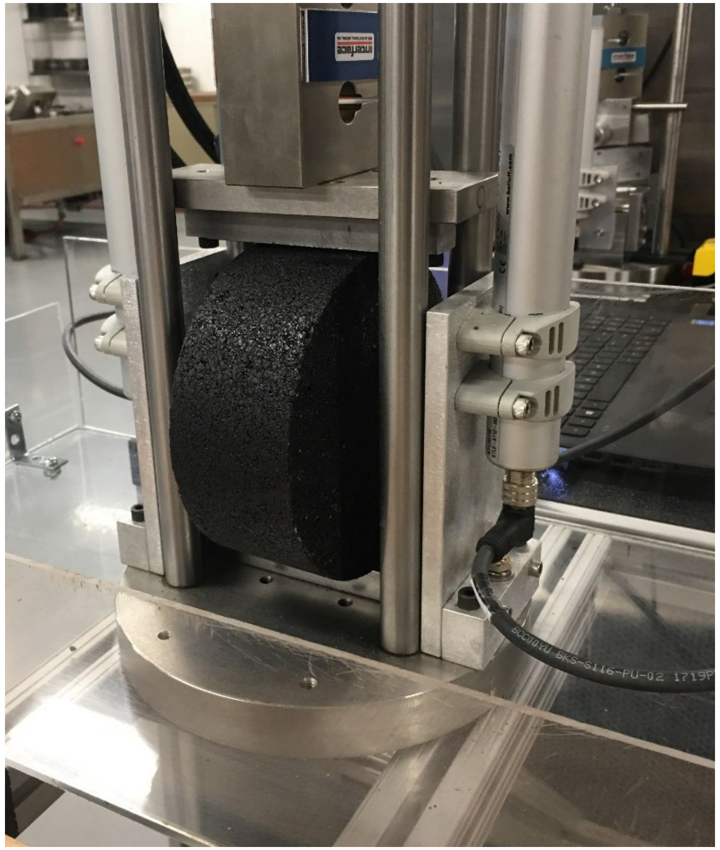
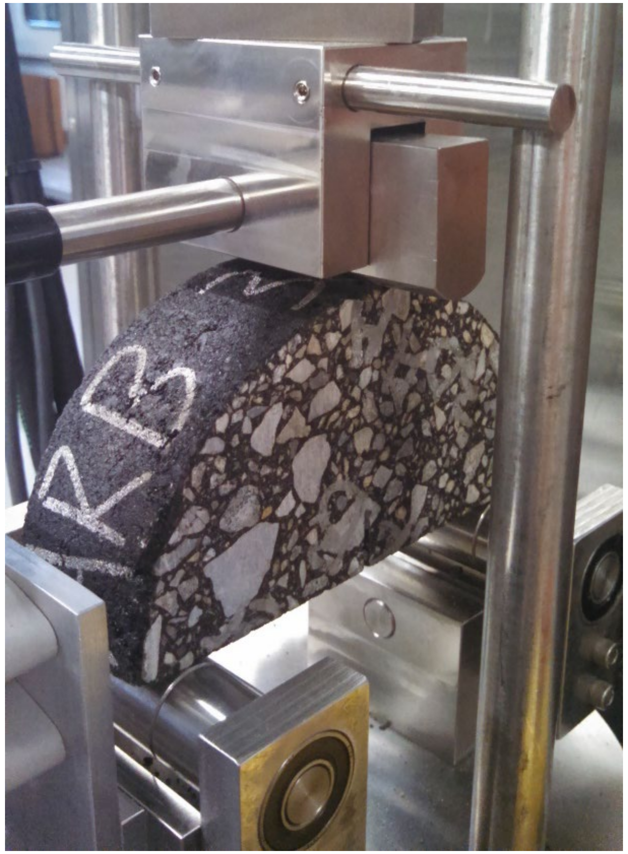
Common BMD Cracking Tests – Intermediate Temp



IDEAL-CT (ASTM D8225-19)



I-FIT (AASHTO T393-22)

Overlay Test (OT)
(Tex-248-F)

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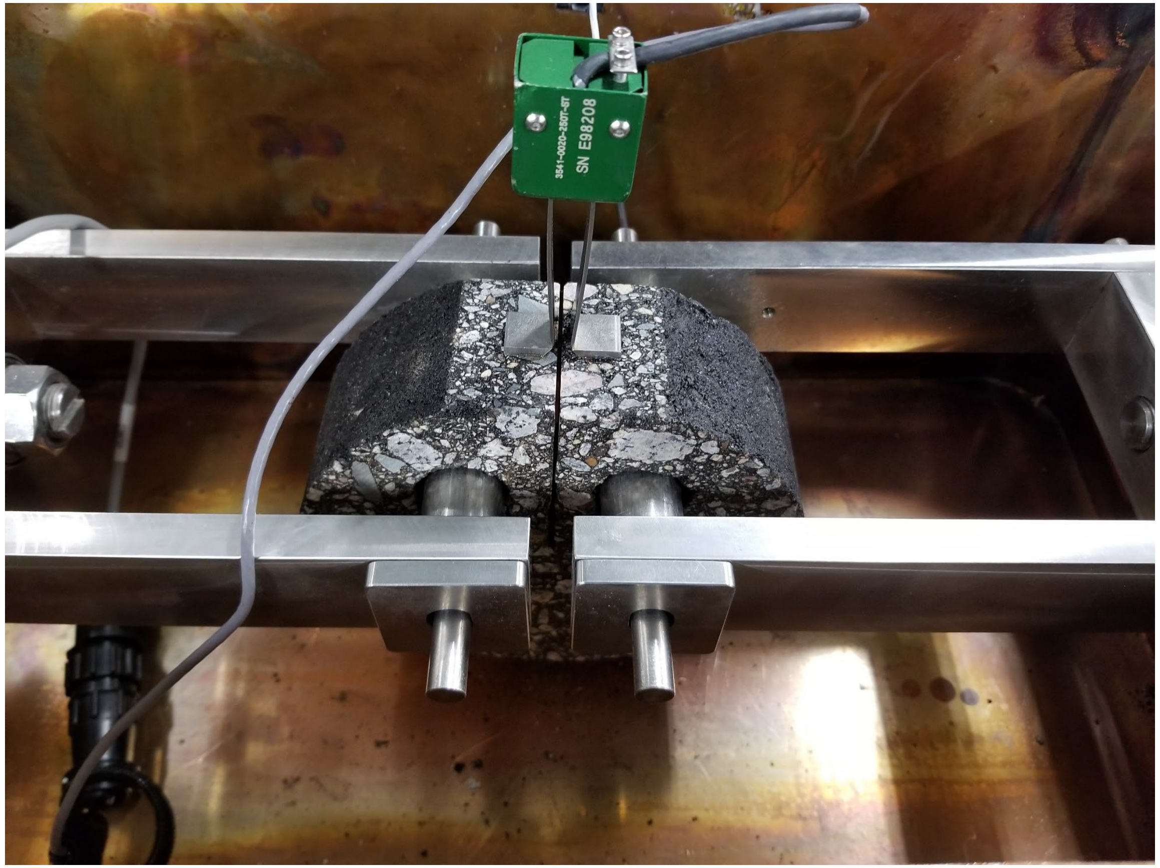
Common BMD Cracking Tests – Low Temperature



Disk-Shaped Compact
Tension (ASTM D7313-20)

BMD Laboratory Tests

- All BMD Performance Tests have benefits and limitations
  - Good laboratory practices are vital to make BMD work
  - Controlling density on BMD specimens is essential
- Performance tests are useful tools to improve mixture performance
- Don’t let the perfect be the enemy of the good (or better)

Mixture Aging

- "Appropriately Conditioned Specimens"
- Most rutting occurs in the short-term
  - Short-term oven aged lab-produced mix or re-heated plant-produced mix
- Most cracking occurs in the medium to long-term
  - Some form of long-term aging is most appropriate
    - Practical during mix design, but…
    - Impractical in a production setting
  - How can this be incorporated in BMD specs?

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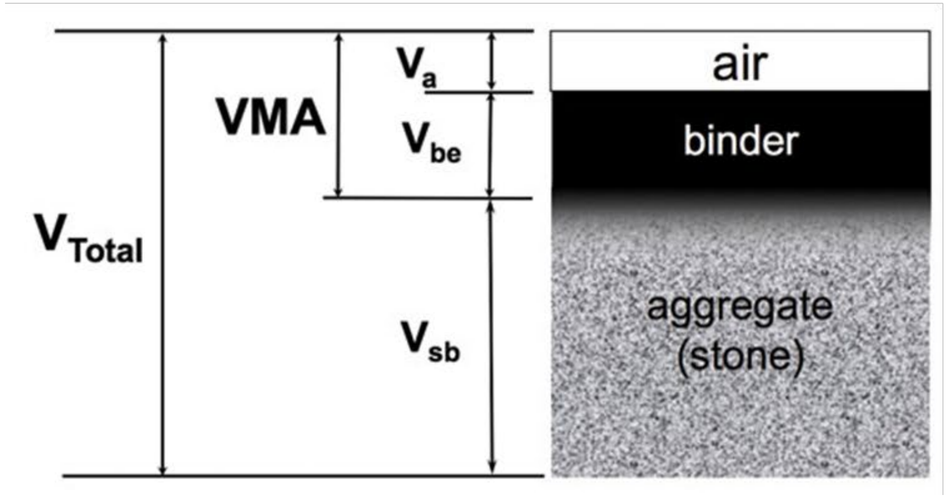
BMD Approaches

A. Volumetric Design with Performance Verification
B. Volumetric Design with Performance Optimization
C. Performance-Modified Volumetric Design
D. Performance Design



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BMD Approaches (AASHTO PP 105)

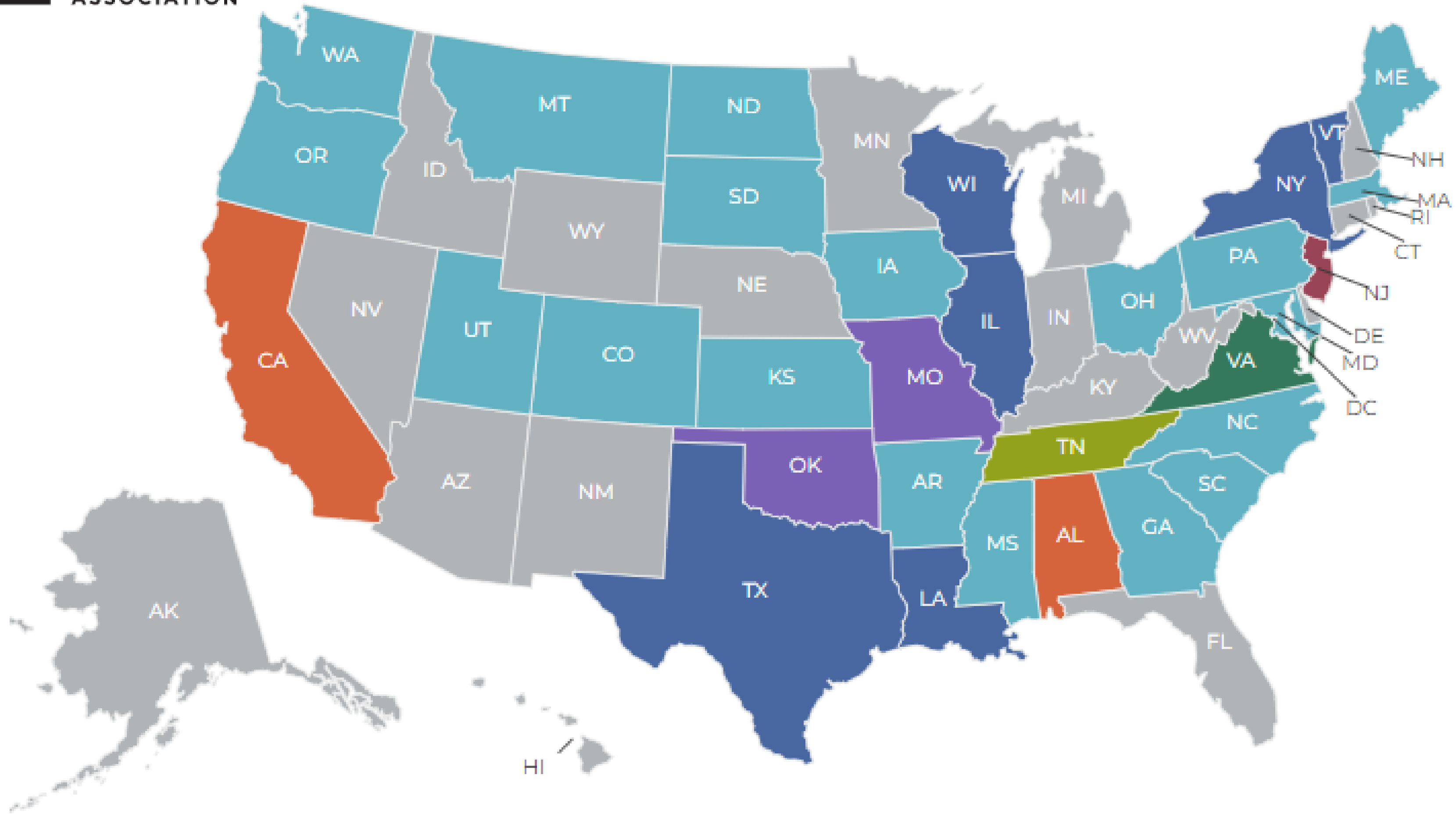
A
V+
- Superpave Volumetrics
- +
- Performance Tests

B
V-Opt. P_b
- Initial SP Volumetrics
- Perf. Tests Opt. Binder ± ½%

C
Perf-Mod V
- Relaxed Volumetrics
- Performance Tests

D
Perf Design
- No Volumetric Requirements
- Performance Tests

Implementation Status *(11/01/2023)*



Method(s)

- A
- A/B (NJ)
- A/D (VA)
- B
- C
- D
- Pre-Impl.

2013 AASHTO COMP Survey: Most Pre-Implementation States are looking at Method A

Some BIG Questions

- Which performance tests will be selected?
- What aging/conditioning protocol should be used?
- How will the performance tests be used in the mix design process?
- Will you use the performance tests in Quality Assurance?
- What criteria should be used in specifications?

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Summary

- BMD versus Volumetrics
  - Idea of binder quality in the final mixture
- AASHTO BMD Specifications
- Multiple options for performance tests
- Four different BMD approaches
  - Varying volumetric requirements
  - Varying innovation potential

Resources

- NAPA BMD Resource Guide
  - https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide
- 'Training and Resources'
  - NAPA IS-143 *Balanced Mix Design Resource Guide*
  - NAPA IS-145 *Guide of Asphalt Mixture Specimen Fabrication for BMD Performance Testing*
- AASHTO BMD Specifications

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Thank you!
Questions?

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BMD Mix Design Adjustments

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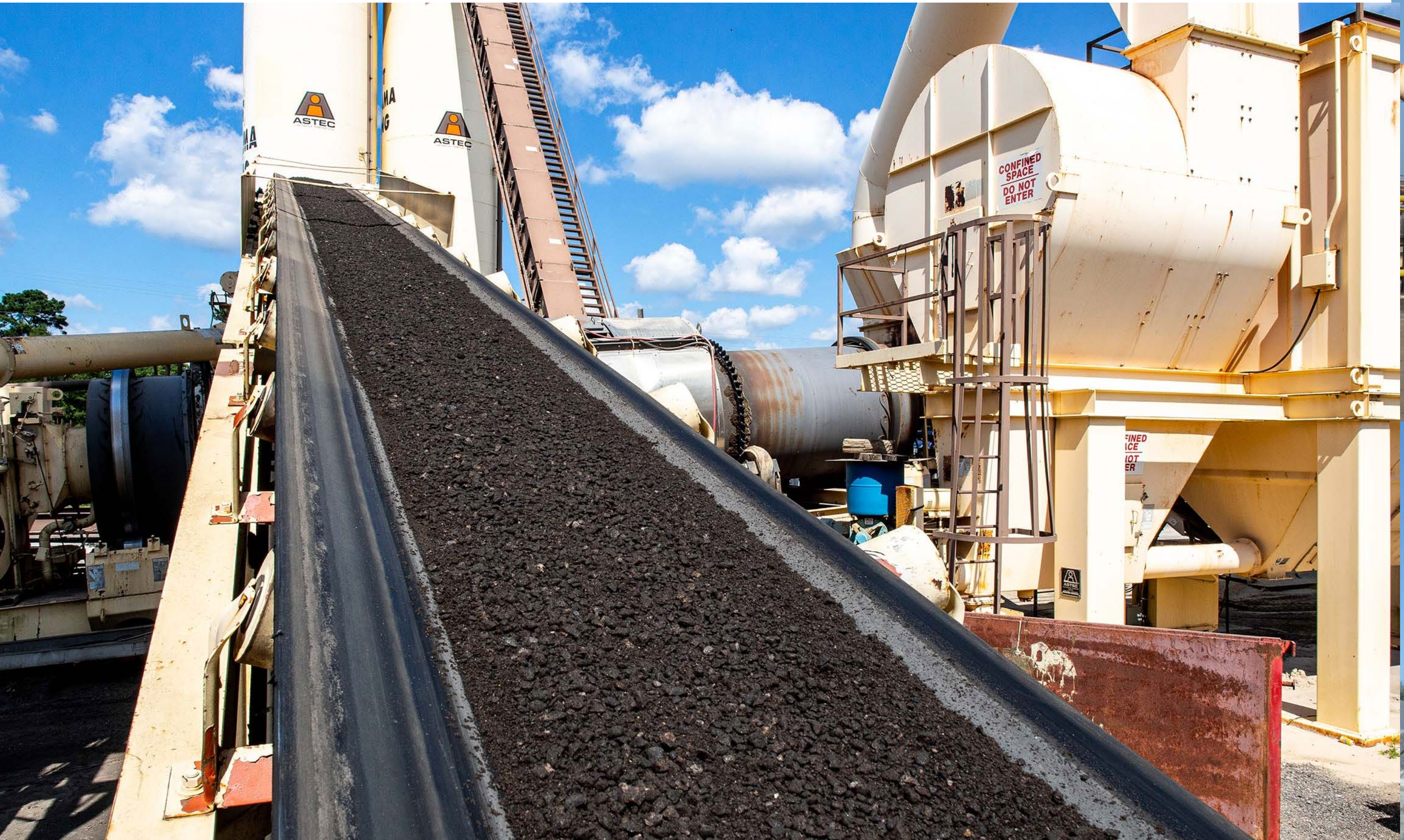
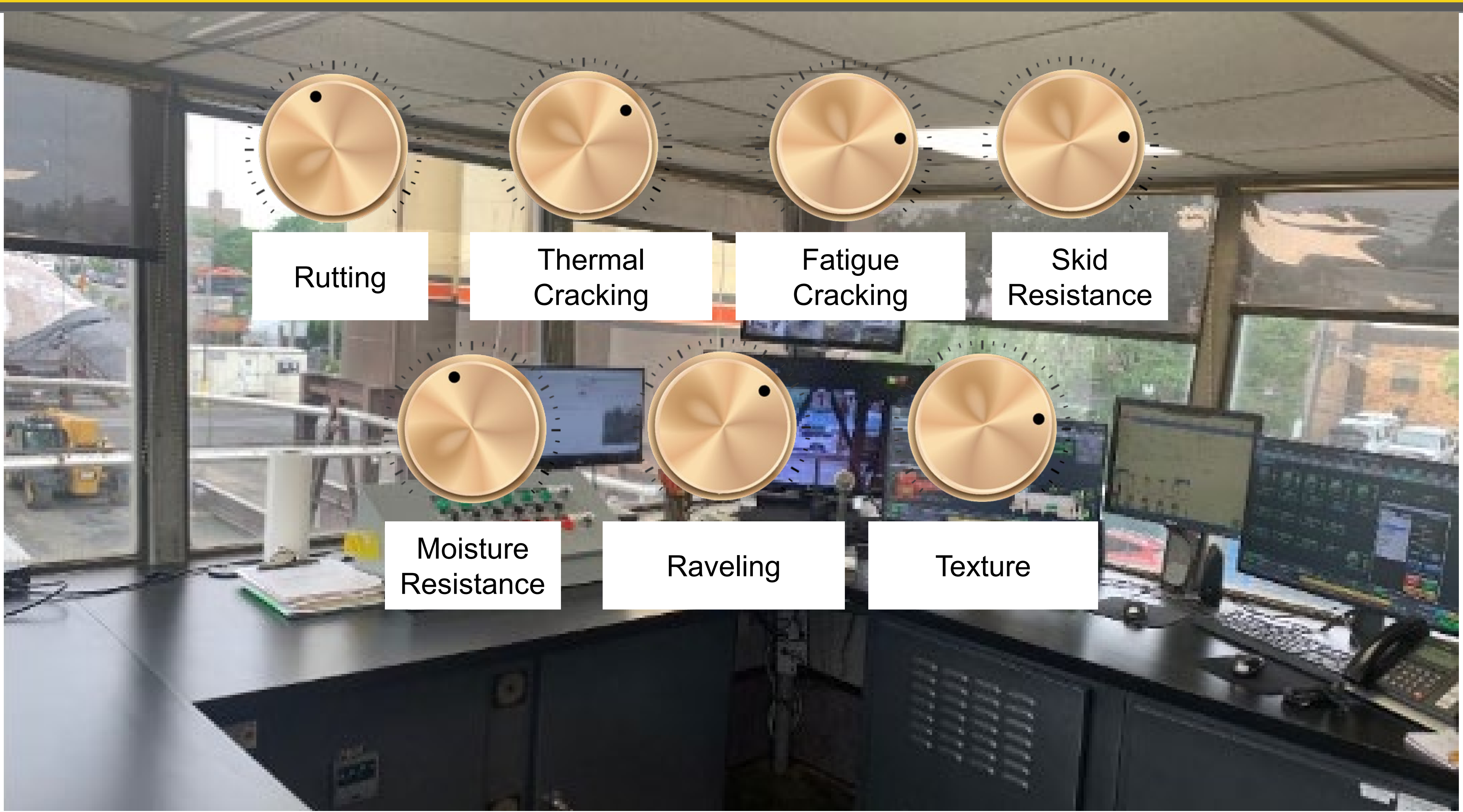
How do we get from here…

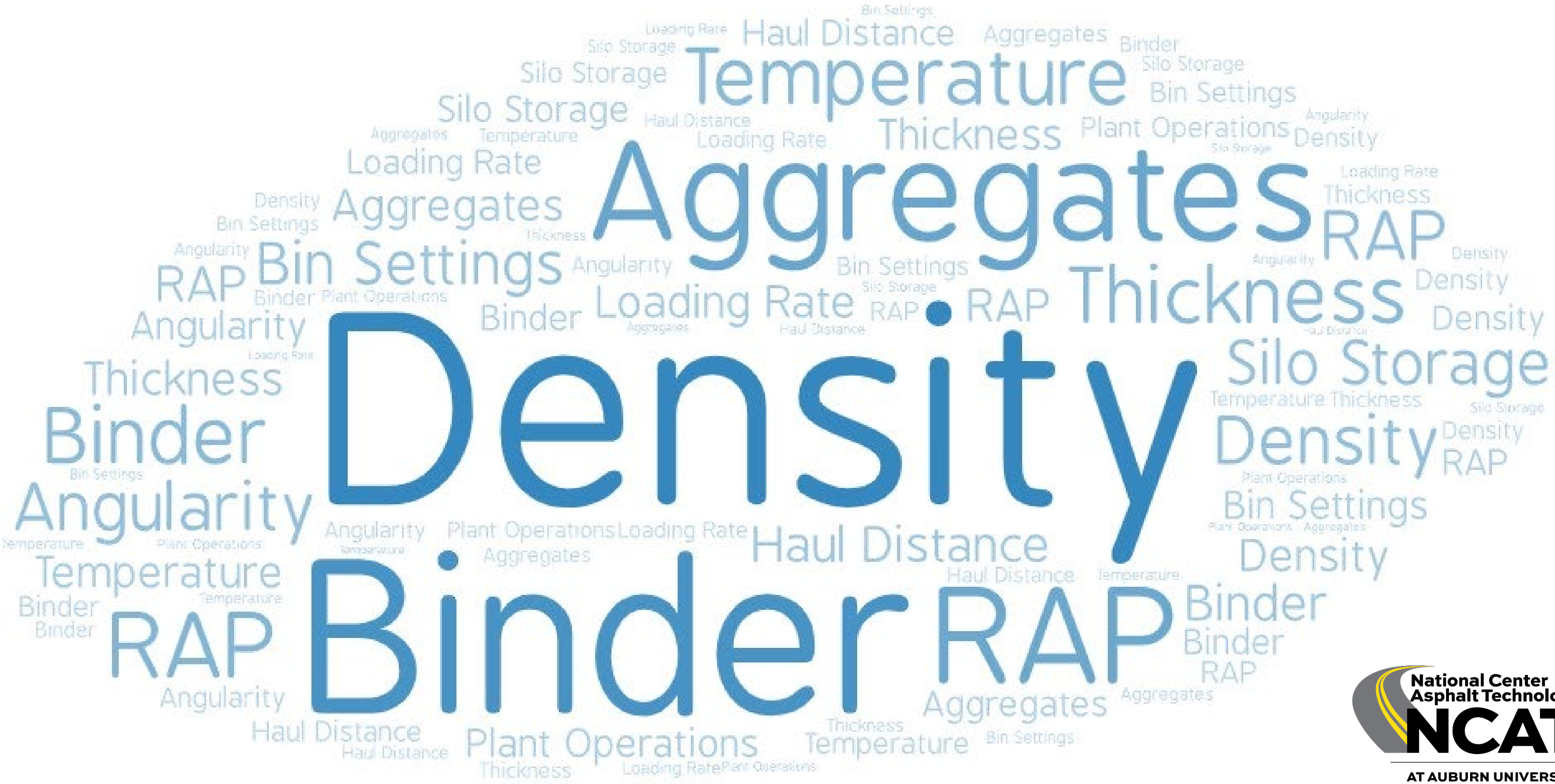
to here?



What can we actually control?



Asphalt Pavement Performance



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Presentation Outline

What mix design variables can be changed to improve

- Rutting resistance
- Cracking resistance
- Moisture susceptibility

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What mix design variables affect performance?

Binder

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- Binder grade
- Crude source
- Anti-strip
- Additives

Aggregate

- Gradation
- Angularity
- Strength
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Recycled

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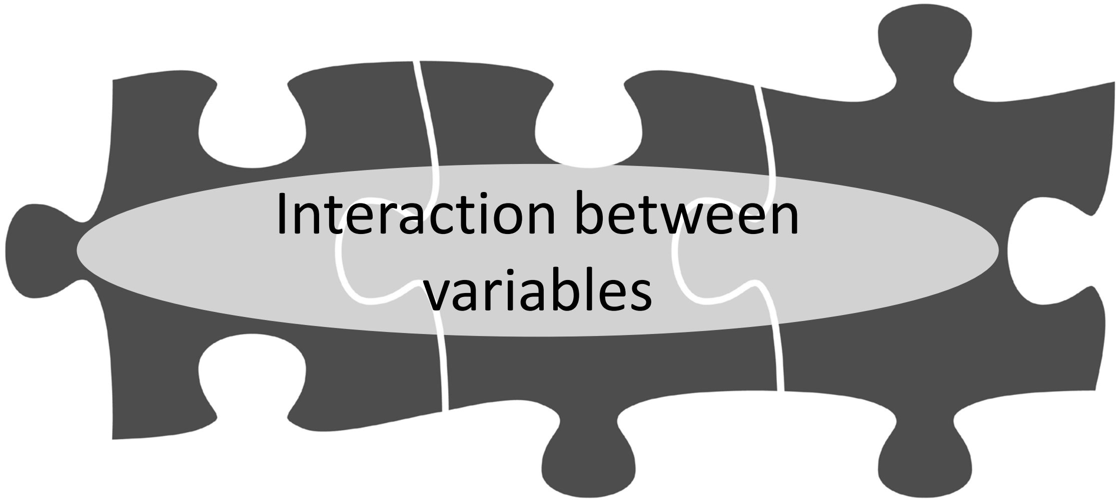

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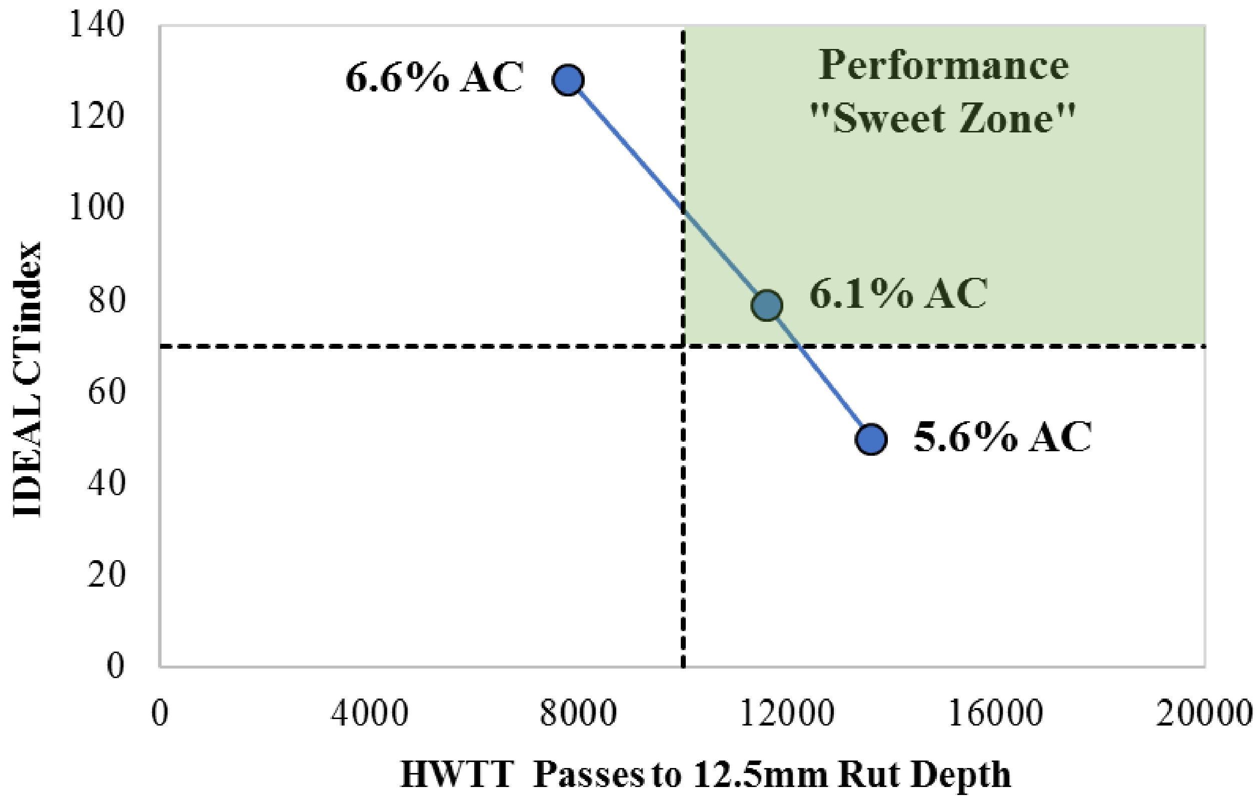
Rutting – Possible Strategies

- Adjusting aggregate gradation
- Using a stiffer asphalt binder
- Polymer modification
- Lowering asphalt content
- Increasing recycled materials content
- Adding fiber additives

Rutting: Case Study 1

- Factor: binder content
- Hamburg Wheel Tracking Test (HWTT)



Virgin Mix
PG 67-22 Binder

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Rutting: Case Study 2

- Factor: binder grade
- Asphalt Pavement Analyzer

Binder Type	APA Rut Depth (mm)
PG 64-22	3.8
PG 70-22	2.4
PG 76-22 (SBS)	1.4

12.5 mm NMAS
Virgin Mix

(Data from Zaniewski, 2003)

Rutting: Case Study 3

- Factors: RAP content, binder content
- HWTT

Binder Content	HWTT Rut Depth (mm)	
	35% RAP mix, PG 64-34 binder	45% RAP mix, PG 64-34 binder
4.3%	3.0	2.4
4.8%	4.0	3.2
5.3%	4.7	3.8

Rutting: Case Study 4

- Factor: Coarse Aggregate Type
- Hamburg Wheel-Tracking Test (HWTT)

Agg Type	HWTT Rutting (mm)
Natural Gravel	8.7
Limestone	7.1

19% RAP Mix
PG 58-28
5.8% AC

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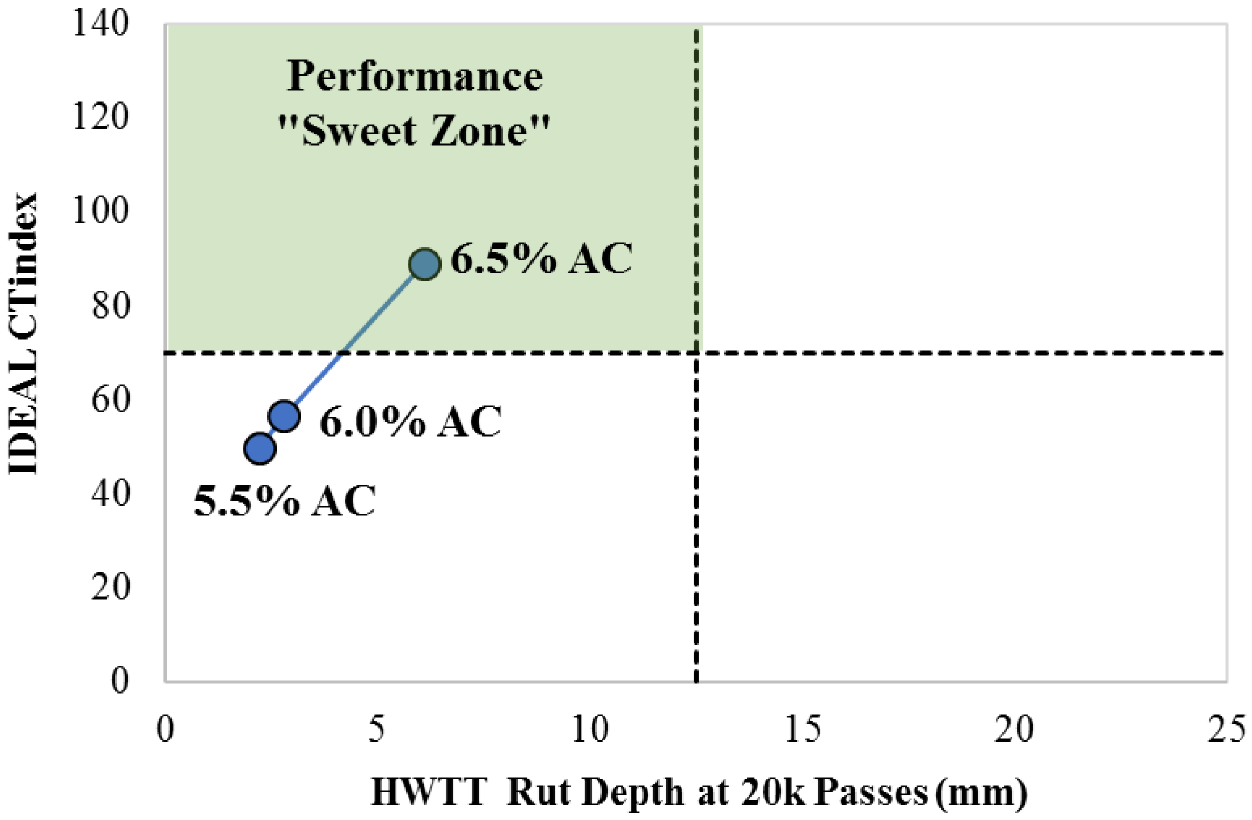
Cracking – Possible Strategies

- Increasing asphalt content or V_{be}
- Lowering recycled materials content
- Using a softer (better quality) asphalt binder
- Adding a rejuvenator or other additive
- Change crude source

Cracking: Case Study 1

- Factor: binder content
- Indirect Tensile Asphalt Cracking Test (IDEAL-CT)



20% RAP Mix
PG 67-22 Binder

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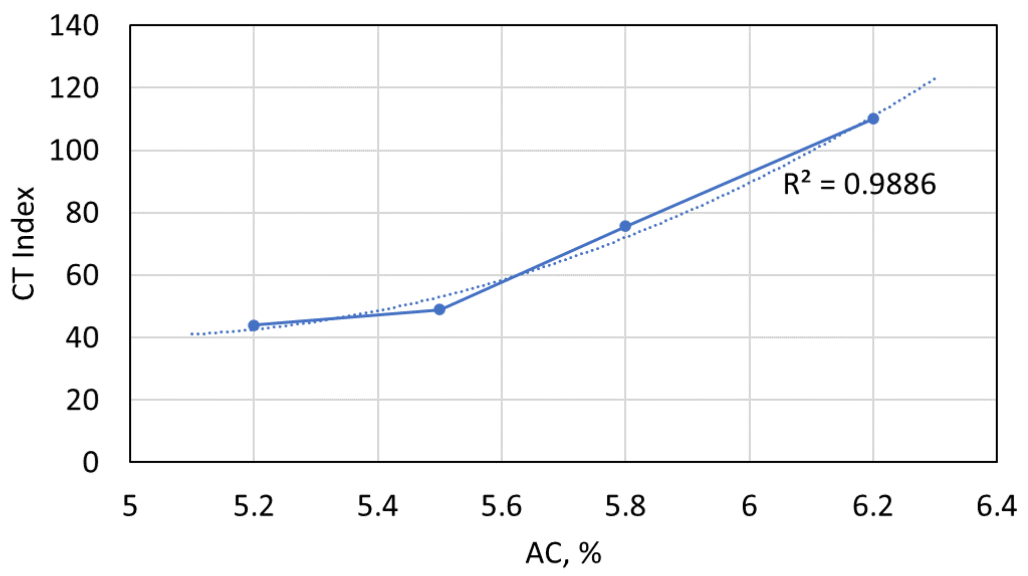
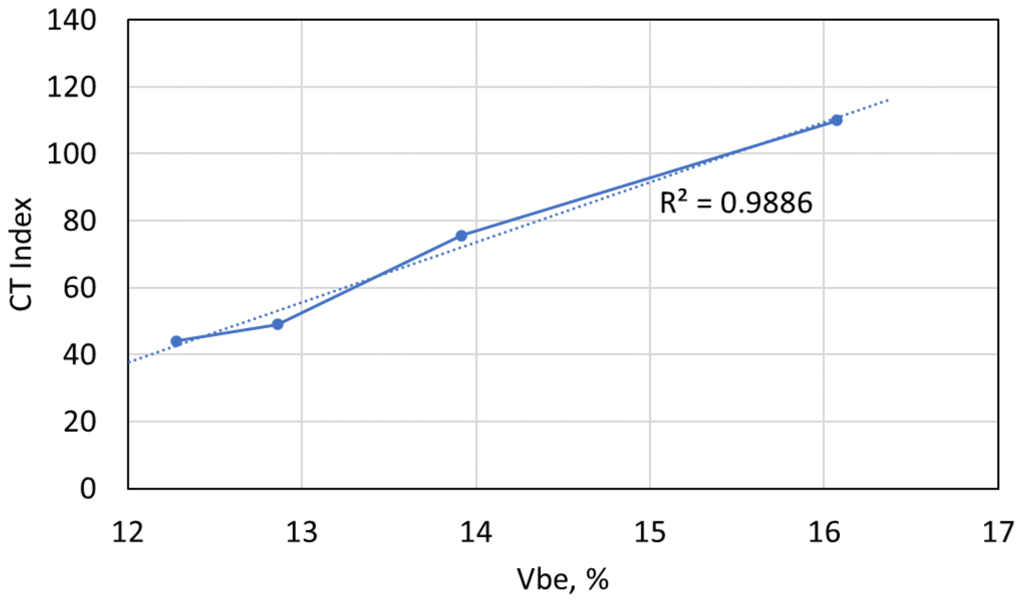
Cracking: Case Study 2

- Factor: Volume of Effective Binder (V_{be}) @ Ndes
- IDEAL-CT





20% RAP Mix

PG 76-22

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Cracking: Case Study 3

- Factors: RAP content
- IDEAL-CT & Hamburg Wheel Tracking Test (HWTT)

RAP Content	Laboratory Test Result	
	IDEAL-CT	HWTT Rutting (mm)
0%	124	5.6
15%	77	3.0
30%	37	2.1

PG 70-28
4.7 – 5.0% AC

Cracking: Case Study 4

- Factor: rejuvenator dosage
- IDEAL-CT

Rejuvenator Dosage	CT_{index}
No rejuvenator	21.1
Low	38.1
Medium	44.1
High	42.2

45% RAP Mix
PG 64-22
5.2% AC

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Cracking: Case Study 5

- Factor: softer binder
- I-FIT

Low-temperature PG	Flexibility Index	
	4h@135C on loose mix	5d@85C on loose mix
xx-22	4.0	1.7
xx-28	5.8	3.0
xx-34	9.0	5.1

(Data from Bonaquist, 2016)

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Cracking: Case Study 6

- Factor: Coarse aggregate source
- IDEAL, I-FIT, & DCT

Aggregate Type	Laboratory Result		
	IDEAL-CT	I-FIT	DCT (J/m^2)
Natural Gravel	83	12.1	597
Limestone	64	7.4	361

19% RAP Mix
PG 58-28
5.3% AC

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Cracking: Case Study 7

- Factor: binder source (quality)
- I-FIT

Binder Source	Flexibility Index
Source A, ΔTc: -0.2	10.5
Source B, ΔTc: -5.7	5.5

12% RAP Mix
PG 70-28
5.6% AC

Stripping – Possible Strategies

- Changing binder source
- Changing aggregate type
- Adding/changing an anti-strip agent

Stripping: Case Study 1

- Factor: binder source
- HWTT

Binder Source	HWTT Rut Depth at 20k Passes
Source A	3.0 mm
Source B	> 12.5 mm

15% RAP Mix
PG 76-28
5.6% AC

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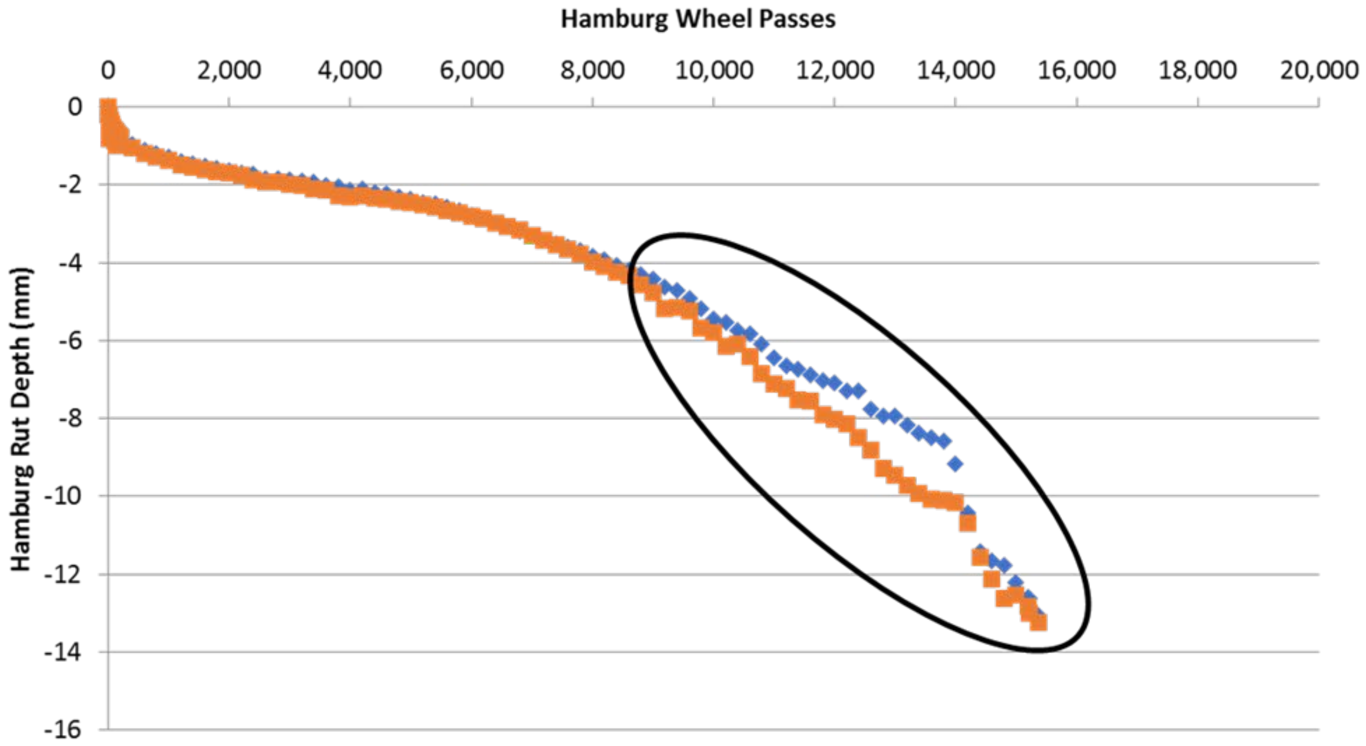
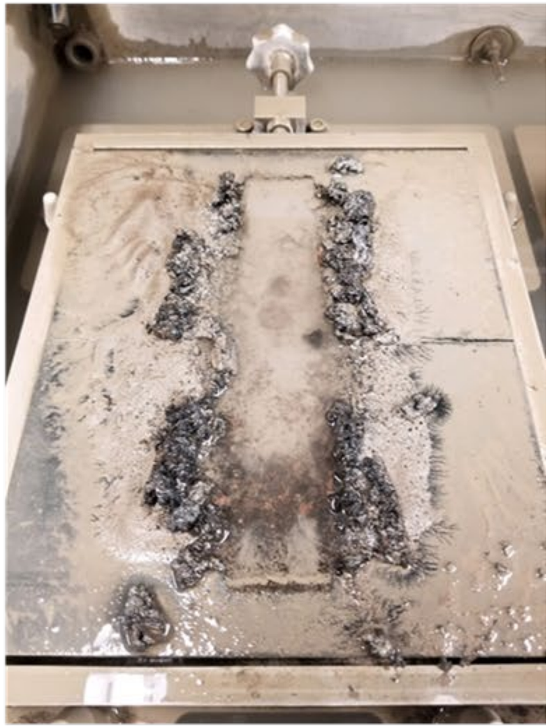
Stripping: Case Study 1

- PG 76-28 Binder, Source B





Stripping: Case Study 2

- Factor: liquid anti-strip additive
- Tensile Strength Ratio (TSR)
- Virgin mix, granite aggregate (with known stripping issues), 5.4% AC

Liquid Anti-strip	TSR
No Anti-strip	0.26
+ Product A	0.67
+ Product B	0.85

Factors to Consider for Design Optimization

Performance

Cost

Material Availability

Closing Remarks

- "When faced with a problem with multiple solutions, begin with the simplest approach first"
- Example: Failing mix design. Need 15 more CT_{Index} units
  - Are data repeatable? Do they make sense based off of historical results?
  - Change gradation? RAP source? Aggregates?
  - Identify different binder source? Binder grade? Decrease RAP content?
  - Additives, Fibers, Oils, Recycling Agents (These are not bad!)
  - What is the simplest/cheapest approach that gets the job done?

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Thank you!
Questions?

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BMD Processes and Procedures

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NCAT Research on BMD Processes

- **How do we make BMD work in the lab?**
- Related NCAT Research
  - NCAT Round Robin
  - Achieving Target Air Voids
  - Specimen Preparation
  - IDEAL-CT Equipment Comparison
  - Resources to help

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NCAT Round Robin

- Help collect data on mixture performance tests that are being considered as part of Balanced Mix Design implementation efforts
  - Understanding Test Variability
    - Within Lab
    - Between Lab
- Help test users gain experience and confidence in their ability to perform these tests
- 2019 and 2022 Round Robins thus far
  - NCAT Report 22-01 (2019 Round Robin)

NCAT Round Robin

- 200+ Buckets (!) sampled for each Round Robin
  - Mix Sampled from a Stockpile that had been passed through a Material Transfer Vehicle
- Plant Mix sent to participating labs
- Requested an Excel Summary file for each lab per test in addition to the raw data
- Labs provided with detailed fabrication and testing instructions

NCAT Round Robin

Test ID	2019	2022
Hamburg	32	40
I-FIT	20 (13 Phase II)	[redacted]
IDEAL-CT	15 (14 Phase II)	46
APA	10	15
HT-IDT	[redacted]	16
IDEAL-RT	[redacted]	13

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NCAT Round Robin

- Phase 1
  - Labs sent buckets of plant mix
  - Each lab prepared and tested their own specimens
- Phase 2 (2019 Only)
  - All specimens fabricated at NCAT
  - Specimens shipped to participating labs for testing

Example Data Collection Form

NCAT Hamburg Round Robin - Data Summary Sheet				
General Equipment Information				
Gyratory Compactor Make and Model:				
Hamburg Make and Model:				
Single or Dual Wheel Tracker?				
General Specimen Info				
Sample ID (only the 4 used for testing)				
Date Compacted				
Number of Gyrations to achieve 62 mm				
Gmb - Dry Mass in Air, g				
Gmb - Mass of Specimen underwater, g				
Gmb - SSD Mass of Specimen, g				
Gmb				
Air Voids (%) - Use Provided Gmm of 2.691				
*Hamburg Results Summary*****				
Sample Location*				
Immersion Time**				
Max Rut Depth at 2,500 passes (mm)***				
Max Rut Depth at 5,000 passes (mm)				
Max Rut Depth at 7,500 passes (mm)				
Max Rut Depth at 10,000 passes (mm)				
Max Rut Depth at 15,000 passes (mm)				
Max Rut Depth at 20,000 passes (mm)				

* LB = Left Back, LF = Left Front, RB = Right Back, RF = Right Front

** = Time between the specimens being covered with water and the test starting - Includes the required 45 minute conditioning period at 50 degrees C

*** = If your data collection does not have the rut depth at a particular interval, you may interpolate between the two surrounding values

**** = In addition to the results summary below, please send the raw rut depth versus cycles to failure

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NCAT Round Robin – Data Analysis

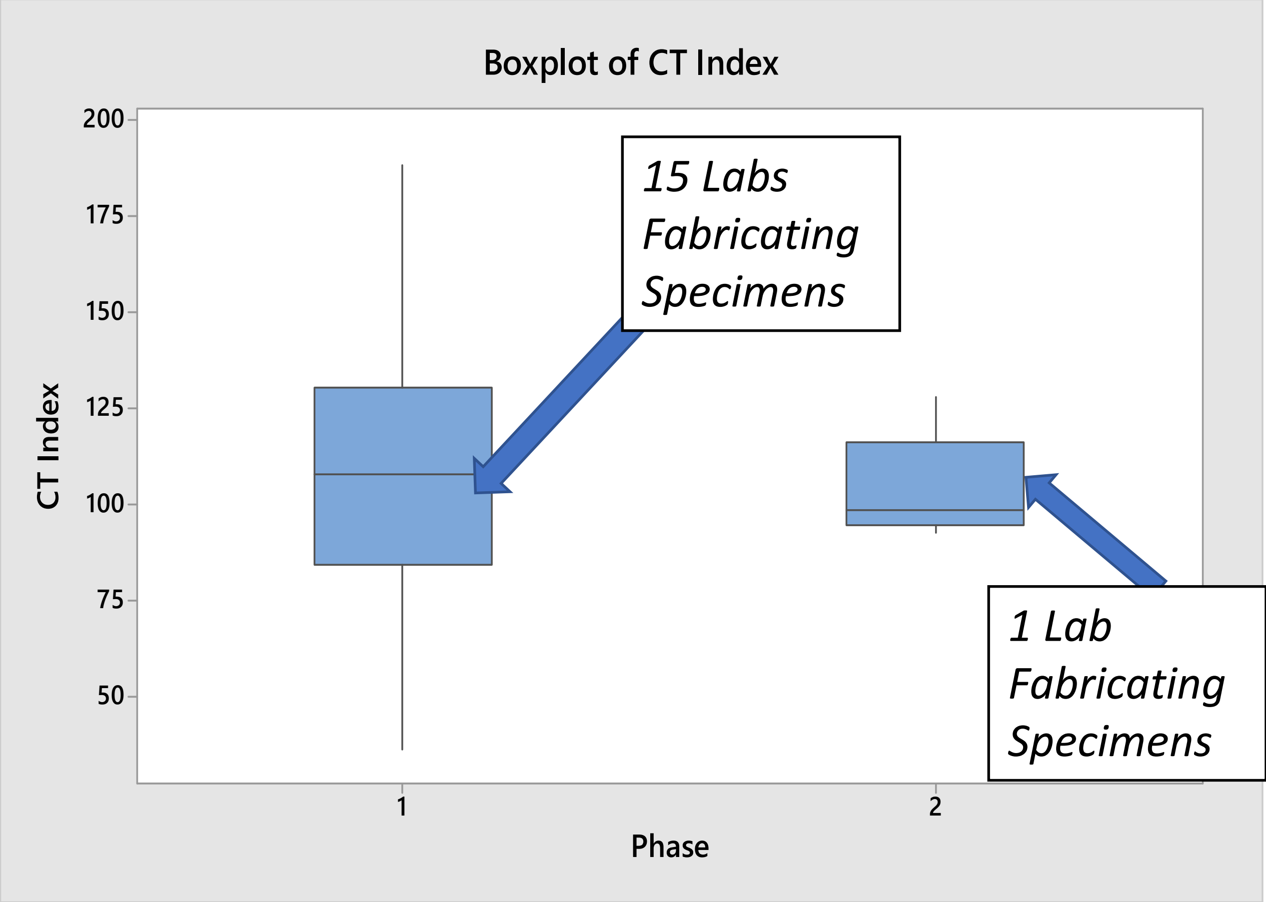
- Populate Database
  - Data quality inspection
  - ASTM E 178 – Outlier Evaluation
- Descriptive Statistics
- Boxplot Analysis
- ASTM E691 Variability Analysis
  - Repeatability (Within-Lab)
  - Reproducibility (Between-Lab)

NCAT Round Robin – Example Summary Report

Lab ID	*N*	*Air Voids (%)*	*Peak Load (kN)*	*FE (J/m²)*	*ITS (kPa)*	*CT Index*			*z-score (Average CT Index)*
		Average	*Average*	*Average*	*Average*	*Average*	*St Dev.*	*CV (%)*	
1	5	6.9	20.4	12,580	1,400	96.8	15.4	15.9	-0.428
2	5	7.1	16.8	11,297	1,149	110.2	11.1	10.1	0.190
3	5	7.0	21.2	11,629	1,456	62.0	15.2	24.5	-2.033
4	5	7.1	16.8	11,633	1,148	131.4	9.4	7.1	1.168
5	6	7.3	20.4	13,388	1,393	114.3	15.2	13.3	0.383
…	…	…	…	…	…	…	…	…	…

NCAT Round Robin – IDEAL-CT ASTM E691 Variability Estimates

Round Robin Year	Number of Labs	Mean CT_{Index}	Within-Lab CV (%)	Between-Lab CV (%)
2019 (Phase I)	15	111.1	19.5	35.3
2019 (Phase II)	14	103.7	18.8	20.2
2022	46	106.0	20.5	30.2



NCAT Round Robin – Hamburg ASTM E691 Variability Estimates

Round Robin Year	Number of Labs	HWTT Wheel Passes	Mean Rut Depth (mm)	Within-Lab CV (%)	Between-Lab CV (%)
2019	29	10,000	2.91	9.0	21.1
2022	38	10,000	2.87	10.4	29.5
2019	29	20,000	3.53	9.4	25.9
2022	38	20,000	3.49	9.5	31.1

- Limitation – Mixture with low rutting and no stripping in both studies

NCAT Round Robin – Rapid Rutting ASTM E691 Variability Estimates

HT-IDT

Round Robin Year	Number of Labs	Mean HT-IDT ITS (psi)	Within-Lab CV (%)	Between-Lab CV (%)
2022	16	31.4	8.3	14.6

IDEAL-RT

Round Robin Year	Number of Labs	Mean RT Index	Within-Lab CV (%)	Between-Lab CV (%)
2022	13	105.9	7.9	24.3*

- Note – RT between-lab variability driven higher by one lab

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NCAT Round Robin – What have we learned?

- Well written instructions and data forms go a long way
- Specimen preparation is a main driver of our variability in these tests
- A better understanding of variability for commonly used mixture performance tests
- Valuable feedback from participants

NCAT Round Robin – What can we continue to learn?

- Helping labs improve their proficiency and understanding of mixture performance tests
- Improved understanding of test variability and helping develop standardized precision statements
  - Impact of material diversity
- Planning underway for next round robin
  - Anticipate sampling mix summer 2024

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Why is Specimen Fabrication so Important?

- Specimen Preparation is the ‘foundation’ of the mixture performance testing house
  - You can’t build a good structure on a poor foundation
- NCAT experience is that much more can go wrong during specimen preparation than while running the test
  - Especially simpler tests – e.g. IDEAL-CT

Resources to Help – Specimen Fabrication

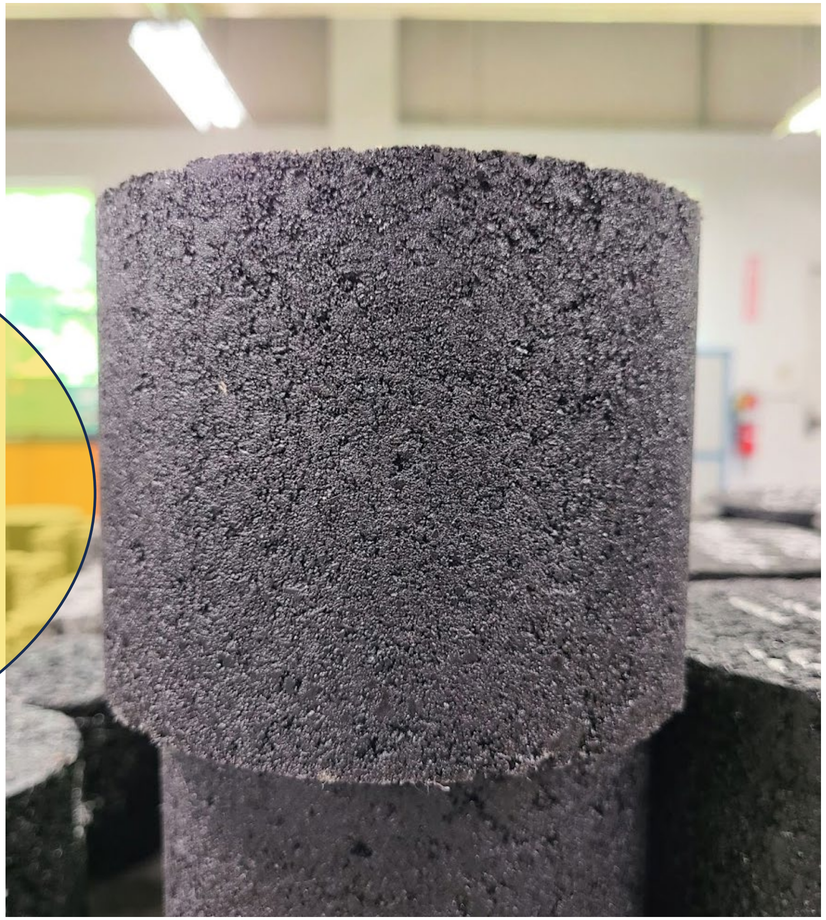
- Achieving a target specimen air voids when compacting specimens to a height while minimizing trial specimens
- Guidance on material handling and aging in the laboratory to help produce consistent specimens
  - Limiting Segregation
  - Limiting Excess Binder Oxidation

Achieving Target Specimen Air Voids

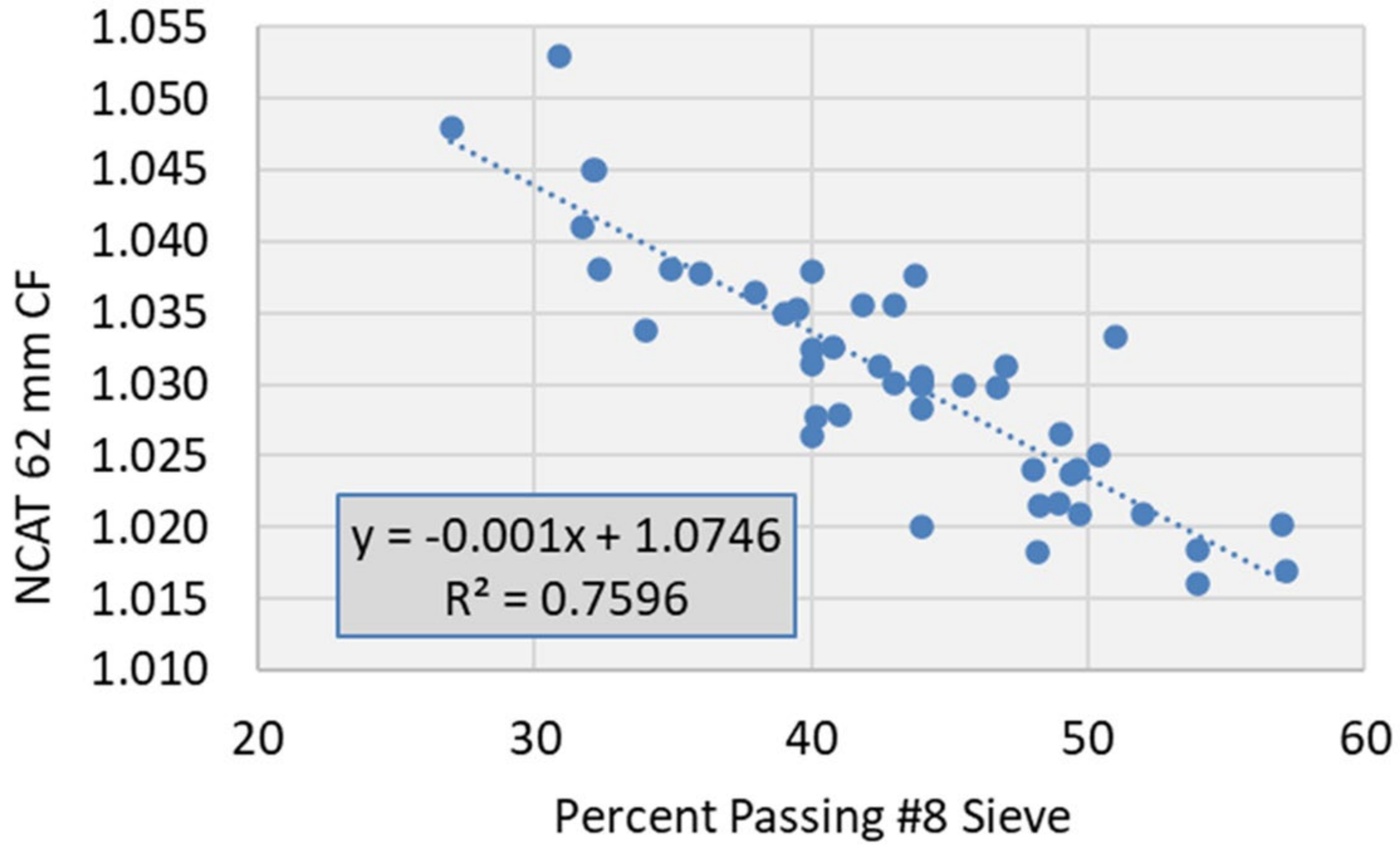
- *NCAT Trial Mix Weight Estimating Spreadsheet*
  - NAPA BMD Resource Guide --- ‘Tools’
  - *https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide/bmd-tools*
  - Uses
    - Estimate mass of mix in gyratory mold to achieve target air voids
    - Refine trial specimen mass
      - Either one or two trial specimens
  - Detailed Instructional Video

Achieving Target Specimen Air Voids

How much mass is needed to achieve equal air voids between these different mixtures?



Achieving Target Specimen Air Voids



Estimate Initial Trial Weight

Inputs

- G_{mm}
- Target Air Voids
- Percent Passing #8 Sieve

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NCAT Trial Weight Estimating Spreadsheet

Mix Gmm:	2.485
Specimen Height (mm):	62
Target Air Voids (%)	7
Passing #8 Sieve (%)	45
	CF
Estimated CF	1.029
User Input CF	
Estimated Weight (g):	2,461
Rounded Weight (g):	2,460

Input
Result

Typical Values		
Test	*Specimen Height (mm)*	*Target Air Voids (%)*
HB/IDEAL	62	7.0
APA	75	7.0
TSR	95	7.0
OT/IDT	125	7.5 - 8.0
I-FIT/DCT	160	7.5 - 8.0

Average Starting CF Values	
Height (mm)	*Average CF*
62	1.036
75	1.031
95	1.030
125	1.028
160	1.024

Refine Trial Weight

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Use this sheet after compacting 1 Trial Specimen

1 Trial Specimen

		Explanation
Mass of Trial Specimen (g) =	2460.0	Trial Specimen Dry Weight
Air Voids of Trial Specimen (%) =	7.3	Calculated Air Voids of Trial Specimen
Target Air Voids (%) =	7.0	Target Air Voids
Adjusted Trial Mass (g) =	2468	Adjusted Specimen Mass for Future Specimens

2 Trial Specimens

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Use this sheet after compacting 2 Trial Specimens

Target Air Voids(%) = 7.00

	Weight (g)	**Air Voids (%)**
Trail Specimen 1	2,480.5	6.7
Trail Specimen 2	2,460.2	7.3

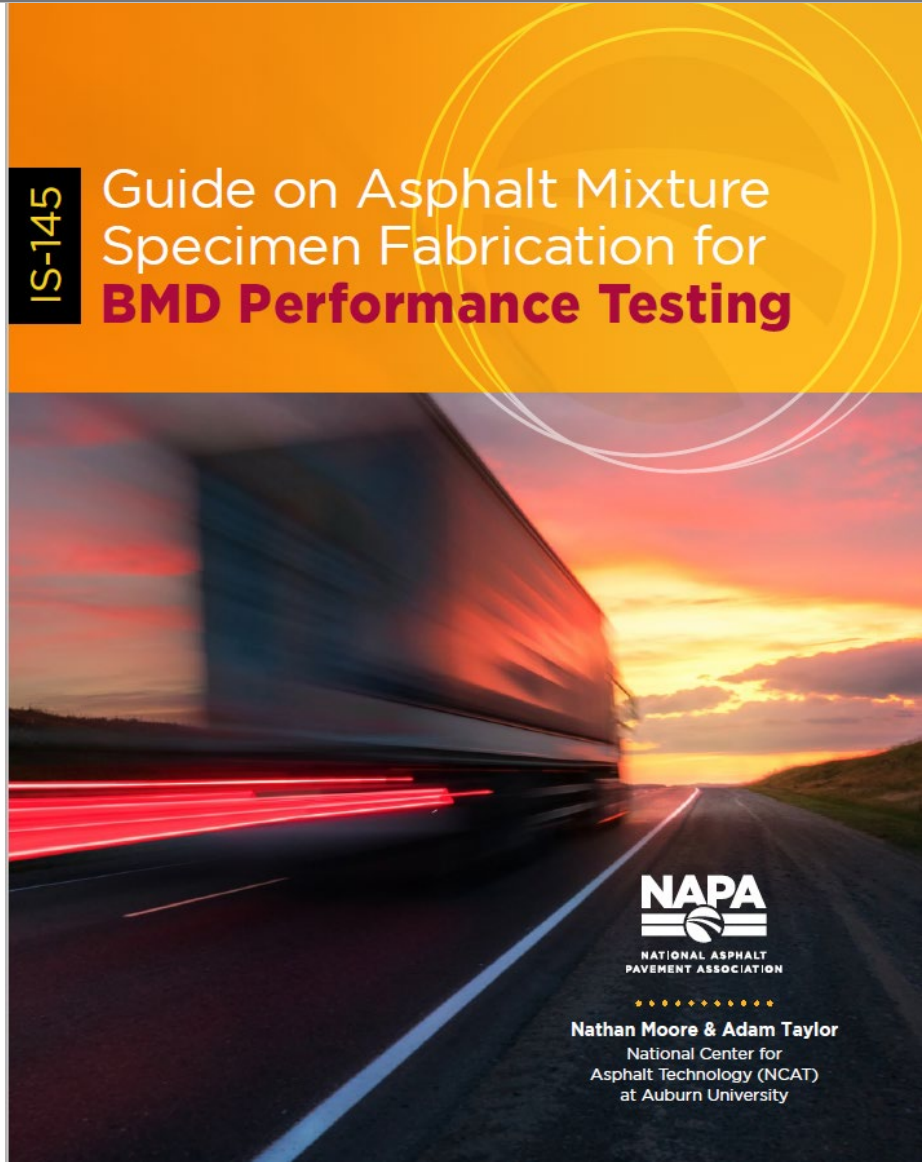
Instructions:
Input Trial Specimen Info In Green Cells
Rounded Target Weight in Orange Cell

Target Weight = 2,470 grams
Rounded Target Weight = 2,470 grams

BMD Specimen Preparation Guide

- NAPA IS-145
  - NAPA BMD Resource Guide
  - Training and Resources

  - *https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide/training-resources*



Specimen Preparation Videos

- NAPA BMD Resource Guide
  - Training and Resources
  - Quick Overview Instructional Videos (total ~16 minutes)
    - Aggregate Processing
    - Aggregate Batching
    - Mixture Heating and Mixing
    - Mixture Sampling, Re-heating, and Splitting
    - Mixture Aging and Compaction
  - Supplement to Detailed Information in the Specimen Preparation Guide

Lab Mix Best Practices

- Binder Heating
  - Minimal amount to do the job
  - Excessive aging will lower your cracking resistance
- Fractionating Aggregate
  - Avoiding Segregation
- Consistent RAP Heating Practices between labs
- Oven timers are a good investment
  - RAP and Binder
  - Long-term aging

Heating Asphalt Binder

- More time in oven = More oxidation
- Practice “First In, First Out” with binder
- Heat the minimum time for binder to reach target mixing temperature
- Don’t reheat the same binder more than twice
- Remove binder from ovens as soon as you are finished mixing
- Oven timers are your best friend

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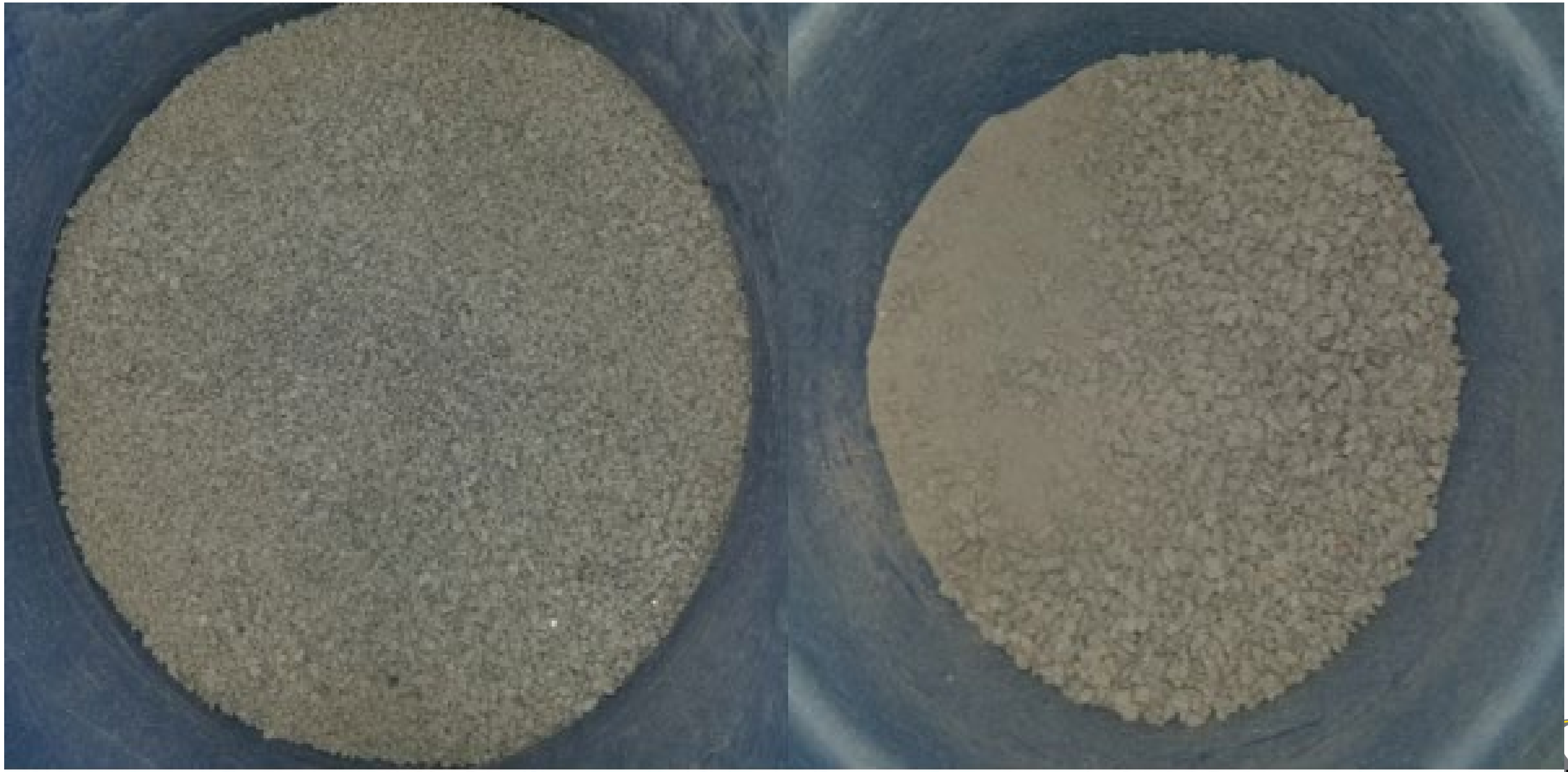
Why Fractionate Aggregates?



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How Much Should I Fractionate?

- <u>Answer</u>: Verify the Final Product is Acceptable
- Make one extra gradation specimen per mix
  - “Check Batch”
- Compare gradation to target aggregate gradation
  - Add fractionation sieves if necessary
  - General Rules of Thumb
    - <1.5% difference two sieves below NMAS
    - <1.0% on other sieves
    - <0.5% on dust

Sieve (mm)	Verification Gradation	Blend Gradation	Difference
25.0	100.0	100.0	0.0
19.0	100.0	100.0	0.0
12.5	100.0	99.9	0.0
9.5	97.5	97.5	0.0
4.75	76.8	76.2	-0.6
2.36	50.7	50.3	-0.4
1.18	34.8	34.7	0.0
0.6	25.6	25.6	0.0
0.3	17.6	17.5	-0.1
0.15	9.4	9.3	-0.2
0.075	5.9	5.7	-0.2

Batching

- Batch from a large representative sample using a flat-bottomed scoop
- Never batch directly from a bucket
  - Exception: Single Size Material

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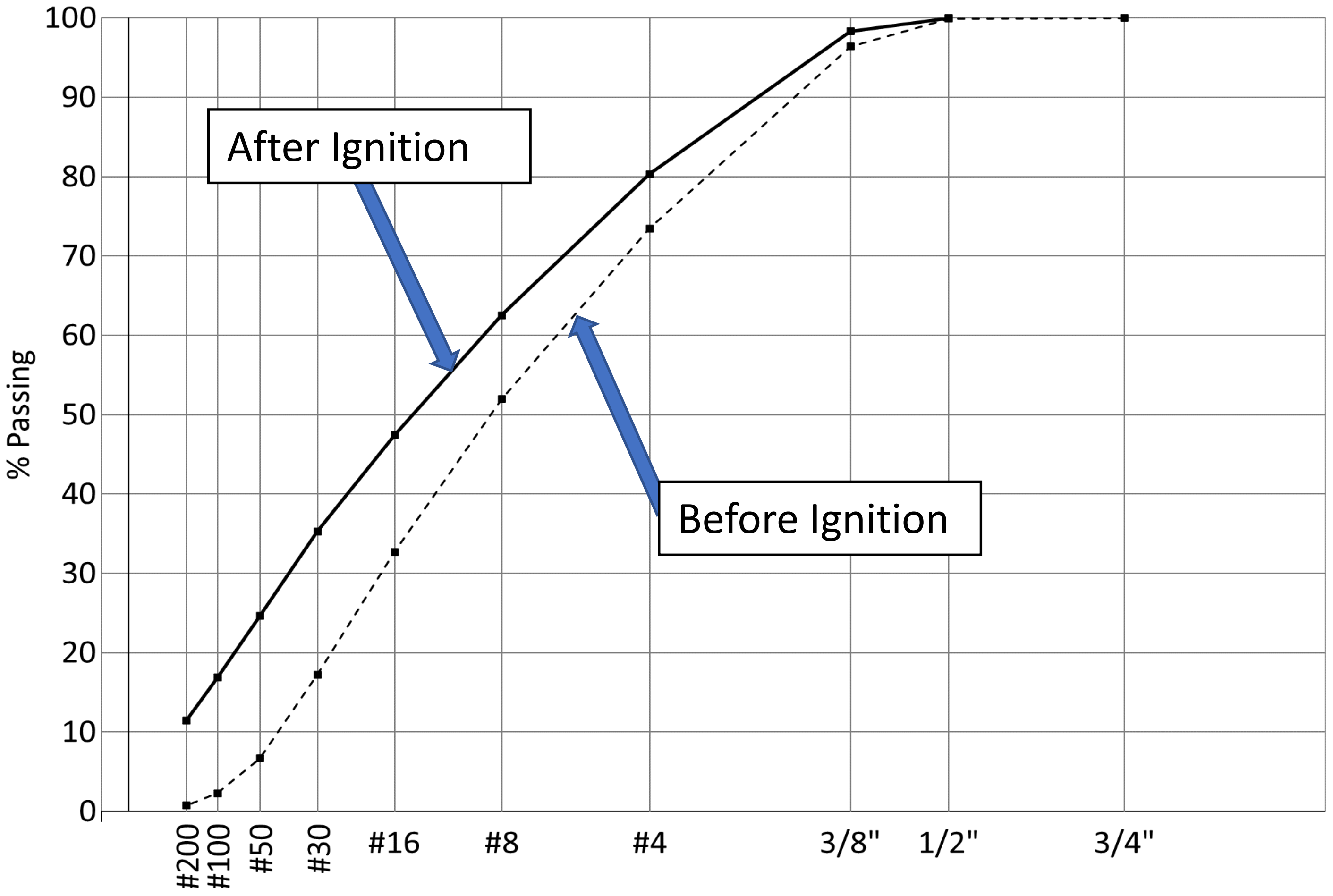
Fractionating RAP

- RAP Gradations are not the same before and after ignition/extraction!
  - Pre-ignition
    - Use for fractionation
  - Post-ignition
    - Use for design



Specimen Preparation – Plant Mix

- Blend multiple buckets/boxes of same mix when possible
  - Don’t sample the bare minimum
- Heat each bucket once
  - More re-heats = More oxidation
- Heat mix minimum time required
  - Thermometer in mix
- Limit Pans in the Oven!
  - Recommend maximum of 6

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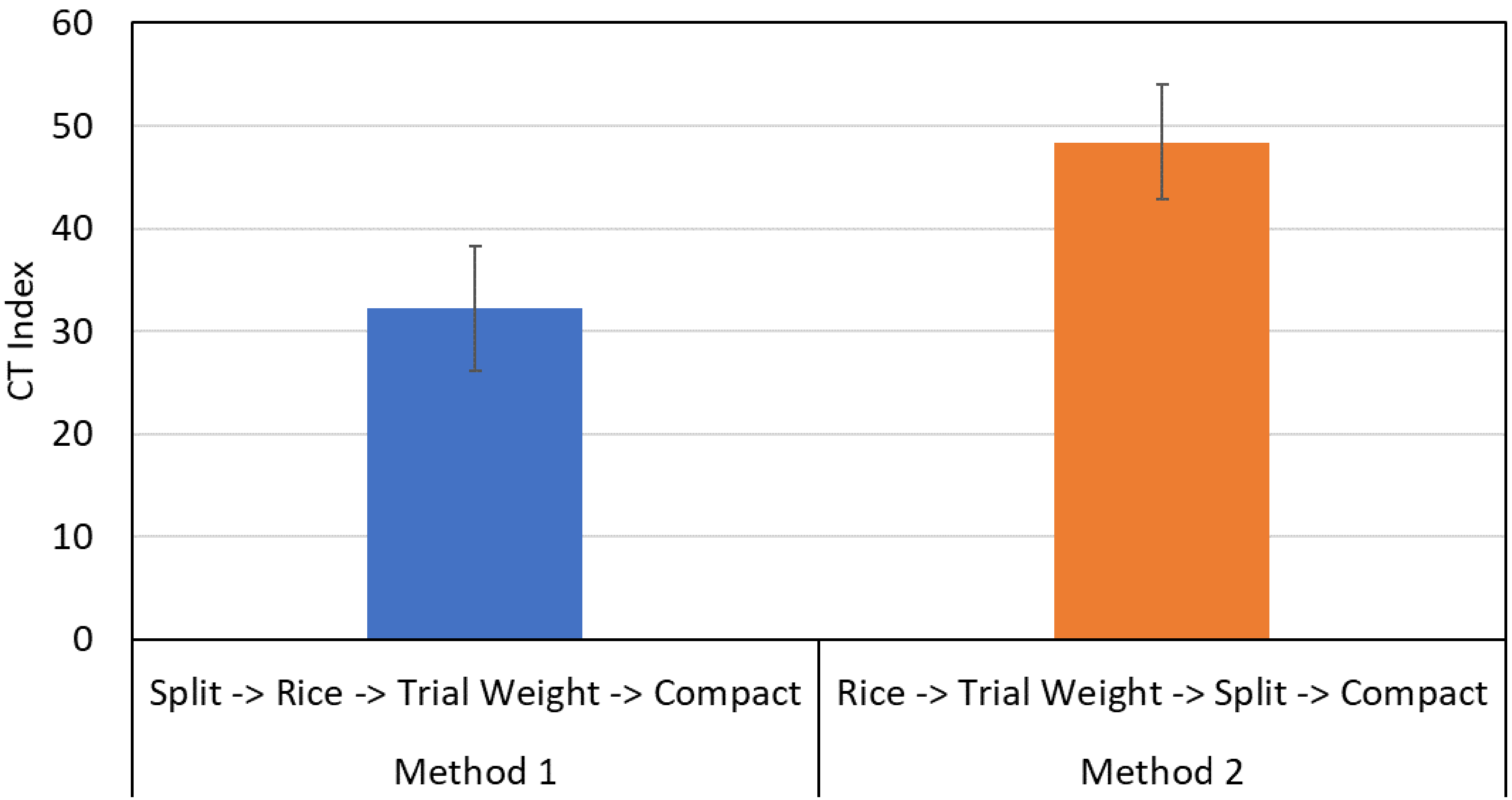
Specimen Preparation – Time in Oven

- Method 1 specimens in oven for ≈ 60 – 90 minutes longer
- Statistically different results



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Specimen Preparation - Segregation

Plant Mix – Avoiding Segregation

- Read AASHTO R47!
- Quartermaster
  - Blend multiple buckets or boxes
- Splitting Pan
  - Homogenize mix before splitting into individual pans

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Avoiding Mix Segregation

- Stir mix well in transfer device
- Add to gyratory mold in one pour without shaking or stopping

Specimen Fabrication – Plant Mix

- Bad Practices
  - Scoop the mix you need directly out of the bucket
  - Re-heating the bucket multiple times
  - Heating buckets overnight or more than half a day
  - Leaving pans of mix in the oven for excessive time
- Key Point
  - These practices lead to excessive segregation and binder oxidation – which flow directly into test results…

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Specimen Prep and Replication

- Do the job once – Do the job right
  - Combining production runs can create problems
  - Don’t make 4 specimens to get 4 specimens
    - Make an extra specimen
    - Variability increases between production runs
- Benefits will outweigh the costs
  - Recommend the following **minimums:**
    - IDEAL-CT = 5 specimens (easy to get 6)
    - HT-IDT = 3 specimens
    - IDEAL-RT = 3 specimens

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Equipment Study – IDEAL-CT

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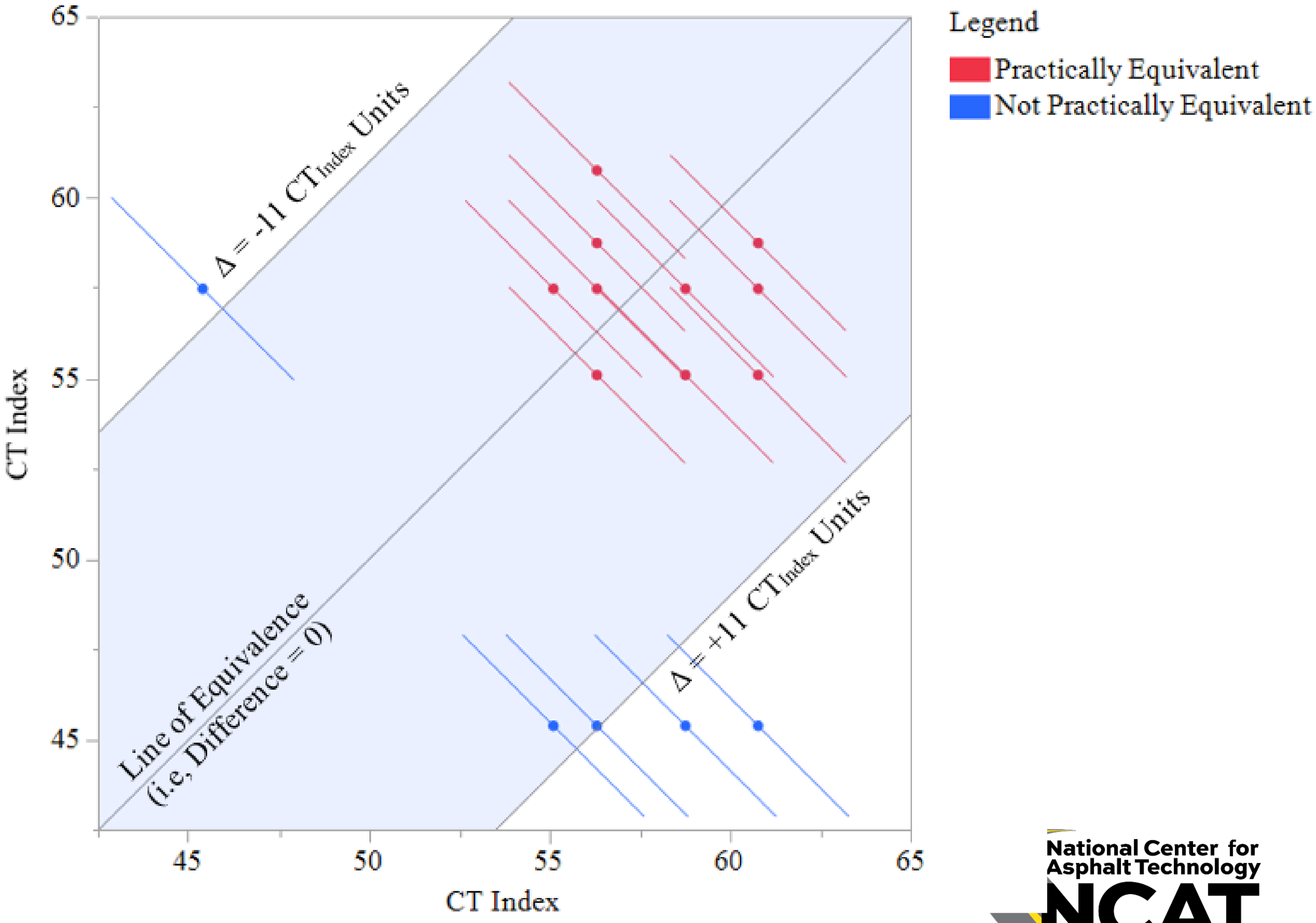
Equipment Study – IDEAL-CT

- NCAT Report 23-02
- 15 head-to-head comparisons
- All data for each comparison combined (N≈50)
- Equivalence limit set at 20% of the mean
- Only one device produced non-equivalent comparisons
  - Lead to improvements by the manufacturer



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What does it all mean?

- It takes a lot of work in the lab to make BMD ‘work’ the way that it should
  - Repetition and attention to detail
- Understand the typical variability of performance tests
- Start with great specimen preparation practices
- Test enough specimens and make extras the first time
- There are resources to help you

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Special Thanks

- A lot of great people at NCAT contributed to all of this work
  - Nathan Moore
  - Fan Yin
  - Jason Moore
  - Carolina Rodezno
  - Javed Monsegue
  - Madison Fillingim

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Thank you!
Questions?

MAPA Spring Training - February 7th, 2024

Adam J. Taylor, P.E.

National Center for Asphalt Technology (NCAT)

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Achieving Density

FOLEY EQUIPMENT CAT

FABICK CAT

Presented by: Bryan Downing, Caterpillar

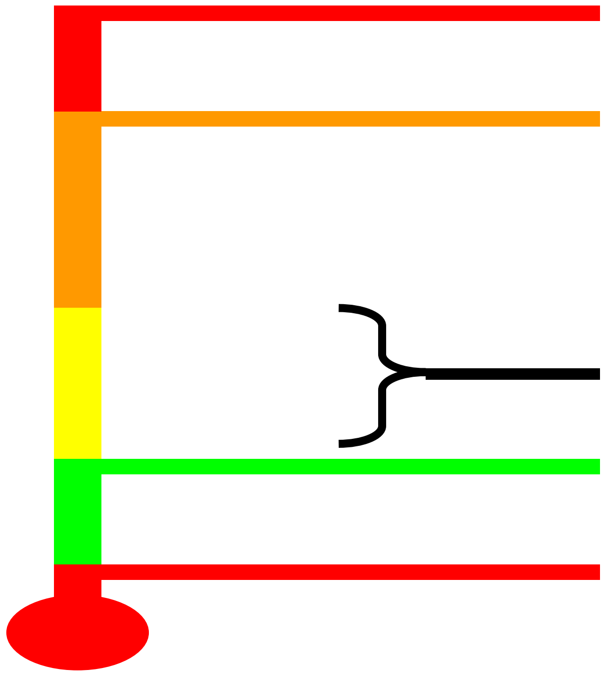
What is Compaction?

- Mechanical Process
- Removes specified amount of air voids
- Develops stone on stone contact
- Builds strength

Compact While the Mix is HOT

- **Stay close to paver – be safe!**
- **Limited time!**

Temperature is Critical



320 – 260F (160-130C) Breakdown rolling

260 – 220F (130-105C) Intermediate rolling

240 – 190F (115-90C) possible tender zone

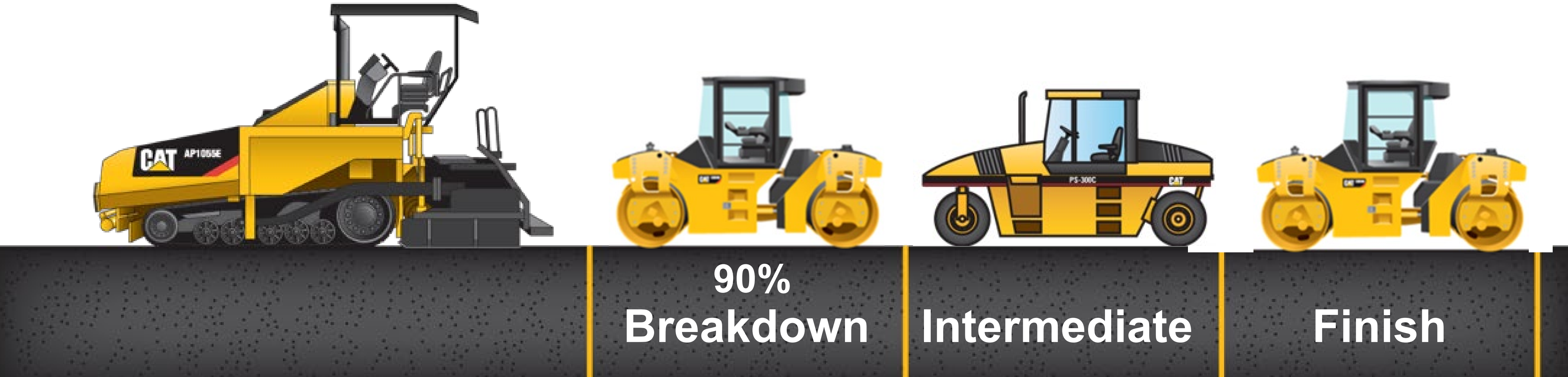
220 – 160F (105-70C) Finish rolling

160F (70C) – Stop rolling

Keep steel drums off the mix!!!

Phases of Compaction – “temp zones”

- **Breakdown – gets majority of density 90% or better**
- **Intermediate – gets final density**
- **Finish – cleans up/removes any roller marks, slight gain density**



Types of rollers

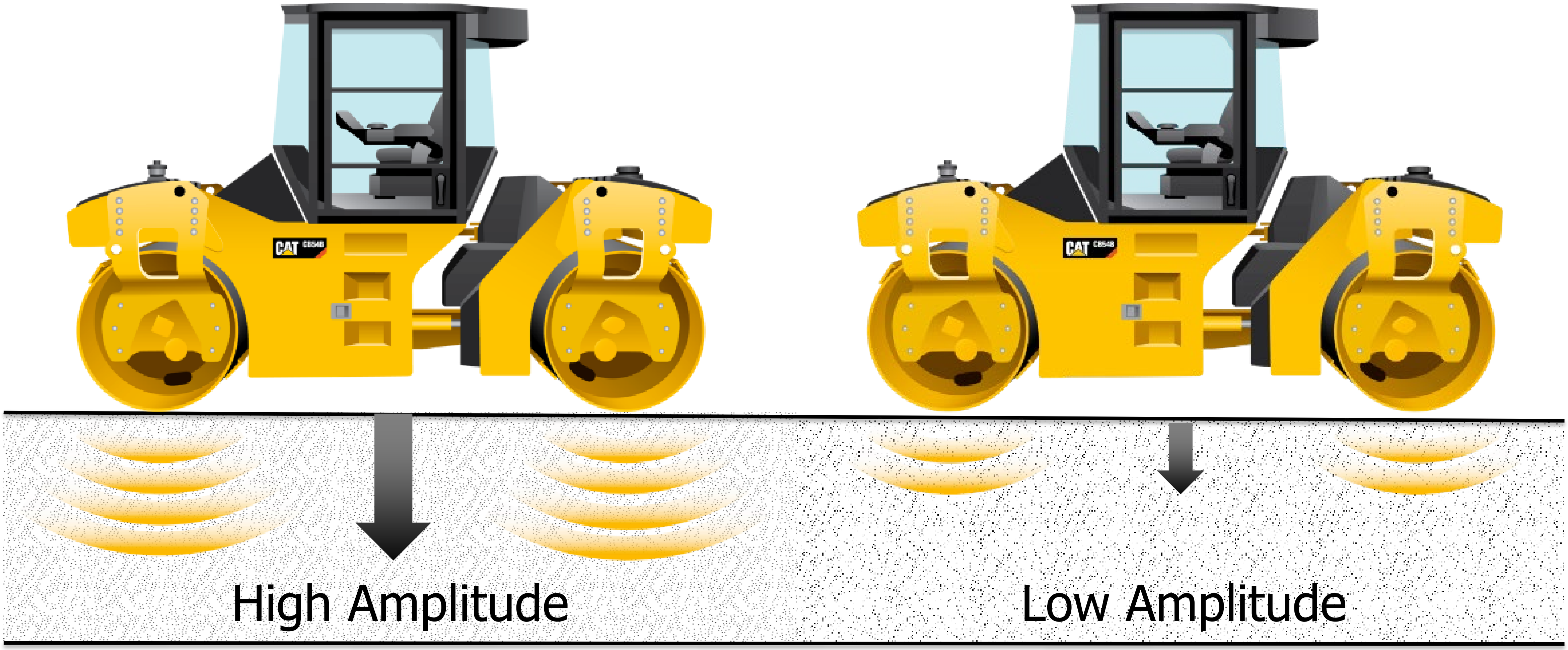
- **Static steel drum**
  - High PLI
- **Vibratory steel drum**
  - Amplitude, frequency
- **Oscillation**
- **Pneumatic**
  - Tire pressures, ballast weight
- **Combination**

Vibratory Steel Drum

- **Breakdown, intermediate and finish rolling**
- **Settings for amplitude and frequency**
- **Static mode for finish rolling**

Build density from the top down

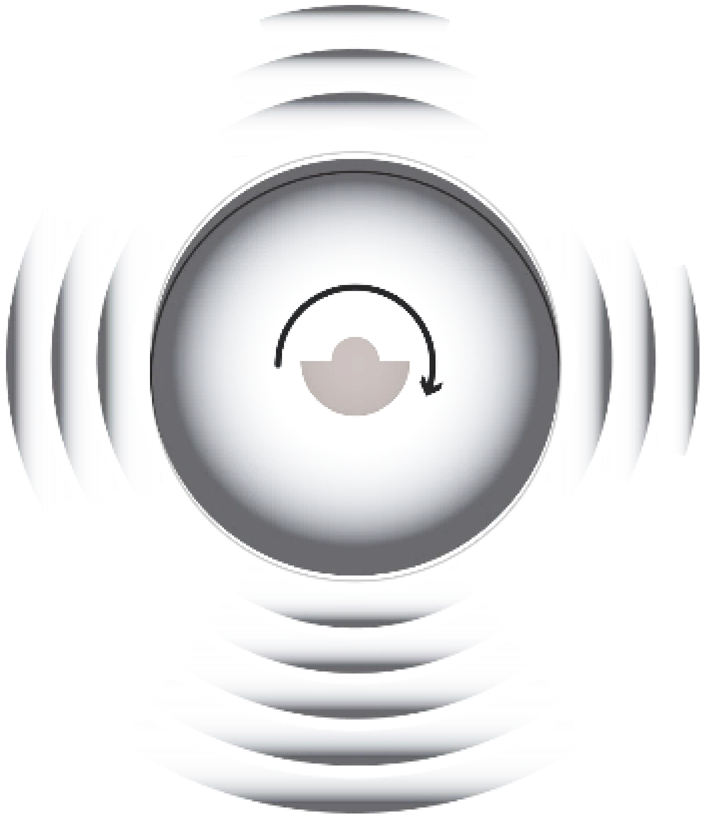
Amplitude = compactive effort



Amplitude Checklist

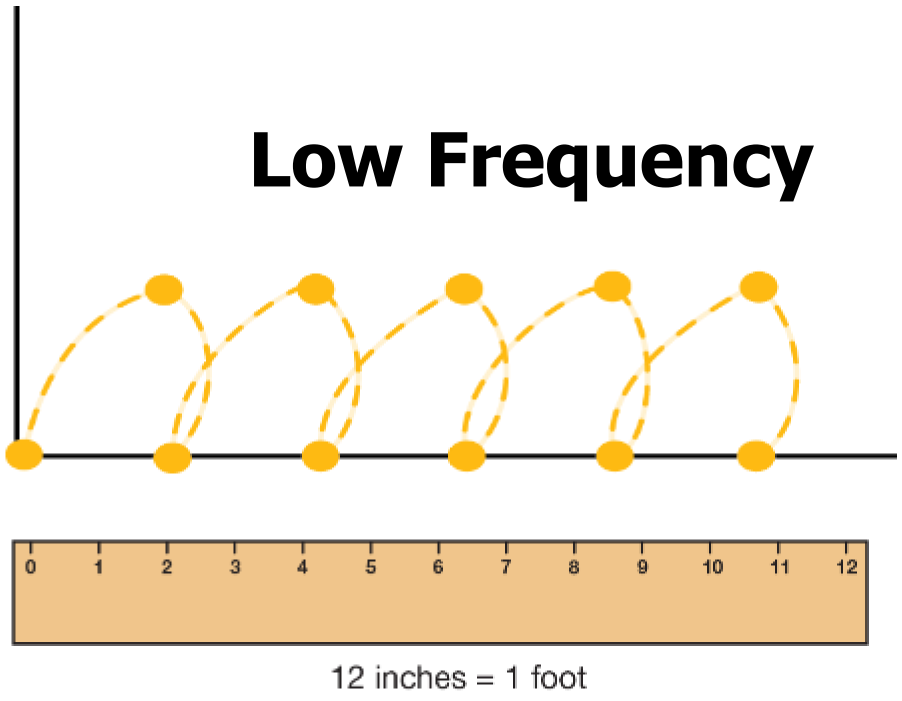
Factor	Lower Force 0.25 - 0.6 mm	Higher Force >0.6 mm
Layer Thickness	< 2.0 in (50mm)	> 2.0 in (50mm)
Base Support	Rigid	Flexible
Binder Viscosity	Low (unmodified)	High (modified)
Aggregate Shape	Rounded	Angular
Ambient Temperature	High	Low
Base Temperature	High	Low

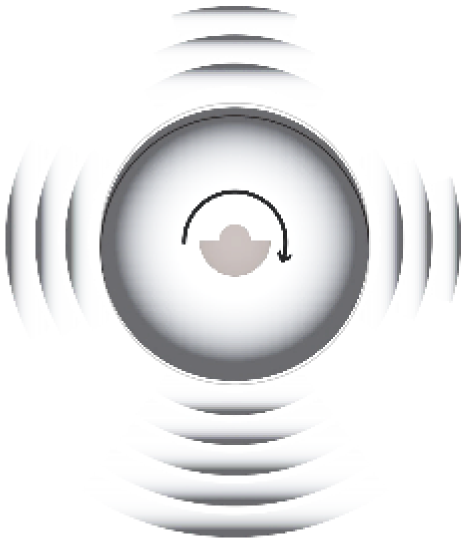
Frequency

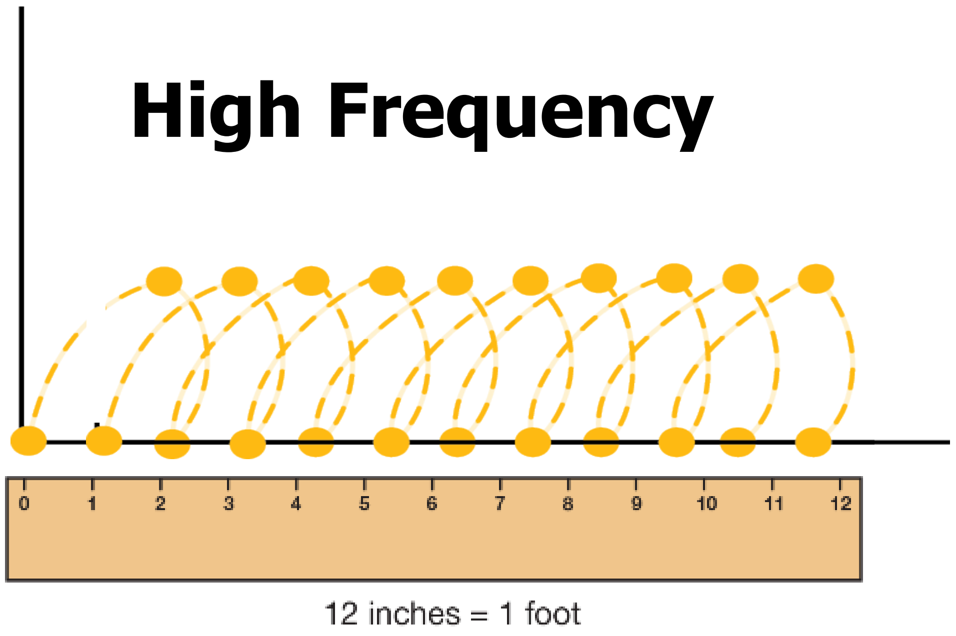


RPM of eccentric weight or shaft in drum

Impacts per foot (IPF)







6 ipf

12 ipf

Roller speed is constant

Impacts per foot, Frequency & Roller Speed

10 to 14

Impacts per foot

10 – 14 impacts per foot

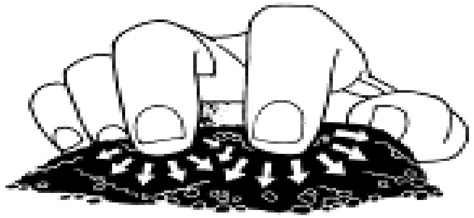
Higher Amplitude ≈ Lower Frequency

Amplitude	Frequency
0.86 mm	2520 vpm
0.73 mm	2520 vpm
0.44 mm	3800 vpm
0.33 mm	3800 vpm

- **When changing to high amplitude, frequency will be lower**
- **What does this mean?**

Pneumatic Rollers

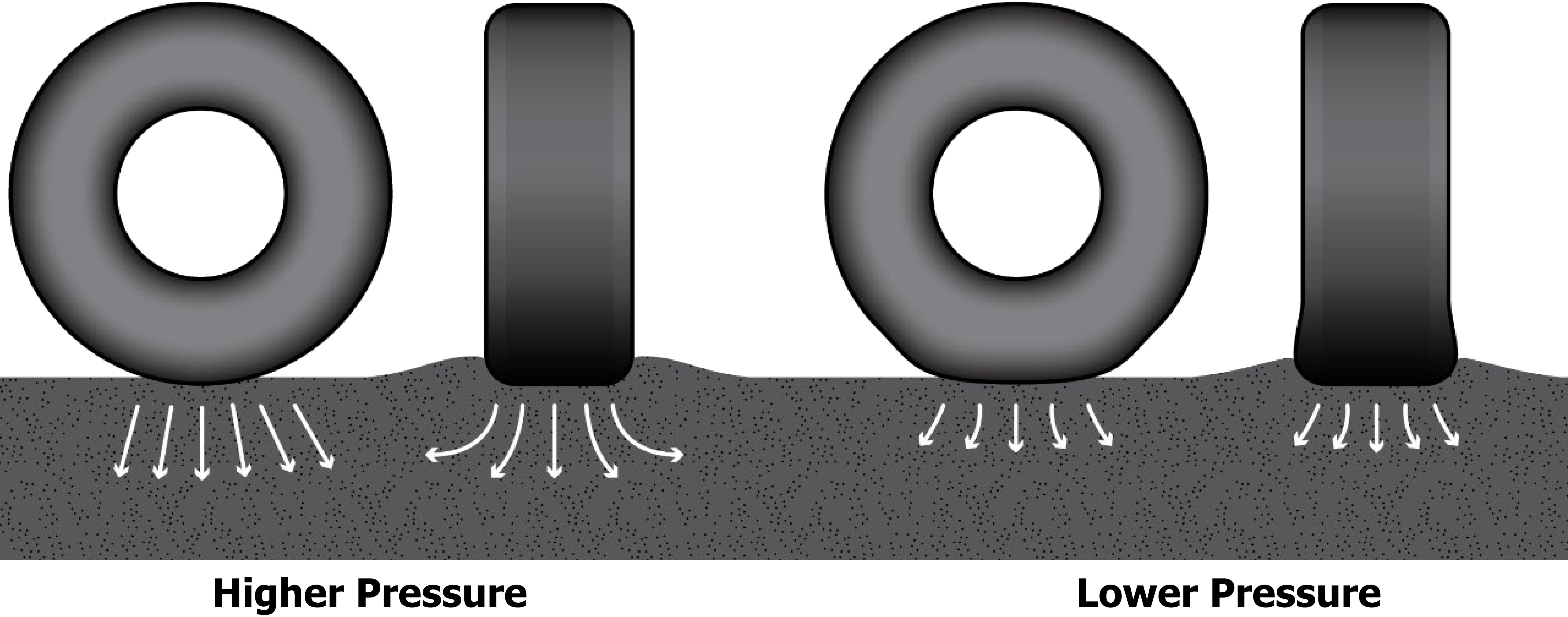
- **Most commonly used for intermediate rolling**
- **Knead the mix**



- **Close up surface voids and tension cracks**
- **Efficient building density**

Build density from the bottom up

Adjusting Tire Pressures & Ballast Weight



Getting More Density

- Add passes
- Increase amplitude
- Increase tire pressure or ballast
- Change rollers
- Add rollers
- Work closer to the paver
- Lower working speed

5-Steps to Establishing a Rolling Pattern

1. Schedule a full-time <u>QC technician</u> to do a Test Strip
2. Set a paver speed to get required tonnage per shift
3. Target 90% density after the <u>breakdown</u> roller(s)
4. Perform Test strip
   - Determine <u>number</u> of passes required for <u>each</u> roller
   - Record the roller settings of Amplitude & Frequency
   - Know the Time Available for Compaction (PaveCool)
   - 10 impacts per foot for density & smoothness
   - Roller distance behind the paver and each other
5. Check, check, check! and adapt as conditions change

Establish an effective rolling pattern

1. Based production and density
2. Equipment Selection

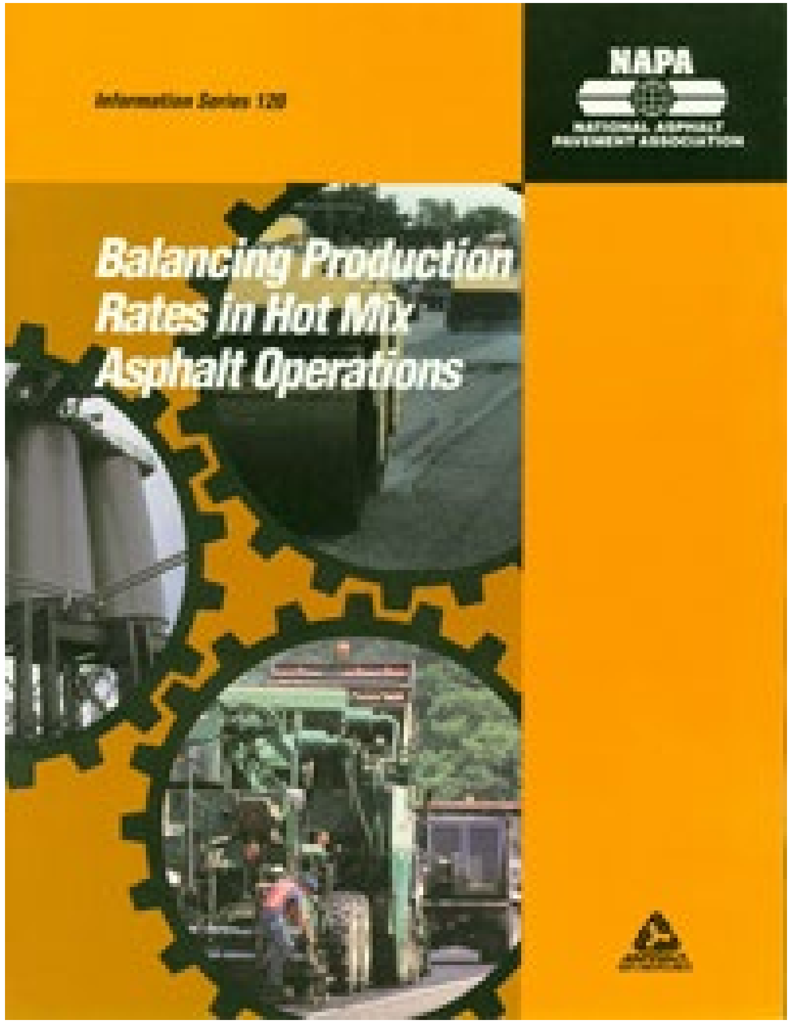
↕ Decision Point

3. Balance paver & roller speed

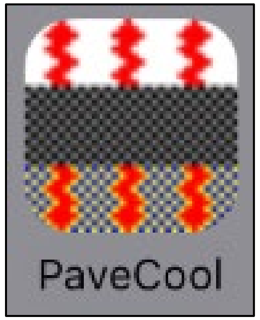
↕ Decision Point

4. Test Strip
5. Verify during production

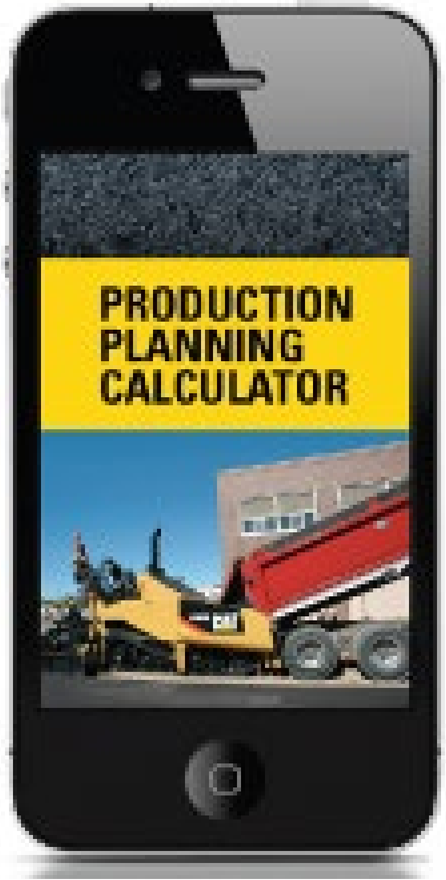
Planning ≈ 20 minutes



Pre- paving planning
- Tons per day
- Number of trucks needed
- Paver speed
- Roller speed
- Rolling Pattern



Tools available
- NAPA IS-120
- Paving Production Calculator App
- PaveCool App



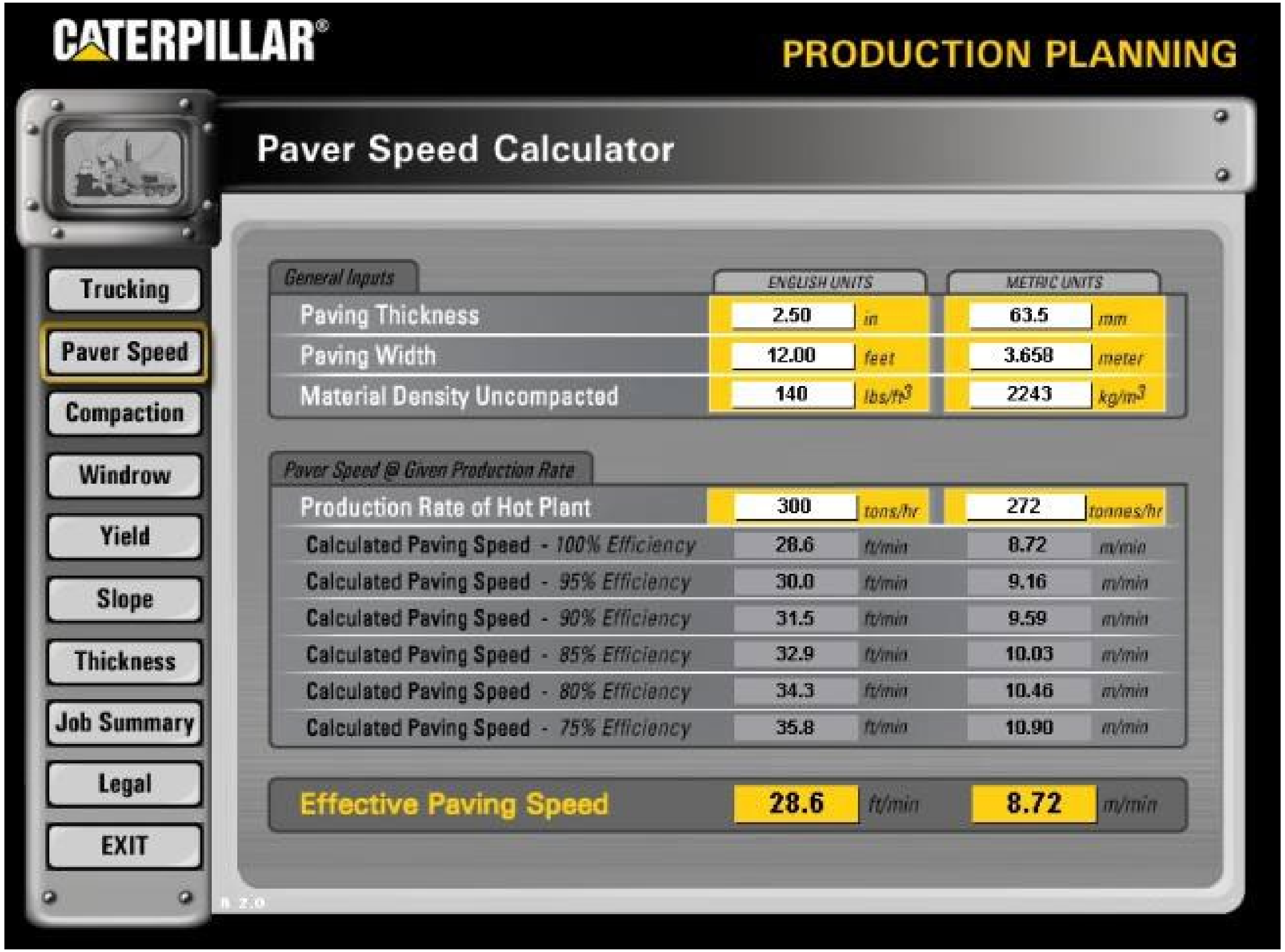
Example: Overlay Job

- Bid 2,500 tons/day (300 tph plant)
- 8-hr paving window
- End dumping (18-ton)
- 12-ft wide, unconfined edges
- 2-inch overlay
- 12.5mm polymer-modified mix
- Autumn < 70°F
- Given 3 rollers
  - 84” steel vibratory (Cat CB64)
  - 79” steel vibratory (Cat CB54XW)
  - 82” pneumatic (Cat CW34)

Step 1: Call to schedule a QC Person

1. TMD of the mix
2. Nuke gauge
3. Coring rig
4. Infrared thermometer
5. List of rollers
6. Know amp & freq settings
7. Notepad
8. Lunch

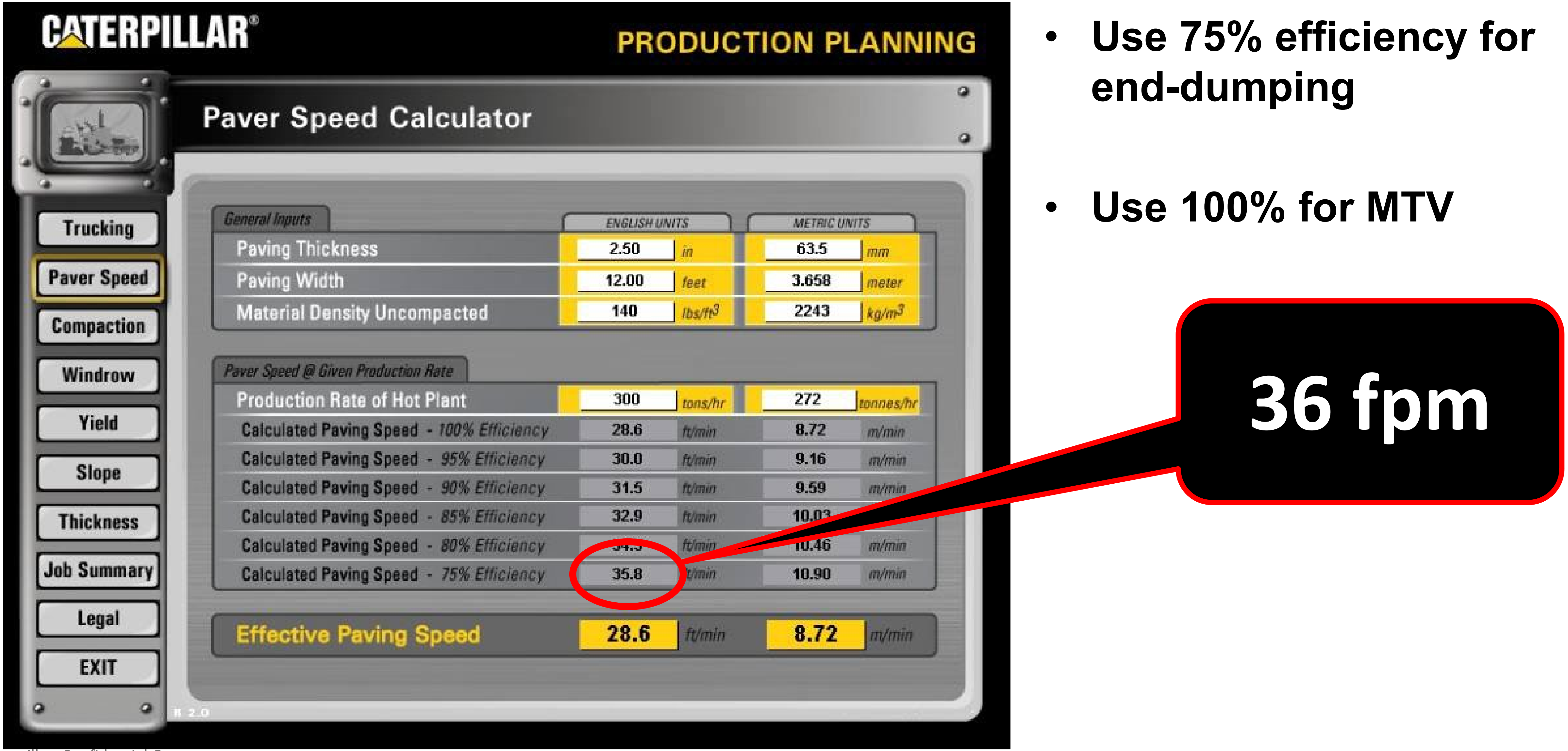
Step 2: Paver Speed



Use Paving Production Calculator or use NAPA IS-120 Worksheets

1. **Plant tph & silo capacity**
2. **Paving window**
3. **Average truck capacity**
4. **Truck cycle time**
5. **Mat thickness (loose)**
6. **Mat width**
7. **Loose mix density**

Step 2: Paver speed = 36 fpm



- Use 75% efficiency for end-dumping
- Use 100% for MTV

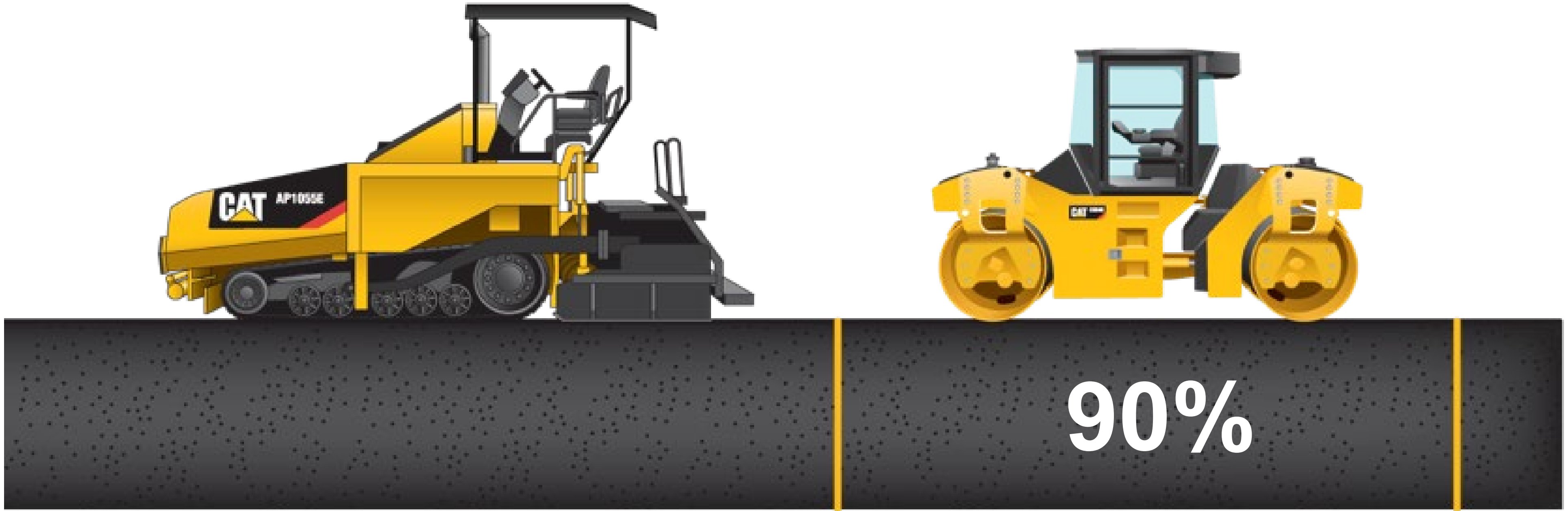
Paver Speed, trucking & plant is balanced

Continuous paving at 36 fpm on this job will deliver 2,500 tons over 8 hours

Step 3: Density target for breakdown

- **Target for final density is 94%**
- **Goal for <u>breakdown compaction</u> is 95% of final target density**

$0.95 \times 94\% \approx 90\%$



Step 4: Test Strip

1. Number passes
2. Amplitude & Frequency
3. 10 impacts per foot
4. Time Available for Compaction
5. Roller distance behind the paver

Choose Amplitude

Versa Vibe™ Vibratory System

CB64

Frequency: 42 Hz (2,520 vpm)

Nominal Amplitude	CB54		CB54 XW		CB64	
High	0.86 mm	0.034 in	0.78 mm	0.031 in	0.67 mm	0.026 in
Low	0.73 mm	0.029 in	0.66 mm	0.026 in	0.57 mm	0.022 in
Centrifugal Force Per Drum						
High	88.8 kN	19,980 lb	88.8 kN	19,980 lb	88.8 kN	19,980 lb
Low	75.4 kN	16,965 lb	75.4 kN	16,965 lb	75.4 kN	16,965 lb

Frequency: 63.3 Hz (3,800 vpm)

Nominal Amplitude						
High	0.44 mm	0.017 in	0.40 mm	0.016 in	0.34 mm	0.013 in
Low	0.33 mm	0.013 in	0.30 mm	0.012 in	0.26 mm	0.010 in
Centrifugal Force Per Drum						
High	103.3 kN	23,243 lb	103.3 kN	23,243 lb	103.3 kN	23,243 lb
Low	77.5 kN	17,438 lb	77.5 kN	17,438 lb	77.5 kN	17,438 lb

Choose Frequency

Versa Vibe™ Vibratory System

CB64

Frequency: 42 Hz (2,520 vpm)

Nominal Amplitude	CB54		CB54 XW		CB64	
High	0.86 mm	0.034 in	0.78 mm	0.031 in	0.67 mm	0.026 in
Low	0.73 mm	0.029 in	0.66 mm	0.026 in	0.57 mm	0.022 in
Centrifugal Force Per Drum						
High	88.8 kN	19,980 lb	88.8 kN	19,980 lb	88.8 kN	19,980 lb
Low	75.4 kN	16,965 lb	75.4 kN	16,965 lb	75.4 kN	16,965 lb

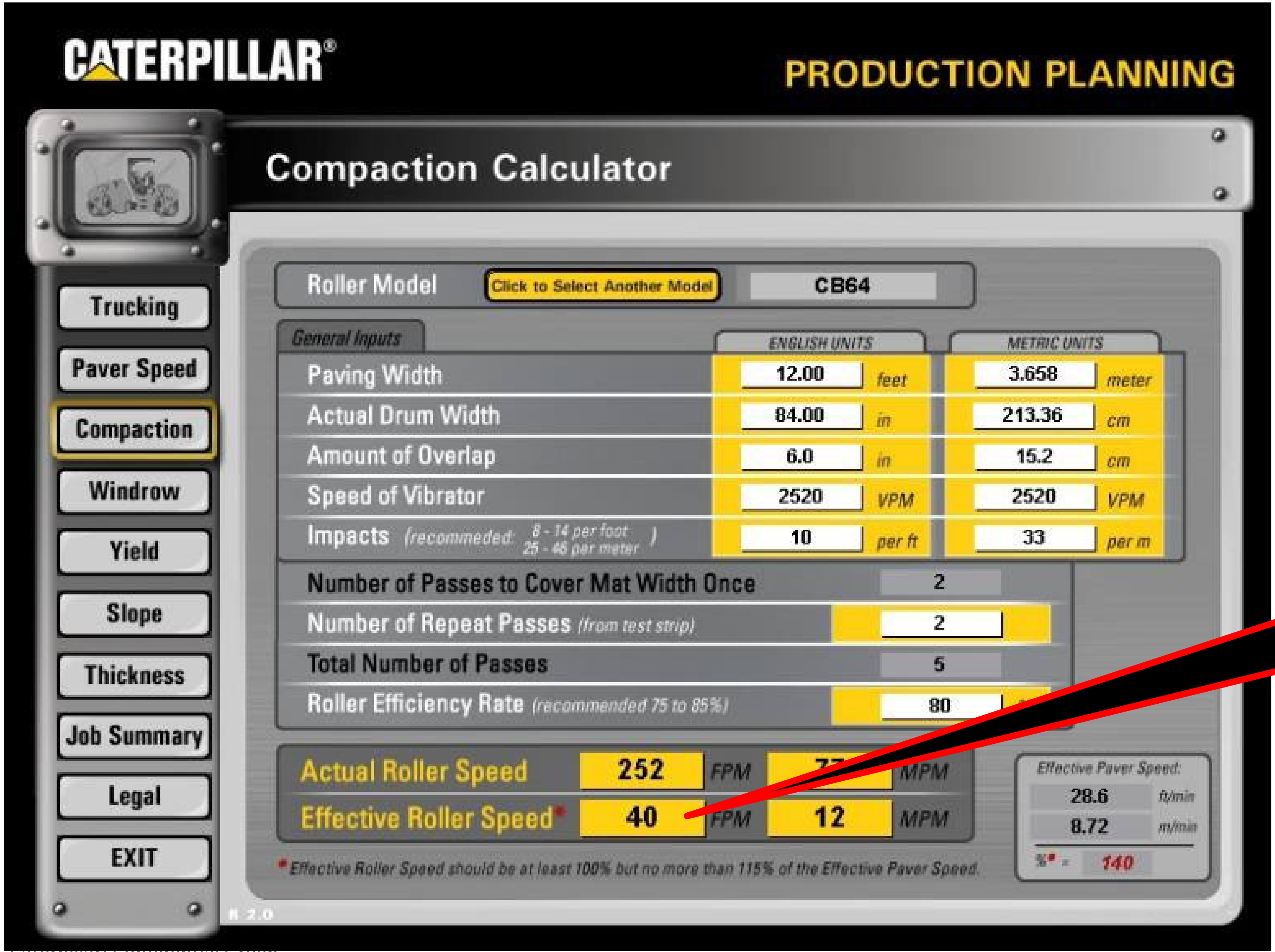
Frequency: 63.3 Hz (3,800 vpm)

Nominal Amplitude						
High	0.44 mm	0.017 in	0.40 mm	0.016 in	0.34 mm	0.013 in
Low	0.33 mm	0.013 in	0.30 mm	0.012 in	0.26 mm	0.010 in
Centrifugal Force Per Drum						
High	103.3 kN	23,243 lb	103.3 kN	23,243 lb	103.3 kN	23,243 lb
Low	77.5 kN	17,438 lb	77.5 kN	17,438 lb	77.5 kN	17,438 lb

Number passes Breakdown CB64

		Breakdown CB64	Intermediate	Finish CB54-XW
	→	12-ton	14-ton tire	10-ton
Settings		Amp 0.022" Freq 2,520	90 psi	
1st Pass	Temp	280F (138C)		
	Density	88%		
2nd Pass	Temp	260 (127)		
	Density	90%		
3rd Pass	Temp	252 (122)		
	Density	91%		
4th Pass	Temp			
	Density			

"Effective" Roller Speed



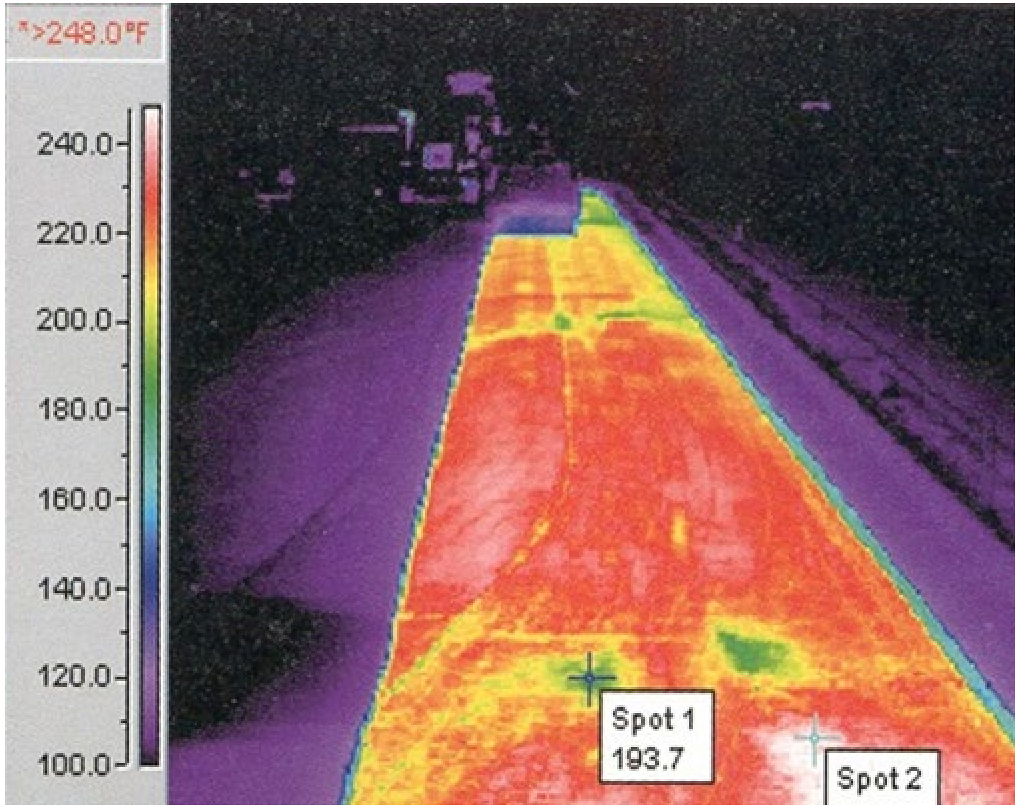
- Drum width
- Number of passes

40 fpm

40 fpm > 36 fpm

What else do I have to watch?

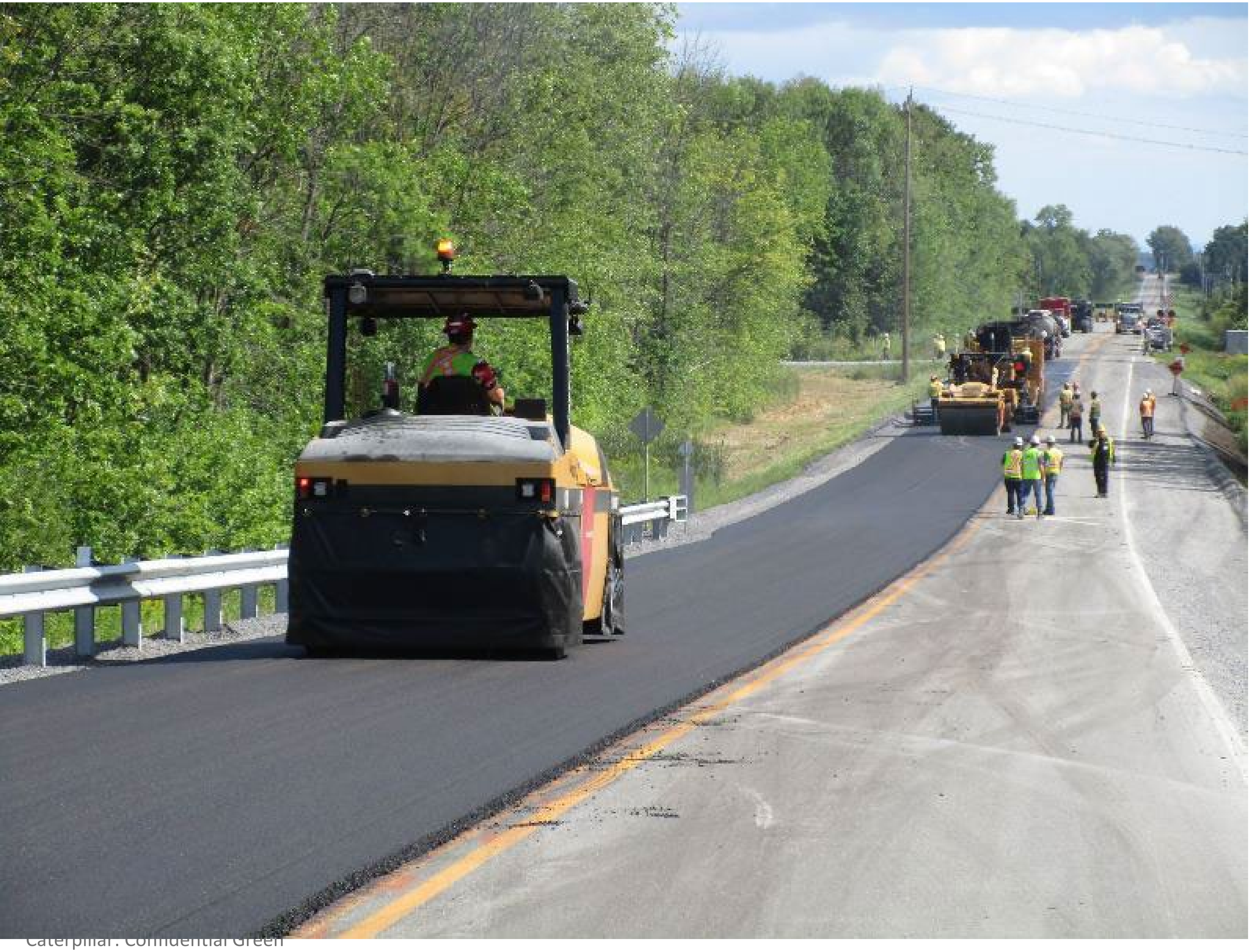
Temperature



Temperature

Temperature

How far back from the Paver should I be ?



- Roller distance behind the paver depends on how fast the mat is cooling down!
- Temperature, temperature, temperature!!!

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Step 4: Rolling Pattern Summarized

	Breakdown	Intermediate	Finish
%TMD	**90-92%**	90-94% ??	94%+ take out marks
			
Temp	**280 - 252˚F**	??	??
Coverage	**2** (5-pass pattern)	??	??
Settings	**High A, Low F**	90 psi	???
Distance	⟷ **120 ft (36m)**	⟷ ???	⟷ ???
Speed	**252 fpm (2.8 mph)**	???	???

Step 4: Repeat for all Rollers

- **Busy!!!**
- **Everyone's watching!**

Step 4: Final Rolling Pattern

	Breakdown	Intermediate	Finish
%TMD	**90-92%**	**92-94%**	**94%** + take out marks
			
Temp	**280-252˚F**	**252-230˚F**	**200-160˚F**
Coverage	**2** (5-pass pattern)	**3** (7-pass pattern)	**2** (1 vibe/1+ static)
Settings	**High A, Low F**	**90 psi**	**Low A, High F, static**
Distance	⟵⟶ **120 ft**	⟵⟶ **200 ft**	⟵⟶ **200 ft**
Speed	**252 fpm**	**300 fpm**	**350 fpm**

Step 5: Check, Check, Check

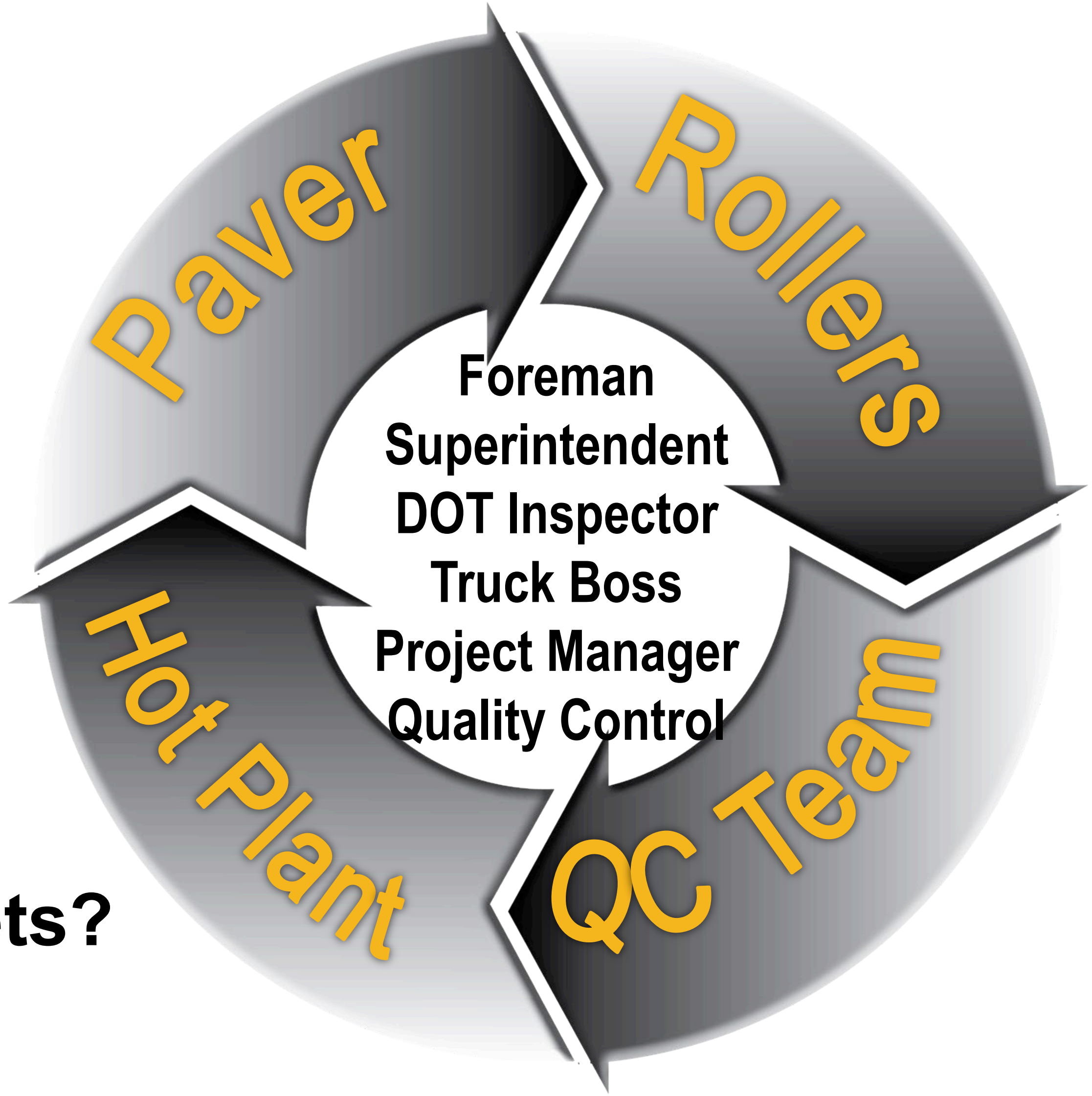
- **Be prepared to make changes if conditions change**
- **Let Foreman and operators know**

Each Project is Different

- **Each project requires analysis**
- **Meeting end result specifications requires planning and communication**

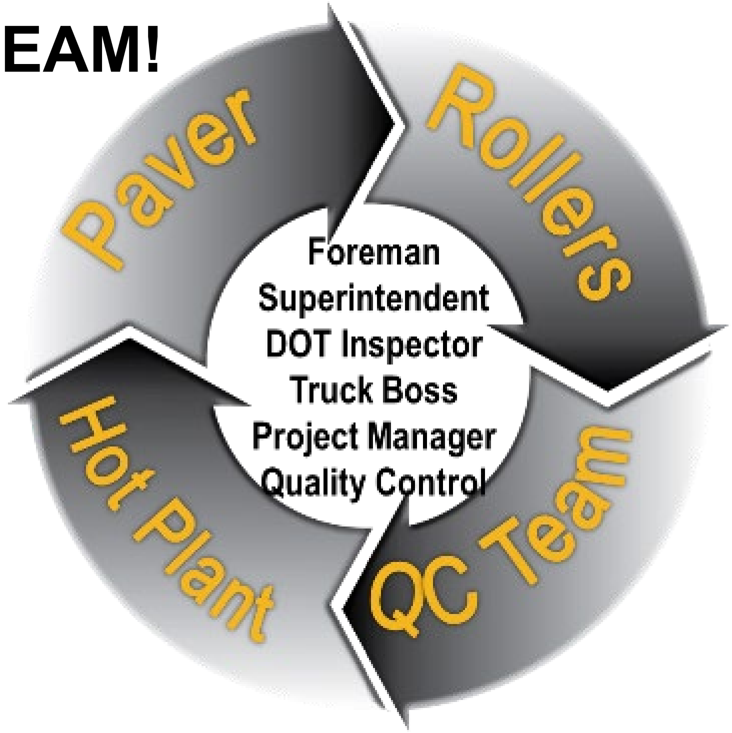
Who's responsibility is it?

- Paver Speed?
  - Paver operator?
- Truck spacing
  - Truck boss, Foreman?
- Roller Speed?
  - Roller operator?
  - Quality Control?
- Meeting Density & Smoothness targets?
  - Quality Control?



Plan for Excellent Compaction!

- Set paver speed
- Set target density
- Set roller speed to paver
- Do a Test Strip
- Check, check, check…
- Work as a TEAM!



Thank-you for your attention.

Paving by the Numbers

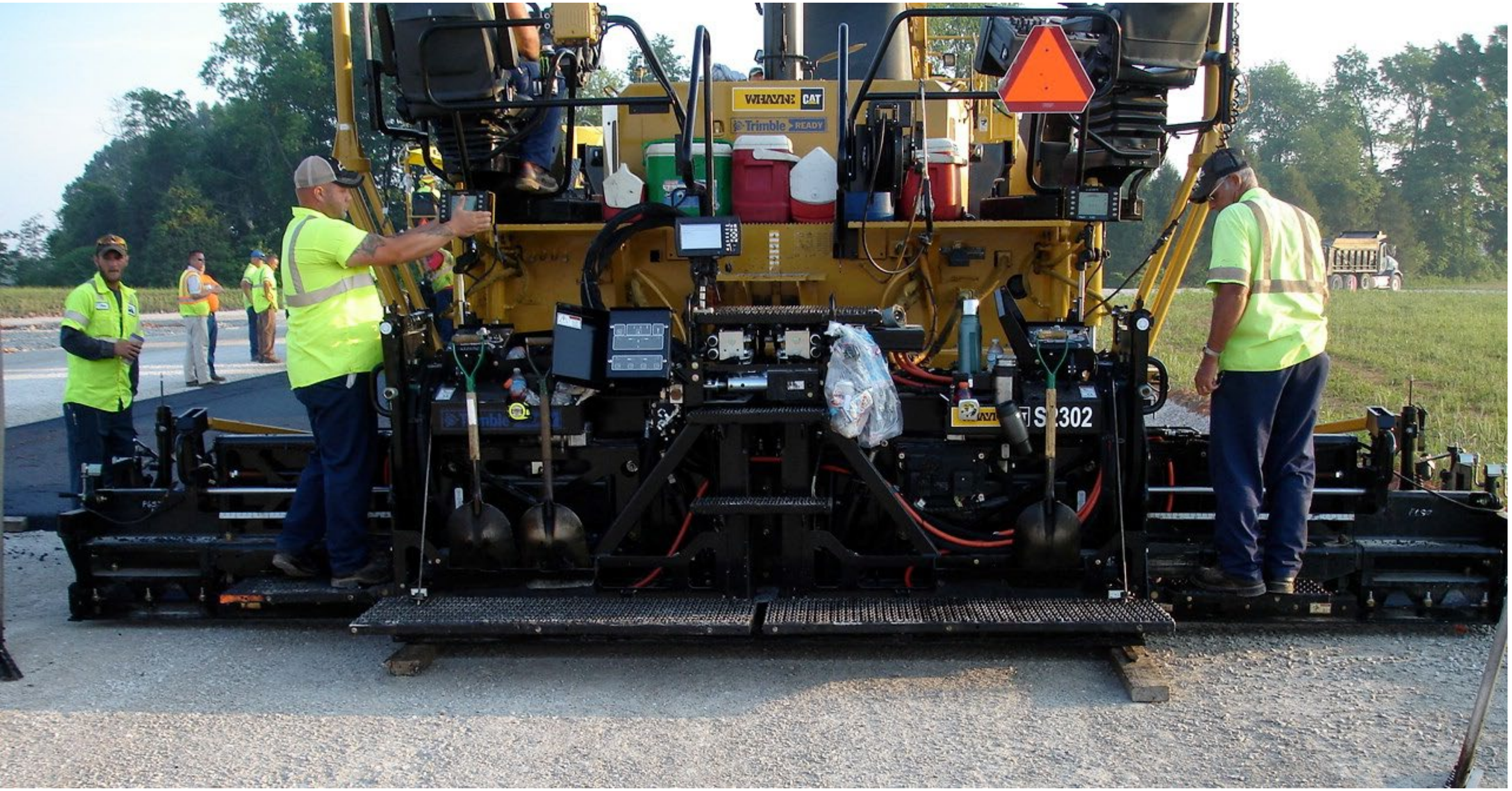
Taking off: Is this a good place to start?

Good Starting Point

- Cut straight starting joint
- Butt joint flat

- Tack butt joint
- Clean area where screed will set down

Set Down & Take Off



PAVING BY THE NUMBERS

1. Heat the screed
2. Set the tow points
3. Set paving width
4. Set crown
5. Set extender height
6. Set extender slope
7. Lower screed and remove slack
8. Null the screed
9. Position end gates
10. Set auger height
11. Position feeder sensors
12. Set feeder controls
13. Fill auger chamber/place in auto
14. Set accessory functions
15. Pull off starting reference

CAT

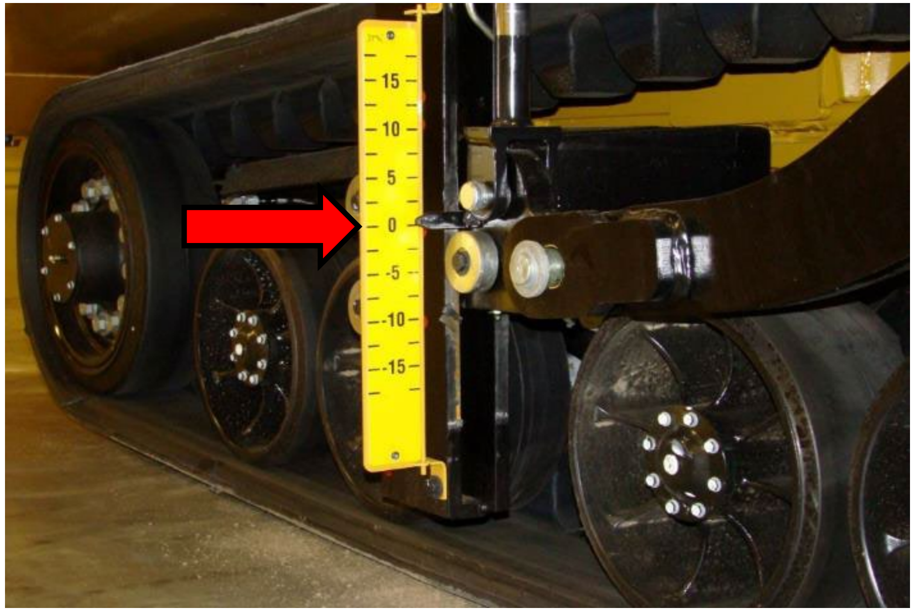
QEXQ1403-04
(Replaces QEXQ1403-03)

Heat the Screed – Step 1

- Mix sticks to cold screed plate
- Creates very open texture
- Screed drops
- Pick up, heat screed and re-start OR
- Repair low spot while screed rests on hot mat to warm up.

Set Tow Points – Step 2

- Based on uncompacted mat thickness
- Establish a straight "line of pull"
- Set tow points <u>BEFORE</u> lowering the screed

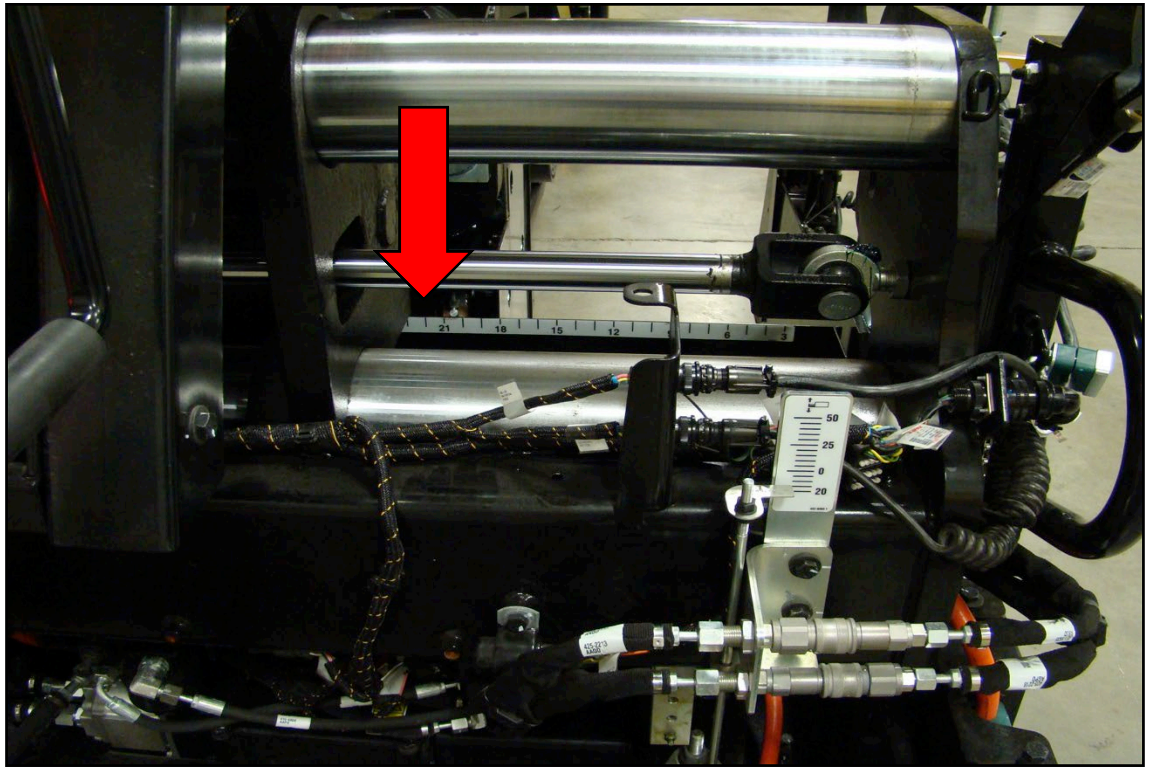


Example: 2 ½ inch mat (rear-mount)

- Tow point scales are different
- Know where "0" is on your paver
- Establish a straight line of pull

Tow Point set at 2 ½

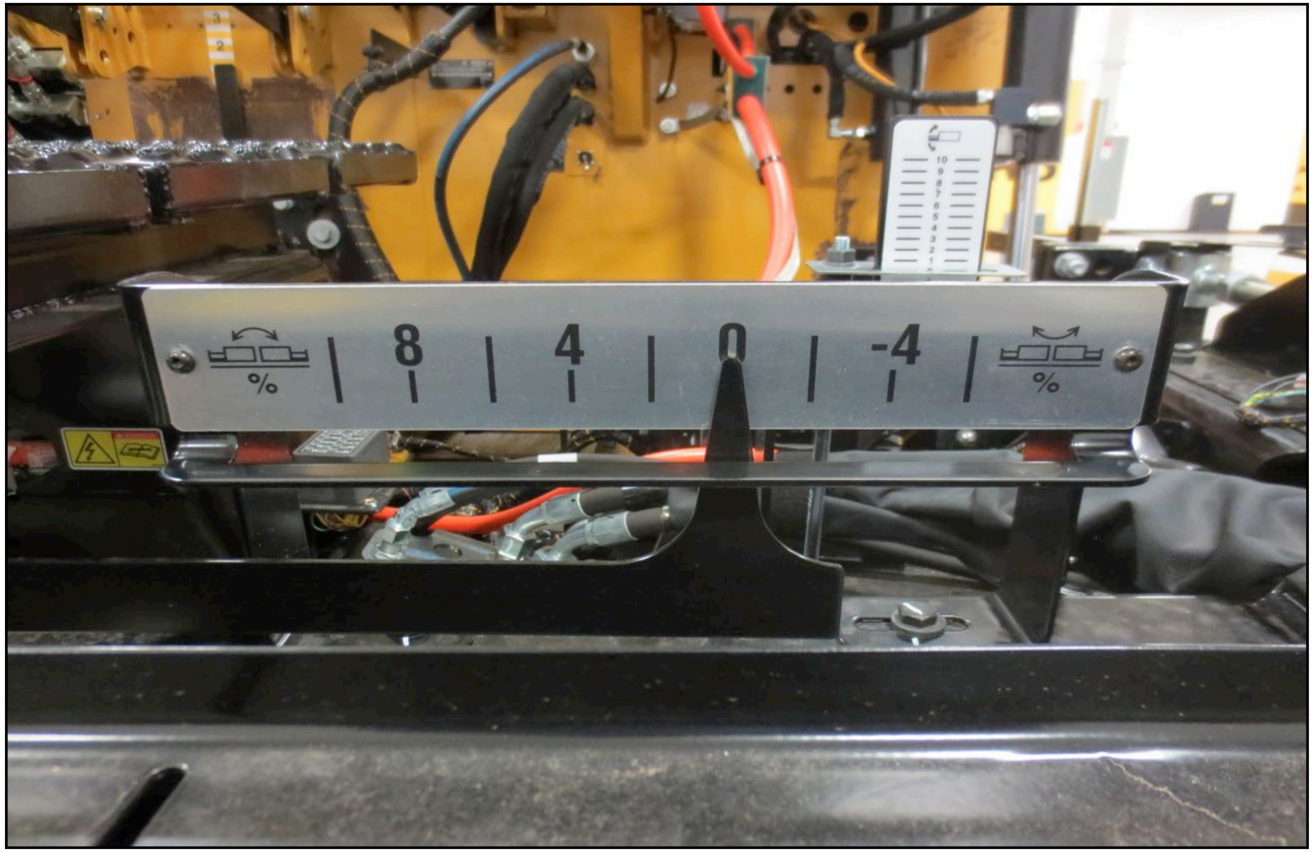
Set Paving Width – Step 3



✓Set Paving width

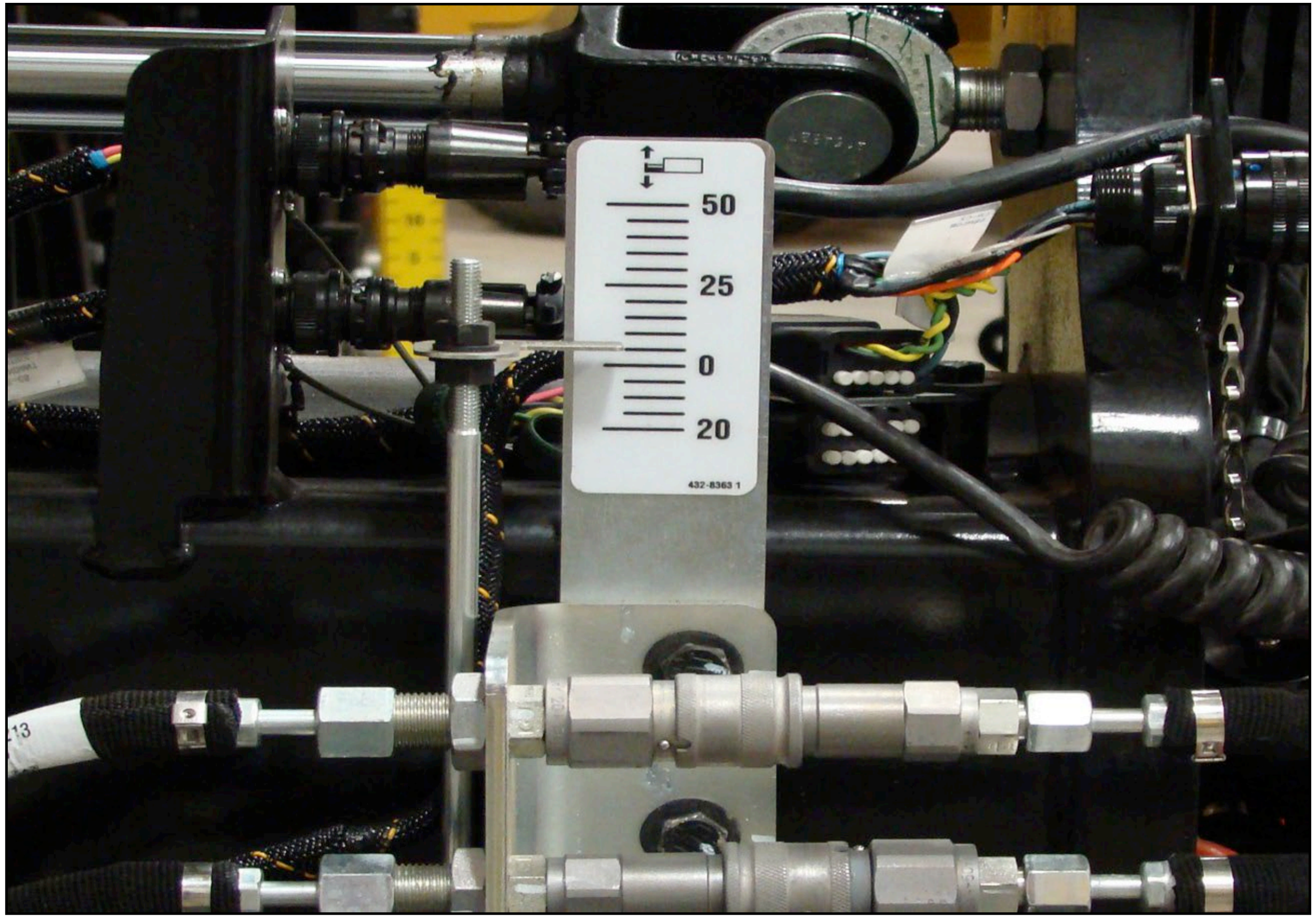
- ❑ Based on the main screed width, set extender width per job specs
- ❑ Use scales on extenders
- ❑ Equal extender width on both sides whenever possible

Set Screed Crown – Step 4



- ✓ **Set Main Screed Crown per job specs**

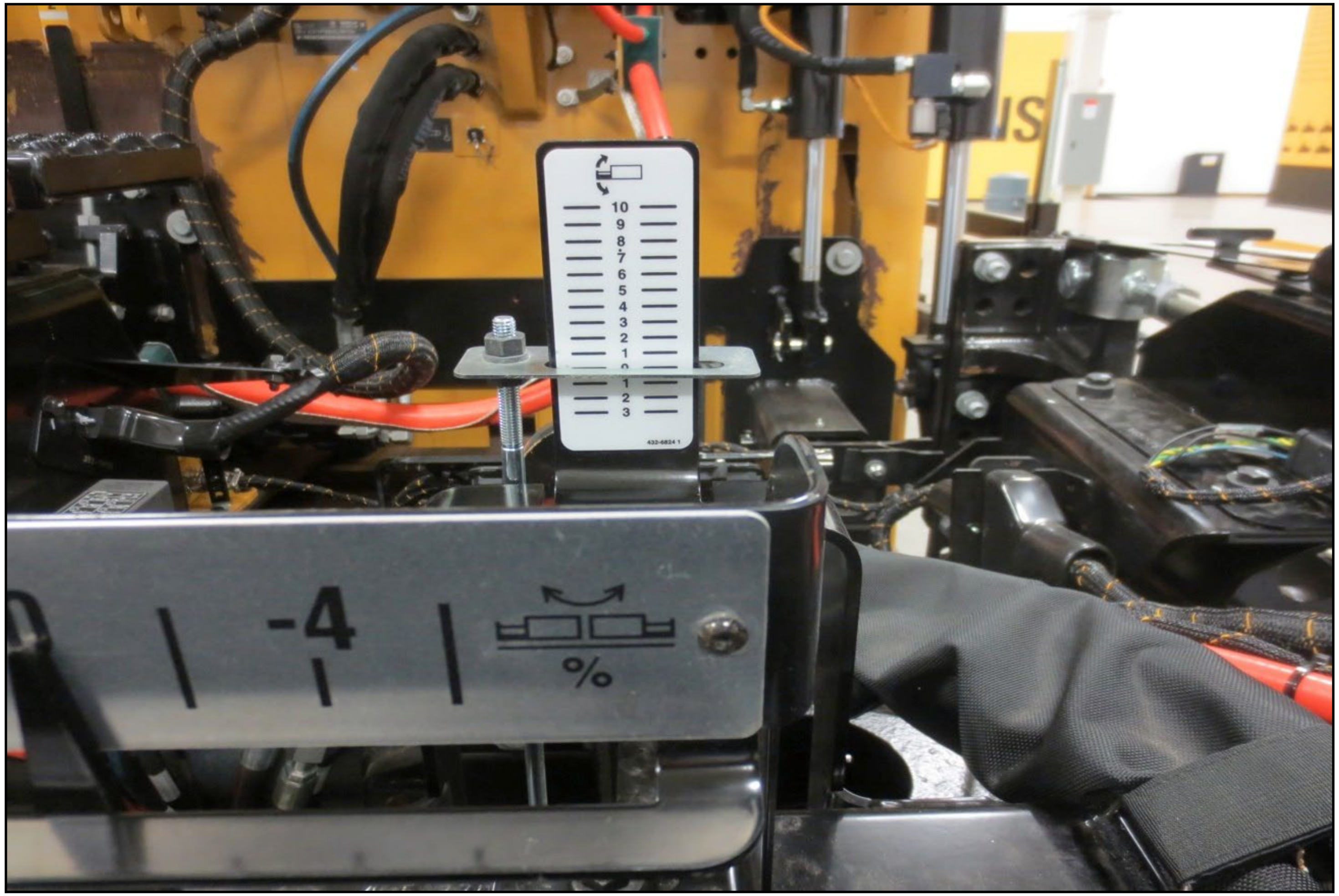
Set Extender Height – Step 5



✓Set Extender height – will set the angle of attack

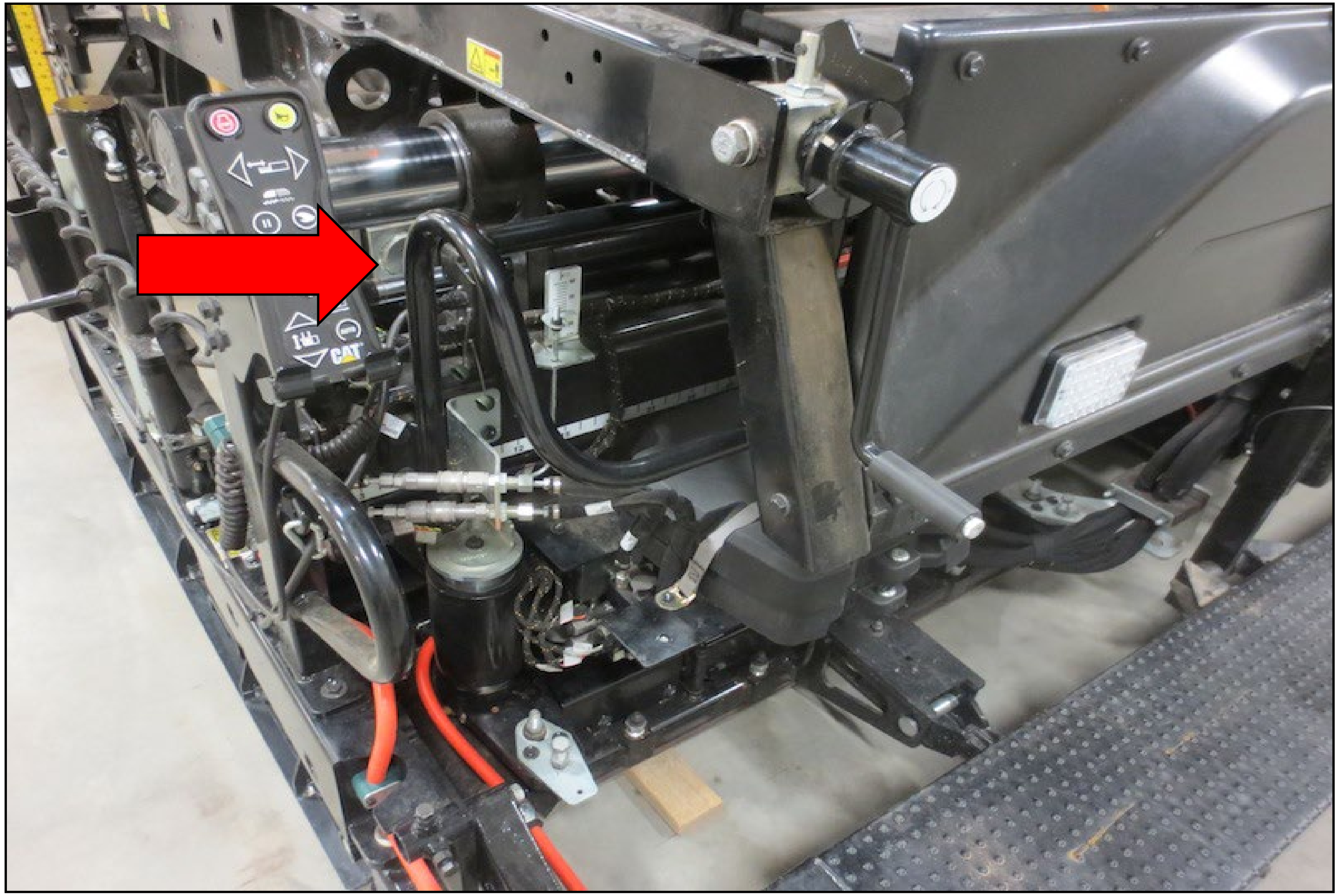
- ❑ ¼" above

Set Extender Slope – Step 6



✓Set Extender Slope per job specs

Prepare Screed – Step 7



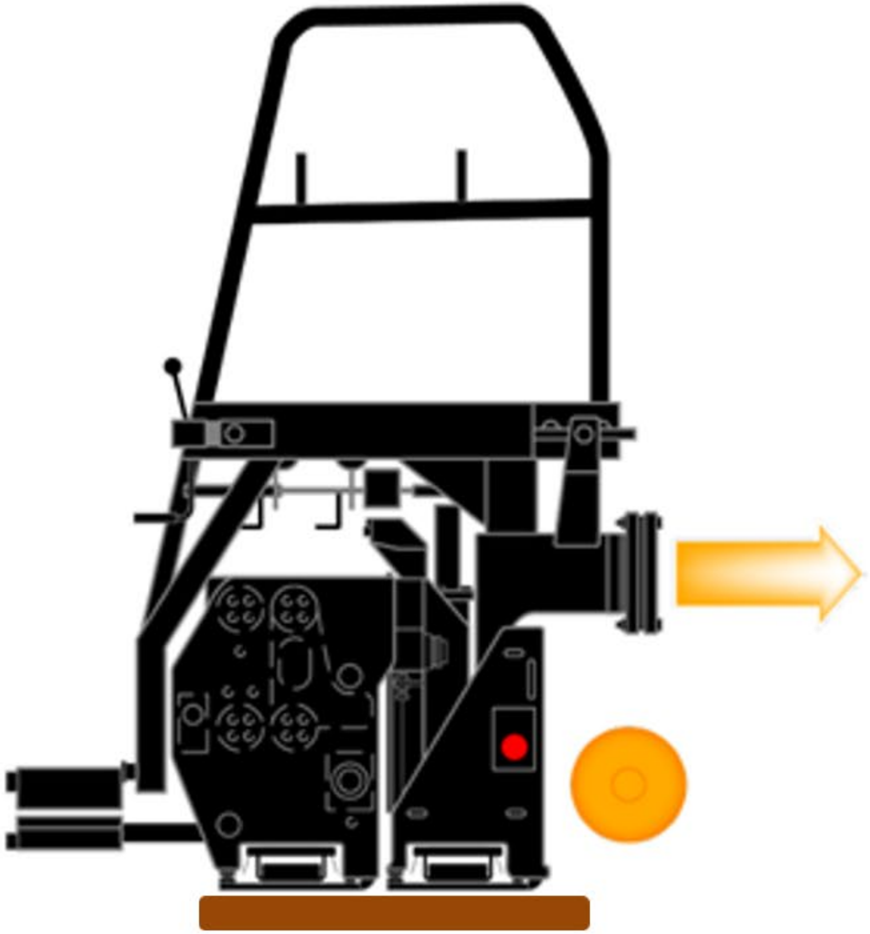
Prepare Screed

- ✓ Raise the end gates
- ✓ Select starting reference that is the proper thickness and length
- ✓ 0.9 – 1.2 m (3 – 4 ft.) and position under extender pivot
- ✓ Support main screed and extender screed

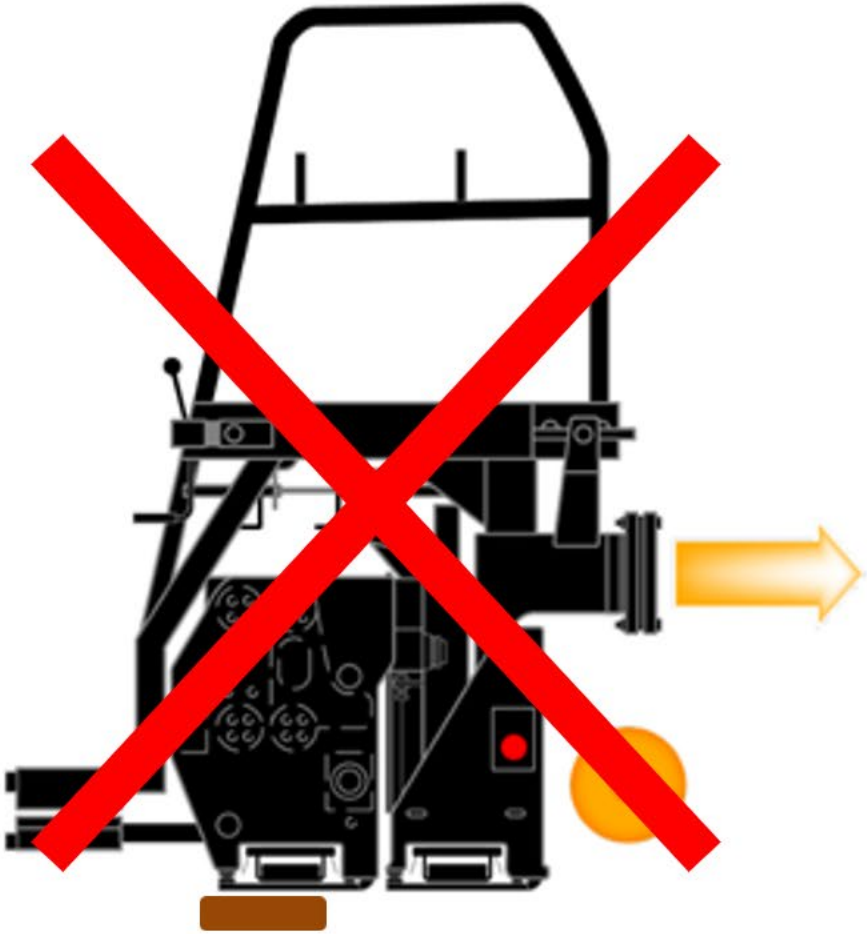
Build a Pad or use Starter Boards

- Support full length of screed & extensions
- 3 to 4 feet long boards
- Based on uncompacted mat thickness (1/4” per 1”)

Boards must support main & extenders



Full Support Main & Extenders



Screed will drop or 'nose over'

What’s wrong with this take-off ?

No starter boards!

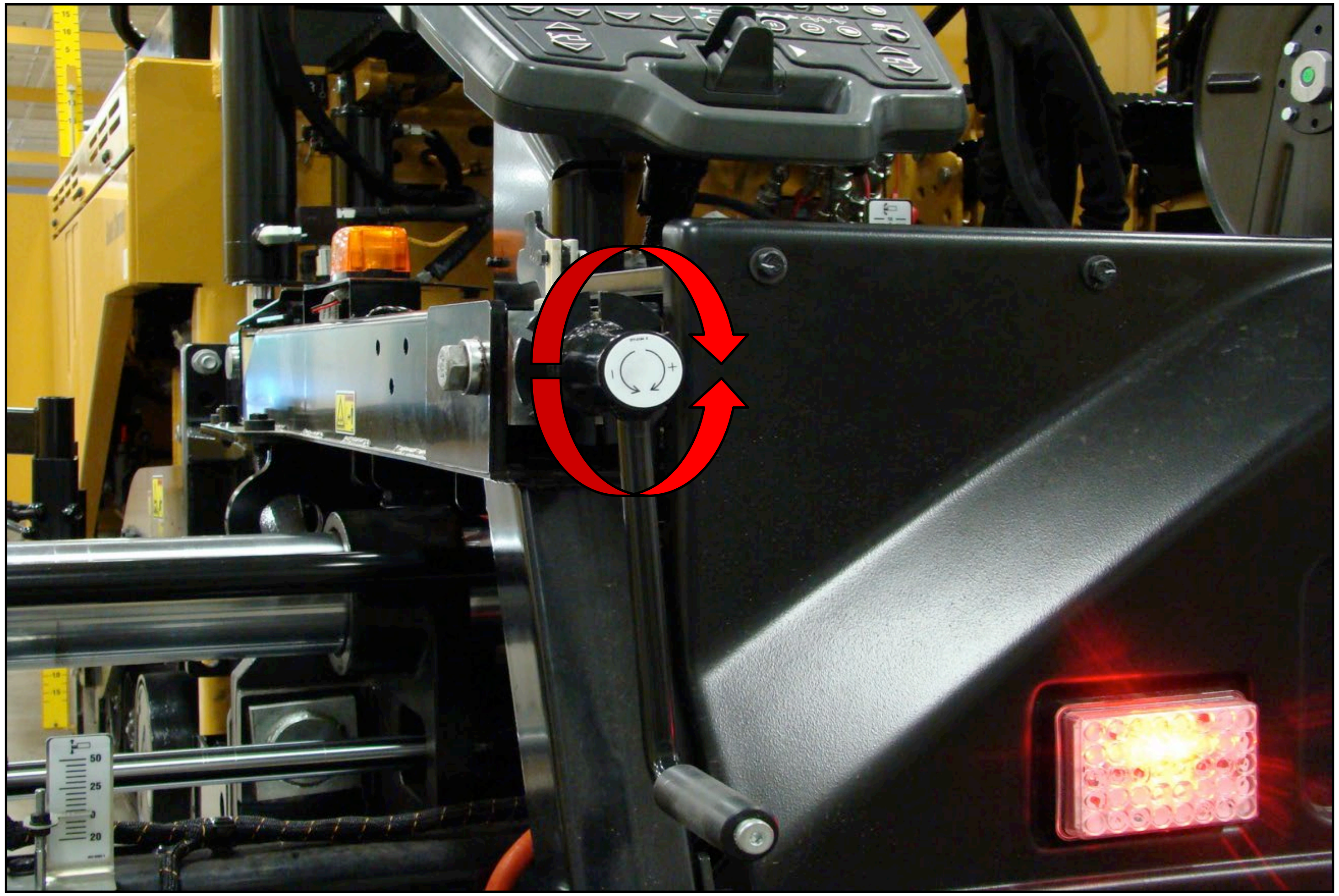
Measure Height of Starting Joint

- Calculate thickness of starter boards
- General rule vibratory screed: ¼” compaction per 1” loose depth
- Example: Place 2-½” loose to end up with 2” after rolling

Lower the Screed & Remove Slack – Step 7

- Lower screed onto starting boards in “float” position
- Take out the slack
- This “sets” the angle of attack at ¼” (or whatever extender height was set at) when we null the screed

Null the Screed – Step 8



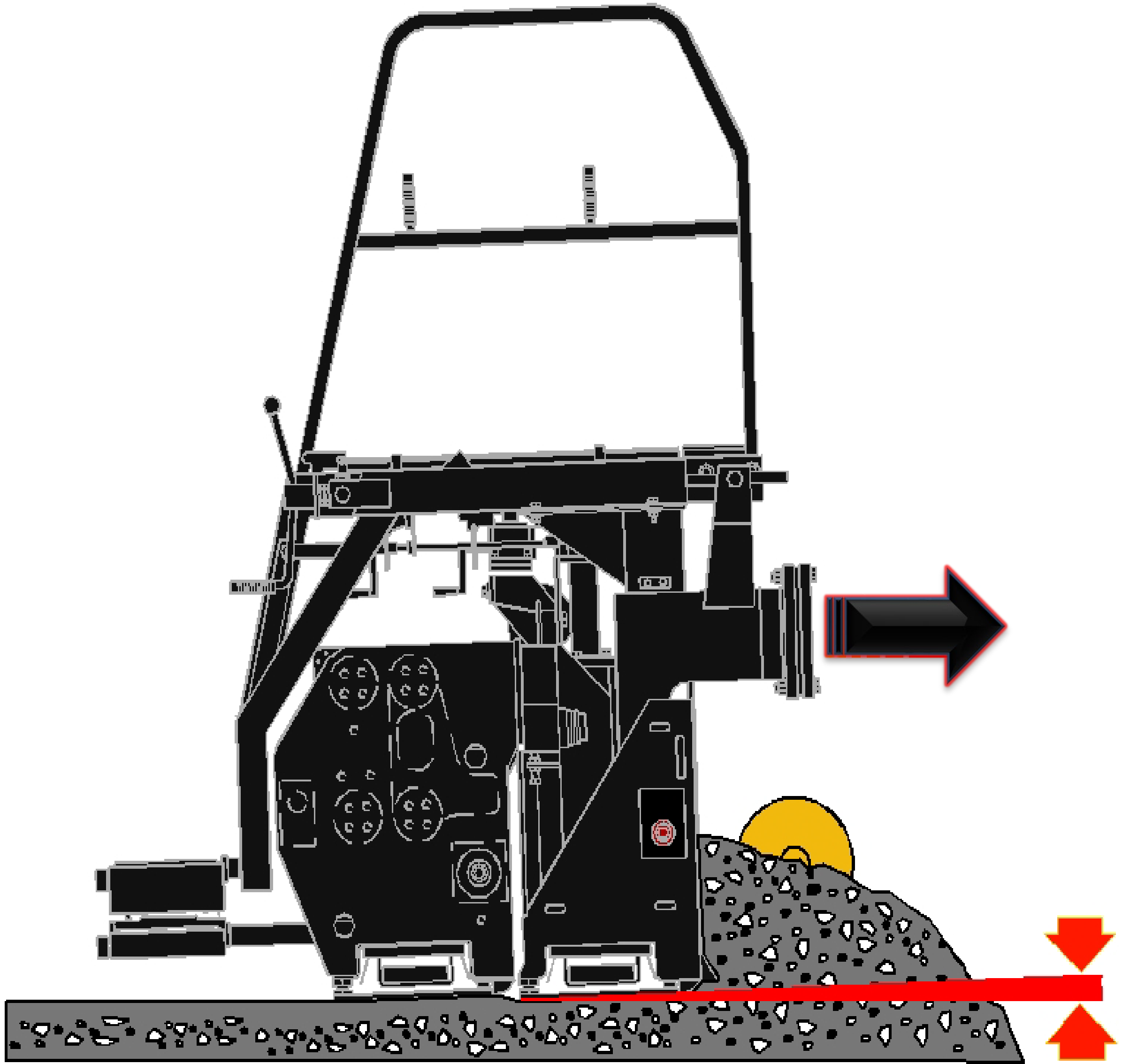
Null the Screed

- ✓ Null one side at a time
- ✓ Turn one depth control crank until no resistance is felt
- ✓ Repeat for the other depth control crank
- ✓ Check the first side again

Null the Screed - must be "free floating"

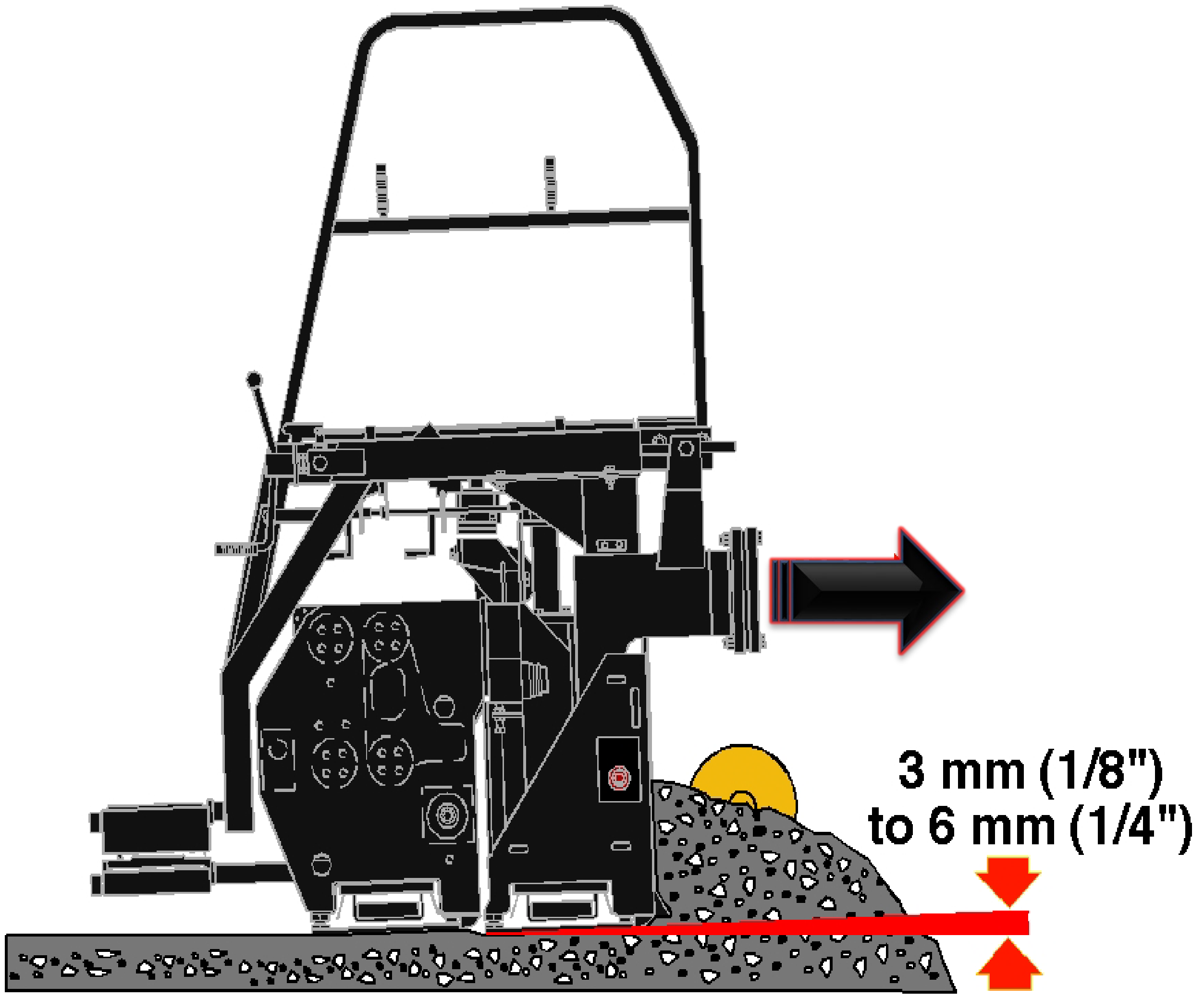
- Nulling the screed removes all the tension in the screed
- Use depth screws on each side until no resistance is felt
- The screed must be "free-floating" on the mix

Angle of Attack



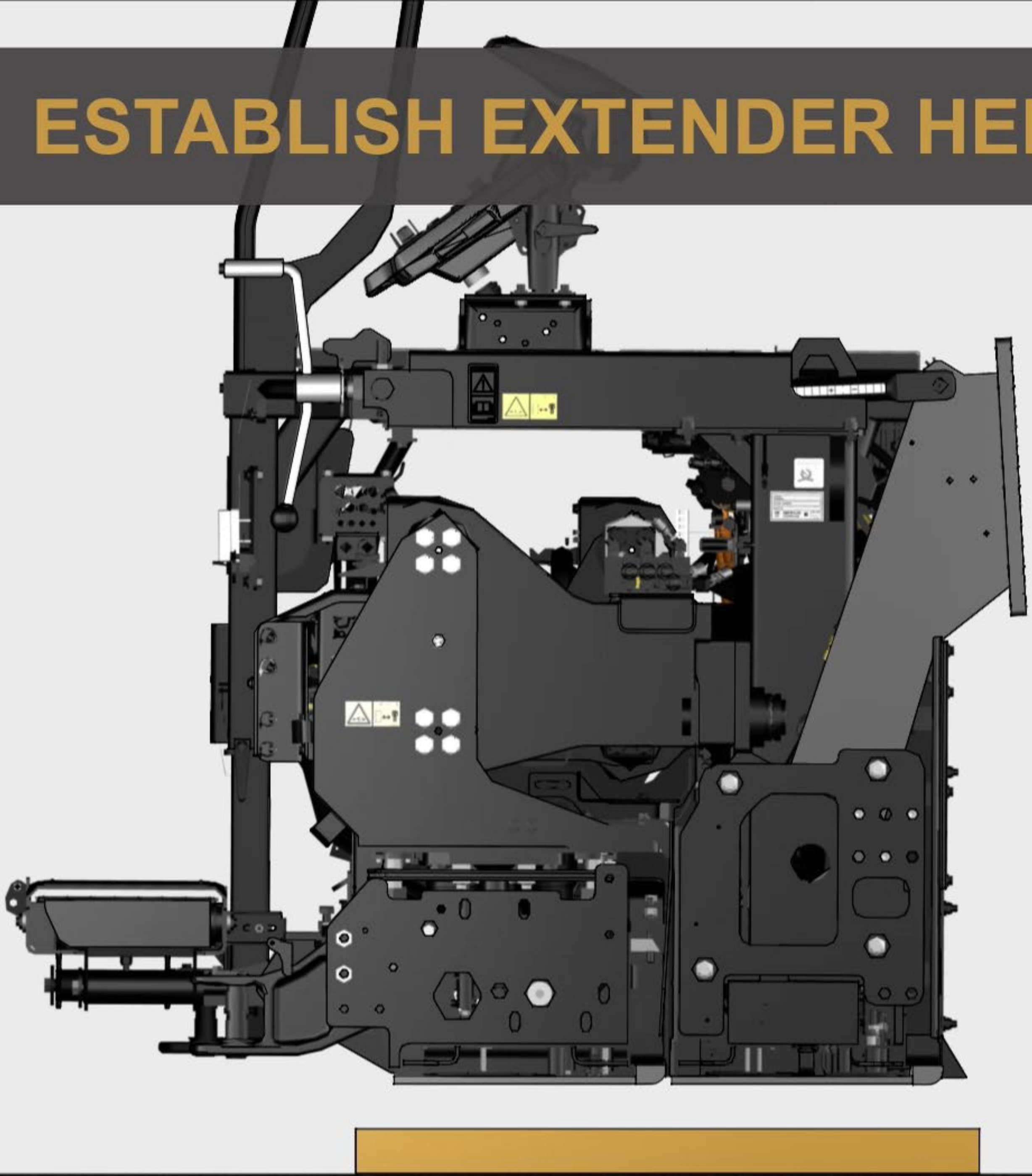
- Angle of attack is the relationship between the nose of the screed & the trailing edge of the screed
- Nose up attitude
- Screed reaches equilibrium

Angle of Attack



- Normally 1/8“ to 1/4“
- Angle too high, screed compacting with trailing edge
- Erratic screed behavior
- Angle too low increases shear factor and wear

ESTABLISH EXTENDER HEIGHT

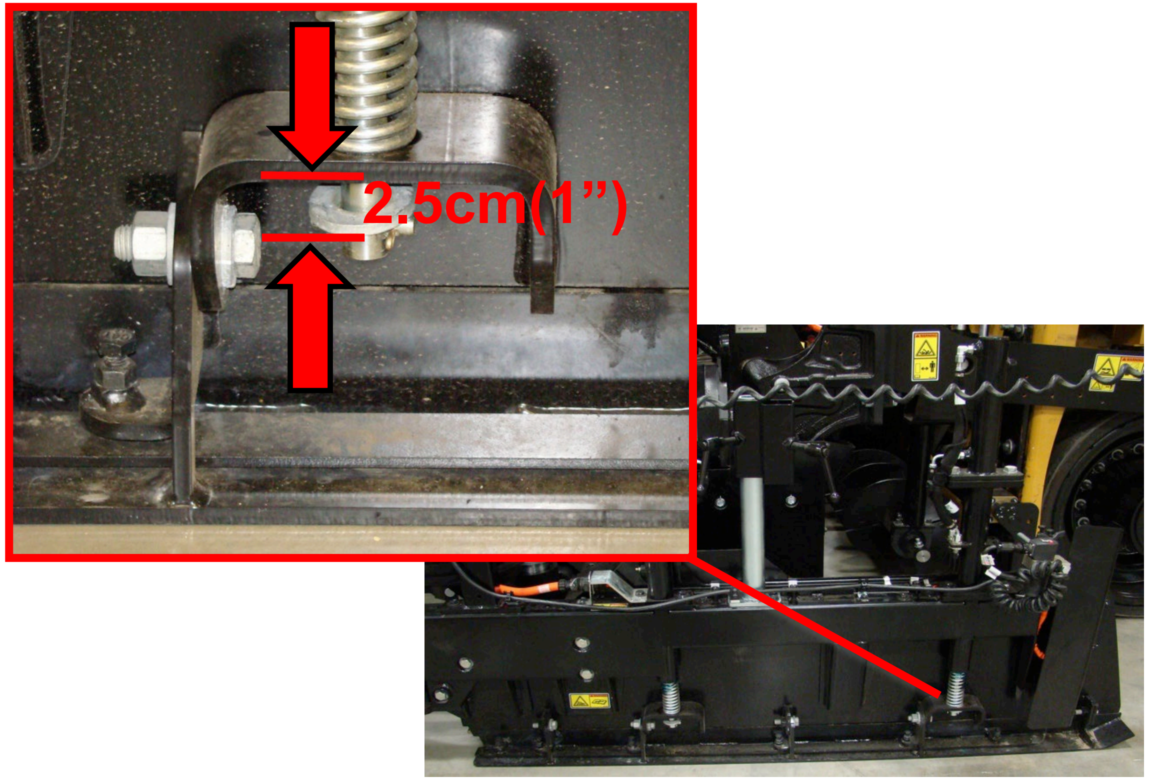


Angle of attack – what you see…

Too high – shiny

Too low – open texture

Position the end gates – Step 9



Position End Gates per job requirements

- ✓ Manual End Gates - lower to contact grade, apply
  2.54 cm (1 in) spring tension
- ✓ Hydraulic Powered End Gates – lower to grade, Press Auto

Set the Auger Height – Step 10

Set Auger Height

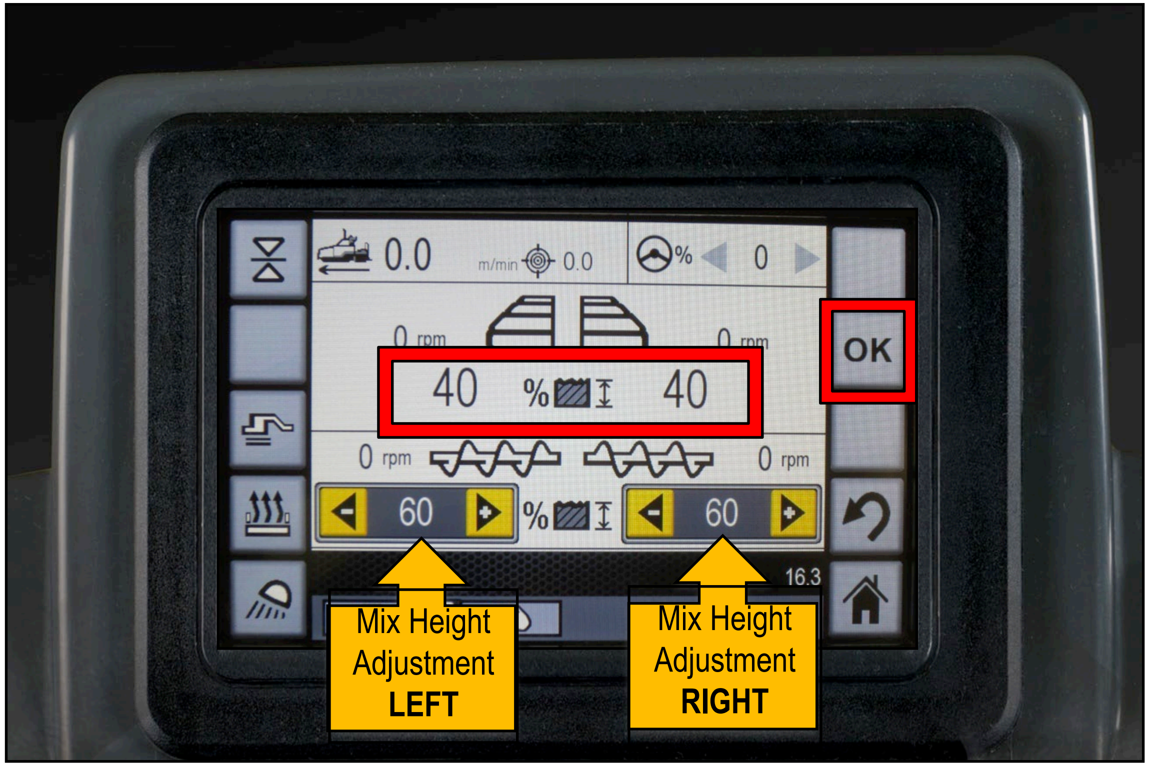
- ✓ Auger height affects mat texture
- ✓ Auger height of 5 cm (2 in) above the mat is right for most mixes
- ✓ Fine tune according to mix

Position Feed Sensors – Step 11

Position Feeder Sensors

- ❑ Sonic feed sensors
- ✓ Perpendicular to the live material flow.
- ✓ 46 cm (18 in) away from the material
- ✓ Target moving material

Set Feeder Controls – Step 12



Set Feeder Controls

- ✓Adjust Conveyor Control Dials to 40%
- ✓Adjust mix height to 60% using arrows
- ✓Select OK after adjusting

Manually Fill Auger Chamber – Step 13

Manually Fill Auger Chamber

- ✓ Machine low idle
- ✓ Manually auger material across screed face
- ✓ Auger material out to establish ½ level
- ✓ Do not overfill

Manually Fill Auger Chamber – Step 14

Set Accessory Functions

- ✓ Set grade controls to specifications
- ✓ Set slope control to specifications

Pull Off Starting Boards Quickly – Step 15

- Quickly get to paving speed
- Check mix feed
- Check auger speed
- Check for lines in mat

Separation Marks – Extension Low

- **Lined up with inner edge of screed extension, extension too low**
- **Raise extension to erase line**
- **If line re-appears behind outer edge of main screed, use extension slope switch to erase line**

The Result: Straightedge tells the story

Paver Speed

- Goal is non-stop paving
- Set to match mix delivery
- Balance with rollers
- Quick starts/stops
- 60 fpm maximum

Why Continuous Paving?

- Screed settlement during long stop
- Compaction process may clean up mark
- Screed assist can help

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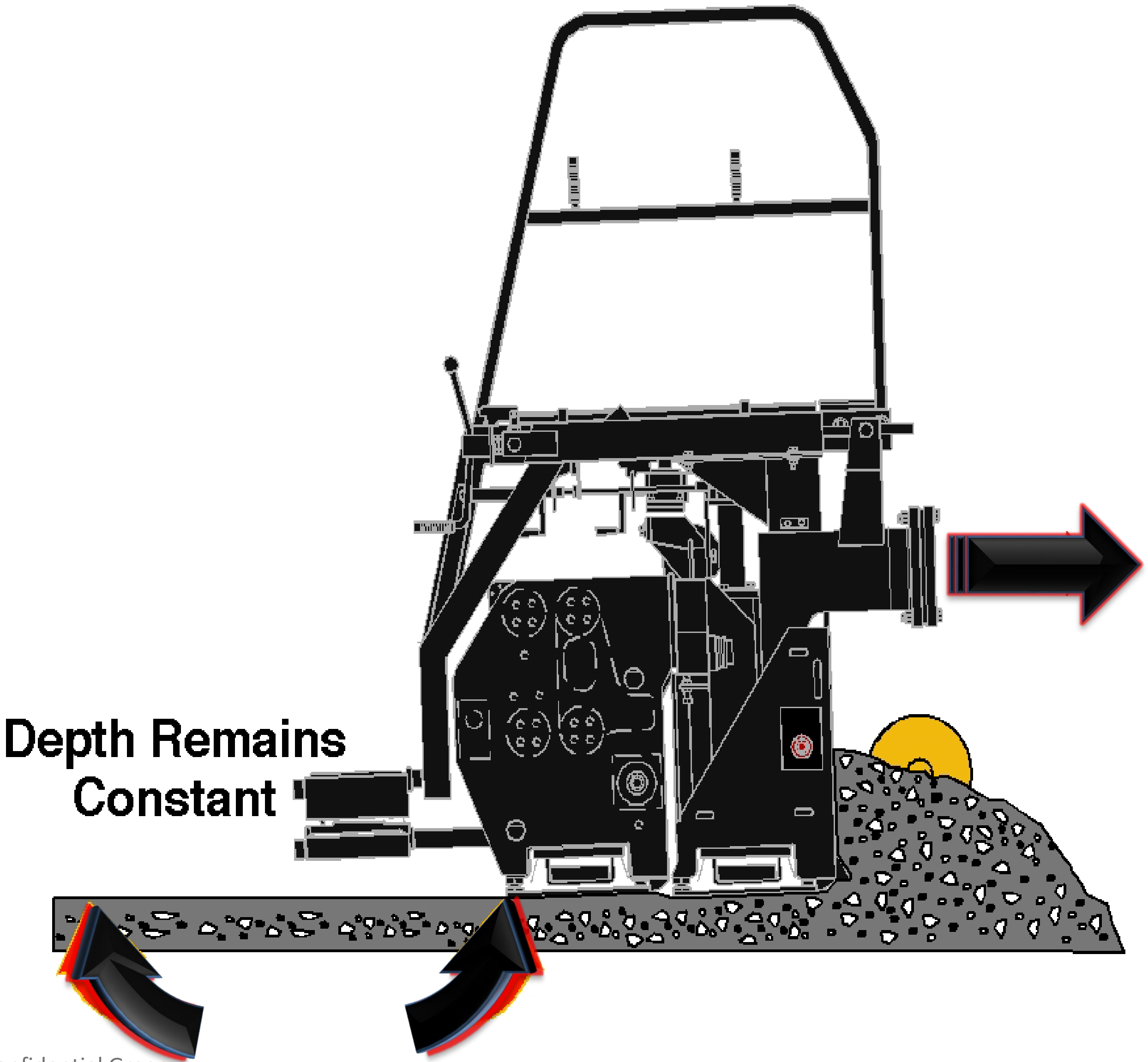
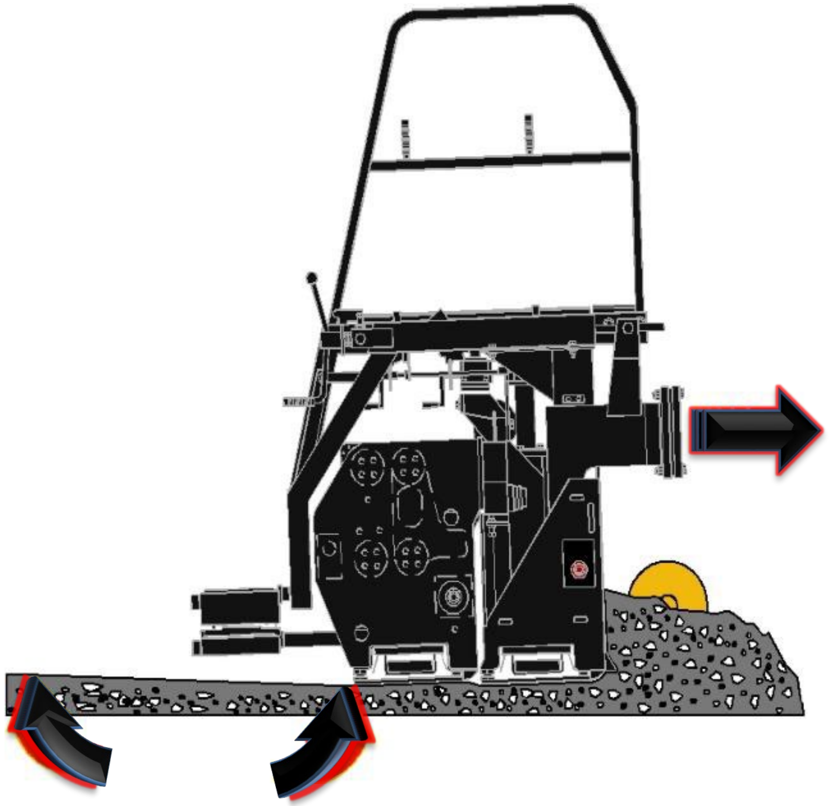
Paver Speed Constant = Smoothness

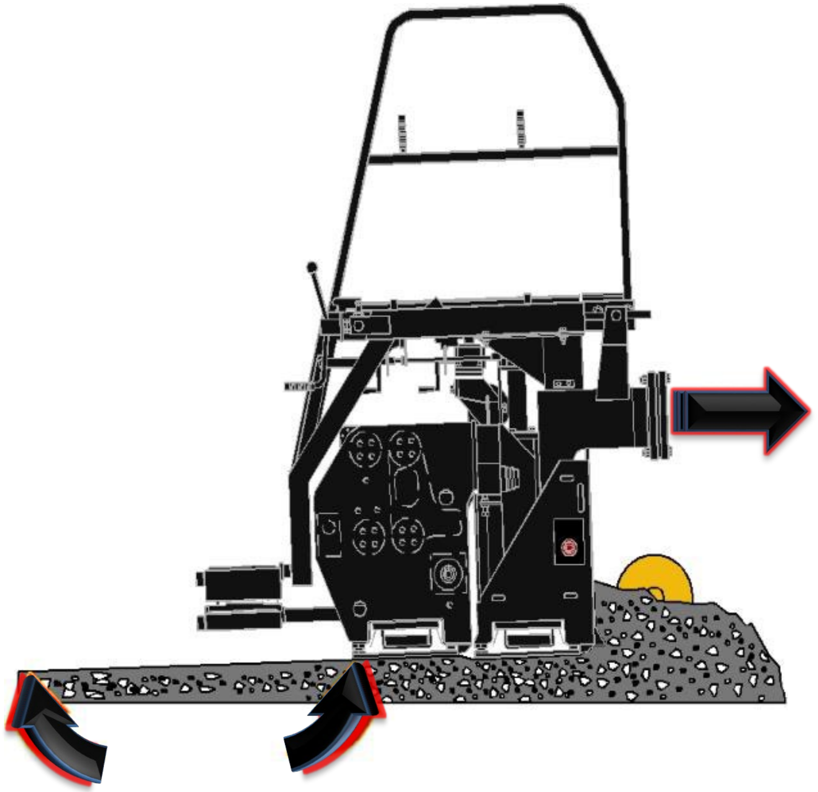


- Shear factor is constant
- Depth remains constant

Changes in Paver Speed



Increased Speed



Decreased Speed

- Shear factor decreases
- Depth decreases

- Shear factor increases
- Depth increases

Thank-you for your attention!

CAT
BUILT FOR IT.

Achieving Smoothness

Smoothness in a Municipal Setting

1. Continuous paving
2. Managing truck exchange
3. Automatic grade & slope control setup
4. Job layout
5. Compaction

Setup Before Paving Starts

PAVING BY THE NUMBERS

1. Heat the screed
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QEXQ1403-04
(Replaces QEXQ1403-03)

Continuous Paving

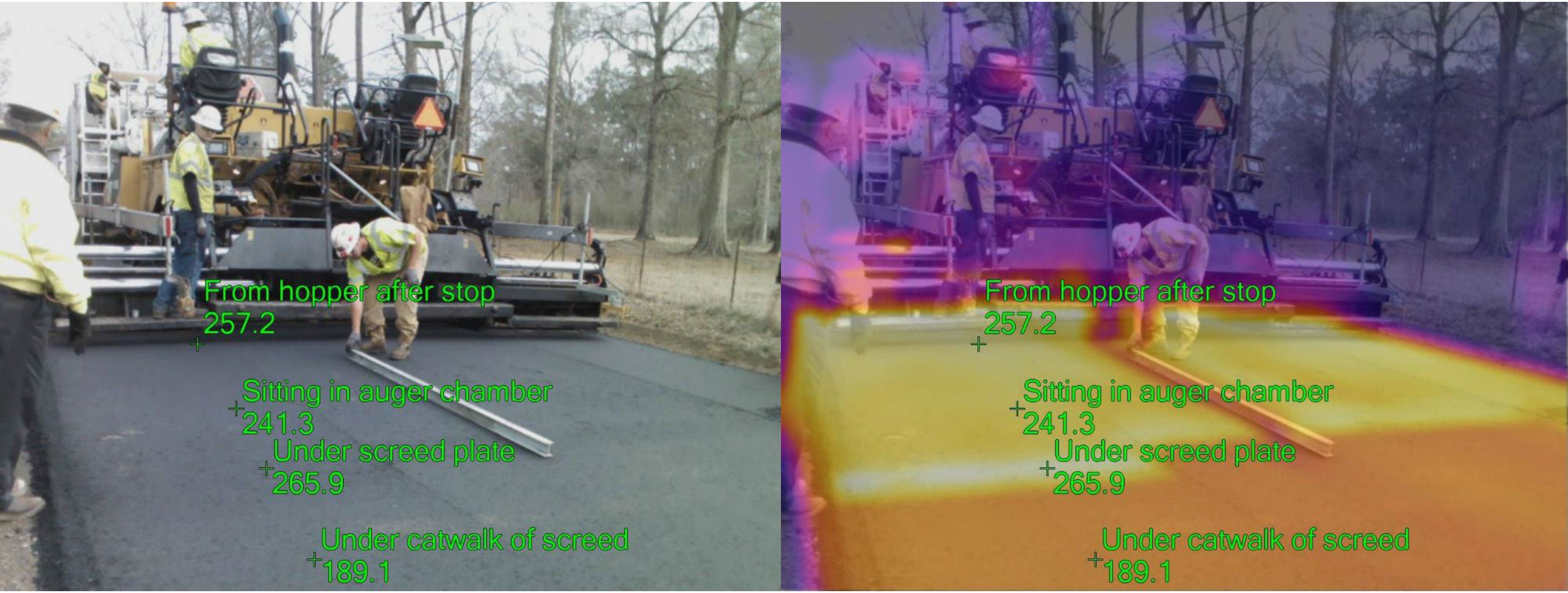
- MTVs can help
  - Windrow elevators
  - Re-mixing type

- Approximately 15% improved smoothness

Paver Stops & Starts...

- Smoothness issue
  - Will it roll out?
- Non-uniform compaction
  - Temperature differentials
- Inefficient trucking?
- Stops > 6 min = bump

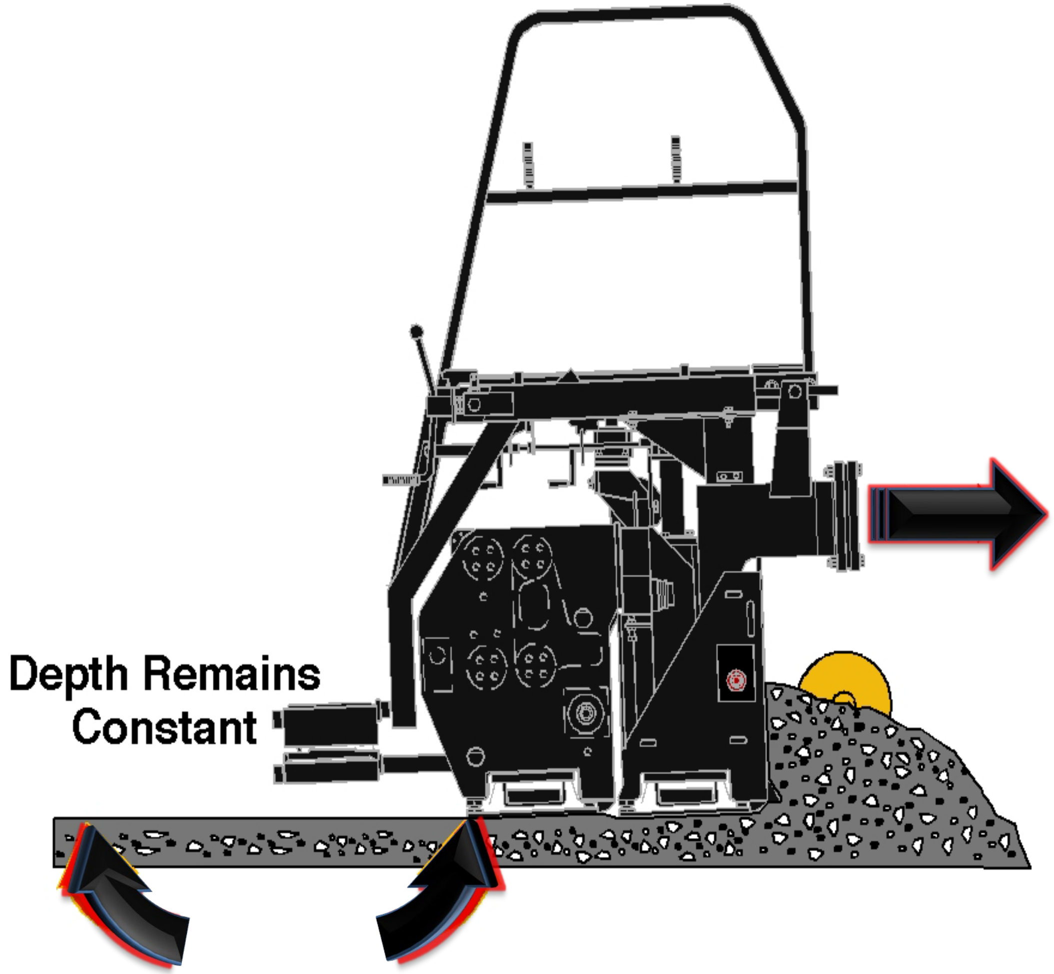
Paver Stops - density & smoothness



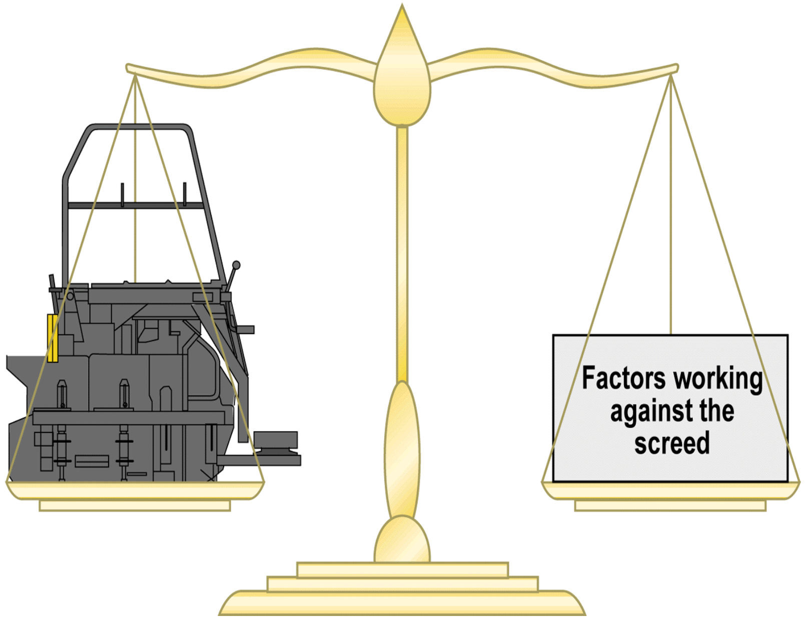
Planning a Balanced Paving Operation

- Goal is non-stop paving
- Set to match mix delivery
- Balance with rollers
- Quick starts/stops
- 60 fpm maximum

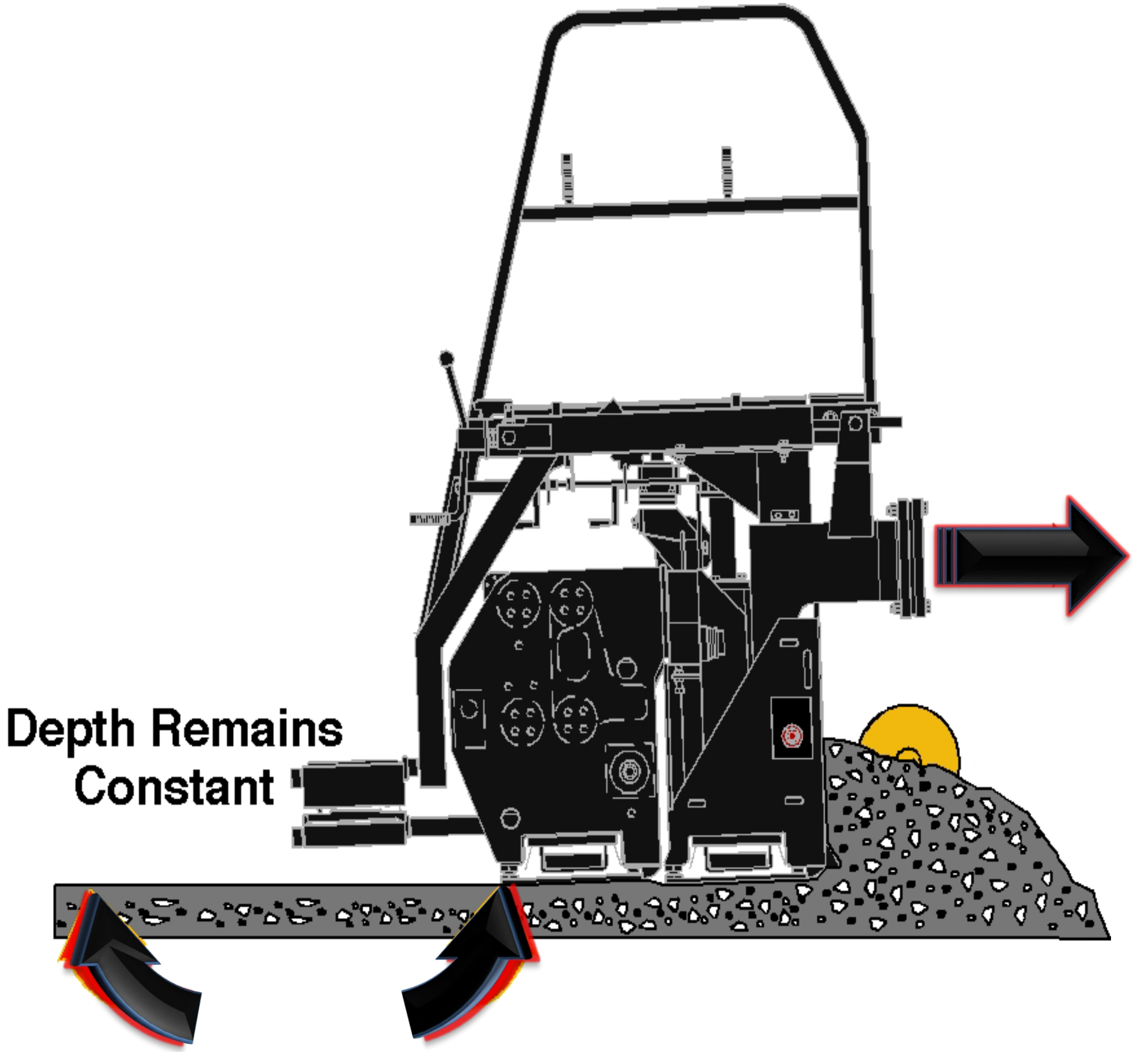
Pavement Smoothness



- Shear factor is constant
- Depth remains constant

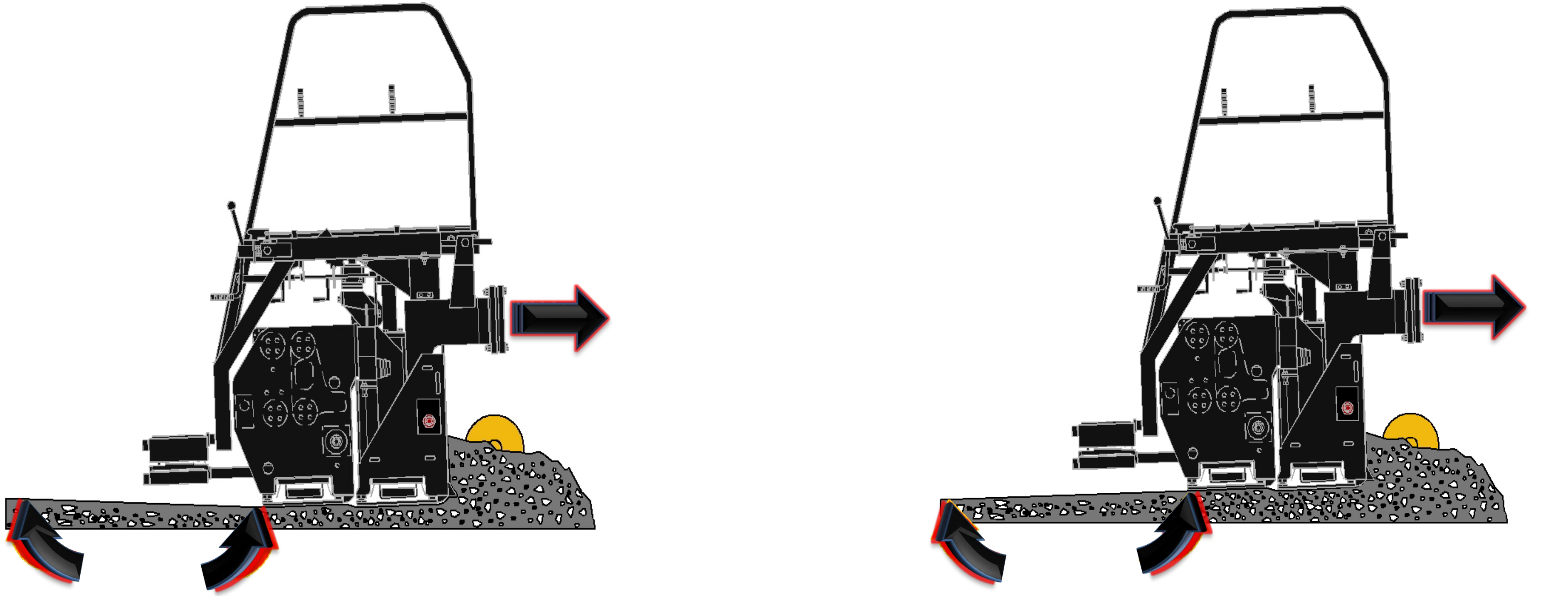


Paver Speed Constant



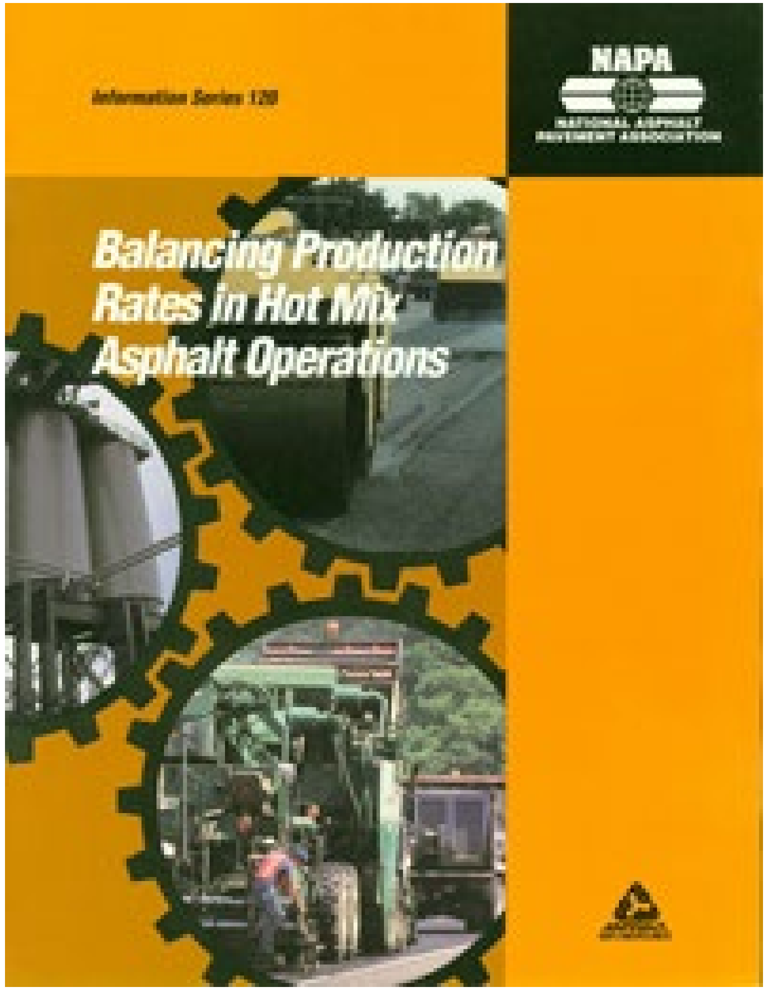
- Shear factor is constant
- Depth remains constant

Changes in Paver Speed



Increased Speed	Decreased Speed
• Shear factor decreases	• Shear factor increases
• Depth decreases	• Depth increases

Planning ≈ 20 minutes

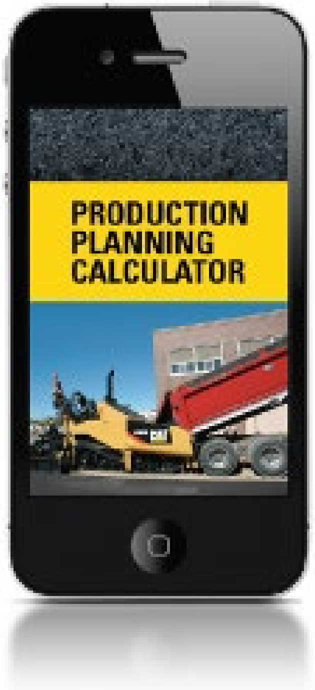


Pre- paving planning

- Tons per day
- Number of trucks needed
- Paver speed
- Roller speed
- Rolling Pattern
  - Density
  - Smoothness

Tools available

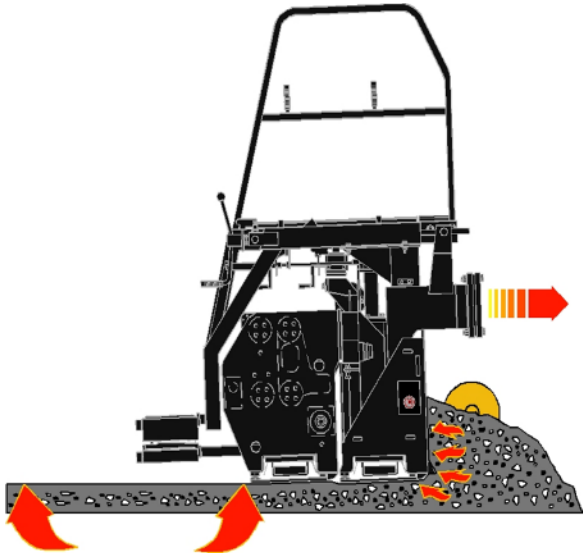
- NAPA IS-120
- Paving Production Calculator App
- PaveCool App



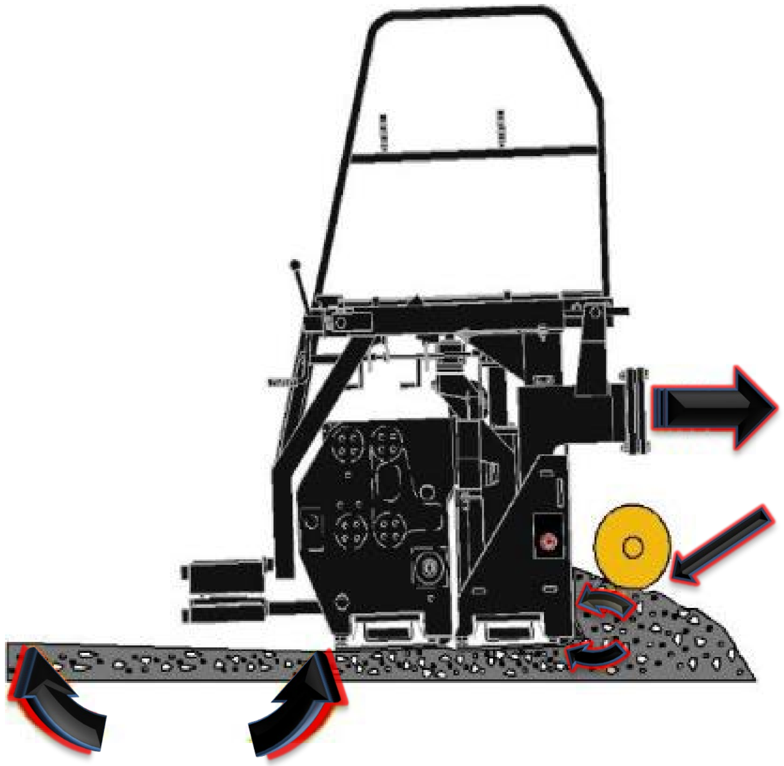
Managing Head of Material @ ½ Auger

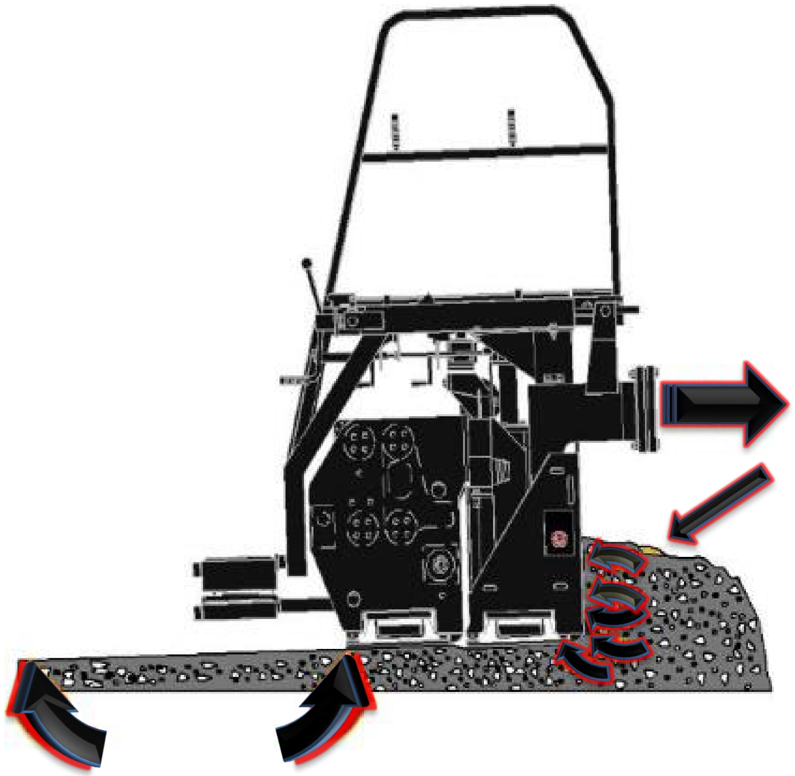
85-95% of all mat defects are related to head of material!!

1. Ratio dials (or flow gates)
2. Auger height
3. Feed sensor position
4. Auger speed



Changes in Head of Material





Head of Material Decreases

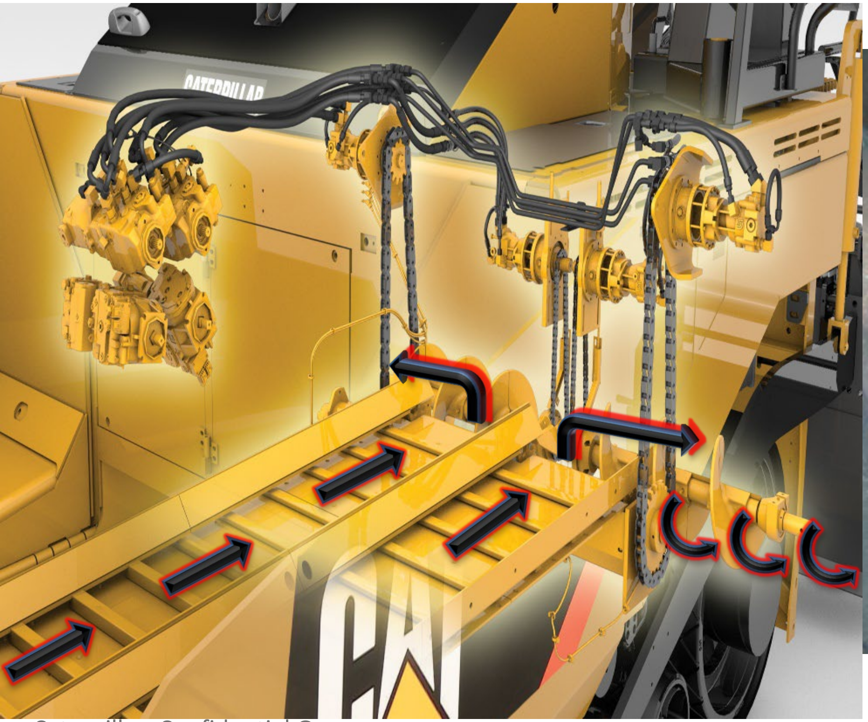
- Resistance decreased
- Depth decreases

Head of Material Increases

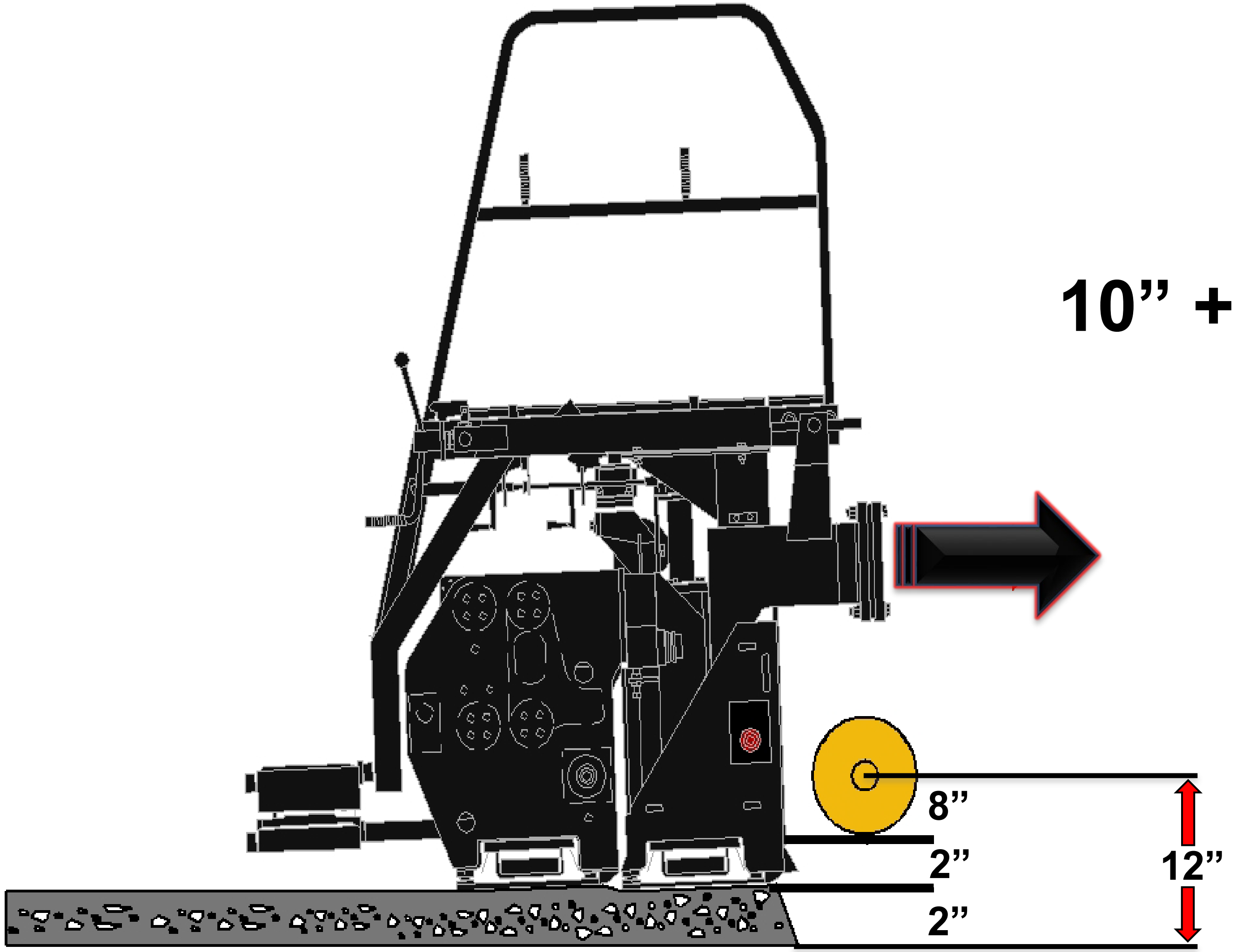
- Resistance increased
- Depth increases

Controlling Head of Material: Mix Feed

- Material level at center of auger chamber
- Material level in center area controls auger speed
- Flow gates on some pavers



Controlling Head of Material: Auger Height



- Start at 2" above level of mat
- Adjust up or down depending on mix type and appearance of mat

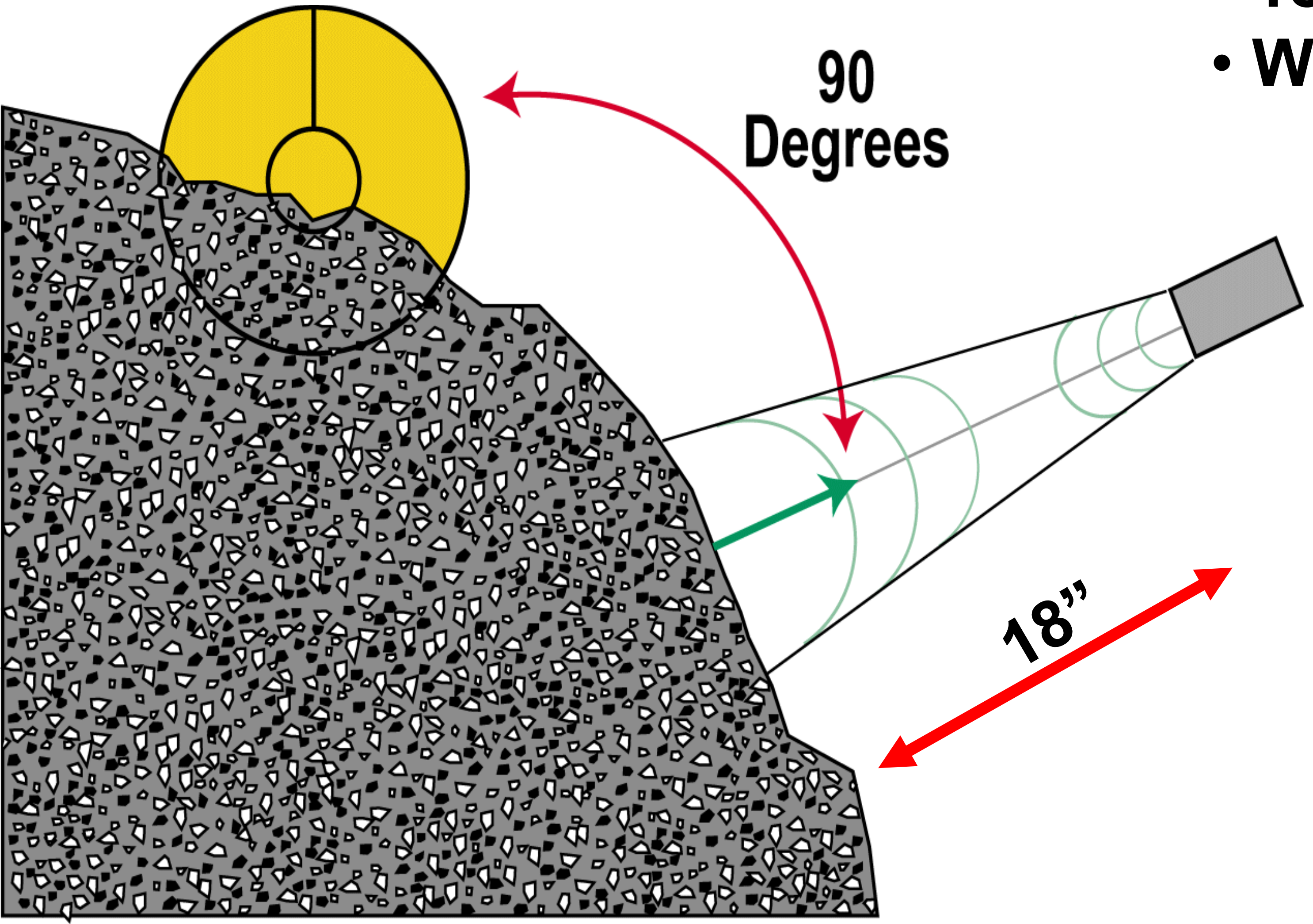
10” + mat thickness = auger height

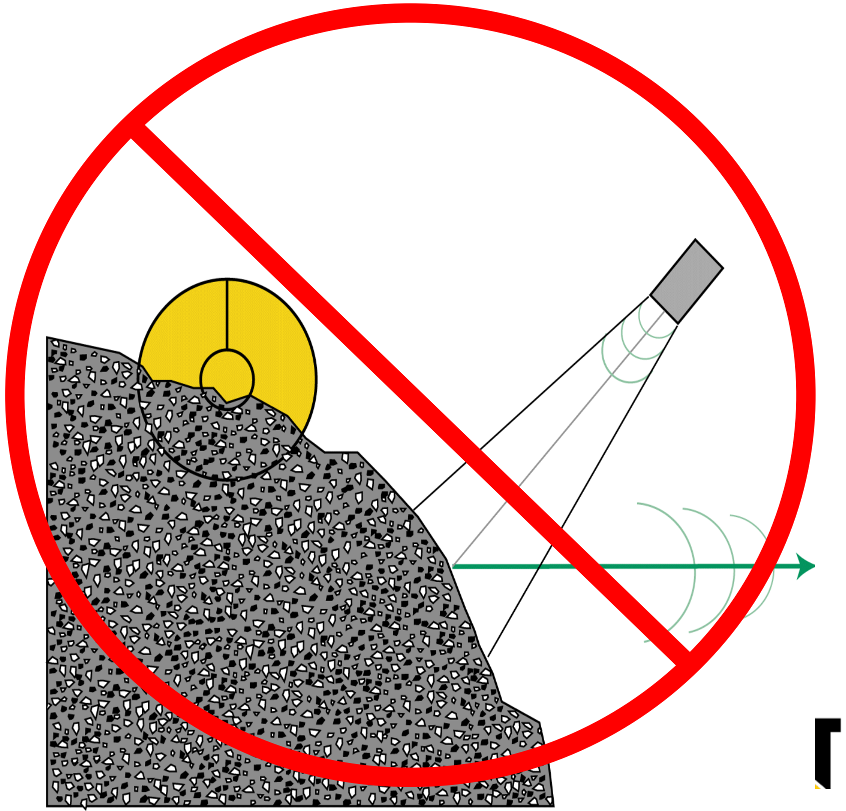
Aiming Sonic Feed Sensors

- Mechanical or sonic
- Control level of material
- Position Sensor 18" from end of augers

Sonic Sensor Mounting Distance

- 18” from mix
- 18” from last auger segment
- Working range is 12” – 32”





Paddle sensor at 18” and 45°

Controlling Head of Material: Auger Speed

- Auger speed uniform
- 20-40 rpm
- 2s per revolution
- Auger speed too high or too low can cause stripes in the mat

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Truck Exchange – HoM – Bumps & Dips

Caterpillar: Confidential Green

Keep Mix in the Hopper between trucks!

- Avoids bump/dip
- Minimizes segregation
- Holds heat in mix

Paver Speed - Real World Paving

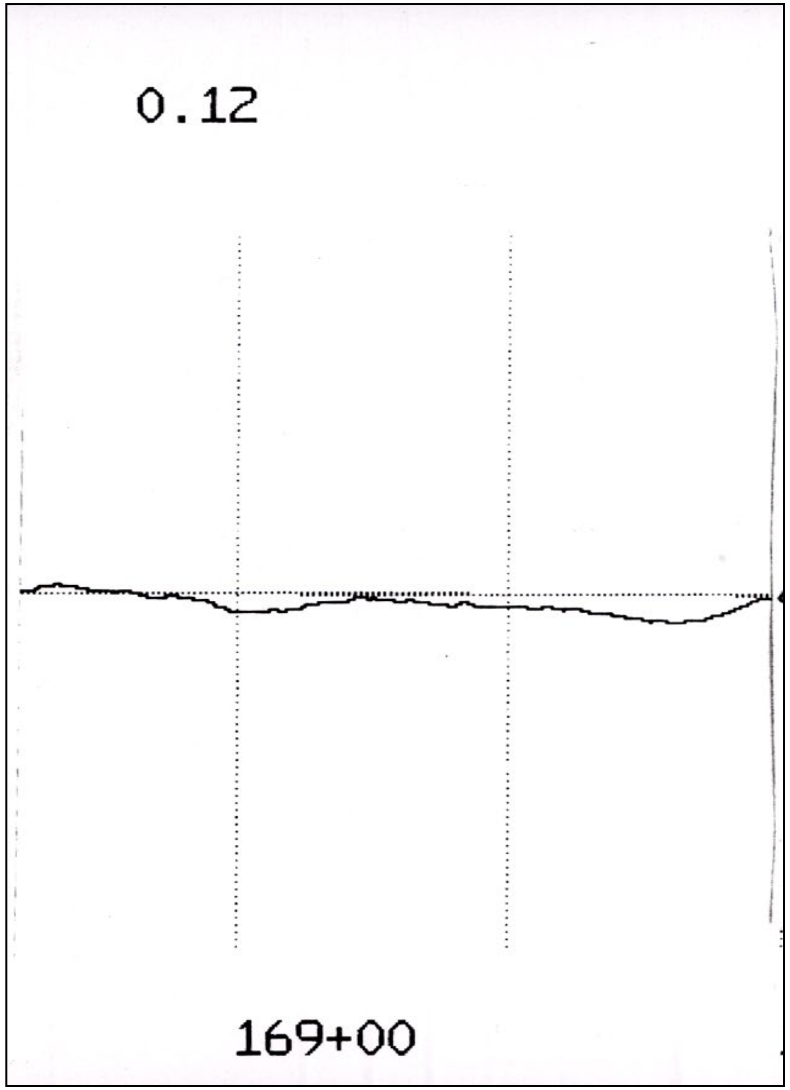
- Do not panic
- Stay with the plan
- Get rid of trucks in an orderly fashion
- Establish a uniform trucking pattern
- Will help density & smoothness

Changes in Paver Speed

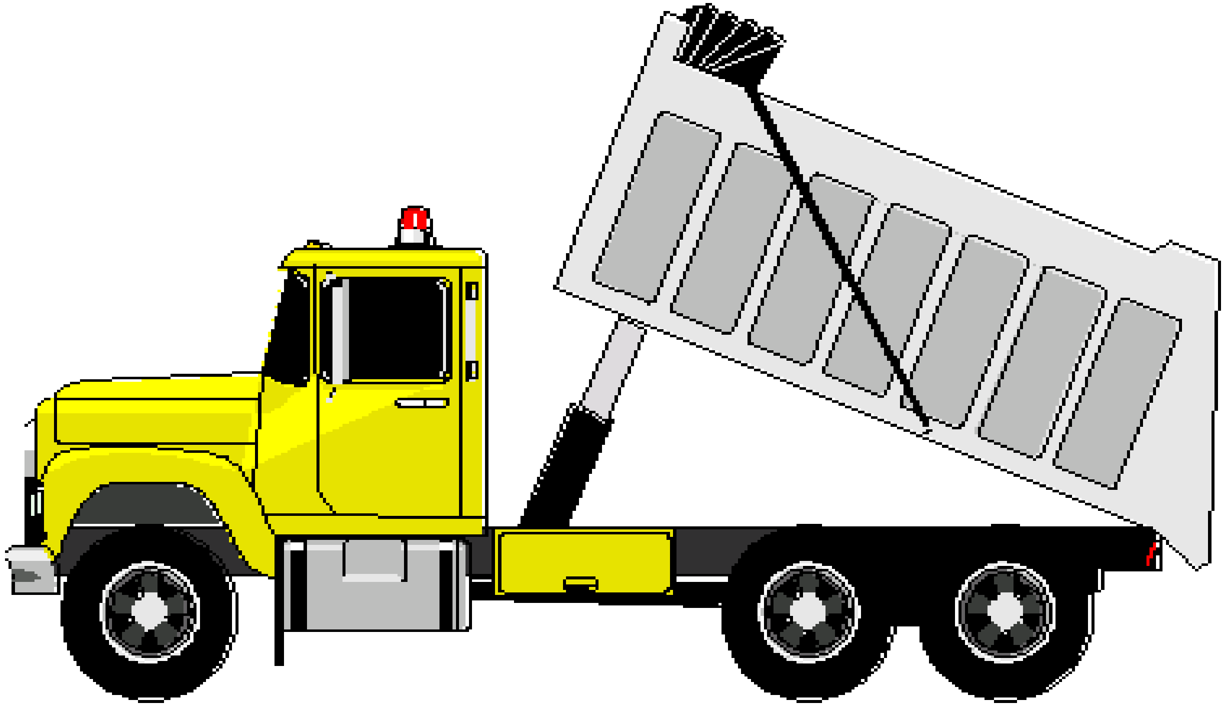
- Changes in paving speed may require feeder system adjustments

- Too often, paver speed changes, but feeder system ratio dials or flow gates are not adjusted to match new paver speed to maintain 20 - 40 rpm auger speed

Quick Starts & Stops – Head of Material



Proper Truck Dumping



- Cover up
- Bed raised slightly
- Release tail gate
- Raise bed enough to dump mass of mix into hopper – not trickle mix into hopper

Managing Segregation – Truck Exchange

Defects Related to Truck Exchange

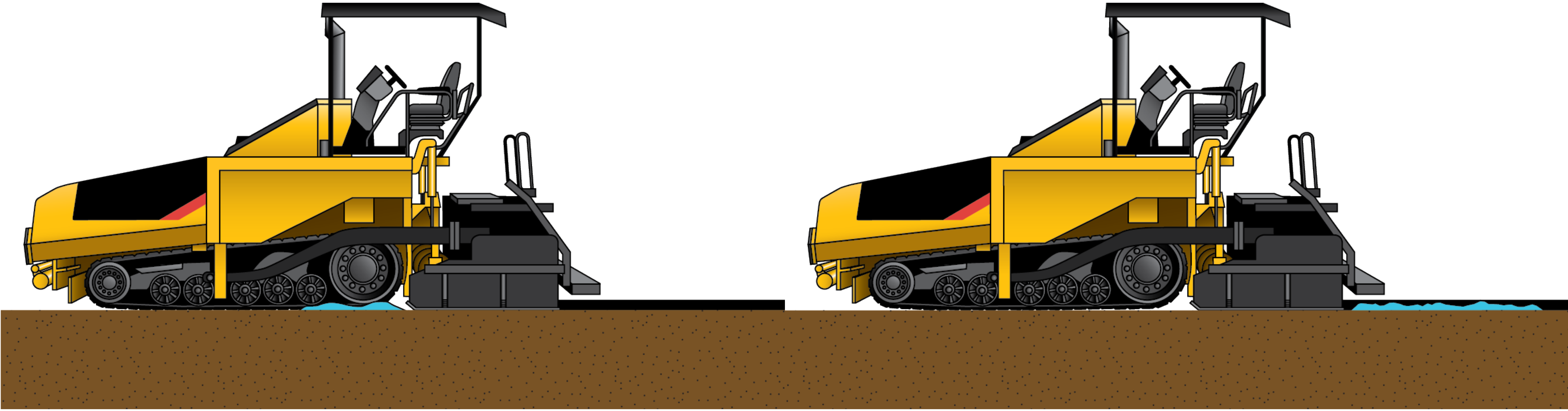
- Truck bumping paver
- Spills on grade
- Low hopper level

Trucks Bumping the Paver

Pave & Fold Hopper Wings

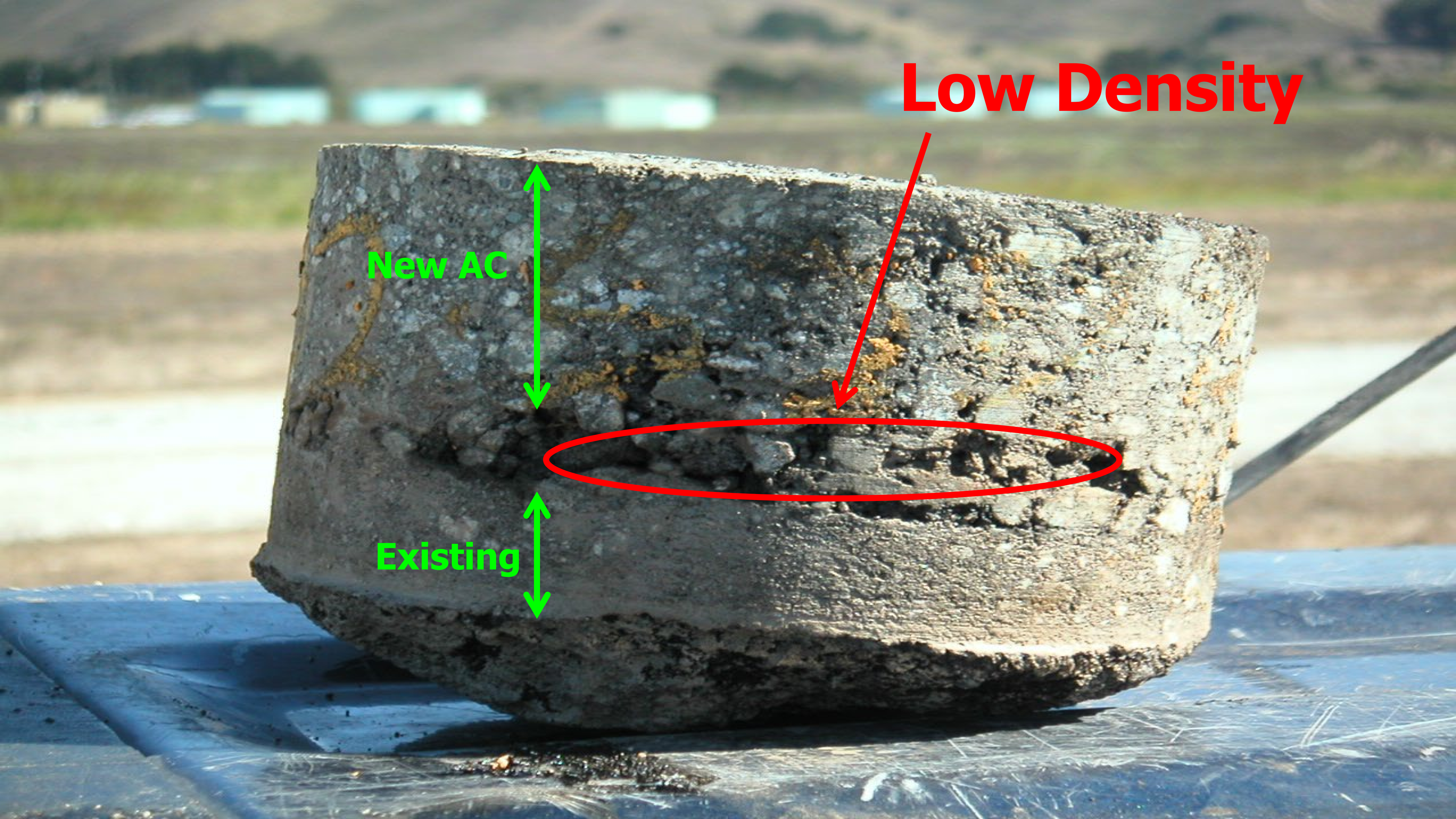
- Step three - continue paving at normal speed
- Slowly fold hopper wings combining mix from sides with mix in middle

Spills on grade are BIG mistakes!



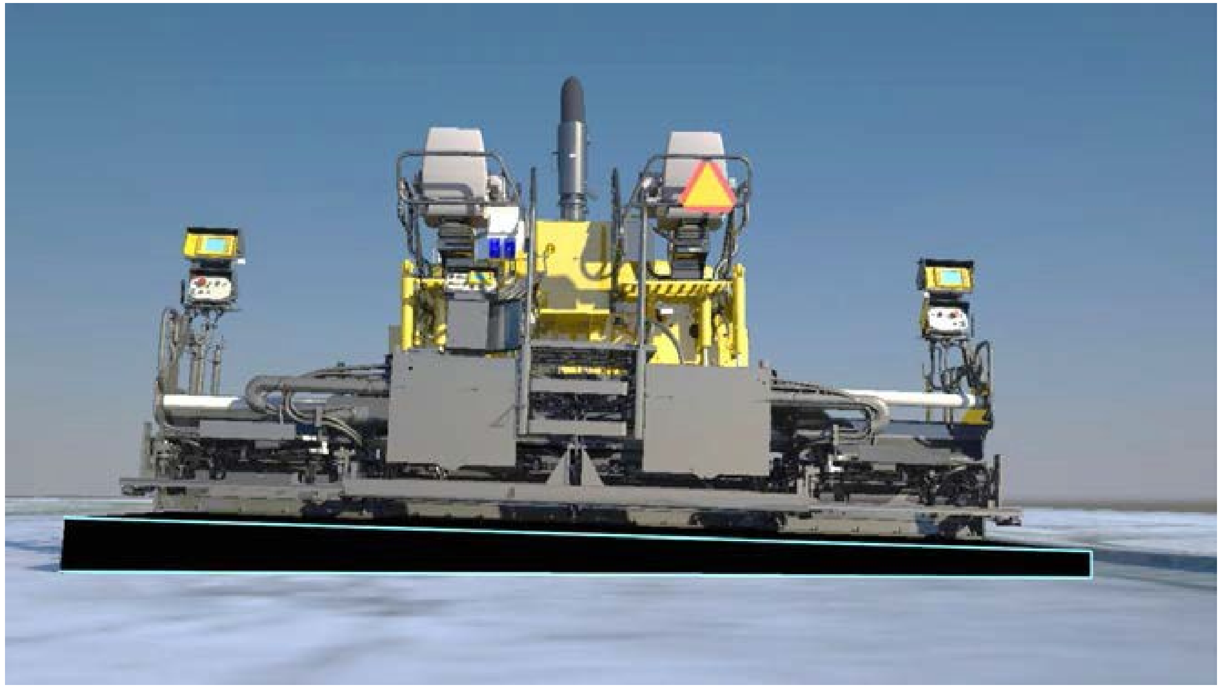
Spills on grade

- Potholes
- Density problem
- Smoothness problem



Low Density
New AC
Existing

What is Grade & Slope?



Grade
(thickness)

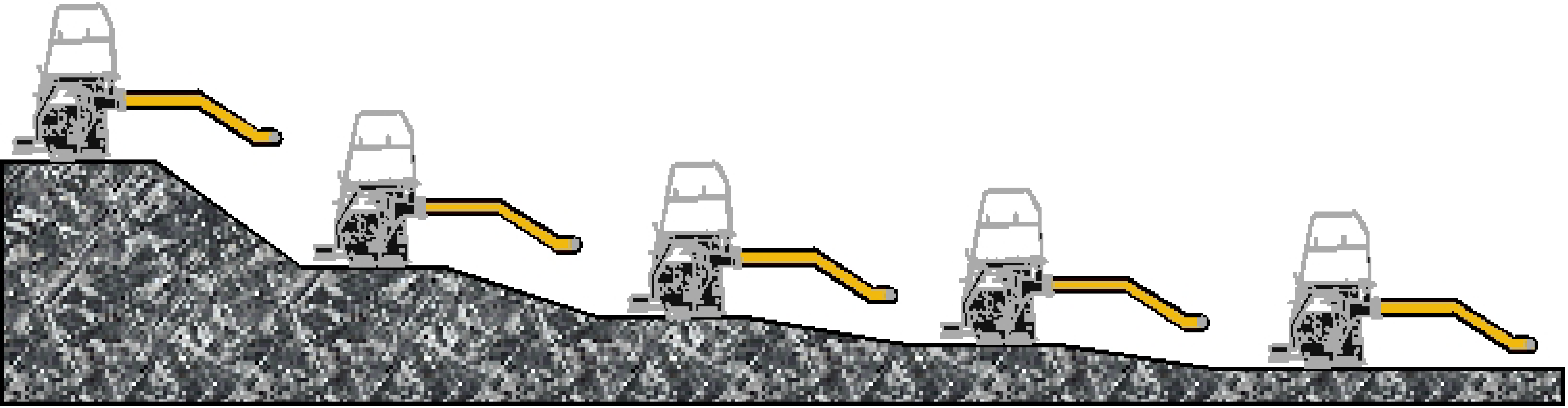
Slope
(% fall)

Change Thickness and Slope by Changing Angle of Attack

- Use depth control cranks or "screws"
- Use tow points

Change Over 5 Tow Arm Lengths

- 65% of change occurs in the first tow arm length
- 35% of change occurs over 4 tow arm lengths



Advantages of Automatic Grade & Slope Control

- Constant mat thickness
- Better yields/quantities
- Smoother roads
- Precise corrections
- Hands-off operation

Automatic Grade & Slope Components

Display Box(s)

Control Box (computer)

Slope Sensor (fixed)

Grade Sensors

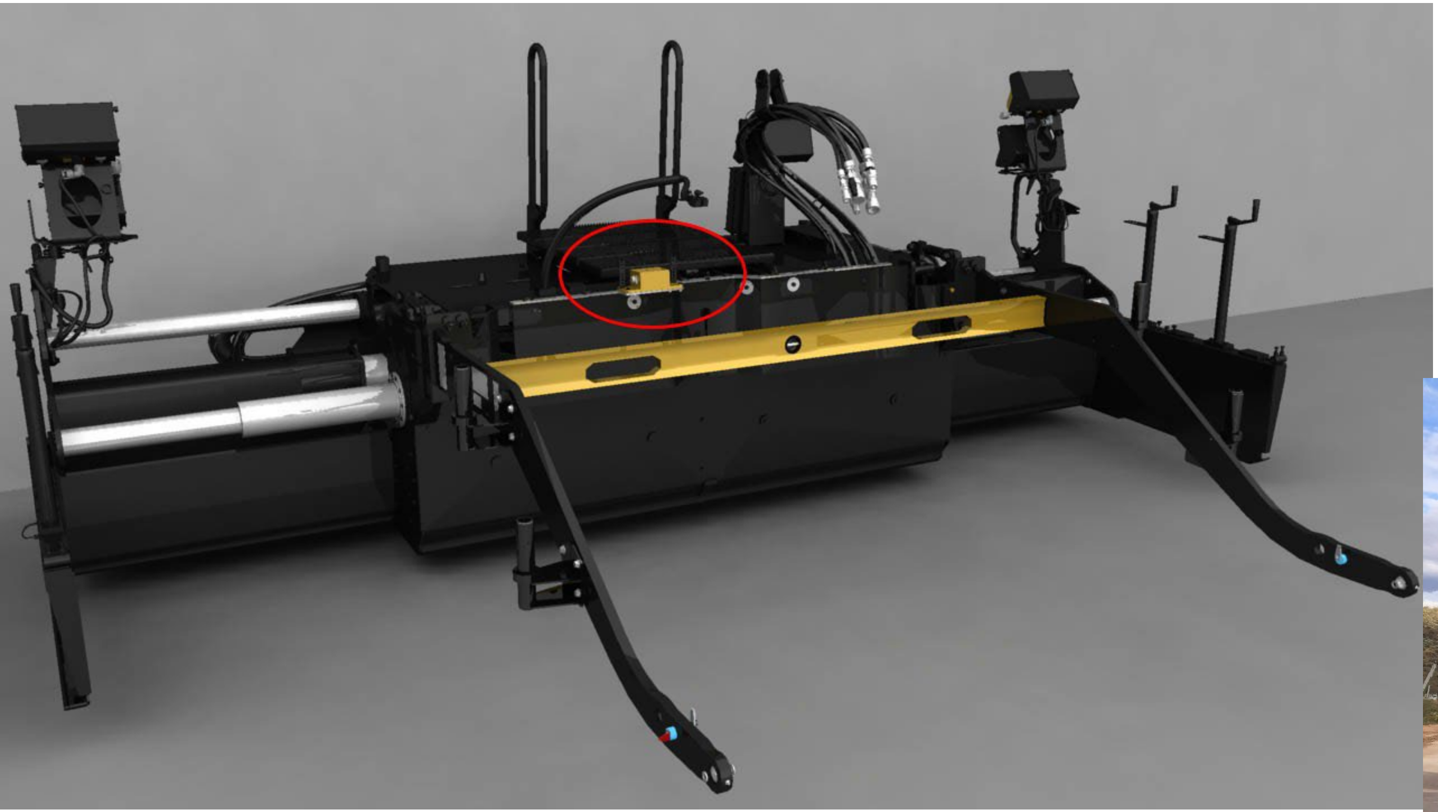
Grade Control

Grade sensor is a moving tape measure

Reading distance to grade

Reading distance to string

Slope Control



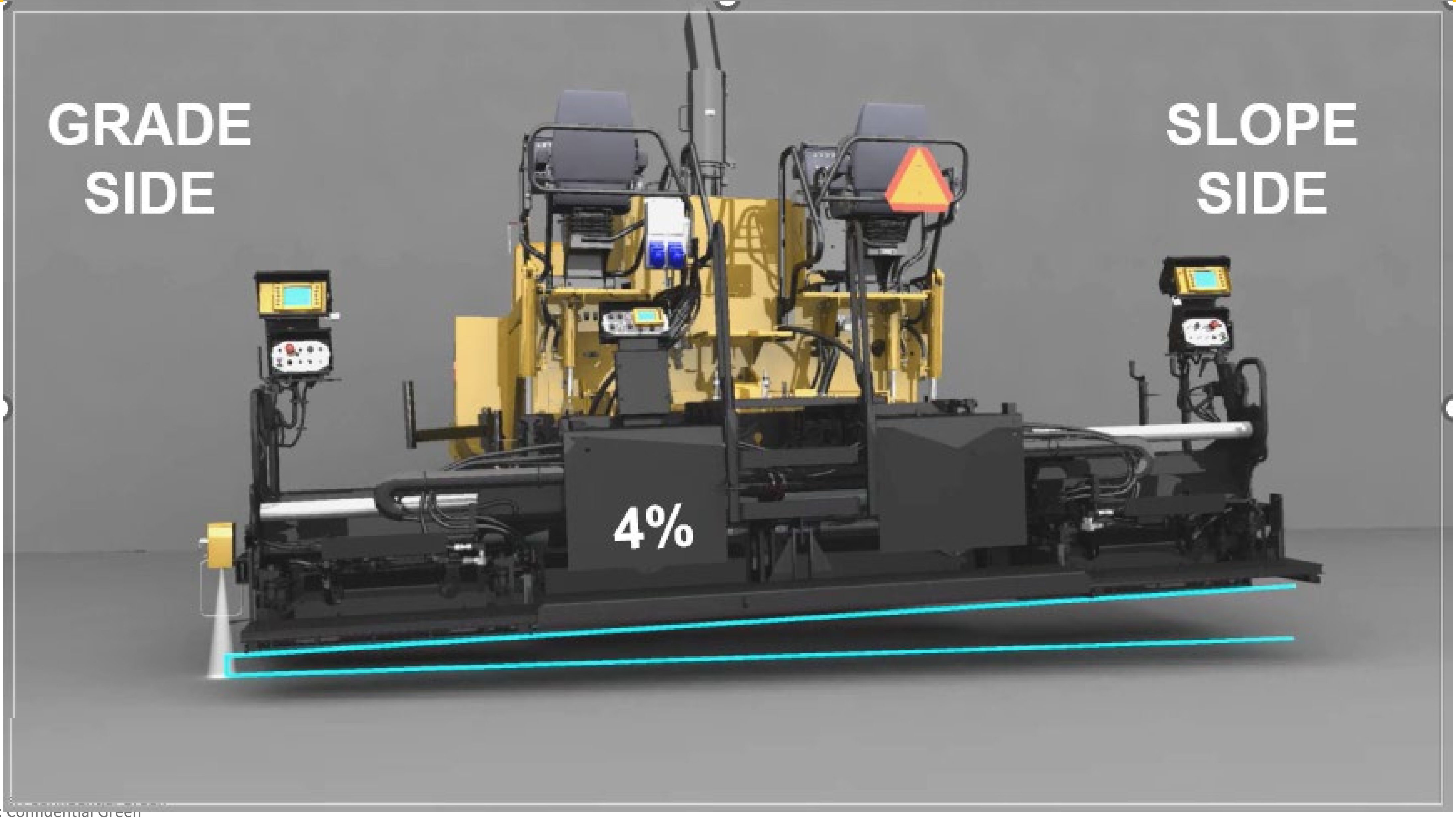
Slope box is like a carpenter's level

How Does Automatic Grade & Slope Work?

- Computer-controlled measurements
- Measurements several times/second
- Signals are sent to hydraulic cylinders to cause tow point movement
- Tow point movement results in mat thickness changes and/or slope changes

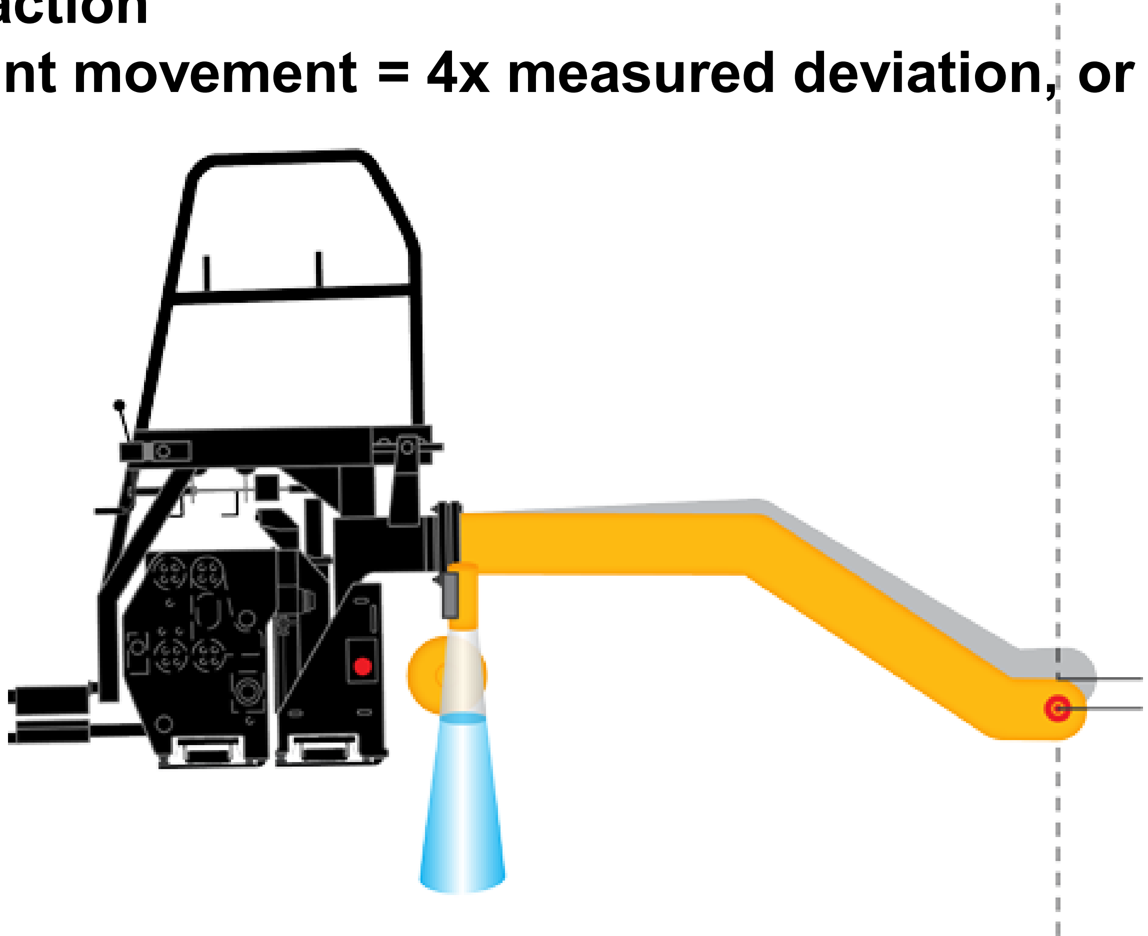
Grade Control Communication

Slope FOLLOWS Grade Side Changes



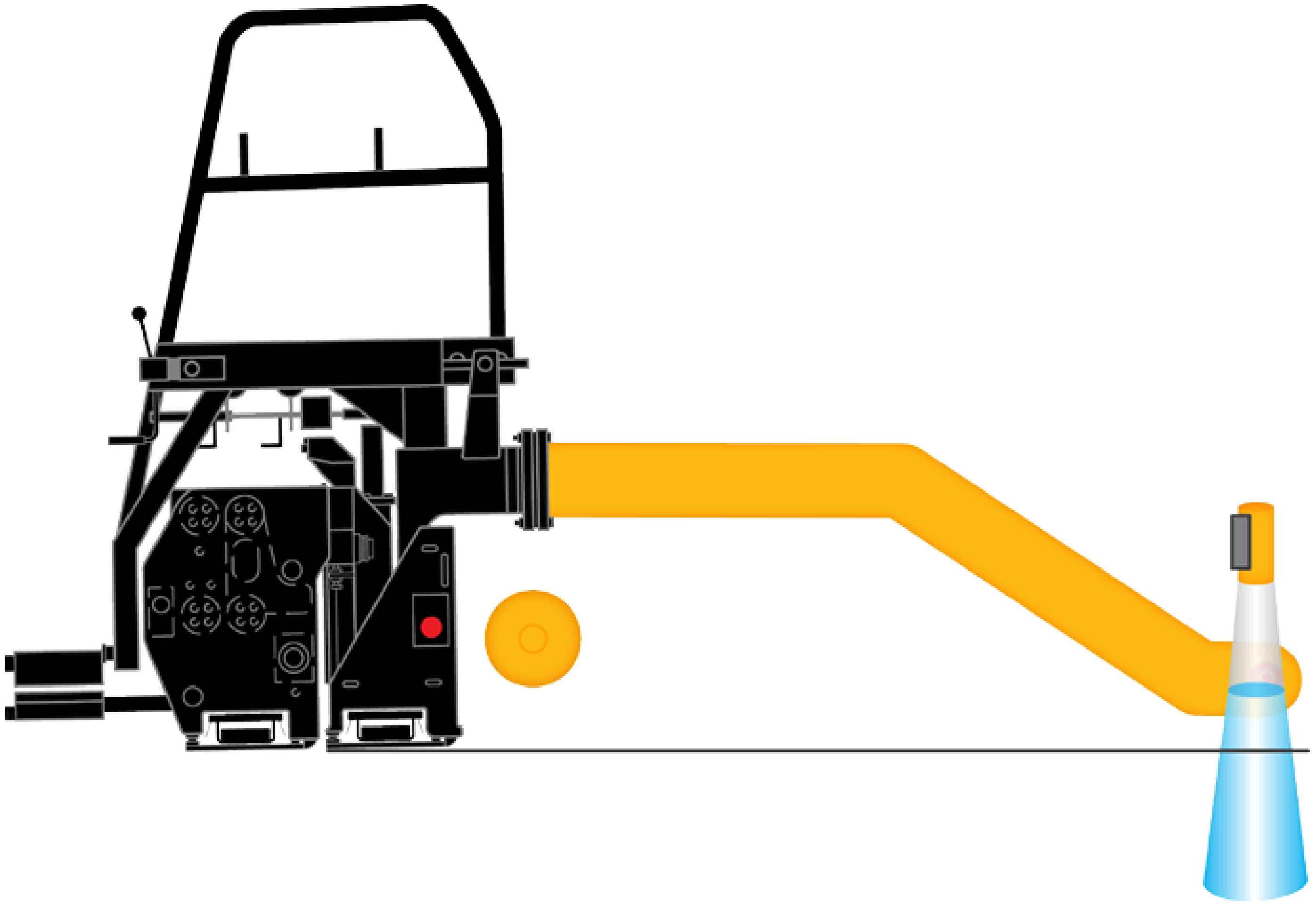
Sensor Position for Joint Matching = Yield

- Sensor at auger for joint matching
- Follows existing grade - no improvement
- Precise yield
- Fast reaction
- Tow point movement = 4x measured deviation, or 4:1



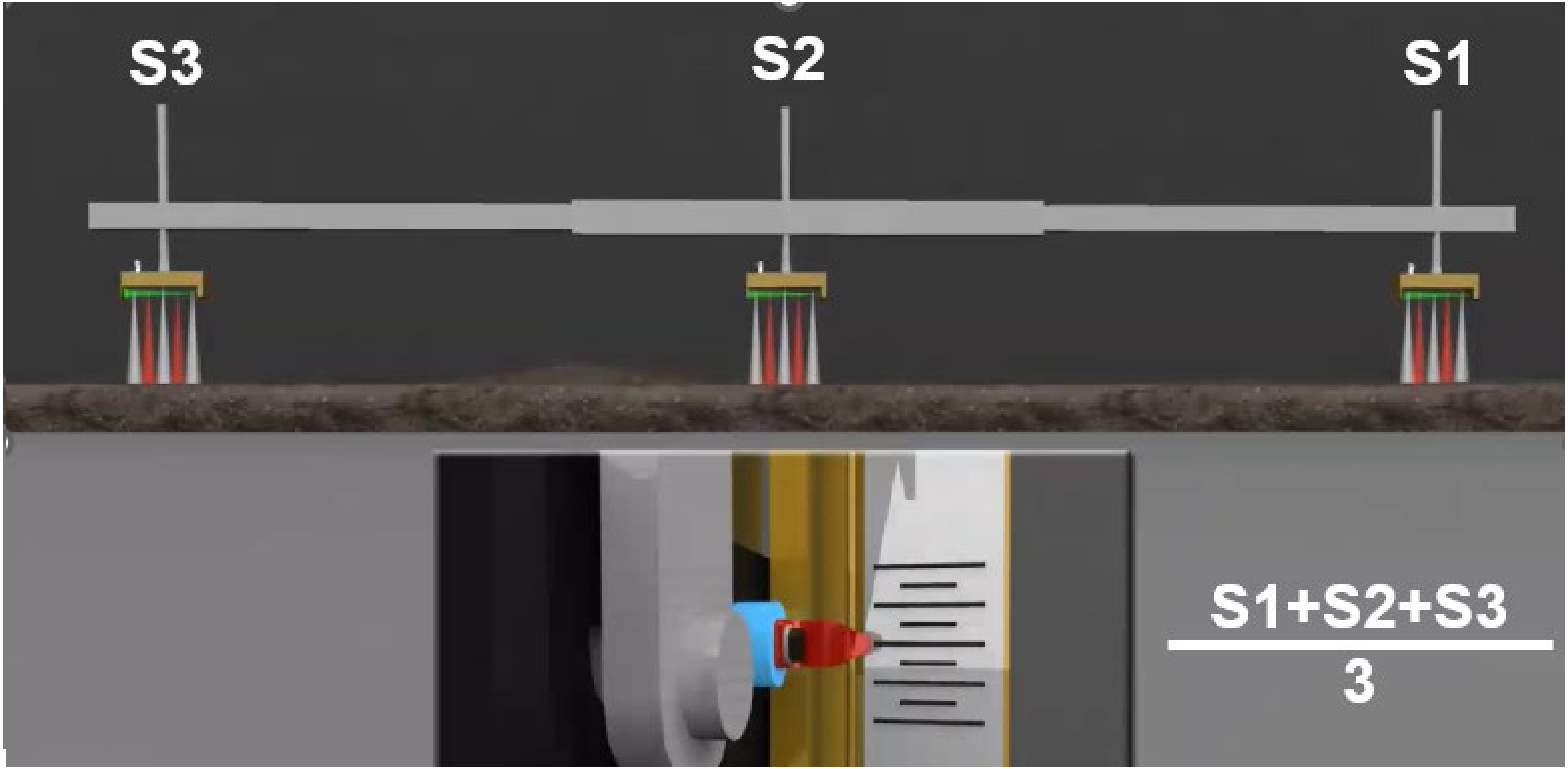
Joint Matching

Sensor Position for Smoothness ≠ Yield



- Sensor at tow point for smoothness
- Slow reaction
- Fills in lows, smooths off high spots
- Difficult to control yield
- Tow point movement = 1x measured deviation, or 1:1
- Screed reacts over 5 tow arm lengths

Sonic Averaging Ski



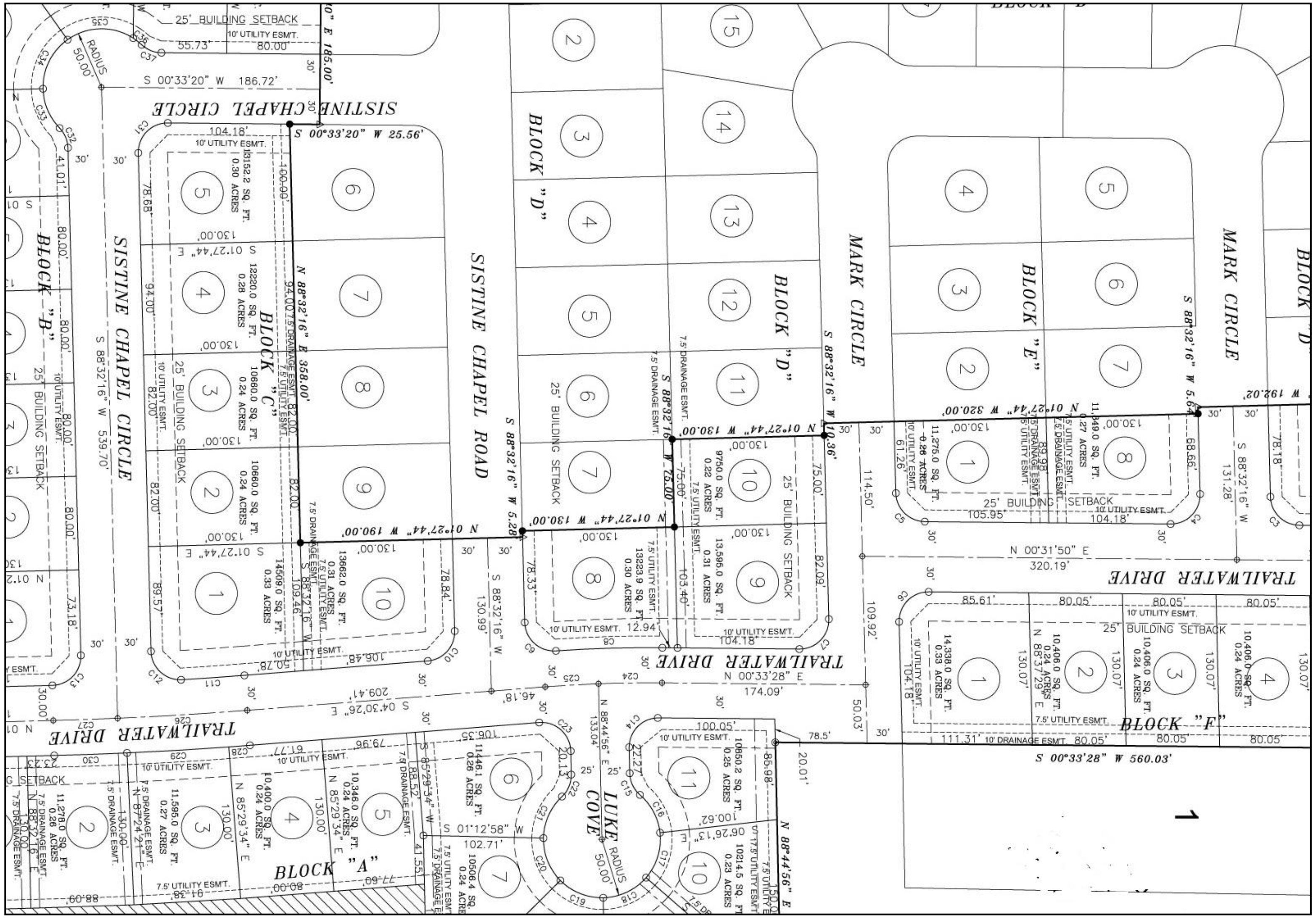
Finding a Good Reference

- Find a reference surface for automatic grade control
  - Concrete curb?
  - Existing grade?
  - Setup stringline?
- Note: curb reference for single grade sensor at auger
- Placed to get exact thickness at the curb

Finding a Good Reference

- Could move grade sensor towards tow point for better smoothness
- Left side single sensor following other curb
- Base is well-graded here

Layout Subdivision



- Careful planning required
- Obstacles
- Reference for automatic grade control (if using)

Obstacles




Obstacles

- Multiple lifts may require extra handwork around obstacles
- Raising the end gate to clear the obstacle may help reduce handwork

How Compaction Affects Smoothness

- Roller stops at an angle to the mat
- Roller stop in cold area of the mat, or off the mat
- Cross-roll transverse joints
- Don’t get ‘trapped’ by paving sequence!

Thank-you for your attention!

CAT
BUILT FOR IT.

GPS & Intelligent Paving

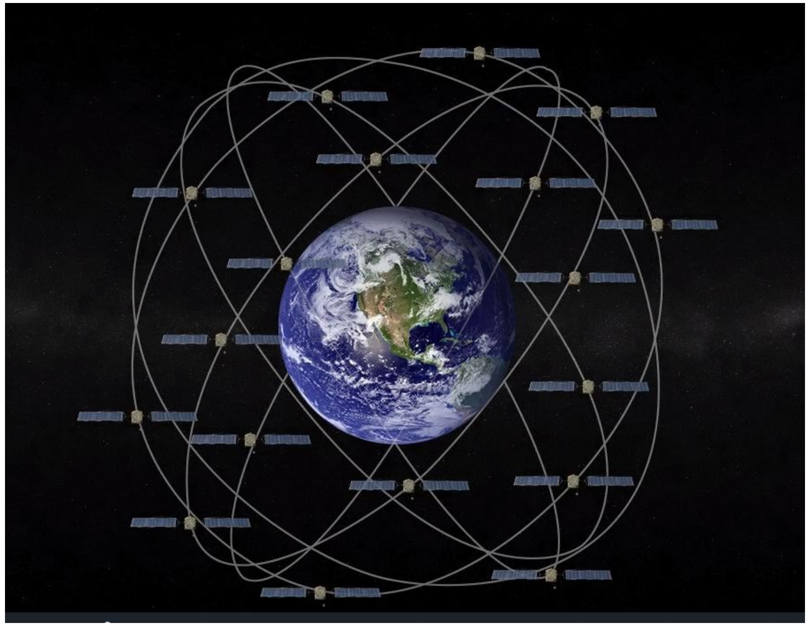
MoDOT Black to Basics Spring Training 2024

Presented By: Connor Kennedy, Accounts Manager – Paving Technologies

Ozark Laser & Shoring

What is GPS?

- NAVSTAR = GPS (Global Positioning System)
- Global Navigation Satellite System (GNSS)
  - GLONASS = Russian Positioning System
  - BeiDou = Chinese Positioning System
  - Galileo = European Union Satellite System



How Does It Work?

- Real Time Kinematic (RTK)
  - Method of correction where a static base station(s) within a general area of the rover can gather, compute and relay correction data of the exact same satellites the rover is reading
  - Brings accuracy to higher levels (+/- ½”)
  - Requires communication from base station to rover
    - RTK Network – Requires cellular signal to transmit correction data
    - Base & Rover – Requires UHF or 915 radio frequency to transmit correction data
- Post Processed Differential GNSS
  - Two or more static base stations collecting data simultaneously over a defined course of time
    - Due to being static for a long period of time, we can get positional accuracy within 1/8” or less
  - Can be collected by placing multiple static base stations on the job site, or from multiple reference stations (Network)
  - Must be calculated on software that can post process GNSS data from multiple base stations over a designated amount of time

Intelligent Compaction

Compaction and Tracking System

- Accurate pass count display
- Secure connectivity to Sitelink3D services
- Synchronized mapping with customized reporting
- Meets FHWA intelligent compaction standards
- Ruggedized temperature and accelerometer sensors

PG-S3 GNSS Antenna

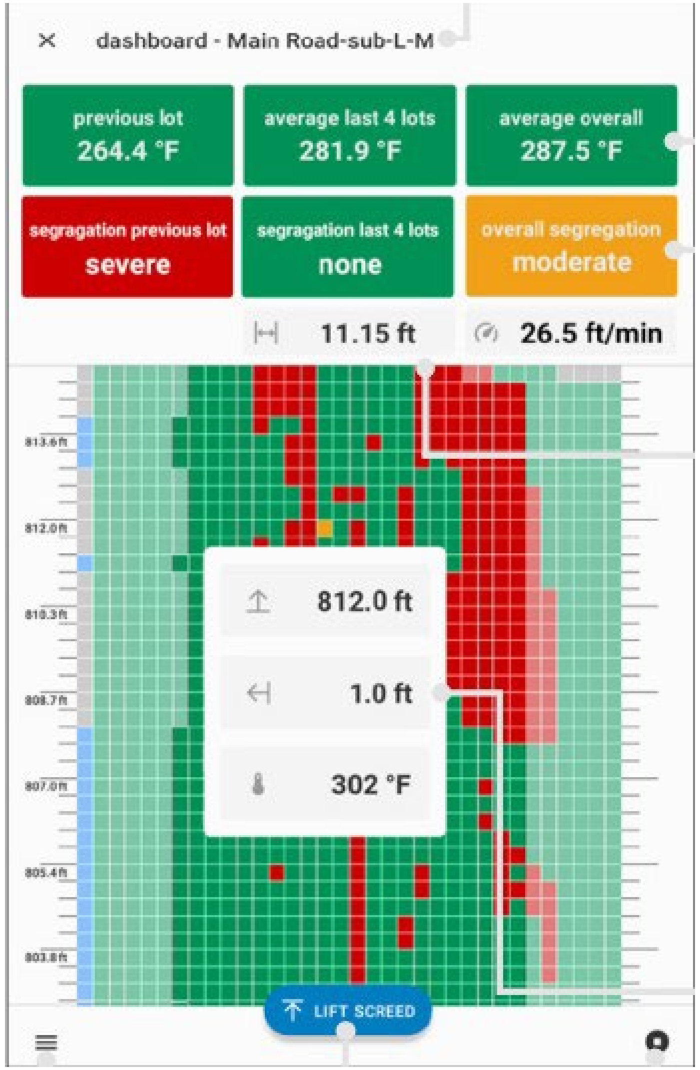
Accelerometer

IR Temperature Sensor (Front & Rear)

GNSS, Radio and Cellular Receiver

OZARK LASER

Thermal Mapping



- ❖ Paver Universal
- ❖ Can be installed/swapped in +/- 30 min
- ❖ No rolling calibration due to onboard RTK functionality
- ❖ Contained on one mount
- ❖ Network, UHF & 915 Capable

GR-i3F GNSS Antenna

TH-C1 Thermal Camera

4G Diversity Antenna

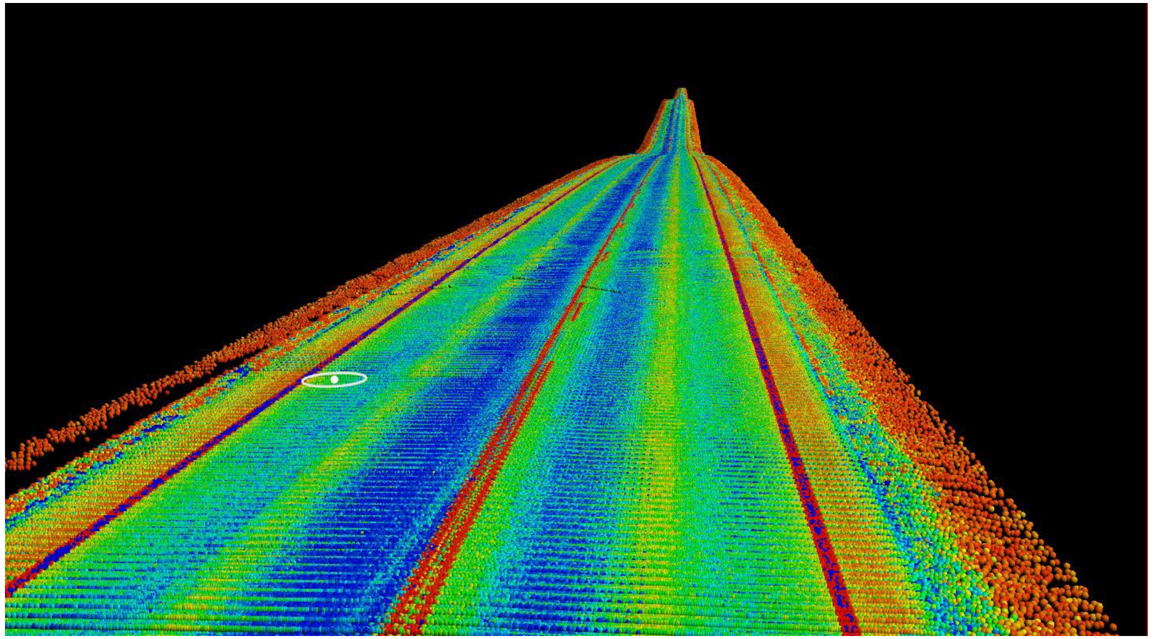
MC-X1 Controller & UR-1 Universal Radio

TH-P1 Thermal Processor

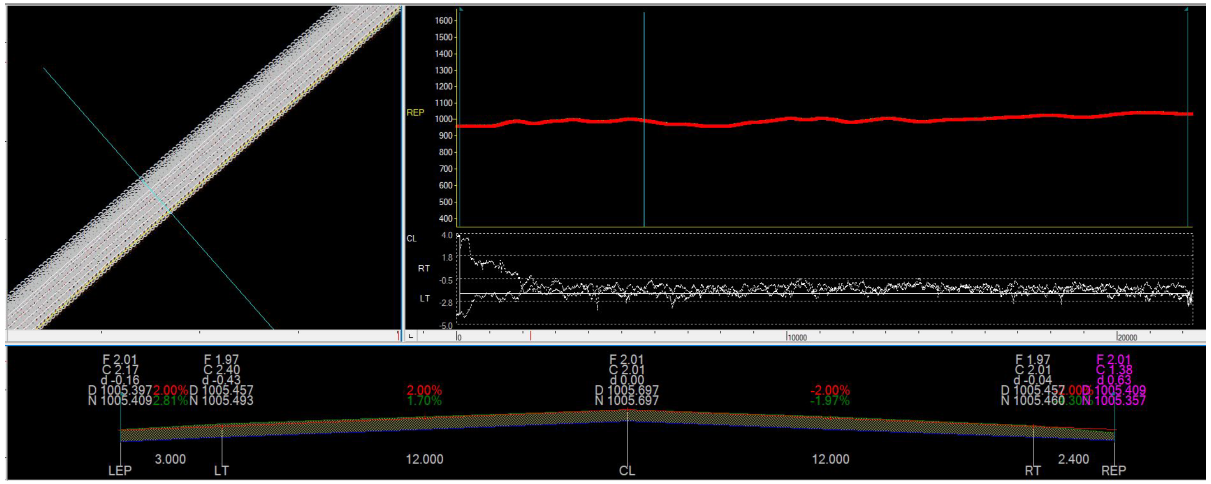
FC-6000A Data Collector

LiDAR Road Scanning

- Scan in open traffic at highway speeds
- Can easily reach 1/8” accuracy when tied to ground control
- Universal hitch receiver, can be mounted and ready to scan in an hour or less



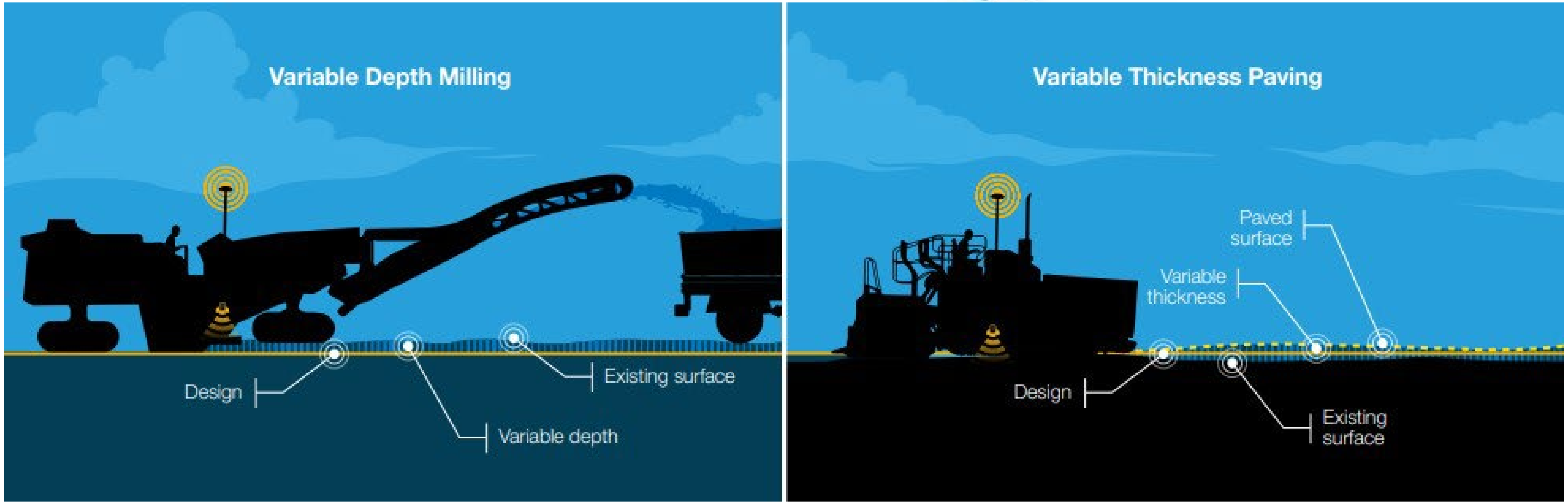
Magnet Collage Cloud Processing



Magnet Office Construction with Resurfacing

SmoothRide Milling & Paving

- Virtual Ski cuts design time in half
- Accurate material quantities and tracking
- Takes guess work out of headers and joints
- Reduced need for ground and screed personell



Cloud & Application Services

Collage

Sitelink3D

Office

- Daily Production and Machine reporting
- Remote Support Desk

- Estimate, design, and plan
- Resurfacing module makes match constraints easy

Our Team

- Eddie Brown, Vice-President – Construction Technologies
  - Email: ebrown@ozarklaser.com
- Connor Kennedy, Accounts Manager – Paving Technologies
  - Email: ckennedy@ozarklaser.com Phone: 417-839-4246
- Price Bowles, Professional Services – Paving Technologies
  - Email: pbowles@ozarklaser.com Phone: 417-880-7024
- Kary Harshbarger, Professional Services – Magnet/Survey/Paving
  - Email: kharshbarger@ozarklaser.com Phone: 913-788-0535

Leading Edge Technology in **GEOPOSITIONING**

Constructing Quality Longitudinal and Tr ansverse Joints

2024 MAPA: Black to Basics 2/7/2024

Jim Cunningham & Cullen Hesterberg

EVERGREEN ROADWORKS

Asphalt Materials, Inc.

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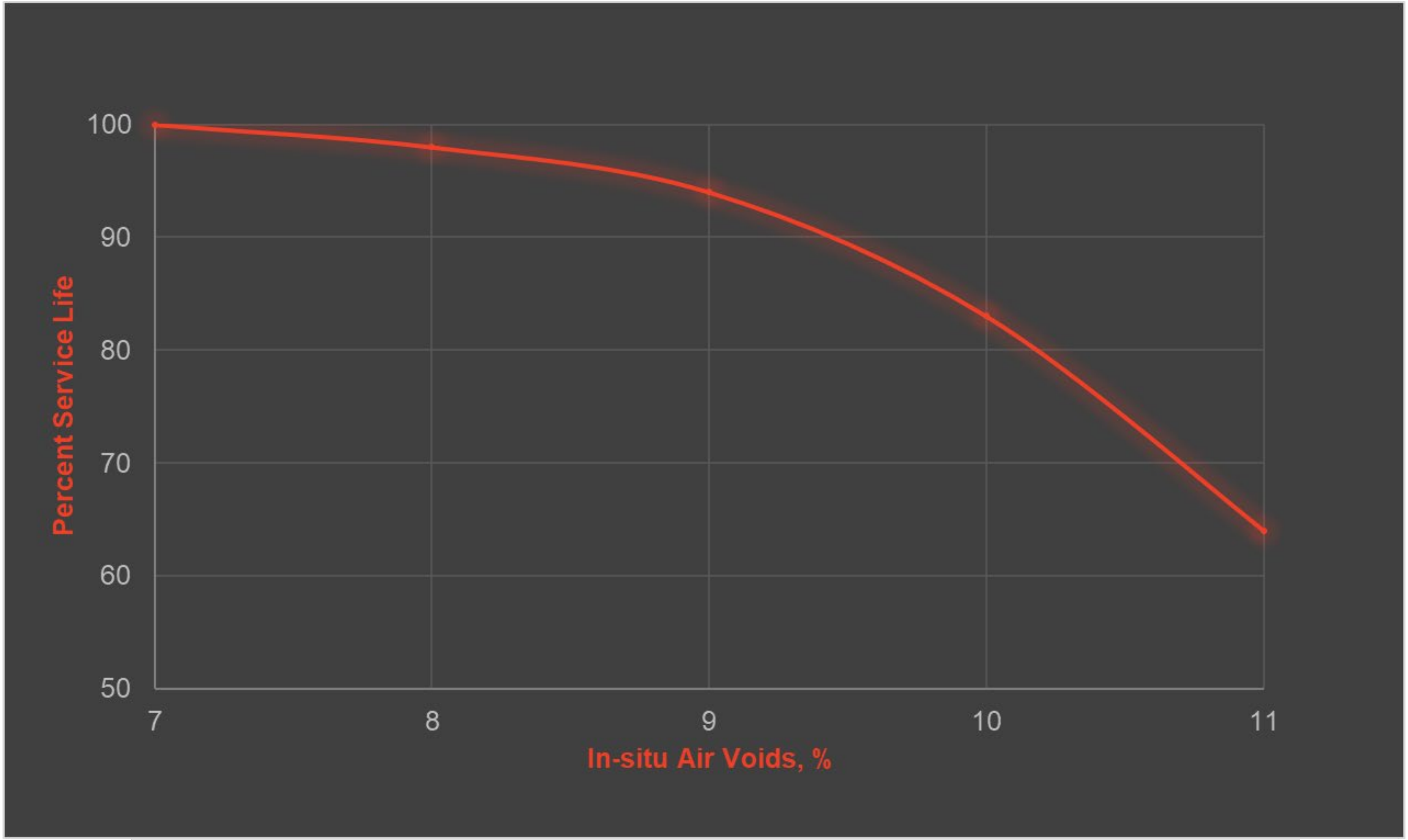
Why do joints fail early?



93% 92% 91% 90% 89%

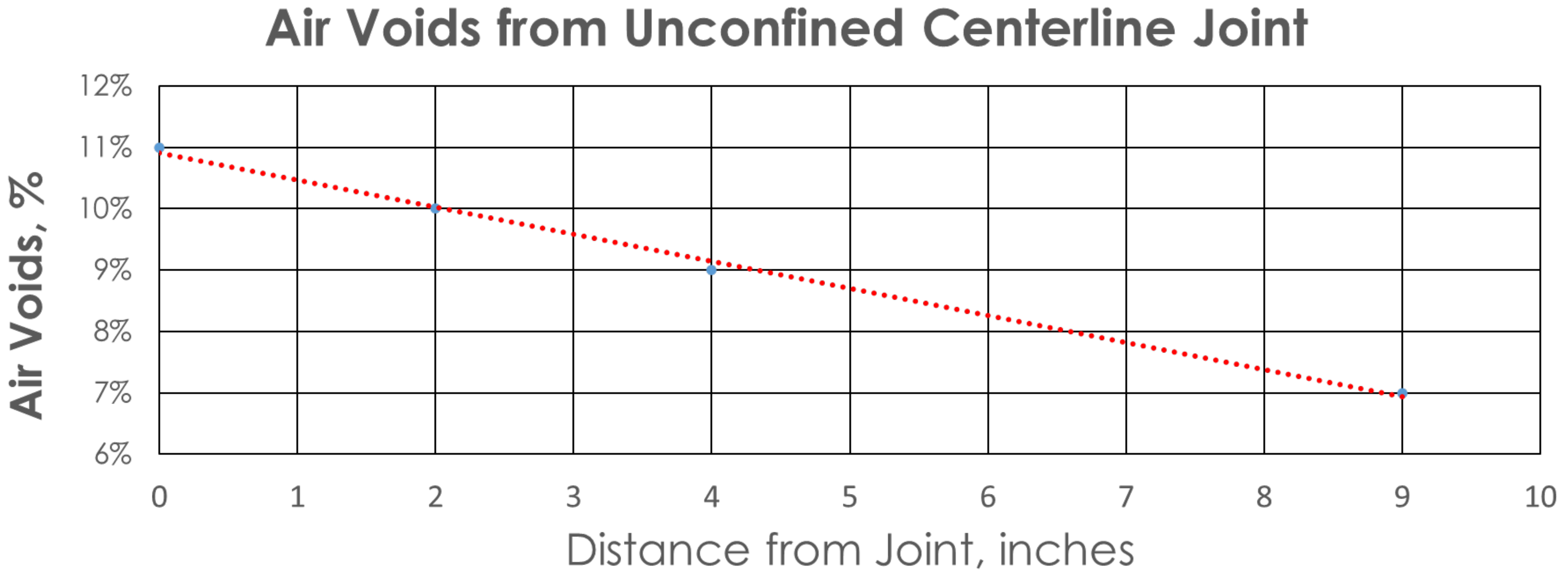
Compaction Level

*Washington State DOT Study
"Effect of In-Place Voids on Service Life"

Longitudinal Construction Joints

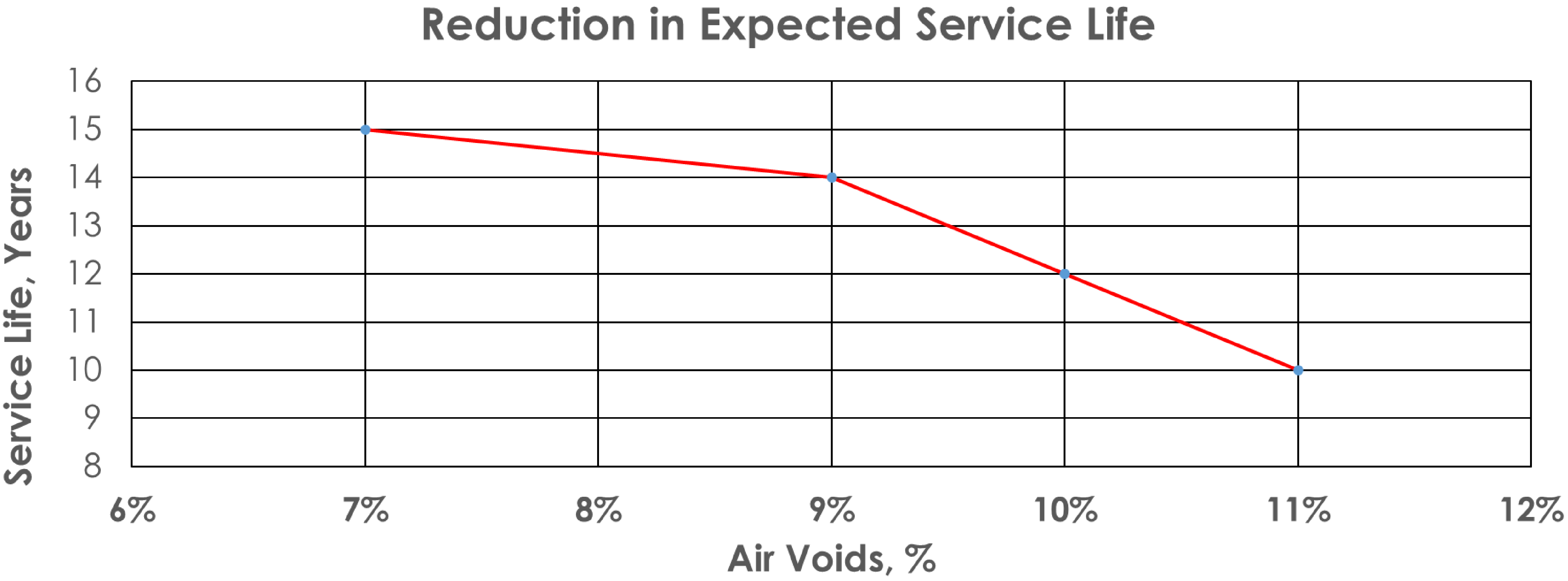
- Issues
  - Cannot achieve the same density at the joint as in the mat
  - Water and air intrusion accelerates damage
- Longitudinal construction joints
  - Commonly, the first area requiring maintenance on a pavement

Air Voids from Joint Towards Center of Lane



Centerline going towards interior of mat →

Effect of Air Voids on Pavement Service Life



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  - Echelon paving (hot joint)
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  - Cutting wheel
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Full Width Paving

Echelon Paving

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Pave wide/mill back

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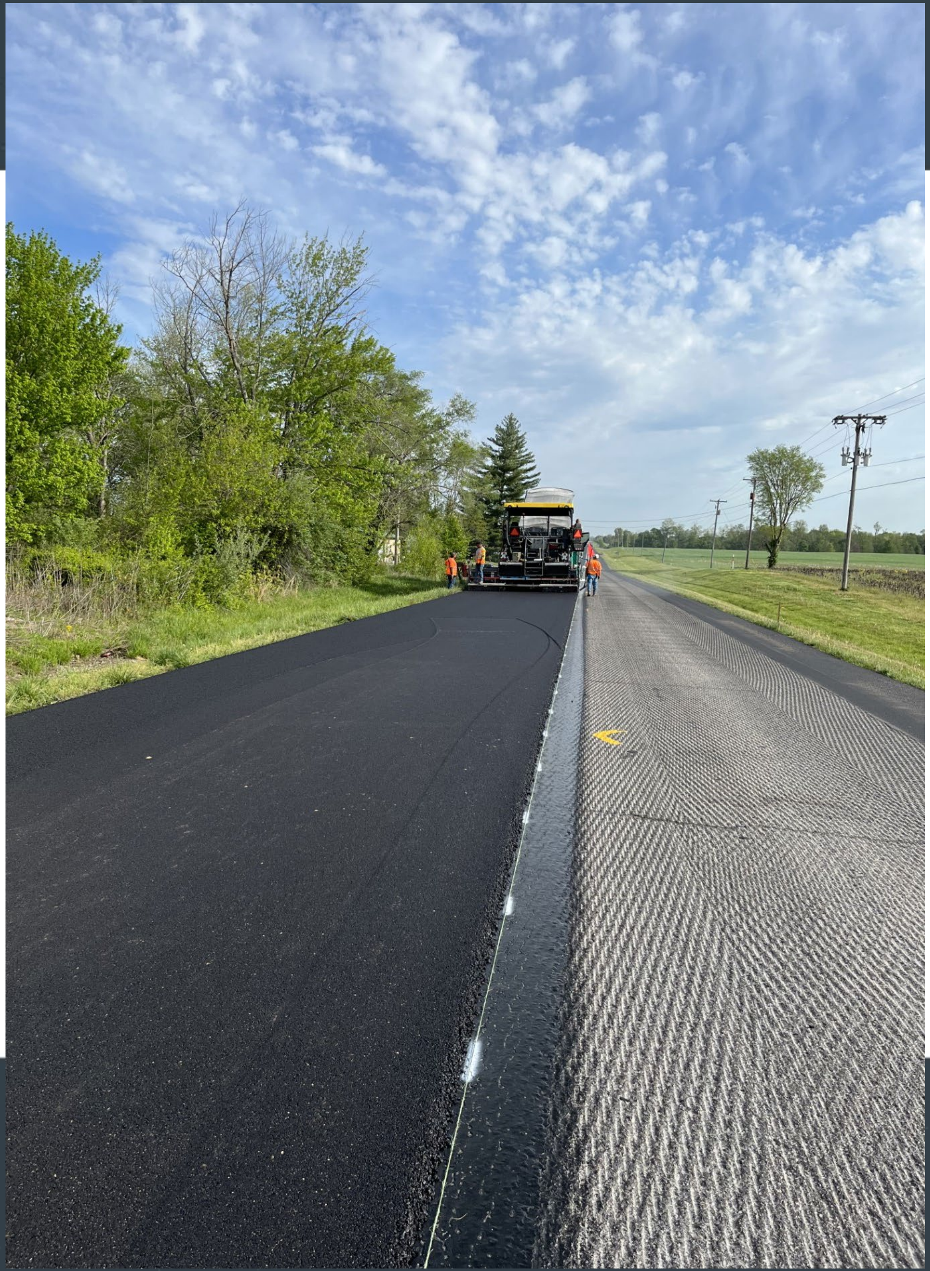

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Contact Ski

Non-Contact Ski

End Gate Up

End Gate Down

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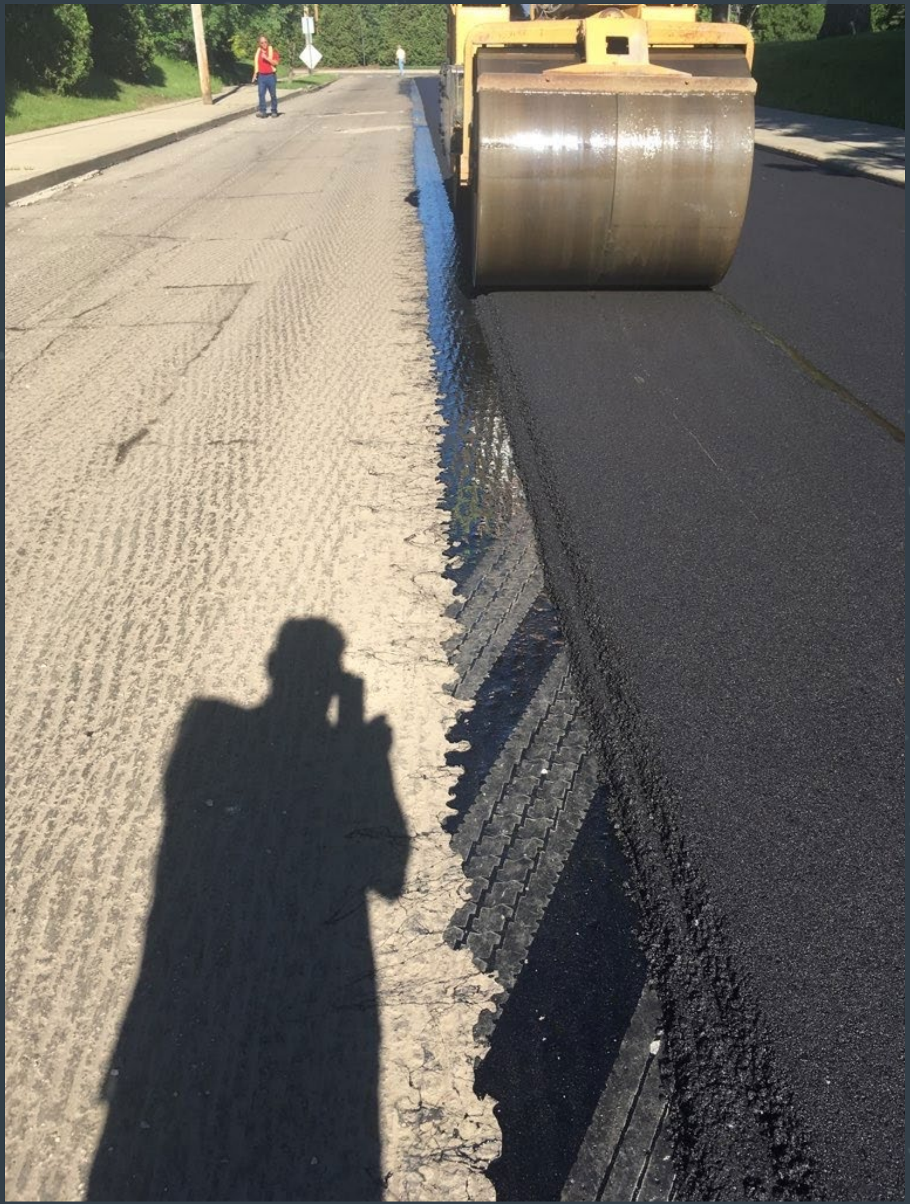

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Rolling Patterns

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Paving 2nd Pass

Paving 2nd Pass

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Joint Pinching

- Left: Hot to Cold
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JBAND
The Bottom-Up Joint Solution

A Materials Solution

EVERGREEN ROADWORKS

Asphalt Materials, Inc.

Terminology

VRAM	Void Reducing Asphalt Membrane
LJS	Longitudinal Joint Sealant (*IL Terminology*)
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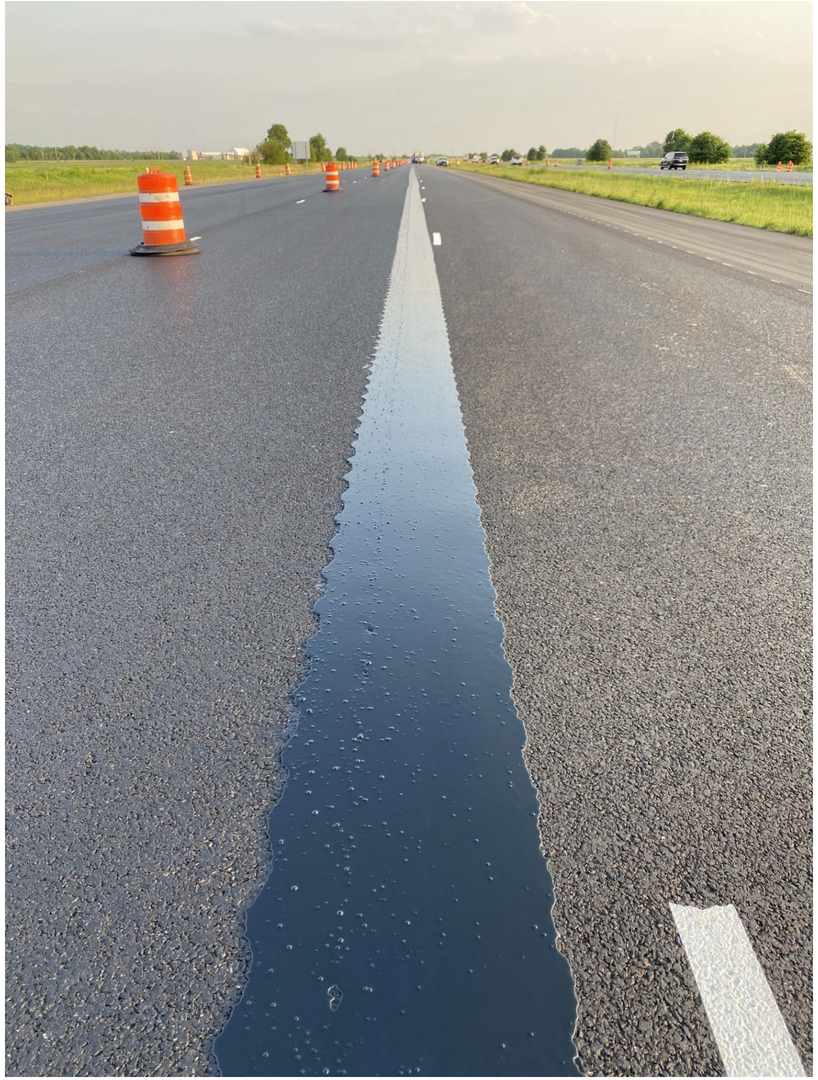
JBAND

Void Reducing Asphalt Membrane (VRAM)

Asphalt Materials, Inc. EVERGREEN ROADWORKS



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I-55 at Elkhart May 24, 2023

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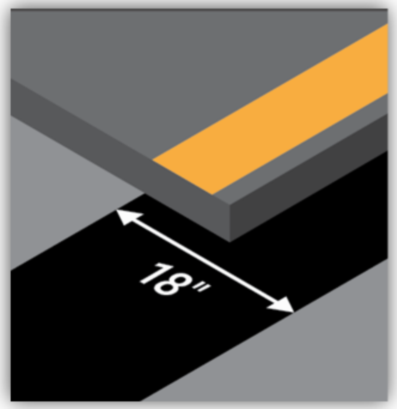
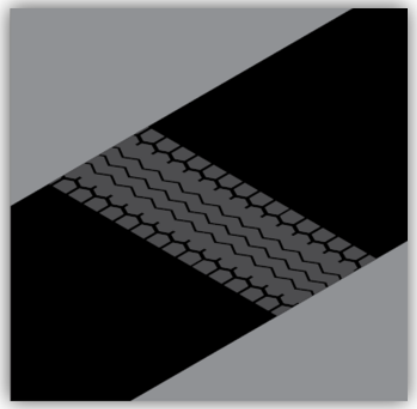


Place the first paving pass over half the width of the band of polymer-modified binder.



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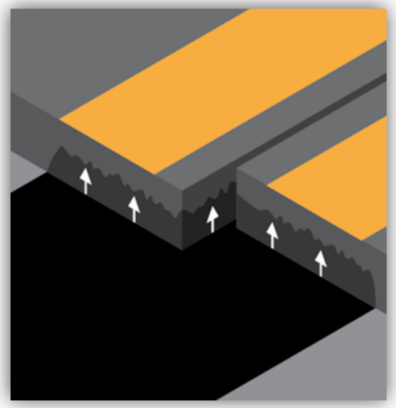

Polymer-modified binder migrates into the HMA at the joint.

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IL-13/IL-127 June 17, 2020

CH-4 Plainville Blacktop August 25, 2020

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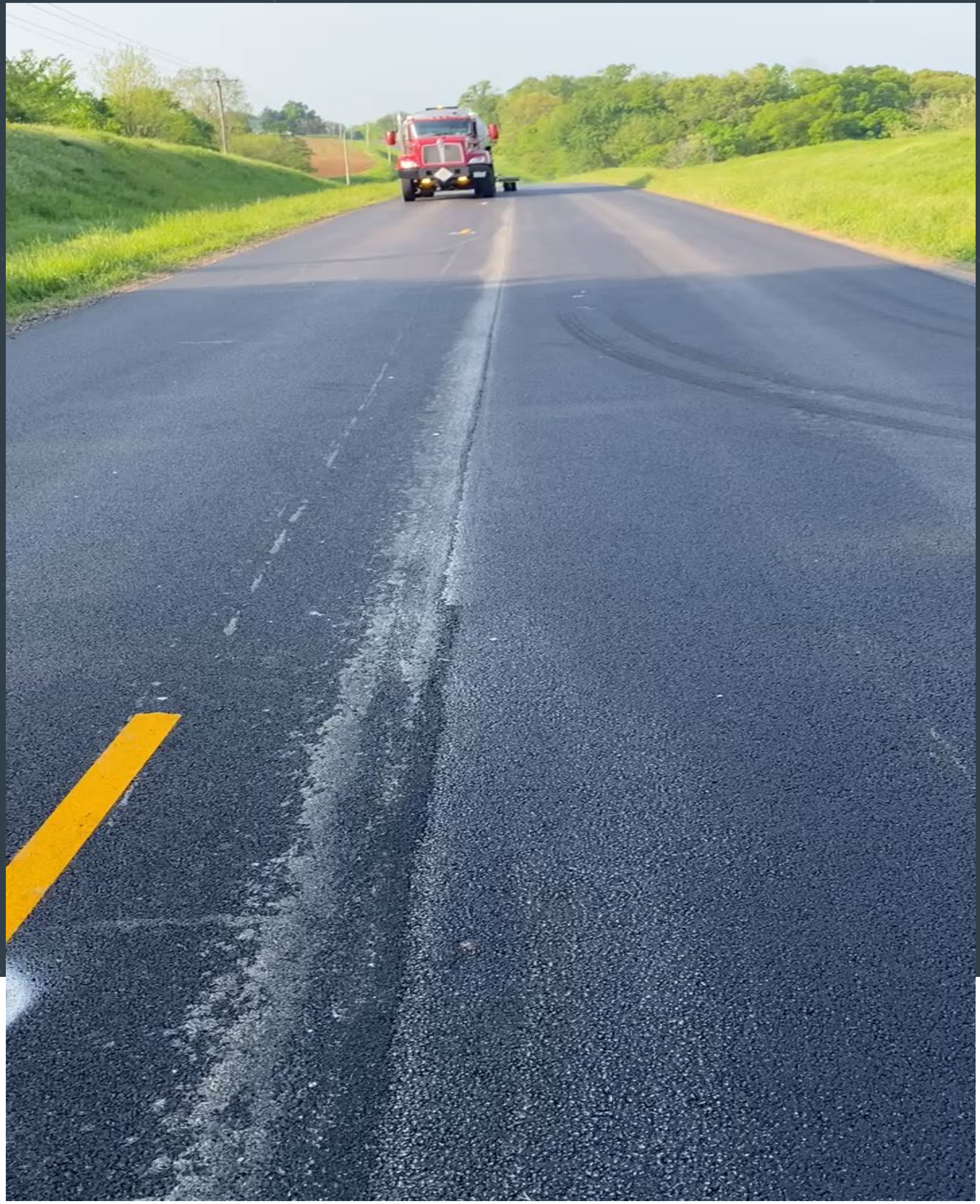

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ROADWORKS

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Sheboygan Falls, WI July 2022

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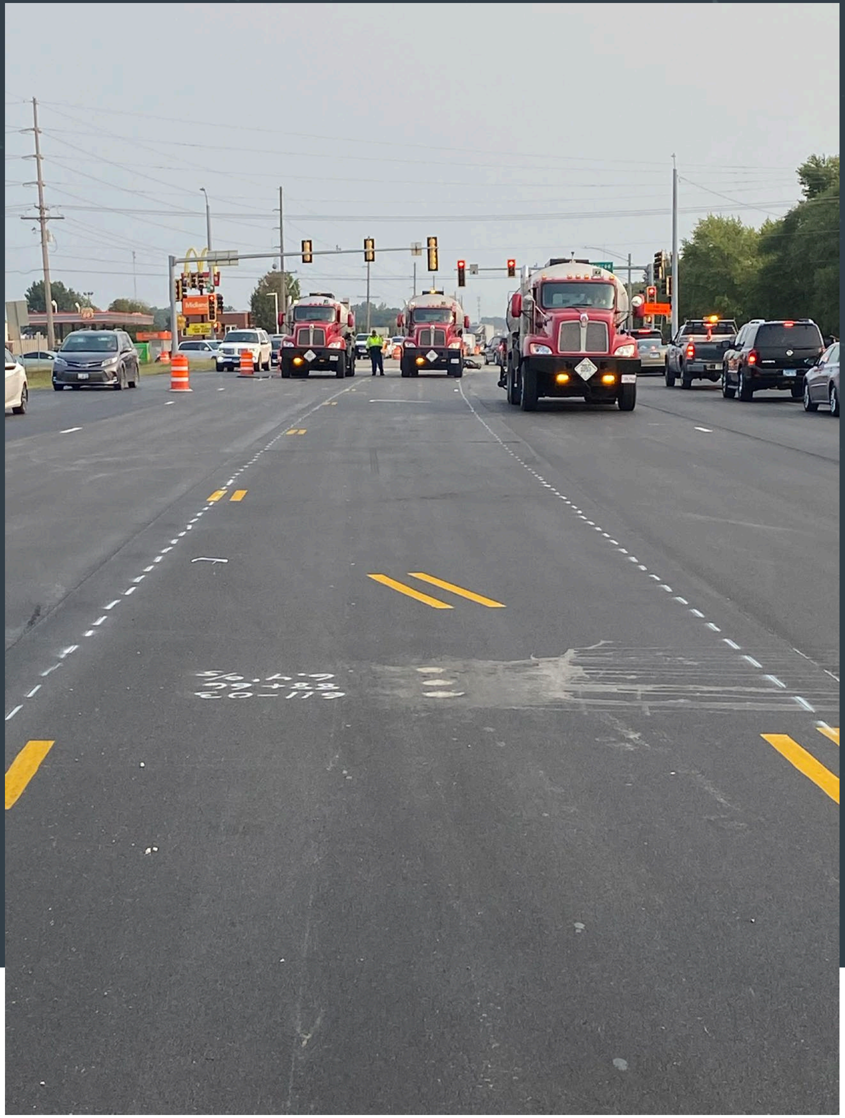

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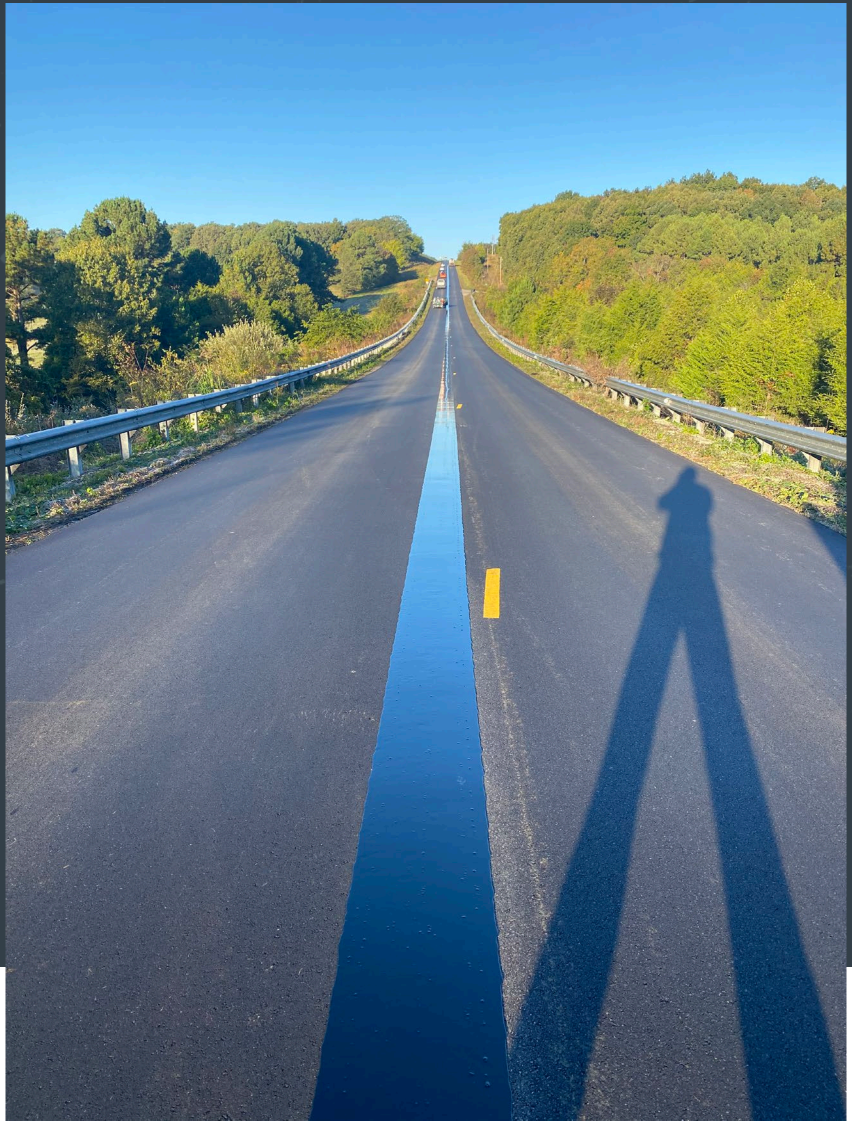

Goreville Road October 5, 2020

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Bloomington, MN May 2023

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IN-149 Porter County

July 27, 2021

Coles County Airport August 5, 2021

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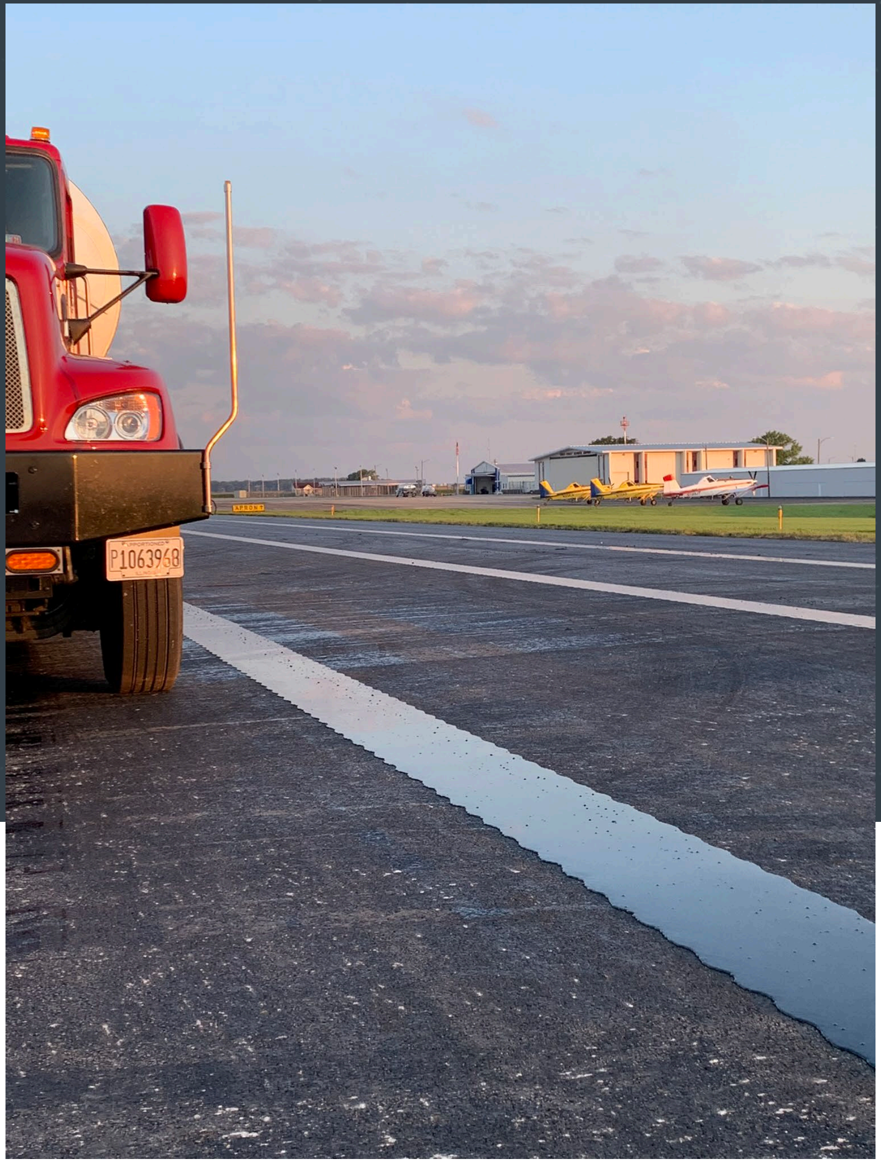

Bowling Green, Ohio Half Width VRAM

Asphalt Materials, Inc.

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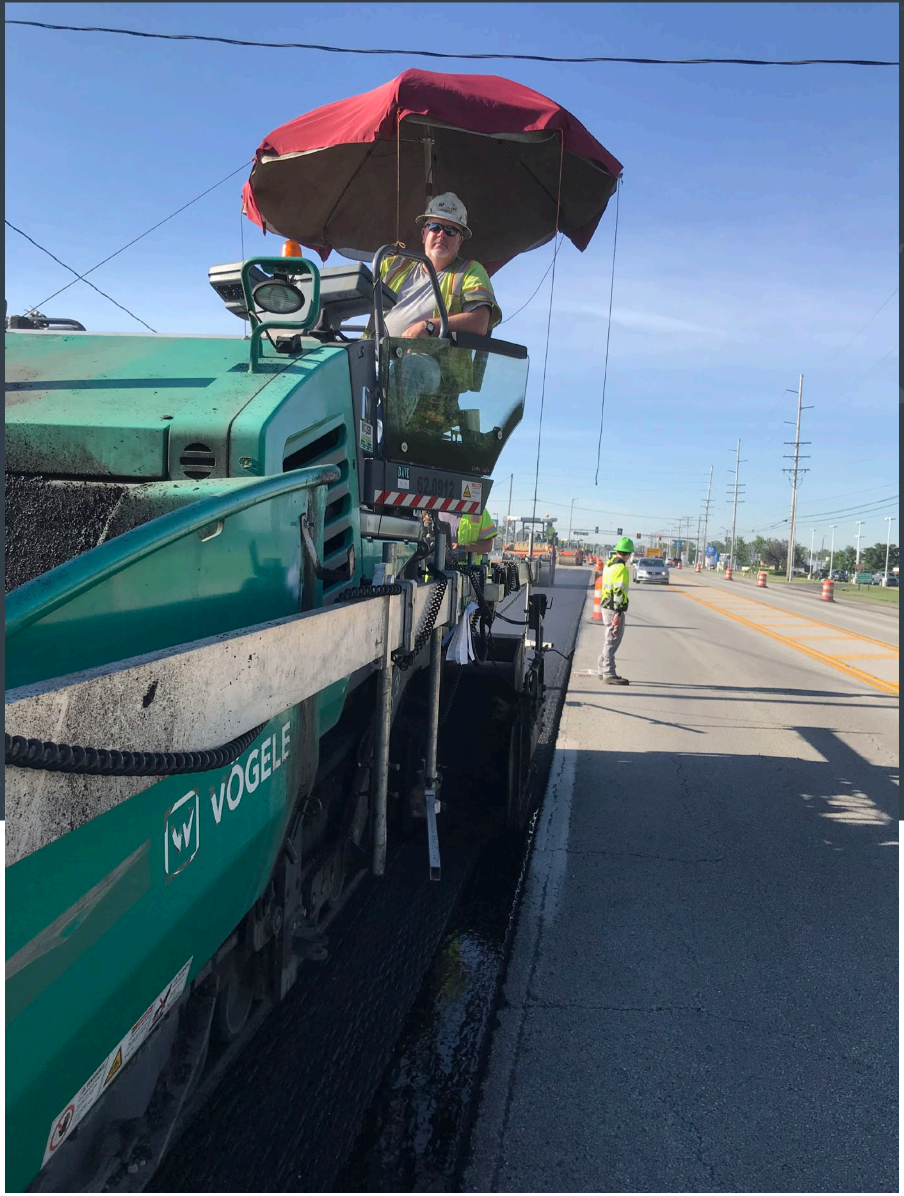

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I-74 Dearborn County, Indiana
June 2020

I-64 Wayne County, IL
April 2021

Upcoming Projects in MO with VRAM

- MO-79 in St Charles County – O'Fallon: Pace Construction
- I-44 in St Louis County – Eureka: Pace Construction
- US-69 in Clay County – Excelsior Springs: Emery Sapp & Sons

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Headers and Bridge Transitions

Goals

- Keep cigarette ash from falling off
- Keep truck from bouncing out of seat
- Don't wake sleeping baby in back seat

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ROUGH
ROAD


BUMP


DIP
AHEAD


BUMP

Types of Transverse Joints

- Bridge Approach
- New to Existing Pavement – Tie In
- Existing Pavement to New – Take Off
- New to New

Helpers

- Lath or steel plates
- String Line
- Paint
- Joint Matcher
- Grade Control
- Staightedge
- 2x4's, bricks

Interesting Facts

- On I-70 between Greensburg, PA and Columbia, MO
- 347 Bridges & Box Culverts
- 1 lane of Surface Course has 674 approaches
- 4 lanes of Surface Course has 2,696 approaches
- Can we just pave across the bridges?

Bridge Approaches

- Tractor trailer length
- Average passenger car length
- Concentrate on the first 30 feet
- New construction, milling and paving all need to be checked

Take Off

- Check grade (string line)
- Lath
- Previous day's settings
- Null screw, then crank to feel
- Ensure mix is at proper temp
- Take of slow
- Lute
- Check with straight edge

Tie In

- Check grade (string line)
- Ensure mix is at proper temp
- Slow down in last 30 feet
- Keep an eye on screw if not using automatics
- Get the screed to the end
- Lute
- Check with straight edge

String Line Grade Control

Saw Cut and Clean

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Tack & Paint the Face

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Introducing the Mix

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TAKE OFF SLOW!!!

Rolling a good joint

Rolling a good joint

- Take your time
- Breakdown from Low side to High side will hold grade
- Intermediate from Low side to High side to continue holding grade
- Finish from High side to Low side will take out creases
- 190F drive through it

Rolling Preference

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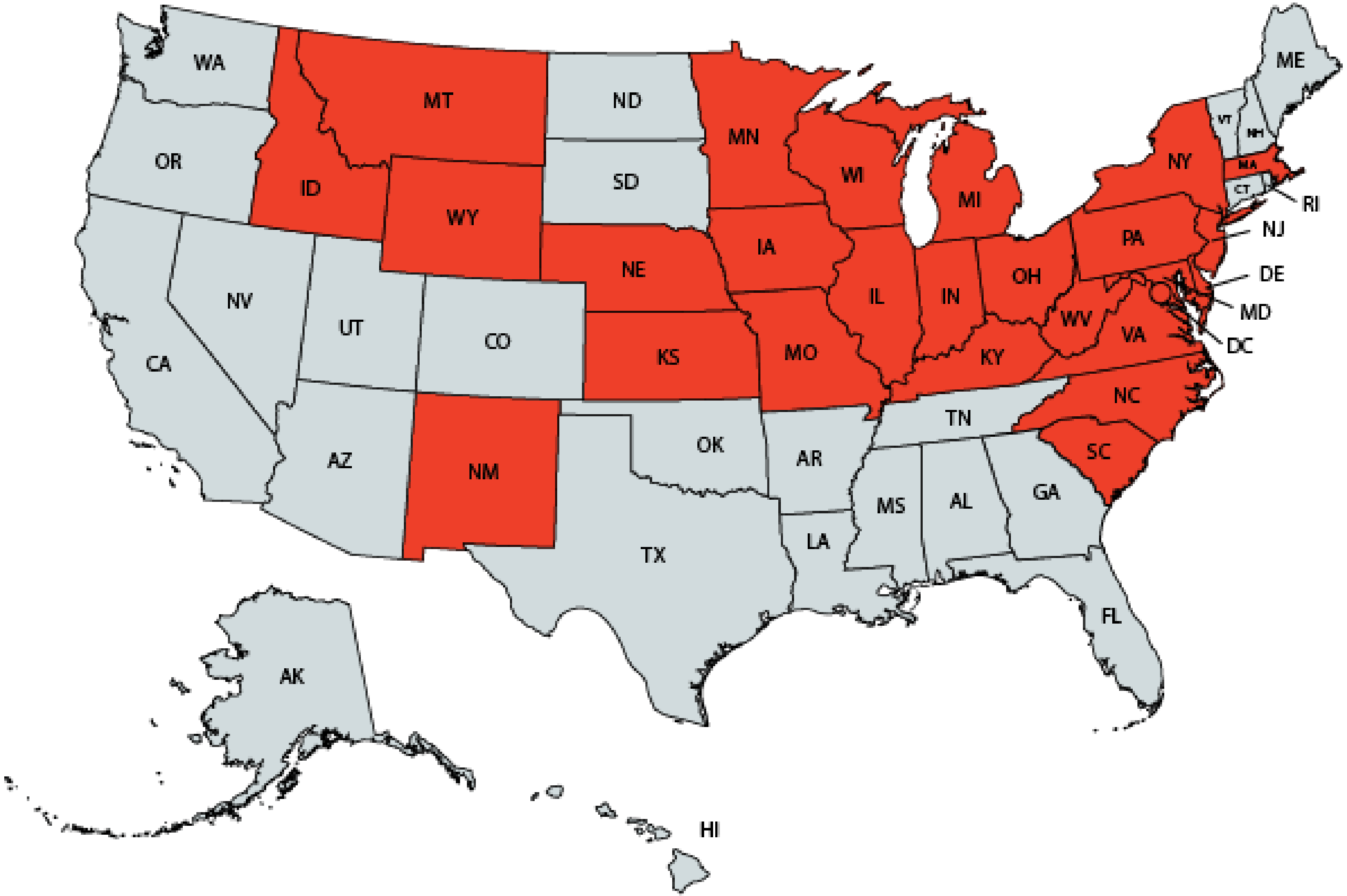
Check your work

States with VRAM



JBAND RESOURCES

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ROADWORKS

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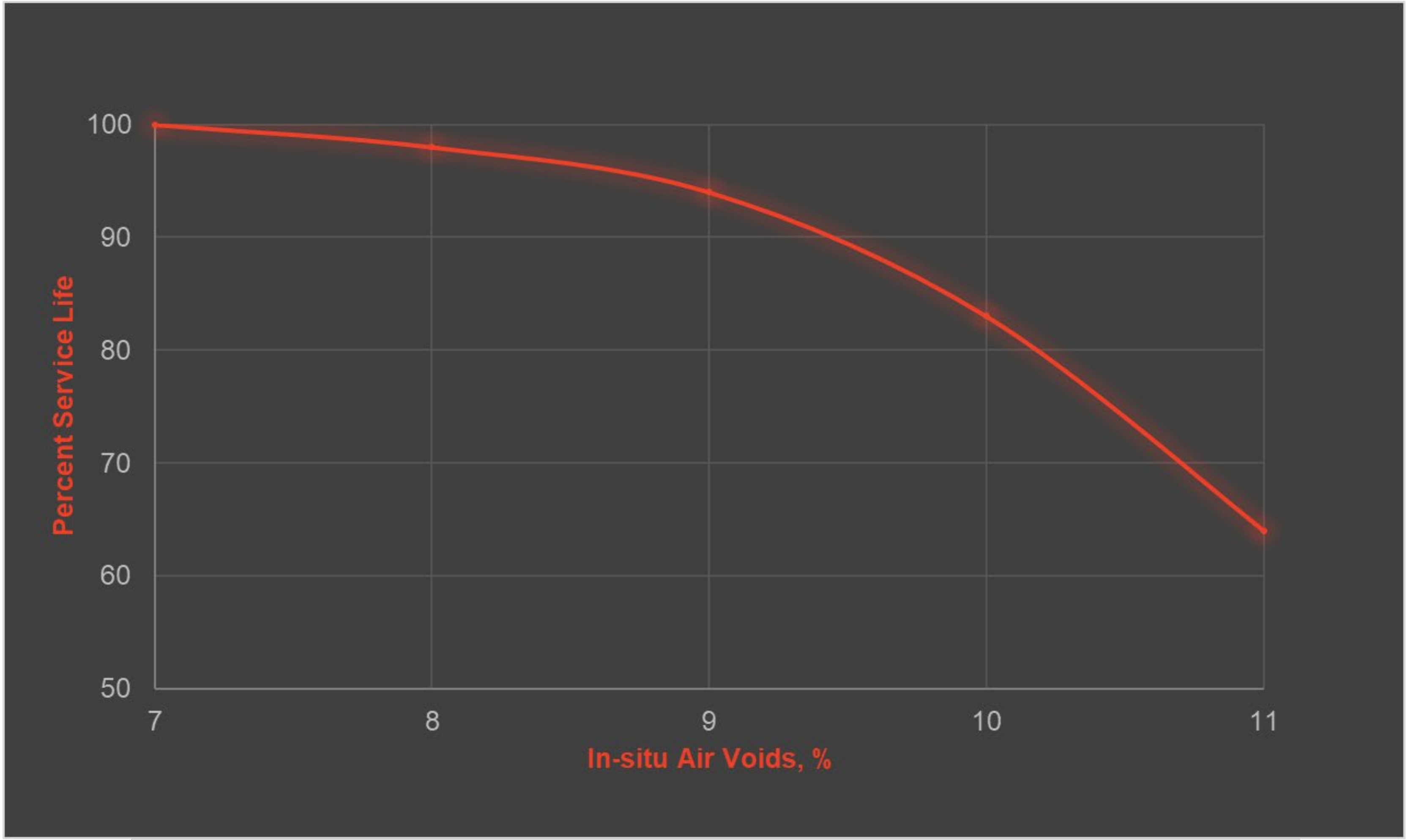

93%	92%	91%	90%	89%

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Asphalt Materials, Inc.

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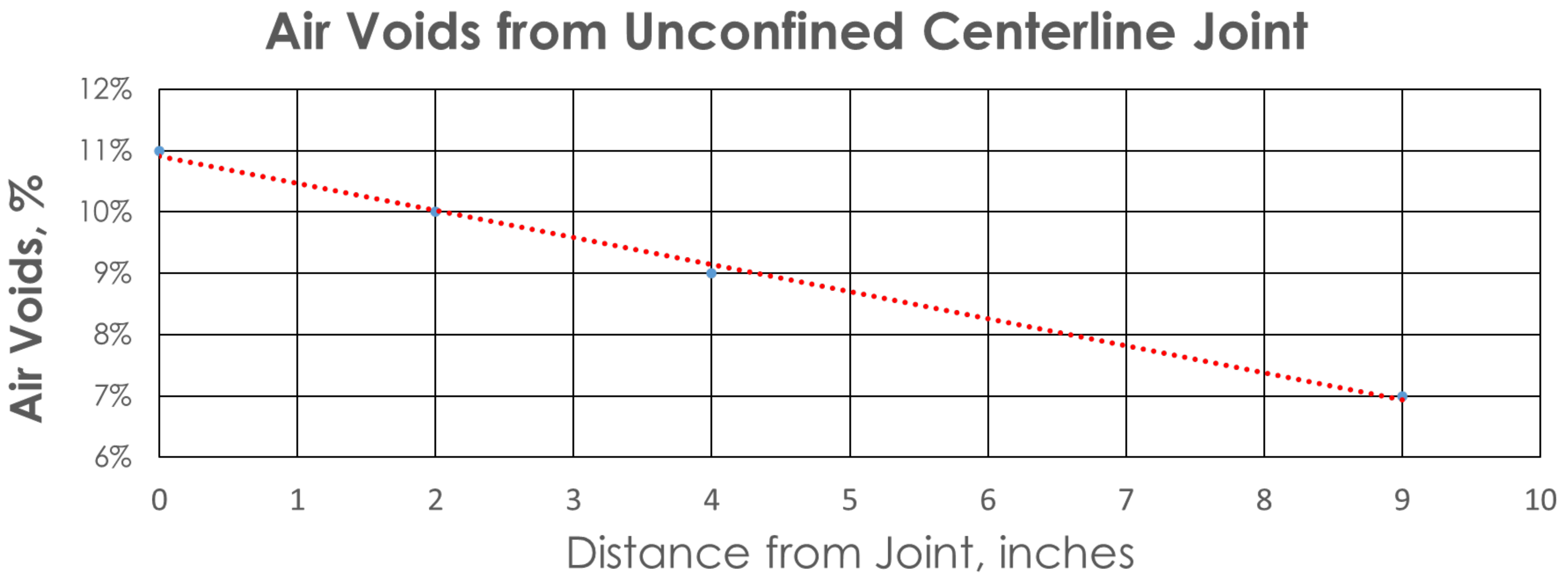
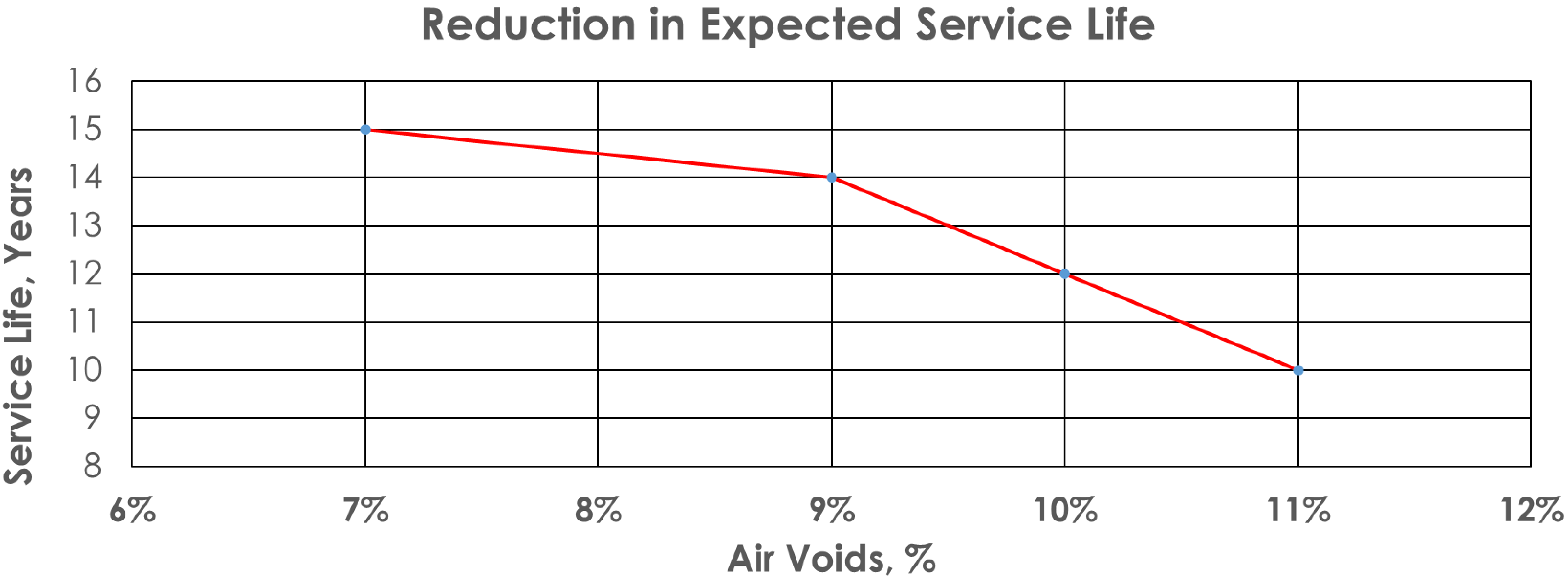


Centerline going towards interior of mat →

Effect of Air Voids on Pavement Service Life



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Notched Wedge Paving

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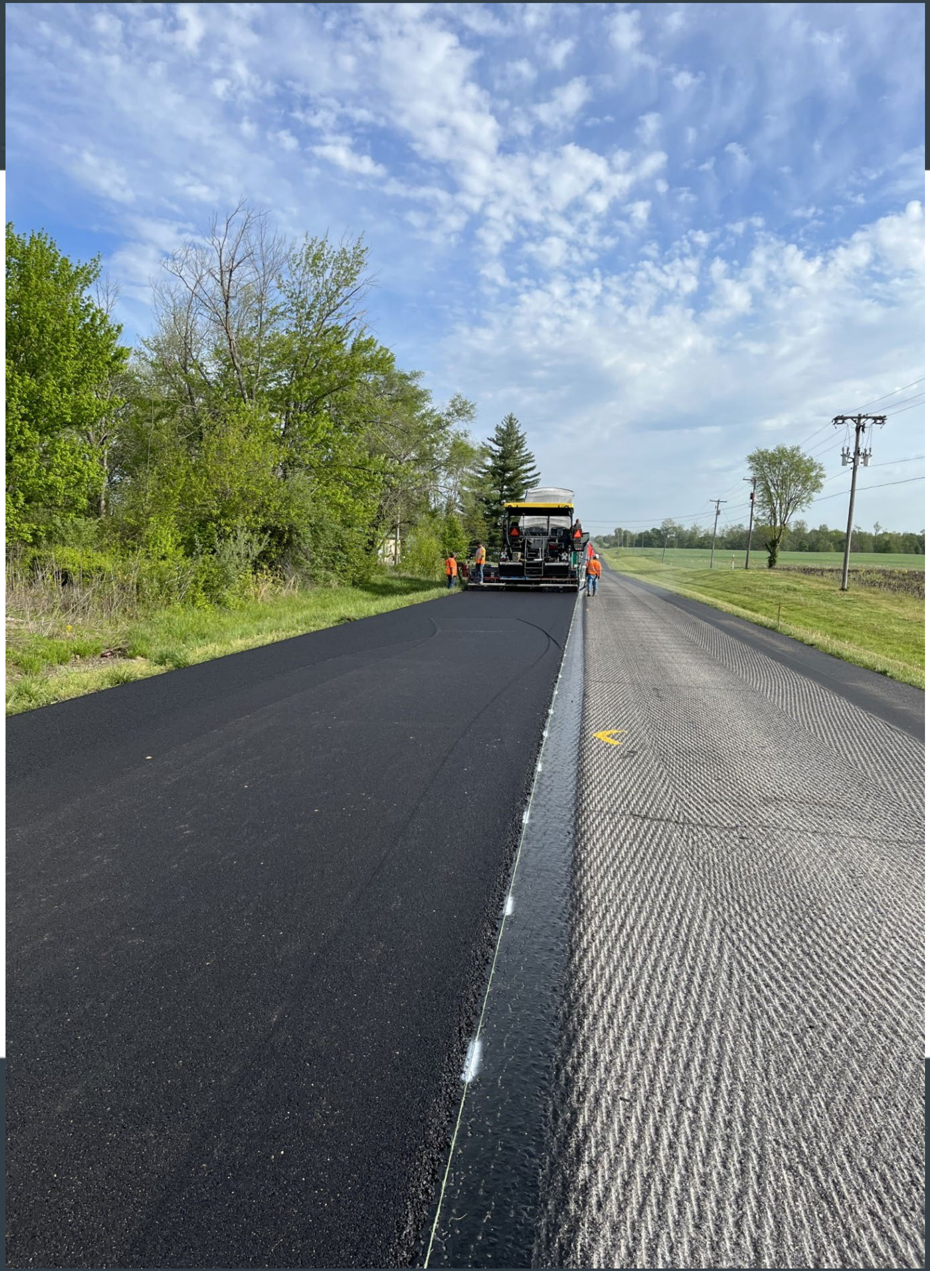

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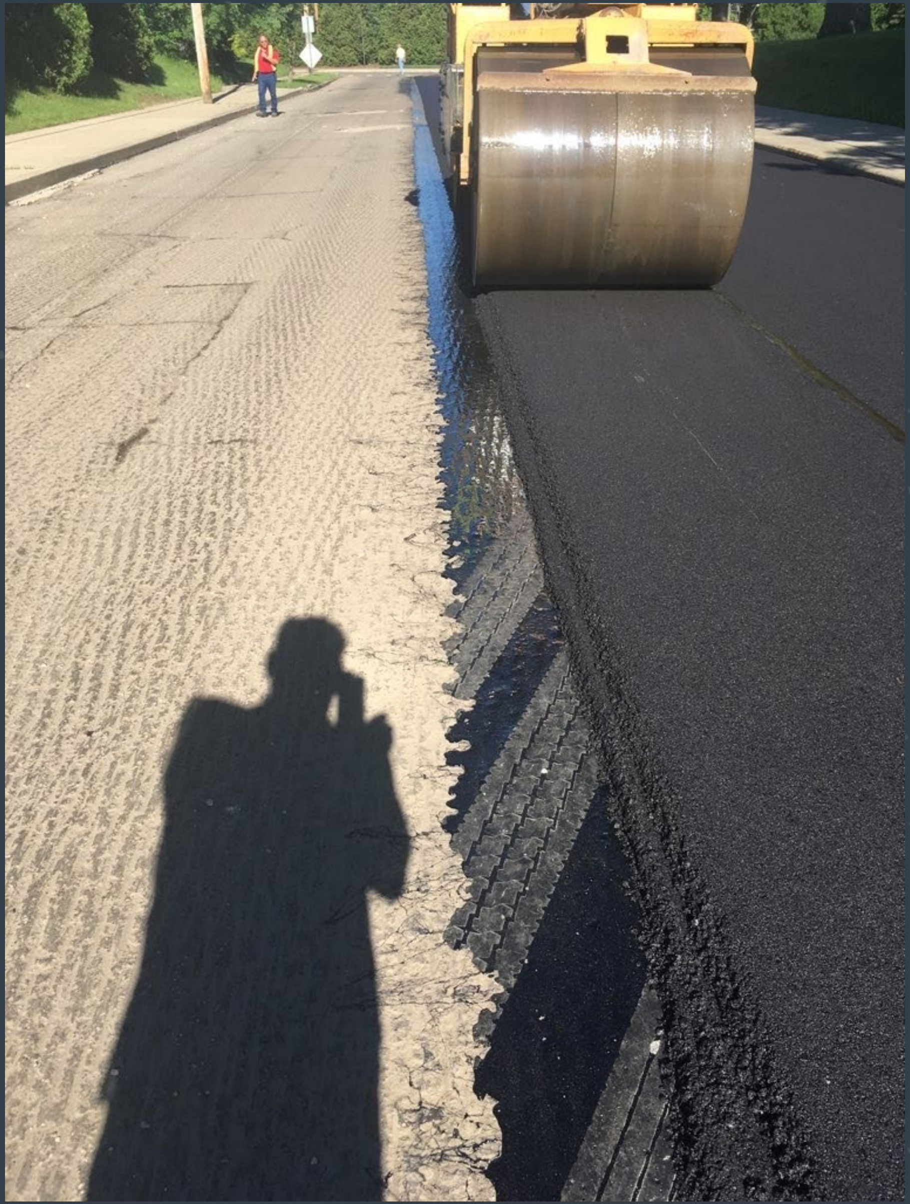

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Tandem

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Paving 2nd Pass

Asphalt Materials, Inc.

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Paving 2nd Pass

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EVERGREEN
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JBAND

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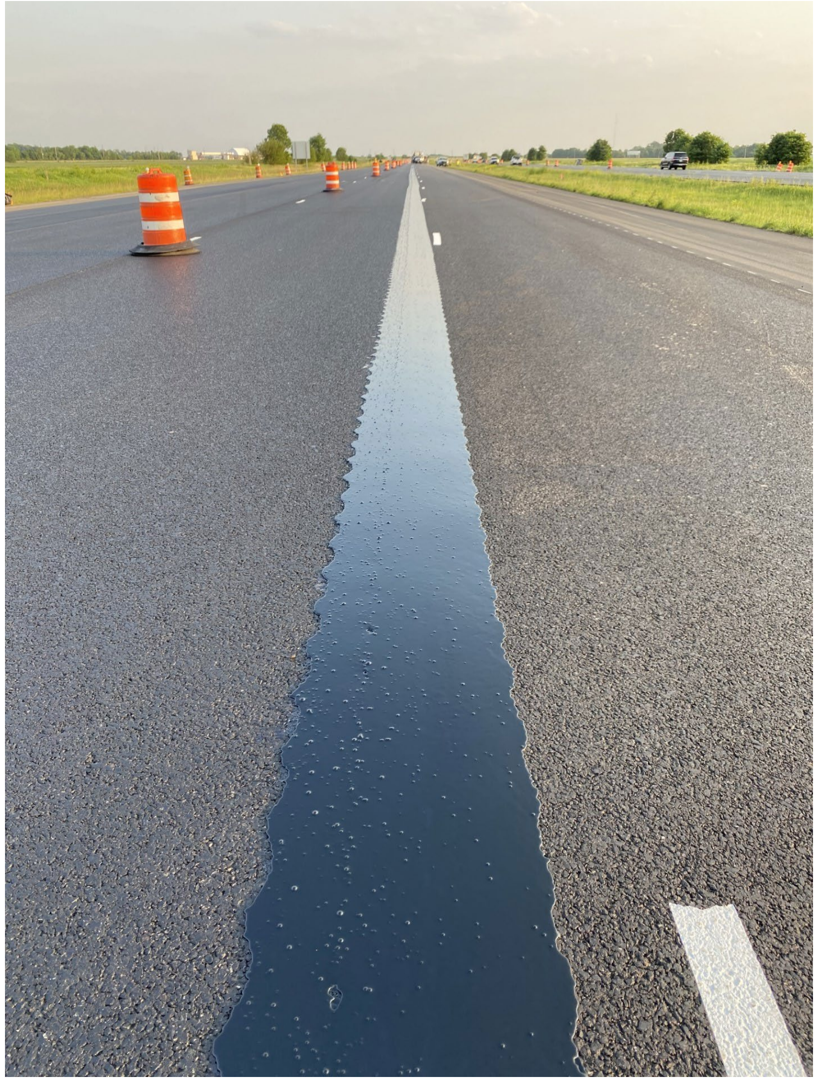

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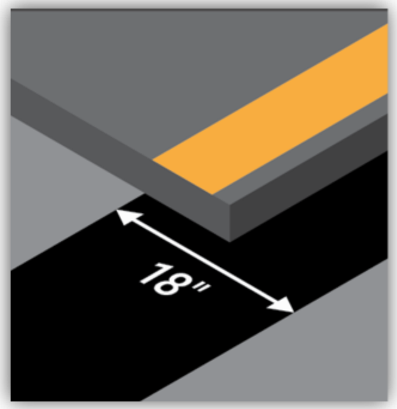

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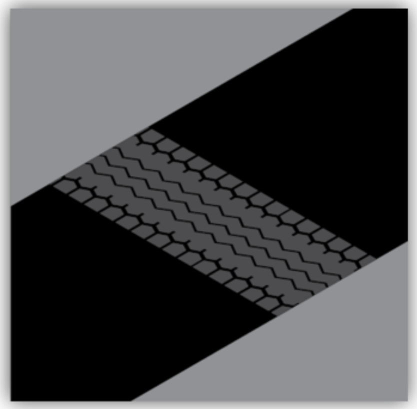

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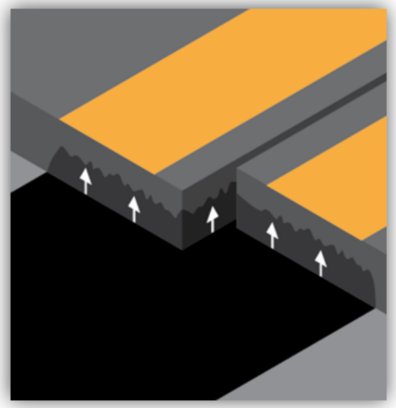

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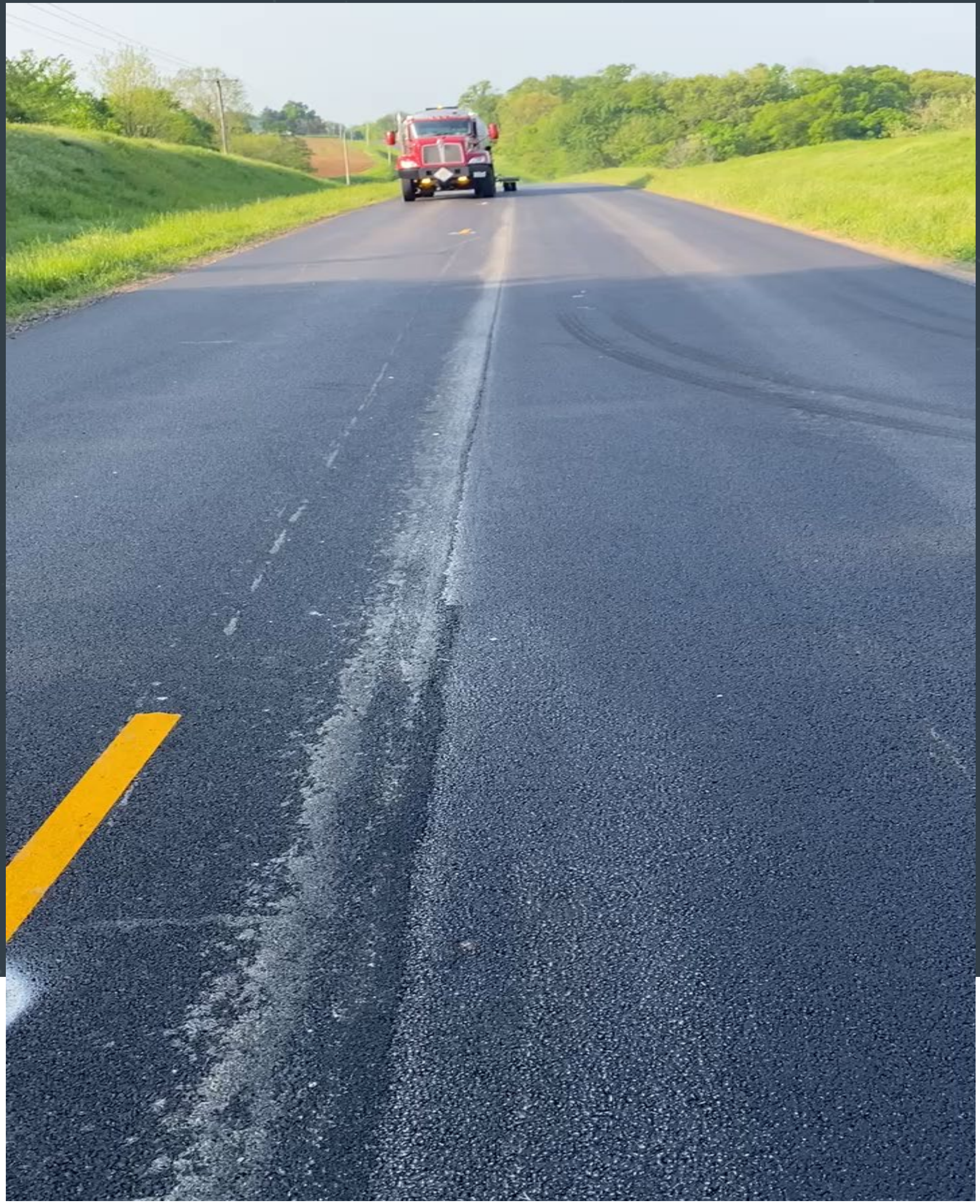

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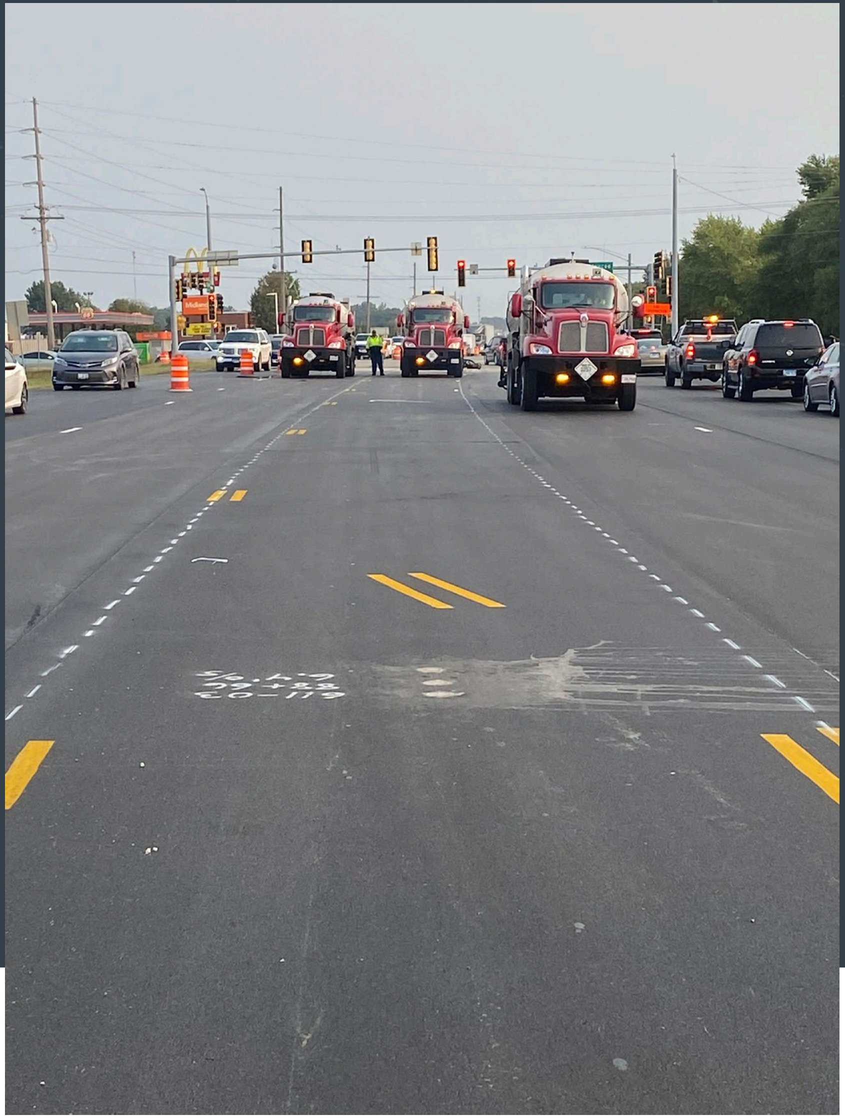

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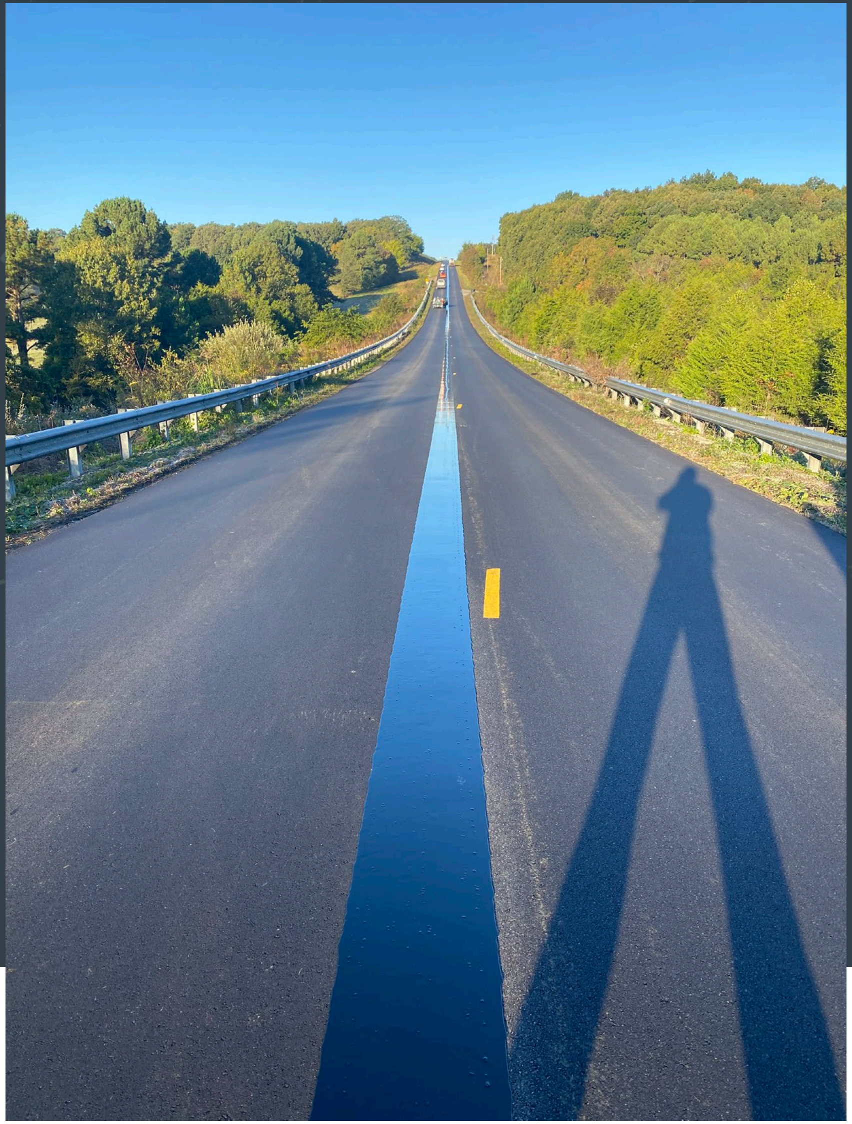

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ROADWORKS

IN-149 Porter County

July 27, 2021

Coles County Airport August 5, 2021

Asphalt Materials, Inc.

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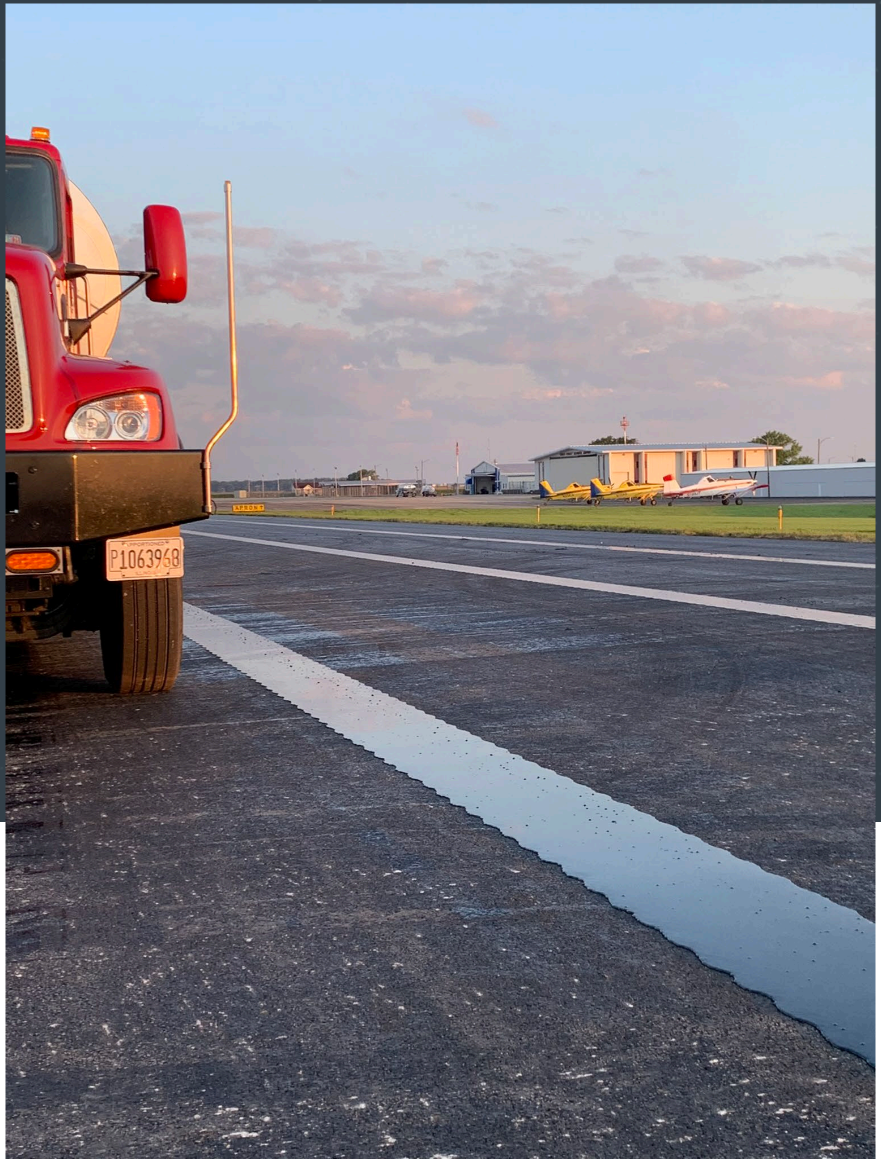

Bowling Green, Ohio Half Width VRAM

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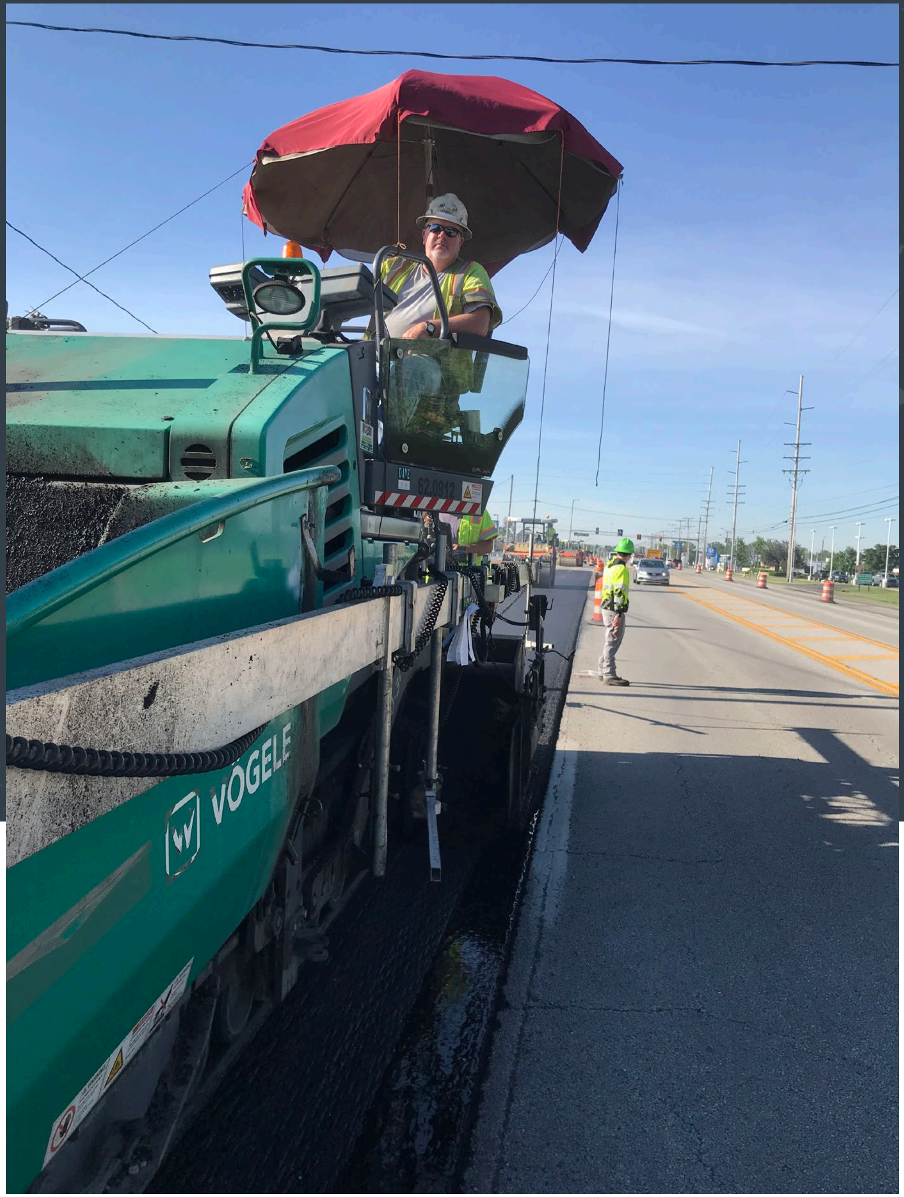

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I-74 Dearborn County, Indiana
June 2020

I-64 Wayne County, IL
April 2021

Upcoming Projects in MO with VRAM

- MO-79 in St Charles County – O'Fallon: Pace Construction
- I-44 in St Louis County – Eureka: Pace Construction
- US-69 in Clay County – Excelsior Springs: Emery Sapp & Sons

Headers and Bridge Transitions

Goals

- Keep cigarette ash from falling off
- Keep truck from bouncing out of seat
- Don't wake sleeping baby in back seat

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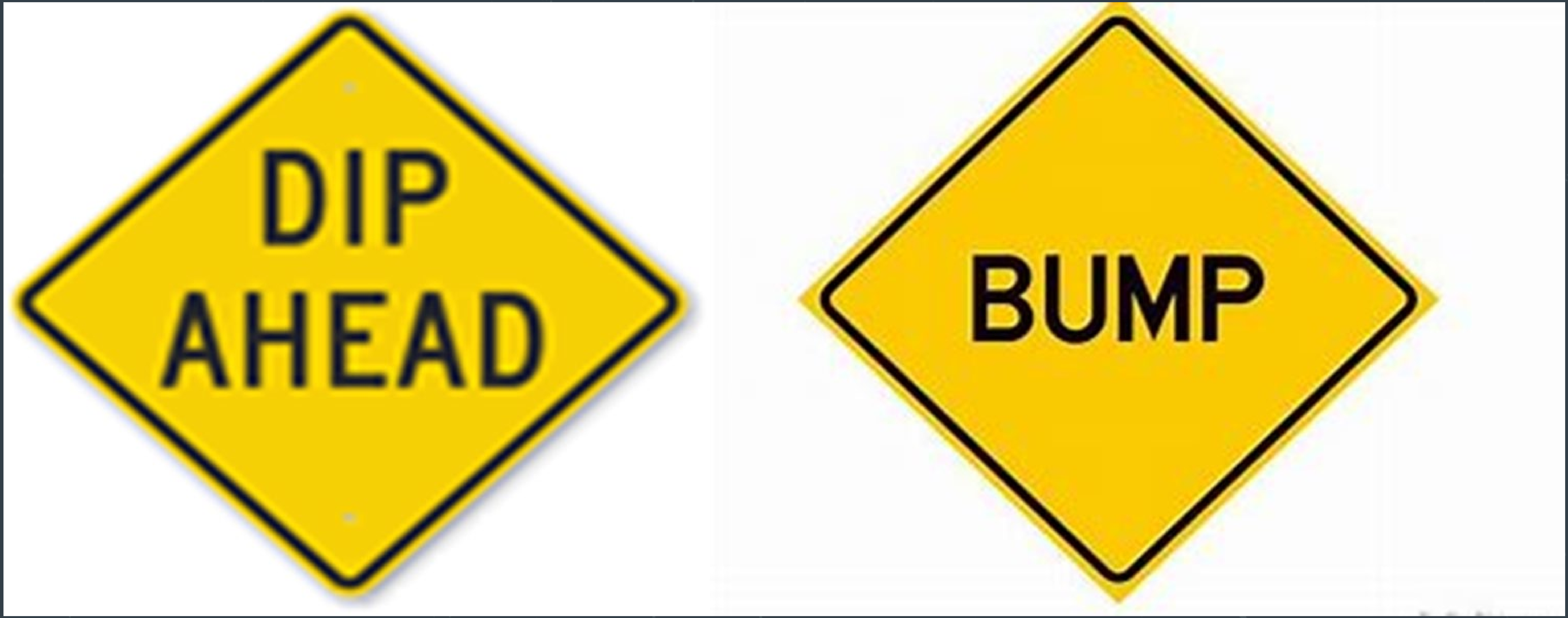
ROUGH
ROAD

BUMP


DIP
AHEAD
BUMP

Types of Transverse Joints

- Bridge Approach
- New to Existing Pavement – Tie In
- Existing Pavement to New – Take Off
- New to New

Helpers

- Lath or steel plates
- String Line
- Paint
- Joint Matcher
- Grade Control
- Staightedge
- 2x4's, bricks

Interesting Facts

- On I-70 between Greensburg, PA and Columbia, MO
- 347 Bridges & Box Culverts
- 1 lane of Surface Course has 674 approaches
- 4 lanes of Surface Course has 2,696 approaches
- Can we just pave across the bridges?

Bridge Approaches

- Tractor trailer length
- Average passenger car length
- Concentrate on the first 30 feet
- New construction, milling and paving all need to be checked

Take Off

- Check grade (string line)
- Lath
- Previous day's settings
- Null screw, then crank to feel
- Ensure mix is at proper temp
- Take of slow
- Lute
- Check with straight edge

Tie In

- Check grade (string line)
- Ensure mix is at proper temp
- Slow down in last 30 feet
- Keep an eye on screw if not using automatics
- Get the screed to the end
- Lute
- Check with straight edge

String Line Grade Control

Saw Cut and Clean

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Tack & Paint the Face

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Introducing the Mix

TAKE OFF SLOW!!!

Rolling a good joint

Rolling a good joint

- Take your time
- Breakdown from Low side to High side will hold grade
- Intermediate from Low side to High side to continue holding grade
- Finish from High side to Low side will take out creases
- 190F drive through it

Rolling Preference

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Check your work

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States with VRAM

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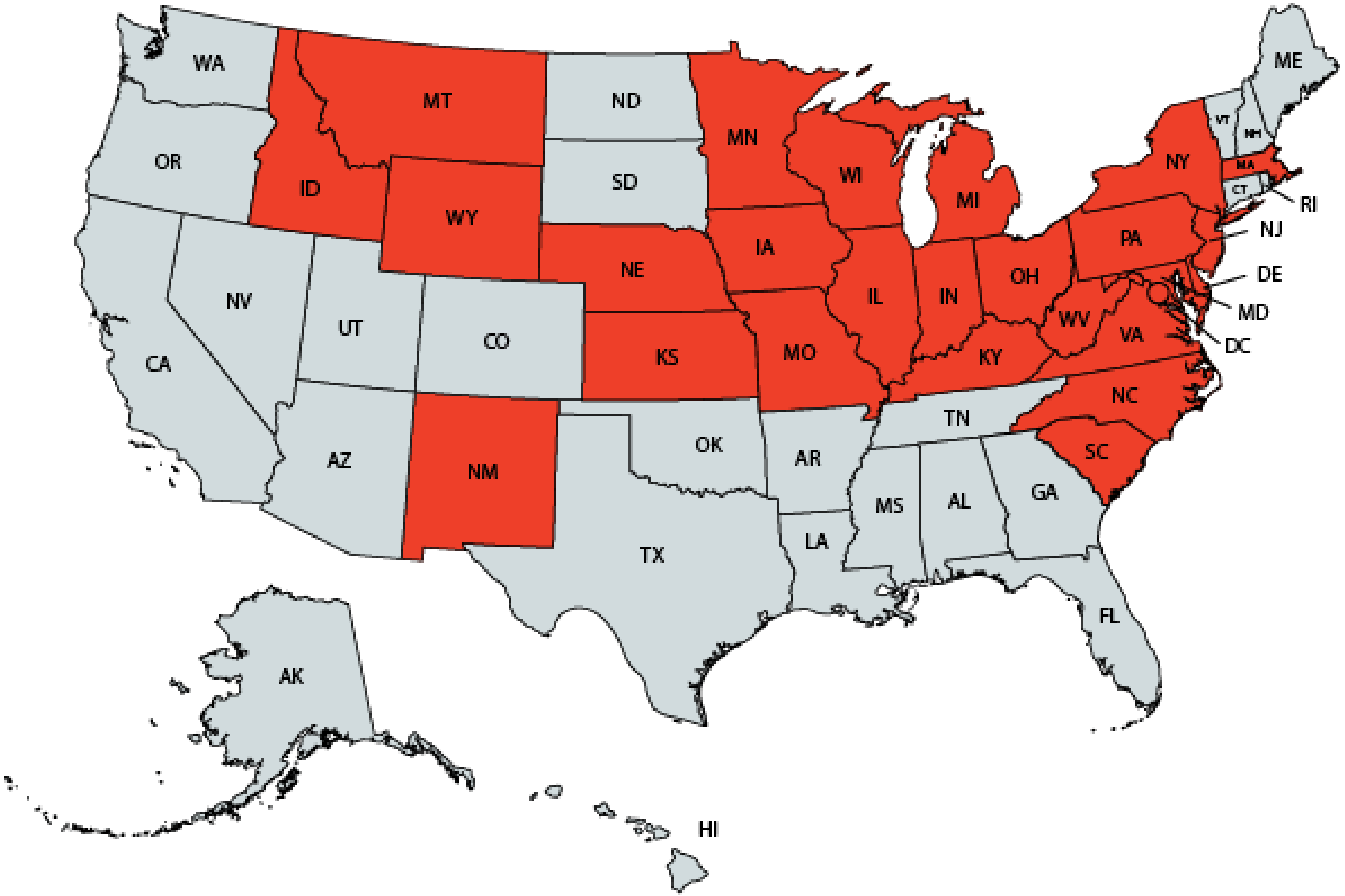

JBAND RESOURCES

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Key Items for Balanced Mix Design (BMD) Implementation: Summaries from Peer Exchanges

2024 MAPA Back to Basic Spring Training
February 7th, 2024

Derek Nener-Plante, M.S., P.E.
Pavement & Materials Engineer
Resource Center
Office of Innovation Implementation

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Acknowledgements

- Tim Aschenbrener (FHWA) and Elie Hajj (University Nevada, Reno) for their work on BMD under the FHWA-UNR Co-Op, for which most of this information was generated.
  - DDIAPT, Tasks C.1.4, C.1.7, & C.1.8.
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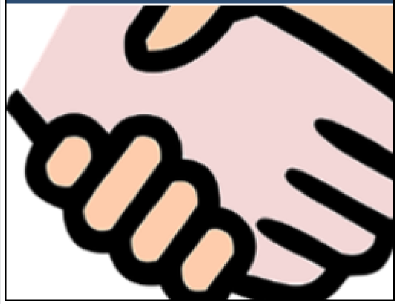

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What do we want to get out of this?

Hear challenges of Balanced Mix Design implementation as heard from State DOT's and Contractors across the country

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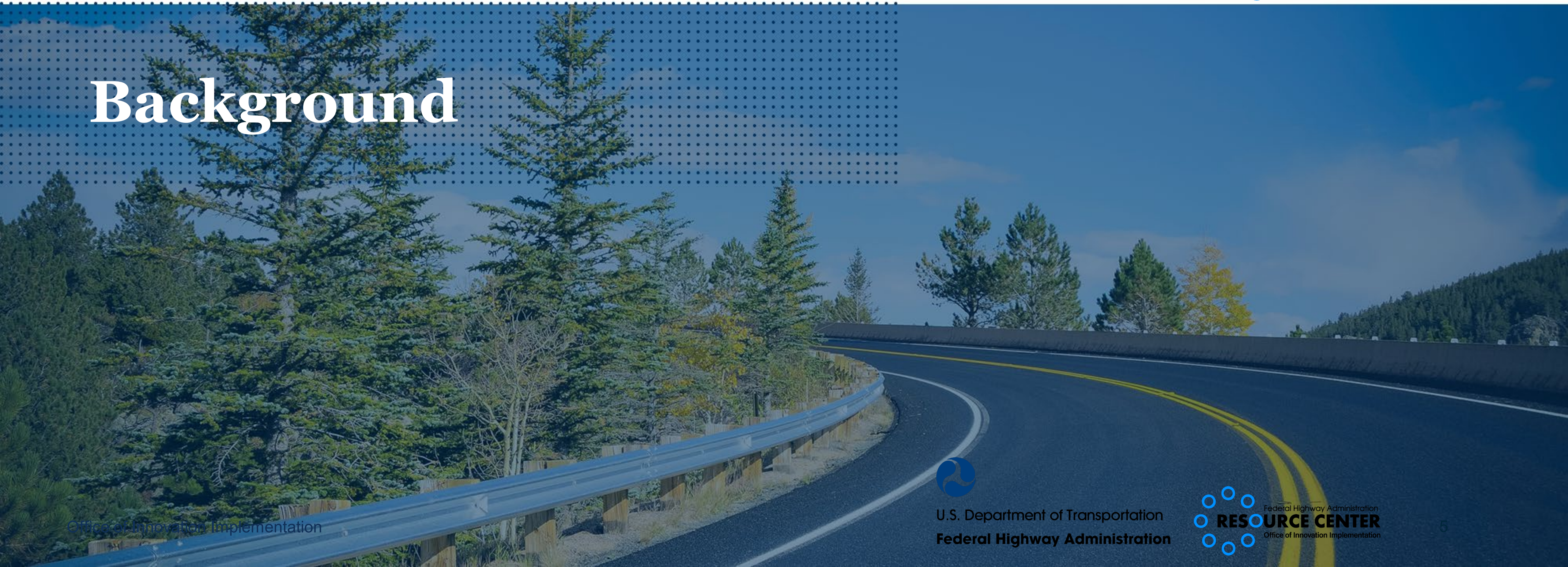
Background



Definitions

What is BMD?

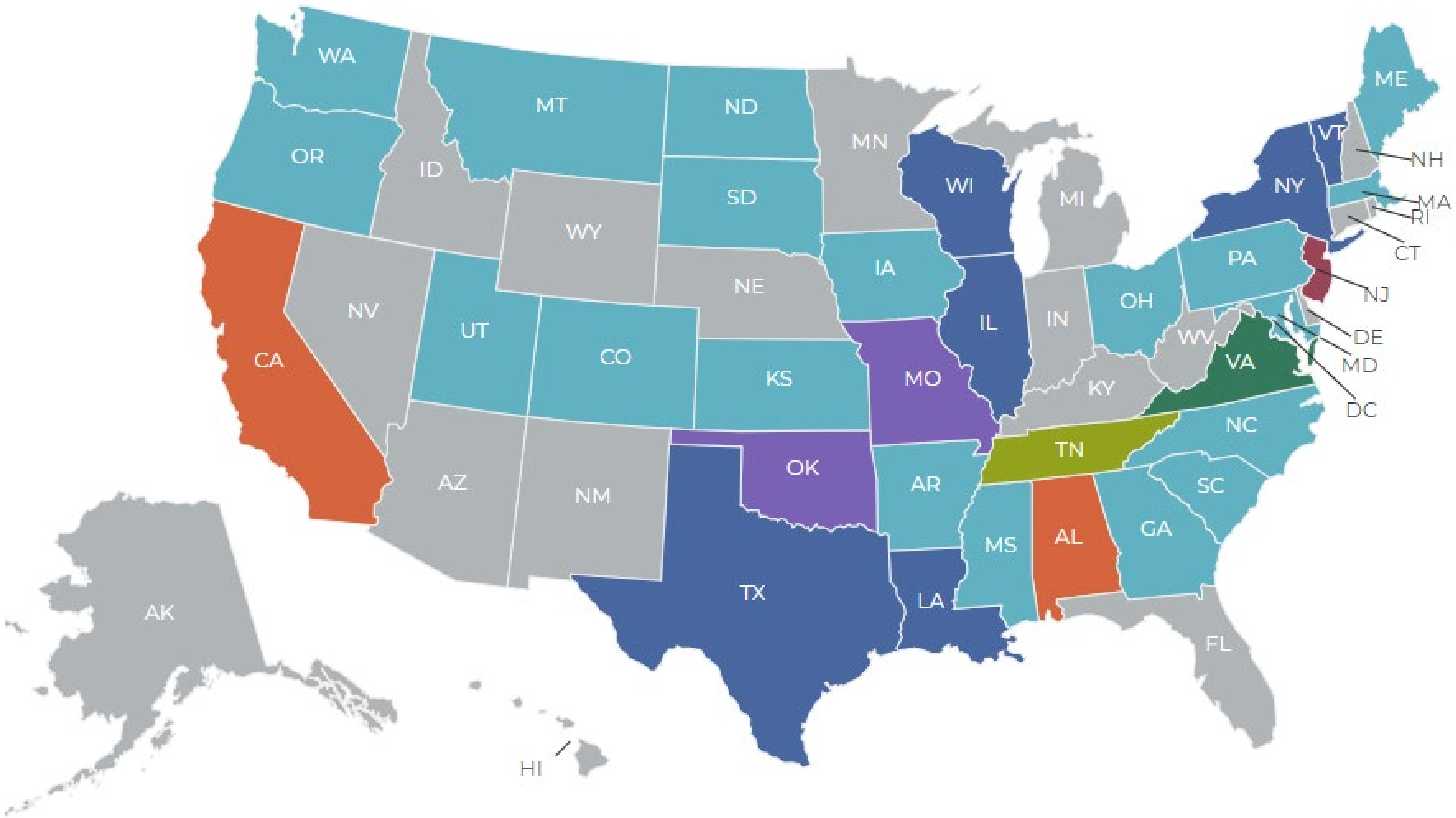
- AASHTO PP 105-20: "*BMD is an asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate, and location within the pavement structure.*"

TRB's *Transportation Research Circular E-C280: Glossary of Terms for Balanced Design of Asphalt Mixtures* provides a reference document for usage of Balanced Mix Design terminology by the asphalt mixtures community in the United States.

Design "philosophy" used to optimize the mix performance against distresses pertinent to the climate & traffic specific to the region where it will be placed.

Numerous States Moving to BMD

- APPROACH A - VOLUMETRIC DESIGN WITH PERFORMANCE VERIFICATION
- APPROACH A AND B
- APPROACH A AND D
- APPROACH B - VOLUMETRIC DESIGN WITH PERFORMANCE OPTIMIZATION
- APPROACH C - PERFORMANCE-MODIFIED VOLUMETRIC DESIGN
- APPROACH D - PERFORMANCE DESIGN
- PRE-IMPLEMENTATION



Source: NAPA
https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide/implementation-efforts

Overall BMD Implementation Process
8 Tasks That Can be Undertaken (Schedule Example)

Task		Sub Task	Description	Years -1	1	2	3	4	5	6	7
1	Understanding the why and benefits of Performance Specifications										
2	Overall Planning	2.1	Identification of Champions								
		2.2	Establishing a Stakeholders Partnership								
		2.3	Doing Your Homework								
		2.4	Establishing Goals								
		2.5	Mapping the Tasks								
		2.6	Identifying Available External Technical Information and Support (periodically)								
		2.7	Developing an Implementation Timeline								
3	Selecting Performance Tests	3.1	Identifying Primary Modes of Distress.								
		3.2	Identifying and Assessing Performance Test Appropriateness.								
		3.3	Validating the Performance Tests								
4	Performance Testing Equipment: Acquiring, Managing Resources, Training, and Evaluating	4.1	Acquiring Equipment								
		4.2	Managing Resources								
		4.3	Conducting Initial Training								
		4.4	Evaluating Performance Tests								
		4.5	Conducting Inter-Laboratory Studies								
5	Establishing Baseline Data	5.1	Reviewing Historical Data & Information Management System								
		5.2	Conducting Benchmarking studies								
		5.3	Conducting Shadow Projects								
		5.4	Analyzing Production Data								
		5.5	Determining How to Adjust Asphalt Mixtures Containing Local Materials								
6	Specifications and Program Development	6.1	Sampling and Testing Plans								
		6.2	Pay Adjustment Factors (If Part of the Goals)								
		6.3	Developing Pilot Specifications and Policies								
		6.4	Conducting Pilot Projects								
		6.5	Final Analysis and Specification Revisions								
7	Training, Certifications, and Accreditations	7.1	Developing and/or Updating Training and Certification Programs								
		7.2	Establishing or Updating Laboratory Accreditation Program Requirements								
8	Initial Implementation										

Not all tasks may be applied/considered.

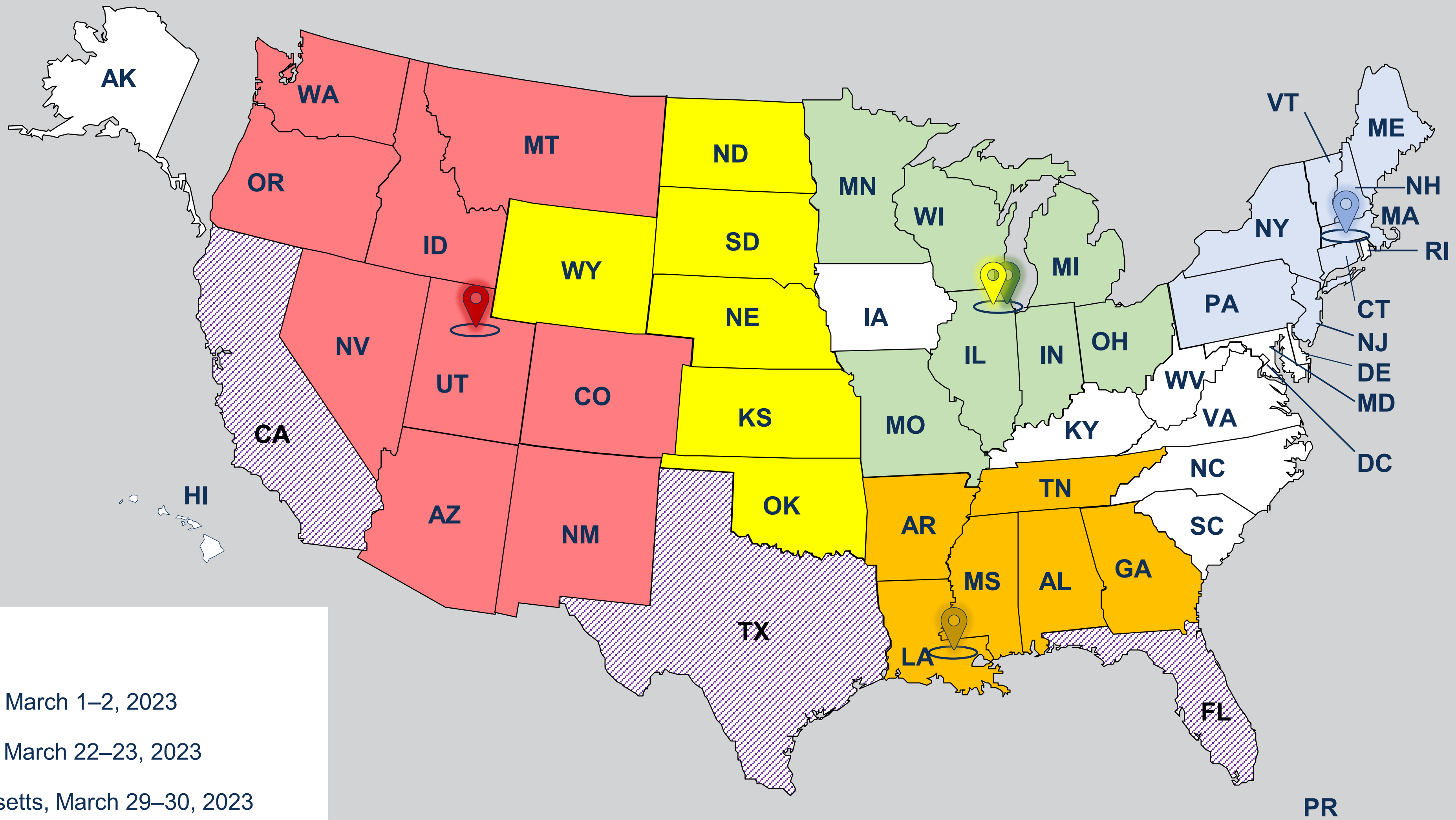
Considerations to:
- Organizational structure, staffing, workspace, asphalt tonnage, etc.
- Industry experiences & practices.

Inter-related tasks or subtasks activities.

Tech Brief: Balanced Asphalt Mix Design: Eight Tasks for Implementation

Balanced Mix Design

Peer Exchanges



Meeting Location

- Southeast Peer Exchange, Louisiana, March 1–2, 2023
- North Central Peer Exchange, Illinois, March 22–23, 2023
- Northeast Peer Exchange, Massachusetts, March 29–30, 2023
- Rocky Mountain West Peer Exchange, Utah, November 28–30, 2023
- Midwest Peer Exchange, Illinois, December 13–14, 2023
- Mega-States Peer Exchange

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Critical Challenges

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Critical Challenges for BMD

Its more than just technical items!

Management Challenges

Technical Challenges

Management Challenges

- Change Management.
- Cost-Benefit Analysis
- Specifications & Risk Management.
- Resource Allocation.
- Implementation Planning.
- Stakeholders Engagement.

- Integration with Existing Practices.
- Education, Training, & Skill Development.
- Information Sharing & Collaboration Among Peers

Technical Challenges

- BMD Tests Validation
- Testing Procedures & Protocols
- Variabilities
- Database Setup, Collection, Analysis, & Management.
- Pathway for Use in Field Quality Assurance (QA).
- Volumetrics Historical Usage

Be Mindful that…

- Not all states are experiencing every challenge listed.
- All raised challenges are listed, even if only mentioned by few states.

Two present statuses for the challenges:

1. The path forward has been identified and implemented.
2. Ongoing efforts are in progress to address and find solutions.

Be Mindful that…

Similar challenges are heard from contractors.

- Implementation requires resources.
- Resistance to change.
- BMD tests may not be able to fully replace current acceptance testing.
- Variability in BMD tests results.
- Etc.

Source: NAPA

Management Challenges

- Change Management.
- Cost-Benefit Analysis
- Specifications & Risk Management.
- Resource Allocation.
- Implementation Planning.
- Stakeholders Engagement.

Summary – Major Items

Management Challenges

- Cost-Benefit Analysis
  - Plans that will allow for measurement of benefit
- Resource Allocation
  - Enough resources to implement – being worked on by only a few people
- Implementation Planning
  - No overall plan or path with milestones
  - Messaging & motivation – goals needed
  - BMD is not a cure all!
- Stakeholder Engagement
  - Workshop was a kicking off point – continue with industry
  - Coordination with Contractors to see what they can change and achieve

Technical Challenges

- BMD Tests Validation
- Testing Procedures & Protocols
- Variabilities
- Database Setup, Collection, Analysis, & Management.
- Pathway for Use in Field Quality Assurance (QA).
- Volumetrics Historical Usage

Summary – Major Items

Technical Challenges

- BMD Test Validation
  - Few w/ plan at this point
  - Pavement performance monitoring – who to do it?
  - Should reflect the distresses and treatments you are applying it to
- Testing Procedures & Protocols
  - Few established
  - Interlaboratory studies
- Pathway for Use in QA
  - Limitation of BMD without including in Acceptance.
  - Handling, conditioning, contractor making samples, silo storage time
  - Concerns about how to integrate and what to do to effectively put into the field
- Volumetrics Usage
  - Variable approaches to volumetrics due to changes in conditions / production

BMD in Quality Assurance?

- Majority of DOT's want to integrate BMD into field production *eventually*….
  - If these tests relate to performance better, why not use them?

- What does the use of BMD tests in QA look like?

Use of BMD in Production

None

Test Strip / Trial Drop

Go / No-Go

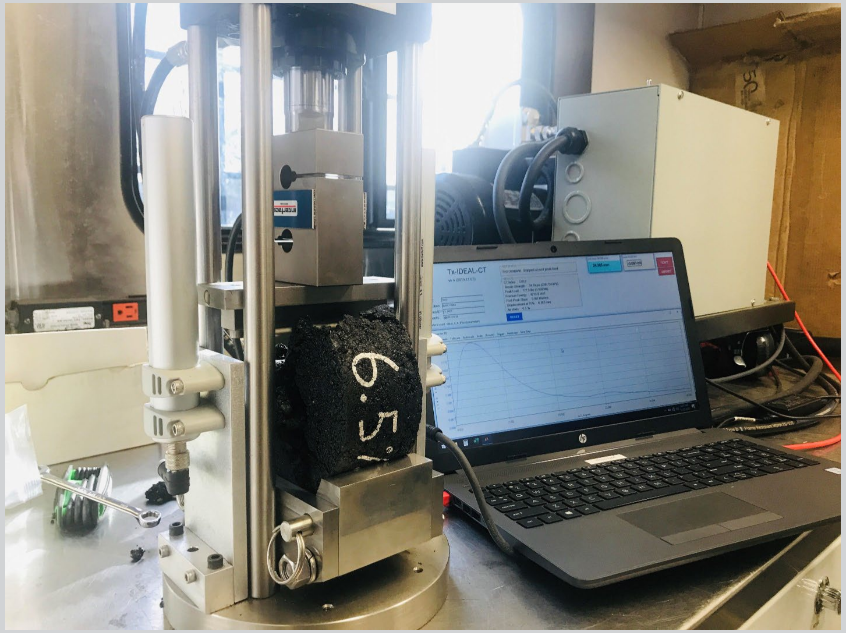
Acceptance

Acceptance with Pay Adjustment

Increasing Difficulty

BMD tests are different…

- Longer time to sample, fabricate, and test
  - More significant effort to prepare and fabricate specimens
  - May be challenging to keep current sample frequencies
- More significant within-lab and between-lab variabilities
  - Lack of established precision & bias statements
  - Variability erodes confidence in results
- Wider range of typical resulting values

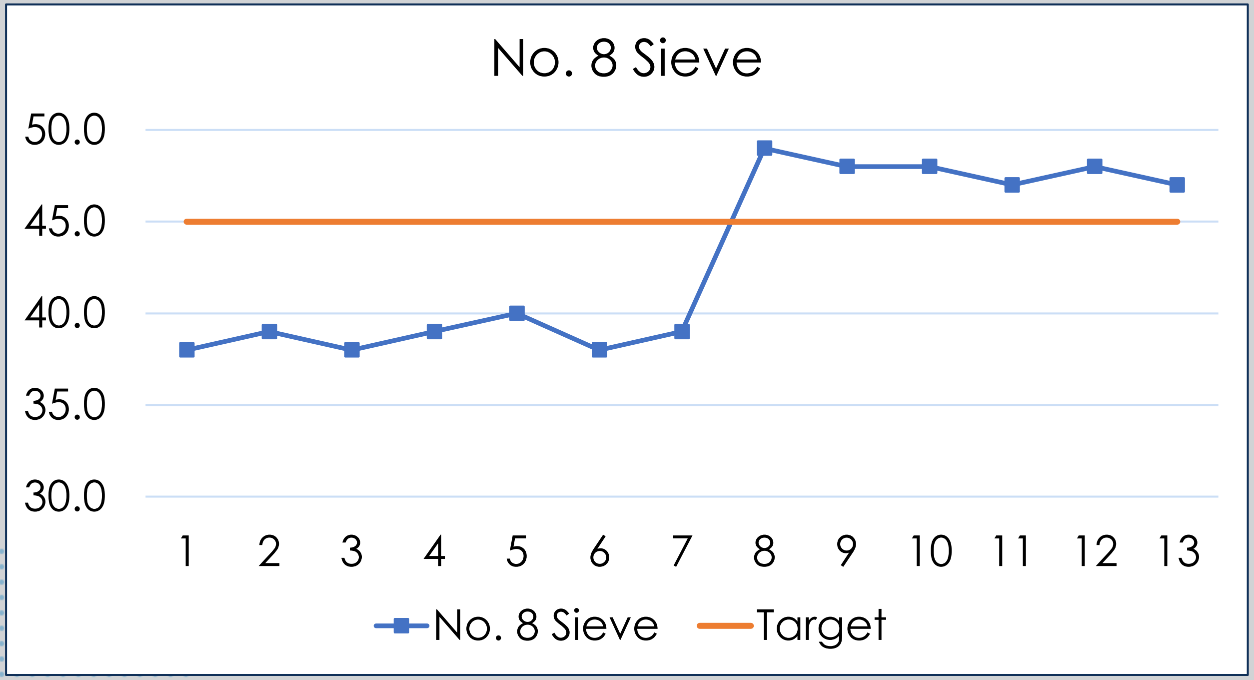


Challenges / Questions

- Need for an aging protocol to shorten test time and establish new thresholds so test is applicable during production.
- Need for a greater frequency of sampling for BMD mechanical tests. Testing frequency and lot size has been a major challenge.
- Finding surrogate BMD tests that will provide quicker turnaround of test results for QA.
- Assigning BMD test results weight factors for pay factors.
  - What BMD tests and weight factors should be used along other volumetric properties?
  - Should same weight factor be used for cracking and rutting tests?

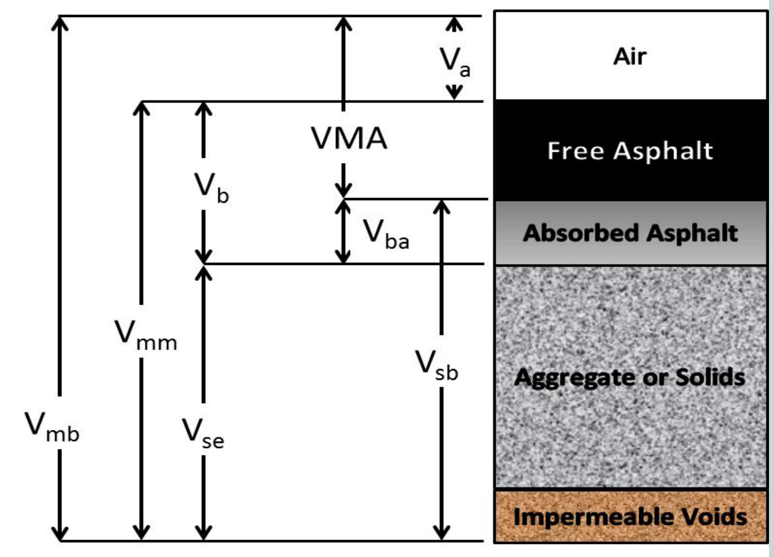
Challenges / Questions

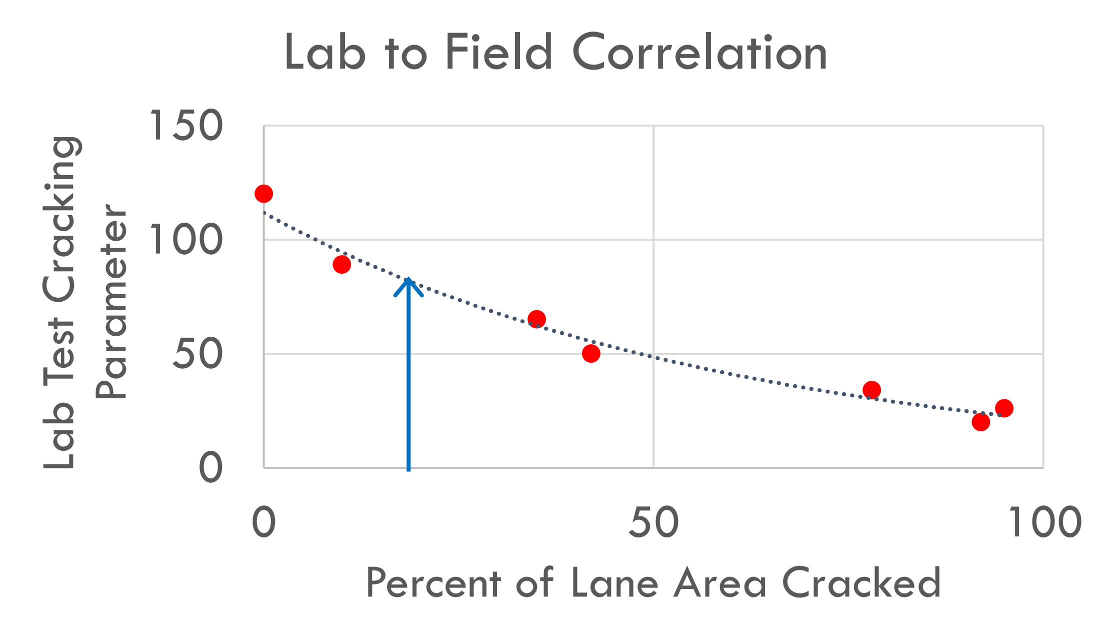
- Fear that the focus is too much on BMD tests for pay and lose sight of production control in terms of consistent production, raw materials, and plant operations.
- Cannot have **Quality** without **Consistency**



Challenges/ Questions

- Confidence in BMD tests.
- Are mechanical tests run through BMD enough to control consistency without volumetric properties? What other parameters can be used to control consistency?
- Can the role of volumetric properties in the mix design and acceptance stage be different?
- Which volumetric properties to use?
- Which criteria to relax? and by how much?





Current BMD Practices in QA

- Numerous states use tests with go / no-go criteria in production
  - LA: Hamburg Wheel Tracker every 10,000 tons
  - IL: Hamburg Wheel Tracker and I-FIT shutdown after two failing tests
  - VA: Numerous tests for production starting in 2024
  - TX: Overlay Test and Hamburg Wheel Tracker once per project (can require removal in-case of Hamburg)

- Some using BMD tests with pay adjustments
  - MT: Hamburg Wheel Tracker with potential rejection
  - NJ: Overlay Test and Asphalt Pavement Analyzer for specialty mixtures
  - ME: Hamburg Wheel Tracker once per lot, QC testing required

Management Challenges

- Change Management.
- Cost-Benefit Analysis
- Regulatory Compliance & Risk Management.
- Resource Allocation.
- Implementation Planning.
- Stakeholders Engagement.

- Integration with Existing Practices.
- Education, Training, & Skill Development.
- Information Sharing & Collaboration Among Peers

Technical Challenges

- BMD Tests Validation
- Testing Procedures & Protocols
- Variabilities
- Database Setup, Collection, Analysis, & Management.
- Pathway for Use in Field Quality Assurance (QA).
- Volumetrics Historical Usage

Ongoing BMD Activity

- BMD Implementation Working Group

- Focus on the ‘next level’ of BMD
  - Dwell & lag time impacts
  - Impact of specimen preparation
  - What existing standards are ‘covered’ by BMD and which aren’t
  - Mix adjustments

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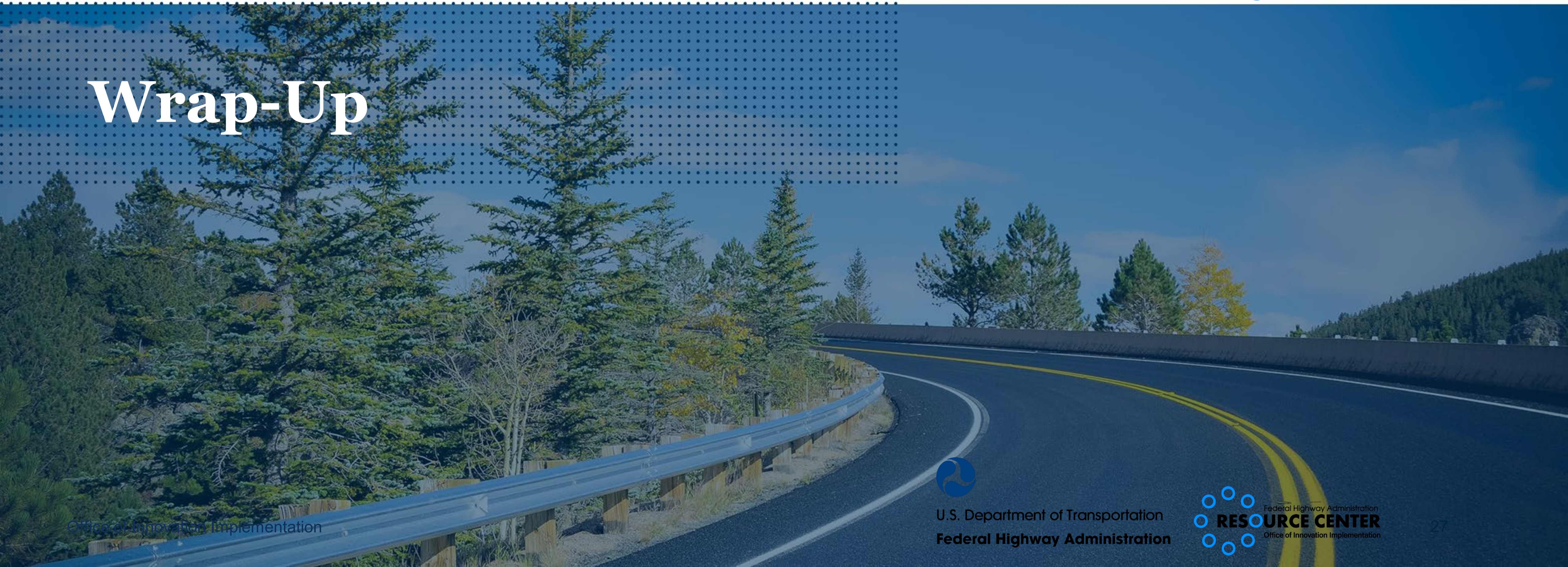
Wrap-Up



BMD Case Studies ~~Virtual~~ Workshop

- https://www.fhwa.dot.gov/pavement/asphalt/
- https://www.fhwa.dot.gov/pavement/asphalt/pubs/20210722_bmd_workshop_flyer_508c_finalv3.pdf
- Contact Derek Nener-Plante

derek.nenerplante@dot.gov

Now offered In-Person!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Balanced Mix Design (BMD) Case Studies Virtual Workshop: Moving Forward with Implementation

Description

This free Federal Highway Administration (FHWA) workshop will provide State DOTs with knowledge on how to get started and/or move forward with the implementation of BMD as learned from in-depth case studies of key State DOTs. It is **customized** to a State DOTs current situation with its BMD implementation program.

This unique workshop includes providing managers and practitioners with knowledge on:

a. the overall BMD process and its benefits;
b. the planning and activities needed for the selection, evaluation, and implementation of performance tests for routine uses in a BMD process; and
c. positive practices and lessons learned by key State DOTs.

The workshop will focus on a BMD implementation process that was developed and conducted from in-depth case studies of key State DOTs.

Location

The **free virtual workshop** will be delivered using Microsoft Teams or any other virtual meeting platform accepted by a State Department of Transportation (DOT).

Length

The workshop is a total of six hours and will include multiple segments with a maximum of three hours per segment. The workshop can be delivered over the course of several days.

Target Audience

The successful implementation of BMD will need to be a team effort. Thus, the target audiences for the workshop are managers and practitioners interested in the implementation of BMD from State DOTs, industry, academia, and consultants. This involves participants from various offices of a State DOT, such as materials, pavement design, construction, and pavement management.

Outcomes

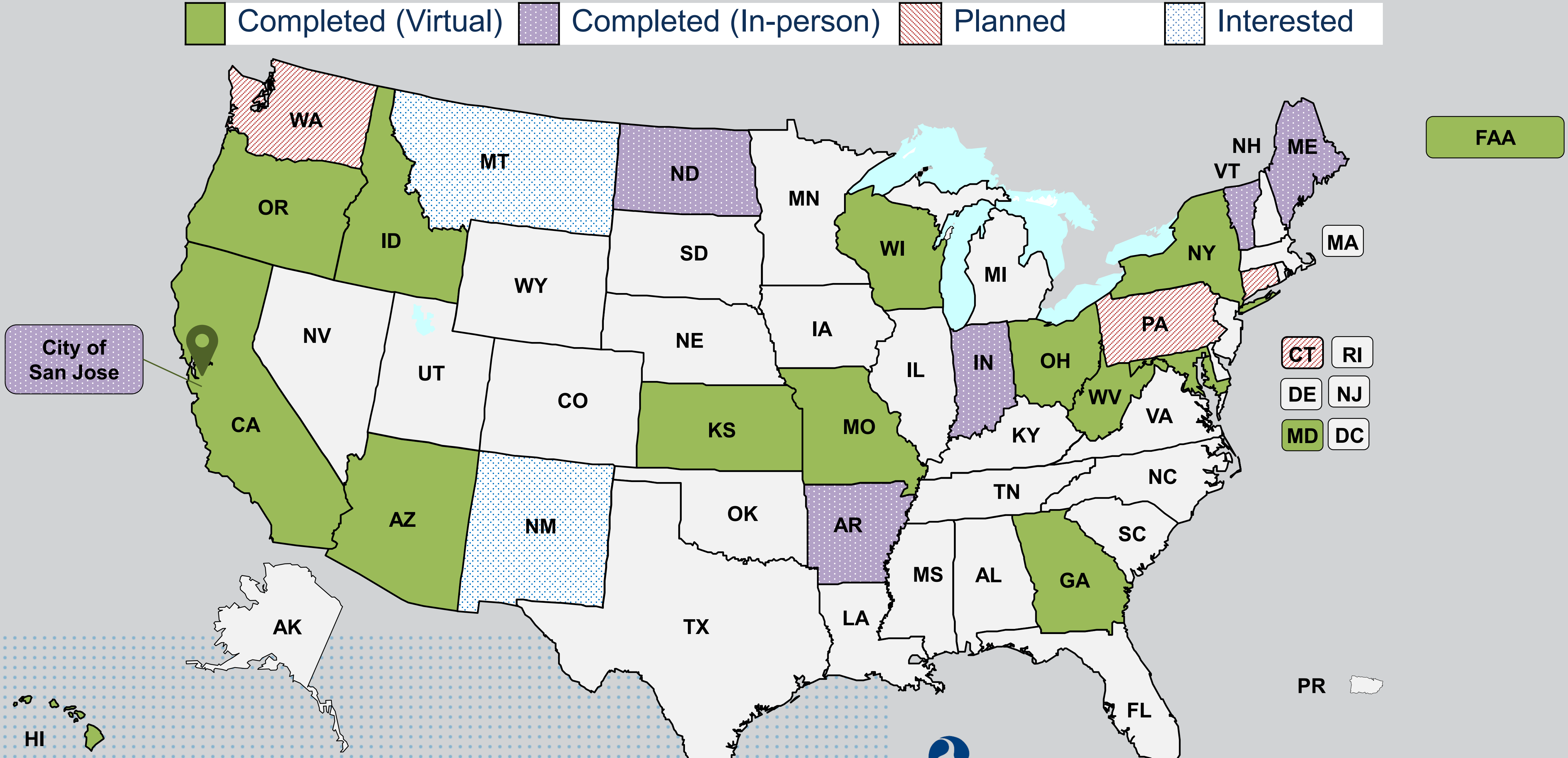
Upon completion of the workshop, participants will be able to:

- Understand the overall benefits of BMD.
- Recognize the planning and coordination effort associate with the implementation process of BMD.
- Identify the tasks that need to be completed for the development and implementation of BMD.
- Recognize successful key State DOTs practices and experiences related to BMD.
- Recognize available external technical information and support.

Register Today

Contact **Derek-Nener-Plante** at derek.nenerplante@dot.gov for more information.

FHWA Balanced Mix Design Case Studies Virtual/In-Person Workshop



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Questions?

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Thank you for your attention!

Derek Nener-Plante
Pavement and Materials Engineer
derek.nenerplante@dot.gov

ASTEC™

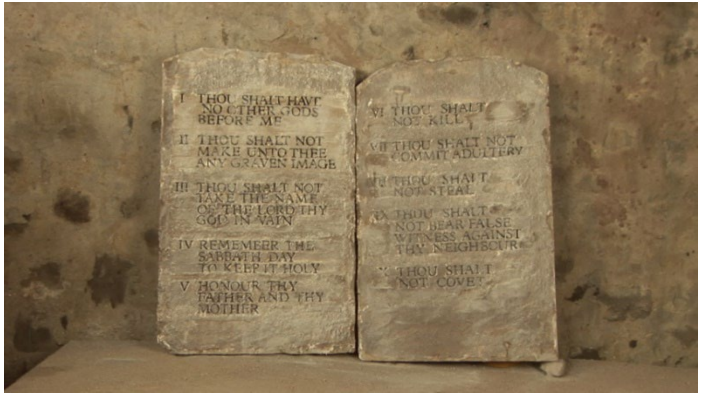
Asphalt Plant Efficiency

BUILT TO CONNECT

Missouri Asphalt Pavement Association
February 2024
Greg Renegar

From concept to action

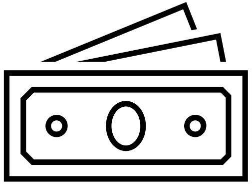
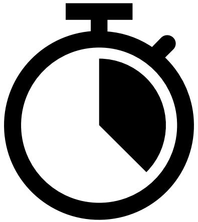
- Preached efficiency far and wide
- Operators, foreman, area managers
- Has behavior changed?
- Goals vs. rules
- Make a list of operation rules as we discuss plant efficiency
- Goals – rules – habits – culture
- Culture of profitability



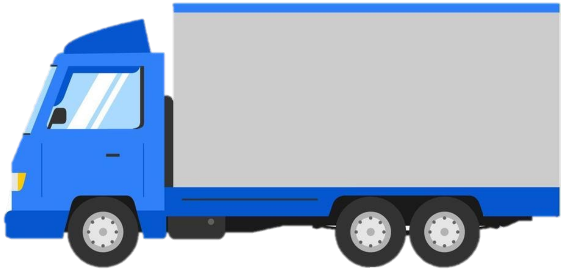
EFFICIENCY - Used to describe many things

The Goal – To think about asphalt plant efficiency differently– **to make good decisions**

What is Efficiency?


$$\text{EFFICIENCY} = \frac{\text{What you get}}{\text{What you give}}$$


DEFINING "**EFFICIENCY**"

EFFICIENCY = **Mix** / **Energy + materials**

(Fuel + Electricity)

- Radiation
- Emissions
- Stack gases
- Friction
- HP loss
- Electrical

- Dust
- Water
- Stockpile

Different "Categories" of Efficiency

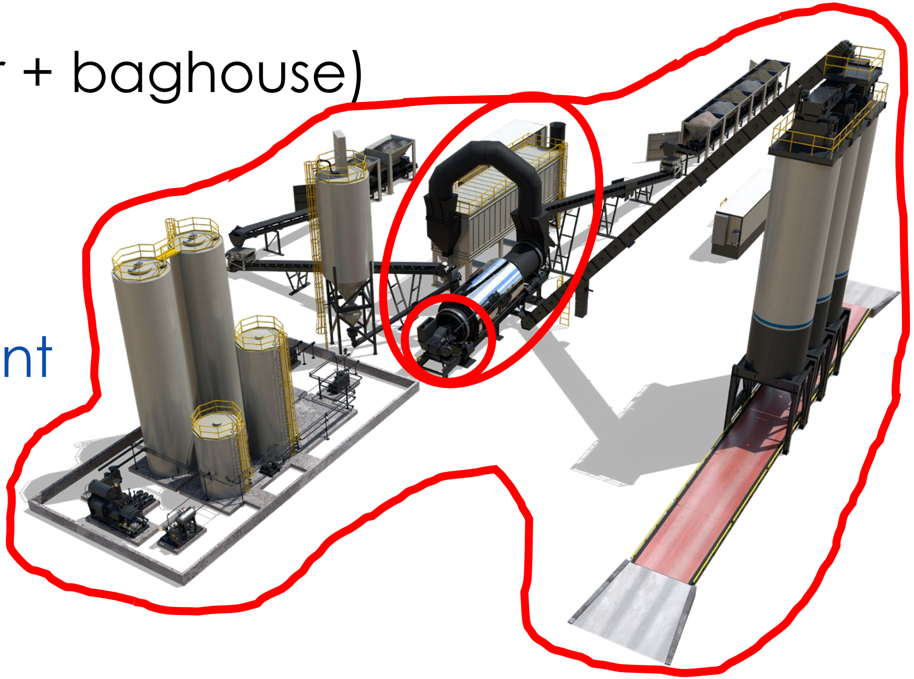
Component efficiency (burner)

System efficiency (burner + dryer + baghouse)

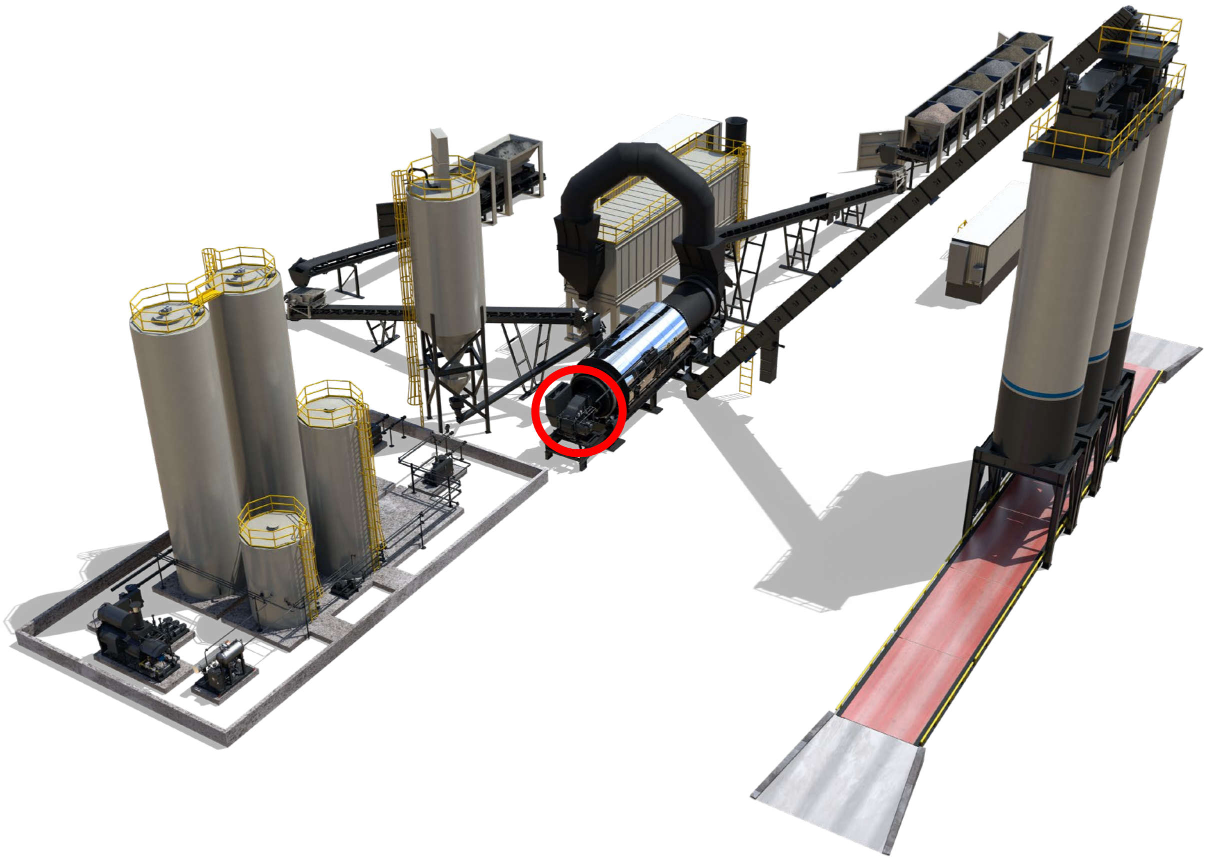
Plant & operation efficiency

You could have good component and system efficiency…

And have a less profitable plant!



Component Efficiency



DEFINING Burner "**EFFICIENCY**"

Burner EFFICIENCY = **Heat** / **Fuel + air + electricity**

These things still have unused energy

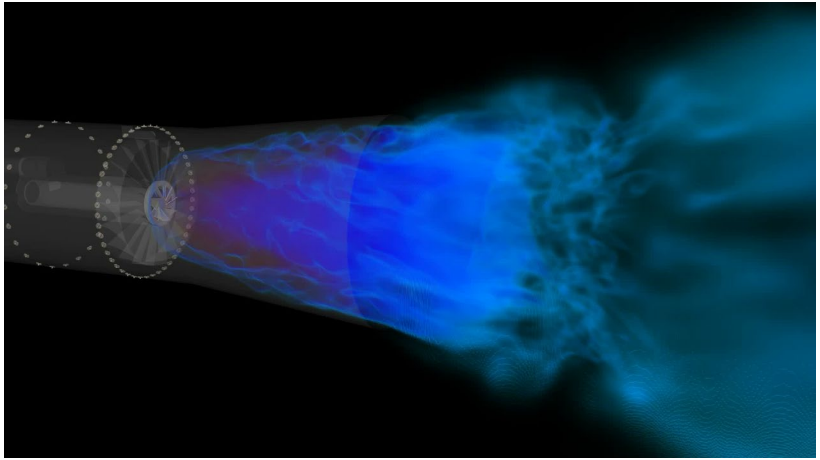
- Carbon Monoxide (CO)
- HC (Hydrocarbons)

Component Efficiency – Burners

$$C_X H_Y + O_2 \rightarrow H_2O + CO_2 \text{ or } CO$$

Fuel (Hydrocarbon) | Oxygen (Air) | Water | Carbon Dioxide | Carbon Monoxide

Can tuning make your burner more "efficient"?
Yes but…



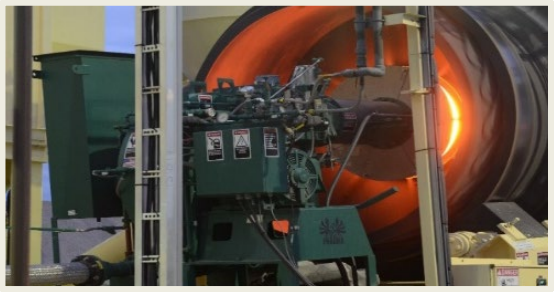
Agreeing on a definition for "efficiency" is absolutely critical!

What about excess air?

- What is it?
- Why is it required?
- How much is needed?
- What if there is too little? Too much?
- Are all burners the same?
- How do you tell if too much excess air?
  - Gas analyzer – not so fast…
  - Out of baghouse cfm at a low production rate
  - Excessive dust carry-out

Burner technologies

TOTAL AIR BURNER



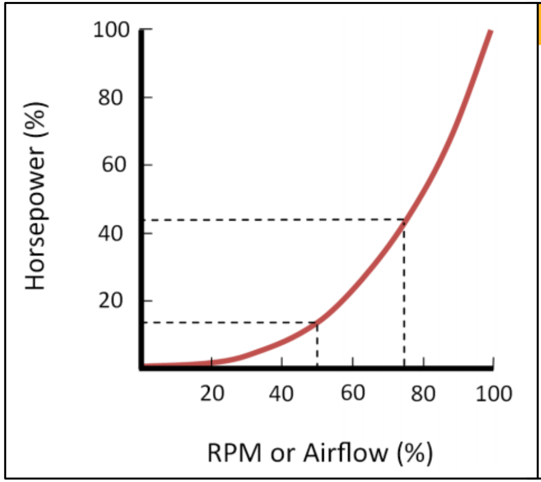
OPEN-FIRED BURNER

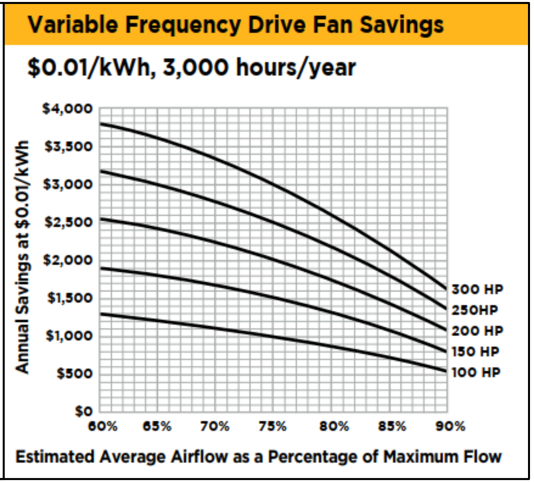
- Which is better?
- Total Air – **don’t oversize the burner !**
- Total Air with VFD really wins
- Does it “move the needle” or is it a baby-step?

Component Efficiency – VFD

Variable Frequency Drive (VFD)

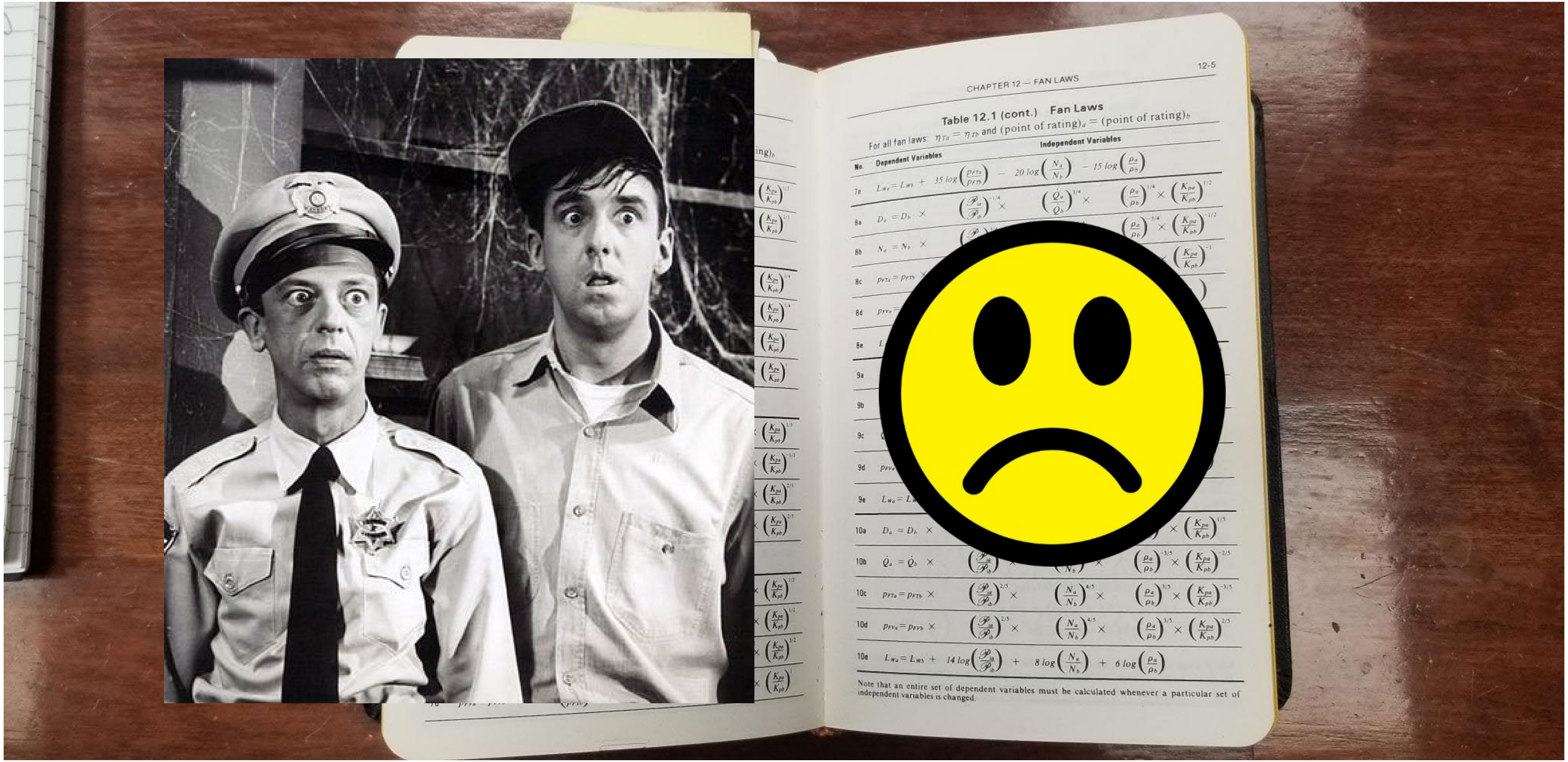
- Fans: Can save a lot of energy compared to a damper
- Drum: Helps keep energy loss down
- Drag: Reduces wear





Source: NAPA Publication QIP-132 / Alliant Energy

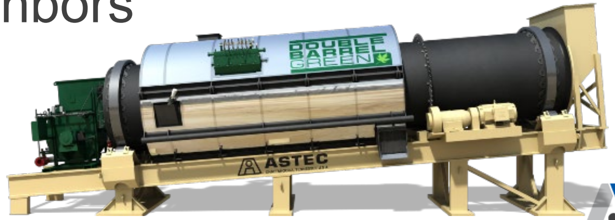
Fan Laws



12-5
CHAPTER 12 — FAN LAWS
Table 12.1 (cont.) Fan Laws
No.
Dependent Variables
Independent Variables
Note that an entire set of dependent variables must be calculated whenever a particular set of independent variables is changed.

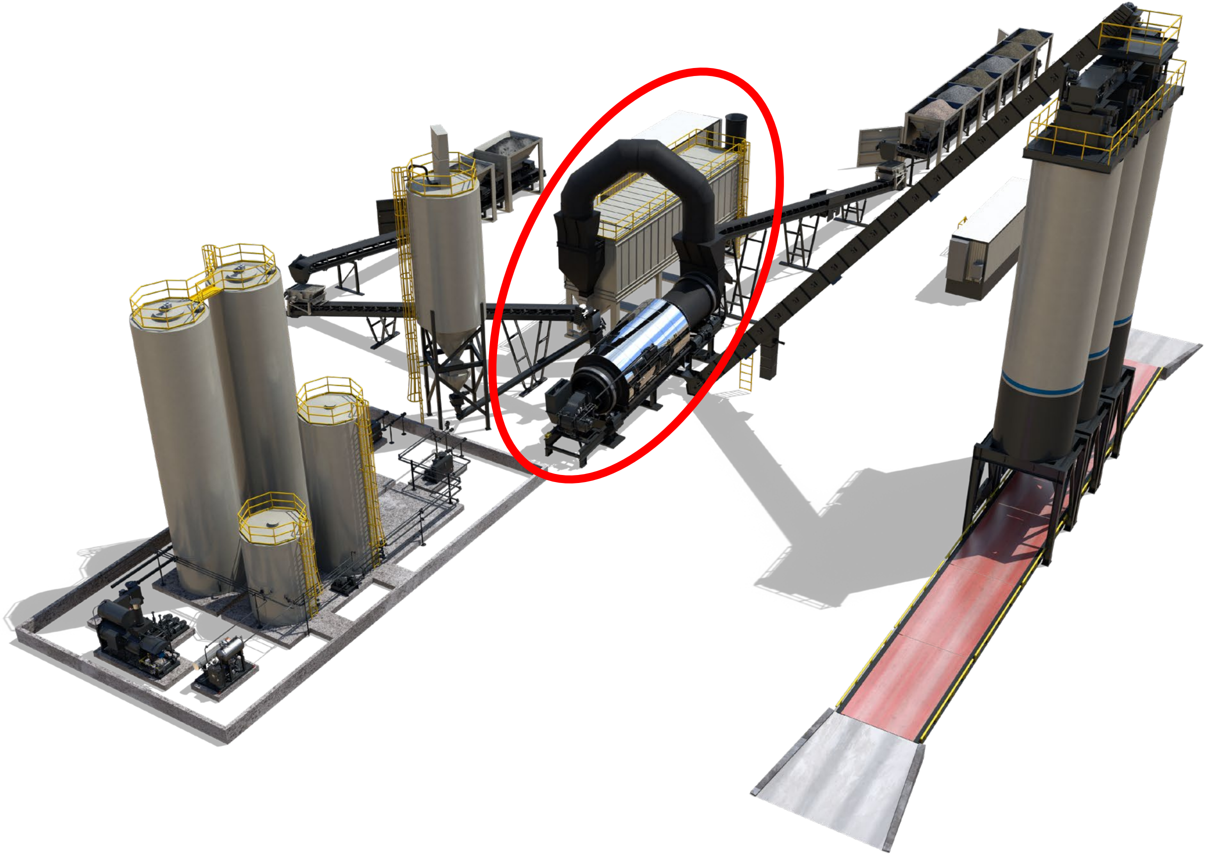
What are VFDs good for?

- **Energy savings:**
  - Baghouse exhaust fan **(80% speed = 50% energy)**
  - Burner fan **(50% speed = 12.5% energy)**
  - Much less noise – happier workers and neighbors



System Efficiency

ASTEC



System efficiency

- Good burner performance doesn’t necessarily equal good heat transfer – WHAT ?!?!?
- How can this be so?
- The burner, dryer, and baghouse comprise a **system**
- The components must be **matched** and **work together**
- **Remember: Manning didn’t win the Championship**

The Difference between thermodynamics and Heat Transfer

- Thermodynamics is how much energy (heat) is needed
- Heat transfer is how the heat is delivered to where it is needed

"Burner"

This is Thermodynamics

"Burner + Dryer + Exhaust System"

This is Heat transfer

System Efficiency

Suppose we have two plants…

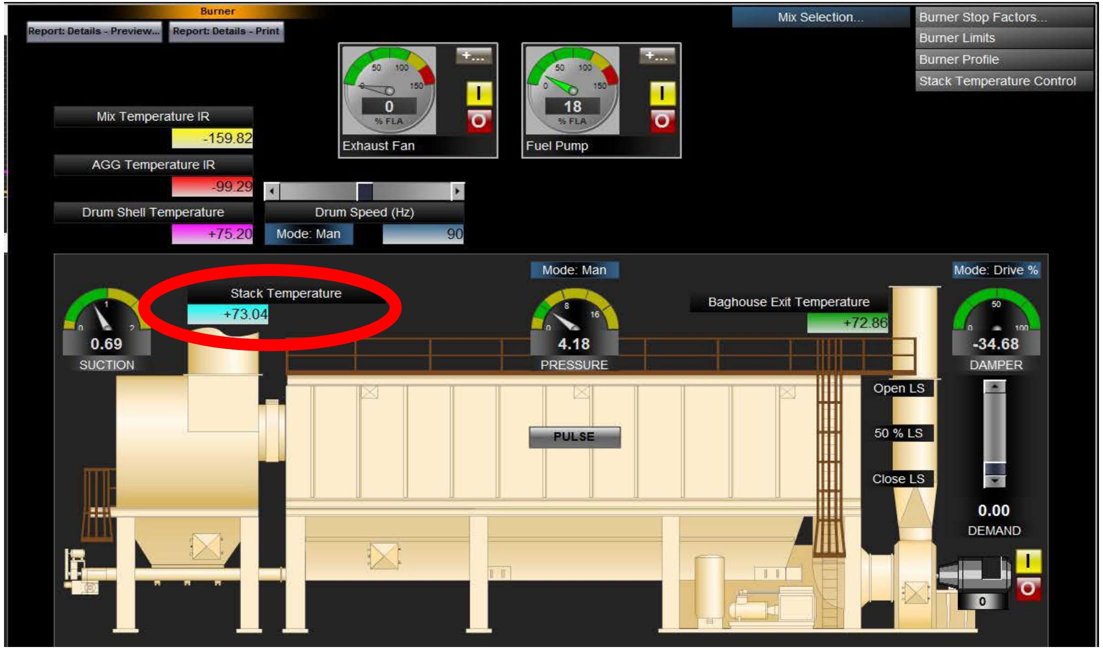
- Same mix
- Same aggregate and RAP source
- Same mix temperature
- Same production rate
- Same moisture contents
- Same fuel
- Same burner

What number on the console indicates which plant is drying more "efficiently"?

(Which plant has more heat going into the aggregate?)

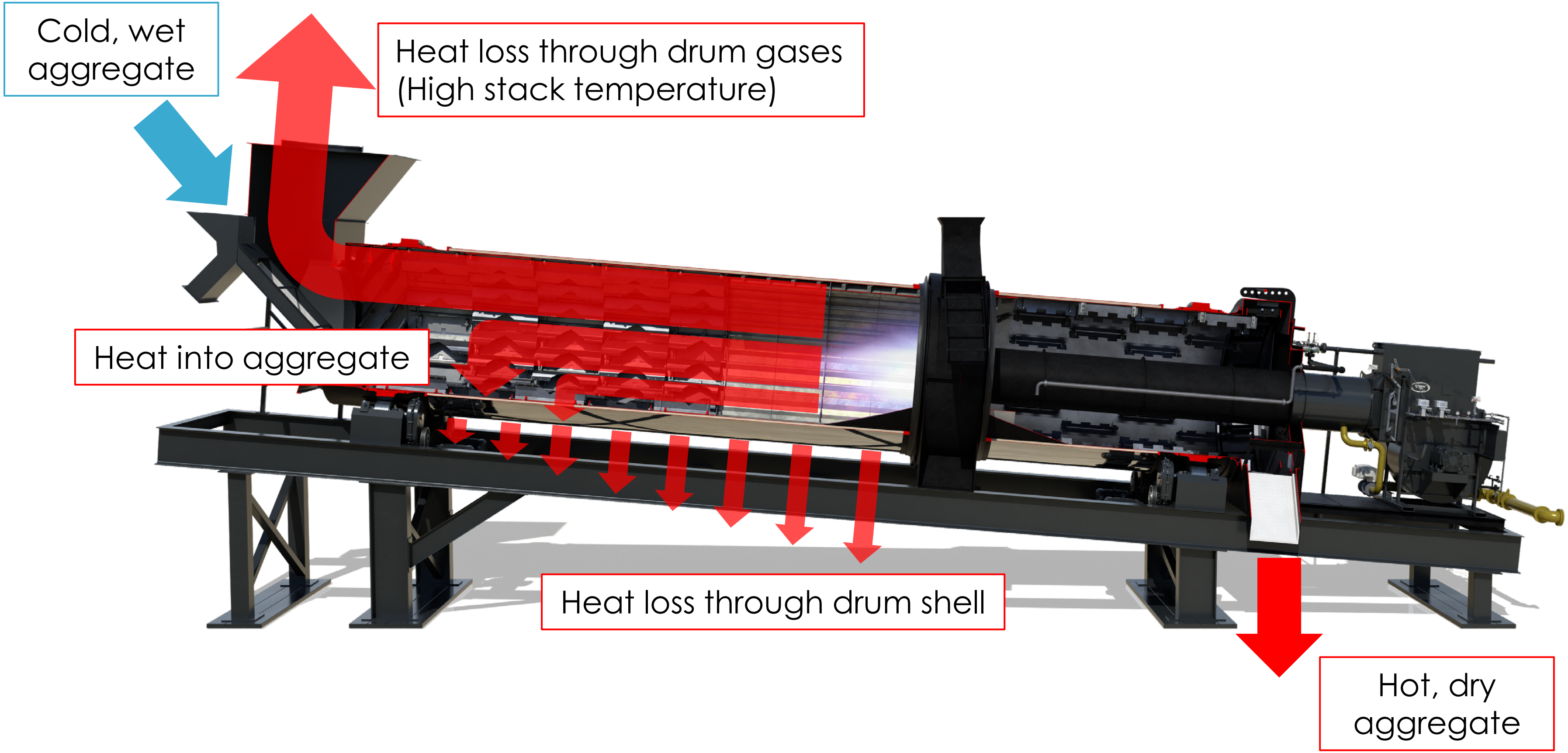
System Efficiency

The ONE thing you see *every day*...

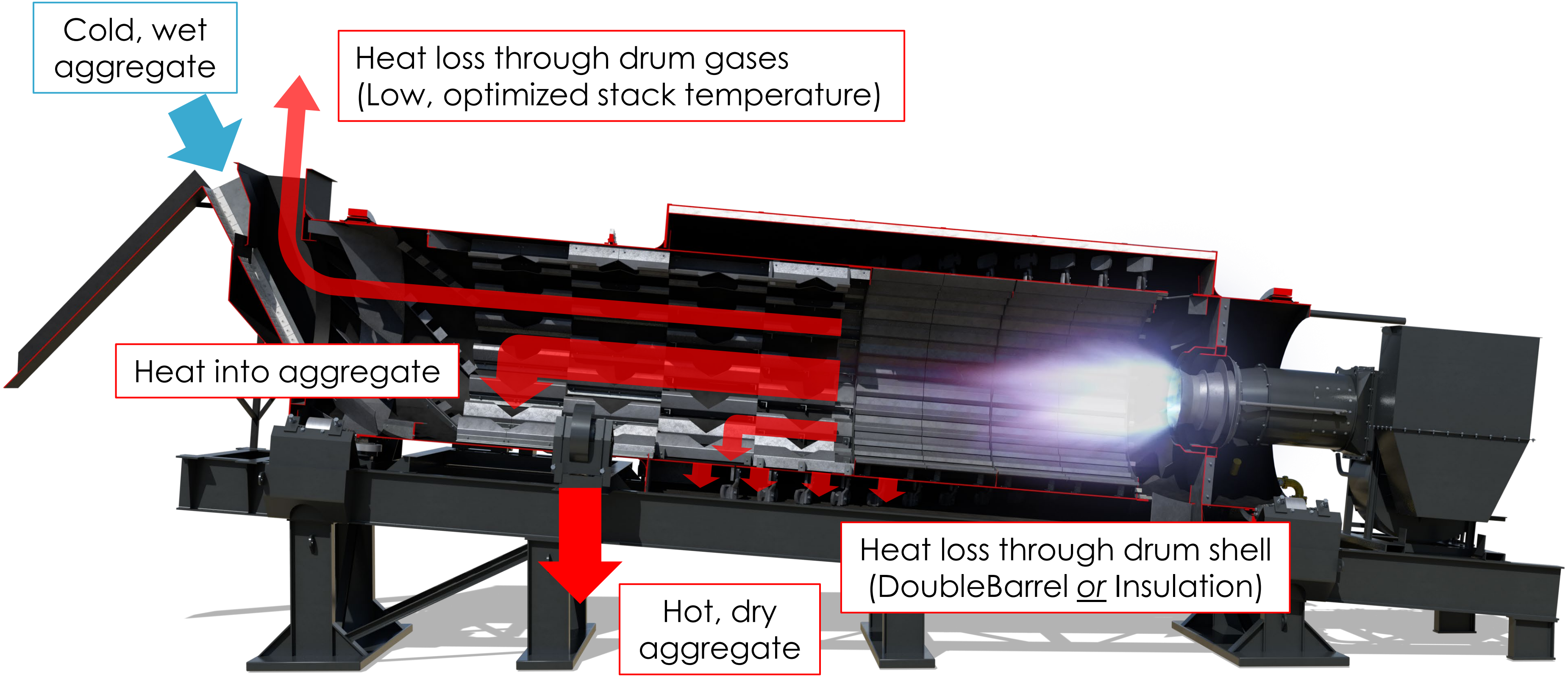


STACK TEMPERATURE!

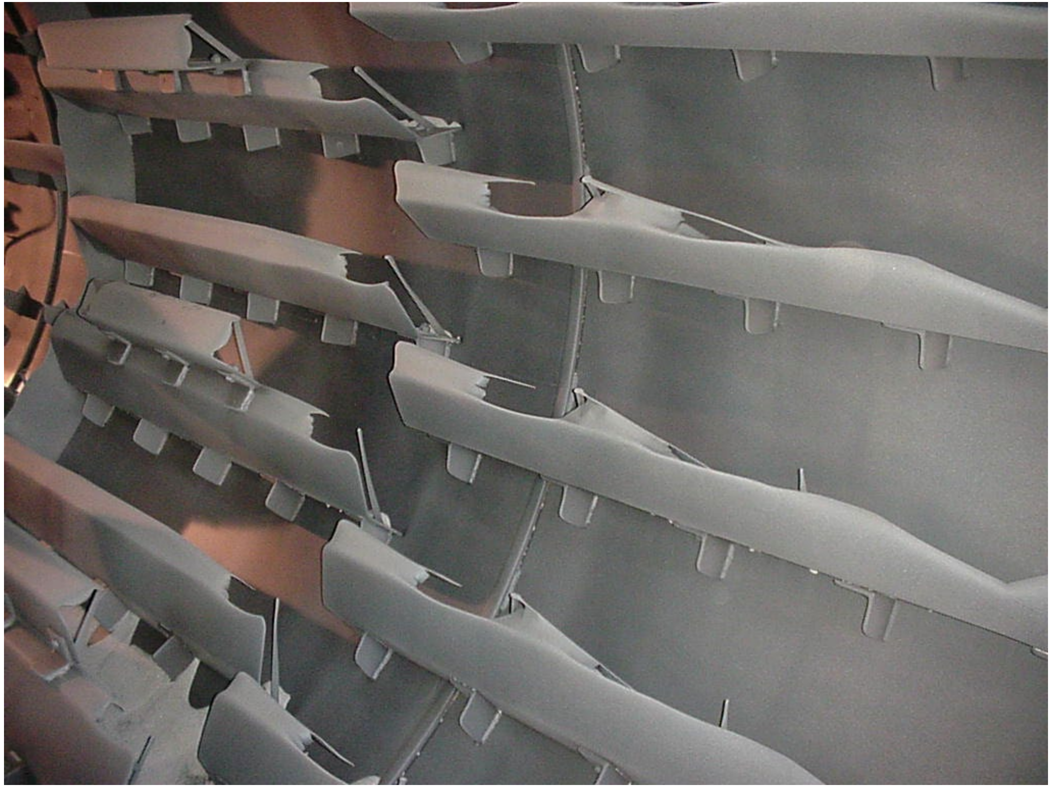
System Efficiency



System Efficiency



Drum flighting and EFFICIENCY



Do these flights veil properly?

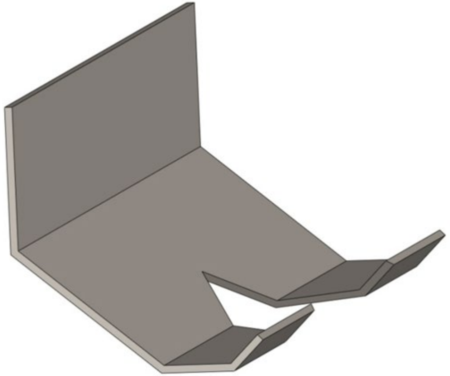
Probably not, but it depends

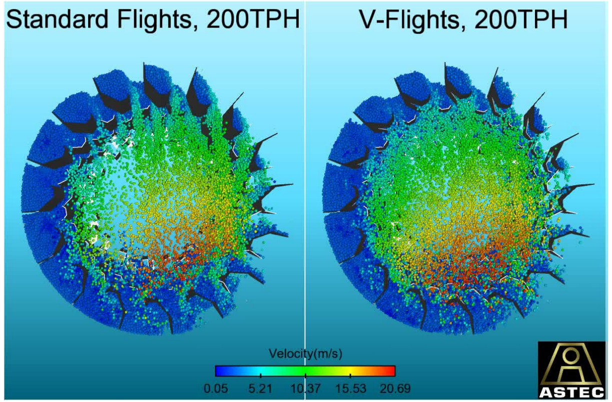
Maintenance Affects Efficiency!

Stack Temperature Control

- How can the stack temperature be changed
  - Change flights
  - Modify flights – cut / weld
  - Modify flight system (Add dams, kickers, etc.)
  - **Press a button in the control house – V-Pac**

V-Pack™ Stack Temperature Control

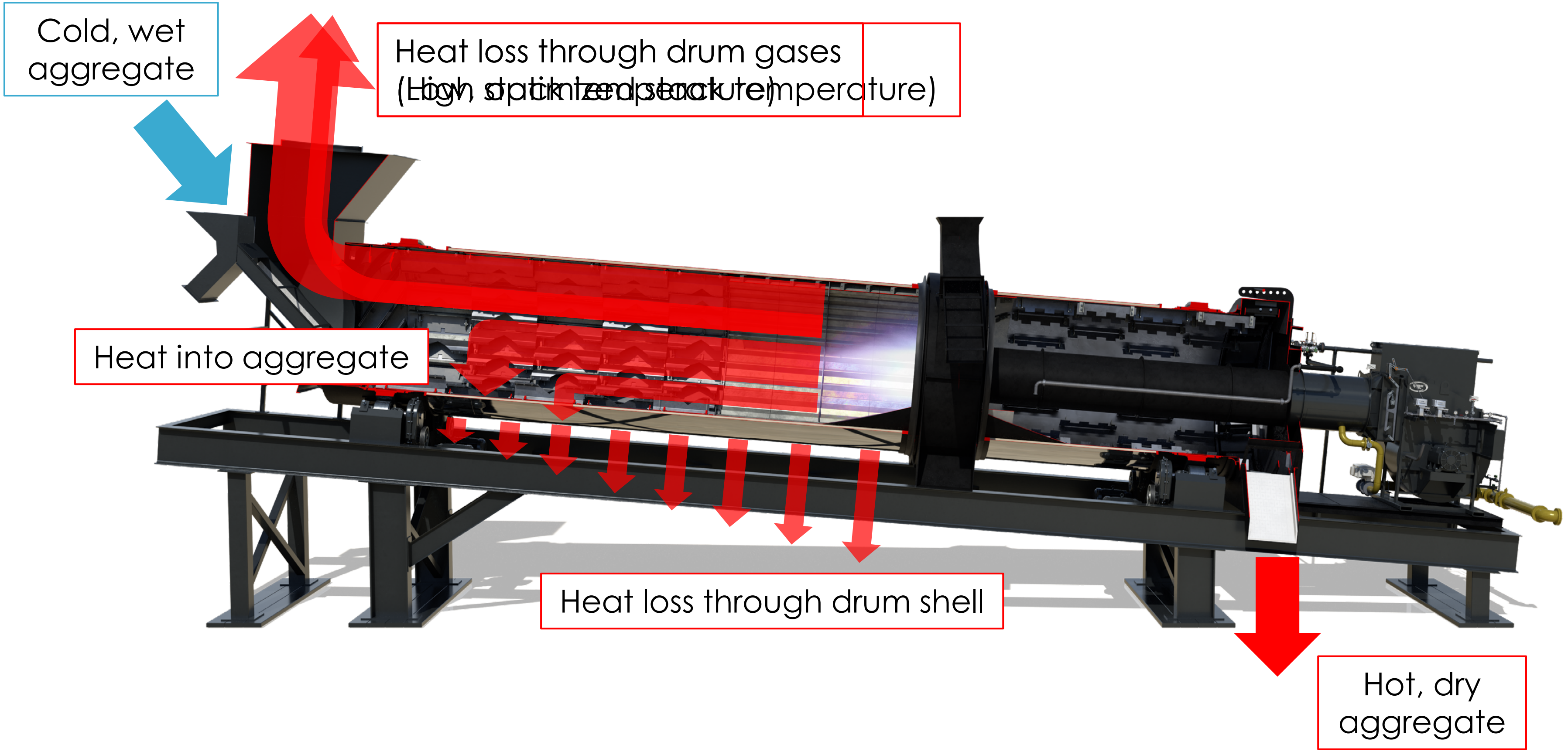




VFD and Controls

The VFD changes the drum speed. Controls determines how much.

System Efficiency



Stack Temperature Effect on Production

60F = 10% production

4% effect on fuel required

60-10-4

Stack temperature

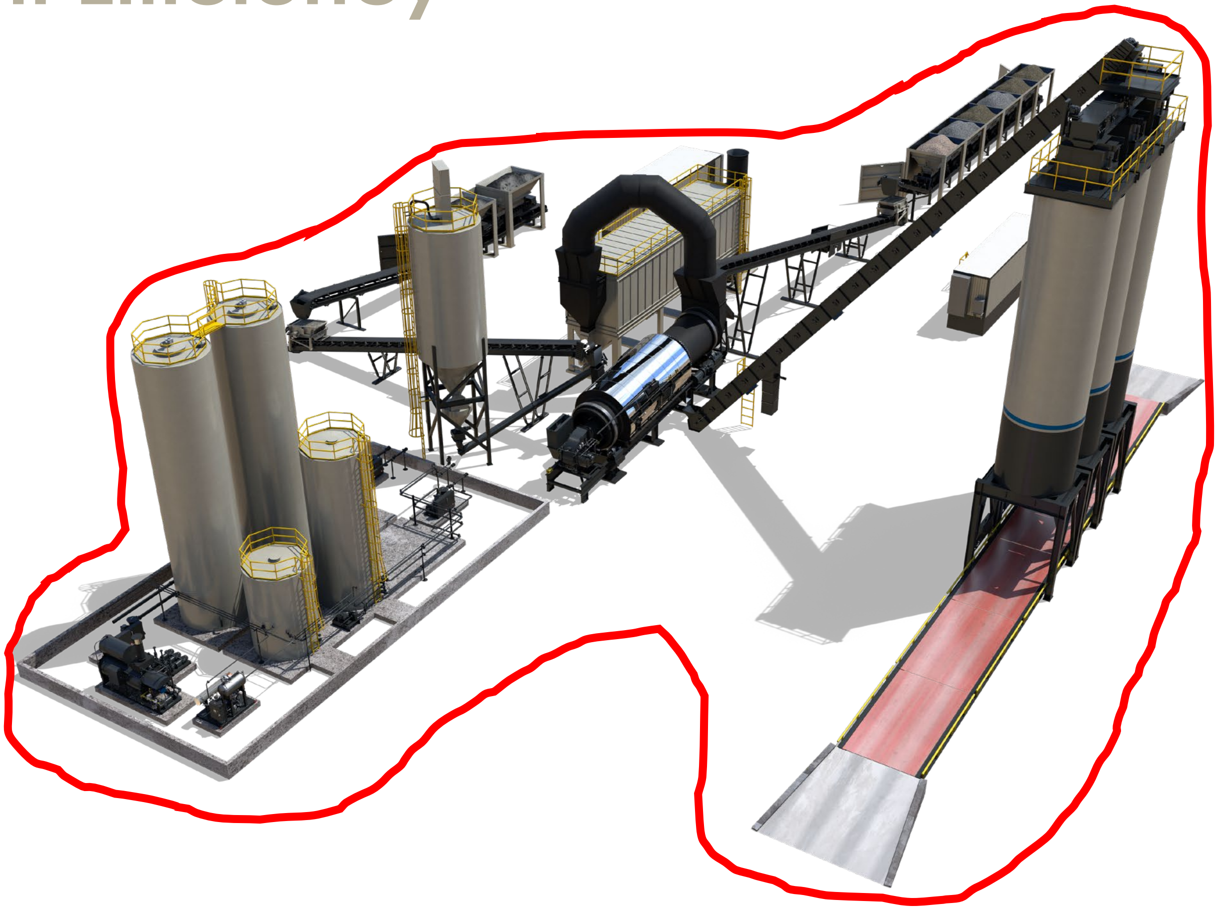
- How low is too low?

- What is the dew point?

- Bad things can happen if you go too low
- mudding on the bags – won't pulse off – high delta P – low tph
- Plug up augers – hopper full of dust – plant down
- Corrosion

High Baghouse ΔP

Plant Efficiency



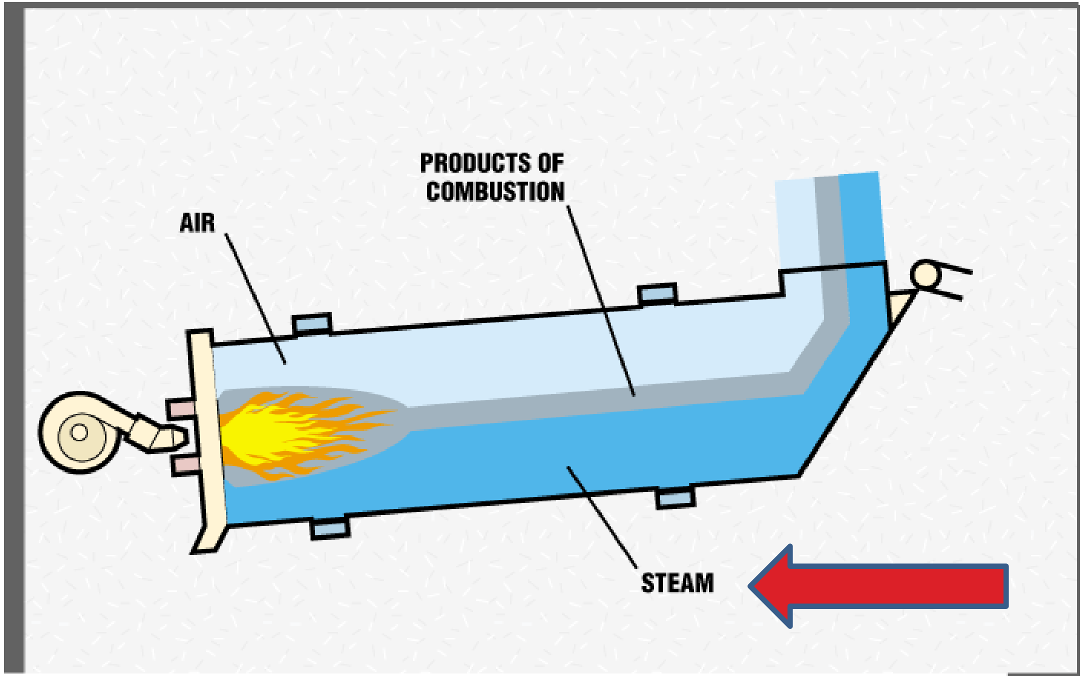
Moisture’s Effect on Fuel Consumption

52% of Fuel is Required to Process the Water

1% change in moisture = 11% Reduction in Fuel Consumption

1-11-11

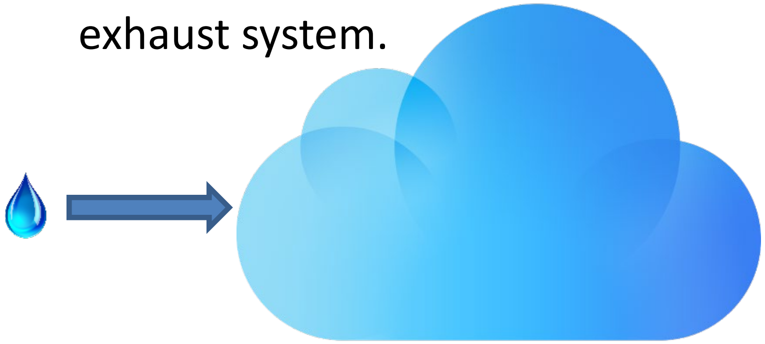
HOW DOES MOISTURE AFFECT PLANT CAPACITY?



EXHAUST COMPONENTS IN A TYPICAL DRYER

As water turns to 240 F steam it expands 1747 times.

That is why a small percentage of water makes a big difference to the exhaust system.

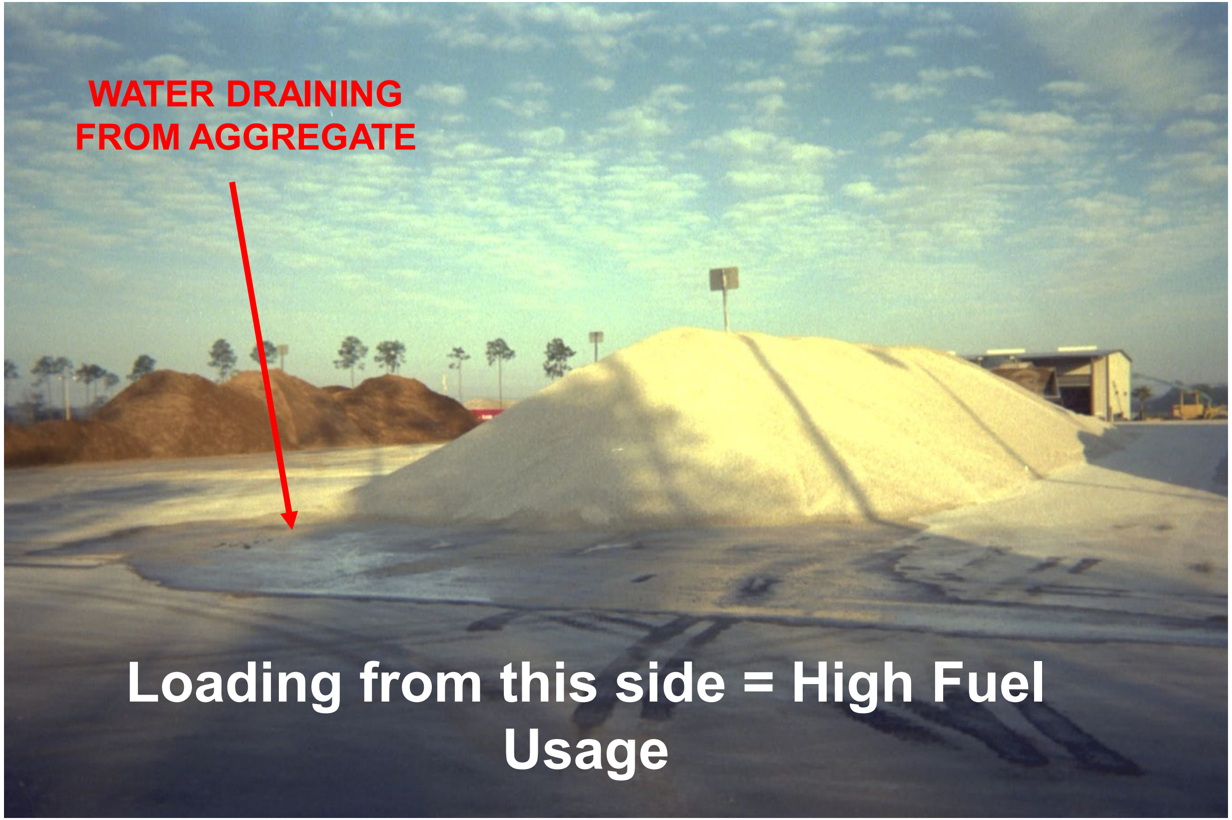


X 1747

Moisture matters!

1% Moisture = 12% production

1-11-11


WATER DRAINING
FROM AGGREGATE
Loading from this side = High Fuel
Usage

Plant Efficiency – Moisture

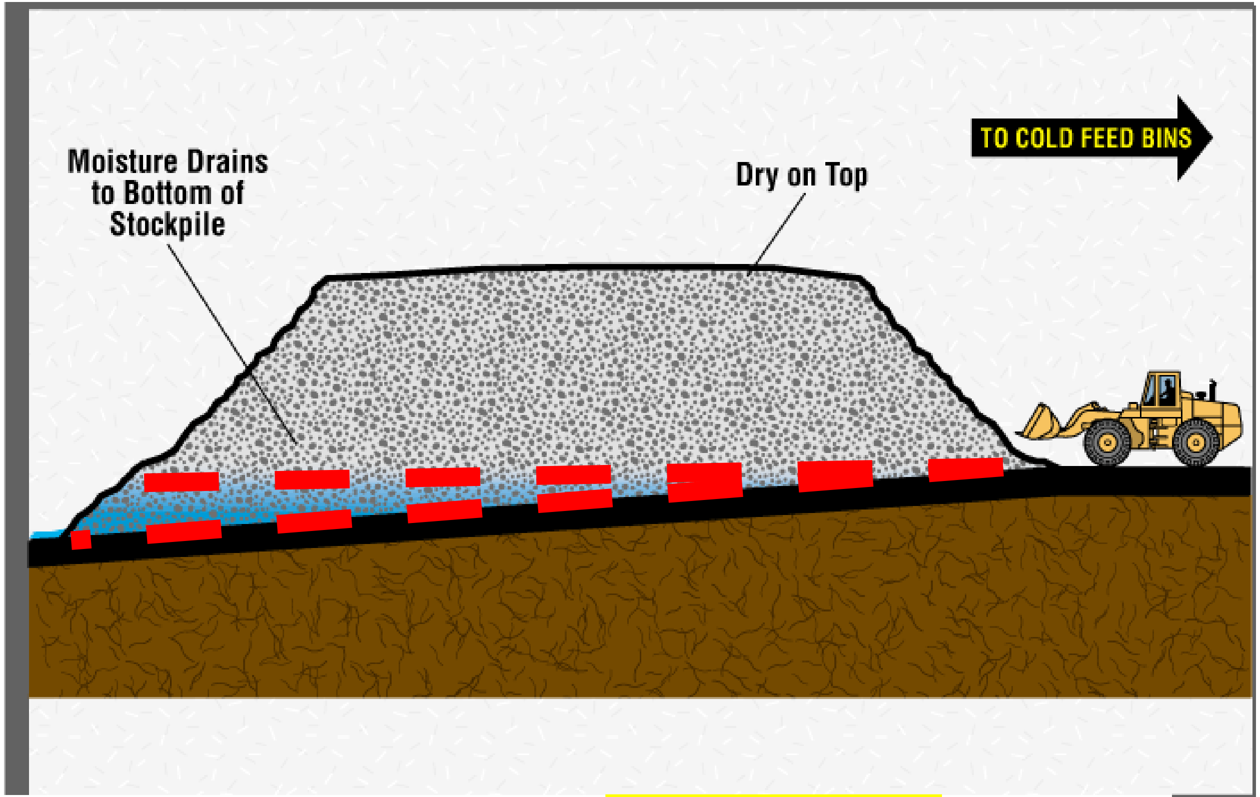
ASTEC

Good stockpile management practices can have an oversized effect on plant efficiency.

- Slope & Pave
- Cover (sometimes)
- Load from the dry material

A 2% reduction in moisture can reduce the burner energy requirement by 21%*.

Based on Astec internal calculations. Third party verification in progress.

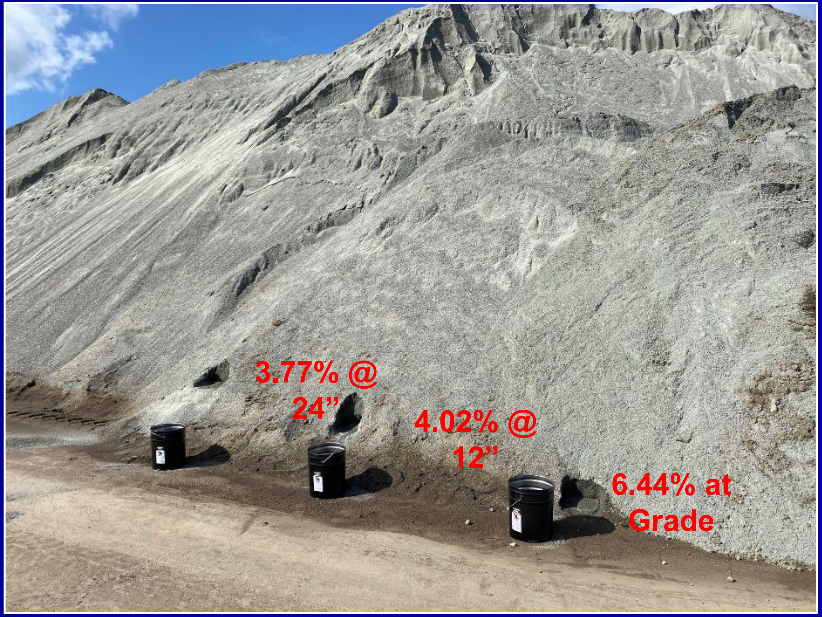


STOCKPILES WITH IDEAL 6% SLOPE

Managing Moisture …

Stone Screenings – A

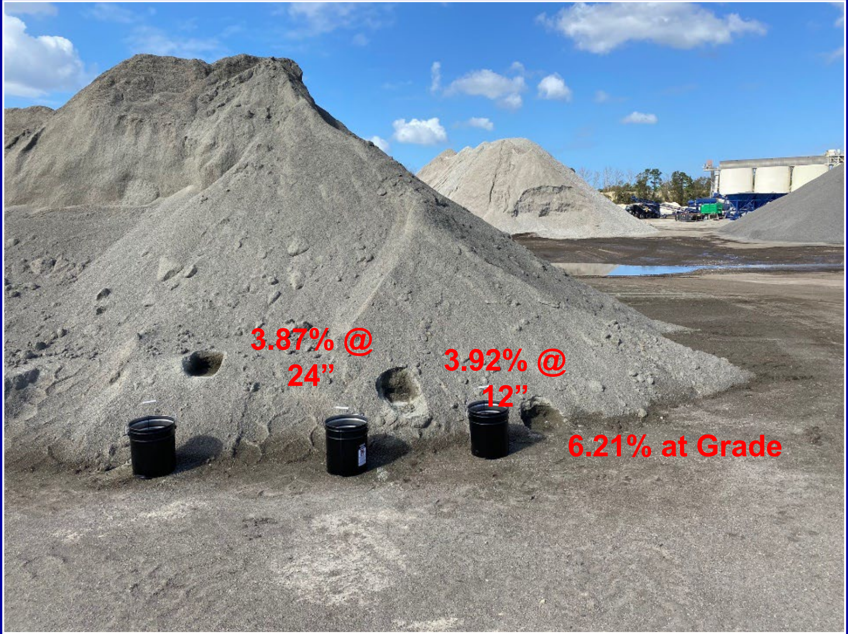
2.4% less up 12”



Managing Moisture …

Stone Screenings – B

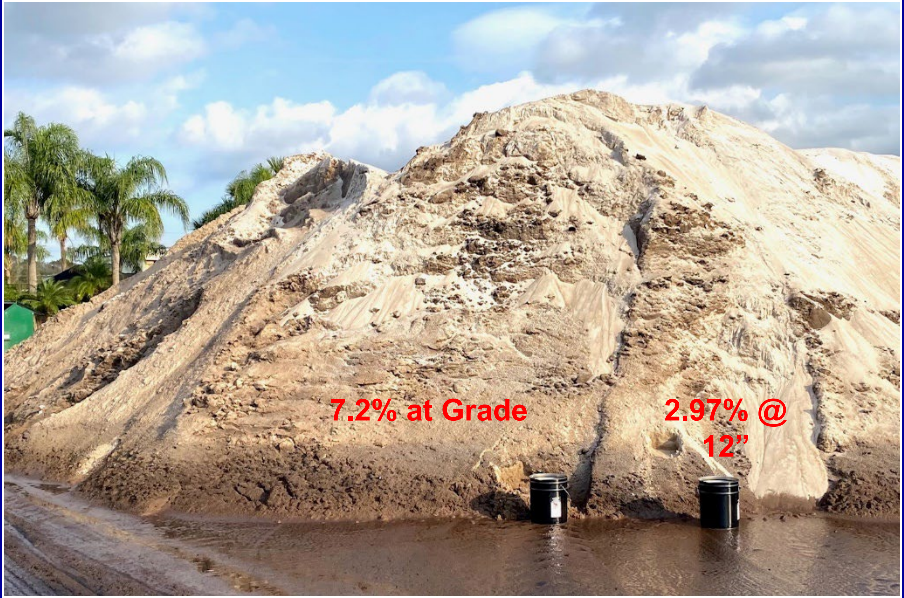
2.3% less up 12”



Managing Moisture …

Natural Sand

4.2% less up 12”



Managing Moisture …

3/8”
(9.5mm)
Stone

(1% less up 12”)

Cold feed bins covered too

Material inside and outside

Feed bin rain covers - Australia

Cold Feed bin covers – Colombia, South America

High operational Efficiency trumps component / system efficiency

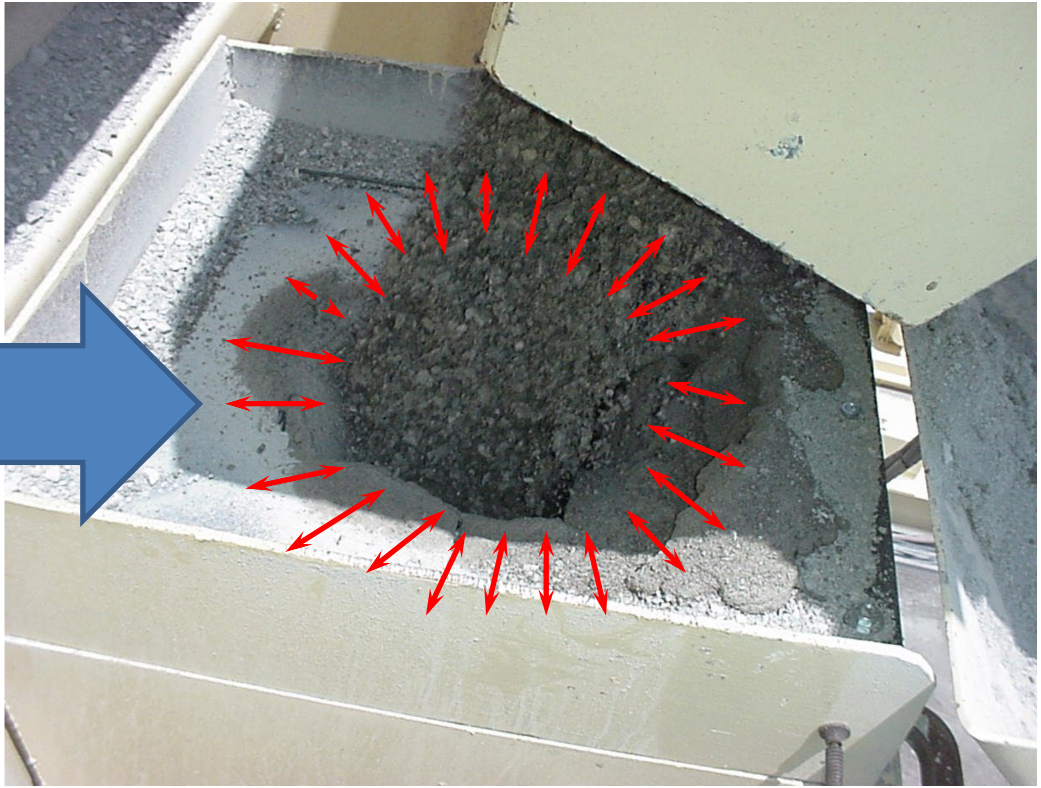
Parallel flow drum mixer (obsolete - high stack temp)

Old burner technology

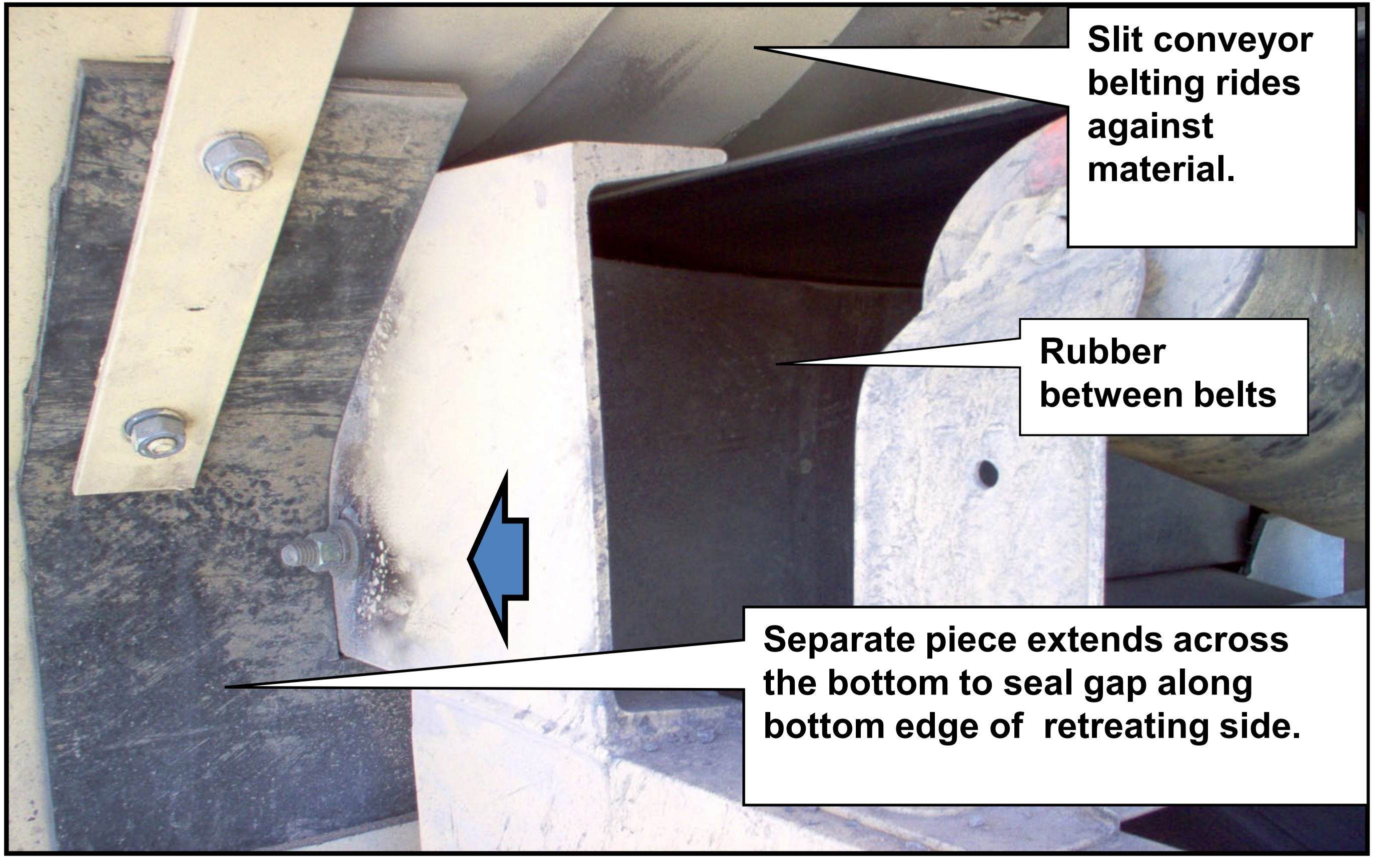
Low component / system efficiency – High plant efficiency

Air Leakage – Drum inlet chute

Drum inlet chute seal made from conveyor belting



Air Leakage – Slinger conveyor to drum

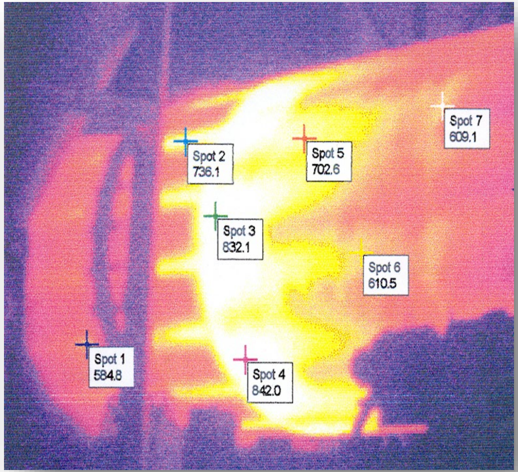


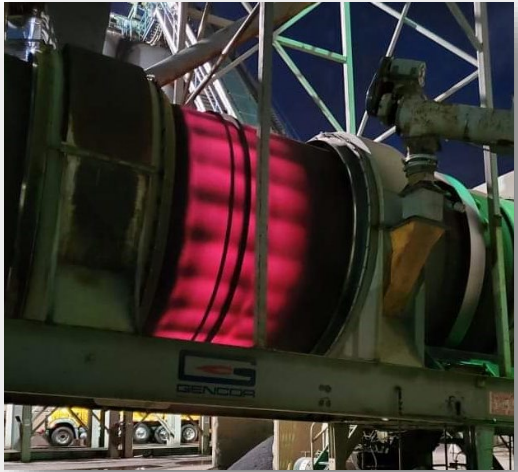
To insulate or not, that is the question!

Everything that gets hot besides the mix is a waste of energy, but what does it make sense to insulate?

Insulating Your Plant

- Dryer drum → Insulate?
- Duct work → Worth the effort?
- Baghouse → Lots of surface area





Insulating Your Plant

- AC tank farm → Yes!
- AC piping → Yes!
- Pipe flanges → Yes!

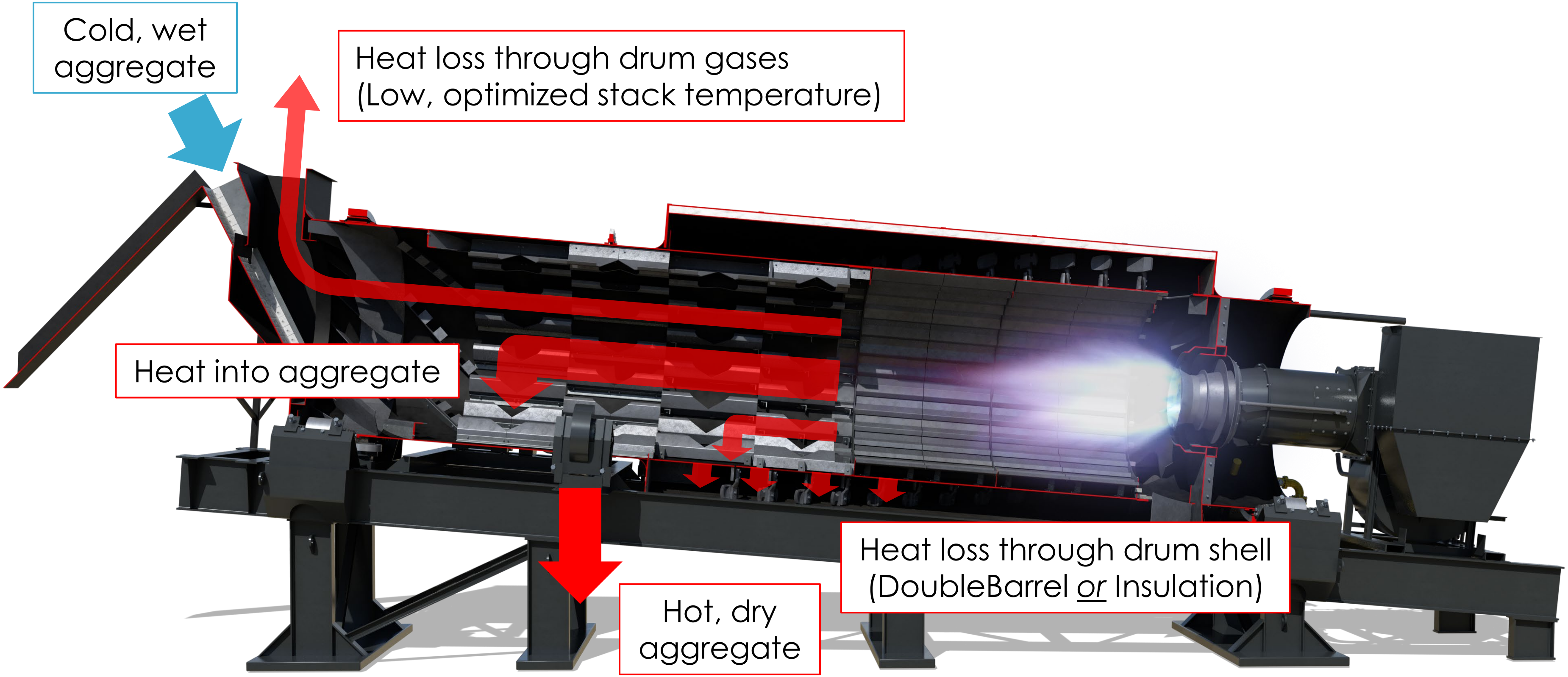
Jacketed Asphalt Piping					
Asphalt Pipe Nominal Size	Hot-Oil Jacket Nominal Size	Loss Per Linear Foot BTU Per Hour		Loss Per Flange BTU Per Hour	
		Un-insulated Jacket	Insulated Jacket	Un-insulated	Insulated
3 inches	4 inches	1598	86	1890	120
4 inches	6 inches	2349	122	2600	134
5 inches	8 inches	3057	148	3240	178

Hot Oil Piping				
Pipe Diameter	Loss Per Linear Foot BTU Per Hour		Loss Per Flange BTU Per Hour	
	Un-insulated	Insulated	Un-insulated	Insulated
1-1/2 inches	676	47	1205	97
2 inches	846	54	1660	115
2-1/2 inches	1024	55	2155	125
3 inches	1243	72	2485	130

Source: NAPA Publication QIP-132 & Astec Technical Paper T-140

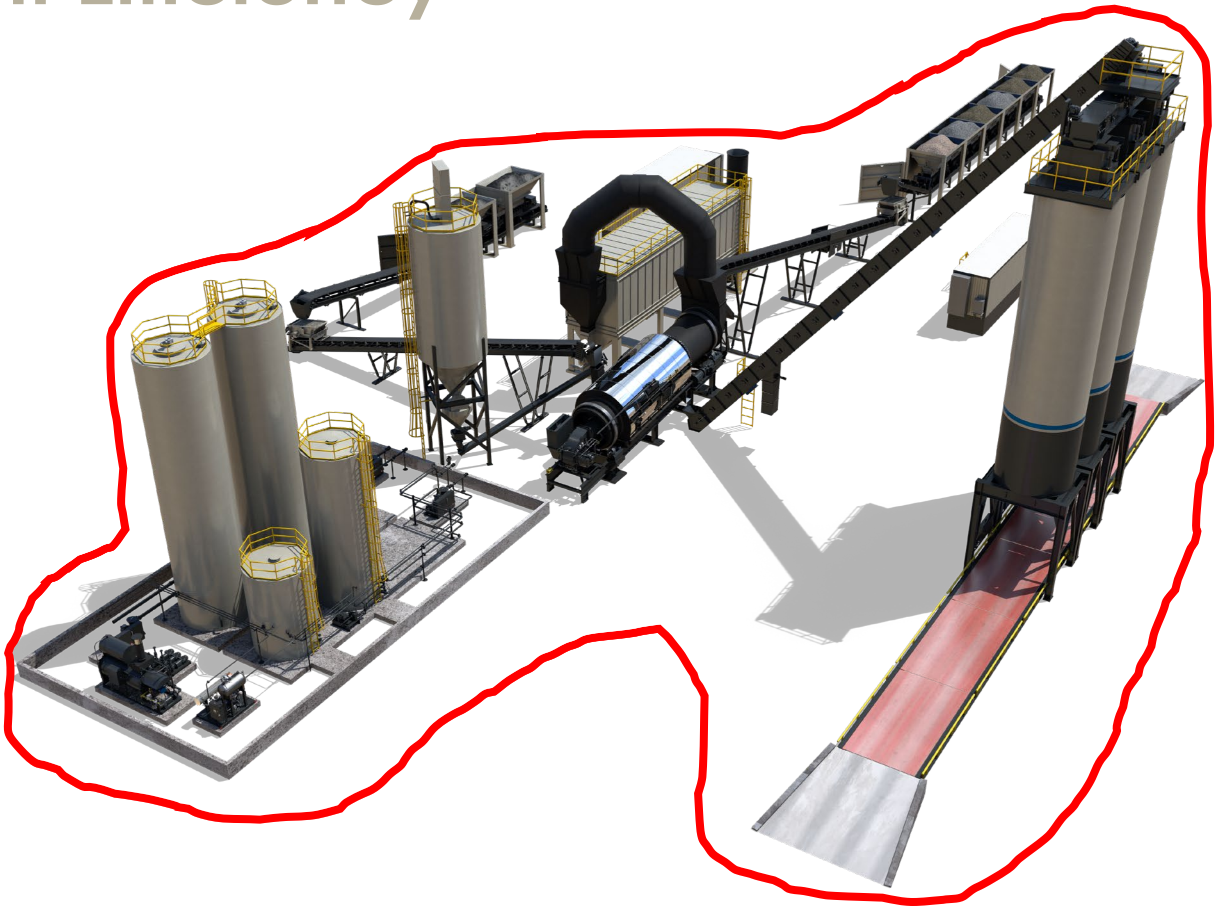
This will become more important as producers look to pick all the “low hanging fruit”

System Efficiency



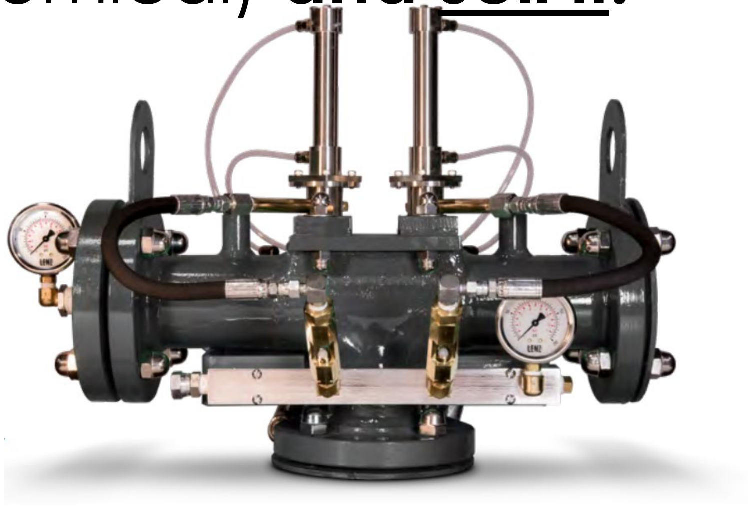
Plant Efficiency

ASTEC



Plant Efficiency – Mix Temperature

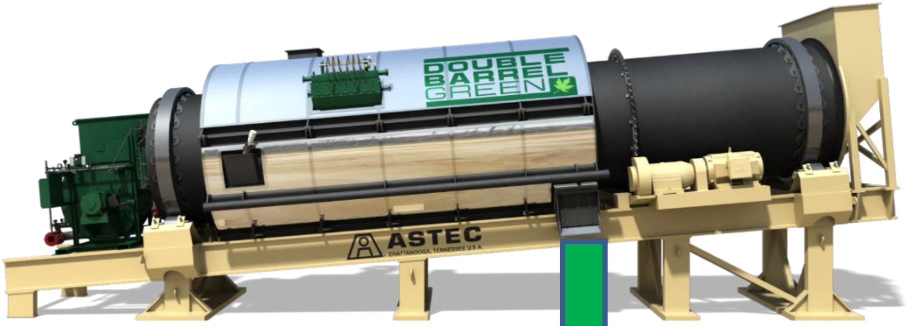
Pick a Warm Mix technology (mechanical or chemical) **and <u>sell it</u>!**

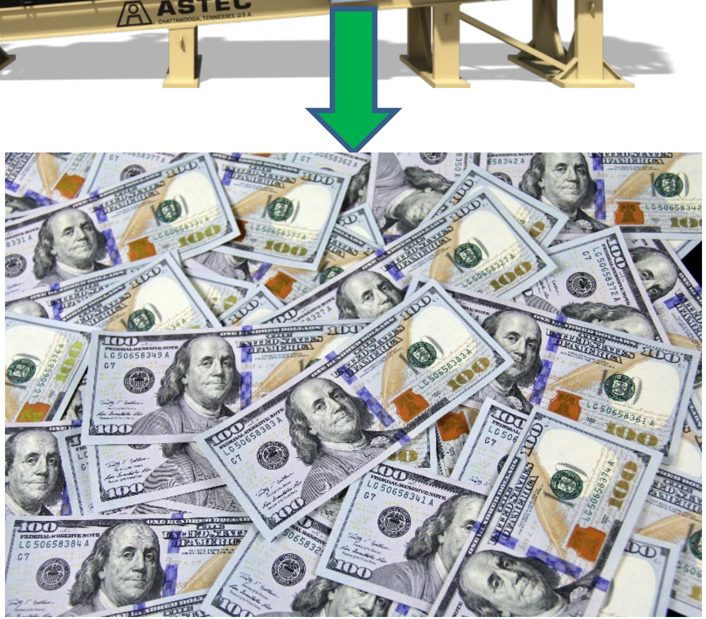


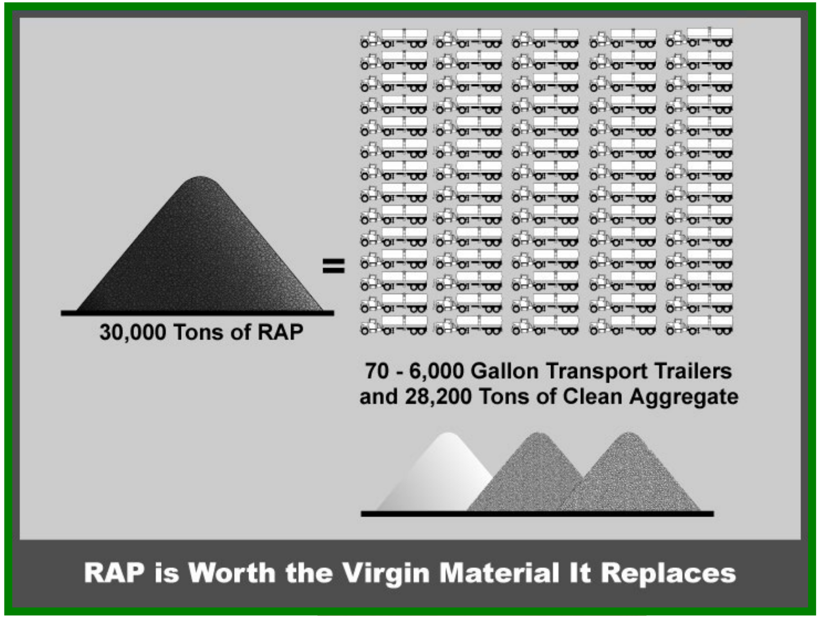
A 50° F reduction in production temperature can reduce fuel consumption by 11%*

Based on Astec internal calculations. Third party verification in progress.

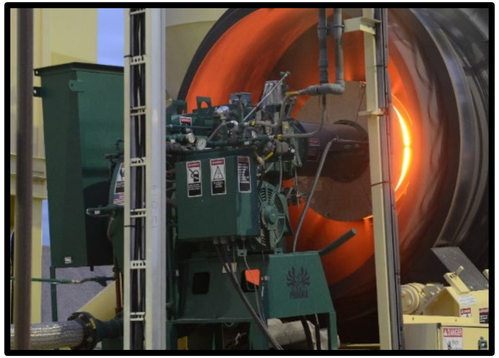
RAP - $$$$$$$


DOUBLE
BARREL
GREEN
ASTEC




30,000 Tons of RAP
=
70 - 6,000 Gallon Transport Trailers
and 28,200 Tons of Clean Aggregate
RAP is Worth the Virgin Material It Replaces

Which plant is more profitable?



Old Technology

- Starts at 6am loading out of pre-filled silos
- Starts up at 8:30am
- Runs 2 to 3 mixes, has enough trucks
- Runs ALL DAY (changeovers, no mid-streams)
- Fills the silos at end of day

New Technology

- Starts at 6am making mix
- Runs 2-3 mixes on various jobs, short of trucks
- Mid-streams at 8:30 for 45min
- Runs another 300 tons (finished for the day)
- Cleans out
- Gets a call at 10:15am for a 150ton parking lot job for afternoon.
- Fires back up at 11:00am
- Runs 147 tons, then midstream while paving foreman figures the last bit needed.

Surge and Storage

How does silo use affect plant efficiency?

Plant Efficiency – Operations

ASTEC

- Plants that start and stop more than 3 times per shift use up to 20 - 35%* more fuel

The solution: Storage silos.

Operate your continuous plant...continuously!

When compared to theoretical steady-state operation. Percentages from NAPA Publication QIP-132.

“Reasons” Not to Store Mix

- Lack of planning. “I never know what mix we are going to need tomorrow.”
- Mix temperature loss
- Mix not coming out of the silo
- Internal moisture effects (temperature, “brown out”)
- Fear of storing polymer

Reasons to Store Mix

- Can get the first round of trucks out even if there is a break-down. (95% of break-downs occur at start-up)
- The plant crew doesn't have to come in as early. (reduced labor cost). Less work in the dark – safety.
- The plant crew doesn't have to stay late waiting for the "last load". Send everyone home but the load-out person.
- More time for maintenance. Increases up-time.
- Can fill silos in the afternoon for night work. Depending on storage capacity and the mix required, only a load-out person might be needed.
- Less likely to have a night job break-down.

Reasons to Store Mix

- Storage in multiple silos plus planning allows FOB customers to get in and out quickly in the morning.
- Serving the FOB customers better than your competition will result in more business.

Operate for Efficiency & Profitability

ASTEC

- Run a continuous plant continuously as much as possible
- Maximize the percent RAP the right way (equipment and best practice)
- Minimize mix temperature – Choose WMA technology, sell tech to customers, measure and manage
- Manage moisture content – Slope and pave under wettest stockpiles if in wet climate
- Use storage silos as part of business plan – Know what is needed the next day
- Minimize waste mix – Measure, train, manage (report)

The Road Forward

A Vision for Net Zero Carbon Emissions for the Asphalt Pavement Industry

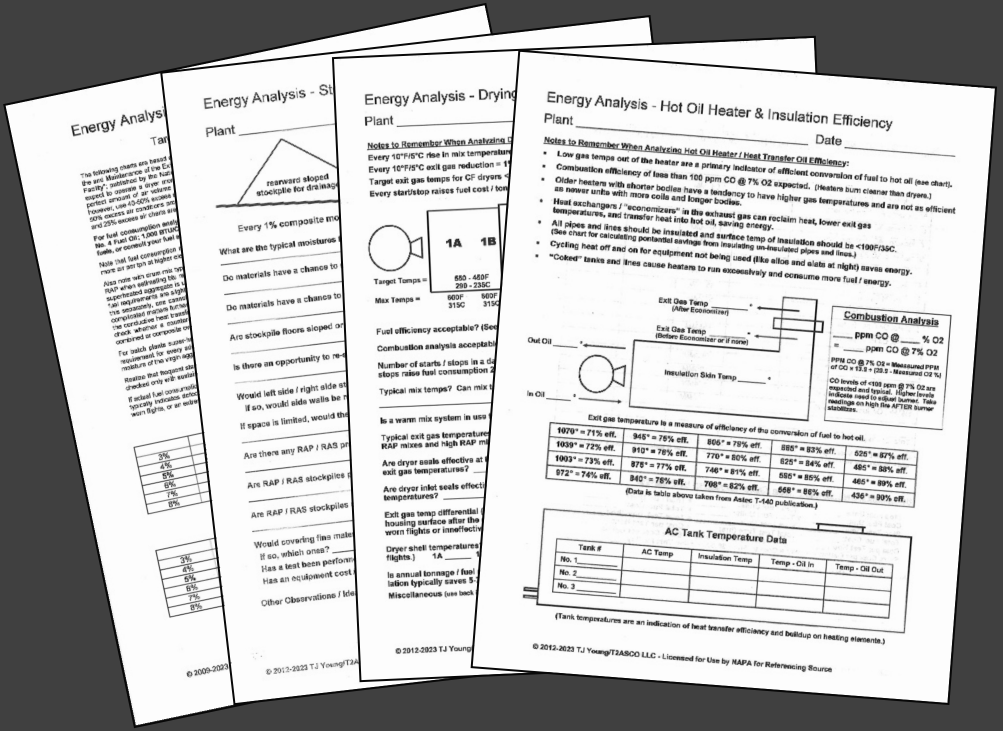
Production Strategies for Saving Money and Reducing Emissions

List of Topics Covered

- Mix Temperature
- Moistures
- Flighting/Exit Gas
- Insulating Drum
- Burner Tuned
- Alternative Fuels
- Production Start/Stops
- Production Rate
- Hot Oil System
    - Design
    - Fuels/Electric
    - Efficiency/Exit Gas
- Storage Tanks
- Pipes/Valves
- Peak Load/Demand
- VFDs
- Equipment Idle Shut-off

Self Audit Worksheets

- Stockpile Management
- Dryer Efficiency
- VFD Exhaust Fan
- Hot Oil System



ABOUT
ASTEC

- Based in Chattanooga, TN USA and founded in 1972
- Unique vision to bring state-of-the-art technology to traditionally low-tech industries
- Built on the legacy of putting customer service first.
- Market-leading brands have become a global leader in the manufacture of equipment from Rock to Road.

ASTEC ADVANTAGE

CONSTRUCTION

- Experienced construction team
- Structural installation- Asphalt and Concrete
- Mechanical and electrical
- Astec crane and certified operators
- Industrial Piping
- Field repairs and rebuilds
- Weld/Fit/Fab
- Project management
- Plant moves dismantle and assembly
- Dedicated site Supervision on large jobs
- Competitor's equipment

ASTEC

ASTEC ADVANTAGE
PARTS EQUIPMENT

ASTEC

Support 24/7/365

Phone – Live Person

On staff parts engineers

OEM and competitive parts

Largest Inventory in our industry

Fastest response to breakdowns

Coverage

Global Footprint

Global Coverage

In Region
Territory Managers

Resources/Experience

Large experienced team dedicated to serve

Unmatched experience and knowledge

New Product
Development Team

ASTEC ADVANTAGE
SERVICE

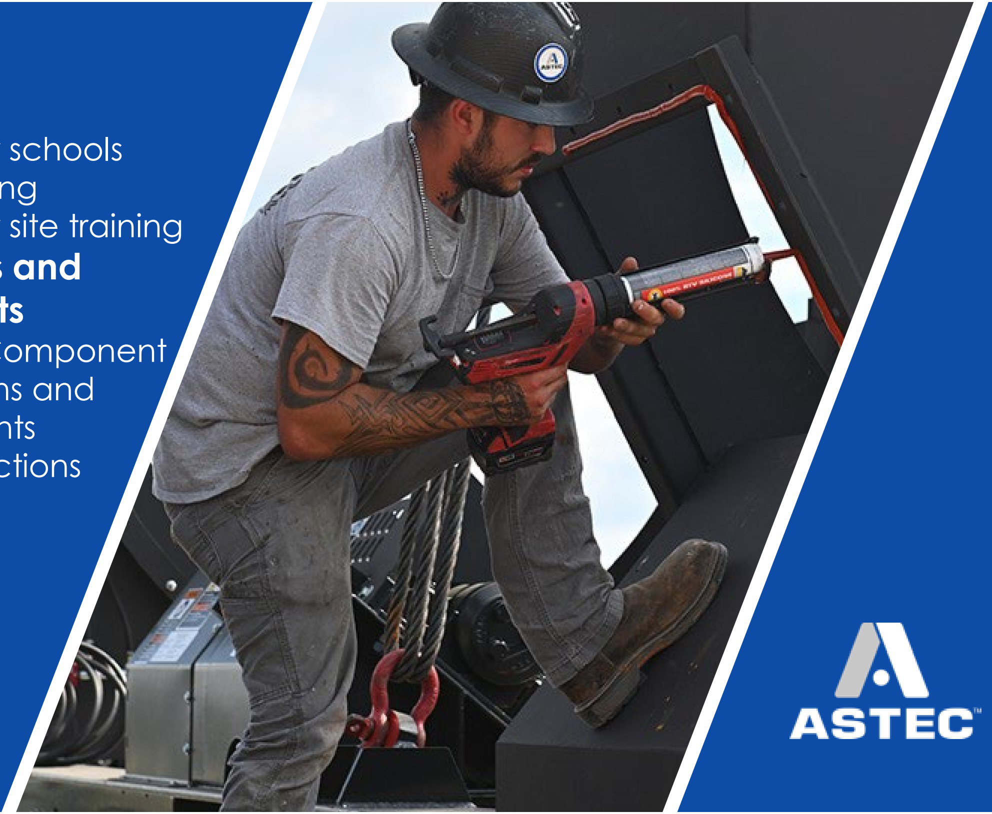
Field Service Response Time
- 36 hours or less on general request, 24 hours or less on plant breakdowns and emergencies

Support 24/7/365
- Phone and Internet Support
- Call logging and tracking
- Robust rotation for after hours support
- Zero cost to the end user

Resources/Experience
- 110+ Service Team dedicated to field services
- Multiple mechanical/electrical engineers and computer programmers included in our staff

Training
- Customer schools and training
- Customer site training

Inspections and Assessments
- Plant or Component Inspections and assessments
- Silo Inspections (Silobot)



ASTEC

CUSTOMER **TRAINING AND SCHOOLS**

Campus Training and Schools

- HMA and Concrete Schools at Jerome Campus
- 9 weeks
- Hands-On
- Instructors are subject matter experts –engineering, service, and etc…

Customer Site Training and Schools

- Classroom and Plant site training
- Customize your curriculum and days of training
- Includes competitors' equipment

ASTEC™

Greg Renegar
grenegar@astecindustries.com

Silos: Surge and Storage

ASTEC
An Astec Industries Company

Surge Bins and Silos

"The ***one*** thing that has changed the industry more than anything else."

Imagine a world without

INVENTORY

What if you were the only one with inventory?

Benefits of Surge Bins and Silos

- Allows plant to keep running

- Allows for different mixes to be stored

Cost Categories

- Material
- Plant
- **Trucking**
- Paving

Increased Trucking Cost Caused By:

- Higher fuel cost
- Higher equipment cost
- Higher fuel tax
- Higher license fees
- Higher labor cost
- Higher insurance cost
- Traffic congestion

How many of these do you control ?

Truck "Qualities"

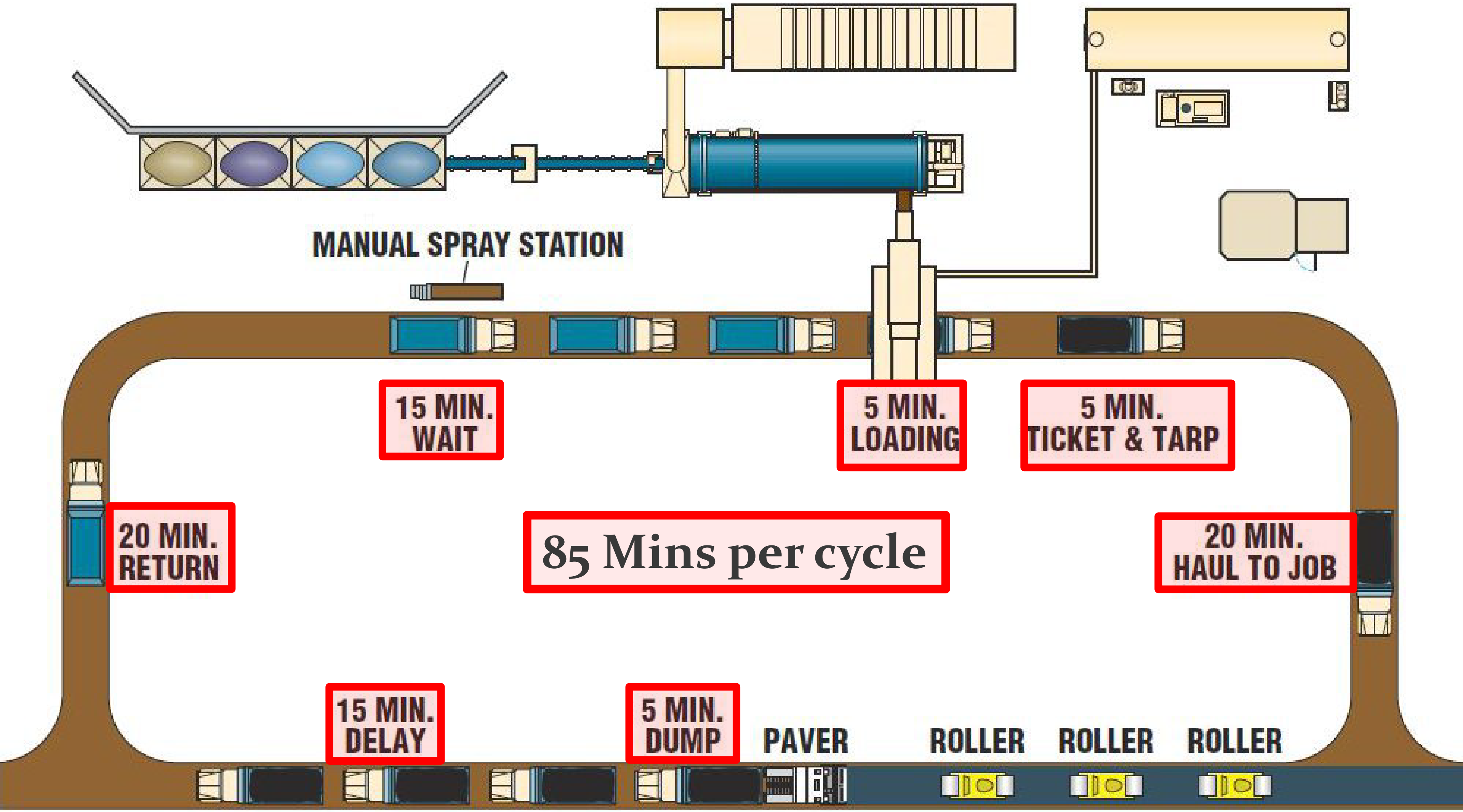
- Requires a driver
- Requires fuel
- Requires maintenance
- Cost $/hr whether hauling mix or not
- Difficult to control once they leave the plant
- Trucks tend to bunch up
- Breaks automobile windshields
- Loading and unloading technique affects mix quality
- Wears out
- Can pull under the wrong silo
- Can be involved in accidents

Silo "Qualities"

- Buy once and will last as long as you are willing to maintain..
- Shows up for work every day
- Doesn't require a "driver"
- Allows plant to run continuously
- Keeps the heat in
- Keeps oxygen out
- Astec silos can store mix for 4 days

Conclusion: Trucks are bad. Silos are good.

Truck Cycle Diagram – No Surge



Batch Plant Productivity

240 Tons per hour = 2400 tons per day
20 tons per truck
$60 per hour truck cost ($1.00 per minute)

85 minutes per cycle * $1 per minute = $85 per cycle

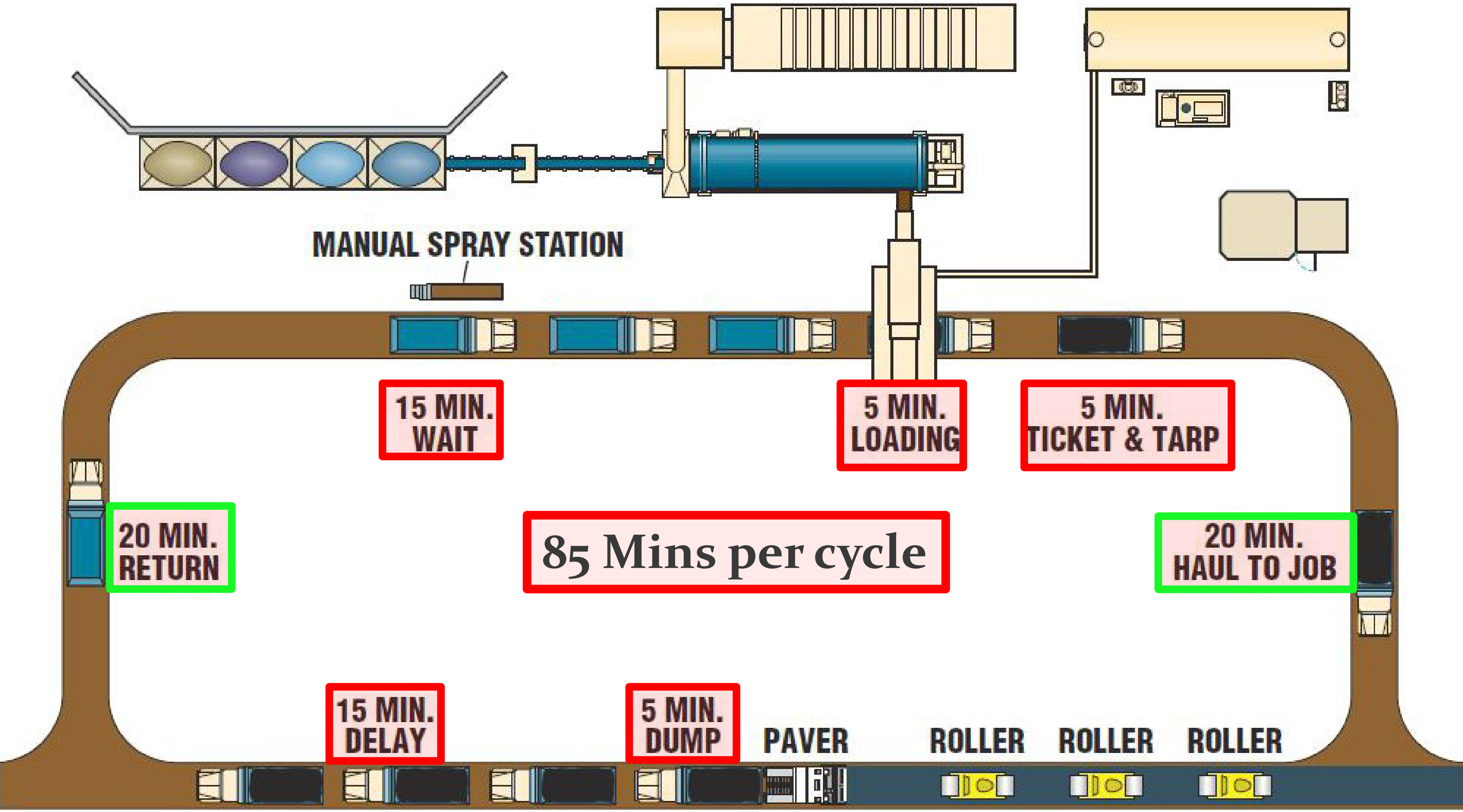
$$\frac{\$85 \text{ per cycle}}{20 \text{ tons per truck}} = \$4.25 \text{ per ton}$$

$$\frac{600 \text{ minutes per day}}{85 \text{ minutes per cycle}} = 7 \text{ cycles per truck}$$

$$\frac{2400 \text{ tons}}{20 \text{ tons per truck}} = 120 \text{ cycles}$$

$$\frac{120 \text{ cycles}}{7 \text{ cycles per truck}} = 17 \text{ trucks}$$

Truck Cycle Diagram – No Surge



Batch Plant Productivity

240 Tons per hour = 2400 tons per day
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$60 per hour truck cost ($1.00 per minute)

85 minutes per cycle * $1 per minute = $85 per cycle

$$\frac{\text{\$85 per cycle}}{\text{20 tons per truck}} = \text{\$4.25 per ton}$$

$$\frac{\text{600 minutes per day}}{\text{85 minutes per cycle}} = \text{7 cycles per truck}$$

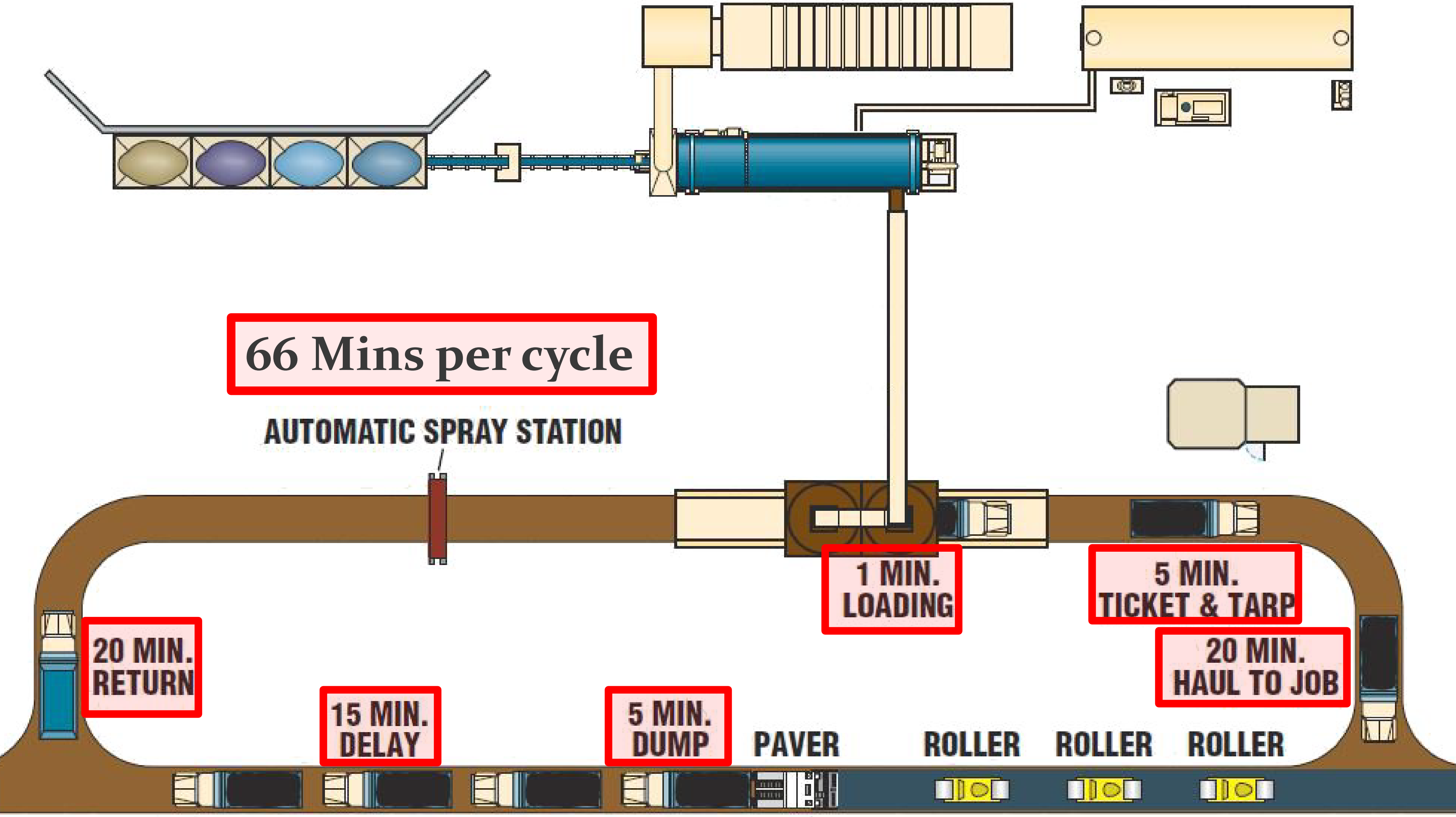
$$\frac{\text{20 min. haul to job + 20 min. return}}{\text{85 minutes per cycle}} \times 100\% = 47\%\ \text{Efficiency}$$

$$\frac{\text{2400 tons}}{\text{20 tons per truck}} = \text{120 cycles}$$

$$\frac{\text{120 cycles}}{\text{7 cycles per truck}} = \text{17 trucks}$$

Batch Plant – Using Trucks as Surge

Truck Cycle with Surge Bin



Continuous Plant Productivity

240 Tons per hour = 2400 tons per day
20 tons per truck
$60 per hour truck cost ($1.00 per minute)

66 minutes per cycle * $1 per minute = $66 per cycle

$$\frac{\$66 \text{ per cycle}}{20 \text{ tons per truck}} = \$3.30 \text{ per ton}$$

23% savings

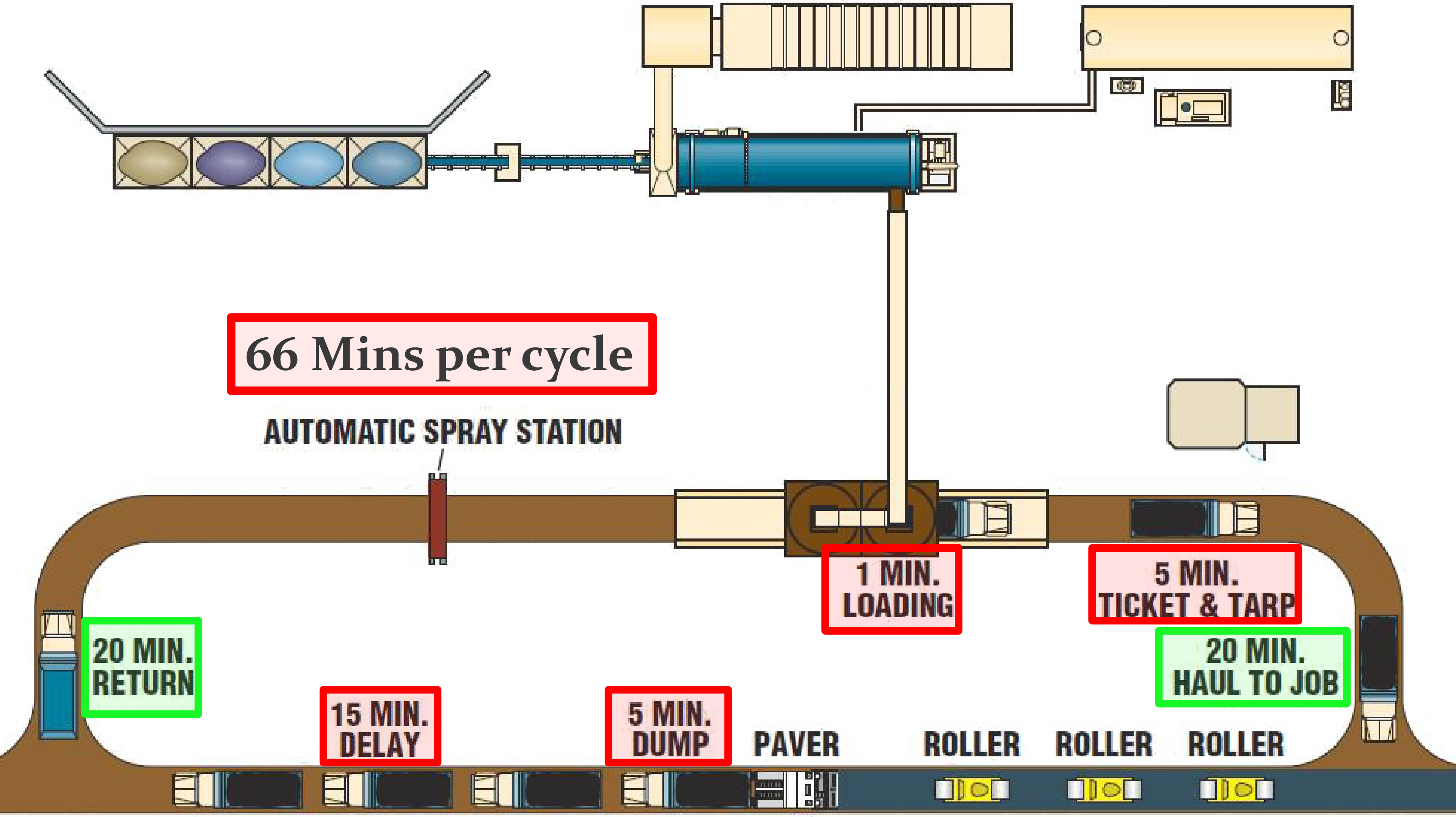
$$\frac{600 \text{ minutes per day}}{66 \text{ minutes per cycle}} = 9 \text{ cycles per truck}$$

$$\frac{2400 \text{ tons}}{20 \text{ tons per truck}} = 120 \text{ cycles}$$

$$\frac{120 \text{ cycles}}{9 \text{ cycles per truck}} = 14 \text{ trucks}$$

3 fewer trucks (and fewer repairs, etc.)

Truck Cycle with Surge Bin



Continuous Plant Productivity

240 Tons per hour = 2400 tons per day
20 tons per truck
$60 per hour truck cost ($1.00 per minute)

66 minutes per cycle * $1 per minute = $66 per cycle

$$\frac{\$66 \text{ per cycle}}{20 \text{ tons per truck}} = \$3.30 \text{ per ton}$$

23% savings

$$\frac{600 \text{ minutes per day}}{66 \text{ minutes per cycle}} = 9 \text{ cycles per truck}$$

$$\frac{20 \text{ min. haul to job} + 20 \text{ min. return}}{66 \text{ minutes per cycle}} \text{ X } 100\% = 61\% \text{ Efficiency}$$

$$\frac{2400 \text{ tons}}{20 \text{ tons per truck}} = 120 \text{ cycles}$$

$$\frac{120 \text{ cycles}}{9 \text{ cycles per truck}} = 14 \text{ trucks}$$

3 fewer trucks

Continuous Plant Productivity

240 Tons per hour = 2400 tons per day

21 tons per truck

$60 per hour truck cost ($1.00 per minute)

66 minutes per cycle * $1 per minute = $66 per cycle

$$\frac{\$66 \text{ per cycle}}{21 \text{ tons per truck}} = \$3.14 \text{ per ton}$$

27% savings

$$\frac{600 \text{ minutes per day}}{66 \text{ minutes per cycle}} = 9 \text{ cycles per truck}$$

$$\frac{2400 \text{ tons}}{21 \text{ tons per truck}} = 114 \text{ cycles}$$

$$\frac{114 \text{ cycles}}{9 \text{ cycles per truck}} = 13 \text{ trucks}$$

Let's look at the effect of loading one more ton of mix on a truck.

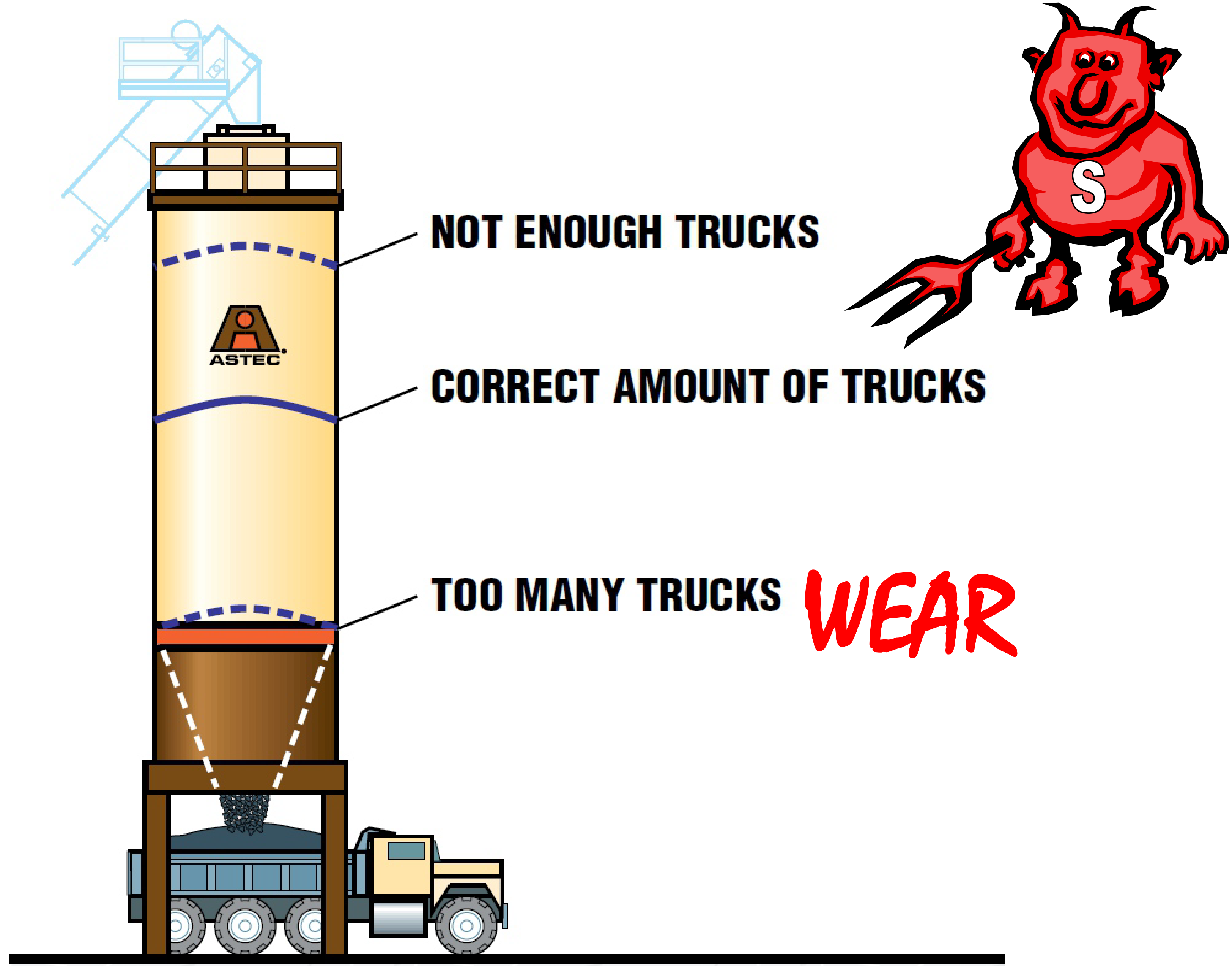
$3.30 vs $3.14 per ton trucking cost

$0.16 per ton of mix

2400 tons x $0.16 = $384 per day

That's $38,400 every 100 days.

Do not over-truck.



NOT ENOUGH TRUCKS
CORRECT AMOUNT OF TRUCKS
TOO MANY TRUCKS
WEAR
S
ASTEC

Surge vs. Storage

SURGE BIN

MULTIPLE SILO SYSTEM

Feb.9, 2012, Mississippi

- Thursday: Stored mix overnight in an Astec silo
- Friday: Rain
- Saturday: Rain
- Sunday: 25F (-4C) ambient temperature
- Monday: Stored mix
- Tuesday: Paved with no problems.

Laurance Warren: “We don’t always communicate very well, but we at least try to know what we need to make for the next day.”

"Reasons" Not to Store Mix

- Lack of planning. "I never know what mix we are going to need tomorrow."
- Fear of mix temperature loss
- Fear of mix not coming out of the silo
- Fear of mix oxidation
- Internal moisture effects (temperature, "brown out")
- Fear of storing WMA
- Fear of storing polymer

Reasons to Store Mix

- Can get the first round of trucks out even if there is a break-down. (most break-downs occur at start-up)
- The plant crew doesn't have to come in as early. (reduced labor cost). Less work in the dark.
- The plant crew doesn't have to stay late waiting for the "last load". Send everyone home but the load-out person.
- More time for maintenance. Increases up-time.
- Can fill silos in the afternoon for night work. Depending on storage capacity and the mix required, only a load-out person might be needed.

Reasons to Store Mix

- Storage in multiple silos plus planning allows private customers to get in and out quickly in the morning.
- Serving the private customers better than your competition will result in more business.
- Allows continuous plants to compete with batch plants in a “drug store” market.

Do use mix storage as a something to do only if you get caught with mix.

Make it part of your business plan.

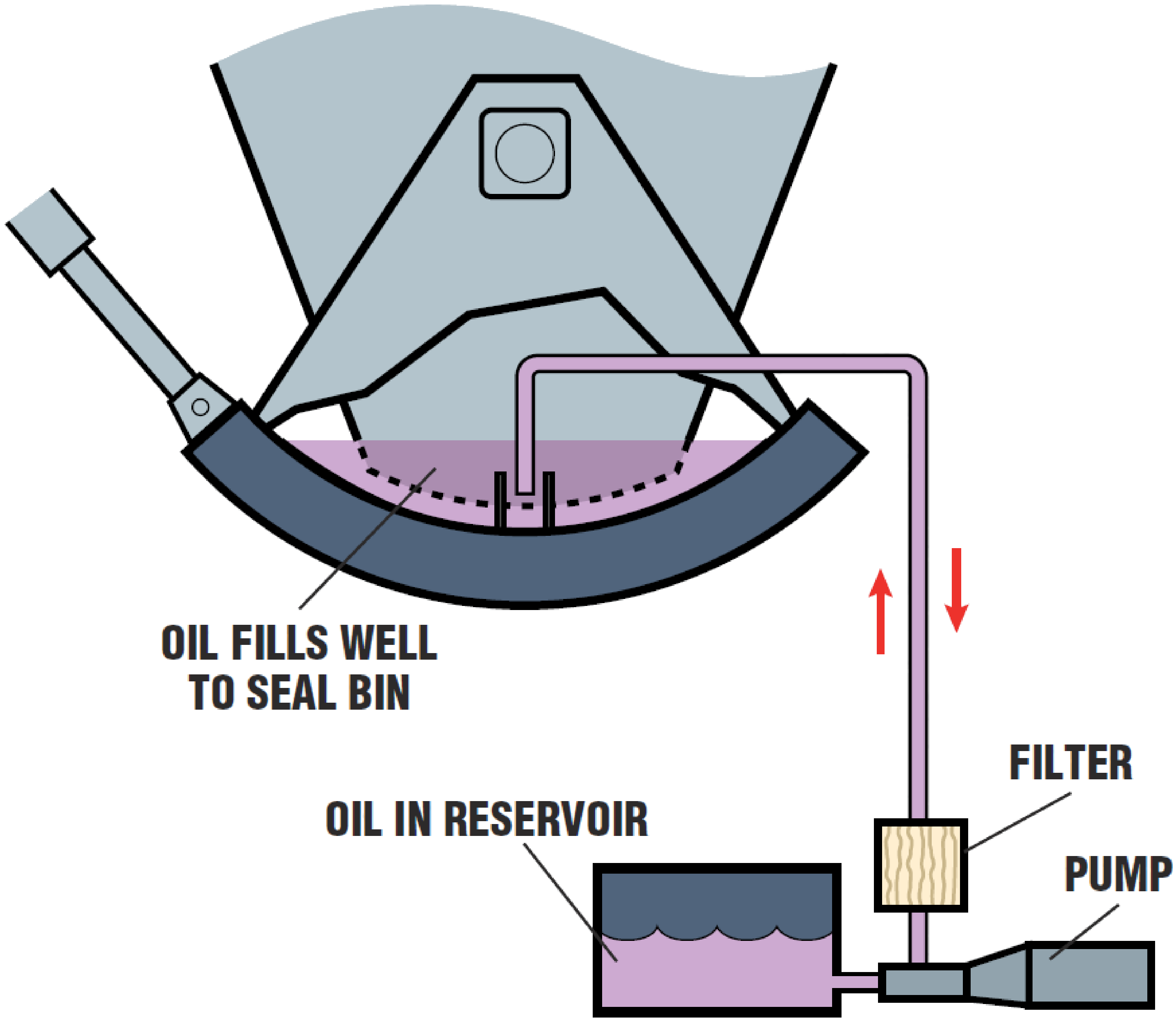
End every day with full silos.

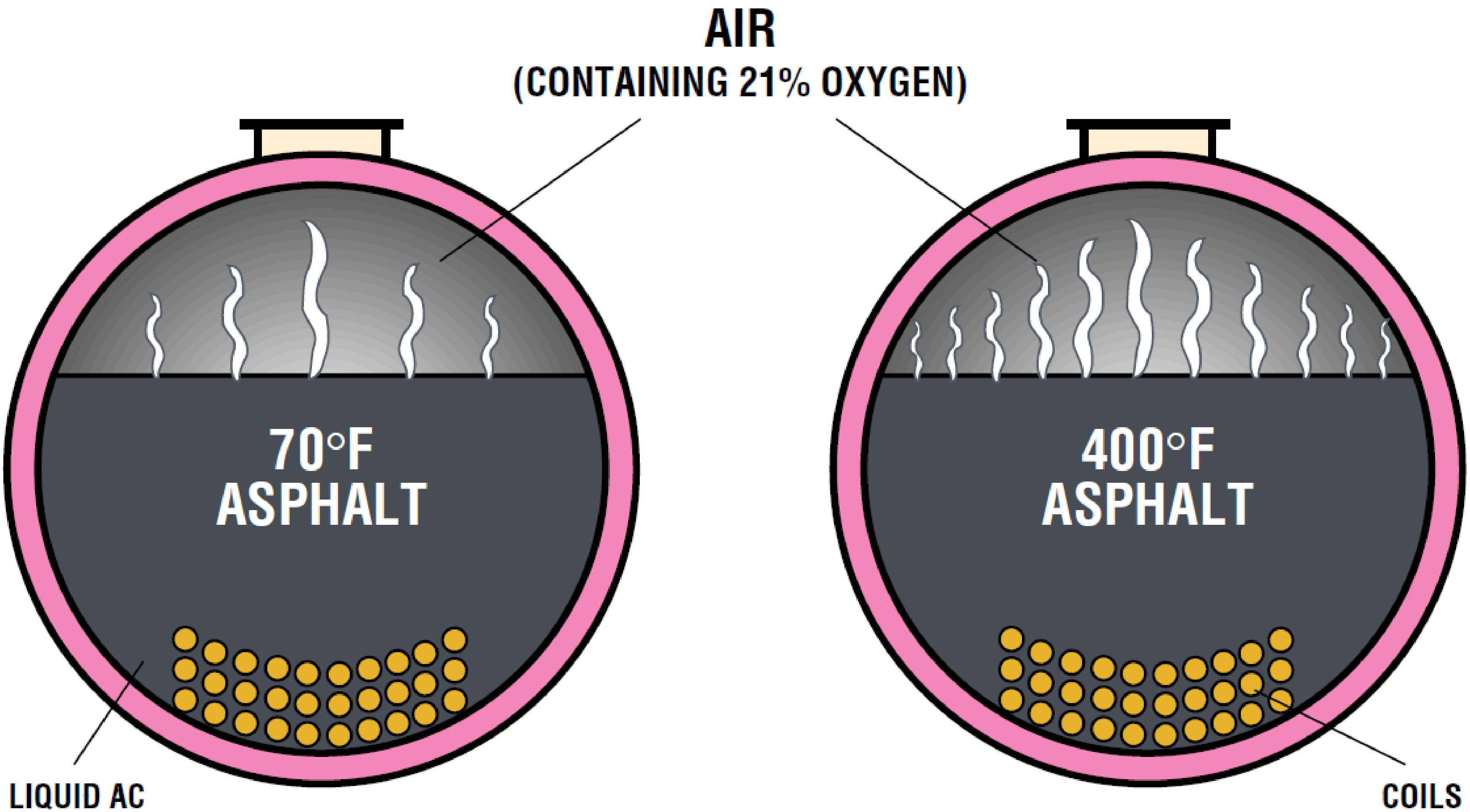
Number One Reason to Store Mix

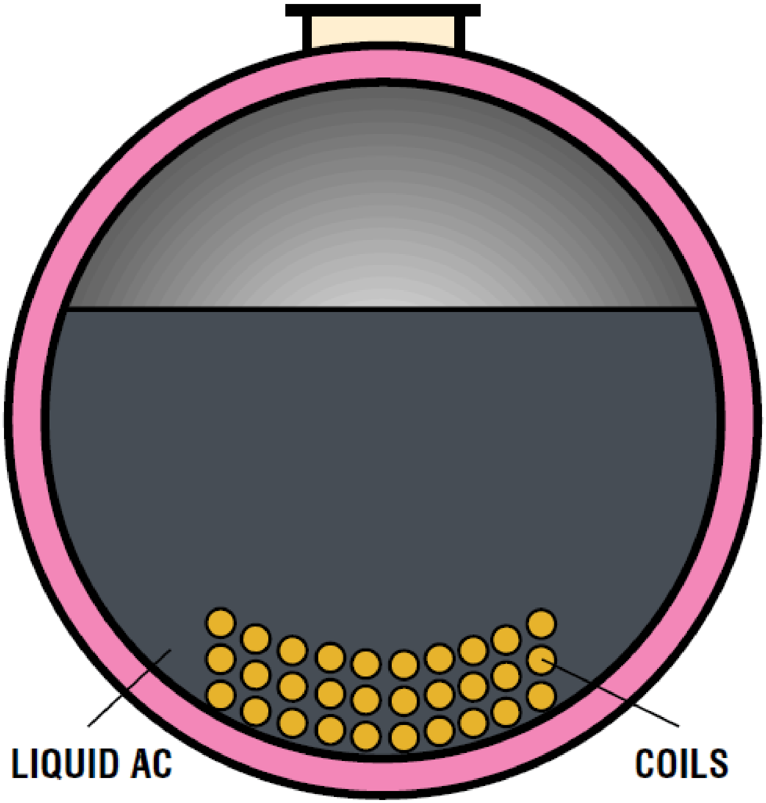
If you have Astec silos and are not storing mix, your plant is not as competitive as it could be.

Factors that affect storage

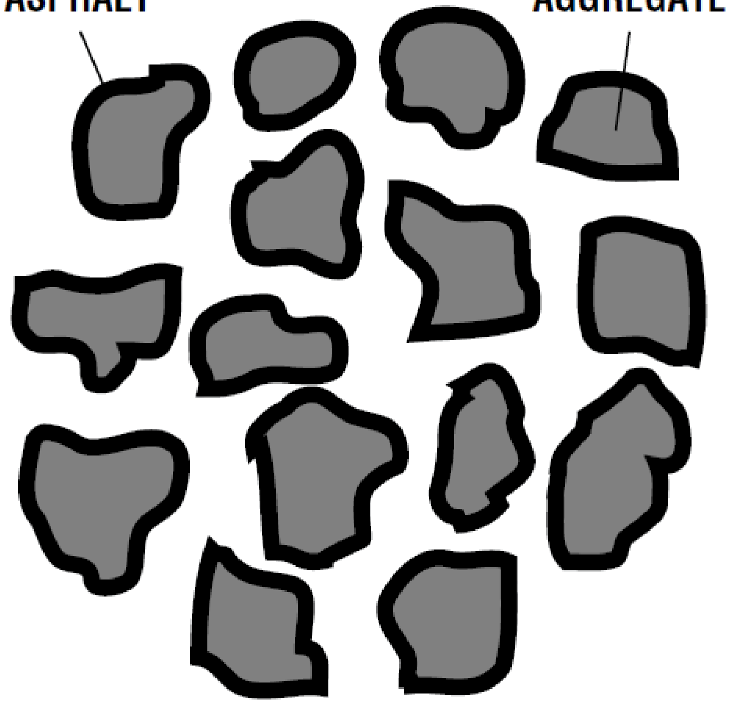
- Time
- Temperature
- Oxygen


OIL FILLS WELL
TO SEAL BIN
FILTER
OIL IN RESERVOIR
PUMP


AIR
(CONTAINING 21% OXYGEN)
70°F
ASPHALT
400°F
ASPHALT
LIQUID AC
COILS



IN TANK
(LITTLE EXPOSED SURFACE)

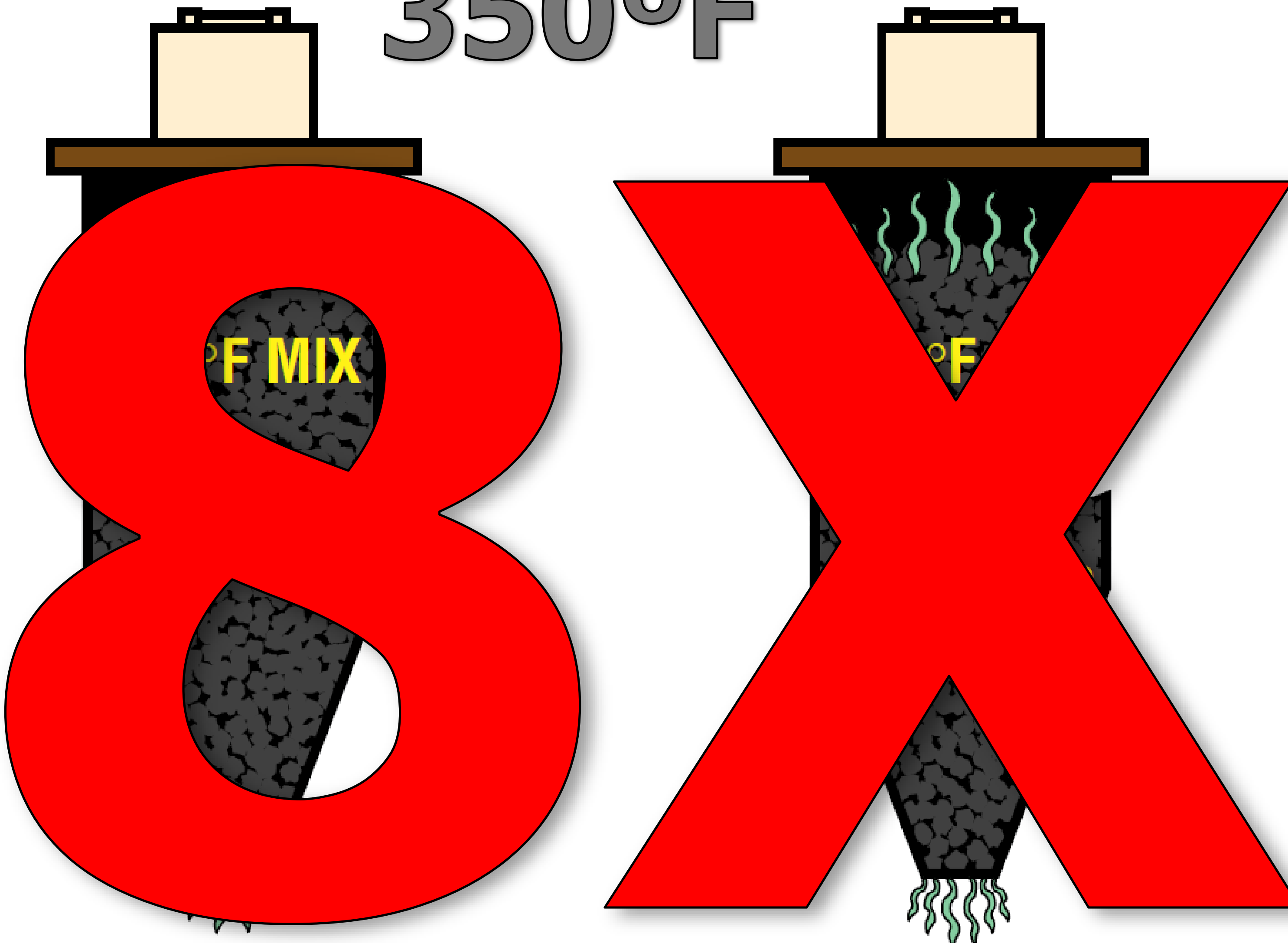


IN MIX
(LARGE EXPOSED SURFACE)

Compared to 275ºF (135ºC) mix…

300ºF	2X
325ºF	4X

350°F



Rate doubles every 25°F (14°C)

Storage Do's and Don'ts

- Try to fill silo to minimize oxygen.
- Maintain seals on top and **bottom** gates.
- Store mix as cool as possible.
- Be careful with polymer mixes.
- Don't overheat cone.
- Don't store mixes that will drain (SMA).
- Make sure aggregate is dry.

“Silos are the most revolutionary development in plant technology in the last 50 years.” Lawrence Warren

- Silos have allowed continuous plants to be possible.
- Continuous plants can run a high percentage of RAP.

ASTEC

INDUSTRIES, INC.

Balanced Mix Design & Intelligent Compaction

Black to the Basics

What is Balanced Mix Design?

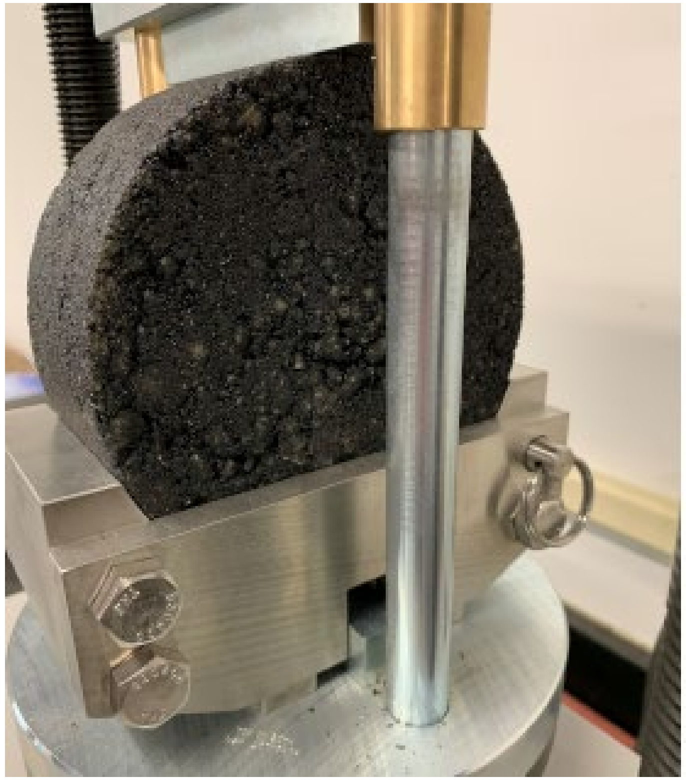
TOO STIFF

TOO SOFT

BMD Performance Testing

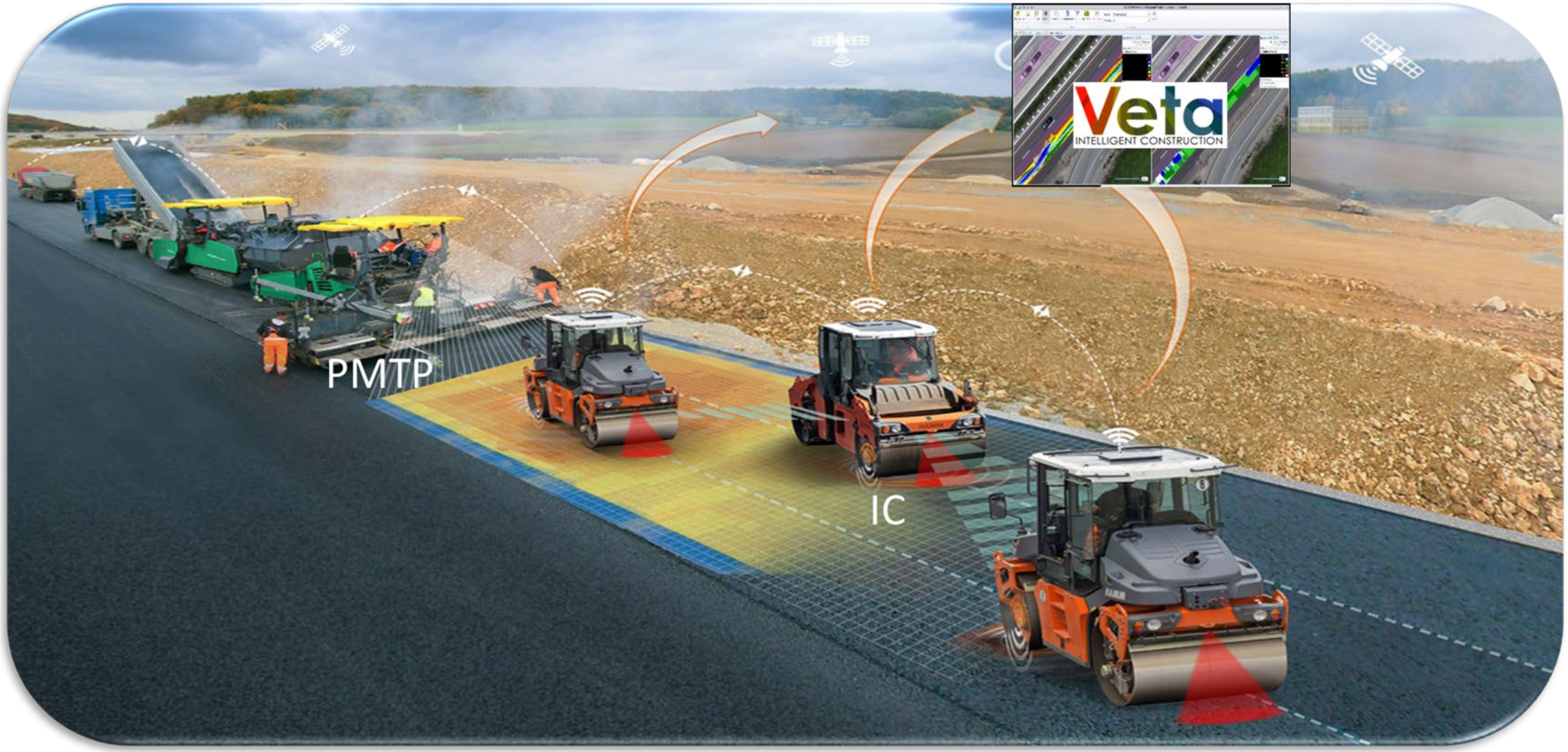
Ideal-RT – Rutting Potential
Ideal-CT – Cracking Potential
TSR – Stripping Potential

Rapid Shear Rutting Test (Ideal –RT)



Indirect Tensile Asphalt Cracking Test (Ideal-CT)

IC for Asphalt Construction



Source: modified from Wirtgen, GSSI

Our Goals…

- Reduce worker exposure to traffic
- Increase pavement quality
- Reduce inspection demand

2024 Performance Specifications

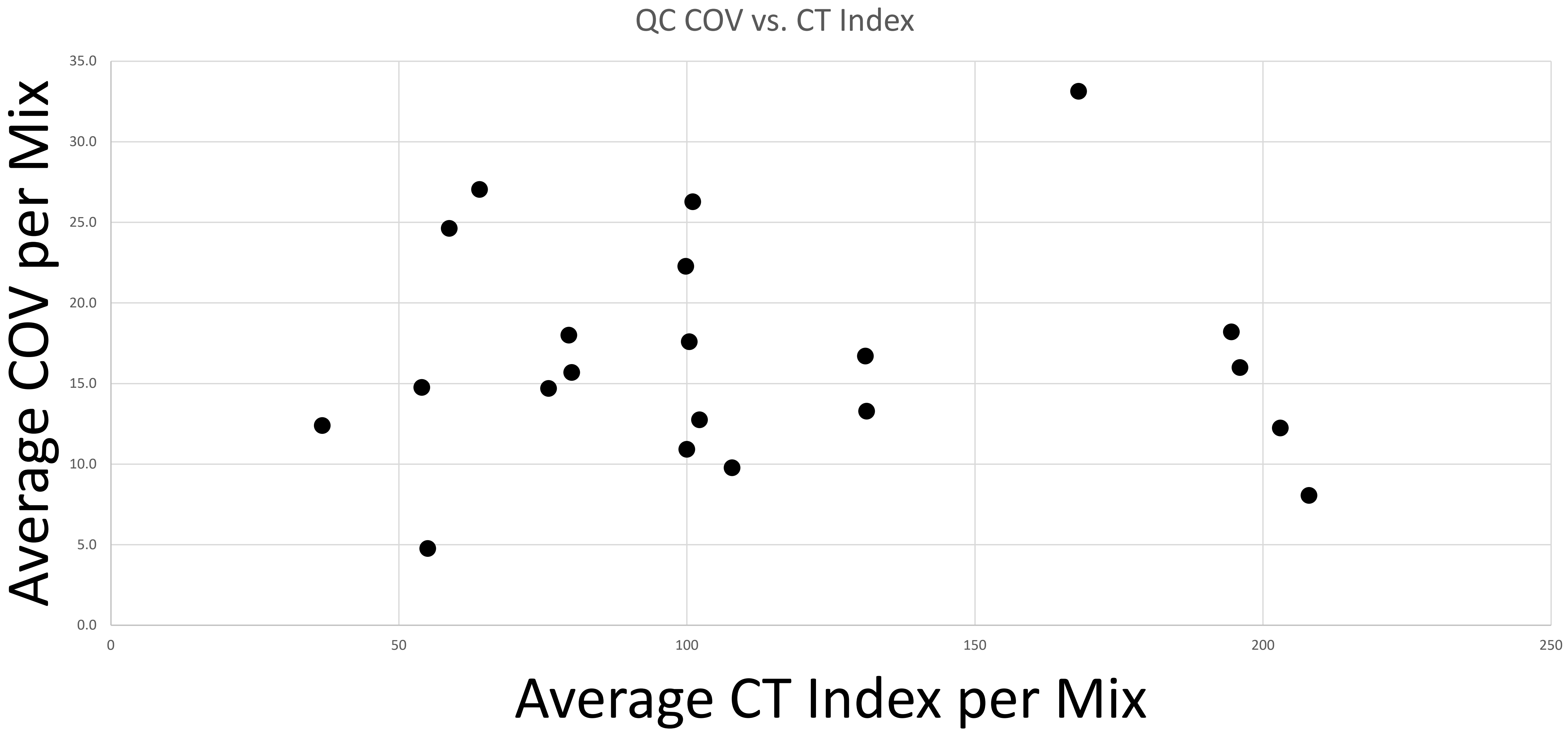
SuperPave Mixtures		
Cracking Tolerance Index (CT_{Index})	Tensile Strength Ratio (TSR)[a]	Percent of Contract Price
40 - 49	70 – 74 %	97%
50 – 99	75 – 84 %	100%
100 or Greater	85 % or Greater	103%

RT-Index Qualifier for CT/TSR Bonus	
PG High Temp. Grade	Minimum RT-Index
64S & 58H	50
64H	65
64V	80

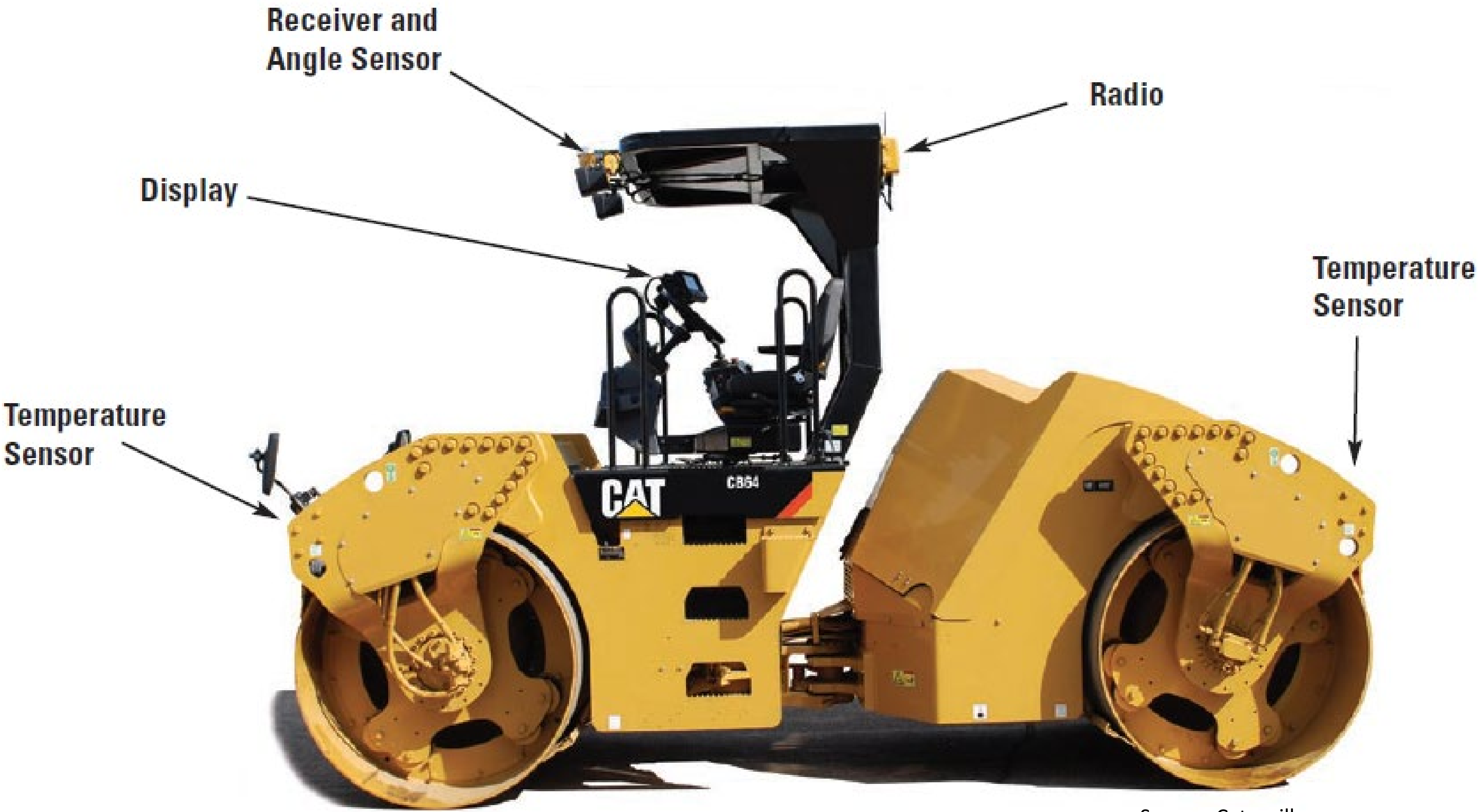
CT-Index Variability

- ❑COV of about 20%
- ❑Sampling
  - ❑Minimizing Segregation
- ❑Specimen Conditioning must be consistent
  - ❑Allowing times for additives to react with mix
- ❑Consistency Overall
  - ❑Human Error and Mix Consistency

Variability of CT-Index for 2023

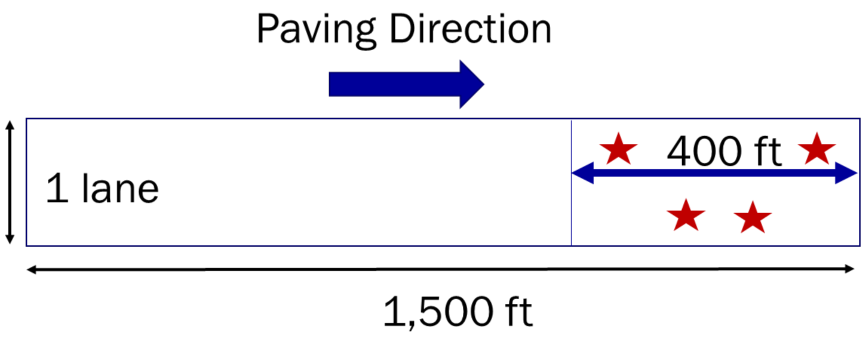


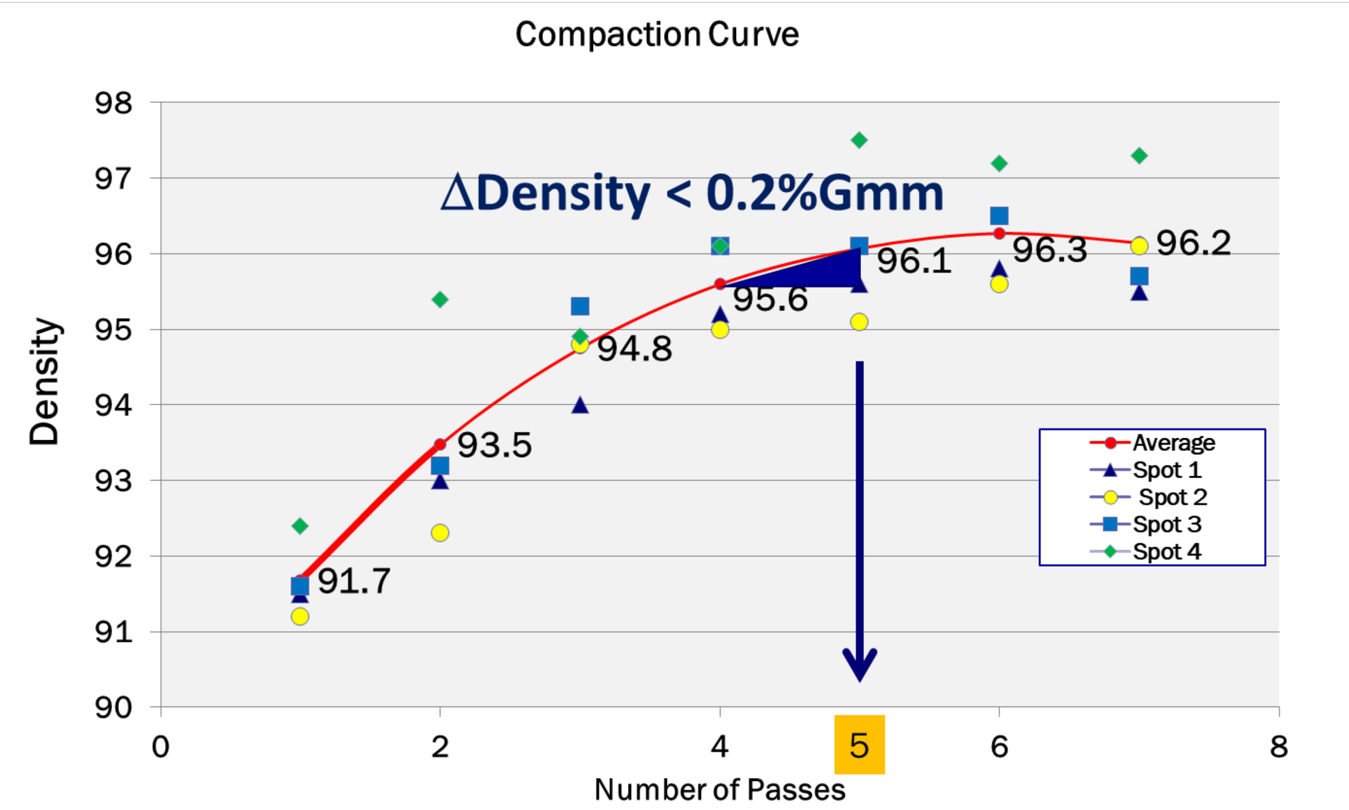
Intelligent Compaction (IC)



Source: Caterpillar

Trial Section - Determine Optimum Passes

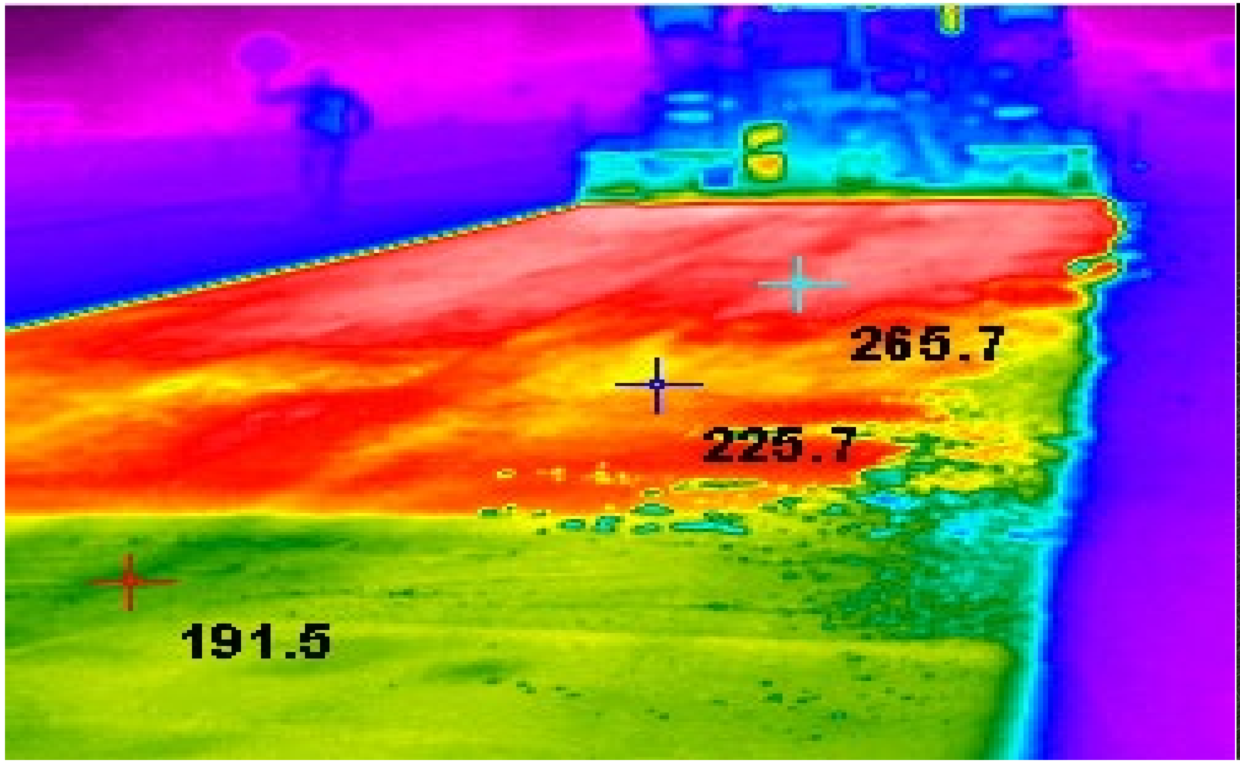




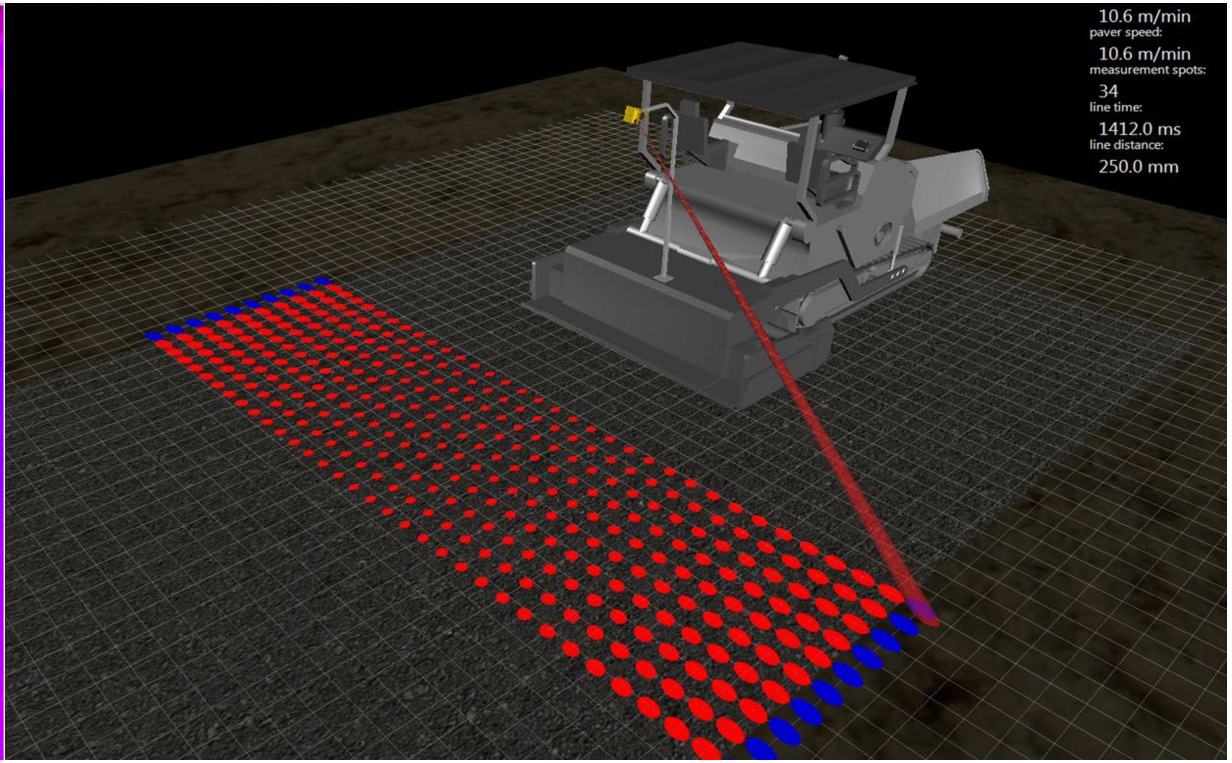
Intelligent Compaction Benefits

- Aids the roller operator in achieving the proper coverage especially at night.
- Provides the roller operator temperature of asphalt to ensure the optimum pass count is achieved above 180°F
- Provides a theoretical density of the entire roadway

Paver-Mounted Thermal Profiler (PMTP)



Conventional Thermal Camera



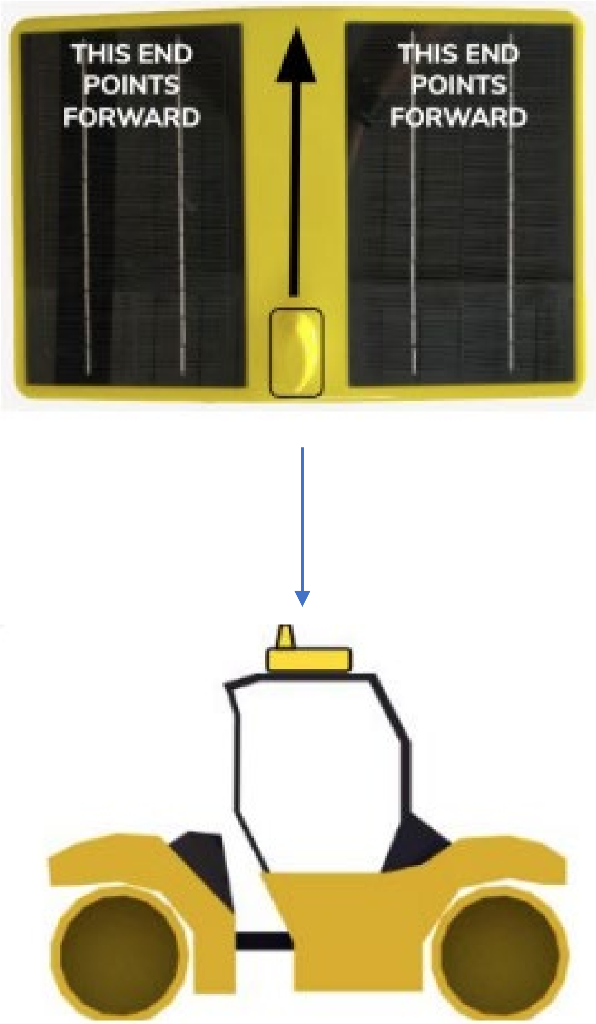
PMTP

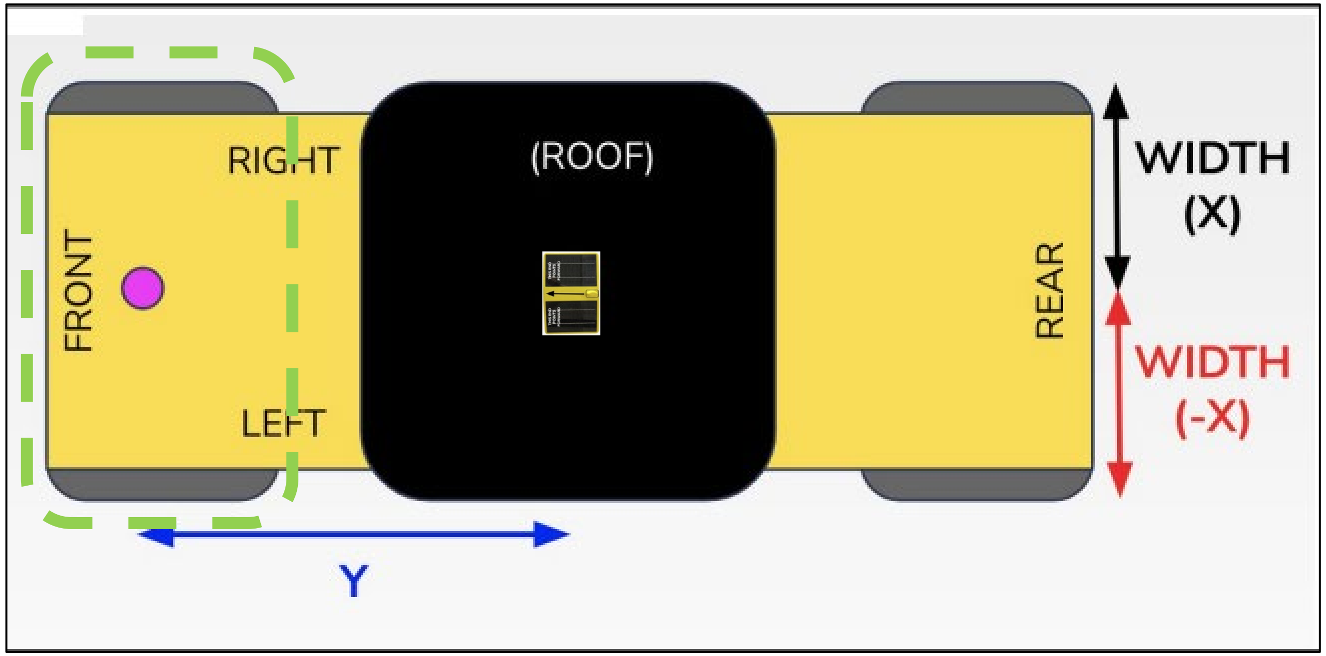
Source: MOBA

PMTP Benefits

- Shows real time temperature map of the asphalt behind the paver
- Allows for adjustment to be made in the field to reduce segregation
- Thermal segregation results in an uneven density of the mat.

IC QA Process

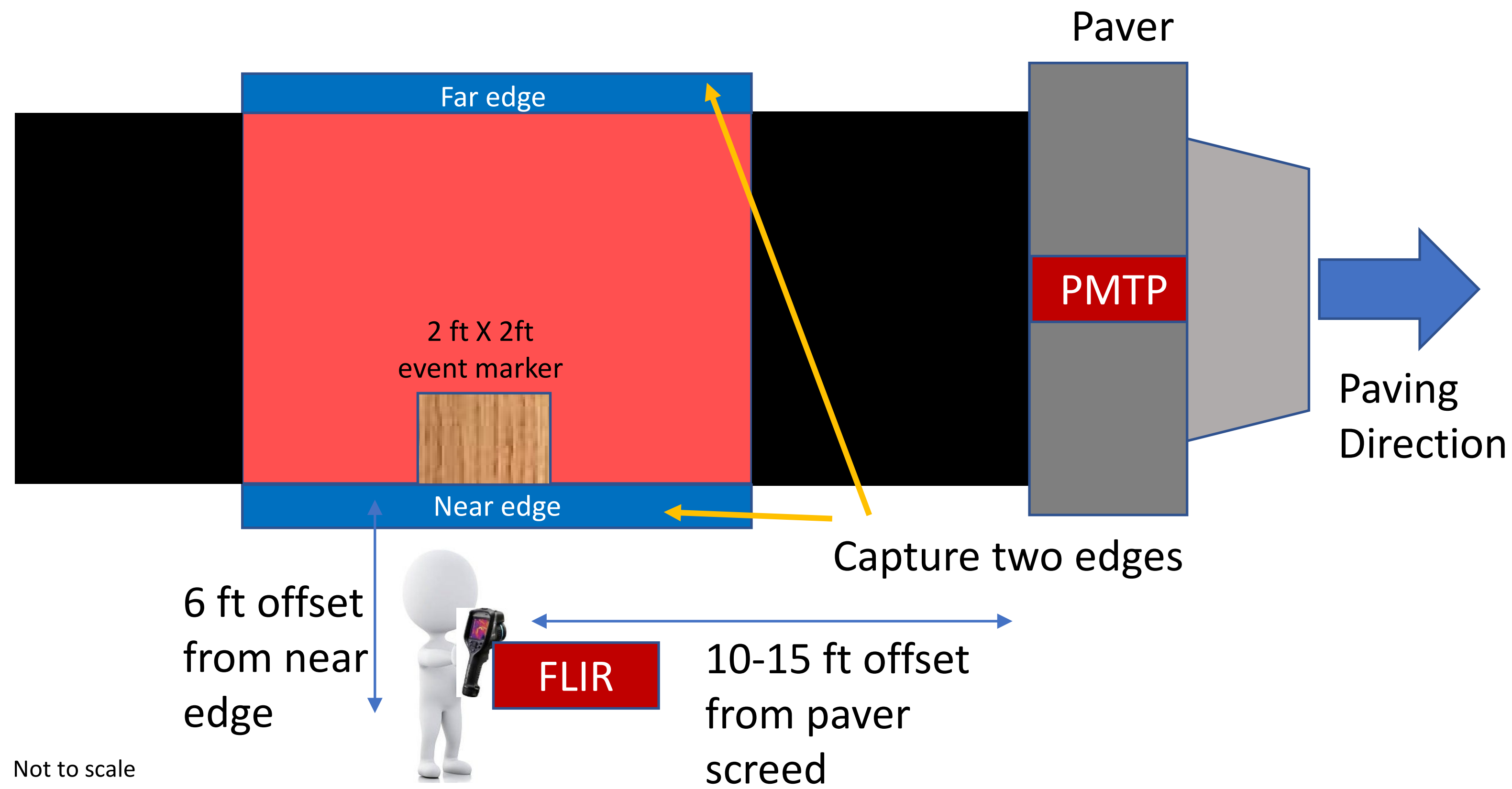




- Magnetic-mounted and solar-powered (independent of contractor equipment).
- Collects RTK location data – similar to contractor data.
- Offset location to the drum footprint – similar to most contractor data.
- Holds 2-3 days worth of data on internal data storage.

PMTP Temperature QA Verification

- Project staff use an infrared camera to take a picture of the new asphalt for temperature comparison.



Tying BMD and IC/PMTP all Together to Improve Asphalt Quality

- BMD Specifications – Crack and rut resistant and durable asphalt mixture without chasing individual mix components.
- IC Specifications – Consistent density of the entire mat

(# Roller Passes @ Compaction Temperature is being achieved)

- PMTP Specifications – Uniform, properly handled asphalt mix is being delivered to the paver.

2024 Spec Revisions

- 403 Spec to include Balanced Mix Design (BMD)
  - Will require collection of loose mix sample to be from the plant, so to ensure segregation is limited PMTP will be required

- PMTP (406) Spec to be added
  - Will be required on all 403 BMD Projects
  - Requires cell service and GPS signal
  - $40 Bonus/Disincentive per 150ft sublot (2% Bonus)

- IC (405) Spec to be added
  - Same requirements as PMTP but currently is only a pre-qualifier for the density bonus obtained from cores

2024 Specification

Thermal Segregation Category	Adjustment per 150 ft. Sublot
Low (DRS<25°F)	$40 Incentive (about 2%)
Moderate (25-35°F)	$40 to $0 Incentive (Linear)
Moderate-High (35-50°F)	0 to -$40 Disincentive (Linear)
Severe (DRS≥50°F)	Unacceptable Material

Future IC Segment Classifications

Daily Coverage	Classification
Coverage ≥ 85%	Passing
Coverage < 85%	Deficient

*All segments with a mean temperature of less than 180 F at the optimum pass shall be considered deficient.

Future Price Adjustments

If the density for a Deficient Segment has not been already declared unacceptable then an additional density verification shall be performed. The location of the density verification shall be marked by the engineer based on coverage shown in Veta. The results of the density verification shall determine actions taken as follows the table below:

Field Density (Percent of Laboratory Max. Theoretical Density)	**Actions to be taken as a result of additional density verification**
For all SP & BP mixtures other than SMA:	
92.5 to 98 inclusive	Continue with PWL
97.1 to 98.0 or 90.5 to 92.4 inclusive	The lower of 100% Pay or PWL Deduct
Above 98.0 or Below 90.5	Remove and Replace Limits*
For SMA mixtures:	
>94.0	Continue with PWL
92.0 to 93.9 inclusive	The lower of 100% Pay or PWL Deduct
Below 92.0	Remove and Replace Limits*

*Removal limits shall be defined by the engineer based on density results and coverage shown in Veta

Innovative Boundary Collection - Lidar

Innovative Boundary Collection – a Paver-Mounted GPS Receiver

- Piloted in 2023.
- Mounted GPS receiver and data collector to paver.

Innovative Boundary Collection – Paver-Mounted GPS Receiver

- Set a distance-based collection rate – collect point every 100 feet.
- Powered by paver.
- Used tilt compensation.

PMTP Challenges

- GPS Signal and Cell Service
  - Base Stations can help with poor cell coverage but not poor GPS signal
- Equipment needs to be kept clean
- Need to stay clear of mat behind paver
  - You could show up as a cold spot in the mat

IC Challenges

- GPS Signal and Cell Service
- Joint Bumps
- Changes in sub-grade stability can change density
- Equipment malfunctions/break downs

Updated Data Loss/GPS Obstructions

406.4.6 Loss of Data. If data collection ceases as a result of circumstances reasonably beyond the control of the contractor, the contractor will be allowed to continue the days paving, but the paved sublots will not be eligible for bonus. The engineer must be notified immediately of the issue and determine if the contractor has made a reasonable effort to resolve the issue. A meeting with the engineer shall be held to determine how to proceed if the issue is expected to extend into the next day's paving. Failure to notify the engineer of the issue at hand will result in the paved sublots to receive a -$40 deduct.

406.4.6.1 GNSS Obstructions. A base station shall be used at any locations having poor cellular reception. Isolated areas influenced by a GNSS obstruction may be excluded from DRS computation provided that the following conditions are satisfied:

(1) The position data is present

(2) The GNSS Reception Mode as recorded by the onsite equipment indicates that an obstruction is present

(3) The location is properly flagged in the Veta project file and the location is identified in the bi-weekly report

(4) The total of these areas is no more than 5% of any single day's production.

Implementation Goals

- Finishing a Final “Draft” BMD Specification for Pilot Projects
  - 14 Pilot Projects per Year

- Working on Interim BMD Specification
  - Allow Contractors to select BMD Spec or Current SuperPave Spec
  - Interim Spec will NOT have IC; but will have PMTP requirement.

Veta Training w/ Transtec Group

Monday, Feburary 26th

GoToWebinar Only

No In-Person Option

Job Mix Formula (JMF) Review, Source Approval Process, and Gsb Impacts

Asphalt Components

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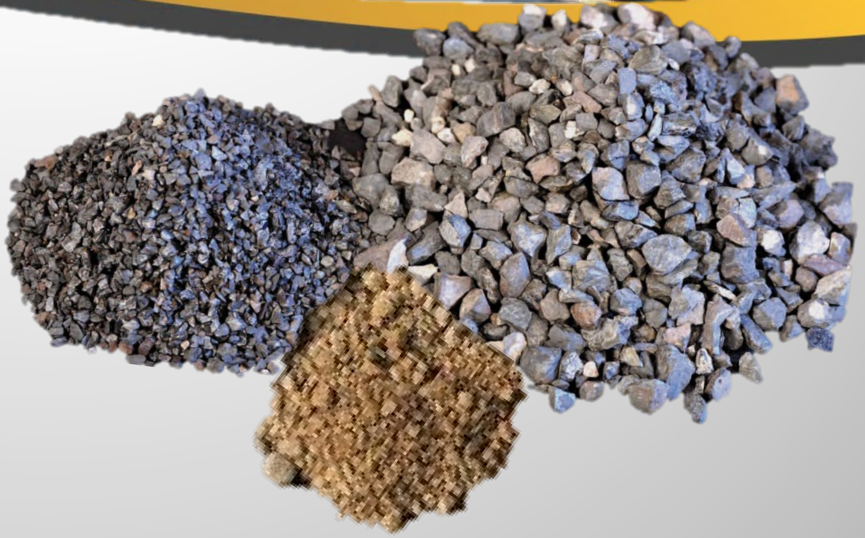

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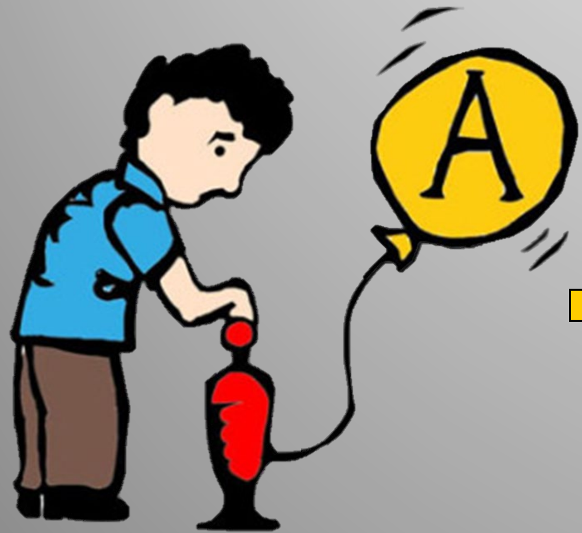

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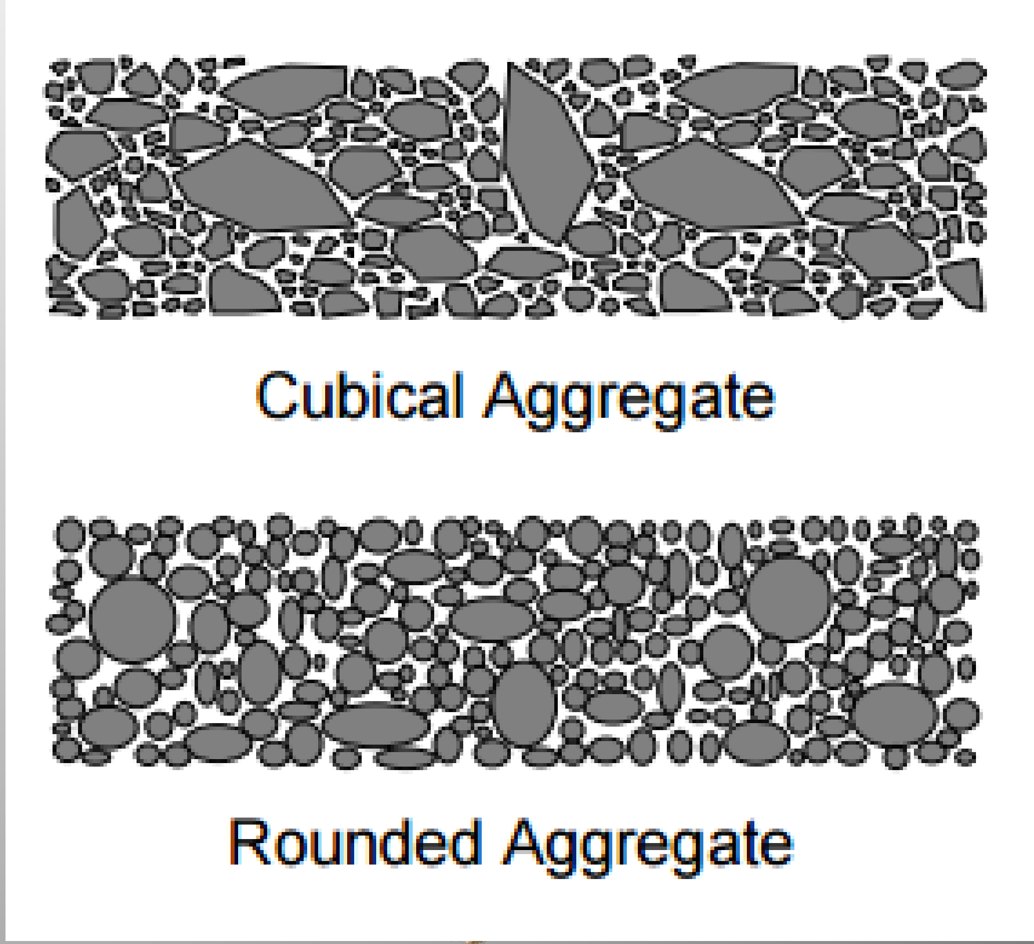
Aggregates in Asphalt

- By weight – 95% mix.
- Gives pavement most of its strength.
- Starts out as Rock within a Ledge & Formation.
- Processed (crushed) by quarries – Aggregates.
- Not all aggregate is good quality.

Aggregate Qualities

- Durability
  - Hardness
  - Absorption
- Angularity
  - Number of crushed faces.
  - Gives the strongest structure.
  - Provides better skid resistance.
- Deleterious Material (clay, shale, foreign material).
- Aggregate size - Gradation



Aggregate Source Approval Process

- Source Approvals Required on All Aggregates of Section 1002, 1003, 1004, and 1005
  - Tested Annually – Make sure the SA is up-to-date
  - Required for each ledge combination
  - 1 – 1 ½” Aggregate Size

- 1002 Aggregate Requirements
  - Coarse Aggregate – LA, SpG, Abs, Gradation, Del, Micro Deval
  - Fine Aggregate – SpG, Gradation, Del/Light Weight

Aggregate Source Approval Process

ASPHALTIC CONCR

Date = 6/29/2023

IDENT. NO.	MATERIAL TYPE	PRODUCER, LOCATION	BULK SP. GR.
23CDTMS093	1		2.654
23CDTMS094	3/4		2.665
23CDTMS095	1/2 Base		2.665
23CDTMS096	3/8"		2.677
23CDTMS097	MS		2.653
23CDC3B028	RAP		2.687
0	0		1.000
Anti Strip			% by weight o
Asphalt Cement			1.030 Gr

MATERIAL IDENT #	23CDTMS093	23CDTMS094	23CDTMS095	23CDTMS096	23CDTMS097	23CDC3B028	0	23
	1	3/4	1/2 Base	3/8"	MS	RAP	0	
1 1/2"	100.0	100.0	100.0	100.0	100.0	100.0	0.0	
1"	100.0	100.0	100.0	100.0	100.0	100.0	0.0	
3/4"	74.0	100.0	100.0	100.0	100.0	100.0	0.0	
1/2"	21.0	87.0	100.0	100.0	100.0	100.0	0.0	
3/8"	6.0	63.0	95.0	99.9	100.0	96.5	0.0	
#4	2.0	12.0	61.0	38.9	99.9	71.3	0.0	
#8	1.8	3.0	41.0	3.2	69.0	51.0	0.0	
#16	1.7	2.4	35.0	2.6	42.0	38.0	0.0	
#30	1.5	2.0	23.0	2.4	27.0	30.7	0.0	
#50	1.3	1.7	19.0	2.2	17.0	23.5	0.0	
#100	1.2	1.5	12.0	1.9	9.0	16.7	0.0	
#200	1.1	1.3	7.5	1.5	6.2	9.6	0.0	

Specific Gravity = Weight / Volume * ρ

Gb: Specific Gravity of **Asphalt Binder**

Gsb: Bulk Specific Gravity of **Aggregate**

Gmm: Max Specific Gravity of **Mix** (No Air)

Gmb: Max Specific Gravity of **Mix** (With Air)

Volumetric Checks

Ps: Percent Aggregate

VMA: Voids in Mineral — VMA = 100 – ((Gmb x Ps)/Gsb)

Va: % Air Voids — % Air Voids = 100 x ((Gmm-Gmb)/Gmm)

VFA: Voids Filled with Asphalt — VFA = ((VMA – Va)/VMA)

Vbe: Volume of Effective Asphalt — Vbe = VMA - Va

Pba: Percent Binder Absorbed — Pba = Gb x ((100-Pb) x ((Gse – Gsb)/(Gse x Gsb)))

Pbe: Percent Effective Binder — Pbe = Pb - Pba

Pb: Percent of Asphalt Content in Mix

#200/Pbe: Effective Dust to Binder Ratio

MATERIAL TYPE SELECTION

Mix Design

a.k.a.

Job Mix Formula (JMF)

DATE = 08/19/14 SP125 14-80

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
			2.652	2.769	1.6			
			2.633	2.761	1.8			
			2.612	2.753				
			2.512	2.635				
			2.696	2.696				

14MFO0027	1071APAS	/ ARR MAZ Custom Chemicals, Inc., Mulberry, FL	F AC
14SEMA0011	1015ACPG..6422V	/ Coastal Energy, Willow Springs, MO	

MATERIAL IDENT # 14080	14CDSMA146 3/4"	14CDSMA147 1/2"	14CDSMA149 MAN SAND	14CDR3R117 MAN SAND	14CDR3R109 RAP	COMB. GRAD
1 1/2"	100.0	100.0	100.0	100.0	100.0	100.0
1"	100.0	100.0	100.0	100.0	100.0	100.0
3/4"	100.0	100.0	100.0	100.0	100.0	100.0
1/2"	82.8	99.8	100.0	100.0	97.1	95.6
3/8"	57.2	83.0	100.0	100.0	89.4	84.0
#4	10.2	19.0	99.9	93.5	64.6	50.5
#8	1.8	3.7	69.0	60.9	42.3	30.4
#16	1.7	3.6	42.0	39.3	31.9	21.0
#30	1.6	3.3	27.0	27.4	28.7	16.5
#50	1.4	3.1	17.0	16.5	19.0	11.0
#100	1.3	2.9	9.0	7.6	12.6	6.9
#200	1.1	1.9	6.2	3.2	7.6	4.2

LABORATORY CHARACTERISTICS AASHTO T312						
Gmm =	2.461	% VOIDS =	[illegible]	MPOSITION		
Gmb =	2.363	V.M.A. =	[illegible]	MIN. AGG.	94.7%	
Gsb =	2.639	% FILLED =	[illegible]	T CONTENT	4.0%	

CALIBRATION NUMBER XXXXX ENT W/ RAP 5.3%

MASTER GAUGE SER. NO. = XXXXX

BULK SP. GR.	APPAR. SP. GR.	%ABS
2.652	2.769	1.6
2.633	2.761	1.8
2.612	2.753	
2.512	2.635	
2.696	2.696	

Job Mix Formula Contractor Submital

- Basic Information – Date, Mix Type, Contract ID, Job Number, Route, County, Contact Info
- Job Mix Formula (JMF) of Proposed Mix
- Raw Material Data Supporting the JMF – Follows Sections 401.4 or 403.4
  - All material sources and characteristics
  - Percentage of each source and combined gradation
  - Volumetrics and raw data calculations
  - All Section 401 or 403 requirements – TSR, Dust/Binder, etc.

Check Contract Requirements (Contract Job Special Provisions, Contract Plans, etc.):

- ☐ Mix Type Confirmed
- ☐ Asphalt Binder Contract Grade Confirmed
- ☐ Proposed Work (Type of Work, job location, and length)
- ☐ Mix Use
- ☐ Quantity of Mix
- ☐ Verify any additional mix requirements in Job Special or General Provisions

Inspectors Check Contract Plans and JSP’s

- On-Line Plans Room
- eProjects

Job Mix Formula Checks:

- ☐ Aggregate Source Approvals – Current (updated annually)
  - Approved for Sec 1002 for Asphalt Quality
  - Correct Formation and Ledge Combinations
- ☐ Bulk Specific Gravity of Stone (Gsb) Check.
  - JMF Gsb within +0.025 of Source Approval Gsb for each fraction
  - If greater than 0.025 for any one fraction; follow flowchart
  - Check if Gsb(combined) is accurate
- ☐ Plasticity Index (PI) and % Deleterious Checks
  - If Plasticity Index on any fraction is greater than 3; TSR data shall be provided for 401 (BP/BB) and 402 (SL) mixtures. TSR data shall be provided on all 403 (SuperPave mixtures).
  - The combined % Deleterious on all fractions shall not exceed 8.0 % for all mix types.
- ☐ Check Bin Percentages = 100
- ☐ Check JMF Gradations of each Fraction matches AWP Gradation
- ☐ Check RAP or RAS JMF Gradation matches AWP Gradation
- ☐ Combined Gradation is accurate and meets 401, 402, or 403 requirements.
- ☐ JMF Asphalt Binder matches AWP Asphalt Binder
- ☐ Check Asphalt Mixing and Asphalt Molding Temperatures are on JMF
- ☐ Check that Mineral Aggregate and Total Asphalt Content (with RAP and/or RAS) = 100

JMF, Source Approval, Cognos, and AWP Checks

Inspectors Now Checking Gsb

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP190CLG

APPROVED BY = Willie Johnson

DATE = 07/11/23 SP190 23-100

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
			2.654	2.789	1.8			
			2.665	2.795	1.7			
			2.665	2.790	1.7			
			2.677	2.797	1.6			
			2.653	2.768				
			2.687	2.687				
23MFO0013	1071APAS	/ Ingevity, North Charleston, SC				MORLIFE 5000	0.5% BY WT OF AC	
23SEMA005	1015ACPG..6422H	/ Coastal Energy, Willow Springs, MO	1.030		PG64-22H	Gyro Mold Temp. 288-298°F		

IN-LINE GRADE = PG64-22H CONTRACT GRADE = PG70-22

MATERIAL IDENT #	23CDTMS093	23CDTMS094	23CDTMS095	23CDTMS096	23CDTMS097	23CDC3B028	23CDTMS093	23CDTMS094	23CDTMS095	23CDTMS096	23CDTMS097	23CDC3B028	COMB. GRAD
23100	1"	3/4"	1/2"	1/2"	MAN SAND	RAP	9.0	23.0	25.0	10.0	8.0	25.0	
1 1/2"	100.0	100.0	100.0	100.0	100.0	100.0	9.0	23.0	25.0	10.0	8.0	25.0	100.0
1"	100.0	100.0	100.0	100.0	100.0	100.0	9.0	23.0	25.0	10.0	8.0	25.0	100.0
3/4"	74.0	100.0	100.0	100.0	100.0	100.0	6.7	23.0	25.0	10.0	8.0	25.0	97.7
1/2"	21.0	87.0	100.0	100.0	100.0	100.0	1.9	20.0	25.0	10.0	8.0	25.0	89.9
3/8"	6.0	63.0	99.9	95.0	100.0	96.5	0.5	14.5	25.0	9.5	8.0	24.1	81.6
#4	2.0	12.0	38.9	61.0	99.9	71.3	0.2	2.8	9.7	6.1	8.0	17.8	44.6
#8	1.8	3.0	3.2	41.0	69.0	51.0	0.2	0.7	0.8	4.1	5.5	12.8	24.0
#16	1.7	2.4	2.6	35.0	42.0	38.0	0.2	0.6	0.7	3.5	3.4	9.5	17.7
#30	1.5	2.0	2.4	23.0	27.0	30.7	0.1	0.5	0.6	2.3	2.2	7.7	13.3
#50	1.3	1.7	2.2	19.0	17.0	23.5	0.1	0.4	0.6	1.9	1.4	5.9	10.2
#100	1.2	1.5	1.9	12.0	9.0	16.7	0.1	0.3	0.5	1.2	0.7	4.2	7.0
#200	1.1	1.3	1.5	7.5	6.2	9.6	0.1	0.3	0.4	0.8	0.5	2.4	4.4

LABORATORY CHARACTERISTICS AASHTO T312										
Gmm =	2.535	% VOIDS =	4.0	TSR =	91	TSR Wt.			MIX COMPOSITION	
Gmb =	2.433	V.M.A. =	13.4	-200/AC =	1.1	3840	Ndes =	80	MIN. AGG.	95.1%
Gsb =	2.672	% FILLED =	70	Gyro Wt. =	4750				VIRGIN ASPHALT CONTENT	3.7%

CALIBRATION NUMBER	XXXXX	MASTER GAUGE BACK CNT. =	XXXX	A1 =	-X.XXXXXX	TOTAL ASPHALT CONTENT	4.9%
MASTER GAUGE SER. NO. =	XXXXX	SAMPLE WEIGHT =	XXXX	A2 =	X.XXXXXX		

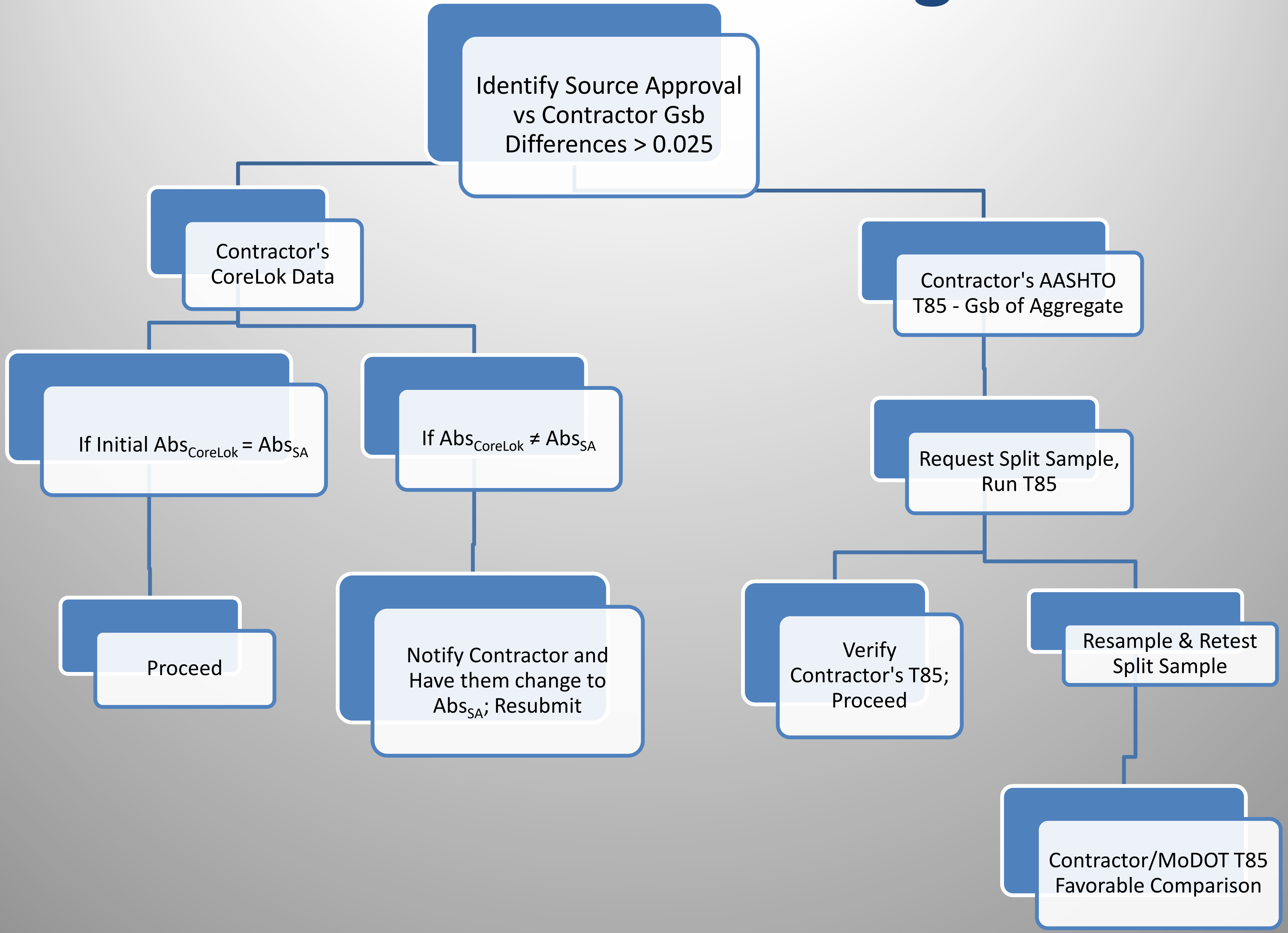
Aggregate & Mixture Properties Based on Contractors Mix Design

Contractor’s Measurements of G_{sb}

- CoreLok – Coarse Aggregate Specific Gravity
  - Most Common Contractor Method
  - Less Subjective, More Consistent, Usually a little higher

- AASHTO T 85 – Coarse Aggregate Specific Gravity

Procedures in Checking Gsb



Missouri CoreLok Aggregate Specific Gravity Calculation

Updated 01/02/2007

Enter Rubber Sheet Density 1.342
Enter Plastic Bag Density 0.932

* Use AASHTO T 84 when no coarse fraction is available; blank will produce an approximate value

Sample ID 3/29/2007	Dry Sample 1 Weight A (g)	Sample 1 weight in container filled with water B (g)	Volumeter Calib. C (g)	Bag weight D (g)	Rubber sheet weight E (g)	Dry Sample 2 weight F (g)	Weight of sealed Sample 2 opened in water G (g)	P1 CorGsb g/cm3	Input initial absorption estimate AASHTO T 85* ABS	Preliminary Absorption CorABS	Apparent Specific Gravity CorGsa (g/cm3)	Gsapred CoreLok Apparent	Gsbpred CoreLok Bulk	ABSpred Corelok Absorption
23CDTMS093	1584.4	6688.1	5679.0	27.2	0.0	1500.0	964.3	2.754	1.9	0.729	2.810	2.789	2.654	1.8
23CDTMS094	1473.4	6619.9	5679.0	27.1	0.0	1500.1	965.0	2.767	1.9	0.602	2.814	2.795	2.665	1.7
23CDTMS095	1452.5	6606.4	5679.0	27.6	0.0	1500.9	964.0	2.766	1.9	0.514	2.806	2.790	2.665	1.7
23CDTMS096	1474.9	6623.5	5679.0	27.0	0.0	1500.5	964.7	2.781	1.9	0.385	2.811	2.797	2.677	1.6
23CDTMS097	500.0	4523.3	4205.3	27.0	0.0	1000.0	638.3	2.747	1.8	0.427	2.780	2.768	2.653	1.6

AASHTO T85 – G_{sb} Measurements

	Aggregate Specific Gravity		
	Coarse: AASHTO T85 / ASTM C127 (+4)		
	Coarse		
Aggregate:	TR&G 3/8" CM16 Trap Rock 23SEMA054		
Weight of Oven Dry Sample	(A)	1682.8	g
Weight of SSD Sample, in Air	(B)	1688.2	g
Weight of Saturated Sample, Water	(C)	1055.7	g
Bulk Specific Gravity	A / (B - C	2.661	
Apparent Specific Gravity	A / (A - C)	2.683	
Absorption	((B - A) / A	0.3	

	Coarse		
Aggregate:	TR&G 9/16" CM14 Trap Rock 23SEMA053		
Weight of Oven Dry Sample	(A)	2944.6	g
Weight of SSD Sample, in Air	(B)	2953.9	g
Weight of Saturated Sample, Water	(C)	1846.3	g
Bulk Specific Gravity	A / (B - C	2.659	
Apparent Specific Gravity	A / (A - C)	2.681	
Absorption	((B - A) / A	0.3	

MoDOT G_{sb} Check in COGNOS

Materials - Aggregates

My content | Team content | Samples | My portal pages

Team content / AASHTOWARE / Headquarters / Materials - Aggregates

QLIS Source

Last Accessed
6/23/2023, 8:26 AM

QUARRY LEDGE INFORMATION SUMMARY - Source

Jan 18, 2024

Willard Constr, St. Robert

PH#: (573)336-2114

2.7 Mi E/O St. Robert   65583   St. Robert   County

Longitude: -92:05:31.92 Latitude: 37:49:23.51

PS#: 3050100619

Ledge	Formation/ Member / Lab ID#	Description/Components / Date	Micro Deval	LA	SPG	Abs	Unit Weight	MoDOT T14	T104	T161
2	Gasconade									
100510..CPCML	23CDMST069	20231204	13.37	30	2.667	1.7	100	1.4	3	

- Source Approval taken from 1” Aggregate Size
- Comparison issues with Contractor’s smaller chip sizes and screenings
- Compare Contractor’s Gsb to MoDOT Source Approval

Identify MoDOT SA G_{sb} vs Contractor G_{sb} Differences > 0.025

STEP 1 - Enter StockPile Bin %, Contractor's Gsb's, and Source Approval Gsb's

Aggregate Blend	% of Aggregate	Contractor's Individual	Source Approval Gsb	Difference	PASS/FAIL
Stockpile # 1	19	2.557	2.588	-0.031	PASS
Stockpile # 2	25	2.590	2.564	0.026	FAIL
Stockpile # 3	20	2.602	2.564	0.038	FAIL
Stockpile # 4	16	2.645	2.625	0.020	PASS
Stockpile # 5	0	2.607	2.600	0.007	PASS
Stockpile # 6	20	2.607	2.600	0.007	PASS
Stockpile # 7	0	2.600	2.600	0.000	PASS
Stockpile # 8	0	2.600	2.600	0.000	PASS
Sum	100	-			
	Gsb (Combind)	2.598			

Missouri CoreLok Aggregate Specific Gravity Calculation

Updated 01/02/2007

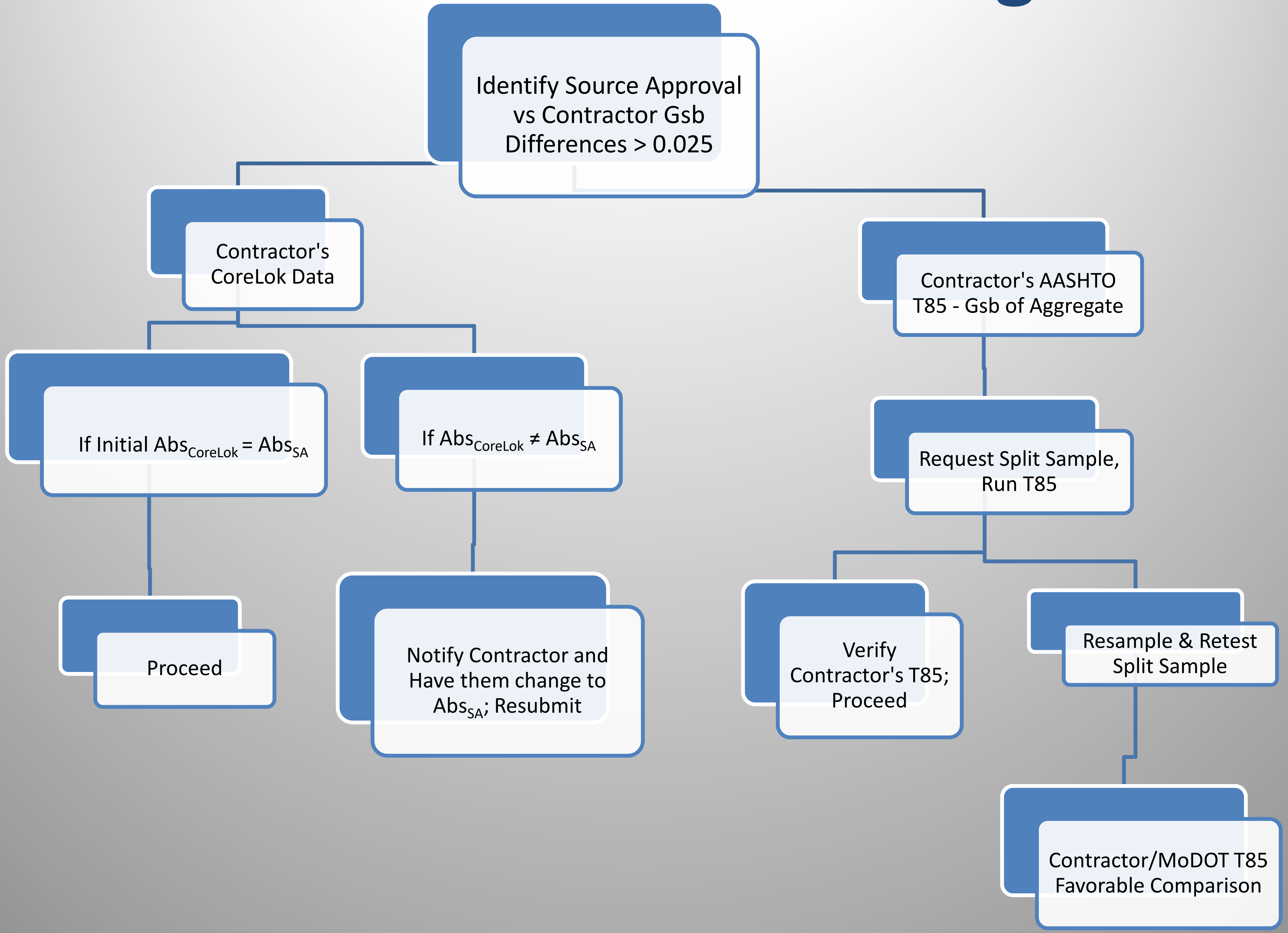
Enter Rubber Sheet Density	1.342
Enter Plastic Bag Density	0.932

* Use AASHTO T 84 when no coarse fraction is available; blank will produce an approximate value.

Sample ID	Dry Sample 1 Weight A (g)	Sample 1 weight in container filled with water B (g)	Volumeter Calib. C (g)	Bag weight D (g)	Rubber sheet weight E (g)	Dry Sample 2 weight F (g)	Weight of sealed Sample 2 opened in water G (g)	P1 **CorGsb** g/cm3	Input initial absorption estimate AASHTO T 85* **ABS**	Preliminary Absorption **CorABS**	Apparent Specific Gravity **CorGsa** (g/cm3)	**Gsapred** CoreLok Apparent	**Gsbpred** CoreLok Bulk	**ABSpred** Corelok Absorption
1/2" CLEAN	1000.0	6299.8	5668.6	27.9	0.0	1500.0	957.3	2.711	3.3	0.836	2.774	2.754	2.544	3.0
5/16" MINUS	500.0	4517.6	4202.6	27.9	0.0	1000.0	635.5	2.703	3.3	0.754	2.759	2.742	2.536	3.0
River Sand	500.0	4513.0	4202.6	27.9	0.0	1000.0	621.5	2.637	0.3	0.274	2.656	2.658	2.635	0.3
Rap									1.0					
SHG									1.0					

1A,1B,1-3	Jefferson City Material represents Ledge 1A,1B,1-3 Jefferson City Formation. Sample complies with Specification 1002 Coarse Aggregate for HMA.								
100210..LD1	23CDT1S008	20230221	24.17	32	2.498	3.4			
1A,1B,1-3	Jefferson City Material represents Ledge 1A,1B,1-3 Jefferson City Formation. Sample complies with Specification 1005 1" max coarse aggregate for PCCM.								
1005CM..LD10	22CDLJK011	20220301	20.66	32	2.541 2.541	3.3	98	15.1 16.1	11

T 85 Procedures in Checking Gsb



Aggregate Specific Gravity			
Coarse:	AASHTO T85 / ASTM C127 (+4)		
Coarse Aggregate:	TR&G 3/8" CM16 Trap Rock 23SEMA054		
Weight of Oven Dry Sample	(A)	1682.8	g
Weight of SSD Sample, in Air	(B)	1688.2	g
Weight of Saturated Sample, Water	(C)	1055.7	g
Bulk Specific Gravity	A / (B - C	2.661	
Apparent Specific Gravity	A / (A - C)	2.683	
Absorption	((B - A) / A	0.3	

Coarse Aggregate:	TR&G 9/16" CM14 Trap Rock 23SEMA053		
Weight of Oven Dry Sample	(A)	2944.6	g
Weight of SSD Sample, in Air	(B)	2953.9	g
Weight of Saturated Sample, Water	(C)	1846.3	g
Bulk Specific Gravity	A / (B - C	2.659	
Apparent Specific Gravity	A / (A - C)	2.681	
Absorption	((B - A) / A	0.3	

2.661 – 2.649 = 0.012

2.659 – 2.649 = 0.010

✓

			Deval				Weight	T14		
2	Rhyolite									
	Material represents Ledges 2 Rhyolite Formation. Sample complies with Specification 1005, 1" max, coarse aggregate for PCCP or PCCM. marsh 7/7/23 Reactivity testing does not apply for this sample.									
100510..CPPY	23SES1L020S	20230515	2.27	15	2.649	0.5	100	1.1	1	

Contractor/MoDOT's Gsbs Do Not Compare Favorably and AASHTO T 85 Test Method was Used

- Split Sample Requested and MoDOT will verify
  - AASHTO T85 results compare favorably and proceed with the mix design approval
- If no split sample available OR Central Lab results did not compare, request the contractor to sample the correct stockpile or aggregate source and provide another split sample
- Inspector/Contractor work together until favorable comparison
- If necessary, contractor resubmits JMF with new Gsb, new combined Gsb, and new volumetric properties.

Jason Blomberg – (573) 508-9720

Jason.Blomberg@modot.mo.gov

ENVIRONMENTAL COMPLIANCE FOR PLANT OPERATORS

Black to Basics 2024 – Jordan Janet, Delta Companies, Inc.

Topics of Discussion

- Air Emissions
- Stormwater Pollution
- Spill Prevention, Control and Countermeasure
- Land Management

Air Emissions

- Application for Permit to Construct
  - Application for Authority to Construct – MO 780-1323
  - DNR quotes 4-12 months for processing
    - The state has 90 days
    - 60 days is typical
    - Construction Waiver
  - Calculations Sheets
    - State has one they will help walk through – can be daunting
    - Some state engineers can go above duty to help

Plant is ready to rock!

- Must have complete construction permit in hand to operate
- Notify your regional office within 15 days of start-up
- Must Stack-Test next!

Stack Test

- Must complete within 6 months of start up
- Production must be representative of typical maximum capacity
- State must be notified 30 days prior to stack test
- 3P engineering firms listed on DNR's website

Required Documentation

- Rolling 12-month production calculation
  - Typical of Section 5 permits, limiting emissions to 15 tons
- Watering requirements
  - Undocumented water will lower your production limit based on assumed emissions
- Baghouse operation
  - Pressure drop reading daily
  - Operating and maintenance log
- Fuel sulfur content <15ppm (depending on your fuel source)

Portable Plants

- Shall not be operated at a location longer than 24 consecutive months
- Relocation Request
  - 7 days prior to move if next site has already been permitted
  - 21 days prior to move if next site has not been permitted
    - Or conditions have changed
      - IE two plants will be there

Stormwater Pollution

- General Operation Permit
  - Allows for stormwater runoff
  - Must sample quarterly
    - Analyzed by 3P lab
    - EDMR
      - Flow
      - TSS
      - Settleable Solids
      - O&G
      - pH
  - SWPPP
    - Inspections and Trainings
    - BMP’s?

SPCC

- Who needs an SPCC?
  - Aboveground oil storage >1320 gallons (max not operational)
    - Do not count containers <55 gallons
    - Including oil-filled equipment
  - Reasonably expected that a discharge could reach navigable waters of the US.
- Each plan must be certified by a PE
  - Facilities can self-certify
    - Oil storage capacity of 10,000 gallons or less

SPCC

Important Elements of an SPCC Plan:

- Facility diagram and description of the facility
- Oil discharge predictions
- Appropriate secondary containment or diversionary structures
- Facility drainage
- Site security
- Facility inspections
- Requirements for bulk storage containers including inspections, overfill, and integrity testing requirements
- Transfer procedures and equipment (including piping)
- Requirements for qualified oil-filled operational equipment
- Loading/unloading rack requirements and procedures for tank cars and tank trucks
- Brittle fracture evaluations for aboveground field constructed containers
- Personnel training and oil discharge prevention briefings
- Recordkeeping requirements
- Five-year Plan review
- Management approval
- Plan certification (by a Professional Engineer (PE) or in certain cases by the facility owner/operator)

Containment

- Containment must be 110% of the largest container
- Substances that share containment must be compatible
- Secondary containments and tanks should have capacity labels
- Containments aren't necessarily what you think
  - Collection and containment area
  - Environmental equivalence

What if I Spill?

- MO state reportable spill is >50 gallons
  - Report to DNR at earliest practical moment upon discovery
  - 25 gallons or more if UST
- Any release of oil that reaches or threatens any waterway
  - Sewers, groundwater, wetlands, lakes, creeks, streams, rivers
  - Road ditches
- How to clean spills?

Land Management

WHO TO CONTACT?

Be proactive – contact Jeff City or your Regional Offices

THANK YOU

Questions or Discussion

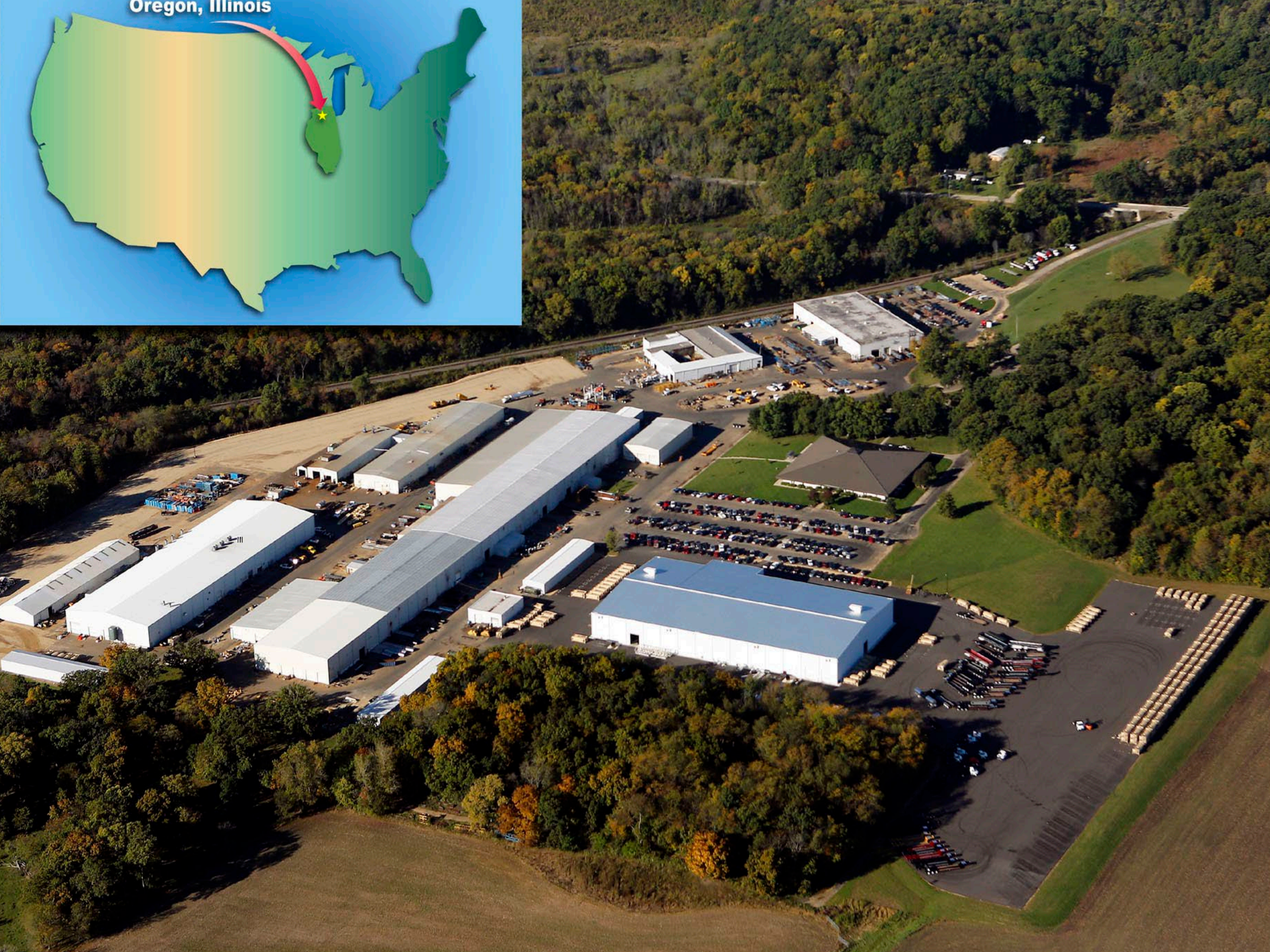
Tack Coat

Problems and Solutions

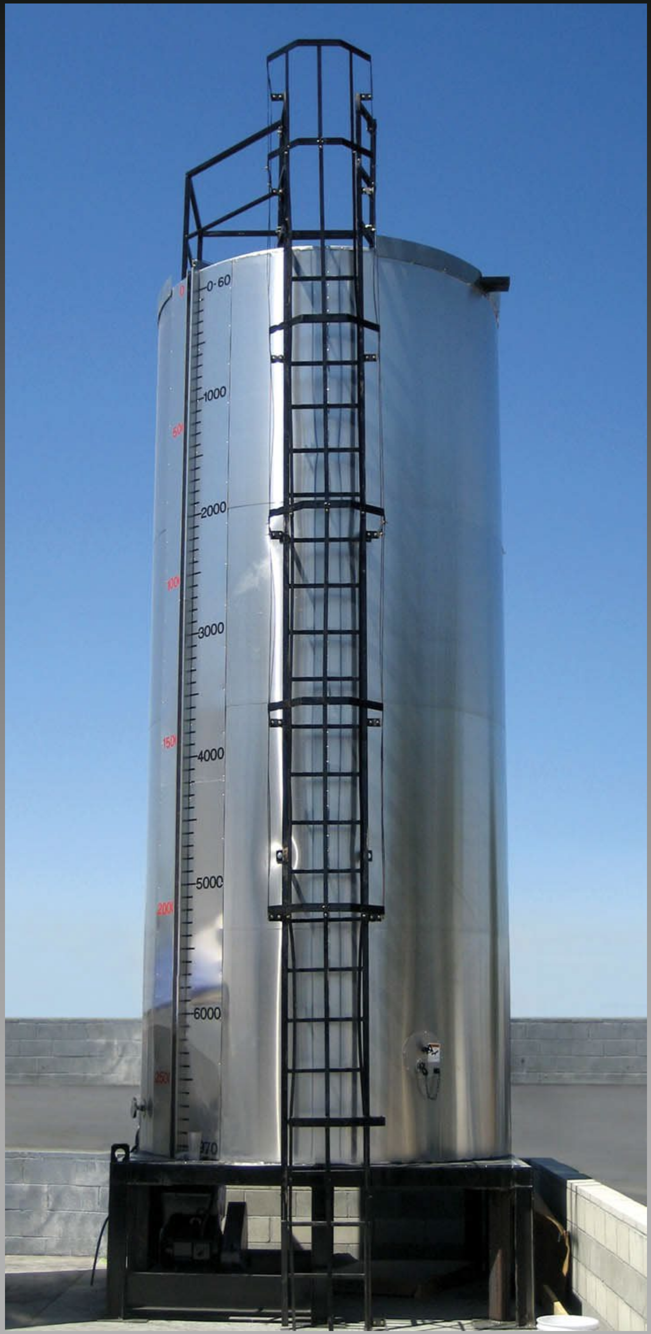
Etnyre®

Etnyre®

Since 1898


Oregon, Illinois

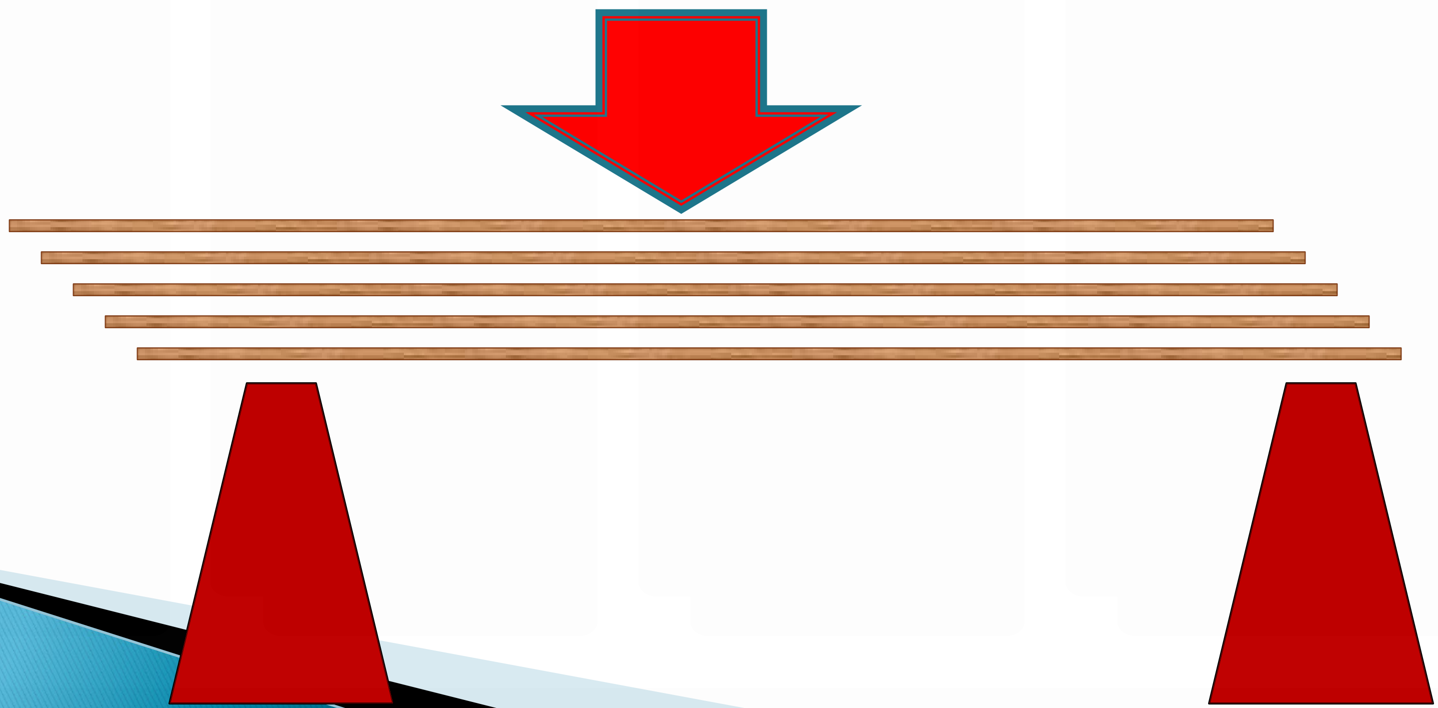
Asphalt Storage Tanks



TACK

Bonded Demonstration

- Up to 5 sheets (layers)
- 48” x 4” x 11/32”
- 60, 100, or 160 pound loadings
- Various Bonding Configurations



Successful Tack Coat

The Ultimate Goal:

Uniform, complete, and adequate coverage

Construction Issues

Uniformity of the Tack Coat Application

Non-uniform Application

Proper Application

Slippage Failure

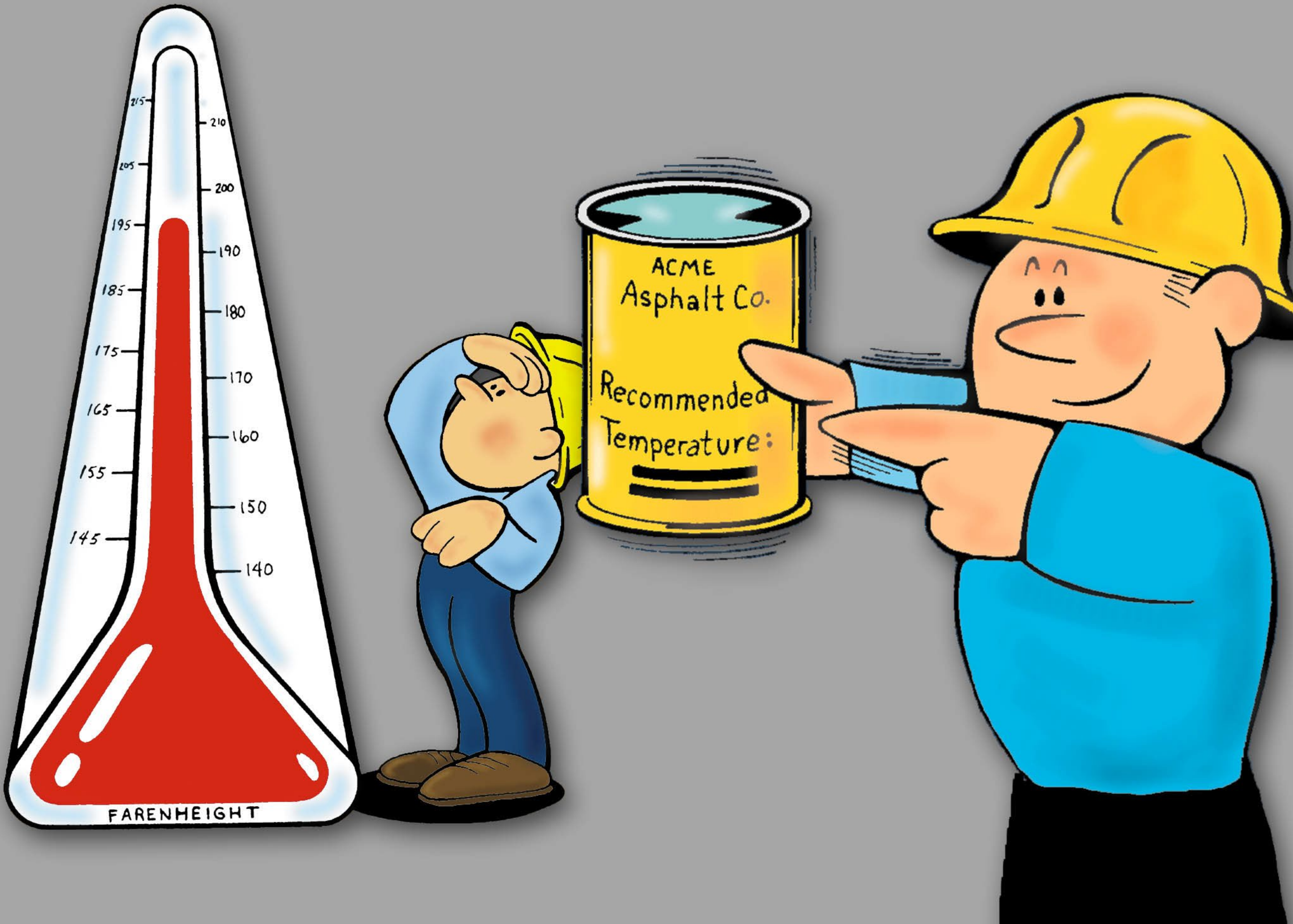
photo courtesy of Asphalt Institute

Types of Tack Coat Failures

Delamination of overlay from underlying pavement


LEFT TURN SIGNAL
LEFT TURN SIGNAL
OLD RIDGE RD
Prattville Medical Park
AMERIFIRST


2012/08/28 05:24


215
210
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160
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145
140
FARENHEIGHT
ACME
Asphalt Co.
Recommended
Temperature:

Example of Emulsion Break

Unbroken Emulsion After Breaking

Basic Functions

1. Fill the tank.
2. Heat material in tank.
3. Circulate material in tank.
4. Circulate material in spray bar.
5. Spray a metered amount of material.
6. Handspray.
7. Suck-back material from spray bar.
8. Wash out.
9. Transfer / unload.

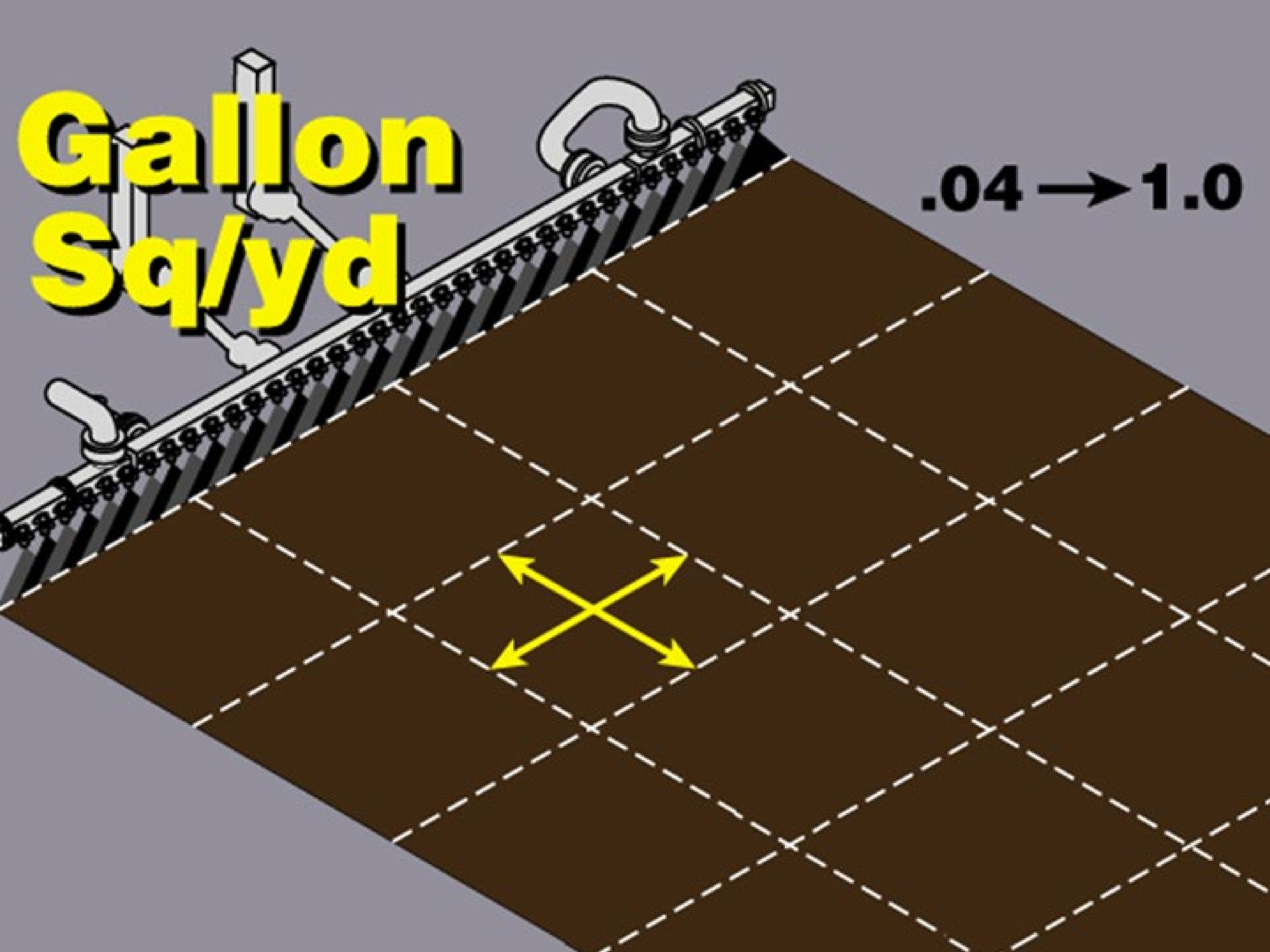
Metering System

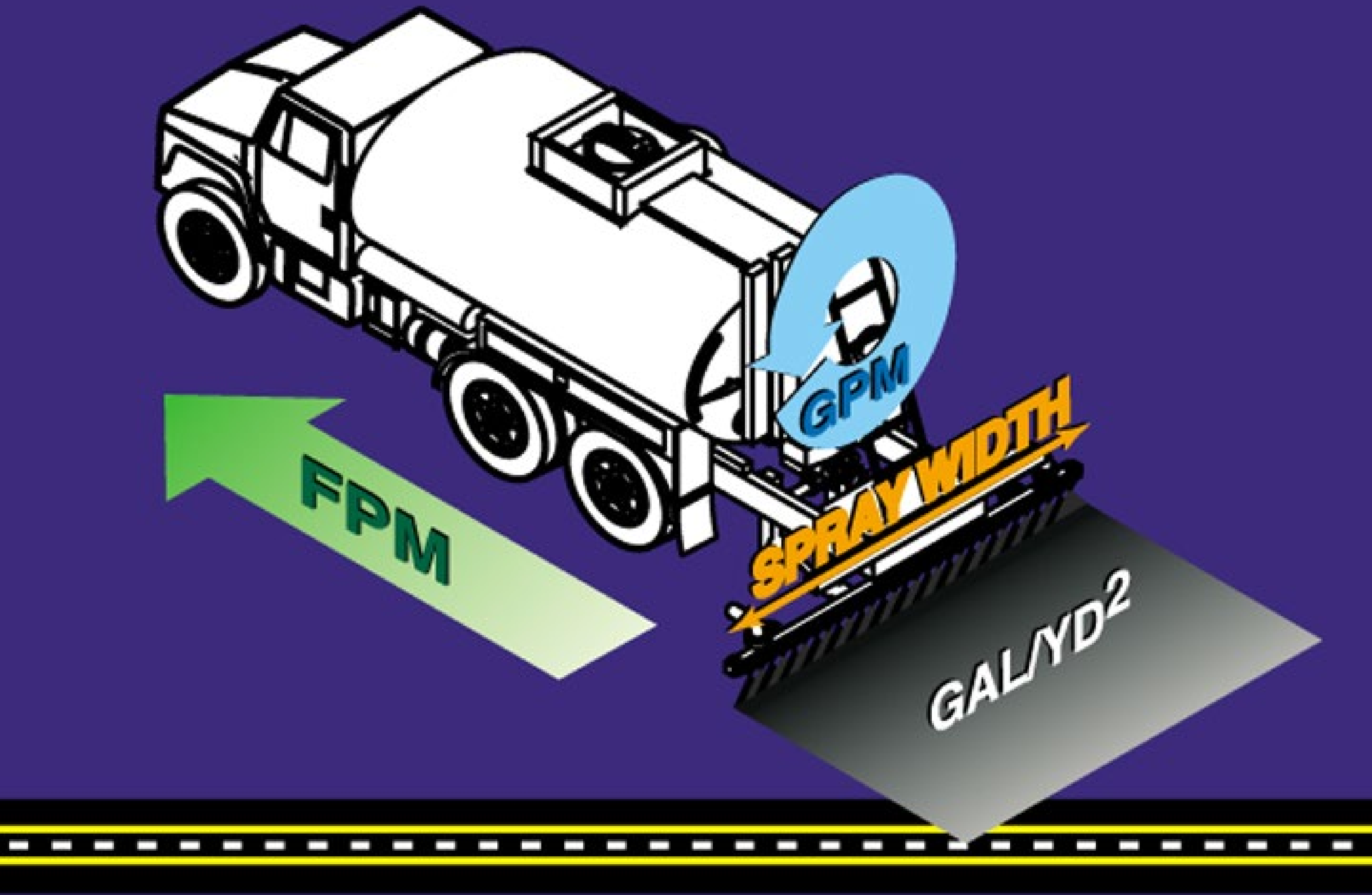
Four important features need to be considered:

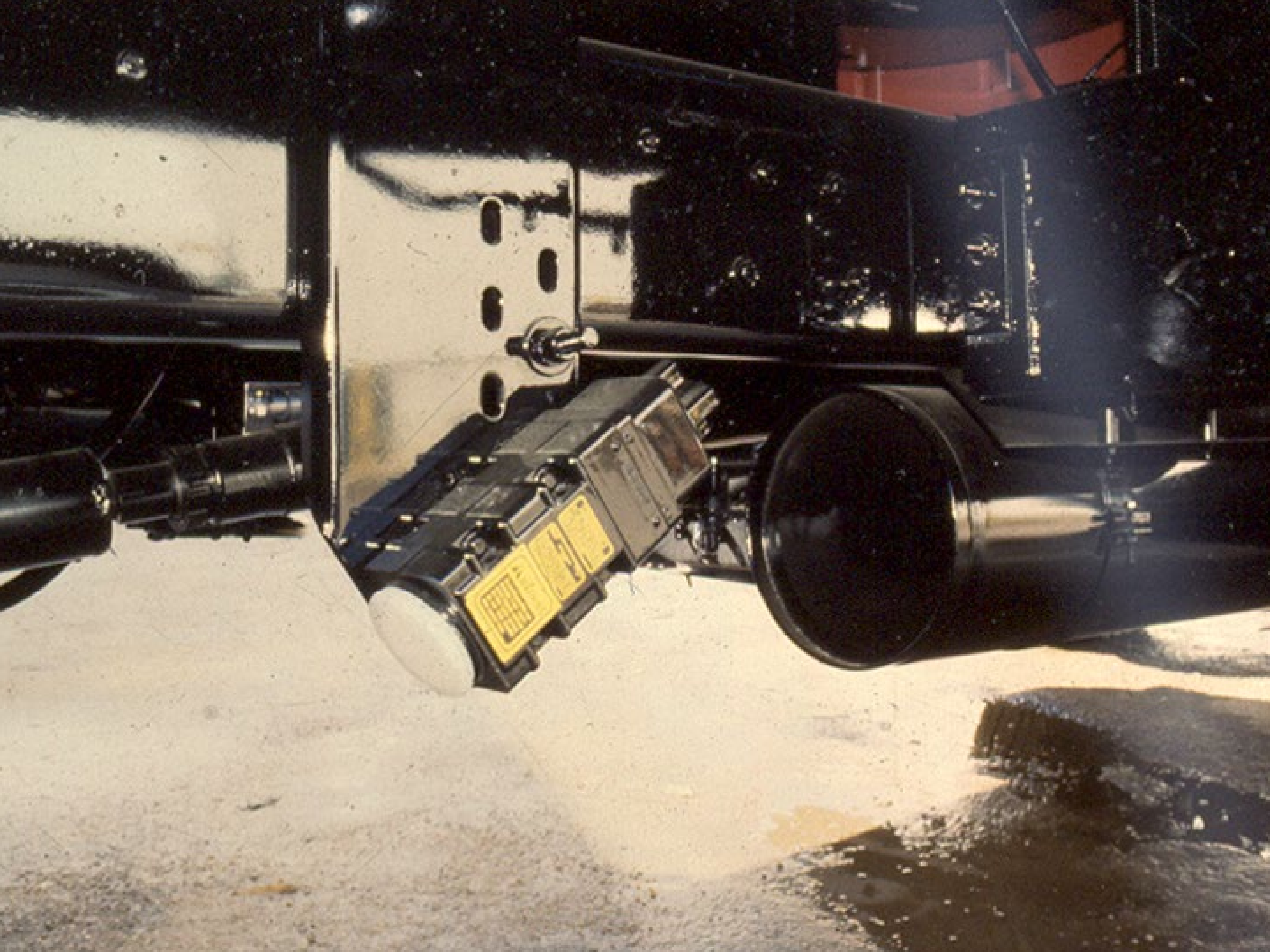
1) Desired Application Rate - Gallon/Yard
2) Forward Ground Speed - Feet Per Minute
3) Asphalt Pump Output - Gallons Per Minute
4) Width of Spray - Feet

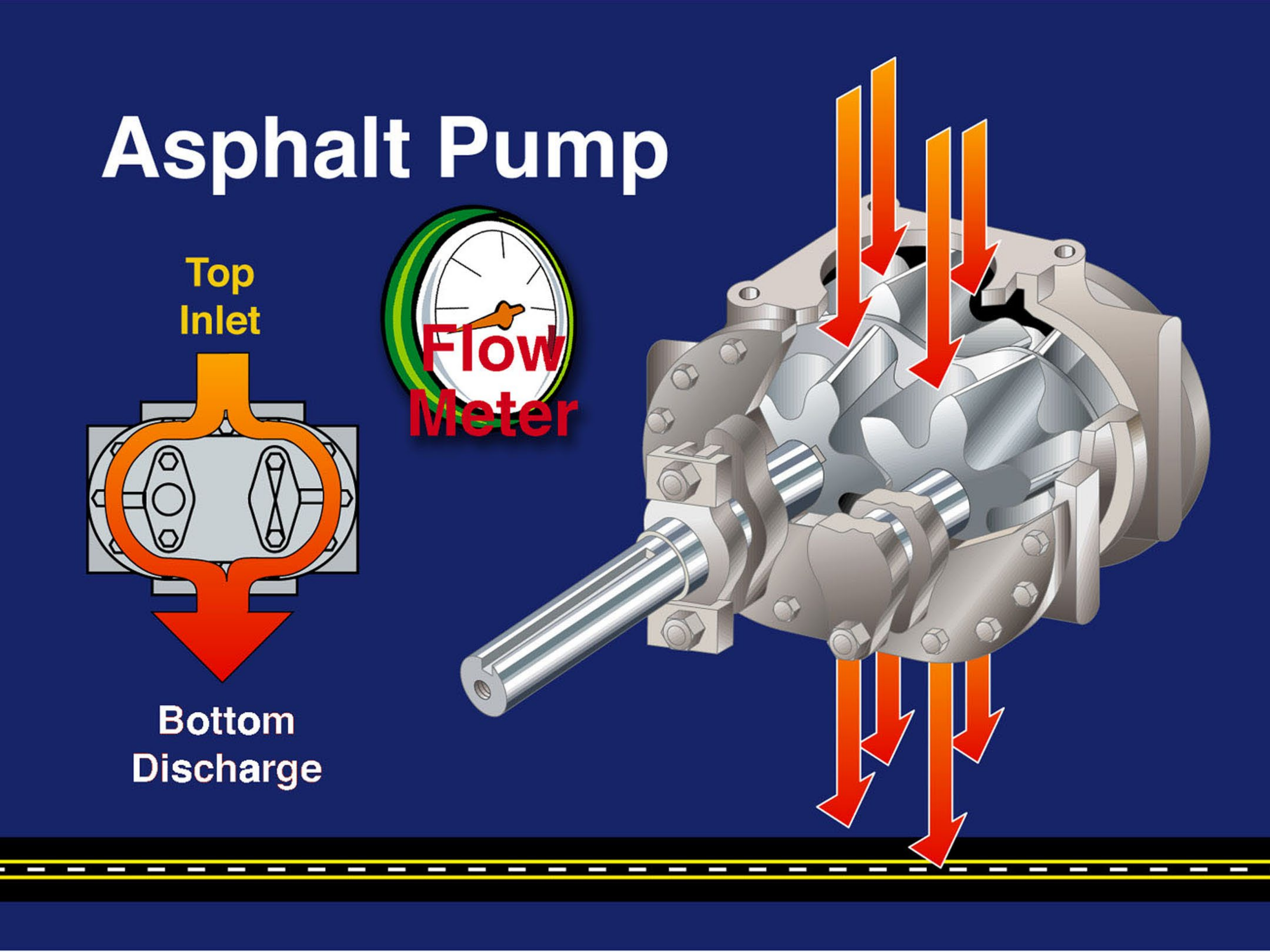

1999

Calculated Eye


Gallon
Sq/yd
.04 → 1.0


FPM
GPM
SPRAY WIDTH
GAL/YD2

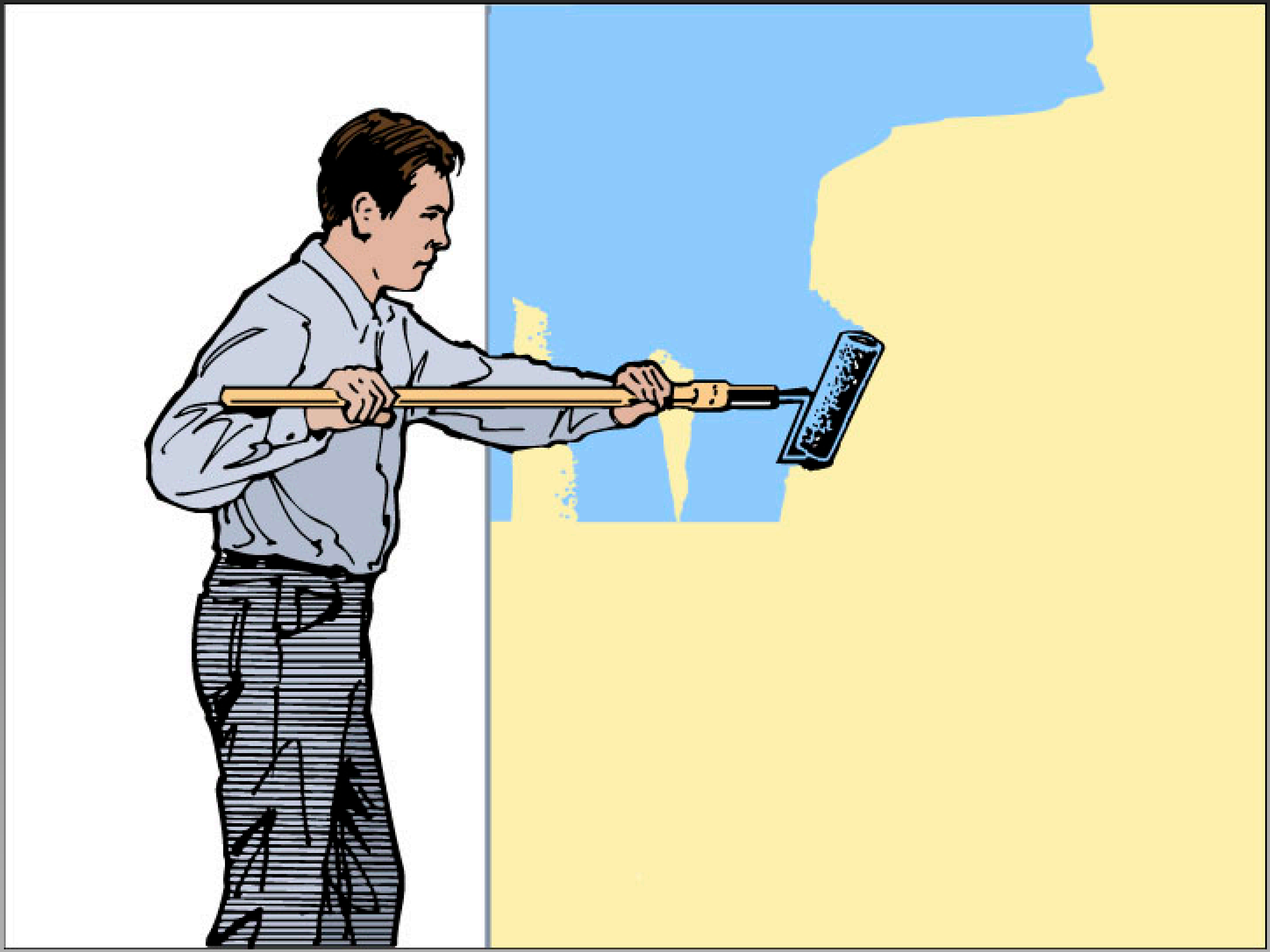



Asphalt Pump
Top
Inlet
Flow
Meter
Bottom
Discharge


FPM
GPM

BT1 CONTROLS FRONT PANEL

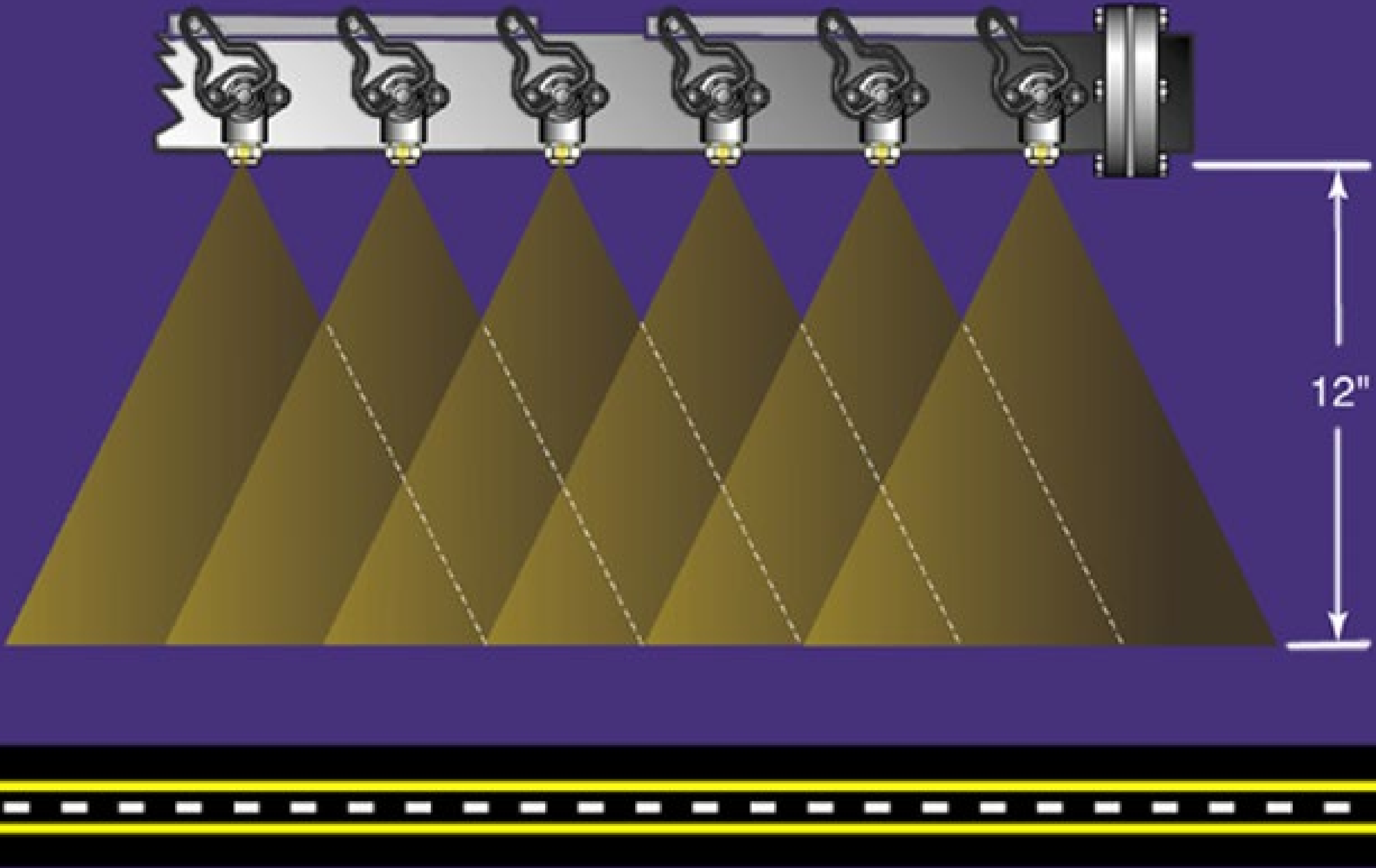
BT1 CONTROLS REAR PANEL



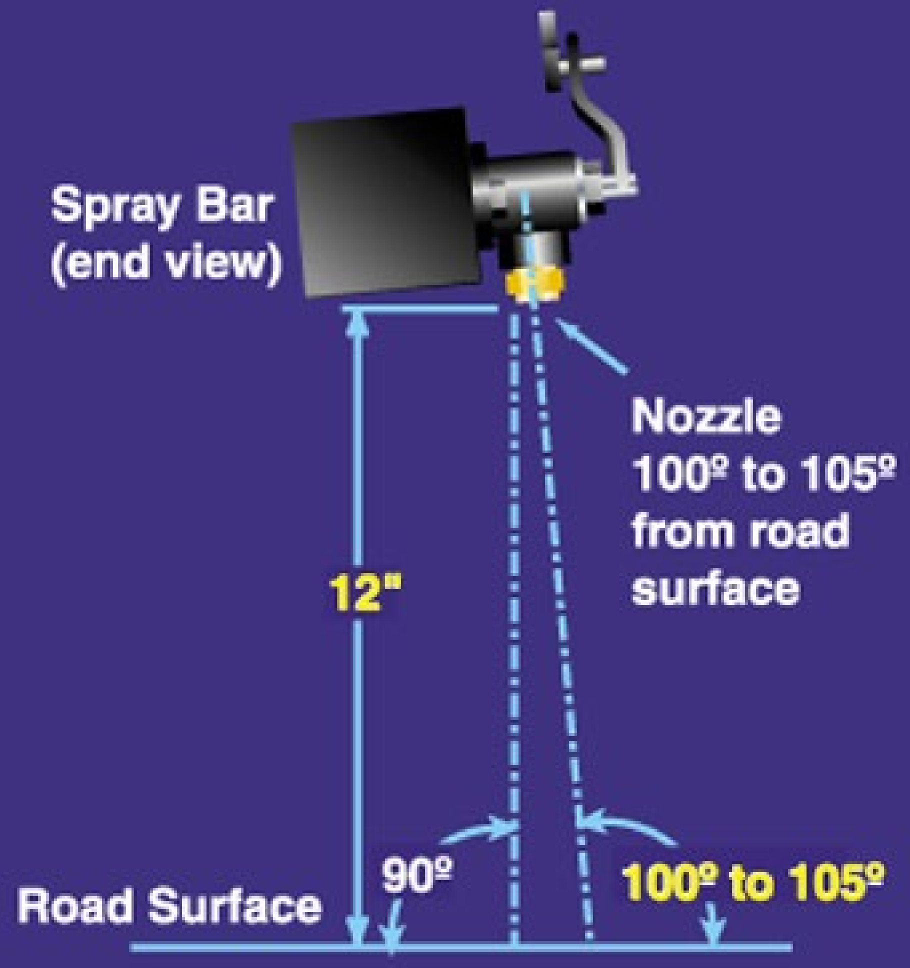

ETNYRE
NON-DRIP
SPRAY-BAR


SPRAY BAR

Triple Lap Coverage

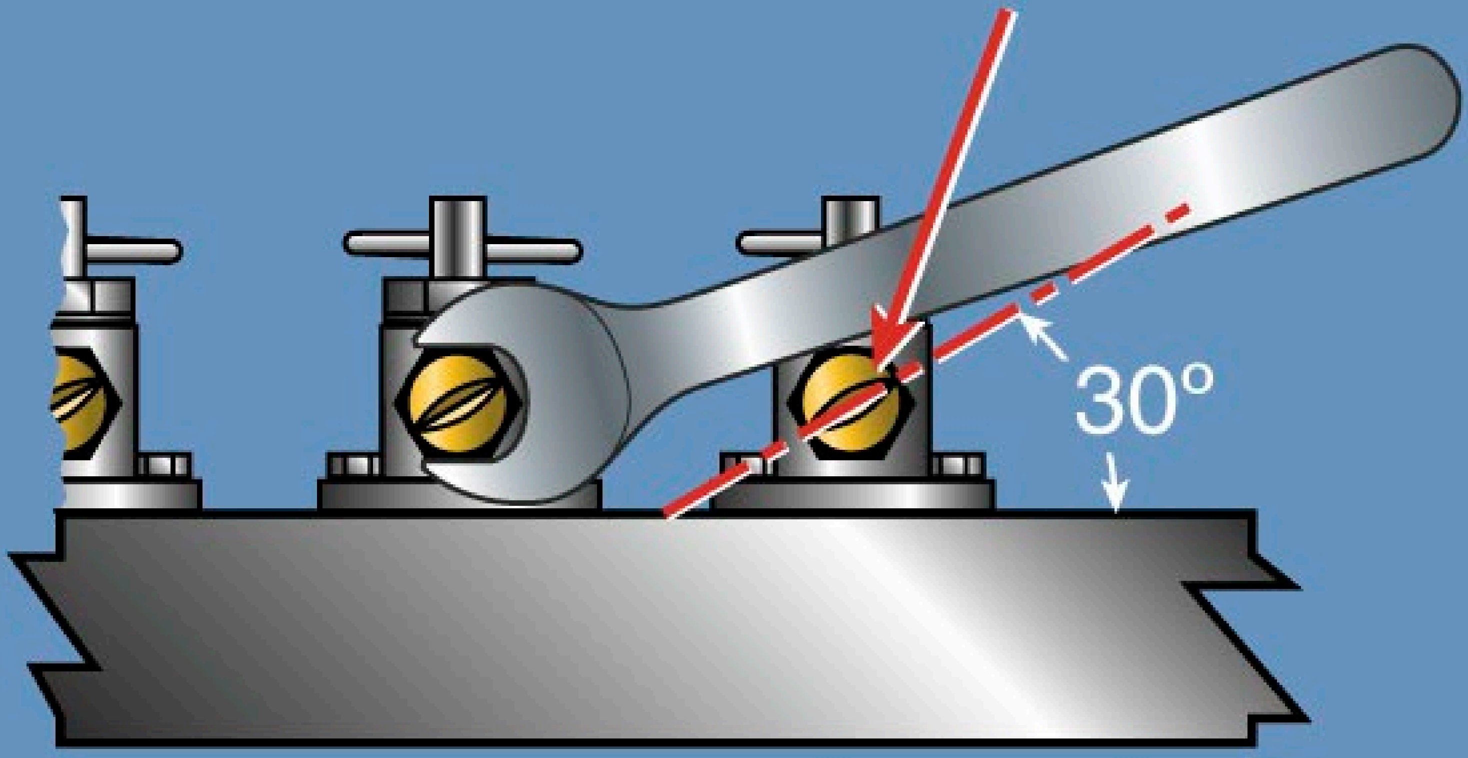


Nozzle Height



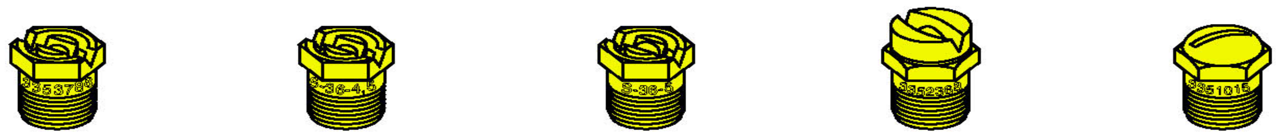
Spray Bar (bottom view)

Nozzle Slot 30° from Spray Bar



Spray Bar (bottom view)

SPRAY BAR NOZZLES



1 3353788 | 2 3351008 | 3 3351009 | 4 3352368 | 5 3351015

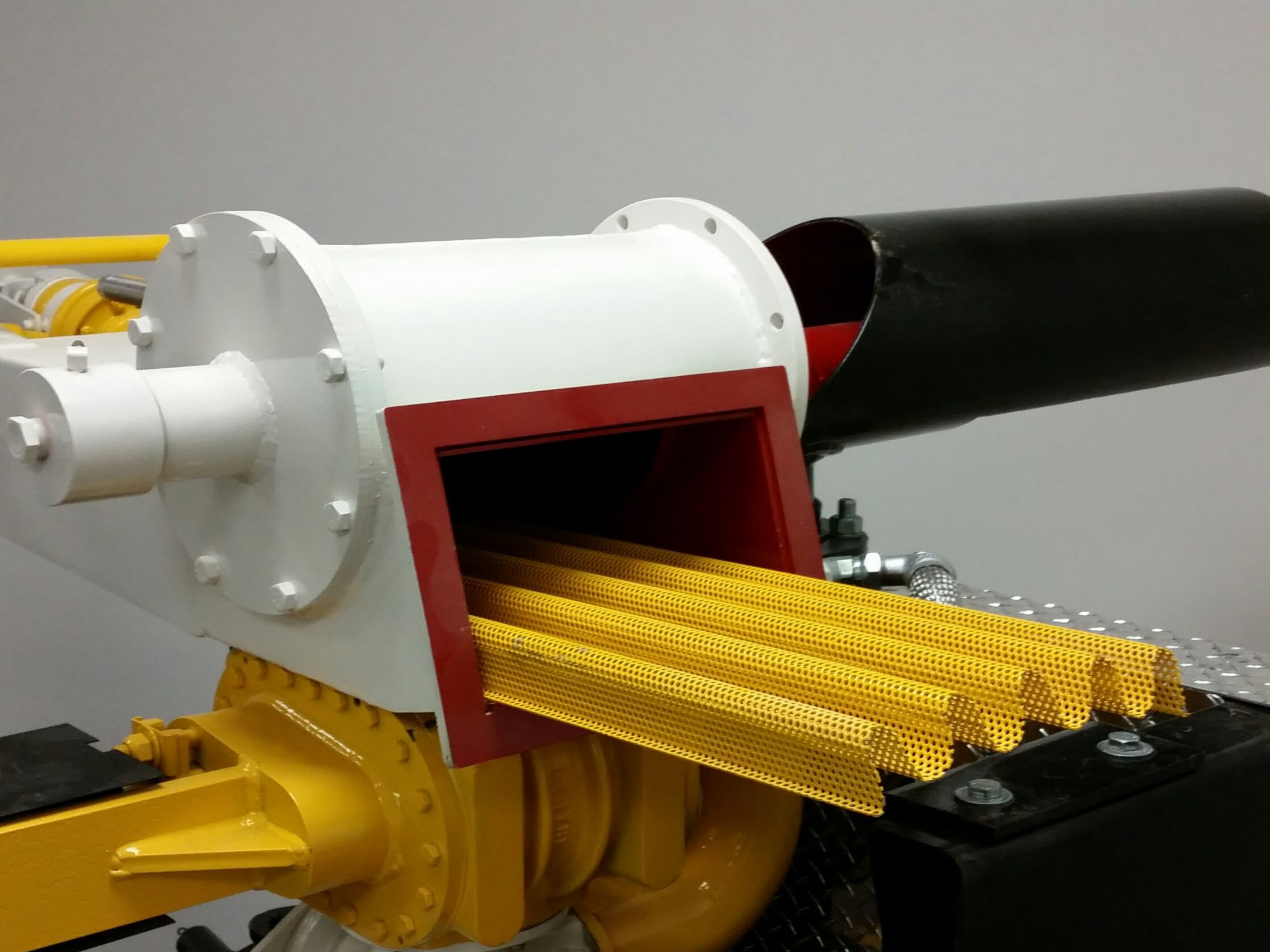
6 3352204 | 7 3352205 | 8 3352210 | 9 3351014 | 10 3351010

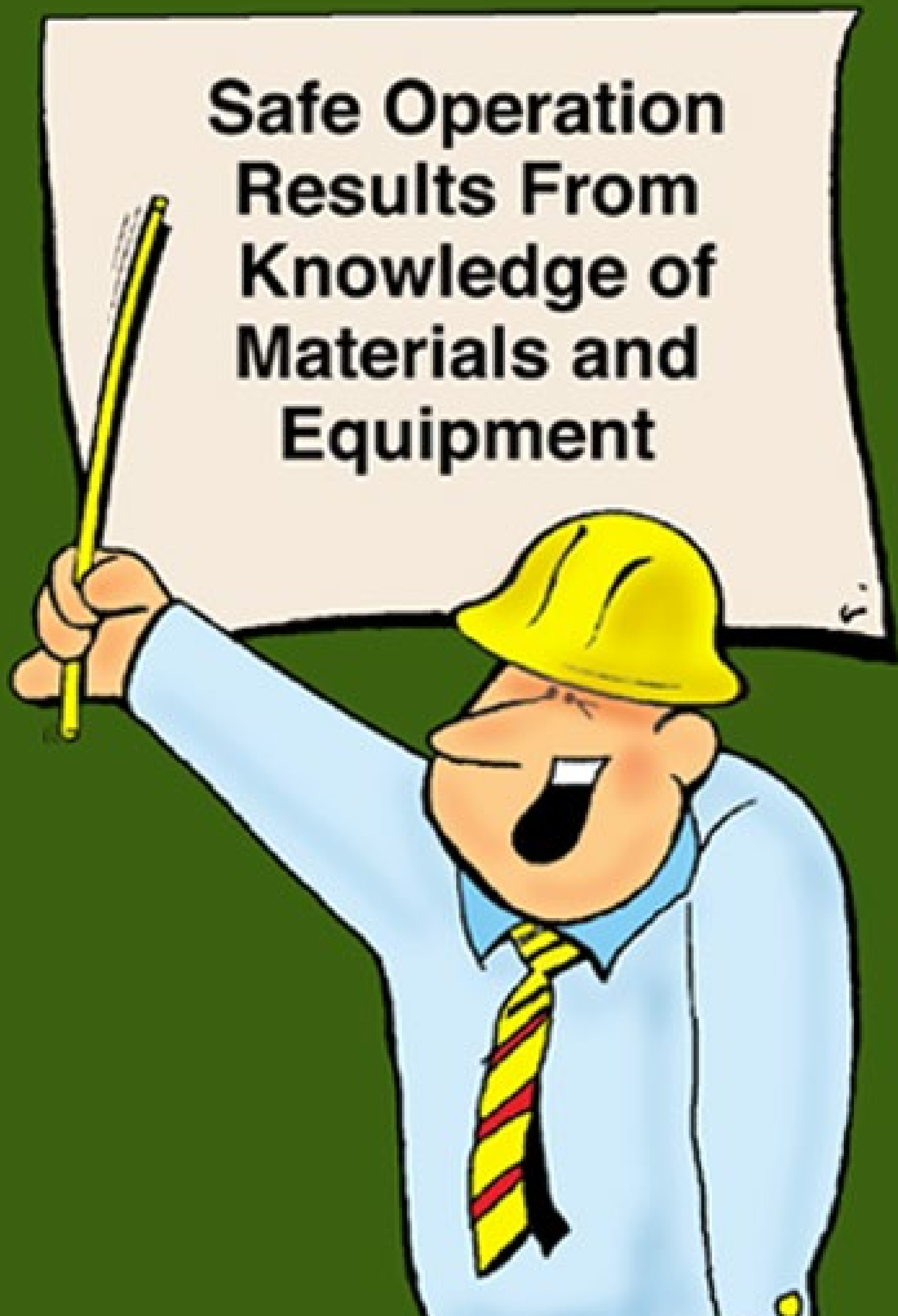
Ref.	Part No.	Description	Application Per Square Yard	Application (Metric) Liters Per Square Meter	Flow Gallons Per Minute Per Foot
1	3353788	V Slot Tack Nozzle	.05 - .20	.19 - .75	3.0 to 4.5
2	3351008	S36-4 V Slot	.10 - .35	.38 - 1.30	4.0 to 7.5
3	3351009	S36-5 V Slot	.18 - .45		7.0 to 10.0
4	3352368	Multi-Material V Slot	.15 - .40	.57 - 1.50	6.0 to 9.0
5	3351015	3/32" Coin Slot	.15 - .40	.57 - 1.50	6.0 to 9.0
6	3352204	Multi-Material V Slot	.35 - .95	1.30 - 3.60	12.0 to 21.0
7	3352205	Multi-Material V Slot	.20 - .55	.75 - 2.08	7.5 to 12.0
8	3352210	End Nozzle (3352205)	.20 - .55	.75 - 2.08	7.5 to 12.0
9	3351014	3/16" Coin Slot	.35 - .95	1.30 - 3.60	12.0 to 21.0
10	3351010	1/4" Coin Slot	.40 - 1.10	1.50 - 4.16	15.0 to 24.0

3353788 Etnyre V Slot Tack Nozzle App Rate .05 - .20

Drive Distributor to achieve GPM between Min and Max for Application accuracy

# of Feet	Min GPM	Max GPM	# of Feet	Min GPM	Max GPM
1	3	4.5	13	39	58
2	6	9	14	42	63
3	9	13	15	45	67
4	12	18	16	48	72
5	15	22	17	51	76
6	18	27	18	54	81
7	21	31	19	57	85
8	24	36	20	60	90
9	27	40	21	63	94
10	30	45	22	66	99
11	33	49	23	69	103
12	36	54	24	72	108




Safe Operation
Results From
Knowledge of
Materials and
Equipment

Success Is Insured With Teamwork!

Teamwork Is the Difference Between Success and Failure

NOT MY JOB!


SEE YA- ALL LATER

THE BASICS OF ASPHALT BINDERS

Chase Gabbert – Interstate Testing Services

2024 Black to Basics Training

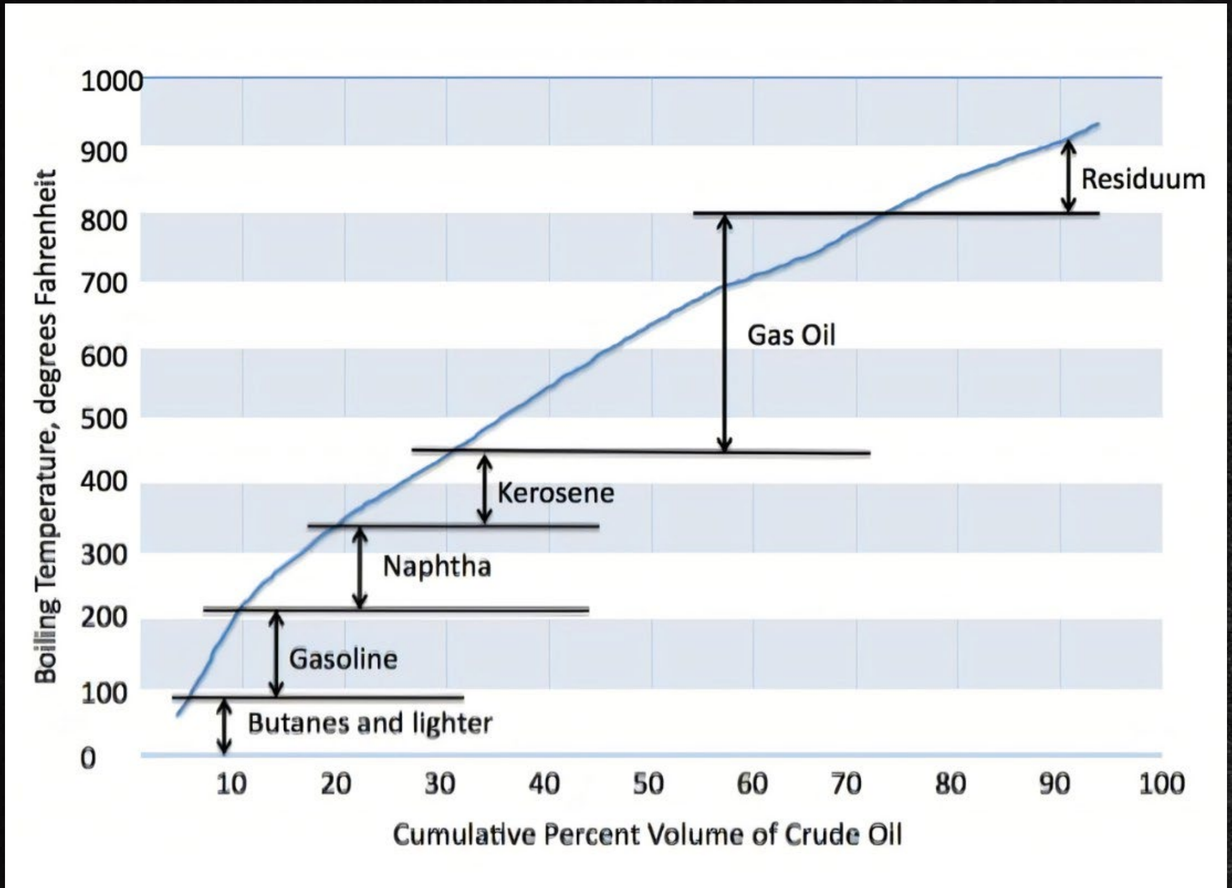
What is Asphalt?

- A high molecular weight thermoplastic hydrocarbon found in crude petroleum oils
- Asphalt can occur naturally – Pitch Lake in Trinidad & Lake Bermudez in Venezuela
- Has been used for thousands of years – Mesopotamia & Ancient Egypt used as an adhesive and waterproofing
- First asphalt road in the U.S. – 1870 in New Jersey
- The “best glue in the world”

Asphalt From Crude Oil

- Crude Oil was formed millions of years ago by the bacterial decomposition of organic matter, both plant and animal, buried under heavy layers of our earth's sediment.
- Asphalt Cement is NOT tar.

Crude Oil Production - Fractional Distillation



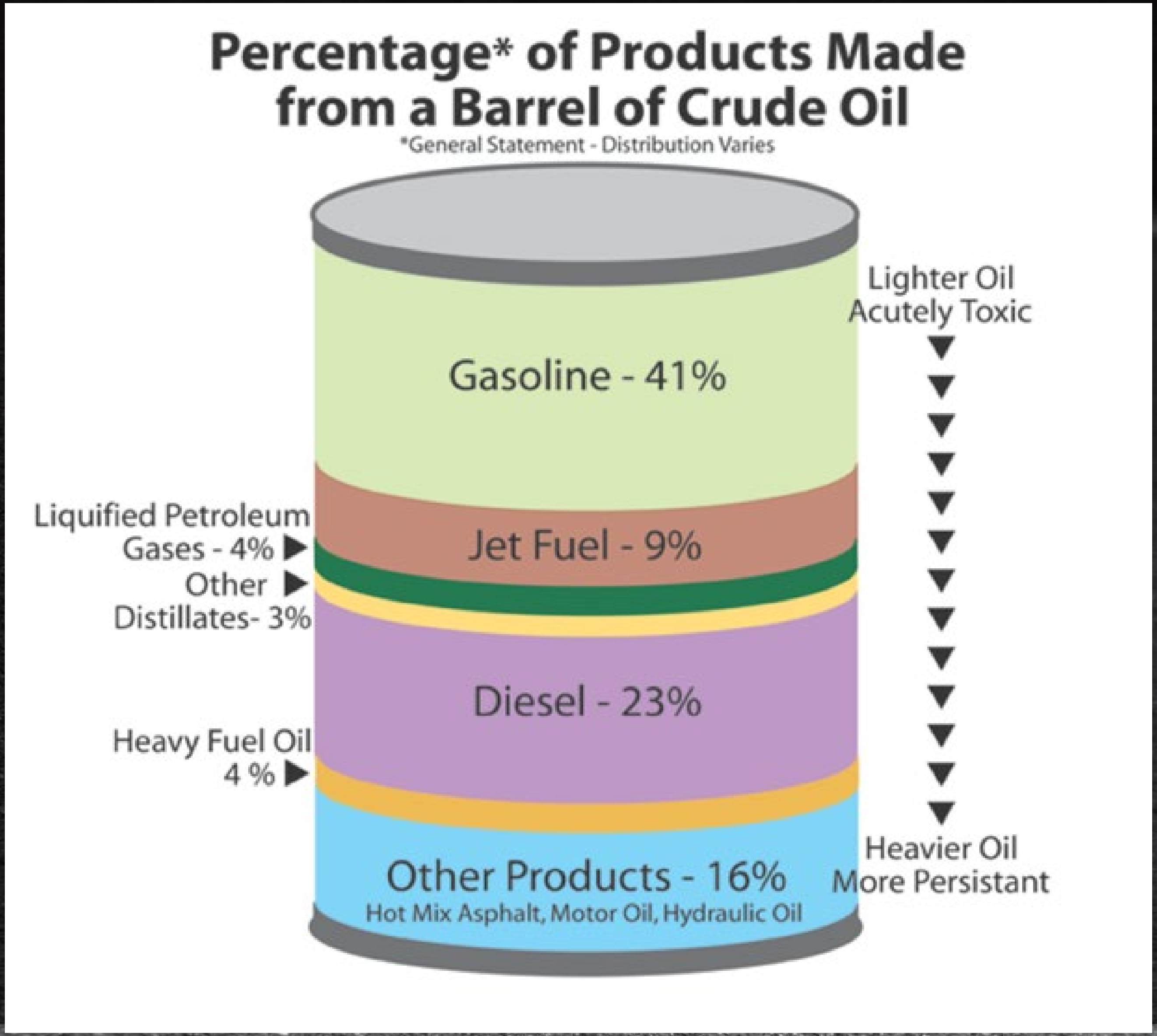
- Propane
- Butane
- Gasoline
- Naphtha
- Kerosene
- Diesel
- Gas Oils
- Asphalt

Crude Oil Breakdown

Asphalt Cement is the “bottom of the barrel.”

Crude oils vary, widely. As a generality:

1 Barrel = 42 gallons



SWEET CRUDE vs. SOUR CRUDE

- Sweet crude oil is considered "sweet" if it contains less than 0.5% sulfur. Early prospectors would taste oil to determine its quality – lower sulfur oil actually - tasted sweet.
- Sour crude oil contains impurity sulfur levels greater than 0.5%.
- Before sour crude oil can be refined into gasoline, impurities need to be removed, therefore increasing the cost of processing.
- Sweet crude is mainly found in the Appalachian Basin in Eastern North America, Western Texas, the Bakken Formation of North Dakota & Saskatchewan, the European North Sea, North Africa, Australia, and the Far East/Indonesia.
- Sour crude is more common in the Gulf of Mexico, Mexico, South America, and Canada. Crude produced by OPEC Member Nations also tends to be relatively sour, with an average sulfur content of around 2.0%.

LIGHT vs. HEAVY CRUDE

- Difference between light & heavy oil - compares to the liquid density of water
- Light Crude Oil has a lower density – lighter than water - floats.
- Heavy Crude Oil has a higher density – heavier than water - sinks.
- Heavier crude oil is harder to refine. Heavy crude oil is also known as "tar sands" because of its high bitumen content.
- Light crude tends to trade at a premium because it is easier to refine and produces more gasoline and diesel fuel.
- Asphalt cement in the U.S. is from a combination of these sources based on the current economics
  - When gas prices are high, refineries want to get more gas out of each barrel of oil – may use a "Coker" to extract more, leaving less asphalt and lower quality asphalt.

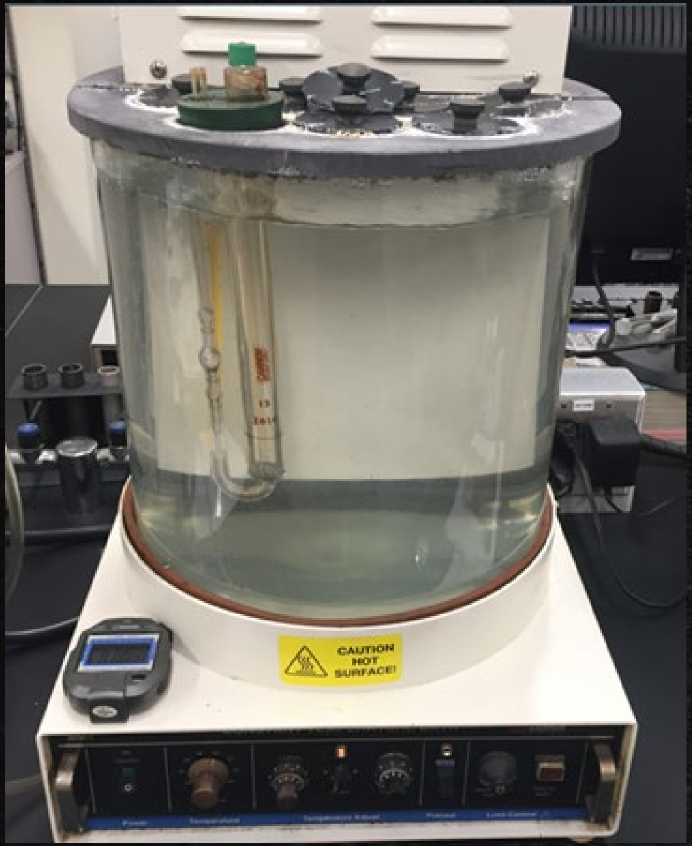
Asphalt Nomenclature

- History of Asphalt Nomenclature
- Todays Performance Graded Asphalts
- Comparison of Performance Graded vs. MSCR

History of AC Nomenclature

- Prior to 1970, asphalts were specified as penetration grades: 5/9, 50/60, 60/70, 85/100, 140/160, and >300 pen
- The penetration of an asphalt is determined by the depth that a free-falling weighted needle penetrates an asphalt sample, at a specified temperature, weight and time. The needle penetration, measured in mm/10, is the penetration of the asphalt. More commonly this is simply referred to as the "pen."

History of AC Nomenclature



- Beginning in 1970, asphalts were specified as viscosity grades. AC-5, AC-10, AC-20, AC-30 and AC-40
- Testing performed in Absolute Viscometer. Measuring flow of material through a calibrated capillary tube under set temperature and vacuum. *What did the 30 in AC-30 mean? Multiply 30x100=3000. This was the middle of the acceptable viscosity range for the AC-30 specification.*
- *Lower the ending number, the thinner/softer the oil was.*

Performance Grades – PG Asphalt

- In the 1990's State DOTs began to specify SHRP (Strategic Highway Research Program) or Performance Grades of Asphalts: PG 58-28, PG 64-22, PG 70-22, PG 76-22, etc.
- Thought process of SHRP – Performance Grades were created at the same time as Super Pave HMA processes. Transitioning the industry toward where we are today.

- PG Binder Criteria:
- Designed to utilize Rheological testing, at different desired climatical temperatures, at different points of binders "life cycle"

- Rheology – *"the science of deformation and flow within a material"*

Performance Grades – PG Asphalt

- PG Binder types are selected geographically, based off that regions 100-year climate history.
- PG Binder nomenclature:

    Max Design Temperature, °C

    Min. Design Temperature, °C

Ex.) PG58-28, PG64-22

Performance Grades

Max. Design Temp.	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
Min. Design Temp.	-34 -40 -46	-10 -16 -22 -28 -34 -40 -46	-16 -22 -28 -34 -40	-10 -16 -22 -28 -34 -40	-10 -16 -22 -28 -34 -40	-10 -16 -22 -28 -34	-10 -16 -22 -28 -34
Original							
≥230 °C	**Flash Point**						
≤ 3 Pa-s @ 135 °C	**Rotational Viscosity**						
≥ 1.00 kPa	**DSR G*/sin δ** (Dynamic Shear Rheometer)						
	46	52	58	64	70	76	82
(Rolling Thin Film Oven) RTFO, Mass Change ≤ 1.00%							
≥ 2.20 kPa	**DSR G*/sin δ** (Dynamic Shear Rheometer)						
	46	52	58	64	70	76	82
(Pressure Aging Vessel) PAV							
20 hours, 2.10 MPa	90	90	100	100	100(110)	100(110)	100(110)
≤ 5000 kPa	**DSR G*sin δ** (Dynamic Shear Rheometer) Intermediate Temp. = [(Max. + Min.)/2] + 4						
	10 7 4	25 22 19 16 13 10 7	25 22 19 16 13	31 28 25 22 19 16	34 31 28 25 22 19	37 34 31 28 25	40 37 34 31 28
S ≤ 300 MPa m ≥ 0.300	**BBR S (creep stiffness) & m-value** (Bending Beam Rheometer)						
	-24 -30 -36	0 -6 -12 -18 -24 -30 -36	-6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24	0 -6 -12 -18 -24
If BBR m-value ≥ 0.300 and creep stiffness is between 300 and 600, the Direct Tension failure strain requirement can be used in lieu of the creep stiffness requirement.							
ε_f ≥ 1.00%	**DTT** (Direct Tension Tester)						
	-24 -30 -36	0 -6 -12 -18 -24 -30 -36	-6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24	0 -6 -12 -18 -24

Performance Grades

Max. Design Temp.	PG 46			PG 52							PG 58					PG 64					
Min. Design Temp.	-34	-40	-46	-10	-16	-22	-28	-34	-40	-46	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-40
Original																					
≥230 °C	**Flash Point**																				
≤ 3 Pa-s @ 135 °C	**Rotational Viscosity**																				
≥ 1.00 kPa	**DSR G*/sin δ** (Dynamic Shear Rheometer)																				
	46			52							58					64					
(Rolling Thin Film Oven) RTFO, Mass Change ≤ 1.00%																					
≥ 2.20 kPa	**DSR G*/sin δ** (Dynamic Shear Rheometer)																				
	46			52							58					64					
(Pressure Aging Vessel) PAV																					
20 hours, 2.10 MPa	90			90							100					100					
≤ 5000 kPa	**DSR G*sin δ** (Dynamic Shear Rheometer)																				
	10	7	4	25	22	19	16	13	10	7	25	22	19	16	13	31	28	25	22	19	16
S ≤ 300 MPa m ≥ 0.300	**BBR S (creep stiffness) & m-value** (Bending Beam Rheometer)																				
	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30
ε_f ≥ 1.00%	**DTT** (Direct Tension Tester)																				
	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30

Max. Design Temp.	PG 70						PG 76					PG 82				
Min. Design Temp.	-10	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-10	-16	-22	-28	-34
Original																
≥230 °C	**Flash Point**															
≤ 3 Pa-s @ 135 °C	**Rotational Viscosity**															
≥ 1.00 kPa	**DSR G*/sin δ** (Dynamic Shear Rheometer)															
	70						76					82				
(Rolling Thin Film Oven) RTFO, Mass Change ≤ 1.00%																
≥ 2.20 kPa	**DSR G*/sin δ** (Dynamic Shear Rheometer)															
	70						76					82				
(Pressure Aging Vessel) PAV																
20 hours, 2.10 MPa	100(110)						100(110)					100(110)				
≤ 5000 kPa	**DSR G*sin δ** (Dynamic Shear Rheometer) — Intermediate Temp. = [(Max. + Min.)/2] + 4															
	34	31	28	25	22	19	37	34	31	28	25	40	37	34	31	28
S ≤ 300 MPa m ≥ 0.300	**BBR S (creep stiffness) & m-value** (Bending Beam Rheometer)															
	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	0	-6	-12	-18	-24
ε_f ≥ 1.00%	**DTT** (Direct Tension Tester)															
	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	0	-6	-12	-18	-24

If BBR m-value ≥ 0.300 and creep stiffness is between 300 and 600, the Direct Tension failure strain requirement can be used in lieu of the creep stiffness requirement.

Performance Grades – PG Asphalt

- *"Different Points of Binders Life Cycle"* – How is that possible?

- Dynamic Shear Rheometer (DSR) Minimum value @ test temperature of <u>original binder</u>.
- Rolling Thin Film Oven (RTFO) <u>Simulation of aging experienced in a hot-mix plant</u>. Maximum mass loss specification. Also, a minimum requirement on the DSR after the RTFO to prevent permanent deformation.
- Pressure Aging Vessel (PAV) - <u>Simulation of five to seven years of aging on the road</u>. DSR maximum specification to prevent fatigue cracking.
- Bending Beam Rheometer (BBR) - <u>Simulation of the low temperature specification</u> to ensure that the binder will not thermally crack.

Performance Grades – PG Asphalt

Performance Grades – PG Asphalt

- PG stands for *"Performance Grade"*

  PG 58 -28

  – 58 is *58 degrees Celsius*

  – - 28 is *negative 28 degrees Celsius*

  – PG58-28 is expected to meet performance expectations with pavement temperatures between 58C (136˚ Fahrenheit) and -28C (-18˚ Fahrenheit) with light volumes of fast-moving traffic.

  – PG64-22 should perform best at temperatures between 64˚C (147˚F) and -22˚C (-8˚F).

  – The higher the second number is, the softer the asphalt.

PG Grades

- Main grades used in this region are
  - PG58-28
  - PG64-22
  - Also referred to as "Neat AC" or "Straight Run"

- Polymer Modified Asphalt Cements
  - PG64-28
  - PG70-22
  - PG76-22
  - PG70-28

Rule of 92: *Max Design Temp – Min Design Temp. = ≥ 92°*
Means that binder has been modified.

MSCR Introduced

- Multiple Stress Creep Recovery Test added to existing PG Grade specifications/testing - MODOT ~ 2010.
- MSCR was designed to designate traffic load counts to standard climate grades for a certain region. Also, to do away with Elastic Recovery testing requirements, would be done utilizing DSR now.
- Traffic count is part of the equation
  - S – Standard Traffic (Ex: PG64S-22.)
  - H – Heavy Traffic (Ex: PG64H-22.)
  - V – Very Heavy Traffic (Ex: PG64V-22.)
  - E – Extremely Heavy Traffic (Ex: PG64E-22.)

Multiple Stress Creep Recovery (MSCR)

- Standard Designation "S" in most typical situations will be for traffic levels fewer than 10 million Equivalent Single Axle Loads (ESALs) and more than the standard traffic speed (>70 km/h) 64S-22
- High Designation "H" in most situations will be for traffic levels of 10 to 30 million ESALs or slow-moving traffic (20 to 70 km/h) 64H-22
- Very High Designation "V" in most situations will be for traffic levels of greater than 30 million ESALs or standing traffic (<20 km/h) 64V-22
- Extremely High Designation "E" in most situations will be for traffic levels of greater than 30 million ESALs and standing traffic (<20 km/h) such as toll plazas or port facilities 64E-22

Multiple Stress Creep Recovery (MSCR)

- Essentially here's what it means:
  - 64S-22 = 64-22
  - 64H-22 = 70-22
  - 64V-22 = 76-22
  - 64E-22 = 82-22

- Dependent upon if full MSCR specification is being followed.

MSCR – Why Fix What's Not Broken?

- The MSCR test uses the well-established creep and recovery test concept to evaluate the binder's potential for permanent deformation. Using the Dynamic Shear Rheometer (DSR), the same piece of equipment used today in the existing PG specification, a one-second creep load is applied to the asphalt binder sample. After the 1-second load is removed, the sample is allowed to recover for 9 seconds.
- The test is started with the application of a low stress for 10 creep/recovery cycles then the stress in increased and repeated for an additional 10 cycles.
- In the MSCR test, higher levels of stress and strain are applied to the binder, better representing what occurs in an actual pavement. By using the higher levels of stress and strain in the MSCR test, the response of the asphalt binder captures not only the stiffening effects of the polymer, but also the delayed elastic effects (where the binder behaves like a rubber band).

MSCR – Why Fix What's Not Broken?

- Speed of testing – much faster now
- Better predictor of rutting
- Modifier neutral- Better indicator of quality of modification
- Same equipment
- Tested at climate conditions

MODOT – Current Practices

How does this presentation apply to current MODOT specifications.

MODOT – As Is Today

State: Missouri	**Materials:** Re: Section 1015 – Bituminous Material
Date Last Reviewed: 9/1/22	**Web Address:** www.modot.org
Materials Engineer: David Ahlvers	**Contact Info:** david.ahlvers@modot.mo.gov

Asphalt Binder		
Section 1015	Highlights	MODOT continues to specify M 320 graded binders but allows the substitution of M 332 (MSCR) graded binders as follows: PG 64V-22 in lieu of PG 76-22; PG 64H-22 in lieu of PG 70-22; PG 64S-22 in lieu of PG 64-22. There are no elastic recovery requirements for M 332 graded binders.
	PMA Notes	See elastic recovery below for M320 graded binders. Ground tire rubber (GTR) with 4.5% transpolyoctenamer rubber (TOR) may be used for modification.
	Exclusions and Limits	None stated.

MODOT Binder Grades + HMA Recycle

- During HMA Design – recycled materials such as RAP (Recycled Asphalt Pavement) and RAS (Recycled Asphalt Shingles) are incorporated back into the mixture to supplement some of the virgin aggregate and virgin oil that is needed to design that mixture.
- Cheaper prices of the recycled materials = cheaper prices of the finished mixture.

- This leads to MODOT allowing Extracted Binder Gradings of the HMA Mixture.

MODOT Binder Grades + HMA Recycle

- With MODOT virtually allowing unlimited amounts of Recycle to be allowed. Binder replacement charts (MODOT Sec. 401) have been put into place in specification.
- Chemical Extraction and Grading has become a major part of our specifications.

Binder	Percent Effective Virgin Binder Replacement		
	RAP	RAS	RAP and RAS combination
Contract Grade Virgin Binder shall be used	0 - 20	0 -10	RAP + (2*RAS) ≤ 20
Virgin Binder shall be Softened One Grade[a]	21 - 40	11 - 20	20 < RAP + (2*RAS) ≤ 40
Blend Chart[b]	0 - 100	N/A	N/A
Extraction and Grading of Binder from final Mixture[c]	0 - 100		

Chemical Extraction and PG Grading

- The HMA Mixture is designed and constructed during the laboratory design process. The final mixture of that HMA is “extracted” to reclaim all asphalt out of the mixture.
- Including virgin asphalt, and any asphalt incorporated by the RAP or RAS.

- Chemical Extraction uses solvents to strip the asphalt from the HMA mixture.
- Utilizing a series of High-Speed Centrifuges, and distillation processes. We are able to reclaim all asphalt from the HMA. Being able to successfully test it for SHRP (PG) Specifications.

Chemical Extraction and PG Grading

Chemical Extraction and PG Grading

- Recycled materials are heavily oxidized and generally very stiff.
- Blending these materials into HMA, requires us to use softer PG Grades. To essentially "meet in the middle" at the desired Contract Grade, set by MODOT.

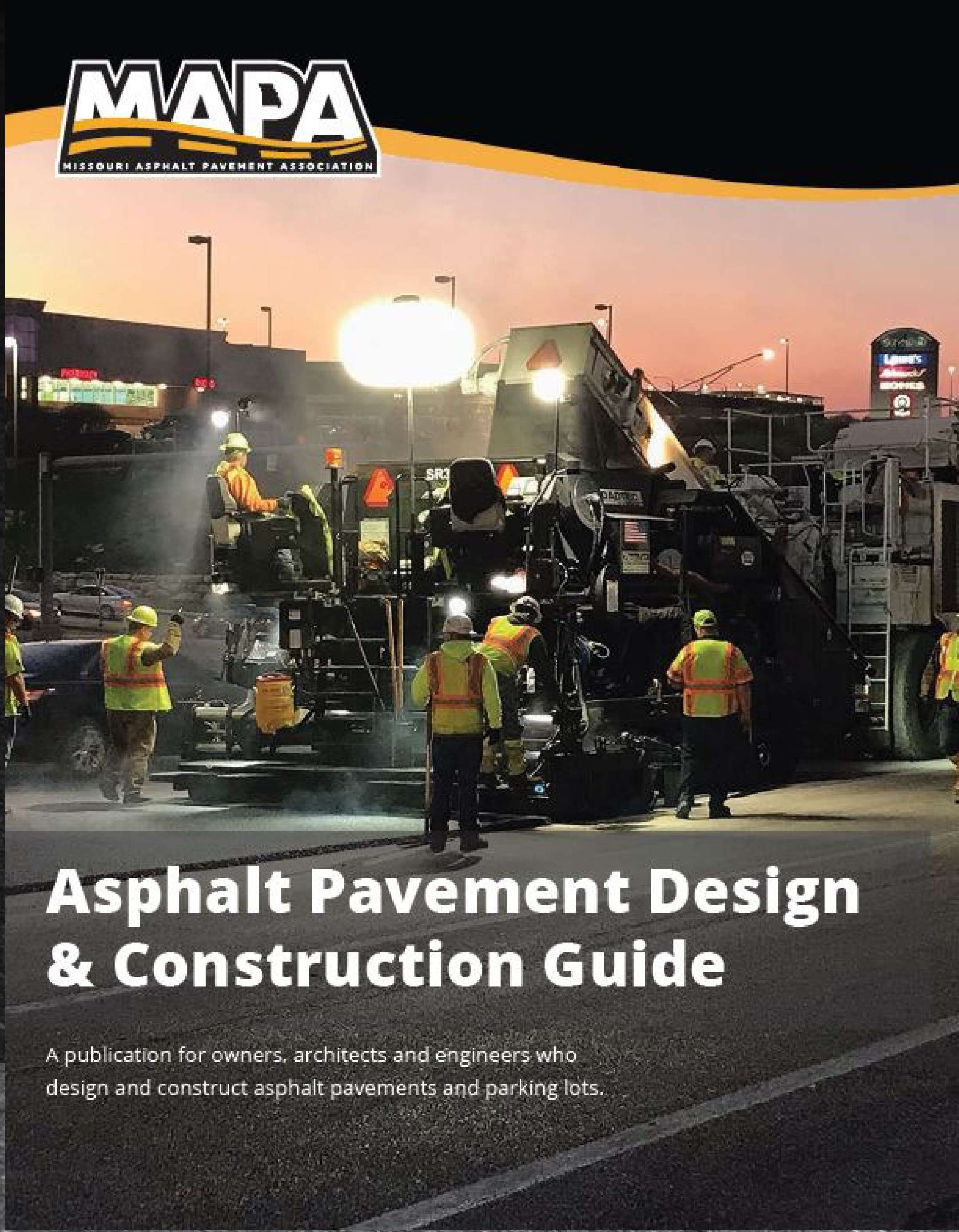
EX.) 40% RAP (PG94-10) + 80% PG46-34 = ?????

Chase Gabbert
Bituminous Technical Director

Interstate Testing Services

10440 Liberty Ave. St. Louis, MO 63132
Cell: 314-220-7417
Office: 314-994-0641
Interstatetesting.com

MAPA Spring Training – Benefits of Asphalt Design & Construction



Contents

Why Is the Bid Package Important?

Desired Outcome

Best Price

Lowered Risk

5 Key Components

- Well Defined Scope of Work
- Current Specifications
- Accurate Plans
- Established Budget
- Itemized Proposal

Well Defined Scope of Work

- Defines Exact Product to Built

  The Scope of Work includes an asphalt surface treatment.

  vs

  The Scope of Work includes cold milling 64,234 S.Y. of asphalt pavement and placing 10,280 tons of BP-2 at a compacted depth of 2 inches on Main Street.

- Well Defined = Increased Competition
- Increased Competition = Best Price

Specifications and Plans

- Current Specifications
  - 1990 vs 2004 vs 2024 Specifications
- Local Specifications (MoDOT Recommended)
  - Is Material Specified Locally Available?
- Accurate Plans
  - Match Site Conditions
  - Clearly Define Desired Work
    - 2 inches asphalt mix vs 2 inches of compacted BP-1

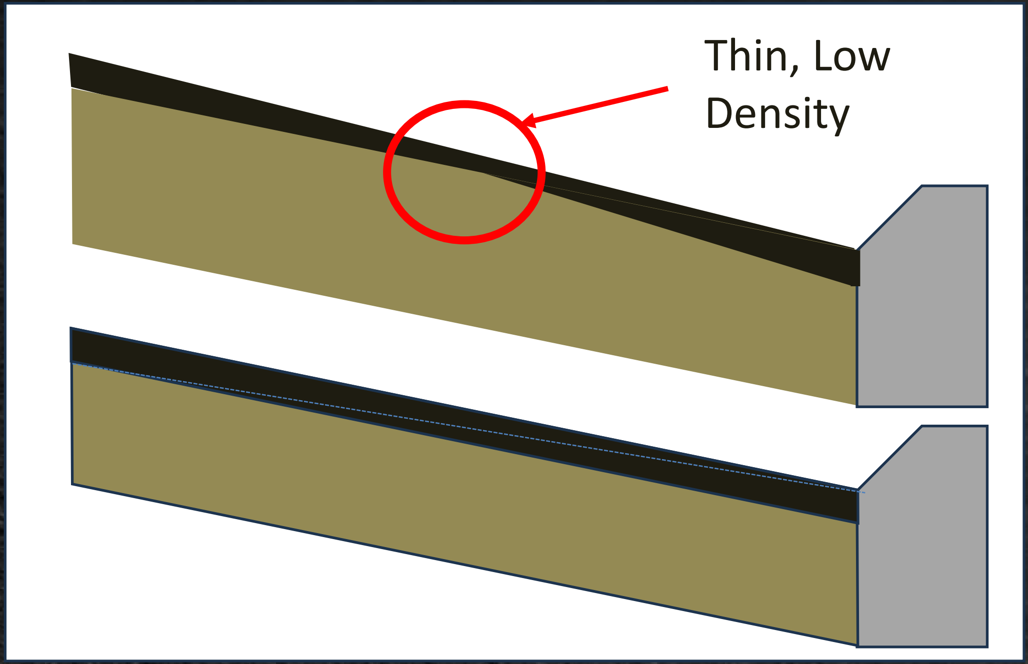
Itemized Proposal

- Get What You Want
- Estimate Project Cost
  - Work With Local Contractors
- Build What You Can Afford
- Itemized Proposal
  - Lower Risk = Best Price
  - Everyone Bidding the Same Deliverable
  - Easier to Administer Over and Underrun Items

Description	UM	Units	Price	Total
Mobilization/Demobilization	LS			$0.00
Maintenance Of Traffic	LS			$0.00
Milling - Mainline	SY			$0.00
Milling - Approaches	SY			$0.00
Tack	GAL			$0.00
BP-1	TON			$0.00

Designing Asphalt Pavements

- New Construction
  - Knowledgeable Pavement Engineer
  - Pavement Design Software such as PaveExpress®
- Pavement Evaluation (Overlay)
  - Geometry – profile, crown, cross-slope, drainage
  - Surface Condition – PASER Manual
  - Tie-ins and Terminal Points (milled butt joint)
  - Spot Patching
  - Utilities



Designing Asphalt Pavements – cont'd.

- Job Special Provision
  - Methods and Materials Not Covered in the Specifications
  - Caution for Single Source and Proprietary Materials and Methods
- Tack Coat
  - Key to Longevity of the Overlay (or between lifts)
  - Application of Diluted Tack
    Should be Increased Accordingly.

Tack Coat Application Rates

Surface Type	Target Rate Undiluted (gal/yd^2)	Target Rate 20% Diluted (gal/yd^2)
New Asphalt	0.05	0.06
Existing or Concrete	0.08	0.10
Cold Milled	0.10	0.13

Mix Selection

Corridor Designation	Traffic	Layer Type	Recommended Mix	Asphalt Binder
Maintenance		Surface/Wedge	SL	PG 64-22
Residential		Surface	BP-2	PG 64-22
		Binder/Base	BB	PG 64-22
Collector	<600 Trucks Daily	Surface	BP-1	PG 64-22
		Binder/Base	BB	PG 64-22
	>600 Trucks Daily	Surface	SP125F	PG 64-22
		Binder/Base	SP190F/SP250F	PG 64-22
Arterial		Surface	SP125C	PG 64-22
		Binder/Base	SP190F/SP250F	PG 64-22

Minimum Lift Thickness - Inches							
SL	BP-2	BP-1	Bit. Base	SP095	SP125	SP190	SP250
1.0	1.5	1.75	3.0	1.5	2	2.25	3.0

Project Cost

- Asphalt Price Index
- Payment Guidelines
  - Tack and Prime Coat by Gallon
  - Asphalt Mixture by Ton (Full Depth - S.Y.)
  - Patching Separate
- Value Engineering

Estimate Factors Ton/yd^3	
BP-2	1.934
BP-1	1.948
Bit. Base	1.943
SP095	1.913
SP125	1.927
SP190	1.940
SP250	1.946

Based on statewide averages; local estimates can be achieved by using the average G_{mm} of local mixtures: G_{mm} * 0.783

Bid Package Components

Invitation to Bid

Bidder Instructions

Contract Execution

Bid Documents

General Conditions

Best Practices

- Advertise through On-Line Plans Rooms
  - E-Plan
  - Dodge
  - Etc.
- Utilize Contractors that are Members of Trade Associations
- Seek Contractor Qualifications

Invitation to Bid

- Defines Project
  - Letting Date, Time and Location
  - Plan Availability
  - Description of Work
  - Pre-Bid Meeting (optional)
  - Project Questions

INVITATION FOR BIDS

FOR

ASPHALT
ROTOMILL AND OVERLAY

The City of Webster Groves is accepting sealed bids for asphalt rotomill and overlay on Project 19PW09, until 10:00 A.M., Wednesday, March 4, 2020. Bid packages are available at planroom.drexeltech.com. A five (5) percent security in the form specified must accompany each bid. A non mandatory pre-bid meeting will be held at 11:00 A.M., Wednesday, February 26, 2020 at City Hall in the Council Chambers. The City reserves the right to reject any or all bids and waive any technicalities.

Description of Work

The Scope of Work includes improvements for cold rotomilling 64,766 S.Y. of asphalt pavement and placing a 2" asphalt overlay pavement, rotomilling 7,641 S.Y. and placing a 2" asphalt overlay on a parking lot in 2 phases, utility adjustments, traffic control, and other incidental items necessary, as shown in the construction drawings and specifications.

ADVERTISEMENT FOR BIDS

NOTICE TO BIDDERS

SEALED PROPOSALS for the Cole County Asphalt Overlay Program, consisting of:

2020 ASPHALT OVERLAY PROGRAM
Project No. 2020-501-1

WILL be received and opened publicly at the office of Cole County Commission, Courthouse Annex, Room 200, 311 East High Street, Jefferson City, Missouri 65101 at

9:00 A.M. on Friday, May 1, 2020

Any and all bids received after the time specified above will be returned unopened.

The proposed work includes cold milling existing asphalt and concrete pavements and placement of new asphalt throughout the County.

Plans and specifications may be viewed and downloaded online in the bids section at www.colecounty.org. A hard copy of the plans and specifications will not be provided. All contractors wishing to bid on this project shall submit the plan holder contact information form found in the specifications to ccpwprojects@colecounty.org prior to the bid opening.

NOTICE TO BIDDERS

Sealed proposals will be received at the office of the Cole County Commission, Courthouse Annex, Room 200, 311 East High Street, Jefferson City, Missouri, 65101, until 9:00 A.M., **Friday, May 1, 2020**. The bids will be opened and read aloud at the Cole County Commission, Courthouse Annex, Room 200, 311 East High Street at 9:00 A.M. on that same day.

The proposed work includes cold milling existing asphalt and concrete pavements and placement of new asphalt throughout the County for:

2020 ASPHALT OVERLAY PROGRAM
PROJECT NO. 2020-501-1

	Pre-Bid Meeting – Optional
Day / Date:	**Thursday, May 21, 2020**
Time:	**11:00 A.M.**
Location / Address:	**Tele-Conference**
	Dial-In Number: 701-801-1211
	Access Code: 758-401-651
	The meeting will be conducted by teleconference only. Interested bidders have the option to submit questions in advance and/or to attend the teleconferenced pre-bid meeting.

Bidder Instructions

- Definitions
- Qualification of Bidders
- Bid Security
- Preparation of Bids
- Addendum
- Submission of Bids
- Bid Modification or Withdrawal
- Consideration of Bids

DEFINITIONS

1.1 Bidding Documents include the Invitation to Bid, Instructions to Bidders, the Bid Form and the proposed Contract Documents including any Addenda issued prior to receipt of bids. The Contract Documents proposed for the Work consist of the City Contractor Agreement, the General Conditions of City-Contractor Agreement, State Wage Determination, Prevailing Wage Law Compliance Affidavit, Non-Collusion Affidavit, Immigration and OSHA Affidavit, Non-Segregation Affidavit, Performance Payment Bond, the Drawings, the Specifications, the Construction Schedule, all Addenda, and all Modifications.

1.2 All definitions set forth in the General Conditions of City-Contractor Agreement or in other Contract Documents are applicable to the Bidding Documents.

1.3 Addenda are written or graphic instruments issued prior to the execution of the City-Contractor Agreement which modify or interpret the Bidding Documents by additions, deletions, clarifications or corrections.

1.4 A Bid is a complete and properly signed proposal to do the Work or a designated portion thereof for the sums stipulated therein, submitted in accordance with the Bidding Documents.

1.5 The Base Bid is the sum stated in the Bid for which the Bidder offers to perform the Work described in the Bidding Documents as the base to which work may be added or from which work may be deleted for sums stated in Alternate Bids.

1.6 An Alternate Bid is an amount stated in the Bid to be considered in addition to the Base Bid if the corresponding alternate to the Work, as described in the Bidding Documents, is accepted.

1.7 A Unit Price is an amount stated in the Bid as a price per unit of measurement for materials or services as described in the Bidding Documents or in the proposed Contract Documents.

1.8 A Bidder is a person or entity who submits a Bid.

1.9 A Sub-bidder is a person or entity who submits a bid to a Bidder for materials or labor for a portion of the Work.

1.10 Standard Specifications are defined as the 1997 St. Louis County Standard Specifications for Highway Construction current edition.

2-4 Qualifications of Bidders

The County of COLE may make such investigations as deemed necessary to determine the ability of the bidder to perform the work and the bidder shall furnish to the County of COLE all such information and data for this purpose as the County of COLE may request. The County of COLE reserves the right to reject any bid if the evidence submitted by the bidder or investigation of such bidder fails to satisfy the County of COLE that such bidder is properly qualified to carry out the obligations of the Contract and to complete the work contemplated therein.

2-6 Bid Security

Each bid must be accompanied by a certified check or bid bond made payable to the County of COLE for five percent (5%) of the amount of the bid. Bid securities will be returned after award of contract except to the successful bidder.

Should the successful bidder or bidders fail or refuse to execute the bond and the contract required within ten (10) days after he has received Notice of Acceptance of his bid, he shall forfeit to the County of COLE as liquidated damages for such failure or refusal, the security deposited with his bid.

2-7 Preparation of Bids

Bid must be made upon prescribed forms attached at the back of these Specifications. Only sealed bids will be considered, all bids otherwise submitted will be rejected as irregular.

All blank spaces in the bid must be filled in and no change shall be made in the phraseology of the bid or addition to the items mentioned therein. Any conditions, limitation, or provisions attached to bids will render them informal and may be considered cause for their rejection.

4.1 FORM AND STYLE OF BIDS

4.1.1 These Contract Documents include a complete set of bidding and contract forms which are for the convenience of bidders. All bids must be submitted on the Bid Forms provided.

4.1.2 All blanks on the bid form shall be filled in by type writer or manually in ink.

4.1.3 Where so indicated by the make-up of the bid form, dollar amount shall be expressed in both words and figures and in case of discrepancy between the two, the amount written in words shall govern.

4.1.4 Any interlineation, alteration or erasure must be initialed by the signer of the Bid.

4.1.5 Where two or more Bids for designated portions of the Work have been requested, the Bidder may, without forfeiture of his bid security, state his refusal to accept award of less than the combination of Bids he so stipulates. The Bidder shall make no additional stipulations on the bid form nor qualify his Bid in any other manner.

4.1.6 Each copy of the Bid shall include the legal name of the Bidder and a statement that the Bidder is a sole proprietor, a partnership, a corporation, or some other legal entity. Each copy shall be signed by the person or persons legally authorized to bind the Bidder to a contract. A Bid submitted by an agent shall have a current power of attorney attached certifying the agent's authority to bind the Bidder.

3.4 ADDENDA

3.4.1 Addenda will be mailed or delivered to all who are known by the City to have received a complete set of Bidding Documents.

3.4.2 Copies of Addenda will be made available for inspection wherever Bidding Documents are on file for that purpose.

3.4.3 No Addenda will be issued later than four (4) days prior to the date for receipt of Bids, except an Addendum withdrawing the request for Bids or one which includes postponement of the date for receipt of Bids.

3.4.4 Prior to submitting his Bid, each Bidder shall ascertain that he has received all Addenda issued, and he shall acknowledge receipt of all such Addenda in his Bid.

4.3 SUBMISSION OF BIDS

4.3.1 Bidders must complete and submit with their bids the "Certificate of Non-Segregation" and the "Non-Collusion Affidavit" included with the Bid Form, and five (5) percent Bid Bond.

4.3.2 All copies of the Bid, the Bid Bond and any other documents required to be submitted with the Bid shall be enclosed in a sealed envelope. The envelope shall be addressed to Department of Public Works, City of Webster Groves, Missouri 63119 and shall be identified with the Project name, the Bidder's name and address and, if applicable, the designated portion of the Work for which the Bid is submitted. If the Bid is sent by mail, the sealed envelope shall be enclosed in a separate mailing envelope with the notation "SEALED BID ENCLOSED" on the face thereof.

4.3.3 Bids shall be deposited at the designated location prior to the time and date for receipt of Bids indicated in the Invitation to Bid, or any extension thereof made by an Addendum. Bids received after the time and date for receipt of Bids will be returned unopened.

4.3.4 The Bidder shall assume full responsibility for timely delivery at the location designated for receipt of Bids.

4.4 MODIFICATION OR WITHDRAWAL OF BID

4.4.1 A Bid may not be modified, withdrawn or canceled by the Bidder within sixty (60) days following the time and date designated for the receipt of Bids, and each Bidder so agrees in submitting his Bid.

4.4.2 Prior to the time and date designated for receipt of Bids, any Bid submitted may be modified or withdrawn by notice to the party receiving Bids at the place designated for receipt of Bids. Such notice shall be in writing over the signature of the Bidder or by telegram. If by telegram, written confirmation over the signature of the Bidder shall be mailed and postmarked on or before the date and time set for receipt of Bids, and it shall be so worded as not to reveal the amount of the original Bid.

4.4.3 Withdrawn Bids may be resubmitted up to the time designated for the receipt of Bids provided that they are then fully in conformance with these Instructions to Bidders.

4.4.4 The amount of the Bid Bond shall be in an amount sufficient for the Bid as modified or resubmitted.

CONSIDERATION OF BIDS

5.1 OPENING OF BIDS

5.1.1 Unless stated otherwise in the Invitation to Bid, the properly identified Bids received on time will be opened publicly and will be read aloud.

5.2 REJECTION OF BIDS

5.2.1 The City shall have the right to reject any or all Bids, to reject a Bid not accompanied by a Bid Bond or by other data required by the Bidding Documents, to reject a Bid which is in any way incomplete or irregular and to rebid the Work at a later date if all Bids are rejected. Deviations in a unit price which are greater than twenty-five (25) percent of the average unit price for the total present bid of a specific line item shall be the basis for rejection of a bid.

5.3 ACCEPTANCE OF BID (AWARD)

5.3.1 The City may make any investigation of a Bidder as it deems necessary to determine the ability of a Bidder to perform the Work. Bidders shall furnish information regarding their qualifications upon the reasonable request of the City. The City reserves the right to reject any Bid if the evidence submitted by, or other investigation of, the Bidder fails to satisfy the City that the Bidder has the proper qualifications to perform the Work in accordance with the Contract.

5.3.2 It is the intent of the City to award the Contract to the lowest responsible Bidder provided the Bid has been submitted in accordance with the requirements of the Bidding Documents and does not exceed the funds available. However, the City reserves the right to accept the Bid which, in the City's judgment, is in the best interest of and most advantageous to the City. The City shall have the right to waive any informality or irregularity in any Bid or Bids received and to accept the Bid or Bids which, in its judgment, is in the City's own best interests.

Bid Documents

- Itemized Proposal
- Contact Information
- Asphalt Index (Optional)

ASPHALT
ROTOMILL AND OVERLAY
PROJECT 19PW09

and being familiar with the local conditions affecting the work, hereby proposes to furnish all labor, materials, equipment and services required for the performance and completion of said project in accordance with the said Contract documents for the following itemized bid.

ITEM NUMBER	ITEM DESCRIPTION	UNIT	PLAN QUANTITY	UNIT COST	TOTAL COST
1	Rotomilling (nominal 2")	S.Y.	64,766		
2	Type "C" Asphaltic Concrete (nominal 2")	Tons	7,228		
3	Reset and/or Adjust Manhole to Grade	EA	40		
4	Traffic Control	L.S.	1		
5	Rotomilling (nominal 2") Parking Lot	S.Y.	7,641		
6	Type "C" Asphaltic Concrete Parking Lot	Tons	853		
	TOTAL BID				

4. ***Response Form***

(Note: This form must be signed. All signatures must be original and not photocopies. In addition, the County uses *Docusign* when making a contract award. When providing a Contact Name and E-Mail Address below, the Contact and E-Mail address provided must be a person who has the legal authority to contractually bind the offeror's/bidder's company in a contract with the County.)

4.1. Company Name: ______________________________

4.2. Address: ______________________________

4.3. City/Zip: ______________________________

4.4. Phone Number: ______________________________

4.5. Fax Number: ______________________________

4.6 Email Address: ______________________________

4.7. Federal Tax ID: ______________________________

4.10. **Optional Asphalt Cement Price Index Provision** (Section 2.9.1.3. of bid document) Failure by the bidder to check an option will be interpreted to mean election to not participate in the Asphalt Cement Price Index.

Check One:

__________ACCEPT **__________DO NOT ACCEPT**

General Conditions

- Contract Specifications
- Notice to Proceed
- Work Schedule
- Contract Time
- Liquidated Damages
- Asphalt Index (Optional)
- Job Special Provisions

TECHNICAL SPECIFICATIONS

The Technical Specifications for the Cole County Asphalt Overlay Program shall consist of the currently effective version of the Missouri Standard Specifications for Highway Construction, Sections 201-1092 except as modified or contradicted herein.

2-23 Notice to Proceed

The contractor's notice to proceed for each road will be as follows. Construction activities shall not commence on the respective roads until these dates:

July 1, 2020
Grand Point Court
Sunnybrook Court
Scrivner Road
Blackburn Lane

July 15, 2020
Highland Waye
Aberdeen Waye
Balmoral Waye
Coventry Waye
Dalwhinne Waye
Edinburgh Waye

August 1, 2020
Terra Bella Drive
Terra Bella Court
Kendalwood Court
Meeting Street
Catalina Drive
Cross Key Court
Ashley Court
Wellington Green

2-24 Work Schedule

To insure that the work will proceed continuously through the succeeding operations to its completion with the least possible interference to traffic and inconvenience to the public, the Contractor shall submit for approval a complete schedule of his proposed construction procedure, stating the sequence in which various operations of work are to be performed. The Contractor may not change the work sequence without the prior approval of the Engineer.

2-27 Contract Time

This contract shall be a completion date contract. The contract shall be completed by no later than **September 18, 2020.**

2-28 Liquidated Damages

Liquidated damages shall be assessed at the rate of **Seven Hundred Dollars ($700.00)** per calendar day until the project is complete, should the project not be completed within the specified time period.

2.9.1. **Asphalt Cement Price Index**

2.9.1.1. If the bidder so chooses, asphaltic pavement and base mixes are eligible for the following price adjustment. This adjustment will apply only to the percentage of virgin asphalt cement actually placed on the job, excluding RAP or RAS, and will be calculated using the following formula: A = (B X C) X (D – E)

2.9.1.2. Where:

A = Adjustment
B = Tons of mix placed
C = % of virgin asphalt binder as listed in the job mix formula
D = monthly price for the month prior to mix placement
E = monthly price for the month prior to bid submission

2.9.1.3. The monthly asphalt prices will be those shown in the Dollar/Ton column of the "Asphalt Price Index" table posted at MoDot.org – Bidding-Road & Bridge Construction Bidding Opportunities – Online Plan Rooms – Asphalt Price Index - on MoDOT's website, also currently located at: http://www.modot.org/eBidLettingPublicWeb/viewStream.do?documentType=general_info&key=658 All prices will be for the entire month regardless of when posted. Separate adjustments will be calculated for each month in which the bidder places eligible material.

JOB SPECIAL PROVISIONS TABLE OF CONTENTS

(Job Special Provisions shall prevail over General Special Provisions whenever in conflict therewith.)

Contract Execution

- Award of Contract
- Performance Bond
- Insurance
- Prevailing Wage (if applicable)
- Anti-Collusion

AWARD OF CONTRACT

7.1 Following receipt to the satisfaction of the City of all information required under Paragraph 6.1 above, the City shall mail to the successful Bidder the Notice of Award of the Contract.

7.2 Within five (5) working days from the date of receipt of the Notice of Award, the successful Bidder shall execute and deliver to the City the Contract Documents, and shall furnish the Bonds required by Paragraph 8.1 below and the Certificates of Insurance required by Subparagraph 10.1.3 of the General Conditions. In the event the successful Bidder fails to execute and deliver the Contract Documents, the Bonds and the Certificates of Insurance as aforesaid, the City may, at its option, consider the Bidder in default and award the Contract to another Bidder, in which case the Bid Bond of the defaulting Bidder shall be forfeited to the City.

2-17 Performance Bond

A Performance Bond in an amount equivalent to one hundred percent (100%) of the Contract price, must be furnished and executed by the successful bidder or bidders, this bond to be in the form contained in this Contract.

The Surety shall be a corporate Surety Company or companies of recognized standing licensed to do business in the State of Missouri and acceptable to the County of COLE.

2-18 Indemnification and Insurance

The Contractor agrees to indemnify and hold harmless the County and the Engineer from all claims and suits for loss of or damage to property, including loss of all judgments recovered therefore, and from all expense in defending said claims, or suits, including court costs, attorney fees, and other expense caused by any act or omission of the Contractor and/or his subcontractors, their respective agents, servants, or employees.

Certificate of Insurance

The Contractor shall be required to provide the County of COLE with a "Certificate of Insurance."

2-21 Prevailing Wage Law

The principal contractor and all subcontractors shall pay not less than the prevailing wage hourly rate for each craft or type of workman required to execute this contract as determined by the Department of Labor and Industrial Relations of Missouri, pursuant to Sections 290.210 through 290.340, RSMo. 1986 (See Determination herewith included in Section 5.)

ANTI-COLLUSION STATEMENT

STATE OF MISSOURI

COUNTY OF ____________________

____, being first duly sworn, deposes and

says that he is ____

(Title of Person Signing)

of____ (Name of Bidder)

that all statements made and facts set out in the bid for the above project are true and correct; and the bidder (person, firm, association, or corporation making said bid) has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in connection with said bid or any contract which may result from its acceptance.

Affiant further certifies that bidder is not financially interested in, or financially affiliated with, any other bidder for the above project

By ________________________________

By ________________________________

By ________________________________

Sworn to before me this___________day of____________________, 20 _______

____

Notary Public

My Commission Expires ____________________________________

Specifications

- General Provisions (If required by scope or funding)
  - Environmental
  - Training Provision
- Job Special Provisions
  - Specialized Products
  - Utility Adjustment or Cooperation
  - Order of Work
  - Etc.
- Technical Specifications

Technical Specification

- Description
- Materials
- Construction Requirements
- Pavement Repairs
- Testing Requirements
  - Asphalt Content
  - Density
- Method of Measurement
- Payment

5 Key Components

Well Defined Scope of Work

Current Specifications

Accurate Plans

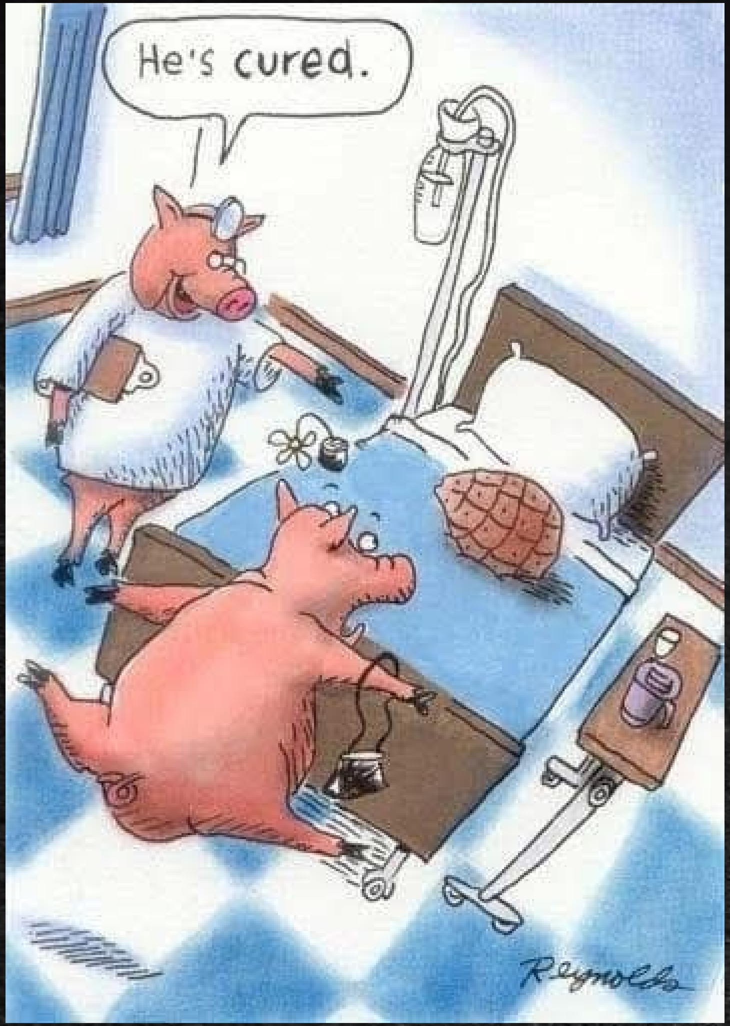
Established Budget

Itemized Proposal

QUESTIONS?

dalewilliams@moasphalt.org

573-635-6071


He's cured.
Reynolds