Improving Pavement Durability With Best Practices

61st Annual Asphalt Paving Conference
FireKeepers Casino Hotel
11177 E. Michigan Avenue
Battle Creek, Michigan 49014

Evolution of Traffic

- Interstate highways - 1956
- AASHO Road Test - 1958-62
  - still widely used for pavement design
  - legal truck load - 73,280 lbs.
- Legal load limit to 80,000 lbs. - 1982
  - 10% load increase
  - 40-50% greater stress to pavement
- Radial tires, higher contact pressure
- FAST Act raising load limit to 120,000 lbs. (in select locations)

Led to Rutting in 1980's

Which led to…Superpave

- Fixed the rutting problem
- Gyratory compaction lowered binder contents
- Add in higher and higher recycled materials?

Improved Compaction = Improved Performance

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A BAD mix with GOOD density
out-performed
a GOOD mix with POOR density
for ride and rutting.

WesTrack Experiment

Effect of In-Place Voids on Life

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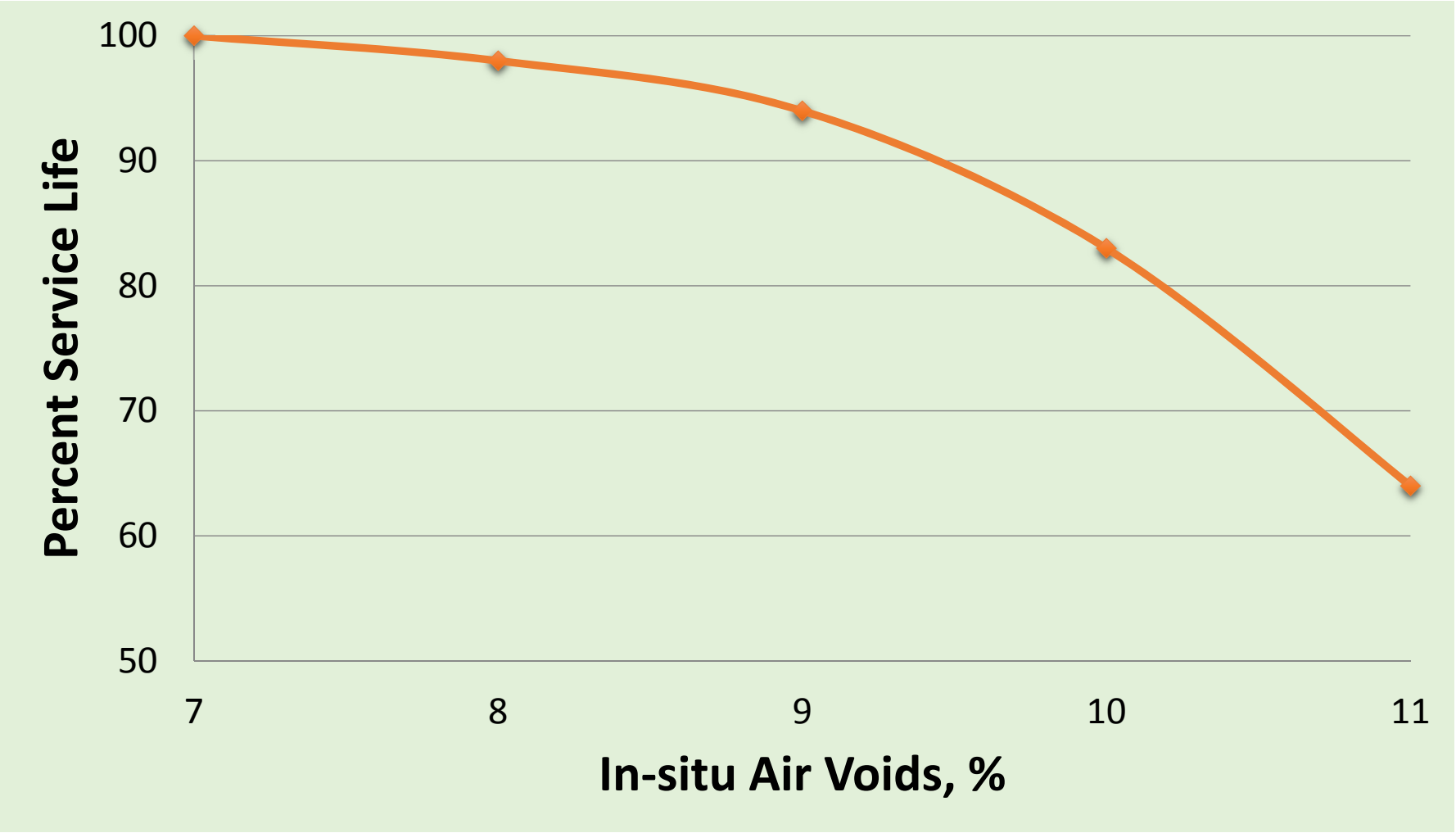
Washington State DOT Study

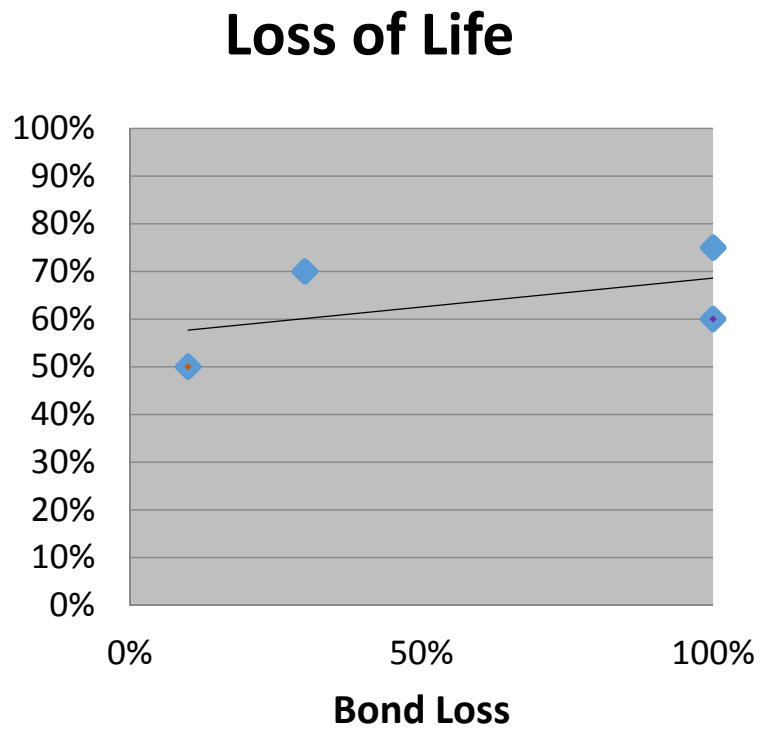


Importance of Tack Coats

- Promotes the bond between pavement layers
  - Prevents slippage between pavement layers
  - All layers working together
  - Vital for structural performance of the pavement
  - Seals all transverse & longitudinal vertical surfaces

Loss of Fatigue Life Examples

- **May & King:**
  - **10% bond loss = 50% less fatigue life**
- **Brown & Brunton**
  - **No Bond = 75% loss of life**
  - **30% bond loss = 70% loss of life**



Everyone MUST be on the same page

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What we are talking about:

- ***Original Emulsion*—undiluted emulsion consists of a paving grade binder, water, and an emulsifying agent.**

- ***Diluted Emulsion*—an emulsion that has been diluted with <u>additional</u> water.**
  - **Critical to sprayed control**
  - **1:1 typical (Original Emulsion:Added Water)**

- ***Residual Asphalt*—the remaining asphalt after an emulsion has set typically 57-70 percent or Original Emulsion**

What difference does it make?

If the example spec *intended* 0.05 *gal/yd²* of residual asphalt:

*To receive **Residual Asphalt** at **0.05 gal/yd²** using an emulsion with 60% residual asphalt, the contractor would need to apply:*

***0.083 gal/yd²** of **Original Emulsion** or*
0.167 gal/yd²** of **1:1 Diluted Emulsion

What is going on and why?

What is going on and why?

Days later!

Courtesy of Road Science™

8–10 years est. Interstate Pavement

Courtesy of MoDOT

What The Worth It To Apply A Tack Coat?

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Cost of Tack Coat

- New or Reconstruction
  - About 0.1-0.2% of Project Total
  - About 1.0-1.5% of Pavement Total Cost

- Mill and Overlay
  - About 1.0-2.0% of Project Total
  - About 1.0-2.5% of Pavement Total Cost

30-100% of Original Pavement Costs

Common Tack Coat Questions

- **What is the Optimal Application Rate?**
  - **Surface Type**
  - **Surface Condition**
- **Workshop Recommended Ranges**

Surface Type	Residual Rate (gsy)	Appx. Bar Rate Undiluted* (gsy)	Appx. Bar Rate Diluted 1:1* (gsy)
New Asphalt	0.020 – 0.045	0.030 – 0.065	0.060 – 0.130
Existing Asphalt	0.040 – 0.070	0.060 – 0.105	0.120 – 0.210
Milled Surface	0.040 – 0.080	0.060 – 0.120	0.120 – 0.240
Portland Cement Concrete	0.030 – 0.050	0.045 – 0.075	0.090 – 0.150

*Assume emulsion is 33% water and 67% asphalt.


Triple Lap Coverage
12"

Tack Coat

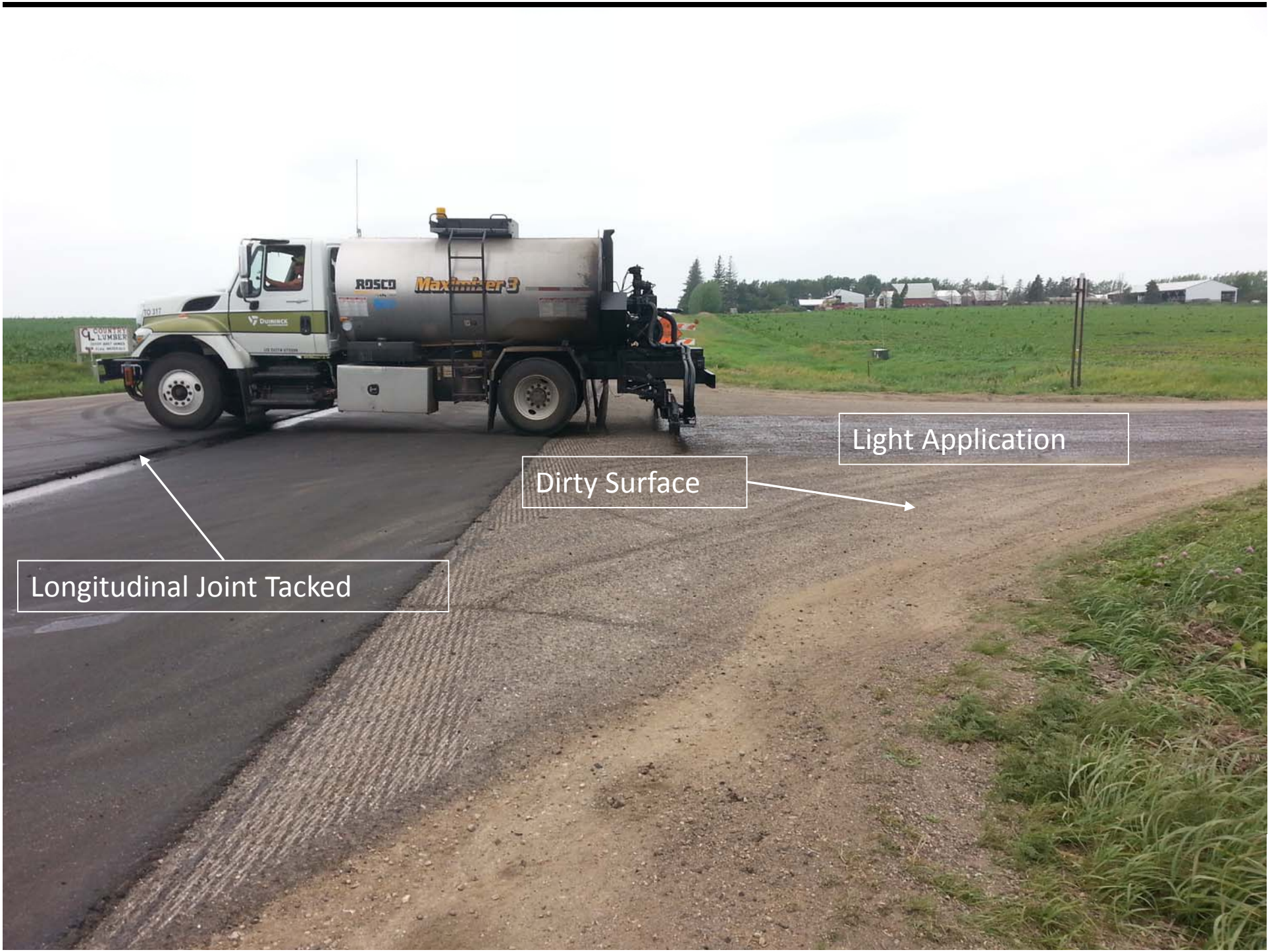
Full width of mat to minimize movement of unsupported edge

Common Tack Coat Question

- When to Re-Tack?
  - Tracking
  - Contamination

If in doubt …

Re-Tack


ROSCO
Maximizer 3
Light Application
Dirty Surface
Longitudinal Joint Tacked

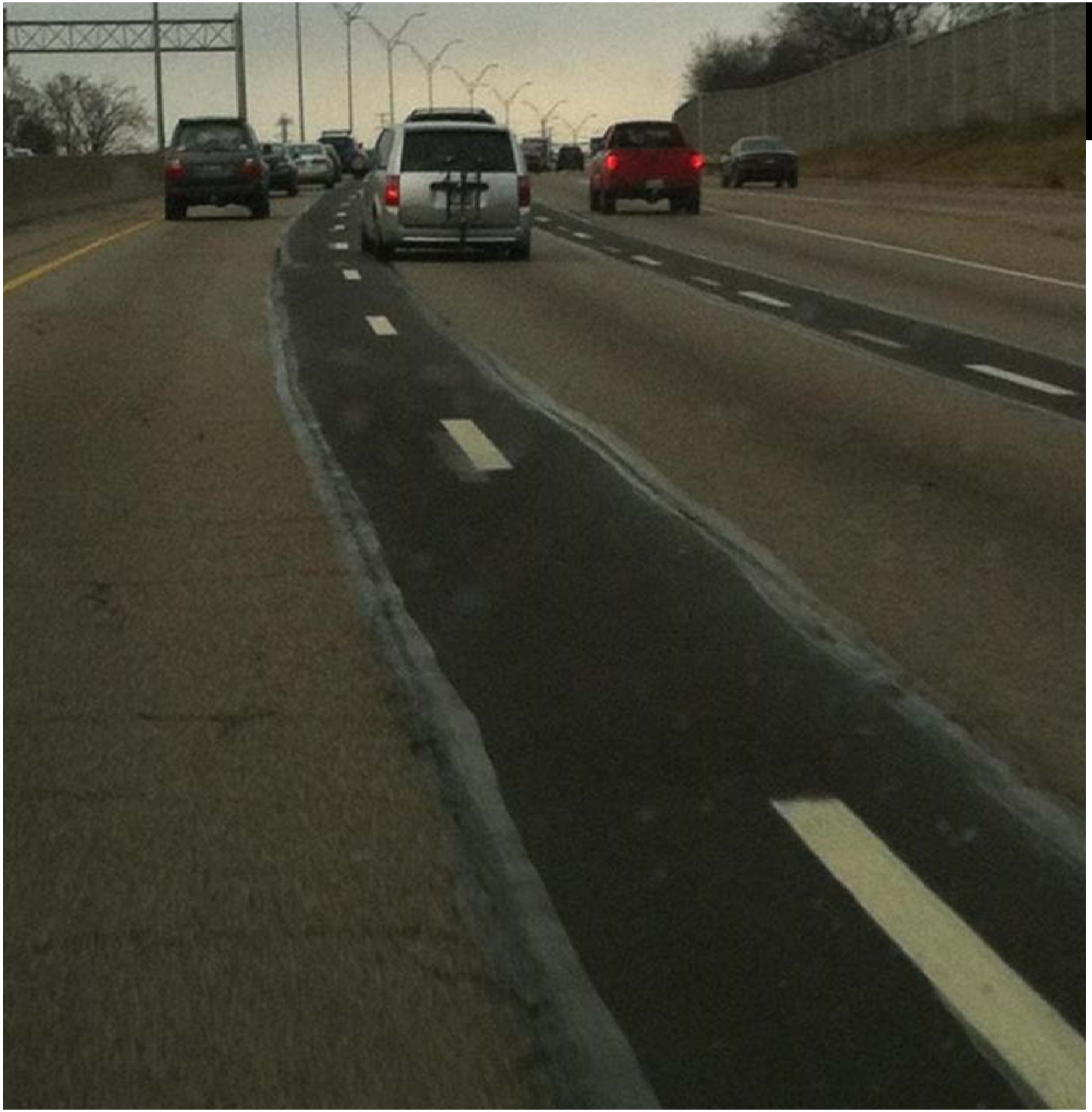

Missed Line
Generally Uniform Application


Filling it in

Don’t We Already Know How To Build a Longitudinal Joint?

Photo: Carlos Rosenberger

Photo: Carlos Rosenberger



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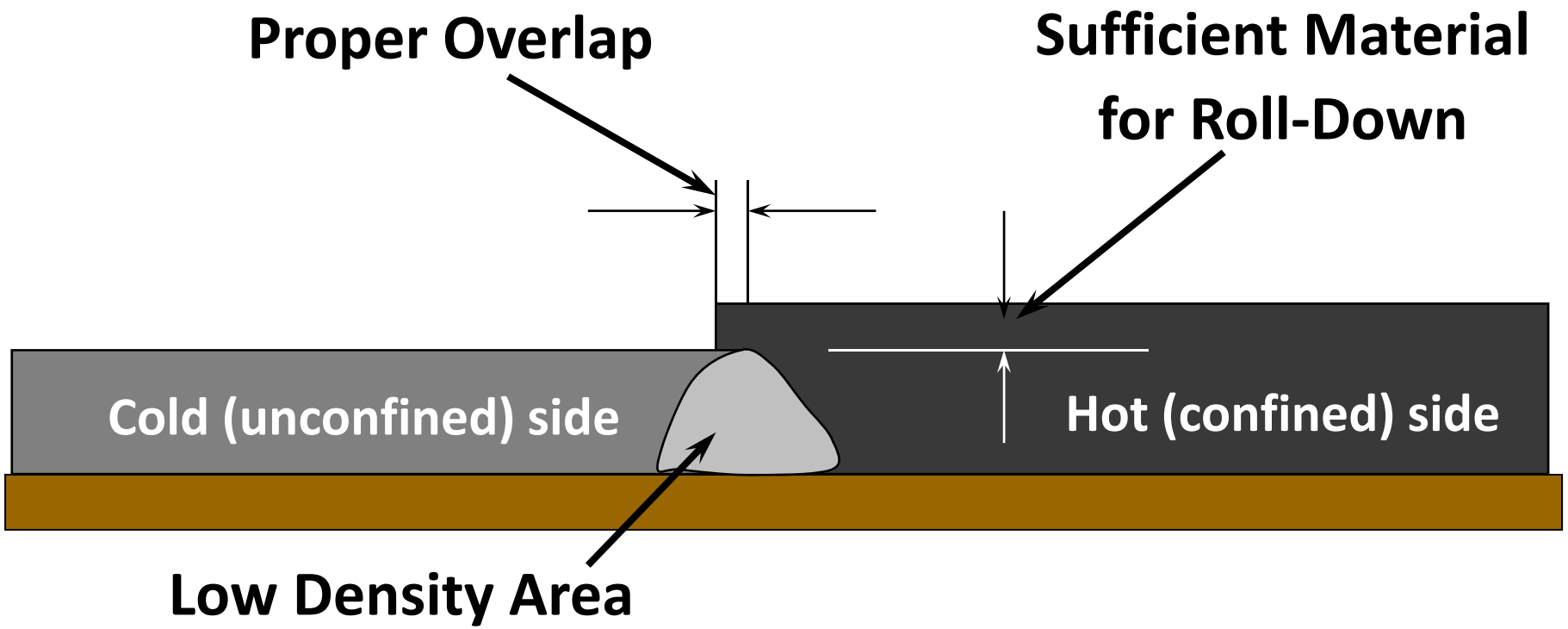
I-71 in Columbus, OH

Longitudinal Joint Definitions

Unsupported Edge Will Have Lower Density



"Cold side" is the first paver pass and "Hot side" is the second

Different Types of Longitudinal Joints

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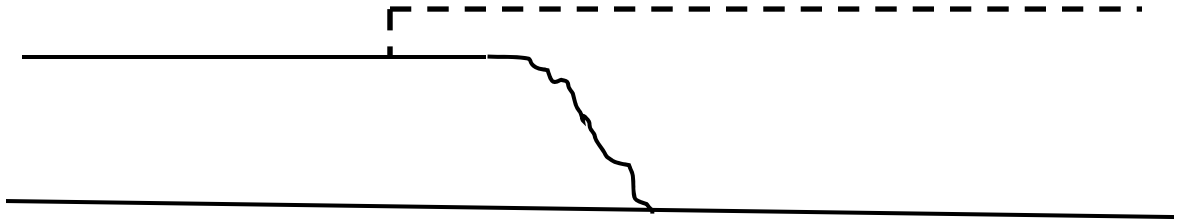
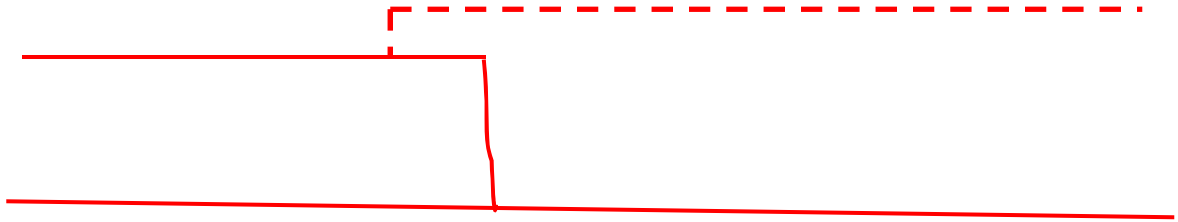
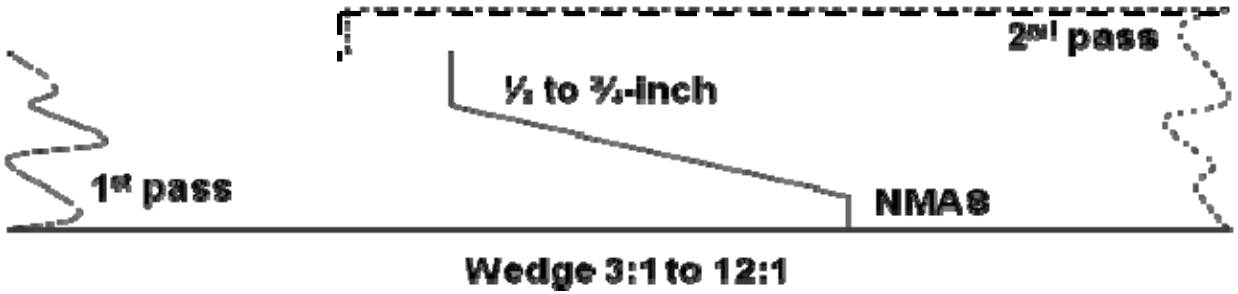
Butt (Vertical) Joint



Milled or Cutback Joint



Notched Wedge Joint

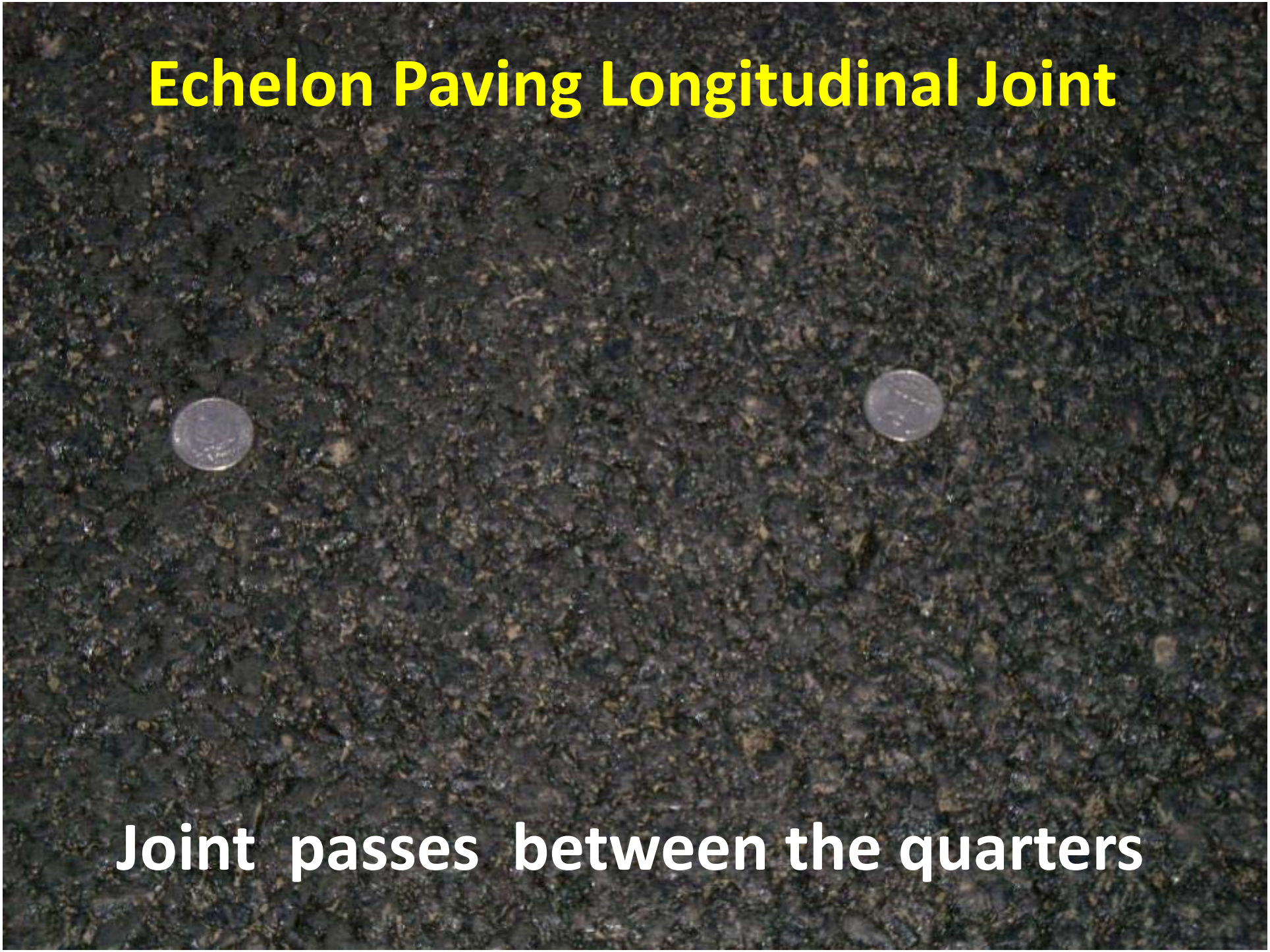


Wedge 3:1 to 12:1

The Best Longitudinal Joint:
Echelon Paving

New Jersey

Rolled Hot


Echelon Paving Longitudinal Joint
Joint passes between the quarters


But, the need to maintain traffic limits the opportunities to pave in echelon
Consequently, most longitudinal joints are built with a cold joint.

First Pass Must be Straight

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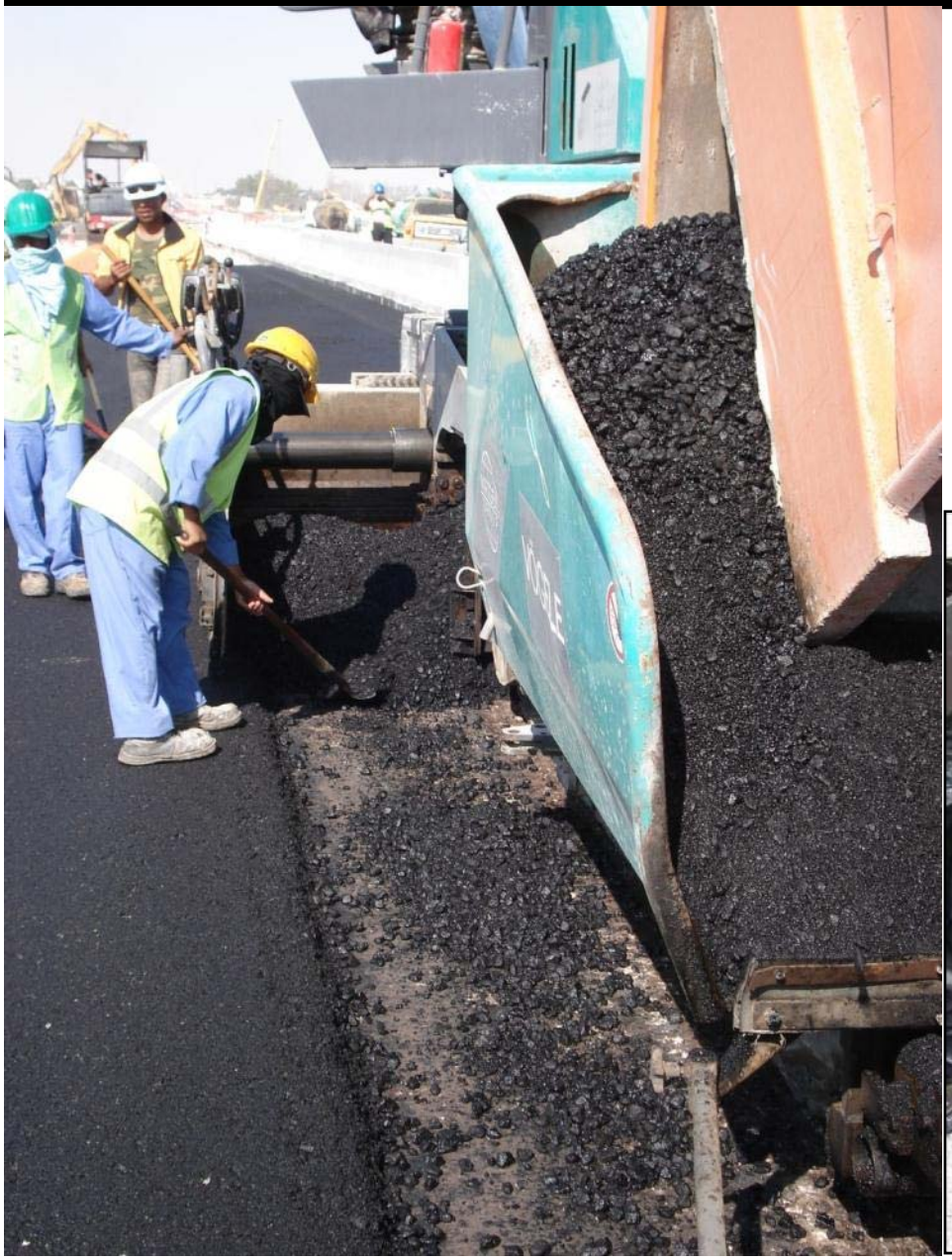
Avoid Segregation at the Joint



- Don’t delivery segregated mix to the joint area
- Use auger & tunnel extensions

Mill & Pave One Lane at a Time

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Photo in IL, Courtesy Hal Wakefield

Paint the Vertical Face

Good: Double Tack with Emulsion

Better: PG Binder

Best: Joint Adhesive

Overlap By 1-inch +/- ½ Inch

- Overlap By 1-inch +/- 1/2
- If milled or cutback joint, then 0.5-inch
- Keep end plate flat
- Set automation to NEVER STARVE THE JOINT!
- Joint Matcher best (versus ski) to match exact amount of material needed at joint

Do NOT Rake Away From the Joint

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Lute the Longitudinal Joint

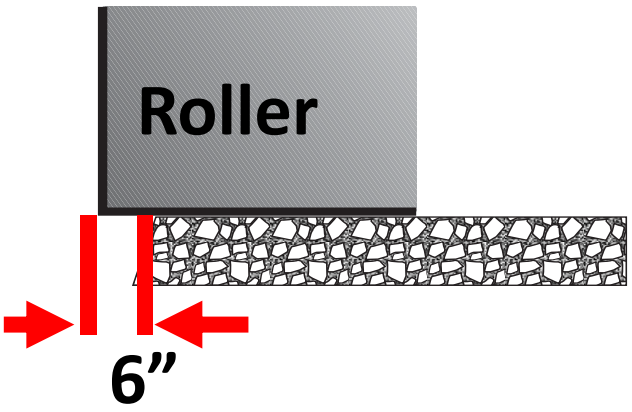
This lute person is doing a great job


Overlap

Rolling Unsupported Edge?

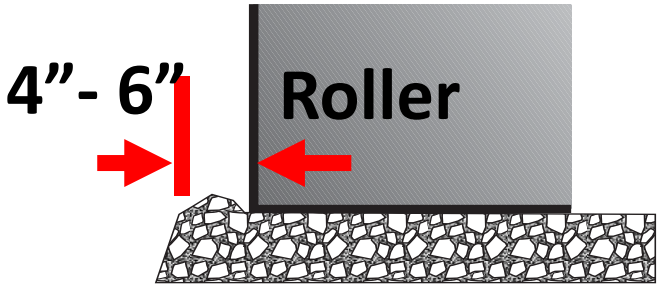
Option 1

Hang over 4-6”

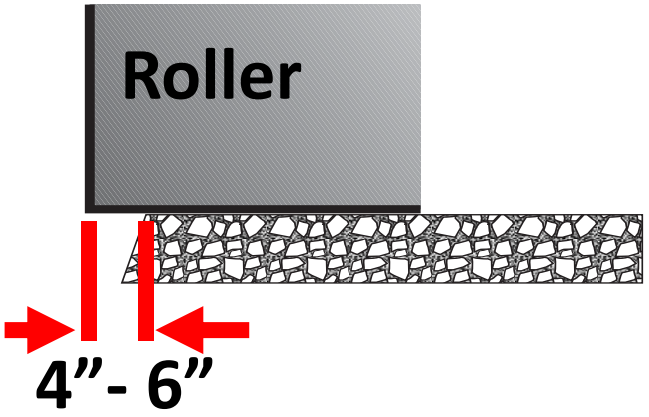


Option 2

1st Pass 4”-6” inside



2nd Pass hang over 4”-6”



What We Don't Want

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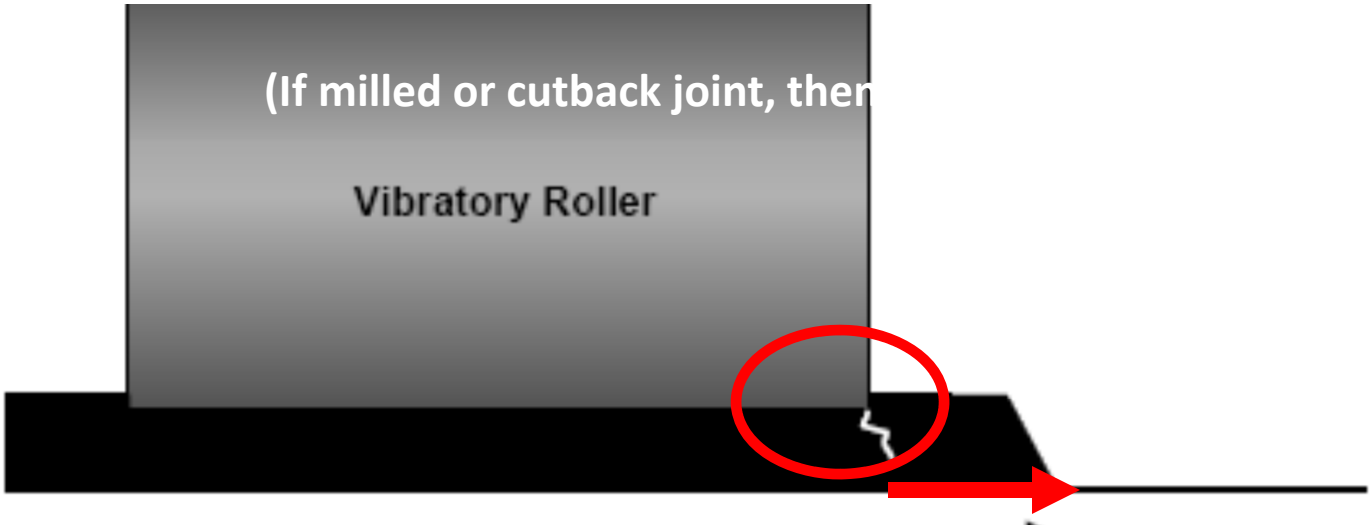
Rolling Unsupported Edge

With First Roller Pass



If edge of drum is located just inside the unsupported edge, a stress crack can occur here.

Rolling the Confined Edge:

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1st pass all on hot mat with roller edge off joint approx 6-12 inches

2nd pass overlaps on cold mat 3-6 inches

IDOT Joint Sealer

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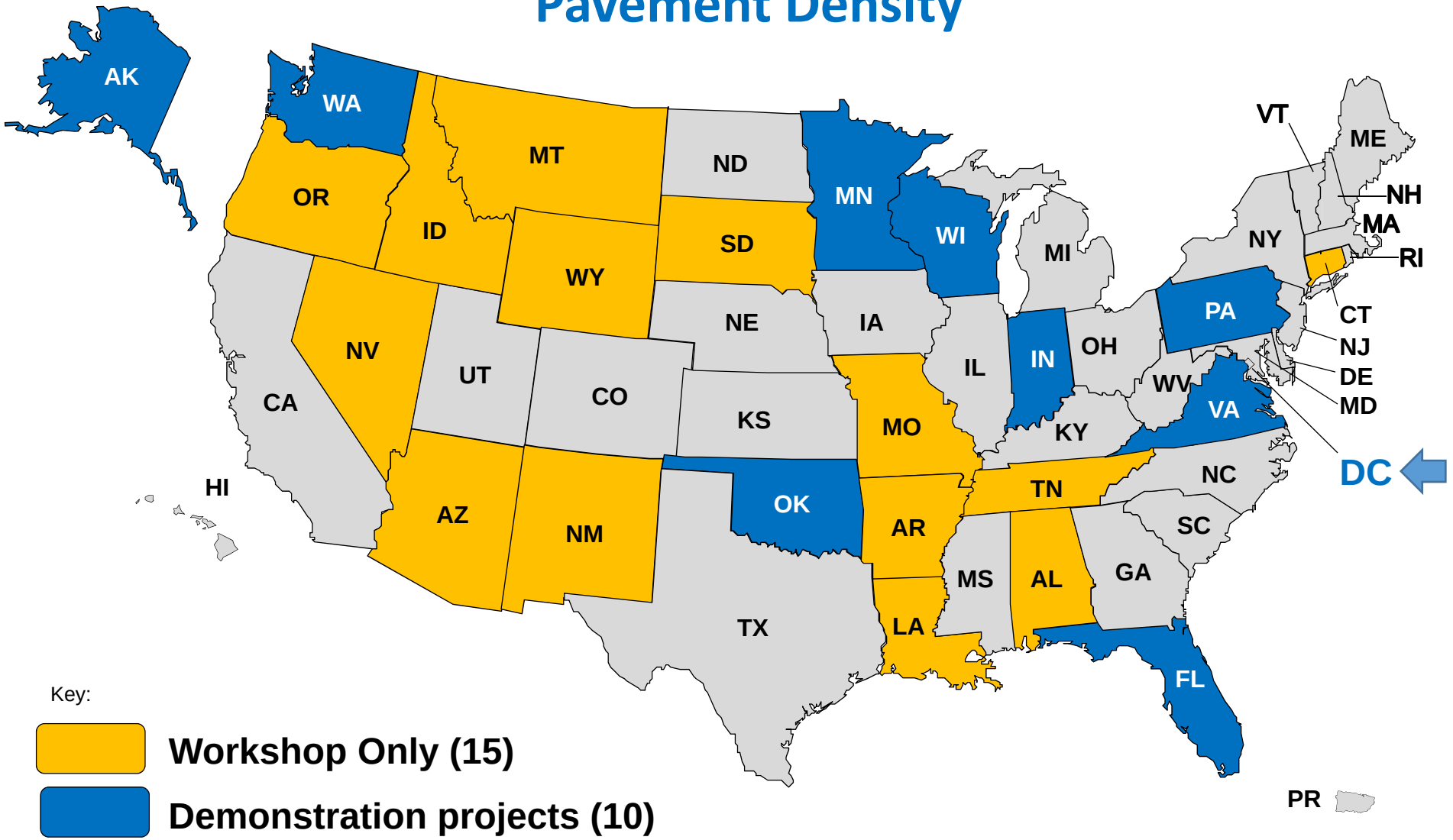
Licensed Subcontractor ≈ 11 Trucks

Also Works as a Tack Coat

Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density



Enhanced Durability

- A 1% increase in field density can increase asphalt pavement service-life +10% (conservatively)
- Today's compaction target is typically 92% of maximum (G_{mm}) (8% air voids),
  - Varying requirements for longitudinal joints
- Increased Density Pavements target a 2% increase across the entire pavement!
  - Just 2% more… makes a huge difference!

Improved Durability

Balance the Mix Design

Strength/
Stability

Rut Resistance

Shoving

Flushing
Resistant

Durability

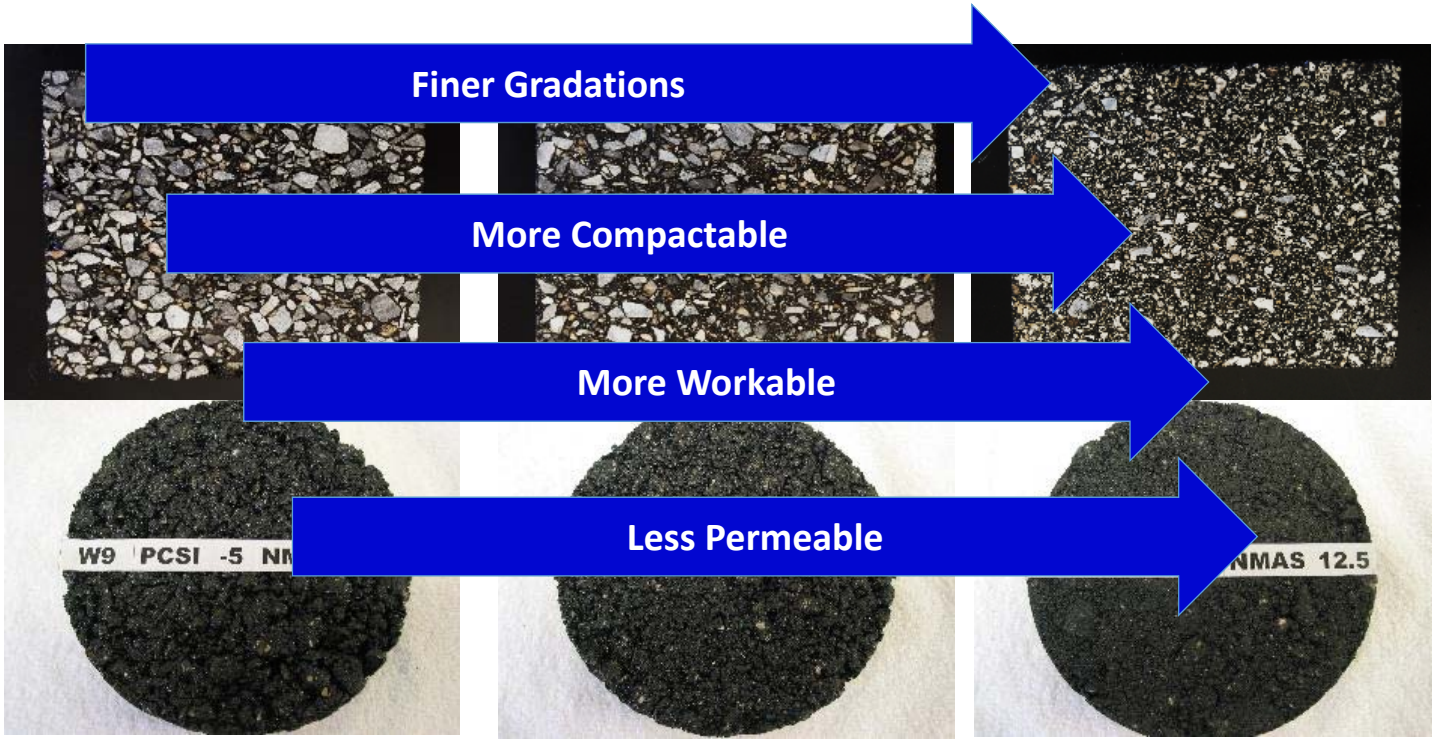
Crack
Resistance

Raveling

Permeability

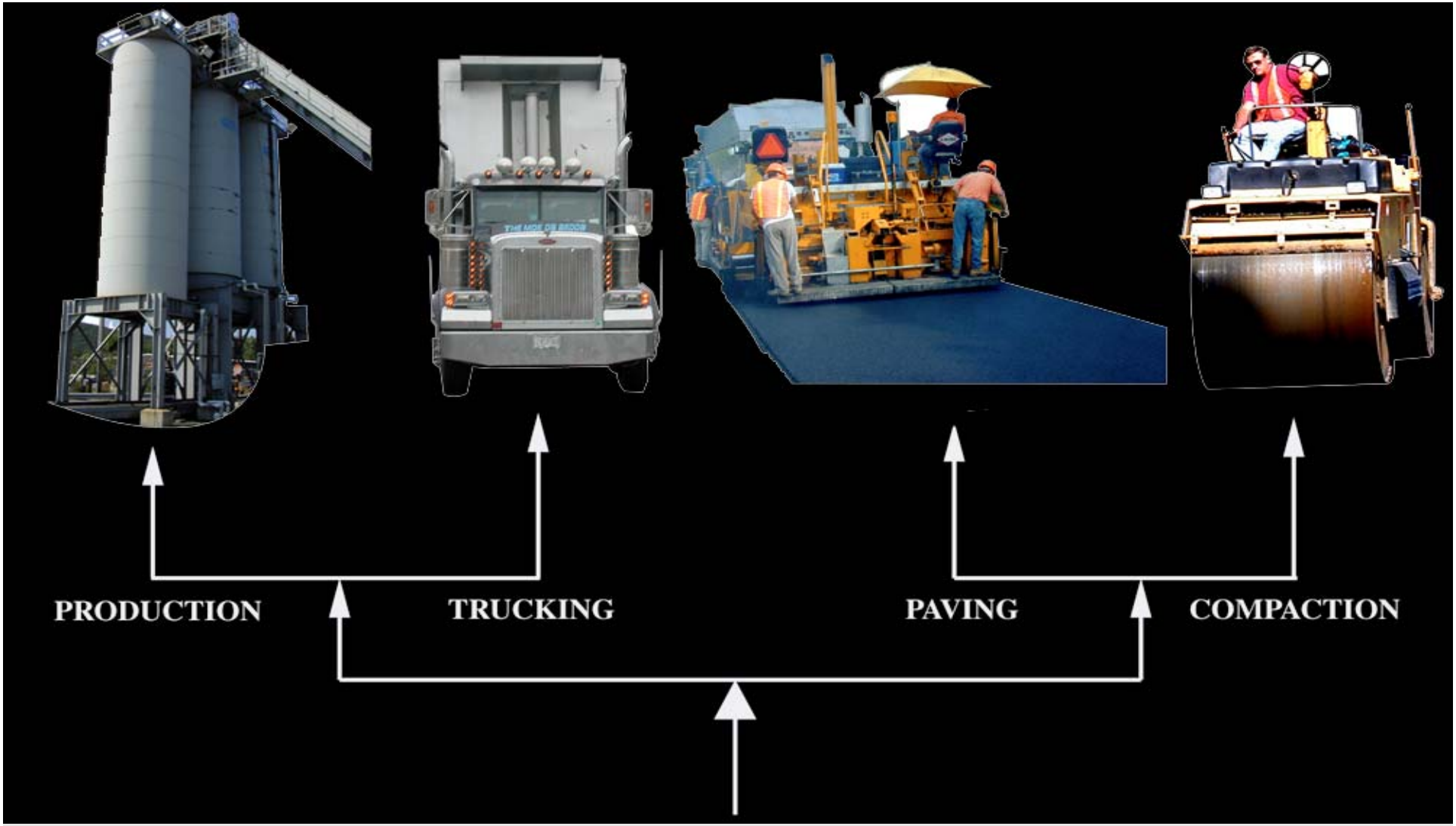
DON'T ATTACK ONE HALF AT THE EXPENSE OF THE OTHER HALF!!

Choosing a Gradation



Requires better aggregate
Higher binder contents

Courtesy of NCAT



Balancing the Paving Operation

Use Best Construction Practices

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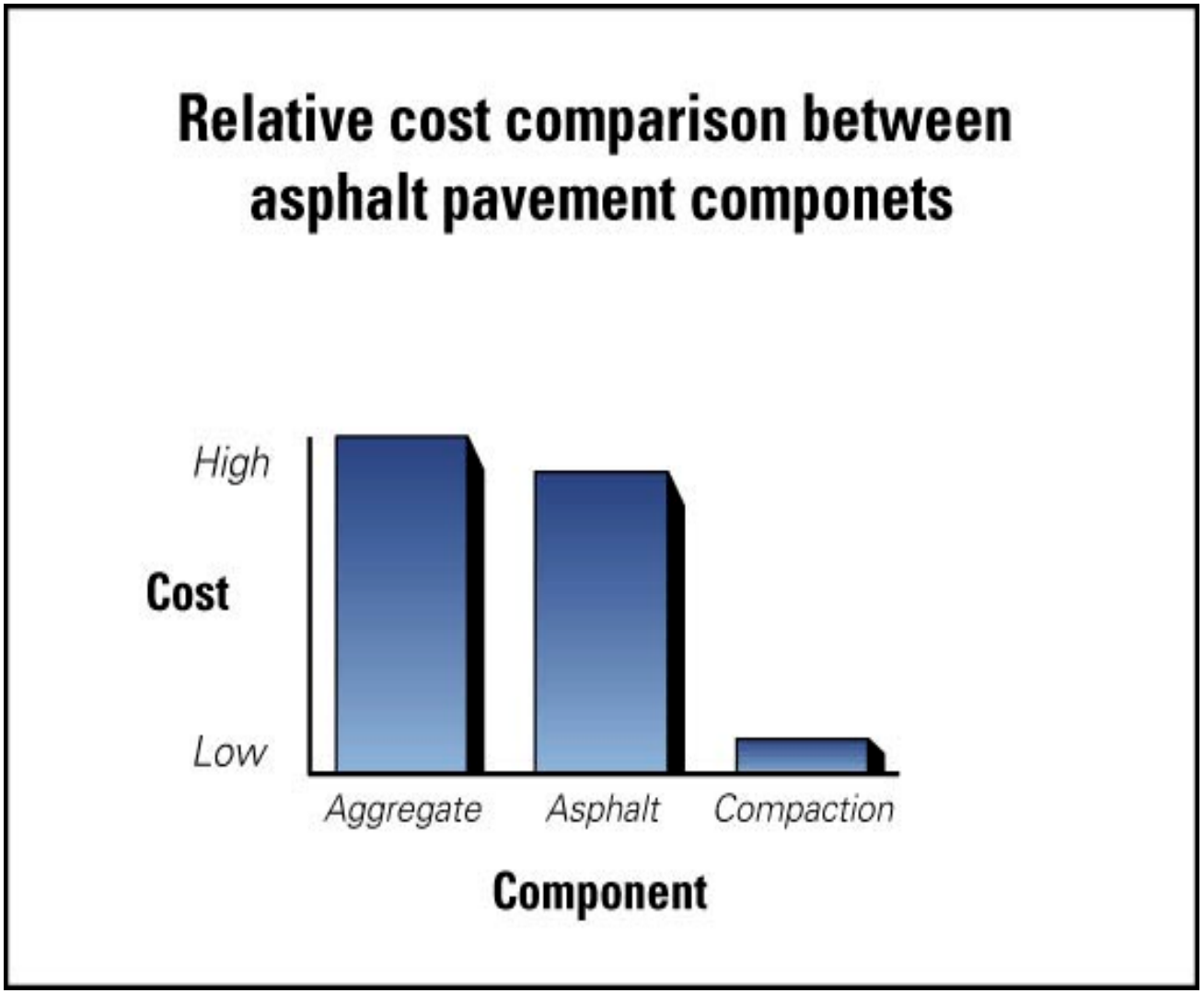
Uniform Paving Train Operation

- Determine plant production rate
- Plan for sufficient, timely mix delivery
- Establish a constant paver speed
- Assure ample rollers are available
  - Keep water trucks close to the rollers
  - On shoulder or cold mat

Cost of Compaction



- Least expensive part of the paving process
- Aggregates and binders are expensive in comparison
- Compaction adds little to the cost of a ton of asphalt

Lift Thickness' Effect on Compaction

- Aggregates need room to densify
- Too thin vs. NMAS leads to:
  - Roller bridging
  - Aggregate lockup
  - Aggregate breakage
  - Compaction Difficulties
- NCHRP Report 531 (2004)
  - Fine Graded Mix—Min Thickness = 3 X NMAS
  - Coarse Graded Mix—Min Thickness = 4 X NMAS
  - SMA Mix—Minimum Thickness = 4 X NMAS

Material Cooling

- Thicker = More Time for Compaction
- Free tools for estimating compaction time
  - PaveCool—single lift (generation 1)
    - PC
    - iOs App
    - Google App
  - MultiCool—multiple lifts (generation 2)
    - PC
    - Google App
    - Mobile Web

Vibratory Screed Should Always be "ON"

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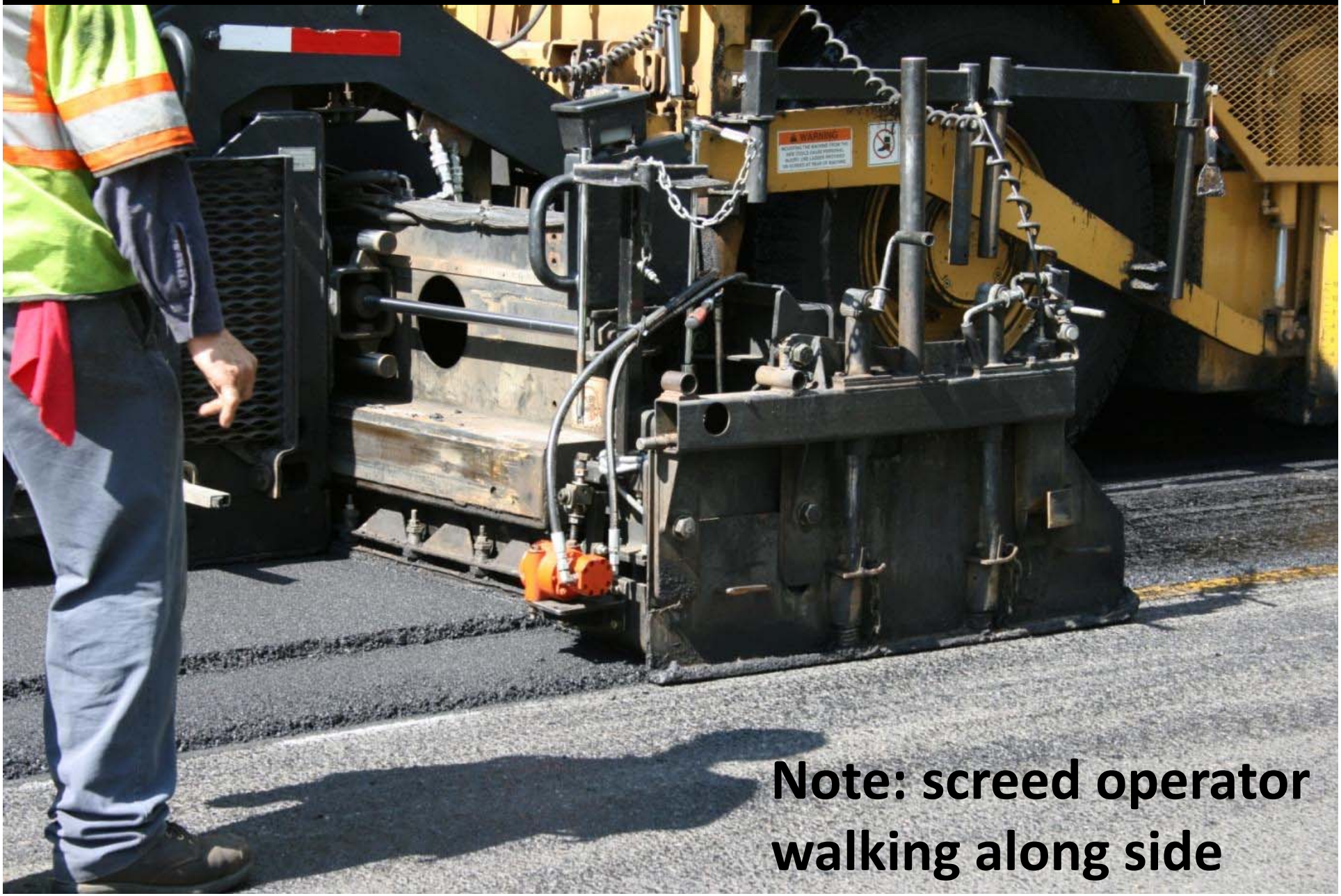
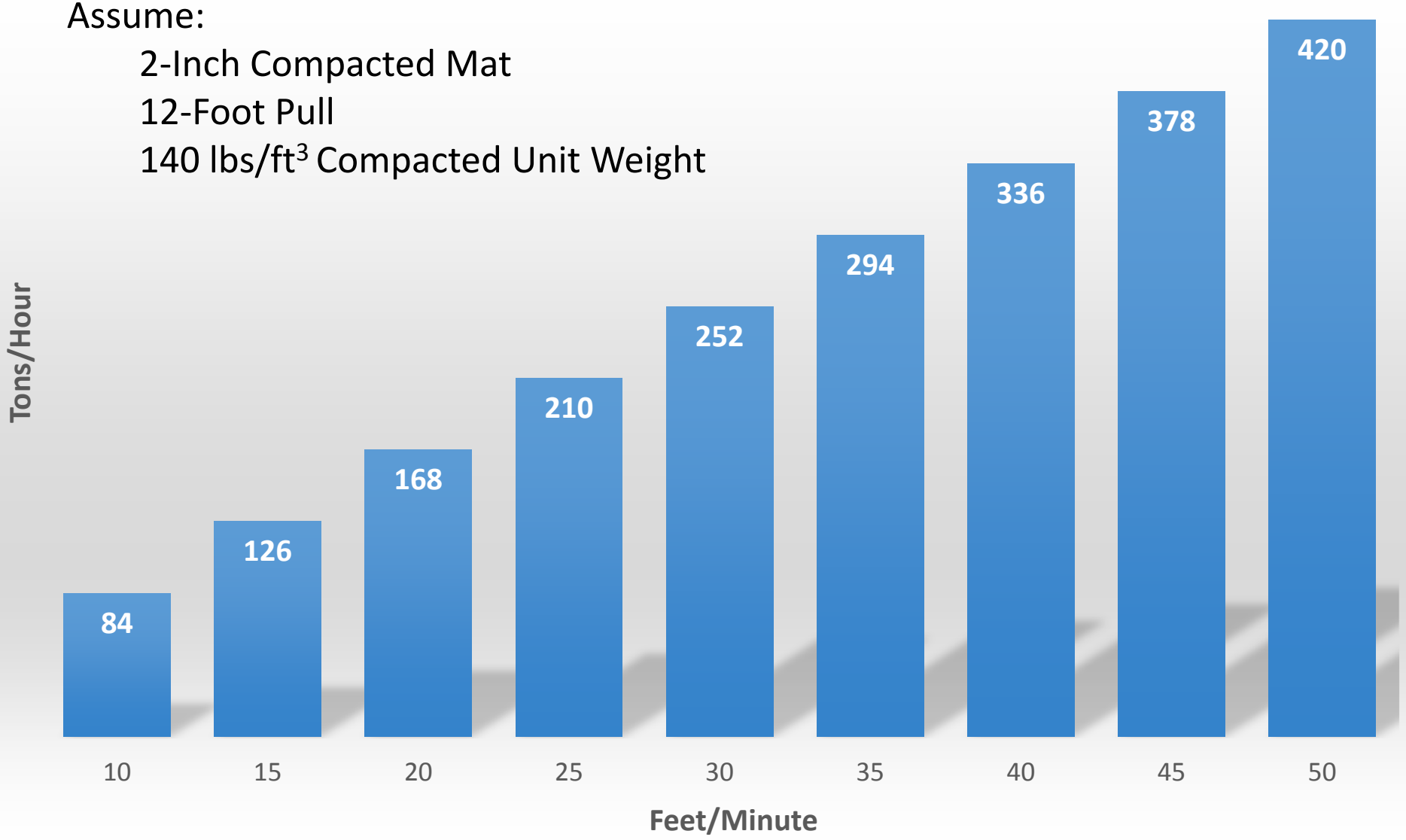


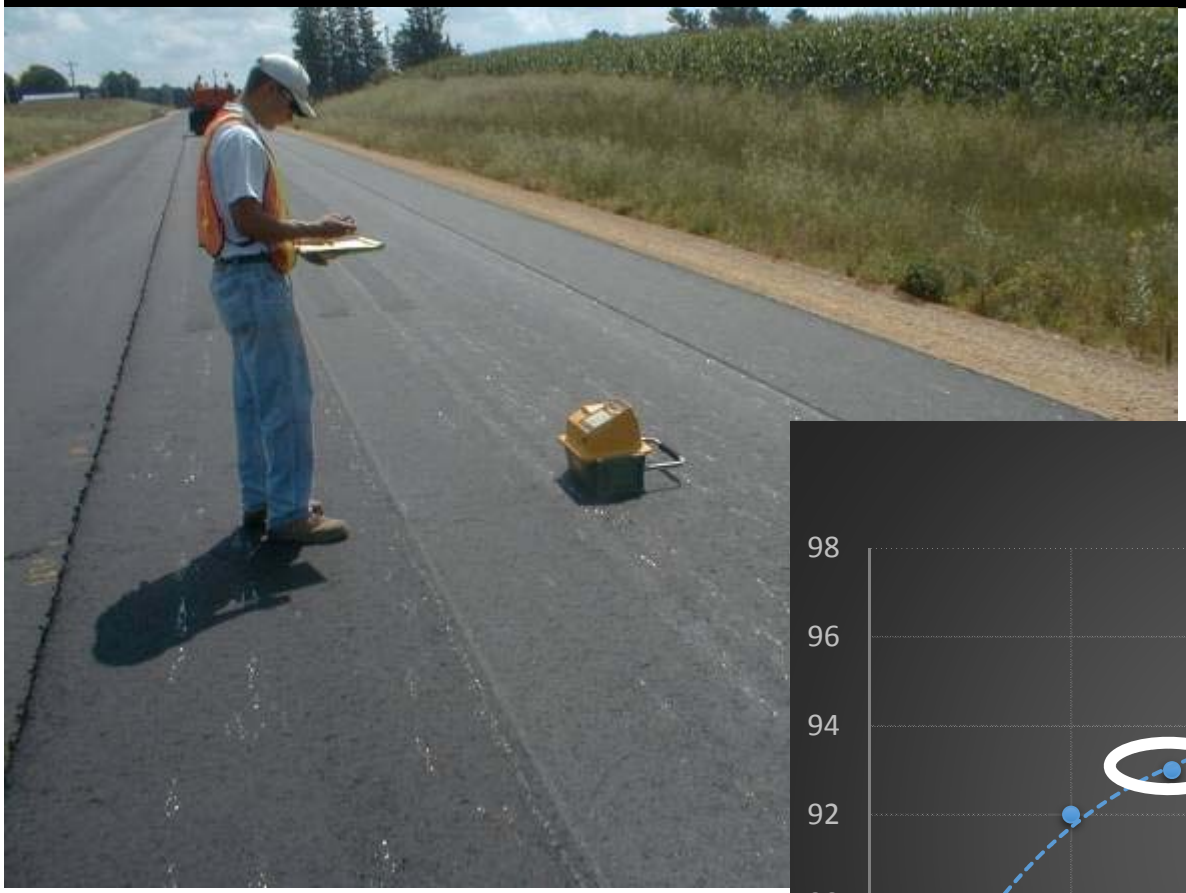
Paver Speed and Output

Assume:

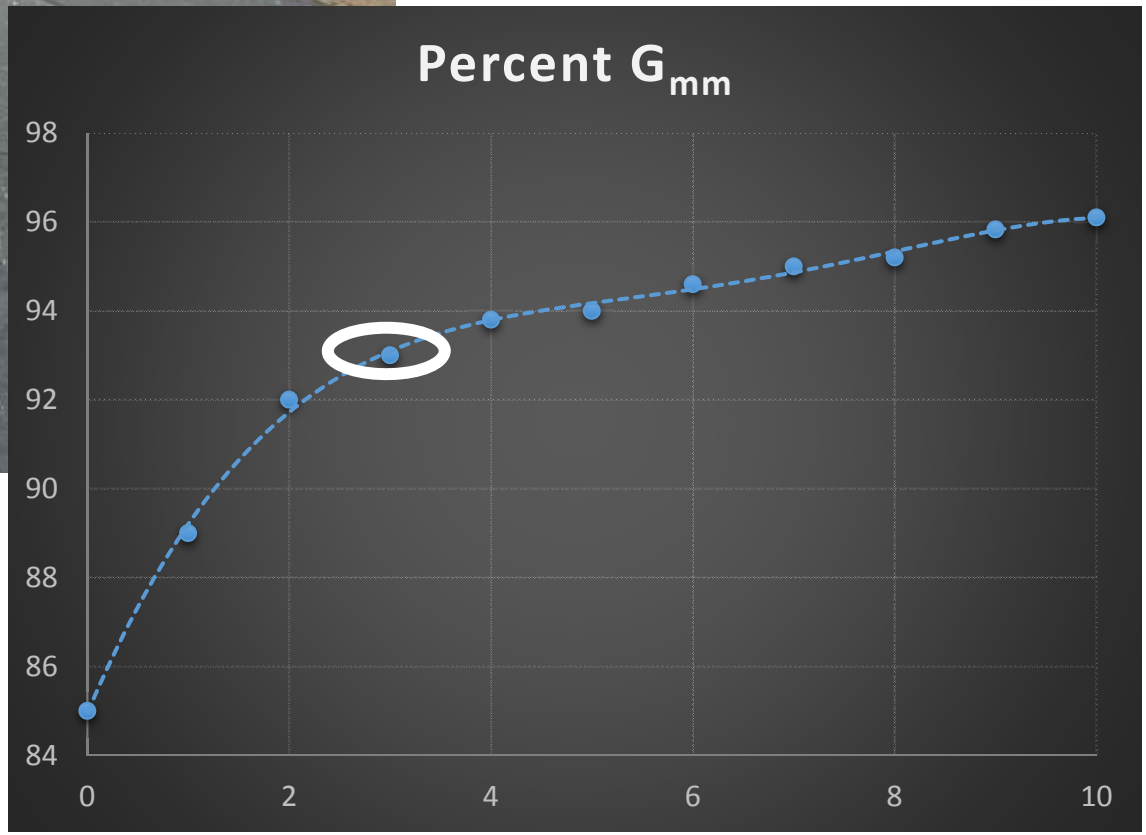
- 2-Inch Compacted Mat
- 12-Foot Pull
- 140 lbs/ft^3 Compacted Unit Weight



Establishing Rolling Pattern

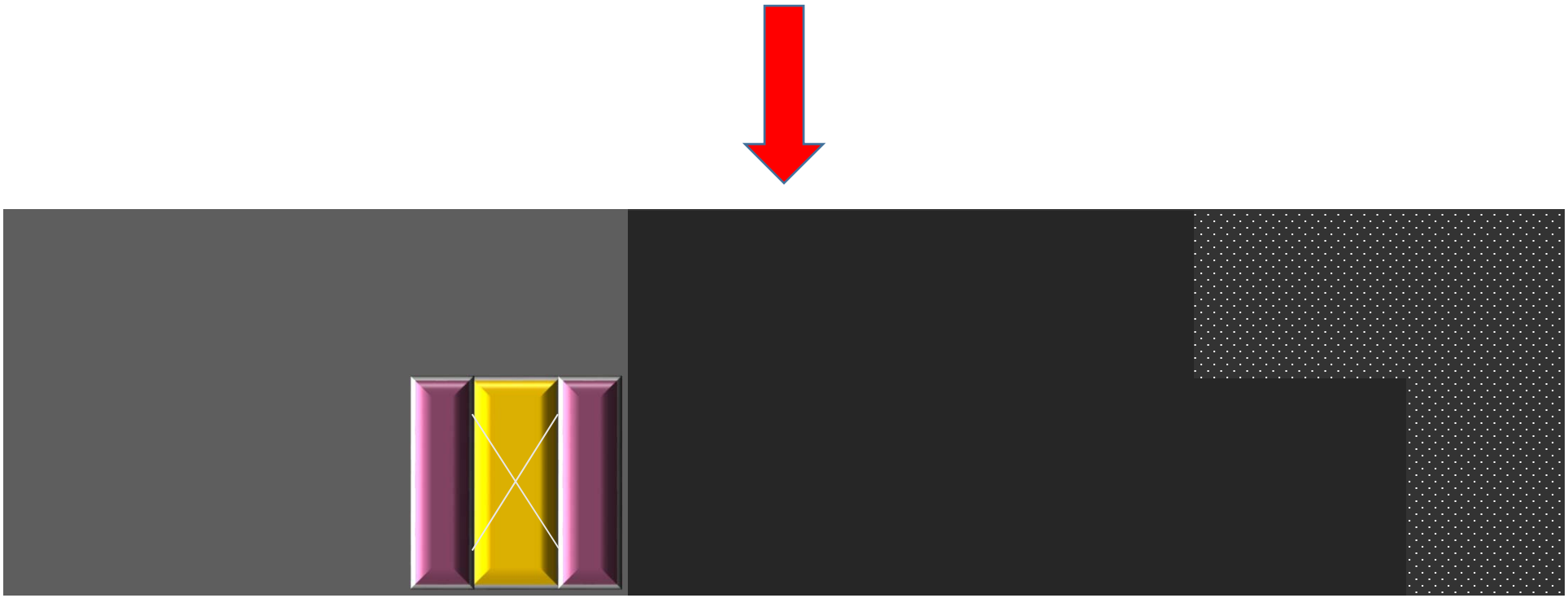


Goal: 93.5% G_{mm}



Select: 3 Passes (Intermediate will get the rest of the density)

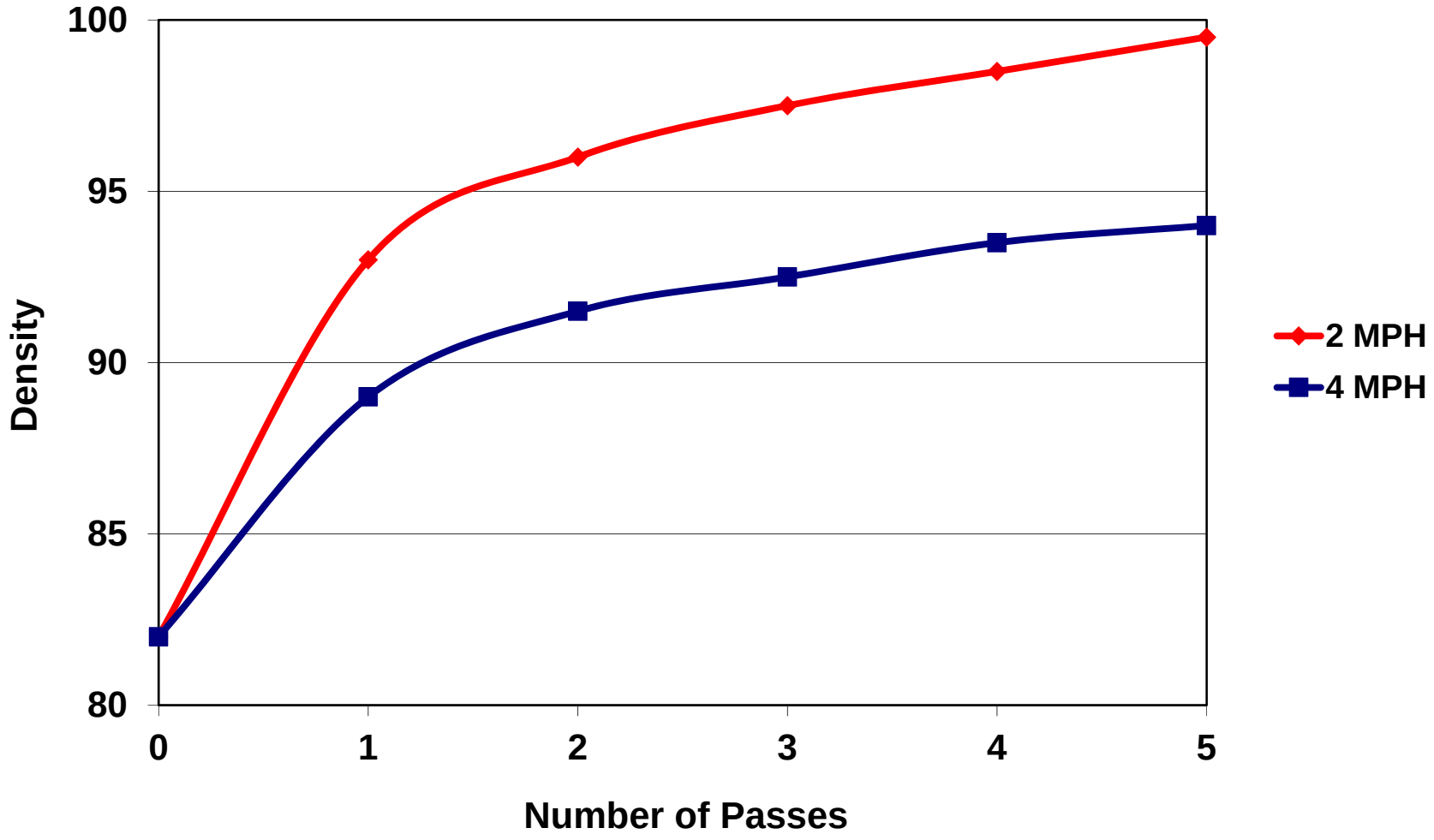
Rolling Pattern



100 - 170 ft

- Roller width should overlap 6 inches
- Odd number of passes to advance
- Repeat uniformly

Roller Speed is Critical



Slower = More Compaction/Pass

Vibratory Rollers - Amplitude

- Amplitude too high
- Travel speed too fast
- Vibrating cool mat
  - Roll closer to paver
- Damaged gutter
  - Roll along interface

Drum Impacts per Foot

Frequency	2 MPH	3 MPH	4 MPH	5 MPH
2000 vpm	11.36	7.58	5.68	4.55
2200 vpm	12.50	8.33	6.25	5.00
2400 vpm	13.64	9.09	6.82	5.45
2600 vpm	14.77	9.84	7.39	5.91
2800 vpm	15.91	10.61	7.95	6.36
3000 vpm	17.05	11.36	8.52	6.82
3200 vpm	18.18	12.12	9.09	7.27
3400 vpm	19.32	12.88	9.66	7.72
3600 vpm	20.45	13.64	10.22	8.18
3800 vpm	21.59	14.39	10.80	8.63
4000 vpm	22.72	15.16	11.36	9.10

Additional Vibratory Rollers

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Maximizing Our R.O.I.

- **Infrastructure loads continue to rise**
- **Budget availability continues to fall**
- **Increased pavement life can be economically achieved**
- **Research shows a 10% increase in pavement life can be achieved by increasing compaction by 1%.**

What would a 3% increase in compaction do for our industry?

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Enhanced Durability Through Increased In-Place Pavement Density

March 28th

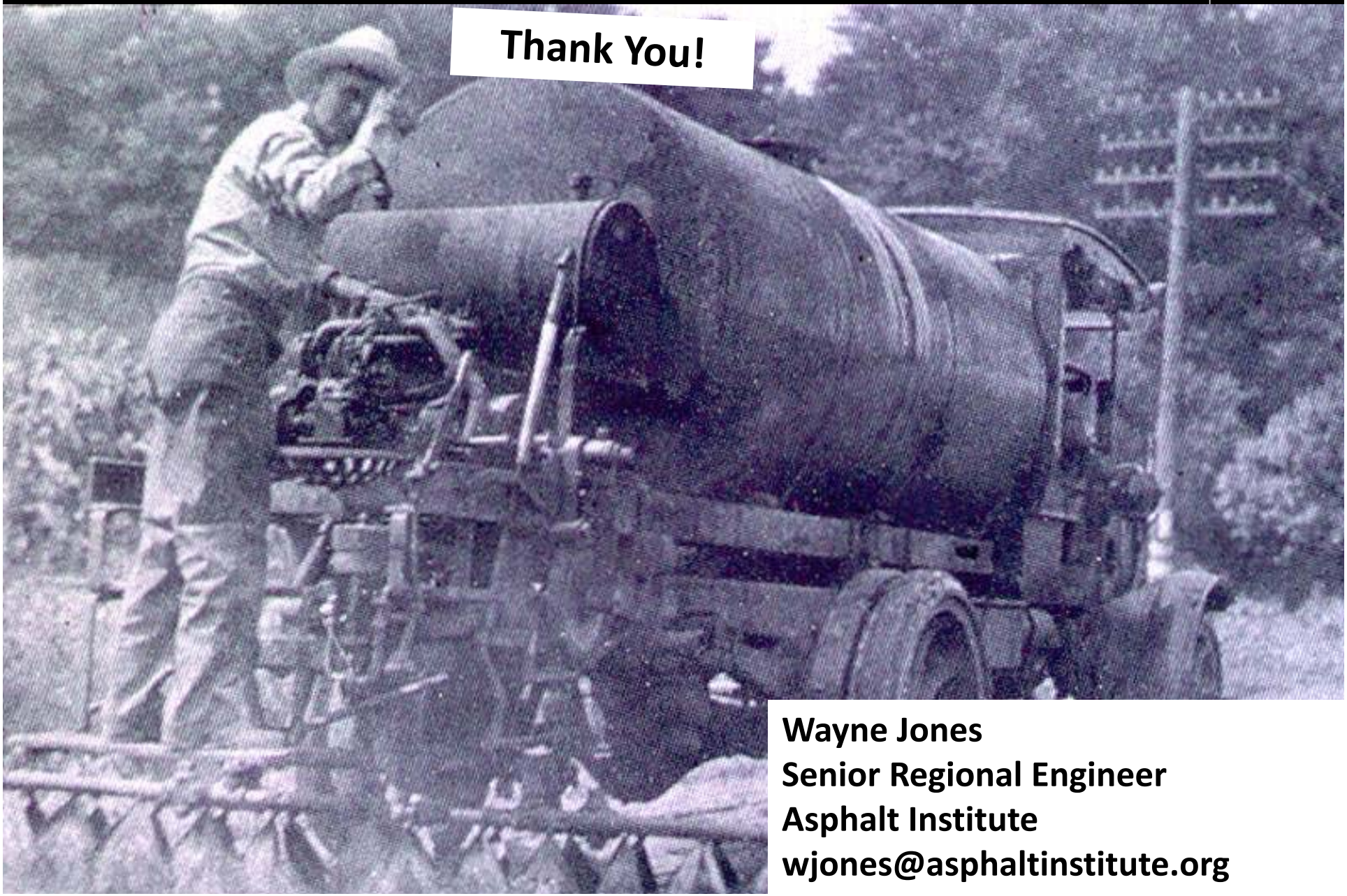
Northern Illinois University, Naperville Campus

Airport Pavement Technical Workshop

April 25th -27th

Rosemont, IL

PDH 22



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