Compaction of Asphalt

What's Known and What's New

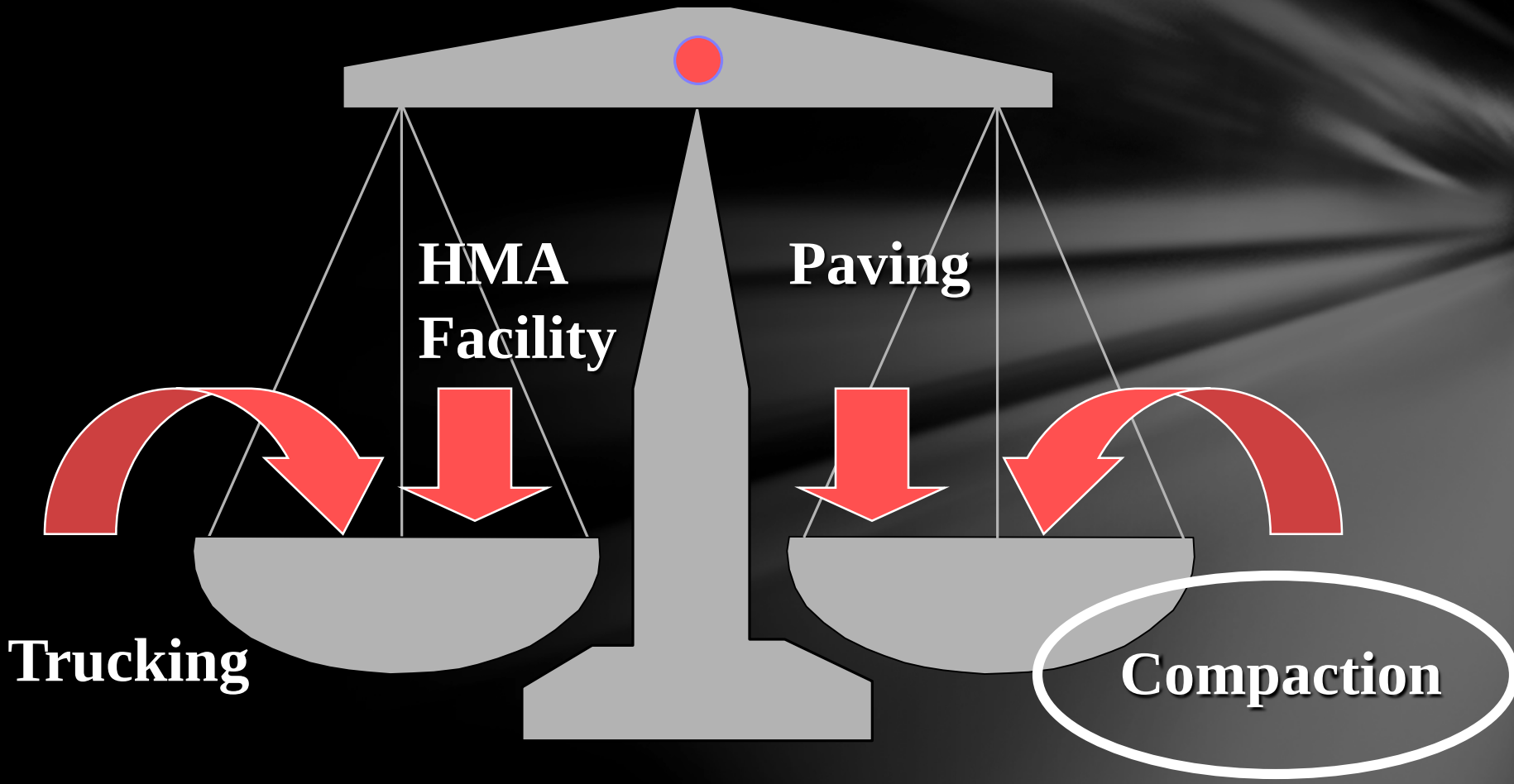
Asphalt 101 - 103

Timothy R. Murphy, P.E.
President

Murphy Pavement Technology


Mr. Allan Wood
US Army, 82nd Airborne
Parachuted into Holland 9/17/1944
Operation Market Garden &
The Battle of the Bulge
Purple Heart
Bronze Star for combat valor
E-mail: ageow@comcast.net'

Balancing Production



Why do we care about compaction?

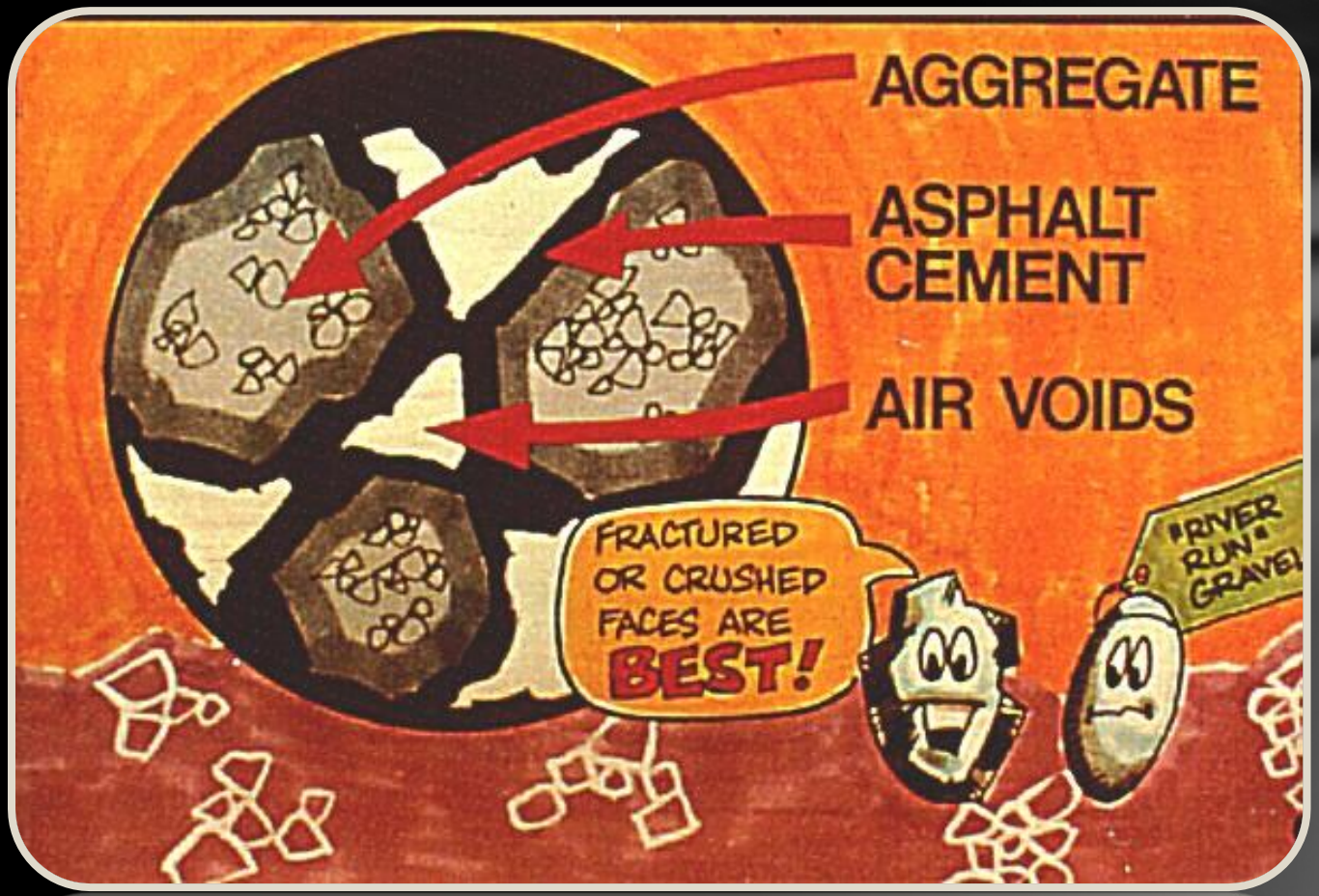
Density, → **Permeability reduction,**

Smoothness, → **Public satisfaction,**

Strength. → **Performance enhancement.**

Compaction Substantially Reduces Fatigue and Low Temperature Cracking.

Hot Mix Asphalt (HMA)

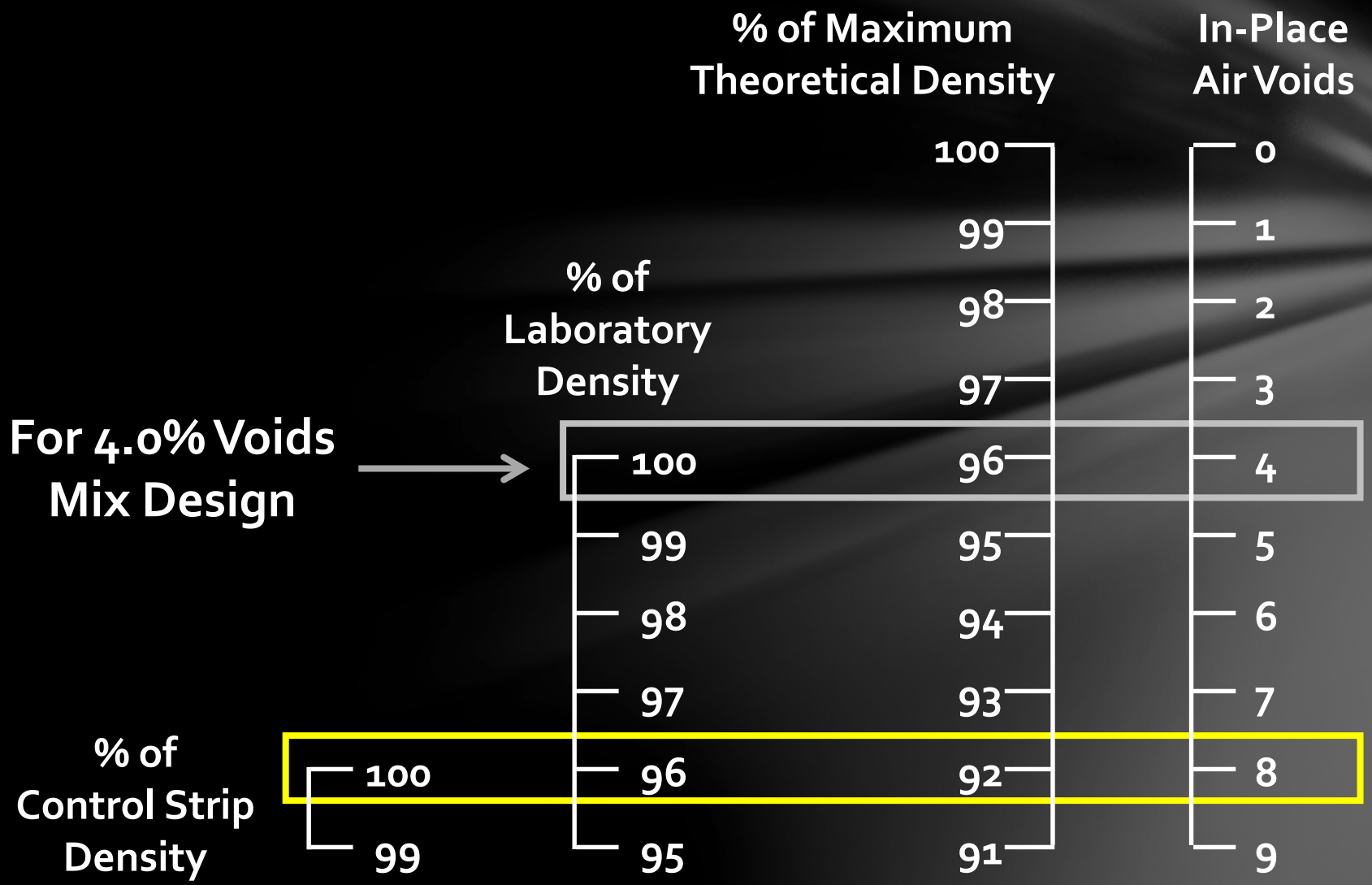


Importance of VMA

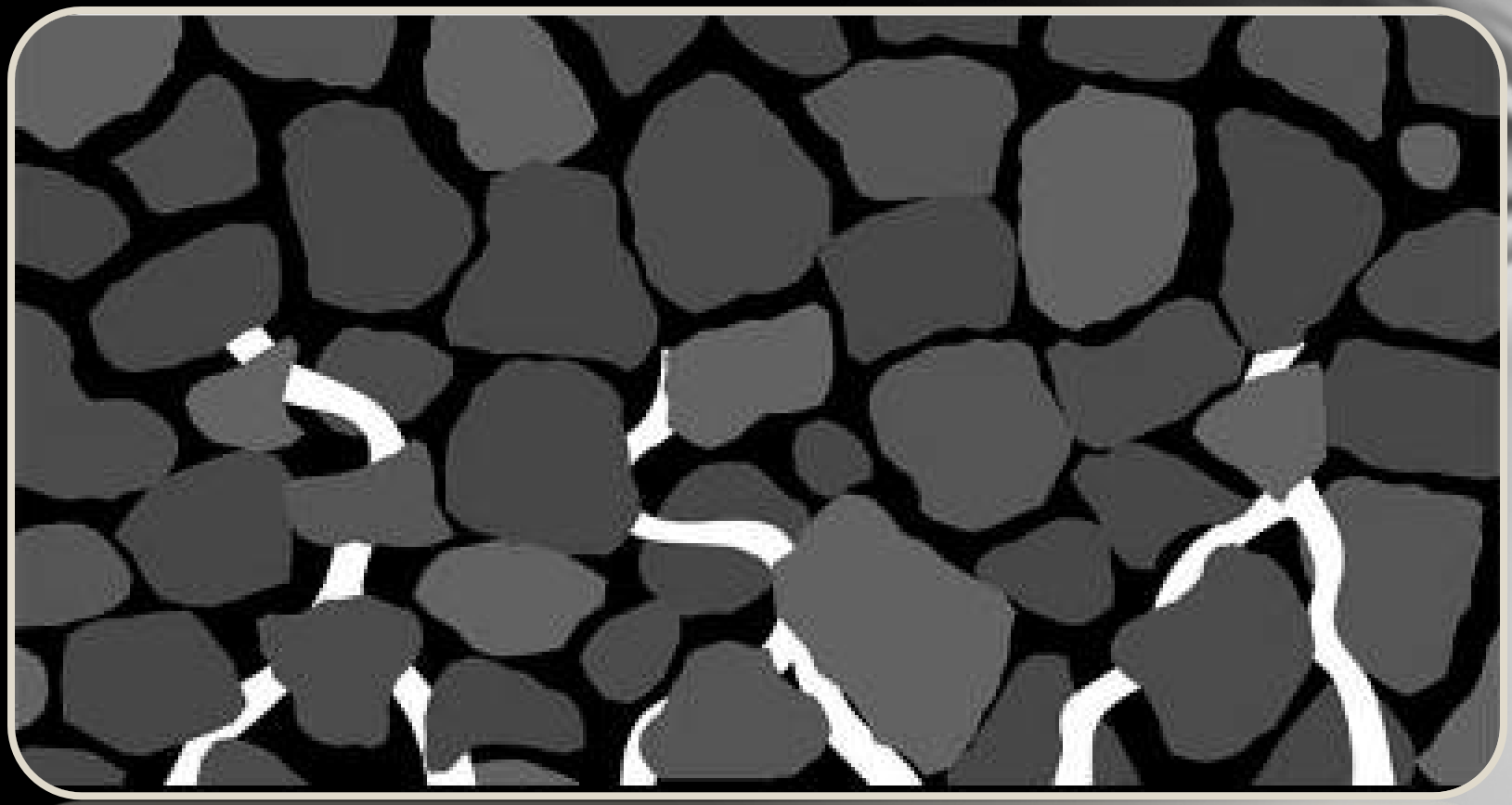
- Improve Mechanical Stability
- Improve Resistance to Permanent Deformation
- Reduce Moisture/Air Penetration
- Improve Fatigue Resistance
- Reduce Low-Temperature Cracking Potential

Permeability and rutting

Reference Density Comparison



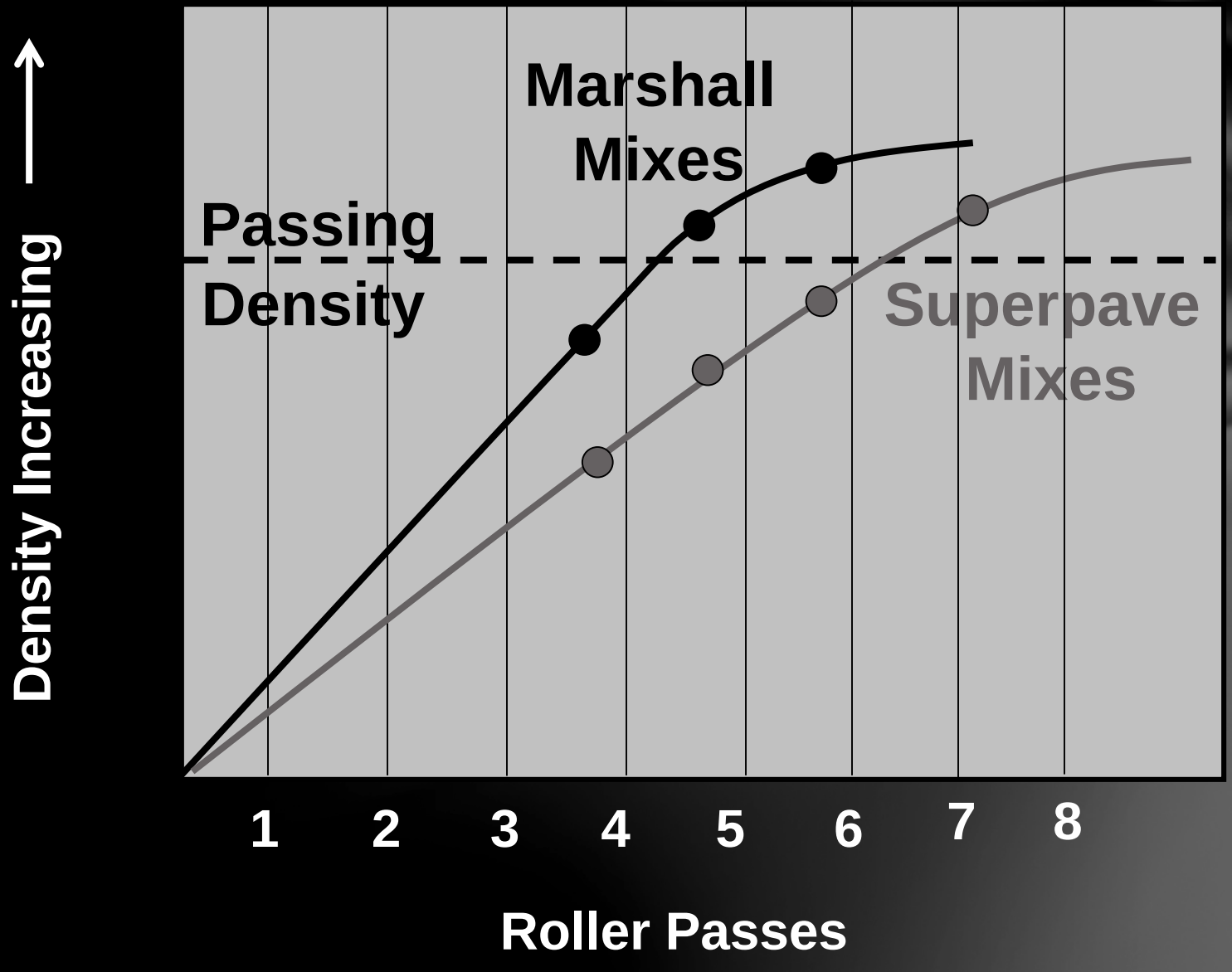
Mat during Compaction



Courtesy of Caterpillar Paving Products

Types of rollers

1. **Vibratory (aka Breakdown)**
2. **Pneumatic (aka Rubber tire)**
3. **Static Steel Wheel (aka Finish)**


Density Increasing
Marshall Mixes
Passing Density
Superpave Mixes
1
2
3
4
5
6
7
8
Roller Passes

Vibratory roller

Unit Total Applied Force (UTAF)

Method of expressing a vibratory roller's impact force on the asphalt pavement.

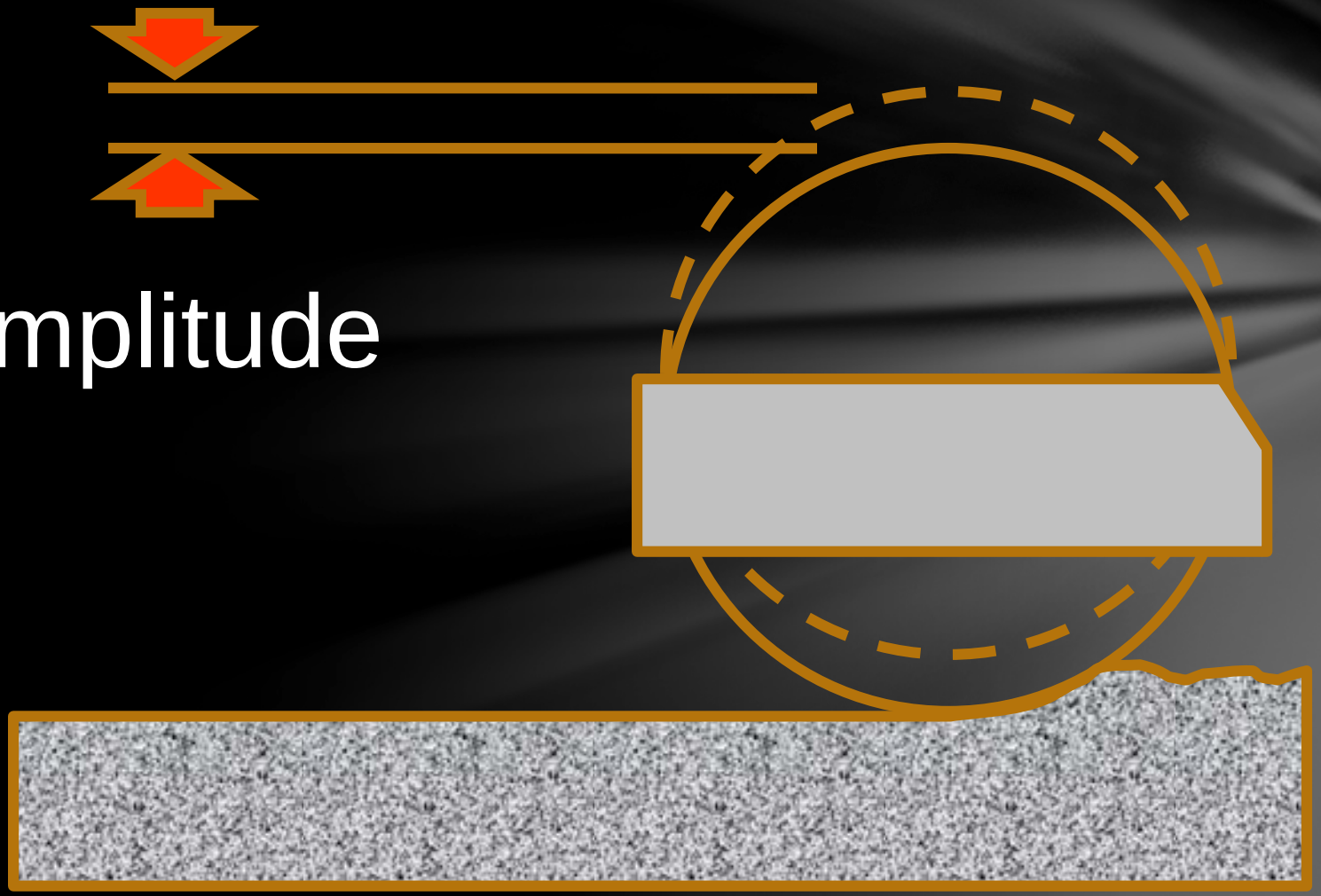
Unit Total Applied Force (UTAF)

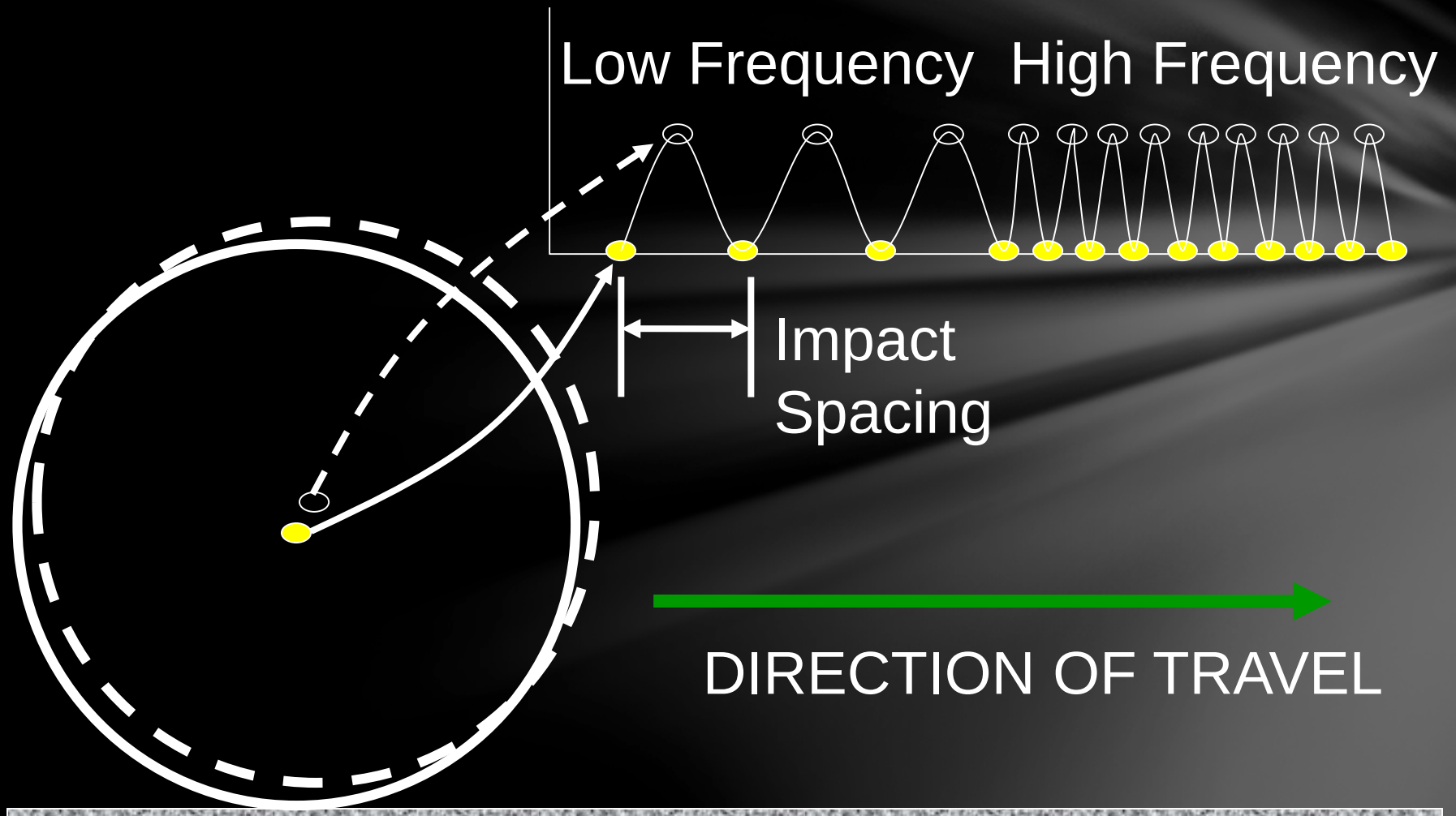
- **Increase with lift thickness.**
- **Vary with mix characteristics.**

Desirable UTAF Ranges

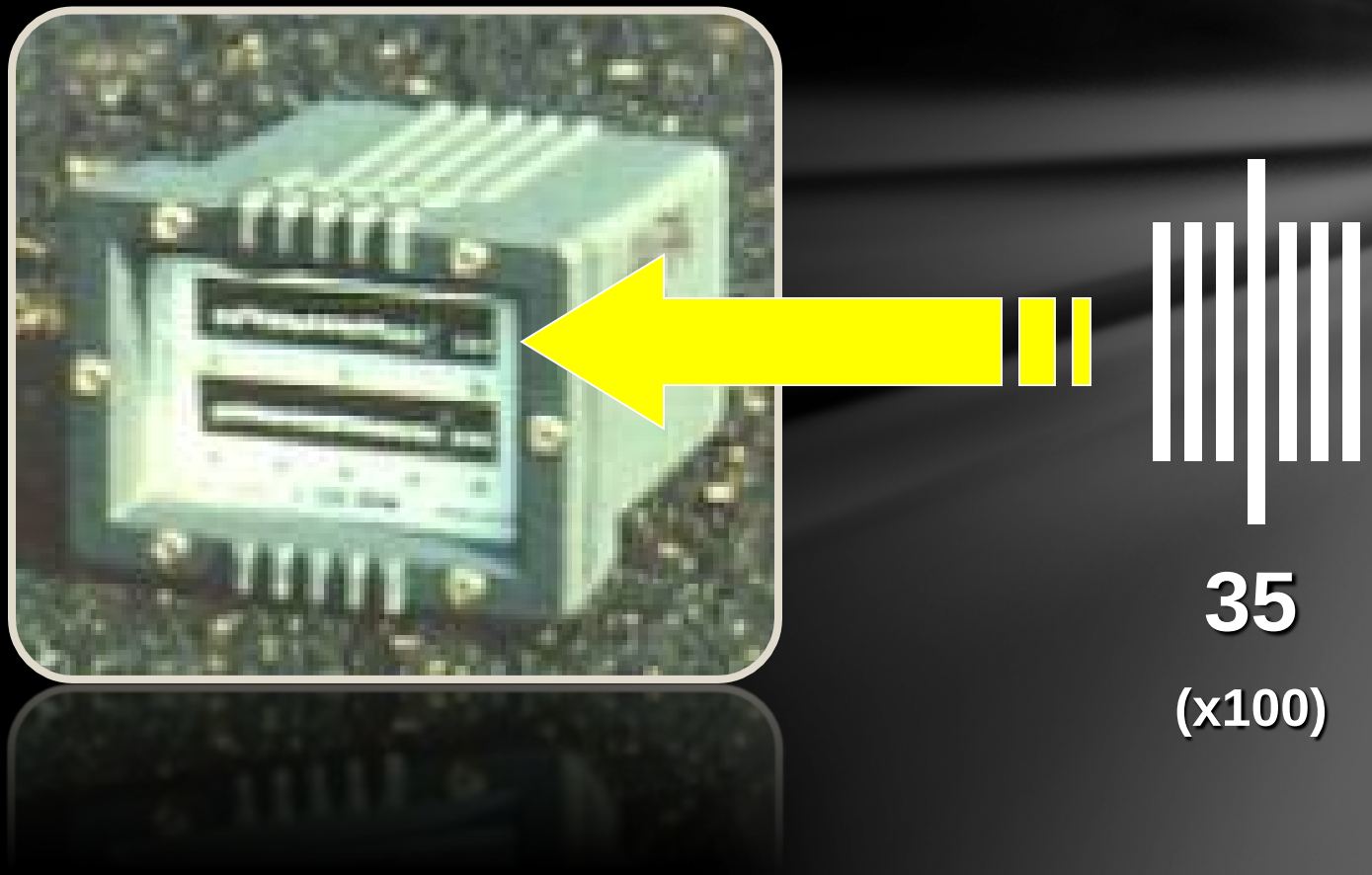
		UTAF (lb. / in.)
1″	Surface Course	290 - 370
1 – ½″	Binder Course	330 - 420
3″	Base Course	400 - 500
4″ plus	Base Course	440 - 600

Amplitude




Low Frequency
High Frequency
Impact
Spacing
DIRECTION OF TRAVEL

Reed tachometer; vibrations per minute (vpm)



Typical Data for Vibratory Tandem Rollers

Vibratory Steel Tandem (ton)	*Oper. Wt. (lb.)*	*Drum Diam. (ft.)*	*Drum Width (ft.)*	***Static Drum (pli)***	***Dynamic Drum (pli)***	*VPM*	**Nom. Amp. (in.)**
6.0-8.0	14,700	3.6	4.6	130	260	2,900	0.025
9.5-11.0	20,500	3.9	5.6	158	384	2,600	0.03
> 13.0	30,000	4.9	6.9	186	423	2,400	0.03

Lack of smoothness

Do not vibrate thin lifts of Asphalt

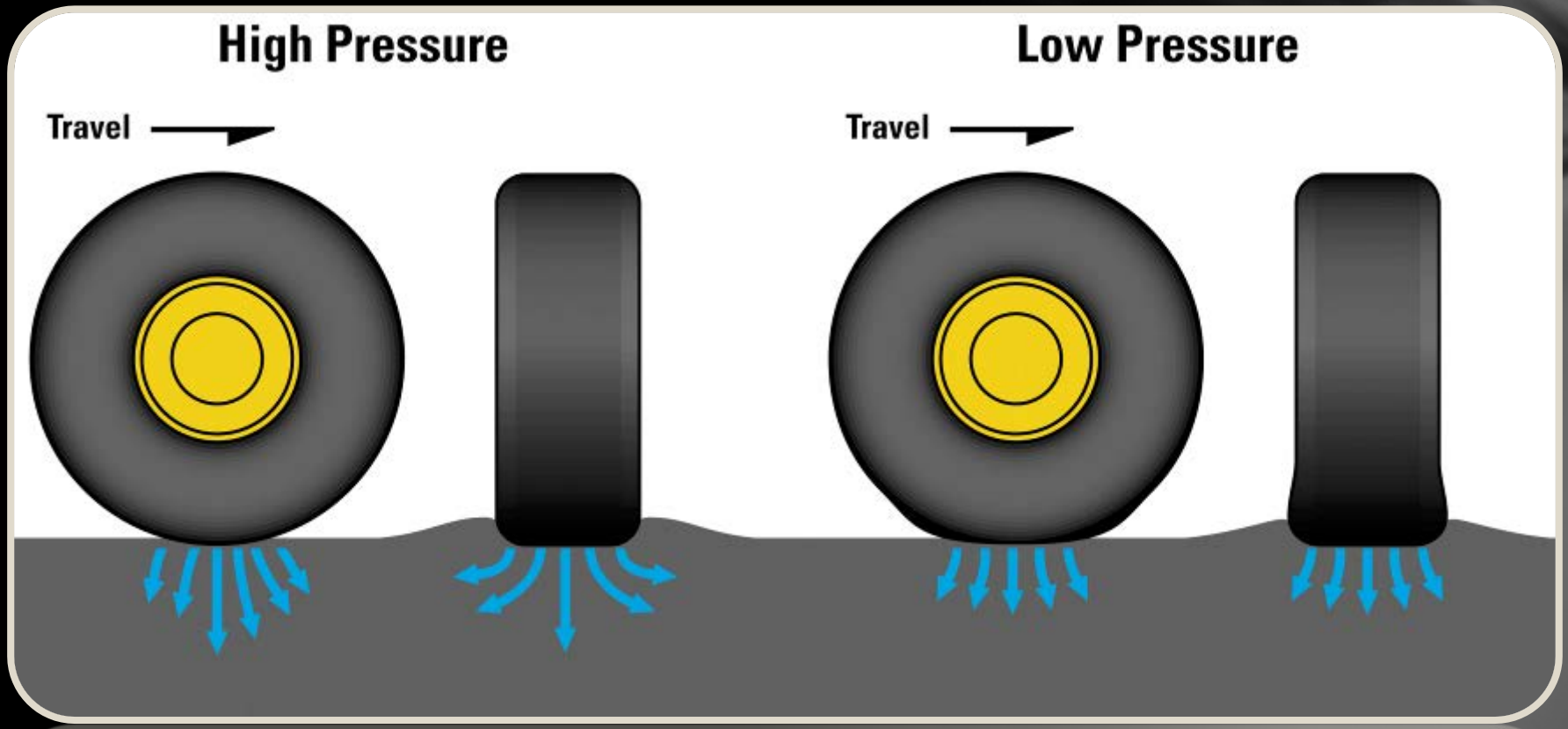
Do not vibrate thin lifts of Asphalt

Roller vs. paving widths

Roller in training

Skirted pneumatic roller

Tire inflation pressure vs. ground contact pressure



Courtesy of Caterpillar Paving Products

Inflation Pressure and Ground Contact Pressure at Various Wheel Loads and Ply Ratings

	Ply Rating	Wheel Load lb	Tire Pressure psi	Contact Area in^2	Ground Contact Pressure psi
*	14	1,250	130	16	78
	14	2,800	130	30	92
*	14	2,300	35	41	56
	14	2,300	130	26	88
*	10	2,800	90	38	73
	14	2,800	130	30	92

Finish rolling removes marks and gets a touch more density with pounds per lineal inch (PLI) ~ 280

Ballasting finish roller to get PLI > 300

Factors Affecting Compaction

- Properties of the Materials
- Environmental Variables
- Laydown Site Conditions

Can mix type and base support cause compaction difficulties?

Compaction compromised

How do we ensure adequate compaction?

Forces must be equal and opposite

- Sub-grade,
- Sub-base,
- Existing pavement structure.

Sub-grade

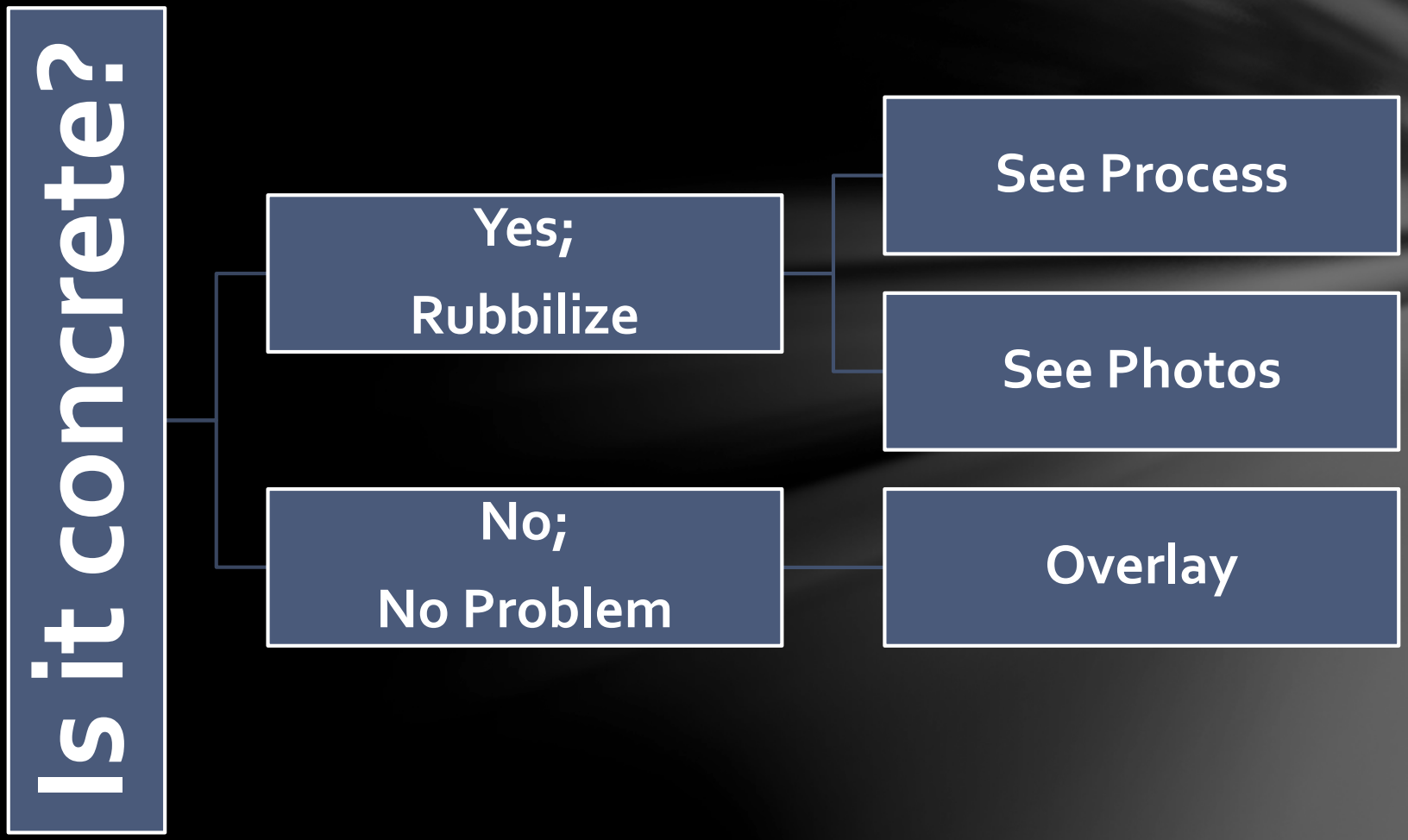
Sub-base

Sub-base density checks

Existing pavement structure

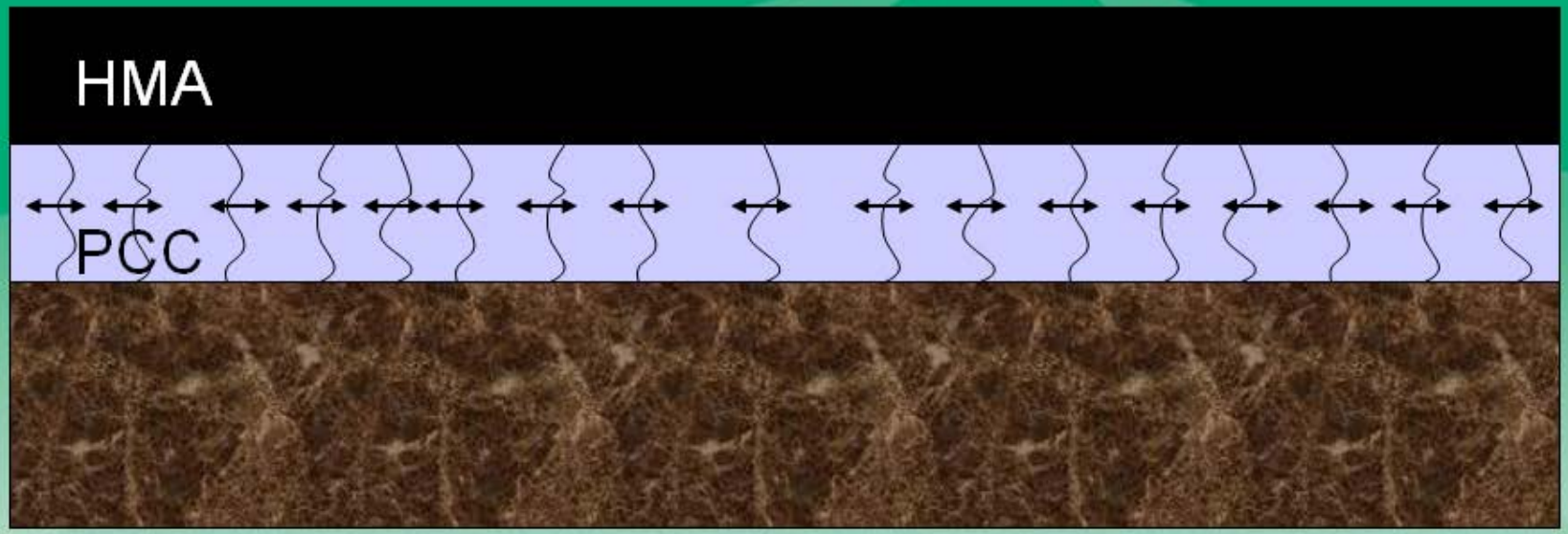
- Hot Mix Asphalt,
- Concrete,
- Oil & chip.

Engineering Flowchart for Concrete Pavement



Rubblization Process

Smaller Pieces = Smaller Movement = No Cracking

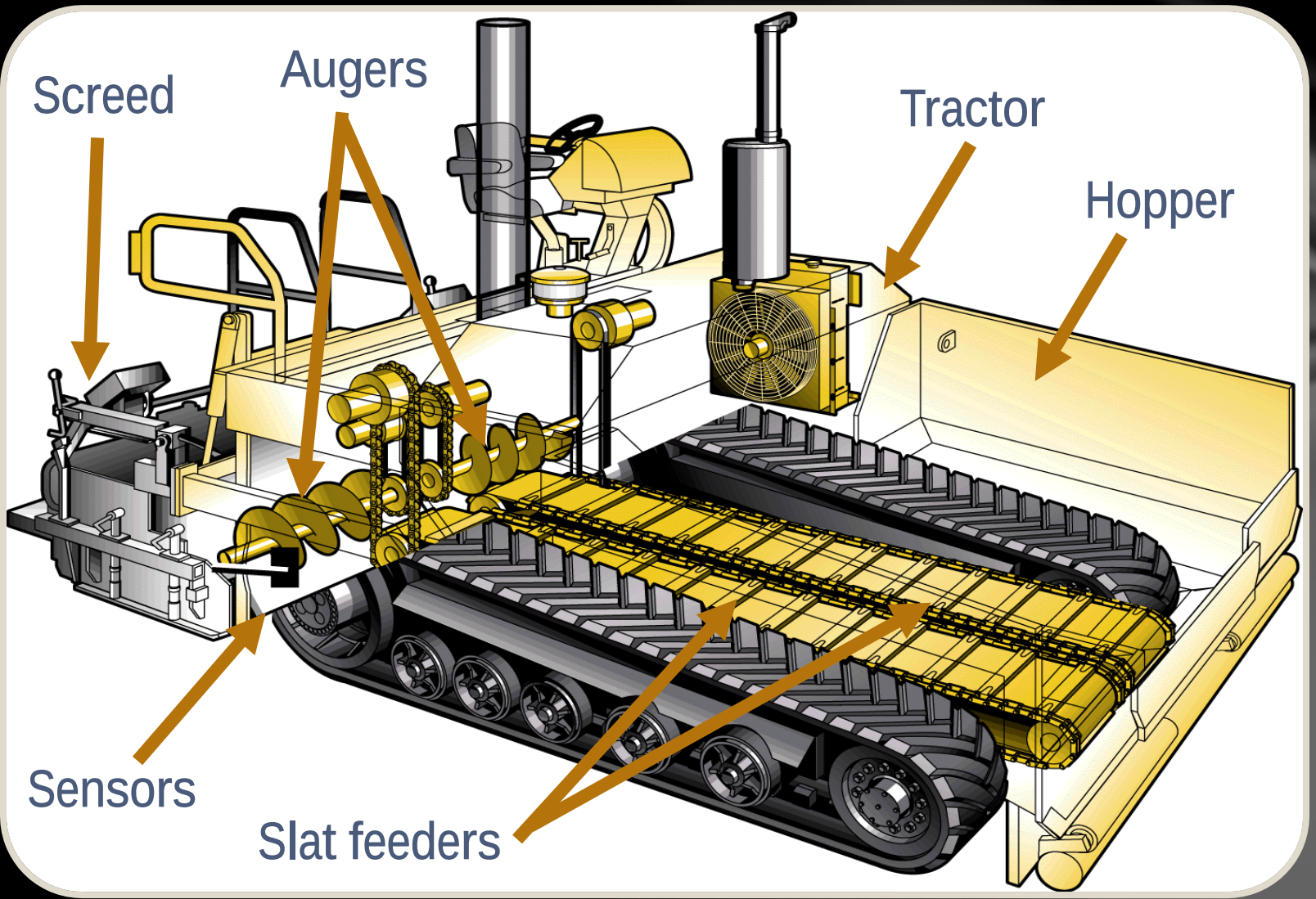


Rubblization Photos

Rubblization Photos

Courteous Contractor

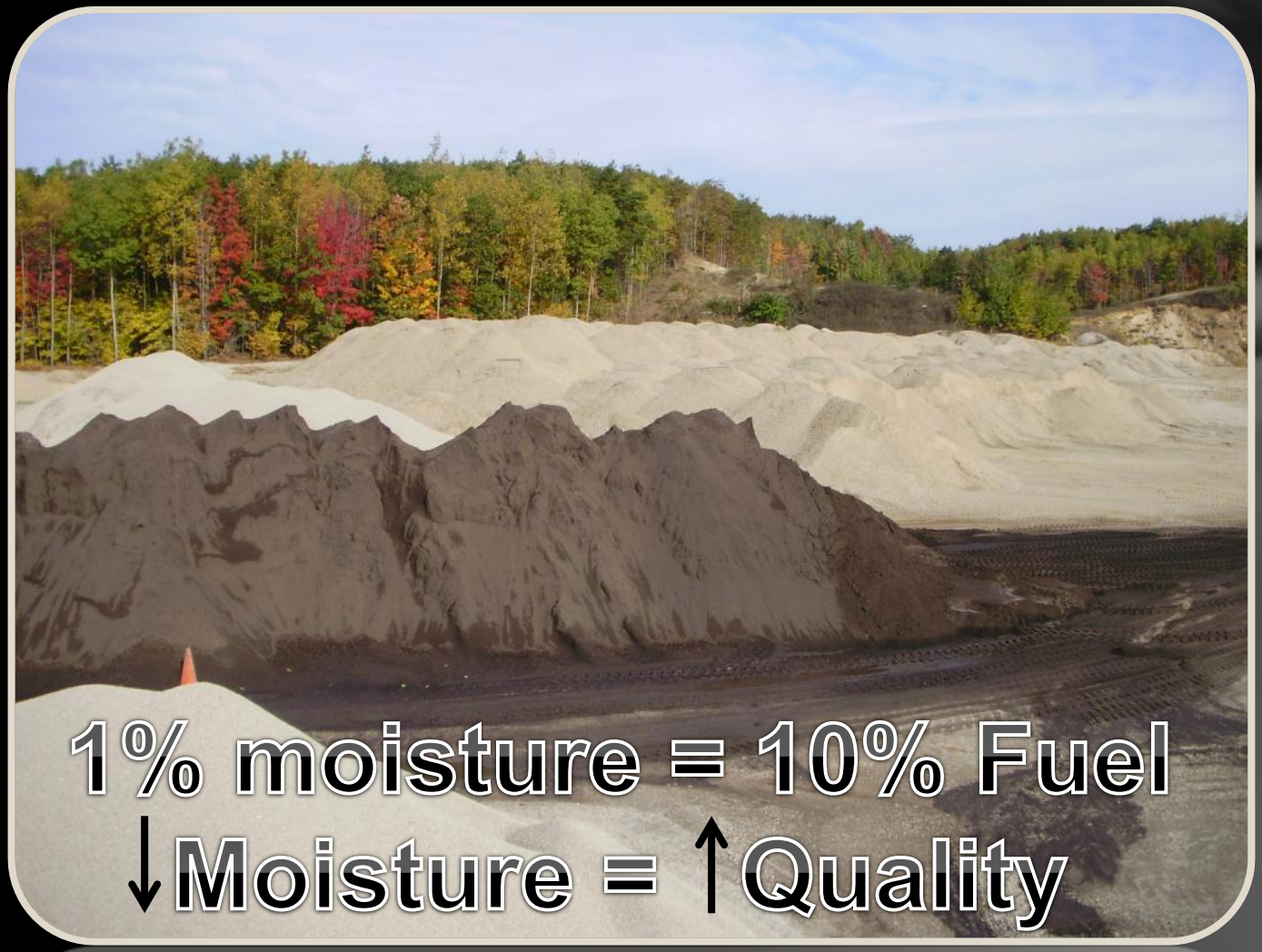
Placement Equipment



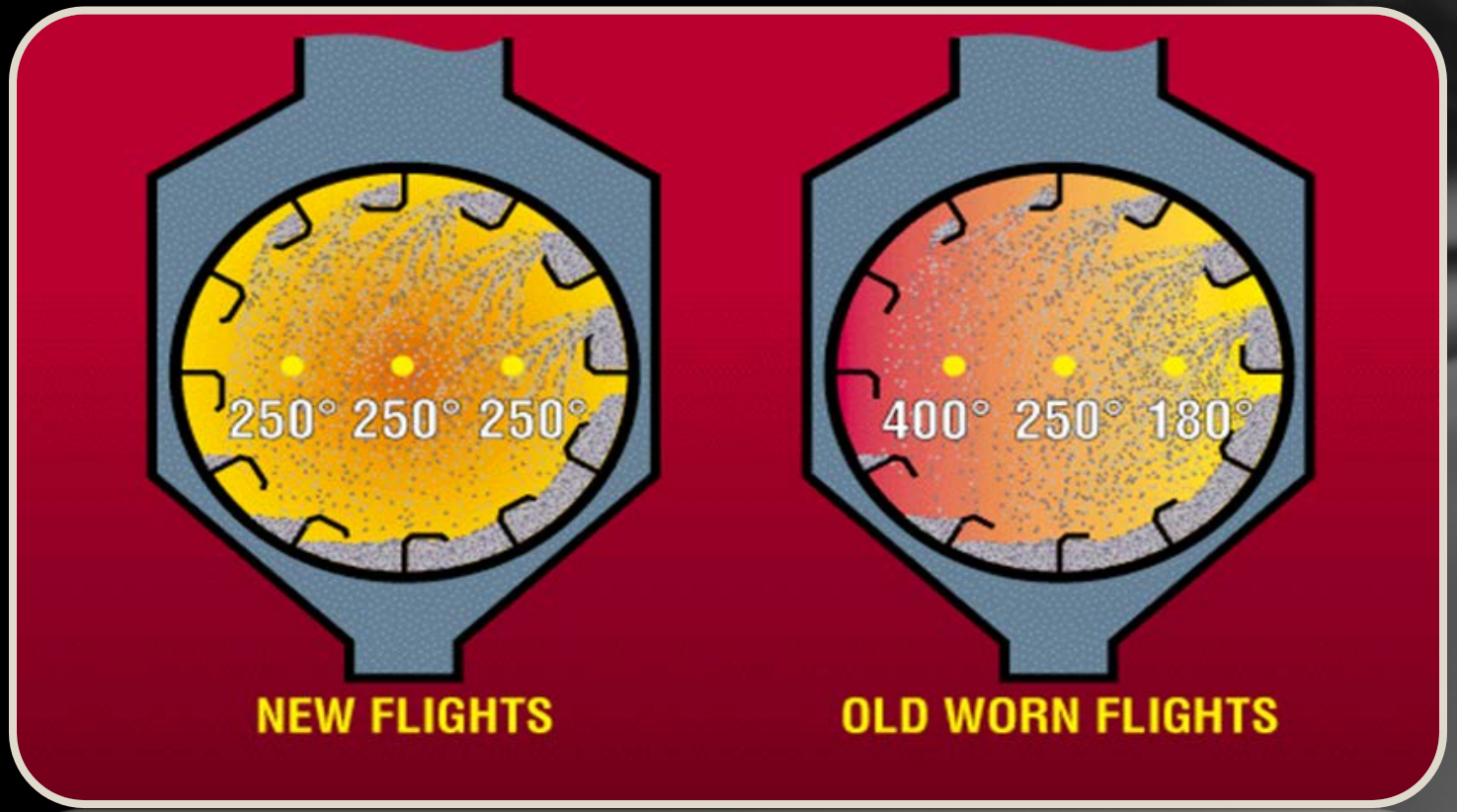
Courtesy of Caterpillar Paving Products

Pre-Pave Meeting

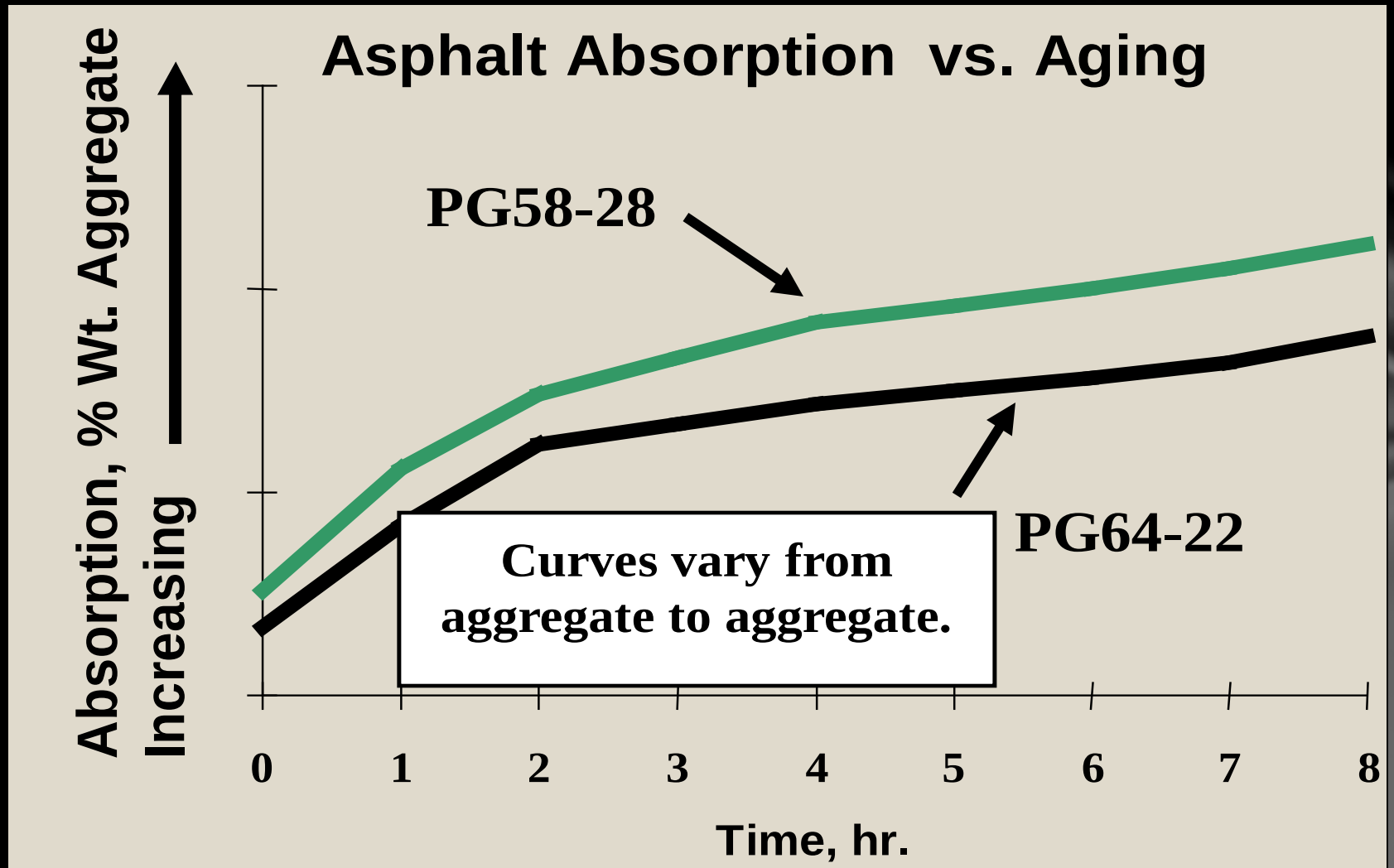
Watch out for moisture



How worn flights affect temperatures



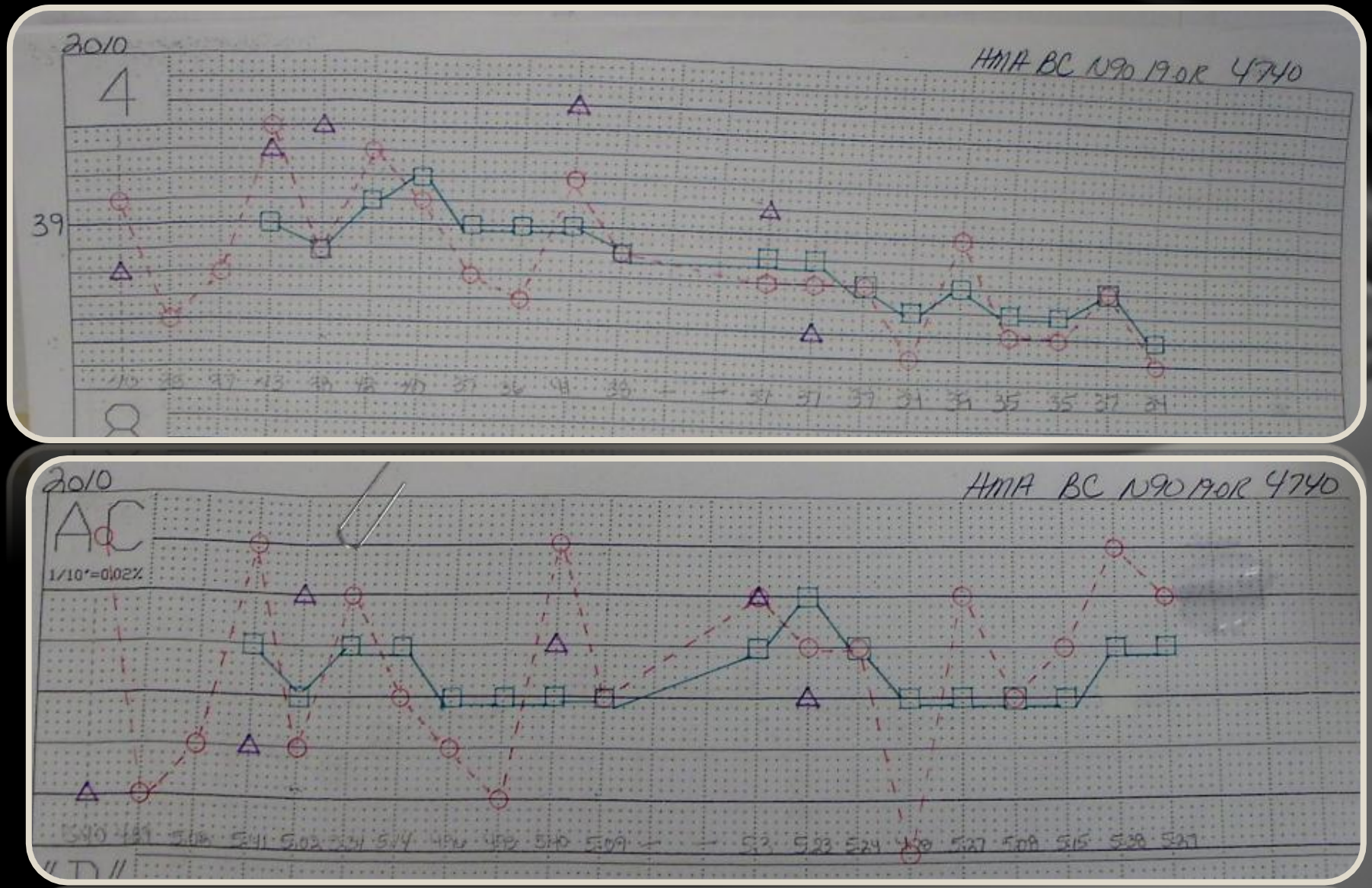
TEMPERATURES ACROSS THE INTAKE BREECHING SHOULD BE CONSTANT.



Evaluation of Asphalt Absorption by Mineral Aggregate
AAPT 1991, p. 207-229.


HARDOX

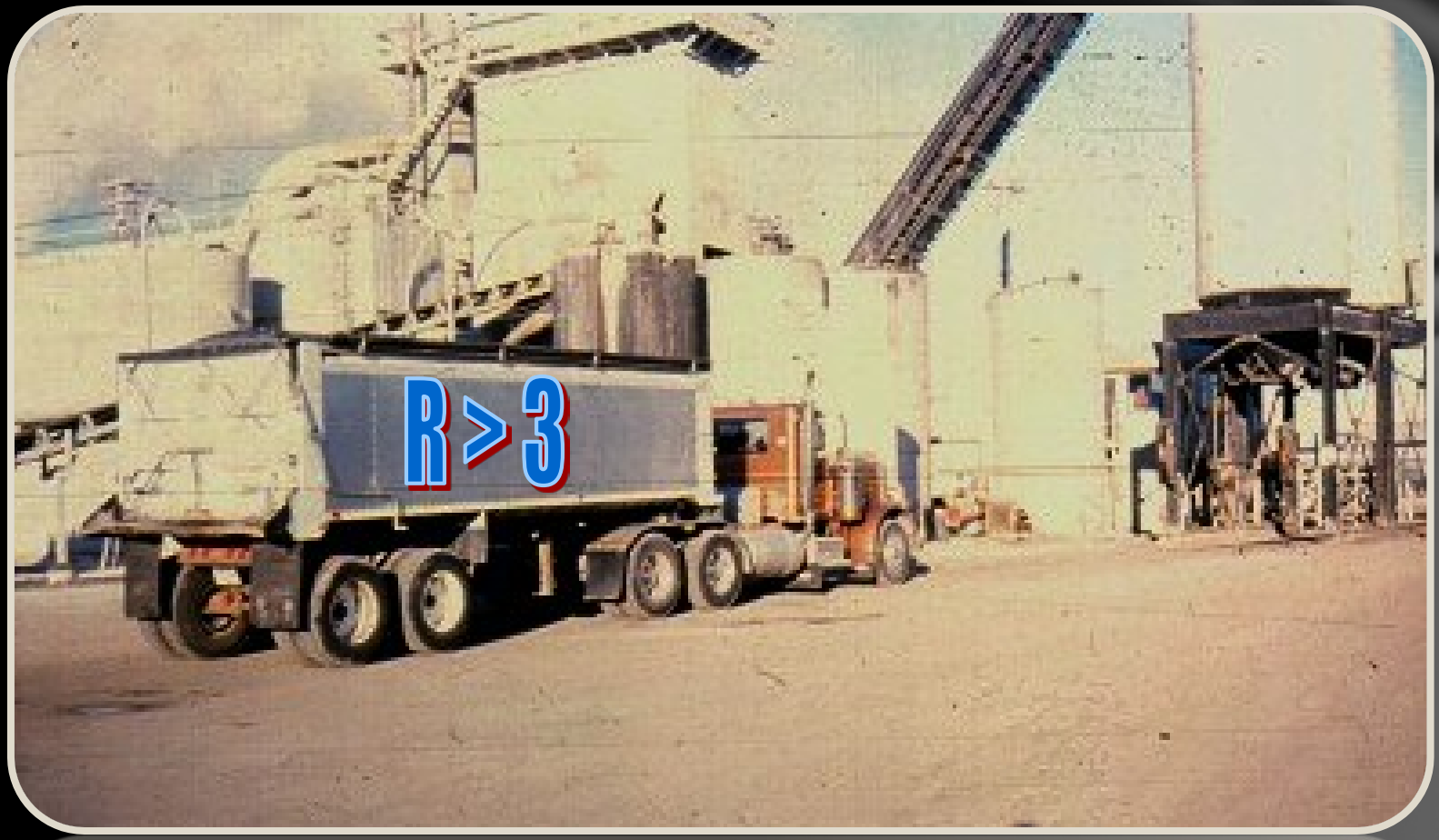
Silo & Truck loading: Recognize the evil spirit


2010
4
HMA BC N90 R90R 4740
39
2010
AQC
1/10"=0.02%
HMA BC N90 R90R 4740

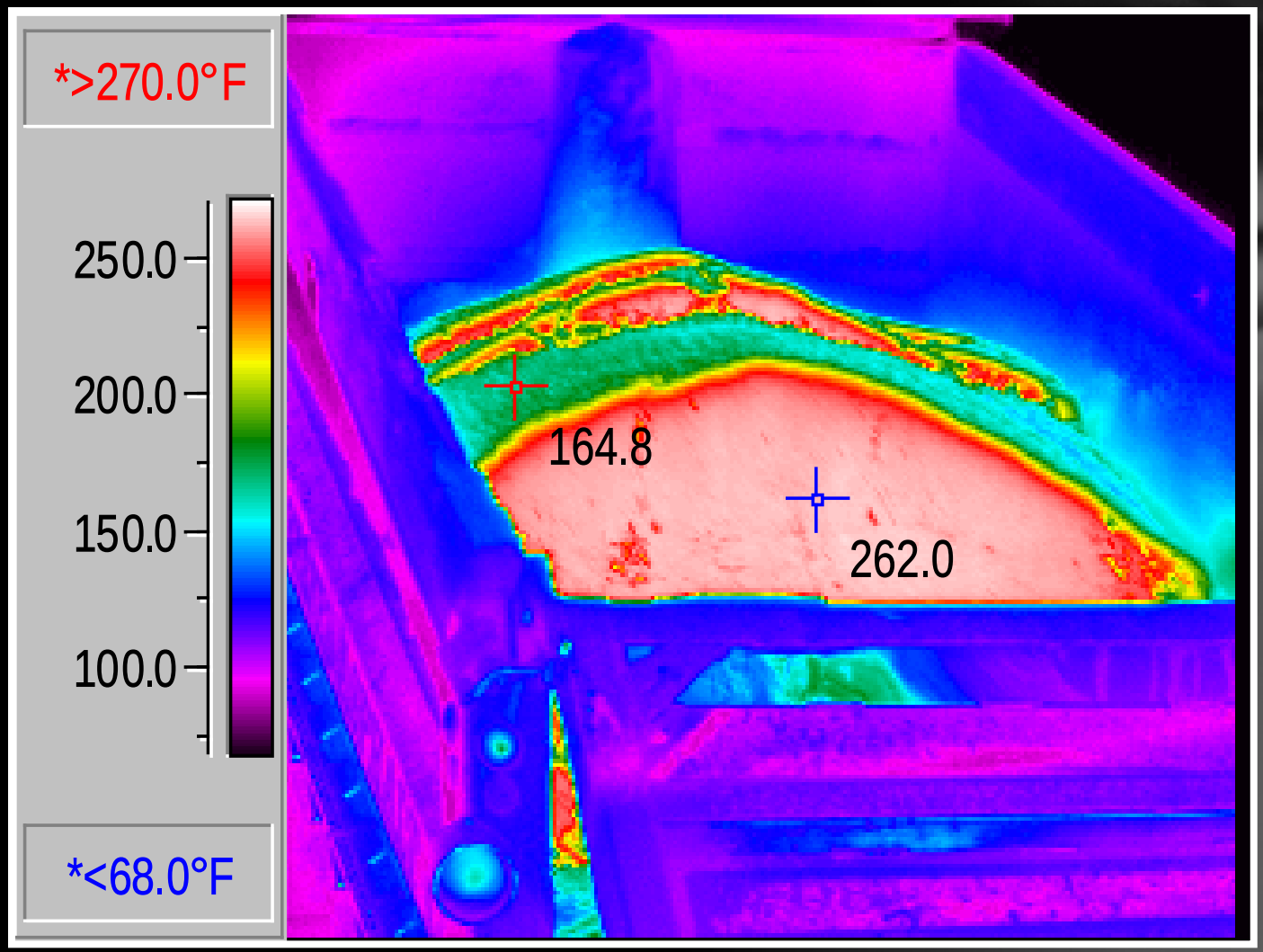
Night paving

Truck Tarping

Side Insulation



Infrared Photo of End Dump



Pre-Pave Adjustments

Screed Unit

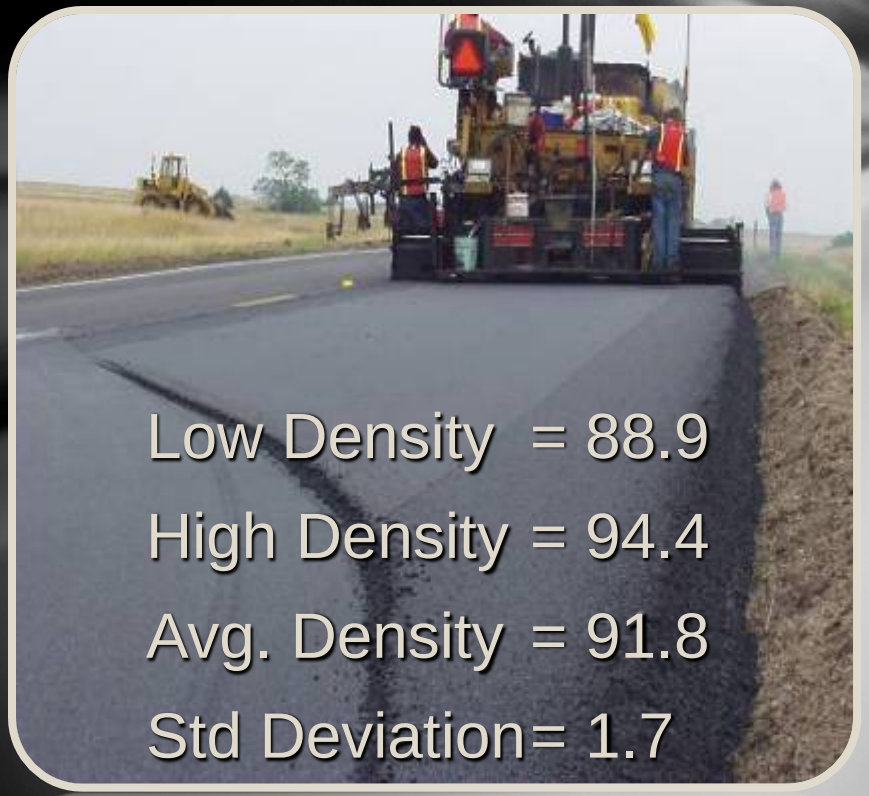
Blaw-Knox

Courtesy of Blaw-Knox Ingersoll Rand Paving Products

Screed temperature

Lift Thickness

- General rule of thumb is 3-times the maximum particle size; compacted lift thickness.
- Variable thickness yields variable density.



Straight Longitudinal Lines

Construction

Longitudinal Joints Start with a Straight Line

Opportunity

Not so excellent joint construction

Where's the Raker?

Compaction problems along the longitudinal joint

We are headed to hanging out at the joint

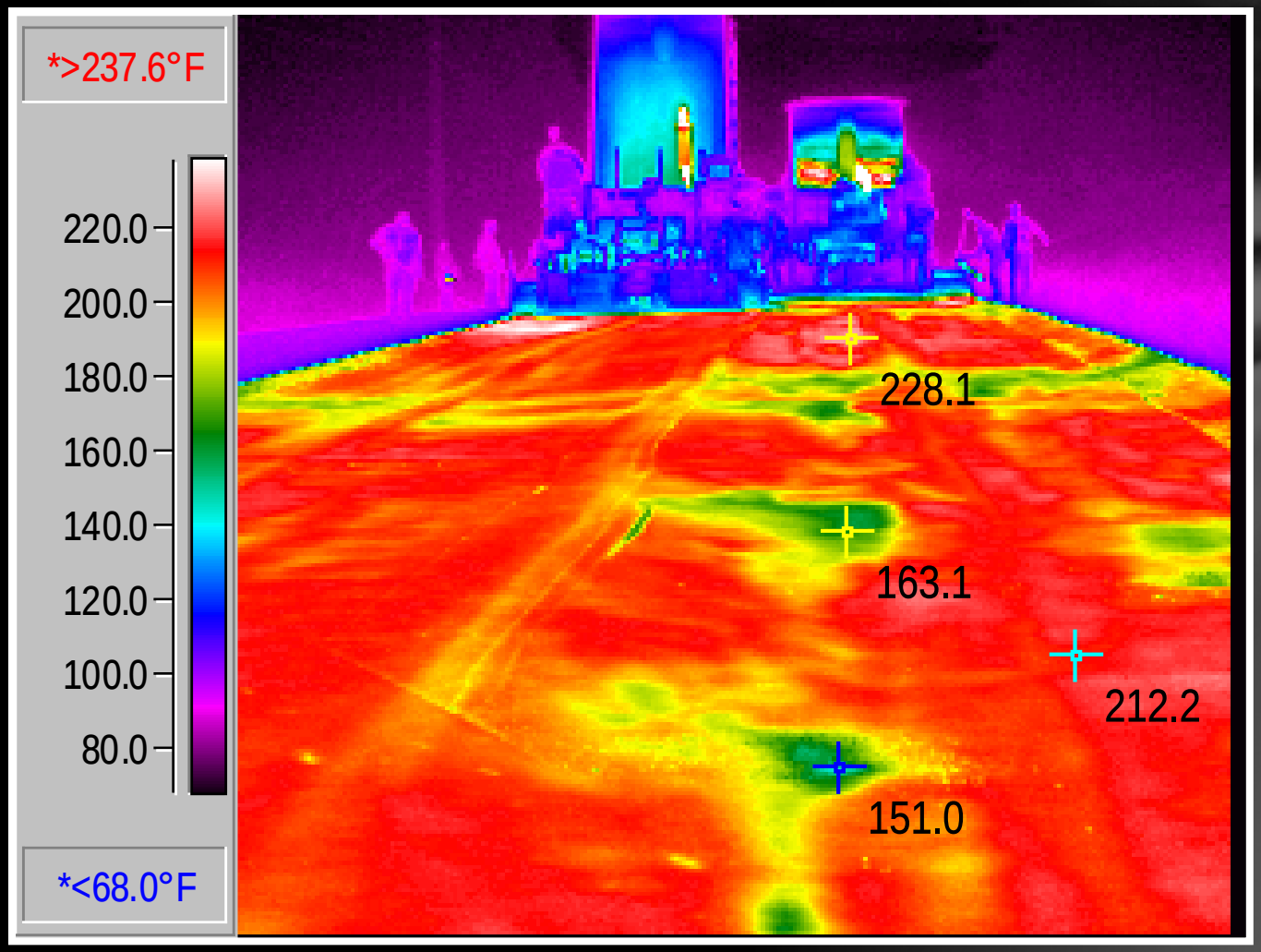
Longitudinal joint solution

Echelon Paving, Part II

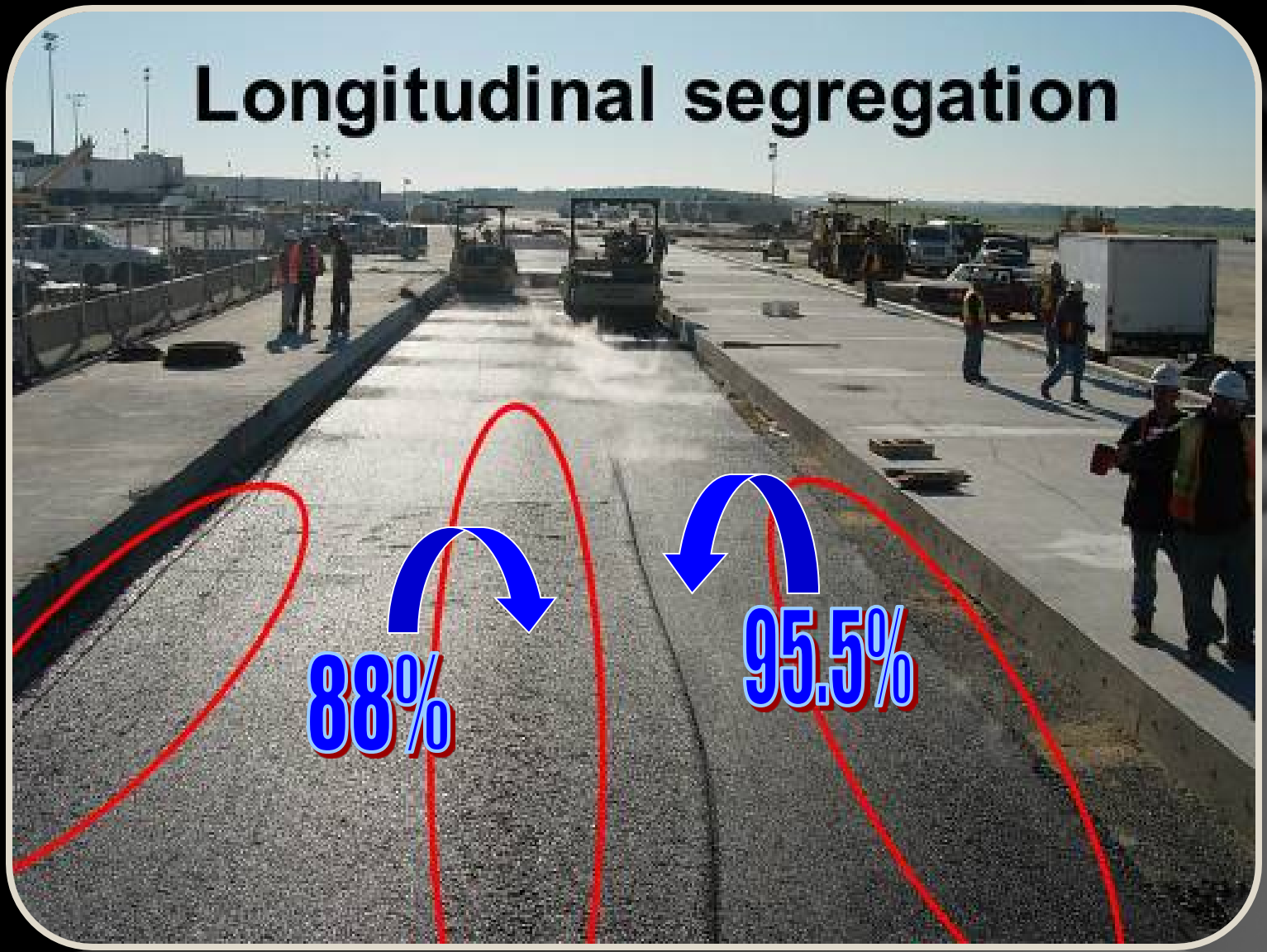
Paver Operation

End of truck load / dumping hopper wings [from afar]

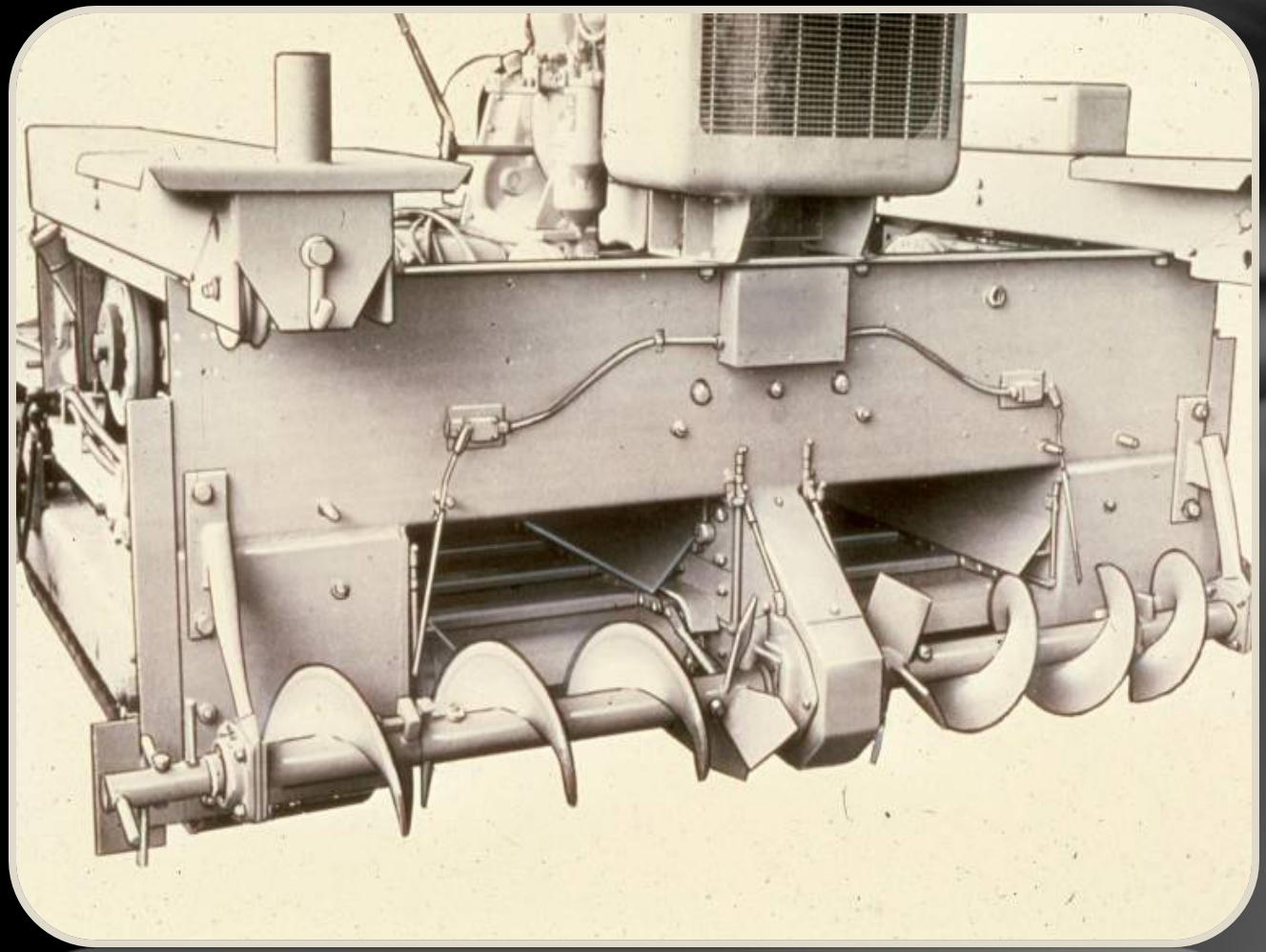
Infrared Photo
(End Dump Mix Behind Paver)



Ingenuity

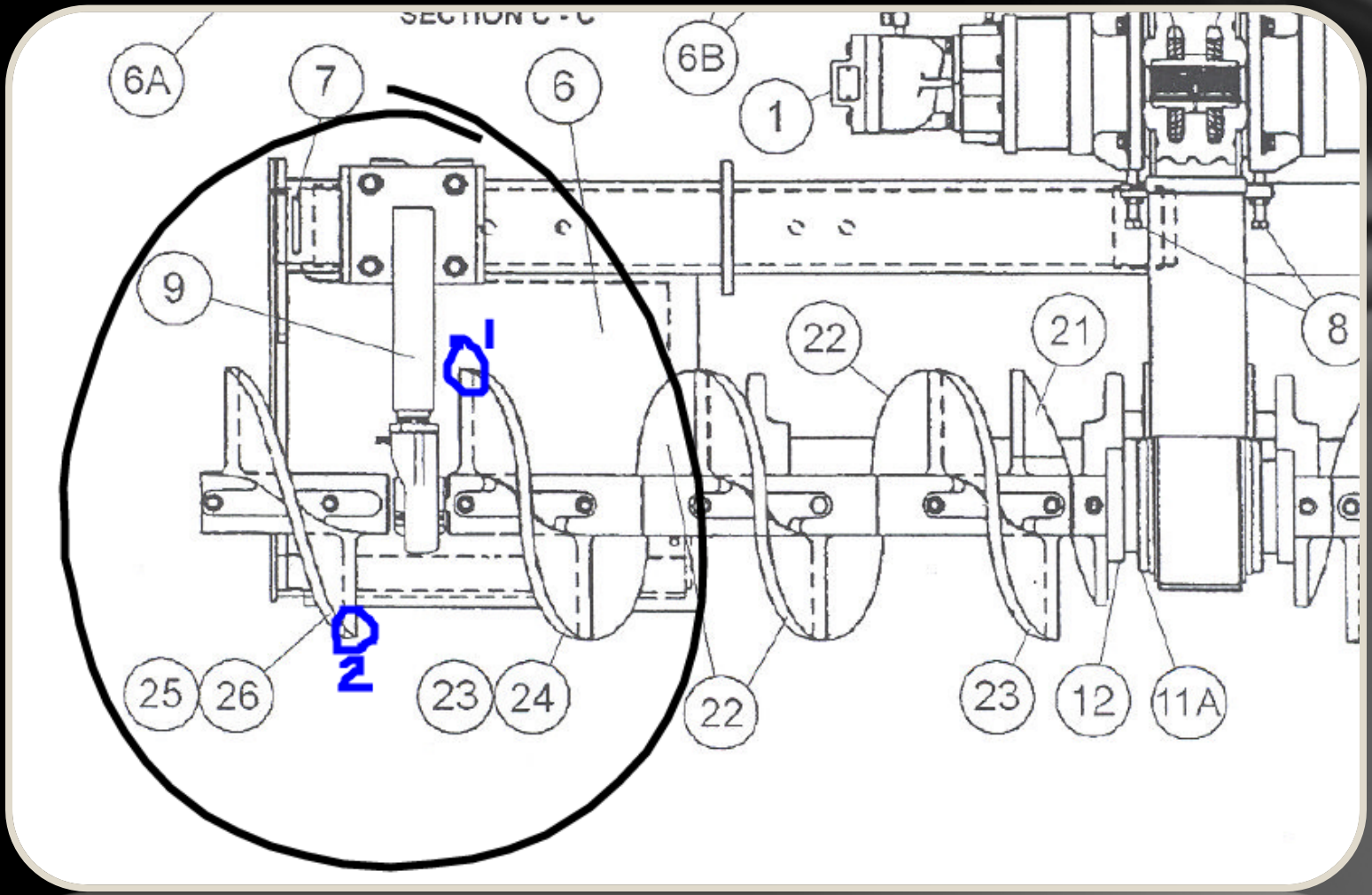

Longitudinal segregation
88%
95.5%

Longitudinal Segregation & Cracking



Auger ‘hold’ point

Bearing / hanger



Tools of the trade

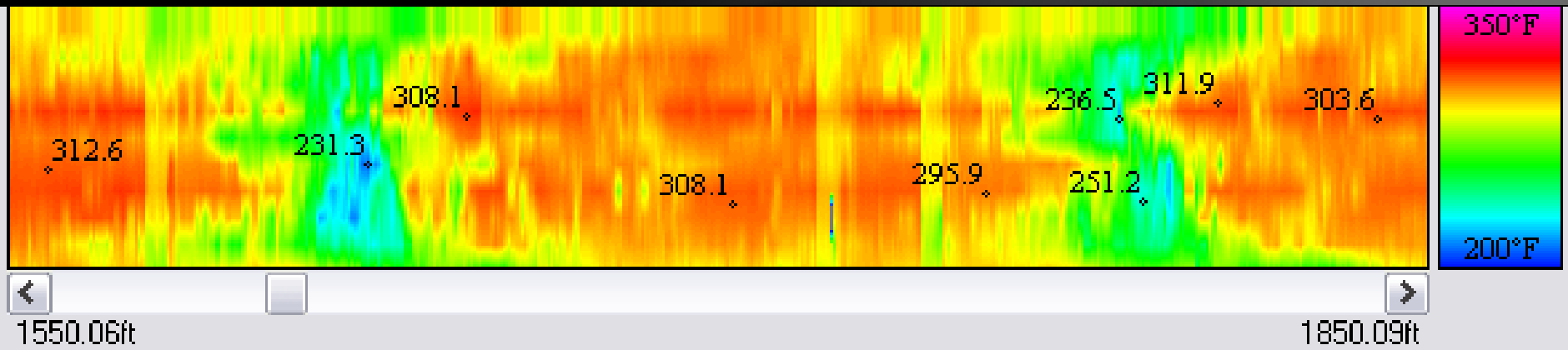
PAVE - IR

Special Thanks to the

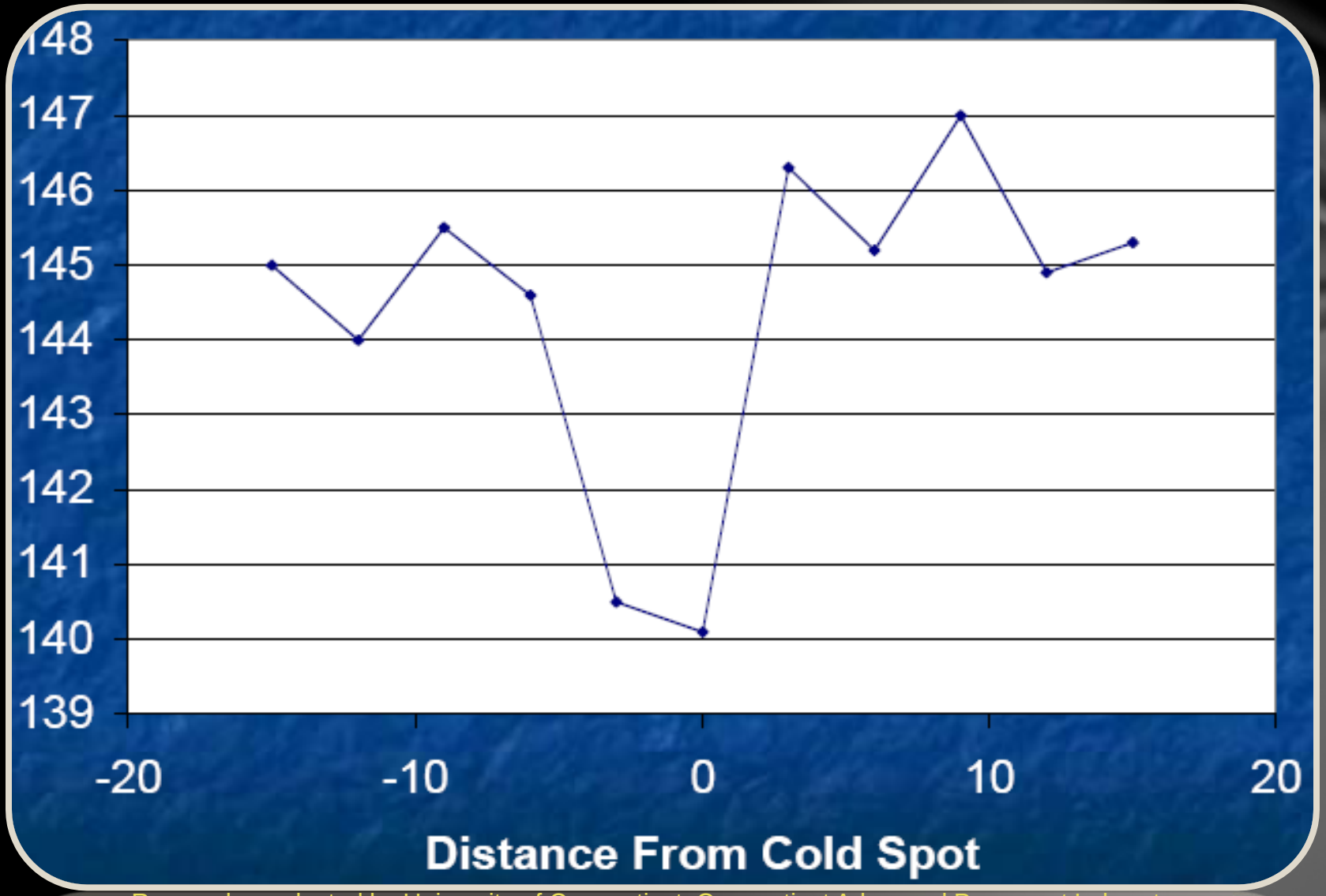
TxDOT – Mr. Dale Rand, P.E.

Why is Thermal Segregation Important?

- **Cold spots typically become low density**
- **Density is the primary contributor to performance**
- **Contractor and agency risk are impacted**
  - **Acceptance and pay schedules are based on density**
  - **Segregated locations may deteriorate prematurely**

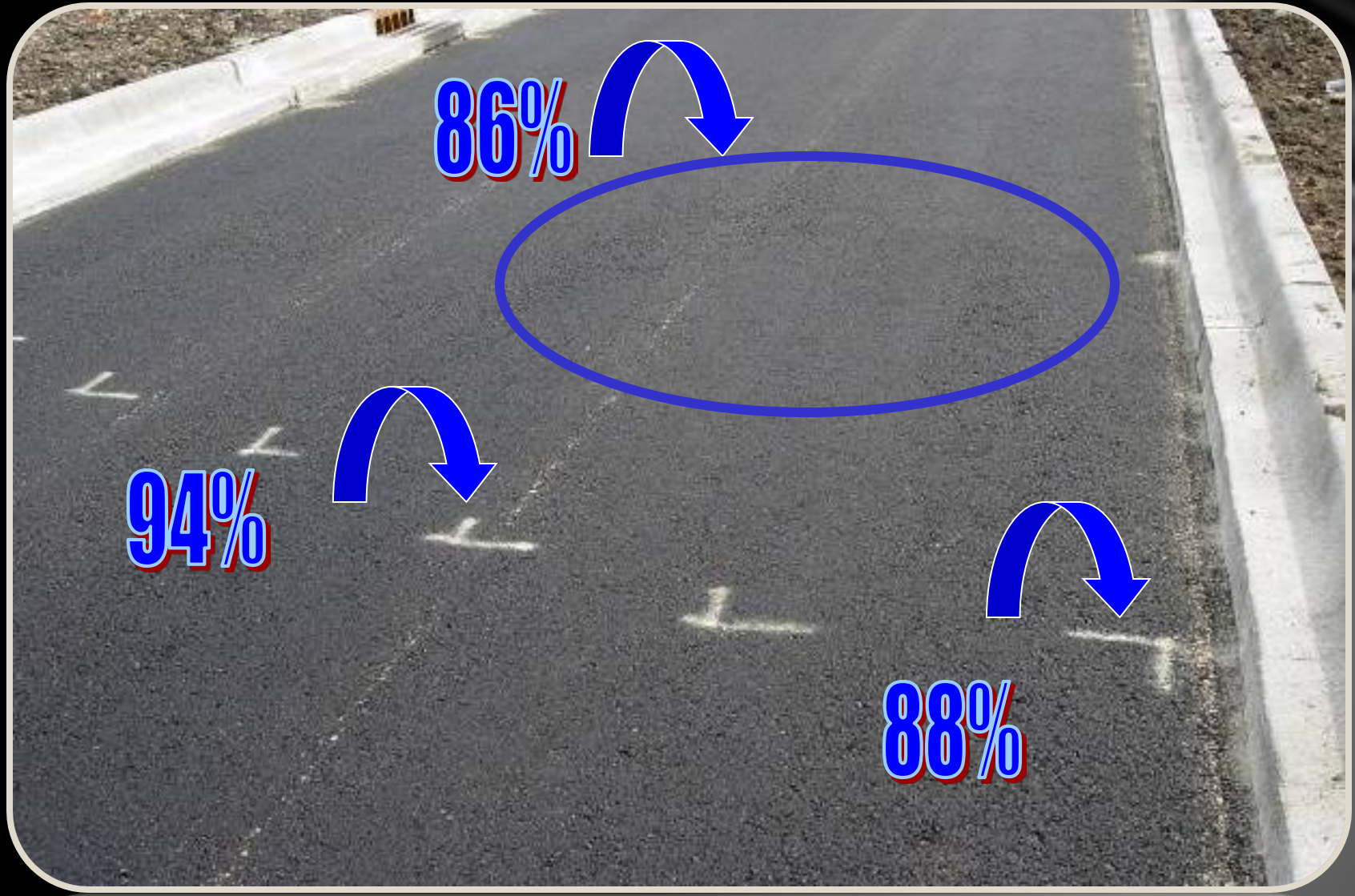


Example of a Density Profile

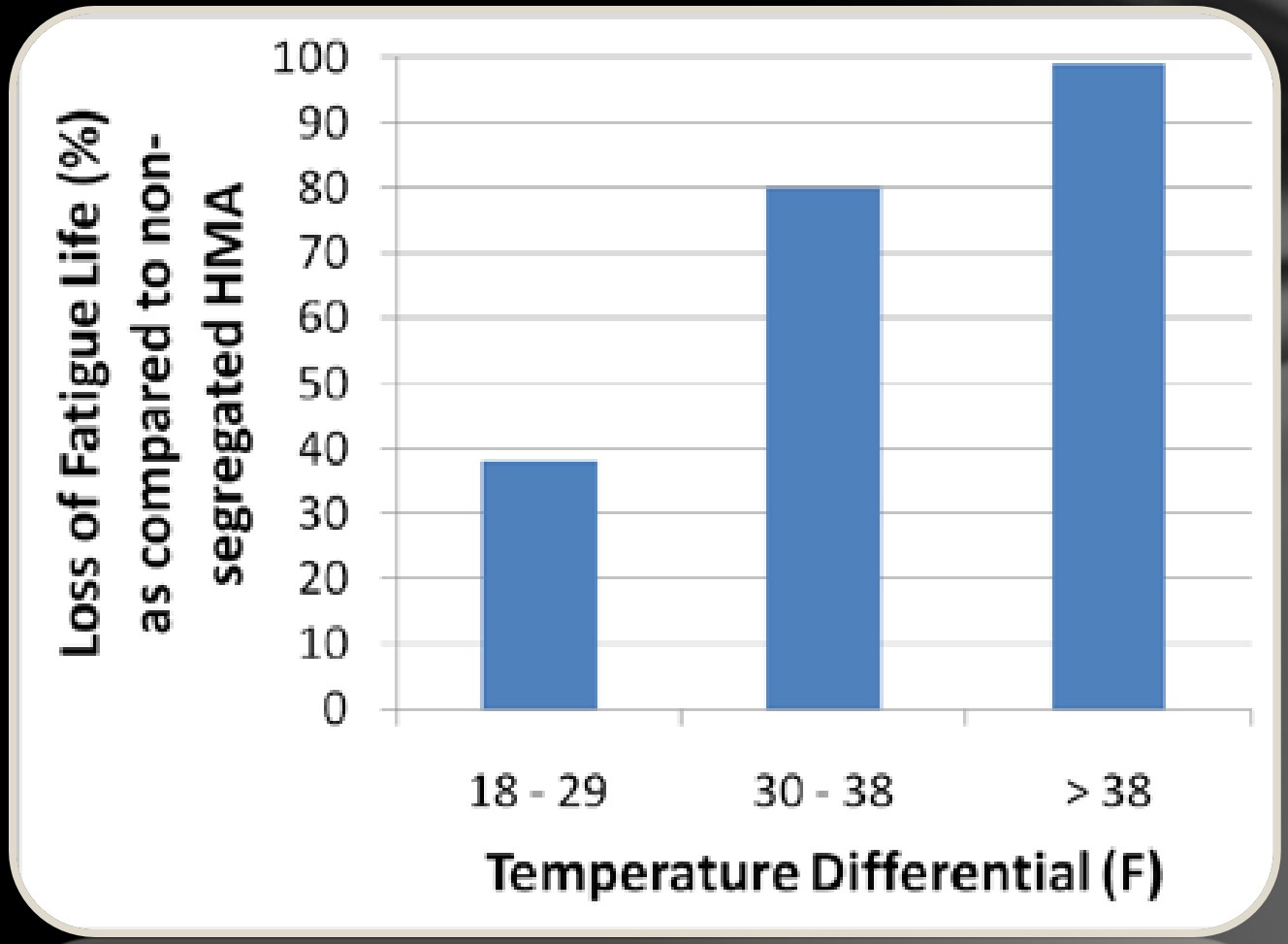


Research conducted by University of Connecticut, Connecticut Advanced Pavement Laboratory

End of truckload segregation

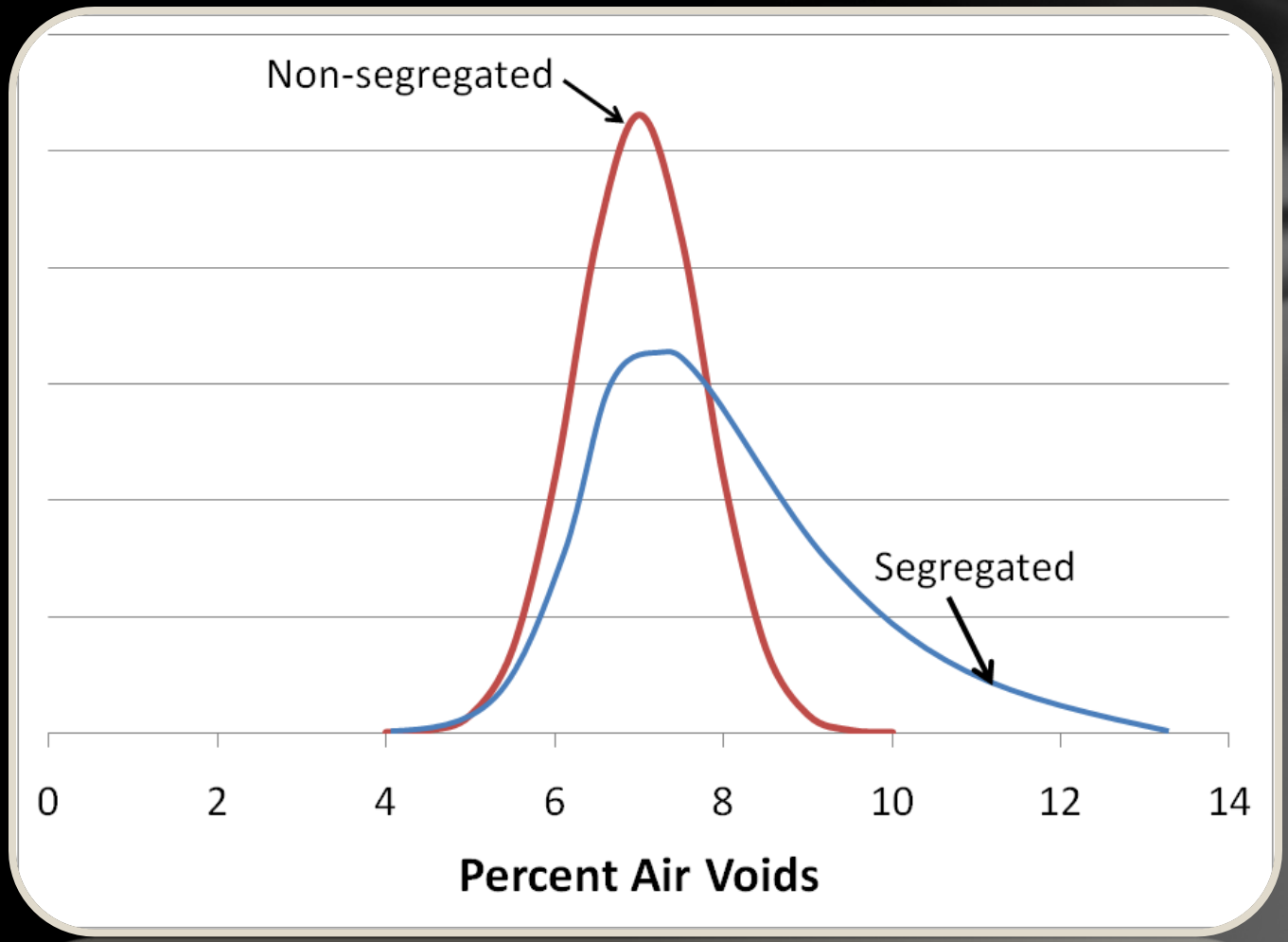


Fatigue Life Substantially Reduced



Source: NCAT (2000)

Sampling Distributions of Segregated and Non-Segregated HMA



Common Methods of Measuring Thermal Segregation

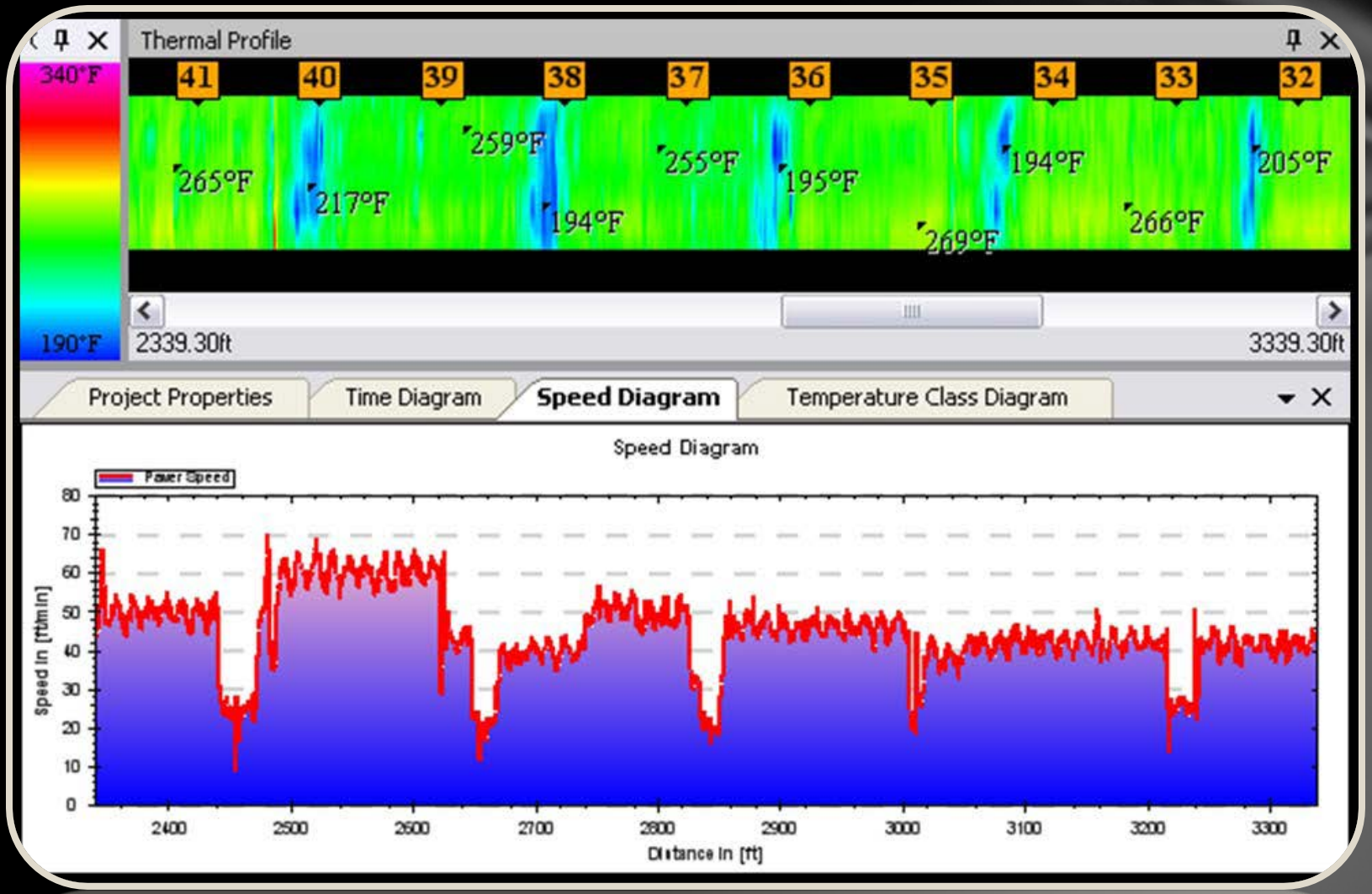
- Infrared Thermometers – less than $200
- Infrared Cameras – less than $5K
- Pave-IR System – less than $30K

Measuring Thermal Segregation

Test Method Tex-244-F

- Handheld IR thermometer
- Thermal camera
- Pave-IR

End dump operation shows cyclic paving speed decrease with cyclic thermal segregation



Background, Use, and Advanced Techniques

Dale Rand (TxDOT)

Richard Izzo (TxDOT)

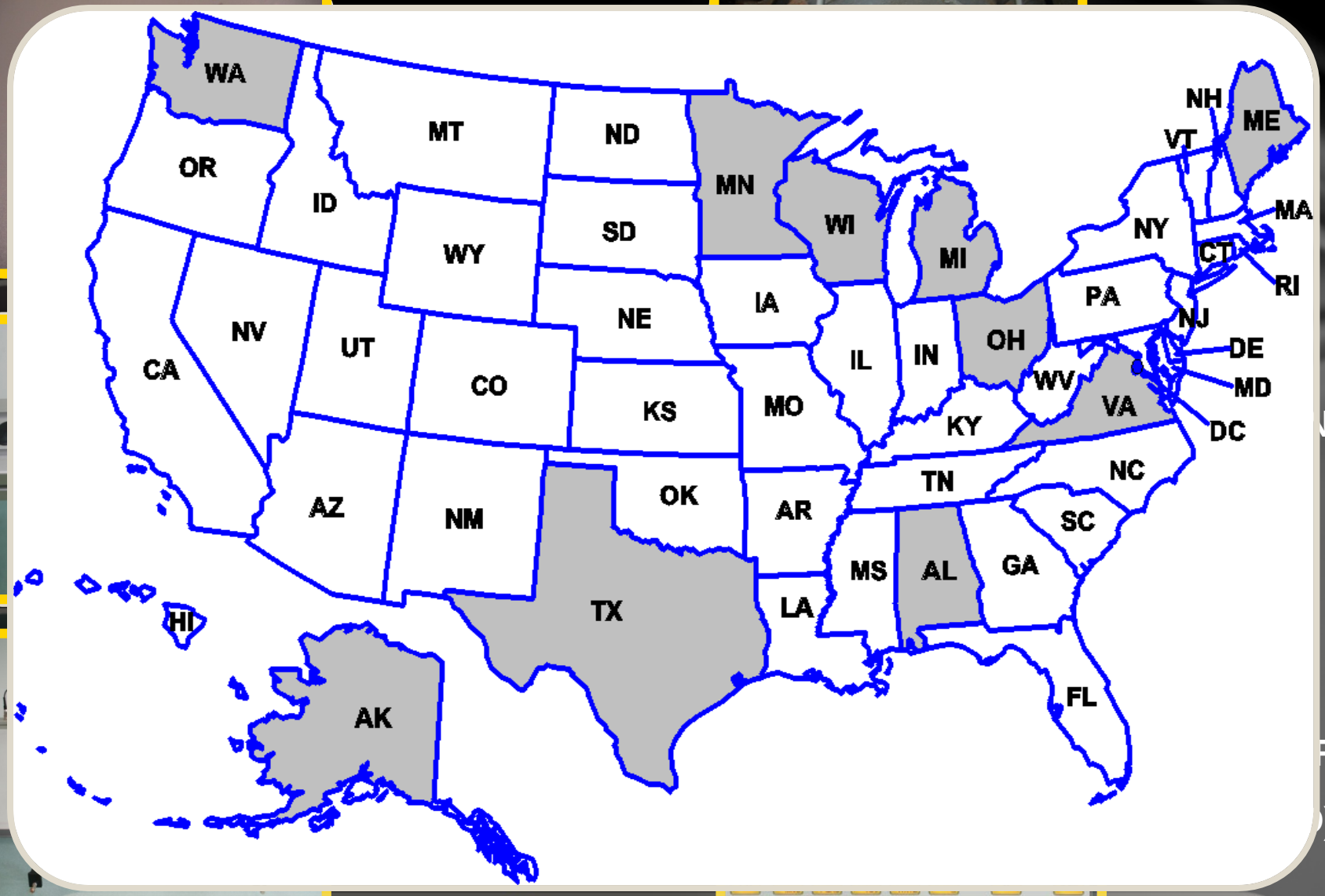
Stephen Sebesta (TTI)

PAVE – IR Conclusions

- TxDOT is implementing better specifications & better techniques to address the problem
- Excellent "Passive Inspection" device that allows end result versus method specifications
- Contractors to see what they are doing and improve their operations
- Contractors can focus on causes & cures

"What Gets Measured Gets Done"

PAVE-IR COMPONENTS



Questions?

tmurphy@murphypavetech.com