# **Best Practices Paving & Compaction**

WEILER Presented by Todd Mansell, CAT Paving **Gregory Poole** CAT HA **Carolina** 

# Outline

#### 1. Balanced Paving

- Paver & Roller Speed
- 2. Paver Setup

#### 3. Density (joints)

- Transverse
- Longitudinal

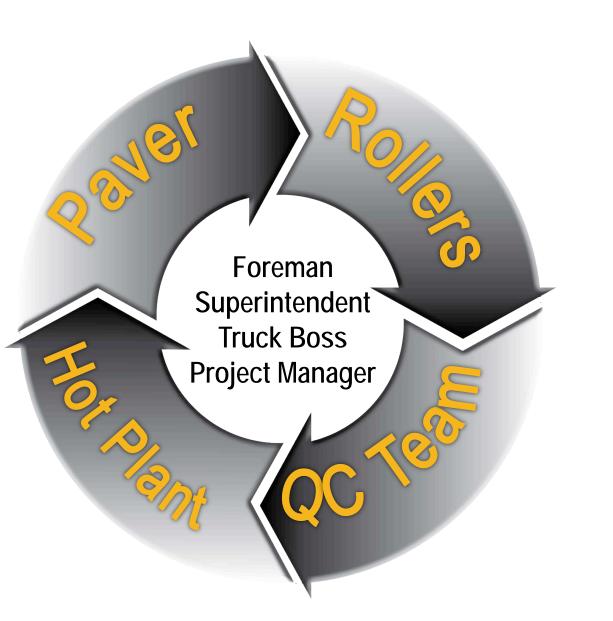


## **Start with Tonnage**



- How many tons of mix can we place today based on plant capacity or job capacity?
- Do we have enough trucks to delivery this tonnage from the plant to the job site?
  - Consider traffic patterns
- Is one paver enough to place?
  - 10-ft paver throughput ≈ 1,700 tph
  - 8-ft paver ≈ 1,100 tph

## **Lines of Communication**



Emergency 911		
Makesno Sense	Project Manager	555-234
Lotsa Iron	Equipment Manager	555-234
Alwayson Myphone	Area Superintendent	555-234
Ihate Timecards	Paving Foreman	555-234
Orange Cone	Traffic Control	555-234
Big Mack	Trucking	555-234
Marshall Hammer	Quality Control Manager	555-234
Thirsty Formore	Water truck	555-234
Reemove Andreplace	DOT Inspector on site	555-234
Hot Mixer	Batch room @ drum plant	555-234
Billitoo Anyjob	Equipment dispatch	555-234
I. Fixit	Mechanic	555-234
		1

# **Balancing Plant, Trucking, Paver, Roller**

- Expected 2,500 tons/day
- 8-hr paving window
- End dumping (18-ton)
- 12-ft wide, unconfined edge
- 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)

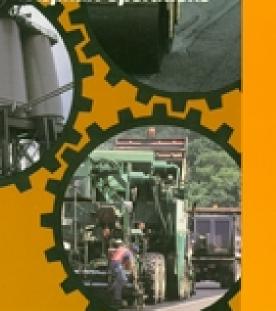


## Planning ≈ 20 minutes

Information Series 120



#### Balancing Production Rates in Hot Mix Asphalt Operations



#### **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
- □ Amplitude Selection App
- □ PaveCool or MultiCool Apps











# **Need 7 pieces of information**

#### CATERPILLAR®

#### **PRODUCTION PLANNING**

0



#### The Production Planning Calculator can be used for project planning prior to the start of paving and compaction.

The calculator will help establish a balance between:

a) Plant output and Trucking;

Introduction

- b) Plant output and Effective Paver Speed; and
- c) Effective Paver Speed and Effective Compactor Speed.

It can also be used to calculate yield per truck or total daily yield. Included is a slope calculator and a windrow dimension calculator.

NOTE: The Production Planning Calculator should not be used for cost estimating. The calculator is designed to assist in project planning and is only as accurate as the raw data entered in the interactive sections. Always verify production estimates obtained from the use of this calculator. Use Paving Production Calculator <u>or</u> 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

# Input 7 pieces of information...

CATERPILLAR®		PRODUCTION PLANNING		
	Trucking Calculator			•
	General Inputs	ENGLISH UNITS	METRICUNITS	
Trucking	Production Rate of Hot Plant	300 tons/hr	272 tonnes/hr	
Paver Speed	Multiple Silo Plants: Initial Storage Paving Hours	100 tons 8.0 hrs	91 tonnes 8.0 hrs	П
Compaction	Truck Capacity <i>(size)</i>	18.0 net tons	16.3 net tonnes	
Windrow	Truck Cycle Times (minutes)		_	
Yield	Load Time and Ticket	6		
	Tarp	4		
Slope	Haul to Job	25		
Thickness	Time on Site	2		
	Dump / Clean	8		
Job Summary	Return Haul		J	
Legal	Truck Cycle Factor (total time in hours)	1.1		
EXIT	Number of Trucks Needed	<mark>19.1</mark>	J	
0 0	f 2.0			_

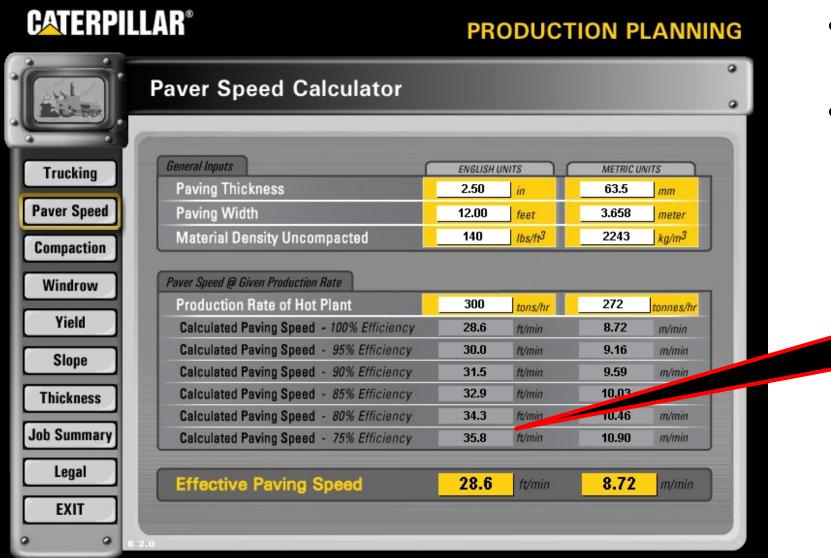
#### **CATERPILLAR® PRODUCTION PLANNING** 0 Paver Speed Calculator 0 General Inputs ENGLISH UNITS METRIC UNITS Trucking **Paving Thickness** 2.50 63.5 mm Paver Speed Paving Width 3.658 12.00 meter Material Density Uncompacted 140 2243 co/m3 Compaction Paver Speed @ Given Production Rate Windrow Production Rate of Hot Plant 272 300 tons/hr tonnes/hr Yield Calculated Paving Speed - 100% Efficiency 28.6 8.72 ft/min m/min Calculated Paving Speed - 95% Efficiency 30.0 9.16 ft/min m/min Slope Calculated Paving Speed - 90% Efficiency 31.5 ft/min 9.59 m/min Calculated Paving Speed - 85% Efficiency 32.9 10.03 Thickness ft/min m/min Calculated Paving Speed - 80% Efficiency 34.3 ft/min 10.46 m/min Job Summary Calculated Paving Speed - 75% Efficiency 35.8 ft/min 10.90 m/min Legal **Effective Paving Speed** 28.6 8.72 ft/min m/min EXIT

Q.

#### **Number of Trucks = 20**

#### **CATERPILLAR®** PRODUCTION PLANNING 0 Trucking Calculator 0 10 20 General Inputs ENGLISH UNITS METRIC UNITS Trucking **Production Rate of Hot Plant** 300 272 tonnes/hr tons/hr Multiple Silo Plants: Initial Storage 91 tonnes **Paver Speed** 100 tons **Paving Hours** 8.0 8.0 hrs hrs Compaction Truck Capacity (size) 18.0 net tons 16.3 net tonnes Windrow Truck Cycle Times (minutes) Load Time and Ticket 6 Yield Tarp 4 Slope Haul to Job 25 Time on Site 2 Thickness Dump / Clean 8 **Job Summary Return Haul** 20 Legal Truck Cycle Factor (total time in hours) 1.1 Number of Trucks Needed 19.1 EXIT 0

#### **Paver speed using end dumps**



 Use 75% efficiency for end-dumping

36 fpm

• Use 100% for MTV

#### Paver Speed, trucking & plant is balanced







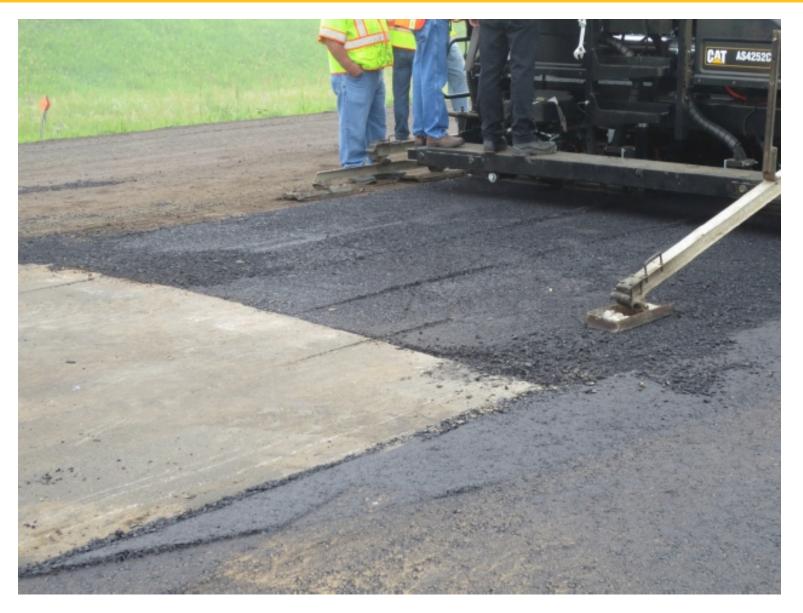
#### Paver: 15 Steps to Setup & Take Off



• Ensures consistent takeoff every time

Goal: To have a smooth transverse joint & no mat defects from the start

#### **Step 1: Heat the Screed**



#### Prevents sticking

### **Step 2: Position Tow Point Cylinders**

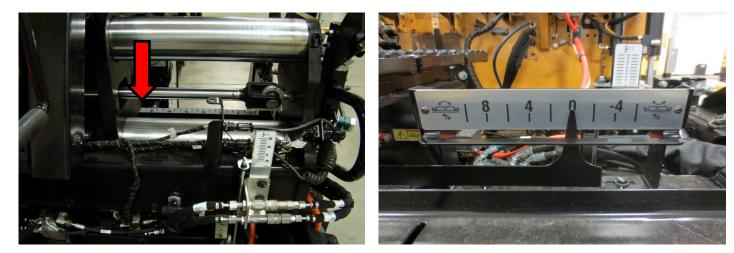


Straight line-of-pull



# **Steps 3 through 6**

- 3. Set paving width
- 4. Set crown
- 5. Set extender height
- 6. Set extender slope







#### **Step 7: Lower Screed**



- Place starter boards = to desired mat thickness
- Lower screed onto starting boards in "float" position
- Take out the slack



# **Step 8: Null the Screed**



- 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

## **Steps 9 through 12**

- 9. Position end gates
- 10. Set auger height
- 11. Position feed sensors
- 12. Set feeder controls (conveyor ratio dial and mix height dial)





### **Step 13: Fill the Auger Chamber**

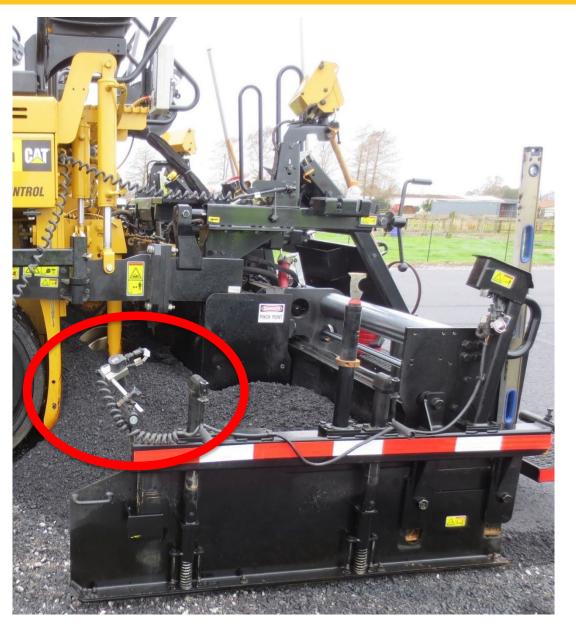


• Fill auger chamber with asphalt mix to 1/2 auger height

• Use conveyors and augers

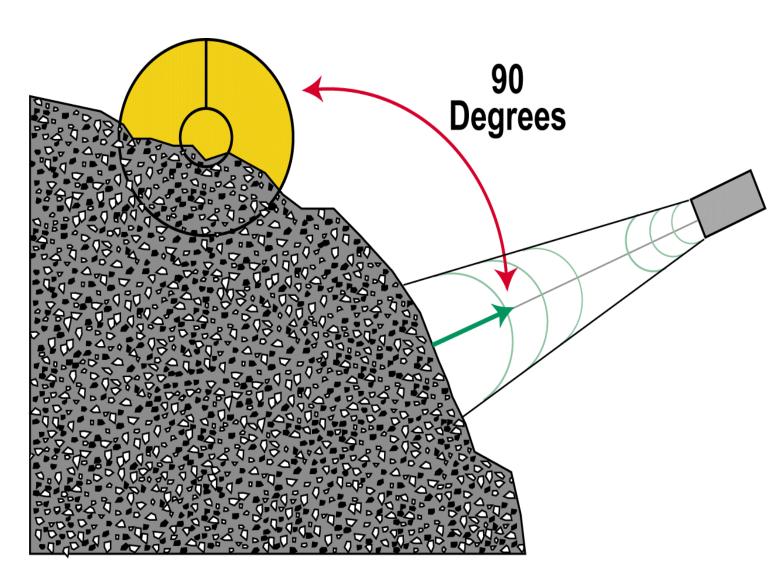
• Do not overfill

# **Feed Sensors**



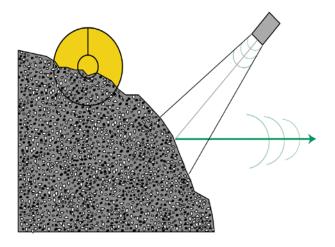
- Mechanical or sonic
- Control level of material
- Position Sensor 18" from end of augers

#### **Sonic Feed Sensors**



#### Sonic Sensor Mounting Distance

- Mounting position at 18"
- Working range of sonic sensor 12" – 32"



#### Steps 14

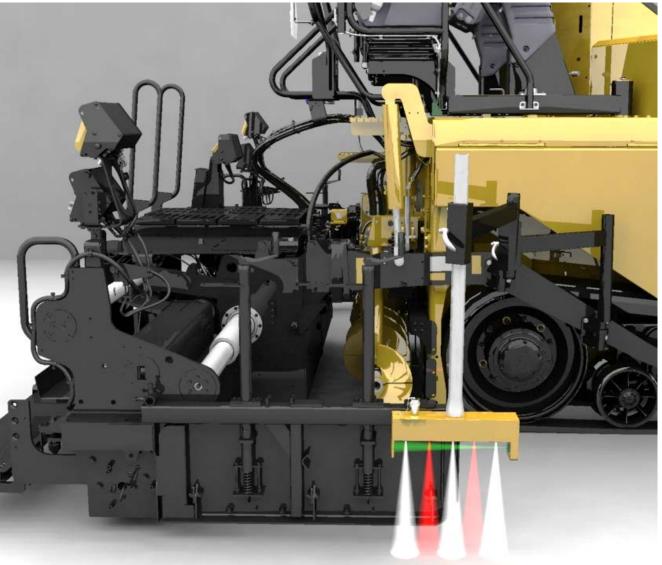


Setup automatic Grade & Slope control (if using)

#### **Step 14: Set Automatic Grade Control**



#### **Joint Match**



#### **Step 14: Set Automatic Grade Control**



#### Smooth



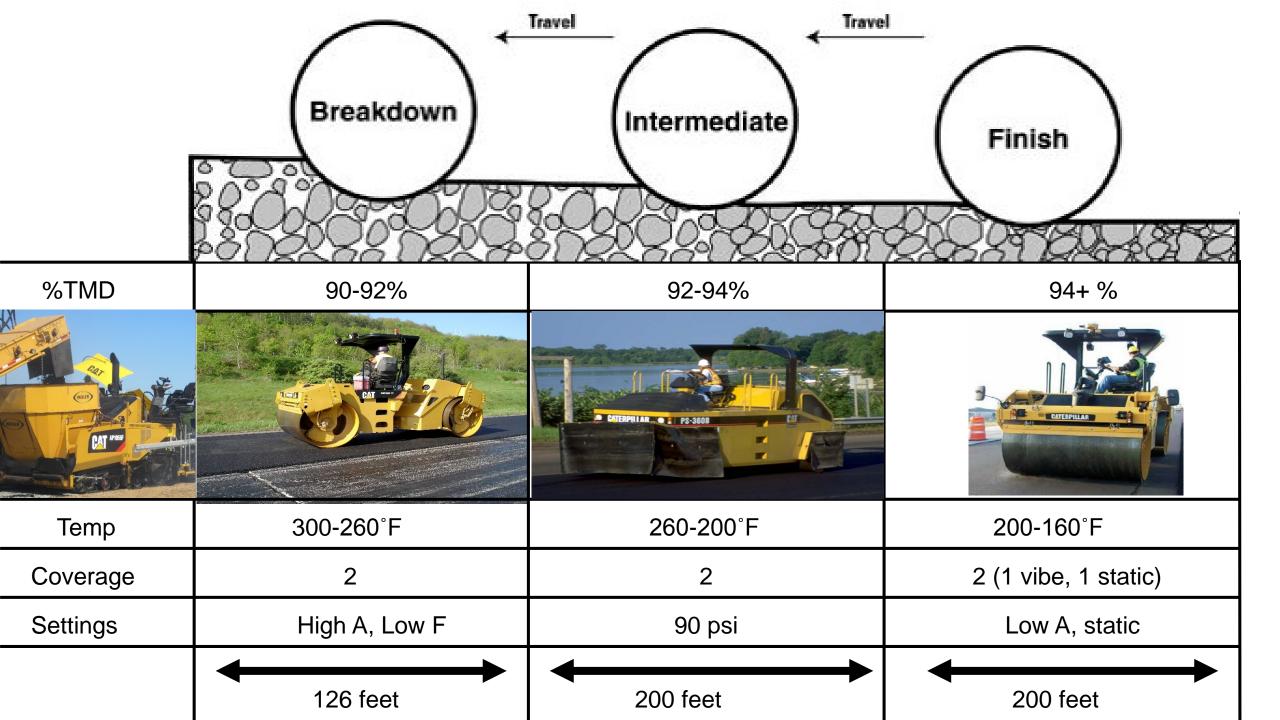
#### Steps 15



- Pull off starting boards and quickly get to paving speed
- Check mix feed
- Check auger speed
- Check for lines in mat







#### Now, let's look at roller settings

- 1 x Cat CB64 (84" wide drum)
- 1 x Cat CB54-XW (79" wide drum)
- 1 x Cat CW34 (82" compaction width)





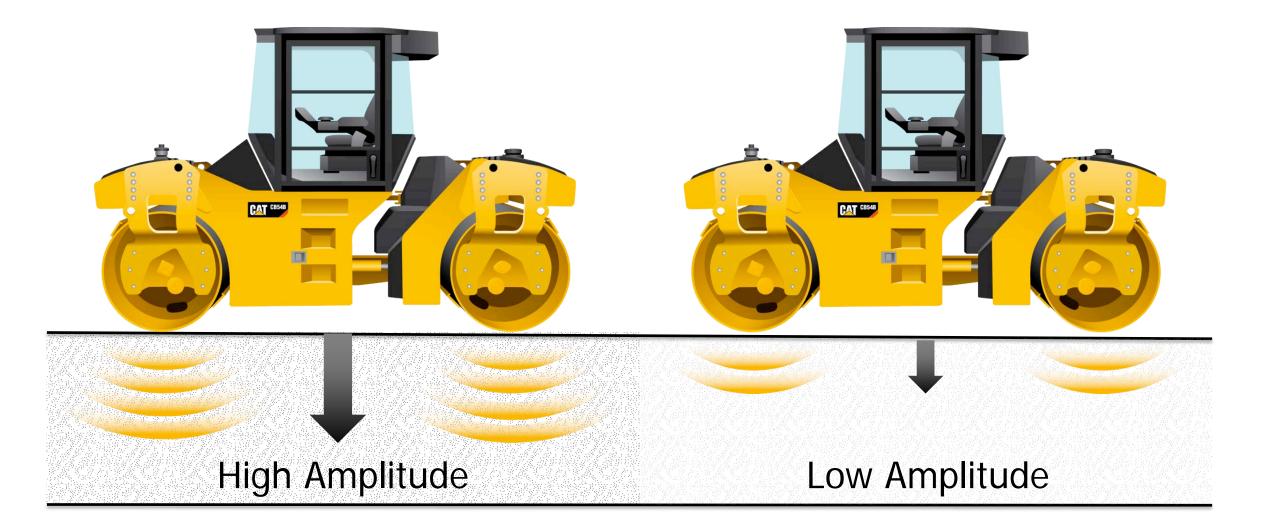
### **Vibratory Steel Drum**



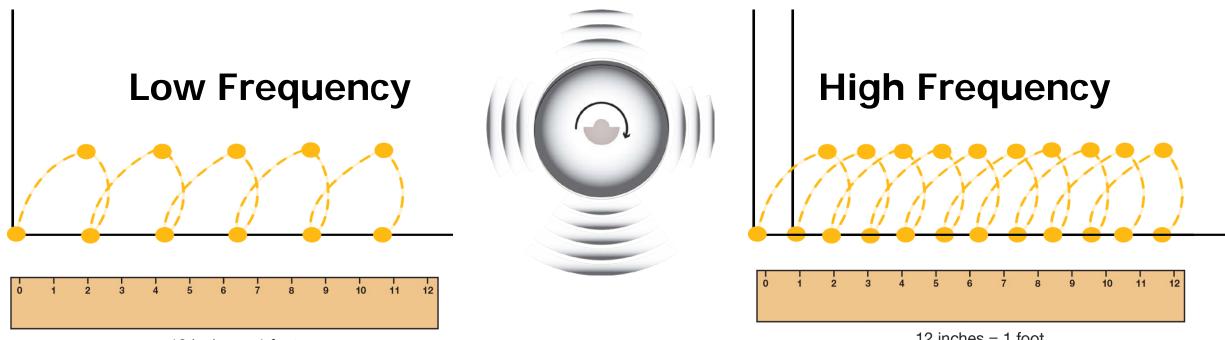
• Breakdown, intermediate and finish rolling

- Settings for amplitude and frequency
- Static mode for finish rolling

#### **Amplitude = compactive effort**



#### Frequency = speed x impacts per foot



12 inches = 1 foot

12 inches = 1 foot

#### **Roller speed is constant**

## Impacts per foot, Frequency & Roller Speed



# **Balancing Plant, Trucking, Paver, Roller**

- Expected 2,500 tons/day
- 8-hr paving window
- End dumping (18-ton)
- 12-ft wide, unconfined edge
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- 12.5mm polymer-modified mix
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  - 84" steel vibratory (Cat CB64)
  - 79" steel vibratory (Cat CB54XW)
  - 82" pneumatic (Cat CW34)



#### **Breakdown Compaction**

- Develops the majority of the density in the asphalt layer
- Works immediately behind the paver where asphalt is the hottest
- Must match the production / speed of the paver



The initial phase roller works close to the paver.

# What is a good target density for breakdown?



• Job spec is 92-97%

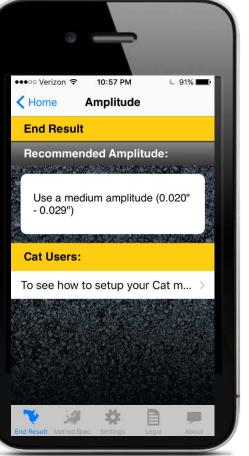
- Our job target for final density is 94%
- A good goal for <u>breakdown</u> <u>compaction</u> is 95% of our overall target density

0.95 x 94% ≈ 90%

#### Amplitude App ≈ 0.020" – 0.029"





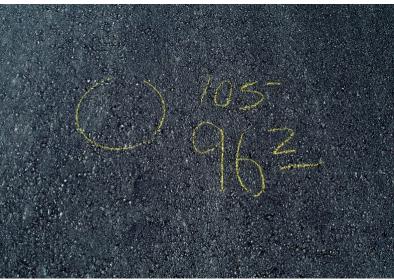






### **Test Strips**





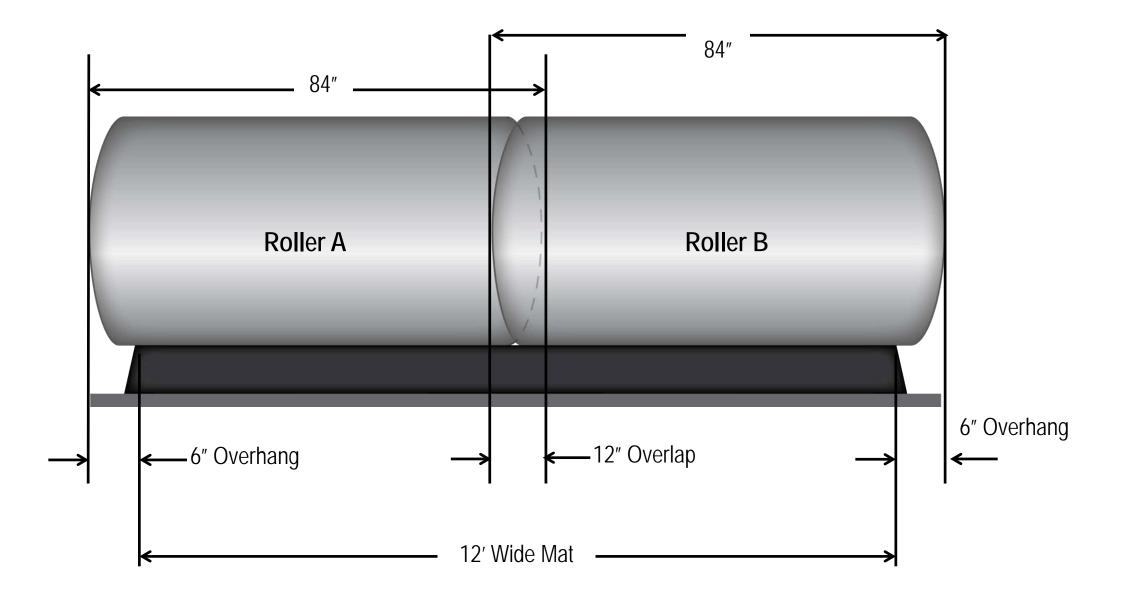


- Verify equipment and patterns develop required density
- Plan each phase of compaction
- Can be done first day of job
  - Sometimes required in advance
  - Don't fake it
- Communicate plan to all crew members

### Number of roller passes

		Breakdown	Intermediate	Finish
	<b>├</b>	12-ton DDV	14-ton tire	8-ton DDV
Settings		High A, Low F		1 vibe, low A, high F, 1 static
1 <sup>st</sup> Pass	Temp	275	250	200
	Density	88%	92%	94% (vibe)
2 <sup>nd</sup> Pass	Temp	260	245	193
	Density	90%	93%	94% (static)
3 <sup>rd</sup> Pass	Temp	252	230	
	Density	91%	93.5%	
4 <sup>th</sup> Pass	Temp			
	Density			

### 12-Foot Wide Lane: 84" x 2 passes



## Amplitude 0.020"- 0.029" for 84" drum machine

Versa Vibe™ Vibratory System					<b>CB64</b>		
Frequency: 42 Hz (2,520 vpm) Nominal Amplitude	)	B54	CB5/	1 XW	CB	64	
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

# **Roller speed using 84" drum**

CATERPILLAR®			PRODUCTION PLANNING				
	Compaction Calculator				9		
Trucking	Roller Model Click to Select Another Model	СВ	64	)			
	General Inputs	ENGLISH UN		METRIC UNITS			
Paver Speed	Paving Width	12.00	feet	3.658 meter			
Compaction	Actual Drum Width	84.00	in	213.36			
oompaoaon (	Amount of Overlap	6.0	in	15.2 cm			
Windrow	Speed of Vibrator	2520	VPM	2520 VPM			
Yield	Impacts (recommeded: 8 - 14 per foot )	10	per ft	33 per m			
	Number of Passes to Cover Mat Width Ond	ce	2		-		
Slope	Number of Repeat Passes (from test strip)	Number of Repeat Passes (from test strip)					
Thickness	Total Number of Passes		5				
THICKICSS	Roller Efficiency Rate (recommended 75 to 85%)		80				
ob Summary Legal	Actual Roller Speed 252 FP	м 73	мРМ	Effective Paver Speed			
Leyal	Effective Roller Speed* 40 FP	MPM	8.72 m/				
EXIT	• Effective Roller Speed should be at least 100% but no more than	115% of the Effe	ctive Paver Spee	d. %* = <b>140</b>			

- Wider drum
- Lower frequency
- Higher amplitude
- 5-Pass pattern



### 40 fpm > 36 fpm

## **Establish an effective rolling pattern**



1. Based production and density

2. Equipment Selection

**Decision Point** 

3. Balance paver & roller speed



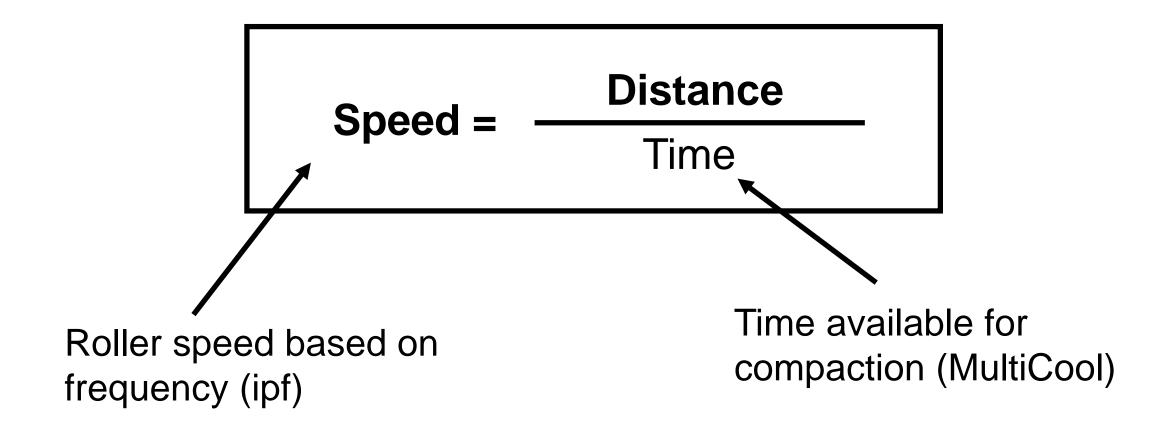
4. Test Strip

5. Verify during production

### How far back ?? Breakdown



### **Length of the Roller Pass**



### Solve the equation for distance

### **Length of the Roller Pass**

# Distance = Speed x Time

### **Roller Ground Speed**

# Distance = Speed x Time

#### **Speed Calculation**

Frequency = 2,520 vpm

We want 10 impacts per foot

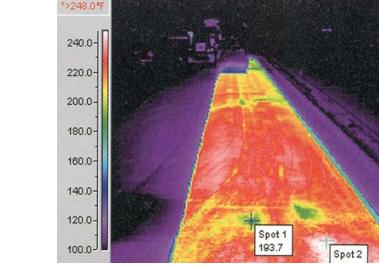
## **Time Depends on Temperature**

300 - 260 Breakdown rolling260 - 220 Intermediate rolling

240 - 190 possible tender zone220 - 160 Finish rolling

**160 – Stop rolling** 

Keep steel drums off the mix!!!





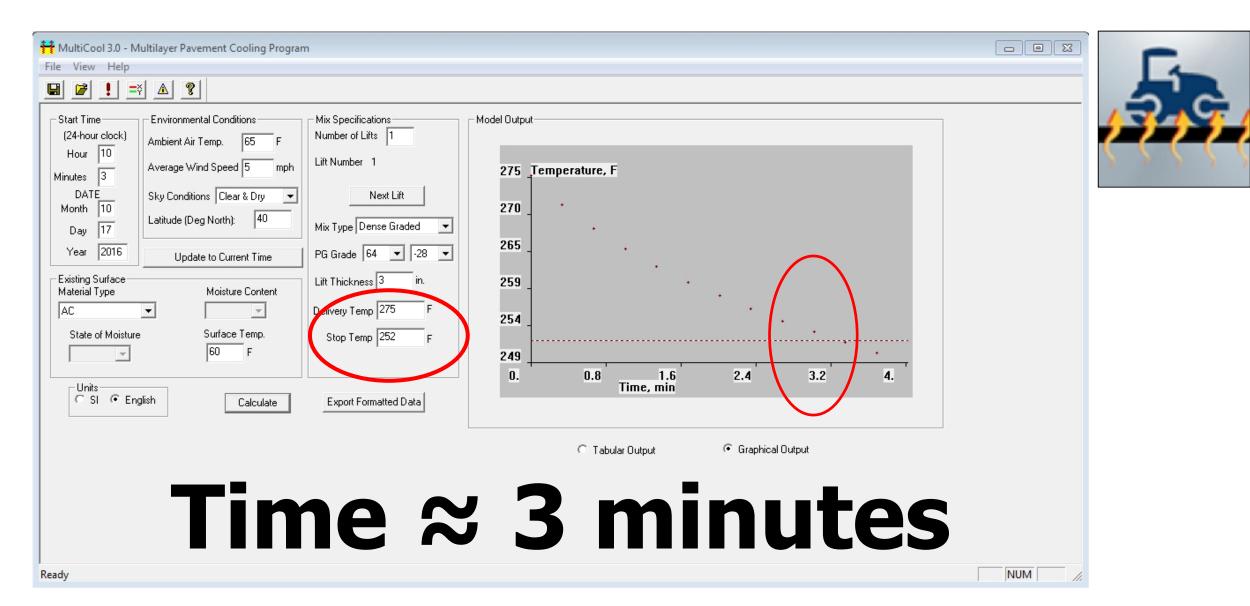
## **MultiCool** Website and Android App

- Google Play App store
- http://www.eng.auburn.edu/users/timmdav/MultiCool/FinalRelease/Main.html

	MultiCool
About	About MultiCool:
1: General Info	MultiCool is an asphalt pavement cooling prediction program for use during construction. Funding for this app was provided by the National
2: Existing Surface	Asphalt Pavement Association. MultiCool is meant to estimate how rapidly a freshly-placed mat will cool as a function of the initial mat
3: Mix Specifications	temperature, ambient conditions, mat thickness and other properties. The cooling rate prediction can help contractors better plan their rolling operations to more efficiently achieve target mat density. MultiCool has been validated in cold (Minnesota) and warm (California and
4: Results	Alabama) climates for typical Superpave mixtures, stone matrix asphalt (SMA) mixes, warm mix asphalt (WMA), reclaimed asphalt pavement (RAP), reclaimed asphalt shingle (RAS) and ground tire rubber (GTR) mixtures. Though it has been validated, in no event will the authors of
5: Raw Data	this program be liable to you or any other person for any damages, expenses, lost profits, lost savings, or other damages arising out of use or
References	inability to use this program.
Mobile	By using this application, you agree to the preceding statement.

PaveCool

## MultiCool from 275°F to 252°F (breakdown roller only)



Roller speed = 252 fpm Time = 3 minutes

# Distance = Speed x Time

- = 252 x 3
- = 756 ft (in 3 minutes)

# Length of the Roller Pass

756 feet traveled in 3 minutes

We have a 5-pass pattern (from test strip) to cover the mat twice

 $756 \div 5 = 151$  feet

Assume 80% roller efficiency

 $151 \times 0.80 = 120$ 

Pass 1 Pass 2

Length of roller pass = **120 feet** 

\*\* If conditions change – re-calculate the length of roller pass

# **Sequence & Timing**

	Breakdown	Intermediate	Finish
%TMD	90-92%	92-94%	94+ %
		CATERPILLAR DE LE SOB	
Temp	300-260°F	260-200°F	200-160°F
Coverage	2	2	2 (static)
Settings	High A, Low F	90 psi	Low A, static
	120 feet	200 feet	200 feet

### To do all this...we need good base!!





### **Joint Compaction Techniques & Issues**





#### **Transverse Joints**

#### **Longitudinal Joints**

### **Transverse Joint Compaction**









### **Transverse Joint Compaction**



- Straight edge tells the story
- Too high more rolling may help
- Too low hand work needed to fill in

## **Poor Transverse Joint Starting Point**



### Incorrect Starting Reference

- Rounded face at the joint
- Plunge cut too deep

### **Good Transverse Joint Starting Point**

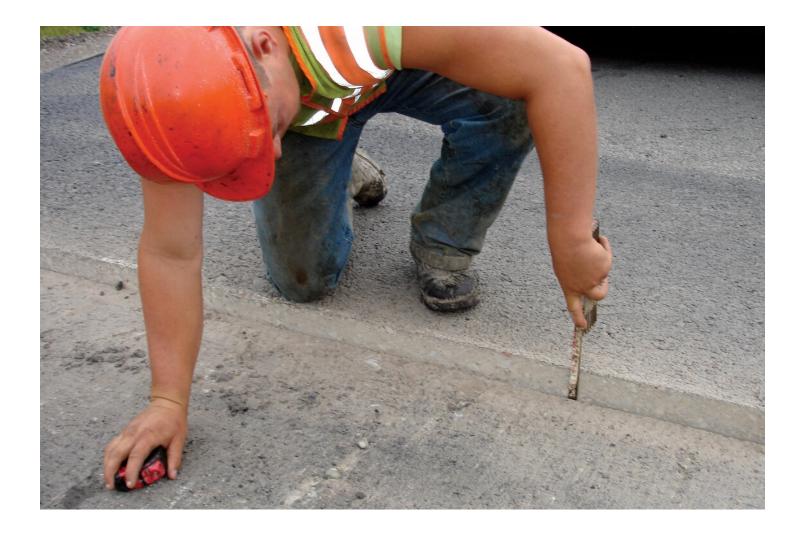




- Cut straight starting joint
- Butt joint flat

- Tack butt joint
- Clean area where screed will rest

## **Good Transverse Joint Starting Point**



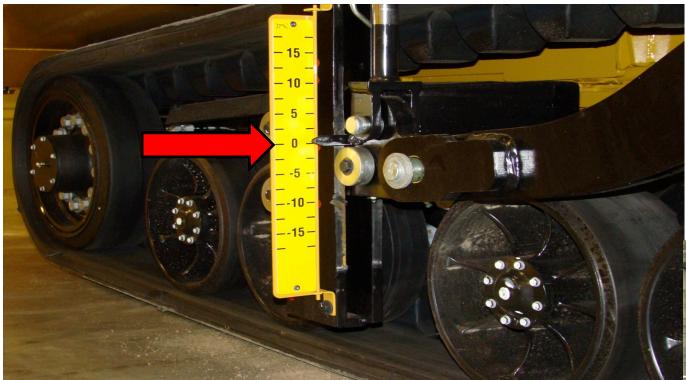
- Measure height of starting joint
- Calculate thickness of starter boards
- General rule vibratory screed:
  6 mm (0.25in) compaction per 25 mm (1.0in) loose depth

### **Correct Pre-Compaction Height**



- Select starter boards of proper thickness
- Support main screed and extender screed
- Board length
  0.9-1.2 m (3-4ft)
- Start with good paving and minimal hand work
- Mat depth must allow for rate of compaction
- Rule of thumb: ¼ in of compaction for each 1 in mat depth

### **Correct Line of Pull**



- Adjust both tow point cylinders to match the height of the screed pivot point
- Helps screed come off starting joint parallel to line of paving



## **Keep Correct Head of Material**



- Screed personnel check material level at outboard end of augers
- Adjust mix height controls if needed to maintain material level at 1/2 auger
- No voids

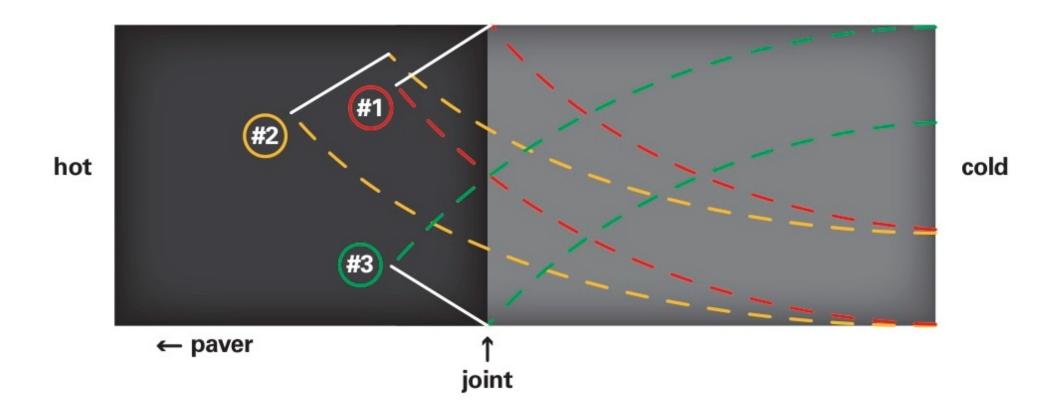
## **Good Transverse Joint Starting Point**

- Minimum hand work is the goal
- Fill in low areas prior to compaction
- Rake off high spots prior to compaction





- Initial phase compactor starts normal pattern
- Paver should not have to stop and wait for joint to be prepared and compacted

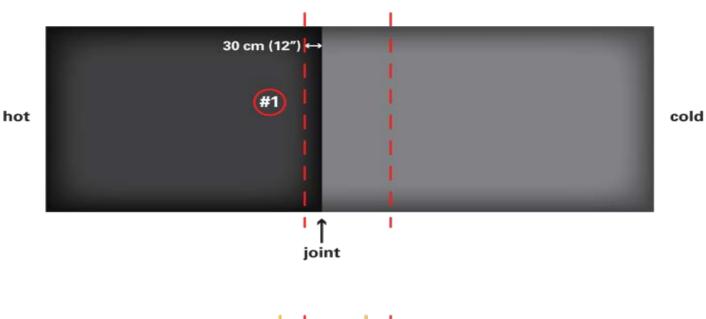


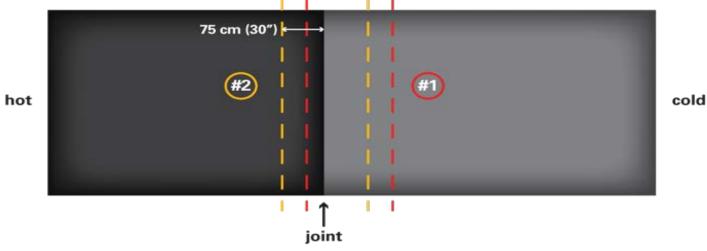
- Pinches joint at angle rather than pushing hot mix away
- All stop marks can be cleaned up during first normal rolling pattern
- Pattern is always available for operator

- Can pinch joint from the side if space permits
- Utility size compactor makes job easier
- Leaves drum edge cut mark perpendicular to direction of rolling pattern









- First pass most of drums on cold side
- Check flatness
- Second pass, if needed, move farther onto hot side
- All passes static
- Should not have to vibrate to pinch a transverse joint

# Longitudinal Joint Techniques & Issues



## Longitudinal Joint -- Build it Right



#### **Build Joint Correctly**

- Paver leaves straight edge to match
- Makes consistent joint overlap possible
- Can use edge cutter



## Joint Overlap / Joint Height



- End gate overlap 1 inch
- Precompaction height ¼ in per inch of mat thickness
- No raking required
- Can use averaging ski or joint matcher

# **Overlap**

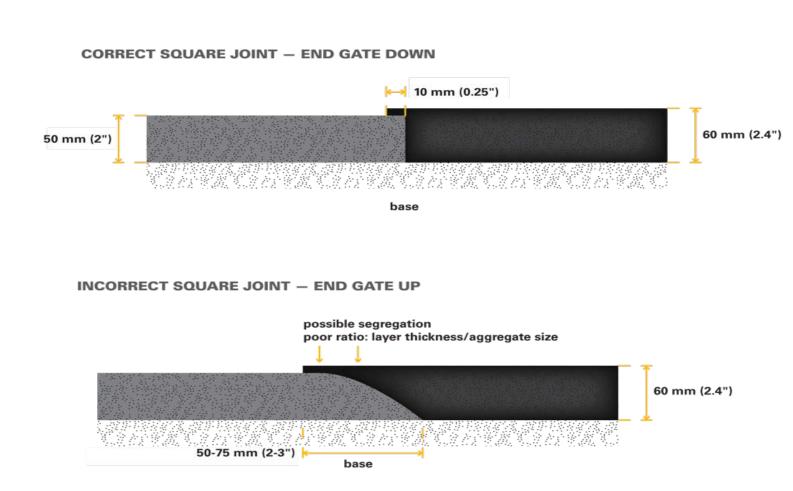


#### Good overlap

Too much overlap

J.A. Scherocman

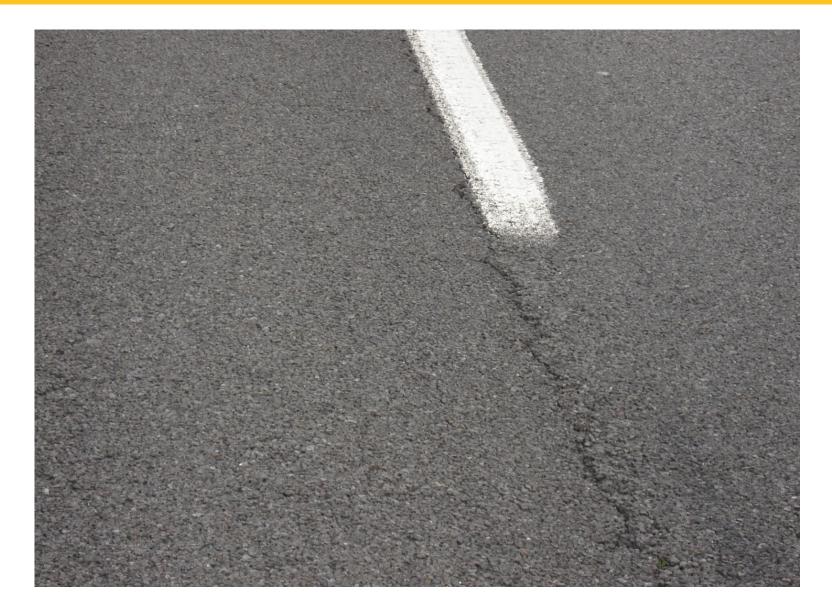
#### **End Gate Overlap**



#### **Build Joint Correctly**

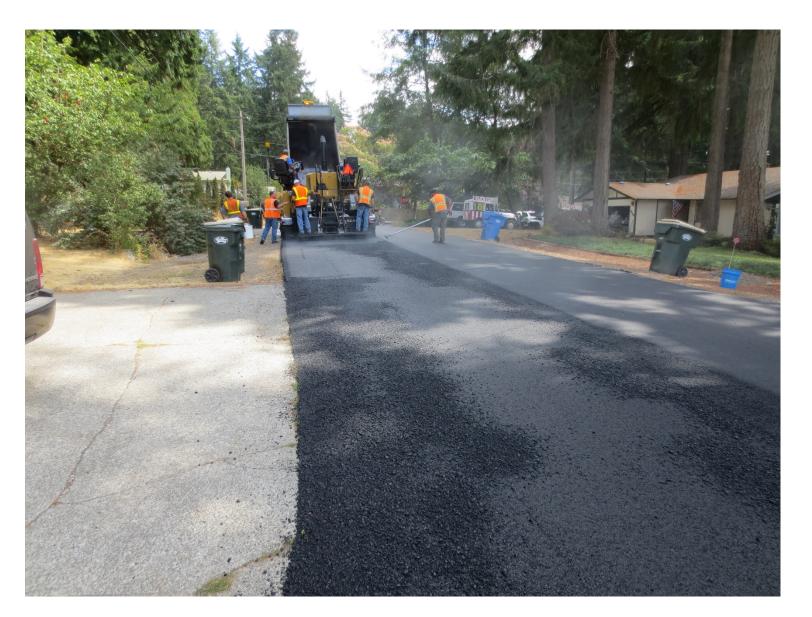
- End gate down to create straight edge
- Overlap cold side 10 mm (1/4in)
- Correct pre-compaction height
- End gate up causes rounded edge, segregation and fractured aggregate

#### **Excessive Overlap**



- Poor compaction, loose rock at joint
- Joint needed raking prior to compaction
- Real solution is to control end gate overlap

# **Raking is not the Answer**



- Creates segregation at the joint
- Pushes mix away from the joint
- Light "bumping" is acceptable

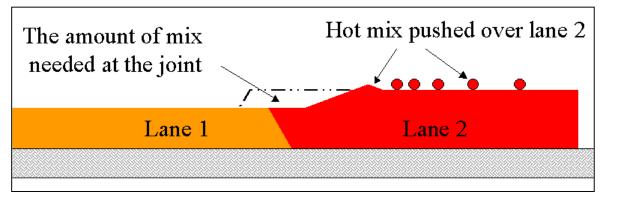
# **Bumping the joint**

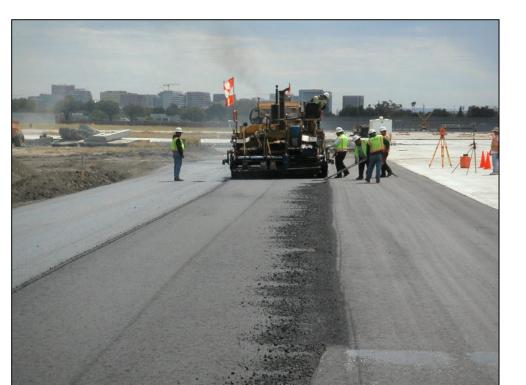


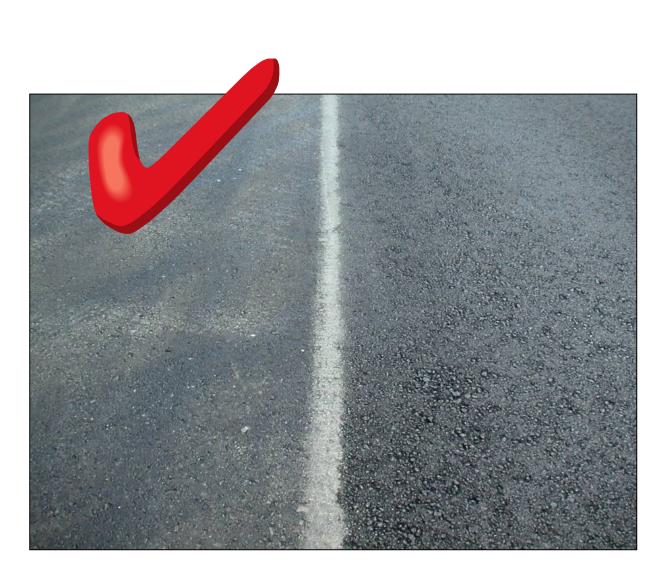
 Light bumping of the joint with coarse mixes

Dr. Ray Brown

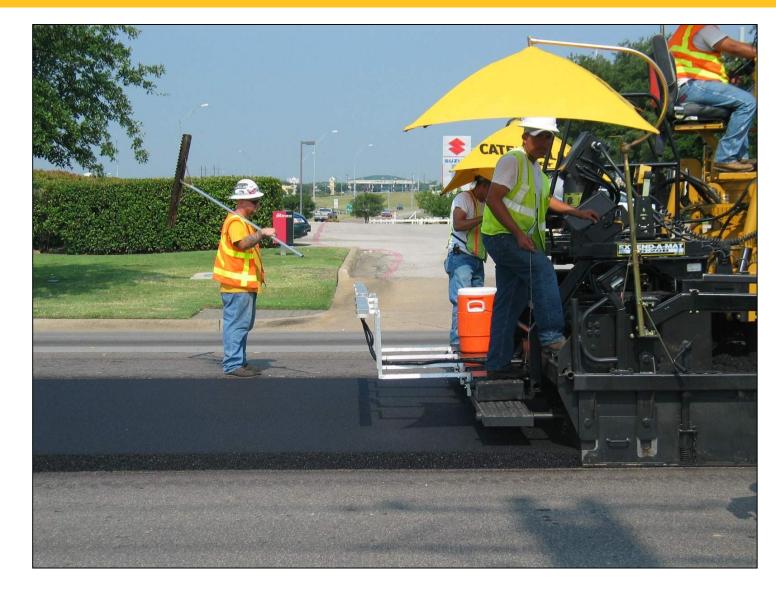
# Which side was paved first?







## **End Gates Down, Auger Extensions**



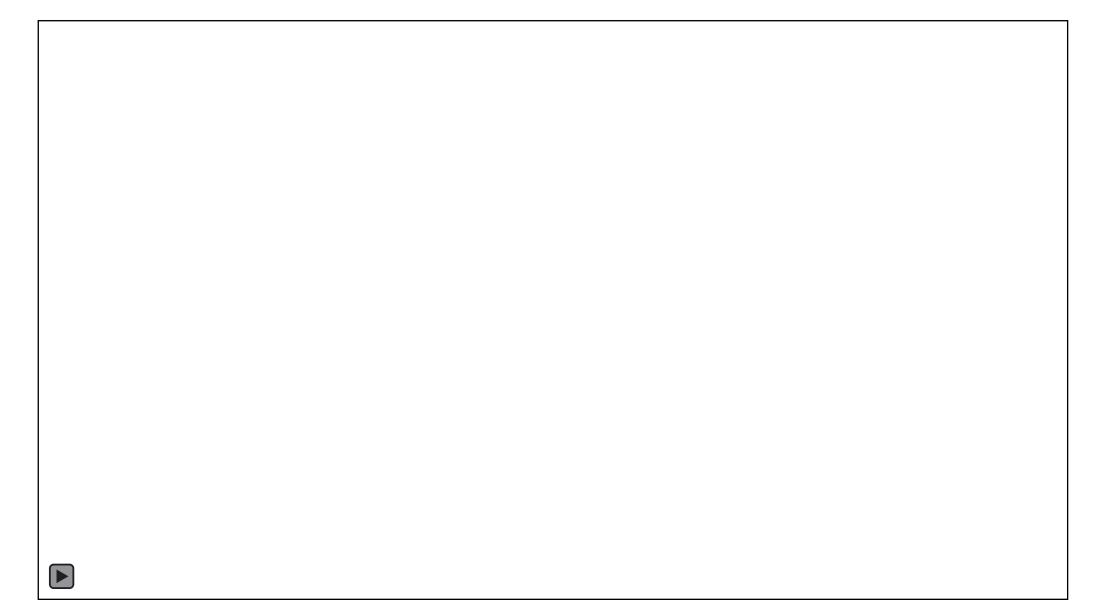
- Get mix out out to end gates
- Have sufficient auger
  extensions and tunnels

# Nice joint – no raking

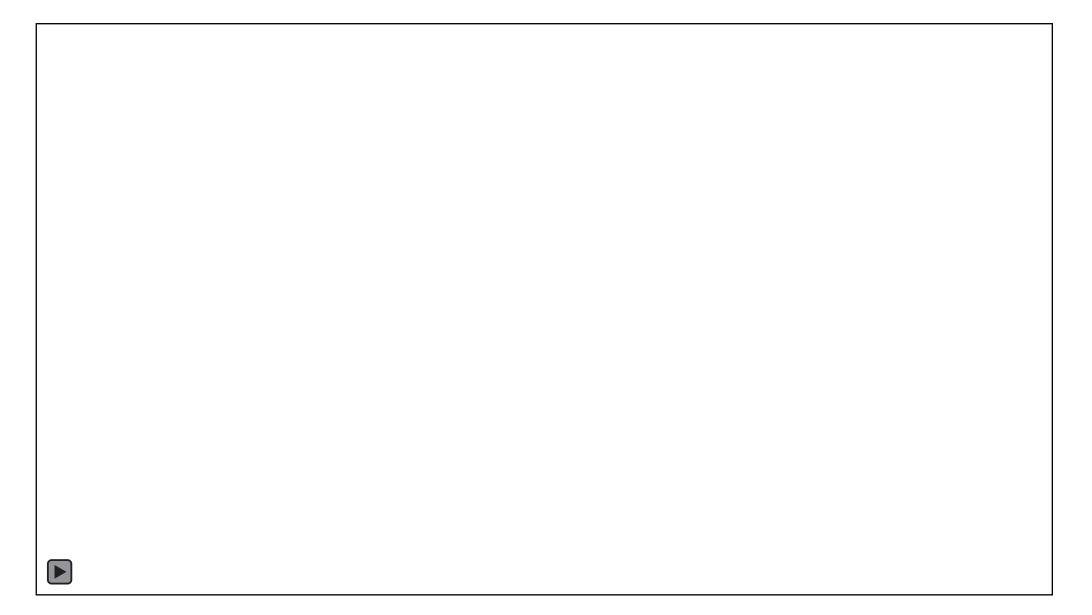
# **Correct height match**



# Locking in the Joint



# Locking in the Joint



### **Use Pneumatic to Seal the Joint**

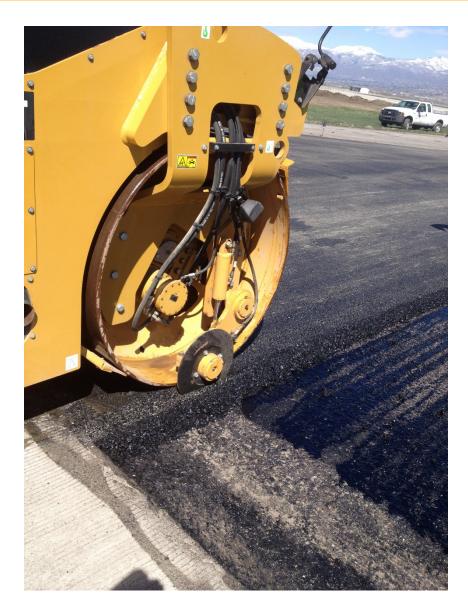
- All other phases should overlap the hot / cold joint
- Pneumatic compactors especially good at pinching joints



# Keep rubber tire off the edge



# **Edge Cutter – airport option**





#### **Don't run inside the unsupported edge**

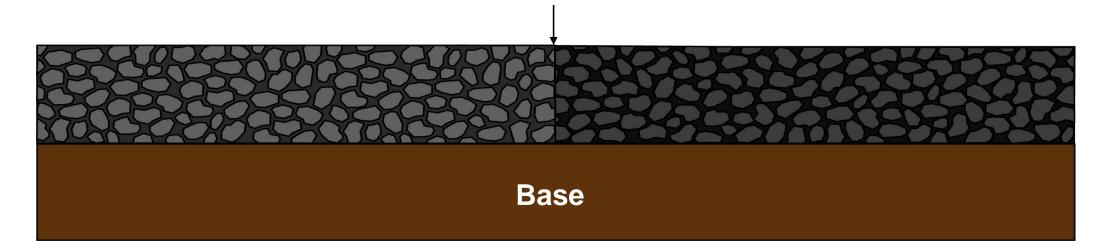




#### **Properly Built & Compacted Joint**

Correct Square Joint End Gate Down

Should pinch down without raking



#### **Don't Roll Over the Crown!**



- Be careful not to roll over the crown – daylight under both drums <sup>(3)</sup>
- Roll low side to high side

# **Summary**

- Paving crew builds joint correctly
- Verify overlap and precompaction height
- Select rolling pattern that meets project requirements



# Thank-you for your attention!

# **Questions?**





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