Understanding Grade & Cross-Slope

SC ASPHALT PAVEMENT ASSOCIATION
2025 WINTER CONFERENCE
& TRADE SHOW
FEBRUARY 12-13, 2025
COLUMBIA METROPOLITAN CONVENTION CENTER

SOUTH CAROLINA ASPHALT PAVEMENT ASSOCIATION EST. 1966

Blanchard CAT

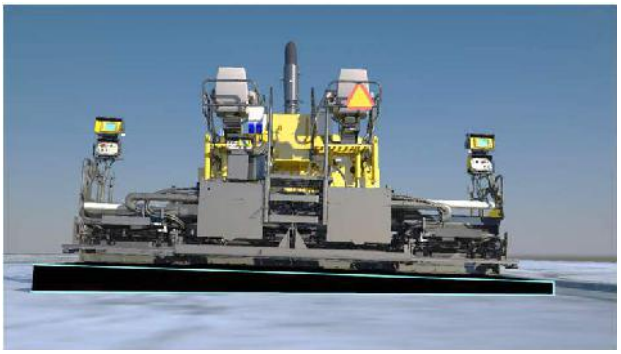
Presented by: Todd Mansell, Caterpillar

CAT

1

What Is Grade & Slope?

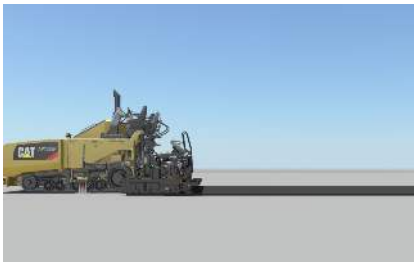
Grade
(thickness)

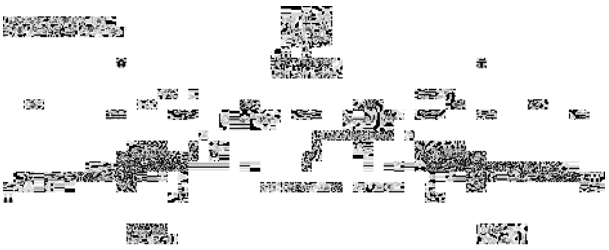


Slope
(% crossfall)

2

What is Grade?





- Thickness
- Vertical profile

Caterpillar: Confidential Green

3

What is Slope?

- Cross-fall in the mat from side-to-side

Caterpillar: Confidential Green

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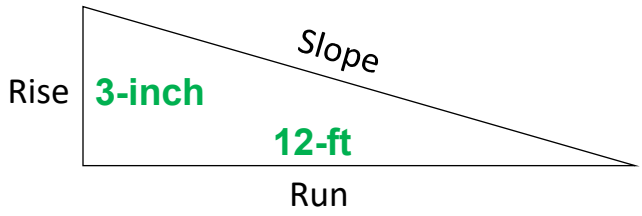
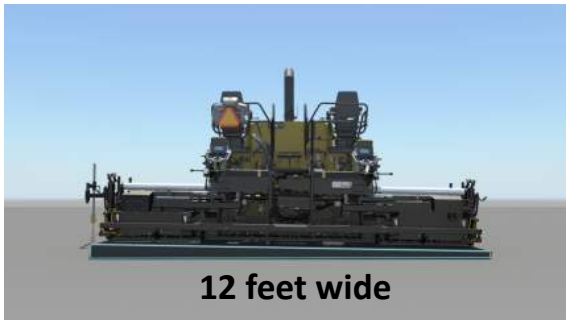
Calculating Slope





$$\text{Slope (\%)} = \frac{\text{Rise (in)}}{\text{Run (foot)}} = \frac{(3 \div 12)\ \text{ft}}{12\ \text{ft}} \times 100 = 2\%$$

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Calculating Slope

SLOPE CONVERSION TABLE

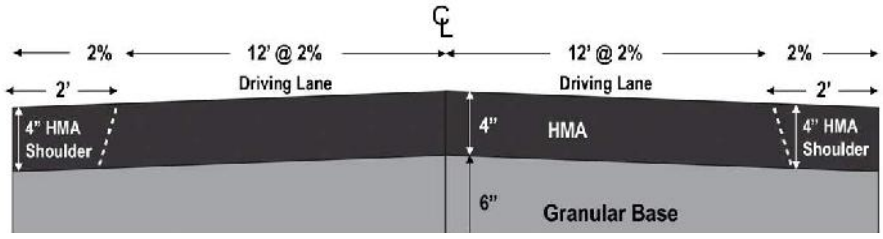
MM per 3.05 Meter	MM per Meter	Percent	Inches per foot	Inches per 12 feet
18	5	0.5%	1/16	3/4
37	10	1%	1/8	1-1/2
55	15	1.5%	3/16	2-1/4
73	20	2%	1/4	3
91	25	2.5%	5/16	3 1/2
110	30	3%	3/8	4 1/4
128	35	3.5%	7/16	5
146	40	4%	1/2	5 3/4
164	45	4.5%	9/16	6 1/2
183	50	5%	5/8	7 1/4
201	55	5.5%	11/16	8
219	60	6%	3/4	8 3/4
237	65	6.5%	3/4	9 1/4
256	70	7%	13/16	10
274	75	7.5%	7/8	10 3/4
292	80	8%	15/16	11-1/2
310	85	8.5%	1	12-1/4
329	90	9%	1-1/16	13
347	95	9.5%	1-1/8	13-3/4
365	100	10%	1-3/16	14-1/2

FORMULA

$\text{PERCENT} = \frac{\text{MM PER METER}}{10}$

FORMULA

$\text{PERCENT} = \frac{\text{INCHES PER FOOT}}{12} \times 100$



1/8” per foot = 1% Slope

How much drop across 12-ft ?

1/8” per foot x 12-ft x 1% = 1.5”

1/8” per foot x 12-ft x 2% = 3”

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Why do we care about Grade & Cross-Slope?

Grade

1. Sight distance (safety)
2. Ride (smoothness)

Cross-Slope

1. Safety (superelevation)
2. Drainage

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General Approach to Paving Grade & Cross-Slope

1. **Know the spec for final grade and cross-slope at each station**
2. **Measure existing cross-slopes**
3. **Plan "how" are we going to get from existing to final?**
   - Does my plan violate any specification? Does my plan fall within material quantities?
   - Modify the plan so that it meets spec and quantity limits
4. **Communicate plan!**
5. **Execute the Plan**

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Equipment

Establishing Grade & Slope

- Motor grader

- Scraper

- Asphalt paver

- Milling machine (cold planer, grinder)

- Compactor (roller)

- Width of blade, drum or screed
- Screed crown and extension slope
- Effect of compaction on grade or cross-slope

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Equipment: Tractor & Screed

Tractor

Screed

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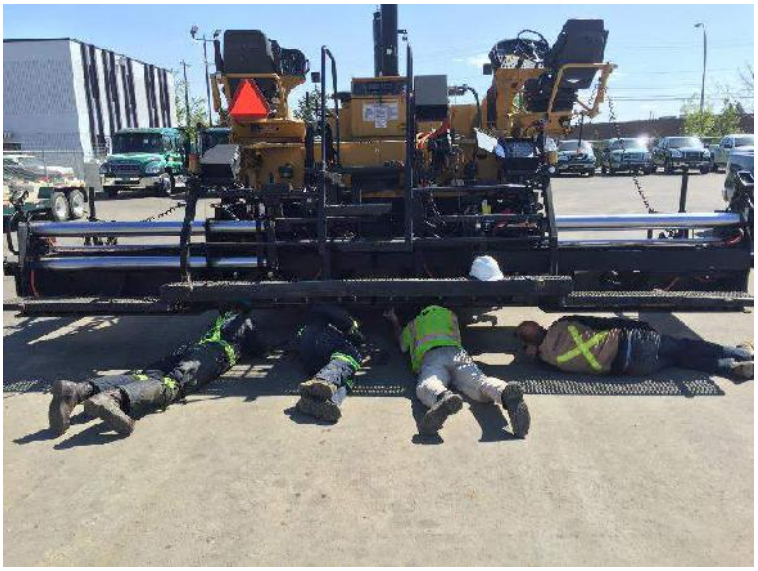
Equipment: Screed



- 10-foot wide main screed with 4’ – 9” extensions on each side
- Total width = 19’-6”

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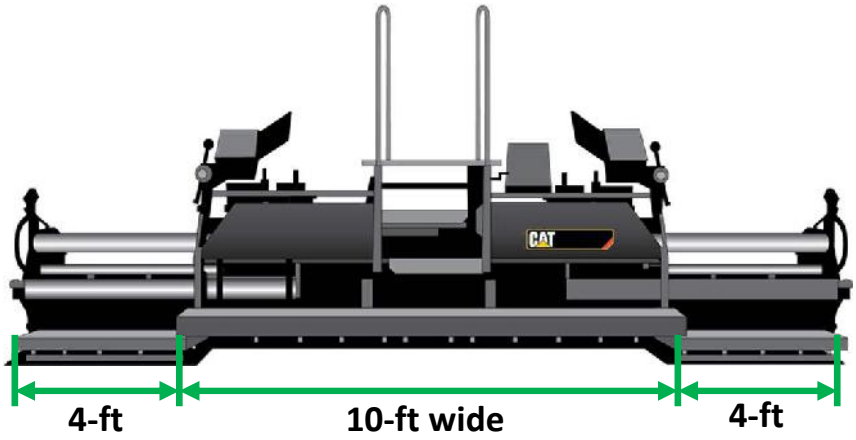
Equipment: Screed Width

- 8-ft and 10-ft wide main screed
- Approximately 4-ft extensions on each side



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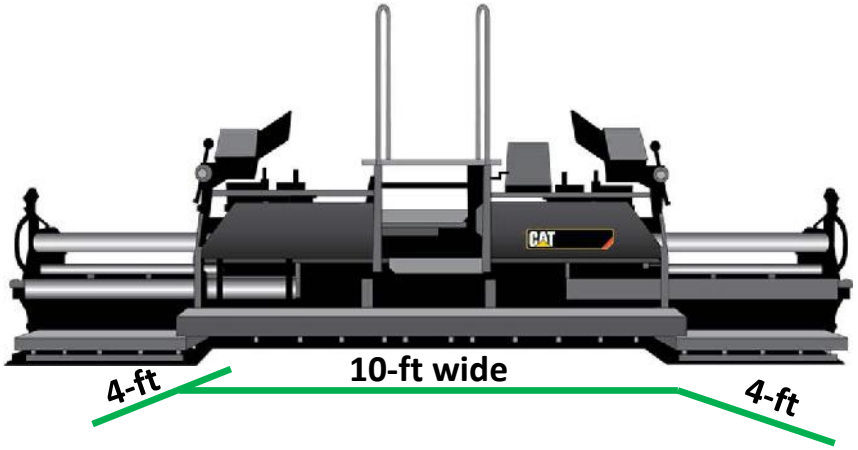
Equipment: Screed Extensions FLAT

- Slope will be accurate for full-width only when screed extensions are FLAT relative to the main screed!



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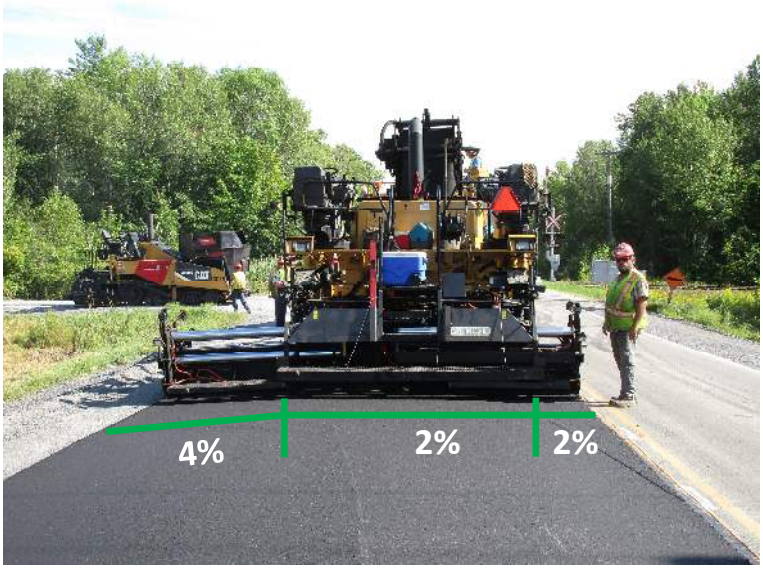
Equipment: Screed Extension Slope

- Screed extensions can have slope introduced, often referred to as a "slope break"
- Common application is mainline with a paved shoulder in one pass



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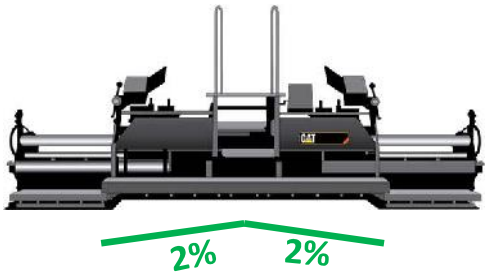
Equipment: Screed Crown



Caterpillar: Confidential Green

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How to Adjust Mat Thickness & Slope

- Use depth control cranks or “screws”
- Use tow points

Caterpillar: Confidential Green

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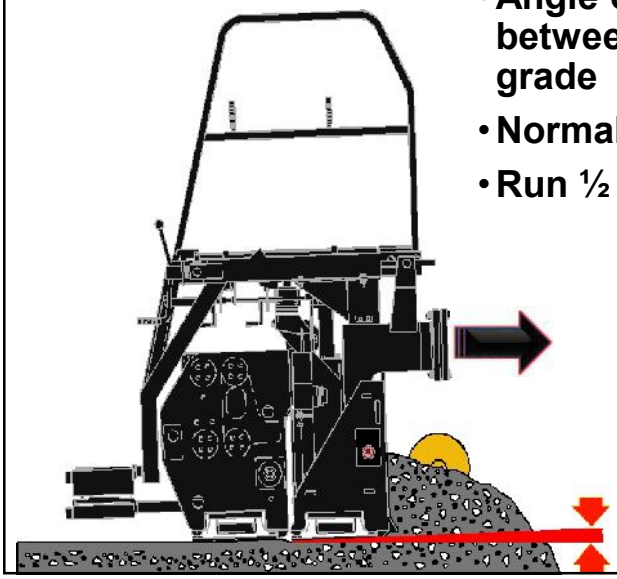
Screed Angle of Attack



- Angle of attack is the relationship between the nose of the screed & the grade
- Normally 1/8” to 1/4”
- Run ½ auger height Head of Material

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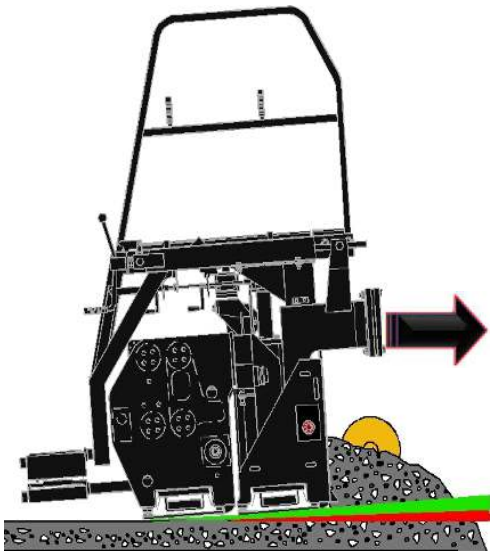
Increase Angle of Attack



- More material passes under screed
- Screed rises to new level
- Re-establish same angle, but at increased depth

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Changing Grade & Slope

- **Only one side (tow point or depth crank) is adjusted –thickness changes on one side and slope changes**

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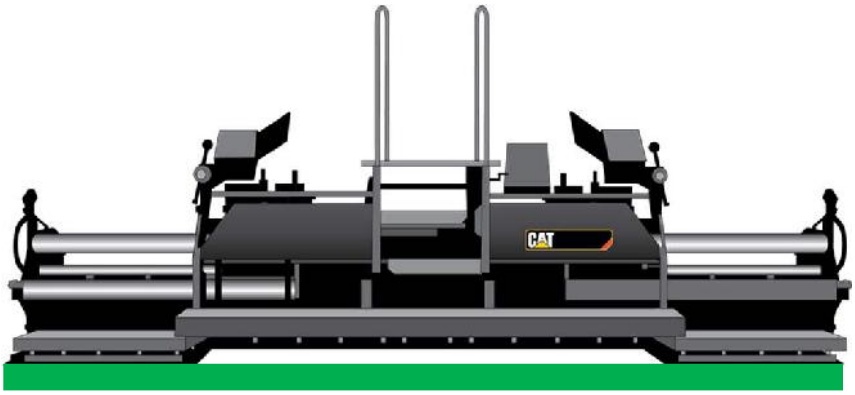
Changing Grade & Slope

- **If both sides are changed equally in the same direction – thickness changes the same on both sides and slope stays the same**



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How Does Automatic Grade & Slope Work?

- Grade and slope sensors send signals to a computer
- Signals are sent to hydraulic cylinders to cause tow point movement
- Tow point movement results in mat thickness changes and/or slope changes

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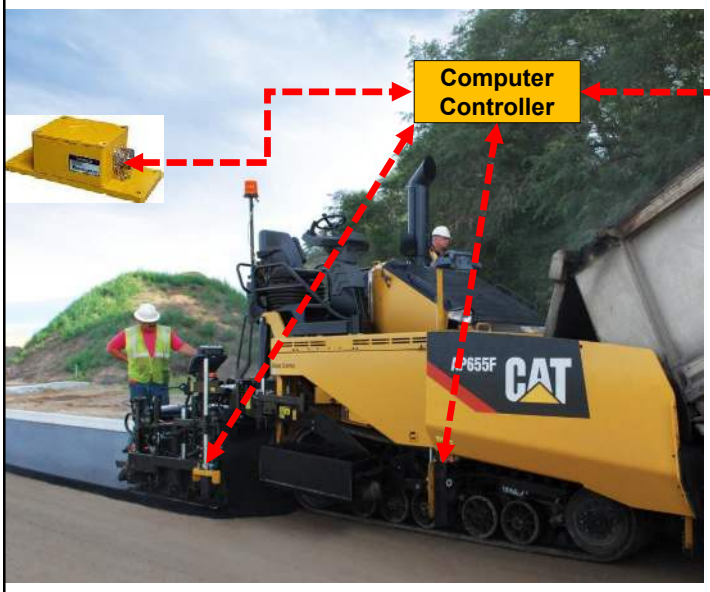
Grade Control Communication



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Automatic Grade Control

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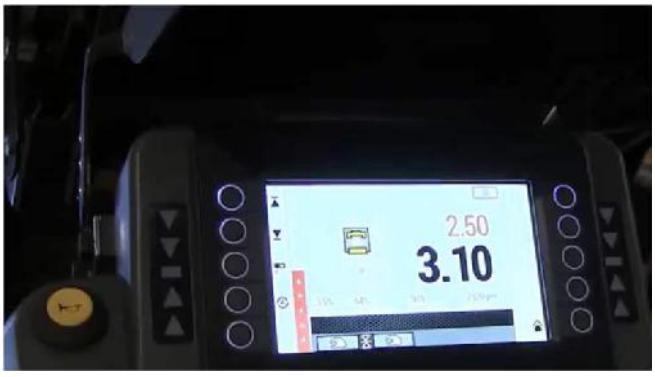
Grade sensor is a moving tape measure



Reading distance to grade

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Where Does the Grade Sensor Go?

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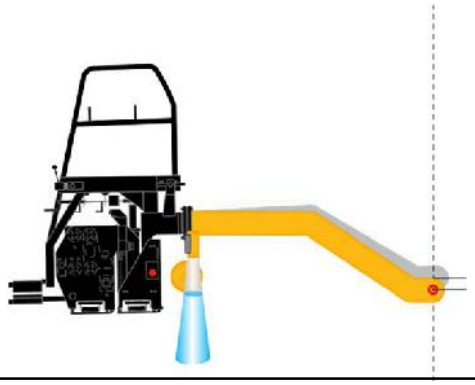
Sensor @ Auger for Joint Matching = Yield

- Follows existing grade - no improvement
- Precise yield
- Fast reaction
- Tow point movement is 4:1



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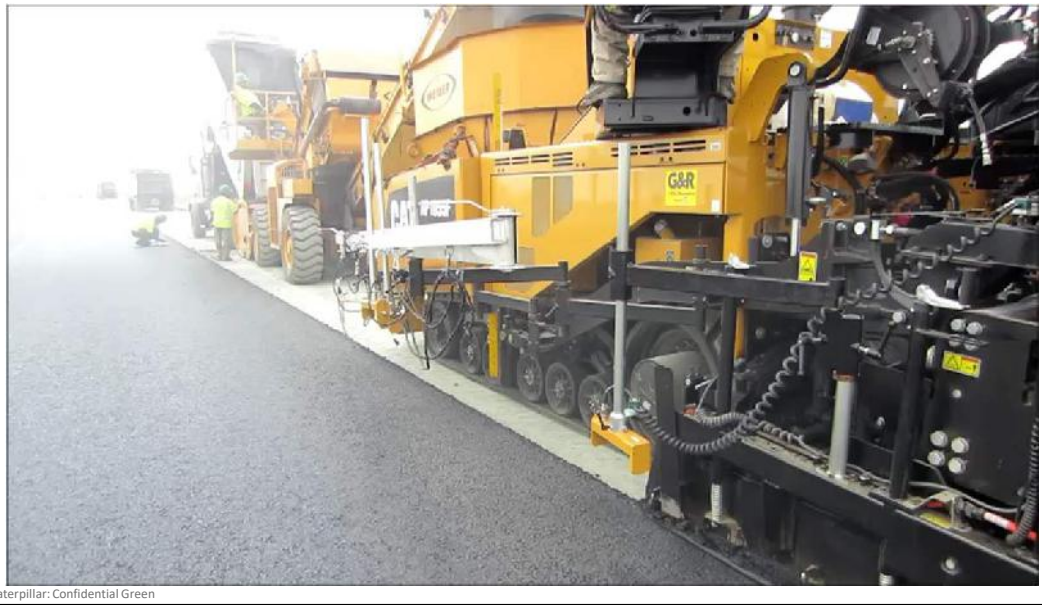
Joint Matching



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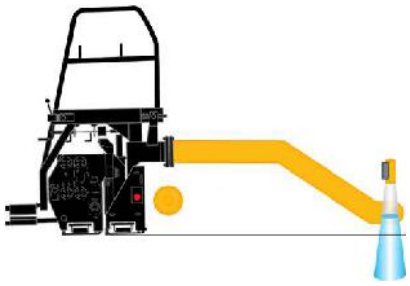
Sensor @ Tow Point for Smoothness

- Slow reaction
- Difficult to control yield
- Tow point movement is 1:1
- Screed reacts over 5 tow arm lengths



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Slope Control

- Slope box is a carpenter's level
- Only across MAIN screed
- Slope reacts QUICKLY (not good for smoothness)

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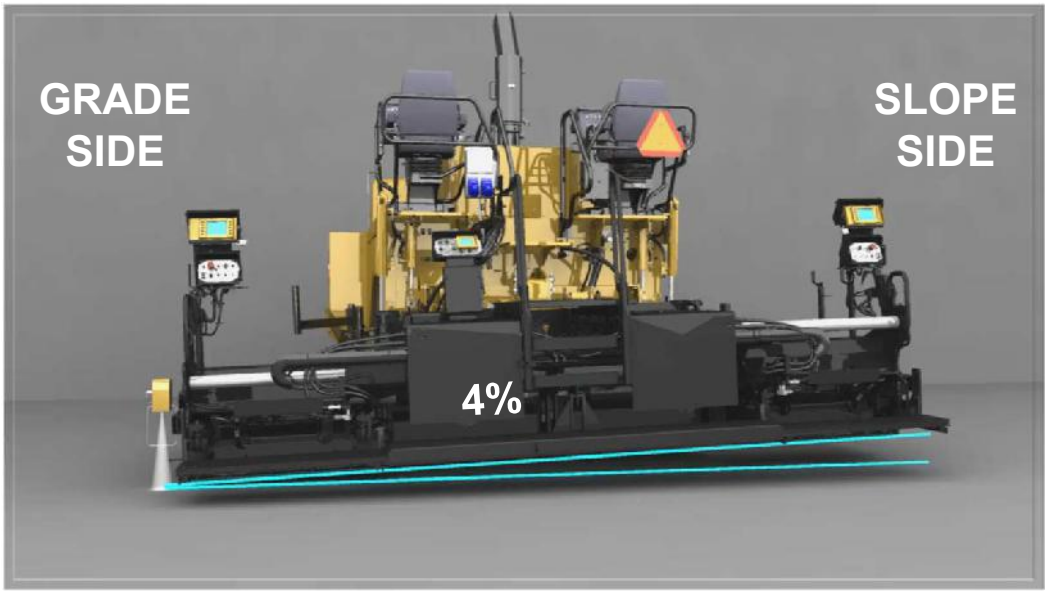
Slope FOLLOWS Grade Side Changes



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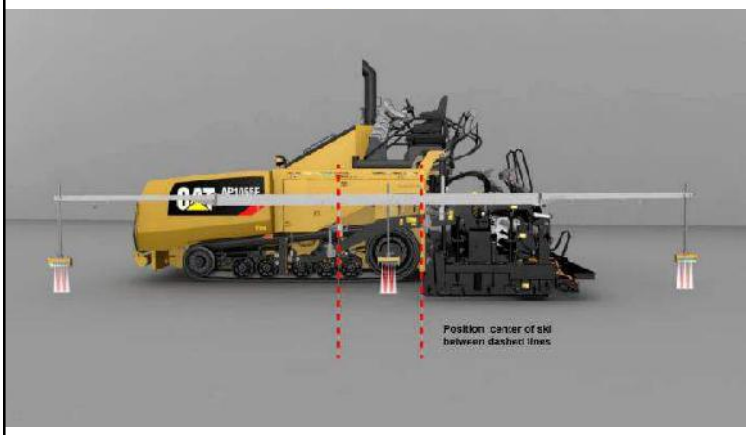
Sonic Averaging Ski (SAS)



- 30 ft beam
- Outside paving width for joint matching
- Inside paving width in tight spaces
- Averages 3 readings
- Swing rear sensor on new mat for better reference
- Yield is off, but may average over entire job

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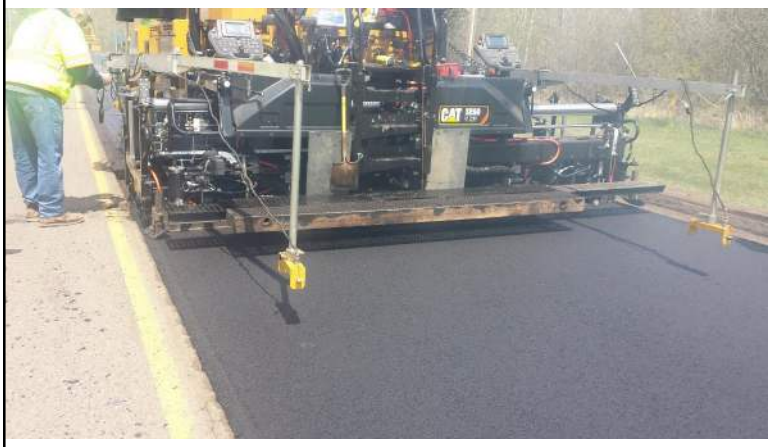
Ride Quality – Non-contact Skis – Advantages



- Stay on the paver when moving around job site
- Ideal for multiple pulls
- Not affected by obstacles
- Maintenance free
- Suited for grade reference with moderate to low roughness
- Set up inside or outside paving width

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Grade & Cross-Slope

New Construction

Build aggregate base to grade & slope specification

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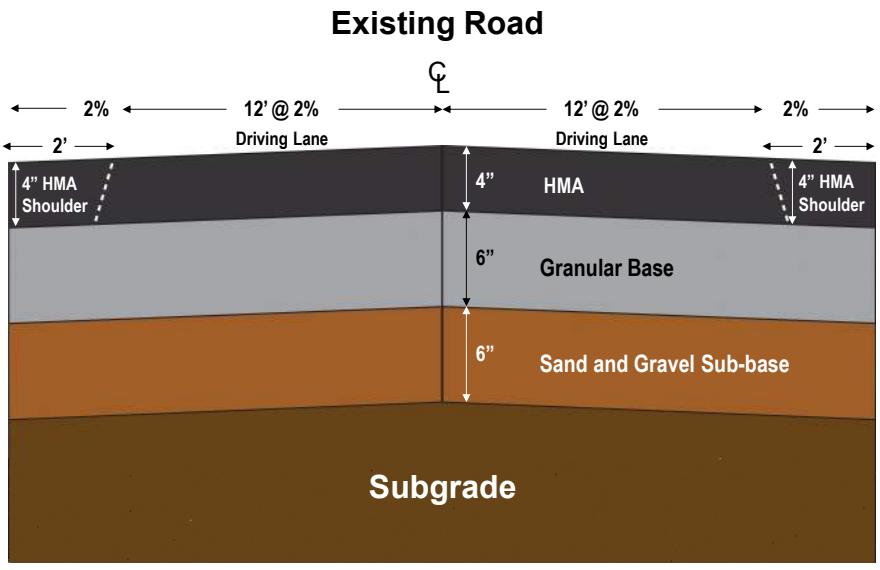
Straight Overlay When Existing is “to spec”



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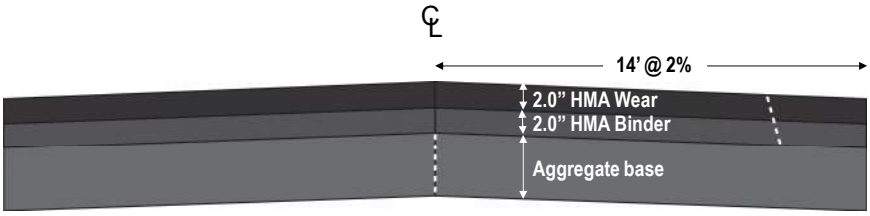
New Construction Over Aggregate Base



- Both sides under grade control
- Both sides using averaging skis
- Check slope with level to verify
- Check thickness at any point -- should be 2.5" loose

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Pave Grade:Grade

- Use automatic grade control on both sides
- Ski : Ski on both lifts
- Yield and thickness should be right on

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Grade & Cross-Slope

"Mill & Fill"

- Mill to correct grade and profile whenever possible
- Sometimes we use asphalt mix to get the correct grade & slope
- Leveling course (scratch course)

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Equipment: Milling Machine (Cold Planer)

- Various drum widths
  - 99" (8 ft 3") down to 39" (3 ft 3")
- Fixed 'flat' width

0% (flat)

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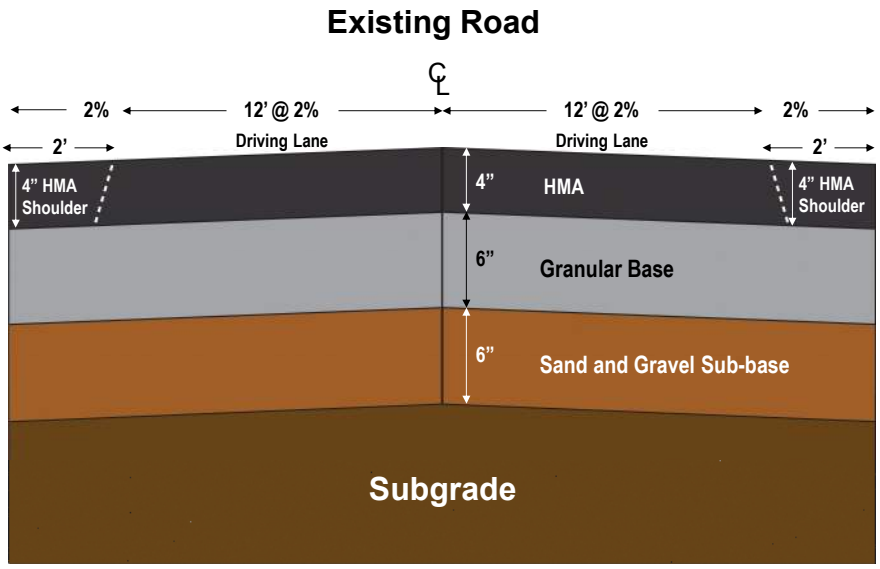
Milling – Maintenance Overlay



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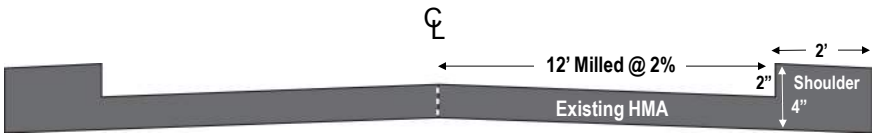
Milling and Paving



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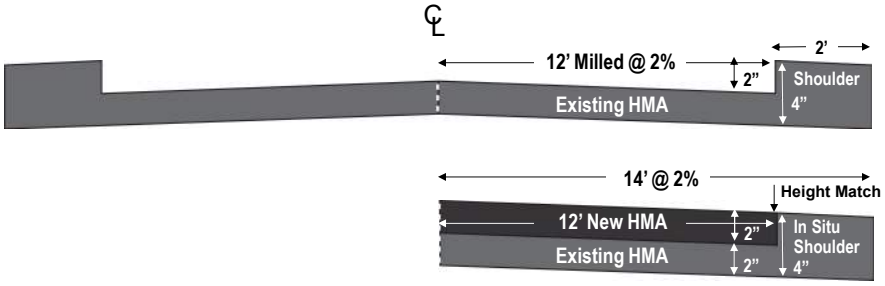
Milling and Paving

Maintenance Overlay



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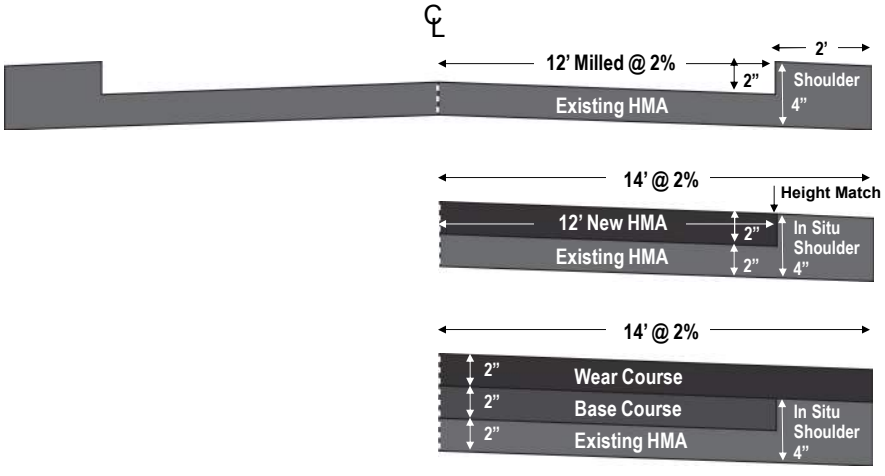
Milling and Paving

Maintenance Overlay



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Cold Planing Step

- Depth control using grade sensors on both sides
- Should duplicate existing profile
- 12’ milling width
- Milling speed 22 fpm

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Condition of Milled Surface

- Properly milled surface simplifies the paving process
- Improper milling creates problems for the paving process
- What problems do you see?

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Slope of Existing Surface

- Check slope at starting reference
- This will be the slope of the mat when paver pulls off starting reference
- If starting slope is wrong, what can we do?

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Slope of Milled Surface

- Check in multiple locations
- What do these slope checks tell us?

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Paver Set-up to build Profile

- Grade control right side provides correct mat thickness
- Slope control left side builds correct profile
- Where do you check depth?
- Will there always be a height match at shoulder?

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Paving under Slope Control

- Slope does not care about depth
- High spots in the grade can cause the screed to drag
- Depth not always equal across mat width
- Emphasizes the need for quality control during milling step

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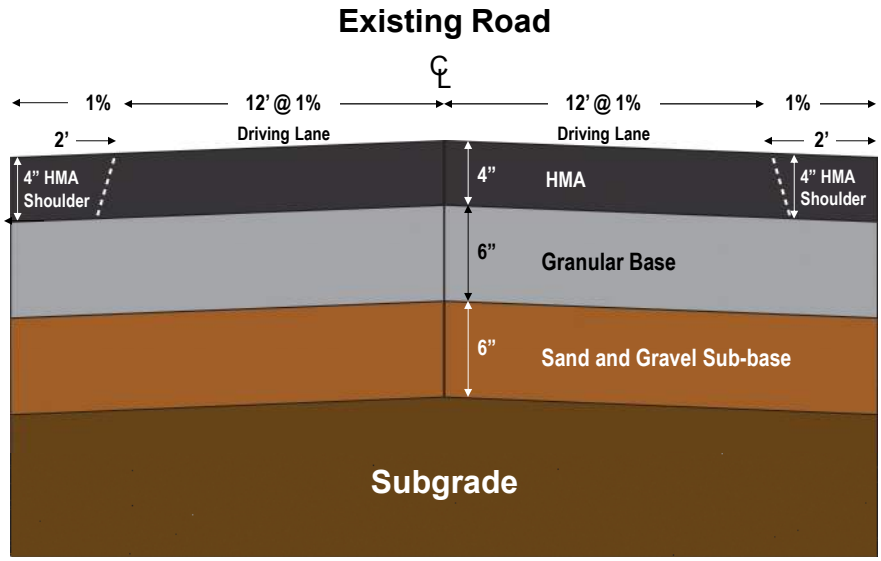
Structural Overlay to be corrected to 2% slope



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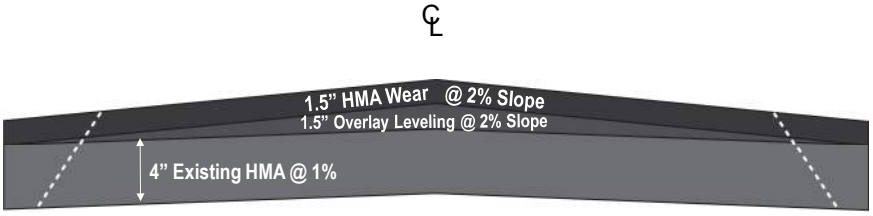
Structural Overlay



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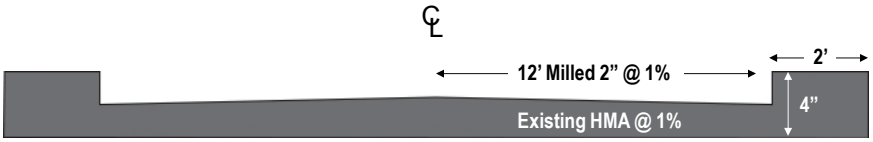
Mill and Fill and Pave Back at 2%

Maintenance Overlay



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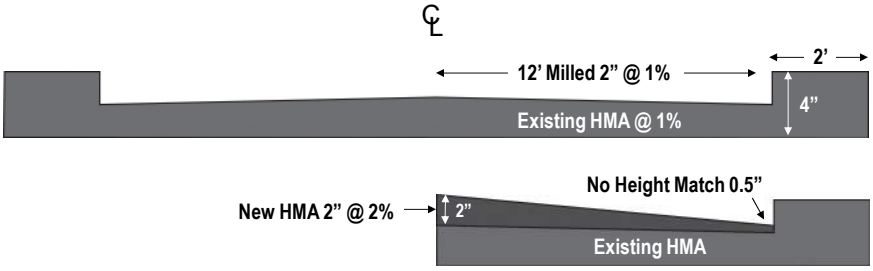
Mill and Fill and Pave Back at 2%

Maintenance Overlay



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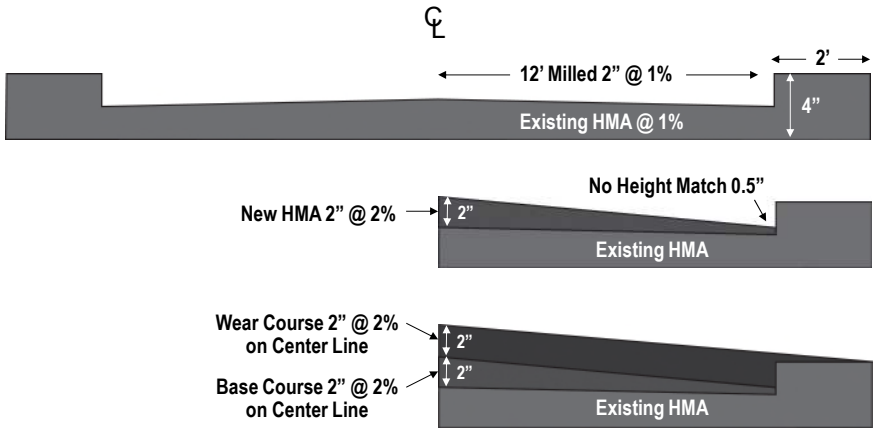
Mill and Fill and Pave Back at 2%

Maintenance Overlay



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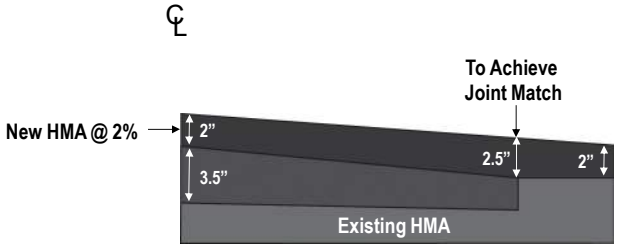
Mill and Fill and Pave Back at 2%

Maintenance Overlay



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Grade & Cross-Slope

Straight Overlay

Can only fix grade and slope using asphalt mix!

Quality may suffer

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Common Problems in the Field

- **Aggregate base or milled surface quality control was poor**
- **Existing grade needs to be brought up to standards (i.e. 2%)**
- **Owner wants paving crew to correct grade or slope using asphalt but doesn't want to pay for it**
- **Poor planning and reconnaissance (checking ahead) existing grade and superelevated sections**
- **Quality Problems: Differential compaction (density), smoothness**

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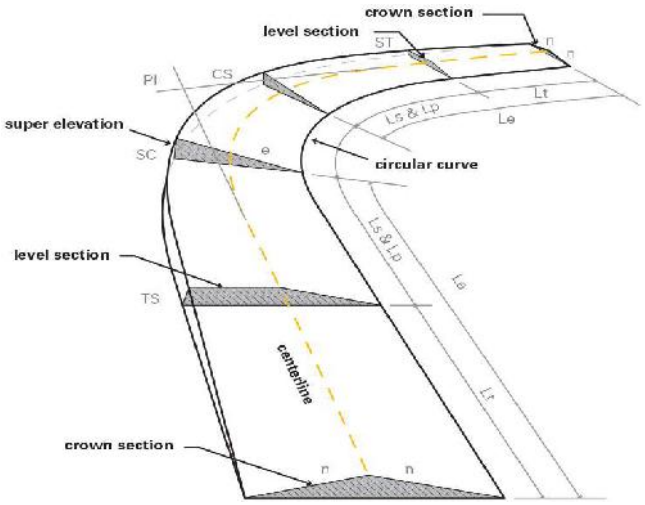
Superelevations



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Super Elevations

Before Paving…

- **Check slopes in multiple locations**
- **Compare measured slope to plan at grade stakes**
- **Note amount of correction needed, if any**

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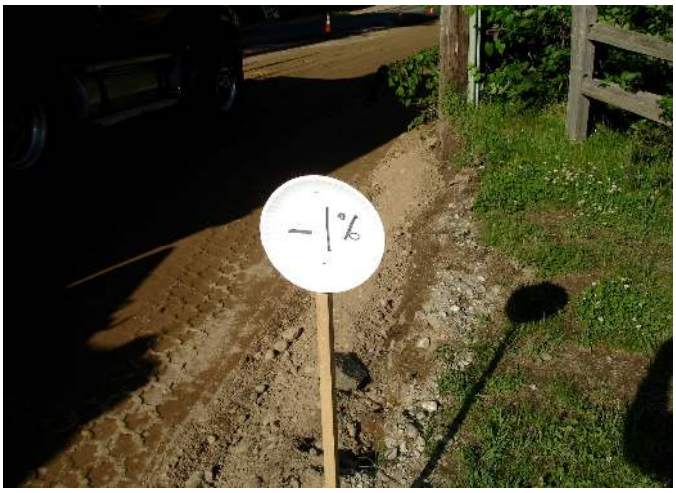
Super Elevations



Before Paving…

- **Verify slopes are clearly marked for screed operator**
- **Readable from 50 feet**

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Super Elevations

Before Paving…

- **Notify inspector or engineer if paver will be making profile corrections**
- **Discuss the effect of slope corrections on yield**
- **Determine how much slope tolerance is acceptable**

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Super Elevations

Before Paving…

- **Choose set-up that makes most sense**

  a. grade control both sides if profile is correct

  b. grade control and auto slope for small corrections

  c. grade control and manual slope for large corrections

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Super Elevations

If Profile Is Correct …

- **Grade control both sides will reproduce existing profile**
- **Best control of yield**
- **Best ride quality**

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Super Elevations

Small Profile Corrections…

- **Grade control one side**
  - **-- manual with screws**
  - **-- auto with one sensor**
  - **-- turn off avg. ski or configure to use one sensor**
- **Auto slope control opposite side**

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Smoother Slope Changes in Manual Mode

- **Often used in superelevations**
- **Select slope sensor**
- **Remain in MANUAL mode**
- **Control using depth cranks**

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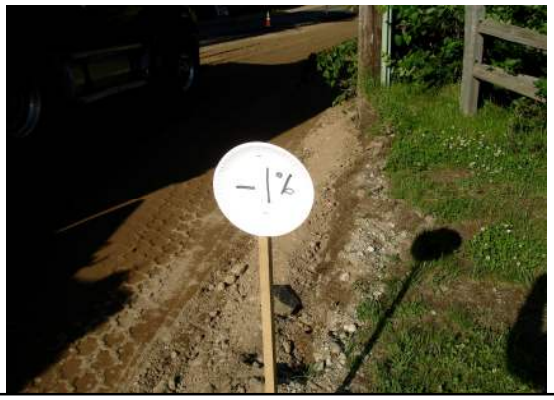
Slope Changes in Manual Mode

Before Paving…

- **Verify slopes are clearly marked for screed operator**
- **Readable from 50 feet**



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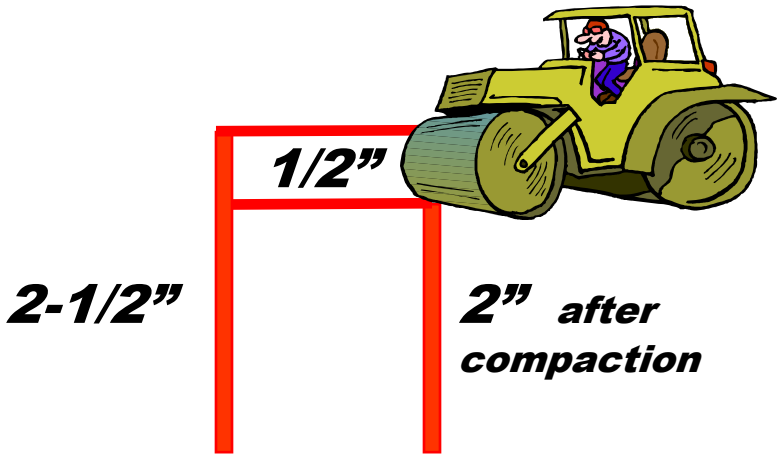
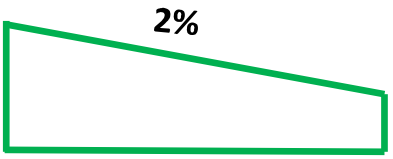
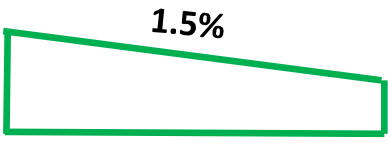
Slope and Rolldown



- **Slope will change after compaction where thickness varies!**





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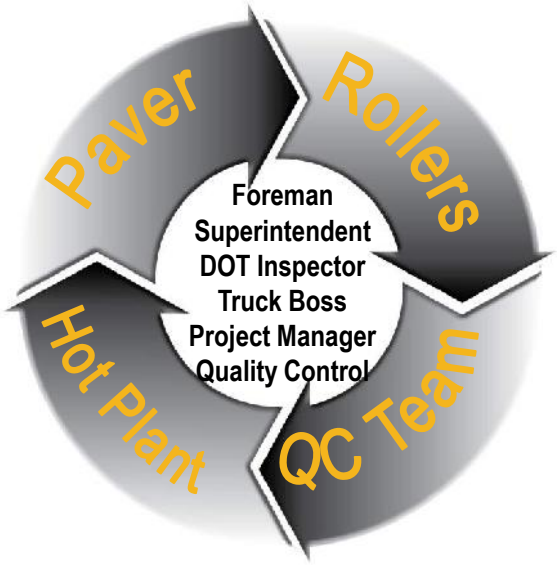
Summary for Success!



1. Know your existing base
2. Plan how you will achieve final grade & slope
3. Communicate your plan!
4. Re-iterate plan if necessary to align with bid and specs
5. Execute during construction

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Thank-you for your attention!
Questions?

CAT
BUILT FOR IT.

Blanchard CAT

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