What is Compaction?

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

What is Compaction?

- Compaction starts immediately behind paver
- Asphalt lift at highest temperature
- Limited time to develop density
- Planning, preparation and operator training required
Best Practices for Compaction

- Type of rollers
- Number of rollers
- Roller settings
- Number of passes (coverage)
- Mix temperature
- Rolling mainline
- Rolling transverse & longitudinal joints
- Pre-compaction w/ screed
- Stopping-Starting the roller
- Smoothness – where do we stop to get water, change direction, supported-unsupported edges, tie-ins

How do we achieve density?

1. Understand the factors affecting compaction
   - Mix temperature & time available for compaction
   - Four forces of compaction

2. Understand different types of rollers and how they work
   - Steel drum, pneumatic, combination, oscillation, offset drums

3. How to establish a rolling pattern that achieves density & smoothness
   - How to determine roller settings
   - Determining the number of passes
   - Dealing with harsh & tender mixes
   - Good communication!!

Lines of Communication
What does it take to get density?

Temperature

• Compact while hot!
• Stay close to paver
• Open-textured mixes cool quicker

Time Available for Compaction

Density must be achieved while the mix is still HOT
Temperature is Critical

- 320 – 260°F (160-130°C) Breakdown rolling
- 260 – 220°F (130-105°C) Intermediate rolling
- 240 – 190°F (115-90°C) possible tender zone
- 220 – 160°F (105-70°C) Finish rolling
- 160°F (70°C) – Stop rolling

Keep steel drums off the mix!!

PaveCool or Multi-Cool website and App

- 12 minutes from 280°F (138°C) to 220°F (104°C) (surface)
- 305°F (152°C) to 285°F (140°C) (internal)

PaveCool
Temperature: End dumps/windrow/MTV

- Keep windrows short
- MTV can help with uniform temperatures
- Keep tarps on trucks

Mix Temperature

- Creating density easiest at high temperature
- Upper limit about 320°F (160°C)
- Watch for layer movement in flow mixes
- Stay back if layer is tender due to high temperature
Mix Temperature

- Reach target density before mat cools
- Lower limit about 190°F
- Work close to paver
- Increase compaction energy
- Add breakdown rollers

Tender Zone

- Some mixes get tender between upper and lower limits
- Surface moves under drums or tires and cracks appear
- Work ahead of tender zone and after

Climate Conditions

- High ambient temperature
  - asphalt retains heat
  - longer compaction time
- Low base temperature
  - heat transfers quickly to base
  - shorter compaction time
- Low ambient temperature
  - asphalt cools faster
  - shorter compaction time
- Adjust rolling pattern as ambient conditions change
Four Forces of Compaction

- Static steel drum
  - high PLI
- Vibratory steel drum
  - low amplitude, high frequency
  - oscillation
- Pneumatic tire
  - should not be used

Roller types and settings...

Design and Specification considerations

- Lift thickness: NMAS
- NCAT Report 9-27
  - Fine 3:1 or greater
  - Coarse 4:1 or greater
  - SMA 4:1 or greater
- Density Specs
  - minimum 94% ??
  - abolish upper limit??
**What are the job specs?**

- What is the minimum density requirement for mainline? 92-97% (Theoretical Maximum Density TMD)
- Joint density? 90%  Shoulders? n/a
- Smoothness? IRI improvement? 67% - one lift
- How will density be measured and accepted? Cores?

**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

---

**Intermediate**

<table>
<thead>
<tr>
<th>Temp</th>
<th>300-260°F (150-127°C)</th>
<th>260-200°F (127-93°C)</th>
<th>200-160°F (93-71°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>3</td>
<td>2</td>
<td>2 (1 vibe, 1 static)</td>
</tr>
<tr>
<td>Settings</td>
<td>High A, Low P</td>
<td>90 psi</td>
<td>Low A, static</td>
</tr>
<tr>
<td>%TMD</td>
<td>90-92%</td>
<td>92-94%</td>
<td>94+</td>
</tr>
</tbody>
</table>

---

**Breakdown**

- 120 ft (38m)
- 200 ft (60m)

---

**Finish**

- 200 ft (60m)
Screed compaction

- Sometimes referred to as “pre-compaction”
- Vibratory screeds
  - On/off
  - Adjust frequency of vibration

Screed Density

- Screed develops initial density
- Vibratory screed produces compaction energy
- Tamping and vibratory screeds produce higher compaction energy

Vibratory screeds

- Typically 78% to 84% density
- No vibration 75 – 82%
- Set vibratory frequency correctly
- Surface texture improved
Mix behind the screed before rollers

• Use screed vibration
• Initial + 0.5 to 3.0%
• What affects optimum screed vibration setting? How do I set it?

Tamper Bar Screeds

• Set amplitude & frequency
• Approx. 84-88% TMD
• 45-120 ipf
• 8 – 15 fpm
• 2.5 – 4 m/min

Breakdown Compaction

• Develops the majority of the density
• Works immediately behind the paver where asphalt is the hottest
• Must match the production / speed of the paver
Good target density for breakdown ≈ 90%

- Job spec is 92-97%
- Job target for final density is 94%
- Goal for breakdown compaction is 95% of our overall target density

0.95 x 94% ≈ 90%

Theoretical Maximum Density (TMD)

Drum Width Considerations

- Maximum 3 drum widths
- Narrower drums have higher PLI
- Consider production vs. ability to get density

<table>
<thead>
<tr>
<th>Paving Width (Meters / Feet)</th>
<th>140 cm (55in)</th>
<th>150 cm (59in)</th>
<th>170 cm (67in)</th>
<th>200 cm (79in)</th>
<th>213 cm (84in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 / 8</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.75 / 9</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.00 / 10</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3.35 / 11</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3.70 / 12</td>
<td>(4)</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4.00 / 12</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.25 / 14</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.50 / 15</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.80 / 16</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.20 / 17</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.50 / 18</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Typical rolling patterns

- 12’ with 84” drum
- 12’ with 79” drum
- 12’ with 67” drum
- Make odd pass back on the wheel path
12-Foot Wide Lane: 84” x 2 passes

Two 84” drums cover a 12-ft lane

12-Foot Wide Lane: 79” x 2 passes
12-Foot Wide Lane: 79” x 3 passes

12-Foot Wide Lane: 67” x 3 passes

5-pass pattern: 12-ft Lane  84” drums

Pass #5 back up the middle and to the paver
Intermediate Compaction

- Normally immediately after breakdown compaction
- Goal is to develop final target density

Finish Compaction

- Goal is to clean up marks left by previous rollers
- Mat warm enough to allow clean up at the surface
- May get some density gain

Test Strips

- Verify equipment and patterns
- Develop required density
- First day of job
  - Sometimes required in advance
  - Don’t fake it
- Communicate plan to all crew members
Getting More Density on the Test Strip

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

Types of rollers

- Static steel drum
- Vibratory steel drum
- Oscillation
- Pneumatic
- Combination

Static Steel Drum

- kg/m (PLI)
- Narrower drum = higher contact pressure
**Vibratory Steel Drum**

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

> Build density from the top down

**Impact Force**

- Impact is a dynamic force
- Drum moves into the asphalt layer to produce high energy
- Increased production benefit
- Over-compaction, broken aggregate risk

**Vibration**

- Spinning eccentric weight causes drum vibration
- Vibratory force sets aggregates in motion
- Aggregates orient better for stone on stone contact
Amplitude: How far the Drum Moves

- Measured in 1/1000ths of an inch or mm

Amplitude = compactive effort

High Amplitude

Low Amplitude

Amplitude Checklist

<table>
<thead>
<tr>
<th>Factor</th>
<th>Lower Force 0.25 - 0.6 mm</th>
<th>Higher Force &gt;0.6 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer Thickness</td>
<td>&lt; 2.0 in (50mm)</td>
<td>&gt; 2.0 in (50mm)</td>
</tr>
<tr>
<td>Base Support</td>
<td>Rigid</td>
<td>Flexible</td>
</tr>
<tr>
<td>Binder Viscosity</td>
<td>Low (unmodified)</td>
<td>High (modified)</td>
</tr>
<tr>
<td>Aggregate Shape</td>
<td>Rounded</td>
<td>Angular</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Base Temperature</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
**Balanced Roller Vibration**

- Optimum compaction occurs when all forces are accepted by the asphalt layer
- Balance between forces of compaction and the asphalt layer

**Drum Bouncing**

- Forces out of balance create drum bounce
- Inefficient operation
- Solve bouncing:
  - change speed
  - lower amplitude
  - higher frequency
  - one drum static
  - both drums static

**Frequency**

RPM of eccentric weight or shaft in drum
Impacts per foot (ipf) or ipm

Roller speed is constant

Roller Speed should be 10 - 14 ipf (32-40 ipm)

Roller Speed

\[ \text{Roller speed (fpm)} = \frac{\text{Frequency (vpm)}}{\text{Impacts per foot}} \]

\[ \text{Speed} = \frac{3,000 \text{ vpm}}{10 \text{ ipf}} = 300 \text{ feet per minute} \]
Effective Roller Speed

Effective roller speed = \( \frac{300 \text{ fpm}}{7 \text{ passes}} \) = 42 fpm

Effective Roller speed = 42 x 0.80 = 34 fpm

Paver can not exceed 34 fpm

Ripples in the Mat

• ipf too low
• Speed too fast

Verify Roller Settings

• Is the equipment in good working condition?
• Settings per test strip?
  – Amplitude
  – Frequency
  – Speed (10-12 ipf)
Higher Amplitude ꞉ Lower Frequency

<table>
<thead>
<tr>
<th>Amplitude</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.86 mm</td>
<td>2520 vpm</td>
</tr>
<tr>
<td>0.73 mm</td>
<td>2520 vpm</td>
</tr>
<tr>
<td>0.44 mm</td>
<td>3800 vpm</td>
</tr>
<tr>
<td>0.33 mm</td>
<td>3800 vpm</td>
</tr>
</tbody>
</table>

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

Oscillation

• Back and forth drum movement
• Maintains contact with surface
• Less aggressive compaction
Steel Drum: Best Practices

• Worker safety is #1
• Be aware of personnel around the paver
• Stop at least 15’ behind paver
• Shut off vibes as roller slows down

Turn off vibration before stopping

• Worker safety is #1
• Be aware of personnel around the paver
• Stop at least 15’ behind paver
• Shut off vibes as roller slows down

Stop at an angle to the mat

• Roller stops at an angle
• Turn off vibration just before roller starts turning
• Next pass rolls through stop mark
• Stop marks are staggered
Don’t Stop Square to the Mat = Bump

- Approximately 30° arc
- Roll through stop marks on next pass with vibe on
- Drum mark will roll out

Stopping Square to the Mat = Bump

Stop at an Angle to the Mat
Don't stop in the same area – roll through

- Major smoothness issue
- Roll through stop marks with vibe on next pass

Roll off onto Cold Mat When Possible

Roll off onto Cold Mat When Possible
Pick-Up On Dry Drum Surfaces

- Most common cause of downtime
- Film of water must cover drum
- Small amount of pick-up becomes big problem

Rolling tips

- Many mixes are prone to sticking to steel drums
- Imperative that water system is working properly
- Soap/release agent mixture

Parking on the Mat

- Never park on hot asphalt
- Leaves dents that will not clean up
- Park on cold asphalt
- Park on shoulder, if available
Stopping for Water Refill

- Plan water refill stops
- Stop on shoulder or turnout or cold asphalt – never on driving lane
- Make sure water hose is long enough for all situations

If necessary, use boards to allow roller to get off hot asphalt during water refills

Rolling with steel drums

- Should I use vibration?
- Careful not to break aggregate
- How do I avoid breaking aggregate?
Get on, get off !!

- It's easy to over-roll and damage the mat using vibration
  - It's also more efficient to use vibration
- Watch for ‘drum bounce’
- Watch for white surface

Vibratory Drum Impact Marks

- Too much force
- Cannot use roller to correct height mismatch

Recommendations:

- Static steel on thinner lifts with rigid base support
- Use vibration on thicker lifts, less rigid base
  - use vibration whenever possible where it doesn’t fracture aggregate
  - the only way to know is to try!!
  - highly temperature dependent
- Oscillation may work in any position
  - less risk of damaging/fracturing aggregates
  - more risk of not achieving density
- Pneumatic tire should not be used on PMA due to pickup
Don’t Roll Over the Crown!

- Be careful not to roll over the crown – daylight under both drums 🎃
- Roll low side to high side

Unsupported edge 6” overhang

6” overhang

First Pass on Unsupported Edge
Pneumatic Rollers
- Most commonly used for intermediate rolling
- Knead the mix
- Close up surface voids and tension cracks
- Efficient building density

Manipulation or kneading action
- Manipulation occurs due to overlapping tires
- Some forces move sideways
- Tightens surface texture

Adjusting Tire Pressures
- Higher Pressure
- Lower Pressure
**Pneumatic Roller: Best Practices**

- Do not turn
- Stop slowly
- Finish roller clean up marks
- Tricky using modified binders

**Keep Off the Unsupported Edge**

- Use approved release agent
- Keep tires within 40°F of mat
- Keep moving

**Avoid Pick-Up On Rubber Tires**
Keep Tire Pressures Equal

- Warm up before rolling
- Keep tires hot
- Tire pressures equal

Establish an effective rolling pattern

1. Based production and density
2. Equipment Selection
3. Balance paver & roller speed
4. Test Strip
5. Verify during production

5-Steps to Establishing a Rolling Pattern

1. Schedule a full time QC person to do a Test Strip
2. Know the target paver speed
3. Target 95% of final density for the breakdown roller(s)
4. Perform Test strip
   - Determine number of passes required for each 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
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

Input 7 pieces of information...

Number of Trucks = 20
Paver speed = 36 fpm

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

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

Step 3: Density target for breakdown

- Job spec is 92-97%
- Target for final density is 94%
- Goal for breakdown compaction is 95% of final target density

0.95 x 94% ≈ 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

<table>
<thead>
<tr>
<th>Vorse Vibro™ Vibratory System</th>
<th>CB64</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td><strong>Amplitude</strong></td>
</tr>
<tr>
<td>60.1 Hz (1,000 rpm)</td>
<td>0.094 in</td>
</tr>
<tr>
<td>18.0 Hz (1,000 rpm)</td>
<td>0.152 in</td>
</tr>
</tbody>
</table>

Choose Frequency

<table>
<thead>
<tr>
<th>Vorse Vibro™ Vibratory System</th>
<th>CB64</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td><strong>Amplitude</strong></td>
</tr>
<tr>
<td>60.1 Hz (1,000 rpm)</td>
<td>0.094 in</td>
</tr>
<tr>
<td>18.0 Hz (1,000 rpm)</td>
<td>0.152 in</td>
</tr>
</tbody>
</table>
Frequency Determines Roller Speed

Frequency = 2,520 vpm
We want 10 impacts per foot

\[
\frac{2,520}{10} = 252 \text{ fpm}
\]

Number passes Breakdown CB64

<table>
<thead>
<tr>
<th>Breakdown CB64</th>
<th>Intermediate</th>
<th>Finish CB54-XW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-ton</td>
<td>14-ton tire</td>
</tr>
<tr>
<td><strong>Settings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amp</td>
<td>0.022&quot;</td>
<td>2,520</td>
</tr>
<tr>
<td><strong>Freq</strong></td>
<td>2,520</td>
<td></td>
</tr>
<tr>
<td><strong>Temp</strong></td>
<td>260°F (127°C)</td>
<td></td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td>88%</td>
<td></td>
</tr>
<tr>
<td><strong>Pass</strong></td>
<td>2nd</td>
<td></td>
</tr>
<tr>
<td><strong>Temp</strong></td>
<td>250°F (121°C)</td>
<td></td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td><strong>Pass</strong></td>
<td>3rd</td>
<td></td>
</tr>
<tr>
<td><strong>Temp</strong></td>
<td>252°F (122°C)</td>
<td></td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td>91%</td>
<td></td>
</tr>
<tr>
<td><strong>Pass</strong></td>
<td>4th</td>
<td></td>
</tr>
<tr>
<td><strong>Temp</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

“Effective” Roller Speed

- Drum width
- Number of passes

40 fpm > 36 fpm
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!!!

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

Cooling Time from 280°F (138°C) to 252°F (122°C)

Length of the Breakdown Roller Pass

Roller Speed = \frac{\text{Frequency (rpm)}}{10 \text{ ipf}} = \frac{2,520}{10} = 252 \text{ fpm}

Time = 3 minutes

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

Distance = \text{Speed} \times \text{Time} = 252 \times 3 = 756 \text{ ft (in 3 minutes)}
5-pass pattern: 12-ft Lane 84” drums

6” Overhang

6” Overlap

6” Overhang

12’ Wide Mat

Passes 3 & 4 up/back

Passes 1 & 2 up/back

Length of the Breakdown Roller Pass

756 feet traveled in 3 minutes
We have a 5-pass pattern (from test strip) to cover the mat twice
756 ÷ 5 pass pattern = 151 feet
Assume 80% roller efficiency
151 x 0.80 = 121 feet
Length of roller pass = 120 feet (36m)

Note: If temperatures change – the length of roller pass changes!!

Step 4: Rolling Pattern Summarized

<table>
<thead>
<tr>
<th></th>
<th>Breakdown</th>
<th>Intermediate</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>% TMD</td>
<td>90-92%</td>
<td>90-94%</td>
<td>94%</td>
</tr>
<tr>
<td>Temp</td>
<td>280 - 320F (138-122 C)</td>
<td>??</td>
<td>??</td>
</tr>
<tr>
<td>Coverage</td>
<td>2 (5-pass pattern)</td>
<td>??</td>
<td>??</td>
</tr>
<tr>
<td>Settings</td>
<td>High-A, Low F</td>
<td>90 psi</td>
<td>???</td>
</tr>
<tr>
<td>Distance</td>
<td>36m (120 feet)</td>
<td>???</td>
<td>???</td>
</tr>
<tr>
<td>Speed</td>
<td>4.6 km/h (252 fpm)</td>
<td>???</td>
<td>???</td>
</tr>
</tbody>
</table>
**Step 4: Repeat for all Rollers**

- Busy!!!
- Everyone's watching!

### Number passes Intermediate CW34

<table>
<thead>
<tr>
<th></th>
<th>Breakdown CB64</th>
<th>Intermediate CW34</th>
<th>Finish CB54-XW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-ton</td>
<td>14-ton tire</td>
<td>10-ton</td>
</tr>
<tr>
<td>Settings</td>
<td>Amp</td>
<td>Freq</td>
<td>Temp</td>
</tr>
<tr>
<td>1st Pass</td>
<td>0.022&quot;</td>
<td>2,520</td>
<td>280F (138C)</td>
</tr>
<tr>
<td>Density</td>
<td>88%</td>
<td>252 (122)</td>
<td>252 (122)</td>
</tr>
<tr>
<td>2nd Pass</td>
<td>260 (127)</td>
<td>245 (118)</td>
<td>90%</td>
</tr>
<tr>
<td>Density</td>
<td>260 (127)</td>
<td>245 (118)</td>
<td>90%</td>
</tr>
<tr>
<td>3rd Pass</td>
<td>238 (128)</td>
<td>238 (119C)</td>
<td>91%</td>
</tr>
<tr>
<td>Density</td>
<td>238 (128)</td>
<td>238 (119C)</td>
<td>91%</td>
</tr>
<tr>
<td>4th Pass</td>
<td>Temp</td>
<td>Density</td>
<td>252 (122)</td>
</tr>
</tbody>
</table>

### Number passes - Finish CB54-XW

<table>
<thead>
<tr>
<th></th>
<th>Breakdown CB64</th>
<th>Intermediate CW34</th>
<th>Finish CB54-XW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-ton</td>
<td>14-ton tire</td>
<td>10-ton</td>
</tr>
<tr>
<td>Settings</td>
<td>Amp</td>
<td>Freq</td>
<td>Temp</td>
</tr>
<tr>
<td>1st Pass</td>
<td>0.022&quot;</td>
<td>2,520</td>
<td>280F (138C)</td>
</tr>
<tr>
<td>shaker</td>
<td>1 vibe, low A (0.012&quot;), high F (3,800 vpm), 1 static</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>88%</td>
<td>252 (122)</td>
<td>200 (93)</td>
</tr>
<tr>
<td>2nd Pass</td>
<td>260 (127)</td>
<td>245 (118)</td>
<td>90%</td>
</tr>
<tr>
<td>Density</td>
<td>260 (127)</td>
<td>245 (118)</td>
<td>90%</td>
</tr>
<tr>
<td>3rd Pass</td>
<td>238 (128)</td>
<td>238 (119C)</td>
<td>91%</td>
</tr>
<tr>
<td>Density</td>
<td>238 (128)</td>
<td>238 (119C)</td>
<td>91%</td>
</tr>
</tbody>
</table>
### Final Rolling Pattern

<table>
<thead>
<tr>
<th>Settings</th>
<th>12-ton</th>
<th>14-ton tire</th>
<th>16-ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amp</td>
<td>0.022&quot;</td>
<td>0.012&quot;</td>
<td>0.013&quot;</td>
</tr>
<tr>
<td>Freq</td>
<td>2,520 vpm</td>
<td>3,800 vpm</td>
<td></td>
</tr>
<tr>
<td>Temp</td>
<td>280F (138C)</td>
<td>252 (122)</td>
<td>200 (93)</td>
</tr>
<tr>
<td>Density</td>
<td>92%</td>
<td>92%</td>
<td>94%</td>
</tr>
</tbody>
</table>

1st Pass:
- Amp 90 psi
- Freq 50 psd
- Amp 90 psi
- Freq 50 psd

2nd Pass:
- Amp 90 psi
- Freq 50 psd
- Amp 90 psi
- Freq 50 psd

3rd Pass:
- Amp 90 psi
- Freq 50 psd
- Amp 90 psi
- Freq 50 psd

4th Pass:
- Amp 90 psi
- Freq 50 psd
- Amp 90 psi
- Freq 50 psd

### Step 4: Final Rolling Pattern

<table>
<thead>
<tr>
<th>%TMD</th>
<th>Breakdown</th>
<th>Intermediate</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-92%</td>
<td>92-94%</td>
<td>94% + take out marks</td>
<td></td>
</tr>
</tbody>
</table>

Temp:
- 280-252°F (138-122°C)
- 252°F (122°C)
- 200-163°F (93-73°C)

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 feet
- 200 feet
- 300 feet

Speed:
- 252 fps
- 300 fps
- 350 fps

### 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

Efficient Compaction of Stiff & Tender mixes

Stiff mixes
- Stable and can take high compactive forces
- Compact easier at higher temperatures
- Use higher amplitudes

Tender mixes
- Temperature sensitive through a specific temperature range
- Achieve density before tender zone by rolling in echelon OR
- Wait until mix cools below tender zone and resume rolling

Echelon breakdown - no finish required

- Get density while it's hot!
- Sets up quickly
- Often no need for finish rolling with echelon rolling
Echelon Breakdown – no finish roller

• Required density achieved in first 4 vibratory passes
• No finish roller needed in many cases

Echelon with same & different rollers

Mix after compaction
Echelon - pneumatics

Longitudinal Joint: Roll from hot side

- First pass on hot side 6-8" away from joint
- Pushes asphalt toward the joint to help gain density

Best Joint Density
Locking in the Joint

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

Use Pneumatic to Seal the Joint
• Breakdown roller starts normal pattern
• Paver should not have to stop and wait for joint to be prepared and compacted
Transverse Joint Rolling Pattern

- 1st pass most of drums on cold side
- Check flatness
- 2nd pass, move farther onto hot side
- All passes static
- Should not have to vibrate to pinch a transverse joint

Tender Mix

- Does not compact in specific temperature range or zone
- Roll in echelon
- Resume compaction below tender zone temp
- Do NOT run a steel drum in the tender zone
**Top 5: Checklist for Compaction**

1. Mix behind the screed is hot
2. Breakdown roller should cover mat in 3 drum widths or less
3. Breakdown roller speed is 10 ipf (10 - 14)
4. Balance roller speed with paver speed
5. Goal: Breakdown roller achieves ≈ 95% of target density
   - e.g. 0.95 x 94 = 90% (TMD)

---

**Who's responsibility is it?**

- Paver Speed?
  - Paver operator?
- 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!
Questions?