QUIZ???

1. NAME & JOB FUNCTION
2. WHAT IS COMPACTION??
3. WHAT ARE THE GOALS OF COMPACTION??
4. WHAT ARE THE FOUR FORCES OF COMPACTION??
5. WHAT FACTORS AFFECT COMPACTION OF HMA

COMPACTION

- Is a mechanical process:
  - _______ compresses HMA into a smaller denser volume after placement by applying one or more of the 4 forces of compaction
- Increases mixture stability:
  - _______ forces asphalt coated aggregate particles closer together
  - _______ achieves particle to particle contact

COMMUNICATION COMPACTION GOALS

- DENSITY
- SMOOTHNESS
- BALANCED PRODUCTION

IMPORTANCE OF COMPACTION

- IMPROVE MECHANICAL STABILITY
- IMPROVE RESISTANCE TO PERMANENT DEFORMATION
- REDUCE MOISTURE PENETRATION
- IMPROVE FATIGUE RESISTANCE
4 FORCES OF COMPACTION
PRESSURE: A DOWNWARD FORCE
IMPACT: A HAMMER BLOW
VIBRATION: A RAPID SERIES OF IMPACT BLOWS
MANIPULATION: KNEADING IN A CONFINED MANNER
FACTORS AFFECTING COMPACTION

- MIX DESIGN
- AGGREGATE AND ASPHALT CEMENT
- LAB DENSITY & FIELD DENSITY
- CLIMATIC CONDITIONS
- PAVER TYPE AND PAVING METHOD
- TEMPERATURE: MAT, BASE AMBIENT, DIRECTION OF SUN; WIND
IN THE BEGINNING

TRINIDAD-TOBAGO LAKE ASPHALT est. 1998
**HOW DO WE BALANCE PRODUCTION**

- **DETERMINE PAVER SPEED**
- **NUMBER AND TYPE OF ROLLERS**
- **NUMBER OF PASSES WITH ROLLERS TO COVER THE MAT AND OBTAIN DENSITY**

**PAVER PRODUCTION FORMULA**

- $S$ = Paver Speed (ft./min.)
- $W$ = Lane Width (ft.)
- $L$ = Lift Thickness (ft.)
- $D$ = Density (lbs./ft.3)

$$\text{Tons/Hour} = \frac{S \times 60 \text{ min. in} \ 1 \text{ hr.} \times 1 \text{ ton in} \ 2000 \text{ lbs.} \times W \times L \times D}{2000}$$

**FORMULA EXAMPLE**

- **Paver Speed** = 40 ft./min.
- **Lane Width** = 12 ft.
- **Density** = 135 lbs./ft.3
- **Lift Thickness** = .166 ft. = 2 inches

$$\text{Tons/Hour} = \frac{40 \times 60 \times 12 \times .166 \times 135}{2000} = 322 \text{ Tons/ Hour}$$

**BALANCING ROLLERS WITH PAVER SPEED**

- Breakdown Roller: 84” Double Drum Vibratory 4000 vpm
- Roller maintains a min. of 10 impacts per foot (IPF) = 400 fpm
- 400 fpm has to be reduced by # of passes to cover paving width=2; # of passes to obtain density=2; $2 \times 2 = 4$ plus 1 return pass total passes
- 400 fpm divided by 5 passes = 80 fpm
- 80% efficiency factor x 80 fpm = 64 fpm
- This 84” double drum vibratory roller will match 40fpm paving speed
needed for compaction
- mix confinement
- correct mix temperature
Thin mat loses heat quickly
- Thicker mat remains workable much longer
- On thin mats, add more rollers; don’t use more

**Time Available for Compaction**

- Temperature of mat passing under screed affects mat workability
- Work close to paver when mat is cool
- Add rollers when mat is

**Temperature**

- 80°F Surface & Air Temperature, 5 mph wind
- 50°F Surface & Air Temperature, 5 mph wind
- 30°F Surface, 40°F Air Temperature, 15 mph wind
### Major Factors Affecting Rolling Time

<table>
<thead>
<tr>
<th></th>
<th>allows MORE time</th>
<th>allows LESS time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mat Thickness</strong></td>
<td>THICK</td>
<td>THIN</td>
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<tr>
<td><strong>Mix Temperature</strong></td>
<td>HIGH</td>
<td>LOW</td>
</tr>
<tr>
<td><strong>Base Temperature</strong></td>
<td>HIGH</td>
<td>LOW</td>
</tr>
</tbody>
</table>

---

**TransTech’s Temperature Sensors**

- Remote, Non-contact, Accurate
- Identify Paving, Rolling Problems
- Continuous, Instantaneous Display
- Data Logging Capability

---

**Hi Mat Temp Limit: 310 F ADJ. With Control Handle**

**Low Mat Temp Limit: F ADJ. With Control Handle**
PAVEMENT CONSTRUCTION
ISSUES
- 1. NO COMPACTION IN
EMBANKMENTS AND BASES
- 2. SEGREGATION
- 3. POOR COMPACTION
TECHNIQUE

Roller mounted compaction measurement and
documentation systems

Development of Omega values during compaction
Causes of Segregation
- Physical segregation of coarse and fine materials
- Mat temperature differentials immediately behind the paver
- Localized cooling of the mix in haul trucks and formation of crust

Key Points in Prevention of Segregation:
- Prevent Dribbling of Materials
- Keep Material Contained
- Move Material in a Smooth Uniform Uninterrupted Manner.

Segregation Prior to Placement:
- Material Production
- HMA Plant
Segregation During Placement

Material feed system

- Flow Gates
- Slit Conveyors
- Hopper
- Augers
- Sensors

LAGGER DUMPING ANGLE ASSURES MASS DISCHARGE
Nonstop Paving
Use of loading or transfer machine

Goals:
To stabilize a paving operation so the paver can maintain a constant unchanging paving speed, eliminating the stops and starts traditionally associated with trucks dumping directly into the paver.

Cause:
- Material Segregated in Truck
- Running Conveyor Deck Dry
- Cycling Hopper Wings Too Soon
3 PHASES OF ROLLING
- BREAKDOWN
- INTERMEDIATE
- FINISH
### Centrifugal Force

Force generated by vibratory mechanism at a stated amplitude and frequency.

Force changes when amplitude and/or frequency changes.

### Impact Spacing

<table>
<thead>
<tr>
<th>Frequency</th>
<th>2 MPH</th>
<th>3 MPH</th>
<th>4 MPH</th>
<th>5 MPH</th>
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<tbody>
<tr>
<td>2000 vpm</td>
<td>1.06</td>
<td>1.38</td>
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<tr>
<td>2200 vpm</td>
<td>0.96</td>
<td>1.44</td>
<td>1.92</td>
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<tr>
<td>2400 vpm</td>
<td>0.88</td>
<td>1.32</td>
<td>1.76</td>
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<tr>
<td>2600 vpm</td>
<td>0.81</td>
<td>1.22</td>
<td>1.63</td>
<td>2.03</td>
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<tr>
<td>2800 vpm</td>
<td>0.75</td>
<td>1.13</td>
<td>1.51</td>
<td>1.89</td>
</tr>
<tr>
<td>3000 vpm</td>
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<td>1.06</td>
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<tr>
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<tr>
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<td>0.93</td>
<td>1.24</td>
<td>1.55</td>
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<tr>
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<td>0.59</td>
<td>0.88</td>
<td>1.17</td>
<td>1.47</td>
</tr>
<tr>
<td>3800 vpm</td>
<td>0.56</td>
<td>0.83</td>
<td>1.11</td>
<td>1.39</td>
</tr>
</tbody>
</table>

*Always check specifications at the highest temperature or within the speed and pressure limits.*
TRAVEL SPEED OF ROLLERS

DOUBLE DRUM VIBRATORY 2-4 MPH
PNEUMATIC ROLLER 2-3 MPH
STATIC STEEL WHEEL ROLLER 3-5 MPH

SPEED CAN KILL

<table>
<thead>
<tr>
<th>Frequency (vpm)</th>
<th>2 MPH</th>
<th>3 MPH</th>
<th>4 MPH</th>
<th>5 MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>11.36</td>
<td>7.56</td>
<td>5.68</td>
<td>4.55</td>
</tr>
<tr>
<td>2200</td>
<td>12.50</td>
<td>8.33</td>
<td>6.25</td>
<td>5.00</td>
</tr>
<tr>
<td>2400</td>
<td>13.64</td>
<td>9.09</td>
<td>6.82</td>
<td>5.45</td>
</tr>
<tr>
<td>2600</td>
<td>14.77</td>
<td>9.84</td>
<td>7.39</td>
<td>5.91</td>
</tr>
<tr>
<td>2800</td>
<td>15.91</td>
<td>10.61</td>
<td>7.95</td>
<td>6.36</td>
</tr>
<tr>
<td>3000</td>
<td>17.05</td>
<td>11.36</td>
<td>8.52</td>
<td>6.82</td>
</tr>
<tr>
<td>3200</td>
<td>18.18</td>
<td>12.12</td>
<td>9.09</td>
<td>7.27</td>
</tr>
<tr>
<td>3400</td>
<td>19.32</td>
<td>12.88</td>
<td>9.66</td>
<td>7.72</td>
</tr>
<tr>
<td>3600</td>
<td>20.45</td>
<td>13.64</td>
<td>10.22</td>
<td>8.18</td>
</tr>
<tr>
<td>3800</td>
<td>21.59</td>
<td>14.39</td>
<td>10.80</td>
<td>8.63</td>
</tr>
</tbody>
</table>

C766C & C778B
MSPI - MULTI SYSTEM PERFORMANCE INDICATOR
ELECTRONIC CONTROL SYSTEM
Effect of Lift Thickness on Density

Summary of Lift Thickness Experiment

Effect of Lift Thickness on Density

[Graph showing the relationship between lift thickness and density]
Lift Thickness

- Recommended 3:1 to 6:1 Thickness: NMAS
- Thin lifts cool faster
  - less time available for compaction

BUILDING QUALITY
HOT MIX ASPHALT
JOINTS

CHUCK DEAHL
BOMAG AMERICAS, INC.
Steps in Making Good Longitudinal Joints

1- Control Segregation at the Outside Edges of the Mat
2- Steer a Straight Line
3- Compact Unconfined Edge
4- Maintain Correct Overlap
5- Place the Proper Depth for Roll Down
6- Do Not Lute the Joint
7- Compact the Joint for Density

Control Segregation at the Outside Edges of the Mat

Minimize Segregation at the Outside Edges of the Mat
Properly Adjust the Material Sensors

Steer a Straight Line

Maintain Proper Overlap
A Must for Proper Joint Construction
Reference String line to assist in getting the 1st pass string line.

Maryland

Great Results
Option 1
Hang over 6”
Roller

Option 2
1st Pass 3”-6” inside
2nd Pass hang over 3”-6”
Roller

Compacting Unsupported Edge using Steel Wheel Roller

Option 1
Hang over 6”
Roller

Option 2
1st Pass 3”-6” inside
2nd Pass hang over 3”-6”
Roller
3. Compaction of Unsupported Edge using Pneumatic Tire Roller

- Recommended
- Not Recommended

Pushes out

4&5. Maintain Proper Overlap and Matching Depth

Proper Roll Down – Start With 25% of the Depth

1st Pass (Cold) 2nd Pass (Hot)

1/2 - 1 1/2" (13-35mm) Overlap

Minimum Overlap for Compaction is 1/2 Inch (13mm)

Always Check Joint Roll Down Behind the First Roller
If Your Joint is Set Up Correctly, Little or No Handwork Should be Required

Maintain Proper Overlap and Matching Depth

Overlap

Frank & John Shipley (SHA) noting aggregate appearance after 1st roller pass; "it blends into the mat within 6 months"
6. Do Not Lute Joint
- Moves material away from joint
- Results in low-density zone at joint

7. Compacting Longitudinal Joints
- 6” – 8” Offset
Material Flow at Joint

Pinching the Joint
Material Flows Away From the Confined Edge & Less Density is Achieved

Material Flows Toward Confined Edge & Builds Greater Density

Compacting Your Longitudinal Joints

First Pass
Hot Cold
6 to 8 Inches
Creates a Confined Edge & Raised Area

Second Pass Use, Vibratory to Build Density

<table>
<thead>
<tr>
<th>Cold</th>
<th>Roller First Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold</td>
<td>Roller First Pass</td>
</tr>
</tbody>
</table>

Roller Drum (Static)
Roller Drum (Vibratory)
BASIC PRINCIPLES OF GOOD COMPACTION

KNOW THE VARIABLES

KNOW THE SPECS KNOW THE LAYOUT

ESTABLISH A PATTERN TO ACHIEVE:
COVERAGE, DENSITY, SMOOTHNESS, AND
BALANCED PRODUCTION

KNOW THE BASIC OPERATION OF EACH
TYPE OF ROLLER

INTELLIGENT COMPACTION

- A SYSTEM FOR MEASURING THE STIFFNESS OF HMA ON THE ROLLER
- A RECORDING OF THAT STIFFNESS MEASUREMENT
- PROOF OF THE STIFFNESS OF THE HMA AS RELATED TO DENSITY
- PROVIDING INFORMATION FOR THE ROLLER TO MAKE DECISIONS
VARIOMATIC roller with directed vibration

**Asphalt Manager with new measuring value** $E_{\text{VIB}}$ [MN/m²]

**Directed Exciter System**

- Vibration motor
- Exciter housing (slewable)
- Unbalanced weights (counter-rotating):
  - inner: No. 2 + 3
  - outer: No. 1 + 4
- Travel motor
- Compaction force
- Steady motor
The Operator

Asphalt Manager: Easy to understand

Bomag Operational Panel

- Start
- Stop
- Print out
- Delete

Test procedure:
- Mark the track to be compacted
- "Manual operation mode" with
  - Fixed amplitude
  - Fixed working speed
**E\textsubscript{VIB} - Printer**

- **E\textsubscript{VIB} Max. / E\textsubscript{VIB} Min.**
- **E\textsubscript{VIB} Average**
- **Frequency**
- **Average Speed**
- **Track length**
- **Temperature**

---

**8.8.2 Test Strip Construction**

- Simulating Actual Conditions
- Establishing Roller Pattern
- Effective Roller Speed
E_{n60} and Density as function of passes; BW 174 AD Asphalt Manager, Automatic mode; Asphalt Base 0/32 CS B65, Nürnberg A3

- EVIB and Density as function of passes; BW 174 AD Asphalt Manager, Automatic mode; Asphalt Base 0/32 CS B65, Nürnberg A3
- 4 cm SMA 0/11 S
- 8 cm binder 0/22
- > 10 cm ATS 0/32

Passes

- EVIB [MN/m²], [°C]
- Surface temp.
- Core temp.
- Troxler density
Asphalt Manager

Benefits for Contractors:

Compaction
- Uniform and predictable results whilst rolling
- Avoids under / overcompaction
- Better eveness and roughness
- Eliminates drum bouncing

Economical and quality aspects
- More efficient roller utilisation with fewer passes
- Reduced shock loads in sensitive environment e.g. buildings, bridges
- Area coverage method
$ VALUE

- I/C MEASURES THE STIFFNESS OF A LIFT OF HMA
- DENSOMETERS MEASURE DENSITY OF HMA
- THIS GIVES US TWO MEASUREMENTS OF THE STABILITY OF THE HMA
- WHY CUT SO MANY CORES THAT COST $800.00-$1000.00 A CORE

THE END

QUESTIONS?