BEST PRACTICES OF HMA COMPACTION

CHUCK DEAHL
BOMAG AMERICAS,INC.

COMPACTION PRINCIPLES

CHUCK DEAHL
BOMAG AMERICAS,INC.

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

COMMUNICATION
COMPACTION GOALS

- *DENSITY*
- *SMOOTHNESS*
- *BALANCED PRODUCTION*

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

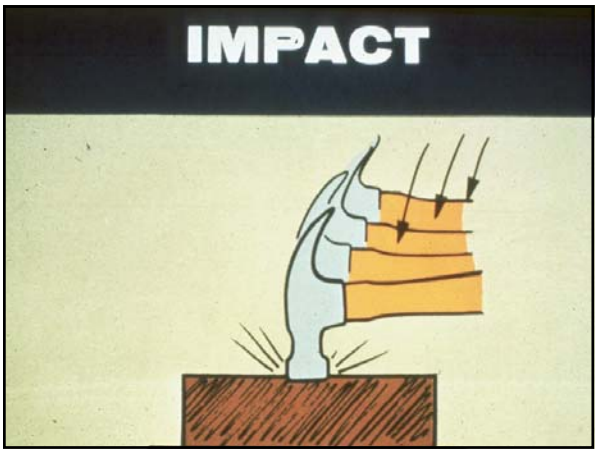
IMPORTANCE OF COMPACTION

- IMPROVE MECHANICAL STABILITY
- IMPROVE RESISTANCE TO PERMANENT DEFORMATION
- REDUCE MOISTURE PENETRATION
- IMPROVE FATIGUE RESISTANCE

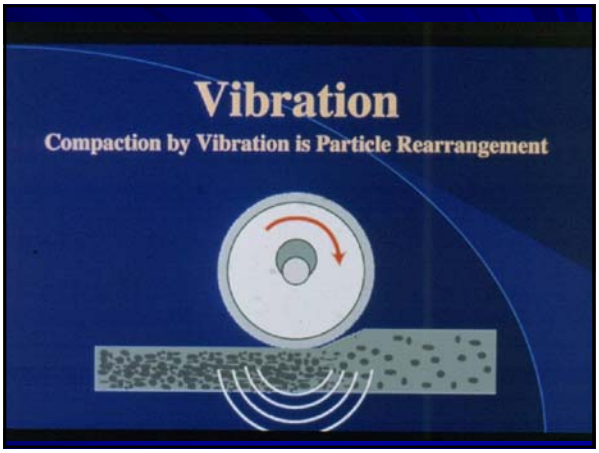
4 FORCES OF COMPACTION

- PRESSURE: A DOWNWARD FORCE
- IMPACT: A HAMMER BLOW
- VIBRATION: A RAPID SERIES OF IMPACT BLOWS
- MANIPULATION: KNEADING IN A CONFINED MANNER


KNEADING ACTION


IMPACT

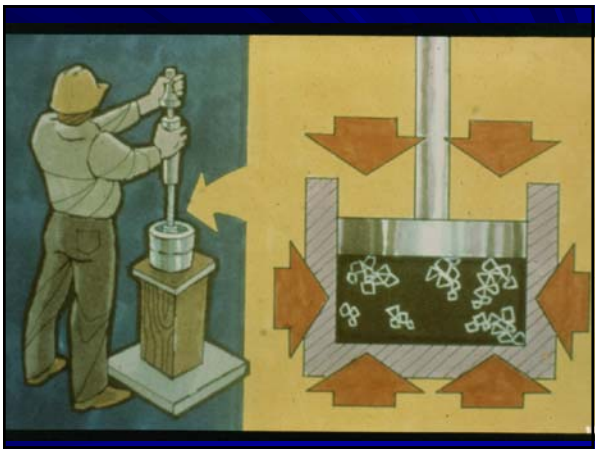

FINE-GRAINED (COHESIVE)

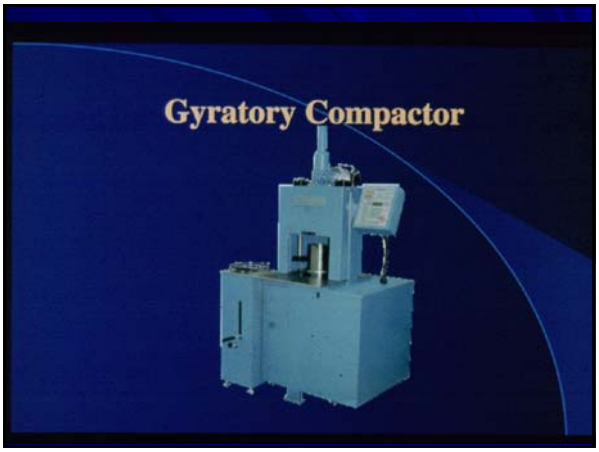

Vibration
Compaction by Vibration is Particle Rearrangement

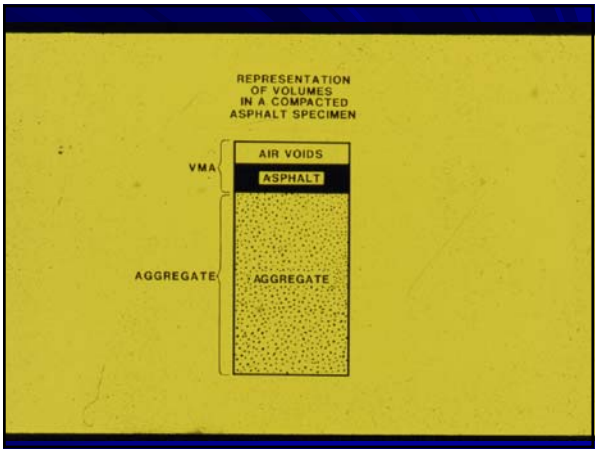

HYPAC

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

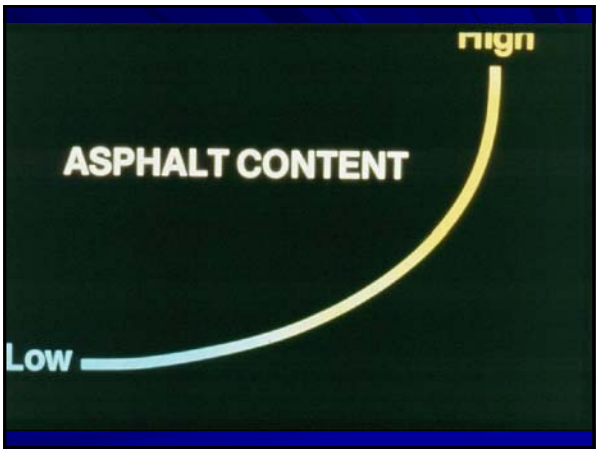


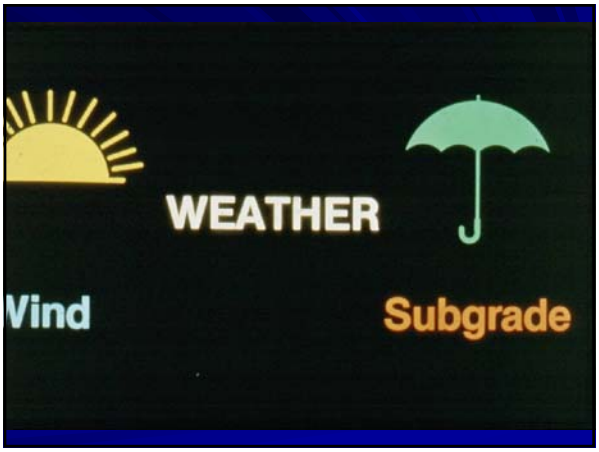




IN THE BEGINNING

TRINIDAD-TOBAGO LAKE ASPHALT est. 1998


High
ASPHALT CONTENT
Low


WEATHER
Wind
Subgrade

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)

- Tons/Hour= S x 60 min. in1 hr.x 1 ton in 2000 lbs.x W x L x D

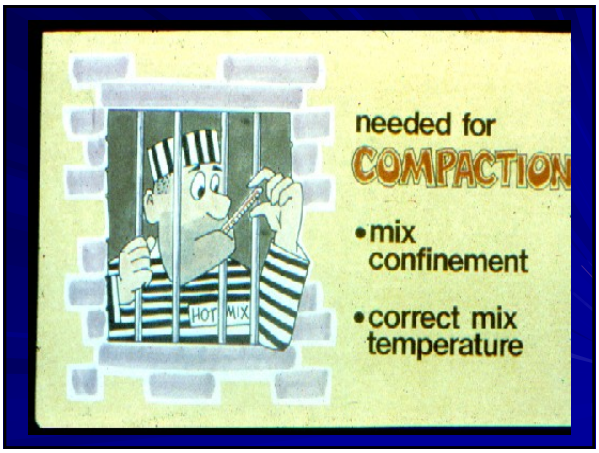
FORMULA EXAMPLE

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

- Tons/Hour = 40 x 60 x 12 x .166 x135 divided by 2000= 322 Tons/ Hour

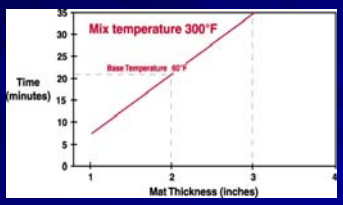
BALANCING ROLLERS WITH PAVER SPEED

- 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; 2x2=4plus 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
HOT MIX

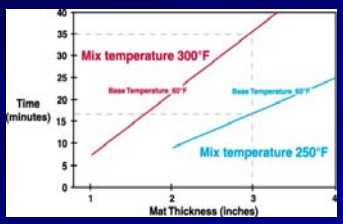

ANTIGO

Time Available for Compaction



- Thin mat loses heat quickly
- Thicker mat remains workable much longer
- On thin mats, add more rollers; don't use more

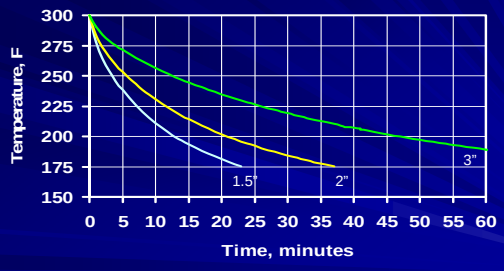
Time Available for Compaction



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

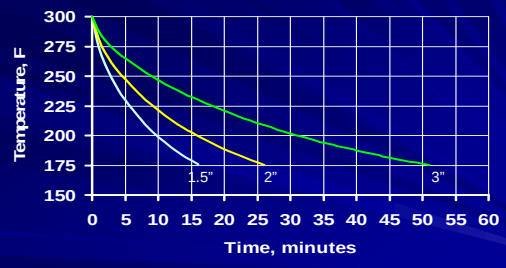
Temperature

80°F Surface & Air Temperature, 5 mph wind



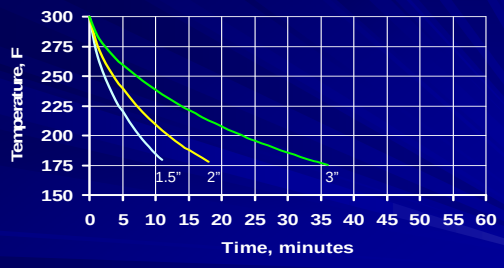
Temperature

50°F Surface & Air Temperature, 5 mph wind



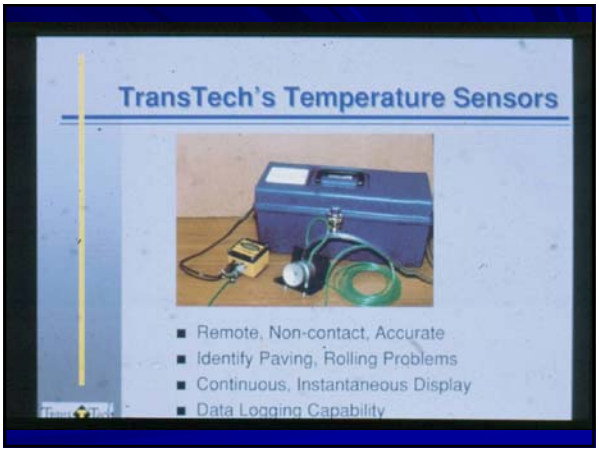
Temperature

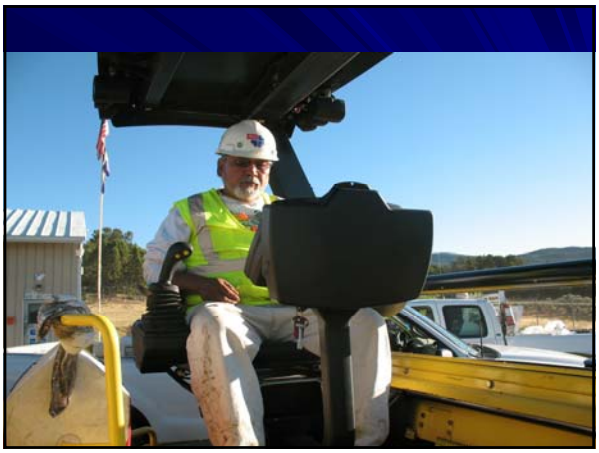
30°F Surface, 40°F Air Temperature, 15 mph wind



Major Factors Affecting Rolling Time

	allows MORE time	allows LESS time
Mat Thickness	THICK	THIN
Mix Temperature	HIGH	LOW
Base Temperature	HIGH	LOW

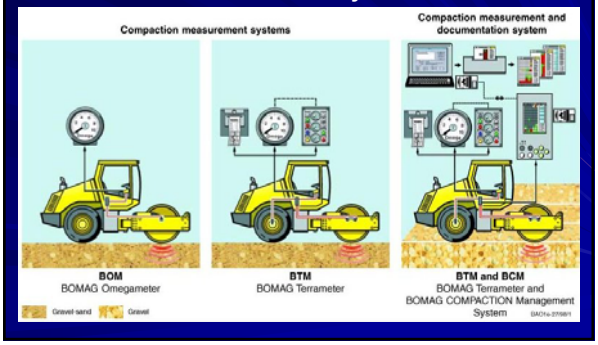




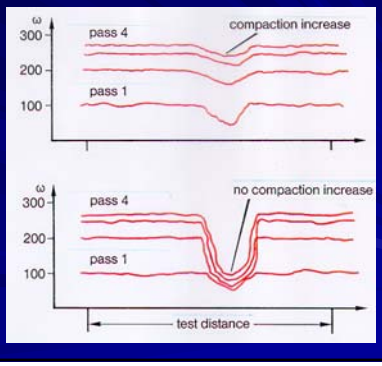
PAVEMENT CONSTRUCTION ISSUES

- 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:

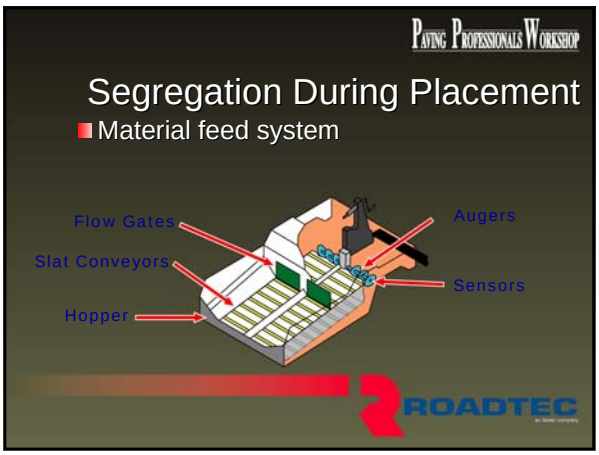
- Prevent Dribbling of Materials
- Keep Material Contained
- Move Material in a Smooth Uniform Uninterrupted Manner.

Segregation Prior to Placement:

- Material Production
- HMA Plant


ROADTEC


MASS MOVMENT
LARGER DUMPING ANGLE
ASSURES MASS DISCHARGE


Paving Professionals Workshop
Segregation During Placement
Material feed system
Flow Gates
Slat Conveyors
Hopper
Augers
Sensors
ROADTEC

Cause:

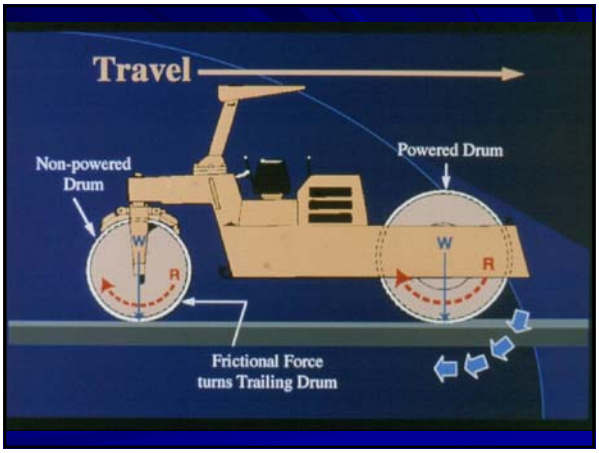
- Material Segregated in Truck
- Running Conveyor Deck Dry
- Cycling Hopper Wings Too Soon

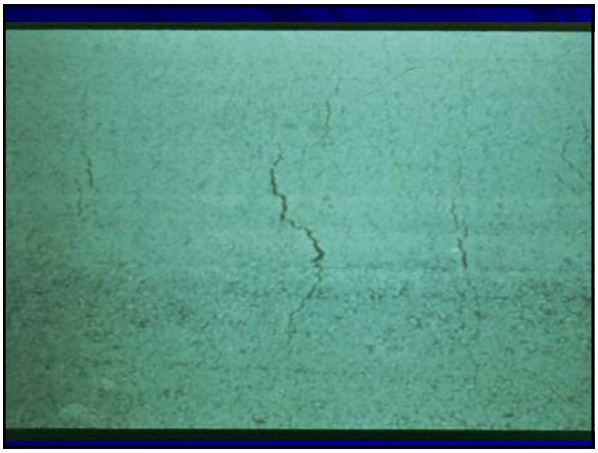
Nonstop Paving
Use of loading or transfer machine

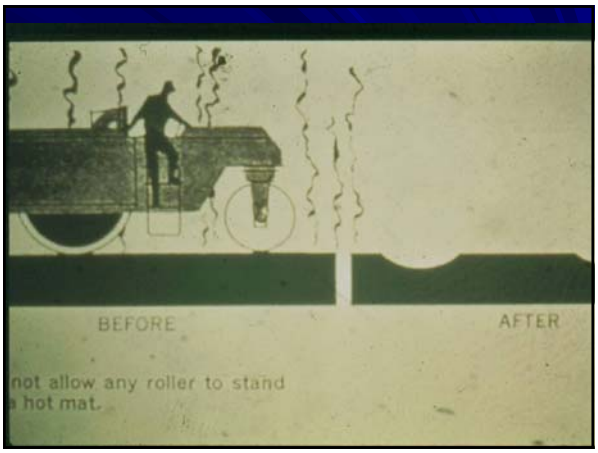
Goals:
To stabilize a paving operation so the paver can maintain a constant unchanging paving speed, eliminating the stops and starts traditionally associated with trucks dumping directly into the paver.

3 PHASES OF ROLLING

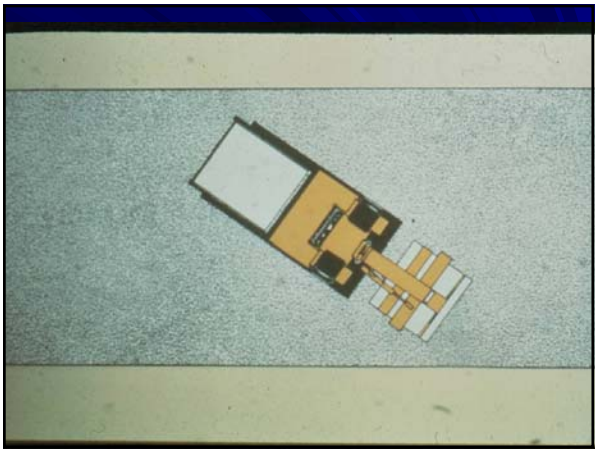
- BREAKDOWN
- INTERMEDIATE
- FINISH

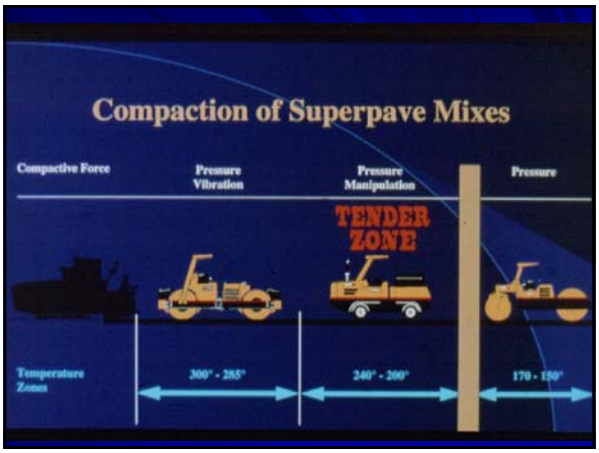


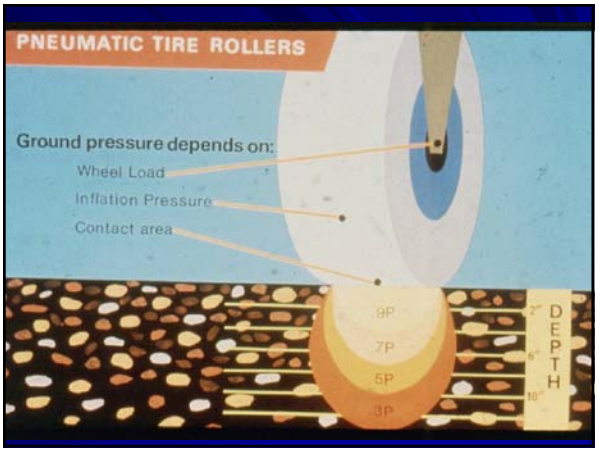


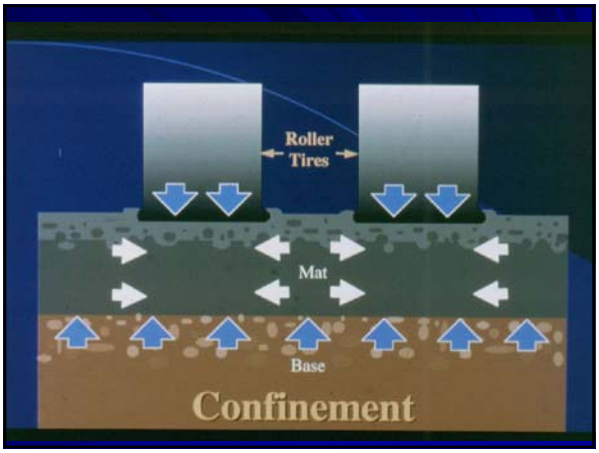

BEFORE
AFTER
not allow any roller to stand
hot mat.

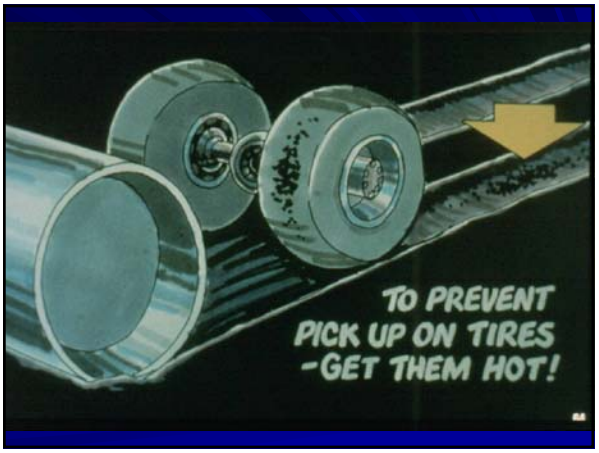

INGERSOLL-RAND

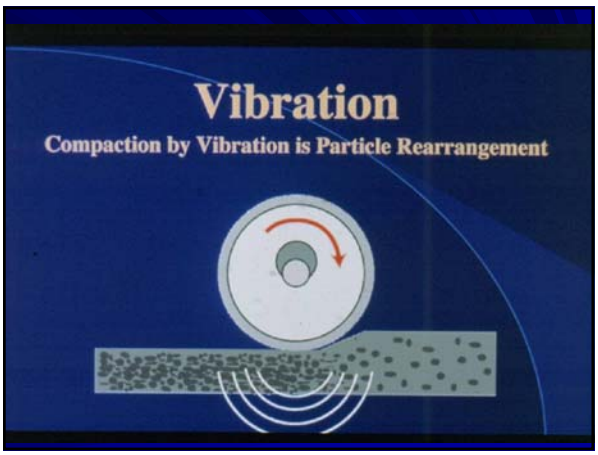


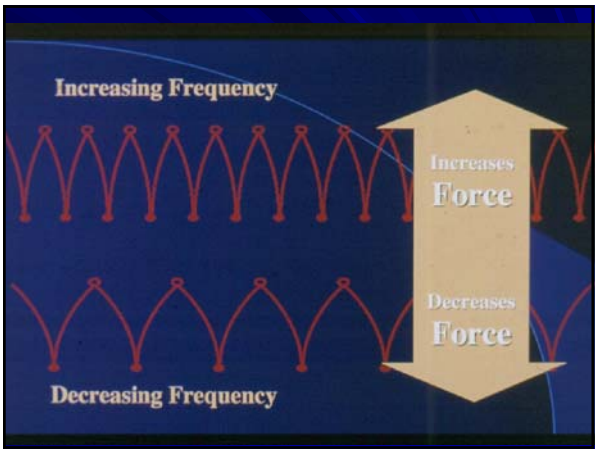

Compaction of Superpave Mixes
Compactive Force
Pressure Vibration
Pressure Manipulation
Pressure
TENDER ZONE
Temperature Zones
300° - 285°
240° - 200°
170 - 150°

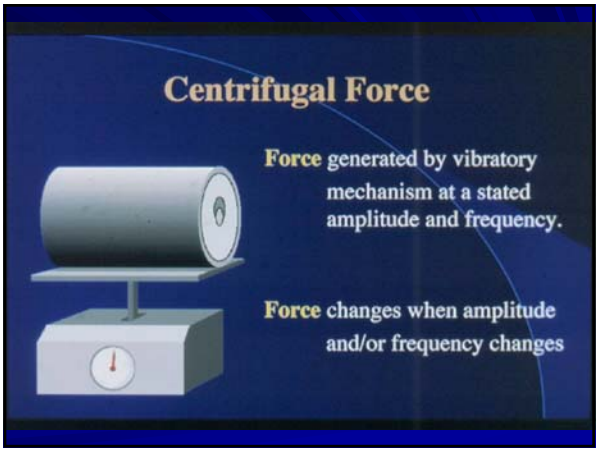

PNEUMATIC TIRE ROLLERS
Ground pressure depends on:
Wheel Load
Inflation Pressure
Contact area
9P
7P
5P
3P
DEPTH

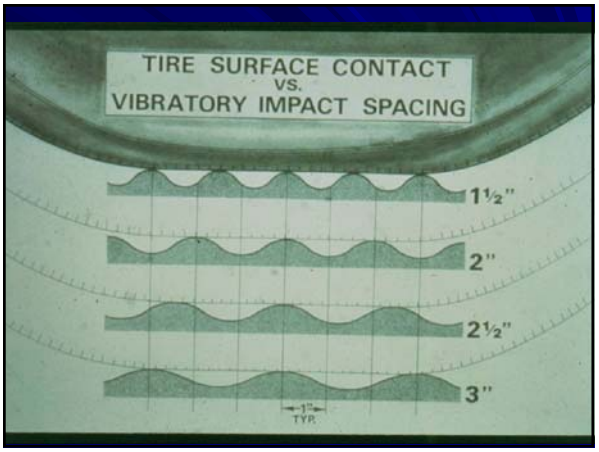

Roller Tires
Mat
Base
Confinement

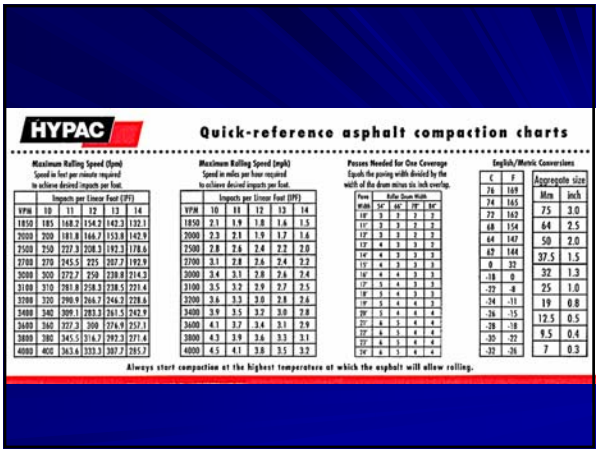

TO PREVENT PICK UP ON TIRES -GET THEM HOT!


Vibration
Compaction by Vibration is Particle Rearrangement









Impact Spacing

Frequency	2 MPH	3 MPH	4 MPH	5 MPH
2000 vpm	1.06	1.58	2.14	2.64
2200 vpm	0.96	1.44	1.92	2.40
2400 vpm	0.88	1.32	1.76	2.20
2600 vpm	0.81	1.22	1.63	2.03
2800 vpm	0.75	1.13	1.51	1.89
3000 vpm	0.70	1.06	1.41	1.76
3200 vpm	0.66	0.99	1.33	1.65
3400 vpm	0.62	0.93	1.24	1.55
3600 vpm	0.59	0.88	1.17	1.47
3800 vpm	0.56	0.83	1.11	1.39

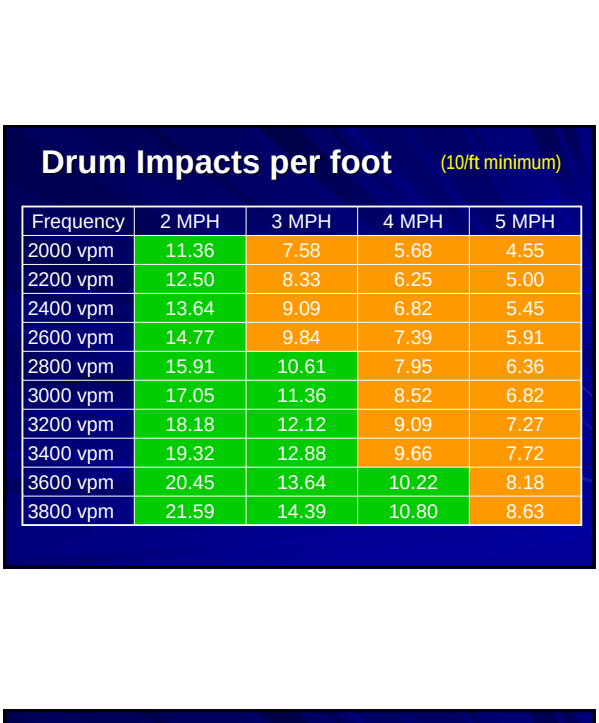
TRAVEL SPEED OF ROLLERS

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

SPEED CAN KILL

Drum Impacts per foot (10/ft minimum)

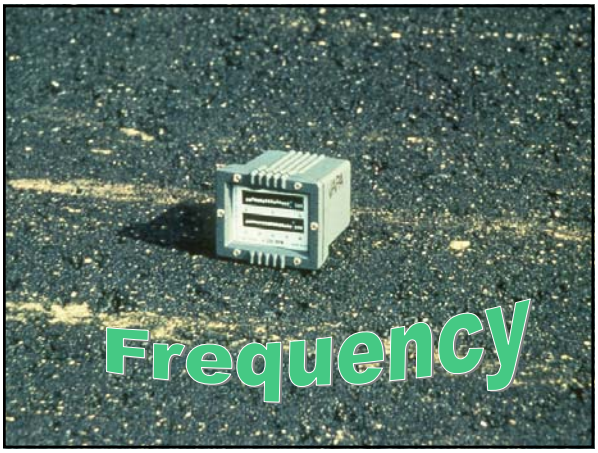
Frequency	2 MPH	3 MPH	4 MPH	5 MPH
2000 vpm	11.36	7.58	5.68	4.55
2200 vpm	12.50	8.33	6.25	5.00
2400 vpm	13.64	9.09	6.82	5.45
2600 vpm	14.77	9.84	7.39	5.91
2800 vpm	15.91	10.61	7.95	6.36
3000 vpm	17.05	11.36	8.52	6.82
3200 vpm	18.18	12.12	9.09	7.27
3400 vpm	19.32	12.88	9.66	7.72
3600 vpm	20.45	13.64	10.22	8.18
3800 vpm	21.59	14.39	10.80	8.63

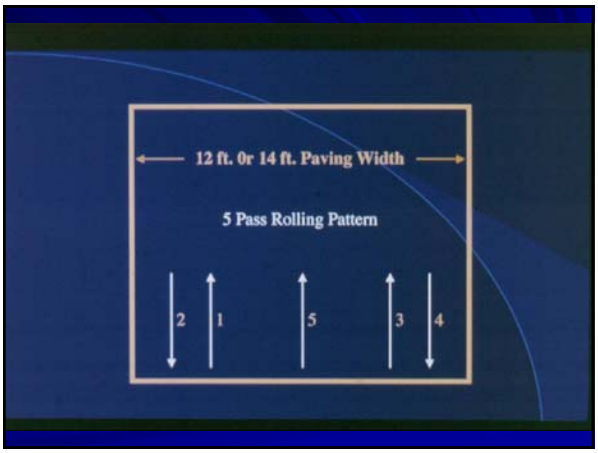


C766C & C778B

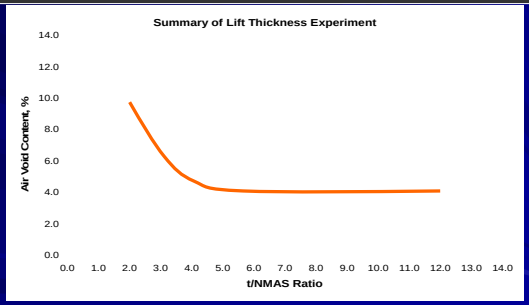
MSPI - MULTI SYSTEM PERFORMANCE INDICATOR

ELECTRONIC CONTROL SYSTEM



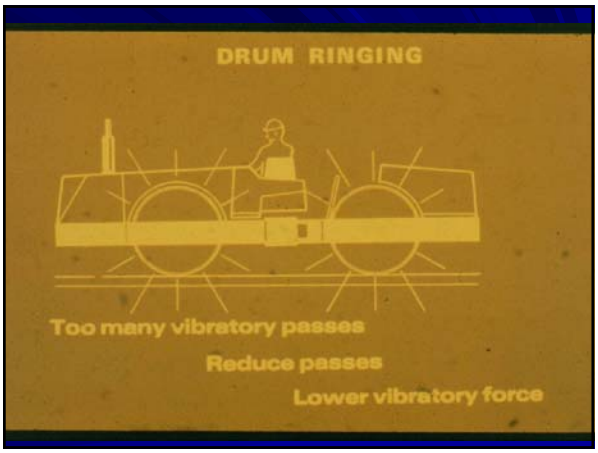


Effect of Lift Thickness on Density



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

1 Control Segregation at the Outside Edges of the Mat

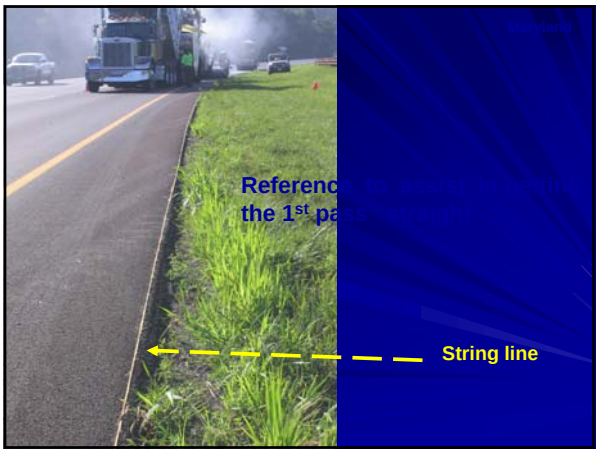
Minimize Segregation at the Outside Edges of the Mat

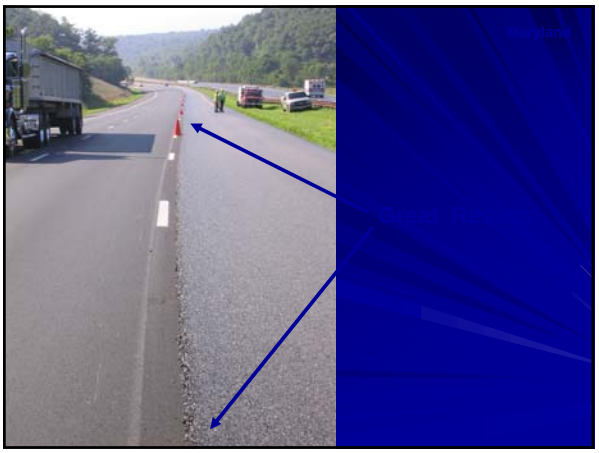
Properly Adjust the Material Sensors

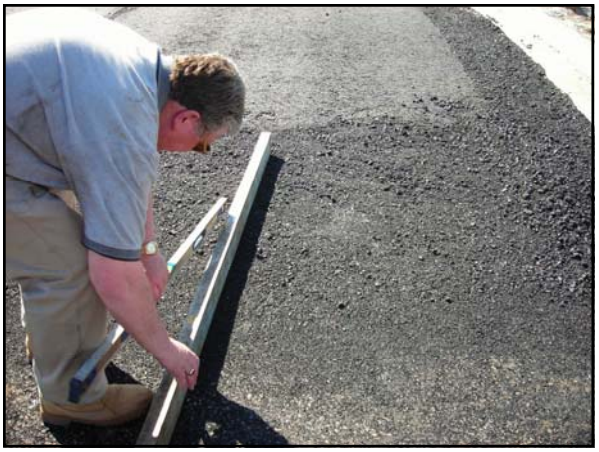
Use Correct Length of Auger Tunnels

2 Steer a Straight Line

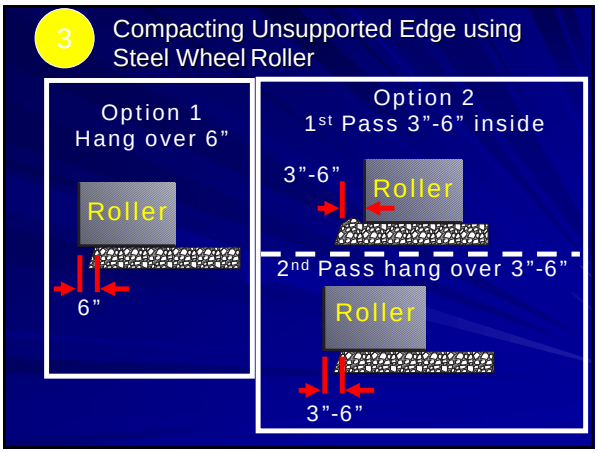
Maintain Proper Overlap
A Must for Proper Joint Construction

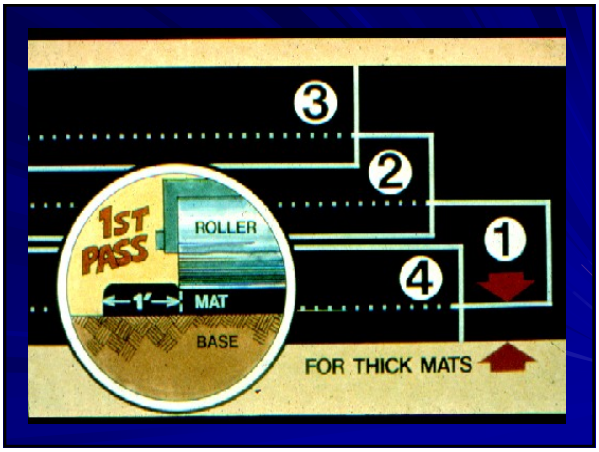

Reference to assist in setting
the 1st pass straight
String line

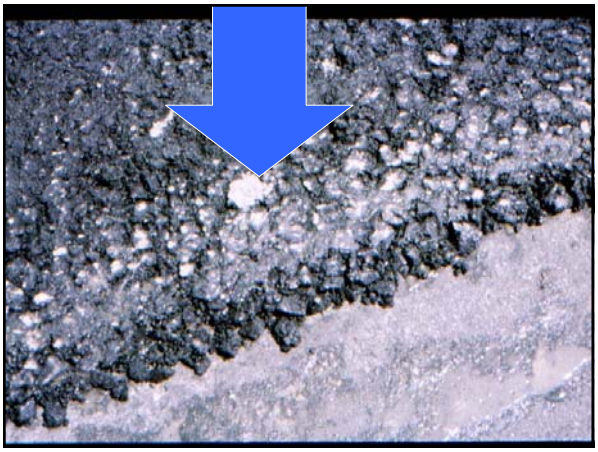

Grade Control




HYPAC

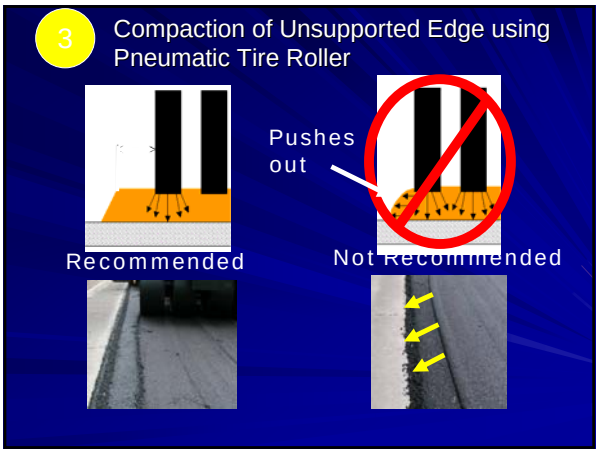

3
Compacting Unsupported Edge using Steel Wheel Roller
Option 1
Hang over 6”
Roller
6”
Option 2
1st Pass 3”-6” inside
3”-6”
Roller
2nd Pass hang over 3”-6”
Roller
3”-6”

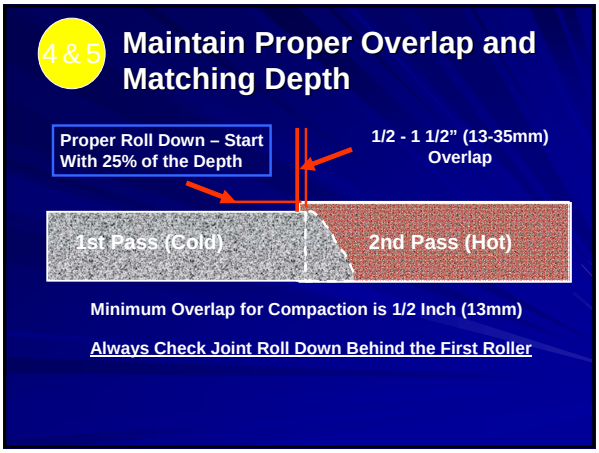

3
2
1
4
1ST PASS
ROLLER
1’
MAT
BASE
FOR THICK MATS




HYPAC


BOMAG


3
Compaction of Unsupported Edge using Pneumatic Tire Roller
Pushes out
Recommended
Not Recommended


4 & 5
Maintain Proper Overlap and Matching Depth
Proper Roll Down – Start With 25% of the Depth
1/2 - 1 1/2" (13-35mm) Overlap
1st Pass (Cold)
2nd Pass (Hot)
Minimum Overlap for Compaction is 1/2 Inch (13mm)
Always Check Joint Roll Down Behind the First Roller

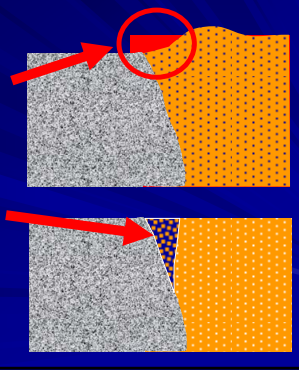
4 & 5 Maintain Proper Overlap and Matching Depth

If Your Joint is Set Up Correctly, Little or No Handwork Should be Required

6

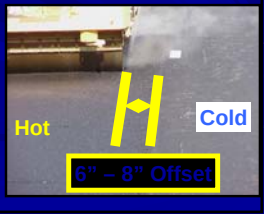
Do Not Lute Joint

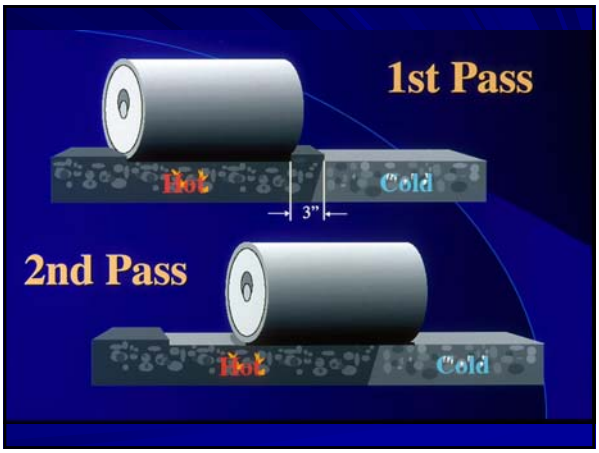
- Moves material away from joint
- Results in low-density zone at joint

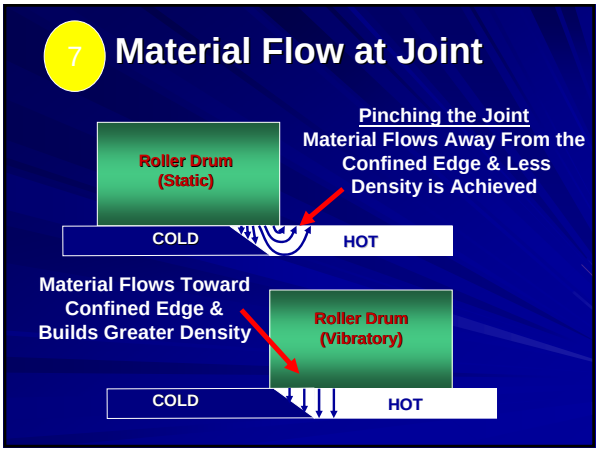


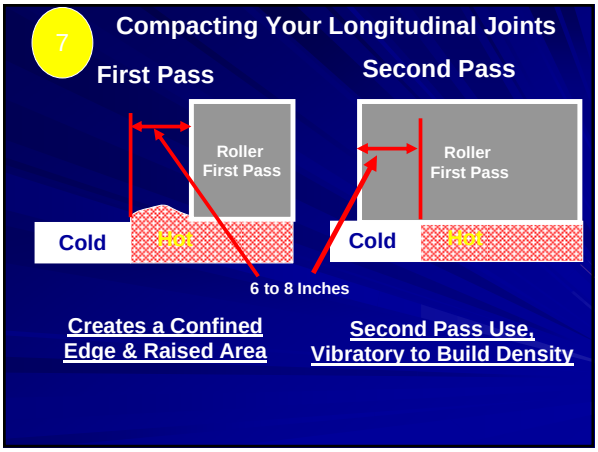
Bump the joint

7 **Compacting Longitudinal Joints**




1st Pass
Hot
Cold
3"
2nd Pass
Hot
Cold


7
Material Flow at Joint
Roller Drum (Static)
Pinching the Joint
Material Flows Away From the Confined Edge & Less Density is Achieved
COLD
HOT
Material Flows Toward Confined Edge & Builds Greater Density
Roller Drum (Vibratory)
COLD
HOT

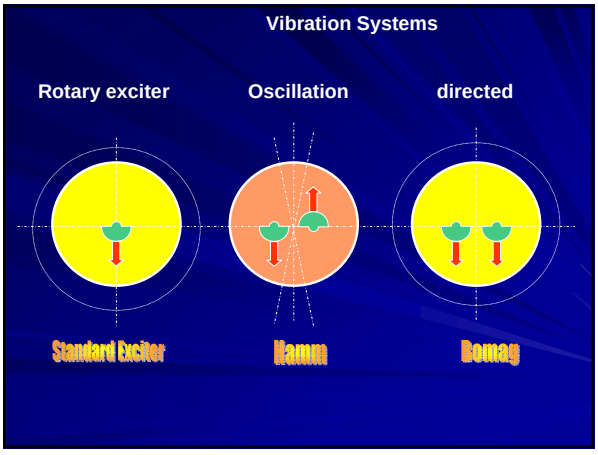

7
Compacting Your Longitudinal Joints
First Pass
Second Pass
Roller First Pass
Roller First Pass
Cold
Hot
Cold
Hot
6 to 8 Inches
Creates a Confined Edge & Raised Area
Second Pass Use, Vibratory to Build Density

BASIC PRINCIPLES OF GOOD COMPACTION

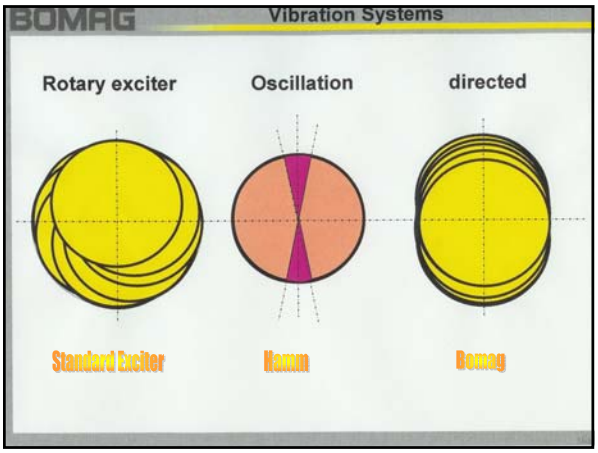
- KNOW THE VARIABLES
- KNOW THE SPECS KNOW THE LAYOUT
- ESTABLISH A PATTERN TO ACHIEVE: COVERAGE, DENSITY, SMOOTHNESS, AND BALANCED PRODUCTION
- KNOW THE BASIC OPERATION OF EACH TYPE OF ROLLER

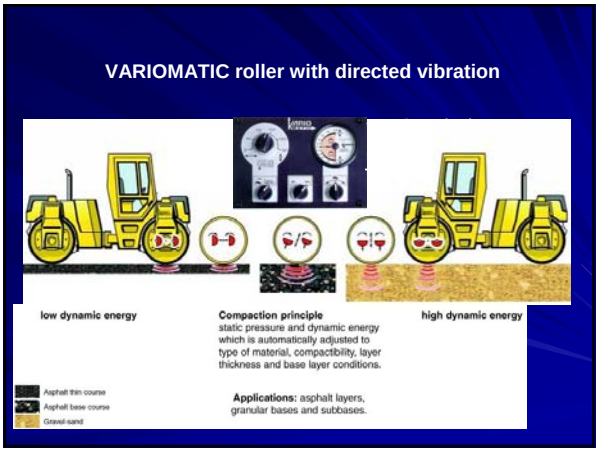
INTELLIGENT COMPACTION

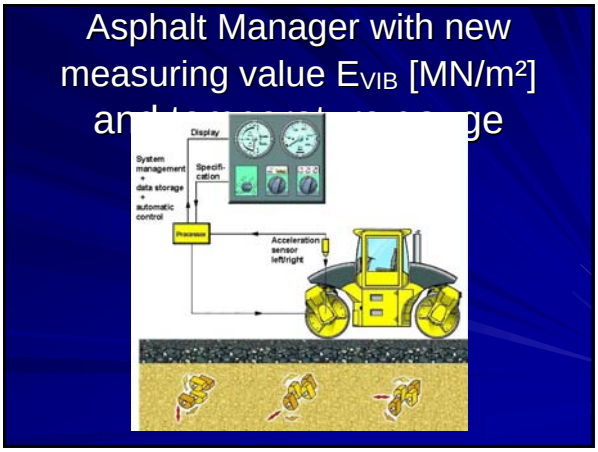
- A SYSTEM FOR MEASURING THE STIFFNESS OF HMA ON THE ROLLER
- A RECORDING OF THAT STIFFNESS MEASURMENT
- PROOF OF THE STIFFNESS OF THE HMA AS RELATED TO DENSITY
- PROVIDING INFORMATION FOR THE ROLLER TO MAKE DECISIONS

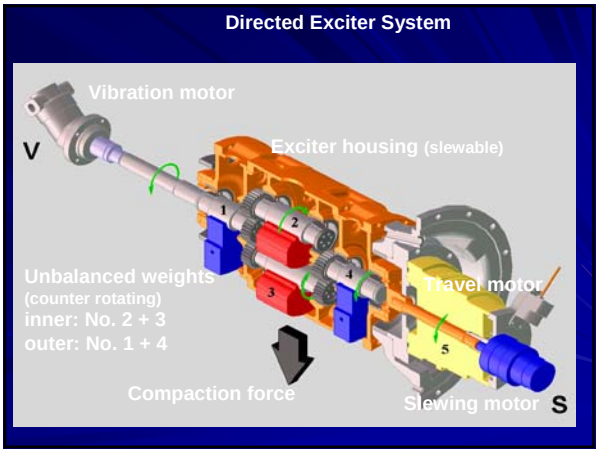


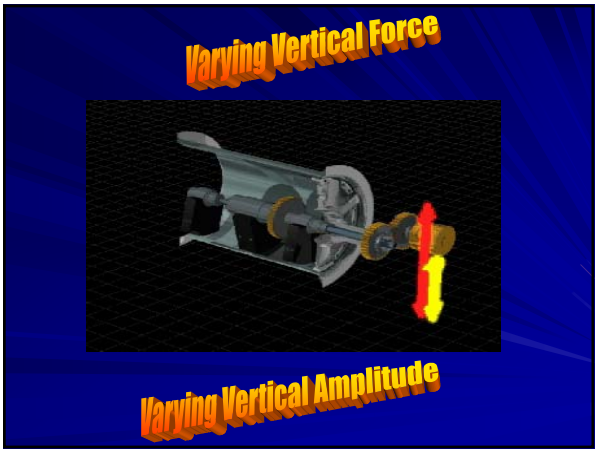

HD 85


BOMAG
Vibration Systems
Rotary exciter
Oscillation
directed
Standard Exciter
Hamm
Bomag


VARIOMATIC roller with directed vibration
low dynamic energy
Compaction principle
static pressure and dynamic energy which is automatically adjusted to type of material, compactibility, layer thickness and base layer conditions.
high dynamic energy
Asphalt thin course
Asphalt base course
Gravel-sand
Applications: asphalt layers, granular bases and subbases.


Asphalt Manager with new measuring value EVIB [MN/m²]
Display
System management + data storage + automatic control
Specifi-cation
Processor
Acceleration sensor left/right


Directed Exciter System
Vibration motor
V
Exciter housing (slewable)
1
2
3
4
5
Unbalanced weights
(counter rotating)
inner: No. 2 + 3
outer: No. 1 + 4
Travel motor
Compaction force
Slewing motor
S


Varying Vertical Force
Varying Vertical Amplitude

The Operator

Asphalt Manager: Easy to understand

Changing From Metric To U.S. Units

6 Settings From Horizontal To Vertical

Bomag Operational Panel

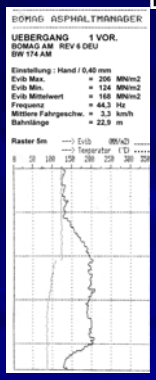
PRINTER
- Start
- Stop
- Print out
- Delete

Test procedere:

- Mark the track to be compacted
- „Manual operation mode“ with
- Fixed amplitude
- Fixed working speed

Printer

E_{VIB} - Printer



E_{VIB} Max. / E_{VIB} Min.

E_{VIB} Average

Frequency

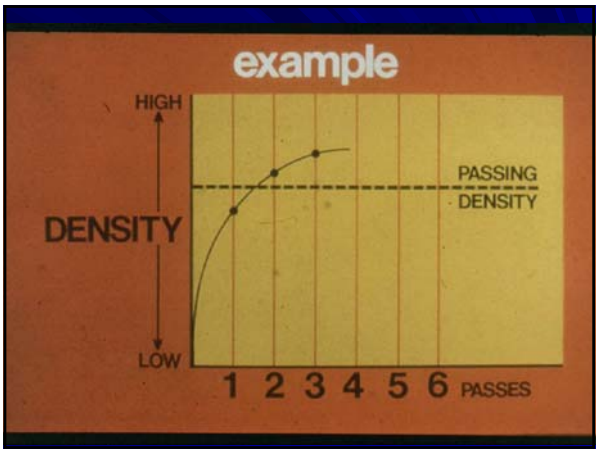
Average Speed

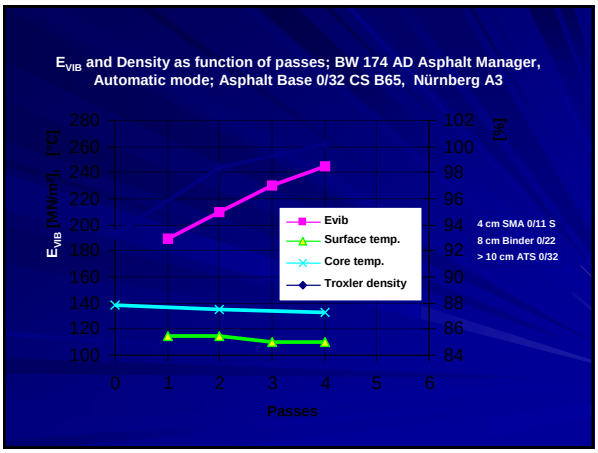
Track length

Temperature

8.8.2 Test Strip Construction

- Simulating Actual Conditions
- Establishing Roller Pattern
- Effective Roller Speed


example
HIGH
DENSITY
LOW
PASSING
DENSITY
1 2 3 4 5 6 PASSES


E_{VIB} and Density as function of passes; BW 174 AD Asphalt Manager, Automatic mode; Asphalt Base 0/32 CS B65, Nürnberg A3
E_{VIB} [MN/m²], [°C]
[%]
Passes
Evib
Surface temp.
Core temp.
Troxler density
4 cm SMA 0/11 S
8 cm Binder 0/22
> 10 cm ATS 0/32

Investment for Profit

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 ?
?