NCAUPG
HOT MIX ASPHALT TECHNICAL WORKSHOP AND CONFERENCE

INTELLIGENT COMPACTION

CHUCK DEAHL

BOMAG AMERICAS,INC.

TOOL BOX TALKS PRODUCED BY NAPA

1. TRUCK EXCHANGE
2. OPERATION OF MTV
3. FOUR FORCES OF COMPACTION
4. COMPACTION PRINCIPLES
5. LONGITUDINAL JOINT CONSTRUCTION

Longitudinal Joint Construction

Building a Sound Longitudinal Joint

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

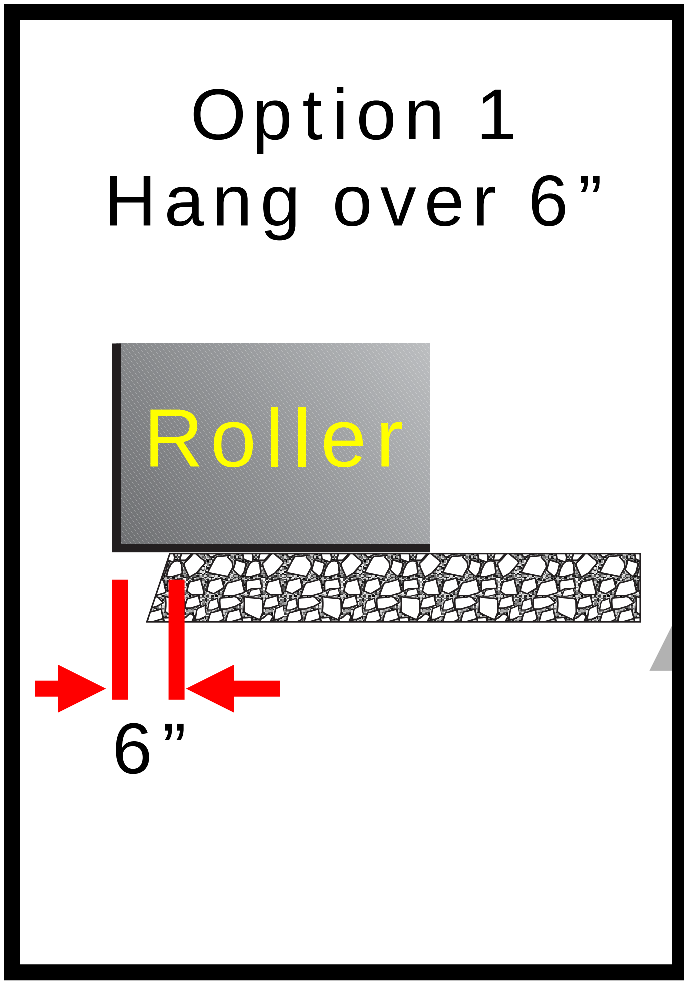
Steer a Straight Line

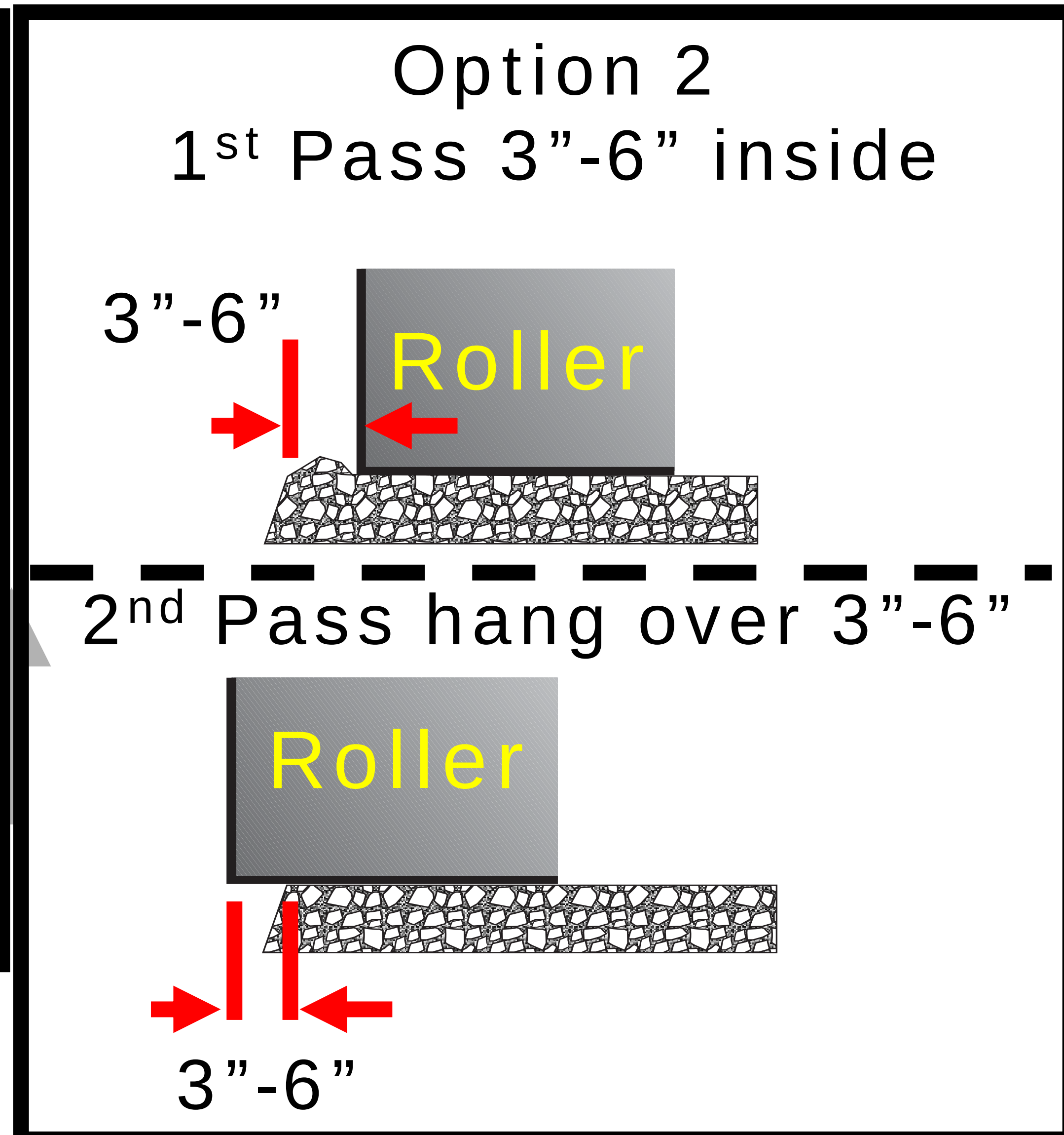
<u>Maintain Proper Overlap</u>

<u>A Must for Proper Joint Construction</u>

3

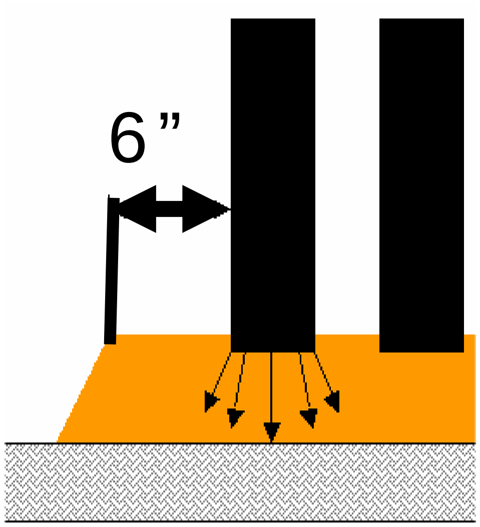
Compacting Unsupported Edge using Steel Wheel Roller

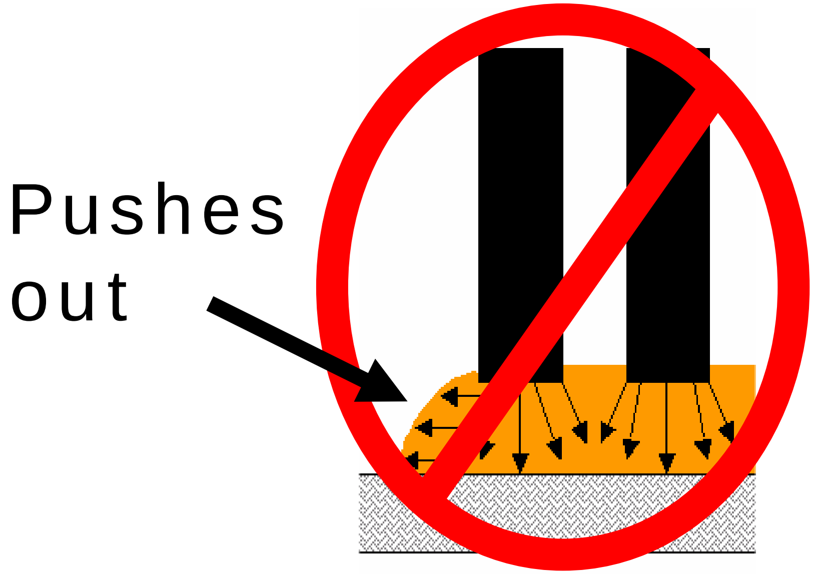




3

Compaction of Unsupported Edge using Pneumatic Tire Roller



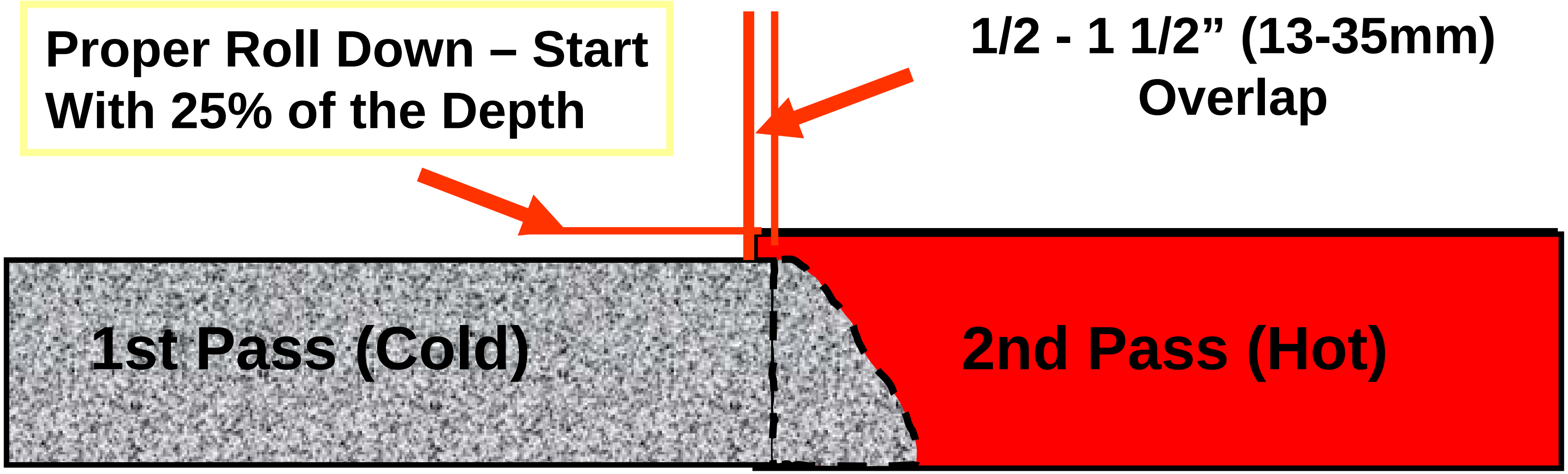


Recommended

Not Recommended

Maintain Proper Overlap and Matching Depth

4 & 5



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

<u>Always Check Joint Roll Down Behind the First Roller</u>

4 & 5

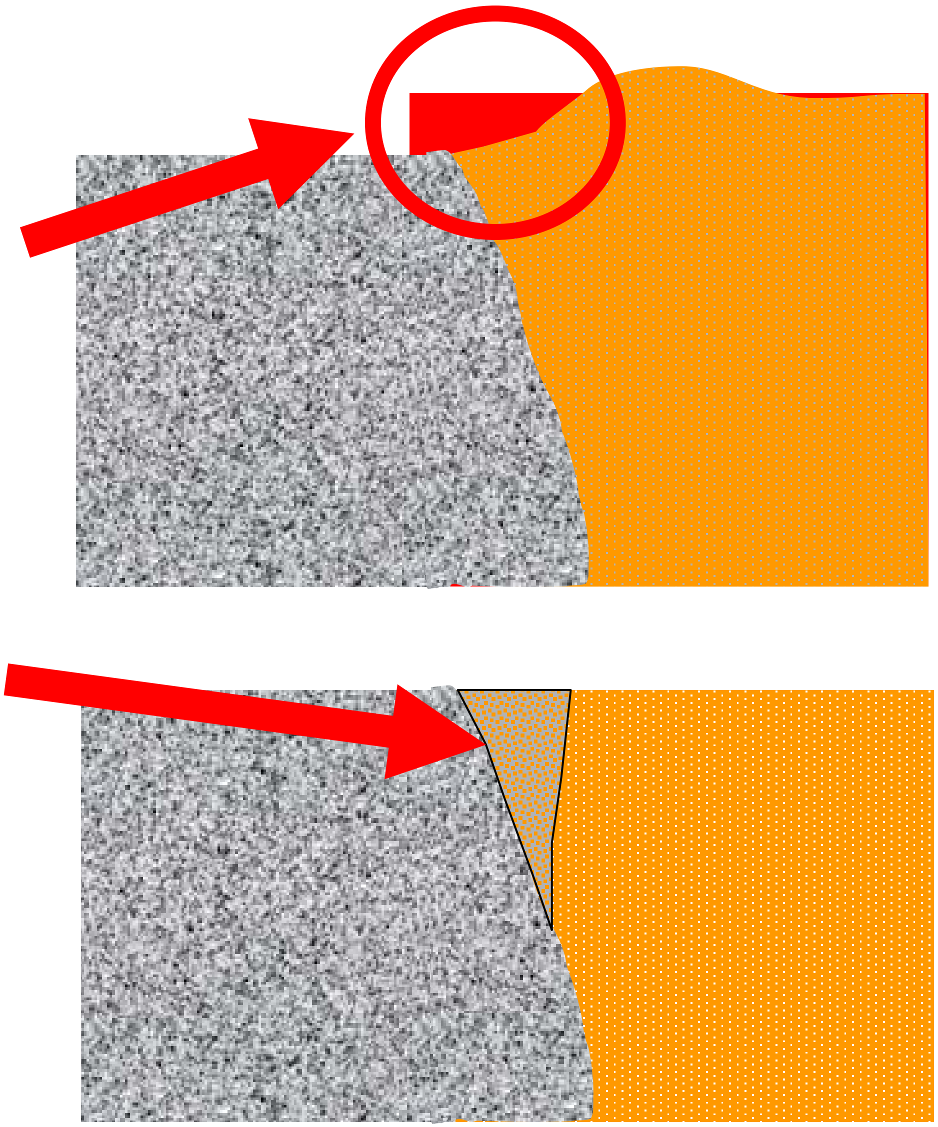
If Your Joint is Set Up Correctly, Little or No Handwork Should be Required

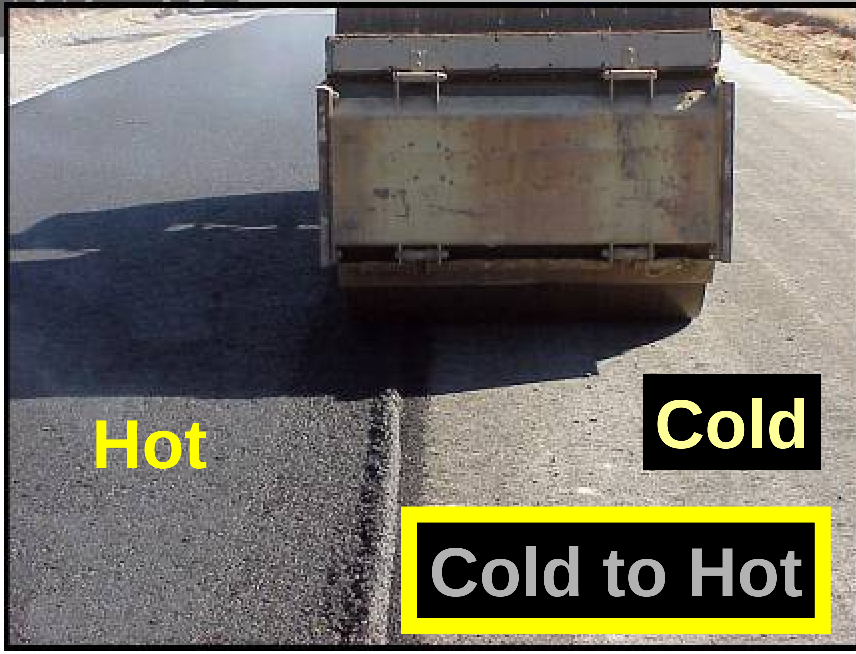
Do Not Lute Joint

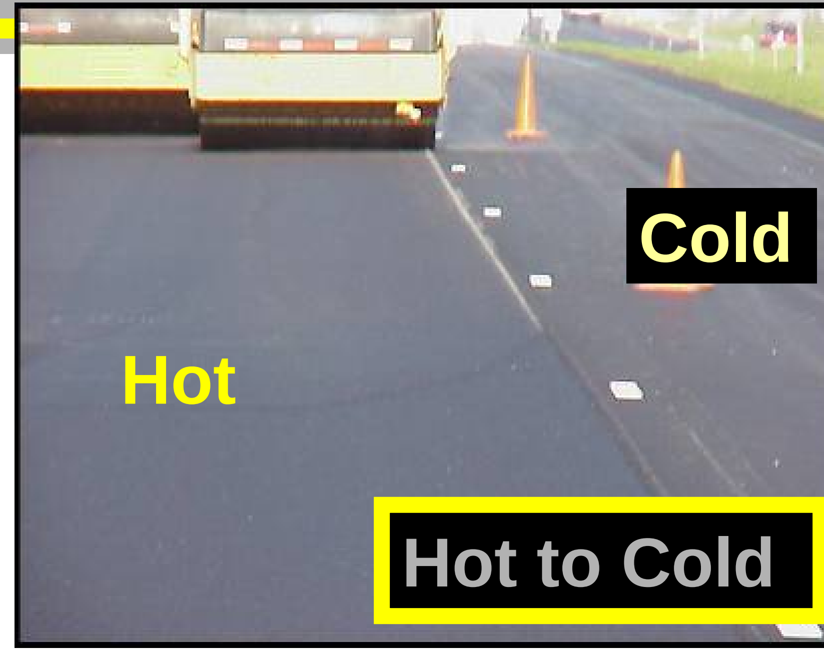
6

Mov al away from joint

Resu w-density zone at joint







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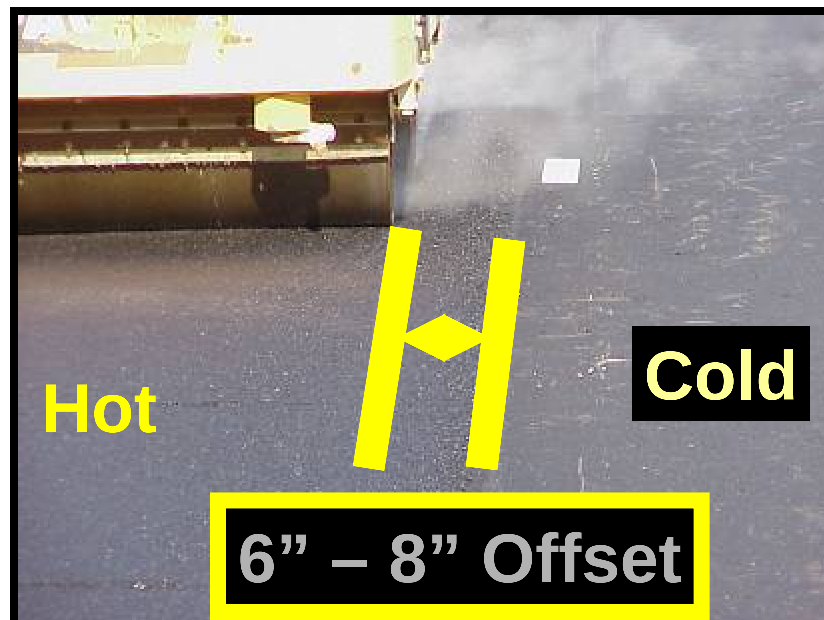
Compacting Longitudinal Joints

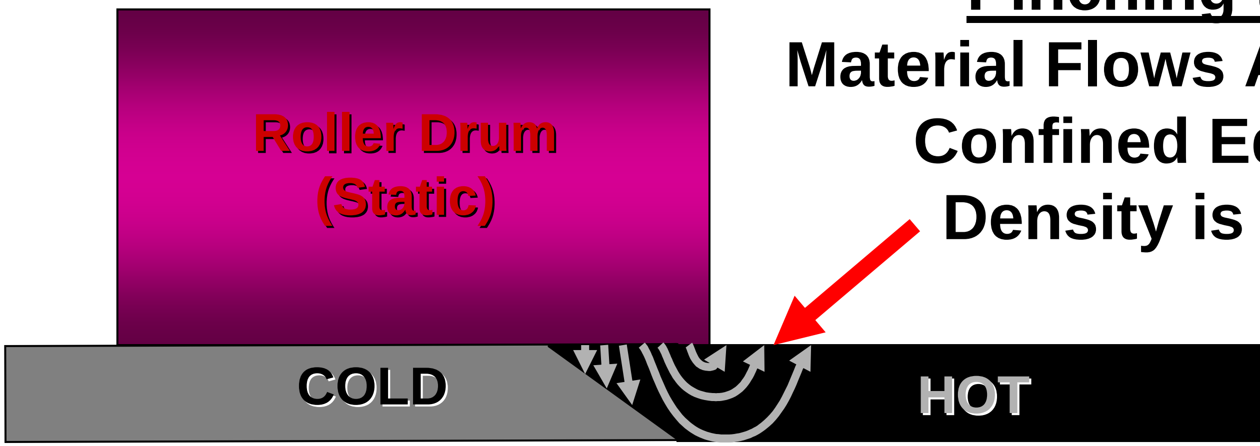


Material Flow at Joint

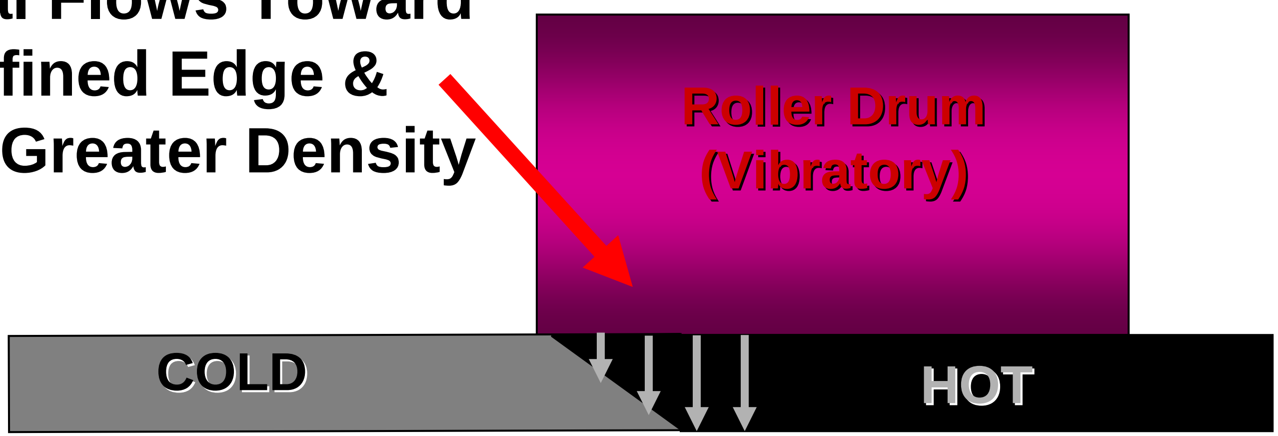
7

<u>Pinching the Joint</u>

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

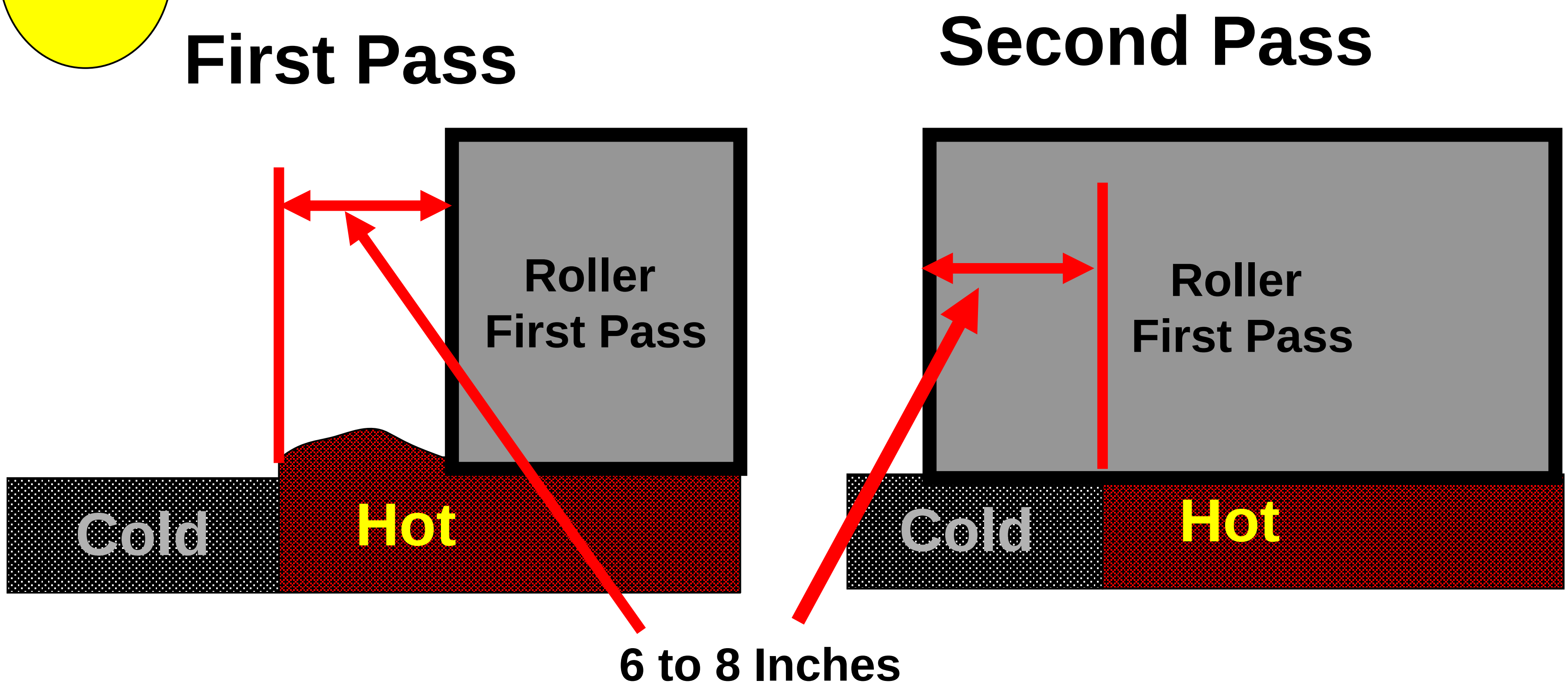


Material Flows Toward Confined Edge & Builds Greater Density



Compacting Your Longitudinal Joints

7



<u>**Creates a Confined Edge & Raised Area**</u>

<u>**Second Pass Use, Vibratory to Build Density**</u>

Temperature is the Key to Getting Density

Temperature

Temperature **Temperature**

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
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5- Place the Proper Depth for Roll Down
6- Do Not Lute the Joint
7- Compact the Joint for Density

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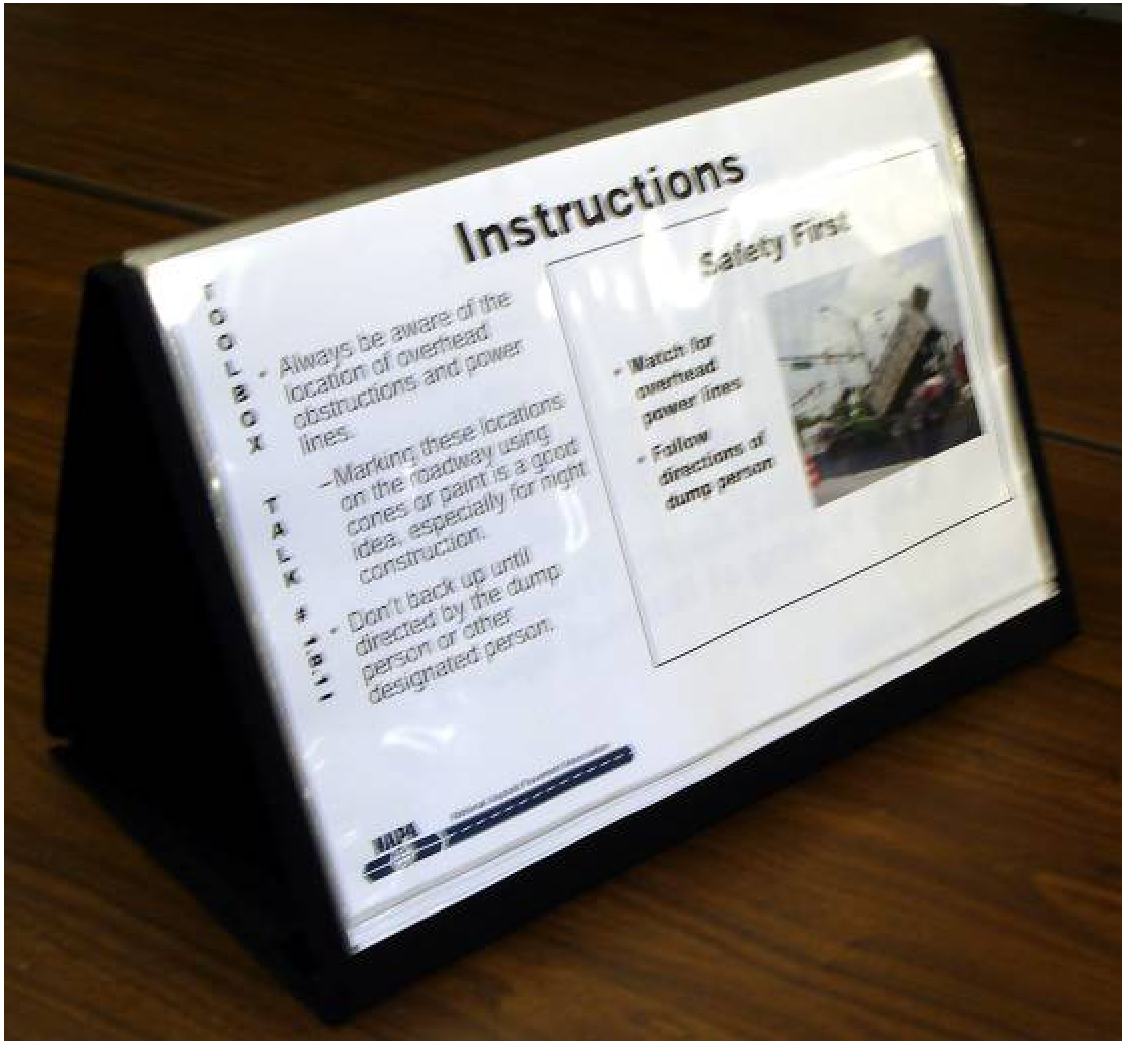
Front

Safety First
•Watch for overhead power lines
•Follow directions of dump person
TOOLBOX TALK # 1.8.11

Back - Instructions



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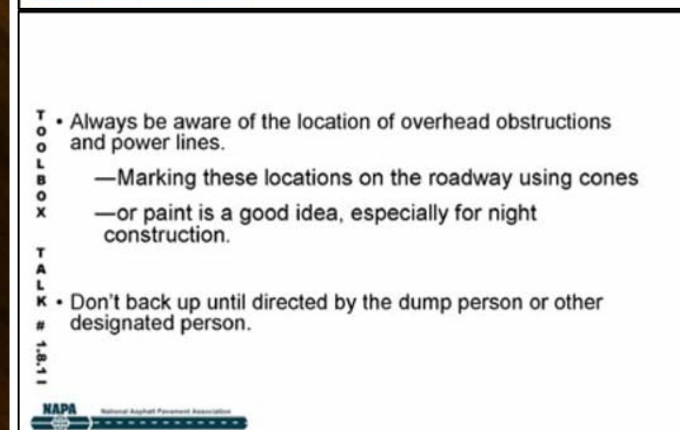
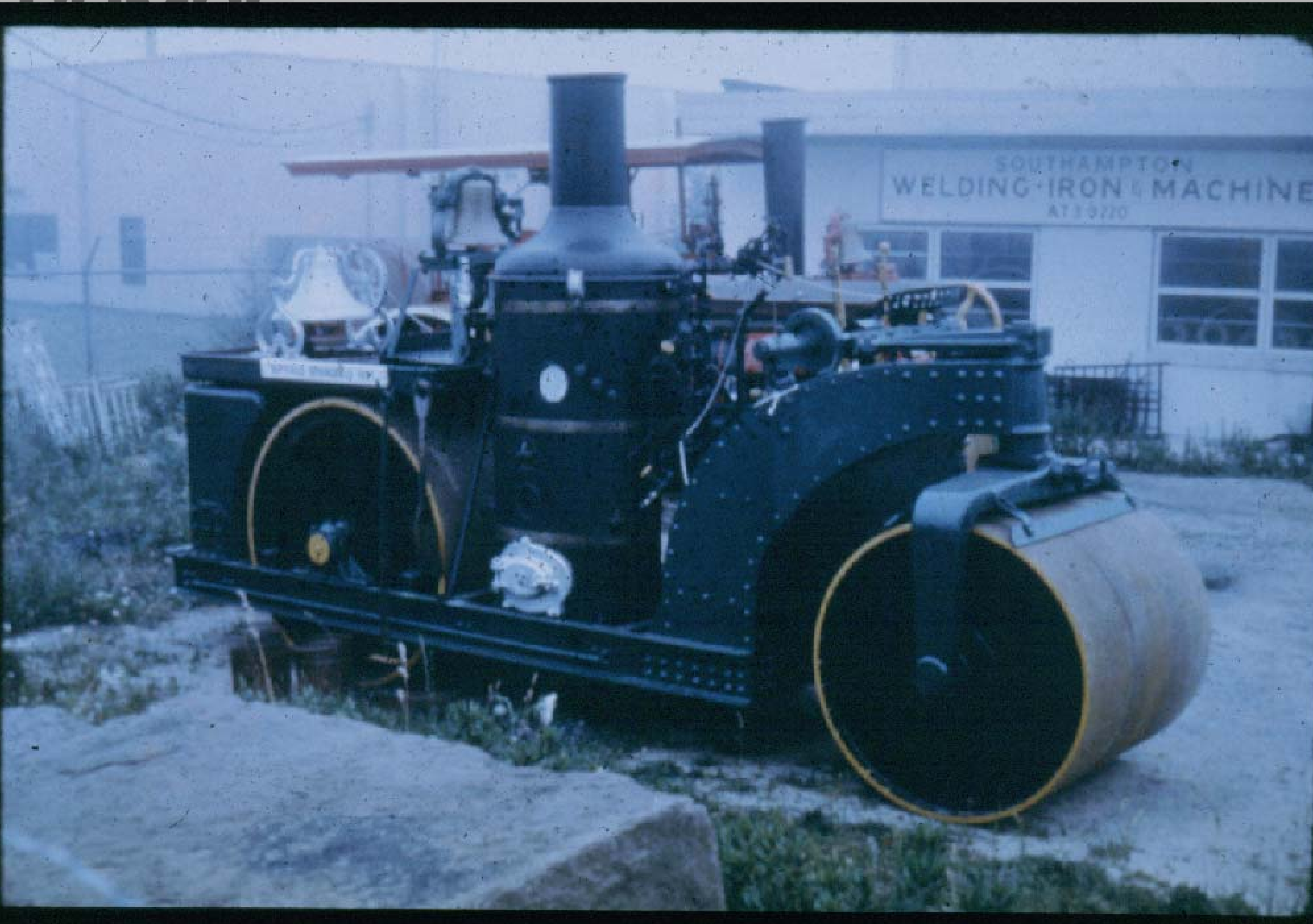
Pocket Size Handout



INTELLIGENT COMPACTION

NEW INNOVATIONS IN COMPACTION EQUIPMENT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WELDING · IRON & MACHINE

Asphalt Manager
Intelligent Compaction

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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

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INTELLIGENT COMPACTION

INTELLIGENT COMPACTION IS:

A SYSTEM FOR MEASURING THE STIFFNESS OF A GIVEN MATERIAL IN MEGA NEWTONS METERED SQUARED OR P.S.I. AND RECORDING THAT INFORMATION, TO BE UTILIZED AS A DOCUMENT 0R PROOF OF ACHIEVING A GIVEN AMOUNT OF COMPACTION.THIS SYSTEM IS MOUNTED ON A MOBILE ROLLER TO RECORD THESE MEASUREMENTS AND THAN RELATE THESE MEASUREMENTS TO MEASURING DEVICES.

COMPACTION GOALS

1. DENSITY
2. SMOOTHNESS
3. NOISE REDUCTION
4. BALANCED PRODUCTION


HOT MIX
needed for
COMPACTION
• mix confinement
• correct mix temperature

8.4 Importance of Compaction

- Improve Mechanical Stability
- Improve Resistance to Permanent Deformation
- Reduce Moisture Penetration
- Improve Fatigue Resistance

COMPACTION ACHIEVED BY..

PRESSURE

IMPACT

VIBRATION

MANIPULATION

Surface Covering Compaction Measurement

1983 Terrameter BTM 01 (OMEGA)

1993 Guidelines for Surface Covering Measurements
National Research Association

1994 ZTVE / TP BF-StB 94, proof methods FDVK/ SCCC

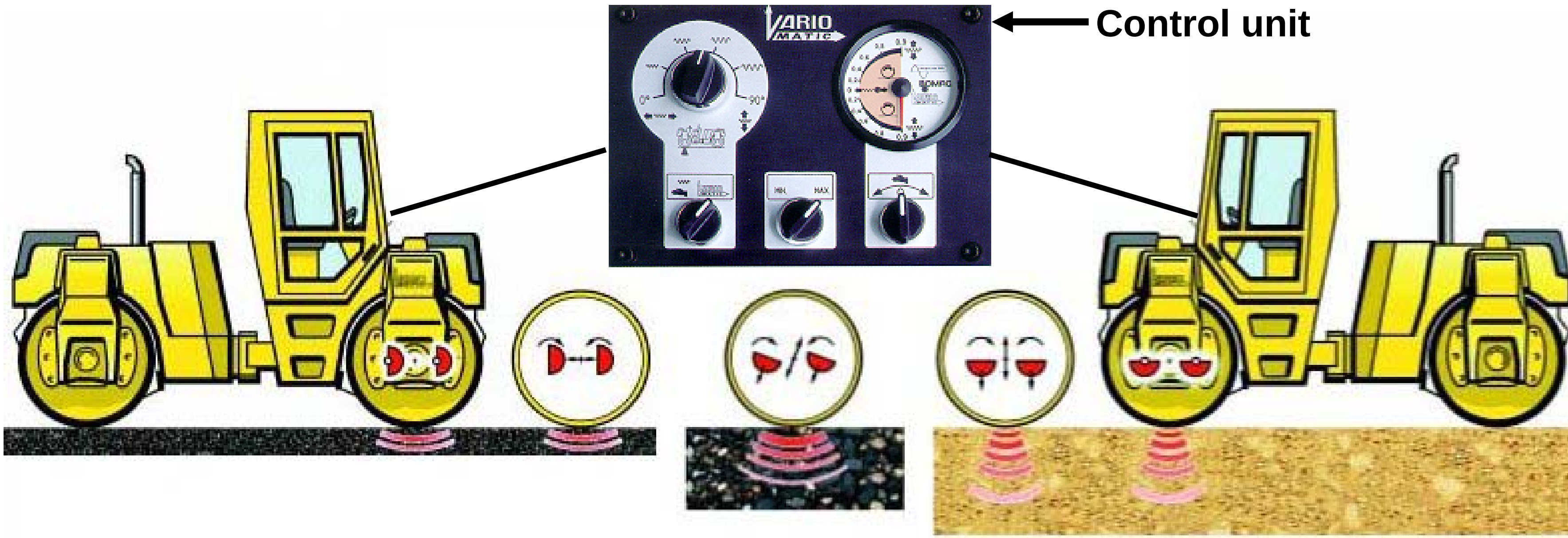
1996 Compaction Management System BCM 03

1998 VARIOCONTROL

2001 Measuring device for evaluation of stiffness (Evib)

2004 Modular Measuring System with GPS support

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

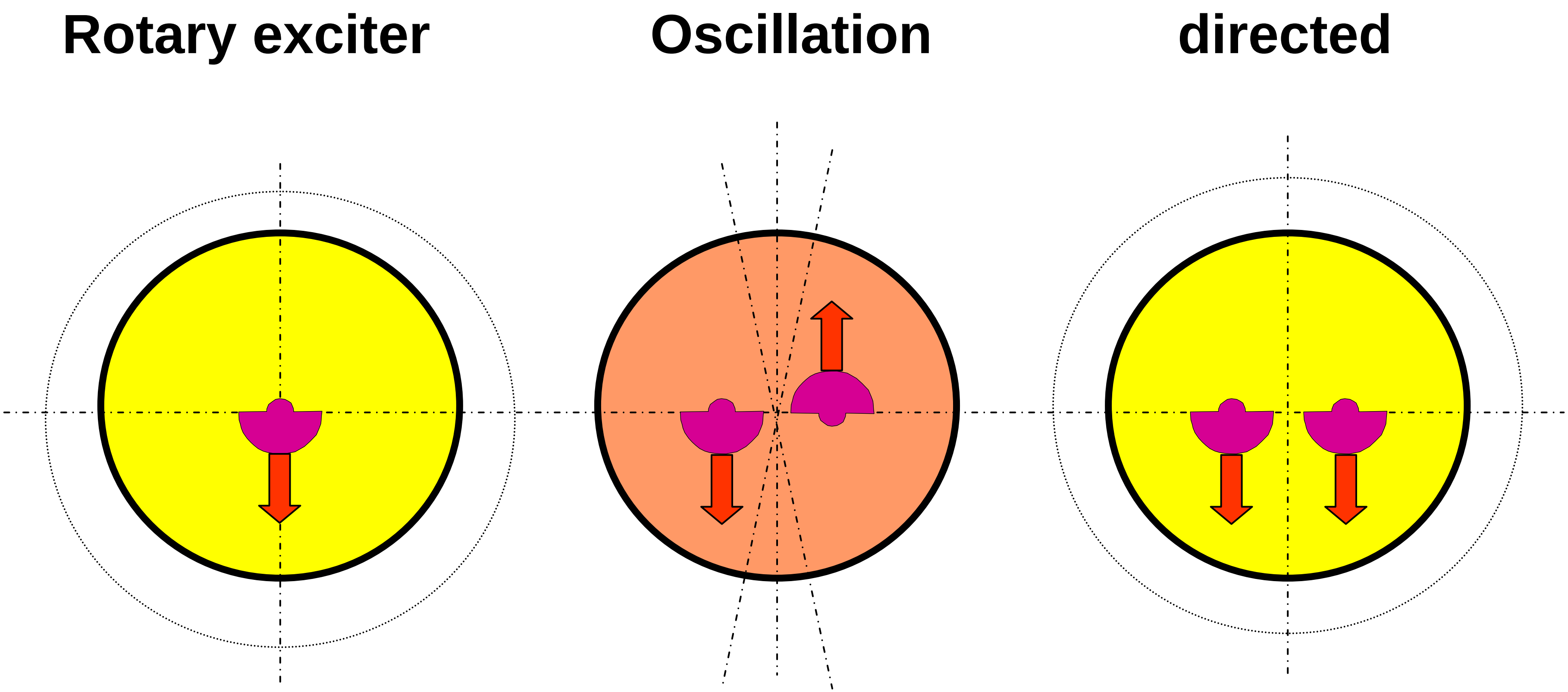
Asphalt thin course
Asphalt base course
Gravel-sand

Applications: asphalt layers, granular bases and subbases.

Worldwide proven design:

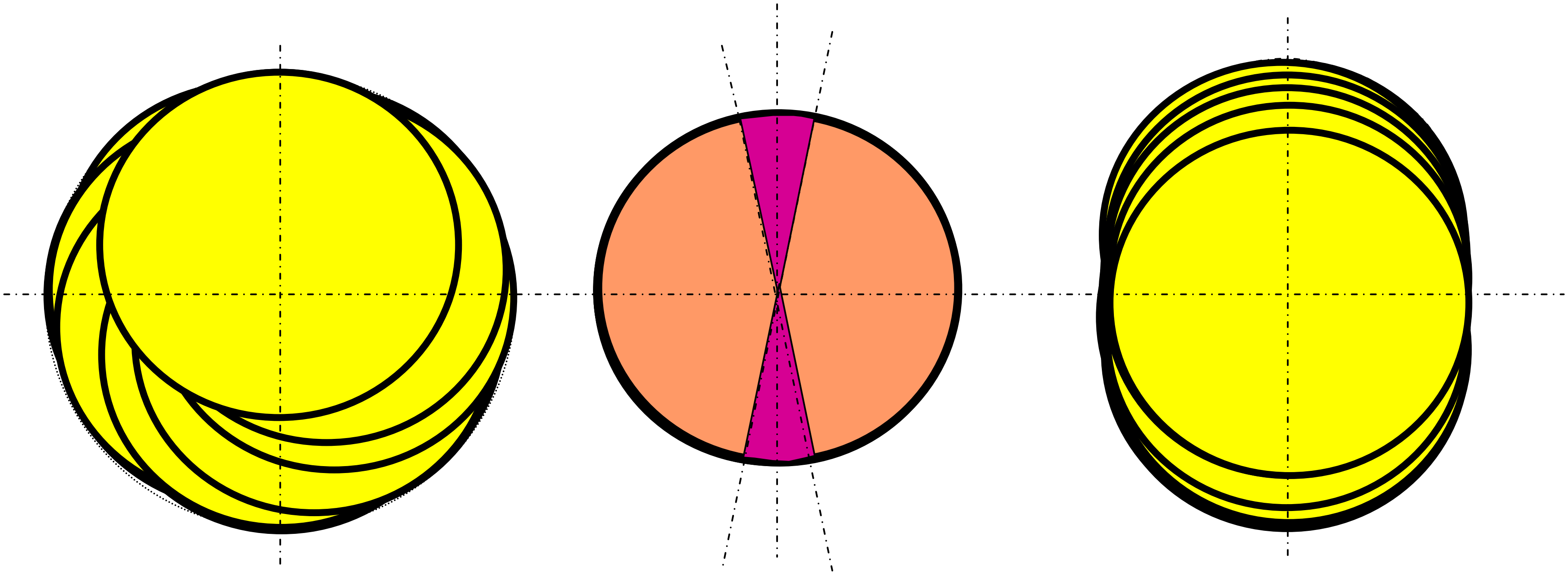
Several hundreds Tandem rollers

Vibration Systems

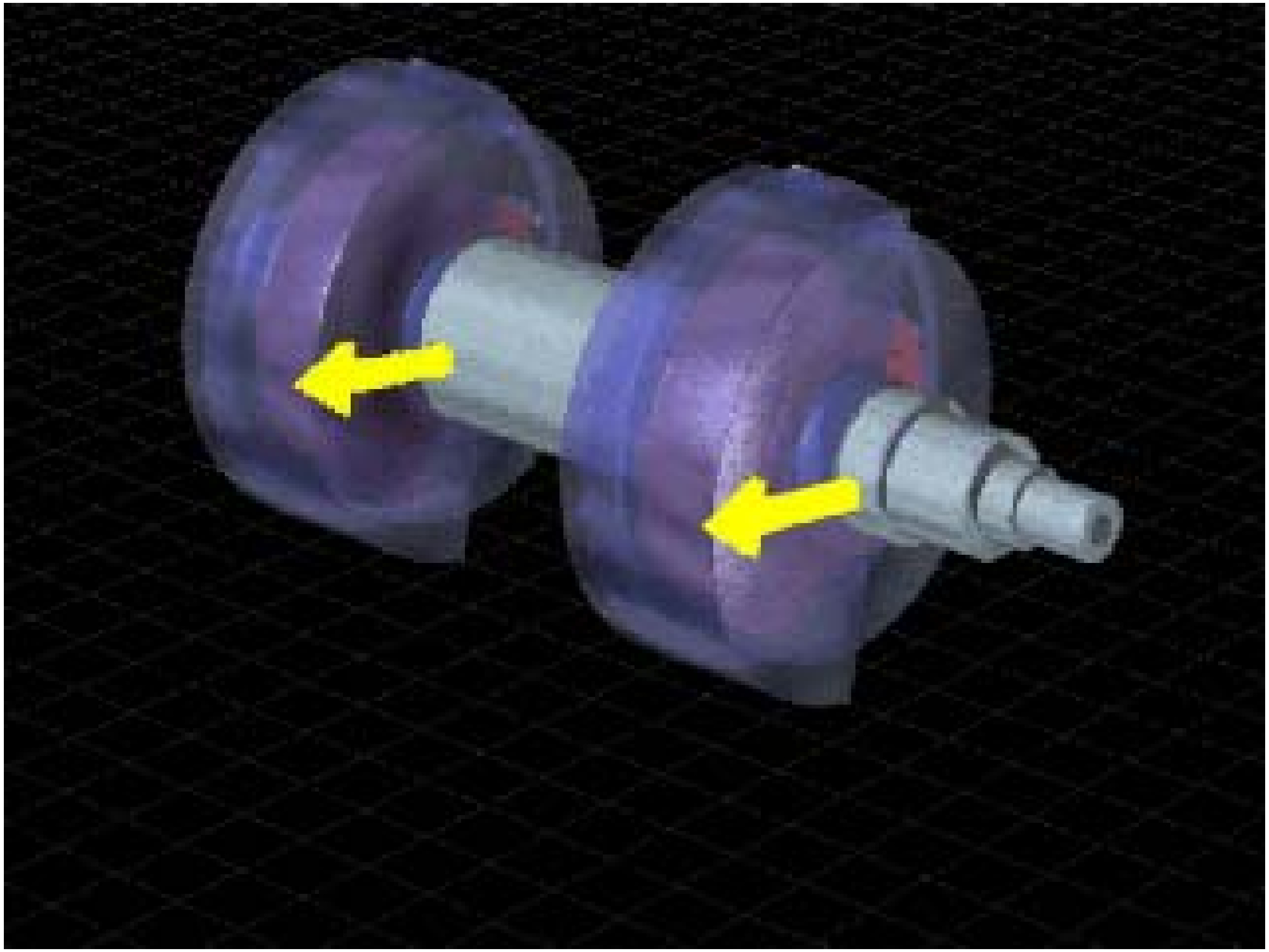


Vibration Systems

Rotary exciter **Oscillation** **directed**



Non Directed Forces:



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Vibration systems / Overview

	Vibration	**Oscillation**	**Variomatic**
Principle	Rotary exciter with	2 rotary exciters with 2	2 rotary exciters with 2
	unbalanced weight	unbalanced weight	unbalanced weight
			counter rotating
Oscillation	non directed	directed	directed
	-	horizontally	horizontally to vertically
Amplitudes	up to 8	2 fixed amplitudes	automatic variation
	up to 1,3 mm	ca. 1,3 mm	0 - 0,9 mm
			horizontal/vertical
Frequencies	35 -70 Hz	33 - 42 Hz	35 - 50 Hz
Control system	manual	manual	automatic variation

Directed exciter system

Advantages vs. Rotary exciter:

- **Better depth effect**
- **Excellent Asphalt surfaces**
  - **Eveness**
  - **Grip / roughness**

Benefits for contractors:

- Universal use on
  - Road base
  - Wearing course layers
  - Thin layers
- Higher compaction performance
- Uniform compaction, even on sub-bases with inhomogeneous stiffness
- Better eveness and more uniform surface structure
- Low tendency to scuffing

Compaction of 6 cm asphalt binder course 0/10, RN13 France

Operating weight and compaction technique affect smoothness and eveness

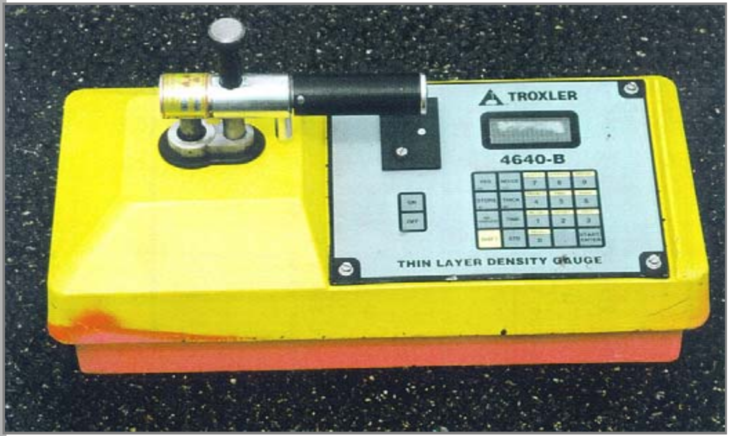
15 t tandem vibratory roller

8 passes

8 t BOMAG VARIOMATIC BW 151 AD

8 passes

Density and roughness measurement on asphalt binder layer



Punctual compaction measurement with portable isotope probe

Continuous compaction measurement with mobile isotope probe [1 measurement / 10 m]]

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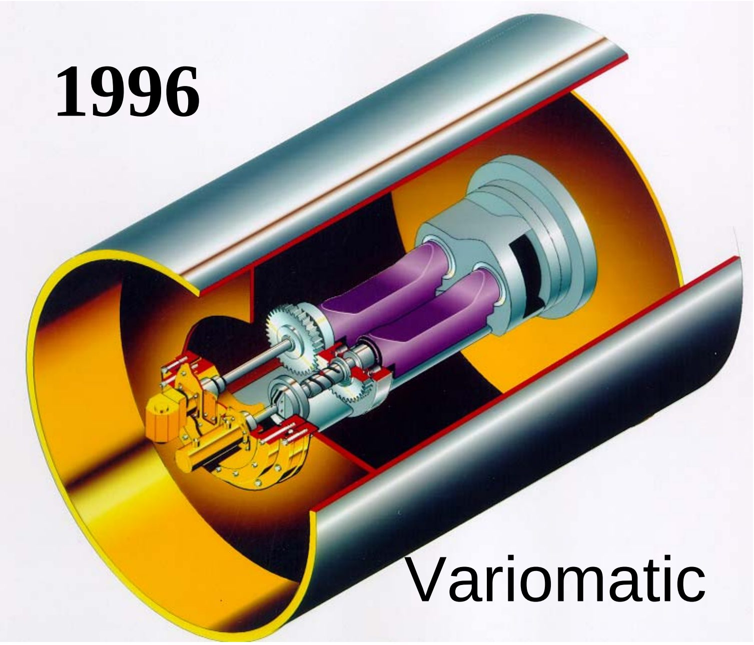
Comparison between conventional compaction concept and VARIOMATIC

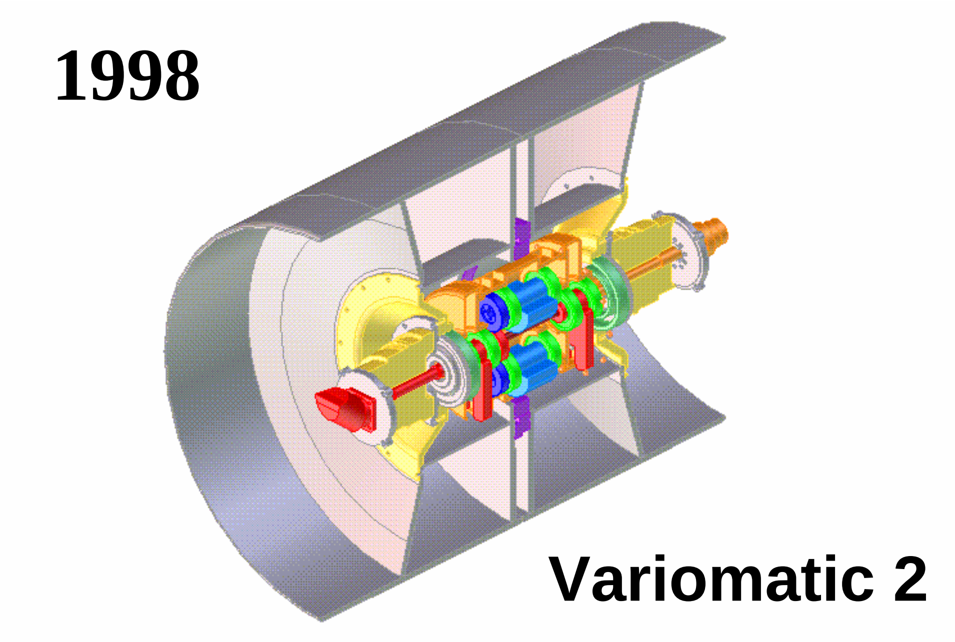
	Compaction						Roughness		
	Portable isotope probe			Mobile isotope probe [1 measurem./10 m]			Sand spot method		
	n	X1	σ	n	X1	σ	n	X2	σ
4 passes with 25 t rubber tire roller and 4 passes with 15 t tandem vibratory roller	14	92,5 %	1,22	59	94,6 %	1,29	12	0,46 mm	0,07
8 passes with BW 151 AD-2 VARIOMATIC	14	92,5 %	0,54	59	93,8 %	1,06	12	0,60 mm	0,05

n = number of measurements, X1 = mean value of achieved Gyrator test compaction value (93% Gyrator value ~ 98% Marshall value), X2 =mean value of characteristic roughness value

1996



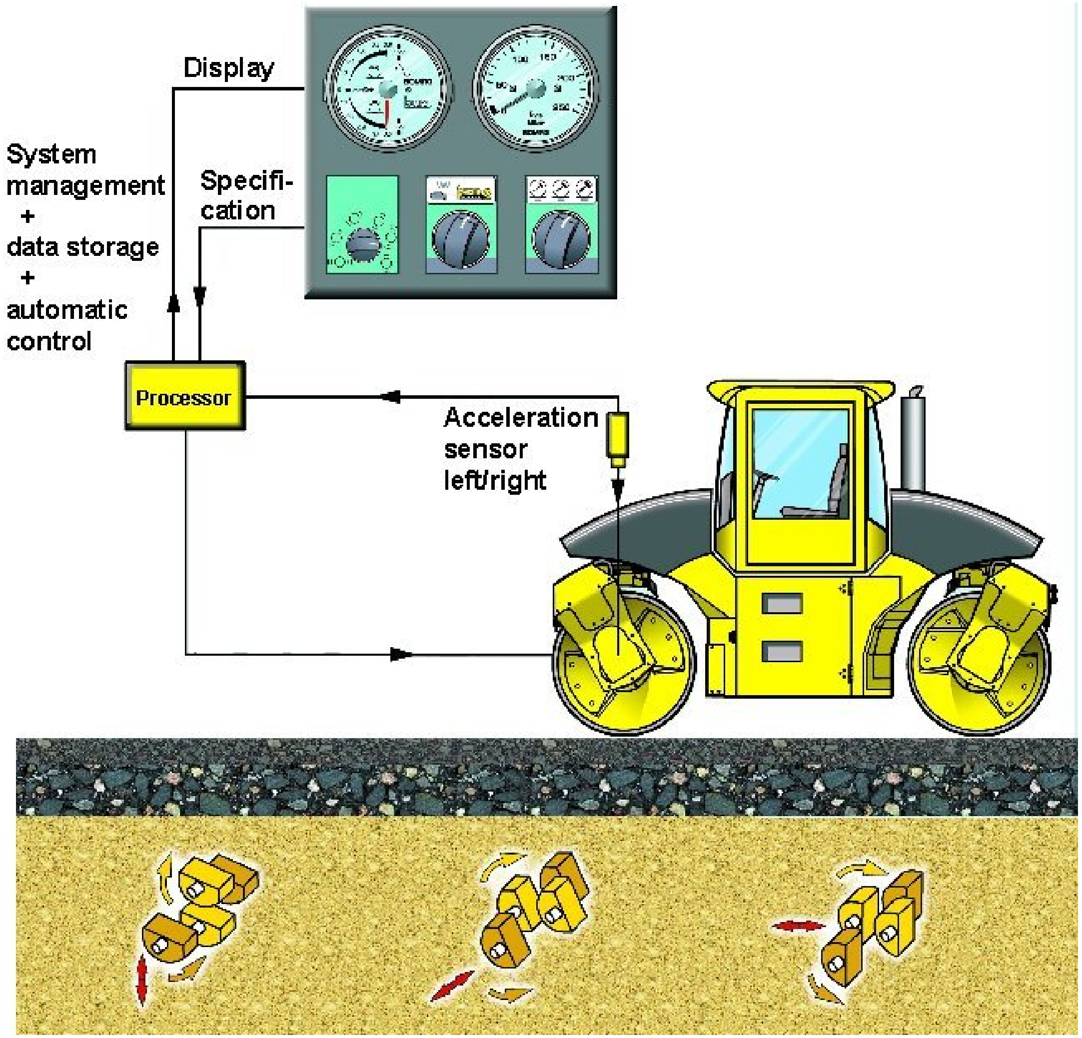
1998



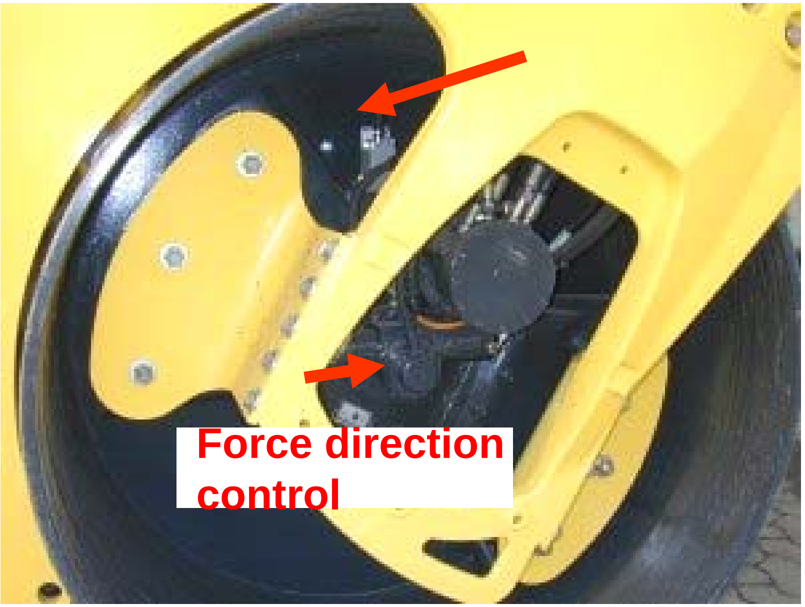
advanced, more powerful

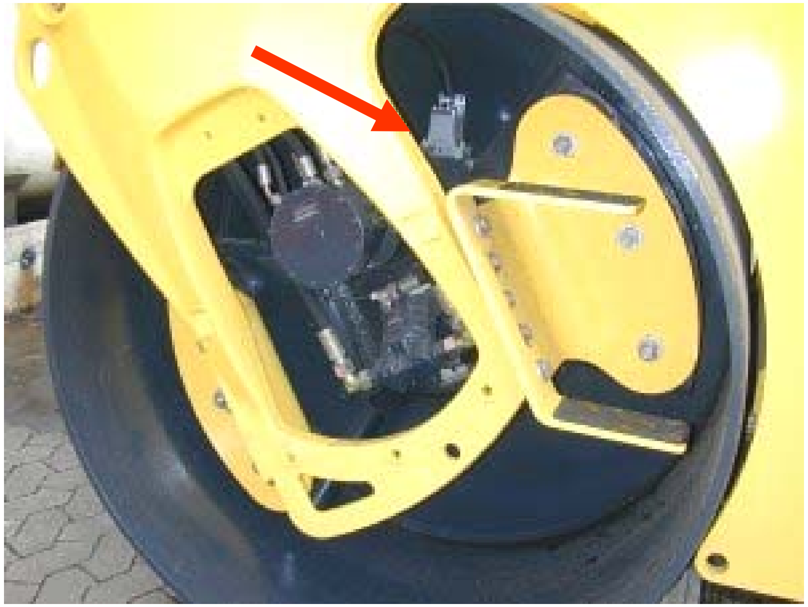
also for split drums !

Asphalt Manager with new measuring value E_{VIB} [MN/m²] and temperature gauge



Acceleration meters





Benefits for Operators:

No critical decisions required

All operators achieve better results:
- good and uniform compaction

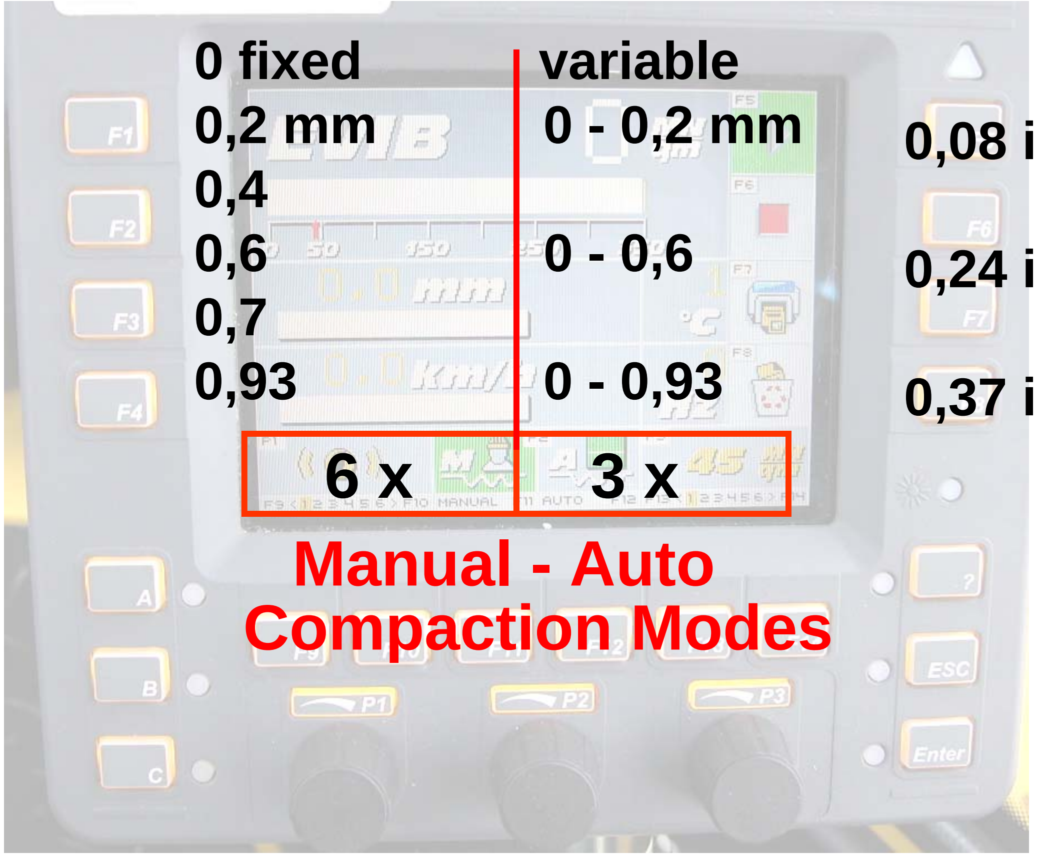
Continuous information on
- asphalt temperature
- compaction increase

Asphalt Manager: Easy to understand

Technical Data

PARAMETERS		BW 141 / 151 AD AM		BW 190 / 203 AD AM	
Front: AM		**Rear: Std. Exciter**			
Oper.weight	kg	8.000	8.400	12.000	13.100
Drum width	in	59	66	79	84
Amplitudes					
front	mm	0,96	0,95	0,93	0,73
rear	mm	0,64 / 0,27	0,6 / 0,25	0,86 + 0,37	0,7 / 0, 3
Frequencies					
front / rear	Hz	45	45	40 + 50 / 46+57	40+50 / 40+50
Centr. force					
front	kN	160	168	247 / 158	247 /158
rear	kN	80 / 34	80 / 34	167 / 109	126 / 84

Bomag Operational Panel



0 fixed	variable	
0,2 mm	0 - 0,2 mm	0,08 in
0,4		
0,6	0 - 0,6	0,24 in
0,7		
0,93	0 - 0,93	0,37 in
6 x	3 x	

Manual - Auto Compaction Modes

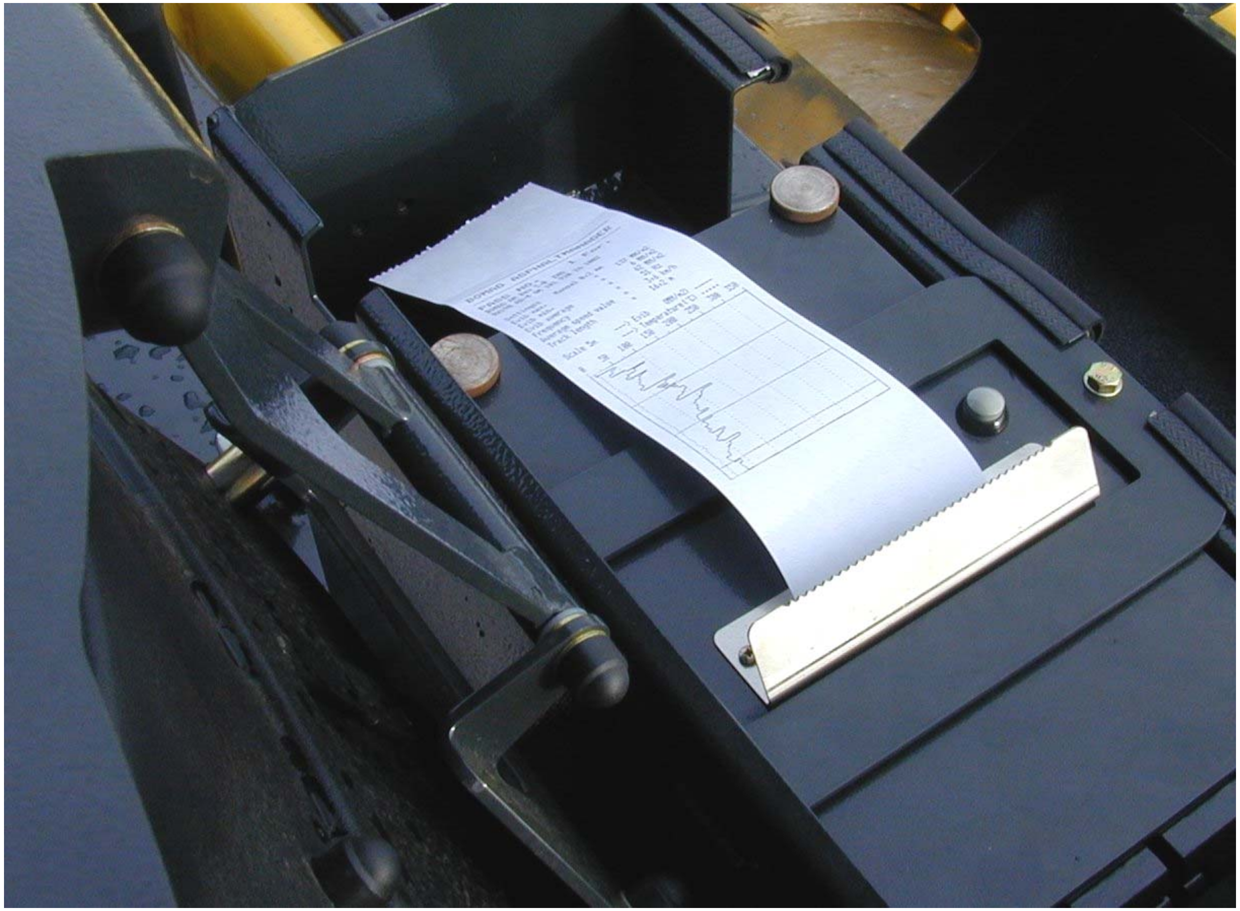
Bomag Operational Panel

PRINTER
- **Start**
- **Stop**
- **Print out**
- **Delete**

Test procedere:

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

Printer

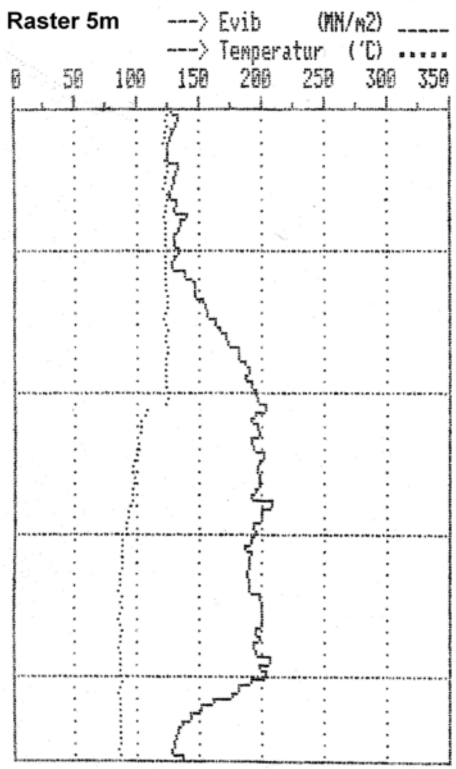


E_{VIB} - Printer

BOMAG ASPHALTMANAGER

UEBERGANG 1 VOR.
BOMAG AM REV 6 DEU
BW 174 AM

Einstellung : Hand / 0,40 mm			
Evib Max.	=	206	MN/m2
Evib Min.	=	124	MN/m2
Evib Mittelwert	=	168	MN/m2
Frequenz	=	44,3	Hz
Mittlere Fahrgeschw.	=	3,3	km/h
Bahnlänge	=	22,9	m



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

E_{VIB} Average

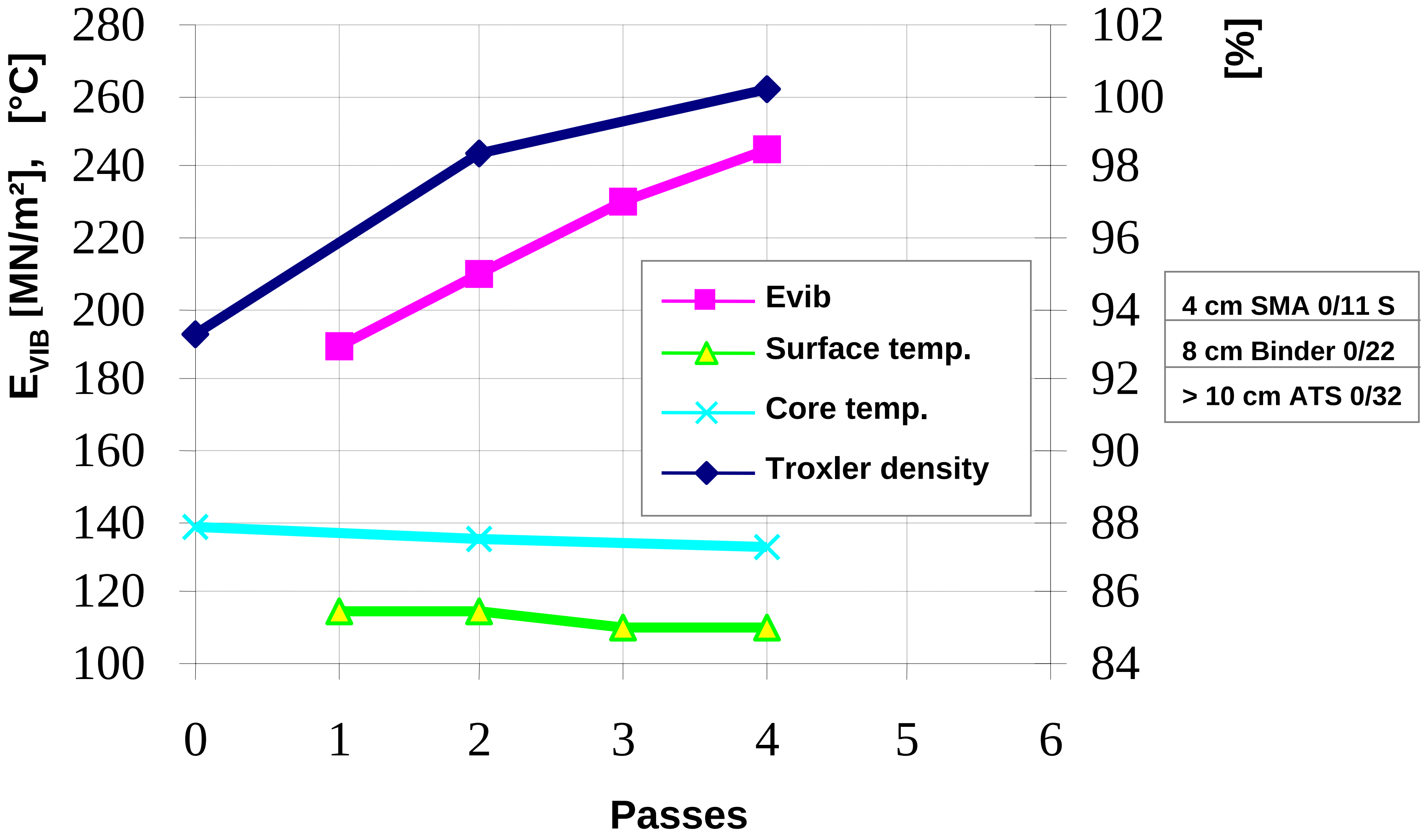
Frequency

Average Speed

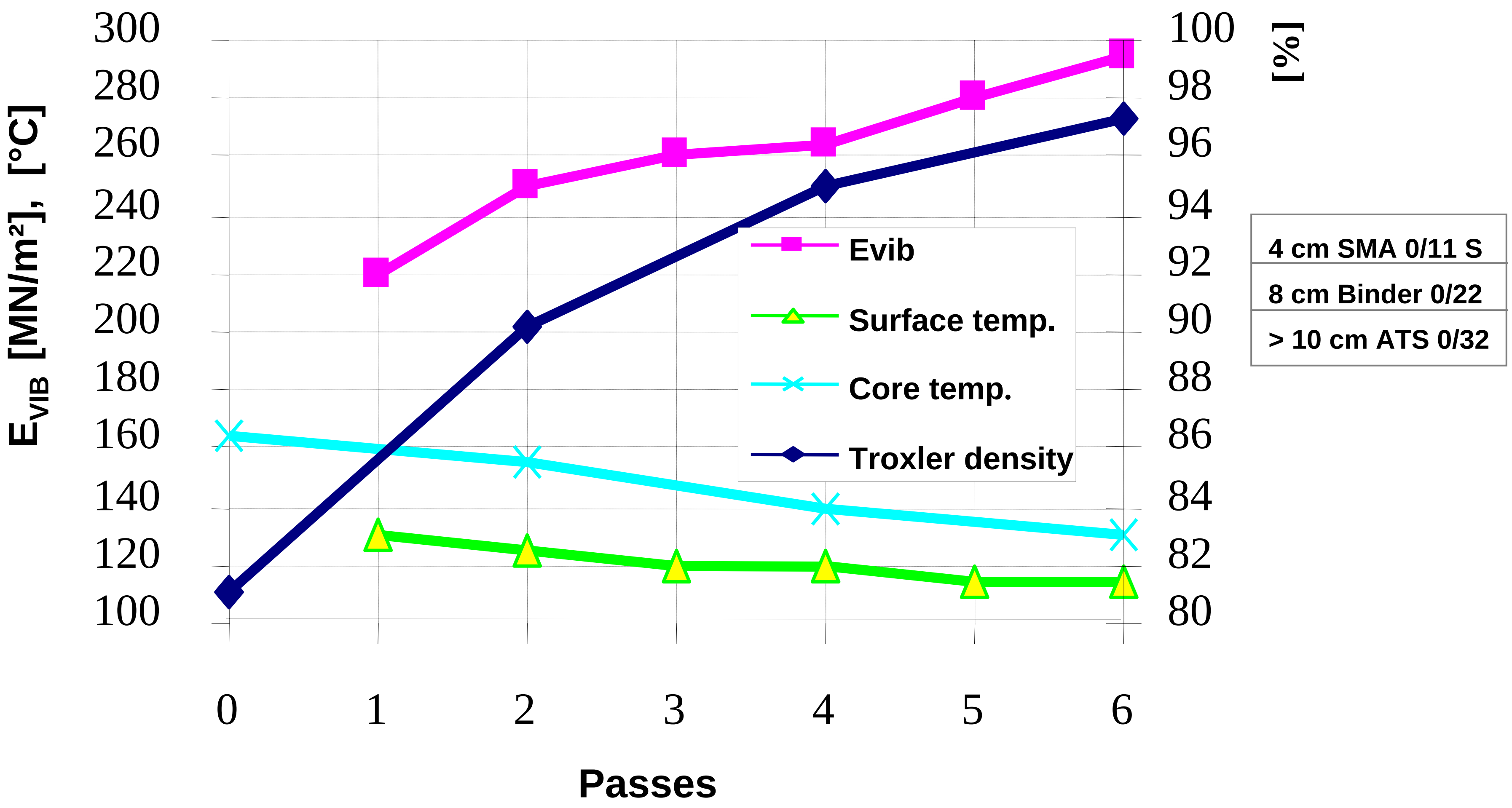
Track length

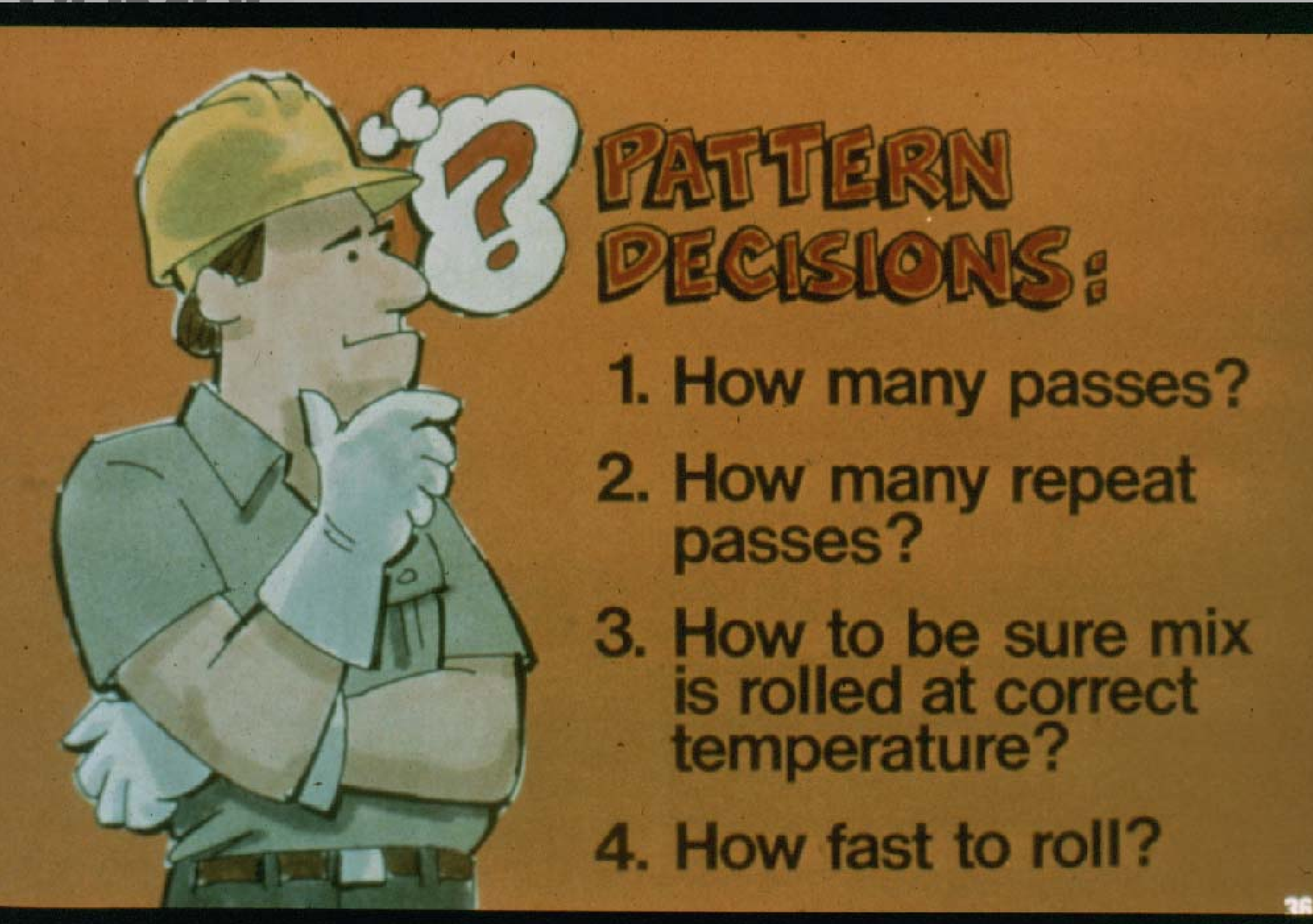
Temperature

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} and Density as function of passes; BW 174 AD Asphalt Manager, Manual mode 4; Wearing course SMA 0/11S PmB45, Nürnberg A3




PATTERN DECISIONS:
1. How many passes?
2. How many repeat passes?
3. How to be sure mix is rolled at correct temperature?
4. How fast to roll?


ASPHALT MANAGER
BW 190 AD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BOMAG ASPHALTMANAGER

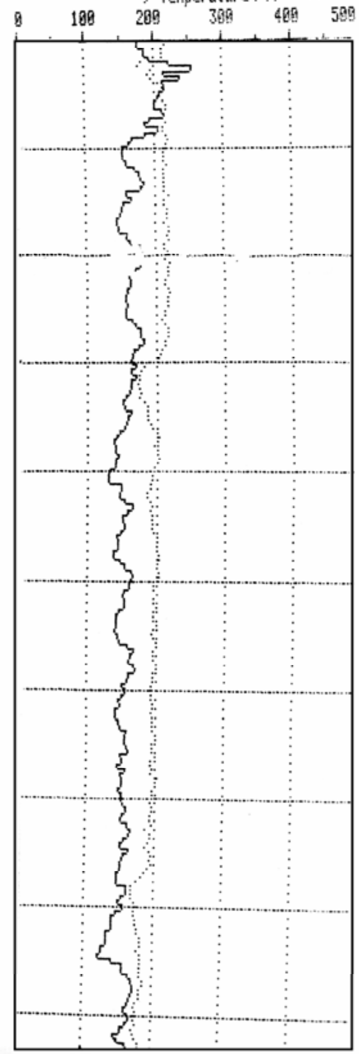
PASS NO. 3 Rev.

BOMAG AM Rev 3.0 ENG
BW190 AD-4 AM

Settings: Auto 2.

Evib max.	=	25520 psi
Evib min.	=	12096 psi
Evib average	=	15992 psi
Frequency	=	2959 vpm
Average speed value	=	3,5 mph
Track length	=	152,1 ft

Scale 16,4ft ---> Evib (psi*100) -----
---> Temperature(°F) .....



Asphalt Manager

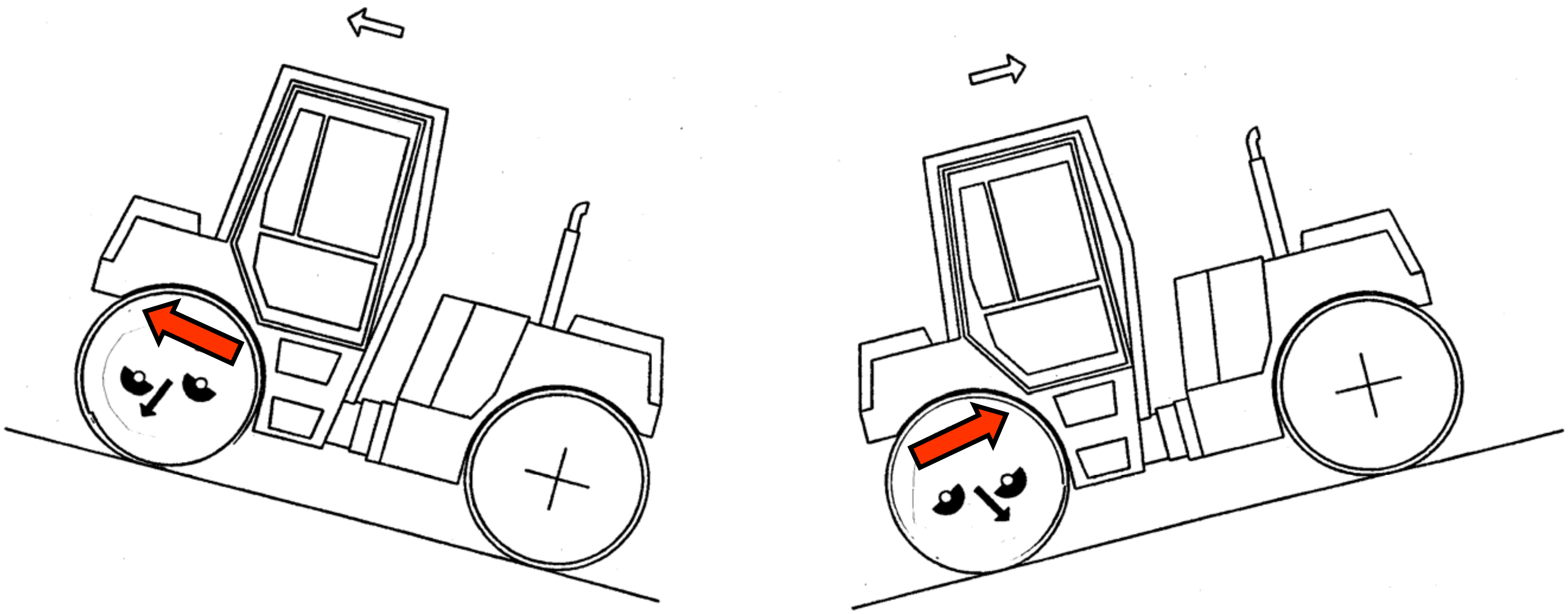
Advantages:

- **Immediate determination of dynamic stiffness in MN/m² (E_{VIB})**
- **E_{VIB} can be correlated with the increase of compaction**
- **E_{VIB} is widely independent from roller parameters**
- **E_{VIB} printouts for area covering compaction control**

In Development:

- **Target E_{VIB} values to be pre-selectable**
- **„Ready“ indication if target value is achieved (red light)**
- **„Ready“ indication if no further compaction is possible (red light)**

Further advantages:
better gradability- less shoving effect



Automatic force adaption with travel direction

Evib (MN/m^2) Vibration modulus

Equivalent for dynamic Stiffness;

Directly picked up by the roller;

Physical value for compaction increase on asphalt.

Benefits for Contractors:

Investment for Profit

Compaction

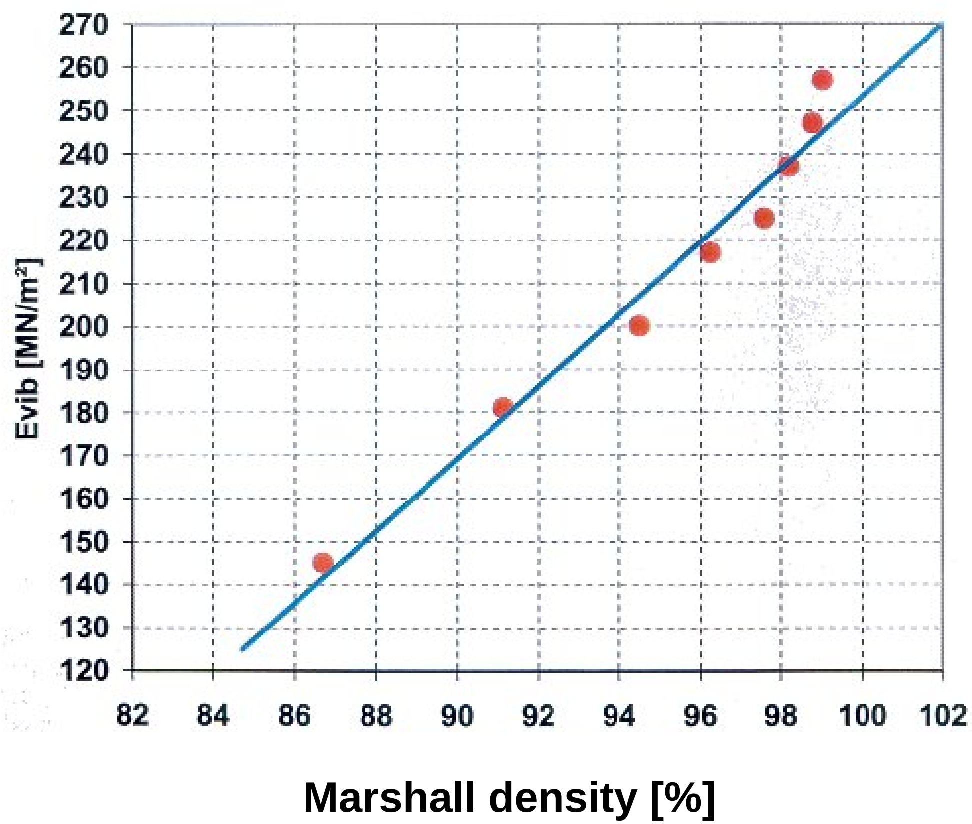
- Uniform and predictable results whilst rolling
- Avoids under / overcompaction
- Better eveness and roughness
- Eliminates drum bouncing

Economical and quality aspects

- More efficient roller utilisation with fewer passes
- Reduced shock loads in sensitive environment e.g. buildings, bridges
- Area coverage method

E_{VIB} [MN/m²] vs. Marshall density [%]

Compaction test on asphalt wearing course (stone mastix asphalt)



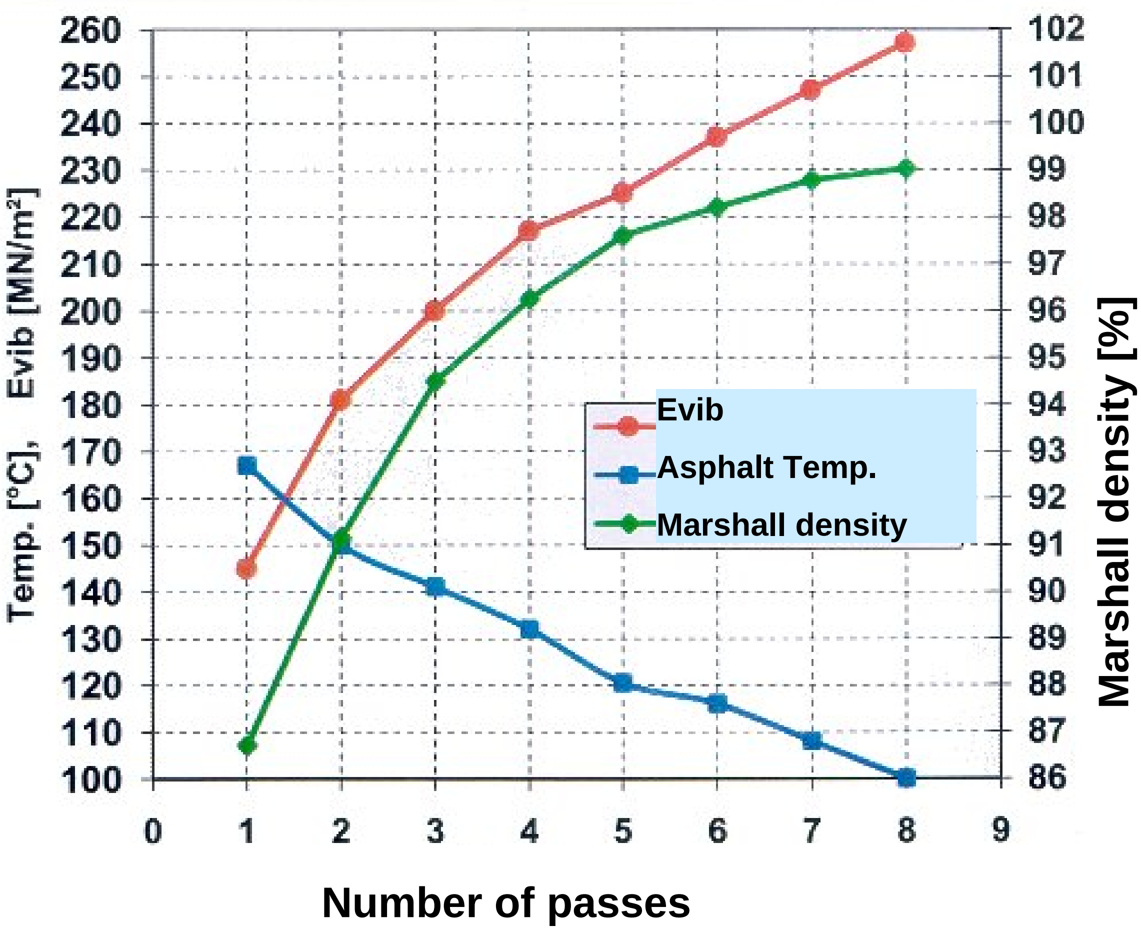
Perfect correlation:

Evib + Marshall density

Adequate conditions:

- **Temperature between (170-120 °C)**
- **Asphalt layer on solid ground**

Compaction test on asphalt wearing course (stone mastix asphalt)



Increase of Evib =

Increase of compaction

Application

Comfort + Quality:

Compaction of joints hot against cold

- avoids shock loads

- no bouncing

- better eveness

Leipzig:

"Augustusplatz"

Compaction on a parking roof top;

Alternatives:

15 t static roller - 15 cm layers
With BVM - 40 cm layers

Application

Avoids shock loads on bridges and near buildings

Depth control via force adjustment

- **3 automatic control ranges**
- **6 manual force directions (fixed)**

FEATURES

BENEFITS

Modular Design Principle:

Less Expenses for Warehousing, Training, and Logistics;

- Operator Platform
- Central Electric System
- Travel- / Vibration Pumps and Motors
- Support Legs

Surface Quality

Perfect Results:

- Roughness

- Eveness

Application soil compaction

Support for compaction works and measuring paths on sub-grade, frost blanket layers and non-bonded bearing layers: the E_{VIB} value increases with increasing compaction. Weak spots are localized.

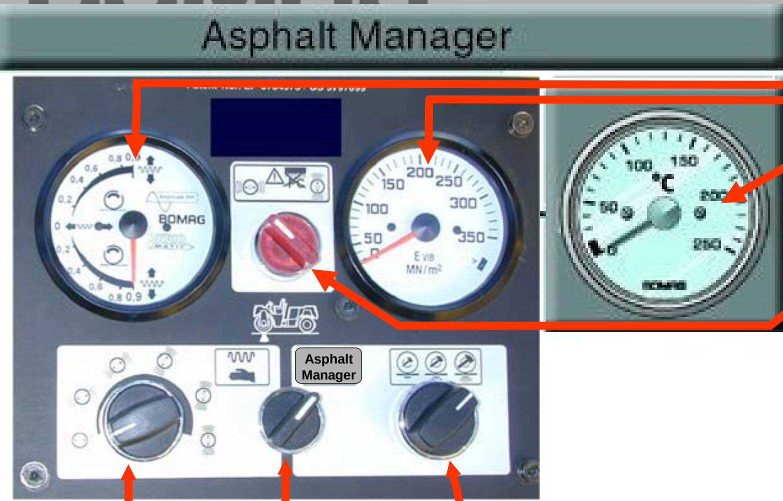
Application asphalt compaction

Support for compaction works on asphalt layers. If compaction is performed within a narrow temperature range (e.g. 120° – 150°C) and the sub base is of sufficient stability, E_{VIB} will show the increase in compaction. A direct statement on the density is only possible after performing comparison measurements with an isotope probe (Troxler). Compaction force and depth effect can be adapted to the layer to be compacted and to the substrate (see matrix of recommended applications).

Condition of the substrate	Setting	Asphalt bearing course	Asphalt binder		Asphalt pavement	
			Easy to compact	Difficult to compact	Asphalt concrete	Stone mastic
evenly firm (stable)	Automatic: **Force level**	3	2-3	3	2	3
	alternative: Manual*: **Position**	6-3	4-3	5-3	4-2	4-2
	Compaction temperature	> 80°C	> 80°C	> 100°C	> 100°C	> 120°C
yielding (soft)	Automatic: **Force level**	2	1-2	2	1	2
	alternative: Manual*: **Position**	4-2	3-2	3-2	2-1	2-1
	Compaction temperature	> 80°C	> 80°C	> 100°C	> 100°C	> 120°C
Layers on bridges	Automatic: **Force level**	1-2	1-2	1-2	1	1-2
	alternative: Manual*: **Position**	3-2	2-1	2-1	2-1	2-1
	Compaction temperature	> 80°C	> 80°C	> 100°C	> 100°C	> 120°C

Temperature specifications related to the asphalt surface, * in manual mode start with higher level first, and reduce after

CONCISE OPERATING INSTRUCTIONS ASPHALT MANAGER



Display, direction of vibrations

E_{VIB} display

Temperature gauge

Emergency switch

Selector switch
Operating mode

Manual/Automatic

Manual mode

6 selectable amplitudes each with constant direction of vibration

Automatic mode

3 selectable force ranges with amplitude control, limited to compaction force and depth effect

Display of vibration direction and amplitude

shows the direction of drum vibration and the size of the vertical amplitude

E_{VIB} display

E_{VIB} shows the dynamic stiffness of the material to be compacted in in MN/m²

- E_{VIB} responds to changes in density. With increasing density the asphalt becomes firmer (stiffer). The E_{VIB} value increases.
- E_{VIB} responds to temperature changes. With dropping temperature the asphalt becomes firmer (stiffer), even if the end of compaction is not yet reached . E_{VIB} increases with decreasing temperature.
- E_{VIB} responds to deviations in the stiffness of the substrate (base layer). On a soft substrate and with a pre-selected high force level the E_{VIB} may remain low.

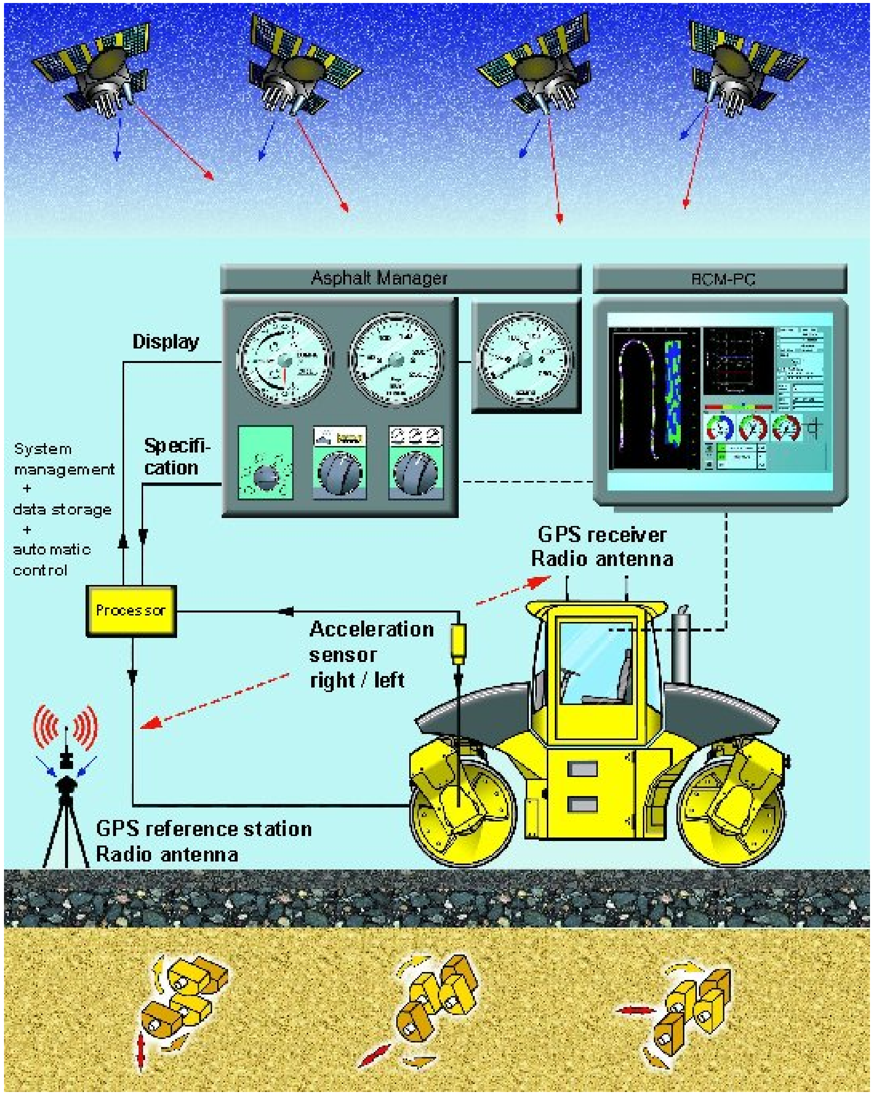
Temperature gauge

The temperature is permanently detected as asphalt surface temperature. Depending on layer thickness, ambient temperature and wind force the mix temperature inside the core of the layer may be up to 40°C higher. At a surface temperature of 80°C compaction should be completed.

Emergency switch

In case of an electronics failure the emergency switch enables the selection of two vibration directions: horizontal (left) or vertical (right)

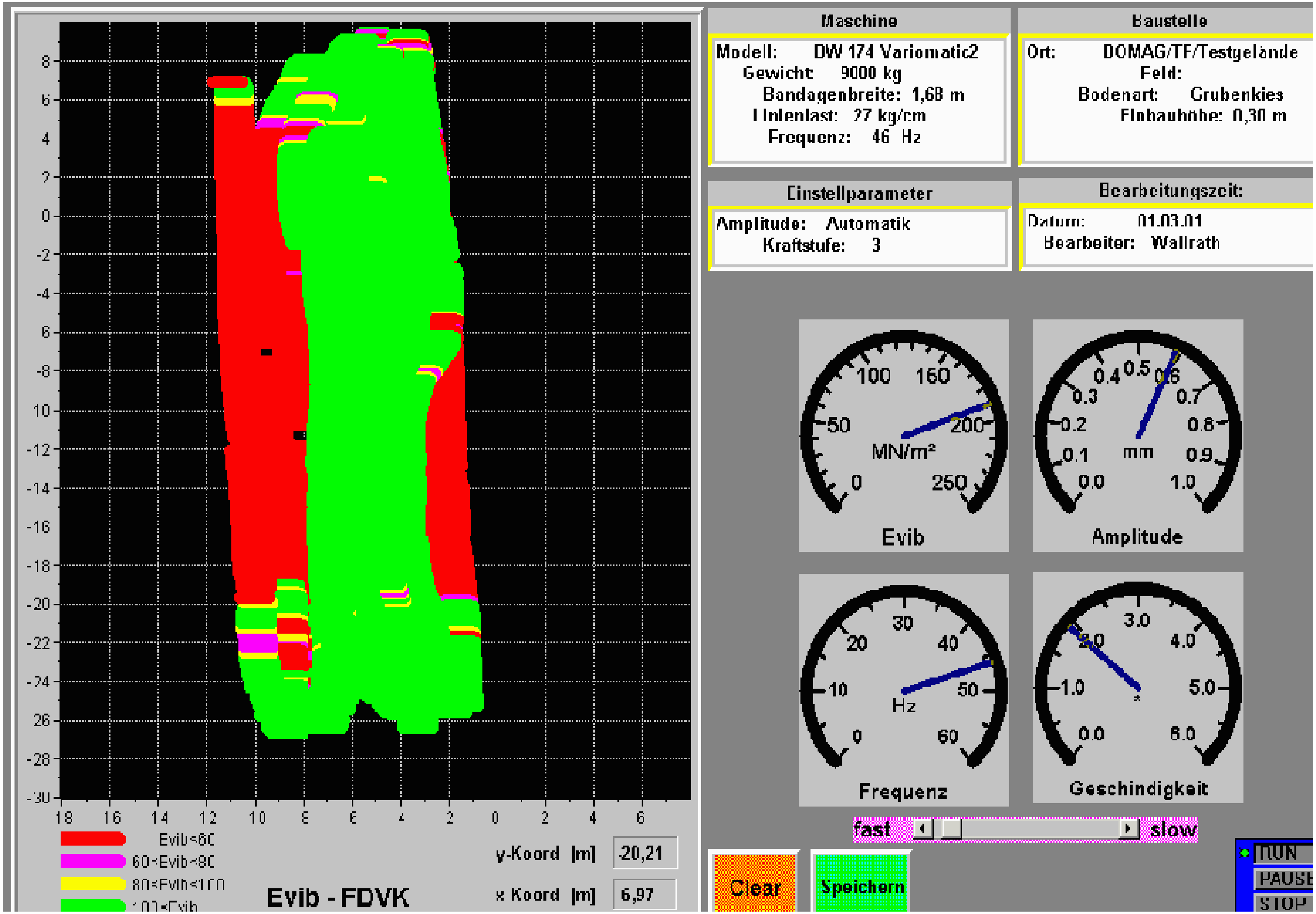
Asphalt Manager + BOMAG GPS System



- **Surface covering compaction control on asphalt layers**
- **GPS receiver**
- **GPS reference station**
- **Roller PC for data managing and graphical representation of roller position and stiffness values**
- **Position accuracy: better than 10 cm**
- **CAD based evaluation program**

Roller positioning with total station (Geodimeter) for continuous compaction control on asphalt layers

Surface Covering Compaction Measurement



Determination of roller positions with GPS

Reference station on the job site

High accuracy: up to 5 cm

GPS Reference service with reference satellite

Accuracy: up to 100 cm

> OmniSTAR (world wide) ~ 1500,- Euro annual charge

> EGNOS (Europe, not yet in operation) free of charge

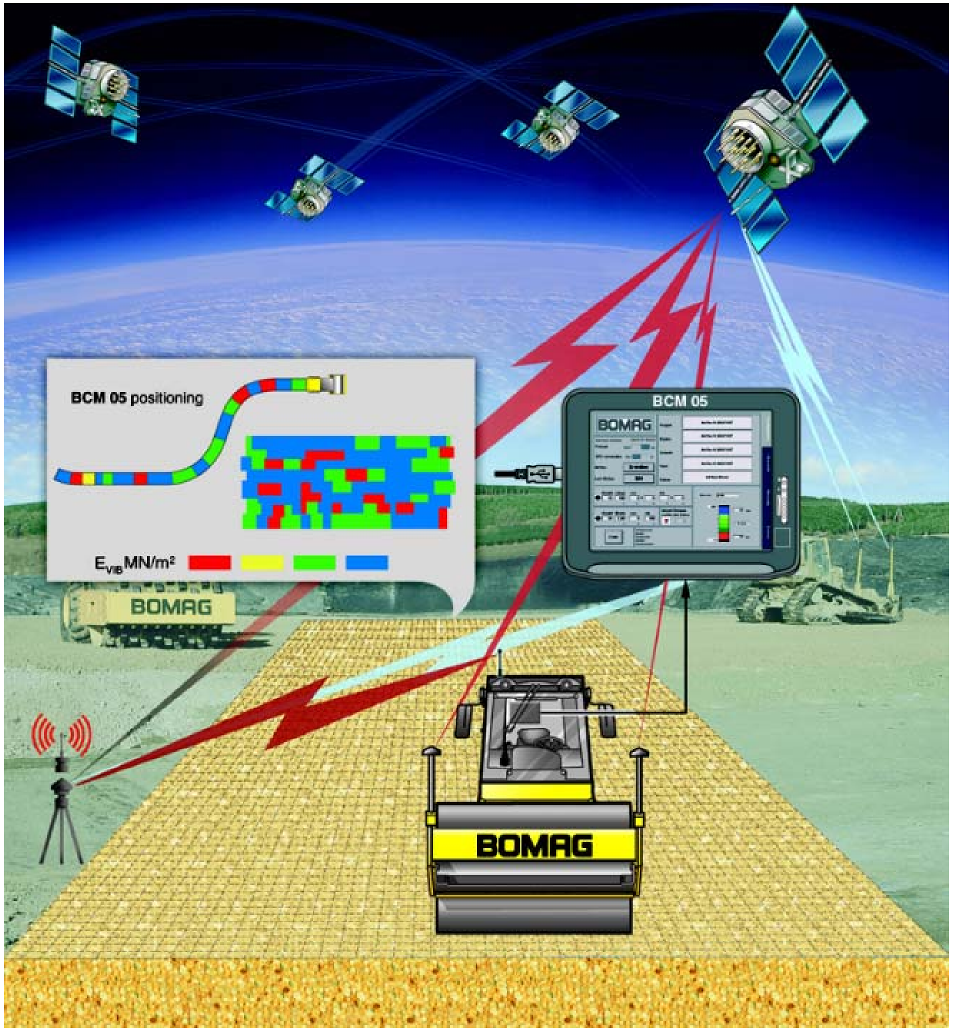
> WAAS (North America)

Local Reference network (reference service)

High accuracy : up to 5cm (depending on service)

> Ascos (since 2001, Ruhrgas / Germany,
(only available in Rhine Area)

GPS / positioning with Reference Station



- Two GPS Antenna
- Reference station (Trimble)
- High accuracy (5cm)
- RTK (real time)
- BCM 05 positioning software

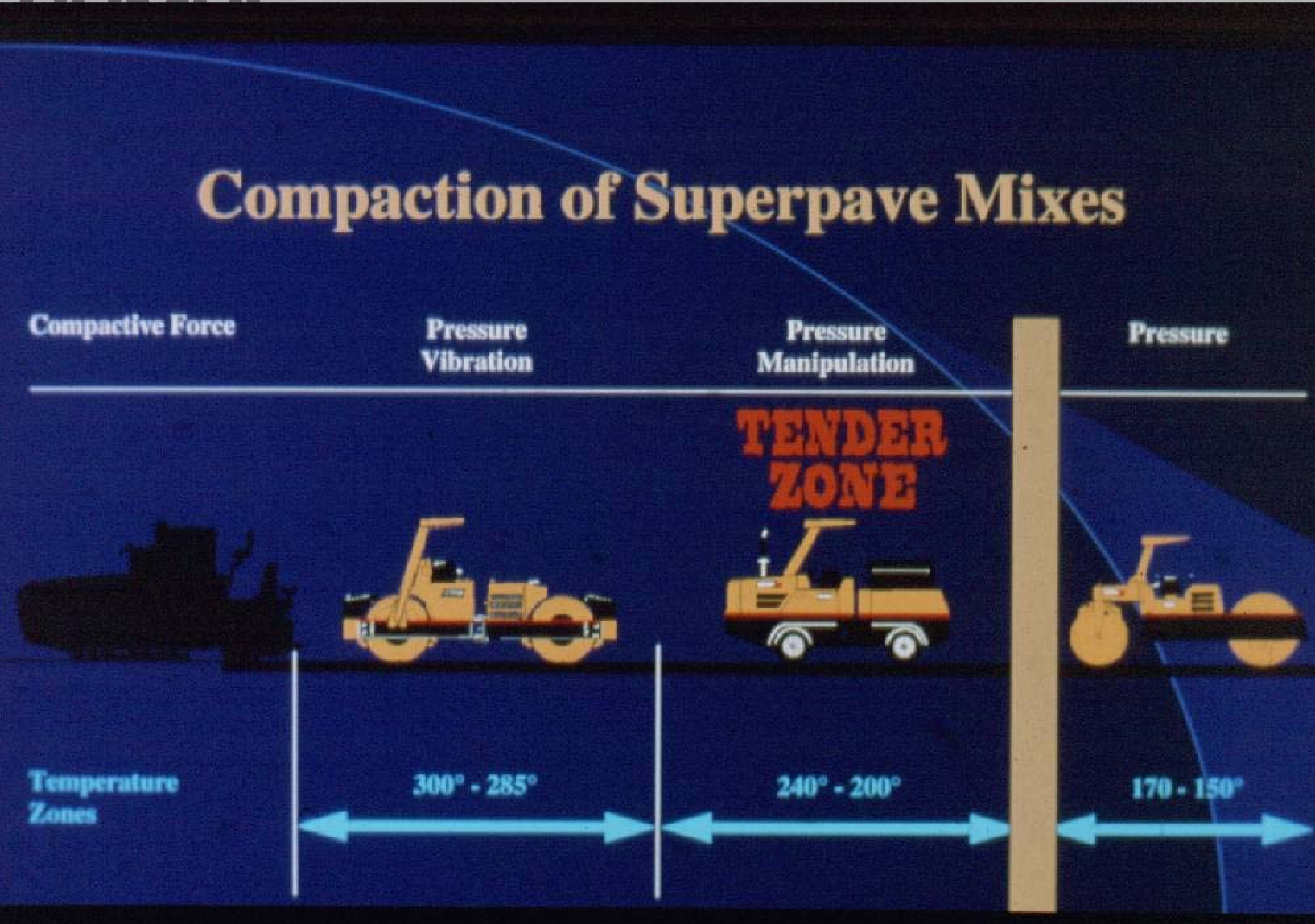

HYPAC
HYPAC
C784
'98 8 15

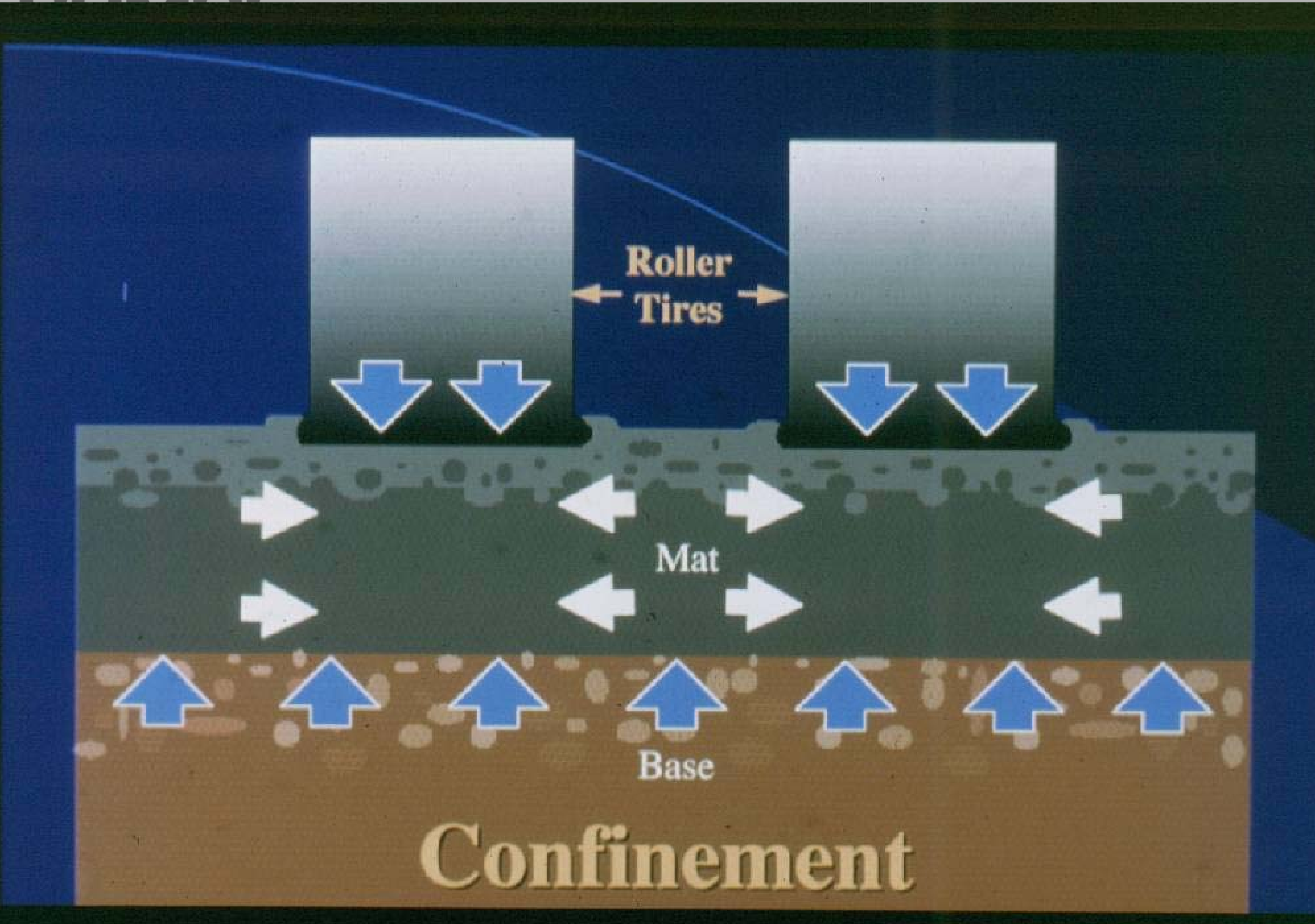

0.0 MPH
0 VPM
0.0 ipf
Mat
38 F


TRAVEL SPD LMT = mph
ADJ. WITH CONTROL HANDLE


HI MAT TEMP LIMIT 310 F
ADJ. WITH CONTROL HANDLE
RUN
AUTO
FRONT


LOW MAT TEMP LIMIT F
ADJ. WITH CONTROL HANDLE


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


Roller
Tires
Mat
Base
Confinement


HYPAC
'01 5 14

QUESTIONS????

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