

AMAP 7th ANNUAL MEETING

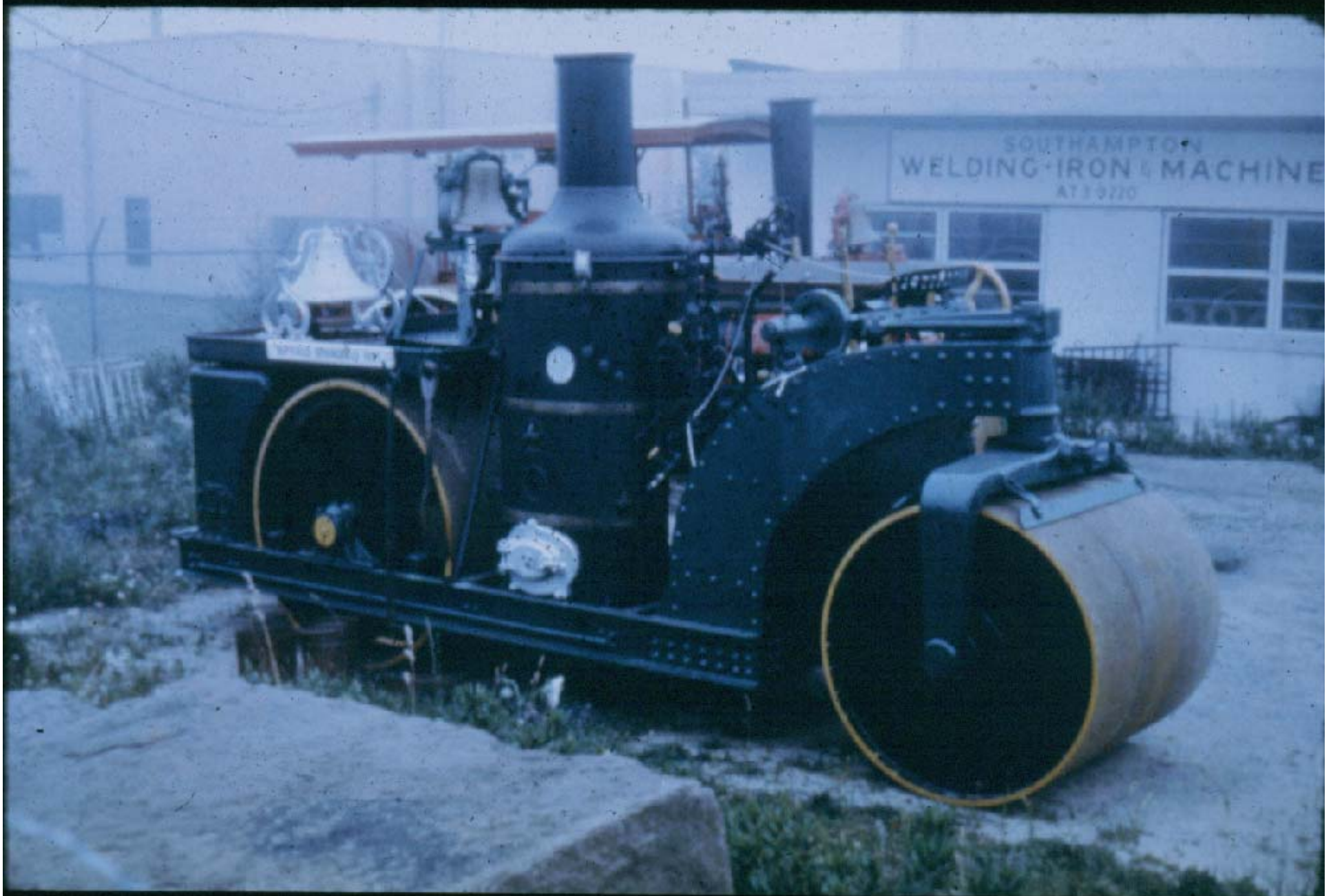
**NEW COMPACTION TECHNOLOGY
FOR MODIFIED ASPHALTS**

**CHUCK DEAHL
BOMAG AMERICAS, INC.**

INTELLIGENT COMPACTION

**NEW INNOVATIONS IN
COMPACTION EQUIPMENT**

ROMOS



Asphalt Manager Intelligent Compaction



Best for
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

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 OR PROOF OF ACHIEVING A GIVEN AMOUNT OF COMPACTION. THIS SYSTEM IS MOUNTED ON A MOBILE ROLLER TO RECORD THESE MEASUREMENTS AND THEN RELATE THESE MEASUREMENTS TO MEASURING DEVICES.

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



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

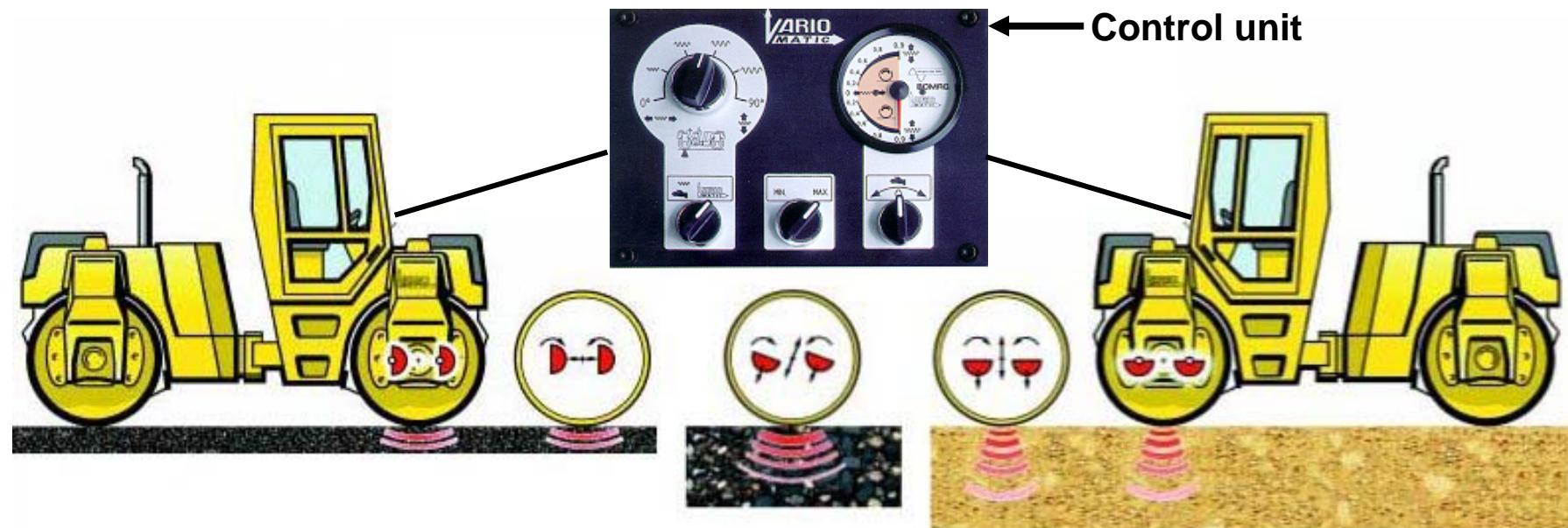
Surface Covering Compaction Measurement

- 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**

BOMAG Compaction Technology

- | | |
|-------------|--|
| 1996 | Variomatic for asphalt rollers |
| 1998 | Variocontrol for soil rollers |
| 2000 | Evib (MN/m²) |
| 2001 | Asphalt Manager |
| 2004 | Research project of German DOT (BAST), Oct / Nov. 2004; |

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

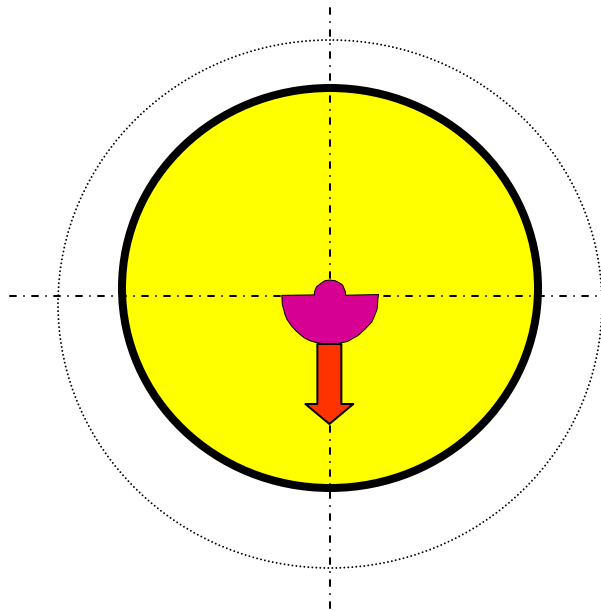
Applications: asphalt layers, granular bases and subbases.

Worldwide proven design:

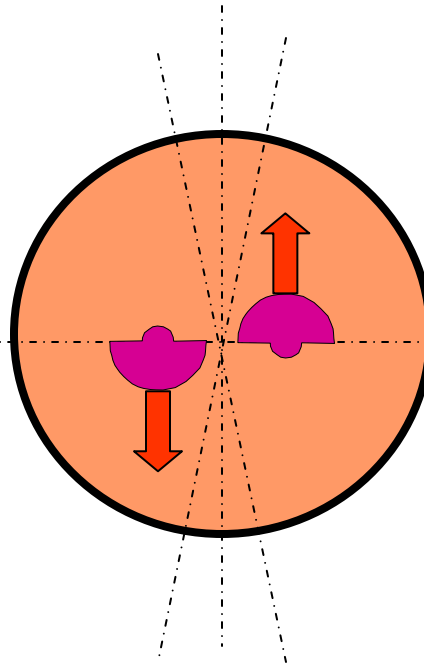
Several hundreds Tandem rollers



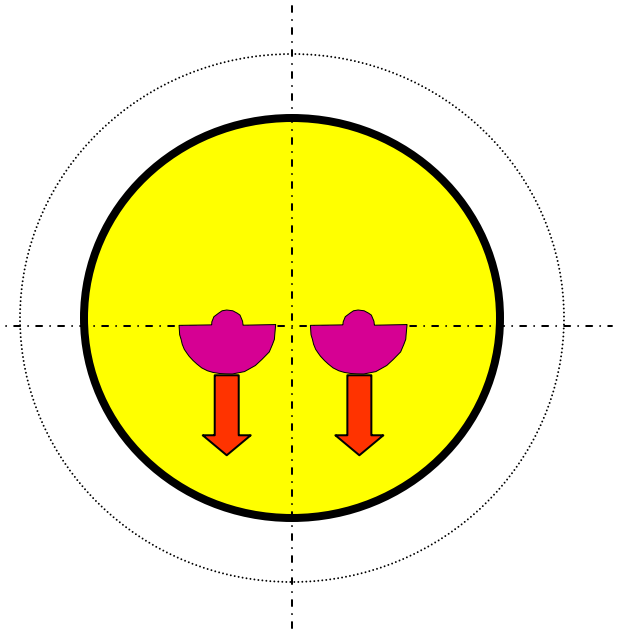
Rotary exciter



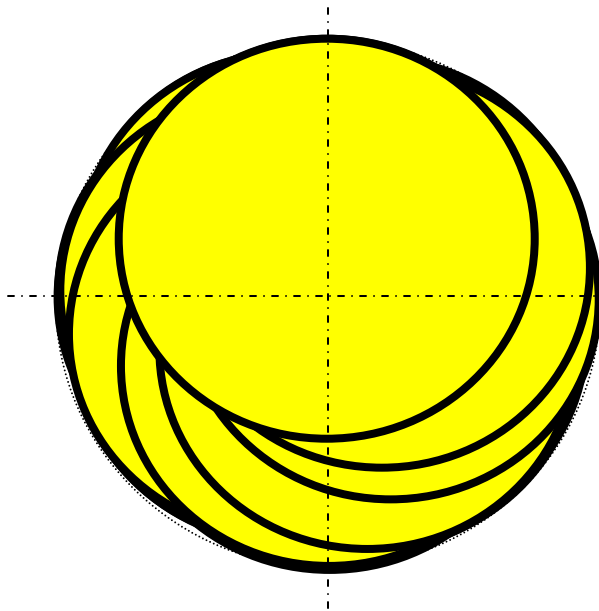
Oscillation



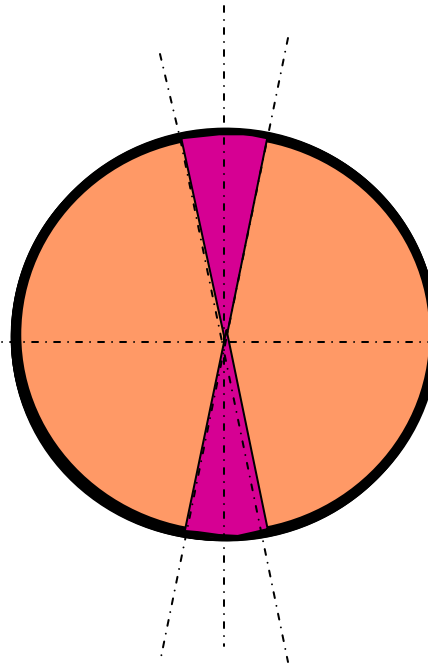
directed



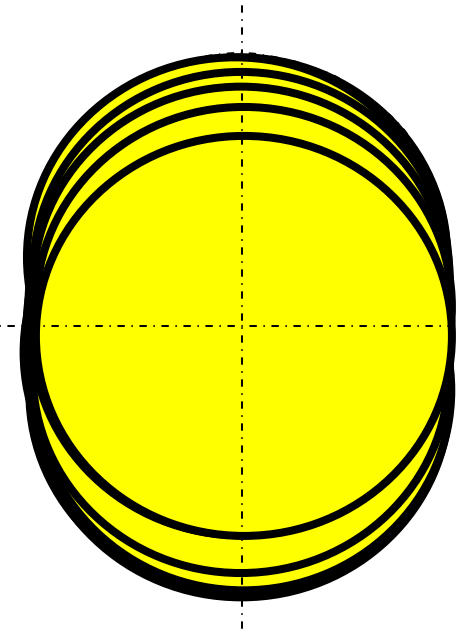
Rotary exciter



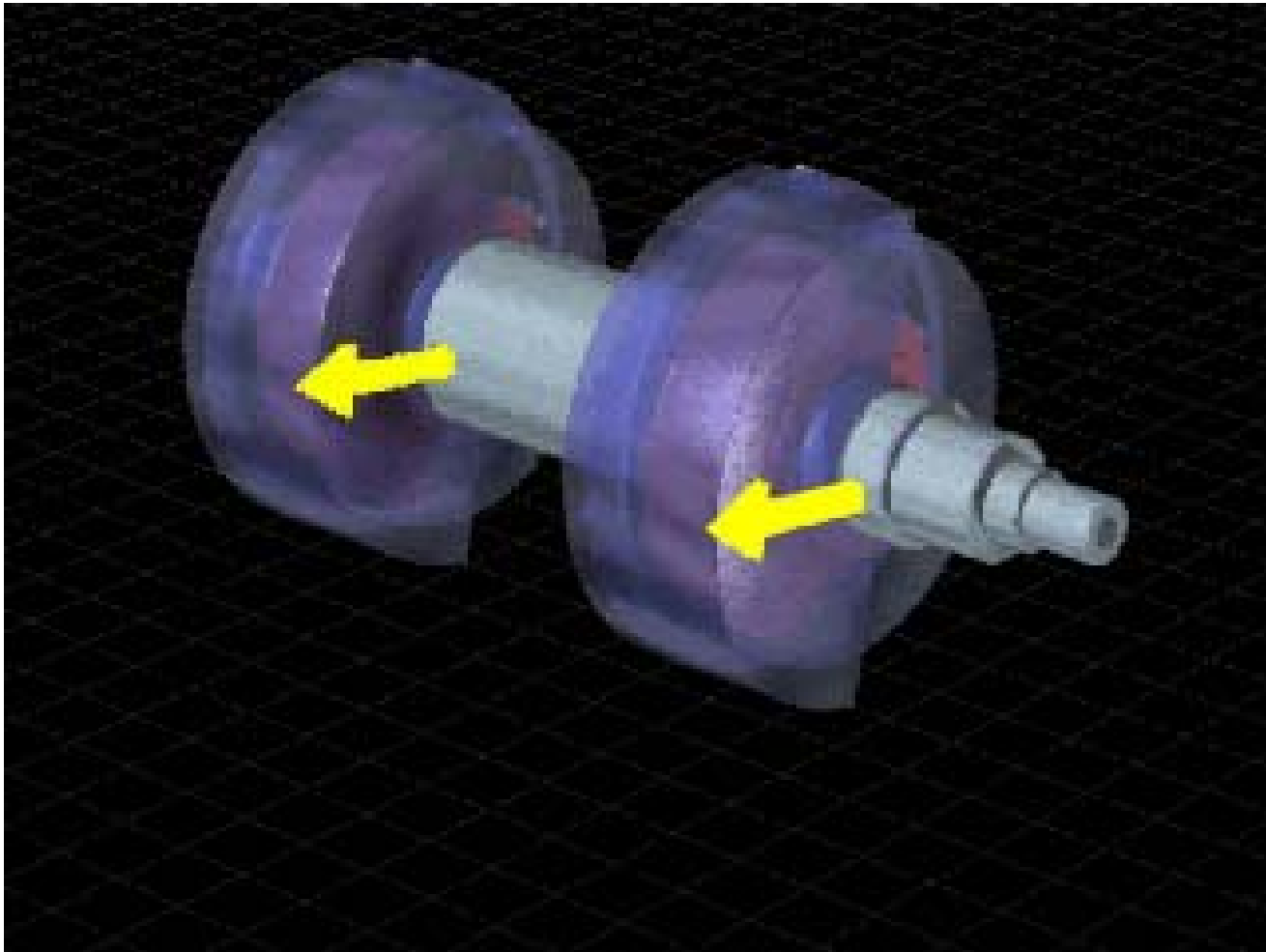
Oscillation



directed



Non Directed Forces:



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

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 evenness 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 evenness

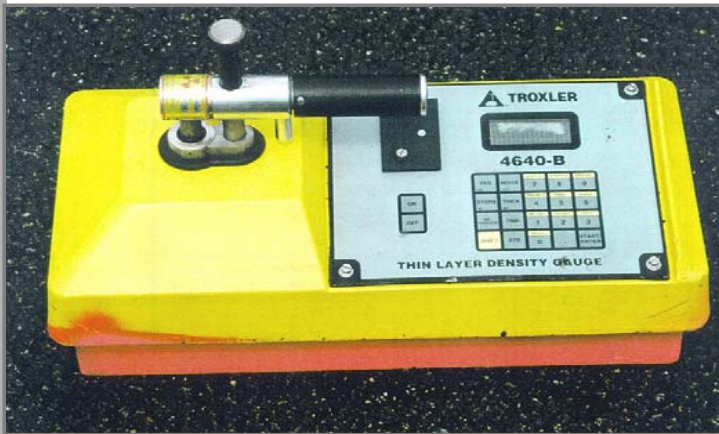


15 t tandem vibratory roller
8 passes



8 t BOMAG VARIOMATIC BW 151 AD
8 passes

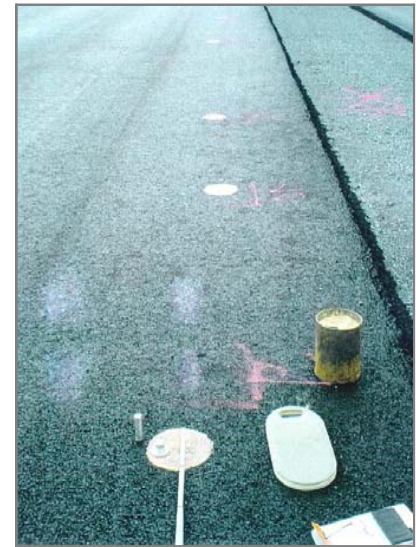
Density and roughness measurement on asphalt binder layer



Punctual compaction measurement with portable isotope probe



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

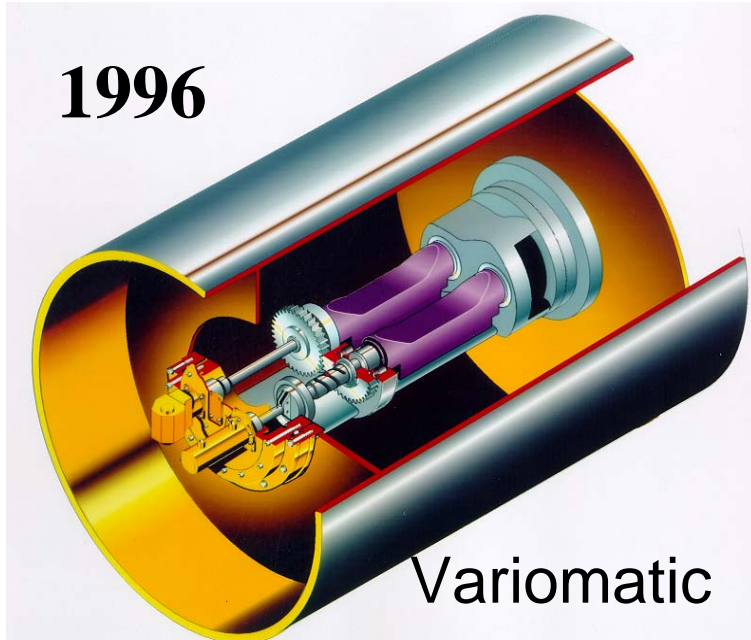


Comparison between conventional compaction concept and VARIOMATIC

	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

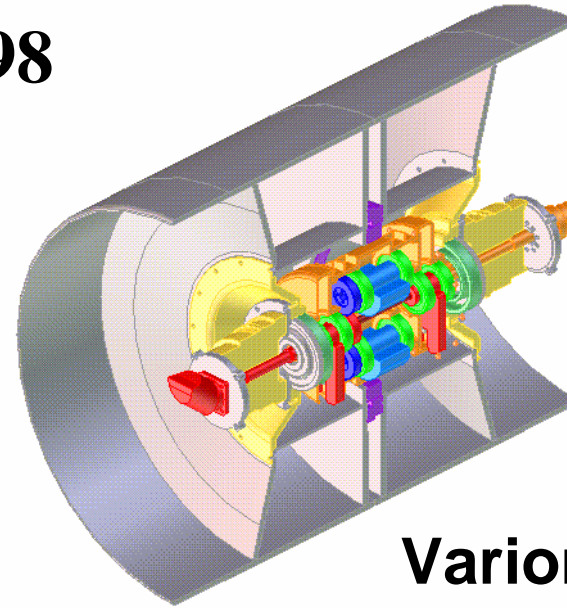
n = number of measurements, X1 = mean value of achieved Gyrator test compaction value (93% Gyrator value ~ 98% Marshall value), X2 = mean value of characteristic roughness value

1996



Variomatic

1998



Variomatic 2

advanced, more powerful

also for split drums !

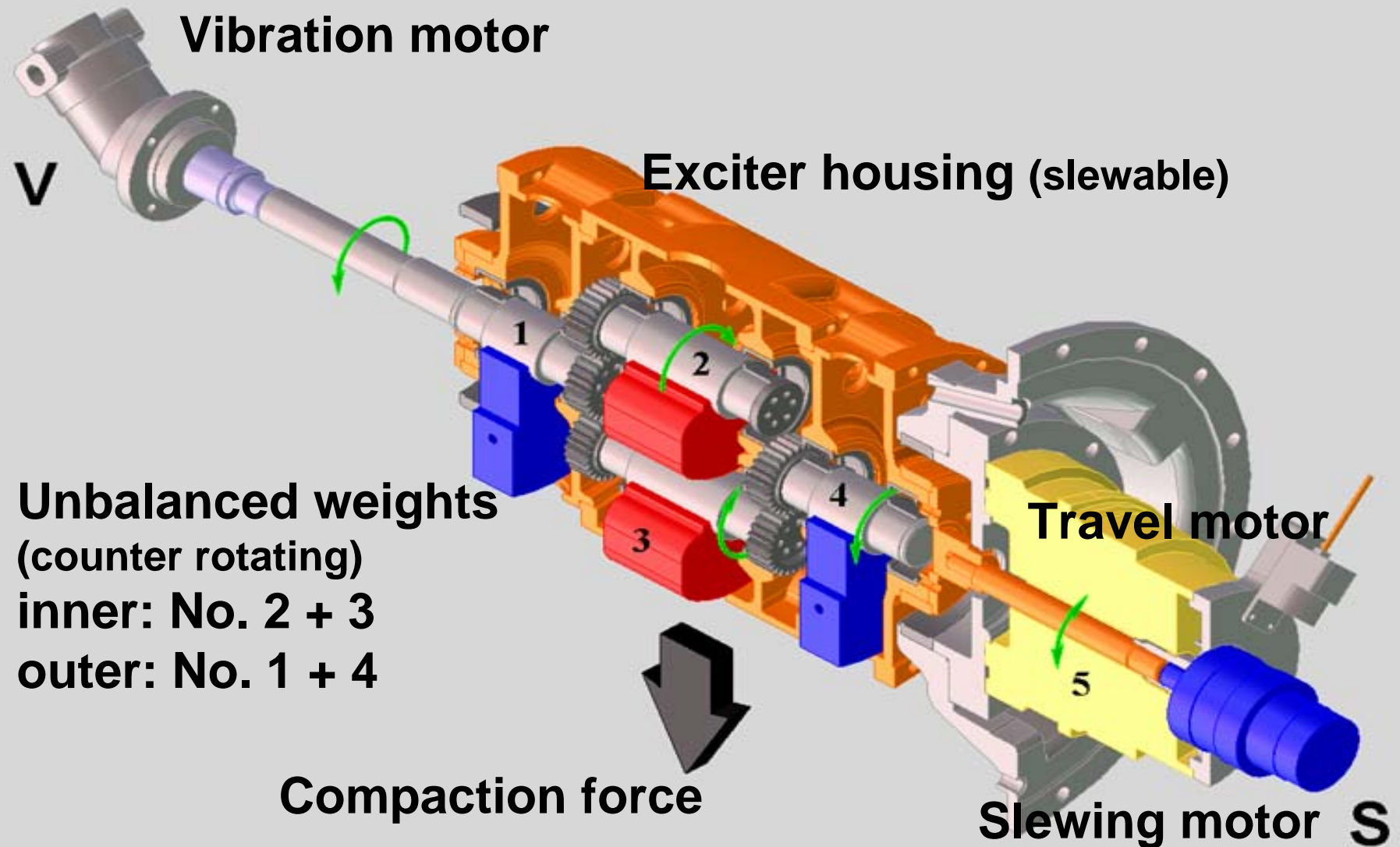
Latest developments of compaction technology

1996 Variomatic for asphalt rollers

1998 Variocontrol for soil rollers

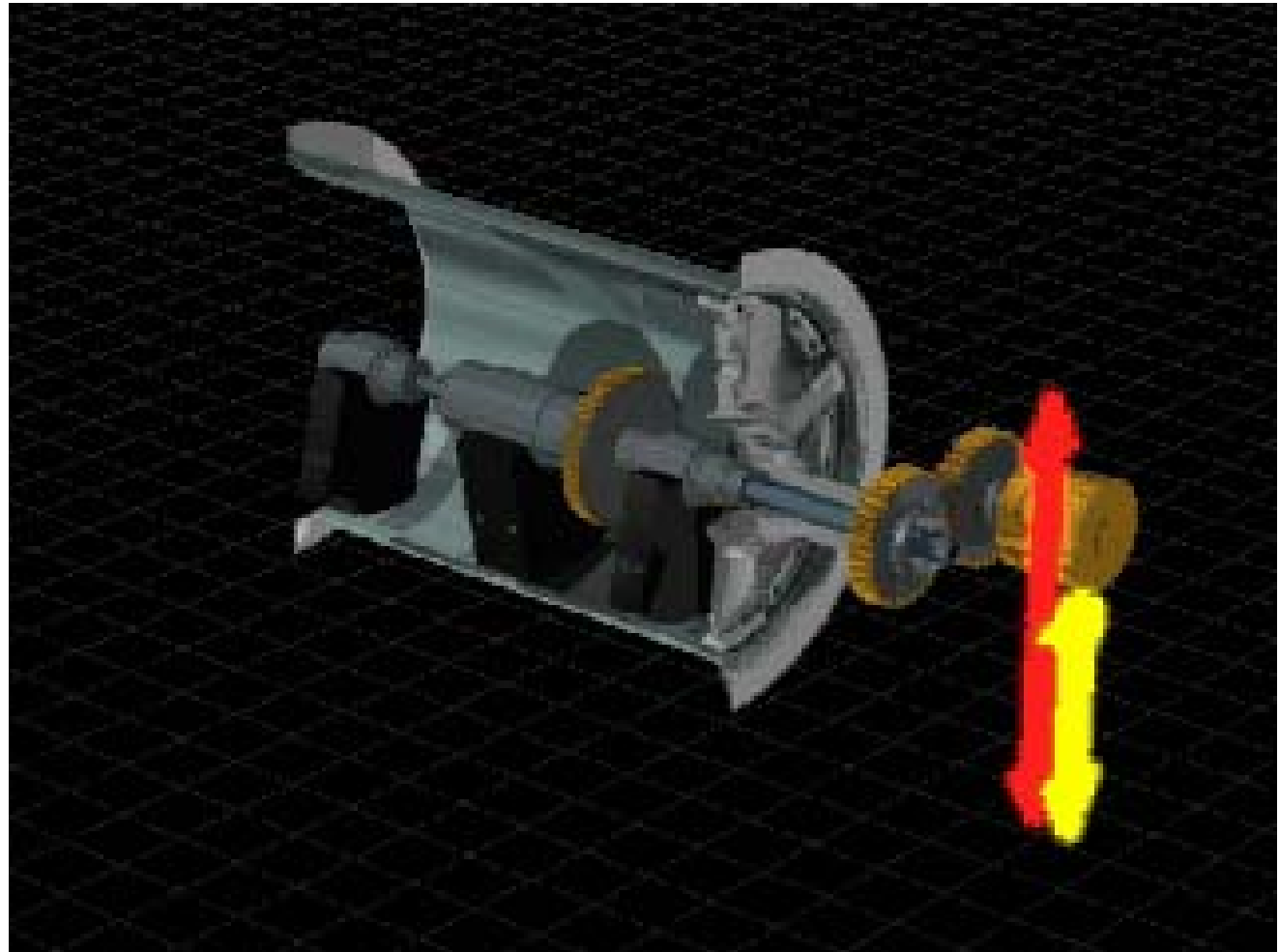
2000 Evib (MN/m²)

2001 Asphalt Manager

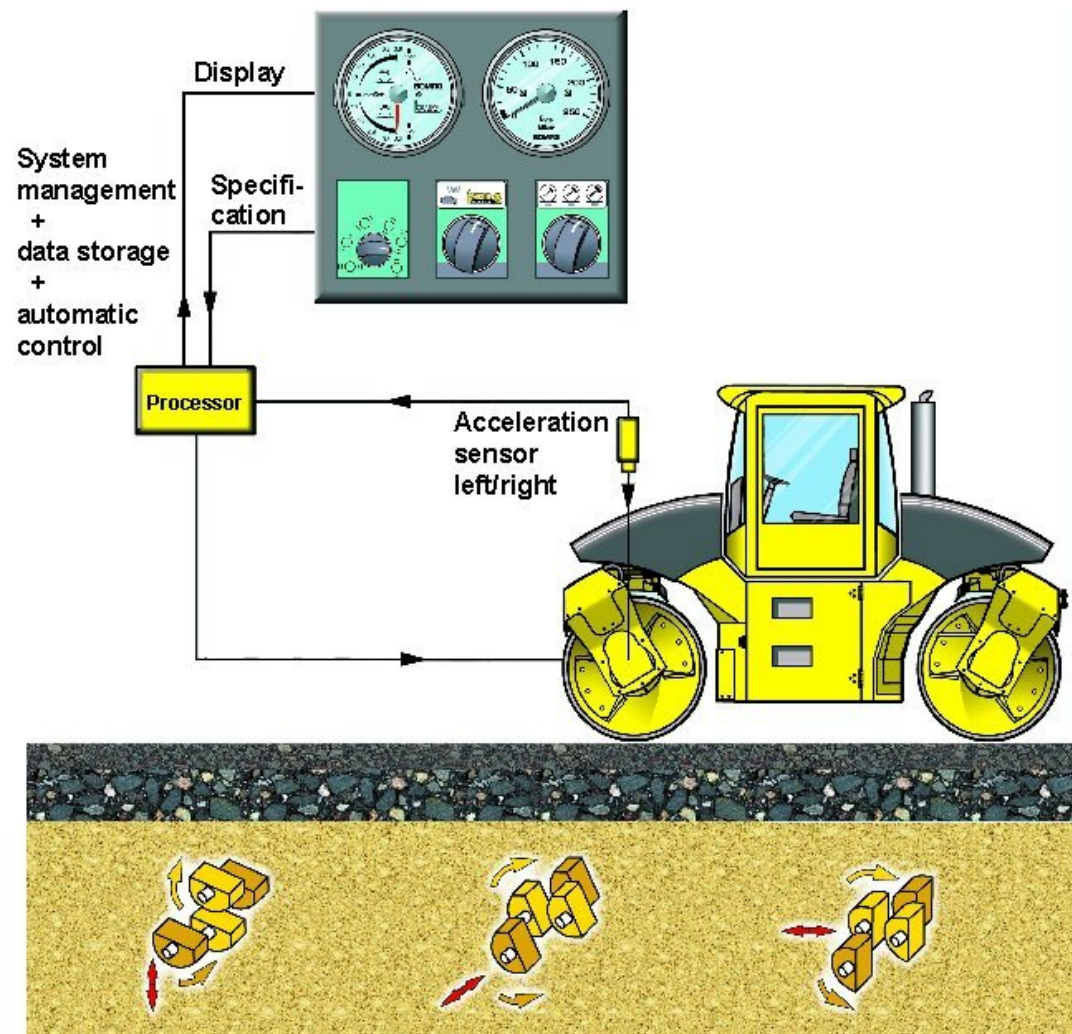


BOMAG VARIOCONTROL

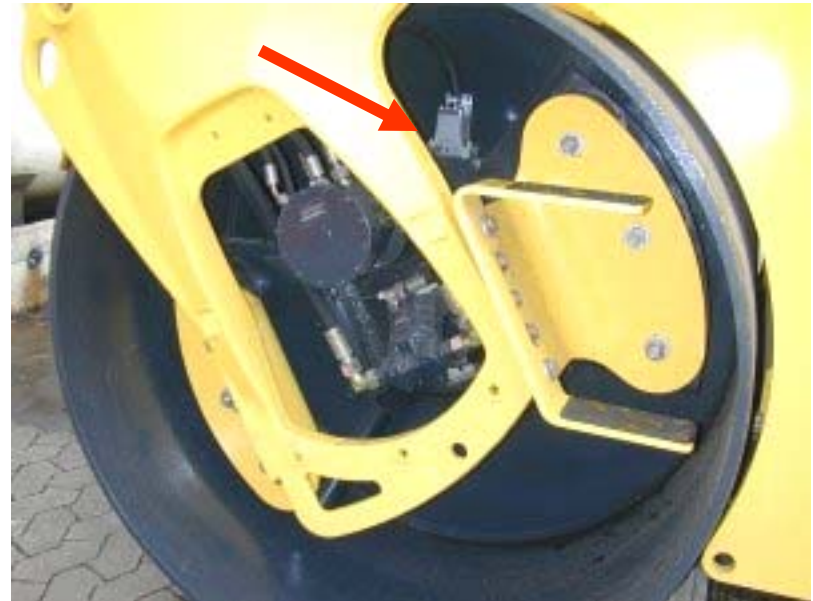
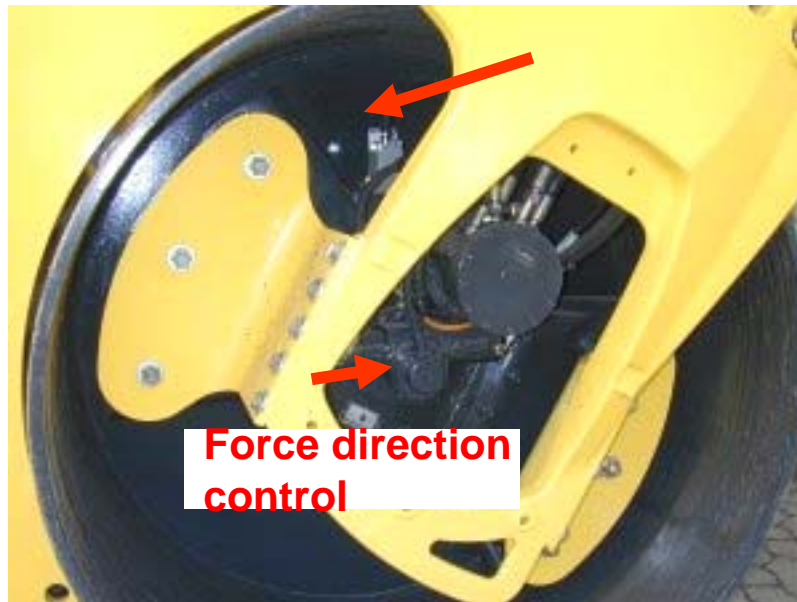
**Force Direction
Control:**
Infinite adjustment
of exciter housing
from
horizontal to
vertical.



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



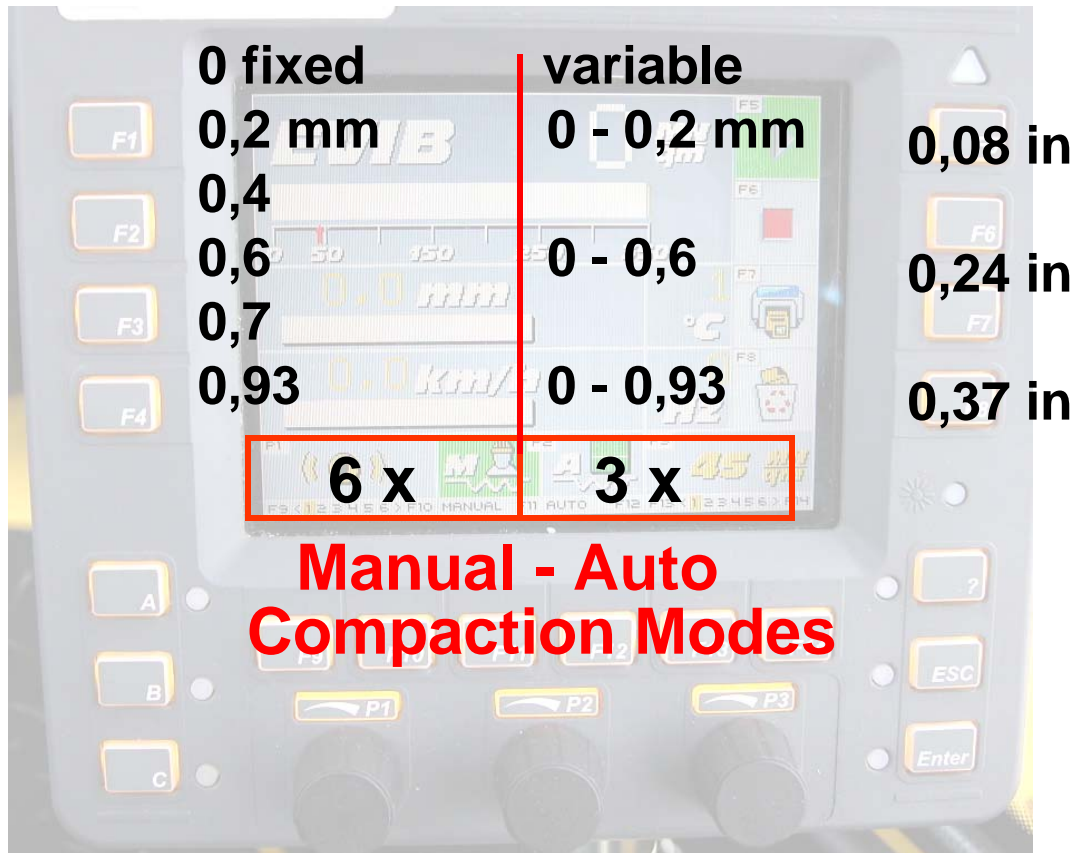
Technical Data

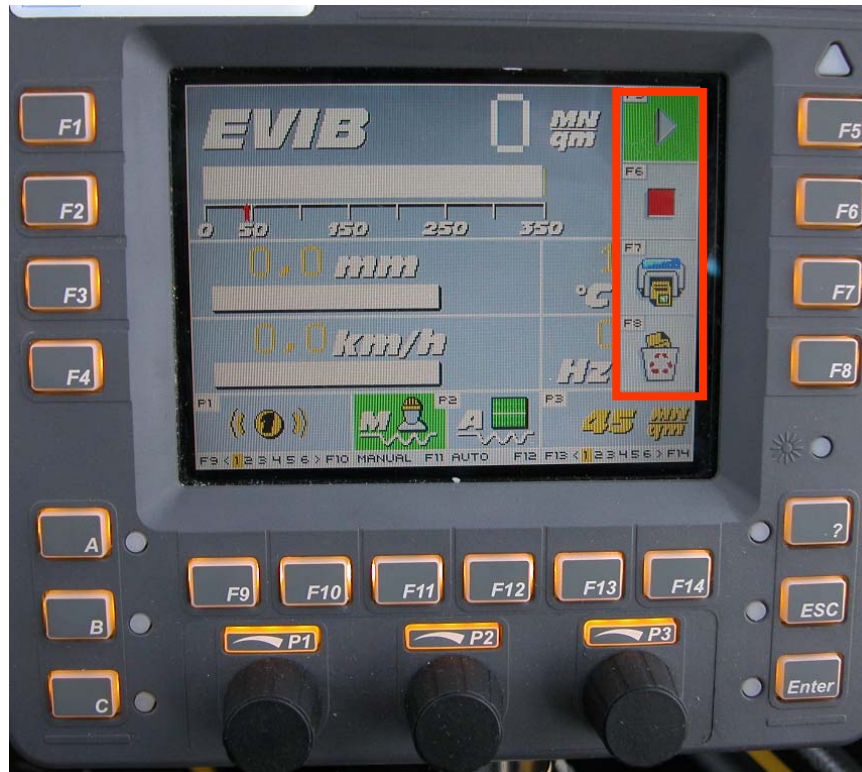
PARAMETERS	BW 141 / 151 AD AM	BW 190 / 203 AD AM
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Front: AM

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	<u>160</u>	<u>168</u>	<u>247 / 158</u>	<u>247 / 158</u>
rear	kN	80 / 34	80 / 34	167 / 109	<u>126 / 84</u>





PRINTER

- Start
- Stop
- Print out
- Delete

Test procedure:

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



SETTINGS
- Escape
- Enter

BOMAG





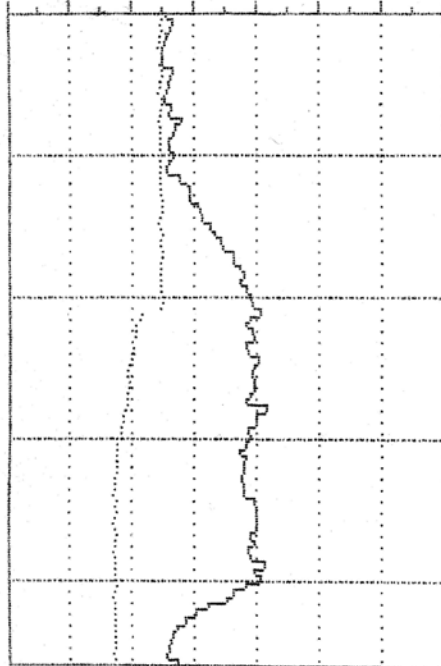
BOMAG ASPHALTMANAGER

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

Raster 5m ---> Evib (MN/m²) -----
---> Temperatur (°C)
0 50 100 150 200 250 300 350



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

E_{VIB} Average

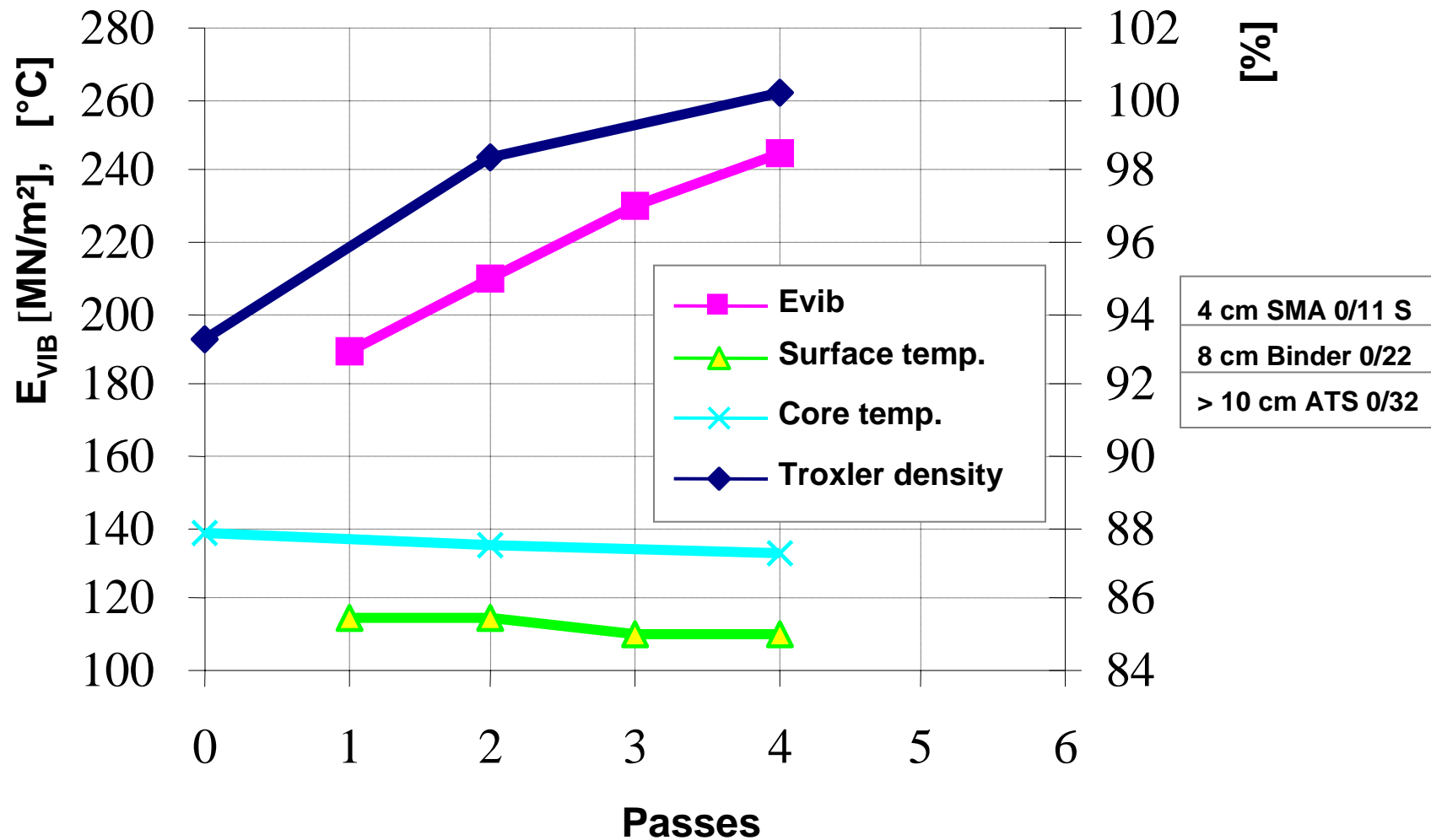
Frequency

Average Speed

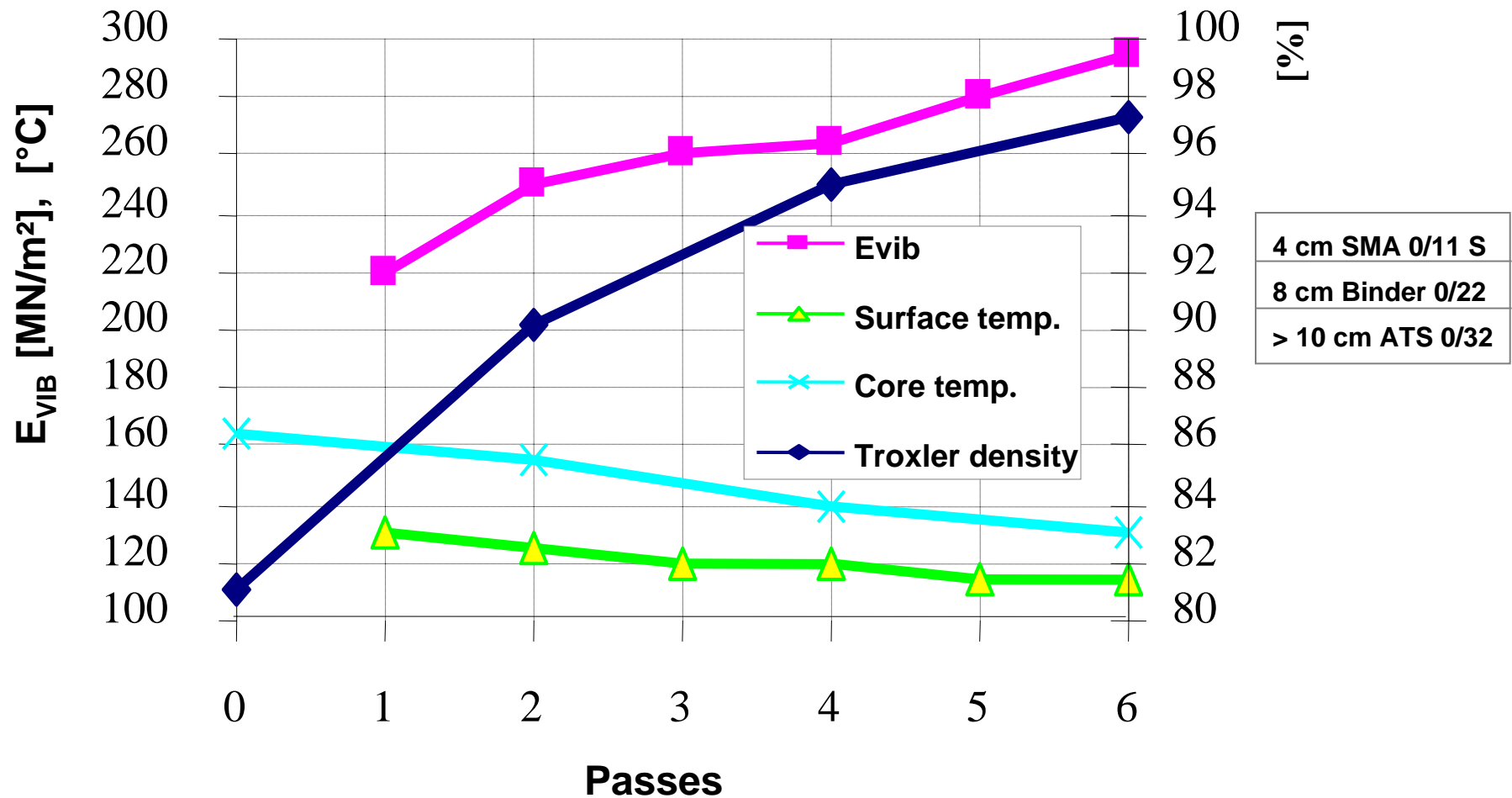
Track length

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



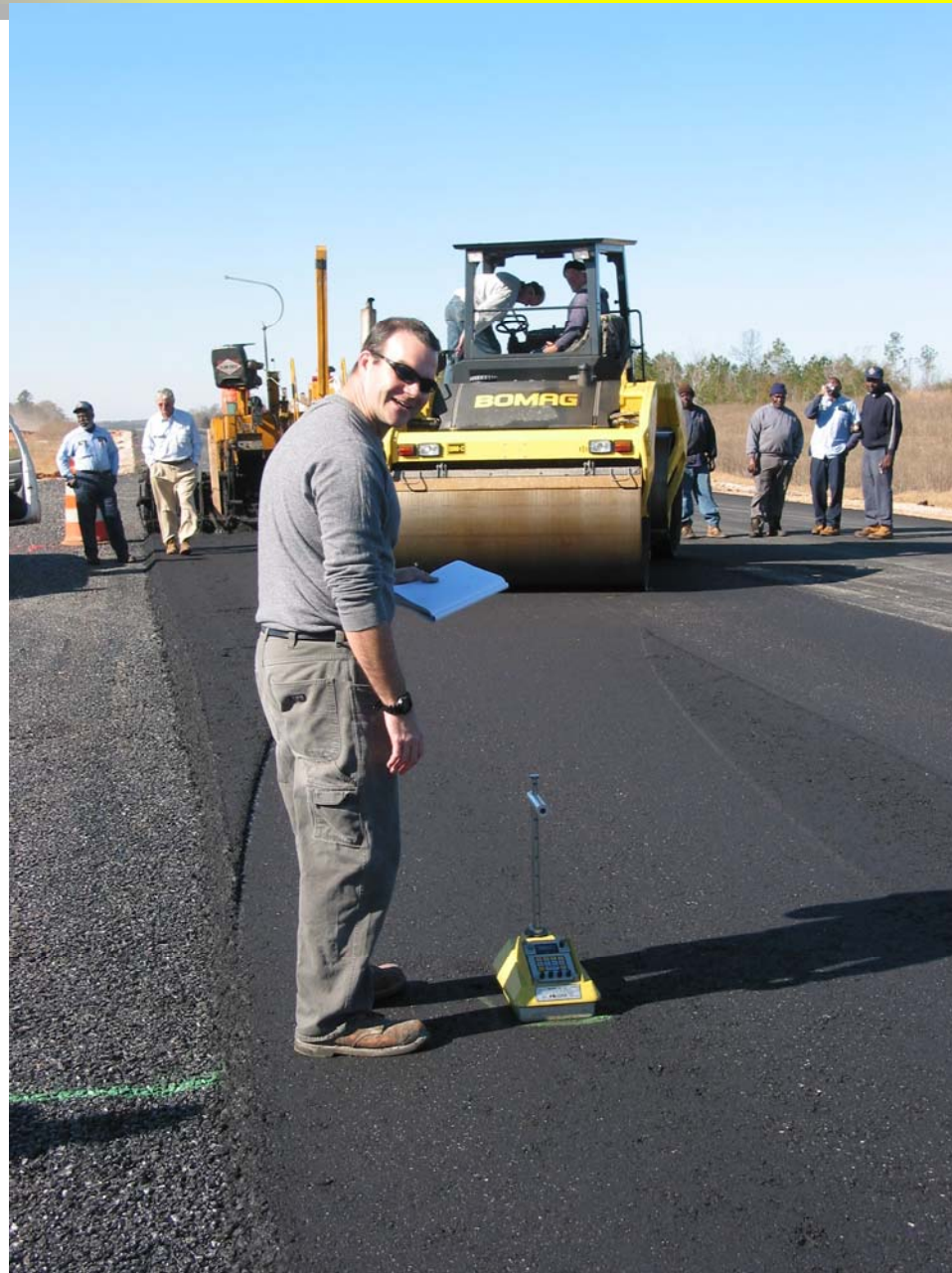


PATTERN DECISIONS:

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?

BOMAG









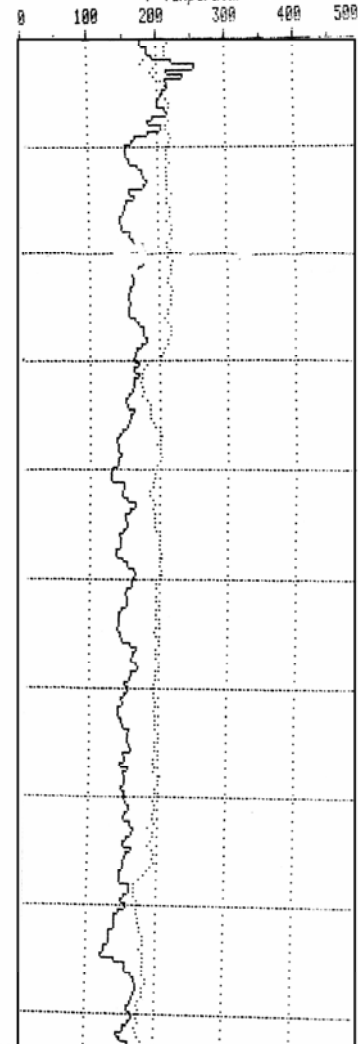
BOMAG ASPHALTMANAGER

PASS NO. 3 Rev.

BOMAG AM Rev 3.0 ENG
BM190 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)



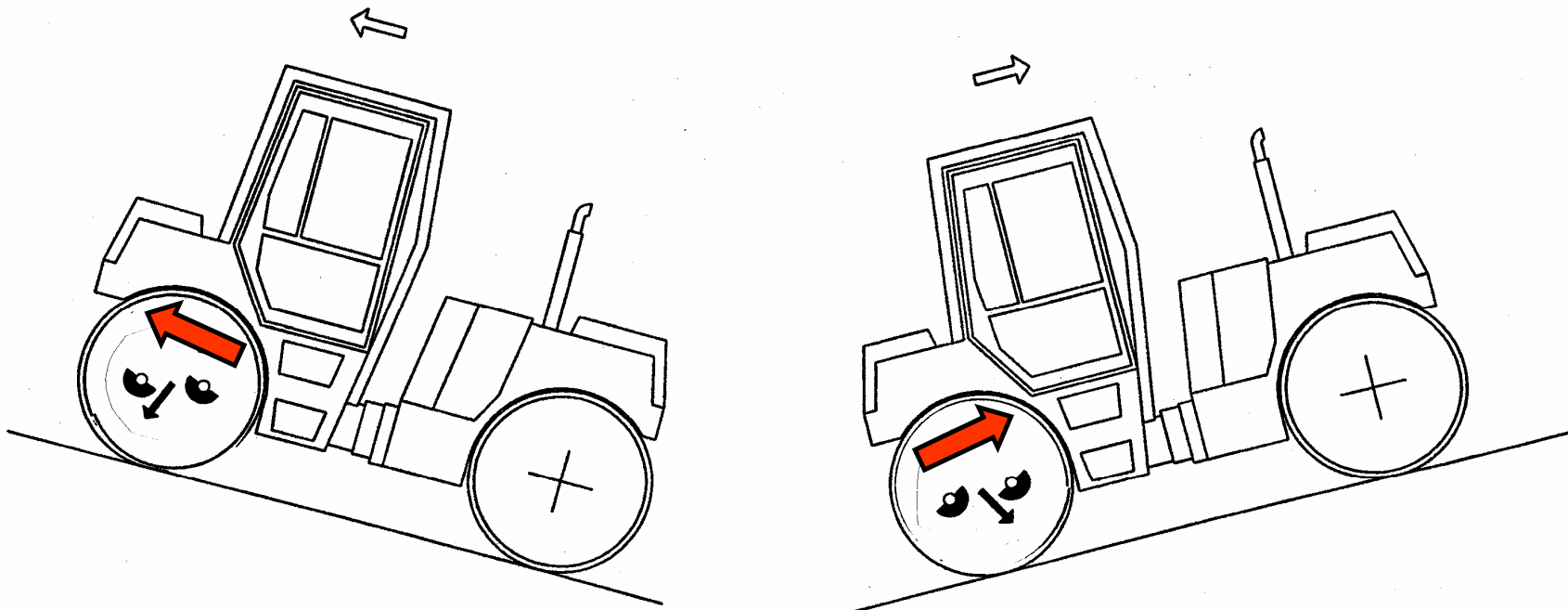
Advantages:

- Immediate determination of dynamic stiffness in MN/m^2 (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/m²) 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 evenness and roughness**
- **Eliminates drum bouncing**

Economical and quality aspects

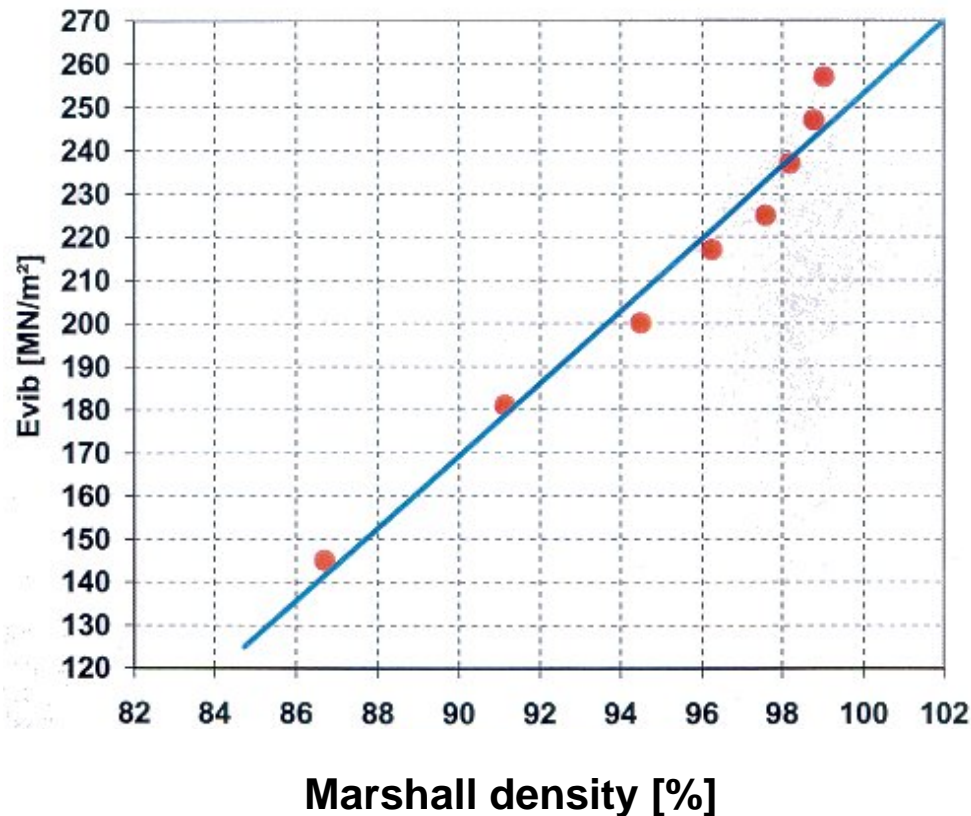
- **More efficient roller utilisation with fewer passes**
- **Reduced shock loads in sensitive environment
e.g. buildings, bridges**
- **Area coverage method**







Compaction test on asphalt wearing course (stone mastix asphalt)

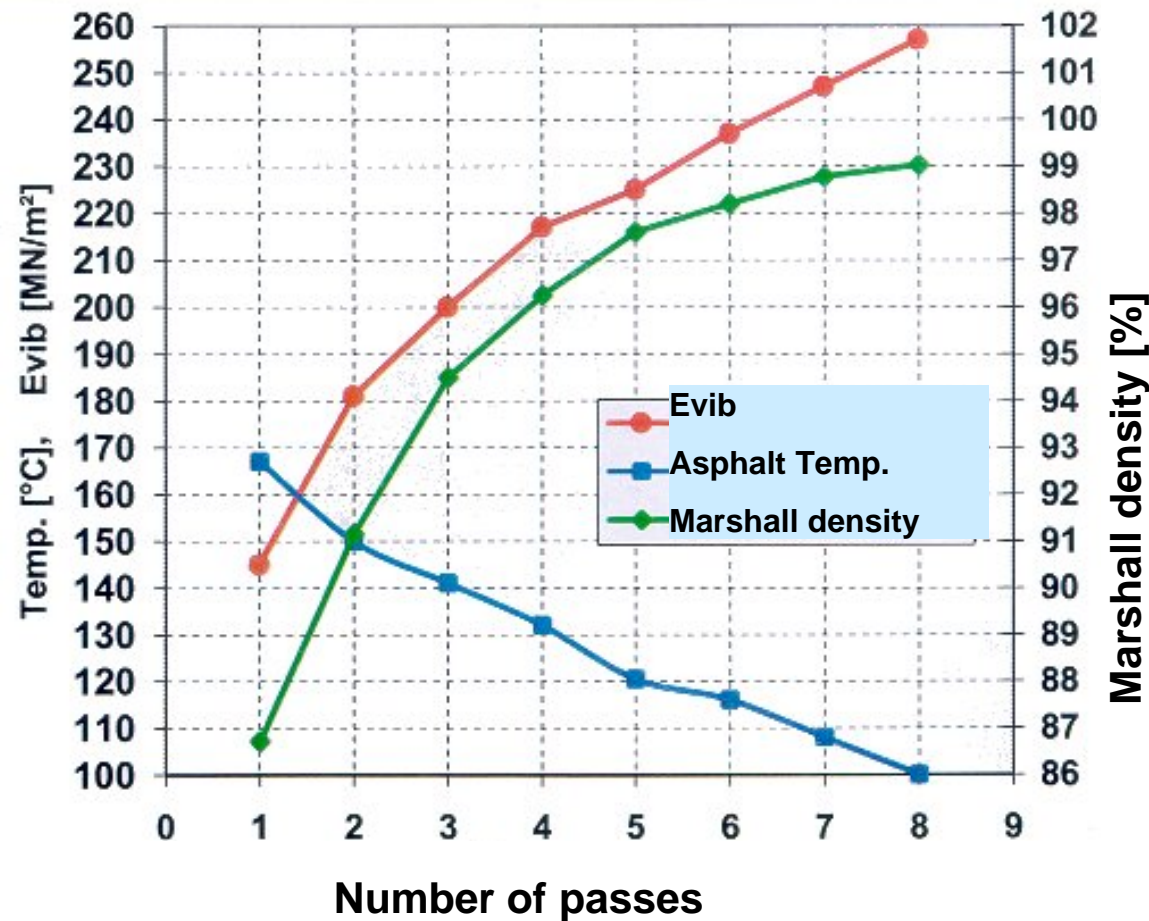


Perfect correlation:
Evib + Marshall density

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**

Comfort + Quality:



**Compaction of joints
hot against cold**

- avoids shock loads**
- no bouncing**
- better evenness**

Leipzig:



“Augustusplatz”

**Compaction on a
parking roof top;**

Alternatives:

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



**Avoids shock loads on bridges
and near buildings**

**Depth control via
force adjustment**

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

FEATURES

Modular Design Principle:

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

BENEFITS

**Less Expenses for Warehousing,
Training, and Logistics;**



Perfect Results:

- Roughness**
- Evenness**

Application soil compaction

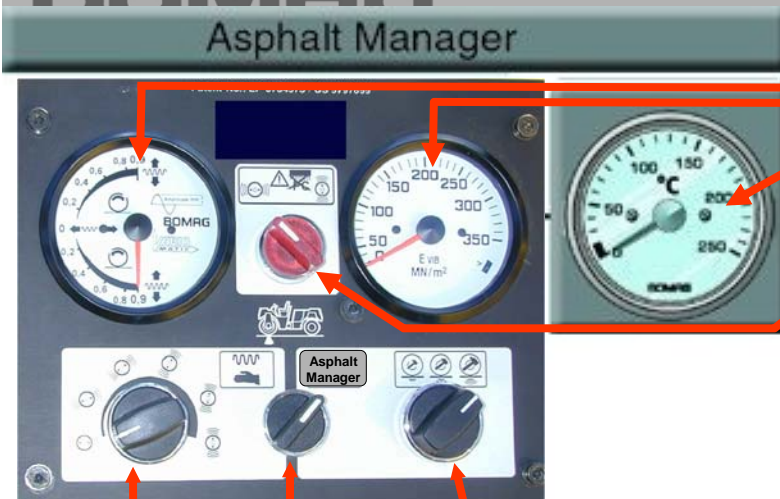
Support for compaction works and measuring paths on sub-grade, frost blanket layers and non-bonded bearing layers: the E_{VIB} value increases with increasing compaction. Weak spots are localized.

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



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, direction of vibrations

E_{VIB} display

Temperature gauge

Emergency switch

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 MN/m^2

- 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.

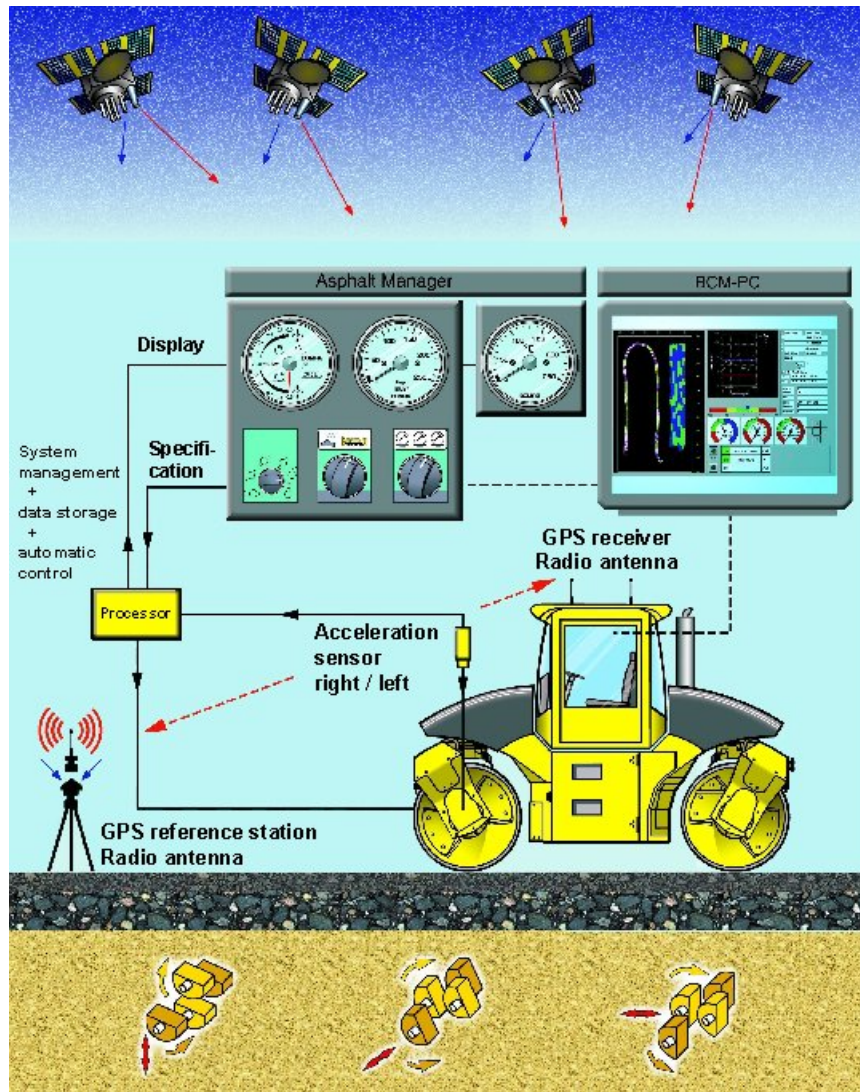
Temperature gauge

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 $40^{\circ}C$ higher. At a surface temperature of $80^{\circ}C$ 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

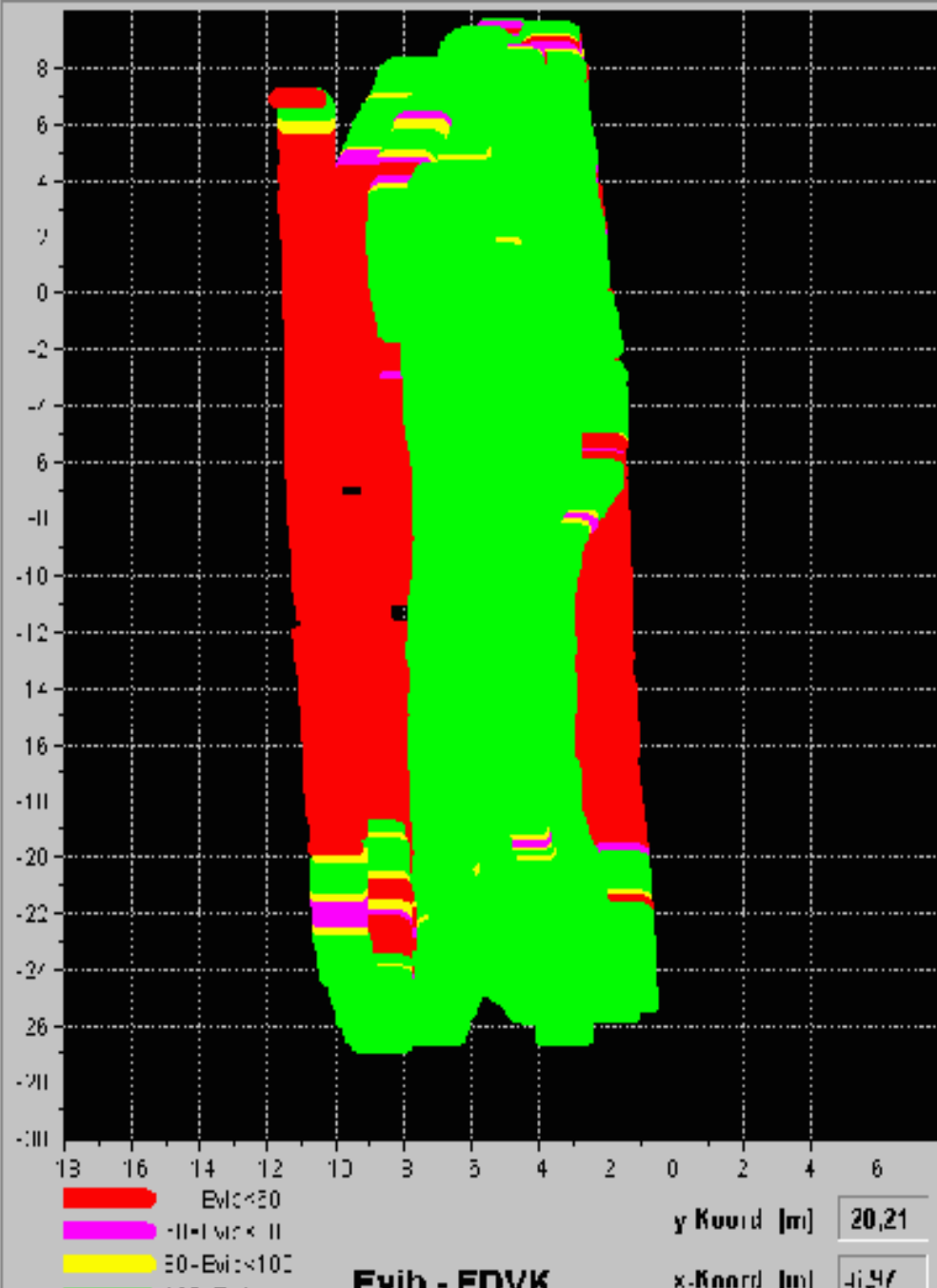


- Surface covering compaction control on asphalt layers
- GPS receiver
- GPS reference station
- Roller PC for data managing and graphical representation of roller position and stiffness values
- Position accuracy: better than 10 cm
- CAD based evaluation program

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



Surface Covering Compaction Measurement



Maschine

Modell: BW 174 Variomat2
 Gewicht: 9000 kg
 Bandagenbreite: 1,68 m
 Linienlast: 27 kg/cm
 Frequenz: 46 Hz

Baustelle

Ort: BOMAG/TF/Testgelände
 Feld:
 Bodenart: Grubenkies
 Einbauhöhe: 0,30 m

Einstellparameter

Amplitude: Automatik
 Kraftstufe: 3

Bearbeitungszeit

Datum: 01.03.01
 Bearbeiter: Wallrath



fast slow

Clear

Speichern

Reference station on the job site

High accuracy: up to 5 cm

GPS Reference service with reference satellite

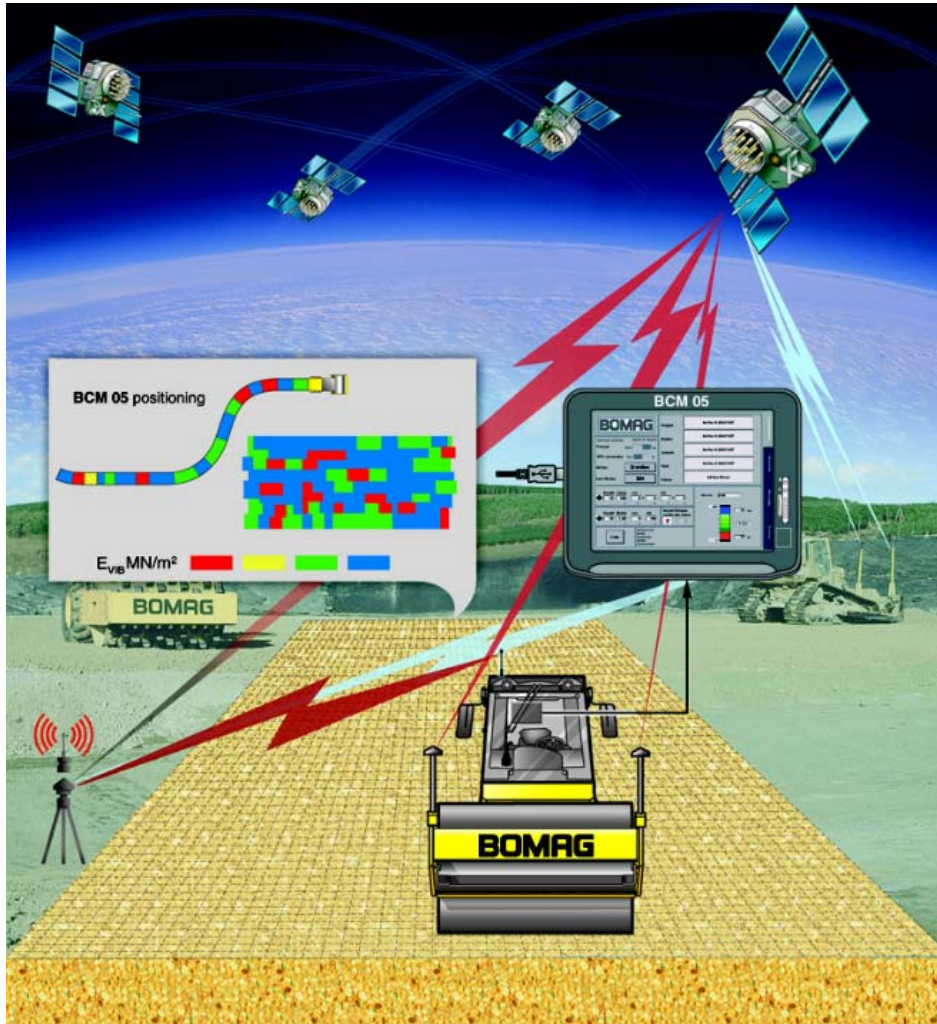
Accuracy: up to 100 cm

- > 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)

- > Ascot (since 2001, Ruhrgas / Germany,
(only available in Rhine Area)**



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

DOMOS









DOMS

HI MAT TEMP LIMIT 310 F
ADJ. WITH CONTROL HANDLE

OFF

RUN

1



AUTO

FRONT



Compaction of Superpave Mixes

Compactive Force

Pressure
Vibration

Pressure
Manipulation

Pressure

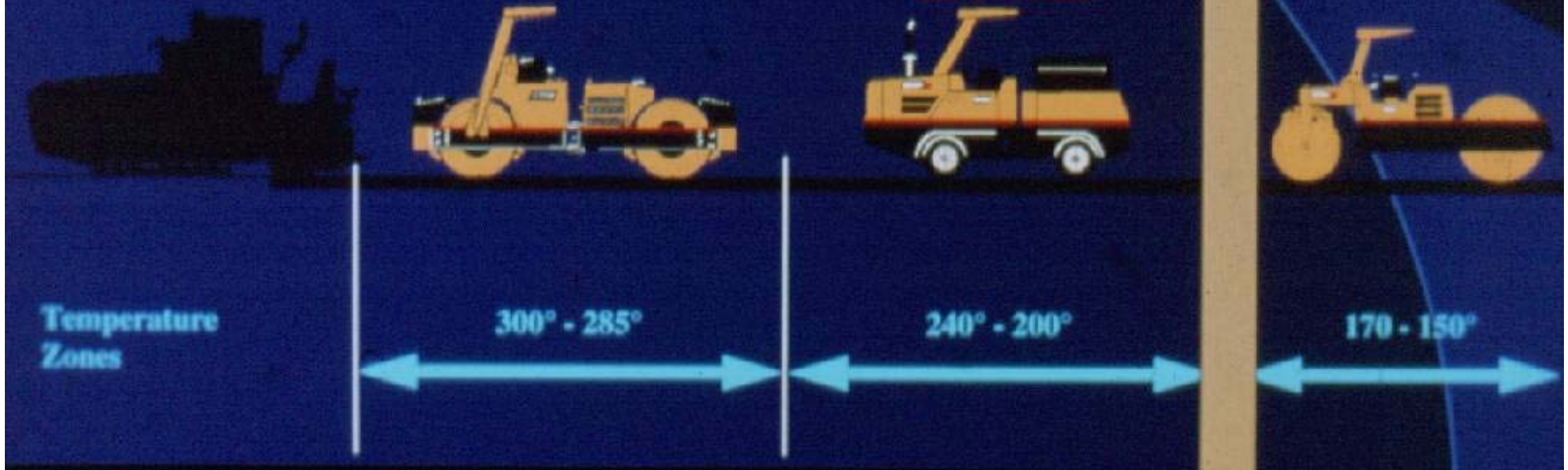
**TENDER
ZONE**

Temperature
Zones

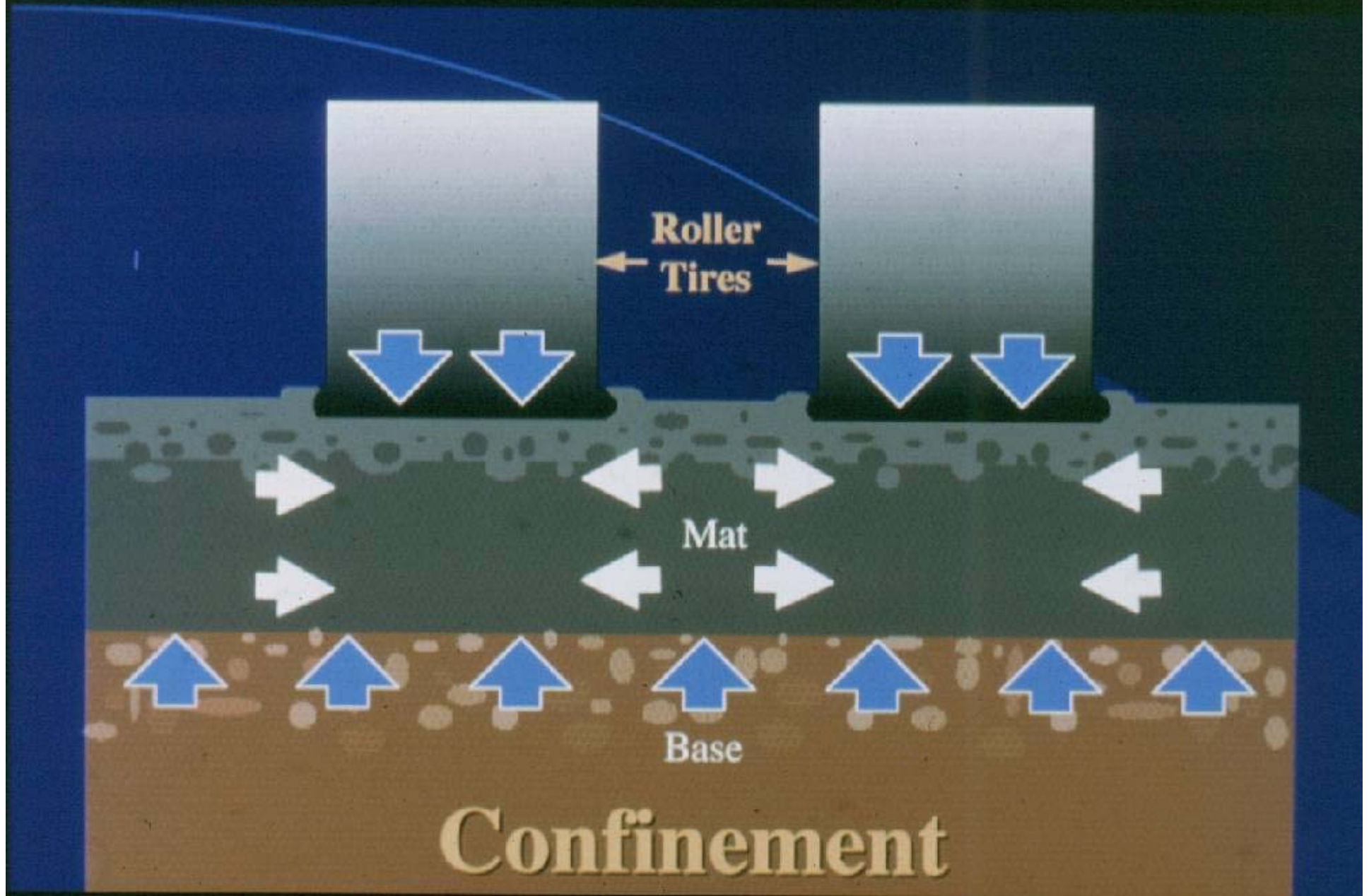
300° - 285°

240° - 200°

170 - 150°



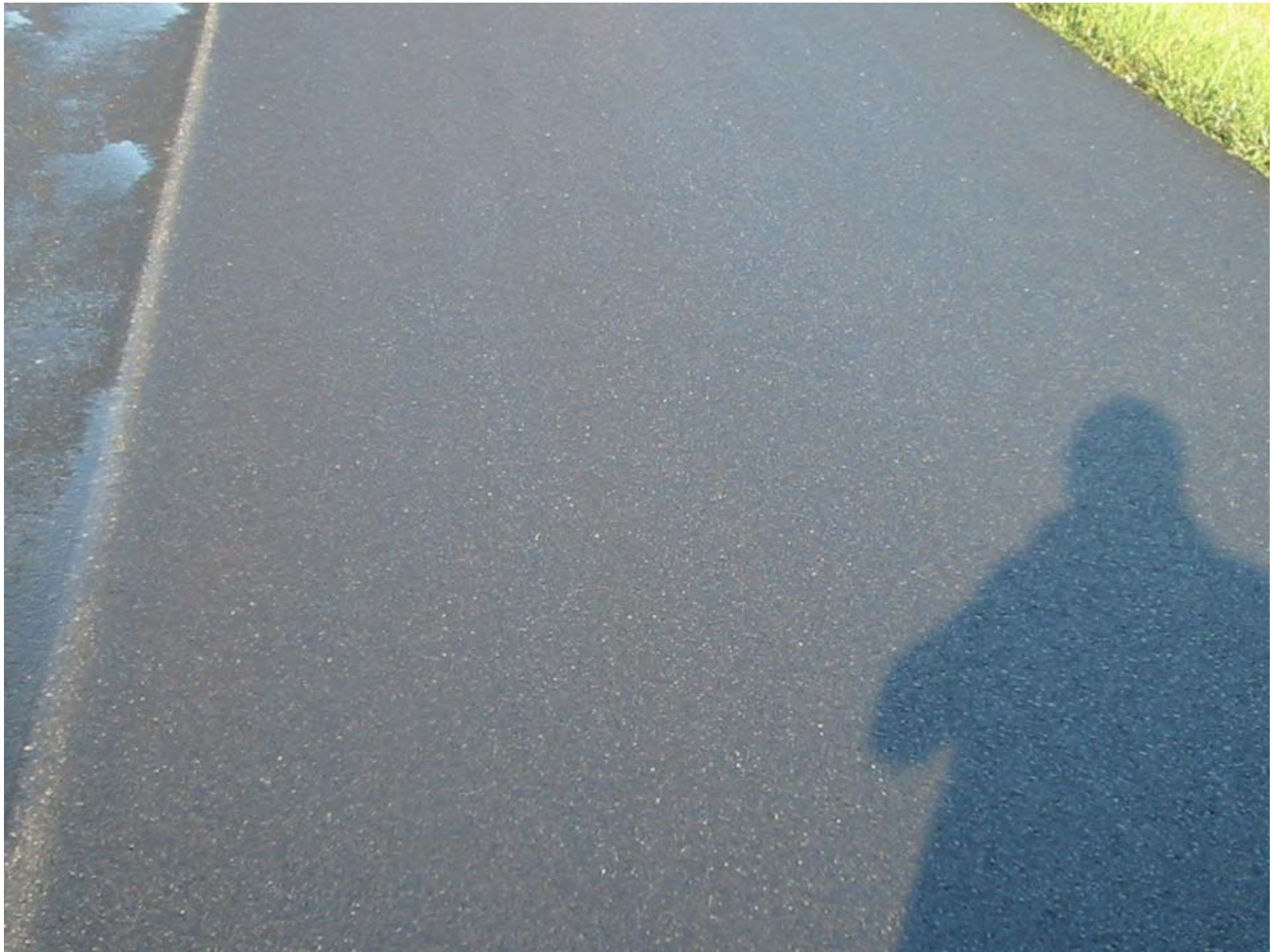




DEMOC







CONCLUSIONS:

POLYMER MODIFIED HOT MIX ASPHALT MIXES CAN BE: COMPACTED WITH VIBRATORY ROLLERS AT TEMPERATURES FROM 280 F- 300 F; WITH WARM MIX MODIFICATION COMPACTION TEMPERATURES CAN BE REDUCED.

ROLLED WITH PNEUMATIC TIRED ROLLERS FROM 180 F- 200 F WITH THE USE OF RELIABLE RELEASE AGENTS.

DAILY MAINTAINENCE OF RADIATORS ON PAVERS AND ROLLERS IS REQUIRED WHEN USING POLYMER MODIFIED MIXES.

QUESTIONS????

QUESTIONS????