Determination of LTPP Properties of Asphalt Materials on Concrete Bridges and in Pavements

by

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Graduate School of Engineering, Hokkaido University

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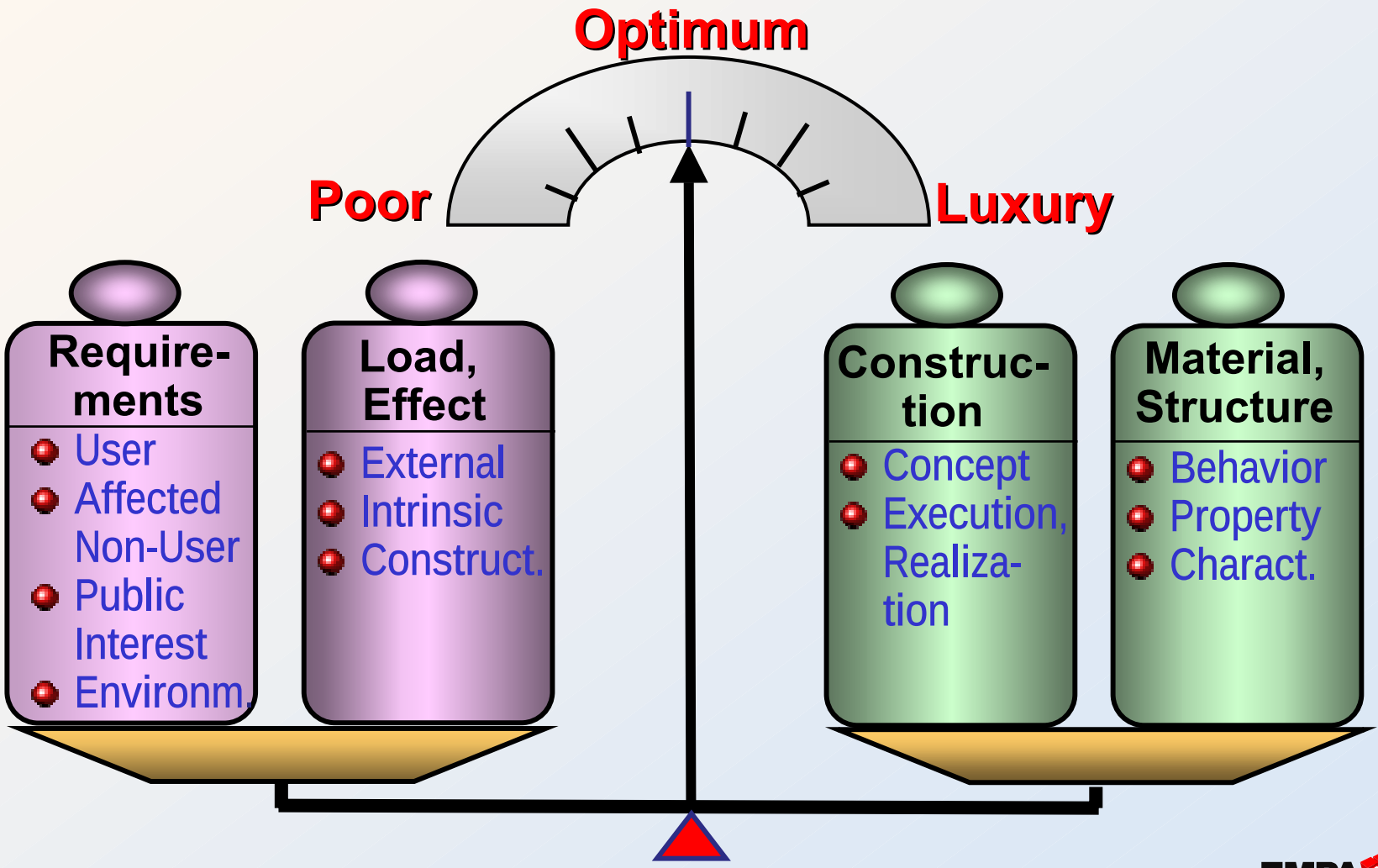
Content

- Introduction
- Compaction
  - Field compaction
  - Lab compaction of test specimens
- Aging and durability
  - Binder-Polymers
  - Artificial Aging
- Water susceptibility evaluation of Mixes
- Inlayer and interlayer bond
- Accelerated pavement testing APT
- Asphaltic plug joints for large movements
- Joints

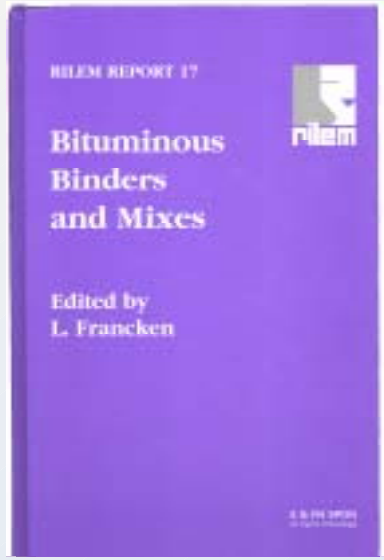
Introduction

Optimization Scale



Pav. Perform. Mechanisms

Partl et Francken in RILEM Report 17 (1998),ISBN 0 419 22870 5



Requirements
- Safety
- Service life
- User comfort
- Noise
- Zero-maintenance & user costs

Distress
- Cracks
- Permanent Deformation
- Material Desintegration
- Surface Defects

Influence Factors

Intrinsic Factors
- Mech. Properties (e.g. Stiffness)
- Aging
- Material Characteristics

Pavement Structure
- Flexible
- Semi-Rigid
- Rigid

Manufact. Procedure
- Mixing & Laying Temp. & Time
- Compaction Energy & Process
- Climatic Conditions
- Expertise (Human Ressources & Equipment)

External Factors
- Climate (Temp.-Moisture)
- Traffic Cond. (Axle Load, Tire Type)
- Traffic Intensity, Sequence and Velocity

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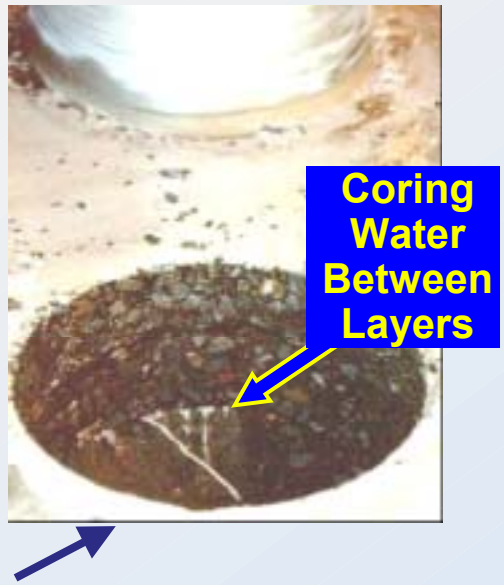
Types of Distress (1)

- **Cracks**
  - Temperature Induced
    - Temp. cycles (fatigue)
    - Extreme cooling (thermal contract.)
  - Compaction and construction induced
    - Surface cracks (compactor)
    - Longitudinal cracks (paver)
    - Delamination & interlayer de-bonding
  - Traffic induced (fatigue)
    - Top-Down (e.g. from tire-surface interaction)
    - Bottom-Up (e.g reflective cracking)
  - Consolidation & sliding
    - Transverse border cracks
    - Longitudinal border cracks
    - Kerbstone cracking



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Types of Distress (2)

- **Permanent Deformation**
  - Vertical layer deformation (material problem, traffic induced)
  - Structural vertical deformation (design problem)
    - Traffic induced ruts (poor fundation, consolidation)
    - Climate induced (frost & water upheaval)
    - In & Inter-layer Blisters
  - Compaction induced (uneavenness)
  - Shear
    - in layer (shoving & washboarding)
    - Inter-layer (can lead to slippage cracks)
    - longitudinal/transversal

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Types of Distress (3)

- **Material Desintegration**
  - Material incompatibility (stripping, bad additives)
  - Leaching
- **Surface Defects**
  - Raveling, loss of aggregates
  - Polishing
  - Wear (ruts, e.g. studded tires)
  - Aging of binder (hardening or softening)
  - Bleeding and pumping
  - Catastrophy (e.g. Fire)
  - Blisters

HRA

Mastic

St.Gotthard 2001

SMA
Airfield

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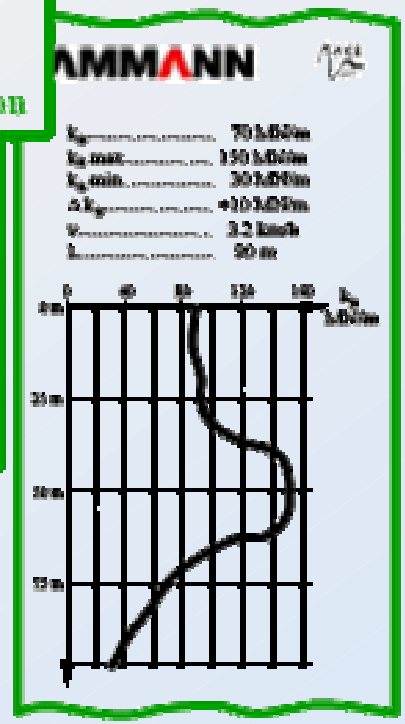
Compaction

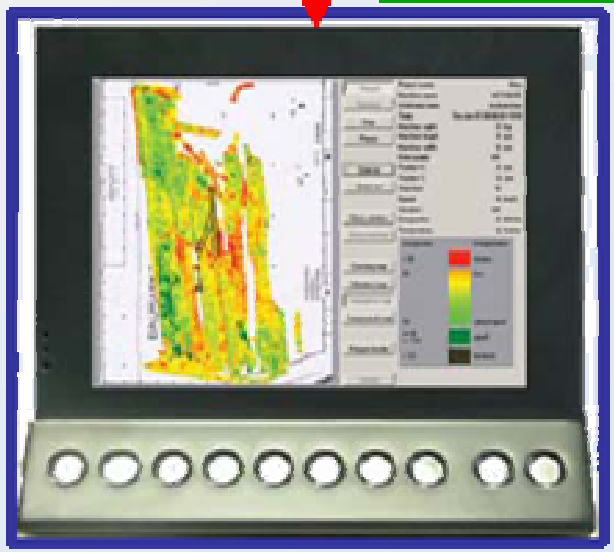
Field Compaction

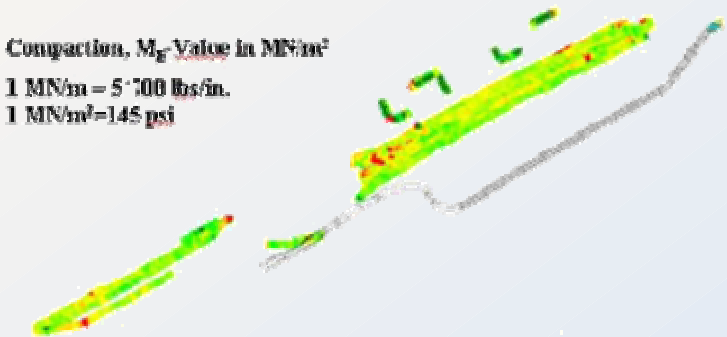
New Developments

- Intelligent Compaction (e.g. ACE Ammann Compaction Expert)

DATAS



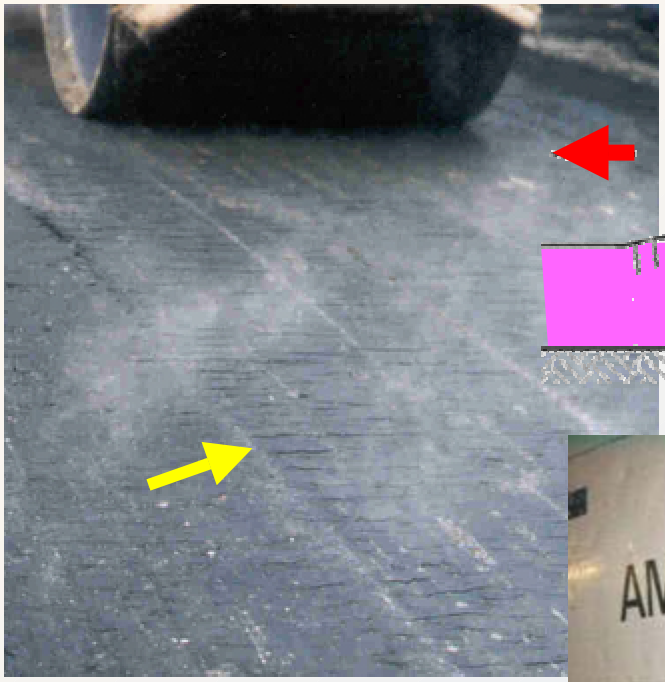


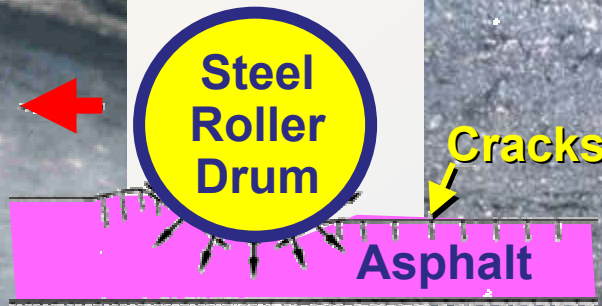


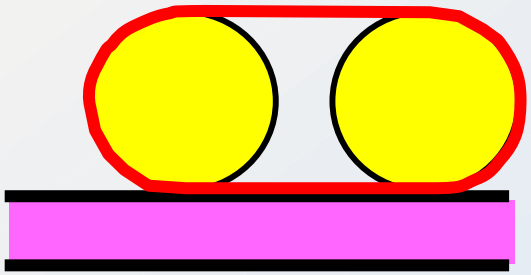
Continuous Compaction Control CCC

Surface Cracks due to Compaction

A. O. Abd El Halim, Carleton University, Ottawa, CN

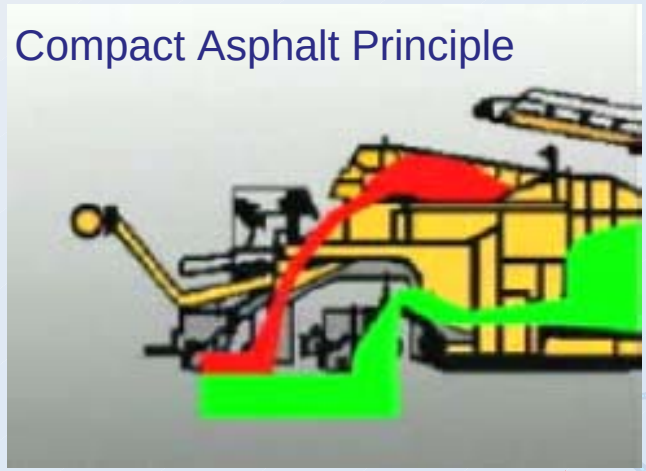






Compaction Main Issues

- Examine & Review **compact. mechanisms**; with steel roller drums higher risk of **crack initiation at surface**; consider alternatives
- Pay more attention to **construction** not only on mix design
- Any special problems when compacting **cold or warm** mixes?
- Use **computer** controlled technologies (e.g. cont. comp. control)
- How to compact **as deep as** possible without crushing the surface and the aggregates?
- Face new compaction challenges, like **compact asphalt** pavements hot/hot Germany



Lab Compaction of Test Specimens

Compaction Devices

M. Jönsson, M.N. Partl

Marshall Hammer

Gyratory Comp.

LCPC Rolling Wheel Comp.

Compaction Methods

M. Jönsson, M.N. Partl

- Changes in homogeneity and isotropy in AB11S asphalt concrete specimens during compaction with Marshall-, Gyratory- and LCPC Rolling-Wheel-Compactor
- Tools: Standard air-void content determination (AV) and X-ray computer tomography (CT).

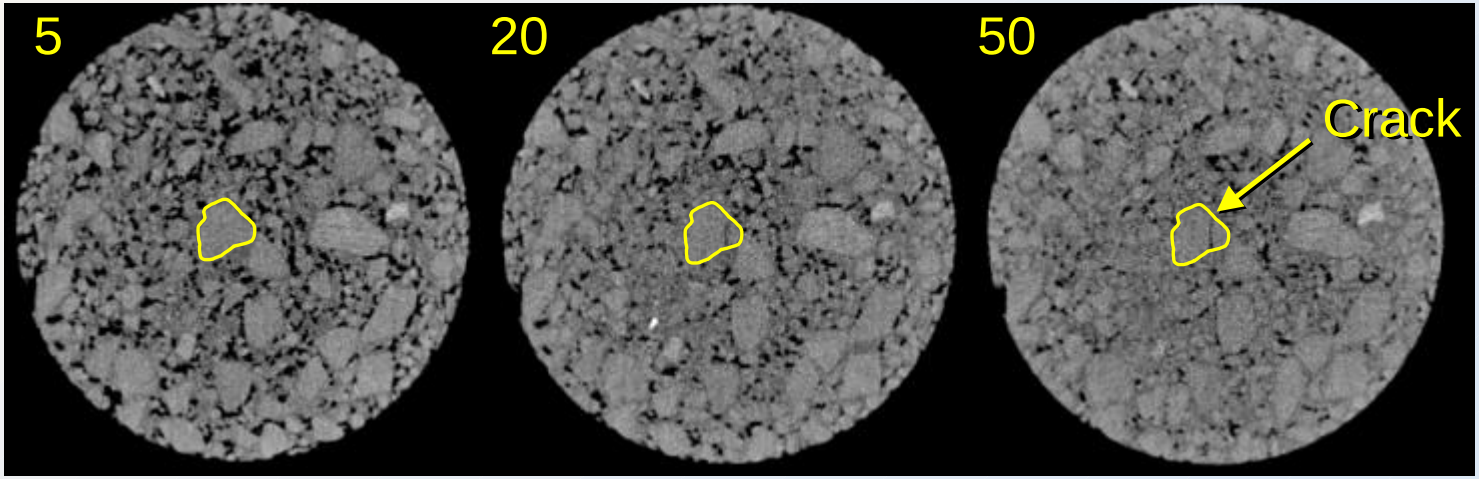
Compaction Method @ 145C	Compaction Level					Compaction Counter	Type of Investigation	
	Initial	Slight	Medium	Strong	Final		AV	CT
Marshall	5	-	20	-	50	Double Blows	X	X
Gyratory #1	0	5	20	50	200	Gyratory Cycles	X	X
Gyratory #2		-	20	-	200	Gyratory Cycles	-	X
Rolling-Wheel	0-0-0	-	8-4-8	-	32-16-32	Wheel Passes	X	X

Gyratory #2: three planes

X-Ray CT: Marshall @58% Height

M. Jönsson, A. Flisch, M.N. Partl

- Amount of pores is reducing during compaction.
- The large outlined aggregate suffered a major crack between 5 and 20 blows.



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Gyratory Compaction: Pin Movement

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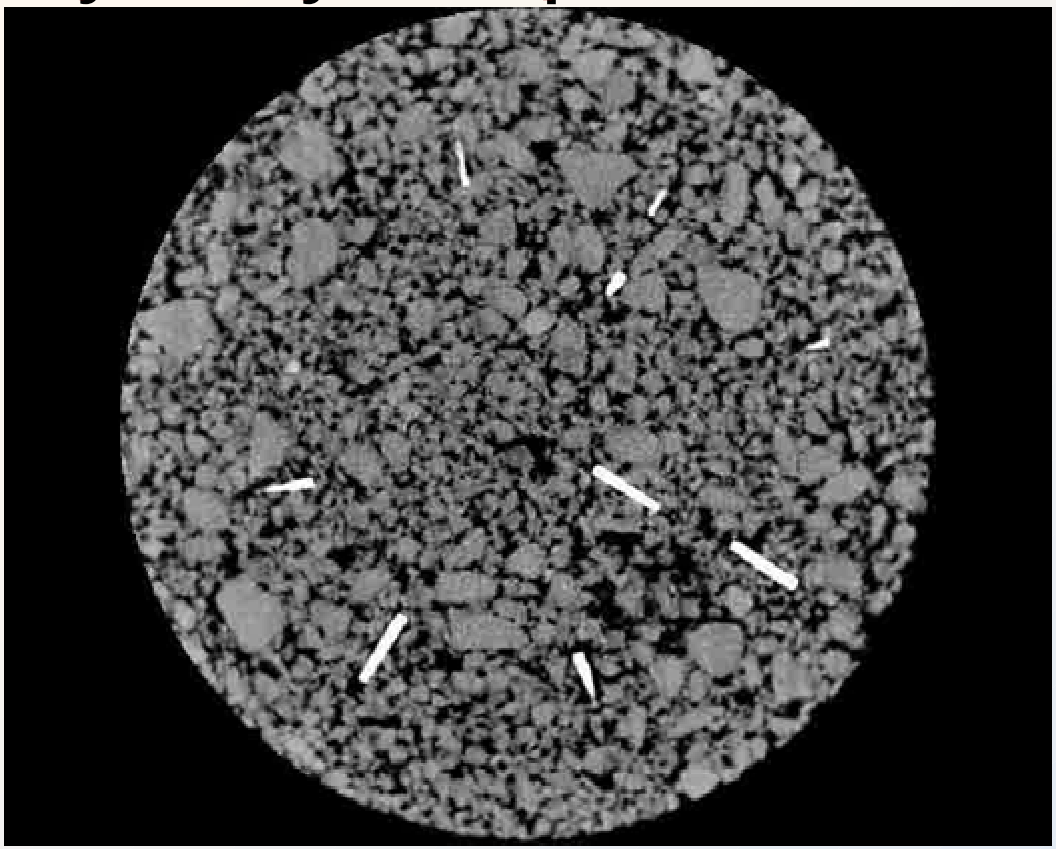
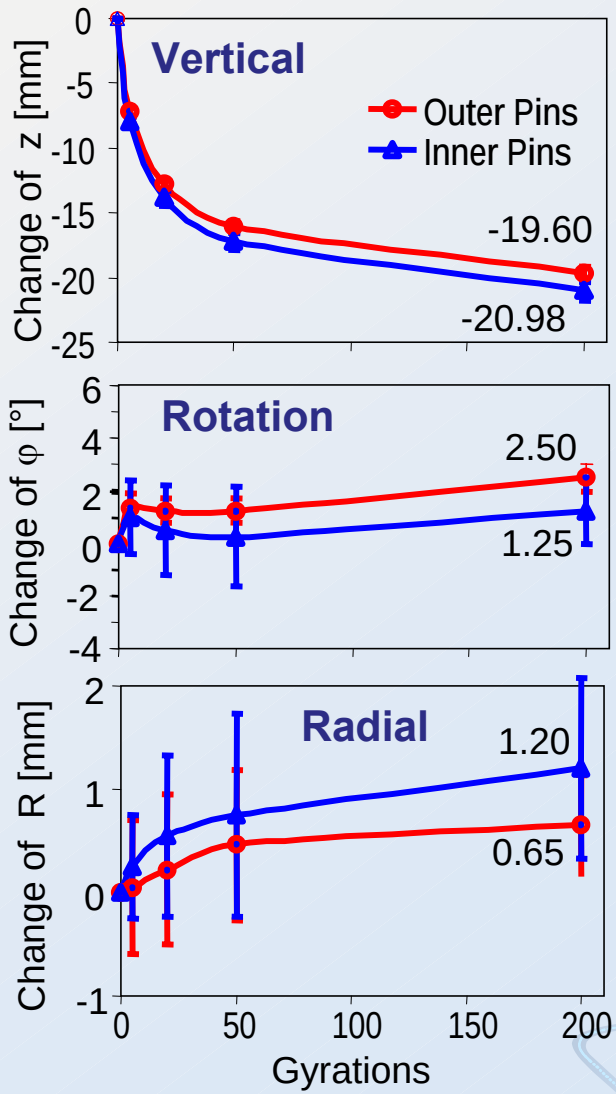
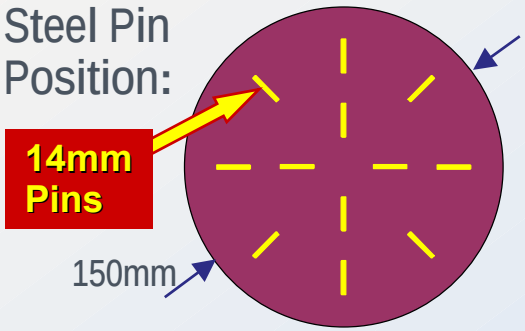
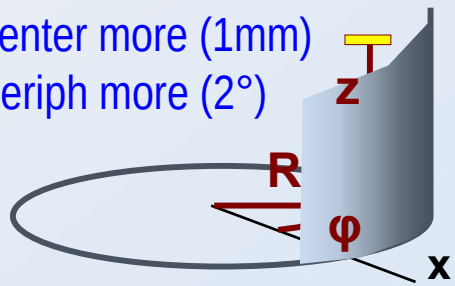




Steel Pin Position:



- z: center moves 1mm more
- R: center more (1mm)
- φ: periph more (2°)



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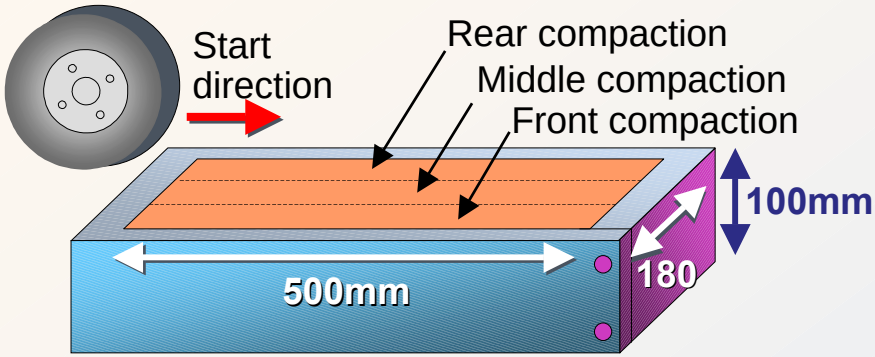
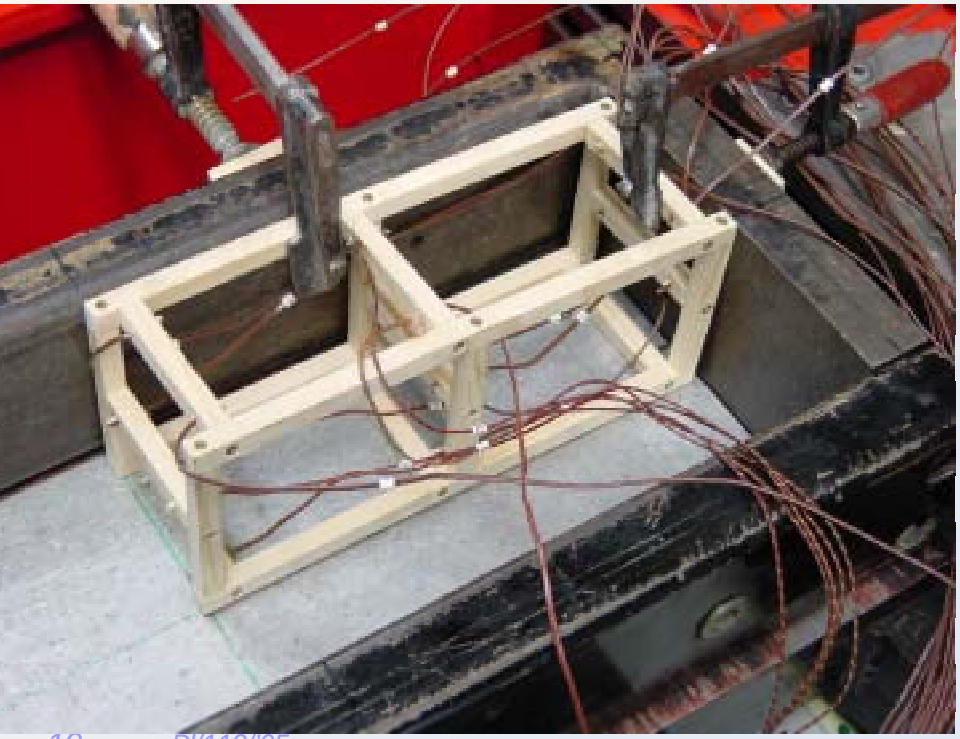
Tire Roller-Compactor

K. Sokolov, P. Kumar



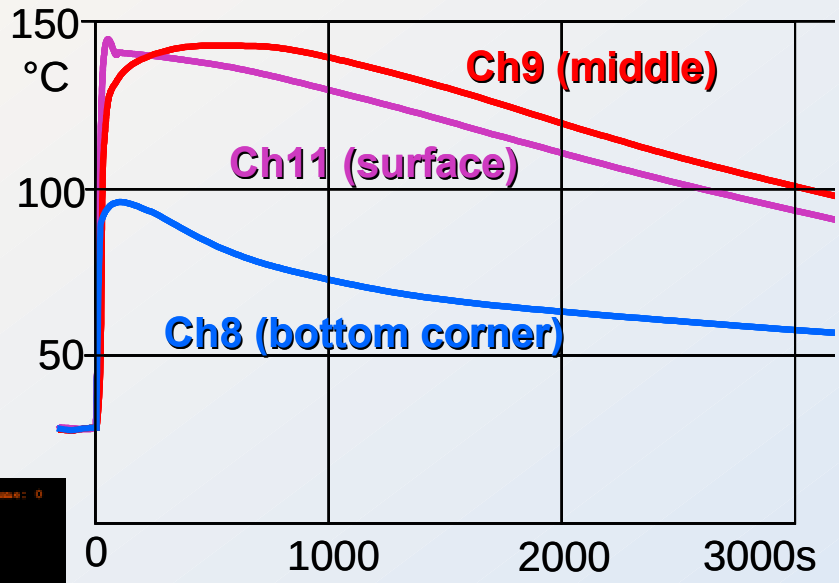


Measuring of Temperature Flow
During Compaction Process

Tire Roller-Compactor

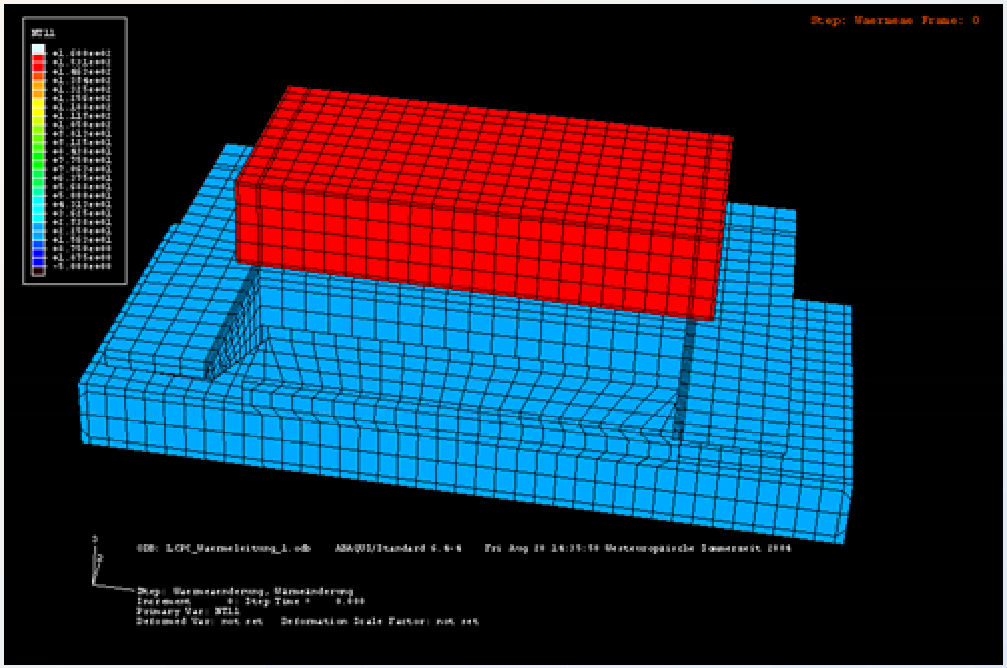
K. Sokolov, P. Kumar

Measurements (cold Mould)→



ABAQUS FE-Model of Heat Dissipation during Compaction

Thermal Conductivity Asphalt κ=0.062 W/m.K
Total time: 1000s

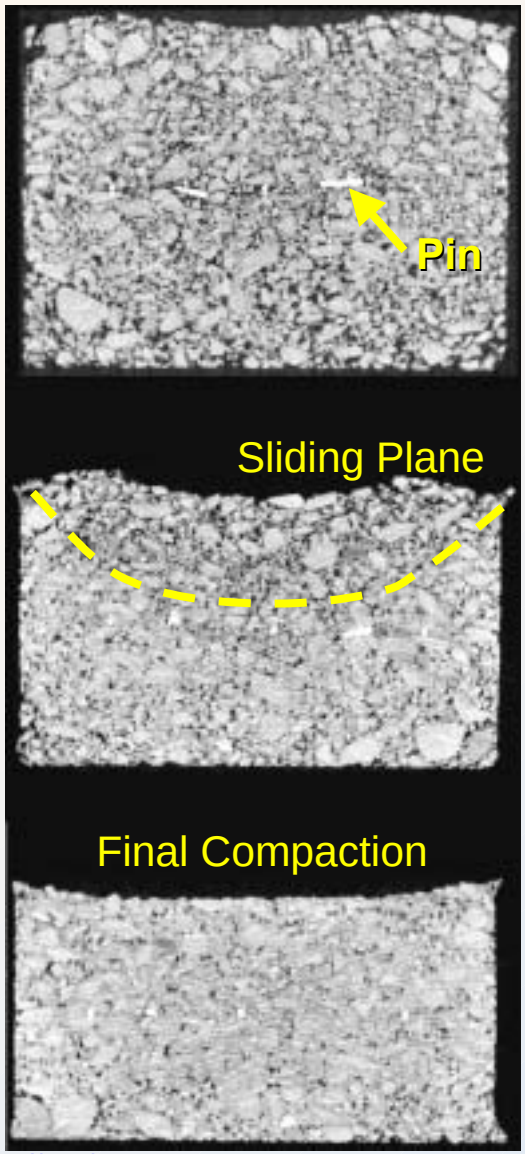


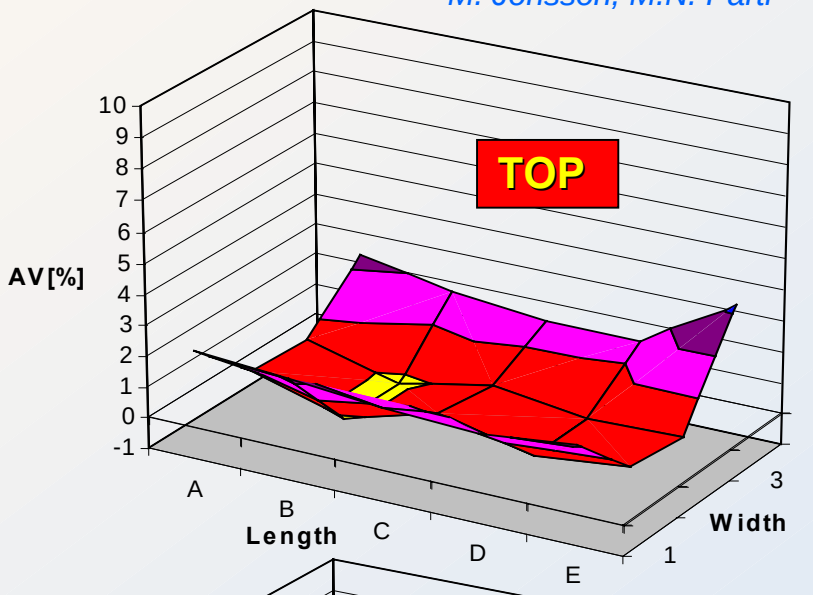
During Compaction:

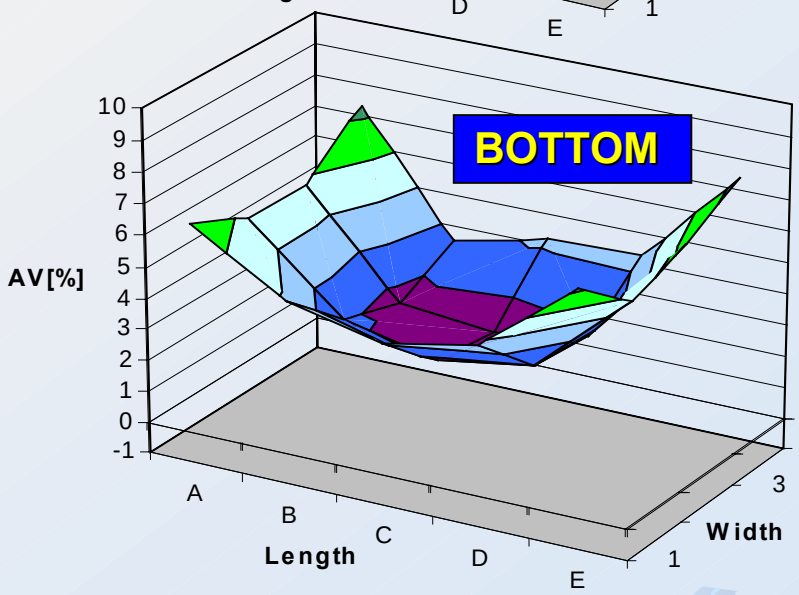
- Specimen cools on surface (from side) **150 →125°C**
- Mould cools down (bottom up) **150→70°C**
- Heat dissipates into base **25 →50°C**

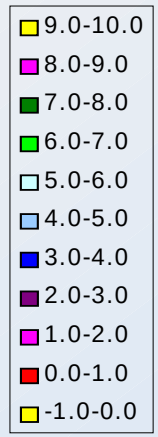
Tire Roller Compactor

M. Jönsson, M.N. Partl



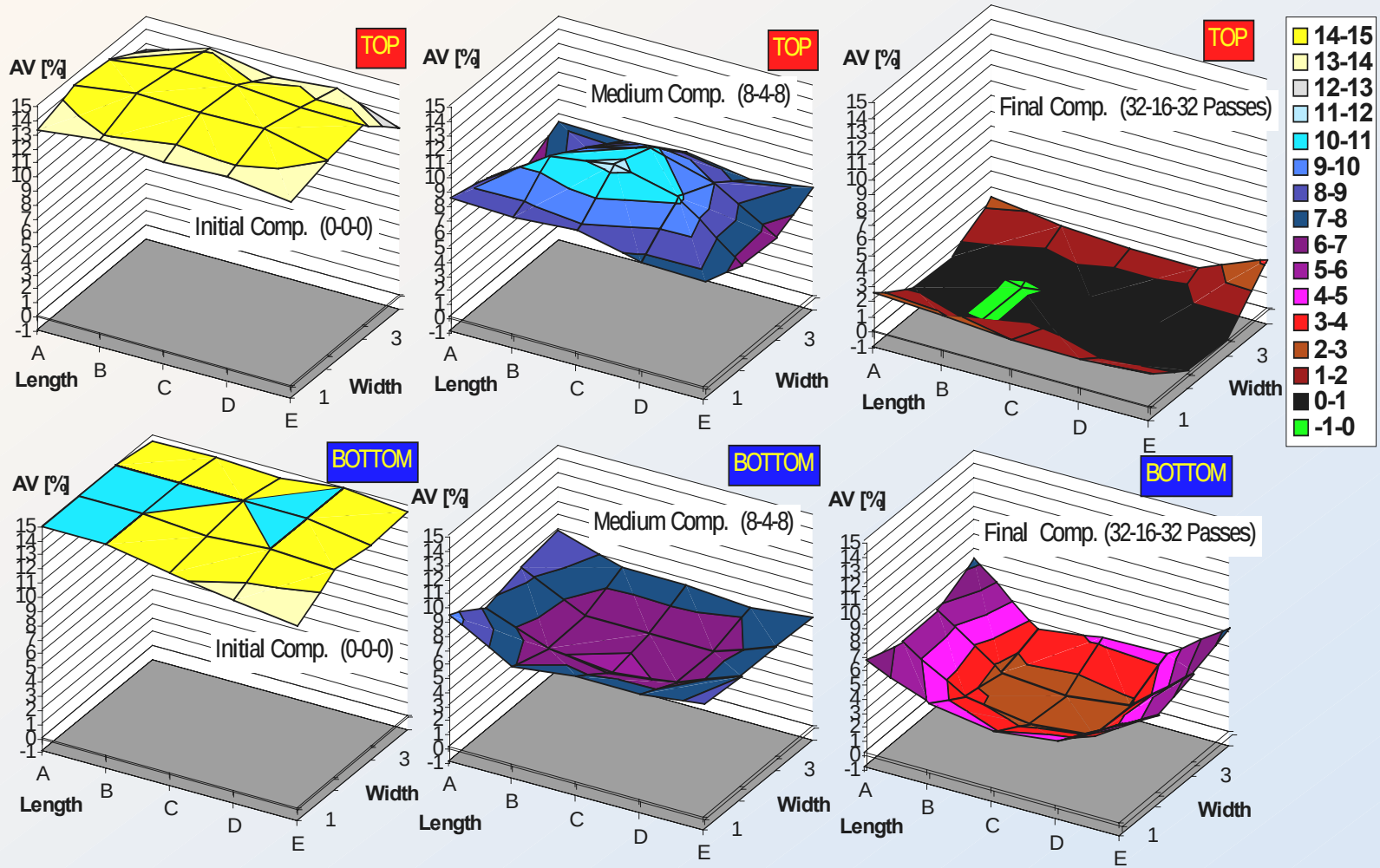






Tire Roller Compactor

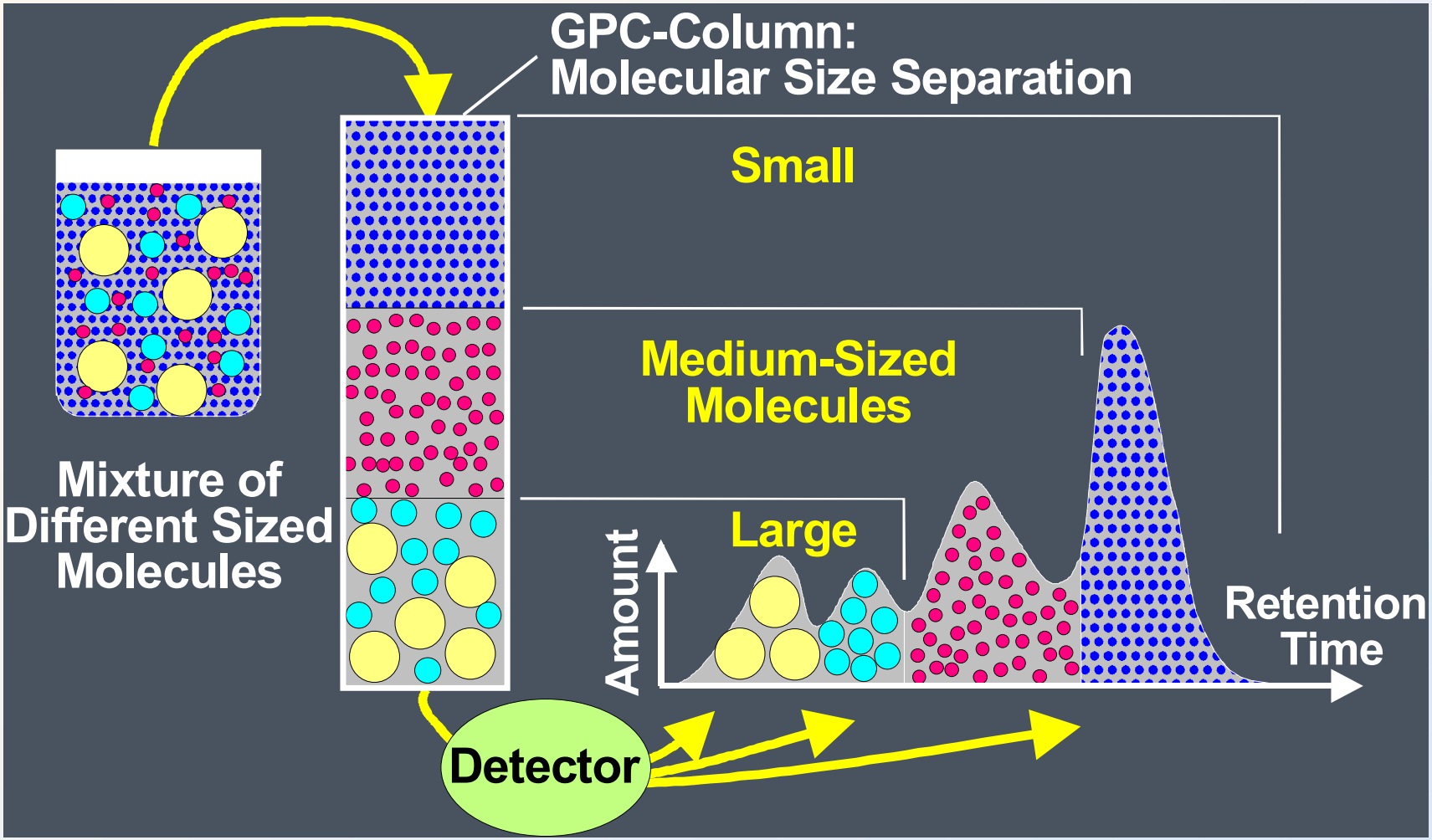
Air Voids



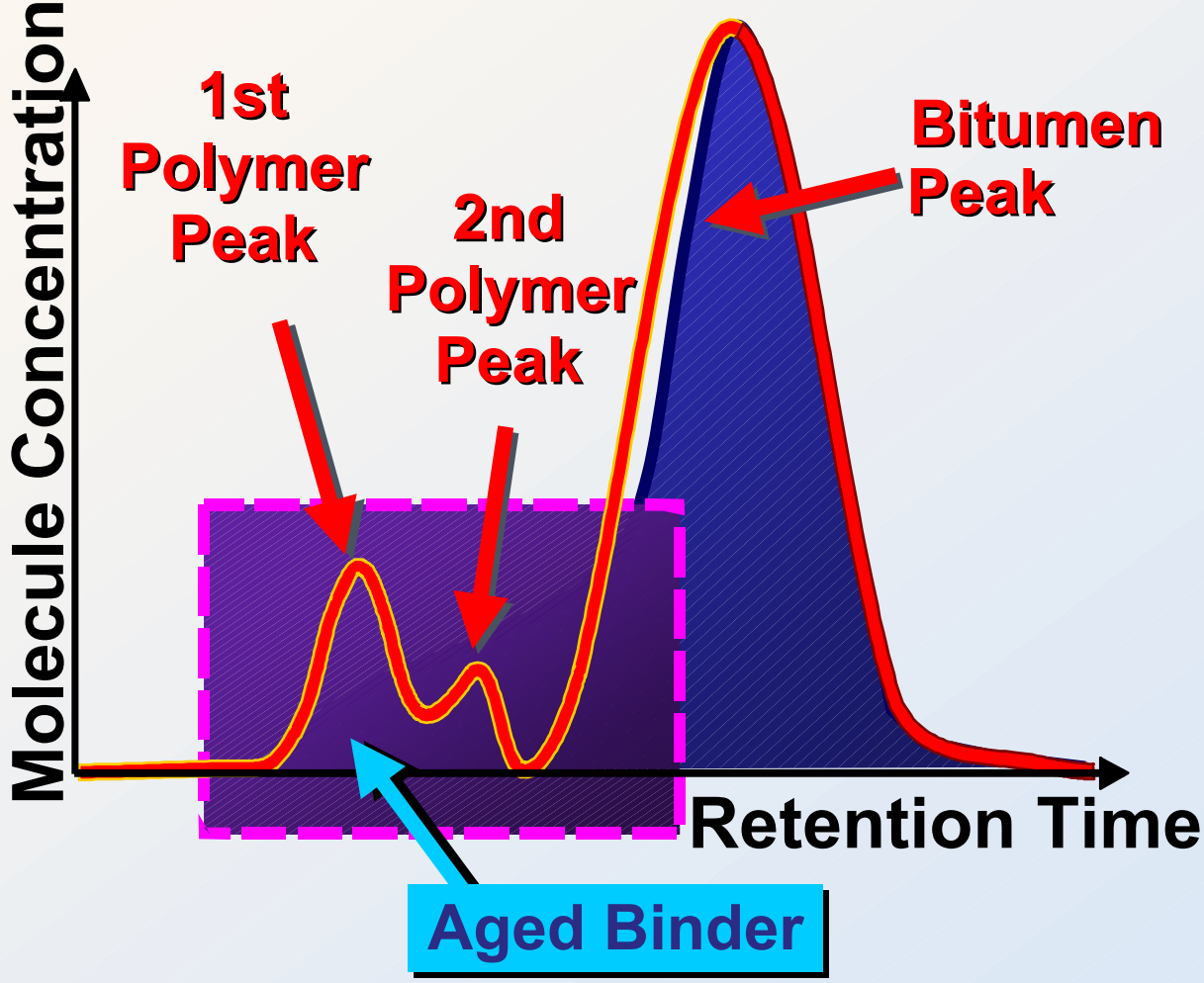
Aging and Durability

Gel Permeation Chromatography

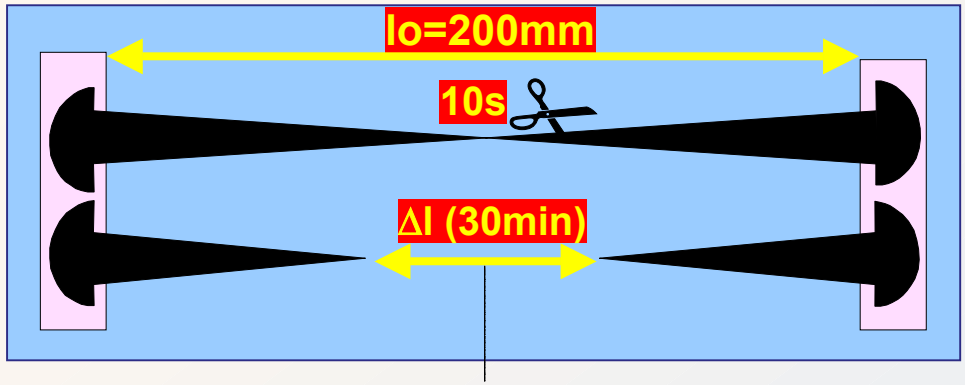
Gelpermeation Chromatography
GPC: Principle



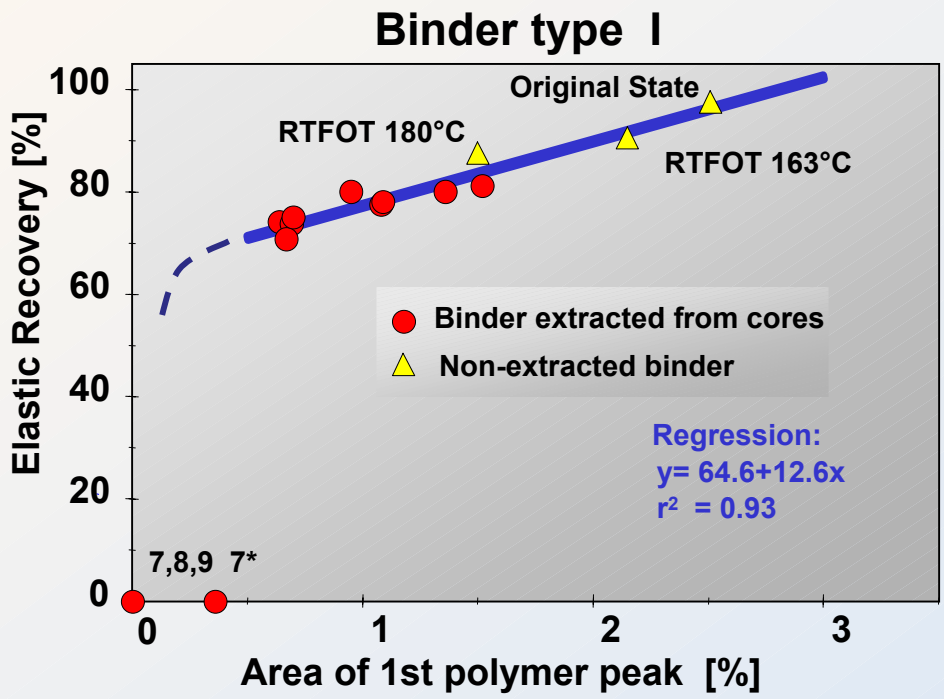
GPC Polymer Modified Binder

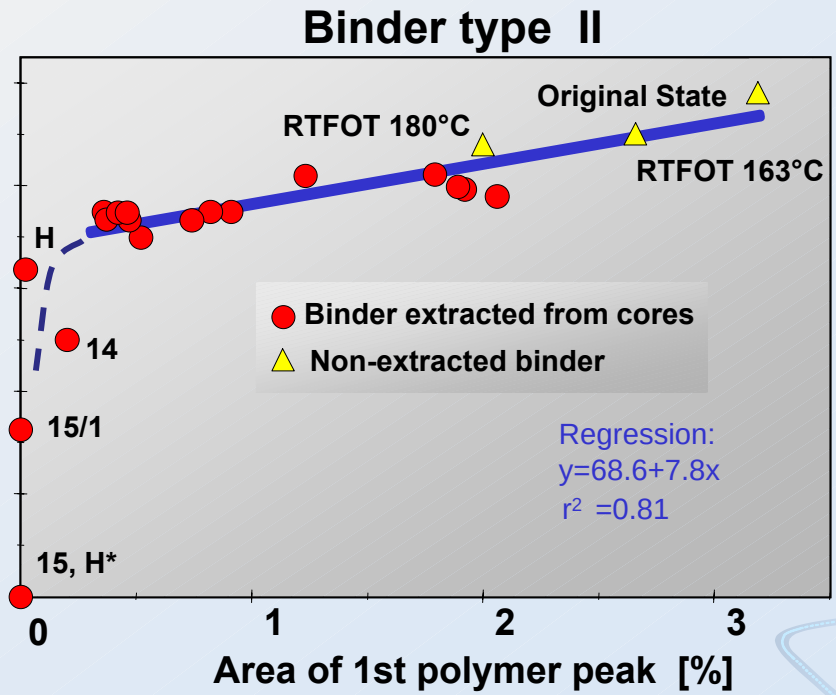


Elastic Recovery SBS fom PA (Results)



M. Hugener





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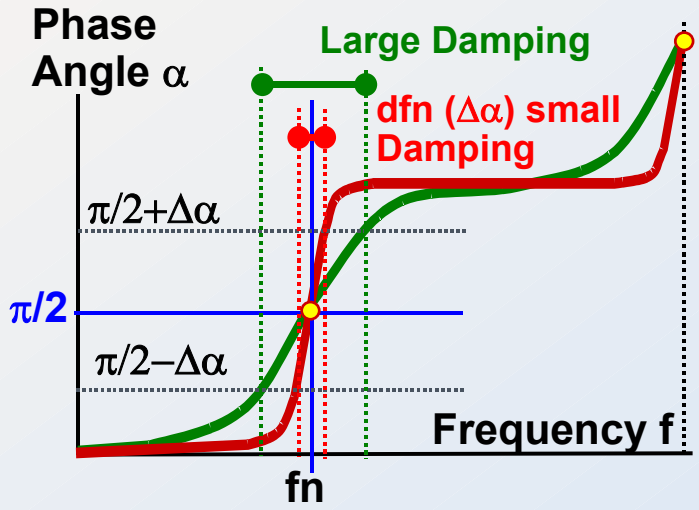
High Frequency Measurements

HFTR (High Freq. Tors. Rheom)

M. Sayir, A. Hochuli, K. Häusler, L.D. Poulikakos, M.N. Partl

Damping inversely prop. to α(f)-slope at resonance. It follows from frequ. difference dfn(Δα) at $\alpha = \pi/2 \pm \Delta\alpha$.



Measurement of:

- ★ Elastic Response related to resonance frequ. f_{air}, f_{bit} at $\varphi = 90°$. Resonance Frequ. $\Delta f = f_{air} - f_{bit}$
- ★ Damping prop. to frequ. difference df for $\varphi = \pi/2 \pm \alpha$. Here: Damping $df_{22.5} = df_{22.5,air} - df_{22.5,bit}$

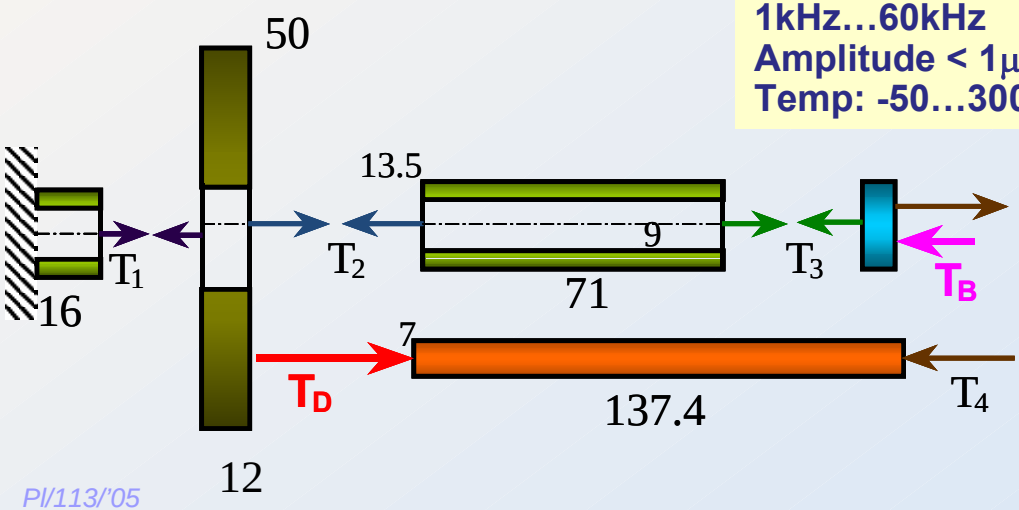
From simple Viscoelastic Spring Modeling:

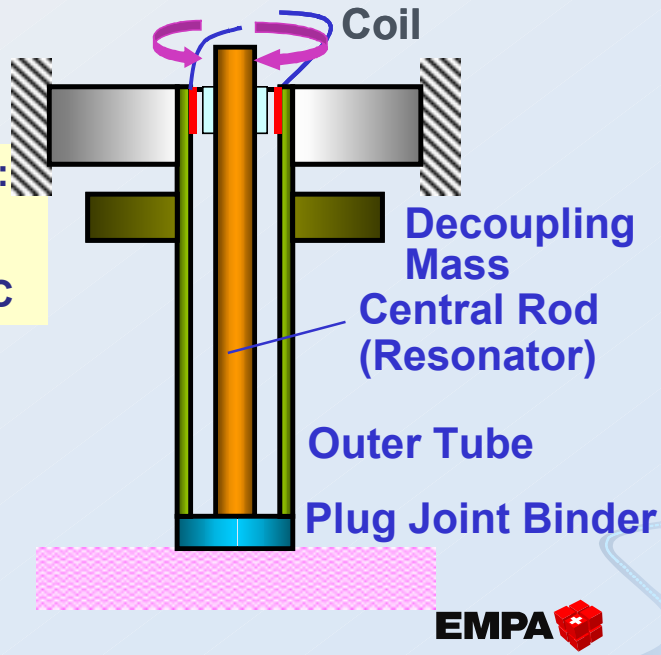
- ★ Storage & Loss Moduli due to interaction with medium.

$$T_B = C^*\theta_B = (C' + i\,C'')\,\theta_B$$

with $cd = C' / C_0$, $ld = C'' / C_0$

Frequency range:
1kHz…60kHz
Amplitude < 1μm
Temp: -50…300°C





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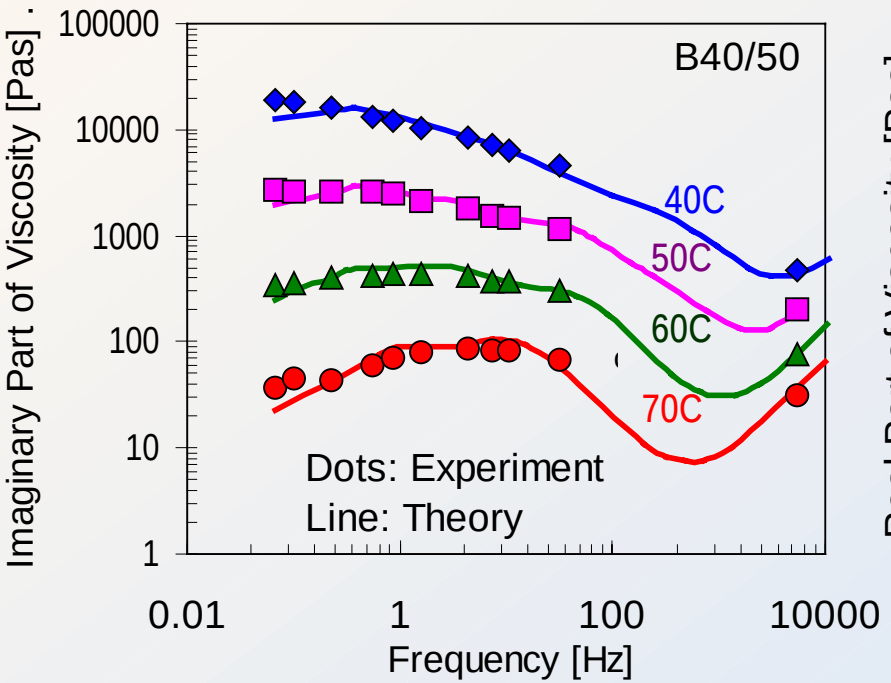
HTFR – DSR Comparison

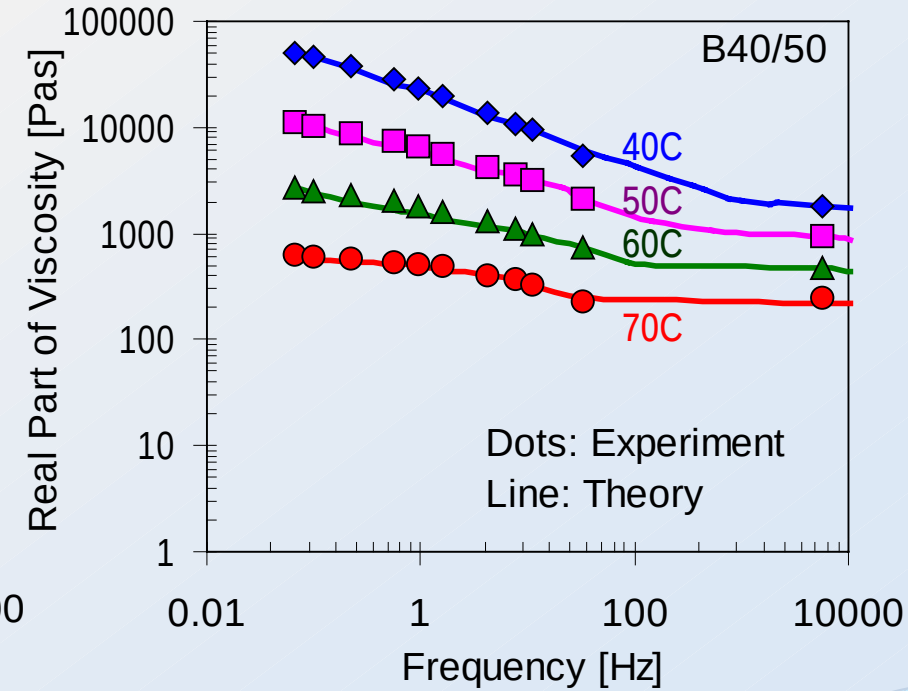
$$\eta^* = \eta_0 \cdot e^{i\omega t} = \eta' + i\eta'' = \frac{\tau^*}{\gamma^*} = \frac{G''}{\omega} - i\frac{G'}{\omega}$$

for Maxwell Model $G(t) = G_o \cdot e^{-t/T}$

(G_0 elastic spring, T relaxation time)

hence $\eta' = \frac{TG_o}{1+\omega^2T^2}$ $\eta'' = \frac{\omega T^2 G_o}{1+\omega^2T^2}$

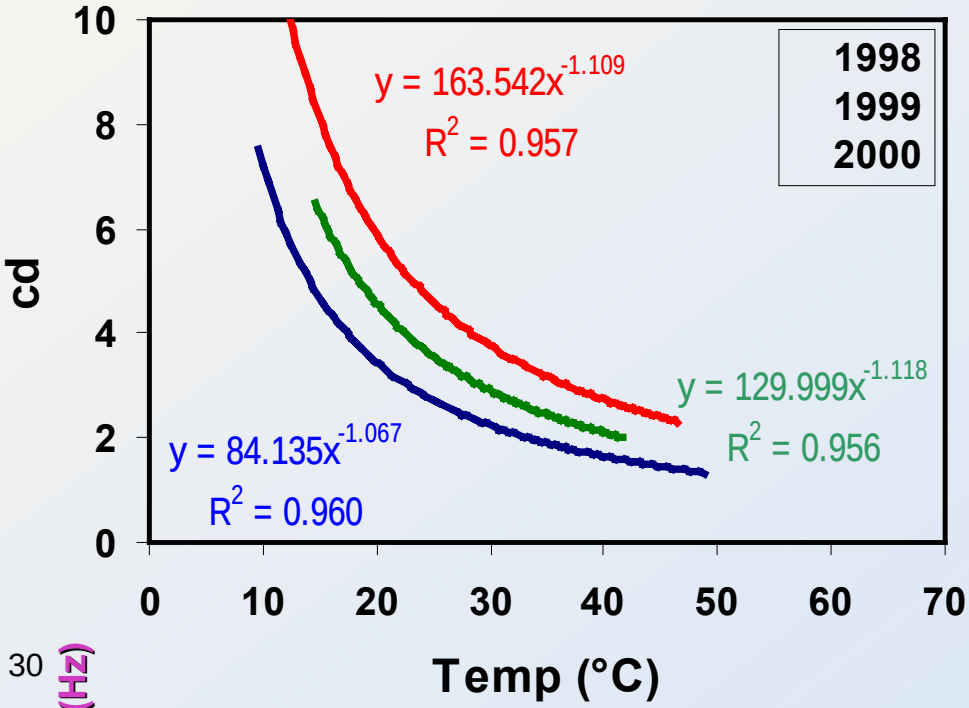


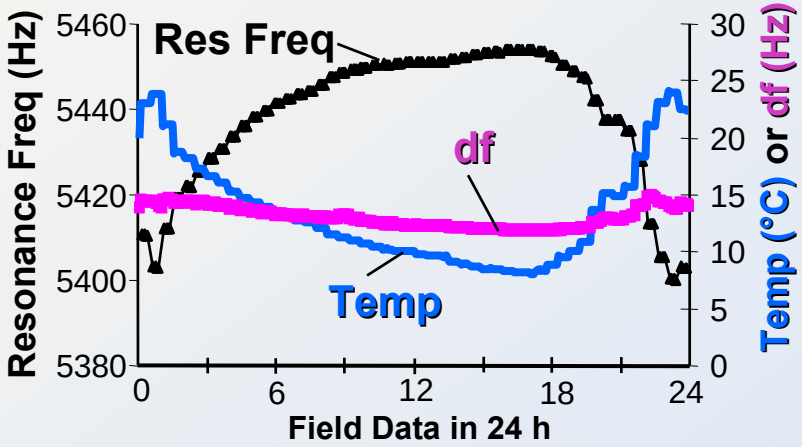


Example: HFTR for APJ Monitoring

(Aug. 1998 …Sept. 2000)

M. Sayir, A. Hochuli, L.D. Poulikakos, M.N. Partl





$T_B = C^*\theta_B = (C' + i\,C'')\,\theta_B$

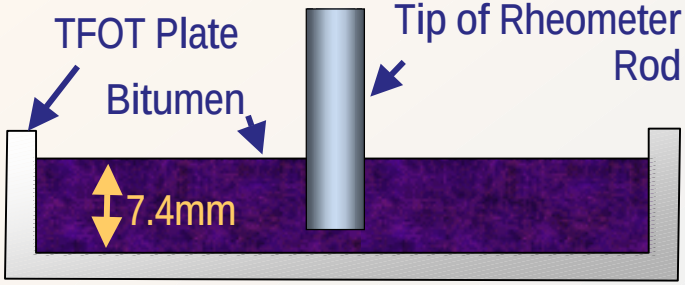
$cd = C' / C_0$

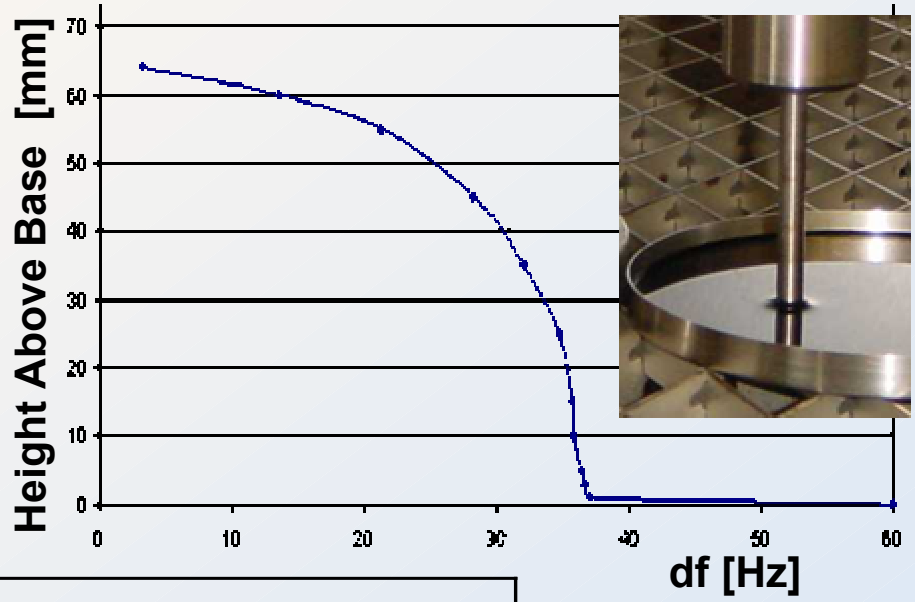
$Id = C'' / C_0$

HFTR Lab Measurements

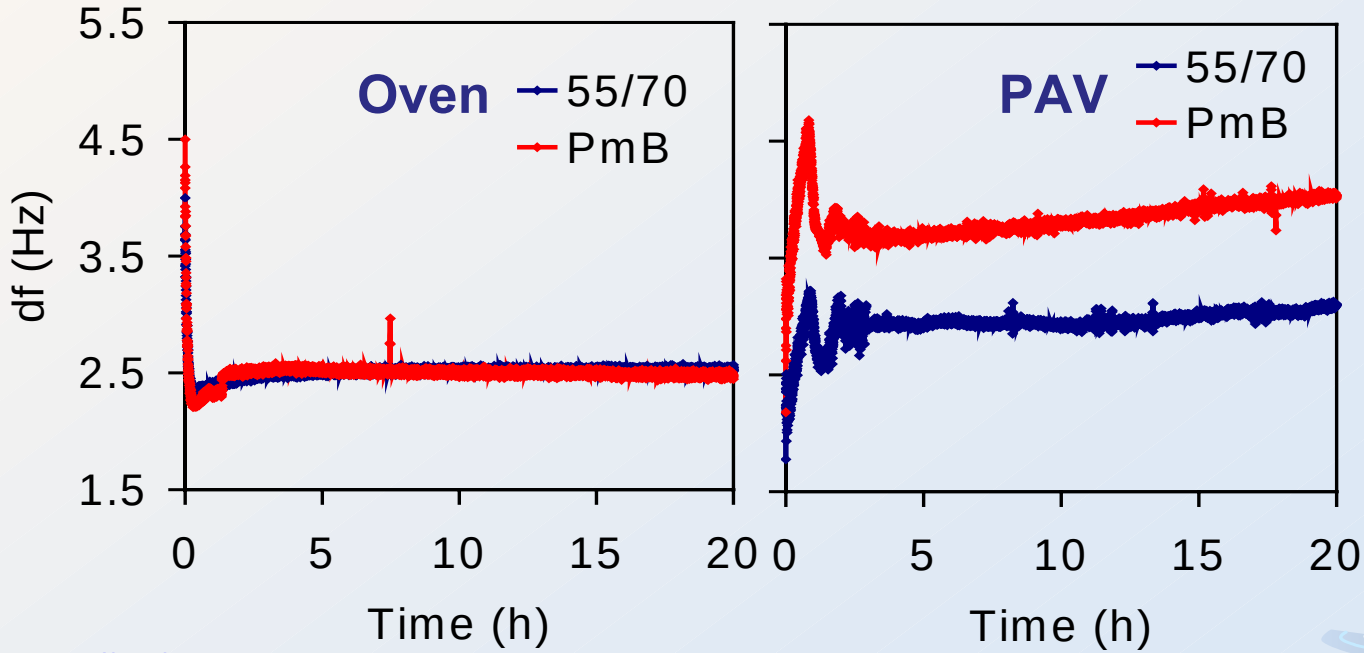
C. Toovey, E. Connery, L.D. Poulikakos

- **Dipping Test**





- **Oven/PAV 110°C Aging**



Water Susceptibility evaluation of Mixes

Contact

Remy Gubler

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General Remarks (1)

- Testing/modeling of moisture effects is still in an early empirical stage.
- New promising research deals with
  - Permeability **k**, based on Kozeny-Carman equation *(e.g. Al-Omari al, AAPT 2002)*

$$k = f(n) \cdot C \cdot D_s^2 = \frac{n^2}{(1-n)^2} \frac{\gamma}{\eta} C D_s^2$$

n: effective %air voids; **γ:** unit weight water; **η:** viscosity, **C:** shape factor of particles (for spheres C=1/180); **D_s** average particle diameter

  - Surface free energy Γ of the binder-aggregate system to predict moisture damage potential *(Cheng et al, AAPT2002)*

$$\Gamma = \Gamma^{LW} + \Gamma^{AB}$$

Γ **:** surface free energy of binder or aggregate; **Γ^{LW}:** apolar Lifshitz–van der Waals component of surface free energy; **Γ^{AB}:** acid-base component of surface free energy.

General Remark (2)

- One main problem is the characterization of the moisture of a specimen. Traditionally this can be done in three ways:
  - Saturation **S**: volume of water in the pores (by volume)

$$S = \frac{V_{water}}{V_{pores}}$$

  - Effective Saturation $\mathbf{S_{eff}}$: Volume of water in a specimen (by volume)

$$S_{eff} = \frac{V_{water}}{V_{specimen}}$$

  - Moisture content **MC**: the amount of water in a specimen (by weight)

$$MC = \frac{m_{water}}{m_{specimen}}$$

  - Often materials are simply characterized/compared as dry and wet, (e.g. strength ITSR, or modulus CAST)
  - The following concentrates on dry-wet testing aspects of mixtures

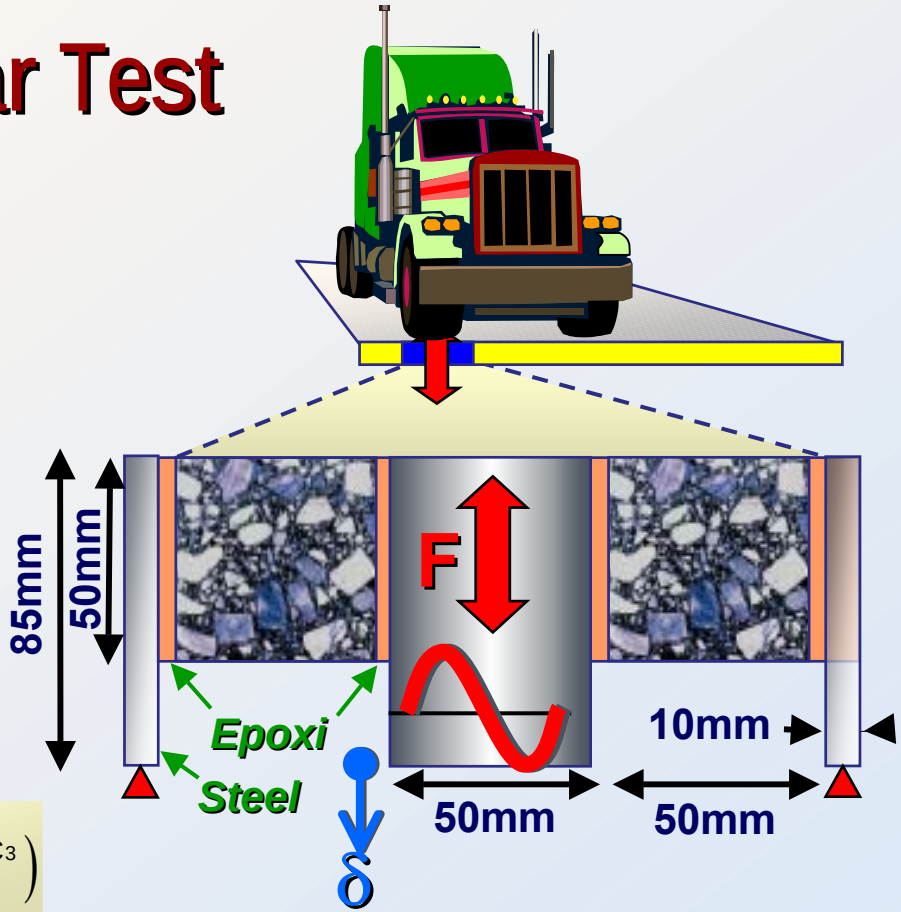
CAST
Coaxial Shear Test (dry)

CAST: Co-Axial Shear Test

J. Junker, R. Gubler, K. Younger, K. Sokolov, M.N. Partl

Concept

- Triaxial, e.g. laterally confined
- Laboratory & field cores
- Multilayer testing possible
- Loading in traffic direction
- Testing of in situ surface
- Conventional test equipment
- Displacement (δ) & temp. controlled



Basic Equation:

$$G^* = G^*_r = \frac{F_a}{\delta_a} \cdot C_{FE}(G^*_s) = \frac{F_a}{\delta_a}\left(C_1 + C_2 \cdot G^{*C_3}_s\right)$$

G^*	: Complex modulus (recursive by iteration)
G^*_r, G^*_s	: Resulting and starting value during interation
F_a	: Force amplitude in central cylinder
δ_a	: Displacement amplitude of central cylinder
C_{FE}	: Coefficient function derived from FEA
C_1, C_2, C_3	: Constants depending on geometry only

Technical Data

T= -20..70°C; f=0.01..16Hz

δ=± 5mm; F=±10kN

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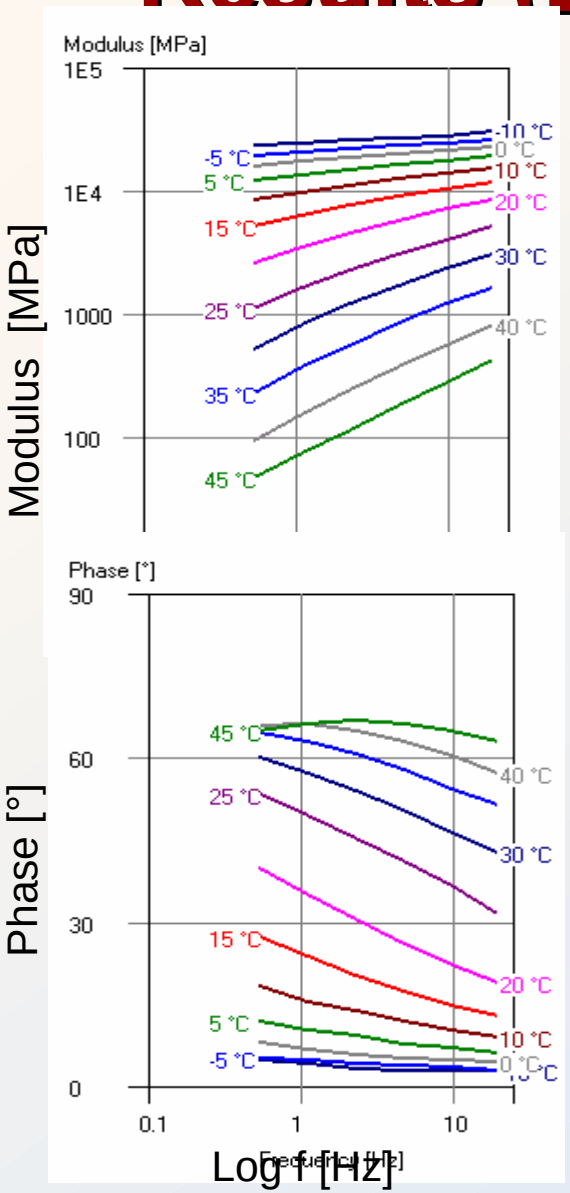
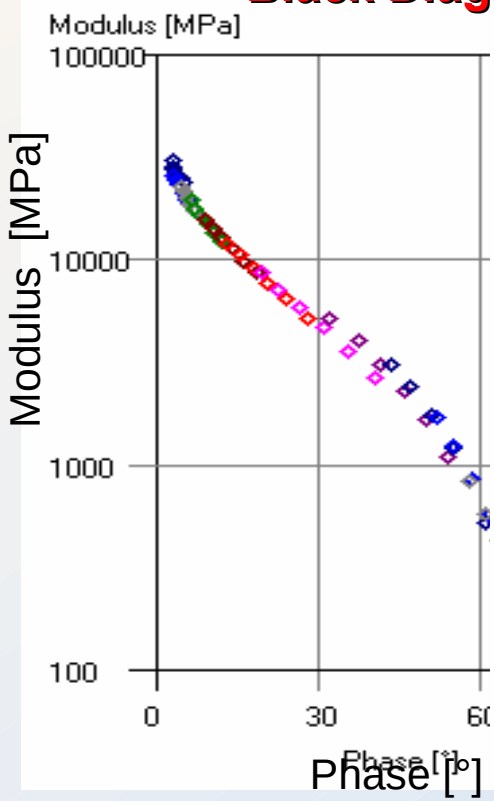
Results (Examples)

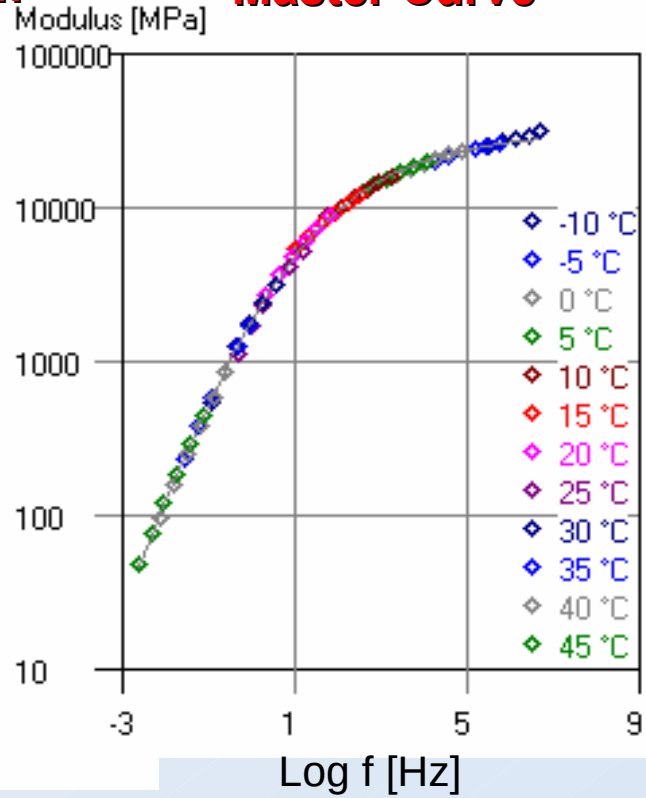
R. Gubler



Black Diagram



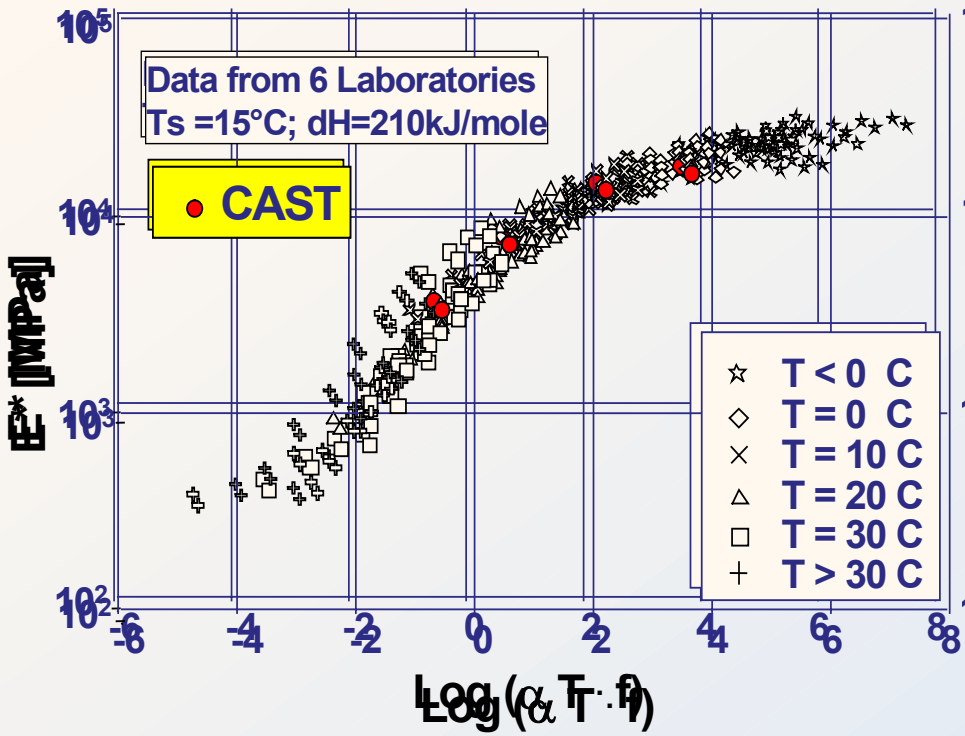
Master Curve

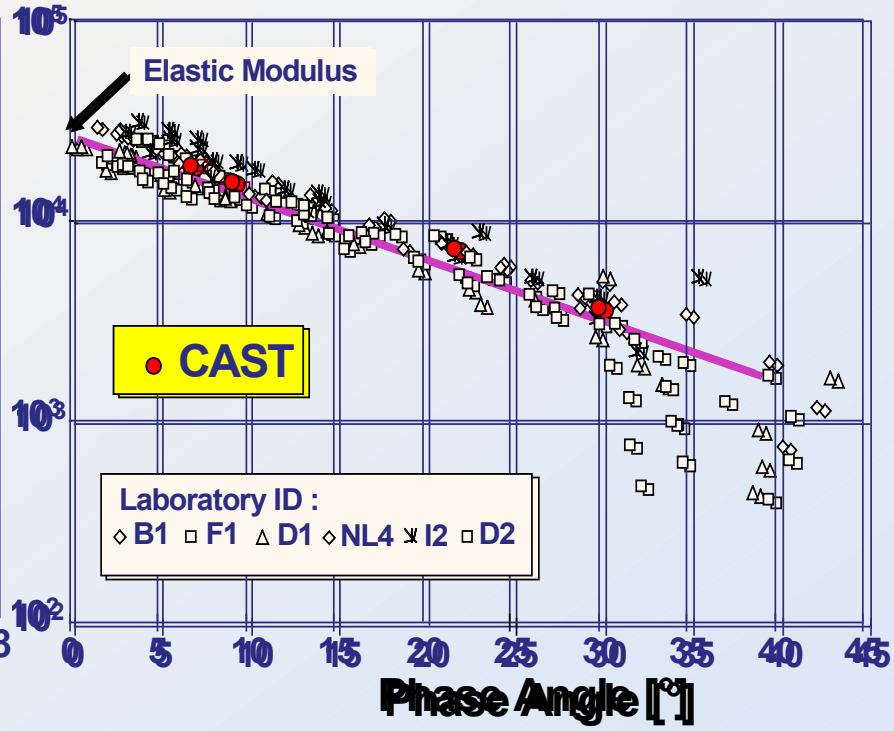


CAST Modulus (RILEM Inter-Lab. Test)

Comparison with Data from RILEM Report Nr 17 (1998)

R. Gubler, K. Younger, M.N. Partl



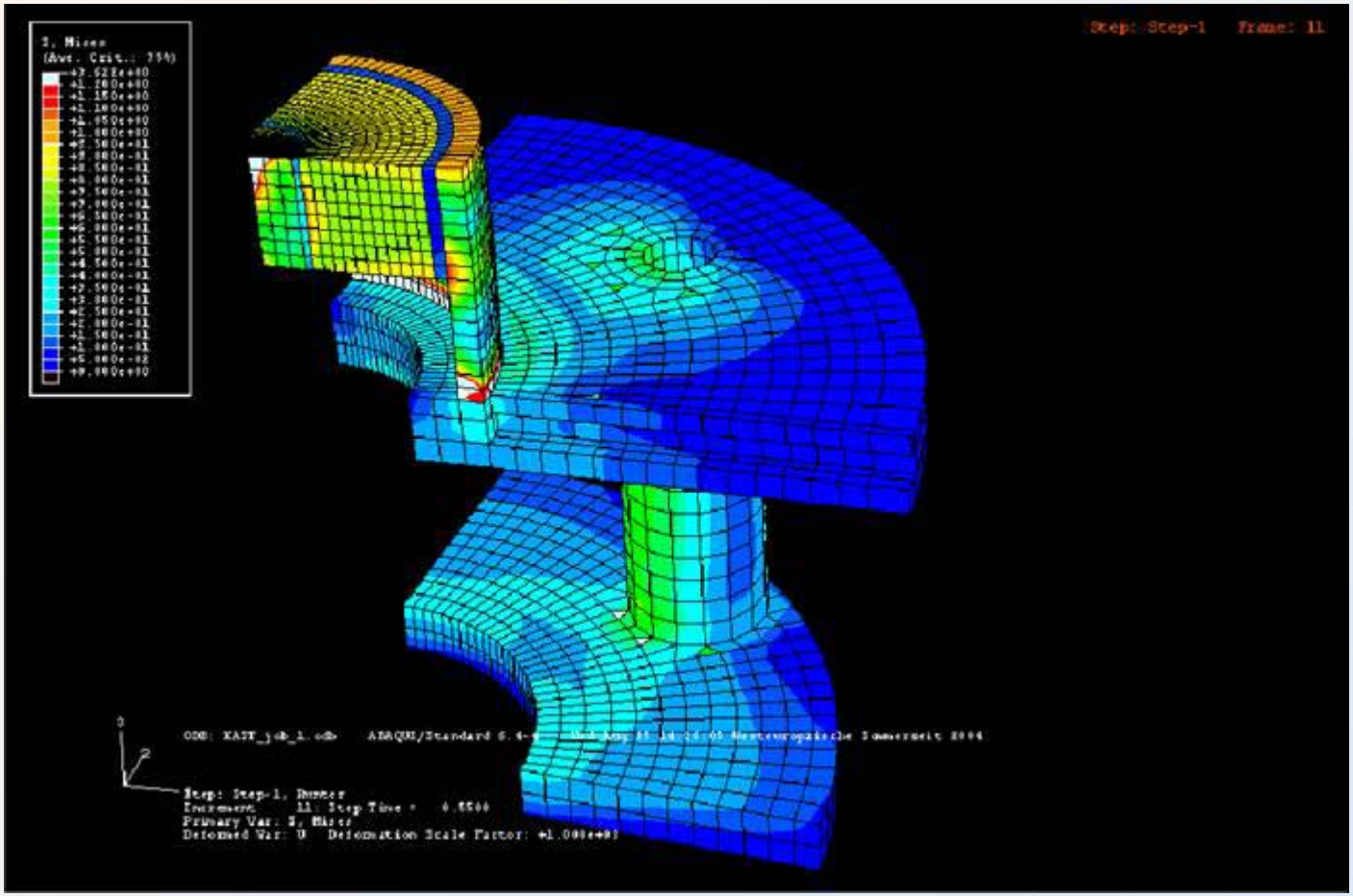


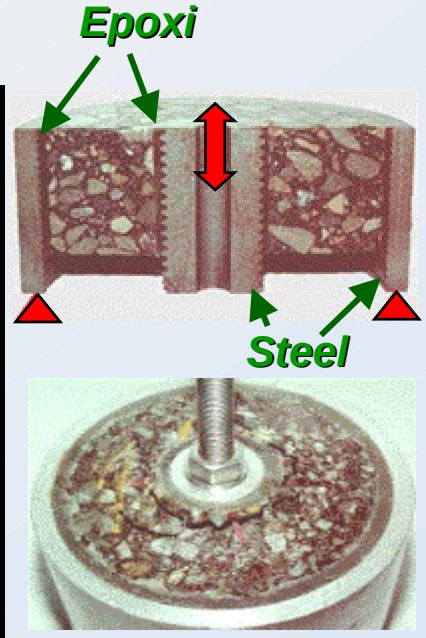
Parameter	[°C; Hz]	0; 1	0; 10	20; 1	20; 10
RILEM avg. (AC)	[MPa]	12751	17019	2921	6139
CAST (E*=3G*)	[MPa]	13602	17105	3893	7701
Δ	[%]	-6.3	-0.5	-25.0	-20.3

CAST von Mises Stress

K. Sokolov

Modeling of CAST including test support and epoxi glue





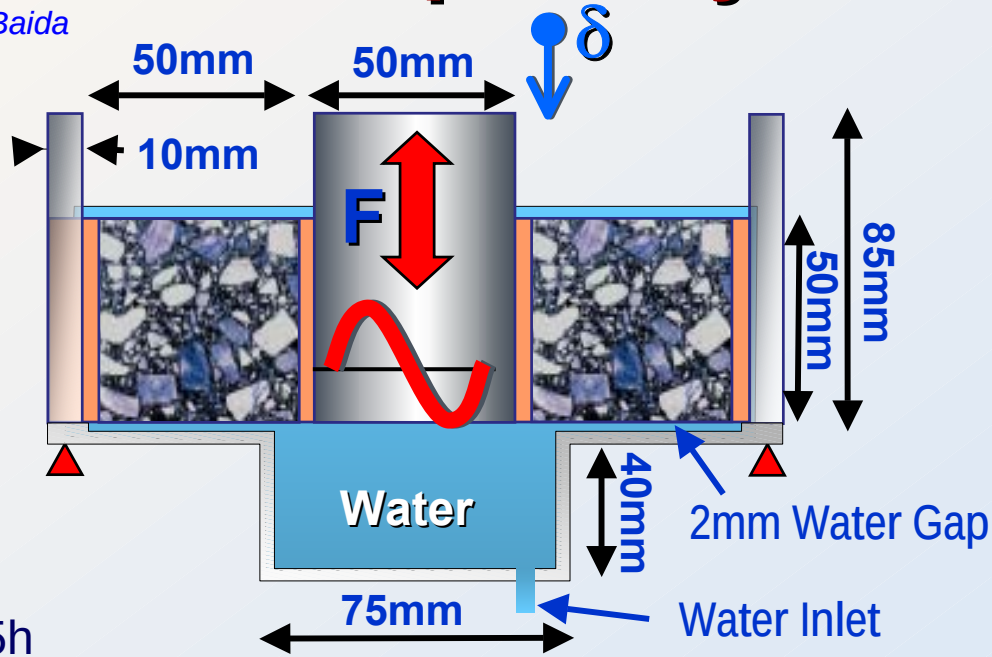
CAST
Coaxial Shear Test (moisture tests)

CAST for Water Susceptibility

R. Gubler, M.N. Partl, L. Baida

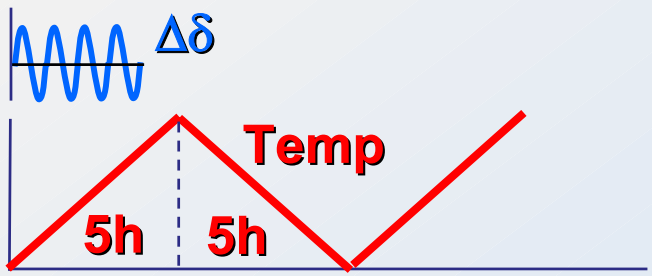
Concept

- Like CAST
- Testing submerged in water
- Cyclic load, displacement & temp. constantly recorded
- Displacem. & temp. controlled



Technical Data

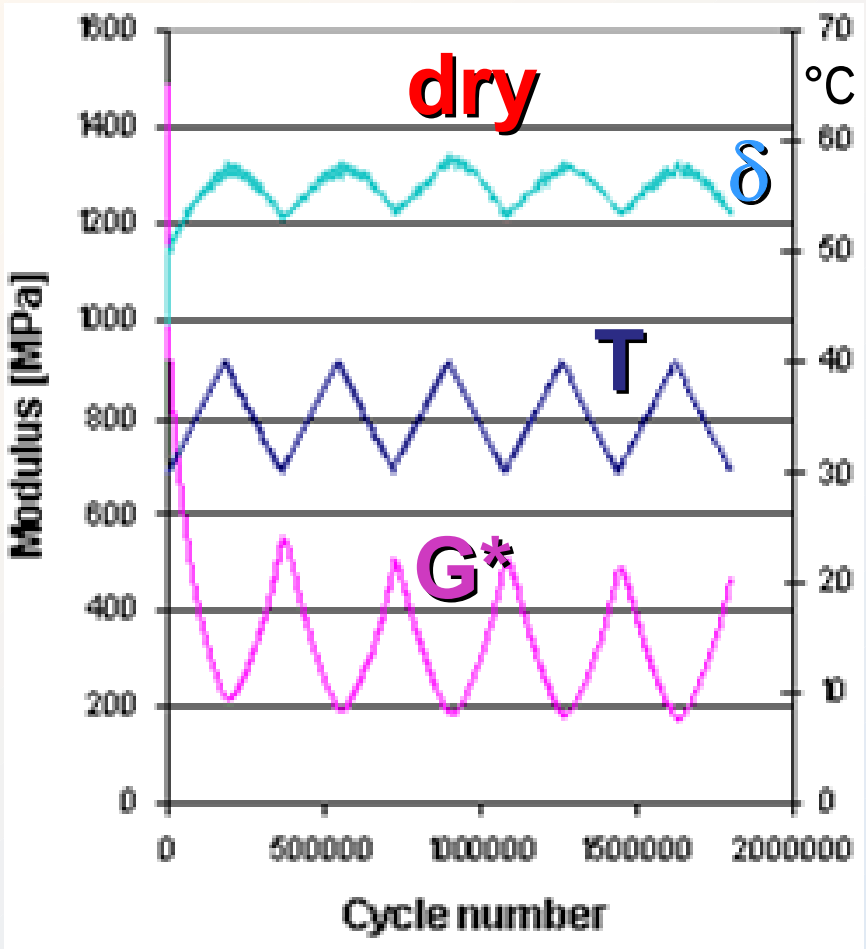
T= 30..40°C (27..32°C) ramps in 5h
(5 up/down cycles)
Amplit. $\Delta\delta$= 0.02mm; f = 10Hz

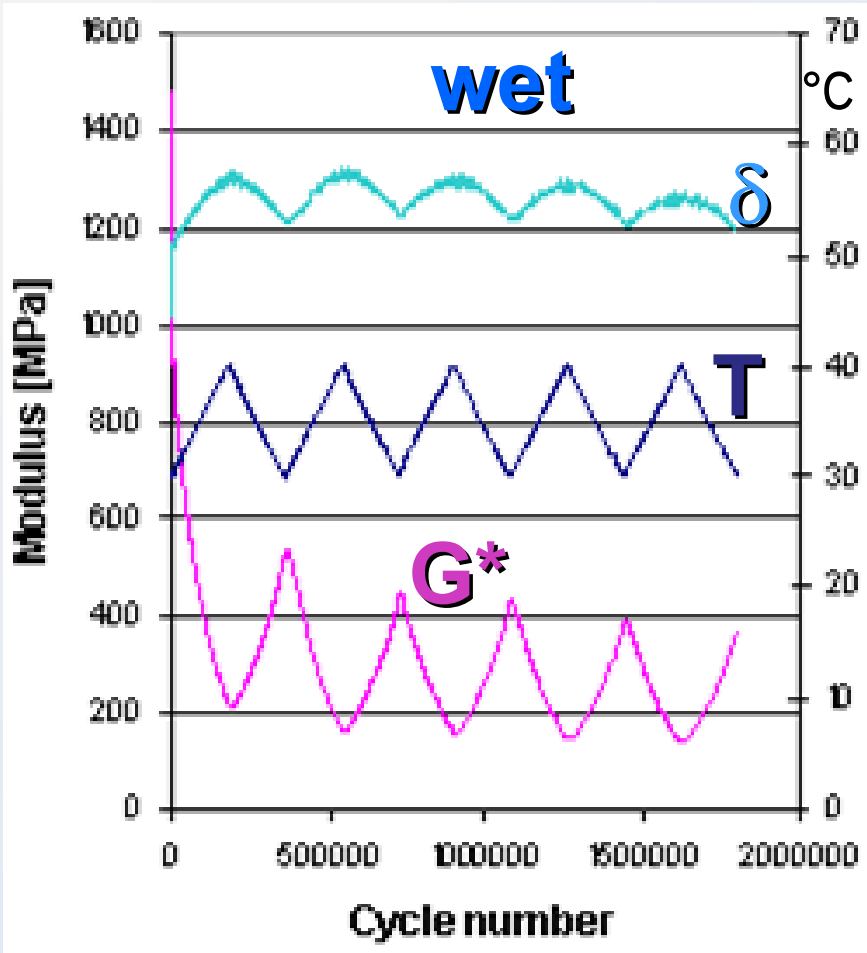


CAST Typical Curve

R. Gubler, L.G. Baida, M.N. Partl

Asphalt Concrete with ca. 12% air voids





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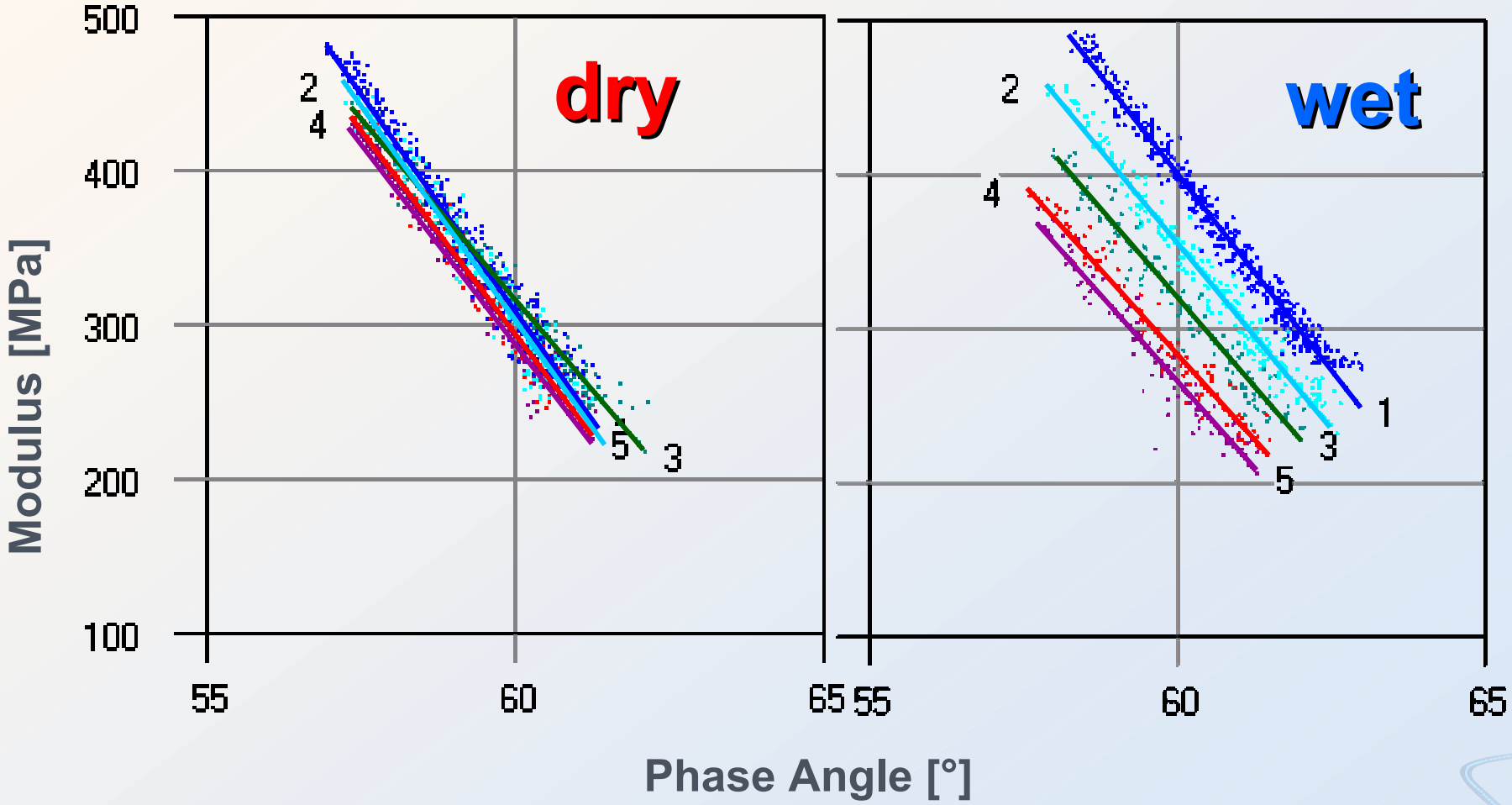
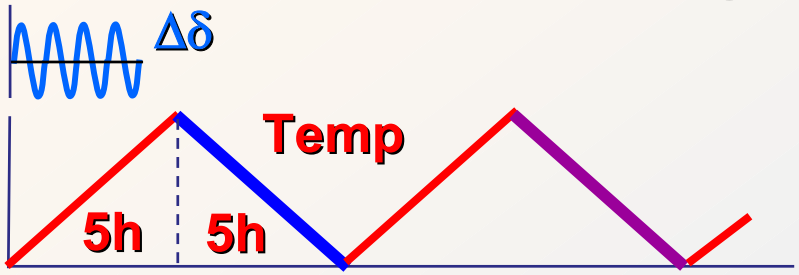
Example: High Water Susceptibility

R. Gubler, L.G. Baida, M.N. Partl

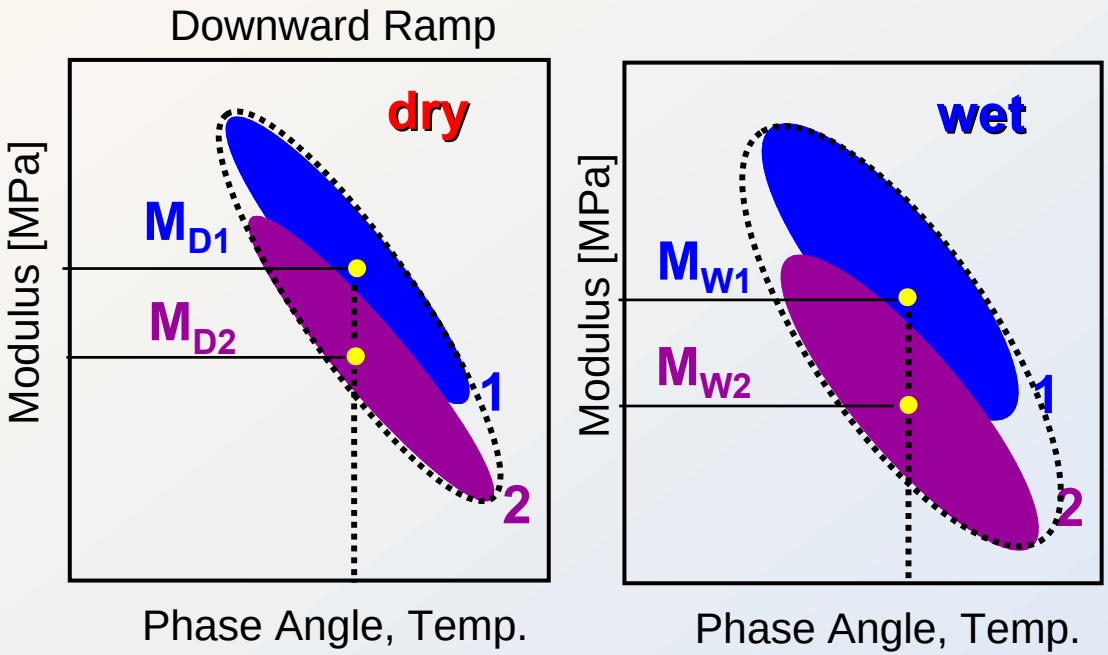
Asphalt Concrete with ca. 12% air voids



Water Damage Index WDI



$$WDI = \frac{M_{D1} - M_{W1} + M_{D2} - M_{W2}}{2}$$



where:

WDI : Water damage index;

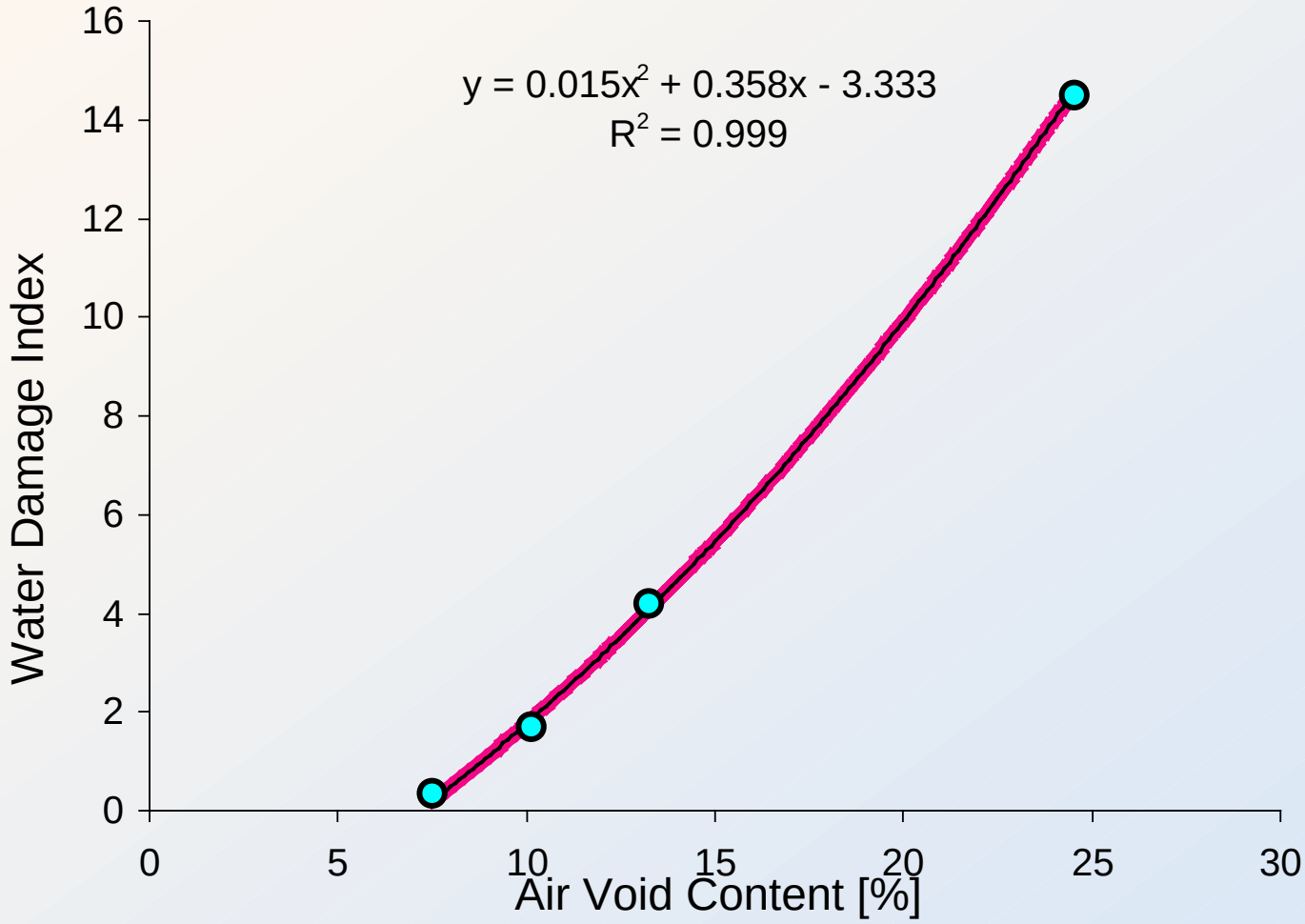
M_{W1}: Modulus @ average phase angle for 1st wet downward ramp;

M_{W2}: Modulus @ average phase angle for 2nd wet downward ramp;

M_{D1}: Modulus @ average phase angle for 1st wet downward ramp;

M_{D2}: Modulus @ average phase angle for 2nd wet downward ramp;

Water Damage Index WDI



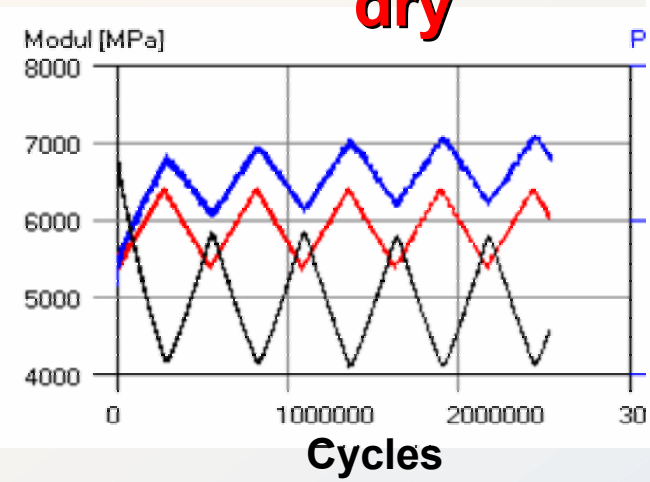
Water Damage in a Road

R. Gubler

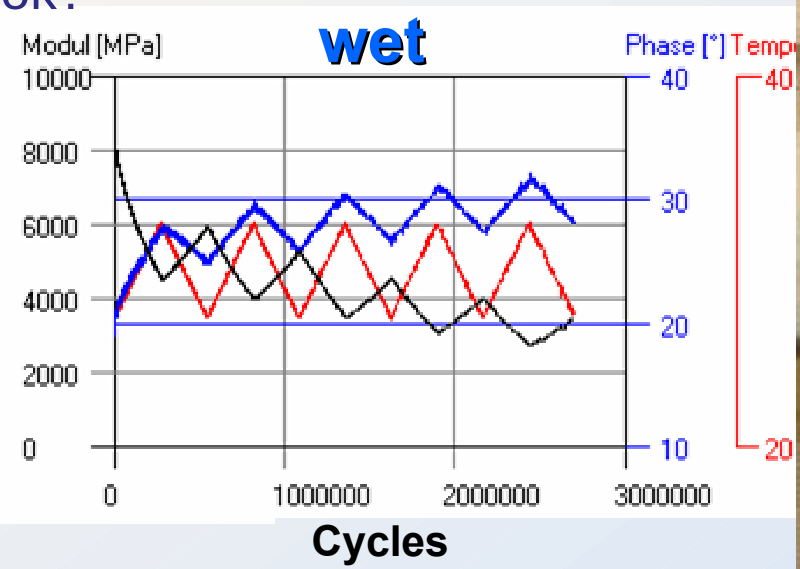
Observations

- Bad adhesion
- Water from below
- Which base course still ok?

dry



wet



Course	Damage	G* [MPa]		DG* per Temp Cycle [%]		
		dry	wet	dry	wet	Difference
Upper Base C.	Water from below	7091	8565	0.4	12.2	11.8
Lower Base C	Interlayer Shear Movement	2350	2056	2.4	3.1	0.7

Inlayer and Interlayer Bond

Contact

Christiane Raab

christiane.raab@empa.ch

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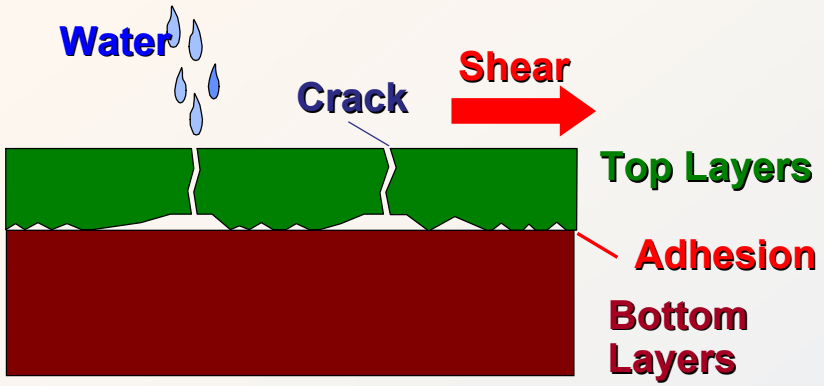
Interlayer Adhesion Problems

C. Raab, M. N. Partl



Coring Water Between Layers

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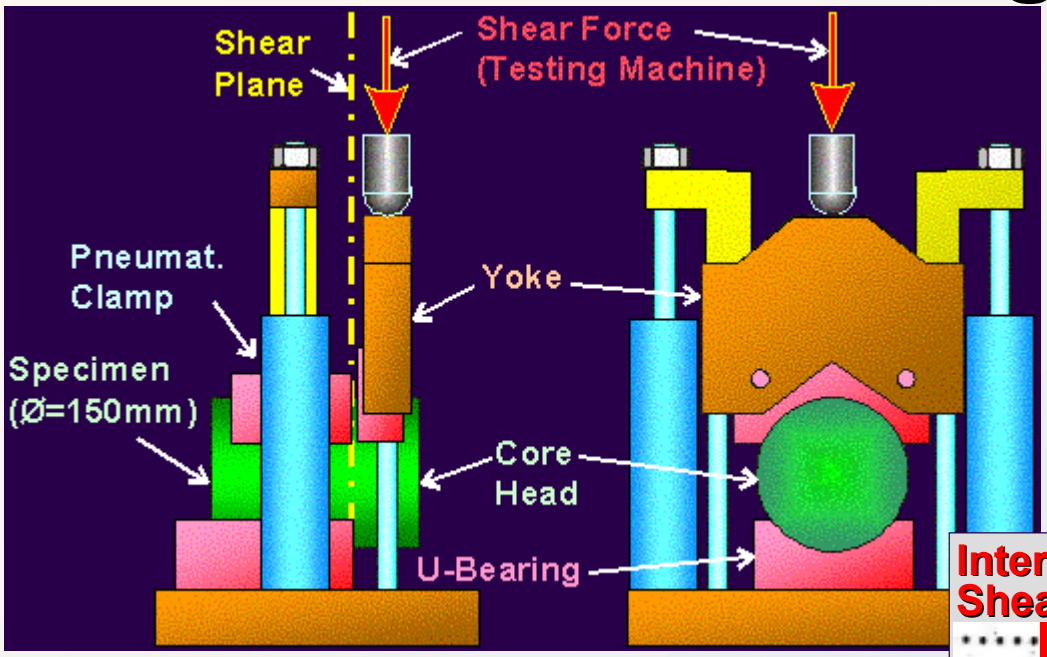
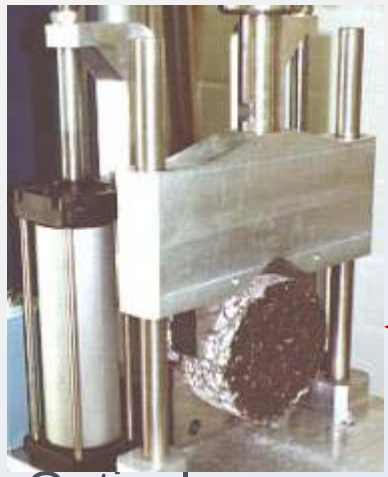
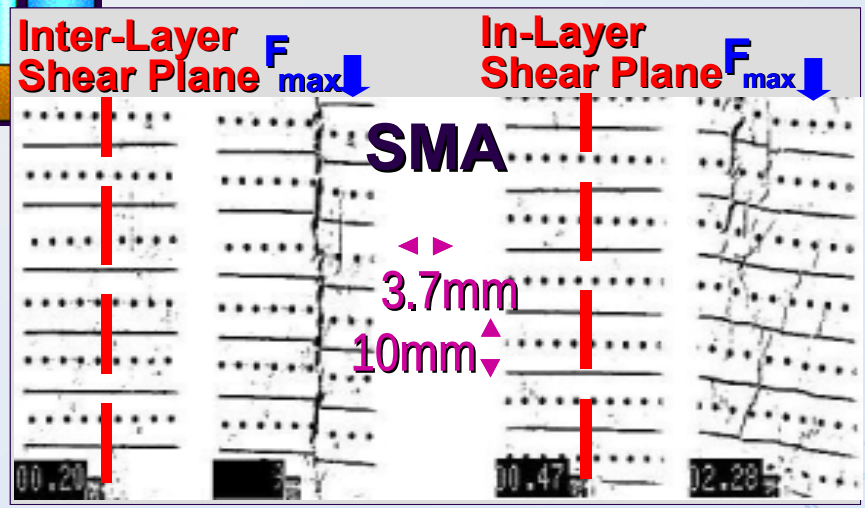
LPDS Investigation

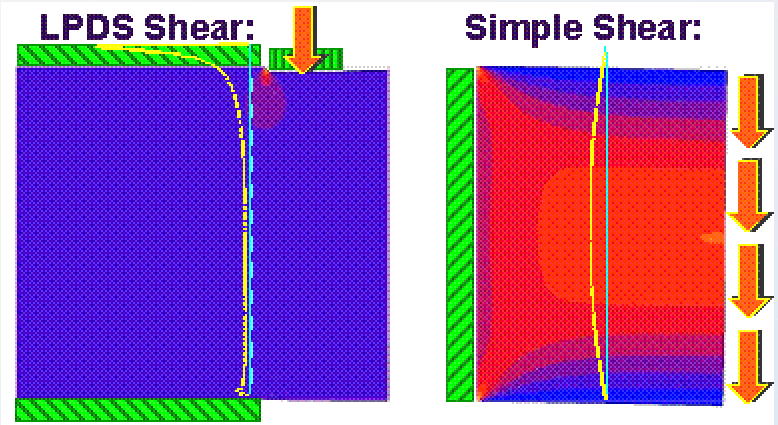




Linear Parallel Direct Shear (LPDS)

Optical measurements





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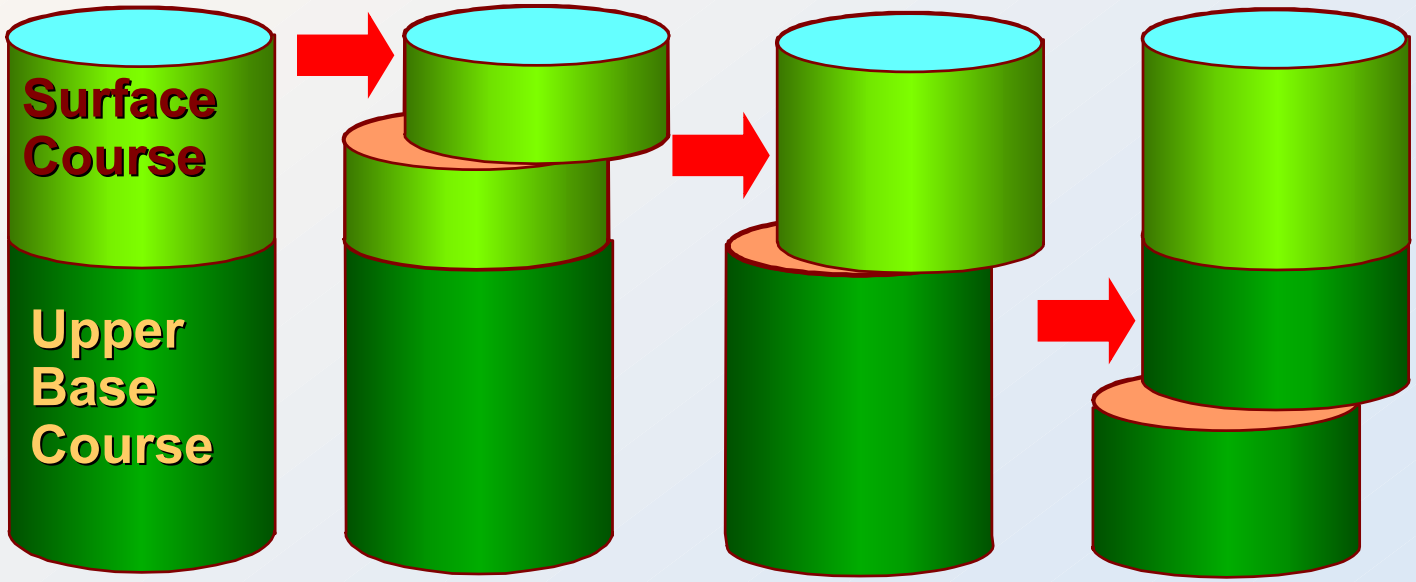
Shear Planes in Cores

Core

In-Layer Shear Force Surface C.

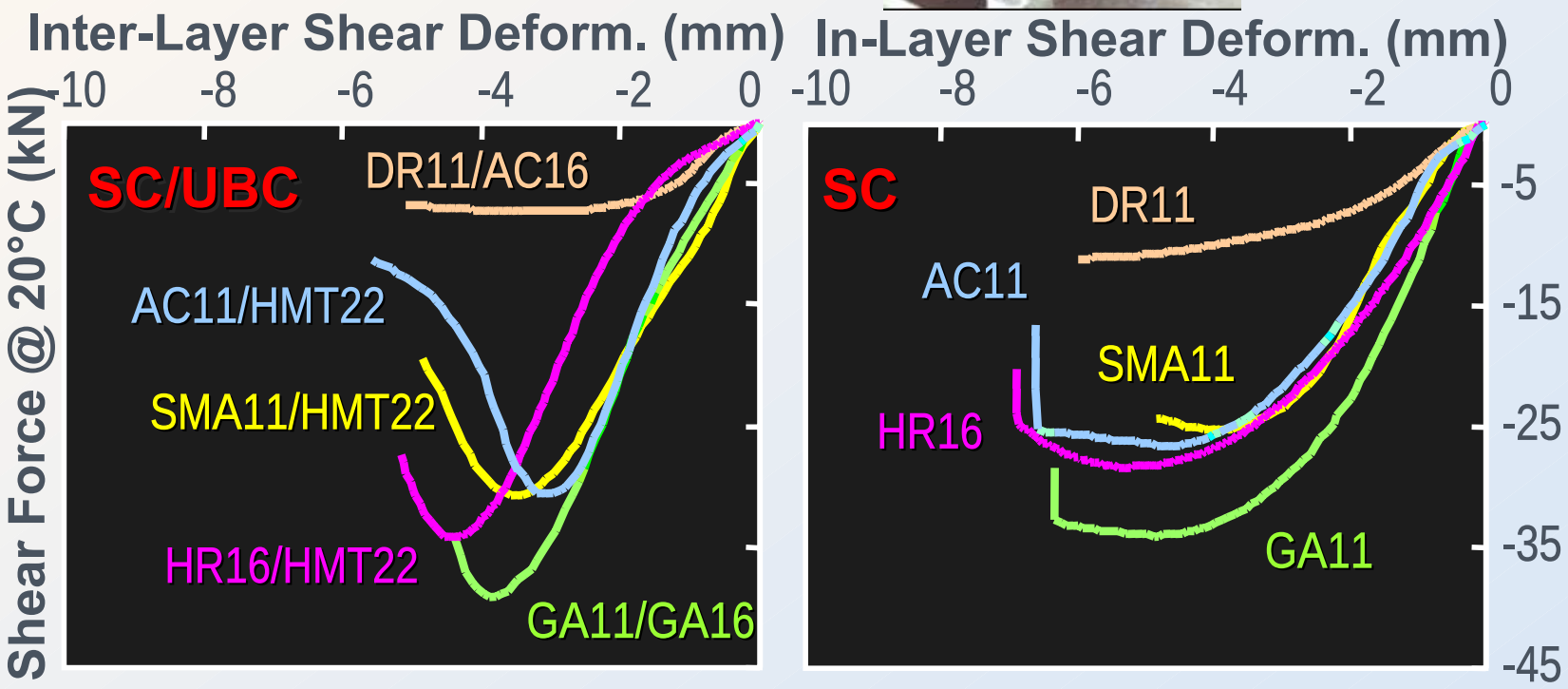
Inter-Layer Shear Force SC/UBC

In-Layer Shear Force Upper Base C.

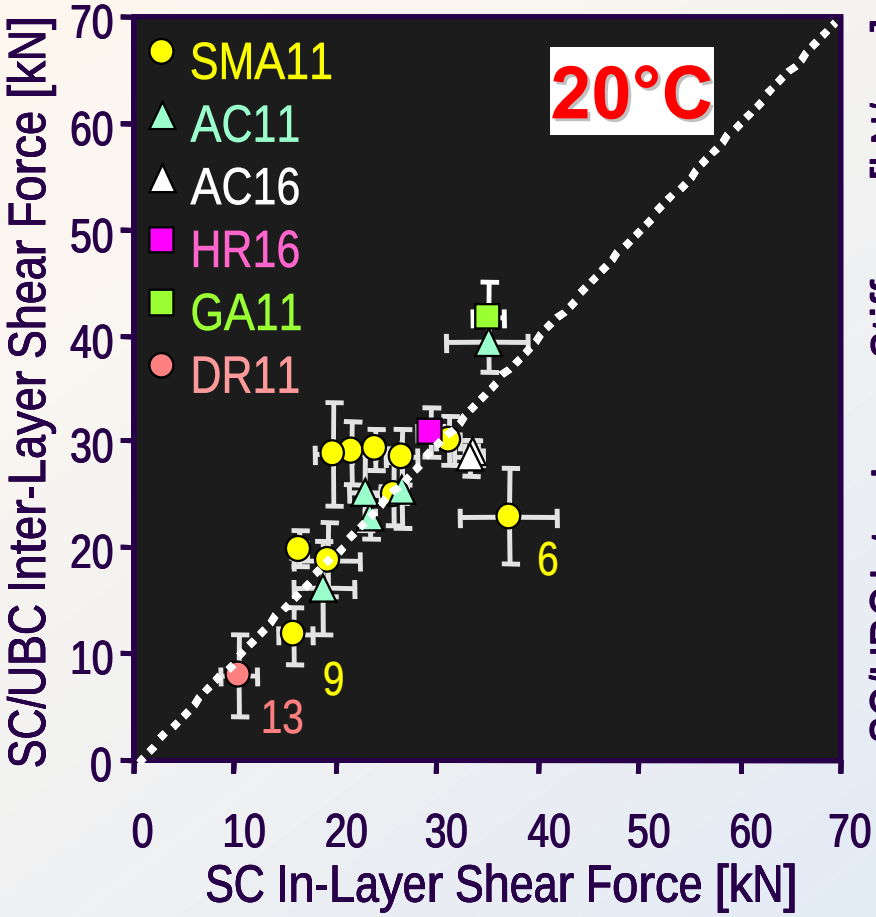


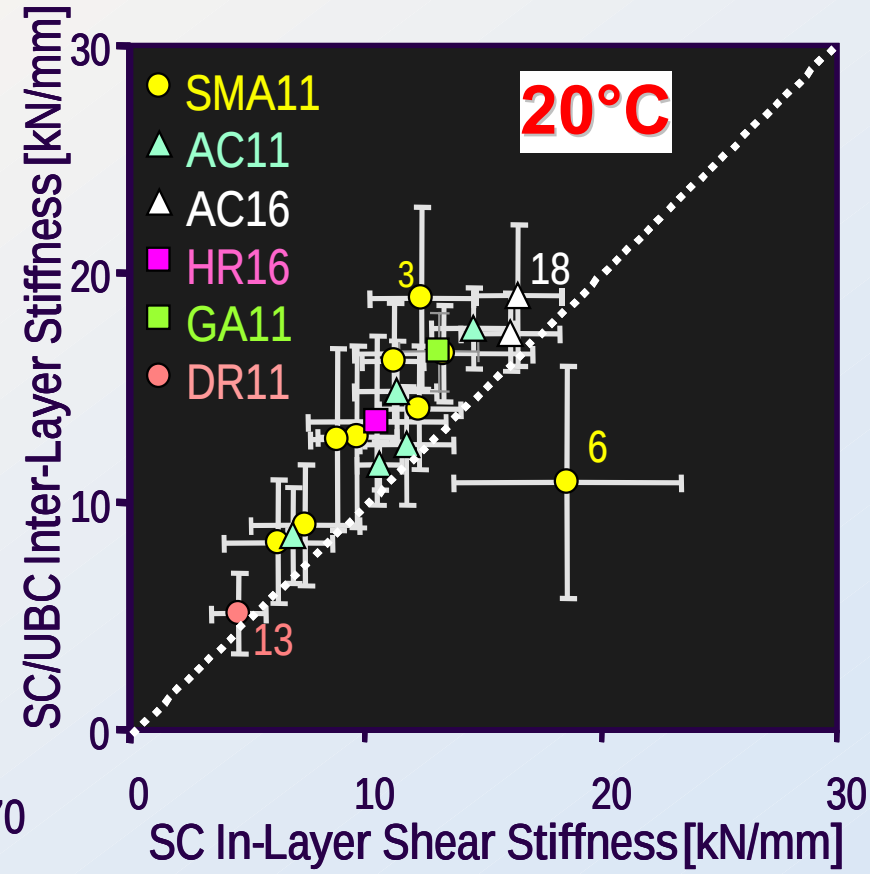
LPDS Inter- & In-Layer Shear @20°C

Linear Parallel Direct Shear (LPDS)

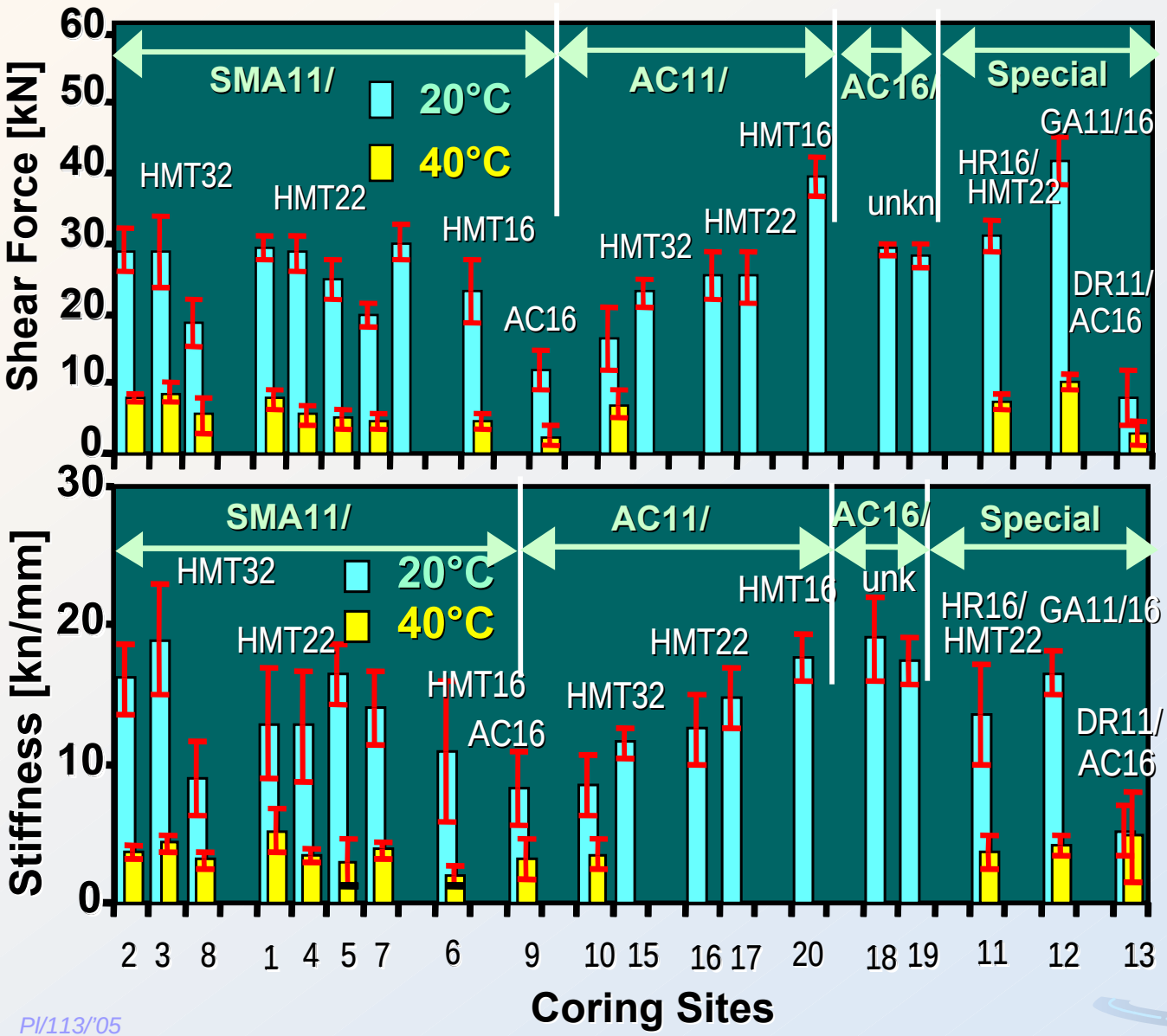


LPDS Results





Interlayer Adhesion Temp. Influence



SC/UBC

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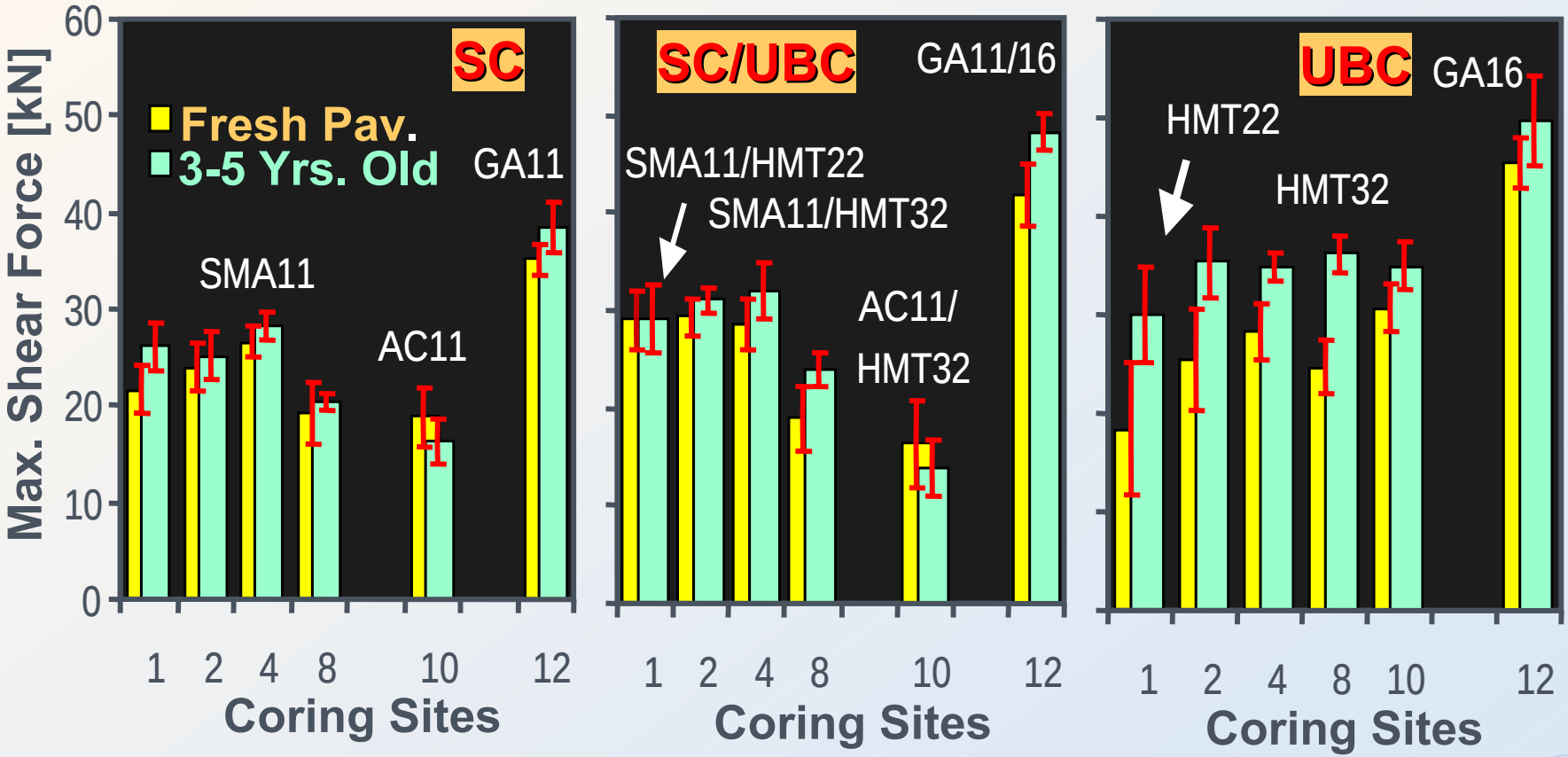
LPDS Traffic & Age:

Shear Force @20°C



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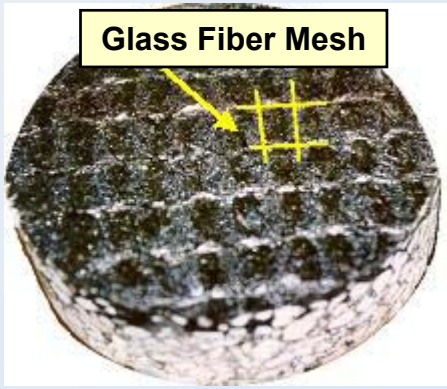
Interlayer Shear Figures

Asphalt/Asphalt	Standard	Possible
Surface C	>0.9MPa	1.3 MPa
Base C	>0.7MPa	

Asphalt/Concrete	Mean Measured
Glass Fiber Mesh	0.4MPa
Steal Mesh	0.2MPa
Tack Coat	0.9MPa



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Accelerated Pavement Testing APT

Contact

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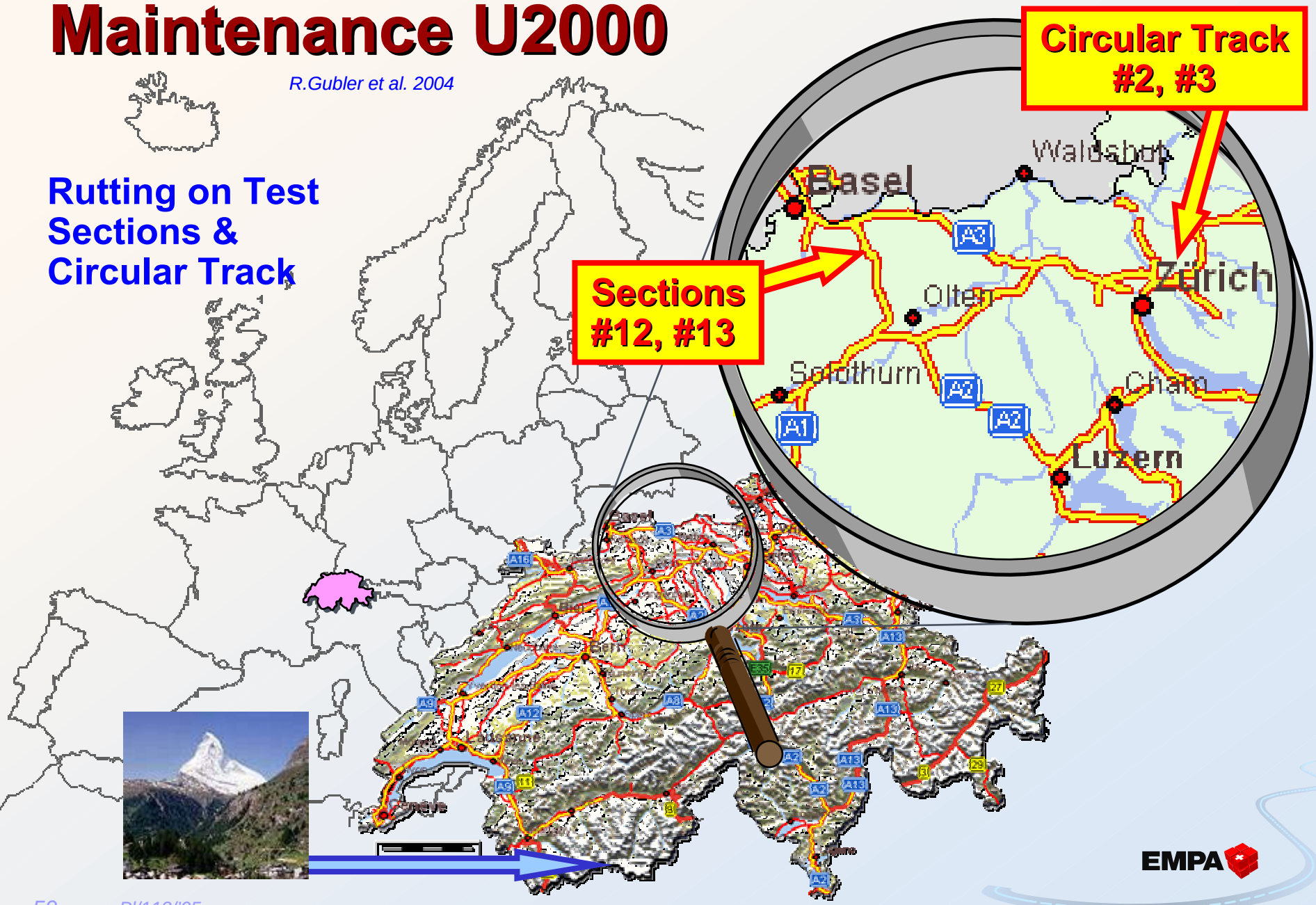
APT Testing in situ

Maintenance U2000

R.Gubler et al. 2004

Rutting on Test Sections & Circular Track



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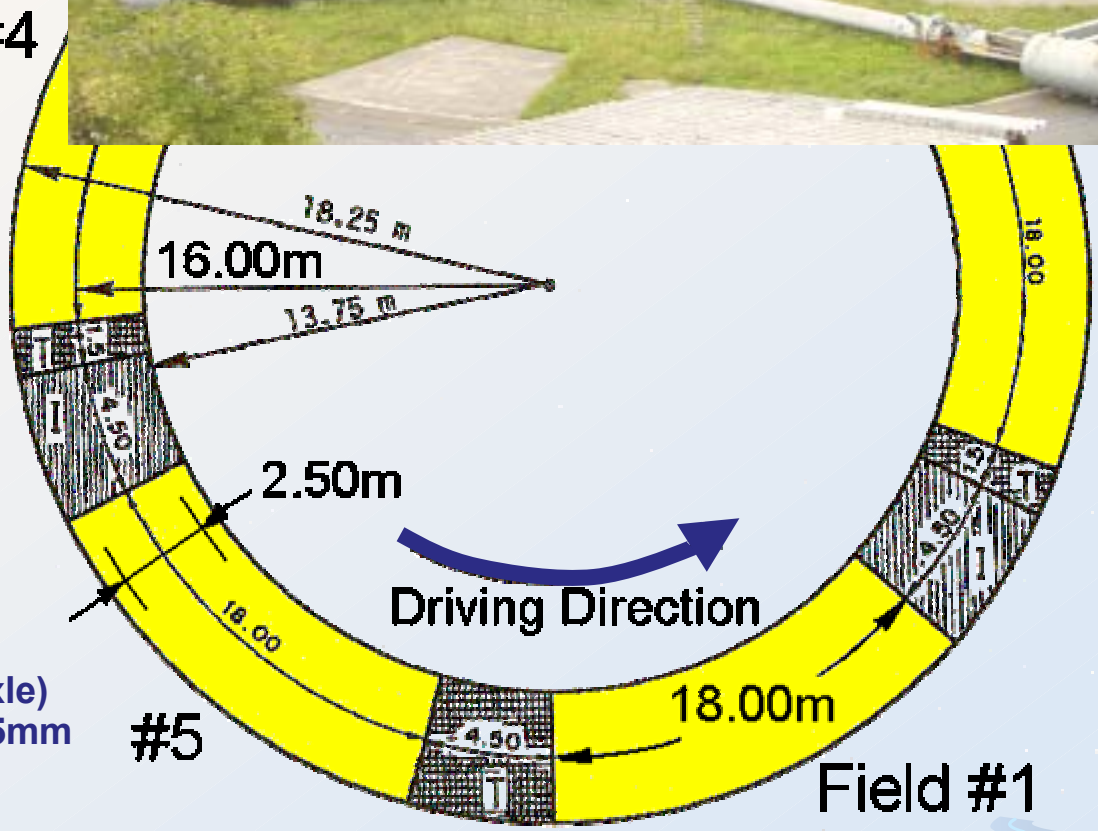
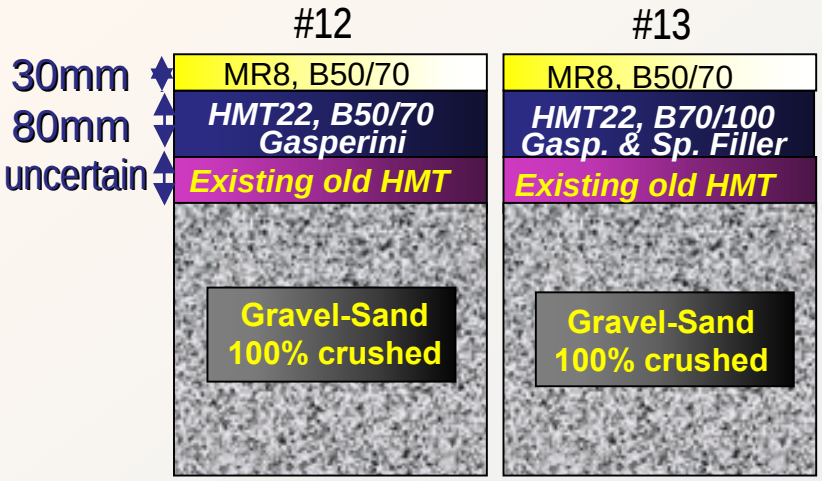
Circular Track ETHZ@ EMPA



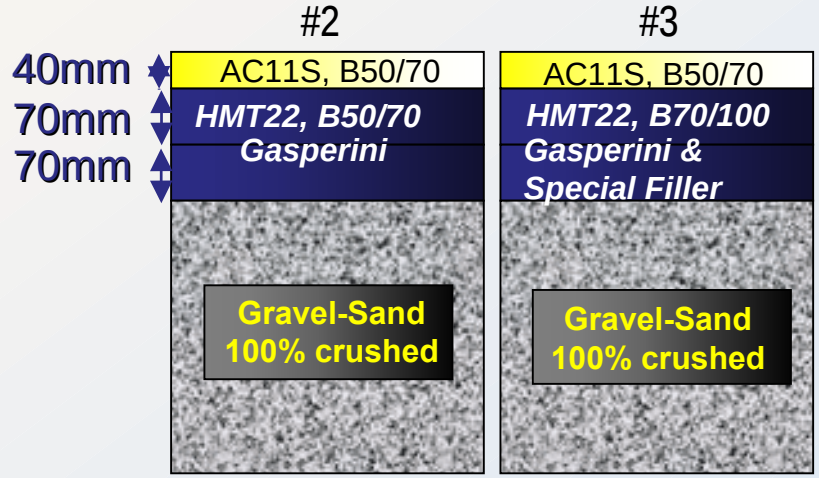
Max 80km/h
Load 80kN (=Half Axle)
Lat. Wandering ±675mm

Materials, Design U2000

A2 Motorway



Circular Test Track



	Motorway	Circular test track
Base Material	**Compacted Gravel-Sand**	**Compacted Gravel-Sand**
Lower bearing course	**Remaining old bearing course**	**70 mm HMT 22S**
Upper bearing course	**80 mm HMT 22S**	**70 mm HMT 22S**
Wearing course	**30 mm MR 8**	**40 mm AB 11S**

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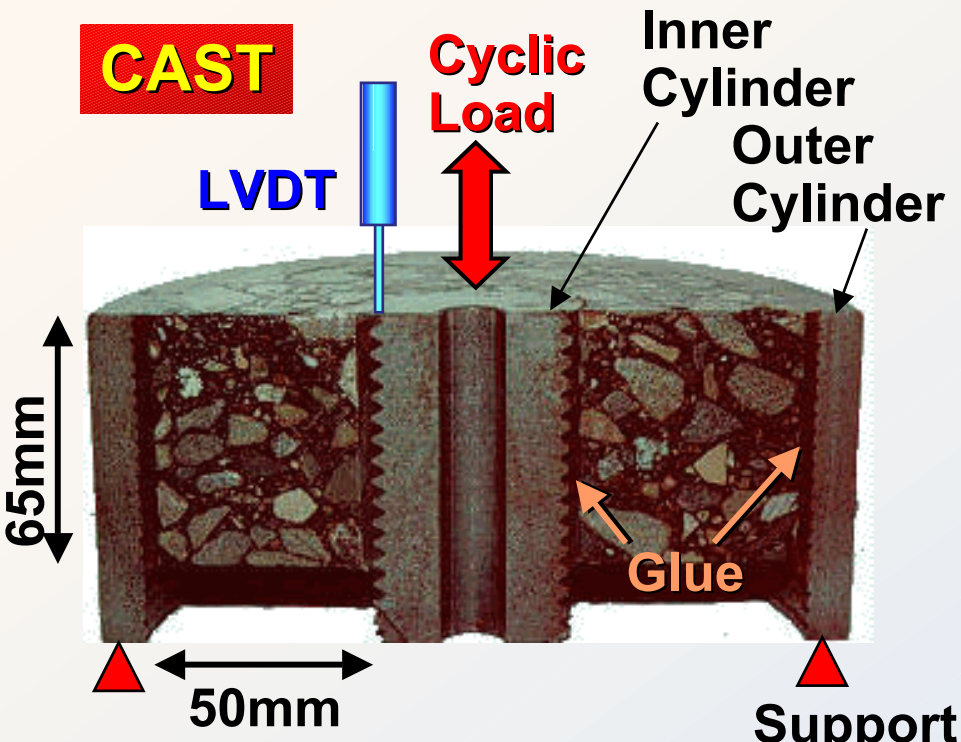
Mixture Tests

CAST

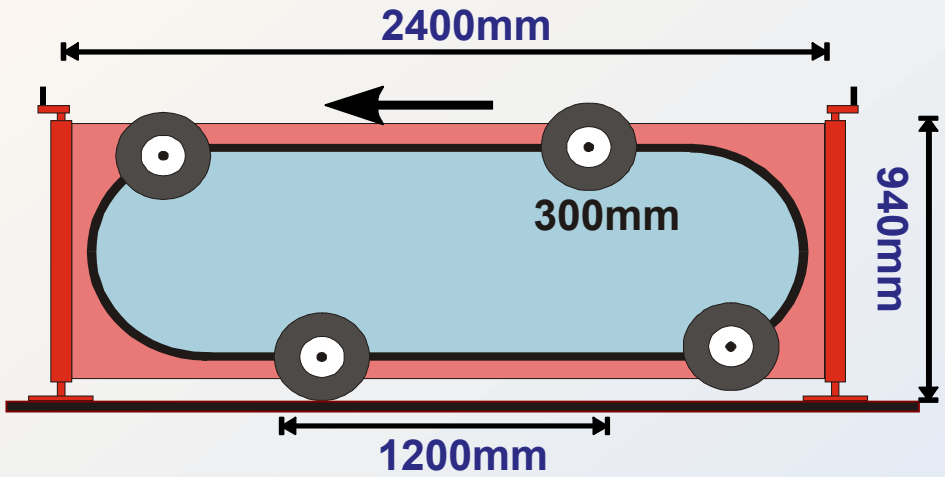


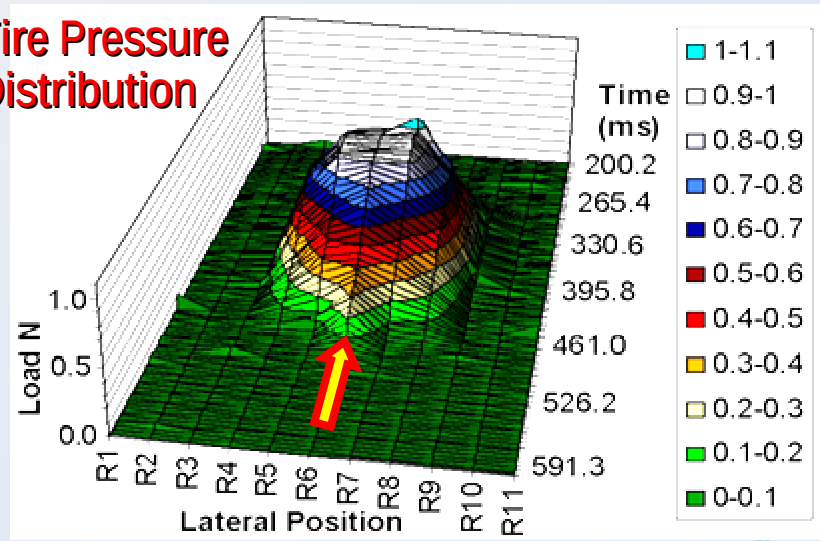
Data
d_o=150mm
d_i=50mm
T=5…40°C
f=0.01..10Hz
h<100mm

LCPC-WT

Data
T=
LxWxH=500x180x100mm
v=2 Passes/s = 2Hz
N=7200 Passes/h
N_{max}=30'000 Passes

MMLS3- Principle





Data

l=2400m
D=30
p=

v=3m/s = 9km/h
N=7200 Passes/h
N_{max}=72'000 Passes
Lateral wandering: No

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MMLS on A2 (Basel) & Circular Track @ EMPA

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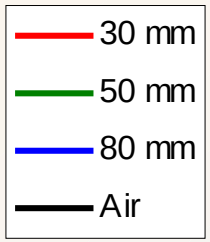
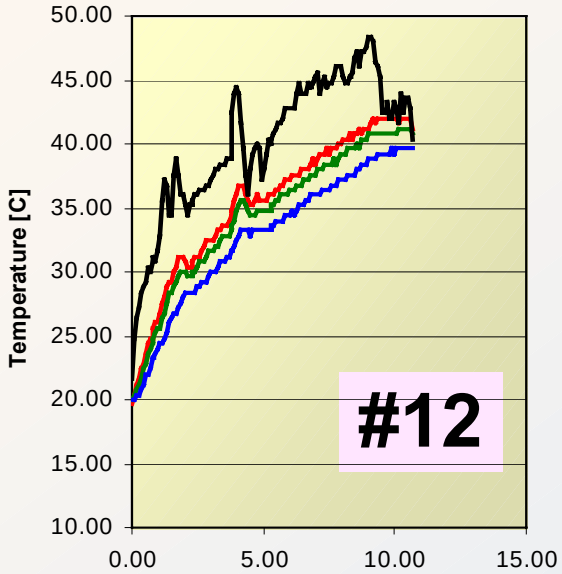
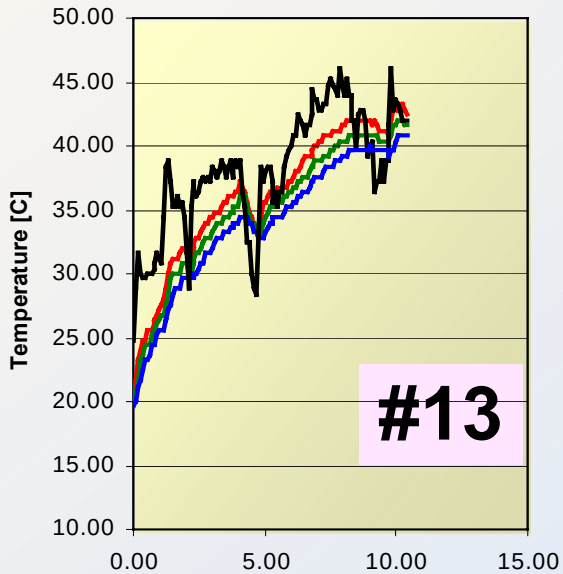
MMLS3 Pavement Temp.

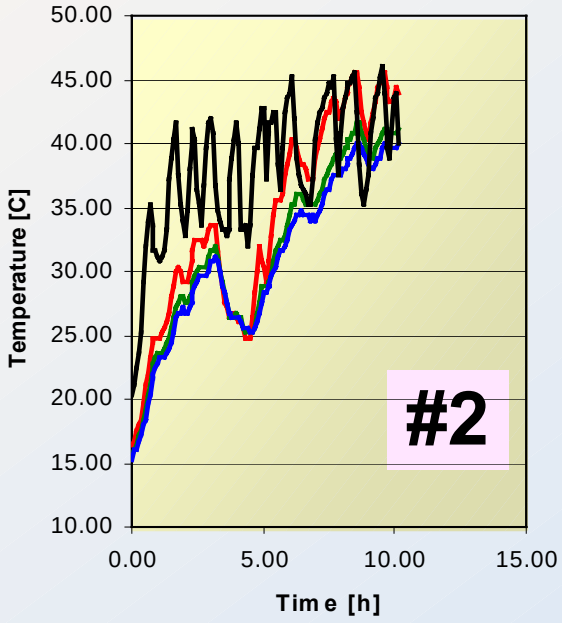
A2 Motor-way

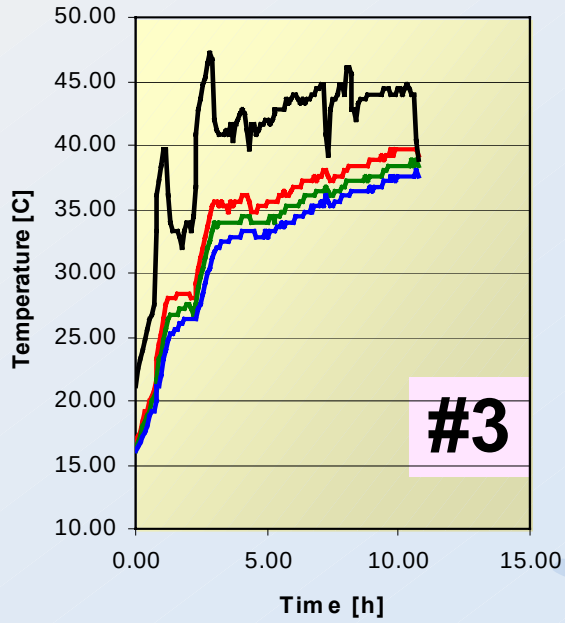






Circular Test Track





Temp. Range in 3cm Depth:

#12 (20…42°C),
#13 (18..43°C),

#2 (13.6…45°C),
#3 (15.2…39°C)

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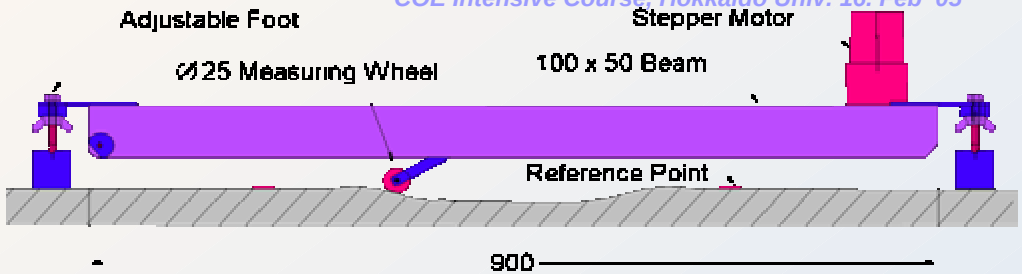
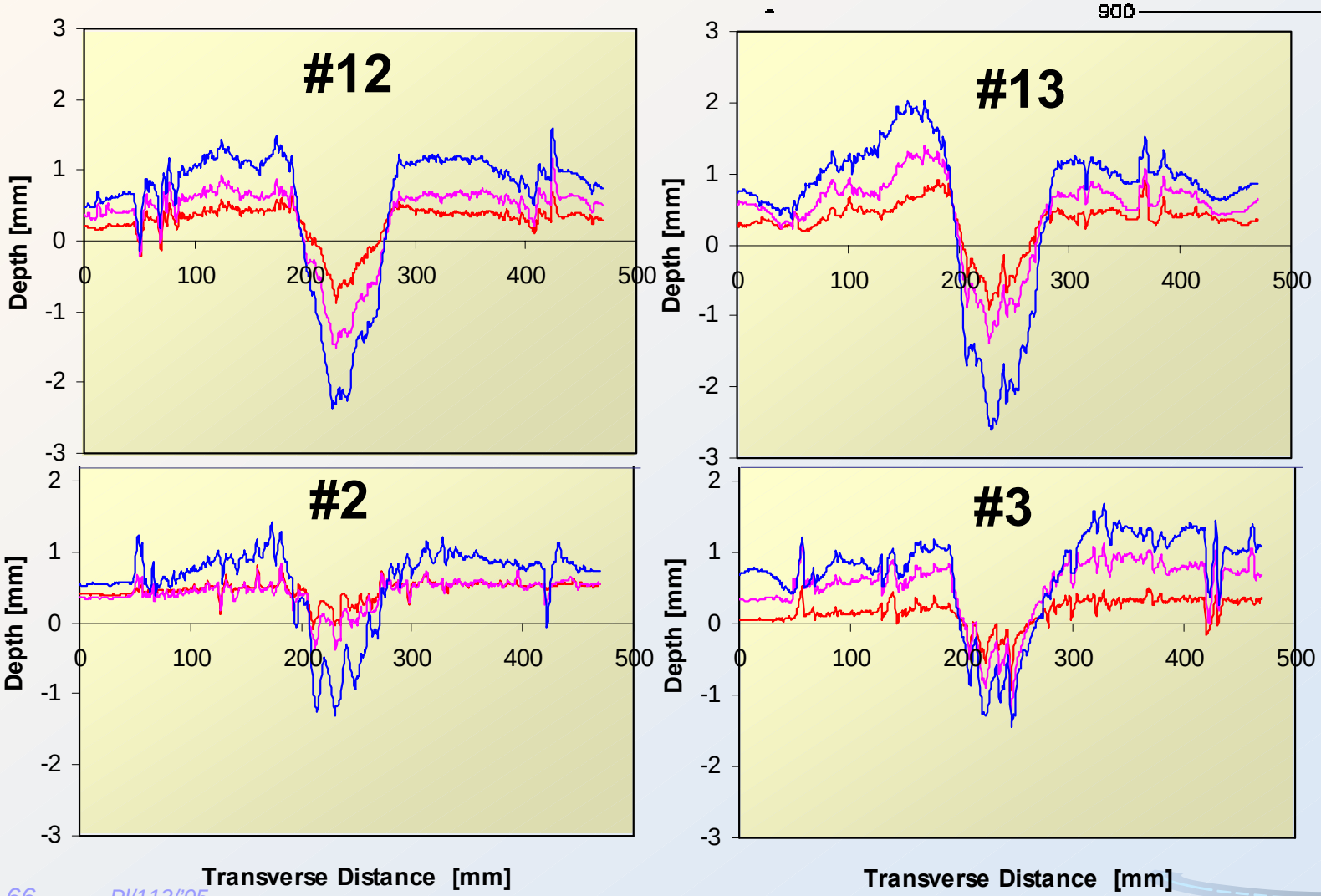
Results MMLS

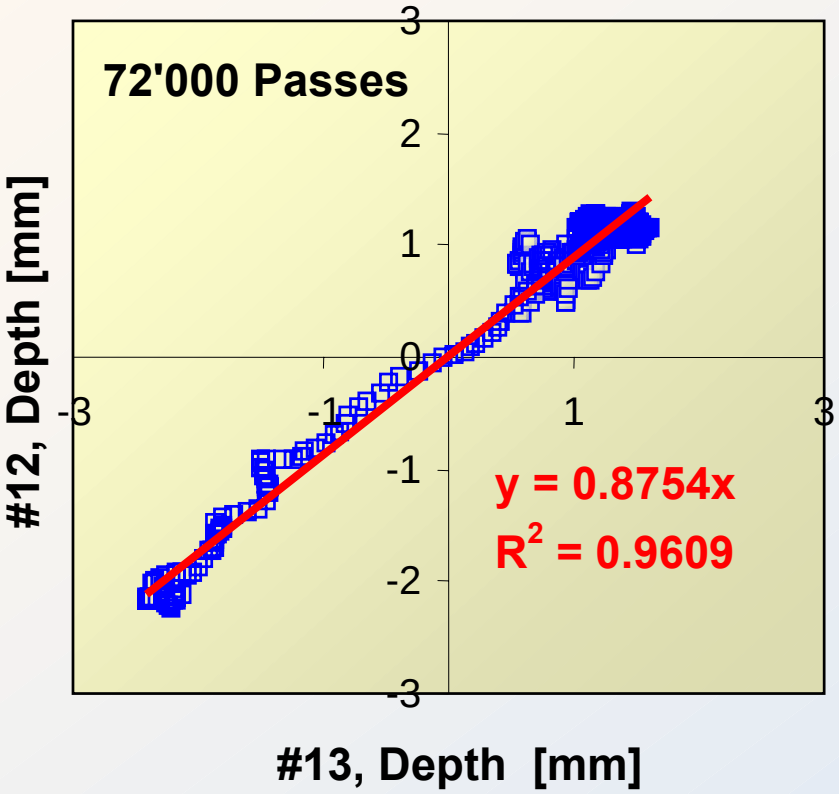
#12, #13 Motorway A3
#2, #3 Circular Test Track

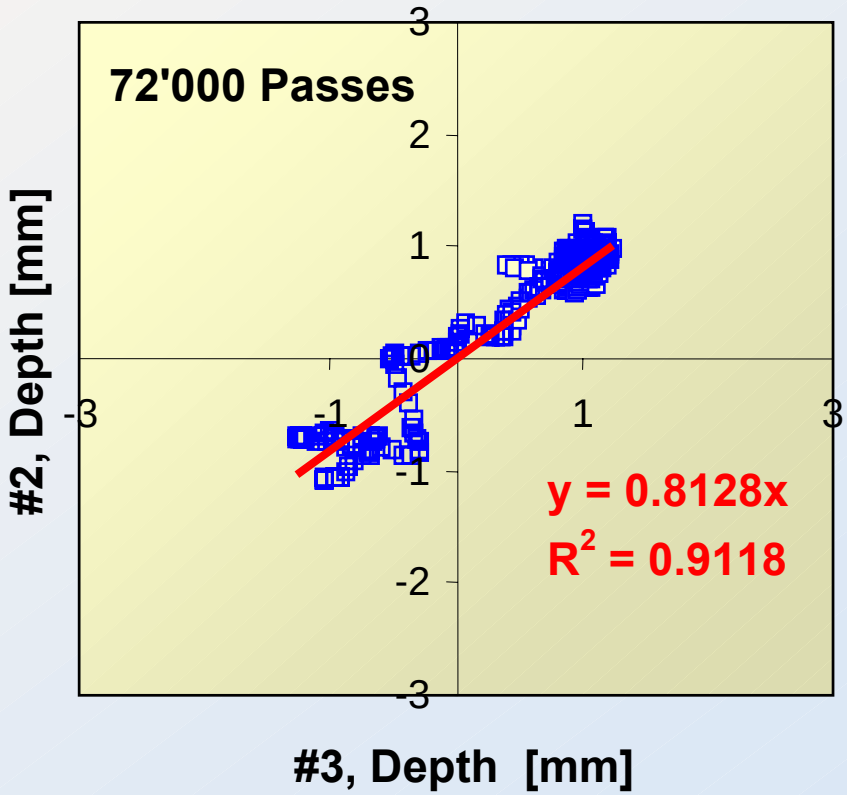




MMLS Rutting Circular Track /Section

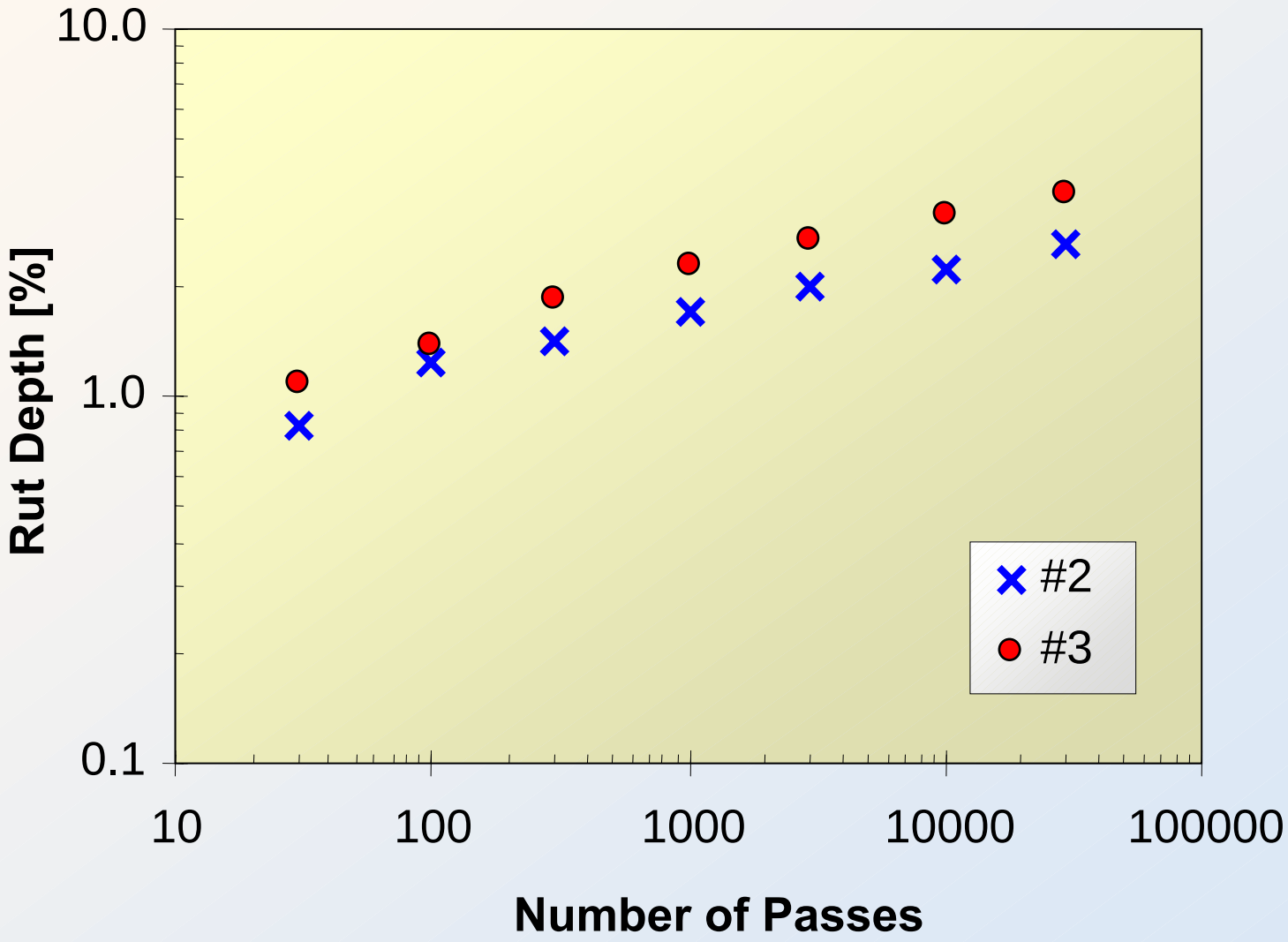
#12, #13 Section; #2, #3 Circular Track





- Sections generally more deformation than circular track
- #12,#2 less rutting than #13,#3 mixture in both cases

LCPC Rut Test of Compacted Mix



Comparison Field & Lab Testing

Section	Cross Section Rut of MMLS ca.15..43C [mm²]	Rut Depth LCPC Rut Test 60°C, 30'000 Passes [mm]	DSR 40°C, 2 Hz [MPa]	CAST 40 °C, 2 Hz [MPa]
#12 (road)	154	-	0.0967	239
#13 (road)	171	-	0.0703	188
#2 circular track	75	2.56	0.0967	-
#3 circular track	84	3.55	0.0703	-

Ratios of „Soft" : „Stiff" Mix

MMLS rut area [mm²] ca 15..43°C, Ratio (#13/#12)	1.11
MMLS rut area [mm²] ca 15..43°C, Ratio (#3/#2)	1.12
LCPC rut depth 60°C [mm], Ratio (#3/#2)	1.39
DSR 40°C, 2Hz G* [MPa], Ratio (#3/#2) $^{-1}$	1.38
CAST 40°C, 2Hz G* [MPa], Ratio (#3/#2) $^{-1}$	1.27

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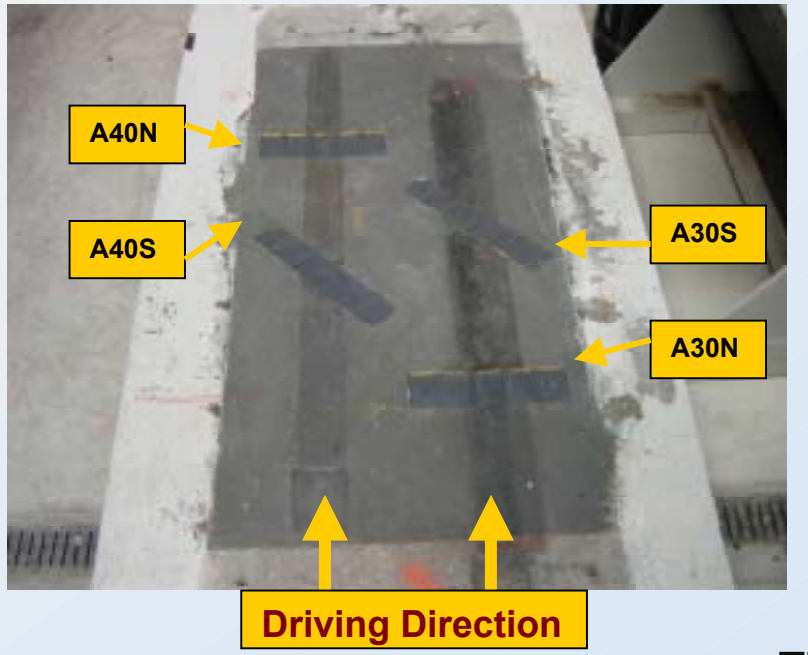
Reflector Testing

Test Program

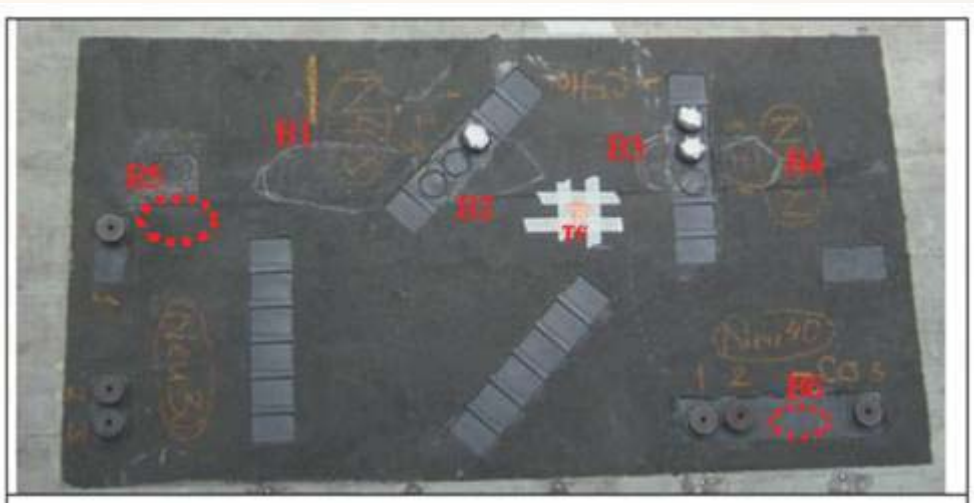
- MMLS Tests 200‘000 cycles at 30°C and 40°C
- Series A: Reflectors applied on old asphalt slab
- Series B: Reflectors applied on new asphalt slab
- Reflectors tested diagonal and rectangular

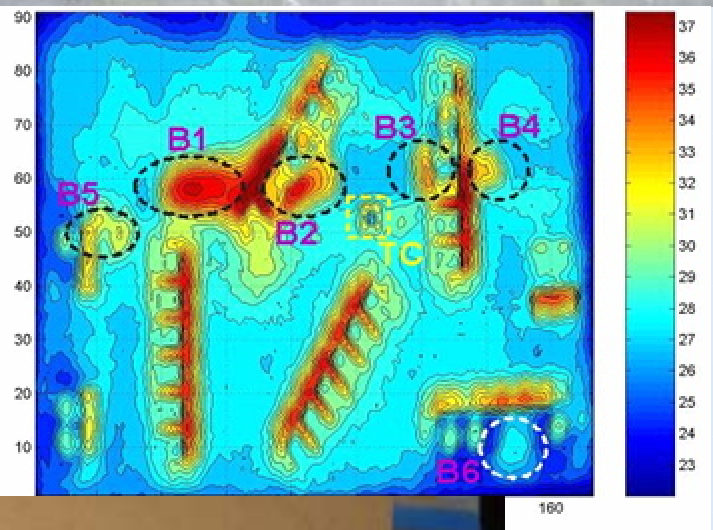


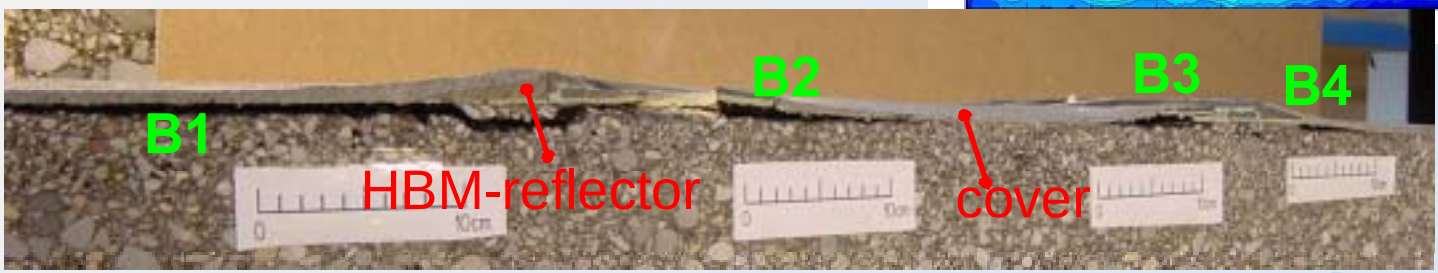
Reflector Testing

Reflector Damage MMLS3

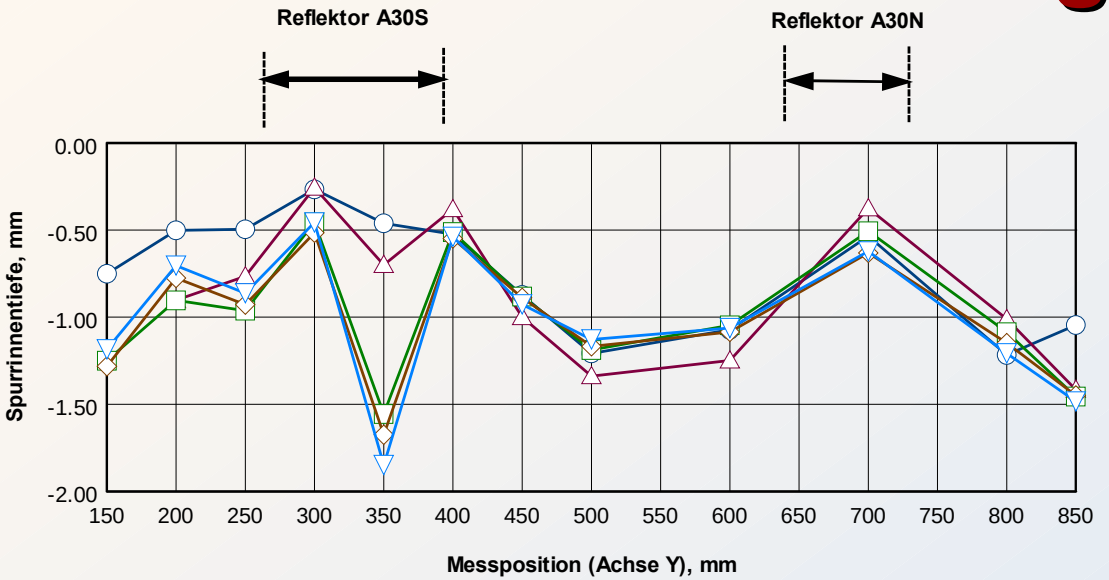
K.Sokolov





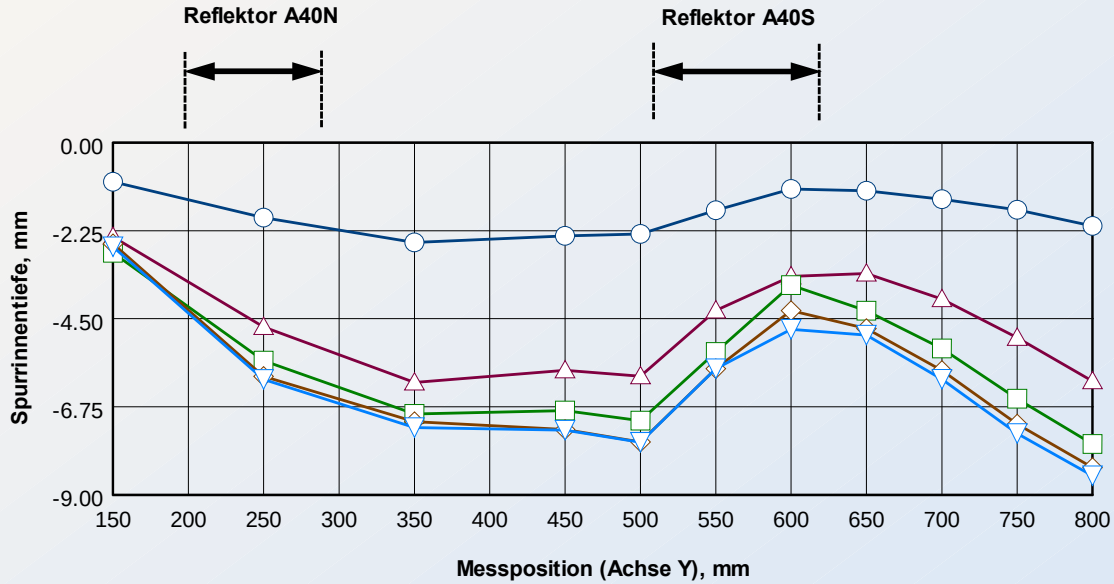


Results Series A Length Profile



30°C

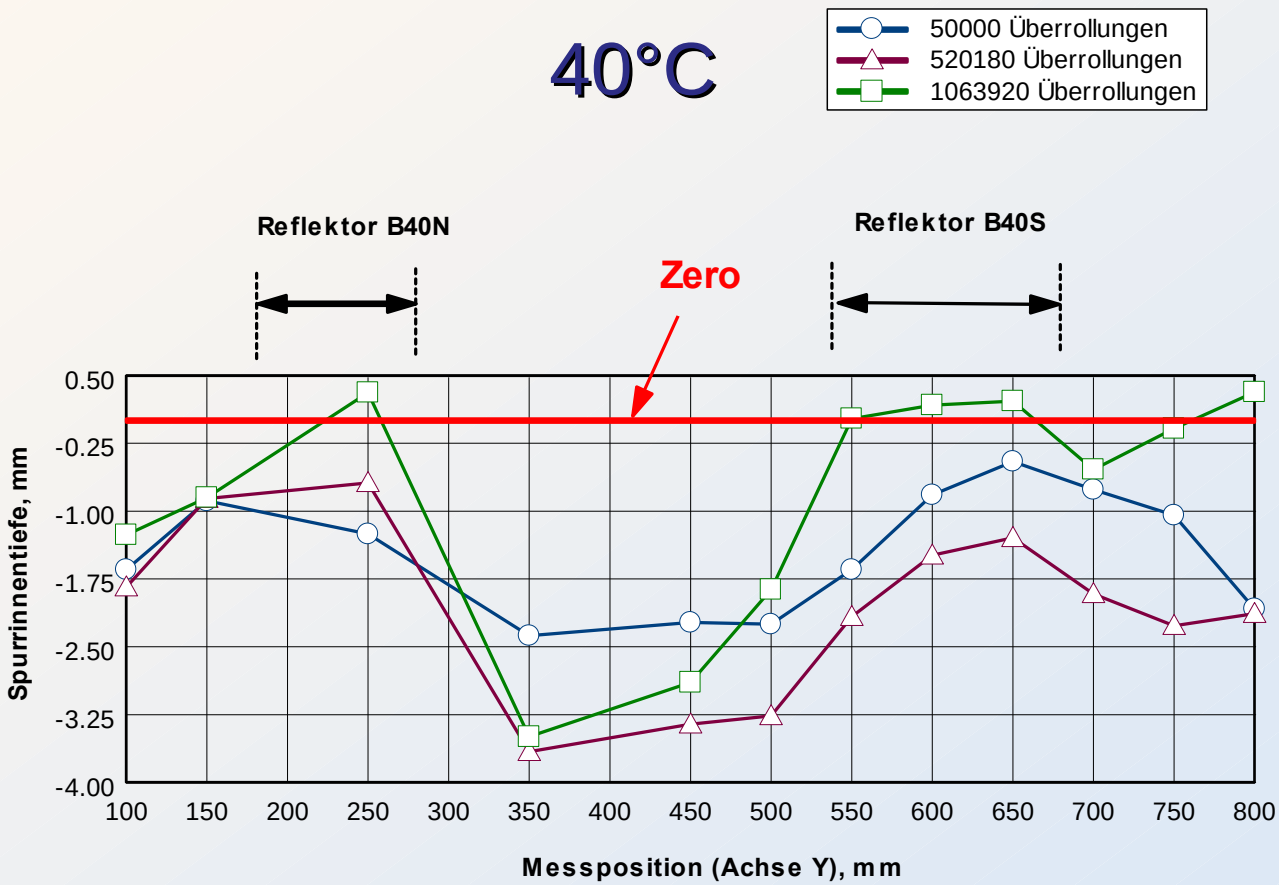
- 50040 Überrollungen
- 227030 Überrollungen
- 712000 Überrollungen
- 1040150 Überrollungen
- 2000000 Überrollungen



40°C

- 50000 Überrollungen
- 520180 Überrollungen
- 1063920 Überrollungen
- 1738580 Überrollungen
- 2089960 Überrollungen

Results Series B Length Profile



Summary of Results

- MMLS was a very helpful tool for accelerated testing of reflectors.
- Series A (old pavement) behaved successfully after 200000 cycles at 30°C and 40°C
- Series B (new pavement) showed at 40°C delamination of the polymer cover after 50‘000 cycles (B3) and 500‘000 cycles(B1)
- Surface preparation and primer application before glueing the reflectors is very important

Joints

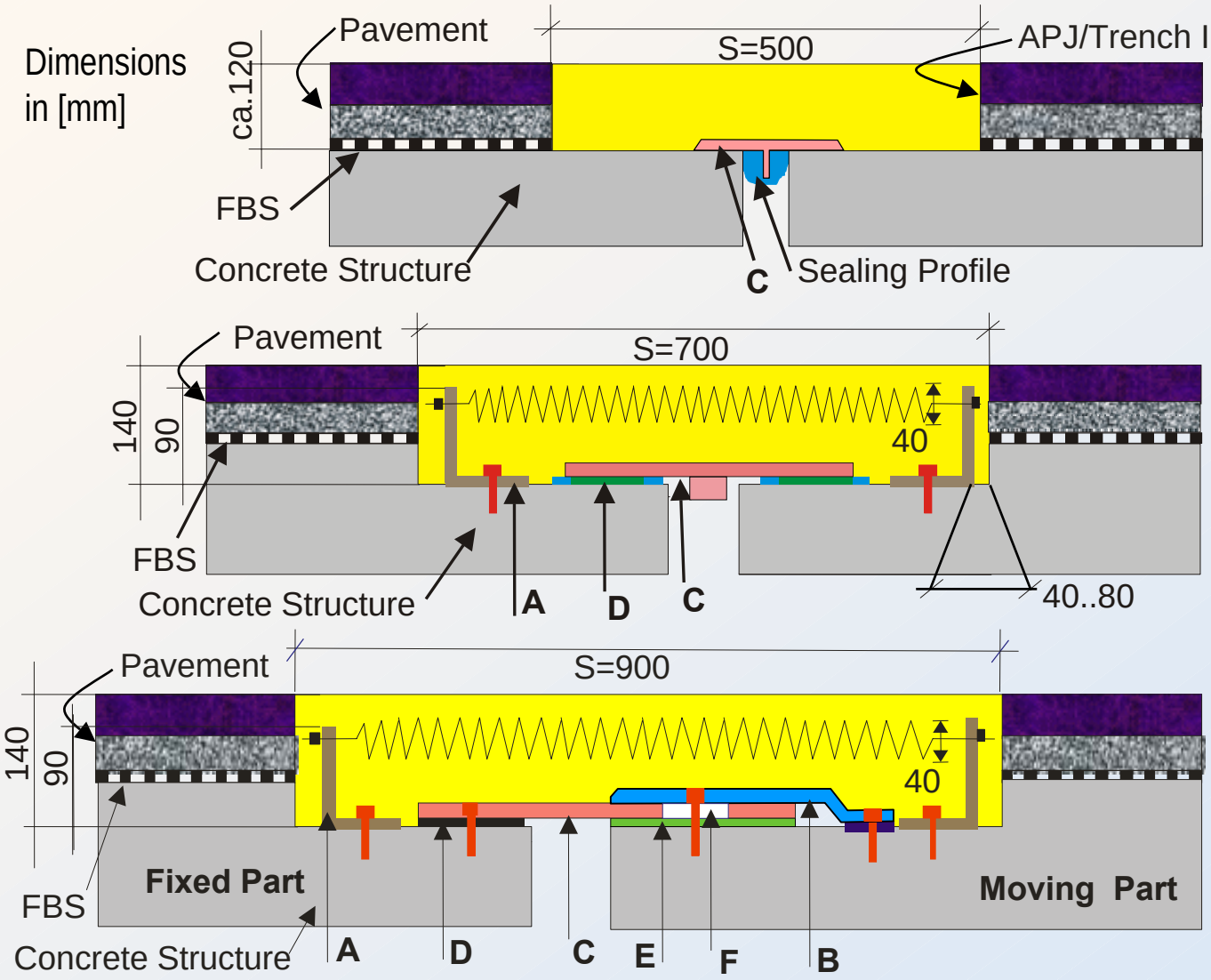
Contact

Sivotha Hean

sivotha.hean@empa.ch

Asphaltic Plug Joints for Large Movements

Asphaltic Plug Joint (APJ) Systems



System TJ

S=500 mm

$\Delta W_{max,yr}$=37.5mm

C: Steel Plate (floating),
FBS: Flex. Bit. Sheet.

System SJ700

S=700 mm

$\Delta W_{max,yr}$=70mm

A: Spring Anchor
D: Slider-Bearing

System SJ900

S=900 mm

$\Delta W_{max,yr}$=100mm

B: Upper Steel Plate,
C: Bottom Steel Plate,
E: Deformation Layer,
F: Slide-Hole

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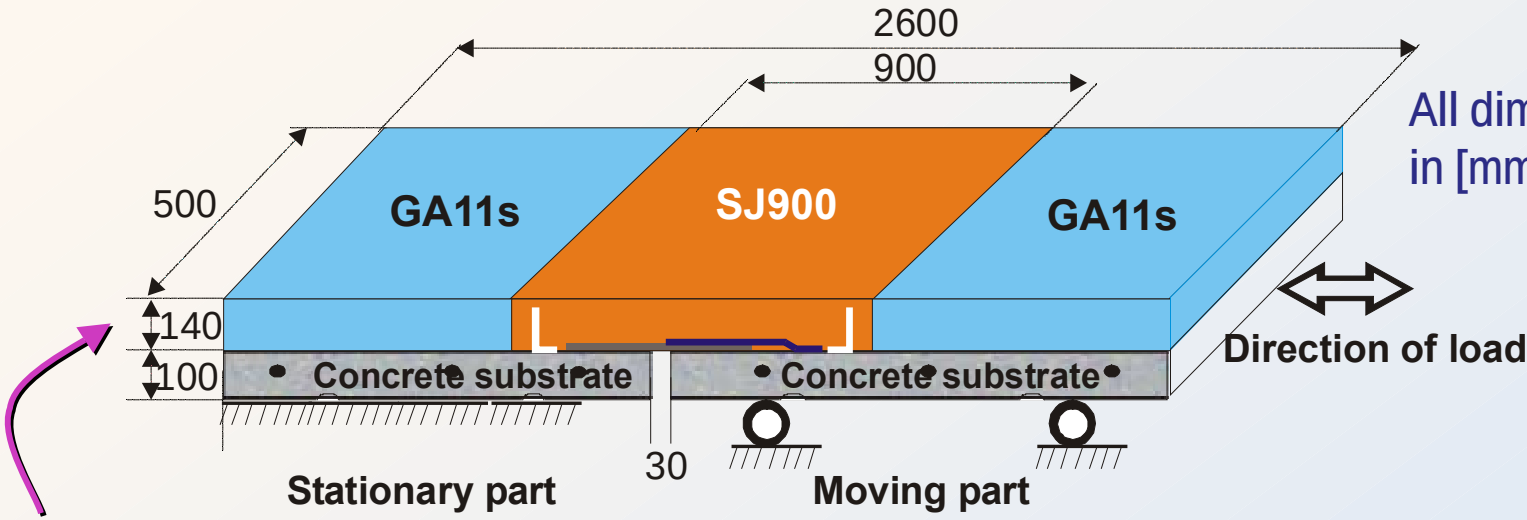
SJ Construction

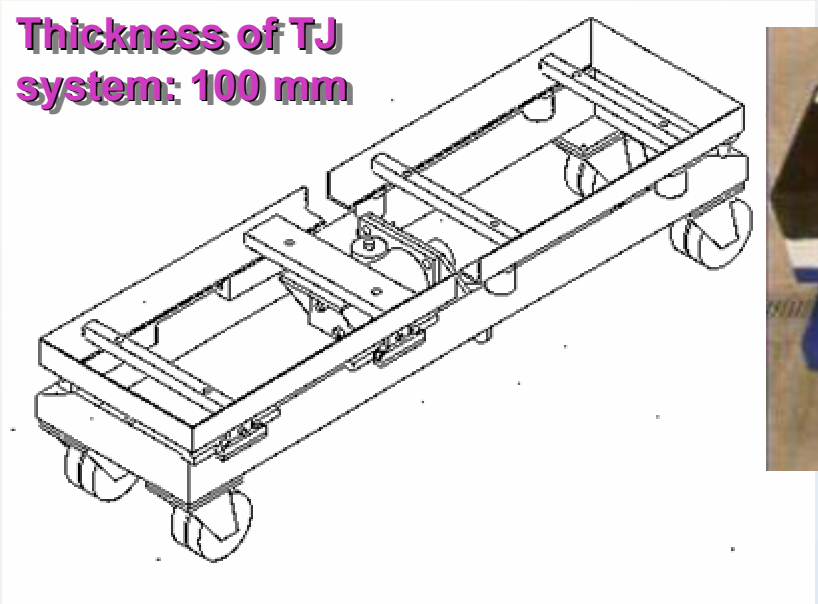
Example: Montbijou Bridge in front of Swiss Parliament in Bern

Joint Movement Simulator JMS



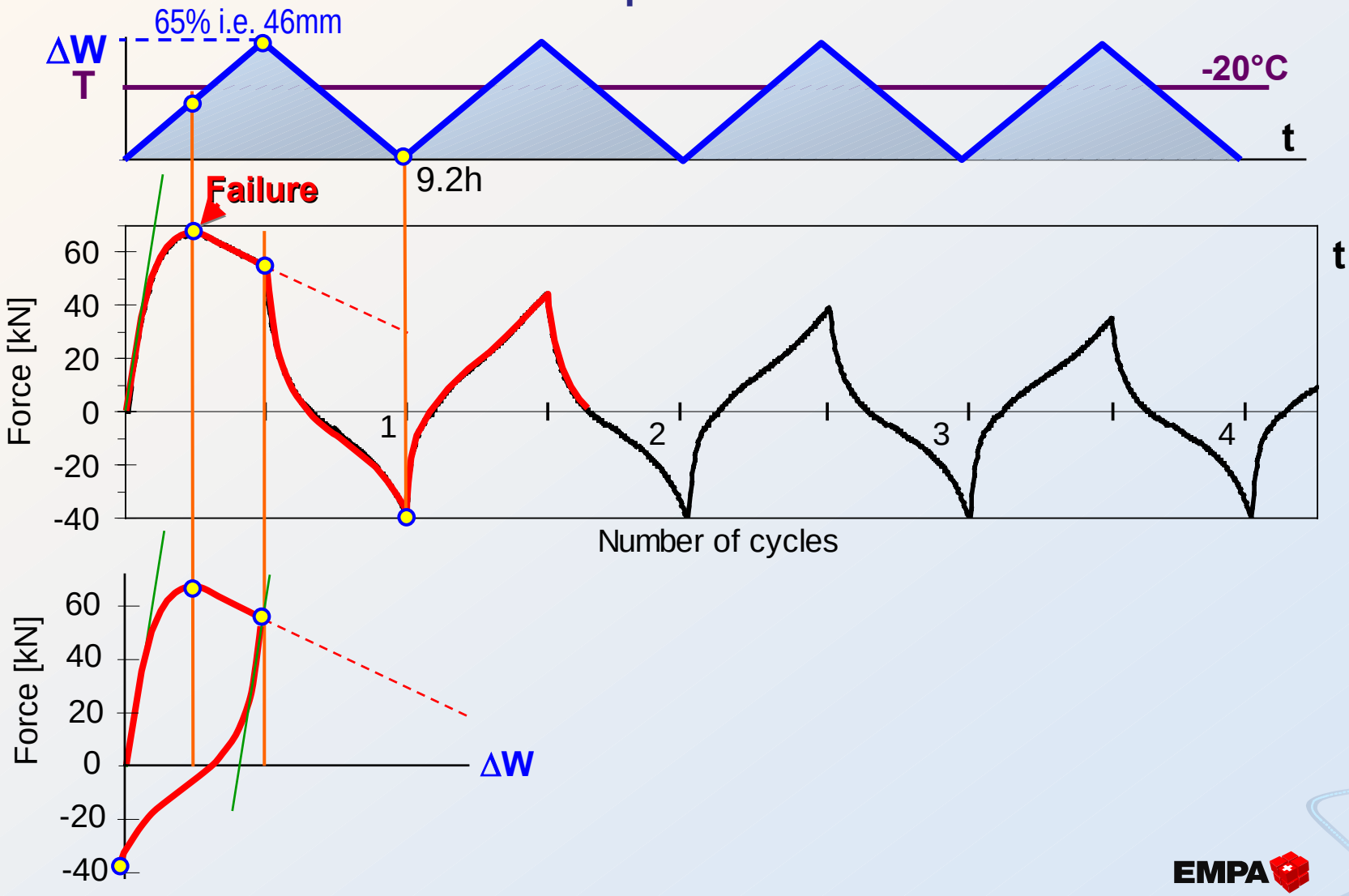
All dimensions in [mm]

Thickness of TJ system: 100 mm



Typical Force-Time Curve @-20°C

Example: SJ700

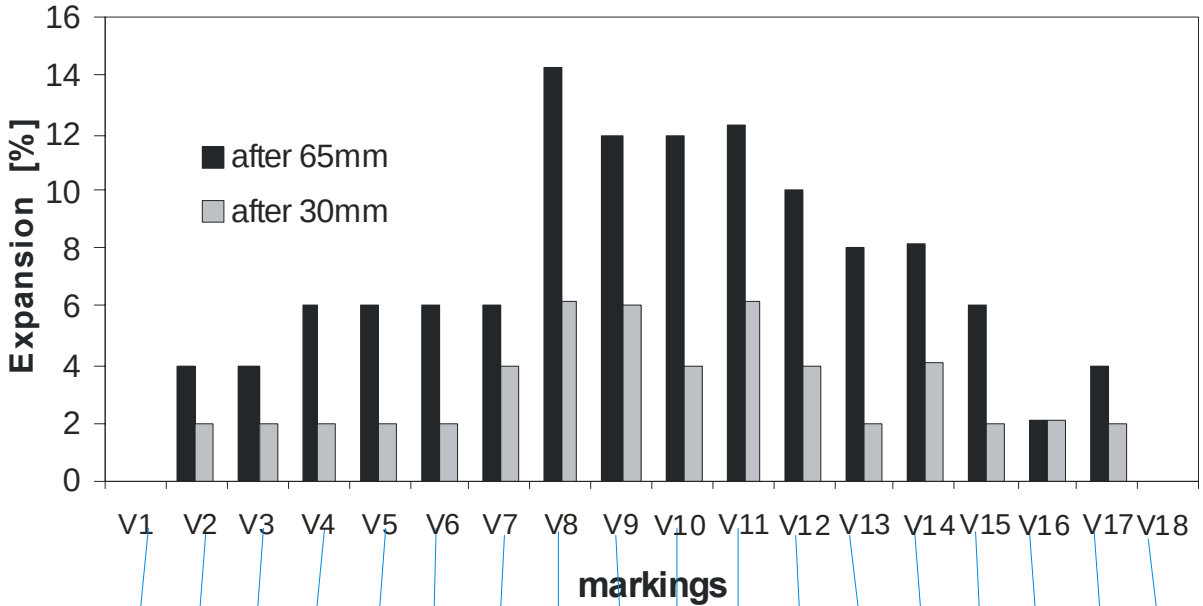


Results of the Quasi-Static Fatigue Test on SJ at Low Temperatures

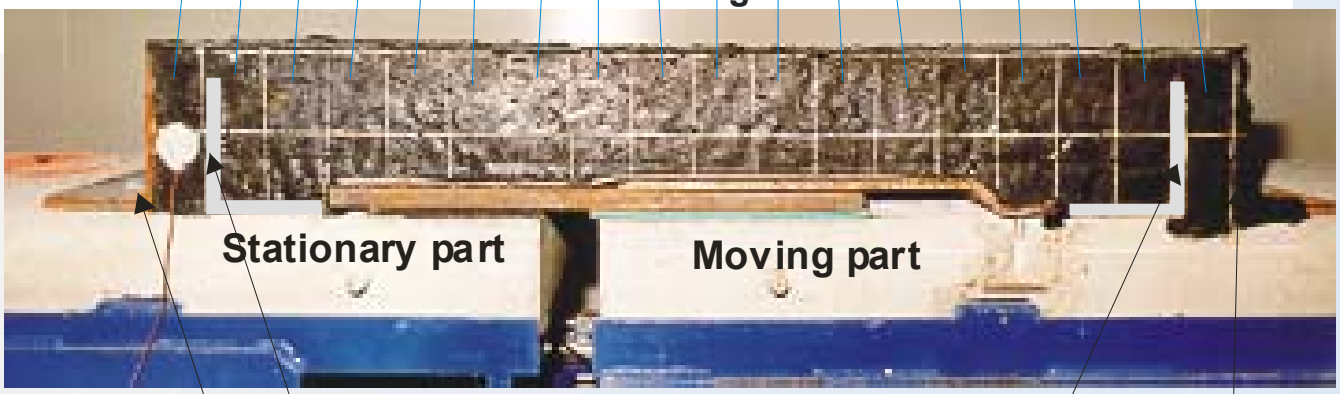
Number of Specimens	Conditions	Result
SJ900		
2	–20°C, ΔW=65 mm	OK
1	–10°C, ΔW = 65 mm	OK
1	–5°C, ΔW = 65 mm	OK
SJ700		
1	–20°C, ΔW = 46 mm	Cracks after 18 cycles
2	–20°C, ΔW = 46 mm	OK

OK = after 20 cycles neither cracking nor de-bonding

SJ900 Horizontal Expansion



Horizontal expansion in the APJ at joint openings of 30 mm and 65 mm in the case of an SJ900 test specimen at –20°C

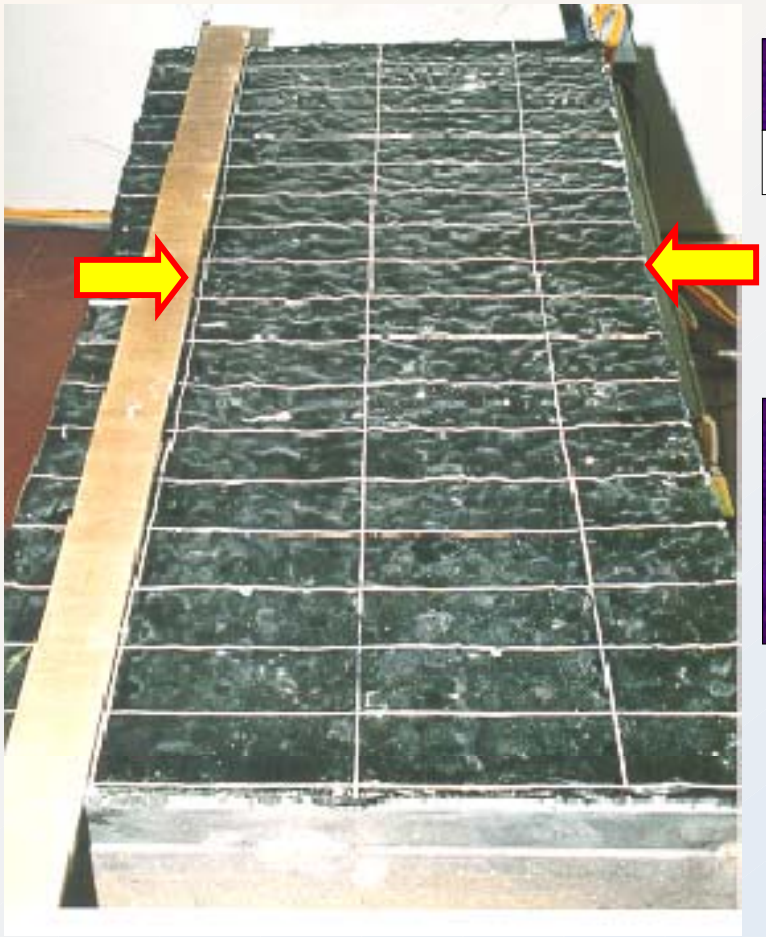


L-shaped steel for anchoring the springs

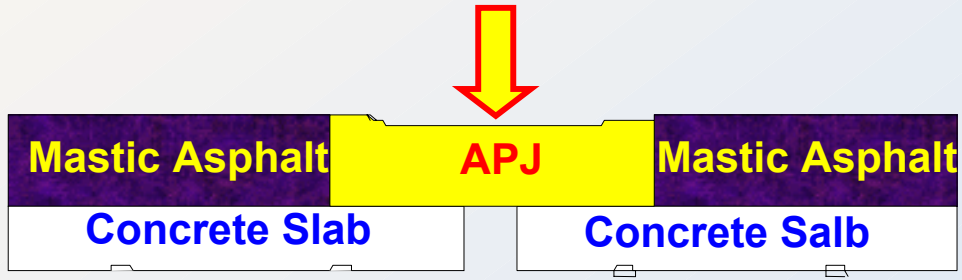
L-shaped steel as substitutes for the adjoining pavement

Lateral Contraction during Expansion

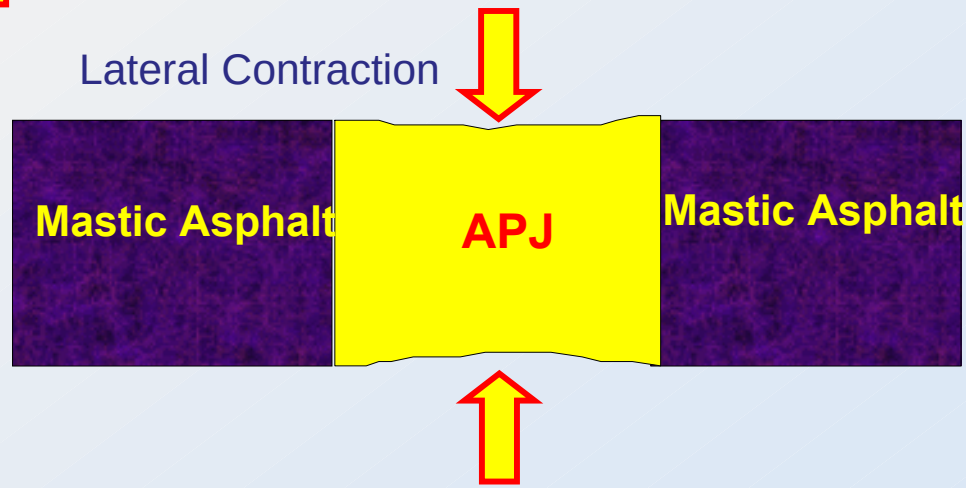
Lateral Contraction during joint opening.



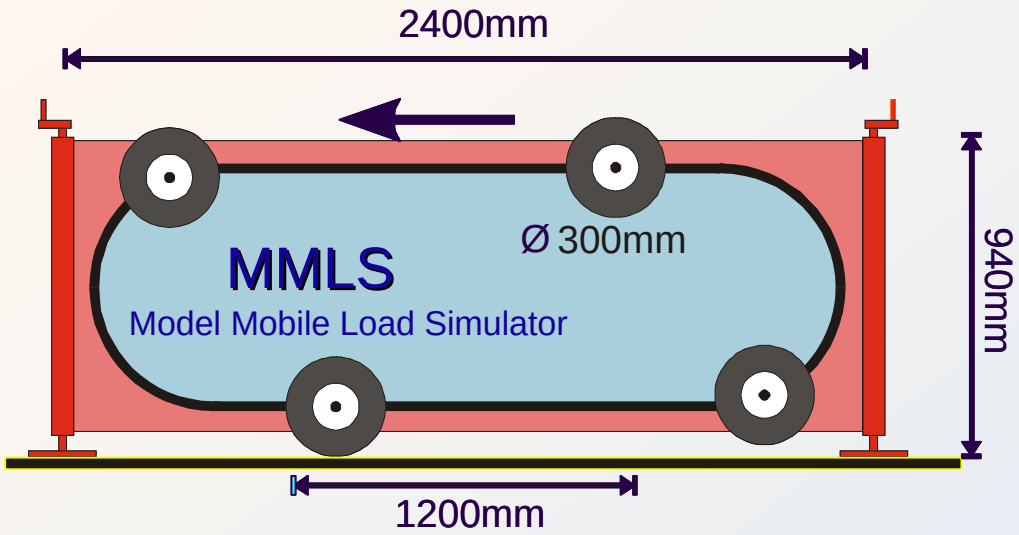
Reduction of Thickness



Lateral Contraction



Model Mobile Load Simulator



MMLS dimension: 2,400 x 940 mm
Length of the test section: 1.200 mm
Wheel diameter: 300 mm
Tire pressure: 600 kPa
Axle load: 2.1kN
Tire width: 160mm
Passing speed: 78m/s
Number of passings: 15'000
Temp: 23 & 35 °C
Lateral wandering: no (in this study)

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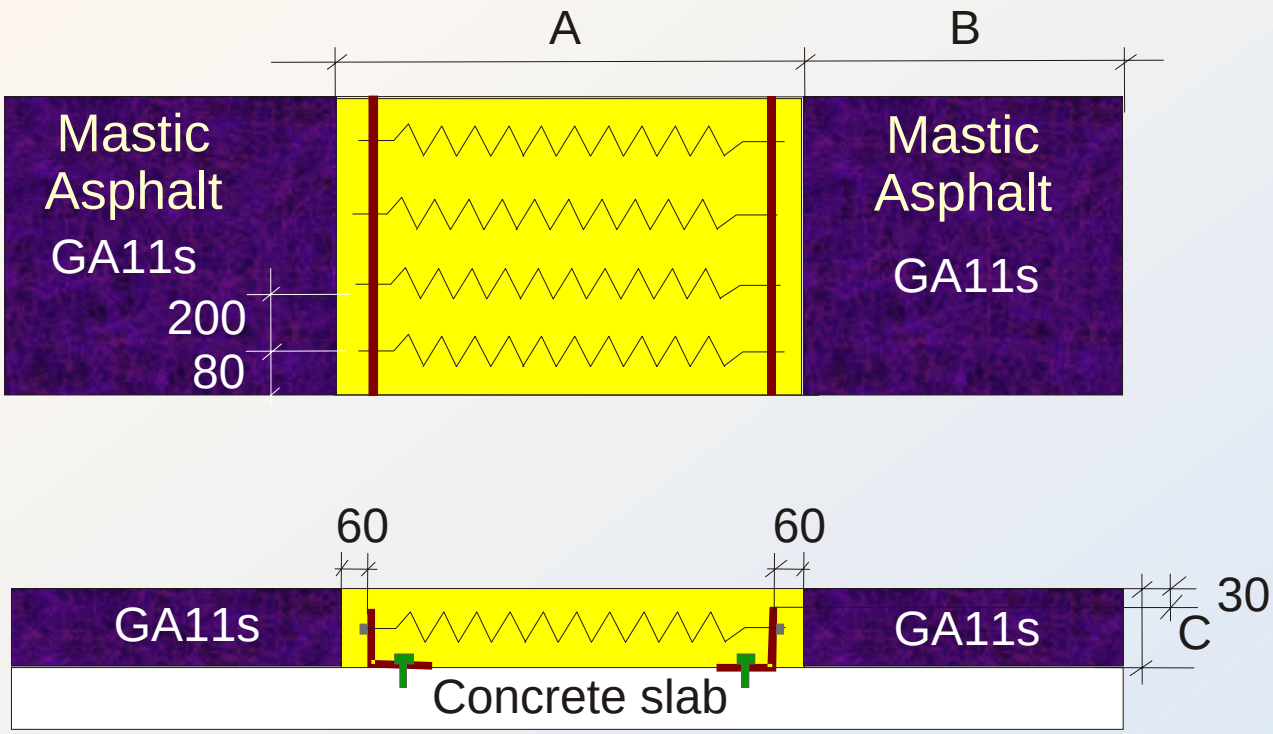
Dimensions of the Test Specimen

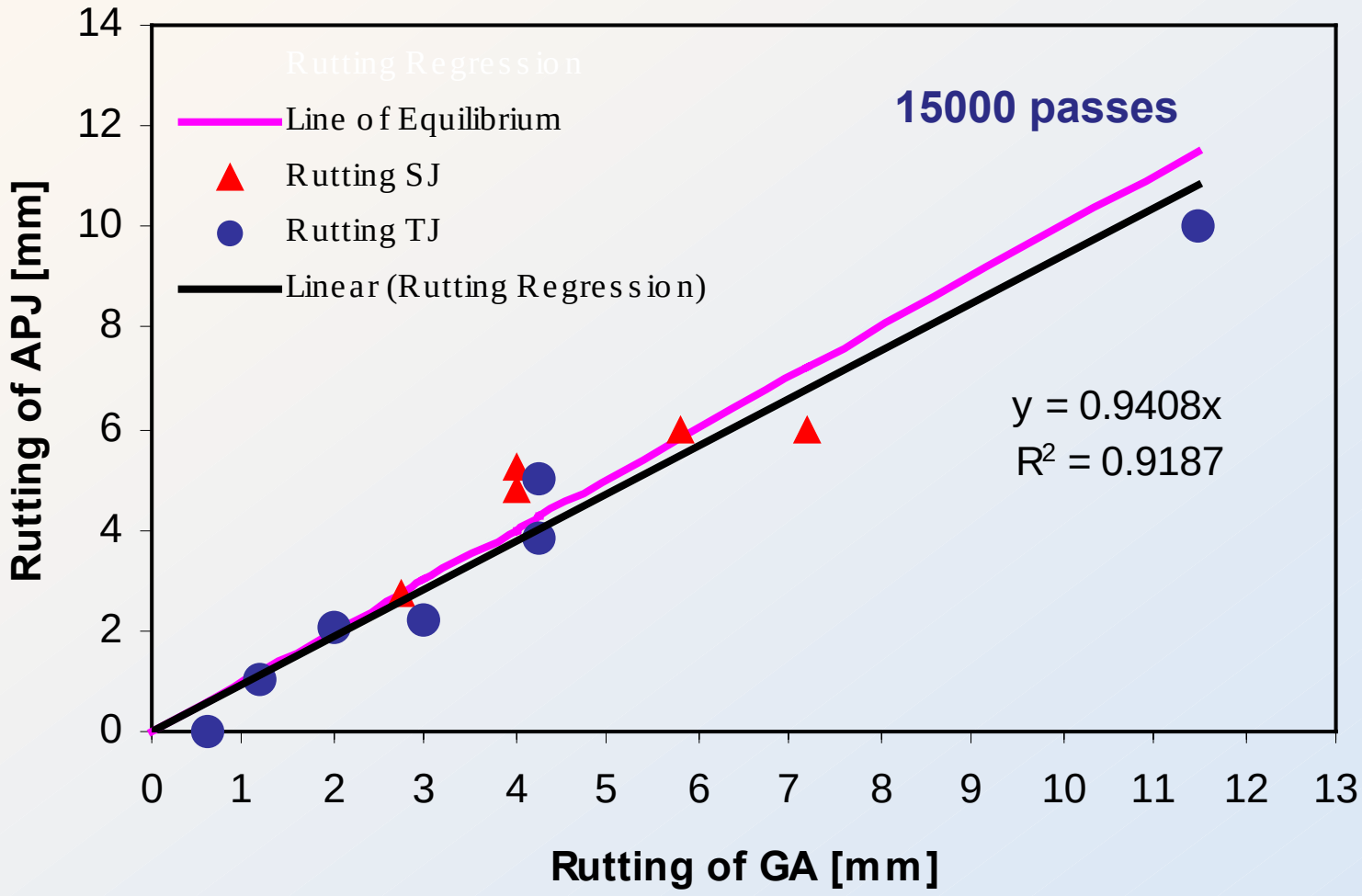
Dimensions of the test specimens in [mm]



SJ:
A = 1,000mm
B = 850mm
C = 120mm

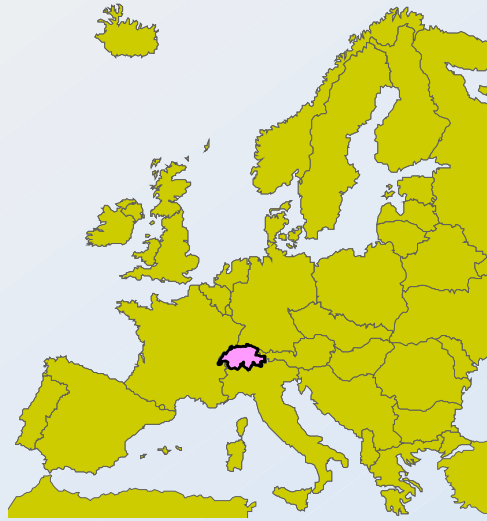
TJ:
A = 500mm
B = 1,050mm
C = 100mm

Rutting of GA11s APJ @35°C



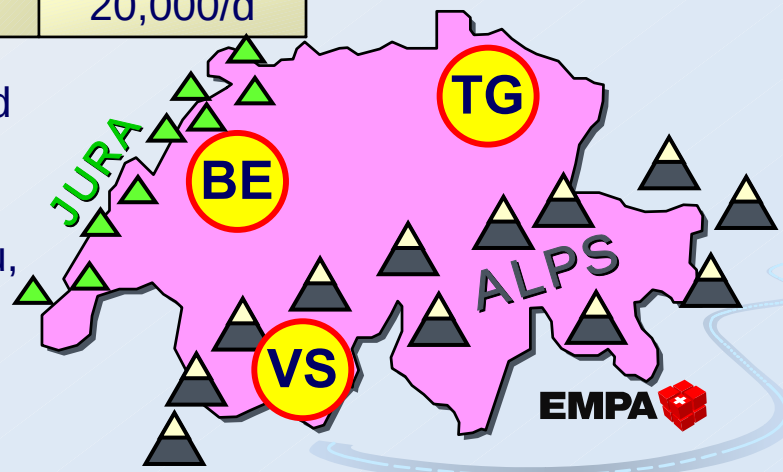
SJ Inspection Sites in Switzerland

Can-ton	Bridge	Num. of APJ's	Place-ment [yr]	Annual joint movement [mm]	SJ	Traffic
BE	#1	2	1995	65	900	7,000/d
	#2	1	1998		700	Moderate
	#3	1	97/98	60		Average
	#4	2	2000	100	900	22,000/d
VS	#5	4	2001	70	700	*)
	#6	1				
	#6	1		80	900	
TG	#7	4		100		20,000/d



#1: "Bönzigen"-Ramp,
#2: St. Johannsen,
#3: Biel/Alfermée,
#4: "Monbijou"-Bridge,
#5: "Hang"-Bridge,
#6: "Stuckisegg"-Bridge,
#7: "Thur"-Bridge,

***):** 250-800 lorries/d
BE: canton Bern,
VS: canton Wallis,
TG: canton Thurgau,



Visual Assessments of Sites (March/April 2002)

Can-ton	Bridge	Years under traffic	Water-tight	CR, SS, BL, MD	ES	Partially repaired	Assessment of state
BE	#1	6	Yes	None	None	Yes	**Sufficient**
BE	#2	4	Yes	None	None	No	Good
BE	#3	5	Yes	None	None	No	Good
BE	#4	2	Yes	None	None	No	Good
VS	#5	1	Yes	None	**Moder.**	No	Good
VS	#6	1	Yes	None	None	No	Good
VS	#6	1	Yes	None	None	No	Good
TG	#7	1	Yes	None	Moder.	No	Good

CR: Cracking,
SS: Side de-bonding (between pavement and SJ),
BL: Blistering,
MD: Material displacement,
ES: Edge de-bonding between SJ and concrete or metal plate at the bridge cordon or at the centre line of the motorway;

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Findings

- The **APJ systems** SJ proved promising regarding certain properties in the lab and performance on site .
- The new SJ systems can be expected to absorb the relevant necessary horizontal joint movements at **low temperature**.
- Positive **rutting** performance is expected from MMLS tests at 35°C with mastic asphalt GA11s, where roughly similar behavior was found for SJ than for the conventional TJ system.
- The SJ sites **inspected** after approx. 1 ... 6 years were intact and evidently fulfilled their function as a joint sealing.
- Experience shows, that **non-substantial defects** from binder accumulation with detached chippings from the surface edging can be avoided by ensuring optimum placement.
- Two relatively new sites suffered **edge stripping** at the bridge cordon and the centre strip. This problem was confirmed by low temperature movement tests where lateral contraction occurred.
- Finally, the site observation confirmed suitability of the relatively elaborate **system tests** conducted at EMPA.

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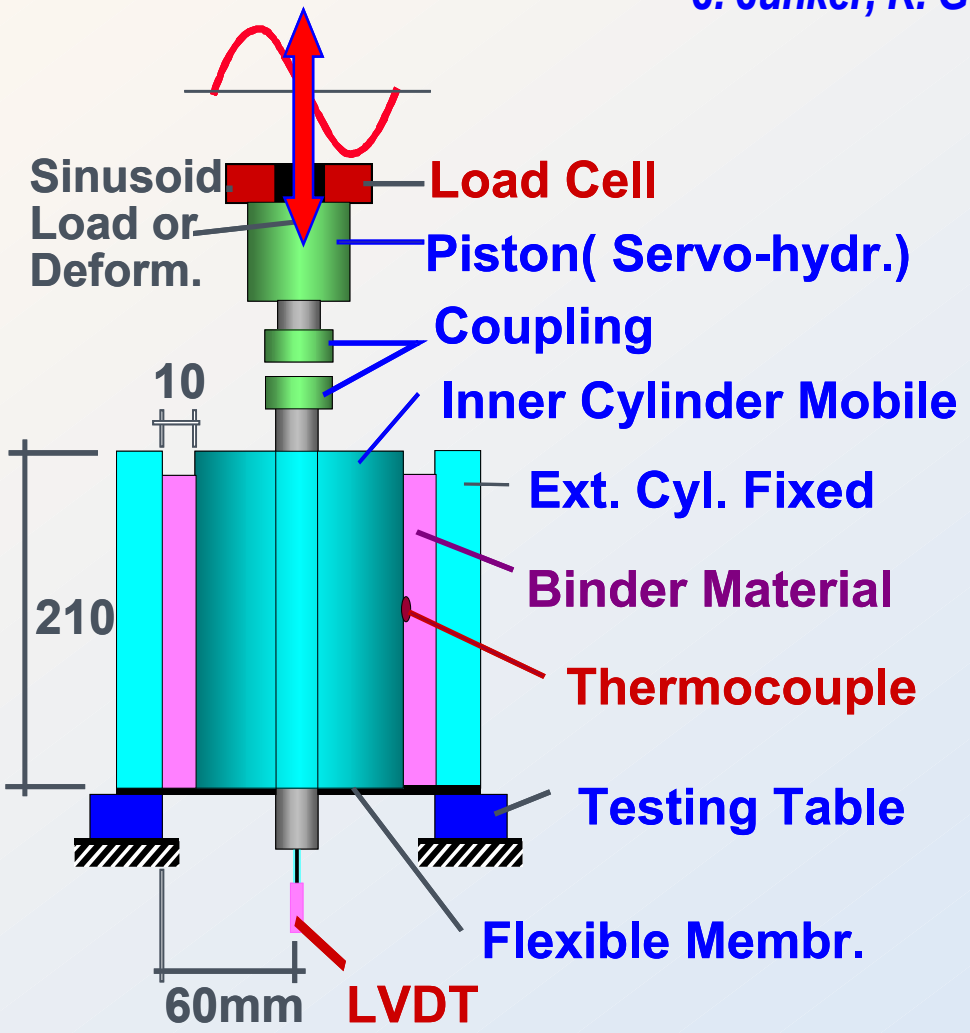
Joint Sealings

CoAxial Shear Test BINder

J. Junker, R. Gubler



Temperatures:
-20, -15,…,40°C

Frequencies:
0.125, 0.25, 0.5, 1, 2, 2, 4, 8Hz

$G' = G^* \cos \Phi$
$G'' = G^* \sin \Phi$
$\Phi = \arctan(G''/G')$

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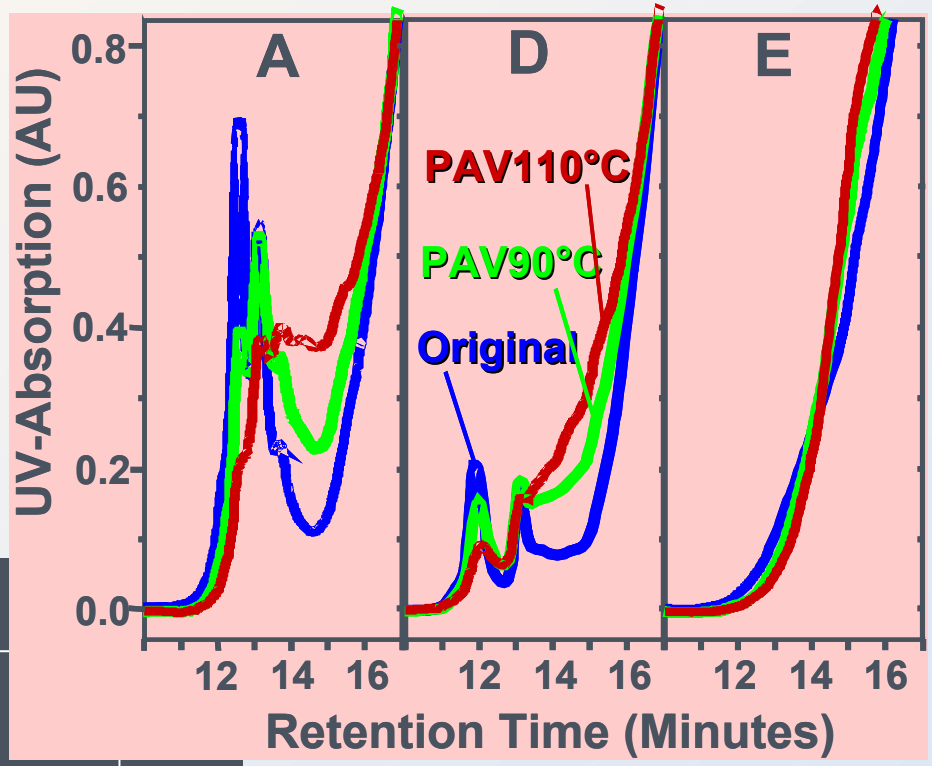
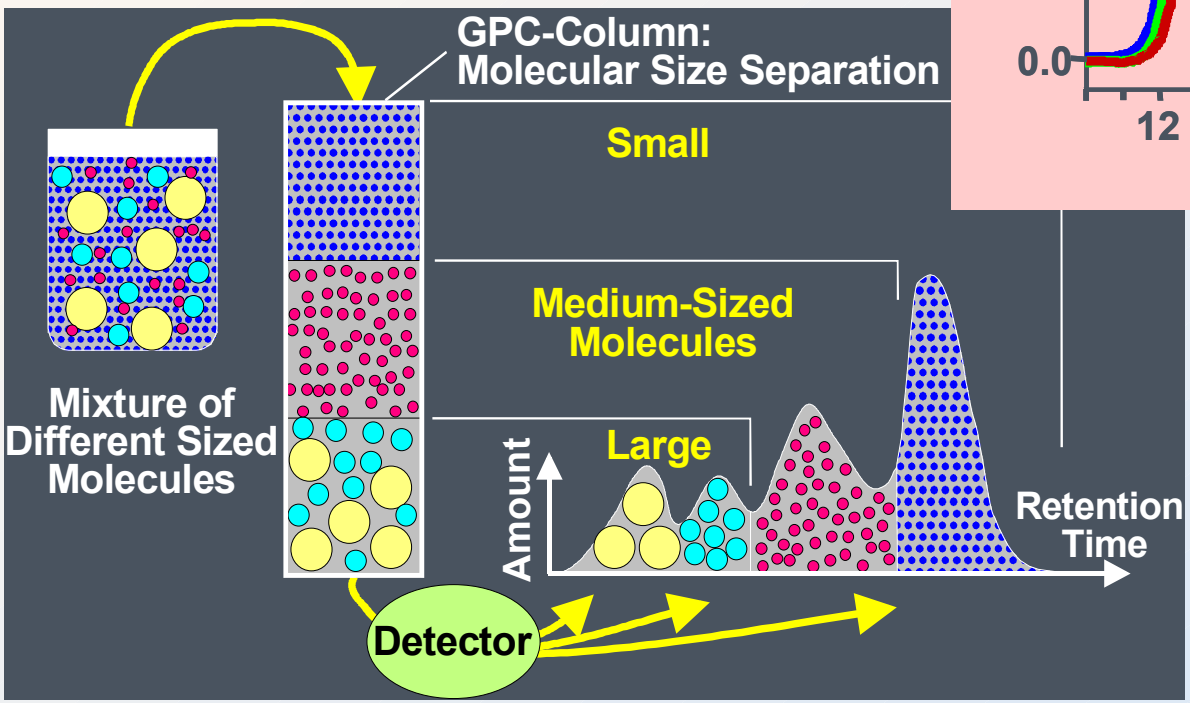
GPC Results

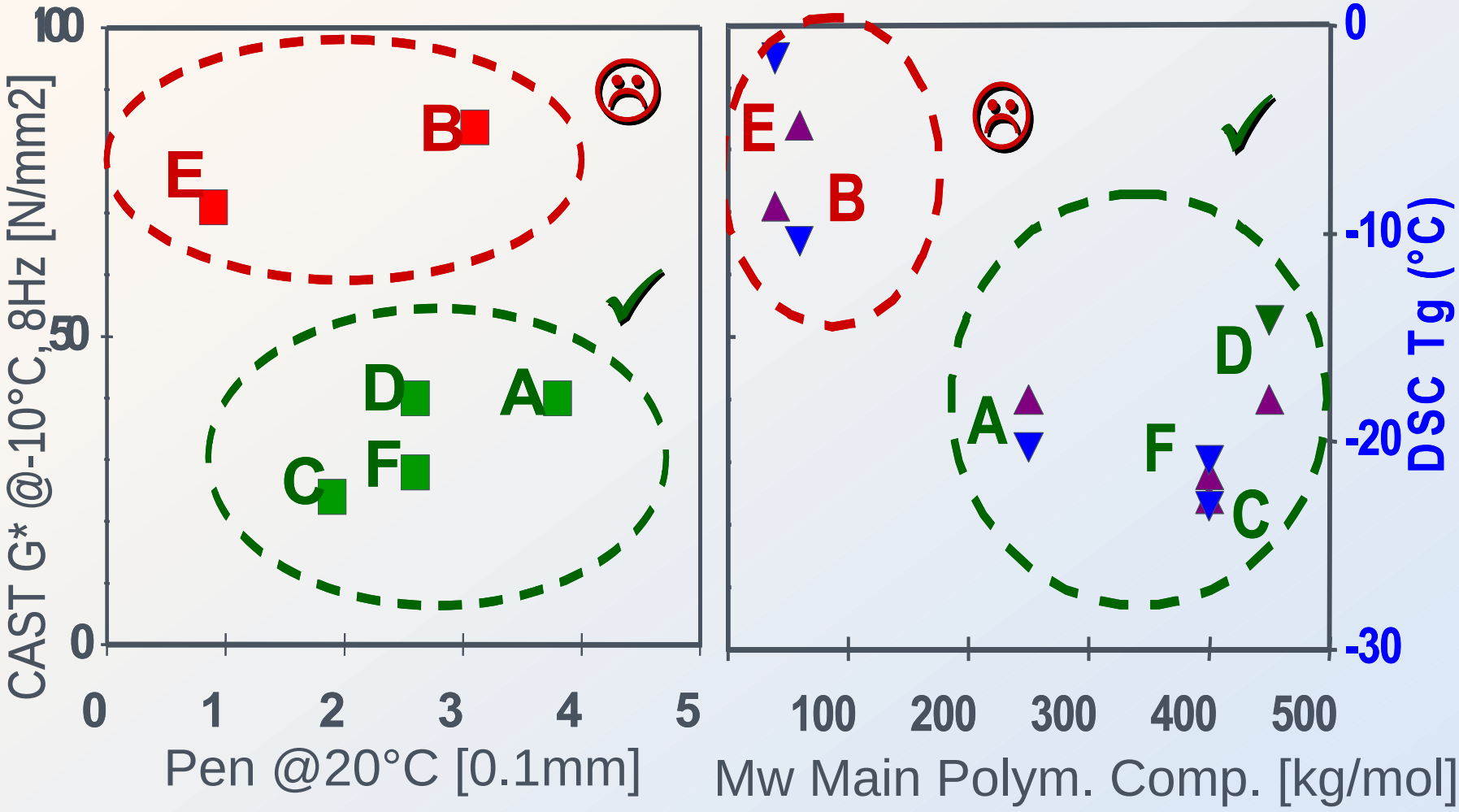
S. Hean





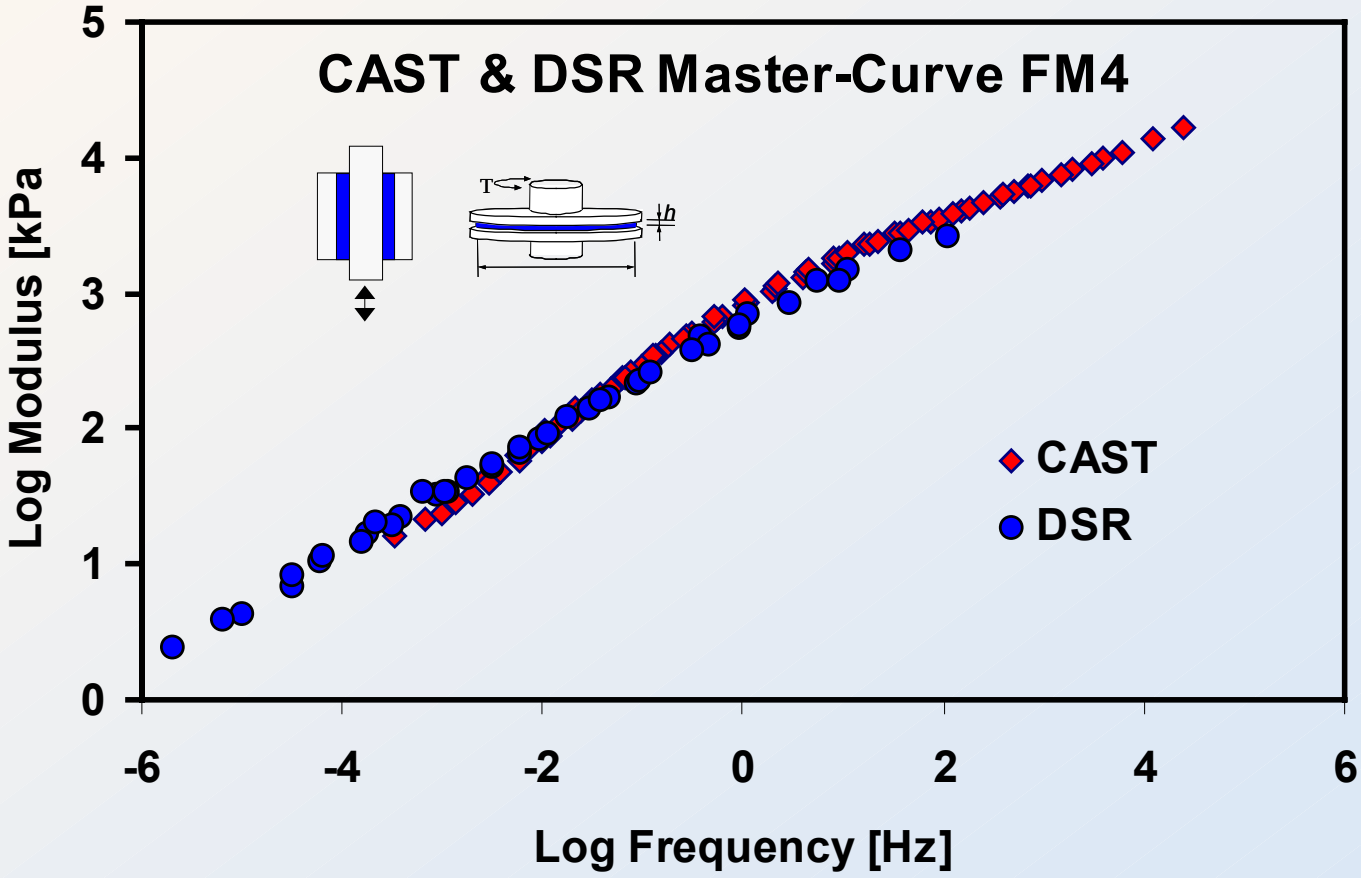
CAST/DSC/GPC/Pen(-20°C)

S. Hean



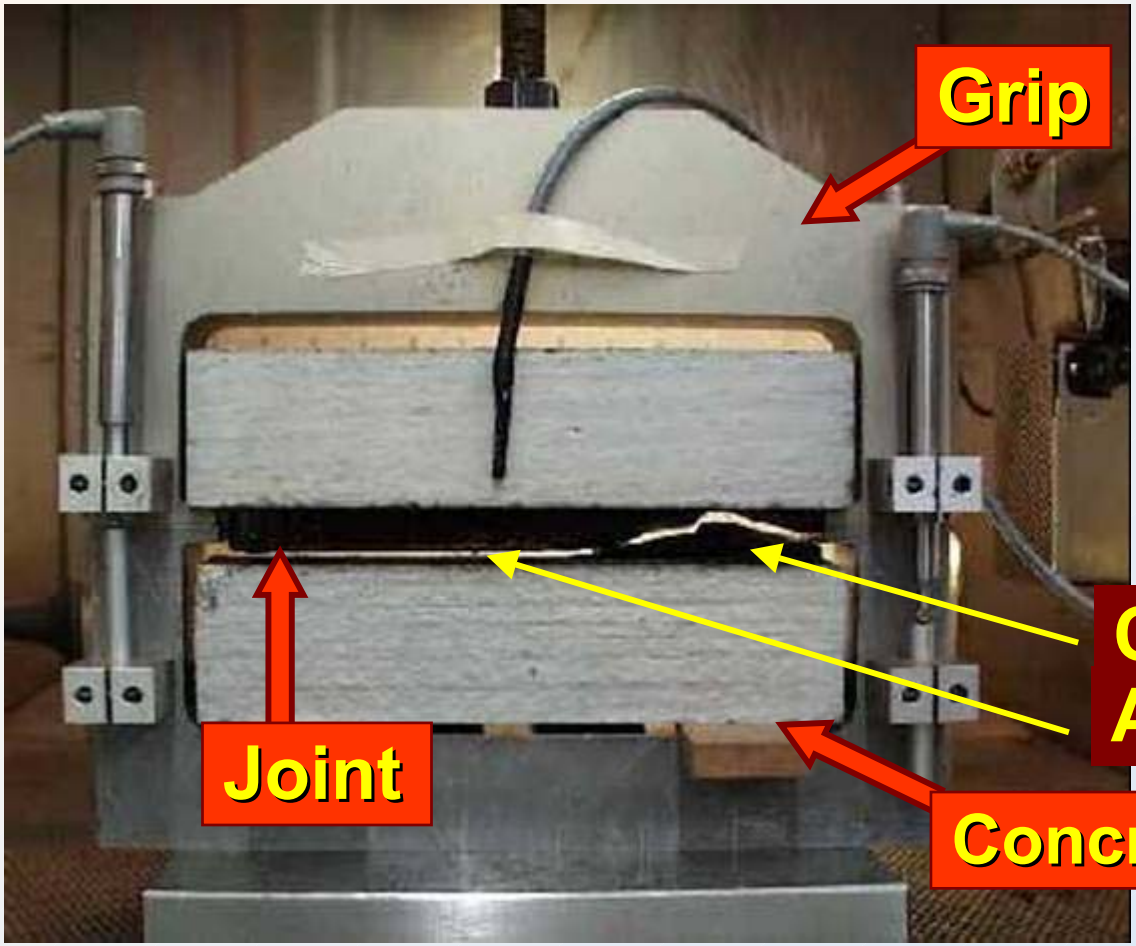
Joint Sealants CAST-DSR

S. Hean



Joint Sealants „LTPP“

- SBS JS1…7; after 0,1,2.5yrs alpine exposure, ….Expansion Test (Concrete Joints)

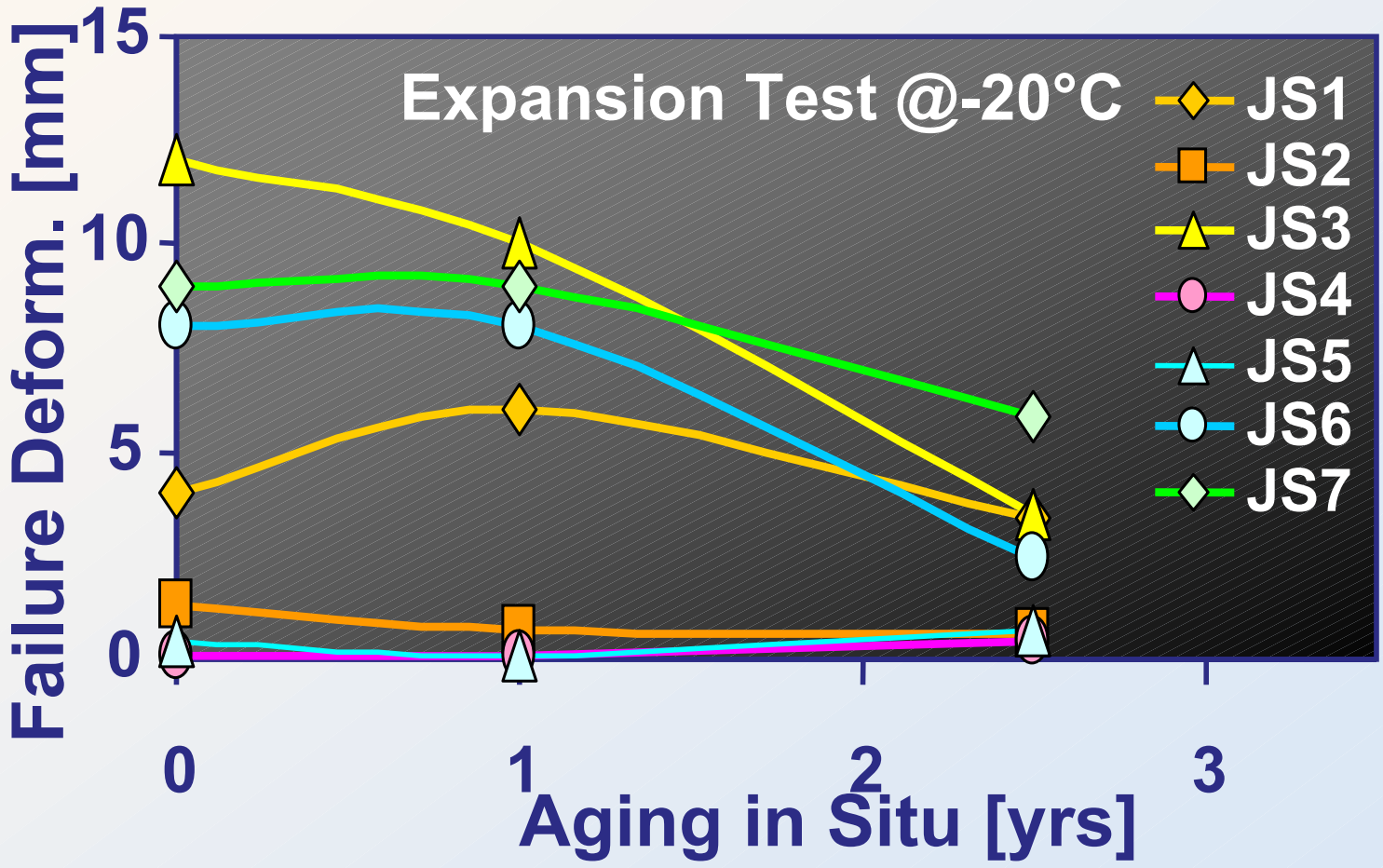


Joint: 150x13x20mm

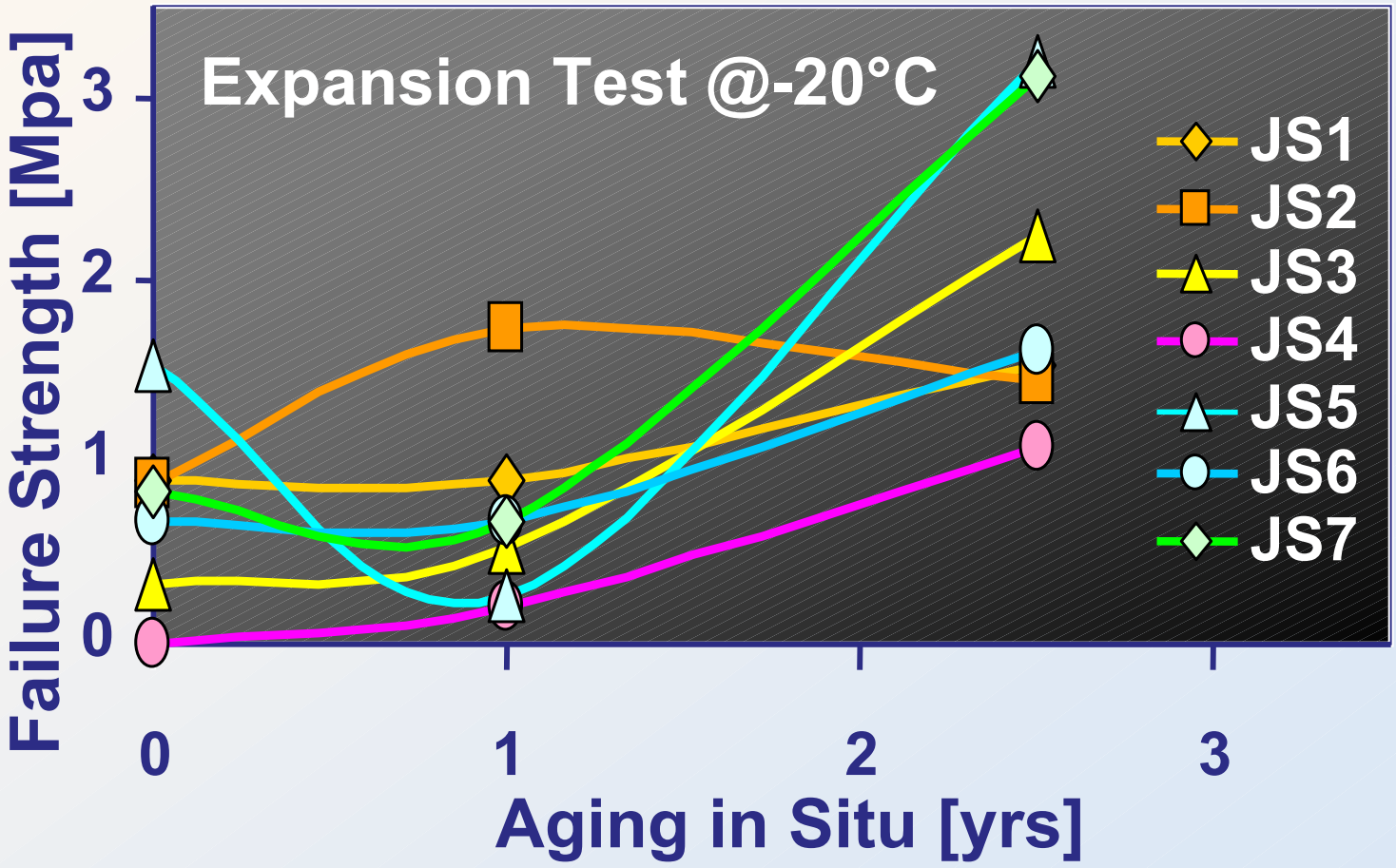
V=3mm/h

From 13mm to 28mm

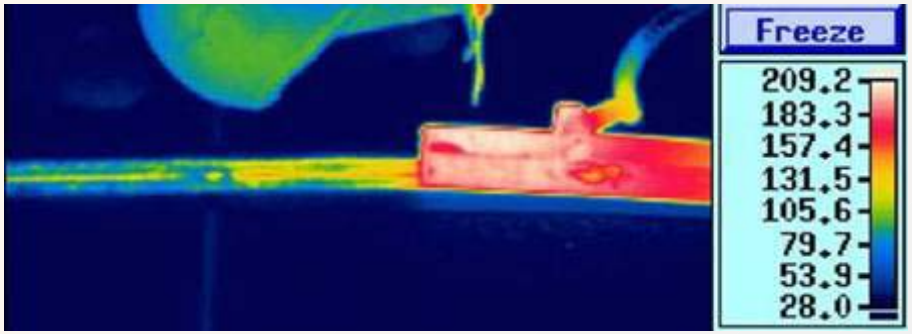
Concrete Joints (1)

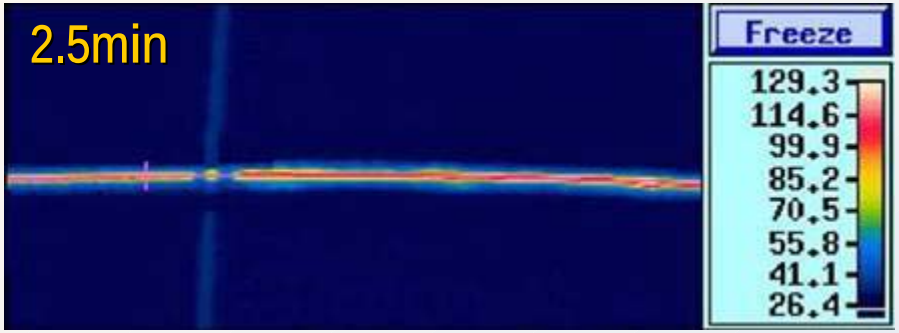


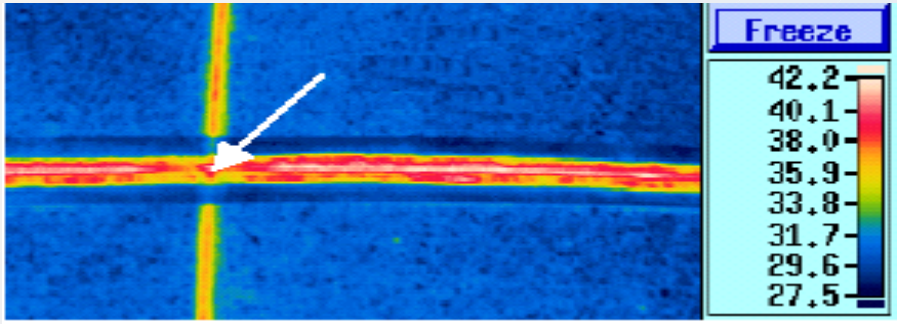
Concrete Joints (2)

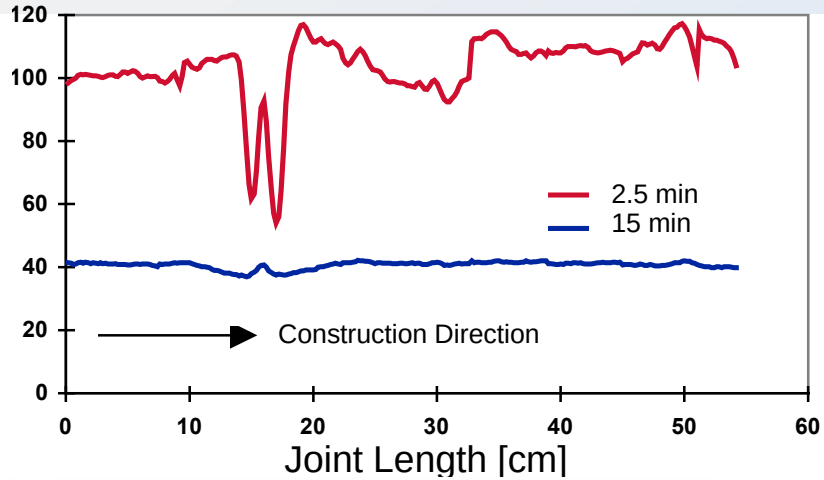


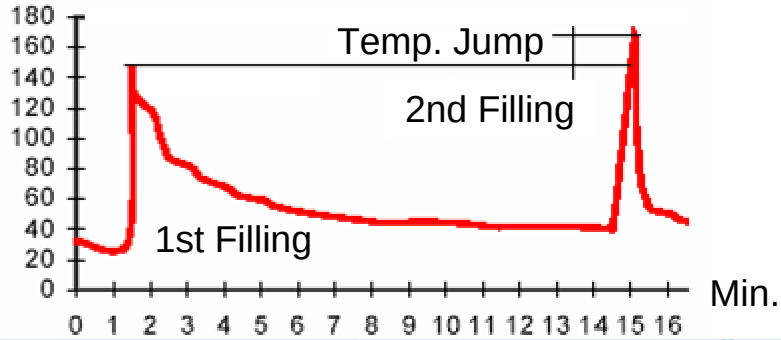
Construction of Joints







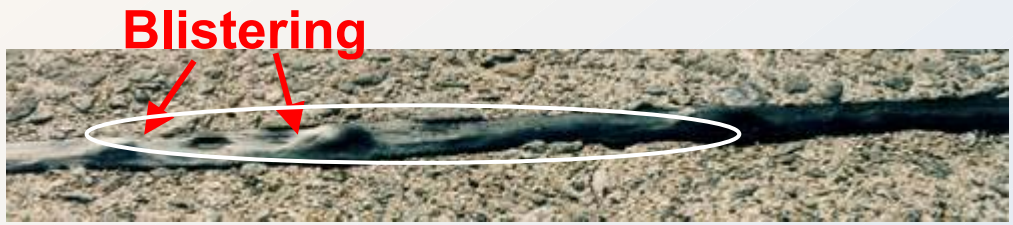




Long-Term Prop. (Joint F4)

S. Hean

FM4. 1 Year

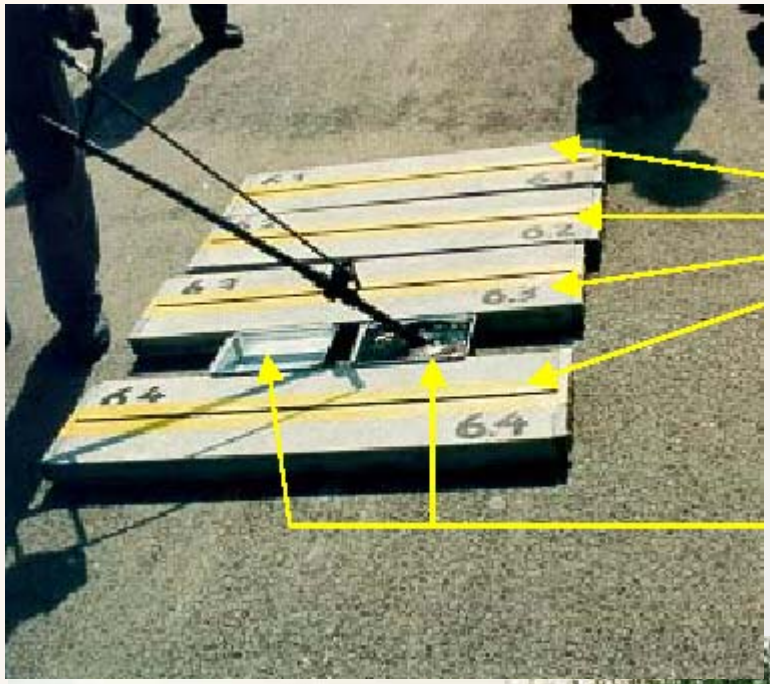


FM4. after 2.5 Years

FM4. after 2.5 Years

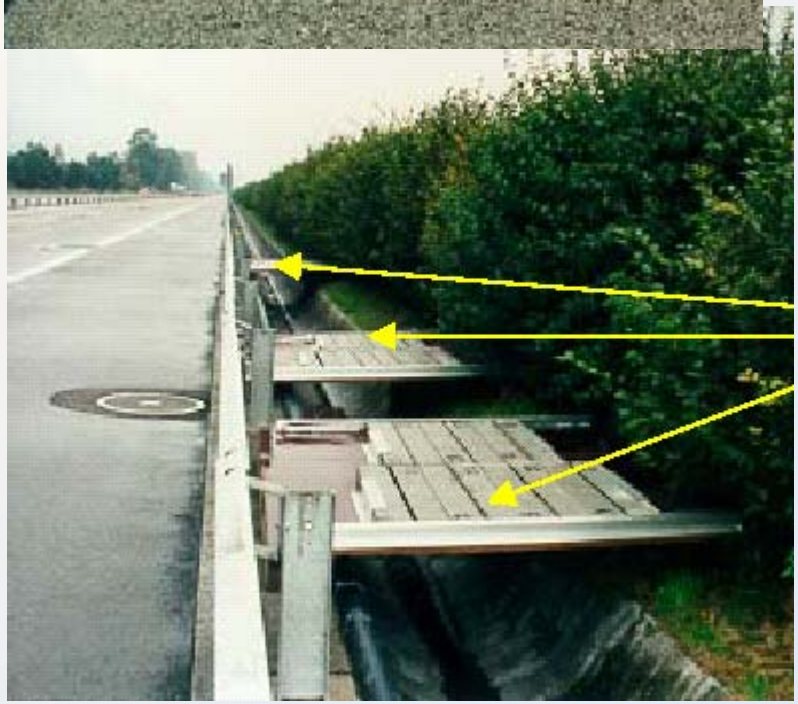
FM4. after 5 Years.

In-Situ Testing



Model Specimens

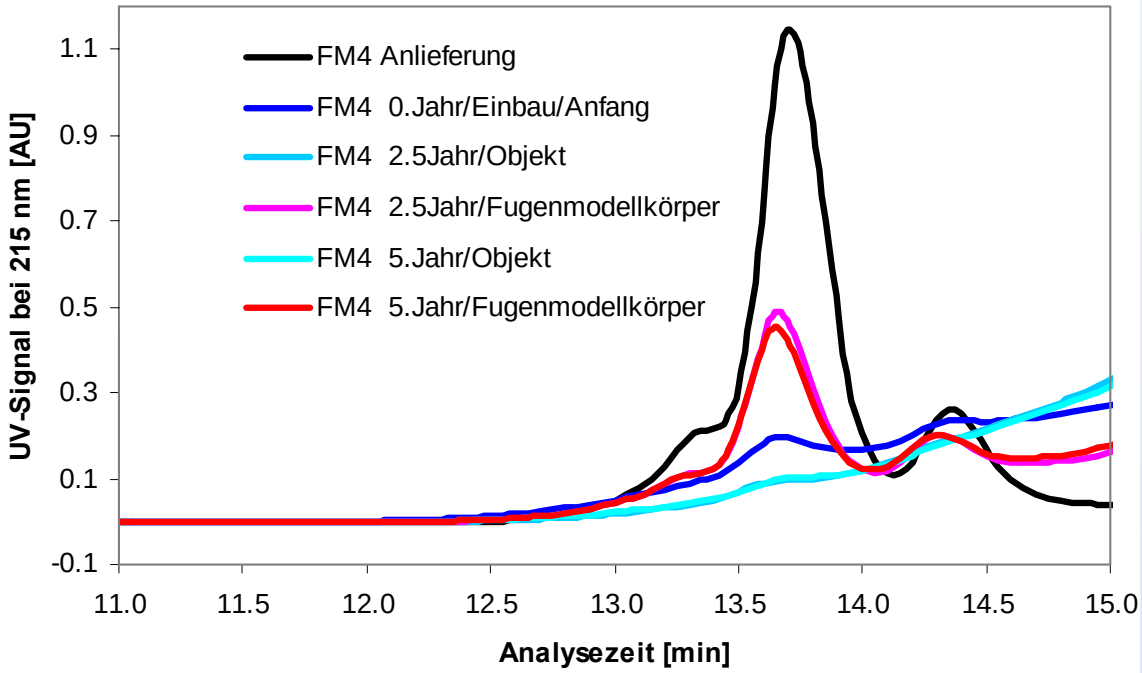
Lab Sampling

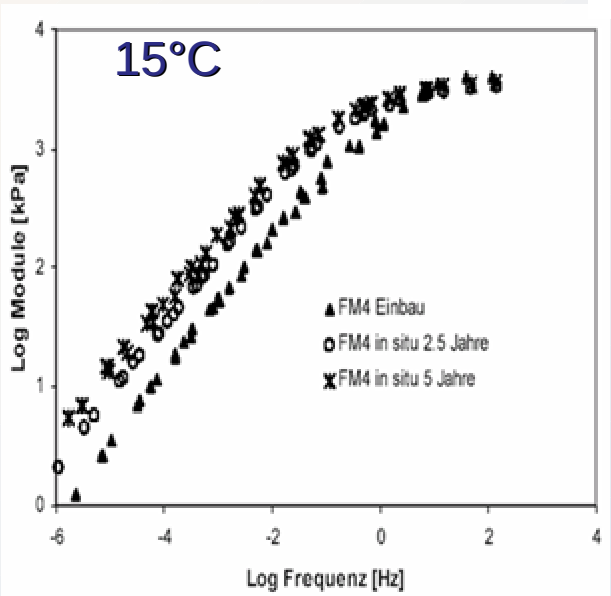


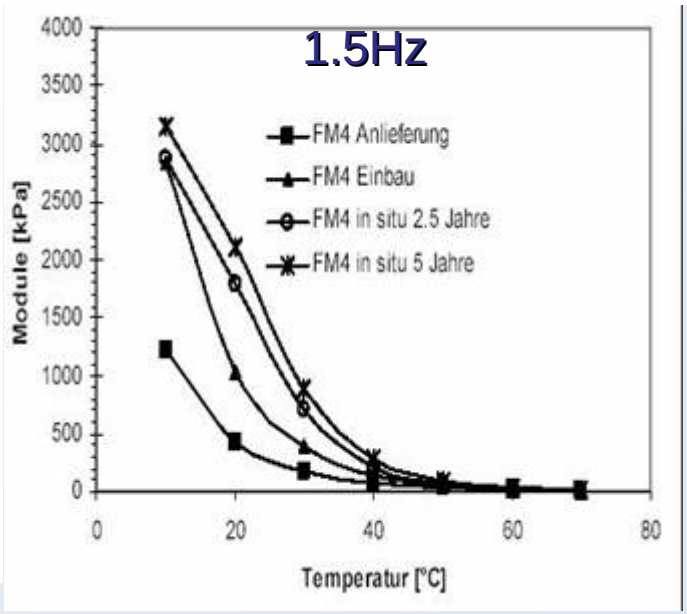
Installation of
Model Specimens

Long-Term Prop. (Joint F4)

S. Hean







Long-Term Prop. (Joint F6)

S. Hean

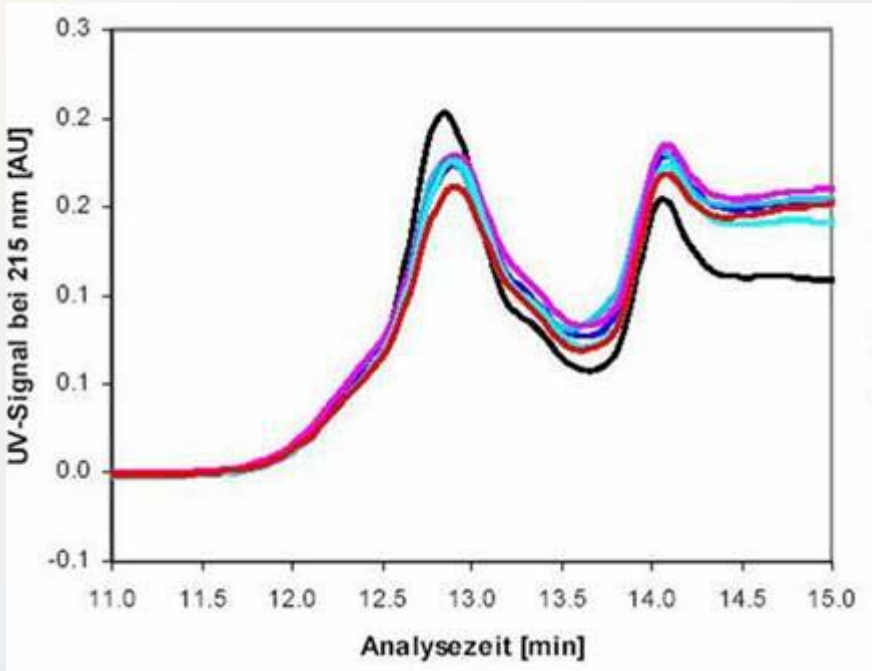
FM6. after 1 Year

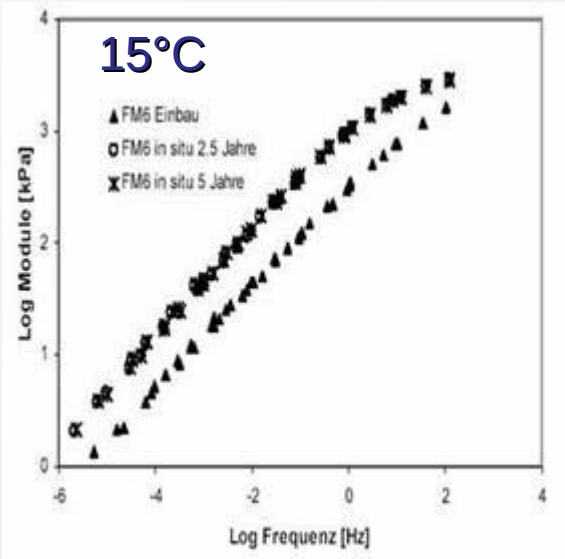
FM6. after 2.5 Years

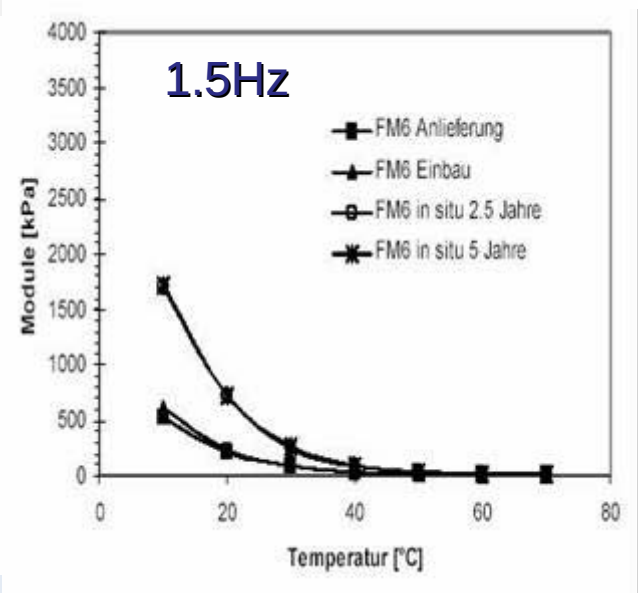
FM6. after 5 Years

Long-Term Prop. (Joint F4)

S. Hean







Thank You

EMPA