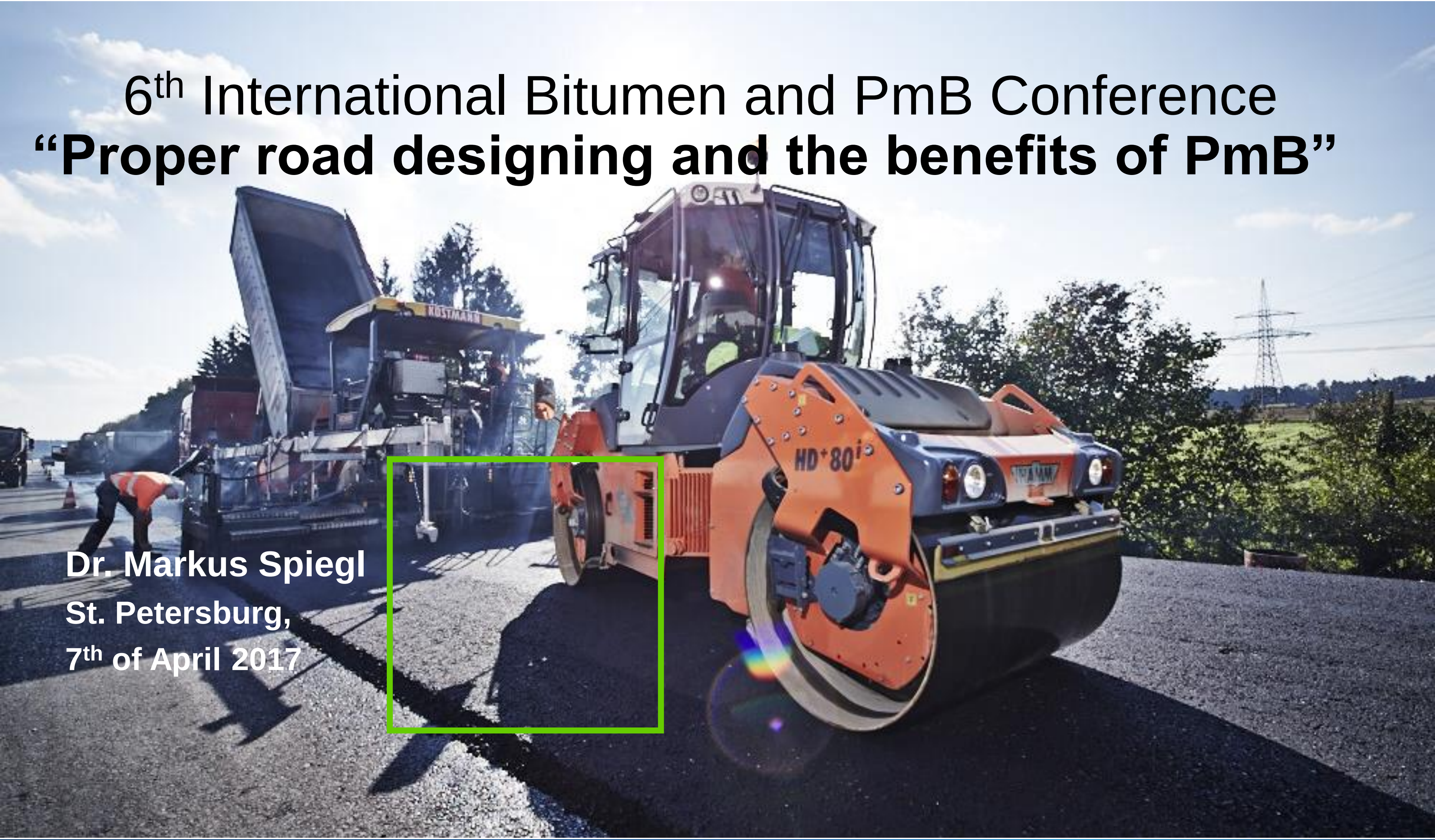


6th International Bitumen and PmB Conference

“Proper road designing and the benefits of PmB”

Dr. Markus Spiegl

St. Petersburg,

7th of April 2017

OMV Downstream

Moving more. Moving the future. OMV

Content

- **New Austrian asphalt pavement design**
  - Influencing parameters
  - Bitumen and asphalt mixture types
  - Input data – performance related material properties
  - Numeric model
- **Pavement Design examples**
  - Highway (load class 10)
- **Life Cycle Cost Analysis**
  - Example – Highway (load class 10)
- **Resume**

New Austrian asphalt pavement design
Influencing parameters

Traffic – heavy vehicles

- Standard collective (predetermined)
- Toll collecting data from ASFiNAG or traffic counting (resp. traffic estimation)
- Vehicle weighing data
  - ➔ **eligible depending on availability of data**

Climate

- Climate zone I or II

Performance related material properties

- Minimum stiffness S_{min} Asphalt (surface, binder and base layer)
- Fatigue resistance ε_6 (base layer)
  - ➔ **performance declaration of asphalt producer (initial type testing)**

Pavement structure

- Minimum bearing capacity of unbound subbase layers
- Type and thickness of unbound or bound subbase layers
- class of the unbound subbase layers according to RVS 08.15.01
  - ➔ **individual eligible**

Bituminous binder properties

OMV Paving grade bitumen 70/100

Requirement / Characteristic	Unit	Range of Values
Penetration at 25°C	x0.1 mm	70 - 100
Softening point	°C	43 -51
Mass change at 163°C	%	≤ 0.8
Retained penetration	%	≥ 46
Softening point after hardening	°C	≥ 45
Increase in softening point	°C	≤ 9
Flash point	°C	≥ 230
Fraass breaking point	°C	≤ – 10
Solubility	% (m/m)	≥ 99
Dynamic viscosity at 60°C	Pa.s	≥ 90
Kinematic viscosity at 135°C	mm²/s	≥ 230

Bituminous binder properties

Type of Binder acc. EN 14023		OMV Starfalt® PmB 25/55-65	45/80-65	45/80 RC	PmB HiM
Requirement / Characteristic	**Unit**	**Range of Values**			
Penetration at 25°C	x0.1 mm	25 - 55	45 - 80	45 - 80	45-80
Softening point	°C	≥ 65	≥ 65	≥ 70	≥ 80
Force ductility	J/cm²	≥ 3 (5°C) ≥ 3 (10°C)	≥ 3 (5°C)	≥ 3 (5°C)	≥ 3 (10°C)
Mass change at 163°C	%	≤ 0,5	≤ 0,5	≤ 0,5	≤ 0,5
Retained penetration	%	≥ 60	≥ 60	≥ 60	≥ 60
Increase in softening point	°C	≤ 8	≤ 8	≤ 8	≤ 8
Flash point	°C	≥ 250	≥ 250	≥ 250	≥ 250
Fraass breaking point	°C	≤ – 12	≤ – 18	≤ – 18	≤ – 20
Elastic recovery (25°C)	%	≥ 80	≥ 80	≥ 80 (95)	≥ 80 (95)
Storage stability - difference in softening point	°C	≤ 5	≤ 5	≤ 5	≤ 5
Elastic recovery (25°C) acc. to EN 12607	%	≥ 60	≥ 70	≥ 70 (80)	≥ 70 (80)

Asphalt mixture types

Surface layer

- AC 11 surface 70/100
- AC 11 surface PmB 45/80-65
- AC 11 surface PmB 45/80-80 (PmB HiM)

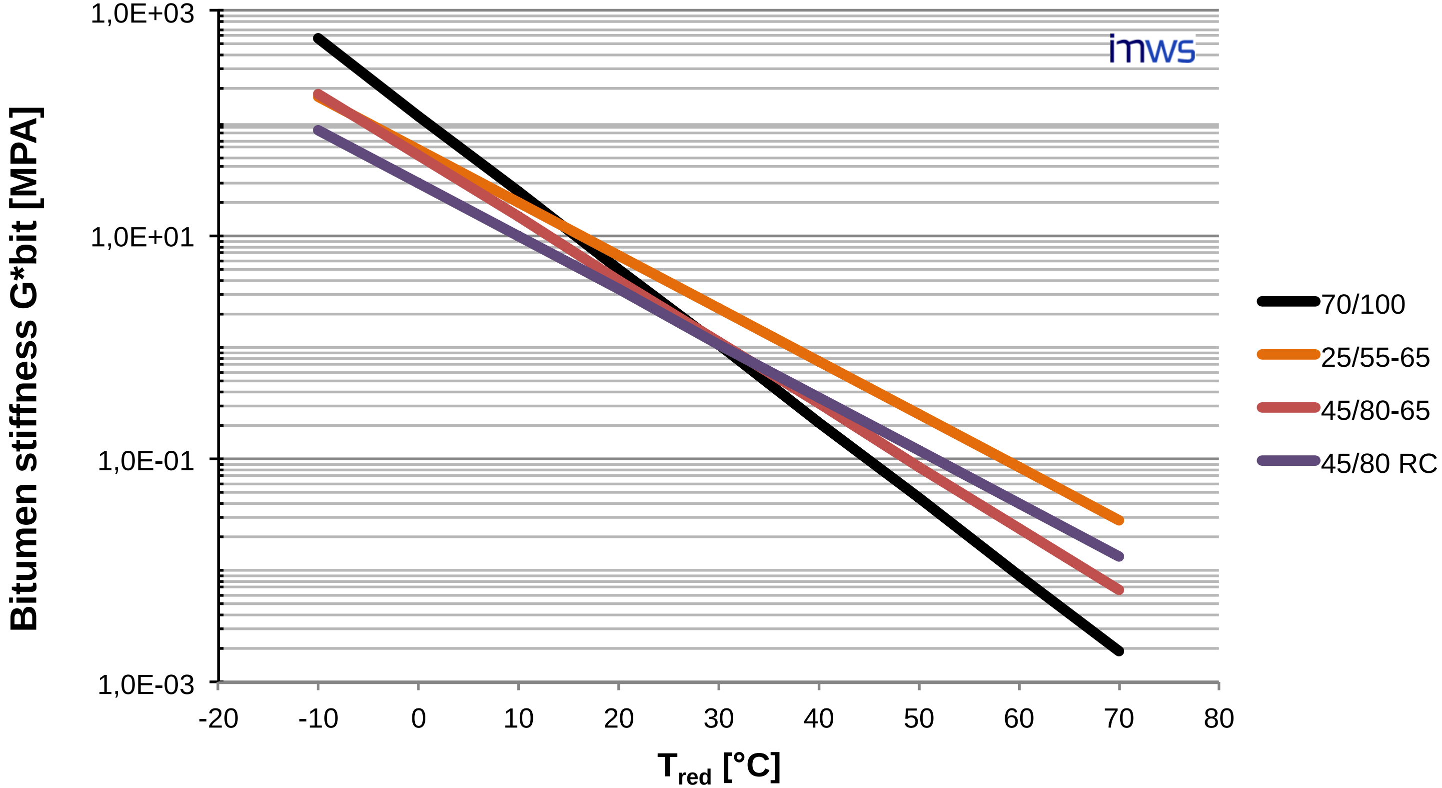
Binder layer

- AC 22 binder 70/100
- AC 22 binder PmB 25/55-65
- AC 22 binder PmB 45/80-65
- AC 22 binder PmB 45/80 RC with 20 % RAP
- AC 22 binder PmB 45/80-80 (PmB HiM)

Base layer

- AC 32 base 70/100
- AC 32 base PmB 45/80-65
- AC 32 base PmB 45/80 RC with 20% RAP
- AC 32 base PmB 45/80-80 (PmB HiM)

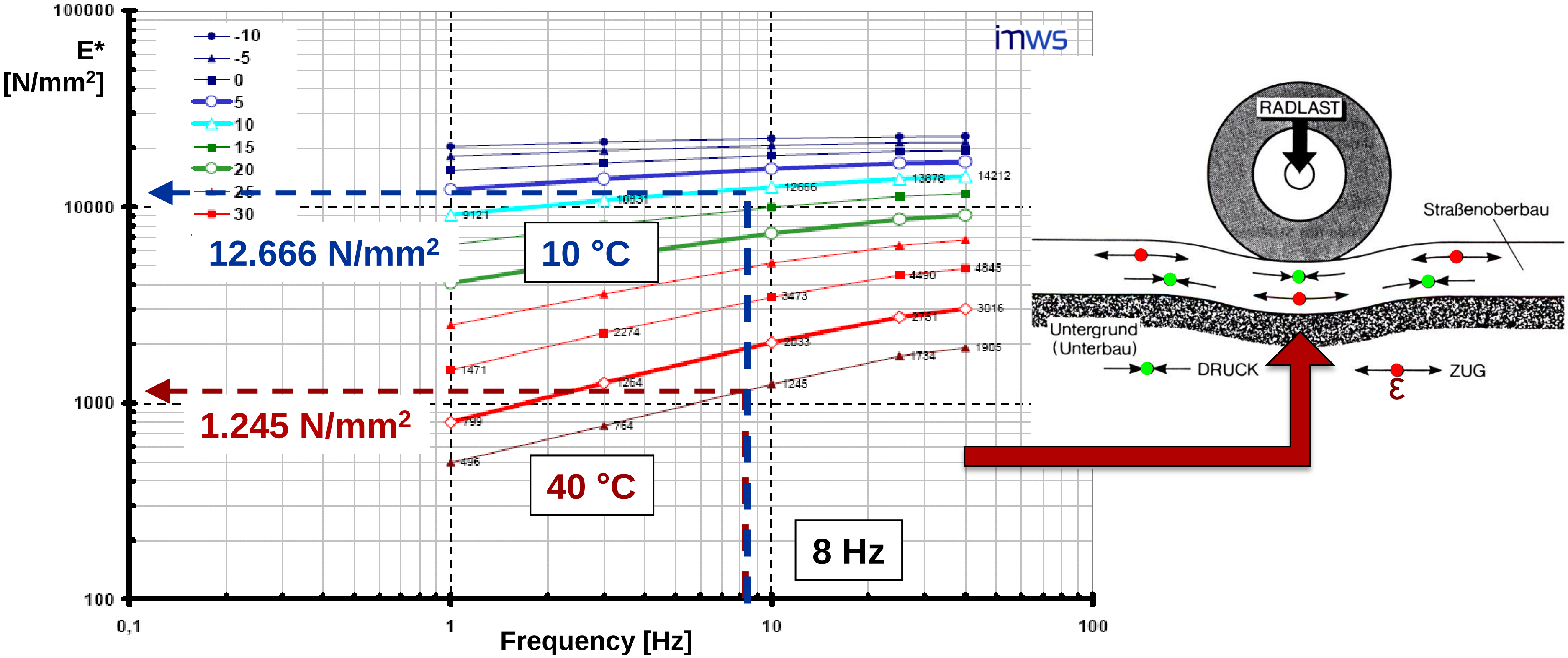
New Austrian asphalt pavement design
Rheological properties (DSR) of the binder



Master curves of the selected bituminous binders to calculate the input parameters for the Vienna Modell

New Austrian asphalt pavement design
Performance related properties of asphalt mix

Asphalt property – stiffness (4PB acc. EN 12697-26)



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New Austrian asphalt pavement design
Stiffness – Vienna Model

$$\boxed{S_{mix}(T)} = \frac{p}{145{,}0377} \cdot \left[a \cdot \left(1 - \frac{\boxed{VMA}}{100} \right) + 145{,}0377 \cdot 3 \cdot \boxed{\left| G^{*}_{bit} \right| (T)} \cdot \left(\frac{\boxed{VFB \cdot VMA}}{10.000} \right) \right] +$$

$$+ \frac{(1 - p_c)}{145{,}0377} \cdot \left[\frac{1 - \frac{\boxed{VMA}}{100}}{a} + \frac{\boxed{VMA}}{\boxed{VFB} \cdot 145{,}0377 \cdot 3 \cdot \boxed{\left| G^{*}_{bit} \right| (T)}} \right]^{-1}$$

$$p = \frac{\left(b + \frac{\boxed{VFB} \cdot 145{,}0377 \cdot 3 \cdot \boxed{\left| G^{*}_{bit} \right| (T)}}{\boxed{VMA}} \right)^{c}}{\left(d + \frac{\boxed{VFB} \cdot 145{,}0377 \cdot 3 \cdot \boxed{\left| G^{*}_{bit} \right| (T)}}{\boxed{VMA}} \right)^{c}}$$

- **Volumetric property** of the asphalt
- **Bitumen stiffness G*** at the relevant Temperature & loading frequency
- **Dynamic stiffness S_{mix}** as input for the road design

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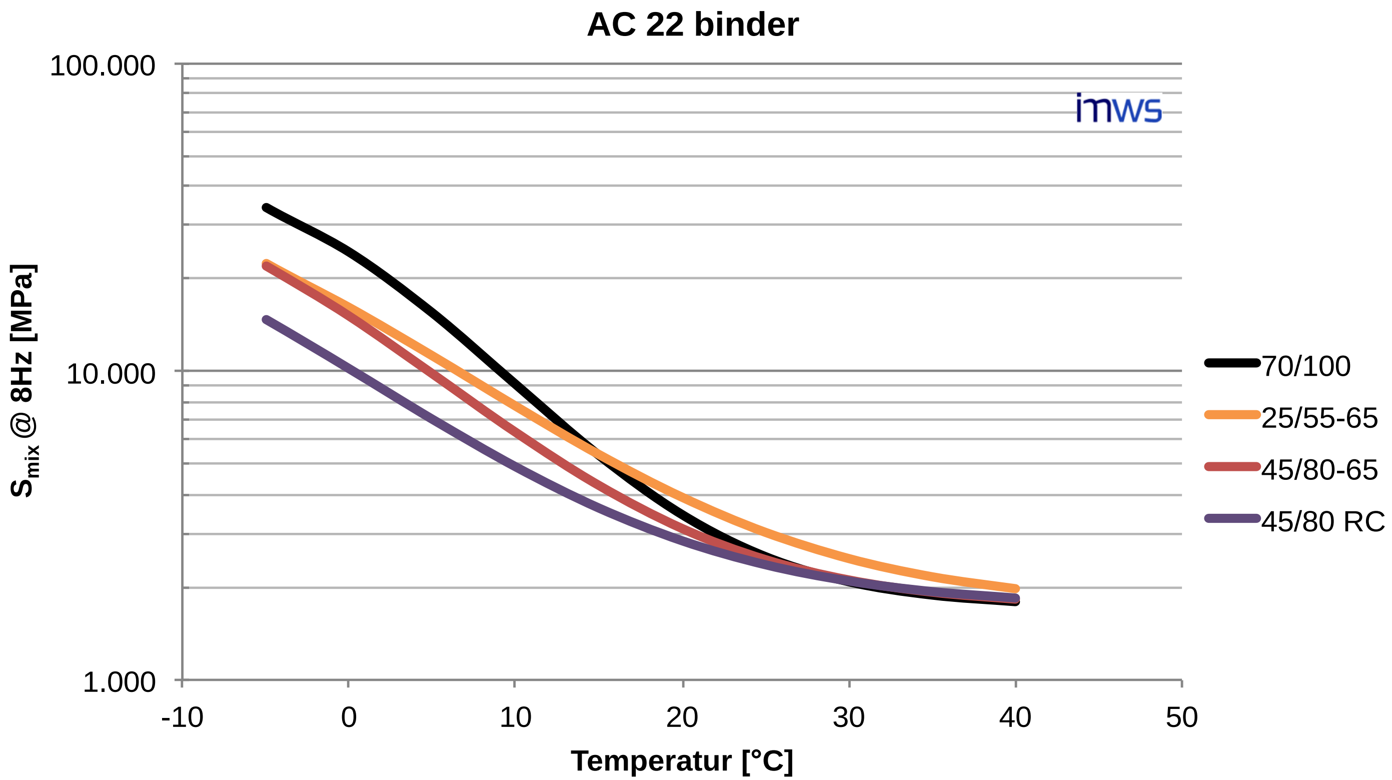
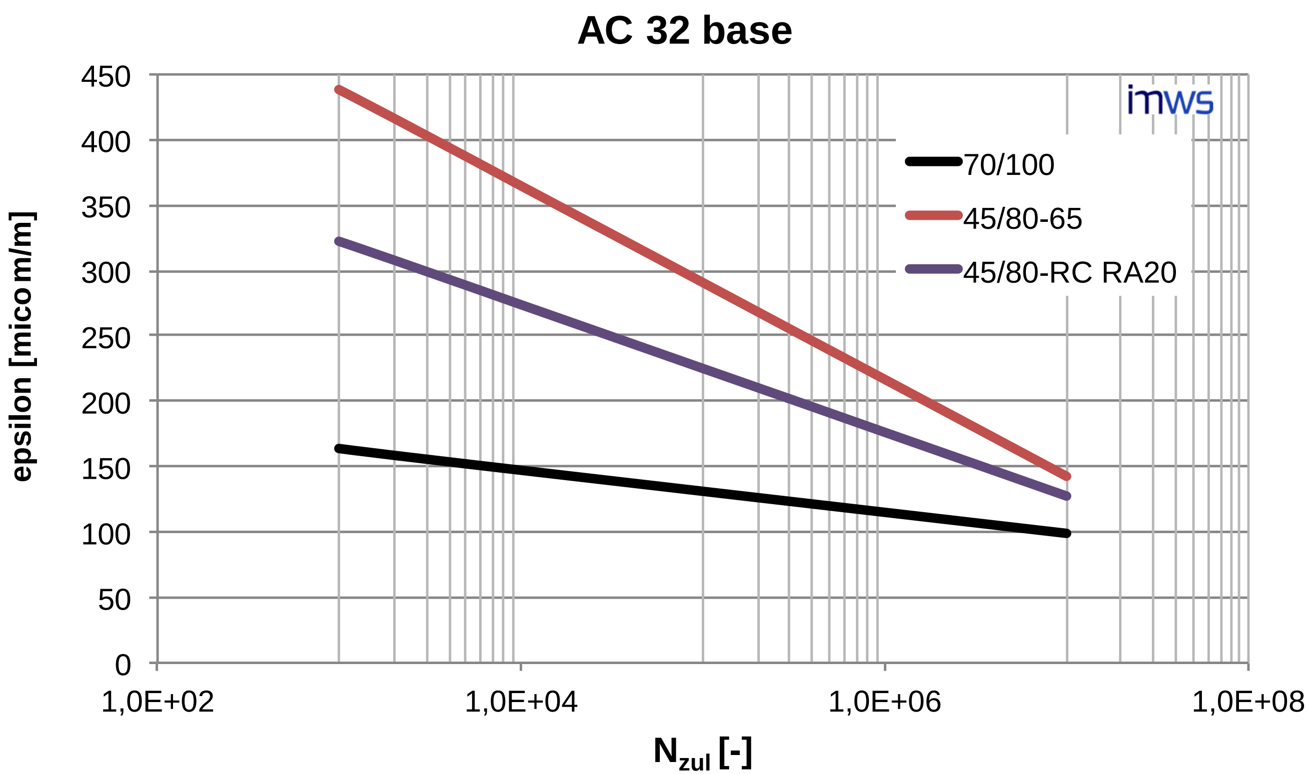
New Austrian asphalt pavement design
Performance related properties of asphalt mix

Asphalt stiffness – Vienna Model



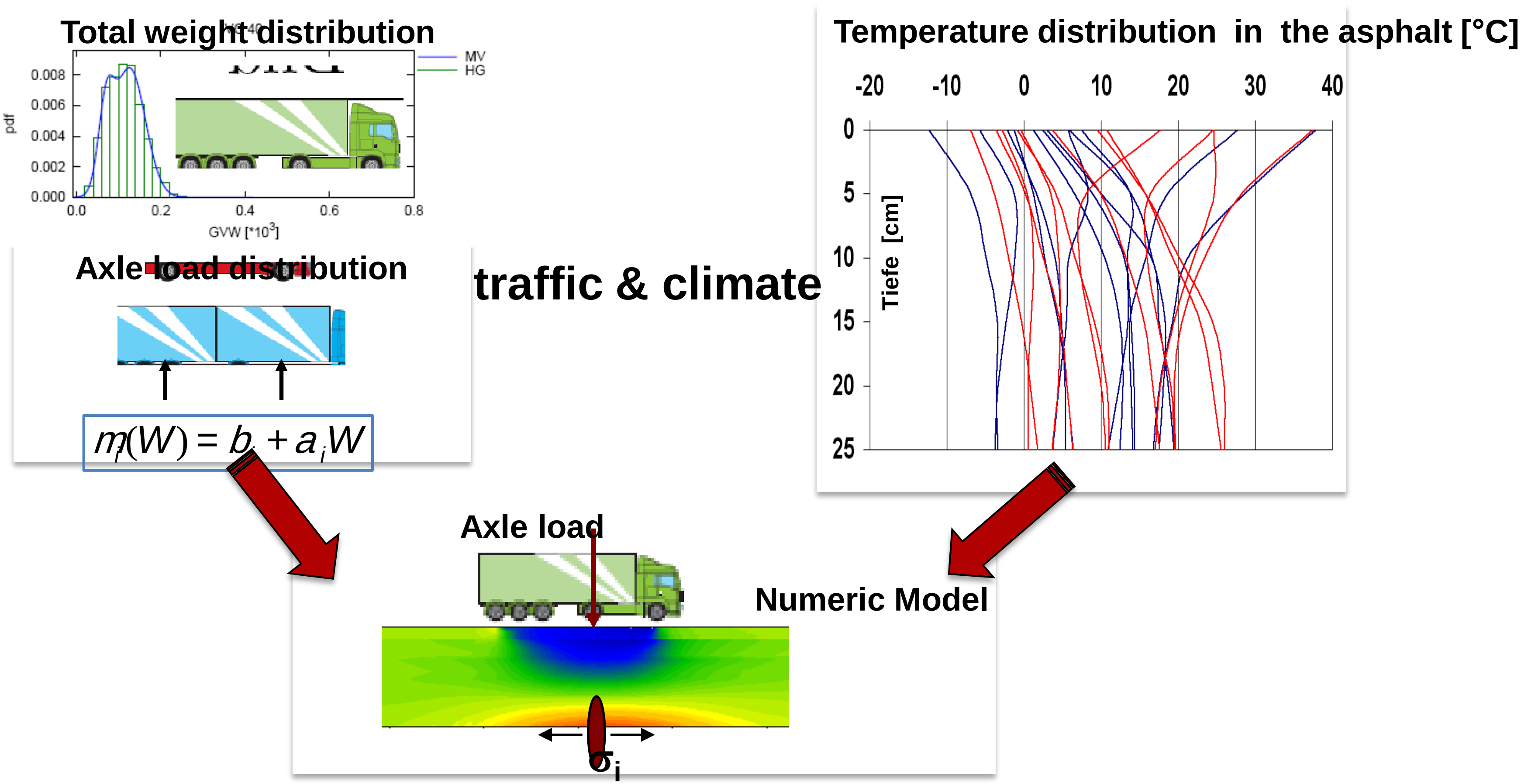
Temperature depended stiffness S_{mix} for AC 22 binder with different bituminous binders

New Austrian asphalt pavement design
Performance related properties of asphalt mix



Fatigue curve based on 4 point bending beam tests for the used asphalt mixtures and bituminous binders

Numeric Model
Determination of the primary effect



New road design approach for asphalt roads

Vienna Model – fatigue criteria

Fatigue parameter

Allowed load cycles

$$\boxed{N_{zul}} = \frac{\boxed{k_1(T)}}{\boxed{F(e_6)}} \left[\frac{\boxed{\left|E^*\right|(T,f)}}{\boxed{s_V}} \right]^{\boxed{k_2(T)}}$$

Vienna Model

requirement

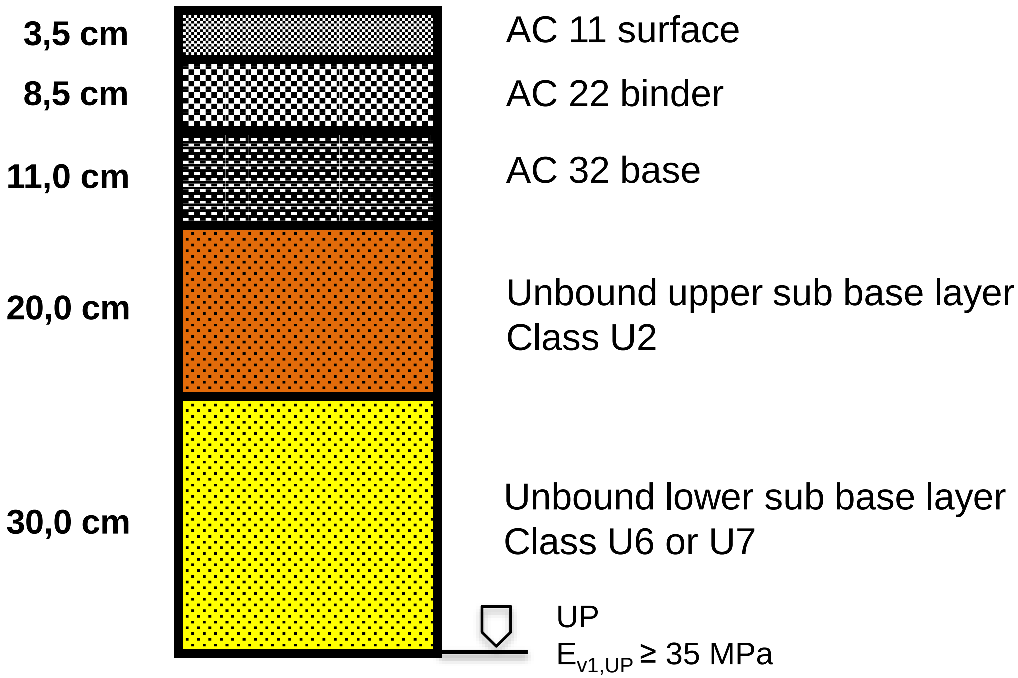
Resistance against fatigue

Stress analysis
numeric model

Calculation of the allowed load cycles until the pavement failure

Example
Highway load class 10

Pavement structure



→ Variant

- 70/100
- PmB 45/80-65
- PmB 25/55-65
- PmB 45/80 RC
- PmB 45/80-80

Example
Highway load class 10

Calculation of the life time until the pavement fails

Thickness of the asphalt pavement: 23 cm

- Model asphalt catalogue

Variant I:	3,5 cm	AC 11 surface	70/100
	8,5 cm	AC 22 binder	70/100
	11,0 cm	AC 32 base	70/100
Variant II:	3,5 cm	AC 11 surface	PmB 45/80-65
	8,5 cm	AC 22 binder	70/100
	11,0 cm	AC 32 base	70/100
Variant IIIa:	3,5 cm	AC 11 surface	PmB 45/80-65
	8,5 cm	AC 22 binder	PmB 45/80-65
	11,0 cm	AC 32 base	70/100
Variant IIIb:	3,5 cm	AC 11 surface	PmB 45/80-65
	8,5 cm	AC 22 binder	PmB 25/55-65
	11,0 cm	AC 32 base	70/100

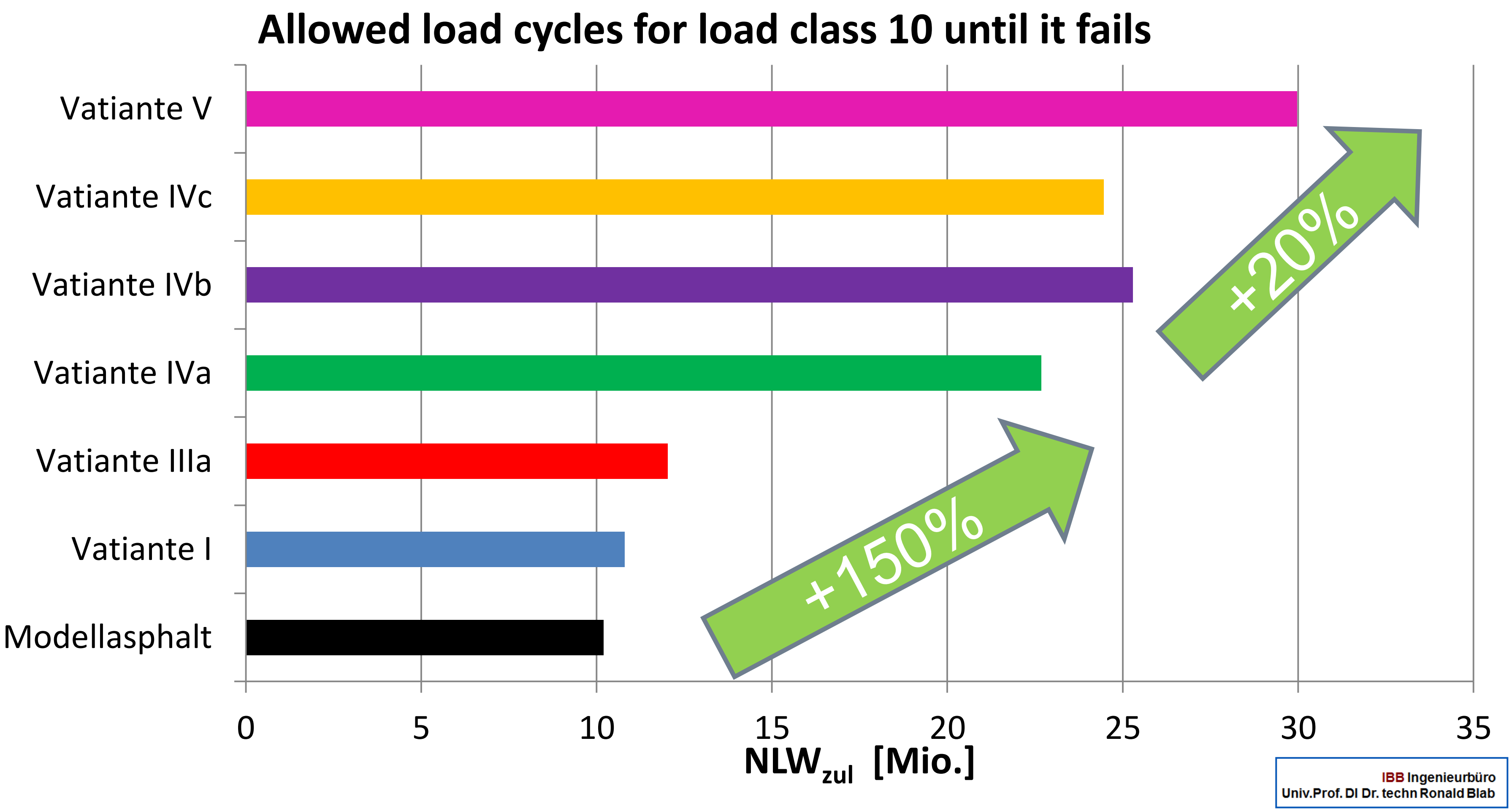
Example
Highway load class 10

Calculation of the life time until the pavement fails

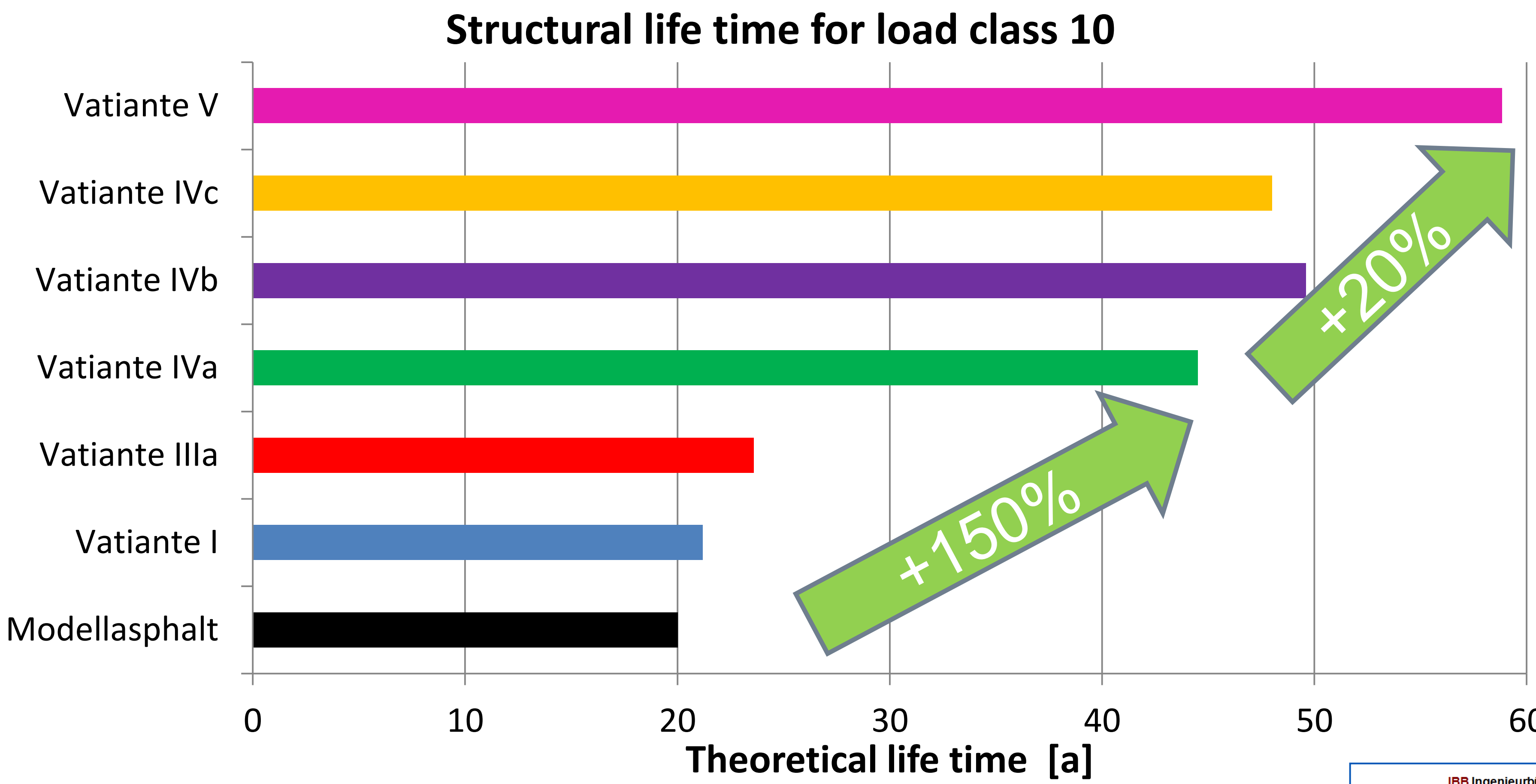
Thickness of the asphalt pavement: 23 cm

► Variant IVa:	3,5 cm	AC 11 surface	PmB 45/80-65
	8,5 cm	AC 22 binder	PmB 45/80-65
	11,0 cm	AC 32 base	PmB 45/80-65
► Variant IVb:	3,5 cm	AC 11 surface	PmB 45/80-65
	8,5 cm	AC 22 binder	PmB 25/55-65
	11,0 cm	AC 32 base	PmB 45/80-65
► Variant IVc:	3,5 cm	AC 11 surface	PmB 45/80-65
	8,5 cm	AC 22 binder	PmB 45/80 RC
	11,0 cm	AC 32 base	PmB 45/80-65
► Variant V:	3,5 cm	AC 11 surface	PmB 45/80-80
	8,5 cm	AC 22 binder	PmB 45/80-80
	11,0 cm	AC 32 base	PmB 45/80-80

Example
Highway load class 10



Example
Highway load class 10



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Univ.Prof. DI Dr. techn Ronald Blab

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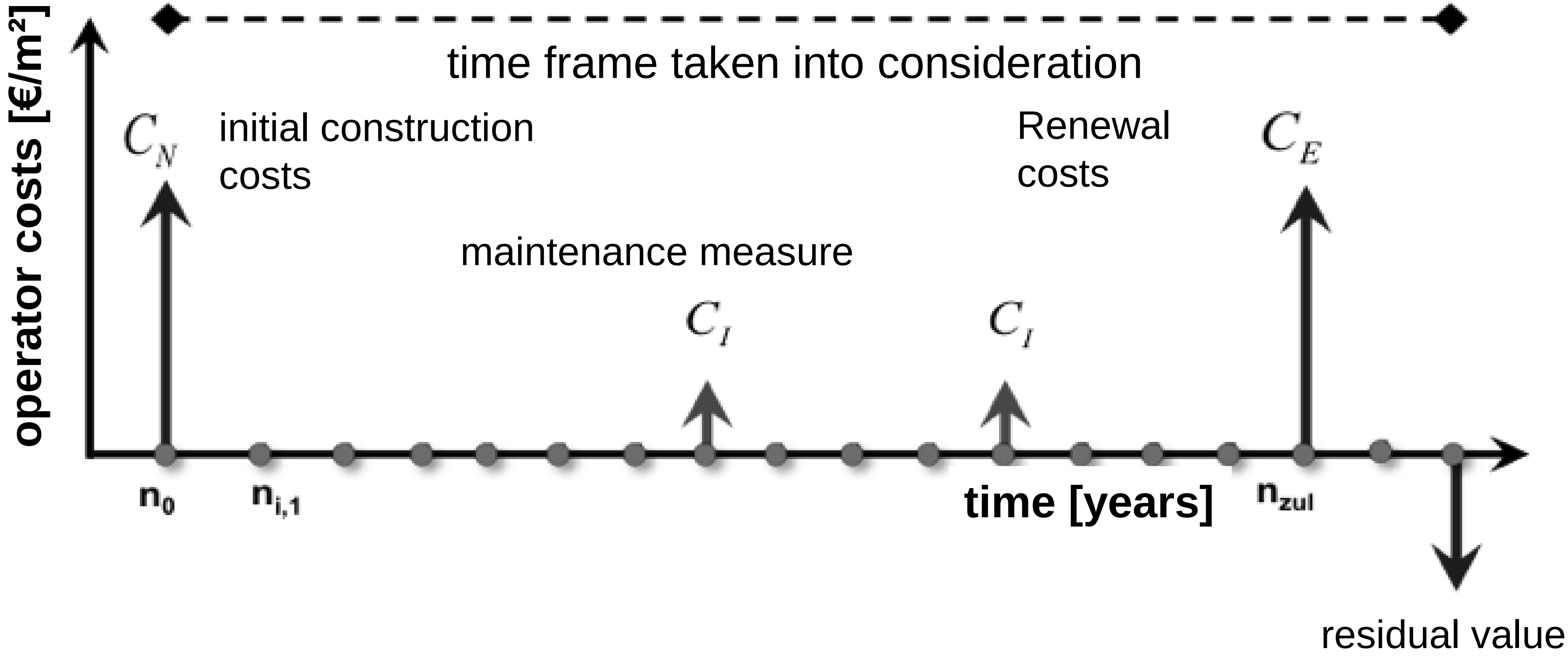
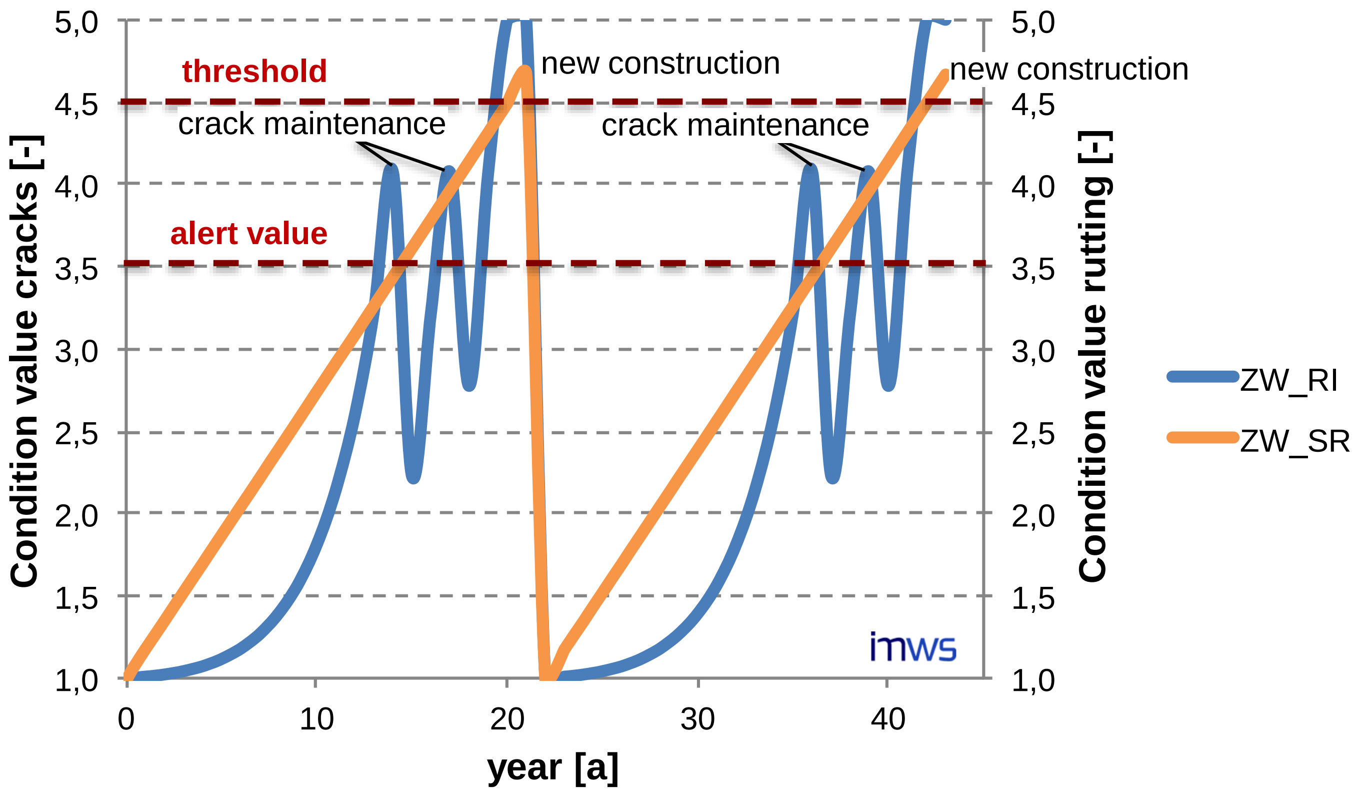
Life Cycle Costs Analysis – LCCA
Methodology

- Consideration of pavements for initial construction, maintenance, renewal and residual value at the end of the life cycle (public easement costs)
- Calculation of **net present value & annuity**



Life Cycle Costs Analysis – LCCA
Simulation of the condition development

Main failure characteristics are cracks and deformation/rutting



Construction type AS1-LC10, Variant I - pavement with paving grade bitumen

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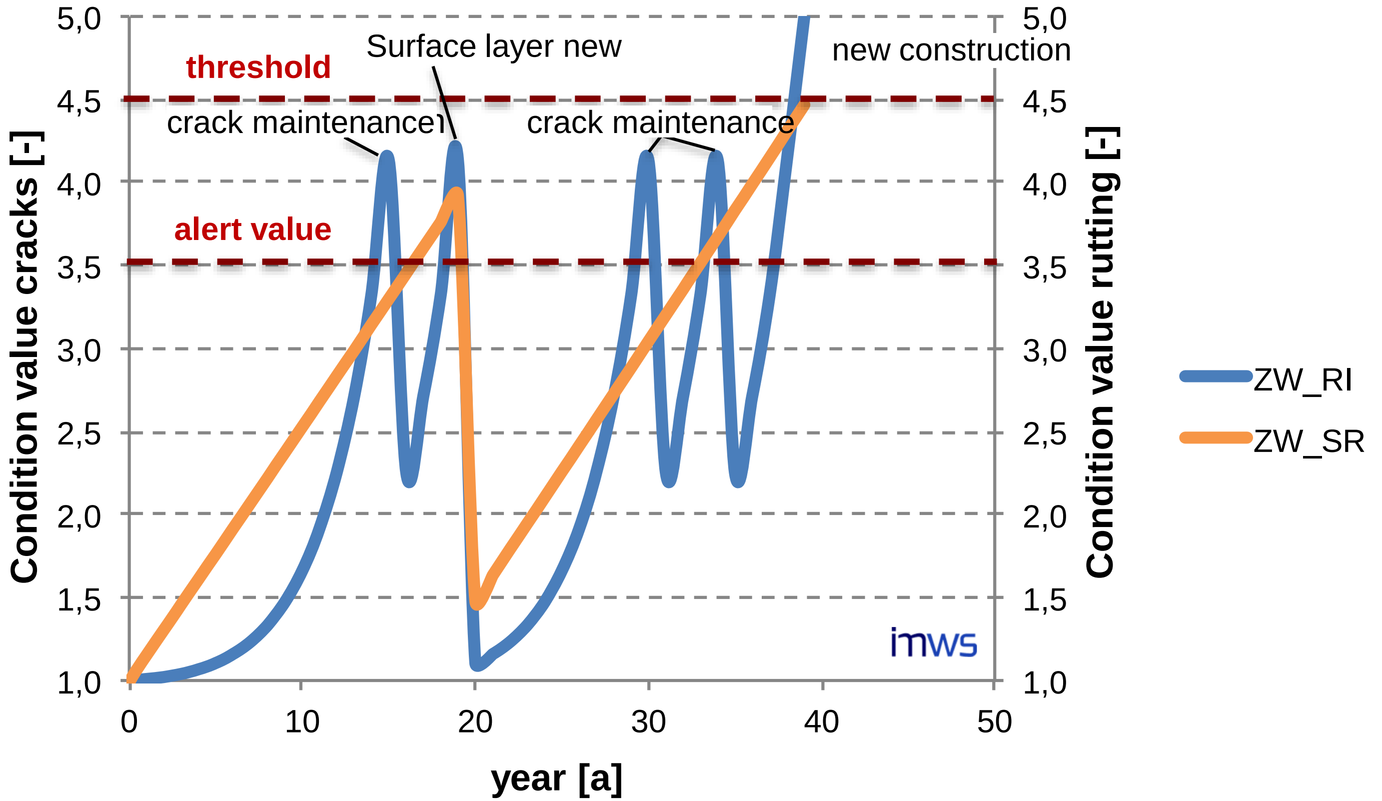
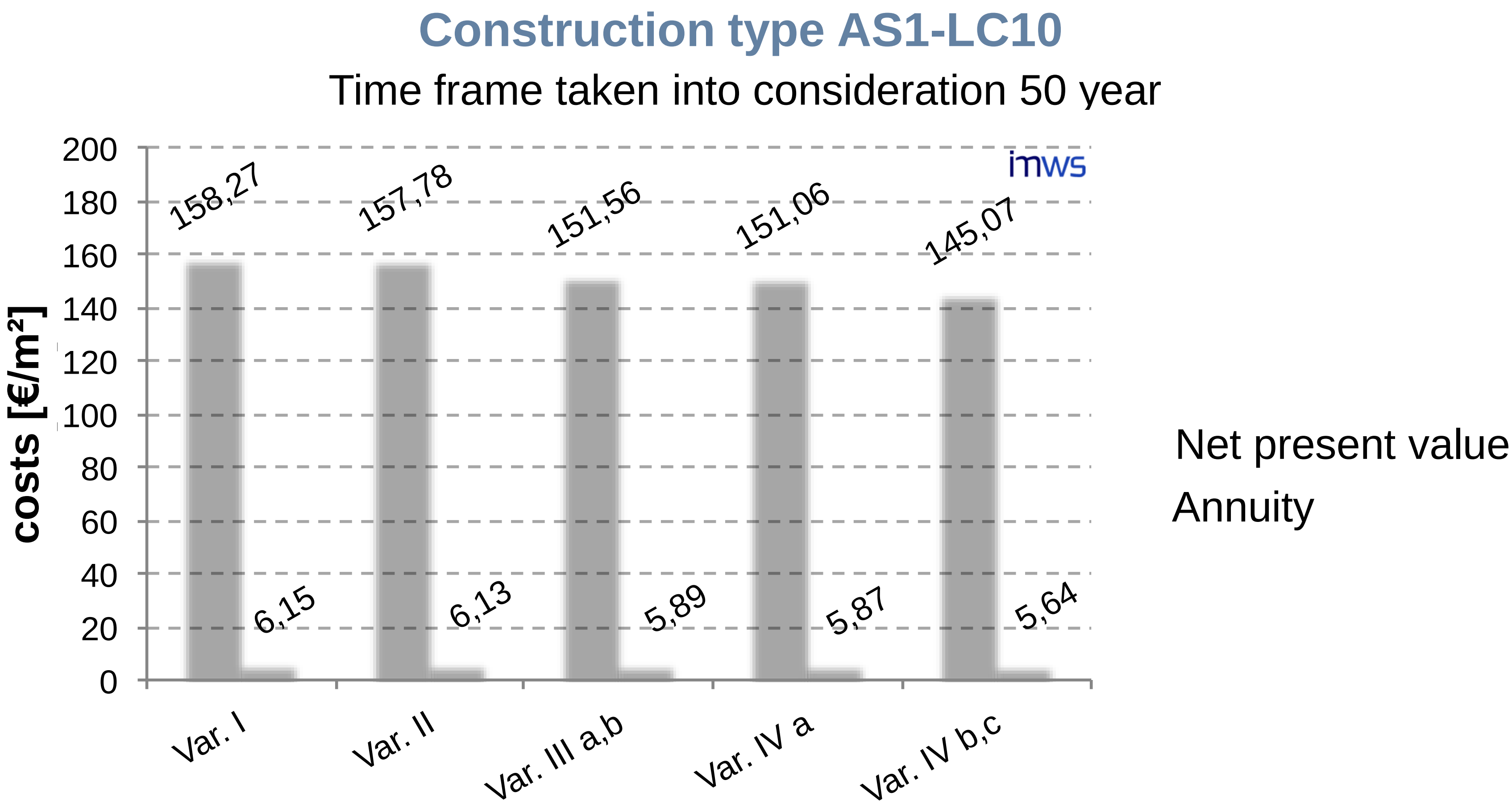
Life Cycle Costs Analysis – LCCA
Simulation of the condition development

Main failure characteristics are cracks and deformation/rutting



Construction type AS1-LC10, Variant IV - asphalt pavement with PmB

Life Cycle Costs Analysis – LCCA
Construction costs vs. Life Cycle Costs

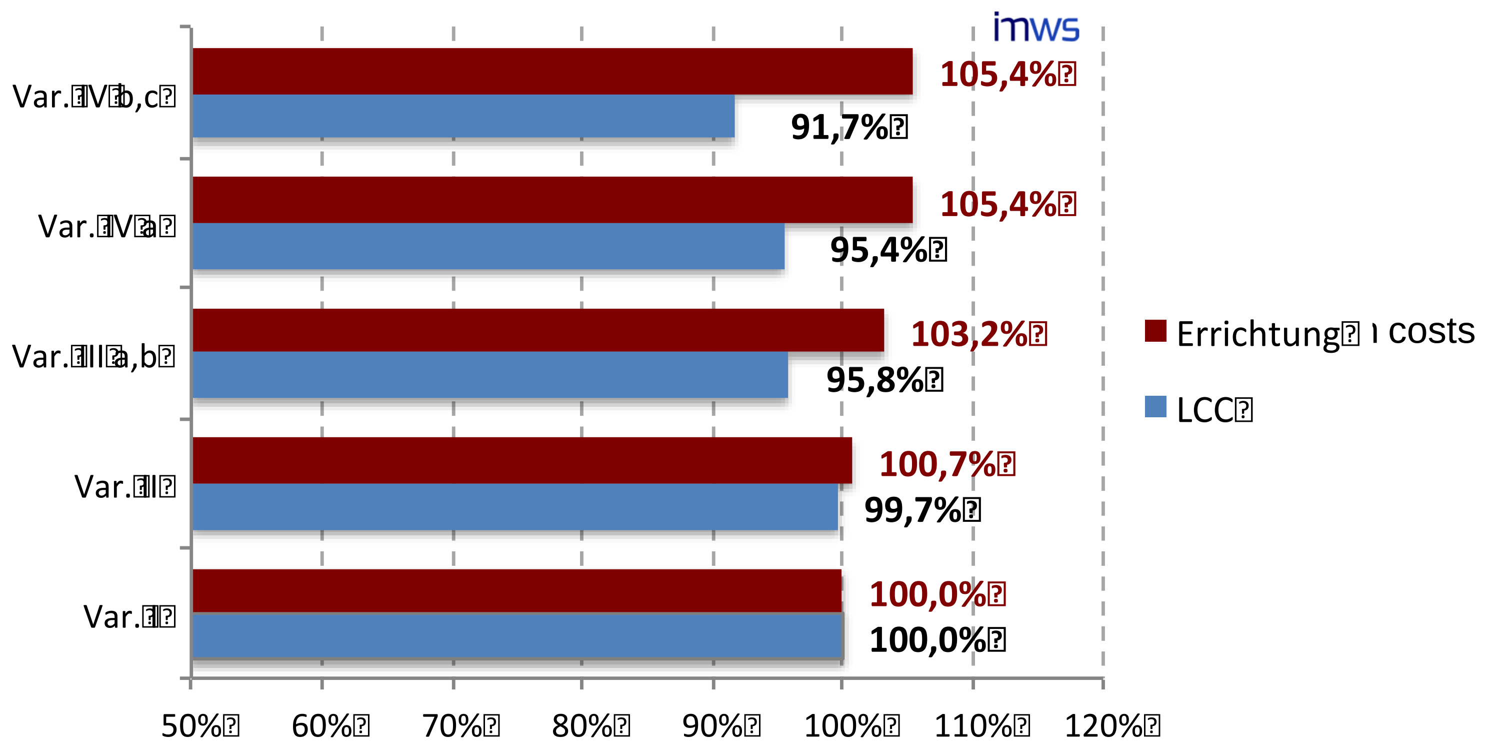


Average prices (price base 2015, construction site bigger than 5.000 m²), interest rate i = 3%

Life Cycle Costs Analysis – LCCA
Construction costs vs. Life Cycle Costs

Construction type AS1-LC10

Time frame taken into consideration 50 year



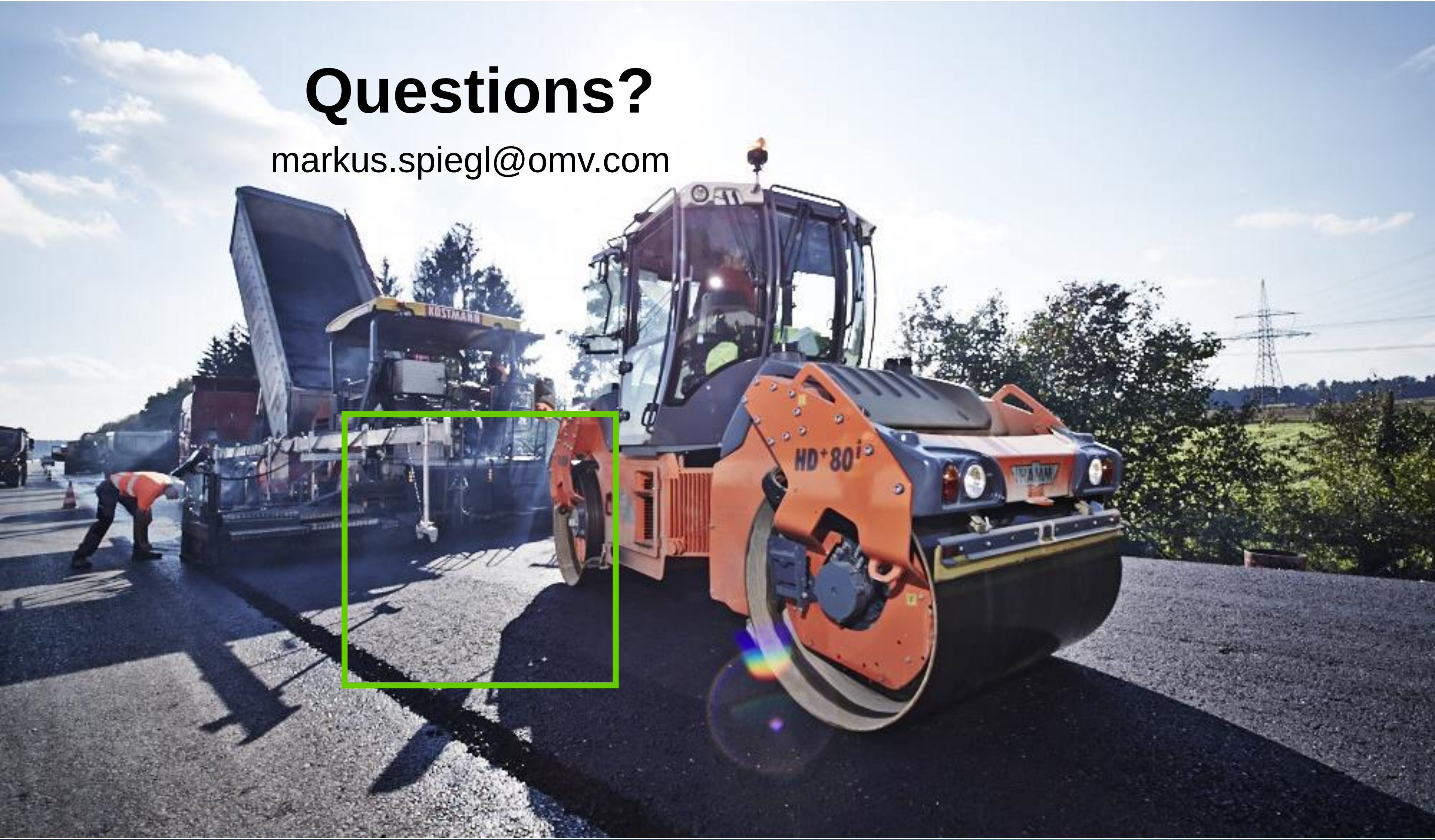
Average prices (price base 2015, construction site bigger than 5.000 m^2), interest rate i = 3%

Resume

- Do **performance related tests** (fatigue and dynamic stiffness tests)
- Change design process – **real properties** of asphalt mixtures considerate (higher quality - longer life time – less maintenance)
- Bitumen **type and quality** has a **huge impact** on the **life span** of a pavement
- Significant **increase of life span** if **high quality PmB is used** for the whole pavement structure
- **LCCA necessary** for a proper evaluation of initial construction costs
- Only PmB -> 5% higher initial costs but **8% less LCC**

Questions?

markus.spiegl@omv.com



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