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ISBS



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Asphalt Pavement Recycling in Germany

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Outline

- Introduction
- State of the art on recycling in Germany
- Past research at TU Braunschweig
- Current research at TU Braunschweig

Introduction

Unbound material:

- Materials from trench and embankment
- Subgrade, gravel and mixtures of aggregates from paved areas and/or natural origin

Hydraulically bound material:

- Concrete pavement
- Material from base courses
- Concrete slabs, concrete pipes and precast concrete
- Concrete and reinforced concrete in buildings and constructions

Bituminous material:

- Scraped asphalt
- RAP

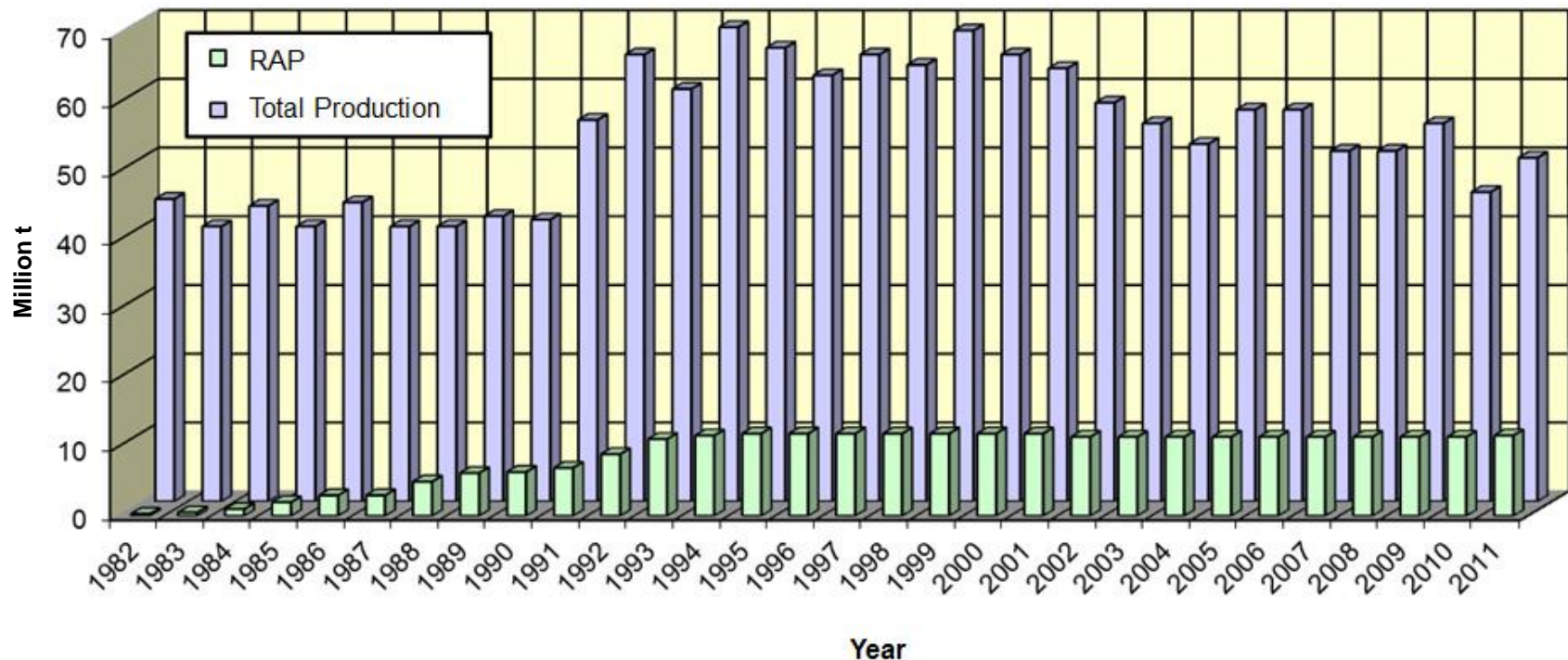
Other materials:

- Clinker bricks, porous concrete, limestone, mortar, plaster, etc.

Recycling and Waste Management Act (KrW- / AbfG) 10/1996

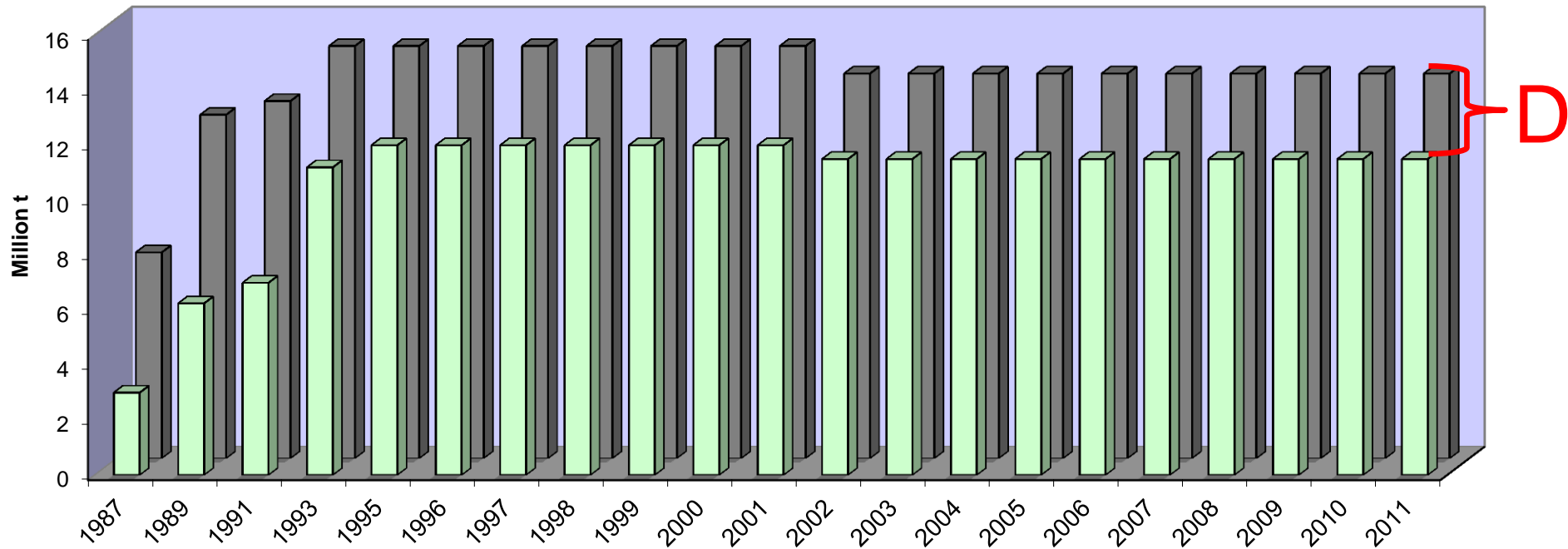
Introduction

Production of asphalt mixture and amount of RAP in Germany (1982 - 2011)



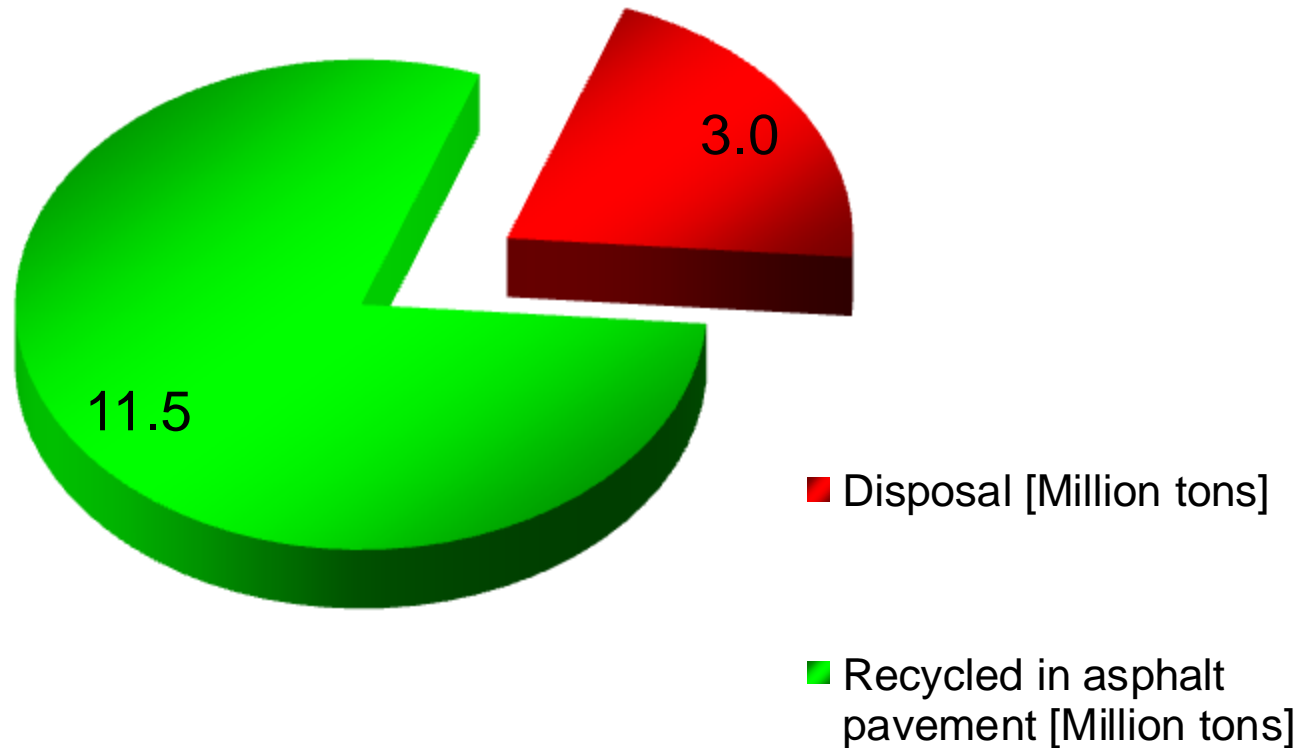
Introduction

Reuse of RAP in Germany (1987 – 2011)



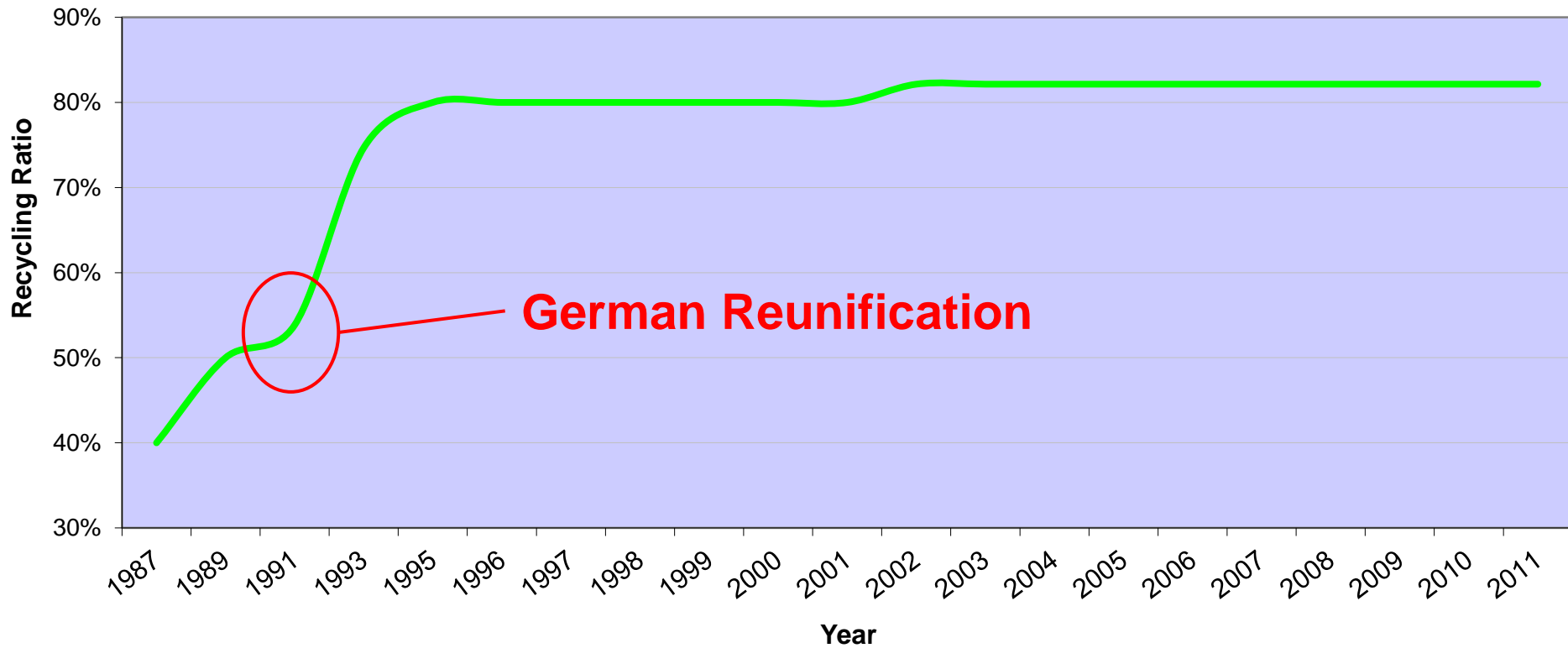
Introduction

Reuse and disposal of RAP



Introduction

Recycling Ratio



Introduction

RAP recycling per country in Europe (2012)

Country	Available reclaimed asphalt (tonnes)	% of the new hot and warm mix production that contains reclaimed material
Austria	750.000	
Belgium	1.500.000	49
Czech Republic	1.400.000	10
Croatia		2
Denmark	580.000	47
Finland	1.000.000	65
France	6.500.000	>60
Germany	11.500.000	97
Greece		0,02
Great Britain	4.500.000	
Hungary	100.777	46
Iceland	15.000	2,5
Ireland	150.000	10,0
Italy	10.000.000	
Luxembourg	210.000	60
Netherlands	4.000.000	73
Norway	787.689	13
Poland	~ 100.000	~ 0,2
Romania	20.000	5,0
Slovakia	33.000	0,0
Slovenia	10.000	
Spain	368.000	6,4
Sweden	1.000.000	70
Switzerland	1.575.000	24
Turkey	3.816.000	1

EAPA 2012

State of the art on recycling in Germany

In situ recycling methods

Reshape	Repaving without changing RAP composition
Remix	Repaving by changing RAP composition
Remix compact	Repaving by changing RAP composition and by placing an additional wearing course
Remix plus	Repaving by changing RAP composition and by placing an additional wearing course with the same machine
Repave	Repaving without changing RAP composition and by placing an additional wearing course with the same machine

State of the art on recycling in Germany

Use of Rejuvenators

Products currently on the market

- Products based on mineral oil
- Products based on vegetable oil
- Resin-based products
- Products based on asphalt binder

Composition is mostly unknown and discoloured



Therefore, these products are currently not defined by German standards

State of the art on recycling in Germany

Case study in Tannheim - Baden-Württemberg

Project on maximization of RAP reuse

90%RAP in base layer

80%RAP in binder layer

82%RAP in surface layer



Past research at TU Braunschweig

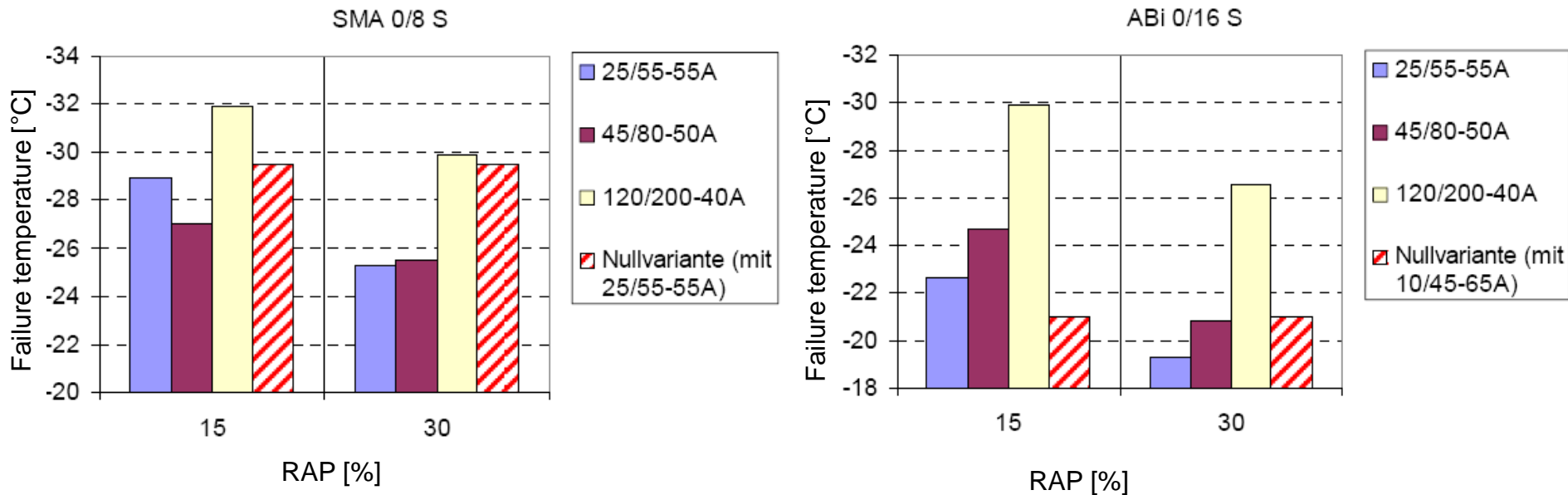
FE 07.0212/2006/CGB

Reuse of RAP from porous pavements in SMA and Binder layers

- Provide a basis for a high-quality reuse of porous asphalt RAP
- Investigate and assess the aging condition of the asphalt binder in porous asphalt pavement and the effects on the recycled mixture
- Evaluate the impact of RAP addition to the performance of the final mixture

Past research at TU Braunschweig

Low temperature cracking - TSRST test



- Positive and significant influence of the virgin binder on resistance against low temperature cracking
- Comparable performance between 15%RAP added and mixture prepared with virgin material

Past research at TU Braunschweig

Results

- Fresh asphalt binder type positively affects low temperature performance and deformation behavior when using up to 30% RAP in SMA and binder layer mixtures.
- The type of fresh binder should be adjusted to the characteristics of the oxidized aged RAP binder
- Is the RAP used in the laboratory experimental phase representative of the one used on large scale production?

Past research at TU Braunschweig

SCP-GA-2008-218747

Re-road – End of life strategies of asphalt pavements

WP 2 – Reuse of RAP in surface layers

- Increase RAP content in surface layers
- RAP characterization
- Long-term aging
- Aging simulation in the laboratory
- Mix design with RAP addition
- Selection of fresh binder
- Review of the mix design for PMB
- **Multiple recycling of surface layer mixtures**

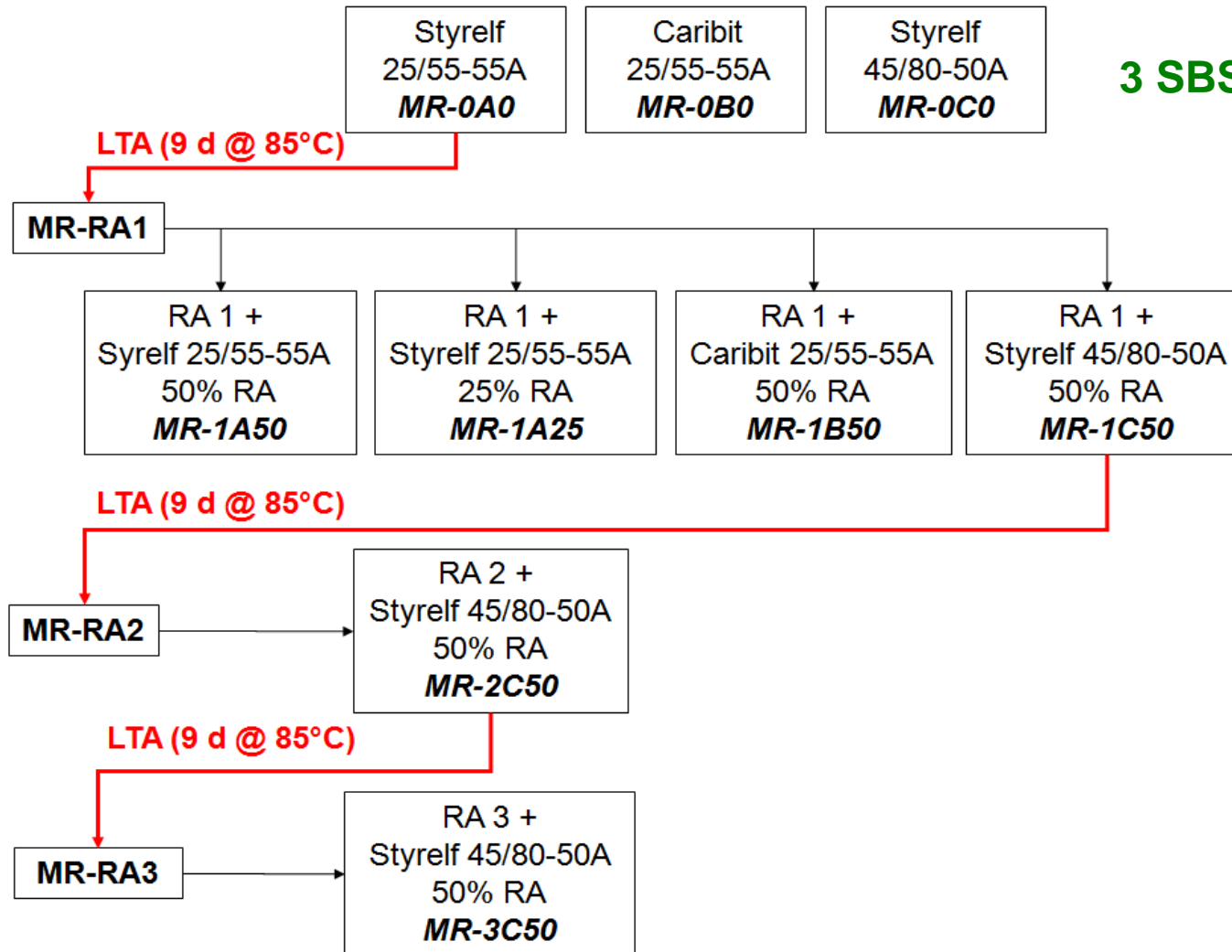
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Multiples Recycling

- Addressing of characteristics of multiple recycled SMA mixtures including SBS modified binders
- Three recycling cycles
- Addition of 50% RAP
- Addition of fresh SBS (45/80-50A) to compensate for the aged RAP binder

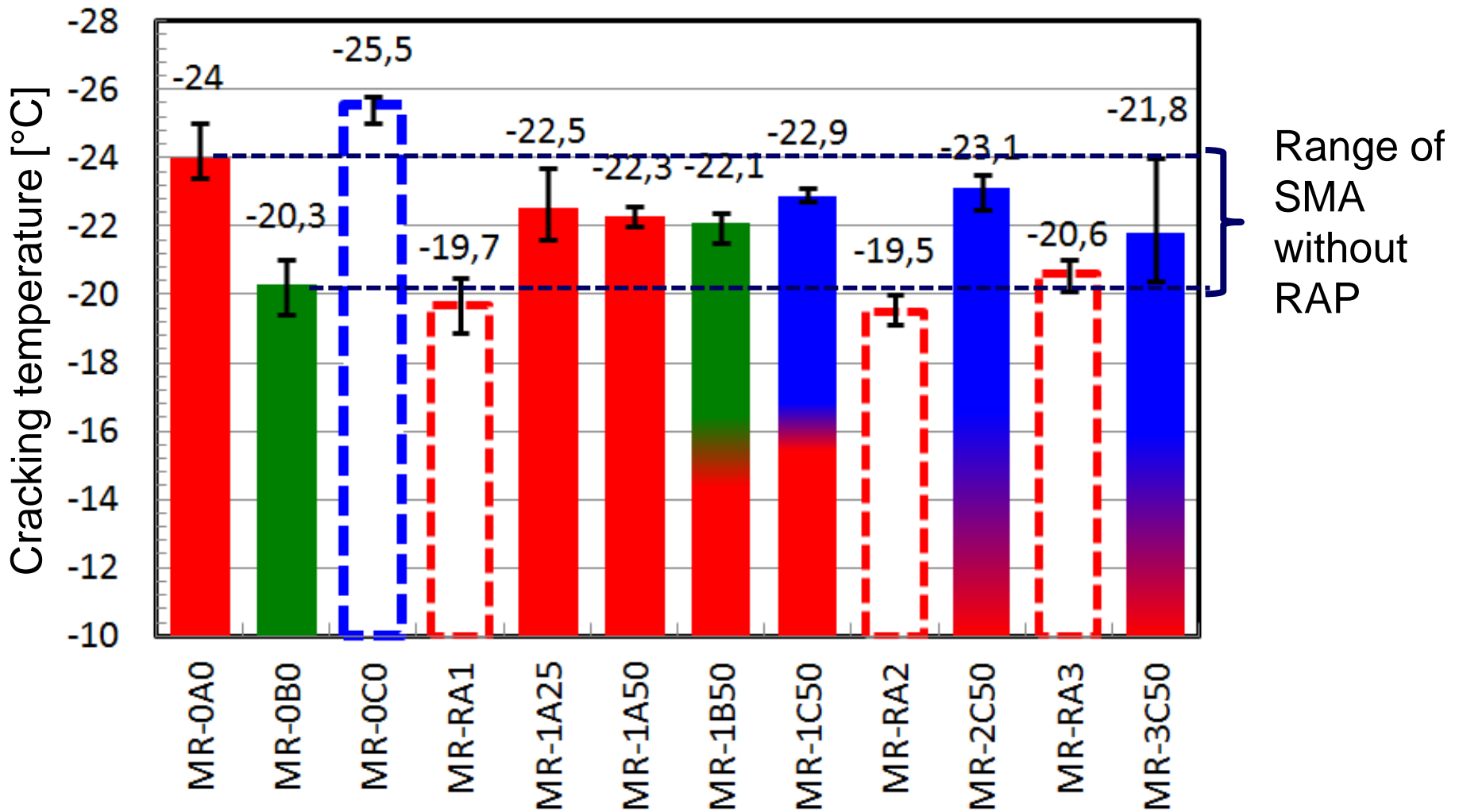
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3 SBS-mod. Binders



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Cracking temperature (TSRST)



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Results 1/2 (Re-road WP 2)

Three Recycling cycles with 50 % RAP:

- Comparable compaction properties
- Higher resistance against low temperature cracking
- Comparable stiffness modulus
- Comparable resistance to permanent deformation

Under ideal production conditions:

- no fragmentation of RAP (e.g. no increase in filler content)
- 100% matching grain size distribution

Past research at TU Braunschweig

Results 2/2 (Re-road WP 2)

Aging

- Long term aging can be simulated by oven storage in the laboratory
- UV-radiation (in the oven) had less effect than in case of modified binders

Overall:

- 50% addition of RAP in SMA - under laboratory conditions – did not significantly affect the mechanical properties of the mixtures
- Three times recycling of SMA is possible without loss of quality (under laboratory conditions)

Current research at TU Braunschweig

- AtA - Reuse of RAP with viscosity reducing additives in HMA
- RACT - Impact of RAP on the mechanical properties of asphalt base layers
- REJU - Use of rejuvenators in the reuse of RAP
- Max Recycling – Maximization of RAP use and determination of the material lifetime
- ORAB - Optimization of RAP content in asphalt mixtures for binder and base layers
- LD - Road asphalt performance properties using Linz-Donawitz slag

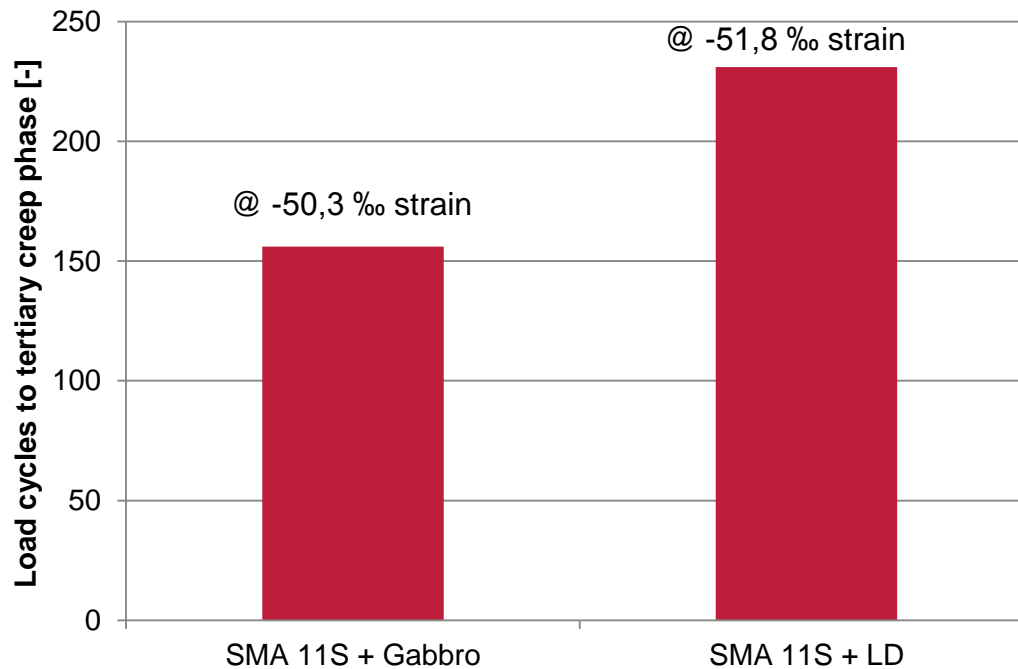
Current research at TU Braunschweig

LD - Road asphalt performance properties using Linz-Donawitz slag

- Replacement of aggregate through industrial by-products
- Investigation on the performance of different types of asphalt mixtures prepared with 100% LD slag
- Comparison to conventional asphalt mixtures (Gabbro aggregate)
- Low temperature cracking was addressed by Uniaxial Tensile Tests (UTST) and Thermal Stress Restrained Specimen Tests (TSRST)
- Resistance to permanent - cyclic Compression Tests
- Resistance to material fatigue - cyclic Indirect Tensile Tests.

Current research at TU Braunschweig

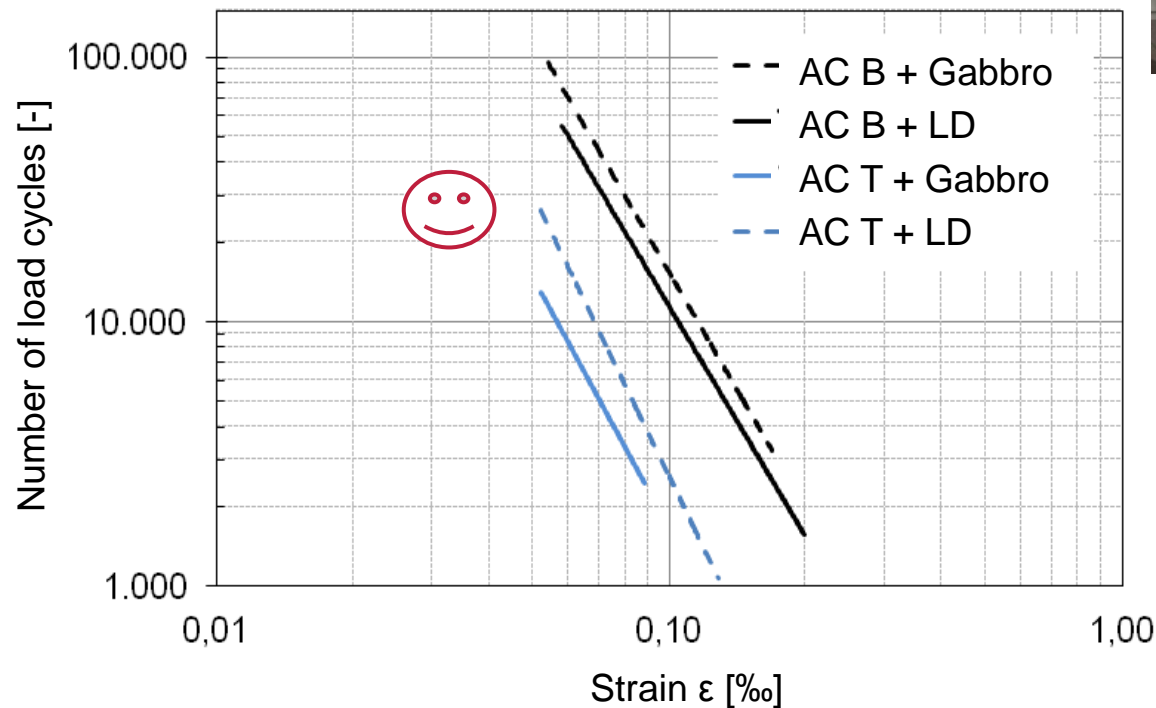
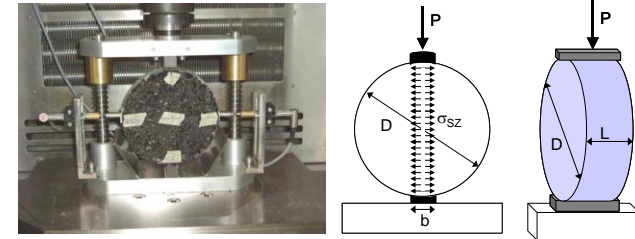
Permanent deformation SMA 11 S



LD slag mixture presents higher number of load cycles to initiate the final phase of tertiary creep

Current research at TU Braunschweig

Fatigue properties (Binder and base layer mixtures)



Binder course and base course:
 favorable fatigue behavior by using LD slag compared to Gabbro aggregate

Current research at TU Braunschweig

Results

- The key performance properties of asphalt mixtures made from LD-slag are suitable for asphalt pavement construction
- Asphalt mix design can be adjusted in a way, that asphalt mixtures made from LD-slag presents equivalent or even better performance compared to conventional asphalt mixtures made from natural Gabbro aggregate

Thank you!