HIGH EFFICIENCY LOW EMISSION MASTIC ASPHALT

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Mastic asphalt mixes are produced at high temperatures (230°C to 250°C) to decrease the viscosity of the bituminous mastic and thus produce a flowable, self-compacting mixture. High production temperatures lead to an increased energy demand and higher emissions of greenhouse gases, as well as health relevant emissions such as particulates.

Temperature reduction potential

Various additives, mainly waxes, are available to lower the viscosity of binder above their dropping point. In the presented research study, mastic asphalt (MA 11) was produced with different wax-modified binders in a lab mixer. The mixer is equipped with a dynamic torque sensor to derive the mixing torque as a measure of the workability of a mix during production. Thus, temperature reduction potential is studied, compared and discussed for different waxes and wax concentrations. From all employed waxes, amide wax has the highest potential for temperature reduction of mastic asphalt (-27°C at a wax concentration of 4 wt.% related to binder mass). As an alternative approach for more economic temperature reduction of mastic asphalt, the usually used crushed mineral aggregates were substituted by round mineral aggregates (RA 0/11). This substitution makes a reduction of 36°C possible and this without additional use of wax. The combination between amid wax and round aggregates decreases the producing temperature by 51°C. (Figure1)

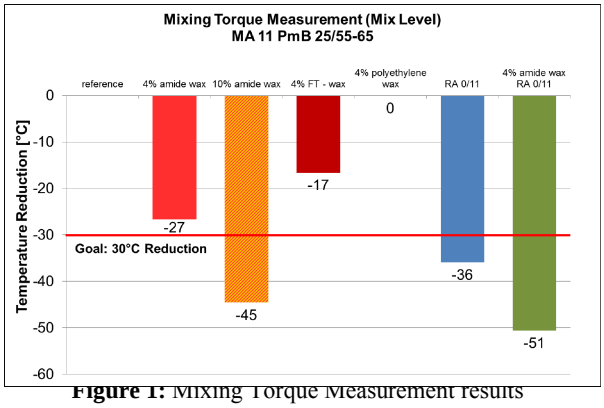

Figure 1: Mixing Torque Measurement results

Performance optimization of the modified mastic asphalts

The modified mastic asphalts were tested by TSRST (Thermal Stress Retained Specimen Test) and UCCT (Uniaxial Cyclic Compression Test) and show the same resistance to low temperature cracking like the reference mix and 50% better resistance to a permanent deformation at high temperatures.

Emission reduction

In addition to the examination of the mechanical performance of the temperature reduced mixes, emission during the mixing process was measured on lab scale. The results indicate the health relevancy of particulate emissions during the construction process (80 mass-% of particulates are size <2,5 µm). According to the lab study the emission can be reduced by up to 80% by controlled temperature reduction.

Mastic asphalt	Absolute emission	Area-specific
reference	740 mg/kg	5,3 g/m2
temperature reduced	148 mg/kg	1,1 g/m2
Emission reduction	**80%**	**79,20%**

Table 1: Emission of particulates ≤ 10µm, comparison of reference asphalt and modified asphalt

Life Cycle Analysis of material, energy and costs

Emissions, energy consumption and costs of the production process and throughout the life cycle of a road pavement are quantified by application of Material Flow, Life Cycle Energy and Life Cycle Cost Analyses [1] [2] [3]. In the analyzed scenarios, the demand of production energy and the associated energy costs are decreased by up to 20%. The total particulate emissions throughout the life cycle can be reduced by up to 40%. First, this is because of the significant reduction of emissions during the construction process due to reduced asphalt temperature. Second, this is because of the relevant reductions in energy demand and thus reduced combustion of primary energy sources.

In this project, modifications of mastic asphalt production have been analyzed, assessed and compared. From a life cycle perspective, the use of additives is controversial, and the substitution of crushed by round mineral aggregates beneficial. Despite its limitations, this project shows the benefits of innovative mastic asphalts, especially regarding energy demand and particulate emissions, while improving the engineering demands of mastic asphalt products for road pavements.

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[1] Brunner, P.H. and Rechberger, H. 2004. Practical Handbook of Material Flow Analysis. CRC Press.

[2] Cabeza, L.F., Rincón, L., Vilariño, V., Pérez, G., Castell, A. 2014. Life cycle assessment (LCA) and life cycle energy analysis (LCEA) of buildings and the building sector: A review. Renewable and Sustainable Energy Reviews 29, 394-416.

[3] Hunkeler, D.J., Lichtenvort, K., Rebitzer, G., Ciroth, A. 2008. Environmental life cycle costing. CRC Press.

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High Efficient Low Emission Mastic Asphalt

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Engineering Performance

Mastic Asphalt (MA 11)

- Aggregates **„swimm“** in the mastic
- **Load transfer** – mainly by the mastic
- Producing temperature: 230°C 250°C

Split Mastic Asphalt (SMA 11)

- **Stone-Stone** contact
- **Load transfer** – by rock skeleton
- Producing temperature: 170°C

Content

Engineering performance

Emission Analysis

Life Cycle Analysis

Summary and outlook

Materials

Binder (PmB 25/55-65)

Filler

Aggregates

Crushed (TC)

Round (TR)

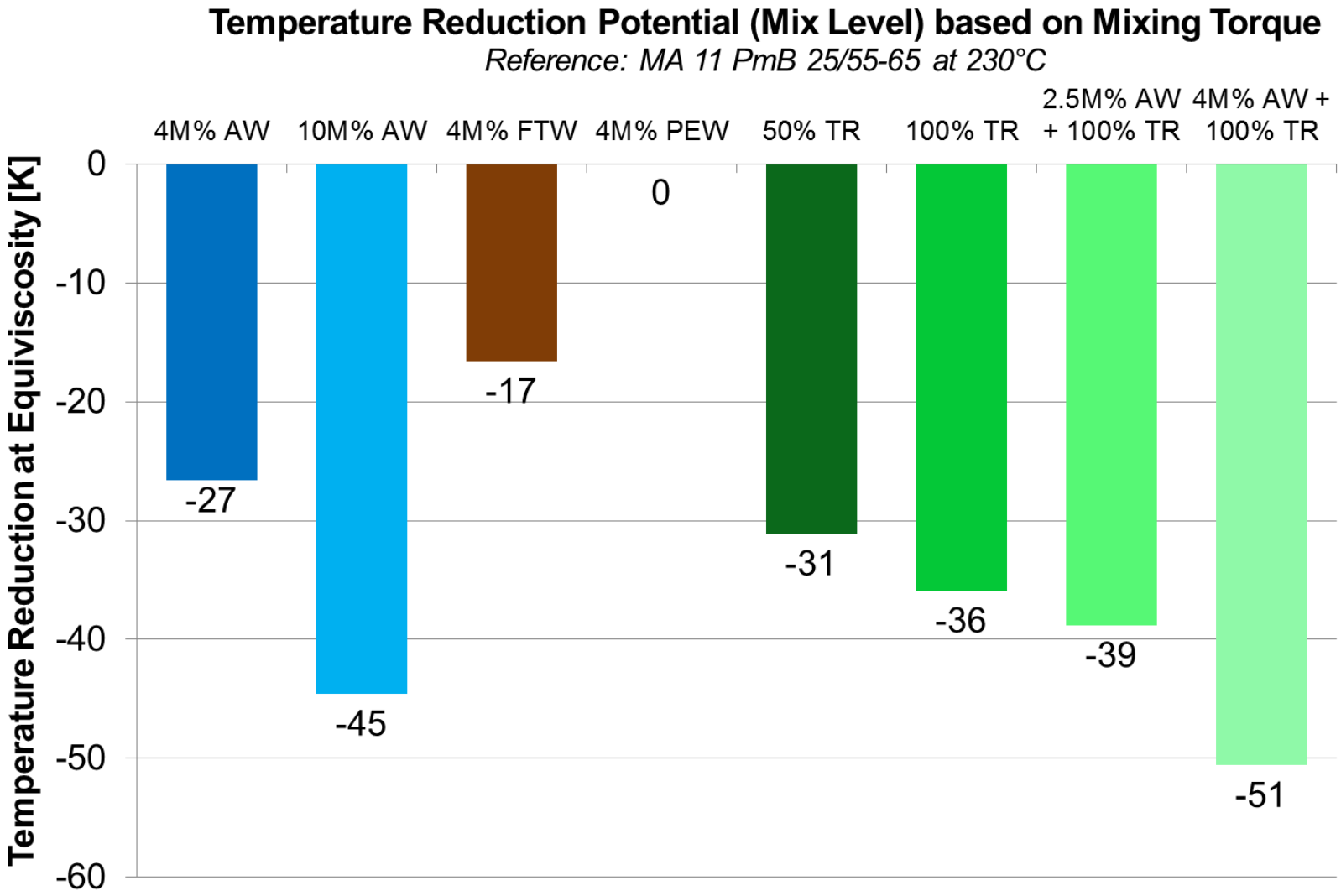
Organic additives

Amide wax (AW)

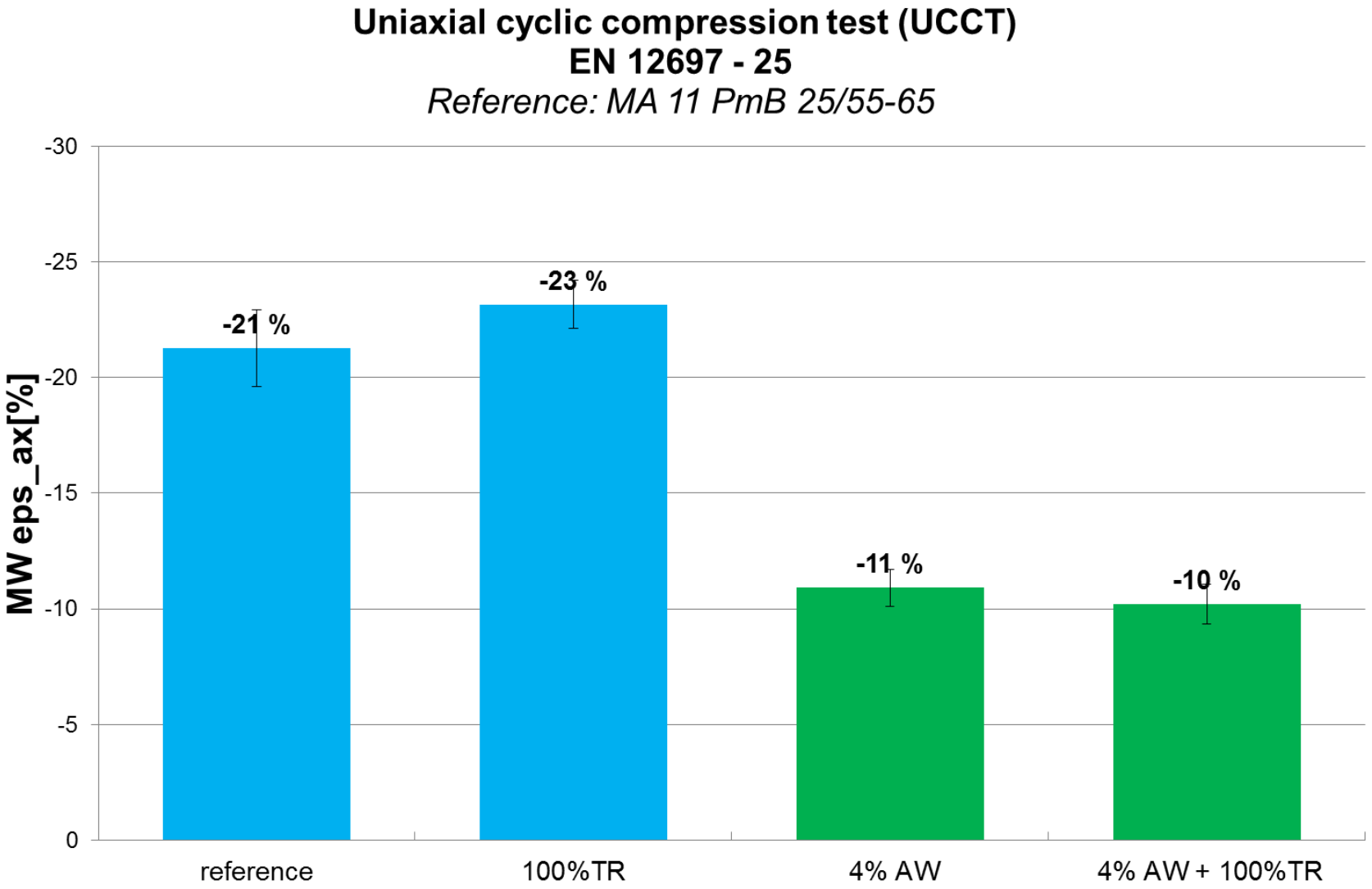
Polyethylene wax (PW)

Fischer-Tropsch wax (FTW)

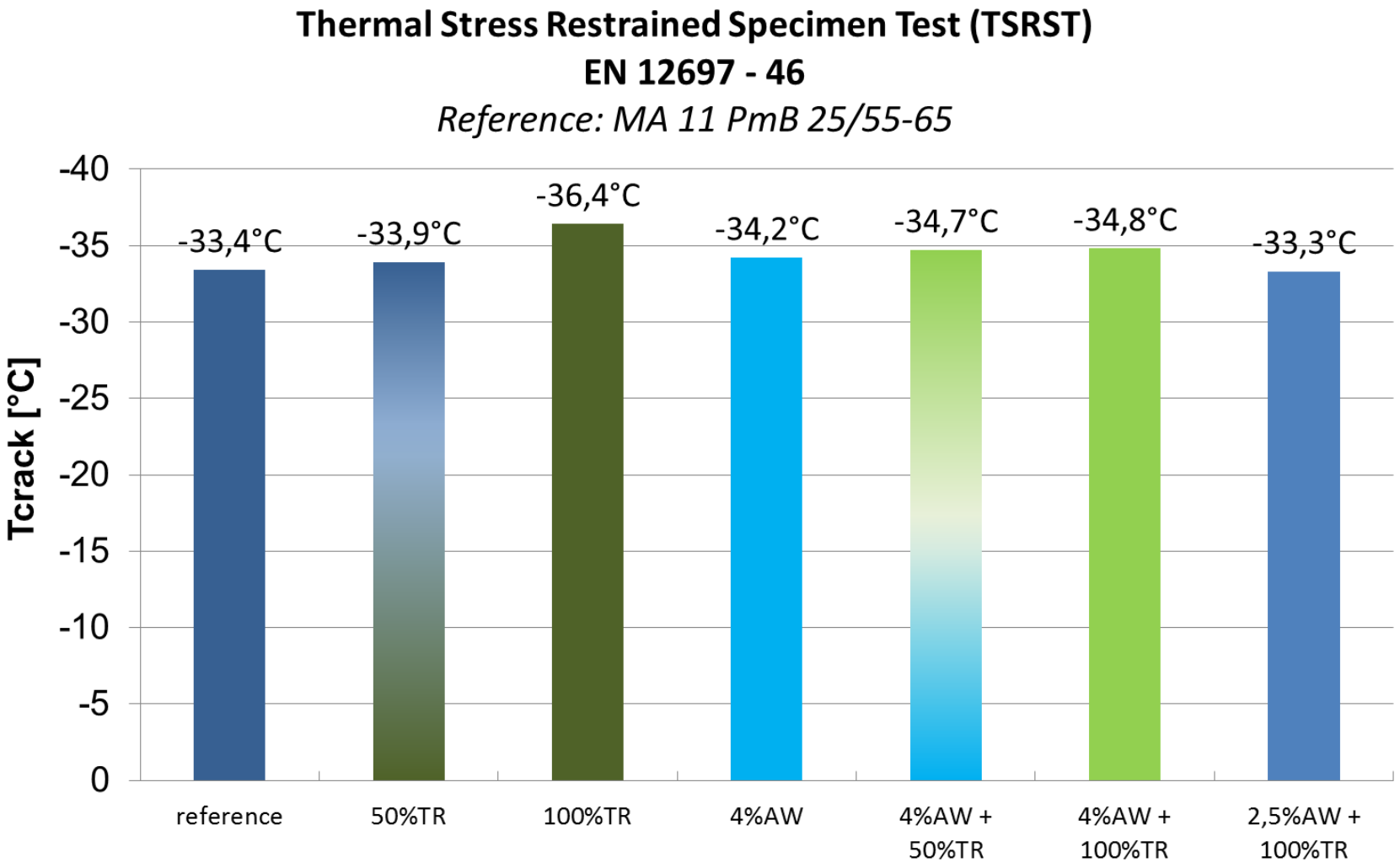
Engineering Performance



Engineering Performance



Engineering Performance



Content

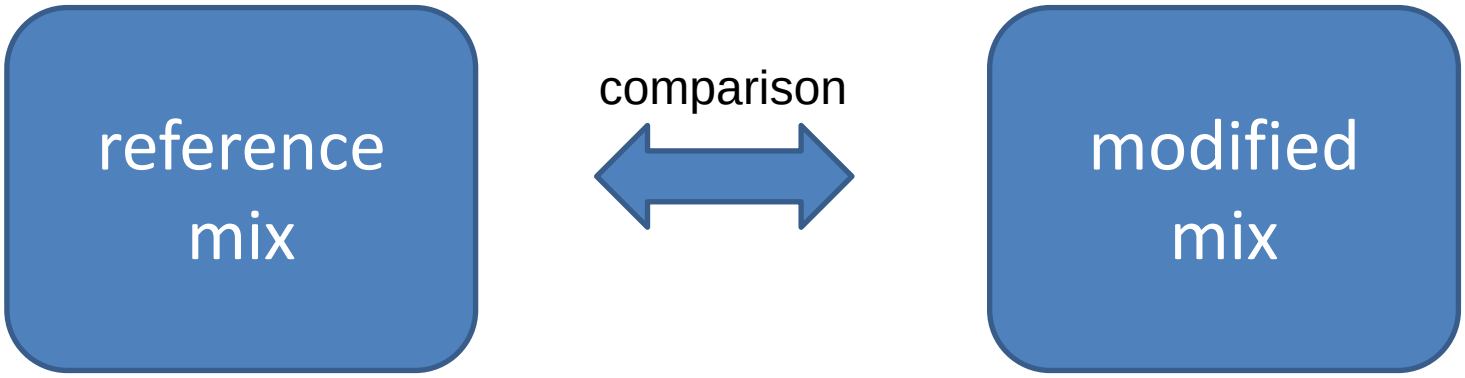
Engineering performance

Emission Analysis

Life Cycle Analysis

Summary and outlook

Emission Analysis



Used Methods:

- Particlefilter / Impactor
- Flameionisationdetector (FID)
- Laser Ablation Particle Time-Of-Flight Mass Spectrometer (LAAPTOF)

Emission Analysis

Results:

Measurements

	PM10 [mg/m^3]
Reference mix	9,7 mg/m^3
Modified mix	2,8 mg/m^3
Difference	-71%

Modelling

	Emission [mg/kg]	Emission [g/m^2]
Reference mix	740	5,3
Modified mix	148	1,1
Difference	-80%	-79%

Content

Engineering performance

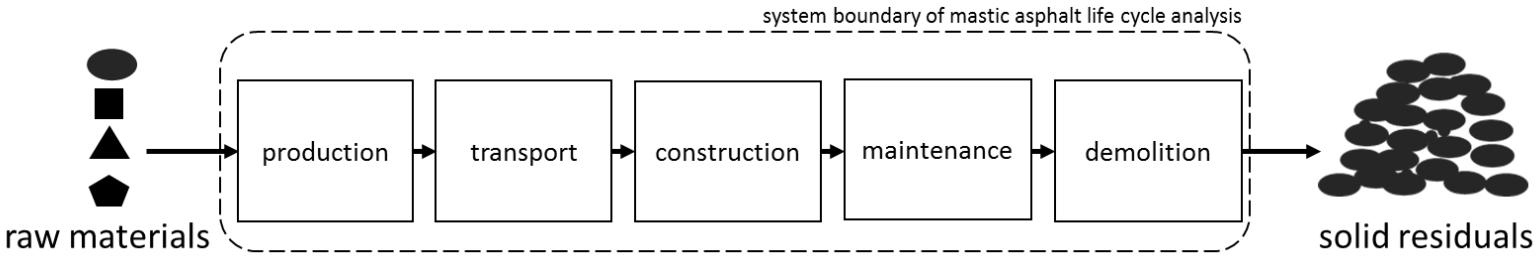
Emission Analysis

Life Cycle Analysis

Summary and outlook

Life Cycle Analysis

System definition



- functional unit (FU) is a road pavement of dimension 1000 x 3 x 0.005 m with a service life of 20 years
- implementation in the software STAN
  (freeware developed at TUW, see www.stan2web.net)

Life Cycle Analysis

Scenarios		Production temperature
0 (reference)	Reference	240°C
1	MA11 4 % amide wax	215°C
2	MA11 4 % amide wax and round aggregates	190°C

Material Flow Analysis particulates emissions [kg/FU]		
scenario 0	scenario 1	scenario 2
19,90[kg/FU]	12[kg/FU]	4,1[kg/FU]

Energy Flow Analysis [GJ]		
scenario 0	scenario 1	scenario 2
556[GJ]	592[GJ]	511[GJ]

Life Cycle Costing [€]		
scenario 0	scenario 1	scenario 2
31.960[€]	35.536[€]	32.893[€]

Content

Engineering performance

Emission Analysis

Life Cycle Analysis

Summary and outlook

Summary

- Temperature reduction potential **of 50K** by combined use of rounded aggregates and 4%AW
- **Better mechanical performance** of the modified mix
- Emission reduction by a factor **of 5** possible
- Temperature reduction causes significant **energy cost savings**
- **Double benefit of round aggregates**: energy cost savings by reduction of mixing temperature and savings of material costs, since cheaper than crushed aggregates

Outlook

- Follow – up project **iMAS**
- **Large-scale production** of all mentioned mastic asphalt mixtures
- Construction of **test fields** on the public road network including regular monitoring
- **Further emission and life-cycle analysis**

Thanks to the colleagues:
Univ.-Prof. Dr. Regina Hitzenberger
Ao.Prof. Dr. Anne KASPER-GIEBL

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THANK YOU FOR YOUR ATTENTION

Vortrag ENER 1

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Reference: Hofko B., Dimitrov M., Schwab O., Weiss F., Kasper-Giebl A., Rechberger H., Grothe H., (submitted). Technological and environmental performance of temperature reduced mastic asphalt mixtures. Road Materials and Pavement Design.

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Hofko B., Dimitrov M., Schwab O., Weiss F., Kasper-Giebl A., Rechberger H., Grothe H., (submitted). Technological and environmental performance of temperature reduced mastic asphalt mixtures. Road Materials and Pavement Design.

Hofko, B., M. Dimitrov, O. Schwab, F. Weiss, 2015, Endbericht zum Projekt "High Efficient Low Emission Mastic Asphalt"; Bericht für Wirtschaftskammer Wien; Berichts-Nr. 14403_02.