1

Green Asphalt?
What's that?

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Opening Thoughts

2

- *Road construction budgets are a popular position for short term cuts*
- *In most mature and even in growing economies there is a distinct shift from construction of new roads to renovation, overpaves and seals*
- *Almost all countries have severe net consumption of road infrastructure in the past 2 decades*
- *High bitumen prices and regional shortages*
- *Higher focus on „green manufacturing" and sustainable use of ressources*
- *HIGH NEED FOR INGENUITY*

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Background

3

- *Specification: Zusätzliche technische Vertragsbedingungen und Richtlinien für Straßenbauarbeiten in Hamburg (ZTV/St-Hmb)*

Widening of upper RAP limits over time

	1983	1992	1996	2005	2007	2009	2012
Base Course	25 %	50 %	50 %	60 %	60 %	100 %	100 %
Binder Course	0 %	20 %	20 %	40 %	40 %	50 %	50 %
HiMa Binder Courses	0 %	0 %	20 %	40 %	40 %	50 %	50 %
Wearing Courses	0 %	15 %	15 %	40 %	40 %	40 %	50 %
Stone Mastic Asphalt	0 %	0 %	0 %	0 %	20 %	20 %	30 %

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Things that are essential to building quality roads with high RA content

4

- *Value of raw materials inside RAP*
- *Moisture inside RAP*
- *Analysis*
- *Commingling*
- *Emissions*
- *Need to rejuvenate*

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Value of raw materials inside RAP

5

- *RAP contains*
  - **Bitumen**
  - **Filler**
  - **Sand**
  - **Coarse aggeregates**
- *At addition levels of below 15-20% designers most often ignore the bitumen properties of the binder inside the RA*

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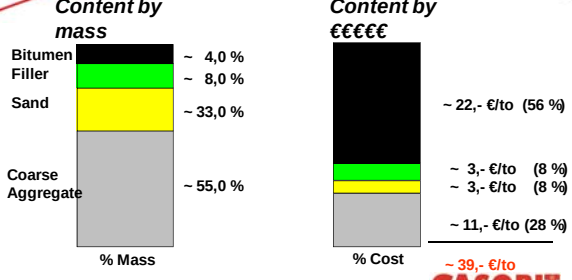
A closer look at RAP

6

Typical base course 0/22 mm AC



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Aggregates in RAP

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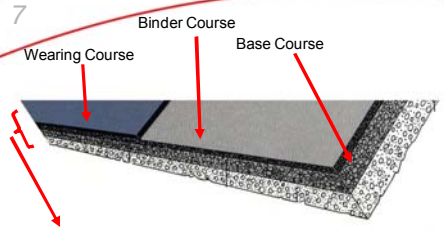


If roads are built according to this construction principle it is always creating value to mill the layers seperately!

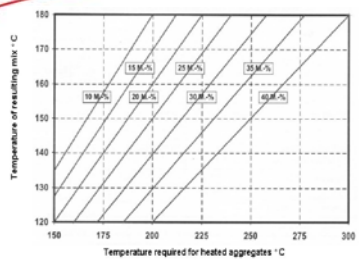
Moisture is limiting use of RAP

8

- *The majority of plants do not have RAP heaters.*
- *They use cold feed RAP addition to pugmills or elevators*
- *Most specs allow up to 30% of RAP, at least in the lesser mix qualities*
- *Most plants only manage addition of 15% RAP*
- *Moisture „eats heat“!*
- *Spontaneous expansion is a problem especially in batch plants*
  - Moisture in RAP is always a concern for the baghouses

Temperature of virgin aggregate

9



- *Required temperature for heated aggregates in ° C for addition of dry RAP at levels up to 10 and 40%M*

Source: FGSV, Merkblatt für die Wiederverwendung von Asphalt, Köln 2009

Moisture cont.

10

	Water content in RAP %M					
	1	2	3	4	5	6
RAP in %M	Temperature correction in ° C					
10	4	8	12	16	20	24
15	6	12	18	24	30	36
20	8	16	24	32	40	48
25	10	20	30	40	50	60
30	12	24				
35	14	28				
40	16	32				

- *Amount of temperature increase needed to correct for water content in RAP*
  The grey background marks the area that is considered critical for most plants

Source: FGSV, Merkblatt für die Wiederverwendung von Asphalt, Köln 2009

Analysis and controls

11

- ***Mandatory items:***
  - **Analysis of RA (1 sample per 500mt of RA)**
    - **Homogenisation of RA**
  - **When necessary; adjustment of grading curve with virgin minerals**
  - **Compactibility identical to „normal“ mix**
  - **Additional proof of performance if R&B of RA > 70° C**
  - **Absolute Homogenity of the mix**
  - **In Germany and other European countries it is standard requirement that any hot mix containing RA must perform identical or better than a „virgin“ mix.**

Emissions

12

- *The majority of plants do not have RAP heaters. Their RAP capacity is limited by*
  - Heat transfer capacity.
- *Plants with conventional RAP heaters have also limits*
  - Bitumen quality of final mix / need for rejuvenation
  - High RAP mix needs to be paved at conventional mix temperatures or even higher. In conventional RAP heating drums this almost always leads to emission problems.

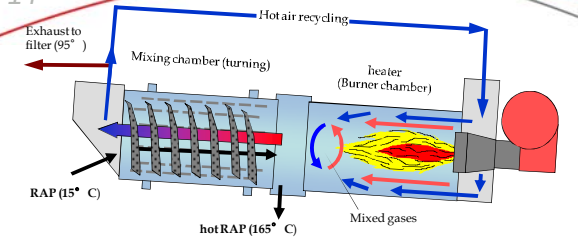
Emissions

13

- *RA heating drums have been designed in the past 20 years with a target of up to 50-60% RA in mixes.*
- *Specifications in most countries only allow much lower limits*
- *If such a drum exists, the only way to push RA %age is to*
  - Turn up the heat
  - Lower the throughput/time
  - Use warm mix technology
- *The first two alternatives will expose the RA to high temperature and cause significant increase of carbon based emissions and deteriorate the binder inside RA*
- *Measurements in Germany show that emissions from conventional RA drums become critical at mix temperatures >145 ° C*

New generation RAP heater

14



No damaged bitumen	High Efficiency	Low emissions
• No contact to flame	• Counter Flow Principle • Hot air is returned	• Indirect Warming • Low temp. heat exchange

Source: Ammann Technology Tour 28.04.2010

New RAP heater generation

MIX IT WELL!!!

16

Mixing time 15 Seconds

Mixing time 45 Seconds

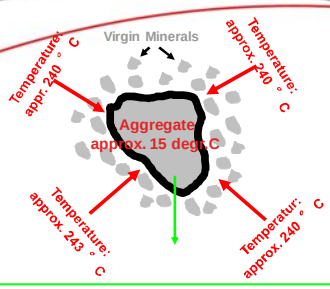
High RA content / need for commingling

17

- *With high RAP contents it is absolutely necessary to fully melt the binder contained in RAP prior to and during mixing.*
- *Binder must blend with virgin bitumen and/or rejuvenants and other additives*
- *Addition of virgin aggregate must be fully coated*
- *Indicative temp target: Bitumen becomes pumpable approx. 70-80 ° C above the softening point R&B. This should be the indicative temp. for efficient commingling*
- *This is especially important if RAP binder is unmodified and „modification while mixing" by addition of highly modified virgin binder is planned.*

High RAP content / need for commingling

18



Resulting mix temp. after 40 Seconds mixing approx.
170 degr. C

How to check commingling

25% RAP, mixed with light coloured virgin aggregate.
The visible difference in colour of the batches can be used to assess a mixing time to achieve good commingling of RAP binder with virgin binder.

A closer look at the binder

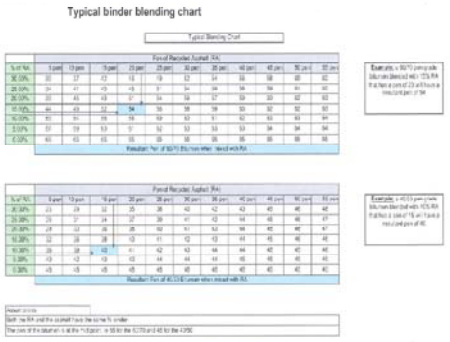
20

- ***The 4 mechanisms of binder ageing***
- *Oxidation*
  Reaction of bitumen with oxygen
- *Volatilisation*
  Evaporation of lighter binder constituents
- *Polymerisation*
  Combination of like molecules to form larger molecules, resulting in progressive binder hardening
- *Separation*
  Removal of bitumen constituents in selective absorption by some porous mineral aggregates

John Read, David Whiteoak, The Shell Bitumen handbook, London 2003

Adjustment of binders

Typical binder blending chart



Source: Technical Recommendations for Highways, TRH 21:2009, Sabita 2009, Ch. 8

Adjustment of binders

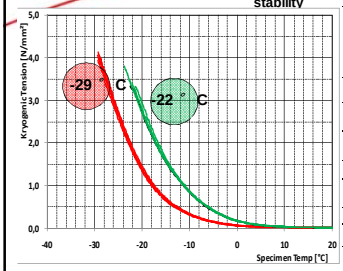
22

- ***In almost all countries of the globe it is best practice to use soft virgin binders to accomodate the aged binders in RAP***
- ***In many countries softer binder grades are capped at PEN 100***
- ***Germany limits softer binders to one grade softer than tendered***
- ***Even with much softer bitumen the „blending in the mixer“ ends at 50-60% RA***
- ***With very high RA content the binder quality needs to be readjusted with rejuvenators***

Trials with rejuvenators at Saseler Weg, Hamburg Germany

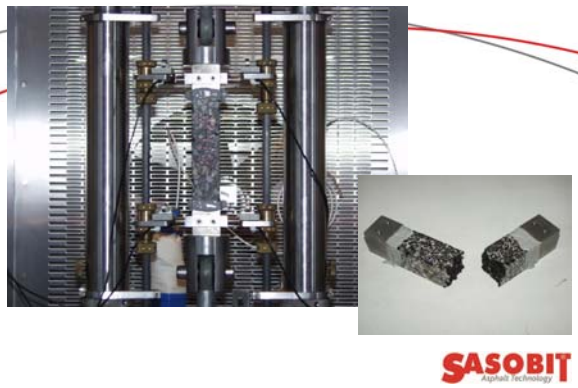
25

- Comparable rut resistance
- Significant improvement in cold stability



	Section with rejuvenator AC 8 D N	Control AC 8 D N
RAP content	40 %	40 %
Binder content from RAP	2,2 M.-%	2,2 M.-%
Virgin binder	3,8 M.-% (PEN50/70)	4,2 M.-% (PEN70/100)
Rejuvenator	0,4 M.-%	-
Resulting binder content	6,4 M.-%	6,4 M.-%
R&B RAP	62,4 ° C	62,4 ° C
R&B virgin bitumen	52,0 ° C	46,5 ° C
Targeted resulting R&B	52,0 ° C	52,0 ° C
R&B found in core	53,0 ° C	55,0 ° C

Tensile Stress Restrained Specimen Test (TSRST)



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Adjustment of binders

27

- *Following the above logic the full recycling method was devised*
- *Rejuvenation to readjust the binder*
- *Addition of Sasobit to ensure Warm Mix effect for*
  - Manufacturing within clean air act limitations
  - Modify asphalt to more deformation resistance
  - Get supreme Workability

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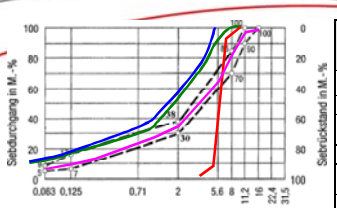
Paving a wearing course with >90% RAP

28

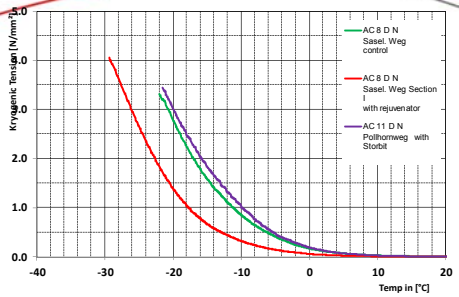


63,7 M.-%	RAP Pollhornweg 16 RA 0/11
27,3 M.-%	RAP different sources 11 RA 0/8
9,0 M.-%	Rhyolith 8/11 *(virgin)*
100,0 M.-%	AC wearing course AC 11 D S

	Mix data AC 11 D
RAP content	
Binder content	
Virgin binder content	0 M.-%
Additives	
Resulting binder content	
R&B RAP	
R&B virgin bitumen	-
Targeted R&B	
R&B found in cores	

Paving a wearing course with >90% RAP

29



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Paving a wearing course with >90% RAP

30

Mischguteigenschaften		Mischgut-zusammensetzung	Sollwert min	Sollwert max
Rohdichte	Mg/m³	2,499		
Raumdichte	Mg/m³	2,427		
Hohlraumgehalt (ber.)	Vol.-%	2,9	2,5	4,5
Hohlraum mit Bindemittel ausgefüllt, HFB	%	81,3		
Proportionale Spurbildungstiefe (60 °C Luftbad / Gummirad)	%	5,8		
Spurbildungstiefe (50 °C Wasserbad / Stahlrad)	mm	3,9		
Verdichtungstemperatur	°C	125,0		

Hamburg Wheel Tracking result 3.9mm deformation after 20000 cycles

- *This mix design normally fails around 12000 cycles!*
- *8mm SMA expected to have 3.5 mm*
- *Warm Asphalt!*

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Paving a wearing course with > 90 % RAP; key data

31

- R&B of recovered binder after paving 2010: 64 ° C
  - Second inspection January 2012: 64,7 ° C
- TSRST measured in 2010: -21,7 ° C
  - Second inspection January 2012: -22 ° C
- Hamburg wheel tracking test 2010: 3,9 mm track depth
- Permanent deformation index (compressive oscillating test on Marshall specimen) according to TP Asphalt-StB is resulting in measurements of ε_{w^*} between 5,7 and 6,3 x 10^{-4} ‰
  - *Expected for this kind of asphalt is a value around 14 x 10^{-4} ‰*
- Visual inspection of project in 2012 confirms measurements

Summary

32

- Project is performing well after two years. Confirms findings of other older private projects built with different mix designs
- Performance after two winters with temperatures below -10 ° C and two summers with maximum temperatures > 35 ° C suggest further good performance in Hamburg climate conditions
- So far the performance is equal to or better than a wearing course built with new materials.
- State of Hamburg will do more projects
- Other German states are building likewise reference projects
- Solution where technical performance and ecologic benefit meet in an economically very viable solution

The End

33

- *Thank you for your attention!*

Questions?