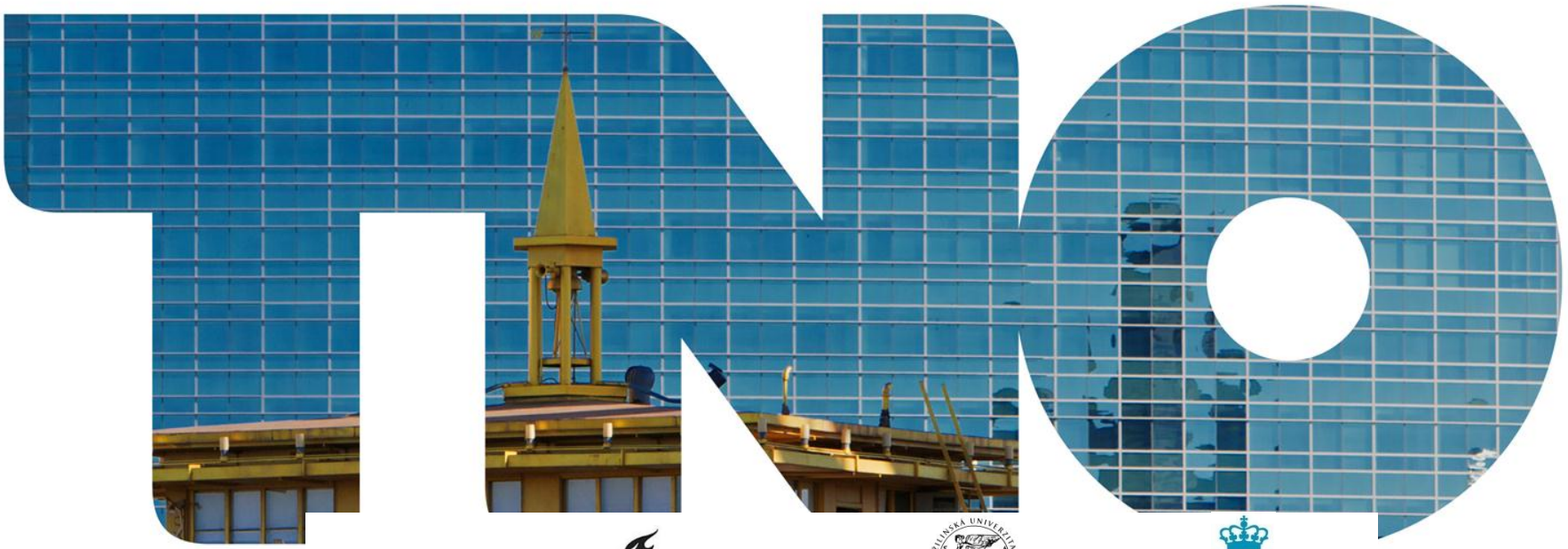
TNO innovation for life

RECYPMA

PEB meeting, December 11th, 2012

Jos Wessels



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TU Delft


Content

- Project
- Progress, work done
- Work packages
- Work to be done

The Netherlands Organization for Applied Scientific Research (TNO)

Delft University of Technology (DUT)

The University of Zilina (UNIZA)

Danish Road Directorate, Danish Road Institute (DRI)

Why RECYPMA

- Polymer modified asphalt (PMA) used extensively in past decades
- For durability and functionality
  - the Netherlands, Denmark, Slovakia
- Reaching end of life => Reclaimed asphalt (RA) with PMB
- PMA to be recycled at its highest practical potential


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Objectives RECYPMA

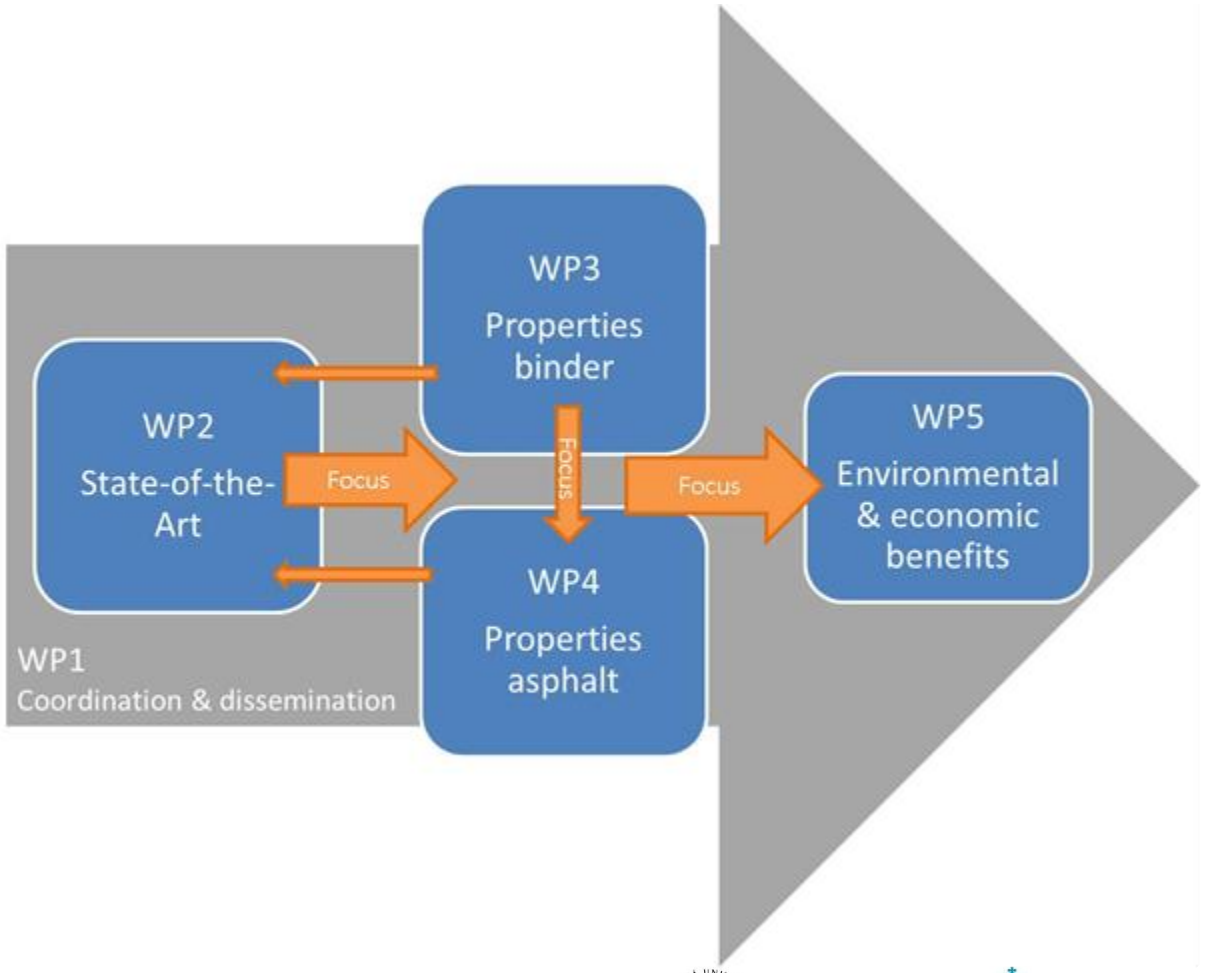
Recycle a significant amount of Polymer Modified RA from *surface* layers into new *surface* layers

- gain *additional* know-how on how to utilise aged polymer modified bitumen (PMB) in new mixes
- study the effect of blending “old PMB” with new soft bitumen and new PMB on the combined binder properties
- investigate the influence of the combined binder on the properties of the asphalt
- estimate the potential environmental (LCA) and economic (LCCA) benefits of recycling of premium quality asphalt containing PMB

Results

- Report(s)
  - What is the potential of using PMRA in new asphalt?
  - What is the benefit?
  - Conclusions based on the agreed laboratory test results

  - What (do we think regarding the results of the project) should be done to get this implemented (technically)


WP3
Properties
binder
WP2
State-of-the-
Art
Focus
Focus
Focus
WP5
Environmental
& economic
benefits
WP4
Properties
asphalt
WP1
Coordination & dissemination

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Step	Milestones and Deliverables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
WP 1: Management andknowledge dissemination																									
	M1.1 Discussion of intermediate results during first meeting with PEB month 9									M1.1															
	M1.2 Discussion of intermediate results during first meeting with PEB month 18																		M1.2						
	D1.1 Half year progress report month 6						D1.1																		
	D1.2 Half year progress report month 12												D1.2												
	D1.3 Half year progress report month 18																		D1.3						
	D1.4 Last progress report month 21																					D1.4			
	D1.5 Quality assurance plan month 3			D1.5																					
	D1.6 Final report month 24																								D1.6
	D1.7 Paper month 24																								D1.7
	D1.8 Presentation month 24																								D1.8
WP 2: State of the art in recycling of modified binders																									
	M2.1 Overview on practical laboratory methods for extraction of aged polymer modified bitumen with the purpose of characterisation of their bulk properties								M2.1																
	M2.2 Overview on laboratory mixing methods with respect to their use and ability to reflect full scale conditions								M																
	D2.1 (Draft) report on State of the art of recycling experience put into the framework of the main asphalt plant configurations for recycling hot mix asphalt																								
	D2.2 (Draft) state of the art report, containing milestones and deliverables including the experience gained through the project on the feasibility of extraction methods and of laboratory mixing method used																							D2.2	
WP 3: Properties of aged polymer modified binder																									
	M3.1 Selection of well documented road surfaces from practice																								
	M3.2 Obtaining samples from road surfaces																								
	M3.3 Selection of laboratory aging protocol						M3.3																		
	M3.4 Mix designs for asphalt mixtures using polymer modified RA cho								M3.4																
	D3.1 (Draft) report on the properties of aged polymer modified bi															D3.1									
WP 4: Properties of asphalt mixtured using reclaimed material wi binders																									
	M4.1 Production of asphalt mixtures											M4.1													
	M4.2 Present preliminary test res															M4.2									
	M4.3 Selection of spec analyses															M4.3									
	M4.4 Final																			M4.4					
	M4.5 Service test results for WP 5																					M4.5			
	D4.1 (Draft) repo t mixtures using RA containing polymer modified binder month 21																					D4.1			
WP 5: LCCA of reclaimed asphalt mixture																									
	M5.1 Materials and production process from WP 2, 3 and 4																					M5.1			
	D5.1 (Draft) report on the benefits of asphalt using polymer modified RA																								D5.1
Projectgroup meetings																									
	Delft TNO and TUDelft	X																							
	Denmark DRI								X																
	Slovenia UNIZA																	X							
PEB meetings																X									

Okt Nov Dec Jan Feb Maa Apr Mei Jun Jul Aug Sep Okt Nov Dec Jan Feb Maa Apr Mei Jun Jul Aug Sep

Planning RECYPMA project


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	Selection extraction protocol	Jan 2012	DRI will make a proposal in January 2012, a decision will be taken in the conference call of January
	Research set-up for bitumen	Feb 2012	In the January conference call the proposal of the TU will be dis[illegible]ssed, comments will be taken into account a it will be agreed upon in the conference call of F[illegible]
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	Literature study on laboratory mixtures	April 2012	Erik will finish the chapter on laboratory m[illegible]
	Design of aphalt mix DRI	June 2012	DRI presents their mix design to UN[illegible]
90%	Binder properties at different replacement ratio's and "log Pen rule"	May 2012	TU Delft and DRI will present re[illegible] % recycling with a first suggestion for the "log Pe[illegible]
	DRI will send their materials to UNIZA	May 2012	
	Final information for report WP2	July 2012	Greet will send[illegible]
	Finish binder tests at TUD	Aug 2012	Gang will [illegible]
	Decision on DSR tests at DRI	Aug 2012	
	Finish concept report WP2 (D2.1 and D2.2)	Aug 2012	
	Laboratory aging plan	Sept 2012	
	TUD will send virgin binders to UNIZA	Sept 2012	
	Finish DSR test on Danish binder	Sept [illegible]	[illegible]ommunicated
	TUD will send materials for Dutch mixtures to UNIZA		
	Respons concept report WP2		[illegible] on concept report WP2
	Design of aphalt mix TUD		[illegible]r mix design to UNIZA.
	Prelimanry results on SMA [illegible]		[illegible]amples for microscropy to DRI
	Concept report WP3		[illegible] will send the concept version of the report of WP3 around
	Final report WP2		[illegible]ik will incorporate comments and finish report WP2
	Respons conc[illegible]		Partners will comment on concept report WP3
	Preliminary resu[illegible]		2x5 AC samples for microscropy to DRI
	Results on labora[illegible]	[illegible]12	Gang will send results on laboratory aged binder
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	Preliminary results on PA [illegible]halt mix	Feb 2013	2x5 PA samples for microscropy to DRI
	Final report on aged binder	Feb 2013	
	Partner meeting at UNIZA	Feb 2013	
	All information assembled for impact analyses	June 2013	
	Concept report impact analyses	July 2013	

Critical information flows and decisions RECYPMA

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WP 2: State of the art on recycling of polymer modified binders

- Three subjects
  1. Extraction of polymer modified binder from reclaimed asphalt => WP 3
  2. Laboratory mixing with addition of polymer modified reclaimed asphalt => WP 4
  3. Experience at asphalt plants

Use of PMRA in practise

- Full scale recycling that focuses on the optimal use of the potential of the old polymer modified asphalt is still in its birth – apart from individual large scale rehabilitation job on very homogeneous stretches. Recent survey of the situation reveals that material handling from production of the reclaimed polymer modified asphalt and pre-processing needs further improvement to fully utilise the potential.

Laboratory mixing (=> WP4)

- A best practise laboratory mixing procedure with mixing order, steps and duration is suggested which after a necessary adaption of local conditions can be used to determine the optimum properties of a new mix containing reclaimed polymer modified asphalt.

Extraction of polymer modified binder (=> WP 3)

- Extraction can be performed satisfactory with dichloromethane and EN 12697-1 & -3 when the polymer in focus is SBS which also is the predominant polymer in hot mix asphalt
- For other polymer types the situation can vary, but this is not the direct subject of RECYPMA

WP2: Laboratory mixing including RPMA

- Dry RA at a low temperature prior to use
- Depending on the amount of RPMA superheated virgin aggregate can be used.
- Dry virgin aggregate for a period at mixing temperature or superheated temperature
- Heat virgin bitumen for shortest possible period prior to mixing
- Mixing temperature:
  - The rheology of the virgin or resulting binder
  - Temperature stated by the binder supplier (especially for PMBs)

Asphalt plant experience with RPMA

- Small amount recycled => no special treatment
- Problem recognizing PMB: analysis or historic background
- Grading curve RA => small amount of Polymers


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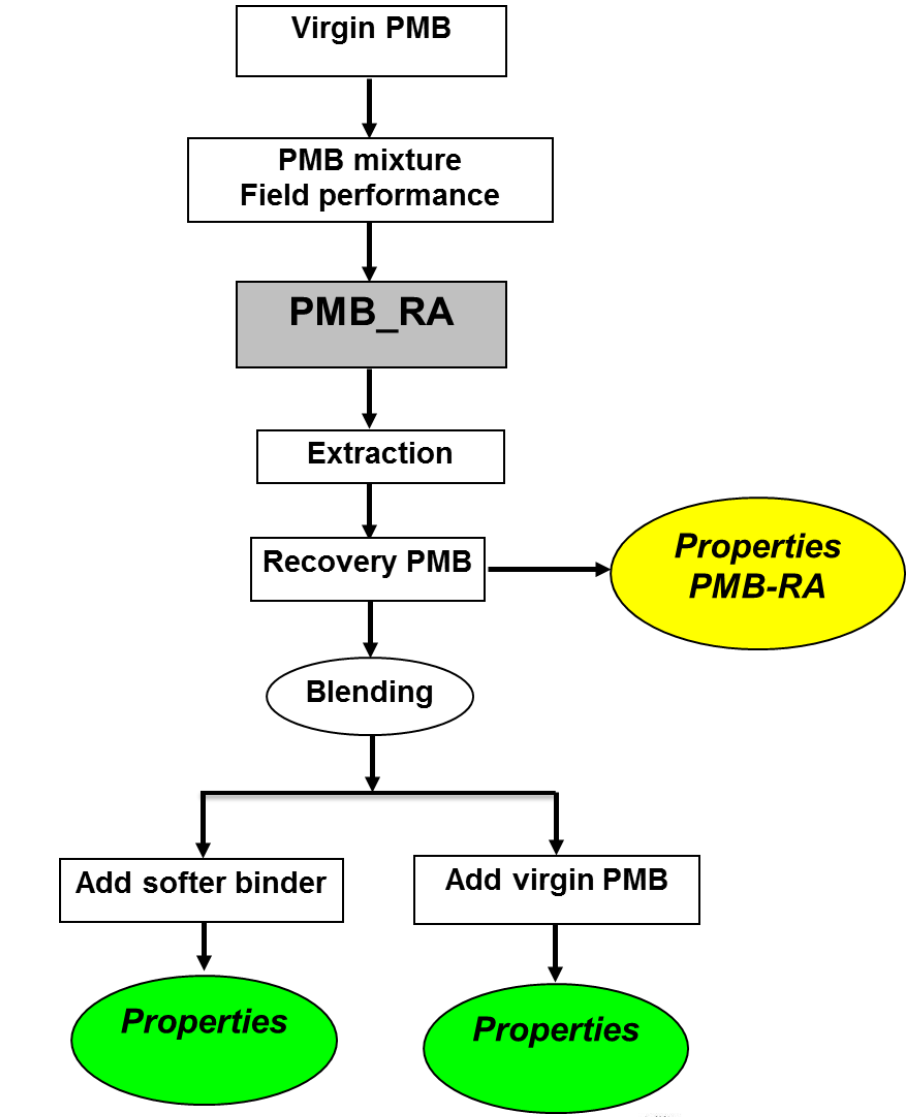
WP 3 Properties of Aged Polymer Modified Binder

- Obtain rheological properties PMB-RA binder PMBA (SBS)
- Study influence of blending with soft virgin pen grade binders and polymer modified (SBS) binders.
- Determine the positive impact on the properties of “new” binder when an aged PMB-RA is mixed with virgin binder for the production of a new mixture.
- Develop simple method / model to predict the effect of recycling on a blended binder (similar to log Pen rule).
- Developed rule will be used to advise on the type of binder that needs to be added for the design of the mixes that will be tested in WP4.


Virgin PMB
PMB mixture
Field performance
PMB_RA
Extraction
Recovery PMB
Properties
PMB-RA
Blending
Add softer binder
Add virgin PMB
Properties
Properties

WP 3

- Properties of aged PMB binder
  - mechanical behaviour at elevated temperatures
  - properties after blending with virgin binder
- RPMA samples
  - Dense asphalt concrete (DAC, from Slovak Republic)
  - Stone mastic asphalt (SMA, from Denmark)
  - Porous asphalt concrete (PAC, NL)
- % (mass) of PMB – RA in mixtures
  - 0%
  - 15%
  - 40%
  - 100%

RA

RAN, reclaimed from the top layer of double porous asphalt with 7 year old. It located at one section between Den Bosch and Eindhoven on Expressway A2 in the Netherlands. The brand is Styrelf PmB 40/100-65 HD.

RAS, reclaimed from dense asphalt mixture constructed in Slovakia, 1996. The brand is Apollobit MCA-S.

RAD, reclaimed from Stone Mastic Asphalt (SMA 11) produced Colas Danmark A/S in 1989 and paved on a motorway in Denmark (Jutland north of the town of Vejle). The bituminous binder was at the time of production called Caribit Plus 85 which was a SBS polymer modified bituminous binder with a penetration range from 70 – 100 x 0,1 mm and a softening point Ring & Ball above 75 °C.

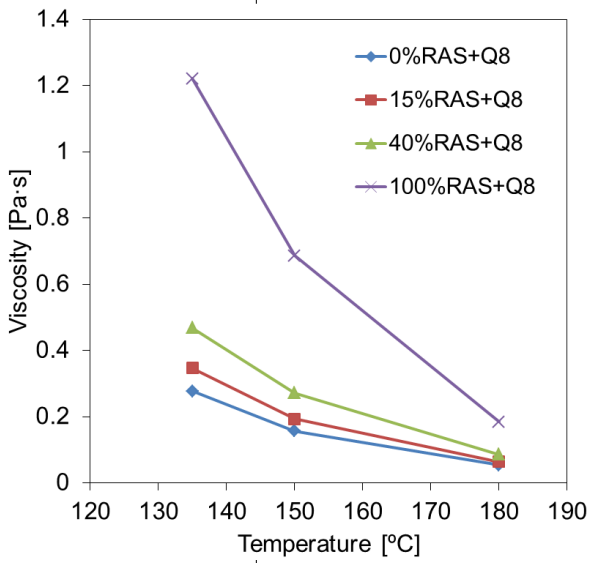
Blending

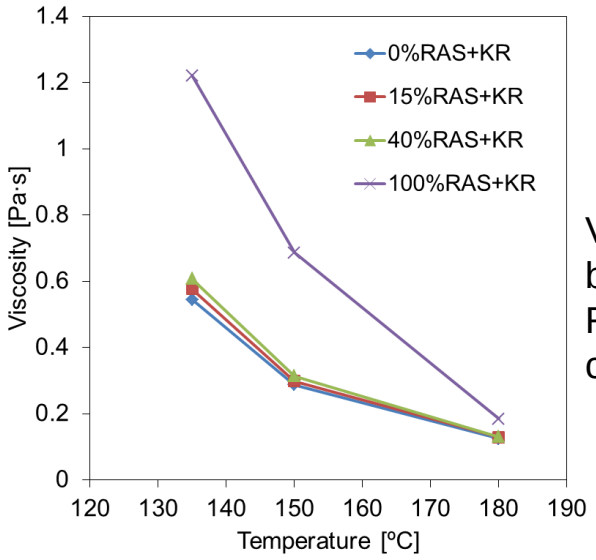
DUT
DRI

Silverson L5M high shear mixer in DUT

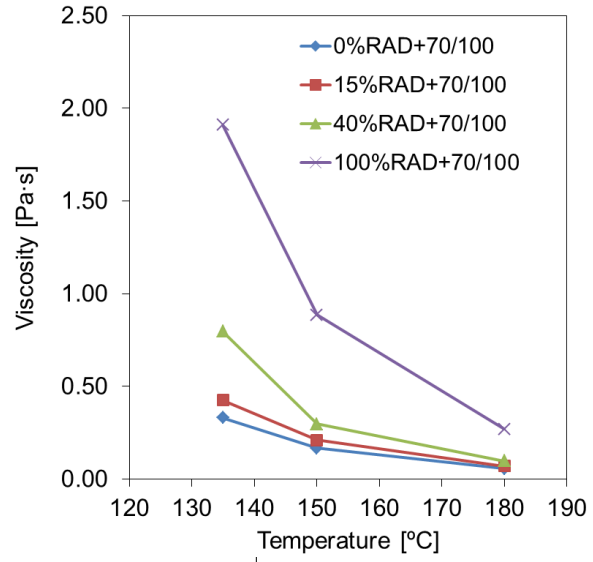

Testing program

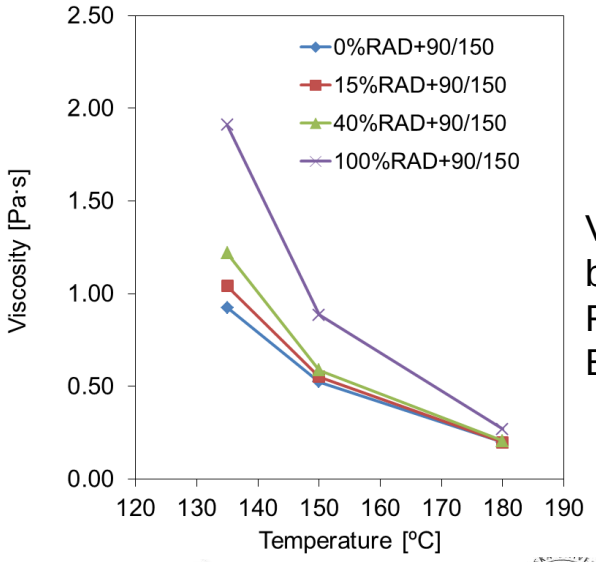
- Penetration, Softening Point
- DSR master curves
- Viscosities
- FTIR
- GPC





Viscosities at three temperatures for binder groups of RAS+Q8 (left) and RAS+KR (right), measured by using the cone/plate rheometer





Viscosities at three temperatures for binder groups of RAD+70/100 (left) and RAD+90/150 (right), measured by using Brookfield rheometer

WP3: Conclusions

- Adding soft virgin PMB can recover the rheological properties of PMB RA binder to original ones. An example has been made by comparing the master curves of 40%RAD+90/150 and the original binder of RAD.

- Soft virgin PMB is suggested to be used in recycling of polymer modified reclaimed asphalt if the polymer in the RA binder has not completely degraded. Because it gives the possibility to recover the properties of PMB RA binder, and then the potential of RA binder can be fully utilized.

WP 4 Properties of asphalt mixtures using reclaimed material with polymer modified binders

Matrix of mixtures (type – RA – bitumen)

% of RA	SMA		PA		AC	
	PG	PmB	PG	PmB	PG	PmB
0	x	x	x	x	x	x
Max possible	x	x	x	x	x	x
½ Max possible	--	x	--	x	--	x

15 different mixtures

Matrix of properties and tests

Test	Mixture		
	PA	SMA11	AC11
Air voids content	x	x	x
Water sensitivity ITSR	x	x	x
Wheel tracking test	x	x	x
Stiffness	x	x	x
2PB fatigue test	–	–	x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Design of mixtures – percentage of components

SMA 11

Table 3 Mix designs: Percentage of various components in the five mix of SMA 11

	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Nominal RA %	0 % RA	40 % RA	0 % RA	15 % RA	40 % RA
Virgin binder type	70/100 SV 12135 Straight run paving grade bitumen		90/150-75 SV 12129 Polymer modified bitumen		
Virgin binder	6,09	3,73	6,09	5,20	3,73
Filler – limestone	2,11	1,92	2,11	1,89	1,92
Filler – hydrated lime	2,10	1,92	2,10	1,89	1,92
Durasplit 0/2 mm	16,38	5,75	16,38	13,22	5,75
Durasplit 2/5 mm	5,62	0,00	5,62	0,00	0,00
Durasplit 5/8 mm	11,23	4,79	11,23	11,33	4,79
Durasplit 8/11 mm	56,17	43,14	56,17	51,95	43,14
RA (binder + aggregate)	0,00	38,45	0,00	14,22	38,45
Fibres	0,30	0,30	0,30	0,30	0,30
SMA 11 mix	100,00	100,00	100,00	100,00	100,00

Production of mixtures – heating temperatures

SMA 11

Bitumen

Agreed in Copenhagen - heating temperature
for 70/100 (SV 12135): approx. 150 °C
for 90/150-75 (SV 12129) approx. 180 °C

Virgin aggregate

20 °C more than bitumen – because of decreasing temperature during a dosage of bitumen

Reclaimed asphalt

The same as a bitumen

It is better from practical point of view – we only need two temeratures in ovens

RA at 110 °C and overheating of virgin aggregate require three temperatures (including bitumen)

Production of mixtures – procedure of mixing

SMA 11

Mix of virgin aggregate – without filler at 200 oC (no mixing)

Fibres at 110 oC (mixing)

Reclaimed asphalt at 180 oC (mixing)

Virgin bitumen at 180 oC (mixing)

Filler at 180 oC (mixing)

Preparation of samples

SMA 11

What temperature for preparation of samples? – (agreed in Copenhagen):

for 70/100 (SV 12135): 140 °C without RA, 150 oC s 15 % RA a 165 oC for 40 % RA

for 90/150-75 (SV 12129) approx. 170 °C

Bulk density – how many blows in Marshall compactor - 2x50 (agreed)

Temperature and number of blows can influence void content !!!!

Void content 1,5 – 4,5 %, voids filled with bitumen 80 – 92 %

ITSR - how many blows in Marshall compactor - 2x35 (agreed)

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Weight of mixture for all tests

SMA 11

	Calculation for SMA11								
	bulk density	maximum density	air void content	water sensitivity ITSR		wheel tracking WTSair	fatigue 2PB	stiffness (IT-CY)	Total weight of asphalt
				ITS dry	ITS wet				in g for all tests
shape	cylinder		only calculation	cylinder	cylinder	slab	slab	cylinder	
dimensions	D 101 mm h 64 mm	D 101 mm h 64 mm		D 101 mm h 64 mm	D 101 mm h 64 mm	266x320x40 mm	266x320x40 mm	D 101 mm h 64 mm	
weight of one sample 1)	apprx. 1250 g	apprx. 1250 g		apprx. 1250 g	apprx. 1250 g	apprx. 8500 g	apprx. 8500 g	apprx. 1250 g	
numer of samples	4	0 3)		3	3	2	3	24 4)	
total weight of samples in g	5000	0	0	4000	4000	17000		30000	60000

	Calculation for PA								
	bulk density	maximum density	air void content	water sensitivity ITSR		wheel tracking WTSair		stiffness (IT-CY)	Total weight of asphalt
				ITS dry	ITS wet				in g for all tests
shape	cylinder		only calculation	cylinder	cylinder	slab		cylinder	
dimensions	D 101 mm h 64 mm	D 101 mm h 64 mm		D 101 mm h 64 mm	D 101 mm h 64 mm	266x320x40 mm		D 101 mm h 64 mm	
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numer of samples	4	0 3)		3	3	2		24 4)	
total weight of samples in g	5000	0	0	4000	4000	17000		30000	60000

Weight of asphalt components

SMA 11

			Weight of asphalts components (g)									
Mixture No.	Binder	% of RA	virgin binder	Filler limestone	Filler hydrated lime	Durasplit 0/2	Durasplit 2/5	Durasplit 5/8	Durasplit 8/11	RA	Fibres	Total
1	70/100	0	3654	1266	1260	9828	3372	6738	33702	0	180	60000
2	70/100	40	2238	1152	1152	3450	0	2874	25884	23070	180	60000
3	PMB	0	3654	1266	1260	9828	3372	6738	33702	0	180	60000
4	PMB	15	3120	1134	1134	7932	0	6798	31170	8532	180	60000
5	PMB	40	2238	1152	1152	3450	0	2874	25884	23070	180	60000
Total weight for 5 mixtures			14904	5970	5958	34488	6744	26022	150342	54672	900	

Weight of asphalt components

SMA 11

Figure 3 EUR pallet No 1

Figure 4 EUR pallet No 2

Figure 5 EUR pallet No 3

Test of asphalts – wheel tracking test

Small size device, the methode B, testing in air (EN 12697-22)

2 slabs (chapter 3.5 test portion)

Dimension of slabs 260 x 320 x 40 mm (chapter 7.1.1.2 Nominal thickness)

Hrúbka dohodnutá na 40 mm

Test temperature - 60 °C SMA, 50 oC AC

$$WTS_{AIR} = \frac{(d_{10\,000} - d_{5\,000})}{5}$$

where

WTS_{AIR} is the wheel-tracking slope, in millimetres per 10^3 load cycles;

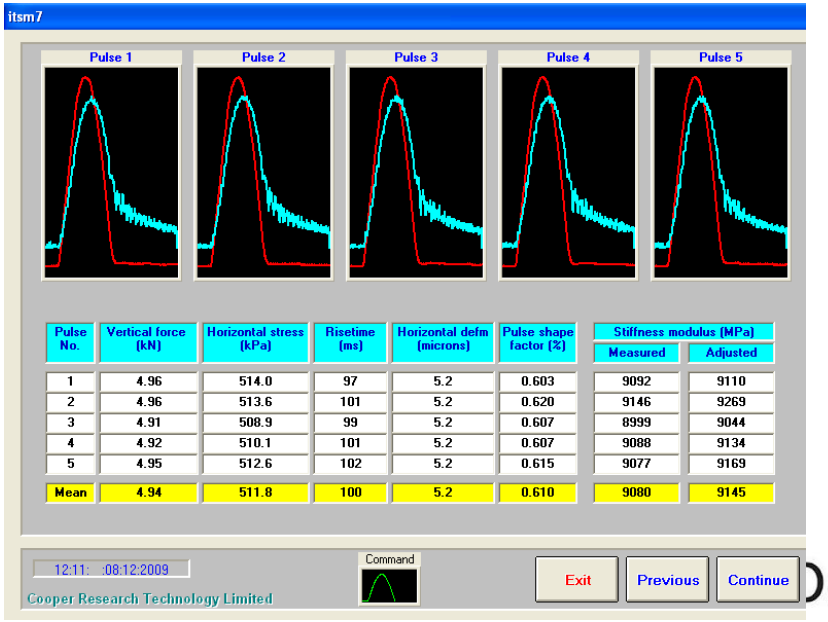
$d_{5\,000}$, $d_{10\,000}$ is the rut depth after 5 000 load cycles and 10 000 load cycles, in millimetres (mm).

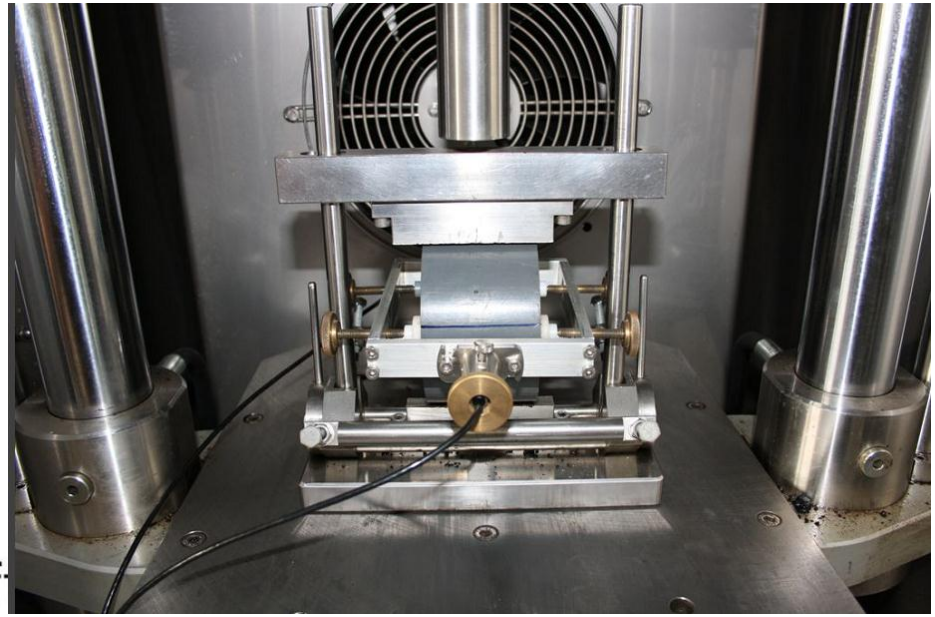
Test of asphalts – stiffness

Indirect tensile test - IT-CY (EN 12697-26, Annex C)

(test applying indirect tension to cylindrical specimens)

4 temperatures (0, 15, 27, 40 °C) 6 samples per one temperature





WP5 Environmental and economic benefits of the use of polymer modified reclaimed asphalt

- Starts end of May 2013
- Scenario (input needs) made in draft
  - Description of road (representative case)
  - Description of asphalt (SMA, PA, CA)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	All information assembled for impact analyses	June 2013	
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Critical information flows and decisions RECYPMA

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	Prelimanry results on SMA asphalt mix	Oct 2013
	Concept report WP3	Okt 2012
	Final report WP2	Nov 2012
	Respons concept report WP3	Nov 2012
	Preliminary results on AC asphalt mix	Nov 2012
	Results on laboratory aged binder	Nov 2012
	Final report WP3	Dec 2012
	List of inputparameters for impact analyses (WP5)	Jan 2012
	Concept report on laboratory aged binder	Jan 2013
	Preliminary results on PA asphalt mix	Feb 2013
	Final report on aged binder	Feb 2013
	Partner meeting at UNIZA	Feb 2013
	All information assembled for impact analyses	June 2013
	Concept report impact analyses	July 2013

Meetings:

- PSU meeting on 3th and 4th of November 2011 (Delft)
- Midterm meeting 25th and 26th of June 2012 (Copenhagen)
- Next project meeting: February 2013 (Zilina)

Telcons:

November 2012
October 2012
August 2012
June 2012
27/4/2012
30/3/2012
17/2/2012
13/1/2012
9/12/2011
Next: January 2013