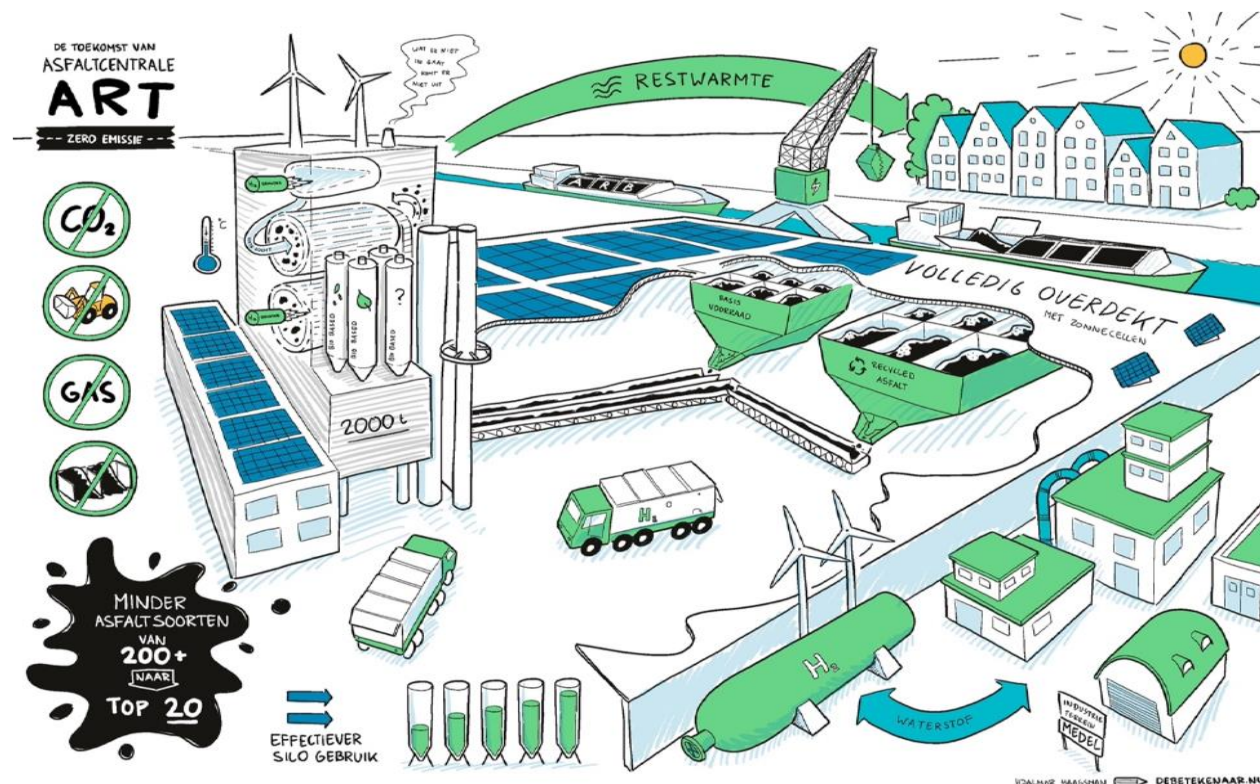


High-Percentage Recycling in Surface Layer Mixtures

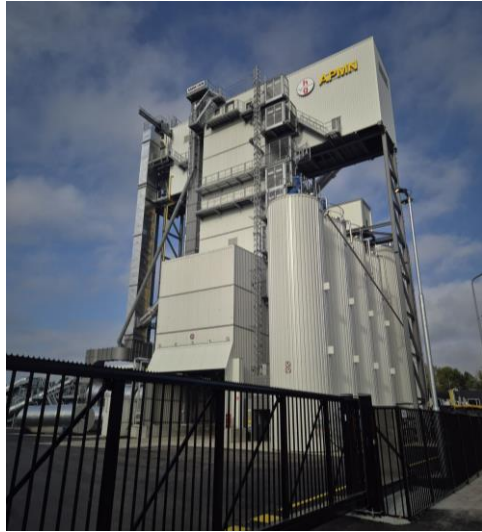


dr.ir. Frank Bijleveld, dr.ir. Milliyan Woldekidan
September 9, 2025
Aachen, Germany

Content of this presentation

- ART asphalt production in general
- RAP in the Netherlands and regulation
- Validation trajectory
- Results 60% RAP in Surface layers (lab + field)
- Environmental impact
- Limitations and future research

Asphalt production and shareholders



- App. 1,5-1,7 Mton asphalt
- App. 20-25% Dutch market



Introduction

Dutch Market driven by (price and) sustainability and recycling has major impact

The RAW standard

- Bin/base asphalt mixes; no limit in RAP
 - Surface layer mixes 0- 30%RAP
 - SMA and PA; no RAP allowed
-
- Current practice NL
 - Bin/base asphalt mixes; 50 to 80% RAP normal
 - AC surface layer mixes, 30% RAP normal (higher RAP contents used with validation)
 - SMA and PA: RAP is used, after validation

Our concept of RAP in surf mixtures

- High-quality RAP from surface layers to surface layers
 - Quality of the aggregate
 - Homogeneous grading
 - Binder content and quality
- Add a rejuvenator to upgrade the RAP-binder (mainly add maltene-fraction)
- Indirect heating RAP in asphalt plant (HGG, no overheating the RAP)



Recycling RAP

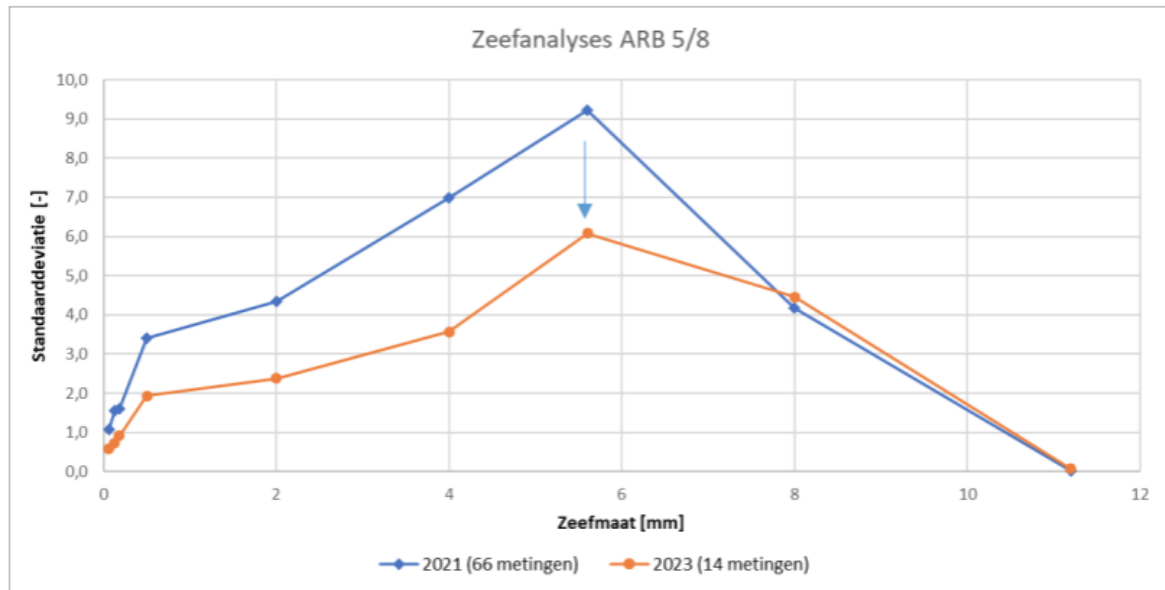
- Controlling the incoming RAP
 - PA (ZOAB/DZOAB; no 2L-PA)
 - Aggregate type 3 (PSV, LA, ..)
- High-quality RAP
 - 8/16 → PA 16, AC 16
 - 8/11 → SMA 11, AC 11
 - 5/8 → SMA 8, AC 8
 - 0/5 → AC (base/bin/surf)
- Scale
 - 4 contractors
 - 5 asphalt plants
 - Aggregate supplier (Bontrup)



Recycling RAP (2)

Quality of ARB material is key:

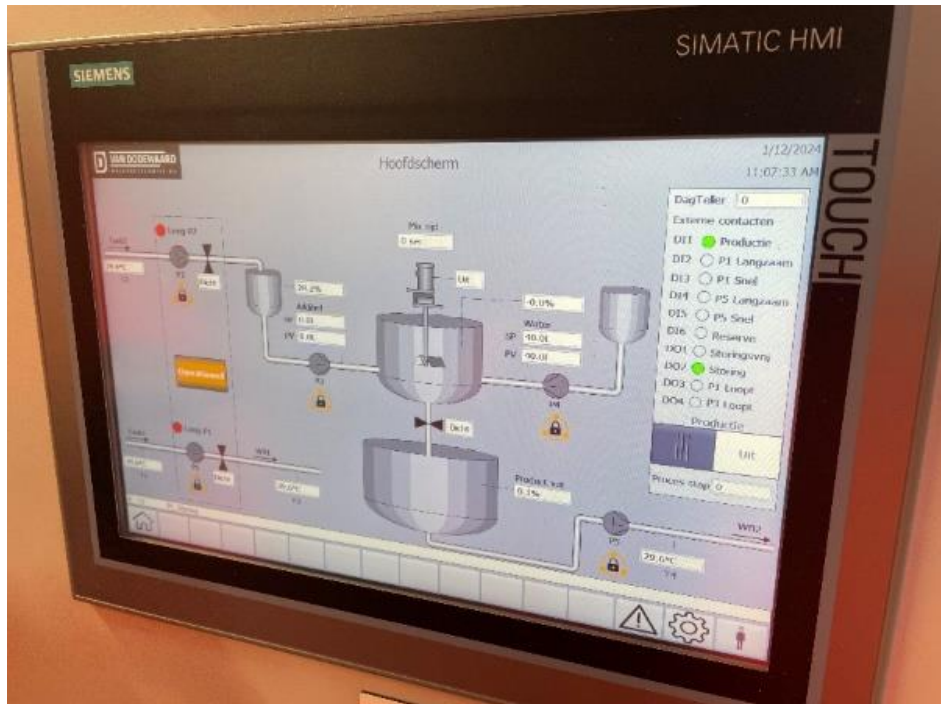
- Homogeneity (grading)
- The quality of old bitumen (Pen, FTIR)
- Aggregate quality (selective milling, only from PA sections)



Available fractions: 0/5 ,5/8, 8/11, 8/16

Dosage rejuvenator asphalt plant

- Comparison study of 4 rejuvenators
- Accurate dosage system, included in software (under- and over-dosage is very critical)
- Dosage directly into beginning of the mixer



Indirect heating RAP

- Heat gas generator (HGG)
- Indirect heating of the RAP material
- Less aging of the RAP in the plant
- More accurately steer on temperature



▲ © Caspar Huurdeman

Asfaltcentrale Tiel té schoon voor milieuprotest

Met het bedrijf Asfalt Productie Tiel (APT) is niks mis: het blijft keurig binnen de milieunormen. Milieuorganisatie MOB (Mobilisation for the Environment) uit Nijmegen haalde daarom deze week een bezwaar tegen de Tielse asfaltproducent van tafel.



Validation trajectory

Validation (AKL and ITC):

- Normal per mixture type
- TRL ladder (TRL1-TRL9)
- Intensive work required and very time consuming
- Assessment by external committee

Group-validation:

- Look into commenalities between mixtures in groups
- Lab and field study on AC Surf, SMA and PA
- Validation for all surface layers



Group Mixtures	
DGD 8 65% RAP	AC 11 Surf 65%RAP
SMA 11 65% RAP	SMA 11 30% RAP
SMA 8 65% RAP	SMA 8 30% RAP
SMA 8G 65%RAP	SMA 8G 30% RAP
PA 8G 65%RAP AC 16 surf 65%PR	PA 8G 30% RAP PA 16 60% RAP

Overview tests

Research on component materials:

	Test	NEN
RAP	Soluble binder content	NEN-EN 12697-1
	Pen, R&B and DSR on extracted bit	NEN-EN 1426/1427 NEN-EN 14770
	Grading	NEN-EN 12697-2
	Density	NEN-EN 1097-6
	Amount of contaminants	NEN-EN 12697-42
Bitumen	DSR on fresh and aged	NEN-EN 14770
	Pen, R&B	NEN-EN 1426/1427
	DSR blend bitumen	NEN-EN 14770
Aggregaat	FAP test (stroefheid)	NEN-EN 12697- 49

Research on mixture level:

	Test	NEN
SMA	Density	NEN-EN 12697-5, water proc.A
	Air voids	NEN-EN 12697-8
	Composition and grading	NEN-EN 13108-1/13043
	ITSR	NEN-EN 12697-12 en 23
	Maximum density	NEN-EN 12697-5, water proc.A
AC surf	Air voids	NEN-EN 12697-8
	Composition and grading	NEN-EN 13108-1/13043
	ITSR	NEN-EN 12697-12 en 23
	4PB Fatigue	NEN-EN 12697-24
	4PB Stiffness	NEN-EN 12697-26
DGD	Permanent deformation	NEN-EN 12697-25-methode B
	Density	NEN-EN 12697-5, water proc.A
	Air voids	NEN-EN 12697-8
	Composition and grading	NEN-EN 13108-1/13043
	ITSR	NEN-EN 12697-12 en 23

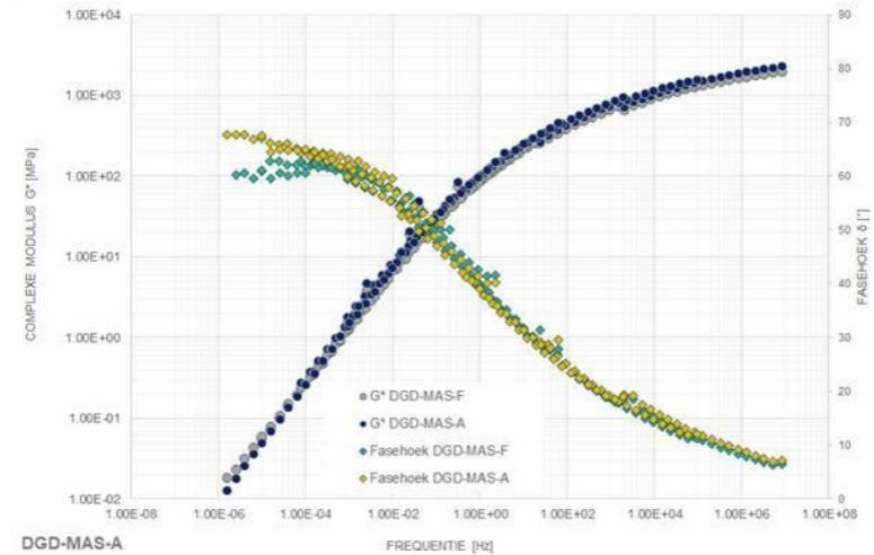
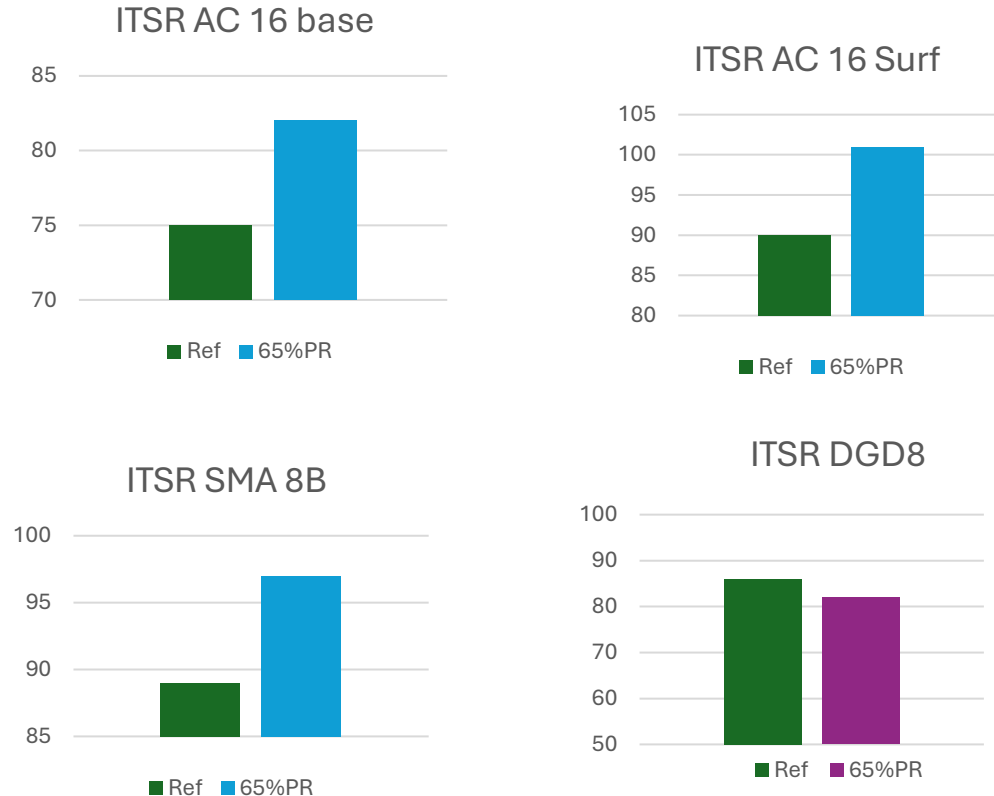
Research on field performance: 19 projects during 2-14 yrs (ave. 6 yrs)

Research on field: Test sections



High RAP Mixes: Performance

Equivalent or better performance with standard mixes

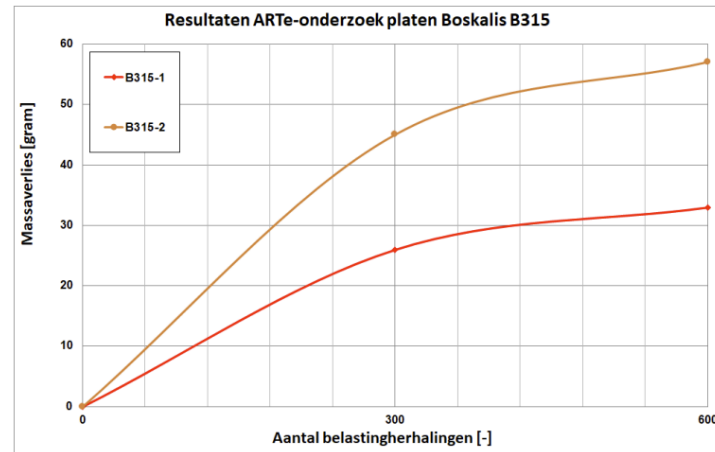
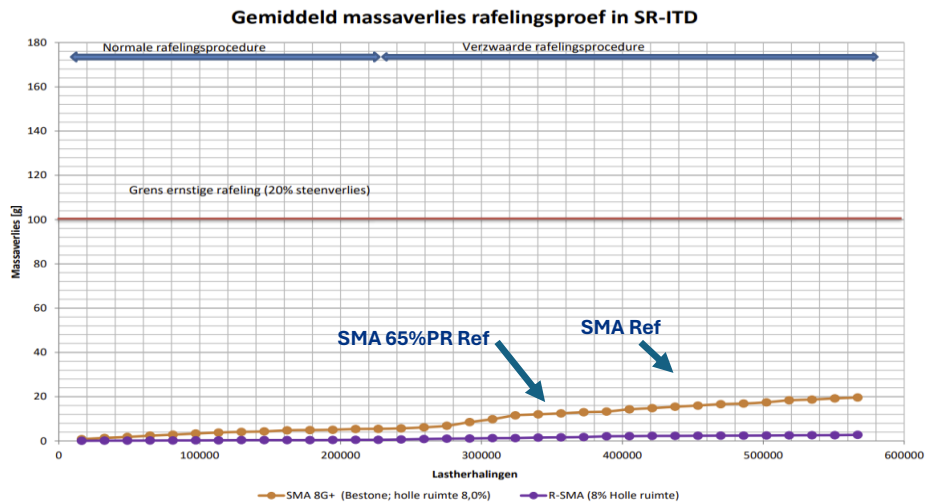
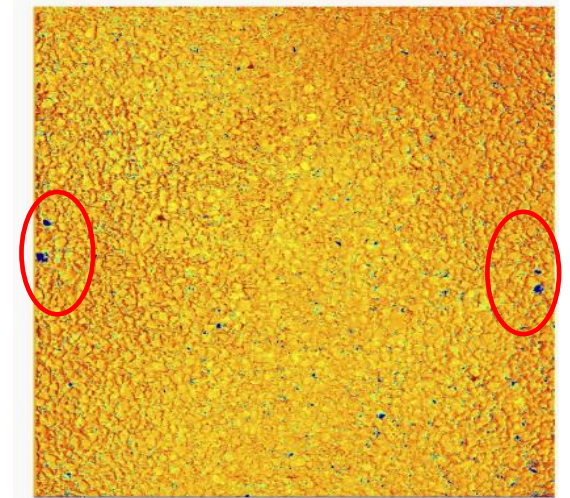
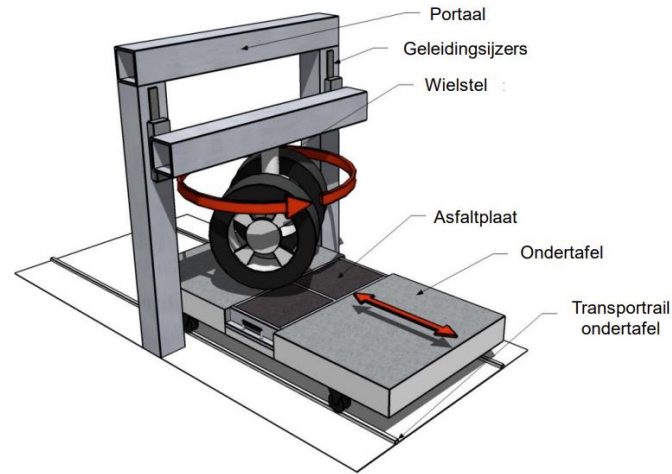
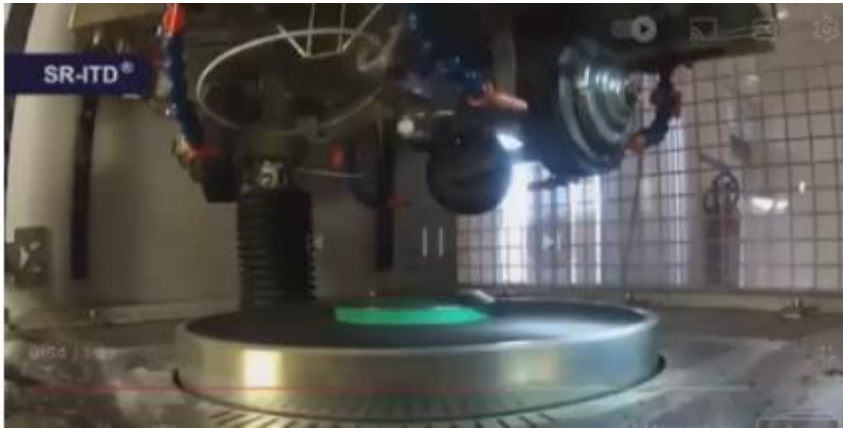


DGD-65%PR before and after aging

Well designed Asphalt Mixtures with high RAP can perform equivalent or better than their equivalents with 0% RAP!

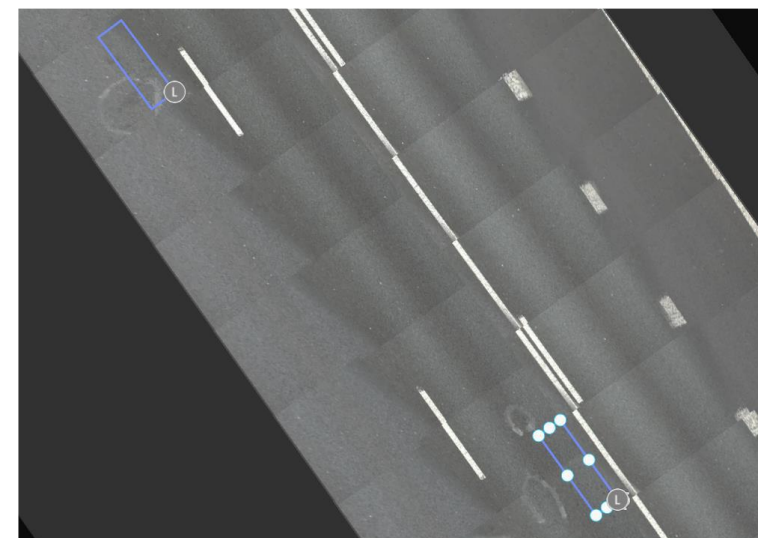
High RAP Mixes: Performance

Ravelling (ARte en SR-ITD)



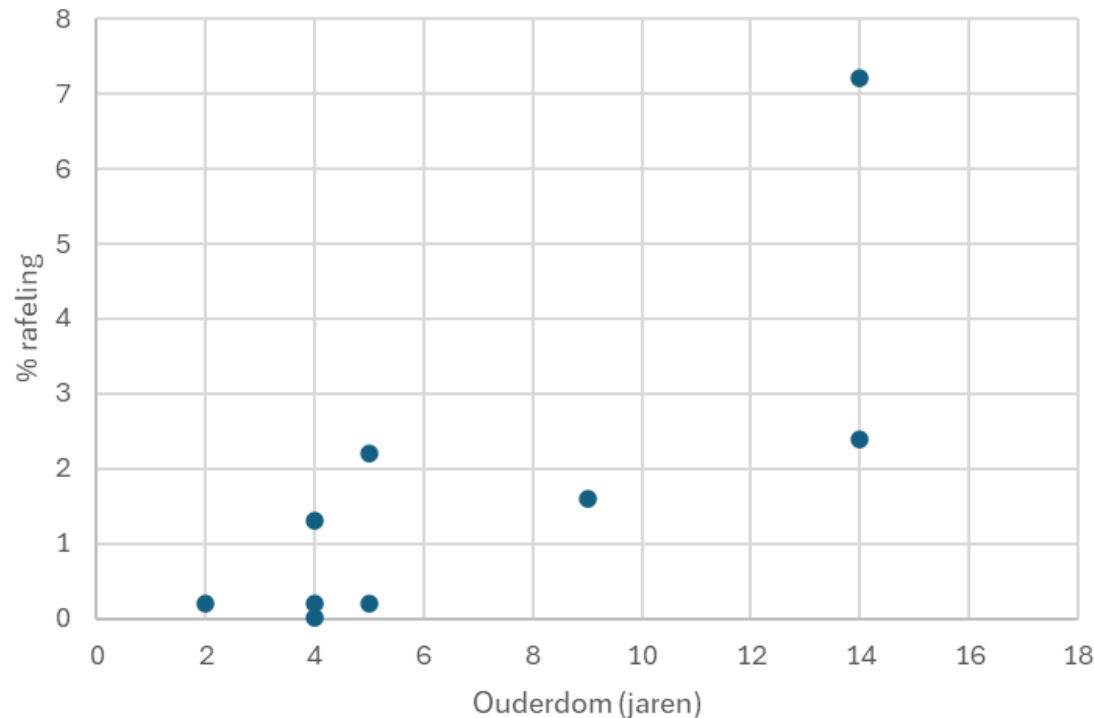
High RAP Mixes: Field Performance

Mix	Location	Specific location	Construction	Asphalt plant	Current lifespan
DZOAB 50% PR	Betonbanen A1	HRR 177,6-178,4 rijbaanbreed	Juni 2010	ACN (continu)	13,5 jaar
DZOAB 50% PR	Betonbanen A1	HRL 178,4-177,1 rijbaanbreed	Juni 2010	ACN (continu)	13 jaar
DZOAB 50% PR	Betonbanen A1	HRR 175,3-177,6 rijbaanbreed	Juni 2010	ACN (continu)	11 jaar
DZOAB 50% PR	Betonbanen A1	HRR 163,8-164,9 rijbaanbreed	Juni 2010	ACN (continu)	13,5 jaar
DZOAB 50% PR	A50	HRR 183,3-193,9 spitsstrook	Nov 2011	ACN (continu)	11 jaar
DZOAB 50% PR	N50 Emmeloord -Ens	HRL 266,4-263,4 rijbaanbreed	Sept 2015	ACN (continu)	8,5 jaar
DZOAB 60% PR	A13	HRL km 17.9 – 18.4 rijbaanbreed	April 2019	APA (charge) en APRR (continu)	5 jaar
		HRL km 10.4– 12.6 rijbaanbreed			
DZOAB-60% PR	A15	A15 HRB-L en HRB-R Papendrecht (Hmp 78.9) tot afslag Sliedrecht-Oost Hmp 84.7)	Juli 2019	APA (charge) en APRR (continu)	4,5 jaar
AC 11 Surf 60% PR	Liergouw	Rotonde Zuiderzeeweg tot Dorpsweg Ransdorp (baanbreed)	Nov 2019	APA (charge)	4 jaar
DGD-8 65% PR	N69	45,63-46,25, 2 richtingen	April 2020	APT (charge)	3,5 jaar
SMA-8 + DGD-8 65% PR	N470	14,00-14,53 2 richtingen 13,00-13,50 2 richtingen	Juni 2020	APT (charge)	3,5 jaar
SMA-8 PmB 65% PR	Hengelo, Van Alphenstraat	Parkeerplaats T.C. 't Weusthag (overdag langsgaan en zo goed als mogelijk beoordelen ivm geparkeerde auto's)	Nov 2020	APT (charge)	3 jaar
AC 16 Surf 60% PR	Wieringermeer	Platform windmolens thv Kolhornerweg 11 Middenmeer. Eerste 2 platforms vanaf de weg.	Nov 2020	APA (charge)	3 jaar
SMA-8 65% PR	Eindhoven, Scherpenering	1 rijrichting, vanaf Landsardseweg naar de rotonde Oersebaan in Veldhoven	Juli 2021	APT (charge)	2,5 jaar
AC 11 surf 60% PR	Delft Noordeindseweg	Tweemolentjeskade – Korftlaan 2 rijrichtingen	Juni 2022	APRR (continu)	1,5 jaar
SMA 8G 55% PR	Eisenhowerlaan Eindhoven	van Insulindelaan tot Oldebarneveltlaan	Aug 2021	APT (charge)	2,5 jaar
AC 16 Surf 65% PR	IJdoornlaan Amsterdam	van Zuiderzeeweg tot Volendammerweg	Juni 2020	APA (charge)	3,5 jaar
AC 16 Surf 60% PR	Borne	Hosbakkeweg – Bornebroeksestraat	Nov 2021	ACN (continu)	2,5 jaar
AC 11 Surf 60% PR	Garderbroekerweg Barneveld	Geheel	Dec 2020	ACN (continu)	3,5 jaar



Main conclusion field monitoring

- After 5 years no ravelling was observed (only some local damage). Even after, 8-14 years ravelling was $< 2,5\%$.
- Only some cracks were observed, related to the underground/foundation.



Impact on environmental performance MKI

- Environmental cost indicator (MKI, PCR1.0)
- Average app. 60% reduction of environmental impact

Mix	APA	APRR	APT
Validatie SMA 8 65% PR	€ 4,94	€ 5,09	€ 4,98
Branchegemiddelde SMA 0% PR	€ 12,67		
Validatie DGD/PA 8 65% PR	€ 3,67	€ 3,94	€ 3,84
Branchegemiddelde DGD 8 0% PR	€ 13,55		
Validatie AC 16 surf 65% PR	€ 3,05	€ 3,26	€ 3,20
Branchegemiddelde AC 16 surf 0% PR	€ 11,90		

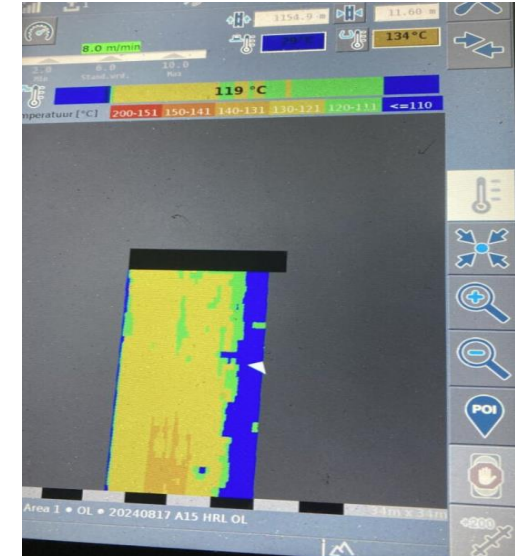
PA (RAP) in WMA

Additive that provides a reduction in the internal friction between aggregate particles.

WMA success stories:

- 2LPA 16 30% RAP
- PA 8 (PMB) without RAP
- PA 8 (PMB) 30% RAP
- PA16 0%PR

(app. 135-150 °C)



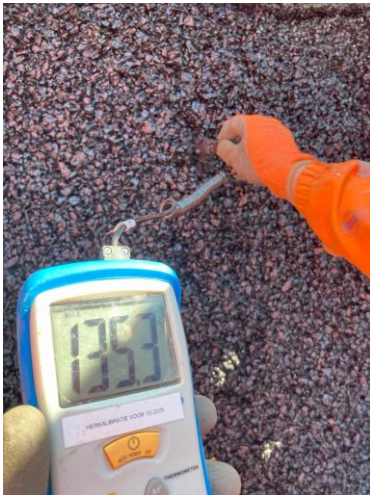
Trial sections with PA 8 and PA 16 mixtures with RAP content of upto 30%PR were positive.

PA (RAP) WMA

WMA challenges:

➔ WMA 60%RAP + PMB:

- Very critical with temp
- Workability problems (machinal)
- Needs optimization



Behind the spreading machine is the mixture workable and can be compacted. However the mixture appears to be very sticky on machines.



Thanks for your attention – questions?

