New life for Porous Asphalt RAP in new Porous Asphalt

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ABSTRACT:

Since 1987 Porous Asphalt (PA) is used in special cases in the Netherlands with the focus on traffic safety, but since 1990 PA is the standard wearing course because of noise reduction reasons.
The average service lifes of standard PA are respectively for the slow and fast lane 11.8 and 16 years. The end of service life of PA is determined by loss of too many stones from the surface, called raveling.
At the end of service life the old PA is milled and new PA is laid back again. In the past the PA Reclaimed Asphalt Pavement (RAP) was only reused in binder and base course layers. Since the eighties, it is standard to reuse 50% RAP in binder and base course layers. In PA and SMA it is not allowed to reuse RAP. In Dense Asphalt Concrete it was allowed to reuse RAP up to 50%, but mostly up to 20% RAP was reused, because wearing courses are more sensitive. Because in PA a high quality coarse material is used, it is a waist of money to reuse such good quality RAP in mostly binder and base course layers. Therefore a project was started to research if reuse of PA RAP in new PA was possible in such a way that the functional properties and durability of this mixture is the same as new PA.
In this paper this research work will be discussed.

KEY WORDS: Porous Asphalt, RAP, reuse, ITT, Cantabro, ITRS, RSAT.

1 INTRODUCTION

With more than 400 inhabitants per km^2 the Netherlands is a very densely populated country. The infrastructure consists of extended motorway networks and provincial and city road networks. As a consequence of that many people live nearby the motorways and suffer from traffic noise pollution. To reduce the traffic noise pollution the policy of the Dutch government is since 1990 to apply noise-reducing asphalt surfacing layers. Most applied surface wearing course for the motorways i the Netherlands is single-layer Porous Asphalt (PA) with a maximum grain size of 16 mm. In 2009 some more than 80% of the motorways are covered with PA 16. Also Two-layer PA, consisting of a 45 mm thick bottom layer PA 16 and a 25 mm thick top layer PA 8, and noise reducing thin layers are sometimes applied as silent wearing courses.
The average service lifes of standard PA 16 are respectively for the slow and fast lane 16 and 11.8 years [Verra et all]. Standard PA 16 has 4.3% pen grade bitumen 70/100. The end of the service life is determined by too much raveling, the loss of stones from the surface.
Normally the PA Reclaimed Asphalt Pavement (RAP) is reused in binder and base course layers. In the Netherlands it is since the eighties usual that such asphalt mixtures consist of 50% RAP. In PA and SMA it is not allowed to reuse RAP, because these mixes are more critical for reuse.
In the past the coarse material of PA could consist of crushed river gravel or quarry material. Crushed river gravel is available in the Netherlands, but quarry material has to be imported from coutries like Belgium, Germany and Norway. In the Netherlands are no rocks available. Mostly crushed river gravel was used, because this was cheaper than quarry material and easy available. But because of serious long-term skid resistance problems with PA with crushed river gravel in 2004, only quarry material with a high Polishing Stone Value (PSV) is allowed in wearing courses. Before 2005 the requirement for PSV was minimum 53, but since 2005 the requirement for PSV is increased to minimum 58. And also only 100% crushed material was allowed.
Because it is a waste of money to reuse RAP containing course material with a high PSV value (>58) in binder and base course layers, a project was started to investigate if PA RAP with good quality of course material could be reused in PA mixtures.
The goal of this project was to investigate if PA with 50% PA RAP has equal functional properties comparing with standard PA with the same durability.

2 MATERIAL AND MIXTURE DATA

2.1 Bitumen research

From test sites research [Voskuilen et all] is known that the PA binder is severely aged at the end of service life. After 3 years the penetration drops enormously and after 9 years the penetration can vary between 10 and 20 10^{-1} mm. It doesn't hardly matter is the start penetration after laying is high or low. Also it doesn't matter weather it is a pen grade bitumen or an EVA, SBS or rubber modified PMB. In figure 1 the results are shown of results of recovered binder from test site PA mixtures with 4.5% bitumen on 100% aggregate (=4.2% binder in the mixture). Test sites with the same mixtures, but with 5.5% bitumen on 100% aggregate (=5.2% binder in the mixture) had the same results.

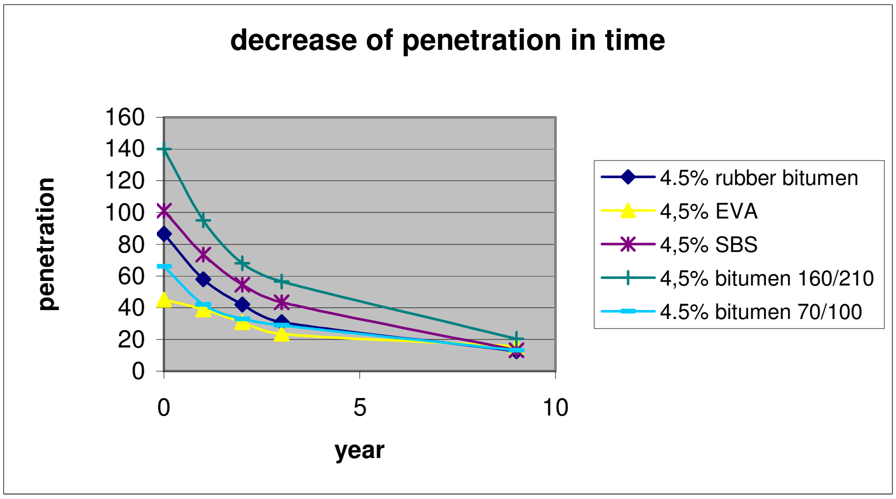

Figure1: Effect of binder ageing in time of PA mixtures with 4.2% binder in the mixture.

PA RAP in PA could be a problem, if due to the short mixing time in the plant the new added binder is not sufficient mixed up with the aged binder. To solve this possible problem binder producer ESHA developed a new type of PMB called ECO-Periphalt HZ90. This PMB contains a high-quality polymer and rapeseed. The goal of the rapeseed is to soften the aged bitumen to improve the mixing with aged new added bitumen. Another advantage is that the use of rapeseed contributes to reduce the green house gasses (CO_2).
In table 1 the binder properties of ECO-Periphalt HZ90 are given.

Tests	**Dimension**	**Typical**
Penetration at 25C, 100 g, 5 sec.	10^{-1} mm	90
Softening point Ring and Ball	ºC	65
Elastic recovery at 25C, 30 minutes	%	>50
Density at 25C	kg/m^3	1020
UV microscopic image	-	homogeneous yellow
Storage stability	-	good
Advised storage temperature	ºC	170
Maximum storage temperature	ºC	200

Table 1: binder properties of ECO-Periphalt HZ90.

Also DSR measurements were carried out to compare the reological behavior of ECO-Periphalt HZ90 with other PMB's used in PA. See figure 2 for the DSR results.
In figure 2 DSR results are plotted of ECO-Periphalt HZ90 and PMB's, which were used inthe Netherlands in PA mixtures. From figure 2 it can be seen that ECO-Periphalt HZ90 has good properties for PA at lower temperatures, which is positive for the raveling resistance. The cause of raveling is a complex of factors, but mostly occurs in wintertime when the binder is more brittle. The hogher value of ECO-Periphalt HZ90 at 80ºC is not negative for the resistance to permanent deformation, because PA gets its stability by the grain-to-grain-contact of the stone skeleton.
Due to the positive binder properties at high temperatures it is possible to mix the PA in the asphalt plant at a 20°C lower mixing temperature than with the use of normal pen grade bitumen.

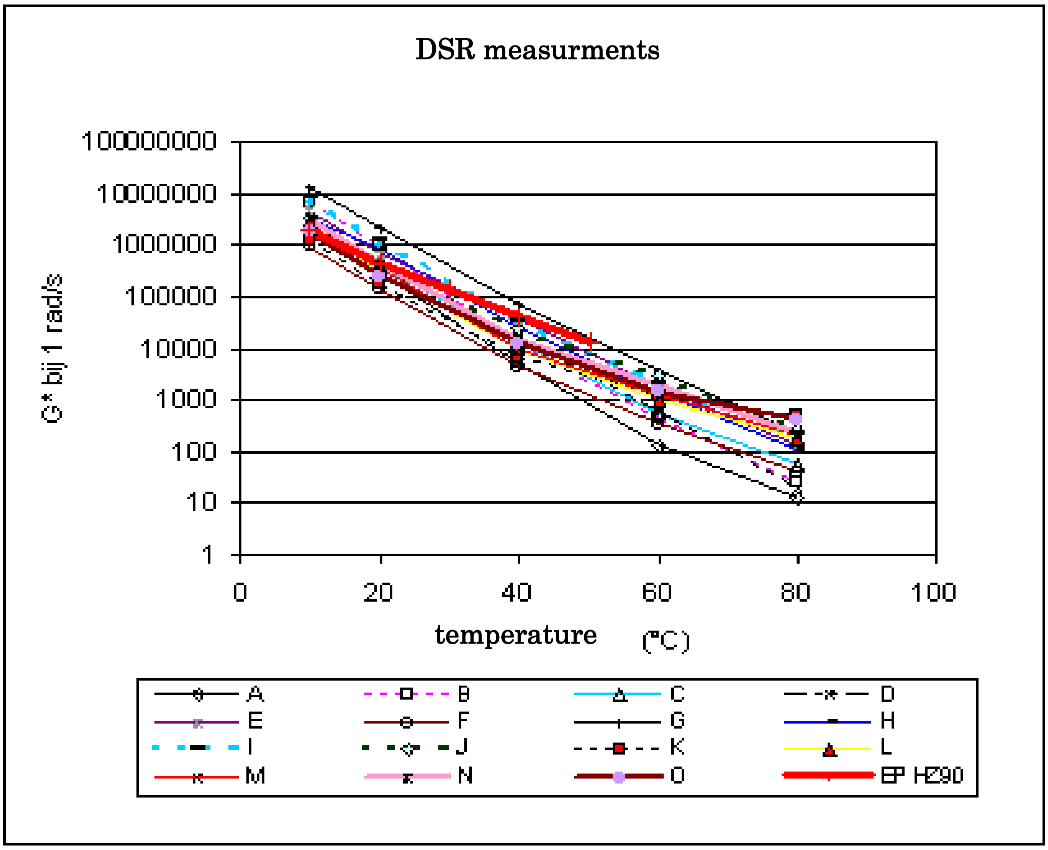

Figure 2: Results of DSR measurements of different binders used in PA.

To compare PA with ECO-Periphalt HZ 90 (R-PA) with standard PA containing pen grade bitumen 70/100 (S-PA) and PMB modified PA (S-PA) Indirect Tensile Tests (ITT) in conformity with EN-12697-12 were carried out at 1 and 25ºC. In figure 3 the test results are shown.

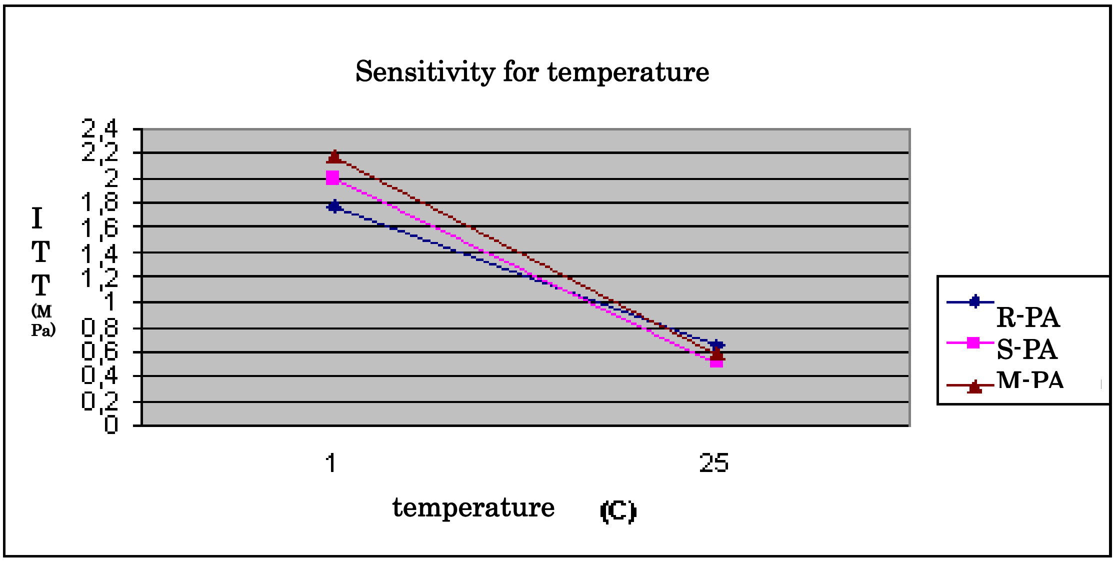

Figure 3: Results of temperature sensitivity of R-PA, S-PA and M-PA mixtures.

From figure 3 it can be seen that the temperature sensitivity of R-PA is much better for R-PA in comparison with S-PA and M-PA. At low temperatures the R-PA is less brittle.

2.2. Mix design

The PA 16 mix composition conform the Dutch national Standard is given in table 4.
The requirement for air voids content for Marshall compacted (2 x 50 blows) is minimum 20%. In the Netherlands there are no mechanical requirements for PA. Since the introduction of the European norm for PA inthe Netherlands only the Indirect Tensile Strength Retained (EN 12697-23) is extra required.

	Requirements national Standard RAW 2005		
Passing sieve	Min.	target	Max.
C16	0.0		7.0
C11.2	15.0		65.0
C 8	50.0		65.0
C5.6	70.0		85.0
2 mm		85.0	
63 µm		95.5	
Bitumen “on”		4.5	
Bitumen “in”		4.2	

Figure 4: Requirements for PA 16 mix composition.

In table 5 the mix composition is given of the investigated R-PA mixture containing 50% PA RAP. Bestone is a sandstone quarry material imported from Norway.

	Mass %	material	Grading (mass %)			
			On sieve	Percentages by weight		
Coarse material				New material	PA RAP	total
			C22.4	0.0	0.0	0.0
C22.4 – C16	1.0	Bestone	C16	2.0	1.0	1.5
C16 – C11.2	14.1	Bestone	C11.2	15.1	10.4	25.5
C11.2 – C8	28.4	Bestone	C8	43.4	21.2	64.6
C8 – C5.6	3.9	Bestone	C5.6	47.2	29.7	76.9
C5.6 – 2 mm	0.6	Bestone	2 mm	47.8	37.9	85.7
<2 mm	0.4	Bestone	63 µm	48.4	47.3	95.7
Filler			Sand			
Lime stone	1.6	Rhecal 60	2.0 – 500 µm		41	40
filler			500 – 180 µm		29	27
			180 - 63 µm		30	33
PA RAP	50%	From A28				
Bitumen	5.0					
Old	1.6	From RAP				
New	3.4	ECO-Peri-phalt HZ90				

Figure 5: mix composition of the investigated R-PA mixture containing 50% PA RAP.

The average air voids content of the Marshal compacted specimens was 21.9% (standard deviation 1.1%), so R-PA fulfils the requirements for grading and air voids for PA 16 mixes.

3 TEST METHODS

In the Netherlands there are no requirements for mechanical properties for PA. To investigate is the expected behavior op PA with PA RAP (=R-PA) is equal to standard PA the following tests are carried out on R-PA, standard PA (S-PA) and PMB modified PA (M-PA): ITT, ITSR, Cantabro test and RSAT.

3.1 Indirect Tensile Test (ITT)

To investigate the tensile strength and the temperature sensitivity the ITT is carried out conform the European norm EN 12697-23 at 1 and 25ºC. The test specimens were Marshall compacted.

3.2 Indirect Tensile Strength Ratio (ITSR)

To investigate the water sensitivity the ITSR is carried out conform the European norm EN 12697-12 at a temperature of 25ºC. The test specimens were Marshall compacted.

3.3 Raveling resistance tests

3.3.1 Cantabro test

To investigate the resistance to raveling the Cantabro test is carried out on Marshall compacted specimen conform the European norm EN- 12697-17.

3.3.2 Rotating Surface Abrasion Test (RSAT)

The resistance to raveling is measured with the RSAT (See photo 1). A loaded steel wheel with a solid rubber tire drives back- and forward on a PA slab, which has been conditioned at 20˚C. In order to simulate the shear loading of traffic, the direction of the axle varies a little from the direction of movement. To achieve this, the wheel was fixed in an angle of 33.7˚. To spread the abrasion force over a certain area the slab rotates slowly, driven by the abrasion forces themselves. In the forward movement of the wheel the slab is rotating with it and in the backward movement of the wheel the rotation of the slab is blocked. In this stage the forces are at maximum. The resistance to raveling is expressed as the total amount of loose material after 24 hours of testing. It is also possible to measure the rut depth during RSAT testing.