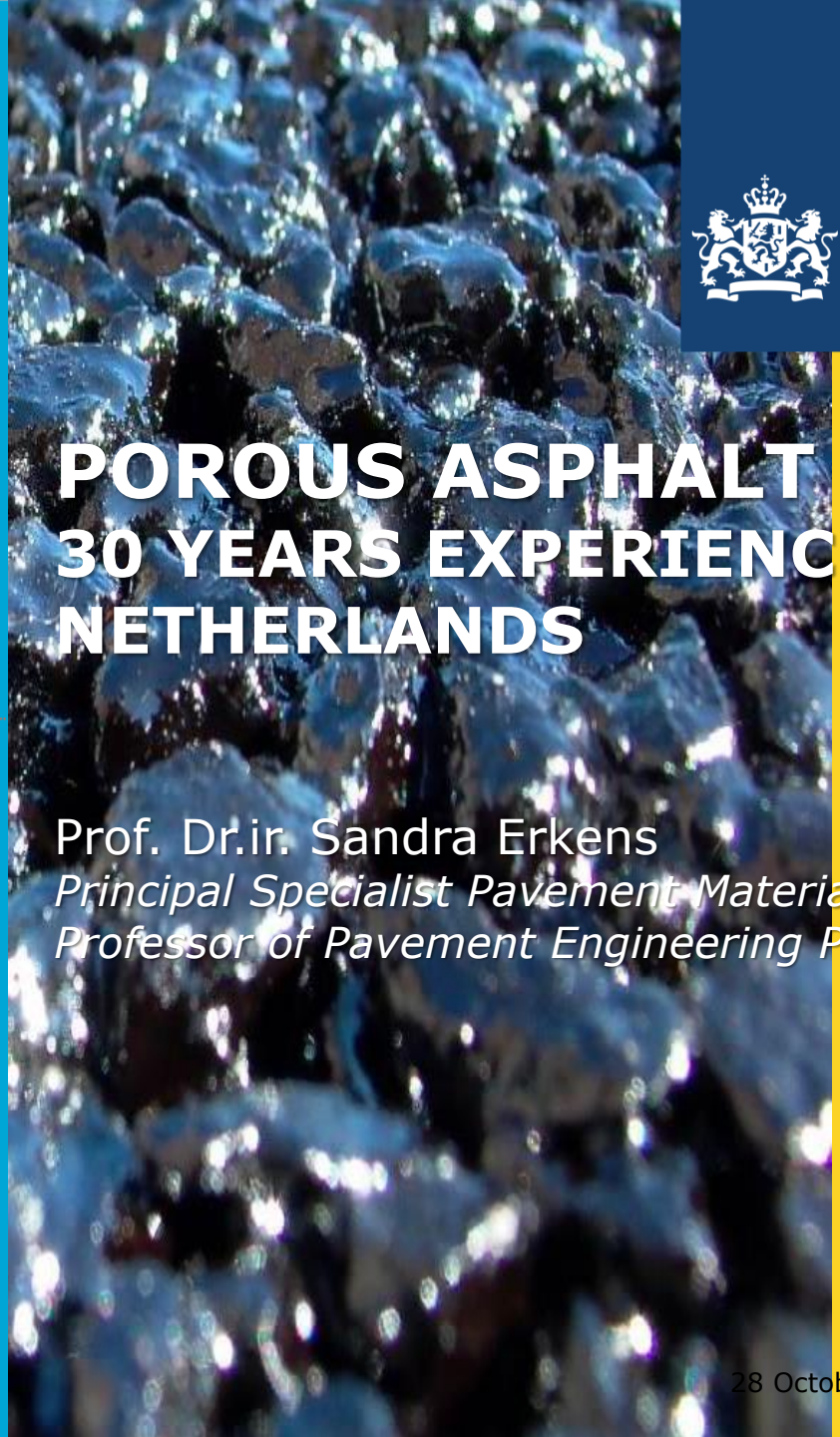

Rijkswaterstaat
Ministry of Infrastructure and Water Management

POROUS ASPHALT CONCRETE
30 YEARS EXPERIENCE IN THE NETHERLANDS

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TU Delft

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- PA performance
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- Summary

History

- Porous Asphalt (PA) developed during 2nd World War in UK for air fields for safe landing and take off

When did the Dutch start with PA?

- In 1971 PA was rediscovered in NL. The first test site was on a provincial road in 1972.
- Continued by RWS for highways to reduce splash and spray and increase safety

The Dutch 'recently' changed policy; PA became the standard wearing course in 1987 by a decision of the minister of Transport. The reason: noise reduction

History

- 2005: two-layer PA allowed on motorways if cost-effective
- 2009: first PoroElasticRoadSurface (PERS) test site
- 2010: PA test sites with rejuvenators and steel fibers
- 2018: about 90% of our motorways have noise reducing pavements, 70% single-layer PA and 19% two-layer PA, 1% thin layer pavement

Advantages

Noise reduction

No rutting problems!!

During rainfall:

- no aqua planing
- reduction of splash and spray
- better visibility of markings
- higher capacity

Better quality of run off water

High appreciation of car drivers!

Comfortable

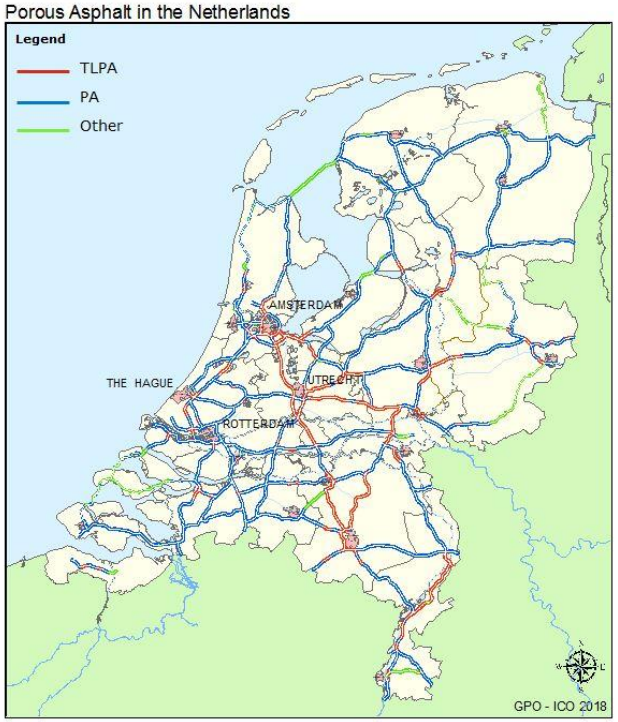
Area of management of Rijkswaterstaat

Motorways

- Pavements: 3.100 kms motorway
  - 6.200 km one direction / 15.000 km lanes
  - 1.260 km sliproads
  - 45 rush hour lanes (approx. 100kms)
- Structures: 6.000 (also on mainwaterways)
  - 2.843 viaducts on highways
  - 767 moveable and fixed bridges on highways
  - 24 tunnels
  - 33 ecoduct
- DTM (6 control centers, 108 DRIPS, 2.000 cameras)

- Area control
  - winter ice, roadside and restplace management, lights, signage, guiding rails, noise barriers …

Area of management of Rijkswaterstaat



- 90% porous asphalt concrete
  - mostly on mainroads
    - 70% PA
    - 20 % two-layer PA
- 10% dense asphalt concrete
  - mostly on sliproads
  - ~3% of the mainroads have a technical exclusion
    - 9% AC
    - 3% SMA / other

Use of PA

Porous asphalt in the Netherlands

PA 16

< 50mm >

TLPA

25 mm top layer 4/8

45 mm 11/16

Application only if it is cost-effective noise reduction (i.e. saves costs of noise barriers)

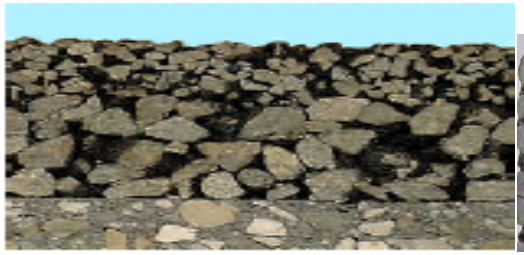
Restrictions

- Where to use PA and where not
  - Principle: noise reduction everywhere
  - Unless: Technical reasons not to use PA
- If PA is not used on highways, the alternative is a dense wearing course => no noise reduction, usually requires extra investments in noise barriers
- Urban situations usually not suited for PA

Restrictions (technical)

- Locations with high shear stresses (short maintenance intervals):
  - curves with radius < 150m, sliproads, roundabouts, junctions
- Radical changes in other parts of infrastructure:
  - structures <1995 extra layer of asphalt
- Regulations:
  - tunnels, test sites
- Road user experience
  - No 500m PA in between two stretches of non PA
  - Highly specific situations
- Non motorways in case of:
  - cross roads, traffic lights, slow (agricultural) traffic
- RWS area not being roads:
  - busstops, service areas, cycle paths

Service life



PA performance

	two-layer PA	single-layer porous asphalt	dense asphalt concrete (AC16)
Service life right lane	9 yrs	11 yrs	11 yrs
Service life left lane	13 yrs	17 yrs	17 yrs
Costs [€]	210%	135%	100%
Noise reduction	1 to 2 dB relative to single-layer porous asphalt	2 – 4 dB relative to AC	0,3 dB

Service life - Surface distresses

PA performance

Damage type	AC	PA
Ravelling	25	**85**
Cracking	40	10
Rutting + unevenness	30	3
Skid resistance	5	2
total	100	100

Dutch Climate

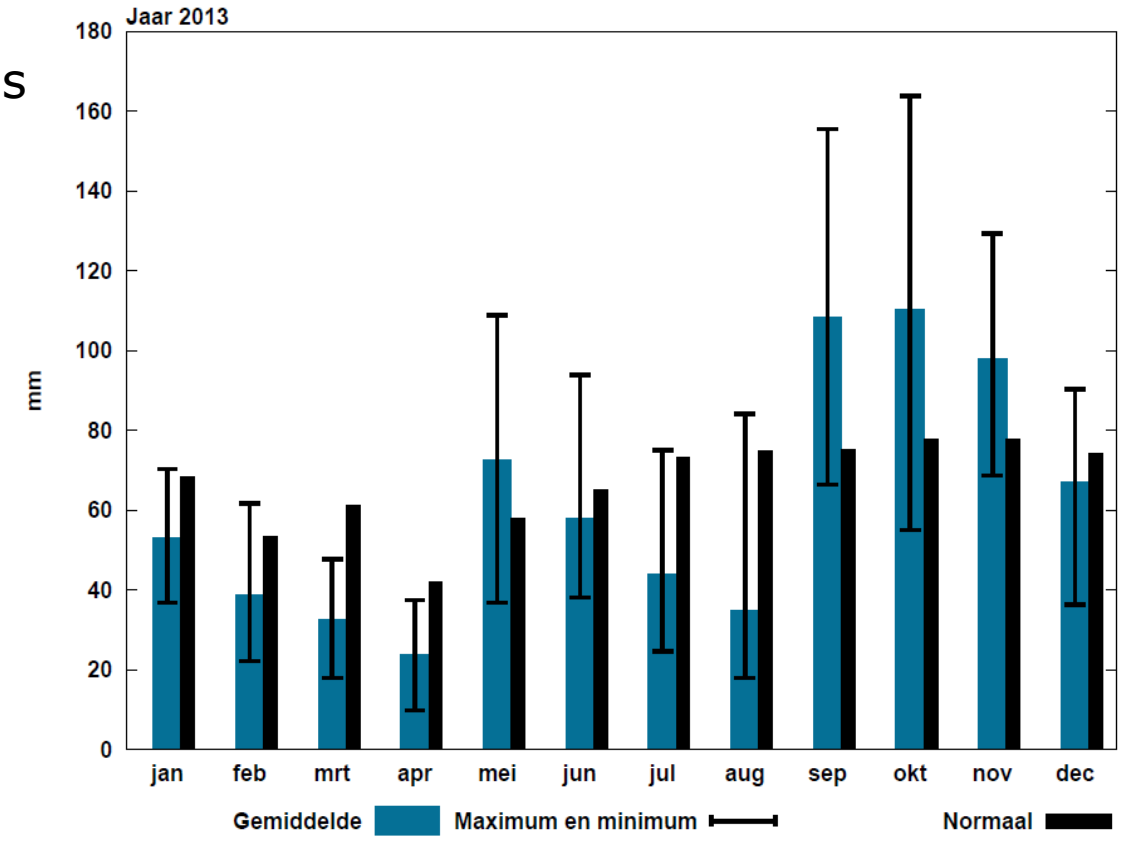
PA Water Drainage

Dutch Climate - precipitation

Rain in all seasons

Climate changes

More extreme showers



PA Water Drainage

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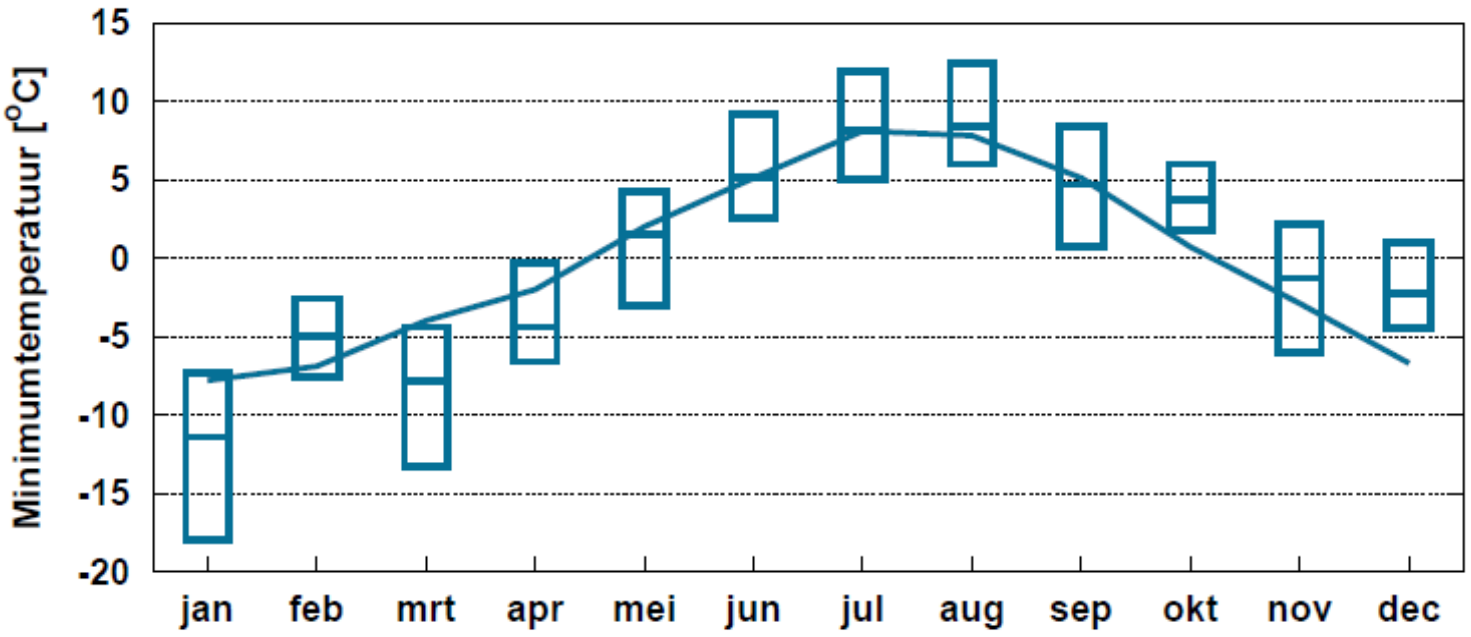
Dutch Climate – temperature (2013)



Winter: High number of frost – thaw cycles

PA Water Drainage

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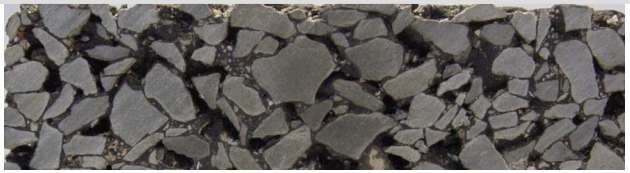
Improved water drainability



PA Water Drainage

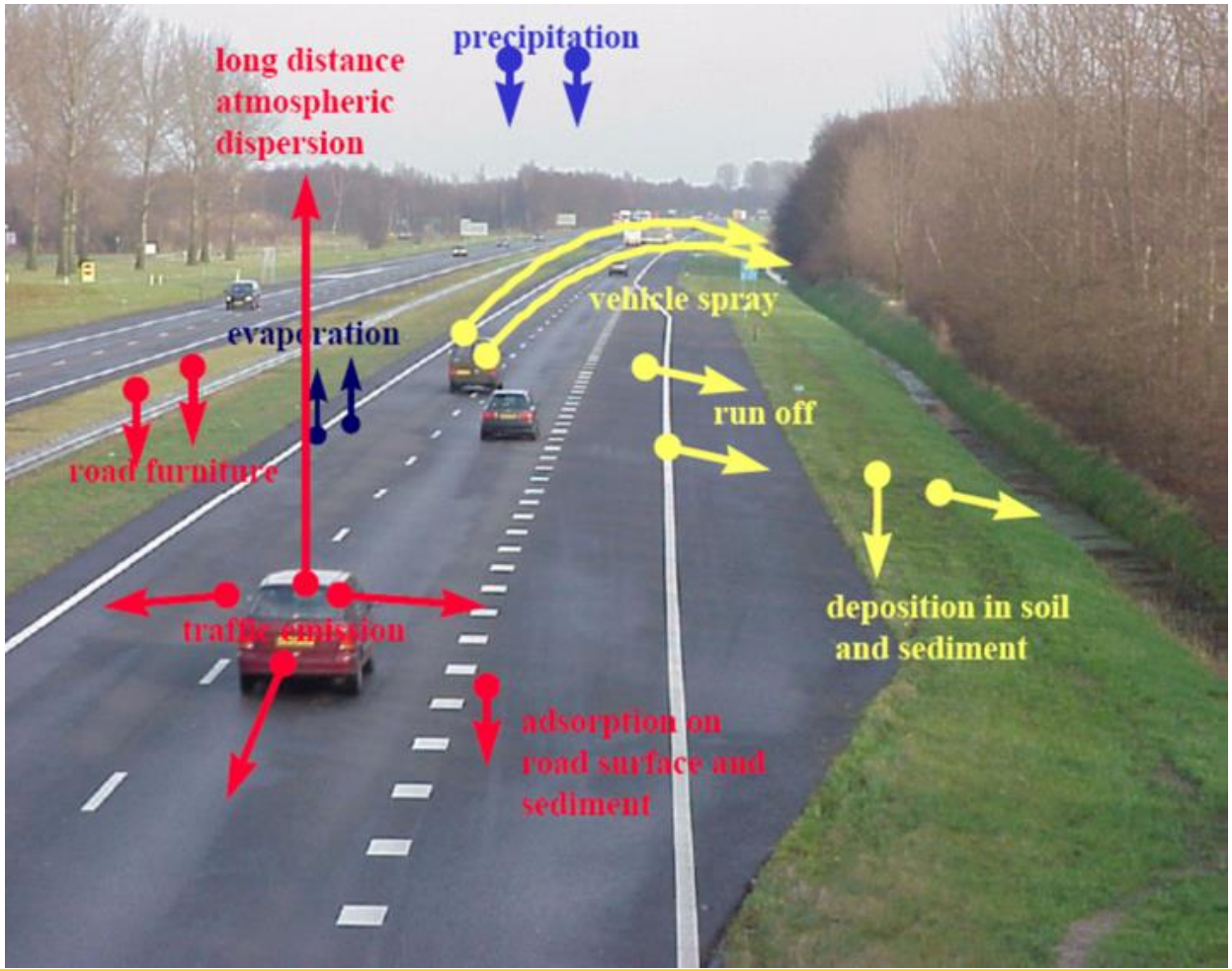
Porous Asphalt

- Void content >20%
  - → Improved water drainability
  - → Improved water Retention

- Stone skeleton
  - → Improved resistance aginst deformation
  - → Lower resistance against shear stresses

PA Water Drainage

Water transport



PA Water Drainage

Improved water drainability: effects

PA Water Drainage

Safety 

- effect compensated due to higher speed on high speed lanes
- Minimize number of "Porous – Dense" Asphalt transitions

Availability 

- Less traffic jams

Comfort 

- Drivers less tired
- Markings better visible
- Drivers more satisfied

Improved water and dirt retention: effects

Verge Quality

- Less polluted, because most of pollutants stay in Porous Asphalt (see next slide)

Detoriation by clogging

- Reduction of water draianability → safety problems
- Loss of noise reduction
- More vulnerable to frost damage

Water longer in asphalt

- Temperature reduction of pavement
- Deterioration of PA material

PA Water Drainage

Quality of run off water

Parameter	Rain	Closed road surface (standard asphalt)	Open road surface (porous asphalt)	Open road surface versus closed road surface
Cd	0,2 – 0,5	1 (1 – 5)	0,1 (0,1 – 1)	Circa - 90%
Cr	-	5 (3 – 26)	1 (0,4 – 3)	Circa - 80%
Cu	2,0	121 (11- 163)	40 14.– 107)	Circa - 70%
Ni	0,6	5 (4 – 15)	1 (1 – 9)	Circa - 80%
Pb	4,6	93 (51 – 195)	7 (2 – 34)	Circa - 90%
Zn	15	452 (225 – 530)	47 (18 – 133)	Circa - 90%
PHA	0,4	4 (3,7 – 4,3)	<0,2 (<0,2 – 0,2)	Circa - 95%
Mineral oil (MO)	< 0,1	4 (3 – 8)	<0,1 (<0,1 – 0,2)	Circa - 95%
Solids undissolved particles	-	187 (153 – 354)	17 (2 – 70)	Circa - 90%

Cleaning to remove dirt

- 2 * per year vacuum cleaner on hard shoulder
- Driven lanes are self cleaning effect due to pumping effect of tyres

PA Water Drainage

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Splash and spray (preventive action)

PA Water Drainage

High numbers of lanes

Emergency stop area

Extra system for water drainage needed

Solutions for urban areas

- PA unsuited for urban areas due to high shear loads
- Other pervious pavement solutions for urban areas:
  - Fast draining from surface
  - Retaining water in structure
- “Water street” is test area in Green Village of TU Delft, mimicking high intensity rainfall to test urban solutions

Summary

- PA is the standard wearing course on Dutch highways (reason: noise reduction)
- ~ 90% of our highways have silent pavements
- Initial noise reduction single-layer PA16 is 4 dB(A)
  - two-layer PA8 is 6 dB(A) (relative to DAC)
- PA has a long service life – comparable with dense asphalt mixes
  - Average service life PA= slow lane 11 years/ fast lane 17 years
  - Average service life TLPA= slow lane 9 years/ fast lane 13 years
- ravelling is the most important cause of end of service life of PA

Summary

- PA used on 90% of Dutch highways, because of noise reduction, not water permeability
- Average life time PA16(+) is 11 (17), TLPA 9 (13) years
- Laying process is done with conventional machines; no special equipment needed
- A lot of experience - all contractors are experts in laying of PA
- PA is more comfortable to drive in wet conditions (splash & spray)
- Water retention and quality of water getting out from PA are better
- With increasing rain fall, advantages of PA increase
- For urban areas other types of pervious pavements are used, developed and tested