Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

Road Engineering in the Netherlands

Dr. Ir. Sandra Erkens - Rijkswaterstaat

The Netherlands

The Netherlands

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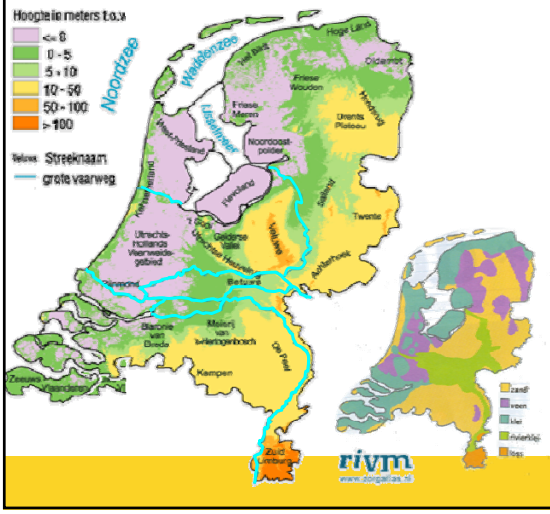
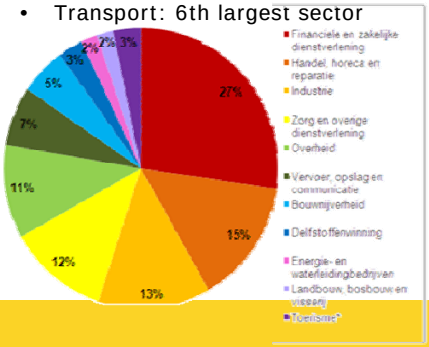
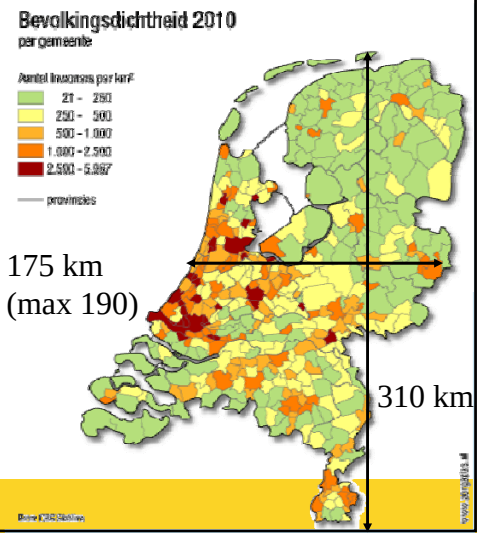


- Netherlands or Holland:
  - Flat country (highest point 321 m, lowest -7m relative to sealevel)
  - About 1/3 of country beneath sealevel
  - Many large rivers (delta)
  - Lots of soft soils
  - No rocks, some natural gas and salt

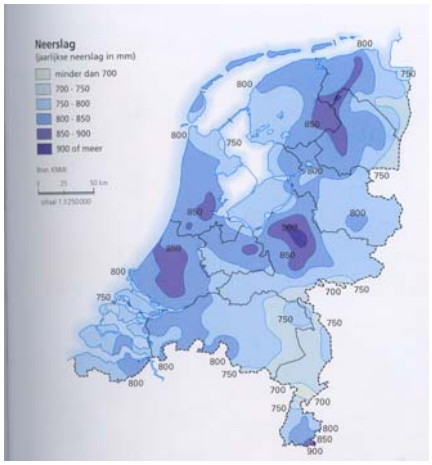
The Netherlands

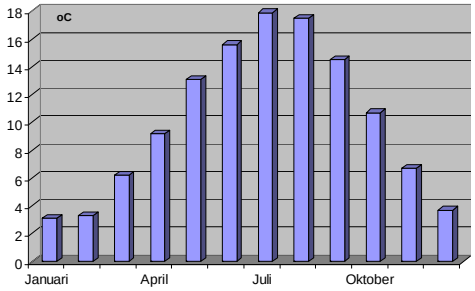
- Area: 41.526 km^2, 20% is water
- population: 17 million
- Densely populated: 491 people/km^2 (2010) (USA:32; Illinois: 86)
- Concentrated in the south-west
- Transport: 6th largest sector





The Netherlands





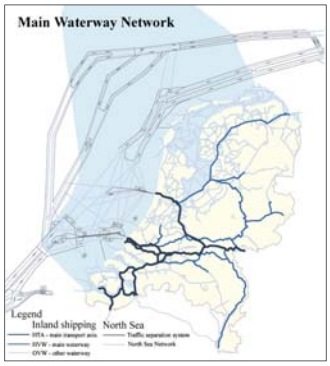
Rijkswaterstaat

Rijkswaterstaat is the executive organisation that manages and develops the main national infrastructure facilities on behalf of the Minister and State Secretary for Infrastructure & Environment.

- Founded in 1798
- Around 9,000 employees
- 10 regional departments divided into 35 districts, 4 specialised departments, 3 project departments
- Annual budget: 4 to 5 billion euros

Rijkswaterstaat

Rijkswaterstaat manages three National Infrastructure Networks



Rijkswaterstaat

Rijkswaterstaat manages:

- 3,102 kilometres of highways including traffic signalling systems
- 2,533 viaducts
- 15 tunnels
- 715 moveable and fixed bridges
- 7 ecoducts

The Netherlands & Rijkswaterstaat

- Bringing Dutch and RWS info together:
  - soft soils:
    - Uneven settlements, preference for asphalt concrete over cement concrete
    - No rocks etc: drive for use of secondary materials
  - Small, densely populated country:
    - high traffic intensities, limited acceptance of delays due to maintenance & no rocks: long life & maintenance strategy (LLM)
    - High traffic intensity, soft soil & LLM strategy: thick structures
  - Lots of people living near busy roads:
    - Noise reducing wearing courses: porous asphalt

Asphalt Concrete and recycling

- In the Netherlands we have 50 asphalt mix plants:
- mostly badge mixers with parallel drum (for RAP) and a few drum mixers
- The total production of hot mix asphalt is 7.5 million ton per year, including 2 million tons Reclaimed Asphalt Pavement (RAP)
- Road base materials are mainly mixes of crushed masonry and concrete, mixed with a small amount of cement, or reclaimed asphalt mixed with some cement

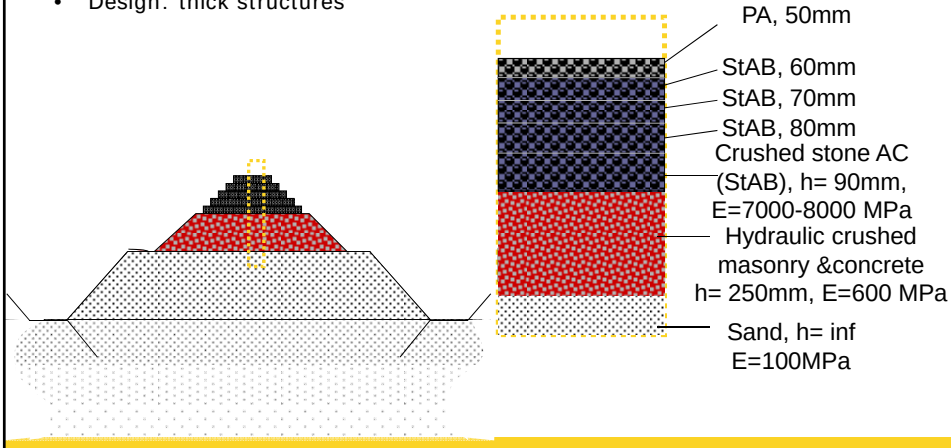
LL & M Strategy

- Soft soils
- High traffic intensities

- Long life & maintenance strategy
  - Thick structures
  - Strengthening through additional layers
- Maintenance strategy based on regular inspections without traffic hindrance

LL & M Strategy

- Design: thick structures

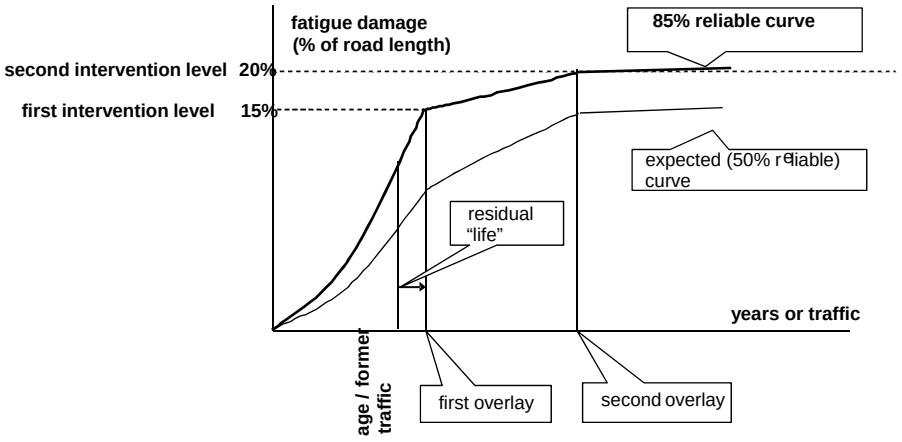


LL & M Strategy

Long life design & maintenance strategy

- pavement is designed such that structural deterioration will end after one or more overlays
- initial stresses & strains are kept low so that distress is limited at overlaying
- overlaying will further reduce stresses and strains
- advantages is that overlay can be combined with profiling and can be optimised depending on the actual behaviour of the pavement
- disadvantage is that possibly no one ever puts on the overlay……

LL & M Strategy



LL & M Strategy

- the choice of design period (period between overlays) is crucial
- this has to be harmonised with intervals for major maintenance of wearing courses
- in the Netherlands, prevailingly porous asphalt is used on the primary network
- this on average has a durability of 11 years for the right hand lane and 15 years for the total carriageway width
- so design period should at least be 15 years, but should incorporate some margin for longer wearing course life (NL uses 20 years)

LL & M Strategy

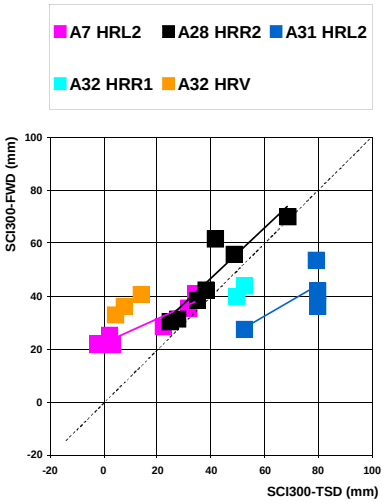
- **Network level**
- **Every other year every highway inspected with**
  - **Automatic Road Analyser (ARAN),**
  - **skid resistance tester,**
  - **ROEMER (noise)**
- **The following properties are measured:**
  - **rut depth**
  - **evenness**
  - **texture**
  - **ravelling**
  - **skid resistance**
  - **noise reduction**
  - **slope variance**
  - **cracks (video)**

LL & M Strategy

- Network level

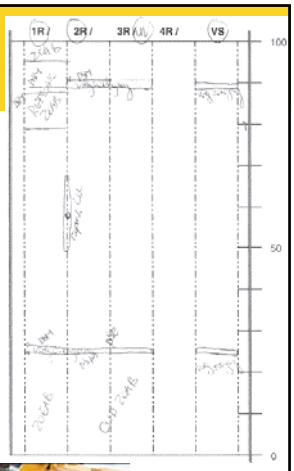
LL & M Strategy

- Network level
  - no systematic BC monitoring in the Netherlands, mainly because deflection testing causes too much traffic hindrance
  - bearing capacity should be verified when mayor wearing course maintenance is due
  - a pilot test with a High Speed Deflectograph was not completely satisfying



LL & M Strategy

- Project level
  - Visual condition assessment
  - Drilling cores
  - Deflection measurements



LL & M Strategy

- Project level
  - Classical method derived from SPDM method
  - based on measurement between wheel paths (‘virgin pavement’)

$$\frac{n_{eq,1}}{N_{eq,1}} + \frac{n_{eq,2}}{N_{eq,1}} = \frac{M_{o,1}}{F_r}$$

waarin

n_{eq1}	=	*traffic load carried to date (ESALs)*
$n_{eq,2}$	=	*residual life (traffic load that can still be carried) (ESALs)*
$N_{eq,1}$	=	*virgin life of existing pavement (ESALs)*
$M_{o,1}$	=	*target Miner’s ratio at first overlay (-)*
F_r	=	*reliabillity factor (-)*

LL & M Strategy

- Project level

Residual life (asphalt concrete strain criterium)

Reliability level [%]	Residual structural life [years]	Expected degree of fatigue [%]		Reliability factor [-]	Reliability using field calibration [%]
95	< 0.0	very high	(15 %)	5.4	91
90	2.9	some	(7 %)	3.7	87
85	5.4	small	(4 %)	2.9	82
80	7.8	small	(3 %)	2.4	77
75	10.2	small	(2 %)	2.0	73
70	12.5	small	(1 %)	1.7	68
60	17.3	very small	(0 %)	1.3	59
50	22.4	very small	(0 %)	1.0	50
30	35.2	none	(0 %)	0.6	
15	> 50.0	none	(0 %)	0.3	
10	> 50.0	none	(0 %)	0.3	
5	> 50.0	none	(0 %)	0.2	

Asphalt concrete modulus [MPa] : 6984
Asphalt concrete strain [mikron/m]: 89.3
Maximal Miners ratio [-] : 0.54
Asphalt concrete thickness [m] : 0.190
Edge effect reduction [m] : 0.000
Thickness for calculations [m] : 0.190

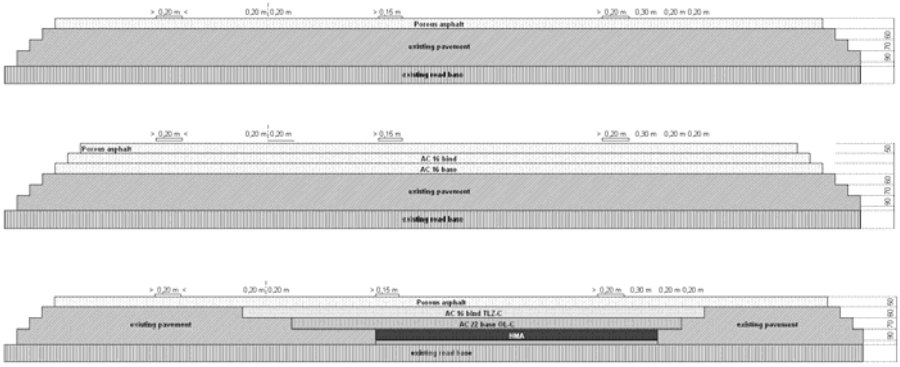
Ok Help

LL & M Strategy

- Project level assessment - strengthening options
  1. overlaying
  2. replacing layers of poor condition with new asphalt
  3. replacing standard asphalt with high modulus asphalt
- option 2. is always recommended, it is not a good idea to overlay pavements with disintegrated layers
- option 3. and sometimes 2. can avoid the pavement becoming too narrow and/or free space under structures becoming too small

LL & M Strategy

- Project level assessment - strengthening

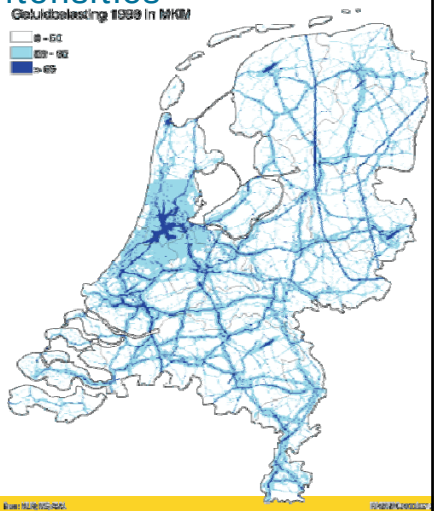


Densely populated & high intensities

- Noise levels around highways are high
- Noise reducing wearing courses are cost effective compared to screens
- PA used on Dutch highways since 1987, first for safety, currently for noise reduction
- Currently, 69% PA (51 PA, 18PA+), 13% TLPA (total: 82%)

Single-layer PA 16

TLPA



Densely populated & high intensities

PA-composition

Passing sieve	desired	min.	max.
16.0 mm		0.0	93.0
11.2 mm		85.0	70.0
8.0 mm		50.0	35.0
5.6 mm		30.0	15.0
2.0 mm	15.0		
0.063 mm	4.5		

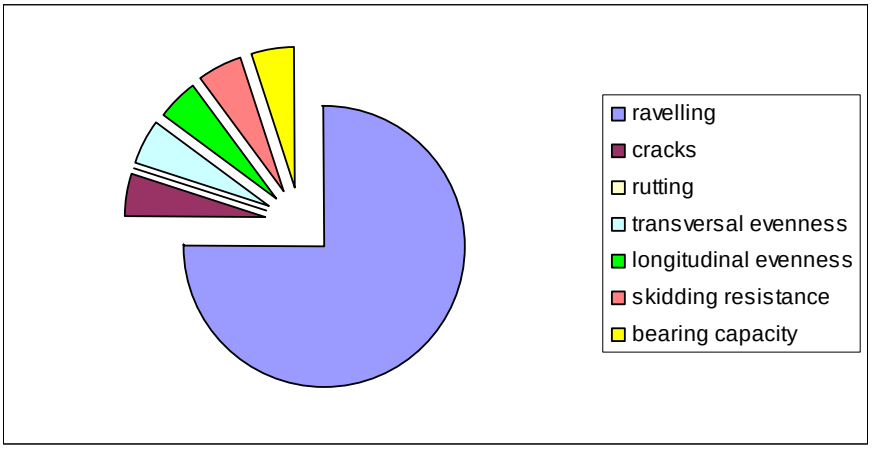
Bitumen 4.5 (= 4.3% in the mix) pen 70/100, no RAP
5.5 (= 5.2% in the mix) with drainage inhibitor

Target air void content mix design is >20%.

Layer thickness is 50 mm

Warranty period is 7 years, average life right hand lane: 11 yrs

Densely populated & high intensities



Densely populated & high intensities

- Extremely poor performance in one project (raveling within 3 yrs!)
  - quality of coarse material was insufficient (wheathered, included clay)
  - too little bitumen in the mix
  - segregation of bitumen, very dry and brittle mastic with bad bonding properties
  - Average hydrated lime [Ca(OH)2] content of filler in SLPA was only 4%! Probably by adding a high amount of baghouse dust?
  - Ca(OH)2 works better than Calcium Carbonate
- Improving performance: investigation into using PMB by comparing sections with PMB those with pen-bitumen both at 4,5 and 5,5% binder
  - Pen-binder sections at 5,5% both with and without drainage inhibitors
  - Performance PMB no better than pen-binder
  - Performance all mixtures with 5,5% binder better than 4,5%
  - After 9 years all binders had pen around 20 [x0,1mm]

Summary

- Road Engineering in the Netherlands:
  - soft soils:
    - Uneven settlements, preference for asphalt concrete over cement concrete
    - No rocks etc: high percentage use of secondary materials
  - Small, densely populated country:
    - high traffic intensities, limited acceptance of delays due to maintenance & no rocks: long life & maintenance strategy (LLM)
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  - Lots of people living near busy roads:
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