Road Engineering in the Netherlands
Dr. Ir. Sandra Erkens - Rijkswaterstaat
The Netherlands

- Netherlands or Holland:
  - Flat country (highest point 321 m, lowest -7 m 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 km², 20% is water
- Population: 17 million
- Densely populated: 491 people/km² (2010) (USA: 32; Illinois: 86)
- Concentrated in the south-west
- Transport: 6th largest sector

175 km (max 190)
310 km
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 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

- **PA 50mm**
- **StAB, 60mm**
- **StAB, 70mm**
- **StAB, 80mm**
- **Crushed stone AC (StAB), h= 90mm, E=7000-8000 MPa**
- **Hydraulic crushed masonry & concrete**
  - h= 250mm, E=600 MPa
- **Sand, h= inf E=100MPa**
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**

- 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, prevailing porosity 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
  - 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

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

waarin

- \(n_{eq,1}\) = 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 (-)
- \(F_r\) = reliability factor (-)
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%)
### Densely populated & high intensities

**PA-composition**

<table>
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<th>Passing sieve</th>
<th>desired</th>
<th>min.</th>
<th>max.</th>
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<td>8.0 mm</td>
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<tr>
<td>2.0 mm</td>
<td>15.0</td>
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<td></td>
</tr>
<tr>
<td>0.063 mm</td>
<td></td>
<td>4.5</td>
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</tbody>
</table>

Bitumen 4.5 (= 4.3% in the mix) pen 70/100, no RAP

Bitumen 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

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![Diagram of pavement performance indicators]

- **Ravelling**
- **Cracks**
- **Rutting**
- **Transversal evenness**
- **Longitudinal evenness**
- **Skidding resistance**
- **Bearing capacity**
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

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