Asset Management in NL

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Outline presentation

- Introduction
- Life cycle based maintenance management
- Management of an ageing bridge stock
- Traffic loads
- Risk based inspections
National highways Network

3100 km highway, of total 60 000 km road outside cities
- of which 2400 km motorway,
- approx. 1100 km with traffic control systems (ITS):
  - 7 road traffic control centers
  - 91 dynamic route info signs
  - 51 ramp metering points
  - 11 peak hour lanes

Traffic movements
- 45 % (vehicle-kilometers)
Asset types
Bridges in the Netherlands
Life-cycle based maintenance management

Maintenance key factors

Asset
- Type and size
- Use
- Performance
- Maintenance programs aimed at performance

Looking ahead
- Future performance
- Life Cycle cost
- Risk based
# Structures in national networks

<table>
<thead>
<tr>
<th>Structure type</th>
<th>Quantity</th>
<th>Replacement value [Billion Euro]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movable bridge</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Concrete bridge (&gt; 200m)</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Concrete bridge (&lt;200 m)</td>
<td>571</td>
<td></td>
</tr>
<tr>
<td>Steel bridge</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Underpass</td>
<td>531</td>
<td></td>
</tr>
<tr>
<td>Tunnel</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Viaduct in highway</td>
<td>1515</td>
<td></td>
</tr>
<tr>
<td>Viaduct over highway</td>
<td>930</td>
<td></td>
</tr>
<tr>
<td><strong>subtotal highways</strong></td>
<td>3700</td>
<td>12.0</td>
</tr>
</tbody>
</table>

| Movable bridge                        | 100      |                                  |
| Concrete bridge (> 200m)              | 15       |                                  |
| Concrete bridge (<200 m)              | 70       |                                  |
| Steel bridge                          | 79       |                                  |
| Underpass                             | 6        |                                  |
| **Subtotal water network**            | 270      | 1.3                              |

| **Total**                             | 3970     | 13.3                             |
Development in Maintenance

- User central
  Integral network performance

- Management plans
  Explicit goals and quality
  Program steering (object classes)

- Repair damage
- Historical spending
- Incident driven (local)

- Technical approach

- Functional approach

- Asset Management
Balance performance - budget

Desired infrastructure quality

Ministry

Rijkswaterstaat

Needed funding

Service Level agreement
Basic Level of Maintenance

Quality level

- Mobility
- Traffic safety
- Environmental quality
- User comfort
- Looks

minimum
Describe basic level of maintenance
Example: Intervention level expansion joints

Epoxy beams;
Bonded seal

<table>
<thead>
<tr>
<th>Damage profile</th>
<th>Intervention level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defects beam</td>
<td>- No fracture</td>
</tr>
<tr>
<td></td>
<td>- Crack width max. 0,4 mm.</td>
</tr>
<tr>
<td>Joint seal</td>
<td>No leakage</td>
</tr>
</tbody>
</table>
Preservation plans

Decomposition into elements for maintenance measure planning

Example decomposition concrete bridge

- Main structure
- Kerbs
- Piers
- Pavement
- Expansion joints
- Bearings
- Guard rail
- Railing
- Drainage system
- Abutments
Maintenance costs reference object

Large concrete bridge (585 x 18 m)
average annual costs 7 €/m²

Costs (€)
- bearings
- expansion joints
- guard rail
- railing
- pavement
- concrete repair
- inspection
- routine maintenance

Bridge age (years)
1/5 6/10 11/15 16/20 21/25 26/30 31/35 36/40 41/45 46/50 51/55 56/60 61/65 66/70 71/75
Life-cycle based maintenance management

- Adjust the preservation plan
- Clustering and optimization
- Inspection
- Decomposition / preservation plan
- Maintenance execution
- End of service life
## Bridge management system

### IHP-inspectie
<table>
<thead>
<tr>
<th>IHP</th>
<th>2006</th>
<th>2012</th>
</tr>
</thead>
</table>

### Instandhoudingsinspectie
<table>
<thead>
<tr>
<th>5000</th>
<th>2012</th>
</tr>
</thead>
</table>

### Referentiegegevens
- **IHP-Maatregel**
  - Latent Std Berek. Kosten vlg:
    - JvU
    - Int.v
    - JvU
    - Kengatal (€)
- **Advies Rijkswaterstaat Bouwdienst**
  - Maatregel Informatie
  - Adv. Uitset Geraamde
  - Actie nr. DISK
  - JvU
  - JvU
  - Kosten (€)

### Totaal: Kosten per planjaar (K€)
|------|------|------|------|------|------|------|------|------|------|------|

### Instandhoudingsonderdelen

#### Groot Onderhooi
  - Kosten vlg:
    - € 2,856
  - Actie: vervangen stijlen
    - 2009
    - 2012
    - € 10,000
    - 2010
  - Vervangen:
    - 1976
    - 25 (2001)
    - Kosten vlg:
      - € 6,678

#### Hemelwaterafv syst.
- **1975**: 10 (1986)
  - Kosten vlg:
    - € 1,200
  - Actie: aanpassen HWA
    - 2008
    - 2010
    - 2010
  - Vervangen:
    - 1975
    - 50 (2026)
    - Kosten vlg:
      - € 3,176

#### Leuning
  - Kosten vlg:
    - € 3,132

#### Asfaltconstrue
- **1996**: 10 (2008)
  - Kosten vlg:
    - € 480
  - Actie: vervangen ZOAB t
    - 2009
    - 2010
    - € 20,000
    - 2011
  - Vervangen:
    - 1996
    - 20 (2018)
    - Kosten vlg:
      - € 8,160

#### Hoofdraagconstructie
- **1976**: 30 (2006)
  - Kosten vlg:
    - € 2,646
  - Actie: Uitvoeren betonre:
    - 2007
    - 2008
    - € 100,000
    - 2010
  - Vervangen:
    - 1976
    - 90 (2066)
    - Kosten vlg:
      - € 313,404

#### Oplegging
- **1976**: 22 (1998)
  - Kosten vlg:
    - € 32,664

#### Schampkant
  - Kosten vlg:
    - € 680

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03G-306-01 | Viaduct over de Tilweg (Zijldijk) (IN) | Rijksweg 46 | Hectometer 32,9 +06 | Bouwjaar 1976 | Dkr. Groningen | << Terug | Naar hoofdscherm
Management of an ageing bridge stock
Development motorways

Number of vehicles 0.5 million (1960) -> 7 million (2007)
Year of construction concrete bridges and viaducts (HWN)

3600 concrete structures
60% built prior to 1975

Period

Viaduct over RW
Viaduct in RW
Bridge fixed - Concrete small
Bridge fixed - Concrete large

Quantity

0 100 200 300 400 500 600 700

Development of heavy traffic and designs 1950 - 2007

**Development heavy trucks**

- **1950**: Increase axle load 8 -> 10 t
- **1960**: Super singles and pneumatic suspension
- **1970**: Super singles on a large scale
- **1980**: Increase mass of “solo” vehicles
- **1990**: Construction boom of highways
- **2000**: 60% structures < 1975
- **2007**: 2005

Quantity 50 tonnes >>>

Rijkswaterstaat Centre for Public Works
Bigger, heavier, larger numbers

1960 - 2007
Development of heavy traffic and designs 1950 -2007

Development heavy trucks

- Increase axle load 8 -> 10 t
  - 1960
  - Quantity 50 tonnes
- Super singles and pneumatic suspension
  - 1970
  - Quantity 50 tonnes
- Super singles on a large scale
  - 1980
  - Quantity 50 tonnes
- Increase mass of “solo” vehicles
  - 1990
  - Quantity 50 tonnes
- Design of bridges / viaducts
  - 2000
- Eurocode (2002)
  - 2005
- Construction boom of highways
  - 2007
- 60% structures < 1975

- VB 74: drastically changed perception concrete design
- VOSB 1963; traffics loads dependent on lane layout
- Quantity 50 tonnes

Super singles on a large scale
Quantity 50 tonnes
Super singles and pneumatic suspension
Quantity 50 tonnes
Increase axle load 8 -> 10 t
Quantity 50 tonnes
Increase mass of “solo” vehicles
Quantity 50 tonnes
Eurocode (2002)
Construction boom of highways
60% structures < 1975
VB 74: drastically changed perception concrete design
VOSB 1963; traffics loads dependent on lane layout
Quantity 50 tonnes
Steel bridges: fatigue cracks in orthotrope decks
Concrete bridges; structural reliability at stake
Development of heavy traffic and designs 1950 - 2007

**Development heavy trucks**

- **1950**: Increase axle load 8 -> 10 t
  - Quantity 50 tonnes
- **1960**: Super singles and pneumatic suspension
  - Quantity 50 tonnes
- **1970**: Super singles on a large scale
  - Quantity 50 tonnes
- **1980**: Increase mass of “solo” vehicles
  - Quantity 50 tonnes
- **1990**: VB 74: drastically changed perception concrete design
- **2000**: ZSM; structural assessments
- **2007**: Fatigue cracks steel bridge decks; 1997 replacement movable part of the ‘van Brienenoordbrug’

**Design of bridges / viaducts**

- **1950**: VOSB 1963; traffics loads dependent on lane layout
- **1960**: Quantity 50 tonnes
- **1970**: Quantity 50 tonnes
- **1980**: Quantity 50 tonnes
- **1990**: Quantity 50 tonnes
- **2000**: Quantity 50 tonnes
- **2005**: Quantity 50 tonnes
- **2007**: Quantity 50 tonnes

**Construction boom of highways**

- 60% structures < 1975
Structural reliability at stake

Sense of urgency – Hollandse Brug
Research Approach

Assessment f(load, condition/strength, future use)

- Measurements: actual traffic loads
- Proof loading/destructive testing
- Desk study; evaluation design
- Philosophy structural reliability
- Inspections
Traffic loads

- Measurement real-life loads
- Prognosis of development
- Analysis of structural effects
- Heavy transports
Use in practice: weight in motion

Figure 1, section of Kistler sensor
Example extreme axle load

Datum: 7 december 2007
Tijd: 16:03:52
Voertuignr: 57771400
Rijstrook: 5 R-L
Meetlocatie: RW 004 1 HR L
Subcategorie: O222
Snelheid (km/uur): 83

<table>
<thead>
<tr>
<th>asdruk (ton)</th>
<th>dynamisch</th>
<th>statisch</th>
<th>lengte (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>tweedehalf</td>
<td>102,0</td>
<td>0,0</td>
<td>19,70</td>
</tr>
</tbody>
</table>

| as 1        | 7,4       |          | 0,00       |
| as 2        | 8,3       |          | 1,51       |
| as 3        | 13,3      |          | 2,06       |
| as 4        | 13,6      |          | 1,40       |
| as 5        | 20,5      |          | 11,58      |
| as 6        | 38,9      |          | 1,62       |
Moerdijk trucks > 35 kN measurements over one year

Number of trucks

week

Christmas

Summer
Vehicle spectra

Spectra of vehicles in one week

Vehicle load [kN]

Number of Vehicles

[Bar chart showing the number of vehicles in different load brackets for the years 1998 and 2007]
Pronosis 2020

Traffic intensity trucks per hour

- < 200 vehicles
- 200-400 vehicles
- 400-600 vehicles
- 600-800 vehicles
- 800-1000 vehicles
- 1000-1200 vehicles
- 1200-1400 vehicles
- 1400-1600 vehicles
- 1600-1800 vehicles
- > 1800 vehicles
Structural details: Expansion joint

Extra damage expansion joint;
Old recommendation:
Max. axle load was 190 kN
New measurements:
Max. axle load becomes 240 kN

Development maximum stress anchorplate

New situation:
Sxx=60.5 N/mm²
means:
2 million cycles

Old situation:
Sxx=47.8 N/mm²
means:
20 million cycles
Risk based inspections

- Inspection focused at timely identification of current and future RAMS-risks:
  - Reliability
  - Availability
  - Maintainability
  - Safety
- Aimed at construction specific or material specific risks
- Aimed at use-specific risks
- Aimed at function specific risks
Example risk based inspection

Large scale concrete damage at abutments:
Condition based: Bad condition;
Risk based: low risk

Bad detail in the main span with no (visual) damage:
Condition based: good condition
Risk based: high risk
Critical bridges come up
Thank you for your kind attention