CPX road surface noise monitoring in Germany and Switzerland

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Agenda

- a short history
- road surface monitoring in Switzerland
- road surface monitoring in Germany
- minimization of uncertainties
Short history

- Germany
  - experimental device
  - no serious intents

- The Netherlands
  - lucky division of budgets: the ministry for transport has to pay for the road pavements, the ministry for environment has to pay for noise protection. Everyone shouts: „Save my budget!“
  - the Netherlands were the political driver for ISO standard 11819-2

- Austria
  - approval tool for cement concrete road surfaces (RVS 11.06.64)
Current situation

- Germany
  - road building that is oriented towards road building regulations without acoustic requirements
  - preventive noise protection strategy
  - no legal duties for road administrations to monitor the acoustic state of their road networks
  - therefore, no reason for road administrations to conduct CPX measurements within their road networks
  - however, in recent years, regional and local road administrations initiated CPX data collection projects to
    - find out which types of road surfaces perform better than others in terms of tyre/road noise
    - assess actions taken to improve the structural quality of road pavements
Current situation

- Germany
  
  *terms and definitions*

  tyre/road noise reference values, passenger cars

<table>
<thead>
<tr>
<th></th>
<th>50 km/h</th>
<th>80 km/h</th>
<th>120 km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPB, dB(A)</td>
<td>72.7</td>
<td>78.8</td>
<td>85.2</td>
</tr>
<tr>
<td>CPX, dB(A)</td>
<td>-</td>
<td>101.0</td>
<td>-</td>
</tr>
</tbody>
</table>

tyre/road noise level correction is determined 3 years after construction (new considerations: 6 years)

no acoustic life-span considerations
Current situation

- Germany

  facts and figures

  - 83 Mio. people
  - 357,000 km²
  - 830,000 road km
    - Autobahnen 13,000 km no speed limit
    - federal roads 38,000 km speed limit 100/120 km/h
    - state roads 87,000 km speed limit 100 km/h
    - district roads 92,000 km speed limit 100 km/h
    - rest (estim.) 230,000 km speed limit 50/80/100 km/h
Current situation

- Switzerland
  - road building that is oriented towards roads building regulations without acoustic requirements
  - both preventive noise protection and periodic revision of noise protection measures is obligatory
  - therefore, there is a legal duty to monitor the quality of the road network in terms of tyre/road noise
  - ⬇ measurement schedule

![Measurement Schedule Diagram]

- new pavement construction

![Time Scale Diagram]

- year 0 0.5 1 2 3 4 5 10
Current situation

- Switzerland
  terms and definitions
    - tyre/road noise reference values, passenger cars

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<tr>
<td>SPB, dB(A)</td>
<td>70.5</td>
<td>77.6</td>
<td>83.7</td>
</tr>
<tr>
<td>CPX, dB(A)</td>
<td>90.1</td>
<td>97.1</td>
<td>-</td>
</tr>
</tbody>
</table>

- low noise road surface

\[ 0 \text{ dB(A)} \quad -1 \text{ dB(A)} \quad -3 \text{ dB(A)} \geq | -3 \text{ dB(A)} | \]

\[ 0 \quad \text{acoustic life-span} \quad \geq 15 \text{ age, years} \]
Current situation

- Switzerland
  
  **facts and figures**

- 8.5 Mio. people
- 41,000 km²
- 72,000 road km
  - motorways 1,500 km speed limit 120 km/h
  - federal roads 400 km speed limit 80 km/h
  - state roads 17,800 km speed limit 80 km/h
  - rest (estim.) 52,300 km speed limit 50/80 km/h
Switzerland – large scale road network monitoring in 2009

- measurement method of choice: CPX
- all motorways
- all traffic lanes on each motorway
- tyre P1 on the right, tyre H1 on the left
- one reference speed 80 km/h
- 6,400 measurement kilometers
- measurements took 3 months
Switzerland – large scale road network monitoring

$CPX_p$, @80 km/h
Switzerland – large scale road network monitoring

$\Delta CPX_p \approx 12 \text{ dB} !$
regarding the entire network

hotspots
Switzerland – low noise road surfaces, best practice

- Two tables: pavements with 4 to 6 mm max. grain size
  pavements with 8 to 11 m max. grain size

<table>
<thead>
<tr>
<th>surface type</th>
<th>contact person</th>
<th>date of constr.</th>
<th>year 0</th>
<th>year 1</th>
<th>year 2</th>
<th>year 3</th>
<th>year 4</th>
<th>year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavements with 4 to 6 mm max. grain size</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Pavements with 8 to 11 m max. grain size</td>
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</table>

Measurement 1 year after construction:

- Noise level reduction:
  - Meas. light heavy mix
  - Method veh. veh. with 8% heavy

| CPX | -8.8 | -6.7 | -7.5 |
Germany – learning from the roads

- transition from regulation based to performance based road construction contracts
- acoustic performance
  - magnitude of the tyre/road noise level
  - homogeneity of the tyre/road noise along the road
  - durability of the noise level reduction
- tyre/road noise monitoring
  - big data collection
  - easy determination of performance parameters
  - assuming that road administration is willing to test materials, machinery, production technology within the boundaries of the building regulations
Germany – learning from the roads

- a good practice example: a road administration’s playground
Germany – road surface monitoring

CPX, dB(A) vs. position, m
Germany – road surface monitoring

- an example

thin layer asphalt 0/5 (low noise asphalt)
11 road sections
48 km
2,400 CPX segments at 20m each
age 0.5 ... 8 years after construction
construction between 2005 and 2010
$CPX_P$, 80km/h
Germany – road surface monitoring

0.5 years cumulative frequency %

Reference value

Acoustic performance

- Magnitude: -6.4 dB
- Homogeneity: 2.3 dB
- Durability: ?

Performance parameter

- 'Homogeneity' (overall = inter and intra road)
- @Building process reliability

- 'Magnitude' @initial noise level reduction

- 'Magnitude' @initial noise level reduction

Performance parameter

- 94.6 dB(A)
Germany – road surface monitoring
thin layer low noise asphalt 0/5

<table>
<thead>
<tr>
<th>Frequency %</th>
<th>Cumulative Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 years</td>
<td>-6.4 dB</td>
</tr>
<tr>
<td>4 years</td>
<td>-3.4 dB</td>
</tr>
<tr>
<td>8 years</td>
<td>-2.2 dB</td>
</tr>
</tbody>
</table>

acoustic performance

- magnitude: -6.4 dB
- homogeneity: 2.3 dB
- durability: 0.75 dB/year, 0.53 dB/year
Germany – road surface monitoring

exposed aggregate cement concrete 0/8

acoustic performance

magnitude

homogeneity

durability

0.80_{4\text{year}} / 0.68_{8\text{year}} dB/year

-4.4 dB

2.0 dB

-1.2 dB

+1.0 dB
Germany – road surface monitoring
Germany – road surface monitoring

- tyre P1
- tyre H1
- 80 km/h

thin layer 0/5

- 0 dB
- 5,000 m

- +1 dB
- 5,000 m

- +2 dB
- 5,000 m

porous asphalt 0/8

- 0 dB
- 7,000 m

- +1 dB
- 7,000 m

- +2 dB
- 7,000 m

- +4 dB
- 7,000 m
Making the CPX method applicable
Minimization of uncertainties – DE’s and CH’s approach

- **Choice of the test vehicle**
  - self powered standard vehicle
  - self powered special purpose vehicle
  - open trailer
  - trailer with auxiliary wheels
  - uniwheel trailer
  - closed trailer with towing van
Minimization of uncertainties

- Choice of the test vehicle in Germany and Switzerland
  - prevention of interfering noise
  - avoidance of interfering sound sources
  - unbiased tyre/road noise
  - well defined sound field
  - closed version
  - no auxiliary wheels
  - two wheels rolling in the wheel tracks
  - absorbing hatches
Minimization of uncertainties

- towing vehicle

80 km/h
13 dB
\( \sim v^6 \)
50 km/h

without towing vehicle

with towing vehicle

\( v_{\text{wind}} \)

normal measurement

semi dense asphalt 0/8

\( v_{\text{wind/drive}} = 80 \text{ km/h} \)
Minimization of uncertainties

- defined positioning of the microphones
  - use of a setting gauge
Minimization of uncertainties

- Tyre management
  - check tread profile depth
  - check hardness

- store suitably

![Graphs showing the relationship between age and hardness for Tyres P1 and H1](image)

- Tyre P1:
  - Equation: \( y = 1.47x + 60.36 \)
  - \( R^2 = 0.94 \)

- Tyre H1:
  - Equation: \( y = 1.95x + 58.12 \)
  - \( R^2 = 0.64 \)
Minimization of uncertainties

- temperature measurement
  continuous and well shielded measurement of ...
  ... air temperature
  ... road surface temperature
Minimization of uncertainties

- temperature measurement

  air temperature measurement under the lee of the towing vehicle

  road surface temperature measurement facilitating the identification of surface transitions
Minimization of uncertainties

- dry road surface condition

waiting period after precipitation events (Central Europe)

<table>
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<th>type of road surface</th>
<th>average air temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5°C</td>
</tr>
<tr>
<td>porous asphalt</td>
<td>72 h</td>
</tr>
<tr>
<td>double-layer porous asphalt</td>
<td>72 h</td>
</tr>
<tr>
<td>semi porous asphalt</td>
<td>48 h</td>
</tr>
<tr>
<td>impervious pavement</td>
<td>24 h</td>
</tr>
</tbody>
</table>
Thank you very much for listening!

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