A METHODOLOGY TO EVALUATE PAVEMENT NOISE PERFORMANCES

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Context

- **Low noise pavements** can be used as **cost-effective means** of road traffic **noise reduction**
- **New efficient pavements** have been developed, showing **high noise reductions**
- **Lack of standard and reference procedure** for comparing pavements is an **obstacle** to the **compilation of experience and further development** of low noise pavements
- **Contractors often face difficulties to reproduce noise performances** of a given pavement type from one site to another
Context

- Road authorities want to introduce noise requirements in tenders for pavement renewal. They need reference methodology to fix the requirements and check on site their application.

- In France, the GNCDS was tasked to develop and implement a consensual method for characterisation & verification of pavement acoustical properties.
What is GNCDS?

• National Group for Road Surface Characteristics
• Created in 1991 by the Road General Director
• 3 subgroups
  ➢ Longitudinal unevenness
  ➢ Texture and skidding resistance
  ➢ Noise
What is GNCDS?

Objectives?

• To define the links between the quality of service and the technical requirements
• To select appropriate measurement methods
• To publish practical reference documents
• To prepare circulars for the Road Administration

How does it work?

• Public/private partnership (50% « administration » / 50% « industry »)
• Exchange of experiences, of opinions
• Consensual production (informative notes, papers, workshops…)
Current situation

• Classification systems are currently active in some EU countries

• A classification method for acoustic performances of road surfaces is under discussion at CEN level

• A system was proposed in the EU projects "SILVIA" and disseminated in "INQUEST"
The “SILVIA” system

- **Classification**: ISO/SPB
  - CPX (for validation of SPB measurement spot and reference for further checking)
  - Texture
  - Sound absorption (porous pavements)

- **Checking Conformity of Production (COP)**: CPX after 2 months
  - texture + sound absorption + others

- **Monitoring**: CPX
Classification

Reference measurement

Rolling noise by Statistical Pass-By (SPB) (EN ISO 11819-1)

+ 

Rolling noise by Close Proximity (CPX) (pr ISO 11819-2)

+ 

Texture spectrum (NF EN ISO 13473)

+ 

Sound absorption (for porous pavement) (ISO 13472-1)
The French methodology

• Based on the « SILVIA » procedure:
  • characterization of pavement products (labelling) by SPB + other measurements
  • checking on site of pavement conformity by CPX
  • acoustic monitoring of pavement sections and networks by CPX

• Simplifications and adaptation to local context introduced: eg. 2 sites for labelling

• Experimental validation

• Adaptation according to the conclusions of the experiment
Characterization

Section 1

SPB
Product Characterization

$L_{A_{\text{max}}} (LV, 90 \text{ km/h}, 20^\circ \text{C})$

$L_{CPX} (v_{\text{ref}})$
Homogeneity ($\sigma_{\text{section}}$)

$\sigma_{\text{section}} < 1 \text{ dB(A)}$

difference $\leq 1.5 \text{ dB(A)}$

Reference data for section 1
- $L_{A_{\text{max}}} (LV, 90 \text{ km/h}, 20^\circ \text{C})$
- $L_{CPX} (v_{\text{ref}})$

Average noise levels

Product Reference data

Section 2

SPB
Product Characterization

$L_{A_{\text{max}}} (LV, 90 \text{ km/h}, 20^\circ \text{C})$

$L_{CPX} (v_{\text{ref}})$
Homogeneity ($\sigma_{\text{section}}$)

$\sigma_{\text{section}} < 1 \text{ dB(A)}$

Reference data for section 2
- $L_{A_{\text{max}}, \text{VI}} (VL, 90 \text{ km/h}, 20^\circ \text{C})$
- $L_{A_{\text{continu}}} (v_{\text{ref}})$
Check of acoustic performances after works

- **Measurement of CPX noise level**, 2 to 3 months after opening to traffic and at a chosen reference speed $(L_{CPX(V_{ref})})$
- **Comparison of** $(L_{CPX(V_{ref})})$ **with the reference CPX level at the same speed obtained during the characterisation test $(L_{CPX(V_{ref})\text{caract}})$
- **The road surface is accepted if**:
  
  $$L_{CPX(V_{ref})} \leq L_{CPX(V_{ref})\text{caract}} + Y$$
  
  *with tolerance $Y = 2$ dB(A)*

- **Y** is due to the **reproducibility** of the **measurement**, the **mix design** and the **laying procedure**
Experimental validation: principles

- **3** road companies
- **1** low noise product per company: $E_i$
- **Very Thin layer 0/6 class 1 or 2 « low noise » (proprietary) products**
- **2** sites per product: $S_{iA}$, $S_{iB}$
- Assessment distributed in **5** different teams: $L_1$ to $L_5$
Experimental validation : sites

<table>
<thead>
<tr>
<th>Prod.</th>
<th>Sites</th>
<th>Speed limit (kph)</th>
<th>Age of surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>$S_{1A}$: Single carriageway urban ringroad</td>
<td>90</td>
<td>3 Y</td>
</tr>
<tr>
<td></td>
<td>$S_{1B}$: Single carriageway interurban road</td>
<td>90</td>
<td>2 Y + 10 M</td>
</tr>
<tr>
<td>P2</td>
<td>$S_{2A}$: Dual carriageway urban ringroad</td>
<td>70</td>
<td>8 M</td>
</tr>
<tr>
<td></td>
<td>$S_{2B}$: Dual carriageway urban ringroad</td>
<td>110</td>
<td>3 Y + 4 M</td>
</tr>
<tr>
<td>P3</td>
<td>$S_{3A}$: 3-carriageway motorway</td>
<td>130</td>
<td>7 M</td>
</tr>
<tr>
<td></td>
<td>$S_{3B}$: Dual carriageway interurban highway</td>
<td>110</td>
<td>14 M</td>
</tr>
</tbody>
</table>

Note : reference speed for noise measurements : 90 kph
Rolling noise by Statistical Pass-By (SPB)  
(EN ISO 11819-1)

+ 

Rolling noise by Close Proximity (CPX)  
(pr ISO 11819-2)

+ 

Texture spectrum  (NF EN ISO 13473)

+ 

Sound absorption  (for porous pavement)  
(ISO 13472-1)

Reference measurement
## Experimental validation: results

<table>
<thead>
<tr>
<th>Road surface Product</th>
<th>Sites</th>
<th>Speed limit (kph)</th>
<th>Age when measured (yrs)</th>
<th>SPB</th>
<th>CPX</th>
<th>ΔSPB</th>
<th>ΔCPX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lab</td>
<td>Avg traffic speed (kph)</td>
<td>$L_{SPB}^{(90)}$ (dB(A))</td>
<td>kph</td>
</tr>
<tr>
<td>E₁</td>
<td>S₁ᵃ</td>
<td>90</td>
<td>3</td>
<td>L₁</td>
<td>87</td>
<td>73.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S₁ᵇ</td>
<td>90</td>
<td>2.8</td>
<td>L₁</td>
<td>79</td>
<td>72.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ΔSPB = -0.8</td>
<td>ΔCPX = -0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₂</td>
<td>S₂ᵃ</td>
<td>70</td>
<td>0.7</td>
<td>L₂</td>
<td>78.5</td>
<td>72.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S₂ᵇ</td>
<td>110</td>
<td>3.3</td>
<td>L₁</td>
<td>107</td>
<td>75.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ΔSPB = 3.6</td>
<td>ΔCPX = 2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₃</td>
<td>S₃ᵃ</td>
<td>130</td>
<td>0.6</td>
<td>L₁</td>
<td>114</td>
<td>74.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S₃ᵇ</td>
<td>110</td>
<td>1.2</td>
<td>L₁</td>
<td>91</td>
<td>76.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ΔSPB = 1.8</td>
<td>ΔCPX = -0.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Experimental validation: conclusions

- At least 2 sections, 100 m long minimum
- Sections with pavements of similar age (difference ≤ 1yr)
- Test sites must allow an average measurement speed of SPB (i.e. average speed of the traffic flow) close to the chosen reference speed.
- Test sites must allow CPX measurements at all speeds within the speed range of use of the road surface
- Acoustic performances (SPB) of sections must not be more than 1.5 dB(A) different
Application

Application of the methodology by the 3 road companies, following the new essential requirements

<table>
<thead>
<tr>
<th>Road surf. Prod.</th>
<th>Sites</th>
<th>Age (years)</th>
<th>SPB</th>
<th>CPX</th>
<th>Final ref. values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$L_{\text{SPB}}$ (90 kph) (dB(A))</td>
<td>$\Delta_{\text{a,b}}$ (dB(A))</td>
<td>$L_{\text{CPX}}$ (90 km/h) (dB(A))</td>
</tr>
<tr>
<td>$P_1$</td>
<td>$S_{1a}$</td>
<td>&lt; 1</td>
<td>69.5</td>
<td>1.4</td>
<td>93.2</td>
</tr>
<tr>
<td></td>
<td>$S_{1b}$</td>
<td>&lt; 1</td>
<td>68.1</td>
<td>1.4</td>
<td>95.1</td>
</tr>
<tr>
<td>$P_2$</td>
<td>$S_{2a}$</td>
<td>&lt; 1</td>
<td>69.6</td>
<td>0.1</td>
<td>95.6</td>
</tr>
<tr>
<td></td>
<td>$S_{2b}$</td>
<td>4</td>
<td>69.9</td>
<td>0.1</td>
<td>93.7</td>
</tr>
<tr>
<td></td>
<td>$S_{2c}$</td>
<td>&lt; 1</td>
<td>69.5</td>
<td>0.1</td>
<td>95.1</td>
</tr>
<tr>
<td>$P_3$</td>
<td>$S_{3a}$</td>
<td>&lt; 1</td>
<td>72.4</td>
<td>0.7</td>
<td>97.0</td>
</tr>
<tr>
<td></td>
<td>$S_{3b}$</td>
<td>&lt; 1</td>
<td>73.1</td>
<td>0.7</td>
<td>95.5</td>
</tr>
</tbody>
</table>
Conclusions

✓ It is difficult for road contractors to reproduce noise performances for a given pavement type

✓ Variations in SPB noise levels lower than 1.5 dB(A) are possible, provided some precautions are taken:
  ✓ Average traffic speed close to the measurement reference speed,
  ✓ The 2 sections to be characterised should be at least 2 month old but no more than 1 year difference between them
  ✓ It is recommended that the same operator performs the measurements on both sites
Conclusions

- Sound absorption can’t be easily evaluated in practical situations.
- The analysis of measured texture spectra did not lead to a meaningful interpretation, in particular regarding the END$_T$ indicator proposed in “SILVIA”
- The methodology presented here proved to be operational and consensual but still needs to gain more experience
Thank you for your attention!

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