Pavement Surface Characteristics

Susan Tighe, PhD, PEng
Canada Research Chair, Norman W. McLeod Professor
Director, Centre for Pavement and Transportation Technology
http://www.civil.uwaterloo.ca/CPATT/

M. Alauddin Ahammed, PhD, PEng
Manitoba Infrastructure and Transportation

Amir Abd El Halimm PhD, PEng
Stantec Consulting
Key Theme Areas

• Climate Change Impacts on Infrastructure
• Sustainability Incorporated into Design, Construction, Maintenance, Management
• Investment balances: PRESERVATION & EXPANSION
• Make decisions: TECHNICAL, ECONOMIC, SOCIAL, ENVIRONMENTAL
• Allocate Budgets: SATISFY ORGANIZATION NEEDS, CUSTOMER REQUIREMENTS, PERFORMANCE EXPECTATIONS
Outline of Presentation

• Introduction
• Overview of surface texture, friction and noise
• Relevant past research
• Data collection, analysis and results
• Performance models and Pavement Management Systems
• Closing Thoughts
Introduction

• 189,000 highway crashes in Canada (2012)
  • Skidding: Up to 35% of wet accidents
  • Splash and spray: 10% of wet accidents
  • Both mainly depend on surface texture
  • Friction increase by 0.1: 13% wet accident reduction
• Anti-skid surfacing in UK: 35% wet accident reduction
  • Friction varies seasonally and reduces over time
  • Important measure of pavement deterioration
  • Increased risk of wet accidents
Introduction

• Increased texture for improved durable friction
• Improved safety and economy
• Noise is environmental pollutant
• Noise barriers: $0.6 to $3.0 million per km
• Not practical for urban roads: Sound escape path
• Noise reducing pavements: Possible economic alternative?
• Need to balance safety, cost, durability and comfort
Objectives of Research

• Overview of pavement surface characteristics and relevant research
• Examine various asphalt mixes and concrete texturization for macrotexture, friction and noise
• Determine effect of prior weather on seasonal surface friction variation
• Quantify long term surface friction and develop performance models
• Develop guideline for desirable (optimum) surface and incorporating into PMS
Surface Texture, Skid Resistance and Tire-Road Noise

Ranges of Texture and Anticipated Effects (PIARC 1987)
Pavement Texture

[Reference: NCHRP 2009]
Surface Friction Over Time

Seasonal and Long Term Skid Resistance Variations [TAC 1997]
Friction Factor and SN

The friction factor:

\[ \mu = f = \frac{F}{L} \]

Where:

- \( f \) = friction factor
- \( F \) = frictional resistance force in the direction of travel
- \( L \) = reaction load perpendicular to the surface

Skid Numbers:

\[ SN = 100 \times f = 100 \times \frac{F}{L} \]
# Life Cycle Assessment

<table>
<thead>
<tr>
<th>Planning and Programming</th>
<th>Design</th>
<th>Construction</th>
<th>Maintenance, Preservation and Rehabilitation</th>
<th>In-Service Evaluation</th>
<th>End of Service Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Traffic and Environmental data information</td>
<td>• Information on materials, traffic, costs, environment, etc.</td>
<td>• Environment during construction</td>
<td>• Standards</td>
<td>• Recycling and reuse of materials for reconstruction</td>
<td></td>
</tr>
<tr>
<td>• Assess network deficiencies</td>
<td>• Design alternatives</td>
<td>• Specifications</td>
<td>• Treatments</td>
<td>• Salvage Value</td>
<td></td>
</tr>
<tr>
<td>• Budgets</td>
<td>• Analysis</td>
<td>• Contracts</td>
<td>• Schedules</td>
<td>• Records</td>
<td></td>
</tr>
<tr>
<td>• Establish priorities</td>
<td>• Optimization</td>
<td>• Construction operations</td>
<td>• Budget control</td>
<td>• Restoration</td>
<td></td>
</tr>
<tr>
<td>• Schedule projects</td>
<td>• Sustainability</td>
<td>• Quality control/quality assurance</td>
<td>• Records</td>
<td>• Zero Waste Management</td>
<td></td>
</tr>
<tr>
<td>• Priorities</td>
<td>• User costs</td>
<td>• Environment during construction</td>
<td>• Periodic monitoring of structural adequacy, roughness, surface distress, and surface friction</td>
<td>• Assess performance</td>
<td></td>
</tr>
</tbody>
</table>

"Working" Management

[Database]

[Research]

[Loop]
CPATT Data Collection Tools

- Sand Patch Texture
- ASTM Skid Trailer
- Portable Skid Tester
- Close Proximity Noise
- In-vehicle Noise
- Pass-by Noise
CPATT Data Collection Tools

ARAN laser

Impedance tube

Reverberation chamber
CPATT Data Collection Tools

15 concrete surfaces in CPATT laboratory: Surface texture and skid resistance
CPATT Test Track
Regional Municipality of Waterloo’s Waste Management Site
CPATT Test Track

7 concrete surfaces at CPATT landfill test track

5 asphalt surfaces at CPATT landfill test track
Collection of Data
Collection of Data
Collection of Data

- 2008 Larger Sample Size Frequent Testing
- 2009/2010 (24 Sections)
  - Windsor, London, Kitchener, Toronto and Ottawa
  - Montreal and Laval area (2010)
- Tested in conjunction with ACPA and CAC
- Equivalent tire-pavement noise dB, Leq
- Maximum tire-pavement noise dB, Lmax
- CPATT Noise Testing equipment
Collection of Data

- Concrete Pavement Longitudinal Tining, PCCP LT
- Concrete Pavement Transverse Tining, PCCP TT
- Concrete Pavement Random Tining, Random TT
- Stone Mastic Asphalt, SMA
- Superpave 12.5 FC2
- Hwy3, Hwy 401, Hwy 410, Hwy 417
- Tested at 100km/hr (2009, 2010)
- 2009 recorded as peak values at specific frequency (not as a sum logarithm) – (SPL A)
- 2010 Leq or Lmax at specific frequency (SPL B)
Noise Data Lmax

Ontario Sections Lmax CPATT

Test Sequence and Pavement Type

Lmax in dB

### Noise Comparison Lmax

#### ONT Lmax Data 2009 Vs. 2010 SPL A

<table>
<thead>
<tr>
<th>CAC Test Sequence 2010</th>
<th>Lmax 2009</th>
<th>Lmax 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>99.2</td>
<td>96.7</td>
</tr>
<tr>
<td>3</td>
<td>101.6</td>
<td>102.5</td>
</tr>
<tr>
<td>4</td>
<td>101</td>
<td>103.1</td>
</tr>
<tr>
<td>9</td>
<td>100.8</td>
<td>102.3</td>
</tr>
<tr>
<td>10</td>
<td>104</td>
<td>104.1</td>
</tr>
<tr>
<td>11</td>
<td>98.9</td>
<td>97.5</td>
</tr>
<tr>
<td>12</td>
<td>98.7</td>
<td>99.1</td>
</tr>
<tr>
<td>13</td>
<td>96.2</td>
<td>95.2</td>
</tr>
<tr>
<td>14</td>
<td>98</td>
<td>96.2</td>
</tr>
</tbody>
</table>

- Lmax (dB): 90, 92, 94, 96, 98, 100, 102, 104, 106
Analysis of Data

- SP, SMA and Fine SP absorb 6.3%, 7.5% and 8.5% of sound
- Textured concrete absorb 5-6% of sound
- 10 km/h speed increase: 1.5-1.6 dBA increase (pass-by and in-vehicle levels)
- Variation with age could not be determined: Variation in actual surface texture/condition
Testing Challenges

- Vehicle Configuration and Tire Configuration (commercial van, others use Chevy Malibu passenger car)
- Tire Types and Pressures: Tread pattern and Size
- Nose Cone versus Windscreen (used nose cone others use windscreen)
- Quality Control Checks (trained staff)
- Test Temperatures
- Sample versus Continuous Measurement (compare only similar measurements)
- Fixture Variability (microphone same height)
Analysis of Data

- Acceptable maximum: NAC or public perception
- No guideline in Canada/US. Being suggested as:

<table>
<thead>
<tr>
<th>Overall Noise Level with Respect to the Maximum Acceptable Limit</th>
<th>Pavement Classification</th>
<th>Action by the Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;5 dBA higher</td>
<td>Very noisy</td>
<td>Actively consider for surface change/treatment to reduce the noise level</td>
</tr>
<tr>
<td>3-5 dBA higher</td>
<td>Noisy</td>
<td>Candidate for surface change/treatment</td>
</tr>
<tr>
<td>Within ± 2 dBA</td>
<td>Normal</td>
<td>Check at 2-year interval for potential increase</td>
</tr>
<tr>
<td>3-5 dBA lower</td>
<td>Less Noisy</td>
<td>Check every 5-year for potential increase</td>
</tr>
<tr>
<td>&gt;5 dB lower</td>
<td>Noise Reducing</td>
<td>No action is needed</td>
</tr>
</tbody>
</table>
Closing Thoughts

• Surface texture is important and should be measured
• Complex testing requires precision, training and good understanding of physics, pavements, field testing
• Needs to be included in the Pavement Management System
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Transportation Association of Canada
2013 Pavement Asset Design and Management Guide
Questions/Comments

Susan L. Tighe, PhD, PEng
Director, Centre for Pavement and Transportation Technology
Professor, Canada Research Chair, Norman W. McLeod Chair
Civil and Environmental Engineering
University of Waterloo
sltighe@uwaterloo.ca or 519-888-4567 x 33152