Tire - Pavement Noise Evaluation

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National Pavement Preservation Conference
Nashville, Tennessee
August 29, 2012
My Presentation Today

- California Quiet Pavement Research
  - Caltrans QP Policy
- QPR Research Results
  - Flexible, 5 years
  - Rigid, 3 years
  - Next Generation Concrete Surface pilot projects
- OBSI Testing in California
  - Issues with Long-Term Monitoring
Quieter Pavement Research (QPR)

• Growing awareness of highway noise

• Pavement Surface Characteristics
  *more than friction*

• Pavement Preservation / Maintenance
Quieter Pavement Research (QPR)

- Growing awareness of highway noise

- Pavement Surface Characteristics

  more than friction

- Pavement Preservation / Maintenance
QPR Objectives

- Understand long-term acoustic properties
- Understand quieter surface performance with time
  - Noise, smoothness, safety, durability
- Identify new surfaces treatments, materials, construction methods
- Providing quieter pavements that are also safe, durable, and cost-effective
- $1.3+ million per mile
- Maintenance problems (graffiti)
- Can not be used everywhere
- Limits future highway expansion
- Not necessarily effective
- Block views
Quiet Pavement Research

• Flexible pavements
  – Started in 2006

• Rigid pavements & Bridge decks
  – Started in 2008

• Collaboration to share knowledge and methods of implementation
  – Caltrans Quiet Pavement Research Task Group
  – Danish Road Institute
Mandatory Application in Noise Sensitive Areas of Frequent Human Use.

Quieter pavement strategies shall be used in noise sensitive areas of frequent human use that meet all of the following criteria:

- In urban locations
- In roadways with speed limit of 40 mph or greater
- When traditional noise abatement measures, such as sound walls or buffer zones, are either not existing or feasible.
Approved Quieter Pavement Surfaces

• Flexible/Composite Pavements
  – Rubberized Open-Graded Hot Mix
  – Open-Graded Friction Course

• Rigid Pavements
  – Diamond grind
  – Rubberized Open-Graded Hot Mix, High Binder
Before Applying Approved Surfaces

- Replace failed areas
- Replace broken slabs
- Seal cracks
- Repair spalls
- Grind faulting
- Address poor Load Transfer Efficiency
- Basically, correct for rough ride
Surfaces for New Pavement

• Flexible / Composite Pavements
  – Use ½” maximum aggregate size or smaller
  – Use polymer or rubber modified binders

• Rigid Pavements
  – Longitudinally tined
  – Diamond ground
  – Burlap drag, longitudinal broom, astroturf drag*
  – Transverse joints - single cut, 1/8” wide

* requires approval from HQ
OBSI Testing in California

Measures OBSI, IRI, macro-texture
Flexible Experiment Design

• Factorial experiment
  – Mix type: DGAC, OGAC, RAC-O, RAC-G
  – Age categories (< 1 year; 1-4 years; 4-8 years)
  – Traffic level (< 32,000 AADT)
  – Rainfall level (< 24 inches/year)

• Not controlled
  – Maximum aggregate size (3/8”, 1/2”, 3/4”)
  – Polymer vs. conventional binders in OGAC

• Included environmental sections for long-term monitoring
OBSI values over 5 years

DGAC  OGAC  RAC-G  RAC-O

Overall OBSI(dBA)

AGE →
Statistical analysis of 5 years of data

- Permeability of surface reduces noise
  - Air-void contents of 10 - 15 %; open-gradation
  - Permeability decreases with traffic, time
- High macro-texture can increase noise
  - Reduce maximum aggregate size
- Distress & roughness generally increases noise
- Other factors affecting tire/pavement noise:
  - Tire type, Temperature, Vehicle speed
Annual Change in Sound Intensity (dBA)

<table>
<thead>
<tr>
<th></th>
<th>DGAC</th>
<th>OGAC</th>
<th>RAC-G</th>
<th>RAC-O</th>
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<tr>
<td>0.48</td>
<td>0.51</td>
<td>0.55</td>
<td>0.31</td>
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</table>

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ROAD TRIP: DRIVING THE MESSAGE FOR CHANGE
Rigid Experiment Design

• Single Factor experiment
  – Texture: Longitudinal Tine, Longitudinal Broom, Burlap drag, Diamond Grind, Grooving
  – Age: New, Aged, Worn Out

• Not controlled
  – Traffic level
  – Rainfall level

• < 30% of CA highway miles are rigid
Rigid Experiment Design

• Single Factor experiment
  – Texture: Longitudinal Tine, Longitudinal Broom, Burlap drag, Diamond Grind, Grooving
  – Age: New, Aged, Worn Out

• Now controlled
  – Traffic level (< 32,000 AADT)
  – Rainfall level (< 24 inches/year)

• Augmented for Phase 4
## Texture types and conditions

<table>
<thead>
<tr>
<th>Texture Type</th>
<th>Texture Condition</th>
<th>Year 1 Locations</th>
<th>Year 1 Sections</th>
<th>Year 2 Locations</th>
<th>Year 2 Sections</th>
<th>Year 3 Locations</th>
<th>Year 3 Sections</th>
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<tr>
<td>LT (21)</td>
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<td>12</td>
<td>5</td>
<td>12</td>
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<td>12</td>
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<td></td>
<td>Worn out</td>
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<td>3</td>
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<td>3</td>
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<td>LB (10)</td>
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<td>4</td>
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<td>3</td>
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</table>
Longitudinal Tine

Overall Sound Intensity (dBA) vs. Age (Year)

- LT Year 1, 2, and 3

Graph shows a scatter plot with data points indicating the relationship between Overall Sound Intensity (dBA) and Age (Year).
Longitudinal Broom

Overall Sound Intensity (dBA) vs. Age (Year)

- LB Year 1, 2, and 3

Graph showing the relationship between overall sound intensity and age for Longitudinal Broom.
Burlap Drag

![Graph showing overall sound intensity (dBA) versus age (year). The graph indicates a scatter plot with data points for BD Year 1, 2, and 3, suggesting a correlation between age and overall sound intensity.]
Diamond Grind

Overall Sound Intensity (dBA)

Age (Year)
Grooved

Overall Sound Intensity (dBA) vs. Age (Year)

Gr Year 1, 2, and 3
Combined 3-yr results - *aged* textures
Sections common to all three years
Results after three years
With larger sample size
Rankings after 3 years

- Longitudinally broomed (small sample size, 102.5, 101.1 to 104.4)
- Burlap drag (104.3, 102.8 to 105.9)
- Diamond ground (104.4, 101.2 to 107.5)
- Diamond grooved (104.8, 102.1 to 107.6)
- Longitudinal tined (105.0, 102.7 to 106.8)
OBSI Testing in California

Issues with Long-Term Monitoring
OBSI Testing in California
SRTT Effect on OBSI on AC

Overall OBSI Measured with SRTT #1 (dBA)

Overall OBSI Measured with Other SRTT (dBA)

- SRTT #2
  \[ y = 0.8124x + 20.181 \]
  \[ R^2 = 0.7608 \]

- SRTT #3
  \[ y = 1.3565x - 36.748 \]
  \[ R^2 = 0.9054 \]

- SRTT #4
  \[ y = 1.0612x - 6.4574 \]
  \[ R^2 = 0.7723 \]

Graph showing the relationship between Overall OBSI and SRTT measurements with different lines for each SRTT set.
SRTT Effect on OBSI on PCC

SRTT #2
\[ y = 0.8124x + 20.181 \]
\[ R^2 = 0.7608 \]

SRTT #3
\[ y = 1.3565x - 36.748 \]
\[ R^2 = 0.9054 \]

SRTT #4
\[ y = 1.0612x - 6.4574 \]
\[ R^2 = 0.7723 \]
Recommended Tire Criteria

• Change tire if half the criteria are met
  • > 4 years old
  • > 11,000 miles
  • > 68 durometer hardness
  • < 7.2 mm tread depth
QPR Surface Characterization

• Texture Tests
  – Circular Texture Meter (ASTM E 2157)
  – Outflow Meter (ASTM E 2380)
  – Laser Texture Scanner
  – NCAT Permeameter

• Friction Tests
  – Dynamic Friction Tester (ASTM E 1911)
  – California Portable Skid Tester (CTM 342)
  – Towed Skid Trailer (ASTM E 274)
    • Ribbed (ASTM E 501) & Smooth (ASTM E 524) Tires

• Noise Tests
  – On Board Sound Intensity (AASHTO TP-76)

Tests require Traffic Control
Texture and Friction Tests

- **Circular Texture Meter**
  - measures Mean Profile Depth, MPD

- **Dynamic Friction Tester**
  - measures Coefficient of Friction
Texture and Friction Tests

- **Outflow Meter**
  - estimates Mean Texture Depth

- **Laser Texture Scanner**
  - measures Mean Profile Depth
  - estimates Mean Texture Depth

- **NCAT Permeameter**
  - measures asphalt permeability
Texture and Friction Tests

- California Portable Skid Tester
  - Measures Coefficient of Friction
  - Requires traffic control
Noise and Friction Tests

• Skid Trailer
  – Measures Coefficient of Friction
  – Requires no traffic control
Next Generation Concrete Surface

• Developed at Purdue in study of variability in noise levels from surface textures
• Benefits of longitudinal saw-cut grooves
  – Stable
  – Quiet
• Investigating the immediate and long-term effects on pavement surface properties
Concrete Surface Comparison

• Conventional Diamond Grinding

• Next Generation Concrete Surface
## NGCS Pilot Projects in California

<table>
<thead>
<tr>
<th>County</th>
<th>Route</th>
<th>Project Limits</th>
<th>NGCS Limits</th>
<th>Evaluation Limits</th>
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<tbody>
<tr>
<td>San Diego</td>
<td>5</td>
<td>PM R36.3 - R37.4</td>
<td>NB &amp; SB</td>
<td>PM R35.8 - R37.9</td>
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<td>PM R36.3 - R37.4</td>
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<td>Sacramento</td>
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<td>PM 17.2 - 22.8</td>
<td>NB PM 18.7 - 22.4</td>
<td>NB &amp; SB</td>
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<td></td>
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<td></td>
<td>PM 20.0 - 21.5</td>
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<tr>
<td>Sacramento</td>
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<td>PM 0.0 - 17.2</td>
<td>NB PM 1.1 - PM 3.1</td>
<td>NB &amp; SB</td>
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<td></td>
<td>PM 1.5 - 3.0</td>
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<tr>
<td>Sacramento</td>
<td>80</td>
<td>PM 12.4 - 18.0</td>
<td>EB PM 12.8 - 17.6</td>
<td>EB &amp; WB</td>
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<tr>
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<td></td>
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<td>WB PM 12.9 - 18.0</td>
<td>PM 13.0 - 14.0</td>
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<tr>
<td>Sacramento</td>
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<td>PM R12.2 - R14.2</td>
<td>WB PM 12.8 - 14.2</td>
<td>EB &amp; WB</td>
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<td>PM 13.0 - 14.0</td>
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<td>San Joaquin</td>
<td>99</td>
<td>PM 29.0 - 30.8 NB</td>
<td>NB PM 29.0 - 30.8</td>
<td>NB PM 29.5 - 30.8</td>
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<td>Yolo</td>
<td>113</td>
<td>PM R0.0 - R11.1</td>
<td>NB PM R0.20 - R1.5</td>
<td>NB &amp; SB</td>
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<td></td>
<td>SB PM R0.25 - R1.5</td>
<td>PM 0.5 - 2.5</td>
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</tbody>
</table>
Evaluation Schedule

- **Texture and Friction Tests** – Traffic control required
  - Before any grinding
  - After conventional diamond grind
  - After flush grind
  - After grooving

- **Noise and Friction Tests** – Traffic control not required
  - Before any grinding
  - After conventional diamond grind
  - After grooving
  - Annually after grooving
**OBSI Testing Summary**

<table>
<thead>
<tr>
<th>OBSI Sound Intensity (dBA)</th>
<th>Existing Surface</th>
<th>Diamond Grind</th>
<th>NGCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sac5-PM20.0/21.5 Lane 1</td>
<td>104.7&lt;sup&gt;1&lt;/sup&gt;</td>
<td>102.9&lt;sup&gt;2&lt;/sup&gt;</td>
<td>101.4&lt;sup&gt;3&lt;/sup&gt;</td>
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<tr>
<td>Sac5-PM20.0/21.5 Lane 4</td>
<td>105.5&lt;sup&gt;1&lt;/sup&gt;</td>
<td>104.4&lt;sup&gt;2&lt;/sup&gt;</td>
<td>102.7&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sac80-PM13.0/14.0 L2 &amp; L5</td>
<td>105.1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>103.1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>101.4&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sac5-PM1.5/3.0 L1 &amp; L2</td>
<td>104.6</td>
<td>103.7</td>
<td>101.5&lt;sup&gt;3&lt;/sup&gt;</td>
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<tr>
<td>SD5-PM37.15/36.80 SB L2</td>
<td>103.7</td>
<td>101.7</td>
<td>100.6</td>
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</table>

1. Both directions  
2. Southbound Only  
3. Northbound Only
<table>
<thead>
<tr>
<th>*Example data</th>
<th>Before Grind</th>
<th>After Grind</th>
<th>After Flush</th>
<th>After Groove</th>
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<tbody>
<tr>
<td>CTM 342 (μ)</td>
<td>-</td>
<td>0.390</td>
<td>0.236</td>
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<td>DFT (μ)</td>
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<td>0.912</td>
<td>0.616</td>
<td>0.647</td>
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<td>CTM (MPD)</td>
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<td>0.308</td>
<td>1.052</td>
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<td>Outflow (ETD)</td>
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<td>1.852</td>
<td>0.788</td>
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<td>LTS (MPD)</td>
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<td>0.425</td>
<td>0.124</td>
<td>0.272</td>
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<tr>
<td>LTS (ETD)</td>
<td>0.635</td>
<td>0.540</td>
<td>0.299</td>
<td>0.417</td>
</tr>
</tbody>
</table>
Quiet Pavements Research Team

• Caltrans
  – Linus Motumah, Bill Farnbach (concrete)
  – Rupinder Dosanjh, Peter Vacura (asphalt)
  – John Drury (structures)
  – Bruce Rymer (acoustics)

• UCPRC
  – John Harvey, Principle Investigator
  – Irwin Guada, Project Manager
  – Arash Rezaei, Project Scientist/Noise analyst
  – Mark Hannum, OBSI Operator
THANK YOU!

Thanks to
QPR Research Team
FHWA for CTM & DFT
ACPA for texture photos

Questions?
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