Next Generation Concrete Surface

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IGGA and ACPA
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Presentation Outline

• What Was the Necessity and How Did the Industry Respond
• Next Generation Concrete Surface (NGCS) Development
• NGCS Deployment
• What is Next
Necessity is the Mother of Invention

- German physicist Arnold Sommerfeld
- 1964, Pyotr Ufimtsev - Soviet mathematician
- 1970s Lockheed analyst Denys Overholser found Ufimtsev's paper
- 1975 to 1988 - Development

“The application of common sense to a really hard problem”
Looking Back

Things Appear Easier Once You Know the Answer
The Necessity

- **Infrastructure Exists** - In the US Concrete Pavements were Textured with Transverse Tining
- **Quality of Life Issue** - At the Turn of the Century Noise Became an Issue
- **Tire-Pavement Noise Measurement** - No Standardized US Method
- **Tire Whine** - Transverse Tining has Objectionable Tonal Properties
- **Tipping Point** - Fifth Largest City In US Covered Up with AC
- **Sounds of Safety** - Wasn’t Working
- **Trading Walls for Pavements** - Gaining Traction
Trading Walls for Pavements

Diagram showing the interaction of a noise source with a barrier, illustrating the concepts of refraction and diffraction in sound paths.
The Solution

- 2005: PCA funds a $2.1 M Noise Research Program Conducted by ACPA
- 2005: ACPA Develops Dual Probe OBSI Equipment (Caltrans, ADOT, Dr. Donavan)
- 2007: First Test Strip at MnROADs and First Test Section on I-355 In Chicago
- 2007 – 2009: ACPA Contracts with Illingworth and Rodkin to Develop Concrete REMELs, Joint Slap App
- 2011- Present: IGGA Takes Over Heavy Lifting of Field Deployment
The Problem

- Tinning Tonal Properties
- No Standard Test Method
- No Standard Test Tire
- Industry Promoting Wider Spacers
Noise Annoyance

Volume
(Too Loud)

Frequency
(Off Station)
Noise Spectrums for Different Textures (CPX)
It’s the Transverse Tining Not the Material!

Honda Musical Road
Commercial 2008 Lancaster CA

City paved over it 18 days later due to noise complaints
No Standard Tire Pavement Procedures
Tire-Pavement Noise Measurement

50 ft. Wayside

GM OBSI

ACPA OBSI
Tire-Pavement Noise Measurement

- What Tire to Use?
- How Does this Represent the Fleet
  2005-2006 Aqua Tread
- 2006-2014 SRTT
Surface Texture
- Effect of Blade and Spacer Width, Grind Depth, and Custom Blades
- Effect of Grooves width and depth
- Friction
- Rolling Resistance

Transverse Joint Effects
- Opening Width
- Sealed or unsealed
- Faulting: Fault Level, step or step down fault
Purdue Tire Pavement Test Apparatus (TPTA)

- Tests 10 – 30 MPH
- Test Two Tires at Once
- Environmental Control
- Both OBSI and Texture Testing
- Six Samples On Wheel
- Sample Size is 84” X 24”
- 12 Test Sections Per Test Interval
Surface Texture Testing

OBSI

New Orleans, LA
# Diamond Grind Texture Evaluated

<table>
<thead>
<tr>
<th>Feature Evaluated</th>
<th>Range of Features</th>
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<tbody>
<tr>
<td></td>
<td>(Blade/Spacer Widths in Thousands of an Inch)</td>
</tr>
<tr>
<td>Blade Width</td>
<td>90, 110, 125, 165, 125 with reduced diameter</td>
</tr>
<tr>
<td>Spacer Width</td>
<td>30, 90, 110, 130</td>
</tr>
<tr>
<td>Grind Depth</td>
<td>1/8” &amp; 3/16”</td>
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</table>
Purdue Grinding Results

- No unique relationship could be found between spacer width, blade width, and spacer/blade configuration.
- The controlling factor was the variability in the fin/land profile height resulting from the grinding process.
It's About the Resulting Fin Profile
Fin/Land Wear Study

- As-Ground Condition
- Lightly Sanded
- Fins/lands Broken Down

- Removing the micro texture by polishing the surface increased the overall noise level
- Reducing the macro texture to promote a uniform fin profile reduced the overall level
NGCS Compared to Post Traffick CDG

• NGCS Type Surface was About 3 dBA
TPTA Transverse Joint Effects

Joint Effect

• Joint Opening (1/8 to 1 inch)
• Joint Fault (0, 1/16, 3/16)
• Sealed and Unsealed
More TPTA Transverse Joint Effects

Cut backer rod inserts in grooves
Joint Effects on Noise

Faulting Effects on Noise – 3/8 Joint

Joint Opening Width

Fault Level (inches)

Increase in Overall OBSI Noise Level (dBA)

Fault Level (inches)

Joint Opening Width (Inches)

Sound Pressure Level (dBA)

Very Noisy
110 dBA

Noisy
105 dBA

Quiet
100 dBA
Proof of Concept of Testing

Cell 37
Mn ROADs Test Center (Courtesy MnDOT)
First Full Size Grinder Application (Chicago I-355)
Test Results Over Time (Chicago I-355)
<table>
<thead>
<tr>
<th>State</th>
<th>OBSI Difference at Time of Construction (dBA)</th>
<th>OBSI Difference in 2010 (dBA)</th>
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<tbody>
<tr>
<td>Arizona(1)</td>
<td>-2.9</td>
<td>NA</td>
</tr>
<tr>
<td>Illinois(2)</td>
<td>-0.2</td>
<td>0 (3 yrs)</td>
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<tr>
<td>Iowa(3)</td>
<td>-1.3</td>
<td>NA</td>
</tr>
<tr>
<td>Kansas(4)</td>
<td>-2.3</td>
<td>-1.9 (2 yrs)</td>
</tr>
<tr>
<td>Minnesota(5)</td>
<td>-4.2</td>
<td>-2 (3 yrs)</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>-1.6</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Average Difference</strong></td>
<td><strong>-2.1</strong></td>
<td><strong>-1.3</strong></td>
</tr>
</tbody>
</table>
Back to the Future Again

Current NGCS

Future NGCS LITE?

1960’s California Texture
NGCS LITE
MnROAD Test Results

Sound Intensity Level, dBA

Pavement Section

NGCS

Montecello

CDG

Exposed Aggregate

CDG
Anisotropic Friction Behavior
MnROAD Friction Results

- **Next Generation Concrete Surface**
  - 2007: 51.3
  - 2008: 48.0
  - 2009: 45.1
  - 2010: 48.7

- **Conventional Diamond Grinding**
  - 2007: 73.5
  - 2008: 65.9
  - 2009: 54.0
  - 2010: 55.3

- Ribbed Tire (SN40R)
- Smooth Tire (SN40S)
- Shadow effect indicates testing at construction
Kansas I-70 Friction Results

<table>
<thead>
<tr>
<th>Condition</th>
<th>Ribbed Tire</th>
<th>Smooth Tire</th>
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<tbody>
<tr>
<td>Longitudinal Tining</td>
<td>33.2</td>
<td>35.6</td>
</tr>
<tr>
<td>Conventional Diamond Grining</td>
<td>40.5</td>
<td>47.0</td>
</tr>
<tr>
<td>Turf Drag With Longitudinal Grooving</td>
<td>41.8</td>
<td>47.9</td>
</tr>
<tr>
<td>NGCS</td>
<td>41.8</td>
<td>47.9</td>
</tr>
<tr>
<td>Exposed Aggregate</td>
<td>45.8</td>
<td>55.1</td>
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</table>
Mean Texture Depth

<table>
<thead>
<tr>
<th>Pavement Section</th>
<th>Mean Texture Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGCS</td>
<td>1.9</td>
</tr>
<tr>
<td>Grooved Astro Turf</td>
<td>1.5</td>
</tr>
<tr>
<td>Exposed Aggregate</td>
<td>1.2</td>
</tr>
<tr>
<td>CDG</td>
<td>1.0</td>
</tr>
<tr>
<td>Astro Turf Drag</td>
<td>0.9</td>
</tr>
<tr>
<td>Long Tined Drag</td>
<td>0.7</td>
</tr>
<tr>
<td>Burlap Drag</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Water Depth For Hydroplaning

**Pavement Section**

- NGCS
- Grooved Astro Turf
- Exposed Aggregate
- CDG
- Astro Turf Drag
- Long Tined Drag
- Burlap Drag

**Maximum Water Depth (mm):**
- NGCS: 1.8
- Grooved Astro Turf: 1.9
- Exposed Aggregate: 2.0
- CDG: 2.0
- Astro Turf Drag: 2.1
- Long Tined Drag: 2.1
- Burlap Drag: 2.2
Studded Tire Damage
NGCS is a Diamond Grinding Procedure
In Summary

- Its Another Tool In the Tool Box
- Quietest Non Porous Texture to Date
- MnDOT, Caltrans, and VADOT have conducted NGCS Research Projects
What’s Next

• Perhaps Narrow Grooving Blade Widths
• Single Pass Head Development?