# Pavement Surface Characteristics New Concrete MPR 6-(021)

<table>
<thead>
<tr>
<th>Participating Agencies</th>
<th>Contract Duration</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minnesota (Lead State), FHWA</td>
<td>Start – March 2007</td>
<td>Total Funds $150,000</td>
</tr>
<tr>
<td>End – November 2012</td>
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</tbody>
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## Abstract
This study examines various new textures and monitors them over time with a litany of standard tests. In the process certain analytic initiatives are performed.

## Specific Surface Types

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Details</th>
<th>Groove Width</th>
<th>Groove Depth</th>
<th>Asperity Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2010 Ultimate Diamond Grind</strong></td>
<td>Cells 37 (TS5) and 71 (Driving). Replicate of I-35 Duluth Grind</td>
<td>3.75 mm</td>
<td>8 mm</td>
<td>15</td>
</tr>
<tr>
<td><strong>Longitudinal Turf Drag</strong></td>
<td>Cells 13, 32, 52, 54, 60, 61,62 and 63</td>
<td>2 mm</td>
<td>1 mm</td>
<td>2</td>
</tr>
<tr>
<td><strong>Transverse Tine</strong></td>
<td>Cells 12, 36, 37 (TS4 and Inside), 38 and 96</td>
<td>5 mm</td>
<td>1.5 mm</td>
<td>18</td>
</tr>
<tr>
<td><strong>Longitudinal Broom Drag</strong></td>
<td>Cell 14</td>
<td>2 mm</td>
<td>1 mm</td>
<td>2</td>
</tr>
<tr>
<td><strong>Transverse Broom Drag</strong></td>
<td>Cell 53 Inside</td>
<td>2 mm</td>
<td>1 mm</td>
<td>2mm</td>
</tr>
<tr>
<td></td>
<td>Cell 53 Outside</td>
<td>3 mm</td>
<td>1.5 mm</td>
<td>2mm</td>
</tr>
<tr>
<td><strong>Exposed Aggregate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
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</tbody>
</table>
| Cell 72 | • Groove Width – 4 mm  
• Groove Depth – 2 mm  
• Asperity Interval – 8 mm |  |

<table>
<thead>
<tr>
<th><strong>Pervious Concrete</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells 64, 85 and 89</td>
<td>Used CA-70 with 18 to 21 percent porosity.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Pervious Overlay</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Cell 39</td>
<td>Used CA-70 with 18 to 21 percent porosity.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Longitudinal Tine</strong></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| Cell 6 June 2011 | • Pre-textured with Astro Turf Drag  
• Tine at ¾ inch Interval  
• 1/8 inch tine depth |  |
• SOUND ABSORPTION RELATIONSHIPS
  Analysis Completed, SA is not an OBSI Predictor
• 2008 CONSTRUCTION REPORT
• EVALUATION OF INNOVATIVE TEXTURE
• ANOMALOUS RIDE OBSERVATION
  Paper submitted to TRB 2011 describes textures were Point laser data are anomalous.
• SAWTOOTH MODELS OF OPTIMUM REHAB PERFORMANCE:
  Study in progress examines texture degradation and rehab Induced Saw tooth model
• PERFORMANCE/TIME HISTORY
  Produced Performance time History to be used for time series analysis
• DATA BASE POPULATION
  Continuously populates data base for TNM and other necessary surface based tools
• PARAMETER CORRELATION
  Acoustic perception in ride quality rating. 2011 Report (Izevbekhai & Nelson)
Frequency domain analysis included the fragmentation of all OBSI data and sound absorption data from all surface types into their 3rd octave values. While in the spatial domain a correlation was not feasible, there was a difference in the frequency domain. However the lack of sufficient coincidence of 3rd octave frequencies of the 2 variables frustrates adequate coherence. In spatial domain The OBSI –SA coefficient of determination (R²) was 0.0018. This necessitated spectral domain analysis. Normal concrete provides only the aggregate and cement component. The model successfully identified developed and validated the above constituents of the sound absorption ratio (SA). Analysis is really summarized below.

Thus \( \alpha \) Concrete \( \approx \alpha_0 + K_1 \alpha_{cem} + K_2 \alpha_{agg} \) \hspace{1cm} (1)

\( \alpha \) Porous Concrete \( \approx \alpha_0 + K_3 X_{cem} + K_4 X_{agg} + K_5 X_{por} \) \hspace{1cm} (2)

Lemma congruent to Sabine and Eyring’s Equations show

\[ T_{60} = 0.161 \frac{V}{(A + 4mV)} S \] \hspace{1cm} (3)

where \( T_{60} \) is the time taken for the sound level to attenuate to \( 10^{-6} \) of the original level. This is equivalent to a 60dB loss of intensity.

\[ A = \alpha_{tot} S_{tot} \text{ and } \alpha_{tot} = \left( \alpha_{T} S_{T} + \alpha_{R} S_{R} + \sum \alpha_{i} S_{i} \right) / S \] \hspace{1cm} (4)

The \( \alpha \)'s (alphas) are the sound absorption coefficient corresponding to the individual areas, \( \alpha_{tot} \) being total absorption coefficient.

and \( S_{tot} = S_{T} + S_{R} + \ldots \ldots + \sum S_{i} \ldots \) \hspace{1cm} (5)

This equation \( S_{R} \) is the residual absorption area, \( S_{T} \) is the acoustical audience area, and \( V \) is the control volume. \( S_{tot} \) is total area and \( S_{T} \) is the acoustic audience area. The above lemma applies to acoustic design in which the proportioning of the absorbent faces affect the overall attenuation. Izvebkhai [1987] had shown showed that with the use of lightweight concrete and enhanced fiber content for acoustic panels, sound absorption properties can be improved. This is used in deriving component models of the porous pavements. Treating the fibers from that lemma as voids in this scenario, facilitated the development of the following equation:

\[ SI(f) = \alpha_{0}(f) + K_1 \alpha_{solid}(f) + K_2 \alpha_{Cement}(f) + k_3 \alpha_{porosity}(f) \] \hspace{1cm} (6)

By Least Squares Levenberg-Marquardt process, the following relationship was developed

\[ SI(f) = 99.5 X_{cement(f)} - 37.32 X_{aggregate(f)} + 75.3 X_{porosity(f)}^{-0.186} + 19.94 \] \hspace{1cm} (R² = 0.5) N=70 \hspace{1cm} (7)

For non-porous Concrete, regression yielded:

\[ SI(f) = 165.9029 X_{cement(f)} -5.516 X_{aggregate(f)} + 6.56 \] \hspace{1cm} (R² = 0.5) N=120 \hspace{1cm} (8)

Ride quality evaluation of innovative boxcar configurations must be evaluated with caution. Aliasing and laser induced anomalies frustrate similarity between line and point laser devices especially in box car configurations. However in the Hessian Drag and even the conventional grind, the disparity is not statistically significant.
FIGURE 4 shows a representation of OBSI data since 2007 for all MNROAD textures. Evidently, the 2010 ultimate grind has the lowest mean and is therefore by that definition the quietest surface in the MnROAD facility. It is also evident that the probability that this surface is louder than 100dBA is only 20% with a mean OBSI of 98.7dBA. To compare this with transverse tining in the same figure, the mean is 105 dBA and the probability of being quieter than 100dBA is zero. The innovative grind shows a 50% likelihood of being quieter than 100dBA. The pervious concrete surfaces exhibit a mean of 99.5 but the full depth pervious cells are much less tailed than the pervious overlay cell. It is also evident that the traditional grind shows a mean of 102.5 dBA and a 25% likelihood of being quieter than 100dBA. The quietest asphalt surface at MnROAD is the 4.75 mm taconite cell as shown in the fitted normal distribution. It exhibits a mean of 100dBA, the 2010 ultimate grinding (2010 UDG) is not only therefore fulfilling the requirement of a quiet pavement but appears to be the quietest surface at MnROAD.

FIGURE 3: PDF of ALL Pavement Types at MnROAD

References


ADDITIONAL INFORMATION
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