New Jersey Micro-Surface Pavement Noise Evaluation

Submitted on: August 29, 2014

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Word Count: Text= 2014; Tables= 1; Figures= 5; Total= 3514
ABSTRACT

New Jersey DOT is evaluating pavement preservation types for interstate resurfacing as a method to increase network pavement lifecycles within depressed budgetary limits. Despite the economic benefits for micro-surface there is concern for the noise quality and pavement noise levels, which will become a significant issue to a greater population as the application increases over an increased area of lane miles throughout the state.

Pavement noise research has been conducted on in-service pavements throughout NJ for several years, but prior to this study minimal data had been collected on traditional micro-service mix employed state-wide. Three traditional micro-surfaces were evaluated at 72.4 km/h (45 mph) with the On-Board Sound Intensity (OBSI) method. Additionally, three innovative flexible micro-surfaces with varying parameters were evaluated as well. Initial noise levels for NJ’s traditional micro-surface overall levels varied between 98.0 dBA and 102.4 dBA. The flexible micro-surfaces exhibited a similar range. This paper evaluates the overall and spectral differences found between the traditional and flexible micro-surfaces.

INTRODUCTION

Historically in New Jersey, having a pavement management system (PMS) has proven to be a critical system to enable the NJDOT to maintain the statewide roadway network. Pavement management systems have proven to maximize return on investment for maintenance and rehabilitation. Pavement management also provides valuable data to legislators and the public to explain the status of the road network (1). The PMS is also useful to identify areas that need maintenance and to establish minimum condition requirement (1). The NJDOT is determined to ensure that the overall state network reaches 80% acceptable levels of PCI by 2021. To accomplish this goal they have concluded that pavement preservation and preventative maintenance needs to be conducted earlier in a pavement’s lifespan to ensure that the currently acceptable sections remain that way.

Micro-surfacing is a thin slurry seal that uses fine aggregate and emulsified asphalt to quickly apply a coat over the desired surface (2). It can be used to fill ruts up to 38mm deep, but can also be paved as thin as 9.5mm thick (2). It has been suggested as a cost effective method to reduce oxidative aging of an underlying pavement and return PCI to 100% (2). As such, NJDOT is conducting in-service test applications on various state-maintained roadways to determine how well the technique works. Noise measurements are being considered an important parameter because of the expected wide-deployment of micro-surface to restore PCI statewide, which will change the soundscape of many places quickly. It is important to determine how loud these surfaces are and if there are innovative techniques to reduce the tire/pavement noise generated on micro-surfaces. Five different micro-surface types were tested in NJ and PA to determine how loud they were and if any provided quieter benefits.

TEST PROCEDURE

Pavement noise is routinely measured on various in-service pavements in NJ utilizing the On-Board Sound Intensity Procedure (OBSI) (3). The recordings are all conducted in-situ without road or lane closures. Each of the micro-surface pavements tested had been placed less than 2 months before we tested them, so they were considered new.

OBSI Testing Procedure

The method utilized to measure the tire/pavement noise for this study was the OBSI method, which provides sound intensity levels measured in dBA (3). The testing was conducted...
in the right lane to provide equal comparisons for each section. The equipment utilized to measure the tire/pavement noise on the outside of the vehicle, shown in Figure 1, included four G.R.A.S. Sound and Vibration A/S, phase-matched free-field microphones and preamplifiers for the two probe systems. The test vehicle was a Chevrolet Impala with the Standard Reference Test Tire (SRTT). By utilizing the OBSI equipment and method, wind noise and noise generated from other vehicles on the road are negated so that the noise generated by each pavement is a value that can be compared evenly to other pavements (3).

![FIGURE 1 The OBSI intensity probes mounted for testing on the test vehicle. The mounting rig allows the wheel to spin freely while the microphones remain in a fixed position relative to the roadway.](image)

The measurements were recorded over a 5.0 second measurement period at 72.4 km/h (45 mph). The 5.0 second recording time allowed for a 100.6 meter (330 ft) average test for each pavement section. Due to the short length and hilly/winding terrain of the micro-surface experimental test sections, one to two different 100.6 m (330 ft) areas were tested for each pavement type. A minimum of three runs were completed to ensure repeatable results. Coherence and pressure-intensity (PI) index were monitored throughout testing to ensure accuracy for run-to-run criteria outlined in AASHTO TP 76-12 (3). Only contiguous pavement sections without sharp curves were utilized.

**Analysis Procedure**

The analysis of the measurements taken was completed in several separate processes using the following methods. Measurements that fit the appropriate criteria were averaged to create a representation for each material. A table of overall material averages were compiled for each
pavement to show the range of differences between each of the pavements tested. Secondly, one-third octave band frequency spectrum graphs were created for each site and averaged to represent each pavement section. The frequency graphs show the measured sound intensity levels along the one-third octave band spectrum, which is the typical frequency band used to show sound measurements for OBSI.

TIRE/PAVEMENT NOISE MEASUREMENTS

Field Testing
The four different micro-surfaces measured on Scotland Road in eastern Pennsylvania were; 1) Conventional, 2) Flexible Road Science System (Road Science), 3) Flexible MWV Fiberglass System (MWV Fiberglass), and 4) Flexible Kraton® HiMA System (Kraton HiMA). For comparative purposes, these surfaces were compared to the current NJ conventional single-layer type II micro-surface that was measured on three different roadways in NJ; 1) NJ Rt. 23, 2) NJ Rt. 133, and 3) NJ Rt. 206. With the exception of NJ Rt. 133, each of these roads had limited space for testing due to terrain and curvature of the road which was not conducive to the testing speed of 72.4 km/h (45 mph) for both safety concerns and repeatability between measurements. Mix designs and additive types or amounts were not provided for this project.

Field Measurements
At 72.4 km/h (45 mph) the flexible micro-surfaces measured similar overall levels as the conventional and NJ surfaces. The results from table 1 below show the average overall noise level for each micro-surface.

<table>
<thead>
<tr>
<th>Material</th>
<th>dBA</th>
<th>St Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraton HiMa</td>
<td>100.89</td>
<td>0.18</td>
</tr>
<tr>
<td>MWV Fiberglass</td>
<td>100.03</td>
<td>0.14</td>
</tr>
<tr>
<td>Road Science</td>
<td>100.77</td>
<td>0.18</td>
</tr>
<tr>
<td>PA Conventional</td>
<td>99.95</td>
<td>0.21</td>
</tr>
<tr>
<td>NJ Rt. 206</td>
<td>101.52</td>
<td>1.10</td>
</tr>
<tr>
<td>NJ Rt. 133</td>
<td>101.58</td>
<td>0.36</td>
</tr>
<tr>
<td>NJ Rt. 23</td>
<td>99.90</td>
<td>2.33</td>
</tr>
</tbody>
</table>

The Conventional and MWV Fiberglass surfaces were approximately 100 dBA, while the HiMA and Road Science surfaces were closer to 101 dBA. NJ Rt. 23 had a high standard deviation because more 100.6 m test spots were utilized. All of the NJ micro surfaces were identical mixes, but the NJ Rt. 23 section was more than 1.5 dBA quieter. Since the overall levels for each of the micro-surfaces were similar, the one-third octave bands were produced to determine if there were differences in frequencies measured. Figure 2 shows the one-third octave band spectrum for the conventional micro-surfaces.
FIGURE 2  One-third octave band levels for three NJ micro-surface sections and the PA conventional mix.

The PA conventional mix in figure 2 was not ably different from the conventional NJ mix. The PA conventional mix was louder than the NJ mixes in the 2000 Hz to 5000 Hz frequencies, while it was quieter than the NJ mixes in the 400 Hz to 800 Hz frequencies. Since the air void percentage of a micro-surface is presumed to be low, this trend is primarily derived from the aggregate size, aggregate angularity, and the amount of positive texture. The measurements shown in figure 2 for NJ sections show higher variability because more test locations were averaged than the PA section.

FIGURE 3  One-third octave band levels for Kraton HiMA vs. PA Conventional.

The Kraton HiMA which is shown in figure 3 compared to the PA conventional mix was slightly louder than the conventional mix from 1000 Hz to 5000 Hz, which translated to the 1
dBA higher overall noise level shown in Table 1. Even though the mix was louder, the trend in the higher frequencies is similar. This is likely related to the on-site mixing or construction process more than the mixture design.

**Figure 4** One-third octave band levels for MWV Fiberglass vs. PA Conventional.

The MWV Fiberglass, shown in figure 4, is almost identical to the conventional mix. The low end was slightly higher, which is related to texture. The fiberglass strands may have prevented the aggregates from sliding into place during compaction which would lead to a higher positive texture and more low-end noise.

**FIGURE 5** One-third octave band levels for Road Science vs. PA Conventional.

The Road Science micro-surface shown on figure 5 also measured approximately 1 dBA louder than the PA Conventional, but unlike the Kraton HiMA was more similar to the PA
Conventional from 1000 Hz to 5000 Hz. The loudness was mostly generated in the lower frequencies from 400 Hz to 800 Hz. This signifies that the Road Science mix likely had the highest percentage of positive texture compared to the micro-surface mixes tested for this study.

CONCLUSIONS

The pavement noise evaluation of three flexible micro-surfaces showed that the surface characteristics of each pavement made slight differences in the tire/pavement generated noise. Since the overall values are all less than 2 dBA different from each other, there is not likely to be a noticeable difference between any of these micro-surfaces for the local residents. Each of the micro-surface sections tested had been placed less than 2 months prior to testing, so they were considered new. Generally micro-surfaces in NJ have been found to smooth and reduce about 1 dBA after an initial 6 month period. The PA conventional mix measured at 99.95 dBA but was different from the NJ conventional mix spectrally; it was quieter than the NJ mix from 400 Hz to 1250 Hz, but louder in the higher frequencies. The experimental materials were more similar to the PA conventional mix, so the differences between the conventional NJ and PA conventional is likely related to the aggregate source properties. Direct comparisons between different paving techniques cannot be made about the differences between the NJ and PA mixes due to the fact that the aggregate source, initial aggregate angularity, and mixed aggregate angularity are unknown. Because the PA mixes all came from the same aggregate supplier and were paved by the same contractor, they were easily comparable. Each mix had slightly different properties, but the MWV Fiberglass and Road Science mixes both exhibited some elevated levels in the low frequencies due to positive texture compared to the Conventional mix, which is likely related to the additives and slurry surfacing process. The Kraton HiMA was louder in the high end of the frequency spectrum from 1000 Hz to 5000 Hz. Although the HiMA was louder, its one-third octave band followed the same trend as the PA conventional, which indicates that the increase was due to the paving process more than the mixture design. The louder high-end frequencies are associated with lower air void percentage whether from the mix properties or the pavement process. Overall the micro-surface mixes tested were considered loud compared to other pavements tested in NJ. Smooth dense graded mixes and open-graded mixes can be in the 100 dBA at 96.6 km/h (60 mph) using the OBSI procedure, which means the micro-surfaces are just as loud at slower speeds. None of the micro-surfaces tested for this paper provided a significant tire/pavement noise reduction. Research should continue on these and additional micro-surfaces to determine how the noise changes with age.

REFERENCES