EVALUATION OF QUIET ASPHALT PAVEMENT TEST SECTIONS IN ONTARIO

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1. BACKGROUND

Road traffic noise is a growing concern and the public has a growing expectation toward governments to reduce traffic noise.

- Noise barriers are costly and not feasible for all projects [1]
- Cost-effective alternative solutions are needed
- Use of quiet pavements as a solution requires investigation

The most common quiet pavement types are open-graded mixes. The benefit of the open-graded pavement structure is its ability to absorb sound as the sound waves can disperse through its voids.

In 2009, a research project was initiated by the Ministry of Transportation of Ontario (MTO) to study the effectiveness of different asphalt mix types to reduce noise at the tire-pavement interface [2]. Five asphalt test sections were built in October 2009 on Highway 405 (westbound direction) in the Niagara Region of Ontario (Figure 1). The types of asphalt mixes used for each test section are summarized in Table 1.

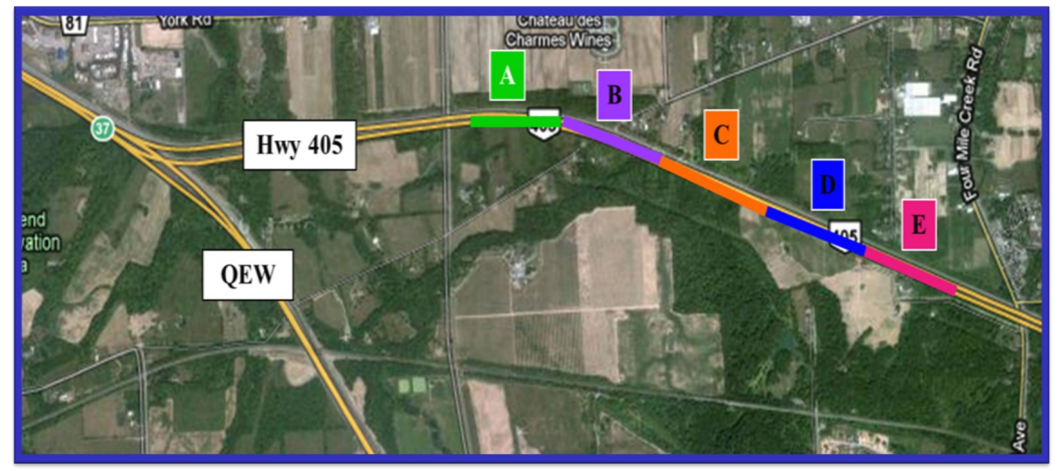

FIGURE 1 – Location of Five Ontario Quiet Pavement Test Sections

TABLE 1 – Asphalt Mix Types used for Quiet Pavement Test Sections

Test Section	Length (m)	Mix Thickness and Type
A	500	30 mm Open-Graded Friction Course (OGFC) over 50 mm Open Binder Course (OBC) over 50 mm Superpave (SP) 19.0
B	500	30 mm Open-Graded Friction Course (OGFC) over 50 mm Superpave (SP) 19.0
C	500	30 mm Rubberized Asphalt Concrete-Open Graded (RAC-O) over 50 mm Superpave (SP) 19.0
D	500	30 mm Stone Mastic Asphalt (SMA) 9.5 over 50 mm Superpave (SP) 19.0
E	500	40 mm Superpave (SP) 12.5 FC2* over 50 mm Superpave (SP) 19.0 [CONTROL]

* FC2 = Friction course mix for which both the coarse and fine aggregates are supplied from MTO's Designated Sources for Materials

Since completion in 2009, MTO has been evaluating the test sections, with the objective of answering the following questions:

- **Are the quiet pavement sections performing well structurally?**
- **Can the quiet pavement sections maintain their noise reduction effectiveness over time?**
- **Can the noise reduction effectiveness of quiet pavements be restored?**

2. EVALUATION

On-Board Sound Intensity (OBSI) Method

- Used to measure tire-pavement noise according to AASHTO TP-76.
- OBSI measurements were conducted in 2009, 2010, 2012, and 2013.
- Two test speeds were used for measurement: 80 km/h and 100 km/h.

FIGURE 2 – OBSI Microphone Setup

Statistical Pass-By (SPB) Method

- Used to measure noise as vehicles passed by a fixed location on the road side, according to ISO 11819-1:1997 guideline.
- Only conducted in 2010 since SPB was more costly than OBSI [2].

Pavement Porosity

- Performed using an outflow meter according to ASTM E2380.
- Plumber's putty provided a water tight seal between the pavement surface and the bottom of the outflow meter.

FIGURE 3 – Outflow Meter used to Measure Porosity

Vacuum Sweeping [3]

- Sections were water blasted and vacuum swept in 2013 in an attempt to restore the noise reduction effectiveness of the test sections by removing debris from the voids.
- Highly pressurized water blasts dislodged debris preceding vacuum cleaning.
- The vacuum applied suction power over a small width (~80 cm).
- OBSI measurements were conducted before and after vacuuming.

FIGURE 4 – Vacuum Sweeper used to Improve Noise Reduction of Quiet Pavement Sections

3. PAVEMENT PERFORMANCE – 4 YEARS

- Pavement performance was assessed based on automated crack detection data that was further verified through visual survey.
- MTO operates an Automated Road Analyzer (ARAN) which is a high speed vehicle capable of measuring pavement roughness, rutting, cracking, and macro-texture.
- ARAN cracking data, shown in Figure 5, was used to evaluate pavement performance of the test sections.
- Less cracking was evident in the open graded pavement sections (A, B, & C) than in the control (E) and SMA (D) sections.
- The control section (E) has seen the most cracking and the OGFC & OBC section (A) the least. It is worth noting that the OGFC & OBC section (A) has the thickest pavement structure.

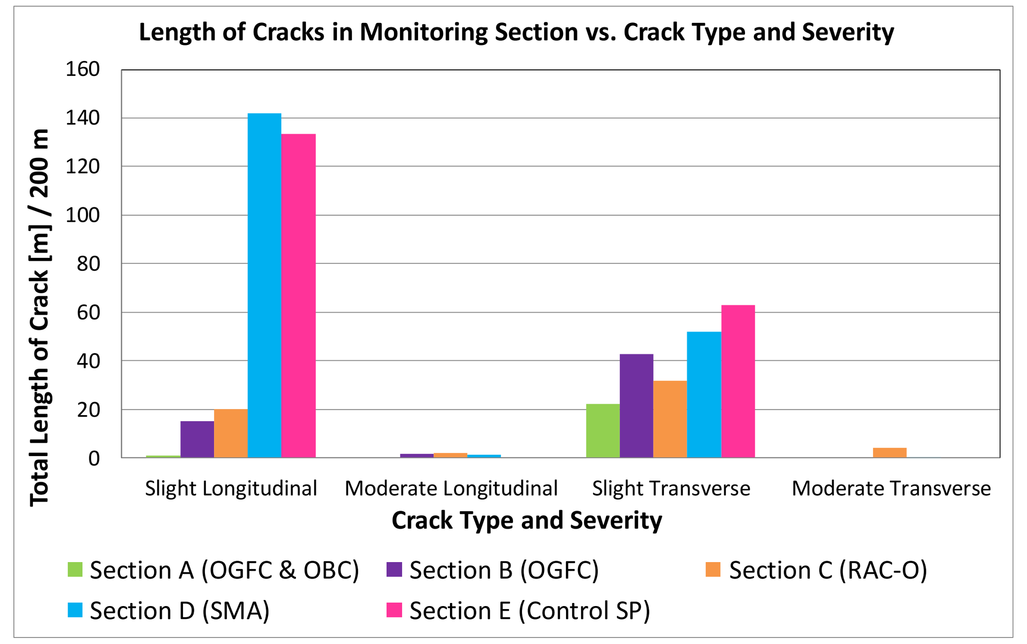

FIGURE 5 – Pavement Cracking obtained from MTO's ARAN

- Pavement performance was measured within the 200 m monitoring section of each pavement section.
- All the pavement sections experienced insignificant rutting, ranging from 1 to 3 mm.
- The International Roughness Index (IRI) ranged from 1.1 to 1.8 m/km.
- Overall, the open-graded quiet pavement sections are performing slightly better than the dense-graded control section (E).

Section A - Centreline Joint is Intact

Section B - Transverse Crack

Section C - Transverse Crack

Section D - Longitudinal Crack

Control Section E - Transverse Crack

FIGURE 6 – 4 Year Pavement Surface Condition (2013)

4. NOISE REDUCTION PERFORMANCE

On average, the 2010 OBSI measured values are approx. 3.6 dBA higher than the 2009 values; the 2012 values are about 1.7 dBA higher than the 2010 values; and the 2013 values are approx. 0.9 dBA lower than the 2012 values. This indicates that the pavements became louder as they aged, but at a decreasing rate. The control section (E) and the SMA section (D) have been the loudest pavements.

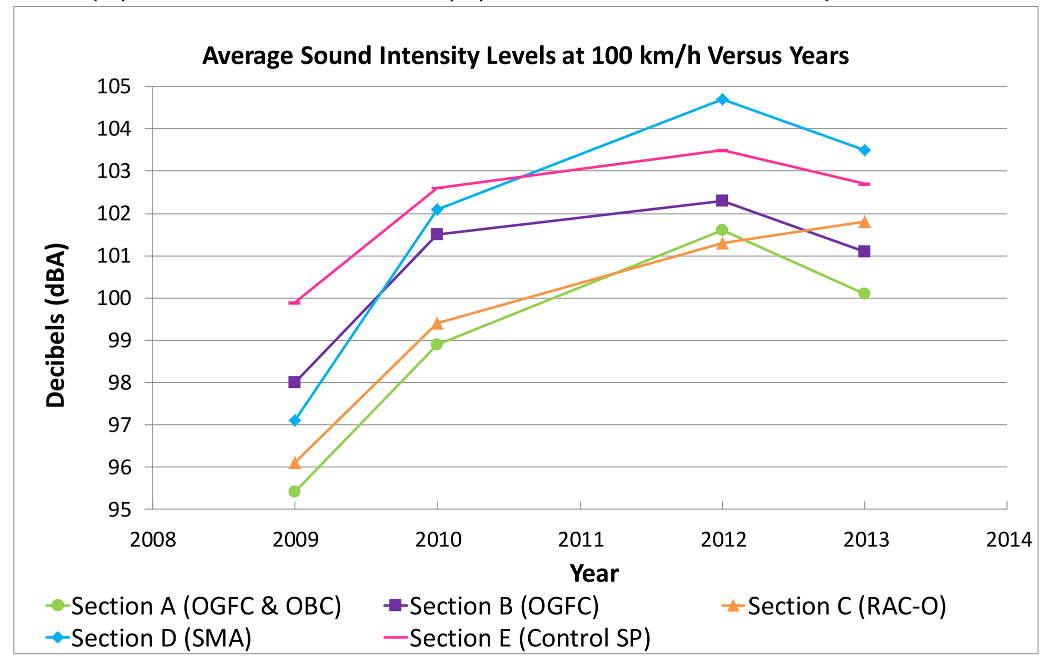

FIGURE 7 – Average Sound Intensity Levels Versus Years

- In 2013 the two OGFC sections (A & B) were the quietest. Section A has a double layer of open-graded mix and is considered the most effective in noise reduction [4].
- The RAC-O section (C) was the second quietest in 2009 and 2010 and the quietest in 2012, but in 2013 it was louder than the two OGFC sections (A & B). It was expected that the RAC-O noise reduction would last longer [5].
- The SMA section (D) has the least noise reduction properties and it actually became louder than the control section (E) as it aged.

TABLE 2 – Difference in Sound Intensity from Control Section (E)

Pavement Section	2013 Average Sound Intensity Level (dBA)			
	80 km/h	Relative to Control	100 km/h	Relative to Control
A	97.1	-2.4	100.1	-2.6
B	98.4	-1.1	101.1	-1.6
C	98.9	-0.6	101.8	-0.9
D	101.1	1.6	103.5	0.8
Control - E	99.5	-	102.7	-

- 2009 and 2013 tests showed that porosity has a moderate correlation with sound intensity for open-graded pavements.
- The correlation in Figure 8 better fits the open-graded pavements at an earlier age than in later years. This may be due to other factors affecting the noise level of an aged pavement.

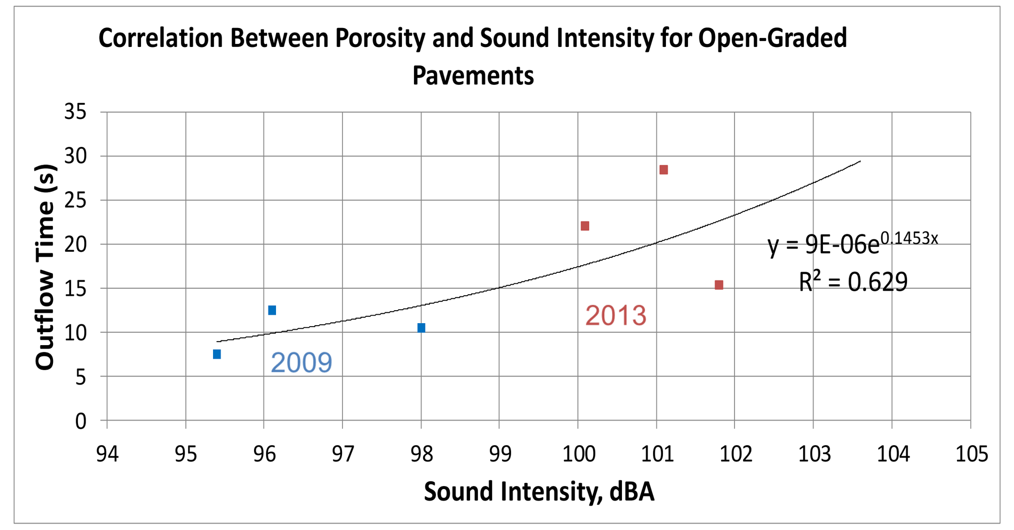

FIGURE 8 – Correlation between Porosity and Sound Intensity

5. NOISE REDUCTION RESTORATION

According to the literature, there are three main theories as to why open-graded pavements lose their noise reduction effectiveness over time [6]:

1. Clogging with Debris

- From a close inspection of the test sections, debris close to the surface wasn't apparent, but debris was visible on the shoulder.
- Traffic is possibly removing debris; and/or pushing it further down into the pavement structure.

2. Compaction from Traffic

- From a close inspection of the test sections in 2013, the surface pores appear to have tightened since 2010.
- Compaction of the pavement from traffic may have occurred decreasing voids and may also be trapping/compacting debris into the pavement.

3. Increased Roughness and Macro-texture

- IRI has increased slightly from 2012 to 2013.
- Effective macro-texture has increased by traffic removing the binder coating and exposing the aggregates on the surface.

Literature has shown that clogging of voids and increased macro-texture are the most common causes for increased noise [6]. Clogging is likely the only factor that can be reversed.

FIGURE 9 – Change in SMA Section (D) Surface Macro-texture

FIGURE 10 – Change in OGFC & OBC Section (A) Surface Macro-texture

On average, the post-sweep values are approx. 0.3 dBA lower than the pre-sweep values. The two OGFC sections (A & B) saw the most restoration (0.9 dBA). The vacuum sweeping did not significantly reduce the average sound intensity of any pavement section.

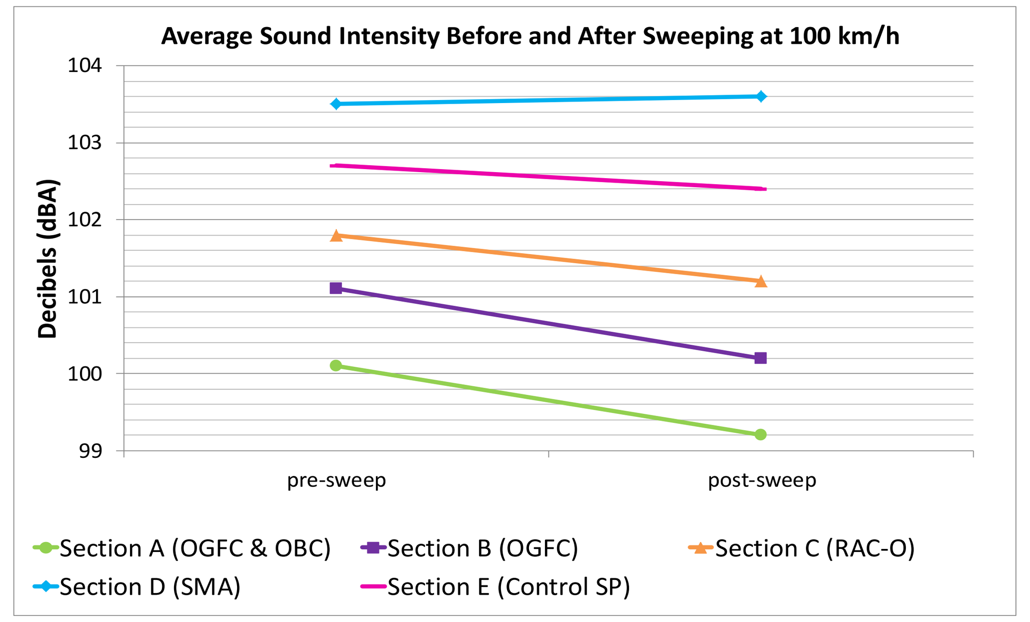

FIGURE 11 – Average Sound Intensity Before and After Sweeping

6. FINDINGS

- Open-graded pavements are quieter than conventional dense-graded and SMA pavements.
- A double layer open-graded mix has the most potential for reducing tire-pavement noise levels.
- The noise reduction performance of open-graded mixes could be further enhanced by the use of rubberized asphalt cement.
- The use of SMA 9.5 did not reduce noise levels as anticipated; however, there was an unexpected loss of asphalt film, and it became louder than the dense-graded Superpave mix over time.
- The porosity test provided a good indicator of the porosity of a pavement and a moderate correlation exists between pavement porosity determined by an outflow meter and the noise level measured using the OBSI method.
- Due to equipment constraints and routine maintenance costs, vacuum sweeping was not found to be a feasible maintenance method in Ontario.

7. CONCLUSIONS

- **After four years in service, the pavement performance of the quiet pavements has been similar to that of conventional pavements.**
- **Noise level increased with time for each mix type. Noise reduction performance diminished the most within the first year of construction, while in subsequent years diminishing at a slower rate.**
- **Vacuum sweeping marginally improved noise reduction performance. Experience by other jurisdictions has shown that vacuum sweeping is effective when carried out every 6 months [7]. In Ontario's study, sweeping was not done until the quiet pavement sections were already 4 years old. It is unknown if similar results would have been found if sweeping had been carried out every 6 months following construction.**

REFERENCES

[1] Robert Otto Rasmussen, "Tire/Pavement and Environmental Traffic Noise Research Study" Report No. CDOT-2008-2, Interim Report – 2006 Testing, Colorado Department Of Transportation, DTD Applied Research and Innovation Branch.

[2] Joseph Ponniah, et al, "Evaluation of the Effectiveness of Different Mix Types to Reduce Noise Level at the Tire/Pavement Interface" for Transportation Association of Canada, Ministry of Transportation of Ontario, 2010.

[3] A.M. Al-Rubaei, et al, "Can Vacuum Cleaning Recover the Infiltration Capacity of a Clogged Porous Asphalt?" Luleå University of Technology, Sweden, 2012.

[4] World Road Association, "Quiet Pavement Technologies", Technical Committee D.2 - Road Pavements, 2013.

[5] Lyle Treleaven, et al, "Asphalt Rubber - The Quiet Pavement?" for Transportation Association of Canada, 2006.

[6] Karol J. Kowalski, et al, "Long-Term Monitoring of Noise and Frictional Properties of Three Pavements, Dense-Graded Asphalt, Stone Matrix Asphalt and Porous Friction Course" Transportation Research Record: Journal of the Transportation Research Board, No 2127, 2009.

[7] David Gibbs, et al, "Quiet Pavement Systems in Europe" Report No. FHWA-PL-05-011, Federal Highway Administration, 2005.