# *TEMPERATURE AND AGING EFFECTS ON TIRE/PAVEMENT NOISE GENERATION IN ONTARIAN ROAD PAVEMENTS*

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# ABSTRACT

Tire/pavement noise is caused by a complex set of interactions in the contact patch. Managing pavement surfaces and materials has been an effective strategy for noise mitigation, because it is often possible to act at the source of the noise. Since traffic noise is a public concern, due to the effects on heath and the economy of a country, it is crucial to understand the acoustic performance of road pavements through continuous monitoring, because their acoustic properties may diminish over the time.

A selection of roads in Southern Ontario with several types of pavement and different ages has been identified for this study, including rigid and flexible sections. The survey methodology includes the evaluation of noise at different times of the day to evaluate various temperatures and obtaining, in parallel, the sound pressure and sound intensity levels at the tire/pavement interface using the Close-Proximity (CPX) and the On-Board Sound Intensity (OBSI) methods respectively. Some of the selected road stretches were already been tested in 2008 by the Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo (UW) and the new results have been compared to the existing ones to determine the aging effects.

Overall, the results show that sound intensity and sound pressure level raise when the age increases, while temperature performs a minor influence. Also, the results demonstrate that sound intensity and sound pressure levels have a significant variation depending on the type of pavement. Finally, good correlation between CPX and OBSI methods was observed.

# INTRODUCTION

Tire/pavement noise dominates other noise sources over a certain crossover speed. For regular tires and dense asphalt concrete the crossover speed is 30-45 km/h for light vehicles, and 45-50 km/h for heavy vehicles (*1*).

Noise generated at the tire/pavement interface is greatly influenced by pavement surface characteristics, such as the type of aggregates, pavement materials, finishing, age, and presence of distresses (*1*). Aggregate shape, homogeneity, spacing and orientation can affect tire/pavement noise mechanisms. For instance, cubic-shape aggregates with uniform distribution are usually related to lower noise (*2*). Pavement materials can also affect tire/pavement noise due to variations in vibration attenuation and damping capacities *(3).*

Differences in noise measurements on similar pavement types can be due to a combination of environmental, tire, loading and vehicle/operator variables (*4*). Temperature is known to affect tire/pavement noise and previous studies in asphalt concrete (AC) pavements have shown decreased noise levels at the tire/pavement interface with increasing temperature (*5*). For bituminous surfaces, the effect is higher on dense asphalt pavements than on porous surfaces (*6*). Smaller effect has been observed on Portland cement concrete (PCC) pavements compared to asphalt ones, sometimes even without noticing a specific trend (*7*, *6*, *5*).

Due to the impact of noise on human health and on the economy of a given country, noise barriers have been the common alternative for noise mitigation. An alternative to noise barriers is reducing the noise produced at the source, this means in the interaction between tire and pavement. In the last decade, a considerable interest has been focused in the noise reduction through managing the pavement surface characteristics and materials in both, flexible and rigid pavements (*8*).

Currently, little attention has been focused to analyse the acoustic performance of road pavements over time. The information about continuous monitoring is important to improve the knowledge in this field, as the acoustic properties of pavements may diminish over time (*10*), due to the effects of traffic and environment.

Also, additional testing and insight are required to determine the effect of temperature on noise production in PCC pavements.

This paper presents the results of noise emission evaluation of several roads in Southern Ontario, including both rigid and flexible sections. The survey methodology includes the evaluation of noise at different temperatures using in parallel the Close-Proximity (CPX) and On-Board Sound Intensity (OBSI) methods, obtaining the sound pressure levels and sound intensity level respectively. The measurements were performed using a vehicle owned by the Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo (UW).

# OBJECTIVES AND SCOPE

The overall objective of this research project is to evaluate, in parallel, sound pressure levels and sound intensity levels emitted at the tire/pavement interface by several AC and PCC road pavements in Southern Ontario. The specific objectives are to:

- Evaluate and determine a relationship between noise and temperature for various road segments;
- Evaluate long-term noise performance of tests sections based on data collected in 2007/2008;
- Compare the result consistency between the CPX and OBSI methods.

The Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo (UW) equipped a testing vehicle with world leading testing equipment for multiple tire/pavement noise evaluation.

## LITERATURE REVIEW OF TIRE/PAVEMENT NOISE MECHANISMS

### Physics mechanism of noise

Tire/pavement noise is caused by a complex set of mechanisms of noise generation and amplification, influenced by the tread pattern and road surface (*11*). Noise generation mechanisms can be divided into two main groups: structure-borne, directly related to mechanical vibrations of the tire, and air-borne, related to aerodynamical phenomena (*12*). Mechanical vibration can be due to impact mechanisms (generally producing radial vibrations) and adhesion mechanisms (mostly producing tangential vibrations). Impact mechanisms are caused by tire tread blocks impacting on road surfaces. Adhesion mechanisms are related to stick/slip phenomena of tread elements with respect to the road surface, as well as to stick-snap adhesive effects of the tire rubber to the road. Aerodynamical mechanisms can be due to air displacement phenomenon, caused by air turbulence around the tire, “air pumping” in and out between tire tread and road surface, pipe resonances in the tire tread pattern, and Helmholtz resonance into and out of connected air cavities in the tire tread pattern and the road surface (*1*).

Noise amplification or reduction mechanisms can be due to the horn effect, the acoustical impedance effect, the mechanical impedance effect and tire resonance (*13*). The horn-effect is caused by the curved (rounded) shape of the tire which, being in contact with the flat surface of the road, creates a kind of horn-shape which amplifies sounds. This shape occurs both at the leading edge (front of the tire) and trailing edge (rear of the tire).

The acoustical impedance effect can be due to communicating voids in porous surfaces, acting like sound absorptive material and affecting both sound strength and propagation. The mechanical impedance effect can be caused by the sound surface reaction to tread blocks and to the vibration transfer of the tire to the road surface, radiating as sound. The tyre resonance can be due to belt resonance and torus cavity resonance, which occur, respectively, at the tire belt and in the air column of the tire (*1*).

### Noise measurements and temperature effects

Noise data collected in the United States showed that the absolute noise levels of PCC pavements are usually higher than the levels measured in AC pavements. Surface texture modifications and finishing techniques in PCC pavement, though, can provide large reductions in tire/pavement noise and be considered a suitable solution to reduce traffic noise (*14*, *9*).

The acoustic characteristics of pavements are known to evolve with time and their noise emissions change over the years: age, presence of distresses, and increasing macrotexture are known to contribute to increasing overall noise levels (*15*). Previous studies have determined that, as the pavement gets older, noise levels from asphalt pavements usually increase even before significant pavement deterioration begins to occur (*16*). In asphalt pavements, noise levels increase linearly with time and it is usually two times higher for cars than for heavy vehicles (*16*). In porous pavements, the increase in noise can be associated with air voids clogging over time, which increases the noise generated from air pumping (*16*) and may cause their noise reduction to disappear in a few years after installation (*10*).

For dense and open graded pavement types, the changes occurring in the surface structure, which caused the increased noise measurements in the period between when the bitumen film wears off and when surface distresses begin to manifest, are not yet well known (*16*). Similarly to conventional pavements, noise levels of thin surfaces, designed to provide effective noise-reduction, are known to increase with time as the surfaces age (*17*).

Sound pressure levels at the tire/pavement interface can be measured with the Close-proximity method (CPX), according to ISO 11819-2 Standard draft (*18*). Sound intensity levels can also be measured at the tire/pavement contact according to On-Board Sound Intensity method (OBSI), which is regulated by AASHTO TP 76-2013 (*19*). Both were used in this experiment.

## TESTING METHODOLOGY

### Description of the Selected Road Sections

Road sections have been selected with different pavement materials and surface finishing. The list of roads includes three asphalt sections (two Stone Mastic Asphalt (SMA) and one hot-laid asphalt (HL3)), and three rigid Portland cement concrete (PCC) sections with transverse tinning). Detailed information of the selected roads is summarized in **TABLE 1**. In the table, it can be observed that the 401 section located in Toronto near Pearson International Airport was constructed in 2013 and was completed only a few months before testing, whereas the other sections were from six to nine years old.

**TABLE 1 Description of the selected road sections**

| Pavement Type | Test Site Location | Highway | Year of Construction |
|---|---|---|---|
| PCC-Transverse Tining | Toronto - Pearson Intl. Airport area | 401 | 2013 |
| PCC-Transverse Tining | Toronto-Brampton | 410 | 2007 |
| PCC-Transverse Tining | Windsor area | 401 | 2005 |
| SMA | London area | 401 | 2005 |
| SMA | Crosshill area | Regional 11 | 2004 |
| HL3 | Crosshill area | Regional 11 | 2004 |

### Testing Methodology

CPX and OBSI tests have been done, in parallel, by means of a frame setup to support two sound probes as required by the CPX test, and a central probe as required by the OBSI test. **FIGURE 1** shows the CPX and OBSI setup, which is owned by CPATT at the University of Waterloo. **FIGURE 1 a)** shows the microphone positions with respect to the tire and **FIGURE 1 b)** presents a picture with the configuration to perform field measurements.

In the CPX method, the average A-weighted sound pressure levels emitted at the tire/pavement interface are measured over a specified road distance by at least two microphones, located close to the tires. According to CPX requirements, the horizontal distance from the plane of the test tire sidewall shall be 0.20 m, microphones shall be mounted at a height of 0.10 m above the pavement level. The front microphone shall be mounted at an angle of 45°C ± 5° to the rolling direction, whereas the rear one at an angle of 135 ± 5° to the rolling direction (*18*).

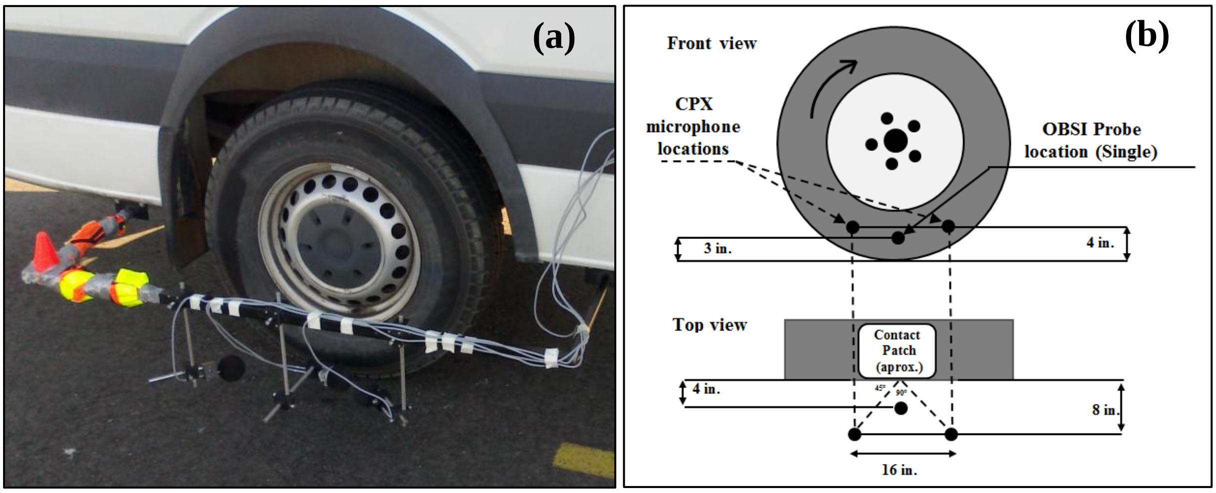

**FIGURE 1 a) On-Board Sound Intensity (OBSI) and Close-proximity method (CPX) microphones locations on the CPATT testing vehicle and b) equipment configuration schematic.**

The OBSI method determines the A-weighted sound intensity levels at defined points near the tire/pavement interface. The testing probe is composed of two microphones placed in parallel at 76 mm above the pavement level and at 102 mm from the sidewall of the tire (*19*).

Tests have been performed at 96 km/h, the speed required by the OBSI standard, whereas the CPX standard requires 110 km/h as a reference speed. Two exceptions had to be made in order to perform both tests at the same time (CPX and OBSI); the first related to the speed and the second related to the tire. Regarding to the speed, the survey methodology established the OBSI standard speed for the all measurements (96 km/h).

Regarding the tire, the CPX and OBSI standards require different types: OBSI method requires the use of the Standard Reference Test Tire, as defined by ASTM F2493 (*20*), whereas CPX method requires the use of four tires with specific tread pattern, two “summer”, one “winter” and one “block” tread pattern. Hence, given the impossibility of matching both standards at the same time, the regular tires of the van were used for the all measurements.

Measurements have been averaged over 10 seconds; therefore, every tested road segment results as 266 m long fulfilling both OBSI and CPX minimum specifications which require, a minimum length of 200 m and 120 m respectively.

Tests have been performed twice for every road section: once in the morning and once in the afternoon. Pavement and ambient temperatures have been measured on both occasions. The time frame when the measurements have been carried out, both in the morning and in the afternoon, was selected to reflect typical pavement temperature ranges throughout the day. Pavement surface temperature in the morning is expected to be much lower than in the late afternoon, after the pavement has been exposed to daily solar radiation. These time frames also coincide with the ones at which previous studies (*21*), which recorded maximum daily change in curling and warping phenomena typical of concrete pavement slabs. These daily changes in concrete slab shapes are due to the temperature differential occurring within the slabs, created by ambient temperature modifications.

# RESULTS AND DISCUSSION

## Air and Pavement Temperature

Temperature data have been reported in **TABLE 2**.

**TABLE 2 Air and pavement temperature in the test sites**

|  | Road Section |  | Air Temperature [°C] |  | Pavement Temperature [°C] |  | Age [years] |
|---|---|---|---|---|---|---|---|
|  |  |  | Morning | Afternoon | Morning | Afternoon |  |
| Cement Concrete Sections | PCC-TT - Toronto- 401 | East bound | 18.8 | 23.8 | 16.8 | 27.0 | 0 |
|  |  | West bound |  |  | 17.4 | 27.3 |  |
|  | PCC-TT - Brampton- 410 | North bound | 17.0 | 23.8 | 14.0 | 26.6 | 6 |
|  |  | South bound |  |  | 14.3 | 27.0 |  |
|  | PCC-TT - Windsor- 401 | East bound | 8.1 | 21.8 | 7.8 | 28.4 | 8 |
|  |  | West bound |  |  | 8.3 | 28.6 |  |
| Asphalt Concrete Sections | SMA – London - 401 | East bound | 8.1 | 22.5 | 1.8 | 23.2 | 8 |
|  |  | West bound |  |  | 2.2 | 23.5 |  |
|  | SMA – Crosshill- Reg 11 | North bound | 18.0 | 26.0 | 17.6 | 31.4 | 9 |
|  |  | South bound |  |  | 17.1 | 31.9 |  |
|  | HL3 – Crosshill- Reg 11 | North bound | 18.0 | 26.0 | 17.2 | 30.6 | 9 |
|  |  | South bound |  |  | 17.5 | 30.9 |  |

## On-Board Sound Intensity (OBSI) Evaluation

Maximum and averaged Sound Intensity levels have been measured with one-third octave band resolution in a frequency range of 200 to 10000 Hz. Maximum Sound Intensity values are displayed in **FIGURE 2** where both morning and afternoon test results are presented.

In **FIGURE 2** it is shown that,, asphalt pavements appear to be generally quieter than concrete pavements; the quietest section is the HL3 pavement in Crosshill, followed by the SMA sections in Crosshill and in London. The quietest concrete pavement is the one located in Toronto, which is also the newest one, whereas the loudest sections are the oldest concrete ones located in Windsor.

Equivalent Sound Intensity values, i.e. time averaged values, can be observed in **FIGURE 3**, where both morning and afternoon data are reported. In **FIGURE 3,** as a general trend, morning data are usually slightly higher than afternoon data, when the pavement temperature is lower. The trend is similar to the one observed for maximum levels, with the exception of the SMA section in London. This section is louder than some PCC sections, such as the one located in Toronto.

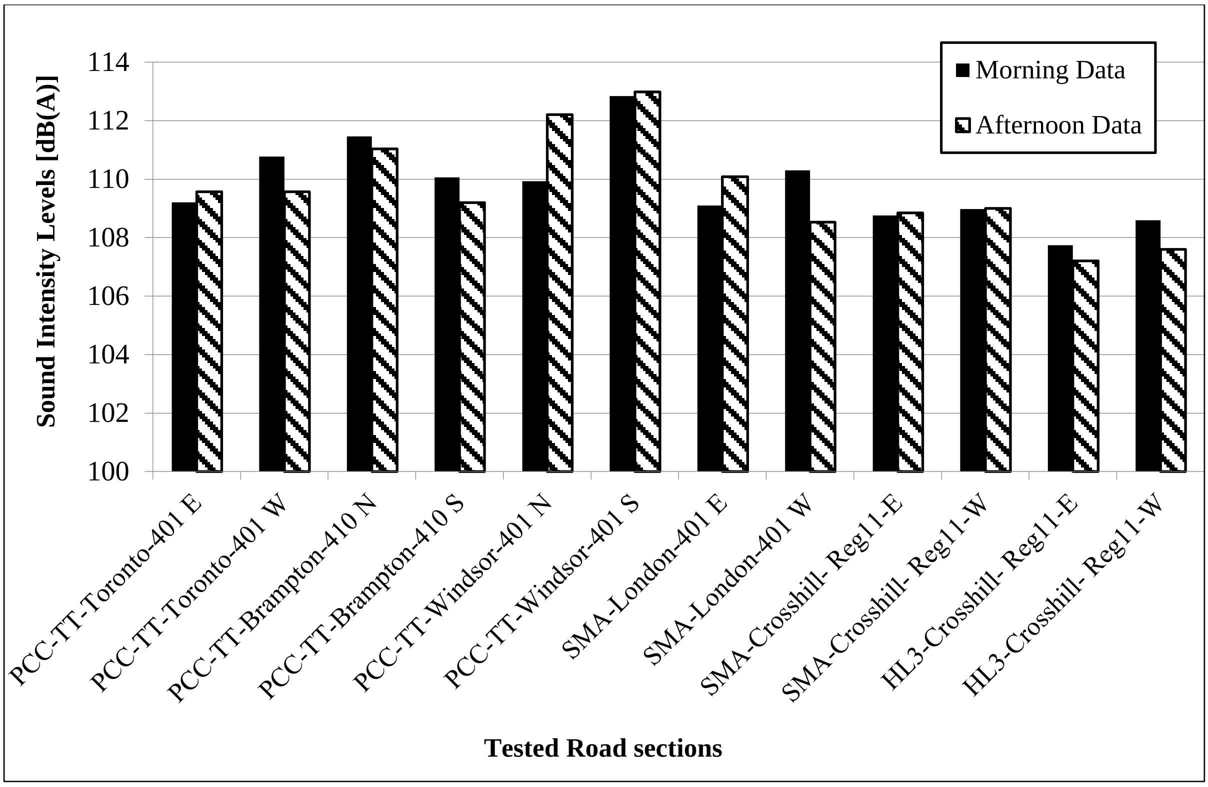

**FIGURE 2 Maximum On-Board Sound Intensity (OBSI) values of the selected road stretches.**

Some general considerations can be made about the OBSI maximum and equivalent test results, i.e. consistency of measurements is attested by the similar values taken at the two different times of the day and, as a general trend, morning data are slightly higher than afternoon data.

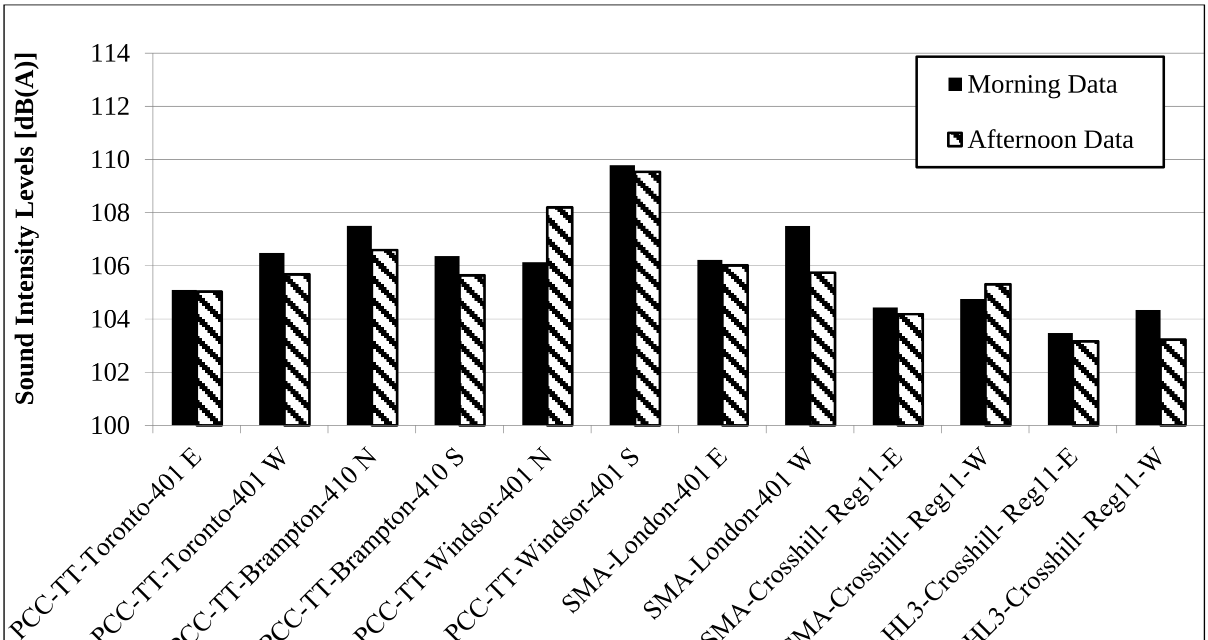

**FIGURE 3 Equivalent Sound Intensity Levels of the selected road stretches.**

### Close-Proximity (CPX) Evaluation

Maximum and averaged sound pressure levels have been measured with one-third octave band resolution in a frequency range of 200 to 10000 Hz. In **FIGURE 4**, the maximum sound pressure levels of all road section have been represented and results taken both in the morning and in late afternoon are shown.

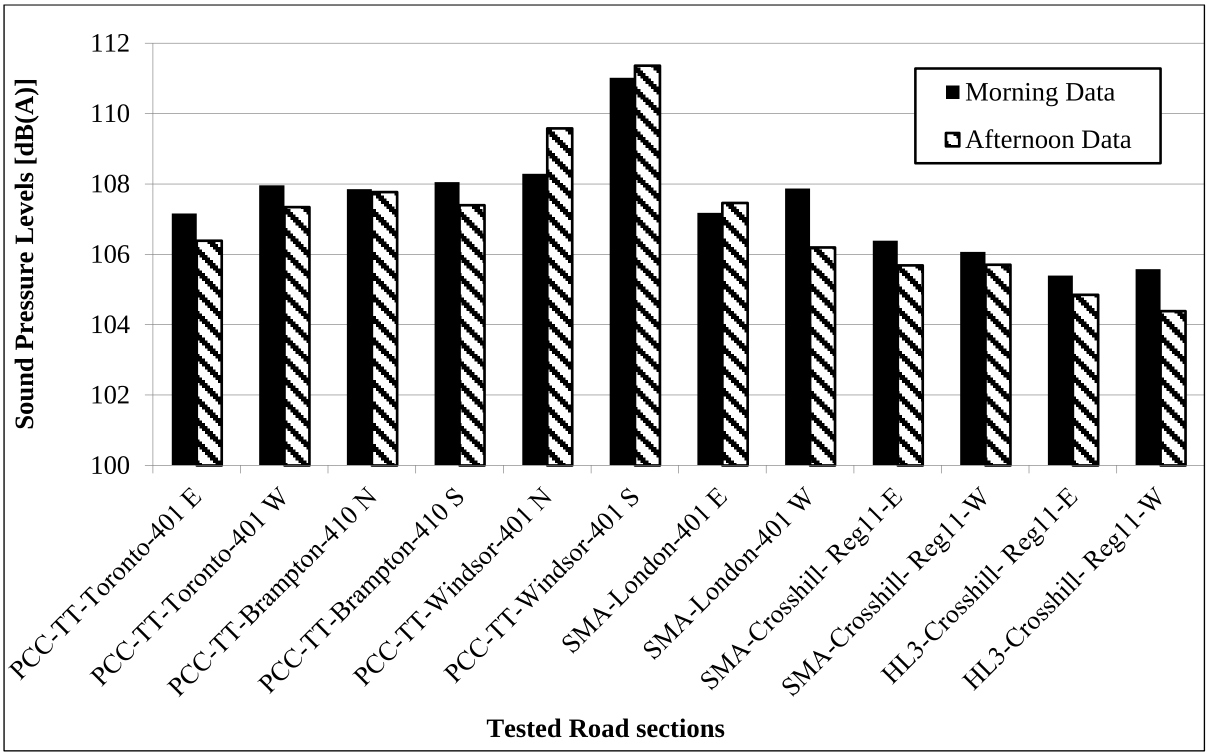

**FIGURE 4 Maximum Sound Pressure Levels of the selected road stretches.**

In **FIGURE 4** it is possible to observe that the HL3 pavements in Crosshill are the quietest, followed by the SMA sections in Crosshill. This result is consistent with the previously described OBSI maximum noise levels. Noise levels of the SMA sections in London and the PCC sections in Toronto and Brampton have provided similar results. The PCC pavements in Windsor have provided the highest maximum sound pressure levels, which is also consistent with the OBSI test results.

Equivalent sound pressure levels are displayed in **FIGURE 5**. Noise trends in the image are similar to the maximum sound levels, with the only exception of the SMA pavements in London.

As for the OBSI results, consistency of measurements is attested by the similar values taken at the two different times of the day. Also, in this case, as a general trend, morning data are slightly higher than afternoon data.

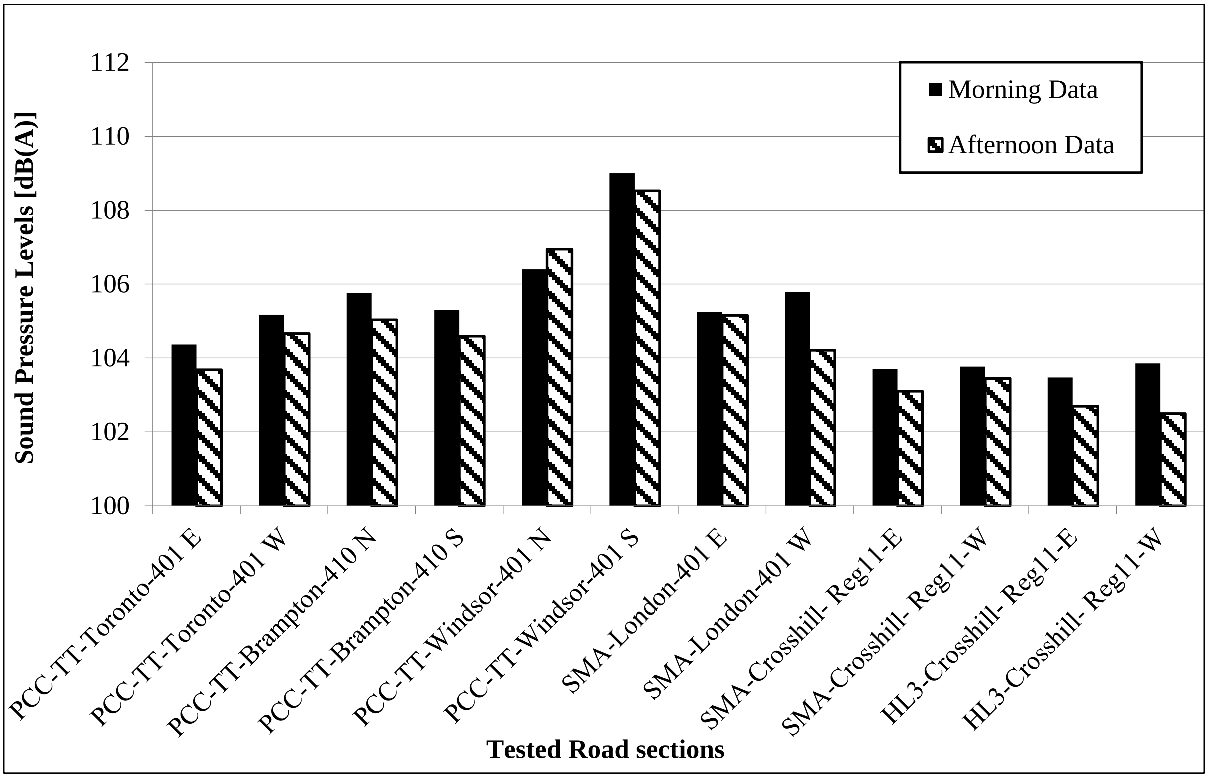

**FIGURE 5 Equivalent Sound Pressure Levels of the selected road stretches.**

## Temperature and noise variation

Comparing the data measured in the same sections at different times of day, it is possible to evaluate how temperature can affect tire/pavement noise values. While **FIGURE 6** shows a poor correlation between OBSI/CPX values in temperature, with all $R^2$ values close to zero, all of the trends identified show a decrease in noise levels as temperature increases. A decrease in noise levels is reasonable and consistent with results reported in literature (*7*).

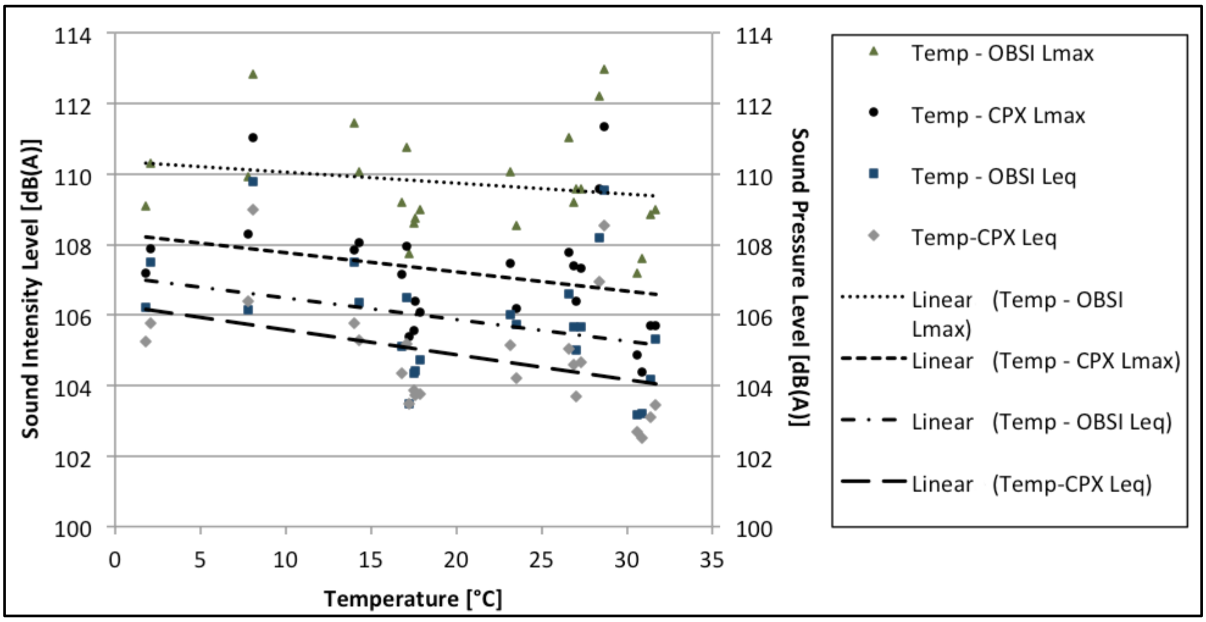

**FIGURE 6 Temperature and CPX and OBSI values.**

An ANOVA analysis has been therefore carried out to evaluate whether the difference between morning and afternoon values are statistically significant. The analysis takes into account PCC and AC pavements both together and separately. ANOVA analysis results are summarized in **TABLE 3.** Although it is possible to observe in the table that afternoon values are slightly lower than morning ones, the analysis indicates that morning and afternoon values are not statistically different, regarding the temperature. Since the evidence is insufficient to reject the null hypothesis, values can be considered as not statistically different.

**TABLE 3 ANOVA analysis results**

| | | Morning Mean | Afternoon Mean | Morning Variance | Afternoon Variance | F | p-level | Fcrit | F>Fcrit? (Hp rejected) |
|---|---|---|---|---|---|---|---|---|---|
| OBSI $L_{max}$ | CC – Mor.-Aft. | 110.72 | 110.76 | 1.68 | 2.48 | 0,00 | 0.96 | 4.96 | No |
| | AC Mor.-Aft. | 108.91 | 108.54 | 0.69 | 1.07 | 0,46 | 0.51 | 4.96 | No |
| | CC+AC Mor.-Aft. | 109.81 | 109.65 | 1.96 | 2.95 | 0,06 | 0.80 | 4.30 | No |
| CPX $L_{max}$ | CC – Mor.-Aft. | 108.39 | 108.31 | 1.81 | 3.33 | 0,01 | 0.93 | 4.96 | No |
| | AC Mor.-Aft. | 106.41 | 105.72 | 0.91 | 1.16 | 1,41 | 0.26 | 4.96 | No |
| | CC+AC Mor.-Aft. | 107.40 | 107.01 | 2.30 | 3.87 | 0,29 | 0.59 | 4.30 | No |
| OBSI $L_{eq}$ | CC – Mor.-Aft. | 106.90 | 106.78 | 2.60 | 3.04 | 0,01 | 0.91 | 4.96 | No |
| | AC Mor.-Aft. | 105.12 | 104.61 | 2.17 | 1.59 | 0,43 | 0.53 | 4.96 | No |
| | CC+AC Mor.-Aft. | 106.01 | 105.69 | 3.02 | 3.39 | 0,19 | 0.67 | 4.30 | No |
| CPX $L_{eq}$ | CC – Mor.-Aft. | 106.00 | 105.57 | 2.61 | 3.26 | 0,19 | 0.68 | 4.96 | No |
| | AC Mor.-Aft. | 104.31 | 103.52 | 0.92 | 1.01 | 1,93 | 0.19 | 4.96 | No |
| | CC+AC Mor.-Aft. | 105.15 | 104.55 | 2.39 | 3.09 | 0,81 | 0.38 | 4.30 | No |

This Correlation between OBSI and CPX values has also been calculated by means of a linear regression. In **FIGURE 6**, maximum and equivalent sound intensity and pressure levels have been displayed with their respective trend lines.

Maximum and equivalent level data has been kept separated to determine whether both the impulsive values, and the averaged values, would share a similar correlation.

In **FIGURE 7** it is observed that the coefficient of correlation is approximately 0.9 for both linear regressions and it is slightly higher for equivalent noise levels. A higher value of correlation is reasonable for equivalent noise levels than maximum ones, as the equivalent noise levels are averaged and, therefore, less sensitive to singular events than impulsive measurements.

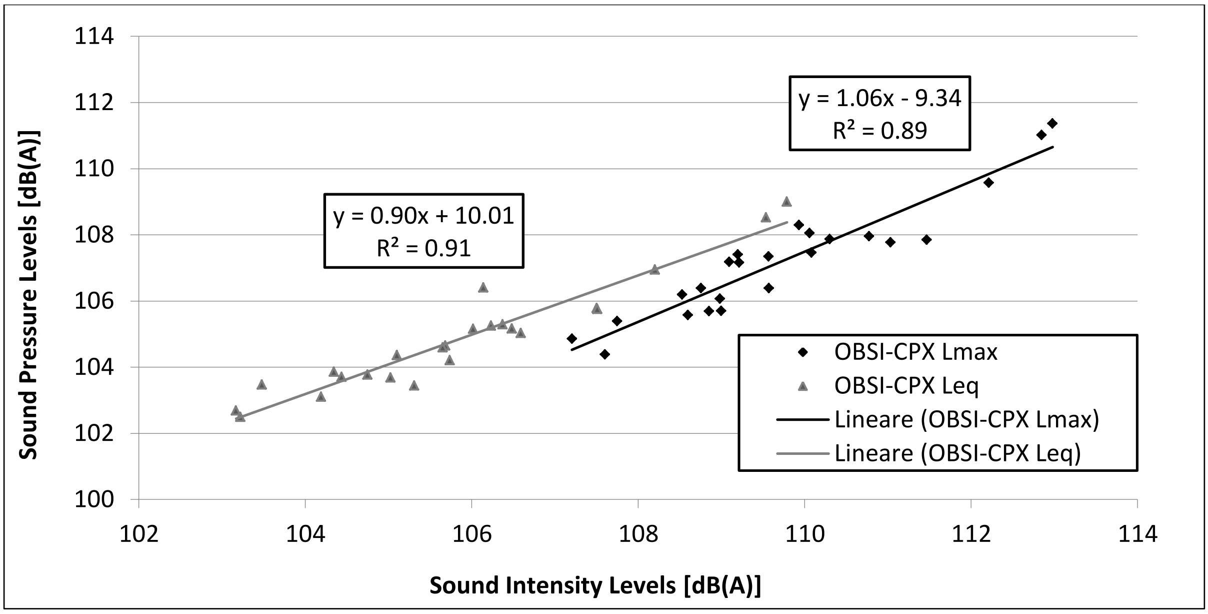

**FIGURE 7 Linear regression between OBSI and CPX values.**

## Aging Effect on Tire/Pavement Noise

Some of the selected road sections had already been tested in winter 2007 and spring 2008 with the CPX method. The same testing equipment and procedure were used, with the exception of windscreens: in these older measurements nose cones were used to protect the microphones from wind noise instead of the windscreens used in the 2013 testing. Nose cones are less effective at protecting the microphones from wind noise than windscreens are, so it is expected that if a significant difference between the two years of testing is found that its magnitude will be a conservative estimate of the sound generation difference.

A comparison between old and new results would provide information about the aging effect on acoustic performance of the tested road pavements. Maximum sound pressure levels of the 2007-2008 measurements are depicted in **FIGURE 8**, where a comparison with new results of the 2013 testing has been represented. As a general trend, it can be observed that the most recent values are higher than older ones, in some cases up to 4 dB (A).

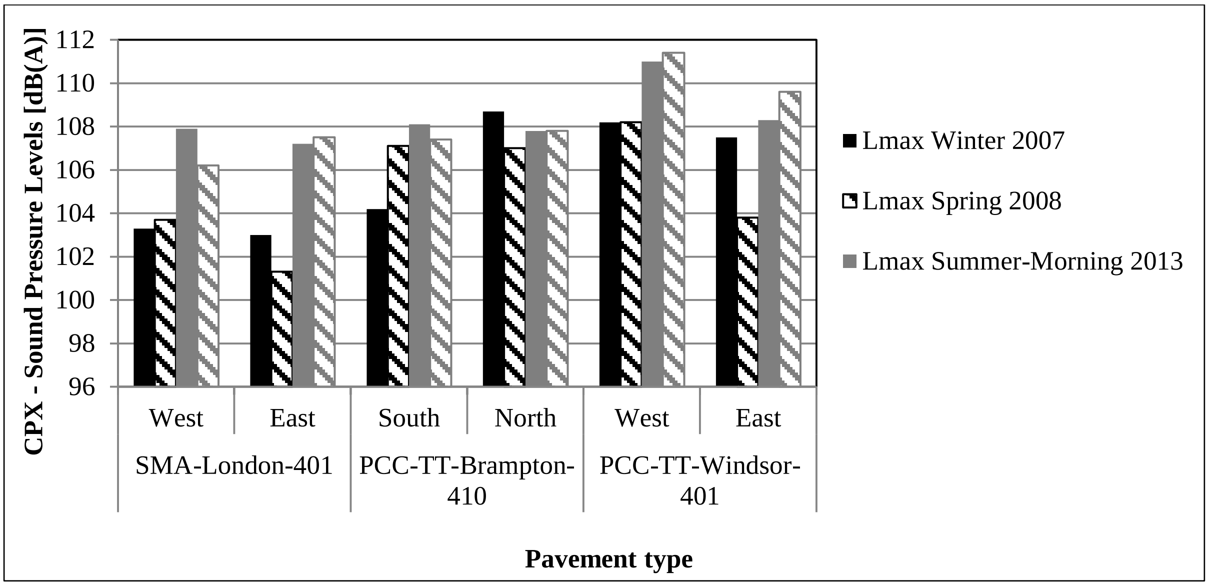

**FIGURE 8 Aging effect on CPX overall maximum Sound Pressure Levels.**

Test results of equivalent sound pressure levels are displayed in **FIGURE 9**, where the comparison between 2007-2008 and 2013 values are also represented. Older values are generally lower than newer values, attesting the trend observed for maximum sound pressure levels. In some cases, the difference was up to 6 dB (A).

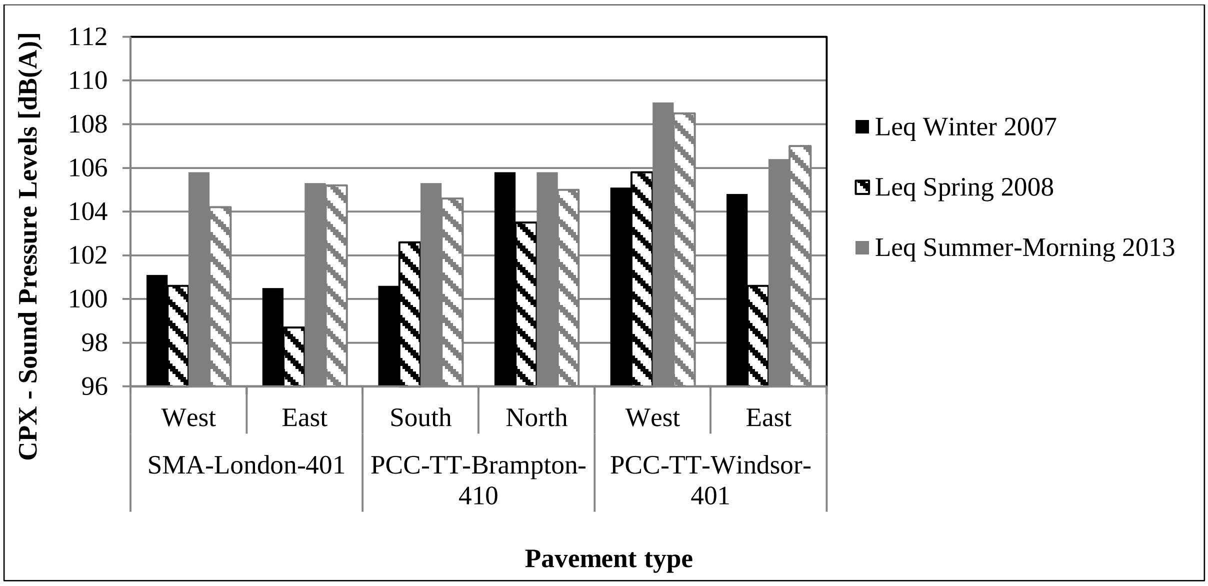

**FIGURE 9 Aging effect on CPX overall equivalent Sound Pressure Levels.**

As related to the SMA and HL3 pavements located in Crosshill, older data available provide the peak frequencies for both CPX maximum and equivalent sound pressure levels. In 2007, the peak frequency of maximum sound pressure levels for the SMA section was 540 Hz, at which 103.8 dB (A) were measured. The peak frequency for equivalent sound pressure levels was 658 Hz and it provided 100.4 dB (A). In 2013, though, the peak frequencies are higher but the levels are lower: the higher maximum levels were measured of 99.9 dB (A) at 800 Hz, whereas the higher equivalent level was 97.7 dB (A), still at 800 Hz.

For the HL3 section in Crosshill, the peak frequency of maximum sound pressure level was 583 Hz, at which 104.7 dB (A) was measured in 2007. The peak frequency for equivalent levels was 625 and it provided 101.7 dB (A). In 2013 the peak frequencies are much higher and, as for the SMA section, the sound pressure levels are lower; the higher maximum level was measured of 99.3 dB (A) at 1600 Hz, whereas the higher equivalent levels was 97.3, still at 1600 Hz. This change in frequencies can be explained by the evolution of surface texture which usually occurs with pavement aging. The decrease in values, though, was not expected and it may be related to surrounding conditions at the time of the measurement. Moreover, nose cone protection of microphones from wind effects is limited; therefore, air turbulence at the time of measurements in 2007 may have affected the results. Also, pavement temperature in 2007 may have also affected noise data. As these assumptions cannot be easily verified, comments about testing data in Crosshill should be considered with care.

## CONCLUSIONS

The evaluation of sound pressure levels and sound intensity levels has been carried out on a set of roads in Southern Ontario by means of the Close-proximity method (CPX) and the On-Board Sound Intensity method (OBSI). The selected road sections were of different ages and different pavement materials.

Of the tested sections, asphalt pavements were shown to slightly be quieter than the concrete ones. The HL3 asphalt sections in Crosshill were shown to be the quietest, followed by SMA pavements in Crosshill. It should be noted that these pavements were designed to be quiet pavements. The oldest tested sections on Highway 401, located near Windsor, were the loudest, while both lanes of Highway 410 in the Brampton area were quieter in comparison to the Highway 401 section.

The new rigid pavement section of the 401 near Pearson Airport showed similar noise results as the SMA section of 401, located in the London area. This can be related to newer construction techniques. Stone Mastic Asphalt is usually considered as a quiet pavement; therefore, it is interesting to observe how its acoustic performance may decrease in time, providing results comparable to new PCC concrete pavement with transverse tinning. Transverse tinning, in fact, is not generally considered as a finishing that contributes to reduced noise.

These CPX and OBSI noise measurements have been taken at two different time of the day; therefore, it is possible to observe the high data consistency. Since the weather conditions were similar during morning and afternoon tests, temperature effect on noise has been evaluated. As a general trend, test results show slightly lower values at late afternoon than at early morning (i.e. when pavement temperature was higher). A decrease in noise values can also be observed in the trend lines of CPX and OBSI linear regression models. However, ANOVA calculations confirmed that there is no statistical difference between morning and afternoon data, suggesting that noise measurements can be carried out at any time during the day without a significant difference in values.

Correlations between OBSI and CPX data have been calculated and provide correlation coefficients of 0.91 for equivalent noise levels and of 0.89 for maximum noise levels. These high values attest to both the consistency of the data and the relationship between sound intensity and sound pressure levels, both for impulsive (maximum) and averaged (equivalent) measurements.

Some of the selected road pavements had previously been tested in 2007-2008 and noise results have been compared to evaluate aging effect on tire/pavement noise. The SMA and PCC sections of 401, as well as the 410 section in Brampton, were tested both in winter 2007 and in spring 2008, thus at different pavement temperatures. Spring data, in fact, were generally lower than winter data, with a wider range than the one observed in 2013 between morning and afternoon results. By comparing 2007-2008 data with the 2013 data, it can be observed that all the pavements are currently louder than five-six years ago. Noise increase is not uniform; it is higher in the SMA asphalt section than in the two PCC ones. Apart from the 410 North lane section, where the measurement taken in winter is almost equal to the recent one, overall tire/pavement noise has increased from 1-2 up to 5-6 dB (A). The noise increase is higher in equivalent noise levels than in maximum noise levels.

Monitoring of the tested pavements will be continued to better analyse the evolution of their acoustic performance during their service life.

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