



Comparative assessment for low-noise pavements by means of the ISO 11819 and the OBSI

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ABSTRACT

In 2013, VicRoads initiated an acoustic test program for low-noise road surfaces. The program aims to assess the acoustic performance and maintenance requirements for different types of pavement surfaces over a period of at least five years. Seven different products were laid on a single section of roadway on the Mornington Peninsula Freeway in Victoria, Australia. Acoustic tests have then been carried out at regular intervals following three different methods: Statistical Pass-By (ISO 11819-1), Close Proximity Method (ISO/DIS 11819-2) and On-Board Sound Intensity method (AASHTO TP 76-10). Results from these tests are presented here. The measured performance of the different pavement is discussed and an insight is given into the comparison of the different test methods.

Keywords: Road Traffic Noise I-INCE Classification of Subjects Number(s): 52.3

1. INTRODUCTION

In March 2013, VicRoads commenced a five year investigation into the road traffic noise reduction performance of selected asphalt road pavement surfacing. The trial is being conducted on an urban freeway, the Mornington Peninsula Freeway, near Melbourne, Victoria, Australia. Seven sections of different asphalt were placed, including a conventional Open Graded Asphalt (OGA), an OGA where the surface was treated using diamond grinding to provide a smoother surface whilst maintaining porosity, two sections of double layer OGA, a stone mastic asphalt (SMA) and two proprietary mixes. Road traffic noise generated on each trial section is being determined by the Statistical Pass-by Method, by the Close Proximity Method and by the On Board Sound Intensity Method. The acoustic performances of the trial pavement surfaces will be determined by these methods over a five year period.

The objectives of the trial are to quantify the opportunity to reduce traffic noise by selection of pavement, update the noise corrections for low noise pavements in traffic noise modeling, and investigate the optimization of the conventional open graded asphalt pavement used by VicRoads. This paper presents the results of the acoustic tests conducted within the first year of the trial.

2. TRIAL LAYOUT

The trial sections are located on the southbound carriageway of the Mornington Peninsula Freeway between La Trobe Parade and Lonsdale Street, in McCrae, Victoria, an area chosen for the close proximity of houses next to the urban freeway and the absence of noise mitigation devices. The freeway is a four lane divided freeway with substantial median, emergency shoulder lanes, roadside open drainage, grade separated intersections and a 100 km/h speed limit. Seven sections were resurfaced with the trial pavements listed in Table 1. Details of the preexisting site conditions and the resurfacing conducted for the trial are given in Simpson (1). Sections 6 and 7 were resurfaced at the end of March 2013. The pavements of Sections 1 to 5 were installed one month later.

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Table 1 – Trial Pavements

Section	Type of asphalt	Depth, mm	Section length, m
1	Standard OGA Size 10mm	30	200
2	Size 10mm OGA, treated by “shaving”	30	100
3	Double layer OGA Size 10mm and 14mm	30 + 40 (resp.)	150
4	OGA Size 10mm (laid in two layers)	2 × 35	150
5	Standard SMA Size 10mm	35	150
6	Boral Noise Reducing Trial Mix2	35	150
7	Boral Durapave Asphalt	35	150

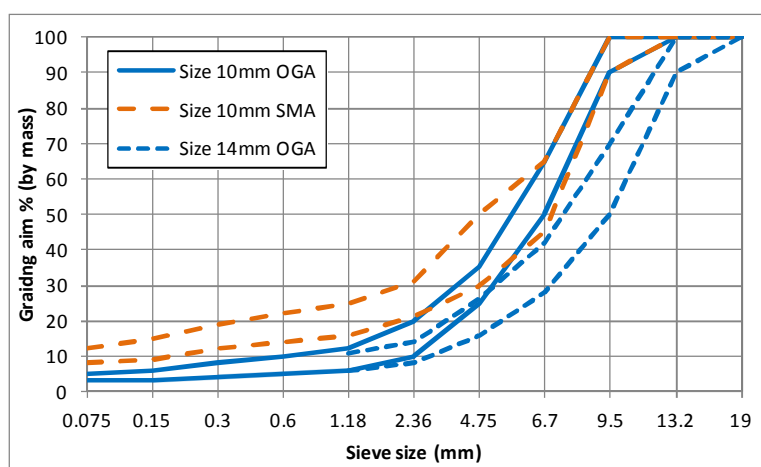


Figure 1 – Grading curves (upper and lower tolerance) for the OGA and the SMA used in the trial.

The selected asphalts for Sections 1 and 5 were conventional VicRoads OGA and SMA mixes (2), respectively. Their grading curves are shown in Figure 1.

Pavement surfaces for Sections 2 to 4 consisted of variations on the standard OGA: Section 2 was treated by “shaving” (grinding off the top surface of the asphalt using a rotary diamond cutter). This configuration was selected based on results from Sandberg and Mioduszewski (3). The treatment, shown in the photographs in Figure 2 was applied to the slow lane of the section.

The pavement in Sections 3 consists of a double layer surface, see Figure 3. Double layered OGA are not uncommon in Europe and in Japan (4). The concept of double layer asphalt is to combine the advantages of using small chipping sizes in the upper layer – which provide a smoother macrotexture giving less impact noise – and those of larger chipping in the lower layer, presenting a lower risk of clogging due to higher porosity (5). Such a configuration was adopted for Section 3 with a Size 10mm OGA for the upper layer, consistent with the VicRoads specifications (2) and a Size 14mm OGA for the lower layer. A mix specified by the Queensland Department of Transport and Main Roads (6) was used for the latter. The grading curve for this mix is shown in Figure 1.

The pavement in Section 4 also consists of two layers, but both are of the same asphalt (Size 10mm OGA), so as to provide some comparison with Section 1 and Section 3 regarding the influence of the pavement thickness and the effect of a different underlayer respectively.

Two proprietary products were introduced in the trial, in Sections 6 and 7: respectively Boral Noise Reducing Trial Mix2, an asphalt with improved noise properties based on work in Europe and aiming to provide a longer life than OGA; and Boral DuraPave Asphalt, an asphalt primarily designed to provide high fatigue life and improved crack resistance but tested on this project for noise properties.



Figure 2 –OGA Treated by *shaving* on Section 2.



Figure 3 –Section 3 double layer OGA. (L.H.S.: the upper layer extends partly onto the emergency)

2.1 Non acoustical testing

Surface texture depths for the seven sections were measured using a multi-laser profilometer immediately after the pavements were laid (1). Average values measured in the slow lane are shown in Figure 4. Air void testing was conducted for the untreated OGA using the mensuration method of Australian Standard AS 2891.9.3 (7,8) on core samples taken in the left wheelpath and the centre of the lanes after one week of trafficking. Results are presented in Table 2. Lower ratios for the wheelpaths are likely to result from some initial compaction of the pavements due to traffic.

Figure 4 – Average surface texture depth

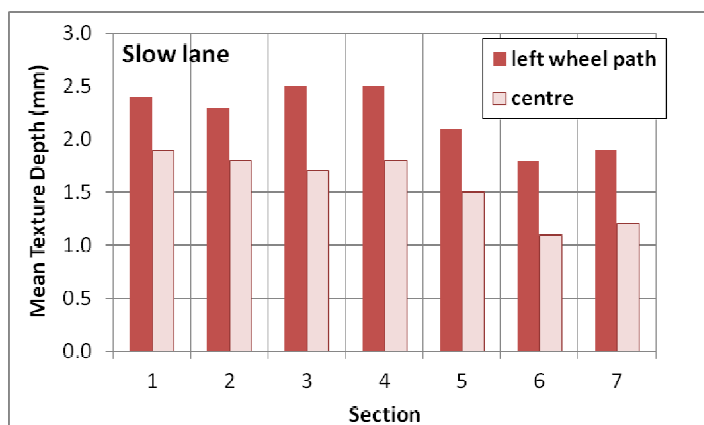


Table 2 – Air voids for OGA

Section	Layer	Average Air Voids (3 samples)	
		Left Wheelpath	Centre of Lane
1	Single	15.1%	16.3%
3	Upper	15.0%	16.1%
	Lower	16.7%	19.8%
4	Upper & Lower	16.6%	17.9%

3. ACOUSTIC TESTING

3.1 Test methodologies and results

VicRoads commissioned acoustic tests by means of three different methods, the Statistical Pass-By method (SPB), the Close Proximity Method (CPX) and the On-Board Sound Intensity method (OBSI). The schedule for the tests and the results, presented in terms of overall A-weighted results are presented in Table 3 and 4 respectively.

The first method consisted of roadside noise measurements, correlated to speed observations, following generally the provisions of ISO 11819-1 (9), except for a speed correction in the form of a normalization that was adopted for calculation of the SPB level in numerous earlier works in Australia (10,11). This procedure shows a good correlation with the ISO standard calculations (linear regression) and was adopted here for its adequacy to the Australian context and for consistency with those previous studies. The measurements were taken for three types of vehicles: passenger cars, medium trucks and heavy trucks. The average speed for each test varied from 91 to 96 km/h for cars, 83 to 93 km/h for medium trucks and 81 to 99 km/h for heavy trucks.

The second and third methods involved measurements of sound pressure level and sound intensity level conducted in the nearfield of the tyre-pavement contact, following the procedures of ISO/DIS 11819-2 (12) and AASHTO TP 76-10 (13) respectively. They were conducted using a trailer that was constructed to allow for measurements according to both standards (14). The CPX and OBSI tests were conducted using reference tyres specified for ISO/TS 11819-3 (15), the Michelin 225/60-R16 Standard Reference Test Tyre (SRTT) for passenger cars and the Avon 195-R14C Supervan AV4 for heavy vehicles (referred to as AV4 hereinafter). Both tyres are shown in the photographs in Figure 5. CPX and OBSI tests were conducted at a travelling speed of 100 km/h. Each test was repeated for 8 to 10 runs. The results presented in Table 3 are the overall A-weighted CPX and OBSI levels measured on the slow lane (left lane), bearing the highest traffic flow.

Table 3 – Test schedule

Section	SPB Tests			CPS & OBSI Tests		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
1						
2 ^(*)						
3	0 month	6 months	12 months	2 months	8 months	12 months
4						
5						
6						
7	1 month	7 months	13 months	3 months	9 months	13 months

(*) The treatment of pavement 2 was carried out 1 month after installation



Figure 5 –Tyres used for the CPX and OBSI tests. L.H.S.: Michelin 225/60-R16 SRTT; R.H.S.: Avon 195-R14C Supervan AV4 (Images extracted from ref. 15)

Table 4 – Test results (All in dB(A))

Section	Test	Passenger Car			Heavy vehicles			
		SPB	CPX (SRTT)	OBSI (SRTT)	SPB (dual axle)	SPB (multi axle)	CPX (AV4)	OBSI (AV4)
1	1	71.6	99.1	100.7	80.0	85.1	99.6	101.4
	2	74.0	99.6	99.6	82.8	82.9	98.3	99.9
	3	73.6	100.9	101.8	82.4	85.2	98.6	100.9
2	1	-	96.6	98.4	-	-	97.6	99.8
	2	71.7	96.8	97.2	81.6	86.1	96.3	98.1
	3	71.0	98.5	99.5	81.4	80.8	96.8	99.7
3	1	69.7	98.2	99.9	80.2	82.7	98.1	100.1
	2	72.0	97.7	97.8	81.1	82.8	96.8	98.4
	3	71.3	99.1	100	80.8	82.7	97.9	100.3
4	1	71.4	98.8	100.4	83.8	84.2	98.5	100.4
	2	71.7	97.9	97.8	82.3	81.7	97.1	98.8
	3	72.3	99.1	100	79.7	82.8	98.5	100.8
5	1	74	101.8	102.9	82.7	85.1	100.6	102.2
	2	75.2	101.0	100.5	82.7	84.9	99.4	100.7
	3	75.9	102.2	102.5	83.1	85.4	100.4	102.3
6	1	72.1	98.5	99.7	80.5	83.5	98.5	100.3
	2	73.6	97.9	97.7	82.2	83.5	97.3	98.7
	3	74.8	99.5	99.9	82.8	84.0	97.7	99.9
7	1	74.7	100.2	101.4	83.3	86.6	99.3	101
	2	73.7	99.5	99.3	82.5	86.9	98.1	99.4
	3	74.5	100.6	101.2	81.3	85.2	99	101.1

It is observed from Table 4 and Figure 6 that, the treated OGA of Section 2 was performing better than the other configurations, confirming the findings of Sandberg and Mioduszewski (3). The loudest surface was found to be the SMA of Section 5. These observations are consistent across the three test methods investigated.

Correlation between the various methods for the measurements conducted for passenger cars and SRTT is shown in Figure 6. The CPX method showed a better correlation with the SPB levels than the OBSI method. Somewhat higher correlation is reported in the literature (16), but for different speeds or a higher number of measurements. It is also noted that for tests 1 and 3, the CPX & OBSI measurements were undertaken up to two months after the SPB tests. Lower correlations were observed for medium and heavy trucks, due to a lower population for the SPB tests and a wider range of variation for speeds.

The correlation between CPX and OBSI measurements is good, which is not surprising given that the CPX and OBSI measurements were made concurrently. Although not shown in Figure 6, it is worth noting that a slightly higher correlation was found for AV4 ($R^2 = 0.88205$).

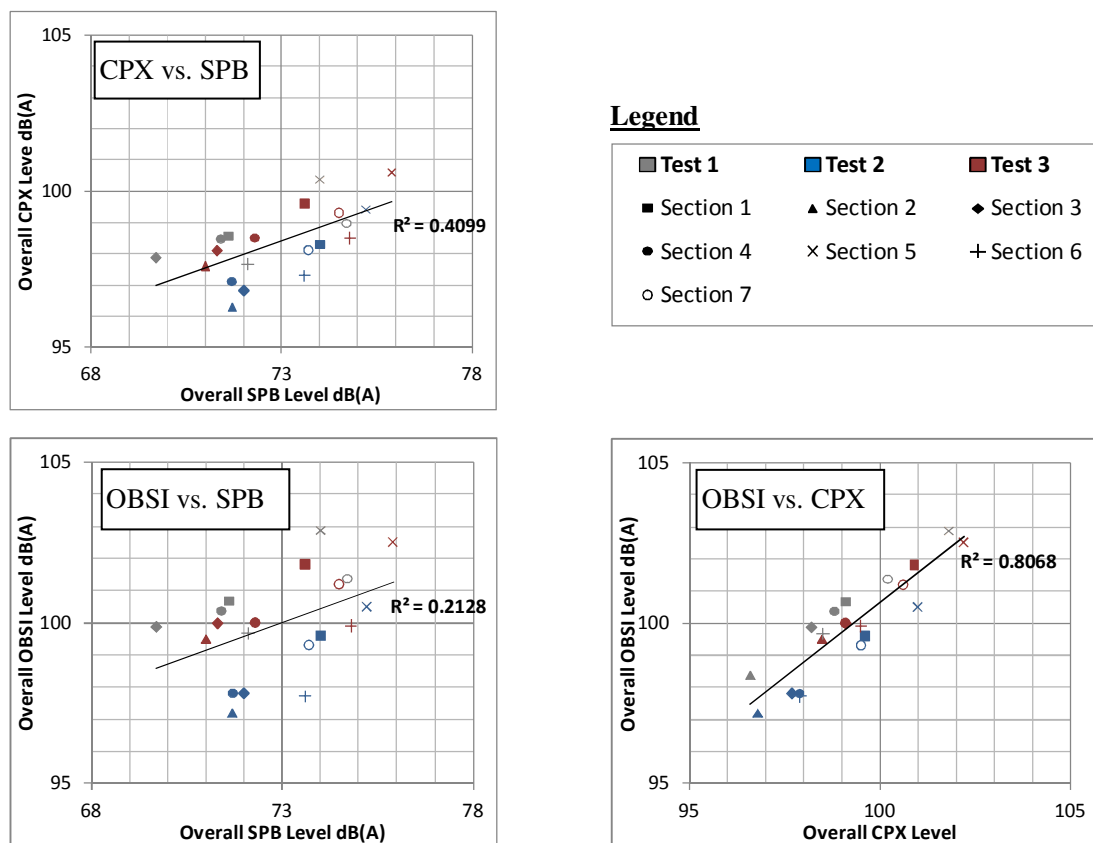


Figure 6 – Correlation between the three measurement methods for the measurements for passenger cars

Further insight is given into the variation with time of the acoustic properties of the investigated pavements and into their relative performance in the following. Results presented are based on the levels obtained by the CPX method. At this stage of the trial, this method was preferred for such analysis since it appeared to be more robust than the statistical pass-by method, particularly for heavy vehicles, and was found to correlate better to the roadside noise levels than the OBSI method.

3.2 Variation over time

Figure 7 shows a plot of the variation over time of the overall A-weighted CPX level for the different pavements, with reference to the first test session. For SRTT an increase of up to 2 dB(A) was observed across the 10 months between the first series and the last series of CPX tests for Sections 1 and 2. An inflexion can be observed with a lower increase in noise levels between test 1 and test 2 than between test 2 and test 3. The increase was limited to about 1 dB for Sections 3 and 7, and quasi-null for Sections 4 to 6. Again, an inflexion was observed for these surfaces, with a slight decrease in CPX levels for test 2.

The increase in CPX level was somewhat lesser (about 1 dB(A) for Sections 1 and 2, and quasi null for the other sections across the 10 months between test 1 and test 2).

3.3 Relative performance of the tested asphalts

As alluded in paragraph 3.1, the Section 5 SMA was found to be the loudest surface amongst the seven pavements investigated. It was therefore used as a reference surface so as to further investigate the relative performance of the six other pavements. It is noted that typically, in Victoria, SMA pavements lead to noise levels approximately 1 dB(A) lower than dense graded asphalts. (16)

In Figure 8, the performance of the six other pavements relative to that of Section 5 SMA, expressed as the difference in overall A-weighted CPX levels, are compared for both SRTT and AV4. Unsurprisingly, with negative differences, all six pavements were quieter than the SMA for the three tests. While the performance of Sections 1 and 2 relative to the Section 5 SMA showed some degradation over time (and particularly over the first few months), the performance of the other pavement seemed to have remained relatively stable over the ten months of trial. A slight decrease in

performance can be observed for Sections 4 and 6 for SRTT. This is however less obvious for AV4.

The treated OGA of Section 2 was found to be up to 5 dB(A) quieter for SRTT and 3 dB(A) quieter for AV4 than the Section 5 SMA.

Further insight in the relative performance of the different OGA configurations tested is given in Figure 9. The performance of the pavements in Sections 2 to 4, relative to that of the standard OGA in Section 1 is plotted for the three tests. The three alternative OGA configurations were found to provide additional noise reduction. The improvement observed for the treated OGA of Section 2 was found to be relatively stable across the 10 months of trial, with an additional reduction in CPX levels of approximately 2.5 dB(A) for SRTT and about 2 dB(A) for AV4. While this result is consistent with that of Sandberg and Mioduszewski (3) for the SRTT, a lower decrease for AV4 (0.5 dB) was observed in that earlier study. This may be explained by the fact the latter was conducted for a double layer porous asphalt concrete, whereas the pavement investigated here in Section 2 is based on a single layer OGA.

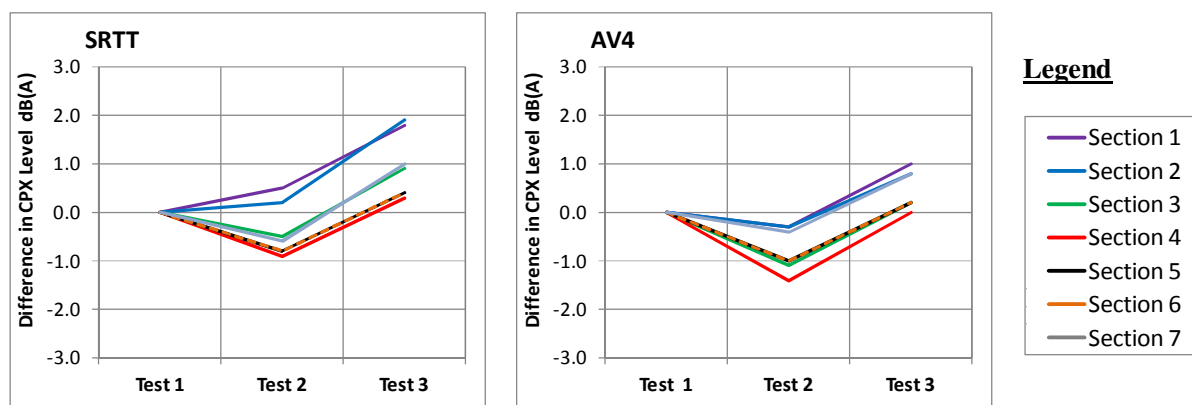


Figure 7 – Evolution with time of pavement performance (CPX levels relative to test 1)

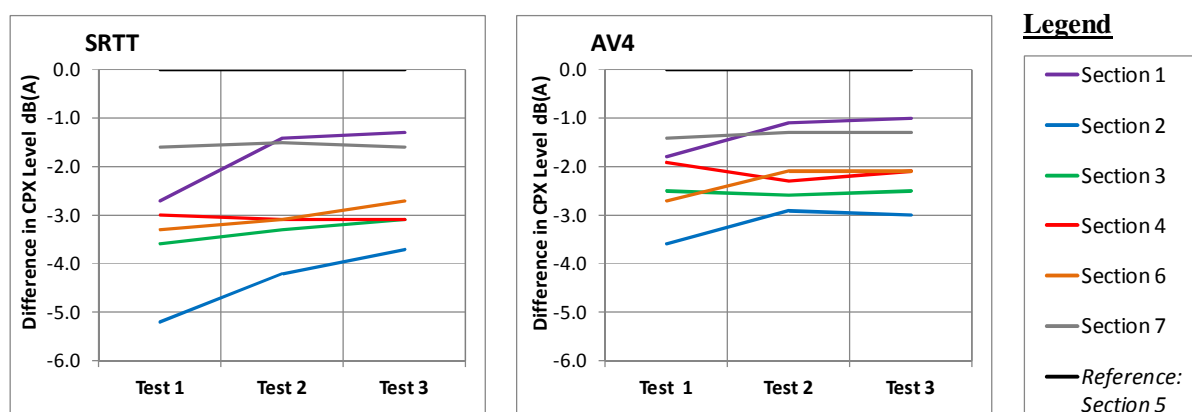


Figure 8 – CPX levels of the pavements in Sections 1 to 4, 6 and 7 relative to that of the SMA in Section 5

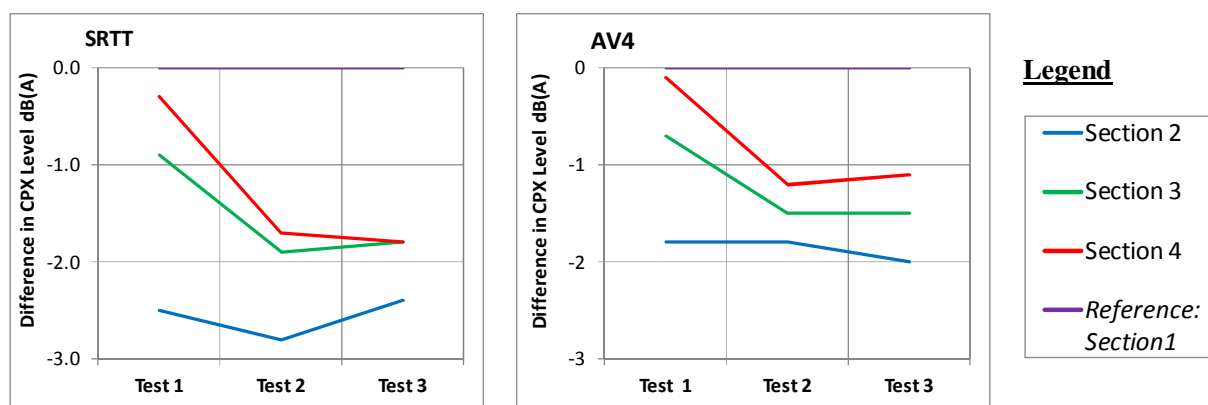


Figure 9 – CPX levels of the OGA pavements in Sections 2 to 4, to that of the standard OGA in Section 1

4. CONCLUSIONS

The results of acoustic tests conducted on seven different pavement surfaces at the Mornington Peninsula Freeway, near Melbourne have been presented here. The tests were conducted during the first year following the installation of the surfaces, and are part of a program intended to take place over a total of five years.

The asphalt pavements tested consisted of four different configurations of open graded asphalt (OGA), one stone mastic asphalt (SMA) and two proprietary products. Acoustic tests were conducted by means of three different methods: Statistical Bypass (SPB), Close-Proximity Method (CPX) and On-Board Sound Intensity (OBSI). The latter two were conducted using a reference tyre representative of passenger car tyres (SRTT) and one representative of heavy vehicle tyres (AV4). The CPX method showed better correlation to the SPB measurements than the OBSI method.

While the Stone Mastic Asphalt was found to be the loudest surface tested, the quietest surface was an OGA treated by grinding off 1-2mm of its surface so as to create a negative texture. Relative to the SMA, a reduction in CPX levels of up to 5 dB(A) was measured for the treated OGA for SRTT, and approximately of 3 dB(A) for AV4. When compared to a standard OGA, the treatment resulted in an additional reduction in CPX levels of about 2.5 dB(A) for SRTT and about 2 dB(A) for AV4.

Consistent with previous works, double layer OGA was found to perform better than single layer OGA, showing improvement in noise reduction, but also lesser loss in performance over time.

The trial is expected to last for another four years, during which tests will be conducted at regular intervals so as to provide an understanding of the acoustic performance of the tested pavements in the long term.

5. ACKNOWLEDGEMENTS

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