RONDA – PAVEMENT NOISE MEASUREMENTS

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Abstract

Road traffic noise affects approximately 8 million people in Australia with 2 million seriously affected, far more than from other forms of transportation. As the principal source of road noise is from the tyre/pavement interface, it is important to understand and quantify pavement noise and to catalogue ongoing performance. A new instrument is now available in Australia for this work comprising a special purpose noise trailer. RONDA (ROad Noise Data Acquirer) is a CPX trailer conforming to international standard ISO/CD 11819-2 [1] intended for measuring road pavement noise. The trailer is of the open frame type without an enclosure and is the first of its kind in Australia. A description of the design of the trailer is provided together with the results of initial testing on asphalt pavements.

1. Introduction

RONDA (ROad Noise Data Acquirer) is a close proximity method CPX trailer designed to measure road pavement noise in normal traffic and over long distances using standard reference tyres. RONDA is 4m long, 2.4m wide, 135cm tall and weighs 715 kg. RONDA is an open frame trailer as distinct from most other CPX trailers which incorporate an acoustic box enclosure [2]. RONDA is made of circular steel tubing to minimise acoustic reflections. The advantage of an open frame trailer is that unwanted acoustic reflections from an enclosure are avoided. However, precautions need to be taken to ensure that extraneous noise from other passing vehicles is not a problem. The frame comprises welded circular steel tubing in two parts – a rigid welded frame supported by two pivoting arms, an airbag and shock absorber. The dynamics of the frame is similar to that of a motor vehicle.

2. ISO STANDARD 11819-2

RONDA is designed in conformance with ISO/CD 11819-2 *Measurement of the influence of road surfaces on traffic noise - Part 2: The close-proximity method* [1]. This standard is in draft form at the time of preparation of this paper.

3. Measurement Instrumentation

Sound level measurements are made using a Sinus Soundbook Mark II and four GRAS 46AE microphones. This instrumentation meets the requirements of IEC 61672-1:2002 as a Type 1 instrument. The frequency range of measurements as specified in the standard is 315 Hz-5 kHz. The microphones are fitted with Bruel & Kjaer UA1650 90mm foam windscreens.

Trailer speed is measured using a Kistler Microstar II non-contact microwave sensor type CMSTRA with an operating range of 0.5-400kph having an accuracy of 0.5% and, for comparative purposes, the speed indication from a Garmin GPS receiver. Tyre and road surface temperature are measured using Optris CT LT laser thermometers with an accuracy of ±1degC. Ambient air temperature is measured using a Dwyer RHP OSA temperature transmitted with an accuracy of ±0.3degC. The precision of all measurement equipment complies with the ISO standard.

Figure 1. CPX trailer RONDA open frame design

4. Data Analysis

The recordings of sound level at the four microphone locations are made at 100ms intervals including tyre temperatures, road surface temperature, ambient temperature, speed and GPS location. The energy average spectrum at the microphone positions is calculated in each 1/3rd octave band. The arithmetic average sound level is then determined for each tyre and the arithmetic average of the left and right tyre is determined. The A-weighted arithmetic average sound level is termed the Lcpx dB. The Lcpx levels can be posted on Google Earth to match the recorded sound levels with the physical section of roads measured, as shown in Figures 3 and 4. After measuring Lcpx levels at different speeds along the test section of road, regression analysis is conducted to determine the relationship between sound level and speed so that sound levels can be corrected to the reference speed.

Figure 2. Microphone frame support structure for left tyre viewed from front of trailer

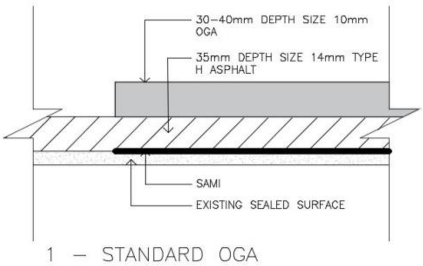
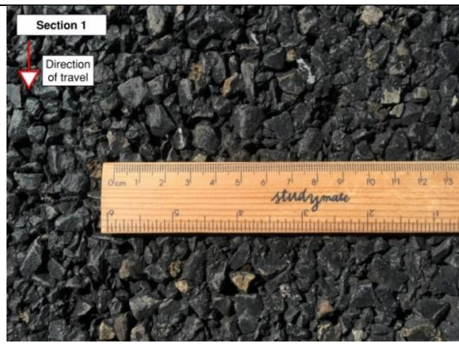
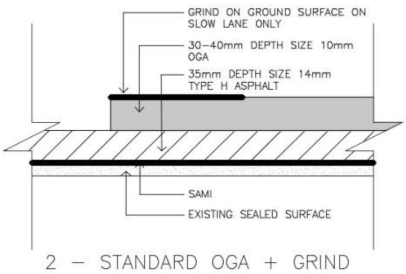
Figure 3. Pavement noise contours along M11 Freeway (extended coverage)

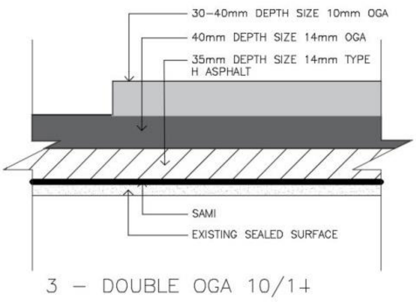
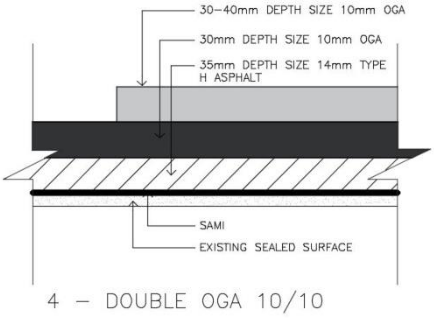
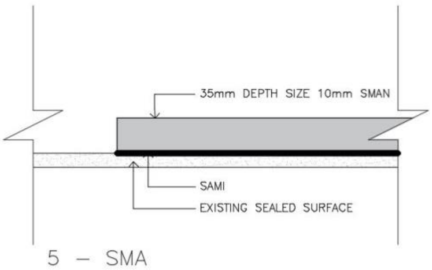
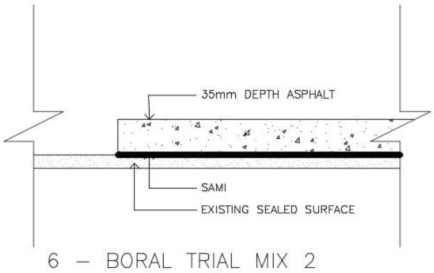
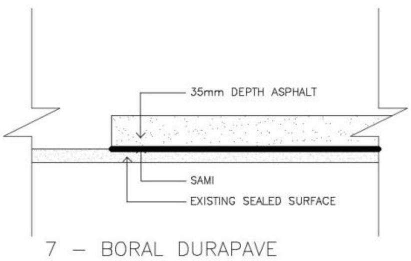
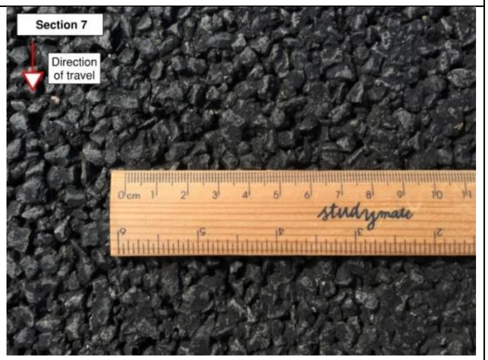
Figure 4. Pavement noise contours along M11 Freeway (detailed)

5. Asphalt Pavements

A trial of low noise asphalt pavement surfaces was established as a joint project between VicRoads and Boral. The trial is being conducted on the Mornington Peninsula Freeway in Melbourne and includes seven different types of asphalt pavement surfaces which were laid in March 2013. RONDA was used to conduct noise measurements along the trial section of the freeway. The seven types of asphalt surfaces measured are shown in Table 1.

Table 1. Asphalt trial pavement surfaces

Section	Pavement	Schematic	Photo
1	Standard 30mm depth of OGA		
2	OGA 30mm depth with surface treated by grinding		

3	Double layer OGA 10mm and OGA 14mm at 70mm total depth		
4	Double layer OGA 10mm and OGA 10mm at 70mm total depth		
5	Standard size 10mm SMA at 35mm depth		
6	Boral noise reducing Trial Mix2 asphalt at 35mm depth		
7	Boral Durapave asphalt at 35mm depth		

6. Measurement Results

Measurements were conducted on the westbound carriageway, in both Lanes 1 and 2, and at speeds from 60km/h to 100km/h. Regression analysis was conducted for each pavement type using the RONDA measured data for the various speeds. Results indicate high correlation coefficients, therefore the regressions determined were appropriate in correcting sound levels to the reference speeds. An example of the regression analysis of sound level versus speed is shown in Figure 5.

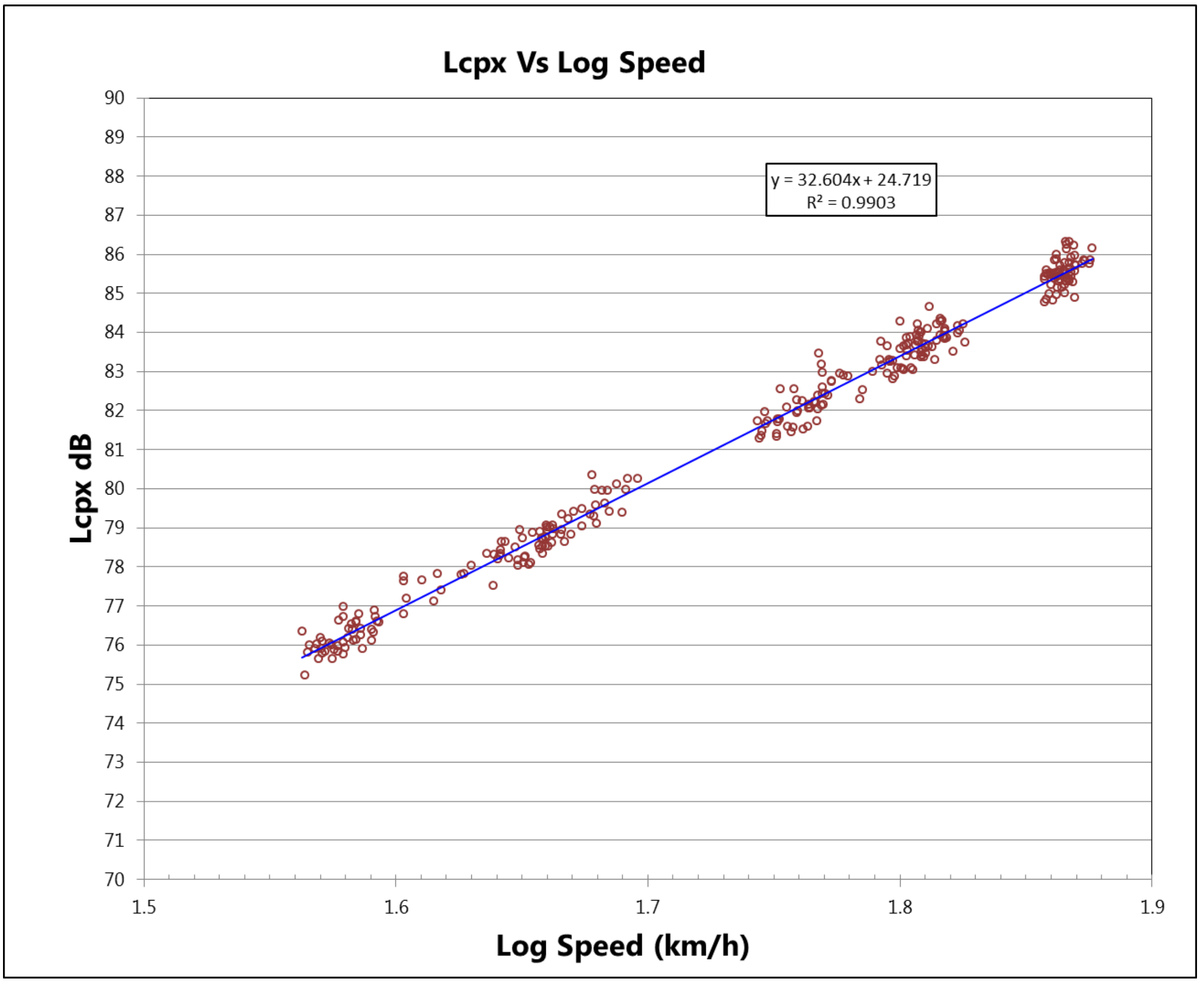


Figure 5. Example of regression analysis of sound level versus speed for DGA

Using the results of the regression analysis for the pavements along each section of road, the sound level comparison between different pavements at a reference speed of 100km/h is provided below. The Lcpx,100 result for a section of DGA measured on the Princes Motorway in NSW is shown for reference.

From the Lane 1 results presented in Figure 6 it can be seen that the OGA which has been ground (Section 2) produces noise levels almost 2dB lower than standard OGA (Section 1). The double layers of OGA (Sections 3 and 4) are slightly louder than the ground OGA, but quieter than standard OGA. The OGA surfaces are typically 6dBA quieter than DGA. The SMA surface is 2 to 3dBA louder than the OGA surfaces, but 3dBA quieter than DGA. The two Boral pavements had noise levels very similar to standard OGA.

Figure 7 shows results for Lane 2 measurements. The relative differences between the noise levels for each pavement are similar to the Lane 1 results, however the absolute levels measured in Lane 2 are consistently lower than those measured in Lane 1, typically by 1 to 2dBA. We expect that Lane 1 carries more traffic than Lane 2 and the surface is therefore more worn, and the pores potentially more clogged than Lane 2, therefore producing a higher noise level.

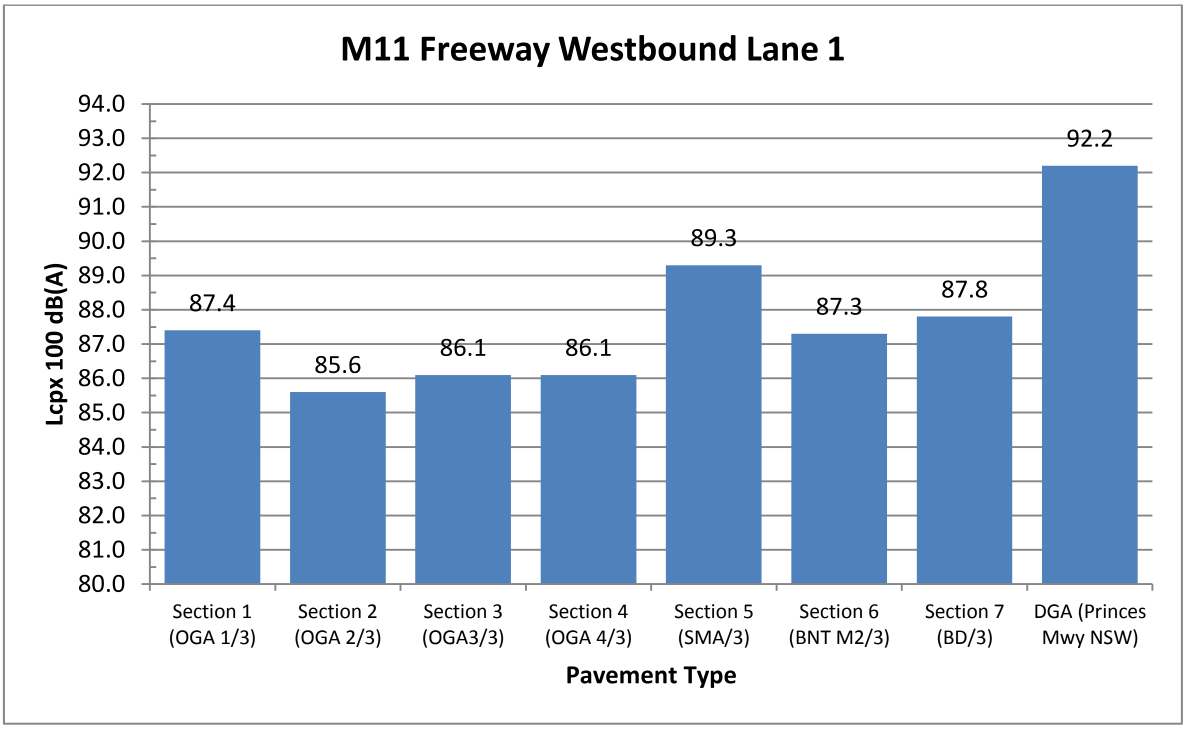


Figure 6. Comparison of road pavement noise levels at 100km/h (Lane 1)

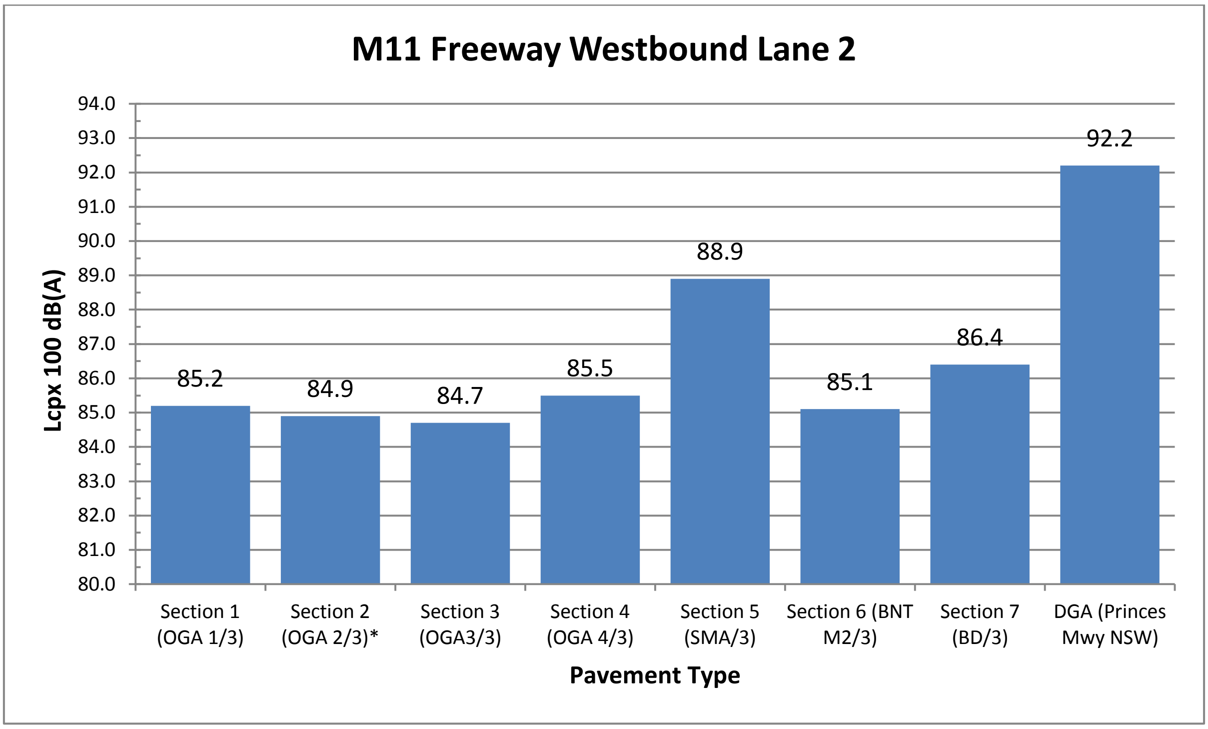


Figure 7. Comparison of road pavement noise levels at 100km/h (Lane 2)

7. Comparison to SPBI Results

The test section of pavement on the Mornington Peninsula Freeway has been measured by others using the SPBI method with the results presented at ARRB 2014 in Sydney [5]. Table 2 compares the findings of both the SPBI and the CPX results compared to DGA. Although the DGA surface used for baseline comparison in the CPX method was not the same section of road used for the SPBI method, nonetheless a relative comparison of noise level change between the test surfaces can still be made.

The SPBI method results show that the trial pavements were 3.3 to 7.7dB(A) quieter than DGA on the Mornington Peninsula Freeway. The CPX results show that the trial pavements were 2.9 to 6.6dB(A) quieter than DGA in on the Princes Motorway. Allowing for a slight difference in noise level of the two different DGA reference pavements, then the results are fairly consistent between the two methods, with the exception of Section 6 which was the only pavement where the CPX result was quieter than the SPBI result.

Table 2. Comparison of CPX and SPBI methods

Section	Pavement Surface	Pavement SPBI compared to DGA*, dBA	Pavement Lcpx,100 compared to DGA*, dBA	Variation (SPBI – Lcpx)
1	OGA	-5.0	-4.8	-0.2
2	Treated OGA	-7.7	-6.6	-1.1
3	Double OGA	-7.2	-6.1	-1.1
4	Double OGA	-6.7	-6.1	-0.6
5	SMA	-3.3	-2.9	-0.4
6	Boral noise reducing trial mix 2	-4.4	-4.9	+0.5
7	Boral Durapave	-4.5	-4.4	-0.1

* The DGA surface used in each test was not the same section of road

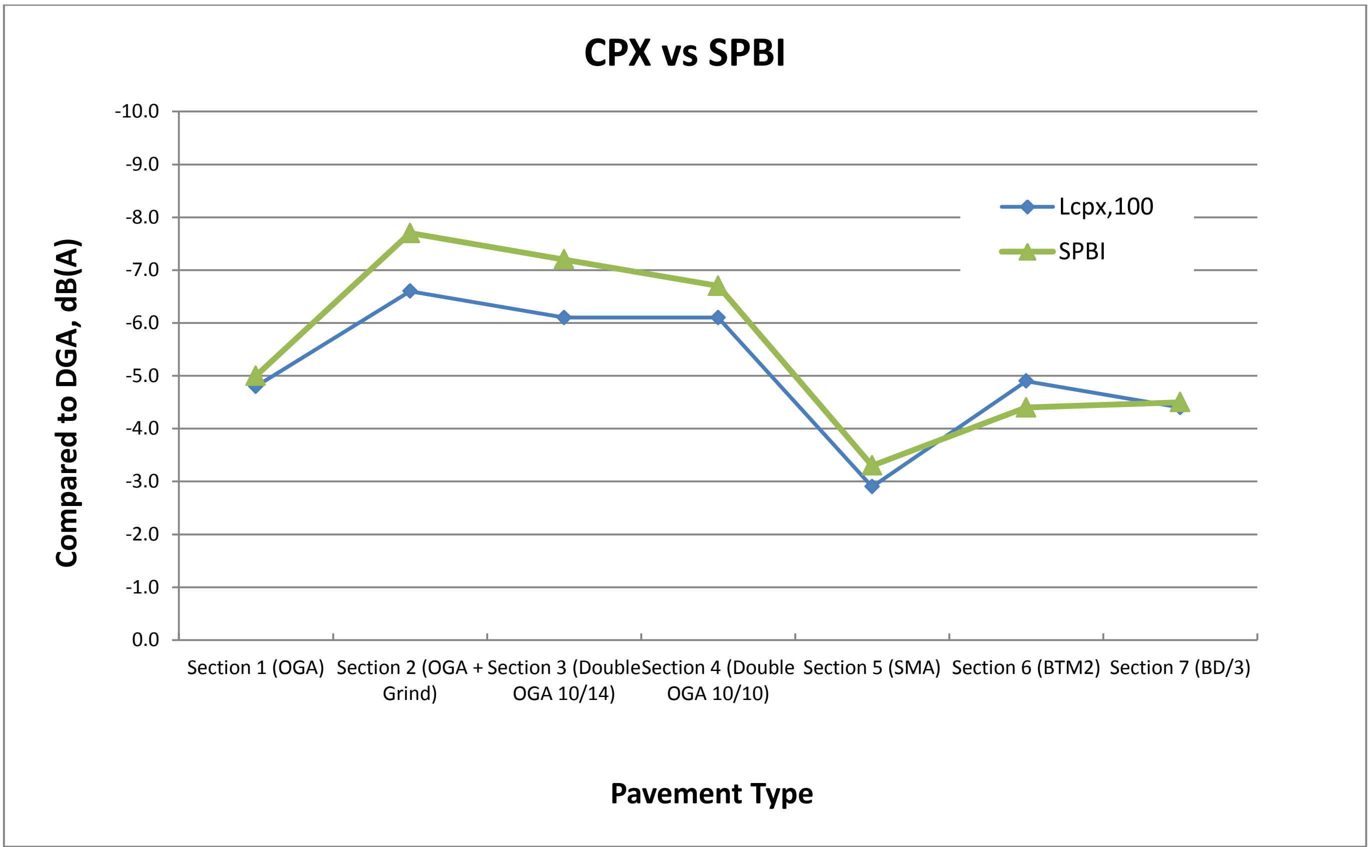


Figure 8. Comparison of CPX versus SPBI Methods

8. Spectral Analysis

A spectral analysis has been undertaken for four of the asphalt pavements discussed in this paper. The spectral comparison is presented in Figure 9 and is in one-third octave band frequency detail. At the high frequencies from 1kHz to 5kHz, SMA is shown to have higher noise levels than OGA surfaces. It is also evident that grinding of the OGA (Section 2) reduces the mid frequency noise (1kHz to 2kHz) but increases the low frequency noise (below 1kHz).

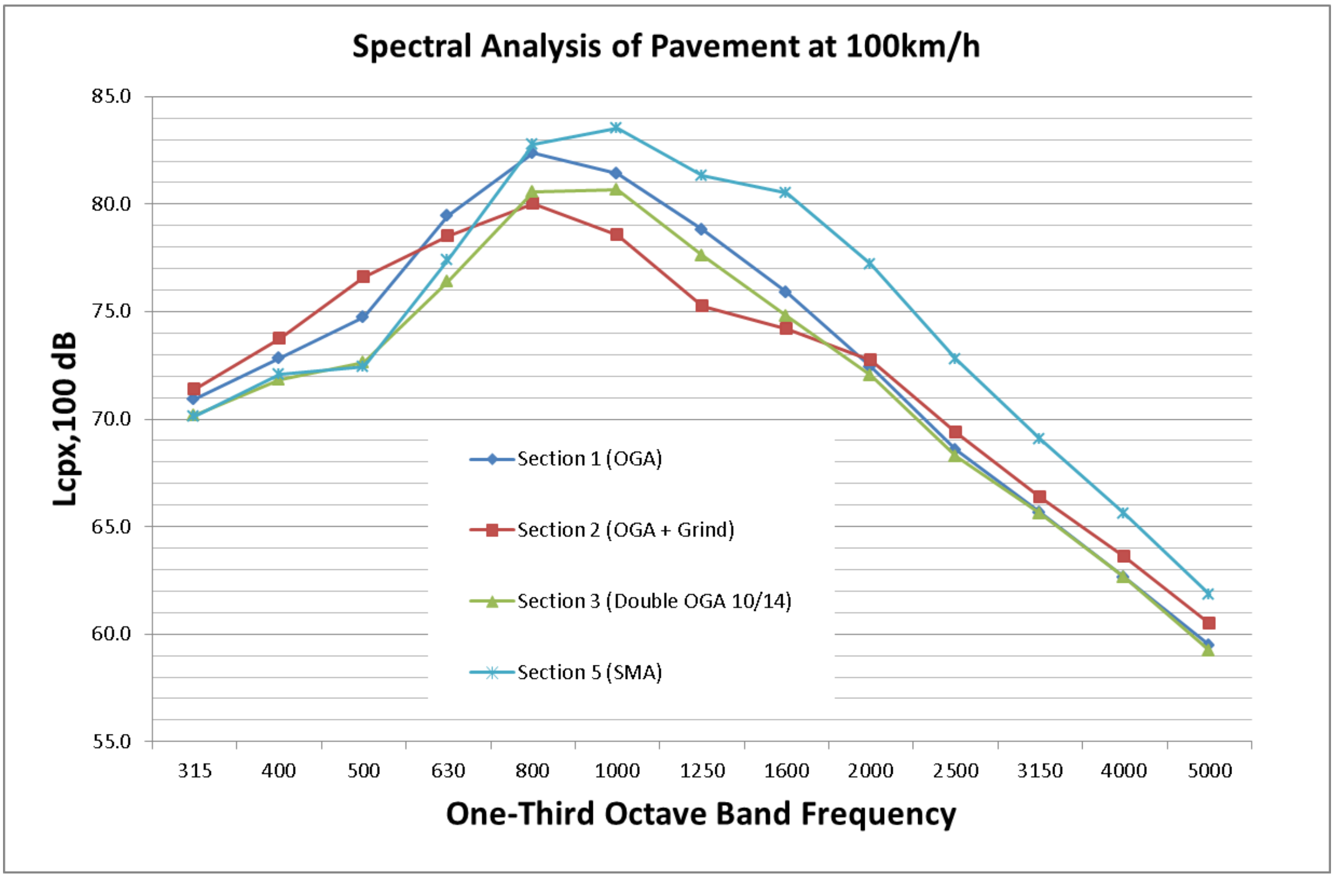


Figure 9. Spectral comparison of road pavement noise levels at 100km/h reference speed

8. Conclusions

A CPX trailer named RONDA has been constructed in accordance with draft international standard ISO/CD 11819-2. The trailer design and the standard of instrumentation specified in the standard has been rigidly adhered to in order to ensure that results can be relied upon for comparison with internationally reported data. The RONDA trailer proved to be an efficient and accurate method of gathering noise data for various pavement types. Pavement noise measurements of a test section of asphalt road in Victoria have been presented. The results confirm that OGA pavements are typically 6dBA quieter than DGA and SMA is 3dBA quieter than DGA. OGA which has been subject to light grinding is 2dBA quieter than standard OGA. Comparison of data between CPX and SPBI methods on the same test section of road shows the two methods give similar results.

References

[1] ISO/CD 11819:2 (2012): *Acoustics — Measurement of the influence of road surfaces on traffic noise - Part 2: The close-proximity method*

[2] de Roo, F., Telman, J., van Blokland, G., van Leeuwen, H., Reubsaet, J. and van Vliet, W. “Uncertainty of close pProximity (CPX) tyre-road noise measurements - Round Robin test results”, *Proceedings of the NAG-DAGA International Conference on Acoustics 2009*, Rotterdam, The Netherlands, 23-26 March 2009.

[3] Morgan, P., Sandberg, U. and van Blokland, G. “The selection of new reference test tyres for use with the CPX method, to be specified in ISO/TS 11819-3”, *Proceedings of Inter-Noise 2009*, Ottawa, Canada, 23-26 August 2009.

[4] Tonin, R. and Szabo, A. “RONDA – CPX trailer initial test results”, *Proceedings of Inter-Noise 2014*, Melbourne, Australia, 16-19 November 2014.

[5] Simpson, C., McIntosh, J., Buret, M. and Samuels, S. “Asphalt trials to reduce traffic noise levels”, *Proceedings of the 26th ARRB conference*, Sydney, Australia, October 2014.