



RONDA CPX Trailer Measurements of Heavily Degraded Open Graded Asphalt

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RONDA (ROad Noise Data Acquirer) is a Close Proximity (CPX) trailer conforming to ISO/CD 11819-2 for the measurement of tyre-pavement noise. The trailer is of the open frame type without an enclosure. Tyre-pavement noise measurements along a major freeway in Melbourne were recently undertaken to quantify noise levels of old and dilapidated low noise pavements along sections of the freeway, which includes open graded asphalt (OGA). Measurement data was analysed to determine the tyre-pavement noise levels for the old OGA pavement. It was found that the old and dilapidated OGA pavement did not provide the noise benefits expected of low noise pavements and the tyre-pavement noise levels were in fact higher than the reference tyre-pavement noise level. Results from the study were used in assisting with the preparation of a validated and calibrated traffic noise model.

1 INTRODUCTION

Eastern BTA is delivering the North East Link South Package which includes major road upgrades to the Eastern Freeway between Burke Road and Tram Road in Melbourne's Eastern Suburbs.

The Eastern Freeway pavement surface is Open Graded Asphalt (OGA), which when compared with reference dense surfaces provides benefits for skid resistance, water spray and improved noise attenuation. However, to maintain acoustic performance, these porous surfaces require regular maintenance / resurfacing.

Limited maintenance history provided by the Victorian Department of Transport & Planning (DTP) indicates that the existing OGA in this region has not been resurfaced in most cases for at least 10 years which leads to risk/uncertainty in terms of existing pavement corrections.

Tyre-pavement noise measurements using the RONDA CPX trailer have been undertaken to determine the variability of noise results for the existing OGA pavement surfaces over an approximately 5.2 km section of the Eastern Freeway between Bulleen Road and Tram Road. Results from the study were used in preparing a validated and calibrated traffic noise model.

2 EQUIPMENT AND INSTRUMENTATION

The RONDA (ROad Noise Data Acquirer) CPX trailer conforms to ISO 11819-2 (2017) 'Measurement of the influence of road surfaces on traffic noise - Part 2: The close-proximity method' and is intended for measuring tyre-pavement noise. The trailer is of the open frame type without an enclosure, as shown in Figure 1.

RONDA incorporates two independent tyres (of the same type) fitted to a frame with no common axle. For the purpose of the noise measurements presented in this paper, standard reference test tyres (SRTT) have been used (Figure 2), which represent typical passenger (light) vehicle tyres in accordance with ISO/TS 11819-3. The wheel-to-wheel spacing between the tyre centres is 1,690 mm, which is in accordance with ISO 11819-2.

For each tyre, there is a microphone located 200 mm front of centre and one 200 mm back of centre, spaced 200 mm horizontally from the tyre sidewall and 100 mm vertically from the road surface, as shown in Figure 3.

Noise 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 Class 1 instrument. The frequency range of measurements as specified in the standard is 315 Hz to 5 kHz.

At the beginning of any measurement and at the end, the measurement instrumentation is calibrated using a GRAS 42AA pistonphone sound level calibrator. The calibrator meets the requirements of IEC 60942 Class 1.

The precision of all measurement equipment on the RONDA CPX trailer and the methods of measurements comply with the ISO standard.



Figure 1: CPX Trailer RONDA Open Frame Design



Figure 2: 16" SRTT Tyre and Tread Pattern



Figure 3: Microphone Setup

3 MEASUREMENTS AND DATA ANALYSIS

The vehicle was driven at the posted speed (typically 80 km/h to 100 km/h) where possible, along each lane of each carriageway for the nominated 5.2 km section of the Eastern Freeway. In order to maintain consistency and not be affected by traffic congestion, all measurements were conducted during the night time period.

The meteorological conditions during the noise measurements were generally conducive for measuring tyre-pavement noise using the CPX trailer.

The recordings of the noise levels at the four microphone locations are made at 100 ms intervals. During the pavement noise measurements, the following data is also recorded:

- tyre temperature;
- road surface temperature;
- ambient temperature;
- speed; and
- GPS location.

The energy average spectrum at the microphone positions is calculated in each one-third octave band centre frequency.

The reported noise levels in this paper are designated as $L_{CPX:P,vs}$ where;

- L_{CPX} is the time averaged A-weighted sound pressure level of the tyre-pavement noise levels averaged for the four microphones (two per tyre) as determined by the CPX method as defined in the ISO standard, expressed in decibels,
- P designates that the standard reference test tyre (SRTT) was used for the measurements, and
- vs is the vehicle speed. The vehicle speed is in km/h and is the average speed of the vehicle / trailer at the time of the measurement.

4 OGA PAVEMENT DETAILS

RONDA was used to conduct tyre-pavement noise measurements along the Eastern Freeway where the pavement was re-sheeted with OGA, considered as a low noise pavement, at different periods over the past 20 years. Measurements were undertaken along each lane of both the westbound and eastbound carriageways of the road. For analysis purposes, the section of the Eastern Freeway between Bulleen Road and Tram Road was segmented into three zones, which are detailed in Table 1 and shown in Figure 4.

Table 1 – OGA Pavements along the Eastern Freeway (Bulleen Road to Tram Road)

Zone ID	Location	Pavement Surface Description
Westbound Direction		
Z1-W	Between Bulleen Road and Doncaster Road	Open Graded Asphalt (OGA) – most recently maintained in 2007/2008 for areas near the Bulleen Rd interchange and 2013/2014 for areas between the existing Estelle St pedestrian bridge and the Doncaster Rd interchange.
Z2-W	Between Doncaster Road and Elgar Road	Open Graded Asphalt (OGA) – potentially unmaintained since initial works (circa 1997)
Z3-W	Between Elgar Road and Tram Road	
Eastbound Direction		
Z1-E	Between Bulleen Road and Doncaster Road	Open Graded Asphalt (OGA) – most recently maintained in 2010/2011 for areas near the Bulleen Rd interchange and 2013/2014 for areas between the existing Estelle St pedestrian bridge and the Doncaster Rd interchange.
Z2-E	Between Doncaster Road and Elgar Road	Open Graded Asphalt (OGA) – potentially unmaintained since initial works (circa 1997)
Z3-E	Between Elgar Road and Tram Road	



Figure 4 – Established zones along the Eastern Freeway (Bulleen Road to Tram Road)

In addition to the measurements of the OGA pavement along the Eastern Freeway, a considerable number of tyre-pavement noise measurements (over 13,000 data points) using RONDA have been undertaken by Renzo

Tonin & Associates along numerous pavements in NSW where Dense Graded Asphalt (DGA) pavements have been laid. Acoustically, DGA is accepted as the reference pavement (i.e. 0 dB(A) noise correction) when determining the noise performance of different pavement types. The noise level data from the DGA measurements underwent a regression analysis so that $L_{CPX:P,vs}$ noise levels at the measured vehicle speed can be determined for the reference DGA pavement and compared to the $L_{CPX:P,vs}$ noise levels for the measurements along the Eastern Freeway.

5 MEASUREMENT RESULTS

The tyre-pavement noise levels measured along each lane for the zones nominated in Table 1 are presented in Table 2. However, it is noted that during the measurements Lane 3 in the westbound direction was blocked due to construction activity and no measurements could be undertaken in this lane.

The noise levels of the reference DGA pavement for the corresponding measured vehicle speeds are also presented, and a comparison between the measured OGA noise levels against the DGA reference noise levels are made to determine the acoustic performance of the existing old and dilapidated OGA pavement along the Eastern Freeway.

Table 2 – Comparison of measured OGA against Reference DGA noise levels

Zone ID	Lane	Average Measured Speed (km/h)	Measured OGA $L_{CPX:P,vs}$ [dB(A)]	Reference DGA $L_{CPX:P,vs}$ [dB(A)]	Difference (OGA minus DGA) [dB(A)]
Westbound Direction					
Z1-W	Lane 1	71.4	99.5	97.0	2.5
	Lane 2	91.1	102.6	100.3	2.3
Z2-W	Lane 1	81.6	102.2	98.8	3.4
	Lane 2	95.3	104.5	100.9	3.6
Z3-W	Lane 1	90.6	103.3	100.3	3.0
	Lane 2	96.6	104.7	101.1	3.6
Eastbound Direction					
Z1-E	Lane 1	81.4	100.9	98.8	2.1
	Lane 2	83.0	101.0	99.1	1.9
	Lane 3	90.7	100.7	100.3	0.5
Z2-E	Lane 1	88.1	102.8	99.9	2.9
	Lane 2	95.3	104.0	100.9	3.1
	Lane 3	96.4	103.0	101.1	1.9
Z3-E	Lane 1	83.0	102.0	99.1	2.9
	Lane 2	94.7	103.9	100.8	3.1
	Lane 3	98.5	102.7	101.4	1.3

According to VicRoads' Road Design Note (RDN 06-01), OGA pavements are expected to provide on average a noise reduction of 3 dB(A) relative to DGA pavements. Additionally, Transport for NSW's Road Noise Model Validation Guideline states noise reductions of 2.5 dB(A) to 4.5 dB(A).

From the results presented in the above table, the measured OGA tyre-pavement noise levels are higher than the reference DGA pavement noise levels for the corresponding speeds. As a result, the old and dilapidated OGA pavement did not provide the noise benefits expected from a low noise pavement and would instead, increase tyre-pavement noise levels compared to a DGA pavement.

As described in Table 1 the OGA pavements in Zones 2 and 3, in both the westbound and eastbound directions, have potentially not been maintained since the initial works on the Eastern Freeway (circa 1997); while the OGA pavements in Zone 1 were maintained between 2007 and 2014. Based on the results presented in the above table, the difference in tyre-pavement noise levels between OGA and DGA pavements in Zone 1 are lower than those in Zones 2 and 3 for the corresponding lanes, which coincides with the maintenance regime for the three zones.

Additionally, the difference in tyre-pavement noise levels between OGA and DGA pavements are measured to be lower in Lane 3 than in Lanes 1 and 2, albeit higher than the reference DGA noise levels. This is likely attributable to restrictions for vehicles over 4.5 tonnes applicable to vehicles in the right-hand lane of the Eastern Freeway since 2010.

Based on the findings from the tyre-pavement noise measurements along the Eastern Freeway, it is confirmed that the age and condition of low noise pavements such as OGA can significantly influence the acoustic performance of the pavement surface. In this instance, the old and dilapidated OGA pavement increases tyre-pavement noise levels compared to a reference DGA pavement.

By quantifying the acoustic performance of the old and dilapidated OGA pavement, a traffic noise model was able to be validated and calibrated accordingly.

6 CONCLUSION

Tyre-pavement noise measurements along an approximately 5.2 km section of the Eastern Freeway between Bulleen Road and Tram Road in Doncaster, Victoria have been undertaken using the RONDA CPX trailer which conforms with the international standard ISO 11819-2.

Measurements of the existing old and dilapidated Open Graded Asphalt (OGA) pavement along the Eastern Freeway in each lane of both the westbound and eastbound carriageways were conducted and results were analysed to determine the L_{CPX} (or L_{Aeq}) tyre-pavement noise levels. Measurement results were compared to the reference DGA pavement noise levels for the corresponding measurement speeds. Results of the comparison indicate that the existing old and dilapidated OGA pavement is no longer considered to be a low noise pavement as tyre-pavement noise levels are higher than the reference DGA noise levels. The results from the study were used to establish a validated and calibrated traffic noise model.

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