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A RECENT INVESTIGATION INTO THE INFLUENCES OF SOME AUSTRALIAN ASPHALT PAVEMENT SURFACES ON ROAD TRAFFIC NOISE

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Abstract
This paper deals with an investigation into the influences of some Australian asphalt pavement surfaces on the generation of road traffic noise. The investigation represents a recent component of an ongoing pavement surface noise research program in which both authors have been involved over several years. It focused on the roadside noise produced by a passenger vehicle travelling under controlled conditions on a set of asphaltic pavement surfaces that are typical of those adopted in the states of New South Wales and Queensland and, indeed, elsewhere throughout Australia. Results of the investigation, which are summarised in the paper, demonstrated that there is a considerable degree of variability in the acoustic attributes of the pavement surfaces studied. Interpretations and explanations of this variability are offered in the paper. Moreover, the outcomes of the investigation were compared with the acoustic attributes of sets of nominally similar and different pavement surfaces constructed in other countries and which had been previously reported in the open literature. Explanations for the similarities and differences between the acoustic attributes of the Australian and overseas asphalt pavement surfaces are also offered in the paper.

1. INTRODUCTION

The materials and techniques used in the construction of any particular road pavement surface are significant contributors to the levels of road traffic noise that are generated by that pavement surface [1], [2], [3], [4] & [5]. Moreover the noise outputs generated from certain types of pavements have been found to be more annoying than those generated on other types of pavements, even when the overall noise levels generated on each pavement are similar [4], [5], [7], [8] & [9].

The investigation reported in this paper focused on the acoustic attributes of some typical asphalt pavements and subsequently compared these attributes with those of some of cement concretes. By utilising a particular data analysis procedure, comparisons of the results with those of other Australian and overseas studies was also facilitated.

2. ROAD TRAFFIC NOISE

2.1 Noise Generation

The roadside noise produced by a vehicle under constant speed and free flow operating conditions is dominated by tyre/road generated noise at speeds above a certain value. For passenger vehicles in reasonably maintained condition this will usually be around 30 - 35 km/h while for heavy vehicles it is typically around 40 - 50 km/h [6]. Above these speeds all other noise sources become negligible contributors to the overall level of roadside noise produced by the vehicle. Moreover the noise produced by these other sources, such as the engine and exhaust system, are much less noticeable than the tyre/road noise unless there are distinct tonal qualities in the frequency spectra associated with these particular noise sources.

Road pavement surface texture is a significant factor in the process by which tyre/road noise is generated [1], [2], [6] & [10]. While there are many theories concerning this noise generation process, it is generally accepted that an air pumping mechanism is the primary mechanism involved. Nevertheless a pavement that is rough and irregular has the potential to cause additional noise as a result of increased vibration of the tyre. Perfectly smooth surfaces tend to enhance the air pumping mechanism with a resultant hissing sound. However, a lightly textured pavement surface can assist in the dispersion of trapped air, thus reducing air pumping without causing deformation or vibration of the tyre [8].

2.2 Pavement Surface Textures

In the pavement design guidelines for Australian roads, Austroads [11] states that the wearing surface texture specified for the road should "take into consideration the traffic speed, grade, cross-fall, carriageway width and rainfall". Furthermore, the orientation of texture can have a significant influence on the noise level that is generated on a particular pavement. Asphalt pavements have a random texture that is similar in all directions and can be considered to be isotropic. The opposite case such as that displayed by transversely or longitudinally tyned concrete is known as anisotropic and refers to textures that are mostly periodic. When a tyre passes perpendicularly over a transversely tyned pavement the tyre impact is in phase over the whole width of the tyre which results in a number of air displacement mechanisms such as pumping and pipe resonances [6]. It is therefore desirable to avoid construction of anisotropic textures unless they are longitudinally orientated.

Asphalt surfaces and especially the low noise range of asphalts have optimised isotropic surface texture as a result of having a more honeycomb surface with cavities (air voids) that tend to capture rather than reflect noise. Additional texturing is not generally applied to asphaltic pavements. Concrete pavements can be finished with a variety of insitu surface treatments that may be varied to suit anticipated traffic levels and local conditions. Provided that the correct concrete strength is specified and it is compacted and cured adequately, the surface should not require retexturing, or resurfacing, for the design life of the pavement. Most concrete surface texturing is carried out during the construction phase, although in some instances, sawing, milling or grinding techniques are used during rehabilitation. Selection of concrete finish types requires the consideration of a number of factors including surface texture, noise properties and aesthetics. Texturing to concrete pavements is commonly achieved by tyning and/or by Hessian dragging of the wet concrete surface.

2.3 Low Noise Pavements

Given the importance of tyre/road interaction in the generation of roadside noise from freely flowing traffic, it is not surprising that for higher speed roads, much research, such as Dash et al [5] has been focused on pavements which purportedly generate lower noise levels. In Australia, the majority of high speed pavements are constructed of Cement Concrete (CC) or Dense Graded Asphalt (DGA). However, differing construction techniques have contributed to considerable variability in the noise levels generated by particular examples of both these type of pavements [10], [12]. There is a range of so called “low noise” pavements available in the market, and these include the following:

- Open Graded Asphalt (OGA)
- The stone mastic range of gap graded asphalts (SMA)
- Proprietary low noise asphalts designs (Included with the SMAs in this paper)
- Exposed Aggregate Concrete (EAC).

3. THE PRESENT STUDY

3.1 Pavement Surfaces Studied

The work reported in the present paper is a subset of a much larger empirical study that involved an investigation of the roadside noise generated by a total of 20 pavement surfaces located in the state of New South Wales. Parnell and Samuels [13], [14] & [15] have already presented the conduct and outcomes of that larger empirical study. The present subset investigation focused on hotmix type asphalts including conventional DGAs and SMAs, along with bitumen sprayed seals, also known as chip seals (CS). Additional data were collected during the subset investigation on seven asphalt pavement surfaces located in the neighbouring state of Queensland to supplement those from selected pavement surfaces in the NSW data set. In addition data from some conventional type CCs covering a range of textures were extracted from Parnell and Samuels [13], [14] & [15] for comparison purposes. Photos of typical examples of the pavements investigated appear in Figure 1.

3.2 The Test Procedure

Roadside noise data were collected for the present study using what is known as the controlled test passby method. This involved measuring the roadside noise levels produced by a test vehicle which was driven by observation locations set up adjacent to each of the pavements included in the study. In New South Wales the noise data were collected using a bank of microphones located adjacent to the section of pavement under investigation. This controlled test passby method was based on the Australian Design Rule 28/01 which deals with the external noise levels of motor vehicles [16]. The microphones were located at a height of 1.2 m above the pavement at a setback of 7.5 m from the centre of the lane in which the test vehicle was driven on each of the pavements being investigated and a nominal separation of 10 m. They were connected to a 01dB Metravib 4 channel analyser. For each measurement the test vehicle always travelled at 80 km/h on the normally travelled wheel tracks and care was taken to ensure that the noise measurements were not influenced by any extraneous noises. This procedure was also very similar to the well known statistical passby method [17] where roadside noise levels and speeds are measured for individual vehicles in the traffic stream. In Queensland, essentially the same procedure was adopted, except that only one microphone was used and this was incorporated into a B&K 2250 precision sound level meter.

The test vehicle used in New South Wales was a typical Australian sedan: a 2005 Ford Falcon sedan which was fitted with Goodyear Eagle NTCS 215/60R16 steel belt radial tyres inflated to 290 kPa. In Queensland the same vehicle type with very similar tyres (Dunlop 235/45R17) was used. Measurements were made at 80 km/h with the velocity of the test vehicle checked externally using a radar speed gun and internally using a Global Positioning System (GPS) receiver. It was determined that all data were collected at a test vehicle speed of 80 km/h +/- 2 km/h. The test vehicle used in Queensland is shown in Figure 2.

	
Stone Mastic Asphalt.	**Dense Graded Asphalt**
	
Chip Seal	**Cement Concrete with transverse tynes**

Figure 1. Typical examples of the pavements investigated.

Figure 2. Test vehicle used in the Queensland component of the subset investigation.

4. ROADSIDE NOISE DATA

At each test site around five replicate passbys were made and these data have been subjected to a wide variety of analyses and interpretations. Parnell and Samuels [13], [14] & [15] have presented the NSW data in some detail and have demonstrated the high quality of the data, as reflected, for example in the low standard deviations of each set of replicate passby noise levels. These standard deviations were all less than 2 dB(A). For the purposes of the present paper the data for the asphalt pavements have been aggregated by pavement surface type and State and summarised in Table 1 and Figure 3. In both States there was a consistent trend for the noise levels on the SMAs to be the quietest, followed by the DGAs, with the CSs being the loudest.

Table 1. Passby noise levels for the asphalt pavements included in the subset investigation.

State	Passby noise level (dB(A)) (Standard deviation (dB(A)) & Sample Size (-))		
	SMA	DGA	CS
NSW	74.6 (0.1, 2)	77.0 (0.0, 1)	79.6 (1.2, 3)
Queensland	73.2 (2.4, 6)	73.8 (0.0, 1)	79.8 (0.0, 1)

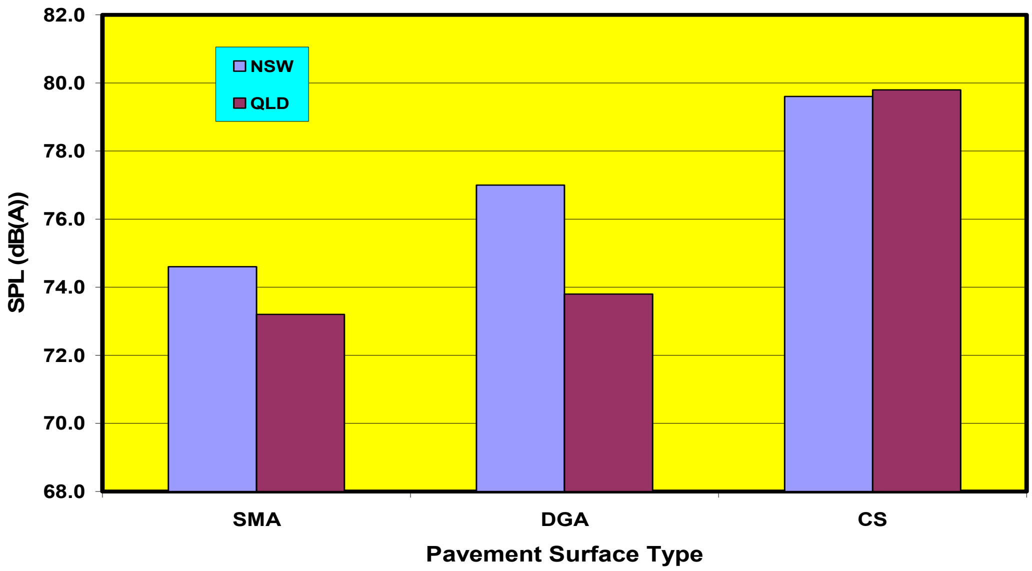

Figure 3. Comparison of Queensland subset investigation to NSW data.

Despite the small sample sizes, the above results are consistent with those of other Australian studies such as Samuels and Hall [10], Dash et al [5] and Samuels and Parnell [4]. The difference between the NSW and Queensland SMAs is negligible, since it is consistent with the variability known in Australia to occur between the noise levels produced by samples of pavement surfaces of the same type [10]. This observation is also true of the difference between the NSW and Queensland CSs. Similarly for the DGAs, although the small sample sizes here preclude further detailed explanations. While increased sample sizes would have been preferable, future work aimed at increasing the sample database has been planned.

Nevertheless, on the basis of the works reported in Samuels and Hall [10], Samuels [12], Dash et al [5] and Samuels and Parnell [4], it was concluded that the data of Table 1 and Figure 3 give a good indication of the range of passby noise levels produced on asphalt pavement surfaces in the states of NSW and Queensland.

One other factor to note in considering the data of Table 1 and Figure 3 is the data collection procedures adopted in NSW and Queensland. In both States the controlled test passby technique was used, as stated previously. However, as also mentioned before, in NSW a sophisticated, and advanced, data logging and analysis process was used. In Queensland a simplified process was used that involved a roadside observer visually recording the passby noise levels off the display of a precision sound level meter. To improve accuracy, the mean of multiple runs recorded. Whilst Parnell [18] has previously found that there may be differences recorded between the two methods employed, and it is recognised that it would be preferable to follow the same procedure exactly, both measurement systems delivered results that have allowed comparison amongst one another. Therefore it was concluded that the two processes were compatible and that both delivered high quality data as required by both the larger empirical study and the subset investigation.

5. COMPARISONS WITH OTHER STUDIES

Comparisons were made of the outcomes of the present subset investigation with those of one conducted in the state of Wisconsin in the USA [19] along with those from a Texan/South African study [20] and data collected in New Zealand [21]. In order to effect these comparisons, the published data from these other studies were reprocessed, taking into account differences in data collection procedures, such as the data acquisition sampling periods and vehicle speed [13], [14], [15] & [18]. In this way, comparisons were made, as presented graphically in Figure 4 and in more detail in Table 2 which shows the extent of in-type variability**.** Whilst the magnitude of the in-type variability can be significant it is consistent with that found by Dash [5] and Parnell [18]. Furthermore it is apparent that the mean noise data determined in present subset investigation fit well with those of the other four international studies despite a lack of precise detail known about the asphalt mix design and paving techniques of the overseas pavements.

Table 2. Comparison of mean noise levels determined in the present subset investigation with those of four other international studies.

Pavement Surface Type	**Passby Noise Level (dB(A))**				
	Australia	**Wisconsin**	**Texas**	**South Africa**	**New Zealand**
SMA	74.3	78.1	76.5	74.0	76
DGA	75.4	77.1	77.7	75.8	75
CS	79.6	-	80.4	83.0	81
CC	80.1	82.0	83.8	-	-

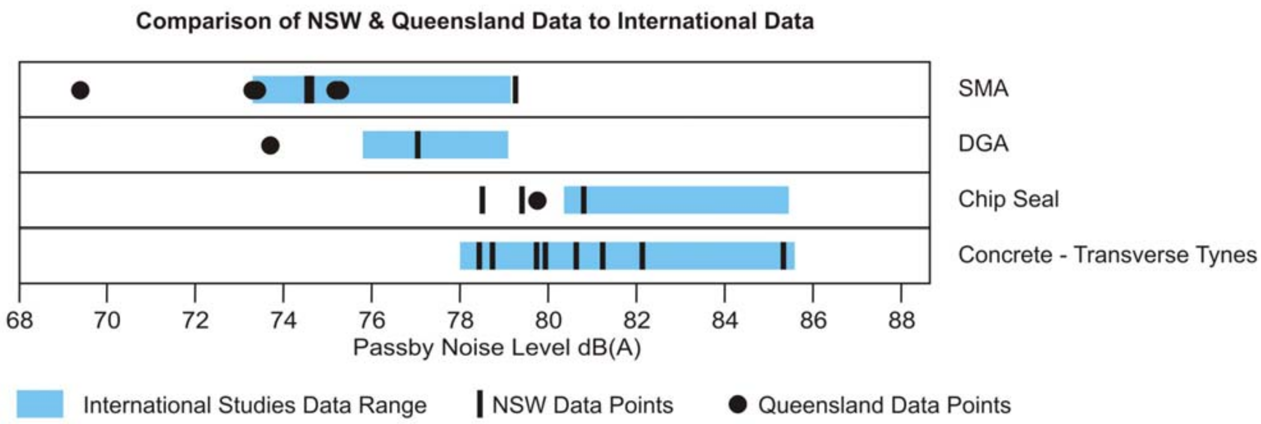

Figure 4. Comparison of noise levels determined in the present subset investigation with those of four other international studies.

6. CONCLUSIONS

On the basis of what appears in the present paper, the following conclusions were made:

- Pavement surface type plays an important role in the generation of vehicle noise and tyre/road interaction is the major component of vehicle noise for cars and trucks in reasonable maintenance travelling at highway speeds.
- Roadside passby noise levels of a car travelling at 80 km/h on SMA, DGA and CS pavement surfaces in NSW compared well with their counterparts in Queensland.
- In both States, the SMA pavements were the quietest, followed by the DGAs and CSs in increasing order.
- The controlled test passby technique proved to be a robust and reliable method, even when somewhat different data acquisition and analysis processes were adopted.
- The outcomes of the present study compared well with those of other international studies.

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