THE LONG TERM ROAD TRAFFIC NOISE ATTRIBUTES OF SOME PAVEMENT SURFACES IN TOWNSVILLE

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Abstract

This paper documents the conduct and outcomes of an extensive study of the noise attributes of several pavement surfaces currently in service in and around Townsville. A specific objective of this study was to examine the acoustic performance of the set of pavement surfaces over time. To do this the study involved two extensive data collection exercises which were separated by one year in time. Analyses of the data produced values of a parameter known as the Statistical Passby Index which was applied to quantifying the acoustic performance of the pavement surfaces over time. It was found that most of the pavement surfaces maintained their acoustic performance over the year. However one which was about the quietest initially exhibited an increase in noise over the year. Some possible reasons for this drop in acoustic performance were also investigated and are reported in the paper.

Introduction

The present paper deals with the conduct and outcomes of an extensive study of the noise attributes of several pavement surfaces currently in service in and around Townsville. A specific objective of the present study was to investigate if and how the noise attributes of the pavement surfaces varied over time. Particular emphasis was given in the study to a group of pavement surfaces that were regarded as providing traffic noise reduction benefits.

The work reported herein comprises one component of a more extensive study being undertaken by the author for the Queensland Department of Main Roads (QDMR) which is directed at investigating the long term noise attributes of pavement surfaces in Queensland. The permission of QDMR to publish the present paper is gratefully acknowledged.

Data Collection and Analysis

Data Collection

The experimental design of the noise study involved collecting samples of passby noise data from three vehicle types (cars, medium trucks and heavy trucks) on five pavement surfaces. These data were collected according to the statistical passby technique, which involved the simultaneous measurement of the noise and the speed of individual vehicles in the traffic stream as they passed by each measurement location (ISO 11819-1:1997) [1].

Roadside measurement locations were set up for this purpose at the five sites. The noise data were collected at all sites by the present author with a Bruel and Kjaer Type 2260 precision Sound Level Meter, the calibration of which was at specification throughout. Speed data were collected at all sites by an assistant utilising a radar speed meter situated adjacent to the noise measurement station. This speed meter was concealed as far as possible so as not to influence driver behaviour at or near to the measurement station. During all the measurements weather conditions were fine and mild throughout, with occasional very light breezes. At all five sites the passby noise levels (dB(A)) and speeds (km/h) were measured repeatedly for around 80 cars, 20 medium trucks and 20 heavy trucks. These data were collected initially in December 2002 and subsequently in December 2003.

Information about the sites, which were located in Abbott and Boundary Streets within metropolitan Townsville, appears in Table I below. Note that the Site Identifiers were specified to be compatible with other similar studies undertaken recently by the author for QDMR. They also relate to the pavement surface types which are as follows.

SMAC: Stone Mastic Asphaltic Concrete
DGAC: Dense Graded Asphaltic Concrete

Reduced photographs of the Abbott Street pavement surfaces are presented in Figure 1 and were taken in December 2003. To appreciate the scale of these photographs, the ball point pen is actually 130 mm long. It may also be reported that SMAC 8 in Boundary Street appeared very similar to SMAC 7 in Abbott Street.

Table 1 Sites Included in the Present Study

Site Location	Pavement Surface Type	Site Identifier
Abbott Street	Boral Novachip	SMAC 5
	Pioneer Hushphalt	SMAC 6
	Boral LoNoise	SMAC 7
	DGAC	DGAC 8
Boundary Street	Boral LoNoise	SMAC 8

Data Analysis

All of the statistical passby data were collated and analysed in accord with the established, scientifically based procedures adopted in other studies such as Samuels and Parnell (2001 and 2003) [2][3]. Parameters involved in the analysis included pavement surface type, vehicle type, vehicle speed and vehicle trajectory to microphone distance. From there, the measured noise levels were applied to calculating a set of Statistical Passby Indices, or SPBIs [1]. Further details about the SPBI are given in Samuels and Parnell (2001 and 2003) [2][3] and will not be repeated here. The SPBI is defined below in Equation 1 [1].

$$SPBI = 10Log\ (W_1 \times 10L_1/10 + W_{2a}(V_1/V_{2a}) \times 10L_{2a}/10 + W_{2b}(V_1/V_{2b}) \times 10L_{2b}/10) \qquad (1)$$

Where:

SPBI = Statistical Passby Index of a given pavement surface (dB)

L_x = Passby noise level of Vehicle Type X on the given pavement surface at a reference speed of V_x and at a reference distance of 7.5m (dB(A))

W_x = Proportion of Vehicle Type X in the traffic (-)

V_x = Reference speed of Vehicle Type X (km/h)

Boral Novachip (SMAC 5)

Boral LoNoise (SMAC 7)

Pioneer Hushphalt (SMAC 6)

DGAC (DGAC 8)

Figure 1. Four of the Pavement Surfaces

There are three vehicle types involved and these are Cars (Subscript 1), Medium Trucks (Subscript 2a) and Heavy Trucks (Subscript 2b).

For the purposes of this paper the SPBIs were calculated for speed conditions, known as “high”, wherein cars and trucks were assigned the reference speeds of 110km/h and 85km/h respectively. A key feature of the SPBI is that it includes the influence of traffic composition and this is achieved through the parameters W_1, W_{2a} and W_{2b}. Thus in order to calculate the SPBI it is necessary to specify the values of these three parameters. This specification was made after consultation with relevant staff of QDMR and on the basis of the present authors’ extensive experiences in the road industry. What ensued was a set of traffic conditions that comprised 90% cars, 5% medium and 5% heavy trucks.

The Pavement Surface Effects on Traffic Noise Over Time

The Statistical Passby Indices

The SPBIs determined for the data collected in both 2002 and 2003 are presented overleaf in Table II where the variations in traffic noise levels with pavement surface type are apparent. Over the five pavement surfaces the total variation in traffic noise from the quietest (SMAC 7) to the loudest (DGAC 8) was 3.8 dB in 2003 and 5.1 dB in 2002.

SMAC pavement surfaces are marketed as “quieter” surfaces and the Table II results confirmed that they did deliver reductions that are both useful and noticeable. Over the year from 2002 to 2003 the acoustic performance of the DGAC 8 and the SMAC 7 pavement surfaces remained essentially constant while that of SMAC 5 improved somewhat. However the performance of the two LoNoise pavements SMAC 7 and SMAC 8 decreased. This observation will be explored further subsequently.

It is useful to consider all the variations of Table II relative to DGAC, so this has been done in Table III. It is very apparent here that the Abbott Street SMAC pavements will produce reduced traffic noise levels, with the LoNoise being demonstrably the quietest. This particular pavement surface produced a 3.8 dB reduction in traffic noise compared to DGAC in 2003. While this is less than the 5.1 dB reduction achieved in 2002, it is still both useful and readily noticeable. However the performance of the LoNoise pavement surface in Boundary Street reduced from a 3.3 dB reduction in 2002 to a negligible 0.5 dB in 2003. Again this observation will be explored subsequently herein.

Pavement surface texture effects

Also shown in Table III are the macrotexture depths of the pavement surfaces which were provided by QDMR during the 2003 data collection period. The corresponding value for DGAC 8A is 0.61 mm, which does not appear in the table. For some time now it has been known that pavement surface macrotexture has a considerable effect on the generation of tyre/road noise and, therefore, on traffic noise (Samuels 1982 [4], Samuels and Glazier 1990 [5], Sandberg and Ejsmont 2002 [6]). Consequently the SPBIs of 2003 were plotted against these macrotexture depths in Figure 2.

What appears in Figure 2 must be considered in two parts: firstly the DGAC and secondly the SMACs. This is necessary because the macrotextures of these two pavement surface types are different in form. In the first case the macrotexture protrudes outwards from the pavement surface whereas in the second it effectively protrudes inwards into the surface. It is this inwards protrusion which provides the reduced noise from SMAC pavement surfaces since it gives these pavement surfaces an apparent type of porosity rather similar to those of Open Graded Asphaltic Concretes[6].

Firstly, DGAC 8A with a macrotexture depth of 0.61 mm produced the loudest noise. On the basis of the extensive data on this topic given in references [4], [5] and in [6], this observation is very much what would be expected. Secondly, with the exception of SMAC 7, there appears to be a trend of reducing traffic noise with increasing macrotexture depth. This is consistent with the theory that greater macrotexture in these types of pavement surface results in more voids being present in the surface structure. That is there is greater apparent porosity which itself leads to more noise reduction [6].

Table II. The Statistical Passby Indices

Location	Site	Pavement surface type	Statistical Passby Index (dB)		
			2003	2002	Change from 2002 to 2003
Abbott Street	SMAC 5	Novachip	79.4	80.8	-1.4
	SMAC 6	Hushphalt	80.1	79.4	0.7
	SMAC7	LoNoise	78.4	76.9	1.5
	DGAC 8	DGAC	82.2	82.0	0.2
Boundary Street	SMAC 8	LoNoise	81.7	78.7	3.0

Table III. Variations in Statistical Passby Indices relative to DGAC

Location	Site	Pavement surface type	DGAC SPBI – SMAC SPBI (dB)		Pavement surface macrotexture depth (mm)
			2003	2002	
Abbott Street	SMAC 5	Novachip	2.8	1.2	1.57
	SMAC 6	Hushphalt	2.1	2.6	1.44
	SMAC7	LoNoise	3.8	5.1	0.80
Boundary Street	SMAC 8	LoNoise	0.5	3.3	0.86

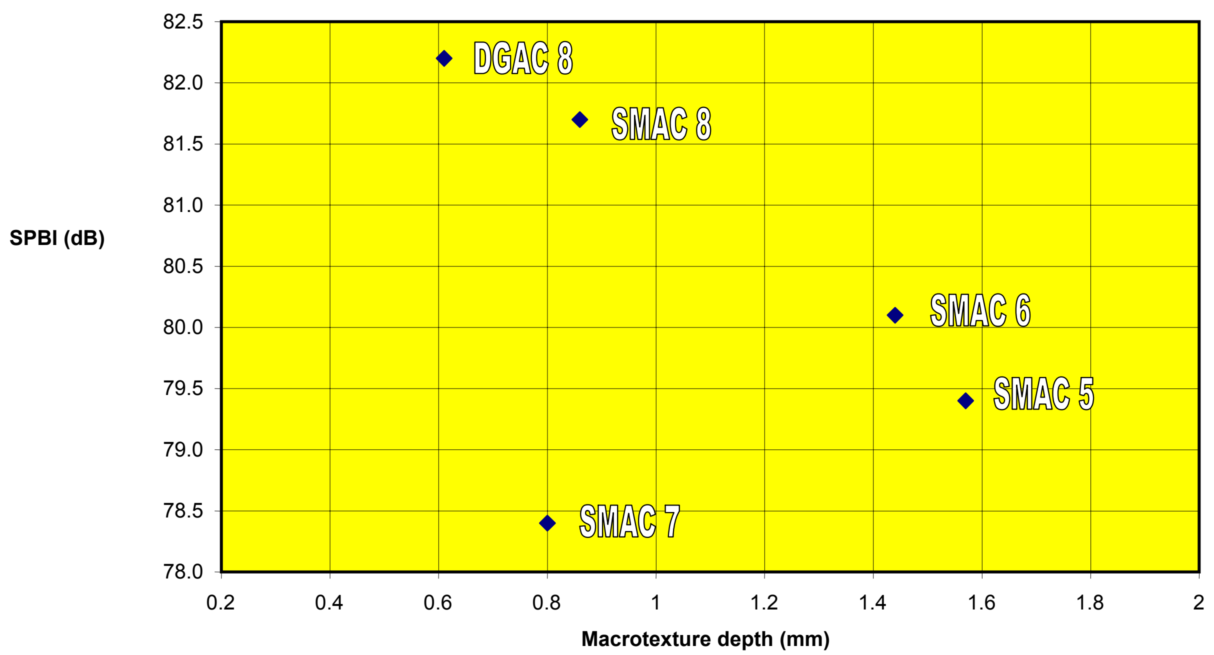

Figure 2. SPBIs measured in 2003 against pavement surface macrotexture

Apparently the SMAC 7 pavement surface behaved somewhat differently here since it produced lower traffic noise while having a macrotexture depth much lower than the other SMAC pavement surfaces. There is not sufficient evidence available to allow further exploration of this observation. One reasonable speculation is that the internal structure of the SMAC 7 (i.e. the apparent porosity) differs from the other SMACs in such a manner as to emulate the noise reducing properties of the other pavement surfaces such as Open Graded Asphaltic Concretes. This matter is worthy of further scientific investigation.

Conclusions

The work reported in this paper has demonstrated the changes in the noise attributes that have occurred over the year on each pavement surface as a direct consequence of changes or other effects that have occurred in the pavement surfaces. Considering firstly Abbott Street, the traffic noise would have decreased slightly on the Novachip over the year. On both the Hushphalt and the DGAC there would have been very small, generally negligible increases in traffic noise over the year. Finally there would have been a slight increase in the traffic noise on the LoNoise. However, in Boundary Street, the traffic noise on the LoNoise would have increased by a considerable 3 dB(A) over the year. To put this increase in context, it is equivalent to the increase that would occur if the traffic volume doubled over the year and all other relevant factors remained constant.

A precise explanation as to why this increase took place was not possible at the time of writing this paper since it would require further scientific investigation. However it can reasonably be suggested that it was the result of some changes that occurred in the LoNoise pavement surface over the year. Perhaps the pavement surface compacted further over the year or became clogged with foreign matter. Maybe the same effects also occurred in the Abbott Street LoNoise pavement surface, but to a somewhat lesser extent than in Boundary Street. This would offer a possible explanation for the slightly lower increase in traffic noise on the Abbott Street LoNoise compared to Boundary Street. There was clear conclusion from the 2003 data that pavement surface macrotexture had a demonstrable effect of the noise generated by the pavement surfaces investigated.

As a consequence of the above conclusions, the present study will be repeated in December 2004 to determine if there is an ongoing trend of increasing noise on the LoNoise pavement surface and to investigate the ongoing performance of all the pavement surfaces included in the present Study.

References

[1] International Standards Organisation, ISO 11819-1:1997, "Acoustics – Methods for measuring the influence of road surfaces on traffic noise. Part 1 – the statistical passby method", ISO, Geneva, 1997.

[2] Samuels, S.E. and Parnell, J. "A novel technique for allowing for the effects of pavement type in the prediction of road traffic noise", Proc. 21st ARRB and 11th REAAA Conference, Cairns, Queensland, Australia, May, 2003.

[3] Samuels, S.E. and Parnell, J. "Some recent Australian developments in the reduction of road pavement noise", Proc. Annual Conf. Australian Acoustical Society, A3.2/1-A3.2/12. Canberra, November 2001. Australian Acoustical Society, Sydney, NSW, Australia.

[4] Samuels, S.E. (1982). "The noise generation of tyre/road noise", ARRB Research Report ARR 121. Australian Road Research Board, Vermont South, Victoria.

[5] Samuels, S.E. and Glazier, G.S.J. "The effects of road surface texture on traffic and vehicle noise", ARRB Research Report ARR 177. Australian Road Research Board, Vermont South, Victoria 1990.

[6] Sandberg, U and Ejsmont, J.A. Tyre/road noise reference book. Informex, Kisa, Sweden, 2002.