THE NOISE PRODUCED BY A CONCRETE BLOCK PAVEMENT

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1. INTRODUCTION

It has been traditionally claimed that concrete block pavements provide potential road safety benefits due to the different noise produced by them compared to asphaltic concrete pavements. That is, the passage of a vehicle over a block pavement would act as a stimulus to the driver (e.g. Hodgkinson and Morrish 1982). This advantage is seen as particularly relevant at low traffic speeds (up to 60 km/h) because at higher speeds, adequate riding quality cannot be achieved on concrete block pavements (e.g. Lilley and Clark 1978; Lekso 1982).

The objectives of an investigation of the noise generation properties of a concrete block pavement were to establish both the magnitude and nature of the noise produced by the block pavement and, where possible, to relate these to comparable attributes of a smooth asphaltic concrete pavement.

2. THE ARRB TESTS

Noise data were collected for a concrete block pavement 90 m long and 4 m wide located at ARRB (Sharp, Armstrong and Morris 1982). The section tested was composed of 80 mm Unipave blocks (see figure 1) laid on a sand bed and a fine crushed rock sub-base. The nominal plan dimensions of the blocks were 220 mm long by 110 mm wide and all edges were chamfered, with the chamfered area being approximately 10 per cent of the total plan area.

Data were recorded via the arrangement shown in figure 2. The microphone was located 1.2 m above ground level on a tripod. Constant speed 'driveby' data were collected at speeds of 20 km/h and 40 km/h. Four sets of tyres were used throughout the tests: two sets of commercially-available tyres, a set of patternless or 'slick' tyres, and a set of experimental tyres that were moulded with tread patterns consisting of uniformly spaced lateral grooves. These four tyre types were identified as numbers 1, 2, 4 and 6 in Samuels (1982) (see figure 3).

Also of interest was the noise generated inside the vehicle as it traversed the pavements. This is a somewhat complex issue which may only be investigated adequately via an extensive experimental program that would vary car, tyre and pavement type. An initial indication of the effects of the concrete block pavement at ARRB was sought by monitoring the interior noise levels as four cars drove over the pavement at speeds of 20 and 40 km/h. For comparative purposes interior noise levels were collected in a similar fashion as the same vehicles drove over the adjacent asphaltic concrete pavement. The first of these vehicles was that used for the previous tests, fitted with a commercially-available set of tyres (number 2 in figure 3), while the remaining three vehicles were selected almost at random from the ARRB car park. Tyre type was not an experimental variable during these tests.

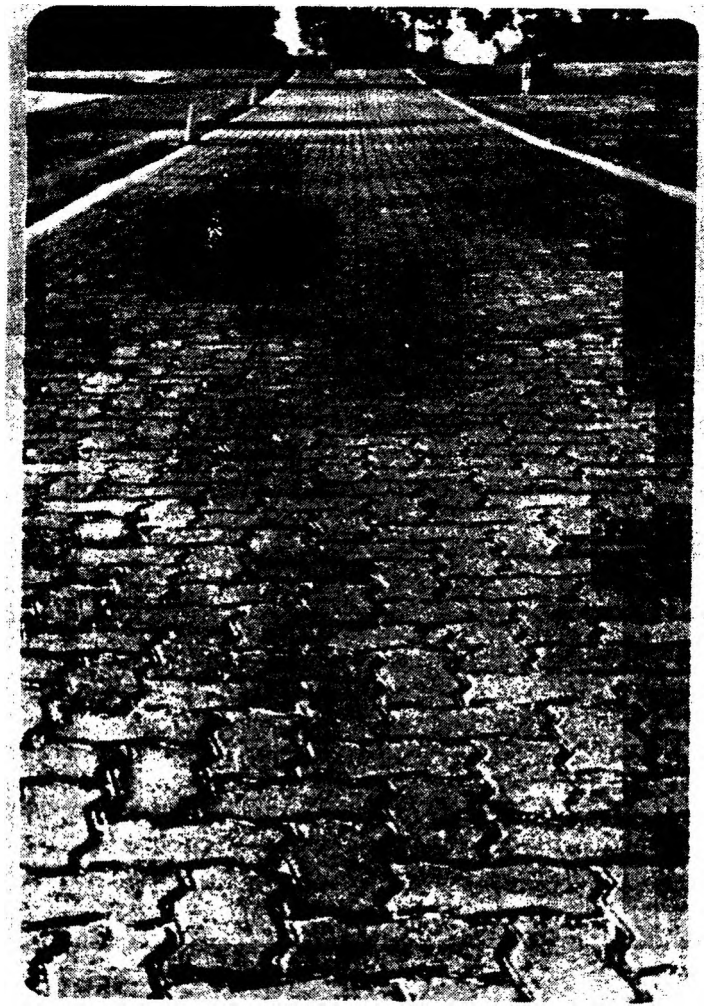

Figure 1. Section of the concrete block pavement tested at ARRB.

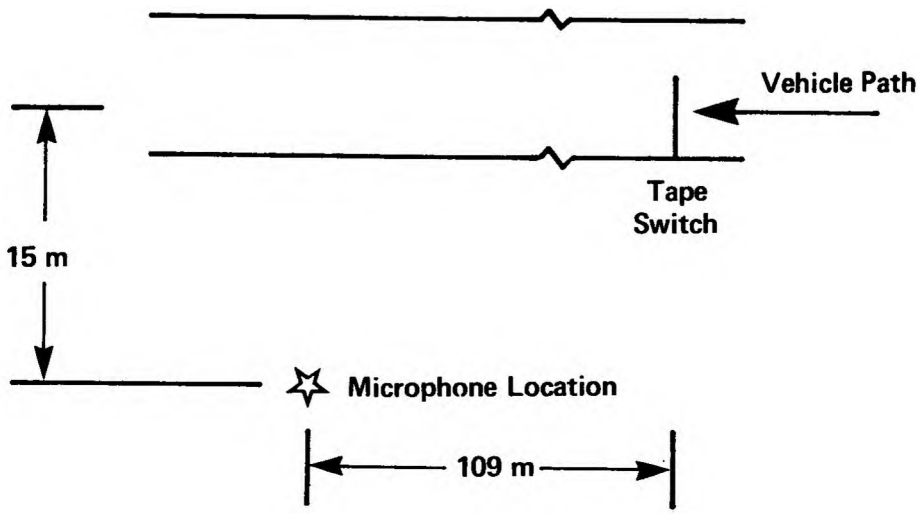

Figure 2. Data measurement arrangement.

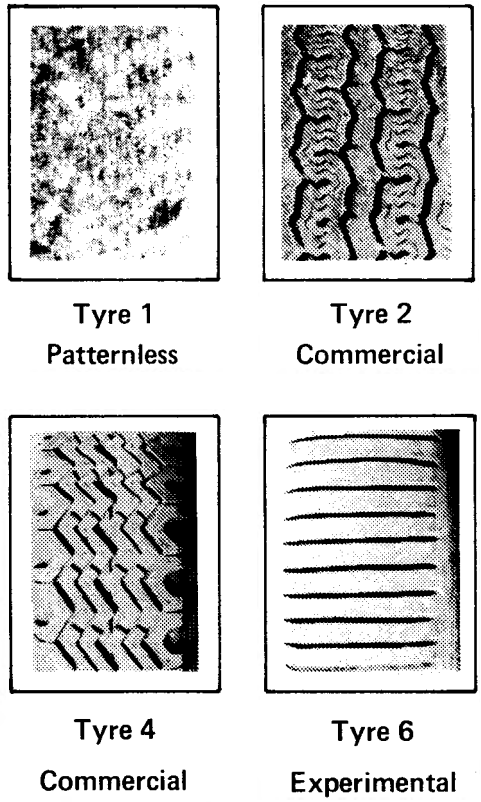

Figure 3. Tyres used in tests.

3. ROADSIDE NOISE

Linear and A-weighted[x] driveby data collected on the concrete block and asphaltic concrete pavements are presented in table 1. Samples of these data are graphed in figure 4, along with similar data extracted from Samuels (1982). Inspecting first the table 1 results it is apparent that there are only small differences between the overall noise levels produced by the concrete block pavement and those produced by the asphaltic concrete. It should be emphasised that the data of table 1 were collected at low speeds of 20 and 40 km/h and that this was so for two reasons. Firstly, concrete block pavements tend to be used in situations in Australia where traffic speeds are low and therefore the primary research interest at ARRB was to investigate the pavement performance under typical operating conditions. Secondly, site conditions and safety considerations restricted the test vehicle speeds to relatively low values. At these low speeds, roadside noise tends to be influenced mainly by engine and exhaust noise sources, rather than by tyre/road interaction (Samuels 1982) and this may offer a first explanation of the table 1 observations.

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x A-weighted sound levels result from sound being passed through an electronic filter which simulates the performance of the human ear. The 'A-weighted' sound levels are measured in dB(A) and more closely represent sound perceived by humans because the low frequency components of sound are substantially filtered.

	Tyre	Concrete Blocks		Asphaltic Concrete	
		20 km/h	40 km/h	20 km/h	40 km/h
Linear Data (dB)	1	63.9	64.5	66.0	65.0
	2	65.5	65.0	66.8	66.7
	4	63.0	65.1	64.0	64.7
	6	65.6	67.0	66.3	68.1
A-Weighted Data (dB(A))	1	43.4	49.9	42.0	48.5
	2	44.3	50.6	42.1	51.1
	4	44.6	51.4	46.5	52.3
	6	46.0	54.7	51.0	57.1

Table 1. Driveby noise data (measured at 15 m).

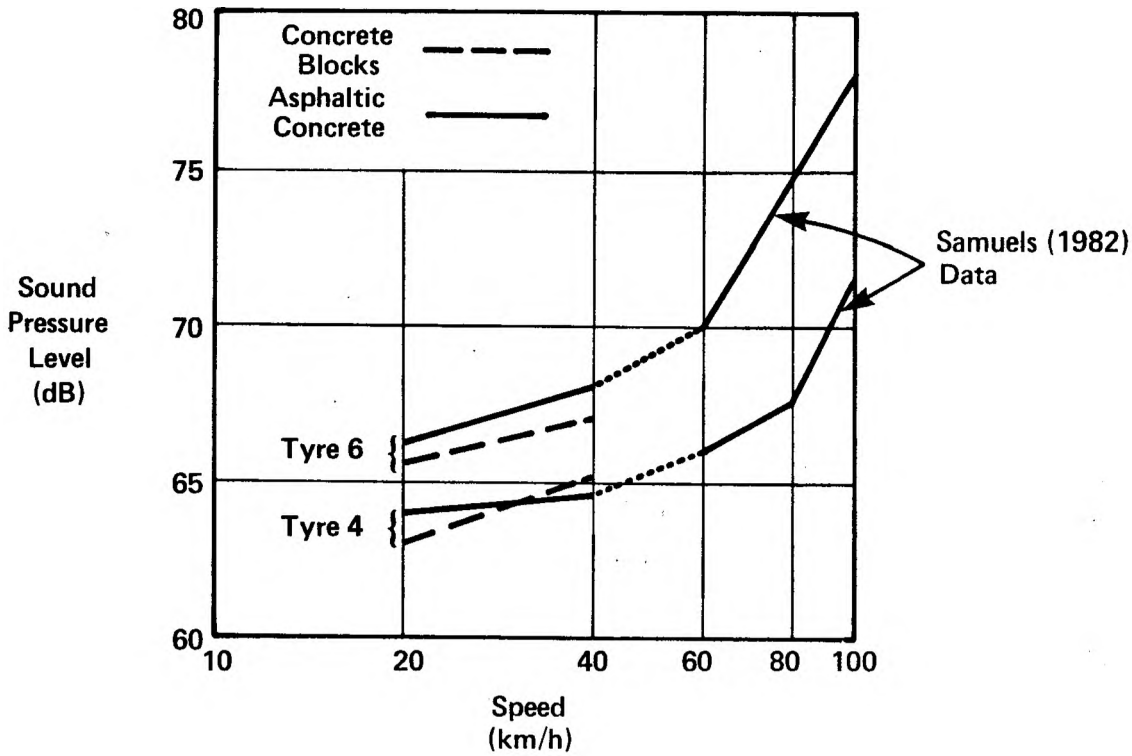

Figure 4. Driveby noise levels.

However, the situation is not quite that simple, as recent research (Sandberg 1979) has indicated that tyre/road interaction becomes the dominant source at around 30 km/h. Since the present test data straddle this speed value, they must be considered to lie in a borderline area, thereby making precise interpretation difficult. This complexity may be resolved in part by examination of the frequency spectra associated with each noise level given in table 1. As an example, two of the spectra associated with the experimental, uniformly-grooved tyre (number 6) operating on both pavements are reproduced in figure 5. On the smooth asphaltic concrete the spectrum is dominated by engine and exhaust related peaks at the lower frequencies (below 150 Hz) and a substantial, tyre-related peak at 420 Hz (Samuels 1982). Similar spectral components are also observed in the concrete block pavement curve, along with some additional low to mid frequency discrete peaks associated with the

block pavement itself. In fact these peaks are related directly to the passing frequency of the concrete block joints which, at 40 km/h, were calculated to occur at various frequencies between 75 Hz and 300 Hz. Although the two spectra of figure 5 are similar in overall level, they differ distinctly in spectral character. The two noise signals described by these spectra would, therefore, appear to a roadside listener as quite different. In fact the block pavement spectrum of figure 5 has quantified the low frequency 'thumping' sound usually associated with the passage of vehicles over such a pavement. Similar observations and conclusions were made regarding the spectra of the other data in table 1.

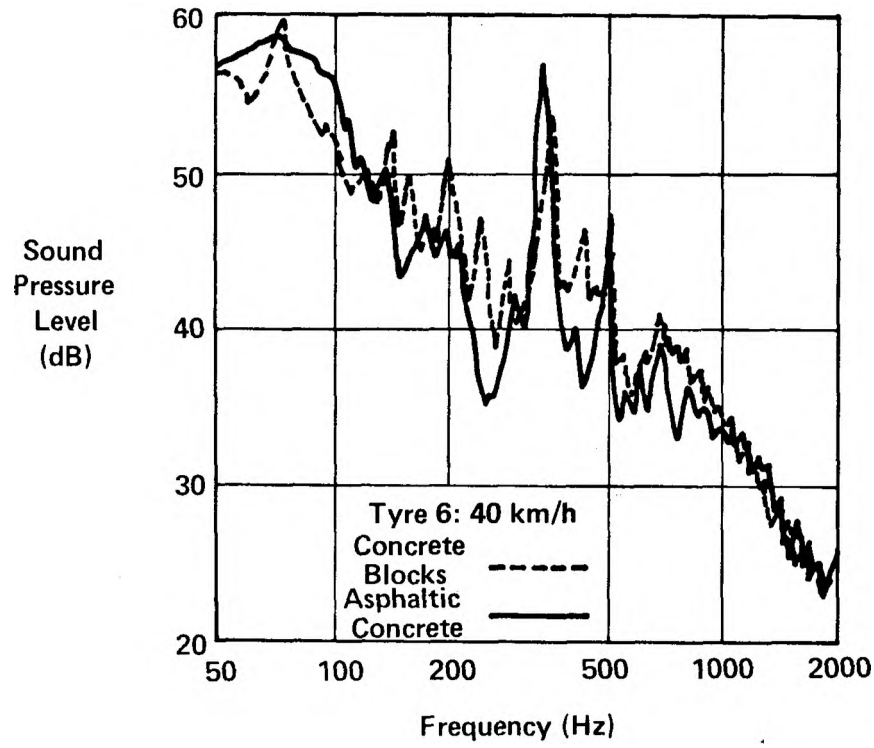

Figure 5. Driveby spectra.

Returning to figure 4, only a small variation in noise level with speed is observed. Again, this may be explained in terms of the figure 5 spectra and in particular it is most likely the result of the strong influence of the engine and exhaust components at these low speeds. The levels measured at ARRB are also shown in figure 4 to be consistent in terms of magnitude with those measured previously by Samuels (1982). The latter data vary more sharply with speed. Altogether, figure 4 suggests that constant speed roadside noise levels decrease with decreasing speed and probably reach a lower limit or plateau at the lower speeds.

4. INTERIOR NOISE

Noise levels monitored inside the four passenger vehicles while driving over the concrete block and asphaltic concrete pavements are presented in table 2, along with brief specifications of the four vehicles. Again, for each vehicle there are only small differences in the overall levels produced on the concrete block pavement compared with those on the asphaltic concrete pavement. The block pavement linear levels are

consistently higher by around 2 dB at 20 km/h and 4 dB at 40 km/h than the asphaltic concrete pavement levels. Indeed, these levels exhibit greater between-vehicle variability on the concrete block pavement and this probably reflects the complex manner in which noise is transmitted from the tyre/road interface, through the vehicle structure and into the passenger cabin.

		Concrete Blocks		Asphaltic Concrete	
	Vehicle	20 km/h	40 km/h	20 km/h	40 km/h
Linear Data (dB)	1	99.0	105.0	97.0	101.0
	2	94.0	95.0	92.0	92.0
	3	97.0	103.0	95.0	99.0
	4	95.0	101.0	93.0	97.0
A-Weighted Data (dB(A))	1	62.0	64.0	58.0	60.0
	2	57.0	59.0	55.0	55.0
	3	60.0	64.0	56.0	61.0
	4	58.0	63.0	54.0	60.0

Vehicle 1 Ford Falcon, Station Wagon
V8 motor, 4 speed manual transmission
Goodyear ER70-14 tyres

Vehicle 2 G.M. Commodore, Sedan
6 cylinder motor, 3 speed automatic transmission
Uniroyal GR60-14 tyres

Vehicle 3 Ford Falcon, Station Wagon
6 cylinder motor, 3 speed automatic transmission
Dunlop ER70-14 tyres

Vehicle 4 Toyota Corona, Sedan
4 cylinder motor, 3 speed automatic transmission
Goodyear 175-13 tyres

Table 2. Interior noise data.

An important observation in table 2 concerns the relative magnitudes of the linear and A-weighted noise levels. In all cases the A-weighted levels are some 37 to 41 dB lower than the linear levels, thereby indicating that the passenger cabin noise signatures are comprised of substantial low frequency components. Based on the earlier figure 5 data, it could reasonably be suggested that the concrete block pavement would generate primarily low frequency interior noise levels. However, considered alone, the A-weighted levels exhibit similar trends to those already observed of the linear levels. Consequently, it would appear that the components of interior noise due to the concrete blocks have largely been masked by existing high levels of low frequency noise.

These results do not necessarily mean that vehicle passengers would not notice interior noise components associated with the concrete block pavement. As indicated previously, such components would probably comprise discrete frequency peaks which are readily picked out by the frequency selective human ear. Rather, the results suggest that the concrete block pavement had only a minor, possibly negligible, influence on the measured vehicle interior noise.

5. SOME CONCLUDING REMARKS

A limited set of low speed experiments has suggested that the concrete block pavement at ARRB did not generate high levels of roadside noise. The noise levels generated were found to be very similar to those produced by an adjacent smooth asphaltic concrete pavement. However, the concrete block pavement did generate discrete peaks in the roadside noise frequency spectrum and these peaks would be readily noticed by roadside observers.

For passengers inside a vehicle traversing the concrete block pavement at low speed, the noise associated with the pavement might only just be noticed. Much of the block pavement noise monitored inside four vehicles seemed to be masked by existing high levels of low frequency noise.

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