inter-noise 96
25th Anniversary Congress – Liverpool

INCE: 52.3

ALTERNATIVE TEXTURES FOR CONCRETE ROADS: A COMPARISON OF VEHICLE NOISE EMISSION LEVELS FOR RECENTLY CONSTRUCTED ROAD SURFACES

P G Abbott & S M Phillips

Transport Research Laboratory, Crowthorne, Berkshire, RG45 6AU, UK

1. INTRODUCTION

High speed roads with concrete surfaces are generally regarded by the population as being associated with higher noise than similar roads surfaced with bituminous materials. One factor which has contributed to excess noise is the difficulty of controlling the level of texture of conventional brushed concrete surfaces. Some concrete surfaces constructed in recent years have had excessive textures created during the brushing process resulting in high levels of tyre/road noise. Additionally public perception has been heightened by media attention and increased awareness of particularly quiet road surfaces such as Porous Asphalt.

In 1992 the Minister for Roads announced new measures to combat the problems of road traffic noise [1]. The most significant elements of this were restrictions on the further use of concrete surfacings on all roads carrying traffic flows greater than 75,000 vehicles per day and research to evaluate alternative construction techniques that would result in quieter concrete surfaces.

This research was to include trials of a method of texturing concrete surfaces called exposed aggregate concrete which has been used in a number of other European countries. The texture of this surface was increased to meet UK specifications. The US practice of texturing concrete surfaces using tines and a burlap drag was also included in the first trial. A second trial of the exposed aggregate technique was then carried out on a larger scale.

The aim of the trials was to identify a concrete road surface satisfying the surface performance and safety standards required by the UK Department of Transport (DOT), without causing unacceptable noise levels. The Transport Research Laboratory has monitored the acoustic and skidding performance of the trial surfaces. This paper presents the results from these trials and compares their acoustic performance with measurements on a number of other newly laid surfaces (including Porous Asphalt).

2. MEASUREMENT SITES

This study compares surfaces laid at three sites. Two of these included sections of exposed aggregate concrete which were laid as part of trials for the UK Department of Transport (DOT) and the third was a new Porous Asphalt surface studied for the Welsh Office Highways Directorate.

The first concrete trials were carried out on both carriageways of a 3.4 km length of the M18 Motorway in Northern England. Four different surface types were laid for comparative assessment and the road was opened to traffic in autumn 1993. Two of the surfaces were conventional UK motorway surfaces - a Hot Rolled Asphalt and a brushed concrete surface. The two novel concrete surface types on trial were exposed aggregate (two sections with a total length of 1.2 km) and transversely tined with a burlap drag.

The exposed aggregate sections were laid using the normal contractors plant for paving concrete roads. The surface was then sprayed with a chemical retarding agent which slowed the setting of the surface layer of cement mortar. After allowing an appropriate time period for the underlying concrete base to cure (i.e. between 12 and 30 hours depending upon weather conditions) the surface cement mortar was removed by mechanical brushing which exposed the coarse aggregate to form the surface. The aggregate exposed forms a random texture comparable to an asphalt with chippings.

The texture requirements for the exposed aggregate surfaces were specified to give a level of texture comparable to that applied to conventional motorway Hot Rolled Asphalt (HRA) bituminous surfaces. This required the average texture depth measured by the volumetric sand patch method to be 1.5±0.25 mm.

The burlap and tined surface was created by dragging burlap longitudinally along the smooth concrete surface to provide microtexture. Randomly spaced 3 mm wide steel tines were then drawn transversely across the carriageway to give macrotexture. The texture specifications for this surface were the same as those applied to the conventional brushed concrete. The sand patch texture depth specified in this case was 1.0±0.25 mm.

The second exposed aggregate trial was on the A50 trunk road near Derby in Central England and was opened in the Spring of 1995. The specification and production of this was essentially the same as the first trial, except for minor adjustments to the aggregate composition. The class of aggregate required to meet the wear criteria for the less heavily trafficked A50 was slightly lower and there was a higher aggregate density in the concrete mix. As on the M18 a new Hot Rolled Asphalt surface was laid nearby for direct comparison.

The third site reported in this paper was on the M4 near Cardiff in South Wales. This was a 3.2 km length and was overlaid in May 1993 with a Porous Asphalt surface made to a draft version of the DOT Specification with a maximum aggregate size of 20 mm and a layer thickness of 50 mm. This specification is designed to achieve maximum acoustic absorption within the frequency range 800 to 1000 Hz [2].

3. MEASUREMENT METHOD

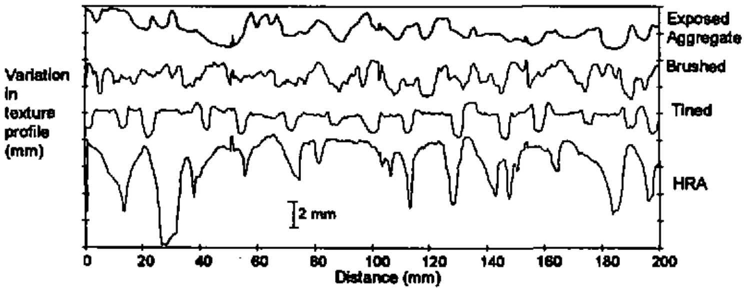
Locations were chosen where vehicle noise measurements adjacent to each of the surfaces could be carried out using the Statistical Pass-by (SPB) method. This method has recently been formalised as a draft international standard as the preferred method for the comparison of road surface influence on traffic noise [3].

In the Statistical pass-by method the maximum A-weighted noise level and the simultaneous speed are measured at the roadside of a significant number of individual vehicles selected from the traffic stream. The measurement microphone was located at 7.5 m from the centre of the test lane and was connected to a ⅓ octave analyzer. All of the vehicles measured were categorised into one of two vehicle classes, 'light' (ie. all cars and small vans) and 'heavies' (heavy goods vehicles). A regression of noise against the logarithm of vehicle speed was performed for both vehicle groups. From the regression statistics the maximum vehicle noise level was calculated at a reference speed of 90 km/h.

The number of sites measured adjacent to each of the surfaces is shown in Table 1. Noise measurements were carried out after approximately one month of trafficking.

Various surface measurements were also made at each of the sites on the M18 and A50 trial sections over a 10 m length of the nearside wheeltrack adjacent to the microphone position. These included sand patch textures, laser scanned profiles and skidding resistance tests. These are not fully reported here, but, representative profiles of the surfaces are shown in Figure 1. The random nature of the exposed aggregate shown at the top is in sharp contrast to the more regular shape of the tined concrete. The larger size of the chippings in the HRA is evident in the lower trace.

Figure 1. Longitudinal profile of nearside wheel track



4. RESULTS

Statistical Pass-by vehicle noise measurements were conducted as described in Section 3. The results have been used to determine the maximum vehicle noise level for the light and heavy vehicle categories. The results for each type of surface have been averaged and are shown in order of noise level in Table 1.

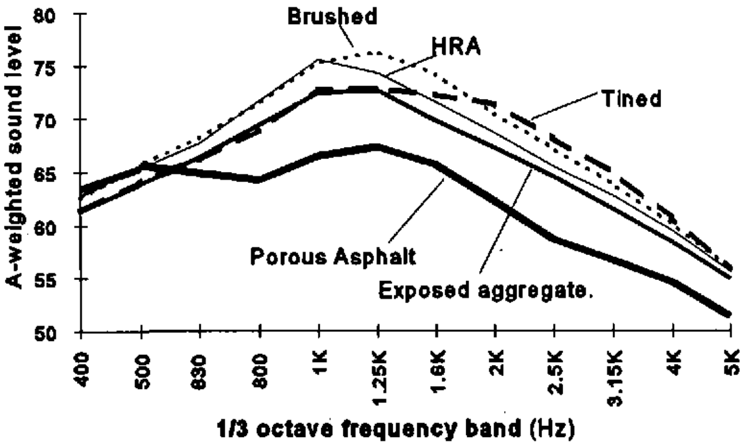
Table 1. Summary of SPB vehicle noise levels and texture after one month of trafficking

Road	Surface type	No. sites	Mean sand-patch texture depth in mm	Mean maximum vehicle noise level in dB(A) [90 km/h at 7.5 m]	
				Light	Heavy
M18	Brushed	1	1.0	82.1	88.4
M18+A50	HRA	3	2.1	81.8	87.8
M18	Tined	1	0.7	80.2	87.4
M18+A50	Exposed agg.	6	1.7	79.2	86.5
M4	PA	3	n/a	75.4	84.2

The results show that the noise levels from light vehicles travelling upon the exposed aggregate surfaces were over 2.5 dB(A) lower than those on the two conventional surfaces, HRA and brushed concrete. Similarly, the noise levels for the heavy vehicles were 1.3 and 1.9 dB(A) lower than on the HRA and brushed concrete surfaces respectively. For the tined concrete surface, the light vehicle noise levels were again lower than on the conventional surfaces by over 1.5 dB(A). The differences between the noise levels of heavy vehicles were smaller with the tined surface levels 0.4 dB(A) lower than the HRA and 1.0 dB(A) lower than on the brushed concrete.

Substantially lower noise levels were measured adjacent to the Porous Asphalt when newly laid compared with the conventional surfaces. For light vehicles, the levels were about 6.5 dB(A) lower, whilst the heavy vehicle noise levels were 4.2 and 3.6 dB(A) lower than on the brushed and HRA surfaces respectively. The frequency spectra of the average maximum vehicle noise level for light vehicles on different surfaces are shown in Figure 2.

Figure 2. Noise spectra for light vehicles on new surfaces



Band levels above 1.25 kHz were higher for the transversely textured surfaces than for randomly textured surfaces. Although the overall light vehicle noise levels for the two trial surfaces differed by only 1 dB(A), above 1.25 kHz the band levels for the exposed aggregate concrete surface were up to 4 dB lower. In the higher frequency range the levels for the randomly textured exposed aggregate were similar to those of the HRA. However, the HRA surfaces produced higher noise levels in ⅓ octave bands below 1 kHz. The band levels for the new Porous Asphalt surfaces were much lower than that of all the other surfaces at frequencies above 630 Hz.

5. DISCUSSION AND CONCLUSIONS

The trials have demonstrated that concrete roads combining good acoustic performance and meeting safety requirements can be produced using the exposed aggregate technique. Whilst the acoustic performance of newly laid Porous Asphalt is superior, exposed aggregate concrete may provide an acceptable and durable alternative in many cases. It is hoped that further trials will be carried out to optimise the texture characteristics of the exposed aggregate surface leading to lower noise levels. However whilst lowering noise levels will be an important consideration, the retention of the safety performance of the surfaces will be paramount. Tined concrete may provide a cost effective option for future consideration.

Differences in the noise spectrum may influence the perception and characterisation of noise. Consequently, it is possible that the noise generated by vehicles travelling over, for example, the tined surface may be perceived differently to the same vehicles travelling over the exposed aggregate surface by a greater degree than that implied by the relatively small difference in the overall levels in dB(A). The effect of the differences between the spectral characteristics of the different surfaces on perception is the subject of on-going TRL research [4].

The performance of existing exposed aggregate and Porous Asphalt surfaces will continue to be monitored to determine their acoustic durability under traffic. The good performance of the exposed aggregate trial surfaces will allow the restrictions on concrete surfaces for heavily trafficked roads to be reviewed

6. ACKNOWLEDGEMENTS

This paper is based upon work carried out in the Safety and Environment Centre of the Transport Research Laboratory. The authors are grateful for the assistance of The Highways Agency of the Department of Transport and the Welsh Office Highways Directorate.

7. REFERENCES

[1] DEPARTMENT OF TRANSPORT. Minister announces steps to tackle road traffic noise. Department of Transport Press Notice No. 204. London. 28 July 1992

[2] S M PHILLIPS, P M NELSON AND P G ABBOTT. Reducing noise from motorways: The acoustic performance of porous asphalt on the M4 at Cardiff. Institute of Acoustics, 1995 Spring Conference. ISBN 873082 73 8, Institute of Acoustics, St Albans (1995).

[3] INTERNATIONAL ORGANISATION FOR STANDARDIZATION, ISO/DIS 11819-1 ACOUSTICS - Method for measuring the influence of road surfaces on traffic noise - Part 1: 'The Statistical Pass-by method. Geneva (1995).

[4] G R WATTS. Perception of exterior noise from traffic running on concrete and bituminous road surfacings. Journal of Sound and Vibration 191(3), 415-430 Academic Press, London (1996)