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Trials of a mobile MLS technique for characterising road surface absorption

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Abstract

A test based upon Maximum Length Sequence (MLS) methods has been developed for the in-situ measurement of the sound absorption of porous road surfaces. This test is described in a draft ISO standard and allows a relatively large area of road surface to be examined over a wide frequency range without the need to extract core samples. In addition, because the signal to noise ratio is very high, valid roadside measurements in the presence of traffic can be realised. Currently these tests are carried out using static MLS equipment, however it would be advantageous to have a mobile method. This is because the requirement to close a lane to traffic in order to gather large numbers of samples largely precludes measurements being carried out on many busy roads. Therefore, TRL has examined the feasibility of conducting such measurements from a mobile platform. This paper describes initial trials carried out on a number of test surfaces using a specially designed trailer suitable for both static and moving measurements. Dynamic measurements were taken on a range of road surfaces including both absorptive and reflective surfaces at speeds up to 20 km/h.

1. Introduction

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To undertake static in-situ measurements of the acoustic properties of a road surface requires at minimum a single lane closure, which can be both costly and disruptive to traffic. Measurements using traditional procedures impose limitations, since cores must be extracted from the road surface or the test apparatus must be set up directly on the road surface. The development of an appropriate mobile technique would overcome these problems. The MLS technique has been demonstrated, e.g. [1], to offer advantages over traditional methods due to the short duration of the measurements and the use of apparatus which does not require to be in contact with the road surface. The system is therefore appropriate for mounting on a mobile platform.

2. Measurement Set-up

The measurement set-up is shown schematically in Figure 1 and conforms to that detailed in the draft ISO standard [2]. The orientation of the microphone and loudspeaker is such that the

impulse response corresponding solely to that part of the signal reflected from the road surface is obtained using signal subtraction techniques. An FFT is applied to each of the impulse responses and the absorption coefficient of the surface under study calculated using the equation

$$\text{Absorption coefficient, } \alpha(f) = 1 - |R(f)|^2 = 1 - \frac{1}{K_r^2} \left| \frac{H_r(f)}{H_i(f)} \right|^2 \quad (1)$$

where $H_i(f)$ is the transfer function of the direct path, $H_r(f)$ is the transfer function of the reflected path, and K_r is the factor to take account of geometrical spreading such that

$$K_r = \frac{d_s - d_m}{d_s + d_m} \quad (2)$$

with d_s and d_m being the loudspeaker and microphone heights shown in Figure 1.

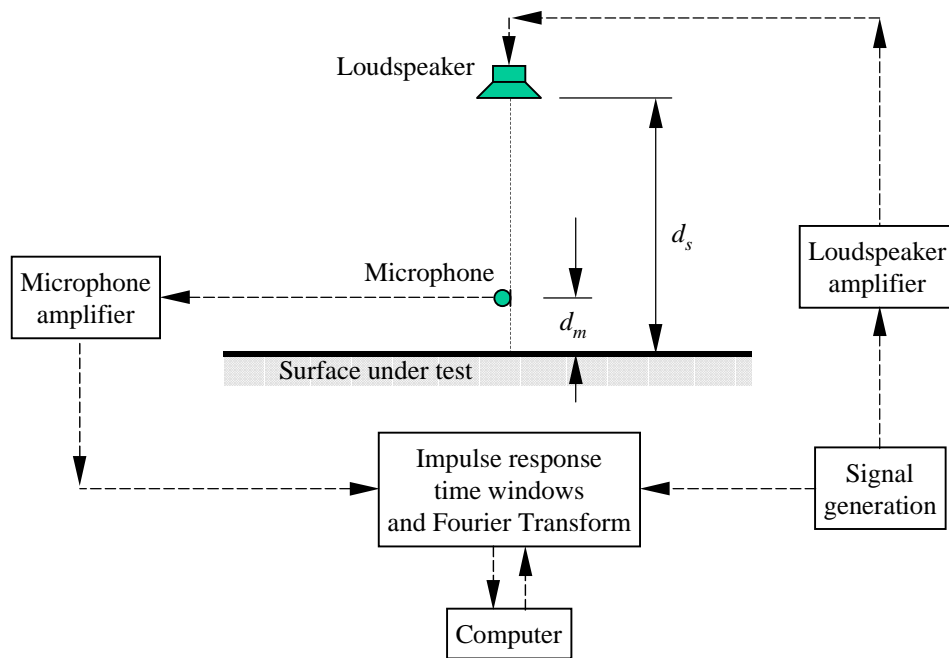


Figure 1: Components of the MLS measurement setup

The loudspeaker and microphone have been mounted onto a trailer system, the second prototype of which is shown in Figure 2. The trailer has been designed so as to minimise the likelihood of parasitic reflections within the preferred time window, and to provide a stable, rigid platform during towing. The loudspeaker has been developed by TC226 WG6 Research Group "Adrienne" specifically for performing MLS measurements [3], and the microphone is a standard ½" B&K Type 4149 microphone. The two are connected together using a lightweight mounting frame (Figure 2) which maintains the required separation $(d_s - d_m) = 1.0$ m, where $d_m = 0.25$ m.

3. Results

Validation of the trailer under static conditions was performed by comparing absorption coefficients calculated from MLS data with those obtained for the same surfaces using



Figure 2: The MLS trailer system and the loudspeaker/microphone arrangement

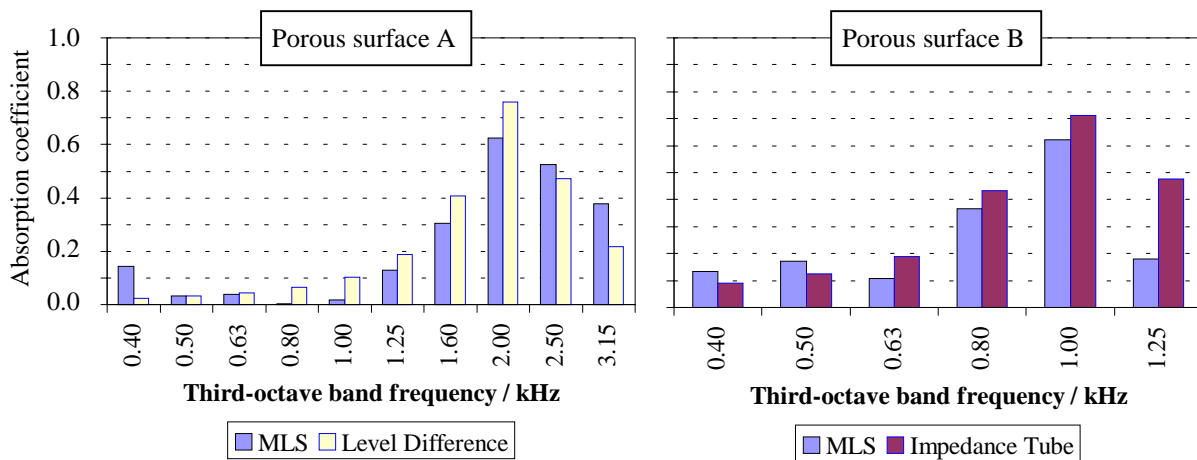


Figure 3: Comparison of absorption coefficients calculated using static MLS and other methods

standard impedance tube and level difference measurements. Figure 3 shows the comparisons for two different porous surfaces. Following this, dynamic MLS measurements were performed on the TRL test track, towing the trailer at speeds of 8, 15 and 20 km/h on three different surfaces: Hot Rolled Asphalt (HRA), brushed concrete and a porous road surface. However the free-field signal (direct path impulse response) was measured under static conditions. The FFT analysis was performed using a 4 ms rectangular time window. The calculated absorption coefficients are presented in Figure 4 for third-octave band frequencies above 800 Hz (inaccuracies were observed for calculations at lower frequencies) and are compared with the corresponding coefficients calculated from the static measurements.

On all three surfaces, it is observed that the predictions at 800 Hz are largely independent of speed. As the speed increases, so the surfaces are indicated to become increasingly

absorptive above 1 kHz. In the case of the brushed concrete, the comparison between the static and dynamic coefficients is particularly poor. However MLS is known to be poor for measurements on reflective surfaces. As expected, the best agreement is observed for the porous surface.

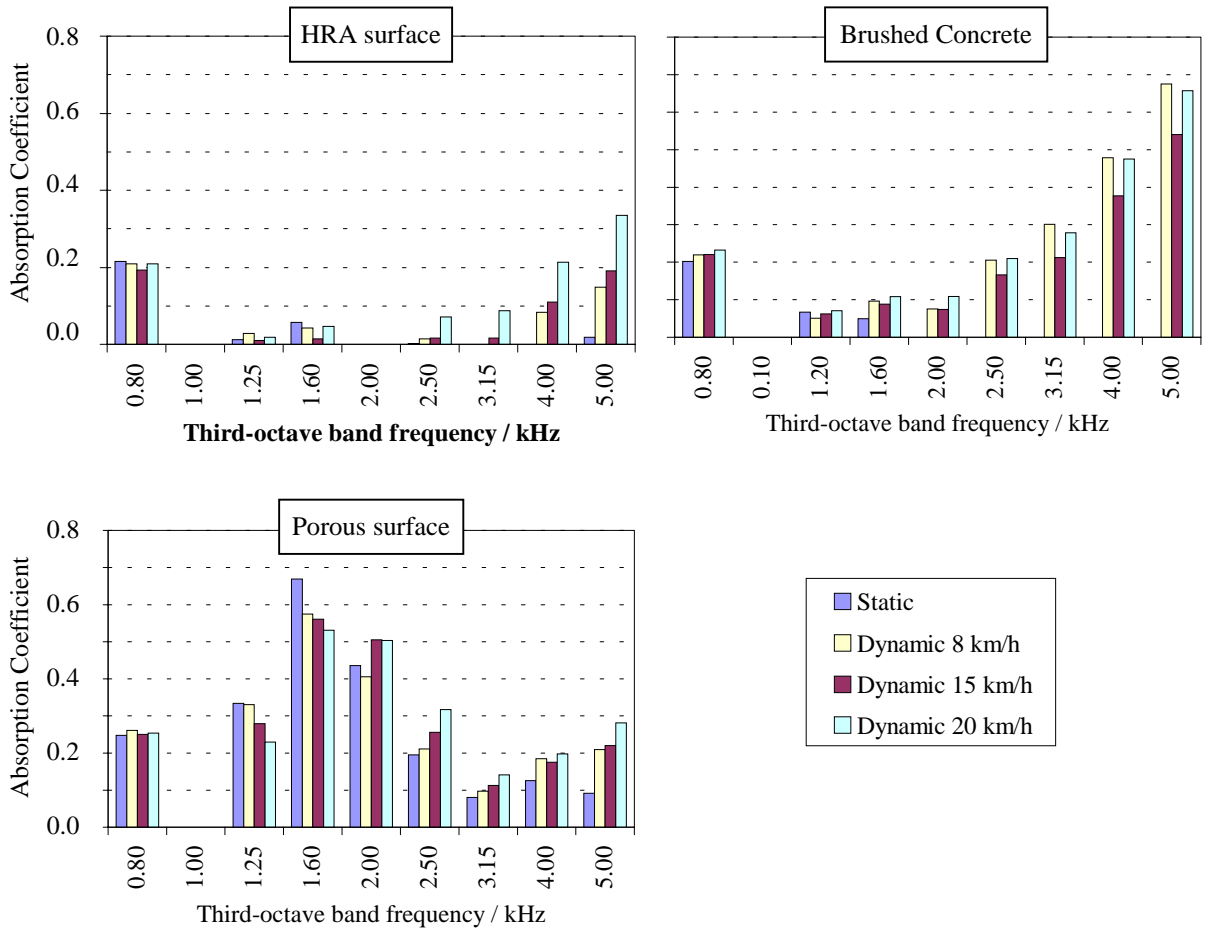


Figure 3: Comparison of absorption coefficients for different surfaces calculated from static and dynamic MLS measurement data

Further research is aimed at improving the accuracy of the dynamic measurements using improved measurement and signal processing techniques.

Conclusions

Measurements taken on a range of road surfaces on the TRL test track have demonstrated that the MLS technique has the potential to be applied as a dynamic measurement method for determining the acoustic characteristics of porous road surfaces. Further work is underway to examine some of the practical issues involved, principally those associated with changes in the geometry of the direct and reflected signals under dynamic operation and the possible influence of atmospheric turbulence.

References

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- [3] European Commission, "Test methods for the acoustic performance of road traffic noise reducing devices, SMT Project MAT-CT94049 "Adrienne" – Final report", 1998.