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TRAFFIC INDUCED VIBRATION IN DWELLINGS

Robert
R.C. HILL

Scientific Branch, Greater London Council

Introduction

Over the past two years the Greater London Council and the Transport and Road Research Laboratory have been collaborating in a study of vibration in dwellings caused by road traffic. The aims of the current phase of the project are to study the subjective response to vibration in dwellings and to relate this response to physical measurements. TRRL have carried out a social survey and have made 24-hour measurements of external low frequency noise and traffic volumes. The GLC contribution to the project consisted of short-term measurements of vibration in each of the areas where the social survey was carried out. Additional measurements of low frequency noise and traffic parameters were made as a control to ensure that the sets of data from the two establishments were consistent. This paper reports the measurements and discusses the relationship between vibration, low frequency noise and traffic parameters. At a later stage it is hoped to relate these measurements to the social survey responses.

Selection of Sites

The aim of the social survey was to establish the response of similar populations to a wide range of traffic conditions and resulting noise and vibration environments. The range of variables likely to affect the subjective responses and physical measures of noise and vibration was reduced by selecting survey areas that all had similar types of property adjacent to the road. The dwellings were all two storeys high, built during the inter-war period and were mostly of the semi-detached type. In all 14 survey areas were selected. All of these were within the Greater London area, mainly in the northern and western suburbs.

The vibration measurements were made in the front ground floor room of one typical dwelling in each of the social survey areas. The decision to make the measurements in occupied buildings created its own set of problems, since many of the households visited included young children and it proved virtually impossible to persuade children of pre-school age to remain still and silent for a period of 20 minutes. Although this and other activities within the dwellings caused much higher vibration levels than those induced by the traffic, the duration of these unwanted signals was very short, being largely impulsive in nature. At the time of measurement it was considered that these transients would have relatively little effect on time averaged units such as L_{10} and L_{eq}.

Measurements

The measurement and analysis techniques employed in this study were developed in an earlier phase of the work and have already been reported in detail (ref.1) so this paper includes only a brief description of the methods used.

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Floor vibration in the vertical plane was measured using a piezoelectric accelerometer attached directly to the centre of the timber floor span about 2 - 3 metres from the window. The horizontal vibration in the window was monitored by mounting an accelerometer to the centre of the window pane using beeswax A condenser microphone mounted 1 metre from the facade was used to measure the external low frequency noise. All three of these signals were recorded simultaneously for a period of 20 minutes on an FM tape recorder. The microphone channel was calibrated using an audio frequency calibrator while an insert voltage system was used for the vibration transducers.

During the recording period the total numbers of light and heavy vehicles passing the dwellings were noted. Records were also kept of the major dimensions of the room and of the distances to the kerb and centreline of the road.

Analysis

A real time analyser with a nominal integration time of 1 second was used to obtain ⅓ octave band RMS levels of both low frequency noise and vibration. At this stage the analysis has been limited to the frequency range 25 - 500 Hz although the recorded data covers a wider bandwidth. A small computer was used to calculate the common percentile levels peak level and equivalent continuous level in each ⅓ octave band. Linear levels over the whole of this frequency range were also computed and in the case of the external low frequency noise the dB(A) levels were included.

Because of the unwanted levels of vibration caused by the building occupants it was considered inappropriate to use the peak, 1% or 5% levels for further study. As in the earlier phases of this study (refs 1 & 2) L_{10}, L_{50}, L_{90} and L_{eq} at any particular site all yielded spectra of almost identical shape but at varying levels. L_{eq} levels have been arbitrarily chosen for the presentation of results in the remainder of this paper.

Results

The external low frequency noise levels exhibited a variation in overall level but a strong similarity in the shape of the frequency spectrum at each of the 14 sites. As expected these spectra showed peaks in the 50 - 100 Hz region corresponding with the vehicle exhaust noise emission frequencies. Figure 1 gives the mean L_{eq} level ± 1 standard deviation for the frequency range 25 - 500 Hz. dB(A) levels over the range 25 - 2000 Hz are also presented.

The levels of floor vibration did not follow the same consistent pattern; each site gave a different frequency spectrum. This appeared to be at variance with the observation made on site that as the noise level rose, the level of vibration in the floor also increased. However, these variations in the spectra could be attributed to resonance effects within the dwellings which varied with room and window dimensions. When the mean values of L_{eq} acceleration for all the sites are plotted (fig.2) a frequency response emerges which is very similar to that for the external low frequency noise although the standard deviations are substantially greater. At this stage no detailed analysis of the window vibration data has been carried out.

The traffic volumes at the sites produced an even distribution over the range 170 - 2800 vehicles per hour with the percentage of heavy vehicles ranging from 9 - 41%. Correlations between these traffic parameters and the levels of noise and vibration are weak with low levels of significance (typically, $r = 0.4$ significant at the 10% level), although some improvement may be achieved when the low frequency noise data is corrected for variation in distance from the road.

In view of these results it does not appear possible at this stage to base a reliable prediction method for floor vibration levels in dwellings on traffic parameters alone. The similarity between the mean L_{eq} level spectra for low frequency noise and for vibration is encouraging but for individual sites the variation in vibration level due to room resonances is greater than the variation induced by the low frequency noise. Analysis techniques that will allow the individual sites to be normalized are currently being developed.

Acknowledgement

This paper is presented with the permission of the Scientific Adviser of the Greater London Council but the views expressed are those of the author and are not necessarily those of the Council or any of its departments.

References

1 D.J. MARTIN, P.M. NELSON and R.C. HILL: 1978: TRRL report SR 402: Measurement and analysis of traffic-induced vibrations in buildings.

2 D.J. MARTIN: 1978: TRRL report SR 429: Low frequency traffic noise and building vibration.

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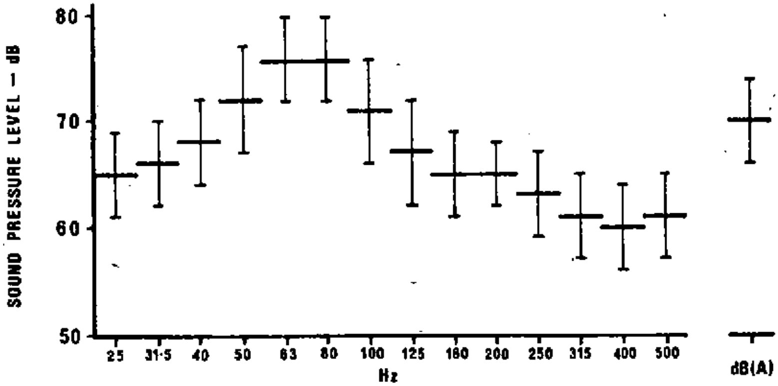

FIGURE 1: External low_frequency noise levels
Mean L_{eq} level ± 1 standard deviation for 14 sites

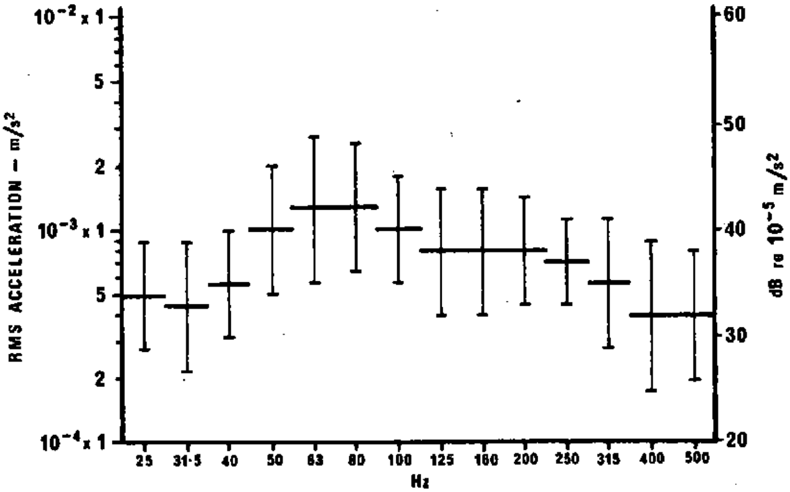

FIGURE 2: Floor vibration, RMS acceleration levels
Mean L_{eq} level ± 1 standard deviation for 14 sites