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DISTURBANCE FROM LOW FREQUENCY TRAFFIC NOISE AND VIBRATION

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Introduction

Among the factors which are sources of disturbance to people particularly in urban areas are traffic noise and traffic-induced vibrations in buildings. Noise is closely related to vibration, and they are not always distinguishable to the layman. Both noise and vibration may be directly experienced as unpleasant sensations, and vibration can further disturb people because of fears of damage to the building fabric.

Building vibrations induced by road traffic may be caused either by ground vibrations originating from the interaction of moving vehicles with road surface irregularities or by low frequency sound emitted from vehicles and coupled into the structure via the windows and doors.(1)

However, it has been found(2) that ground vibrations are unlikely to cause perceptible structural vibrations in buildings located near to a well maintained and smooth road surface. Since most roads have good surface finishes, ground vibrations from road traffic are not a major problem.

At TRRL a research programme has begun to study the effects on people and the occurrence of vibrations in buildings generated by road traffic. These studies have been at sites where the road surfaces were smooth, that is with no discontinuities of the kind which give rise to ground vibrations.

The studies have included physical measurements of low frequency traffic noise and structural vibration, and qualitative attitude surveys using interview techniques.

Vibration disturbance

Attitude surveys have been carried out using the techniques of postal questionnaires, and unstructured and structured interviews.

These surveys have produced a number of useful findings.

A National Survey(3) indicated that about eight per cent of the population of England were considerably disturbed by traffic vibration. However, of the ten per cent of the population experiencing vibration often, 53 per cent were considerably disturbed. It appears, therefore, that vibration is a major source of disturbance to those people experiencing it.

More detailed surveys have found that the main ways in which traffic vibration was noticed were the house or floor shaking and doors and windows rattling. Damage to the house is frequently stated to have resulted from traffic vibration, although in fact no cases have been authenticated. To a lesser extent, objects moving and distortion of television pictures were mentioned. Respondents also experienced vibration as a sensation in their body, head or ears, through their feet and also while in bed.

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The main source of vibration was considered to be heavy vehicles, often thought to be caused by the gross weight of these vehicles but also supposed to result from the speed, the type of engine or the gradient of the road.

The degree to which people were disturbed tended to reflect actual traffic conditions such as traffic volume, and the position of the house in relation to the road.

The most disturbing aspects of vibration were fear of damage to the house, together with the more intense unpleasant sensations in the body. This supports the suggestion that vibration disturbance is not primarily caused by the perception of structural vibration. It appears likely that vibration disturbance is conditioned by a combination of effects involving whole body exposure to low frequency noise, which can be either heard or felt as body vibrations and by the occasional perception of structural vibrations.

Low frequency noise

Structural vibration caused by acoustic excitation occurs in the frequency range below about 200 Hz. Acoustic coupling can excite the window pane and the contents of the room into vibration. Floors and walls can also be caused to vibrate. The occupants of buildings exposed to sufficiently high levels of low frequency noise may detect these responses of the building and its contents and they may also detect the noise by direct perception as body vibrations.

Body vibrations in humans are caused by air pressure changes acting uniformly over the whole body surface. Resonances of parts of the body can be induced at certain frequencies when the sound pressure levels are sufficiently high. Experiments in low frequency noise exposure rooms have shown that chest resonances are the most marked and occur at frequencies around 50 Hz in male subjects[4].

Auditory sensations which may be described as "vibration" sensations occur in response to low frequency noise, and can give rise to a considerable degree of annoyance at relatively low exposure levels[5].

Measurements of low frequency noise and building vibration[6] have shown that low frequency acoustic excitation was responsible for floor and window vibrations. The floor vibrations were generated in two frequency ranges. The dominant vibrations were at 63 to 125 Hz which corresponded with the excitation frequencies of exhaust emissions and were generated on lower and upper floors of buildings. Other vibrations were at 10 to 25 Hz which corresponded with the natural frequencies of the upper freely-suspended floors.

The magnitudes of the floor vibrations were compared with the perception threshold proposed by ISO for the evaluation of vibration limits for occupants in buildings. It was found that the floor vibrations exceeded the perception threshold for less than one per cent of the time at most sites studied.

The floor vibrations were perceptible for relatively short periods of time even at sites where a high proportion of residents were known to be bothered by vibration. Clearly, low frequency noise can cause both body and auditory sensations which can give rise to disturbance, as well as generating floor

vibrations. This leads to the suggestion that either comparing the ISO perception thresholds with the floor vibrations is inappropriate as a guide to determining possible vibration disturbance, or vibration disturbance is not primarily determined by structural vibration.

As well as direct perception of body vibrations, people may also detect vibrations by secondary effects such as hearing windows rattling, an important factor being the condition of the window. When a window has a loose fit in its frame, an audible effect is produced, which can be annoying.

Conclusions

In situations where there are no road surface discontinuities which could give rise to ground vibrations, low frequency traffic noise can be a significant source of vibration disturbance in buildings.

Vibration disturbance arises from low frequency noise effects in the body combined with the perception of structural vibrations.

It is suggested that vibration disturbance could be related to a measure of low frequency traffic noise.

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