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# VIBRATION NUISANCE FROM ROAD TRAFFIC - PRELIMINARY FINDINGS FROM A SURVEY OF 50 SITES

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## Introduction

The extent of vibration nuisance in residential properties caused by road traffic is indicated by the fact that 8 per cent of respondents in a study covering the whole of England stated that they were bothered very much or quite a lot by traffic induced vibrations[1]. Previous studies have demonstrated the importance of airborne low frequency noise in causing structures and objects in buildings to vibrate[2,3].

A recent survey of 14 residential sites[4] showed how people experienced vibration in their homes and attempts were made to relate the degree of disturbance to physical measures of noise and traffic flow. In this survey the type of house and the distance of the dwellings from the road were similar at all sites. The aim of the present study was to extend this 14 site survey by selecting sites to cover a wider range of situations so that results could more readily be generalised. A major objective of the survey was to examine the relationship between vibration nuisance ratings and various physical measures based on traffic noise, building vibration and traffic flow parameters. It was hoped that this analysis would lead to a physical scale of measurement which would be of use in appraising vibration nuisance in residential areas. The survey included interviewing approximately 30 people at each of fifty residential locations and making a 24 hour recording of traffic noise and vibration at one house per site. The sites were chosen in the South of England and the Midlands and ranged from quiet residential roads to heavily trafficked dual carriageways.

## Questionnaire design and interviewing

A questionnaire was designed to gather information from heads of households and spouses (at alternate addresses along the road) about the nature and degree of vibration nuisance from road traffic (if any). Questions on the types of vibration noticed, possible damage to property caused by vibration and the types of vehicle and their modes of operation that had produced building vibrations were included. An overall rating of vibration nuisance was obtained using a 7 point scale, viz:

NOT AT ALL BOTHERED 0 1 2 3 4 5 6 EXTREMELY BOTHERED

The site median vibration nuisance ratings were determined from these scores and used in computing the correlation coefficients.

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## Physical measurements and analysis

At one house per site noise and window vibration levels were recorded for 15 minutes every hour over a 24 hour period. For noise recordings a microphone was placed 1 m from the facade nearest the road and at a height of 1.2 m. The window vibration levels were monitored by attaching a small accelerometer (sensitivity approximately 40 mV per g) to the largest window pane facing the road on the ground floor. Signals were recorded on a Racal 7D or 7DS tape recorder. The levels derived from the analysis of noise data included linear levels for the frequency ranges 25-4000 Hz and 40-125 Hz, weighted levels A, B and C and octave levels at 63 and 80 Hz. The vibration levels derived were linear levels for the frequency ranges 5-31.5, 40-125 and 5-500 Hz and octave levels at 63 and 80 Hz. Over the 18 hour period 06:00 to 24:00 h and 24 hour period the exceedance levels $L_1$, $L_5$, $L_{10}$ and the average energy level, $L_{eq}$, were computed for all noise and vibration measures. Manual classified counts of the vehicles passing each site were made for the period 06:00 to 24:00 h.

## Results

The total number of completed questionnaires was 1625. The number of people interviewed per site varied from 25 to 39 and the average response rate was approximately 80 per cent. Responses to two of the questions are given in Tables 1 and 2. From Table 1 it can be seen that a large percentage (62 per cent) noticed window or doors rattling or buzzing and 16 per cent noticed ornaments rattling or buzzing. Thus it is apparent that vibration is often noticed because objects or structures in the home emit audible noise when set into vibration. Vibration was also perceived directly through tactile stimulation. Thirty per cent noticed that floors shook or trembled. The types of vehicle that respondents thought produced noticeable vibrations in their homes are given in Table 2. As expected a high proportion (73 per cent) said that 'big' lorries were responsible for vibration.

To test the validity of the site median vibration nuisance ratings in reflecting dissatisfaction with vibration the scores were correlated with responses to other questions. The Pearson correlation coefficients (r) between the dissatisfaction scores and the percentage of respondents noticing particular vibration effects were: those noticing floors shaking or trembling, $r = 0.78$; those noticing windows or doors rattling, $r = 0.74$. The correlation between dissatisfaction score and the percentage of respondents bothered very much or quite a lot by vibration was $r = 0.88$.

Table 3 lists the correlation coefficients for various 18-hour measures based on traffic flow, window vibration and noise levels. Correlation coefficients based on 24 hour noise exposure levels are very similar to the corresponding levels for 18 hours and for this reason are not included. Generally the acoustic indices are more closely associated with dissatisfaction scores than traffic flow or window vibration measures.

## Discussion

Table 3 shows that the traffic flow parameters examined are not particularly well correlated with vibration nuisance scores. The largest correlations found were based on the number of heavy goods vehicles in the traffic stream, which is consistent with the fact that a large percentage of respondents (73 per cent) had reported that these vehicles had caused vibrations in their homes.

Furthermore, measures of window vibration were not highly correlated with the median nuisance rating. The largest correlation coefficient was only 0.54. This may be due to the fact that vibration levels as measured are poorly related to the phenomena of window rattle which was widely reported and was expected to contribute significantly to the nuisance ratings. It is likely that the degree of window rattle is affected by the quality of the window fittings, the mobility of the glass and frame as well as the type of surround.

It was considered that measures most likely to show a high correlation with the median vibration nuisance rating would be acoustic measures, particularly those based on low frequencies, since it is this range of frequencies which has been shown to induce noticeable building vibration. However, the 18-hour $L_{eq}$ dB(A) index was found to be most closely associated with the median vibration nuisance rating and the low frequency measures examined all showed marginally lower correlations. A reason for the small range in the sizes of the correlation coefficients is due to the high level of association between most of the noise measures over the 50 sites. For use in predicting vibration disturbances both the $L_{eq}$ and $L_{10}$ dB(A) measures have the advantages of ease of measurement, of being capable of prediction from traffic flow parameters and of being widely used. Median vibration nuisance ratings are plotted against $L_{eq}$ dB(A) levels in the Figure.

## Conclusions

A survey of traffic noise, window vibration and residents' attitudes to vibration has shown that the site median vibration nuisance rating is a valid measure of vibration nuisance. This rating was well associated with the percentage of respondents bothered a lot or quite a lot by vibration and the percentages of people noticing various vibration effects.

Respondents considered large goods vehicles to be a major cause of building vibration. Measures based on the number of heavy vehicles were the traffic flow parameters most closely associated with the site median vibration nuisance rating. However, the 18-hour noise exposure measures were more highly correlated with the site median vibration nuisance ratings than window vibration or traffic flow levels. The 18-hour $L_{eq}$ dB(A) index was the best correlated measure explaining about 50 per cent of the variance in the median dissatisfaction scores. However a number of other noise measures were only slightly less well correlated and so no preferred noise index can be determined solely on the rank order of the correlation coefficients.

## References

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Table 1

Percentages of respondents who noticed various vibrations (all sites combined)

| Vibration effect | Percentage noticing effect |
|---|---|
| Windows or doors rattling or buzzing | 62.2 |
| Feeling vibration in the air | 30.2 |
| Floors shaking or trembling | 29.5 |
| Muffled sensation in the ears or fluttering sensation in the chest | 18.9 |
| Ornaments rattling or buzzing | 15.7 |
| Traffic causing the bed to shake | 13.6 |

Table 2

Percentages of respondents reporting that various vehicles produce vibration

| Vehicle | Percentage reporting vibration |
|---|---|
| Big lorries | 72.9 |
| Buses | 51.1 |
| Coaches | 42.4 |
| Small lorries | 36.0 |
| Motorcycles | 21.4 |
| Cars | 11.9 |

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Table 3

Correlation coefficients for physical measures for 18 hour period with median vibration nuisance scores

| Traffic flow measures | r | Window vibration levels | | r | Acoustic indices | | r |
|---|---|---|---|---|---|---|---|
| Number of MGVs † | 0.40 | 63 Hz octave | $L_{eq}$ | 0.54 | 63 Hz octave | $L_{eq}$ | 0.63 |
| Number of HGVs †† | 0.37 | " | $L_5$ | 0.53 | " | $L_5$ | 0.60 |
| Total number of vehicles | 0.42 | " | $L_1$ | 0.54 | " | $L_1$ | 0.61 |
| Percentage of MGVs * | 0.32 | 80 Hz octave | $L_{eq}$ | 0.51 | 80 Hz octave | $L_{eq}$ | 0.61 |
| Percentage of HGVs | 0.40 | Linear 40-125 Hz | $L_{eq}$ | 0.50 | Linear 40-125 Hz | $L_{eq}$ | 0.65 |
| Percentage of (MGVs + HGVs) | 0.40 | " | $L_5$ | 0.48 | Linear 25-4k Hz | $L_{eq}$ | 0.66 |
| $Log_{10}$ (1 + No. of HGVs) | 0.57 | " | $L_1$ | 0.51 | Weighted A | $L_{eq}$ | 0.71 |
| $Log_{10}$ (No. of MGVs + HGVs) | 0.49 | Linear 5-31.5 Hz | $L_{eq}$ | 0.42 | " | $L_{10}$ | 0.68 |
| $Log_{10}$ (Total number of vehicles) | 0.42 | Linear 5-500 Hz | $L_{eq}$ | 0.53 | " | $L_5$ | 0.69 |
| $Log_{10}$ (Percentage of (1 + No. of HGVs)) | 0.59 | | | | " | $L_1$ | 0.69 |
| $Log_{10}$ (Percentage of (MGVs + HGVs)) | 0.46 | | | | Weighted B | $L_{eq}$ | 0.68 |
| | | | | | Weighted C | $L_{eq}$ | 0.67 |
| | | | | | " | $L_5$ | 0.65 |
| | | | | | " | $L_1$ | 0.66 |

* All correlations are significant at the 1 per cent or 0.1 per cent levels except the correlation for the percentage of MGVs which is significant at the 5 per cent level.

† Definition of MGV: two-axled goods vehicles with an unladen weight greater than approximately 1.5 tons, buses and coaches.

†† Definition of HGV: goods vehicles with three or more axles.

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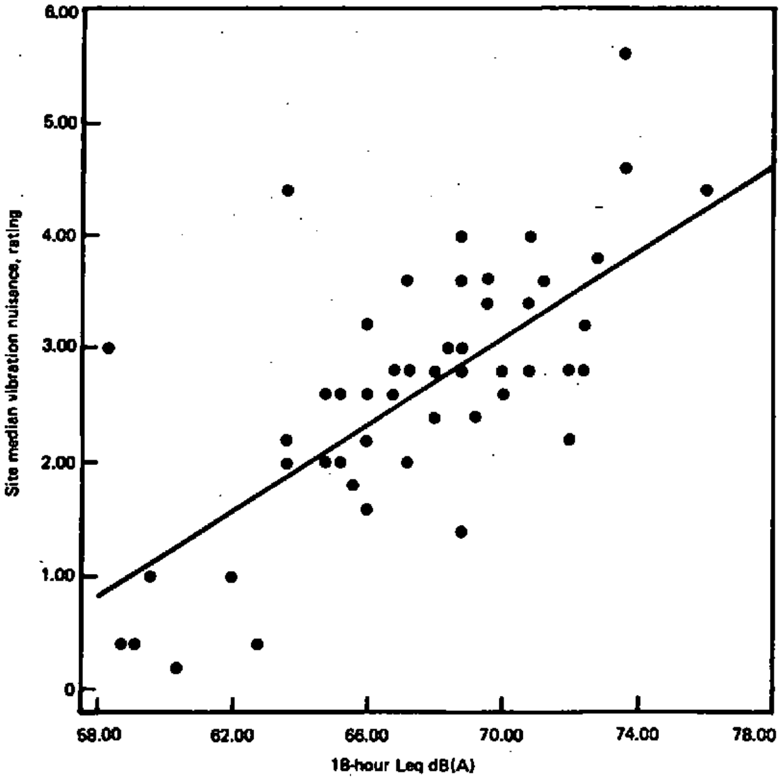


Fig. 1 Median vibration nuisance rating and 18-hour Leq dB(A)