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COMPARISON OF STEADY STATE AND IMPULSE MEASUREMENTS OF SOUND INSULATION WITH PARTICULAR REFERENCE TO SPEECH

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INTRODUCTION

The fact that the intelligibility of speech within auditoria depends not only on the amplitude of the signal (relative to the background noise) but also on the pattern of energy arrival with respect to time has been known for some time. This relationship was first expressed by Sabine in the general concept of reverberation time whilst the more recent work of Niese (1), Thiele (2), Lochner and Burger (3) and others, has sought to develop precise definitions of useful and detrimental speech energy by dividing it into 'early' and 'late' components.

Where the transmission of speech takes place through walls, however, the situation is different and there has been no corresponding recognition of the importance of the temporal structure of the transmitted signal on its intelligibility. Instead, it is assumed that the ability of a wall to provide speech privacy depends only on its steady state sound insulation.

This paper presents experimental data which shows that some walls introduce significant 'temporal distortions' of impulse signals transmitted through them which could affect the intelligibility of transmitted speech and discusses the implications.

EXPERIMENTAL DETAILS

Aims

At the present time, the general view is that the energy which arrives within interval 0-50 msec of the direct sound, early energy, increases its intelligibility whereas later energy reduces it. The aim of the measurements was to compare, for a range of wall constructions, the following three measures of sound insulation:

i. steady state sound insulation using continuous signals of random noise, as measured by conventional techniques

ii. impulse sound insulation, using the total energy received in the source and receiving rooms

iii. impulse sound insulation, using energy received in interval 0-50 msec in source and receiving rooms.

Theoretically, measurements i. and ii. should provide identical results provided source and receiver positions and directional characteristics are the same in both cases. (This has been demonstrated experimentally by Tricaud (4) using an analogue impulse technique.) Comparison of i. and ii. therefore provides a check on the validity of the results from the impulse tests.

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The relation between iii. and either i. or ii. depends on the response characteristics of the wall with respect to time and was the subject of the investigation.

Methods

Steady state measurements:

These were carried out in the conventional way using a dodecahedral omnidirectional loudspeaker emitting filtered random noise as the source.

Impulse measurements:

The measurements on site employed a 3.5 kV spark discharge as the source (producing a clean 37 Joule N-wave signal of 0.2 msec duration) and recording the signals in source and receiving rooms on a Nagra IVSJ tape recorder. These signals were processed digitally by first passing them through a 14 bit A/D converter operating at 20 kHz into a PDP11 minicomputer and stored on floppy disc. 16 K FFT's (corresponding to 0.8 sec length of signal) were then carried out on the two signals and the resulting data sets normalized and integrated to obtain the $\frac{1}{3}$ octave band spectra of the two signals. This procedure was repeated for the first 50 msec of the data file (filling the remaining data points with zeros). The impulse sound insulation was obtained from the difference between the source and receiving room spectra in the normal way.

RESULTS AND DISCUSSION

The results of field measurements of the sound insulation characteristics of three different types of wall constructions are shown in Figures 1-3. These graphs illustrate the general pattern that was found in the full set of results.

Two points emerge: first, the insulation curves obtained by the digital impulse method where the whole of the source and receiving room signal are used corresponds closely to those obtained from the steady state method and second, that the insulation curves obtained by the impulse method using the shorter integration period of 0-50 msec can be substantially higher than the steady state values for some, but not all, wall constructions.

The first point confirms that the digital impulse method is satisfactory giving results which agree with theory and with analogue impulse measurements (4). The second point demonstrates that the sound insulation that is measured using an impulse source depends in certain cases, on the integration characteristics adopted for the measuring instruments. When using an integration interval of 0-50 msec, the results can be as much as 15 dB higher than the steady state value in a $\frac{1}{3}$ octave band.

IMPLICATIONS

These findings raise the question amongst others, as to what integration time it is appropriate to employ when measuring the sound insulation of walls with impulse sound. Clearly, if a 0-50 msec interval is appropriate for speech intelligibility, as it is considered to be for auditoria, then steady state measurements would appear to inadequately reflect the ability of walls to provide privacy.

The answer will depend on how the ear processes the impulse signals received transmitted through walls. This subject is being examined by the authors under a current grant from the Science and Engineering Research Council.

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ACKNOWLEDGEMENT

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FIGURE 1 Comparison of impulse and steady state measurements of sound insulation: plasterboard partition with cellular core

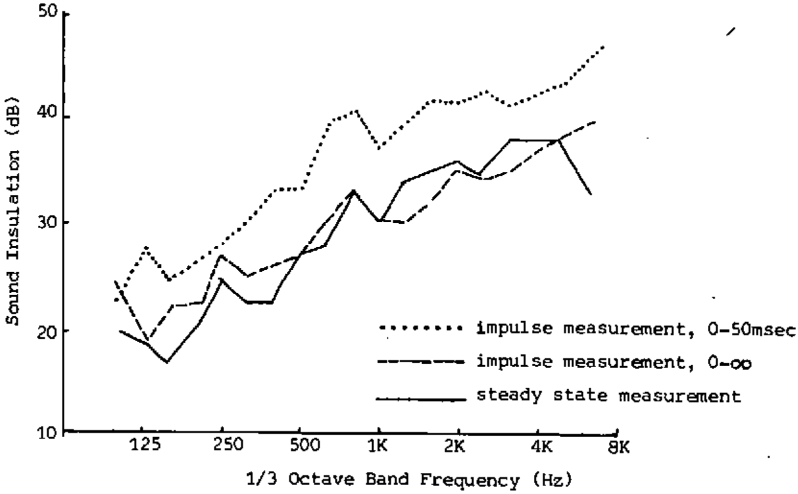

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FIGURE 2 Comparison of impulse and steady state measurements of sound insulation: timber stud partition.

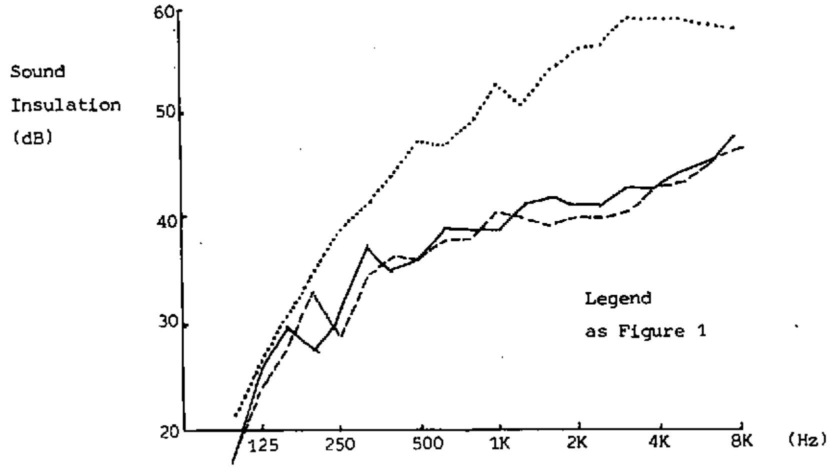

FIGURE 3 Comparison of impulse and steady state measurements of sound insulation: 112 mm brick wall.