BRITISH ACOUSTICAL SOCIETY

71 / 45

ACOUSTIC TESTING FACILITIES

16 JUNE 1971

SITE MEASUREMENTS OF ACOUSTIC PARAMETERS IN SEMI-REVERBERANT SURROUNDINGS

by R F Higginson

INTRODUCTION

Acoustic measurements obtained on site, as opposed to laboratory measurements of one kind or another, can be broadly categorised from the nature of the sound fields and the techniques involved into two types: measurements obtained outdoors and those obtained indoors. Sound fields in the open are dominated by direct radiation from the source. The propagation rate depends on the nature of the source, and is influenced by reflection and absorption at the surface of the ground and at building facades. Sound fields in enclosed spaces usually have a strong component, maybe the predominant one, due to repeated reflections at the boundaries. A truly reverberant field has a negligible component directly from the source, and is usually only encountered in a hard-walled laboratory. A semi-reverberant field has a significant contribution due to direct radiation, though this might be limited to the region near to the source. Further, the mode density in the enclosure is likely to be variable and low at low frequencies. Individual modes are therefore likely to be prominently excited. This is the nature of the sound field most commonly found in ordinary buildings and measurements in and of such fields are the subject of this paper.

Site measurements indoors are necessary for various reasons. One is proof testing, of the building itself, or of materials or components of the building, or of the performance of some piece of equipment which has to operate in the building. Performance requirements incorporating acoustic data are being used increasingly. In certain cases conditions which affect the acoustic data are only reproduced adequately in the building, eg structural transmission of sound, or proper representation of the sound source. In such cases, fundamental investigations and development have to be carried out on site.

SITE MEASUREMENTS IN CURRENT USE

1 Sound Insulation in Buildings

(a) Internal sound insulation
Field measurement is the only way to obtain an accurate determination of the sound insulation given by a complete structure. Only in the building itself are all possible transmission paths incorporated (directly through partitions and floors, structural flanking paths, and airborne paths in the form of gaps in the structure, ventilation ducts, etc). Further, in the building the partitions and floors have realistic edge conditions: this is not necessarily

the case in the laboratory.

The method of measurement is the subject of a British Standard (1). It consists, in the case of airborne insulation, of the setting up of a sound field 'as diffuse as possible' in the transmitting room, using loudspeakers, and of the measurement of the average sound pressure levels over a range of frequencies in that room and a neighbouring receiving room. The average level differences are corrected for the amount of sound absorbing material in the receiving room to give the sound insulation between the rooms. In the case of impact insulation of floors, the Standard gives a specification for a tapping machine to be used to excite the floor. With this machine operating, the average sound pressure levels in the receiving room are again measured and corrected for the amount of sound absorption present. These 'normalised' impact sound levels are taken as the measure of sound insulation of the floor construction.

Performance requirements for dwellings are already in use (2), based on these measurements, and requirements in other types of building are becoming increasingly common (3).

(b) External sound insulation
Measurements are most often used to investigate the sound insulation of windows, but sometimes it is the complete external shell of the building that is of interest.

Since no Standard exists for the measurements, the procedure used by different teams varies considerably. Firstly for the sound source the real noise on site (road traffic, aircraft, etc) has sometimes been used, while some organisations have used loudspeakers or horns. Second, there is no general agreement on the meaning of the external sound level, whether it should be measured very close to the facade or a short distance away, say 1 m from the facade (the latter is the BRS preference). Finally, the sound pressure level inside the building has sometimes been taken to be that measured very close to the window, etc, and sometimes the average level over the receiving room. In the case of the latter, a correction is applied for the amount of sound absorption in the room.

2 Reverberation Time and Sound Absorption

The quantity actually measured is always reverberation time. In some cases this is required for its own sake, as when establishing the acoustic properties of auditoria, and in others the property is used to calculate the total amount of sound absorption, for use say in sound insulation measurements.

There is no Standard for field measurements, but the procedures employed are normally adapted from that applying to laboratory conditions (4). Loudspeakers are used for the sound source, relaying random noise or warble tones, and the rate of decay of sound pressure level in the room when the source signal is suddenly cut off is determined. This is directly related to reverberation time, and an average from a number of measuring positions is normally derived. Variations in this procedure very often arise when the measurements are made in large auditoria, such as concert halls. The sound source is then sometimes of an impulsive nature, such as a pistol shot, and indeed use is occasionally made of a full orchestra, playing musical chords.

Further, there can be disagreement as to the positions at which measurements should be made, whether at the podium, above the stall seats, under balconies, etc.

3 Sound Propagation

Propagation measurements are not often required inside buildings. Their most common application is probably in open plan offices, where the spread of noise and its effect on privacy is of interest.

The measurements are as a rule simple and crude, utilising a loudspeaker as source, and plotting variation of sound pressure level against distance from source with a sound level meter. The results are sometimes analysed in octave frequency bands.

4 Noise Levels

These are most likely to be required in connection with some piece of plant or equipment, to ensure that the levels are within given limits. The extent of the measurements depends very much on the particular situation. In some cases they will amount to no more than isolated spot checks, while in others there will be a consistent series of measurements at specified positions, say at machine operators' head positions. In a reverberant receiving area they could even amount to a determination of the average noise levels, corrected for absorption conditions. A sound level meter is usually adequate, possibly incorporating octave filters.

PROBLEMS AND LIMITATIONS OF MEASUREMENTS

Some of the difficulties are obvious, such as practical problems of transport of equipment and performing measurements on say a raw building site. The cost can be considerable, especially if it is necessary to erect prototype buildings. Less obviously, it is not easy to obtain results which are meaningful and repeatable. This is due to the nature of the sound fields set up, having prominant individual mode components. Care and precision are necessary in order to determine accurate values for average sound pressure levels, decay rates, and so on. These difficulties are aggravated by lack of standardisation in the measurements. Even the methods that are described in a British Standard (sound insulation) are general, and considerable variation is permitted in the equipment and techniques of application. BRS has a current research project that is aimed at improving the repeatability of measurements of sound insulation.

The most serious limitation of site measurements, however, is that results and deductions obtained in one situation cannot necessarily be assumed for a different situation. This again is due to the nature of the sound fields excited. These are a compound of the direct sound from the source, whether loudspeakers or noisy machinery, and the acoustic response of the enclosure. In the case of sound insulation measurements the response of the structure in its own modes of vibration, having varying degrees of coupling with the acoustic modes of the rooms, provides added complication. For the majority of measurement situations it is impossible to distinguish between these different effects, and so the results have to be reserved to their place of origin.

There is a further problem in some cases, though not peculiar to site measurements. This is the unrealistic nature of the sound sources sometimes used. The most obvious example is the tapping machine for measurement of impact insulation. The Standard machine applies a loading to the floor quite unlike that due to real footsteps or any other source of impacts, and can give misleading results.

CONCLUSIONS

Site measurements are essential for a realistic assessment of in-situ acoustic performance. They must be performed carefully, however, and more standardisation would improve repeatability and make comparisons easier. They have the limitation that usually the results are limited to the situation where they were obtained.

REFERENCES

1 Recommendations for field and laboratory measurement of airborne and impact sound transmission in buildings. British Standard 2750:1956

2 The Building Standards (Scotland) Regulations 1963. Statutory Instrument 1963 No 1897 (S 102)

3 Code of Basic Data for the Design of Buildings, Chapter III Sound Insulation and Noise Reduction. British Standard Code of Practice CP3: Chapter III (1960)

4 Method for the measurement of sound absorption coefficients (ISO) in a reverberation room. British Standard 3638:1963.