ACOUSTICS IN THE DIVISION OF BUILDING RESEARCH

by

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The Noise and Vibration Section of the Division of Building Research (DBR) is concerned as the name suggests, with problems of acoustics and vibration as they relate to buildings. The work in the Section includes (1) studies of basic physical processes of propagation of sound and vibration in buildings; (2) studies of responses of people to sounds and vibration in their environment; and (3) the development of standard methods of measurement of the appropriate physical descriptors. The commitment, beyond research, is to apply the knowledge gained to the solution of specific building problems and to disseminate the information in appropriate form to designers, builders and the public.

ACOUSTICAL TESTING

The major part of the building is given over to three reverberation rooms. Figure 1 is a view of the largest (250 m^3). Standard tests that are carried out include:

airborne sound transmission loss of partitions,
impact sound measurements on floors,
random incidence sound absorption,
sound power measurements,
impedance tube measurements.

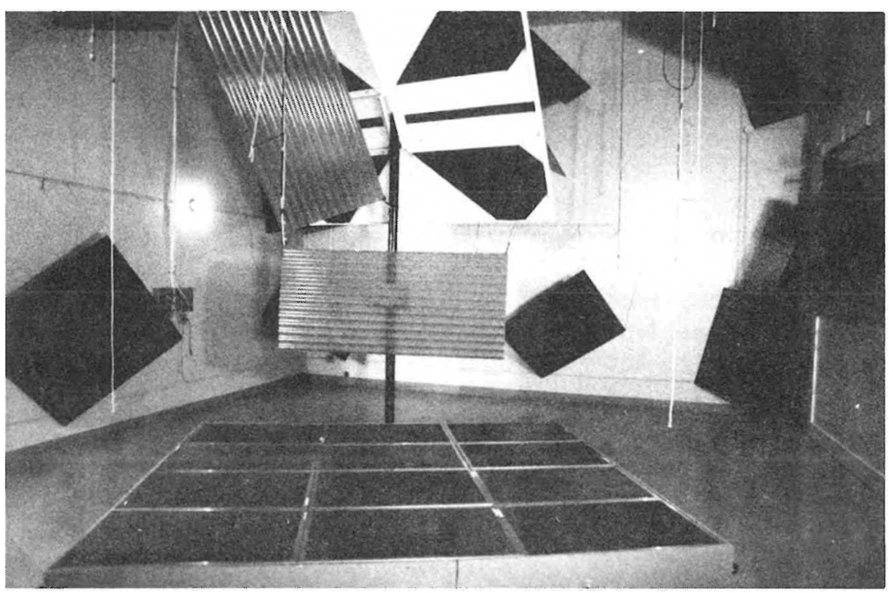

Figure 1

The large reverberation room at DBR

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In addition to the suite of reverberation rooms, there is an anechoic room that can be used in making sound power measurements. It has also served in investigations of some of the acoustical properties of the components of open-plan offices and as a quiet space for subjective evaluation of noise signals.

For many years the Section has been actively involved with standards writing groups such as ASTM, ISO and CSA. This aspect of the work is essential when commercial tests are performed and ensures that results from the laboratory will be accepted throughout the world. As a consequence, much of the research is aimed at improving the accuracy and precision of the measurements.

Over the last few years the single most important step in this direction has been the changeover to a computer-controlled measuring system that can control the sound in the appropriate room, select microphones and measure the sound pressure levels and decay curves in as many frequency bands as required. The program can then calculate any further quantities needed such as spatial averages, sound transmission losses, sound powers and so on.

The ability of real-time analysers to make measurements of sound pressure levels in several bands simultaneously over a short time-interval simplifies enormously the measurements of sound decay rates in the room. Sound decays have been measured in reverberation rooms for decades but it is only in the last five years or so that computer systems have allowed researchers to look closely at them. The beauty of the computer system is that it can sample many of these decay curves at fixed time-intervals and add them together in memory. By this means the irregularities in the curve that are due to the random nature of the room excitation can be averaged out to give a much smoother decay curve.

DEVELOPMENT OF NEW TEST PROCEDURES

In addition to the constant review and implementation of standard test procedures, DBR has a strong interest in the development of new acoustical test procedures. As one example, part of the development work for the CSA test method Z107.71 for measuring the sound power of small appliances was performed in the DBR laboratory. This work required sound power measurements in the reverberation rooms, in the anechoic chamber, and in some semi-reverberant rooms.

For many years impact testing of floor structures has been carried out, using the standard ISO hammer machine with its five steel hammers impacting ten times each second on the structure under test. A great deal of criticism has been directed at this test procedure, especially in North America where light-weight floor structures are common. The Section has examined this problem over the years in an intermittent fashion, and is at the moment fairly actively investigating a proposed new test procedure that uses hammers believed to be a better approximation to the shoe and human foot than the ISO hammer. Initial results from this research are encouraging, but a great deal of work remains to be done since only about 20 floor systems have been investigated so far.

REVERBERATION ROOM ACOUSTICS RESEARCH

The assumption underlying tests performed in reverberation rooms is that there is a good approximation to a diffuse sound field in the room. It has been known for many years that reverberation rooms have a modal response determined by the geometry of the room, and devices such as diffusers have been used to try to change the room response in such a way that the field becomes more uniform. Diffusers are panels suspended or moving (usually rotating) in the reverberation room that are supposed to break up the regular structure of the room, thereby making the sound field more diffuse. The rooms at NRC are fitted with both types (Figure 1).

Despite the fact that diffusers have been in use for many years, their effects are not completely predictable and research is needed to clarify some issues. As well, there is in North America an increasing movement towards accrediting laboratories for making acoustical measurements. This has forced the standards writing bodies to examine more closely some of the requirements written into the standards to be sure that they can in fact be satisfied by the laboratories. In parallel with these research interests, standard test measurements must still go on. For these reasons construction has recently been completed of a model of the large reverberation room on a scale of 1:2.5. It is hoped that the research to be performed in this model will answer some of the questions about diffuser performance, the measurement of the degree of diffusion, and other factors.

The experimental research program is supported by theoretical studies and computer simulations based on theoretical models in a concerted effort to extend understanding of this complicated subject.

FIELD PERFORMANCE

For many years the Section has made measurements in multi-family dwellings in order to compare field performance with results obtained in the laboratory, and to maintain an awareness of the faults and problems that arise in practical situations. It is important to remember that laboratory testing is carried out under carefully controlled conditions, in which the only significant transmission is through the partition under test. In the field situation this is not the case. Quite apart from the possibility of construction errors, sound energy can be transmitted by way of surrounding structures, a phenomenon known as flanking transmission. It is only by careful study of the details of the processes involved that the best performance can be obtained from a selected party wall or floor. The proliferation of small, highly precise instrumentation is facilitating work in this area and offers the possibility of using more modern, sophisticated techniques to investigate some of the problems.

INTRUSION OF EXTERNAL NOISE

For the past several years a large part of the activity of the Section has been committed to the study of intrusion of outdoor noise into homes. This research has included study of aircraft noise and road and rail traffic noise. The original excursion into this field began at the request of Canada Mortgage and Housing Corporation (CMHC) and the work was a joint effort that included DBR, CMHC and Transport Canada. A test house was constructed near Uplands airport in Ottawa, and penetration of noise was measured as windows and other components of the structure were changed. The result of this work was a publication entitled "New Housing and Airport Noise."[1]

Following the efforts with aircraft noise it was decided that a similar set of guidelines was necessary for traffic noise. As this naturally entailed a great many measurements on site, a van was equipped with a computer-controlled measuring system to allow real-time measurement and analysis of the data. The studies included the effects of terrain, barriers, aggregations of buildings and absorbing and reflecting boundaries on the propagation of sound. The product of this work, apart from research papers, was the document "Road and Rail Noise: Effects on Housing."[2]

In both cases the windows of the houses proved to be the dominant factor in controlling the penetration of the sound into the building. This result, together with the observation that the available literature on windows was somewhat equivocal, led to a very thorough study, performed under laboratory conditions, of the transmission losses through approximately 130 variants of single-, double-, and triple-glazed windows.

BUILDING VIBRATIONS

The study of acoustics in buildings naturally includes some study of building vibrations. Interest at DBR/NRC extends, however, outside the frequency range of acoustics to cover the low frequency motions of whole buildings and building elements. About half of the effort is devoted to experimental and theoretical evaluation of structures subjected to dynamic loads such as wind, traffic vibrations and earthquakes. The structures investigated are typically quite large and include the CN tower, the Lions Gate Bridge in Vancouver, the Manic 5 dam and some tall buildings. Apart from the intrinsic interest of these studies the information obtained is of immediate use in making recommendations for changes to the National Building Code of Canada (NBC). They are also useful in selecting benchmark structures for CANCEE, the Canadian Committee on Earthquake Engineering.

The NBC includes structural requirements for buildings constructed in areas in Canada considered to be at some degree of seismic risk. In the event of a strong shock in Eastern Canada it would be extremely valuable to have a record of the ground motion so that NBC requirements could be refined, if necessary. For this reason the Section maintains a network of strong motion seismographs at selected locations in Eastern Canada, so that if an earthquake were to occur there would be a seismograph record of it.

At the other end of the scale, the vibrations of building elements, especially floors, can cause considerable disturbance to sensitive instruments and even people. One research program concentrates on this area. This type of problem can occur with dance floors, where the amplitude of vibration can be quite unnerving. Two long floor strips have been constructed in DBR to examine more closely the parameters that control the level of vibration and possible means of economical control. Part of the study includes a subjective experiment to determine how people react to different frequencies and levels of vibration.

REFERENCES

[1] New housing and airport noise. Canada Mortgage and Housing Corporation, Ottawa, NHA 5185 M 79/08.

[2] Road and rail noise: effects on housing. Canada Mortgage and Housing Corporation, Ottawa, NHA 5156 12/77