BRITISH ACOUSTICAL SOCIETY

71/44

ACOUSTIC TESTING FACILITIES

16th June 1971

INDUSTRIAL TESTING IN REVERBERANT ENCLOSURES

by

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The design and construction of a completely satisfactory reverberant room acoustic test facility is dependent upon a number of factors, the most important of which are availability of cash, availability of a suitable site and the type of investigations required of the facility. It is unfortunate that the first of these criteria is probably the most important since experience has shown that meaningful acoustic test results on full sized building elements and machines cannot be bought cheaply.

The main types of measurements carried out in a typical acoustic testing laboratory are listed as follows:

Airborne Sound Transmission Loss of Building Partitions and Panels[1]

Airborne and Impact Sound Transmission Loss of Floors, Ceilings and Floor Coverings

Random Incidence Absorption Coefficients of Acoustical Materials[2]

Sound Power Measurements on Noise Generating Equipment and Machines [3]

Sound Transmission Measurements on Building Facades.

It is usually necessary to design into the facility the capability of carrying out these measurements at minimum cost and maximum efficiency in order that the designer can expect to offer his client a satisfactory return on his investment of capital.

Design of Facility

Layout: There are now two recognised approaches to the layout of a modern acoustic test laboratory. These depend upon whether the laboratory is primarily intended to be used for research and development by one company, or alternatively whether it is intended that it be used for commercial testing on a fee-paying basis.

For R. and D. purposes it can be argued that it is better that each reverberant room pair is built as a separate entity and the reverberant room likewise. For commercial testing, it is usual that the largest reverberant room forms the nucleus for several transmission rooms. See Figs. 1 and 2.

For tests in the Fig. 1 type of facility, one test aperture is usually sufficient for each category of measurement. The development programmes in each test suite can then be planned so as to run in series without interference from each other's background noise, and interruptions during building up or removing test elements. The Fig. 2 type of facility (which occupies less space and is usually cheaper to construct) allows the use of two or more test apertures for any one type of test and in this respect is more useful commercially since one aperture can be used for say, 'wet' masonry structures and the other for 'dry' lightweight structures derived from sheet materials. In this way, continuity of testing is maintained during drying and curing of plastered masonry. To overcome this problem in the Fig. 1 type of facility, it is necessary to construct the laboratory so that the apertures are removable by crane on the 'picture frame' principle so that a queue of partitions, mounted in these removable aperture frames, can be duly tested after the appropriate curing time has elapsed.

Construction of the Laboratory Shell

This will, to some extent, depend upon the site location and background noise environment. There seem to be two alternatives.

(1) Use the walls and roof of the acoustic chambers as part of the exterior structure, build them very massively, then build the ancillary control rooms and offices as a separate entity.

(2) Build the chambers no more massively than they need to be, and then construct a sound resistant shell around them.

Both solutions have been used extensively, appear to work equally well, and seem to cost about the same.

Construction of Test Chambers

Where rooms are constructed inside another building, the walls and roof need to have an average insulation of about 50dB with good low frequency insulation. This necessitates the use of 230mm solid brickwork or 200mm insitu re-inforced concrete. If both the roof and walls are to have non-parallel dimensions, the latter is probably cheaper. Floors are almost always concrete, not less than 300mm thick for spanning across vibration isolation mountings or springs.

Where chambers form part of the exterior of the building, it is recommended that they be constructed from poured concrete not less than 300mm thick (about 56dB). Other critical factors governing the construction of satisfactory (for standardised tests) test rooms are given in ASTM part 14[4]. These notably cover such items as critical volumes, test aperture sizes, and control of diffusion. Briefly, a reverberation room should, for absorption coefficient measurements, have a volume of not less than $200m^3$; the smallest dimension of the room should preferably be more than two wavelengths of the centre frequency of the lowest one-third octave at which the measurements are made. No two room dimensions should be equal, nor in the ratio of small whole numbers. The ratio of the largest to the smallest dimension should be less than 2:1. The specimen area should approximate to $10m^2$.

The surfaces of the rooms should be as reflective as possible. A surface absorption coefficient less than 0.05 is a good target to aim for, and this can be best achieved by using a suitable thin coat of squashcourt plaster painted with two coats of gloss paint. It is usual to introduce artificial diffusion into the test chambers. Most of the laboratories in North

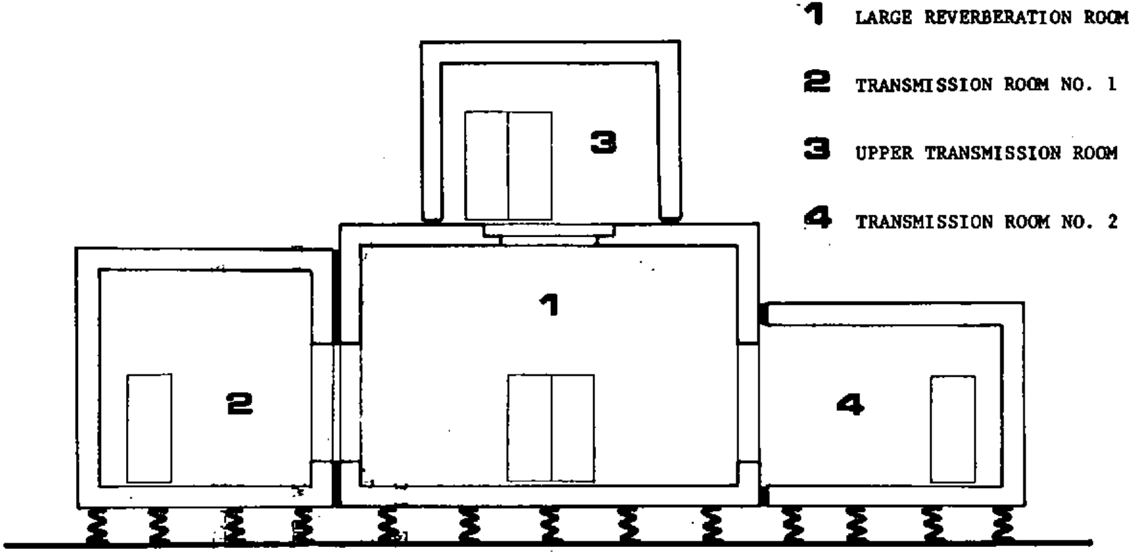

Fig. 2: TYPICAL COMMERCIAL ACOUSTIC TEST LABORATORY

1 LARGE REVERBERATION ROOM

2 HORIZONTAL TRANSMISSION ROOM PAIR

3 VERTICAL TRANSMISSION ROOM PAIR

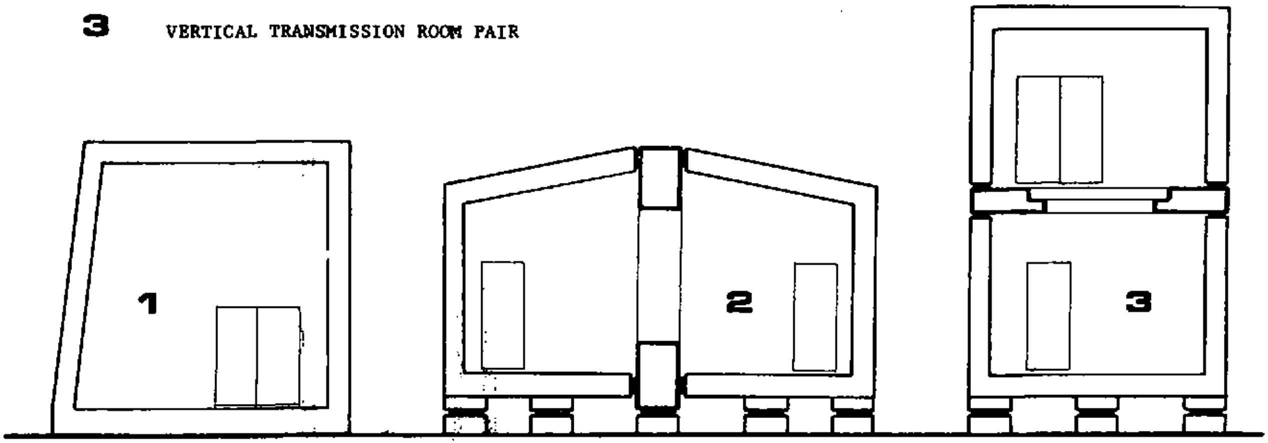

Fig. 1: SECTION THROUGH AN R. AND D. ACOUSTICS LABORATORY

America use rotating vanes, whereas most of the laboratories in Europe use stationary diffusor panels - both seem to be equally satisfactory for all practical purposes. At one time it was thought that all reverberant rooms should be constructed so as to have non-parallel dimensions. Some recently constructed laboratories have, however, been given parallel surfaces and are alleged to perform equally satisfactorily. It is, therefore, now thought that where adequate diffusion is provided by other methods, non-parallel walls need not be specified. For transmission loss measurements, it is desirable that the room volumes should exceed $160m^3$ and that no two dimensions of either room should be equal. Again the ratio of the largest to the smallest dimension should be less than two.

Flanking Transmission

In almost all cases a reverberant room laboratory is used to measure the acoustic properties of a particular element of structure. It is very important, therefore, that all flanking noise is eliminated at the design stage. (A laboratory has been built recently which has the facility to introduce controlled artificial flanking.)

The procedures adopted for isolation mountings vary. Steel coil springs, compressed glass-fibre, and Metalastic pads have all proved equally satisfactory in recent times. For isolation of vertical surfaces, popular materials seem to be, bitumenised foamed plastic or bitumenised wood fibreboard, resin bonded glass-fibre, evacuated rubber tubing and polysulphide or acrylic mastics. It is particularly important that in a transmission room facility, each room is built as an independent structure and the wall containing the test aperture is so massive that its transmission loss exceeds that of any wall that is likely to be tested. This can be achieved in one of two ways (see figs.1 and 2) viz. either build the rooms as two open ended masonry boxes on vibration isolation mountings and separately isolated test aperture wall, or build each room as two abutting boxes each having an adjacent hole cut out of one side. Each method has its own particular advantages associated with ease of construction and type of application. Both seem to be equally satisfactory for most purposes, though it is advisable that, in the latter case, the specimen should not be rigidly connected to the source room structure since there is a possibility that extra energy may be imparted to its edges because of vibration in the source room structure.

Operation

For efficient operation, it is important that the laboratory is provided with a centralised control room fitted with permanently installed proprietary acoustical measuring equipment. Adequate spare parts and knowledgeable technicians should be available for both servicing and carrying out routine measurements. As far as possible, in order to increase accuracy and reduce tedium in manpower, techniques can be automated wherever possible.

Modern industrial laboratories now have facilities for computerised recovery of reverberation decay times, digitalised measurement of sound transmission loss and automatic sound field averaging by means of remotely controlled moving microphones.

References

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3. BERANEK, Leo L. Noise Reduction, 1960, CH8 P.175 Sound-Power Measurements in the Reverberant Field

4. American Society for Testing and Materials, Part 14, 1970 C423 and E90.