ACOUSTICS FOR MULTI-PURPOSE HALLS

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INTRODUCTION

Though single-use or nominally single-use concert halls, theatres and opera houses have been built and developed over centuries, the multi-purpose hall is a recent phenomenon. This has arisen from the need to optimize the usage of expensive auditoria and from the ability to supply more flexible facilities.

The greatest challenge confronting the designer of a multi-purpose hall is to have to accommodate both unamplified music and unassisted speech within the same space. The major concern in any multi-purpose situation is generally to provide appropriate reverberation times.

1. THEORETICAL APPROACH

Each acoustic use of a hall has an optimum reverberation time associated with it. In the case of concert and drama use, RT of 2 seconds and 1 second are ideal, though the optimum time for music decreases for smaller halls. The two variables to hand are the auditorium volume and the total acoustic absorption. It is simplest to illustrate the argument with the basic RT equation:

$$T = \frac{0.16V}{\left(S_A \cdot \alpha_A + \Delta A\right)}$$

The reverberation time T is a function of the auditorium volume divided by the total acoustic absorption. The total absorption has been stated in terms of the audience absorption.

This formula indicates that the RT varied by changing the volume, the audience seating area or additional absorption.

2. PRACTICAL CONSIDERATIONS

Changing the auditorium volume by a substantial amount is often the most rational approach on acoustic grounds, though it is usually a costly exercise. More modest volume changes have in some buildings been incorporated by using reverberant chambers round the perimeter, which are coupled acoustically to the main volume.

If the seating is upholstered, by removing seating the reverberation time will be extended.

The third variable component is additional acoustic absorption not associated with seating. In a small auditorium, this can be handled with curtains, which can either cover hard surfaces or be stowed away. The use in large auditoria of acoustic banners has become commonplace. For radical RT changes the areas of banner required are considerable and drawbacks associated with introducing extra absorption where mentioned.

Total sound level is a function of absorption and is nominally independent of room volume. Additional absorption produces a quiet sound and it may also unavoidable when large areas are involved to place absorbent in positions which obscure valuable early reflections as well.

The acoustical solution of a multi-purpose hall depends also on the specific program types for which it is to be used. In design and construction practice, a compromise decision is most often sought. A comparatively short RT is provided in the hall and its internal surfaces are constructed so that some of them direct strong early-reflections towards listeners and the others create non-directional scattered reflections of sound, increasing the diffusivity of the sound field. Those surfaces that do not provide early reflections should be divided into parts to provide diffuse reflections, other surfaces (especially, surfaces adjoining the stage) should not be so heavily divided into parts. As in halls for music, early reflections from the side walls adjacent to the stage are desirable in multi-purpose halls, because they will enhance both clarity and spatial impression. The delay of the first strong reflection as well as the intervals between subsequent strong reflections should not normally exceed 30ms throughout the whole audience seating area.

Strong overhead reflections are

considered undesirable for music, but reflection direction is of no concern with speech. Additional lateral reflections which arrive early enough to enhance speech intelligibility can be viewed as beneficial for both uses.

In large multi-purpose halls, the problem of combinating different speech and music programs becomes significantly more complicated. The trend to construct wide halls, as well as the requirements of the technical equipment in cinemas, often lead to halls where the width at the front is 30 or 40 m, and the height is 10 m or higher. With such dimensions, the delay of reflections arriving in the front zone of audience seats considerably exceeds 30 ms.

When changing from one type of use of the hall to another, one can also employ changes of volume which are usually accompanied by an alteration of the seating capacity of the hall. The decrease of the volume is achieved quite simply by installing a removable partition in a remote part of the hall. In order to reduce the volume, the upper balcony is sometimes closed by lowering part of the ceiling.

There are two other approaches to the acoustical design of large multi-purpose halls.

The first of them requires the use of electroacoustics. In this case, the RT in the hall is provided to meet the requirements of speech and cinema. The RT for concert programs is increased by means of an electro-acoustic artificial reverberation system. The problem of providing the seats with early arriving reflections can be solved with the help of high quality loudspeakers placed at points from which natural sound reflections arrive too late.

The second approach to the acoustical design of large multi-purpose halls is based on the use of architectural acoustics techniques. This involves added sound absorption to transform sound reflecting surfaces, and the variation of the hall volume. Varying the added sound absorption serves to control the RT of the hall. The volume and lining of the hall are chosen so as to provide the RT recommended for symphonic music. Reverberance is reduced by adding efficient sound absorbers to the reverberant space. Despite certain advantages, variable sound absorption has not been very popular. This can be attributed to the fact that the method requires additional expense and does not provide a sufficient range of reverberation times, as well as the architect is restricted to a certain extent in his design of the interior.

The most frequently encountered method consists of a layer of porous sound absorber placed on the side walls covered by rotating sound reflecting panels. Rotation of the panels exposes or covers the surface of the sound absorber. One side of the panel is sometimes made sound absorbing and the other, sound reflecting. With the rotation of the panels by 180°, sound absorption in the hall changes.

Both methods have a significant drawback. The electronic systems require regular maintenance, as well as control by informed operators. Due to unavoidable slots in between the panels, the efficiency of the added absorption, particularly at low frequencies, is considerably reduced. To minimize the unwanted effect of slots, the panels should be large in size. A better solution is to remove the sound absorber out of the reverberant space of the hall using mechanical systems of special blinds of banners.

The weight of cloth used in making the blinds should not be less than $1 kg/m^2$ and be placed at least 200 mm from the wall. In addition to the acoustical requirements, the cloth should be decorative, not produce detrimental dust, be fire proof, be resistant to moths and be of adequate mechanical strength.

3. CONCLUSIONS

The most common elements which influence the multi-purpose hall acoustics are variable volume and absorption. Variable absorption is easy to include in small quantities, difficult in large quantities. Variable volume is often more appropriate, but confronts severe architectural limitations. Electronic systems which extend the RT and improve the sound quality are valuable for multi-purpose halls.

The state of the art of acoustics and auditorium design has reached the point where significant advances can be made in satisfying demanding briefs. The design of multi-purpose halls will be the most dynamic area of progress in the future.

Bibliography

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