ACOUSTICAL DESIGN IN BUILDINGS

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Acoustical defects in buildings are forced on the attention of the public in a considerable number of instances. These defects are sometimes found in auditoriums where speaking or music, or both, are heard at a disadvantage, or again in rooms where sounds from other parts of the building become noticeable in an objectionable way.

The usual cause of the defects in an auditorium is found in the hard, non-porous walls of the room which reflect a large percentage of the incident sound with a consequent small absorption of the sound energy. This results in an undue prolongation so that successive sounds, as in speaking, are thus thrown in competition with each other and a listener has difficulty in following the sequence of a speech. This prolongation of the sound, or reverberation as it is called, may be corrected or avoided by having a suitable amount of sound absorbing material in the room. For music, the defect is not so objectionable, because musical sounds can overlap and yet be acceptable for most cases.

These principles may be illustrated by describing two auditoriums recently built at the University of Illinois which incorporated acoustical features designed by the writer in co-operation with the architects. In both auditoriums, the acoustical specifications were detailed in the plans before the rooms were constructed.

One auditorium is the Concert Hall of the Smith Music Building, for which Professor James M. White was architect with Mr. George E. Wright as associate architect. In this case it was desired to have a room with qualities that would co-ordinate as far as possible in the acceptable production of music. For this purpose, as shown by the theory of the subject and illustrated in the cases of auditoriums already built and found suitable for music, the room was designed with a moderate amount of absorbing material so that the reverberation would be somewhat prolonged. The walls were to be quite reflecting, with ventilators at critical positions to avoid echoes and undue reverberation. The absorbing material was located largely in the seats which were to have considerable upholstery. The results obtained are in accordance with the predictions. One performer stated: "It is easy to sing in the Hall—the notes flow freely and the voice can be used almost without effort." Instrumental music—that is, chamber music of moderate intensity—is also rendered so as to produce a pleasing effect. A maximum audience reduces the reverberation somewhat without detriment to the acoustics. The room is not suited for heavy music of great intensity, since this would be rather overpowering. Neither is it well suited for speaking because of the relatively long period of reverberation.

The other auditorium to be described is located in the Wesley Foundation Social Building. This room was to be used primarily for speaking; therefore, the acoustical design was quite different from the Concert Room of the Music Building. The period of reverberation should be short in order that a spoken word after making its impression should die out quickly. As in the preceding case, here too, the theory of the subject with illustrative halls gave suitable guidance for the acoustical prescription. It was recommended that the ceiling walls of the room, which formed an inverted V, should be covered with a sound absorber—a pulp board in this case—that could be easily installed and which presented an acceptable appearance. Calculations showed that this material would give a reverberation acceptable for speaking for a room with the volume of the Wesley Auditorium. The outcome confirms the prediction. Speaking is heard distinctly even when only several people are present. With a maximum audience of about 700 people, the conditions are improved. One rather surprising feature in the acoustics is the satisfactory rendering of vocal music. This was not anticipated, but it would seem that a room acceptable for speaking is also suited for vocal music. Instrumental music, such as that of a piano, is heard at a disadvantage. For this, the room is too "dead."

The two auditoriums described indicate the degree of development of the acoustical design of auditoriums. The theory and practice have been tried in many cases with success. There appears to be some range of latitude in the acceptable time of reverberation and in the intensity of the resulting sound so that the amount of sound absorbing material recommended for a room may be varied within certain limits without prejudicing seriously the successful outcome.

In addition to the acoustical design of auditoriums, another problem in buildings presents itself — namely, the sound proofing of rooms. Great annoyance and inconvenience are suffered because of the unwelcome intrusions in a room of sounds coming from other parts of the building. The noise of a piano in an adjoining apartment, the hum of a motor, the click of typewriters, etc., are familiar instances of sounds that annoy people and reduce their efficiency in the performance of work.

The sound proofing of rooms to reduce this defect is not a simple matter, nor is it attended with the same certainty of success as in the acoustical design of auditoriums. Sound progresses along unsuspected paths so that practical attempts to stop it, even if based on the suitable theory and in accord with other successful insulations, are not always effective.

In this connection, two kinds of sound should be considered. First, those generated by the voice, a violin, etc., which originate in the air and proceed through the air. These are reflected in large proportion when they strike a continuous wall of some rigidity. Another type of sound originates in the vibrations of a piano, cello, motor, etc.— instruments which make an intimate contact with the building structure. These vibrations travel with ease through the continuity of structure and are converted into sound in air, even at distant points in the building, when a wall or some structural member responds in a resonant way to the vibrations. The insulation for this latter type of vibration lies in the interposition of some medium varying in elasticity or density from the medium in which the vibrations are traveling. Thus, an air space inserted in masonry would be quite effective in stopping sound, provided the air space were not bridged over by solid material. But the practical requirement of rigidity does not allow the interposition of an unbridged air space, so that the next best arrangement is used, namely, hairfelt or some other air filled material as part of a floating floor, double wall, etc. The problem is not yet solved in a practical way for all conditions; but progress has been made.

For instance, in the Smith Music Building already mentioned, an effort was made by the Supervising Architect and the writer to sound proof the entire building from attic to basement. This problem involved the sound insulation of some fifty small practice rooms, twelve studios, and the larger concert hall, besides the acoustic control of sounds of motors, fans and elevators. Double walls, floors, and ceilings were constructed in accordance with the descriptions set forth in the previous paragraph. Tight fitting doors and windows were specified to prevent leakage of sound and separate ventilation ducts were designed to convey air to and from each room.

Without dwelling on all the details it is perhaps sufficient to state that some degree of success attended the efforts. Students use adjacent rooms for piano practice, singing, violin and other instrumental drill, etc., without serious disturbance to each other. The rooms are not absolutely sound proof nor does this appear necessary because the sound that leaks into the room is so diminished in intensity that it is unnoticed when practice is in progress. The ventilators transmit sound between different parts of the building, but the use of separate pipes for each room diminishes the intensity of these transmitted sounds so that they become unimportant compared with sounds generated in the room itself.

After several months of use, the building is considered satisfactory for the purpose. Absolute sound proofing cannot be attained without very unusual, and perhaps inpractical, building constructions. It appears from the experience with the Music Building thus far that absolute sound proofing is not essential. There are many things yet to be learned by further experience, but enough has been revealed to give encouragement to the belief that sound-proofing may be prescribed in the near future with some of the certainty that now attends the acoustic design of auditoriums.

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