Notes on Office Acoustics

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Abstract: Based on theoretical aspects of acoustics and years of experience, practical methods of office acoustic design have been determined. When installing partitioning for cellular offices, care needs to be taken to ensure that the sound transmission loss of the partition construction is matched by surrounding constructions and details. When designing open office plans, a careful balance of all of the factors, including sound absorption, distance, shielding and background noise level, is required. The acoustic design of conference rooms must also allow for the modern audio technology associated with such rooms.

1. INTRODUCTION

This paper discusses some acoustical aspects of modern offices. It is intended to summarise some of the conclusions that have resulted from years of experience of the acoustical design of office spaces. It is not intended to be fully comprehensive and the technical basis for some of the conclusions is also not discussed in detail.

Changes which have occurred over the last decade or so in the way offices work have changed the acoustical requirements of office spaces. Such changes as the extensive use of computers, the introduction of audio visual facilities into Conference Rooms and the more common use of Tele-Conferencing and Video-Conferencing facilities. This Technical Note discusses both the acoustics related to the recent changes and conventional office acoustics. In particular, office partitioning, open office plans and conference rooms are discussed in some detail.

2. OFFICE PARTITIONS

To allow flexibility within office spaces, it is common to provide office partitioning using dry construction, as opposed to brick or concrete block. Where acoustical performance is required, the partition is often a stud and plasterboard partition. Such partitions allow medium to good sound transmission loss performance and overall acoustical attenuation in the speech range. This is achieved at a low weight to performance ratio, compared with such materials as brick. Details of plasterboard wall sound transmission loss are readily available from plasterboard manufacturers.

However, where a plasterboard partition is used to separate spaces in an office, the transmission through the partition is not the only noise path to be considered. Noise can also be transmitted up through the ceiling and back down again in the adjacent space as well as through any poor seals at the junctions. The main noise paths are demonstrated in Figure 1.

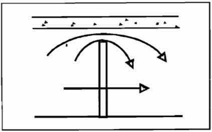

Figure 1. Noise Transmission path through and around an Office partition (section).

Whilst it is relatively easy to obtain good seals through the plasterboard wall at the joints of sheets of plasterboard (since manufacturers have standard taping and setting methods), seals to the ceiling and to window mullions are often difficult to achieve. To maximise the flexibility within office spaces, builders are reluctant to use good acoustic sealants (such as Mastic) between the head of the partition and the underside of the ceiling. Often standard foam strips are used and, whilst these provide better seals than can be provided without such strips, good airtight seals are not possible. This problem is aggravated by the types of acoustic ceilings commonly used in office spaces, such as mineral fibre ceiling tiles laid in a grid or perforated metal pan ceiling tiles also laid in a grid.

It is also common to find poor seals between office partitions and window mullions, where such partitions extend to the building perimeter walls. The expansion and contraction of the window mullion, especially where it is exposed to direct sunlight, tends to crack a standard plaster seal. It is therefore necessary to use a sealant with a degree of flexibility in the joint, such as a non-setting Mastic or a silicone sealant. It also follows that the end of the partition abutting the external wall needs to be constructed so as to follow the profile of the wall and to take account of the window sill and any other construction above and below the window.

In respect of sound transmission from room to room via the ceiling space, the ceiling material needs to be selected so that this path does not become a weak link in the system. Most major ceiling manufacturers have had their ceilings tested to provide room-to-room sound transmission loss performances. For common mineral fibre ceiling tiles, the sound transmission loss is normally in the vicinity of Sound Transmission Class (STC) 35-40. Such a performance is adequate for most standard office partitions, but some form of upgrading is required where a high standard office partition is needed, such as STC 40 or 45. The best way of upgrading the ceiling performance is to install a vertical baffle extending from the ceiling to the underside of the slab above to provide a third barrier between the two rooms via the ceiling. The third barrier is normally so effective that only a single layer of standard building material, such as plasterboard, is necessary to substantially improve the room-to-room sound transmission loss.

Care should be taken where perforated metal pan ceiling tiles exist within the building. Although these tiles commonly have insulation laid over them, they are almost transparent to noise. Accordingly, sound transmission loss via the ceiling space is substantially below that of a low performance partition. This problem can be overcome by again installing a baffle within the ceiling space or, alternatively, by fixing a solid màterial to the back of the tiles (such as single unperforated metal).

Improving the room-to-room sound transmission loss via the ceiling space by the installation of baffles or by backing of tiles will have no effect upon the quality of seal between the partition and the underside of the ceiling. This weakness often limits the performance of office partitions unless the partition extends through the ceiling, preferably to the underside of the concrete slab above.

Whilst the most critical partitions within office spaces are those that separate individual rooms, such as two offices, two conference rooms or an office and a conference room, partitions separating such rooms from corridors can also be of some acoustical importance. However, these walls are often substantially weakened by the installation of doors for access. Since a good solid core door with acoustical seals is unlikely to provide more than STC 30, no benefit is gained by installing a partition with a sound transmission loss greater than STC 40. In fact, little benefit is gained by installing a partition with a sound transmission loss of greater than STC 35.

The frequency characteristics of plasterboard partition sound transmission loss performance need to be considered in some circumstances. As demonstrated in Figure 2, the STC of a stud/plasterboard partition with insulation in the cavity can be as good overall as a single brick wall. However, the sound transmission loss performance in the low and high frequencies is less than that for a brick wall and the low frequency performance particularly can prove important where audio-visual facilities are to be installed. Since all partitions and walls are weaker in the low frequency bands, it can be important to maintain the highest practicable performance in those low frequencies. Accordingly, stud/plasterboard partitions can often result in low frequency noise transmission from rooms with audio-visual facilities to adjacent rooms and, for larger conference rooms, brick construction or heavy plasterboard construction is often required. One should be aware that STC performance does not give a true indication of the overall subjective performance in many instances.

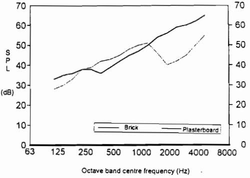

Figure 2. Sound Transmission Loss for 110mm brick wall and 16mm plasterboard each side of 64mm steel studs with 50mm insulation in the cavity (STC 44).

3. OPEN OFFICE PLANS

When developing open office plans instead of cellular offices, one of the most difficult features is establishing sufficient acoustical privacy between workers. The success in this regard depends upon a number of factors:

* Sound absorption in the space.
* Distance between office personnel.
* The degree of shielding between personnel.
* The background noise level.

Sound absorption is most commonly provided by the use of an acoustic ceiling. The perforated metal pan ceiling tile with sound absorbent insulation above provides the best available ceiling absorption and this level of absorption is highly desirable. However, the most common form of acoustic ceiling within modern offices is the mineral fibre ceiling tile. Its sound absorption coefficient is less than the perforated metal pan tile, but it can prove an acceptable compromisee.

Other reflective surfaces, particularly walls, can affect the transmission of sound throughout the open office space. Open plans therefore work best in large areas where reflective walls affect a limited proportion of the office personnel. On the other hand, it is possible to apply sound absorption to reflective walls. Over and above this, all screens to be used within the space should be the sound absorbent type and this limits the selection to a small proportion of commercially available "acoustic" screens.

Obviously, the further apart that office personnel are, the less likely that a lack of acoustical privacy will occur. In practice, a distance of 3 m between personnel orientated back-to-back will prove adequate, but greater distances are required where the personnel are face-to-face. However, shielding by office screens can provide the required privacy at much reduced distances.

The shielding is best provided by free standing screens or screens which form part of work stations. The line of sight between the heads of office personnel must be clearly broken to ensure significant reduction in sound transmission occurs. This means that the screens should be of a height of at least 1.5 m above the floor. Such screens can then reduce the minimum distance between office personnel orientated face-to-face to approximately 1.5 m, depending upon other factors such as sound absorption and background noise level.

Most office spaces have a background noise level generated by operation of the air-conditioning system. This background level can mask the intrusion of sounds from nearby office personnel, thereby reducing the intelligibility and increasing the acoustic privacy. The background noise level is best when sufficient in level and of a spectrum shape to provide good masking, whilst at the same time being subjectively unobtrusive. Figure 3 shows a range of background noise levels which appear to have the correct balance between masking and unobtrusiveness. For convenience the RC curve (say RC40) may be used as an approximation, although the shape of that curve is not tuned to provide the fine balance that is often necessary.

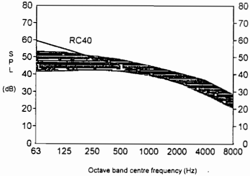

Figure 3. Suggested Background Noise Spectrum.

Air-conditioning systems can be used to specifically create a background noise level similar to the type required for an open office plan. The air outlets can be adjusted or dampered back to provide approximately the correct level and spectrum. However, this method is relatively unreliable and does not give great flexibility in setting the spectrum shape.

The best way of providing the background noise level is by the use of an electronic system. This system commonly incorporates a noise generator, a graphic equaliser, an amplifier and a series of loud speakers installed in the ceiling space. The method of installing the loud speakers in the ceiling space is important in obtaining a good spread of sound throughout the space. Since loud speakers are quite directional in the high frequencies, loud speakers mounted behind standard loud speaker baffles within the ceiling give a substantially different spectrum shape directly under than to one side One of the best ways of overcoming this, whilst at the same time providing a well rounded unobtrusive quality of sound, is to mount the loud speaker above the ceiling tile and allow the sound to be transmitted through the tile. Figure 4 shows a successfully used system for offices containing mineral fibre ceiling tiles.

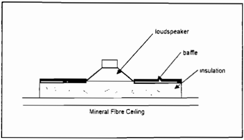

Figure 4. Suggested loudspeaker mounting detail for a mineral fibre ceiling.

4. CONFERENCE ROOMS

The acoustical design of conference rooms to provide a higher degree of intelligibility is widely understood by acousticians. However, the extensive use of tele-conferencing and video-conferencing in today's conference rooms changes the acoustical characteristics required within the room. These systems commonly use microphones which are often located at some distance from the person speaking. Under these circumstances, many existing conference rooms will generate quite reverberant sounds for the receiver at the end of the conference transmission line.

To overcome this, the conference rooms should be designed to be relatively dead acoustically. As a general rule, small conference rooms work relatively well where there is good carpet on the floor and an acoustic ceiling over. However, some sound absorption on wall areas will improve the overall performance.

For larger conference or seminar rooms, a more detailed analysis of reverberation times is required. These rooms should be designed as if they are low standard sound studios (where this is practicable) and it is suggested that a reverberation time somewhere between that recommended for a room for speech and a talk studio would suffice.

5. CONCLUSION

Today's office building occupants are demanding a higher acoustical standard within their offices than they did two decades ago. Acoustical privacy, whether within cellular offices or an open office plan, is the over-riding requirement. With the new office audio-visual aids, providing this privacy is getting harder and harder.