ACOUSTICAL CHARACTERISTICS IN RESTAURANTS AND FOOD COURTS / LARGE DINING AREAS WITH VARYING LEVELS OF OCCUPANCY

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1 Introduction

Dining areas vary in type from quiet and intimate to very lively, and the acoustical character varies as well. Large spaces tend to be more lively and see more transient occupancy, but the designs often try to balance a more intimate setting for conversations, while retaining a dynamic and exciting atmosphere. The atmosphere will also vary depending on the type of space: the acoustical character will differ in food courts, smaller, more intimate restaurants, and urban restaurants with lively bar areas. In spaces without significant amplified background music, the sound level is dominated by speech, and communication quality is therefore of importance. The acoustic properties of such spaces are strongly affected by the occupancy level, due to the changes in reverberation and 'self-noise' or 'din' of the occupants themselves. Recent field measurements and experience with several dining spaces at varying levels of occupancy are reviewed herein.

2 Dining Venues

2.1 Description and Characterization

The background sound level during the mid-day rush when the space is at maximum activity was measured in three separate food courts and a sports bar/restaurant, each with various acoustical characteristics of the space, as well as demographics. All had hard-surfaced floors, drywall or glass walls and ceilings, and minimal upholstering of furniture or draperies, etc.

Food court A included a high ceiling in a suburban mall with perimeter openings. Food court B had a low panelized ceiling around the perimeter with a notably higher glass skylight in the centre. Food court C had low drywall and panelized ceilings throughout. (Panels were typically offset lattice or wooden blades, etc., offering some diffusion but not absorption). These two spaces (B and C) were in urban concourses, serving downtown office staff, and many patrons were in small groups carrying on conversations. Restaurant D included a low ceiling area, but comprised predominantly a double-height ceiling, serving the same demographic area as food courts B and C, but included a bar and wait staff. As well, D included background music with strong bass, but also required more speech communication with staff, and most patrons were in groups having lively conversations.

The reverberation time (RT60), which is the time required for sound to decay by 60 dB in a space, was also measured in each space in the speech-relevant frequency range of 500 Hz to 1 kHz. Reverberation measurements were conducted when the spaces were at 5% or less occupied to focus on the architectural acoustics, rather than the occupant acoustics.

2.2 Occupancy Sound Levels

The background sound level was measured continuously, with the 5-minute (D) or 15-minute (A, B, C) average reported as typical. As well, the range of levels (the difference between the typical maximum and minimum 1-second levels) due to variations from lulls in conversations to peaks from chair scuffles, staff activity, loud conversations or laughing, sneezing/coughing, music, etc., is also presented for each location. The data are shown for occupancies of about 5%, 40%-50%, and 80% or higher.

3 Measurement Results

3.1 Reverberation

The reverberation times for each location were measured when the spaces were essentially unoccupied to quantify the room characteristics, but also due to the difficulty of measuring with patrons present.

The measurement results for each venue are summarized below in Table 1. It is noted that the RT_{60} nominally correlates to the ceiling heights.

Venue	A	B	C	D
RT_{60}, s	2.2	1.6	1.3	1.8

Table 1: Reverberation time, RT_{60} (500 Hz) in each venue, (s).

3.2 Occupancy Sound Levels

The total sound levels in each venue were averaged over the measurement periods (5 to 15 minutes) and are summarized in Figure 1 as a function of percent occupancy. Also presented in the figure is a representation of the range of sound levels during each measurement period. For venues A, B, and C, the durations were 15 minutes and the values are the difference between the L_{10} and L_{90} slow time constant, A-weighted sound levels. For venue D, the sound levels were averaged over 5 minutes and the range is represented by the difference between the maximum and minimum slow time constant A-weighted sound levels during those periods. While these are not the same descriptors, they do both provide a similar estimate of the range of sound levels.

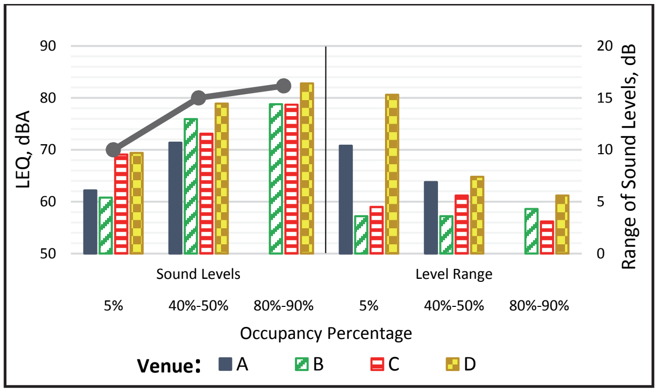

Figure 1: Representative average and range of sound levels under varying occupancy at each venue.

4 Discussion

4.1 Overall Sound Levels

The data in the figure indicates that the background sound clearly increases with occupancy as a percentage of venue capacity. It is also apparent that the sound level increase is generally greatest from low to medium occupancy, and the sound level increase is much less from medium to near-full occupancy. Note that in venue A, the occupancy did not exceed about 40%.

A reference curve is overlaid in Figure 1 which indicates a simplified model of sound level increase due to added occupancy. The model assumes that each talker has a representative sound power emission level, with the sound level at 5% occupancy arbitrarily normalized to 70 dBA. The sound level increase at 50% and 85% occupancy were calculated as a simple decibel logarithmic function of the ratio [1]. Thus, the 50% sound level is 10 dB higher than 5%, and the 85% occupancy is about 2.3 dB higher than the 50% value. This simple model appears to represent the trend quite well, especially in venue D. The two data points for venue A also appear to follow this trend.

For the two office food courts, the general trend of increase with occupancy is apparent, and is in reasonable agreement with the model from medium to high occupancy (minor change), but two different factors may account for the deviations at low occupancy. Venue B was populated by mostly single diners during low occupancy (with minimal speech), whereas, venue C included a busy coffee concession which represented a small percentage of occupancy, but a continuous line of conversing patrons.

4.2 Range of Sound Levels

Some of the above effects are also evident in the data for the range of sound levels. In venue A, the conversations are sporadic with small groups of shoppers, but as the occupancy increases, the levels are more steady. This trend is also very evident in venue D, and extends to the 85% occupancy condition, that is, decreasing range with increasing occupancy. Interestingly, these trends are not apparent in either of the urban food courts.

4.3 Reverberant Effects

It is noted that the above-noted range trends do appear to correlate to the reverberation times of the spaces; that is, the more reverberant spaces experience larger low-occupancy sound level ranges than the less reverberant food courts. Whether this is due to the reverberation or the extra volume from the high ceilings, or both, is not clear. It should be noted that the increase in absorption from the additional occupancy (that is, acoustical absorption of humans) has not been considered. Further measurements would be required to determine if the added absorption (tending to reduce sound levels) may be offset by people speaking louder as the overall sound level increases (known as the Lombard Effect [2]).

The wait staff at venue D had complained of difficulty in taking orders during high occupancy (not relevant in the food court venues), and it is noted here that the recommendation was to introduce substantial amounts of absorptive material on the ceiling and walls to reduce reverberation and hence the overall sound levels at higher at all occupancy levels. At this time, it is not known whether this has been implemented nor the resultant effect.

5 Conclusion

Sound levels were measured over the course of typical lunch time periods in four different dining venues, including a sub-urban and two urban food courts, plus a sports bar/restaurant. Measurement data confirms the expected trend of increasing sound with increasing occupancy, on an approximate logarithmic basis. The acoustical character of the spaces (reverberation and ceiling height) also appeared to be related to an increased range of sound levels during periods of lower occupancy. Further investigation would be required to determine if the simple model of level versus occupancy is accurate, or if other factors, namely occupant acoustic absorption and the Lombard effect (which may have been offsetting in these cases), should be considered.

References

[1] I.L. Ver and L.L. Beranek, Noise and Vibration Control Engineering: Principles and Applications, Second Edition, 2006.

[2] E. deRuiter, Lombard Effect, Speech Communication and the Design of Large (Public) Spaces. *European Acoustics Association, Forum Acusticum* 2011.