Measured Effects of Absorption Location, Receiver Position, and Source Direction on Reverberation

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The use of variable acoustics in performance halls, especially multi-purpose halls, is becoming relatively standard acoustic design practice. The desired goal is a high degree of reverberation control and limited spatial variation across the audience. Given the possible locations for variably absorbing finishes with respect to the audience areas, spatially non-uniform conditions are exhibited. The effects of absorption location and listener position are further highlighted when taking source directivity into consideration. This paper presents measurements showing the variations in reverberation time (RT) across the seating area due to the use of soft banners deployed in various locations. A directive source was employed to examine variations as a function of emission direction. Measurements were performed in a 1500-seat auditorium equipped with variable acoustic curtains in various locations in the audience chamber: lower side walls, upper side walls, and rear walls. The results of these measurements are presented, highlighting variations due to absorption location, receiver position, and source direction. The auditorium chosen is used for all types of music performances, theater, and conferences.

INTRODUCTION

Acoustic variability of multi-purpose halls is important in an age where events and performances ranging from classical orchestra to speech are programmed in the same space. Variable absorption is the most commonly used method to achieve variability of the acoustical quality of the room. While general rules of thumb are used to predict the effects of absorption areas, few studies have been done on the effect of absorption location within the hall.

This study examines the effects of three different factors on the reverberation time of a particular performing arts hall: receiver location, source directivity, and absorption location. The selected hall for this study is the Auditorium de Dijon, France.

MEASUREMENT OVERVIEW

A number of measurement configurations were defined for the purposes of this study and a limited number of combinations were employed. Figure 1 shows an internal view of the hall from the stage in which the source are receiver locations are identified.

The hall is equipped with three sets of acoustic curtains/banners of similar construction at the following locations and with the given approximate surface areas: upper side walls (405 m^2), lower side walls (260 m^2), and lower back walls (135 m^2). These locations are indicated in Figure 1 using different patterns. Eight receiver locations (A-H) are located within the audience seating areas of the hall. All locations are used in the measurements without variable absorption, while receivers B, F, G, and H are used in the variable absorption configuration measurements. Five absorption configurations were used: none, lower side walls, upper side walls, lower back walls, and all variable absorption. The upper portion of the stage house was closed off with a movable ceiling partition.

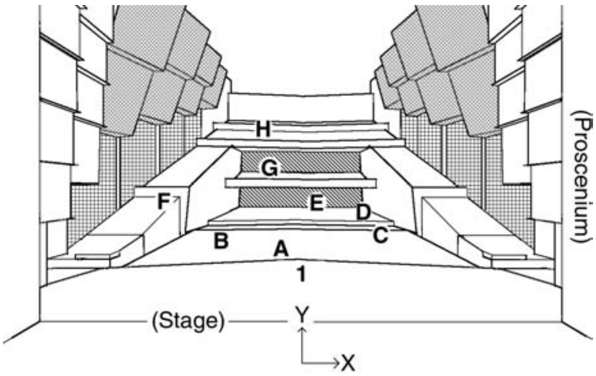

FIGURE 1. Internal view of the hall showing variable acoustic areas, source ID (1), and receiver IDs (A-H).

The sound source was a cluster of five stage monitors, configured along Cartesian coordinates ±X, ±Y, and +Z (there was no "down" speaker), cf. Figure 1. For every source/receiver combination an individual measurement was done for each source component.

Repeatability of reverberation time measurement results was within ±0.05 sec. Reported reverberation times are octave-band mid-frequency reverberation times averaged over 500 Hz – 2 kHz.

RESULTS & CONCLUSION

Variations due to source direction are shown in Figure 2, with no variable absorption in place. Variations due to receiver position are of the order of 0.2 sec, and variations due to source direction are equally of the order of 0.2 sec. Taking both factors into account, differences of up to 0.35 sec were observed between measurements.

Deploying all the variable absorption results in a general decrease in reverberation time of 0.2 – 0.4 sec. Figure 3 shows the dependency of reverberation time as a function of source direction and receiver location, using a smaller set of listener locations. A measurement with all source components active was equally recorded, allowing for an ‘all’ or ‘omni’ directional source comparison. Variations due to receiver location are on the order of 0.15 sec. Variations due to source direction (including ‘all’) are on the order of 0.3 sec. Maximum variations are of the order of 0.45 sec.

Figures 4 and 5 show the variations in reverberation time due to absorption location for the four listener locations with two source directions, ±Y (forward and backward emission). It is readily apparent that different absorption locations have varying influences on listener locations, as a function of emission direction. The degree of variability for a given source direction is generally within 0.15 sec, slightly greater than the repeatability limit of ±0.05 sec. Between different source directions variations are of the order of 0.2 sec for those examples.

This study investigated the influence of absorption location, receiver location and source direction on the measured reverberation time of a 1500-seat performance hall. The reverberation time across the hall is non-uniform, both with respect to source direction and receiver location. Careful use of the different variable acoustics elements will allow to influence the acoustical conditions in the different seating locations more or less independently, either in the aim of homogenizing reverberation time, or in order to achieve adapted listening conditions for each receiver location. While this study focused on reverberation time, it is clear that other acoustical parameters come into play as well–and that a reverberation time that differs as a function of seat location may be preferred under certain conditions.

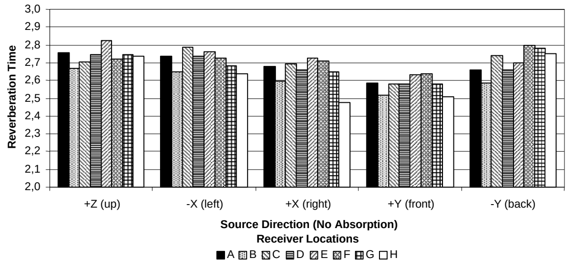

FIGURE 2. Variations in reverberation time due to source direction, with no additional absorption.

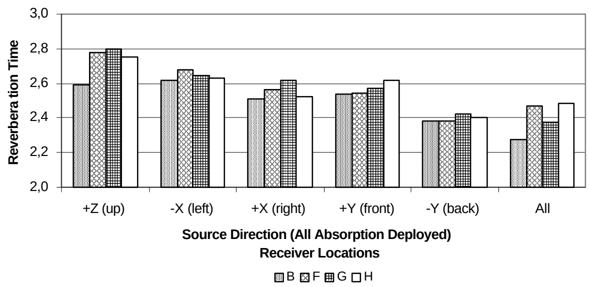

FIGURE 3. Variations in reverberation time due to source direction, with all additional absorption.

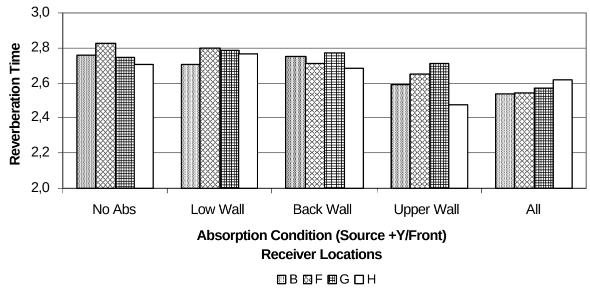

FIGURE 4. Variations in reverberation time due to absorption location with source direction +Y (frontal).

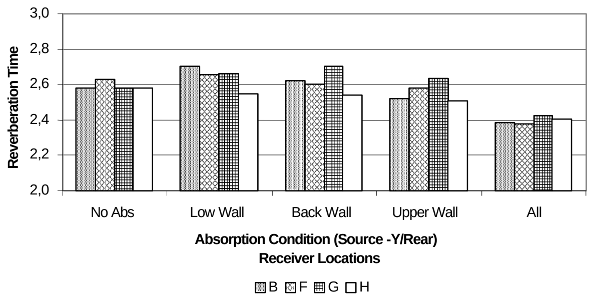

FIGURE 5. Variations in reverberation time due to absorption location will source direction –Y (backwards).