Testing The Sensitivity Of Stage Acoustics Measurement Techniques

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INTRODUCTION

The stage acoustics parameters proposed by Gade[1] and Naylor[2] in the 1980s have gained general acceptance but been have applied in various and sometimes incompatible ways. Some measure Support at 0.5 m while others measure it at 1.0 m. Some measurements have been performed on empty stages, others on fully equipped stages with chairs and music stands. These new stage measurements offer the promise that the early energy audience related measurements did in the 1960s and '70s. If a consistent database of stage measurements is to be established, it would seem prudent to test the sensitivity of these measurements and the effects of the various measurement techniques.

MEASUREMENT SYSTEM

The acoustic source used in the measurements was a dodecahedron with 75 mm Altec ALS 35 loudspeakers. Source height was typically 1.1 m above the stage and, unless mentioned otherwise, Support ratios were measured at a source receiver distance of 0.5 m. Similar to the author's previous studies[3], measurements were performed at and between five locations on each stage corresponding to Soloist, Violin, Viola, Horn and Bass. For the occupied seating measurements, responses were recorded on Digital Audio Tape (DAT) recorders for subsequent processing in the laboratory. For all other measurements, processing was done on site.

ABSORBENT LAYER

In their initial studies, both Gade and Naylor placed a 50 mm thick glass fibre blanket beneath the source, reasoning that it represented a crude estimate of the absorption of the musician seated in his or her chair. Gade and others no longer use a blanket, O'Keefe & Bracken[3] still do.

Measurements have been performed with and without a blanket in two rooms and at two different source receiver distances. The first room is Roy Thomson Hall, Toronto which at the time was equipped with seating and music stands for approximately fifty musicians. The second room was an empty lobby that had a reverberation time of 1.7 seconds and was devoid of furniture or acoustically absorbent materials.

In Roy Thomson Hall, the effect of the blanket was less than 0.5 dB. In the lobby there was a slightly more pronounced effect, notably at higher frequencies. The effect of the absorbent layer was marginally higher for measurements at 0.5 m than it is at 1.0 m.

SOURCE-RECEIVER DISTANCE

Gade and others measure Support ratios at a distance of 1.0 m from the centre of the dodecahedron. Naylor has pointed out that a 0.5 m source receiver distance is a bit closer to reality, i.e. it is difficult to play an instrument held out 1.0 m from the performer's head! Naylor used a 6 dB adjustment for a modified version of Gade's Early Ensemble Level and some of the Support ratios. The adjustment was to account for hemispherical divergence of the direct sound and allow for direct comparison with Gade's measurements. O'Keefe and Bracken[3] applied a similar adjustment.

Support ratios have been measured on a number of concert platforms and proscenium arch stages using source receiver distances of 0.5 and 1.0 m. The data makes two things immediately clear. The average difference between 0.5 and 1.0 m measurements is less than 6 dB and it varies considerably, both in frequency and from stage to stage. Floor reflections explain part of this discrepancy but cannot explain all of it. The "direct" sound component of a Support ratio is measured over a temporal window of 10 ms. It would seem therefore that any reflecting surface within approximately three metres of the microphone will affect the adjustment factor. Of the six halls that were measured only the Queen Elizabeth Theatre had a completely bare stage. It was also to closest to 6 dB. To conclude, it does not seem practical or prudent to compare 0.5 and 1.0 m Support ratios through the use of a correction factor.

CHAIRS & MUSIC STANDS

Measurements were performed on two stages with and without chairs and music stands. In both cases measurements were performed with a 50 mm layer of glass fibre blanket underneath the source. There were chairs and stands for approximately 24 musicians on both stages. Care was taken to move the music stands away from the source and receiver.

Both Support and Modulation Transfer Functions are remarkably insensitive to the presence of chairs and music stands. The Support ratios changed by less than 1 dB at high frequencies. At 500 and 1000 Hz the difference was less than 0.5 dB. Mean MTFs were hardly changed at all. The only noticeable difference in MTFs was at the higher modulation frequencies (12 to 20 Hz) and here the change was in the order of 0.1. Naylor suggests that this is subjectively insignificant[4].

OCCUPIED CHAIRS

Following up on this finding, it made sense to see if the measurements were sensitive to the difference between empty and occupied chairs. The measurements were performed in a shoe box shaped gymnasium with a mid-frequency reverberation time of 2.3 seconds, unoccupied. Chairs and music stands were set up for 25 musicians at one end of the room and the first set of measurements were performed. The glass fibre blanket underneath the source was omitted in a effort to maximise the difference between the empty and occupied configurations. The musicians were then asked to enter the room and take their seats. Once seated, the measurements were quickly repeated. Again, the Support and MTF changed very little. Mean MTFs changed approximately 2% at low and high (audio) frequencies and about 0.5% at middle frequencies. Support changes were of a similar magnitude. The only significant differences in the impulse response functions were quantified by the Early Decay Time and Reverberation Times which were reduced by about 10% when the musicians entered the room. These results suggest that the presence of musicians on the stage affects the later part of the decay more than the first few reflections.

REGRESSION ANALYSIS

If one assumes for the moment that sound levels on a stage can be quantified with a simple linear regression, it is possible to extract some useful information. Figure 1 shows a typical result at 1000 Hz. The room radius in most concert halls is approximately 5.0 m. In Figure 1 therefore, the classical definition of sound in a reverberant field would suggest a curve. The data in fact has a good fit to the straight line. Figure 2 shows that on a stage, sound levels decrease at a rate of approximately 1 dB/m depending on the octave band frequency. The notable exception is the 250 Hz octave which consistently shows a smaller slope. Both figures demonstrate interesting results and suggest new avenues of research.

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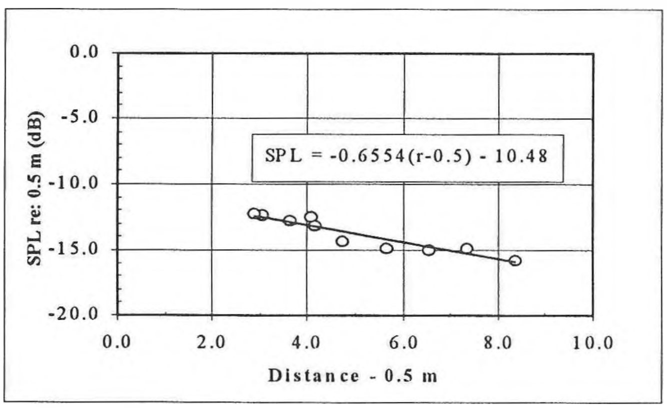

Figure 1 Sound Level Regression, 1000 Hz, duMaurier Theatre, Hamilton, Ont.

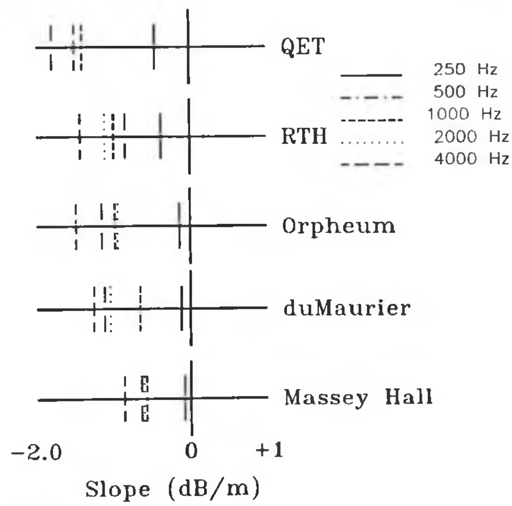

Figure 2 Slopes of linear regressions in dB/m