Objective Comparisons of Massey Hall and Boston Symphony Hall

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Introduction

Massey Hall (MH) and Boston Symphony Hall (BSH) are of about the same age with generally similar acoustical properties, but with a number of distinct differences. This paper summarises comparisons of extensive objective acoustical measurements in each hall. These comparisons are intended to demonstrate how various newer auditorium acoustics measures can be used to better understand the acoustical properties of large halls and to more reliably diagnose acoustical problems in halls.

BSH is a long, rectangular or "shoe-box" shaped hall with a volume of 18,746 m^3, a width of 23 m, and with seating for 2631 people. MH has an approximately square floor plan with a volume of 14,190 m^3, a width of 34 m, and with seating for 2500 people. Both halls were measured in a completely unoccupied condition and therefore the differences in the acoustical properties of the seats in the two halls will significantly influence the comparisons. BSH has seats that are leather covered while MH has more absorbent cloth-covered seats on the main floor and 1st balcony seats. The second balcony seats in MH are molded plywood.

In both halls, measurements were made using our RAMSoft-II computer based measurement system that calculates 12 different quantities in 6 octave bands from impulses in a few seconds while at each location in the hall. Responses were obtained for the combinations of three source positions and 12 receiver positions in MH, and 14 receiver positions in BSH (i.e. 36 measurement combinations in MH and 42 in BSH). Quantities measured included: reverberation times (RT), early decay time (EDT), early/late sound ratio (C80), lateral energy fraction (LF5), and relative sound level (G). In addition, the relative level of the early arriving sound energy, G80, the late arriving sound energy, G(late), and the early lateral energy, GEL, were also calculated.

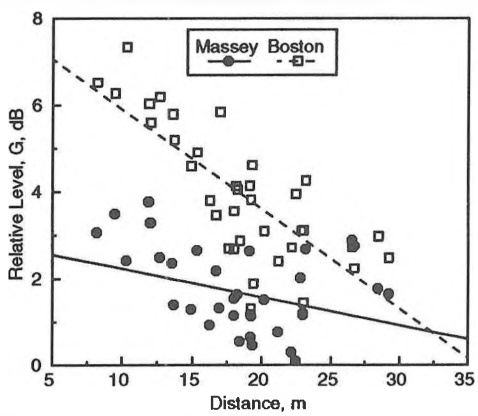

Figure 1: G values at 2000 Hz versus source-receiver distance in both halls.

Hall Average Results

Averages of all measurements in each hall can be used to compare the mean properties of the two halls in their unoccupied conditions. (Differences could be quite different when occupied.) The two halls had quite similar average RT, EDT, and G values at low and mid-frequencies (125 to 1000 Hz). At higher frequencies (2000 and 4000 Hz), RT, EDT, and G values were lower in MH, probably due to the more absorptive seats. C80 values indicated that there would be higher clarity in MH. The LF5 values were generally higher in MH, thus providing an increased sense of envelopment and spaciousness.

Within Hall Variations of Measures

There are many ways of looking at the variation of acoustical measures within halls. Examining these variations helps one to better understand the acoustical properties of a hall. Figure 1 compares plots of 2000 Hz G values versus source-receiver distance. At closer seats, 10 m from the source,

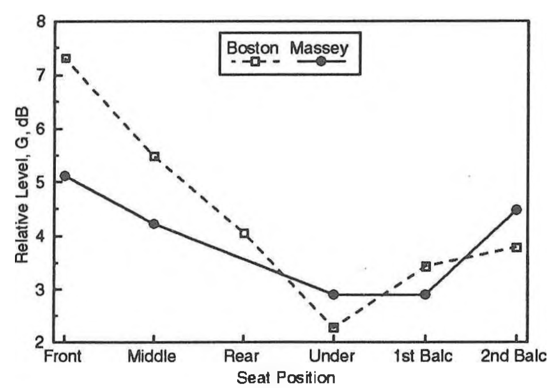

Figure 2: Position average 1000 Hz G values versus position in the hall.

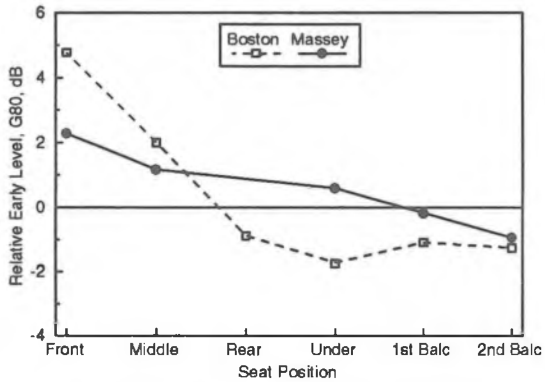

Figure 3: Position average 1000 Hz G80 values versus position in the hall.

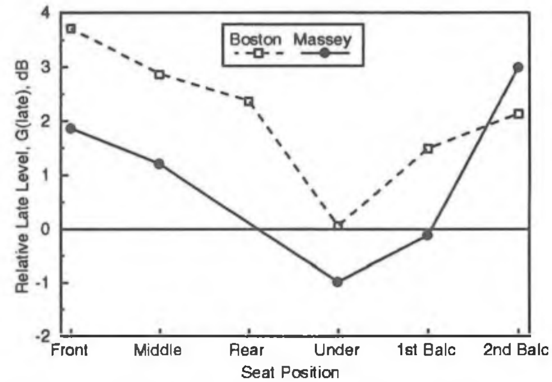

Figure 4: Position average 1000 Hz G(late) values versus position in the hall.

levels in BSH are approximately 4 dB higher than at the same distance in MH. However, in BSH levels decrease more rapidly with distance. Because BSH is much longer than MH, this decreasing level trend leads to similar levels at the rear of BSH and MH. There is considerable scatter about these trends that increases at lower frequencies.

To eliminate the scatter and to relate variations to the geometry of the halls, average values of quantities were calculated for combinations of seat groups and all three source positions. Thus, these results were the average of measurements for the combinations of three source positions and two or three receiver positions. Figure 2 plots 1000 Hz average G values versus position in each hall. Because MH is shorter, there were no "Rear" positions in MH and the distances to each seating group would be different in each hall. These results again show higher levels in BSH close to the source that decrease more rapidly towards the rear of the hall. These average levels tend to be lowest at seats under the balcony. In MH, levels were also low in the 1st balcony at seats under the second balcony.

Figures 3 and 4 compare the area average values of 1000 Hz G80 and G(late) versus position in the halls. In BSH, early sound levels, G80, are higher closer to the source but are lower than in MH towards the rear of the hall and at seats in the balconies. The late sound energy, G(late), shown in Figure 4 was higher in BSH than in MH at all locations except in the second balcony.

It is thought that the higher levels close to the source are due to the narrower width of BSH and also to the shape of the orchestra enclosure that directs reflected sound to the closer seats in the hall. The wider MH has a more even distribution of early energy (from this position average data), but a generally lower level of late arriving sound energy.

While sound levels seemed more reduced at seats under the balcony in BSH, C80 and EDT values were more changed at under-balcony seats in MH. In MH, 1000 Hz EDT values were less than other seating areas by 0.4 seconds or more. Clarity, as measured by C80, was highest at under-balcony seats in MH.

The position average results hide the observed variation of sound levels across the width of MH. Each position shown on Figures 2,3, and 4 was an average of the results obtained for the combinations of three source positions and two receiver positions. One of these receiver positions was closer to the centre line of the room and the other was closer to the side of the room. Sound levels decreased by 1 to 3 dB from the centre to the side seats in MH. This effect contributed to the generally larger spatial variation of measured results in MH.

Conclusions

Massey Hall and Boston Symphony hall have similar average unoccupied RT, EDT and G values at lower and mid-frequencies. The two different plans of these halls causes differences in the spatial variation of acoustical quantities. In the wider MH, levels varied more across the hall. In the longer and narrower BSH, levels varied more from the front to the rear of the hall. At seats under the balcony in MH, early sound and early lateral sound were stronger than in BSH.