

Echo Suppression in a Large Fan Shaped Auditorium

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Introduction

In 1996, the acoustically beleaguered O'Keefe Centre received a \$5M grant from the software developer Hummingbird Corporation and, not long after, assumed that company's name. Part of the grant was used to address the well known acoustical problems, this time with the LARES electro-acoustic enhancement system¹. Prior to installation, a full set of acoustic measurements was undertaken to quantify the existing natural acoustics and to identify any potential impediments to the operation of the enhancement system.

Measurements

Initially, measurements were performed in the traditional fashion: sound source on the stage and receivers in the audience chamber. The results of this round of measurements give objective credence to some thirty-five years of acoustical complaints. The room is virtually devoid of reflected sound. One seat in the balcony had an Early Decay Time of 0.25 seconds. A room of this kind should have Early Decay Times in the range of 1.2 to 1.4 seconds. Lack of loudness had always been a problem at O'Keefe Centre and the Strength measurements shown in Figure 1 present clear physical evidence to corroborate the complaint.

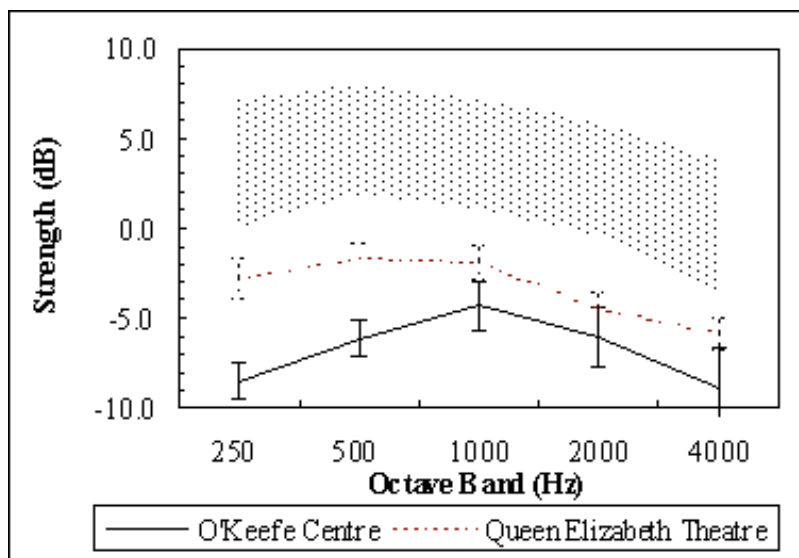


Figure 1 Strength measured in the former O'Keefe Centre compared to Vancouver's Queen Elizabeth Theatre and the 12 halls measured by the Concert Hall Research Group² (shaded area of the graph)

The paucity of reflected sound demonstrated in Figure 1 led to another chronic problem at O'Keefe Centre - echoes. The back wall of the audience creates an audible echo on stage, even though it has been treated with acoustic absorption. Half way through the measurements a side wall echo was discovered. The echo was severe and can be best described as "head spinning". For a source on one wall, the opposite (partially curved) wall returned reflections at 160 to 180 ms. The focus of the curved portion of the wall was outside the room and in other halls might not cause too much concern. In this room however, the lack of late masking reflections meant that any impulsive sound from the sixty-two (62) loudspeakers that were planned for each of walls would be heard as an echo. These speakers were to be used for LARES enhancement and other multi-media presentations. It was the latter of these two applications that would be most affected by the echo. This formidable concern led to a second series of measurements, this time with the source on the side wall. At this point in the project, the feasibility of a successful enhancement installation was seriously in doubt.

Scale Model and Diffuser Design

A 1:50 scale model was built to investigate ways to eradicate the echo. Scale model measurements were carried out using the MIDAS small scale modelling techniques³. Four different diffusers were designed; the first three using the stepped type of diffuser profiles originally suggested by Schroeder⁴ and the last employing a smooth profile generated by a boundary element optimising algorithm⁵. Trevor Cox, the developer of the algorithm, assisted in this final design, working in association with RPG Diffusor Systems. The crescent shaped optimised diffuser that came out of this exercise fits seamlessly into the room's difficult though elegant architectural aesthetic.

The scale model tests of the stepped diffuser suggested that the echo could be significantly reduced, although not completely eradicated. Boundary element calculations on the optimised diffuser indicated a 4 to 7 dB improvement over the stepped diffuser. This would render what was thought to be appropriate reduction in echo and it was decided to proceed with the enhancement installation.

The diffusers were fastened to the walls and, in keeping with heritage concerns, may be easily removed if so required in the future. Measured results were not available at press time but listening tests indicate that the side wall echo has been eliminated. A full set of measurements with and without the enhancement system will be presented at the meeting. Both staff and users at the new Hummingbird Centre have expressed satisfaction with the room's new acoustics.

References

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