ACOUSTIC RENOVATION OF VANCOUVER'S QUEEN ELIZABETH THEATRE: 2006 – 2009

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1. INTRODUCTION

The Queen Elizabeth Theatre (QET) is a seminal building in the history of North American theatre design. The 1956 competition was won by a design team that would go on to build most of Canada's large post war auditoria. The cities of Regina, Winnipeg, Ottawa, Montreal and Charlottetown – to name a just few – all have venues designed by this team. The acousticians included a young Russell Johnson, making one of his first major contributions to auditorium design. In the Johnson oeuvre the QET is second only to the Tanglewood Music Shed and, even then, only by a few weeks[1].

The building opened in 1959 with the 2929 seat main auditorium. Erected in an age before the importance of lateral sound was known[2], it was wide and flat. With the advantage of hindsight, we now know that that was a lethal combination[3]. In 1962, the 668 seat Playhouse Theatre was added to the north end of the building. In 1962, rock and roll acts rarely performed in a venue like the QET and, if they did, their sound equipment could easily have been transported in the back of a station wagon. Structure borne noise control was not a concern at the time. That is hardly the situation today, in this age of tractor-trailer touring shows. This led inevitably to the first phase of the renovation.

2. STRUCTURE-BORNE NOISE

With "soft seat" rock and roll now a major income source for any performing arts centre, the need to extend beyond normal air-borne noise control designs is obvious. The solution at the QET was at once simple and radical: the building was cut in two. In the summer of 2006, while the Playhouse Theatre was dark, the two rooms were separated by a 75 mm acoustic joint extending from the east side of the building to the west along the north side of the QET flytower. This was a formidable task, given that the concrete footings for the flytower were several feet deep.

3. SPATIAL SOUND

The remainder of the renovation will be completed in the summers of 2007, 2008 and 2009. In 2007, the ceiling was removed to increase the height of the room. This has increased the enclosed volume and, consequently, the Reverberation Time. More importantly, it has improved the Height to Width ratio of the room which, as discussed elsewhere[3], will increase the Early Decay Time (EDT).

Typical of its age, the room is very wide: 32 m. Mindful of the seat count but recognising the need for lateral reflections, the renovation design borrows from two obvious ante-decedents: Christchurch Town Hall[4] and Berliner Philharmonie[5]. With the ceiling removed, an elliptical array of lateral reflectors has been installed in the truss space, similar to the Christchurch model. Lateral reflections are also provided by a terraced floor plan similar to the recently renovated Jubilee Auditoria[6] ; a design influenced by Berlin[5].

The overhead lateral reflectors went through several generations of design prior the final version. They started out as four large, flat and rather awkward looking reflectors located towards the back of the room, providing lateral energy mostly to the balconies. Later on they developed into the final elliptical plan but the individual panels still remained flat. Concerns about image shift generated by the flat panels suggested a need for diffusion. Diffusion would also spread the sound out, increasing the zone of coverage. The question was how much diffusion was enough and how much was too much. An early scheme provided diffusion in the form of a three layer fractal, 2-dimensional Quadratic Residue Diffuser (QRD). This was questioned by the architects on aesthetic grounds. Acoustically, there was also concern that the 2-D QRD provided too much diffusion and that lateral energy levels received by listeners would be too low. These concerns were corroborated by Jerry Hyde, who kindly shared some of his experience with the design of the lateral reflectors at the Michael Fowler Centre.[7]

Reflection coverage zones were easily determined using CATT Acoustic 8.0. Aiming the reflectors was easy; determining where to aim them was not. Should a reflector aim for seats on its side of the room or the opposite side? Aiming for the opposite side of the room meant a larger zone of coverage but, because the room is so large, the reflections were arriving rather late; between 60 and 70 ms in the orchestra level. If a reflector was aimed towards the same side of the room the reflections arrived earlier but the angle of incidence became more vertical than lateral. The decision, once again, was informed by the Christchurch Town Hall design – in this case its descendent, the 1982 Michael Fowler Centre. A quick method of images study of an AutoCAD version of the drawings[8] confirmed that the

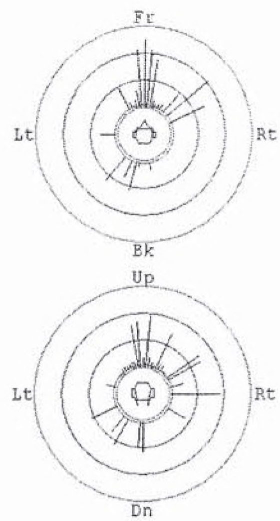

Figure 1 Computer model calculation for a seat in the orchestra level of the existing room demonstrating the paucity of laterally reflected sound.

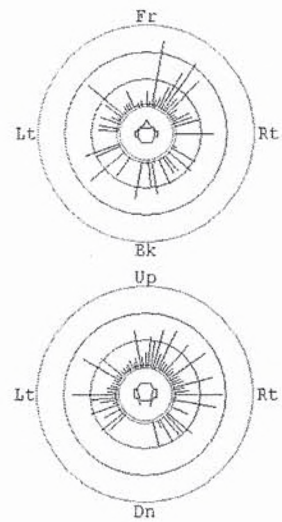

Figure 2 Computer model calculation for the same seat as Figure 1. Laterally reflected sound has been increased by the overhead reflectors and the terraced floor plan.

Before and after computer model calculations, shown in Figures 1 and 2, indicate a significant increase in laterally reflected sound.

4. MULTI-PURPOSE ACOUSTICS

The Queen Elizabeth Theatre is, above all, a multi-purpose venue. Although much of the acoustic design was centred around the needs of Vancouver Opera, most of the bookings for the room rely on amplified sound. The traditional solution, of course, is to provide the appropriate room volume for opera and when amplified productions are on stage, absorb the excess reverberation with adjustable acoustic banners. Recognising that these banners don't absorb low frequency sound very well, the client stated that they wanted something better. Discussions between the author and the architect led to a novel solution.

Coupled volumes have long been used to extend the Reverberation Time of a room. While there are many successful examples, some acousticians remain sceptical. What most agree on, however, is that coupled volumes can be used as very efficient low frequency absorbers. We informed the architect of this and a few days later he came up with a proposal to put a series of doors in the side walls, opening them up to the Sound and Light Lock (SLL) corridors that run down the sides of the auditorium. The SLLs will be lined with as much glass fibre as possible, typically 100 mm thick and more. The doors will be 55 mm thick wood. For opera, ballet, etc. these doors will be closed and will provide strong early lateral reflections. For amplified sound, the doors will be open, exposing the absorption material to the room. Other absorption will be

reflectors could indeed be safely aimed to the opposite side of the room.

found on the back walls, in the form of moveable fabric covered panels, and in the ceiling, in the form of vertical roll-up curtains at the catwalks.

5. ENHANCEMENT SYSTEM

If there was a "prime directive" from the client, it would be to maintain the seat count. The result is a wide room with 2 very long balcony overhangs. The wide room will be compensated for with the lateral reflectors, described above. An electro-acoustic enhancement underneath the balconies will compensate for their problematic geometry. The enhancement system is limited to the balcony areas. Enhancement is not used in the main body of the auditorium or on the side wall boxes. A late design change deleted two rows from the 1st balcony thus eliminating the need for enhancement at the back of the orchestra level.

6. OTHER ISSUES

A number of other modifications are being made to improve acoustics. The side walls are currently lined with thin wood panels that absorb low frequency sound and will consequently be removed. To improve acoustic warmth, all surfaces exposed to the auditorium will be massive, either 50 mm plaster or the equivalent weight.

The existing Heating Ventilation and Air Conditioning (HVAC) system is very noisy. Substantial re-design of the system, necessitated in part by the removal of the ceiling, will see HVAC noise levels reduced to Preferred Noise Criterion (PNC) 15 or lower.

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I should like to dedicate this paper to the memory of Russell Johnson, who passed away as it was being written.