

AERCOUSTICS ENGINEERING

Queen Elizabeth Theatre Acoustical Renovation

The use of new tools and ingenuity has turned a post-war theatre in downtown Vancouver into an opera house with excellent acoustics.

The **acoustical renovation** of the Queen Elizabeth Theatre in downtown Vancouver has been described by the Vancouver Opera company as “a minor miracle.”

Using the latest acoustical tools and theories — some created by themselves — Aercoustics Engineering turned a notoriously poor performance venue into one celebrated for its excellent acoustics.

Much of the focus of the acoustic design was on the needs of the Vancouver Opera, although opera only occupies the room 30% of the time. Most opera houses limit their seats to 2,000, but since the Queen Elizabeth Theatre also hosts popular music acts, the renovated space has almost 2,800 seats. The leading acoustical engineers of the world would never set out to build an opera house this big, but there was no other choice.

Old acoustics were poor

The acoustics of the Queen Elizabeth Theatre have long been lamented. It was typical of its post-war era. It had a very dry acoustic — not reverberant enough. It had a poor spatial sound, the sound wasn't loud enough and it lacked warmth. The only thing it had going for it was acoustical clarity — if anything, too much of it.

In a room that is too big acoustically it is possible to compensate with strategically located reflecting surfaces. In addition, if those reflectors direct sound to arrive at listeners from the sides, an over-wide room can be made to sound more like the well-loved narrow shoe-box shaped rooms



Reconfigured auditorium. The acoustical reflectors are carefully adjusted, sometimes within less than a degree.

of the 19th century — a single violin can appear to fill the whole room.

Ceiling removed and new HVAC system installed

First in 2006, the building was literally cut in two. This was done to prevent noise being structurally borne from the second theatre in the building, the smaller Playhouse Theatre.

The ceiling of the Queen Elizabeth

Theatre was then removed to make the room taller. As well, originally plans called for two new balconies (for a total of three) to be added. The new design also incorporated some modern concepts of the so-called “Directed Energy” halls.

Most background noise in a concert hall comes from the ventilation system, so many new venues use a dis-

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placement system to provide air slowly and very quietly from a plenum below the seats and floor. At the Queen Elizabeth Theatre this option was precluded, so Aercoustics proposed a scheme whereby air is blown into a series of plena in between the roof joists. The plena act as a noise control mechanism and don't take up precious acoustic volume in the room.

Redesign forced new strategies

When hazardous lead dust had to be removed from the site in 2007, it forced a major redesign to finish the project for the 2010 Vancouver Olympics.

The two extra balconies had to be deleted from the original design, as did the terraced seating levels that were providing the critical lateral reflections.

Fortunately, at this point Aercoustics discovered a new software tool, originally intended to optimize lighting in green buildings. It is extremely difficult to design a reflector to its optimum location and orientation in three-dimensional space. This software, for the first time, allowed the engineers to calculate reflection direction and coverage in real time. The tilt on many of the reflectors has been optimized to within less than a degree. Aercoustics believes that it was the first to optimize reflectors on this scale and this accurately.

Project name: Queen Elizabeth Theatre Acoustical Renovation, Vancouver

Award-winning firm (acoustical engineer): Aercoustics Engineering, Toronto (John O'Keefe, P.Eng., Kiyoshi Kuroiwa, P.Eng., Daniel Ruvacalba)

Owner: City of Vancouver

Client: Vancouver Civic Theatres

Architect: Proscenium Architecture + Interiors

Other key players: Engineering Harmonics (sound system), Douglas Welch Design (theatre consultant), Read Jones Christoffersen (structural engineering), Stantec (mechanical engineering), Schenke Bawol Engineering (electrical), Heatherbrae Construction (contractor).

The renovated "directed energy" theatre performed exactly as predicted and the new sound in the room has been widely acclaimed by the client, users, press and public. The renovated acoustics have also been quantified scientifically, proving the audible improvement.

The acoustical approach had to be far more cost effective here in Canada than elsewhere. Seattle renovated a similar sized building for their opera company in 2003 at a cost of US \$127 million. In 2009, the Queen Elizabeth Theatre was renovated for only C \$45 million. **CCE**

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