Canadian Consulting Engineering Awards 2015

Category A. Buildings

Thunder Bay Consolidated Courthouse

125 Brodie St. N., Thunder Bay, ON, P7C 0A3

Acoustics and Vibration Consultant

Aercoustics Engineering Limited

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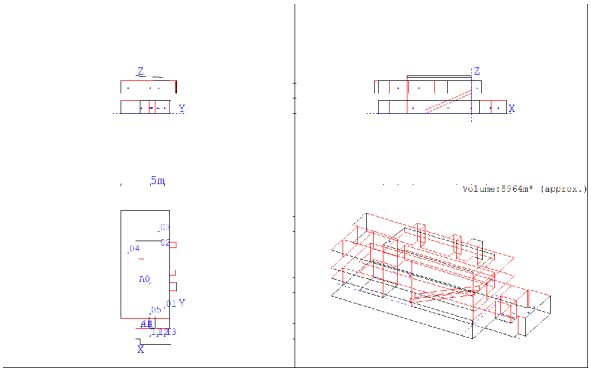
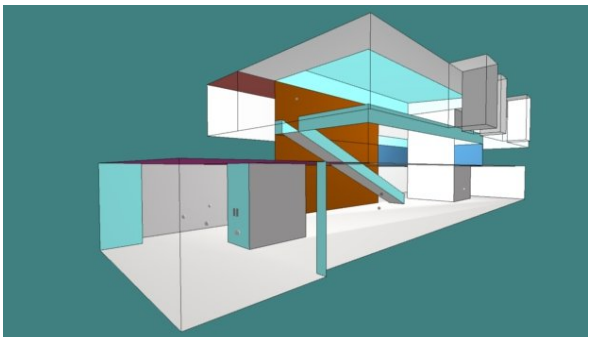
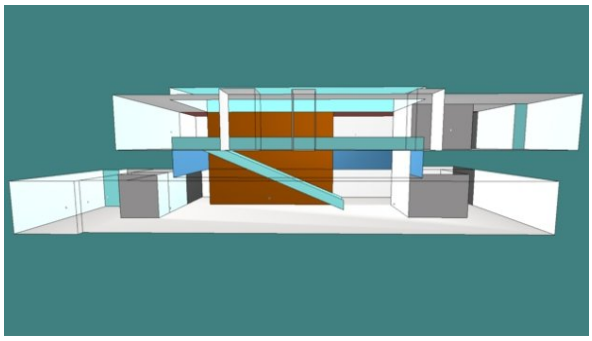
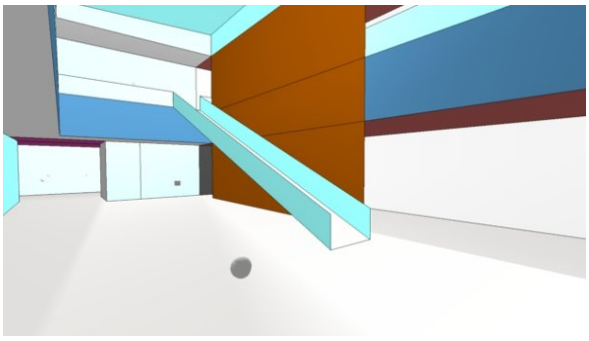
aercoustics | Experience the sound. Feel the silence.









Top: The Thunder Bay Consolidated Courthouse atrium and feature staircase. Bottom: Acoustic model of the space to address the potential noise intrusions from the atrium into the sensitive courtrooms,and design subtle acoustic treatments disguised in the atrium finishes.

Project Vision

The project vision was to revitalize courthouse design to restore the grandeur of traditional civic buildings. Modern day courtrooms have been designed as black box theatres, where there is no natural light or natural acoustics. Aercoustics' role was to optimize the space to enhance the natural acoustics in the courtrooms. The project incorporated glass construction to allow natural light into every courtroom and resulted in acoustic performance in the courts equal to concert halls. Opened in Spring 2014, the Thunder Bay Consolidated Courthouse has been called the best courthouse in Ontario.

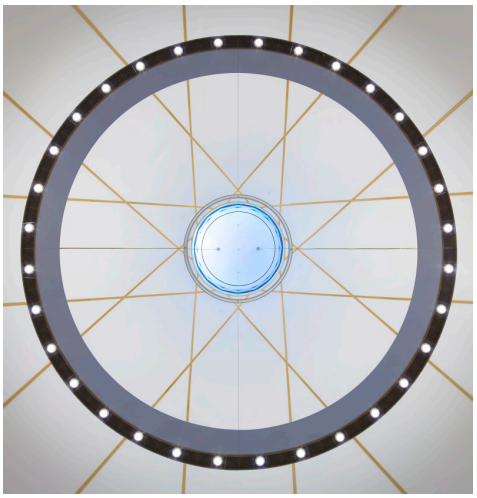
Innovation

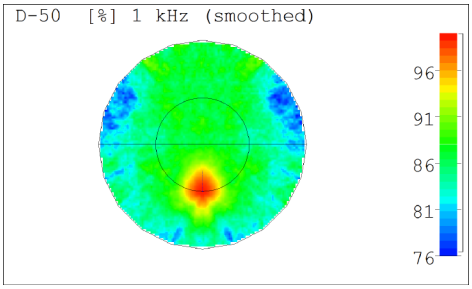
The key acoustical innovation was to employ design parameters that are typically used for performing arts centres. In order to achieve the goals of the project and restore the grandeur of courthouses, traditionally built of stone and marble, the approach was to optimize the space for natural acoustics.

The intent was to allow for a judge or participants to speak, and allow for their speech to be heard clearly throughout the space. Typically when courthouses are designed the focus for the interior acoustics relies on a single parameter: the reverberation time. The reverberation time generally controls the amount of reverberation or "echo" in a space. A low reverberation time results in acoustically "dead" spaces which means that there will be little reverberation or "echo" in the space, and higher reverberation times results in acoustically "live" spaces. To provide context to this explanation, if we consider that the traditional courthouses that were built using stone and marble, these often have high reverberation time which can allow for unamplified speech to project across the court. Most modern day courthouses are acoustically "dead" spaces with low reverberation times and must rely on amplification. It is also important to note that there is a fine balance where the reverberation time if too high can be detrimental to speech intelligibility. Modern day courthouses migrated to this acoustically "dead" environment because of the need to incorporate audio visual equipment and recording equipment into the courts. Regardless of how sophisticated today's technology may be, these systems always have difficulty in highly reverberant environments. As such, the current Ministry of Attorney General (MAG) Design Guidelines specify a significant amount of acoustic treatment which would result in low reverberation times. Aercoustics relied on an innovative approach and technique and explained that MAG could satisfy all of their functional requirements and still achieve a better acoustic environment.

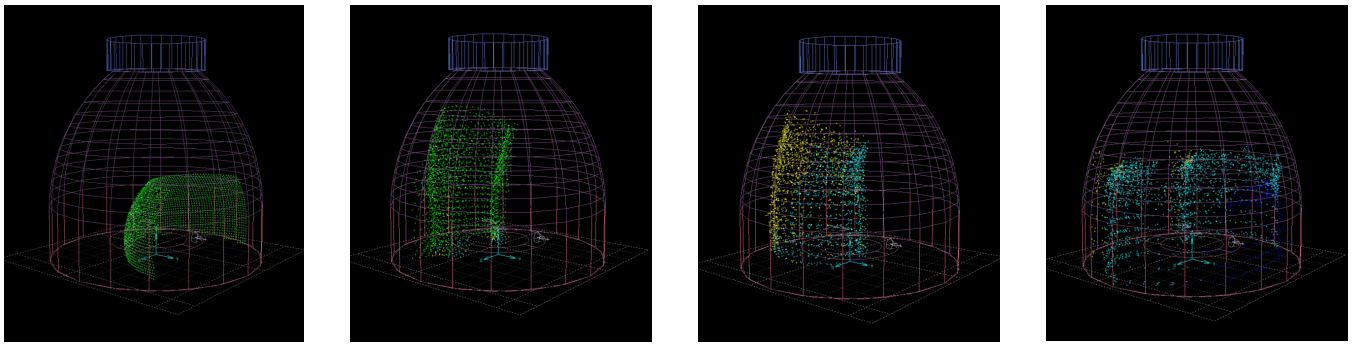
In order to do this, Aercoustics increased the reverberation time, but also considered additional acoustic parameters such as D50 and acoustic strength. The D50 or Distinctness is a measure of the ratio of early to late energy at a given location. As a general rule, achieving a ratio greater than 50% (D50) ensures good speech intelligibility. The second parameter, the acoustic strength (G) is a measure of how loud a space may be. By relying on the reverberation time, D50 and the acoustic strength, we were successful in optimizing each of the courtrooms to allow for uniform and excellent speech intelligibility across the courts. The amount of acoustic absorption needed in the Thunder Bay courts is far less than the requirements of the MAG Design Guidelines and by strategically locating the treatment we were able to obtain an acoustic environment in the courts that rival a concert hall.

Above: The ACSS, showcasing the sublty of the geometric relief sound diffusing panels and





Top: The elliptical dome of the Aboriginal Conference Settlement Suite was treated with acoustically absorptive panels to prevent reflection from the surface. Bottom: Acoustical computer model of the ACSS.



Above: By creating an acoustic model of the ACSS, and running simulations and animations using custom tools, it was possible to visualize the focusing problems.

Steel structures present unique problems, creating a problem in achieving high-degrees of sound isolation and, as a result, traditional construction uses poured concrete. Aercoustics had to specifically determine the concrete thickness for the floor and ceiling assemblies to ensure the sound isolation and vibration response was sufficient for courtroom functionality. Our work demonstrated that high end spaces could be cost effective while satisfying all project requirements. The design and construction was so effective that the Aboriginal drumming performed in the atrium during the ribbon cutting ceremony could not be heard inside of the courtrooms.

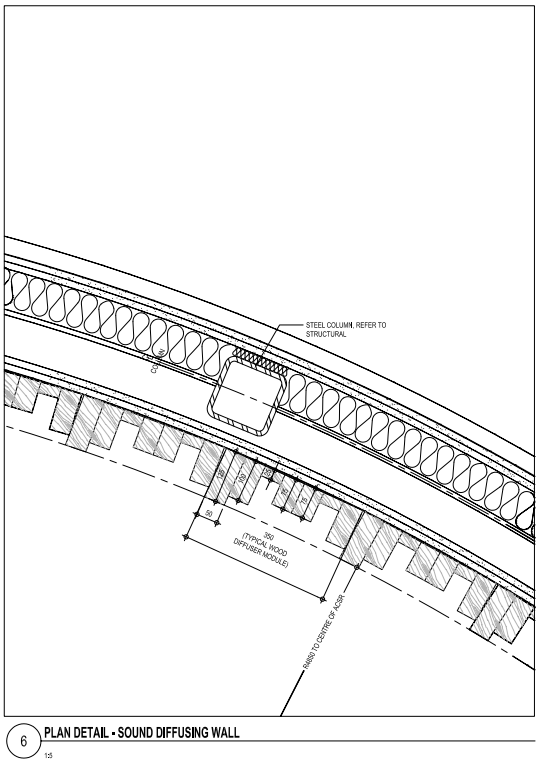
Complexity

The Thunder Bay Consolidated Courthouse presented many challenges: designing for speech intelligibility in technical and sometimes chaotic spaces, employing complex techniques for natural acoustics, and rewriting the standards for acoustics in the courtroom.

The most challenging space by far was the Aboriginal Conference Settlement Suite. The circular room, with an elliptical domed roof, was designed to meet typical courtroom requirements, all while presenting unique acoustical conditions. The circular plan, with seating in the round, meant that speech could originate from any point in the room. This can create a negative effect known as 'whispering' or focusing. This acoustic phenomenon creates a high concentration of energy at a specific location, or acoustical 'hot-spots' in different parts of the room. In order to determine how significant the focusing may be and how that could affect the operation of the courts, Aercoustics developed a customized 3D model for this space that simulated the sound waves in the room. This model allowed us to determine exactly where the focal points would occur in the space, and further allowed us to develop a more unique and innovative design for this room.

Because of this detailed visual modelling, the design departed from the traditional school of thought which would be to treat the space heavily with acoustic absorption. While this approach would have resulted in a space that provided speech intelligibility, it would not have created an environment which was consistent with the rest of the courthouse – which relied on more "live" acoustics.

To combat this problem, the key was to create a customized diffusive wall along the circular portion of the wall. Diffusion is another acoustical phenomenon which allows for sound to be reflected, but as it is reflected it does so by dispersing the energy, rather than creating a specular reflection. Essentially, it allows for the sound wave to "scatter". The theory of diffusion is somewhat understood in certain modes and there are panels that are available that provide diffusion, however these panels require significant depth for mid to low frequency diffusion. The most common type of diffusor available is a quadratic residue diffusor (QRD) and it works by creating wells in a surface which allow for different frequencies or wavelengths to reflect; it also creates an interference pattern that allows for the sound wave to reflect in a more dispersive manner. However, the science and theory of diffusion is still evolving today, and Aercoustics relied on some of the theory behind QRDs to develop a customized diffusive wall in the Aboriginal Conference Settlement Suite (ACSS). The design ultimately resulted with a customized wood panel that included a geometric relief to create a more dispersive and diffuse reflection. This work also resulted in the development of further software tools and research that allowed us to predict the diffusive nature of different types of geometries by incorporating the theory of diffusion and also considering the



Above left: The geometric relief was designed with Aercoustics staff to subtly redistribute energy, preventing the whispering phenomenon, and maintain the elegant design of the space. Above right: Detail of sound diffusing wall in ACSS.

Left: The stringent requirements for sound isolation in courtrooms were in direct opposition to the design vision and LEED mandate to incorporate natural light access in many spaces.

areas of where "just noticeable differences" occur to offer an alternative approach to the traditional diffusion theory. Admittedly, this software and predictive nature was experimental and is still currently in progress, but provided excellent results for the Thunder Bay courthouse. This design not only addressed the potential for negative acoustic effects inherent in a circular room, but it also allowed us to keep the consistency of the design between the ACSS and the other courtrooms.

Social and Economic Benefits

Clear and open, the Thunder Bay Consolidated Courthouse it is the embodiment of the permanence, grandeur, and civic authority of the courthouse – furthering the delivery of justice in Ontario.

The Aboriginal Conference Settlement Suite, the first in Ontario, was designed with input from elders and leaders within the aboriginal community. The ACSS will host Direct Accountability and Restorative Justice Programs, along with a variety of community events. The suite was designed to respect and acknowledge aboriginal traditions, in a manner that supports the healing process. Aercoustics helped design the ACSS to optimize acoustics, down to the smallest detail.

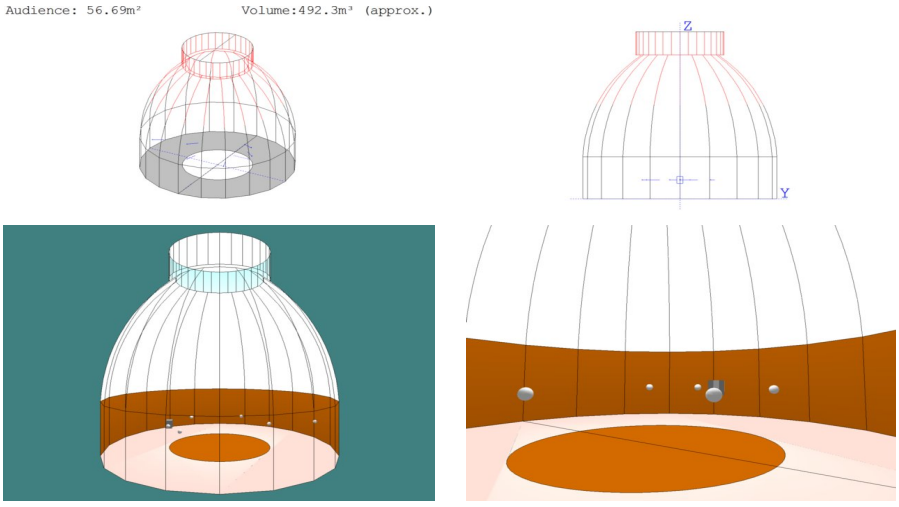
This project moves away from the closed off, 'dead' courthouse spaces, overly reliant on acoustically absorptive materials. It is a return to the open, inclusive, and effective spaces that play a significant role in the civic and social realm. The vibrant acoustic quality of the TBCC and ACSS is the result of Aercoustics' dedicated effort and collaborative design approach. This design has the significant societal benefit of creating an environment which is less stressful and less oppressive, given the sombre and sobering use of the space.

Given the use of steel construction, the structural design was reviewed and a finite-element model of the courthouse and feature staircase was developed to determine the possible vibration impact of pedestrian traffic. This project has demonstrated that even highly sensitive use spaces can be constructed using cost effective steel construction.

Aercoustics worked as a part of the design team, to ensure that the bright and open rooms were acoustically possible. Aercoustics and Adamson Associates Architects share a 'total systems' approach, considering and balancing all elements of design to provide fully integrated, fully realized projects. Aercoustics' approach was a complete departure from existing guidelines, revitalizing acoustics to deliver a better building, serving the needs of a diverse community.

Crown Attorney, Dan Mitchell
Quite frankly I think this building elevates the spirit, with the light and the spaciousness.

Above: The wooden dome of the ACSS is visible from the courtyard of the the TBCC.



Above: Computer model of the ACSS.

Environmental Benefits

As acoustic privacy, i.e. sound isolation requirements, for courts are extremely high it is challenging to design courtrooms using windows or glazings. Aercoustics developed specific wall assemblies and glass types to incorporate into the assembly that allowed for light to access each courtroom without compromising the acoustic performance of the assembly. The glazing was very important to the TBCC's pursuit of LEED Silver designation – which needed to maximize the daylight by employing the energy conscious design strategies.

Meeting Client's Needs

The TBCC was delivered for the Ministry of the Attorney General (MAG) as a Design-Build-Finance-Maintain (DBFM) project, to consolidate the services of two older courthouses, servicing the Superior Court of Justice and Ontario Court of Justice.

The project mandate was to demonstrate modern day courtrooms do not need to be closed in, acoustically "dead" rooms. As per client's design needs, the specific acoustical challenges were to introduce light – direct or borrowed – into each courtroom and also to optimize natural, unamplified speech throughout the facility, while incorporating the technical audio-visual requirements of a modern courtroom. Aercoustics facilitated the innovative design requirements, collaborating with the client and design team to realize their vision of justice in Ontario. Aercoustics developed an innovative approach and technique and ensured that MAG could satisfy all of their functional requirements and still achieve a better acoustic environment.

By employing acoustic design techniques normally reserved for performing arts spaces, Aercoustics delivered a project that met and exceeded the client's expectations, working within the budget and on schedule.

Madeleine Meilleur, Attorney General

This modern and accessible facility brings together all court services in the region under one roof. The Thunder Bay Courthouse is another example of our commitment to building courthouses that meet the highest standards for accessibility, sustainability, security and technology, including an Aboriginal Conference Settlement Suite, the first of its kind in Ontario."

Source: New Thunder Bay Courthouse Officially Complete, Press Release, April 23, 2014

Project Details

Aercoustics Engineering Limited Team

Steven Titus, P.Eng.	Principal in Charge
Lindsay Davies, P.Eng.	Project Engineer
Sarah Mackel	Project Engineering

Design Team

Owner	Ministry of the Attorney General
Architect	Adamson Associates Architects
Structural Engineer	Read Jones Christoffersen
Mechanical Engineer	VRM Engineering
Electrical Engineer	H.H. Angus & Associates
Audio-Visual	Sight N Sound
Contractor	Bird Construction

Completed: April 2014

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