Project Into

Course Bachelor's Thesis

Submitted April 2013 (6th semester)

Program The assignment was to design a music venue for a university college in Montréal, Canada. The assignment was partly a test of architectural vision and skill, partly a test of acoustical knowledge. The real challenge of the competition was to combine the two elements to create something truly spectacular, but even more so, this was the ultimate challenge of the Architecture and Engineering bachelor's program. This was the final test where engineering abilities were a prerequisite to succeed in an architectural competition.

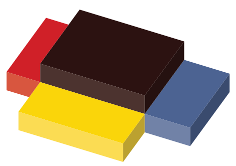
Assignment intentions The assignment was to complete an entry for the 2013 Acoustical Society of America student competition.

Software used

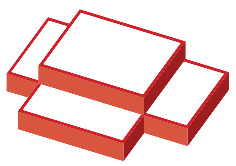
- AutoCAD 2013
- Adobe CS5
- Rhinoceros 4
- Grasshopper

Into

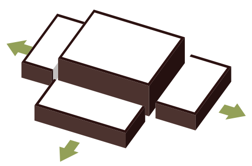
A HUMBLE OPERA BUILT ON ACOUSTICAL PRINCIPLES CREATES A UNIQUE MUSICAL VENUE WHERE STUDENTS CAN LEARN FROM THE MASTERS. THE DENSE BRICK WALLS CREATE INTERIOR SPACES OF QUIET TRANQUILITY, VERSATILE AND ADAPTABLE TO VARYING NEEDS.



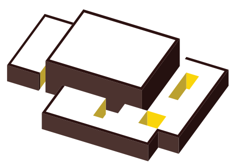
Separation of functions
- Public
- Semi public
- Professional



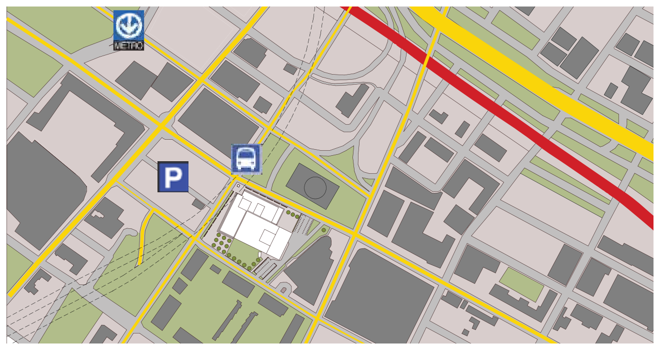
Exterior noise isolated by thick walls



Separation of floor slabs disrupt wave propagation and creates areas of different sound qualities



Sunlight provided through atriums and light wells

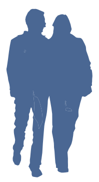


Traffic 70 dBA

Railroad 50 dBA

Aircraft 70 dBA

- Traffic noise is primarily from the north eastern direction. SPL peaking in mid frequency range.
- Railroad noise also from the north east, in low to mid frequency ranges.
- Aircraft noise affects the site omnidirectionally in all frequencies.
- Best transportational services are located to the north west.

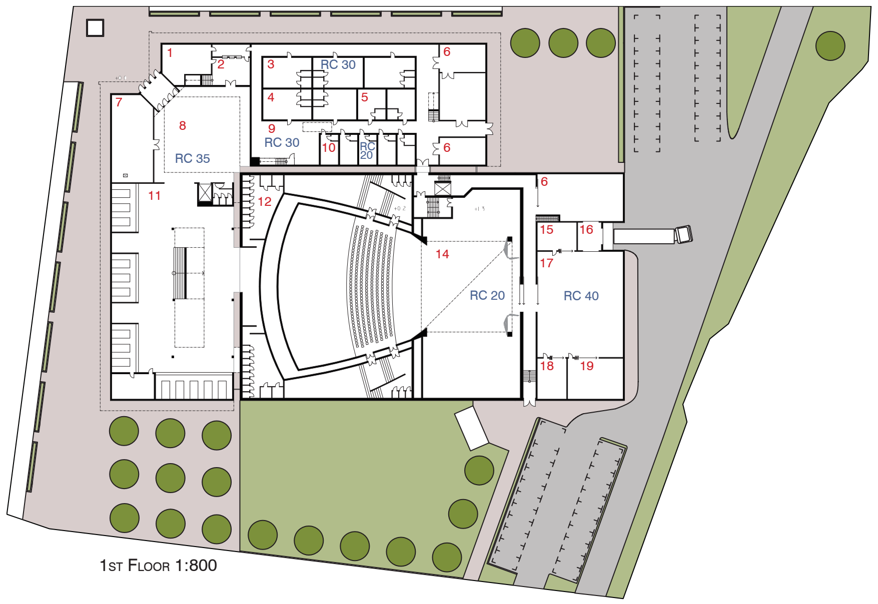


Audience
- A directed journey through the opera house.
- Access to public facilities at operating hours.
- Possibility to access green room and main rehearsal room for special events.

Students
- Possibility to use the semi public space of the opera freely, not just during operating hours.
- Extra rehearsal rooms provided to share between students and professionals, creating opportunities to .

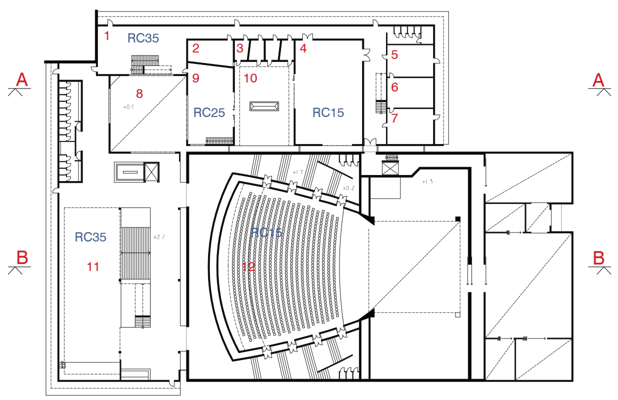
Performers
- Effective communication between dressing rooms, rehearsal rooms, stage and green room.
- Sound insulated dressing rooms close to the stage for pre-performance preparation.

Workers and staff
- Private entrance, access during all hours.
- Obvious logistics, good communications between stage, storage and workshops.
- Noisy spaces clustered together and separated from sensitive areas.



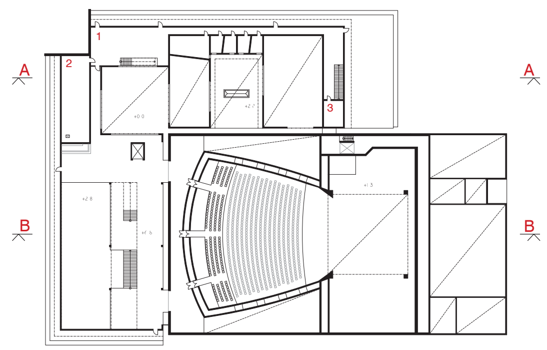
1st Floor 1:800

1. House Managers Office
2. Box Office
3. Chorus Dressing Room
4. Orchestra Dressing Room
5. 4-Person Dressing Room
6. Storage
7. Café / Shop
8. Atrium
9. Break Room
10. Solo Dressing Room
11. Cloakroom
12. Restrooms
14. Stage
15. Metal Workshop
16. Loading Dock
17. Assembly Hall
18. Paint Shop
19. Carpentry



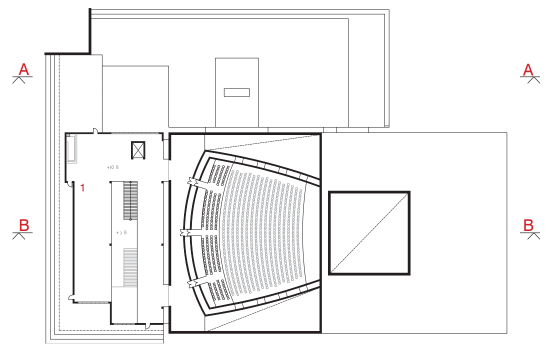
2nd Floor 1:800

1. Study Area
2. Ensemble Rehearsal Room
3. Solo Rehearsal Room
4. Main Rehearsal Room
5. Wig Shop
6. Wardrobe
7. Costume Shop
8. Atrium
9. Green Room
10. Courtyard
11. Lobby
12. Auditorium



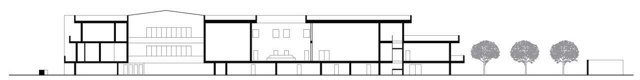
3rd Floor 1:800

1. Study Area
2. Kitchen
3. Recording Studio

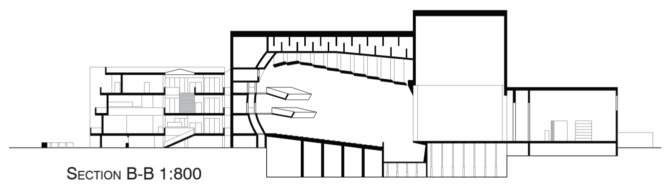


4th Floor 1:800

1. Restaurant



Section A-A 1:800



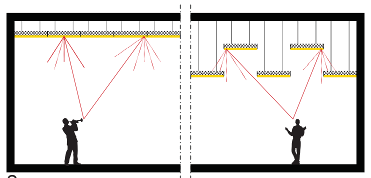
Section B-B 1:800

Main Rehearsal Room

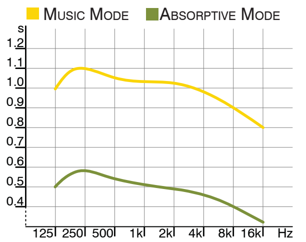
■ Retractable risers for choir practice can also be used as a stage.

■ Mirror for dance rehearsals. Can be covered by curtain for added absorption.

■ The acoustics of the rehearsal room can be controlled by pulling the curtains and changing the height of the ceiling panels. The panels feature a diffusive side facing down and an absorptive facing up. By setting the panels to different heights, the reverberation time can be lowered during lectures and workshops.



Section of multi-purpose rehearsal room



Reverberation Time, Main Rehearsal Room

Courtyard

■ The open air courtyard provides daylight to all rehearsal rooms and the green room from a space absent of traffic noise.

■ A light well brings light to the dressing rooms situated beneath. Additional light is brought down in the separating space between the building parts.

Solo Rehearsal Rooms

■ Diffusers with randomized surface irregularities scatter high and mid frequency sounds.

■ Slanted side walls reduce the risk of flutter echoes.

■ Double glazed doors allows access to the courtyard while sustaining a high sound insulation.

■ Curtains for privacy and variable absorption.

■ Absorptive ceiling.

Green Room

■ A stage for small performances, speeches and lectures in the corner is supported by reflective walls for good sound propagation throughout the room.

■ A bar makes the room suitable for receptions and special events.

■ Easy access to stage and dressing rooms through a hidden flight of stairs.

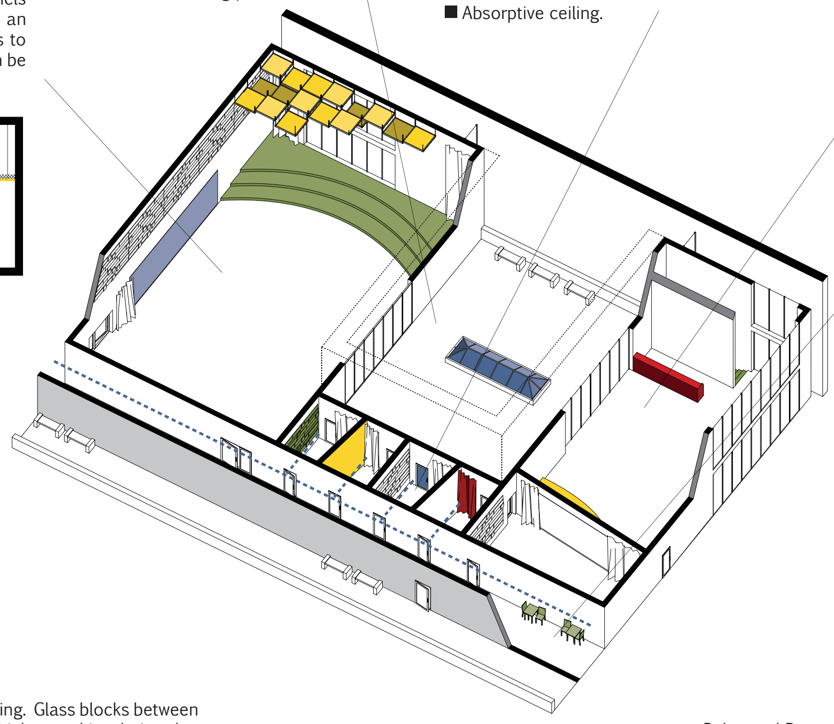
Hallway

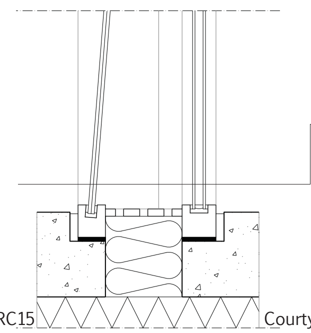
The hallway acts as a sound buffer between the outside and the rehearsal rooms.

■ Dense double brick walls ensures high sound insulation. Glazed perforations let sound inside, creating an engaging interior.

■ Ventilation ducts with silencers mounted in the hallway ceiling prevent sound transmission between rehearsal rooms.

■ The wide hallway can be used by students that wish to study in a musical environment, as well as by musicians waiting to start their rehearsal.

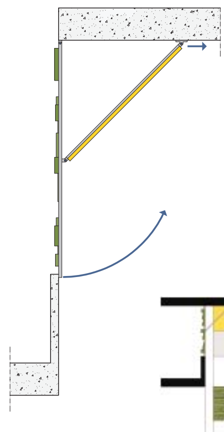




Courtyard Window

STC-55

Tilted 8 mm laminated glass
52-120 mm air gap
16 mm insulated glass unit

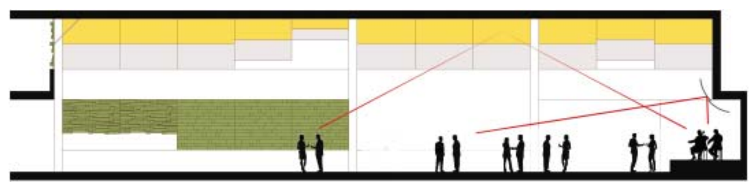


Acoustical enclosure panel

The spacious lobby is set on multiple floors with daylight flowing through a central shaft, supplementing the array of daylight provided through the sound insulating brick walls.

The wardrobes are situated on the ground floor, enabling the audience to make their entrance to the actual lobby liberated of their coats. A restaurant is situated on the third floor, provided with a balcony facing the Montreal skyline.

The first floor feature a large space useful for various events. A stage is provided for ensemble performances and speeches. To improve the acoustical properties of the space during performances, convertible panels can be tilted down to enclose the space and focus reflections toward the audience. In their default setting the panels act as ceiling diffusors.



Section of lobby event area showing the enclosure feature ■ Reflective surface ■ Diffusive surface

Wall Types

A double brick wall encloses the entire building. Glass blocks between the bricks let light inside while maintaining high sound insulation due to their thickness and small size.

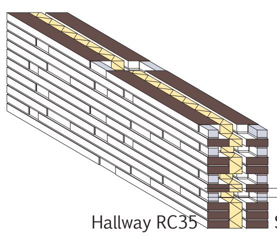
Two types of walls are used for soundproofing indoor noise. Both have similar sound transmittive properties, but one is load-bearing and set in concrete, and the other one is lighter and more easily constructed.

Exterior Wall

STC-55

108 mm brick
70 mm PIR insulation
20 mm air gap
108 mm brick

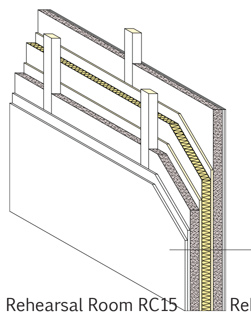
80 mm glass block
140 mm air gap
80 mm glass block



Partition Wall

STC-60

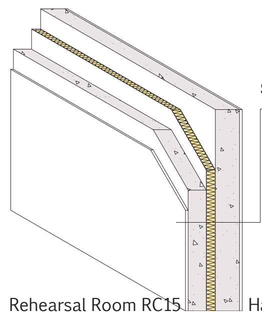
2 x 13 mm plaster board
45 mm sand
12 mm plywood
45 mm batt insulation
12 mm plywood
45 mm sand
2 x 9 mm plaster board

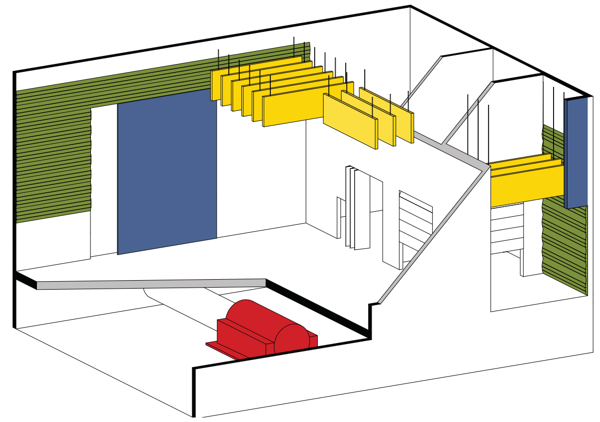


Load Bearing Wall

STC-60

13 mm plaster board
90 mm concrete
45 mm batt insulation
120 mm concrete
13 mm plaster board





Loading dock

■ The loading dock is at the same height as the stage, making for good logistics.

■ Sound baffles with porous absorbers in the ceiling for absorption of high frequencies.

■ Slit absorbers on the walls for absorption of low and mid frequencies.

■ A high space with a small opening toward the truck makes sure the noise is absorbed in the space and not transmitted to neighbouring areas.

Workshop Area

Scene Shop

■ The scene shop is divided into four parts; central assembly hall, metal workshop, paint shop and carpentry. All workshops are attached to the assembly hall through large sound insulated doors for high flexibility and good working conditions.

■ Porous sound baffles to reduce the noise level.

■ Slit absorbers for absorption of low and mid frequencies.

■ Sound proof double doors which allows a close proximity to the auditorium

Mechanical Equipment Room

■ The MER is located in the basement, beneath the scene shop, where it's isolated from noise sensitive spaces.

■ Air ducts are fitted with silencers, preventing noise to spread in the ventilation system.

□ Machinery mounted on spring isolators with rubber pads to reduce wave propagation through slabs.

Hall Shape

■ The shape of the auditorium derives from the need of a multi-purpose hall. The fan shape combines the good visual properties of the conventional horse shoe shaped opera with the acoustic qualities of a rectangular concert hall.

□ The walls are made of the same type of bricks as the exterior, although shifted back and forth, making for high diffusion.

Double Shell

The auditorium is enclosed by two concrete shells of STC-65, separated from roof to foundation by a wide airspace.

■ The two walls create an immersive space which constitutes the transition into the auditorium. The space also acts as a sound sluice and since the walls are covered with heavy textile, good sound absorption is achieved.

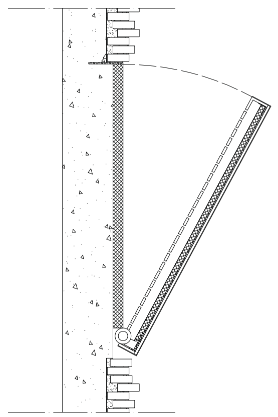
■ The sluice doors are supplied with a spring loaded seal to prevent sound leakage. When the door is closed, a lever is compressed, forcing a rubber seal onto the door jam, thus sealing the door tightly.

Reflectors

■ The balcony fronts are plastered and tilted down, reflecting sound toward the stalls.

■ The overhead reflectors can be individually lowered to control reflections.

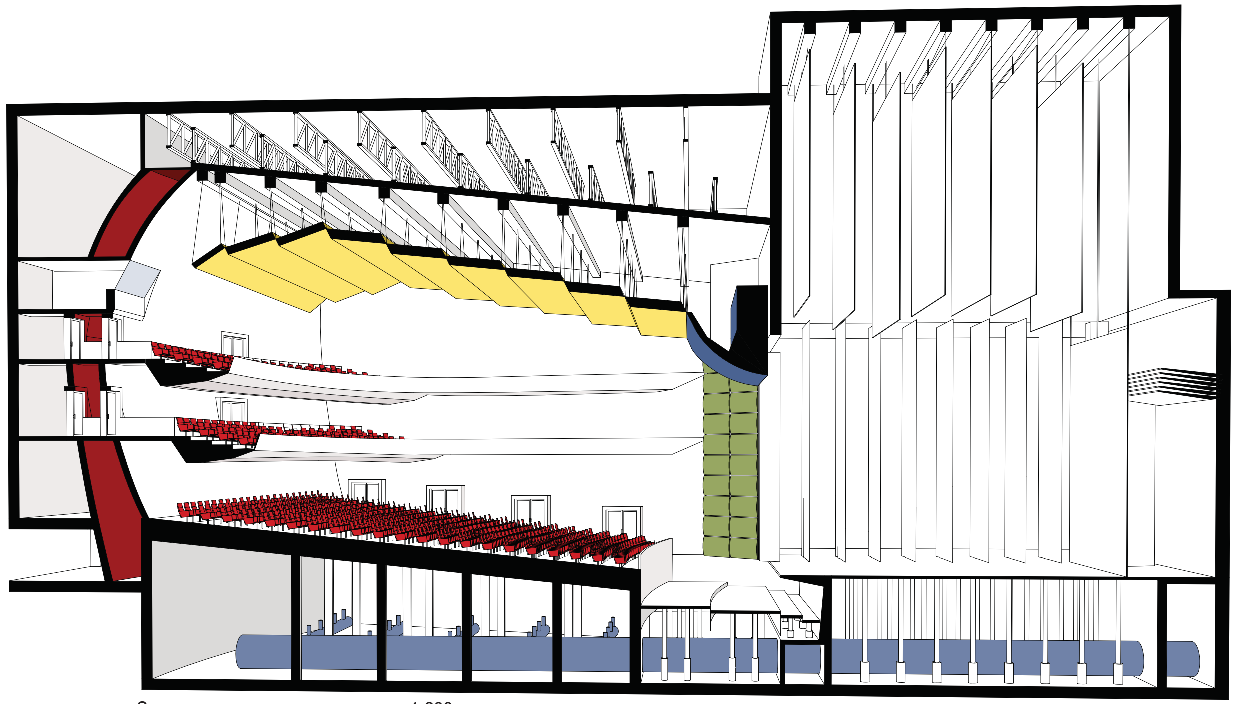
□ The ceiling above the reflectors is modeled as a perforated absorptive surface with a fiber wool layer behind. This absorbs the late sound reflections ensuring a high clarity.



Tiltable Wall Reflector 1:20

■ The balcony fronts are extended along the side walls, functioning as tiltable wall reflector. The panels have reflective plaster on the fronts and both porous and resonant absorbers on their backsides.

□ When tilted down they increase early reflections for the audience, and expose the absorptive back of the reflectors, increasing clarity and reducing reverberation time.



Section through stage and auditorium 1:200

Flying Balconies

■ The two tiers of balconies are suspended from the back wall to ensure good sound envelopment.

□ The absence of side balconies and a steep angle ensures good vision for all seats.

Seats

■ The seats are arranged in the continental way, with wide rows for easy passage.

The slope of the stalls is steep to ensure a good view from every seat.

The seats are lightly upholstered to avoid sound overabsorption and provide similar acoustics regardless of the number of audience.

Proscenium

■ The top of the proscenium can be raised, resulting in a height variable between 9 and 11 meters (30'-36').

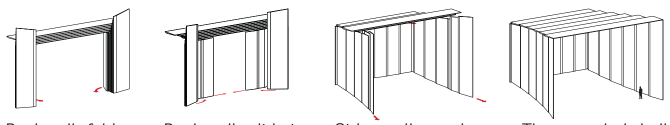
■ The side and top proscenium reflectors are scattering, convex reflectors which ensure an even distribution of sound from the orchestra throughout the hall.

Hvac

■ Air is brought inside the auditorium through a duct coming from the mechanical equipment room, passing through a silencer, and into a plenum chamber below the stalls. The air finally enters the auditorium through outlets under each seat at a velocity of 1 m/s.

Stage Shell

The stage shell is made of painted wood on steel plates and is easily folded and stored in the back of the stage. The shell is fully automated and can be unfolded quickly and effortlessly. The components are individually tilted along outbound curvatures, scattering the sound and distributes it in both the auditorium and inside the shell.

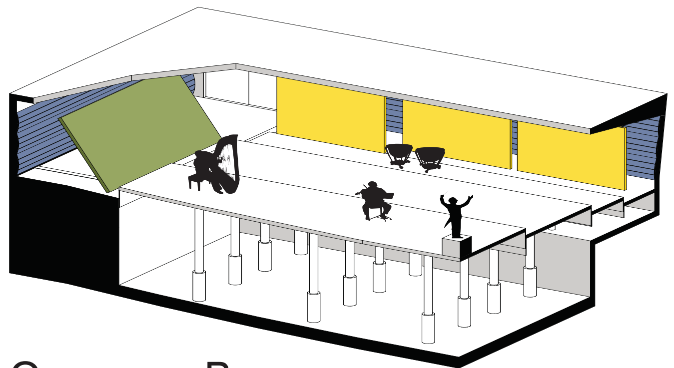


Back walls fold out.

Back walls slide in and side walls fold out.

Side walls and ceiling slide out.

The extended shell may be supplemented by risers.



Orchestra Pit

■ Four platforms on separate lift systems. Two platforms can be raised up to stage level for orchestral performances.

■ Movable panels with reflective and absorptive surfaces on opposite sides for controlling sound level and balancing different sections of the orchestra.

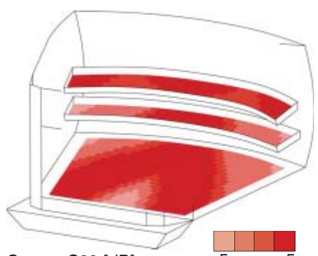
■ Reflective side panels, which can slide in to reduce the size of the pit. The angle is adjustable to create different modes of sound propagation from the the pit.

■ Diffusive slit absorbers on the walls to ensure an optimal low frequency response from the orchestra and control the work environment inside the pit.

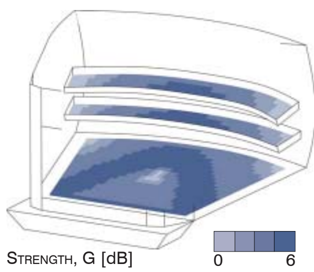
□ Back wall tilted to avoid flutter echoes. Diffusive stage overhang.

Opera Hall Mode

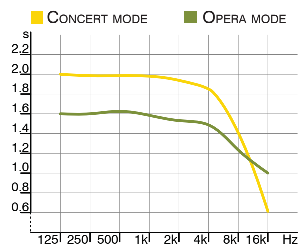
The main use of the auditorium is opera. In opera mode, the clarity is high and the reverberation time is around 1.5 seconds. This is achieved by putting the ceiling reflectors in a low setting and tilting the wall reflectors down. This results in more early reflections towards the audience and increased absorption.



Clarity, C80 [dB]



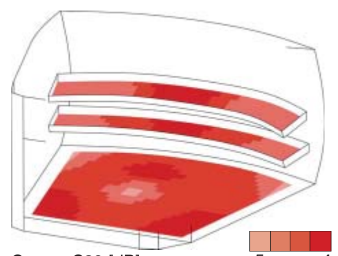
Strength, G [dB]



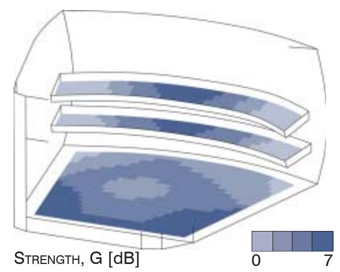
Reverberation Time

Concert Hall Mode

In concert mode, the reverberation time is expected to be around 2s. To achieve this, the ceiling reflectors are lifted up and the wall reflectors tilted into upright position. To accommodate a large orchestra, the orchestra pit is raised to the stage level, and the stage shell provides direct sound from the orchestra towards the audience. The proscenium reflector is raised to allow sound from the back of the stage to spread in the auditorium.



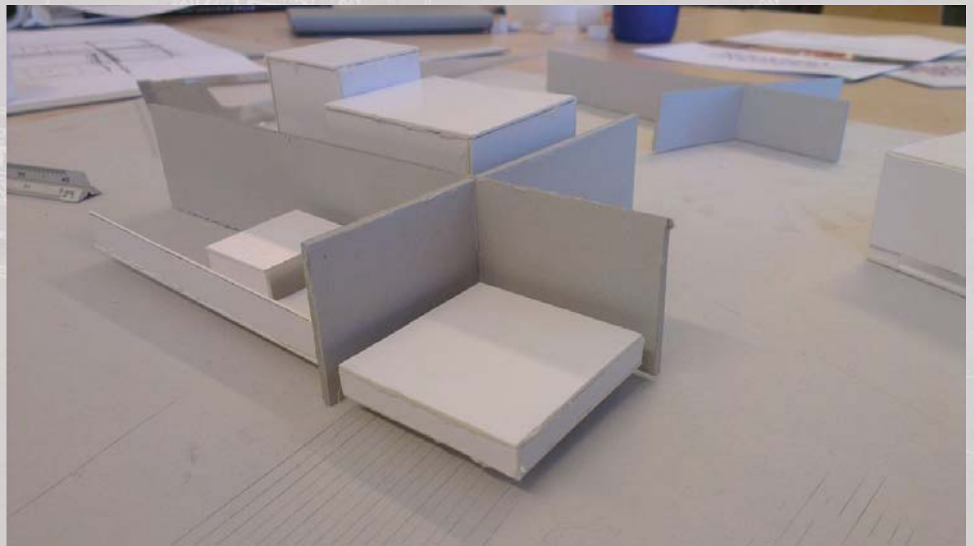
Clarity, C80 [dB]



Strength, G [dB]

Process and Methods

Our project came to a tipping point about four weeks into the design process. We had a clear picture of the interior and the communication between areas, but no clear exterior concept. We had an idea of separation of functions internally which we tried to visualize by cutting through the building with thick, heavy walls. This would create a distinctive separation and a strong external concept which the project previously lacked.



A concept model of the thick separating walls

This however posed a couple of problems:

- *Too* much separation between areas, minimal permeability.
- How would the rooms relate to the wall?
- Physical problems (construction, heat transmission)

After long consideration and discussion, we came up with the idea of removing the walls themselves, but keeping the benefits created by them. We kept the separation of rooms, but divided by a void rather than by a wall. The concept went from closedness to candidness, from dark to light.

Reflections

I am happy with our project and by the way it developed. I feel that our proposition was complete, with no unfinished parts or unsolved problems. I do however feel that we made a project proposition rather than a competition entry.

In our decision to discard the thick heavy walls, we lost the distinctiveness of the project. What was missing from our project was a clear visual concept to aid it in getting remembered conceptually. I feel that our project had many really good architectural qualities, but they were however not distinguishable enough to make a solid impression.

The program for the project was very large, and thus the contents of the presentation had to be prioritized. Since this was a competition entry for the Acoustical Society of America, we put a lot of effort into solving acoustical problems, and presenting viable and innovative solutions. This meant that we had less space to display the project's visual qualities, and in retrospect I realize that we would have benefitted from having a strong exterior concept which was easy to read. It takes too much time to understand subtle qualities, compared to a powerful exterior.

I do however, despite our failure to qualify for the competition, feel very pleased with our design proposal. I think that we produced a viable option for a music venue, with good qualities and overall design. I also think that we produced an opera which focused on the acoustics, and I am content in our ability to include engineering skills in architectural work.