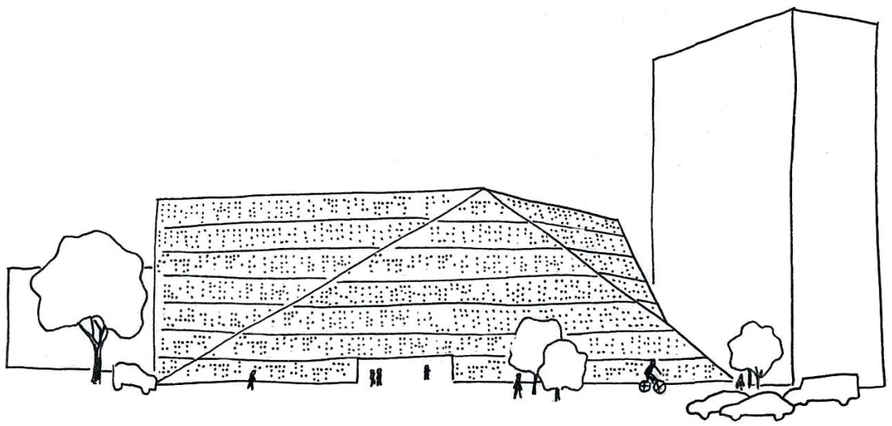


MUSIC BOX

STUDENT OPERA IN MONTREAL

COURSE	ARKX01 Bachelor project 15 hec
EXAMINER	Morten Lund
YEAR	Spring 2013, Year 3
TEAM	Mia Callenberg, Ylva Wilder
TOOLS	AutoCAD, Rhinoceros, Vray, Adobe CS, CATT
ENGINEERING	Room Acoustics

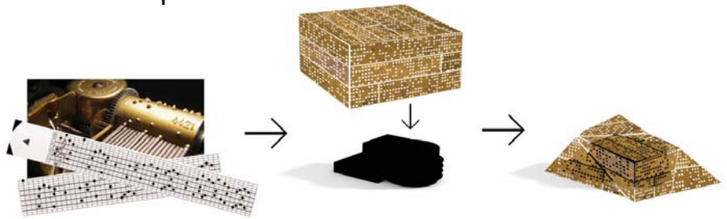
Our bachelor project was to participate in a student competition, arranged by the American Association of Acoustics. The task was to create a student opera for 1200 people, with all the facilities that are needed in such a building. Two students from my class of Architecture and engineering together with a master student from the program of Sound and Vibrations formed group. This was a good way of working with competences and to get deeper knowledge in room acoustics. In the competition, the architectural experience and the acoustics were equally important, which led to a lot of investigations and calculations of the acoustics.

The concept with the music box was found at an early state during model work. This was an effective was to elaborate with volumes and design and helped us to improve the expression of the opera. The chosen materials refer to the industrial tradition of the site.

music box

Inspired by old music boxes, the opera rises humbly and beautifully. The perforated brass walls are made after the notes of famous opera works, which create a characteristic pattern. Please take a step in. Leave the loud and messy city behind, and enter the lush gardens in a magnificent borderland between inside and outside. It is an enthralling place to enjoy, embraced in melodies.

concept



From pianola sheets and brass music boxes, inspiration is taken to form perforated metal sheets

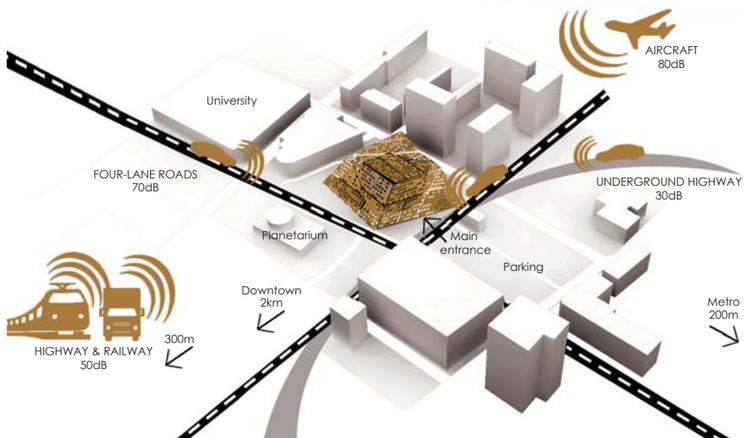
The sheets are put together into a shell placed around the opera building

The walls are tilted to get a more intimate space and to create interesting rooms both exterior and interior

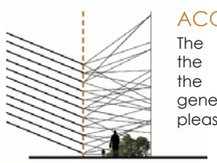
the site

The site, located close to the centre of Montréal, is an old industrial estate. It is surrounded by high buildings, a parking lot, a planetarium and a lot of traffic. The best way to use the lot was to create something new and different. A golden shell lifts the whole area and makes a novel place inside.

The main entrance is facing downtown and towards the closest metro station. The illustration shows noise sources from the outside, with estimated sound pressure levels. Aircraft is the biggest contributing noise source.



external shell



ACOUSTICALLY

The shell diffuses the noise from the outside and generates a more pleasant sound.

VISUALLY

The shell lets natural light in but shadows the big glass façades.

concept in details

DIFFUSERS

A perforated metal sheet in front of a wooden plate with holes of various depths

Used on the balcony fronts, in the orchestra pit and in green room

POROUS ABSORBERS

A perforated wooden plate in front of an absorbing panel, with a thin foil in between

Used in scene shop and under balconies in the lobby

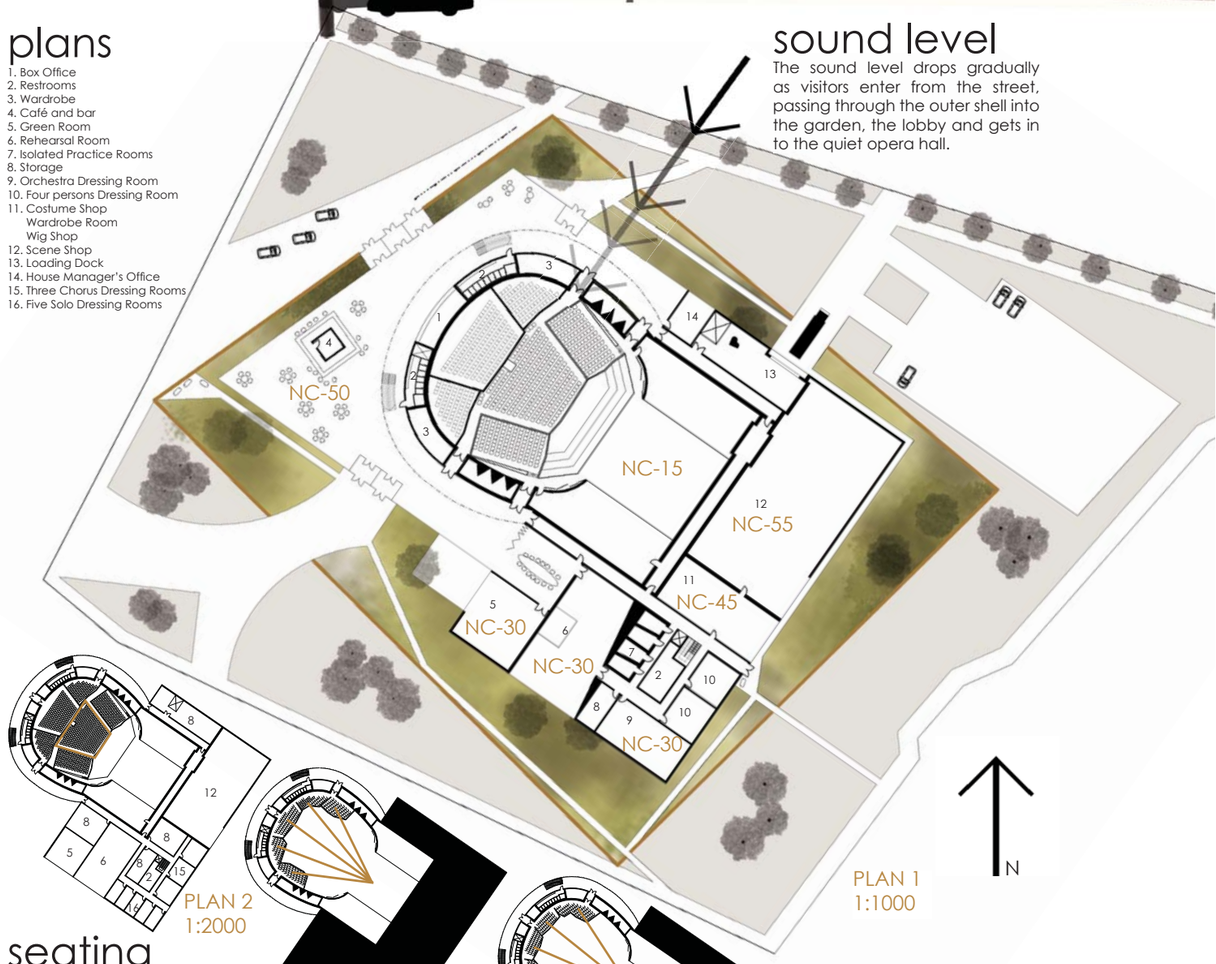
HELMHOLTZ RESONATORS

Air bricks in front of a concrete wall with a large air gap in between

Used in the lobby on the outer wall of the auditorium

plans

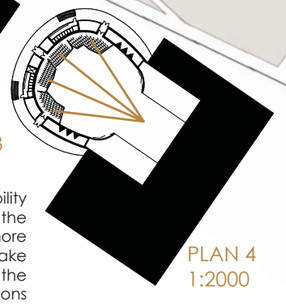
1. Box Office
2. Restrooms
3. Wardrobe
4. Café and bar
5. Green Room
6. Rehearsal Room
7. Isolated Practice Rooms
8. Storage
9. Orchestra Dressing Room
10. Four persons Dressing Room
11. Costume Shop
    Wardrobe Room
    Wig Shop
12. Scene Shop
13. Loading Dock
14. House Manager's Office
15. Three Chorus Dressing Rooms
16. Five Solo Dressing Rooms



PLAN 1
1:1000

PLAN 2
1:2000

PLAN 3
1:2000



PLAN 4
1:2000

sound level

The sound level drops gradually as visitors enter from the street, passing through the outer shell into the garden, the lobby and gets in to the quiet opera hall.

seating

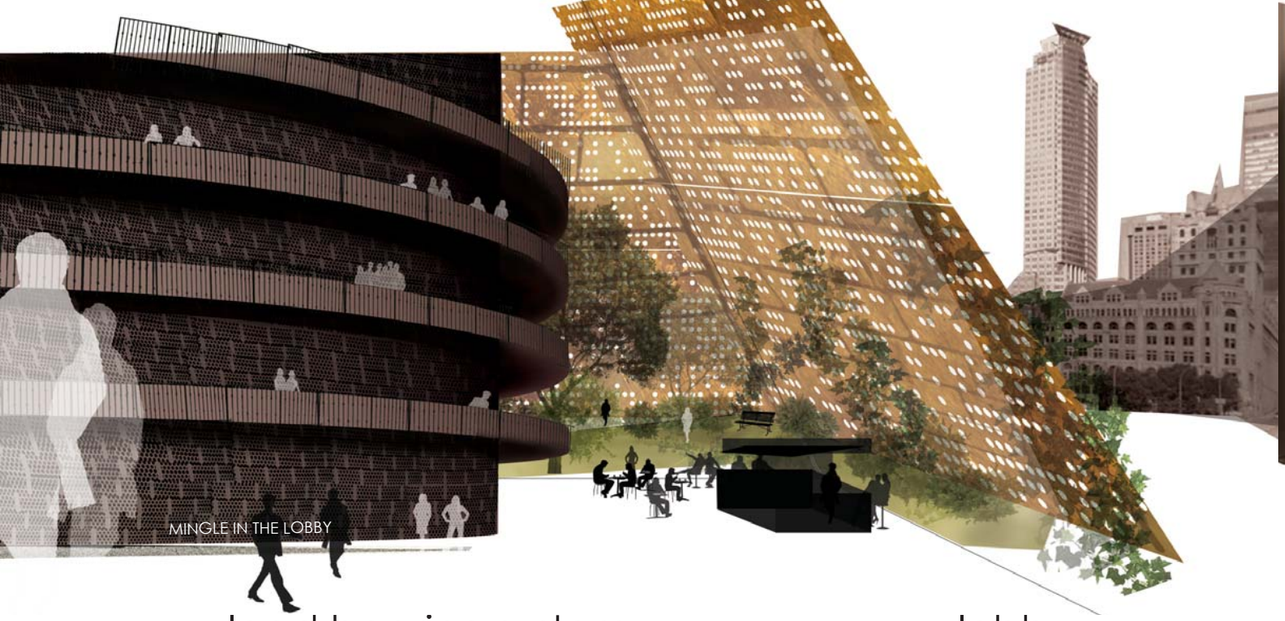
1188 SEATS

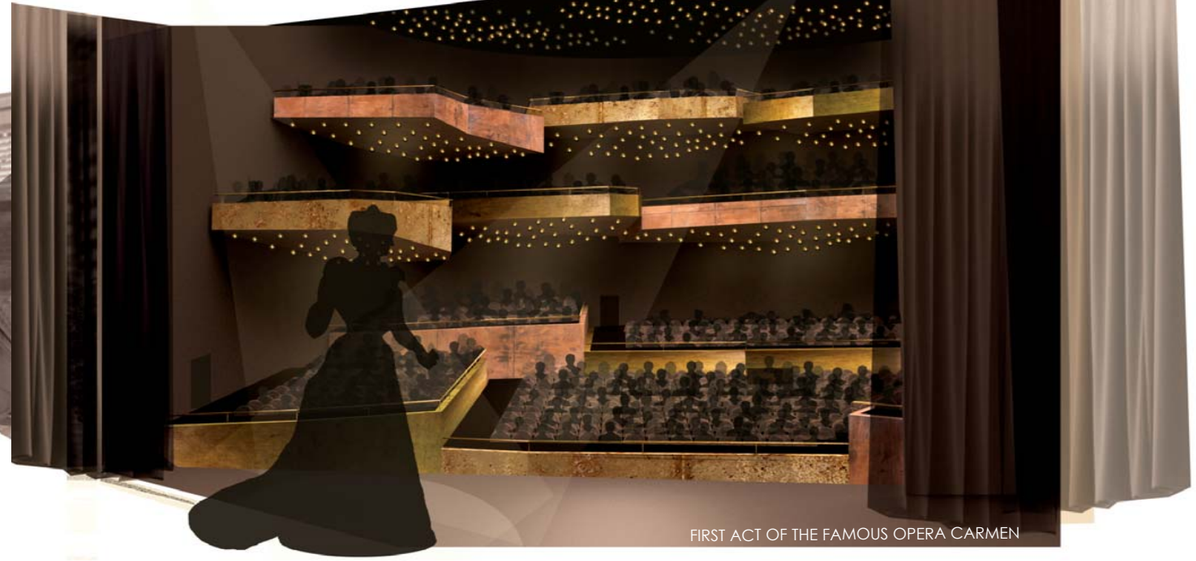
Orchestra lower: 420 seats
Orchestra upper: 268 seats
First Balcony: 245 seats
Second Balcony: 215 seats

Since it is a multi-purpose auditorium, good sight lines and flexibility are of importance. Therefore all the seats are turned to face the scene, without imposing the audience to turn their heads more than 20 degrees at any seat. The balconies are stacked, to make it feel like the orchestra and balconies floats together. To keep the intimacy during smaller events, the orchestra is divided in sections which can be used separately.

gardens

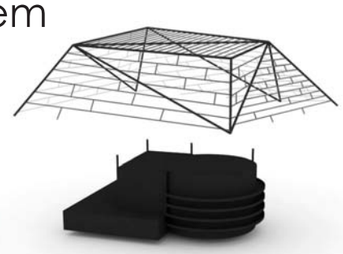
The gardens between the shell and the inner building have rich vegetation, benches and playgrounds. These are for all the citizens of the city.





load bearing system

A framework of large steel beams works as the primary bearing system for the shell, with slimmer secondary beams to stabilize. The whole structure gets support from the ground and from the roof of the opera building. Attached to the frame is a façade cladding, consisting of an inner glass façade and the outer shell of brass. The four meter high sheets are perforated and the holes have a diameter of 400 mm. The placements of the beams coincide with the solid parts of the sheets and will not impede the sunlight.



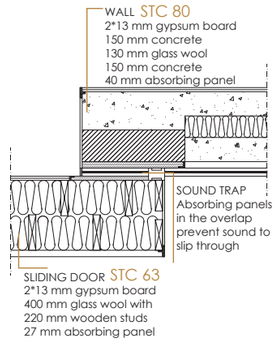
lobby

A high ceiling and big glass façades create a grand lobby perfect for mingle and events. To ensure a pleasant sound environment it is necessary to handle reverberation time and sound level. The air bricks on the outside of the auditorium absorb low frequency sound. Mid and high frequency absorbers are placed under the outer balconies. This creates a sufficient sound environment for smaller music events while larger performances are supposed to be held in the green room or the rehearsal room.

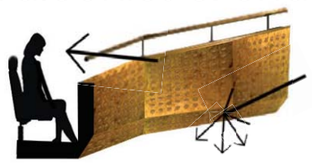
auditorium wall

The wall into the auditorium is a double wall with air space. This enables big and effective sound locks. In the air space as box office, restrooms and wardrobe are housed. The outer wall is made out of masonry dark air bricks and the inner wall is a fully isolating concrete wall. Inside the auditorium the surface is finished with black paint.

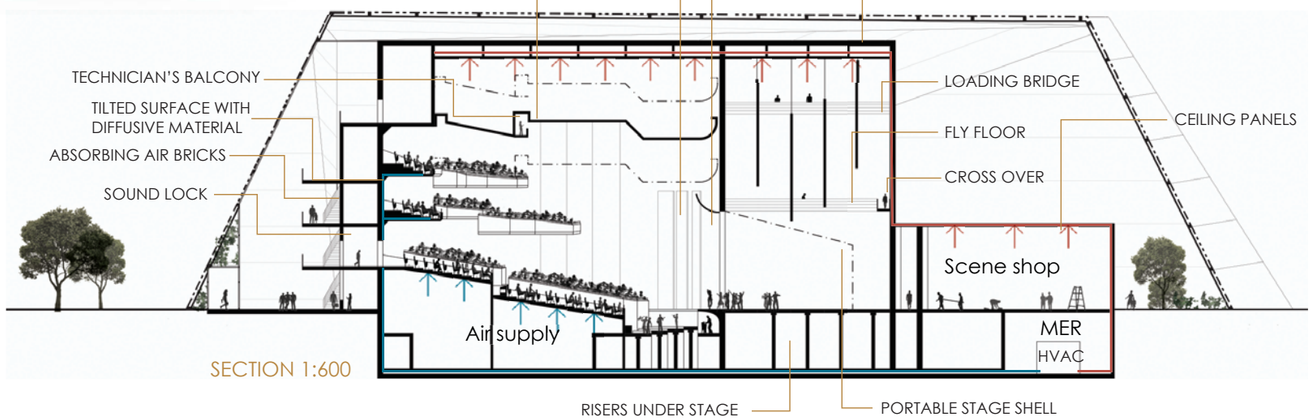
DETAIL 1:40 WALL AND SLIDING DOOR



balconies & chairs



The balconies are irregularly shaped with angled surfaces to spread the sound in the auditorium. The fronts are made of different metal plates with diffusive holes. To reflect the sound down on the orchestra the bottoms of the balconies are angled. The absorption of the upholstered chairs will resemble a fully seated auditorium. To avoid complete absorption, the armrests are made out of wood and will create some reflection.

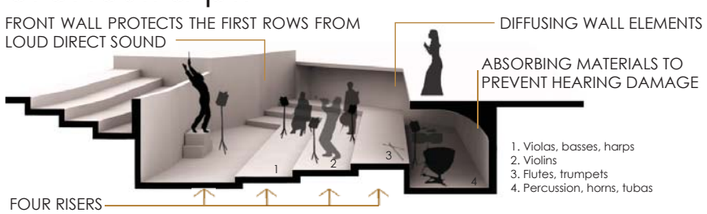


SECTION 1:600

quiet passage

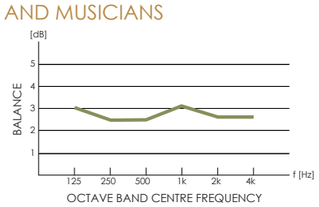
A wide aisle between the stage and the scene shop functions as an isolating zone, with thick walls of concrete on each side. This makes it possible to use the scene shop during performances. The scenery entrance from scene shop is two sliding doors between the rooms. These will take up less space than hinged doors and ease of access is an issue. A wooden framework with disordered studs makes the doors lightweight and highly sound isolating. In the critical overlap between wall and door, absorbing panels are used to create a sound trap.

orchestra pit



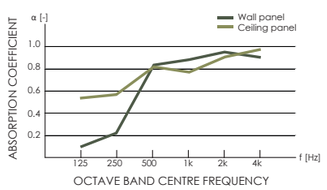
The orchestra pit has four individually adjustable risers. Lowering the pit to the bottom makes a close connection to the nearby instrument storage. The pit is also lowered during opera performance, which will reduce the loudness of the orchestra relative to singers and actors on the stage. The musicians will also have good sight of the conductor without being seen by the audience. Diffusing elements are placed on the sidewalls and on the underside of the stage.

BALANCE BETWEEN SINGERS AND MUSICIANS



The sound balance between singers and orchestra is the difference between sound levels in dB. To change the balance the floor level or the absorbing materials in the pit can be changed. A balance somewhere 3 and 4 dB is reasonable for an opera house.

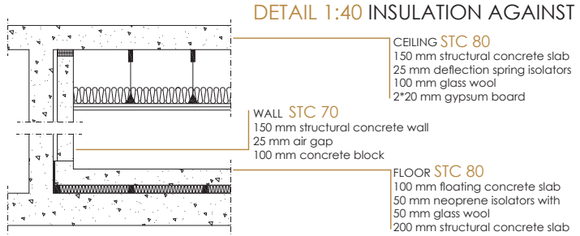
SOUND ABSORPTION SCENE SHOP



Because of high sound levels in scene shop, there are different absorbing panels on walls and in the ceiling, combined to reduce the sound. The walls will absorb more of the low frequency sound while the ceiling is more effective for the high frequencies.

mechanical equipment room

DETAIL 1:40 INSULATION AGAINST VIBRATIONS



The Mechanical Equipment Room (MER) is strategically placed under the scene shop, the least noise-sensitive room. Flexible connections between walls, floor and ceiling prevent structure-borne sound. The blue and red arrows show the Heat Ventilation Air Cooling-system (HVAC). The air supply in the auditorium is placed under the seating and the exhaust is hidden in the ceiling. By that the HVAC-system is allowed to generate a slow air flow which lowers the noise production.

THE SHINING OPERA BY NIGHT

BALLET PRACTICE IN THE NATURAL SPOTLIGHT

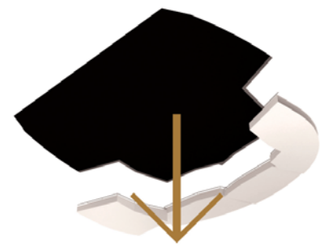
flexibility

This multi-purpose opera hall will also be used for example lectures and orchestral concerts. All these different occasions need different acoustical settings.

Therefore the hall has a lot of easily adjustable equipment, for a satisfactory experience for each and every one of the different purposes.

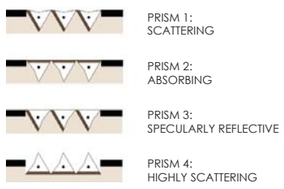
movable ceiling

The ceiling is shaped to reflect as much sound as possible down on the audience. The ceiling is also movable and has three different positions. By changing the volume of the room, the reverberation time can be adjusted. The highest position is for concert, and the middle position is for opera. For speech and drama performances the ceiling is lowered. Then the upper balcony is closed and the hall seats 950 persons. The movable part of the ceiling is shaped to fit the upper balcony and has edges of flexible rubber to make the splice well sealed.



rotatable prisms

The rotatable parts of the wall in the auditorium and in the rehearsal room are shaped like prisms. They provide a possibility to adjust the acoustics. The state of each prism can be altered independently by a remote control. Each prism has three faces with different acoustical properties. This will allow plane reflections, absorption or scattering, or all kinds of intermediate combinations.

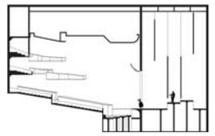


portable stage shell

An effective way to create flexible acoustics is to use a stage shell. It gives a feeling of enclosure, both visually and acoustically. With the shell on stage some of the stage house volume is used to increase the volume of the auditorium. This gives a significantly longer reverberation time. The shell consists of convex sheets with stiffeners in the rear for structural support and increased bass reflection. Each sheet is build up by smaller pieces of plywood, which provide a functioning reflective surface that is easy to disassemble and store.

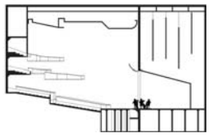
different modes of acoustics

OPERA



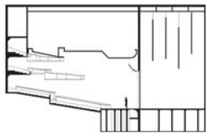
- LOWERED PIT
- CEILING IN MIDDLE POSITION
- PRISM 1: SCATTERING

CONCERT



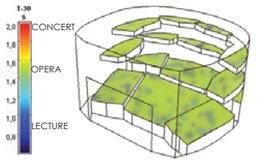
- RAISED PIT
- CEILING IN HIGHEST POSITION
- PRISM 2: REFLECTIVE
- STAGE SHELL

LECTURE

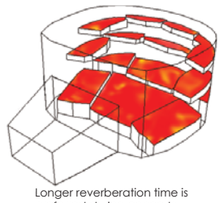


- RAISED PIT
- LOWERED CEILING
- PRISM 3: ABSORBING
- CURTAIN DOWN

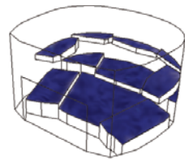
REVERBERATION TIME T_{30}



A reasonable reverberation time for opera
AVERAGE RT OPERA 1.5 SEC

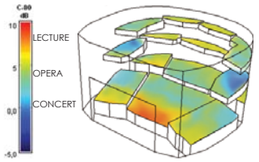


Longer reverberation time is preferred during concerts
AVERAGE RT CONCERT 2.0 SEC

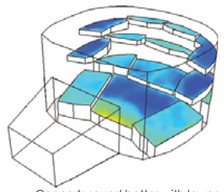


For better speech intelligibility, a shorter reverberation is better
AVERAGE RT LECTURE 0.9 SEC

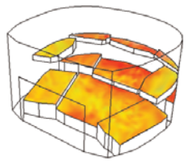
CLARITY C_{80}



Opera with clarity that will work for both singing and music
AVERAGE CLARITY OPERA 4 dB

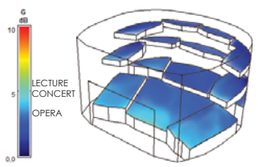


Concerts sound better with lower clarity
AVERAGE CLARITY CONCERT 1 dB

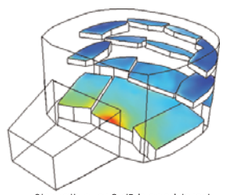


A clearer sound is suitable for speech
AVERAGE CLARITY LECTURE 8 dB

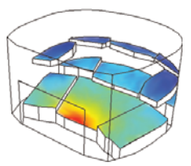
STRENGTH G



A minimum of 0 dB is reasonable from experience
AVERAGE STRENGTH OPERA 3 dB

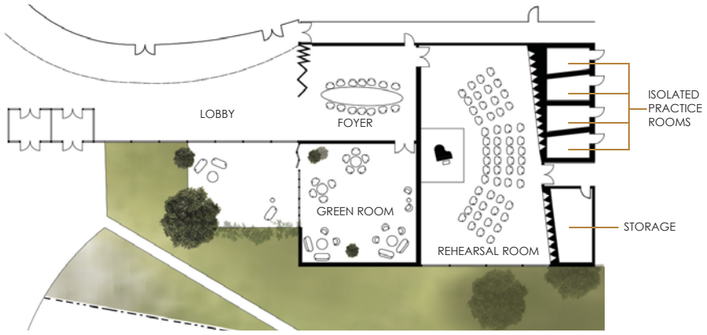


Strength over 3 dB is considered good for concerts
AVERAGE STRENGTH CONCERT 5 dB



Relatively high strength works well for speech mode
AVERAGE STRENGTH LECTURE 6 dB

rehearsal room and green room

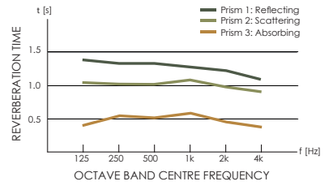


Adjacent to the lobby lies a smaller foyer with access to both the green room and the rehearsal room. This area can be used during different events such as dance performances, receptions, lectures or group ensembles. Bigger events can take place in the rehearsal room, whereas small scale events advantageously are held in the green room. These two connected rooms can be used separately or both together.

The façades of glass in both green room and rehearsal room let natural light in, and folding walls in the green room make it possible to have an opening to the gardens. In the rehearsal room one wall is angled 7 degrees to avoid flutter echo. One of the long sides is covered with adjustable rotatable prisms similar to those in the auditorium. The rectangular shape and the folding scene make the room flexible.

FOLDING SCENE

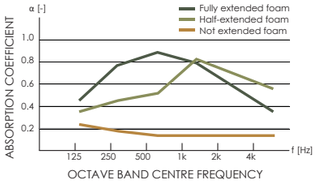
REVERBERATION TIME REHEARSAL



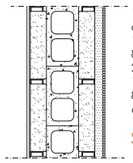
isolated practice rooms

Four small practice rooms are located close to the rehearsal room. These rooms have thick walls with very high sound isolation. One wall in each room is angled and all walls are coated with compressible foam as variable absorbers, for a good sound control.

VARIABLE ABSORPTION PRACTICE

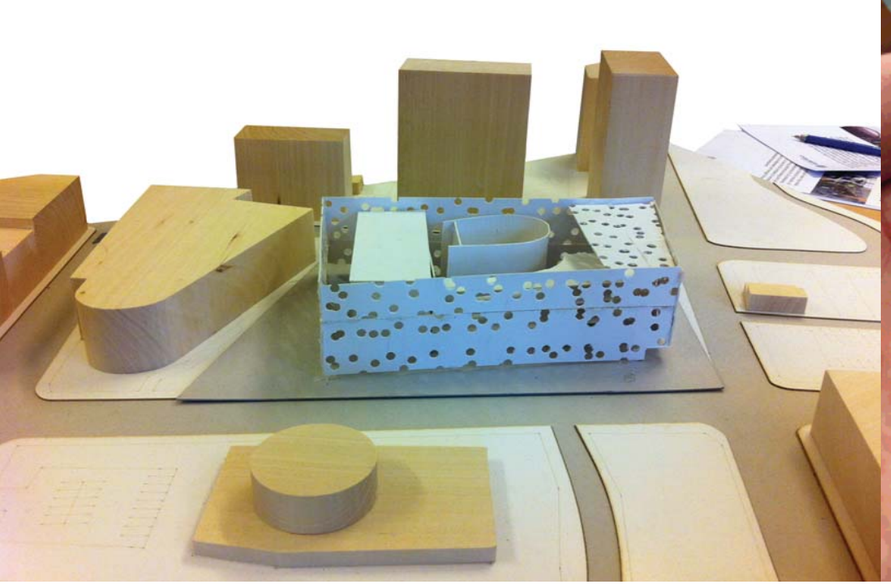


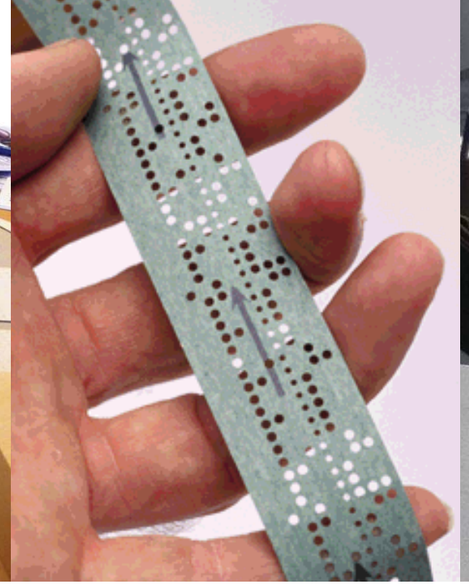
DETAIL 1:20 ISOLATING WALL WITH VARIABLE ACOUSTICS



10 mm perforated wooden plate
compressible absorbing foam
100 mm sound attenuation fire blankets
80 mm steel stud
200 mm concrete masonry unit
100 mm sound attenuation fire blankets
80 mm steel stud
6 mm acoustical panel
15 mm gypsum board

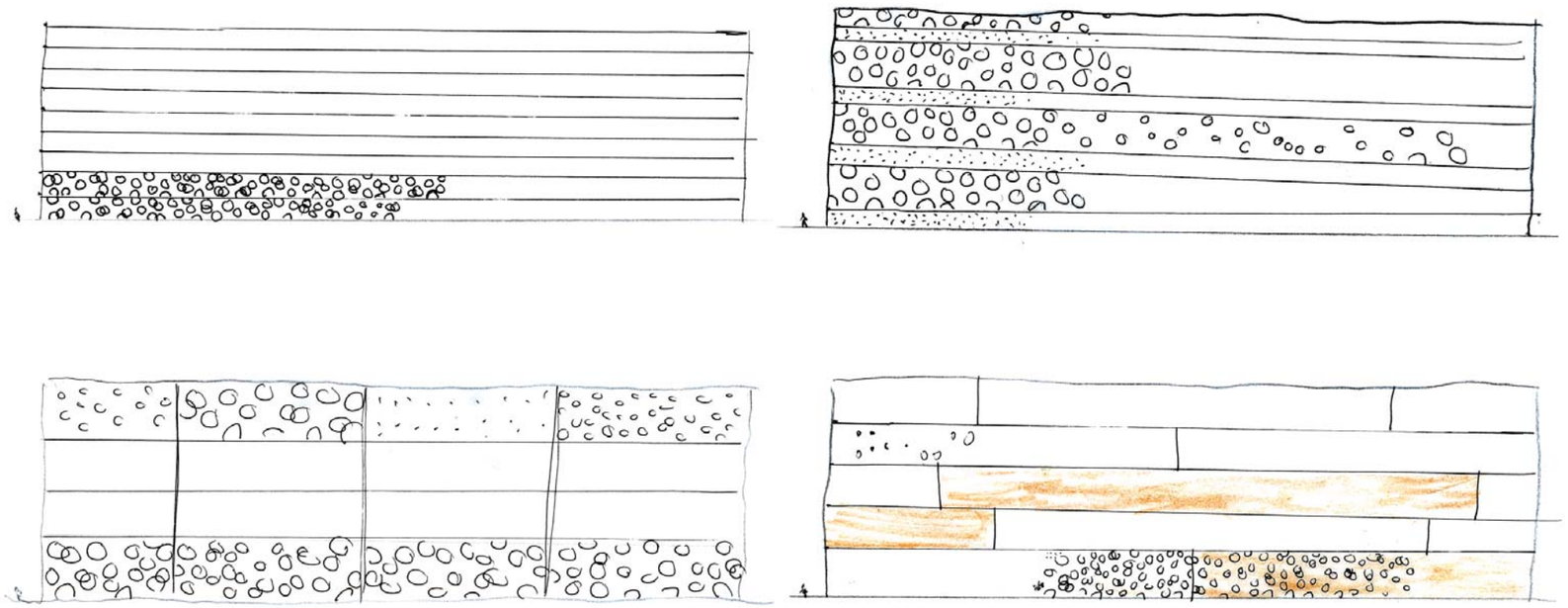
STC 85





models and sketches

To find a design for the façade we did models and drawing trying different combinations of patterns and hole-sizes. We wanted a transparent wall that could be looked at from the road, where people came in high speed and had a distance to the building. Still we wanted the holes to be in a human scale, so that you could go really close and still appreciate it.



REFLEKTION

Tankar kring projektet

Detta var ett intensivt samarbete, och vi jobbade tätt ihop hela tiden. Det var viktigt att inte glida isär på vägen, och att utnyttja den externe akustikern på bästa sätt. Han hade även idéer om gestaltning och formuleringar som var värdefulla. Eftersom det var en del i en tävling handlade det om att kommunicera snabbt och ha ett tydligt koncept som var lätt att ta till sig. Samtidigt fick man inte glömma att det var en del i vår utbildning. Även om det var en tävling kände vi att vi ville utveckla vissa delar som var viktiga hos byggnaden, även om det inte alltid var sådant som man hinner se på fem minuter. Det är ju trots allt en utbildning vi går.

Vad blev bra?

Jag tycker styrkorna hos projektet var konceptet, presentationen och hur vi förmedlade vårt budskap. Akustiken fick verkligen vara fokus och var inget som fick tummas på. Det faktum att vi läste på ordentligt och samlade fakta och information gjorde att vi kunde komma fram till goda resultat. Det kräver mycket kunskap att göra akustiklösningarna!

Ett gott sammarbete var grunden till allt. Vi var effektiva och strukturerade vilket gjorde att vi han arbeta igenom projektet ordentligt, och kunde även lyfta fram många olika akustiska detaljer. Bilderna blev bra och kommunicerade väl, och tog inte orimligt lång tid att göra, vilket verklighetstrogna renderingar lätt gör om de skall bli bra. Muntliga presentationen var väl förberedd och flöt på bra.

Vad hade kunnat utvecklad?

Kontexten och relationen till platsen hade vi jobbat mycket med, men eftersom det inte visades på planscherna föll det resonemanger bort, vilket var synd. Det blev en följd av att akustiken tog så stor del, och det var inte så konstigt med tanke på uppgiftens natur. Vissa ritningstekniska detaljer kunde också arbetats på mer.

Vad har jag lärt mig?

Att får konsulthjälp var nytt för oss. Det var roligt att få jobba med andra kompetenser och kunna dela upp projektet där var och en får jobba med det den är bra på. Annars jobbar vi tillsammans med människor som har exakt samma kompetent och erfarenhet, och dessutom samma ställning och befogenheter. Så är det ju inte i arbetslivet.

En nyttig erfarenhet var att bli bedömd och få ett kort och koncist utlåtande av kritiker med stor kunskap i att delta i tävlingar. Samtidigt som det känns sjukt att hela kandidatarbetet ska presenteras och bedömmas på tre minuter är det en situation som kan uppstå i verkligheten. Det är väldigt svårt visa allt. Eftersom tävlingen var utformad som den var fick akustik och upplevelser ta plats, medan kontext och omgivning inte lyftes fram så mycket. Skalet jobbade vi t ex väldigt mycket med. Det fick inte riktigt plats på presentationen, där syns bara slutresultatet och inte den långa vägen dit. Det är antagligen så det får vara i ett tävlingssammanhang.