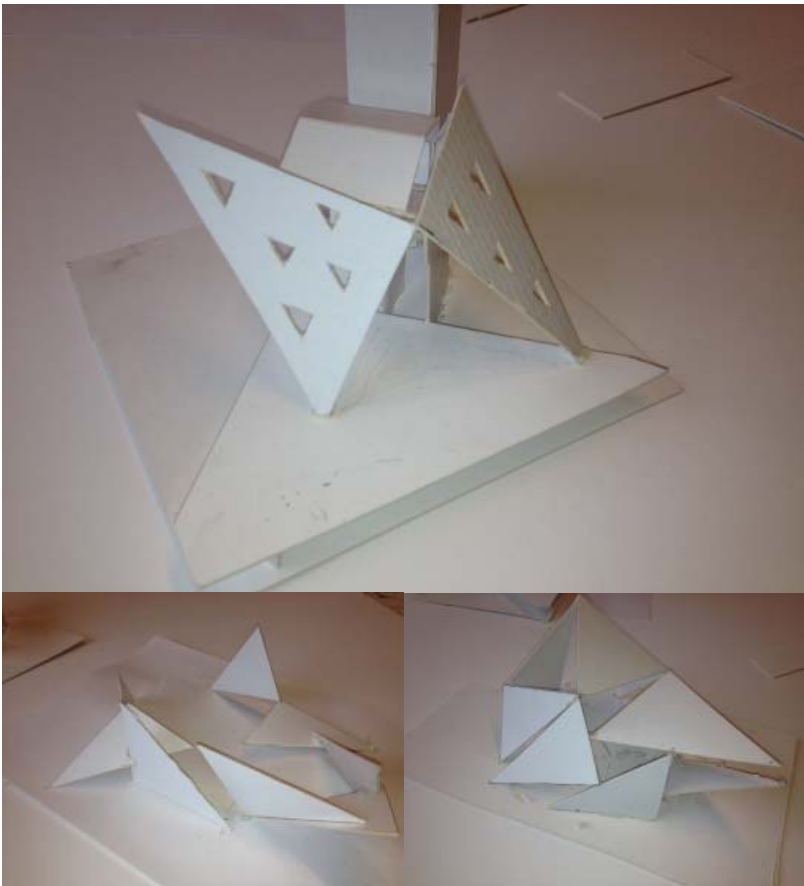




VOYAGE

KURS	Kandidatarbete	UPPGIFT	Uppgiften gick ut på att skapa en opera sal för en skola i Montreal med starkt musikprogram. Opera salen skulle även vara en sal för andra typer av föreställningar så som teater och konserter.
OMFATTNING	15Hp		Salen skulle få plats med ungefär 1200 personer och ungefär 40% av sittplatserna skulle vara ovanför mark-nivån (balkonger). Sen hade vi andra begränsningar inom programmet så som att scenen skulle vara 560m ² , scenöppningen skulle vara 15m bred och 9 m hög. Scen-huset skulle vara ungefär 2.5 till 3 gånger så hög som scenöppningen. Orkesterdiket skulle vara 170m ² och få plats med ungefär 70 musiker. Det var viktigt att tänka på att salen skulle användas för olika föreställningar och ljudet skulle kunna ändras för olika ändamål. Programmet innehöll många rum och begränsningar för mer detaljerat information se bifogat programbeskrivning.
PERIOD	Våren 2013 (tredje året)		
OMRÅDE	Södra korsningen av Rue Saint-Jacques och Rue Peel, Montreal, Canada		
GRUPP	Joakim Sättermann Carlos Mora Meran Alwan		
EXAMINATOR	Morten Lund		
HJÄLPMEDEL	AutoCAD, Rhinoceros, Vray, Adobe Photoshop, Adobe InDesign, MATLAB, CATT Acoustics		

Tidigt i arbetet började vi göra pappmodeller våra pappmodeller består av trianglar är ingen slump. Vi ville skapa dramatik med trianglarna genom att ha ena spetsen nedåt mot marken vi gjorde väldigt många modeller och första bilden var den utformningen vi ville fortsätta med. Att bara ha två trianglar som märker ut entrén/framsidan till operan och som man kan se är marken är upphöjt det gjorde vi för att ge besökarna en upplevelse när de går in under det låga taket och ut till lobbyn som är stort och luftigt. Efter långt skissande av förslaget kom vi inget vart. Det var svårt och få ihop trianglarna och bli en del av fasaden samtidigt som man skulle få till en fungerande lobby innanför. Så vi valde att släppa förslaget och börja tänka i nya banor och ta tag i problemet i ett senare skede.

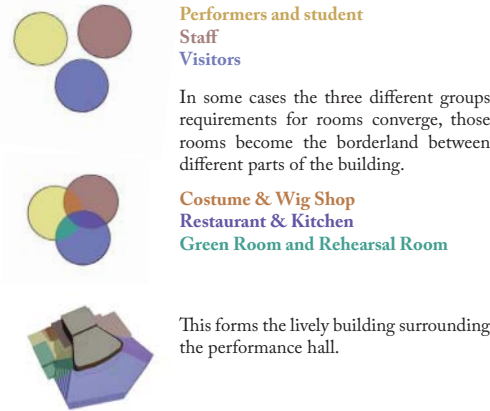


Vi tänkte att det var tre huvudgrupper vi behövde tänka på, scenartister & studenter, personal, besökare alla behövde sina egna avdelningar och i vissa fall korsade vissa rum andra så som restaurang där personalen och besökare sammansmälter. Green room är ett rum som korsas mellan scenartister & studenter och besökarna och där alla avdelningar sammansmälter är opera salen.

Opera is more than just a stage performance. The opera experience do not start when the curtain goes up, it starts with entering the site, with all the excitement that rises when you stand in the lobby waiting to get in. The experience continues in the lobby between the acts, by the meeting of old friends and new, by that amazing dish in the restaurant or that post-performance concert in the Rehearsal room or the Green room. Opera is more than just a stage performance, it is a breath taking experience, an amazing **voyage**.

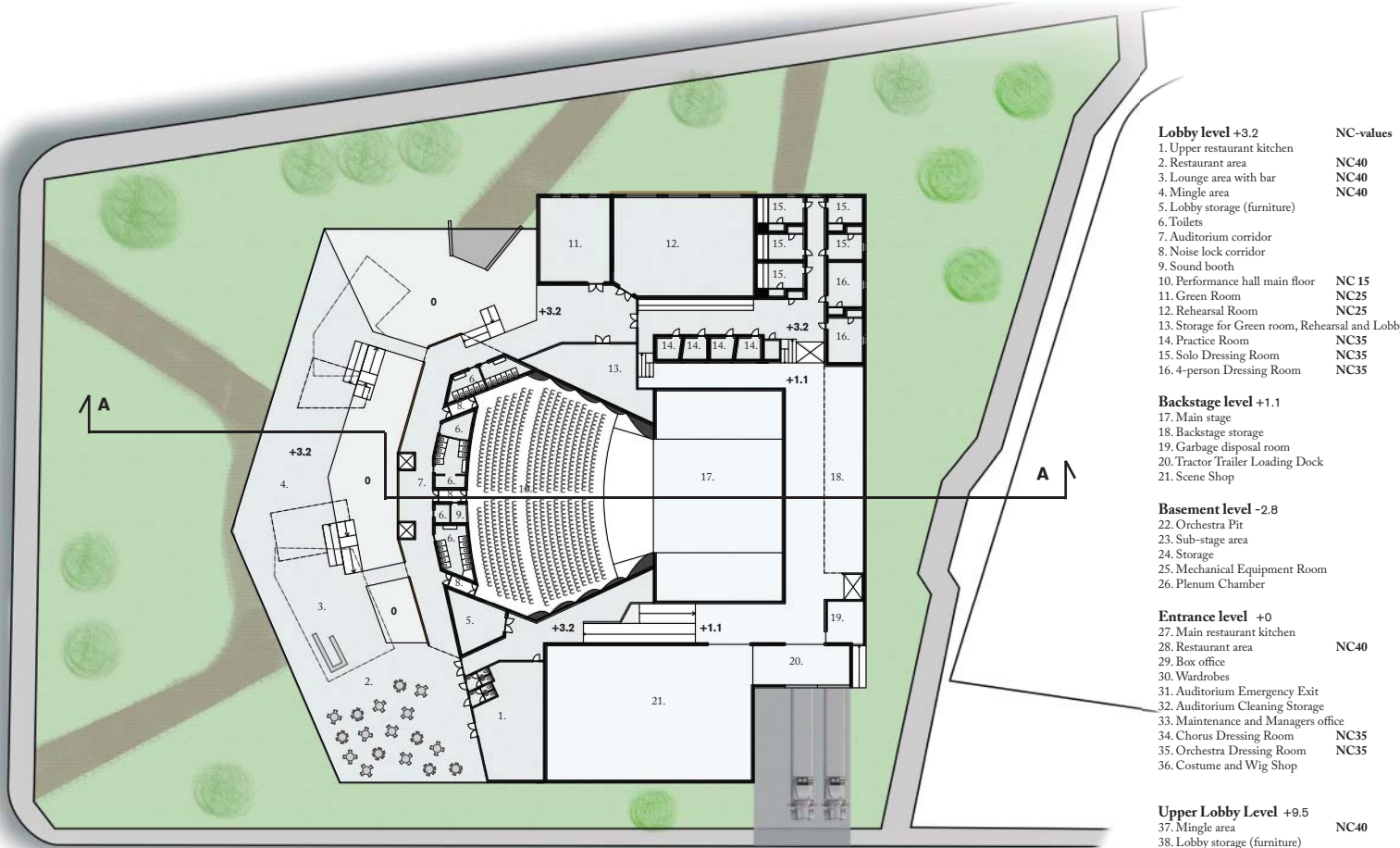
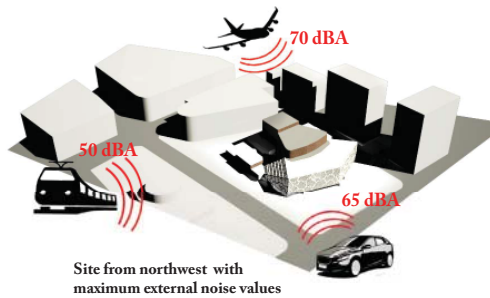
Floor plan concept

Different people needs different rooms and facilities around the performance hall, they are sum up into three categories:



The Site

The site is located east of downtown Montreal and the most of the visitors will come from northwest. The students and performers have their own entrance on the north side and the loading dock is placed on the south side, by the least busy of the three surrounding streets. External noise will mainly come from car traffic from west and north, train traffic from northeast and airplanes from above.



- | | |
|---|-----------|
| Lobby level +3.2 | NC-values |
| 1. Upper restaurant kitchen | |
| 2. Restaurant area | NC40 |
| 3. Lounge area with bar | NC40 |
| 4. Mingle area | NC40 |
| 5. Lobby storage (furniture) | |
| 6. Toilets | |
| 7. Auditorium corridor | |
| 8. Noise lock corridor | |
| 9. Sound booth | |
| 10. Performance hall main floor | NC 15 |
| 11. Green Room | NC25 |
| 12. Rehearsal Room | NC25 |
| 13. Storage for Green room, Rehearsal and Lobby | |
| 14. Practice Room | NC35 |
| 15. Solo Dressing Room | NC35 |
| 16. 4-person Dressing Room | NC35 |

- | | |
|----------------------------------|--|
| Backstage level +1.1 | |
| 17. Main stage | |
| 18. Backstage storage | |
| 19. Garbage disposal room | |
| 20. Tractor Trailer Loading Dock | |
| 21. Scene Shop | |

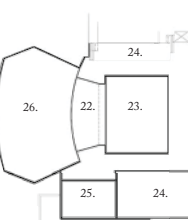
- | | |
|-------------------------------|--|
| Basement level -2.8 | |
| 22. Orchestra Pit | |
| 23. Sub-stage area | |
| 24. Storage | |
| 25. Mechanical Equipment Room | |
| 26. Plenum Chamber | |

- | | |
|-------------------------------------|------|
| Entrance level +0 | |
| 27. Main restaurant kitchen | |
| 28. Restaurant area | NC40 |
| 29. Box office | |
| 30. Wardrobes | |
| 31. Auditorium Emergency Exit | |
| 32. Auditorium Cleaning Storage | |
| 33. Maintenance and Managers office | |
| 34. Chorus Dressing Room | NC35 |
| 35. Orchestra Dressing Room | NC35 |
| 36. Costume and Wig Shop | |

- | | |
|-------------------------------|------|
| Upper Lobby Level +9.5 | |
| 37. Mingle area | NC40 |
| 38. Lobby storage (furniture) | |
| 39. Toilets | |
| 40. Performance hall balcony | NC15 |

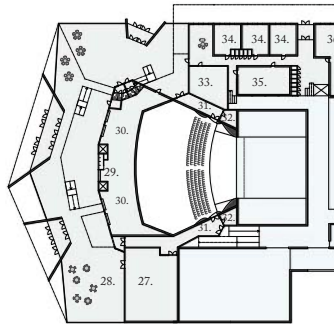
- | | |
|---|--|
| Technical level +20 | |
| 41. Stage lighting, recording and ventilation exhaust | |

Lobby and Backstage Level
scale 1:500

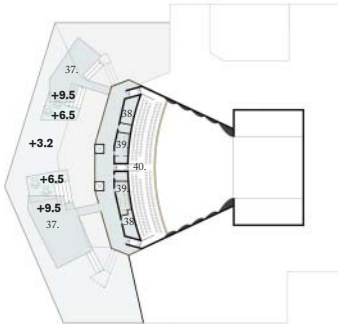


Basement Level
scale 1:1000

Entrance and Backstage Level
scale 1:1000



Upper Lobby Level
scale 1:1000



OPERASAL

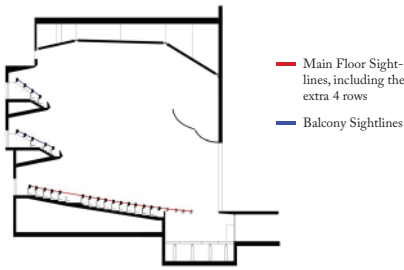
Vårt motto för operasalen var att alla sittplatser skulle få full vy över scenen och höra bra och tydligt. Därför valde vi att jobba med en solfjäderformad sal med tillhuggna sidor så att platserna längre bak inte skulle bli alldeles för långt bak.

För att få en uppfattning av hur stort salen skulle bli programmerade vi en kod som skapade ett antal cirkelsegment med ökande radie på en meter eftersom vi tyckte att det var ett bra avstånd att ha mellan stolarna och programmet delade senare upp cirkelsegmeten i 0.8 meters delar och programmet räknade i slutet ut det totala antalet segment. Som var en siffra på antalet stolar. Vi skrev också ett program som räknade ut hur mycket högre upp personen bakom måste sitta för att kunna se över personen framför.

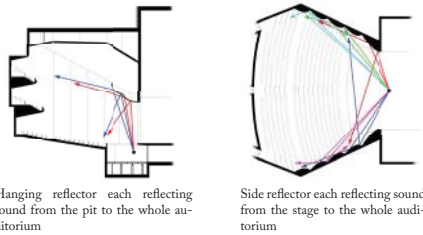
The Seating

The performance hall is formed so that every seat is should be both acoustically and visually good. The criterion that every seat should be facing the stage makes it better to place the balconies in the back instead of in a classical horseshoe-shape. Making the auditorium fan-shaped results in that the auditorium does not have to be that deep and the rear balconies will be closer to the stage.

The auditorium hall has 1210 seats plus 6 places for wheelchairs (4 in the back of the main floor and 2 in the middle of the first balcony). 720 seats are on the main floor, 270 on the first balcony and 220 on the second. When there is no need for the orchestra pit it can be raised giving space for 130 extra seats plus a larger stage.



The main floor is sloped so that the stage is fully visible above the head of the audience two rows in front of you. The seats are laterally staggered so the heads of the people on the row in front are not disturbing the sight. The balconies are sloped so that you see the stage above the row in front of you.

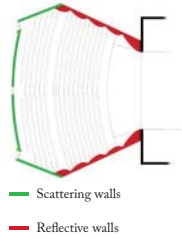


The Reflectors

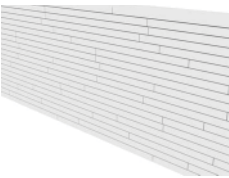
To make every seat acoustical excellent the early reflections are of importance. The sides of the auditorium are shaped like five curved reflector, each distributing early reflections from stage to the whole auditorium. The side wall reflectors are tilted inwards 3° increasing the early reflections. Above the orchestra pit are two reflectors hanging, each sending reflectors to the whole hall.

The Wall Material

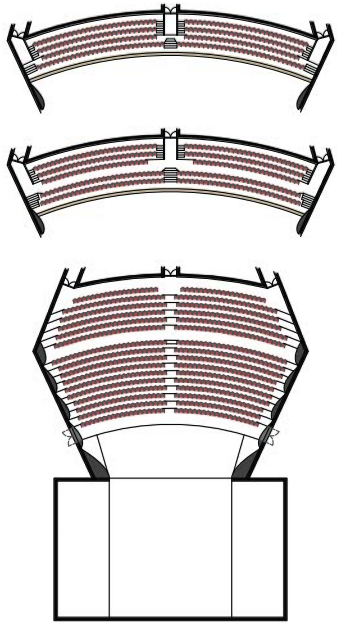
The auditorium wall surface is made of bricks. By adding bricks offset relative to each other, scattering walls are created on the four back walls. The reflecting walls and reflectors have bricks stacked without displacement to each other and a small mortar layer.



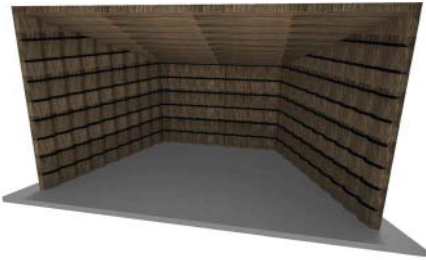
Scattering brick walls



Reflective brick walls

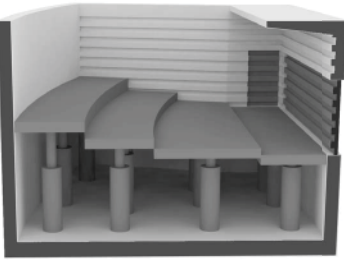


Seating Plan scale 1:500



The Shell

The orchestra shell is built up by 1.2 m long curved rigid plywood elements. The ceiling of the shell is when not in use hung up in the stage tower while the side elements are stored behind the stage. The wall curvature in addition with horizontal ribs makes the shell optimum both for the sound environment for the musicians and for reflecting the music out to the auditorium.



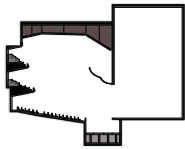
The Orchestra Pit

The pit is divided into four floor segments which can be individually raised to the desired height. The back and side walls of the pit are diffusing allowing the musicians to properly hear each other improving the unison of sound out to the audience. The front wall of the pit is reflecting, giving reflections to the stage performers.

The Multi-purpose Hall

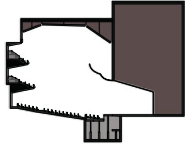
The auditorium is formed to serve different purposes with different acoustical requirement. The three different modes that mainly are concerned are, Opera Mode, Concert Mode and Lecture Mode. The main differences of the three modes are the reverberation time which is alternated by changing the volume and partly also the absorption of the room. To change the volume a moveable ceiling is used.

The Three Modes



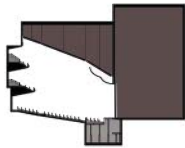
Opera Mode

The orchestra pit is in use, it can be lowered or higher in segments to serve the different needs for different orchestras. The performers are singing from the stage towards the audience.



Concert Mode

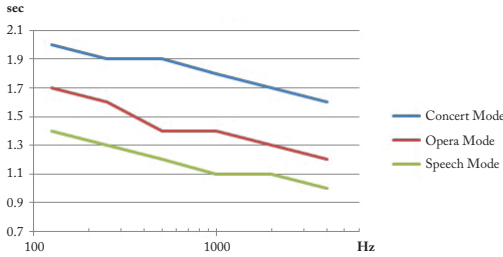
The pit is raised so that half of it is filled up with 130 extra seats and the other half becomes stage. The orchestra is sitting on the stage which are enclosed by a stage shell



Speech Mode

The pit is raised in the same way as in concert mode but the stage tower is closed with the firewall. The lowered, more flat ceiling both reduces the reverberation time and helps sending early reflections to the balconies.

Reverberation Time



G (1 kHz)
The strength is an indicator of the loudness in the room.



C-80 (1 kHz)
Clarity measures how well individual sounds can be distinguished one after the other. Strong early reflections are desirable in order to achieve a better clarity.



STI
Speech Transmission Index is a better indicator than C-80 to measure a good speech intelligibility.

T-30
Reverberation time gives an impression of the largeness of the room. High reverberation times are desirable for music while for speech reverberation time is preferred to be lower.

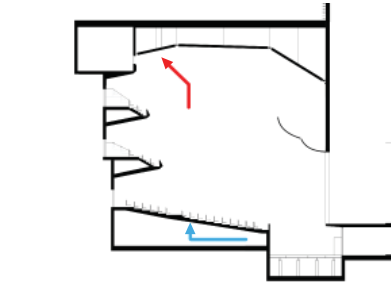
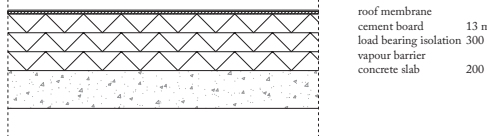
Controlling HVAC and plumbing

The ventilation system in the auditorium will be used both for cooling and for air quality control. The ventilation is handled through a plenum chamber beneath the auditorium. Air will be supplied through vents located below the audience seats. Warm air rises and is being replaced by cool air from below, which means that there is no need for fans transporting air into the auditorium. The Air Handling Unit is located in the mechanical room below the scene shop, this will supply air into the chamber below the auditorium. The walls in the chamber are built in absorbing material to prevent any noise generation. In order to achieve a good comfort environment, it is needed a ventilation air flow of 10 m³/s with full occupancy. Air will be supplied at low velocities around 1 m/s. The air exhaust devices are located in the technical level and heat recovery will be used. The exhausts are supplied with mufflers preventing external noise to leak in.

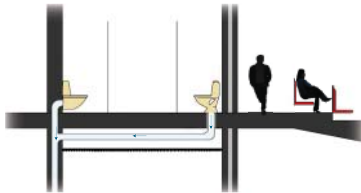
The wall between the auditorium and the restroom provides an STC 75. In order to maintain the noise isolation properties, waste water pipes will not be embedded within this wall, instead the plumbing from the toilets are lead through the floor and then out to the outer wall.

Auditorium Roof - STC 70

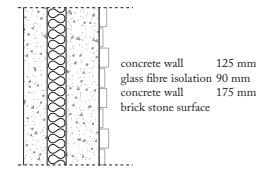
Roof construction will isolate from aircraft noise and will provide sufficient transmission loss to have NC15 within the auditorium.



HVAC are handled through a plenum chamber beneath the auditorium. Warm air rises and are being replaced by cool air from below.



Auditorium wall - STC 75



The Rehearsal Room

The rehearsal room serves for multi-purpose in the same way as the performance hall. The use of the rehearsal room differs from dance and choir practice to concerts, receptions and lectures. For dance and choir practice a shorter reverberation time is preferred in comparison with concerts and lectures.

Choir Practice Mode
RT ~0.6 sec (1 kHz)
Risers and diffusing panel in use

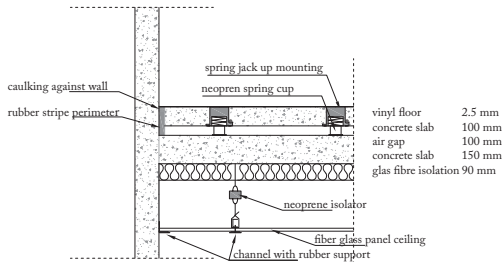
Dance Practice Mode
RT ~0.6 sec (1 kHz)
Risers push into the walls, diffusing panel folded

Concert & Lecture Mode
RT ~1.1 sec (1 kHz)
Risers can be used if desired, diffusing panel in use.

The walls of the rehearsal room

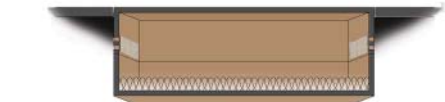
The walls of the rehearsal room are off concern both for isolating to adjacent rooms and for the sound environment in the rehearsal room. The walls are the same kind surrounding the auditorium, preventing sound both from reaching into the rehearsal room and to get out.

The inside of the walls are important to control the reverberation time and sound strength in the room. The outer wall and the wall against the green room are primarily absorbing and the other two walls are scattering or reflection depending on the current use.



Floating floor in rehearsal room - STC 90 IIC 80

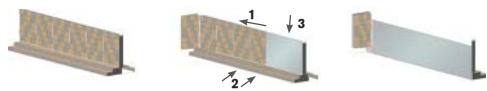
Due to dancing practice the rehearsal room floor should be properly isolated so vibrations will not cause unwanted noise in the dressings rooms below. The floating floor and the suspended ceiling together attains an IIC of 80 dB which make the impact noise nearly inaudible.



Helmholtz Resonators using wooden boxes

The ceiling in the rehearsal room is covered with wooden boxes in different sizes. The upper parts of the sides are perforated making the boxes to work as Helmholtz resonators. The inside of the holes is covered with gauze adjusting the box for an octave wider esonance. Porous absorption is added to the inside of the boxes further increasing the absorption.

The boxes are used for reducing the reverberation time for the practice modes. For the high RT mode the boxes are raised so that the perforation is covered. If the boxes are raised just above the holes the ceiling will be scattering, if they are raised all the way the ceiling becomes flat and reflecting. The scattering ceiling is better for concert and the reflecting is preferred for speech.



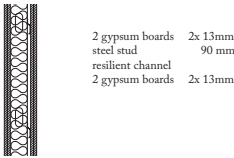
Changing from Choir Practice to Dance Practice

- 1 The diffusing panels are folded into the corner.
- 2 The risers are pushed into the wall. On the long side they are hidden in fixed risers in the corridor, opposite to the practice rooms. On the other side of the short wall the risers are hidden in the wardrobes of the solo dressing rooms.
- 3 The mirrors are lowered to floor level.

The Practice Rooms

The small practice rooms each have two neighbouring walls equipped with the same kind of diffusing panel as in the rehearsal room.

The two remaining walls can be covered by curtains when a short reverberation is desired.



Lightweight wall between dressing rooms - STC 60

The wall is design allowing artists to warm up prior to performance without disturbing their neighbours.

The Lobby

The spacious lobby is subdivided into different levels. The higher level slabs are hung from the ceiling. The feeling of spaciousness in the lobby is enhanced by the comparison to the entrance level where visitors are entering through a volume with a low ceiling height.

The same enhancement of spaciousness works for the performance hall which is entered through the noise lock corridors. The low ceiling in the noise lock corridors also works for absorbing reasons, preventing noise to reach into the hall.

The auditorium corridors are separated from the rest of the lobby by horizontal wooden planks. When entering the lobby the wooden panel appears as a solid wall due to the angle. Move vertically up through the lobby the panel turns more translucent.



The center of the main lobby level are visible from all the different levels. In case of a performance the hanging slabs turns into balconies.

The Multi-purpose lobby

The lobby is more than only a waiting room for the auditorium. The different slabs create room of different sizes appropriate for events and receptions in different scales.

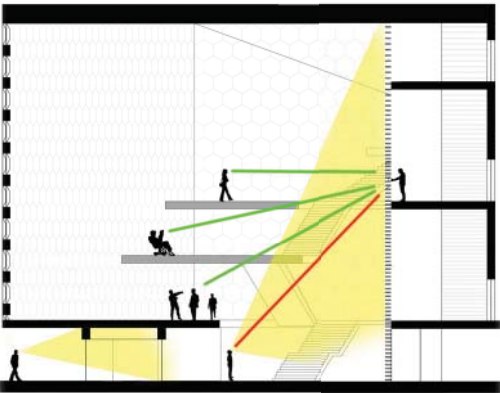
From the mingle area on the main lobby level you get a view over the entire lobby. This is ideal for a concert where a smaller stage can be placed on the lobby level and the hanging slabs will work as balconies.

Controlling the reverberation time

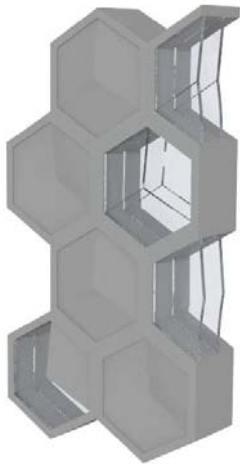
The reverberation time in the lobby is 1.1-1.2 sec at mid-frequencies depending on the number of people present. The reverberation time is reduced by absorption in the ceiling and in the auditorium corridors. The auditorium corridors work as absorbing volumes behind the wooden panel. Helmholtz resonators in form of light fixtures are hung from the ceiling to reduce low-frequency noise. They are in three sizes with resonance frequencies from 63-250 Hz, in addition they are tuneable with respect to center-frequency and Q-value.



Detail section through the lobby light fixture



Section through the lobby showing low vs high and the gradually translucent wooden panel scale 1:500



Detail section through the lobby facade The glass are of 6 mm pane, 15 mm argon and 4 mm pane. This will achieve a noise reduction of 40 dB.

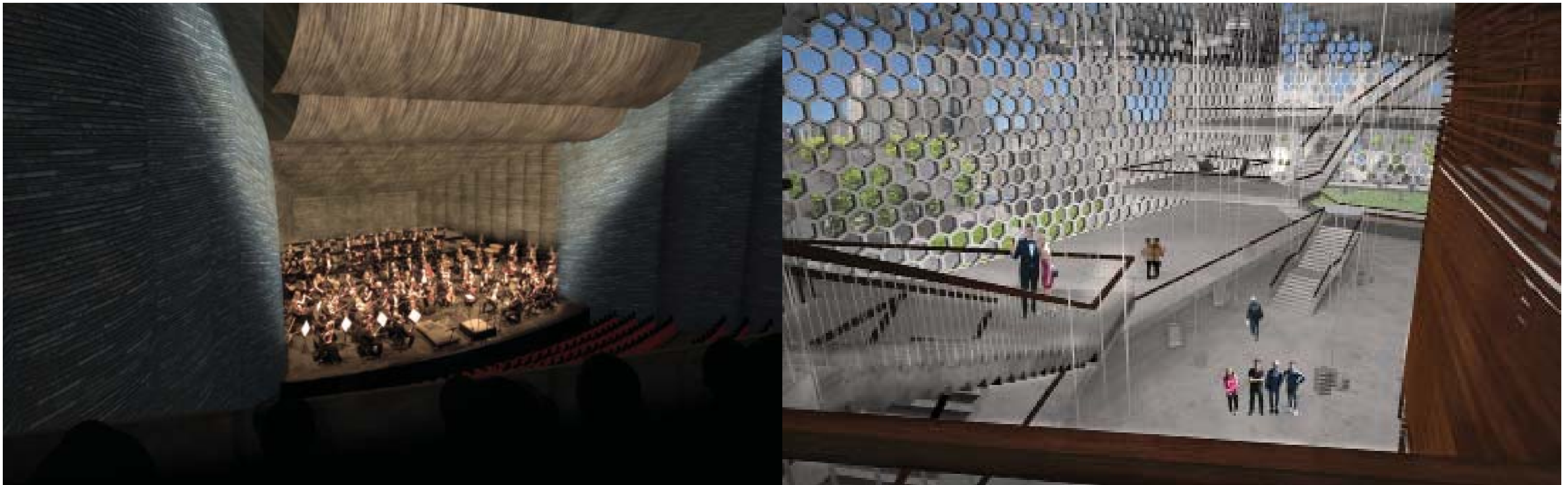
The facade

The facade of the lobby is composed of a concrete hexagon grid. The grid is glazed and partly filled with concrete. The midpoints of the hexagons are extended either inwards or outwards to prevent direct reflections and instead working as scattering.

LOBBY

Lobbyn består av en entréplan på marknivå och flera nivåer ovanför som är upphängt i taket. De upphängda nivåerna är plats för mingel där man kan hänga mellan akterna och samtidigt så kan nivåerna fungera som balkonger man kan titta ner ifrån mot nedersta mingelvåningen där man kan ha föreställningar. Nivåerna blir inte bara en väntplats utan en plats där man kan vandra och uppleva.

Fasaden är uppbyggd av hexagoner med en mittpunkt som skjuts in eller ut i vissa delar här hexagonen i betong och andra i glas det skapar en intressant fasad som samtidigt diffuserar ljud så att det inte blir högljudd med lång efterklangstid i lobbyn. Vi har dessutom hängt upp Hel-mortz lampor i lobbyn för att refusera efterklangstiden. Som jag tidigare nämnde så ville vi att man skulle entrén ha låg takhöjd och plötsligt bli stort rum. Rummet upplevs större än det faktiskt är eftersom väggen till opera-salen lutar inåt mot lobbyn. Väggen består av liggande träreglar med en ökande mellanrum allt högre upp man kommer så att man uppfattar väggen solid från entrén. Men när man kommer längre upp så kommer man kunna se igenom och få kontakt med besökarna där.



REFLEKTION

När vi började med projektet hittade vi inte ett riktigt koncept fastän vi försökte hitta ett starkt koncept. Det var ett stort problem och gjorde arbetet mycket svårare än vad det hade blivit om vi hade haft ett koncept eftersom vi inte visste vart vi ville landa. När vi stötte på ett problem som vi inte hade lösningen hoppade vi över det och gjorde något annat. Vi kan aldrig egentligen hoppa tillbaka och lösa problemen.

Vi sa väldigt många gånger att vi skulle sätta upp våra mål och skriva ner vad vi hade bestämt oss för men det gjorde vi aldrig och det försvårade vårt samarbete eftersom vi inte alltid visste vad vi hade bestämt oss för. Det ledde till långa diskussioner som vi redan hade haft och vi försökte övertyga varandra igen.

Hade jag gjort om projektet hade jag börjat i en annan ände. Hittat ett starkt koncept som jag vill följa projektet ut. Skriva ner saker vi bestämt oss för och följa ett schema som vi satt upp med mål. Trots alla motgångar vi stötte på så tycker jag att vi fick ihop en fin opera som fungerar som en helhet. Det bästa med projektet är lobbyn, jag tycker att det är en intressant miljö och vistas på.