

waves of sound

KURS Kandidatarbete vid Arkitektur

STORLEK 15 Hp

PERIOD VT 2013

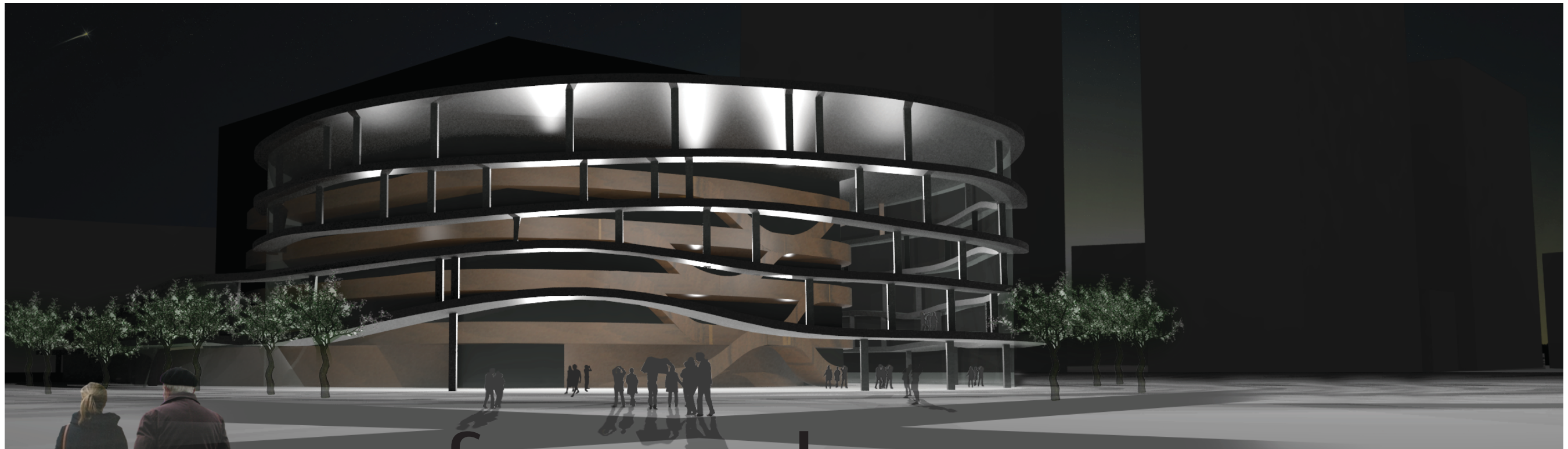
TYP Team Emma Johansson, Maïke Lühr, Henrik
Guldbrandsen (Masterstudent vid Chalmers Akustik)

EXAMINATOR Morten Lund, Mendel Kleiner

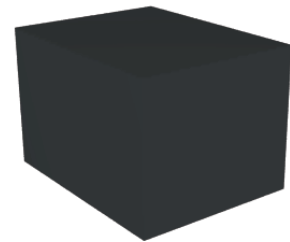
HJÄLPMEDEL Rhinoceros, Grasshopper, CATT
acoustics, Autocad

Kandidatarbetet utgjordes av ett arkitektur- och akustikprojekt där uppgiften var att utforma en opera till ett universitet i Montreal, utformningen var därmed viktig både ur arkitektonisk och akustisk synpunkt. Krav på varierbar operasal fanns då byggnaden skall kunna användas till så många ändamål som möjligt - tex för operatillställningar, konserter och konferenser.

Projektet utfördes genom ett samarbete mellan Arkitektur- och teknikstudenter samt en masterstuderande vid Chalmers Akustikprogram.



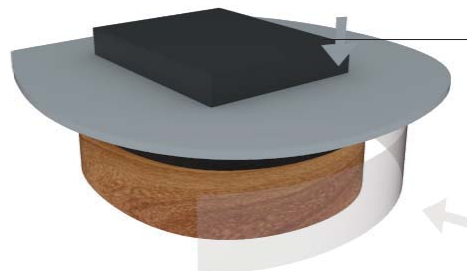
waves of sound



Concrete shell - contains the auditorium, stage and sidestages. The concrete shell composes the primary protection from surrounding noises - for the rooms that are most dependent on sound protection.

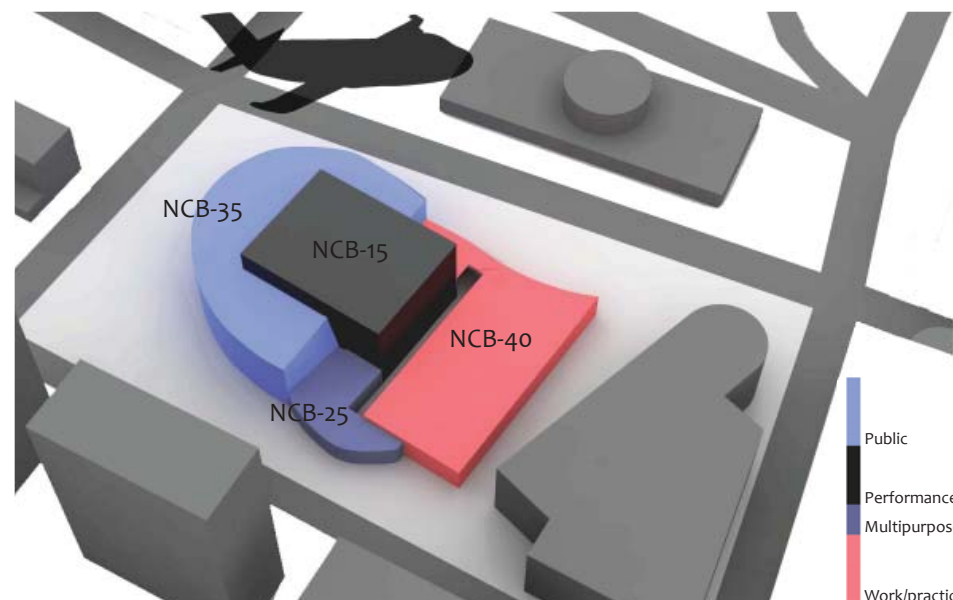


Second protection shell - contains all the functional rooms needed in an opera, such as rehearsal rooms, dressing rooms, costume shops, storage and scene shop.



Transparent sound barrier - an extra facade protects the entire building from exterior sound. The thick concrete roof spreads over the entire building and acts as a shield from airborne traffic passing over head.

Separating noisy spaces from quiet spaces



Public
Performance
Multipurpose
Work/practice etc.

Public

The NCB -35 for the public space is achieved by an isolating double glass facade and a thick concrete roof.

Performance

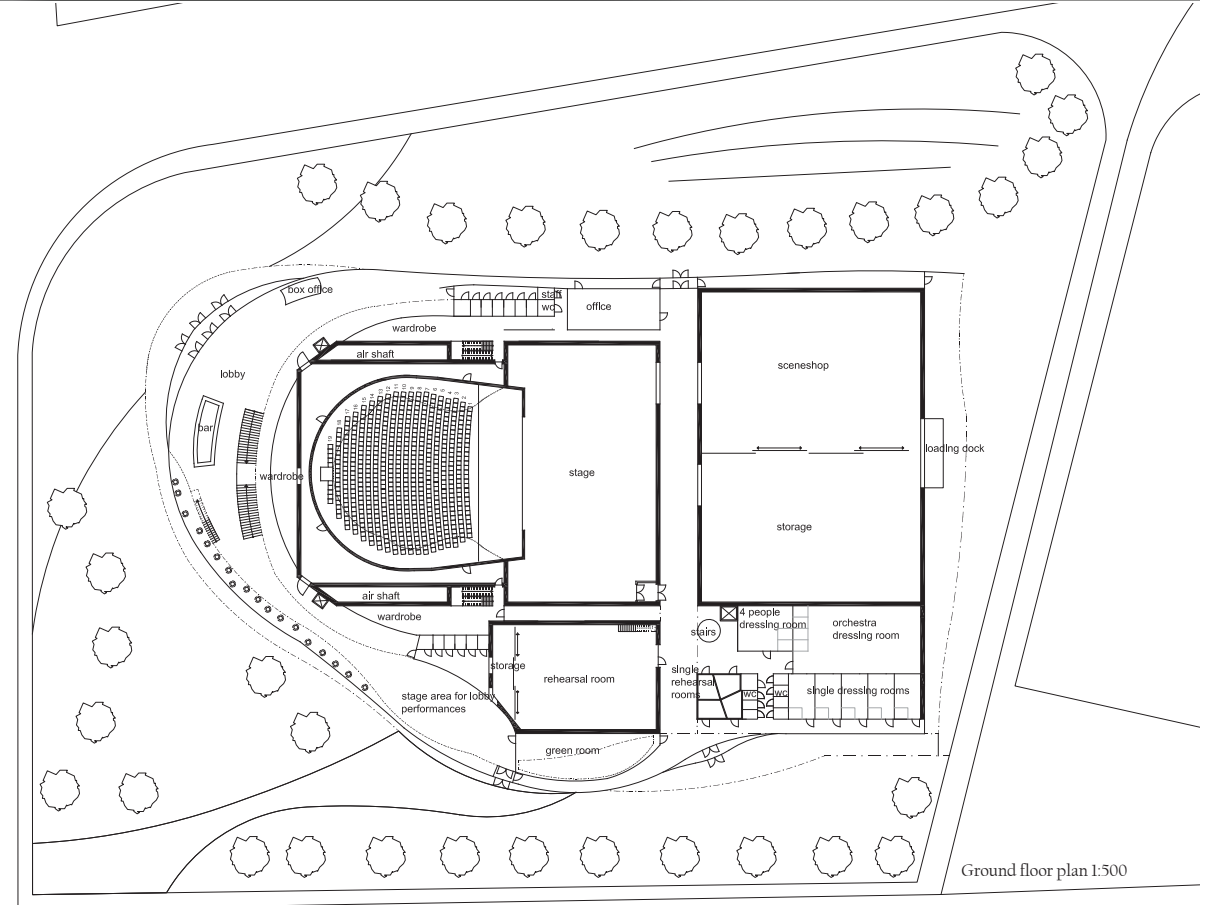
The sound criteria in the auditorium is achieved by double walls and a double roof - all separated by air space. The space between the walls functions as a noise lock, while the space between the roofs is used for ventilation air.

Multipurpose

The multipurpose zone contains the large rehearsal room and the green room. These are for both private use and for public events. These rooms are situated at the quiet end of both the lobby and the workspace areas - giving it good qualities both acoustically and logistically.

Work/practice etc.

This zone - containing storage, sceneshop, machine room, dressing rooms etc is separated from the other zones by a wide corridor, minimizing the risk for sound transmission.

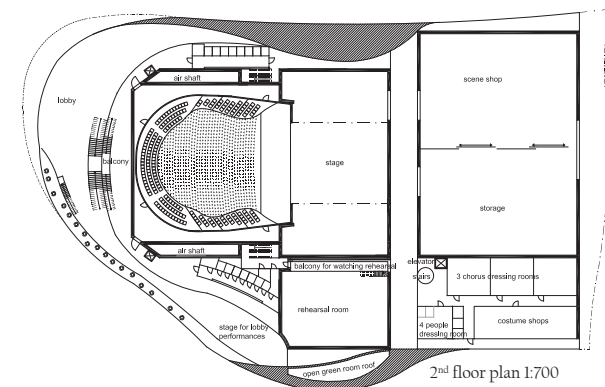


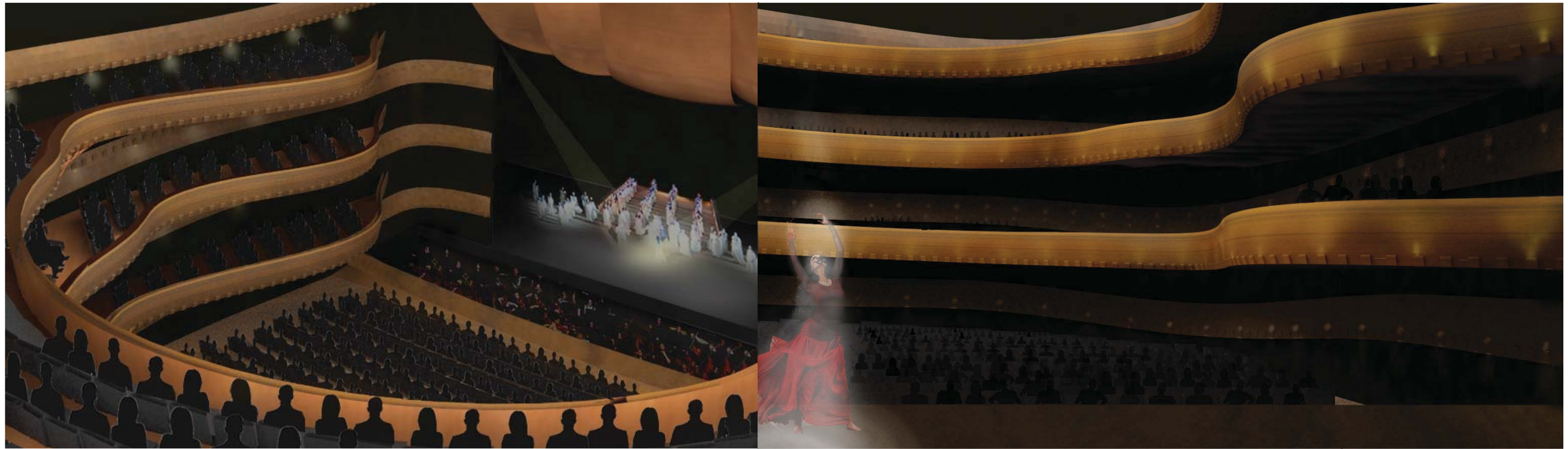
Maximising efficiency of sound isolation

To maximise efficiency of sound protection the building is designed to be sound effective. It is divided into different zones which are separated from one another. This effectively reduces sound transmission between the zones.

The airshafts on each side of the auditorium are effectively placed outside of the thickest shell wall that embraces the auditorium. Their large

cross-section area minimises the noise from the shafts. The ventilation of the auditorium is practically soundless by air rising up through the floor and continuing through to the ceiling. By having a ventilation opening at each chair, and a separate used-air chamber over the ceiling, the air velocity is always kept below 2 m/s.

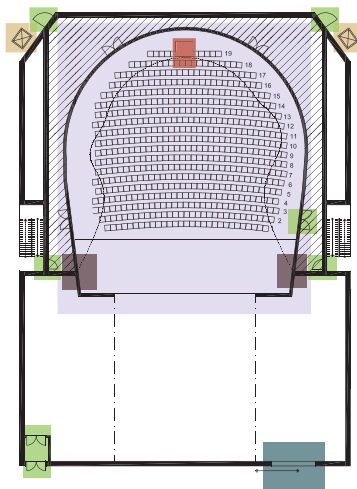




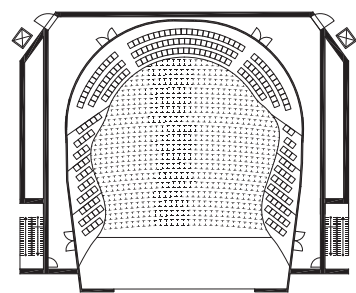
Auditorium

Overview

1st floor, parkett



2nd to 4th floor, balconies

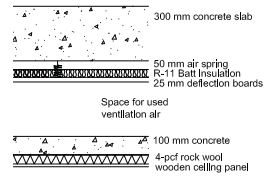


- Free standing auditorium
- Air lock between auditorium and the concrete shell.
- Isolating doors, sealed by magnetic strips
- Free standing elevator shafts
- Decoupled walls to prevent flanking
- Technician sound booth
- Sliding door - sealed, with heavy core

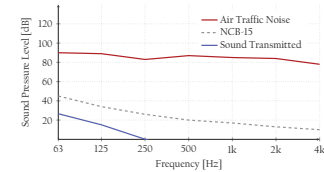
Roof acoustics

The entire building is covered by a concrete slab roof with additional vibration isolation through batt insulation hanging on springs.

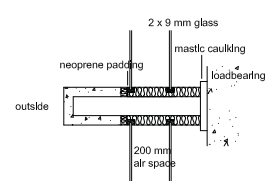
The auditorium has an additional sound isolating roof of a concrete slab and rock wool. The space between the two roofs where the used up ventilation air is held serves as additional sound isolation.



Sound pressure level in the Auditorium

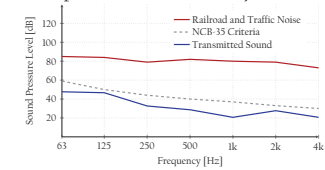


Glass facade



The glass facade, the third protecting shell around the building, is an important sound reducer, especially in the lobby. The detail above describes the glass facade with one of the facade bands through it.

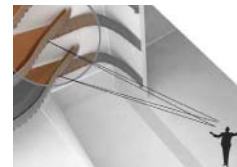
Sound pressure level in the Lobby



Balconies

Sinuating balconies

At the front of the auditorium the balcony fronts are bent inwards to provide feedback reflections to the performers on stage.



Balcony front profiles

The balcony fronts are double curved to improve the spreading of sound throughout the auditorium. Their tilting angle increases with the balcony levels to provide all seats with early reflections.



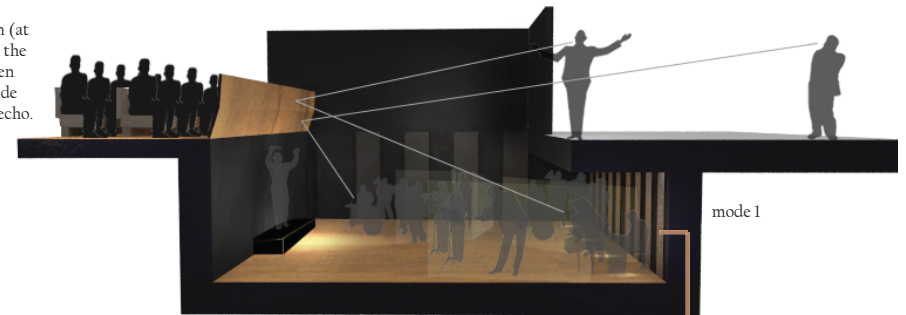
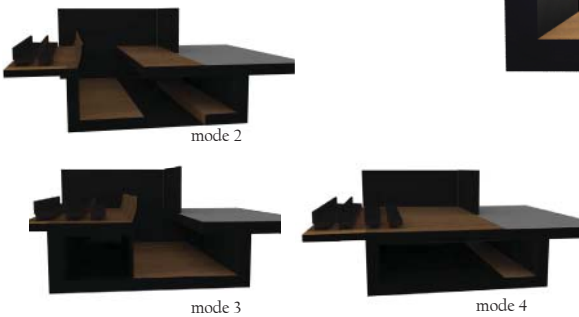
Diffusers

15x15 cm cuboids with a depth of 5 cm are placed on the lower part of the balcony fronts to attain a more even and pleasant distributed sound towards the stall seatings. Integrated in the relief are decorative lighting.

Orchestra pit

The orchestra pit in plan measures 7.5x23 m (at its widest) with 2 m integrated underneath the scene floor. The pit depth is variable between 0 to 3 m with two separate elevators. The side walls of the pit are tilted to prevent flutter echo.

Multiple pit modes

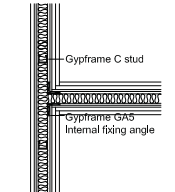


Flexible pit acoustics

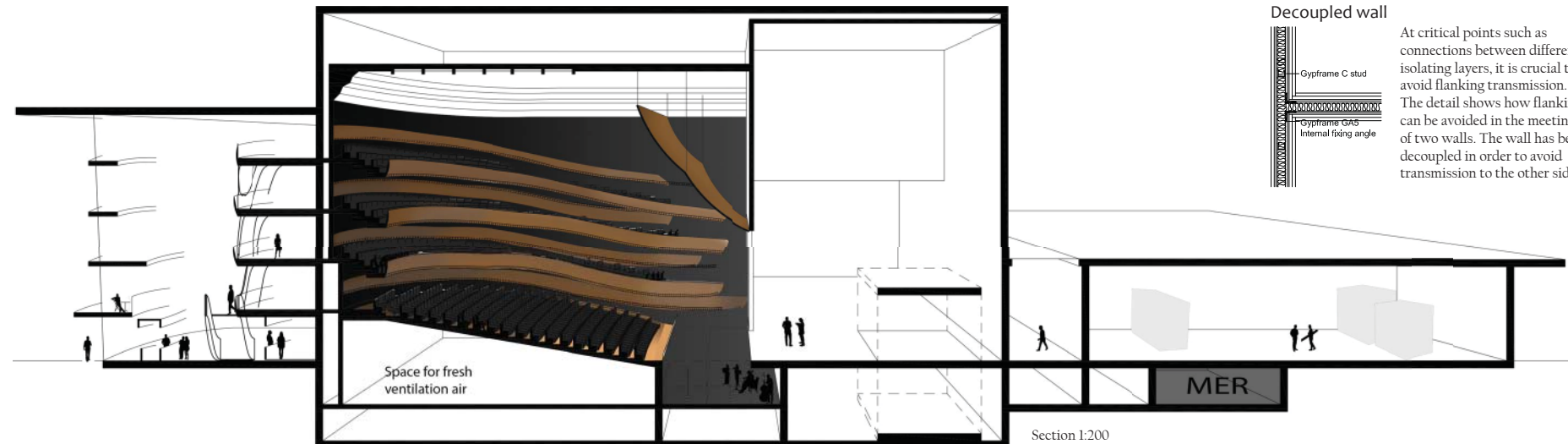
Rotatable prisms are integrated in the pit walls making the pit acoustically flexible through its three different surfaces - diffusive, absorbing and reflective. The prisms are evenly distributed on three of the four pit walls. Each side of the prisms measures 60 x 250 cm.



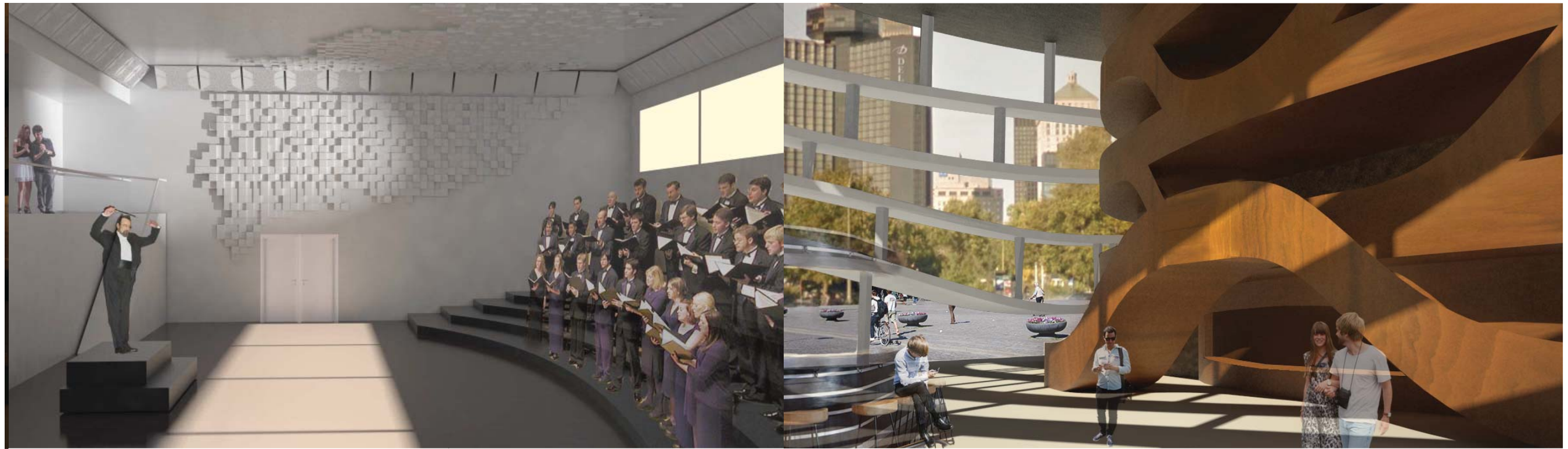
Decoupled wall



At critical points such as connections between different isolating layers, it is crucial to avoid flanking transmission. The detail shows how flanking can be avoided in the meeting of two walls. The wall has been decoupled in order to avoid transmission to the other side.



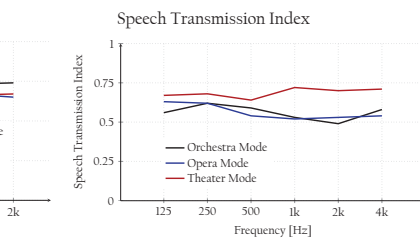
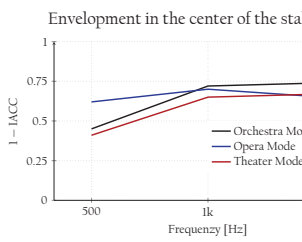
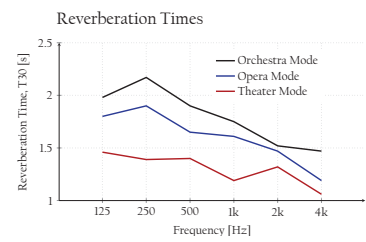
Section 1:200



Flexibility in the Auditorium

Flexible acoustics played the primary role in the design of the auditorium.

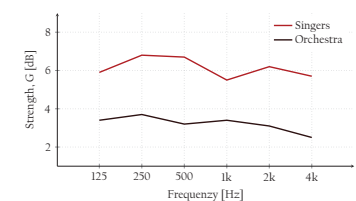
A wide variation of performances ranging from opera and concerts to conferences is possible without the use of sound reinforcement.



Opera mode

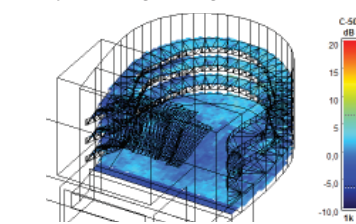
In opera mode the orchestra is lowered into the pit to provide a balanced sound level between musicians and singers.

Balance between singers and orchestra

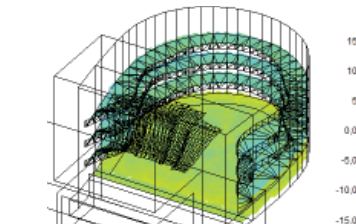


The design of the auditorium and its double curved balconies enables early reflections to all seatings. This results in an overall great clarity and enables the audience to understand the opera singer.

Clarity for one singer on stage without orchestra

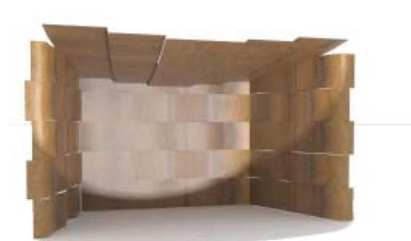


Strength in Opera mode



Orchestra mode

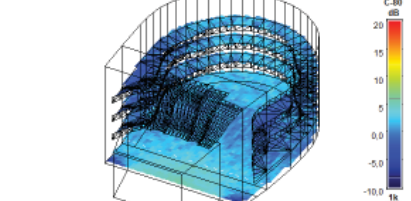
Orchestra shell



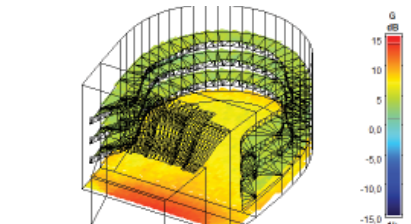
The orchestra shell is made of double curved, form pressed wooden panels. The wavy sides connect to the bands in the auditorium while the roof blends in nicely with the reflector over the proscenium.

When not in use the different sides are easily folded away to the sides and parts of it raised up into the stage tower.

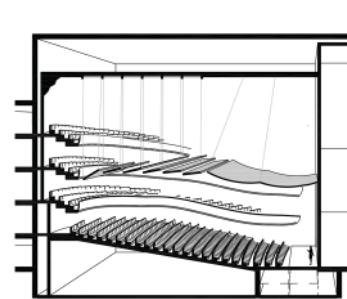
Clarity in Orchestra mode



Strength in Orchestra mode



Speech mode



In speech mode the auditorium roof is lowered in order to receive optimum speech reflections.

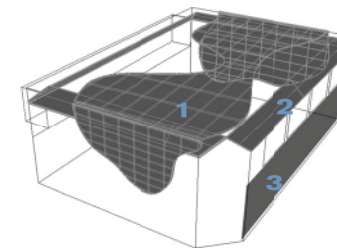
The orchesterpit is altered to mode 4. Half of the orchestra pit is covered with extra seating to move the audience closer to the speaker. The speaker is standing on the other half of the pit, with the stage proscenium closed behind him providing additional sound reflection.

The proscenium reflectors are rotated to a horizontal position and provide reflection patterns spreading the sound to the back of the auditorium.

Rehearsal spaces

Large rehearsal room

The rehearsal room is daylighted with an inner ceiling height of 7 m. It has a balcony from which you can watch the rehearsals. The balcony can be reached both from inside the rehearsal room and outside from the 2nd floor. The rehearsal room is provided diffusers, absorbers and flexible curtains to enhance its



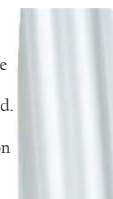
1 wall/roof diffusers

1-10 cm irregularities scatters the sound around the room and prevents flutter echo. The relief pattern covers 50 per cent of the roof area



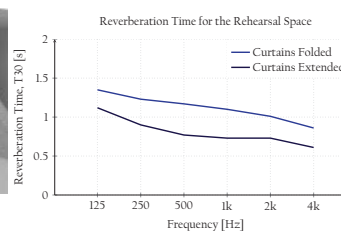
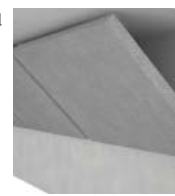
3 curtains

To ensure flexibility of the acoustics in the rehearsal room curtains are installed. Depending on the type of rehearsal the reverberation time can be altered by extending the curtains.

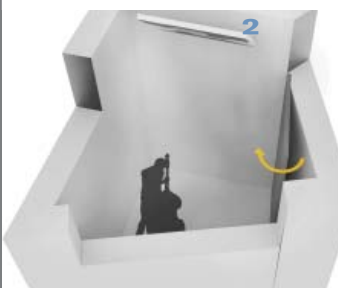


2 diagonal absorbers

The absorbers are mounted diagonally in the ceiling ends, this orientation enhances the acoustic effects and absorbs even the very low frequency sounds. The absorbers are completely covered in white fabric and blend in to its surrounding surfaces.



Practice rooms



The small rehearsal rooms have differently angled walls in order to prevent flutter echo. One of the walls has a separately attached diffusing panel which the musician can adjust to suit her own needs.

The small rehearsal rooms also have diagonal absorbers along the top edge of the walls, as described above.

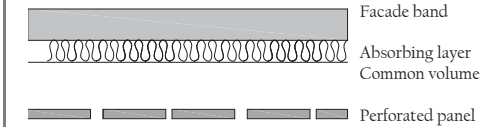
Lobby

The space between the transparent facade and the wooden sound protection layer becomes the lobby with beautiful stairs leading up to the balconies from where the visitors reach the dark and mysterious black box - the concrete shell containing the auditorium.

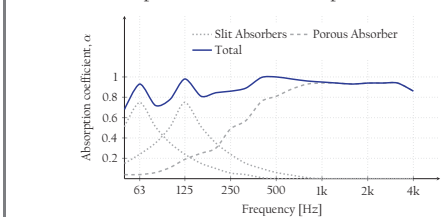
Absorption

The facade bands function as slit absorbers throughout the interior of the lobby. These are tuned to two different octave bands, 63 and 125 Hz, and together with porous absorbers in the ceiling this provides an even absorption through the frequency range of interest.

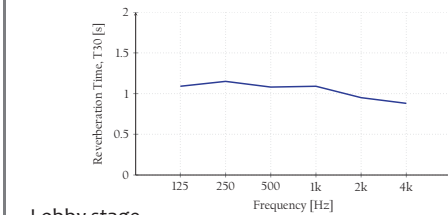
Slit absorbers



Combined absorption of slit absorbers and porous absorbers



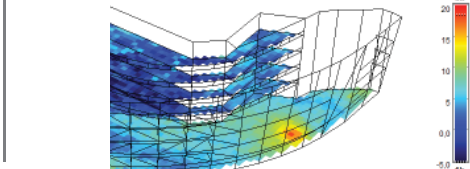
Reverberation time



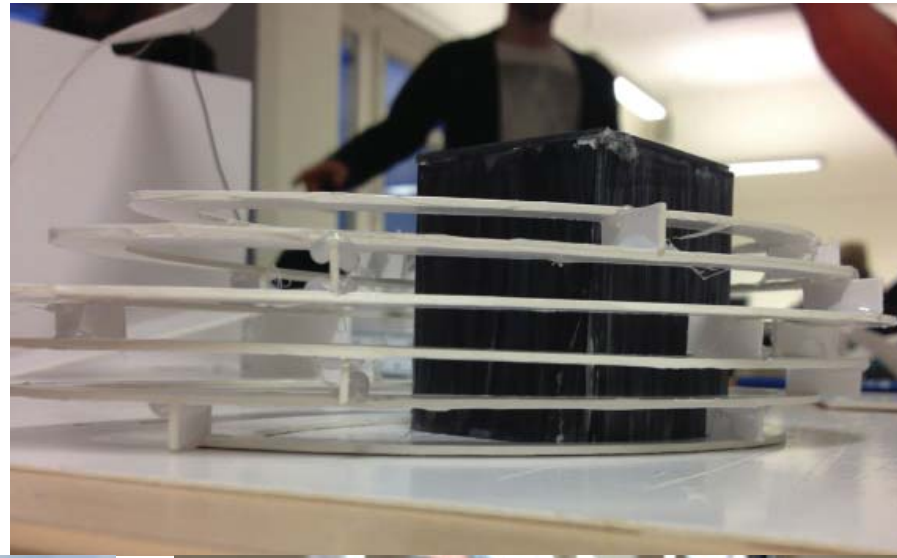
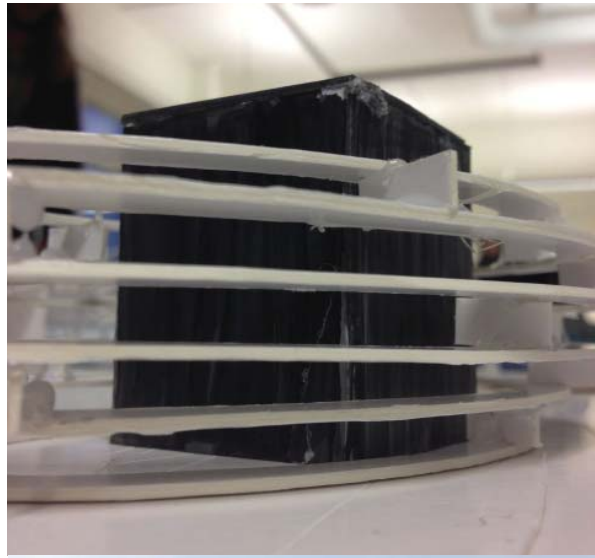
Lobby stage

A part of the lobby is suitable for spontaneous performances, an area created by a bottle neck in the floor plan. The balcony ceilings there are reflective rather than absorbing to ensure listening quality. There is room for placing seats on the ground floor near the stage and the balconies above serve as room for standing audience.

Clarity



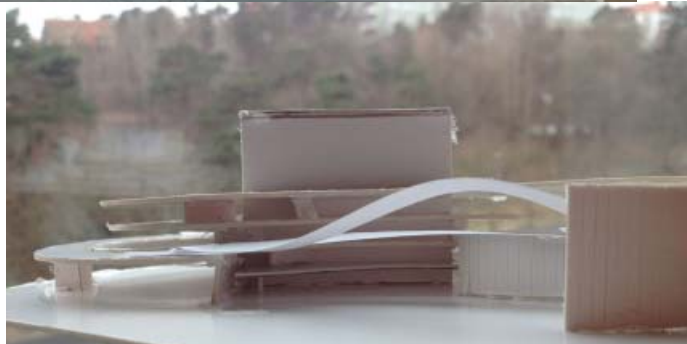
skissprocess



Vi experimenterade tidigt med band i fasad, en "genomsiktig" struktur med en sluten stenjärna som omsluter auditoriet.

Från en början var banden raka men utvecklades sedan till att få ett mer levande oregelbundet uttryck. Vår idé var att man skulle på banden kunna vandra runt och upp på byggnaden.

Som kommande steg arbetade vi mycket med band som skjuts ut och bjuder in mot entré. Vi skrotade efter en del kritik idén med att vandra utmed och upp på byggnaden - något jag önskar idag att vi kanske inte skulle gjort.



Samtidigt som vi jobbade med bandkonceptet i fasad ville vi också få igen konceptet i auditorium och lobby. Vi arbetade med auditoriet i skisser och modell med balkonger som flyter likt band och hur man samtidigt kan få till bra sikt- och platsmöjligheter till de som ska sitta där.

När vi spikat interiöruttryck i auditoriet lät vi samma material och lekfullhet i vågor gå igen i lobbyn där vi experimenterade mycket med trapplacering och form i rhino.

reflektioner .

Ett väldigt spännande projekt där man fick lära sig otroligt mycket, det var speciellt en stor utmaning att möta de höga kraven både på arkitekturen och akustiken och att få dessa att fungera som helhet i slutändan.

Jag är speciellt nöjd med hur fasad och entré bjuder in och välkomnar besökaren, samt hur vågorna - konceptet som var med oss genom hela projektet, går igen både i fasad, lobbybalkonger samt balkonger och detaljer i operasalen. Jag önskar dock att konceptet skulle kommit fram tydligare i presentationen. Det jag hade önskat att arbeta mer med i utformningen är mark och yta runt omkring operan, då detta är otroligt viktigt då stora grupper människor kommer att vistas där samtidigt och det är också en plats som ska fungera och locka besökare även dagtid.

Något jag hade önskat att vi jobbat mer med är övningsrummet vilket vi kunde ha tagit något steg längre, jag är lite besviken att vi lät oss begränsas av de akustiska kraven som fanns istället för att experimentera mer med form och uttryck.