

# aniara

## opera i Montreal

|                        |   |
|------------------------|---|
| I VAD                  | Kandidatarbete  |
| OMFATTNING             | 15 hp   |
| NÄR                    | Våren 2013  |
| EXAMINATOR             | Morten Lund   |
| ANKNUTEN INGENJÖRSKURS | Klimatsystem  |
| HJÄLPMEDEL             | AutoCAD 2013<br>Rhinoceros, V-ray<br>Adobe CS, PS, ID, AI |

### KURSENS PROGRAM

Projektet är ett bidrag till en tävling som årligen utlyses av American Acoustical Association. Uppgiften det här året var att rita ett operahus i downtown i Montreal och enligt programmet skulle mycket av fokus skulle ligga på akustiken i byggnaden.

### IDÉ OCH KONCEPT

Genom att på något sätt knyta an till befintliga rörelsstråk och placera byggnaden på en naturlig genväg över torget ville vi skapa en opera som bjuder in, är öppen för alla med ett tydligt offentligt yttre rum som kärnan i hela komplexet.

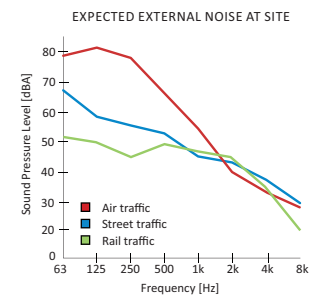
# ANIARA

A striking university opera house in southern Montreal links the nearby lively downtown area to existing structures in the surrounding cityscape. In addition to the utilization of natural outdoor walking paths and public spaces, the building's classic form and translucent façade create connections among many groups of people. Feelings of both inspiration and affable mystique are derived from this welcoming building for performers, pupils, patrons and passersby alike.

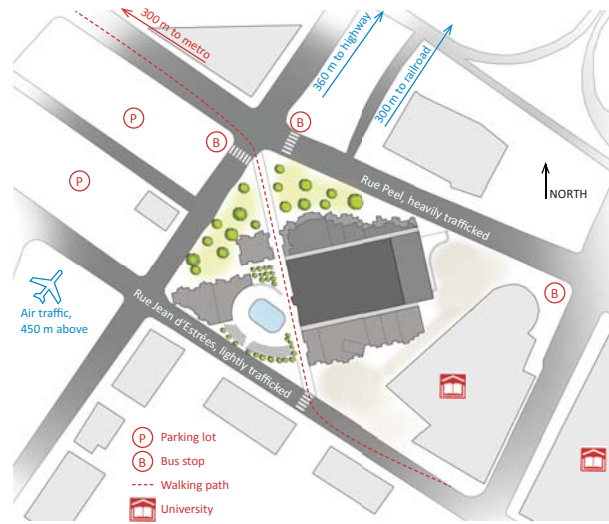
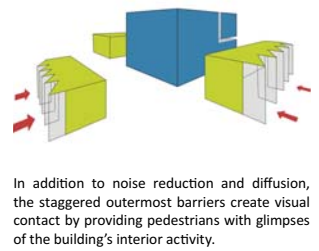
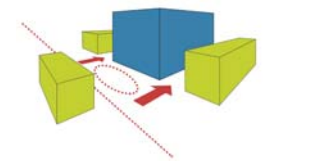
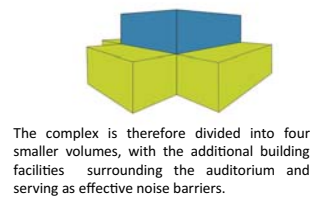
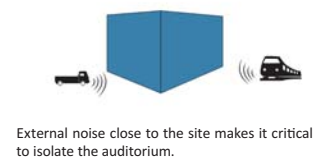


## THE SITE

The building site for the opera complex is located next to a technical college in the southern end of downtown Montreal. Heavily trafficked roads surround this block and a large tunnel lies to the north of the lot. In addition to road traffic, the most critical external noise source is the commercial air traffic that passes approximately 500m above the opera house.

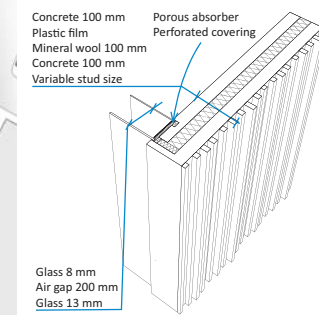


## CONCEPT



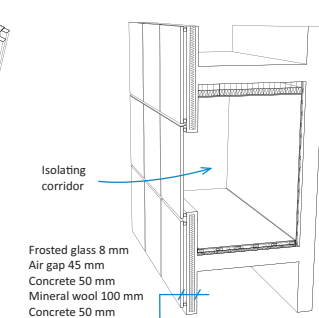
## STAGGERED SCREENS

The complex's outermost noise barrier is composed of polished concrete screens covered by wooden laths of varying depths. These screens have offset heights and are illuminated from below to create a vivid impression of the building as visitors approach the opera. The staggered placement of the screens allows passersby to catch glimpses of the activities taking place inside.



## BUILDING FACADE

The building façade is multifunctional. Acoustically it provides additional noise reduction with an outer resistive layer and an air gap between the façade and interior building wall. The flat, uniform surface allows for projection of light onto the building, which aids in welcoming visitors into the space. Behind the screens is a corridor that links the opera's entrance lobby to a serene foyer.



## PUBLIC PLAZA

The complex is intersected by a promenade with an accompanying public plaza that provides pedestrians with the possibility of entering the opera building or cross to the adjacent city block. This arrangement allows the complex to serve as an open meeting place for the city, in addition to its primary role as a center for the performing arts.

## ENTRANCE LOBBY

The entrance lobby serves as a subtle transition between the outdoor plaza and the indoor performance space. The lobby's glazed façade faces the outdoor plaza and reveals its welcoming interior for passersby, as well as a restaurant across the courtyard. The spiral staircase surrounds a central elevator shaft and is separated from the auditorium wall in order to reduce vibration and structure-borne noise. An intermediate atrium emphasizes the lobby's impressive ceiling height and connects the various levels of the building to one another.

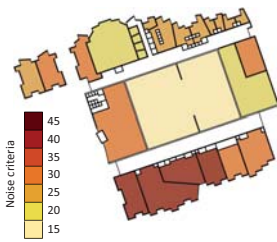


# BUILDING FACILITIES

One major concern is to ensure that the performance areas are sufficiently isolated from external noise. To accomplish this, specific solutions for airborne noise, structure-borne noise, and ventilation were developed with the goal of optimizing the noise reduction around the auditorium and rehearsal spaces.

The building envelope consists of detailed constructions to ensure that the various noise criteria of the facilities are met. Sound transmission classes for walls have been chosen and designed to match these firm criteria.

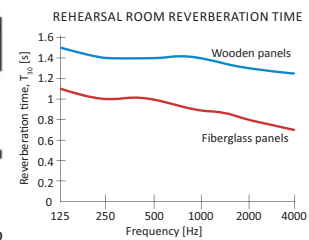
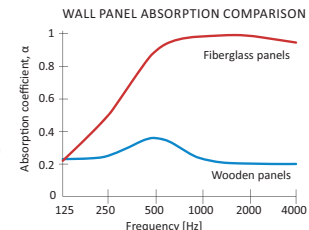
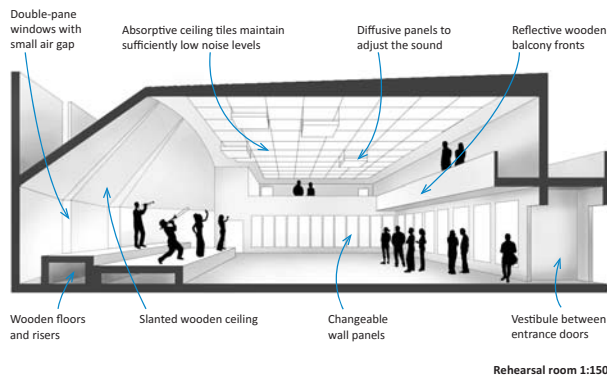
| STRUCTURE                | STC |
|--------------------------|-----|
| Auditorium roof          | 80  |
| Corridor wall            | 75  |
| Rehearsal wall           | 70  |
| Outer barriers           | 70  |
| Second floor slab        | 60  |
| Structural interior wall | 55  |
| Thin interior wall       | 50  |
| Exterior wall glazing    | 50  |
| Screen wall              | 45  |



## REHEARSAL ROOM

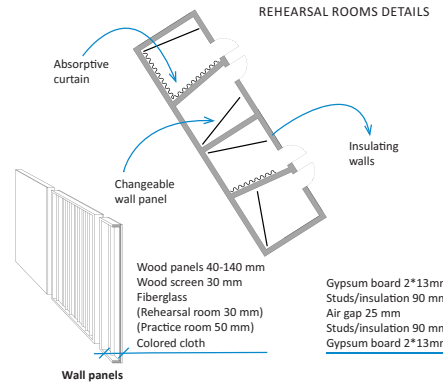
The rehearsal room is to be used for both orchestral and vocal practice, as well as a secondary performance space for smaller concerts. The room has changeable absorptive/diffusive acoustic panels on the

lower side walls in order to permit both long and short reverberation time settings, 1.4 s and 0.9 s respectively. The second floor has a shallow balcony allowing for additional seating and versatility when necessary.



## INDIVIDUAL REHEARSAL ROOMS

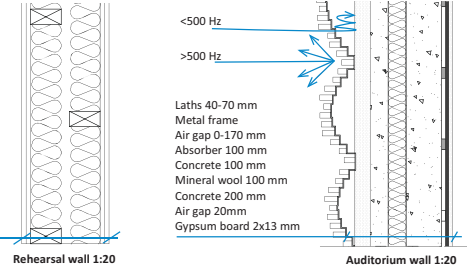
The soloists' practice rooms are connected to the main rehearsal room by a common wall, but are reached from an adjacent corridor to eliminate noise leakage between the rooms through the doors. These small rooms have adjustable diffusive walls to avoid flutter echo and change the effective room size. Absorptive curtains are used to keep the noise levels safe for the musicians' hearing.



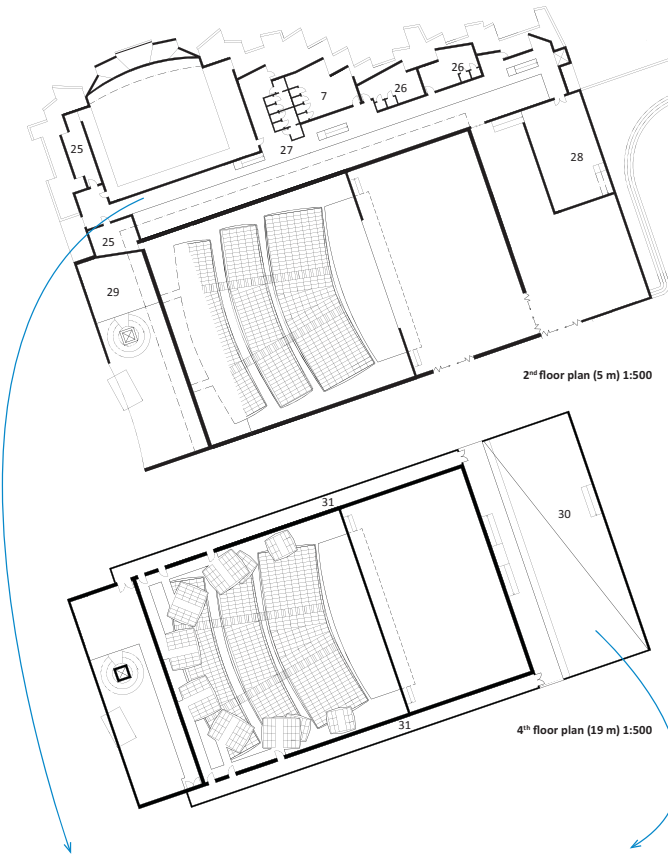
## CORRIDOR

The corridors surrounding the auditorium permit a direct line of sight through the entire building, giving visitors in the outdoor plazas visual contact with life inside of the opera. The surrounding rooms are oriented in a way that small alcoves are naturally formed in the corridors, creating natural places to study, relax, or engage in conversation.

The corridor wall has the same expression as the façade; the laths work as a resonant absorber at low frequencies and as a cylindrical diffuser for vocal frequencies. Openings in the roof bring daylight into the corridor, which then create reliefs on the lath walls.

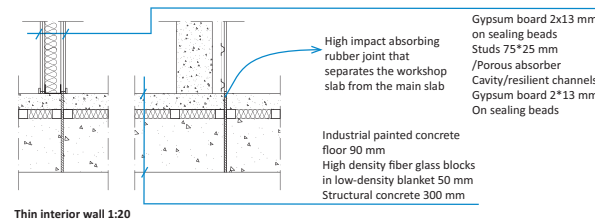


- Interior**
  - 1 House manager's office
  - 2 Box office
  - 3 Costume, shop
  - 4 Rehearsal room
  - 5 Soloist rehearsal room
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  - 7 Dressing room, chorus
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  - 27 2nd floor walkway
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- Exterior**
  - A Public restaurant
  - B Dining room
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  - D Fountain
  - E Terrace
  - F Afternoon ledge
  - G Screen walk
  - H Promenade
  - I Park
  - J Forenoon ledge
  - K Student plaza
  - L Driveway/Parking



## SCENE ASSEMBLY

The scene shop is connected to the loading dock and MER, which includes the primary HVAC system components. All of the appropriate scene shop facilities are consolidated along an assembly line. These rooms are insulated not only for airborne noise, but also from vibration and high impact noise. This is accomplished with absorptive ceiling and wall panels, double-layer walls, and separated slabs with floating floors.

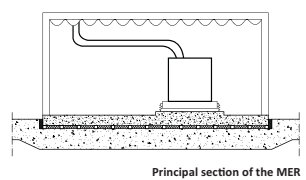


## LOADING DOCK

The loading dock has the possibility to unload large trucks from the rear and smaller trucks from the side. Trucks up to 12 m in length can be parked inside the loading dock when necessary.

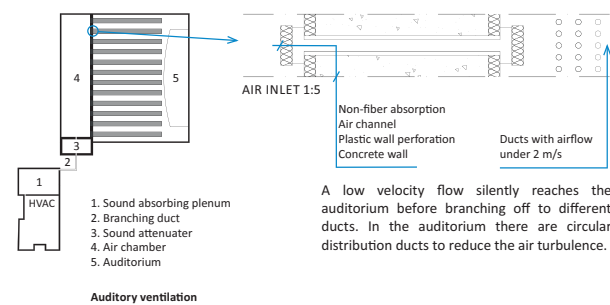
## MER

Air handlers and other HVAC equipment are supported by heavy vibration damping springs on top of a concrete platform. This platform then stands on top of another floating concrete floor on the structural floor.



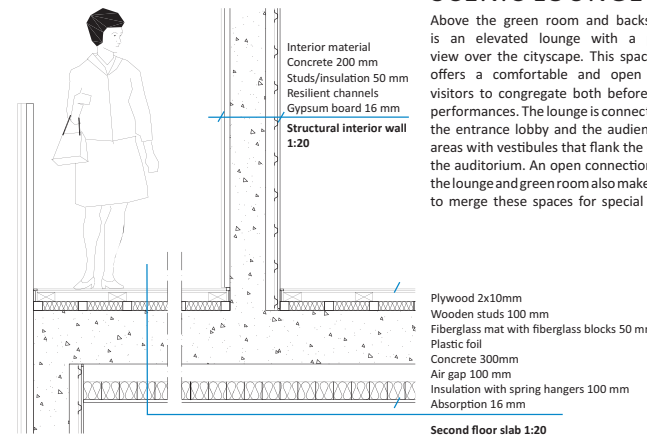
## VENTILATION

A maximum of 17 dBA is allowed from the building's HVAC system, so the design of this subsystem is critical. The ducts have a thick non-fiber lining to attenuate any breakout noise caused by the fan, and the inlet and outlet are separated by one floor level. From the outlet the air then travels through a silencing chamber before reaching ducts with small vents that feed fresh air to the audience and performers in the auditorium.



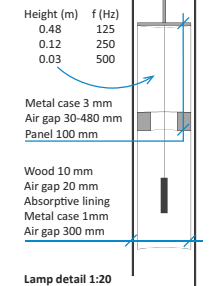
## SCENIC LOUNGE

Above the green room and backstage area is an elevated lounge with a panoramic view over the cityscape. This spacious room offers a comfortable and open place for visitors to congregate both before and after performances. The lounge is connected to both the entrance lobby and the audience seating areas with vestibules that flank the exterior of the auditorium. An open connection between the lounge and green room also make it possible to merge these spaces for special occasions.



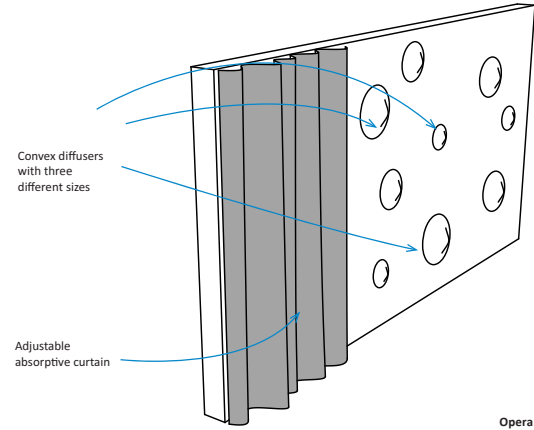
## MULTIFUNCTIONAL LAMP

The lamps in the lobbies and corridor diffuse vocal frequencies, while a slit resonator formed by the lampshade attenuates high frequencies. Low frequencies are absorbed by an interior Helmholtz resonator.



# AUDITORIUM

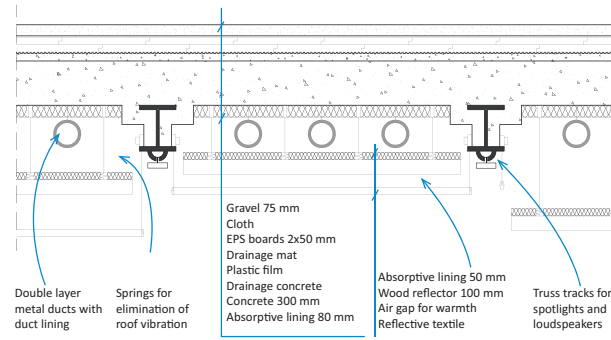
Three different sized convexly shaped 'bump' diffusers on the auditorium's side walls provide scattering for the opera and orchestral modes of operation. For the speech mode, a heavy velour curtain is draped over the side and back walls in order to increase their equivalent absorption area.



Opera wall

# AUDITORIUM ROOF

The roof consists of a thick concrete slab on top of supporting steel beams. Heavy adjustable absorbing/reflecting tiles in the ceiling can be lowered to change the room volume depending on the required function of the auditorium. There is also a reflective textile that can be utilized to separate lower and higher frequency to create additional warmth when desired.



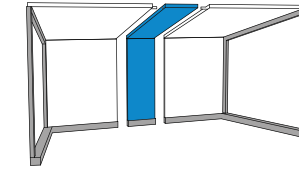
Section auditorium roof 1:20

# PROSCENIUM

The proscenium is made of highly reflective white oak, underneath which there is a stage apron. Above the first reflector is a second variable reflector that continues along the length of the entire orchestra pit. Between the two reflectors is a truss system that can be used for mounting lights and loudspeakers needed for playback of sound effects and any recorded cues.

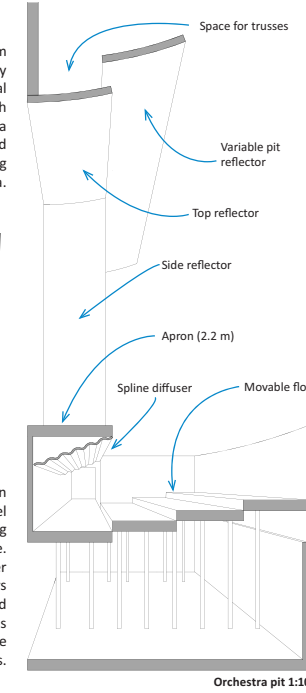
## ORCHESTRA SHELL

The orchestra shell is constructed from Canadian white oak veneer mounted on heavy chipboard. The shell is used for orchestral concerts and provides the audience with additional reflected sound while an orchestra performs onstage. It is possible to easily expand the shell into different configurations depending on the size of the performing orchestra.



## ORCHESTRA PIT

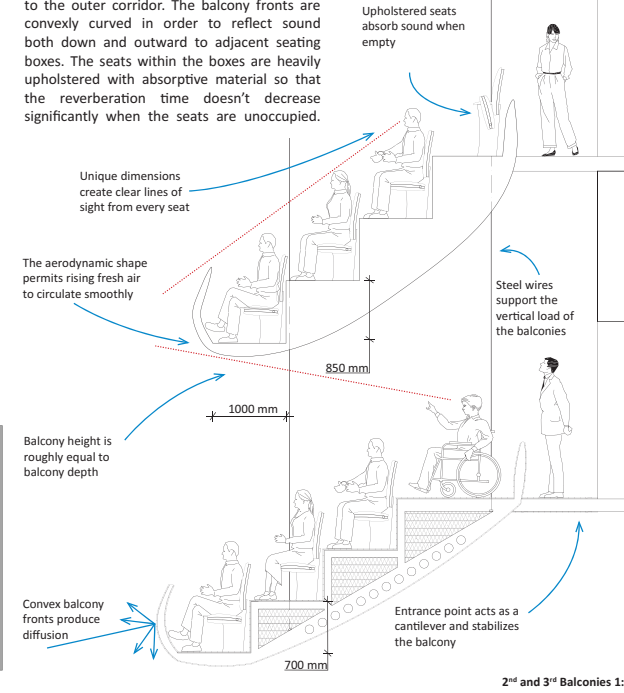
The orchestra pit has four adjustable wooden floor panels that can be lifted to stage level for concerts and speeches, thus extending the stage and performers closer to the audience. Under the stage a wooden spline diffuser forms the pit ceiling and effectively scatters high frequencies within the pit. The front and rear pit walls have 3 cm thick fiberglass panels wrapped in black fabric to reduce the noise level in the pit for the safety of the musicians.



Orchestra pit 1:100

# BOXES IN SPACE

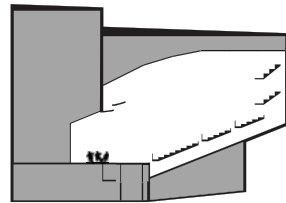
The balcony boxes are made from Canadian white oak wood mounted on a steel frame. Steel wires carry the vertical load, and the boxes are further stabilized by connections to the outer corridor. The balcony fronts are convexly curved in order to reflect sound both down and outward to adjacent seating boxes. The seats within the boxes are heavily upholstered with absorptive material so that the reverberation time doesn't decrease significantly when the seats are unoccupied.



2<sup>nd</sup> and 3<sup>rd</sup> Balconies 1:50

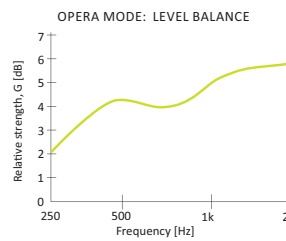
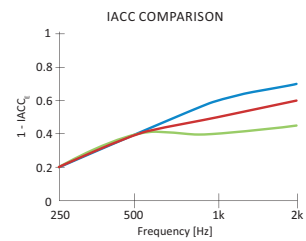
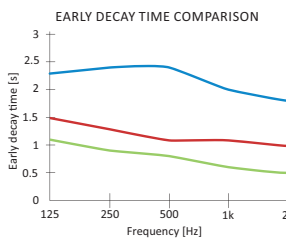
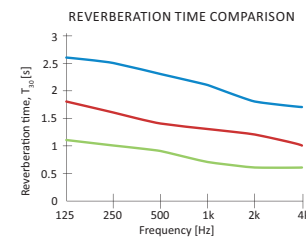
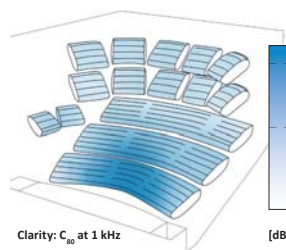
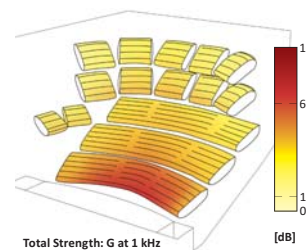
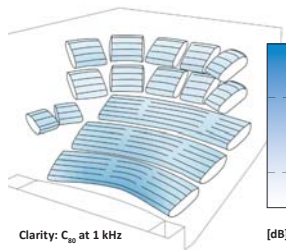
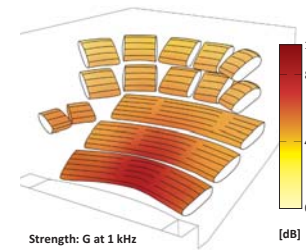
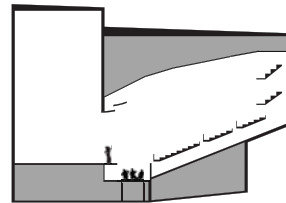
## ORCHESTRA

The orchestra mode of performance has been designed to have the largest effective volume. This is done by maintaining the highest ceiling setting, raising the orchestra pit, and using the orchestra shell to direct reflected sound towards the audience areas. This configuration produces appropriately high strength, clarity, and a reverberation time of 2.1 seconds.



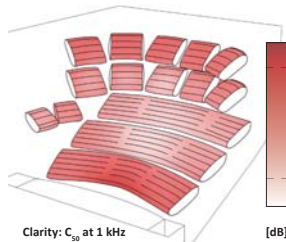
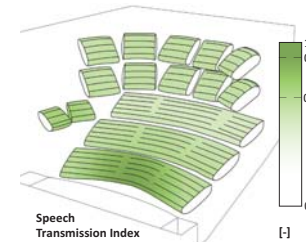
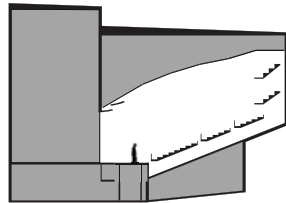
## OPERA

The opera mode has been designed to have an intermediate reverberation time of approximately 1.3 seconds. This is achieved by lowering the ceiling panels closest to the stage to decrease the effective volume of the hall. The lowered orchestra pit with absorptive walls allows the chorus to maintain a proper strength balance with the accompanying music.



## SPEECH

The speech mode has been designed to have the smallest effective volume and the largest equivalent absorption. This is accomplished by lowering the ceiling, using the highly absorptive ceiling panels, raising the orchestra pit, and closing the proscenium and side walls off with a heavy curtain. This configuration produces a sufficiently short reverberation time of 0.7 seconds, high clarity, and 'good' to 'excellent' speech transmission indices.



## DATA SUMMARY

Several important subjective acoustic qualities were related to corresponding objective measures for each of the three configurations in order to judge acoustic performance. Commonly accepted ranges for appropriate performance were set as goals for each of the metrics, then CATT-Acoustic software was used as a prediction tool to calculate modelled values for each room configuration. For the values shown in the table below, the strength, clarity, early decay time, and the early interaural cross correlation (IACC<sub>0</sub>) are all reported for 1 kHz.

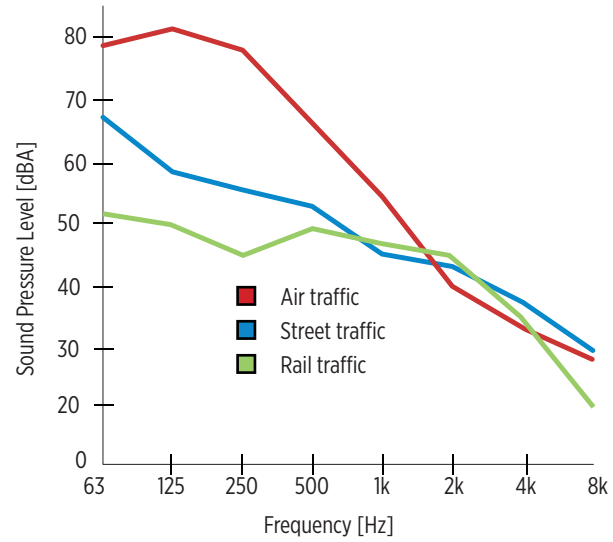
| Subjective Acoustic Quality | Objective Measure      | Target Values            | Modelled Values |             |
|-----------------------------|------------------------|--------------------------|-----------------|-------------|
| ORCHESTRA                   | Intimacy, Loudness     | Strength, G              | 4 to 8 dB       | 4.5 to 8 dB |
|                             | Definition             | Clarity, C <sub>80</sub> | -5 to 2 dB      | -3 to 2 dB  |
|                             | Perceived Reverberance | Early Decay Time         | 1.8 to 2.2 s    | 2.2 s       |
|                             | Apparent Source Width  | 1 - IACC <sub>0</sub>    | 0.6 to 0.8      | 0.6         |
|                             | Warmth                 | Bass Ratio               | 1.1 to 1.3      | 1.2         |
| OPERA                       | Intimacy, Loudness     | Strength, G              | 4 to 8 dB       | 1 to 6 dB   |
|                             | Definition             | Clarity, C <sub>80</sub> | -2 to 4 dB      | 0 to 4 dB   |
|                             | Perceived Reverberance | Early Decay Time         | 1.2 to 1.7 s    | 1.2 s       |
|                             | Apparent Source Width  | 1 - IACC <sub>0</sub>    | 0.5 to 0.7      | 0.5         |
|                             | Warmth                 | Bass Ratio               | 1.1 to 1.4      | 1.3         |
| SPEECH                      | Speech Clarity         | Clarity, C <sub>80</sub> | 0+ dB           | 2 to 8 dB   |
|                             | Speech Comprehension   | Speech Trans. Index      | 0.6 to 1.0      | 0.7 to 0.9  |
|                             | Perceived Reverberance | Early Decay Time         | 0.7 to 1.0 s    | 0.8 s       |



"WE SUSPECT NOW THAT WHAT WE CALL SPACE AND CLARITY AROUND ANIARA IS SPIRIT, ETERNAL SPIRIT ELUSIVE... WE LOST OURSELVES IN THE SPIRIT SEAS"

# THE SITE

The building site for the opera complex is located next to a technical college in the southern end of downtown Montreal. Heavily trafficked roads surround this block and a large tunnel lies to the north of the lot. In addition to road traffic, the most critical external noise source is the commercial air traffic that passes approximately 500m above the opera house.

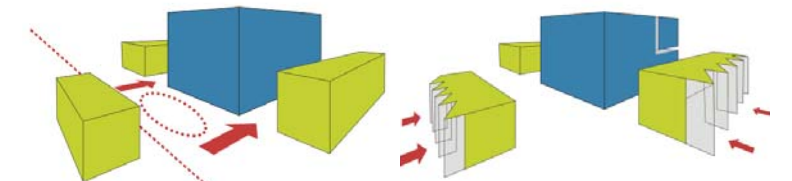


# CONCEPT



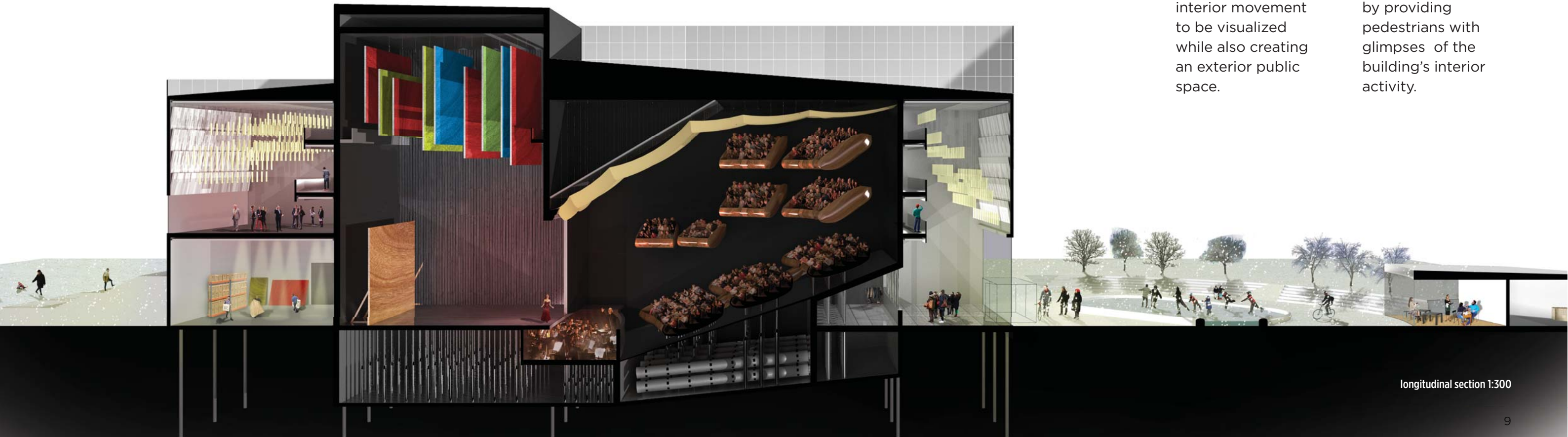
External noise close to the site makes it critical to isolate the auditorium.

The complex is divided into four smaller volumes, with the additional building facilities surrounding the auditorium and serving as effective noise barriers.



This configuration integrates natural movement throughout the entire lot and into the opera, allowing interior movement to be visualized while also creating an exterior public space.

In addition to noise reduction and diffusion, the staggered outermost barriers create visual contact by providing pedestrians with glimpses of the building's interior activity.





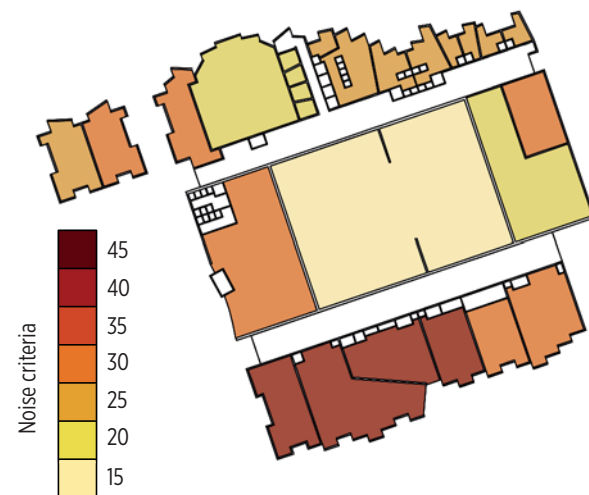
entrance floor and surroundings 1:500

- | Interior |                          |
|----------|--------------------------|
| 1        | House manager's office   |
| 2        | Box office               |
| 3        | Costume, shop            |
| 4        | Rehearsal room           |
| 5        | Soloist rehearsal room   |
| 6        | Dressing room, orchestra |
| 7        | Dressing room, chorus    |
| 8        | Dressing room, soloist   |
| 9        | Public corridor          |
| 10       | Entrance foyer           |
| 11       | Cloak room               |
| 12       | Auditorium               |
| 13       | Orchestra pit            |
| 14       | Stage                    |
| 15       | Backstage                |
| 16       | Main storage             |
| 17       | Staff corridor           |
| 18       | Mechanical equip. room   |
| 19       | Loading dock             |
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| 22       | Paint shop               |
| 23       | Scene assembly           |
| 24       | Break room               |
| 25       | Technicians' booth       |
| 26       | Dressing room, 4-person  |
| 27       | 2nd floor walkway        |
| 28       | Green room               |
| 29       | Landing                  |
| 30       | Scenic lounge            |
| 31       | Seating vestibule        |
- 
- | Exterior |                   |
|----------|-------------------|
| A        | Public restaurant |
| B        | Dining room       |
| C        | Restaurant patio  |
| D        | Fountain          |
| E        | Terrace           |
| F        | Afternoon ledge   |
| G        | Screen walk       |
| H        | Promenade         |
| I        | Park              |
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| K        | Student plaza     |
| L        | Driveway/Parking  |

# noise reduction

One major concern is to ensure that the performance areas are sufficiently isolated from external noise. To accomplish this, specific solutions for airborne noise, structure-borne noise, and ventilation were developed with the goal of optimizing the noise reduction around the auditorium and rehearsal spaces.

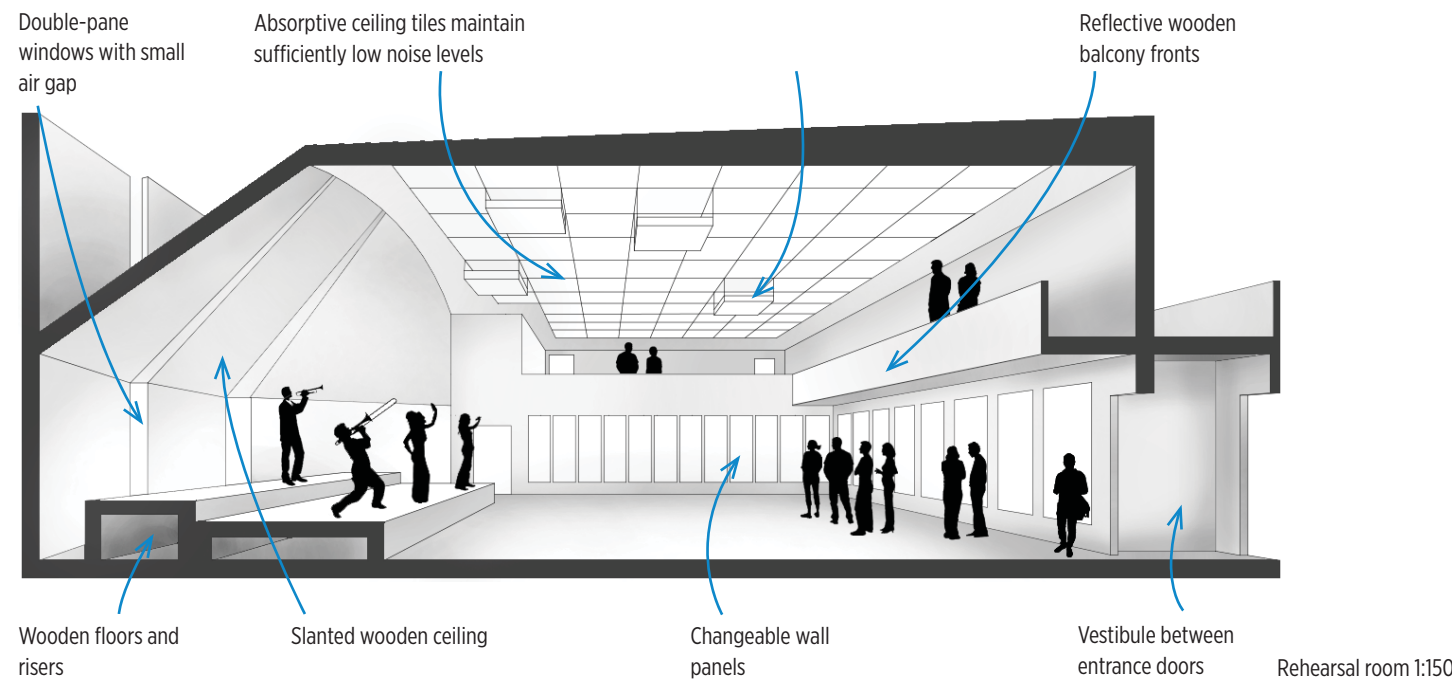
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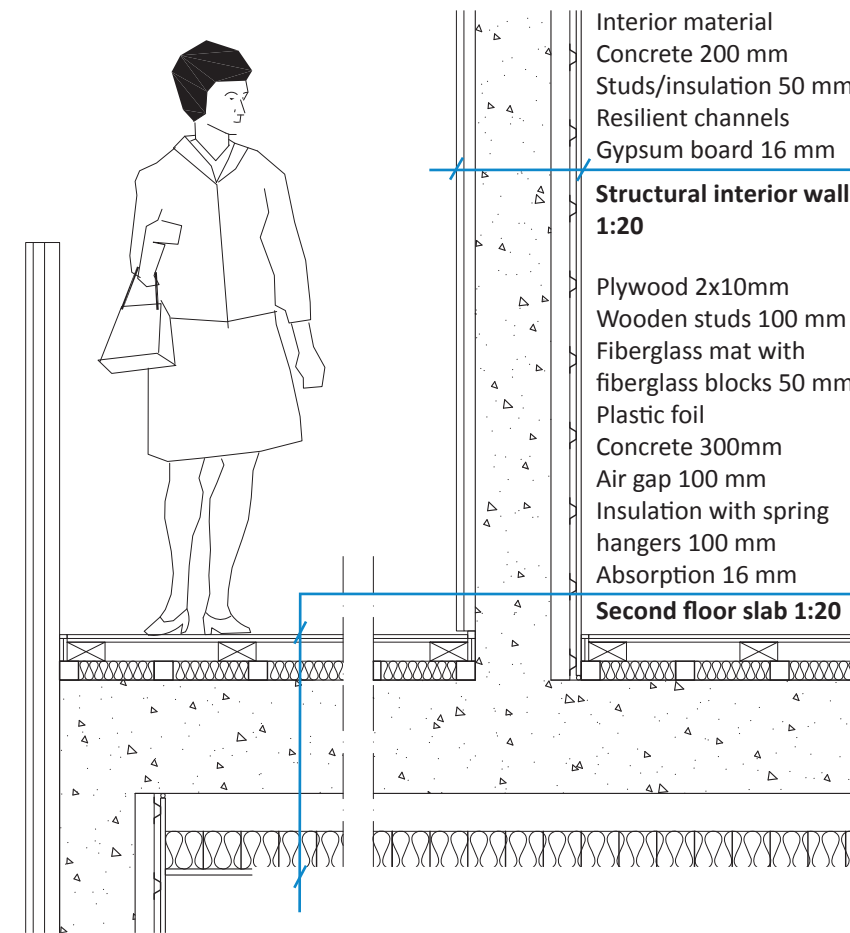
# rehearsal room

The rehearsal room is to be used for both orchestral and vocal practice, as well as a secondary performance space for smaller concerts. The room has changeable absorptive/diffusive acoustic panels on the

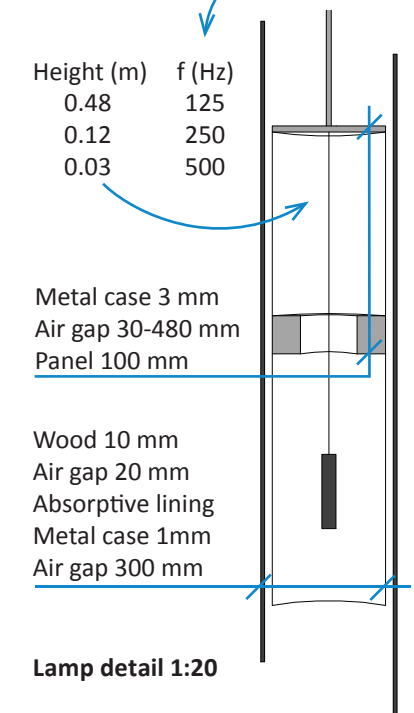
lower side walls in order to permit both long and short reverberation time settings, 1.4 s and 0.9 s respectively. The second floor has a shallow balcony allowing for additional seating and versatility when necessary.



# details



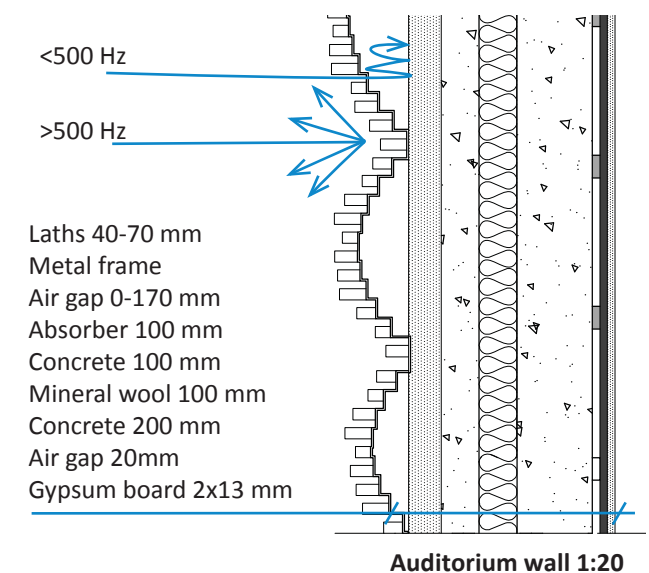
The lamps in the lobbies and corridor diffuse vocal frequencies, while a slit resonator formed by the lampshade attenuates high frequencies. Low frequencies are absorbed by an interior Helmholtz resonator.



# corridor

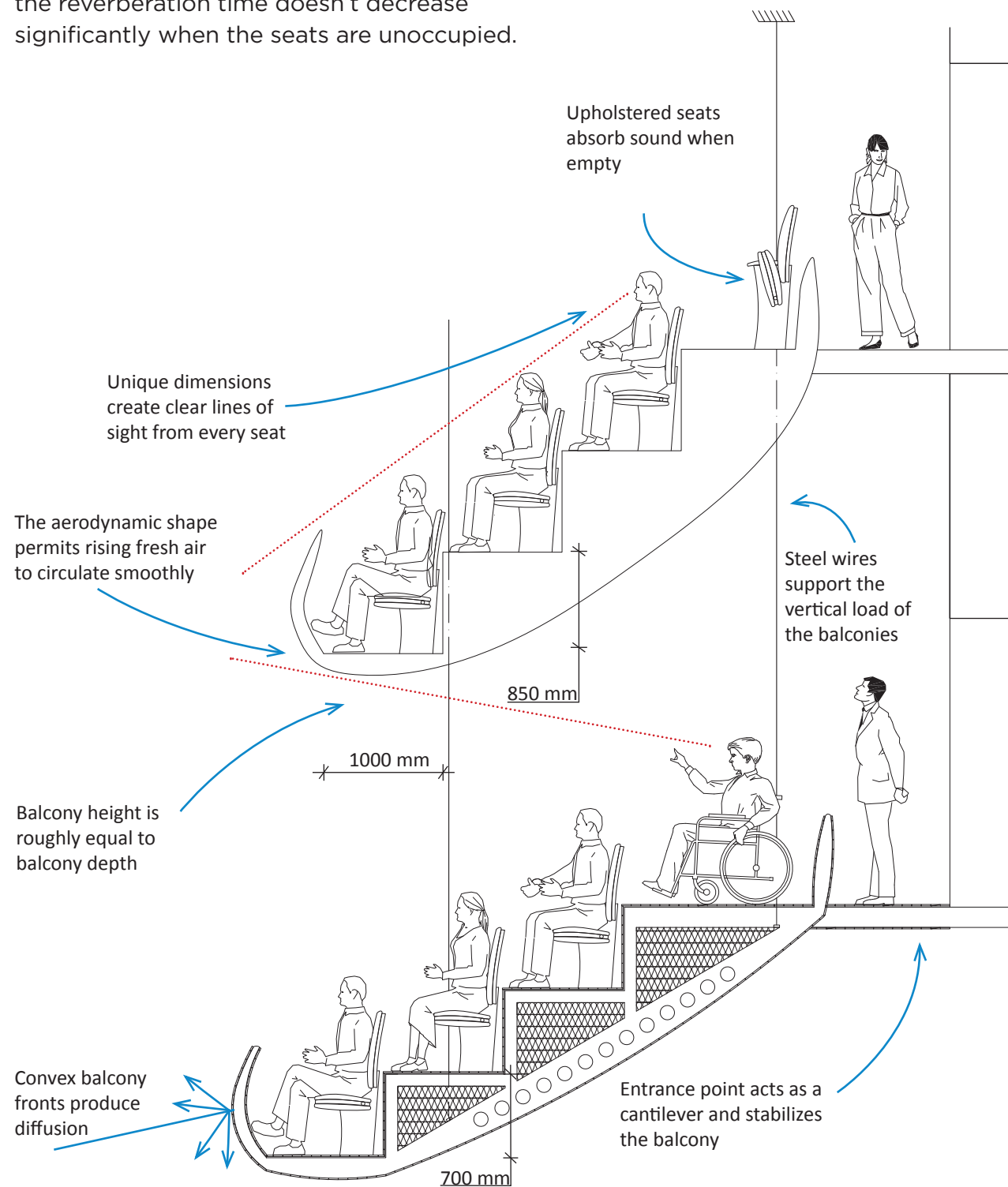
The corridors surrounding the auditorium permit a direct line of sight through the entire building, giving visitors in the outdoor plazas visual contact with life inside of the opera. The surrounding rooms are oriented in a way that small alcoves are naturally formed in the corridors, creating natural places to study, relax, or engage in conversation.

The corridor wall has the same expression as the façade; the laths work as a resonant absorber at low frequencies and as a cylindrical diffuser for vocal frequencies. Openings in the roof bring daylight into the corridor, which then create reliefs on the lath walls.



# boxes in space

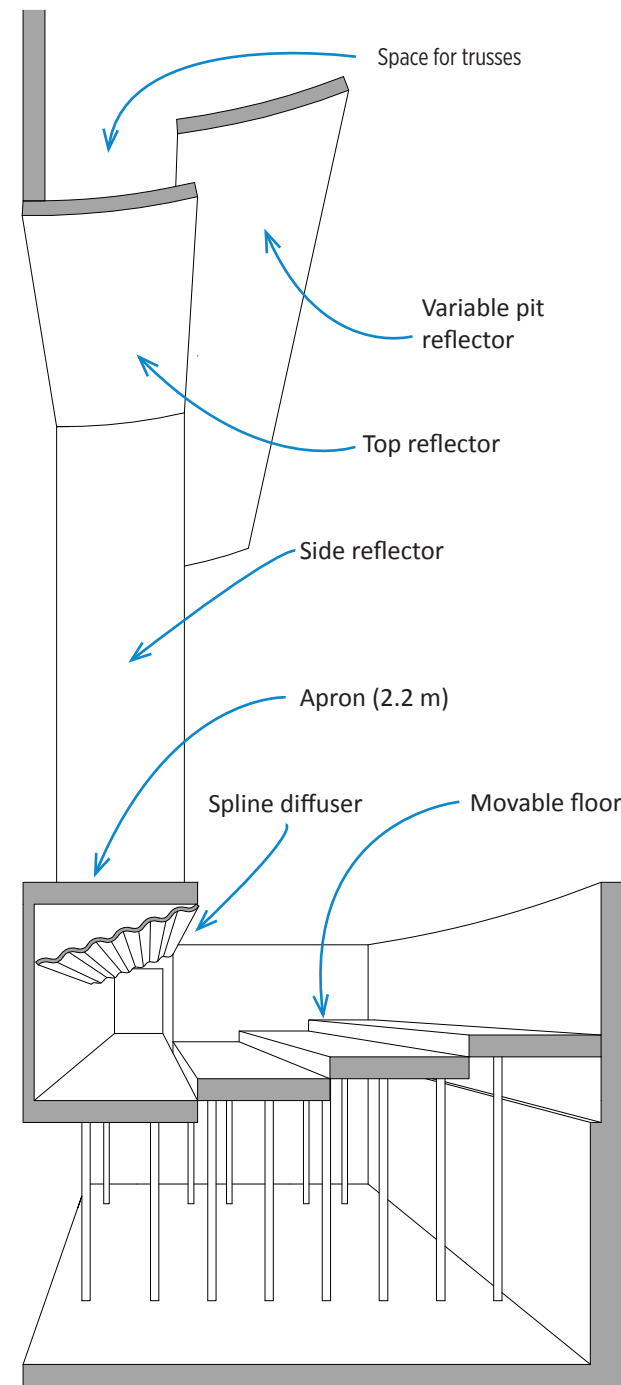
The balcony boxes are made from Canadian white oak wood mounted on a steel frame. Steel wires carry the vertical load, and the boxes are further stabilized by connections to the outer corridor. The balcony fronts are convexly curved in order to reflect sound both down and outward to adjacent seating boxes. The seats within the boxes are heavily upholstered with absorptive material so that the reverberation time doesn't decrease significantly when the seats are unoccupied.



2<sup>nd</sup> and 3<sup>rd</sup> Balconies 1:50

# orchestra pit

The orchestra pit has four adjustable wooden floor panels that can be lifted to stage level for concerts and speeches, thus extending the stage and performers closer the audience. Under the stage a wooden spline diffuser forms the pit ceiling and effectively scatters high frequencies within the pit. The front and rear pit walls have 3 cm thick fiberglass panels wrapped in black fabric to reduce the noise level in the pit for the safety of the musicians.



Orchestra pit 1:100



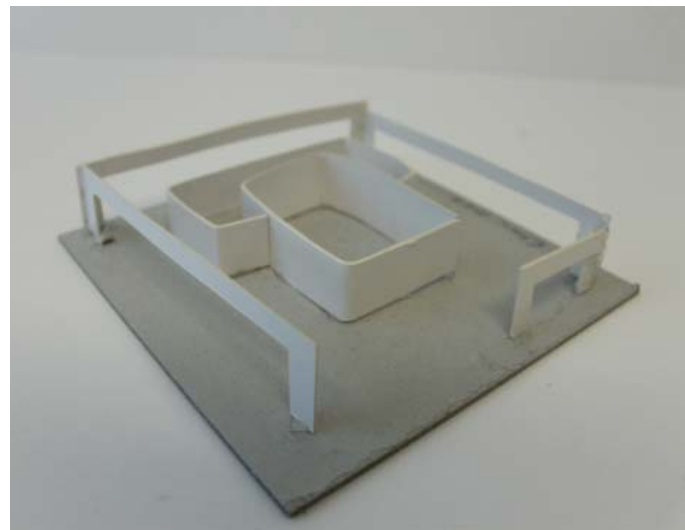
# process

## konceptmodeller

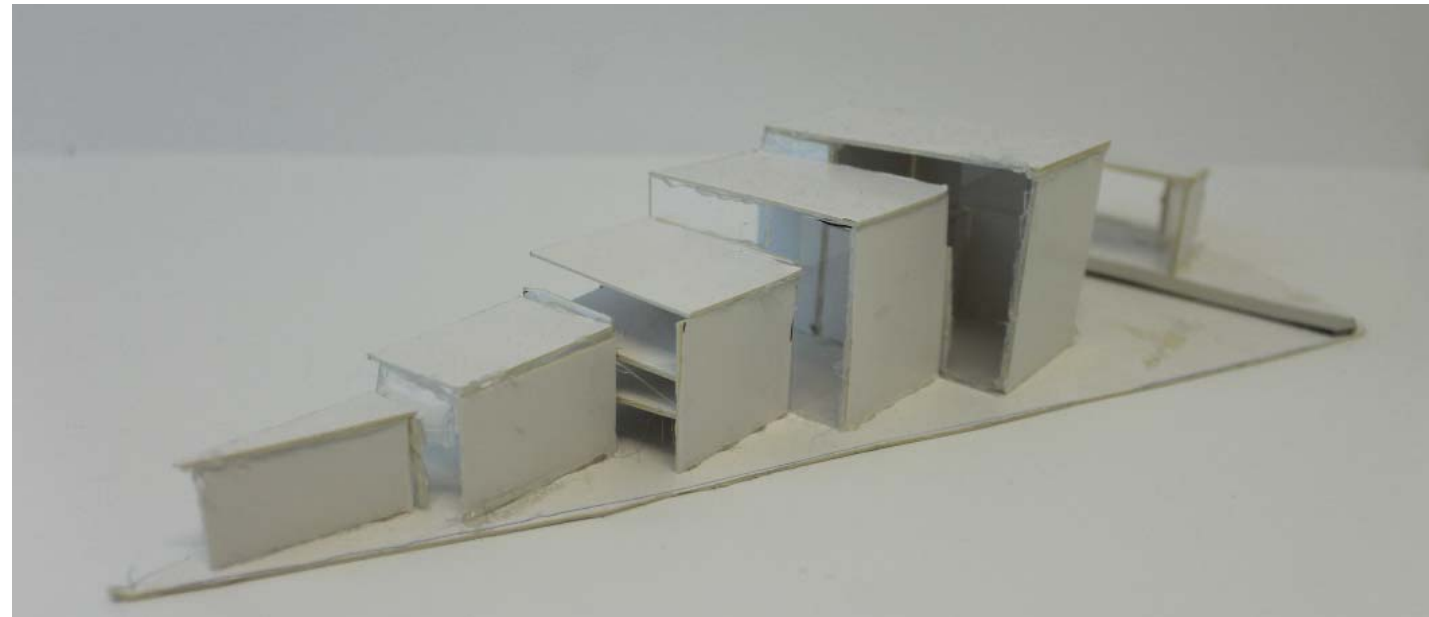
Vi började att i grupp arbeta med konceptmodeller. Arbetet som sådant var även ett kursmoment.

I arbetet såg vi på byggnaden först från utsidan och sedan inifrån. Jag tyckte det var viktigt att man som besökare skulle ha möjlighet få visuell kontakt med de som arbetar på operan, eftersom verksamheten framför allt kommer att drivas av studenter såg jag en poäng med att minska trösklarna.

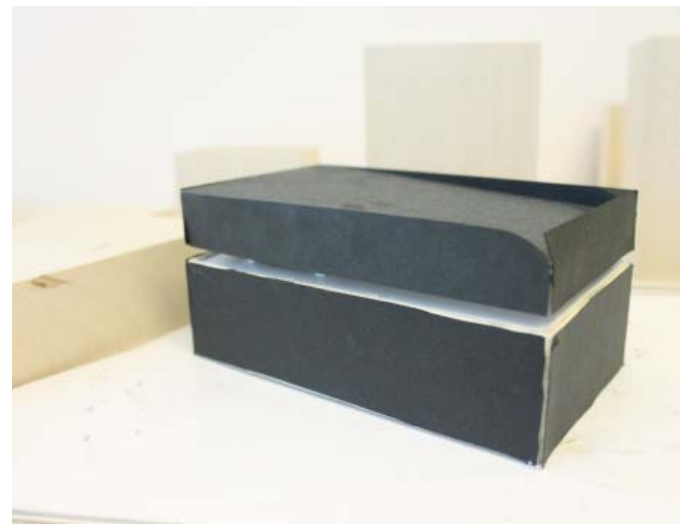
Från insidan sett ville jag att mystiken skulle behållas, vi skissade på olika modeller där man i auditoriet skulle känna att man var *lost in space*.



Tidig konceptmodell med möjlighet för besökaren att vandra runt om i byggnaden.



Konceptet med väggar som skivor som skapar inblickar till verksamheten



Lounge på taket vars fönster band delar volymen till två



Idé med lounge på baksidan som får konsekvenser i volym

## första utveckling

Vi bestämde oss för att arbeta vidare med idéerna om *lost in space* och att man som besökare skulle få komma nära in på arbetet bakom operan. Vi skissade i skala på olika fasadkoncept som skulle göra att man som förbipasserande bika av från den stora gatan och gå längs fasaden som då skulle vara slitsad för att erbjuda besökaren att få en inblick in.

## realisera

I ritningarna skulle vi nu göra en opera med ett givet program där vårt koncept och våra idéer skulle forma den. Vi hade en tanke där vi skulle separera de olika verksamheterna inuti operan och på så sätt optimera den med avseende på logistik och buller. Tidigt kom idén om att låta livet inuti operan ske i korridorerna som skulle vara synliga utifrån, på så sätt skulle vi vara lojala mot vårt koncept. Vi arbetade också vidare med mystiken, att man på efter operan skulle få möjlighet att röra sig till ett nytt rum en *scenic lounge* istället för tillbaka till lobbyn.

# reflektion

## VAD HAR JAG LÄRT MIG?

Projektet gjordes i väldigt stor skala, det i sig var en lärdom. Som ett förslag till en tävling lär man sig att förstå att det framför allt är idéerna och tydligheten som är viktiga snarare än alltså fungera i detalj.

I kursen som sådan lärde jag mig mycket om rumsakustik och akustiska kvalitéer men också hur arbetet i en verksamhet som en opera eller konserthall fungerar, vilka ytor som behövs eller vad olika yrkesgrupper tycker är viktigt.

## VAD ÄR JAG MEST NÖJD MED?

Förslaget är väldigt genomritat. Vi koncentrerade oss på rörelserna inuti byggnaderna och satte oss in i hur man som verksam vid operan beter sig. Hur man arbetar i en verkstad, på vilket sätt man lossar olika stora lastbilar eller hur man rör sig mellan scen och loger.

Förslaget är också väl anpassat till kontexten; inför arbetet zoomade vi ut och tittade på närbelägna kommunikationer och hur man som besökare, student eller operamedarbetare troligast rörde sig mot byggnaden. Med det i beaktning skapade vi tydliga yttre rum och naturliga rörelser och entréer till operakomplexet.

## VAD KUNDE BLIVIT BÄTTRE?

Jag tycker att det yttre fasadkonceptet inte var tillräckligt starkt. Den fasad som vi motiverade dels med akustiska skäl men också med att man som besökare skulle kunna se in blev från långt håll ganska sluten. När vi arbetade vidare med den inre volymen och var tvungna att släppa en av idéerna med en lounge på taket blev den inre volymen inte heller lika tydlig vilket skapar en svårighet med en såpass spretig yttre volym.

Livet inuti operan och den inre rörelserna är en av projektets styrkor som borde presenterats bättre. Tydliga sektioner över korridoren och dess koppling till resten av byggnaden och de yttre rummen hade både förklarat och motiverat korridorerna bättre.