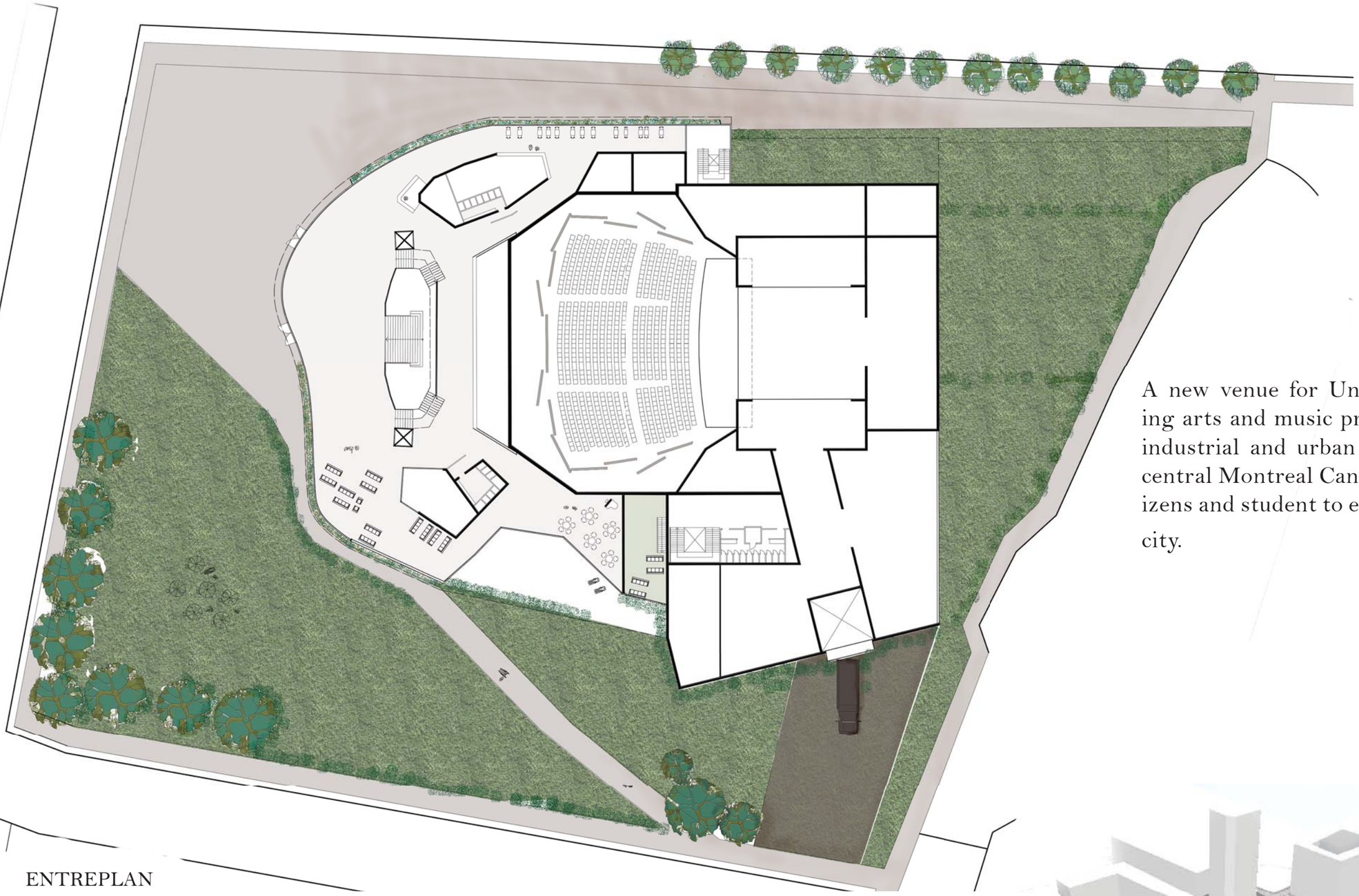
a musical layering

Opera Montreal

Cours	Bachelor Thesis
Date	Spring 2013, 3rd year
Work	Group
Teacher	Morten Lund
	Mendel Kleiner
Using	Autocad
	Rhinoceros
	Revit
	Sketchup
	Photoshop
	Illustrator

In Montreal, the multicultural city of Canada, a college of moderate size with a very strong music program intends to construct on their campus a performance hall primarily for opera. The hall will be used by student as well as professional opera performers. The main purpose of the hall will be the traditional opera program, the hall will also have a multipurpose function that's allow musical theater, orchestral concerts, chamber music, dance and occasional lecture.

The building program:
Performance hall with an audience seating that allow 1200 seats where 40% of the seats are placed in the two or three levels balconies. The orchestra pit should accommodate an orchestra of approximately 70 musicians and variable acoustics should be considered.
The scene shop, dressing rooms and costume shop should have adequate sound isolation.
The rehearsal room should be planed and require a space with daylight for dancers, small instrument and chorus.
The lobby should serve as the entrance and have same other facilities.

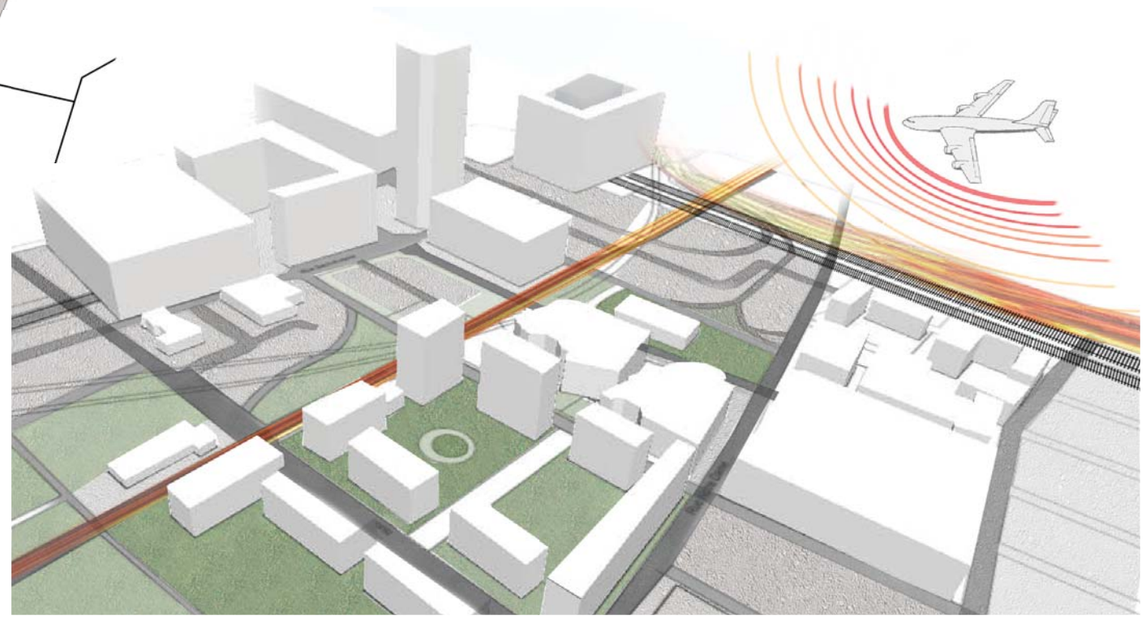


ENTREPLAN

A new venue for Université de Montreal's performing arts and music program is being presented in the industrial and urban environment of Griffintown in central Montreal Canada. An opera offered to both citizens and student to enhance the musical culture in the city.

THE SITE

There are many noise sources in the site's proximity. A busy street is located next to the venue, an underground tunnel run beneath the site, and an interstate highway and a railroad are located 350 and 300 m away, respectively. The flight path of Montreal's international airport goes directly over the location at a 500 m height.



The concept use layers to define the building's variations in intimacy, openness and spaciousness. The layers gradually close in as the audience move towards the auditorium - surrounding the heart of the building. The glass façade is open and inviting while thick slatestone walls mask the auditorium making it private and alluring.

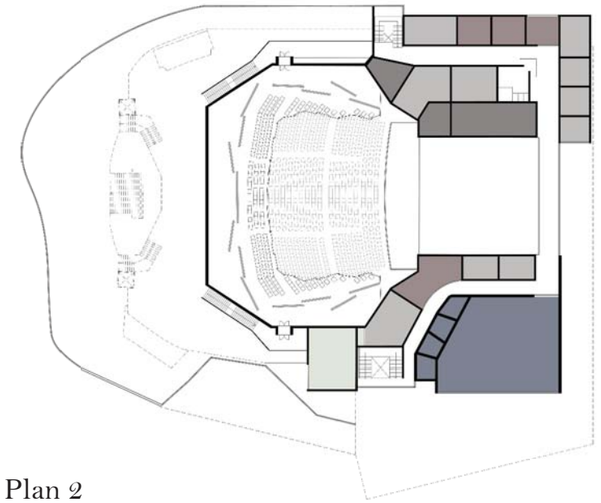
Scene shop [RC 40]]
Costume shop [RC 40]
Storage [RC 45]
Dressing room [RC 35]
Green room [RC 25]
Rehearsal room [RC 20]

LOBBY
A combination of an urban, vibrant restaurant with calm and tranquil lounge areas, together with the many visitor services form a flexible and welcoming space. The lobby is an invitation to a musical experience, taking the visitor on a journey in to an incredible world of song, dance and theatre.

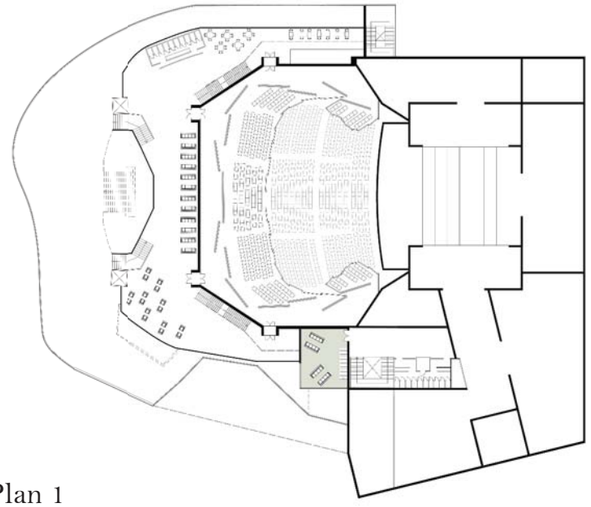
INDOOR/OUTDOOR SPACE
The building's orientation provides the south side with an acoustic shadow. It becomes a natural meeting place where the building merges into the park with a sliding glass façade. The space opens up to an indoor/outdoor musical venue, suitable for Montreals warmer spring and summer months.

WARDROBE
The main wardrobe on the ground floor functions as a sound barrier. The additional wall and the absorbents of coats, textiles and fabrics help secure optimal acoustics in the auditorium.

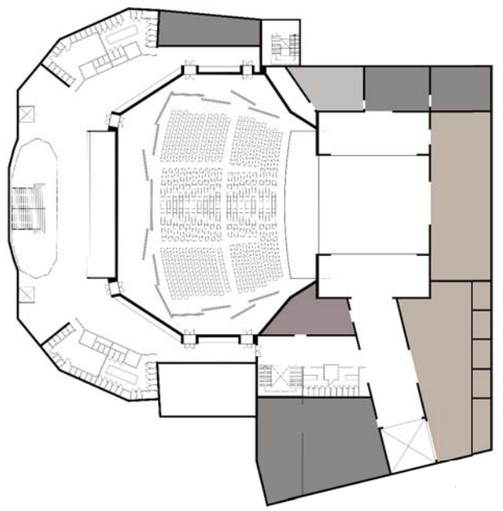
GREEN ROOM
In the versatile green room extending over two levels, the performers, musicians and employees have a place to relax and unwind. It's located in a near proximity to the stage for easy access and in a quiet part of the building. The nearby staircase leads you up to practice rooms and dressing rooms, or down backstage.



Plan 2



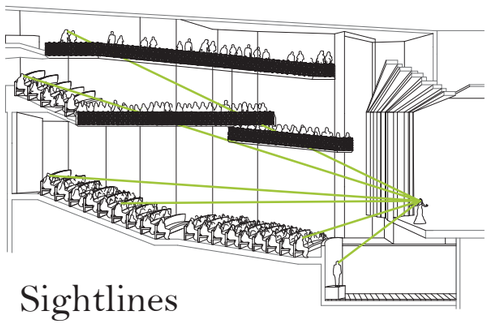
Plan 1



Plan -1

Light slipping through the openings in the inner shell guide you all the way to the auditorium. Winding balconies in two floors extending from the back to the side embrace the main floor seating and give you an intimate feel, allowing you to enter a musical state of mind and to enjoy an outstanding performance.

This intimacy is further enhanced by a ceiling height of 15 meters and a maximum distance of 30 meters between the audience and performers.
All seats are directed towards the stage, making the angle between the stage and audience less than 30o. The side balconies are sloping towards the stage, ensuring good sight lines at all seats.
Movable seats on the second balcony offer flexibility and allow standing public under graduations and other big events.
The first floor side balconies only overlap the side isles and the lowest under balcony ceiling height is 4.5 meters. This ensures envelopment and spaciousness for all audience positions.

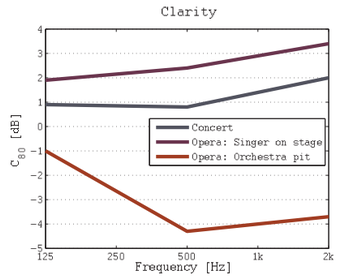


Sightlines

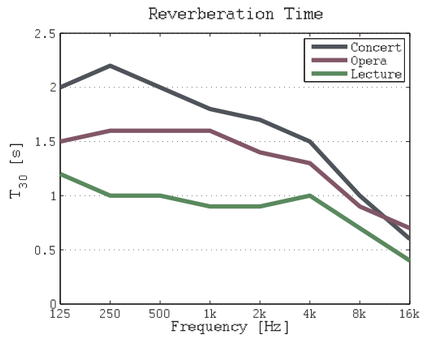
The auditorium has three different acoustic modes: Concert, opera and lecture. It is designed for the background noise criteria RC 15 due its noise sensitive use. A double wall consisting of two thick concrete layers with mineral wool in the cavity is used for the hall's outer shell, and the audience entrance is designed as a sluice with quiet closing doors and absorptive materials in the ceiling and walls to minimize noise transmission from the lobby when the doors are opened. The room formed between the inner and outer auditorium shell will also contribute to the noise reduction from the lobby. A silent ventilation system is also required in order to fulfil the background noise criteria.

Large variations in the acoustical properties are needed for the three modes. A short reverberation time and high clarity is necessary to achieve good speech intelligibility in the lecture mode. The opera and concert modes need longer reverberation times to support the singer and the orchestra. An adjustable ceiling height make it possible to change the room volume and thereby the reverberation time. Heavy curtains on the side and back walls give adjustable absorption for further reverberation time reduction.

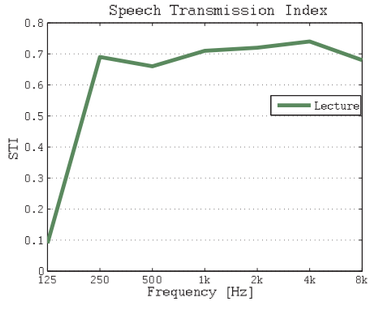
Stacked slate stone of varying depth is used on the inner shell for its scattering properties and rough and industrial look. This surface roughness prevents coloration of the reflected sound together with irregularities in the stage reflectors, ceiling and balcony fronts. A minimum distance of 1.5 meters from the audience seating and the walls give unnoticeable difference in sound arrival time at the listener positions.



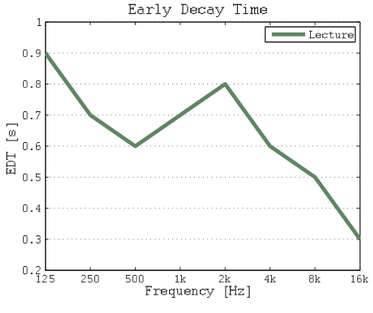
Clarity is important for the listener's word perception. A relatively high clarity for singers on stage makes it a suitable venue for operas where perception of the lyrics is desirable.



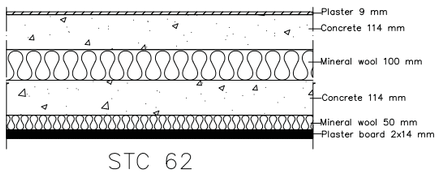
Short reverberation times for speech are obtained by lowering the ceiling height and adding absorption with curtains on the side and back walls. The room between the inner and outer auditorium shell is used as a reverberation chamber for the long reverberation times in the concert mode.



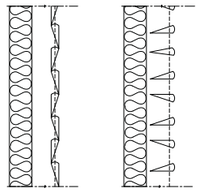
A speech transmission index of approximately 0.7 for all frequencies above 250 Hz in lecture mode make it suitable for speech.



An average early decay time of 0.7 s for 500-2k Hz give suitable clarity for speech.

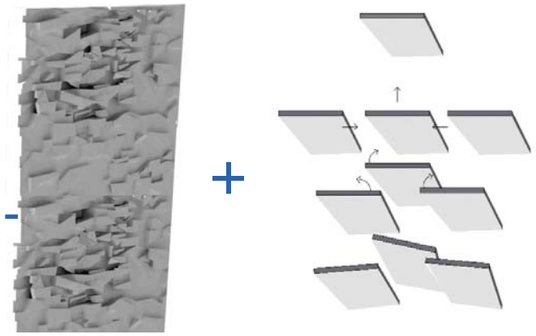


STC 62

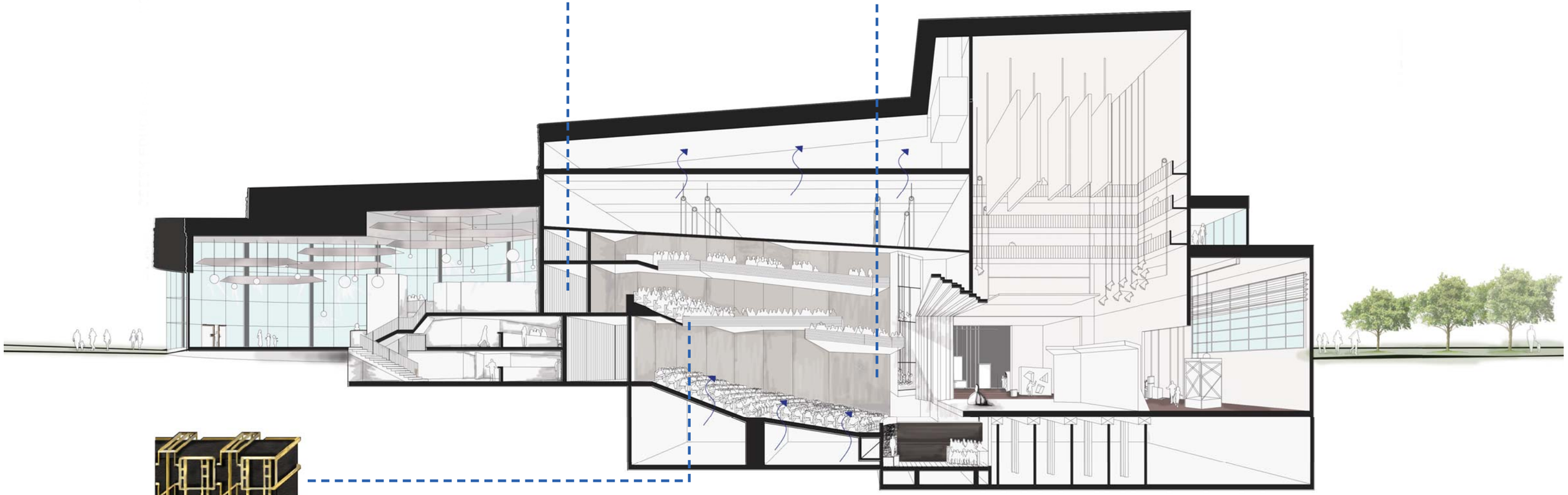


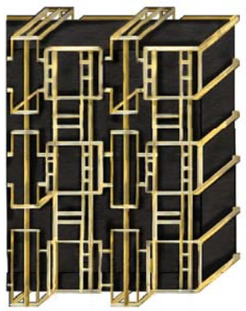
The concept of layers is reflected in the thick double concrete wall and the interior wall surrounding the auditorium, acting as outer and inner shells. The outer shell isolates the auditorium from the rest of the building both visually and acoustically. A volume is created between the two shells and acts as a reverberation chamber when sound is allowed to travel through adjustable openings in the inner shell.

Acoustic blinds on the outer shell give variable sound absorption in the volume between the two shells. Closed blinds create reflective and scattering walls giving a strong and diffuse reverberant sound field when used as a reverberation chamber, while open blinds make it a pleasant space for the audience.

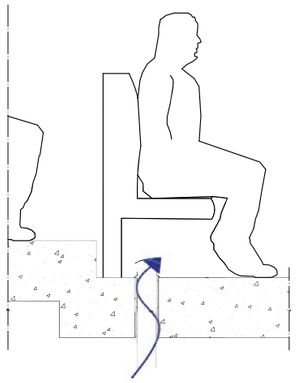


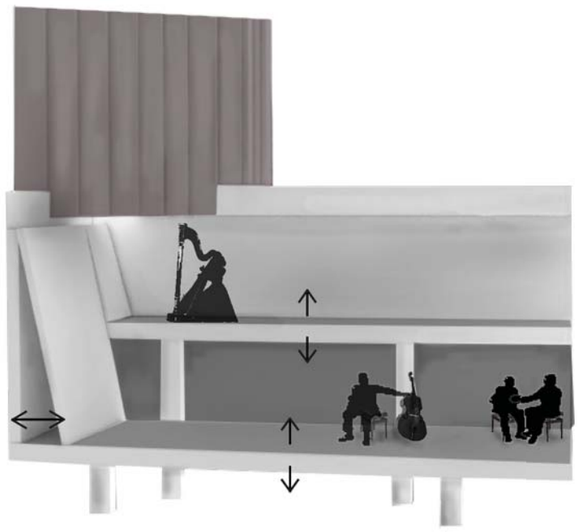
Irregularities in the inner shell give scattering, contributing to a diffuse sound field and prevent coloration in the reflected sound. Heavy velour curtains on the side and back walls allow shorter reverberation times for lectures along with a lowered ceiling height which decrease the auditorium's room volume.

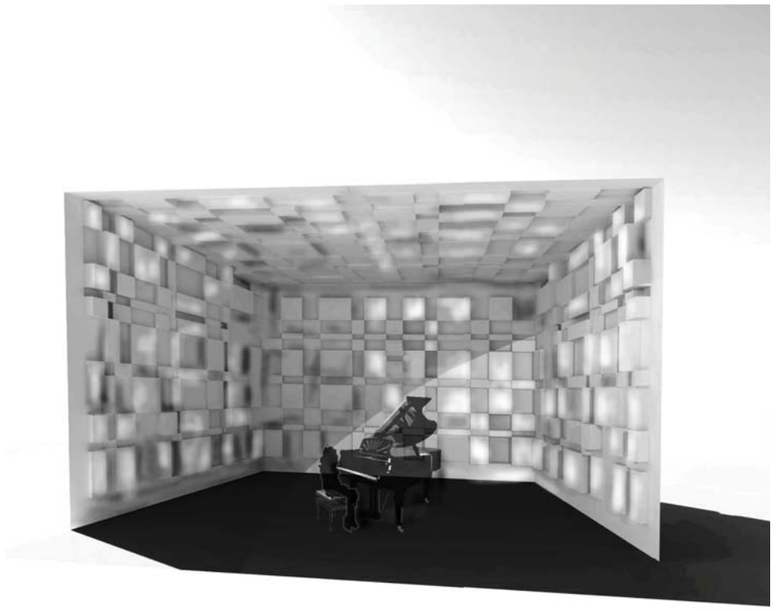




The balcony fronts consist of a hard reflective surface covered with brass piping for scattering. This gives an old industrial touch.







The ventilation machinery and humidifier is located in the mechanical equipment room to avoid vibrations and noise in the auditorium. The chimney effect is used for a silent air exchange in the auditorium, feeding fresh air through valves under the audience seats and let old air out through the ceiling. Large cross sections are used for the ventilation ducts, making sure the air velocity does not exceed 2 m/s. Mufflers with non-fibrous absorbers are used for prevention of sound transmission through the ducts. The humidifier ensures the correct air humidity for the singers.

The orchestra pit is divided into two separate floors that can be raised and lowered. The sidewalls can be tilted to help send out sound to the auditorium and at the same prevent flutter echo in the pit. The curved wall behind the conductor has the same finish as the orchestra shell so that the different orchestra sections hear each other. Loud sections are shielded by movable barrier when necessary.

The orchestra shell stands on wheels and can be disassembled into four plates that are stored in the stage tower. A rough surface consisting of rectangles with large variations in size and depth give both horizontal and vertical scattering. It is built as a sandwich construction with an asphalt core to prevent sound absorption. The same finish is used for the shell and the stage reflectors to make them merge together.

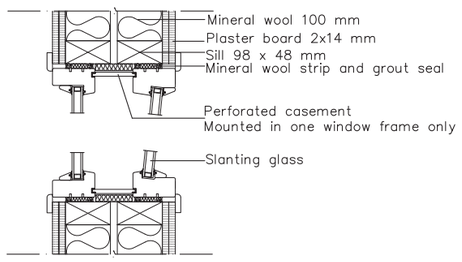
The rehearsal room serves a multiple of purposes: dance, chamber and choir music, meetings and lectures. Variable acoustics is a necessity in order to accommodate the different requirements in reverberation times spanning from T30 values of 0.6 to 1.8 seconds for meetings and chamber music, respectively.

A ceiling height of 4.5 meters gives a large room volume and longer reverberation time. Acoustic blinds give a scattering wall and can be opened for reduction of the reverberation time along with thick and heavily draped curtains.

Scattering is further enhanced by irregularities in the ceiling, proventing coloration of the sound together with non-parallel walls that eliminate flutter echo.

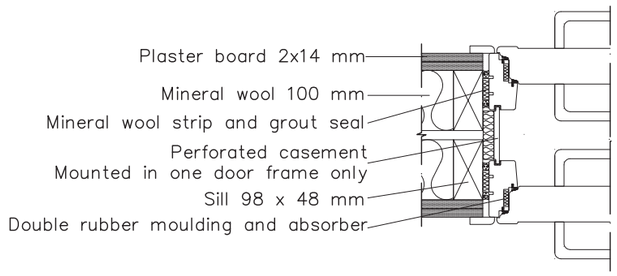
A quiet environment is especially important for choir music, giving the background noise criteria RC20. This is obtained using a “box in box” construction that reduces both airborne sound and flanking transmission. A heavy floating floor prevents impact noise from spreading to adjacent rooms. Double windows mounted in separate frames without rigid connection provide daylight while still accommodating the need for high sound isolation. The window’s sound reduction is further improved by slightly slanting the window glass.

window detail



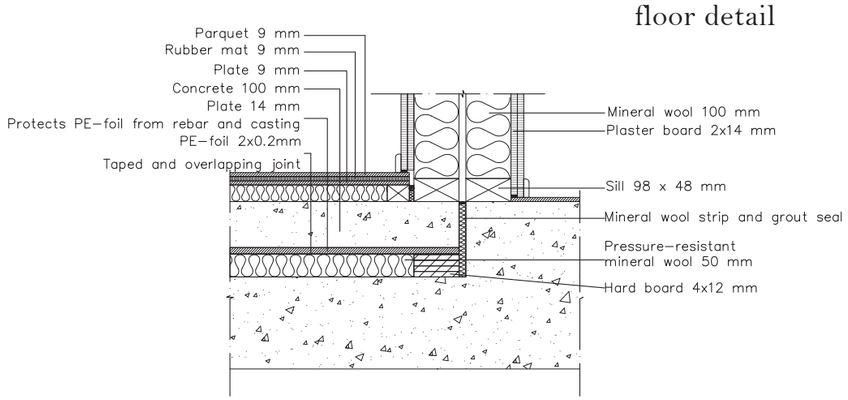
STC 59

door detail



STC 59

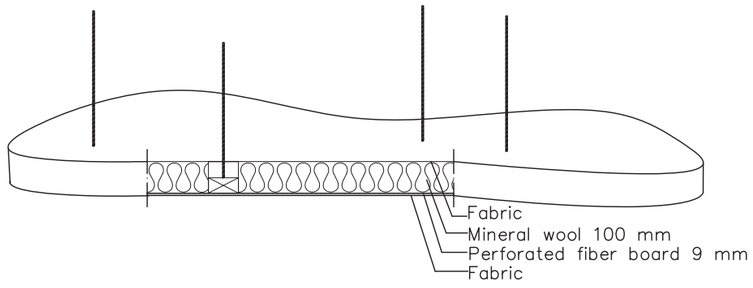
floor detail



The practice rooms are built using the same “box in box” construction as the rehearsal room. Scattering is introduced by irregularities on the wall and in the ceiling, and an angled wall to prevent flutter echo. Reverberation time can be adjusted with a thick and heavily draped curtain. Longer reverberation times can be achieved by using an electroacoustic system such as LARES.

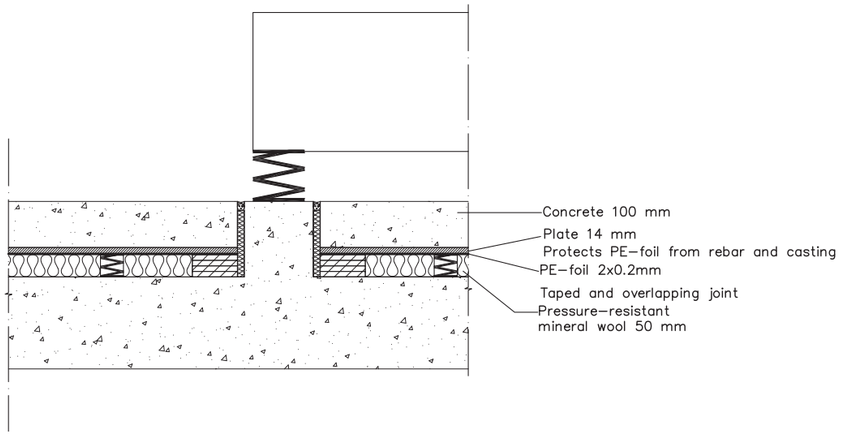
Visitors are welcomed in the spacious lobby with cloud like absorbents floating above amongst thin light fixtures. The porous absorbers are fixed on top of perforated plates and suspended from the lobby ceiling to reduce reverberation time and noise buildup. Theground floor lounge, gift shop, wardrobe and box office are centralized round the staircase and elevators. Toilettes are located away from the auditorium and on all main floors, with the largest one level down serving the main floor.

On performance nights there are several locations to find refreshments. A restaurant situated on the ground floor serve food and coffee and in addition there are several lounge areas with bars and serving carts for socializing.
Linking the venue together, slatestone is featured as a façade as well as an outer auditorium wall and throughout the building. Bringing some of the outdoors and the industrial fell of the neighborhood in to the building makes it an urban, interesting and inspiring space for performances and creation.



The mechanical equipment room is placed on the underground floor to avoid vibrations spreading in the structure. Sound and vibration isolation is achieved by building it as a “box in box” construction with heavy double walls and floating floor in concrete. Spring-supports isolate vibrating machinery and heavy machinery is supported at the foundation. Piping does not have rigid contact with the walls in the conduit entries in order to reduce vibration transmission, and airborne sound is isolated using mineral wool and grout seals.

The scene shop is built using the same construction as the mechanical room for maximum sound reduction. Absorbers cover the ceiling and upper parts of the walls to reduce the noise buildup inside the shop. A double door design with heavy sliding doors in separate frames ensures the sound reduction required between the scene shop and backstage.



REFLEKTION

Kandidatarbetet började med en intensiv kurs i akustik där man introducerades till opera-konserthall och föreläsningssalarnas undangömda funktioner. Dessa funktioner som man annars inte lägger märke till.
Några veckor efter detta introducerades vi till området där universitetsoperan skulle placeras. I grupp började man att undersöka platsen och analysera staden, i samband med detta började man att fila på ett koncept och arbetade i modell.

Konceptet är platsen. Focusen under skissprocessen har varit integrationen av byggnaden i miljön. Att jobba med material som är simpla och skapa öppenhet, transparens i konstruktionen.

Studentoperan placerades med entrén mot väst och backstage mot öst vilket var givet då stadens puls ligger på den västra sidan. Området vi hade tillgång till var spatiöst vilket gav en stor frihet och ledde i sin tur till idéer om hur man kunde integrera det gröna till byggnaden. Detta fall tyvärr lite undan då man började framställa planerna. Man hade velat jobba vidare med det samt utveckla och komplementera byggnaden med en aktiv ute plats för att skapa en mer trivsam miljö för vardagsbesökarna.
Detta koncept framgår inte så tydligt i det material som vi har valt att presentera.

Planerna har man bearbetat mycket. Svårigheter uppstod när man skulle placera dem specifika rummen. Själv har man inte varit så mycket på backstagen i en opera och kunde därmed inte alltid identifiera mig till problematiken. Handledningstillfällen och diskussionerna i arbetsgrupperna hade en avgörande plats i denna del och hjälp en på vägen till operan.

Efter detta arbetade man vidare med fasaden och taket som jag personligen tycker inte framstår som förväntat. Tanken var att dölja utsticket från scenen. Den lösning som vi presenterade, då vi jobbade med skiffer i fasaden som sträcker sig vidare upptill tacket, gav inte rätt uttryck och behöver bearbetas mer.

Föreställningssalen, där sammarbetet med akustik studenten var avgörande, har gestaltat med hänsyn till god ljudmiljö och uppfyller förväntningarna. Rummet som uppstod har en god akustik och en talande estetik.

I detta omfattande projekt så fick man främja vissa delar vilket ledde till att vissa rum, som är viktig för operaceremonin, inte är lika bearbetad. Hade velat ha mer presentationsmaterial som skapar en rödtråd och förtydligar konceptet. Jag är i helhet väldigt nöjd med resultatet.

a musical LAYERING

| STUDENT DESIGN COMPETITION |TCAA and NCAC 2013|

A new venue for Université de Montreal's performing arts and music program is being presented in the industrial and urban environment of Griffintown in central Montreal Canada.The layering of the building captivates the vibrant feel of the location, and its unusual space. It defines the creative use of acoustical design for a wide range of performances.

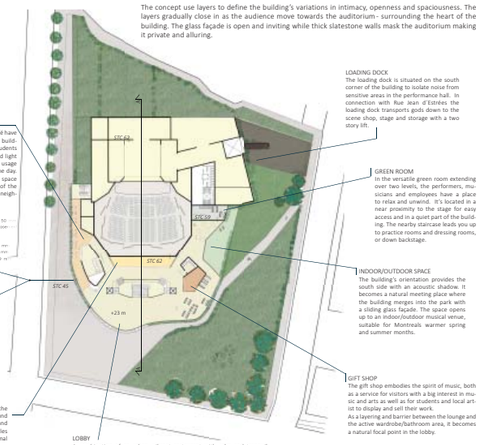
External noise contributions at the site.

There are many noise sources in the site's proximity. A busy street is located next to the venue, an underground tunnel run beneath the site, and an interstate highway and a railroad are located 350 and 300 m away, respectively. The flight path of Montreal's international airport goes directly over the location at a 500 m height.

An outdoor entrance area is placed above the tunnel and noise-sensitive areas, such as the auditorium, are located at the other end of the site. Existing buildings screen the site from the highway and railroad, and only noise from aircrafts and the adjacent street is therefore considered. The street's noise contribution is more or less continuous, while the aircraft noise only will occur over short periods. Equivalent and maximum levels are therefore considered for road traffic and aircraft noise, respectively.

Sound level map

The concept use layers to define the building's variations in intimacy, openness and spaciousness. The layers gradually close in as the audience move towards the auditorium - surrounding the heart of the building. The glass façade is open and inviting while thick slatestone walls mask the auditorium making it private and allluring.



LOADING DOCK
The loading dock is situated on the south corner of the building to isolate noise from sensitive areas in the performance hall. In connection with Rue Jean d'Estrées the loading dock transports gods down to the scene shop, stage and storage with a two story lift.

RESTAURANT & CAFÉ
A combined restaurant and café have been incorporated in to the building to service visitors and students with refreshments, snacks and light foods. It's a way to stimulate usage of the venue in all hours of the day. The restaurant is a versatile space to cater the different needs of the buildings residents and the neighborhood as a whole.

[Det. 1]

STC 45

GREEN ROOM
In the versatile green room extending over two levels, the performers, musicians and employees have a place to relax and unwind. It's located in a near proximity to the stage for easy access and in a quiet part of the building. The nearby staircase leads you up to practice rooms and dressing rooms, or down backstage.

INDOOR/OUTDOOR SPACE
The building's orientation provides the south side with an acoustic shadow. It becomes a natural meeting place where the building merges into the park with a sliding glass façade. The space opens up to an indoor/outdoor musical venue, suitable for Montreals warmer spring and summer months.

GIFT SHOP
The gift shop embodies the spirit of music, both as a service for visitors with a big interest in music and arts as well as for students and local artist to display and sell their work.
As a layering and barrier between the lounge and the active wardrobe/bathroom area, it becomes a natural focal point in the lobby.

GLASS FAÇADE
A double glazing façade consisting of thick laminated windows with 150 mm spacing together with stone walls of stacked slate give an industrial appearance in accordance with Griffin Town's past. The thick glass and big spacing give the necessary façade sound reduction. A further reduction improvement is achieved by using different glass thicknesses for the two windows and covering the frame in the air gap with mineral wool. A perforated metal foil covering the mineral wool adds to the industrial look while still being acoustically translucent.

WARDROBE
The main wardrobe on the ground floor functions as a sound barrier. The additional wall and the absorbents of coats, textiles and fabrics help secure optimal acoustics in the auditorium.

LOBBY
A combination of an urban, vibrant restaurant with calm and tranquil lounge areas, together with the many visitor services form a flexible and welcoming space. The lobby is an invitation to a musical experience, taking the visitor on a journey in to an incredible world of song, dance and theatre.

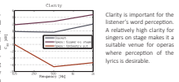
Performance Hall

Multi purpose hall

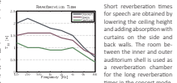
The auditorium has three different acoustic modes: Concert, opera and lecture. It is designed for the background noise criteria RC 15 due its noise sensitive use. A double wall consisting of two thick concrete layers with mineral wool in the cavity is used for the hall's outer shell, and the audience entrance is designed as a sluice with quiet closing doors and absorptive materials in the ceiling and walls to minimize noise transmission from the lobby when the doors are opened. The room formed between the inner and outer auditorium shell will also contribute to the noise reduction from the lobby. A silent ventilation system is also required in order to fulfill the background noise criteria.

Large variations in the acoustical properties are needed for the three modes. A short reverberation time and high clarity is necessary to achieve good speech intelligibility in the lecture mode. The opera and concert modes need longer reverberation times to support the singer and the orchestra. An adjustable ceiling height and an openable inner shell makes it possible to change the room volume and thereby the reverberation time. Heavy curtains on the side and back walls give adjustable absorption for further reverberation time reduction. Helmholtz resonators in the ceiling under the first side balcony add low frequency absorption, and their distance from the audience ensures that they do not disturb the listener's soundfield. Thick upholstering minimizes the difference in absorption between empty and occupied seats. Acoustic blinds in the room between the inner and outer shell can be opened for absorption when it is not used as a reverberation chamber, making it more pleasant.

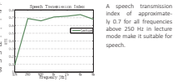
Stacked slate stone of varying depth is used on the inner shell for its scattering properties and rough and industrial look. This surface roughness prevents coloration of the reflected sound together with irregularities in the stage reflectors, ceiling and balcony fronts. A minimum distance of 1.5 meters from the audience seating and the walls give unnoticeable difference in sound arrival time at the listener positions.
Loudspeakers for special effects are hidden behind the stage reflectors.



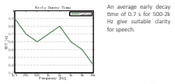
Clarity is important for the listener's word perception. A relatively high clarity for singers on stage makes it a suitable venue for operas where perception of the lyrics is desirable.



Short reverberation times for speech are obtained by lowering the ceiling height and adding absorption with curtains on the side and back walls. The room between the inner and outer auditorium shell is used as a reverberation chamber for the long reverberation times in the concert mode.



A speech transmission index of approximately 0.7 for all frequencies above 250 Hz in lecture mode make it suitable for speech.



An average early decay time of 0.7 s for 500-2k Hz give suitable clarity for speech.

Audience seating

Light slipping through the openings in the inner shell guide the audience on their way into the auditorium. Winding balconies in two floors extending from the back to the side embrace the main floor seating and give an intimate feel.

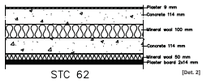
This intimacy is further enhanced by a ceiling height of 15 meters and a maximum distance of 30 meters between the audience and performers.
All seats are directed towards the stage, making the angle between the stage and audience less than 30°. The side balconies are sloping towards the stage, ensuring good sight lines at all seats.
Movable seats on the second balcony offer flexibility and allow standing public under graduations and other big events.
The first floor side balconies only overlap the side isles and the lowest under balcony ceiling height is 4.5 meters. This ensures envelopment and spaciousness for all audience positions.

Balcony fronts
The balcony fronts consist of a hard reflective surface covered with brass piping for scattering. This gives an old industrial touch.

Section A-A

Opera Shell

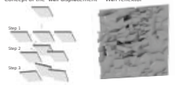
Exterior Opera Shell
Wall detail horizontal



STC 62

[Det. 2]

Interior Opera shell
Concept of the wall displacement Wall reflektor



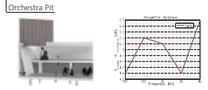
Air supply

The ventilation machinery and humidifier is located in the mechanical equipment room to avoid vibrations and noise in the auditorium. The chimney effect is used for a silent air exchange in the auditorium, feeding fresh air through valves under the audience seats and let old air out through the ceiling. Large cross sections are used for the ventilation ducts, making sure the air velocity does not exceed 2 m/s. Mufflers with non-fibrous absorbers are used for prevention of sound transmission through the ducts. The humidifier ensures the correct air humidity for the singers.

Stage Shell

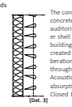
The orchestra shell stands on wheels and can be disassembled into four plates that are stored in the stage tower. A rough surface consisting of rectangles with large variations in size and depth give both horizontal and vertical scattering. It is built as a sandwich construction with an asphalt core to prevent sound absorption. The same finish is used for the shell and the stage reflectors to make them merge together.

Orchestra Pit



The orchestra pit is divided into two separate floors that can be raised and lowered. The sidewalls can be tilted to help send out sound to the auditorium and at the same prevent flutter echo in the pit. The curved wall behind the conductor has the same finish as the orchestra shell so that the different orchestra sections hear each other. Loud sections are shielded by movable barrier when necessary.

Absorbers blinds



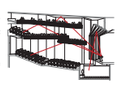
[Det. 3]

The concept of layers is reflected in the thick double concrete wall and the interior wall surrounding the auditorium, acting as outer and inner shells. The outer shell isolates the auditorium from the rest of the building both visually and acoustically. A volume is created between the two shells and acts as a reverberation chamber when sound is allowed to travel through adjustable openings in the inner shell.
Acoustic blinds on the outer shell give variable sound absorption in the volume between the two shells. Closed blinds create reflective and scattering walls giving a strong and diffuse reverberant sound field when used as a reverberation chamber, while open blinds make it a pleasant space for the audience.
Irregularities in the inner shell give scattering, contributing to a diffuse sound field and prevent coloration in the reflected sound. Heavy velour curtains on the side and back walls allow shorter reverberation times for lectures along with a lowered ceiling height which decrease the auditorium's room volume.

Sightlines

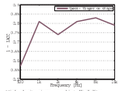
All seats have unhindered sightlines to the stage.

Sound reflection



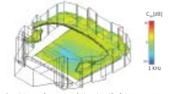
The stage reflector and ceiling provide first order reflections to all seats and to the performers on stage and in the pit.

Envelopment



High clarity gives good intelligibility.

Lecture mode Clarity



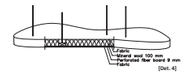
Low interaural cross correlation gives the listener a sensation of being enveloped by the sound.

Lobby

Visitors are welcomed in the spacious lobby with cloud like absorbents floating above amongst thin light fixtures. The porous absorbers are fixed on top of perforated plates and suspended from the lobby ceiling to reduce reverberation time and noise buildup. Theground floor lounge, gift shop, wardrobe and box office are centralized round the staircase and elevators. Toilettes are located away from the auditorium and on all main floors, with the largest one level down serving the main floor.

On performance nights there are several locations to find refreshments. A restaurant situated on the ground floor serve food and coffee and in addition there are several lounge areas with bars and serving carts for socializing.

Linking the venue together, slatestone is featured as a façade as well as an outer auditorium wall and throughout the building. Bringing some of the outdoors and the industrial fell of the neighborhood in to the building makes it an urban, interesting and inspiring space for performances and creation.

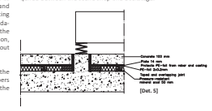


[Det. 4]

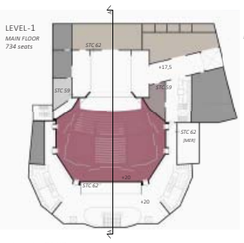
Mechanical Equipment Room and Scen Shop

The mechanical equipment room is placed on the underground floor to avoid vibrations spreading in the structure. Sound and vibration isolation is achieved by building it as a "box in box" construction with heavy double walls and floating floor in concrete. Spring-supports isolate vibrating machinery and heavy machinery is supported at the foundation. Piping does not have rigid contact with the walls in the conduit entries in order to reduce vibration transmission, and airborne sound is isolated using mineral wool and grout seals.

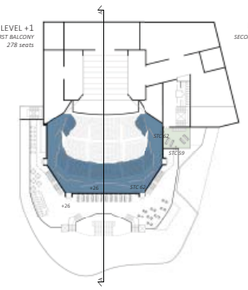
The scene shop is built using the same construction as the mechanical room for maximum sound reduction. Absorbers cover the ceiling and upper parts of the walls to reduce the noise buildup inside the shop. A double door design with heavy sliding doors in separate frames ensures the sound reduction required between the scene shop and backstage.



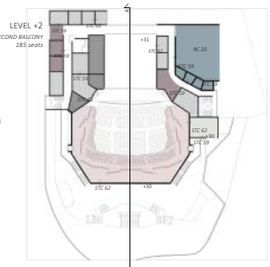
LEVEL-1
MAIN FLOOR
734 seats



LEVEL +1
FIRST BALCONY
278 seats



LEVEL +2
SECOND BALCONY
185 seats



Scene shop [RC 40]
Costume shop [RC 40]
Main floor [RC 15]
Storage [RC 45]
Dressing room [RC 35]
First balcony [RC 15]
Green room [RC 25]
Rehearsal room [RC 20]
Second balcony [RC 15]

Rehearsal room

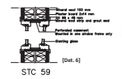
The rehearsal room serves a multiple of purposes: dance, chamber and choir music, meetings and lectures. Variable acoustics is a necessity in order to accommodate the different requirements in reverberation times spanning from f.ex 30 values of 0.6 to 1.8 seconds for meetings and chamber music, respectively.

A ceiling height of 4.5 meters gives a large room volume and longer reverberation time. Acoustic blinds [Det. 3] give a scattering wall and can be opened for reduction of the reverberation time along with thick and heavily draped curtains.

Scattering is further enhanced by irregularities in the ceiling, preventing coloration of the sound together with non-parallel walls that eliminate flutter echo.

A quiet environment is especially important for choir music, giving the background noise criteria RC20. This is obtained using a "box in box" construction that reduces both airborne sound and flanking transmission. A heavy floating floor prevents impact noise from spreading to adjacent rooms. Double windows mounted in separate frames without rigid connection provide daylight while still accommodating the need for high sound isolation. The window's sound reduction is further improved by slightly slanting the window glass.

window detail

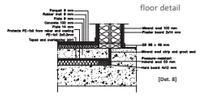


[Det. 6]

door detail

[Det. 7]

floor detail



[Det. 8]

The practice rooms are built using the same "box in box" construction as the rehearsal room. Scattering is introduced by irregularities on the wall and in the ceiling, and an angled wall to prevent flutter echo. Reverberation time can be adjusted with a thick and heavily draped curtain. Longer reverberation times can be achieved by using an electroacoustic system such as LARES.