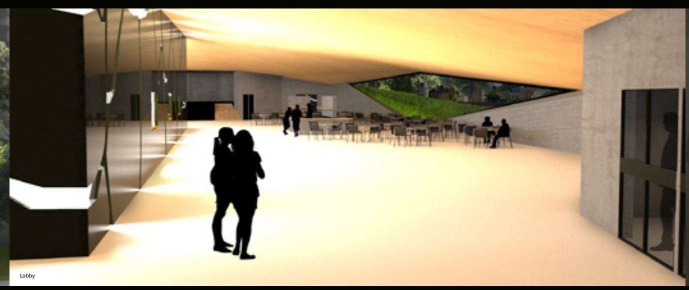
Obsidian

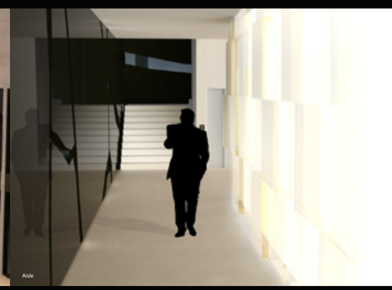
Uppgiftsbeskrivning

Uppgiften var att designa ett operahus för Montreals universitet. Byggnaden skulle framförallt fungera för stadens musikhögskola men även kunna ta emot professionella uppsättningar av olika slag. Det var även av vikt att huvudsalen i byggnaden skulle kunna användas i ett flertal olika sammanhang så som för föredrag och klassiska orkestrar, men dock ha som huvudsyfte att vara en operasal.
Ett stort fokus akustiken i byggnaden i allmänhet och operasalen i synnerhet. Ett antal olika värden inom detta ämne skulle behandlas, allt från ljudisolering till olika rumsakustiska värden så som efterklang.
Att det var just ett universitet som skulle använda byggnaden gjorde att budgeten var något begränsad vilket gjorde att byggnaden blev relativt liten i förhållande till kommersiella operahus.

Den angivna tomten är relativt centralt belägen och ligger intill Montreals tekniska högskola. Den omgivande bebyggelsen är relativt blandad med dels universitetsbyggnaderna, dels bostadshus, en mindre park och en parkeringsplats.



Lobby



Aisle

Rehearsal room

Obsidian

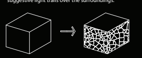
Montreal University Opera

Inspired by the tremendous forces of nature and music, the Obsidian states a break from everyday life into the magnificent world of opera. Its secretive form and acoustical design gradually raises the visitors' expectations from outside and in and makes sure to sustain them when the curtain draws.

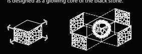
Concept

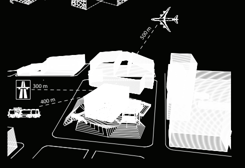
To define the site the ground is raised, whereunder public and backstage areas are housed. In the middle of this new landscape a black monolithic box is placed, containing the main auditorium.

An opera performance is and should be something out of the ordinary. Parallell to this the exterior of the opera hall is made extraordinary by a cracked facade pattern. This gives interesting outlooks and spreads suggestive light trails over the surroundings.



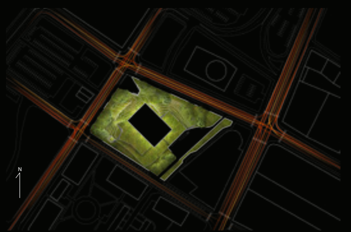
In nature, obsidian is formed when hot lava gets cooled down rapidly. Inspired by this the opera hall is designed as a glowing core of the black stone.





The Site

Analysis of Acoustic Environment 1:2000



Access

The building faces northwest, as this is the main direction of arrival, where parking and a metro station are situated. This becomes the front of the opera. On the backside the loading bay is placed, accessed by a new road.

Traffic

In the near surroundings, noise is mainly emitted from traffic north and west of the site. The street east of the site is partly shielded by an adjacent building and only a smaller street runs along the southern border.

Greenery

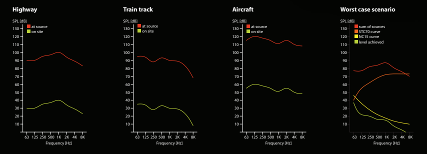
With a vision to make the opera not only an opera, but also a new social hub the site is designed as a green park. Large parts of the roof of the opera is accessible and trees cover this new park from the streets.

Noise Calculations

In the far surroundings, main sources of noise include a highway 300 metres away from the site, a train track 400 metres away and a flight path 500 metres directly above the area.

The impact of the different sources on the site were calculated, with results as shown in the graphs to the right.

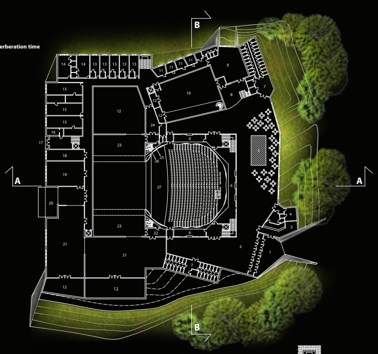
The noise levels at the site were added to simulate a worst case scenario.



Plan

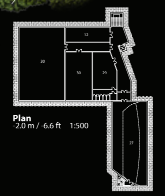
+2.5 m / 8.2 ft 1:500

Rooms	Noise Criteria	Reverberation time
1. Entrance	-	-
2. Lobby	NC40	1.1 s
3. Box office	NC35	0.5 s
4. Manager's office	NC35	0.5 s
5. Bar area	NC40	-
6. Cloakrooms	NC40	-
7. Restrooms	-	-
8. Lobby stage	NC40	1.1 s
9. Green room	NC30	0.9 s
10. Rehearsal room	NC20	1.3 s
11. Small rehearsal rooms	NC25	0.5 s
12. Storage	-	-
13. Solo dressing rooms	NC35	0.6 s
14. 4-person dressing rooms	NC35	0,7 s
15. Chorus dressing rooms	NC35	0.8 s
16. Doorman	NC35	-
17. Stage door	-	-
18. Kitchen	NC40	0.6 s
19. Costume/Wig shop	NC40	0.6 s
20. Loading bay	-	-
21. Scene shops	NC40	0.6 s
22. Stage escape	NC15	-
23. Wings	NC15	-
24. Ready area	NC15	-
25. Stairs to service balcony	NC20	-
26. Ventilation shaft	-	-
27. Orchestra pit	NC15	1.1 s
28. Mixing position	NC15	-
29. Orchestra dressing room	NC35	0.8 s
30. Mechanical Equipment Room	-	-



Plan

-2.0 m / -6.6 ft 1:500

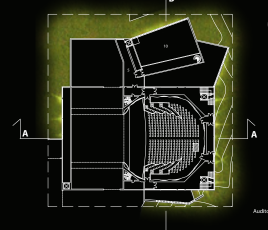


Spatial experience

The journey through the building

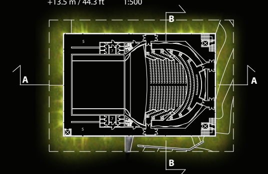
Plan

+5.2 m / 17.1 ft 1:500



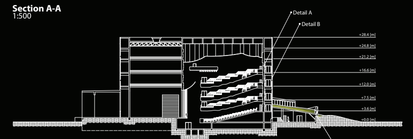
Plan

+13.5 m / 44.3 ft 1:500



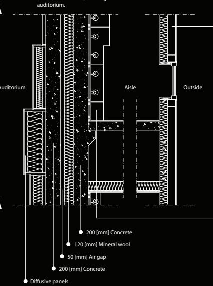
Section A-A

1:500



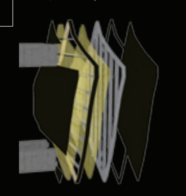
Detail A

Wall section STC70+ 1:20



Detail B

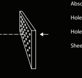
Facade



Helmholtz absorbers

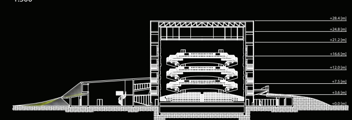
The low-frequency noise, transmitted through the facade is absorbed by microperforated Helmholtz absorbers to reduce noise in the aisles outside the auditorium. The cavity depths are varied in order to cover a wider frequency range. Light fixtures behind the absorbers light the aisles and the outside of the building.

Principle



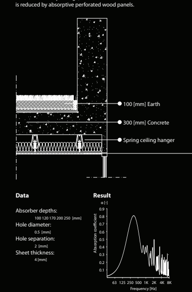
Section B-B

1:500



Detail C

Green lobby roof 1:20



Data

Absorber depths:
100 120 170

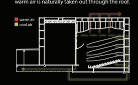
Hole diameter:
0.5 [mm]

Hole separation:
2 [mm]

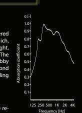
Sheet thickness:
4 [mm]

HVAC

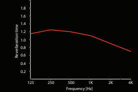
Silent air supply



Suspended ceiling



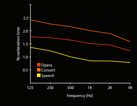
Lobby reverberation time



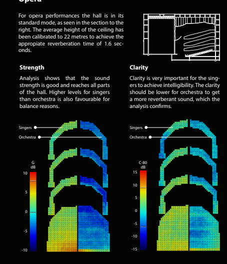
The Auditorium

Acoustical analysis for three modes

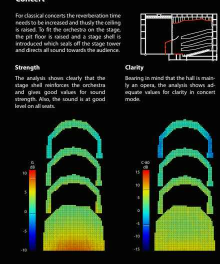
Hall reverberation time



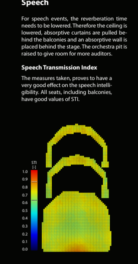
Opera



Concert

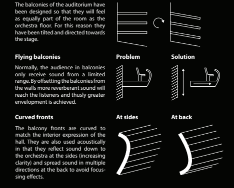


Speech



Balconies

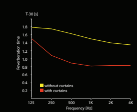
Architectural and acoustic measures

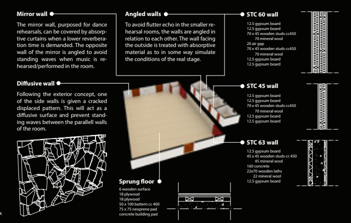


Rehearsal room

Acoustics and privacy

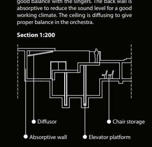
Rehearsal room reverberation time





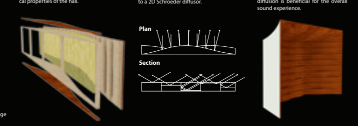
Orchestra pit

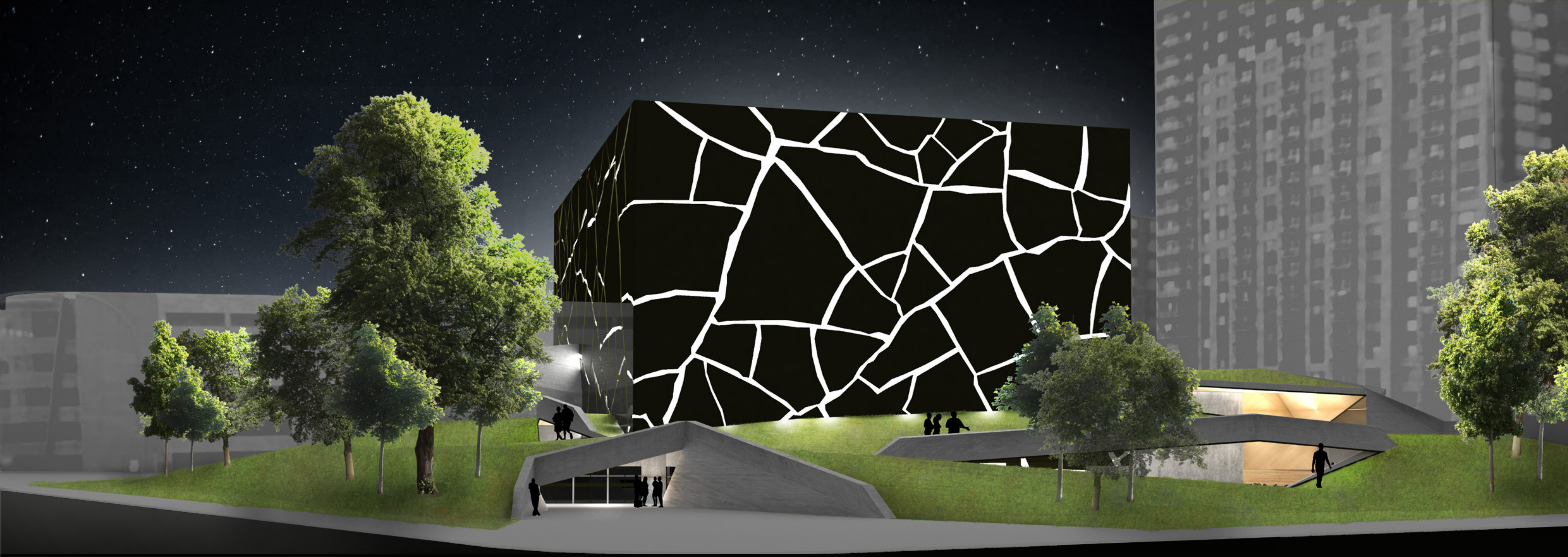
Acoustic measures

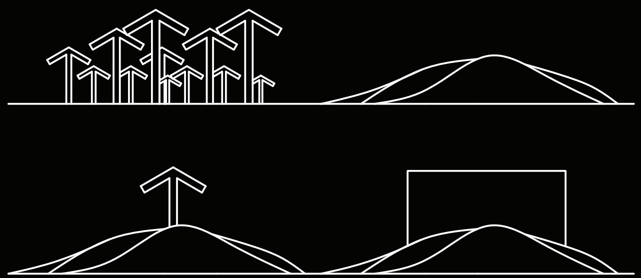


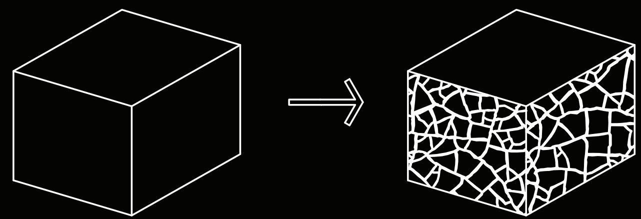
Curved panels

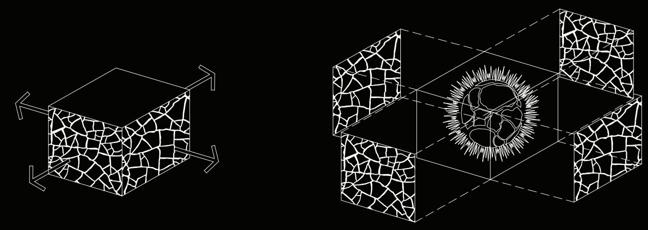
Diffusive walls and stage shell









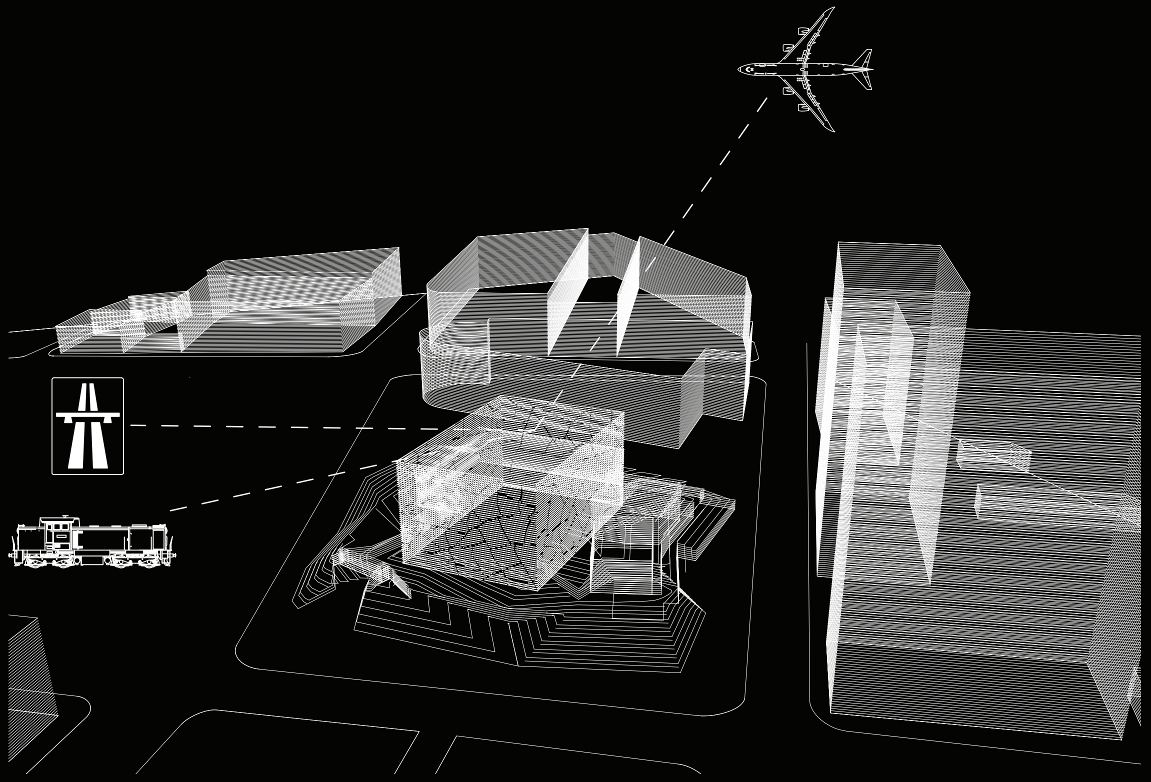


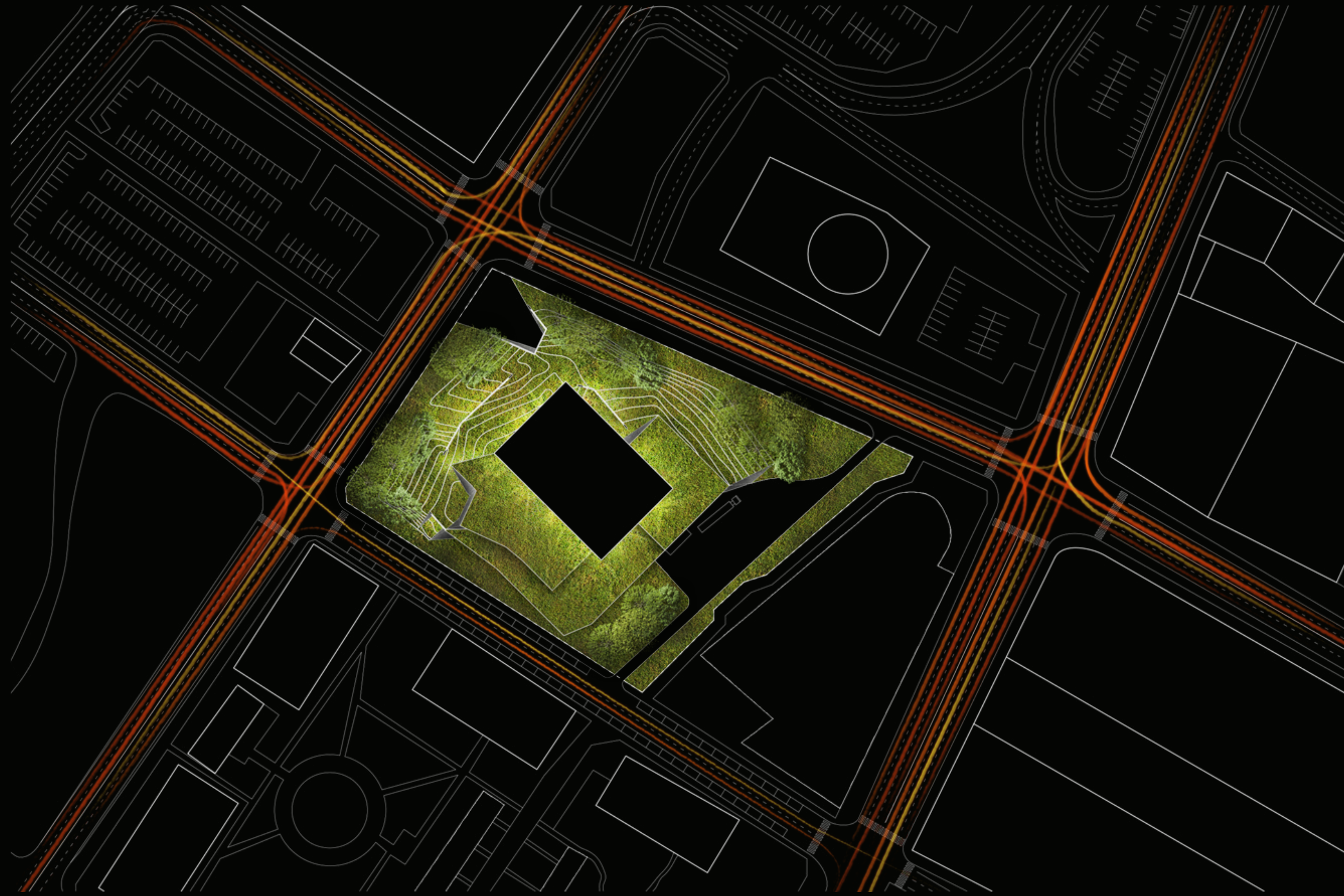
Koncept

För att skapa rum för publika och "backstage" zoner och samtidigt möjliggöra för en offentlig utomhusplats höjs marken upp. I mitten av detta nya landskap placeras en svart monolit.

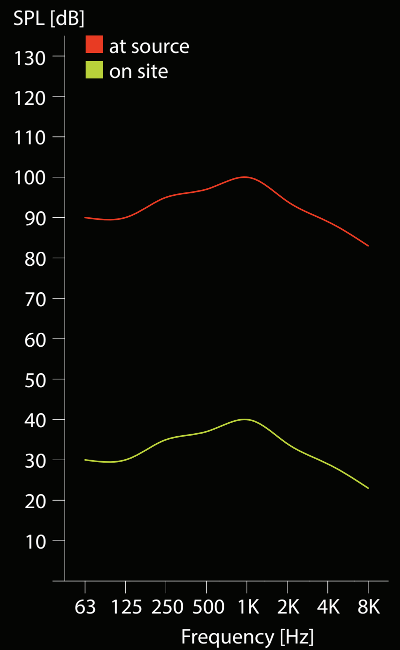
Då en operabyggnad är en byggnad som inhyser verksamhet som verkligen inte hör till det vardagliga borde även byggnaden signalera detta. Fasaden på monoliten får krackelera och bilda sprickor vilket hjälper till att signalera detta.

Obsidian är vulkaniskt glas som bildas av lava. Följande detta tema blir operasalen den svarta stenens lysande kärna.

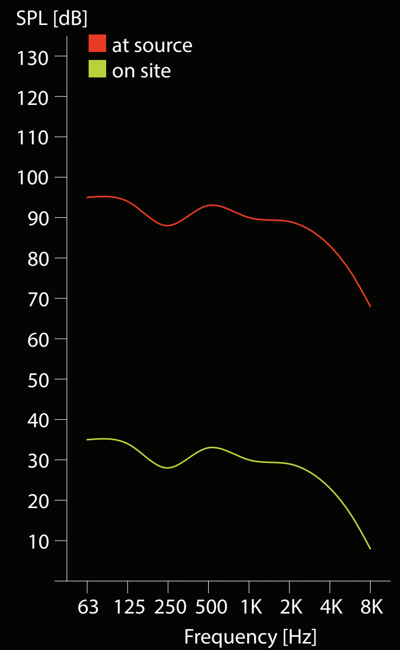




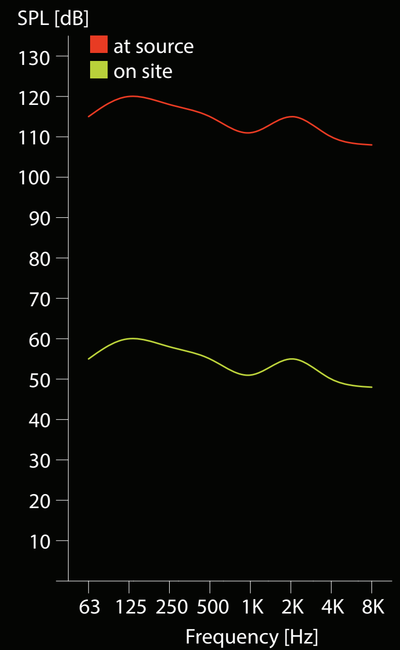
Motorväg



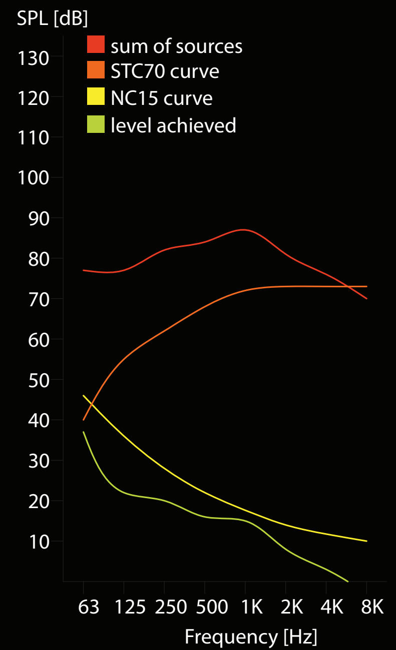
Tåg



Flygplan



Worst case scenario

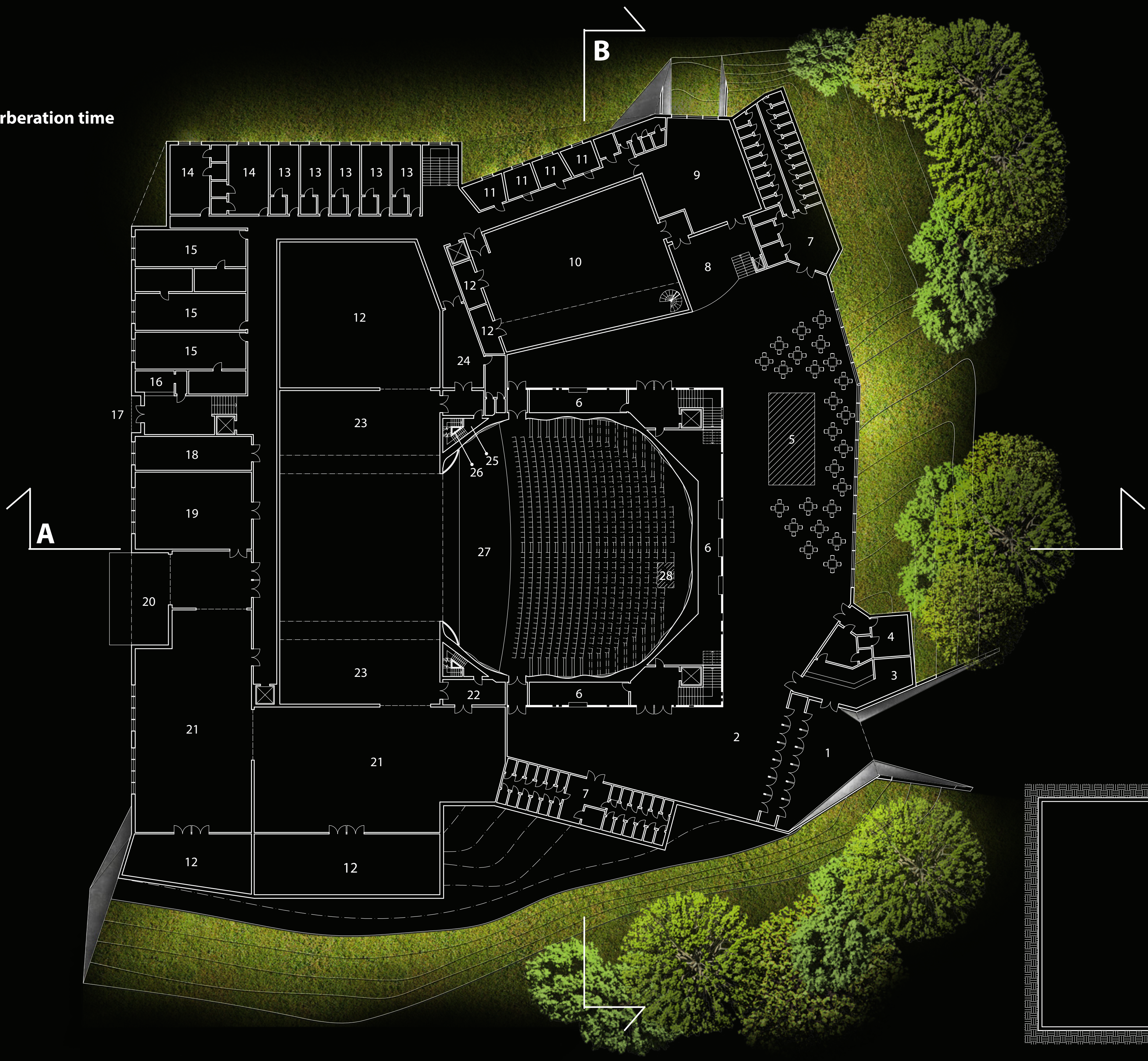


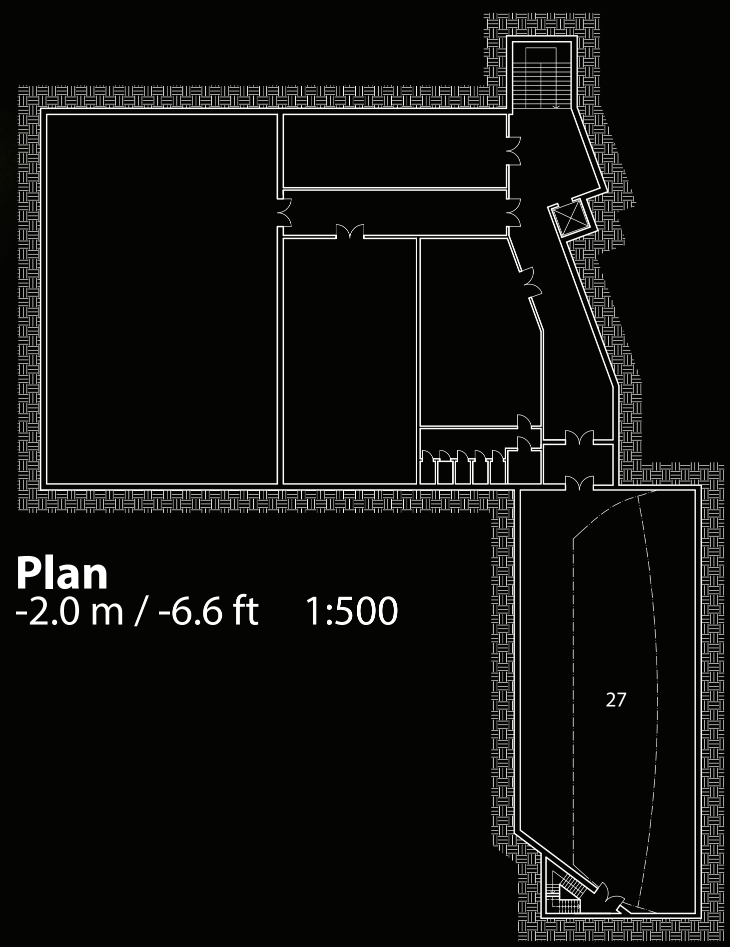
Buller

Att sänka bullernivåer är viktigt i så gott som alla byggnader. I ett operahus är det dock av ännu större vikt då det skapar en grundförutsättning för att ge besökarna en riktigt god ljudmässig upplevelse. Platsen analyseras utifrån de omkringliggande bullret, i synnerhet trafik.

Plan
+2.5 m / 8.2 ft 1:500

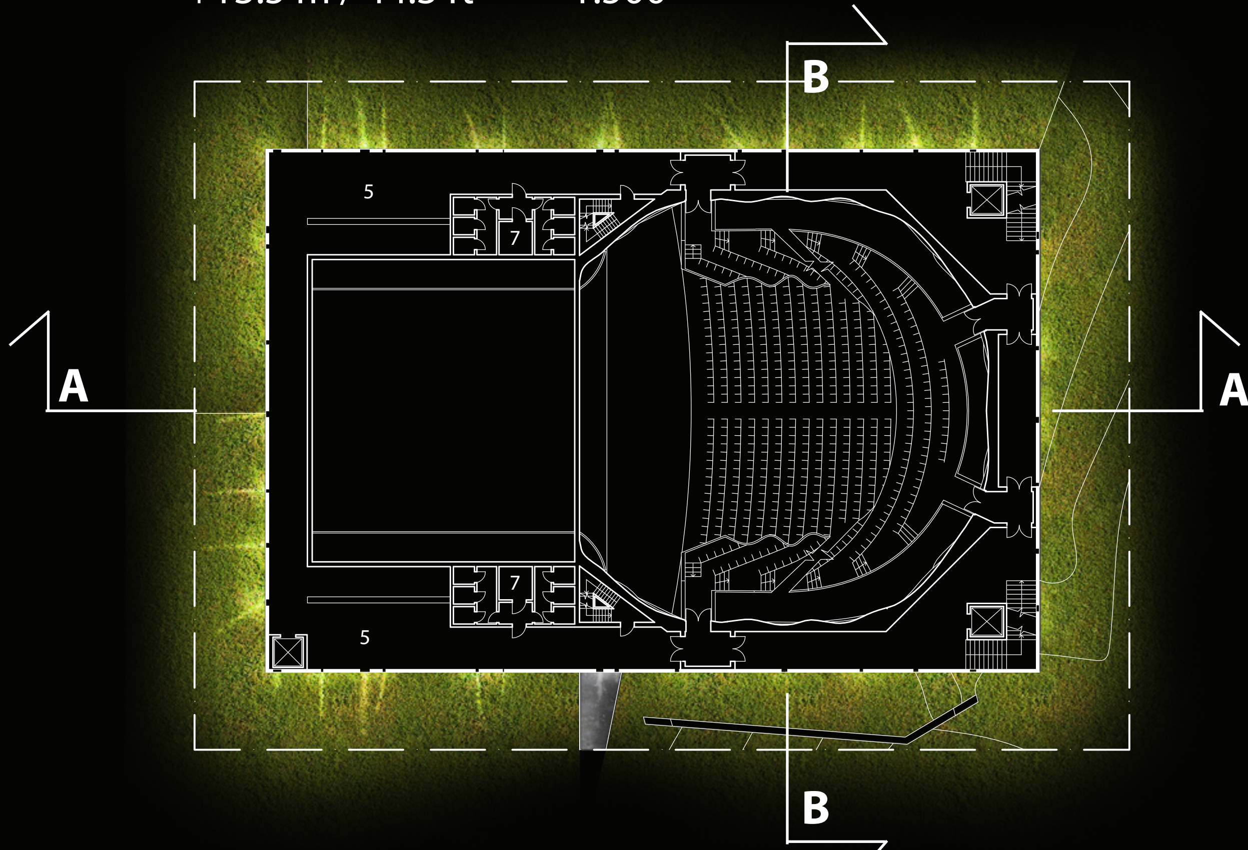
Rooms	Noise Criteria	Reverberation time
1. Entrance	-	-
2. Lobby	NC40	1.1 s
3. Box office	NC35	0.5 s
4. Manager's office	NC35	0.5 s
5. Bar area	NC40	-
6. Cloakrooms	NC40	-
7. Restrooms	-	-
8. Lobby stage	NC40	1.1 s
9. Green room	NC30	0.9 s
10. Rehearsal room	NC20	1.3 s
11. Small rehearsal rooms	NC25	0.5 s
12. Storage	-	-
13. Solo dressing rooms	NC35	0.6 s
14. 4-person dressing rooms	NC35	0,7 s
15. Chorus dressing rooms	NC35	0.8 s
16. Doorman	NC35	-
17. Stage door	-	-
18. Kitchen	NC40	0.6 s
19. Costume/Wig shop	NC40	0.6 s
20. Loading bay	-	-
21. Scene shops	NC40	0.6 s
22. Stage escape	NC15	-
23. Wings	NC15	-
24. Ready area	NC15	-
25. Stairs to service balcony	NC20	-
26. Ventilation shaft	-	-
27. Orchestra pit	NC15	1.1 s
28. Mixing position	NC15	-
29. Orchestra dressing room	NC35	0.8 s
30. Mechanical Equipment Room	-	-



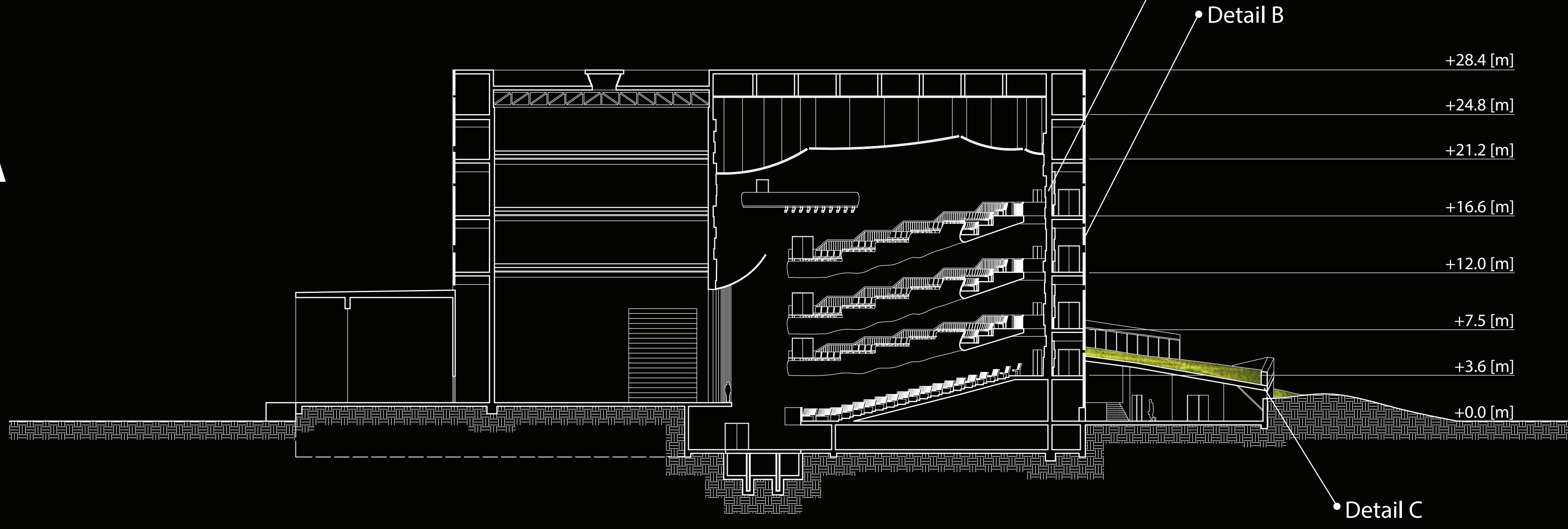


Plan
-2.0 m / -6.6 ft 1:500

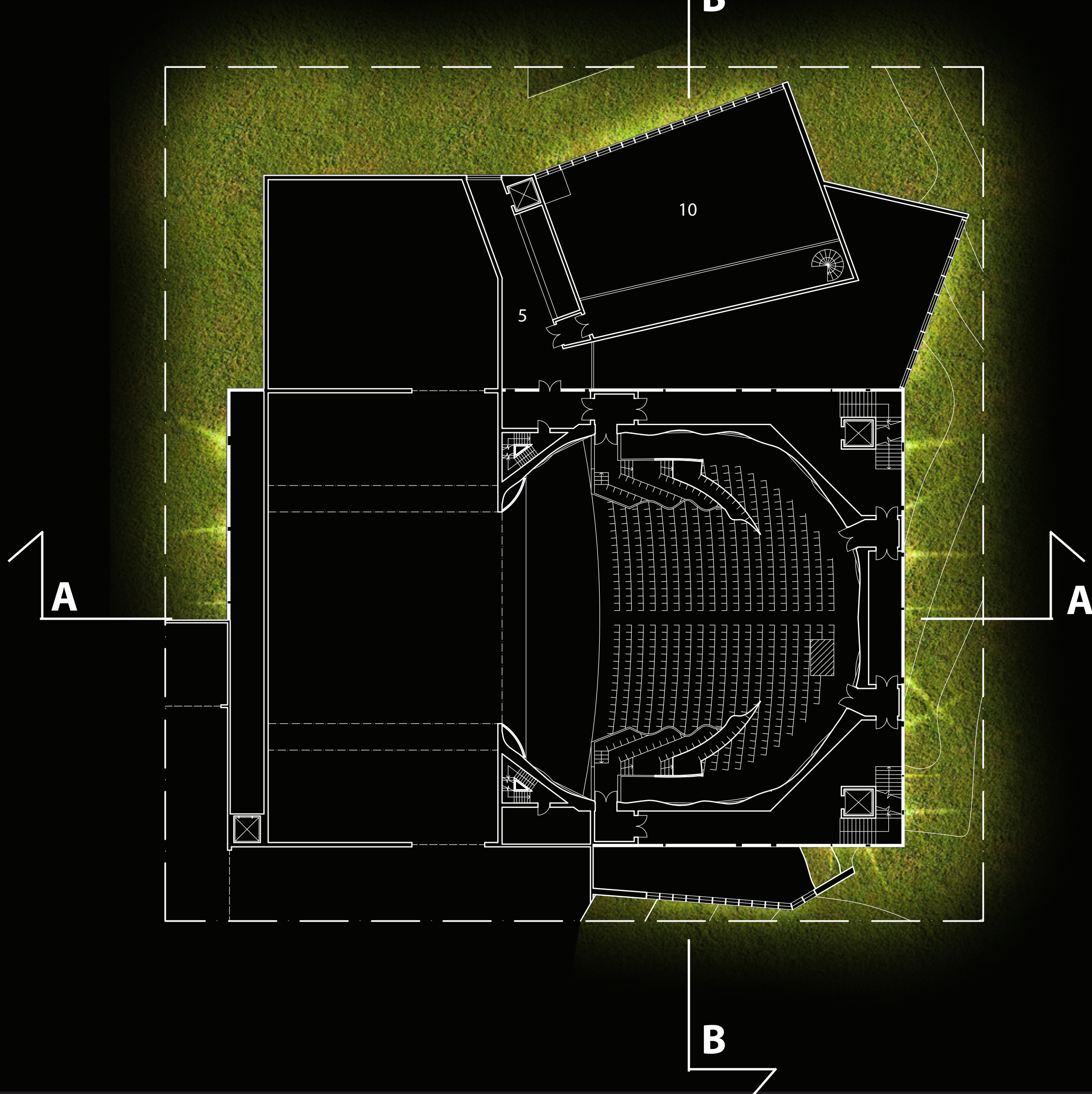
Plan
+13.5 m / 44.3 ft 1:500



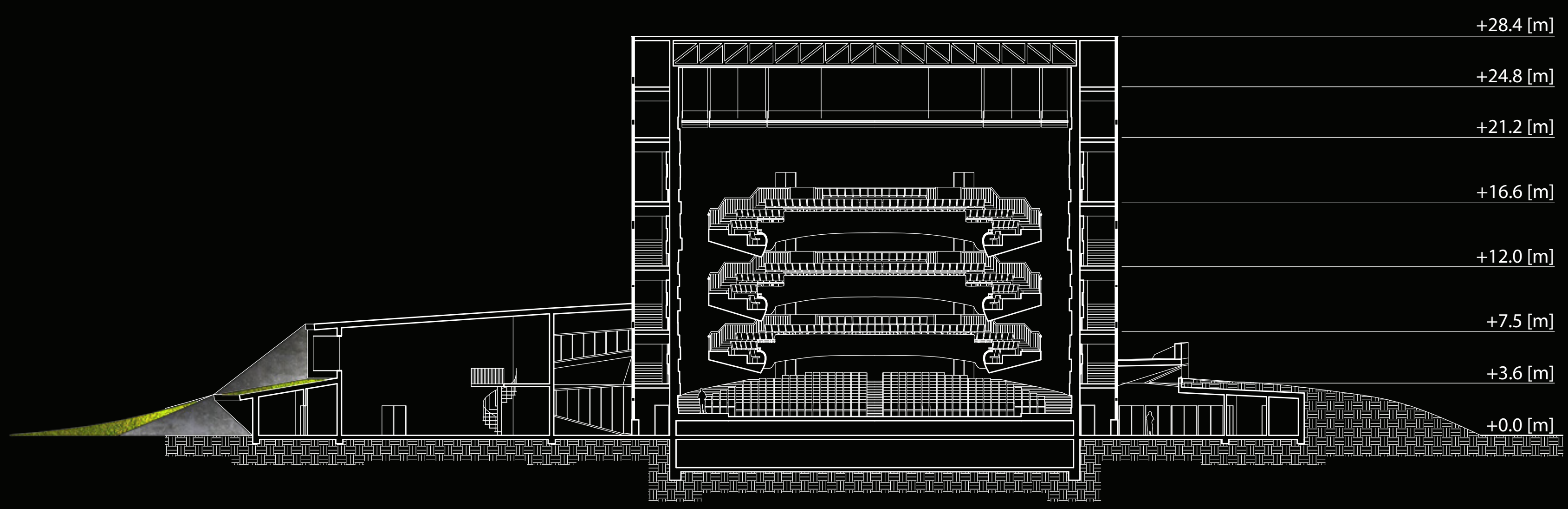
Section A-A
1:500



Plan
+5.2 m / 17.1 ft 1:500

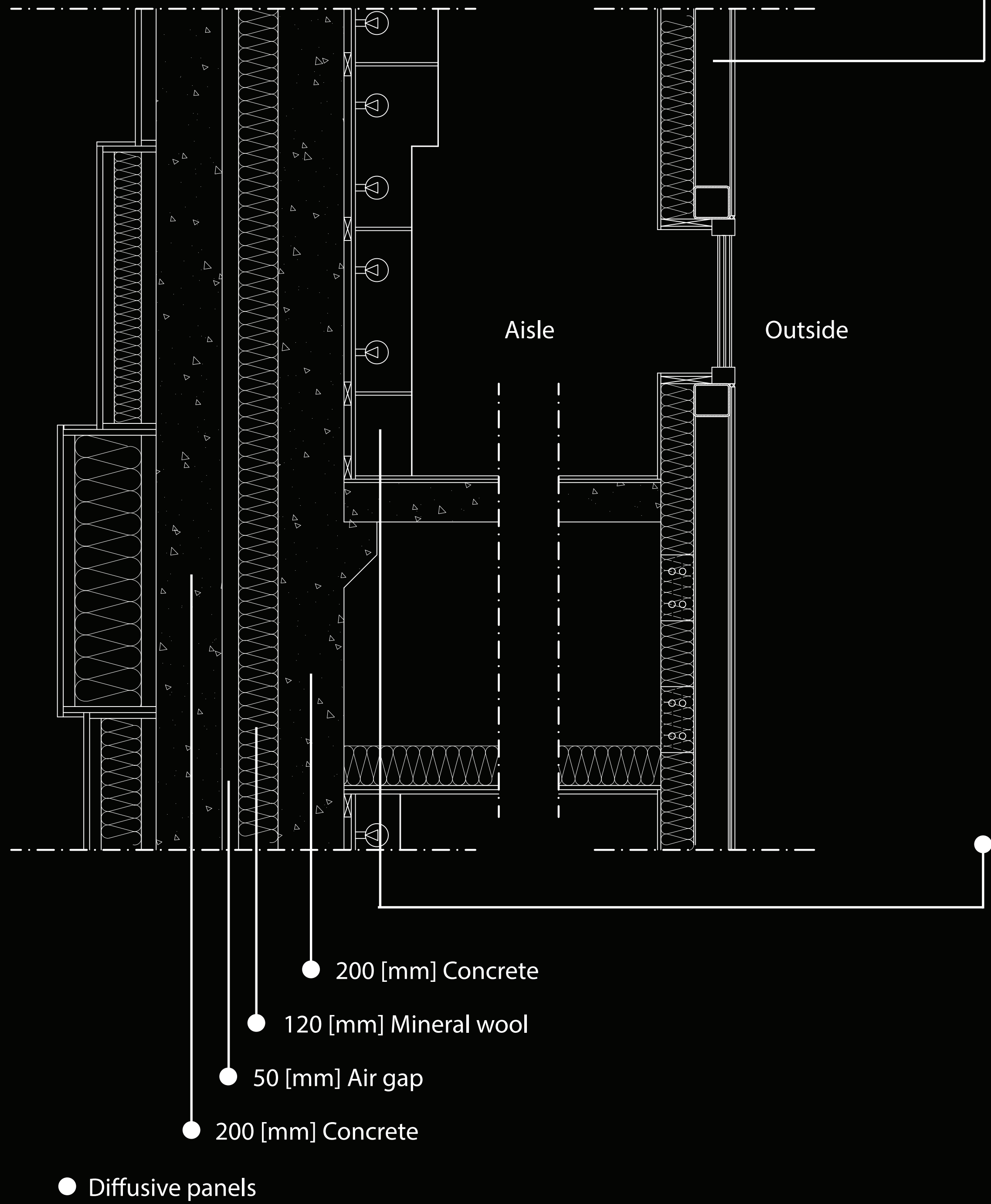


Section B-B
1:500



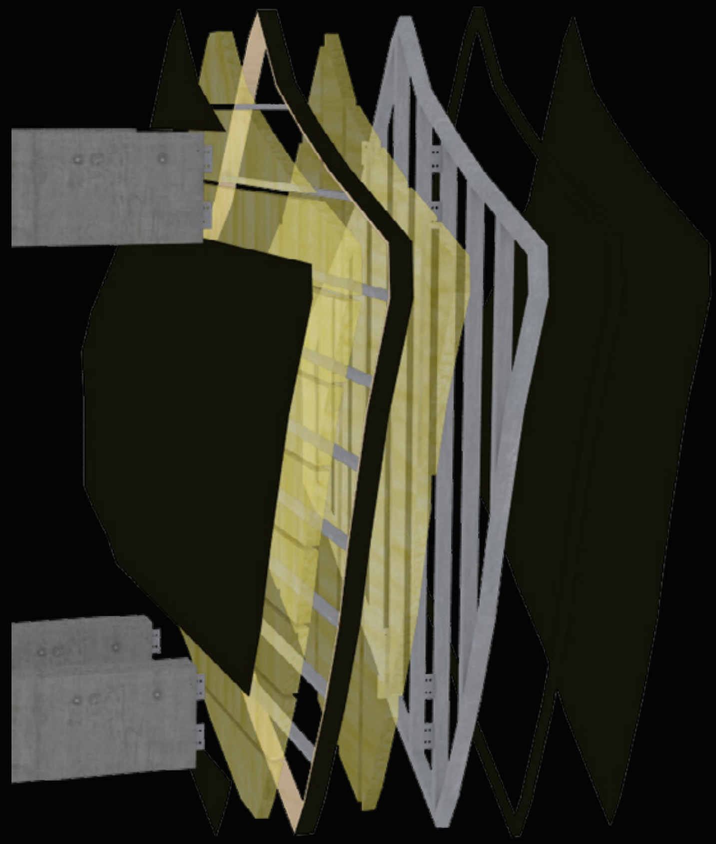
Detail A
Wall section   STC70+   1:20

The auditorium is sound isolated by the room-in-a-room principle. The perimeter walls are separated from the rest of the structure to avoid structure-born noise transmission . By comparison with similar wall structures the sound transmission class is estimated to be above STC70, which guarantees NC15 in the auditorium.



Detail B
Facade

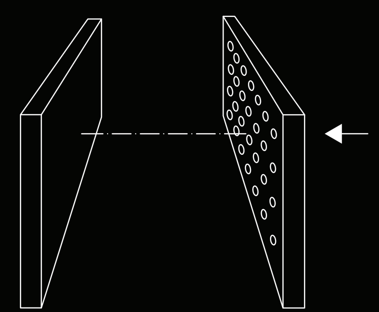
The facade acts as a first front of sound isolation - mainly reducing high frequency noise, because of the light weight. The cracked panels are made of high-pressure laminate, which gives the exterior its black shiny expression. The panels cover a frame construction, which is carried by concrete beams.



Helmholtz absorbers

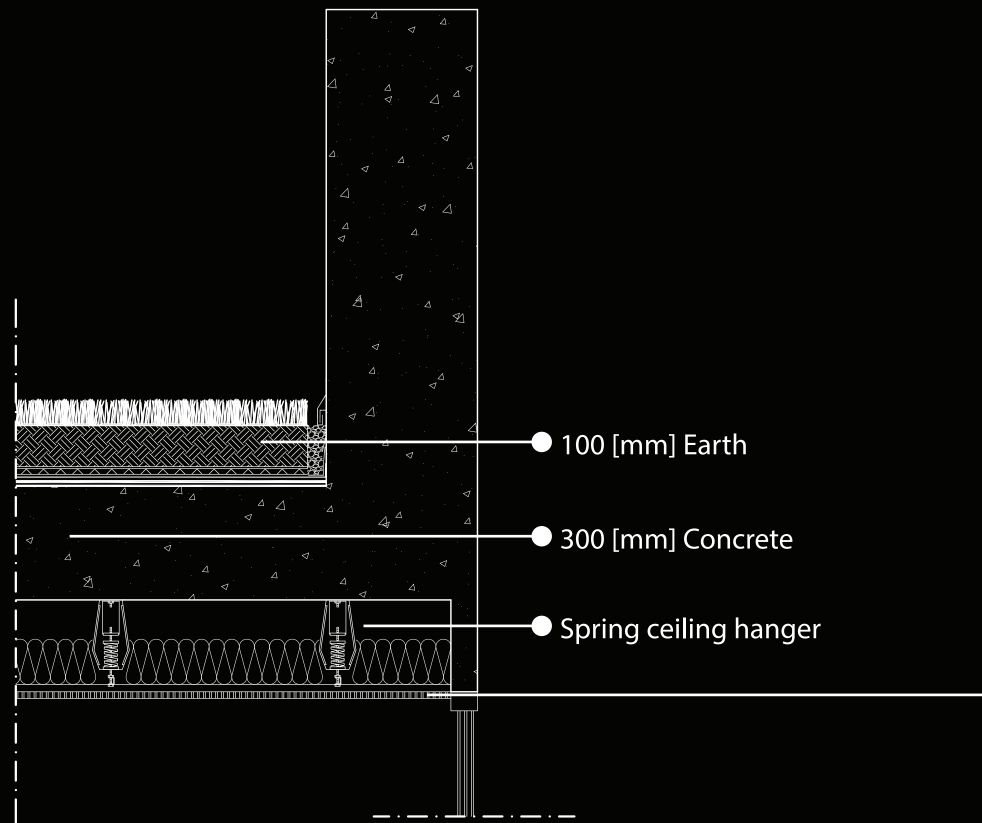
The low-frequency noise, transmitted through the facade is absorbed by microperforated Helmholtz absorbers to reduce noise in the aisles outside the auditorium. The cavity depths are varied in order to cover a wider frequency range. Light fixtures behind the absorbers light the aisles and the outside of the building.

Principle



Detail C
Green lobby roof   1:20

To create a good acoustical environment in the lobby different measures have been taken. Airborne noise is reduced by mass in the concrete walls and roof. Structure-born noise and step sound from passers-by on the roof is taken care of by an earth layer and a spring-suspended ceiling. Since the volume of the lobby is large, the reverberation time is reduced by absorptive perforated wood panels.



Data

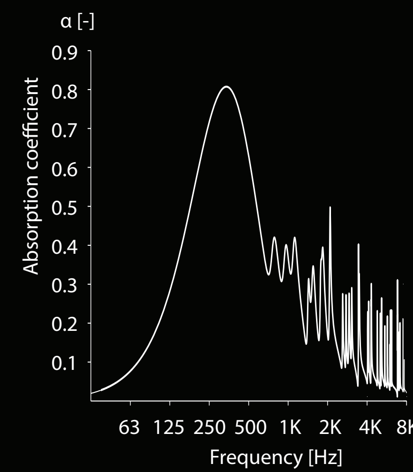
Absorber depths:
100 120 170 200 250 [mm]

Hole diameter:
0.5 [mm]

Hole separation:
2 [mm]

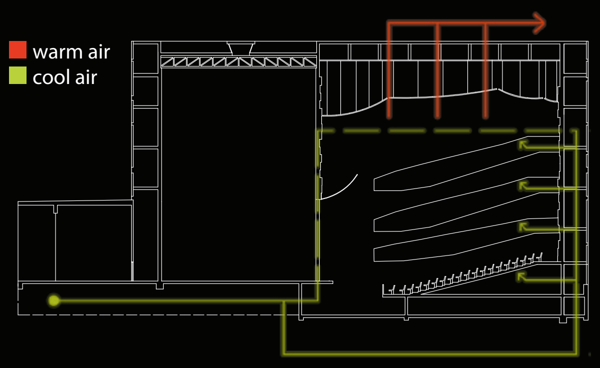
Sheet thickness:
4 [mm]

Result



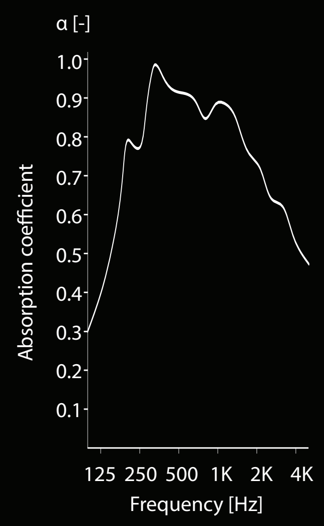
HVAC
Silent air supply

The ventilation is made silent by two methods. Firstly, the MER is placed under the backstage area which has lower noise criteria than the auditorium. Secondly, the air is supplied at low level, under the seats and at low speed. The rising warm air is naturally taken out through the roof.



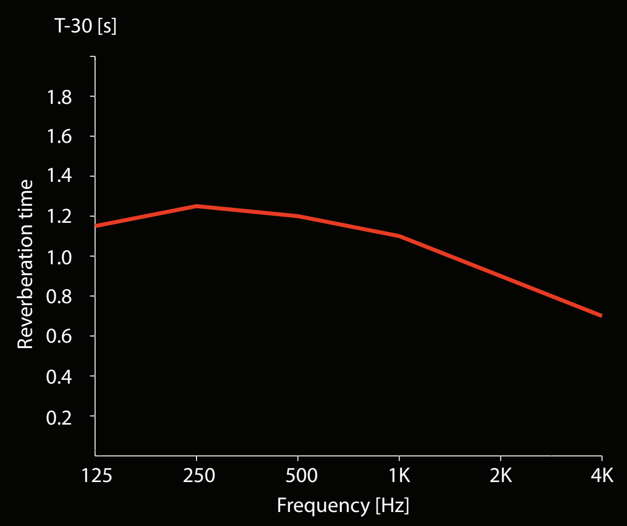
Suspended ceiling

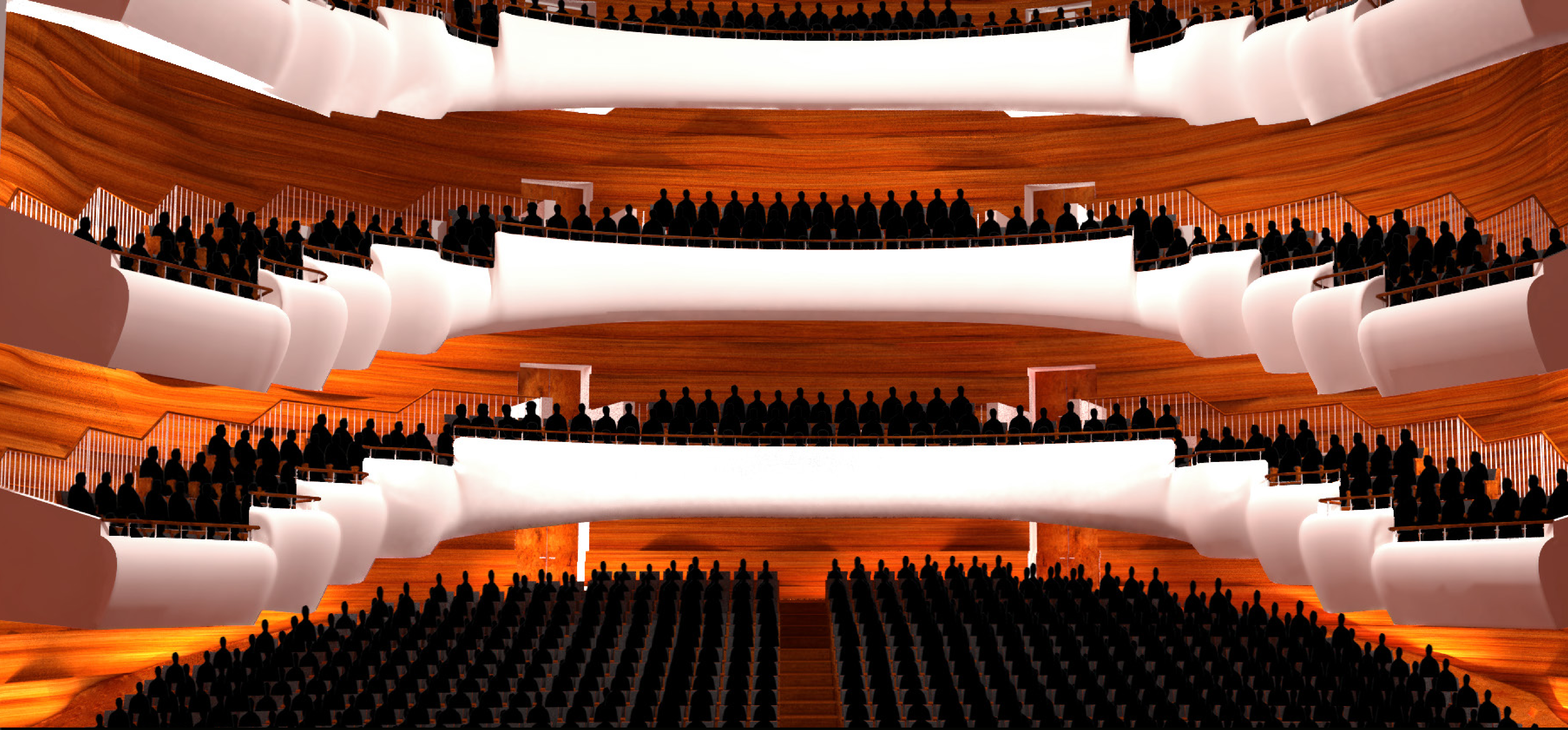
The ceiling of the lobby is covered by perforated wood panels, which, as seen in the graph to the right, have high absorptive qualities. The reverberation time for the lobby was calculated to about 1 second - suitable for intermission mingling as well as foyer concerts.



Lobby reverberation time

Absorptive surfaces reduce the reverberation time in the large open volume of the lobby.





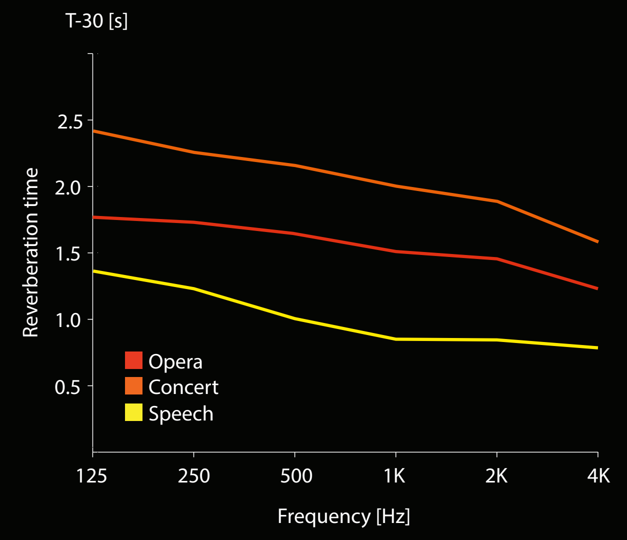
The Auditorium
Acoustical analysis for three modes

The main purpose of the auditorium is for opera performance. Its design is therefore focused on this mode with regards to reverberation time and balance between vocalists and ensemble.

The hall is however also adjustable to suit other performances, such as classical concerts and speech events. This is realized by use of different methods, explained under each of the following sections.

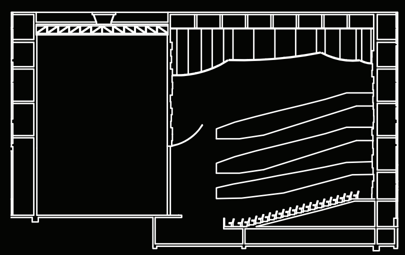
Hall reverberation time

Calculations show that the reverberation time is suitable for each of the three modes of the auditorium. The average is 2.0 seconds for concert, 1.6 for opera and 1.0 for speech.



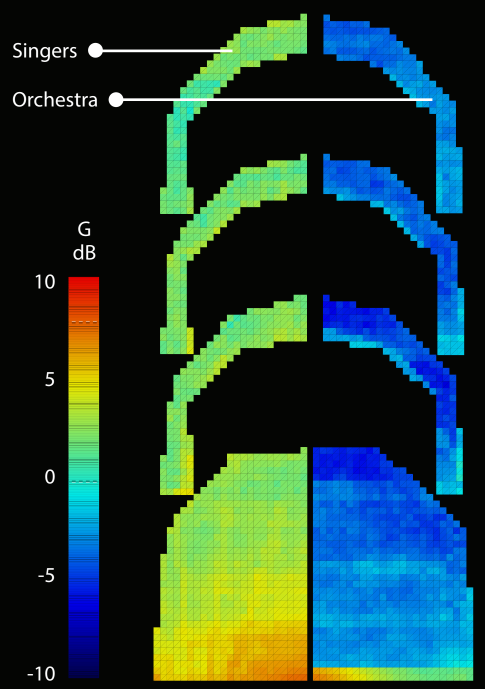
Opera

For opera performances the hall is in its standard mode, as seen in the section to the right. The average height of the ceiling has been calibrated to 22 metres to achieve the appropiate reverberation time of 1.6 seconds.



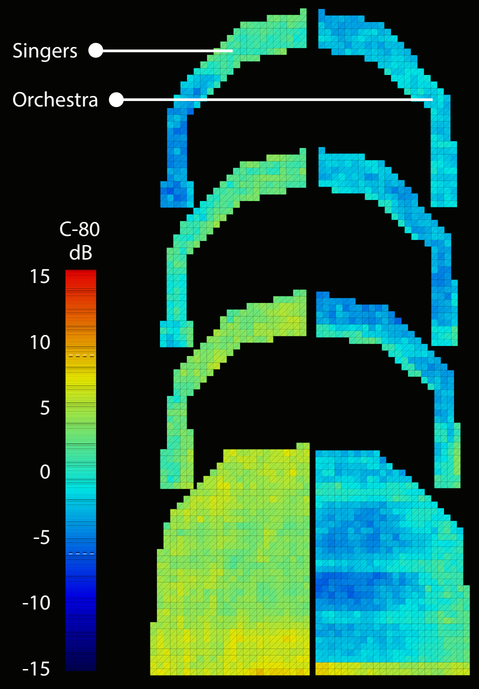
Strength

Analysis shows that the sound strength is good and reaches all parts of the hall. Higher levels for singers than orchestra is also favourable for balance reasons.



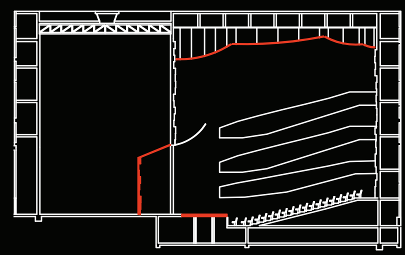
Clarity

Clarity is very important for the singers to achieve intelligibility. The clarity should be lower for orchestra to get a more reverberant sound, which the analysis confirms.



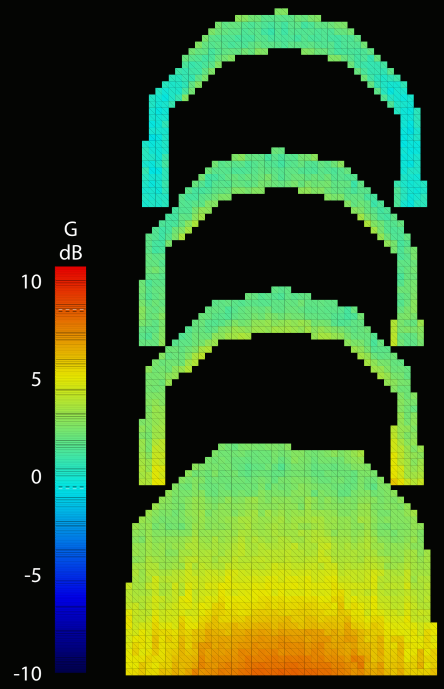
Concert

For classical concerts the reverberation time needs to be increased and thusly the ceiling is raised. To fit the orchestra on the stage, the pit floor is raised and a stage shell is introduced which seals off the stage tower and directs all sound towards the audience.



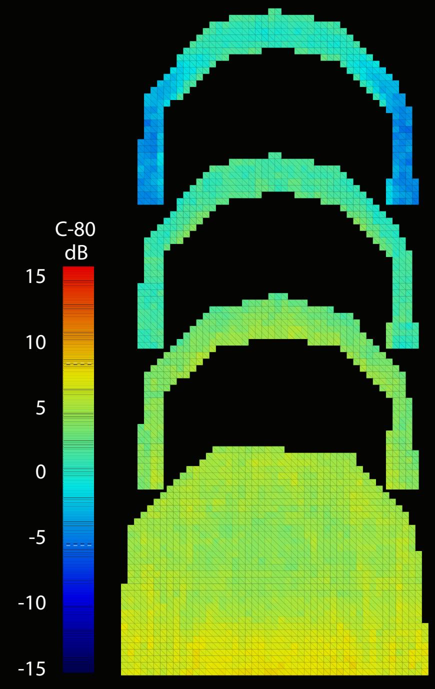
Strength

The analysis shows clearly that the stage shell reinforces the orchestra and gives good values for sound strength. Also, the sound is at good level on all seats.



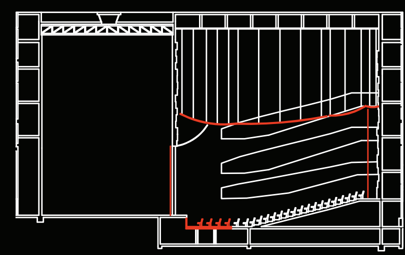
Clarity

Bearing in mind that the hall is mainly an opera, the analysis shows adequate values for clarity in concert mode.



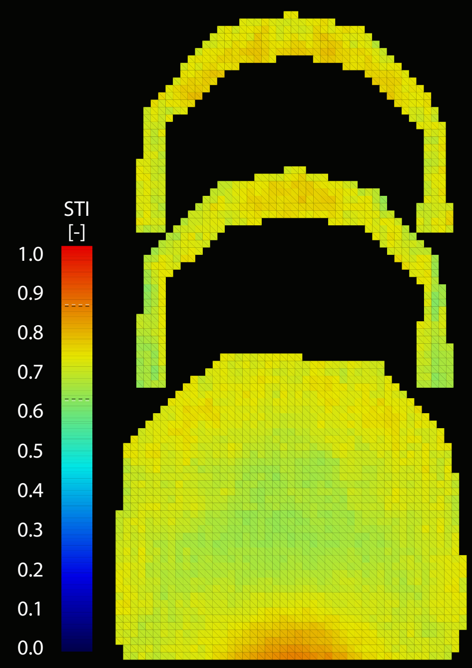
Speech

For speech events, the reverberation time needs to be lowered. Therefore the ceiling is lowered, absorptive curtains are pulled behind the balconies and an absorptive wall is placed behind the stage. The orchestra pit is raised to give room for more auditors.



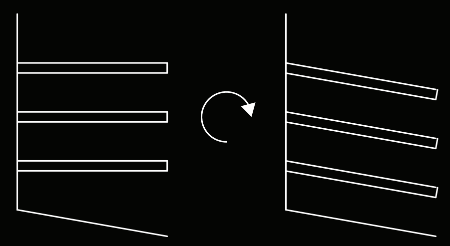
Speech Transmission Index

The measures taken, proves to have a very good effect on the speech intelligibility. All seats, including balconies, have good values of STI.



Balconies
Architectural and acoustic measures

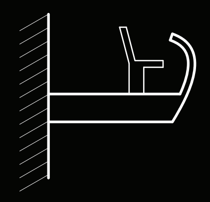
The balconies of the auditorium have been designed so that they will feel as equally part of the room as the orchestra floor. For this reason they have been tilted and directed towards the stage.



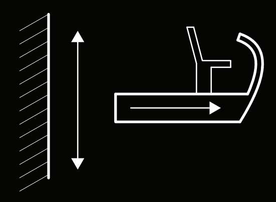
Flying balconies

Normally, the audience in balconies only receive sound from a limited range. By offsetting the balconies from the walls more reverberant sound will reach the listeners and thusly greater envelopment is achieved.

Problem



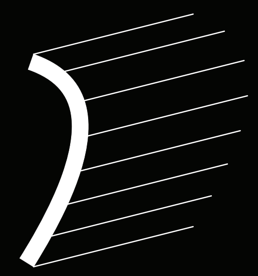
Solution



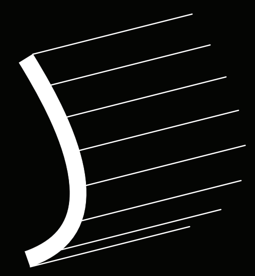
Curved fronts

The balcony fronts are curved to match the interior expression of the hall. They are also used acoustically in that they reflect sound down to the orchestra at the sides (increasing clarity) and spread sound in multiple directions at the back to avoid focussing effects.

At sides



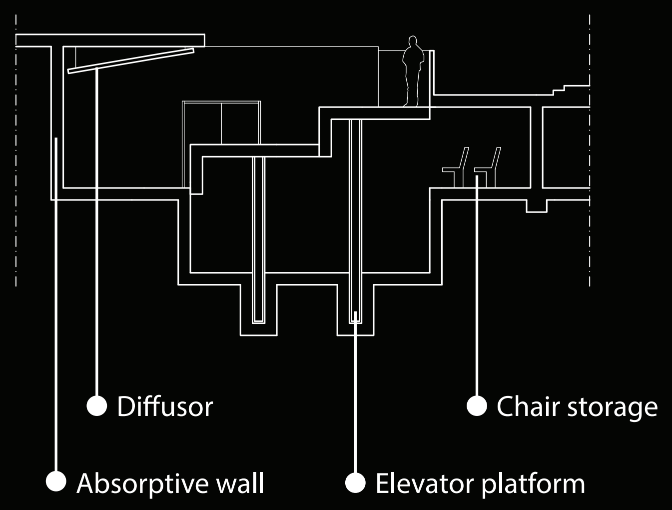
At back



Orchestra pit
Acoustic measures

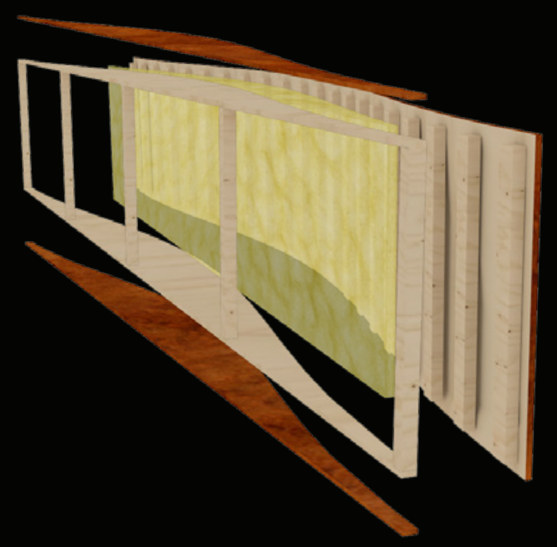
The orchestra pit is semi-open and has adjustable floors to create various settings for the performers and to create a good sound environment. The floors and all walls except the back wall are reflective to spread sound and give good balance with the singers. The back wall is absorptive to reduce the sound level for a good working climate. The ceiling is diffusing to give proper balance in the orchestra.

Section 1:200



Curved panels
Diffusive walls and stage shell

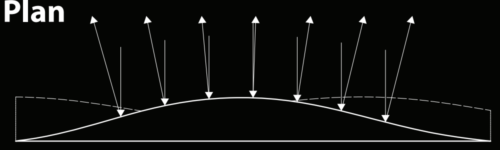
The interior of the hall is designed as a glowing core with walls that are clad with curved wooden panels. When lit upon these panels give the room its warm tone. The panels are also diffusive in order to achieve good acoustical properties of the hall.



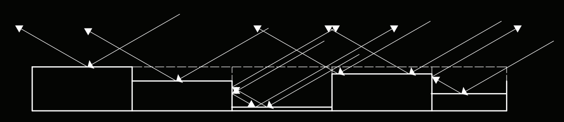
Principle

The walls act as diffusive surfaces in two different ways. The curvature will spread sound waves in multiple directions as seen in the plan illustration below. A section through the walls reveals that they also function similarily to a 2D Schroeder diffusor.

Plan



Section



Stage shell

When the stage shell is introduced for classical concerts it seamlessly blends into the expression of the hall, since the same curved surfaces are used for it. The panels are rigid to avoid sound leakage into the stage tower, and the diffusion is beneficial for the overall sound experience.

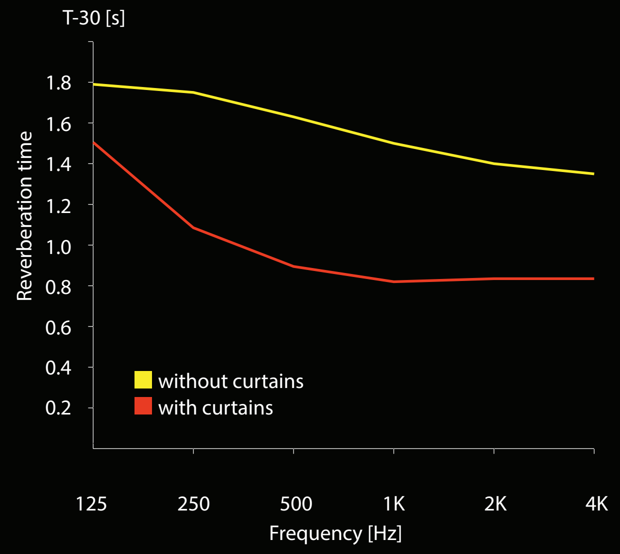
Rehearsal room
Acoustics and privacy

The rehearsal room is designed to give acoustical properties similar to those of the opera hall but in a smaller room. Calculations show that this is achieved with regards to reverberation time as seen in the graph below.

The rehearsal room is also a multi-purpose room. Therefore the reverberation time can be changed by pulling of absorptive curtains in front of the mirror wall.

Rehearsal room reverberation time

The reverberation time can be changed in the rehearsal room to host different events.

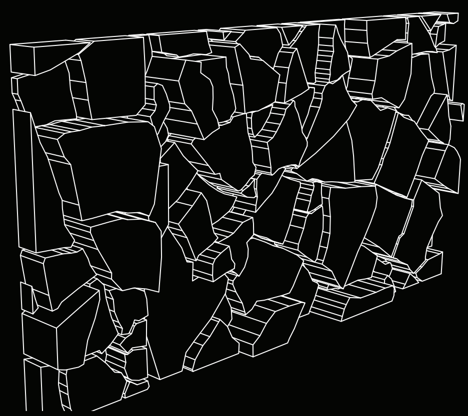


Mirror wall

The mirror wall, purposed for dance rehearsals, can be covered by absorptive curtains when a lower reverberation time is demanded. The opposite wall of the mirror is angled to avoid standing waves when music is rehearsed/performed in the room.

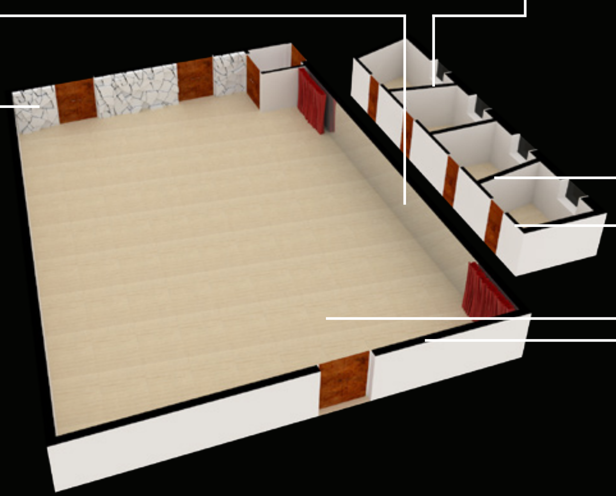
Diffusive wall

Following the exterior concept, one of the side walls is given a cracked displaced pattern. This will act as a diffusive surface and prevent standing waves between the parallell walls of the room.



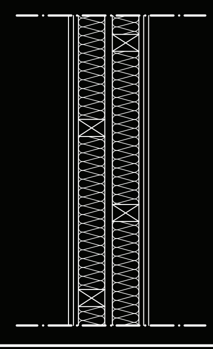
Angled walls

To avoid flutter echo in the smaller rehearsal rooms, the walls are angled in relation to each other. The wall facing the outside is treated with absorptive material as to in some way simulate the conditions of the real stage.



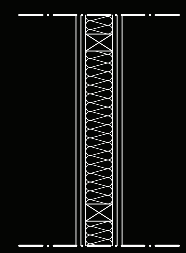
STC 60 wall

12.5 gypsum board
12.5 gypsum board
70 x 45 wooden studs cc450
70 mineral wool
20 air gap
70 x 45 wooden studs cc450
70 mineral wool
12.5 gypsum board
12.5 gypsum board



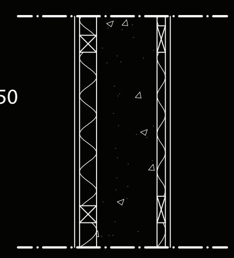
STC 45 wall

12.5 gypsum board
12.5 gypsum board
70 x 45 wooden studs cc450
70 mineral wool
12.5 gypsum board
12.5 gypsum board



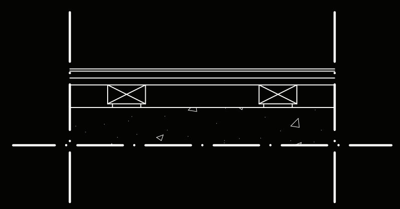
STC 63 wall

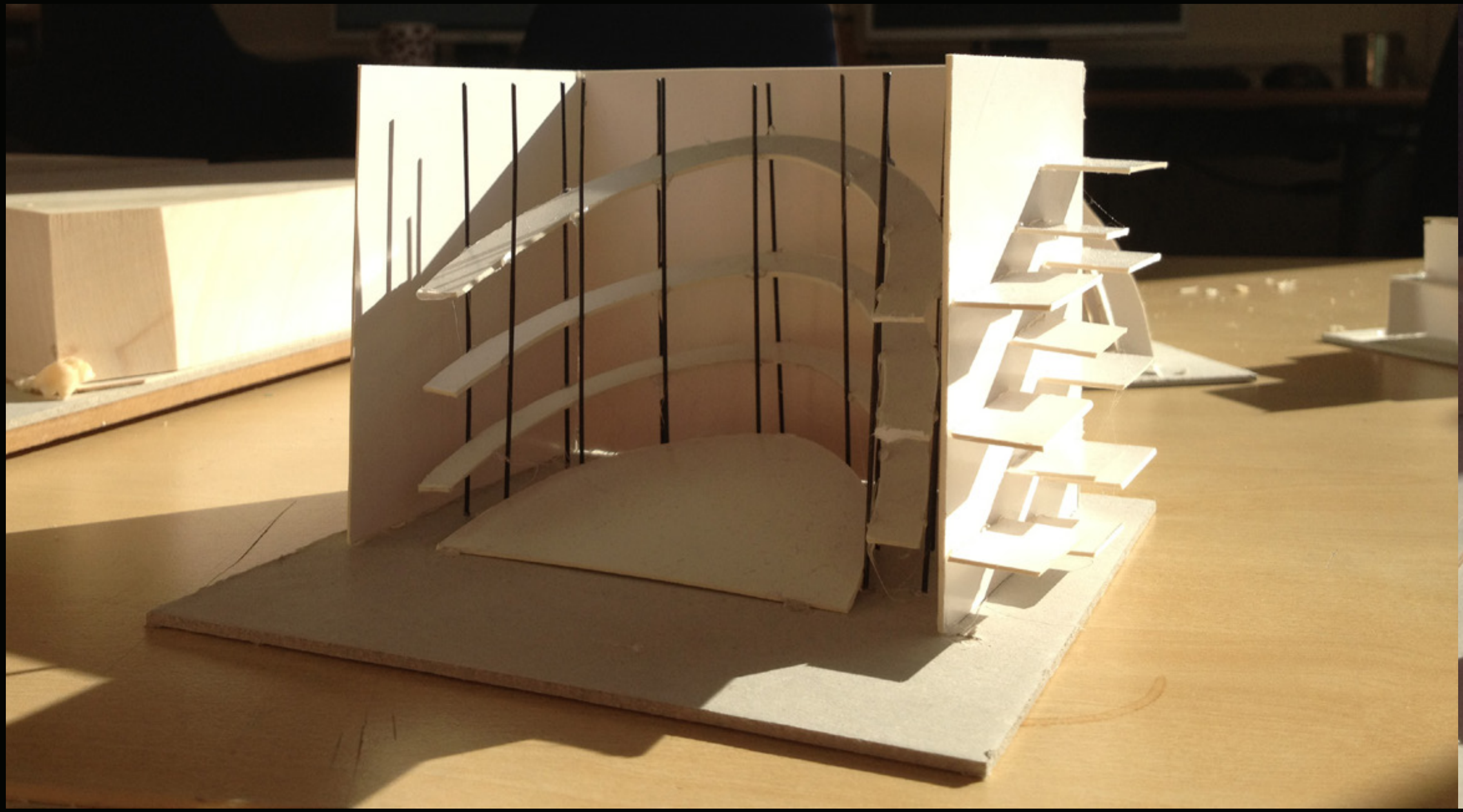
12.5 gypsum board
45 x 45 wooden studs cc 450
45 mineral wool
160 concrete
22x70 wooden laths
22 mineral wool
12.5 gypsum board



Sprung floor

6 wooden surface
18 plywood
18 plywood
50 x 100 battern cc 400
75 x 75 neoprene pad
concrete building pad



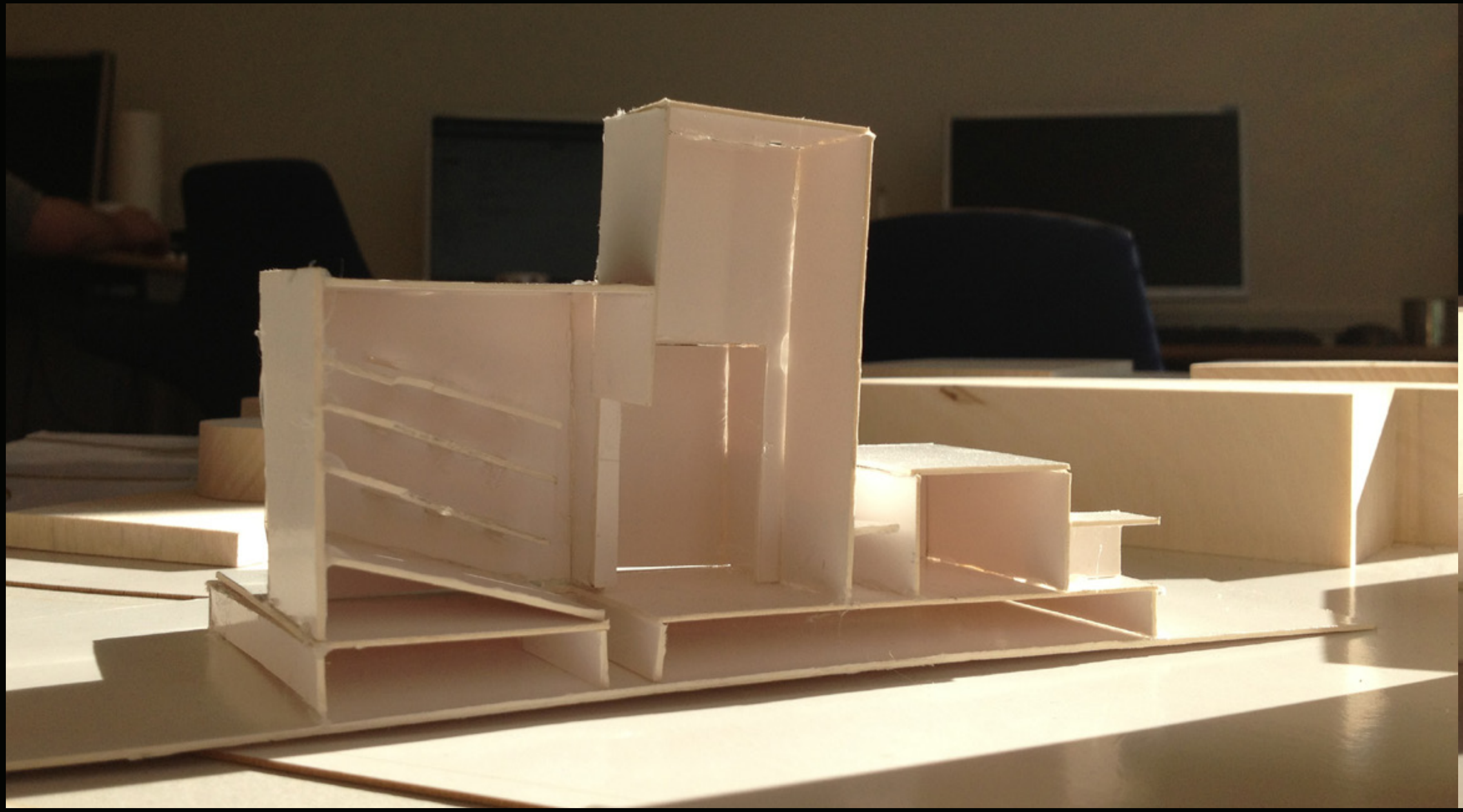


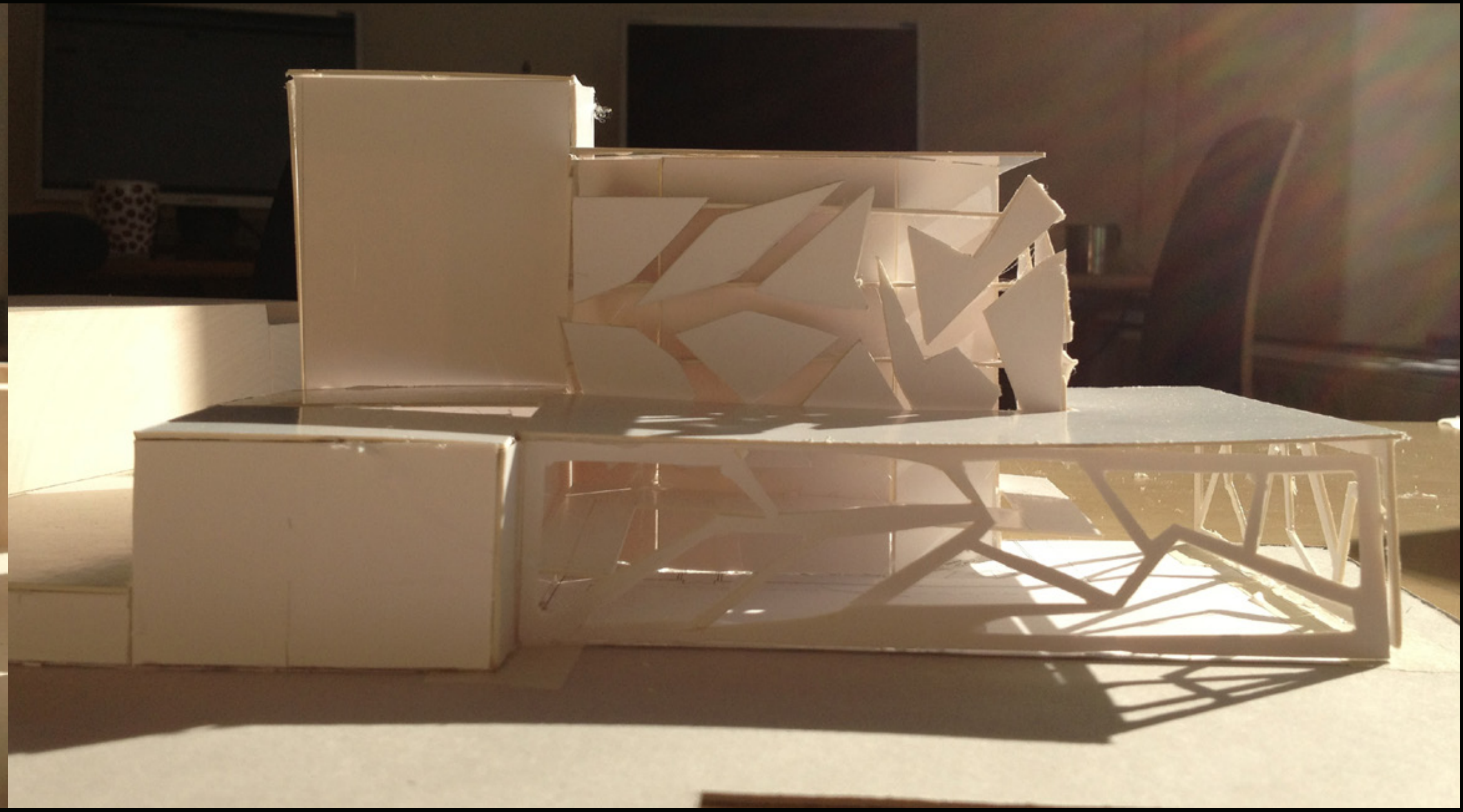
Första tidig skissmodell över operasalen. Fokus låg på balkongernas grundutformning genom att både luta dem och låta dem "flyga", dvs inte sitta fast längs med väggen. Detta behölls hela vägen till den färdiga utformningen.

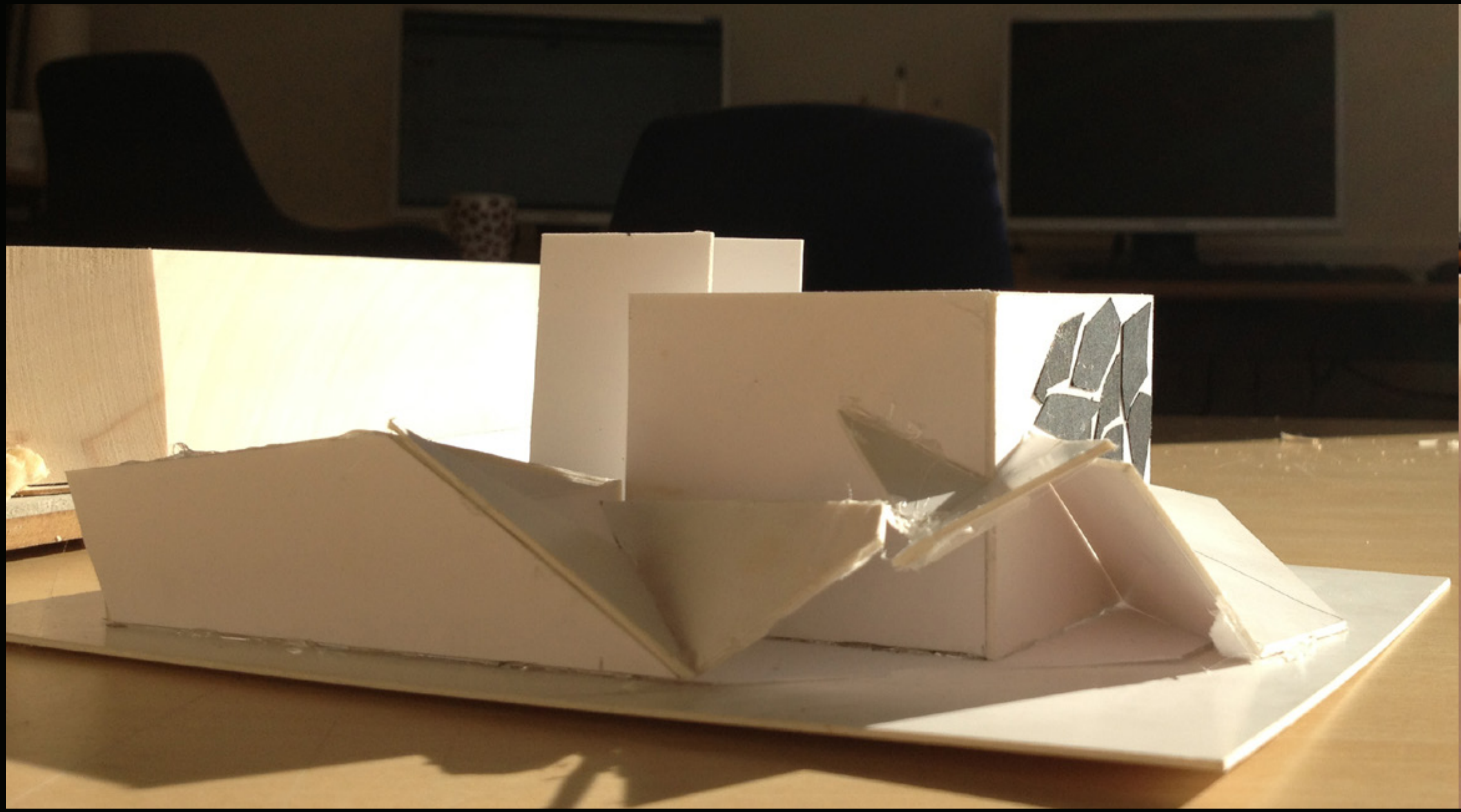
Tidig sektionsmodell genom operasalen. De lutande balkongerna är syns även här. Undersöker bland annat hur man kunde separera scenen från verkstäder för att minska bullerspridning.

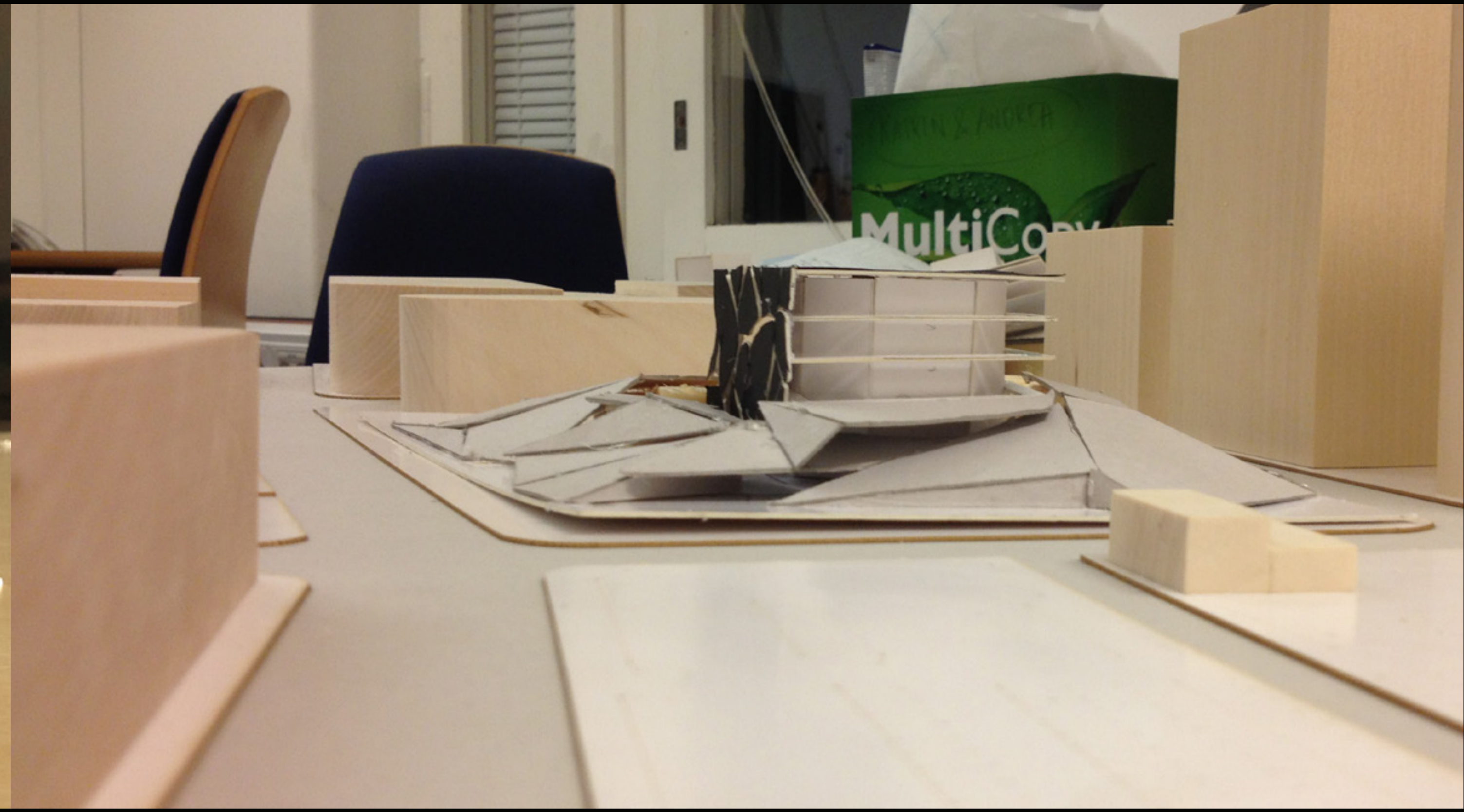
Första koncept angående den yttre utformningen med operasalen insvept i stora plan. Konceptet släpptes ganska tidigt då bland annat det var en omöjlighet att fylla all yta med det proramet efterfrågade.

Första steget in i det slutgiltiga konceptet. Idén om en sprucken sten har börjat växa fram. Finns en idé om att låta lobbyns fasad vara en invertering på sprickorna med karmar där stenen har sprickor och glas där stenen har skivor.







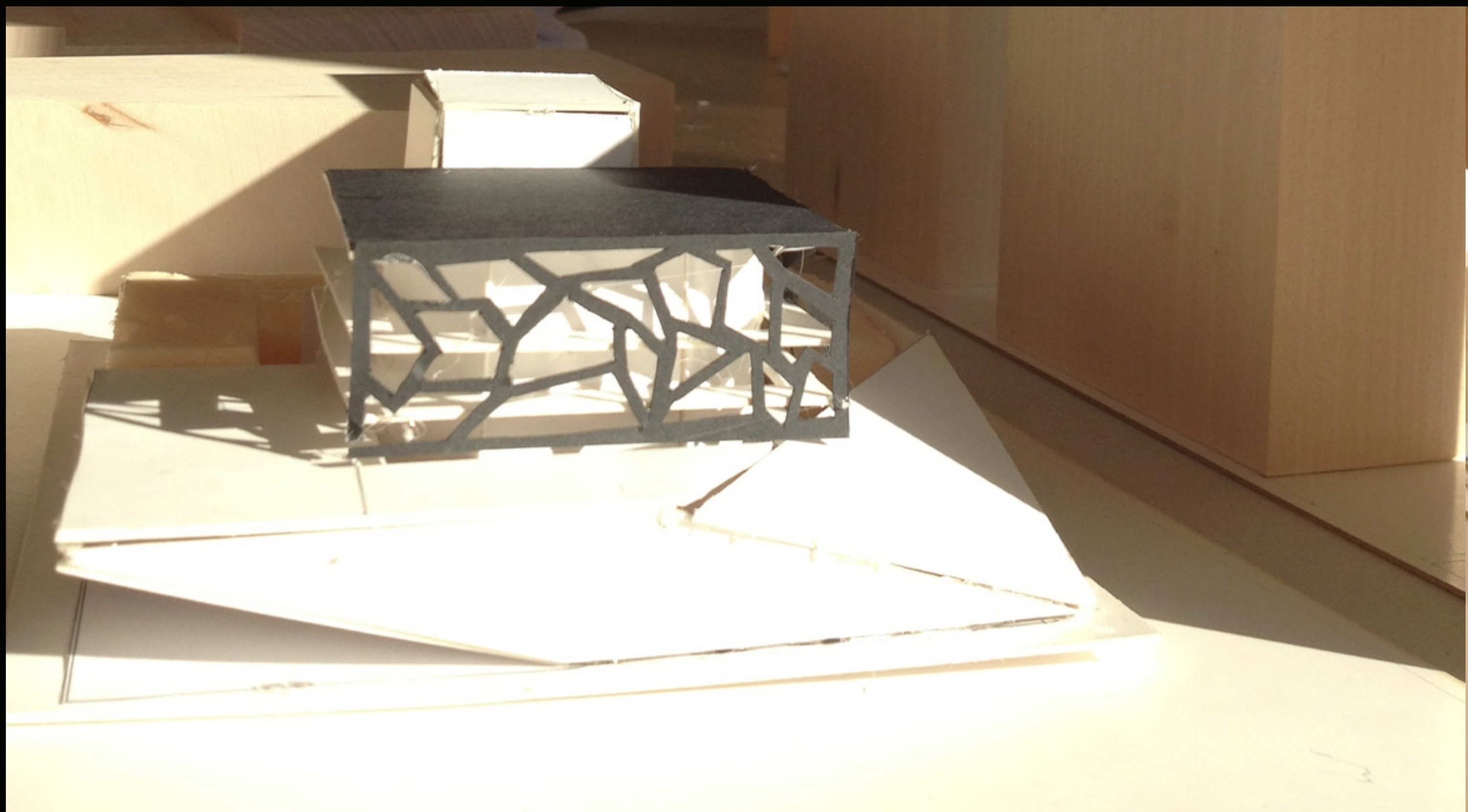


Modell som börjar behandla inén om att lyfta upp marken och skapa ett nytt landskap med funktioner under.

Landskapet börjar rafineras och planas ut för att ge möjlighet att även kunna vistas ovanpå det. Test av en idé att invertera fasaden för att få in mer ljus, vilket slopas.

Halvklar version av den slutgilltiga skissmodellen. En viss anpassning har gjorts för att möjliggöra en inbyggning av scentornet i monoliten. Landskapet har rafinerats ytterligare och lyfts upp på sina ställen för att skapa möjligheter för ljusinsläpp. Man kan även se gångarna som leder in till balkonen.

Den slutgiltiga skissmodellen. Liknar i stor utsträckning det färda förslaget. En stor svart sprucken solitär i ett upphöjt landskap. Landskapet omarbetades senare ytterligare för att anpassas bättre till planer, sektioner och ljusförhållanden.



Reflektion

Överlag är jag mycket nöjd med projektet. Jag tycker att vi lyckades hitta ett starkt koncept som skiner igenom hela byggnaden och dess karaktär. Den svarta stenen och operasalen tycker jag fungerar bra ihop. Vi ville skapa en byggnad som sticker ut och det tycker jag vi lyckades göra.
Det upphöjjda landskapet tycker jag fungerar bra. Det ger både möjlighet att använda den yttre miljön som en park för allmänheten och ger byggnaden ett interessant uttryck.

Planerna är jag nöjd med, men hade kunnat optimerats ytterligare med ett antal fler iterationer. Överlag tycker jag dock de fungerar bra med avseende på de olika delarnas funktioner och har en karaktär som signalerar att det är en byggnad med en speciell verksamhet och ingen bostad eller ett kontor.

En stor del av projektet var att jobba med akustiken. Här tycker jag vi lyckats bra, men med utrymme för förbättring. Balkongernas utformning och placering en bit från väggen gillar jag, och verkar även fungera relativt bra enligt vad vi ville åstadkomma. Det finns dock en hel del i form av refletorer och liknande som hade kunnat förbättra akustiken ytterligare, som inte har behandlats fullt ut.

Överlag är jag nöjd med hur vi löste den komplexa och svåra uppgiften och tycker att det varit ett spännande, lärorikt och roligt projekt att jobba med.