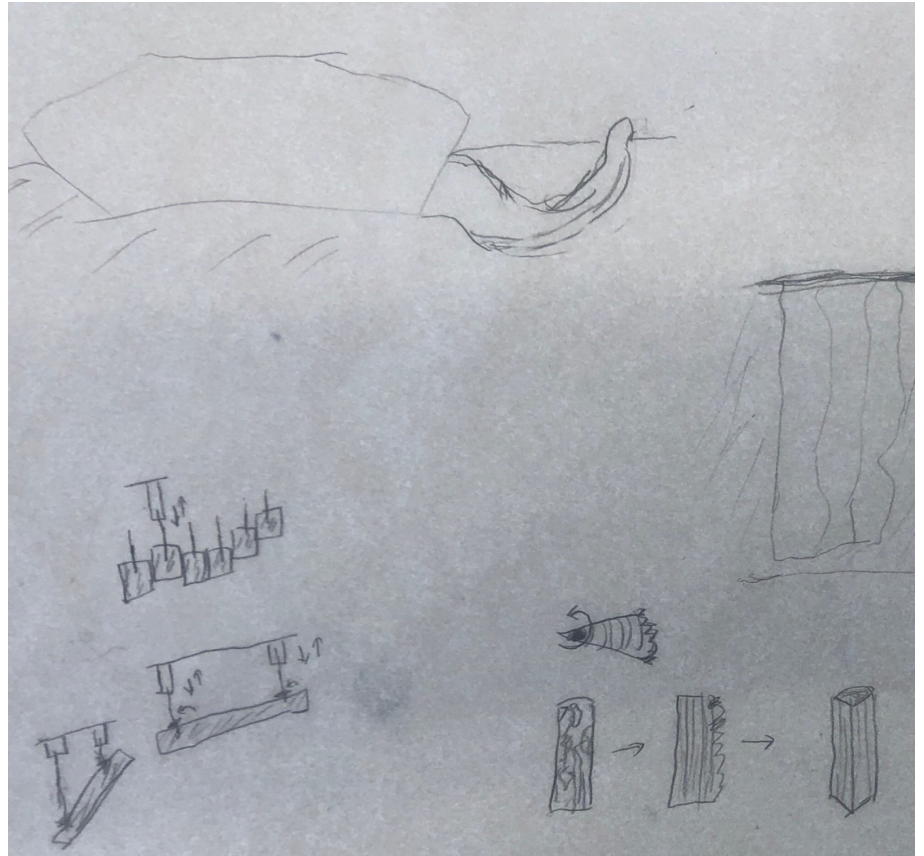


A Brilliant Theater

Architectural
Journey
and
Acoustic
Materials

Loke Lennartsson

Bachelors Thesis in
Architecture and Engineering



The project

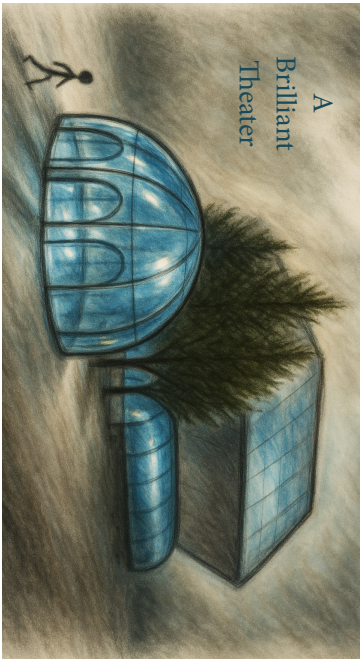
The core of the bachelor's thesis for Architecture and Engineering is the making of a proposal for the international student competition held by the Newman Student Award Fund and the Acoustical Society of America. This year's competition program was to design a 700-seat theater for a university that provides a strong drama, vocal and dance program.

The most important part of the project was to make sure the proposal had sufficiently high quality in both architectural design and acoustic performance. In order to make the latter part possible, our group of Architecture and Engineering students collaborated with students from the master's program for Applied Acoustics.

Further, to supplement the sparse competition program, we were encouraged to account for other architectural and engineering considerations. Among these were location, daylight, color and construction.

Our concept, briefly

Our concept took its form from two different angles, one being the exterior volume of our proposed building, the other being the interior material choices of the theater hall. The exterior is characterized by the combination of two shapes, the main volume is an octagonal sort of crystal shape, and the lobby is a round and more organic piece. The interior of the theatre hall has walls lined with pillars of wood with the bark left on them, and a ceiling covered in stone plates. The two different angles of approach converged with creating a journey for the visitors, who are taken underground, seemingly entering a cave before finally arriving at the theater hall.

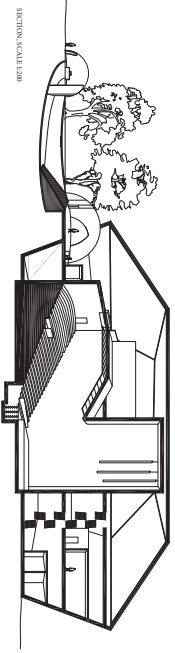


VIEW FROM OUTSIDE THE ENTRANCE

A Brilliant Theater

The building sits on a slope, with the main backstage functions placed on the bottom. This places part of the theater hall and rehearsal hall below ground, which greatly reduces the amount of space needed for the building. The theater environment outside it is also above the underground lobby, greatly insulating the world from the ground.

The lobby consists of a glass dome, seemingly separate from the diamond shaped main building. The dome is made of glass and is supported by either stairs or elevators as they descend. The air is filtered once, making the lobby an environment that has been cut in place, giving it a unique atmosphere.



SECTION, SCALE 1:200

uneven, but otherwise untreated, creating a cave-like atmosphere, both visually and acoustically. Crystal-like air is also flowing.

A great staircase leads up to a second dome. The movement upward. There are also elevators, for the sake of accessibility, back above ground, the lobby branches into two glass corridors leading into the rehearsal hall and the theater hall. They are headed to, or if they are headed to the rehearsal hall, the dome is above ground, creating a cave-like atmosphere. The glass is not the lobby.

Theater hall

The theater hall is a circular room, allowing all visitors a good view of the stage. Visitors enter the hall from the back and descend the stairs as they enter the theater.

The ceiling of the theater hall is covered in stone, unevenly, but otherwise untreated, creating a cave-like atmosphere, both visually and acoustically. Crystal-like air is also flowing.

A great staircase leads up to a second dome. The movement upward. There are also elevators, for the sake of accessibility, back above ground, the lobby branches into two glass corridors leading into the rehearsal hall and the theater hall. They are headed to, or if they are headed to the rehearsal hall, the dome is above ground, creating a cave-like atmosphere. The glass is not the lobby.

Courtyard

Since the diamond shaped volume of the building is so large, it is necessary to have a courtyard. The courtyard is a central space, with a view of the theater hall. This provides the building with a view of the theater hall.

Acoustics

The large wooden pillars that the walls are made with are irregular in shape, creating a unique atmosphere. The pillars are made of wood, and the walls are lined with wooden panels. The pillars still have bark on them, as if someone had taken them directly from a tree. The walls are also covered in stone, creating a cave-like atmosphere.

Another feature that makes the acoustic performance variable is the ceiling, which consists of stone plates of various sizes and shapes. The ceiling is made of stone, and the walls are lined with wooden panels. The pillars still have bark on them, as if someone had taken them directly from a tree. The walls are also covered in stone, creating a cave-like atmosphere.

Noise

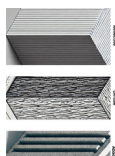
To reduce sound transmission from the courtyard, the walls are lined with wooden panels. The pillars still have bark on them, as if someone had taken them directly from a tree. The walls are also covered in stone, creating a cave-like atmosphere.

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VIEW FROM THE LOBBY

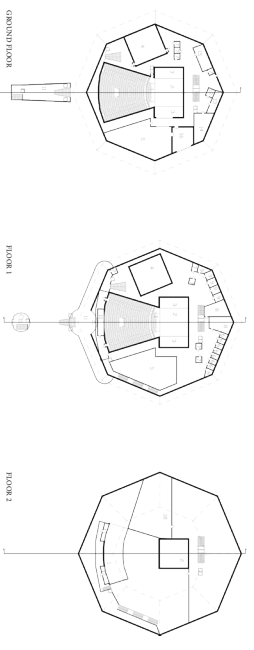


ADAPTIVE MATERIALS: CONCRETE FEATURES

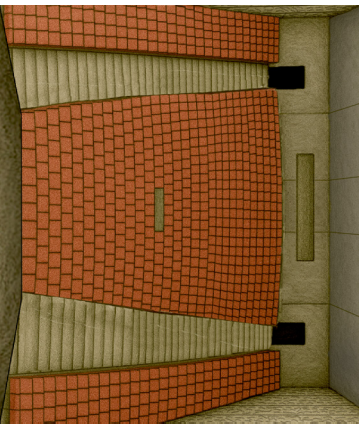


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- 3. Concrete wall (100 mm)
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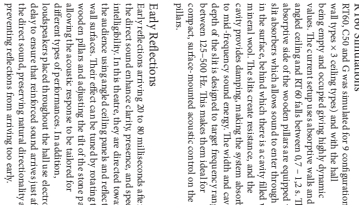
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VIEW FROM INSIDE THE THEATER HALL



VIEW FROM INSIDE THE THEATER HALL

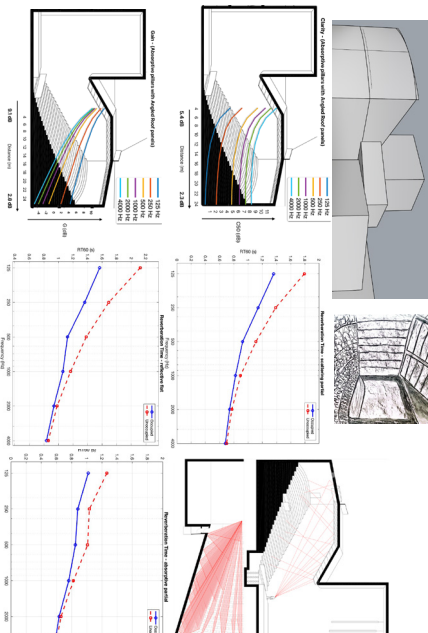


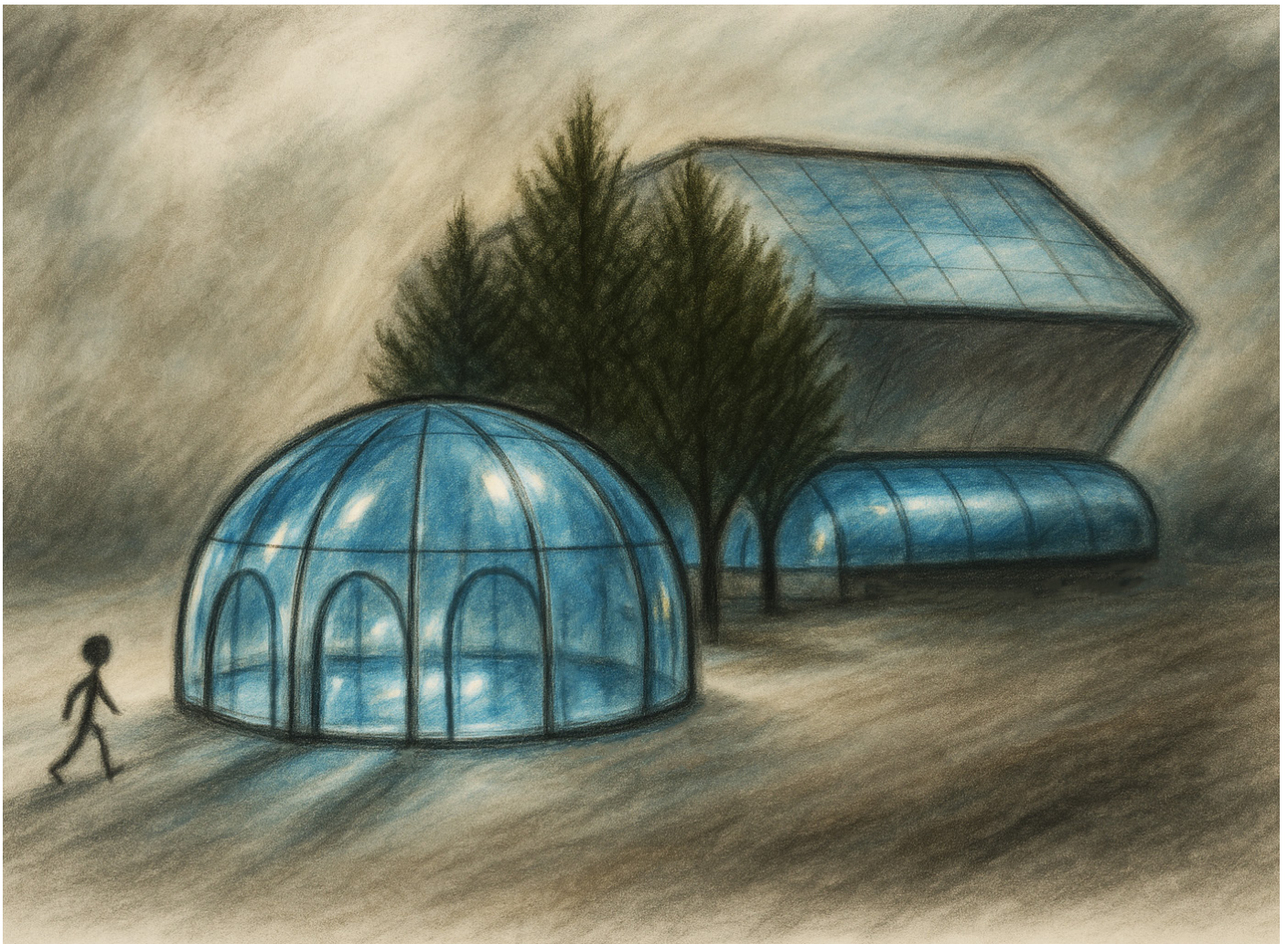
RT60 Simulations

The current setup uses absorptive walls and an irregular ceiling to create a unique atmosphere. The pillars are made of wood, and the walls are lined with wooden panels. The pillars still have bark on them, as if someone had taken them directly from a tree. The walls are also covered in stone, creating a cave-like atmosphere.

Early Reflections

The direct sound arrives, clarity, presence, and speech intelligibility. In this case, they are directed toward the audience using angled ceiling panels and reflective wooden pillars and allowing the fill of the stage paths along the acoustic response. In addition, decorative elements are used to ensure that reflected sound arrives just after the direct sound, preserving natural directionality and preventing reflection from arriving too early.





VIEW FROM OUTSIDE THE ENTRANCE

Site

The building sits on a slope, with the main entrance placed on the higher ground and the backstage functions placed on the bottom. This places part of the theater hall and rehearsal hall below ground, which greatly reduces the amount of noise that reaches in from the busy urban environment outside. It also allows the underground lobby a gentler inclination than would have been possible had the building been placed on flat ground.

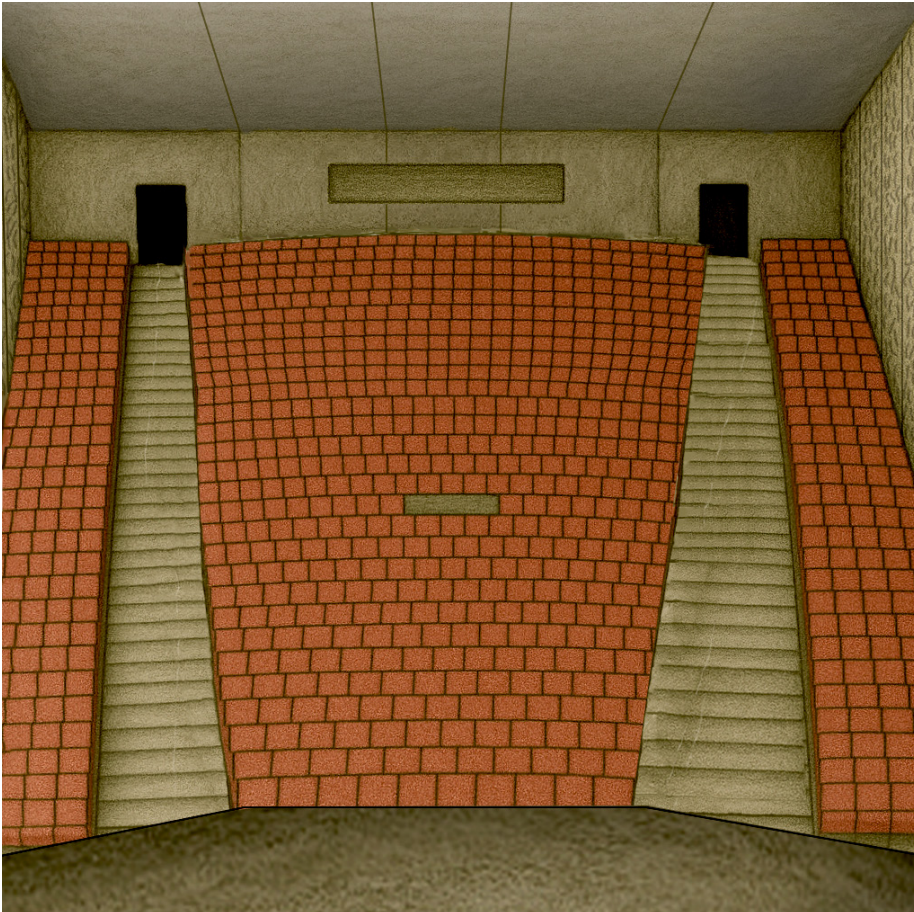


VIEW FROM THE LOBBY

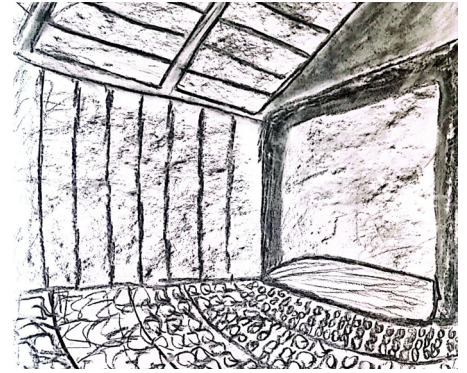
Lobby

The entrance consists of a glass dome, seemingly separate from the diamond-shaped main building volume. From there, visitors are led underground, by either stairs or elevator. As they descend, visitors enter a broader underground space. It is like an artificial cave, making the lobby an experience in itself. Floor, walls and ceiling are made of concrete that has been cast in place, giving the space a raw and solid feel. The walls and ceiling are intentionally uneven, but otherwise untreated, creating a cave-like atmosphere, both visually and acoustically. Crystalline shapes protrude from the surfaces, enhancing the cave-like experience.

A grand staircase leads up to a second dome. The staircase gradually widens as it ascends, inviting movement upward. There are also elevators, for the sake of accessibility. Back above ground, the lobby branches into two glass corridors leading into the main building volume. Visitors choose the corridor depending on which theater hall entrance they are headed to, or if they are headed to the rehearsal hall. The domes and above-ground corridors are made of glass, giving lightness, transparency, and spaciousness to the lobby.



VIEW FROM INSIDE THE THEATER HALL



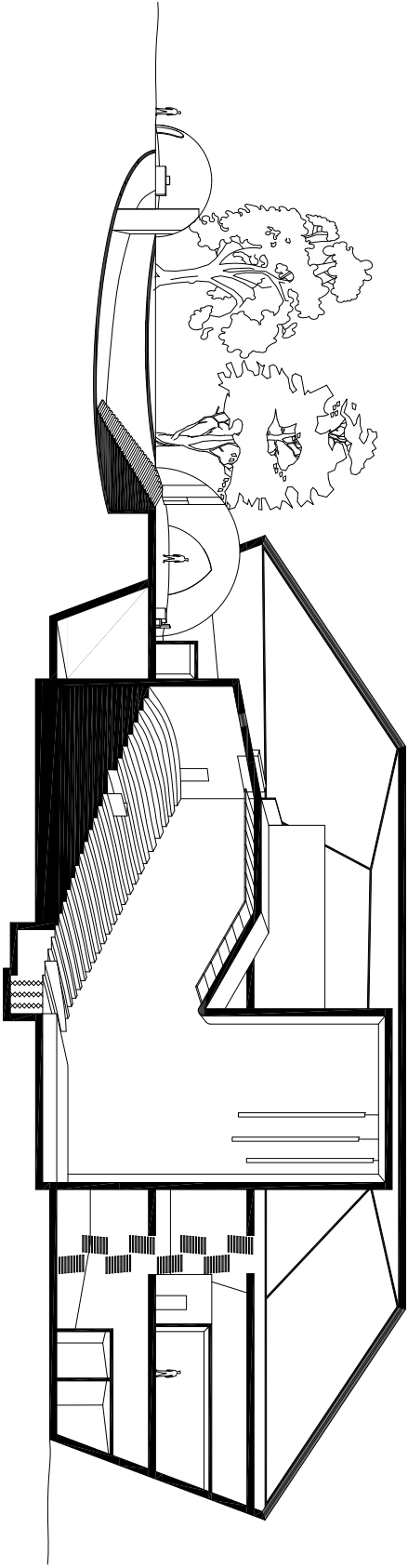
Theater hall

The theater hall is relatively narrow, allowing all visitors a good view of the stage. Visitors enter the hall from the back and descend the stairs as they move toward the stage. The stairs are placed four seats in from the side walls.

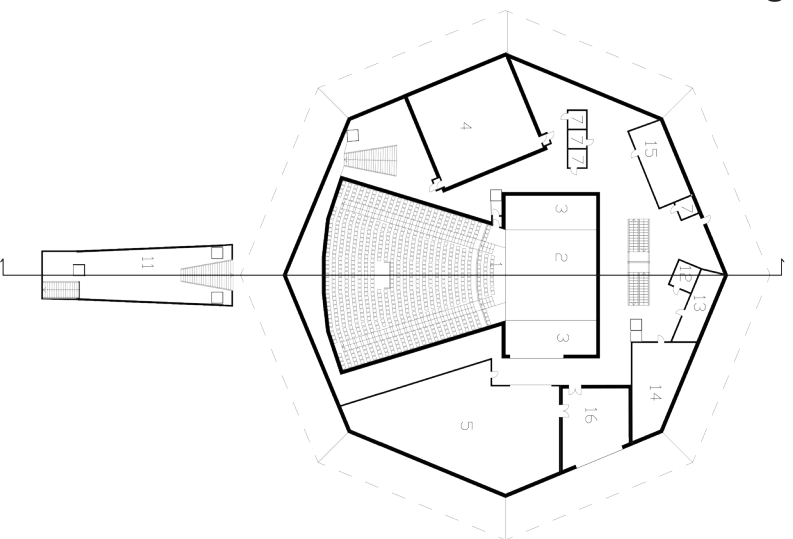
The ceiling of the theater hall is covered in stone, giving the impression that the hall has been hewn directly from the bedrock, and the walls are lined with wooden pillars. The pillars still have bark on them, as if someone has taken trees directly from outside and put them there to hold up the heavy stone ceiling. There are five glass-concrete windows at the back of the ceiling, which let daylight into the theater hall, beautifully diffused by the glass-concrete.

Courtyard

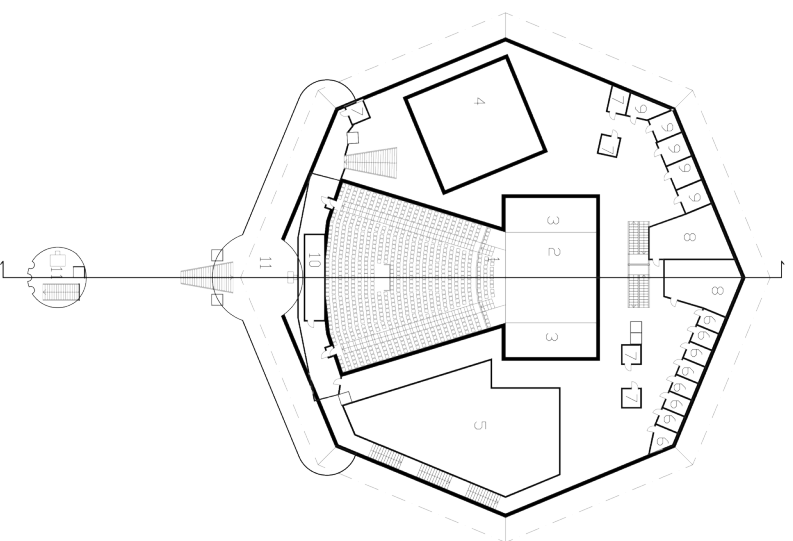
Since the diamond-shaped volume of the building leaves us with a lot of unused space, we have placed a courtyard with a glass roof on the floor above the theater hall. This provides the building with a vast recreational space that is both light and airy. A low wall keeps people from walking onto the back part of the theater hall ceiling.



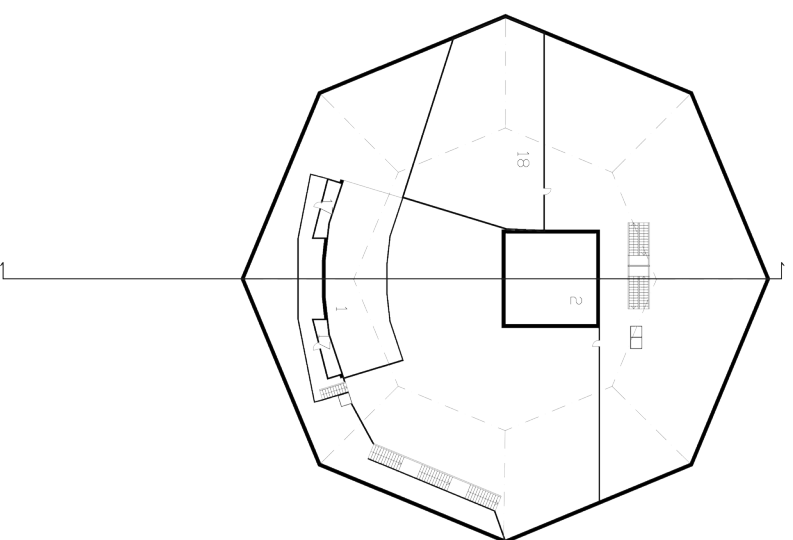
SECTION, SCALE 1:500



GROUND FLOOR



FLOOR 1



FLOOR 2

Legend:

- 1-3. Concert Hall
- 4. Rehearsal hall 182 sqm
- 5. Scene shop 310 sqm
- 7. WC 5,5 sqm (each)
- 8. Chorus dressing room 100 sqm (both rooms)
- 10. Lighting & stage control room 28 sqm
- 12. Prop storage 10,7 sqm
- 13. Wig & make up 30 sqm
- 14. Costume shop 72 sqm
- 15. Green room 47 sqm
- 16. Loading dock 80 sqm
- 17. Follow spot booth 12,5 sqm (each)
- 18. MEPFIT 380 sqm



Noise Criteria:
dB(A)

- - 40
 - 30
 - 15
- Allows for moderate ambient noise without impacting operations.
- Comfortable background level without compromising communication.
- Quiet environment for unamplified music and performance clarity.

Acoustics

The large wooden pillars that the walls are lined with are triangular in cross-section and can be rotated around their own axle independently of each other. One side is covered in bark, allowing it to act as a diffuser. Another is flat and acts as a reflector. The third is perforated, in order to function as an absorber. This makes the acoustic performance of the hall variable, allowing for an optimal acoustic environment for different use-cases.

Another feature that makes the acoustic performance variable is the ceiling, which consists of stone plates that can be angled and moved vertically according to the user's needs and wishes. The plates are only covered with a thin layer of stone in order to prevent hazards such as plates cracking, leading to pieces falling off.

The glass concrete in the windows of the theater hall offers excellent sound insulation, which greatly reduces noise in the hall from the lobby and the courtyard.

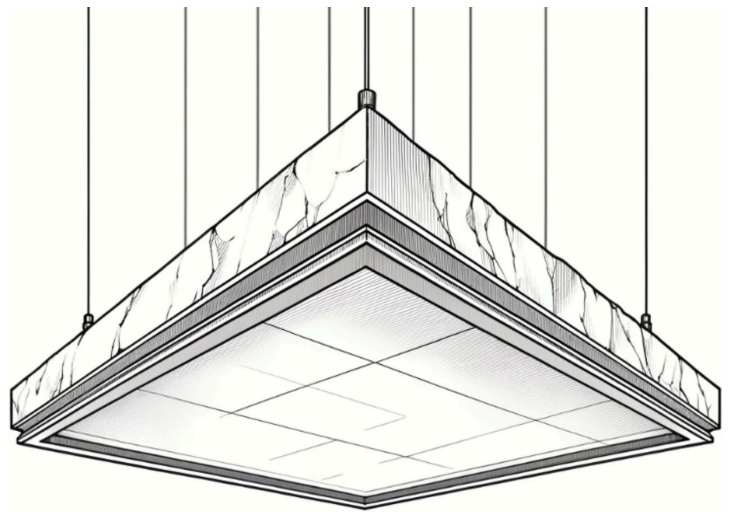
Noise

Double walls and floating slabs are used for insulation against external noise.

External Noise Control:

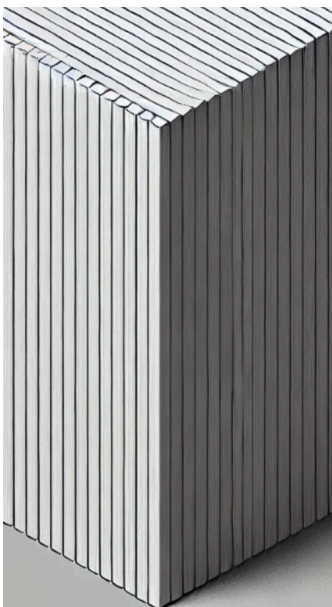
- Day: 55–70 dB LAeq
- Night: 45–60 dB LAeq

To reduce sound transmission to and from the auditorium and rehearsal room, the spaces use room-in-room construction with floating floors, suspended ceilings, and double walls filled with mineral wool. These elements are decoupled to reduce both airborne and structure-borne sound. Additional measures include sealed acoustic doors, sound-lock vestibules, and carefully treated junctions to minimize flanking transmission.



MODELS OF VARIABLE ACOUSTIC FEATURES
RIGHT: STONE PLATE
BELOW: WOODEN PILLARS

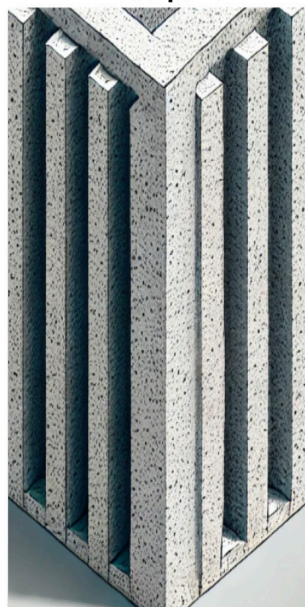
Reflective



Diffuse



Absorptive



RT60 Simulations

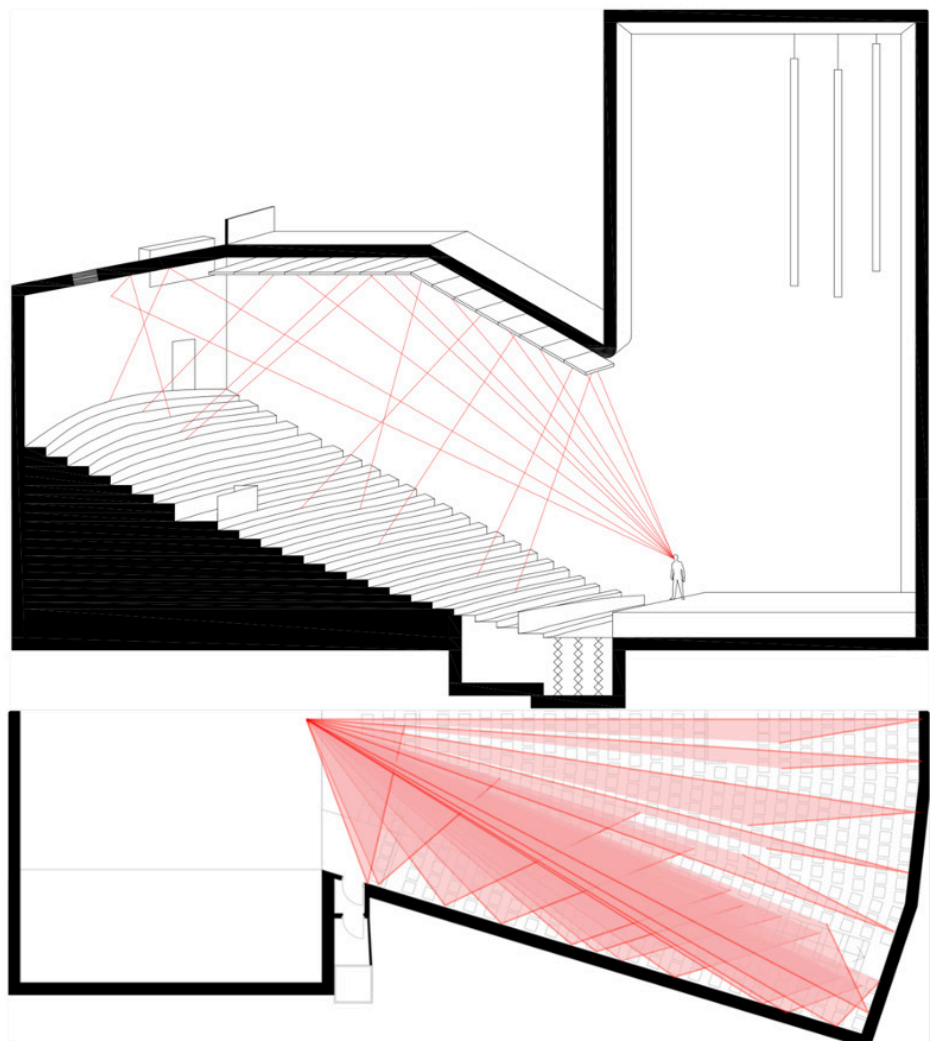
RT60, C50 and G was simulated for 9 configurations (3 wall types \times 3 ceiling types) and with the hall being empty and occupied giving highly dynamic values. The current setup uses absorptive walls and an angled ceiling and RT60 falls between 0,7 – 1,2 s. The absorptive side of the wooden pillars are equipped with slit absorbers which allows sound to enter through slits in the surface, behind which there is a cavity filled with mineral wool. The slits create resistance, and the cavity provides damping, making the system absorb low to mid-frequency sound energy. The width and cavity depth of the slit is designed to target frequency ranges between 125–500 Hz. This makes them ideal for compact, surface-mounted acoustic control on the pillars.

Acoustic Performance Targets

Parameter	Target Range	Purpose
RT60	0.7–1.2 s	Speech/music balance
G	+3 to +8 dB	Strength and presence
C50	+3 to +6 dB	Intelligibility
C80	-3 to +3 dB	Music clarity

Early Reflections

Early reflections arriving 20 to 80 milliseconds after the direct sound enhance clarity, presence, and speech intelligibility. In this theatre, they are directed toward the audience using angled ceiling panels and reflective wall surfaces. Their effect can be tuned by rotating the wooden pillars and adjusting the tilt of the stone panels allowing the acoustic response to be tailored for different types of performances. In addition, loudspeakers placed throughout the hall use electronic delay to ensure that reinforced sound arrives just after the direct sound, preserving natural directionality and preventing reflections from arriving too early.



Design process

One particular problem that I spent a lot of time on was the seating layout of the theater hall — and by extension the theater hall as a whole. Possibly the most critical decision in this process was reducing the size of the seats to fit more seats in the same area. Before that, the design included a balcony that had so many rows it became hugely impractical. The only other way to remove the problem would have been to instead compromise on other qualities that I considered more important, such as the width of the theater hall. I wanted a relatively narrow hall for the sake of ensuring good line of sight for the whole audience, which may not have been possible to ensure with a wider hall.

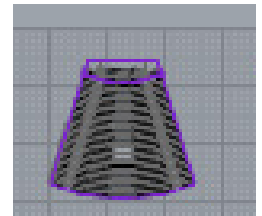
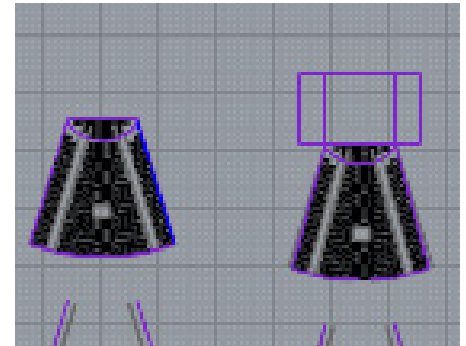
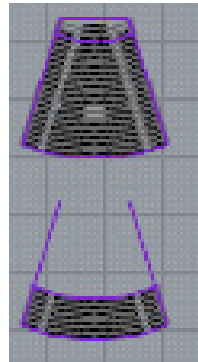
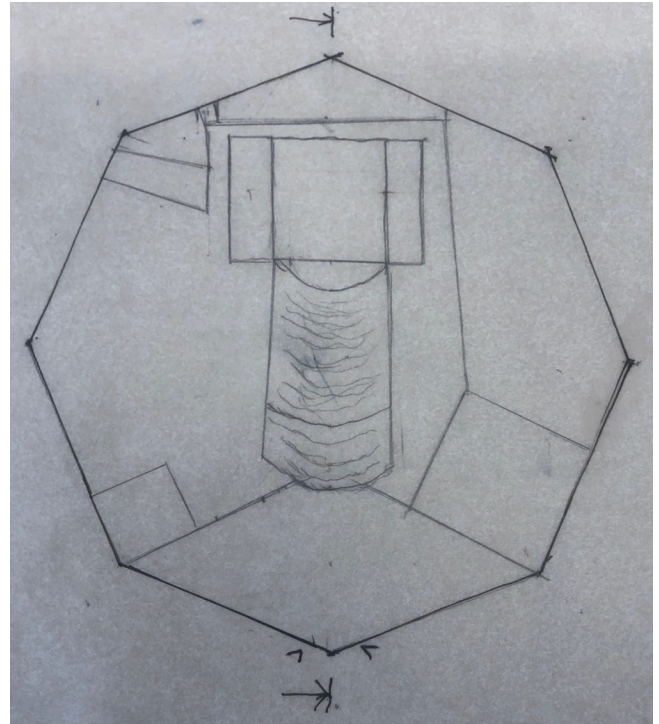
Reflections

I believe the most significant architectural qualities in this design are the highly interesting building volume and the journey that visitors undertake as part of the directed movement through the building. First down into the dark underground, then up to the light and airy surface level, before once again descending as they move to their seats in the theater hall. I would have liked to call the unusual material choices an important quality as well, but unfortunately it is not communicated well enough in the final proposal. So if there is anything I would have liked to iterate on further, it would be that.

I am very pleased with the Jan Lööf-like style of our perspectives, and I would like to continue making similar perspectives in the future, using similar methods. It would also have been nice to work with mixed medium and enrich the section with the style of the perspectives to better communicate what is contained within. The section could in fact do with a bit of a rework in general, it is for example quite difficult to make out the lines for the windows currently.

The proposed design takes care to let plenty of daylight into the building, and a decent amount into the theater hall itself. Not letting daylight into the subterranean lobby was also a conscious choice, a reinforcement of the journey. The lobby is instead lit in many different colors from crystal shaped fixtures scattered around the room.

The large courtyard risks being an unattractive space. It is open and empty and may be an acoustically unwelcoming environment, because of high reverb and echoes. The reverb is more detrimental to the



ITERATIONS ON THE THEATER HALL LAYOUT

courtyard than the lobby, since it becomes part of the intended journey in the lobby but not in the courtyard. The building would also be hard to get approved in real life since there is a distinct lack of accommodations for accessibility.

Working with the acoustics students has been very fruitful and the collaboration worked smoothly. They functioned largely like consultants for us. We asked them if they could make our idea work, they asked for important in-data, and in the end we had all the resulting information we needed for the project, presented comprehensibly.

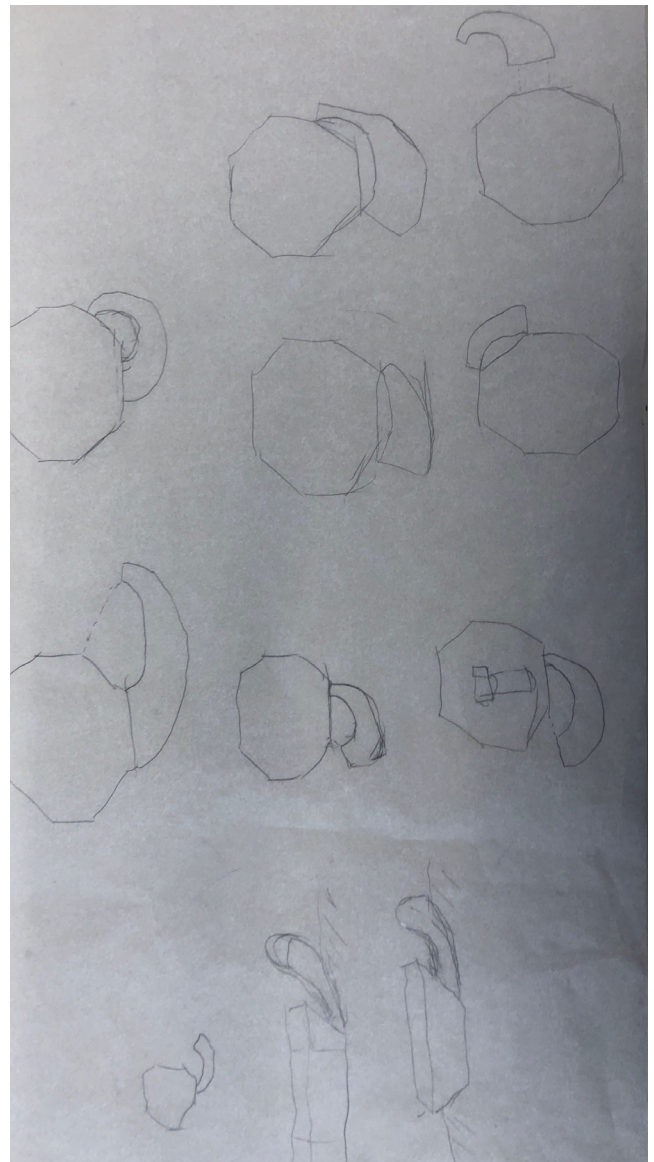
Improvisation, Iteration & Translation

The exterior of the building was improvised by simply making a number of volumes in Rhino, and combining two of those shapes for the final proposal was another improvisation on top of that. The specific implementation of our chosen materials for the theater hall was also improvised. It was a way of making the material choices work with our desire to have variable acoustics.

Many parts of our design have gone through several iterations. The floor plans have been changed gradually over time, with the decision to split BOH-functions over two floors being made about halfway through. The shape of the theater hall was changed at about the same time. It had started as a straight-forward and simple design, but was changed to parallel the exterior of the building. As mentioned above, the seating layout went through several iterations. The joining of the two volumes making up the building was also iterated upon. Initially, we thought to have the curved structure bend horizontally, before changing it to bend vertically and taking visitors underground.

We started out working with mainly pencil and charcoal on paper, to quickly work out rough sketches of our design. We continued in AutoCAD and Rhino, to make accurate drawings and 3D models. These CAD-drawings were then used for the technical drawings in the final proposal, with some touch-ups done in Illustrator.

For the “money shot” perspectives however, the technically accurate drawings and models were only used for reference. The bulk of the work was done by hand, with charcoal and colored crayons. These perspectives were then scanned and processed in Photoshop, giving us a very comic book-like finished product. This helped hammer home the idea that the proposed building presented a journey, or a story, for visitors.



On Architecture and Engineering

I have thoroughly enjoyed Architecture and Engineering. I simply love the wide scope of the program, which ensures that no matter which path you choose going forwards, you have a good understanding of the work that the people around you do and not just your own. My own plan is to make the best use possible of the program's width, as I wish to graduate with both an applied acoustics master and an architecture master (jury's out on which one, though).