

SILENT CUBE - OPERA HOUSE

2024

DAVID EDLUND

LOCATION: GRAZ, AUSTRIA
COURSE: ACEX15 BACHELOR THESIS
COLLABORATORS: ARVID HALL (AT) & ELLA STÅLHANDSKE (MPSOV)
SUPERVISORS: MORTEN LUND, PETER CHRISTENSSON & WOLFGANG KROPP
EXAMINER: KARL-GUNNAR OLSSON

PROJECT BACKGROUND

The final course in the Architecture and Engineering program (AT), concluding in a bachelor's degree, is a collaborative project between architecture and acoustics. Two students from AT work together with one master student from the first year of the Sound and Vibration program (MPSOV).

The general framework and deadlines are set by an annual international student competition organized by the Acoustical Society of America (ASA). The scope of the 2024 competition was to design a 1200 seat opera house for a university with a strong music and vocal program. Key rooms with respective areas and functions were given, together with schematic plans and sections for room distribution. A specific site was not provided, instead simply referring to an open city block surrounded by highly trafficked streets in all four cardinal directions.

COMPETITION POSTERS



SILENT CUBE

CONCEPT AND LOCATION

The concept of Silent Cube is an intersection of two simple geometries: a substantial and heavy-looking cube housing the opera hall and a tent-like structure encapsulating the overall building and its surrounding functions. Combining these two structural shapes results in a distinct yet contrasting appearance.

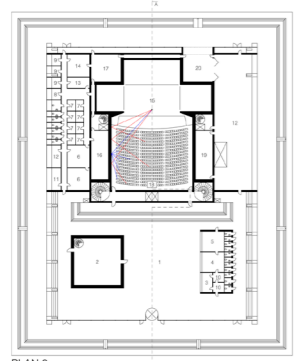
Silent Cube is imagined in the Austrian city of Graz, between the Universität Graz to the north and the Kunstuniversität to the south. The campus area between the two universities is located in the heart of the city and is both traffic and pedestrian dense, resulting in a vibrant environment.

CONTRASTING BUILDING

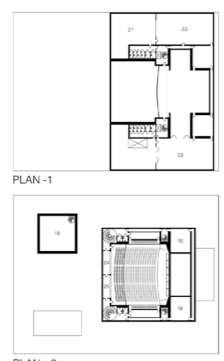
Whilst the walls containing the opera hall and the rehearsal room are heavily isolated, the surrounding spaces covered by the thin steel structure and polycarbonate panels are not. This emphasizes the quietness and isolation of the rooms partially hidden inside the larger opera hall cube and smaller rehearsal room cube. In addition to acoustical and structural contrast, there is also the experience of light. The polycarbonate roof is semi-transparent and lets in a uniform dimmed light over the hall during the day, and out towards the city during the night. Entering the cube, visitors are first faced with a dark passage, followed by stripes of light leading into the opera hall where more lights reveal the size of the room.



SITE PLAN



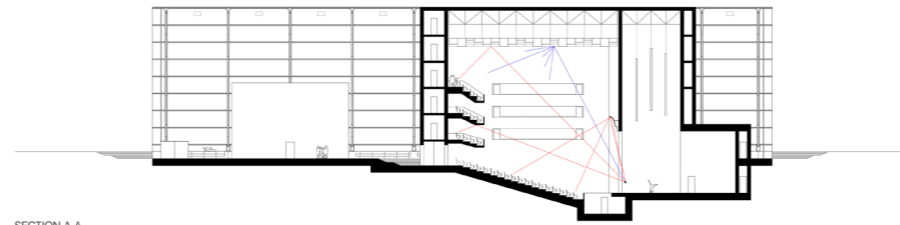
PLAN 0



PLAN -1

PLAN +3

NOISE CRITERIA		NC-15	NC-30	NC-40
1	Lobby	1850		
2	Rehearsal Room	225		
3	Reception	21		
4	Cloakroom	46		
5	Cafeteria & Bar	46		
6	Chorus Dressing Rooms	102		
7	Solo Dressing Rooms	70		
8	Administration	10		
9	Offices Technical Staff	30		
10	Offices Company Staff	22		
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23	Scene Shop	621		
24	Lighting & Stage Manager Control Room	30		
25	Follow Spot Booth	30		
		[m ²]		



SECTION A-A

OPERA HALL

The opera hall is shaped like a shoebox and relies on its wooden elements to balance the soundscape. 55 percent of the 1178 seats consists of orchestra seating and the other 45 percent is divided on three balconies. There is a slope of 20 degrees downwards towards the scene and most of the seating is pushed to the back of the room, as opposed to the side walls. This is to make sure that everyone has good line of sight to the entire proscenium and stage.

REHEARSAL ROOM

The rehearsal room is built by the same principle as the opera hall, but in a smaller size and with slightly tilted inner walls. It is placed inside of a sound isolating cube, free-standing in the lobby area. The same acoustical panels that are used in the opera hall are also used in the rehearsal room, but with a higher share of absorptive panels to reduce loudness. The reverberation time is variable, but generally lower than in the opera hall to accommodate for the smaller volume.

MULTIPURPOSE USE

The building is designed to accommodate uses beyond rehearsals and scheduled events. Firstly, the opera hall serves a dual purpose as an auditorium, featuring a sloped roof and variable acoustics that also make it suitable for speeches, presentations, or ceremonial events. Secondly, the open and inviting atmosphere of the entrance section creates a flexible space, allowing for smaller events, informal gatherings, or fairs to be hosted in the lobby area.



NOISE AND VIBRATION

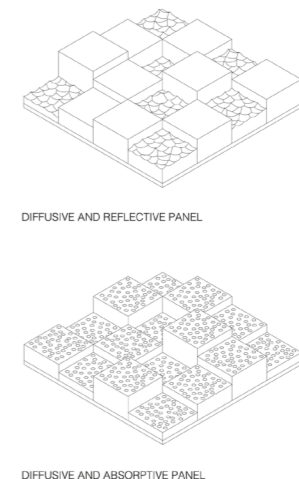
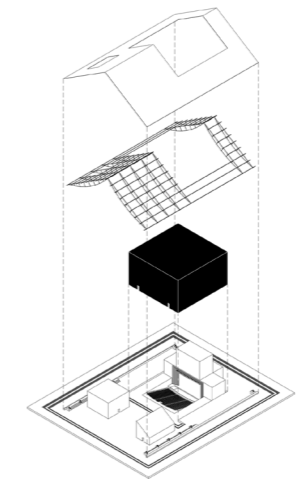
The opera hall and rehearsal room use a box-in-box design with double walls. The construction includes two layers of cross-laminated timber with a dampened cavity for noise control. This achieves noise reduction suitable for MER systems and outdoor noise, ranging from [28 38 46 58 70 64 53] dB across frequencies from 63 Hz to 4 kHz. The combination of decoupled walls and a spring-mounted inner structure help minimize noise and vibration transmission.

ACOUSTIC PANELS

Both the opera and rehearsal halls use two types of wooden panels made from square timber beams of varying depths. The first type is diffusive and reflective with smooth and textured surfaces to reflect and diffuse sound. The other type is diffusive and absorptive, combining perforated surfaces with a layer of mineral wool underneath for enhanced sound absorption. Their modular design allows for easy combination to achieve the desired acoustical environment.

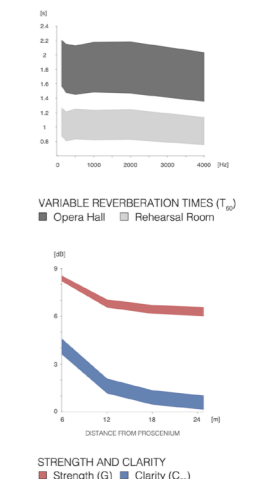
VARIABLE ACOUSTICS

The inner ceiling of the opera hall can be lowered by up to 6 meters, allowing for adjustments in room volume between 11,000 m³ and 14,800 m³ to achieve varying reverberation times. Similarly, the inner ceiling of the rehearsal room can be adjusted by 2 meters, varying the volume between 800 m³ and 1,250 m³. The strength of the sound remains consistent regardless of changes in room volume, while clarity slightly reduces with increasing volume.



DIFFUSIVE AND REFLECTIVE PANEL

DIFFUSIVE AND ABSORPTIVE PANEL



PROCESS

EARLY CONCEPTS

Our starting point was quick and conceptual model making. We built a site model in wood from the general instructions given, and proceeded to fold paper models to try different shapes in the context. Having made a number of base ideas, we then started sketching and expanding on these ideas using pen and paper. This resulted in three initial concepts that we referred to as The Beetle, The Porcupine and The Mole (based on their shapes and expressions). The Beetle having a round shell, stating a structural intent. The Porcupine with a sharper and more erratic appearance, making it the most visually abstract. The Mole with a different approach in that all of the building, except for a small entrance, would be underground.

We presented our ideas to the students from MPSOV and were chosen by Ella to be our acoustical student advisor. Going forward, the three of us decided on a starting concept to develop further based on a combination of The Beetle and The Porcupine, with some additional ideas we got along the way. Our idea was to combine two geometries: a thin tent-like roof and a cube of another material breaking up said roof. Both sharing the same height creating an interesting three-dimensional effect when viewed in elevation.

SCULPTING THE IDEA

In the next step we divided the work into three parts. The first one was to update the physical model to the current design. This gave us a better grasp of how the building would present itself, as well as how to improve it going further. Always working from a model that we could see, feel and flip around became a fundamental process in our thesis work. The second step was getting more familiar with the plan and flow of the opera house. This meant developing the hand drawings and trying to figure out the puzzle of fitting everything into the building. The third step was to create acoustical prototypes. We went back to the wood workshop and made two types of panel prototypes that would reflect, diffuse and absorb sound in the opera hall. These ideas were exchanged and approved by Ella so that we could make sure to get it right.

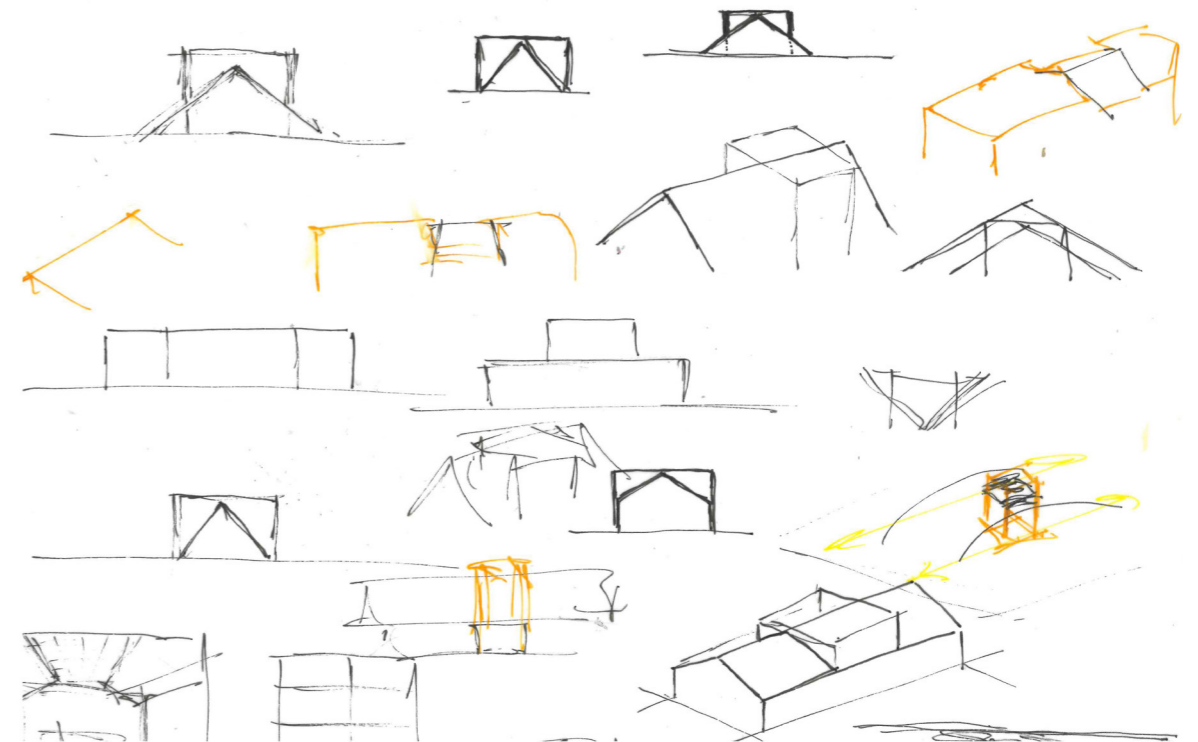
MOCK-UP COMPETITION POSTERS

In order to solidify our ideas and maintain focus on the competition format, we were tasked with making three preliminary posters in accordance with the submission requirements from ASA. Hand drawn perspectives were used to present our visions of the opera building. For drawings, we made the switch from pen and paper to AutoCAD and started working on what would eventually become the final plans and sections. Ella helped us with acoustical diagrams based on what we knew at the time, and together we started writing the texts for the posters.

In parallel to this, we felt that it was a good time to choose an actual site. Even though it wasn't necessary for the competition, we had felt since the beginning that it could only benefit the project. Without context there can be no real, or attempt of real, architecture. We started scouting cities and universities that felt relevant to the format. We started looking in North America and then moved to Europe. In the end, we opted for either Kunstuniversität in Graz, Austria or Conservatorio di Musica in Milan, Italy. We liked that both cities already had strong historical connections to opera, as well as having appropriate empty plots that fit in with the competition brief. In the end, we chose Graz because of the vibrant university area as well as the cooler climate which would benefit our roof design.

FINAL MATERIAL

The last step was about finalizing all material and making it presentable on the actual posters. In the same manner as the previous iteration, we refined text, diagrams and drawings as well as making renders to visualize our ideas in the style we wanted. As the shape and dimensions of the last physical model and the acoustical prototypes had pretty much remained intact, they also served as relevant presentation material which made for more tangible discussions about the opera house during the final critique.



EARLY CONCEPTUAL SKETCHES

RESULT (TEXT FROM POSTERS)

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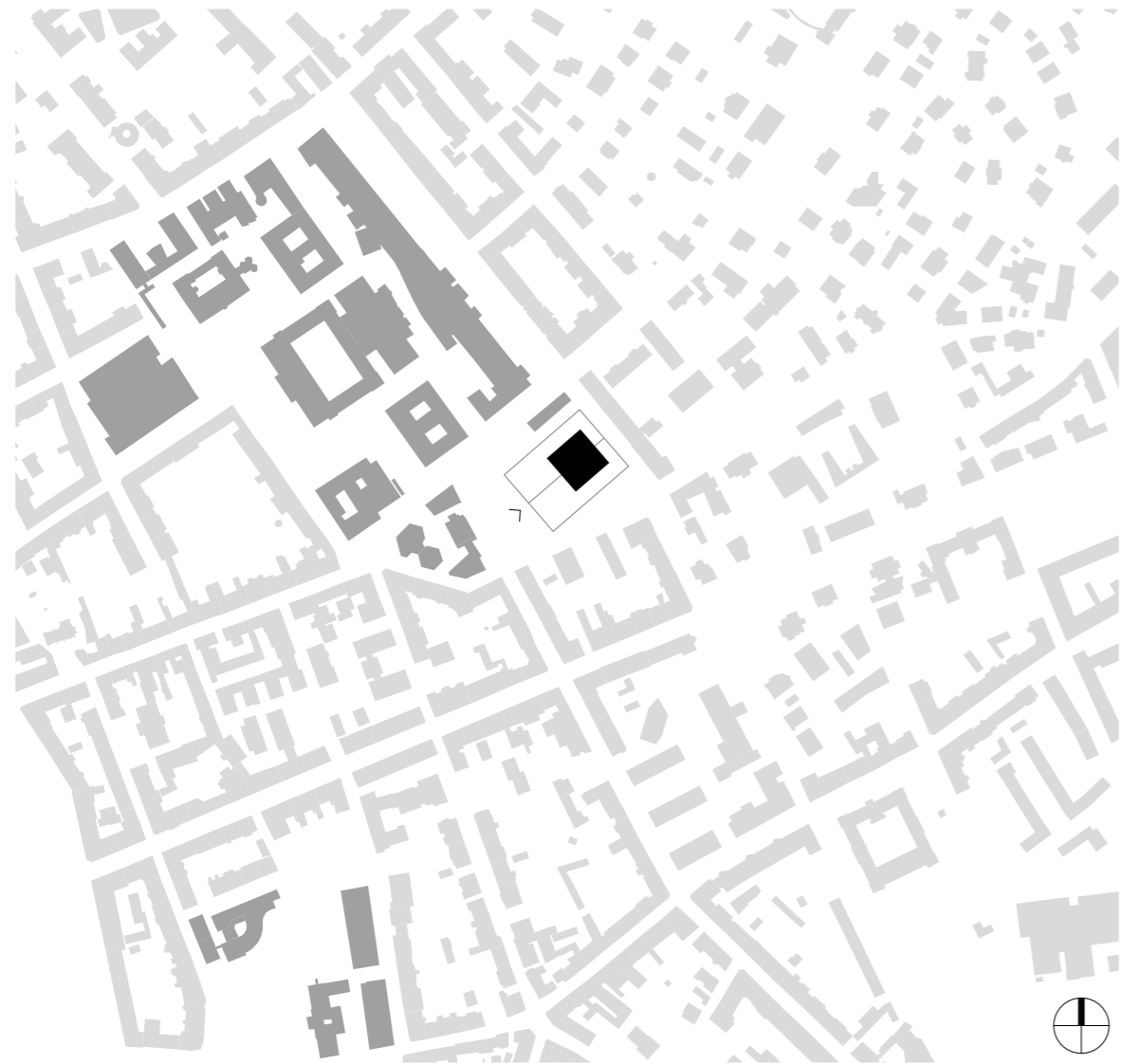
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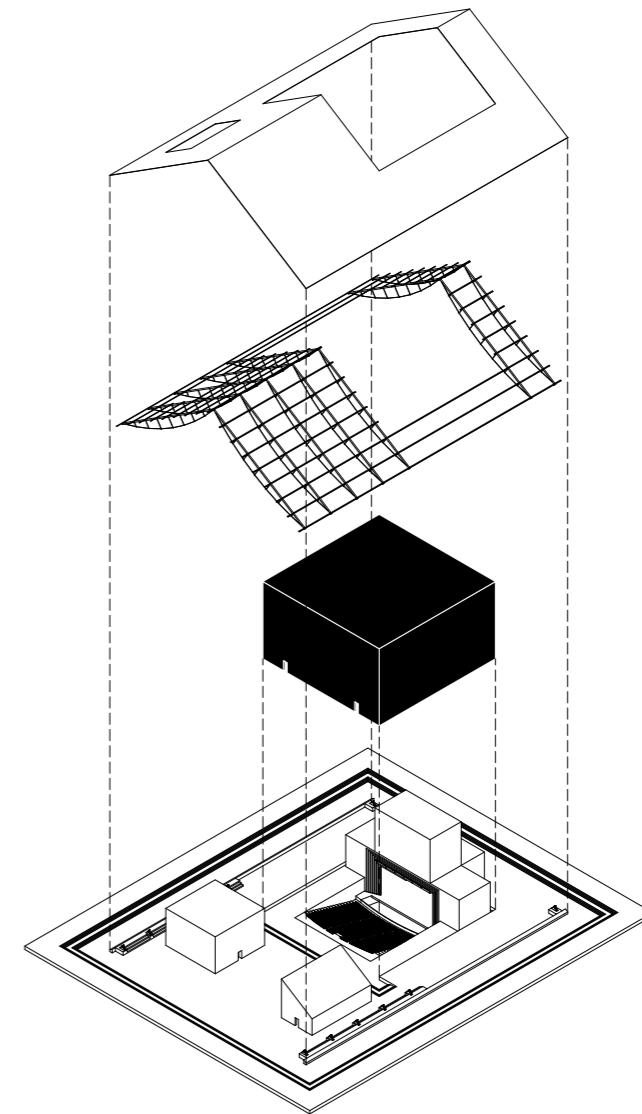
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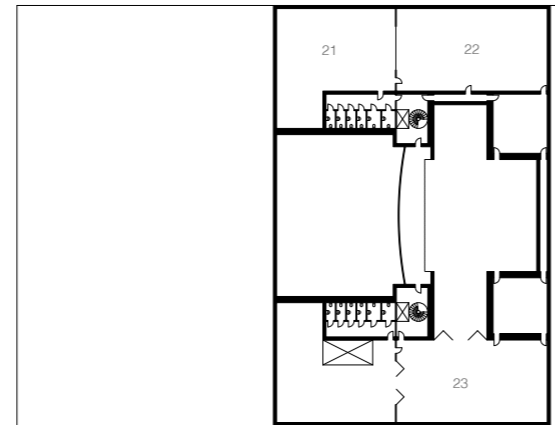
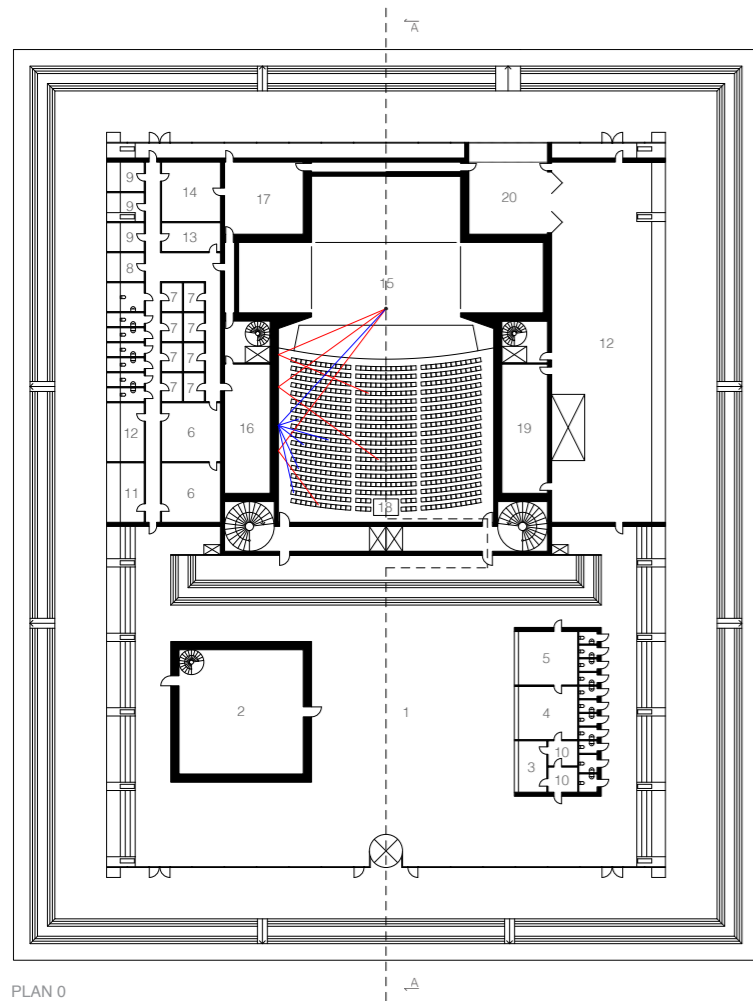
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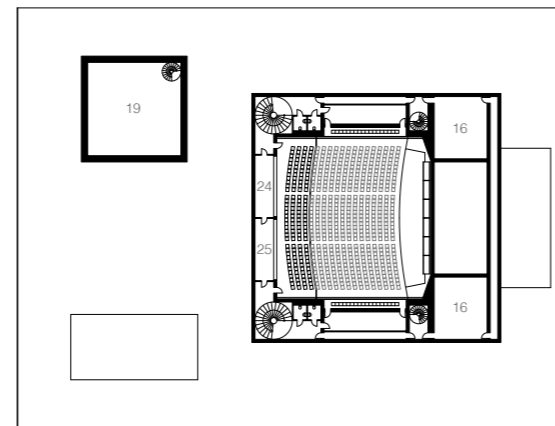
SITE PLAN



AXONOMETRIC VIEW



PLAN -1



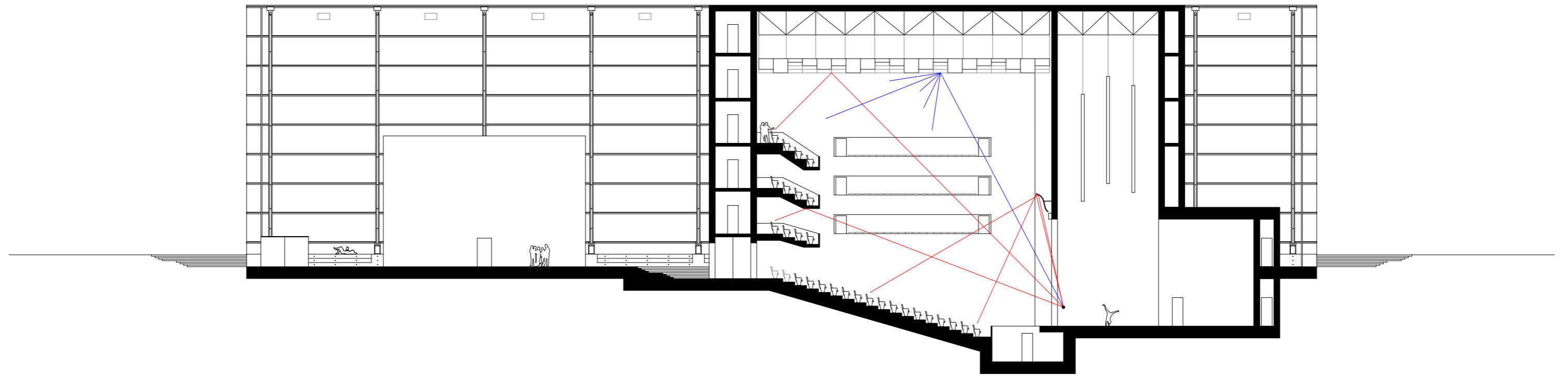
PLAN +3

NOISE CRITERIA

■ NC-15 ■ NC-30 ■ NC-40

1	Lobby	1850	□
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5	Cafeteria & Bar	46	■
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7	Solo Dressing Rooms	70	■
8	Administration	10	■
9	Offices Technical Staff	30	■
10	Offices Company Staff	22	■
11	Cleaning & Laundry	21	□
12	Storages	546	□
13	Conductor Dressing Room	25	■
14	Green Room	51	■
15	Opera Hall	1100	■
16	Technical Rooms	256	□
17	Staff Entrance	83	■
18	In-house Audio Mix Position	6	■
19	MER/MEPFIT	311	□
20	Loading Dock	105	□
21	Wig & Makeup	298	■
22	Prop Pantry	321	□
23	Scene Shop	621	■
24	Lighting & Stage Manager Control Room	30	■
25	Follow Spot Booth	30	■

[m²]



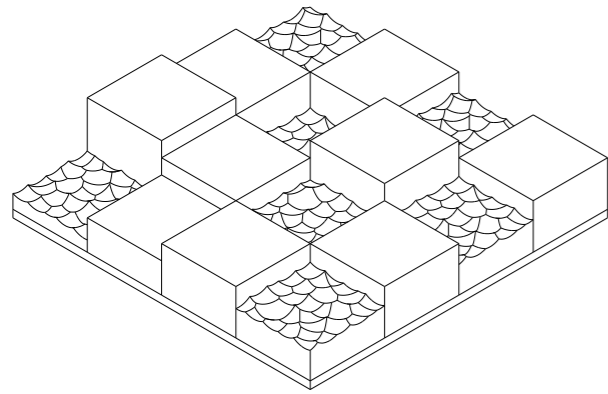
SECTION A-A

ACOUSTIC OPERA VALUES

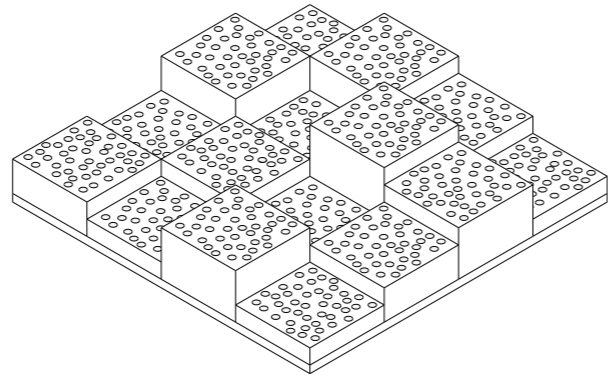
Reverberation Time (RT_{80}):	1.5 - 1.9 (1.6 - 2.1*) [s]
Initial Time Delay Gap (ITDG):	25** [ms]
Strength (G) [1 kHz]:	8.4 - 6.4 [dB]
Clarity (C_{80}) [1 kHz]:	3.9 - 0.4 [dB]
Maximum distance to stage:	23 [m]

* Unoccupied

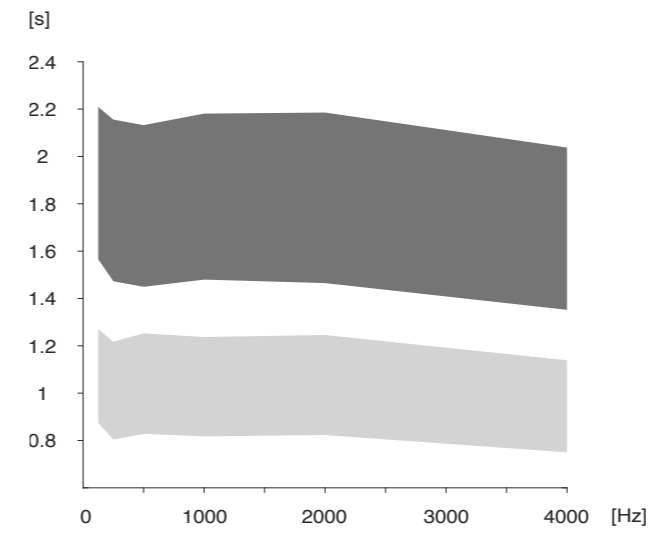
** With exception of middle front rows



DIFFUSIVE AND REFLECTIVE PANEL

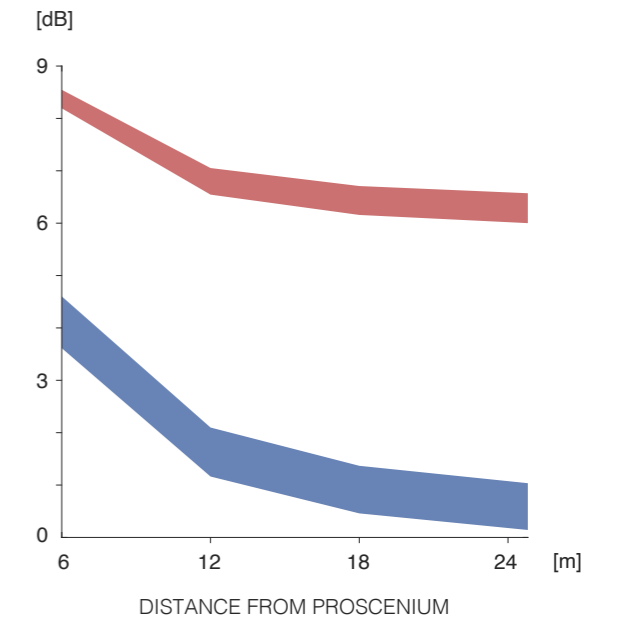


DIFFUSIVE AND ABSORPTIVE PANEL



OPERA HALL REHEARSAL ROOM

VARIABLE REVERBERATION TIMES (RT_{80})



STRENGTH (G) CLARITY (C_{80})

STRENGTH AND CLARITY



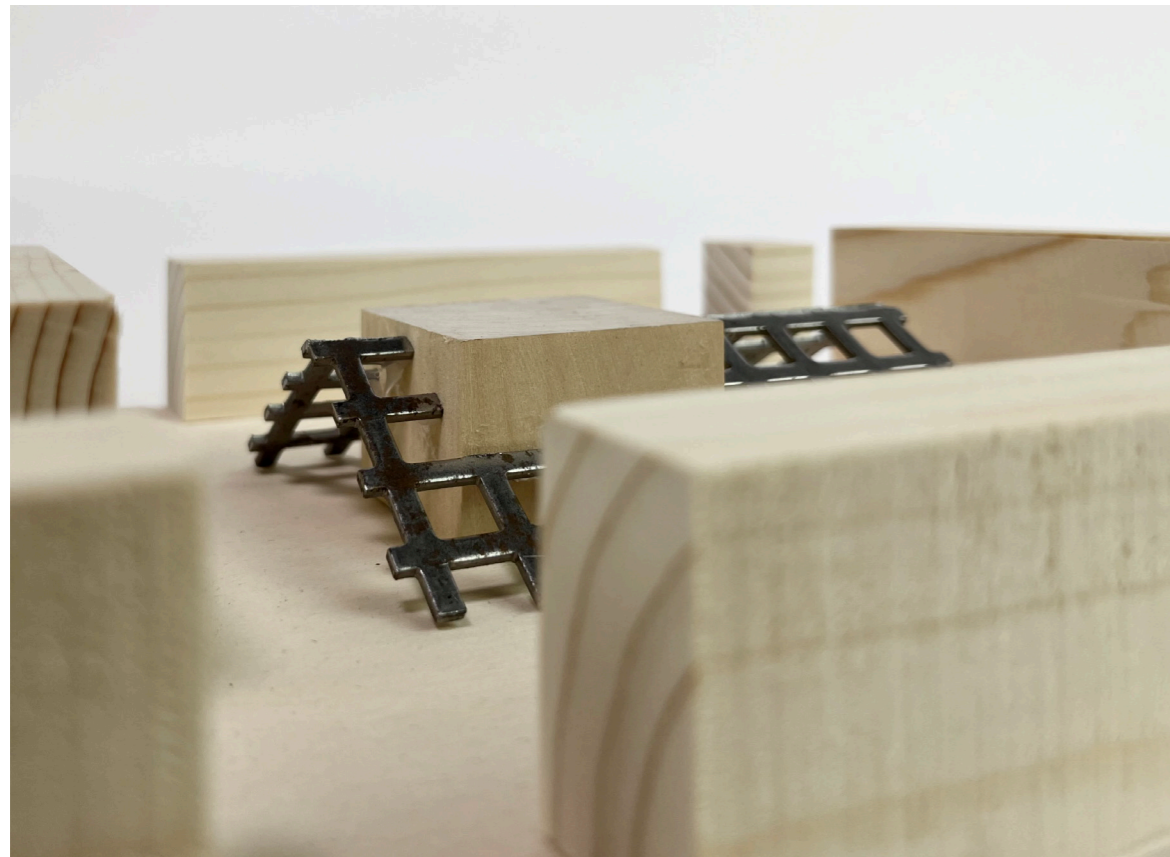
EXTERIOR PERSPECTIVE FROM THE SOUTH EAST



LOBBY AREA FACING THE OPERA HALL CUBE



INTERIOR PERSPECTIVE OVERLOOKING THE STAGE



CONCEPTUAL METAL STRUCTURE IN MODEL



MODEL WITH TRANSLUCENT PLASTIC COVER



DIFFUSIVE AND REFLECTIVE PANEL PROTOTYPE



DIFFUSIVE AND ABSORPTIVE PANEL PROTOTYPE

REFLECTION

DESIGN METHODOLOGY

I believe that me and Arvid managed to find a way of working that fit us both from the start. This also remained true when Ella joined our project and brought skills and ideas of her own. It felt like most of the process came naturally and from a place of inspiration. We found a concept and decided to work it all the way through. This can be a dangerous design methodology if the idea is complex or not well thought out. We were lucky however, as the base concept was quite forgiving. All we had to do was lay the puzzle without losing any pieces. This also meant that we were able to keep in line with the competition brief without sacrificing ideas of our own.

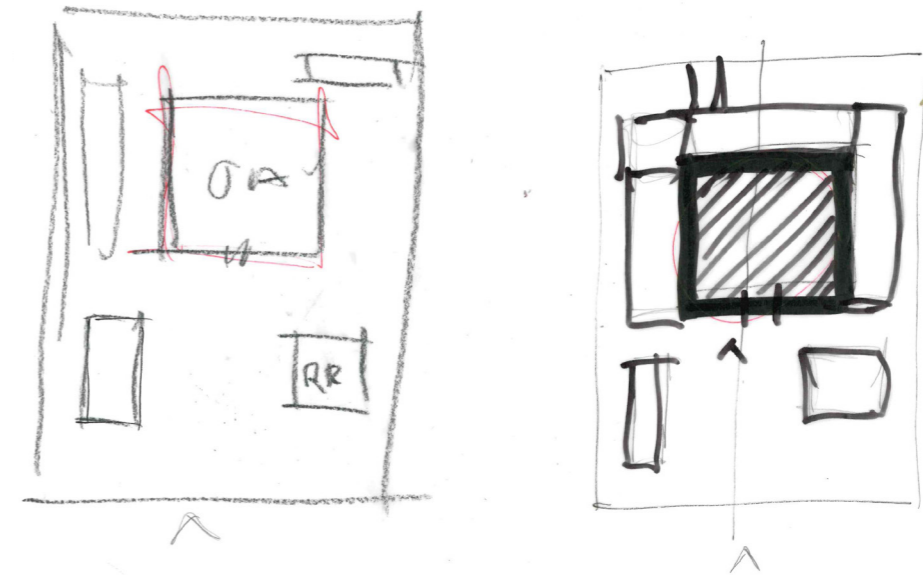
QUALITIES OF PROJECT

I think that one of the biggest strengths in our project was the sense of balance. We kept focus on what interested us both methodology and material wise, which kept us invested in making sure that what we did turned out good. We wanted to make models, so we started doing that in the concept phase. We wanted to highlight material and structure, so we did research about international projects as well as conducting visits to local projects of relevance in Gothenburg. We wanted concise and straight forward text and diagrams with ethereal, but still very rational, drawings and visualizations, so that became the core of our posters.

It would have been interesting to go deeper on the actual performance of our design choices. To better analyze our acoustics in the opera hall, to check if our construction is under (or over) dimensioned, and to gain better understanding of the environment (light, temperature and even sound) under the polycarbonate roof. However, I do believe that we managed our time well for the scope of this thesis project.

GOING FORWARD

This project further solidifies my belief in the importance of curiosity for a concept. A good design methodology is important and keeps structure in a project, but interest and investment in an idea is driving. I also learned a great lesson about the value of site visits. How much information that can be gained and what happens when you try to adapt something into a new project. From trying to make it fit in your own design to finding new possibilities and developments. Lastly, I would like to highlight the strength of working in a good team. Everything becomes much easier when your work ethics and ambitions align and/or complement each other.



SCHEMATIC FLOOR PLANS

