# OPERA GLAS

As part of a student design competition, the task was to create an opera hall situated within an urban setting. The competition came with its own set of instructions, and the requirements were clear. The various spaces within the opera and their respective areas were predetermined, which served both as an advantage and a challenge in the design process. There were no limitations on the choice of concept and the architectural design of the building.

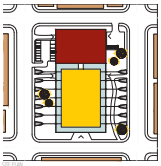
The assignment placed significant emphasis on acoustics since a part of the competition involved designing an auditorium with optimal acoustics for an opera while considering factors that could affect sound, such as traffic and mechanical rooms. To achieve the desired acoustic values, a collaboration was initiated with a student from the acoustics master's program. This marked the first instance in our education where two professions collaborated. To seize this opportunity, we chose to challenge ourselves by devising our own acoustic solutions for the opera hall that would seamlessly integrate and with the concept. Our goal was to merge design and acoustics, highlighting the acoustic solutions as an integral part of the architecture rather than concealing them.

## DON'T SHAKE- SUSPENDED OPERA

Opera Glas presents an unique suspended construction made of glass blocks. The opera hall is entirely detached from both the ground and the surrounding building, effectively isolating it from vibrations. The volume is suspended by wires attached to steel frames beneath the hall. These delicate wires are anchored outside the opera house, lending a sense of weightlessness and creating the illusion of the cube floating above the ground.

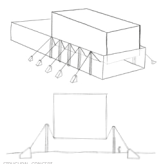
The opera hall is adorned with illuminated glass blocks whose colors can be altered to reflect the season, occasion, or the opera being performed. This elevated volume resembles a hanging lamp, casting its light over the city's streets at night.

OUTDOOR PERSPECTIVE - URBAN LAMP



SITE PLAN

CONCEPT MODEL - VOLUME



STRUCTURAL CONCEPT

## THE RHYTHM OF THE OPERA

The plan reflects the modular nature of the glass cube, comprising three distinct volumes: the cube itself, the lobby, and a solid volume for additional opera house functions. Visitor flow centers around the lobby and stairs leading to the opera hall along transparent walls. On special occasions, guests can dine at the opera restaurant above the hall.

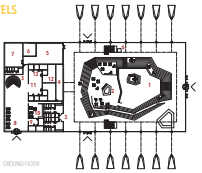
Other functions are positioned to minimize disruptions to the opera hall. The MEPFIT room is divided into two areas, with the larger one located away from the hall's influence. An airlock separates the MEPFIT area above the hall, insulating it from equipment noise and vibrations. The rehearsal hall is similarly isolated from the scene shop.

GLASS BLOCK - T.3

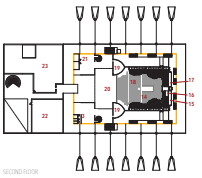
## PLAN DRAWINGS & NOISE LEVELS

NC-15 NC-20 NC-25 NC-30 NC-35 NC-40

1- Lobby
2- Café
3- Toilets
4- Wardrobe
5- Kitchen
6- Elevator
7- Loading Dock
8- Staff Entrance
9- Tech Offices, 19.4 m² each
10- Lounge
11- Green Room, 105 m²
12- Chorus Dressing Rooms, 54.5 m² each
13- Solo Dressing Rooms, 7.8 m² each
14- Auditorium
15- Follow Spot Booth, 2.8 m²
16- In-House Audio Mix, 5.7 m²
17- Control Room for RH, 26 m²
18- Conductor Podium
19- Orchestra Pits, 72 m²
20- Stage, 588 m²
21- MER Offices, 24.7 m² tot
22- Rehearsal Hall, 378 m²
23- Scene Shop, 1076 m²
Restaurant (third floor)
MEPFIT with MER (third floor), 1952 m²



GROUND FLOOR



SECOND FLOOR

## GLASS - DESIGN MEETS ACOUSTICS

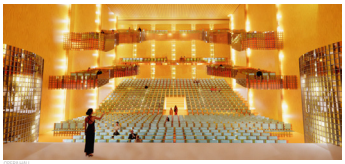
Opera Glas takes on its distinctive character from glass concrete, which serves as a consistent theme throughout the entire building, from the façade to the opera's seating. The glass blocks used vary in size, with dimensions of 450x450x160 mm for the façade and 190x190x80 mm for finer details. With the semi-transparent characteristics of the glass, the aim is to awaken curiosity as the silhouettes of visitors are glimpsed from the lobby and by passersby on the street.

Constructing an opera house with glass concrete presents both acoustic challenges and benefits. Further details on the acoustic considerations are provided on the next page along with the acoustical prototypes.

OPERA GLAS

ALMA JOHANSSON KAISA HOLMQUIST RICHARD HEIKKILÄ

GLASS BLOCK - T.3



OPERA HALL

## A NIGHT AT THE OPERA

The opera hall accommodates 1295 seats, with 60 percent distributed across the ground floor with a tiered balcony, and 40 percent across two levels of balconies. The orchestra is divided into two sections elevated on balconies, with the conductor positioned centrally and visible to all.

The glass concept defines the interior of the opera hall. Walls and balconies are adorned with glass blocks, and chairbacks made of glass emerge from the glass floor. The opera is designed to stand out, to be a space that transports the visitor from everyday events and the hectic life outside, to a place where nothing is impossible, where all stories are real. With the use of color and lighting, a joyful, inspiring, and anticipatory atmosphere is created.

A - GLASS SEATS WITH VENTILATION

B - WOLFRAM PERFORATED WALLS

C - GLASS BALCONY OPERA

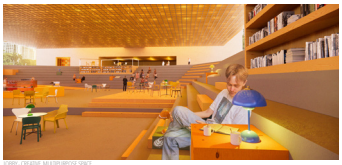


C - GLASS BALCONY SPEECH

D - GLASS HELMHOLTZ

E - TRIAL GLASS HELMHOLTZ

SECTION DRAWING



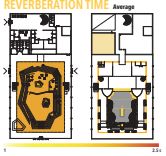
LOBBY - CREATIVE, MULTIPURPOSE SPACE

## A LOBBY THAT TAKES SPACE

The space beneath the elevated opera expands by excavating steps into the ground, inspired by the chaotic pit created when a meteorite strikes the earth. It is a dynamic and playful environment for schoolwork, speeches and lectures, and also a social meeting place for students. Designed with creativity and functionality in mind, bold colors and wood elements enhance the vibrant atmosphere. Here, you can enjoy a coffee while observing opera guests through the luminous glass floor above.

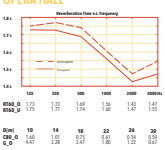
The glass ceiling blocks reduce airborne sound levels by up to 40 dB, like the double glass facade, made of laminated panes and a PVB layer. Thus, these barriers are sufficient to meet the noise criteria stated in the plan drawings.

## REVERBERATION TIME



Average

## OPERA HALL



Reverberation Time v.s. Frequency

| | 125 | 250 | 500 | 1000 | 2000 | 4000Hz |
|---|---|---|---|---|---|---|
| RT60_O | 1.72 | 1.73 | 1.69 | 1.56 | 1.43 | 1.47 |
| RT60_U | 1.75 | 1.77 | 1.74 | 1.60 | 1.47 | 1.55 |

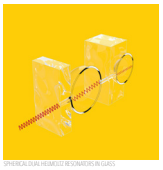
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| D (m) | 10 | 14 | 18 | 22 | 26 | 30 | |
| C80_O | 1.60 | 1.50 | 0.25 | 0.61 | 0.56 | 0.59 | |
| C_O | 4.47 | 3.28 | 2.47 | 1.80 | 1.22 | 0.87 | |

## REHEARSAL ROOM

To imitate the acoustic environment of the opera hall, the rehearsal room is clad in the same combination of materials. Like in the opera, Dual Helmholtz resonators are integrated in the rear wall of sparkling glass blocks. To dampen the perceived loudness of the sound strength and to create an ergonomic environment for rehearsals, additional sound absorption- and sound scattering panels have been installed on the walls.

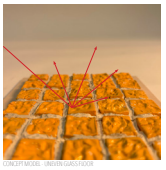
| F (Hz) | 125 | 250 | 500 | 1000 | 2000 | 4000 |
|---|---|---|---|---|---|---|
| RT60_O | 1.08 | 1.00 | 0.99 | 1.05 | 0.96 | 1.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| D (m) | 10 | 12 | 14 | 16 | 18 | 20 | |
| C80_O | 3.33 | 3.25 | 3.19 | 3.16 | 3.14 | 3.13 | |
| C_O | 9.30 | 8.87 | 8.46 | 8.03 | 7.73 | 7.28 | |



SPHERICAL DUAL HELMHOLTZ RESONATORS IN GLASS

CONCEPT MODEL - ADJUSTABLE BALCONY RAILINGS



CONCEPT MODEL - UNEVEN GLASS FLOOR

## DUAL HELMHOLTZ RESONATORS

Crafted from spherical glass volumes, these serially connected Helmholtz resonators have been designed to target frequencies in both the 125 Hz and 250 Hz bands.

Functioning akin to mass-spring systems with two degrees of freedom, these dual resonators exhibit two natural frequencies. This enables each resonator opening to effectively absorb two frequencies. Thus, the desired target frequencies can be chosen by small changes of the parameters.

Installed within the glass block walls, this design suggests a solution to successful sound absorption despite using hard and reflective materials.

## THE GLASS SLIT BALCONIES

Balcony railings will be adorned with separate glass elements. With this prototype, the acoustic and architectural design work together, as the railings act as high frequency absorbents or diffusors.

These multi-functioning elements are comprised of small glass blocks, intermediate air gaps, and an absorbent cloth behind, extend the glass-based theme within the auditorium down to the smallest detail. The spacing between each piece and the rear absorption layer can be adjusted. This design renders them versatile in acoustic terms, as they can function as slit absorbers, diffusers, or diffractors, depending on the chosen configuration.

## HEELS OVERHEAD - UNEVEN BLOCKS

The semi-transparent floor is completely constructed of glass blocks. Since this glass floor also functions as the ceiling in the lobby, visitors can catch a sparkling glimpse of the auditorium when it is filled with the audience before performances.

The uneven surfaces enable dispersion of high-frequency sound waves in the hall. This characteristic endows the hall with a vibrant acoustic environment, while simultaneously tackling optimal reflections and thus reduces the effects of acoustical glare. Single Glass-Helmholtz resonators are mounted inside the blocks, facing both towards the opera hall and the lobby, tackling challenging reverberation times in the 250 Hz band.

GLASS BLOCK

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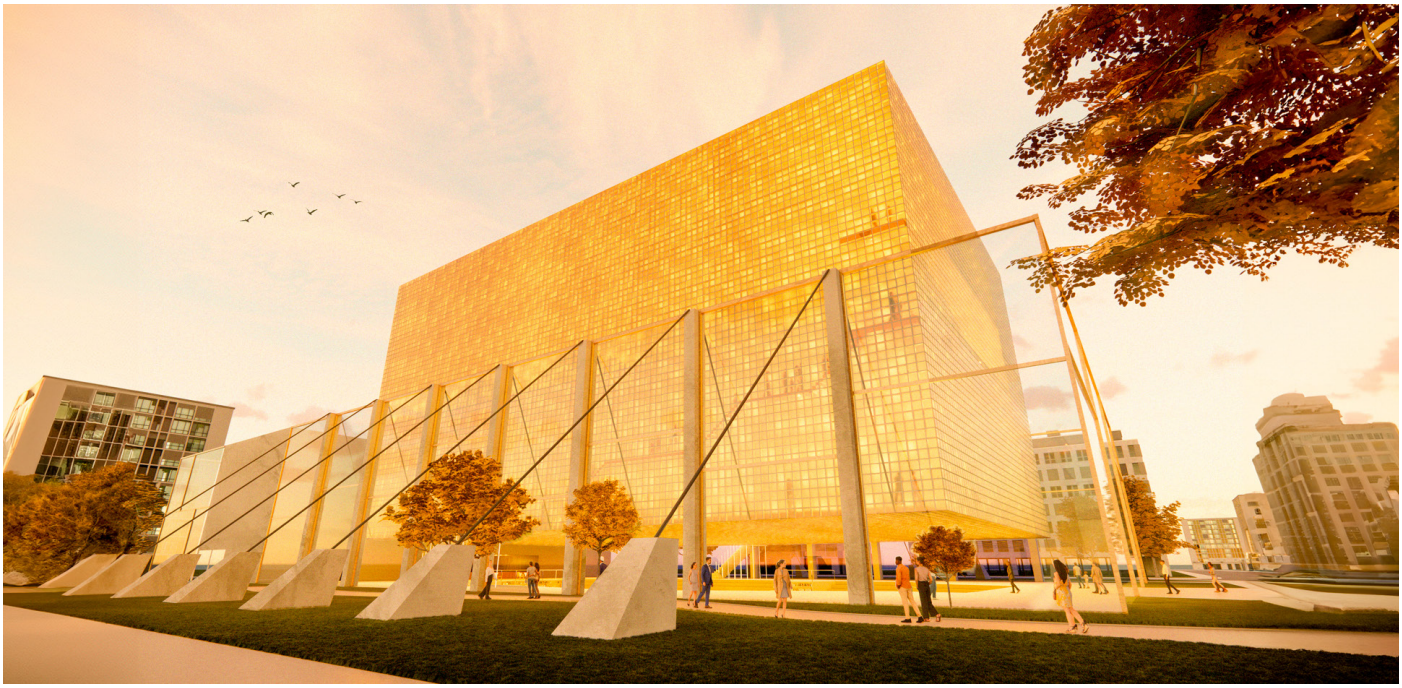

OUTDOOR PERSPECTIVE- URBAN LAMP

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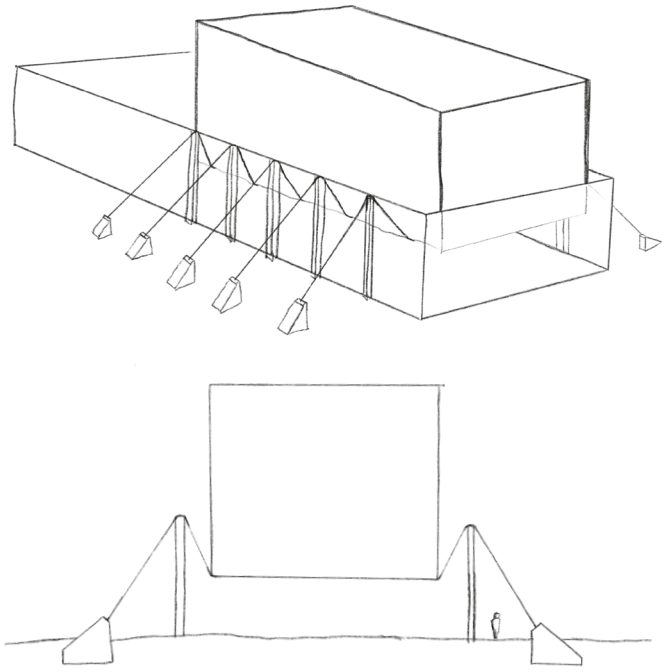

STRUCURAL CONCEPT SKETCH

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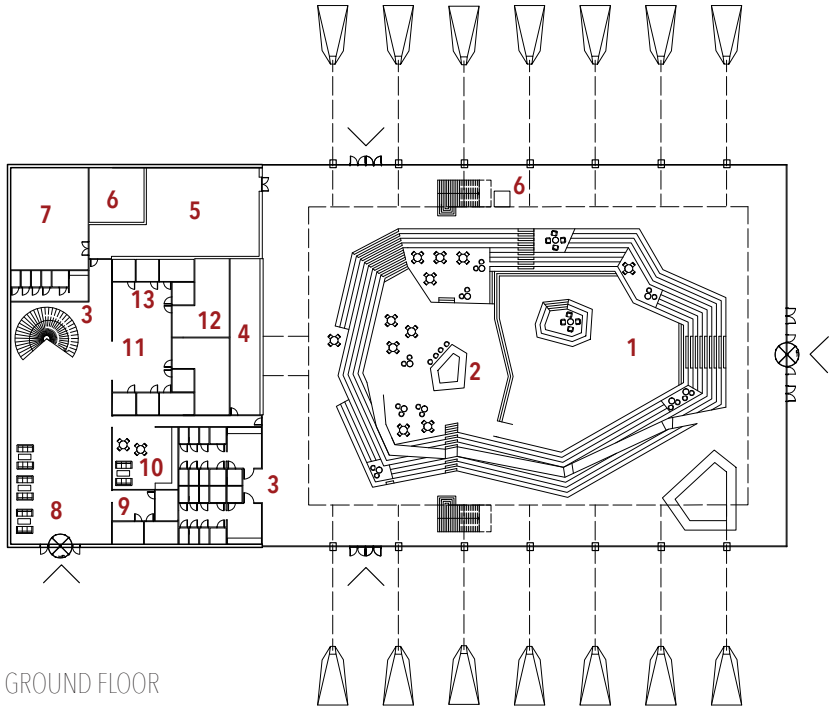
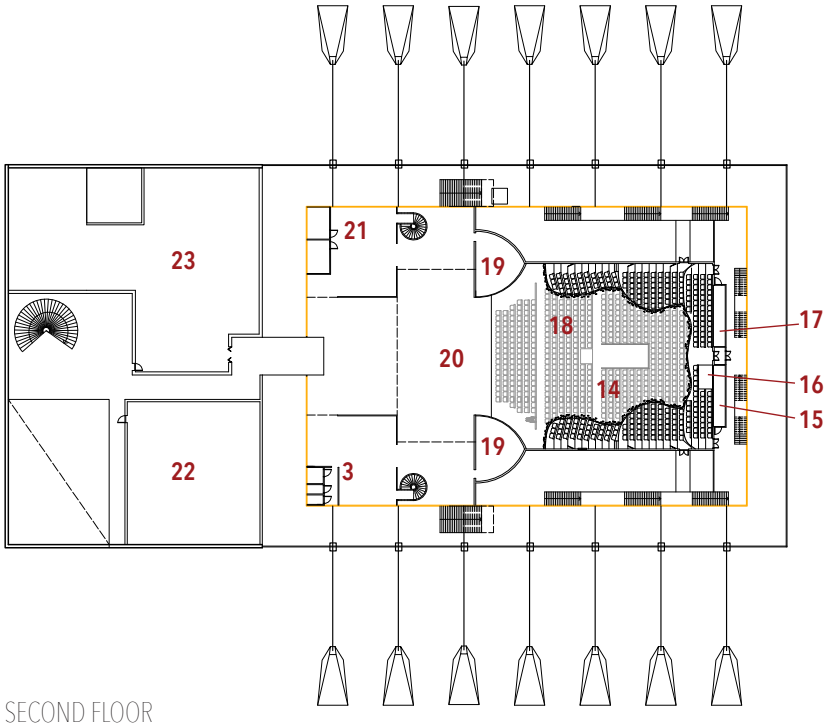
- NC-15
- NC-20
- NC-25
- NC-30
- NC-35
- NC-40

1- Lobby
2- Café
3- Toilets
4- Wardrobe
5- Kitchen
6- Elevator
7- Loading Dock
8- Staff Entrance
9- Tech Offices, 11.6 m² each
10- Lounge
11- Green Room, 105 m²
12- Chorus Dressing Rooms, 54.5 m² each
13- Solo Dressing Rooms, 7.8 m² each
14- Auditorium
15- Follow Spot Booth, 28 m²
16- In-House Audio Mix, 5.7 m²
17- Control Room for RH, 28 m²
18- Conductor Podium
19- Orchestra Pits, 73 m²
20- Stage, 588 m²
21- MER Offices, 24.7 m² tot
22- Rehearsal Hall, 318 m²
23- Scene Shop, 570 m²
Restaurant (third floor)
MEPFIT with MER (third floor),1952




GROUND FLOOR




SECOND FLOOR

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CONCEPT MODEL - VOLUME

## A LOBBY THAT TAKES SPACE

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LOBBY - CREATIVE, MULTIPURPOSE SPACE

OPERA HALL


SECTION DRAWING

## DUAL HELMHOLTZ RESONATORS

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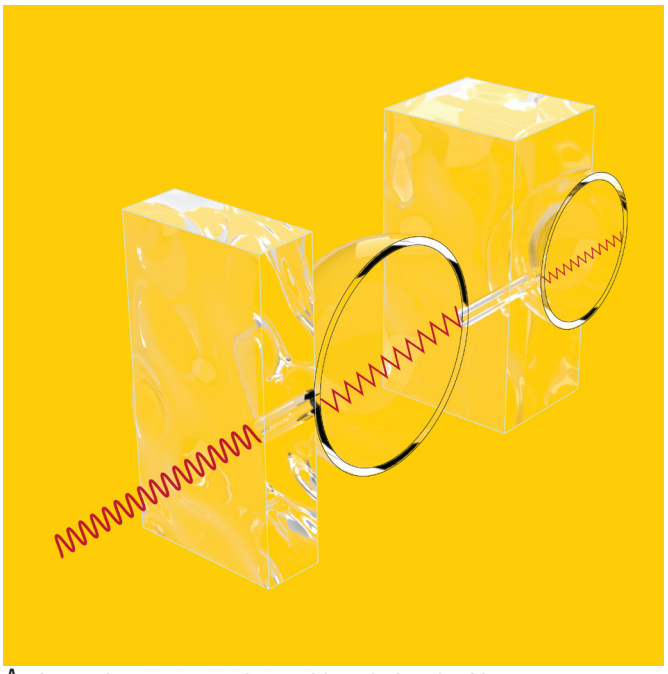

A - SPHERICAL DUAL HELMOLTZ RESONATORS IN GLASS

## THE GLAS SLIT BALCONIES

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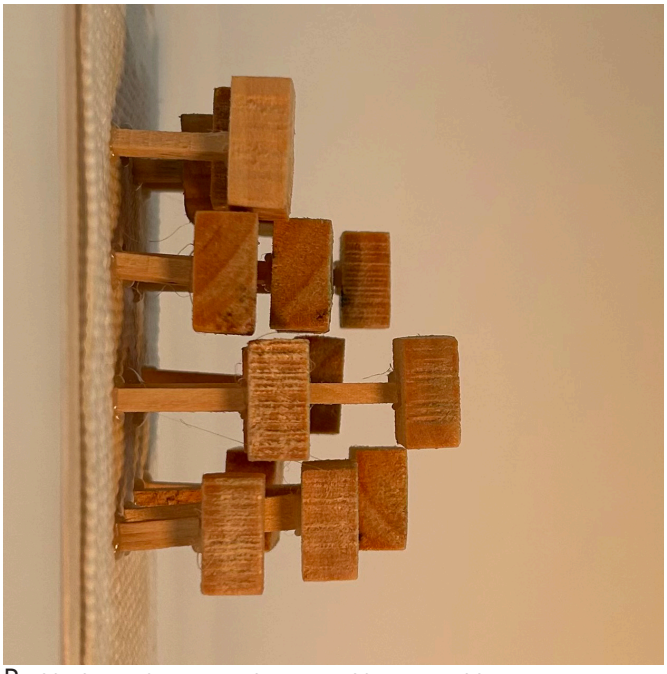

B - CONCEPT MODEL - ADJUSTABLE BALCONY RAILINGS

## HEELS OVERHEAD-UNEVEN BLOCKS

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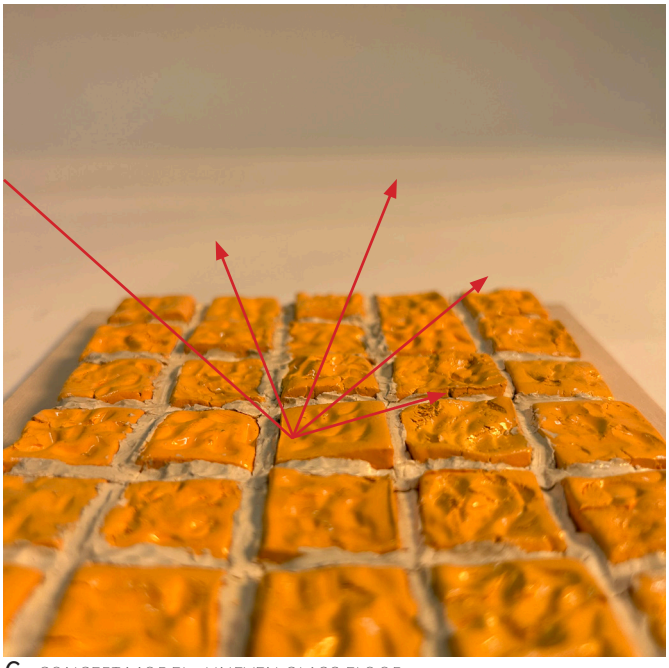


C - CONCEPT MODEL - UNEVEN GLASS FLOOR

# THE PROCESS

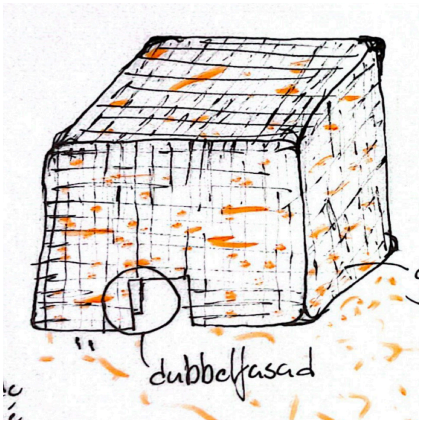
Ever since I saw an image of Hermes Maison in Tokyo, I've been drawn to glass blocks. I admired the material's retro style, modular structure, mysterious transparency and beautiful reflections. A curiosity lingered in me about what could be created with these blocks, so when the thesis project was presented two years later, glass blocks were a natural choice for a concept. However, to explore other ideas, we began the process by brainstorming various concepts. The first concept, Blue, featured an organic design, with the building's facade meandering and flowing like water. The second concept, Grey, embraced a brutalist style while flirting with classical columns and clear structure. Despite two very compelling concepts, the allure of glass blocks was undenieble. The material's possibilities, unique character and challenges inspired more ideas and thoughts, but above all, it ignited a joy and eager to creation. Ultimately, we chose the glass concept and named it Yellow.

The process continued with a highly creative phase where we experimented with different designs and how the material could be intergated in a building. From the beginning we knew that we wanted the opera's facades would be characterized by glass blocks, but the question was to what extent. One proposal was for the entire facade to be made of glass blocks, with regular window glass inserted intermittently to play with the material's transparency. Throughout this creative process, we created physical concept models to gain a better understanding and further develop the concept. Eventually, we decided on a double facade where the opera hall was elevated, clad in glass blocks. The idea behind the double facade and suspension was for both to contribute to good acoustics. At this stage, we also decided to integrate light sources into the blocks so that the suspended structure could resemble a lamp illuminating the urban space around the opera. To make use of the space created beneath the elevated volume, we chose to dig out various levels and stairs, creating a unique and dynamic space, perfect for a lobby, study area and social gathering space.

As the next iteration began, focusing on acoustic prototypes, the challenges of glass blocks regarding acoustics became apparent. Despite the difficulties of achieving good acoustics with the hard material, we were uncompromising in letting it influence our concept. In collaboration with our acoustician, we turned the problems around and managed to use the glass to our advantage in acoustics. We created three acoustic solutions, all entirely made of glass. In this way, architecture and acoustics merged, creating something entirely unique; an opera hall that doesn't conceal its acoustic solutions but highlights them and lets them become part of the spatial character and experience.

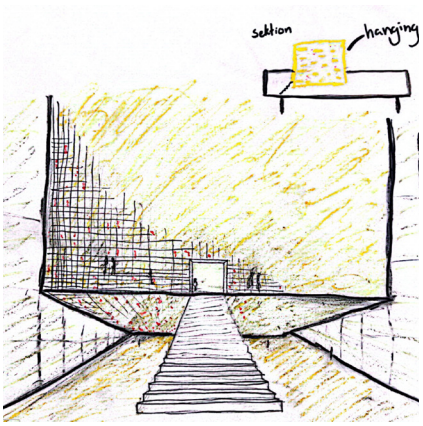
To present our concept and the acoustic aspects in a clear yet engaging manner, we chose to blend various representations. The light and transparency of glass were best showcased through renderings of the exterior, lobby and auditorium. To create the renderings, we first digitally modeled an 3D-model. Throughout the process, we built physical concept models, which were then photographed and used on the posters. In addition, we used sketches and a hand-painted glass block to reinforce the concept. We also purchased real glass blocks to drive our own process and for investigative purposes.

And just like that the opera was born, and we had no other choice than to name it Opera GLAS



FIRST SKETCH - GLAS FAÇADE

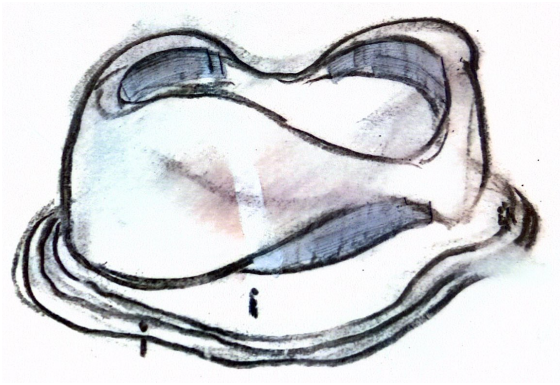

CONCEPT MODEL - VOLUME

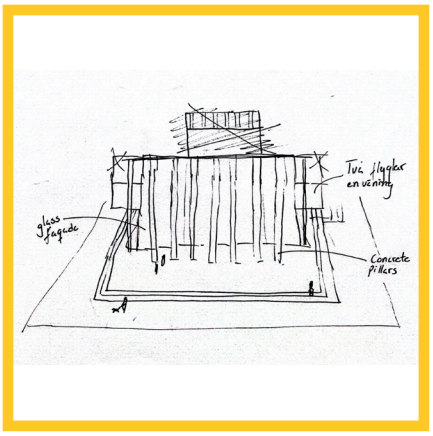


FIRST SKETCH - LOBBY

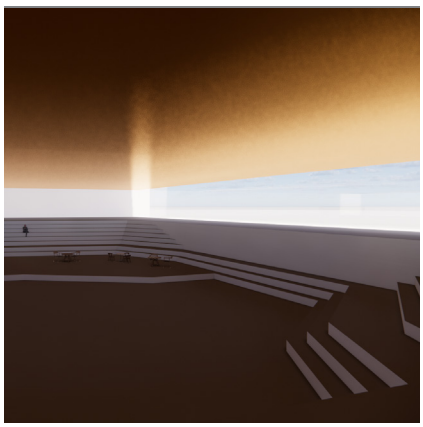

EARLY VISUALIZATION - STAIRWAY

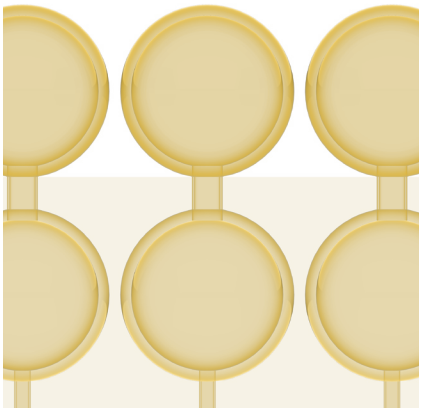

SECOND RENDERING OF LOBBY

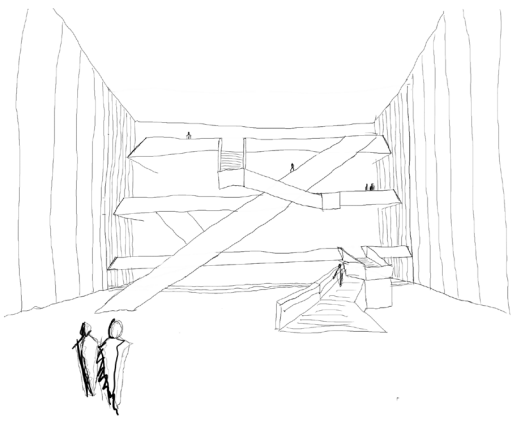

CONCEPT BLUE

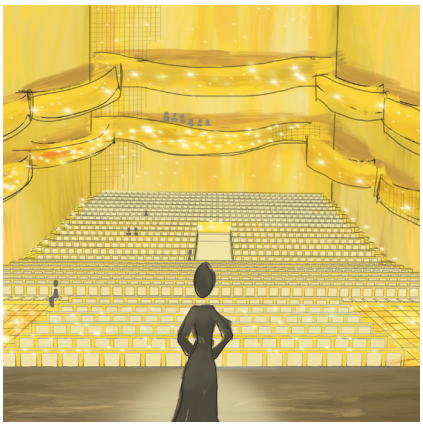


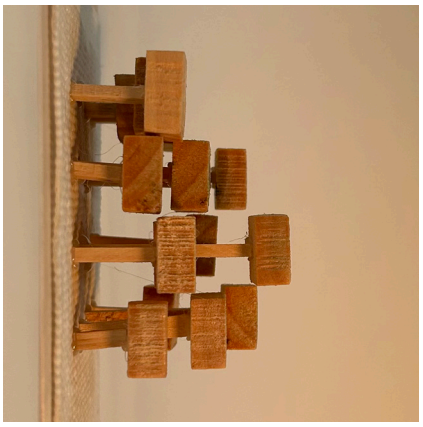
CONCEPT GREY


FIRST RENDERING OF LOBBY


FIRST VISUALIZATION- DUAL HELMHOLTZ


CONCEPT GREY - LOBBY


EARLY VISUALIZATION - OPERA HALL


CONCEPT MODEL - BALCONIE RAILINGS

# THE REFLECTION

I will forever look back on this project with great joy and pride. I believe we made an incredible effort in deciding on a concept early in the process and then daring to stick with it all the way through. While glass blocks had their advantages, they also posed unique challenges, which in turn demanded unique solutions. Without compromising the concept, we managed to create our own acoustic solutions, entirely crafted in glass. It was an incredible process, and it was exciting to present something so different. This work wouldn't have been possible without the help of our acoustician. I had prejudices that conflicts always arise when two professions meet because they have difficulty understanding each other's visions and needs. Our collaboration took a different path; it became a success story. Right from the start, there was an understanding between us that allowed us to assist each other in the process of achieving the desired result. The collaboration has brought great joy to our group and is definitely one of the reasons for our good outcome.

Given more time, we would have developed the construction further and detailed how the suspension works. We acknowledge that this part was left unclear and agree with the criticism we received that our presented solution wouldn't function in practice. Another improvement would have been to include the sustainability factor in the project. We are aware that sustainability is an important aspect, but unfortunately, it wasn't prioritized this time due to time constraints. The choice of glass blocks was made with the awareness that it is a fully recyclable and robust material with a long lifespan. However, this aspect wasn't highlighted in the final result. A potential development could have been to determine that the plywood used in the opera was also recycled, and that the concrete foundation was made with more environmentally friendly, alternative binders. A simple solution to make the opera more environmentally friendly would have been to use renewable energy by installing solar panels on the roof.

In conclusion, this project has inspired me a lot. The creative process and the new challenges have sparked a desire to create. The collaboration with the acoustician was particularly exciting. Working with other professions was very instructive, and in my opinion, the end result was much better when different expertise came together. The good collaboration has inspired me to continue working with other professions, and I hope my future career is filled with encounters with different people who all want to combine their knowledge and create something magical.


FINAL PRESENTATION