SHUTTER

Realising an acoustic concept

ACEX15

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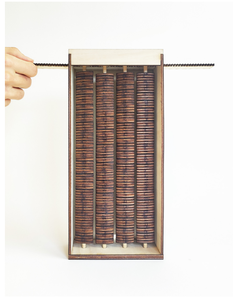
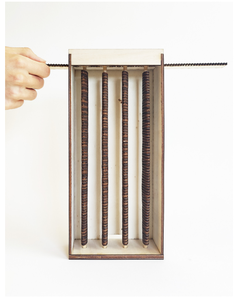
A college with a very strong music and vocal program intends to construct a new 1,200-seat performance hall primarily for opera. Their wish is to build an opera that is able to change its acoustic properties to allow for a wide range of performances as well as speeches. In addition, the building needs to accommodate students, performers and visitors alike.

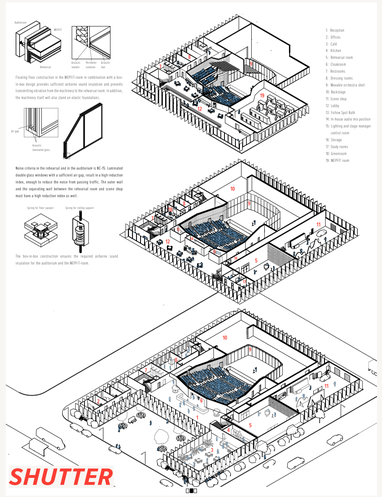


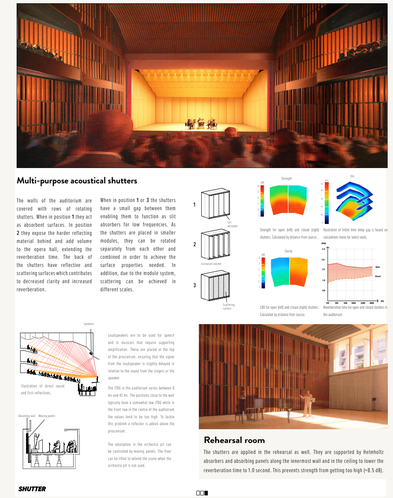


Physical shutter model, Plywood

CONCEPT

Our design concept is shutters. With a simple rotation they can either hide or reveal the secrets behind. Using this we have created multipurpose acoustical elements. Simply rotating the shutters will turn a hall suitable for speech into an opera. The shutters allow students to experiment with the acoustics in the room, enabling them to expand their intuitive understanding of how these changes affect their performance.





Final posters (710x560 mm)

Context

We imagine the opera in a bustling area of a big city, integrated into a university campus. The facade is made up of pillars resembling the acoustical shutters. These may at first appear static, but if you are lucky you will catch them in movement. The shutters create a separation between the interior spaces and the busy street. The building opens up towards the street and invites the students in to study or buy tickets for the evening show.

Rotating facade

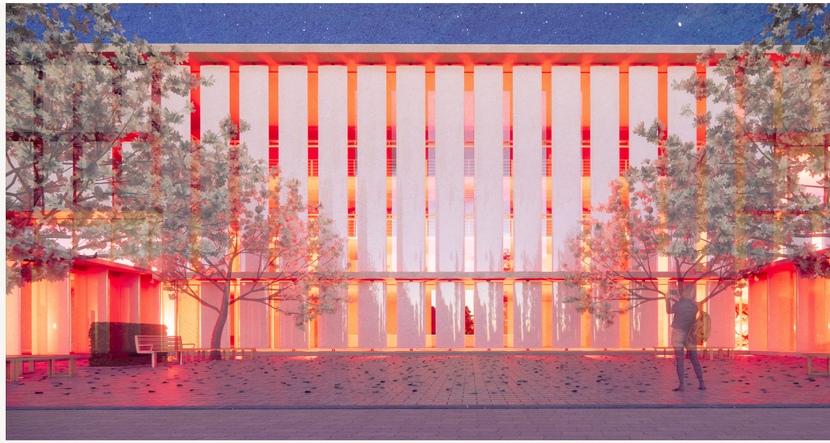
Morning

The facade is painted with a white gloss paint to brighten up the streets and reflect light into the building.

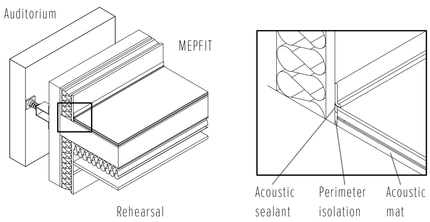
Daytime

The rotation of the facade-elements allows for different amounts of light to enter or leave the building.

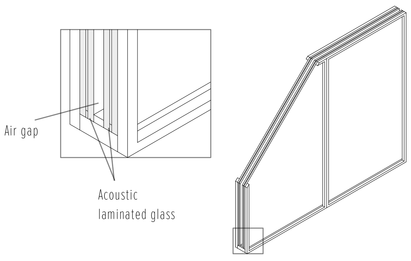
Evening, during performance



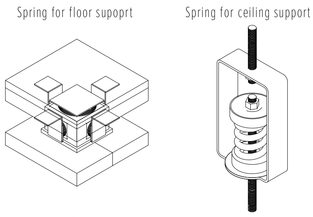
The facade closes and the lights change color when there is an ongoing performance.



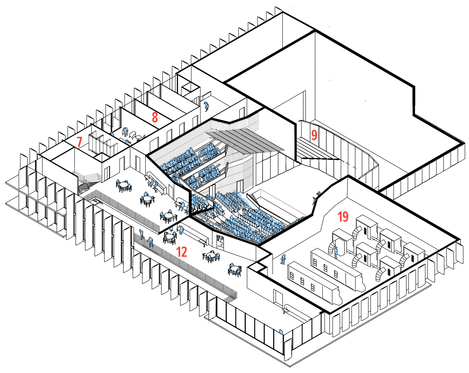
Floating floor construction in the MEPFIT-room in combination with a box-in-box design provides sufficient airborne sound insulation and prevents transmitting vibration from the machinery to the rehearsal room. In addition, the machinery itself will also stand on elastic foundations.



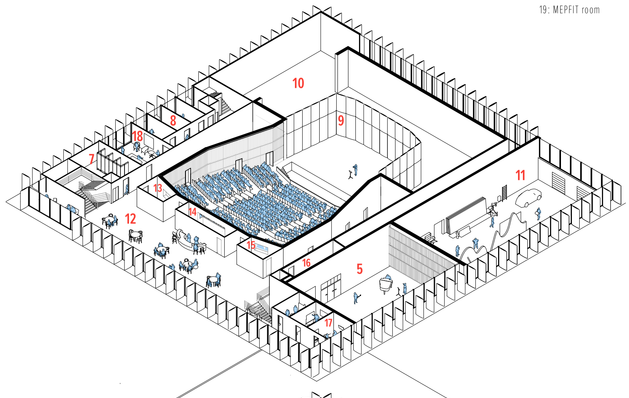
Noise criteria in the rehearsal and in the auditorium is NC-15. Laminated double glass windows with a sufficient air gap, result in a high reduction index, enough to reduce the noise from passing traffic. The outer wall and the separating wall between the rehearsal room and scene shop must have a high reduction index as well.

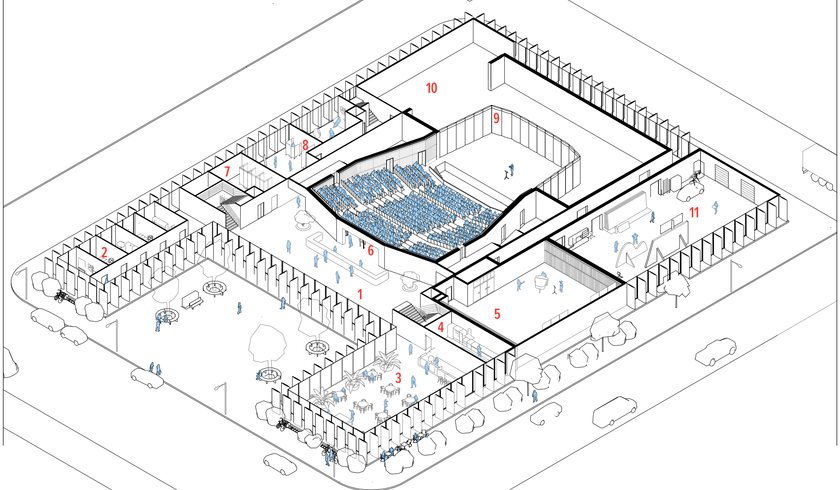


The box-in-box construction ensures the required airborne sound insulation for the auditorium and the MEPFIT-room.



1: Reception
2: Offices
3: Café
4: Kitchen
5: Rehearsal room
6: Cloakroom
7: Restrooms
8: Dressing rooms
9: Movable orchestra shell
10: Backstage
11: Scene shop
12: Lobby
13: Follow Spot Both
14: In-house audio mix position
15: Lighting and stage manager control room
16: Storage
17: Study rooms
18: Greenroom
19: MEPFIT room

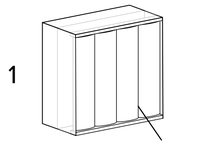


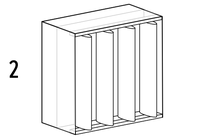


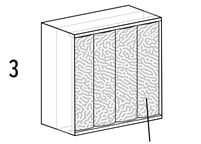
Multi-purpose acoustical shutters

The walls of the auditorium are covered with rows of rotating shutters. When in position 1 they act as absorbent surfaces. In position 2 they expose the harder reflecting material behind and add volume to the opera hall, extending the reverberation time. The back of the shutters have reflective and scattering surfaces which contributes to decreased clarity and increased reverberation.

When in position 1 or 3 the shutters have a small gap between them enabling them to function as slit absorbers for low frequencies. As the shutters are placed in smaller modules, they can be rotated separately from each other and combined in order to achieve the surface properties needed. In addition, due to the module system, scattering can be achieved in different scales.







Working with acoustics

This project was a group effort composed of 2 architecture and engineering students as well as one student from the sound and vibrations masters program. This relationship was essential to our success which made it very important to make everyone feel involved and invested. To achieve this we met up almost every day, and even if we worked on different aspects, with different backgrounds we discussed all of the choices, problems and compromises as they revealed themselves. By doing this, everyone was onboard, and we could tackle difficulties quickly and efficiently. This methodology also made us learn from each other, and I personally learnt a few things about acoustics.

Loudspeakers are to be used for speech and in musicals that require supporting amplification. These are placed at the top of the proscenium, ensuring that the signal from the loudspeaker is slightly delayed in relation to the sound from the singers or the speaker.

The ITDG in the auditorium varies between 8 ms and 42 ms. The positions close to the wall typically have a somewhat low ITDG while in the front row in the centre of the auditorium the values tend to be too high. To tackle this problem a reflector is added above the proscenium.

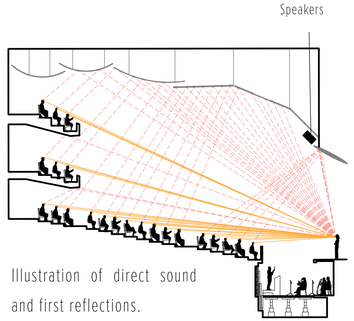
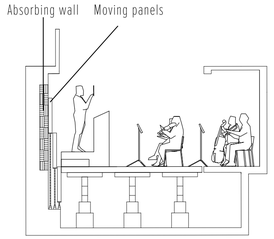


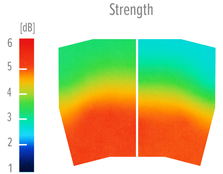
Illustration of direct sound and first reflections.



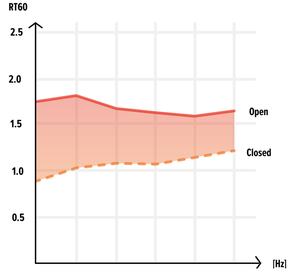
The absorption in the orchestra pit can be controlled by moving panels. The floor can be lifted to extend the scene when the orchestra pit is not used.

Rehearsal room

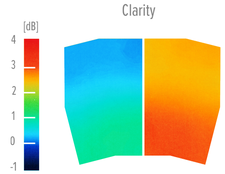
The shutters are applied in the rehearsal as well. They are supported by Helmholtz absorbers and absorbing panels along the innermost wall and in the ceiling to lower the reverberation time to 1.0 second. This prevents strength from getting too high (~8.5 dB).



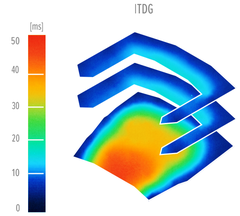
Strength for the open (left) and closed (right) postitions.



Reverberation time for open and closed panel configurations in the auditorium.



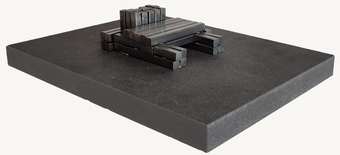
C80 values for the open (left) and closed (right) postitions.



Initial time delay gap (ITDG) for the auditorium including the balconies.

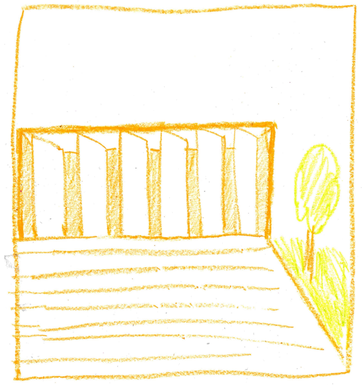
View from lobby

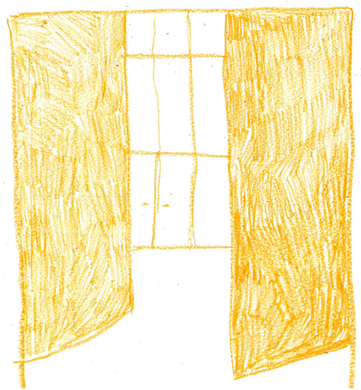
The process

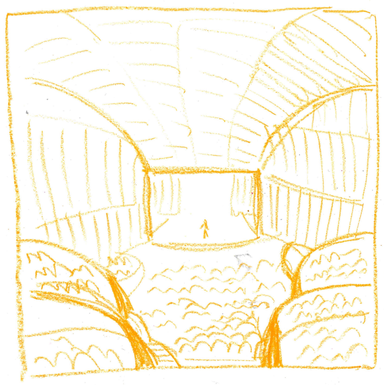


Model exploring the volume of the opera, Steel on MDF

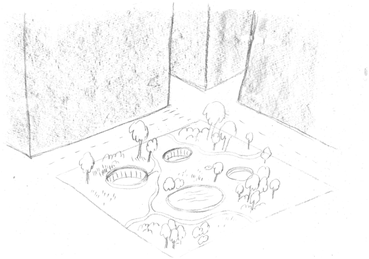
During the course we were given assignments to help keep us on track, and to lay a natural design path for us to follow. Each assignment had a different theme, but the main focus of them was to explore and expand our knowledge of spatial acoustics and further develop our project. Early assignments made us come up with 3 different concepts and had us choose between them. This allowed us to feel both included and motivated, and taught us to make hard decisions early on in the process. The next assignment was to create 3 different physical acoustics elements from our chosen concept. This challenged our creativity and made us work with our hands, allowing us to approach our concept from a totally different angle. The final 2 assignments had us making a full draft of our final posters and refine them.







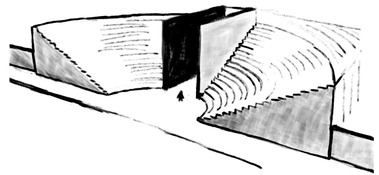
First sequence walkthrough based on the chosen concept



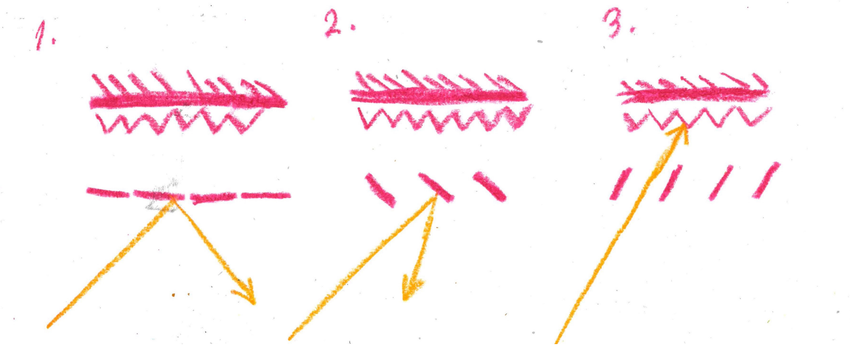
Underground concept

Personal thoughts

This way of working feels very refined, and is definitely something I will be using in the future if the opportunity arises. The assignments made sure we felt on track and the manny smaller presentations held with each of these really helped us to be inspired by other groups, and to see what we need to make clearer or cut down on. If i had to pick a favorite, i would definitely say the 4th one (poster draft). Creating the mock-ups really helped us focus on what we wanted to refine.



amphitheatre concept

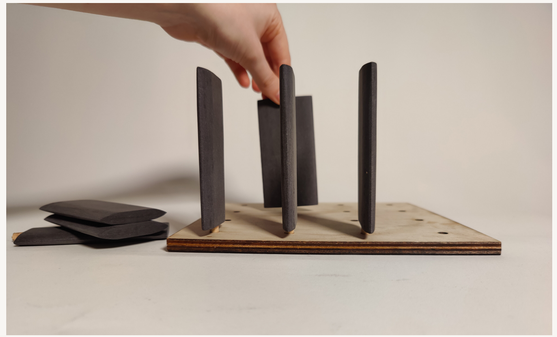


First drawing of the shutter

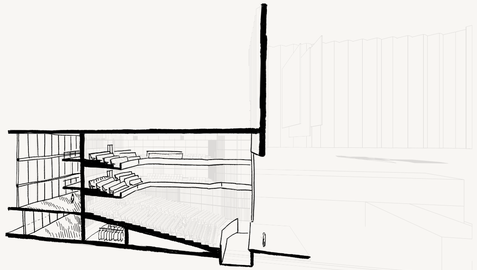
Reflection

It felt really gratifying to apply what I have learnt from these 3 years of study. Feeling confident 3D modelling, building physical models, sketching new ideas and in myself presenting these made the whole process feel productive and fun. I am very pleased with the outcome of our project. We all took it seriously and supported each other through highs and lows. Our structured way of working combined with passion for our work enabled us to really refine our product to a high level of detail. Even if one is never entirely done with a project, this is the one I feel is the most finished of the projects I have previously been working on.

Throughout this project I found myself in a coordinating role. Most of my time I spent producing, expanding and developing our ideas. But I also enjoyed planning what to prioritise, making sure we all worked on stuff we wanted to work on, discussing what material each of us needed from each other to make sure no one got stuck waiting on decisions we needed to make together or for someone to produce something.
This made me see clearer what role I would enjoy and want to develop and employ in my future career.



Early pegboard model for experimenting with facade configuration, Plywood / MDF



Section being drawn form 3D model viewcapture