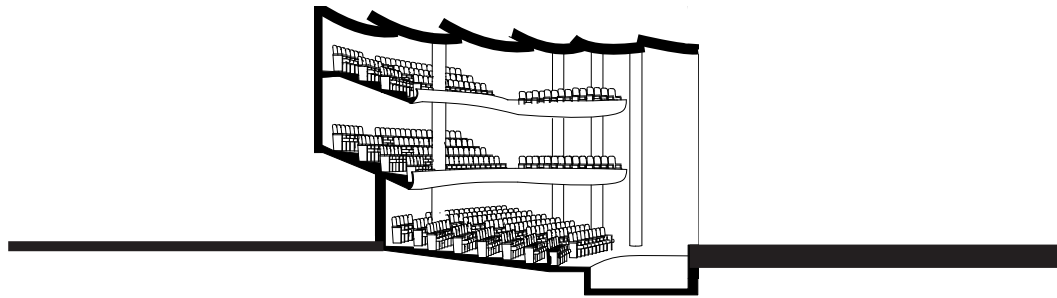


THE SHADOW PLAY

A PLAY WITH LIGHT AND SHADOWS



NUO XIN MARY-ANN CHANG

2025

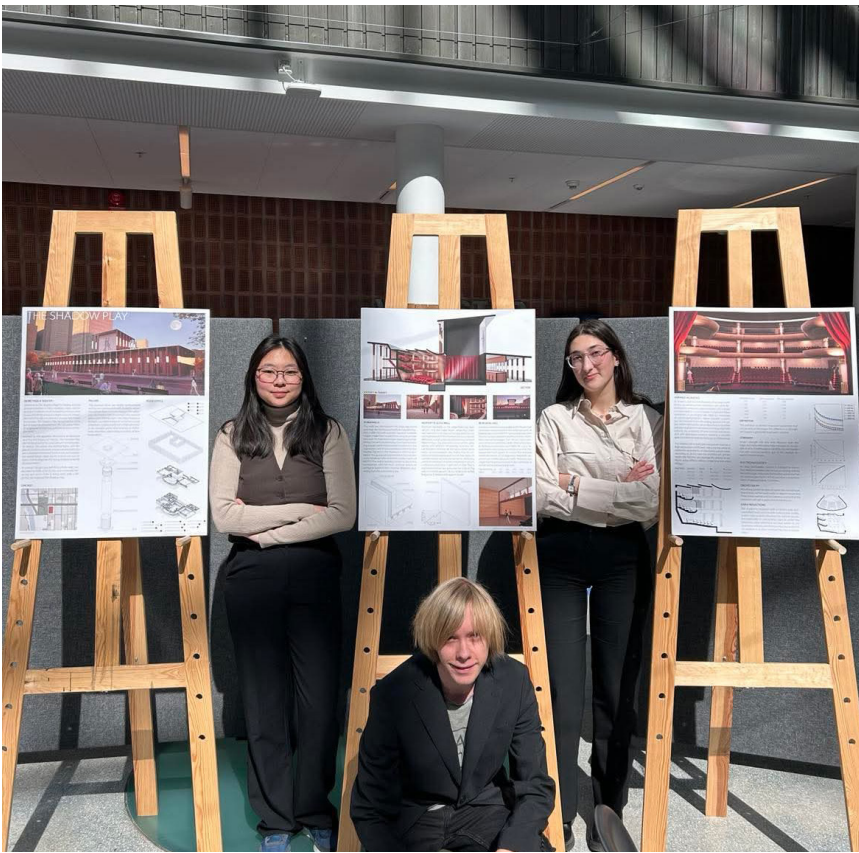
PROJECT

Year: January-April 2025

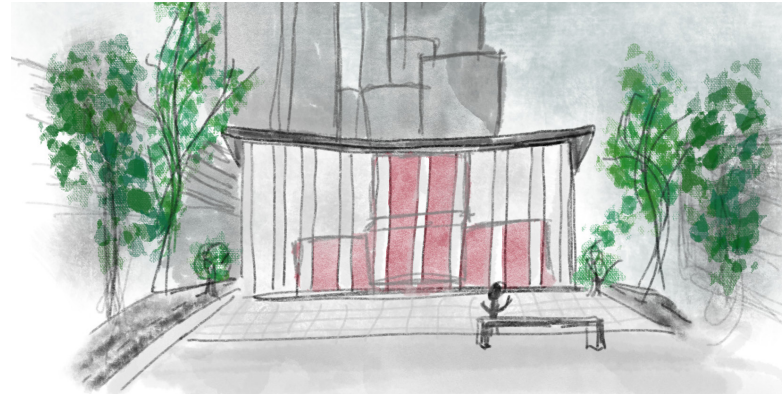
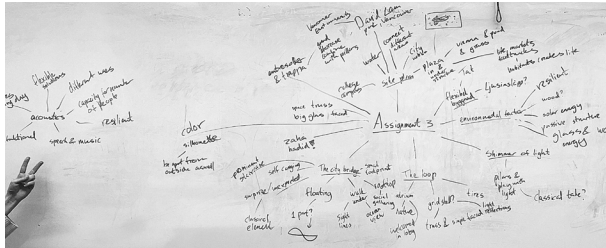
Collaboration: Rafaella Al-Homsi & Carl Höjdefors

Software: AutoCAD, Rhino, Illustrator, Photoshop, Twinmotion, Revit, Matlab

During this bachelor's thesis project the goal was to design a 700 seat theatre hall according to the program given from the Acoustical Society of America's Student Design Competition. The main objective was taking into consideration the acoustical properties in the architectural design process. This was accomplished by a collaboration between Architecture and Engineering students and Sound and Vibration students. Throughout the entire design process 5 gallery critiques where classmates and supervisors could reflect and discuss our initial concepts, models and sketches. Furthermore, regular weekly supervisions from Morten Lund, Wolfgang Kropp, Peter Christensson and Lukas Nordström where valuable feedback was gained.

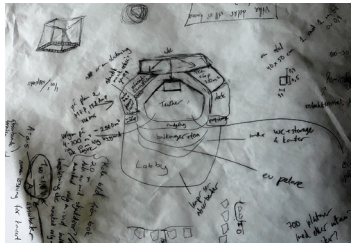


Group members with final posters

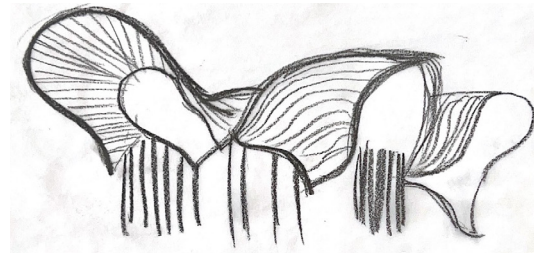
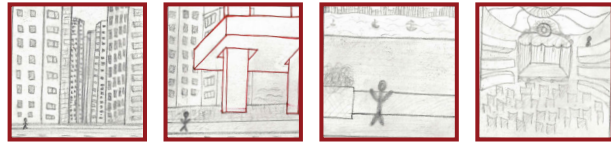


INITIAL SKETCHES AND PROTOTYPES

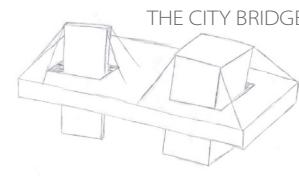
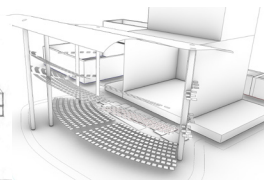
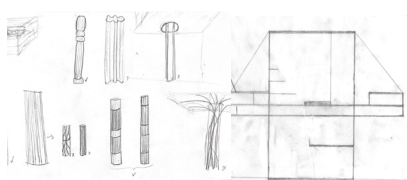
Starting with a blank whiteboard we started to brainstorm our initial thoughts and ideas onto a mind map. This was used as a reference throughout the entire project. As we gained more insight further in the project the mind map expanded.



To bring the project forward me and my group members collaborated with everything and if one group member was stuck on something we often switched tasks in the group to get a new input on the problem. For instance, this was the case when we worked with the floorplan. I was stuck with the layout and my group member helped with it.



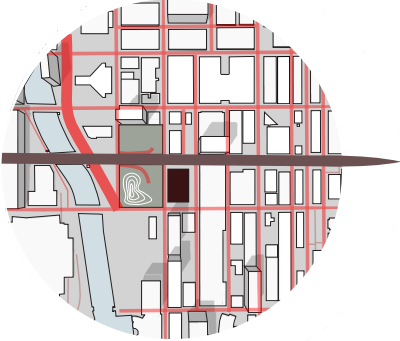
We also worked a lot with compromises to meet in the middle and we also consulted with supervisors and classmates who gave us beneficial input.



SUSTAINABILITY

Our acoustical concept for the theatre walls is to have two rubber layers, made out of recycled rubber tires, which will stop soundwaves by friction. This is a new way of taking care of waste products. It is important with sustainability in the built environment, not only in the design process but also during and at the end of the life cycle. Therefore, using renewable material and minimising the global impact is of uttermost importance.

CHICAGO





ARCHITECTURAL QUALITY

Our main architectural qualities are our innovative design concepts. We have deconstructed the definition of what a pillar is to bring down light into the theatre hall, instead of using windows.

Furthermore, we wanted an interactive theatre that is accessible for everyone which will be accomplished by having a shadow play projection which will enable people on the outside to take part of the act on the inside.

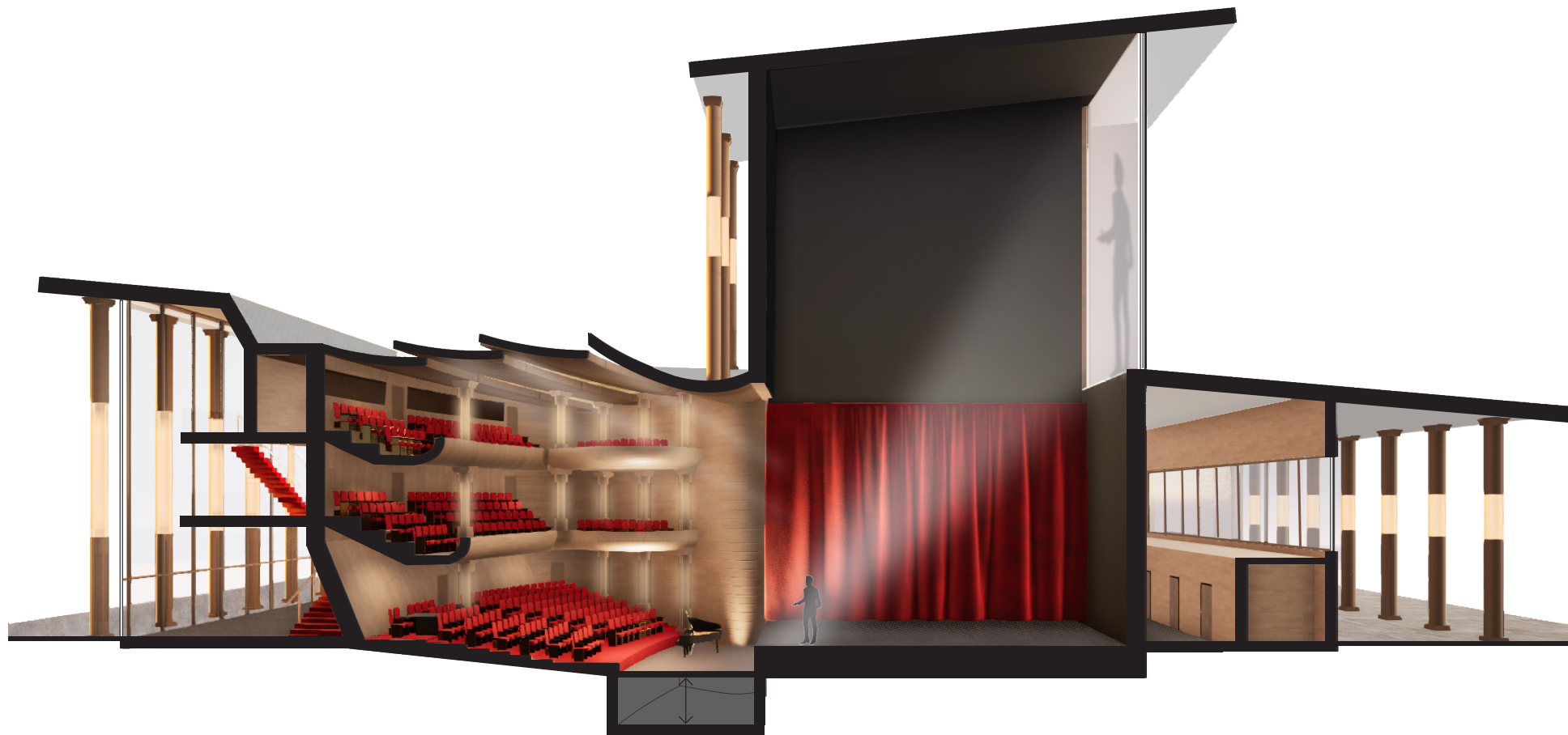
With our robust facade and pillar design we also connect to the classical architecture qualities.

A JOURNEY IN FRAMES

We have taken a lot of consideration of light and shadows since it is one of our main concepts with lights through a pillar and a silhouette projection. A prominent maroon red colour is used in the theatre hall with the classical seats. The colour is also used on the facade of the theatre hall facing towards the entrance, thus this colour can be viewed through the lobby.

Regarding the structural design we wanted to accomplish a pillar design in the facade which would carry up the roof and integrate the stage house as well as create an walkable arcade. The light up pillar arcade also helps create a narrative, encouraging people towards the backside of the building where the shadowplay can be viewed.





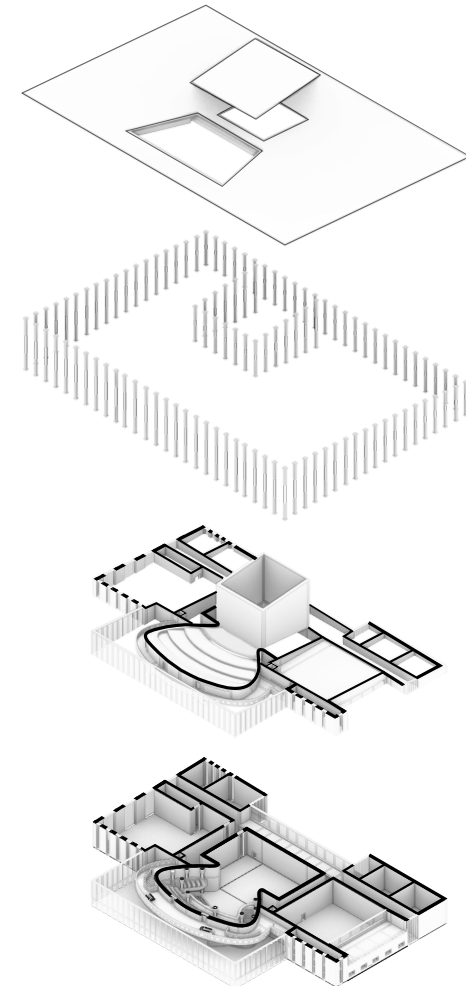
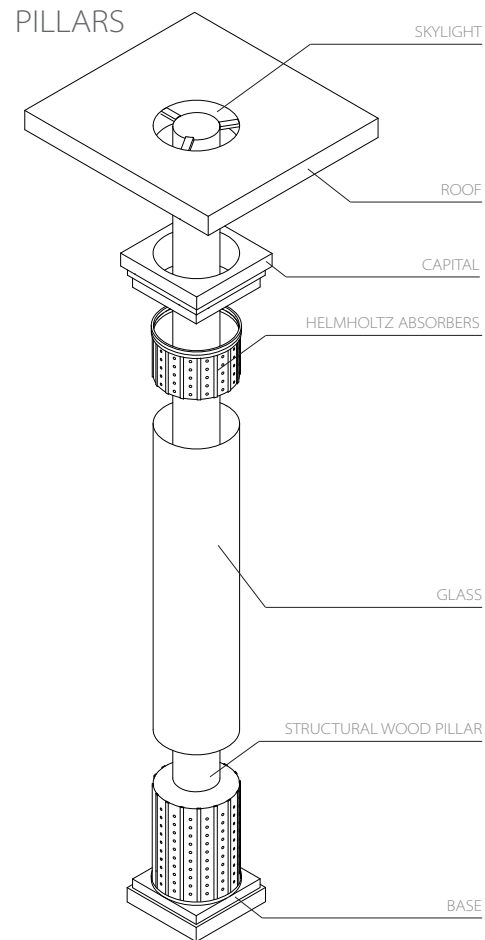
ARTISTIC METHODS

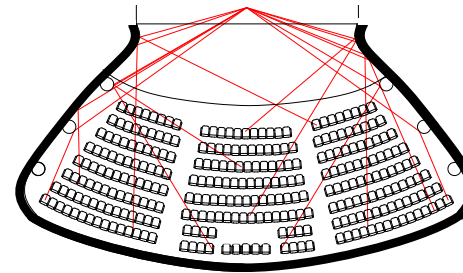
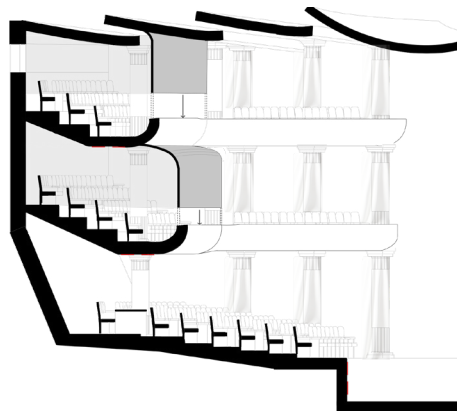
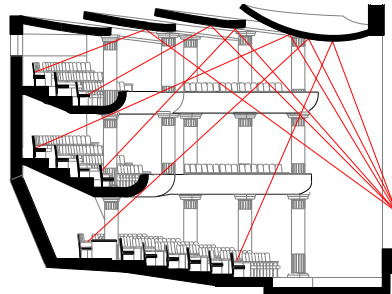
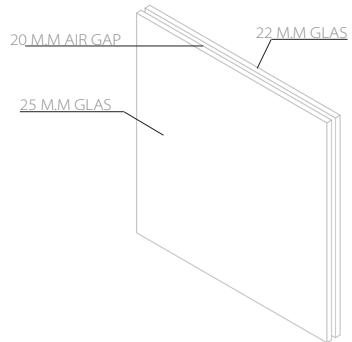
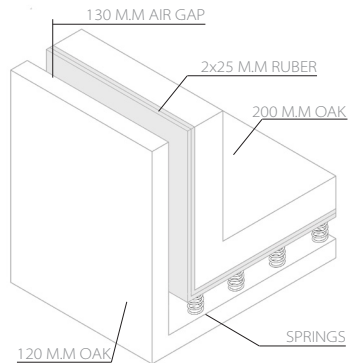
We worked iteratively, constantly refining and testing ideas to achieve a coherent and aesthetically pleasing result.

Quick hand sketches evolved into digital 2D drawings in rhino such as the section and floorplan. To give a depth to the 2D drawings we converted them into 3D sections and axonometric floorplans in rhino as well as rendered perspectives in Twinmotion with a touch of photoshop.

We used our initial acoustical model concepts and portrayed our vision of the shadow play projection with pictures of the silhouette model, and these further evolved into drawing and renderings. To make our drawings come to life in a new way we used poetic narrative text to describe our vision. Furthermore we implemented rhetoric techniques to catch the audience attention during our critiques.

In conclusion we used different ways of conveying our project with drawings, pictures, models, renderings, text and oral words.





ACOUSTICS

When working with the theatre hall the main focus was to achieve an optimal room acoustics. A lot of time was spent to get the volume down to 1900 m² as well as to get good reflections. This was accomplished by using convex structures both in the ceiling, for the balconies and in the walls.


We also worked a lot with variable acoustics by using sound absorbing curtains, panels and movable partition walls which increases the room volume as well as the number of seats. Furthermore we integrated the pillars as a helmholtz absorber.

| FREQUENCY (Hz) | T60 occupied (s) | T60 unoccupied (s) |
|----------------|------------------|--------------------|
| 125 | 0.97 | 0.98 |
| 250 | 0.97 | 0.99 |
| 500 | 0.95 | 0.98 |
| 1000 | 0.91 | 0.94 |
| 2000 | 0.94 | 0.97 |
| 4000 | 0.89 | 0.94 |

| BALCONIES | VOLUME | SEATS | RT | RT with curtains |
|-----------|---------------------|-------|-------------|------------------|
| 0 | 1900 m ³ | 700 | 0.94-0.99 s | 0.77-0.91 s |
| 1 | 1541 m ³ | 577 | 0.80-0.85 s | 0.74-0.88 s |
| 2 | 1197 m ³ | 419 | 0.87-0.93 s | 0.70-0.85 s |

OUR THREE BOARDS

THE SHADOW PLAY



© JENNIFER PERAZICH FOR HOK ARCHITECTS


MORE THAN A THEATER

Welcome to The Shadow Play! It's theatre, but not as you've known it. Here, shadows, light, and interaction unite to create something entirely new. In a world where privacy is highly valued, interactions are through a screen and people find it hard to connect. The Shadow Play brings back a social and interactive environment. It's not just a show, it's a dynamic interaction with the essence of the theatre itself.

Inspired by the grandeur of classical architecture and the rich legacy of theatre, The Shadow Play blends the old and the new with an innovative pillar design. The pillars, the shifting lights, and the play of shadows create an environment where you are constantly immersed, both inside and outside the performance. Here, you're invited not just to watch, but to step into the living, breathing world of performance.

In central Chicago you will find a lively spot, surrounded by traffic and city life, near Roosevelt University and across from a lovely park, with a hill perfect for enjoying The Shadow Play.

CHICAGO




STURDIVANT PLAN

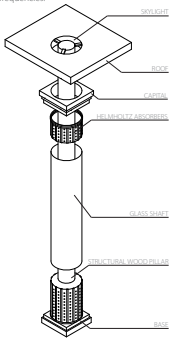
PILLARS

The classical pillars are boldly reinterpreted as they are constructed with skylights, allowing natural light to pour through the pillars into the theatre hall. In contrast, the exterior pillars emit artificial light. The pillars feature a smooth, rounded design to enhance sound reflections. Constructed with small openings in the wooden parts, they function as Helmholtz absorbers, optimizing acoustics, at low frequencies.

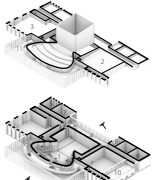
NOISE LEVELS



- 88.10 ● 88.30
- 88.10 ● 88.30
- 88.15 ● 88.35
- 88.40



REHEARSAL HALL



- 1. THEATRE
- 2. REHEARSAL HALL
- 3. SCENE SHOP
- 4. DRESSING ROOM
- 5. GREEN ROOM
- 6. OFF-STAGE TOILET
- 7. COSTUME SHOP
- 8. HANG AND MAKE-UP
- 9. PROP STORAGE
- 10. OFFICES
- 11. LOBBY

JOURNEY IN FRAMES



RUBBER WALLS

The walls are constructed with thick oak panels with high density to ensure sufficient sound reduction. Inside the wall assembly layers of synthetic rubber, made from recycled tires, serve as an isolation layer. As these layers move against each other, friction converts sound energy into heat, enhancing acoustic performance while introducing a new way to take care of waste products. Wall thickness reaches 500 mm in the theater and 300 mm elsewhere. This guarantees prevention of noise annoyance, including traffic noise from nearby roads and MEFFIT. The entire building follows a box-in-box construction, with the inner structure resting on springs to isolate it from external vibrations originating from the surrounding city.

SILHOUETTE GLASS WALL

Recessed spotlights in the stage floor cast light upward into the stage house, projecting shadow narratives to be seen on the glass wall. You can catch glimpses of these shadowy narratives during rehearsal, as well as during performances without flown scenery. The glass wall consists of two glass panels with different thicknesses, thus the critical frequency will not be the same, which gives better sound insulation. This means that the coincidence phenomena won't occur that easily. To maintain proper acoustic performance, absorbing panels in the stage house are integrated to ensure a minimum absorption coefficient of 50%. That is important because the glass wall has a dip in the reduction index around 150 Hz. Apart from that frequency, it isolates well against sound.

REHEARSAL HALL

Acoustic conditions comparable to the theater hall have been implemented in the rehearsal room. A floating floor in the MEFFIT room is essential, with thin connections between the floor and the wall to eliminate sound bridges. The 150 mm floor thickness combined with heavy walls, effectively reduces flanking transmission and fulfills NC curve requirements, preventing sound intrusion from the equipment room above. To control the rehearsal room's dominant 20 Hz frequency, Helmholtz absorbers are installed along the walls. These not only target low-frequency resonance but contribute to overall sound dampening as well.



| FREQUENCY (Hz) | 1.25 | 250 | 500 | 1000 | 2000 | 4000 |
|----------------|------|------|------|------|------|------|
| R60 (dB) | 0.95 | 0.94 | 0.95 | 0.97 | 0.95 | 0.92 |



REHEARSAL HALL (continued)

| BALCONIES | VOLUME | SEATS | RT | RT _{unoccupied} |
|-----------|---------|-------|-----------|--------------------------|
| 1 | 1000 m³ | 780 | 0.94/0.91 | 0.71/0.51 |
| 2 | 1541 m³ | 577 | 0.80/0.85 | 0.74/0.85 |
| 3 | 1197 m³ | 419 | 0.87/0.93 | 0.70/0.85 |



VARIABLE ACOUSTICS

To achieve optimal reverberation time, seats with heavy, sound-absorbing upholstery are used. Reverberation measures approximately 0.95 s when occupied and 1.1 s unoccupied. To replicate these conditions in an empty hall, ideal for rehearsals or varied performances, heavy discrete curtains can be lowered from the ceiling around the pillars which will function as an absorber. A movable partition wall at the balconies can reduce the hall's volume, by screening off one or both balconies, and add absorptive surfaces, creating a versatile space suitable for daytime lectures or conferences.

The theater hall is built with oak panels that has a high absorption coefficient, reducing the need for additional absorbers. 43 absorbing panels corresponding to 26 m² near the orchestra pit and beneath the balcony are strategically placed to enhance edge effects without impacting the visual design.

ELECTROACOUSTICS

An array loudspeaker system is installed to ensure that listeners perceive the sound as coming directly from the stage, with even distribution across the hall. An optimal gain factor of five provides a maximum reach of approximately 15 meters.

ORCHESTRA PIT

Absorbing panels are placed inside the orchestra pit. Four panels will be used inside to absorb sound and three panels will be used to scatter sound so that the musicians will get a good sound experience.

EARLY REFLECTIONS

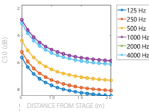
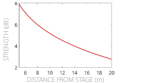
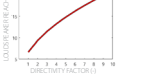
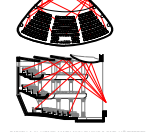
The theater is designed with a convex roof, outward-titled walls and smooth surfaces that evenly scatter early sound reflections for optimal acoustics, especially in critical areas such as under the balconies. Early reflections are kept within 50 ms to prevent echoes, and the balconies are angled at 23 degrees to further enhance the sound experience.

DEFINITION

The definition is another important parameter that can be seen in the graph. The difference in strength will require a good electroacoustic solution.

STRENGTH

Sound strength will vary with distance from the stage, but early reflections help maintain an acceptable level at 7.9 dB to about 2.8 dB across the theater hall with minimal variation due to the carefully designed interior shape.

BOARD TEXTS

Welcome to The Shadow Play! It's theatre, but not as you've known it. Here, shadows, light, and interaction unite to create something entirely new. In a world where privacy is highly valued, interactions are through a screen and people find it hard to connect, The Shadow Play brings back a social and interactive environment. It's not just a show, it's a dynamic interaction with the essence of theatre itself.

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REFLECTION

It was good to choose your own groups which ensured that the members have the same level of ambitions. It was fun to collaborate with sound and vibration students as well and we worked a lot together when we had the opportunity.

Our project, with the silhouette and the pillars, is quite complex and it has not been done on this scale before but when there is a will there is always a way so I believe that the shadowplay can be built in the future!

To conclude I am happy with the decision of pursuing architecture and engineering. In the future I would love to apply my knowledge I have gained in the industry and I have found a keen interest in parametric modeling. I am excited and look forward to what the future holds.

Handwritten signature or initials, possibly "A. King", written in black ink.