AQUILION

Course: ACEX15 Bachelor’s thesis in Architecture and Engineering

Year: 3, spring semester 2020

Teachers: Morten Lund & Peter Christensson

Group: Samira Sarreshtedari, Chennie Johansson & Aditya Thombare

PRESENTATION

THE SHELL STRUCTURE

The shell consists of two parallell layers joined at the vertices. Panels are mounted on every voronoi cell; both at the top and the bottom. This allows water to be transported through the shell structure. Panels can be mounted or dismounted depending on the desired acoustics, feeling and conditions in a certain performance, which makes the shell structure adaptable. Smaller panels will be mounted between two voronoi cells in areas where the adjacent panels are dismounted in order to ensure a tight and close structure.

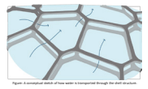


Figure: A conceptual sketch of how water is transported through the shell structure.

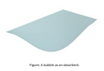


Figure: A bubble as an absorbent.

FLEXIBLE ABSORPTION

In Aquilion, the level of absorption is controlled by the water system in the shell structure. By increasing the water pressure, the pressure will cause the lower panels to descend and create bubbles. These bubbles will act as absorbents in the music hall. If more absorption is needed, more bubbles can be formed by increasing the water pressure in a specific panel.

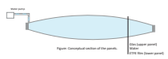


Figure: Conceptual section of the panels.

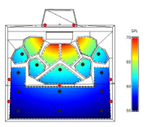
MATERIAL - MODIFIED ETFE

ETFE, Ethylene Tetrafluoroethylene, is a translucent polymer that is intended to be used as lower panels in the shell structure. As a building material ETFE is strong, lightweight and stretchable without loss of elasticity. ETFE has high sound insulation, high light transmission and minimizes reflections. A modified and further developed version of ETFE will be used where the material has more absorption properties.

ACOUSTICS

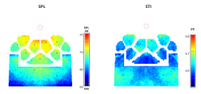
The shell structure contributes to a flexible acoustic environment in the music hall. For performances requiring more reflections, wooden reflectors are added on the stage and side walls act as diffusers using gypsum. The waterfall and water pool act as reflectors and also give the audience early reflections. Absorbents are not only placed in the shell structure in form of bubbles, but fabric on the seats, floor and on the inside walls of the seating area will also absorb.

The electro-acoustic sound reinforcements are strategically placed on the shell structure. Woofers will amplify low frequencies and the loudspeakers will have an approximate delay time of 20 ms close to the stage, 45 ms in the middle and 50 ms at the back.



ORCHESTRA AND BALLET

For orchestra more reflection is needed. The side panels act as Helmholtz resonators, absorbing multiple frequencies (125 Hz, 250 Hz, 500 Hz).

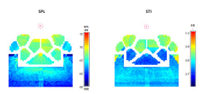


To adress the potential audience on the open lawn, the SPL can be improved with the help of loudspeakers.

The achieved range of STI is considerable for orchestra and ballet performances.

OPERA

To reduce the RT to the desired value, the absorption from the shell structure is increased by forming bubbles.

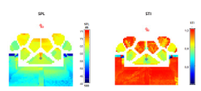


Loudspeakers can be placed on the shell structure to improve the SPL for the potential audience on the open lawn.

The STI is improved since the absorption is increased, making the direct voice more clear.

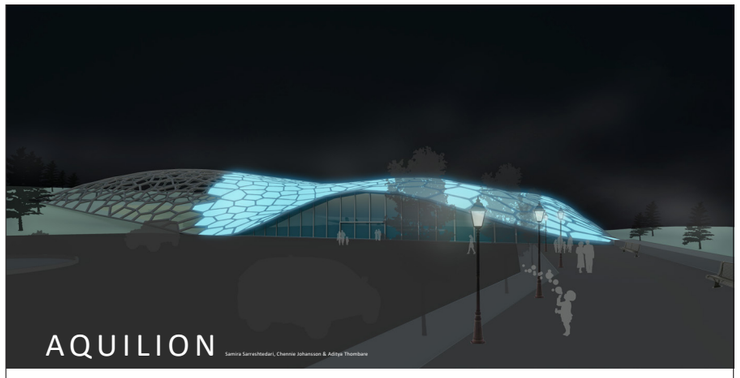
THEATER AND POP / ROCK

To achieve the desired RT all panels including bubbles are dismounted, creating an open environment with less reflections.



For theater, the sound will be amplified using loudspeakers. For pop/rock, a high SPL is achieved by line arrays on the stage with woofer systems, giving a directional characteristic.

The open environment and direct sound transmission through the speakers improves the STI.



AQUILION

Samira Sarreshtedari, Chennie Johansson & Aditya Thombare

CONCEPT

A shell structure lays softly on an open lawn. Water flows gently over the structure, compelling visitors into an unforgettable experience.

Inspired by the qualities of water, Aquilion is a multipurpose music pavilion made of a shell structure with a system that transports water. Not only does this give the visitors an extraordinary experience of being surrounded by water, but the structure is also used as an acoustic element, controls the indoor environment and reuses water from the nearby river, which also decreases the river flow.

Aquilion is designed for different types of performances such as orchestra, opera, ballet, theater and popular acts. The pavilion serves 5000 guest in seats and up to 20000 people on an open lawn. All functions lie under a shell structure made of the voronoi pattern. This design concept allows control over the acoustics and indoor climate for the entire pavilion through panels that are mounted on the shell. Water flows through the panels and depending on the water pressure, the idea is that the panels will descend and form bubbles. These bubbles will acts as absorbents when needed.

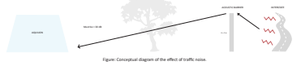


Figure: Conceptual diagram of the effect of traffic noise.

VORONOI

The shell structure, seating arrangements and room designs are all inspired by and based on the voronoi pattern.

WATER

The properties and attributes of water are continuously used through the entire pavilion to enhance the experience.

WATERFALL

Visitors can enjoy beautiful waterfalls in anticipation of the expected show, leaving them with a stunning and unforgettable experience of water.

BAR LOUNGE

Before, after or during the ongoing show, the bar lounge is always open for all guests to grab a snack, drink or meal.

NOISE PROTECTION

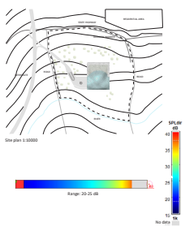
To keep noise levels down, vegetation is planted around the pavilion. The music hall is also placed in a pit on the lawn in order to make it more difficult for sound to spread.

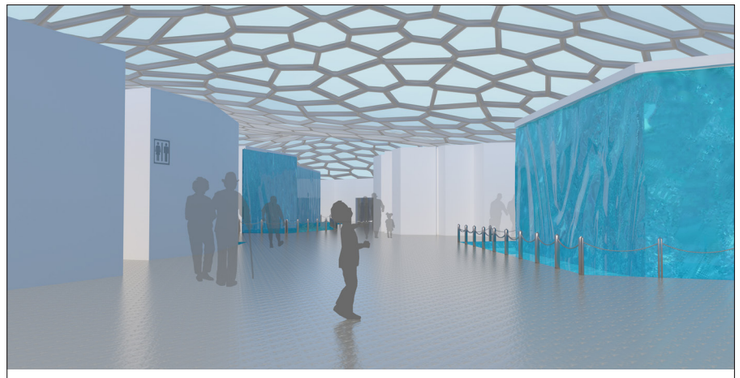
TRANSPORT AND PARKING

Visitors arriving at the site by car can park at Aquilion's underground parking lot. Buses and taxis will drop-off guests at the terminal right outside the entrance.

NOISE CONTROL

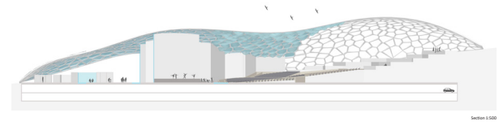
Acoustic barriers will be placed facing the residential area and interstate to control the sound pressure level coming from the traffic and to not disturb the residential area. The acoustic barriers have steel mesh on the outside which absorbs high frequencies and a mineral wool layer to handle mid and low frequencies. Trees will also be planted around the pavilion to further reduce the noise. The acoustic barriers are adapted for covering with vegetation which contributes to the nature around the pavilion.



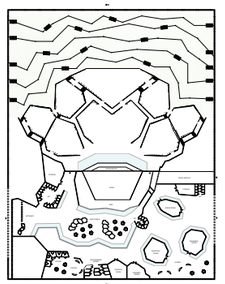


WATER EXPERIENCE

The beautiful scene as water cascades from top to bottom or from left to right is an exceptional stunner. Light shimmering on water, the relaxing sound of water flow and the free feeling that water gives makes us drawn to water in all its forms. When visiting Aquilion, the magical experience of water is enhanced. Visitors are quickly introduced to water in the entrance and in the shell structure. Streams of water are used as guidance in the pavilion and visitors are surrounded by dazzling waterfalls in the bar lounge. Performers and employees working in the offices are also surrounded by waterfalls and streams of water, not only to give them an extraordinary experience but also to induce calmness.



Section 1:500



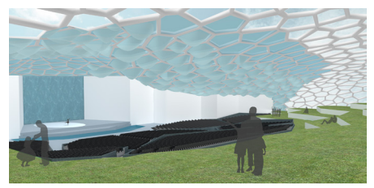
Plan 1:800

PRIVATE / PUBLIC AREA

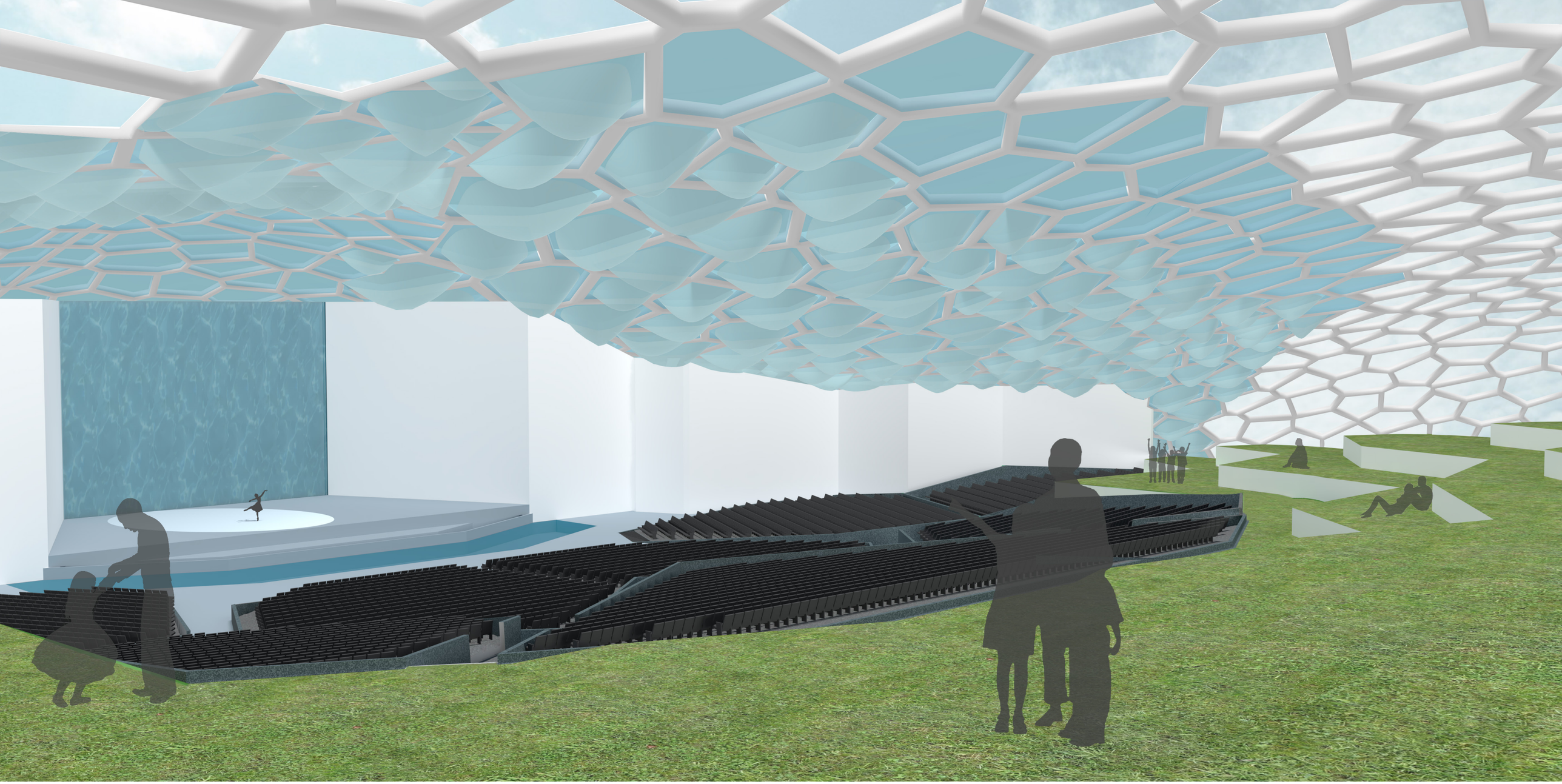
The plan consists of a private and a public area. At the private area performers can warm up in the rehearsal rooms, socialise in the lounge area or mingle in the green room. The rehearsal rooms are designed as separate islands with surrounding pools that are placed in an open space. These rooms will have an active reverberation time system, which allows similar acoustic conditions as in the music hall. The music hall is divided into two sections; the covered seating area and the open lawn. The seating area consists of 5000 seats intended to be mainly used for orchestra, opera, ballet and theater performances. The seats are divided into sections to give a more intimate feeling. When needed, the open lawn has the capacity to hold up to 20000 people. Here, guests can either dance, stand, sit or even have a picnic!

INDOOR CLIMATE

Visitors are welcomed to Aquilion through a spacious glas entrance where they are met by water in the shell, on the walls and on the floor. The flow of water leads the visitors from the entrance to the bar lounge or to the music hall. The shell structure and use of water in the pavilion benefits the indoor climate. The indoor temperature can be controlled by the temperature of the water falls, pools and the water in the shell structure. The design proposal of having a shell structure that covers the entire area also enables a greater control over the open lawn. Panels can be mounted over the open lawn to make it entirely enclosed and useful during winter time. Ventilation and heat systems can also be installed on the shell structure to reach any desired conditions of the indoor climate.



Samira Sarreshtedari AT3



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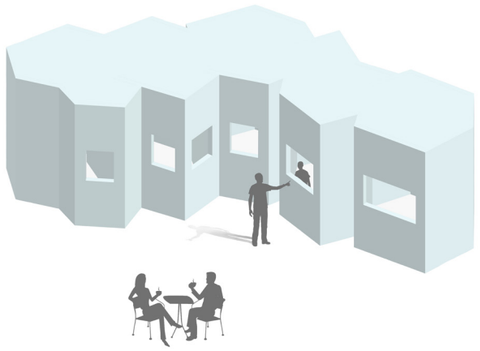

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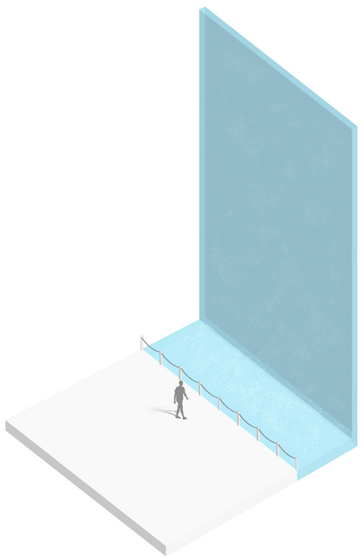

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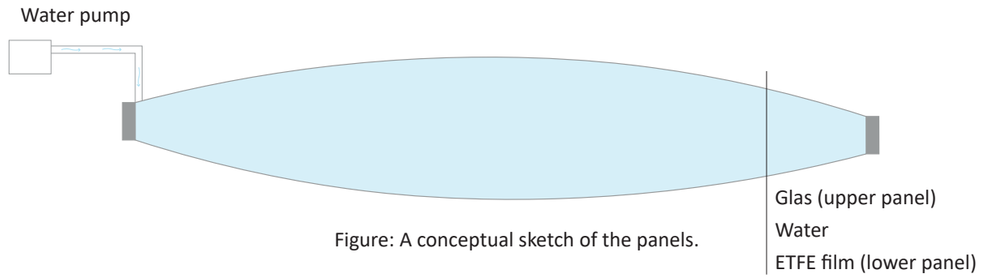

Figure: A conceptual sketch of the panels.

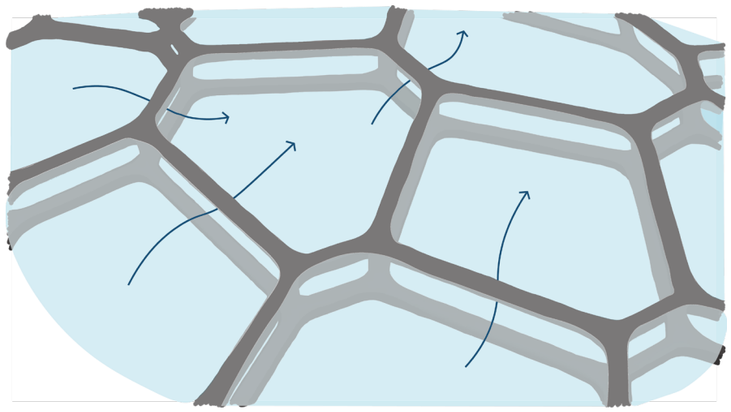

Figure: A conceptual sketch of how water is transported through the shell.

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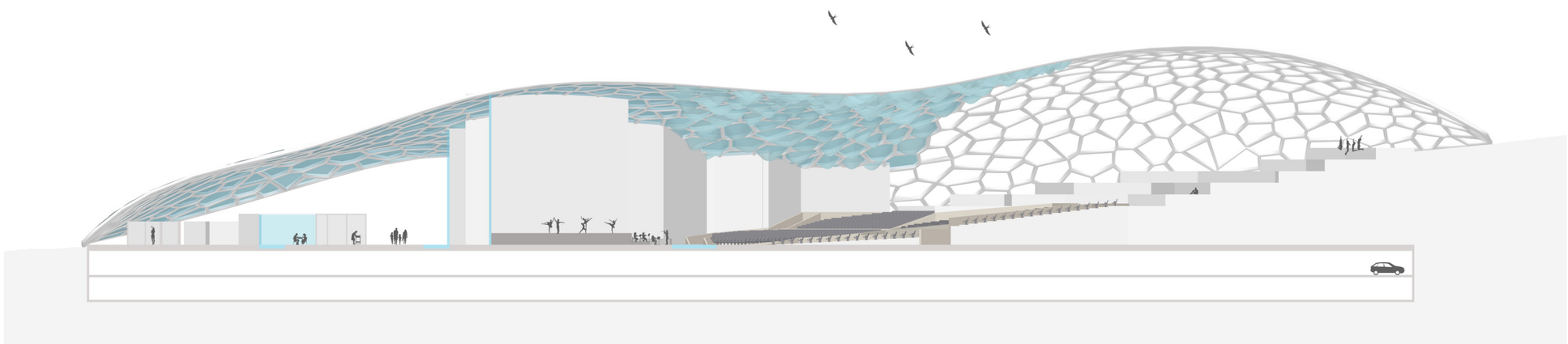

ACOUSTICS

The shell structure contributes to a flexible acoustic environment in the music hall. For performances requiring more reflections, wooden reflectors are added on the stage and side walls act as diffusers using gypsum. The waterfall and water pool act as reflectors and also give the audience early reflections. Absorbents are not only placed in the shell structure in form of bubbles, but fabric on the seats, floor and on the inside walls of the seating area will also absorb.

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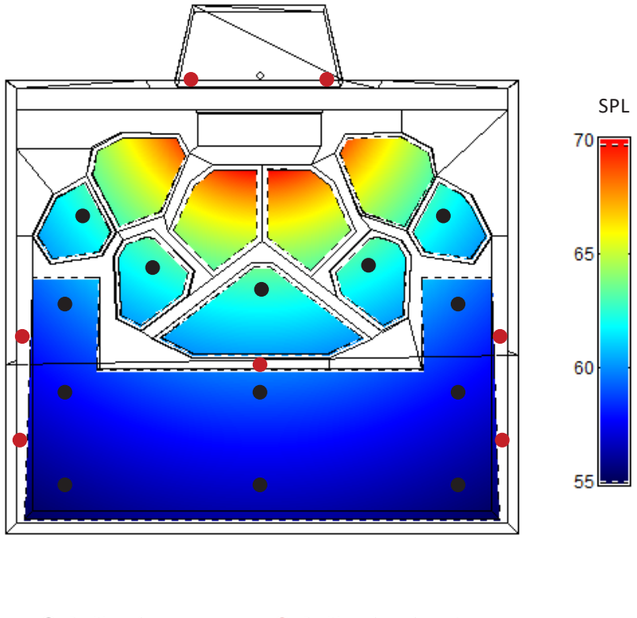
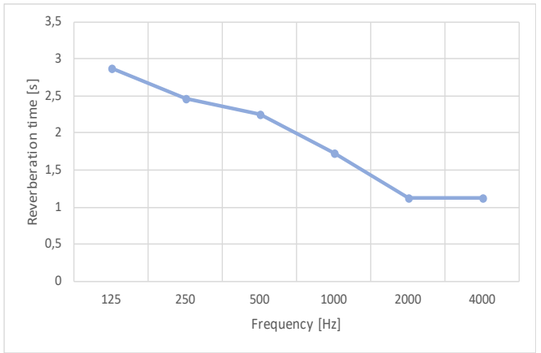


ORCHESTRA AND BALLET

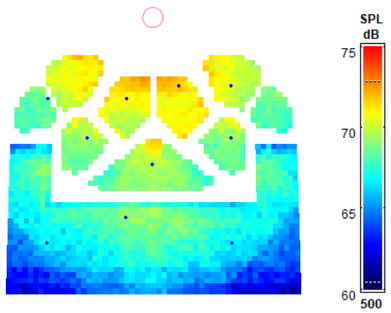
REVERBERATION TIME



Average RT - 1.93 s

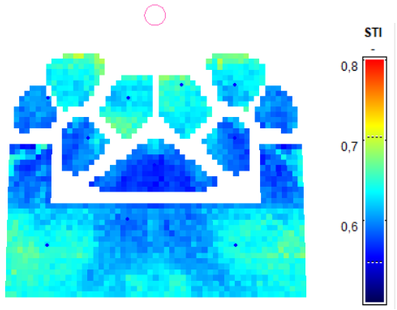
For orchestra more reflection is needed. The side panels act as Helmholtz resonators, absorbing multiple frequencies (125 Hz, 250 Hz, 500 Hz).

SPL



To adress the potential audience on the open lawn, the SPL can be improved with the help of loudspeakers.

STI

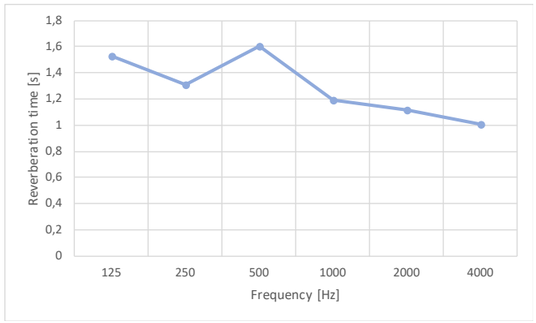


The achieved range of STI is considerable for orchestra and ballet performances.

Samira Sarreshtedari AT3

THEATER AND POP / ROCK

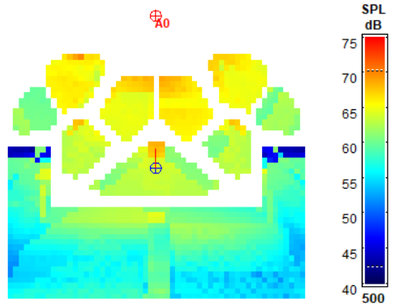
REVERBERATION TIME



Average RT - 1.29 s

To achieve the desired RT all panels including bubbles are dismounted, creating an open environment with less reflections.

SPL



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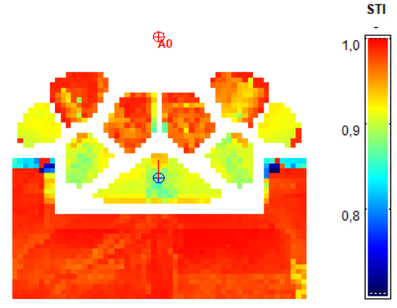
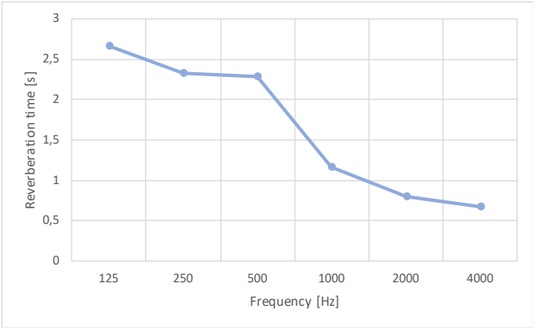


The open environment and direct sound transmission through the speakers improves the STI.

OPERA

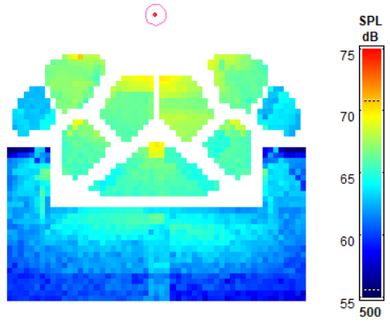
REVERBERATION TIME



Average RT - 1.65 s

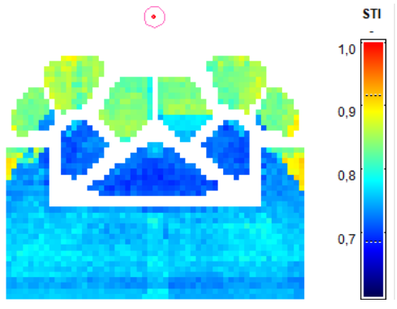
To reduce the RT to the desired value, the absorption from the shell structure is increased by forming bubbles.

SPL



Loudspeakers can be placed on the shell structure to improve the SPL for the potential audience on the open lawn.

STI



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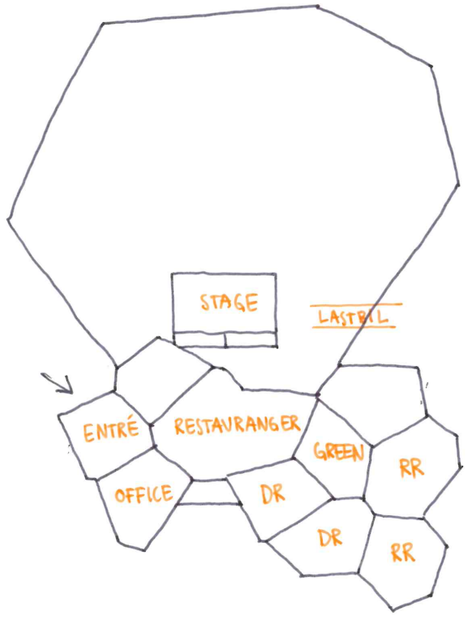
Samira Sarreshtedari AT3

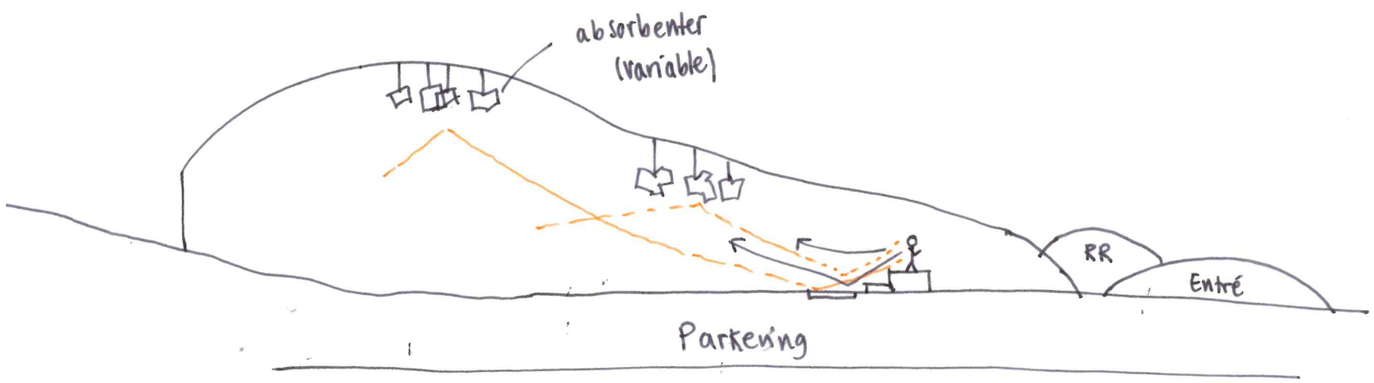
DESIGN PROCESS

The design process in this project has been based on an iterative design method. Each iteration has had its own theme and focus. The first assignment after the introductory lecture was to get out in Gothenburg and scream. The purpose of this task was to measure the sound pressure level at different distances to get an understanding of how sound without reinforcement sounds like. We visited three places in total; all with different charachteristics. At one location we screamed over a river and what surprised us was how much clearer we could hear the sound compared to a location without water in between the sound source and receiver. This sparked the thought of using water in some way in our project.

There is something attractive about water, most of us feel it but it's difficult to put it in to words. Long before the project began I was curious to investigate a design proposal in which water was the main focus. I thought of a water park or underwater museums. This in combination with my newly acquired knowledge in acoustics was the beginning of what developed in to Aquilion. We both liked the idea of having a sweeping structure over the entire site. The challenge was how this structure would be designed to fit the requirements of the programme.

We started exploring geometries in Grasshopper and Rhino to get inspired. Eventually we noticed a component that created 3D voronoi shapes. Both of us liked the pattern and decided that the shell could be composed of a voronoi grid instead och a gridshell. We also wanted the functions and seating arrangements to be inspired by the voronoi cells. Therefore, we tried to place the different rooms in voronoi cells and eventually developed a plan. After that we made a plane surface over the rough plan and dragged a part of the plane upwards and through that created ”bubbles”. The shell was now a sweeping roof with bubbles over the entrance, music hall and rehearsal rooms.





In the competition programme they asked for covered seating and a open lawn. Our challenge to achieve this was how to design the shell so that it had a natural look since we didn't want the shell to suddenly stop. Initially we also thought that the seats would be placed in the rear, but later realized that the pavilion would feel empty during for example opera performances where most people will sit down. Due to this, we placed the seats in front of the stage and didn't have to deal with a shell that suddenly stops and then reappears. We eventually decided that the shell should go over the entire area and instead take away panels from the shell to create a outdoor feeling. This was not only a solution to our problem, but we also realized that we should use and enhance the advantages of the shell. This later sparked the idea of having water flowing through the panels and also letting the water pressure cause panels to sink down and form bubbles.

REFLECTION

I feel like this was the first and only project during these three years where we got the time to investigate different ideas and designs to finally decide on something that we liked. We spent most of our time working on the shell and how we could enhance and use the advantages of it. Our challenge was the trustworthiness of the project, since the idea of using water in the shell has many problems. I strongly like the idea of using water pressure to create bubbles which will act as absorbents when needed in the music hall. Many times we had to remind ourselves that our project is a design proposal and not a finished project where all problems are solved. We have presented a proposal that we are satisfied with and have learnt a lot about architecture and acoustics along the way.

INTERDISCIPLINARY COLLABORATION

After a couple of weeks of sketching on the project, a student from the master's programme Sound and Vibration joined our group. His role in the project was to help us with the acoustic simulations and discuss different solutions regarding the acoustics. The main challenge with this interdisciplinary collaboration was to convey our project and ideas to someone who is not as familiar with architecture as we are. We also noticed the problem that arises between architects and engineers; we wanted to integrate acoustic solutions in the design while the acoustician solved problems without taking the design in to account. Our solution with acoustic barriers to handle the noise from the highways is an example of this, but unfortunately we didn't have the time to integrate them in to the design.

ARCHITECTURE AND ACOUSTICS

Through this project I have learnt a lot about architecture and acoustics, though I feel that it's difficult to explain the artistic and creative knowledge I have gained. I have further developed the skill to work conceptually, to work more creatively and to question and explore different concepts and their benefits and disadvantages. I feel more confident to take on architecture projects in the future and to dare to believe in my ideas and thoughts. Furthermore, I have not only learnt about acoustics theoretically but also had the opportunity to apply that knowledge in the project. I have learnt how the acoustics affect the design and vice versa, and also different solutions to various acoustic problems that can arise in a music pavilion.

Samira Sarreshtedari AT3