Lundbystrand Theater

Membrane structures and acoustics

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Course: ACEX15 - Bachelor’s thesis in Architecture and engineering
Place: Gothenburg
Year: 2025
Collaborator: Leo Klevenås Kraft

Bachelor’s thesis and 2025 Newman Award Fund student design competition submission.

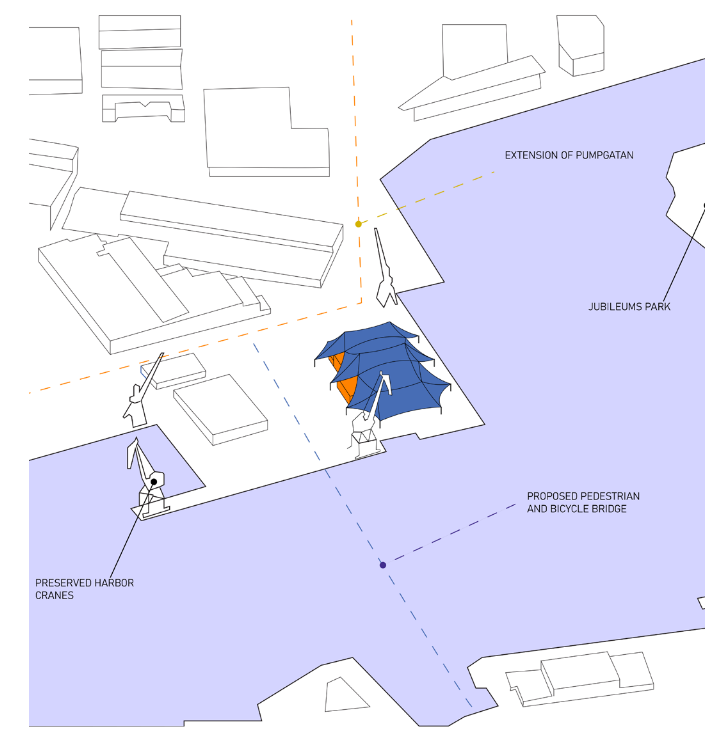
Shielded under a Teflon-coated fiberglass fabric, the theater is protected from Gothenburg’s harsh weather, while still letting through diffused light during its sunnier days. Tensile structures make very efficient long-span structures. It is cheaper, lighter and easier to construct. Because of the Teflon coating, the fabric is protected against damage from rain and sun.

The theater hall has an acoustic ceiling also made of fabric, whose geometry can be altered for variable acoustics.

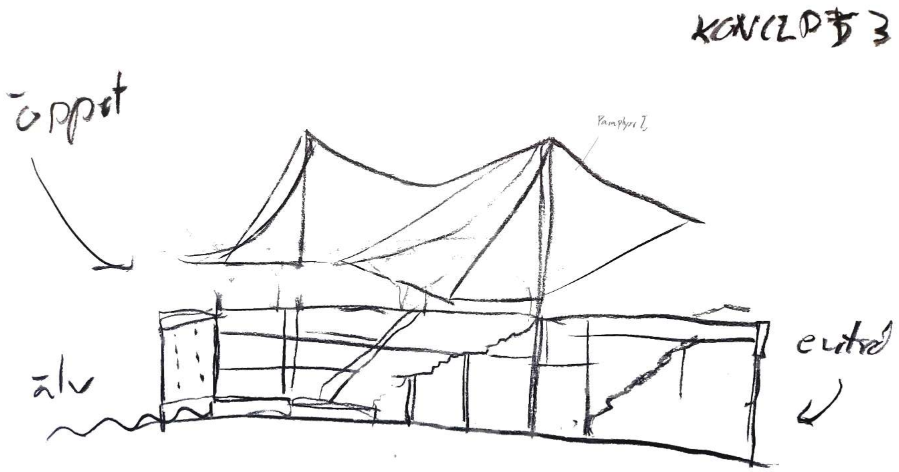
Competition submission boards

Location

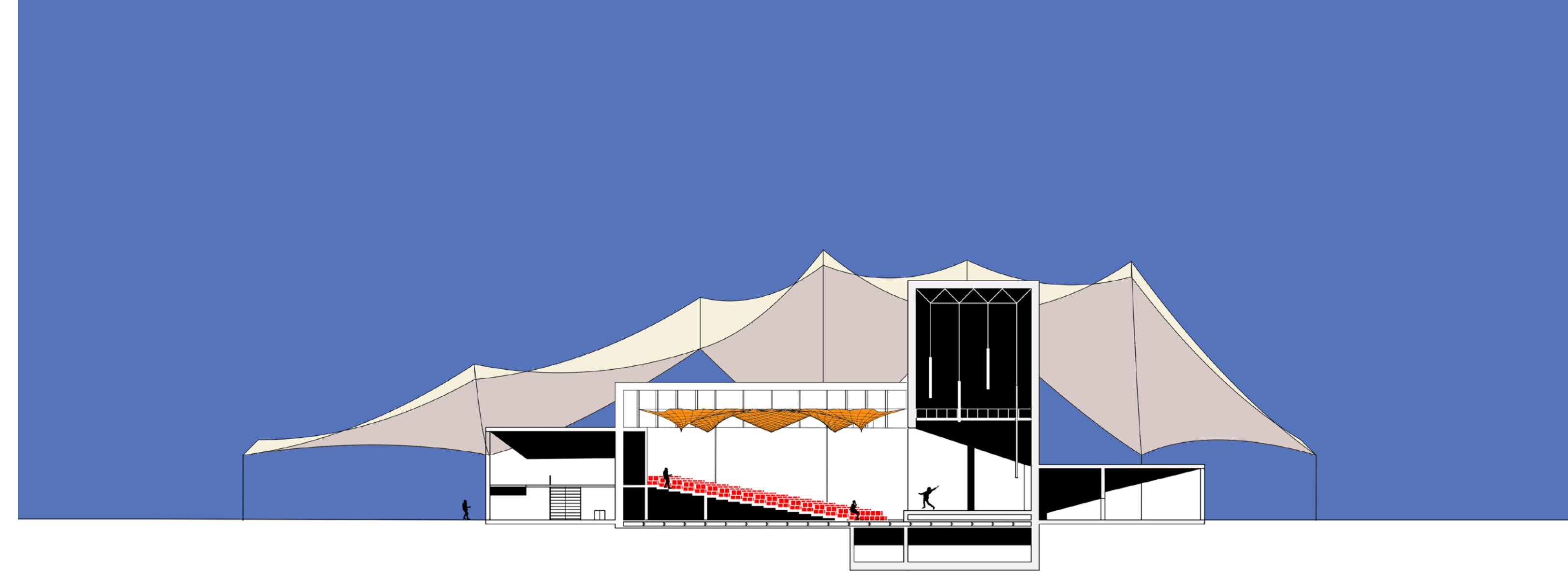
Located at Pumpgatan in the old Gothenburg Harbor, the theater becomes one of Gothenburg’s many landmarks along the river. It also helps bind the city toghether, following Gothenburg municipality’s plan to build another bridge across the river. The theater would be in a strategic location, easily accessible and a public meeting space for people living in either side of the city. What is currently an industrial area, would finally become accessible for the public to experience Gothenburg’s rich history as an important harbor city by being around those iconic cranes.



Lundbystrand site

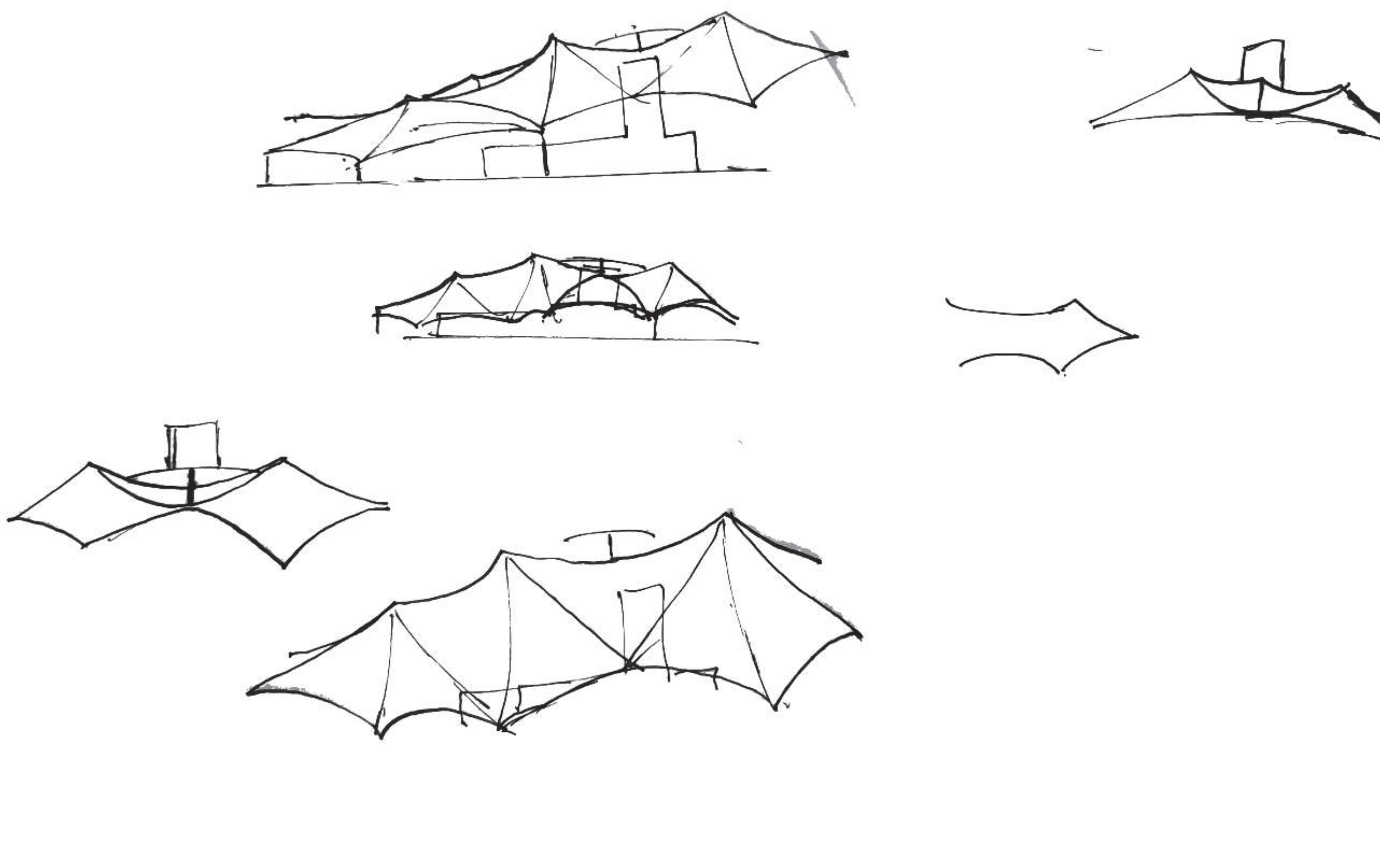


Early concept that was developed

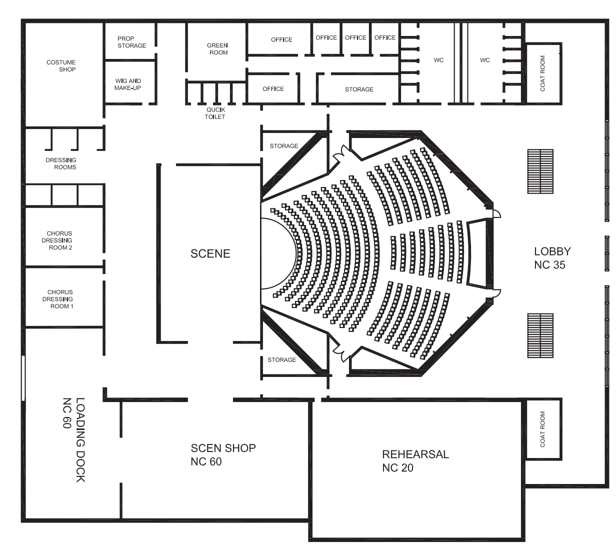


The membrane structure is a skeleton membrane structure, since it provides better stability, compared to a tension membrane structure. The skeleton is made up of masts, arches and beams which the fabric is tension on.

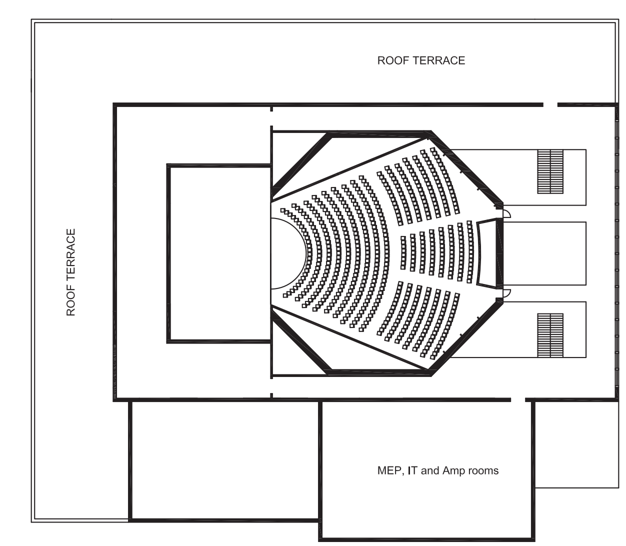
The building shielded under the membrane has roof terraces which allow the public to visit the building, even when not attending a performance.



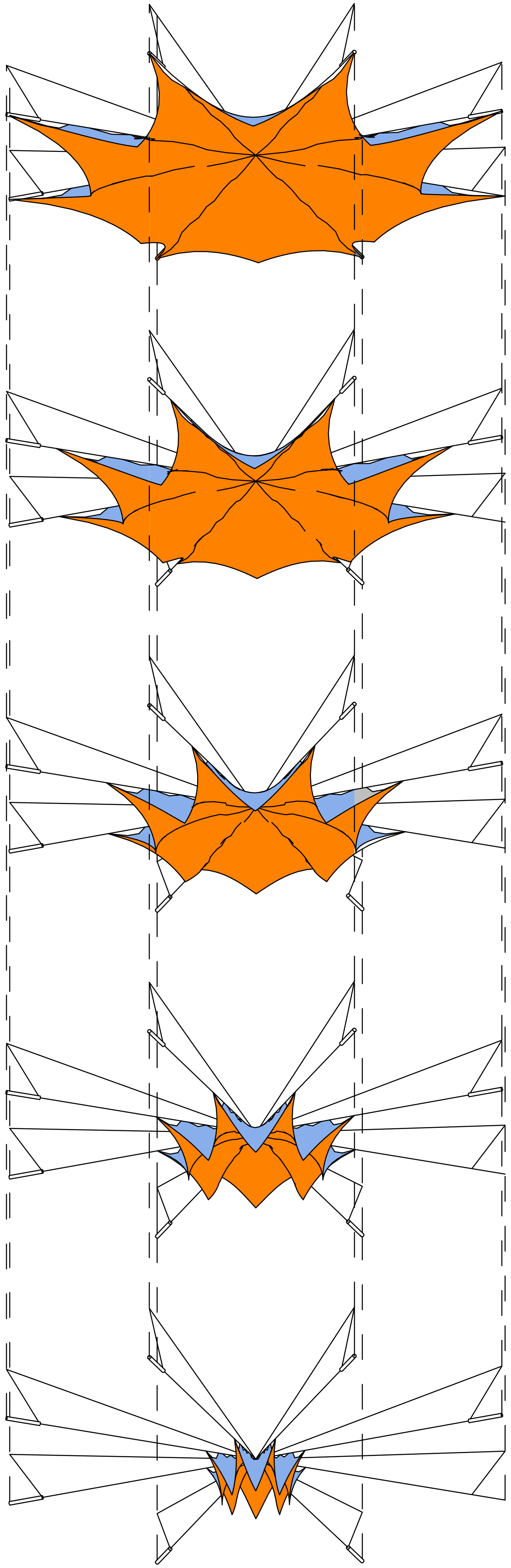
Tensile membrane structure sketch



Ground floor plan



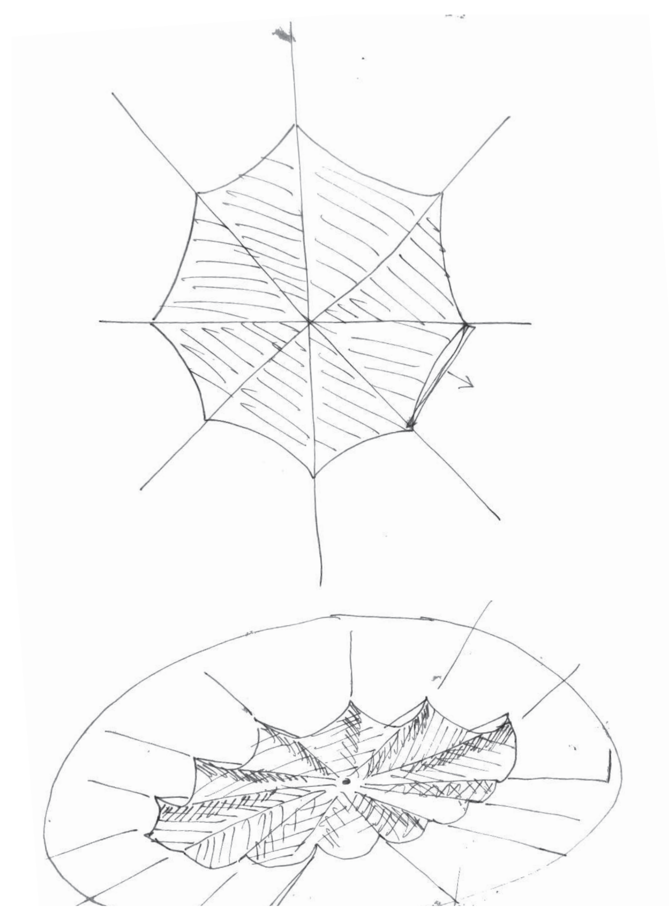
Upper floor plan



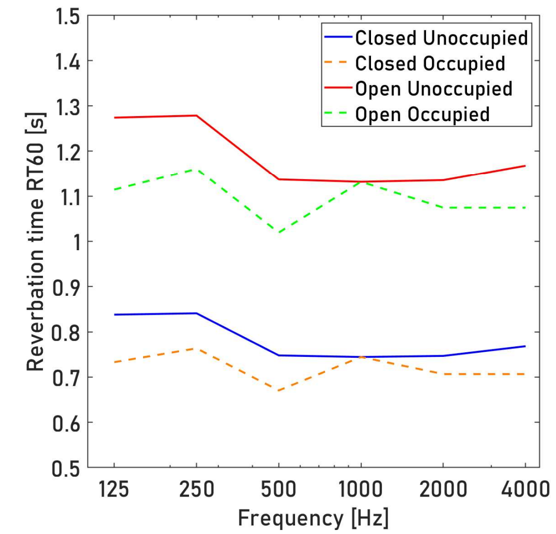
Mechanism of the acoustic ceiling

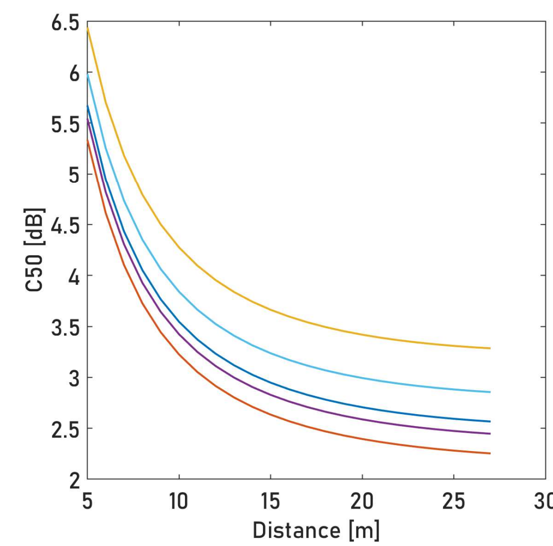
Acoustic ceiling

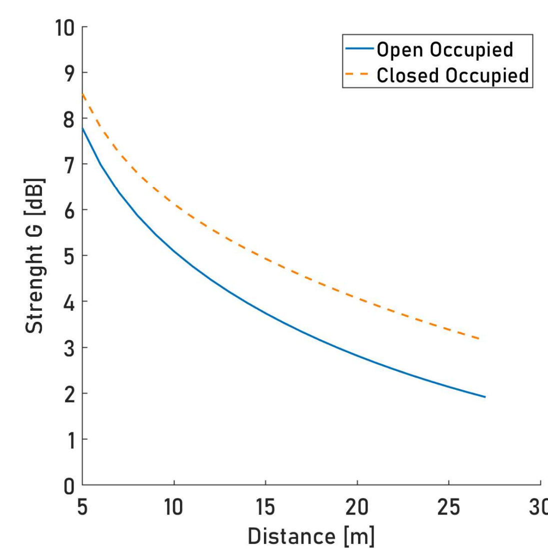
The ceiling in the theater hall utilizes a tightly woven fabric that is able to reflect sound. It is controlled through a mechanism which changes its geometry. The fabric expands and contracts radially. Although modelled and illustrated, this is a very experimental concept that I would like to refine and research more in, as there may be better geometries for this.



Concept sketch





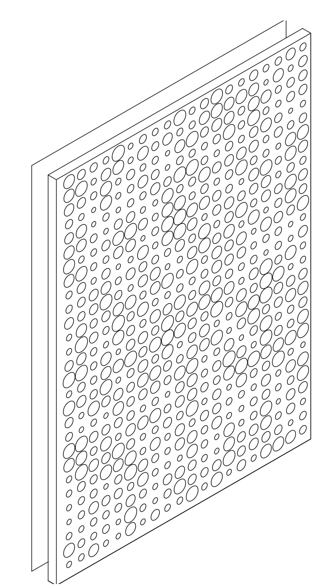


Acoustic performance

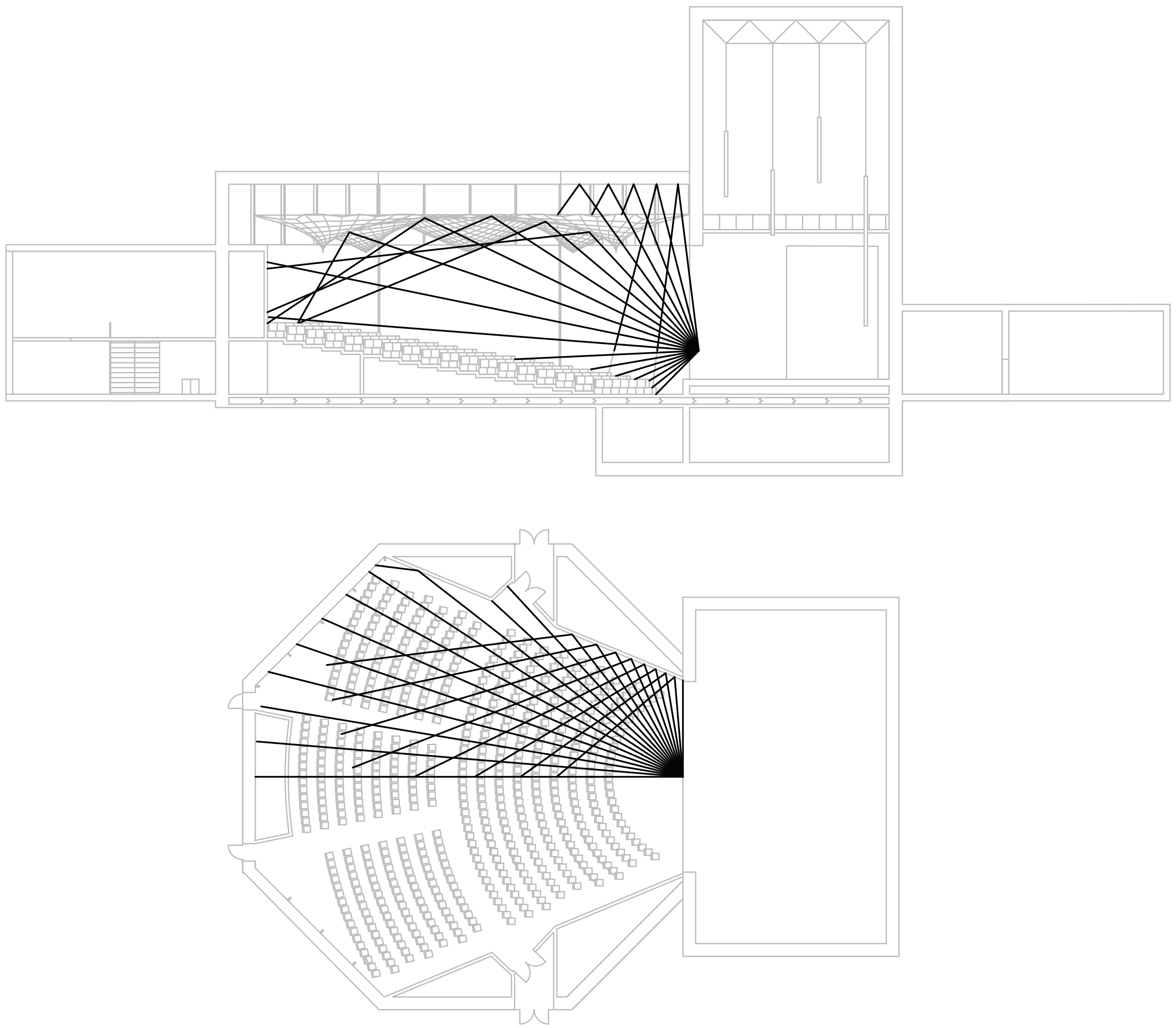
For reverberation time we receive a value at 1000 Hz 0.75 s for a closed and lowered roof. This is favorable for speech where distincts sounds are wanted. For the open roof with a higher volume we receive a value of 1.15 s. More favorable for music.

For strength G we measeured Gmid at 1000 Hz. For closed and lowered roofs we receive a value between 8.54 dB at the front to 3.15 dB at the back. For open we receive a value of 7.79 at the front and 1.92 at the back.

For clarity C50 we receive values at the front from 5.34 dB at 125 Hz to 6.44 db at 4000 Hz. At the back we receive values at 2.25 db at 125 Hz to 3.28 at 4000 Hz.



To keep the reverberation time more consistent at different frequencies, Helmholtz resonators are installed in the theater hall, which helps reduce the reverberation time at 125 Hz.



Ray tracing of the theater hall

Reflection

The design was of the type that we had in mind, namely a membrane structure. It did not quite live up to our initial ambitions, however, as it was not quite well integrated into the acoustics

.We chose to work with a membrane structure because we wanted a light and cheap structure that is sustainable. That was our way of pursuing sustainability.

The acoustic ceiling is operated through a mechanism which allows it to expand and contract radially. This was an idea that was very experimental, and I am not sure if it would work in real life.

Working across different disciplines was challengning. Partly because acoustics was a subject new to us, but also because our cooperation did not work well with our acoustician.

There was a lot of improvisation throughout the design process and we had to find a way to make our concept work. The argument was that the fabric would be heavy enough to reflect sound and that we assumed that such a fabric existed or could be produced.

The last three years of studying Architecture and Engineering has been challenging, in a good way. We pushed ourselves outside of our comfort zones, exploring unfamiliar topics, supported by our teachers. I would say that I am proud of where I am. I have learnt much both from my teachers and my own work. Each project has taught me new skills and methods that I bring with me to the future. My ambition is to be an architect/engineer who is able to design unconventional geometries and structures that are beautiful, efficient and sustainable, using the unique skills picked up from my background in Architecture and engineering.