

THE DRAGONFLY

- An immersive music pavilion

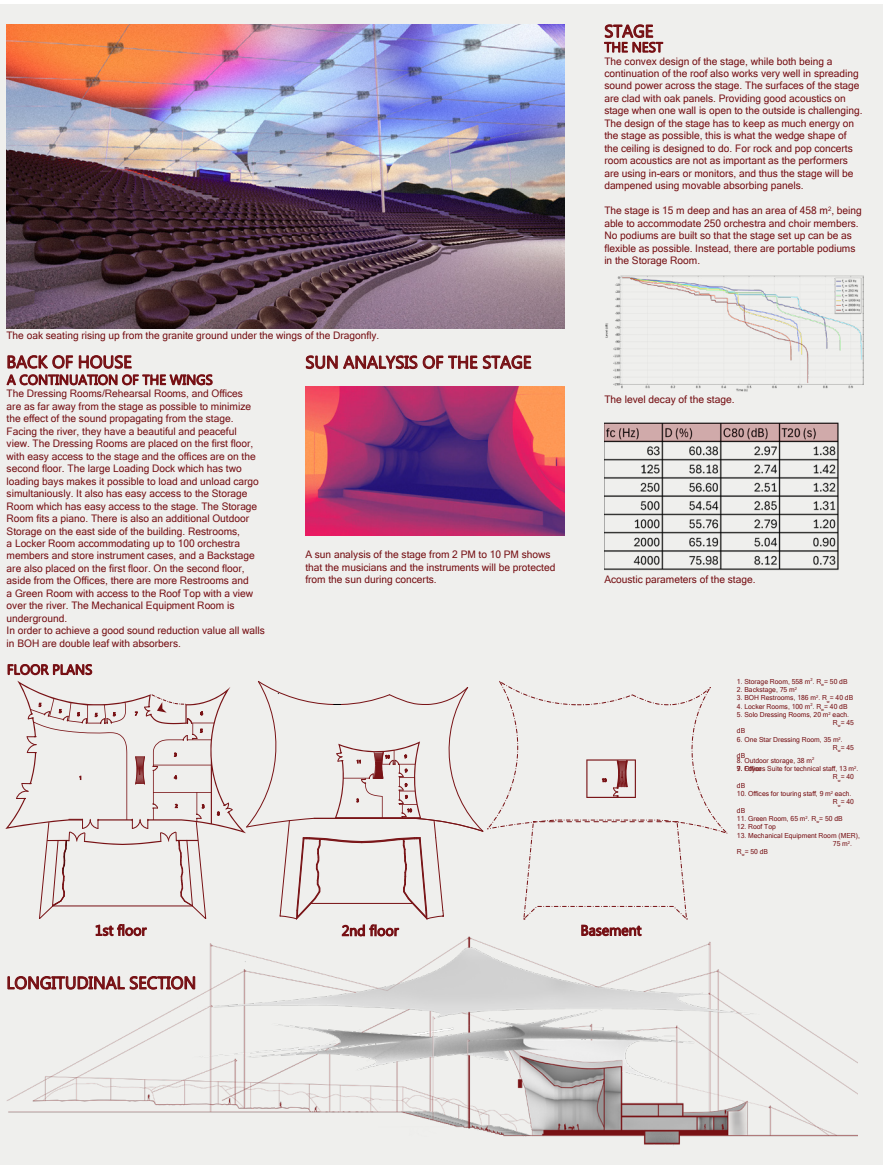
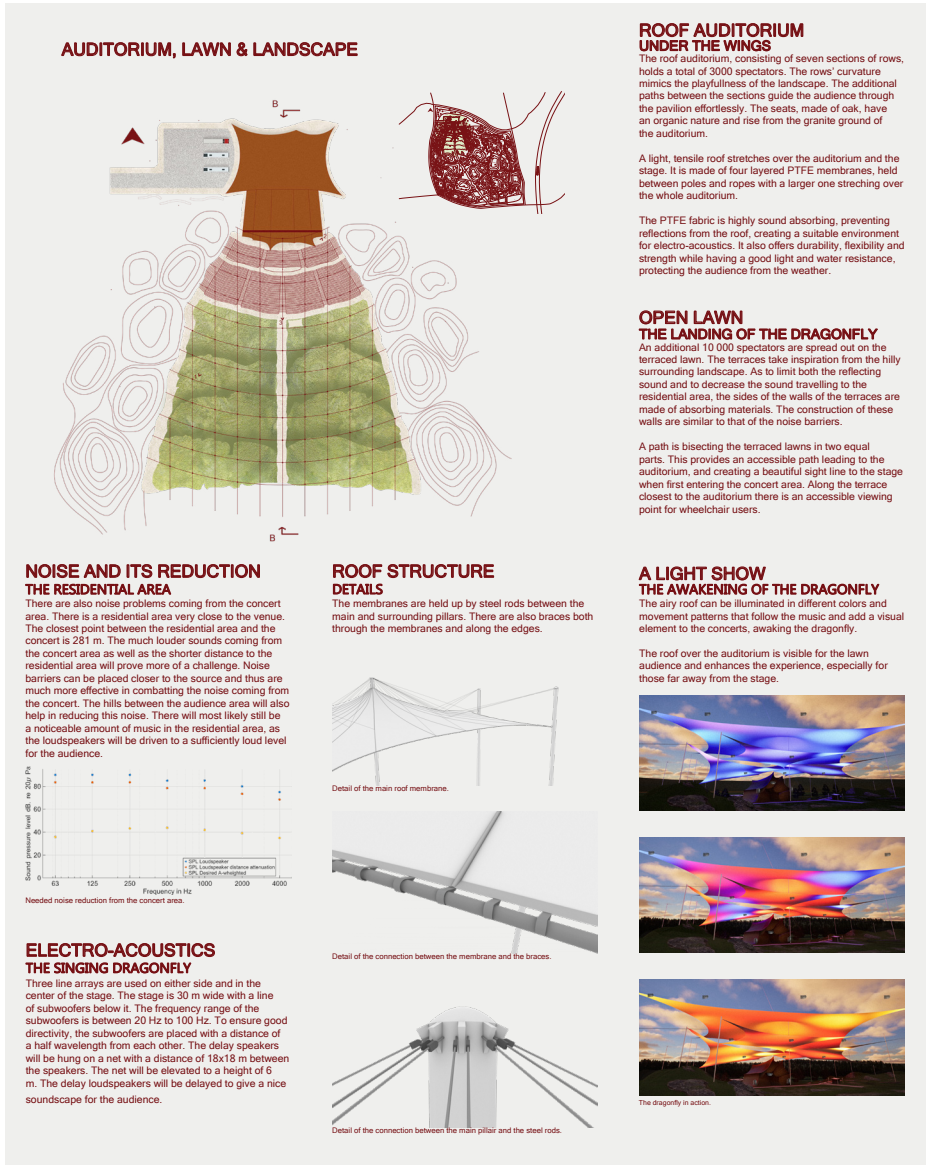
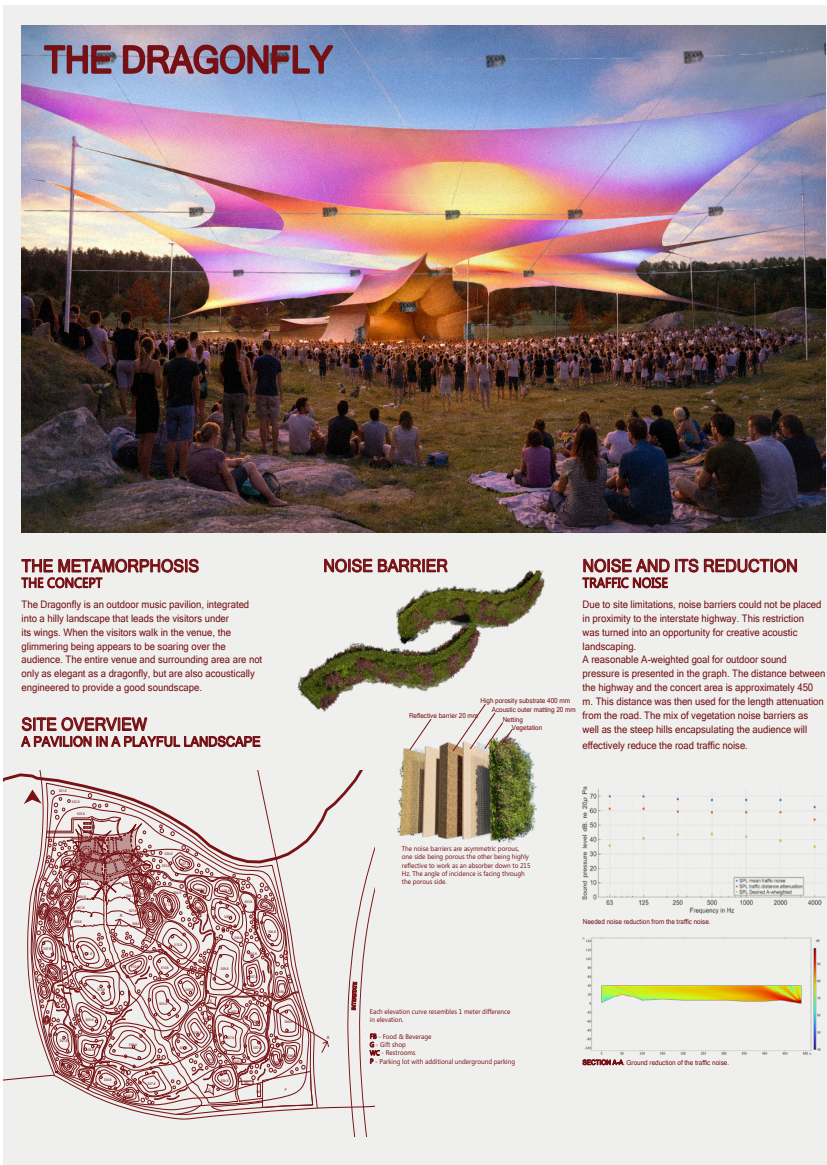
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ACEX16 Bachelor Thesis in Architecture and Engineering
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The assignment

The assignment was to design a music pavilion with a roof that shelters the seated audience. The remaining audience would sit or stand spread out around the area, with the entire space covered by electroacoustics. The stage is self supported acoustically, with room acoustics. The project was a collaboration between two Architecture and Engineering students and one Acoustics student. From February to May, several iterations were developed until the final design was completed.



Competition posters



THE DRAGONFLY - The Process

The design process of the Dragonfly began with the drawing of three longitudinal sections where we unleashed our creativity and did not think about solving problems quite yet. The only thing we had in mind at this stage was that we wanted the roof structure over the seated auditorium to be the main factor of the concert area. Already from the start, we wanted to create an experience beyond the concert, for the audience to not only get the acoustical element, but also a beautiful visual one. It was also important to us that the stage would be designed so that it creates the best acoustic conditions for the musicians, as well as it would be beautiful and part of the experience, both for the artists and the audience.

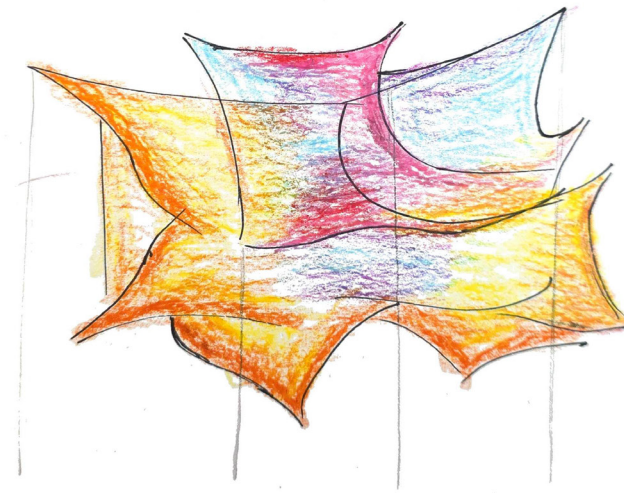
In longitudinal sections, our idea of a seated auditorium which reminds of an amphitheater, with an open lawn area with less incline is already obvious. During these sketches we imagined that there would be a structure over the open lawn area as well, in the same style as the roof over the seated auditorium. The speakers would be integrated in the roof of both the auditorium and the open lawn. We eventually chose to only have a roof structure over the auditorium, and to let the open lawn area feel as natural and outdoors as possible. Not only would this enhance the experience of a concert in the open air, but it would also make the tensile structure, the wings of the Dragonfly, over the seated auditorium be the main focus. The only thing covering the open lawn in the end is the grid of speakers, which stretches over the entire concert area, and is as discrete as possible.

After the three longitudinal sections, we chose to start building models to explore different roof structures, which helped us a lot with deciding which roof we liked the most. We decided to continue with our very first sketch, and explore the endless possibilities of tensile roof structures and how the membranes can be decorated with colored lightning, and how we could make the Dragonfly's wings as magical as possible.

For our prototypes, we used a lot of clay, which was really helpful in the iteration process. The clay is forgiving and very easy to use, especially a perfect tool for exploring landscapes, noise barriers and organic shapes. It was very easy to be playful and creative with the clay, and it is one of the reasons that we were able to achieve such playful landscape and seating.

Where the venue was placed on the site was also an early decision. We had a clear vision about the river being a part of the landscape and enhancing the outdoor experience for both the audience and the Back of House. We also wanted the venue to somewhat follow the inclination of the site, which is another reason why the audience faces the river.

While designing both the landscape and the venue area, our biggest concern was not only how they would fit aesthetically, but also which design would build the most suitable soundscape. We also consulted with our acoustician in every step of the process to ensure the best decisions were made.



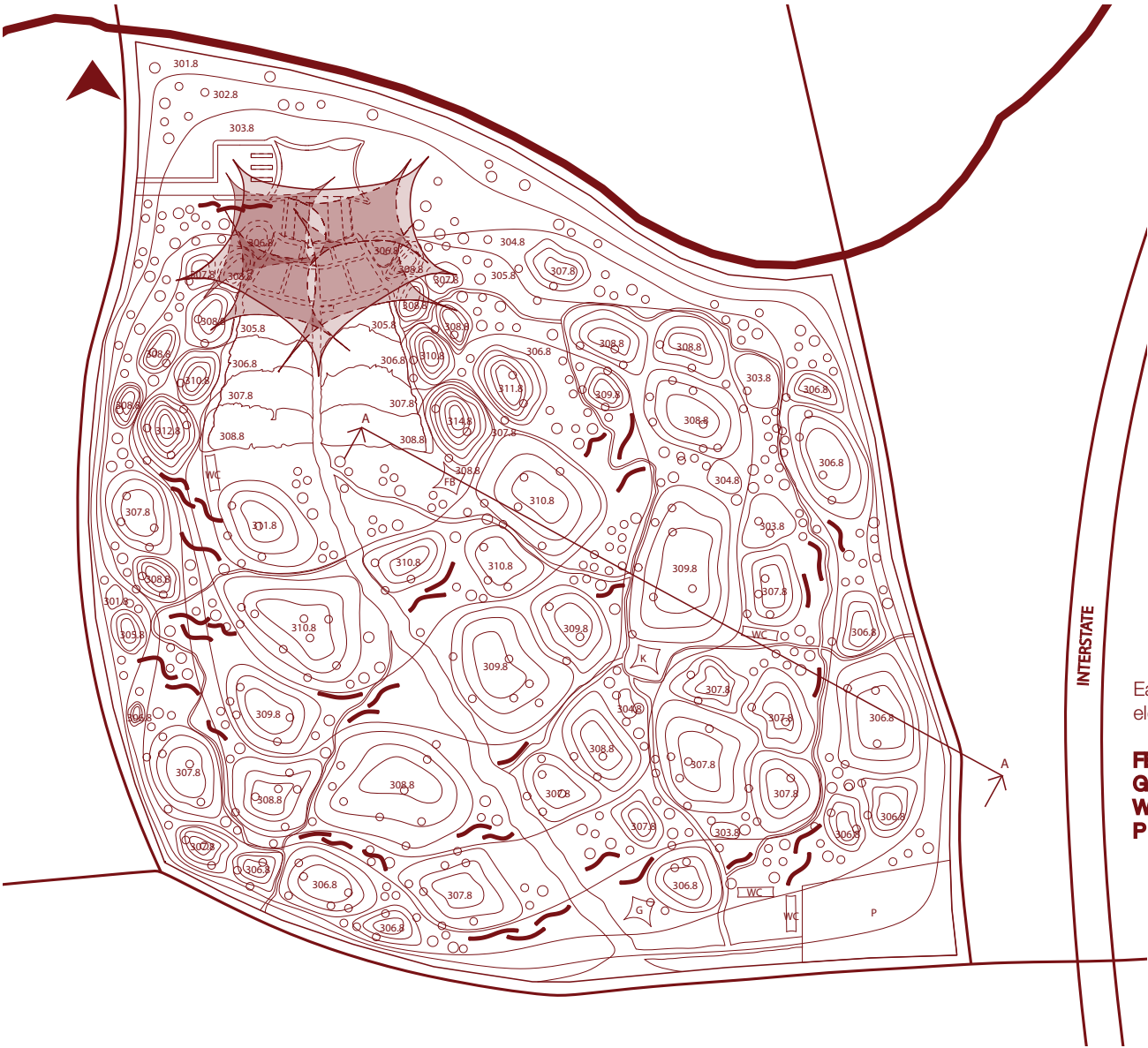
THE METAMORPHOSIS

THE CONCEPT

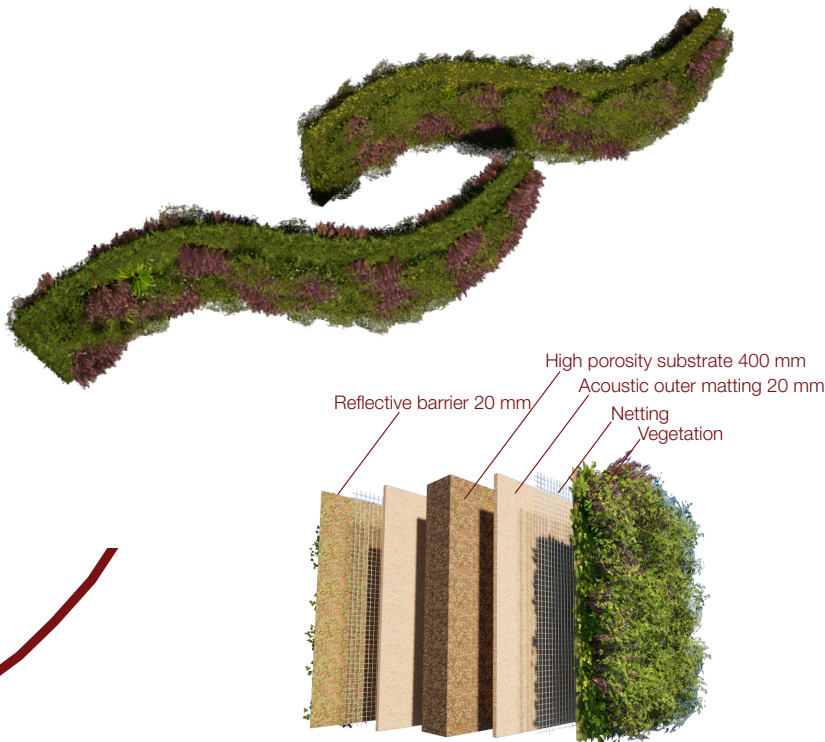
The Dragonfly is an outdoor music pavilion, integrated into a hilly landscape that leads the visitors under its wings. When the visitors walk in the venue, the glimmering being appears to be soaring over the audience. The entire venue and surrounding area are not only as elegant as a dragonfly, but are also acoustically engineered to provide a good soundscape.

SITE OVERVIEW

A PAVILION IN A PLAYFUL LANDSCAPE



NOISE BARRIER



The noise barriers are asymmetric porous, one side being porous the other being highly reflective to work as an absorber down to 215 Hz. The angle of incidence is facing through the porous side.

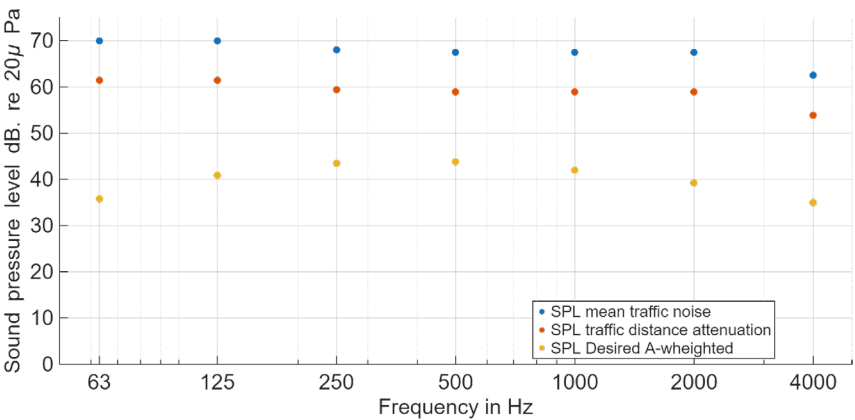
Each elevation curve resembles 1 meter difference in elevation.

FB - Food & Beverage
G - Gift shop
WC - Restrooms
P - Parking lot with additional underground parking

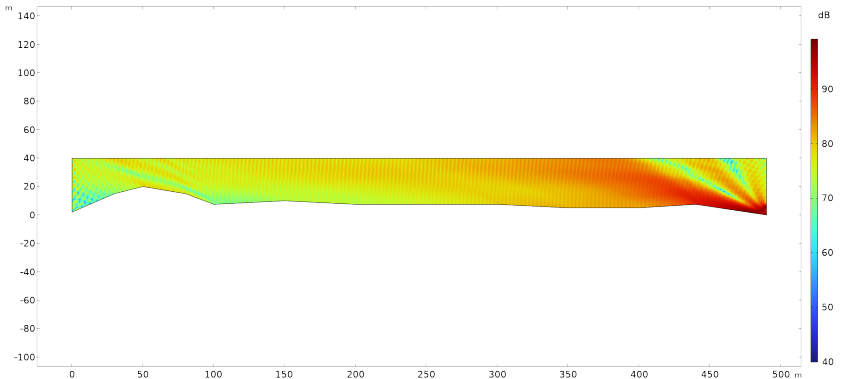
NOISE AND ITS REDUCTION

TRAFFIC NOISE

Due to site limitations, noise barriers could not be placed in proximity to the interstate highway. This restriction was turned into an opportunity for creative acoustic landscaping. A reasonable A-weighted goal for outdoor sound pressure is presented in the graph. The distance between the highway and the concert area is approximately 450 m. This distance was then used for the length attenuation from the road. The mix of vegetation noise barriers as well as the steep hills encapsulating the audience will effectively reduce the road traffic noise.

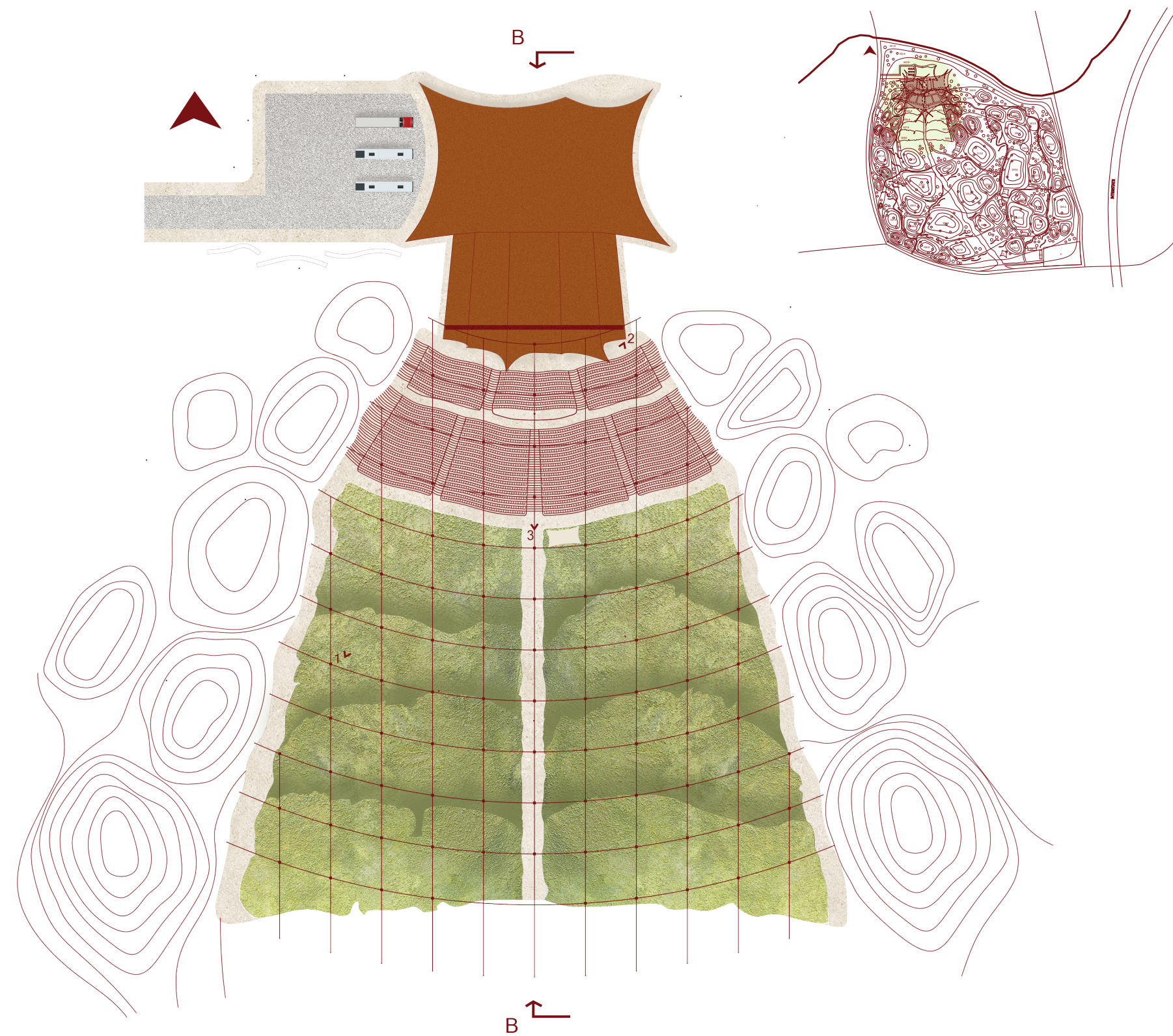


Needed noise reduction from the traffic noise.



SECTION A-A. Ground reduction of the traffic noise.

AUDITORIUM, LAWN & LANDSCAPE



ROOF AUDITORIUM UNDER THE WINGS

The roof auditorium, consisting of seven sections of rows, holds a total of 3000 spectators. The rows' curvature mimics the playfulness of the landscape. The additional paths between the sections guide the audience through the pavilion effortlessly. The seats, made of oak, have an organic nature and rise from the granite ground of the auditorium.

A light, tensile roof stretches over the auditorium and the stage. It is made of four layered PTFE membranes, held between poles and ropes with a larger one streching over the whole auditorium.

The PTFE fabric is highly sound absorbing, preventing reflections from the roof, creating a suitable environment for electro-acoustics. It also offers durability, flexibility and strength while having a good light and water resistance, protecting the audience from the weather.

OPEN LAWN THE LANDING OF THE DRAGONFLY

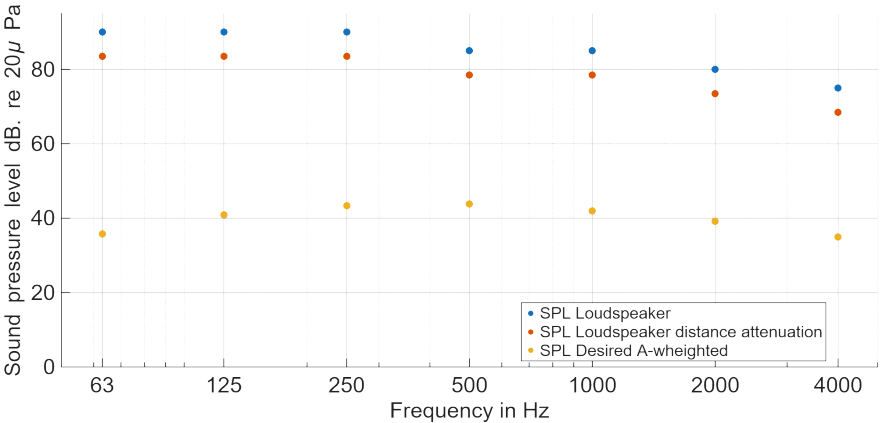
An additional 10 000 spectators are spread out on the terraced lawn. The terraces take inspiration from the hilly surrounding landscape. As to limit both the reflecting sound and to decrease the sound travelling to the residential area, the sides of the walls of the terraces are made of absorbing materials. The construction of these walls are similar to that of the noise barriers.

A path is bisecting the terraced lawns in two equal parts. This provides an accessible path leading to the auditorium, and creating a beautiful sight line to the stage when first entering the concert area. Along the terrace closest to the auditorium there is an accessible viewing point for wheelchair users.

NOISE AND ITS REDUCTION

THE RESIDENTIAL AREA

There are also noise problems coming from the concert area. There is a residential area very close to the venue. The closest point between the residential area and the concert is 281 m. The much louder sounds coming from the concert area as well as the shorter distance to the residential area will prove more of a challenge. Noise barriers can be placed closer to the source and thus are much more effective in combatting the noise coming from the concert. The hills between the audience area will also help in reducing this noise. There will most likely still be a noticeable amount of music in the residential area, as the loudspeakers will be driven to a sufficiently loud level for the audience.



Needed noise reduction from the concert area.

ELECTRO-ACOUSTICS

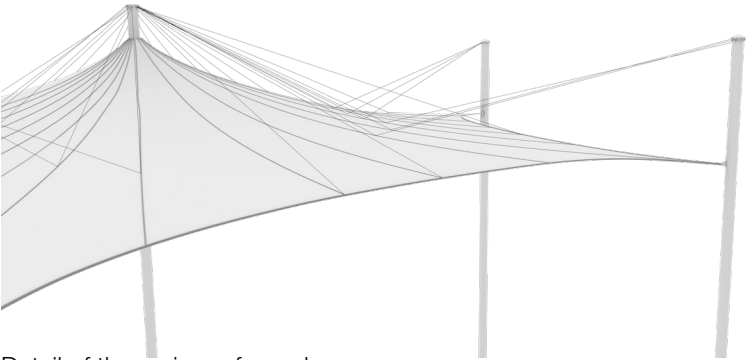
THE SINGING DRAGONFLY

Three line arrays are used on either side and in the center of the stage. The stage is 30 m wide with a line of subwoofers below it. The frequency range of the subwoofers is between 20 Hz to 100 Hz. To ensure good directivity, the subwoofers are placed with a distance of a half wavelength from each other. The delay speakers will be hung on a net with a distance of 18x18 m between the speakers. The net will be elevated to a height of 6 m. The delay loudspeakers will be delayed to give a nice soundscape for the audience.

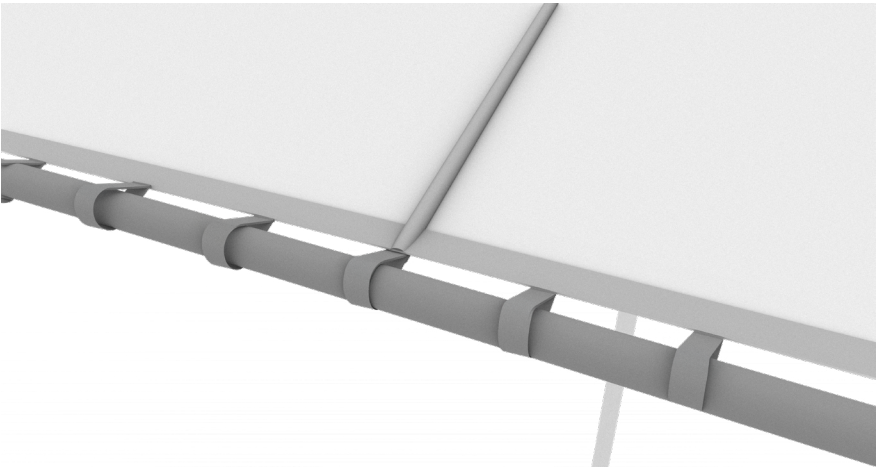
ROOF STRUCTURE

DETAILS

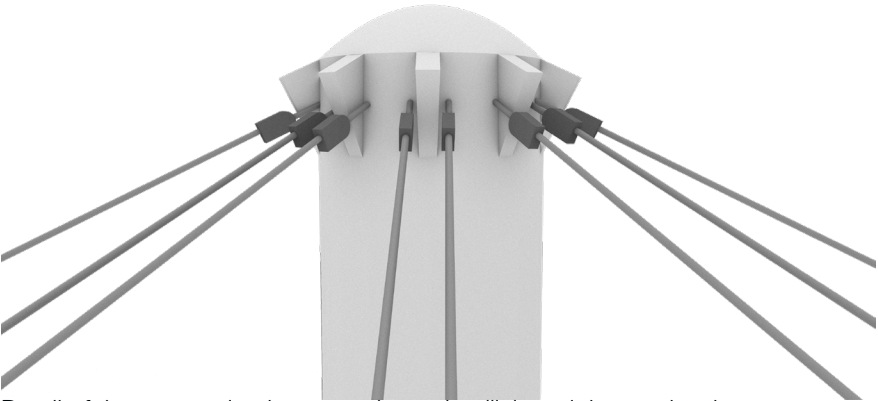
The membranes are held up by steel rods between the main and surrounding pillars. There are also braces both through the membranes and along the edges.



Detail of the main roof membrane.



Detail of the connection between the membrane and the braces.



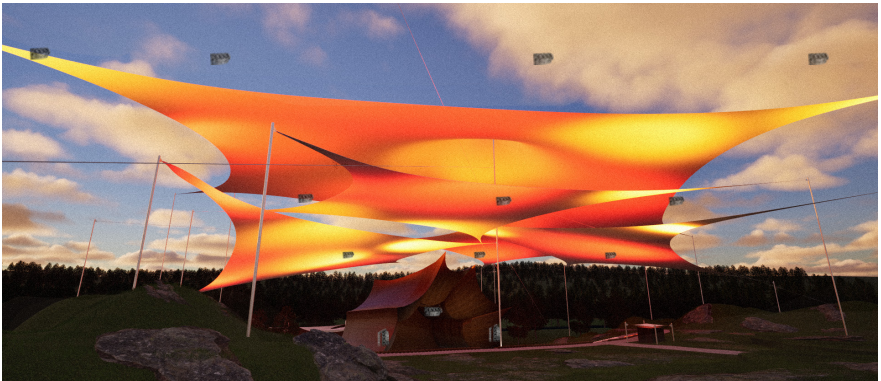
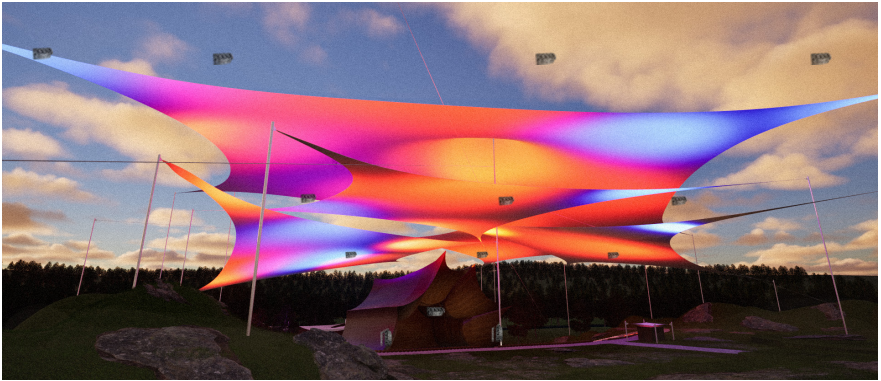
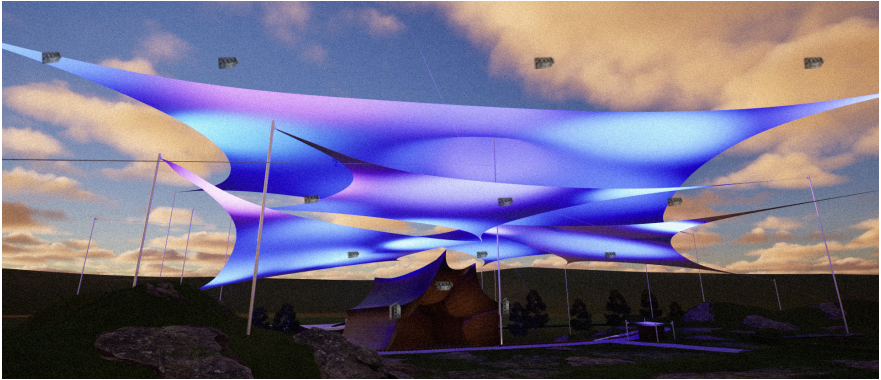
Detail of the connection between the main pillar and the steel rods.

A LIGHT SHOW

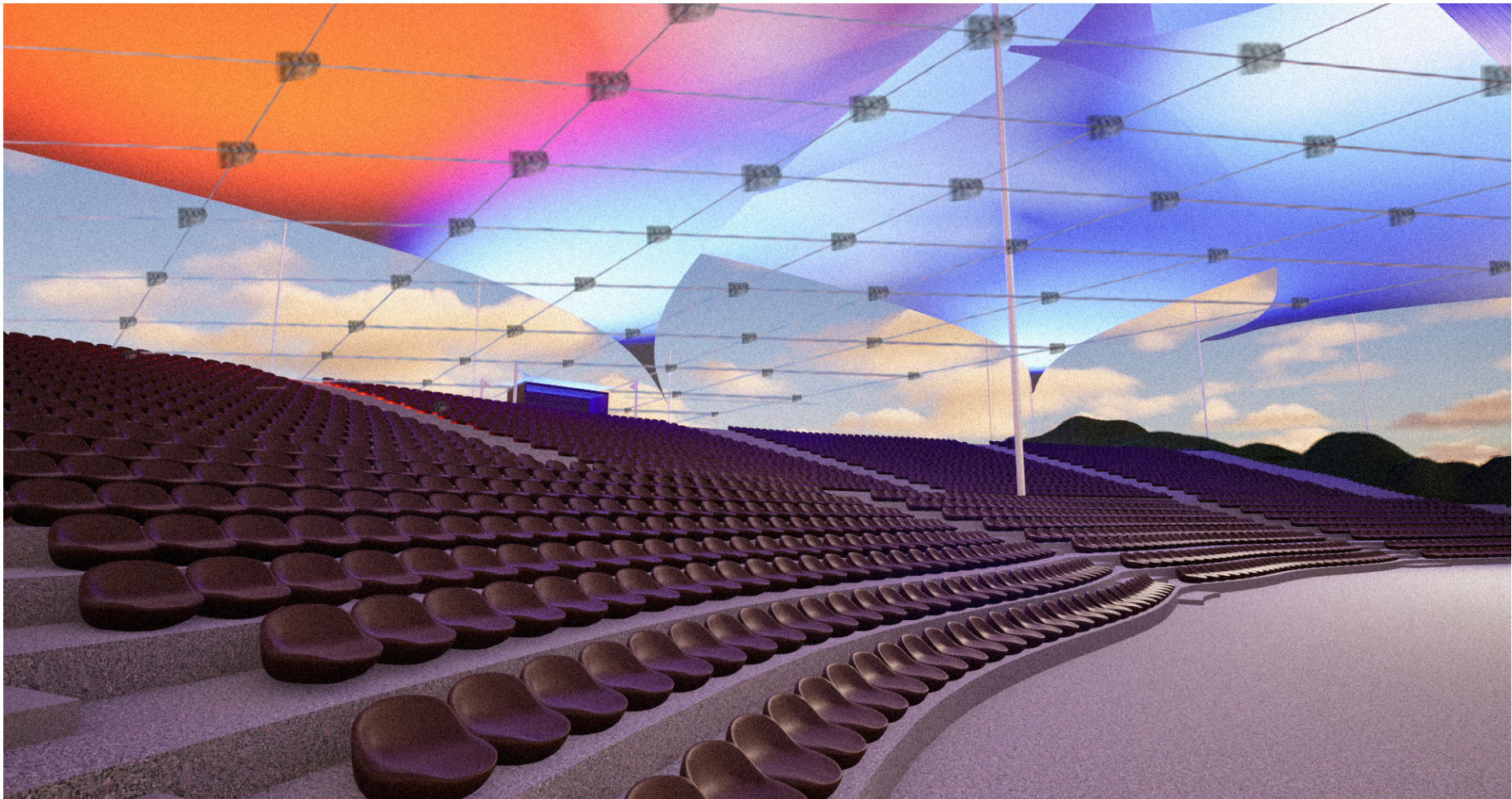
THE AWAKENING OF THE DRAGONFLY

The airy roof can be illuminated in different colors and movement patterns that follow the music and add a visual element to the concerts, awaking the dragonfly.

The roof over the auditorium is visible for the lawn audience and enhances the experience, especially for those far away from the stage.



The dragonfly in action.



The oak seating rising up from the granite ground under the wings of the Dragonfly.

BACK OF HOUSE

A CONTINUATION OF THE WINGS

The Dressing Rooms/Rehearsal Rooms, and Offices are as far away from the stage as possible to minimize the effect of the sound propagating from the stage. Facing the river, they have a beautiful and peaceful view. The Dressing Rooms are placed on the first floor, with easy access to the stage and the offices are on the second floor. The large Loading Dock which has two loading bays makes it possible to load and unload cargo simultaneously. It also has easy access to the Storage Room which has easy access to the stage. The Storage Room fits a piano. There is also an additional Outdoor Storage on the east side of the building. Restrooms, a Locker Room accommodating up to 100 orchestra members and store instrument cases, and a Backstage are also placed on the first floor. On the second floor, aside from the Offices, there are more Restrooms and a Green Room with access to the Roof Top with a view over the river. The Mechanical Equipment Room is underground. In order to achieve a good sound reduction value all walls in BOH are double leaf with absorbers.

SUN ANALYSIS OF THE STAGE



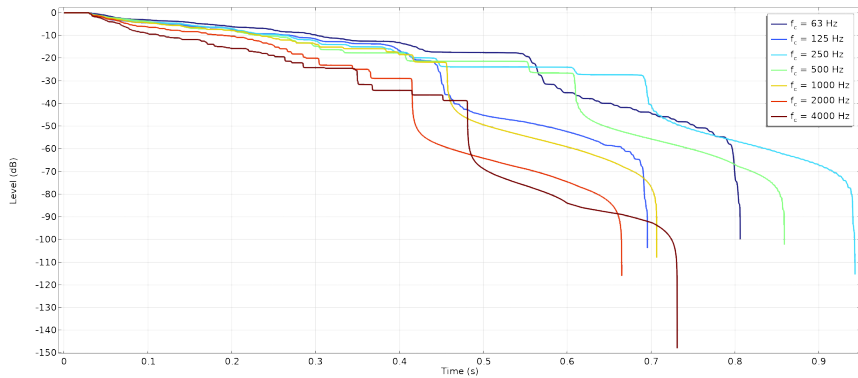
A sun analysis of the stage from 2 PM to 10 PM shows that the musicians and the instruments will be protected from the sun during concerts.

STAGE

THE NEST

The convex design of the stage, while both being a continuation of the roof also works very well in spreading sound power across the stage. The surfaces of the stage are clad with oak panels. Providing good acoustics on stage when one wall is open to the outside is challenging. The design of the stage has to keep as much energy on the stage as possible, this is what the wedge shape of the ceiling is designed to do. For rock and pop concerts room acoustics are not as important as the performers are using in-ears or monitors, and thus the stage will be dampened using movable absorbing panels.

The stage is 15 m deep and has an area of 458 m², being able to accommodate 250 orchestra and choir members. No podiums are built so that the stage set up can be as flexible as possible. Instead, there are portable podiums in the Storage Room.

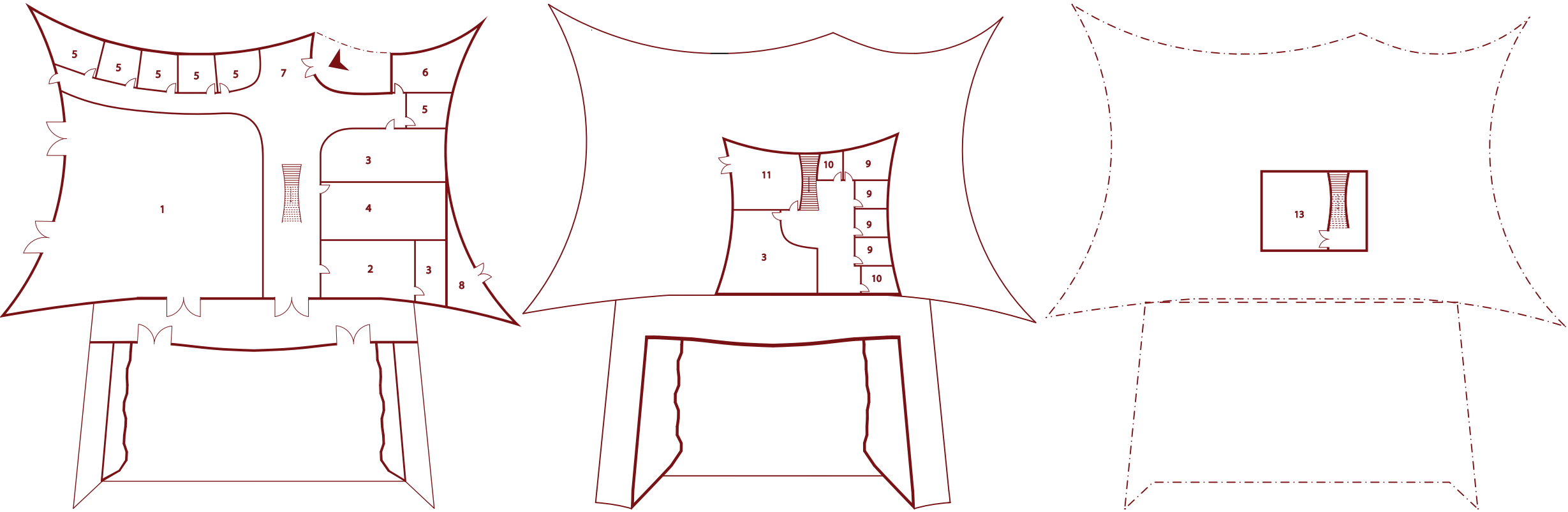


The level decay of the stage.

fc (Hz)	D (%)	C80 (dB)	T20 (s)
63	60.38	2.97	1.38
125	58.18	2.74	1.42
250	56.60	2.51	1.32
500	54.54	2.85	1.31
1000	55.76	2.79	1.20
2000	65.19	5.04	0.90
4000	75.98	8.12	0.73

Acoustic parameters of the stage.

FLOOR PLANS



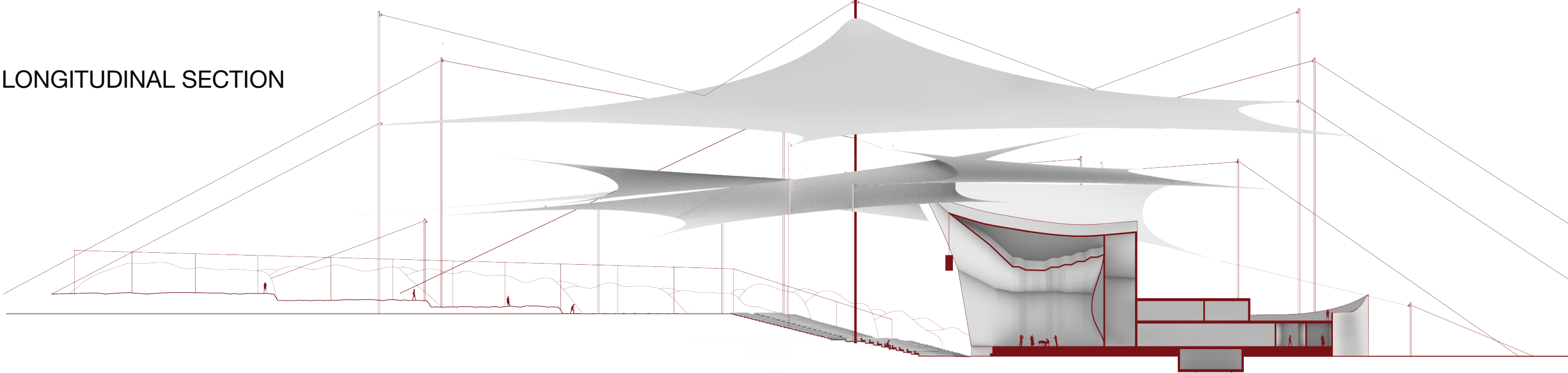
1st floor

2nd floor

Basement

- 1. Storage Room, 558 m². $R_w = 50$ dB
- 2. Backstage, 75 m²
- 3. BOH Restrooms, 186 m². $R_w = 40$ dB
- 4. Locker Rooms, 100 m². $R_w = 40$ dB
- 5. Solo Dressing Rooms, 20 m² each.
 $R_w = 45$ dB
- 6. One Star Dressing Room, 35 m².
 $R_w = 45$ dB
- 7. Foyer
- 8. Outdoor storage, 38 m²
- 9. Offices Suite for technical staff, 13 m².
 $R_w = 40$ dB
- 10. Offices for touring staff, 9 m² each.
 $R_w = 40$ dB
- 11. Green Room, 65 m². $R_w = 50$ dB
- 12. Roof Top
- 13. Mechanical Equipment Room (MER),
75 m². $R_w = 50$ dB

LONGITUDINAL SECTION



THE DRAGONFLY - Architectural Qualities

The Dragonfly is an outdoor music pavilion, integrated into a hilly landscape that leads the visitors under its wings. When the visitors walk in the venue, the glimmering being appears to be soaring over the audience. The entire venue and surrounding area are not only as elegant as a dragonfly, but are also acoustically engineered to provide a good soundscape.

The landscaping is an important part of the project. The way to the concert area is an experience in itself, with all the hills and paths that creates a sensation of you do not know what to expect. Instead the roof of the Dragonfly soars between the hills, leading the way. The landscape has one main, larger path that leads effortlessly to the audience area for accessibility, but still it has the same experience of walking in a hilly landscape. There are also wavy noise barriers, spread out in the park, which together with the hills creates an acoustic landscape that reduces the road traffic noise as well as encapsulates the audience.

The roof auditorium, consisting of seven sections of rows, holds a total of 3000 spectators. The rows' curvature mimics the playfulness of the landscape. The additional paths between the sections guide the audience through the pavilion effortlessly. The seats, made of oak, have an organic nature and rise from the granite ground of the auditorium. A light, tensile roof stretches over the auditorium and the stage. It is made of four layered PTFE membranes, held between poles and rods with a larger one stretching over the whole auditorium. The PTFE fabric is highly sound absorbing, preventing reflections from the roof, creating a suitable environment for electro-acoustics. It also offers durability, flexibility and strength while having a good light and water resistance, protecting the audience from the weather.

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The Back of House and stage design takes inspiration from the roof over the auditorium with the pointy corners and stretched appearance. The stage's protruding roof is asymmetrical to mimic the roof and the liveness it has while the walls of the stage are convex. The surfaces of the stage are clad with oak panels. Every piece in the project is carefully designed for a continuous expression.

THE DRAGONFLY - Reflections

I am very satisfied with the outcome of the project. The concept comes across clearly and is present throughout a large part of the project. The roof, which we struggled with for a long time, finally achieved the right architectural expression, although structurally it would have been exciting to continue developing it further. The landscape leading up to the stage and audience turned out the way we envisioned it, an exciting and playful experience, with the roof emerging between the hills. I also believe that the final drawings communicate clearly with the viewer, with the text serving as effective support. One aspect I am especially pleased with is how the design language of the roof, the stage, and the Back of House connects together. All of them share a stretched and asymmetrical expression with sharp points and curves. Many of the chosen materials, for example the PTFE and the wood, are sustainable for the environment in the long run.

All of the iterative assignments throughout the project were valuable in helping us avoid getting stuck too early in the process. Thanks to these exercises, we were always able to keep moving forward. I especially enjoyed the assignment where we worked with clay. The clay models were very helpful in shaping the landscape, and we even traced certain parts of the models and applied them directly to the final drawings. This made the drawings feel more lively and dynamic.

The collaboration between me, Ilinca and the acoustician worked very well. Communication functioned smoothly throughout the process, and everyone contributed positively to the development of the project.

ARCHITECTURE & ENGINEERING

During my three years studying Architecture and Engineering, I have developed very much. The interdisciplinary nature of the programme has given me a deeper understanding of how architectural design and structural engineering can work together to create sustainable and functional buildings. What I find particularly interesting is the balance between creativity and technical problem solving. Throughout the programme, I have gradually learned how architectural ideas can be supported and strengthened through structural design and engineering principles. Courses in structural mechanics, mathematics, and building technology have complemented the architectural studios and helped me approach projects from both an aesthetic and technical perspective.

This autumn, I will begin the Structures master's programme, which is a field I became interested in during my bachelor's studies. I am really looking forward to it.