PROJEKTPORTFOLIO
Kandidatarbete i Arkitektur och Teknik

Typ av arbete:	Grupparbete
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Omfattning:	15 hp
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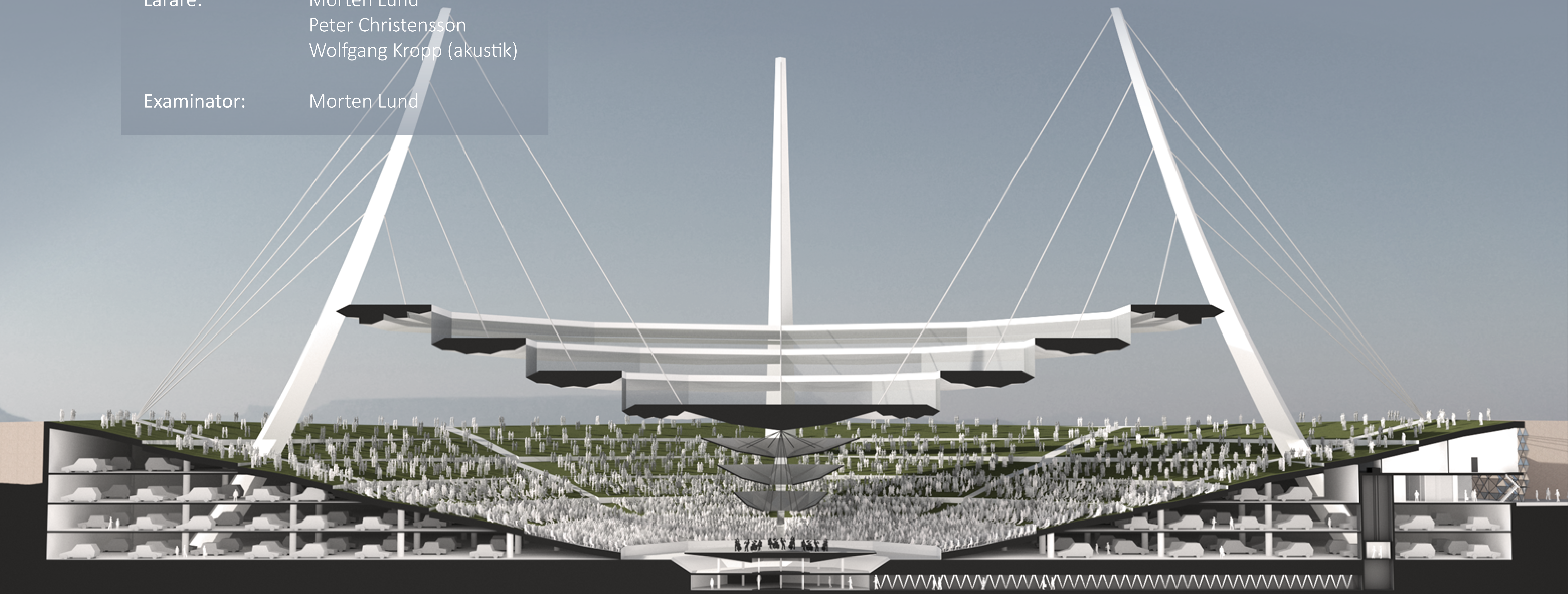
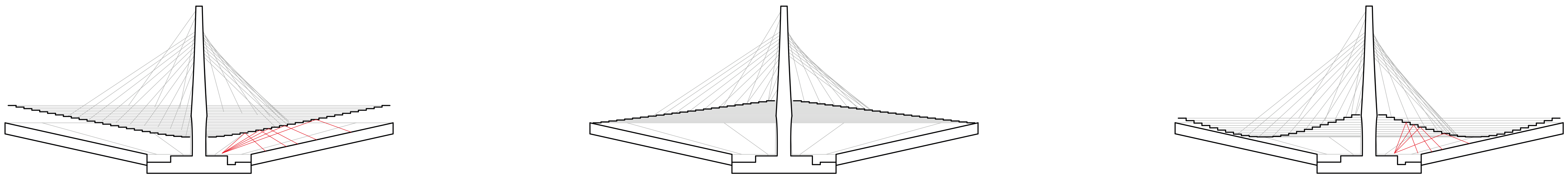


The design process

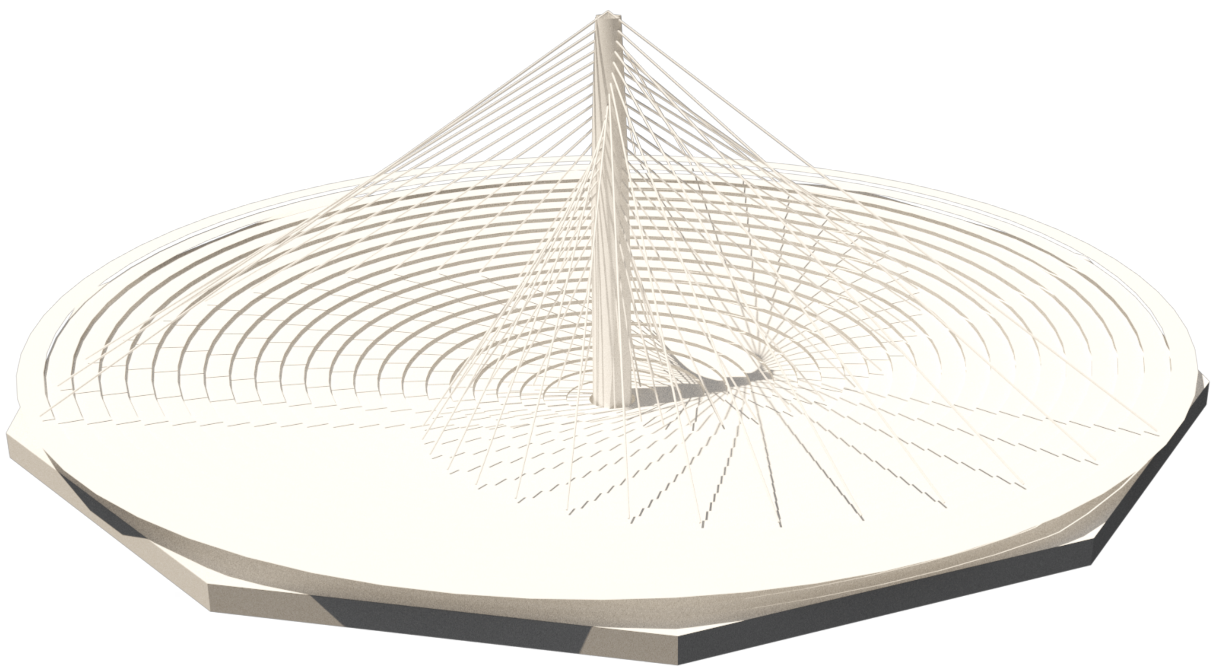
First stages



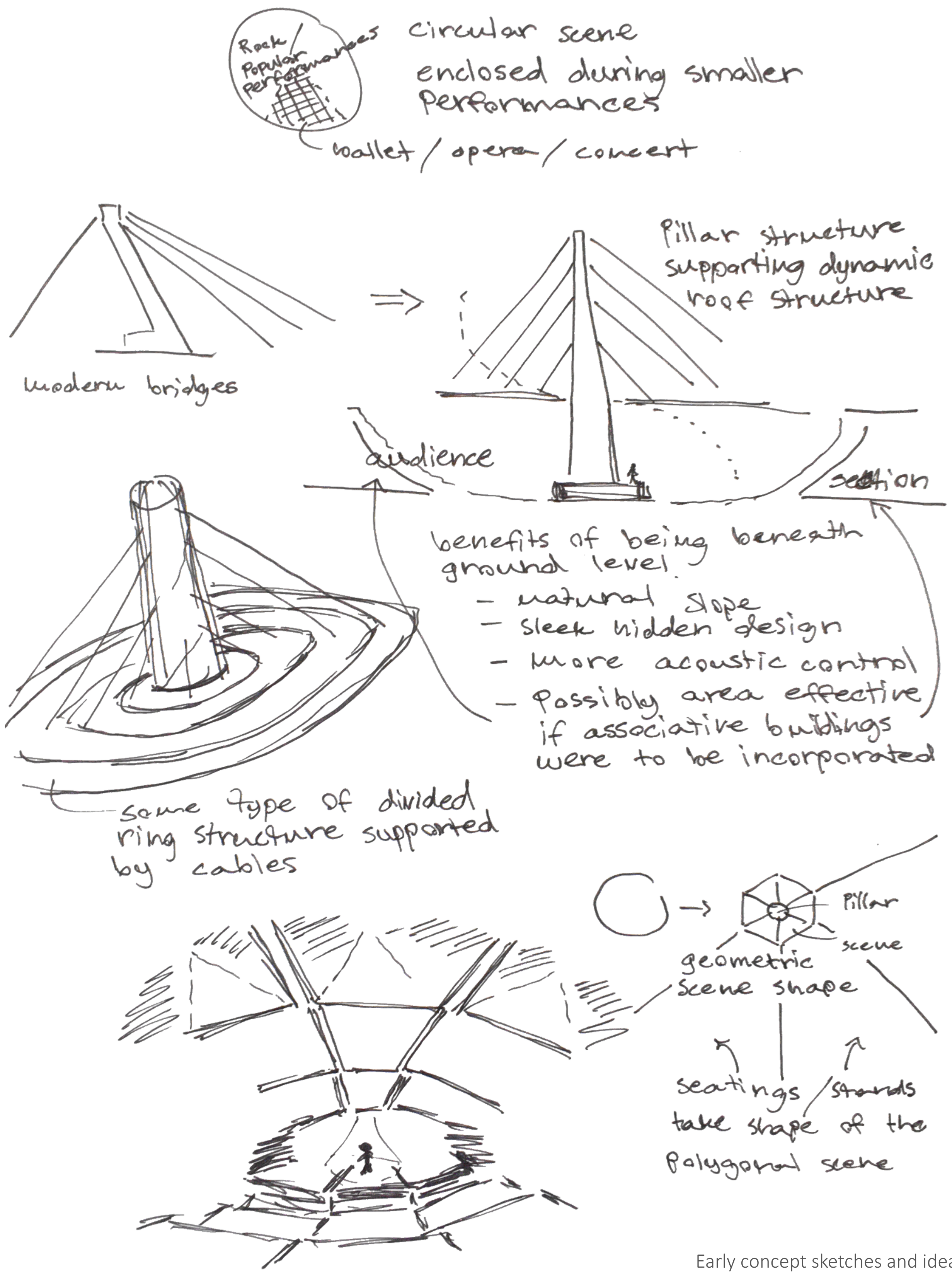
Sections of the early concepts, illustrating the flexibility of the ceiling

The initial ambition of the concept was to work with a round, polygonal stage, in order to bring the audience closer to the performers, thereby providing a more intimate atmosphere. A natural addition to that was to bury the pavilion, having the stage at the lowest point being surrounded by a polygonal, funnel-shaped seating and standing area. In combination with a round stage design, a flexible round ceiling was proposed to primarily aid with the natural acoustics. Except for the acoustical aspect, the ceiling could have different settings for different performance types, for example: an open setting for large performances such as rock and pop and a closed setting where the ceiling can preferably cover a certain sector of the stands, leaving only a smaller sector open for a smaller audience.

Inspired by the aesthethics and structural design of cable-stayed bridges, we proceeded with designing a proposition to a structural system to carry the flexible ceiling. Cable-stayed bridges consist of two main, contrasting, structural elements: the robustious, compressed pylons and the light, tensioned cables. These were adapted to our concept in the form of a massive, pillar at the center passing through the round ceiling and carrying it from above with cables.



First proposed pavilion concept

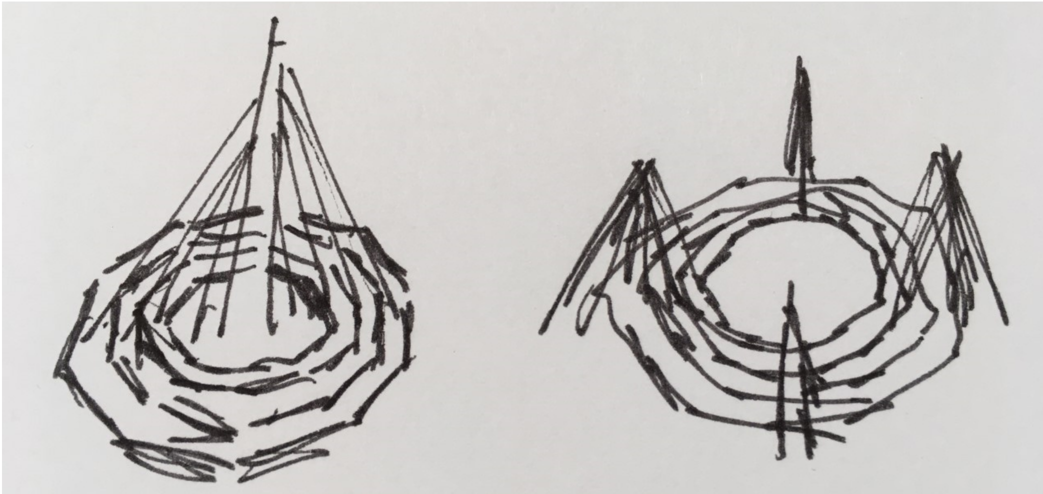


Early concept sketches and ideas

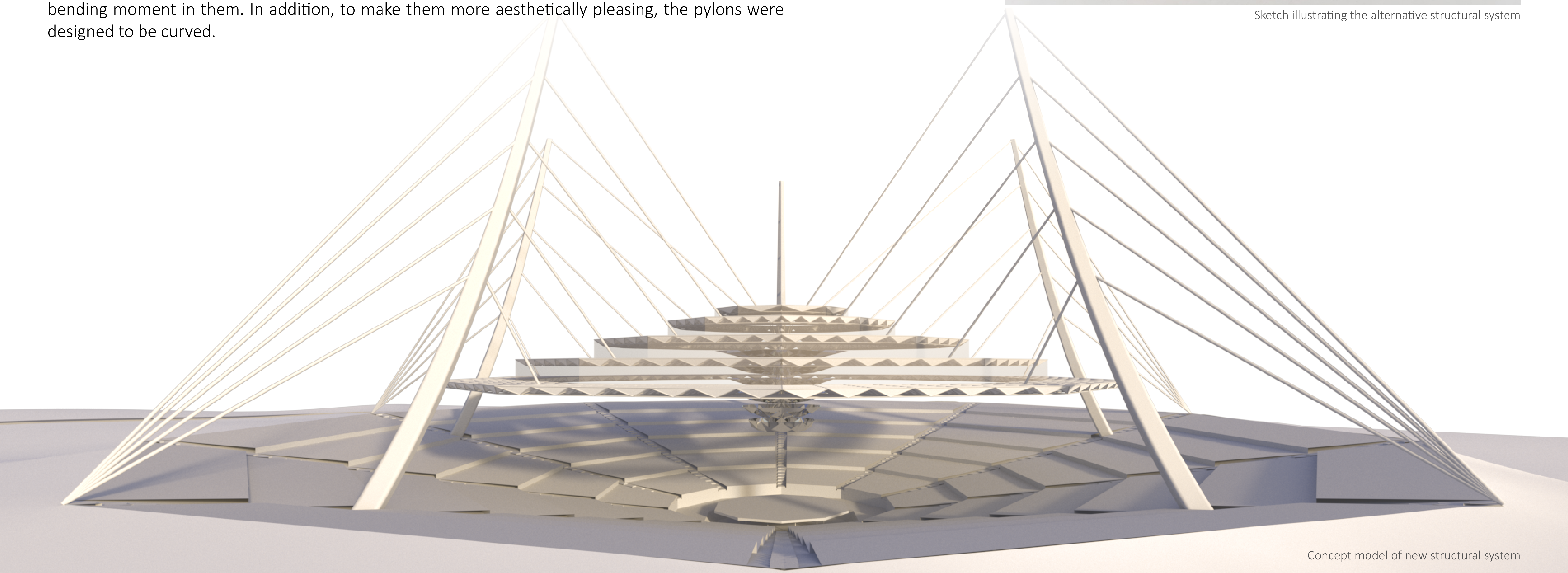
The design process

Problems

Besides the problems associated with the round stage, there was an additional one of great importance which was the large pillar. Its placement and size would lead to inconviniences such as the poor visibility of the audience, which couldn't be ignored. After a few iterations, including an arch with different cable configurations, a commonly agreed upon structural equivalent was found, replacing the one, massive central pylon with five smaller ones equally distributed on the perimeter of the stands. At the same time, it was decided that the ceiling could have the same decagonal shape as the stage and stands, and also only keeping the part of the ceiling closest to the stage, in order to combine completely open lawn stands and ceiling-covered stands/seats. This, in turn, led naturally to the decision of moving the pylons closer to the center and having them cable-stayed in order to reduce the bending moment in them. In addition, to make them more aesthetically pleasing, the pylons were designed to be curved.



Sketch illustrating the alternative structural system



Concept model of new structural system

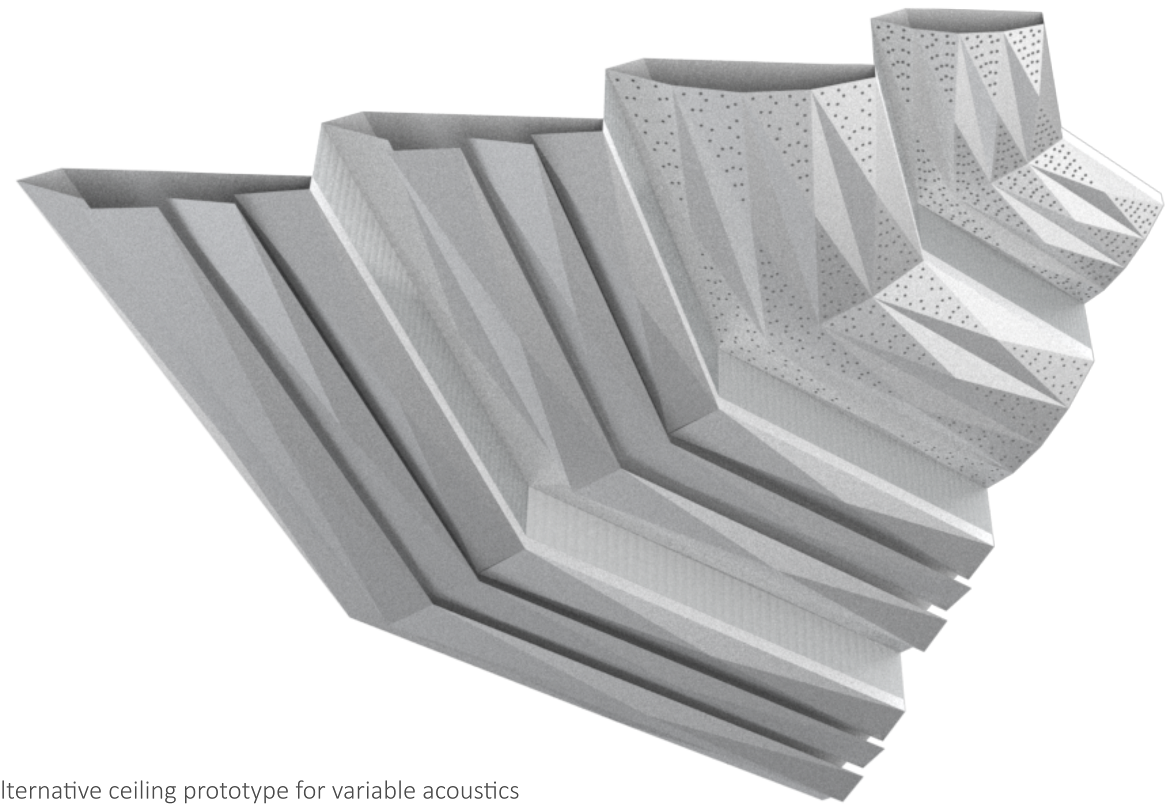
The design process

Prototype development

Ceiling variable acoustics

The central part of the concept is the adaptability of the pavilion to different performance types. This is synonymous with a pavilion with variable acoustics, and in order to achieve that, controllable absorptive properties of some surfaces is needed. Primarily, this was fulfilled through the integration of helmholtz resonators in the triangulated space trusses carrying the ceiling segments. This prototype was later discarted due to its aggressive character, that is especially noticeable for the standing audience furthest away from the stage when the ceiling is closed.

The alternative worked out was the division of each ceiling ring into four with metal panels that shape pyramids. Later on in the process, parallel to the acoustic simulations, it was shown that there were too high reverberation times in the lower frequencies in the closed ceiling setting. These were lowered through making the first two ceiling rings into static helmholtz resonators, and letting the panels of the rest rotate, revealing an absrorbing surface in the form of absorbers or helholtz resonators, thus achieving variable acoustics in the closed setting of the ceiling.



Alternative ceiling prototype for variable acoustics

First ceiling prototype for variable acoustics, with a paneling of the truss' pyramids

The design process

Prototype development

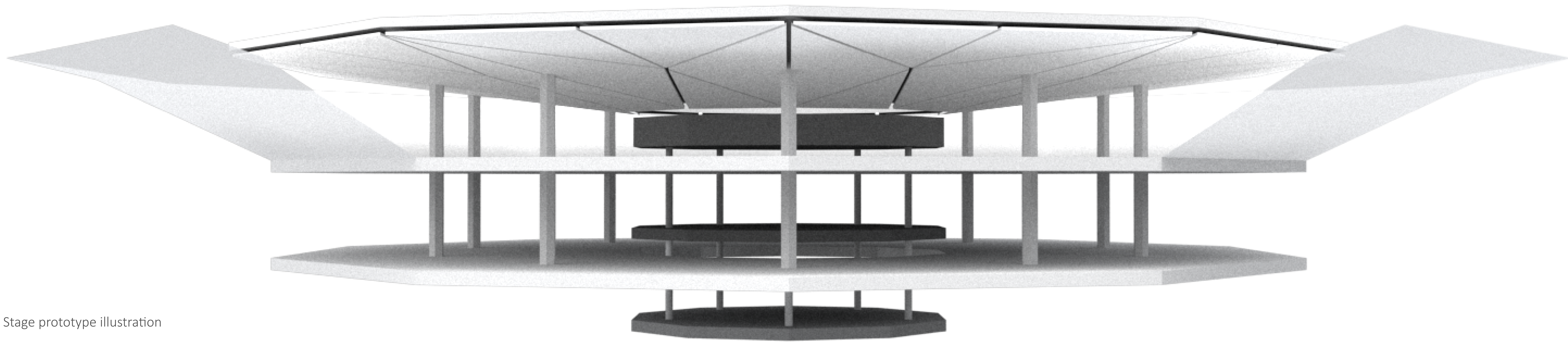
The stage

The prototype development wouldn't be complete without a special stage design. The major complication came with the orchestra placement and operation due to the round configuration of the pavilion. So the stage was completed with two lower levels, one pit level directly underneath, and one green room-level at the bottom. The access between these levels was obtained through an elevator in the middle. In order for the sound to travel to the audience, and not remain in the pit, leading to complications with clarity, the pit level ceiling is sloped. This ceiling is supplied with sound absorbers towards the center, aiding with clarity, and reflectors outwards sending the sound waves out through the sloped walls enclosing the pit.

The stage sound reflector (sound spreader)

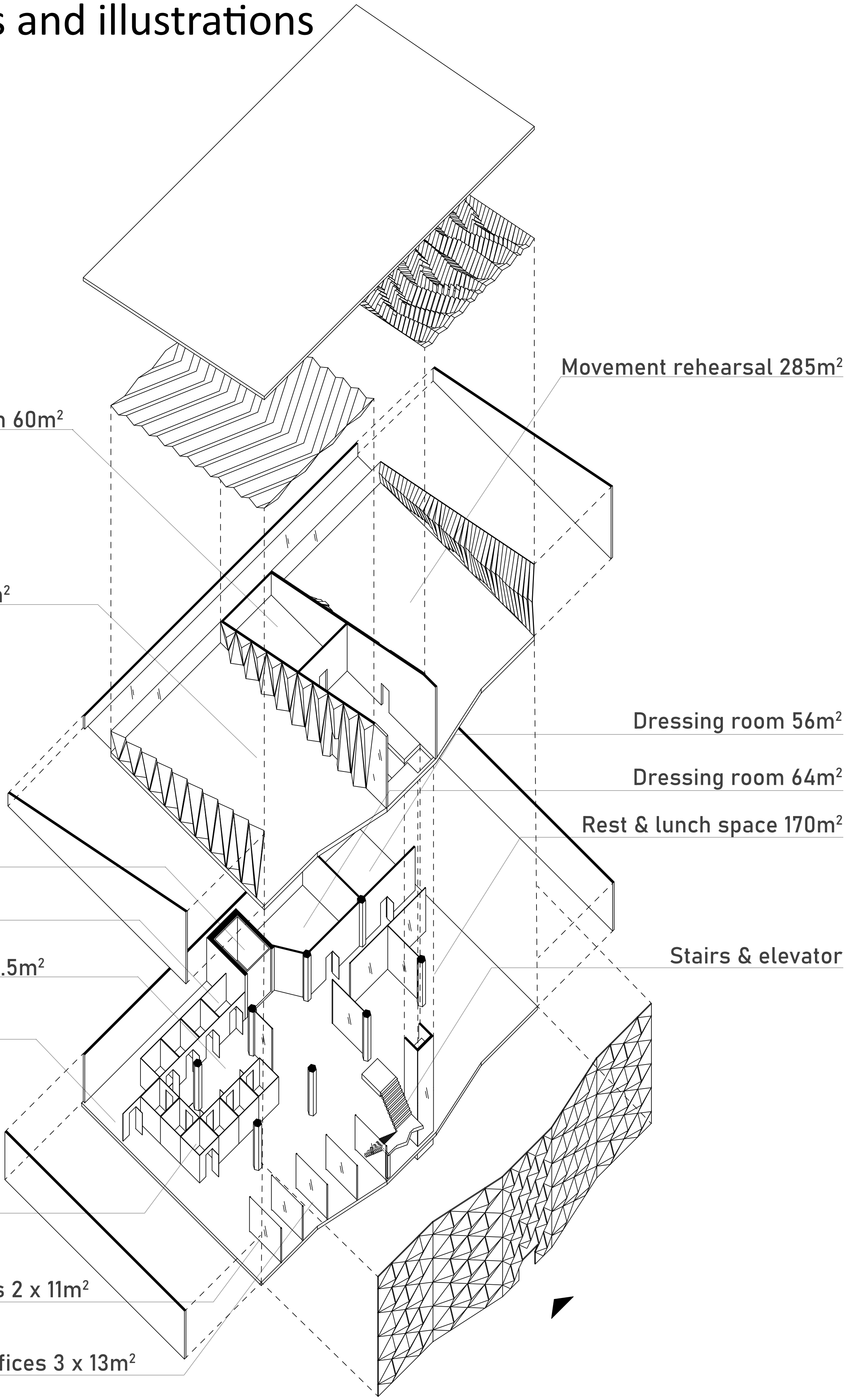
An important part of room acoustics are the early reflections, and how they are managed. Apart from the direct sound, early reflections are needed in order to assist the early sound. This was of great importance in our case, since the stage is round and the acoustics need to be as equal as possible for the whole audience. A round sound reflector was a natural solution to the problem and was implemented, but with some additions. The sound reflector was chosen to consist of several decagonal structures, decreasing in size the closest to the stage they are. These structures have openings at their lowest levels, that instead increase in size having the largest opening directly above the stage. This approach of designing a reflector is to spread the sound with a good quality and strength to all the audience, regardless of their seating/standing area.

Illustration of stage reflector



Stage prototype illustration

Picked drawings and illustrations



1:500 Exploded axonometric view of the functions facility

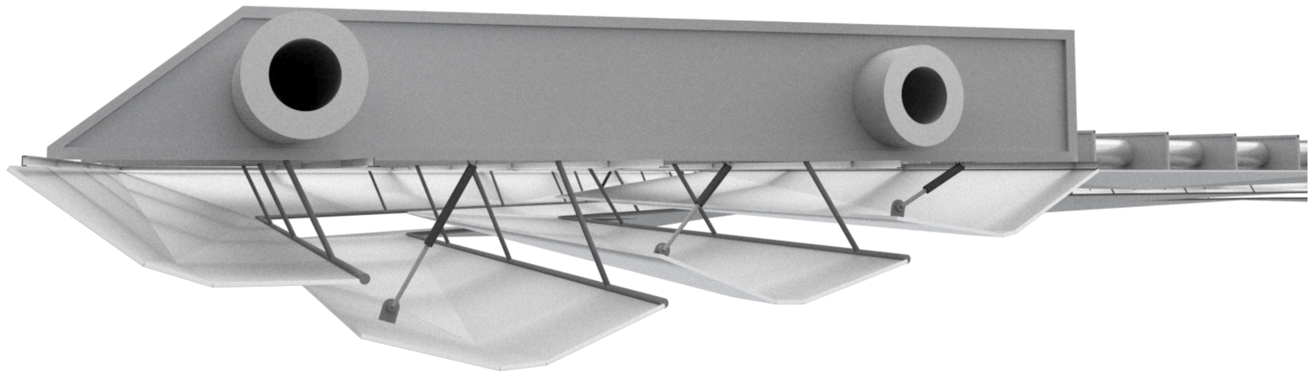


Illustration of the working of the kinetic ceiling panels


Illustration of the stage and stage reflector prototypes

Reflections

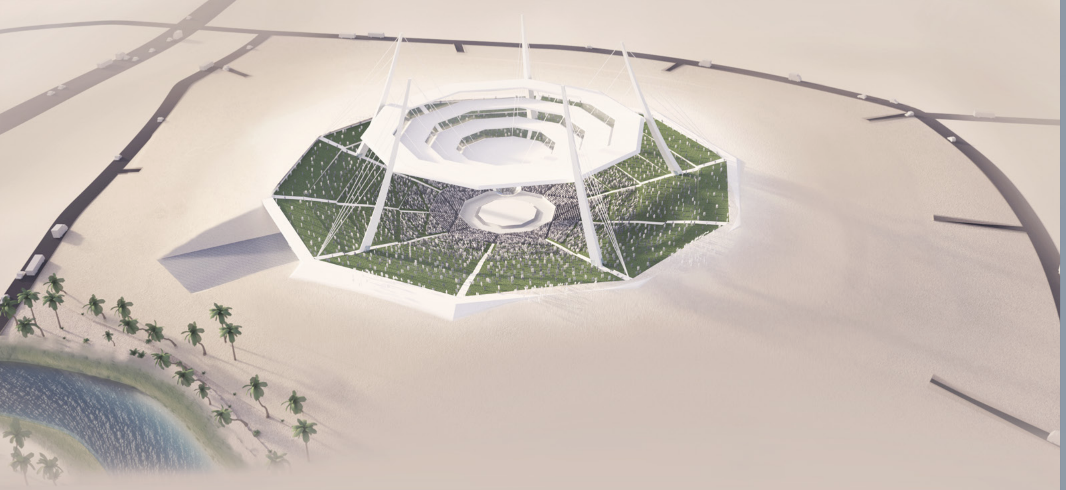
The interdisciplinary character of the group project led to interesting realizations regarding the potential and weaknesses of the concept. Our basic knowledges in room acoustics were reinforced by the group's acoustician and the acoustics mentor, in order to make realistic and informed design decisions. The communication between us and the acoustician was a vital part which, due to the extraordinary circumstances that implied remote communication, was a bit of a challenge and some misunderstandings couldn't be avoided. Luckily, this didn't mean any major issues in the process, and we were able to get good final results.

In the own group, the workflow that came naturally was common brainstorming, when problems arose or when in need of new ideas, and having assigned focus fields to each member. We could then work effectively in parallel, periodically discussing and updating eachother on our works. This worked well in our case, since it was compatible with the current circumstances and every member could work freely on their own even quite independently most of the time.

The iterative design process was dynamic, meaning quick shifts from sketching to virtual modelling, with priarily the aid of grasshopper. This gave an appreciated opportunity of studying the capacities of different design proposals, often even parametrically.

Integrating architecture and acoustics was an aspect of great importance in our work, and this meant a constant weighting between aesthetic and acoustic values. In the end, we were able to achieve a pompous design which simultaneously gives the opportunity of carefully adjusted acoustics despite its size and openness to the surroundings.

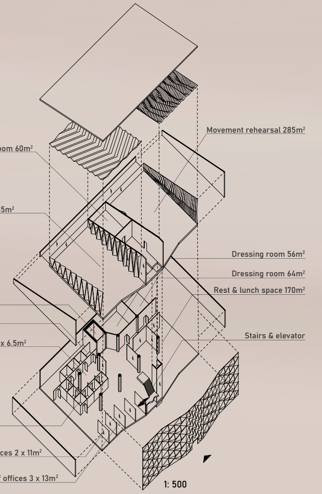
The early establishment of a movable and divided ceiling meant the unique property of uncountable combinations of ceiling heights and configurations, and thereby a wide acoustic and architectural variability.

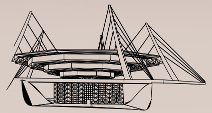


The Oasis is a buried pavilion with five tall pillars carrying a roof structure that spans over large green seating areas. Like an oasis is born from unusual circumstances, this oasis was born from unusual acoustical needs, resulting in a structure with many faces that lends to interesting and unique performances.

The venue will serve as an outdoor summer concert arena where life and music are celebrated together with thousands of people, musicians and dancers. Popular acts will be combined with orchestra, theatre and ballet in a mix of a flourishing environment.

To supply the circular stage and the audience with proper acoustics and utilities, the pavilion can be shaped to fulfill the preferences of all kinds of performances and audience members. By heightening and lowering the ceiling together with a kinetic ceiling structure, a wide range of acoustical demands can meet.





SUPPORT FACILITY FACADE

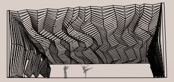
A glassed facade connected to an outdoor area for facility staff and associatives. The glassed facade with the high ceiling allows for a bright floor plan with interesting light plays.

SUPPORTING FACILITY

The supporting facility is located beneath the north-eastern stand and constitutes only a slight portion of what would otherwise be parking space, which is only limited by terrain. The facility houses the needs of the performers and the facility staff, as shown opposite. The facility is connected to the stage through a long tunnel beneath the parking space accessed through an elevator.

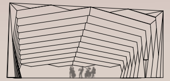
MER & STAGE CONTROL ROOM

Between the two rehearsal rooms, a room is fitted that can control stage variables like headlamps, curtains and backdrop. This room is spacious and could serve multiple facility technicians and the equipment required to control the stage.



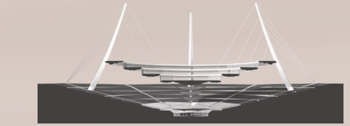
MOVEMENT REHEARSAL ROOM

The movement rehearsal has a reflective ceiling in a stripe like fashion that that resumes its shape on the walls where they act as retractable mirror stripes that offer the opportunity of variable acoustics and room types. When the stripes are flat, they cover absorbers attached to the walls, and when extended they vary the shape and acoustics of the room.



ORCHESTRA REHEARSAL ROOM

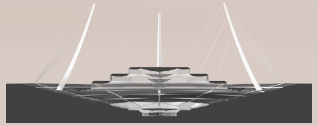
On the second floor the facility houses a rehearsal room equipped with reflective ceiling panels joined together with absorbing wall panels that cooperate to ensure a desirable distribution of sound and clarity at the same time.



NATURAL ACOUSTICS & SOUND REINFORCEMENT

Rock, Pop & Jazz

During the larger popular performances for up to 25.000 audience members, the roof structure opens up and the acoustics are then combined between natural and reinforced.



NATURAL ACOUSTICS

Orchestra, Opera, Ballet & Theatre

During the smaller performances ranging from 5.000 to 10.000 audience members, the roof structure comes down to increase the reverberation time and allow for better controllable natural acoustics.

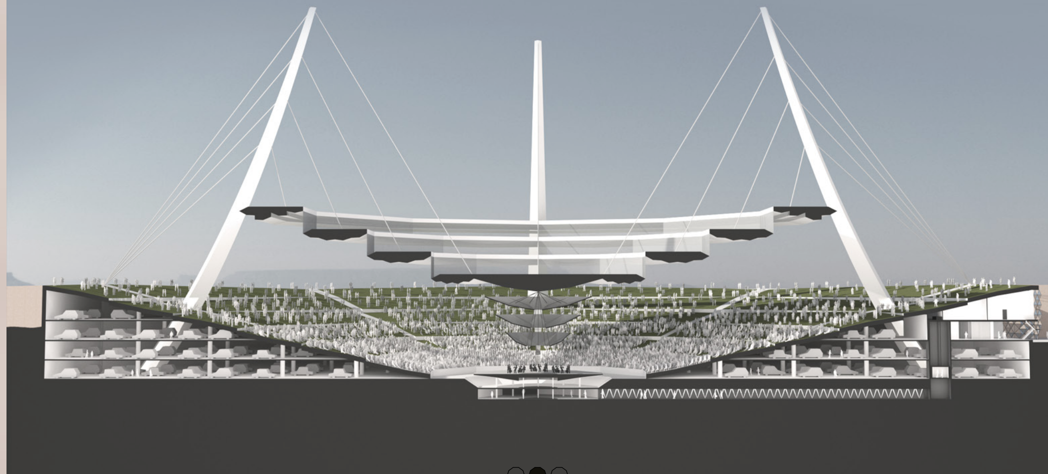
IMPROVISED ACOUSTICS

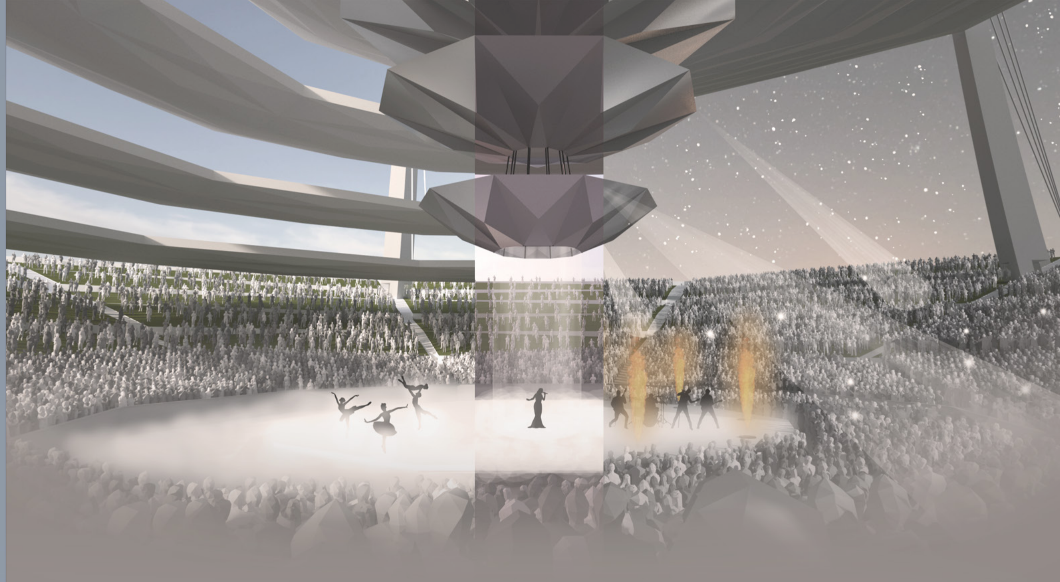
Special performances

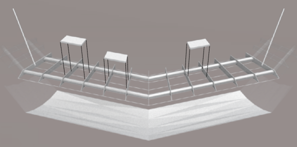
During special occasions and performances that does not conform to conventional acoustics, the flexibility of the arena allows for a wide range of acoustic properties and different spatial experiences.

OASIS

IN A DESERT LANDSCAPE
NEAR A LAKE WITH FLOURISHING GREENERY,
AN OASIS IS BORN





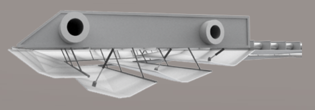


CEILING DESIGN

The ceiling elements hang in cables and are each supported by a structure consisting of two main beams running tangentially along the element, and secondary perpendicular beams with sound absorbers in between.

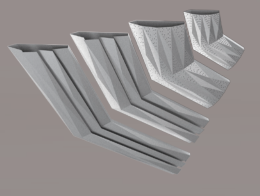
SEPARATING PANELS & ABSORBERS

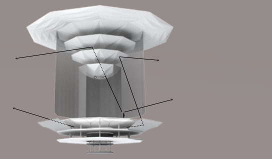
The ceiling consists of four decagonal rings each with a wider radius than the previous. These “rings” are divided into four segments of panels able to slightly open up, revealing absorbing material between the segments, allowing for adjustable acoustics.



HELMHOLTZ RESONATORS

To control the acoustics through a wide spectrum of frequencies, we have integrated Helmholtz resonators to the two inner rings of panels. These resonators have the purpose of absorbing low frequency sound waves during performances when the ceiling would be closed, allowing for a good baseline high reverberation time that can be further lowered by either separating the panels or raising the ceiling structure.





REFLECTOR DESIGN & EARLY SOUND

The sound reflector continues the geometric shape of the ceiling rings and ties them together with a diamond shaped structure that extends down towards the stage. The reflector panels make up four separate reflector structures that gradually opens as they reduce in size. The purpose of the openings increasing in size is to allow for some of the sounds to be evenly distributed to the reflector structure where they are reflected to the listeners, allowing for more controlled early sounds.

The distance between the reflector structures and the stage dictates the time for the sounds to travel to the listeners ear, thus we have decided to allow for adjustable distances between the reflectors structures themselves and the stage to allow for more adjustable acoustics.

INTEGRATED CURTAIN & BACKDROP

The outer ring of the lowest hanging reflector structure allows curtains to enclose the stage lift for a transition of the stage. For some larger transitions, or even a scene change, a curtain can be lowered from the outside ring of the highest reflector structure to enclose the whole stage.

The curtains roll out from each of the 10 sides of the decagonal silhouette, allowing for an adjustable number of curtains to enclose the scene. This feature allows the pavilion to be used by smaller performances by letting a set number of curtains to be fixated as a backdrop.

INTEGRATED LIGHTING

Within the reflector structure headlamps are concealed and allows for dynamic scenery with discrete equipment.

STAGE ELEVATOR

The elevator consists of three decagonal platforms acting as a large multifunctional lift, allowing for travel between the three levels; ground, pit and stage. The purpose of the lift having three platforms is to allow for travel between the ground level and stage level in one motion whilst always maintaining one platform at the ground level when not in motion.

ORCHESTRA PIT & REFLECTORS

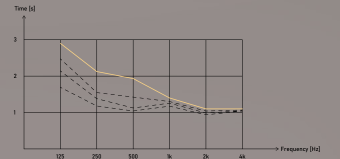
The orchestra pit sits right underneath the stage and is a spacious decagonal area with carefully planned structural support as to not obstruct the view for the sitting orchestra, and to allow for a seemingly hovering stage.

Because the stage takes the shape of a reflector structure, it has a natural slope to its underside which aids the sounds coming from the orchestra to escape the orchestra pit by bouncing off the roof of the stage and the sloped area enclosing the pit.

The orchestra pit has the function to be closed during performances that usually have a crowd closer to the actual stage, like concerts, otherwise it grants a hovering effect to the stage, if desirable.

GREEN ROOM & STAGE SUPPORT

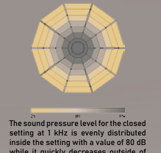
On the ground floor right beneath the orchestra pit, sits the green room with supporting stage rooms such as the mechanical equipment room (MER), additional dressing rooms and space for stage logistics.



REVERBERATION TIME

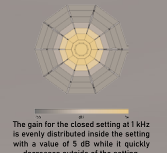
The reverberation time for the closed setting with closed panels ranges from 1.2 seconds at 4 kHz to 2.8 seconds at 125 Hz and are displayed in the graph with a yellow line. The flexibility of the roof can adjust the values if preferred by heightening or lowering the ceiling and by opening or closing the panels. The reverberation times that can be achieved are displayed with the dotted lines.

SPL CLOSED SETTING



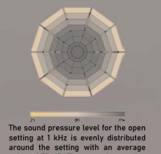
The sound pressure level for the closed setting at 1 kHz is evenly distributed inside the setting with a value of 80 dB while it quickly decreases outside of the setting.

GAIN CLOSED SETTING



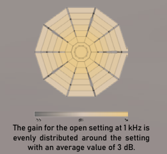
The gain for the closed setting at 1 kHz is evenly distributed inside the setting with a value of 5 dB while it quickly decreases outside of the setting.

SPL OPEN SETTING



The sound pressure level for the open setting at 1 kHz is evenly distributed around the setting with an average value of 75 dB. The natural acoustics are reinforced with electro acoustics to compensate for the loss of sound pressure with an open roof.

GAIN OPEN SETTING



The gain for the open setting at 1 kHz is evenly distributed around the setting with an average value of 3 dB.