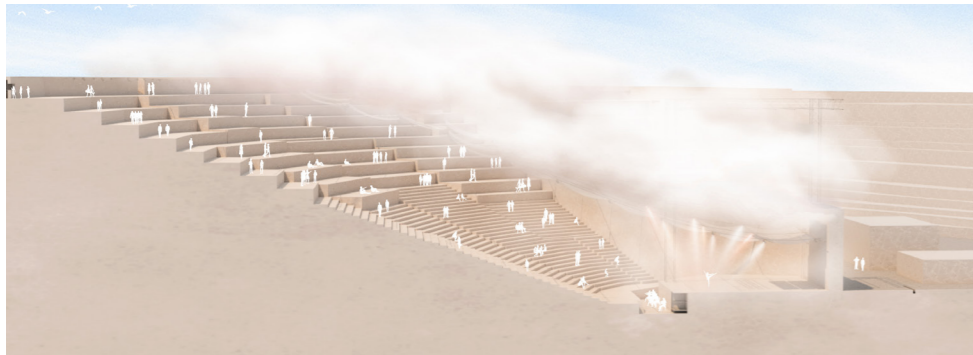


CLOUD NINE

*Chalmers University / Bachelor thesis / Spring year three
Examiner - Morten Lund*

TYPE	Open air music venue
WORKING	Group of three
FOCUS	Acoustics Atmosphere

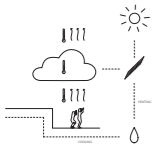


Illustrated section

CLOUD NINE

[Cloud] is a state of perfect happiness, an utopia of pleasure, heaven, rhapsody, euphoria, paradise etc.
 Cloud nine is our proposal for the ADA student competition of 2020. The program requires an open air music pavilion serving as the summer home of a city orchestra.

We wanted to embrace the open air venue and thought about how much we are affected by the atmosphere, the sky and the clouds. Therefore, we created the virtual cloud, hanging over the venue enhancing the atmosphere.



OPEN AIR VENUE

The open air venue is an immediate requirement for the program of the ADA student competition. On the vertical elements of the stage, rough, massive surfaces are reflecting and scattering the sound rays from the stage, while the horizontal planes are smooth surfaces welcoming the audience.

A fine, dissolved terracing is applied to the front and rear levels for seating with larger platforms in the rear grass room for a standing dancing audience. On top of the terracing an irregular pattern is arranging



CLOUD PHENOMENA / TECHNICAL-

The audience in smaller groups making the venue more intimate is achieved by the terracing of the cloud that allows for a closer contact with the stage from all seats.
 Over the bleachers the cloud is floating. A hanging lightweight grid attached to a massive limestone wall embracing the pavilion is providing the cloud with water and smoke. The grid also carries technical solutions such as sound reinforcement and spotlights. Altogether a virtual soundcloud is realized which makes it possible to customize the ambience of the limestone venue.
 A) The cloud is fixed vertically by thermally stable layers of air. Due to its structure, the cloud floats above the bleachers. When the air inside the cloud gets heated by the audience, an upward flow of air prevents the cloud from descending.
 B) The stone quarry is sheltered from strong winds by a massive stone wall surrounding the venue. The base of the cloud in its position horizontally. However, the top of the cloud is free and will spread over the site.
 C) The phenomenon of sound attenuation in fog is the main reason to introduce a cloud to the venue. This method of blocking noise is called by those during sound launches and is now applied to Cloud Nine. The synthetic cloud functions as an effective noise barrier between the venue and the surrounding areas. This way it is possible to block sound from leaking out to the residential areas and traffic noise from getting in, while embracing the experience of being outside.
 D) The massive stone wall surrounding the venue and cloud also acts as a noise barrier. With a thickness of 4.2 m all frequencies are blocked going through



The atmosphere of Theater

THEATER

At the theater, scene lights and backdrops are used frequently changing the settings synchronized with the dramaturgy of the play. During a Theater 7000 spectators are expected, where natural acoustics are applied for the 8000 sitting in the front.

The acoustic elements of the theater are a short reverberation time and a specific soundscapes under a high ceiling. The acoustic elements are applied for the 8000 sitting in the front.

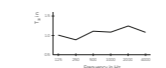


Diagram of direct sound, reflected sound

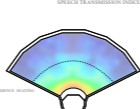
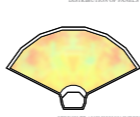
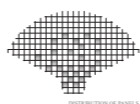


Diagram of direct sound, reflected sound



The atmosphere of rock

ROCK / JAZZ

At Rock and Jazz concerts the epic atmosphere is a big part of the show. Highly illuminated lights, smoke, and sound reinforcement systems are used to create a specific atmosphere.

Sound reinforcement systems are evenly distributed in the grid forming a soundcloud to support the standing audience. A high number of speakers enables lower sound pressure levels and prevent local variations in the overall sound climate. The speakers can be fixed to achieve any reverberation time required, and the

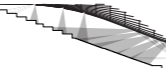
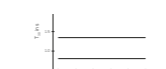


Diagram of direct sound, reflected sound

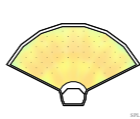


Diagram of direct sound, reflected sound



Perspective backstage

SITE

The design of the pavilion is inspired by its location in Austin, Texas, with its limestone, hot summer days, innovative spirit and live music culture. As a matter of fact, Austin is known as "The Live Music Capital of the World". More precisely, the site of the project is a slightly sloping limestone quarry with a big turquoise river. The assets of the existing nature have been utilized and the program has a humble approach to the existing nature. Inspired by the terracing of the quarry, bleachers have been formed as a regular grid. Along the skyline of the venue, a massive stone wall is anchored by the high illumination of 20 degrees, which is providing a visual contrast and a seating area for both the sitting and standing audience. Austin summers are hot and humid, which we have taken consideration to in the orientation of the venue. The seating audience is always shaded to

reduce the temperature and avoid dusts.
 Surrounding the site are heavy trafficked roads and an interstate highway to the east is a big source of noise. This has been considered in the placement of the pavilion which is located southwest on the site with a big distance to the noisy traffic. Calculations on the distance have been made and only by the distance and height of the massive stone wall the noise has been reduced with 20 dB. However, when the distance and height of the massive stone are being considered the noise will be reduced to almost nothing.

BACKSTAGE

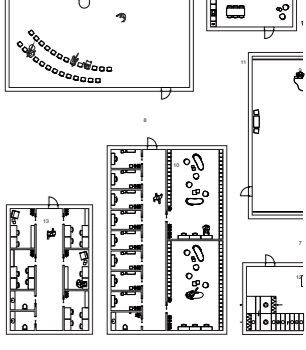
At the backstage area there are facilities for musicians as well as site workers. The backstage area is acting as a front face for the performing musicians and is a big part of their impression of the venue. By working with high ceiling limestone blocks a sense of monumentality is achieved. The different functions are scattered, the bouncers in an open landscape. The backstage area is placed at a ground level matching the stage which allows for transportation of instruments and equipment to and from the stage. The low placement also helps blocking noise from the surroundings.

Many of the buildings are acoustically sensitive and they are therefore separated and isolated from the ground with springs installed in the floor construction. All buildings have, like the venue, an elevated ceiling. By a transparent reinforced absorber inside a perforated stone wall construction the rooms get light from above and are isolated from exterior noise. Due to these details and a flexible furnishing many buildings are multipurpose. The green room for example, can be used as music practice room.



FUNCTIONS

- 1 Stage
- 2 Orchestra pit
- 3 Seating area
- 4 Standing area
- 5 Bar
- 6 Movement rehearsal room
- 7 Musical rehearsal room
- 8 Office
- 9 Toilet
- 10 Change and suit dressing rooms
- 11 Green room
- 12 Mechanical Equipment Room
- 13 Warehouse
- 14 Water reservoir
- 15 Limestone quarry
- 16 Walking area
- 17 Reception area
- 18 River
- 19 Interstate highway
- 20 State highway
- 21 Road
- 22 Parking



Plan 1:200



Noise barrier, Reflective panels, Optical effects, Soundcloud, Connections

Noise barrier
 -Attenuate noise energy from traffic

Reflective panels
 -Adapt RT to different performances

Optical effects
 -Atmosphere

Soundcloud
 -Increase straight RT

Connections
 -Mount temporary equipment

The cloud is implemented combining water vapor and smoke. Water is pumped with high pressure through pipes and nozzles creating a fine mist. The smoke particles are angled differently for the smoke particles to collide with the water droplets, resulting in a dense fog.

Since the venue naturally has a higher reverberation time for the lower frequencies, the panels are designed to evenly reflect sound of the higher frequency range (1 - 4 kHz) and absorb lower frequencies. This selective effect is achieved using panels of lightweight sheets and the lower frequencies are absorbed by the water droplets of the cloud.

Each cylinder has two speaker surfaces angled and fixed differently to generate direct sound as well as reflections. The direct sound comes from the surface directed towards the audience and is fixed based on the distance from the stage. Reflected sound comes from the downward facing surface and is delayed with optional reverberation time.



The atmosphere of Symphony Orchestra

SYMPHONY

A Symphony Orchestra creates magic and order a story right away the natural acoustics of the venue will shine. During an orchestra concert 10 000 spectators are expected, where natural acoustics are applied for the 8000 sitting in the front.

With reflections from the roof and walls the reverberation time is around 2 seconds. The clarity of an orchestra concert is required to be in the interval of -40 ± 1 , which is achieved naturally.

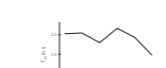


Diagram of direct sound, reflected sound

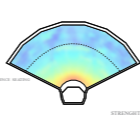
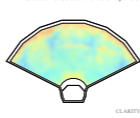
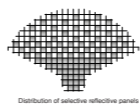


Diagram of direct sound, reflected sound

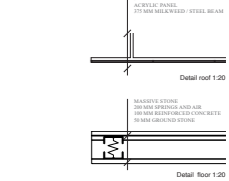
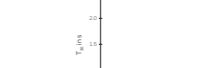


Perspective rehearsal room orchestra

REHEARSAL

The concept of the multifunctional cloud has also been applied to the design of the music and movement rehearsal rooms. Instead of a water droplet the sky is simulated by a translucent polycarbonate ceiling. Similar to the cloud, the ceiling has absorbing properties which means that the reverberation time can be controlled in the same manner as for the pavilion. The absorption is achieved combining micro perforated acrylic panels with the porous absorber released which is a natural fibre.

The walls are covered by rough finished limestone with diffuse reflective properties and the stone floor is polished to serve as a dance floor. The air volume of the music rehearsal room is 3000 m³, which contributes to an acoustical environment optimized for symphony orchestra music. The movement rehearsal room is multifunctional and serves as a warm up facility for the ballet, theatre, circus and opera.



Detail floor 1:20

OVERVIEW PRESENTATION

PROCESS

Early in the project we decided that we wanted to work with a cloud, with the intention of creating a head-in-the-clouds-experience. The following question was how? How do you interpret a cloud as an architectural element? Well, you could achieve light white structures by free formed grid shells or slim pillars supporting flowy textiles, glass, or polycarbonate. But a cloud is much more in real life, constantly changing, varying in density, hovering without support. This is when we realised that we can't imitate a cloud, we must make a real one.

"This is when we realised that we can't imitate a cloud, we must make a real one"

Deep investigations on the phenomenon of clouds we started formulating the properties of our cloud. We wanted our cloud to be a super cloud, being a visual beauty, a noise blocker, a source of electroacoustics and natural acoustics. By combining architecture with chemistry, acoustics, and physics we finally delivered cloud nine.



cloud imitations



cloud in reality

CLOUD NINE

*[noun] : A state of perfect happiness,
an utopia of pleasure*

Cloud nine is a proposal for the ASA student competition of 2020 made in a team of two architect students and one sound and vibration master student. The program inquires an open air music pavilion serving as the summer home of a city orchestra.

The mood of human is very much affected by the atmosphere, the sky, and the clouds. Therefore, the proposal is a virtual cloud, hanging over the venue enhancing the atmosphere. The cloud contributes to the acoustics of the venue, but also it characterizes the whole site and makes it possible to customize the ambience completely for every event imaginable.

"You hear what you see" - Morten Lund

Balancing on the edge of materiality, smoke particles sticks to micro droplets, creating a matter lasting for just a moment, soon being replaced by new compounds. This constantly reproduced artificial cloud, makes us aware of time and presence as well as the space of air.

On intimate performances the cloud can be lowered, and the mist will create a visual barrier. In this space you can be lost and found within yourself, alone yet in a mist of presence. A place where you are with others and you are not. A play of perception.



The atmosphere of Butoh dance theater

OPEN AIR VENUE

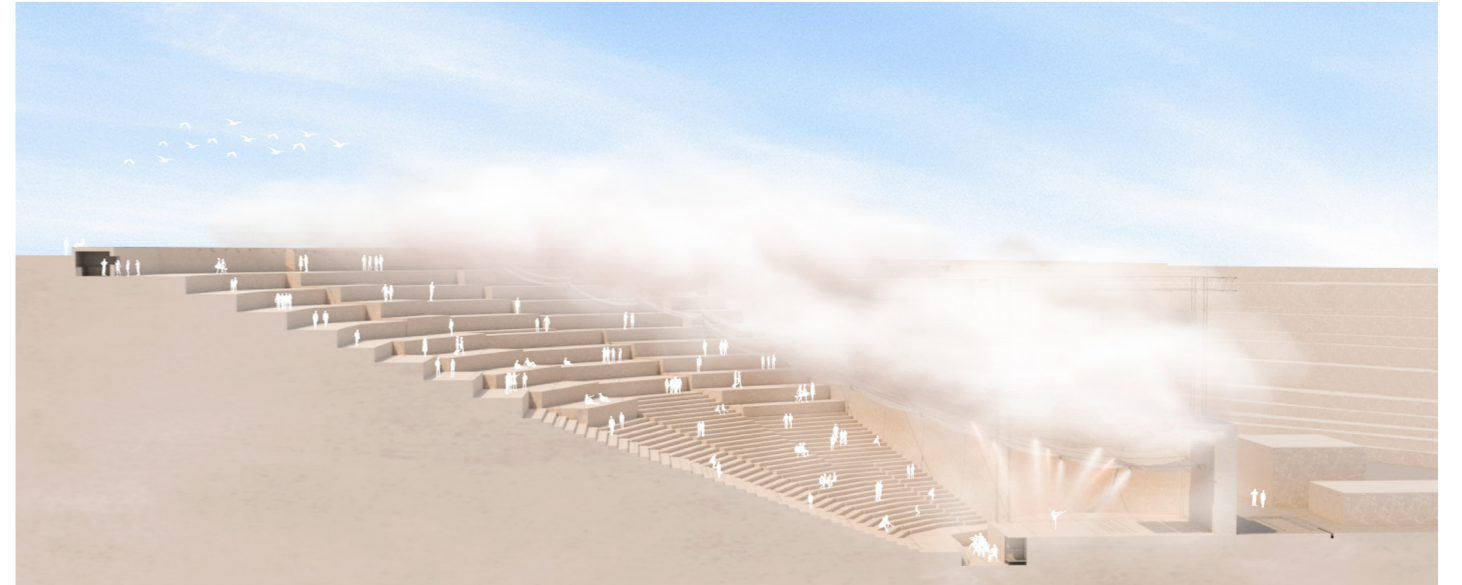
The design of the pavilion is inspired by its location in Austin, Texas, with its limestone, hot summer days, innovative spirit, and live music culture. As a matter of fact, Austin is known as "The Live Music Capital of the World".

The open air venue is an limestone amphitheatre inspired by the terracing of limestone quarries. On the vertical elements of the steps rough limestone surfaces are reflecting and scattering the sound rays from the stage, while the horizontal planes are smooth surfaces welcoming the audience.

A fine dissolved terracing is applied to the front and form levels for seating while larger platforms in the rear gives room for a standing or even dancing audience.

On top of the terracing an irregular pattern is arranging the audience in smaller groups making the venue more intimate. Intimacy is also achieved by the high inclination which secures both visual and acoustical contact with the stage from all seats.

Over the bleachers the cloud is floating. A hanging lightweight grid attached to a massive limestone wall embracing the pavilion is providing the cloud with water and smoke. The grid also carries technical solutions such as sound reinforcement and spotlights. Altogether a virtual soundcloud is realized which makes it possible to customize the ambience of the limestone venue.



Illustrated section over the venue and site



Perspective of the rehearsal room for the orchestra with an acoustic interior sky



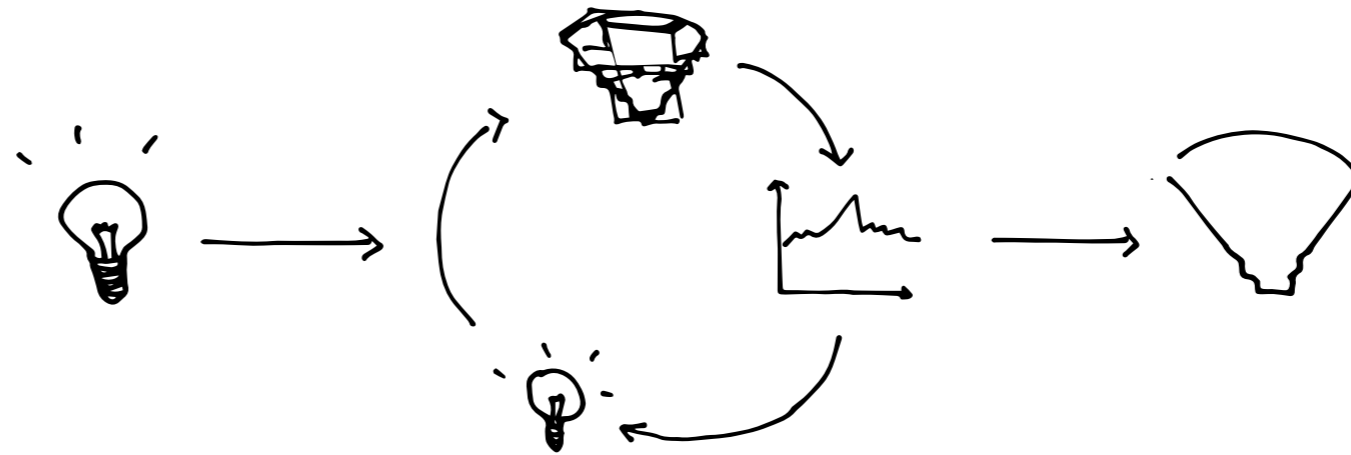
Perspective of the backstage area, a scatter of functions

INTERDISCIPLINARY COLLABORATION

The project has been made in collaboration with Karin Hülling, a Sound and Vibration master student.

She joined the process after the concept had been formed and contributed with inputs on the big scale geometry. Karin also made several analyses in CATT, a program for room acoustic analysis. We made many iterations of simplified 3D models, that Karin analysed and together we evaluated them. The design has been optimized due to these acoustical values.

Working together with Karin have been a true pleasure.



CLOUD PHENOMENA

The methodology of the project has been research based. Based on the natural phenomena of clouds the architectural elements have been given its form and function.

The phenomenon of sound attenuation in fog is the main reason to introduce a cloud to the venue. This method of blocking noise is utilized by Nasa during rocket launches and is now applied to Cloud Nine. The synthetic cloud functions as an effective noise barrier between the venue and the surrounding areas, the interstate highway in particular.

The cloud is fixed vertically by thermally different layers of air. Due to shadows cast by the cloud itself it is cooler below the

cloud than above. Additional cooling can be achieved by a flow of water below the bleachers from the nearby river. When the air inside the venue gets heated by the

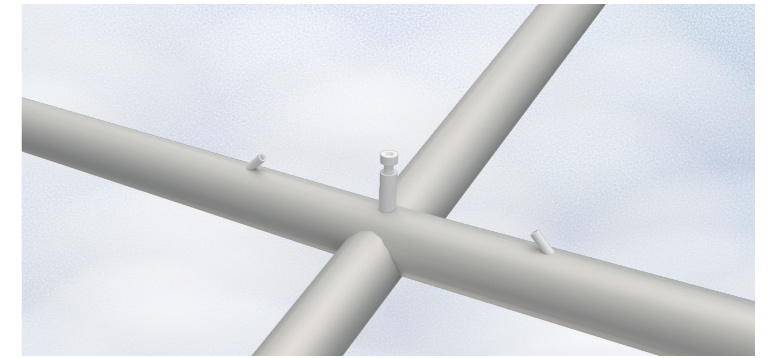
audience an upward flow of air prevents the cloud from descending.

The stone quarry is sheltered from strong winds by a massive stone wall surrounding the venue, this keeps the cloud in its position horizontally. However, the top of the cloud is free to spread over the site. The massive stone wall surrounding the venue and cloud also acts as a noise barrier. With a thickness of 4.2 m all frequencies are blocked going through the wall. Rays passing over the wall are reduced by the cloud.

Altogether a virtual soundcloud is realized which makes it possible to customize every ambience imaginable. On the next page the acoustics of three different performances are presented to show the wide variety of acoustics and ambiances. Acoustically we achieved very satisfying results due to the adaptability of the cloud.

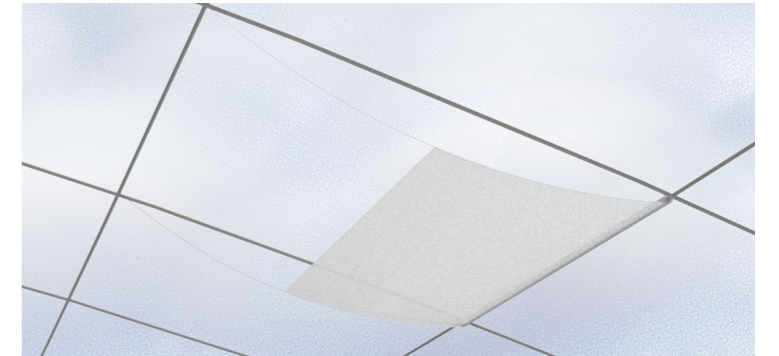
NOISE BARRIER

The cloud is synthesized combining water vapor and smoke. Water is pumped with high pressure through pipes and nozzles creating a fine mist. The smoke nozzles are angled differently for the smoke particles to collide with the water droplets resulting in a dense fog.



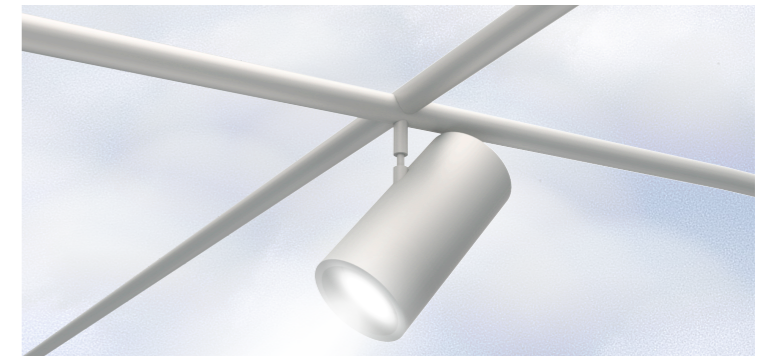
REFLECTIVE PANELS

All squares of the grid can be covered by rollable reflective panels. By adjusting the number of panels, reverberation time can be set to any value between 0.8 -2.2, suitable for all different performances. Since the venue naturally has a higher reverberation time for the lower frequencies, the panels are of lightweight sheets designed to mainly reflect sound of the higher frequency range (1 - 4 kHz) and absorb lower frequencies.



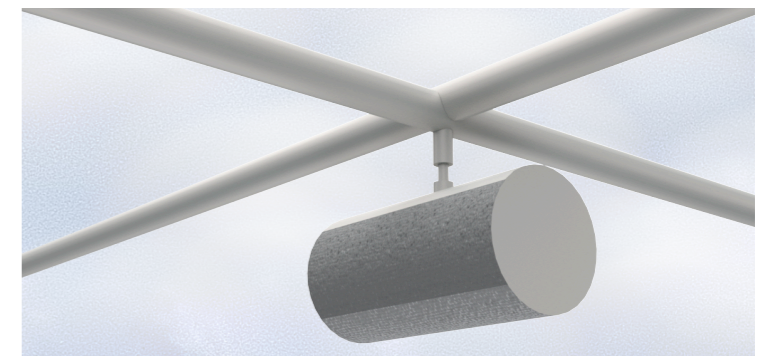
OPTICAL EFFECTS

Combining a performance with light effects enhances the feeling and experience of a music performance or a show. Since they require mist or smoke to be visible the venue provides optimal conditions for this purpose. Spotlights are frequently distributed in the grid for variable ambiances.



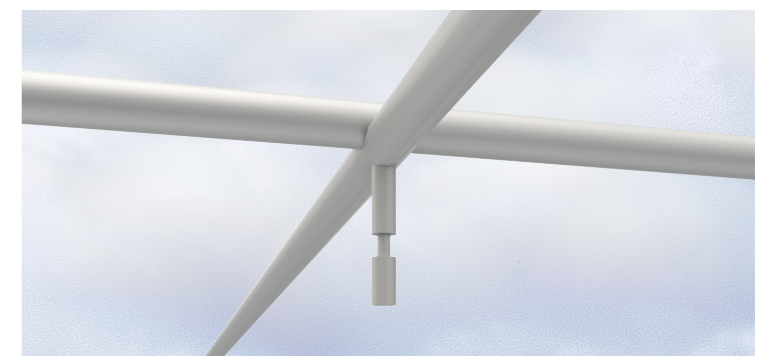
SOUNDCLOUD

A number of 70 cylindrical sound reinforcement speakers are evenly distributed in the grid to support the lawn area. A high number of speakers enable lower sound pressure levels and prevent local variations in the overall sound climate. Each cylinder has two speaker surfaces angled and timed differently to generate direct sound as well as reflections.



CONNECTIONS

The stage proscenium as well as the grid provide connections for mounting equipment brought by the performers. The connections can be rotated and angled to support any device.

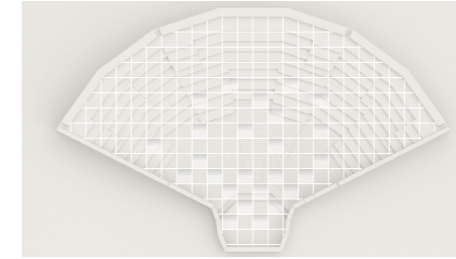


THEATER

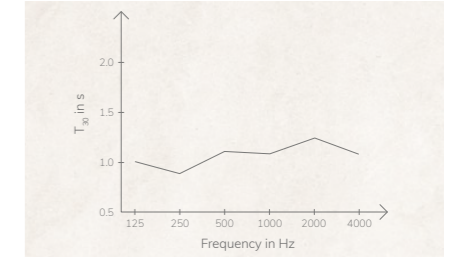
SPECTATORS 7000
 STI < 0.75
 RT 1s
 ATMOSPHERE bright, misty and intimate



The atmosphere of Butoh dance theater



Distribution of panels



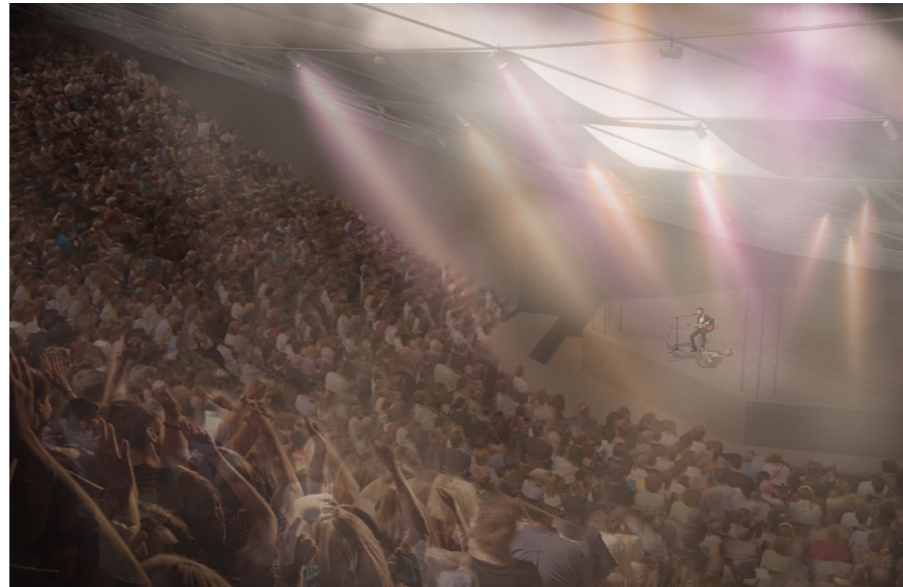
Reverberation time



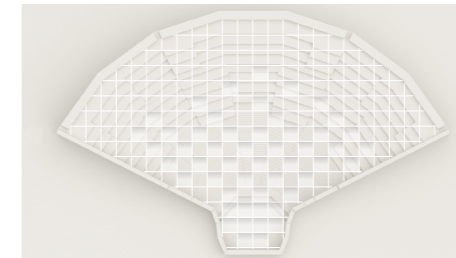
Diagram of direct and reflected sound

ROCK / JAZZ

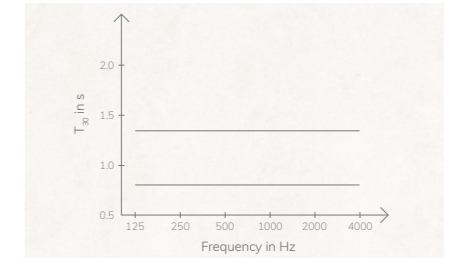
SPECTATORS 25 000
 SPL 70 dB, sound reinforcement applied
 RT 0.8-1.4 s
 ATMOSPHERE spic, saturated lights and smoky



The atmosphere of John Mayer



Distribution of panels



Reverberation time



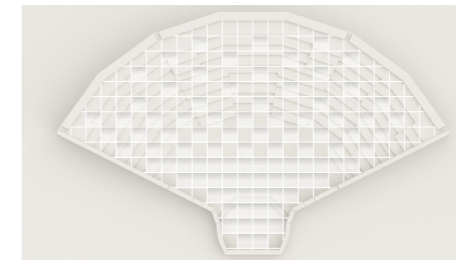
Diagram of direct and reflected sound

SYMPHONY ORCHESTRA

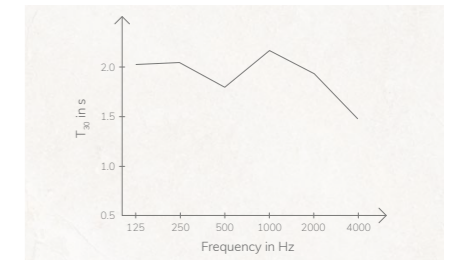
SPECTATORS 10 000
 CLARITY -4 - +1 dB
 RT 2 s
 ATMOSPHERE starry, dark and magic



The atmosphere of Austin Symphony Orchestra



Distribution of panels



Reverberation time



Diagram of direct and reflected sound

REFLECTIONS

The methodology of the project has been research based. Based on natural phenomenon the architectural elements have been given its form and function.

The concept of the cloud and the limestone quarry have been our guidance through hard decisions. When we have not been sure of which way to go, the concept has led the way, and we followed the path most true to the ideas of the concept.

For example, the backstage functions are placed in separate buildings, scattered like boulders from the quarry, and they achieve daylight from above, like in nature.

This project balances on the edge of materiality. It challenges the conception of architecture as being static and physical. The architectural qualities achieved is a mix of conventional architecture, with solid stone handled with care and lightness contrasted with a mist of poetry.

The acoustical concept is well integrated in the design and the acoustical and optical experience goes well hand in hand. Acoustically we achieved very satisfying results. Working with the well-known acoustical concept of the amphitheatre was a stabile contrast to the more innovative and experimental cloud mist.

The small nozzles creating the mist will emit a certain low frequent noise, which can be blocked by the speakers sending out noise blocking signals, resulting in a negative interference. In any case, this background noise might not be that prominent. The mist will contribute to a certain atmosphere, affecting the interpretation of the sound.

