

Illustrated section



The atmosphere of theater

THEATER

At the theatre scene lights and backdrops are used frequently changing the settings synchronized with the dramaturgy of the play. During a concert 7 000 spectators are expected, where natural acoustics are applied for the 5000 sitting in the front.

The acoustical demands of the theatre are a short reverberation time and a speech transmission index above 0.75, which is achieved by few reflective panels and a high ratio of absorbent cloud. The reverberation time is stabilized around 1 s with the help of Helmholtz resonators placed in the bleachers reducing frequencies below 1kHz.

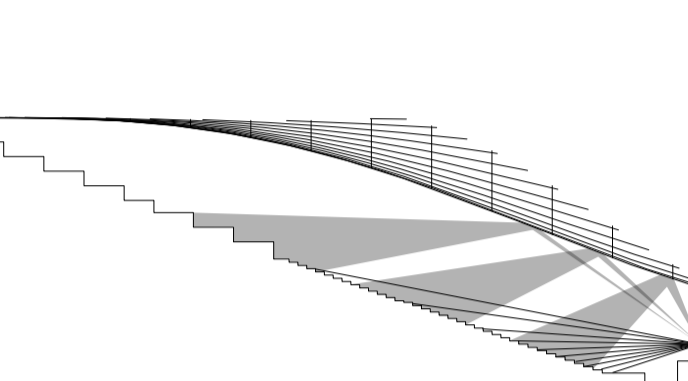
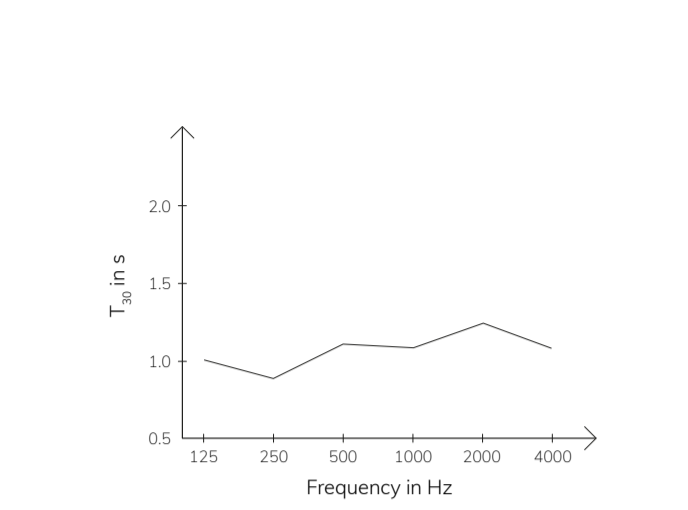


Diagram of direct and reflected sound



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 proposal has a humble approach to the existing nature. Inspired by the terracing of the quarries, bleachers have been formed, as a negative cut out, leaving the skyline of the nature untouched. Inside the venue intimacy is achieved by the high inclination of 20 degrees, which is providing a visual contact and satisfying acoustics 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 dizziness.

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 noise have been made and only by the distance and height of the massive stone wall the noise have been reduced with 26 dB. However, when the absorbent cloud and thickness 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 raised limestone blocks a sense of monumentality is achieved. The different functions are scattered, like boulders in an open landscape. The buildings are placed at a ground level matching the stage which eases 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 acoustic ceiling. By using transparent milkweed absorber inside a polycarbonate steel construction the rooms get light from above and an isolation 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.

CLOUD NINE

[noun] : A state of perfect happiness, an utopia of pleasure
Syn. : Heaven, rhapsody, euphoria, paradise etc.

Cloud nine is our proposal for the ASA student competition of 2020. The program inquire 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 this virtual cloud, hanging over the venue enhancing the atmosphere.

OPEN AIR VENUE

The open air venue is an limestone amphitheater 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 terrace for seating while larger platforms in the rear gives room for a standing 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.

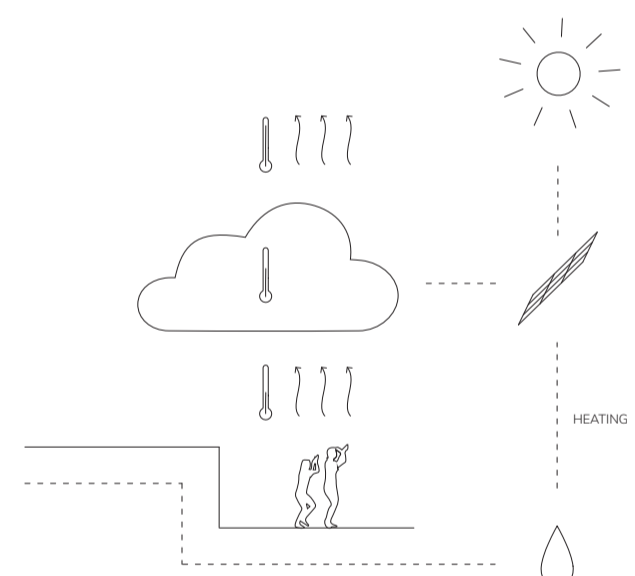
CLOUD PHENOMENA / TECHNICALITIES

A) 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. When the air inside the venue gets heated by the audience an upward flow of air prevents the cloud from descending.

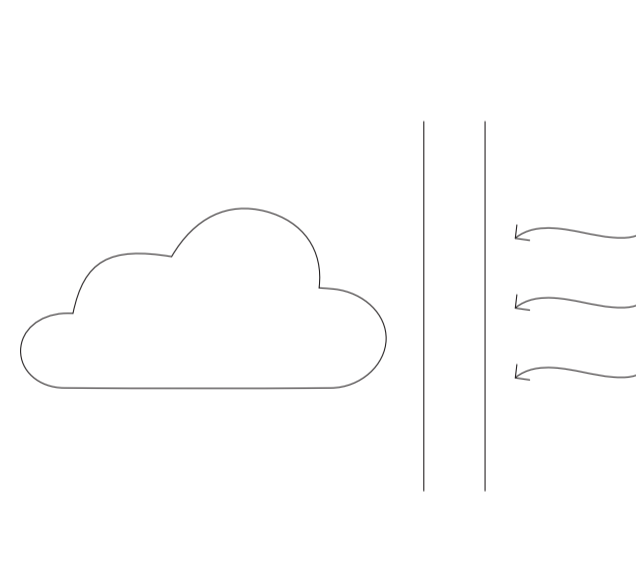
B) The stone quarry is sheltered from strong winds by a massive stone wall surrounding the venue. This keeps the cloud in its position horizontally. However, the top of the cloud is free and will spread over the site.

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 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. 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.

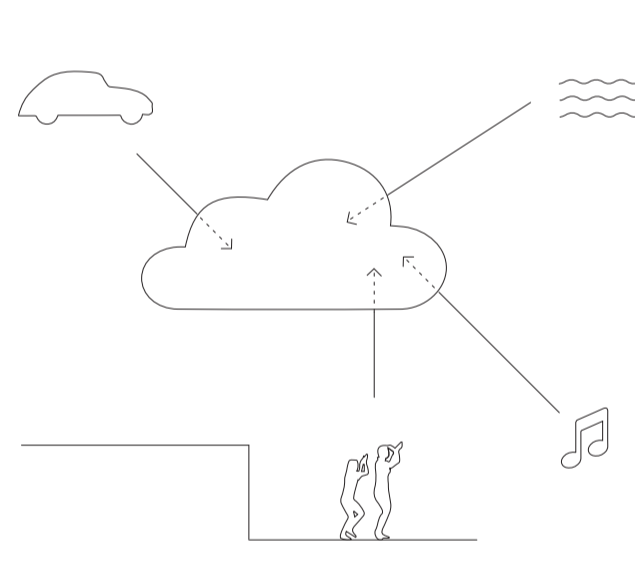
D) The massive stone wall surrounding the venue and cloud also acts as a noise barrier. With a thickness of 4.2 m all frequencies are blocked going through the wall. Rays passing over the wall are reduced by the cloud.



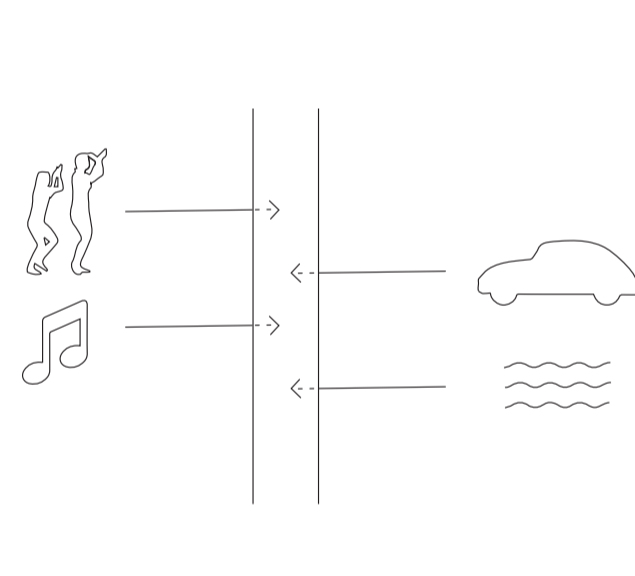
A) Diagram of vertically fixing the cloud



B) Diagram of horizontally fixing the cloud



C) Diagram of the cloud as a noise barrier



D) Diagram of the stone wall as a noise barrier



The atmosphere of rock

ROCK / JAZZ

At Rock and jazz concerts the epic atmosphere is a big part of the show. Highly saturated lights, smoke and beats combined is the key to cloud nine. 25 000 people are expected in the audience and electro acoustical support is required.

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

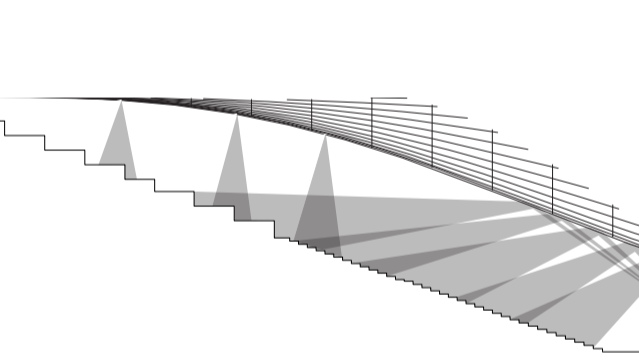
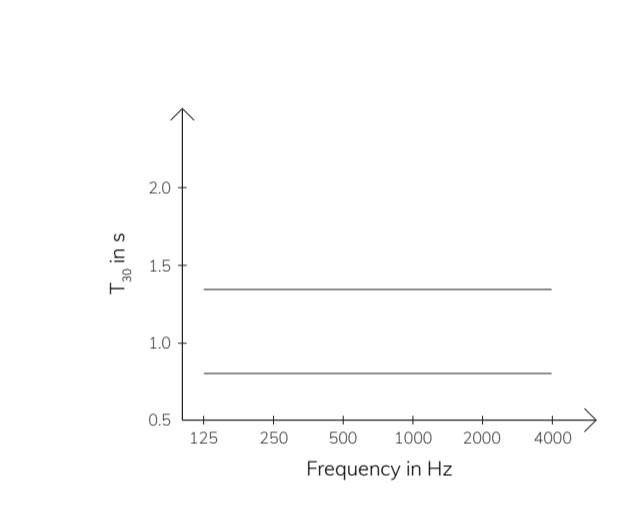
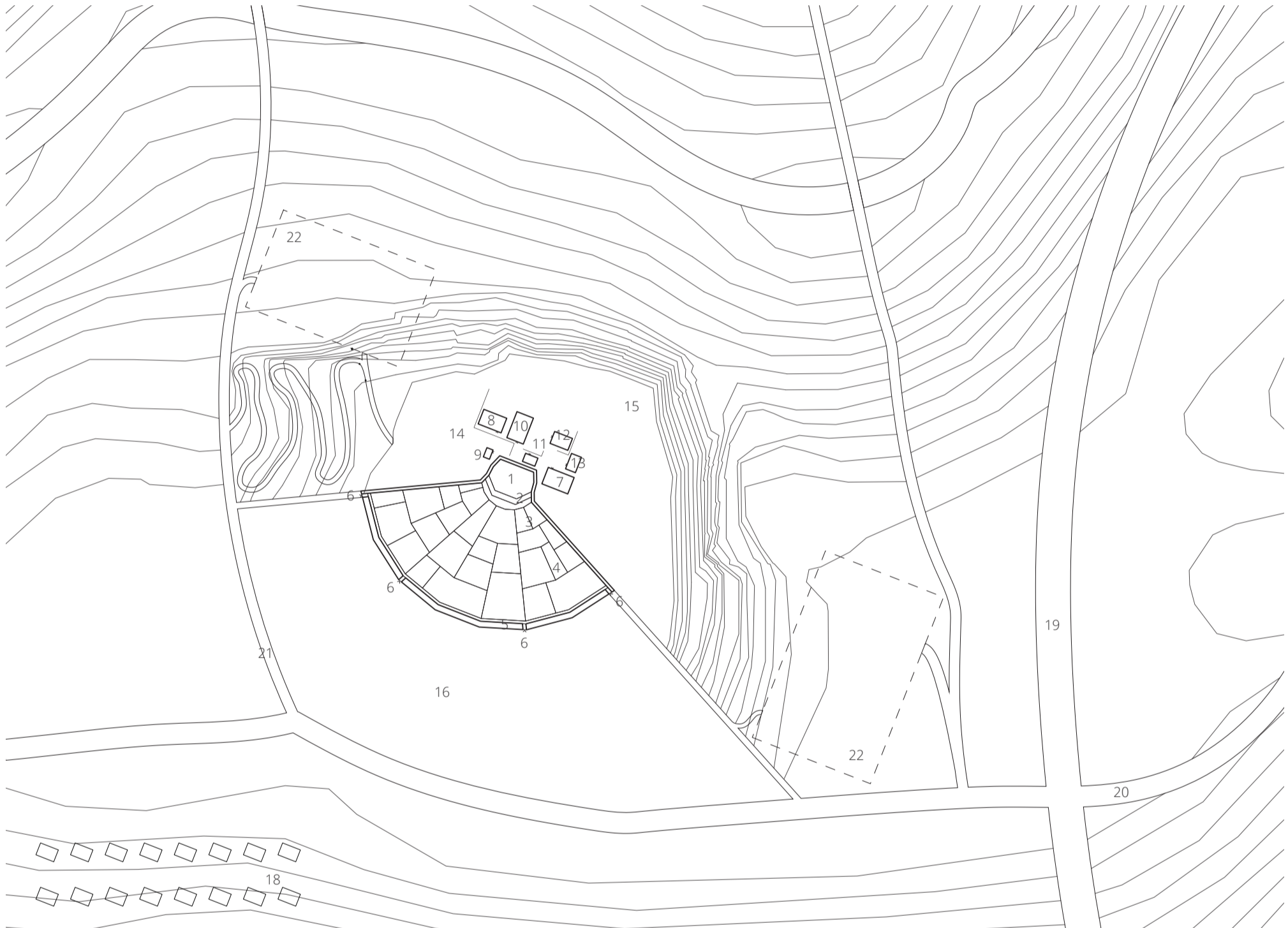
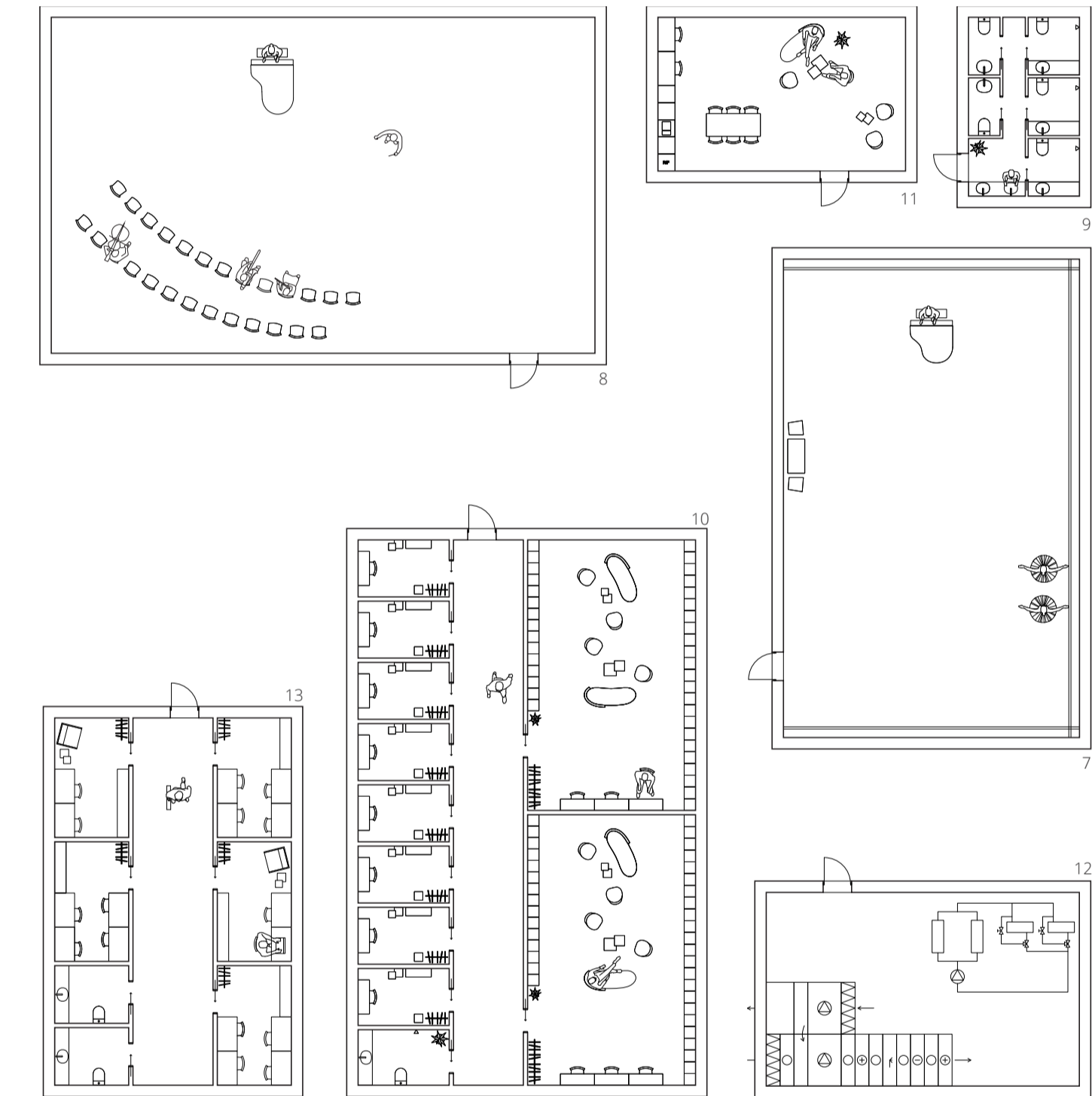


Diagram of direct and reflected sound

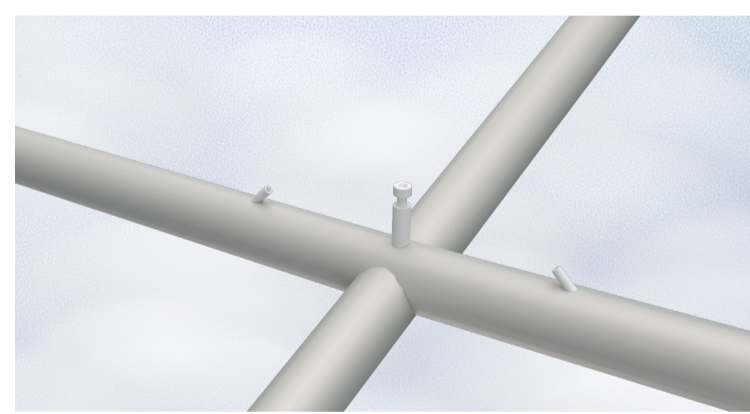


FUNCTIONS

- 1 Stage
- 2 Orchestra pit
- 3 Seating area
- 4 Standing area
- 5 Bar
- 6 Entrances / Ticket booth
- 7 Music rehearsal room
- 8 Movement rehearsal room
- 9 Toilets
- 10 Chorus and solo dressing rooms
- 11 Green room
- 12 Mechanical Equipment Room
- 13 Offices
- 14 Water reservoir
- 15 Limestone quarry
- 16 Welcoming area
- 17 Residential area
- 18 River
- 19 Interstate highway
- 20 State highway
- 21 Road
- 22 Parking



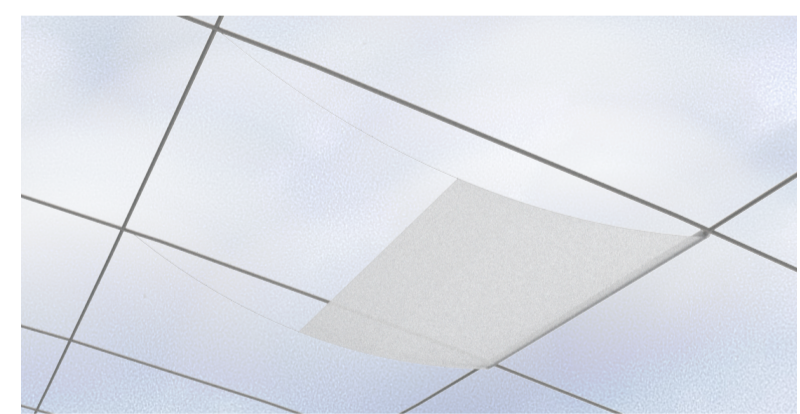
Plan 1:200



Noise barrier

- Attenuate noise energy from traffic

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

- Adapt RT to different performances

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 1-2.2, suitable for all different performances.

Since the venue naturally has a higher reverberation time for the lower frequencies, the panels are designed to mainly 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.

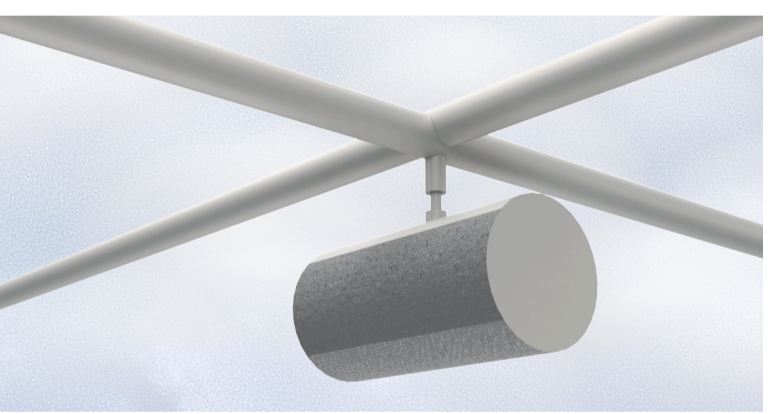


Optical effects

- Atmosphere

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. Imagine listening to a symphonic orchestra while sitting under a starry night sky or enjoying a theatre through sprinkle light shining from above. On cloud nine it is possible to customize the ambience completely for every event imaginable and is delayed with optional reverberation time.

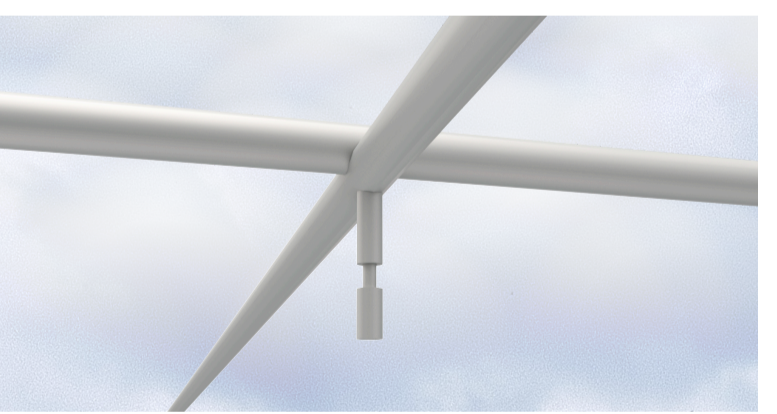


Soundcloud

- Increase strength RT

A number of 70 cylindrical sound reinforcement speakers are evenly distributed in the grid to support the low 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. The direct sound comes from the surface directed towards the audience and is timed based on the distance from the stage. Reflected sound comes from the downward facing surface and is delayed with optional reverberation time.



Connections

- Mount temporary equipment

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.



The atmosphere of Symphony Orchestra

SYMPHONY ORCHESTRA

A Symphony Orchestra creates magic and under a starry night sky the natural acoustics of the venue will shine. During an orchestra concert 10 000 spectators are expected, where natural acoustics are applied for the 5000 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 -4 to +1, which is achieved naturally. However, for the rear audience, electroacoustics will support the strength.

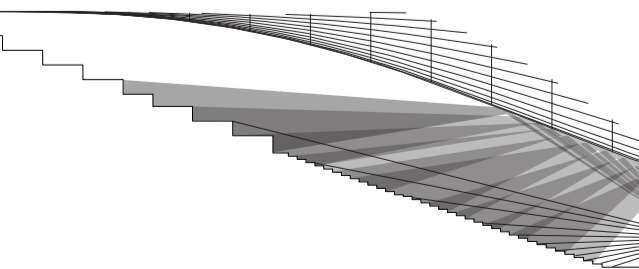
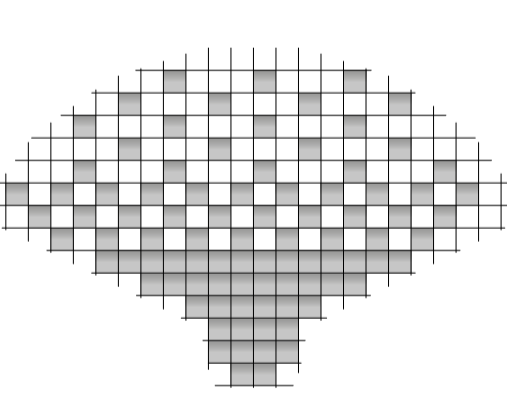
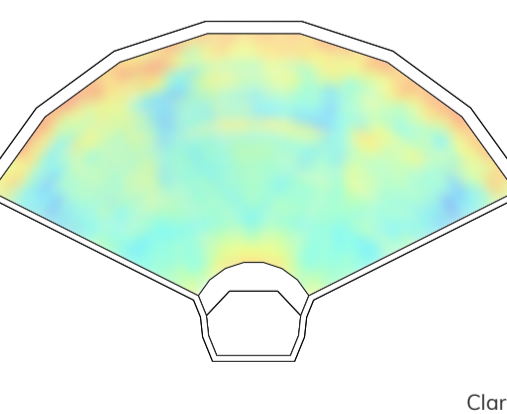


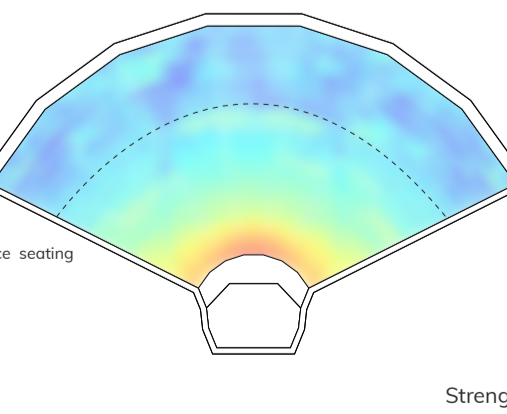
Diagram of direct and reflected sound



Distribution of selective reflective panels



Clarity



Strength

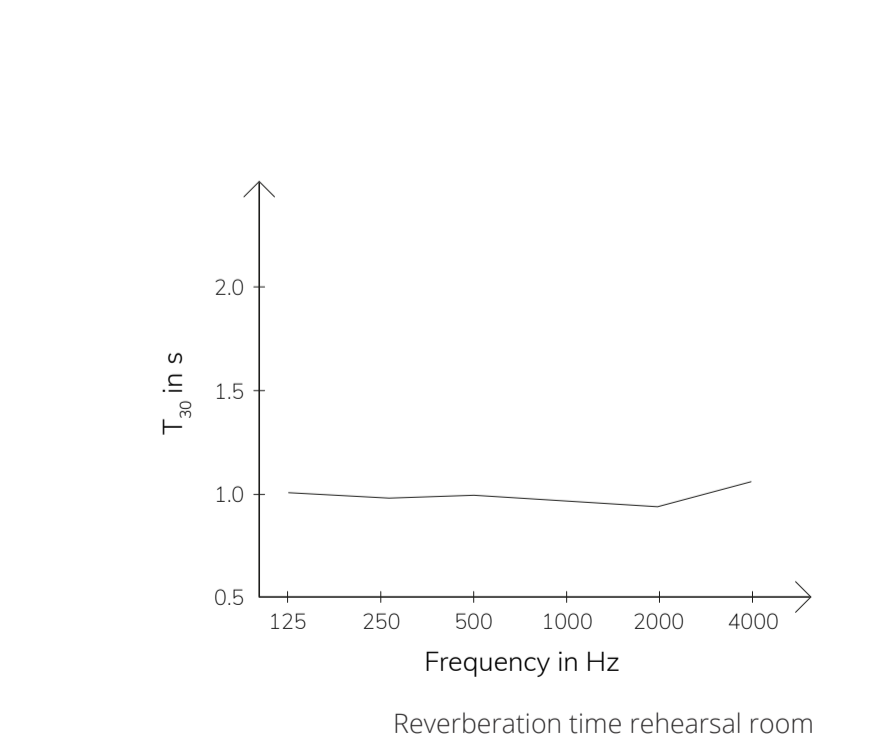


Perspective rehearsal room orchestra

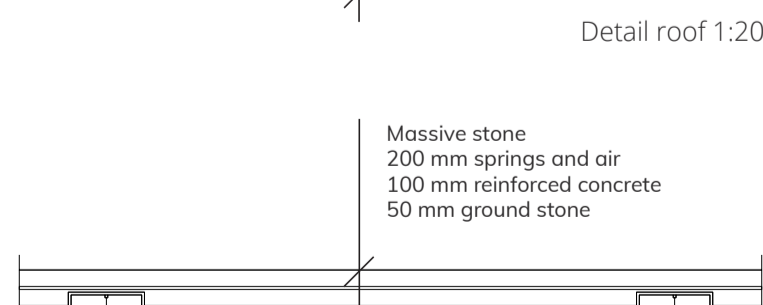
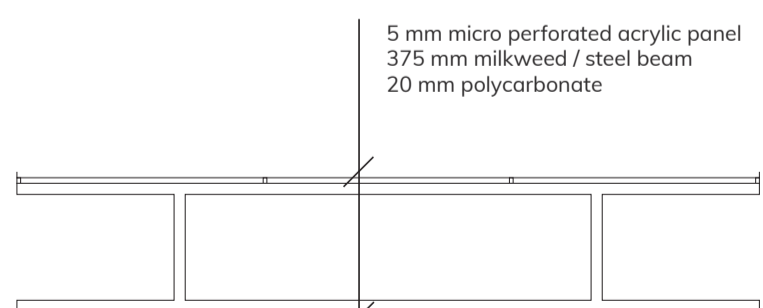
REHEARSAL

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 cloud the sky is symbolized 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 milkweed which is a natural fibre.

The walls are covered by rough finished limestone with diffusive reflective properties and the stone 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, chorus and opera.



Reverberation time rehearsal room



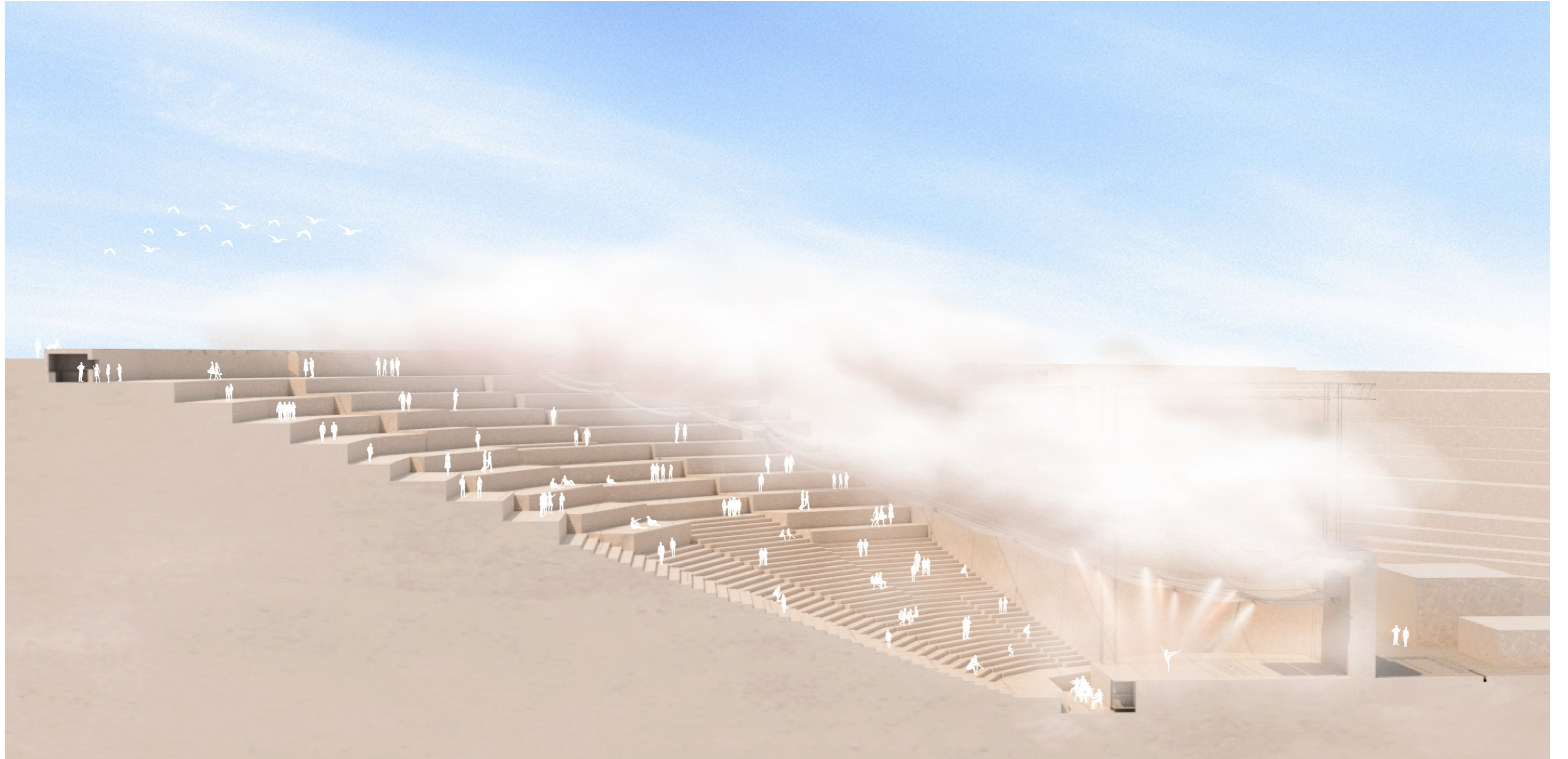
Detail floor 1:20

Course
Bachelor thesis

Examiner
Morten Lund

Group of 2

Project name
Cloud 9



Cloud 9

[noun] : A state of perfect happiness, a utopia of pleasure
Syn. : Heaven, rhapsody, euphoria, paradise etc.

The open air venue

The proposal embraces the open air part of the program by presenting a virtual cloud instead of a more traditional roof. Our state of mind is very much affected by our environment, colours, lighting, space and materials all have an impact. Being outside is not an exception, on a sunny day or during a thunderstorm you get two rather different experiences.

This project aim to create a unique atmosphere for every event imaginable. The virtual cloud offers a controllable environment combining a synthetic cloud with light effects and integrated acoustics. Regardless of what type of performance, if you are in the audience you will be on Cloud 9.

The site

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

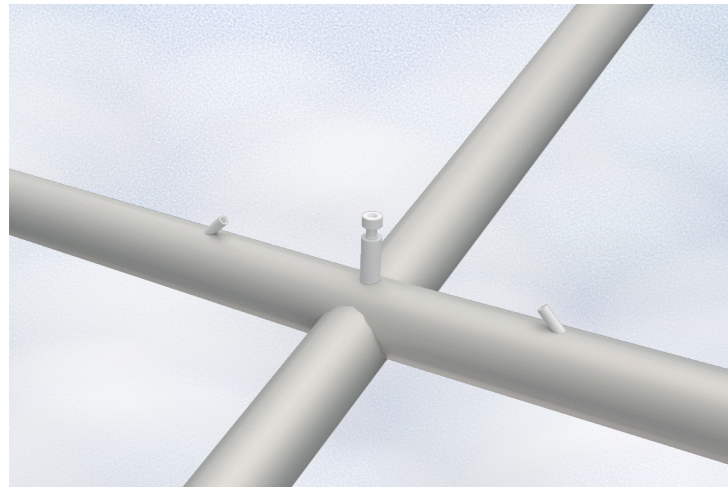
The site chosen for this project is a slightly sloping limestone quarry with a big turquoise river. The project has a humble approach to the existing nature by utilizing the water and enhancing the aesthetics of the quarry by forming irregular bleachers as negative cut-outs.

For this large venue with a maximum of 25 000 people in the audience, intimacy is achieved by the high inclination of 20 degrees. Bleachers these steep provide visual contact to the stage and satisfying acoustics from all levels.

Austin summers are hot and humid, which has been considered in the orientation with a stage pointing north. This way shadow is provided and dazzles are prevented.

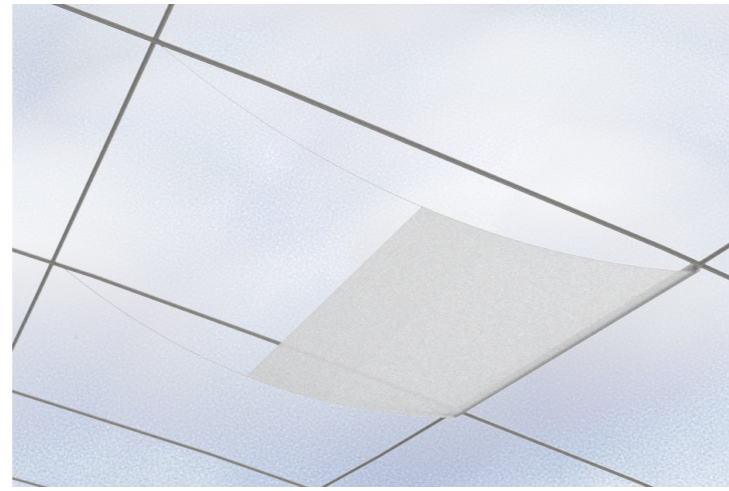


site plan 1: 4000



Noise barrier
 – Attenuate noise energy

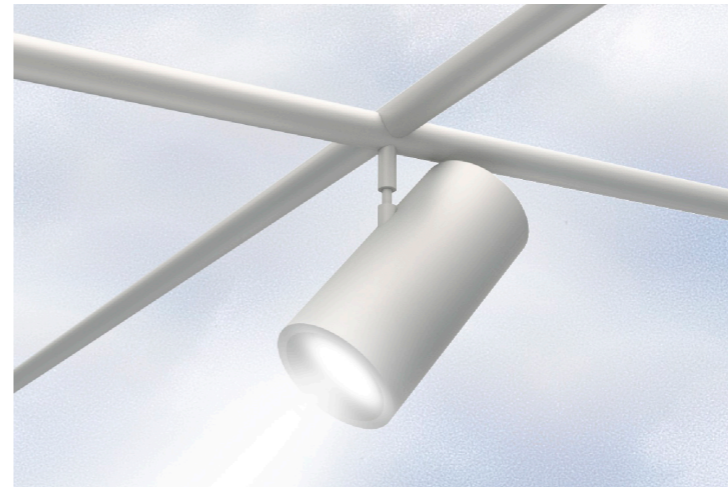
The cloud is synthesized combining water vapor and smoke. Water is pumped with high pressure through pipes and nozzles creating a fine mist. The smoke nozzles are angled differently for the smoke particles to collide with the water droplets resulting in a dense fog.



Reflective panels
 – Adapt reverberation time

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 1-2.2, suitable for all different performances.

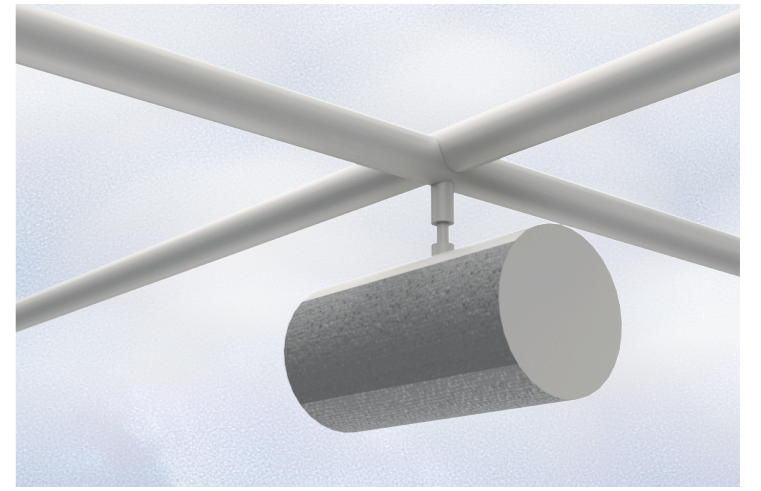
Since the venue naturally has a higher reverberation time for the lower frequencies, the panels are designed to mainly reflect sound of the higher frequency range (1 - 4 kHz) and absorb lower frequencies.



Optical effects
 – Control the ambience

Combining a performance with light effects enhances the feeling and experience of a concert or a show. Since they require mist or smoke to be visible the venue provides optimal conditions for this purpose.

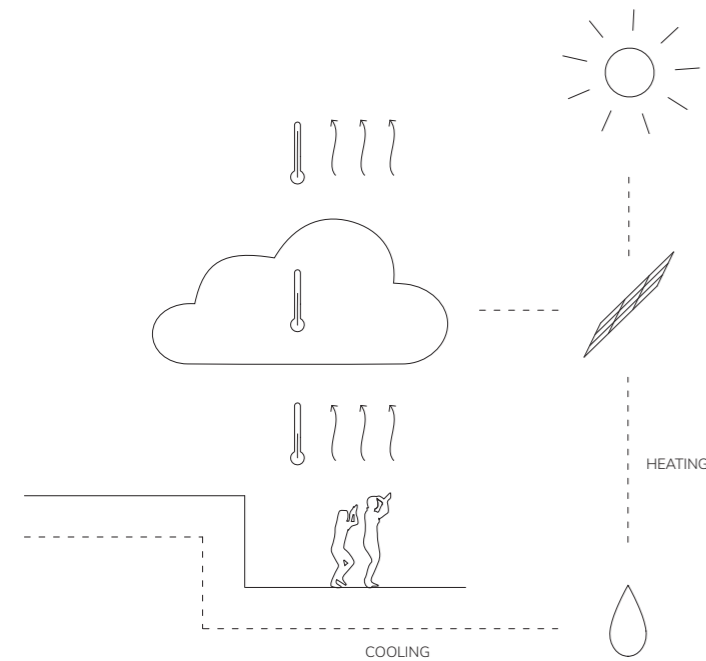
Spotlights are frequently distributed in the grid for variable ambiances. Imagine listening to a symphonic orchestra while sitting under a starry night sky or enjoying a theatre through sprinkle light shining through the clouds. On Cloud 9 it is possible to customize the ambience completely for every event imaginable



Soundcloud
 – Increase strength and reverberation time

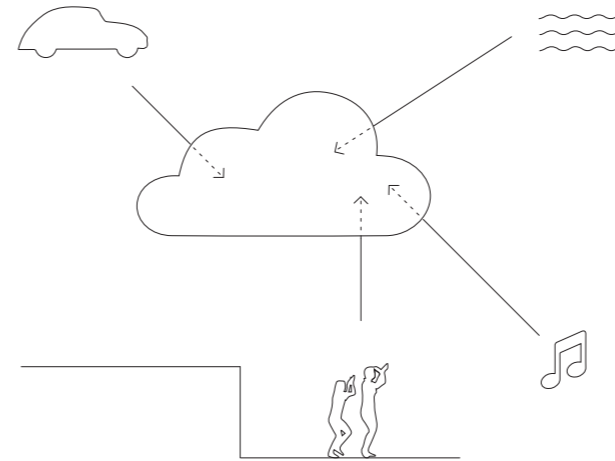
Cylindrical sound reinforcement speakers are evenly distributed in the grid to support the lawn area. A high number of speakers enable lower sound pressure levels and prevent local variations in the overall sound climate.

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



Cloud phenomenon

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. When the air inside the venue gets heated by the audience an upward flow of air prevents the cloud from descending.



Cloud as a noise barrier

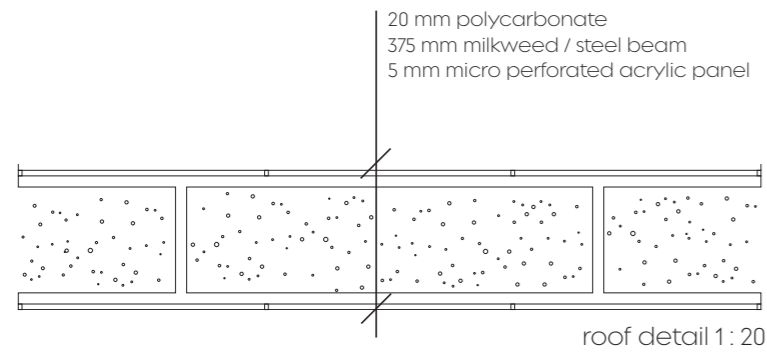
The phenomenon of sound attenuation in fog is the main reason to introduce a cloud to the venue. This method of blocking noise is utilized by Nasa during rocket launches and is now applied to Cloud Nine. The synthetic cloud functions as an effective noise barrier between the venue and the surrounding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

Backstage

In the backstage area there are facilities for musicians as well as site workers. The backstage area functions as a front face for performers and staff and gives them their first impression of the venue. By working with high raised limestone blocks a sense of monumentality is achieved.

The different functions are scattered, like boulders in an open landscape. The buildings are placed at a ground level matching the stage which eases 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 acoustical and skylike ceiling.

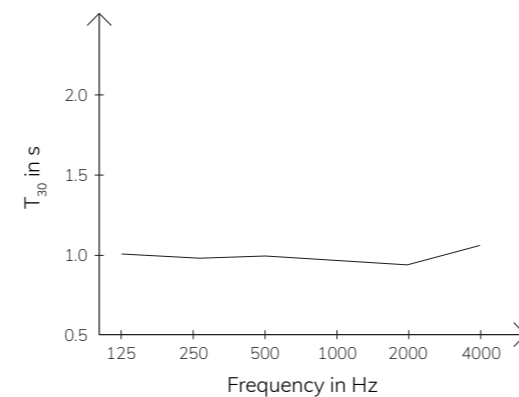
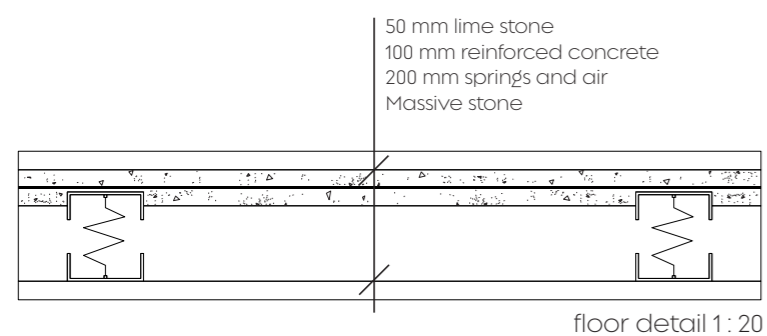


Perspective backstage

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 cloud the sky here is symbolized 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 milkweed which is a natural fibre.

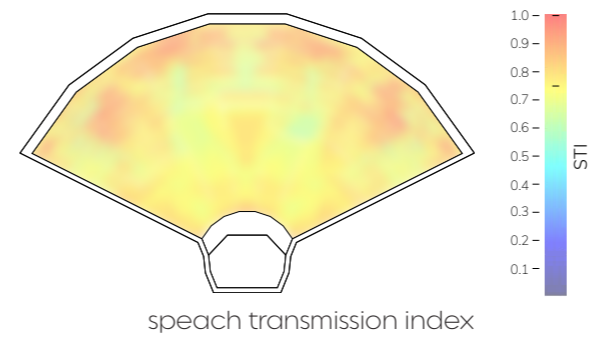
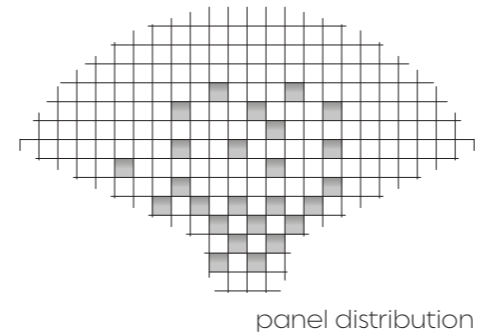
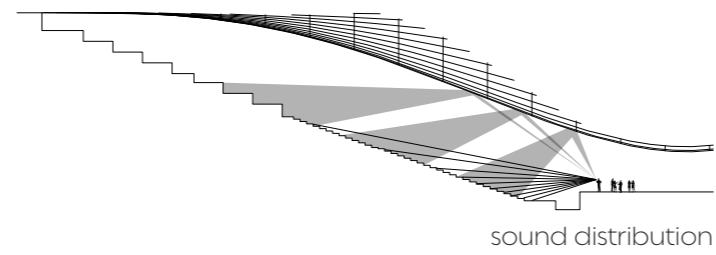
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Perspective rehearsal room orchestra ³⁹



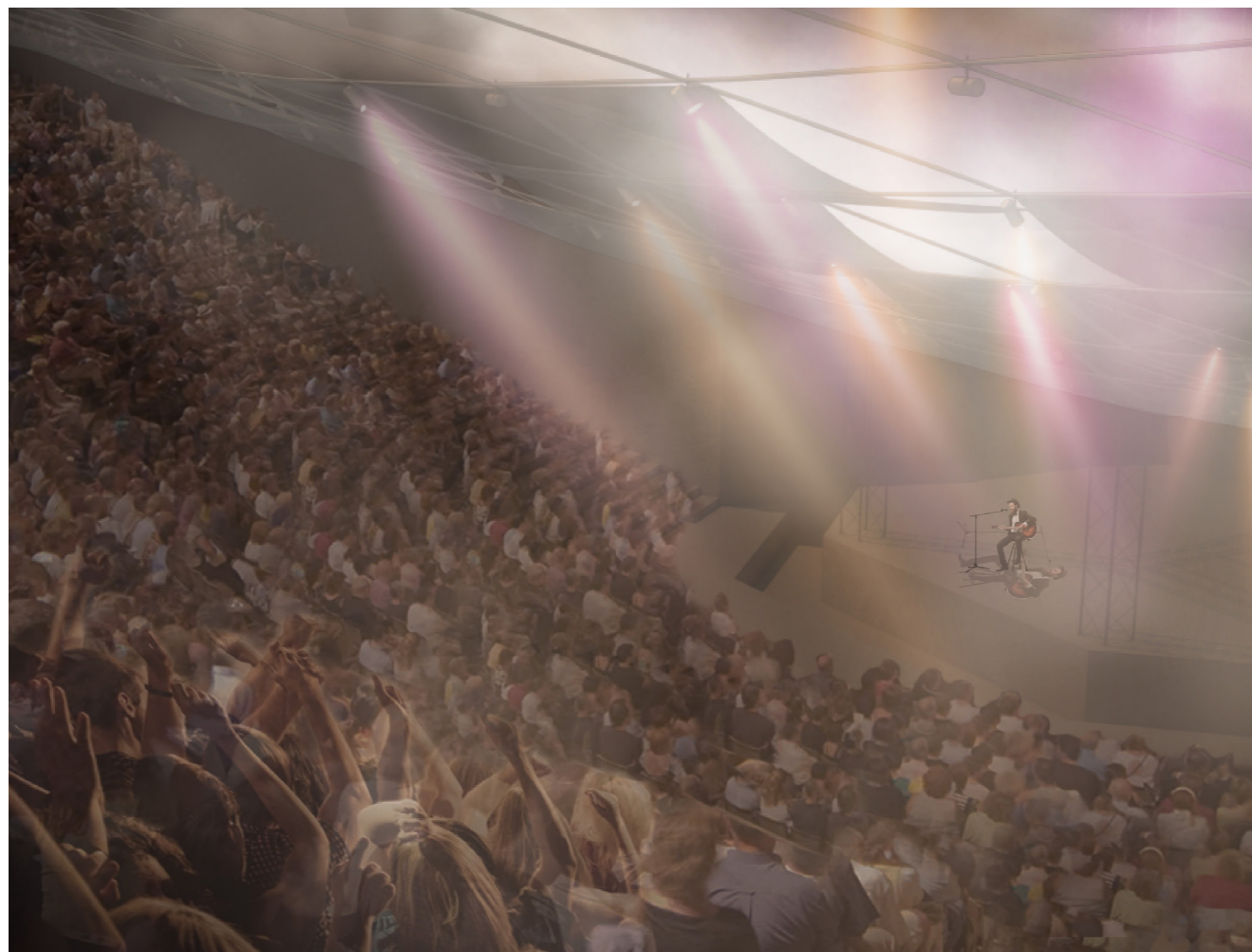
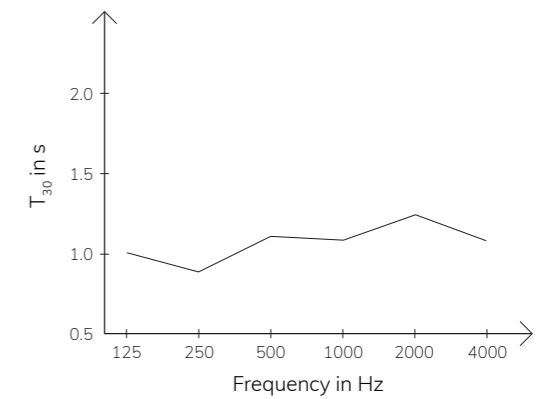
The atmosphere of theater



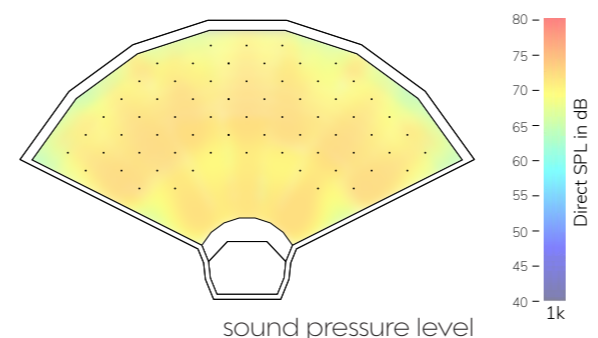
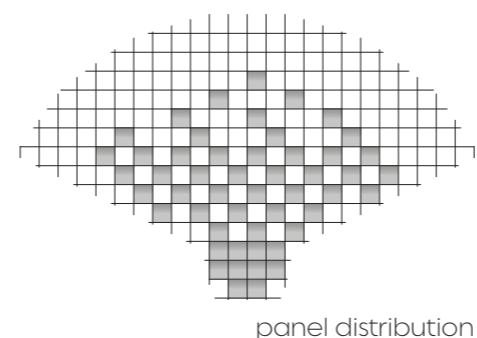
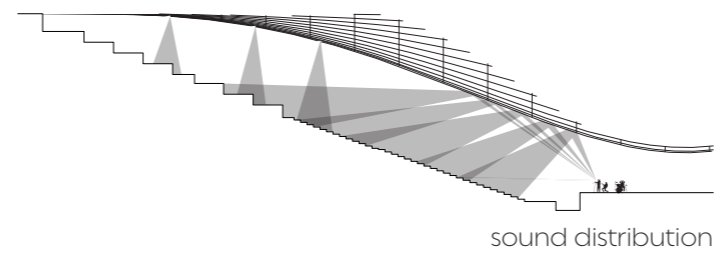
Theatre

At the theatre scene, lights and backdrops are used frequently to change the settings, synchronized with the dramaturgy of the play. For a theatre evening 7 000 spectators are expected, with natural acoustics applied for the 5000 sitting in the front.

The acoustical demands of the theatre are short reverberation time and speech transmission index above 0.75. This is achieved by few reflective panels and a high ratio of sound absorbing cloud. The reverberation time is stabilized around 1 s with the help of Helmholtz resonators placed in the bleachers reducing frequencies below 1 kHz.



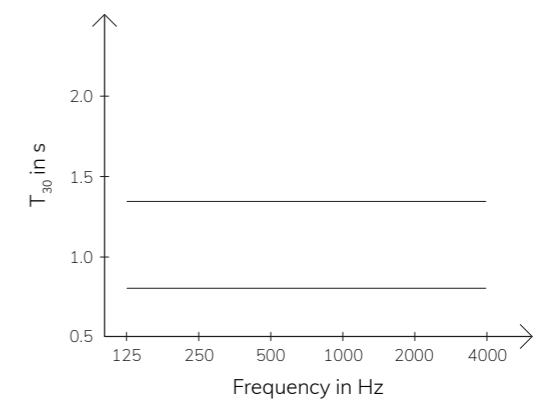
The atmosphere of rock



Rock / Jazz / Pop

At Rock concerts the epic atmosphere is a big part of the show. Here highly saturated lights, smoke and heavy bass beats combined is the key to Cloud 9. 25 000 people are expected in the audience and electro acoustics is required.

Sound reinforcement speakers are evenly distributed in the grid forming a soundcloud to support the standing audience. A high number of speakers enable lower sound pressure levels and prevent local variations in the overall sound climate. The speakers can be timed to achieve any reverberation time, this way the acoustics can be finely tuned.



Reflection

A crucial decision

I think that a turning point in the project was when we had found our concept, the cloud, and investigated different representations of it. We built sketch models representing different ways to “carry” the cloud, which we for quite a long time had imagined would consist of textile. To complete the collection I put some cotton wool on thin sticks, to communicate the weightlessness of a real cloud.

Suddenly we had a favourite, a favourite that we had not even considered before because it felt too unrealistic and imaginary.

Interdisciplinary collaboration

Me and Ellen were lucky to work with Karin, an ambitious and very cooperative acoustician master student. We all had some difficulties in the beginning, with file formats and digital models, but later on we could take the project further together.

The process got iterative, we wanted to optimize the placing and amount of acoustical reflectors so Karin looked into the ratio between cloud and reflective surfaces for different types of performances. That was our main focus but we also adjusted the shape of our stage in plan view, because Karin noticed that a lot of sound got “stuck” in the back corners.

I look forward to work in such a multidisciplinary industry, and I believe that this chance to try collaborating while still in school is a great experience to have when entering an employment, independently of which profession you end up with.

Methodology

Early on, from when we decided to go with a realistic, steamy cloud and not an abstraction, our work depended a lot on research. We read countless scientific articles about sound attenuation in fog, cloud synthesis and we searched for all reference projects related to this subject we could find. In this sense the project got very based on facts, which may be hard to believe since the whole concept is pretty “out there”. With a concept that brave, we worked really hard to make our proposal trustworthy.

In the design process, when we considered certain aspects, for example the positioning of the backstage buildings, we often worked with multiple and parallel ideas. After the investigation we examined what option we wanted to go with and why. This way we both felt conscious and safe with our design choices, they were always compared with alternative ideas.

Architectural and acoustical quality

The design of the music venue is very holistic, I believe, in the sense that we thought of every aspect of a concert experience. We designed the sound reinforcement system in detail with mounting spots and even the speakers themselves. We thought a lot of concert lighting and the overall vibe of Cloud 9.

I feel very happy that we achieved a very equal experience for everyone in the audience. The cloud and the grid provides high quality experiences to everyone, with the only difference that acoustical reflectors are placed more densely over the seated audience and sound reinforcement speakers over the standing audience. The steep slope of the amphitheatre enables visual contact from all levels.

I believe that we created something new, innovative and magical with our Cloud 9. A one of a kind experience you cannot get anywhere else.

