

# Magnolia Opera House - Conceptual throughlines from Nature in Parametric Design



## The Aim

The Magnolia Opera was a project centered around applying acoustical knowledge and architectural design together in a cohesive project. Its aim was an opera house meant for the use of a college with a very strong music and vocal program that now needed a performance hall primarily for opera. The seating hall was to have around 1200 chairs, among which at least 40% as balcony seating and although the main purpose was opera

the hall should also be able to host speaking engagements. With this came a big emphasis on variable acoustics and working with a building meant for people in learning. To aid in the challenge there was also established that ventilation and other heavy and noisy equipment would be housed in a room that was in contact with the main hall and the rehearsal space meant for the venue.

## The Core

In this project we decided to work with a big centerpiece that also worked as an acoustical element and also laid focus on a strict geometry for the outer shell, which both presented opportunities for different strategies. The shape of the flower was in the design process chosen as a pillar for both architecture, structure and

acoustics to rest upon. It became the core in the project and took the stage in grand gestures. We wanted the challenge to take a central concept from inside and out, starting in the budding center and working us outwards.

# Student Design Challenge

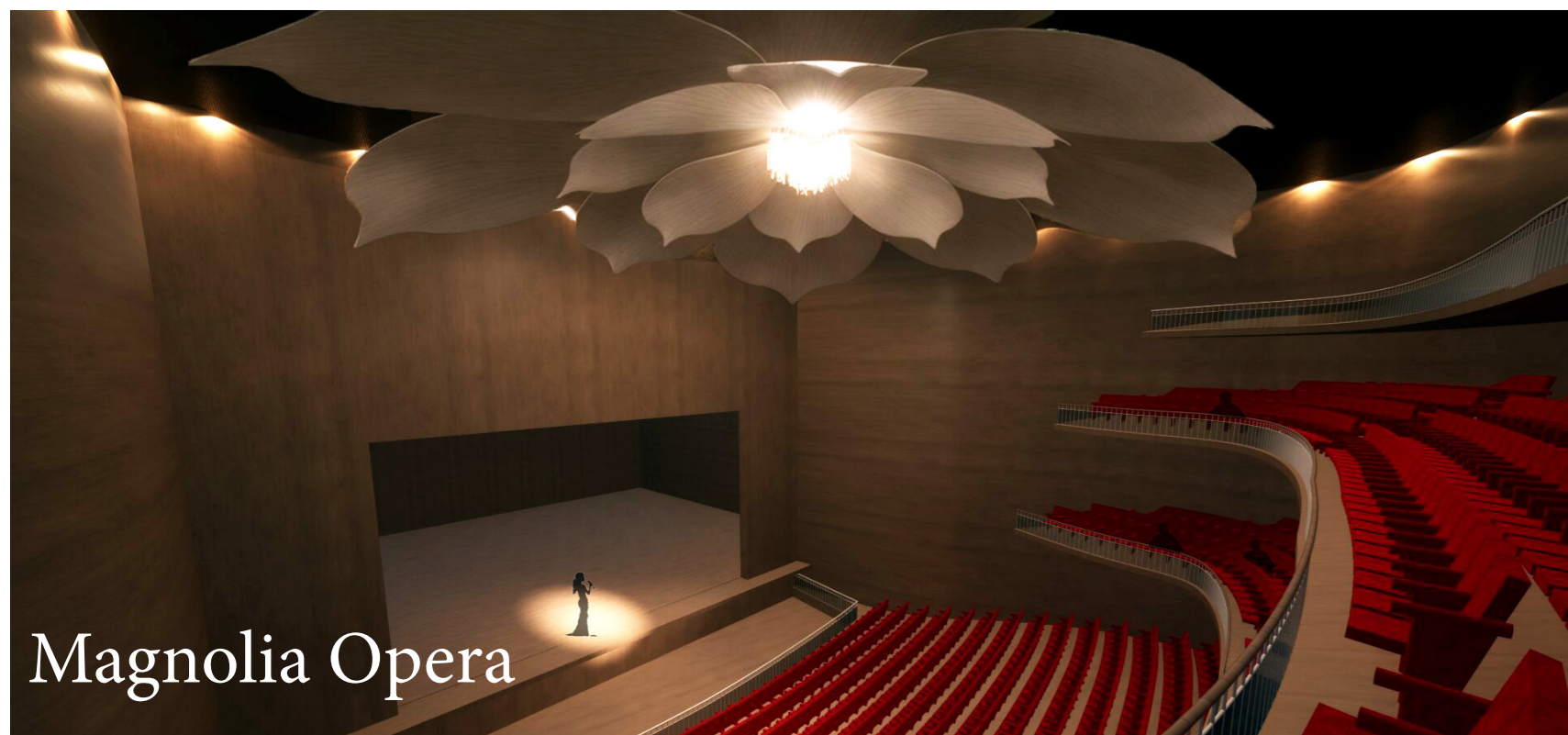
## Our Contribution



?

?

?



Magnolia Opera



Sound System

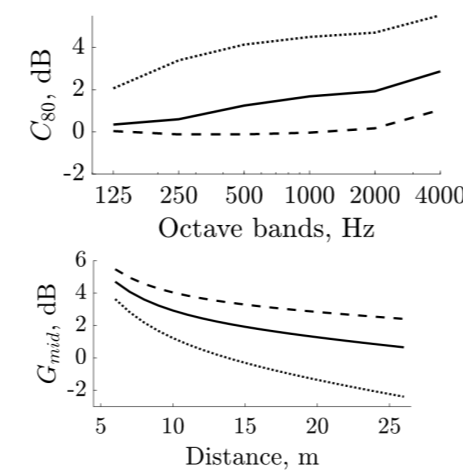
Main hall sound system has been designed using a combination of hanging line array loudspeakers and subwoofers along the upper part of the proscenium. Additional attachment points on walls and balconies for smaller point source loudspeakers enhance the possibilities for sound design,

creating a truly immersive experience where the listener is enveloped in sound not only from the stage and pit but also from the sides, behind and above.



### Main Hall Acoustics

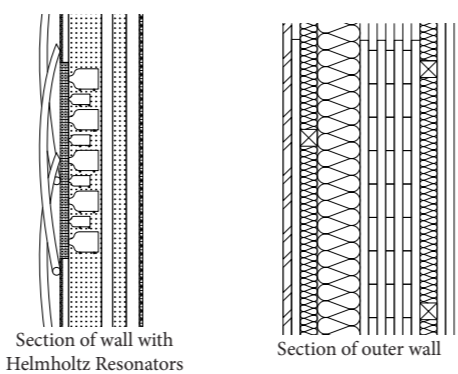
The main hall is designed to accommodate un-amplified or lightly amplified opera as its main purpose, while also being adaptable for speaking events and concerts with higher amplification levels. It's the beating heart of the opera house and its central placement highlights its importance. This placement also achieves valuable sound reduction from adjacent rooms acting as insulation.



Clarity and Gain in the Main Hall for different acoustical environments

Integrating absorbing elements to be functional parts of the interior creates versatile variable acoustical options using the flower in the roof and openable leaves placed along the walls. Distance from walls and sizes between individual leaves vary, having coarse wood surfaces mimicking the magnolia leaves' distinguished pattern to create diffusion in the hall while closed.

Opened they expose porous absorbers and Helmholtz resonators evenly dispersed behind to keep the absorption curve of the hall consistent independent of how many leaves are opened. Leaves placed at human height along the main audience floor are not openable, instead they are angled towards the stage to enhance early reflections and achieve ITDG = 22 ms at central point. In the orchestra pit acoustical fabric is stored in compartments attached to adapt their working environment.

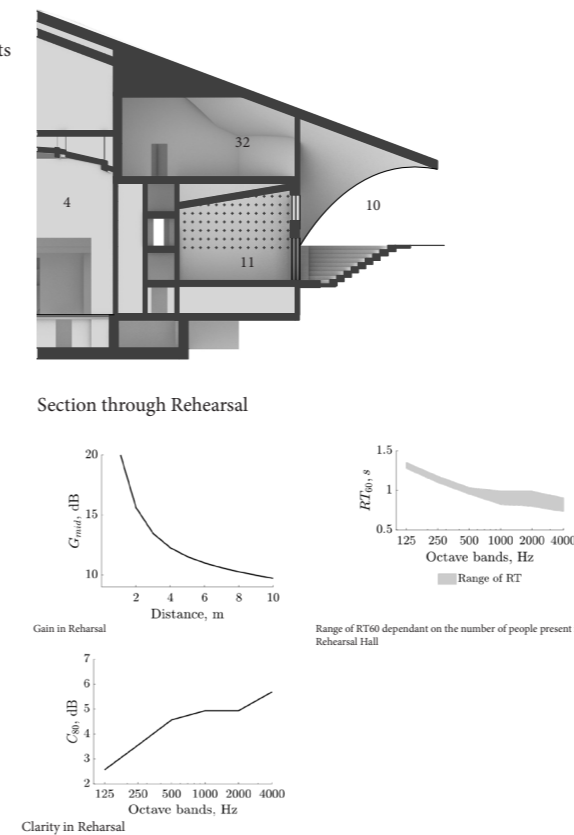


### Sound Insulation

The building's primary material is wood so extra attention has been put on sound insulation both from external and internal sources. This is done by presenting noise criterion demands per room but also through calculations and design of windows, floors, outside and inside walls with noise sources added to make sure neither main hall or rehearsal is disturbed. Both inside and outside walls have been designed as cross laminated timber (CLT) constructions. The inside wall is double leaf construction using two CLT layers which should be decoupled from each other. One is always 120 mm thick and the other leaf thickness varies to increase or decrease the critical frequency depending on sound source. Floors between the main hall and scene workshop needs to be decoupled. Floors in MEPFIT is specially designed using vibration isolators below the air handling units (AHU) in addition a double floor/roof construction to adjacent rehearsal space.

### Rehearsal Hall

The multipurpose rehearsal hall is located adjacent to the main hall. Its dual purpose is based on its second function as a stage opening to an outside amphitheater through an openable outside wall. Two walls are placed at an angle which gracefully gives the impression to visitors that it's a stage they are visiting with front towards the outside and opening wall. The rehearsal halls walls are primarily made of pine tree panels and the upper two thirds are covered in much thinner wood panels with large elliptical holes, just behind a pattern of porous and Helmholtz resonators are placed to increase absorption area.



Clarity in Rehearsal

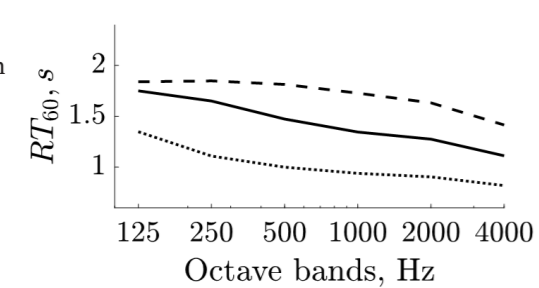
### Flower

There is a universal ritual between audience, cast and orchestra members just as a performance is about to start. The audience lightning dims down and the hall goes quiet in anticipation for what is about to start, it's tense and you can sense everyone getting ready. In this hall an extra step is added. The lightning dims down and the flower opens up, you can see and hear the petals moving, sense its impact on the acoustical landscape. Looking up you see the chandelier in the middle of the flower symbolizing the stamens and pistils illuminating the inside and staying lit just a moment longer than the audience lightning before the hall goes dark.

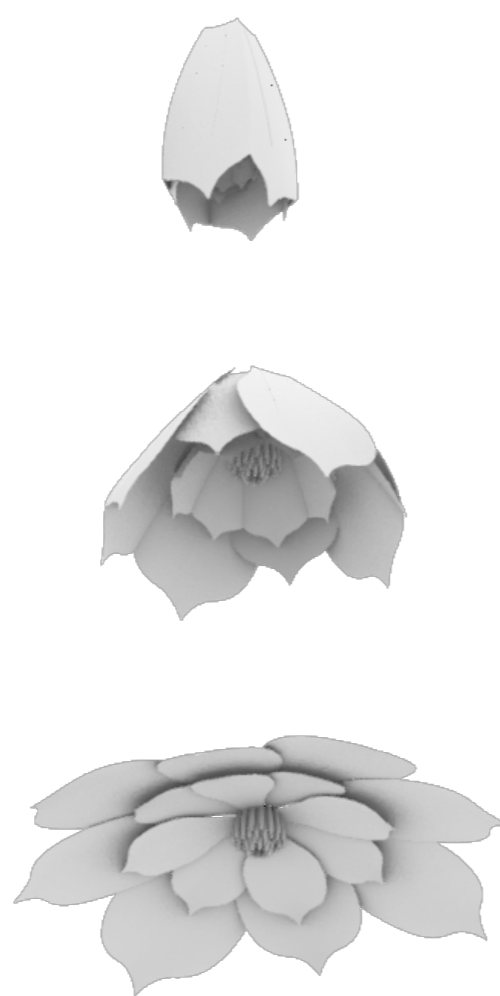
The flower is an art piece and an acoustical sculpture. An integral part of the design and expression and also necessary in order to achieve enough absorption area in the hall. As it unfolds it reduces reverberation time, its structure working in tandem with its function. Its individual petals consist of coarse wood sheet cladding on the outside, housing porous absorbers inside. It ascends through the roof and individual petals are suspended by ropes. A nod to history when scenery was moved with ropes, pulleys and muscle power.

### Concept

The Magnolia came as an idea to work with a natural phenomena that opens and closes, impacting the soundscape at the same time. Its central space in the creative process then made the building grow around it, enveloping it as the outer petals around the blossoming center. To aid this the opera is buried into the ground, not just to enable a lower highest point of the stage house but to also take help from the earth's sound insulating properties. The sweeping roof of the Magnolia then lands on level with a park around it and makes it sit like a perfectly fallen flower. The petals open up to shaded entrance areas that still let the evening sun in under its volume.



Reverberation time in Main Hall with flower folded, unfolded, or unfolded and open leaves



Sequence of flower unfolding

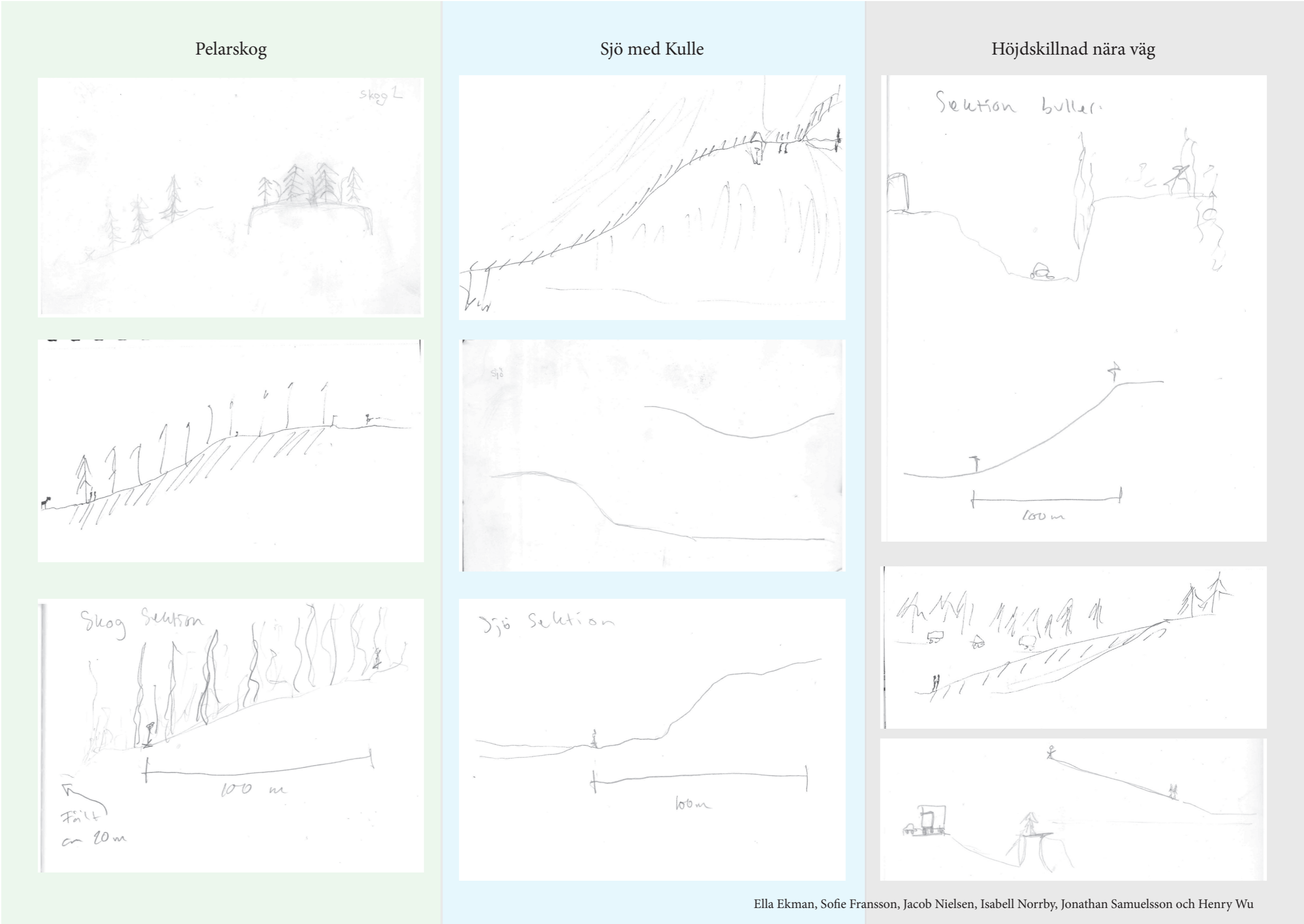
# Early Design Process

## Getting Inspired

The project started with scale, we went out with some friends to try and understand the scale of sound in different environments, how the landscape and shape of the surrounding shapes the audioscape, and in this we went to nature for answers. We then measured different kinds of speech at different sites and felt the sound. It was a pleasant experience that also enabled some more rigorous thinking when designing regarding distances and how sound works. It felt like it made the context between sound and space more clear and what restrictions a volume gives the sound.

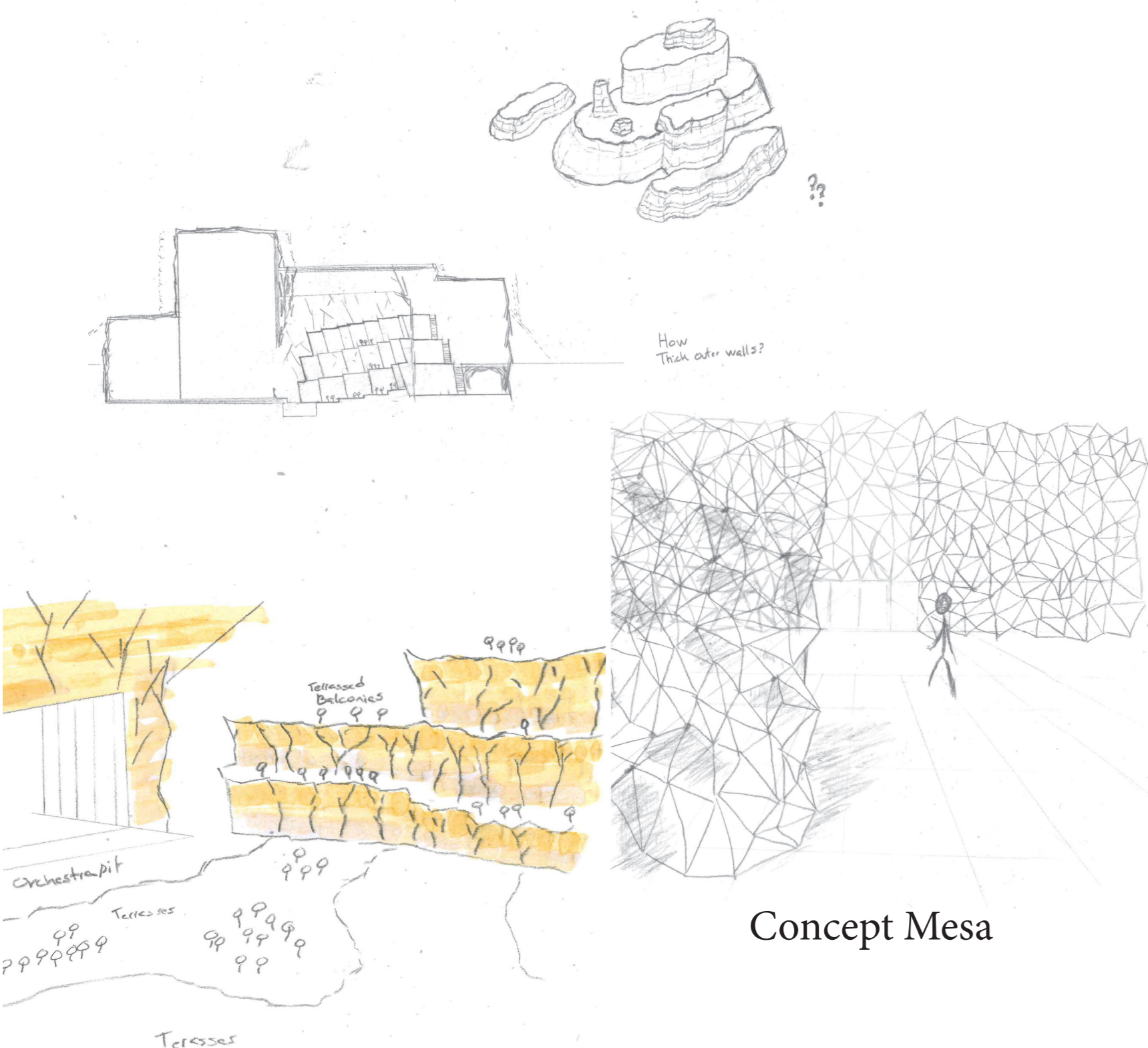
## Getting Inspired

With this knowledge we then went into the design process and looked for our core. We worked very closely with our acoustician in this project and discussed mostly 3 different possibilities that we might wanna work with; Snowflake, Mesa, and Flower. I feel like it was a good decision to work closely with different acoustical phenomena we encountered in the first stage of our iterative process and worked in quick sketches to get the broad strokes. Among these we discussed vividly and settled for the flower concept, working more heavily with variable acoustics and with the focus of making the changing of the soundscape also a great visible gesture. That which became the Magnolia Opera.

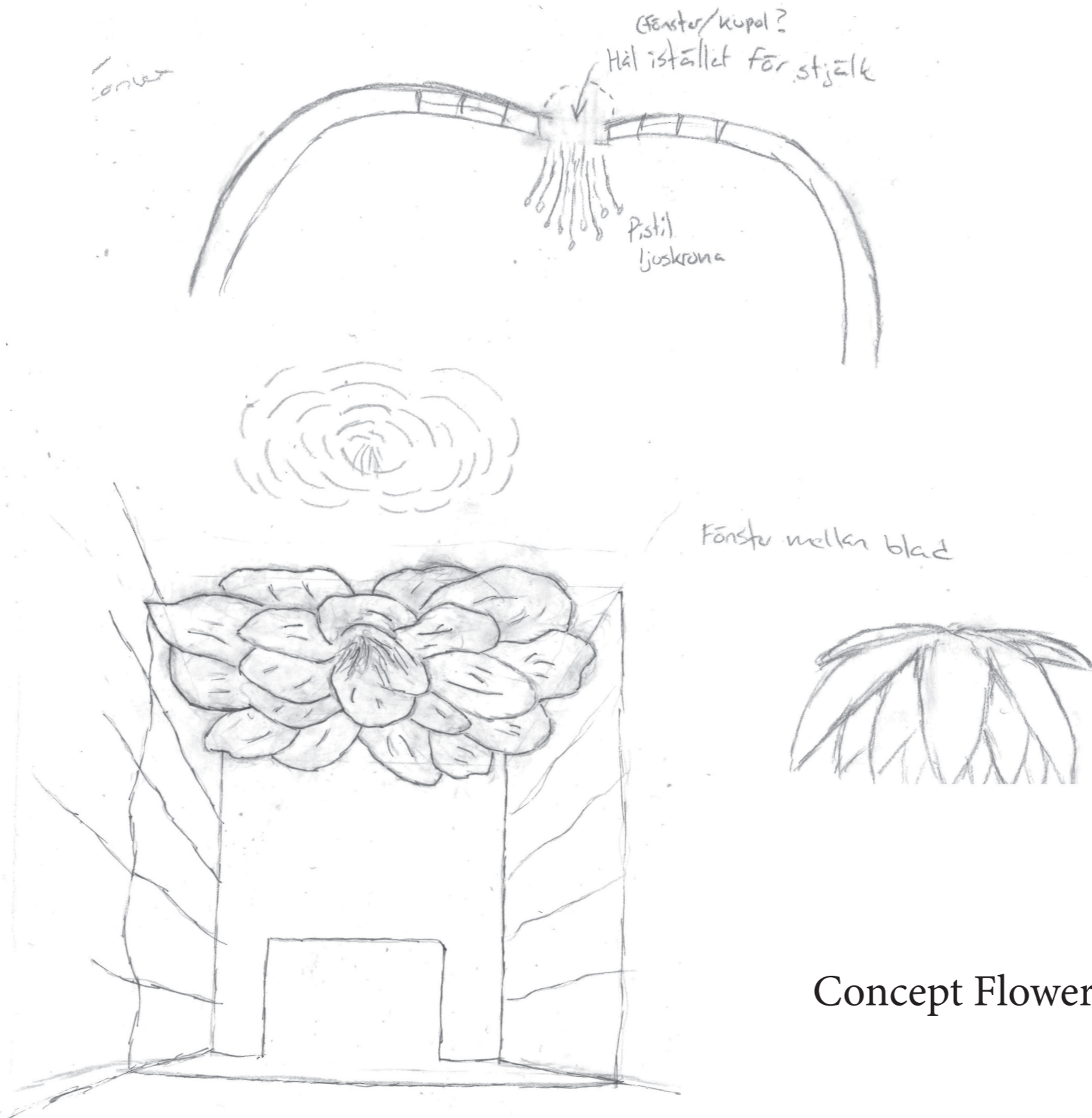


Ella Ekman, Sofie Fransson, Jacob Nielsen, Isabell Norrby, Jonathan Samuelsson och Henry Wu

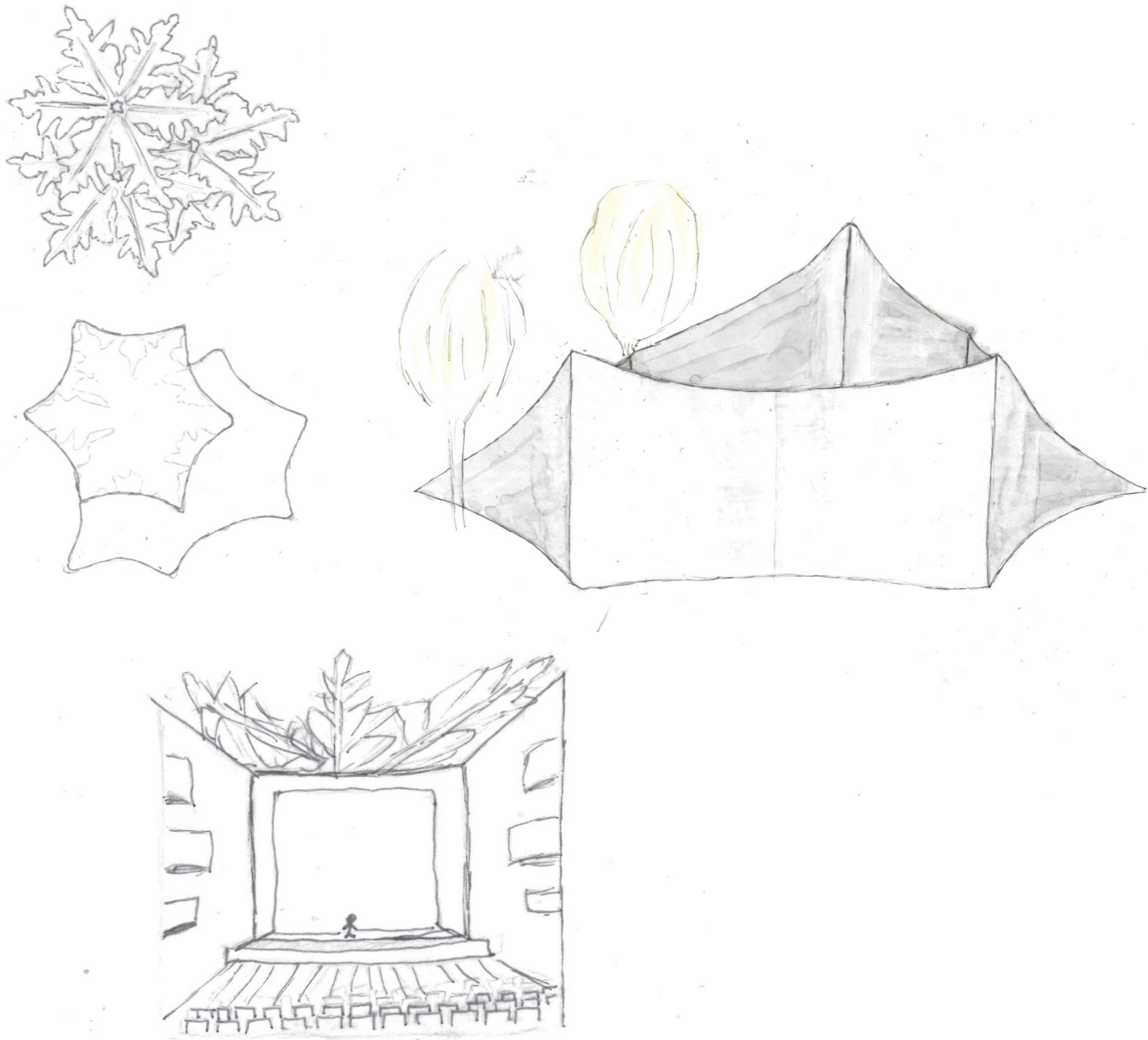
Sketches from some of the places we visited and their sectional layout



Concept Mesa



Concept Flower



Concept Snowflake

# Working With the Flower

## Physical Modelling

With this, the flower now made our centerpiece, we worked with the different acoustical prototypes to make something more real of our budding thoughts. In physical models we tried to get “The great gesture”, that was a part of the design from the start, the central flower over the seating hall opening and folding. It was something that helped greatly to understand the limitations and the possibilities of the real world. The folding that we made a model of became not something that could maybe reasonably be replicated on a bigger scale but really sold us on it as the central WOW-factor and we thus worked more with it to make it possible another way.

We also in this stage designed prototypes for other elements.. Wall paneling inspired by leaves to make a more diffusing area and enable hiding of other acoustical elements behind, and something that became more of a visual phenomena under more scrutiny. Petal vines was not viable as diffusing sound, they did not do enough in that aspect but they did enable the lobby to feel a lot different.

## Early Design in 3D software

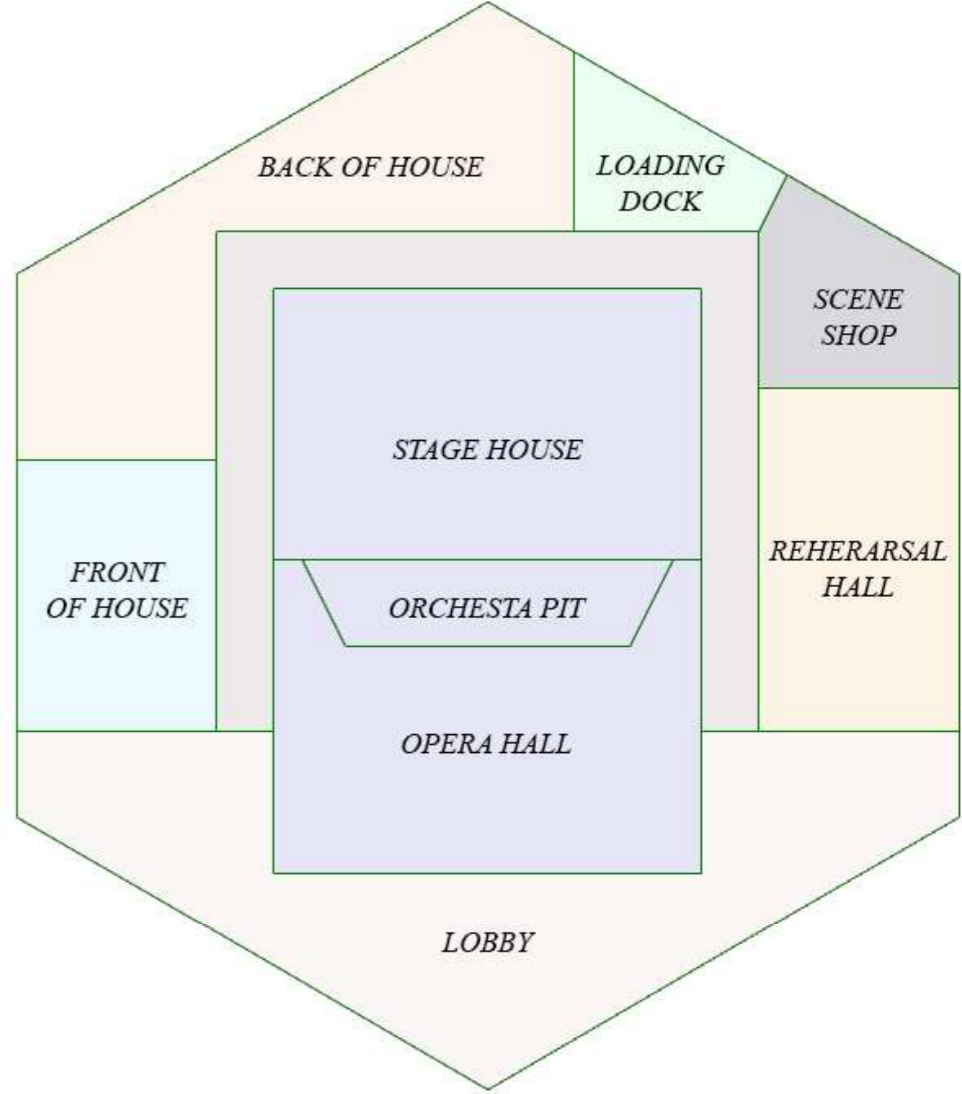
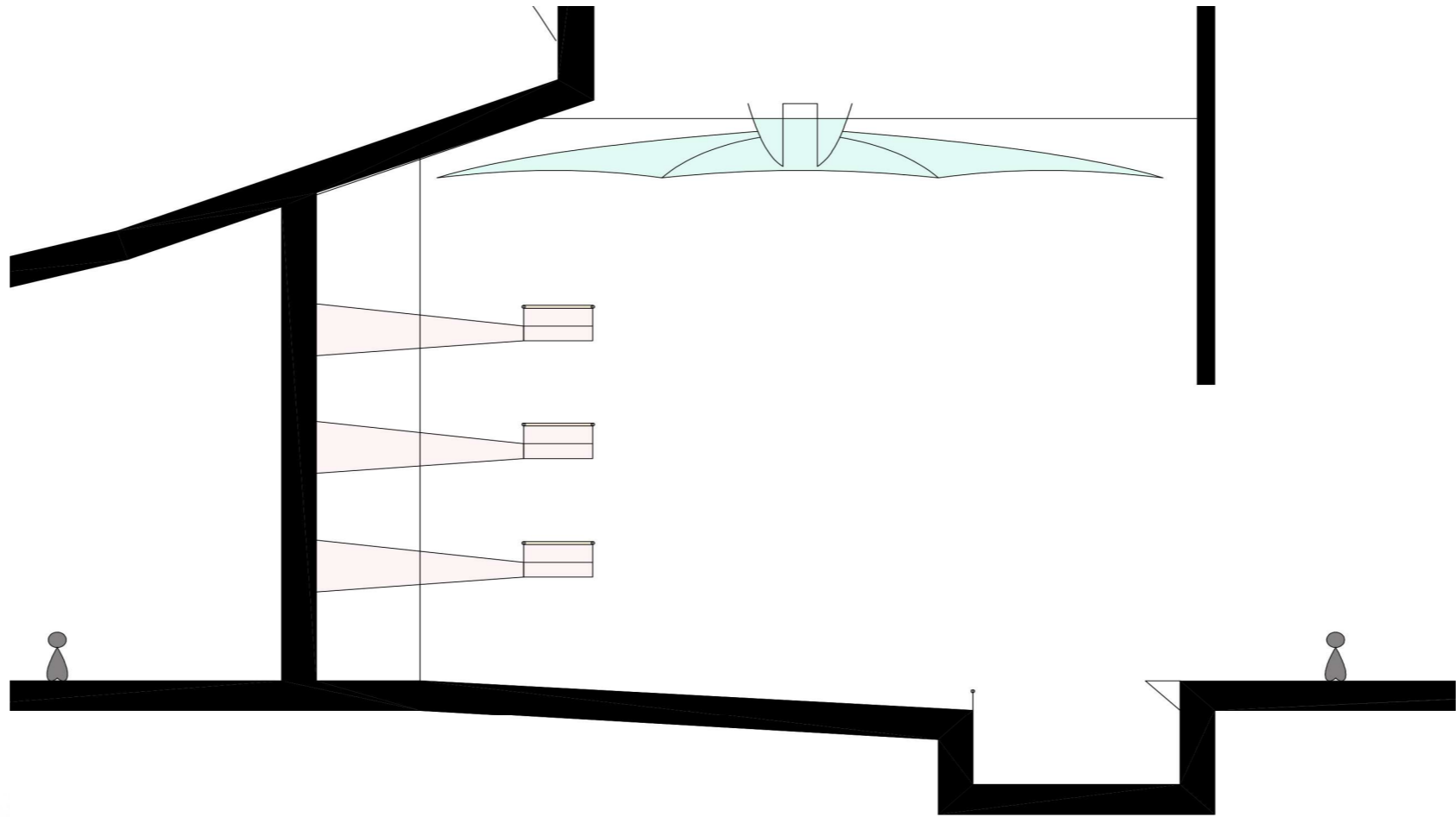
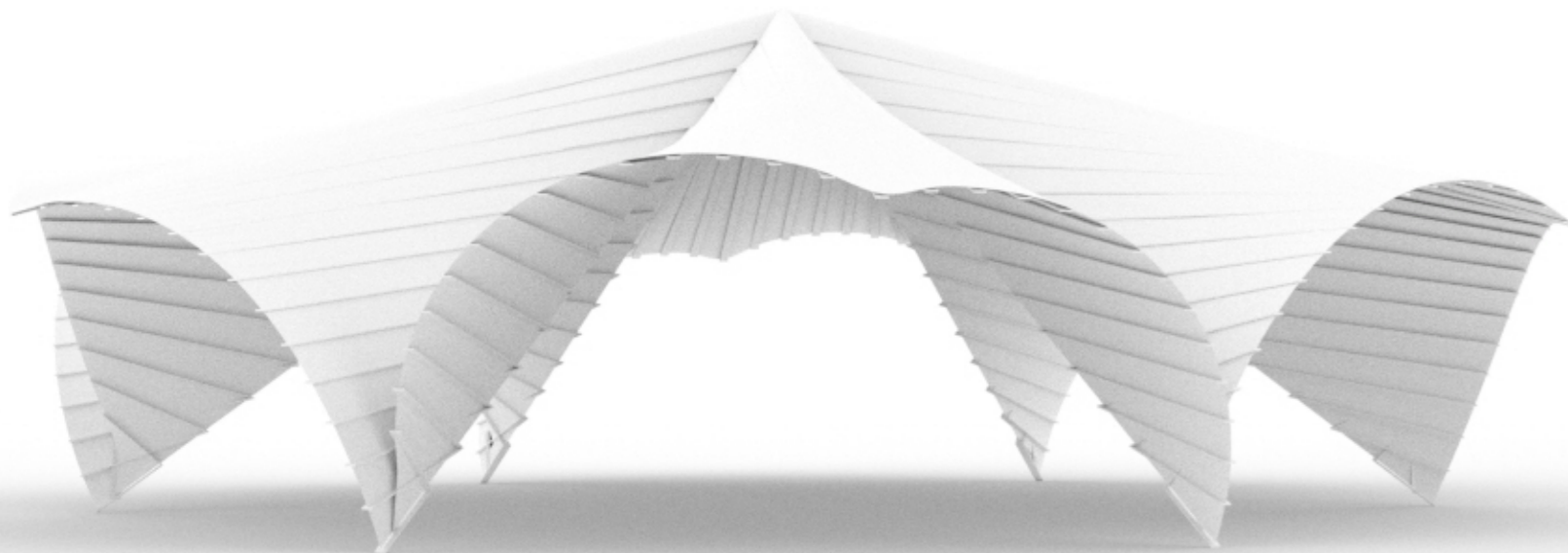
Together with this we also worked with some early concepts of how things would work together, where the flower should be placed, and a schematic floor plan got its first legs among other things.



Early model of Roof Structure



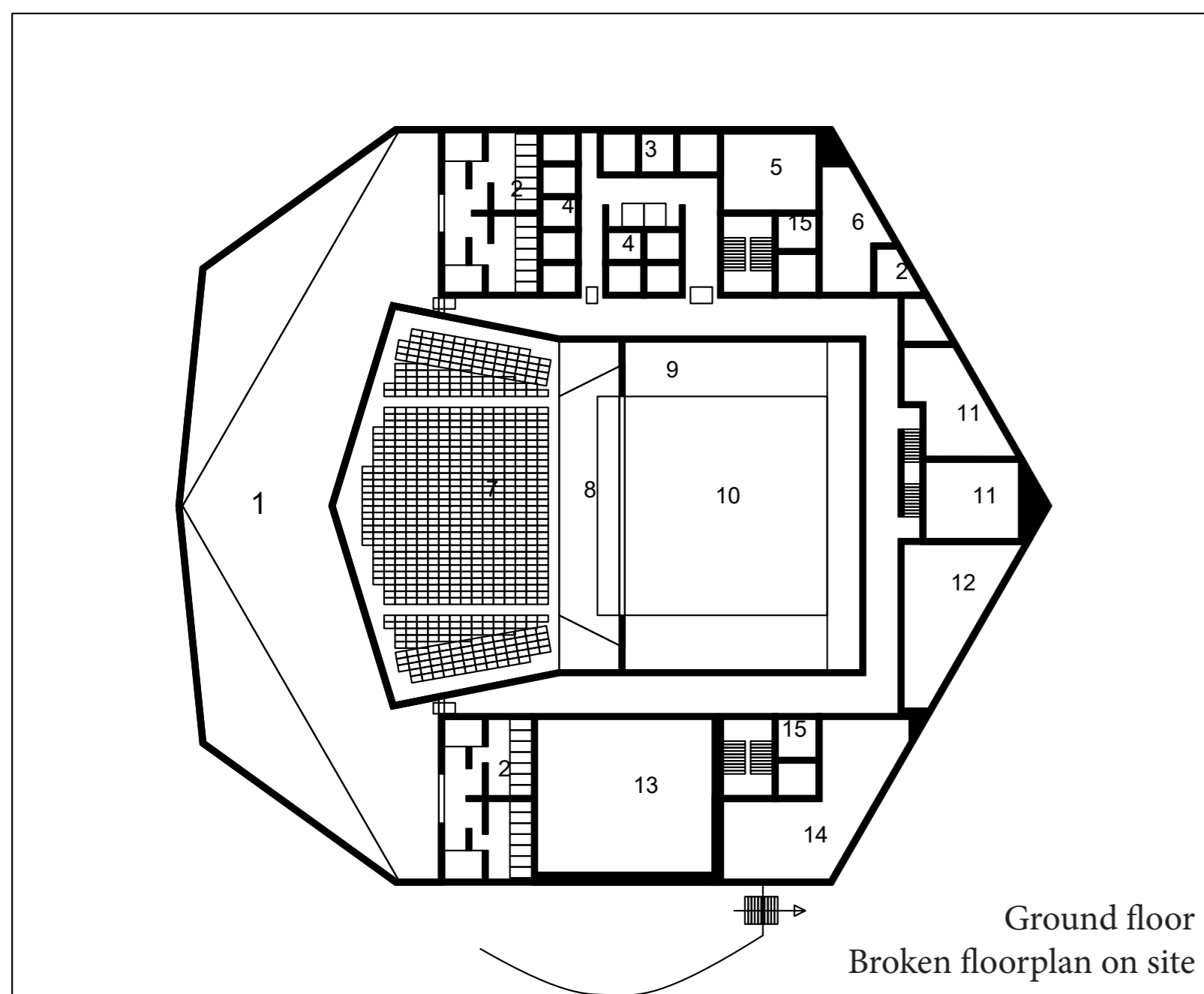
Proposal of Central Mechanism



# Working with CAD

## Iterating Upon the Design

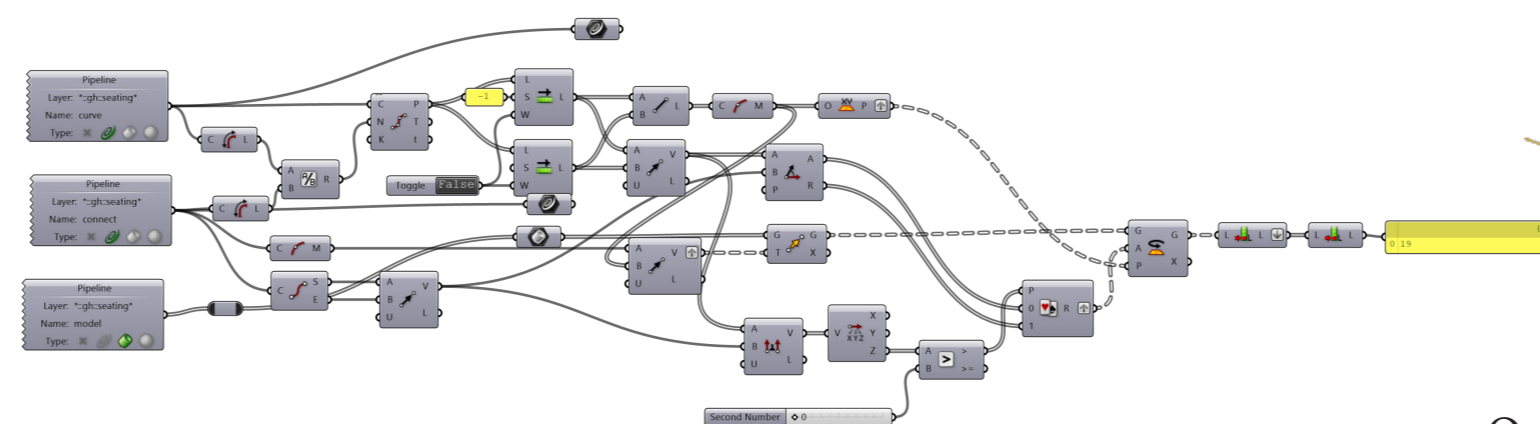
With all this we started to form the whole building more concretely, it was something we had done for a while now as something on the back burner but now we could iterate on the buildings general shape and how we wanted it to reflect the building's core. This process was sometimes the most fun and exciting part but also sometimes the most repetitive. Many an hour got iterated in the planning in the floorplans, specially when we could not really figure out exactly how we wanted the outside to look like. We felt some parts could not get their proper place and toed around with breaking the geometrical symmetry. A bad decision we later concluded. The work here flowed really well sometimes with the different parts finding their place. We aimed for wood as the main material, to hearken back to the flower once again and also aim for a more sustainable building but had to some extent backtrack on this a little.



The backtracking came from us having decided upon our outer shell shape of a strict geometric flower, also having to fit our 40 meter stage house under this shell. Our solution, taking the building underground, made it harder to work with wood to the extent that we first planned. In retrospect there might have been other solutions but I still feel that the way we took enabled new ways of designing and made some fun challenges to overcome and work with, not against.

## Parametric Design Principles

During this step of the project I also put in an extra effort to make smaller tools for our group. This with the aim to have an easier communication between acoustics and architecture as well as tools to enable more iteration later in the process. Some of those tools was an easy real time area display, a chair placement script.

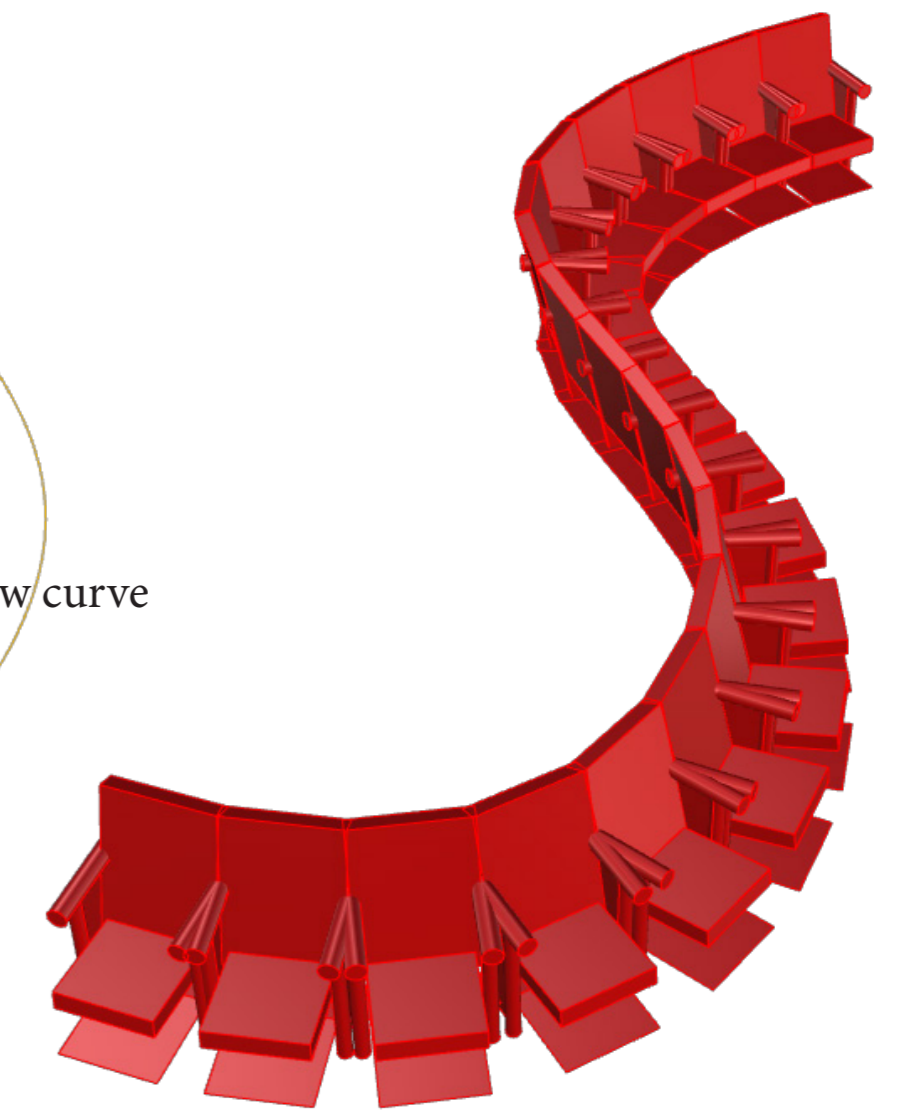


Script has 2 main distinctions from curve array:  
 Arraying from top of curve and not models base position.  
 Place amount of chairs that fits according to the size of the curve

## Chair Script

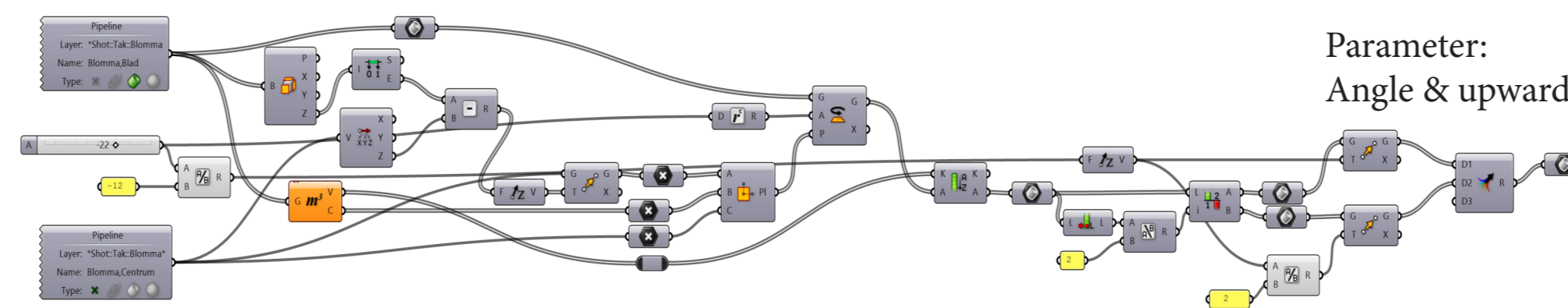


Input:  
 Back of chair line, Model & Follow curve



Output:  
 Model follows line in step and places chairs.  
 Displays amount of chairs placed.

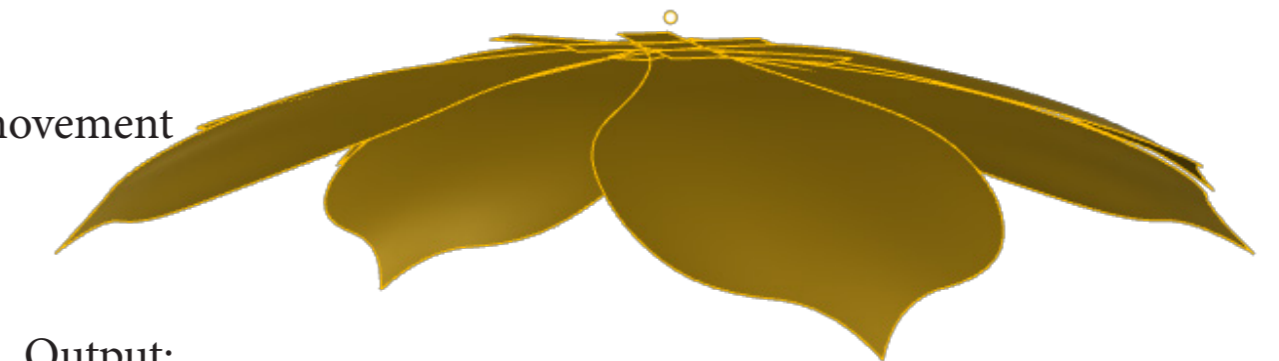
## Flower Script



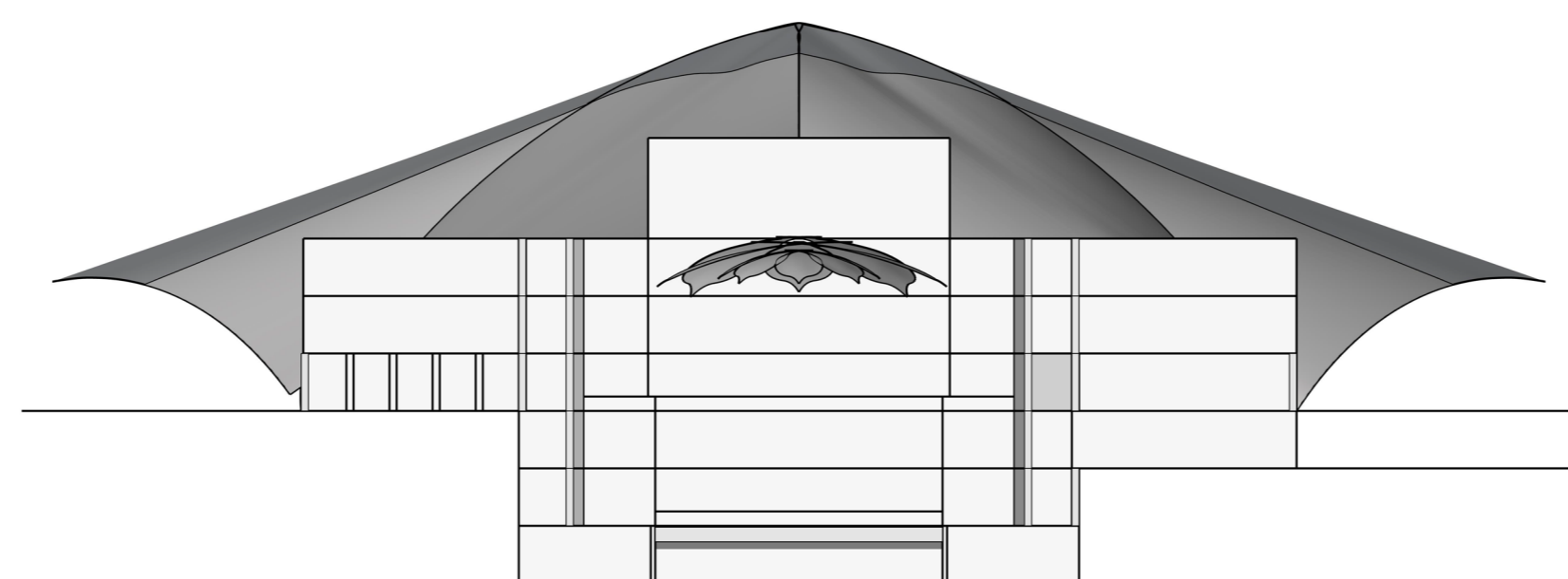
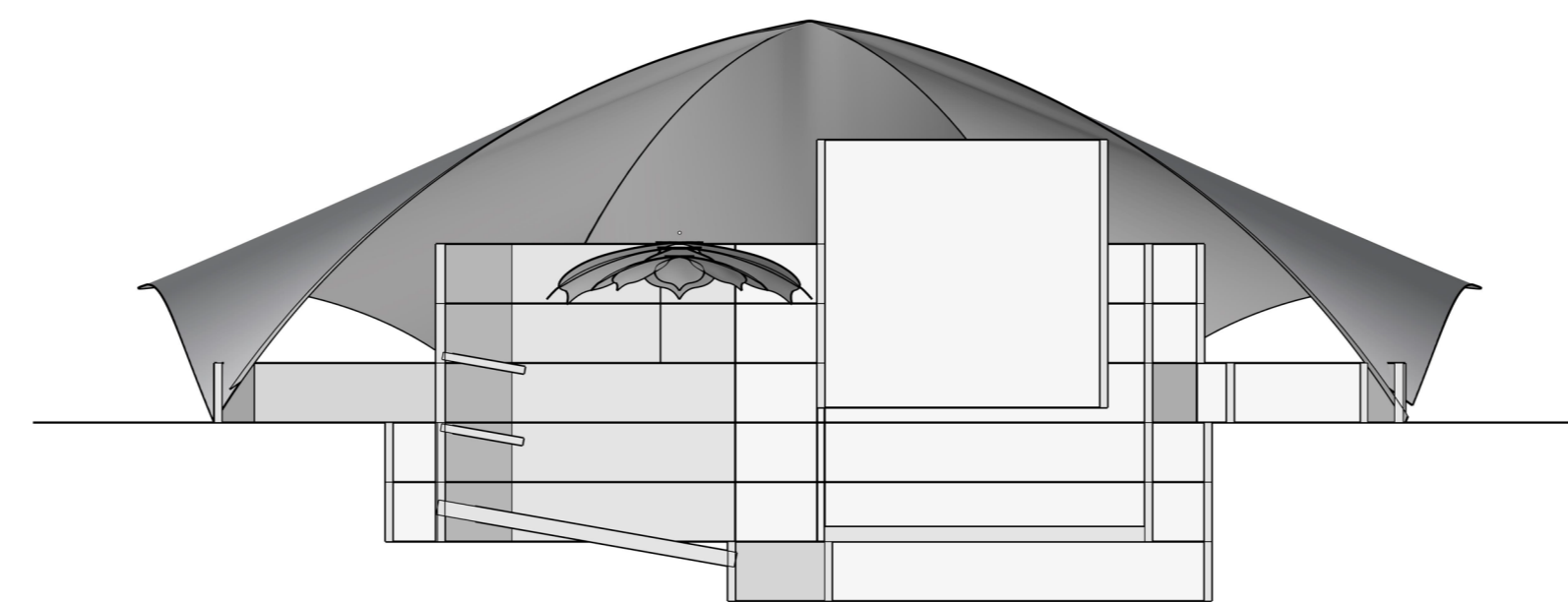
Script has 2 main distinctions from curve array:  
 Script uses petal volume centrum to make rotation planes and sorts petals into 2 groups by size.  
 This enables different rotation of different petals (inner and outer), as well as according to its placement.

Input:  
 Petals & Centrum of flower

Parameter:  
 Angle & upwards movement



Output:  
 Flower going up and rotating



## Reflections On Our Project

With the project I feel very happy with some aspects and feel like I could have experimented more and worked out a different solution that I now see before me. I really like how the flower made its central place a stronghold there we made it the crown it deserved to be, and I also like how the outside gives a not so subtle nod to the core although it is not so clear from the ground view. It is in between these parts I feel our project could have made a greater effort. The floorplan was much made with a top down view and I feel that If we worked maybe a bit more with sections and tried to unburden ourselves from our strict symmetry we had above ground we could have made something more memorable even here, not so much a solution to fit A to B with the constraints of C. But it was also here I had the bigger part in designing. In the project I really like the ways we could work with parametric design, not only as a tool for the more complex shapes but also as a tool for enabling the workflow. In this I made some tools to display Areas and volumes in our environment so that our acoustician had an easier time with getting their numbers and also made tools for the dimensioning of the main hall, placing chairs, the folding of the main flower and other smaller programs that made the process easier in the long run.

## Reflections on Work in Project

From this project I feel like I have gained a greater interest in the phenomena as a central point of design and want to in the future work more with it when able. I also feel like I have learnt quite a bit in the importance of not only working in planes but also to work with the feeling of rooms in sections and perspectives. This I feel, in the future, will help in creating more vibrant spaces when working under constrictions from both the inside and the outside.