# RAIN OF LIGHT

A public space acknowledging rain as the author of architecture

Fatima Khavari
Chalmers School of Architecture
Department of Architecture and Civil Engineering
Examiner: Morten Lund
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Master of Architecture and Urban Design
Matter Space Structure
2020

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CONTENTS

## ABSTRACT

Gothenburg is known as one of the rainiest cities in Sweden. The rain is a part of everyday life here. It rains approximately every third day in Gothenburg. With climate change, the rainfall is going to increase in the future. The municipality wants to see rain as a resource and be better at managing rainfall, they want to be the best rain city in the world. This vision is called Rain Gothenburg. With Rain Gothenburg the city wants to create a more positive perception of rain through architectural, social, cultural and climate related efforts.

The way we perceive rain affects our conception of the city. In Gothenburg where it rains frequently, rain is often perceived as dark, gloomy and cold, unlike bright, sunny weather. People tend to avoid rain and seek shelter from it or stay inside. Walls and roofs are built up in response to the weather and our connection to the outside world is lost. During the rainy days the use of public space is reduced.

This thesis explores how to increase the use of public space by using rain as an element of design. This proposal allows to embrace the rain and the discomfort of it to create a better connection to nature in an urban context. It aims to highlight the different aspects of rain and encourages the sensation of the weather to contradict the negative perception of it. This is best presented through a public pavilion where people can take shelter and experience the rainfall at the same time.

The methods used in this proposal are mainly practical. The design is developed by studying and experimenting with different materials and physical models. The qualities of rain are explored through literature studies, reference studies and by experiencing the rain in the city. By constructing a pavilion that is responsive to the weather the resulting architecture can embody the site fully and create a closer relationship to nature in an urban context.

## STUDENT BACKGROUND

2014 - 2015 Umeå School of Architecture, Umeå, Sweden

2015 - 2018 Bachelor in Architecture, Chalmers University of Technology, Gothenburg, Sweden

2018-2020 Master's Program in Architecture and Urban Planning, Chalmers University of Technology, Gothenburg, Sweden

Studios:
Fall 2018 - Material and Detail
Spring 2019 - Housing inventions

Direction for master's thesis: Matter Space Structure
Examiner: Morten Lund
Supervisor: Jonas Carlson

Internship:
Fall 2019 - Internship at White Arkitekter in Gothenburg, Sweden

## PURPOSE AND AIM

The purpose of this master's thesis is to investigate how rain can be an asset in architecture. This thesis explores how to increase the use of public space by using rain as an element of design. The proposal is to design a public shelter, in shape of a pavilion, where you can experience the rainfall.

This pavilion also explores and presents a new type of architectural skin where you can reconnect with nature and the surroundings during rainfall. To create a pavilion that can be adapted to the context and accentuate the link to the environment, a flexible structure is being researched.

## THESIS QUESTIONS

How can rain be used as an architectural element in the design?

How can you through light accentuate the experience of rain?

How can you with interactive design highlight the experience of rain?

How can you through the structure accentuate the connection between nature, rainfall, and the site?

## METHOD

The methods used in this thesis are mainly practical. Since this proposal is public the design of the pavilion is very crucial to how it is perceived by people. To encourage the people to interact with the architecture the form of the pavilion needs to be investigated. This is explored through physical models and reference studies.

Working with light is an important element in this thesis and is studied through physical models. It is important to investigate how the light creates the space, how it reflects water and can amplify the rain. Another important method in this thesis is material study. Different type of materials needs to be investigated and experimented with.

To get a better understanding about rain as a phenomenon and how it is experienced in the city a few walks in the rain are documented. These rain walks are based on my own sensory experience of the rainfall and perception of a place. This personal experience of rain is then used as the main concept for the design of the pavilion.

## BACKGROUND

Gothenburg is the second largest city in Sweden and has the most days with measured rainfall. It rains almost every third day here and meteorological data suggests that rainfall will increase in the future (Goteborg 2021, 2018).

The municipality of Gothenburg wants to see the rain as a resource and be better at managing rainfall. One of the goals for the four hundredth anniversary of the city is to be the best rain city in the world. This vision is called Rain Gothenburg. With Rain Gothenburg the city wants to create a more positive perception of rain. This is possible trough architectural, social, cultural and climate related efforts (Goteborg 2021, 2018).

When it is not raining in Gothenburg the city sidewalks pulse with energy, the residents are enjoying the sunny day. However, the same sidewalks turn quiet when the rain starts to pour. People retreat to isolated interiors and take shelter leaving the city quiet. Walls and roofs are built up in response to the weather and our connection to the outside world is gradually lost. But what if the rain could be a variable for a vibrant urbanity in Gothenburg? How can architecture help create a new urban Rain City?

Living in a city like Gothenburg, you have to learn that there is no bad weather, only the wrong clothing. Maybe this way of thinking should also apply to architecture. The façade of the buildings can be seen as its clothing, maybe they are dressed in the wrong clothes.

The buildings today limit our connection to the weather. Developing architecture that allows integration with the environment is needed. The rainfall in Gothenburg plays a significant role in the background of people's daily lives and to ignore it denies them its true potential. Rain can be seen as an asset in architecture, a positive attribution. Inserting rain into the design in joyful ways allows people to celebrate it.

By proposing a public pavilion that is responsive to the weather results in architecture that can embody the loci of the site. This pavilion presents a new type of skin that increases the use of public space in the city center. It is a shelter that allows connection with the surrounding environment and experiencing the rain at the same time.

## PERCEPTION OF RAIN

Rain is perceived differently across the world. Many people avoid rain and prefers to stay inside. Others celebrate it as a form of new life, a matter of survival.

The image of a city changes depending on how we perceive rain. While raining, the atmosphere of the city gets darker and the air becomes humid and cool. Drops of water blurs the edges of the buildings, intensifies the faded colours. Temporary ponds and puddles reflects the surrounding cityscape. During rainfall plants and trees get water, the dust from the streets and buildings washes off (Krenz, 2007).

During and after a rainfall the smell of ozone is released into the air. Different places have its own distinctive smell of rain. In the countryside the scent can be more sweet and in the city it smells more of wet asphalt (Barnett, 2015).

Rain influences our perception of environment. Through the damp air, the smell of wet soil, the sound of rain drops and the feeling of rain on skin, a well known space can be experienced and perceived in a new way (Krenz, 2007).

## RAIN - An ecological phenomenon

Depending on the temperature, precipitation can have many forms including rain, hailstones, sleet or snow. The fallen rain flows through streams and rivers back into the sea where the cycle starts (SMHI, 2018).

**Water cycle** – The cycle begins at sea, where the sun heats up the water which causes evaporation. The water vapour starts to rise as hot air tend to be light. The higher up the vapour gets the cooler it becomes. This causes condensation as the vapour can not store water droplets. The condensation forms clouds that starts precipitation when it can not store more vapours (SMHI, 2018).

**Types of rainfall** – There are three main types of rainfall; convectional, orographic and frontal rainfall (SMHI, 2018).

Convectional rainfall occurs on hot days when the sun heats the ground, within a moist atmosphere, leading to evaporation. This gives heavy and thundery showers (SMHI, 2018).

Orographic or relief rainfall occurs near mountains beside the sea. Mass of air is forced upwards over a rising terrain and the lift of the air results in cooling of it which later leads to condensation and precipitation (SMHI, 2018).

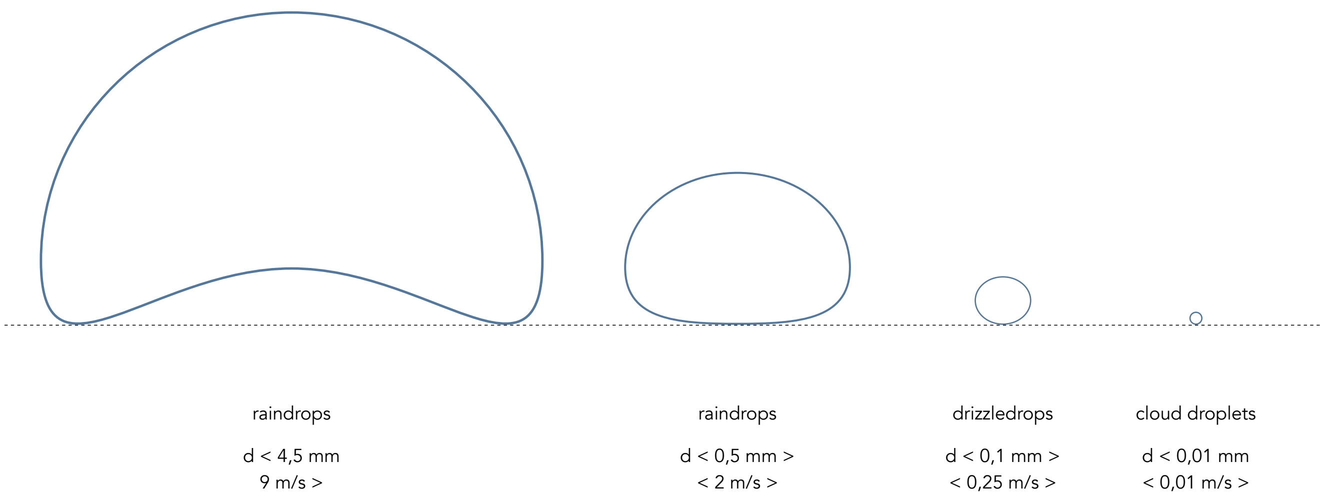
Frontal rainfall occurs when warm air mass comes in contact with cold air mass. The warm air mass rises over the cold front and is cooled down. The condensed air forms clouds leading to precipitation (SMHI, 2018).

## Raindrops formation

**Raindrops formation** – Falling raindrops can adopt different characteristics. The droplets can fall as a drizzle, a warm spring rain, heavy summer rains, sometimes as a storm, a downpour or a long monsoon. The rainfall can, in a dispersed way, from mist, fog or dew and create puddles and pools on the ground (SMHI, 2017).

The height and the size raindrops fall differ. Raindrops usually falls at the speed of 5-9 m/s, depending on the size of the droplets (SMHI, 2017).

**Shape of raindrops** – Raindrops are often represented in the shape of a teardrop. In reality the droplets take on a spherical shape as the molecules bind together and are held by surface tension. As the raindrops begin to fall their shape changes, with the air resistant the bottom of the drops flattens and they take more of a dome shape (SMHI, 2015).

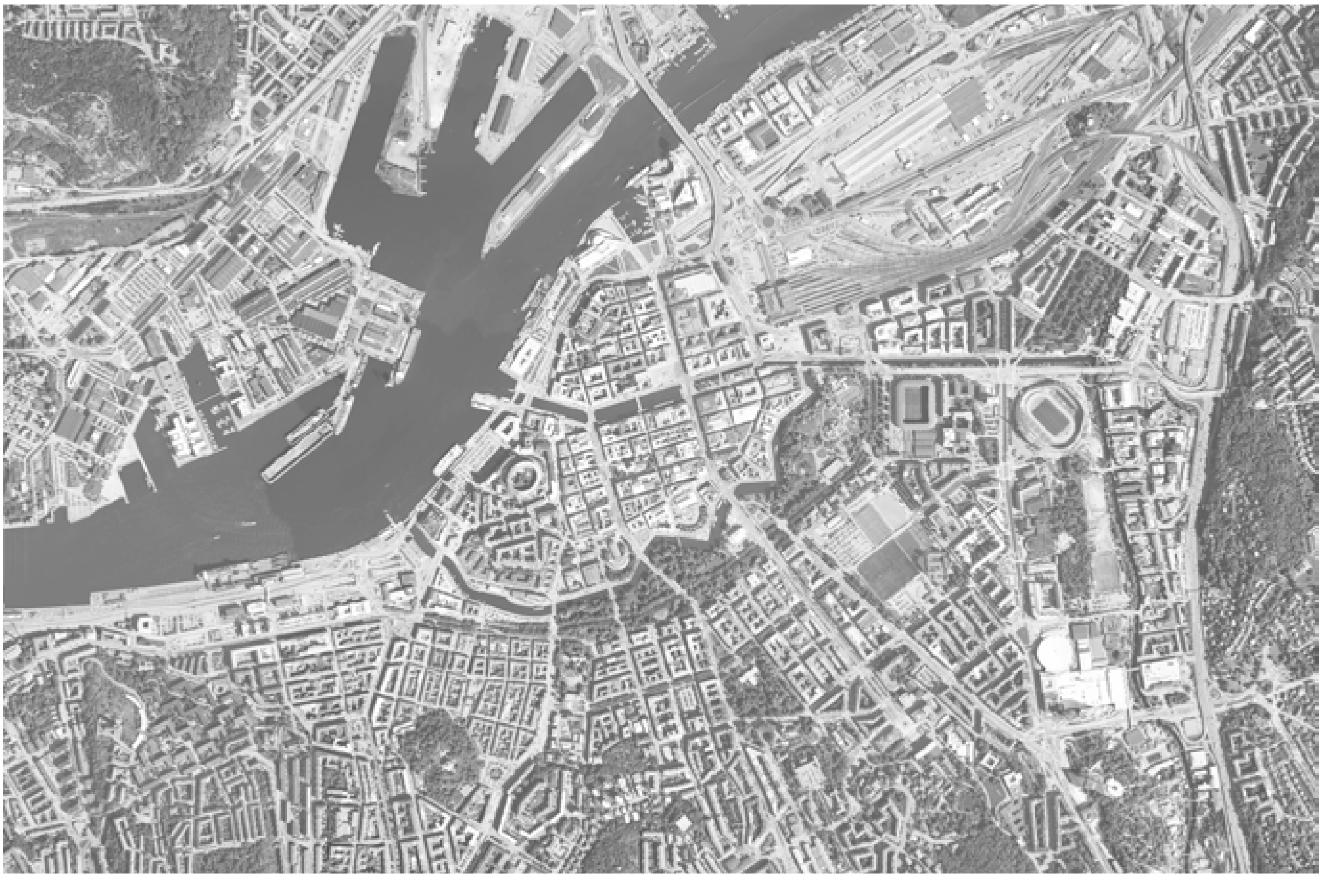


## Smell of rain

The smell of rain, known as petrichor, changes depending on places, seasons or sometimes the type of rainfall. The scent feels different from drops falling on a hot sidewalk in the city to rain on dry sand, in a grassy field, a forest or by the sea. For example, the smell of a storm is slightly metallic while the rain in the forest is rich and fungal. But what is significant about all of them is the pleasant aroma (EarthSky, 2018).

Petrichor is a combination of fragrant chemical compounds, so called geosmin. Geosmin is also the source of scent in many plants. When raindrops fall on dry ground, especially porous surfaces such as loose soil or rough concrete, they trap air bubbles that rises to the top and bursts out of the water droplet. These air bubbles are so called aerosol. The pockets of scents that are produced into the air causes the familiar smell of rain (EarthSky, 2018).


*Figure 1. Aerosol generation by raindrops (Young Soo Joung, 2014).*



## GOTHENBURG CONTEXT

Gothenburg is the second largest city in Sweden. It is located on the west coast and is known for its harbour and proximity to water. Because of the great location the city established itself as an important port city in Scandinavia and relies on its water sources for trade and business (Göteborgs Stad, n.d.).

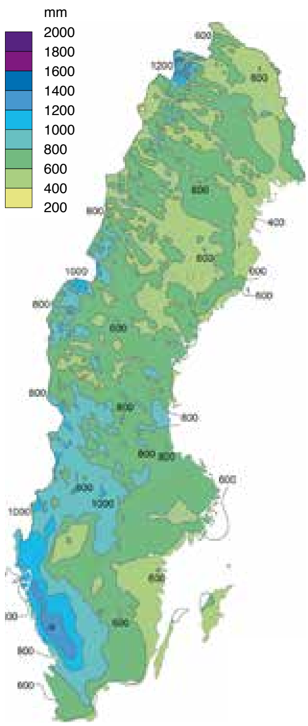
The climate in this region is affected by the Gulf stream and gives it a humid continental climate. The characteristics of the weather is the regular rain and wind (Göteborgs Stad, n.d.).

The site proposed for this thesis is the city centre of Gothenburg. This is one of the densest areas in the city. There are mostly offices and shopping destinations located here, and some residential buildings. Because of the central location, there are a lot of movements here, which makes it the ideal place for an interactive pavilion.

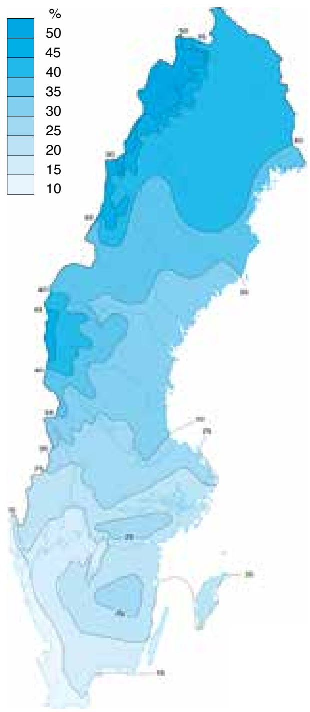
## Rainfall

Gothenburg has a humid continental climate. Temperatures are mild throughout the year despite its northern latitude. This is because of the exposure to ocean currents which also brings regular rain (SMHI, 2019a).

The maps below show the average amount of precipitation in Sweden. Gothenburg is located on one of the rainiest areas (SMHI, 2019a).




Average precipitation in year 2019.




Percentage of snowfall out of all precipitations in year 2019.

*source: smhi.se*

## Rainfall

It rains almost every third day in Gothenburg and meteorological data suggests that rainfall will increase even more in the future. Precipitation amounts to around 770 mm per year. The driest and coldest month is February with 40 mm rain on average, with approximately 11 rainy days. The rainiest month is October with around 87 mm rain and 16 rainy days (Climate-Data, n.d.).

The average amount of rainfall, counting for the last ten years, per rain-day is around 4,9 mm (SMHI,2020).

| jan | feb | mar | apr | may | jun | jul | aug | sep | oct | nov | dec | year total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 53 | 41 | 37 | 32 | 53 | 146 | 131 | 74 | 130 | 80 | 48 | 849 |
| 71 | 65 | 31 | 43 | 67 | 58 | 121 | 156 | 129 | 106 | 39 | 146 | 1032 |
| 88 | 55 | 9 | 75 | 74 | 95 | 94 | 92 | 134 | 155 | 94 | 65 | 1031 |
| 57 | 17 | 3 | 45 | 73 | 139 | 50 | 50 | 56 | 98 | 80 | 154 | 823 |
| 66 | 101 | 39 | 47 | 81 | 52 | 39 | 142 | 36 | 166 | 67 | 133 | 970 |
| 157 | 40 | 66 | 57 | 121 | 61 | 97 | 94 | 83 | 13 | 158 | 119 | 1066 |
| 87 | 54 | 50 | 78 | 15 | 71 | 74 | 95 | 49 | 44 | 94 | 53 | 763 |
| 46 | 73 | 6 | 50 | 48 | 112 | 47 | 90 | 106 | 140 | 88 | 127 | 993 |
| 104 | 59 | 38 | 71 | 22 | 43 | 15 | 118 | 113 | 73 | 41 | 55 | 751 |
| 47 | 105 | 141 | 39 | 81 | 42 | 38 | 142 | 155 | 93 | 70 | 136 | 1090 |

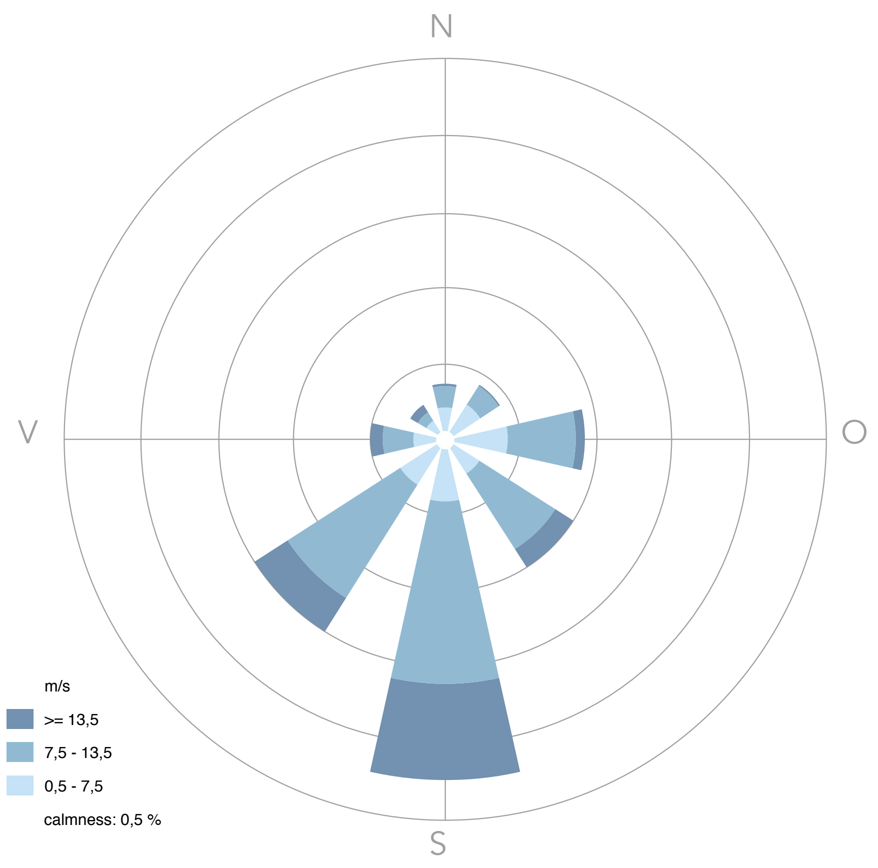
Amount of rainfall (mm) for the last ten years in Gothneburg. Starting from 2010 to 2019 (SMHI, 2020).

*source: smhi.se*

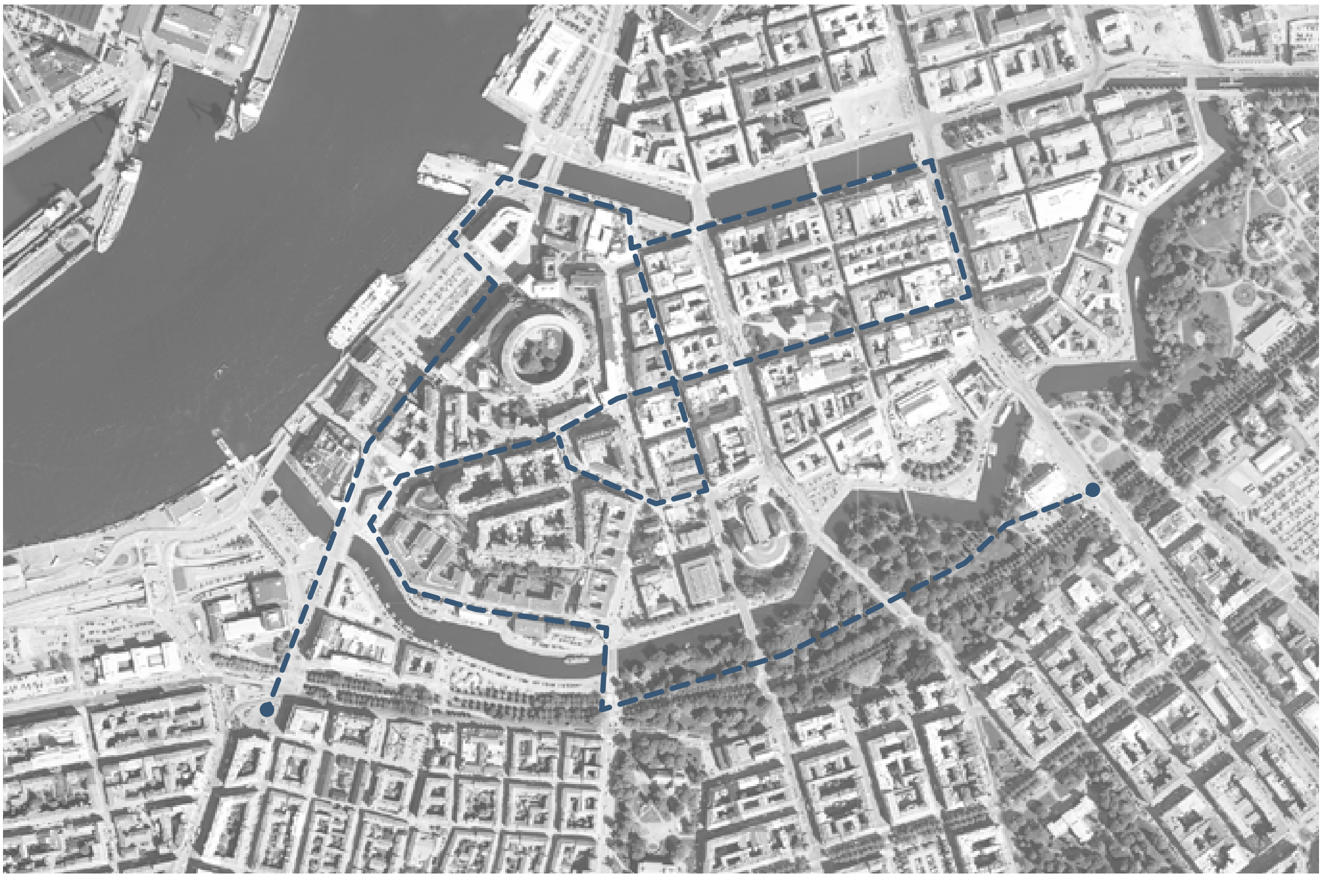
## Wind

Gothenburg is located in the west wind belt which means that the average wind direction, when undisturbed, is from west or south-west. The wind direction closest to the ground is affected by buildings, vegetation and topography resulting in variation of speed and direction (SMHI, 2019b).

The so-called wind rose below shows the wind speed and direction during rainfal. Since the city is located on the west coast, the most common wind direction during rainfall is from south or south-west. The average wind speed is around 4 – 6 m/s (SMHI, 2019b).




source: smhi.se



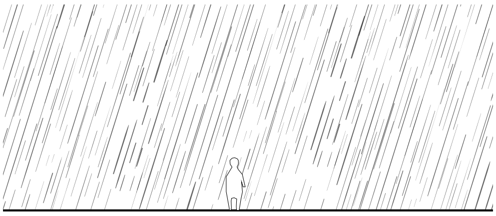
## EXPERIENCING THE RAIN

My own experience of rain is an important part in this thesis. To better understand and explore the qualities of rain I decided to take walks in the city during rainfall. The purpose of these rain walks are to further explore how the city highlights different qualities of rain. The method used to document consists of different observations during rainfall, meaning that places or elements that accentuates the rain.

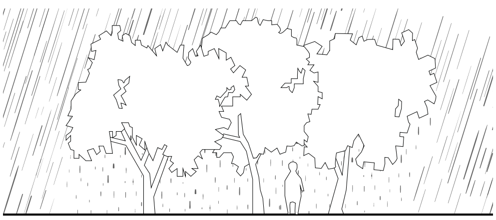
The experience and perception of a place is multisensory. You use the senses to take in information about a place. The method used to document the experience of rain is based in sensory registration of a place. In other words, taking in the surroundings and the atmosphere during rainfall based on sound, vision, touch and smell. This method also allows to present and manage the collected materials. One disclaimer is that there was no noticeable change registered with the smell of rain which got excluded. This can be due to the cold weather these walks took place during.

My experience of rain was strongly linked to the context resulting in different rain scenarios. The collected material is presented in three rain scenarios; exposed space, urban space and enclosed space.

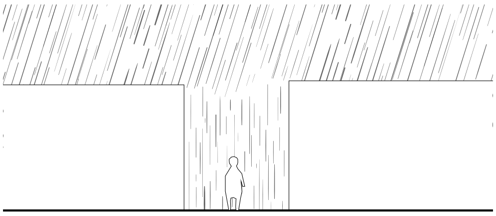
THREE RAIN SCENARIOS



Exposed space

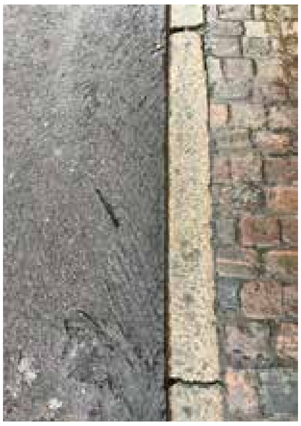


Enclosed space



Urban space



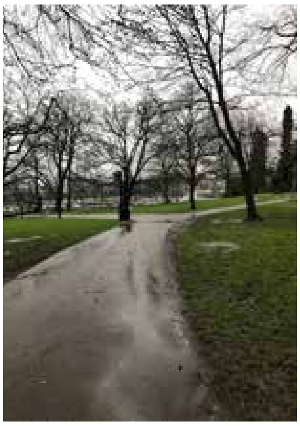



## Exposed space

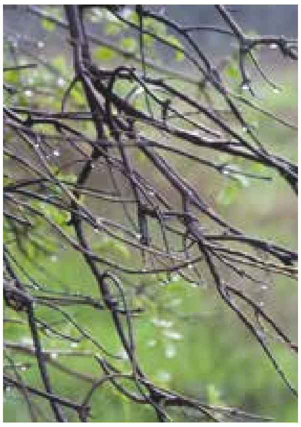
**Touch**
- Open space with strong winds that makes the rainfall really harsh.
- Water and wind sipping through the clothes, feeling exposed.
- The water droplets splashing back on you from the wet ground.
- A lot of water collecting on the street, there is no obstacle between rain and ground.
- Water splashing when walking.
- The rain is very present.

**Sound**
- The rain hitting the open water.
- The water and rain sounds louder here.
- Rain flowing down the drain.
- Hearing splashing footsteps on water.

**Vision**
- The raindrops hitting the open water creating a clear visual image.
- Water flowing down facades and the stone walls.
- Raindrops falling in the collected water on the streets.
- Seeing the wind direction changing with the rainfall in the air and on the open water.
- Reflection of the scenery everywhere.





## Enclosed space

**Touch**

- The raindrops filters trough the trees getting more heavy while pouring down, the rainfall is more diffused.
- Feeling the wet and muddy ground while walking, the rain affecting the movements, getting slower.
- Puddles on the grass and muddy ground.
- Water collecting on the wooden benches.
- Raindrops sitting on vegetation making it more wet while walking through.

**Sound**

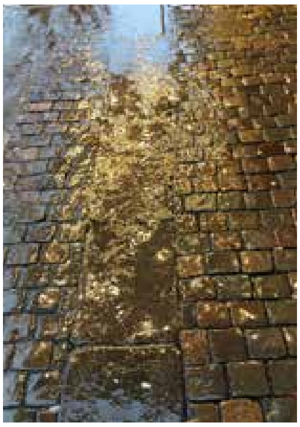
- Hearing the raindrops getting more heavy while under a tree.
- Rain falling on the wet grass and muddy ground.
- Squishy footsteps while walking on the muddy paths and wet grass.
- Raindrops falling on leaves and bushes.

**Vision**

- The raindrops collecting on branches and leaves, reflecting the light.
- The rain flowing down the tree trunk.
- Rainfall infiltrates in the wet grass making the ground very muddy.
- Puddles collecting under the trees and along the path, muddy and cloudy water.








## Urban space

**Touch**
- Wind tunnels where the streets meet making the rain feel harsher. Calmer rainfall when you walk further into the street, the surrounding buildings protecting you.
- Many shelter to stand under and be protected from the rain.
- The water droplets splashing back on you from the wet ground.
- Stone pavement on some streets letting the rain to sink trough the ground.
- Water being lead away in the middle of the street.
- A lot of different materials getting wet by the rain, wood, stone, glass, concrete etc.
-

**Sound**
- The rain hitting on the metallic window frame and the glass.
- Rain falling on some tin roofs and bus stop roofs.
- The rain hitting the stone paved street. Cars driving by splashing water.
- Rainwater flowing away in the gutters.
- Rain falling on the umbrellas.

**Vision**
- The lights from the stores reflecting on the puddles and wet ground.
- Water droplets forming and glisten on the glass of the store windows.
- The facades of the buildings turning darker and more vibrant when getting wet.
- A lot of shelter options for example the roofed entrance to the stores and buss stops that lets you watch the rainfall protected.

## STRATEGY

**Exposure and enclosure**

Creating a shelter that is exposed. A space that is enclosed during rainfall and exposed otherwise. This can be achieved by guiding the rain.

↓

**Guiding the rain**

Manipulating and guiding the falling rain to define and create an enclosed space when it starts raining. Enhancing the architectural experience through rain which also leads to interactive design.

↓

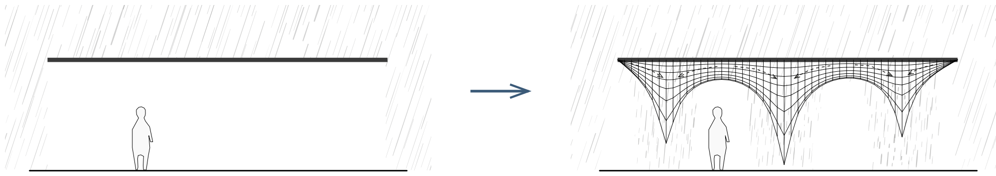
**Interactive design**

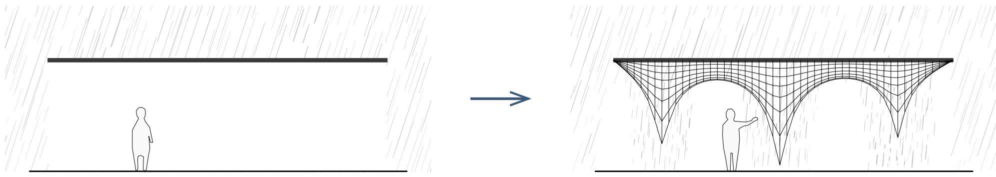
Designing a pavilion that reacts when raining. Enabling the visitors to interact with the structure to enhance the experience of rain.

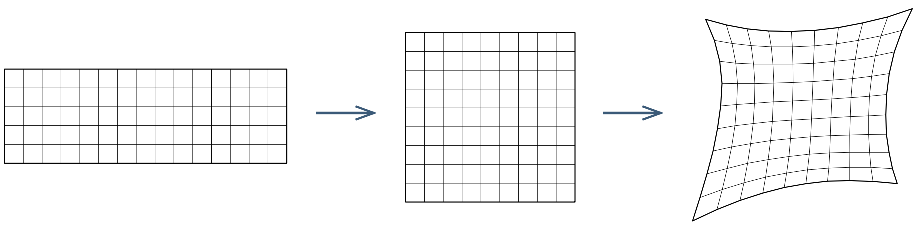
↓

**Transformable structure**

A structure that is responsive to the context and embodies the site. This gives stronger connection between nature and surrounding environment.







## MATERIAL STUDY - Net

To explore the strategy of a transformable design I started looking into different types of flexible structures. To accentuate the connection to surroundings the pavilion could be adapted to the context by a flexible structure. I was really interested in textile structures and wanted to further investigate it. The main idea is to have a flexible and elastic grid that can easily adjust to the context. This leads to the following investigations on different types of net structures.

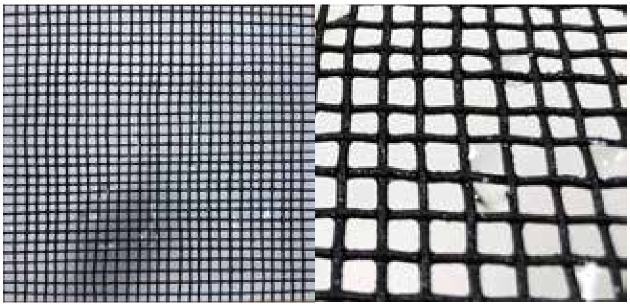
In this chapter different types of nettings are experimented with to see how materials reacts to rain. The netting materials are textile, fishing net and metal net. To highlight the characteristics of rain, three different concepts are explored; how the raindrops form on the net, how the net leads the water, how flexible or elastic the net is.

The idea with an elastic net is to be able to design a vertically moving structure. I wanted the net to move and transform with the rain, to define the space underneath when raining. This reflects back on the strategy of exposure and enclosure. By collecting the rain on some parts of the elastic roof, it can drop down and define a space that was not there before. This idea gives an enclosed space during rainfall, that is exposed otherwise.

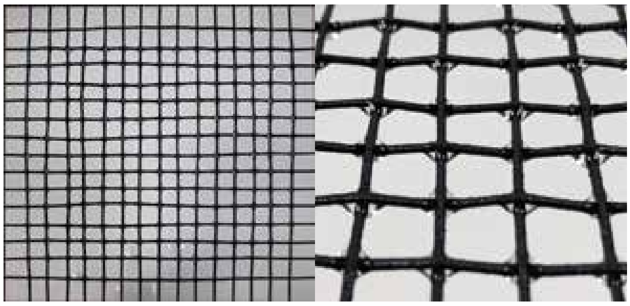
The concept of how the net leads the water is explored to answer the strategy of guiding the rain. By guiding and channelling the rain water on the net to where the anchor point is you can define the space further. The rainwater gets more concentrated and falls heavier where the net drops down.

When the mesh-roof lets the rain fall through, the visitors can interact with it. The concentrated rainfall under the pavilion provides different spatiality that allows the visitors to get closer to rain and interact with it from a protected position.

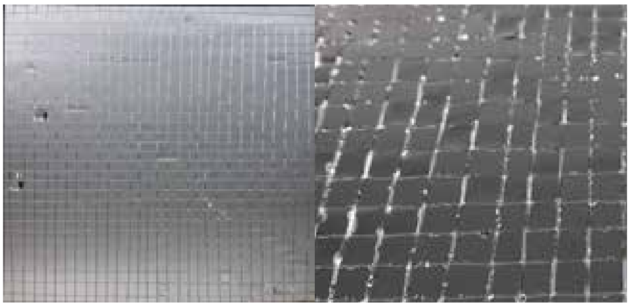
## Raindrop formation



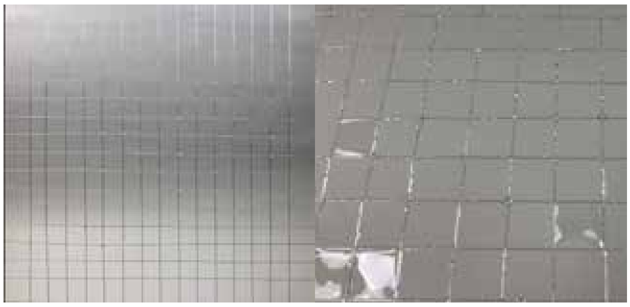
Textile net 150x150mm, mesh 5x5mm, wire Ø 1mm. The textile net absorbed water creating water surfaces inbetween the squares. There were not a lot of dropets forming.



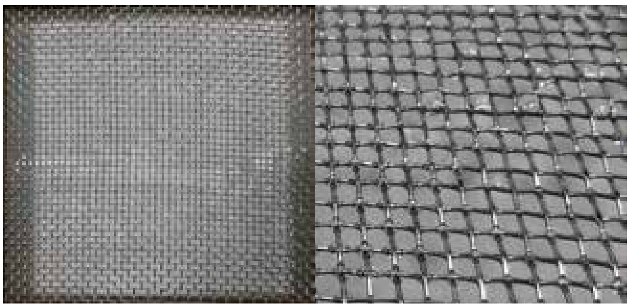
Textile net 150x150mm, mesh 10x10mm, wire Ø 1mm. The net absorbed water but since the mesh was larger there were not as much water squares created. Instead there were droplets forming where the net crossed.



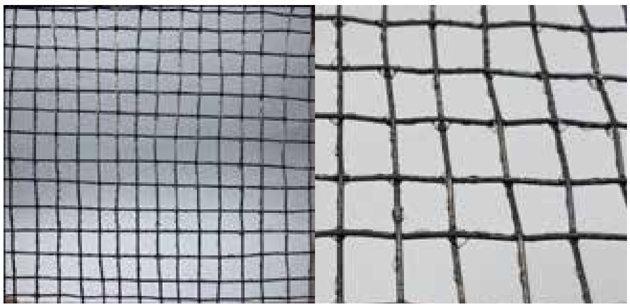
Fishing net 150x150mm, mesh 5x5mm, wire Ø 0,25mm. The water was not absorbed resulting in more droplets and water squares. The droplets were more visible like.



Fishing net 150x150mm, mesh 10x10mm, wire Ø 0,25mm. The water was not absorbed resulting in formation of droplets but they were less becouse of the larger mesh. The water fell through.

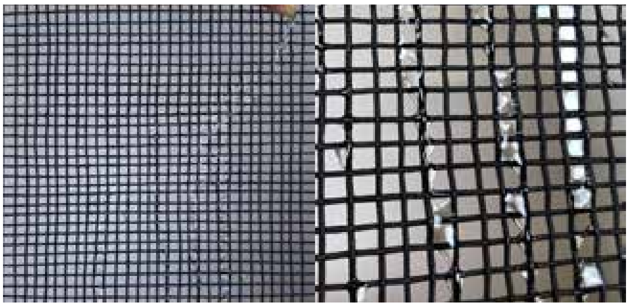


Metal net 150x150mm, mesh 5x5mm, wire Ø 0,5mm. The water was not absorbed resulting in formation of droplets only where the net crossed. A lot of water squares where visible too.

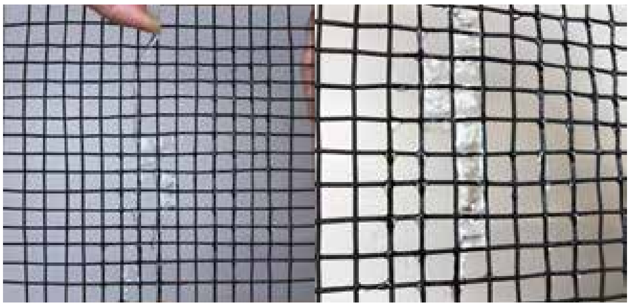


Metal net 150x150mm, mesh 10x10mm, wire Ø 1mm. The water was not absorbed here resulting in droplets forming only where the net crossed. Almost no visible water squares since the mesh is larger.

## Guiding the rain



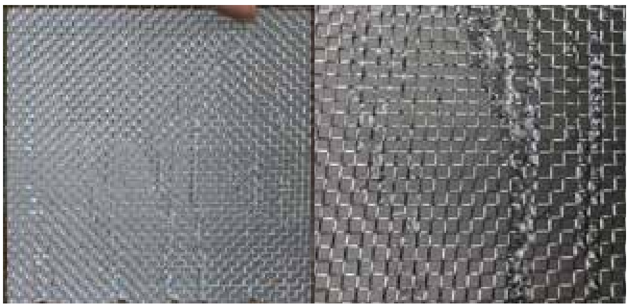
Textile net 150x150mm, mesh 5x5mm, wire Ø 1mm. The water ran down along the ways that were already wet. It connected to more grids creating its own way to fall down along, multipule paths at the same time.



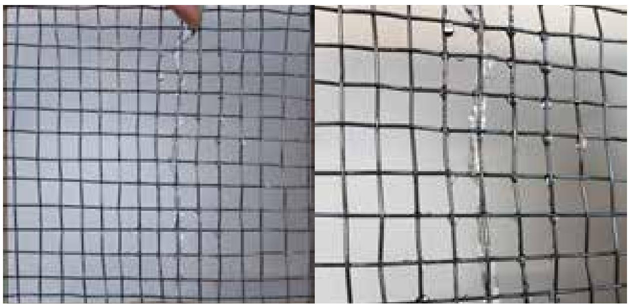
Textile net 150x150mm, mesh 10x10mm, wire Ø 1mm. The water ran down along the squares that were wet. The larger mesh did not allow a many paths.

Fishing net 150x150mm, mesh 5x5mm, wire Ø 0,25mm. The water chose different ways down depending where you poured it. The smaller mesh allowed multiple ways. A lot of droplets formed since the mesh could not absorb.

Fishing net 150x150mm, mesh 10x10mm, wire Ø 0,25mm. The water fell down only where you poured it. The larger mesh did not allow multiple ways down. Droplets did form after a pourdown since the mesh could not absorb.



Metal net 150x150mm, mesh 5x5mm, wire Ø 0,5mm. A lot of resemlance with the fishing net but the droplets did not form as frequently here as on the fishing net. Where the water poured down was very prominent.

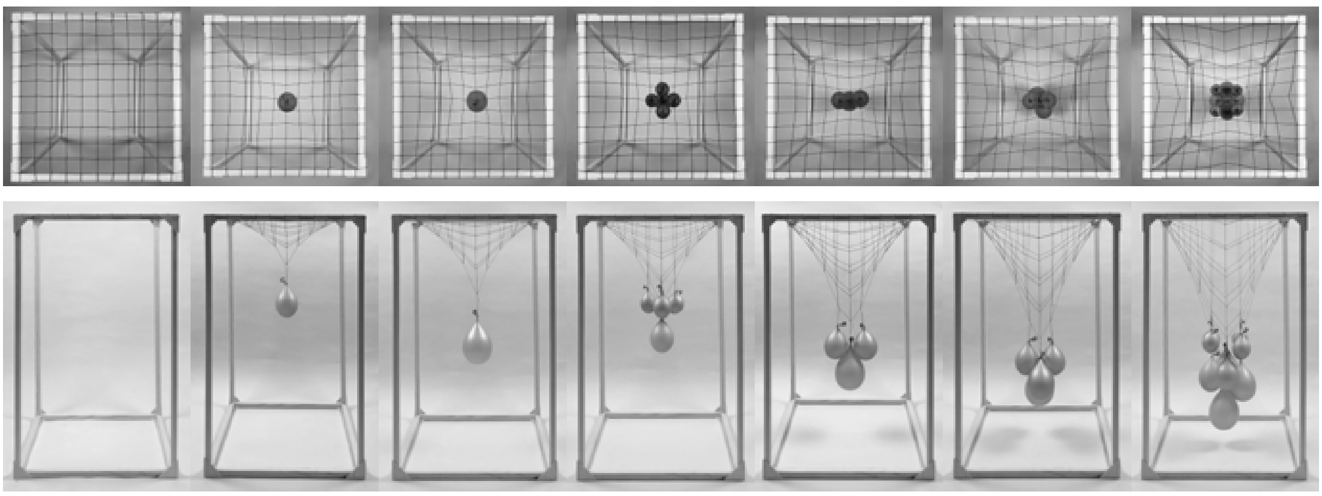


Metal net 150x150mm, mesh 10x10mm, wire Ø 1mm. Water fell down only where you poured it. It was difficult for the water to grab on the material resulting in dropping water insted of flowing.

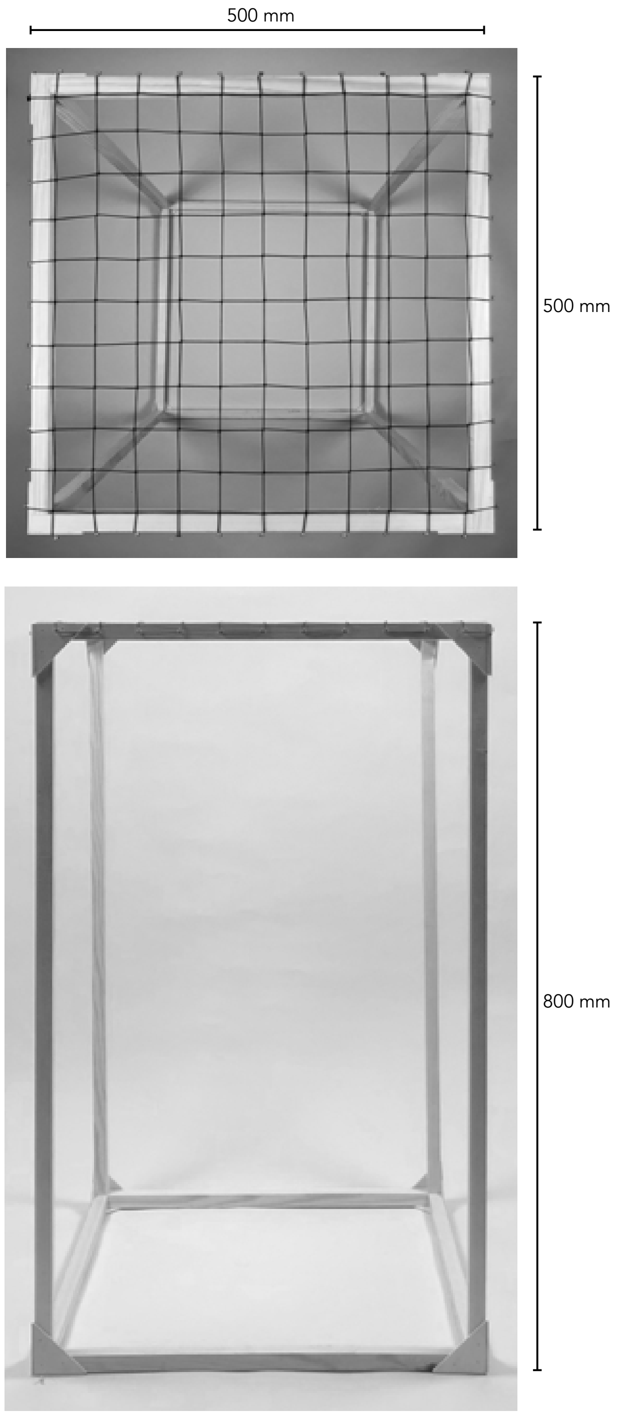
## Net elasticity

After experimenting with different netting materials I decided to further explore the textile net, since it was the only elastic enough material. The textile net also leads the water best, absorbing it and leading it through multiple paths. Below you can see the relation between net elasticity and the amount of water needed for the net to start reacting and dropping down. To be able to control the shape of the arch different types of weight was used, concentrated weight, divided weight and decreasing weight.

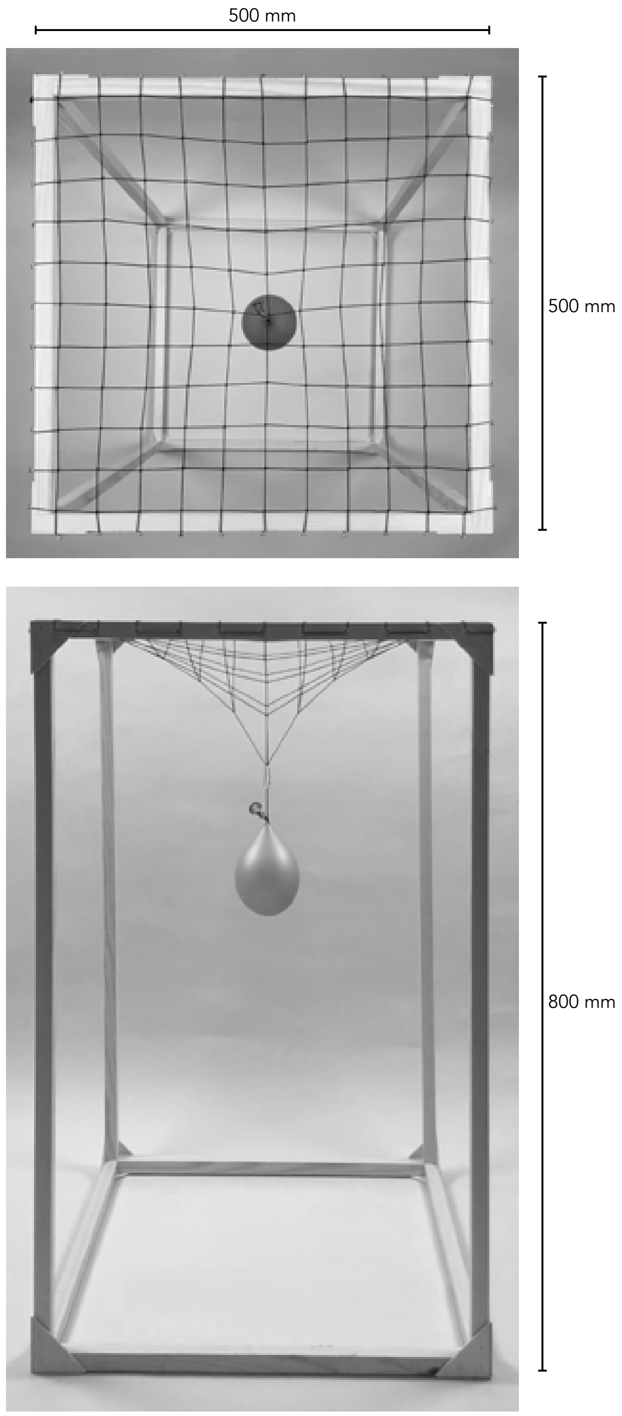
Through this experiment I decided that using different weights that decreases further out gives the best looking arch in the net. I also noticed that the weights can only hang from the knots, where the net crosses, the arch can otherwise be deformed.



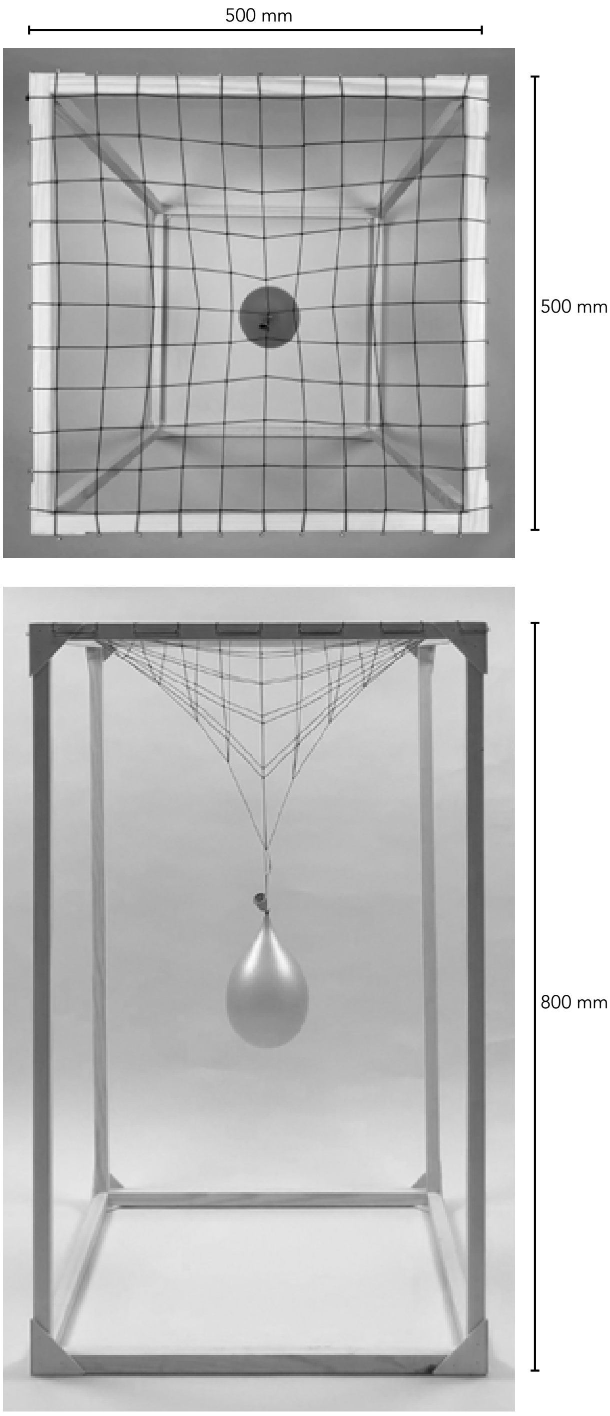
0 kg | 0,5 kg | 1 kg | 1,5 kg | 2 kg | 3 kg | 4 kg



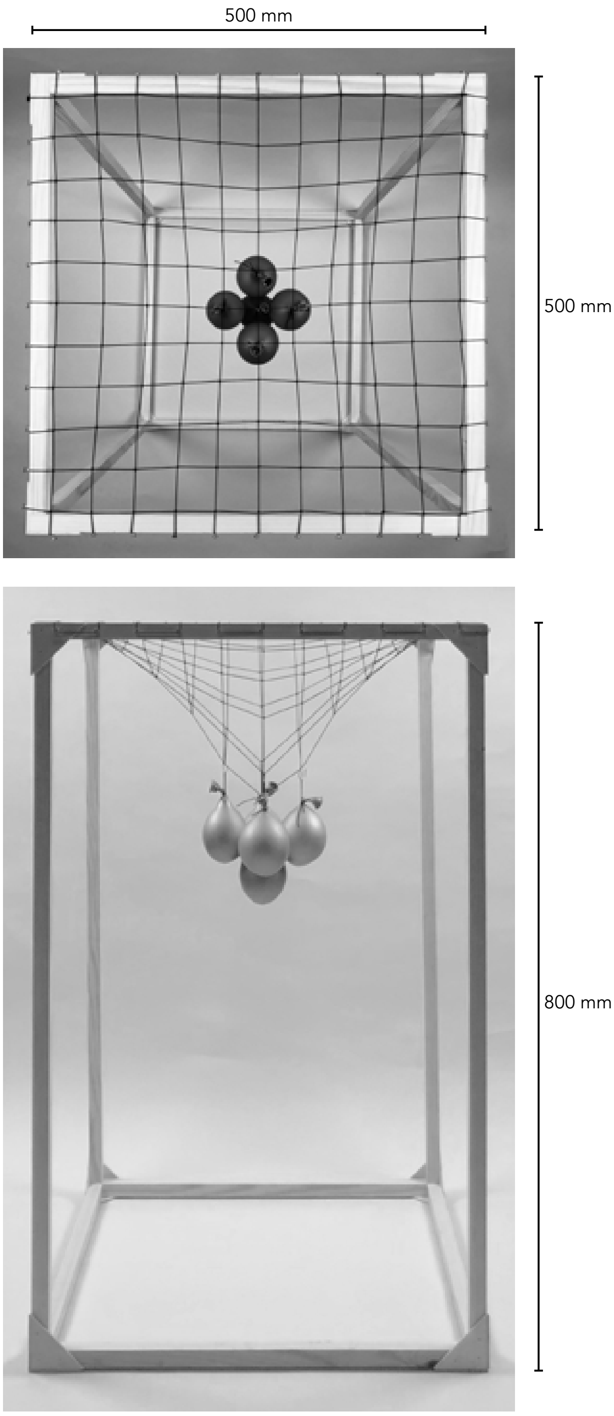

0 g



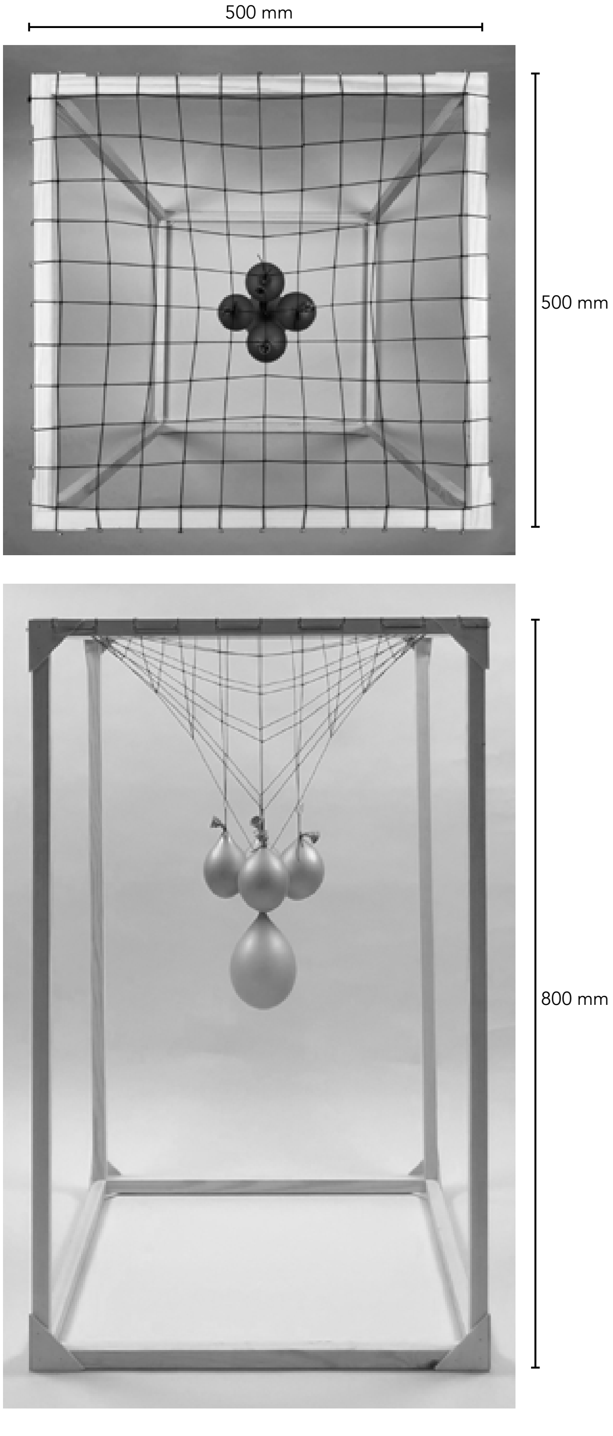

500 g



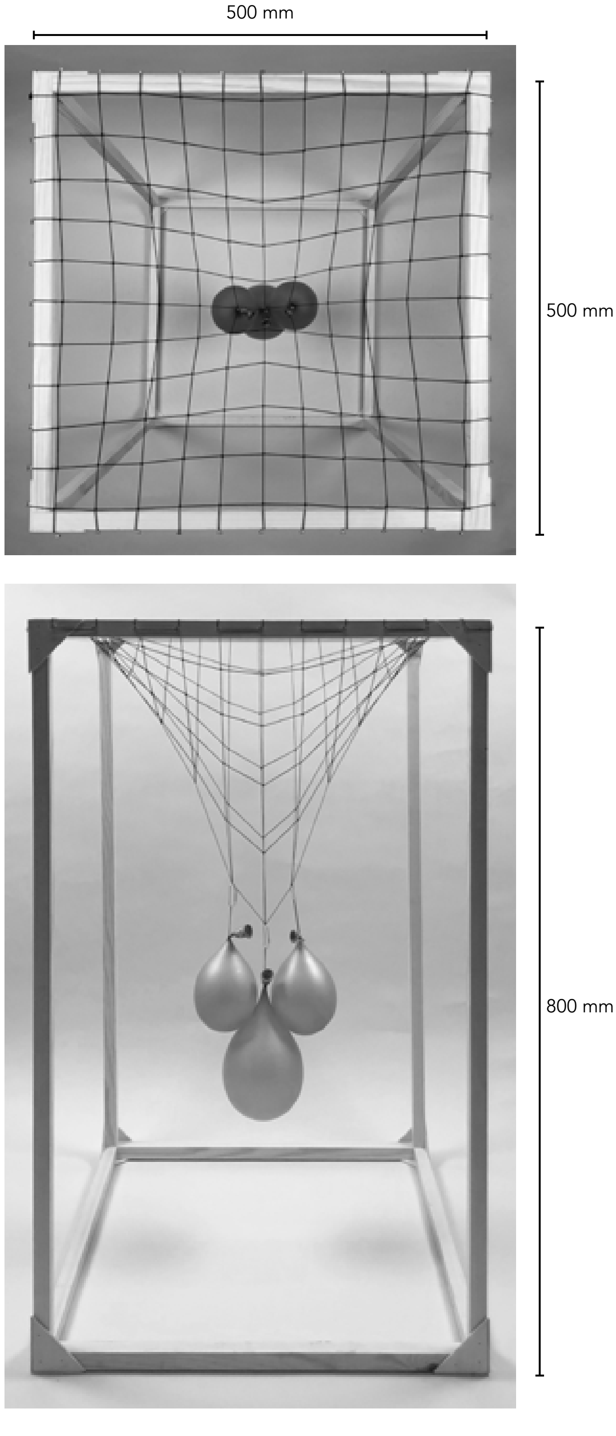

1000 g



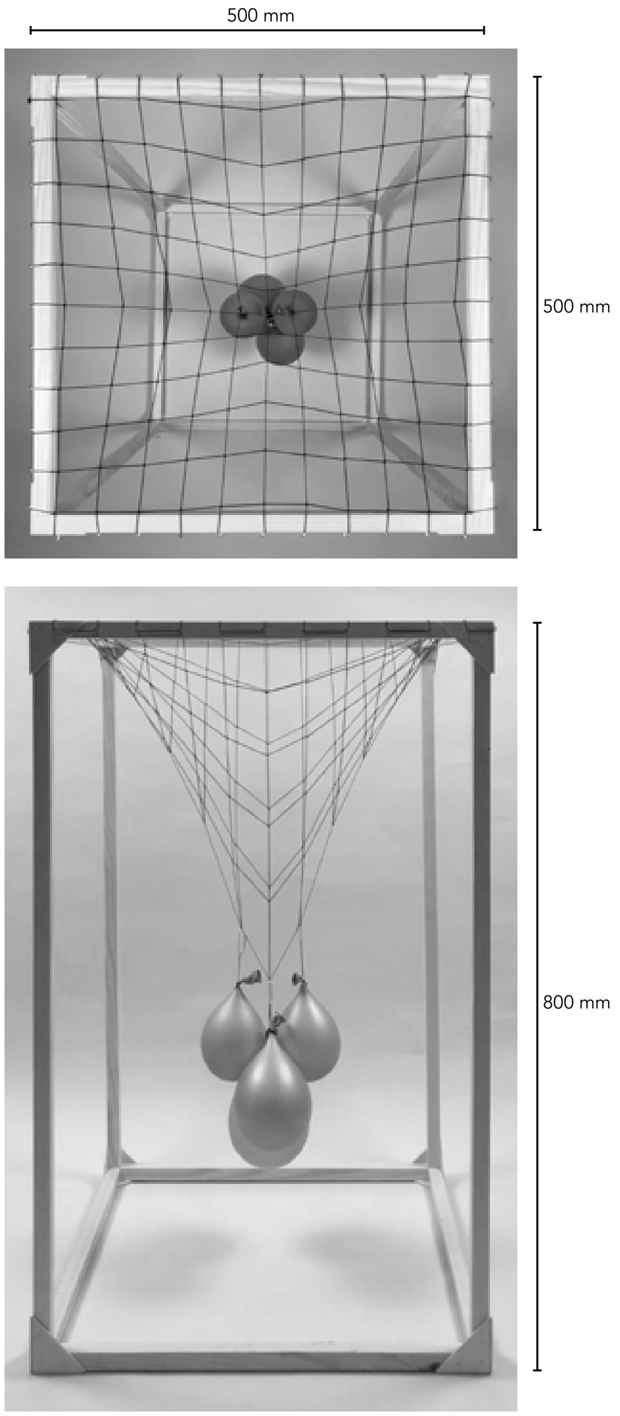

1000 g divided



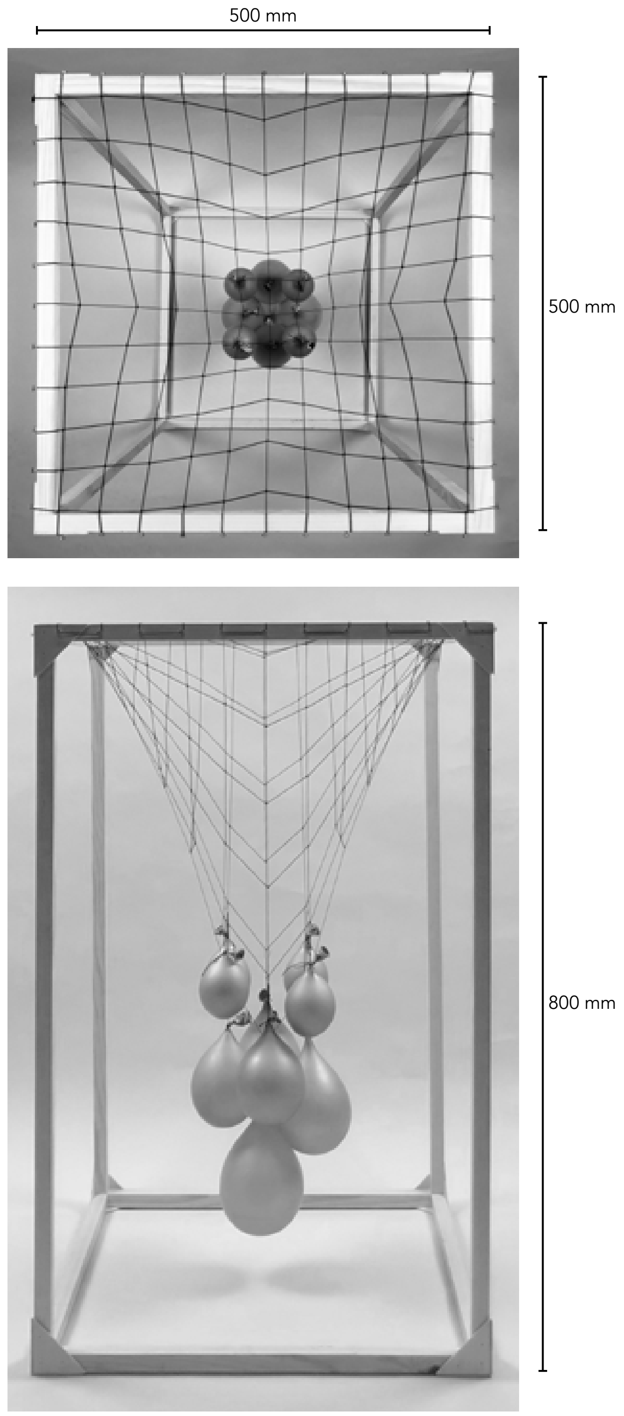

1500 g




2000 g

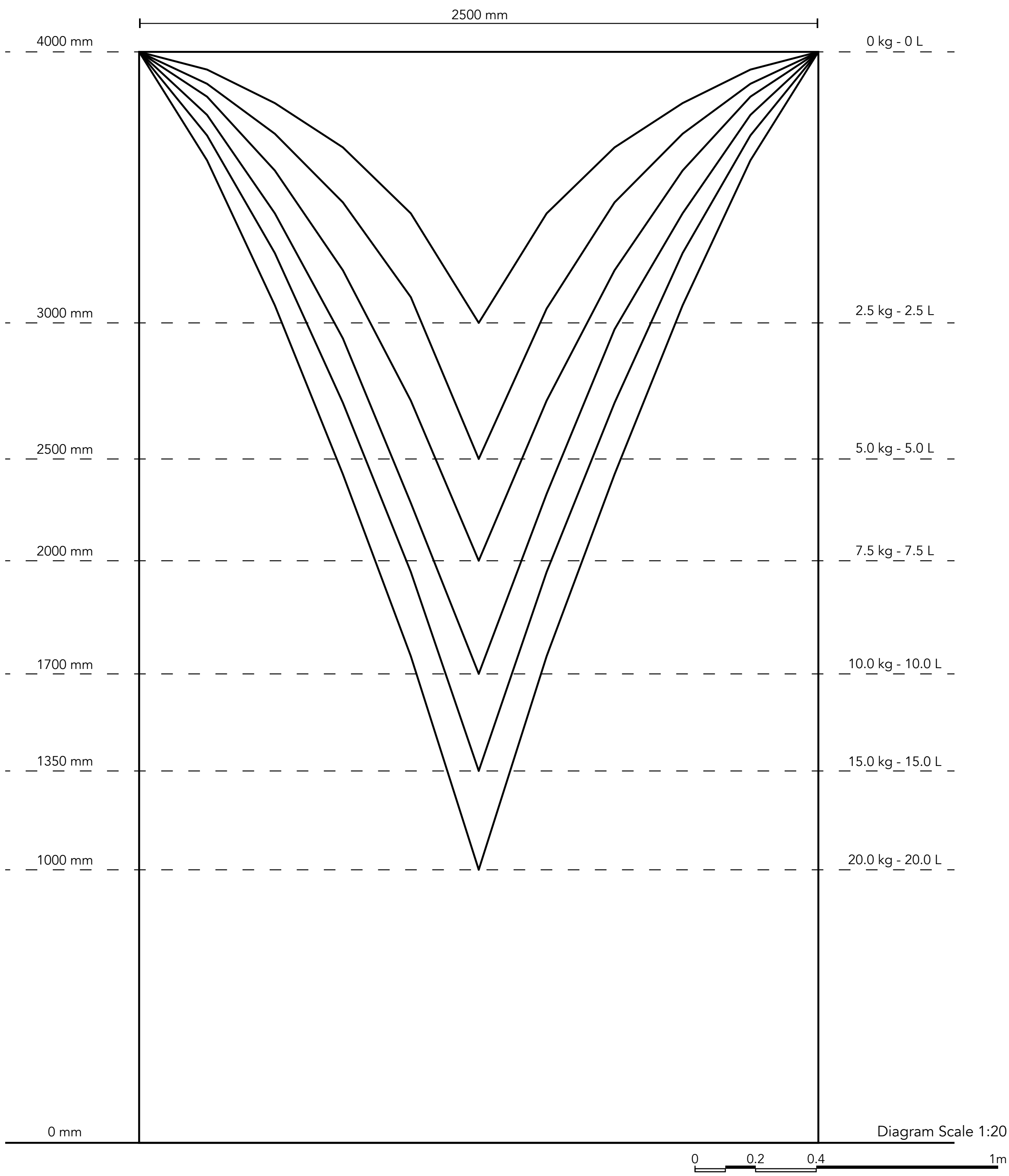



3000 g




4000 g

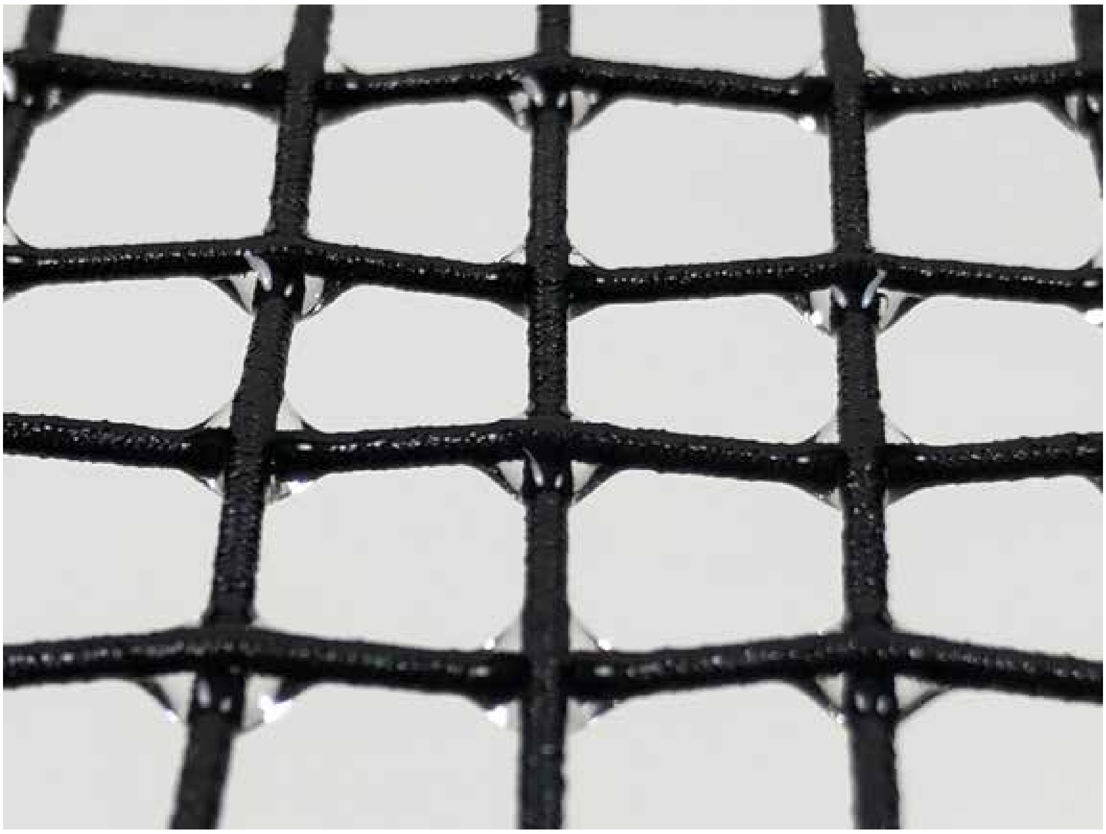
# Water weight and curves development



## Mesh size

The mesh size is dependent on the amount of water that needs to be collected and therefore the size of the droplets is an important factor. The droplets need to be big enough to cover the mesh, to collect as much rain as possible. In the prototype experiment I also noticed that the weight can only hang from the knots for the arch to form smoothly. If you skip a knot the net will deform. The weight needs to decrease hanging from every knot on the mesh to get a smooth and beautiful arch.

After knowing how much water is needed for the net to transform I decided to make the mesh size larger. It has to be a lot bigger than the drop formation experiment that I did earlier meaning that the net will not have the same effect as the experiments. The rain droplets will still form and the rainwater will still run along the net, but it will not be as visible. Instead I decided to work with the light and the droplets to get the same effect of drop formation and guiding the rain.



## The metal frame

The net needs a frame to be weaved in between. To be able to have a thin structure that does not overpower the arch of the pavilion I decided to use a metal frame. The metal frame is the load bearing structure of the pavilion. To be able to withstand both the tension and mechanical deformations, the weight of the net, droplets and collected water is taken into consideration to decide the right dimensions for the frame.

The metal frame is also not affected by the rainfall, which gives a more durable structure. The frame is also darker in color to blend in more with the net. The connection between the steel frame and the ground is through a concrete foundation. The column foot is welded to a steel plate and bolted to the concrete foundations.

## Amount rainfall

It rains almost every third day in Gothenburg. The average amount of rainfall during rainy days here is around 4,9 mm, as mentioned in my discourse. This means that one square meter space can collect up to 4,9 liters of rainwater. The prototype model is 2,5 square meter large which means that it can collect up to 30 liters of rain if the whole surface area is covered. The most amount of water needed for the net to drop down is around 20 litres. This means that if the most part of the prototype is covered the net reacting to rainfall is successful.



Average rainy day
4,9 mm

One square meter
4,9 liter

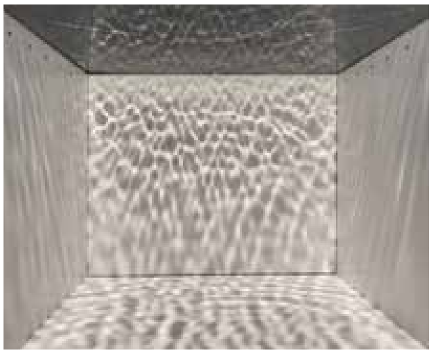
Prototype model (2,5x2,5 m)
30 liters

## Light study

Light is an important part in this project. Light can elevate the experience of rain by using it to reflect the water and highlighting the rainfall. I started to explore how flat and curved surface reflects rain. The water creates stronger and more concentrated reflection when the surface is curved. This effect is called caustic light. This is a phenomenon that occurs when light bounces inside a shape and becomes concentrated. The concentration of light needs only natural light, which is something I want to work with in this design.

Reflection of flat surface.

Water droplet’s reflection on flat surface.



Collected water reflection on flat surface.

Reflection of curved surface.

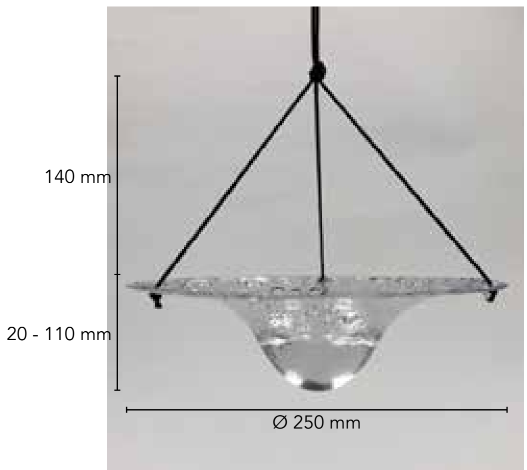
Water droplet’s reflection on curved surface.

Collected water reflection on curved surface.

## Droplet - design

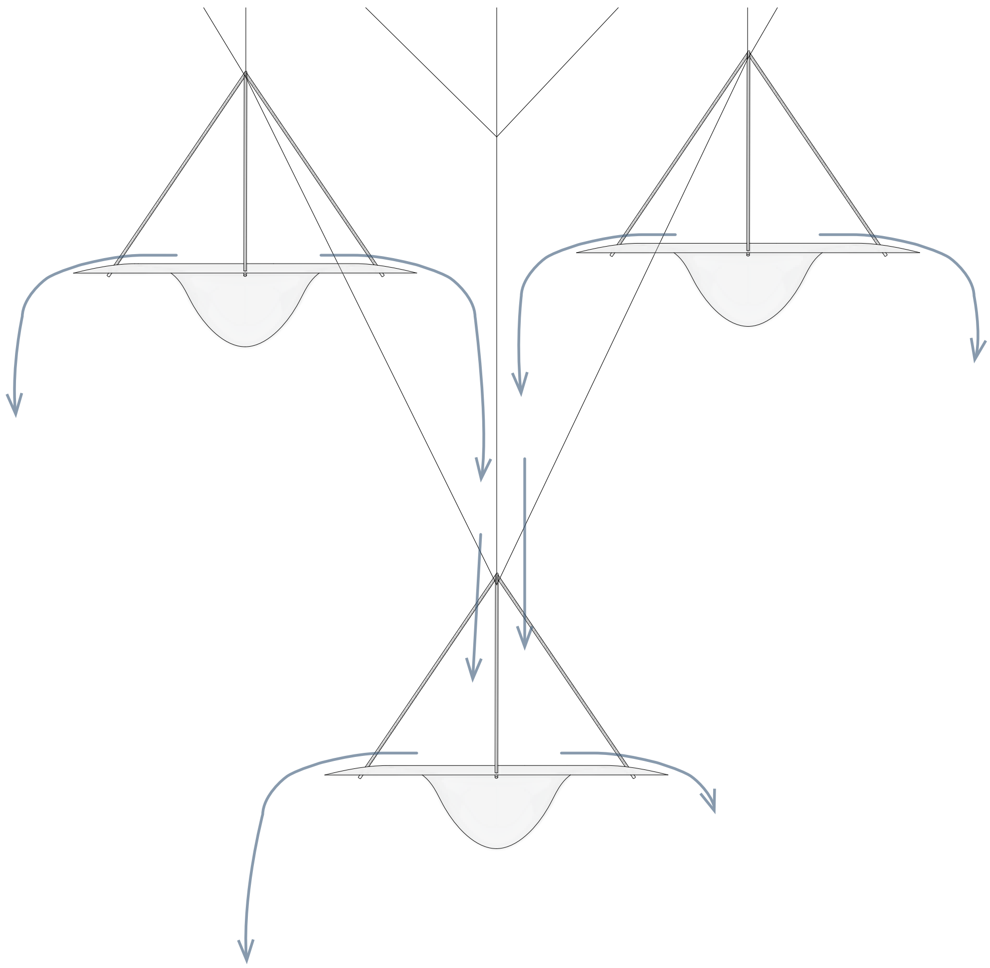
In the curve development experiment I noticed that the weight needs to hang from the knots or where the net crosses for the arch to shape best. The design of the droplets is therefore dependent on this. The droplets need a handle to hang from and then a wider surface to collect water from which gives it this kind of form. This also creates a flexibility to freely hang when the net starts to drop and the droplets gets more concentrated. It can also create interesting sound effect when the wind is strong.

The size of the droplet in dependent on the amount of water that needs to be collected. I experimented with different sizes and decided to have a droplet that is 250 mm in diameter. The shape of the droplets covers more surface to, maximizing the collecting effect. This size allows different volumes for the droplets without the need to change the diameter, only the depth of the "bowl".



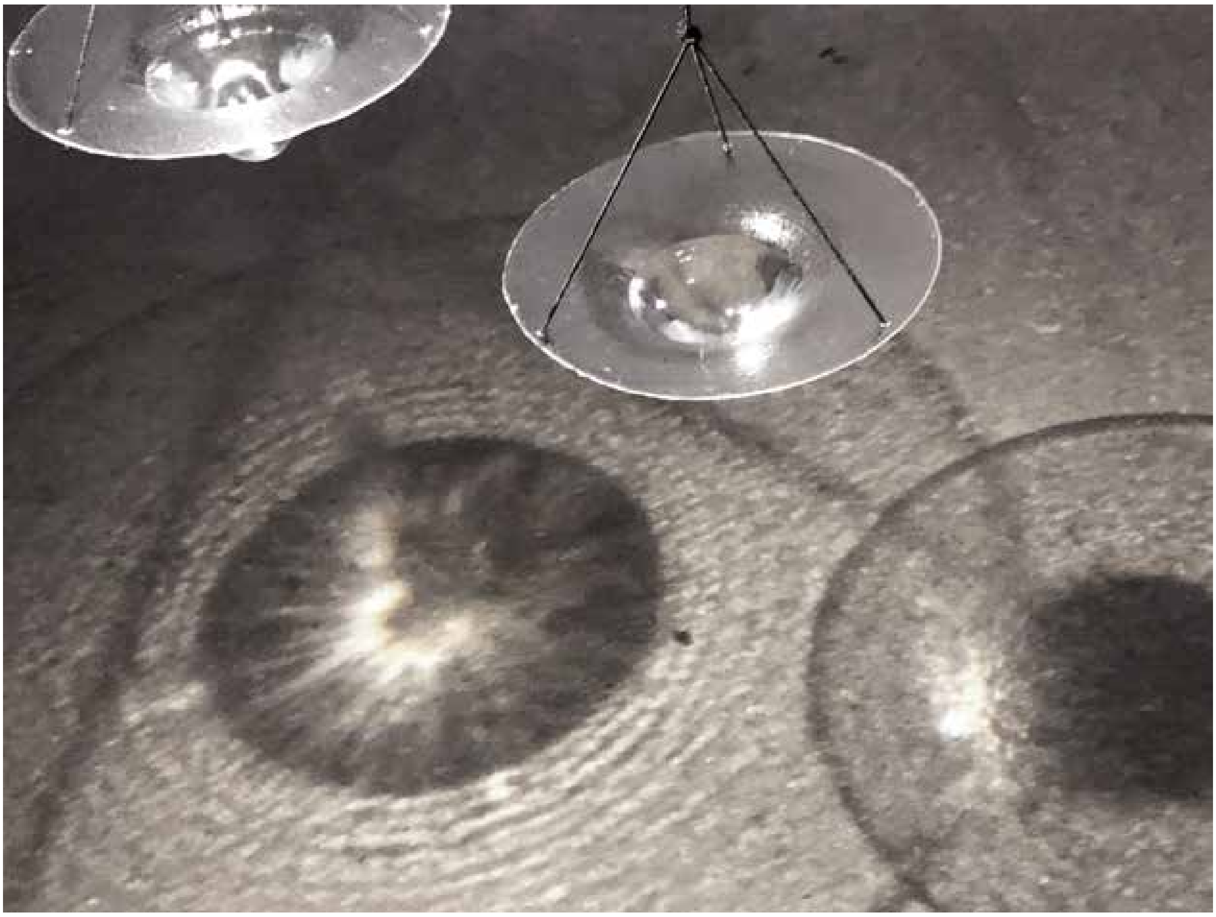

## Droplet - guiding the rain

The top surface of the droplets is slightly curved down which guides the rain and pours it down on the droplet underneath. Depending on where the droplet is hanging, the surface is curved down towards the anchor point. This creates a fountain effect where the rainwater steps down and gets more concentrated where the anchor point is.



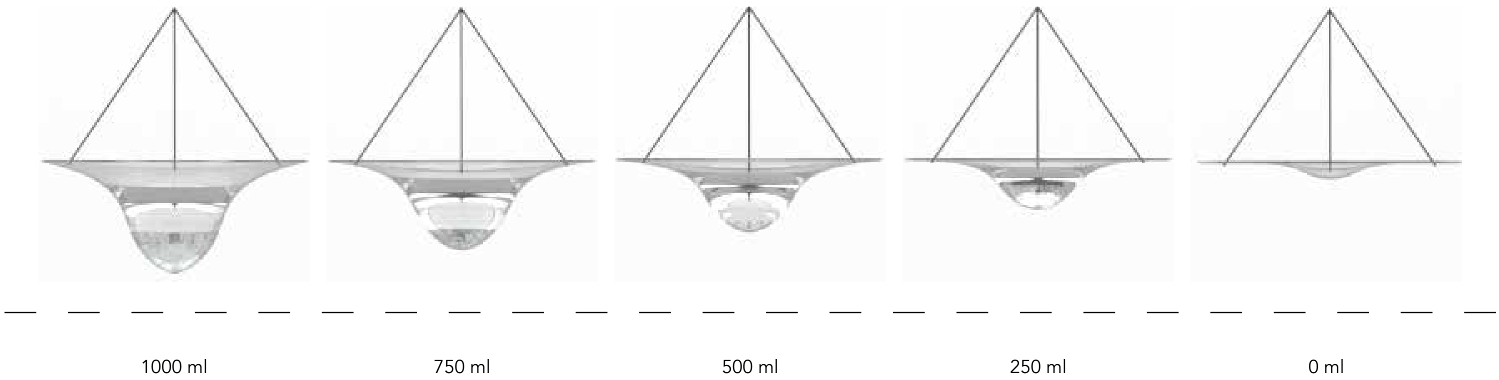
## Droplet - reflection

To be able to use the light to accentuate the rain I decided to collect the rain water in transparent cups. With the caustic light effect in mind the shape of the droplets concentrated the light in the middle and fans it out. This gives ripple like effect, mimicking the waves created on water when a raindrop falls. The caustic light gives concentrated reflection creating a light show that reminds of the rain, even when the sun is out.



## Droplet sizes

Since the weight needs to be distributed and decrease, I am using five different sizes for the droplets. The further out from the anchor point the smaller the size of the droplets get. The amount of weight, from the arch development experiment, is distributed over the net. this gives the different volumes you can see below. It was important to have a heavier weight at the anchor point to get the best arch shape. The smallest of the droplets are mostly there to guide the rain towards the anchor point.



## Smell of rain

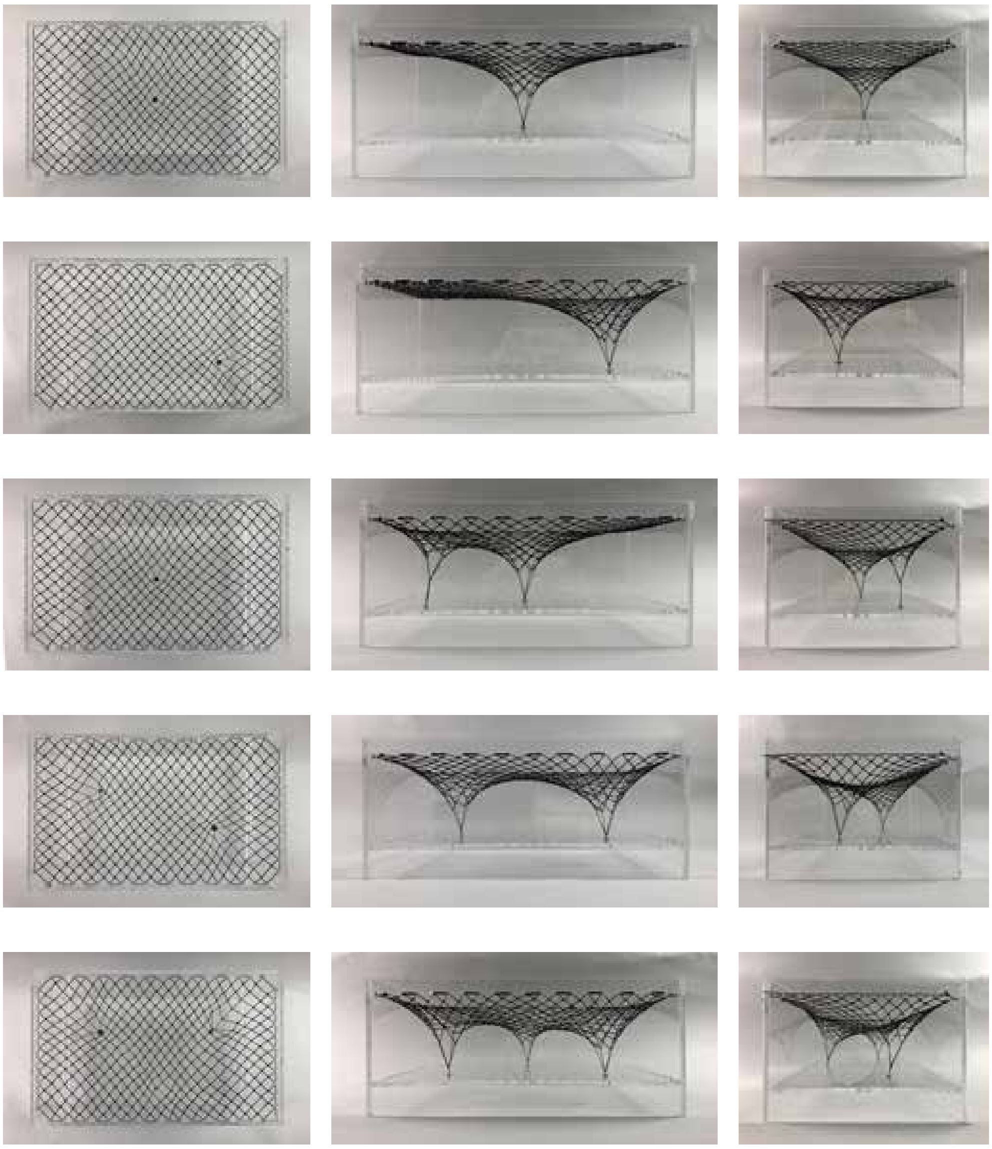
There are two important factors for the rain to smell. The first one being a dry ground and the second a porous material. The raindrops need to react with air to be able to release the scent, as mentioned in my discourse. The use of grass or other vegetation can also accentuate the smell of rain. Potential materials for the ground can be rough concrete, loose soil or stone pavement and hint of vegetation.

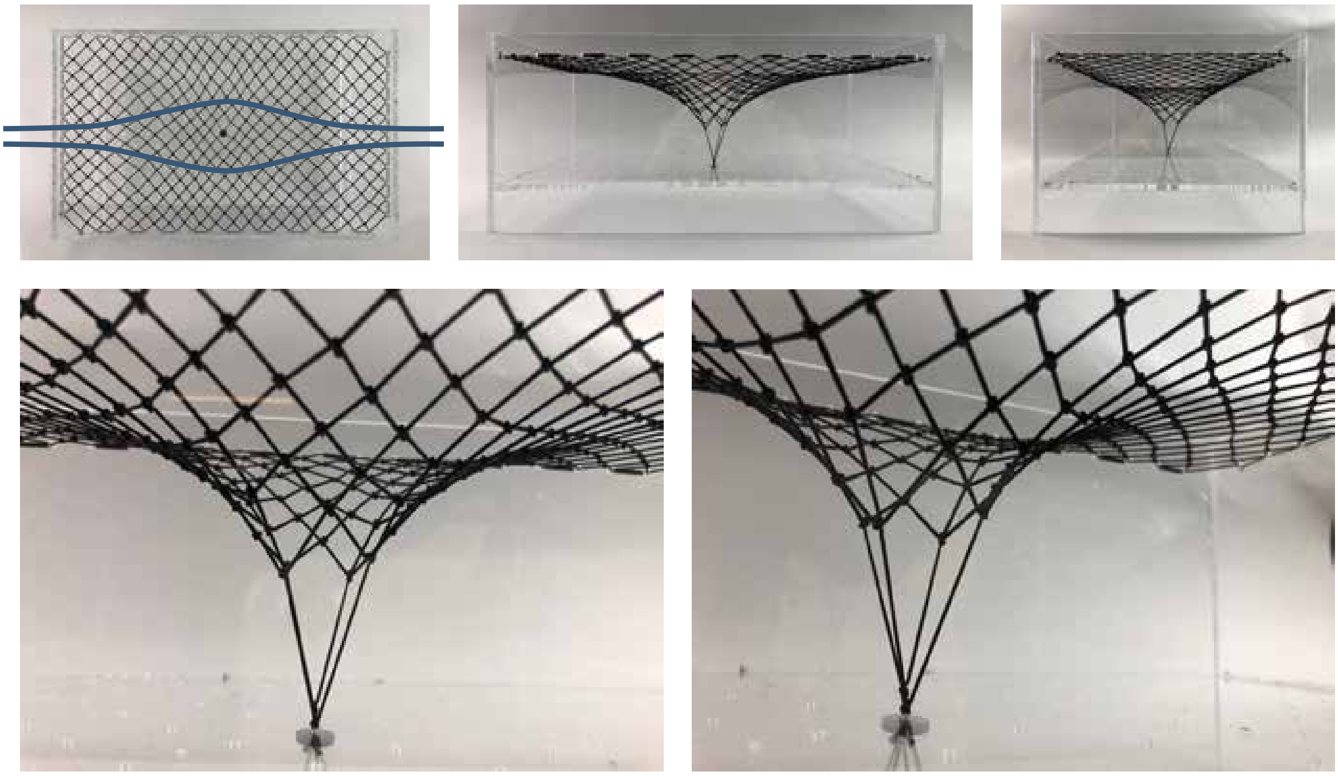
Since the light is an important part in the rain experience the ground need to be smooth enough to reflect the light. Consequently, I decided to have two different ground materials with different texture. The material you walk on is loose gravel where the access to air is plenty, increasing the smell of rain. Also, allowing the rainwater to sip through avoiding standing water during rainfall. The walking path can also be grass depending on the context.

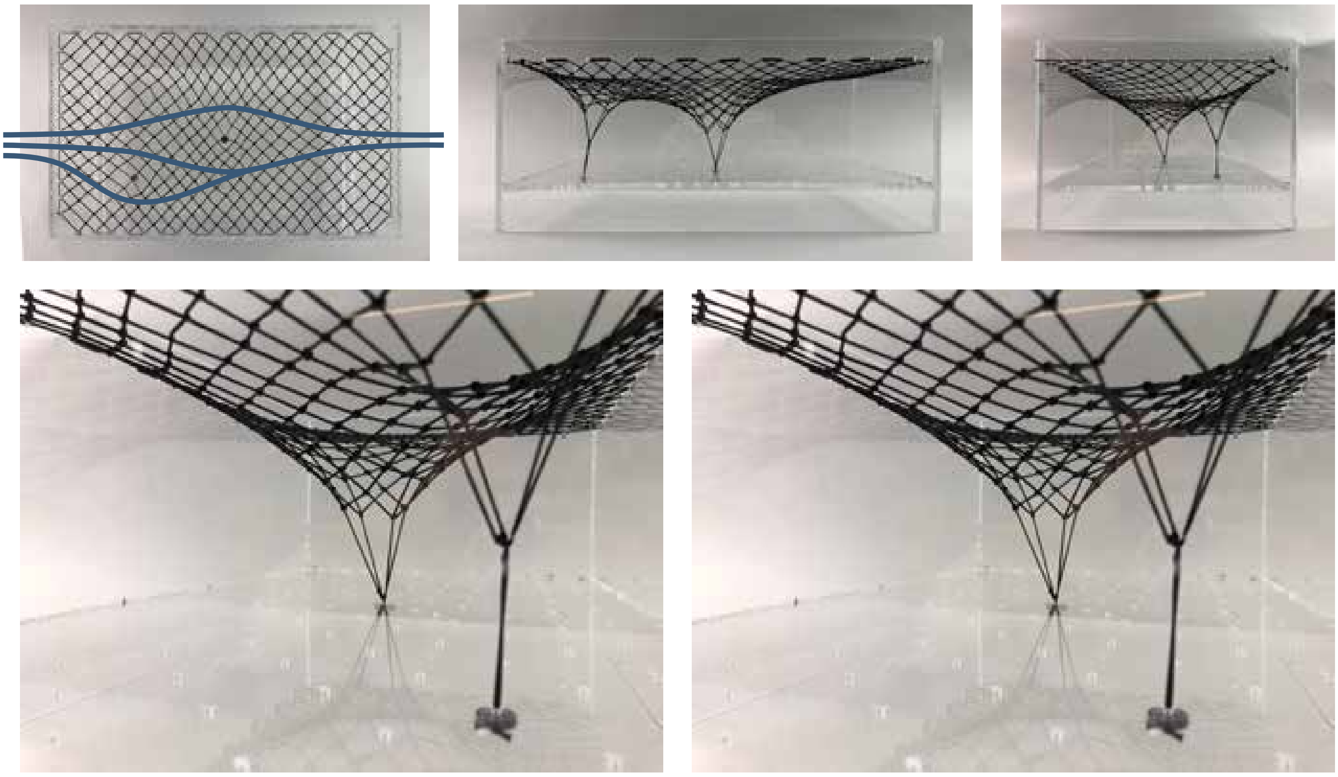
The second material is a smooth dark concrete surface which is located under the anchor points in the net where the rainwater collects. This flooring amplifies the light reflection from the transparent droplets. It also allows standing water which can highlight the falling droplets and the reflection on water is intensified.

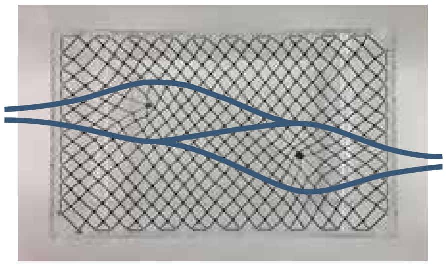
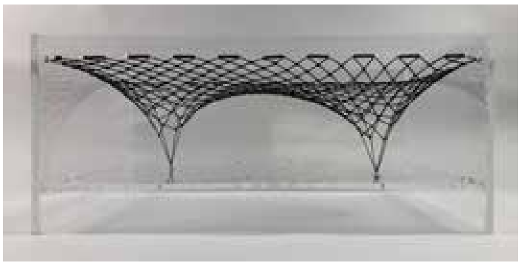
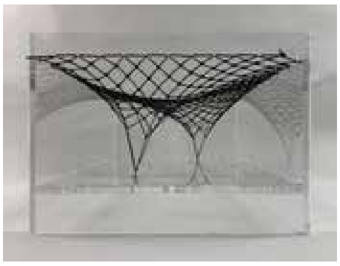
## Movements and spatiality

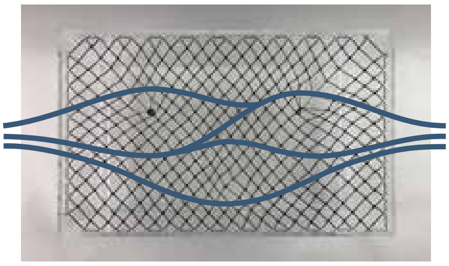
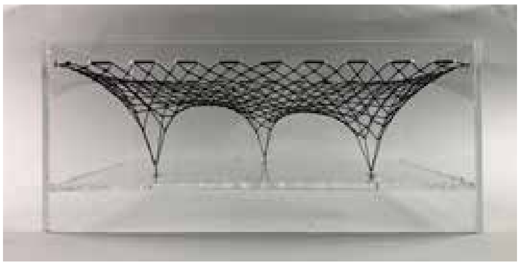
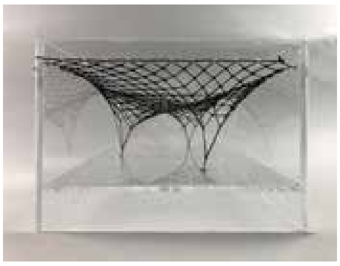
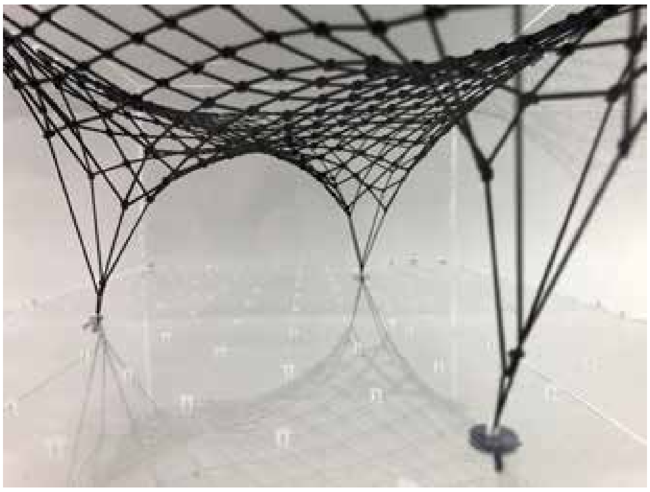
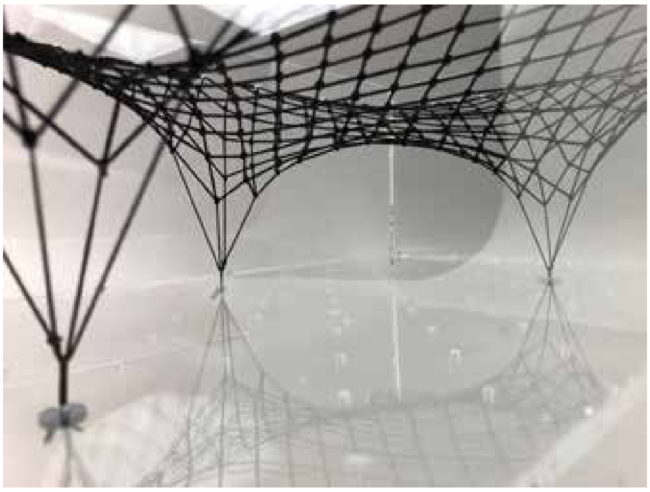
With this model I wanted to experiment the movement and the atmosphere that is created when the mesh drops down in different anchor points. One anchor point in the middle divides the movement and gives a central core. Two anchor points across from each other gives a more s-shape movement, creating a one direction path. Three anchor point gives a dynamic atmosphere and allows a lot of movement options.







Potential rain locations appointed by the city.

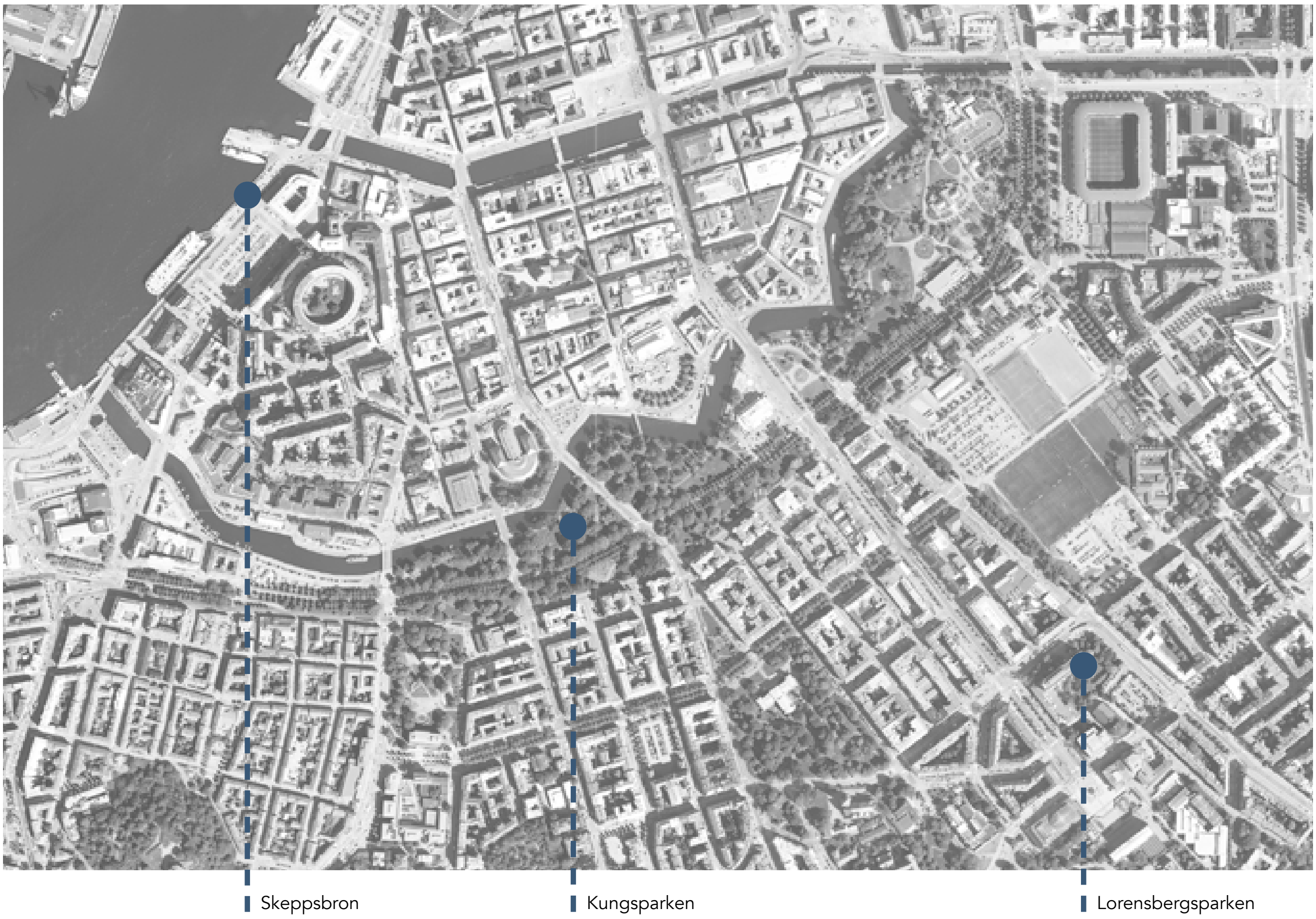
Locations that are affected during rainfall.

## RAIN LOCATIONS

To find the most suitable locations for the pavilions I started to research where in Gothenburg rain can be most prominent. The results where a few places appointed by the municipality and some locations where the rainfall has great presence.

As a part of the 400th anniversary, the city of Gothenburg wants to become the best city when it rains. The aim is to install water and rain related projects around the city to enhance the rain experience. The municipality has appointed some locations in the central part of the city for these projects. The locations are Frihamnen where Jubileumsparken is, Skeppsbron, Lorensbergsparken and the amusement park Liseberg (Gothenburg 2021, 2016).

There are some locations in the city where rain has great impact. I was able to locate these places by studying the city's flood map (Göteborgs Stad, 2020), which shows the areas in Gothenburg that are most affected by rainfall. These locations will have problem with standing water during rainfall, meaning that the effects of rain will be noticeable on site. The focus area is the central parts of the city. The locations are Vallgraven, Kungsparken, Heden, Mölndalsån and Näckrosdammen.



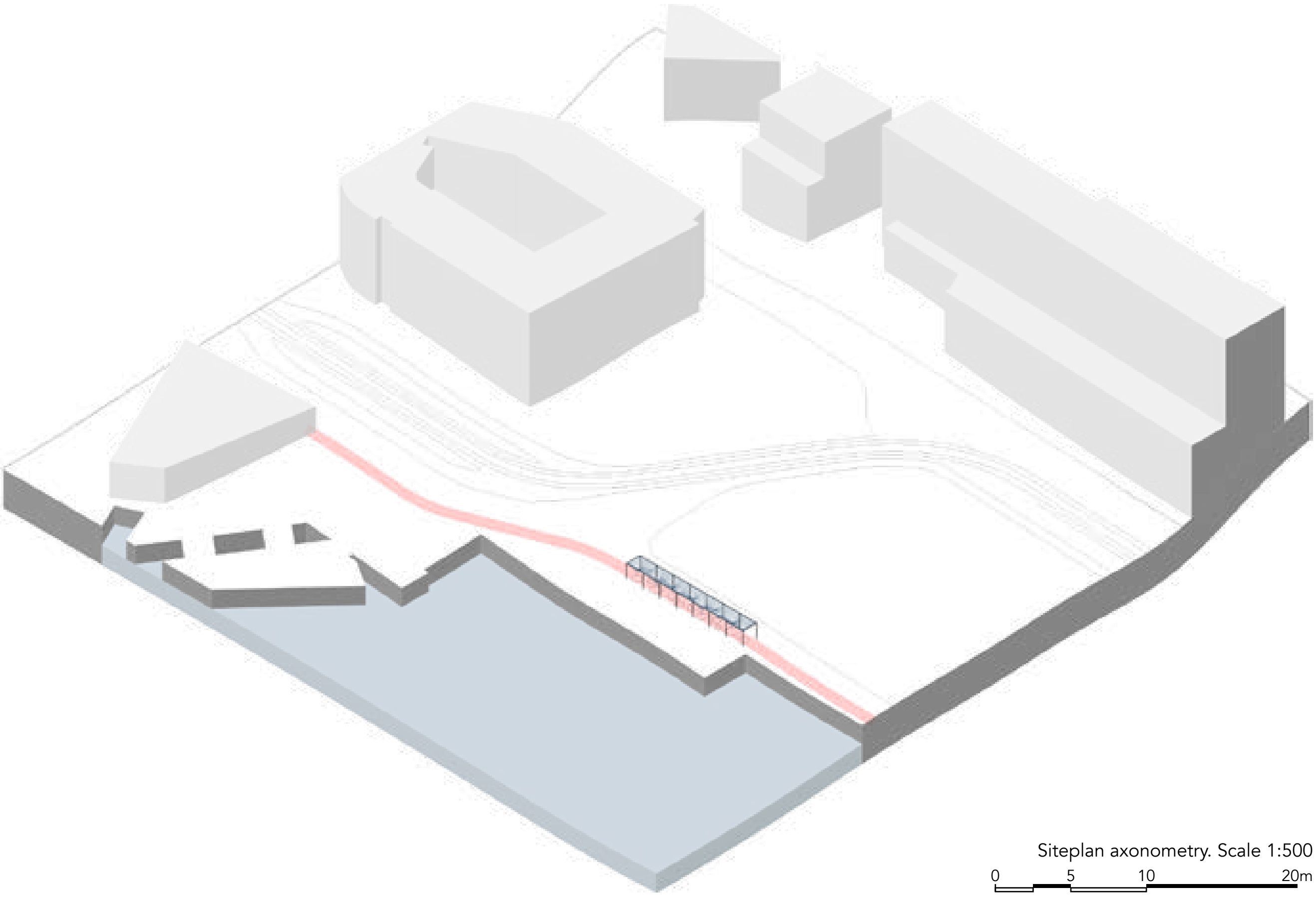

## PAVILION LOCATIONS

The three sites chosen for this proposal are Skeppsbron, Kungsparken and Lorensbergsparken. The different characteristics of the sites reflects back on the three rain scenarios from the rain walks in the city. Skeppsbron is where the exposed pavilion will be located. Kungsparken is where the enclosed pavilion is located and lastly Lorensbergsparken is where the urban pavilion is located.

The pavilions introduce three different ways the structure can be adapted on to context. The form is depending on the movement patterns, the surrounding buildings or vegetation and other elements. They are located in a city context to make them more accessible. The pavilions are also in walking distance from each other allowing a relation between them.

## SKEPPSBRON

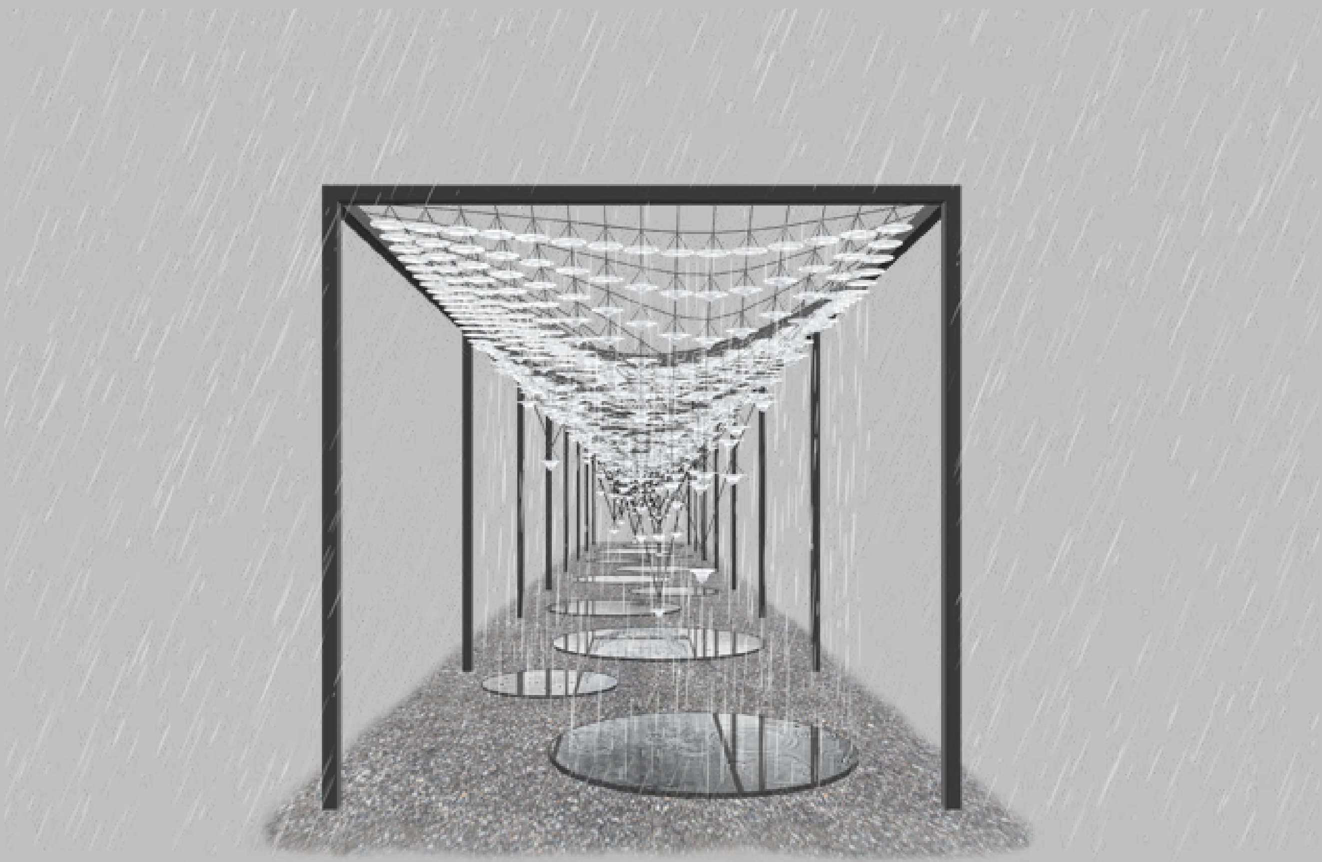
The site chosen for the exposed pavilion is located in Skeppsbron, a pier along the Göta river. Skeppsbron connects the city to the water but the area today is not well used. The traffic is heavy here and the area is mostly used for parking the cars. But the municipality wants to make the connection to water stronger and plans to develop the area into a central meeting point by the water. To place a rain pavilion here will highlight the connection to the water further.





## Skeppsbron site

The area is very open and exposed. There is a walking path here today, close to the water edge, that goes from the city centre down. I decided to locate the exposed pavilion on this path. The rain is harshest close to the open water and I wanted to create the opportunity to enjoy it while walking by. Since there is not a lot of other places to walk on here the movement is almost linear, which results in this 35meter long, tunnel like pavilion. The shape of the pavilion embodies the qualities of the site, allowing people to walk on the path during rainfall and enjoy the rain.



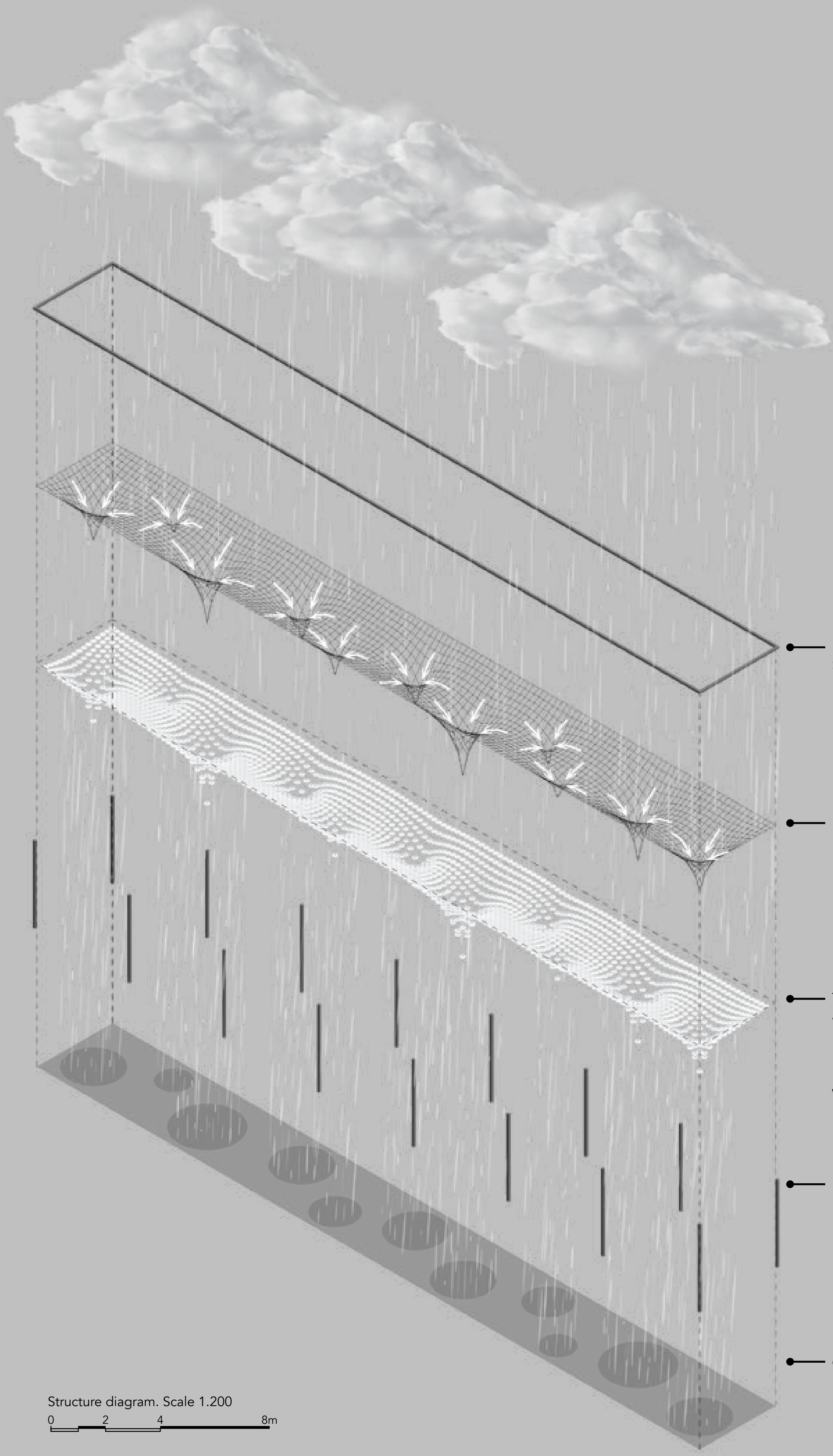
## The pavilion

The long shape of the pavilion follows the path it is placed on. It creates a semi shelter where the visitors can walk under and still feel the rain and the strong winds. The experience of rain will be very different in this context. The winds are stronger and you are surrounded by water in an open space.

During rainfall the droplets guide the rain to the anchor points where it will pour down. This encloses the space underneath and creates a changing tunnel to walk through. The strong winds here will blow the falling rain away making it almost feel like you are walking through water instead of under it. This embodies the phenomenon and highlights the experience even more.

In Skeppsbron the smell of rain after a hot day will be of ozone and salt because of the closeness to water. The area is covered in concrete and asphalt otherwise which will accentuate the scent further. But the weather is very windy here so the smell of rain will be short term and not noticeable but you will still feel all the water.

The droplets here will create a sound effect when the winds blow making the experience multi sensory. Since you are surrounded by water here the sensation of rain is accentuated even more.



## Structure

Metal beams - 100x100 mm
Size - 4500x35000 mm

Textile net - 4 mm thickness
Mesh - 250x250 mm
Weight - 4,8 kg

Transparent plastic droplets
4 sizes - 1000 ml
750 ml
500 ml
250 ml
Weight with water - 165 kg

Metal columns - 100x100 mm
Height - 4000 mm

Ground - gravel on path
- concrete under anchor points

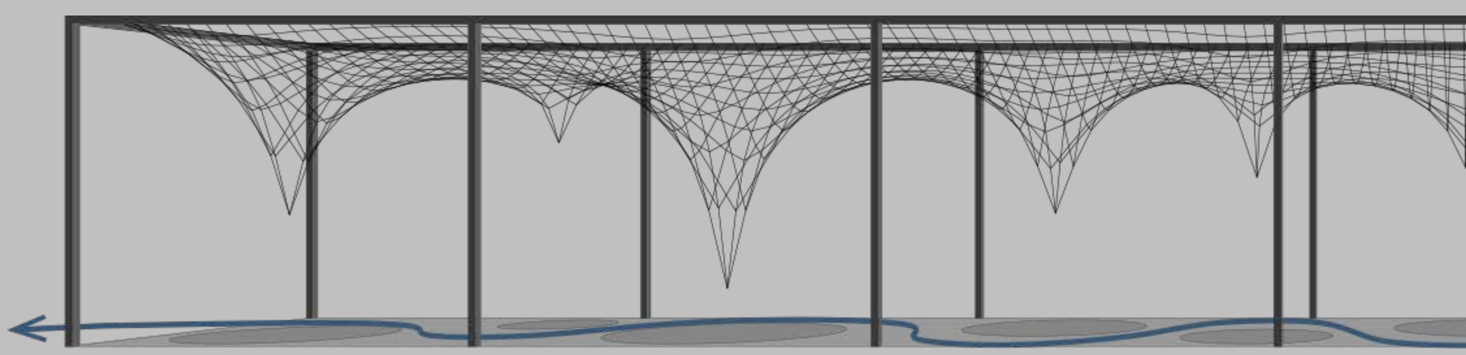
Structure diagram. Scale 1.200

0 2 4 8m

## Movement and spatiality

During rainfall when the net drops down, it created a s-shape movement allowing people to slow down a little and enjoy the rain while still walking forward. The anchor points are across from each other and differs in size.

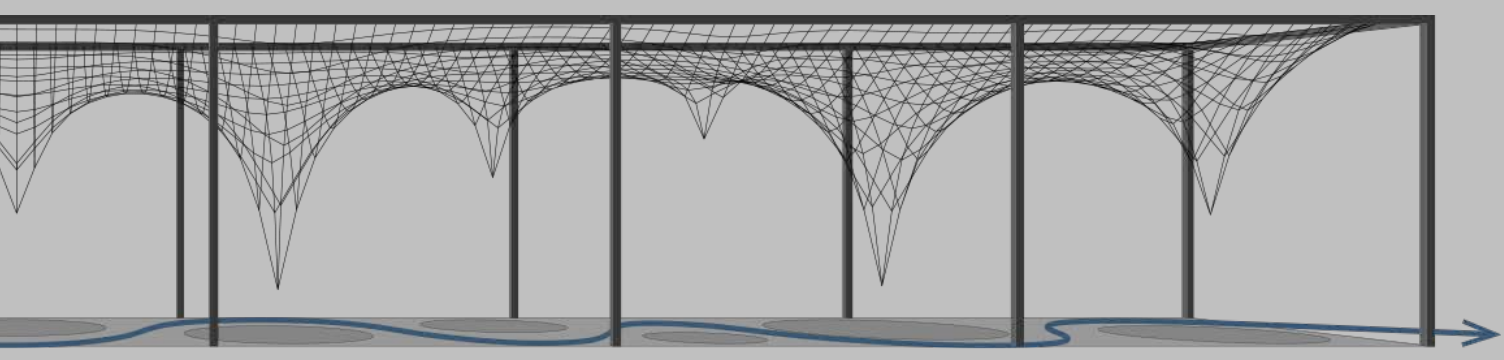
The gravel covered path will be even more important here since standing water so close to the river is a given. The gravel will filter the rain water through and give the visitors a more comfortable path to walk on. The ripples created by rain drops on the water surface will be everywhere but the pavilion will provide a closer access to it making the connection to rain stronger.

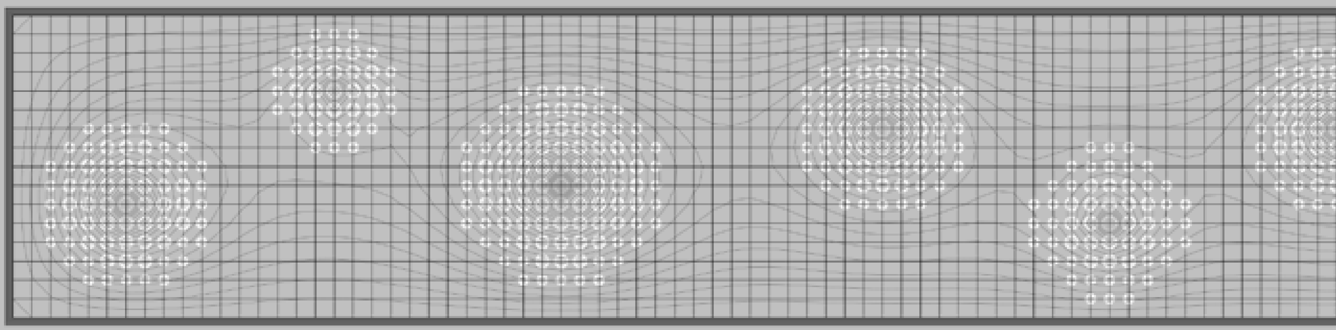


## Plan and elevation

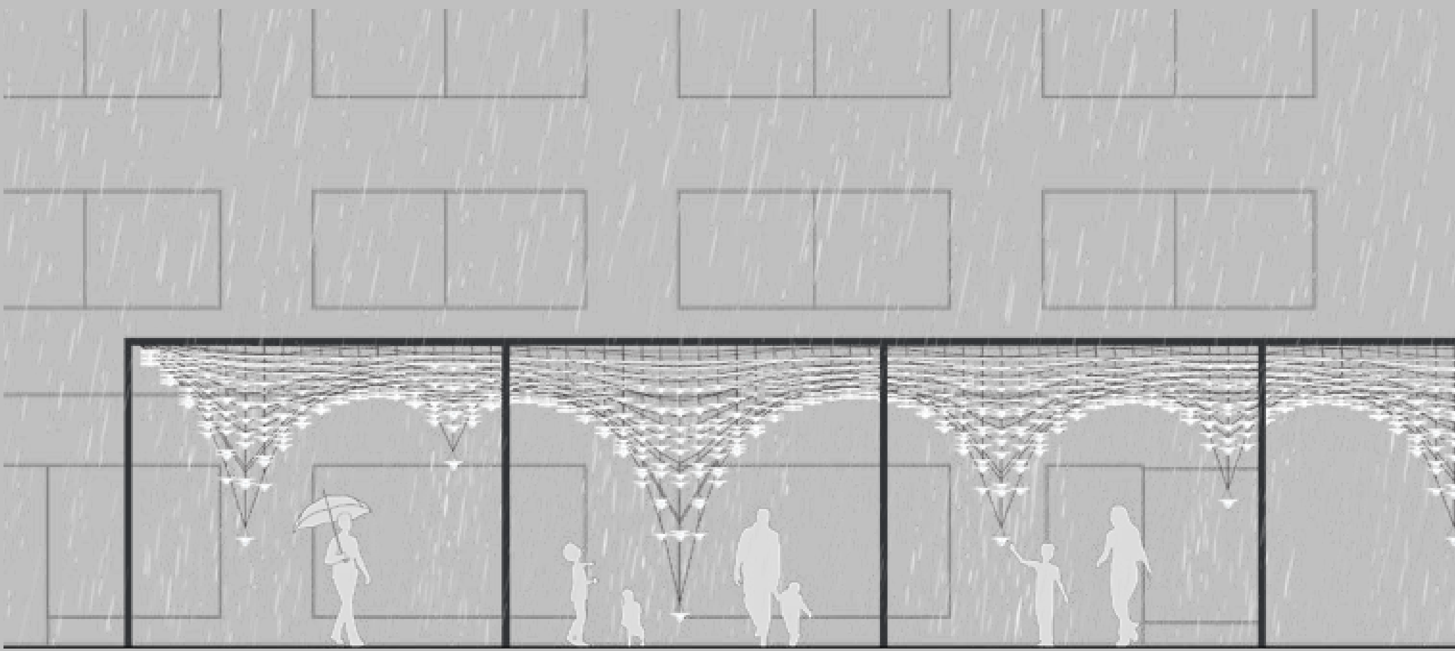
The curve developing plan illustrates how the curves develop and how the droplets are spread. During rainfall the droplets guide the rain to the anchor points where it will pour down. This encloses the space underneath and creates a changing tunnel to walk through, illustrated in the rain elevation. The strong winds will blow the falling rain away making it almost feel like you are walking through water instead of under it. This embodies the phenomenon and highlights the experience even more.

The relation between the pavilion and the water is very close. This is also highlighted by the narrower shape of the pavilion. This dimension also accentuates the exposed spatiality during sunny days. The ground material illustrates the materiality of the ground and the sizes of the concrete surfaces beneath the anchor points. The standing water on the concrete during rainfall reflects and highlights the falling rain further. The elevation without rain illustrates how the light will reflect down through the droplets.

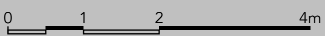


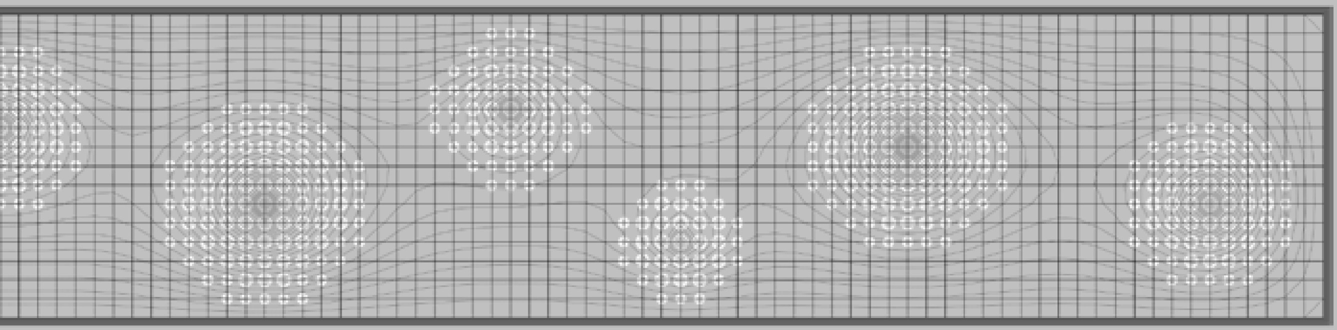


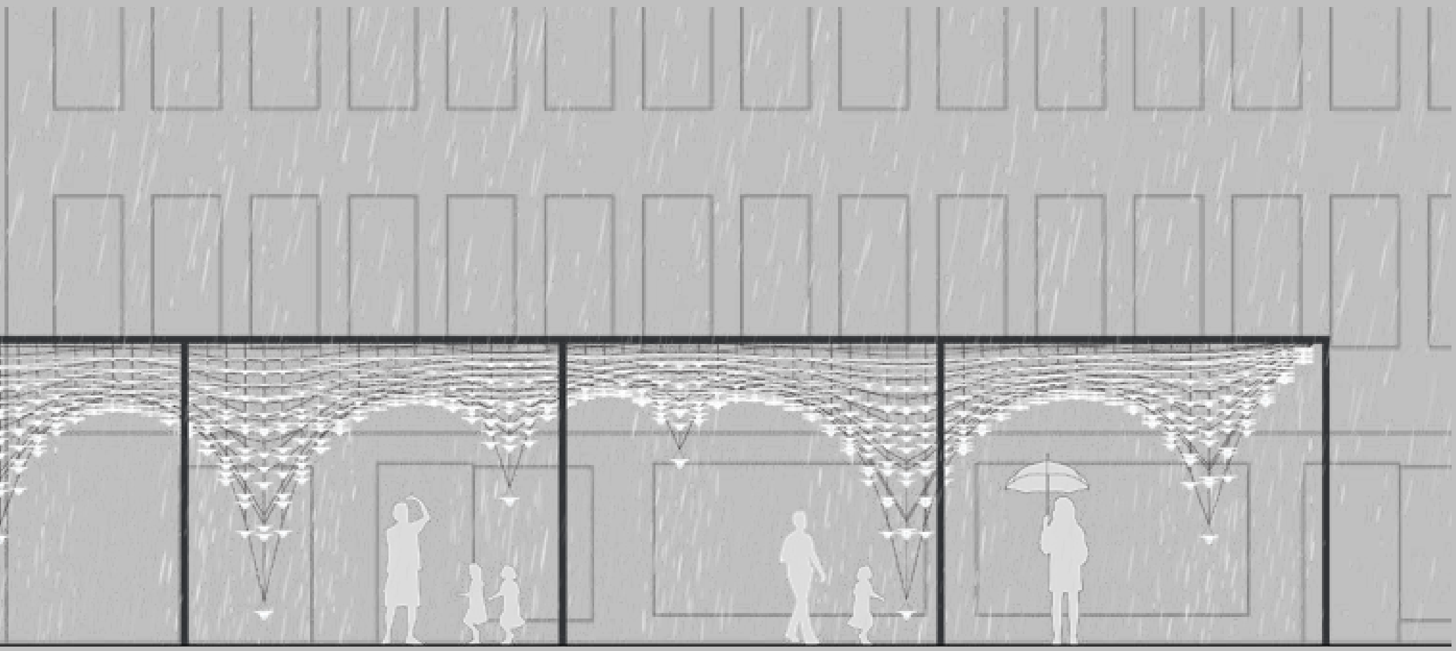
Plan curve development. Scale 1.100

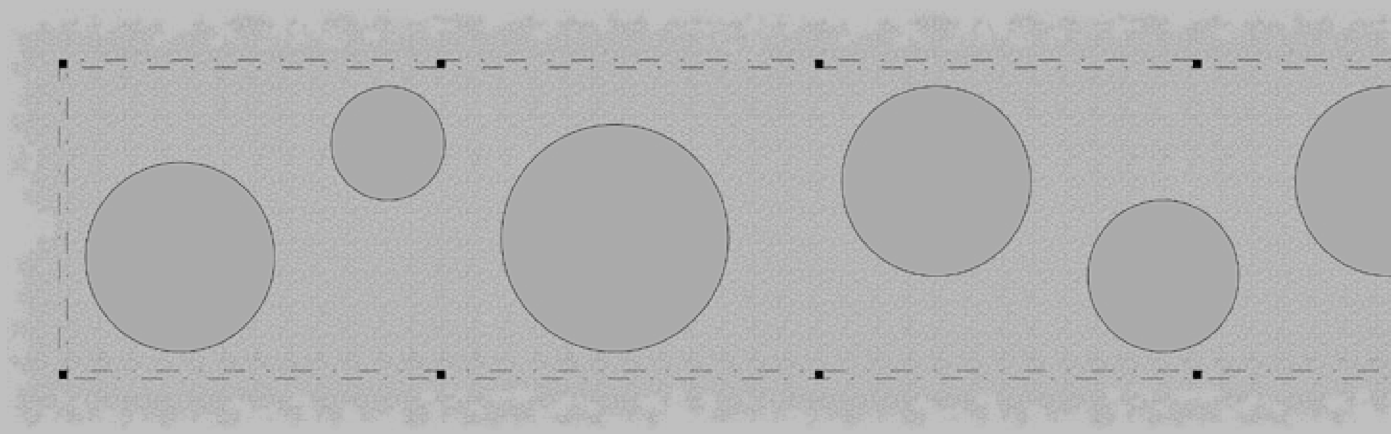


Elevation with rain. Scale 1.100

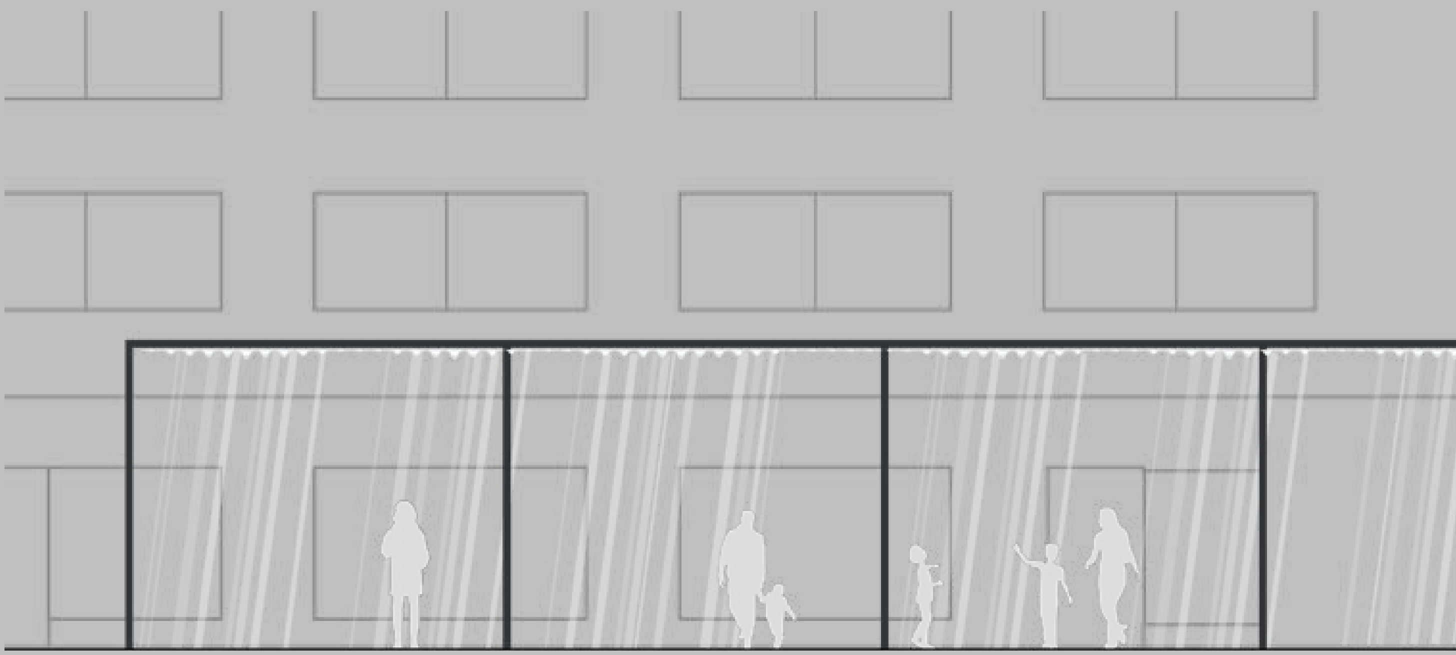




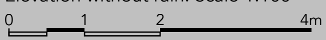


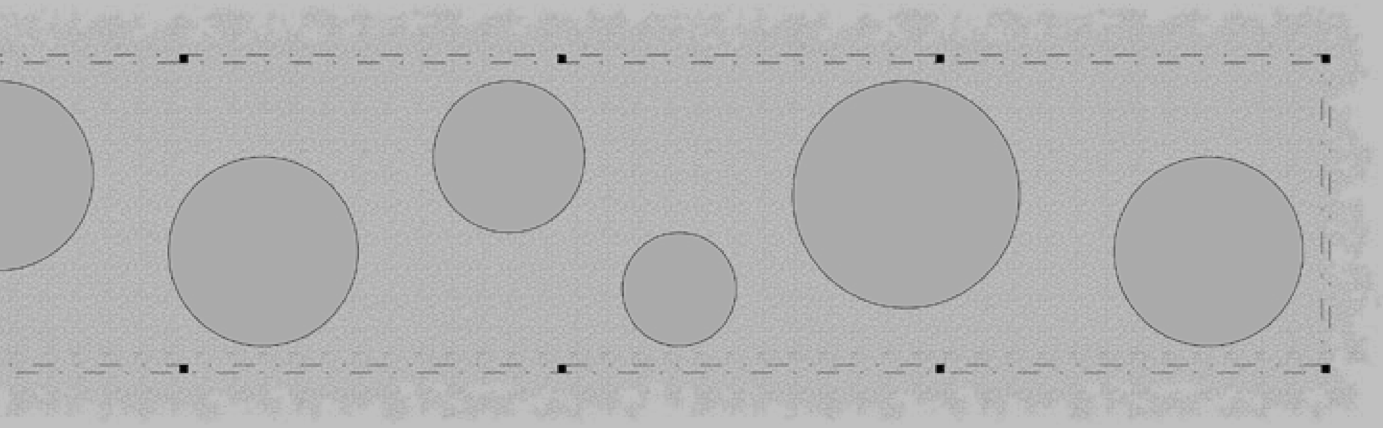


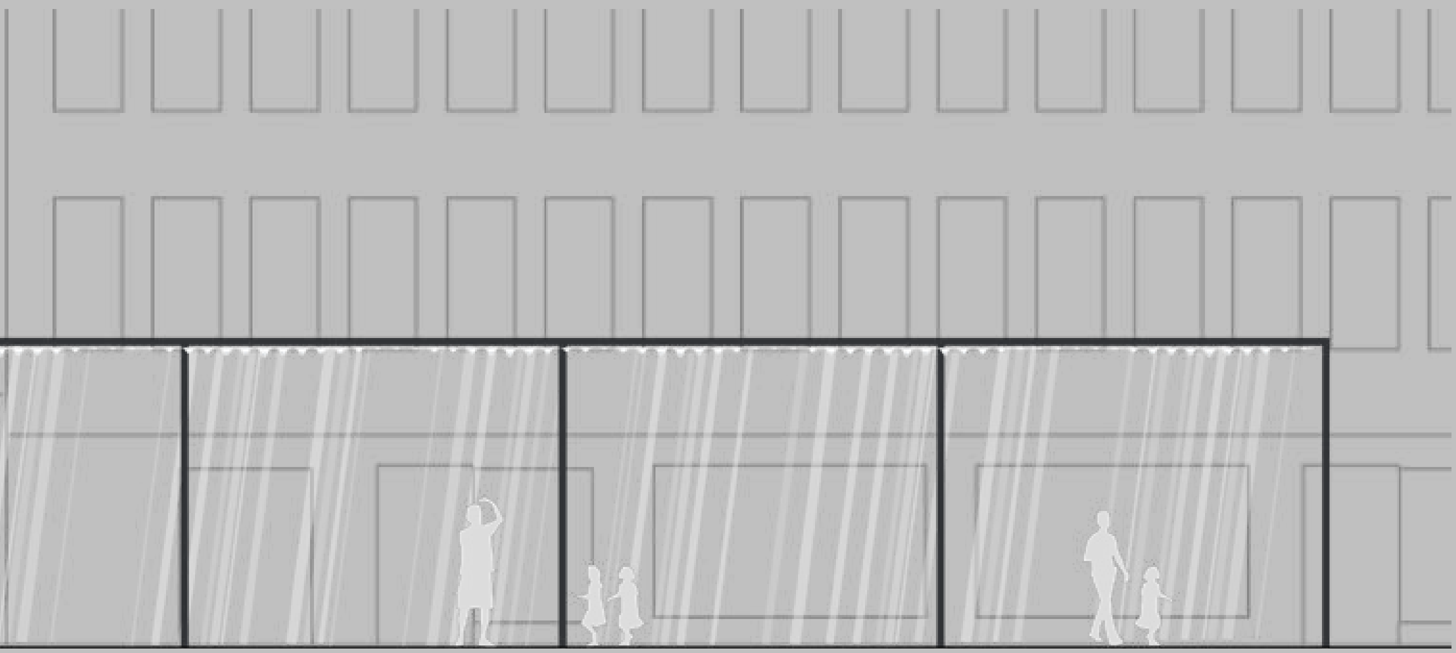
Plan ground materiality. Scale 1.100



Elevation without rain. Scale 1.100

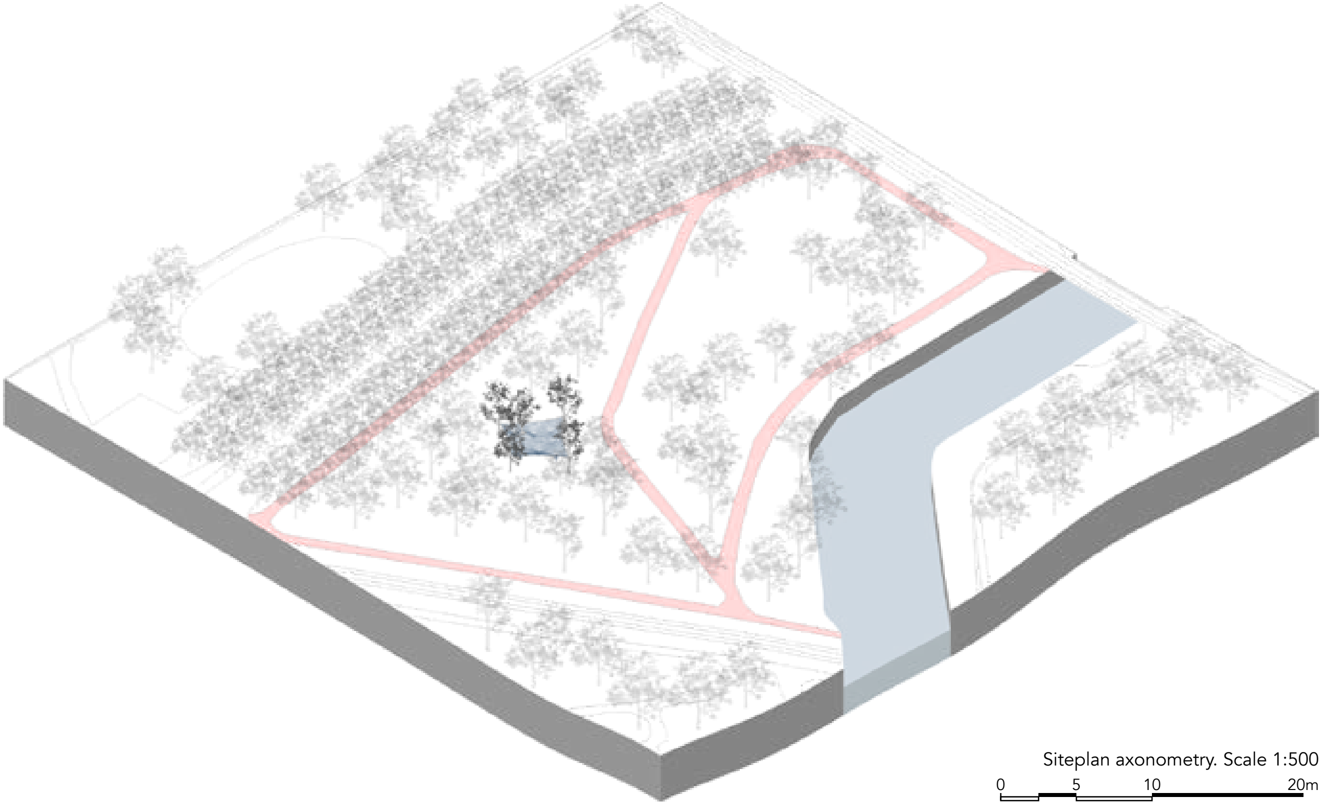






## KUNGSPARKEN

The location for the enclosed pavilion is Kungsparken. Kungsparken is a central green belt in the middle of Gothenburg. It connects several central areas in the city. You have the canal close by making the park even more appealing. It is located along Nya Allen and stretches from Stora Teatern to Järntorget. Vasabron is the bridge closes to the pavilion connecting it to Grönsakstorget and inner Vallgraven. The location of the park is very suitable for a public pavilion.

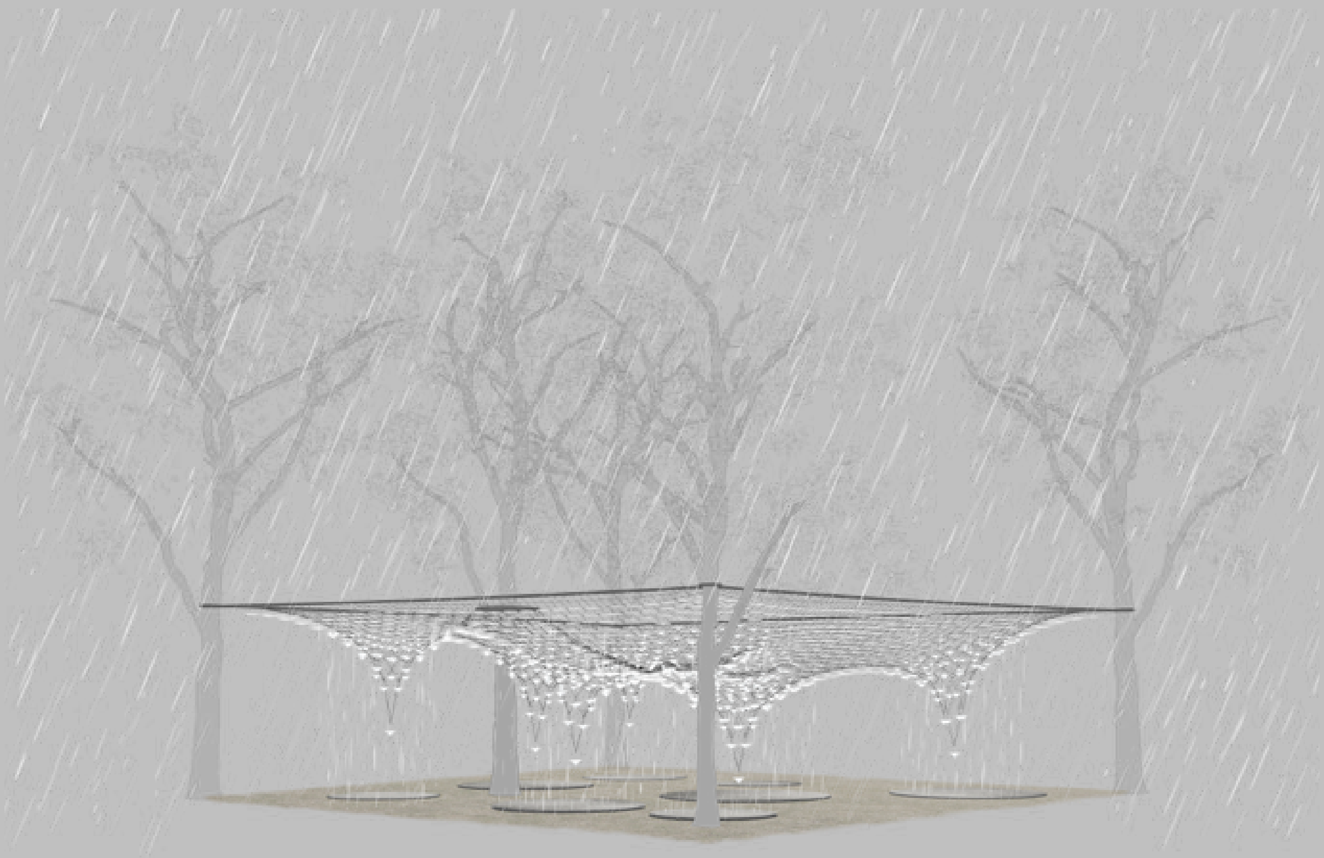


Siteplan axonometry. Scale 1:500



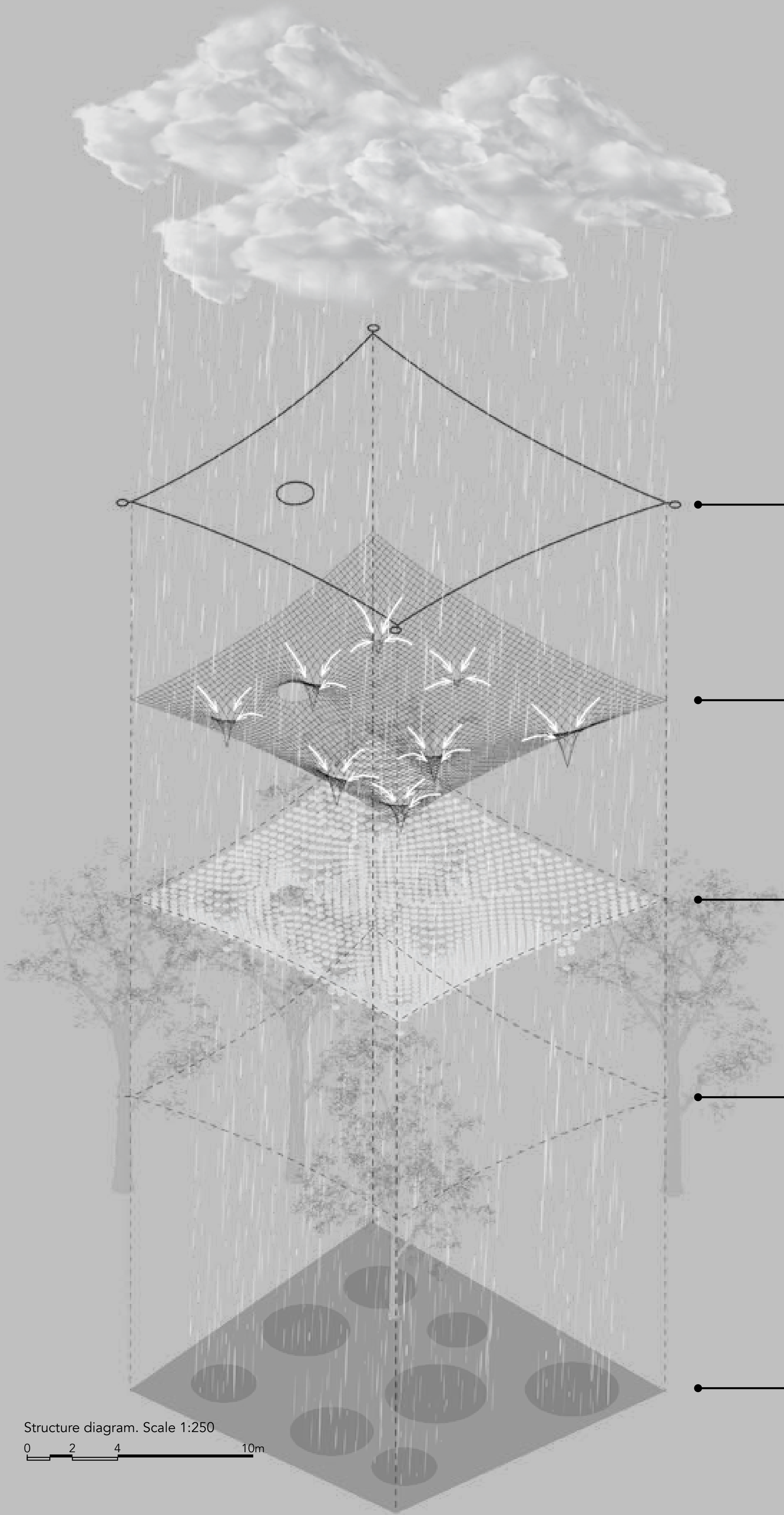
## Kungsparken site

Kungsparken is covered in big trees and vegetation which is a suitable location for the enclosed pavilion scenario. The pavilion is placed in the middle of the park surrounded by large trees. Active walkways go around the pavilion making it easier to access. The park is one of the areas in the city centre where rain has great effect on. Since it is mostly covered in grass, and lays low, during heavy rainfall the area is risking to be flooded. When walking around in the park I notice a lot of puddles and standing water. This can give the visitors a new experience of rain. To highlight differences in the phenomenon I decided to locate the pavilion here.



## The pavilion

To embody the site and the qualities it provides I decided to have the flexible netting structure in tension between the trees. Instead of beams to carry the load, the pavilion will have steel wire rope that the net is weaved on. The structure is then supported by the tree trunks four meter up. Since the rain here is delayed by the trees and does not fall as heavily as in an open area I decided to cover more area to be able to catch as much rain as possible. The net layer is consequently larger but the mesh size is the same. To be able to concentrate the rain for a fuller effect the area of the droplets is slightly larger. The cups have the same volume, only the top surface is wider. This catches more raindrops and guides them towards the anchor points.



Structure diagram. Scale 1:250

0 2 4 10m

## Structure

Steel wire - Ø 50 mm
Size - 15000x13500 mm

Textile net - 4 mm thickness
Mesh - 250x250 mm
Weight - 9 kg

Transparent plastic droplets
4 sizes - 1000 ml
750 ml
500 ml
250 ml
Weight with water - 230 kg

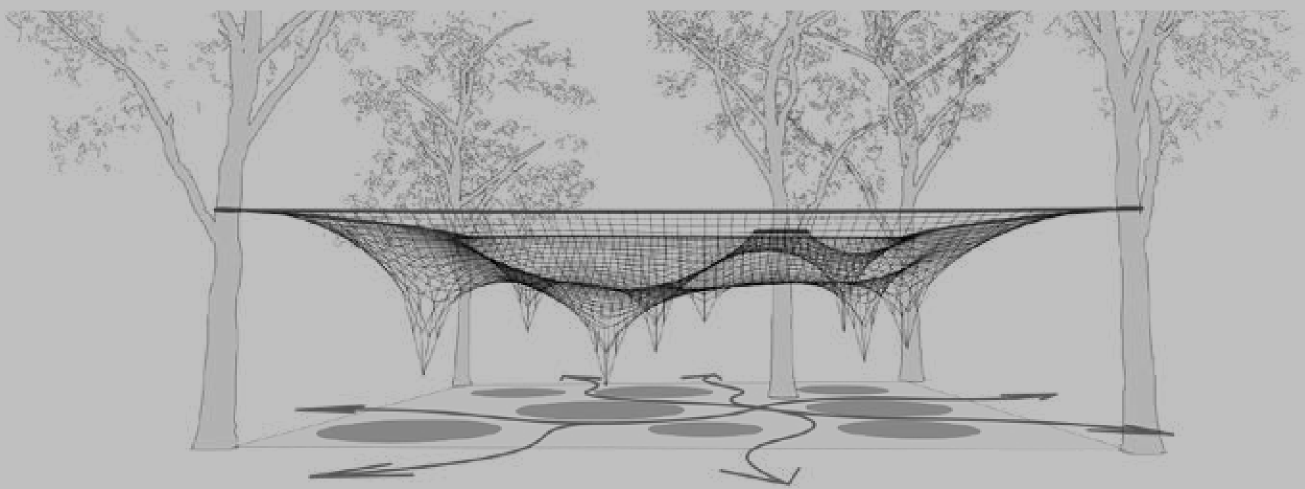
Supporting tree trunks
Height - 4000 mm

Ground - grass to walk on
- concrete under the anchor points

## Movement and spatiality

The anchor points are more randomly places here to give a dynamic spatiality. To get a fuller effect of the enclosed space during rainfall the anchor points are fewer and further apart from each other. This gives bigger spaces below for the visitors to stay under and enjoy the rain. The wider shape also encourages visitors to stay and move around under the droplets and trees instead of walking by.

The smell of rain is also accentuated by vegetation as mentioned in my discourse. Consequently, the gravel stone covered walkways are not needed here because of the grass. The visitors will walk on the grass instead. This also embodies the qualities of the site. In Kungsparken the smell of rain is more sweet and and grassy when raining after a warm sunny day. The soil under the grass will accentuate the scent further.



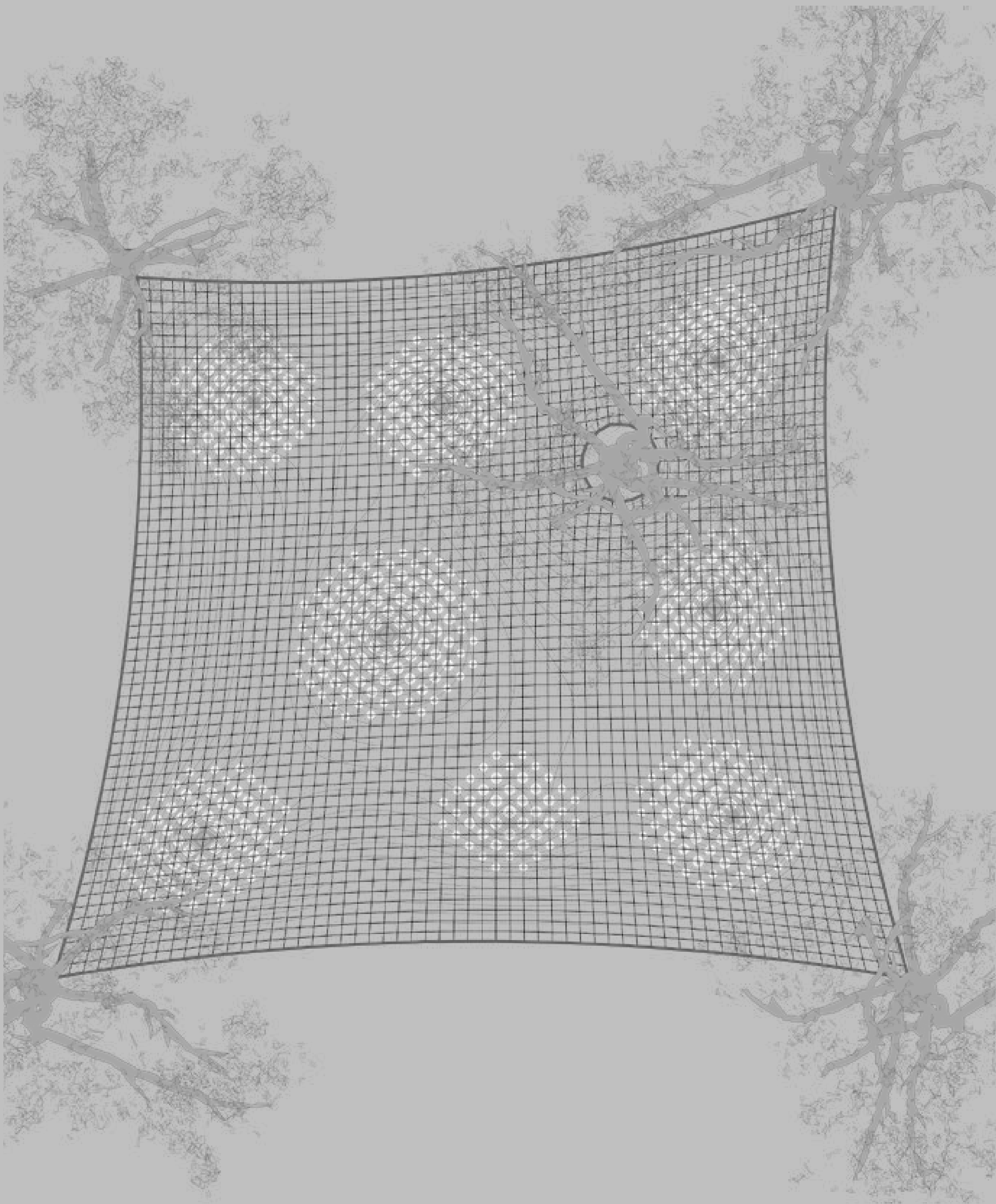
## Plan and elevation

Instead of beams to carry the load, the pavilion will have steel wire rope that the net is weaved on. The steel wire is not supposed to be straight, but bent inward with the net during rainfall. This accentuates the transformation of the structure further and blends more in with the organic surroundings. This is illustrated in the curve development plan. In this plan you can see where the anchor points are located and how the curves develop from them, pulling the structure inward when it gets heavy.

The pavilion rises and falls with precipitation differently each time it rains. As the rain falls the structure gets heavier and drop down in the anchor points, and when it is warm the water evaporates and the net rises back into its original form. The elevation with rain illustrates the depth of the pavilion and different rain situations that is created by guiding the rain on the droplets. The net falls lower in this pavilion because of the wider dimensions which accentuates the enclosed feeling further.

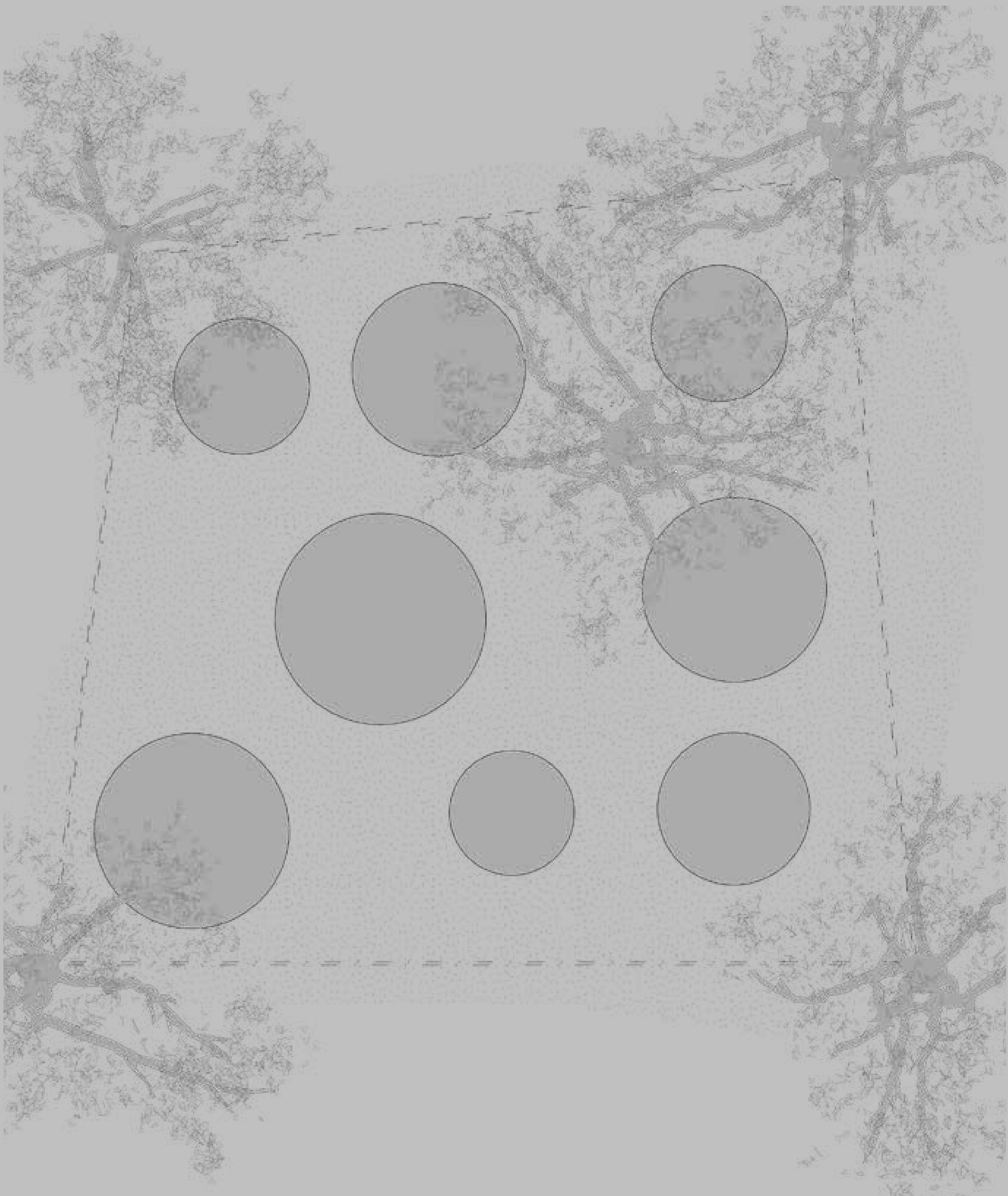
The ground materiality plan illustrates the placement of the concrete circles on the ground. The surfaces help divides the space into different rooms. Here you can also see the shape of the steel wire rope when it is not loaded. The wire is relaxed and straight.

The elevation without rain illustrates the weighted down net even without rain. This is because of the wide area and the use of wire rope. You can also see how the light glistens through the transparent droplets and creating a light show in the pavilion. The light concentration is visible on the concrete surfaces. The visitors will also see the tree crowns through the droplets which gives the droplet covered roof an invisible border.

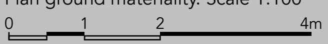


Plan curve development. Scale 1.100

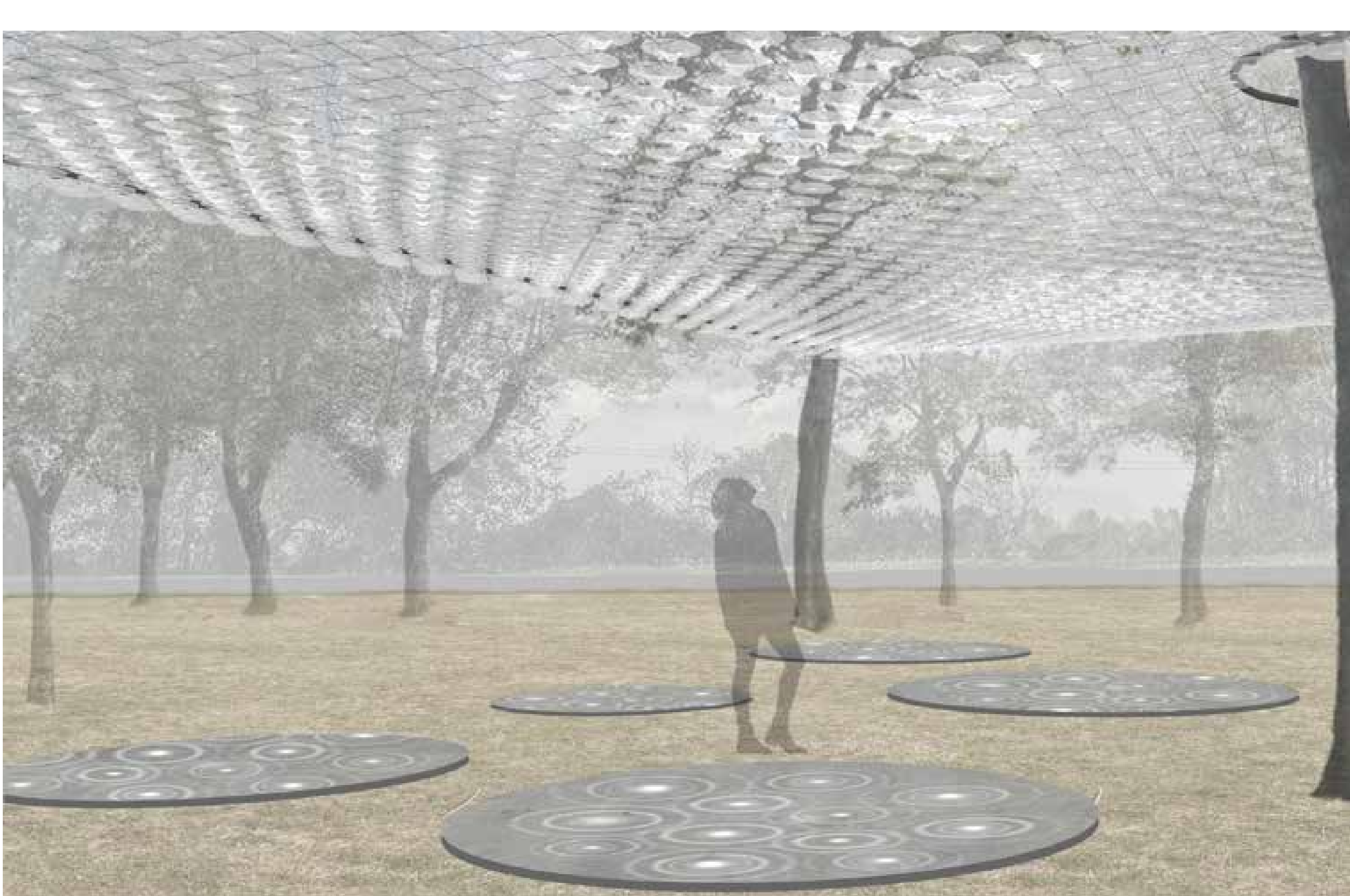
Elevation with rain. Scale 1.100

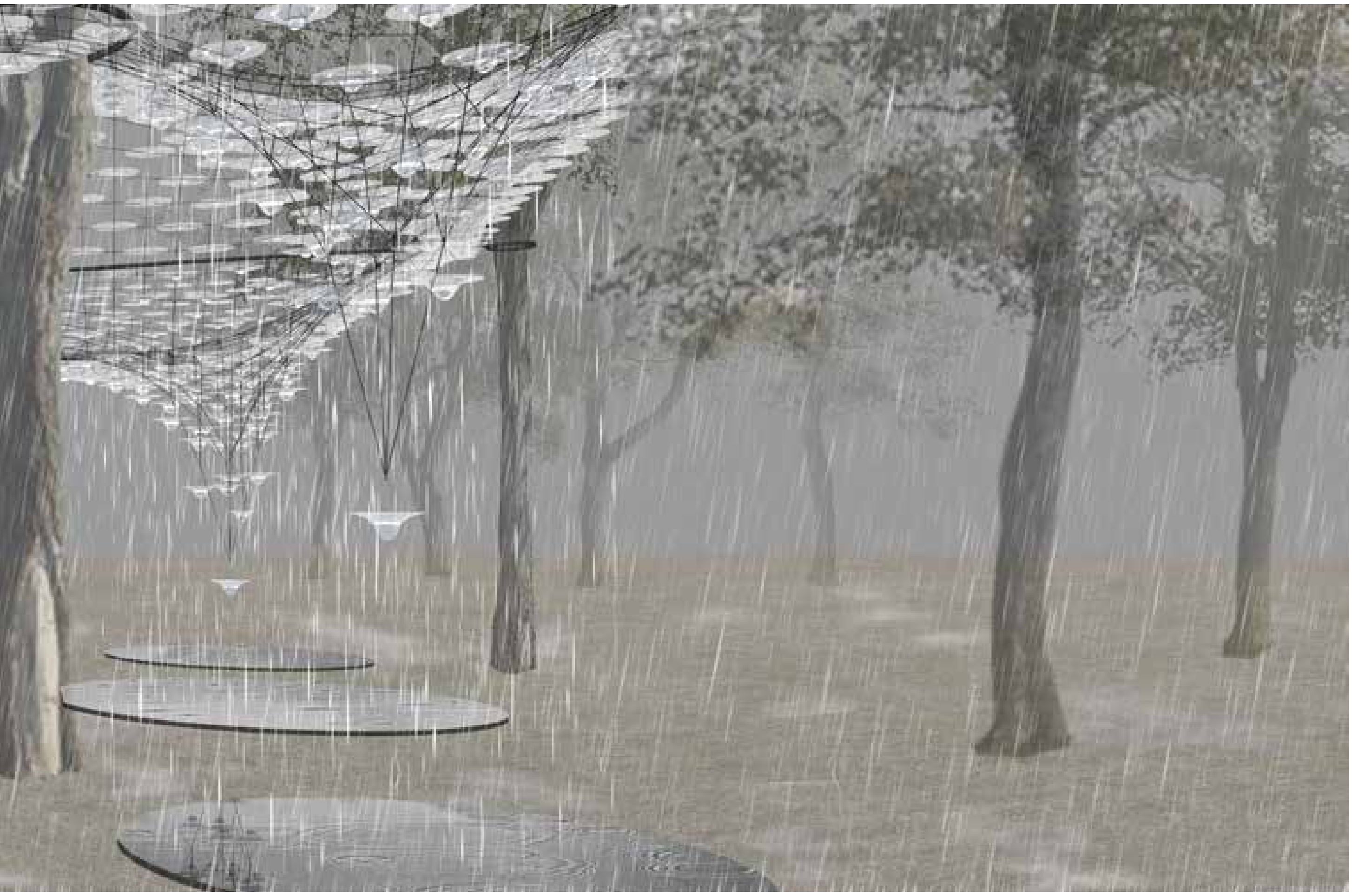


Plan ground materiality. Scale 1.100



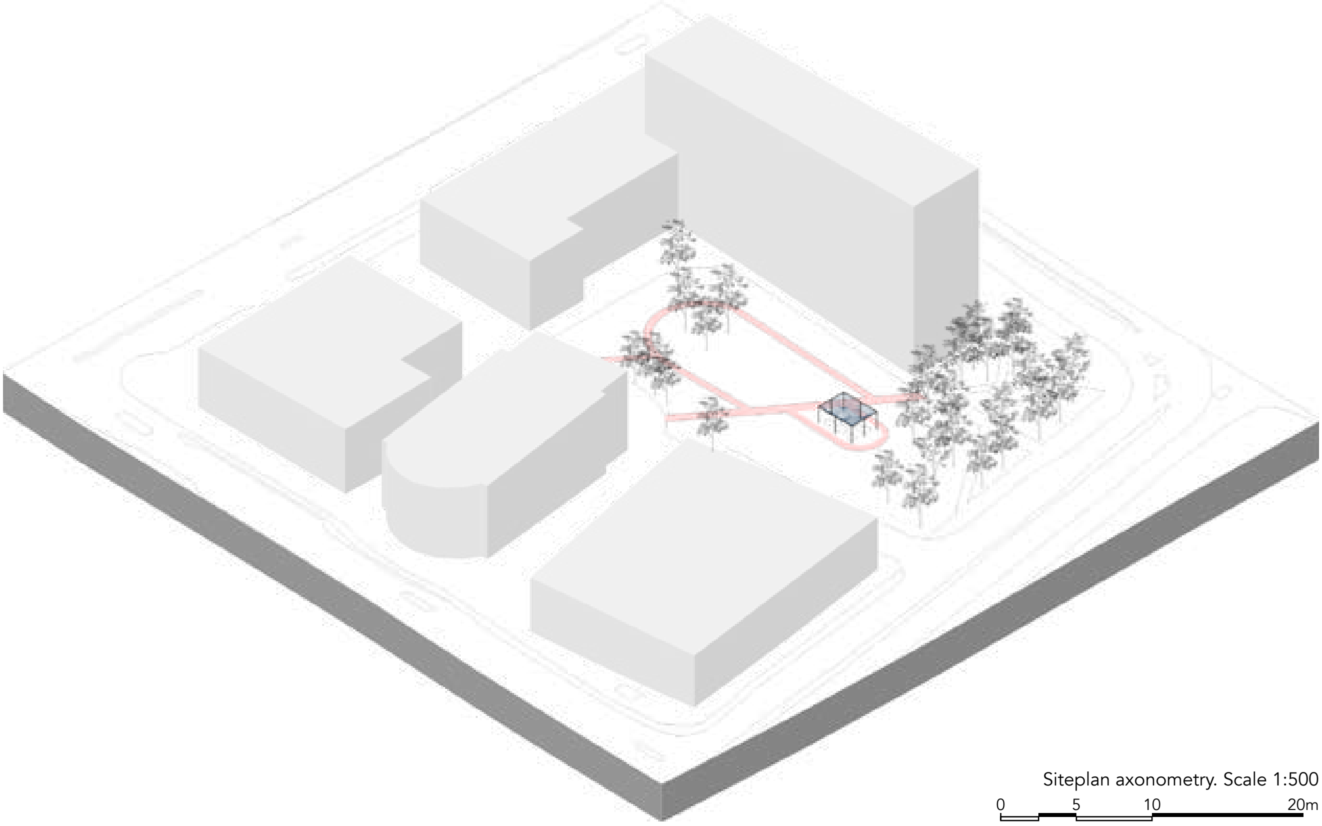
Elevation without rain. Scale 1.100





## LORENSBERGSPARKEN

The site chosen for the urban pavilion is Lorensbergsparken, which is a small park in the middle of the inner city of Gothenburg. Kungsportsavenyn and Götaplatsen is located here, where important cultural institutions such as the city library, museum of art, city theatre is situated. The area is consequently very active but the park itself is not frequently used. It is mostly used as a passage. The park is surrounded by buildings making it almost a backyard, although the location is central. With this urban rain pavilion I hope to activate the place.



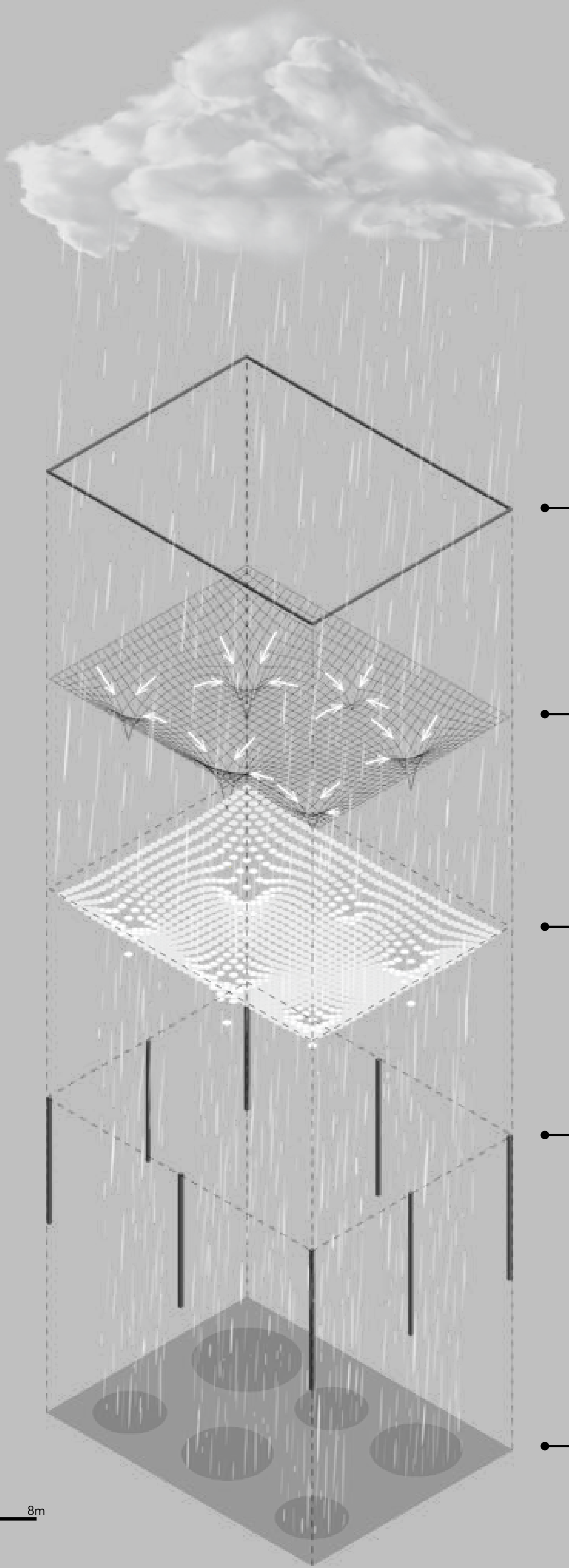
Siteplan axonometry. Scale 1:500

## Lorensbergsparken site

The pavilion is located in the middle of the park in a "pocket" along the walkway. I wanted to encourage people to stop on their way and enjoy the pavilion instead of walking through. The small pocket is therefore the perfect place for the pavilion to stand on because of the location on the side of the walkway and the wider size. The wide rectangular shape gives a dynamic atmosphere during rainfall, encouraging people to stand under and experience the rain instead of moving through.

## The pavilion

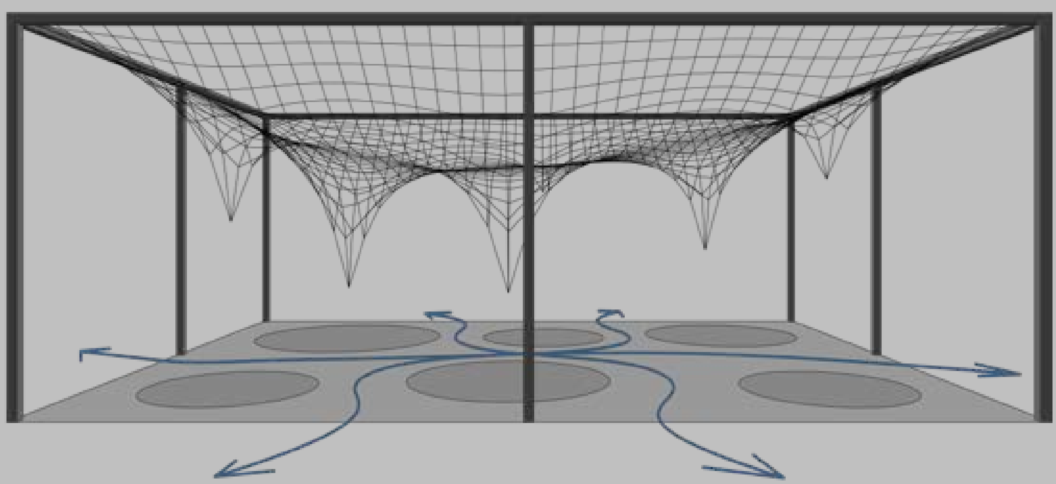
The rectangular shape of the pavilion embodies the site, encouraging people passing by to stop and enjoy and celebrate the rain. There are six different anchor points around the net. During rainfall the droplets get heavier and the anchor points drops down, enclosing the space underneath and creating different rooms. The pavilion is four meter tall allowing passage even when the net drops down. The droplets guide the rain and concentrates it around the anchor points. This creates different rain scenarios underneath the net. One scenario happens where the arch is the highest allowing people to stand under and walk through. Here the rain is transferred away and only sipping through the gaps between the droplets. The other scenario is where the rain is concentrated and rushing down on the droplets. This allows the visitors to get closer to the falling rain and interact with the design. The visitors have the option to enjoy the rain from a sheltered space or experience the full effect of the rainfall.




Structure diagram. Scale 1.200

## Movement and spatiality

The many anchor points give the pavilion a dynamic movement pattern. The differences in height when the enclosed spaces are created gives many arches to walk under. The visitors can almost move freely underneath the pavilion. The anchor points are placed so that the middle part of the pavilion is surrounded by falling droplets which encourages the visitors to pause and stand under instead of moving on. Different materiality on the ground accentuates the different spaces created during rainfall. The gravel covered ground highlights the walking path further.

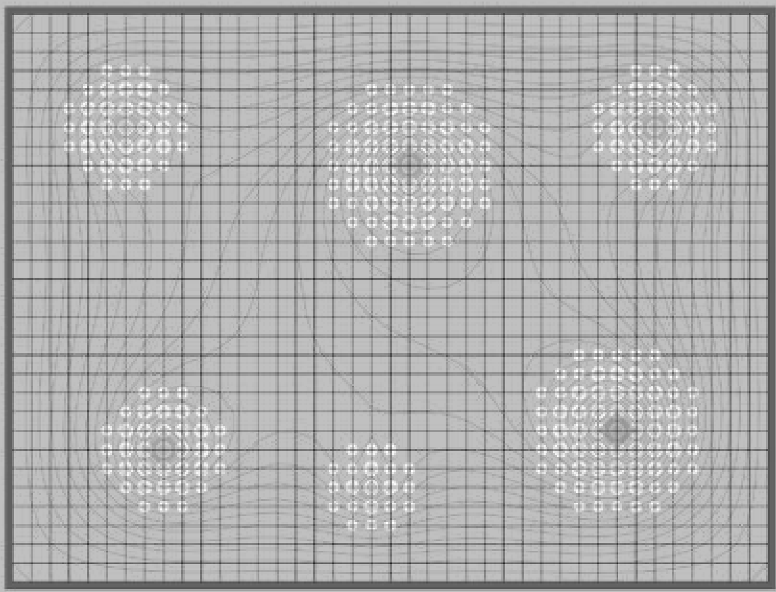


## Plan and elevation

The curve development plan illustrates the placement of the anchor points and how low the curves can develop during rainfall. The curved net allows the droplets to form a second skin that surrounds the visitors. Over the droplets and under the net runs the rain water. The droplets catch the rain and guides it to towards the anchor point where the rain is more concentrated. This gives the phenomenon more effect and really accentuates the qualities of rain, allowing the visitors to enjoy the full effect. This is illustrated in the elevation with rain.

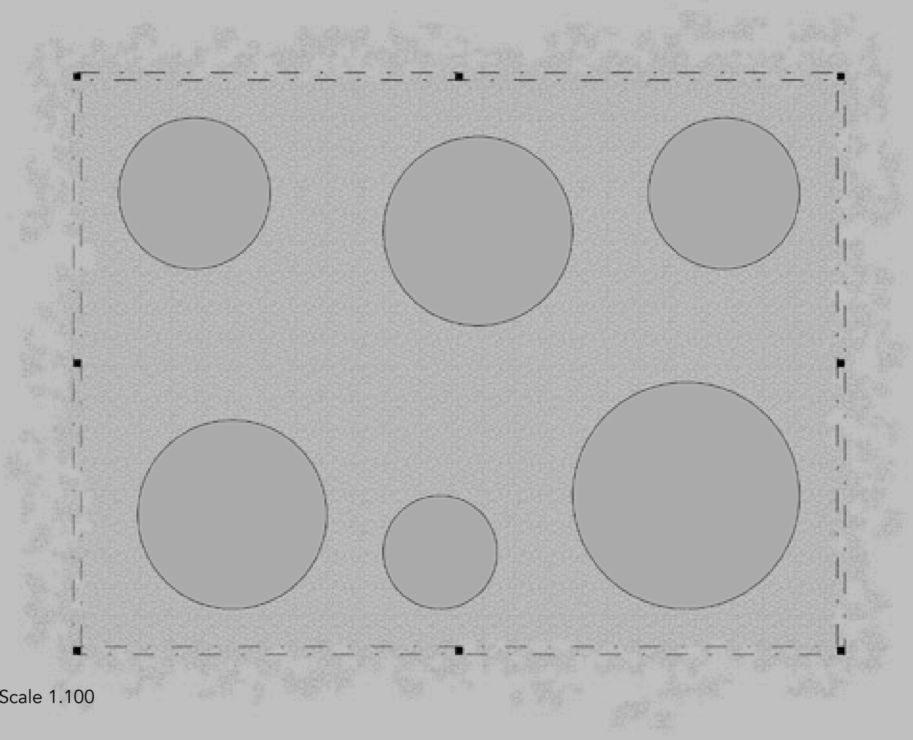
The ground materiality plan illustrated the placement of the concrete surfaces. Standing water created by the smooth concrete material on the ground, accentuated the falling drops when raining. The ripples on the water surface are highlighted and the reflection on the water is clear. The visitors walk on gravel stones, which lets the rain water sip through. This gives a more comfortable walking path.

During a light shower when the enclosing effect is not in full mode, the transparent droplets highlight the raindrops through light, creating a light show. The transparent material catches and reflects the glistening water drops. The elevation without rain illustrates how the light filters through the droplets. When the sun is shining the caustic effect of the droplets mimics falling raindrops on the smooth concrete floor beneath the anchor points. This reminds the visitors of the beauty of rain.



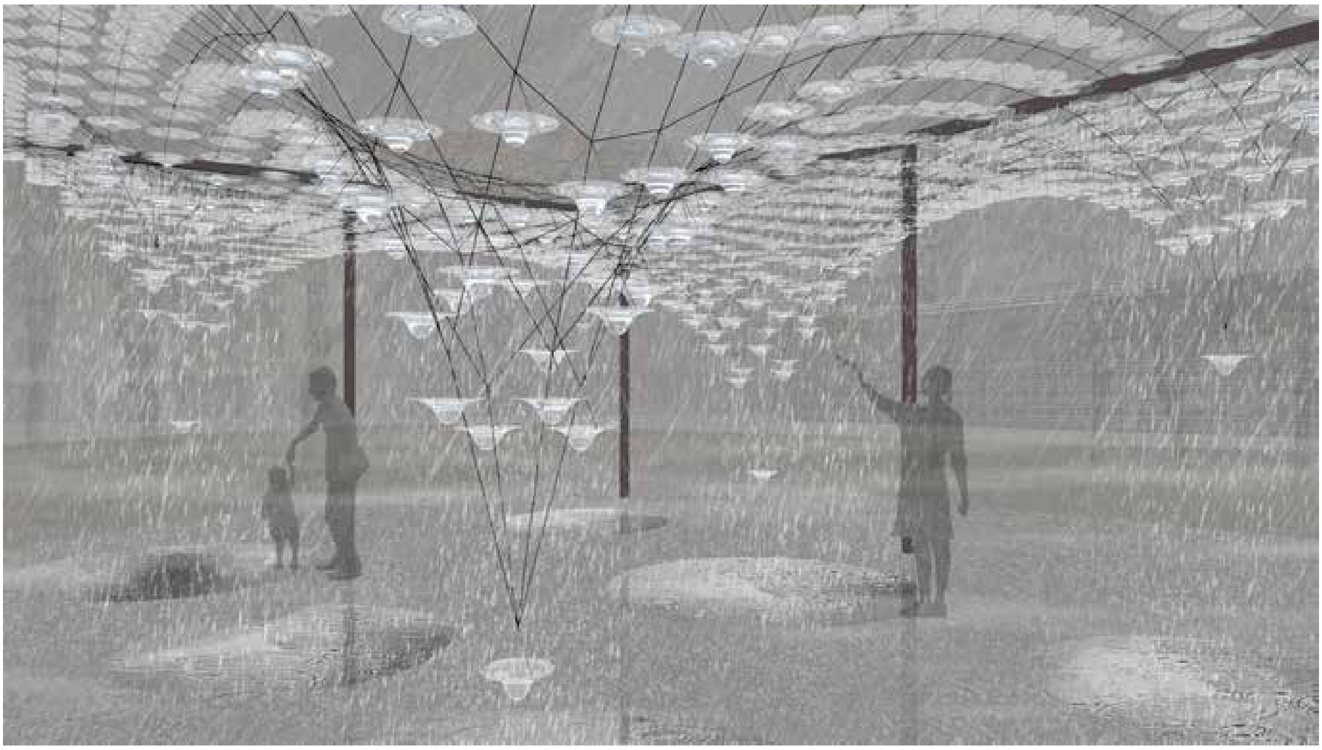
Plan cuve development. Scale 1.100

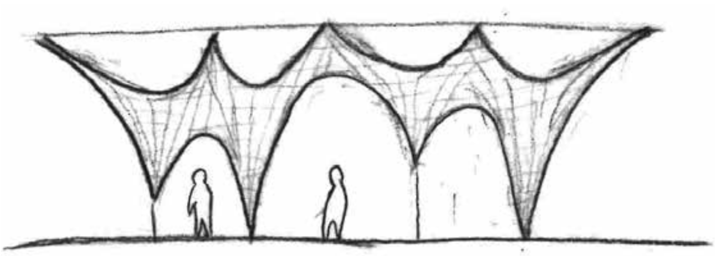
Elevation with rain. Scale 1.100

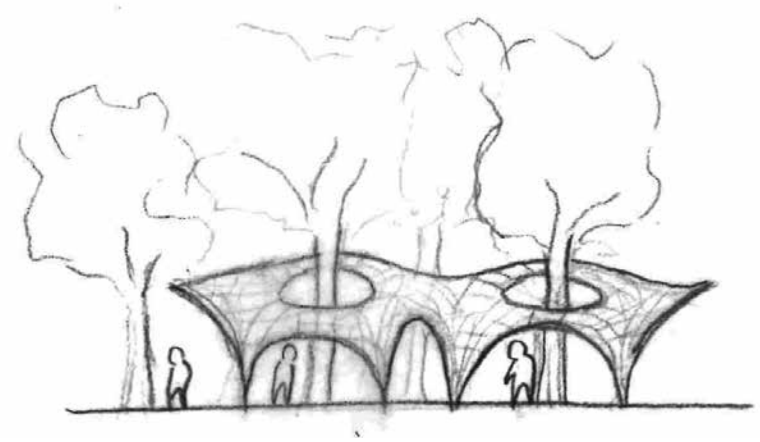


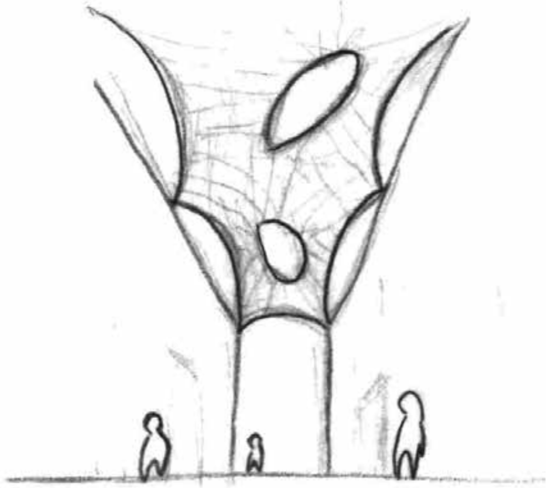
Plan cuve development. Scale 1.100

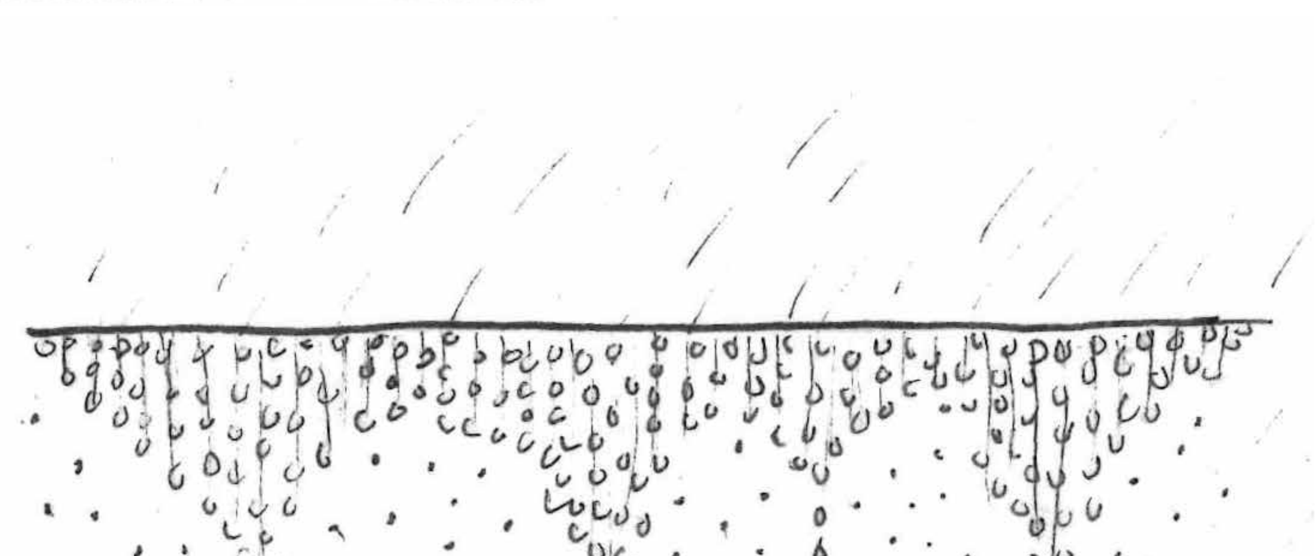
Elevation without rain. Scale 1.100



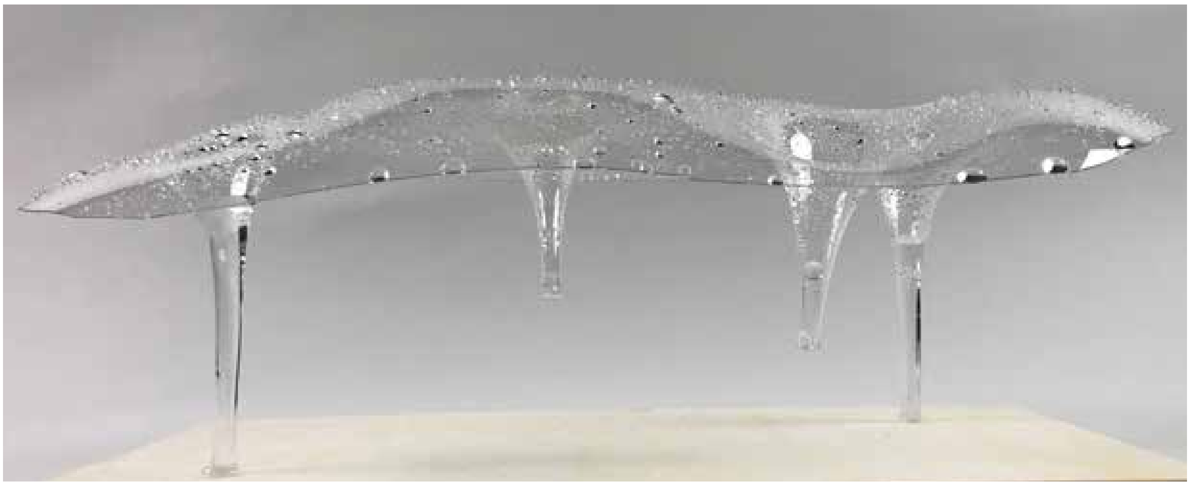


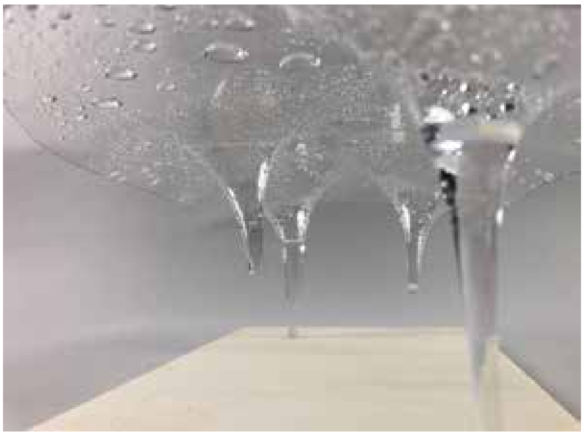












## REFERENCE PROJECT 1

**RainRoom by Random International, international installation**

This project explores the relationship between human and nature trough technology. This international installation lets the visitors experience walking in the rain without getting wet. This is possible with the help of cameras and sensors that tracks the movement and stops the curtain of rain when approaching (Random International, 2012).

## REFERENCE PROJECT 2

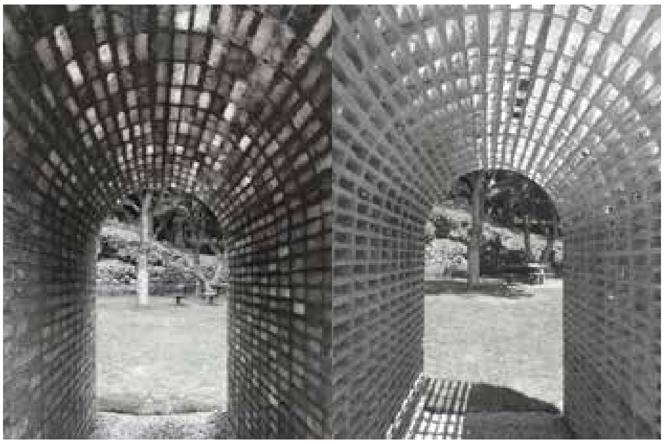
**Light in water by DGT Architects, Paris, France**

Light in water is a site specific installation that was selected to be presented in the oldest concrete dome in Paris, éléphant paname. The exhibition provides an immersive experience of falling water and light show. The structure is built of sixteen rings of slotted tubes that runs along the ceiling leaking 60 drops of water per second. The installation is a commentary on the essence of life, highlighting the crucial part light and water have in life (Designboom, 2015).

## REFERENCE PROJECT 3

**Dissolving arch by Stpmj, Jeju Island, South Korea**

Dissolving arch is a weather-specific installation that responds to the tropical environment it is in. The structure is made from rock-salt bricks that creates a solid, translucent arch. The arch starts to slowly dissolve during the rainy periods and finally leaves a porous skeleton behind. As the structure starts to let in more light the space within gradually transforms, which makes the connection to nature stronger (Archdaily, 2019).



## REFERENCE PROJECT 4

**Reservoir by John Grade, Trento, Italy**

Reservoir is an installation within an Italian forest that appears like a chandelier among the trees. It is constructed of translucent filament nets that are supported by tree trunks above. Attached to the nets are five thousand heat-formed, clear droplets with bent wooden frame that collects the rainwater. This installation is inspired by how rain falls through the trees, the canopy delaying the droplets and creating a shelter (John Grade Studio, 2018).

## CONCLUSION

When the rain falls a connection between sky and earth is created. Guiding the rain through the building creates an architectural dialogue between the building and its surroundings. This dialogue celebrates rain by articulating the architectural space.

The aim of this thesis was to present a design that creates a connection between nature and architecture by highlighting the experience of rainfall. What I hope to bring into the discussion about rain as an element of design is that the possibilities of this phenomenon is endless. After researching and experimenting with rain I discovered that there are many beautiful qualities to this phenomenon that we do not think about. The experience of rain is also very individual which increases the opportunities further. There are many features of rain that can be used and highlighted in the design. The result is architecture that connects us to nature instead of creating barriers. By presenting this connection in our cities we can activate the public space.

Through this thesis I discovered that you have to try and create the experience instead of the architecture. By highlighting the qualities of rain people can experience it instead of avoiding it. I want to also specify that I have been able to bring a lot of my own experiences of rain in this thesis, other people may not have the same experience at all. Every individual will have their own personal connection to rain and that is the beauty of this phenomenon.

One important tool you can use to highlight the rain is the light. There is always light after rain. Light and rain complement each other and by taking that into consideration you can accentuate the experience of rain. The effects of light are many, through the right design you can manipulate these effects to highlight the qualities of rain. This triggers the visual sense, which in this case can be a big part of the rain experience.

The rainfall in Gothenburg plays a significant role in the background of people's daily lives and to ignore it denies them its true potential. Rain can be seen as an asset in architecture, a positive attribution. Inserting rain into the design in joyful ways allows people to celebrate it.

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