Sail Over the Tracks

Varberg's new Railway Station

Master's Thesis in the Architectural Engineering Program

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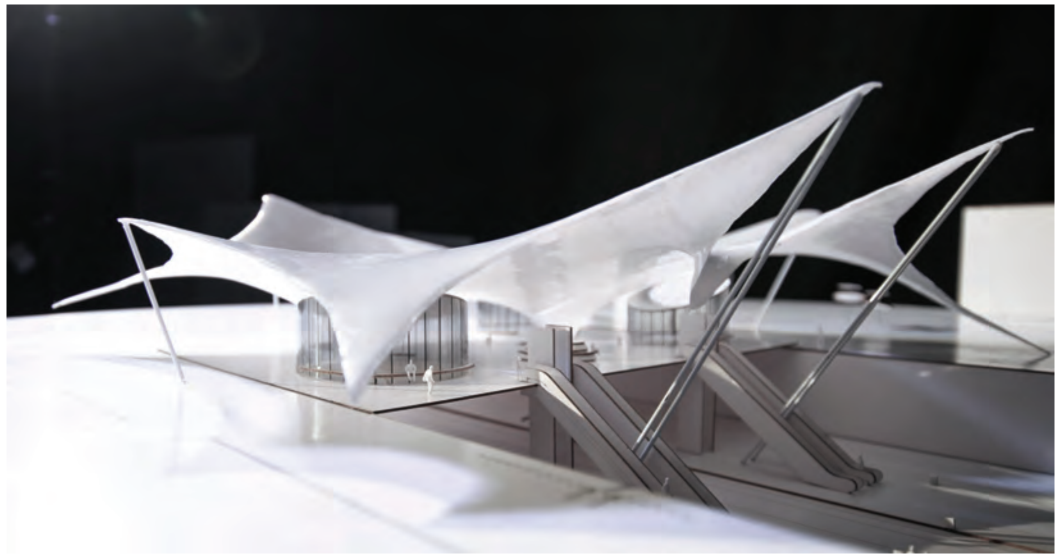
Göteborg, Sweden 2014

Master's thesis



Abstract

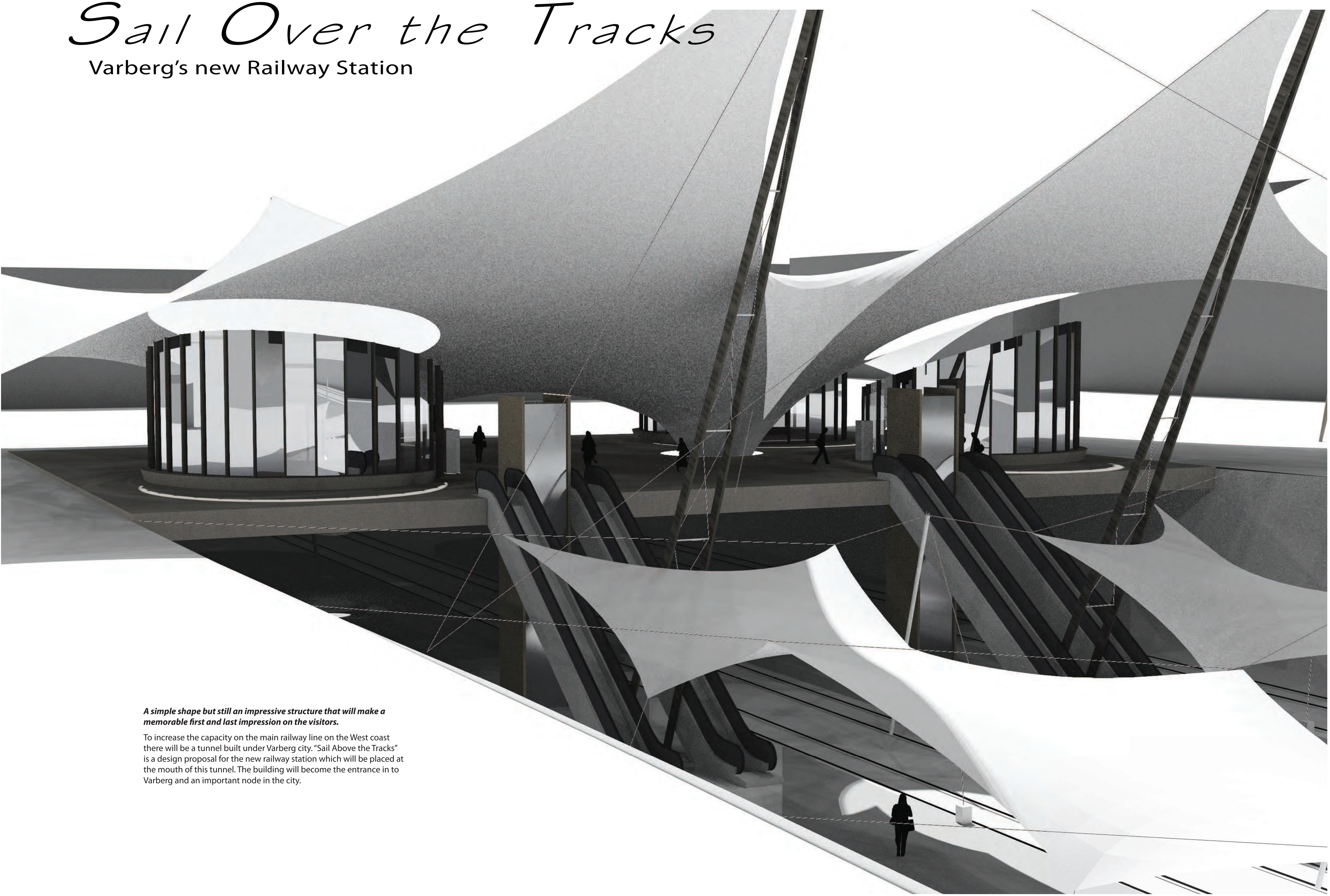
To increase the capacity of the railway between Oslo and Copenhagen a tunnel will be built under Varberg city. This means that a new train station needs to be built, in the city, and it is proposed that it will be placed at the mouth of the tunnel. As people today are traveling more and more, and an increasing percentage of these travels are done by train, this station is an important new building.

"Sail Over the Tracks" are a design proposal for the new station. With a large roof it connects different ways of traveling, at the same time as it houses the sought functions of a modern, medium sized, train station. By using a light weight tension structure, less material is needed, and the design is thereby both economical and eco-friendly.

The slender structure reaches out over the area, welcoming travellers from all directions, and becomes a suiting new entrance to this popular tourist destination and rapidly growing town.

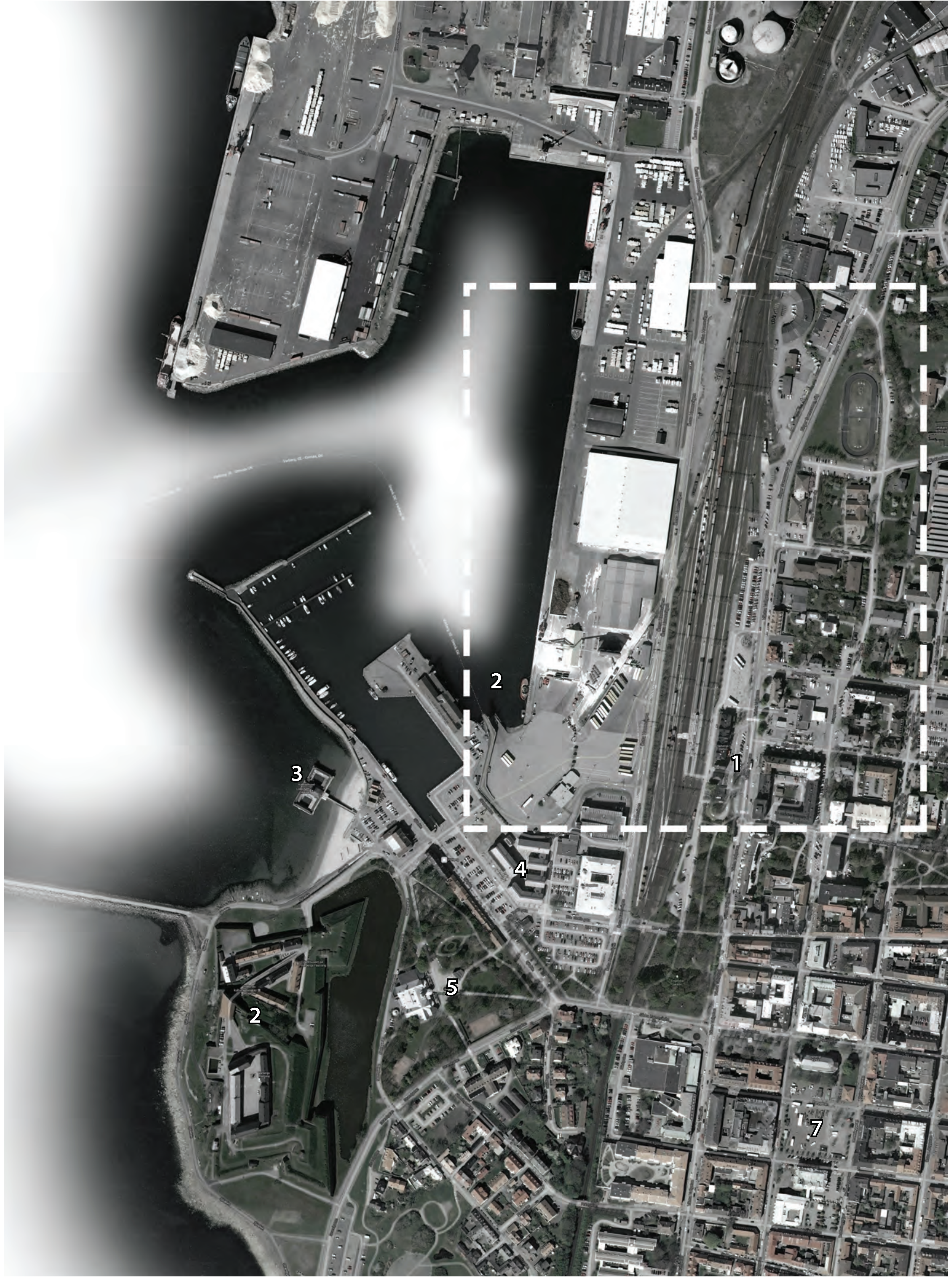
Sail Over the Tracks

Varberg's new Railway Station



A simple shape but still an impressive structure that will make a memorable first and last impression on the visitors.

To increase the capacity on the main railway line on the West coast there will be a tunnel built under Varberg city. "Sail Above the Tracks" is a design proposal for the new railway station which will be placed at the mouth of this tunnel. The building will become the entrance in to Varberg and an important node in the city.



The old Railway Station

Built in the end of the 19th century, probably after drawings by Adrian C Peterson.

2 Varberg Fortress

The oldest parts of the fortress were built in the end of the 13th century by the Danish count Jacob Nielsen. After changing nationality eight times during the first half of the 14th century, Varberg were to be ruled by Denmark for almost 300 years.

Under the direction of the Dutch architect Hans van Steenwinckel, the fortress were extended in the late 1500s. It took 30 years to build the new defence system, and Varberg fortress was, at the time, one of the most modern fortresses in Europe. It was however, from this point, never involved in any war.

From the Middle Ages until 1931 parts of the fortress was used for holding prisoners, at times with as many as 400-500 prisoners housed in the fort simultaneously.

3 The Cold Bathhouse

With over 200 years of Varbergbeing a health resort this is only one of the many historic bath facilities. But it is probably the one with the most special architecture. Today's building is from 1902 and is the third one built, after the original from 1866. The two previous ones being destroyed in storms.

4 Campus

A campus housing both a high school and a collage

5 Socitetshuset

A resturant and a club house, from 1886, drawn by architect Adrian C Peterson

6 Stena Line

The ferry between Grenå in Denmark and Varberg docks in the middle of the city and becomes a natural part of the landscape.

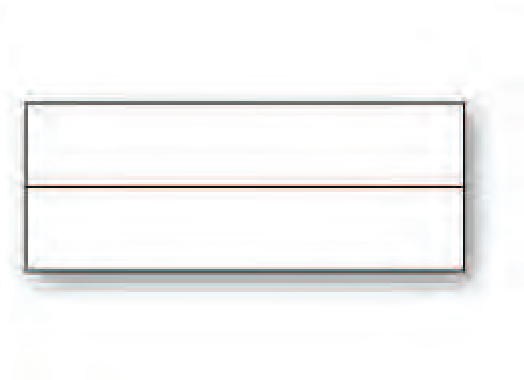
Windsurfing

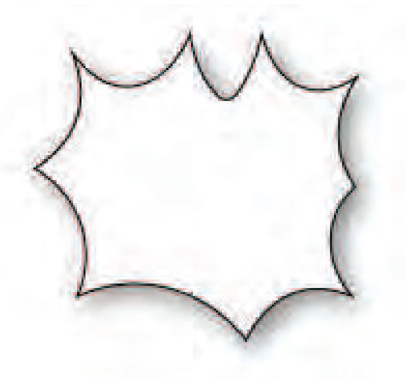
Varberg is a very popular area for windsurfing, with surf shops, surf bars and of course the surfers themselves. More often than not several windsurfers can be spotted at beach suoth of the city centre.

7 City centre

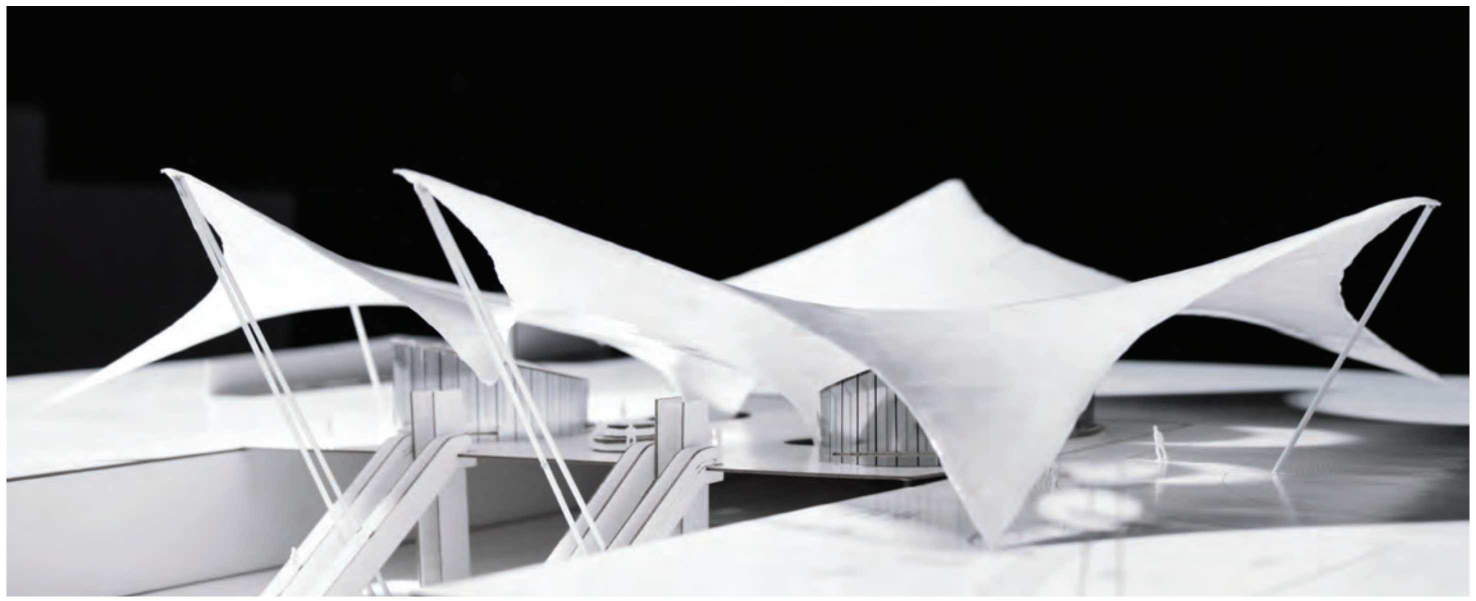
The city is oriented around the church and the popular market square.

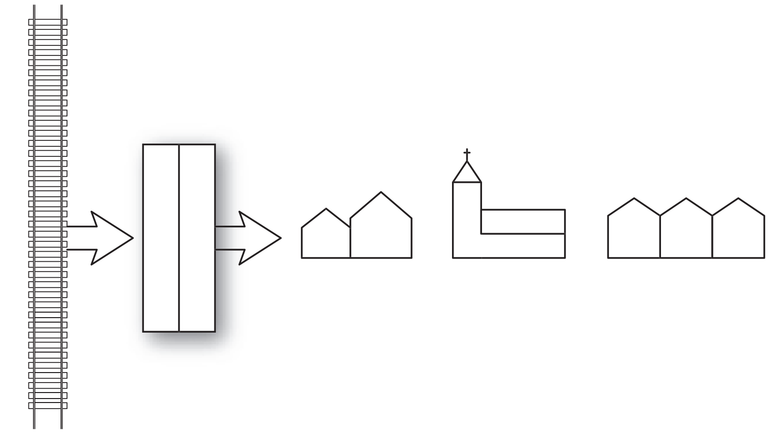
The Role of the Station





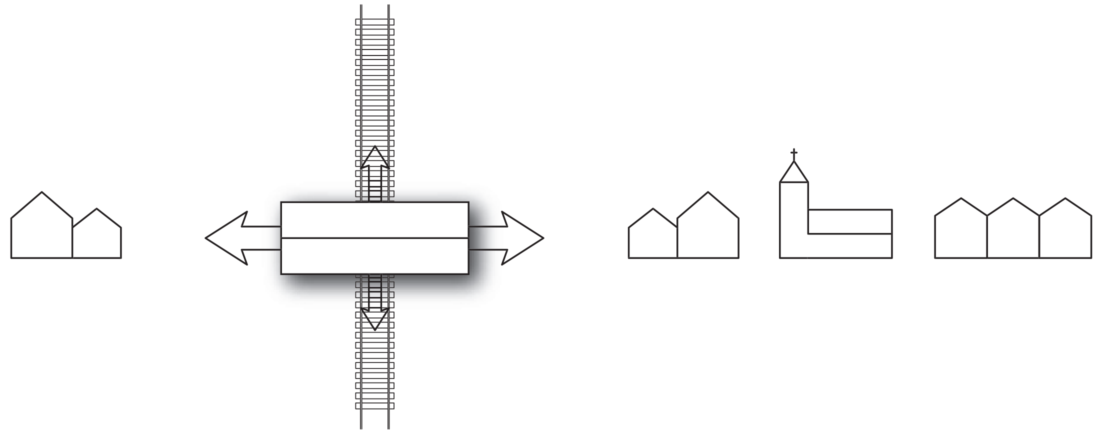
The shape of a railway station
Traditionally a station house of this size would have a rectangular floor plan. This made a lot of sense, since it could then follow the direction of the tracks, turning its main facades towards the city and towards the trains. However, with a different ways of traveling, the old stations start to look more and more like an obstacle. While people formerly visited station houses with the train ride as the primary goal, a station today serves a broader purpose as a node connecting a lot of transportations (trains, busses, cars, taxies, bikes, and pedestrians), as well as offering other services such as shops and restaurants. A "multi directional" floor plan would therefore be desirable, especially when the building is situated in the middle of a city, as it is in Varberg.





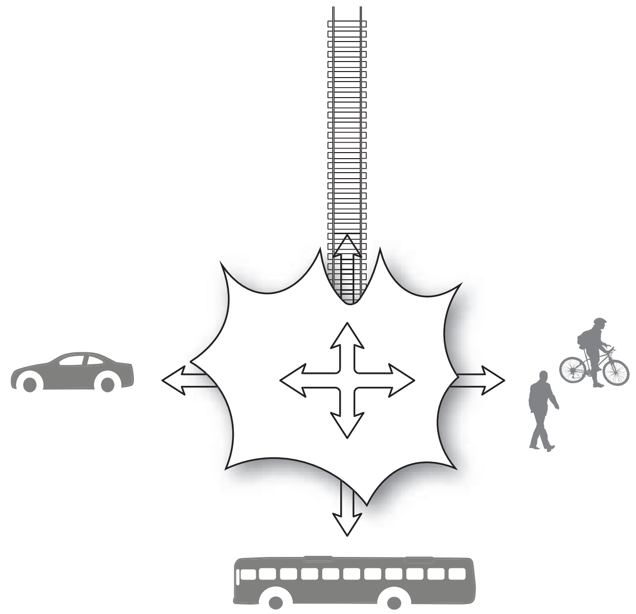
Before

The station house was a destenation in itself. It was an important building that made a very solid impression, typically placed parallell to the track.



Now

Different travelling habit call for a different kind of design for the station house. A safe way to cross the railway track is often sought, this could be done by placing the building across the tracks (over or under) enabling a safe and easy passage to the platforms as well as to the other side.

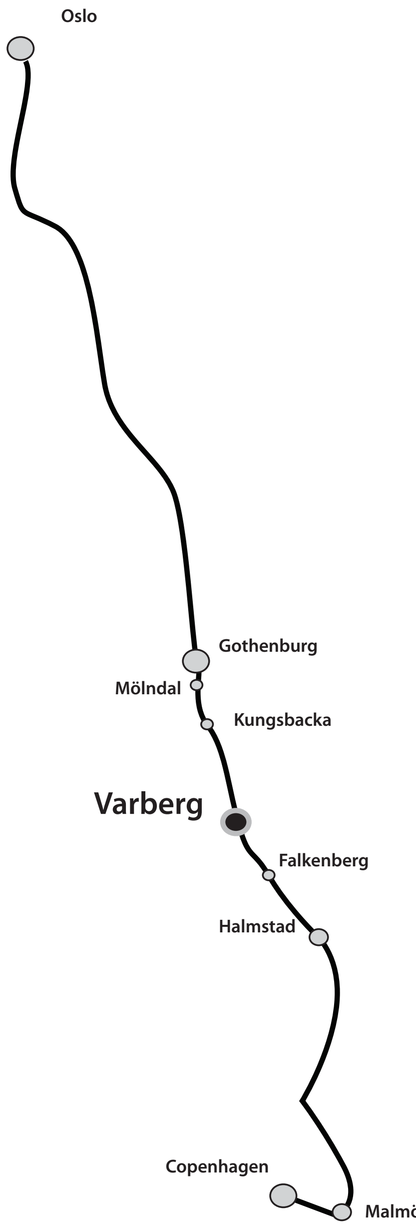


This design

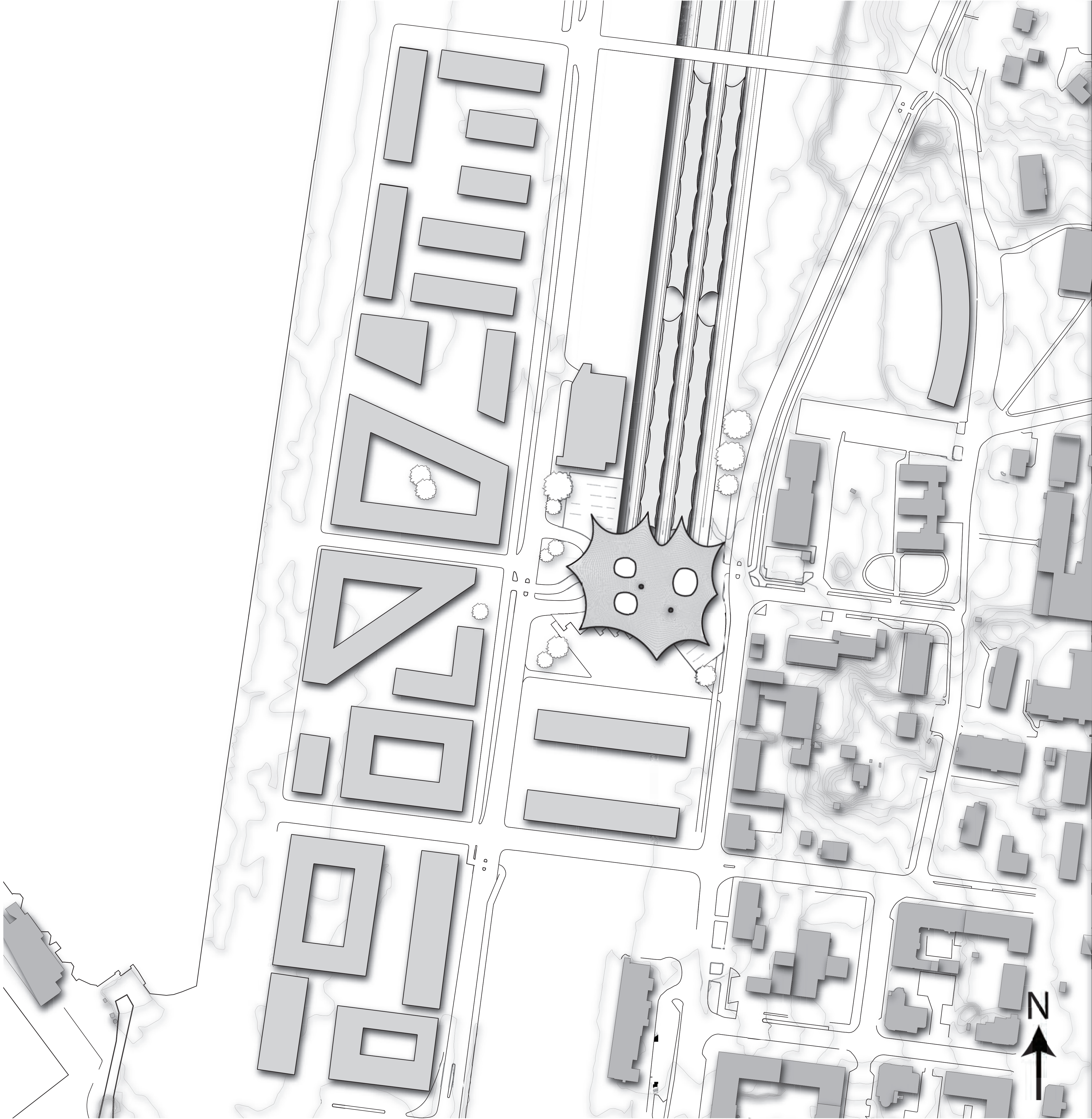
With an irregular shape people can enter the building from different directions. This makes it possible to weave together the many different ways of travelling to and from the station in one building, making it both safe and easy to get from A to B.

History

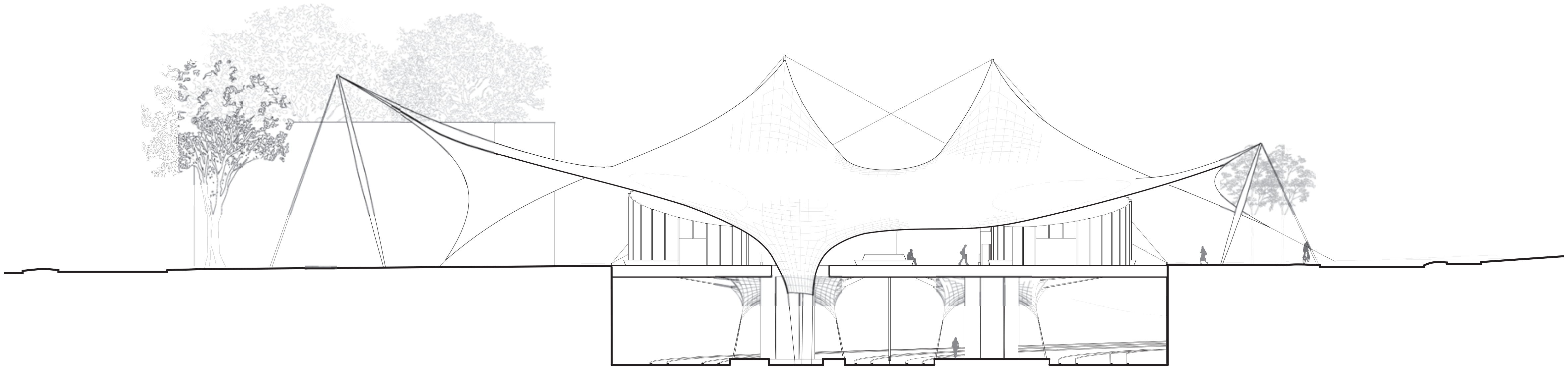
During the 15th century the town was situated on the hill east of the fortress, but after a severe fire 1666, the city was rebuilt, in a grid pattern, at today's location. Even here the town were to be burnt down. The north part in 1767 and 1768, after which it was rebuilt with wooden one story houses. The south part were destroyed in a fire 1863, this part were rebuilt with both wooden hoses as well as stone houses in a romantic medieval style. The railway between Varberg and Borås was built late in 19th century, and with this Varberg expanded to the north.



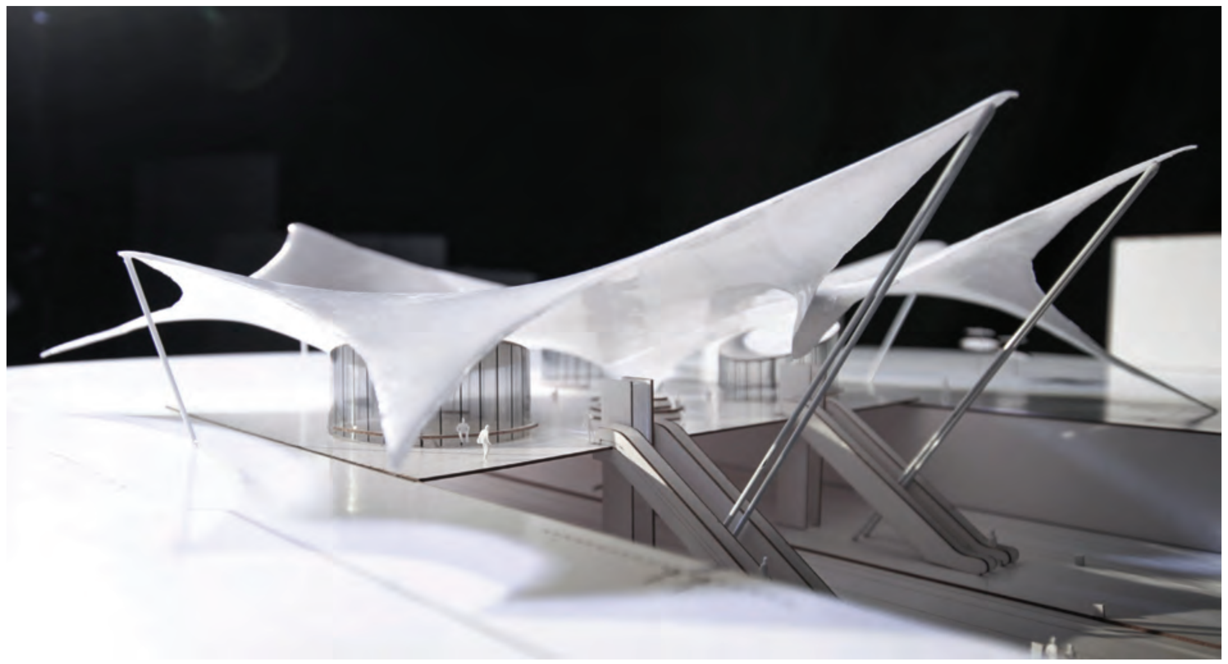
A few of the stops along the west coast railwai line



Site plan 1:1000

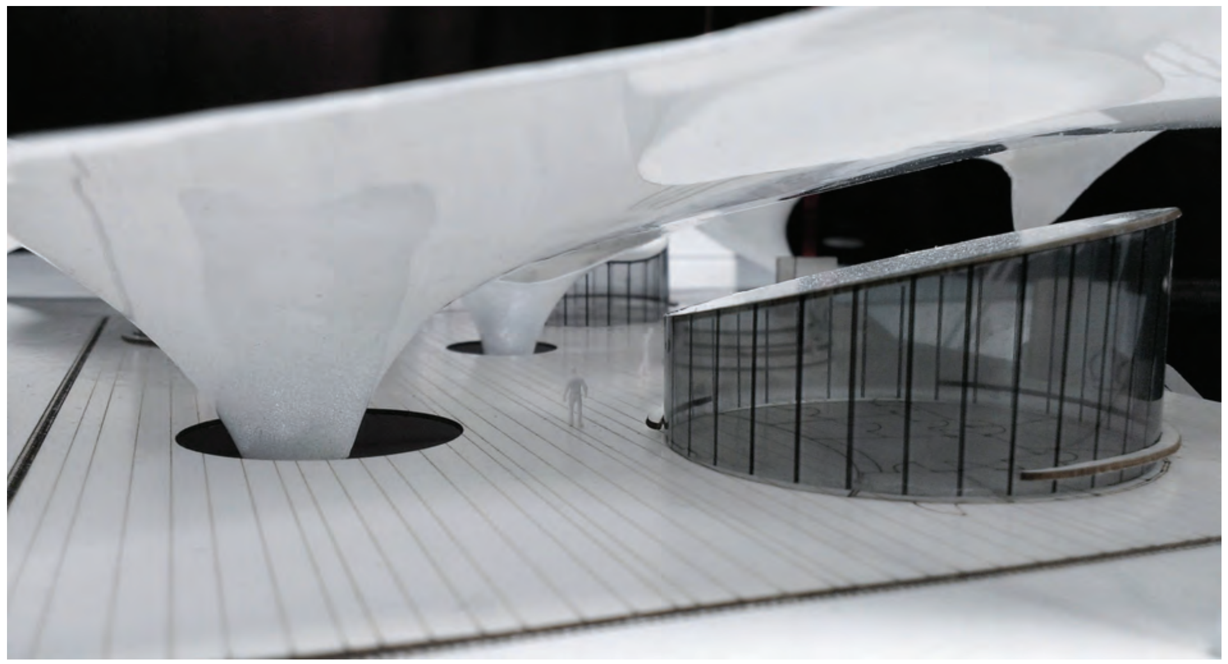


Section A-A   1:400



Main entrance

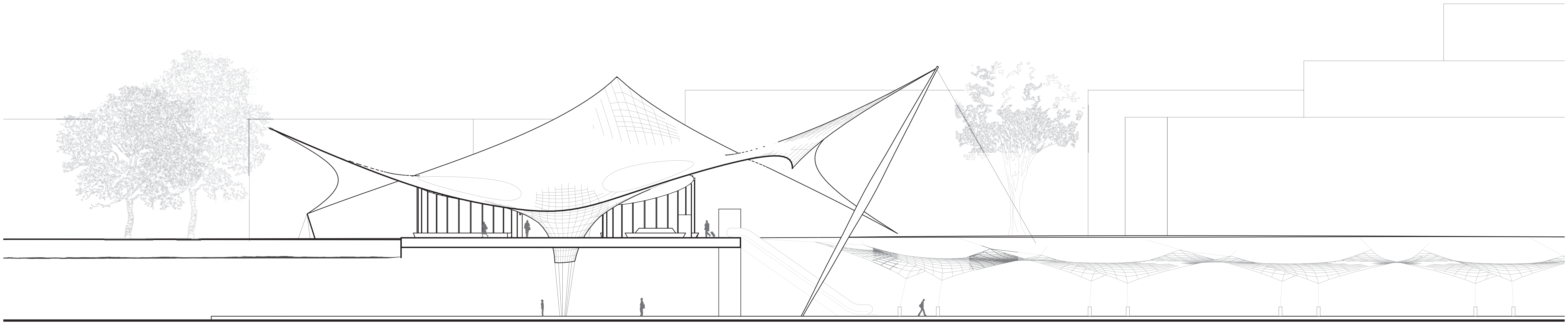
This is the entrance closest to the city centre, easily accessed for pedestrians and bikers



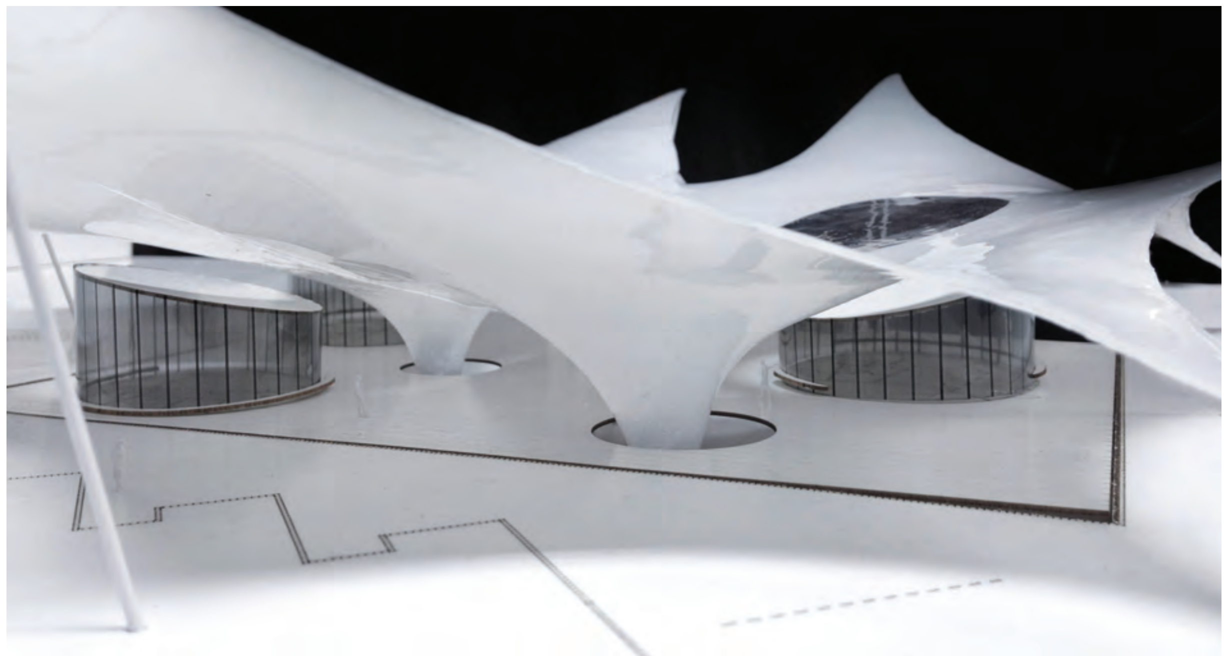
West entrance

People arriving by car would enter the station from this side.

On the west side of the building there are a few spaces for short time parking as well as parking for taxies.
Just north of the this entrance there is also a multistory car park.

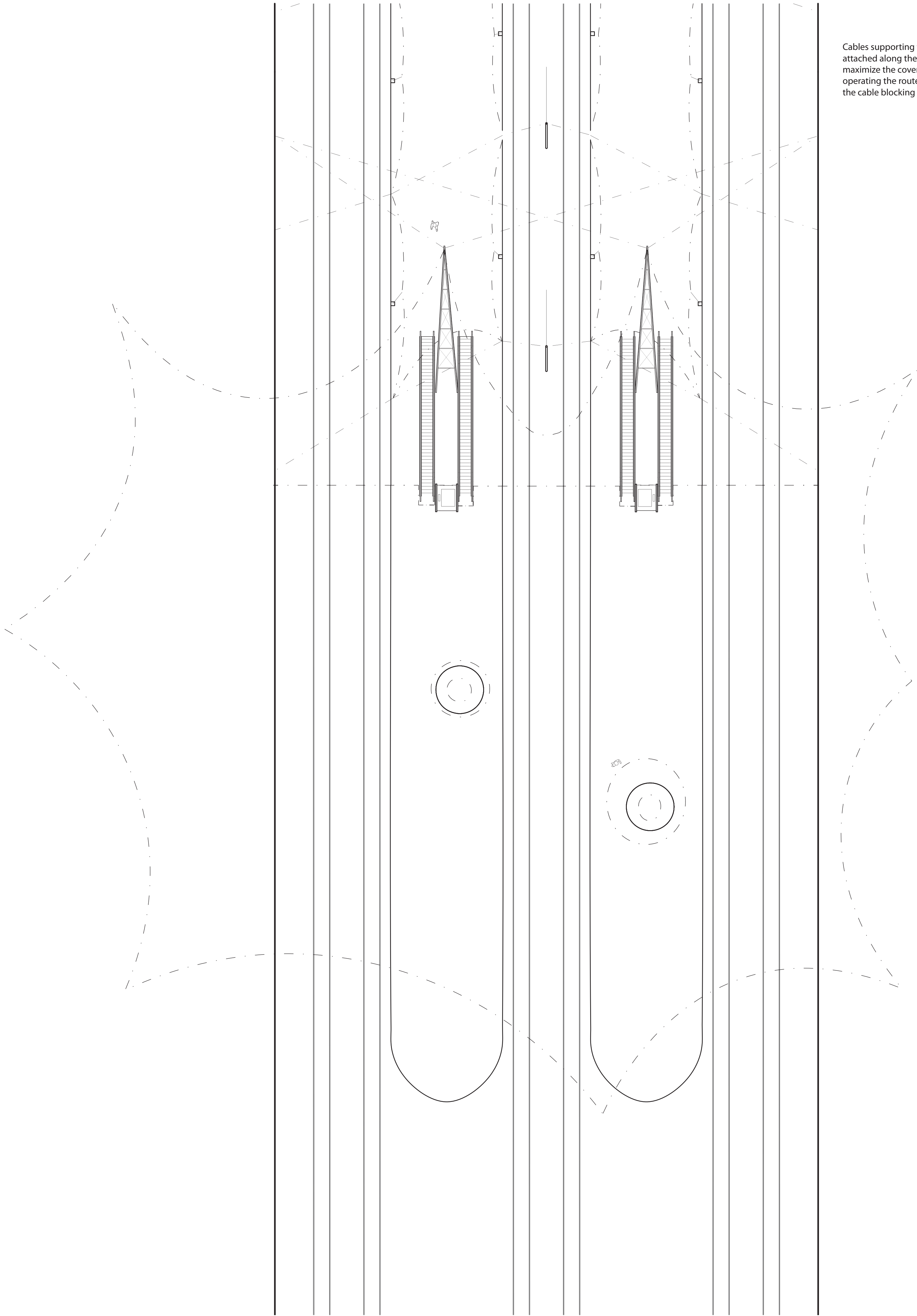


Section B-B 1:400



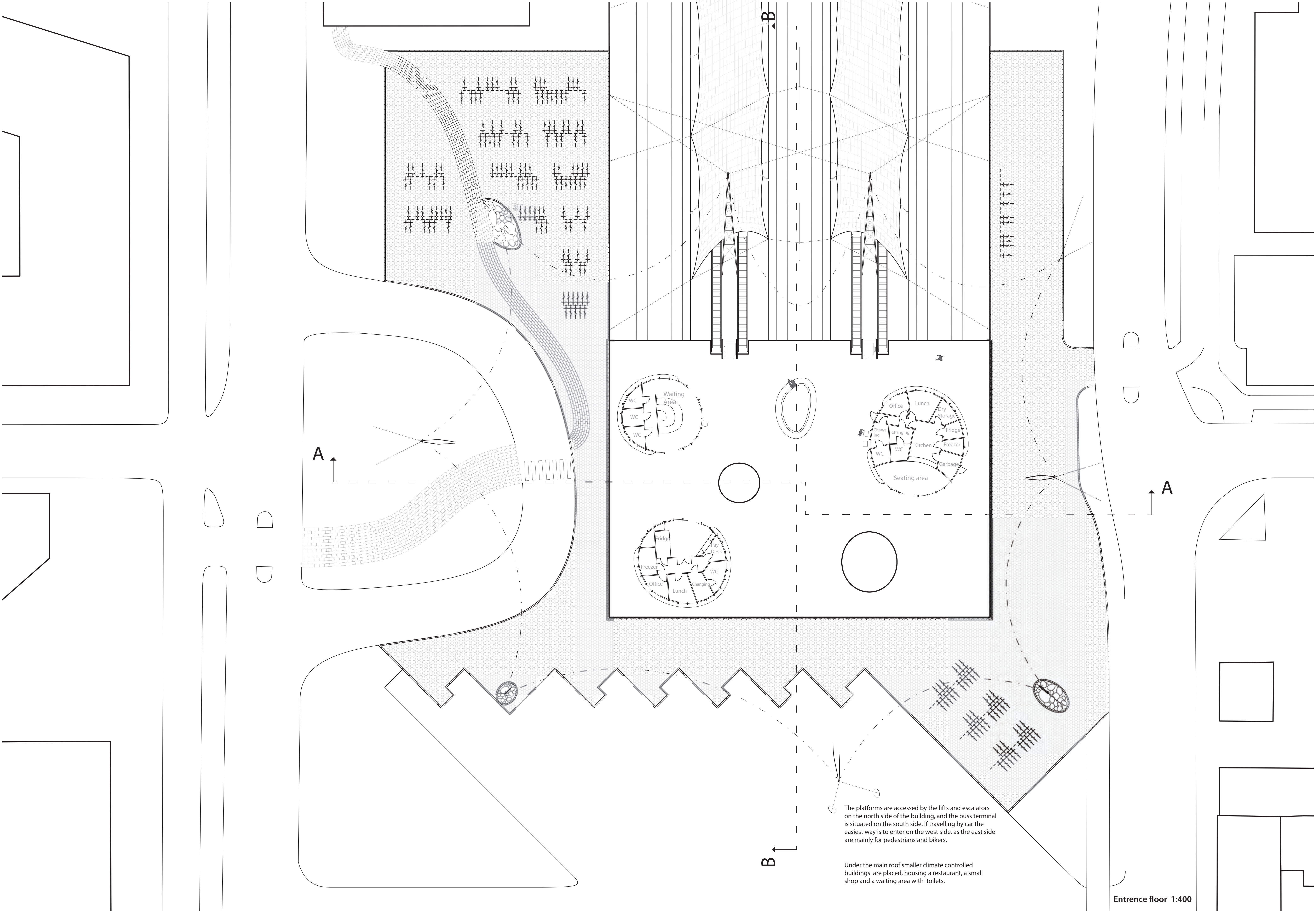
Buss terminal

The roof streches over the docking area for the busses allowing people to wait, and enter many of the busses, in an area sheltered from the rain.



Cables supporting the roof above the platforms are attached along the edges of the platforms. This will maximize the coverage, and since it is standard trains operating the route, they should be able to stop without the cable blocking the doors.

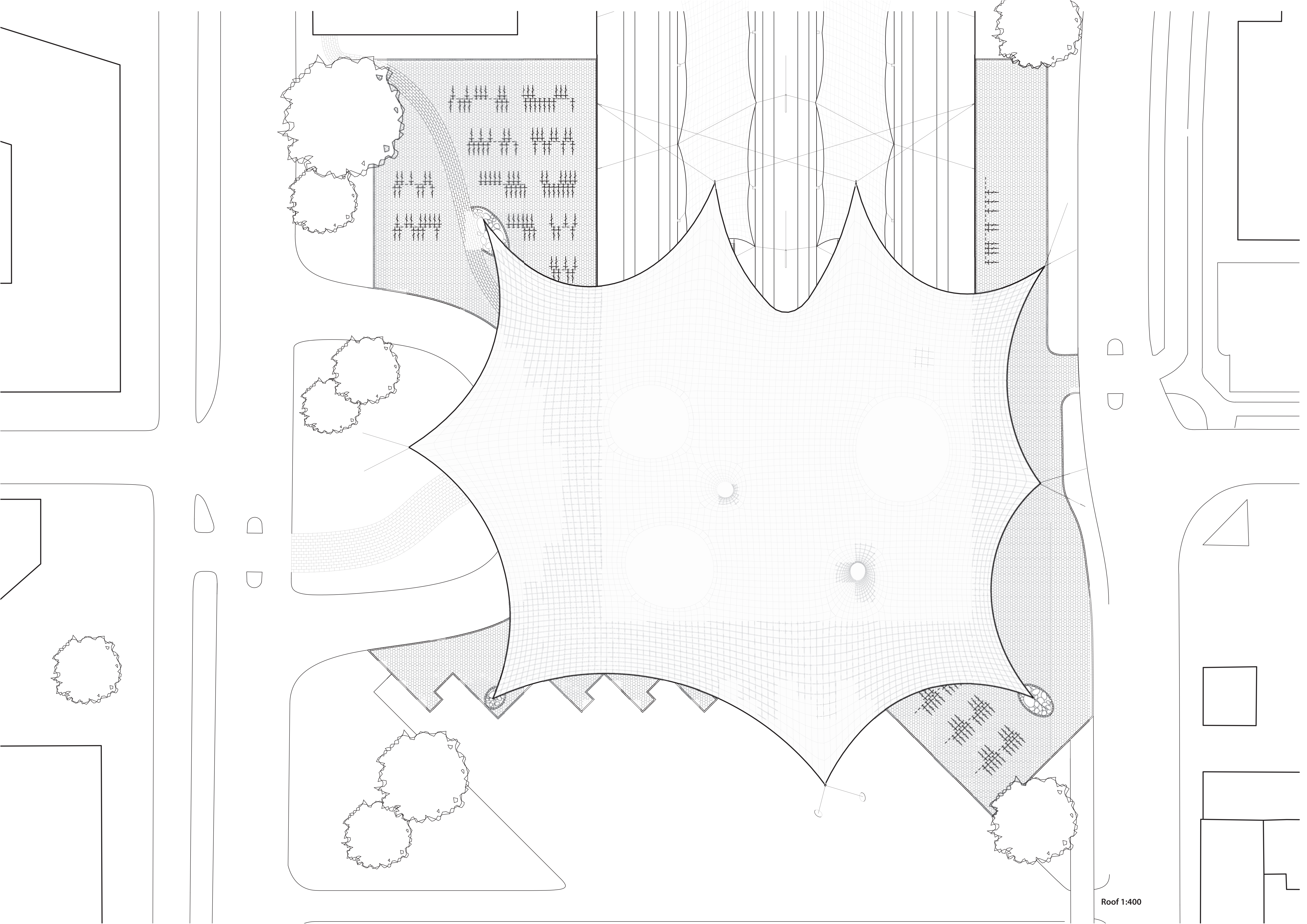
Level -1 1:400



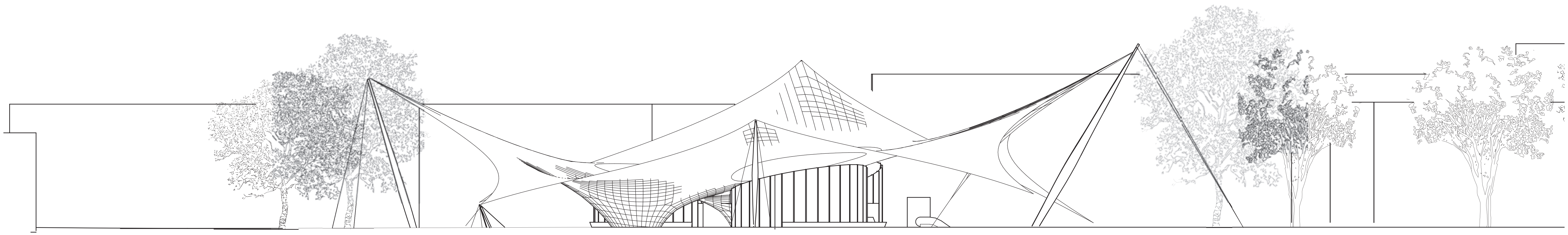
The platforms are accessed by the lifts and escalators on the north side of the building, and the buss terminal is situated on the south side. If travelling by car the easiest way is to enter on the west side, as the east side are mainly for pedestrians and bikers.

Under the main roof smaller climate controlled buildings are placed, housing a restaurant, a small shop and a waiting area with toilets.

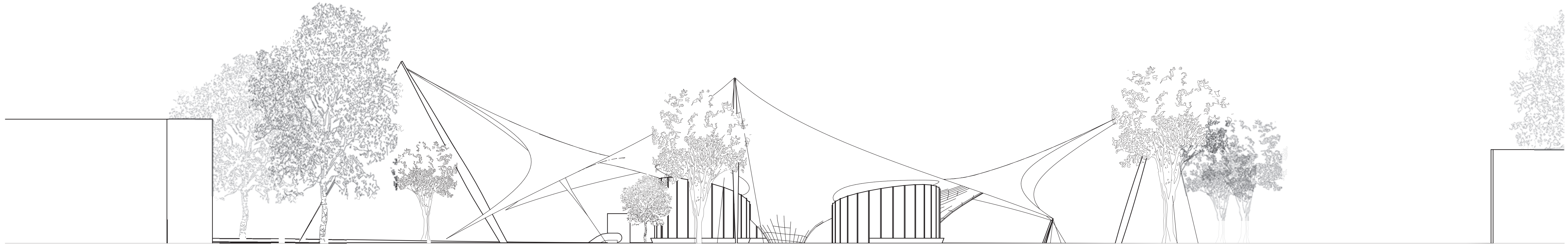
Entrence floor 1:400



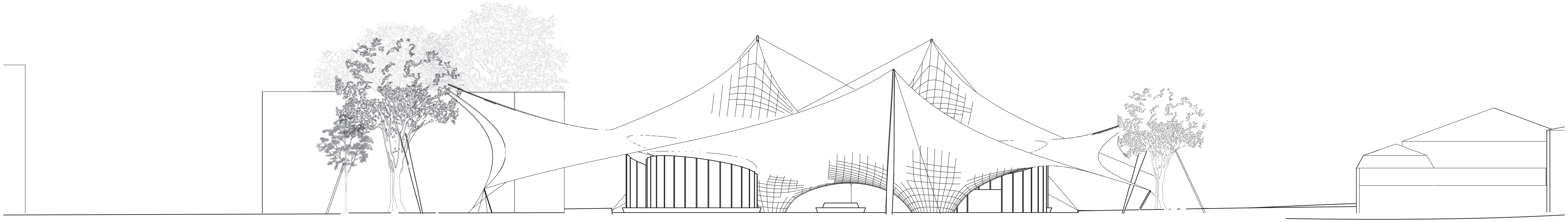
Roof 1:400



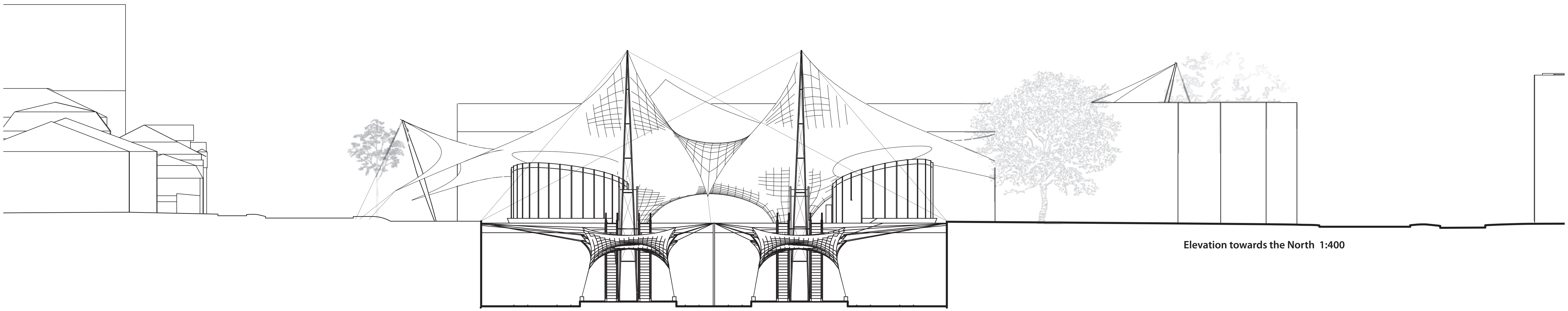
Elevation towards the East 1:400



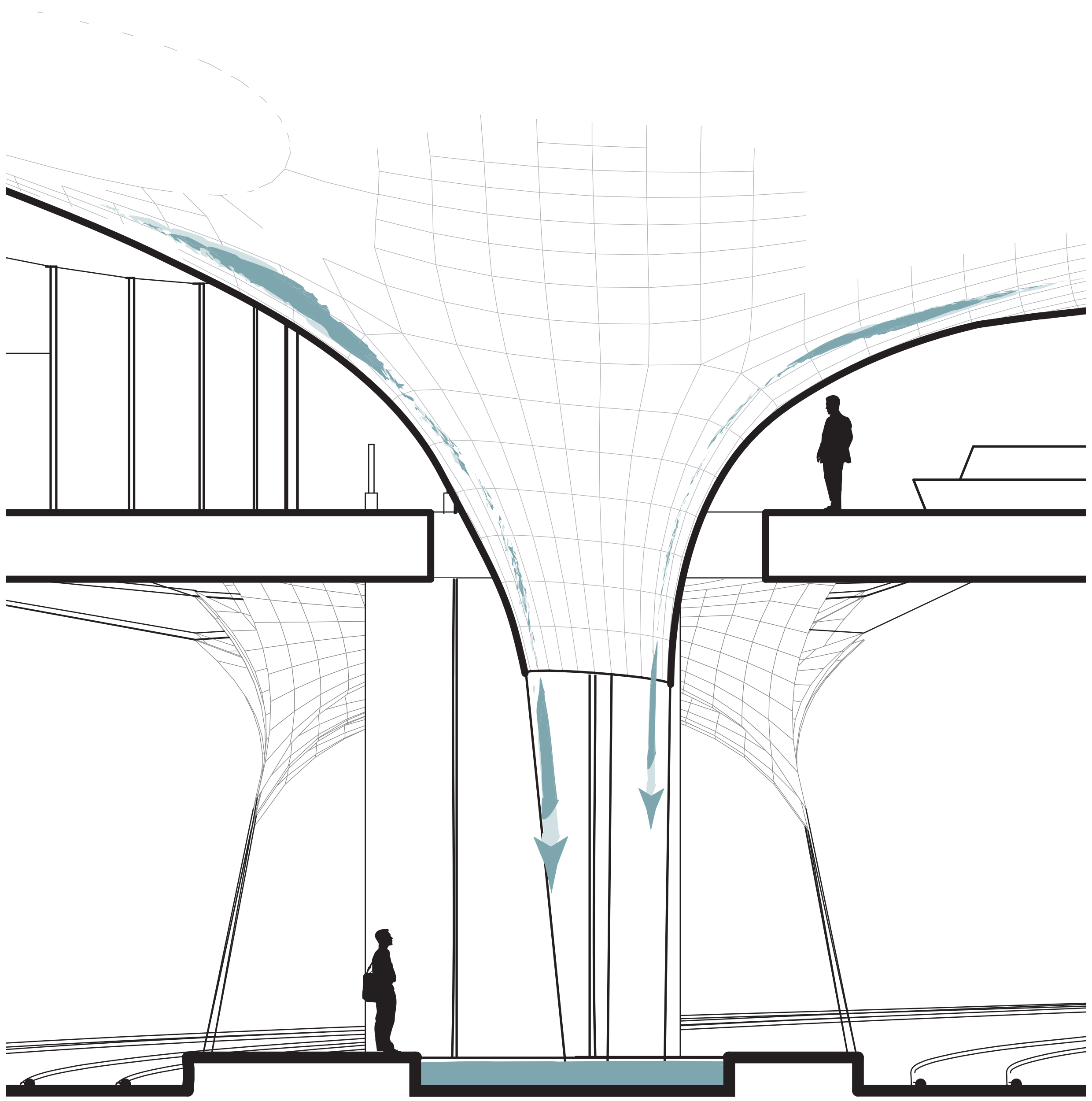
Elevation towards the West 1:400



Elevation towards the South 1:400



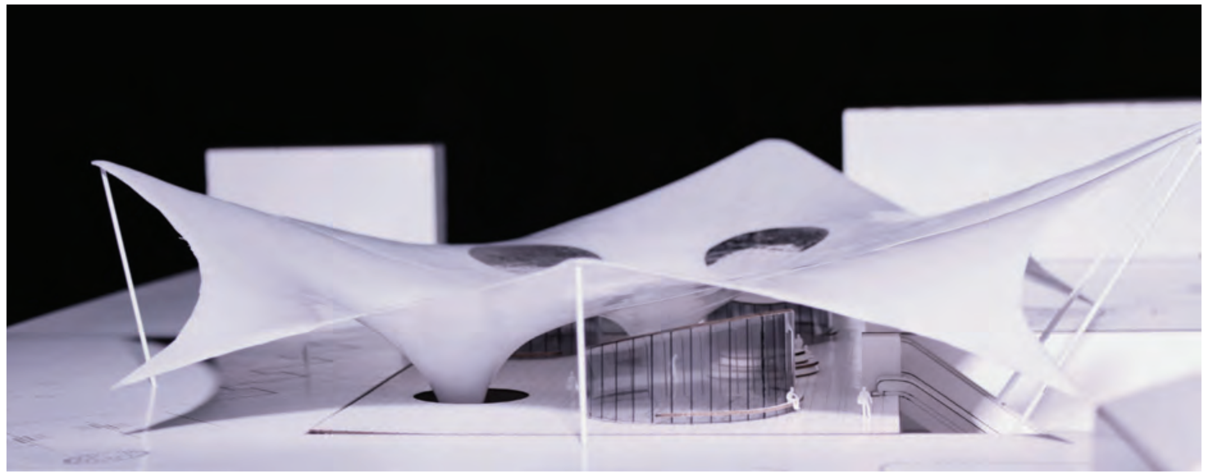
Elevation towards the North 1:400



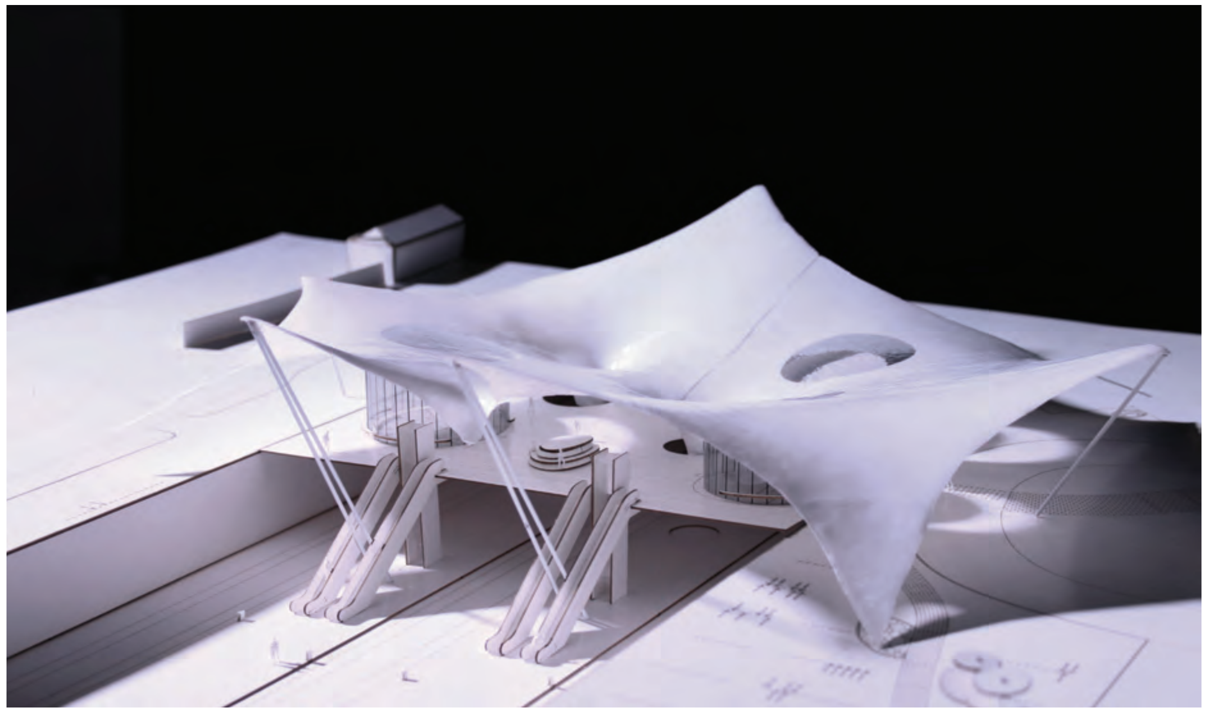
Rainwater

Because of the way the roof is shaped rain water will run down in the "cones" crossing the floor slab.
Placing small pounds underneath these cones will create a beautiful spectacle during the many rainy days.

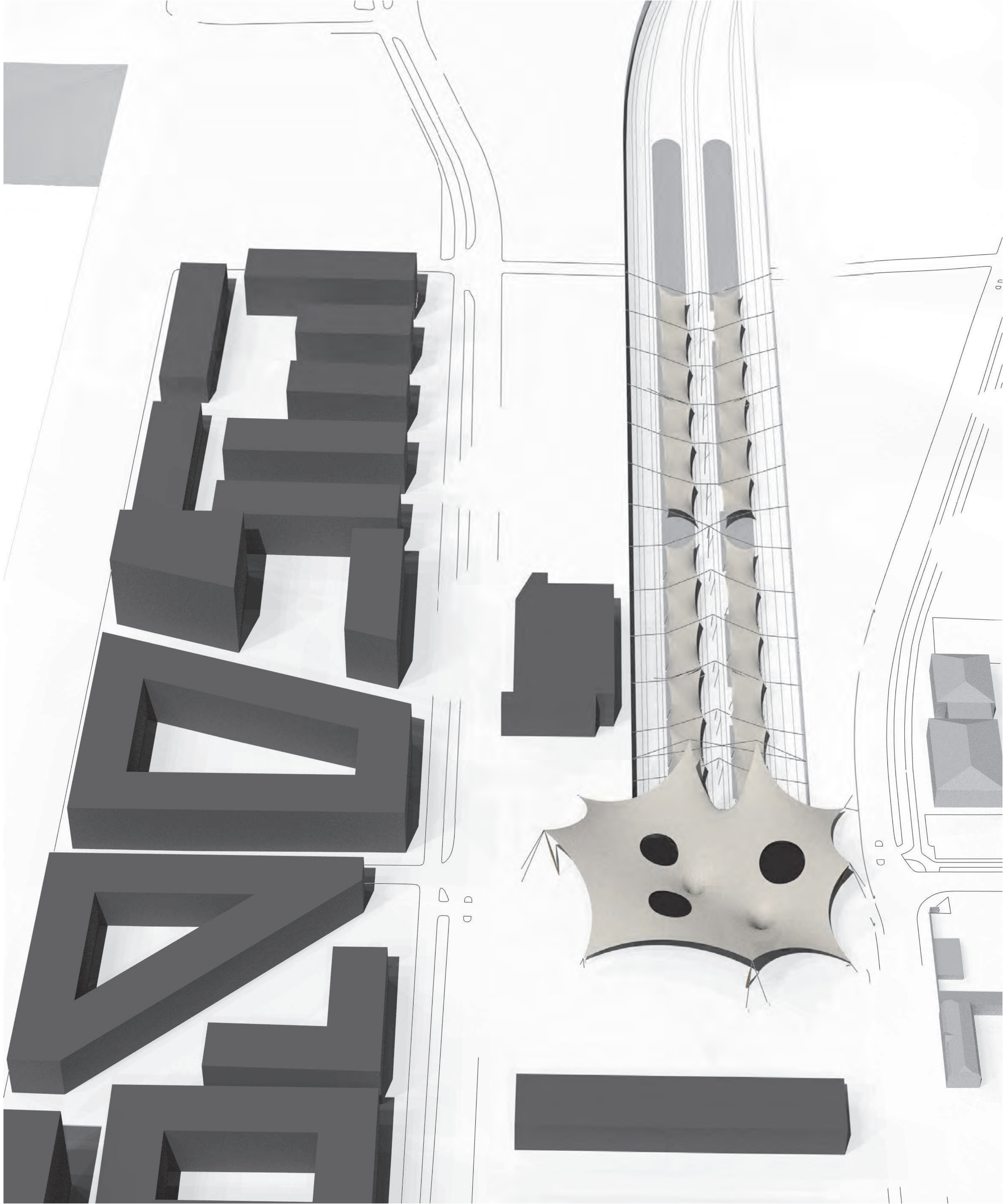
View from the platforms

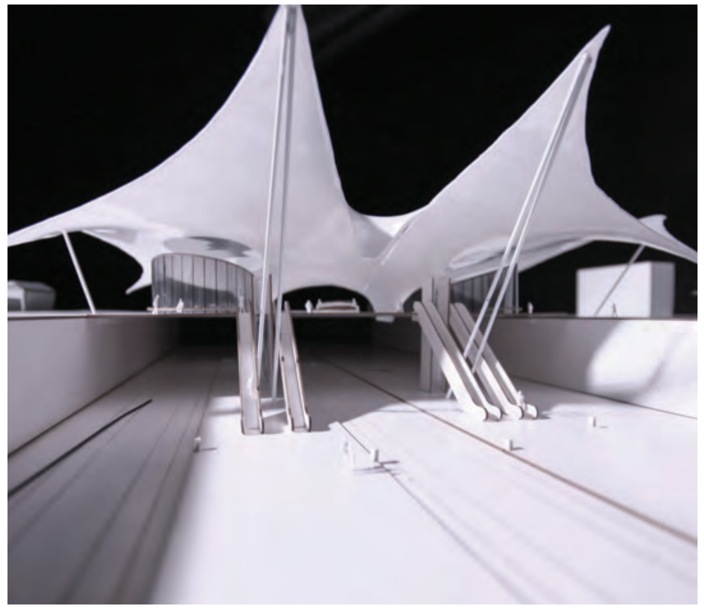


Main entrance



View from above





View from the plattforms (without any membrane roof above them)

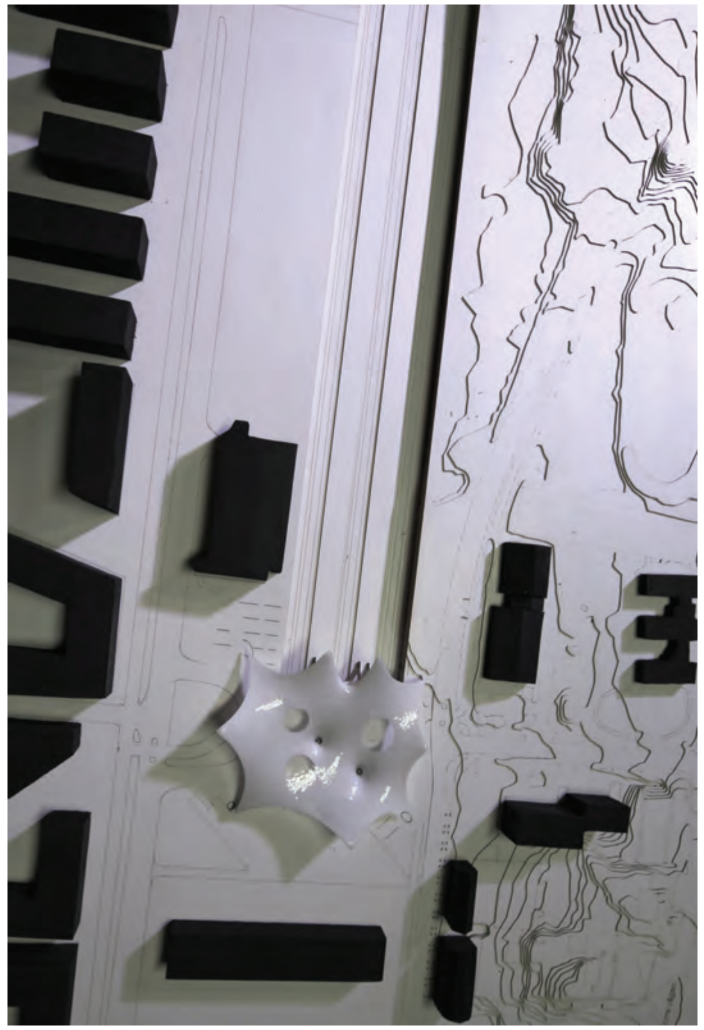


Photo of a physical model

The Process

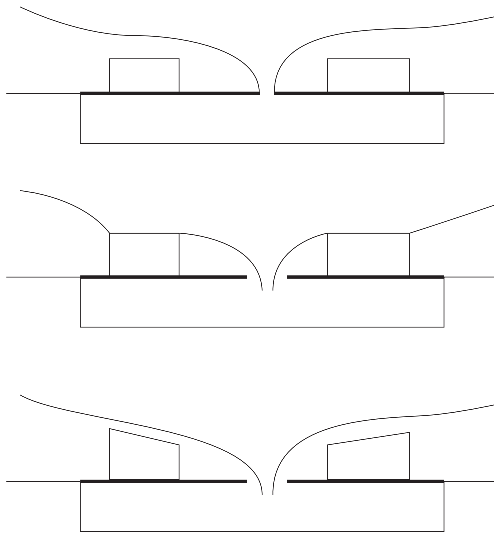
Physical models

Early sketch models, experimenting with the shape.

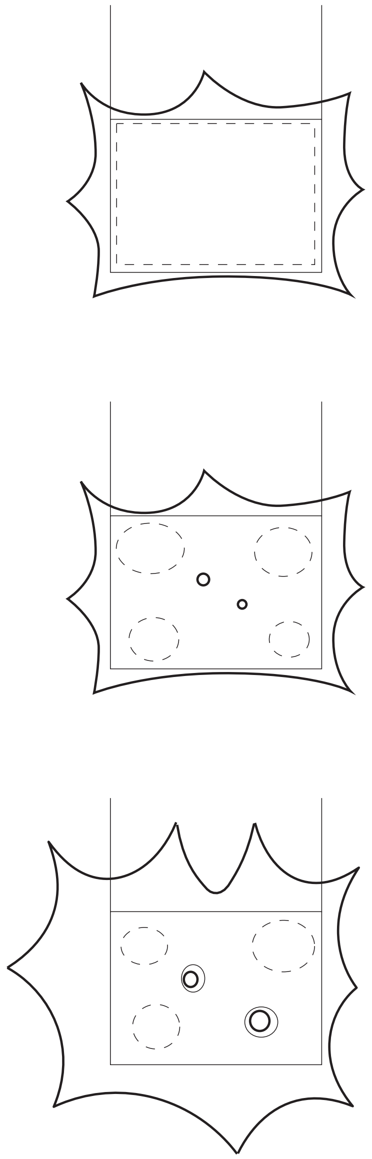
Scetch models in 1:200

In these models different concepts were tested, susch as allowing the membrane of the roof carry the bridge slab, in diffferent ways.

In the model at the bottom the relationship between the roof and small shops are tested.

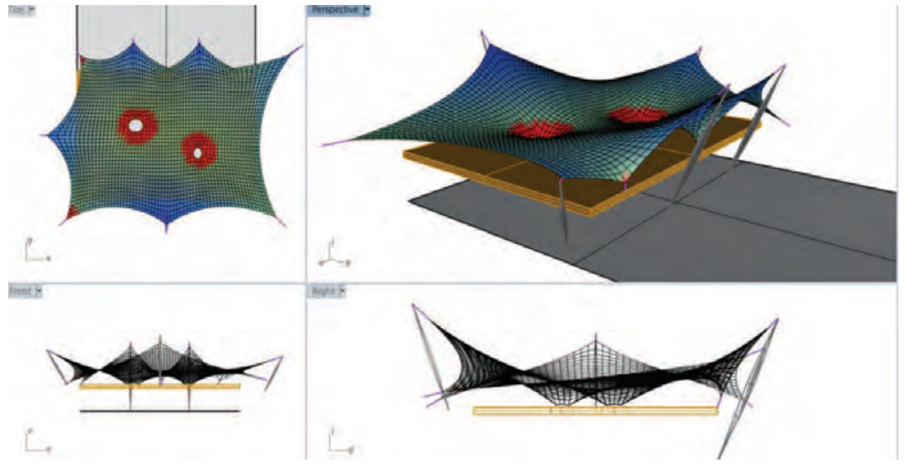


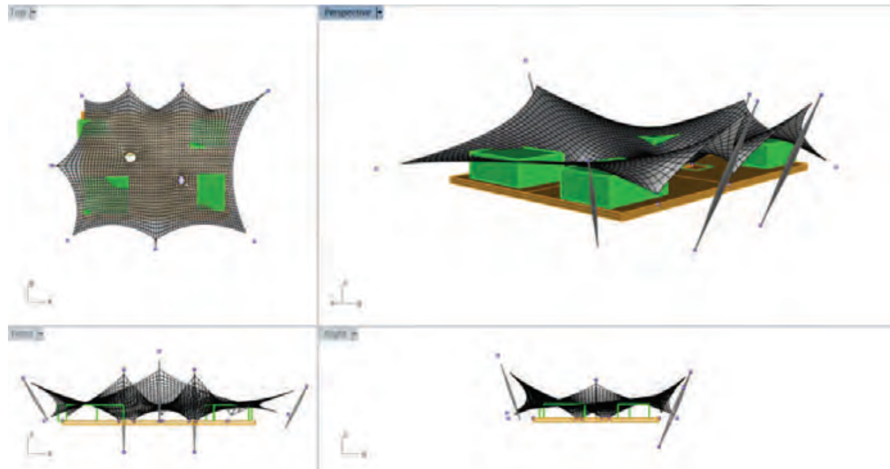
Illustrating the evolution of the form, in section

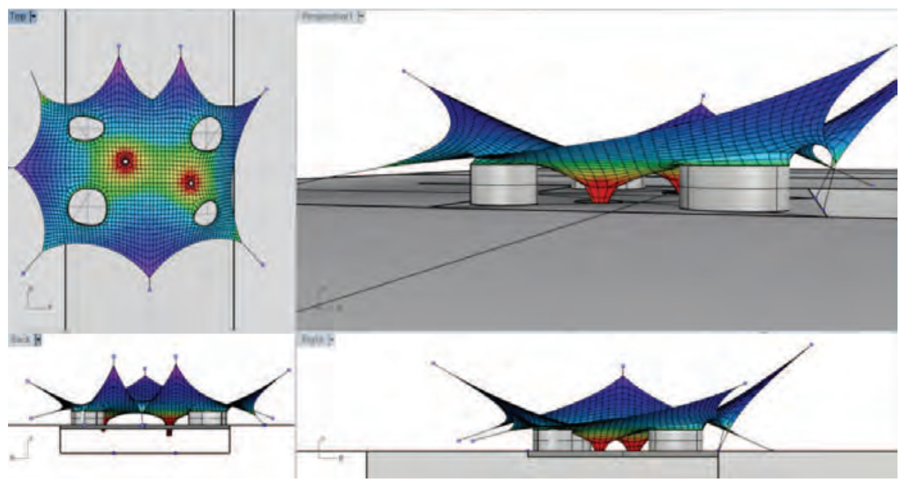


Illustrating the evolution of the form, and buildings under the roofs, in plan

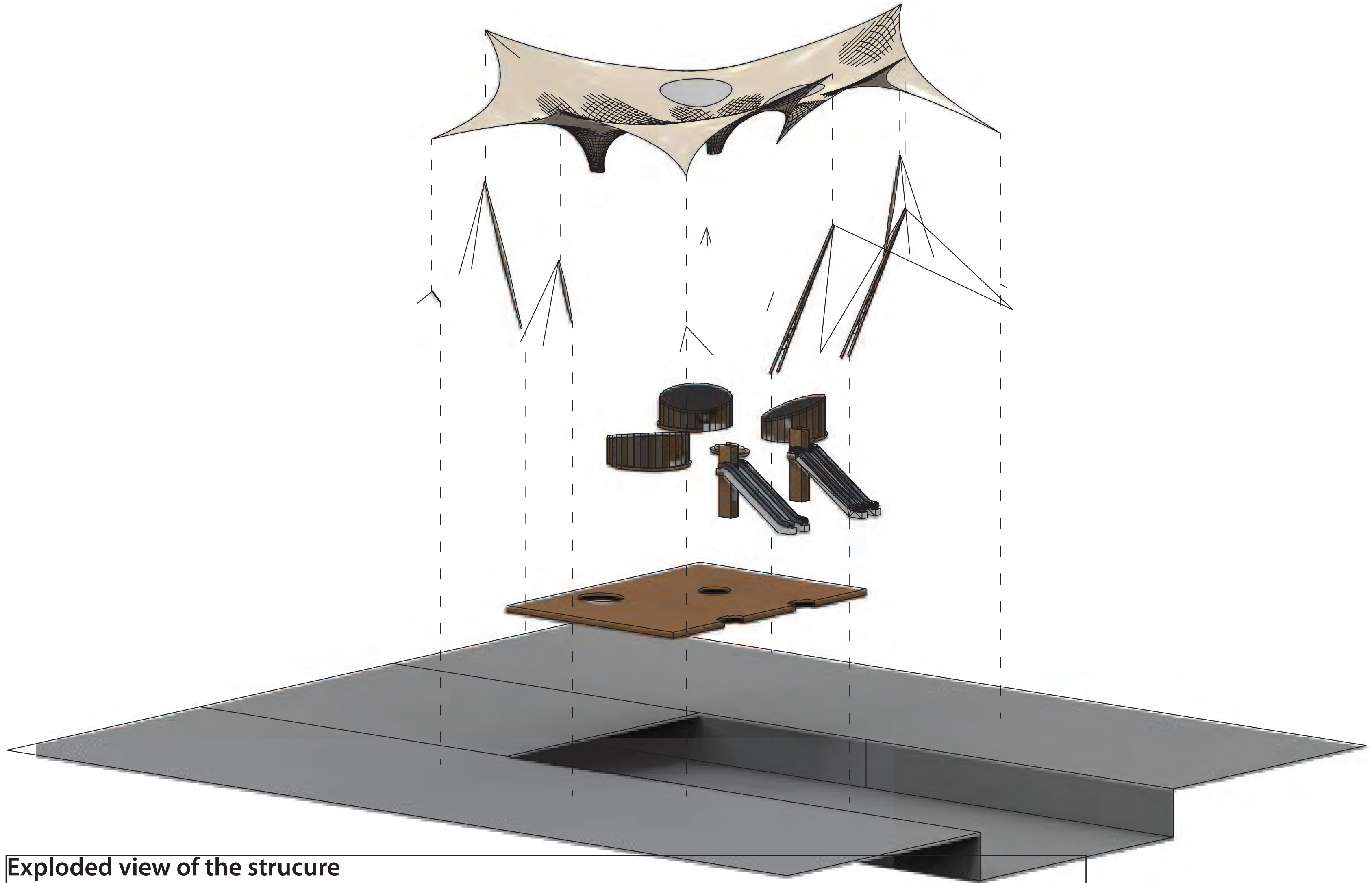
Digital models



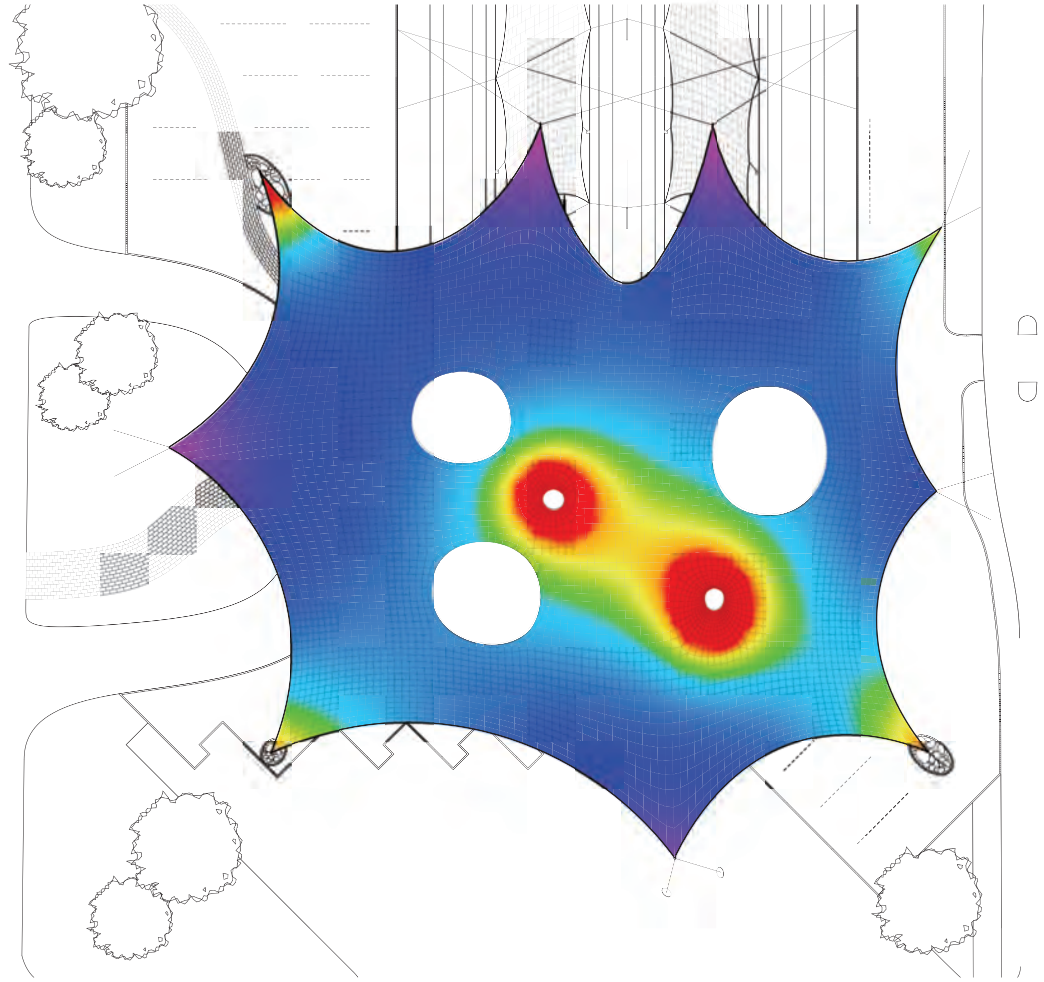




The Structure



Exploded view of the strucure

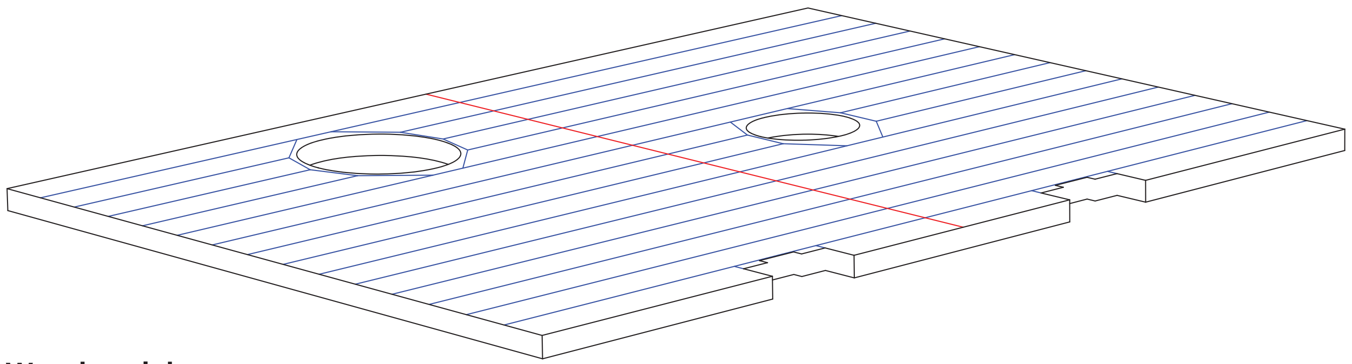


Ceiling height

The colours in the plan above is showing the ceiling height at the station, where the red areas have a height equal to, or below 2,4 m, and purple is showing the highest points of the structure.

Main Pillars

By connecting two gluelam pillars with steal bars and cables, creating a truss, they can be kept slender. Thereby not imposing too much on the view.

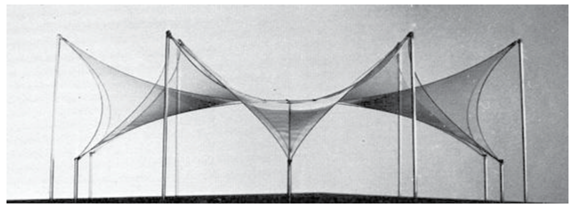


Wooden slab

The red line is illustrating the primary load carrying structure. This beam is held up by the tunnel roof in the back and with the lifting power from the fabric roof, in the front. The secondary beams are, then, spanning between the primary beam and the sides of the railway trench.

The Process

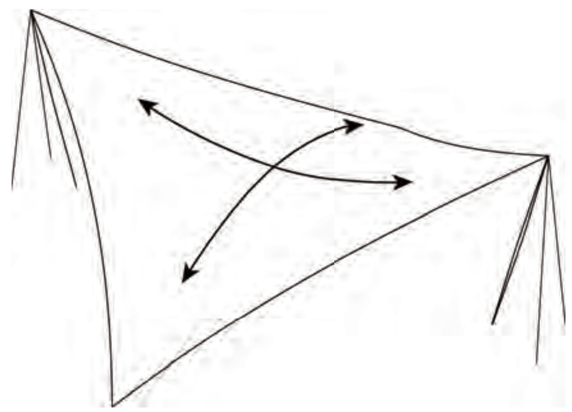
the Concept of tensile structures

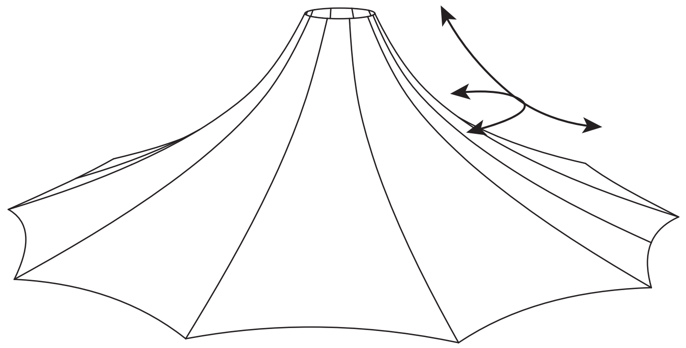


Soap film model of the Dance Fountain in Cologne, designed by Frei Otto

Minimal surface

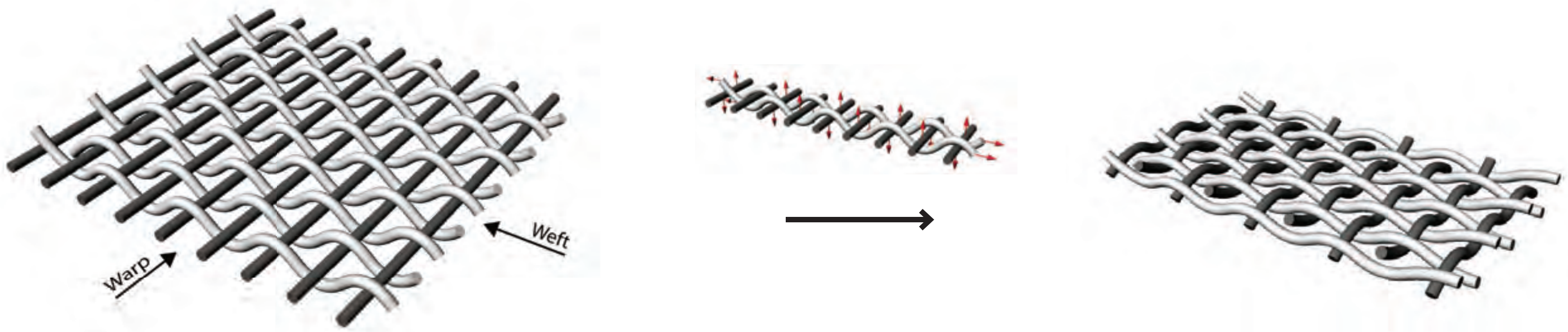
A classic way for finding the shape of membrane structures is the soap film model. Within a frame a soap film always contacts to smallest surface possible, i.e. the minimal surface, which is what membrane structures, in general, strive towards. When it comes to geometry the soap film can, therefore, be seen as the optimal membrane. It is a good material for representing a large structure in a small scale model, something that is otherwise difficult to do with different kinds of textiles, since they have a different thickness and weight. The behaviour of a soap film can, however, be modelled mathematically in a computer.





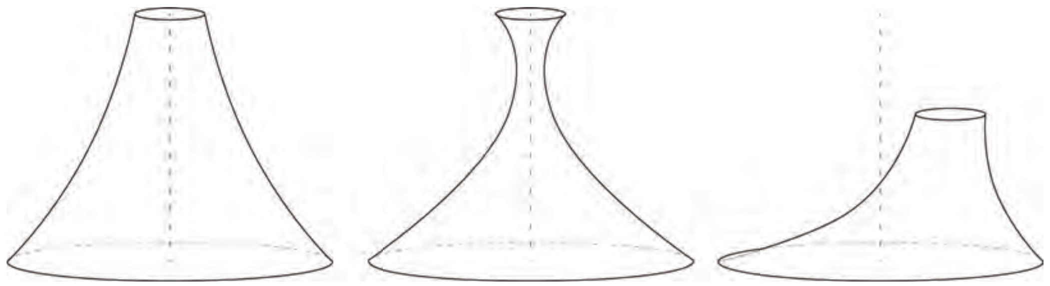
Anticlastic shape

Tensioned fabric structures can, as the name implies, only carry load in tension, therefore most of the structures are anticlastic. (double curved), as in the illustrations above. This way at least one direction will be working in tension, even under heavy loads.



The weave and prestress

A fabric weave is clearly an orthotropic material. The stiffness in the warp direction is different from the stiffness in the weft direction and the fabric is a lot less stiff if pulled in a direction different from these principal ones. This is evident when you pull in any woven textile; it will deform a lot more when pulled in a direction diagonally to the weave, than when pulled along it. The reason for this is the way the weave is built up, with warp stretched in the production, and the weft (also called fill) going over and under the warp threads. Looking at illustrations above it is evident that the effect of pulling in either the warp or weft direction should have consequences one the other. The threads in the weft are forcing the warp to move up and down, and thereby adding tension to it.



Conics

Although uniform prestress is preffered in many cases, when it comes to conic shapes it is often necessary to apply different prestress in the warp and weft directions, to keep the shape from necking in, as illustrated in the middle figure.

Stress patterns

The pictures to the left are showing stress patterns for a hypar that has been analysed under wind pressure (pushing the membrane down). The fabric is oriented so that the warp is parallel to a fictive line between the two high points in the structure.

The two top pictures are showing the warp-stress and the third one is showing the weft stress (for the same load case).

At the bottom is an figure showing the warp stress for a double hypar, with the same load case as the rest.