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 lightweight 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.
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 to Varberg and an important node in the city.
The Cold Bathhouse
With over 200 years of Varberg being 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.

Campus
A campus housing both a high school and a collage.

Socitetshuset
A restaurant and a club house, from 1886, drawn by architect Adrian C. Peterson.

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 was ruled by Denmark for almost 300 years. Under the direction of the Danish architect Hans van Steenwinckel, the fortress was extended in the 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 200-500 prisoners in the fort simultaneously.

The Old Railway Station
Built in the end of the 19th century, probably after drawings by architect Adrian C. Peterson.

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

Wind surfing
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 beaches south of the city centre.

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.

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The Role of the Station

Before

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

Now

Different travelling habits 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.

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 different ways of travelling, 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 transportation (trains, buses, cars, taxis, 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.
History

During the 15th century the town was situated on the hill east of the fortress, but after a severe fire in 1666, the city was rebuilt, in a grid pattern, at today’s location. Even here the town was 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 1803, this part were rebuilt with both wooden houses 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 railway line
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 this entrance there is also a multi-storey car park.
Buss terminal
The roof stretches over the docking area for the busses allowing people to wait, and enter many of the busses, in an area sheltered from the sun.
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 cables blocking the doors.
The platforms are accessed by the lifts and escalators on the north side of the building, and the bus 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.
Rainwater

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

Physical models

Early sketch models, experimenting with the shape.

Scotch models in 1:200
In these models, different concepts were tested, such as allowing the membranes of the roof to carry the bridge slab, in different ways.
In the model at the bottom, the relationship between the roof and small shops are tested.

Digital models

Illustrating the evolution of the form, in section

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

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.

Exploded view of the structure

Main Pillars
By connecting two gluelam pillars with steel 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 beams and the sides of the railway trench.
The weave and prestress

A fabric is 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 diagonal to the weave, than when pulled along it. The behaviour of a fabric can, however, be modelled mathematically in a computer.

Conics

Although uniform prestress is preferred 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 hyper 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).

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 illustration above. This way at least one direction will be working in tension, even under heavy loads.

The Process

the Concept of tensile structures

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 minimal 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 stiffness and weight. The behaviour of a soap film, however, is not modelled mathematically in a computer.