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## Textil Akademie Mönchengladbach, Job Report

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### Abstract

The textile façade for the Textil Akademie in Mönchengladbach, Germany, is developed as a pretensioned membrane and cable structure with valley and ridge cables. The cables are the forming and load carrying elements which are vertically spanned along the façade. This paper presents the development of the façade from the architectural concept to a shape that is suitable for membranes, the supporting steel structure attached to the concrete wall, the connection details, patterning process and the installation.

**Keywords:** PTFE, mesh membrane, cable structure, analysis

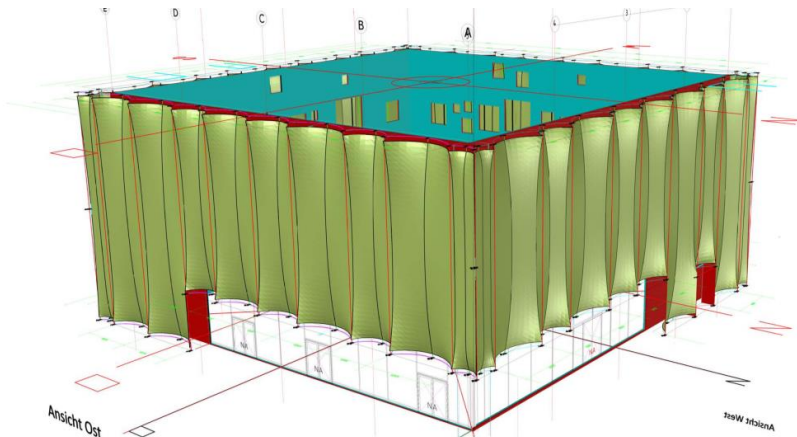


Figure 1: isometric view textile façade

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## 1. Introduction

In Mönchengladbach a new school of the textile industry has opened in autumn 2018. The school is surrounded by a textile facade, and transporting with its appearance also the contents of the teaching. The surface area of the façade membrane is approximately 2100m<sup>2</sup>.

On the top and the bottom a steel structure is attached, which acts as upper and lower fixation. To shape the membrane, the attachment lines consist of arches, which are connected in the peaks. Vertical cables span between these lines and shape the membrane into its undulation.

In order to allow the view from the class rooms to the outside, an open mesh material with 42% opening was chosen. This mesh is coated with silver PTFE, and gives a shiny surface to the project.

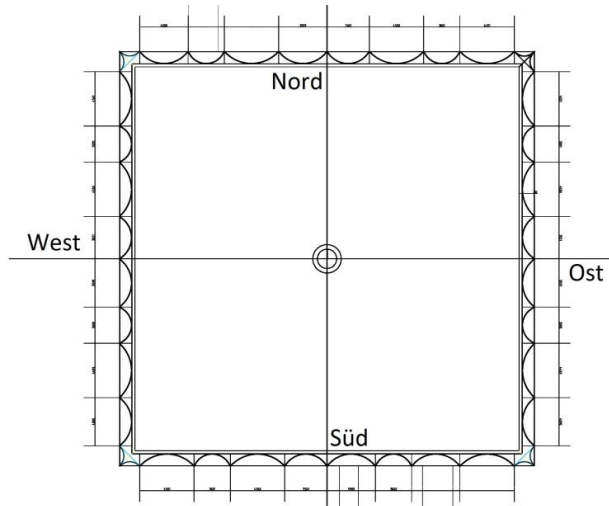


Figure 2: plan view academy building

## 2. Structural system

Between the undulated support system span membrane panels. The height of the facade is up to 16 m. With the chosen boundaries the membrane would have become almost flat, and would not be able to carry the applied wind load. Furthermore the textile facade should form higher folds.

Vertical cables in distances between 1.5 and 2.5 m are spanning from top to bottom. They carry the wind loads and form at the same time the membrane, Alternating, these cables are sitting as ridge cables behind the membrane and as valley cables in front of the membrane.

Even with these cables, it is difficult to shape the membrane, that is why a relative high prestress in the cables was required, as well as in the vertical direction of the membrane.

### 3. Analysis

The analysis of the membrane has been performed with the software TL\_form and TL\_Load, special software for membrane and cable systems, taking into account large deformation, as well as the orthotropic behaviour of the membrane. The stiff supporting structure was analysed with the truss software Rstab.

The façades in the North and in the West were representative for the whole façade. In the west the panel has the full height, in the North we have over one half a glass façade under the membrane, and we have one integrated door frame.

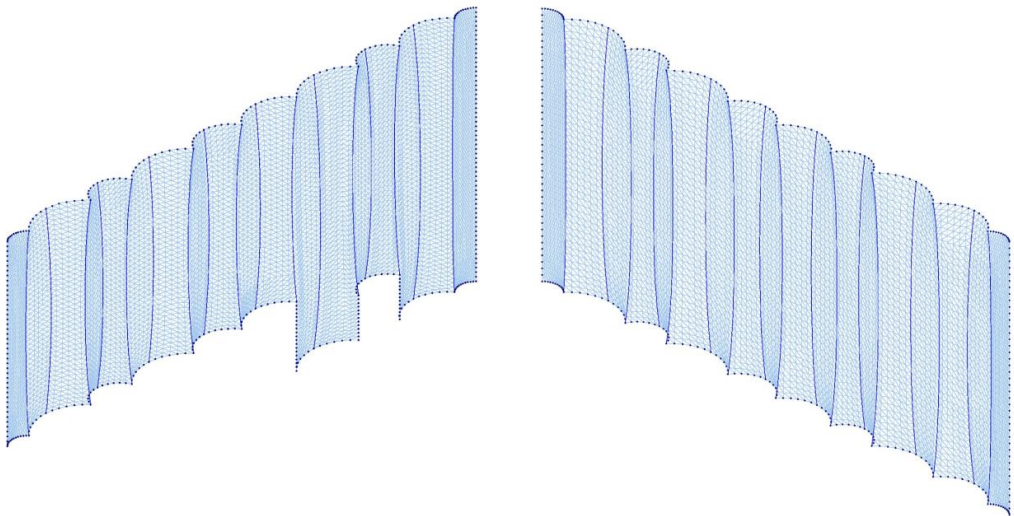


Figure 3: Numerical model membrane and cables North and West

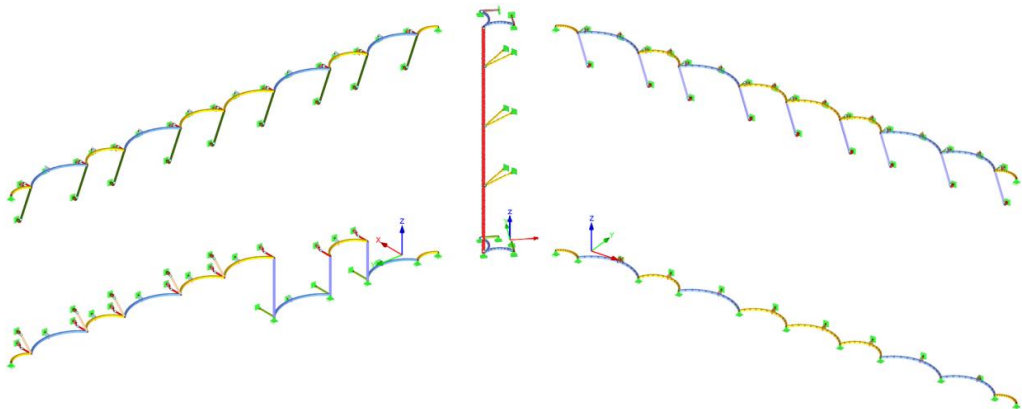


Figure 4: Numerical model supporting structure North, Corner and West

Wind has been applied according to Eurocode 1 for a cubic building. Due to the undulation also wind friction along the façade has been taken into account. The stiffness of the membrane has been determined in a biaxial test, which has also been used to determine the compensation factors. Beside this only prestress and selfweight were applied.

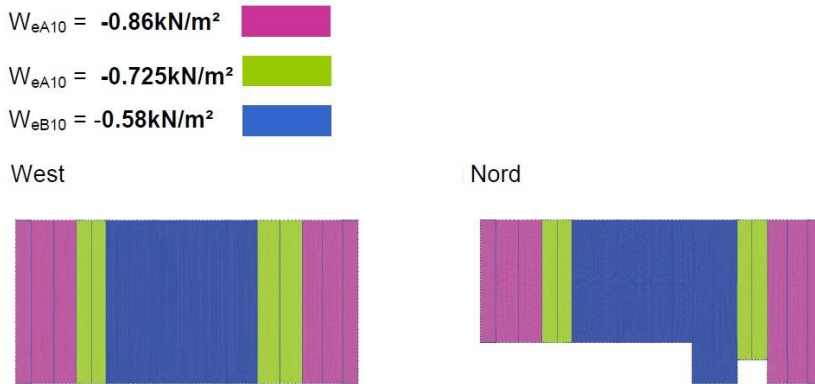


Figure 5: Distribution of the wind load for the two representative façades

The prestress in the membrane is 4 kN/m in warp and 3 kN/m in weft. Under windload the stress in warp is increased to 18 kN/m and in weft to 8 kN/m. The warp direction is vertical.

The cables are prestressed with 50 kN. Under wind load the inner cables get a maximum force of approx. 130 kN in the service limit state.

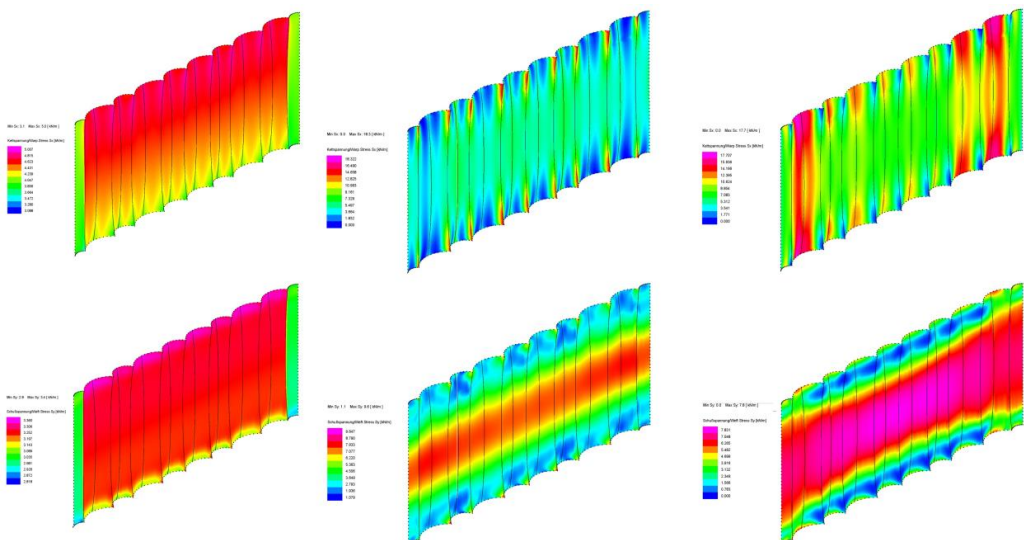


Figure 6: Membrane stress: prestress, wind pressure and windsuction West

## 4. Detailing

The architecture required minimised details, as well as a minimised distance to the insulated wall, that is why adjustable details have not been used along the rigid edges. The only adjustability is within the cables, which have threaded sockets at their upper end.

### 4.1. Upper connection detail

At the upper end the cable has a threaded fitting that allows to adjust the cables in case of tolerances. To ensure the rotation, the cable is sitting on a spherical washer.

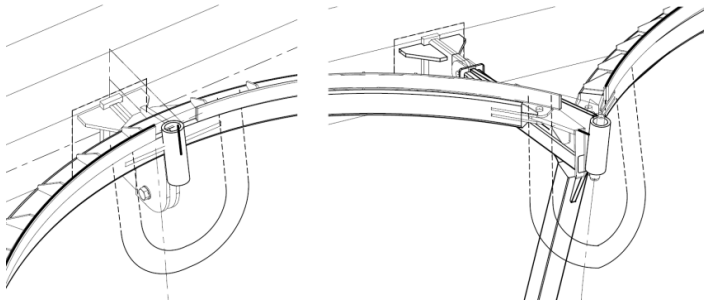


Figure 7: Upper detail wind suction and wind pressure cable

### 4.2. Lower connection detail

At the lower end, the cable has a fixed connection that allows for rotation perpendicular to the façade.

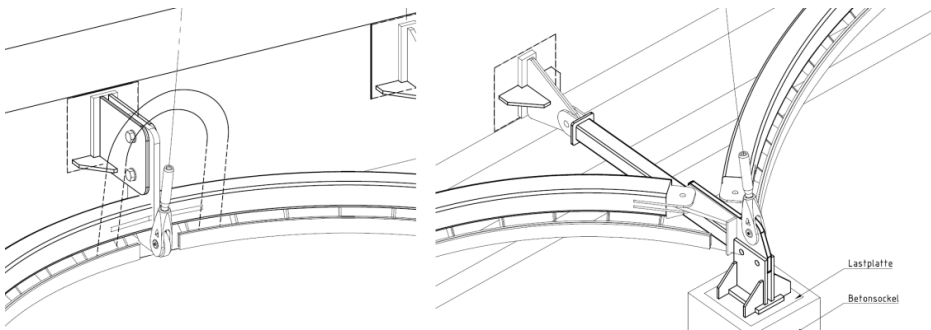


Figure 8: Lower detail wind suction and wind pressure cable

### 4.3. Lateral detail

The horizontal fixation of the membrane panels is made with rigid linear supports. The membrane is clamped to a U-shaped steel profile. With V-shaped struts this is fixed in-between the upper and the lower attachment line.

At the top and the bottom, this vertical beam is fixed to the circular arches of the neighbour panels.

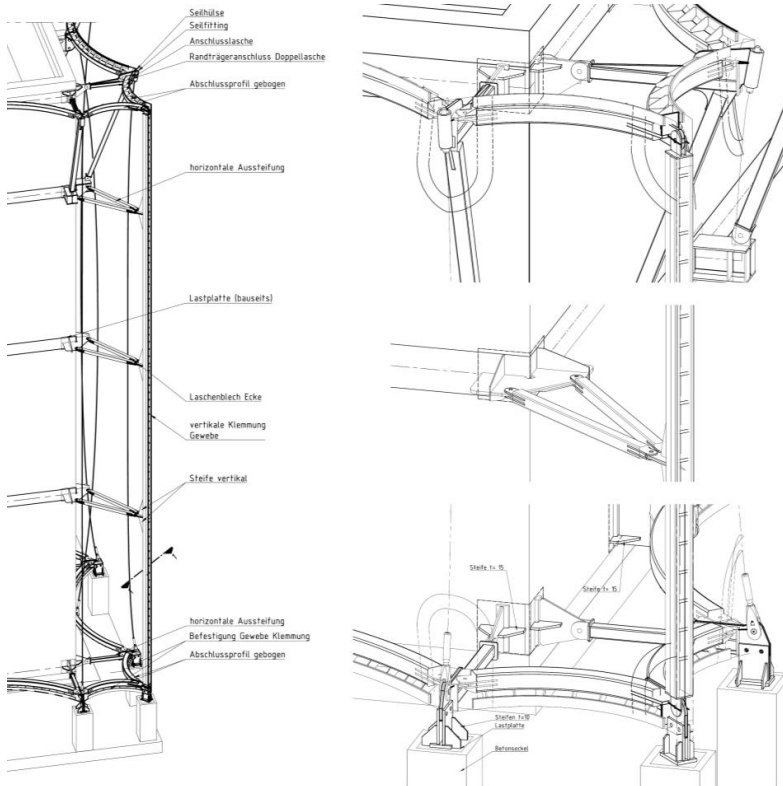


Figure 9: Corner detail from Top to Bottom

#### 4.4. Membrane connection details

As mentioned before, the details were required to be almost invisible. Therefore along all edges we have a small clamping detail without any adjusting. The covering clamping plates were made so that also the keder disappeared behind the plate.

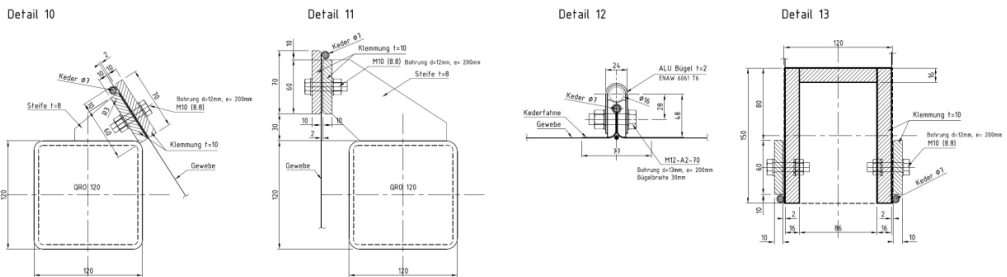


Figure 10: Clamping details of the membrane panels

## 5. Cutting pattern

To minimize the visual impact all bays have their welds only in the lines of the cables. The compensation has been determined in a biaxial test. Due to the specific behaviour of the glass mesh, the final compensation was very low, which caused additional effort to the installation.

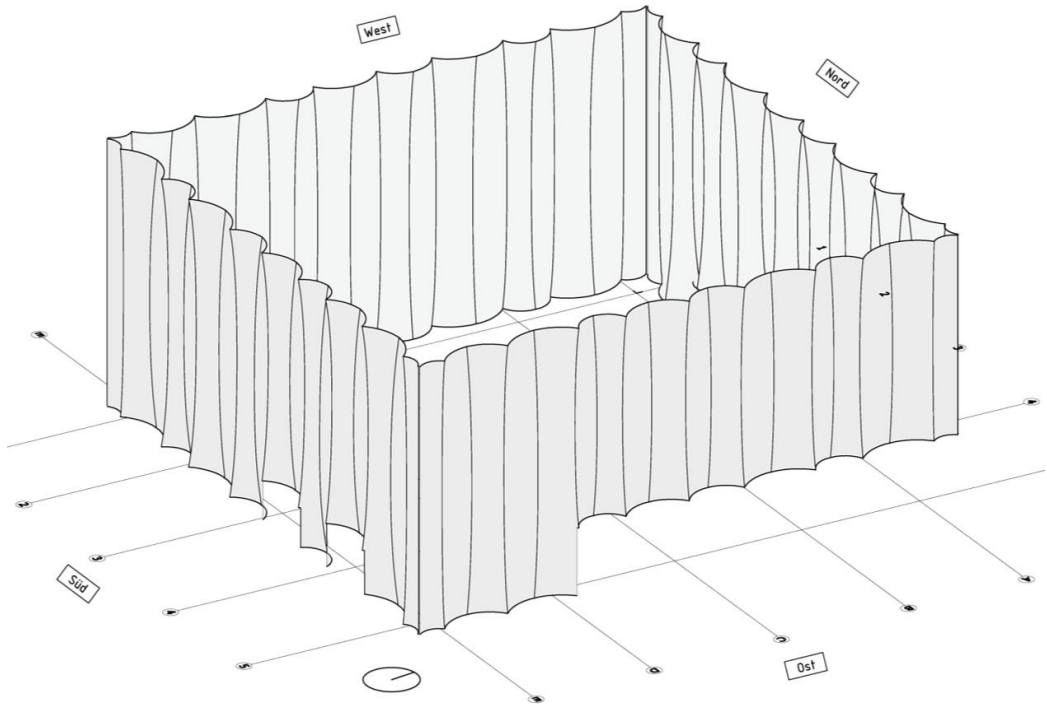


Figure 11: Final seam layout

## 6. Installation

The textile façade is fixed on the concrete wall of the building. Embedded steel parts had been placed in the formwork, where later the brackets had been attached with site welds. The wall was then covered with thermal insulation and plaster.

The supporting steel structure was then connected to these brackets, and geometrically surveyed for a final geometry check.

The membrane installation has been made per facade. The panels have been unfolded and laid out on the ground. With the help of mobile cranes, the panels have been lifted and attached to the upper attachment line.

The cables have been installed to the final length, and the membrane panels were stressed and clamped in the final position.



Figure 12: Support structure installed



Figure 13: Attaching of the membrane panel



Figure 14: Stressing and fixing along the lower edge



Figure 15: View from below at a door frame



Figure 16: East and North façade



Figure 17: South façade



Figure 18: East façade in the twilight



Figure 19: Transparent appearance during the night

## **7. Conclusion**

The result of the project comes close to the design intent. The textile appearance is remarkable, and gives already an idea what might be taught in this school. From inside the façade is nearly transparent but still provides shading, while from the outside its appearance depends on the light conditions and ranges between reflecting and semi-transparent.

The use of almost invisible details made the detailing and the installation quite complex. Adjustable details would have allowed more tolerances, and a simplified installation, but they would remain visible. The installation team has worked out suitable methods to deal with these constraints. The developed installation tools can be used for future maintenance.

The textile character of the chosen mesh material appears also from far. The wish of client and architect to have a remarkable undulation over the full height of the façade leads to high tensile forces in the vertical direction. The final shape is a good balanced compromise, still appearing undulated, but with reasonable tensile forces.

## **Acknowledgements**

Client: Textilakademie NRW gGmbH

Architect: slapa oberholz pszczulny | architekten | sop GmbH & Co. KG, Düsseldorf

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Contractor: Koch Membranen GmbH, Rimsting

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