

RENS OTTENS

REFLECTION

ON GRADUATION PROJECT

*HIGH STRENGTH THIN GLASS
AS
STIFF STRUCTURAL FABRIC*

REFLECTION

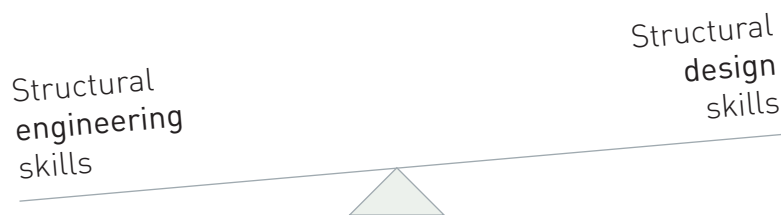
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The goal of this graduation project is to research the possibility of cold bending high strength, thin, flat glass into a double anticlastic surface. With P5 coming close and having covered most technical investigations proposed in the graduation plan, it is now time to evaluate if the approach chosen worked based on four different aspects.

Research & Design



The research part have played a dominant role in this research, especially the tests in the lab. The research started with a design assignment which is based on a first literature review. Because high strength thin glass appeared to be such a high tech material, lots of information had to be gathered before being able to design. The design assignment to implement this glass as a tensile membrane structure is relatively so unknown, that no scientific information is available about this topic.

To come up with a design of cold bent, double curved in the opposite direction (anticlastic), thin glass plate, research is needed into scientific information about the high strength thin glass, its tensile strength and analysis about the desired geometry. In this research, technical validation of all of these three aspects is covered. However, it took time to come up with a design that took every technical requirement into account. It was an iterative process of gathering information that followed with a design concept, a preliminary design and an elaborate design.

In this research thin glass is chosen, because it is a material with promising, yet challenging material properties for implementation as architectural product.

The hypothesis of this research is that the conventional cold bending technique of twisting glass elements would not result in a double curved, but a single curved thin glass plate, based on its structural behaviour of a membrane. However, based on its high strength, adding tension load should induce the twist again, that result in an anticlastic surface. Besides the higher tensile strength, the created tensile stresses by the twisting assumed to be way lower, because of its membrane behaviour. To proof the concept of using thin glass as tensile membrane structure, all knowledge from the research is integrated into a design.

Graduation lab & Case Study

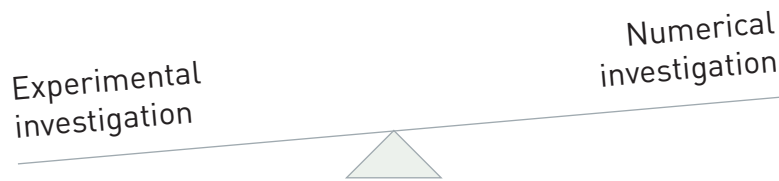


Although it depends totally on the scope of the research, it was my personal interest to understand the structural mechanics part totally. The structural mechanics part within the structural design theme played in this research a dominant role. That is not easy for a student with a bachelor in Architecture as basic foundation. I read a lot of papers, but kept designing to solve problems. With the wisdom I now have, it was better to come with hard facts earlier in the process. I, constantly, tried to solve problems with structural design skills, instead of structural engineering skills. Although the graduation lab assume the student constantly switch between these two approaches to solve problems, it can be hard to estimate which one is in a certain phase most effective. This has led to an incredible learning curve for me as a person during my graduation project.

For the sustainable design graduation studio of the building technology track, three main themes are leading for each graduation topic: Climate Design, Structural Design and Façade Design. The graduation lab stands for innovative and sustainable concepts that could be applied in the built environment. This research focusses on the development of a building component of thin glass. It is a new material that needs to be treated differently than any other material that can be imagined.

The chosen subject of cold curved structural glass elements can play a big role in future curved or geometrical complex shaped building envelopes by giving new knowledge, information and/or insights. It also could lead to an easier alternative for more lightweight curved façades.

Research Approach



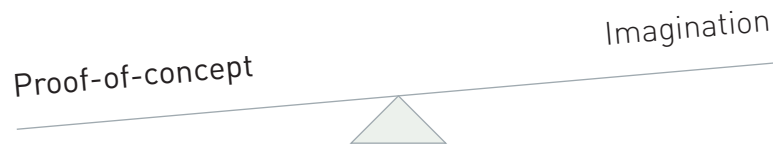
Every student who is graduating in the building technology track is somehow testing its concept by experimental and/or numerical investigation, before it starts to design in detail. However, a big difference is the approach. A student can start with a case study and integrate the best suitable technique to build the case study. Or a student can start with a technique and then searching for a suitable case study in which it can applied to. The second approach is someway a reversed methodical line approach which is sensitive to loose track if facts are not well founded and the research is not scoped properly.

The experimental phase within this research played the biggest role why the progress of this research have not been linear. The knowledge that comes along of the behaviour of materials have made me think more than twice on every thing I wrote, said or thought. I might have taken too much effort in this in relation to the usual approach of the graduation lab and probably underestimated the value of investigating certain matters by numeric simulation, instead of real-life objects. Simply, because the material behaviour of chemically strengthened thin glass is not to mimic.

At the start of the graduation project I had the vision of a tent structure made out of glass instead of plastic or textile fabrics. Substituting these ductile or stretchable materials for a stiff one, resulted in a case study with not only a high tech researched material, but also a high tech solution for enabling the anticlastic cold shaped curvature. It is the art then, to use the right tools to still being able of making the right decisions. Although I had enough willpower, the topic raise beyond the mind. And definitely cannot be solved by sketching or 3D modelling.

For a research that is driven on finding innovative technology, the path can be long to finally scope the research enough and finding the essence of what is critical to the research. This does not mean that a research that is not driven on finding innovative technology cannot result to new techniques, but it is not a goal on itself. In this research I tried to re-invent the wheel in each phase of the project.

Project & Context



This research might affect the way of how we see glass today. Although glass is still that stiff and brittle material, using it as fabric, is a new structural glass application. It started with a vision to use thin glass in curved tensile structures, such as tent structures. And with the conclusion of this research this vision is one step closer to reality: high strength thin is capable to be cold bent in an anticlastic curvature. But, to what reality we are closer to? Are we able to create tent-like glass structures? I think, the hard reality is that it is not worth a try. Accomplishing a safe double curvature fail to achieve its objective of creating transparent curved façades. Accomplishing a noticeable double curvature is very difficult, and less transparent than we can make with conventional glass structures.

The created gap needs to be filled to fulfil the objective of starting and ending with a squared hypar surface. Therefore the added material needs to be stretchable, but capable of transferring the tension. The result of this research is a connection method composed of glass and plastic. Plastic is needed to fulfil the objective, but plays a dominant role to create a cold bent double anticlastic curvature of a flat sheet of thin glass. Therefore the final technical design might be called a fabric structure with stiff structural fabric inserts, instead of only a stiff fabric structure.

Although high strength thin glass is a strong and flexible material, it will not contribute to a better transparent built building envelope. The view, however, on using glass as a stiff structural fabric in a tensile structure or compressive structure is totally new and can bring many new designs with it in the future. The potential of high strength thin glass as stiff structural fabric in a larger tensile structure seems very unlikely, but further research how the wind load behaves on such a patchwork blanket structure should be researched with numerical simulations.

The technique of adding tension to the twisting should rather be seen to improve its stiffness than to create a complex shape, because the shape is barely noticeable. In addition to this, the work put in, to see a double curvature, will go at the cost of the transparency. Although the created façade will be light, it will not be transparent enough. With thicker glass and conventionally used techniques to create complex shapes, the facade might become heavy, but certainly more transparent.

