Reflection

This project started with the aim of reducing the weight of facades by implementing aluminosilicate thin glass instead of regular soda lime glass sheets. With structural, insulating, sunshading and transparent features (figure 1). To ensure that thin glass façade panels can be used in the built environment it had to meet a number of requirements. Concerning safety, thermal insulation value and light transmittance.

Because of its slenderness, thin glass is quite flexible, when subjected to a load it bends easily. Although it is possible to bend this glass type in terms of strength, for technical and psychological reasons this is undesirable when applied in buildings. Thus, the panel will have to meet the serviceability limit state (SLS) requirements for conventional glass panels. To avoid thermal leakages though this panel, it should meet the current thermal insulation demands. In the Netherlands the minimum required u-value is 2.2 W/mK. However, in order to achieve a better competitive position in the market, this project aims to achieve a U-value of at least 1.4 W/mK (figure 2). The final aim of this thesis is to reduce solar gain and excessive heat accumulation through glass surfaces while also retaining a certain amount of transparency.

Approach

The intention of this project was to integrate all these features into a thin glass panel with low weight. To achieve this, a literature study must be done first, about the material properties of thin glass, and its processing possibilities. By exploring precedents, methods were found to stiffen, thermally insulate and create sun shading for a glass façade panel, without adding too much weight. After this exploration, an initial panel design geometry could be chosen. This initial design was tested for its mechanical and climatological performance. Once this was done, conclusions could be drawn about the geometry of the panel. The mechanical, visual and thermal performance was studied in order to optimize the geometry for the selected case study, the façade of the Faculty of Architecture. Once the panel design itself is finished, the façade could be designed. This research method can be described as ‘design by research’.

Reflection

When the theoretical research was largely over, a number of things could be concluded about this research method and approach.

1. Due to the design by research by design approach, a lot of time was spent on the theoretical research. First, about soda lime glass, its material properties and processing possibilities, followed by the differences of soda lime glass and thin, aluminosilicate, glass. The challenges of applying thin glass were identified
and they formed the basis for the rest of the project. These challenges being sufficient thermal insulation and stiffness.

When research turned out that using a honeycomb sandwich panel was the most lightweight stiffening solution, the sandwich theory had to be investigated. Also the selection of a bonding method, the material of the core, its thickness and cell size had to be done. It turned out that honeycomb sandwich panels also offer good thermal insulation properties. Therefore, it was possible to design a lightweight facade panel according to the design criteria (figure 3). The selected core material, aramid, provides solar shading, stiffness and thermal insulation. Therefore, it could be said that the chosen approach and methodology was great to achieve the desired goal of this research. Unfortunately, only transparency was not achieved.

2. The theoretical research had to be proven through calculations, mechanical- and physical tests. Once the panel design was finished, finally the design of the facade could start. The theoretical research, calculations and tests has cost a lot of time, choosing a case study and designing are, unfortunately, discussed less dominantly in this thesis. In order do design an actual ultra lightweight structure, it might have been a better choice to design a lightweight pavilion instead of choosing an existing building which is fictionally renovated. The existing structure of the Faculty of Architecture largely limited the design of the façade because it is a monument.

3. Especially because of the breakage scenario, it is very important when working with glass to do a thorough mechanical research. Thus in this thesis, the mechanical properties of the panel played the biggest role for the final design. I do however believe that it is very important for a ‘new’ facade panel to also have a high thermal performance and it should also have a visual quality. My personal goal was to design a facade panel that could actually be sold. If more time was available, I would have tried to improve the visual quality of the panel by finding an optimum between the thickness of the core, the cell size and the thermal insulation, an optimum should be found between the mechanical- and thermal- performance and the amount of transparency. Further elaboration could improve the visual and thus the overall quality of the panel, increasing its overall market value.

4. It must be stated that there might be some deviations in the outcomes of the calculations. The mechanical properties of the panel are influenced by the strength of the interlayer, in the samples, SG is used. The best possible attachment of the film interlayer such as SG is achieved when the adhesion is created in an autoclave. In this project, the bonding is created by a regular oven. Also, to achieve better performance results, it would have been better to do more tests of the same type of sample. The more samples, the more results and thus the more reliable the results become.

5. The wider social context of this thesis is based on the concept of reduction. By reducing the weight of a façade while retaining the required thermal performance resources, waste and energy can be saved. By using thinner glass thus less material, the ecological footprint of facades, and the support construction of buildings could be reduced. In the end this goal was achieved, compared to traditional insulated glazing units, resources, waste and energy can be saved by implementing thin glass in the built environment.
Recommendations
This project provides an insight in lightweight stiffening methods of thin glass. However, there is still much more to explore, recommendations for further research include:
- Testing the actual thermal performance of this panel, should be done by performing a guarded hot plate test. With this testing method, a sample of material is then placed between two plates. One plate is heated and the other is cooled or heated to lesser extent. The temperature of the plates is monitored until they are constant. The steady state temperatures, the thickness of the sample and the heat input to the hot plate are used to calculate thermal conductivity.

- The thermal properties could be improved even further. For example, the thermal performance could be improved by creating a cavity construction with two sandwich panels. Or the thickness of the core could be increased.

- Almost every property that a façade panel could require is elaborated in this thesis. However, there is one more property that should be further explored: acoustics. The acoustic performance of honeycombs cores and thin glass should be further researched in order to actually apply this panel in the built environment.

- Because both thin glass and the honeycomb core are quite flexible (depending on its material and thickness), so it could be a possibility to design a single or even double curved panel by laminating them onto each other with the vacuum bag process. This production technique creates many possibilities for freeform architecture which could be a very interesting starting point for a design.

Figure 5. Possible future facade design.
Source: by author,