Final Reflection – Minke Venus, 4998502

Graduation process

"How is your graduation topic positioned in the studio?"

My graduation topic focuses on the main themes **Structural Design** and **Design Informatics**. The core focus was the development of a structurally feasible and reusable float glass system.

For the development and structural verification of the design, computational tools such as **Grasshopper for Rhino3D** and **Ansys** - a finite element analysis software - were used.

Grasshopper3D was utilized to:

1. Explore modular adaptability: investigate how the structure could be designed using standardized components, while still allowing for spatial adaptability to different building locations.

2. Develop a tool that enables users to explore and evaluate various design alternatives tailored to specific span requirements that perform similarly in terms of ease of assembly and structural weight.

3. Parameterize the module geometry to establish an efficient workflow for performing stress analysis in Ansys.

The finite element software Ansys was used to:
– Map the magnitude and exact location of stress concentrations at critical points in the module, and to determine appropriate sizing for the structural component.

In addition to using computational tools, a laboratory test was conducted at the module's most critical location to verify whether it can withstand the expected design load associated with the adaptable system. The test also aimed to draw conclusions about material efficiency, structural weight, final module dimensions, and directions for further research into structural performance.

"How did the research approach work out (and why or why not?) And did this lead to the results you aimed for? (SWOT of the method)"

Strengths

The research method incorporates different approaches, including literature study, design development, parametric modelling, and physical testing. Literature research enabled me to make well-informed design decisions and supported the development of concept designs. Subsequently, through computational design, I was able to extensively test the spatial capabilities of the system. The advantage of this approach is that the computer can explore a wide range of design options far more efficiently than would be possible manually.

In addition, the digital structural analysis and physical testing enabled an assessment of the system's structural performance, an essential step toward facilitating the design's potential application in practice.

This approach led to the results I was aiming for: a structurally feasible design – within the boundary conditions - of a float glass system, consisting of two standardized modules with the potential to be easy assembled and disassembled and adapt to spatial changes, in order to be reused.

Weaknesses

- In order to test a wide range of design variants, the parametric model of the system had to be simplified. For example, to study the effect of angle variation on the system's span, it was assumed in the model that the modules always interlock at the same position, whereas in reality, this is not the case. A resulting weakness is that the parametric model represents only a simplified version.

Opportunities

- The method could have been strengthened by integrating more physical testing during the conceptual design phase, allowing for immediate validation of design assumptions. Additionally, to test the adaptability of the system, creating physical prototypes of the modules would have been valuable. This would have enabled real-life exploration of the system's potential configurations, while simultaneously providing insight into the structural stability of different arrangements.

Threats

- Because the system was primarily developed in a digital environment, there remains a risk that its real-life performance may differ from expectations. For example, assembling physical prototypes has already shown that it can be challenging to ensure that a module is connected exactly at its midpoint. In practice, this might require marking the modules to indicate the precise connection point.

- The research relied heavily on methods and tools with which I initially had limited experience. This posed a risk in terms of interpreting results - such as those from the stress analysis or the multi-objective optimization. Although I frequently consulted professional help for confirmation, the process ultimately required me to take the lead and make decisions independently.

Additionally, this unfamiliarity made it unclear at times whether my intended approach was feasible within the available timeframe - or even technically possible. For instance, I lacked knowledge about the capabilities of the compression equipment, which led to a constant change of plans for the physical testing method.

A similar issue arose with the use of the parametric model. Initially, the algorithm was not set up to explore design variants, but rather to develop ‘perfect’ spans. Due to my limited initial understanding of how parametric modeling could be used as an experimental tool, this approach had to be re-evaluated and adjusted during the process. Fortunately, this became clearer as the research progressed, allowing for timely corrections.

“If applicable: what is the relationship between the methodical line of approach of the graduation studio (related research program of the department) and your chosen method?”

The Structural Design studio focuses, among other things, on the general principle that a structure can define and shape a space and contribute to architectural quality. Building on this idea, I explored how structural float glass - traditionally considered a secondary building material - can serve as a primary load-bearing element. This approach enables the creation of diverse spatial configurations while simultaneously enhancing architectural expression. This investigation aligns closely with the studio's commitment to integrated structural design.

The project reflects the core principles of Design Informatics by employing computational methods such as parametric modelling, and finite element analysis (FEA). Tools like Grasshopper and Ansys were used to analyze adaptability and structural performance, while a multi-objective optimization process allowed design variants to be evaluated for spatial fit, ease of assembly, and lightweight performance. This methodical approach is directly in line with the studio’s ambition to model, analyze, and optimize architectural performance using digital technologies.

“How are research and design related?”

Theoretical research served as a foundation for developing the concept designs. Parametric studies were then employed to experiment with design parameters of the proposed system. This knowledge was applied in the development of an algorithm capable of generating multiple design variants. In this way, both literature-based and parametric research continuously informed the design process.

The literature study guided the overall design direction and helped define what is and isn't feasible with the chosen material. Parametric research, on the other hand, provided insight into the spatial possibilities of the proposed concept. For example, while working with the parametric model, certain assumptions about the adaptability of the system were confirmed or disproven, revealing the extent to which the design could truly adapt to different spatial configurations.

Furthermore, structural analyses and a laboratory test provided insights into the system's performance. This information was crucial in determining the feasibility of the design and establishing the final dimensions of the system. It also offered guidance for identifying relevant future tests and further development opportunities.

"Did you encounter moral/ethical issues or dilemmas during the process? How did you deal with these?"

Moral or ethical issues were not applicable. However, some dilemmas arose during the process, mainly related to ensuring that the methods and measurements used would genuinely contribute to answering the research question. Initially, I approached it with a mindset that was too restrictive. For example, by already defining that the arch that had to be created had to start and end on the same y coördinate, and must be symmetrical. Later, it became clear that the right approach was to explore what the system *was capable of*, rather than prescribing beforehand what it *should* be capable of. Whenever I encountered uncertainty or conceptual obstacles like these, I reached out to professionals, such as my mentors.

Graduation process

"To what extent are the results applicable in practice?"

The designed system is not yet ready for direct application in practice, as this research explores an innovative topic that does not build on extensive prior studies. There is limited existing research on modular structural glass and adaptable glass systems. This study is one of the first to combine modularity, manual assembly and disassembly, and spatial adaptability with the goal of enabling reuse.

Rather than focusing on the detailed engineering of the connections, the research primarily investigated the *potential* of the concept design in terms of adaptability and manual assembly. However, this research represents a step toward practical implementation, demonstrating that the system is structurally feasible - within the boundary conditions of a maximum span of approximately 8 metres (and potentially more), and under compressive loading in-plane.

Furthermore, to ensure full practical applicability, the entire assembly process should be tested at full scale to assess whether the module weight can be managed without the use of a crane, and to evaluate the overall assembly experience

"To what extent has the projected innovation been achieved?"

The research has demonstrated that the proposed system provides a solid foundation for further development. With just two types of modules, the system is capable of generating spans and configurations that vary across several meters. The parametric tool successfully produces design variants that closely match the desired span, while also optimizing structural performance and assembly simplicity. Importantly, the modules remain small enough to be theoretically assembled by hand, without the need for a construction crane.

In addition, the system has shown promising structural potential, which could serve as an incentive for further refinement and eventually a real-world application.

The physical models - from scale models to the 1:1 prototype – also encourages reflection on the practical assembly process. The full-scale model offers a partial experience of the actual assembly, confirming that the theoretical concept can indeed function in practice. At the same time, it highlights details that require further attention, such as the precise alignment points where one module slides into the others. It also raises the question of whether acrylic is a suitable material for the slot infills - not only in terms of strength, but also in terms of flexibility to absorb production tolerances and in that way prevent asymmetric load distribution.

That said, several steps remain before the system can be considered fully ready for practical application. While the modules have not yet been completely engineered, the goal of this research has been achieved: the development of two standardized modules and corresponding connections that enable the reuse and manual assembly of structural float glass. The system has been demonstrated to be structurally feasible within the defined boundary conditions, thereby directly answering the research question: "**Which structural elements and connections enable the design of a structurally feasible and spatially adaptable float glass system that can be assembled and disassembled by a small team for reconfiguration at different locations, ensuring its reusability?"**

"Does the project contribute to sustainable development?"

This graduation project focuses on the design of an innovative structural system, offering a new paradigm for extending the lifespan of glass structures. A key strategy to reduce the environmental impact of construction materials, is the transition to a circular economy, in which reuse is considered as the most effective way to extend the lifespan of a product or component. Since there is lack of reusable design strategies for float-glass structures, the designed system aims to stimulate designers and researchers to look beyond traditional recycling methods and actively explore new circular strategies such as reuse. Despite its versatility and widespread use of float glass in both historic and modern contexts, it is still rarely considered a reusable material.

This project aims to make its potential for reuse tangible and open to discussion, serving as an inspiration for how buildings might be designed in the future.

“What is the impact of your project on sustainability (people, planet, profit/prosperity)?”

Planet

This project has a direct environmental impact by addressing one of the core strategies of the circular economy: the reuse of products and components. The proposed system presents an initial version of a potentially applicable solution aimed at extending the lifespan of structural glass within its lifecycle. In doing so, it contributes to reducing waste, conserving resources, and minimizing unnecessary energy consumption. By enabling glass components to be disassembled and reconfigured for reuse, the system actively promotes more sustainable material use in the built environment.

People

The system offers architectural freedom, with a strong emphasis on transparency. It has the potential to serve as an architectural attraction that draws visitors due to its innovative design. In addition, because the system is designed for manual assembly and disassembly, it reduces the need for heavy machinery on-site, supporting safer and more accessible construction processes.

Profit/prosperity

The designed system has economic potential due to the use of standardized components, which can help reduce production costs. During the optimization process, particular focus was placed on generating design variants with straightforward assembly sequences, potentially reducing construction time and associated labor costs. Additionally, the minimal reliance on heavy machinery can lower planning complexity and overall building expenses.

The modular nature of the system also adds long-term value. As long as the components remain within their expected lifespan, they can be reused in new configurations. Even in the case of partial damage, only the affected module needs to be replaced, making the system more cost-efficient over time.

“What is the socio-cultural and ethical impact?”

This project could question the usual way of construction - where materials are often demolished and thrown away - and encourages designers and users to think in a new way to design buildings. On the other side, because the design is quite innovative in its appearance, it may provoke discussions about whether such a structure is appropriate for specific locations. The intention was that, due to its transparency, the system could be applied in a wide range of settings, including historic ones. Research also shows that glass structures are used in various contexts. Still, the design could challenge traditional architectural principles and norms.

“What is the relation between the project and the wider social context?”

This research also aims to inspire a broader audience by presenting an elegant and artistic system with architectural value, whose functional and aesthetic potential can spark imagination. Beyond its structural function, the system can be applied as a sculptural element - suitable for events, exhibitions, festivals, or public spaces such as museums - encouraging reflection and discussion about the built environment of the future and the boundaries of structural design.

Glass plays a key role in this vision, as it has historically been regarded as a delicate and special material. To the general public, it often appears unsuitable for structural use. Precisely this tension between perception and performance invites designers to challenge what seems impossible - and to make it possible.

One envisioned application, still to be structurally verified, is the creation of a long curve that is placed on its side to form a transparent partition wall. This could be implemented in both indoor and outdoor spaces, such as office layouts, exhibition areas, or hospitality settings.

“How does the project affects architecture / the built environment?”

The project challenges existing assumptions and conventions about material use in architecture. On the one side, it shows that glass - typically seen by most people as fragile and non-structural - can in fact serve an innovative structural role. On the other side, this project suggests that buildings of the future may no longer be fixed in one location, but instead have the potential to move and adapt over time.