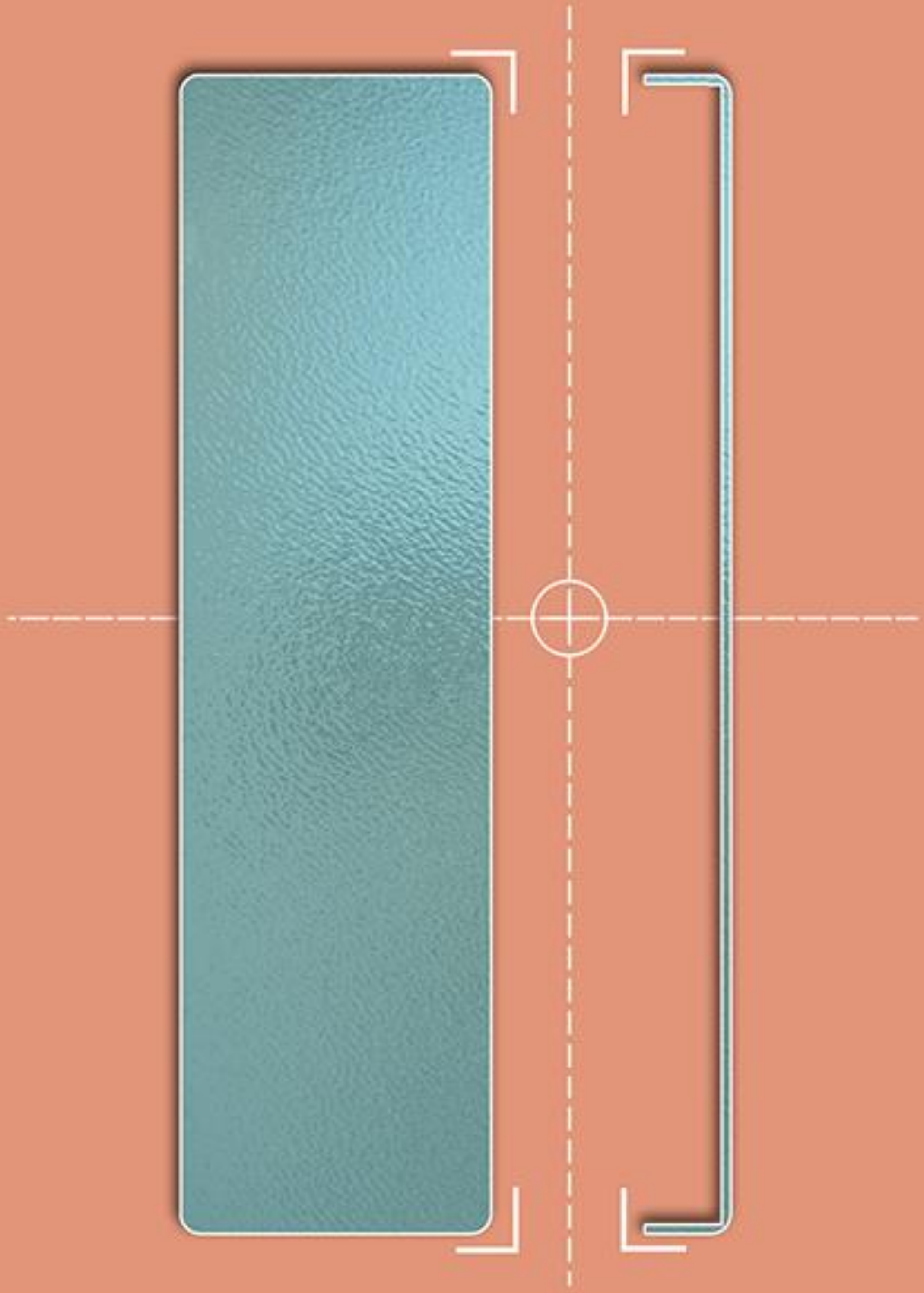

HYBRID GLASS BLOCK

Load bearing and thermally sound glass block

REFLECTIONS

Student
Twinkle Nathani | 5069041

Mentor Team
Dr. ir. Faidra Oikonomopoulou | Structural Design and Mechanics (1st)
Dr. ir. Martin Tenpierik | Building Physics (2nd)

Aspect 1. The relationship between research and design

The thesis explores the possibilities of developing a hybrid glass block by examining its structural and thermal performance. This involves studying the existing system of glass blocks, its properties, production, and installation and developing ideas that will lead to this technology's development. Therefore, research plays an integral part in the project. The available technology of hollow and solid glass blocks was examined. Besides, various experiments and ideas to improve the structural and thermal performance were carefully studied to understand and inform the process of design. The literature review phase concluded with the design guidelines for the development of hybrid glass blocks. To define the structural and thermal performance of the hybrid system, various alternatives were analyzed with the help of relevant software. In addition to the theoretical framework, a case study was chosen to demonstrate the impact of this newly developed system on the existing building's façade, addressing construction and assembly aspects.

Aspect 2. The relationship between my graduation topic and my master track

The sustainable design graduation studio aims for innovative design technologies in the built environment. The material glass is widely used in the building industry for its unique optical properties in various forms, for example, glazing units, glass blocks, etc. The present glass block systems used in building facades have limited potential as they offer either structural stability or optimal thermal performance. With the increasing demand for energy-efficient constructions, it is important to explore the possibilities of making glass blocks energy compliant. Therefore, this research focuses on developing a novel glass block system that responds well mechanically and adheres to the new energy criteria. This system in an examination is new, and not many experiments have been done in this area. This makes studying and experimenting with this technique challenging but gives a great amount of freedom in exploring new ideas. A thorough understanding of the system in a realistic environment is possible in combination with a case study. The topic is related to the ongoing research at TU Delft on sustainable structures. The focus is on Structural and Climate design, two sub-directions of the Building Technology track. The hybrid glass assembly under consideration is self-bearing; therefore, it will significantly affect the structural system of the applied building. The thermal performance of the entire system will also serve as valuable inputs to evolve this technology further.

Aspect 3. Elaboration on research method and approach chosen by the student in relation to the graduation studio methodical line of inquiry, reflecting thereby upon the scientific relevance of the work.

The process of development of the novel hybrid block is divided into four phases: Research, Design & Analysis, Verification & Prototyping and, Conclusions & Reflections. The thesis began by primarily focusing on studying various books, research papers, journals, and websites relevant to the chosen topic and developing a thorough understanding of the problem in question. An in-depth study was conducted on hollow and solid glass blocks, their distinguished properties, manufacturing, and installation processes. A case study was selected to provide a realistic scenario in defining structural, thermal, and optical properties. These helped in defining the design guidelines. Based on these guidelines, concepts for improving structural and thermal performances were explored and evaluated to suggest the most probable ideas to be taken forward in the next phase.

In the following phase, the selected concepts were first evaluated based on their heat-resistant properties. This was carried out with the help of the software TRISCO. Various alternatives of different sizes, cavity widths, and insulative material were developed and analyzed for their thermal transmittance values. These options were then evaluated on their ease of manufacture, optical properties, and recyclability to shortlist the best ones. A risk analysis was carried out to inform the design of the structural process. The analysis identified scenarios that can impact the performance of the system and the measures for those were considered in the design process. The chosen options at the end of thermal analysis were then optimized to carry the loads based on the materials' parameters and constraints. Various connection options were studied and evaluated to design the final connection system for the block. This phase was a continuous back and forth process, which ended in two designs that meet the set rules. Further, the manufacturing and installation process was investigated for the new block, and the designs were evaluated based on the parameters set for this procedure.

The third phase would have been largely focused on verifying the final designs through prototyping. However, it was challenging to develop, experiment, and test prototypes in the current unprecedented circumstances. The prototyping would have been helpful in understanding the practical challenges in developing the design. In order to understand these practical challenges theoretically, a detailed investigation was carried out on how these blocks would be manufactured taking the case study example. The research concluded by summarizing details about the hybrid block, its properties, engineering, and installation. In conclusion, there was a methodical line of approach that used literature review, design research, and numerical validation, thus producing a reliable result.

Aspect 4. Elaboration on the relationship between the graduation project and the wider social, professional, and scientific framework, touching upon the transferability of the project results.

In recent years, the world is slowly transitioning towards creating robust environments due to rapid climate change, scarcity of natural resources, and depletion of fossil fuels. The infrastructure needs to be adaptive more than ever, have less carbon footprint, and be compliant with the energy regulations. While we have developed many building systems (smart façade's, EWF for ventilation, etc.) that can help, it is also important to investigate the unit level (the size of a brick) for overall impact. Glass and energy efficiency has been an oxymoron for a long. A lot of research has been conducted to make glass buildings use less energy, and we have achieved it by applying coatings, making them non-recyclable. Thus, this thesis aims at developing a block of glass that adheres to the energy regulations by changing the design and alternating the way we perceive glass.

The current research can function as a basis on how 3-dimensional structural glass components can be made more energy-efficient. This study provides fundamental insight into various methods explored in developing the novel technique, which can further lead to more energy-compliant glass structures. Hence, this research provides a scientific relevance as it illustrates possibilities of glass in structural configuration and is also socially relevant as it will improve the portrayal of glass structures in being energy giants.

Aspect 5. Discuss the ethical issues and dilemmas you may have encountered in (i) doing the research, (ii, if applicable) elaborating the design and (iii) potential applications of the results in practice.

During the design research, it was concluded that to meet the thermal performance criteria set by the Dutch government and to achieve a thin cross-section with glass, coatings are inevitable. Applying coatings renders glass non-recyclable but aids in the thermal performance of the system. To achieve the recyclable glass block system without coatings, the cross-section thickness of glass needs to be a minimum of 150mm. Also, cavities seem to impact the performance of blocks by reducing thermal transmittance greatly, but the more the number of cavities, the less cross-sectional glass thickness. In turn, this impacts the overall structural performance of the block. Due to time constraints, only standard units were analyzed. Further research could be to find the optimal cross-section thickness of glass and cavity width for the required structural and thermal performance.

Also, due to the Covid 19 situation and inability to prototype, the research and analysis results are purely software based and certain assumptions had to be made when designing the manufacturing and assembly process of the block. This was also done due to the unavailability of standardized data for cast glass structures. Nevertheless, all procedures and methods suggested in this research are considered carefully and are designed according to the practical scenario. However, for application of this technology, validation from experimental testing is a must as it is a novel technique.