Sustainable design graduation studio
MSc in Building technology
Faculty of Architecture and the built environment

Glass Sandwich Panel: Exploring the potential of glass sandwich structures for relatively lightweight planar elements with high stiffness and controlled transparency.

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REFLECTION

Aspect 1 The relationship between research and design.

The subject of this thesis is an innovative all-glass sandwich panel which provides the glass construction industry with a relatively lightweight yet stiff planar element. Researching on a new structure leads to extensive use of the trial and error approach. Effective though it might seem to be, a well-formulated research framework is still needed in order to ensure that the thesis can be conclusive in the period from P1 to P5. For that reason, literature review was a key aspect of this research and was based on the investigation of glass as a material and of sandwich structures. This entailed a research on safety measures, adhesives, sandwich core topologies etc. The aforementioned process helped me shape the research and spot the potential as well as the weaknesses of the application.

The Case Study provides the connection between research and design. It is through design decisions that the research is guided. More specifically, the literature study yielded a series of diverse specimens to be tested by means of a 4-point bending test. The results of those tests were not the only criterion to help me proceed with one of those topologies. Design requirements (qualitative-quantitative criteria) were also important insofar as the selection of the right geometry is concerned. Furthermore, the final part of the thesis project is mainly design-based in the sense that the rest of the experiments to be made are guided by design decisions (Appendix 1).

Finally, I strongly maintain that the graphical method to dimension a sandwich structure is one of the most important outcomes of this research. It was validated to a certain extent by the bending tests and will be further validated by the future lab experiments. This is the product of both research and design and helped generalise the findings of this research and provide a design toolbox for future purposes.

Aspect 2 . The relationship between the theme of the graduation lab & the subject/case study chosen by the student within its framework.

The sustainable graduation studio focuses on innovative applications in the built environment that use Building Technology to provide sustainable and effective solutions to contemporary problems while shaping the future of architecture through research and design. The scope of the chosen case study is to showcase the potential of glass sandwich panels by facing the structural and design challenges of a glass floor. There is a wide variety of glass floors but the majority of them cover very small areas and work mostly as light pipes. This particular case study was chosen because it poses big structural, environmental and design considerations that can be solved using Building Technology with a focus on Structural Design, Facade Design and Material Science. The main goal is to investigate the limits of the material and provide a solution that will be affordable, feasible, efficient, thought-provoking through customisability and will help reduce the embodied energy of glass floors

Aspect 3 . The relationship between the methodical line of approach of the graduation lab and the method chosen by the student in this framework

The approach of the BT graduation lab is highly technical-scientific and aims to support design decisions with calculations and experiments. At the same time, one of the following methods must be utilised: a) Research by Design or b)Design by research.

As far as the technical-scientific approach is concerned, the validation and dimensioning of glass sandwich panels was approached in three ways namely: FEA, Graphical method and Bending Tests (Appendix 1). The correlation between the three aims to provide a safe way of predicting the structural behaviour of an all-glass sandwich panel. It is worth mentioning that a significant number of bending tests need to be performed in order to collect statistics and make sure that the concept safely works. However, this is not possible in the context of a Master Thesis due to affordability and strict time limits. The tests are just enough to support the main assumptions and partly evaluate the other 2 methods: analytical and FEA. It is quite clear that the thesis is devided into 2 parts regarding the relationship between research and design. From P1 to P3 the research is following Design by Research approach while from P3 to P5 the approach is mainly Research by Design. Throughout the former period, research provides the tools to design with while throughout the latter, design provides the topics to research on.

Hence, the BT approach is strictly followed throughout the whole process and has yielded the desired results.

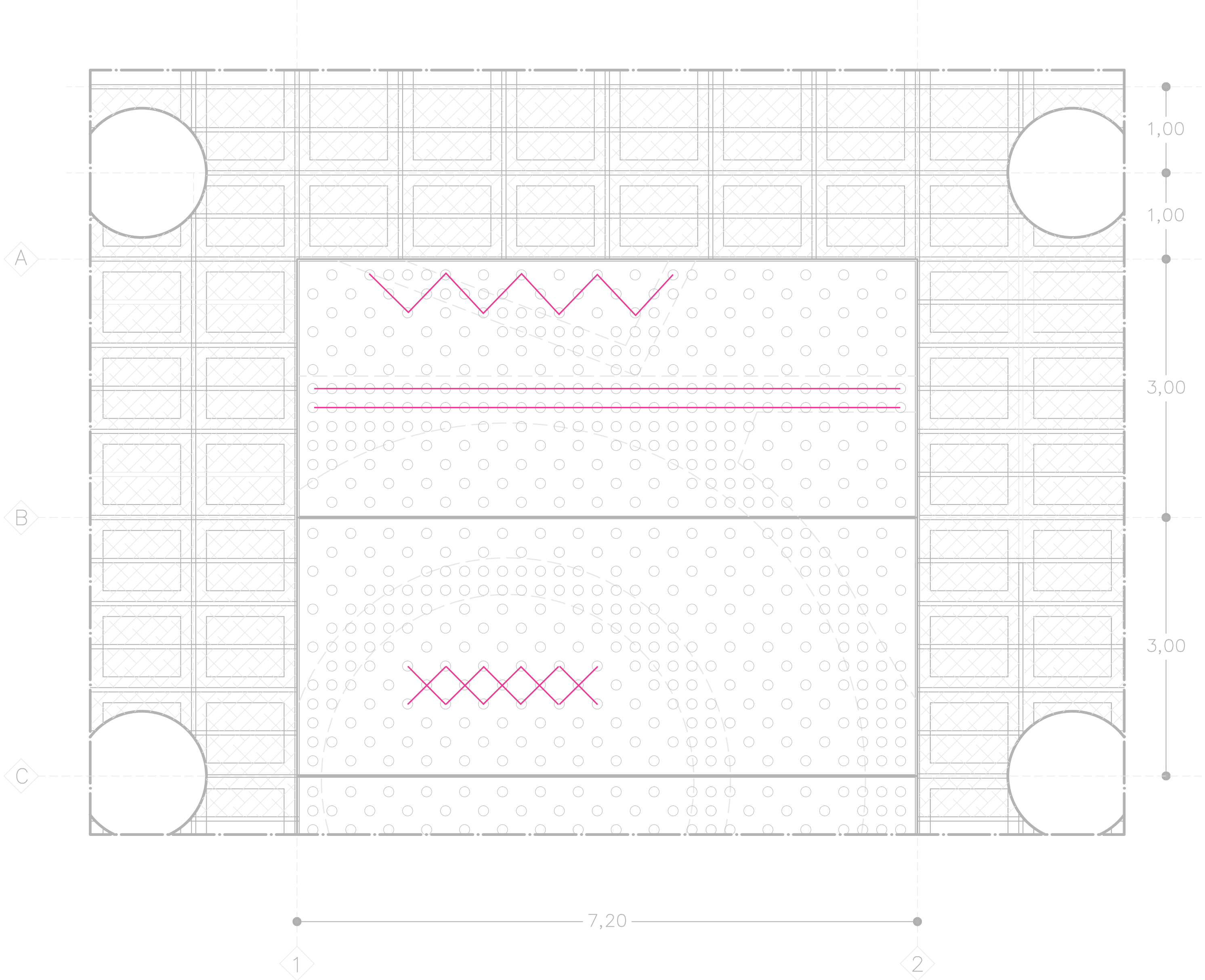
Aspect 4 the relationship between the project and the wider social context

There is a three-fold value of the graduation project in the larger social and scientific framework: Material Development, Geometry Development, Sustainability.

Material and Geometry Development: Glass is a relatively new yet up-and-coming structural material. It is used more and more structurally in a way to reduce metal substructures and provide maximum transparency. With this research, I aim to provide the glass industry with a new way of using glass in planar elements. This may revolutionize the way of designing with glass which currently is limited to glass bricks, glass fins and corrugated glass. One reason why glass is the only material used as a spacer is also that my purpose is to push the material to the limits. At the same time, this research will ideally constitute a significant addition to the sandwich technology.

Sustainability: Nowadays, sustainability is more pressing than ever and there is a need to think of the embodied energy of the materials we use and an even higher need to reduce material consumption. By using the material in the most efficient way, not only can we reduce the material used in the element itself but we could also inherit the redundancy of the substructure. In modern facades, a lot of extra material is used in the façade substructure. If the element is stiff enough it can be attached to the main structure or it can constitute the structure by itself. Another advantage would be the low embodied energy of glass. The embodied energy of glass is really low and comparable to the embodied energy of wood, making glass one of the most sustainable materials overall.

Finally, one beneficial aspect of this research, related to the chosen case study, is that the transparency of the floors highlights the importance as well as the scale of the artifacts of the Acropolis Museum. These constitute artifacts from different eras of the Hellenic culture that show the scale of an ancient city and the life of ancient civilisations. With the current setup visitors cannot perceive the scale and this is the reason I strongly believe that an all-glass sandwich floor would constitute an important addition to the museum and to other archaeological places (Appendix 3).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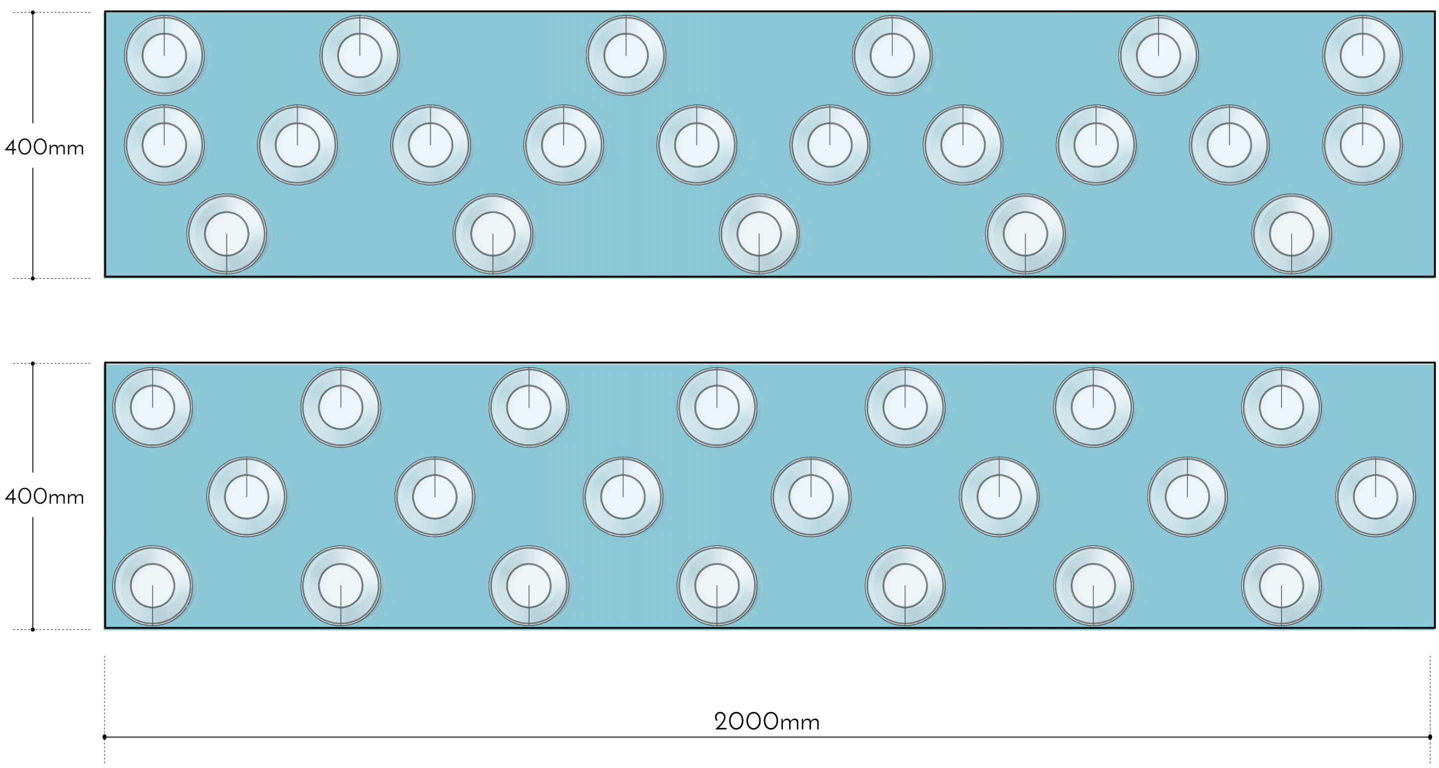
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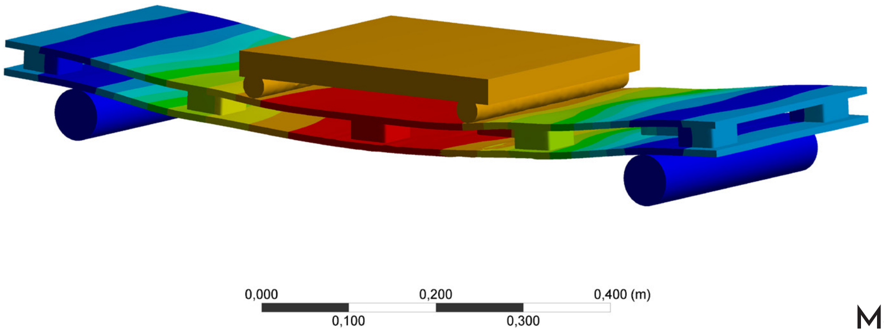
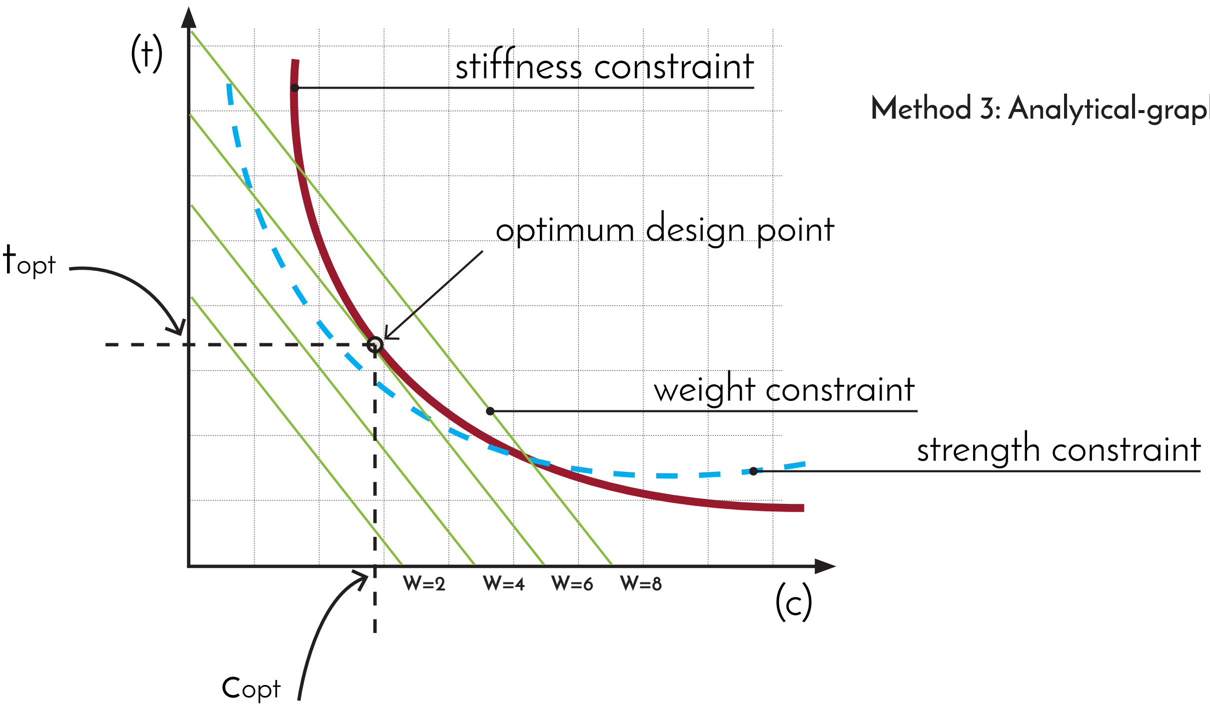


Method 1: Finite Elements Analysis

Method 2: Bending Tests



Method 3: Analytical-graphical Method

$$t(c) = -\frac{1}{2}\frac{\rho_c}{\rho_f}(c) + \frac{W}{C}$$

Weight Constraint **t(c):**

$$(t \circ G)(c) = \frac{2B_2}{B_1} \times \frac{1}{cE_fE_c^3} \times \left(\frac{1}{(d/P/l)\ \ bG(c) - 1} \right)$$

Stiffness Constraint **(t ∘ G)(c):**

APPENDIX 3