Glass giants:
Mass-optimized massive cast glass slab

Reflection P4

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Aspect 1:
The relationship between research and design.

The designing stage of the thesis was conducted in accordance with the research of the literature framework and the methodology from the previous phase.

The established design criteria based on the requirements of cast glass, the specific structural conditions of the case study and the manufacturing constraints were used for the design development process. The design phase started with a structural simulation of an initial solid design. From the structural analysis the optimum thickness of the slab was emerged, while further tests showed the thin-vaulted shape with the best structural performance. In a later stage, according to the strategy that was set, the topology optimization of the slab was started with Ameba, a grasshopper plug-in, which due to license limitations and weakness of software computing and student experience, failed to give any results in a 3d geometry.

As it was already arisen from the research, ANSYS is a more reliable software which can give more advanced analyses and optimization results, in which most of the design criteria that had been established were feasible to be taken into account.

During the designing and optimization stage, issues, which had already been realized from the research and others that had not, emerged. A structural analysis after each optimization in order to prevent the peak stresses was necessary according to the compliance-based optimization research. On the other hand, a slightly vaulted design that was provided from the literature needed a lot of adjustments to be efficient in the current design. Similarly, although many aspects of the software usage were referred in previous theses, the limitations and possibilities had to be explored and solved from the beginning with guidance from the research.

Aspect 2
The relationship between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master program (MSc AUBS).

The main goal of the thesis is to feasibly generate a structural cast glass slab without any substructure, by reducing the mass of the component in a way that it will respect the material properties and its annealing time, the structural behavior of it, in combination with solution of the fabrication methods. The mass reduction is achieved due to topology optimization, having as a result feasibility of the cast glass fabrication, facilitating of transportation and assembling, minimizing of cost and a more sustainable structure.

As a student of Building Technology track, material properties, structural analyses and alternative methods for design generation such as topology optimization are some of the important requirements I have been trained for. All these working techniques and methods, which can be found in my thesis, are some of the features that distinguish students from Building Technology among the rest architecture students.

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.

Building Technology aims to bridge the gap between architecture and engineering. To do so, after the research from both points of views, the design proceeds through alternative methods with respect to the laws of the nature and the construction factors. Afterwards, the realization phase needs to be considered and solved. Prototyping and proper validation of the results ensure a sustainable final product. However, due to the Covid-19 crisis prototyping was impossible due to the university and many other services lockdown.

The current thesis was developed under a similar approach. The initial research was conducted in three main frameworks: cast glass, topology optimization and fabrication technique.

After all the relevant aspects of the topic were studied and comprehended, the design phase started with some initial hand calculations and structural analyses. Later, the boundary conditions and the design criteria were set in order to start a procedure during which the topology optimization, the manual redesign and the structural validation were continuously rotated until the final result.

In a later stage the fabrication, transportation and assembling procedure were studied. Unfortunately, because of the pandemic Covid-19, the prototyping phase was eventually skipped and the final results were obtained through simulations. However, the fabrication method of the slab, starting from the moulds printing until the kiln-casting of the glass are studied.

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.

Although the usage of cast glass as a structural material is now gaining more attention, it is still restricted in several aspects such as the limited size and shape of the components. In the current thesis, solutions are given regarding a large scale of a structural cast glass component.

Due to the topology optimization of the slab, the annealing time can be reduced, making the realization of such a project feasible for the time and cost demands of the construction field.

The results of this research can be applicable in every slab which requires highest transparency performance since glass can be the only material that consist it.

The fabrication method of the 3d printed sand moulds which is explored in this thesis can also be transferred in several cases of casting complex glass geometries.

In addition, the method which is used in this project can be applied in slabs or other horizontal structural elements from different materials of similar properties with glass, such as concrete. In this way, the weight, the material consumption and the working labor demands of an element can be minimize, making the component more sustainable and cost-efficient, significant aspects for every construction project.

Last but not least, an unusual designing technique is explored which can contribute in the design generation of architectural projects. The combination of the form-follows-force approach of the topology optimization with the constant manual redesigning according to architectural and engineering logic and the structural validation of the results in rotation endorse an alternative designing technique. This technique can be considerably time consuming but can produce unique, holistic and accurate results.

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.

Regarding the ethical issues that the thesis meets with, although the requirement for reduction of the material demands derived from the need of minimizing the annealing time, it affects more aspects of designing and producing such a structural element.

The long and meticulous annealing period and the need to cope with it started from studying several realized and academic projects using cast glass in structural components. Most projects restrict in terms of size and complexity of the glass component, therefore an optimization of the 6.2x7m slab in order to reduce the mass, create holes and more exposed surfaces could help in the annealing procedure.

However, the other effects of the optimization could not be neglected. The mass reduction of 55.2% that was reached, in combination with the 3d printed sand moulds as a fabrication technique lead to material minimization, less production energy and labor. In addition, the sand moulds, which are produced from a material in abundance, can be reused to produce many segments.

Therefore, the ethical issue which was consider from the research, during the design stage, until the fabrication technique is the sustainability of such a project, which can be a significant reason for further applications.