Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Robert Akerboom
Student number	1382829
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Studio	
Name / Theme	Building Technology, Sustainable Design Graduation Studio
Teachers / tutors	Prof. Ir. Rob Nijsse, Ir. Faidra Oikonomopoulou, Ing. Marcel Bilow (Ir. Telesilla Bristogianni)
Argumentation of choice of the studio	Within the program of Building Technology, only this studio is a possibility.

Graduation project	
Title of the graduation project	Exploring the potential of free standing glass columns assembled from stacked cast elements
Goal	
Location:	The Berlage Zaal 01 within the faculty of Architecture at the TU Delft
The posed problem,	Many architects worldwide have been fascinated by the usage of continues, uninterrupted spaces in building design. These spaces can add value to the building and its users. An engineer however, prefers the placement of columns in open spaces to reduce the span of beams and floors and to make the structure simple and safe. It is this contradiction that triggers my fascination to think about a solution that provides a satisfying answer for both parties: glass columns.
research questions and	- What type of glass columns can we use best - How can we best implement safety in the column design? - How can we gain maximum transparency in the column?

	- How can we integrate internal and external connections best in the column? - How do we make the column structurally sufficient for a maximum of three floors above - What possibilities are there to shape and visualize this column?
design assignment in which these result.	Based on the research, propose a design for a free standing, safe, all glass column from stacked cast elements. In the design proposal, address how you will implement safety, create maximum transparency, handle internal and external connections, shape and visualize the column & make the column structurally sufficient for its purpose.

Process

Method description

P1 – P2

During this period, the main focus has been on reading background information about the global topic of glass columns and exploring its boundaries and already explored fields. By analyzing the literature about the material glass, mapping the precedents regarding glass columns and by gathering the results of previous compression tests of glass columns by TU Delft, I was able to make a matrix in which I could map the possible types of columns and compare them regarding the most important criteria. From this matrix, the graduation aim could be established and the boundary conditions will be stated.

P2 – P3

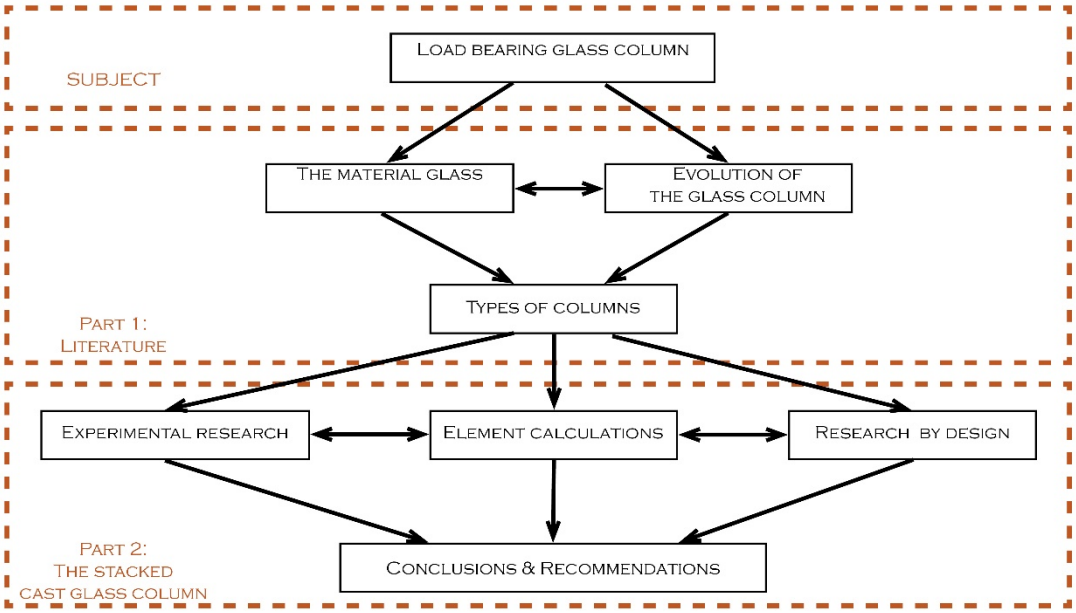
In this period, I will again start reading literature within the topic of the established direction, which is the glass column of stacked cast elements. I will explore, and therefore research, the potential of this column in different terms which will be guided by several research questions. This will involve hand-calculations, model-making, force flow design, 3D modeling, probability / consequence analysis, collect and compare and possible structural testing.

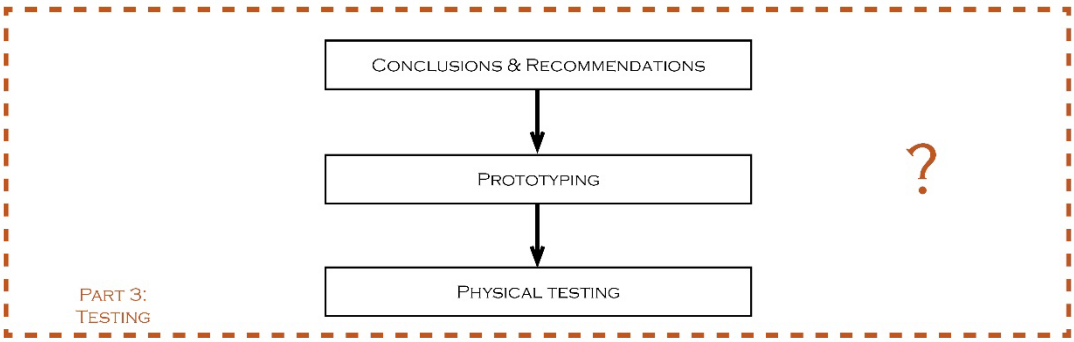
P3 – P4

After reviewing the progress so far, potential adjustments will be made to the research. From this built-up research, an optimized design proposal can be formed in which will be clarified how the glass column of stacked elements will be visualized and function within the building. This will be done by putting together the best possible combination of answers which were given to the research questions previously. Depending on how promising the results will be, a prototype of the column could be tested under compression in a controlled environment at the faculty of civil engineering.

P4 – P5

This period will only be used to improve both presentation and report on details. Besides that, possible future continuation of this research or its results will be addressed.





Literature and general practical preference

Books:

Alsop, D. J. A., Saunders, R. J., Colvin, J., Desai, S. B., Gilder, P. J., Ledbetter, S. R., Otlet, M., Parke, G. A. R., Pike, D., Smith, J. G., Taylor, S. N. (1999). Structural use of glass in buildings. London, SETO.

Hibbeler, R. C. (2005). Mechanics of Materials. Singapore, Prentice Hall.

Schittich, C., Staib, G., Balkow, D., Schuler, M., Sobek, W. (1999). Glass Construction Manual. Basel, Switzerland, Birkhauser - Publishers for Architecture.

Papers:

E.J. van Nieuwenhuijzen, F. P. B., F.A. Veer (2005). The Laminated Glass Column. Glass processing days, TU Delft.

Oikonomopoulou, F., Veer, F., Bristogianni, T. & Nijsse, R. (2015). Developing the bundled glass column. International Conference on Structures and Architecture 2016. Guimarães, Portugal.

Journal Articles:

Blaauwendraad, J. (2007). "Buckling of laminated glass columns." HERON **52**(No. 1/2): 18.

Bos, F. P. (2007). "Towards a combined probabilistic / consequence-based safety approach of structural glass members." HERON **52**(No. 1/2): 28.

S.A.J. de Richemont, F. A. V. (2007). "Glass-aluminium bonded joints; testing, comparing and designing for the ATP." HERON **52**(No. 1/2): 17.

Veer, F. A. (2007). "The strength of glass, a nontransparent value." HERON **52**(No. 1/2): 18.

Other graduation reports:

Ouwerkerk, E. (2011). Glass columns, A fundamental study to slender glass columns assembled from rectangular monolithic flat glass plates under compression as a basis to design a strutural glass column for a pavilion Faculty of Civil Engineering and Geosciences. Delft, TU Delft**:** 230.

Reflection

Relevance

The relevance of this project can be given in twofold

Material development

Glass has already proven that it has some amazing structural properties to work with, but it shows just as many struggles to use it in structural building design nowadays.

The material glass itself is not per definition further developed in this research, but the way of using it as a structural material is still a very young and unknown concept which is addressed. By researching and exploring the structural possibilities of a free standing all glass column, the material is developed on a whole new level which can give new dimensions to both the structural engineer and the architect.

By focusing on usage in a high rise building, this research will really aspire to find the structural limits of the material and the potential it therefore holds.

Sustainability

Never has there been so much attention for climate change and the need to save the planet as there is now. Global warming is acknowledged and severe changes have to occur in the way we live to give our future generations a proper perspective for living on this planet. We need to be using less toxic materials which are easier to recycle and are less energy-intensive. We should look at the lifecycle of a material from manufacture to final disposal and look at the energy content and pollutants that come with this. The great advantage of glass as a material is the fact that it is a 100% recyclable without loss in quality or purity and it can endlessly be done. The transparency of the material enables light admittance and therefore a sustainable way of naturally enlighten a building. On top of that, it can play a very important role in allowing sun heat to naturally heat the building which lowers the demand of burning fossil fuels for mainstream heating systems.

Glass has shown to be a very durable material to use. Very old findings of glass which are going back towards 10.000 B.C. still show signs of good quality. This is mainly achieved by the fact that glass has extremely good resistance against salt water, strong acids, organic solvents, ultra-violet radiation and aerated water. The only weakness of the material seems to be strong alkalis, which is not a very common chemical element for glass to get in touch with.

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