Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

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

Personal information	
Name	Ronald Rijsterborgh
Student number	4483014
Telephone number	
Private e-mail address	

Studio		
Name / Theme	Building Technology	
Main mentor	Dr. ir. Regina Bokel	Building Physics and Services
Second mentor	Prof. James O'Callaghan	Architectural Glass Structural Design & Mechanics Glass & Transparency Research Group
Argumentation of choice of the studio	From the first day of my bachelor at this faculty I knew that my interests were in building physics and structural design. In this master track I hoped to be able to build on my interest in a more technical and mathematical way.	

Graduation project	
Title of the graduation project	Cheese bell The design of a full glass dome structure as a protective shelter for a small monument in Alkmaar.
Goal	
Location:	Alkmaar, The Netherlands
The posed problem,	Because the status of a national monument, it is not allowed to place a structure against the building to create a covered terrace to give it a real hospitality function. That is why a more drastic measure is needed: placing a glass dome over the monument. The idea is to preserve the desired temperature inside a, to be designed, full glass dome, in the most passive manner.
research questions and	Main question: *How can a full glass dome structure be built, to cover 'Het Kruithuisje' in Alkmaar, The Netherlands, in which the thermal comfort is maintained in the most passive manner, without impeding the visual benefits of glass?*

	Sub questions: • What is glass and what can be done with it? • What should be taken into account with glass as a structural material? • What is his domes and how do they behave? • How can thermal comfort be achieved? • What building physical problems are there in glass buildings and how can they be solved (passively)?
design assignment in which these result.	The design of a full glass dome structure as a protective shelter for a small monument in Alkmaar, where the thermal comfort in the structure is maintained without obstructing the visual benefits of glass.

Process

Method description

This research can be roughly divided into four parts: literature, designs, analyzes and conclusion / final design.

- **Literature**
  This part of the research will consist of a literature study with the following main themes:
  - *Glass as a structural material*
    In this part glass will be discussed as a general material, but also what is needed to turn glass into a construction material, with the associated production techniques.
  - *Dome structures*
    In this part dome structures will be discussed, whereby the forces in the domes are mainly considered.
  - *Thermal performance*
    In this part, there will be looked at how thermal comfort can be realized, by looking at which steps and methods are needed and how some problems can be eliminated.
- **Design and analyze**
  These two parts will be closely connected. Various coarse designs will be made that will be analyzed. From these analyzes follow improvement points that will be adjusted in the design which will eventually lead to the final design. There are two main design strategies:
  - *Designing a glass dome structure that is as transparent as possible.*
  - *To maintain the thermal comfort in the most passive manner, without impeding the transparency.*

  The constructive simulations will be run in Diana and Ansys. The thermal simulations will be run in DesignBuilder. To validate the different values, hand and computer based calculations will be combined and compared.
- **Conclusion / final design**
  Based on the analyzed designs, a final design can be designed in which the structural performance and thermal comfort are known. These results will lead to a design with building plans that can ultimately be built, with guidelines, recommendations and conclusions for possible upcoming similar structures.

Literature and general practical preference

As mentioned earlier, the literature study can be divided into three main themes: glass as a structural material, dome structures and thermal performance. Resources are needed for each of these three themes. The search for suitable sources will be done by looking at theses where these themes are dealt with, where hopefully relevant references can be obtained for this research.
For the design and analysis part of the research the knowledge will be used for the constructive simulations of Diana and / or Ansys, the building physical simulations the knowledge of DesignBuilder.

Below is a list of the collected literature so far:

ASHRAE-Standard-55. (2010). Thermal Environmental Conditions for Human Occupancy. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

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Bagger, A. (2010). Plate shell structures of glass: Studies leading to guidelines for structural design. Kgs. Lyngby, Denmark: Technical University of Denmark. BYG-Rapport, No. R-221

Bos, F. P. (2009). Safety Concepts in Structural Glass Engineering. Toward an Integrated Approach, 592.

Connor, J. J. (2011). The Effect of Reinforcement on Loadbearing Capacity of Structural Glass by LIBRARIES The Effect of Reinforcement on Loadbearing Capacity of Structural Glass.

Eekhout, M., & Staaks, D. (2010). All-Glass Dome for Mosque in Haarlem. Challenging Glass 2 – Conference on Architectural and Structural Applications of Glass, TU Delft.

Felekou, E. (2016). Structural Glass in High-Rise Buildings. (Master Thesis). Delft University of Technology, Delft.

Flügge, W. (1973). Stresses in Shells. Springer Berlin Heidelberg.

Fröling, M. (2013). STRENGTH DESIGN METHODS FOR GLASS STRUCTURES. (Doctoral Thesis). Lund University.

Gatsiou, V. (2015). A study about the structural and thermal performance of large glass masonry façade. (Master Thesis). Delft University of Technology, Delft.

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Gemeente Alkmaar. (2016). Het Bolwerk. Retrieved on 2019, December 31, from https://www.alkmaar.nl/voorzieningenkaart-Algemeen-parken-Het_bolwerk.html

Het Kruithuisje. (2017). Geschiedenis Kruithuisje. Retrieved on 2019, December 2019, from https://kruithuisje.nl/geschiedenis-kruithuisje-2/

Heyman, J. (1995). The Stone Skeleton. Cambridge, USA: Press Syndicate of the University of Cambridge.

Janssens, E. J. (2018). THE GLASS DOME, Design technology for a dry assembled and cast glass dome. (Master Thesis) Delft University of Technology, Delft.

Lambert, J. B. (2005). THE 2004 EDELSTEIN AWARD ADDRESS; THE DEEP HISTORY OF CHEMISTRY. Bull. Hist. Chem., 30.

Leitch, K. K. (2005). Structural Glass Technology : Systems and Applications By

Certified by Structural Glass Technology : Systems and Applications.
Louter, P. C. (2011). Fragile yet Ductile: Structural Aspects of Reinforced Glass Beams. (Doctoral Thesis). Delft University of Technology, Delft.
Nakano, J., & Tanabe, S. (2004). Thermal Comfort and Adaptation in Semi-Outdoor Environments. ASHRAE Transactions; Atlanta, 110, 543-553.
Neumann, D., Stockbridge, J. G., & Kaskel, B. S. (1995). Glass block. In Twentieth-Century Building Materials: History and Conservation. ed. Thomas C. Jester. 194-99. New York: McGraw-Hill.
Nicol, F., Humphreys, M., & Road, S. (2012). Adaptive Thermal Comfort. Londen, United Kingdom: Routledge
Oikonomopoulou. (2019). Unveiling the third dimension of glass; Solid cast glass components and assemblies for structural applications. (Doctoral Thesis). Delft University of Technology, Delft.
Prenis, J. (1973). The Dome Builders Handbook. Philiadelphia, Pennsylvania, United States: Runnign press.
Regnier, C. (2012). Guide to Setting Thermal Comfort Criteria and Minimizing Energy Use in Delivering Thermal Comfort. U.S. Department of Energy.
Santarsiero, M., Louter, C., & Nussbaumer, A. (2016). Laminated connections for structural glass components: a full-scale experimental study. Glass Structures and Engineering, 2 (2017), 1-23.
Schimmelpenningh, J. (2012). Acoustic Interlayers for Laminated Glass – What makes them different and how to estimate performance. Acoustic Interlayers for Laminated Glass – What makes them different and how to estimate performance, 2-8.
Schittich, C. (1999). Glass construction manual. Basel: Birkhauser.
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Sombroek, I. (2016). Structural cast glass; A research process of design and experiment towards a feasible geometry for a cast glass element. (Master Thesis). Delft University of Technology, Delft.
Swift Glass. (2020). Thermal Glass Tempering & Chemical Glass Strengthening. Retrieved on 2020, January 2, from https://www.swiftglass.com/glass-tempering-strengthening
Szabo, A. (2018). Integrated Concentrating Solar Facade Cast glass component, embedded photovoltaic solar cells. (Master Thesis). Delft University of Technology, Delft.
Ten Brincke, E. H. J. (2019). abt Technoledge SD Glass Calculations [PDF]. Retrieved from Delft University of Technology AR0105 Technoledge Structural Design
Ungureanu, V. (2011). Lecture 3 – Laminated glass and interlayers Laminated glass introduction, 1–26.
Weller, B., Härth, K., Tasche, S., & Unnewehr, S. (2009). Glass in Building. Basel, Switzerland: Birkhäuser.
Wurm, J. (2007). Glass Structures. Basel, Switzerland: Birkhäuser.

Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

   "Designing with glass is a good learning tool to learn the engineering profession. If you can design with glass, you can design with any material." (Veer, 2019) "A complete glass building often has building physical comfort problems." (Bokel, 2019) By combining these two interesting topics, two chairs from my master track are filled.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.
   - "A complete glass building often has building physical comfort problems." (Bokel, 2019) In my graduation work, hopefully solutions will come forward for building physical comfort problems. These solutions can hopefully also be used in other buildings with a lot of glass, so that it does not have to be a full glass structure.
   - With the transparency of glass structures, things can be shown that are not visible with other structures. Even wider, high transparency can be achieved with glass constructions. This research can provide tools for projects where high transparency is required, while also taking physical problems into account.