Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences
**Graduation Plan: Building Technology**

<table>
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<tr>
<th><strong>Personal information</strong></th>
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<tbody>
<tr>
<td>Name</td>
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<td>Student number</td>
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<td>Telephone number</td>
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<td>Private e-mail address</td>
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<th><strong>Studio</strong></th>
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<tr>
<td>Name / Theme</td>
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<td>Teachers / tutors</td>
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<td>Argumentation of choice of the studio</td>
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<th><strong>Graduation project</strong></th>
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<th><strong>Goal</strong></th>
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<tr>
<td>Location:</td>
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<td>The posed problem,</td>
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<td>research questions and design assignment in which these result.</td>
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<td>Solely glass dome out of dry assembled cast glass components that ensure the desired durability and structural performance.</td>
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**Problem statement:**
Glass domes have been realized since the industrial revolution. Until now domes are constructed from a steel main structure and glass substructure causing reduction in transparency. Most of the structural elements in dome structures are in compression, tension stresses occur when the load is unevenly distributed (wind and snow) or when buckling appears. This makes glass a prefect material for dome structures due to its high compressive strength. Stiffening elements are needed to prevent buckling failure, however when assuming a fully transparent dome, stiffening elements need to be replaced and therefore float glass cannot be used due to its production technique and the required geometry. Cast glass makes an increase in thickness possible, creates a monolithic strong structure and has a high form flexibility. Dry transparent interlayers are required to create a full transparent demountable structure and prevent the components from glass to glass contact. In addition, a minimal number of different components are required to reduce the production costs of the steel molds. These were all technical driven arguments and sociological considerations need to be taken in account as well, i.e. the impact on thermal comfort. When no measure are taken uncomfortable environments occur due to the high thermal conductivity of glass. This research provides a design technology for a transparent, dry assembled and compressive cast glass dome with strategies to create thermal comfort.

**Objectives:**
The objectives of this research are divided into two main aims: transparency and thermal comfort.

Concerning the transparency, glass type, geometry, arrangement and connection of the components should be analysed and assessed. Resulting in sub goals:
• Create an optimal shape.
• Create a minimum amount of different components.
• Create dry transparent interlayers.

Regarding the thermal comfort, passive strategies and thermal comfort criteria should be analysed and assessed. Resulting in sub-goals:
• Create a near to zero energy building.
• Create thermal comfort based on the defined thermal comfort criteria.

Main question:
"How can a structural dome be developed, assembled from a minimum amount of different cast glass dry components while optimizing transparency?".

Sub questions:
• What is the optimal shape for a cast glass component?
• What techniques can be used to minimize the number of components?
• What techniques can be used to connect the components and create a demountable structure?
• What strategies can optimize the transparency of the dome?
• What strategies can be used to create a near to zero energy building?

Process

Method description
This research is structured into four phases: literature, analyses, design and the conclusion phase. An overview is given at the end of this document.
The first phase, the literature study, consists of the following literature: glass technology, dome structures and thermal comfort. Glass technology literature includes the properties of glass, glass types, production methods, connections and glass dome figurations. Dome structures literature includes forces in domes, shapes and main reference approaches. Thermal comfort literature includes theory about how to create comfort and which strategies should be used to minimize the energy demand.
The second phase is divided into reference assessment and design research. Most important references (dome figurations and main approaches) are assessed and the significant results are used as fundamental background for the design research. The design research includes concept generation, design criteria and design limits obtained from the assessed reference and literature (production methods, shapes of domes and comfort criteria).
There are two main design strategies: dry assembly of the components and a strategy to create near to zero energy. The dry assembly strategy expounds the shaping process, assembly method, dry connections and detailing. While the near to zero energy strategy points out the thermal comfort design, used passive strategies, compatibility between transparency and thermal comfort and detailing. In the validation phase these strategies are validated by using hand and computer based calculations, mechanical testing of the scale model and qualitative analyses to address the concentrated stresses of the prototype. To validate the near to zero energy strategy, hand and/or computer based calculations are made in Design Builder.
The last phase is the conclusion phase consisting of evaluations of the structural performance, results of how much near to zero equals zero energy design and compatibility of transparency. This compatibility of transparency is a result of the correlation between glass technology and thermal comfort. Finally, this research ends with recommendations and conclusions.

Literature and general practical preference


Reflection

Relevance
Since cast glass applications become more popular in the (building) industry, e.g. in real applications such as the Crystal house or the Giant Telescopic mirror research on cast glass has taken a big improvement. However there are a lot of structural configurations that require research to find out if cast glass is suitable or not. The current research could be set as a basis on how cast glass can be used in structural configurations, i.e. a dome structure. Therefore this research provides a scientific relevance and could be useful for structural engineers and architects to see the possibilities of cast glass in structural configurations. The current research provides insight in the optimal shape, assembly method and energy demand of the cast glass dome.

Time planning
See below.
LITERATURE STUDY
- GLASS TECHNOLOGY
  Properties
  Glass types
  Productions methods
  Connections
  Structural configurations
- DOME STRUCTURES
  Force action
  Shapes
  Main reference approaches
- THERMAL COMFORT
  Climate
  Criteria
  Passive strategies

PRELIMINARY DESIGN
- Design criteria
- Concept generation
- Concept limits
- Preliminary design

DESIGN STRATEGIES
- Literature: dry assembling methods
- Form finding shape
- Interlayer investigation
- Thermal comfort design
- Energy calculations (Design Builder)
- Structural calculation (hand/Diana)

SCALE MODEL
- Manufacturing
- Mechanical test
- Qualitative test

3D MODEL
- Drawings & visualisation
- Report
- Presentation