Transparent COLUMN

A Column made of Cast Glass Interlocking Elements

Eline de Vries - 4258053 - P2 - 18/01/2018

Ir. Faidra Oikonomopoulou - Dr. Ing. Marcel Bilow - Dr.ir. Marjolein Spaans
Motivation

Practical Research

Glass Fascination

Scientific Gap
Motivation

Practical Research

Glass Fascination

Scientific Gap
Program

WHAT?

WHY?

HOW?

Research Framework

Literature Research

Design Principles & Challenges

Next Steps
Program

- Research Framework
- Literature Research
- Design Principles & Challenges
- Next Steps
Research Framework

- Background
- Problem Statement
- Objectives
- Research Questions
- Methodology
- Planning
Research Framework

WHAT?

- Background
- Problem Statement
- Objectives
- Research Questions
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Research Framework

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Research Framework

Literature Research

Design Principles & Challenges

Next Steps
Research Framework

WHAT?

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Research Questions

WHAT?
Background

Giuseppe Terragni - Danteum (1942, Unbuilt)
Background

The Building Technology track encompasses a broad spectrum of engineering and architectural design skills that lead to one of the dominant professions of the future: the sustainable designer.
Problem Statement

- **Wood**
  - Compressive Strength: 100 MPa
  - Flexural Strength: 200 MPa

- **Concrete**
  - Compressive Strength: 200 MPa
  - Flexural Strength: 100 MPa

- **Steel**
  - Compressive Strength: 300 MPa
  - Flexural Strength: 200 MPa

- **Glass**
  - Compressive Strength: 100 MPa
  - Flexural Strength: 200 MPa
Problem Statement

- **Compressive Strength**
  - Wood
  - GLULAM
  - Concrete
  - HIGH-PERFORMANCE
  - Steel
  - S355
  - Glass
  - BOROFLOAT

- **Flexural Strength**

Uncertain Variables
- Regulations
- Costs

Glass

Structural Glass
Problem Statement

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<tr>
<th>Material</th>
<th>Compressive Strength (MPa)</th>
<th>Flexural Strength (MPa)</th>
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Uncertain Variables

- Regulations
- Costs

Glass Column

Architect vs Structural Engineer
Objectives

Understand how an interlocking cast glass component in a column will behave when under (Compression) force

Sub Objectives:

• To bridge the scientific gap regarding the innovation of glass structures in general

• Set a database for interlocking cast glass structures

• Formulate design decisions and their results
Research Questions

**How can we design and produce a safe, engineering-sound, transparent, re-stackable, free-standing column made of cast glass interlocking components?**

Sub Questions

• What size should the components be in respect to the limitations of the casting process?

• What are the possibilities in the shape of the column and its components?

• How will the components be connected to each other?

• How can redundancy be included in the design of this column?

• How can we make a glass column fire resistant?

• How will a glass column be connected to the levels underneath and above?
Methodology

P1

- Literature Research
- Design Principles and Challenges

P2

- Concept
- Design
- Final Design

P3

- Calculate
- Prototype
- Physical Testing
- Evaluation
- Recommendations & Conclusions

P4

- Report & Presentation

P5

- Research Framework
- Literature Research
- Design Principles & Challenges
- Next Steps
Methodology

P1

Literature Research → Design Principles and Challenges

P2
Methodology

P2

Concept  ➔  Design  ➔  Final Design

P3

Research Framework  Literature Research  Design Principles & Challenges  Next Steps
Methodology

Handcalculations & FEM-Modelling (Diana)

Compression Testing (HOW do the elements break)

P3
Calculate → Prototype → Physical Testing → Evaluation → Recommendations & Conclusions

P4
Made of Glass or Ice

Research Framework  Literature Research  Design Principles & Challenges  Next Steps
Planning
Literature Research

- Material Glass
- Glass Column
- Cast Glass Structures
- Interlocking Geometries
- Case Study: Glaspaleis
Literature Research

Material Glass

Glass Column

Cast Glass Structures

Interlocking Geometries

Case Study: Glaspaleis

Research Framework

Literature Research

Design Principles & Challenges

Next Steps
Literature Research

- Material Glass
- Glass Column
- Cast Glass Structures
- Interlocking Geometries
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Literature Research

- Material Glass
- Glass Column
- Cast Glass Structures
- Interlocking Geometries
- Case Study: Glaspaleis
Literature Research

- Material Glass
- Glass Column
- Cast Glass Structures
- Interlocking Geometries
- Case Study: Glaspaleis
Literature Research

- Material Glass
- Glass Column
- Cast Glass Structures
- Interlocking Geometries
- Case Study: Glaspaleis
Material Glass

- Transparent
- Durable
- Recyclable
- Compressive Strength
Material Glass

Brittle

Tensile Strength

Thermal Expansion
Material Glass

Design Principles & Challenges

Glass Type

Material Costs
Temperature Differences
Annealing Time

Safety Measures
Glass Column

Design Principles & Challenges

Big Cross-section
Glass thickness
Glass Type (Heat resistance & Eccentricity)
Glass Column

(Oikonomopoulou, van den Broek, Bristogianni, Veer, & Nijssse, 2017)
## Glass Column

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<tr>
<th></th>
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### The Material Glass

- **Glass Column**
- **Cast Glass Structures**
- **Interlocking Geometries**
- **Case Study: Glaspaleis**
- **Research Framework**
- **Literature Research**
- **Design Principles & Challenges**
- **Next Steps**
## Glass Column

### Glass Column made of Cast Glass Elements

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The table above compares different design aspects of the Glass Column: Architectural, Mechanical, Financial, and Sustainability. Each aspect is further divided into specific categories and evaluated on a scale from 0 to 2.
Cast Glass Structures

Example Components

Atocha Monument  Crystal Houses  Optical House  Crown Fountain
Cast Glass Structures

- Adhesive
- Substructure
- Interlocking
## Cast Glass Structures

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<tr>
<th>Adhesive</th>
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<td>Transparency</td>
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<tr>
<td><strong>Total</strong></td>
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Cast Glass Structures

Adhesive

Substructure

Interlocking
Cast Glass Structures

Design Principles & Challenges

Limited Component Size (annealing time)

Possible Complex Component Shape

Interlocking Structure
Interlocking Cast Glass Geometries

Example Components

- Barou
  - Façade
- Sombroek / Aurik
  - Bridge
- Akerboom
  - Column
- Jacobs
  - Façade (& Column)
Interlocking Cast Glass Geometries

Design Principles & Challenges

- Restacable & Recyclable
- Limited Moulds
- Constraints in Planar Direction
- Even Mass Distribution
- Multi-functionality
Case Study: Glaspaleis

The Netherlands
Case Study: Glaspaleis
Case Study: Glaspaleis

Heerlen
Case Study: Glaspaleis

Heerlen
Case Study: Glaspaleis

Heerlen
Case Study: Glaspaleis

Glass Facade
Case Study: Glaspaleis

30 Load-bearing Columns on Every level
Case Study: Glaspaleis

6 Meter High Columns
Case Study: Glaspaleis

Carrying 6 More Levels
Design Principles & Challenges

- Cast Glass elements
- Wide Cross-Section
- Interlocking System
- Multiple Elements on Horizontal Level
- Limited Annealing Time
- Recyclability & Restackability

- Limited moulds
- Even Mass Distribution
- Constrains in Planar directions
- Multifunctionality
- Constrictions of Case Study
- Fire Safe
Design Principles & Challenges

- Cast Glass elements
- Wide Cross-Section
- Interlocking System
- Multiple Elements on Horizontal Level
- Limited Annealing Time
- Recyclability & Restackability
- Limited moulds
- Even Mass Distribution
- Constrains in Planar directions
- Multifunctionality
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- Fire Safe
Next Steps: Concepts

Design Principles & Challenges

- Cast Glass elements
- Wide Cross-Section
- Interlocking System
- Multiple Elements on Horizontal Level
- Limited Annealing Time
- Recyclability & Restackability
- Limited moulds
- Even Mass Distribution
- Constrains in Planar directions
- Multifunctionality
- Constrictions of Case Study
- Fire Safe
Next Steps

Activity/Week

DESIGN

- Literature Study: Design Methods Bricks
- Literature Study: Design in Elements
- Designing
- Detailing and Integration
- Final Design

FEB

22-28  29-04  05-11  12-18  19-25

MRT

26-04  05-11  12-18  19-25

2.9  2.10  X  3.1  3.2  3.3  3.4  3.5  3.6
Thank You

Questions?