River Team
Winter Quarter Presentation
AEC Global Teamwork
2017
River Team
Members

Avril  USA
MEP

Sohan  USA
SE

Briana  USA
CM

Fathi  UK
CM

Marcel  Germany
SE

Thomas  Germany
LCFM

Ewelina  Poland
A
River Team

Owners

Jana
Germany
LCFM
Project engineer
Deutsche Bahn

Jakob
Denmark
A
Assistant Lecturer
Aalborg University

Steve
Germany
SE
Construction engineer
in bridge construction

Hussain
Denmark
CM
BIM Consultant
RAMboll
River Team
Team Process & Dynamics
Communication, Coordination, Collaboration
River Team
Team Process & Dynamics
Multidisciplinary collaboration by BIM clash detection

Each Discipline clash avoidance
Multidisciplinary clash detection

Resolve Approved clashes
Report action required clashes
Discuss clashes
Weimar
Site Specific Constraints

Flooding risk
River Ilm’s occasional surprises
A-SE-CM-LCFM

UNESCO heritage
Impact on environment
A-SE-CM-LCFM

Logistics
Limited site access & footprint location & Trees
CM-SE-A

Weimar, Germany
Site Analysis

Old City Issue

- Our plot location
- River Ilm

Ilm Flooding
Site Analysis

Historic landmarks

1. Old castle
2. Ilm River Park
Site Analysis

City highlights

- Bauhaus university campus
- Student Accommodation
- Tourist Attractions

- People flow
11 Site Access

Resource supply

- Plot location

- Site access
Climate

Average: 8°C

Average High (July): 22°C

Average Low (Jan): -3°C

Annual Heating Degree Days: 6616
Weimar, Germany

Climate

Wind Speed (m/s)
Climate

Average Relative Humidity: 79%

Highest Average Dewpoint (Jul): 12°C

Average Annual Precipitation: 58 cm
Climate

Solar Analysis

1695 kWh/m²/year
Collect more site information

Drone Data

January:
Panorama Photos from the ground

February:
More Pictures and Videos

March:
Use a drone
Drone Data

The Procedure

Area for 3D-Model:
- Architect
- CM
- LFCM + SE

Points for 360°-Views:
- Architect
- CM

Take the pictures

Georeferenced point cloud / 3D-Model & 6 linked 360°-Views
Arch + CM: exact tree location
Arch + CM: sloped terrain
Arch: how the building fit in the surrounding area
SE + LCFM: detailed flood simulation
CM: most recent data for site plan & delivering space

Arch: detailed information about surrounding area & buildings
CM: More information for site accessibility

3D-Model

18

Drone data

Our next steps in spring quarter

360°-Views
The survey

Binding students in the planning process

In your opinion, is there ample space for student collaboration?

- Yes, but not enough: 9.5%
- Yes, and it is too much. The students do not use it: 14.3%
- Yes, and it is exactly the correct amount: 52.4%
- No, but at least there is space for communication: 19%
- No, there is not even space for communication: 0%

On a typical weekday (M-F), how many hours do you spend in educational buildings (classrooms, study spaces, labs)?

Location spaces on...
The survey

Binding students in the planning process

Workplace of your dreams

“Comfortable and with enough opportunity for social exchange with employees”

“[...] lots of space, sockets everywhere, maybe a small cafe in the corner [...] a place to work alone but also for group work [...]”

Problems and Improvements

“More integration of international students with German culture and society”

“Not enough study spaces”

“More snack options”

“More space for spending free time”
Dramatic Flow

Inspired by the flow of the river Ilm
Main Idea

Dramatic Flow

Inspired by flow of the river Ilm, this building is catching you with the flow, reflected to overall building shape.
Form

Dramatic Flow
24

Dramatic Flow

Entrance view
Ground Level

Level 1

Room Legend
- flow hall
- lab
- large class
- MEP
- MEP shaft
- restrooms
- seminar
- storage
Room Legend
- auditorium
- flow hall
- MEP shaft
- restrooms
- small class
- stairs
- storage
- student office
- tech.
Section 1

From the park to the river

Room Legend

- large class
- MEP
- office
- seminar
- server backup
- small class
- storage
- student office
- tech.
Section 1

Flood Mitigation

Flood avoidance -
Lifting the building up
Over the flood level

Highest recorded flood level = 350cm
Section 2

Auditorium & Flow hall

Room Legend

- auditorium
- flow hall
- lab
- large class
- MEP shaft
- office
- small class
- storage
Exterior - solid, regular, traditional  
Interior - fluid, irregular, new
Loads and Soil

Gravity
Office: 2 kN/m²
Large Classroom: 4 kN/m²
Large Corridor: 5 kN/m²
Auditorium: 4 kN/m²
Snow load: 0.81 kN/m²

Lateral
Wind load: -0.78 - 0.455 kN/m²

Design based on Eurocode 0 - 8 (DIN EN 1990 - DIN EN 1998)
Structural Alternatives

Steel Braced Frame

Structural Walls
Steel Braced Frame | Ground Level

Floor Plan

Key
- **HE 300M Beam**
- **HE 250M Beam**
- **HE 180M Beam**
- **UC 305x305x97 Col**
- **Brace (Varies)**
- **300 mm Shear Wall**
Steel Braced Frame | Level 2

Key
- **Red:** HE 300M Beam
- **Blue:** HE 250M Beam
- **Green:** HE 180M Beam
- **Square:** UC 305x305x97 Col Brace (Varies)
- **Orange:** 300 mm Shear Wall
Steel Braced Frame | Level 3
Framing Plan

Key
- Red: HE 300M Beam
- Blue: HE 250M Beam
- Green: HE 180M Beam
- Orange: UC 305x305x97 Col
- Pink: Brace (Varies)
- Yellow: 300 mm Shear Wall
Steel Braced Frame | Roof
Framing Plan

Key
- 40 cm depth Roof Truss
- HE 250M Beam
- HE 180M Beam
- UC 305x305x97 Col
- Brace (Varies)
- 300 mm Shear Wall
Steel Braced Frame | Gravity Load Path

N-S Section

Key

Compression

Tension

Flexure
Steel Braced Frame | Gravity Load Path
E-W Section

Key

- Compression
- Tension
- Flexure

7200 mm
Steel Braced Frame | Lateral Resistance

Key

- **Pink** Braced Frame
- **Orange** R.C. Shear Wall
- **Blue** Shear Resistance
Steel Braced Frame | Torsional Resistance

Key
- Pink: Braced Frame
- Orange: R.C. Shear Wall
- Blue: Shear Resistance
Structural Walls | Ground Level
Framing Plan

Key

- Ice Protection Wall 1,2m x 20 cm (concrete)
- Column HEB200 with single Footings
- Column HEB500 with single Footings
- Brace (Varies)
- 240 mm Masonry Brick Wall with strip foundation
Structural Walls | Level 2
Framing Plan

Key
- Beam HEB 500
- Beam HEA 200 (composite)
- Beam HEA 200
- Column HEB 200
- Column HEB 500 with single Footings
- Brace (Varies)
- 240 mm Masonry Brick Wall

240 mm Masonry Brick Wall

Cantilever

DRAMATIC FLOW
Structural Walls | Level 3

Framing Plan

Key
- Beam HEB 500
- Beam HEA 200 (composite)
- Beam HEA 200
- Column HEB 200
- Column HEB 500 with single Footings
- Brace (Varies)
- 240 mm Masonry Brick Wall

Cantilever
Structural Walls | Gravity Load Path

N-S Section

Key

- Compression
- Tension
- Flexure
Structural Walls | Gravity Load Path

E-W Section

Key
- Compression
- Tension
- Flexure
Structural Walls | Lateral Resistance

Key

Wind

Resistance
Structural Walls | Curved Brick Walls

Material Details

**Structural restrictions:**

- max. width of the gap: 1.6 cm

**Brick dimensions**

\[ W \times L = 24 \text{ cm} \times 37.2 \text{ cm} \]

**Prefabrication:**

- higher accuracy and faster assembling

**Center Plates/ Elastomer Strip:**

- Reduce load eccentricity because of slab rotation
Design Goals

Standards & Certification

High Performance Building Envelope

- ≤ 0.15 W/m²K walls, floors and roofs
- 15 kWh/m² maximum heating/cooling load

High Quality Air

- 21 cfm/person

Comfortable Internal Temperatures

- Internal set point temperature
  - 21°C - 24°C
### Primary Systems
- Packaged AHU
- VAV with HW Reheat
- Air Source Heat Pump
- Ground Source Heat Pump
- Earth to Air Heat Exchanger
- Cogeneration
- Solar Cooling
- Water Cooled Chiller
- Air Cooler Chiller
- Solar Heating
- Condensing Boiler
- Heat Recovery VRF
- DOAS
- Aquifer Thermal Storage

### Secondary Systems
- UFAD
- Radiant Floors
- Radiant Ceilings
- Radiant panels at perimeter
- Active Chilled Beams
- Passive Chilled Beams
- Displacement Forced Air H/C
- Natural Ventilation
- Overhead Forced Air H/C
Inefficient

Primary Systems

- Packaged AHU
- VAV with HW Reheat
- Air Source Heat Pump
- Ground Source Heat Pump
- Earth to Air Heat Exchanger
- Cogeneration
- Solar Cooling
- Water Cooled Chiller
- Air Cooler Chiller
- Solar Heating
- Condensing Boiler
- Heat Recovery VRF
- DOAS
- Aquifer Thermal Storage

Secondary Systems

- UFAD
- Radiant Floors
- Radiant Ceilings
- Radiant panels at perimeter
- Active Chilled Beams
- Passive Chilled Beams
- Displacement Forced Air H/C
- Natural Ventilation
- Overhead Forced Air H/C
Not Appropriate for our Climate

Primary Systems

- Ground Source Heat Pump
- Cogeneration
- Solar Cooling
- Water Cooled Chiller
- Solar Heating
- Condensing Boiler
- Heat Recovery VRF
- DOAS
- Aquifer Thermal Storage

Secondary Systems

- UFAD
- Radiant Floors
- Radiant Ceilings
- Radiant Panels
- Active Chilled Beams
- Passive Chilled Beams
- Natural Ventilation

System Selection
### Primary Systems
- Ground Source Heat Pump
- Cogeneration
- Water Cooled Chiller
- Condensing Boiler
- Heat Recovery VRF
- DOAS
- Aquifer Thermal Storage

### Secondary Systems
- UFAD
- Radiant Floors
- Radiant Ceilings
- Radiant Panels
- Active Chilled Beams
- Passive Chilled Beams
- Natural Ventilation
VRF System

**Heating/Cooling:** Heat Recovery
VRF system with ductless indoor fan coil units

**Ventilation:** DOAS with Heat Exchanger
VRF System

Roof

Mechanical Room  Vertical Shaft  PV Panels
VRF System

Level 3

Air return through ceiling plenum.
VRF System

Level 2

Air supply in auditorium from below.
VRF System

Level 1

Air supply to atrium from edge of walkway.
VRF System

Floor Sandwich
UFAD System

**Heating/Cooling:** Water-cooled chiller & condensing boiler

**Ventilation:** AHU with heat exchanger + UFAD + Active Chilled Beams in floor at perimeter
UFAD System

Distribution Tree
UFAD System

Floor Sandwich

Worst case when return ducts cross beams.
No drop ceiling.
Sustainability Target Value

VRF System

- Carbon (kgCO₂e): 38%
- Water (kgH₂O): 94%
- Energy (MJ): 15%

UFAD System

- Carbon (kgCO₂e): 46%
- Water (kgH₂O): 93%
- Energy (MJ): 22%
MEP Decision Matrix

Scale 1 - 5 (1 = Worst, 5 = Best)

<table>
<thead>
<tr>
<th></th>
<th>Construction Cost</th>
<th>Energy Consumption</th>
<th>Occupant Comfort</th>
<th>Air Quality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF System</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>UFAD System</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>11</td>
</tr>
</tbody>
</table>
From Design to Construction

CM/LCFM solutions for Flow alternatives
Flow Steel Crane Usage Histogram

Crane Usage Histogram

Dramatic Flow

Crane of choice
Construction Sequence

1. Car park, Management offices and indoor storage
   - Sep 30 to Dec 12
   - May 01 to Aug 12

2. Toilets and locker rooms
   - Mar 08 to May 01

3. Outdoor Material Storage
   - Security and Timekeeper office
   - First Aid room and Lunch area

- 40-01 to 09-07
## Flow Structural Walls Construction Schedule

<table>
<thead>
<tr>
<th>Name</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminaries</td>
<td>30/09/2019</td>
<td>05/11/2019</td>
</tr>
<tr>
<td>Substructure</td>
<td>06/11/2019</td>
<td>24/12/2019</td>
</tr>
<tr>
<td>Super structure</td>
<td>13/12/2019</td>
<td>14/02/2020</td>
</tr>
<tr>
<td>Interior Finishing</td>
<td>05/02/2020</td>
<td>21/05/2020</td>
</tr>
<tr>
<td>Services 1st fix</td>
<td>17/02/2020</td>
<td>28/02/2020</td>
</tr>
<tr>
<td>Services 2nd fix</td>
<td>25/02/2020</td>
<td>28/04/2020</td>
</tr>
<tr>
<td>Services-commissioning</td>
<td>22/04/2020</td>
<td>07/05/2020</td>
</tr>
<tr>
<td>Furnishing</td>
<td>01/05/2020</td>
<td>11/06/2020</td>
</tr>
<tr>
<td>Testing and Commissioning</td>
<td>12/06/2020</td>
<td>08/07/2020</td>
</tr>
</tbody>
</table>
Flow Steel Crane Usage Histogram

Crane Usage Histogram

Line | Name | Duration
--- | --- | ---
1 | Prerement | 5w 20d
2 | Site preparation | 1w
3 | Foundations | 2w 10d
4 | Placing temporary offices and equipment | 1w 20d
5 | Crane | 2w 20d
6 | Demolition and sewage connection | 1w 20d
7 | Frame of tower foundation and equipment | 1w 30d
8 | Foundations | 2w
9 | Decking | 2w
10 | Excavation | 2w
11 | Bending base | 2w
12 | RC foundations installation | 1w
13 | Crane | 1w
14 | Pouring slab on grade | 3d
15 | Rebuilding | 1w 30d
16 | Shoring structure | 2w
17 | Ground floor | 4w
18 | Frame Floor | 3w
19 | Roof | 1w 6d
20 | Façade | 2w 6d
21 | Interior Finishing | 1w 60d
22 | Services 1st fix | 2w
23 | Services 3rd fix | 3w
24 | Services commissioning | 2w 20d
25 | Furnishing | 2w
26 | Testing and commissioning | 3w 30d

Crane of choice
Construction Sequence

1. Sep 30 to Dec 12
   - Car park, Management offices and indoor storage
   - Toilets and locker rooms
   - Outdoor Material Storage
   - Security and Timekeeper office
   - First Aid room and Lunch area

2. Mar 05 to May 01
   - Car park, Management offices and indoor storage
   - Toilets and locker rooms
   - Outdoor Material Storage
   - Security and Timekeeper office
   - First Aid room and Lunch area

3. May 01 to Jul 08
   - Car park, Management offices and indoor storage
   - Toilets and locker rooms
   - Outdoor Material Storage
   - Security and Timekeeper office
   - First Aid room and Lunch area
Functional Labs During Construction

Area to be functional on May
Construction Cost Estimation

Databases & Tools

BKI: German Building Cost Index
- Higher level cost categories
RSMeans Data
- Detailed assembly cost data
BKI and RSMeans relation factor

Target Value: €9.2 million

- A Substructure: 24%
- B Shell: 8%
- C Interiors: 5%
- D Services: 3%
- E Equipment and Furnishing: 2%
- F Specialty Construction: 3%
- G Building Sitework: 40%
- H General Conditions: 16%
Construction Cost
MEP & Structural Systems

Dramatic Flow - Steel
€ 6.8 million

Dramatic Flow - Brick
€ 7.2 million

Legend:
- A Substructure
- B Shell
- C Interiors
- D Services
- E Equipment and Furnishing
- F Specialty Construction
- G Building Sitework
- H General Conditions
The Path
Settled on your way to go
Imagine the building as a point on your daily path, embedded into the Goethe Park;

Where the green is taking control over inside walls all the way up to the atrium,
giving the most of it to the students inside the building.
Concept Development
Concept Development
Mission Invisible

With tradition to innovation
Imagine a building which targets being invisible in many dimensions:

1) Would blend into UNESCO surrounding in aesthetic way, using traditional aesthetics
2) Would blend into environment for thoughtful design and use of resources
3) Would blend in time of life occupancy for neutral use of energy
Main Idea

Mission Invisible

Imagine a building which targets being invisible in many dimensions:

1) Would blend into UNESCO surrounding in aesthetic way, using traditional aesthetics
2) Would blend into environment for thoughtful design and use of resources
3) Would blend in time of life occupancy for neutral use of energy
Imagine a building which targets being invisible in many dimensions:

1) Would blend into UNESCO surrounding in aesthetic way, using traditional aesthetics
2) Would blend into environment for thoughtful design and use of resources
3) Would blend in time of life occupancy for neutral use of energy
Reference

Exploring Invisible Standards

2226 - office building in Austria
By be baumschlager eberlee

A building with no heating or cooling system

Image credits
www.baumschlager-eberle.com
Reference

Exploring Invisible Standards

2226 - office building in Austria

Key elements used:

- Optimised room layout
- Natural ventilation only
- Passivhaus standard thick brick walls
- Reduced number of window openings
- Minimized service area

Image credits
www.baumschlager-eberle.com
Our Targets

Mission Invisible

- Minimum use of systems
- Minimum use of energy
- Minimum impact on environment

Invisible design

- Maximum sustainability
- Maximum user comfort
- Maximum efficiency
Form

Mission invisible

- Optimised, simple layout
- Clear form and communication
- Openings for natural ventilation
Exploded floor diagram

Circular staircase

Level 2

Ground Level

Basement

Interiors

Mission Invisible

Interior Staircase
Basement Level

Room Legend
- auditorium
- cafeteria
- large class
- MEP
- restrooms
- seminar
- storage
Ground Level

Room Legend
- common area
- lab
- MEP
- restrooms
- small class
- storage
- storage/ cloakroom
- student offices
Level 2

Room Legend
- lounge
- MEP
- office
- open office
- restrooms
- server backup
- storage
Section 1

Room Legend

- cafeteria
- large class
- lounge
- office
- seminar
- small class
- student offices
Flood Mitigation

Section 2

Flood avoidance -
Lifting the building up
Over the flood level

Highest recorded flood level = 350cm
Elevations
Mission Invisible - Earth
River view
Structural Design Philosophy

Targeting the invisible

Invisible in a structural context:

- Minimise construction waste
- Minimise carbon footprint
- Maximise efficiency
Structural Alternatives

*Earth* - Rammed Earth System

*Brick* - Brick System
Rammed Earth Wall

Detail

- 450 mm thick reinforced earth wall
- Minimize moment transfer to earth wall

Ultimate Compressive Stress:

2 N/mm^2
Rammed Earth | Flooring System

Precast
Cast-in-place
Post-tensioned
Rammed Earth | Flooring System

Detail

- 3m x 3m precast concrete slab elements
- 20 cm slab thickness
- Shear keys for temporary stability
- Continuity strip between slab elements filled on site.
- Quick erection time
Rammed Earth | Basement
Framing Plan

Key
- **HE 300M Beam**
- **HE 250M Beam**
- **HE 180M Beam**
- **UC 305x305x97 Col**
- **HSS 203 Brace**
- **450 mm R.E. Wall**
- **300 mm Shear Wall**
Rammed Earth | Ground Level

Framing Plan

Key
- **HE 300M Beam**
- **HE 250M Beam**
- **HE 180M Beam**
- **UC 305x305x97 Col**
- **HSS 203 Brace**
- **450 mm R.E. Wall**
- **300 mm Shear Wall**
Rammed Earth | Level 2
Framing Plan

Key
- HE 300M Beam
- HE 250M Beam
- HE 180M Beam
- UC 305x305x97 Col
- HSS 203 Brace
- 450 mm R.E. Wall
- 300 mm Shear Wall
Rammed Earth | Roof
Framing Plan

Key
- **Red**: HE 300M Beam
- **Blue**: HE 250M Beam
- **Green**: HE 180M Beam
- **Purple**: UC 305x305x97 Col
- **Pink**: HSS 203 Brace
- **Brown**: 450 mm R.E. Wall
- **Orange**: 300 mm Shear Wall
Rammed Earth | Vertical Load Path

N-S Section

- Compression
- Tension
- Flexure
- Column in earth
Rammed Earth | Horizontal Load Path

N-S Section

- Compression
- Tension
- Flexure
- Column in earth
Rammed Earth | Horizontal Load Path

N-S Section

- Compression
- Tension
- Flexure
- Column in earth
Brick System | Basement
Framing Plan

Key
- Beam GL28h 24 cm x 110 cm
- Field Joint & Duct Crossing
- 240 mm Masonry Brick Wall
- 490 mm Masonry Brick Wall with included heat insulation
- Waterproof wall (concrete)

Floor:
CLT 28 cm thick (because of vibration and 90min fire resistance), one and two way span
Brick System | Ground Level

Framing Plan

Key
- Beam GL28h 24 cm x 110 cm
- Field Joint & Duct Crossing
- 240 mm Masonry Brick Wall
- 490 mm Masonry Brick Wall with included heat insulation

Floor:
CLT 28 cm thick (because of vibration and 90min fire resistance), one and two way span
Brick System | Level 2
Framing Plan

Key

- Beam GL28h 24 cm x 110 cm
- Field Joint & Duct Crossing
- 240 mm Masonry Brick Wall
- 490 mm Masonry Brick Wall with included heat insulation

Floor:
CLT 28 cm thick (because of vibration and 90min fire resistance), one and two way span
Brick System | GLT - Beams
CM + MEP + SE - Clash Solving

4x16 bolts 8.8
\( d = 24 \text{ mm} \)

Sheet metal
\( t = 16 \text{ mm} \)

Opening for ducts
30 cm x 30 cm

2 m
15,5 m (max. Length for delivering)
Brick System | Lateral Resistance

Key

Wind

Resistance
Natural Ventilation

**Heating/Cooling:** GSHP + Hydronic radiator panels at perimeters

**Ventilation:** Operable windows + trickle vents

**Auditorium and WC:** Packaged AHU
Natural Ventilation

Preliminary Concept

Needs further A & MEP coordination and development.
Natural Ventilation

Roof

- AHU
- Vertical Shaft
- PV Panels
Natural Ventilation

Ground Level & Level 2

Mechanical ventilation in WC only.
Natural Ventilation

Basement

Air supply to auditorium from below.
Air supply to WC from overhead.
Return air exhaust in auditorium overhead.

- Supply
- Return
Natural Ventilation

Floor Sandwich

Most of the building has no ducts.
Worst case is in WC.
Radiant Floors + DOAS

**Heating/Cooling:** GSHP + Radiant Floors + Active Chilled Beams

**Ventilation:** Natural Ventilation controlled by CO2 sensors, supplemented by DOAS with heat exchanger
Radiant Floors + DOAS

Roof

- AHU
- Vertical Shaft
- PV Panels
Radiant Floors + DOAS

Level 2 - SE/MEP Clash

Supply air ducts avoid most girders.
If necessary duct will punch through.

- **Supply Air**
- **Return Air**
- **Girders**
Radiant Floors + DOAS

Ground Level

Return air through ceiling plenum.
Radiant Floors + DOAS

Basement

Air supply to auditorium from below.

- Supply Air
- Return Air
Radiant Floors + DOAS

Floor Sandwich

Supply air ducts avoid most girders.
If necessary duct will punch through.
Worst case below ceiling diffuser.
Sustainability Target Value

Natural Ventilation

- Carbon (kgCO2e): 29%
- Water (kgH2O): 90%
- Energy (MJ): 12%

Radiant Floors + DOAS

- Carbon (kgCO2e): 18%
- Water (kgH2O): 88%
- Energy (MJ): 7%

MISSION INVISIBLE
## MEP Decision Matrix

**Scale 1 - 5 (1 = Worst, 5 = Best)**

<table>
<thead>
<tr>
<th></th>
<th>Construction Cost</th>
<th>Energy Consumption</th>
<th>Occupant Comfort</th>
<th>Air Quality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Ventilation</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>Radiant Floors + DOAS</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>14</td>
</tr>
</tbody>
</table>
Mission Invisible R.Earth
Construction Schedule

<table>
<thead>
<tr>
<th>Name</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminaries</td>
<td>30/09/2019</td>
<td>05/11/2019</td>
</tr>
<tr>
<td>Substructure</td>
<td>06/11/2019</td>
<td>09/01/2020</td>
</tr>
<tr>
<td>Super structure</td>
<td>10/01/2020</td>
<td>11/03/2020</td>
</tr>
<tr>
<td>Interior Finishing</td>
<td>02/03/2020</td>
<td>19/06/2020</td>
</tr>
<tr>
<td>Services 1st fix</td>
<td>02/03/2020</td>
<td>12/03/2020</td>
</tr>
<tr>
<td>Services 2nd fix</td>
<td>10/03/2020</td>
<td>22/05/2020</td>
</tr>
<tr>
<td>Services-commissioning</td>
<td>21/05/2020</td>
<td>05/06/2020</td>
</tr>
<tr>
<td>Furnishing</td>
<td>01/06/2020</td>
<td>10/07/2020</td>
</tr>
<tr>
<td>Testing and Commissioning</td>
<td>13/07/2020</td>
<td>06/08/2020</td>
</tr>
</tbody>
</table>
# Mission Invisible Bricks

Crane Usage Histogram

<table>
<thead>
<tr>
<th>Line</th>
<th>Name</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preliminaries</td>
<td>5w 2d</td>
</tr>
<tr>
<td>2</td>
<td>Site preparation</td>
<td>1w 4d</td>
</tr>
<tr>
<td>3</td>
<td>Hoardings</td>
<td>1w 2d</td>
</tr>
<tr>
<td>4</td>
<td>Placing temporary offices and toilets</td>
<td>1w 2d</td>
</tr>
<tr>
<td>5</td>
<td>Crane</td>
<td>1w 2d</td>
</tr>
<tr>
<td>6</td>
<td>Electrical and sewage connection</td>
<td>1w 2d</td>
</tr>
<tr>
<td>7</td>
<td>Tower crane foundation and installation</td>
<td>1w 3d</td>
</tr>
<tr>
<td>8</td>
<td>Substructure</td>
<td>5w 2d</td>
</tr>
<tr>
<td>9</td>
<td>Super structure</td>
<td>8w 4d</td>
</tr>
<tr>
<td>10</td>
<td>Masthead</td>
<td>3w 4d</td>
</tr>
<tr>
<td>11</td>
<td>Ground Floor</td>
<td>2w 2d</td>
</tr>
<tr>
<td>12</td>
<td>First Floor</td>
<td>2w 2d</td>
</tr>
<tr>
<td>13</td>
<td>Second Floor</td>
<td>3w 2d</td>
</tr>
<tr>
<td>14</td>
<td>Roof</td>
<td>1w 4d</td>
</tr>
<tr>
<td>15</td>
<td>Exterior</td>
<td>3w 2d</td>
</tr>
<tr>
<td>16</td>
<td>Interior Finishing</td>
<td>16w 4d</td>
</tr>
<tr>
<td>17</td>
<td>Services 1st fix</td>
<td>10w 4d</td>
</tr>
<tr>
<td>18</td>
<td>Services 2nd fix</td>
<td>10w 4d</td>
</tr>
<tr>
<td>19</td>
<td>Services commissioning</td>
<td>2w 2d</td>
</tr>
<tr>
<td>20</td>
<td>Furnishing</td>
<td>6w 4d</td>
</tr>
<tr>
<td>21</td>
<td>Testing and Commissioning</td>
<td>3w 3d</td>
</tr>
</tbody>
</table>

### Crane Usage Histogram
Construction Sequence

- Car park, Management offices and indoor storage
- Toilets and locker rooms
- Outdoor Material Storage
- Security and Timekeeper office
- First Aid room and Lunch area

Substructure

Superstructure
Mission Invisible Bricks
Construction Schedule

<table>
<thead>
<tr>
<th>Name</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminaries</td>
<td>30/09/2019</td>
<td>05/11/2019</td>
</tr>
<tr>
<td>Substructure</td>
<td>06/11/2019</td>
<td>09/01/2020</td>
</tr>
<tr>
<td>Super structure</td>
<td>10/01/2020</td>
<td>28/02/2020</td>
</tr>
<tr>
<td>Interior Finishing</td>
<td>06/02/2020</td>
<td>22/05/2020</td>
</tr>
<tr>
<td>Services 1st fix</td>
<td>02/03/2020</td>
<td>12/03/2020</td>
</tr>
<tr>
<td>Services 2nd fix</td>
<td>10/03/2020</td>
<td>24/04/2020</td>
</tr>
<tr>
<td>Services-commissioning</td>
<td>23/04/2020</td>
<td>08/05/2020</td>
</tr>
<tr>
<td>Furnishing</td>
<td>04/05/2020</td>
<td>12/06/2020</td>
</tr>
<tr>
<td>Testing and Commissioning</td>
<td>15/06/2020</td>
<td>09/07/2020</td>
</tr>
</tbody>
</table>
Crane Usage Histogram
Construction Sequence

1. Car park, Management offices and indoor storage
   - Sep 30 to Dec 12

2. Toilets and locker rooms
   - Mar 09 to May 01

3. Outdoor Material Storage
   - May 01 to Jul 09
   - First Aid room and Lunch area

Color codes:
- Light blue: Car park, Management offices and indoor storage
- Red: Toilets and locker rooms
- Pink: Outdoor Material Storage
- Black: Security and Timekeeper office
- Yellow: First Aid room and Lunch area
Functional Labs During Construction

Area to be functional on May
Construction Challenges

- Hoardings that fits in the environment
- Noise reduction Layer on hoardings
- Rapidam Technology
- Ground protection mats
- Soil Runoff
- Silt Fence
Construction Cost
MEP & Structural Systems

Mission Invisible - Earth
€ 6.6 million

Mission Invisible - Brick
€ 8.2 million
TVD Cost Comparison
Initial Estimates

€ 6.8 million
€ 7.2 million
€ 6.6 million
€ 8.2 million
€ 9.2 million

- H General Conditions
- G Building Sitework
- F Specialty Construction
- E Equipment and Furnishing
- D Services
- C Interiors
- B Shell
- A Substructure
TVD Cost Comparison
Initial Estimates

- **Dramatic Flow - Steel**
  - €6.8 million
  - A Substructure: 3%
  - B Shell: 4%
  - C Interiors: 11%
  - D Services: 20%
  - E Equipment and Furnishing: 15%
  - F Speciality Construction: 14%
  - G Building Sitework: 6%
  - H General Conditions: 4%

- **Dramatic Flow - Brick**
  - €7.2 million
  - A Substructure: 2%
  - B Shell: 22%
  - C Interiors: 10%
  - D Services: 3%
  - E Equipment and Furnishing: 14%
  - F Speciality Construction: 3%
  - G Building Sitework: 5%
  - H General Conditions: 3%

- **Mission Invisible - Earth**
  - €6.6 million
  - A Substructure: 2%
  - B Shell: 16%
  - C Interiors: 25%
  - D Services: 30%
  - E Equipment and Furnishing: 7%
  - F Speciality Construction: 11%
  - G Building Sitework: 2%
  - H General Conditions: 3%

- **Mission Invisible - Brick**
  - €8.2 million
  - A Substructure: 1%
  - B Shell: 34%
  - C Interiors: 19%
  - D Services: 9%
  - E Equipment and Furnishing: 6%
  - F Speciality Construction: 11%
  - G Building Sitework: 7%
  - H General Conditions: 3%
Construction Contingency

Construction & Planning **Risks** -> Contingency

- Dramatic Flow - Steel
- Dramatic Flow - Brick
- Mission Invisible - Earth
- Mission Invisible - Brick

**H. General Conditions**

![Graph showing general conditions for different projects: Dramatic Flow - Steel, Dramatic Flow - Brick, Mission Invisible - Earth, Mission Invisible - Brick, and Target Value.](chart.png)
Collaboration

Initial costs
- Planning & Design
- Construction & Site Development
- Furniture & Equipment

Future costs
- Energy
- Maintenance
- Staffing & Operations
- Renovation
- Interests

\[ \text{Life cycle costs (LCC)} = \text{Initial costs} + \text{Future costs} \]
Risk Identification

- Flood risk
- Dimensioning risk
- Vandalism risk
- Management risk

Risk evaluation

Prevention Methods
## Risk Allocation

<table>
<thead>
<tr>
<th>Risk categories</th>
<th>Risk Name</th>
<th>Risk measures</th>
<th>Risk measures undertaken</th>
<th>Consequences</th>
<th>Possibility</th>
<th>Detection</th>
<th>TOTAL Risk</th>
<th>RPZ Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Flooding risk</td>
<td>Flood protection system, Warning system, insurance</td>
<td>All</td>
<td>8.0</td>
<td>3.8</td>
<td>6.2</td>
<td>177</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>3 Dimensioning risk</td>
<td>Iterative exchange between A and SE, reviewing/double checks</td>
<td>A, SE</td>
<td>7.3</td>
<td>5.0</td>
<td>3.3</td>
<td>77.6</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>10 Management risk</td>
<td>Pre-planning, Buffers, clear path (requirements, responsibilities)</td>
<td>CM, LCFM</td>
<td>4.5</td>
<td>5.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27 Location risk</td>
<td>Classification of location conditions</td>
<td>All</td>
<td>6.8</td>
<td>2.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25 Ground risk</td>
<td>Review of given information, own research of ground conditions</td>
<td>All</td>
<td>8.0</td>
<td>2.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Risk Management

- **Risk costs with prevention**
- **Risk cost without prevention**

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>RPZ</th>
<th>Need for action</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 &lt;= RPZ &lt;= 1000</td>
<td>A</td>
<td>Urgend</td>
<td><strong>Must</strong> be formulated and implemented</td>
</tr>
<tr>
<td>50 &lt;= RPZ &lt;= 100</td>
<td>B</td>
<td>Need for action</td>
<td>Should be formulated and implemented</td>
</tr>
<tr>
<td>2 &lt;= RPZ &lt;= 50</td>
<td>C</td>
<td>Not necessarily</td>
<td>Could be formulated and implemented</td>
</tr>
<tr>
<td>RPZ &lt;= 1</td>
<td>D</td>
<td>No need</td>
<td>None</td>
</tr>
</tbody>
</table>
Risk Management

- Lifting building
- Waterproof materials
- Allocation of installations
- Security system
- Pre-Planning
- Buffer
- Clear requirements
- Use of (different) software
- Double checks
## Life cycle costs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent</td>
<td>750.000 €</td>
<td>820.000 €</td>
<td>730.000 €</td>
<td>910.000 €</td>
<td>920.000 €</td>
<td>920.000 €</td>
</tr>
<tr>
<td>Construction Costs</td>
<td>6.800.000 €</td>
<td>7.200.000 €</td>
<td>6.600.000 €</td>
<td>8.200.000 €</td>
<td>8.900.000 €</td>
<td>8.900.000 €</td>
</tr>
<tr>
<td>O+M Costs</td>
<td>3.000.000 €</td>
<td>3.100.000 €</td>
<td>2.800.000 €</td>
<td>2.800.000 €</td>
<td>5.200.000 €</td>
<td>5.000.000 €</td>
</tr>
<tr>
<td>Replacement Costs</td>
<td>1.000.000 €</td>
<td>1.200.000 €</td>
<td>1.000.000 €</td>
<td>1.400.000 €</td>
<td>1.300.000 €</td>
<td>1.400.000 €</td>
</tr>
<tr>
<td>Risk Charge</td>
<td>250.000 €</td>
<td>270.000 €</td>
<td>320.000 €</td>
<td>330.000 €</td>
<td>490.000 €</td>
<td>490.000 €</td>
</tr>
<tr>
<td><strong>Life Cycle Costs</strong></td>
<td><strong>14.800.000 €</strong></td>
<td><strong>15.400.000 €</strong></td>
<td><strong>14.700.000 €</strong></td>
<td><strong>16.800.000 €</strong></td>
<td><strong>16.800.000 €</strong></td>
<td><strong>16.400.000 €</strong></td>
</tr>
</tbody>
</table>
### Summary - Decision Matrix

<table>
<thead>
<tr>
<th></th>
<th>Legend</th>
<th>Weighted Score per Criteria</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dramatic Flow - Steel</td>
<td>Dramatic Flow - Brick</td>
<td>Mission Invisible - Earth</td>
<td>Mission Invisible - Brick</td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>Outdoor design</td>
<td>2.4</td>
<td>2.7</td>
<td>3.1</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indoor design/ Footprint</td>
<td>2.9</td>
<td>3.1</td>
<td>2.9</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Site Challenges</td>
<td>Heritage/ Flood/ Trees/ Site access</td>
<td>2.5</td>
<td>2.8</td>
<td>3.0</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Construction Time</td>
<td>2.4</td>
<td>2.6</td>
<td>2.4</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>Material &amp; construction</td>
<td>2.2</td>
<td>2.3</td>
<td>3.4</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td>Construction costs</td>
<td>2.6</td>
<td>2.4</td>
<td>2.6</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Life cycle costs</td>
<td>2.2</td>
<td>2.4</td>
<td>3.1</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Energy/Sustainability</td>
<td>Energy demand</td>
<td>1.9</td>
<td>2.2</td>
<td>3.3</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CO2 Footprint</td>
<td>1.9</td>
<td>2.5</td>
<td>2.9</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Functional Quality</td>
<td>Space efficiency</td>
<td>2.1</td>
<td>2.3</td>
<td>3.0</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Risks (e.g. prevention of flood risk)</td>
<td>2.3</td>
<td>2.7</td>
<td>2.6</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student needs</td>
<td>2.6</td>
<td>2.8</td>
<td>2.7</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>27.9</strong></td>
<td><strong>30.7</strong></td>
<td><strong>35.1</strong></td>
<td><strong>32.6</strong></td>
<td></td>
</tr>
</tbody>
</table>
Summary - Decision Matrix

Dramatic Flow - Steel
- Outdoor design: 3.0
- Indoor design/Footprint: 2.5
- Heritage/ Flood/ Trees/ Site access: 1.0
- Construction Time: 1.0
- Material & construction: 0.5
- CO2 Footprint: 0.0
- Energy demand: 0.0
- Life cycle cost: 0.0

Dramatic Flow - Brick
- Outdoor design: 3.0
- Indoor design/Footprint: 2.5
- Heritage/ Flood/ Trees/ Site access: 1.0
- Construction Time: 1.0
- Material & construction: 0.5
- CO2 Footprint: 0.0
- Energy demand: 0.0
- Life cycle cost: 0.0

Mission Invisible - Brick
- Outdoor design: 3.5
- Indoor design/Footprint: 3.0
- Heritage/ Flood/ Trees/ Site access: 2.0
- Construction Time: 1.5
- Material & construction: 1.0
- CO2 Footprint: 0.5
- Energy demand: 0.0
- Life cycle cost: 0.0

Mission Invisible - Earth
- Outdoor design: 3.5
- Indoor design/Footprint: 3.0
- Heritage/ Flood/ Trees/ Site access: 2.0
- Construction Time: 1.5
- Material & construction: 1.0
- CO2 Footprint: 0.5
- Energy demand: 0.0
- Life cycle cost: 0.0
Summary - Decision Matrix

Overall Scoring

- Outdoor design
- Indoor design/ Footprint
- Heritage/ Flood/ Trees/ Site access
- Construction Time
- Material & construction
- Construction costs
- Life cycle costs
- Energy demand
- CO2 Footprint
- Space efficiency
- Risks (e.g. prevention of flood risk)
- Student needs

The Winner is
Mission Invisible
Earth
River Team
Thanks for your attention

Questions?

You can reach us at riverteam2017@gmail.com