Site Conditions

University building in Weimar, Germany

Main aspects:
- Flooding (river)
- Climate (+/-)
- City/nature
- Old Town, Castle

<table>
<thead>
<tr>
<th>Monat</th>
<th>Temp. max.</th>
<th>Temp. min.</th>
<th>Sun hours</th>
<th>Rain days</th>
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<tbody>
<tr>
<td>Januar</td>
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<td>2.6 h</td>
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<td>0.7 °C</td>
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<td>4.9 h</td>
<td>14 d</td>
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<td>Dezember</td>
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Cooperation Process

“Transparency” idea

“Boring Box”

“ReUse” idea

“Def Design”
## Decision Matrix

<table>
<thead>
<tr>
<th>aspect</th>
<th>TRANSPARENCY</th>
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<th>REUSE</th>
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<td>Floor to ceiling height</td>
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<td>Lateral System</td>
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<td>Connections</td>
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</table>

Rating: 1 low - 5 high
Historic

Owner’s wish

Harmony
Proportions
Symmetry

ReUse

Big Idea

- reusing historical style
- reusing old materials
- reusing water
- “reusing” sunlight
- reusing rooms

Spiral

Core Area

- Iconic place
- Vertical circulation
- Integration area
- Visually attractive
- Building identity
- SE challenging :D
Atrium Area
Atrium Area
Main Entrance view
West Façade [city, entrance]

East Façade [river, parc]
North-South Section

East Façade [river, park]
North Façade

East-West Section

31’6”

28’

13’6”

13’6”

51’

21’
Details Materials, Small Architecture

Slanted windows -> river view

Benches (reused stone)

Glass handrails in circular staircase

Stone Sphere-fountain
(in the middle of atrium, +1)
Loading Considerations

**Gravity Loads**

**DEAD LOADS:**
- MEP: 5 psf
- CLADDING: 20 psf
- MISC: 12 psf
- SELF-WEIGH: 80 to 100 psf

**LIVE LOADS:**
- ROOF: 20 psf
- SNOW: 40 psf
- CLASSROOM: 50 psf
- OFFICE: 50 psf
- AUDITORIUM: 60 psf
- LABORATORY ROOM: 100 psf
- CORRIDOR: 100 psf
- STORAGE: 120 psf
- PARTITIONS: 20 psf

**Lateral Loads**

- AVERAGE WIND LOAD: 12 mph
- DESIGN WIND LOAD: 60 mph

**Dome Loads**

- 40 psf snow
- 60 mph wind

\[ \Delta \leq 0.05 \]
Soil Considerations

High Water Table – 4 ft below Grade

Bearing capacity 8000 psf at 7 ft below grade

Excavation needed

Building will not be under water table
Structural Plan + 1

- Sloped to support cantilever

- Steel Column:
  - W18 x 60
  - W16 x 77
  - W14 x 60
  - W12 x 60
  - W10 x 61

- Concrete Column:
  - W 14 x 30
  - W 16 x 77
  - W 24 x 55
Structural Plan + 2

![Structural Plan + 2 Image]

- **Concrete Column**: W14x61
- **Steel Column**: W12x60, W10x61

**Dimensions**:
- 37.5', 12.5', 50', 31.5'
- 19', 25', 50'

**Columns**:
- W 14 x 30
- W 16 x 77
- W 18 x 60
- W 24 x 55
Shear Wall Design

Shear Wall Detail

Shear Wall Location

Wind Load

- 14.6 k
- 13.3 k
- 11.4 k

Cantilever Load

- 400 k

Design Moment = 13,000 k-ft
Reinforced Concrete Steel Framing

Auditorium Supported by:
- 3 – 12” square columns
- 2 – 18” square columns
- 2 – concrete shear walls

Most Challenging Connection

Section A - A

- 3200 kips
- 2200 k-ft / 18” column

Dimensions:
- 25’ 12.5’ 12.5’ 12.5’ 37.5’ 31.5’
Reinforced Concrete Steel Framing

Steel Beam to Concrete Column

Section X - X
- 12 No. 9 bars
- No. 4 bars @ 3"
- W10 x 61

Section Y - Y
- Band Plate
- 6 – 7/8” ASTM 325 bolts
- 18”

Lap Splice

W18 x 60
W16 x 77
18”

W10 x 61
18”
Connections

**Composite Deck**

- 6 ½” LWC – 3VLI18

**Steel to Steel**

- 6 – 3/4” ASTM 325 bolts
- ½” - L shape Plate

**Details**

- **Studs:** ¾” diam, 4” @ 10”
- **Rebars:** No. 3 @ 8”

**Structural Components**

- W14x30
- W14 x30
Connections

**Footing**

- Footing: 6’ x 6’ x 18”
- Retaining Wall: 14”

**Steel beam to shear wall**
The Signature Dome

Section Model

Dome Layout

Loading Diagram

40 psf Snow Load

10 psf Wind Load
Spiral Stair Design

Main supports located at floor landings
Spiral Stair Design

Additional supports at middle landings
Ecotect Model: Baseline Building

Roof: Foil Insulation, Polystyrene, LW Concrete, Plaster

Glass: Double Glazed, Timber Frame

Interior Partitions: Plaster, Tile

Mechanical: Dual-Duct, VAV system

Exterior Walls: Sandstone, Polystyrene, Concrete, Plaster
Resource Consumption

Peak Monthly Heating Load for Baseline: 150,362,912 Btu

Peak Monthly Cooling Load for Baseline: 36,597,124 Btu

January

December
Geothermal

Energy Consumption from Ecotect

Geothermal System Sizing
- Heat Pump
- Tubing

Geothermal System = 50 tons less Carbon emitted per year (than baseline)

26,000 ft tubing
Geothermal
Soil Conditions
Insulation Options

Expanded Polystyrene

Vacuum Insulation Panels + Expanded Polystyrene

7% reduction in heating using Vacuum Insulated Panels
Daylighting
Glazing Options

Cooling Efficiency

- Double Glazed, Low-e, Aluminum Frame
- Double Glazed, Aluminum Frame
- Double Glazed, Timber Frame

Heating Efficiency
Water Reuse System

- **Storage**
- **Waterless urinals**
- **Toilets**
- **Sinks**
- **Greywater**
- **Sewage plant**

- **Rain Water**
- **Watering**
- **Greywater**
- **Drinking Water**
- **Greywater**
Precipitation
Water Efficiency

Potable Water Savings

- **Baseline**: Maximum water usage
- **Waterless Urinals**: Significantly reduced water usage
- **Rainwater Collection + Greywater Reuse**: Further reduction in water usage

Chosen System: 70% reduction in potable water
LEED

- Sustainable Sites: 20/26
- Water Efficiency: 8/8
- Energy & Atmosphere: 9/35
- Materials & Resources: 10/14
- Indoor Environmental Quality: 15/15
- Innovation & Design Process: 1/6

Total: 63/110

LEED Gold
LCC Analysis options and choices

Combination of systems...
... doesn’t compromise architecture
... doesn’t depend on subsidies
... is educative
Effect on O&M cost

- Present Value Total Savings: $710,000; 22%
- Present Value O&M Cost: $2,470,000; 78%
Cash Flow
Life Cycle Cost

- **Construction cost**: $7,840,000 (41%)
- **Interest**: $4,240,000 (22%)
- **Risk charge**: $319,047 (2%)
- **Other O&M cost**: $5,530,000 (29%)
- **Replacement cost**: $1,110,000 (6%)
Construction Management

Owner

A

E

C

L

S

David
Urszula
Joanna
Nima
Sebastian
Alex
Pre-construction analysis

- Gas station
- Sewer system
- Electricity
- Internet, phone,...
- Steel structure manufacture
- Concrete, asphalt batching plant
- Local hospital
- Glazing
- Potable water
- Earth removal: Highway construction
  Site needs earth for noise barriers

Distances:
- 2 MILES
- 4 MILES
- 15 MILES
- 2,5 MILES
- 2 MILES
- ON-SITE
- ON-SITE
- ON-SITE
- ON-SITE
- ON-SITE
- ON-SITE
- ON-SITE
- ON-SITE
Construction Methods

- Flood-protecting system during construction
- Sheet piles during excavation
- Dewater
- Similar beam sizes
- No building components greater than 50’
- Special construction
  - Geothermal, horizontally installed
- Just in time delivery
Site Layout - Foundation

- 31 Parking lots (5000 SF)
- Offices
- Trailers
- Toilets
- Storage container
- Recycling

Storage:
- Steel: 1400 SF
- Steel: 1900 SF
- Earth: 2200 SF

Notes:
- Site Layout - Foundation
- Foundation
- Parking lots (5000 SF)
- Offices
- Trailers
- Toilets
- Storage container
- Recycling
- Storage:
  - Steel: 1400 SF
  - Steel: 1900 SF
  - Earth: 2200 SF
Site Layout - Erection
Site Layout – Plan view

Normal Water Level

3.7 tons (8.15 kips) at 150 FT

Movement of Mobile-crane for the heaviest lift (5.3 kips)
Site Layout

High water level

Dewatering wells

Aqua barrier (Hydro baffle)
Construction schedule

MS Project schedule optimized with Navisworks

- End of dewatering: 2015-12-21
- Shell finished (supports removed): 2016-04-01
- Lab and computer room finished: 2016-05-29

Project duration: 257 days
Construction schedule

Model-based schedule (VICO Software 2008)

- MPP import
- Steel structure and concrete walls interference
- Optimized

- Project duration: 236 days
- 3 weeks
Model based cost estimate

Revit → Excel
Cost estimate

Allocation of costs

- Substructure: $675 000
- Shell: $2 435 000
- Interiors: $1 130 000
- Services: $2 500 000
- Sitework: $500 000
- Other: $415 000

Total: $7 655 000
Risk Management

From certain costs to uncertain costs

Diagram:
- From certain costs: Probability of $0
- To uncertain costs: Probability distribution with $0 to $100 range
Risk Management

Example Steel price

- CM: Cost for Steel
- LCFM: Probability Distribution

Cost Distribution → Risk charge

Scrap prices:
S/t World 12 yrs
$/t
Export price f.o.b.

Steel on thenet.com
Construction Cost Adjustments

- Inflation: $410,000
- Risk charge: $105,000

Bar chart showing:
- 2008
- 2015
- 2015 including risk charge
Tornado diagram

return on equity
Regression Coefficients

- HVAC system performance
- inflation in construction cost
- electricity price
- soil-conditions
- inflation in O&M cost
- gas price
- 33 year flood
- life expectations
- concrete price
- water price
- 100 year flood

@RISK Trial Version
For Evaluation Purposes Only

Coefficient Value
-0.66
-0.49
-0.22
-0.16
-0.10
-0.08
0.08
0.07
0.06
0.04
0.03
0.02
Flooding Challenge

Detailed terrain profile and different water levels

- Normal water level
- 33 year flood
- 100 year flood
Sustainable Performance
Continuously Enhancing User’s Performance

Flexible

- 2x Classroom loading
- Conservative structure
- Flexible Rooms
- Small Classrooms

Flexible

- Exposed structure
- Water reuse system
- Reused materials
- Renewable energy
- Reuse

Educational

- Atrium
- Simplistic orientation
- Natural Materials
- Natural light
- Natural Ventilation

Productive

- Between users
- With nature
- Thermal Comfort
- AC
- Dome

Sustainable Performance
Continuously Enhancing User’s Performance

Swinerton
Pre-modeling sequence

1. zone: Axis 5-1
2. zone: Axis 5-9
3. zone: Axis 9-13
Model Coordination

Autodesk Revit Architecture and Navisworks

<table>
<thead>
<tr>
<th>ID</th>
<th>Date</th>
<th>Description</th>
<th>Floor</th>
<th>Drawing No.</th>
<th>Picture</th>
<th>Phase</th>
<th>Author</th>
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<tbody>
<tr>
<td>2-3/H-17</td>
<td>27.04.10</td>
<td>Structural framing beams are visible from outside under the 2nd floor slab.</td>
<td>Floor 2</td>
<td>Level 2</td>
<td><img src="image1.png" alt="Image" /></td>
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<td>Joanne</td>
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<td>1-10/A-18</td>
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<td>Beams penetrate windows.</td>
<td>Floor 1</td>
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<td>Column penetrates the Facades window.</td>
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<td>Level 2.3</td>
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<td>Urszula</td>
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</table>
“Little change”
Working on BIM Model

A: “What do you think?”
E: “Not like this, wait…”
C: “OK”
L: “OK”
S: “OK”

E: “OK”
A: “Ok”
E: “Change that”
Spiral-Stairway to IPD-Success

Who needs what from whom, and when?
Early Working Schedule
Pull scheduling
Commitments
1 week/1 month look ahead

“Go around the table”
Color codes in discipline progression
Weekly recalibrating
Make hidden conversations visible on wave
Tracking BIM-workload
Visible task allocations

Early involvement; Pre-modeling sequence; BIM; Clash detection; Constructability report; Revit flood levels; Early Software testing
Lessons Learned

“Stay patient”

“What has been committed does not mean it will be completed”

“Collaboration requires exceptional organization in idea and calculation sharing”

“Everything takes much more time than one would expect”
Thank you!

Main Boss:
- Renate Fruchter

Owner:
- Dave Borowicz

Architects:
- Willem Kymmel
- Jan Słyk
- David Bendet

Structure Engineers:
- Professor Oliva
- Greg Luth
- Professor H. Krawinkler
- Professor Bank

Construction Managers:
- Jonas Bill
- Stefan Söderberg
- Terje Håkansson
- Mirko Penko
- Tomo Cerovšek
- Daniel Gonzales

Life Cycle Financial Managers:
- Andrea Frank Jungbecker
- Matthias Ehrlich
- Jens-Uwe Wagner
- Tobias Wolff

Sustainable Design Experts:
- Glenn Katz
- Afaan Naqvi