Site Conditions

University building in Weimar, Germany
Flooding Challenge

detailed terrain profile and different water levels

Normal water level  
33 year flood  
100 year flood
Big Idea: **Transparency**

Showing interior processes and actions

Inspiration: **Bauhaus**

University Building in Dessau by Walter Gropius, 1919

- innovation
- **visual communication**
- **no barriers** between students and profs
- functionality / simplicity

**Our goals:**
- NO: naive copy of the building
- YES: use the way of thinking
3D views

South view
West facade
North-South through cantilevered auditorium

West-East through atrium (verticular circulation) and auditorium
# Loading Considerations

## Gravity Loads

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Load (psf)</th>
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<tbody>
<tr>
<td>MEP</td>
<td>5</td>
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<tr>
<td>Cladding</td>
<td>20</td>
</tr>
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<td>Self-Weigh</td>
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## Live Loads

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<td>Green Roof</td>
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<td>Classroom</td>
<td>50</td>
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<td>Office</td>
<td>50</td>
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<td>Auditorium</td>
<td>60</td>
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<td>Laboratory Room</td>
<td>100</td>
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<td>Corridor</td>
<td>100</td>
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<td>Storage</td>
<td>120</td>
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<td>Partitions</td>
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## Lateral Loads

- Average wind load = 12 mph
- Design wind load = 60 mph
- Solution = Lateral Braces & Shear Walls
Soil Considerations

High Water Table

Bearing capacity 8000 psf

Excavation needed
Structural Steel

**L-Shaped**

**Typical Member Sizes**

- Beam: W16 x 67
- Girder: W18 x 71
- Column: W12 x 40

**Composite Floor System:**
3” decking + 3” LWC slab

**Lateral System:**
HSS21/2”x1/2”x1/4”

**Foundation:**
- Square Footing (8’ x 8’)
- 2 Layers of No. 9 bars @ 6” (Bottom)
- 2 Layer of No. 3 bars @ 18” (top)
Ground Floor

Typical Bay Size: 24’ x 12.5’

Max Bay Size: 29’ x 29’
Structural Steel Transparency

Third & Roof Floor

- 24'
- 24'
- 10'
- 16'
- 8'
- 14.5'
- 29'

Dimensions:
- 17' 29' 29'
- 36'
- 24'
- 14.5'
- 8'

Structural Steel Model
Reinforced Concrete Transparency

Typical Member

Floor: 5"
Column: 14"
Beam: 14” x 20”
Girder: 12” x 20”
Shear Wall: 10” x 6’
Foundation: 10’
Square Spread
**Reinforced Concrete Transparency**

**Grid Layout**

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<th>22'</th>
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**Largest Bay Size**

29’ x 22’
Reinforced Concrete

First Floor

- Column
- Beam
- Girder
- Bearing Walls

Cantilever: 24” x 50”
Reinforced Concrete Transparency

Second Floor

- Column
- Beam
- Girder
- Bearing Walls

Auditorium Span: 50’ Long 18”x32” Beams every 10’
Wind Load

- Diaphragm Action
- Shear Walls Carry Load
Reinforced Concrete

Cantilever Load Path

- Large Moment Reaction
- Requires beam 24”x50”
- 13 #10 bars
- Wall at 50” long has tension component of 700 kips.

Diagram:
- Wall length 50”
- Load path extending 23’
- Arrows indicating load directions
## Structural Comparison

<table>
<thead>
<tr>
<th>System</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>RC</td>
<td>Lightweight, Shorter Depth</td>
<td>Expensive</td>
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<tr>
<td>SS</td>
<td>Cheap, Thermal Mass</td>
<td>Schedule, Larger members</td>
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**Slab**
- **RC Depth:** 20"
- **SS Depth:** 18"

**Floor to ceiling:** 13’6”

**MEP:** 24”
Site Layout

- Offices
- Trailers
- Toilets
- Storage container (tools)

Storage:
- Storage: 4000 SF
- Earth: 2300 SF

Recycling

Signs (stop, warnings)

25 Parking lots (4000 SF)
Site Layout  Transparency

Normal Water Level

3.7 tons (8.15 lbs) at 150 FT
Site Layout  Transparency

33 Year Flood
Second Big Idea  Inspiration

Historical buildings

Features
- Symmetry
- Simple mass
  - Detail

Harmony and Proportions
- Function
- Structure
  - Form
Big Idea: ReUse

How do we understand it?

- reusing the **historical style**
  (composition)

- reusing **old materials**
  (from existing building – sustainability)

- reusing the **water**
  (gathering rain water)

- “reusing” **sunlight**
  -(ex. light shelves)

- reusing **rooms**
  (flexibility of spaces)
Building Mass

**General Idea**

Formal goals:
- symmetry in plan
- axes
- atrium – focal core area
- historical facade feeling

Modularity in plan
(reuse of “ad quadratum” idea)

- view to the river and parc
- cantilevered auditorium
- modern structure
Façade Explorations

Start:
Historical building...

..use symmetry!
..boring...
..too monumental...
..no more symmetry!
..make it modern!

..play with it!
..no more symmetry!
..look for inspirations!
..messy...
..put it together!
..go back to symmetry!
Final: decision
3D Views
Sections ReUse

N-S, through entrance bridge and auditorium cantilevering over the river

W-E, through atrium core (vertical circulation)
The Signature Spiral ReUse

Core area
Structural Steel ReUse

Square Shape – Steel frame

Foundation:
  Square Footing (10’ x 10’)
  2 Layers of No. 9 bars @ 6” (Bottom)
  2 Layer of No. 3 bars @ 18”(top)

Typical Member Sizes

Beam: W14x30
Girder: W16x77
Column: W14x61

Composite Floor System:
  3” deck + 3.5” LWC Slab

Lateral System:
  HSS2”x2”x1/4”
Ground Floor

Structural Steel ReUse

44'
50'
44'
50' 63'

LARGE CLASSROOM
SMALL CLASSROOM
Cafe Backroom
Cafeteria
Stairs
ReUse

See floor plan for details.
Structural Steel ReUse

Second Floor

Max Bay Size: 50’ x 19’

Typical Bay Size: 19’ x 25’
Typical Bay Size: 19’ x 19’

Max Bay Size: 50’ x 25’ (sloped)
Structural Alternative Reuse

Roof Floor

Typical Bay Size: 19’ x 25’

Max Bay Size: 50’ x 25’
Structural Steel ReUse

Staircase Solution (NS X-section)

Floating Staircase
Structural Steel ReUse

Cantilever Auditorium Solution (EW X-section)
Reinforced Concrete ReUse

**Typical Member**
- Floor: 6"
- Column: 18"
- Beam: 16” x 25”
- Girder: 10” x 25”
- Shear Wall: 10” x 6’
- Foundation: 10’
- Square Spread
Reinforced Concrete ReUse

Grid Layout

Largest Bay Size
25’ x 33’
Reinforced Concrete ReUse

First Floor

- Column
- Beam
- Girder
- Bearing Walls

Dimensions:
- 33' x 33' x 33' x 37.5'

Rooms:
- Cafeteria
- Hall
- Atrium
- Small Classrooms
- Corridor
- Stairs

Areas:
- Cafeteria: 460.55 sq ft
- Hall: 255.83 sq ft
- Atrium: 445.45 sq ft
- Small Classrooms: 209.06 sq ft
- Corridor: 152.05 sq ft
- Stairs: 247.74 sq ft

Floor Plan:
-布局图展示了房间和走廊的分布，标注了尺寸和面积。
Structural System

Third Floor

- Column
- Beam
- Girder
- Bearing Walls
Structural System

Cantilever Load Path

- Large Moment Reaction
- Requires beam 24”x68”
- 14 #10 bars
- Wall at 68” long has tension component of 966 kips.
Reinforced Concrete ReUse

Overturning Moment

Check Under Most Extreme Case

Wind

Weight

\[\Sigma M\]

Bouyant Force
Reinforced Concrete ReUse

Comparison

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<tr>
<th>Slab</th>
<th>RC Depth: 25&quot;</th>
<th>SS Depth: 16&quot;</th>
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</thead>
<tbody>
<tr>
<td>System</td>
<td>Advantages</td>
<td>Disadvantages</td>
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<td>Lightweight,</td>
<td>Expensive</td>
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<td>Shorter Depth,</td>
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<td>Balance</td>
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<tr>
<td></td>
<td>Cantilevers</td>
<td></td>
</tr>
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<td>Cheap, Historic</td>
<td>Schedule, Difficult</td>
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<td></td>
<td>Material</td>
<td>Cantilever</td>
</tr>
</tbody>
</table>

Floor to ceiling: 13’6”

MEP: 24”
Site Layout  Concrete Option - ReUse

- Offices
- Trailers
- Toilets
- Storage container (tools)

Storage:
- Rebar: 1400 SF
- Formwork: 2200 SF
- Earth: 2300 SF

Recycling

25 Parking lots (4000 SF)

Signs (stop, warnings)
Normal Water Level

1.7 tons (3.7 lbs) at 180 FT
Site Layout  Concrete Option - ReUse

33 Year Flood
Site Layout  Steel Option - ReUse

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

- Offices
- Trailers
- Toilets
- Storage container (tools)
- Recycling

- 25 Parking lots (5000 SF)
Site Layout  Steel Option - ReUse

Normal Water Level

3.7 tons (8.15 lbs) at 150 FT

Movement of Mobile-crane for the heaviest lift
Site Layout  Steel Option - ReUse

33 Year Flood
General Issues

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

Distances:
- 2 MILES
- 300 FT
- 4 MILES
- 15 MILES
- 2,5 MILES
- 2 MILES
- 2 MILES
- 2 MILES
- 2 MILES
- 2 MILES
Concrete: 263 days

Steel: 252 days
Equipment

- **Alternative fuels**: Biodiesel, Dimethyletheris (DME): close to CO2 neutral
- **95% of the machine recyclable**
- **Reduced external sound levels**
- **Rental**: 2 miles from site
- **1 excavator, 1 Mini excavator, 2 Dumpers**

Transport: 15 miles
Excavation: 90 000 CF
Duration of task: 10 days

**Mobile crane**: Liebherr LTM 1160 5.1
  - Capacity at 180 ft: 1.7 tons – Concrete
  - Capacity at 150 ft: 3.7 tons – Steel
  - Heaviest lift: steel structure: 2.8 tons

**Concrete pump**: Radius 35 FT

**Pilling rig**
Cost Estimates

Methods

• Four different methods
  – RSMeans SQFE-Estimator
  – German SQFE-Estimator
  – Own Calculations with RSMeans as base
  – Reference Project
Cost Estimates

RSMeans SQFE
*(Based on basic constructions)*
- Building Type
- Story Count
- Story Height
- Floor Area
- Perimeter

German SQFE
*(Based on 13 universities with advanced laboratory facilities)*
- Site Total
- Gross Floor Space
- Outside Area
- Excavation
- Footprint
- Exterior Walls
- Interior Walls
- Ceiling
- Roof
Cost Estimates

- Project Name: ArrheniusLaboratoriet
- Building Type: School Building
- Location: Stockholm, Sweden
- Floor Area: 27,000 SF
- Cost: $6,150,000
- Cost/SF: $228
- Similar Building Program
## Cost Estimates

### Result Data

<table>
<thead>
<tr>
<th></th>
<th>Transparency</th>
<th>ReUse</th>
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<tr>
<td><strong>RSMeans SQFE</strong></td>
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<tr>
<td>Concrete</td>
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<td>($179/SF)</td>
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<tr>
<td>Steel</td>
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<td>($185/SF)</td>
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<td><strong>German SQFE</strong></td>
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Cost Estimates

Transparency
Concrete: $6,767,000 ($214/SF)
Steel: $6,930,000 ($219/SF)

ReUse
Concrete: $6,677,000 ($200/SF)
Steel: $6,858,000 ($206/SF)

Calculations

- Substructure
- Shell
- Interiors
- Services
- Sitework
- Indirect Costs
Cost Estimates

Inflation Data

- Construction Costs
- Inflation

- Graph showing the comparison between construction costs and inflation from 2005 to 2009.
Cost Estimates - Inflation Forecast

Construction Costs
Inflation
Inflation forecast
Construction Forecast

Construction Methods

- Cast-in-place concrete (prefab auditorium roof)
- Similar beam sizes
- No building components greater than 50’
- Just in time delivery
## Risk Items

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<th>Risk Category</th>
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**Flooding Strategy**

- **Strategy for „Transparent“**
- **Strategy for „ReUse“**
Flooding Strategy

“Let it in”

Reduced damages

Arrangement of rooms and facilities

easy to clean

Action plan for tenant

Present value of future payments: $25,000

“Keep it out”

Impermeable bowl

Bowl of water impermeable concrete

Windows above flood level

No doors in first floor

Present value of future payments: $15,000
Flooding Integration

Architect:
Placing windows

Construction Managers:
Site layout

LCFM:
Repair costs
Sustainability

Focus on water reuse and geothermal energy
No focus on photovoltaic

Precipitation

Soil conditions
Geothermal

Excellent site conditions for geothermal system, heat transfer in moist soil

Geothermal cages around pile foundation

Minimal ground disturbance

no extra boreholes
Combination underfloor and ceiling air distribution

LEVEL 1: Ceiling Distribution

LEVEL 2: Underfloor distribution

LEVEL 3: Underfloor Distribution
Radiant heating: tubing embedded in concrete slab will be safe from flooding
Minimal mechanical ventilation in offices and classrooms
Underfloor distribution for auditorium
Water Reuse

Pretreatment system for greywater
Rainwater directly to storage tank

- Rain Water
- Ground Water
- Watering
- Drinking Water
- Sinks
- Toilets
- Waterless urinals
- Storage
- Grey water
- Service Water
- Excrement
- Urine

Agricultural use

External Reactor

Service Water

Grey water

Urine storage

Urine

Drinking Water
• Minimal site disturbance and filters for runoff during construction
• Reuse of existing building materials for façade and interior
• Efficient HVAC systems and heat recovery
• Graywater reuse/rainwater harvesting
• On site renewables: geothermal
• Maximum daylight and natural ventilation strategies
• Maximum occupant comfort and safety:
  – Low VOC materials, occupant control of windows and task lighting,
• Measurement and verification strategies
  – Flexible systems like underfloor allow for reconfiguration according to performance evaluations

Building Program

The graph shows the square footage (sqft) for different spaces in a building program, categorized by three different criteria: owner wanted, transparency, and reuse. The spaces include Faculty Office, Auditorium, Small Classroom, Instructional Labs, Large Classroom, Student Office, Lounge, Storage, Admin, Seminar Rooms, Server, and Technical Support. Each category is represented by a different color: blue for owner wanted, red for transparency, and green for reuse.
## Life Cycle Benchmarks

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Transparency</th>
<th>Reuse</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>non assignable area / assignable area</td>
<td>0.421</td>
<td>0.403</td>
<td>minimize</td>
</tr>
<tr>
<td>circulation area / usable area</td>
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<td>0.229</td>
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<tr>
<td>building surface / building volume</td>
<td>0.099</td>
<td>0.093</td>
<td>minimize</td>
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</table>
River Team Communication, Collaboration, Cooperation

Team meeting

Google Wave

Time zone optimization

Zero wait

Documentation
Communication Wave

1200 messages in 64 Waves

Mainly discipline Waves

Gadgets to expand functional range
Excavating is so expensive!

There will be a flood every 5th year!

Avoid long spans!

HVAC system will cost us 3 feet in floor to ceiling height!

“Boring Box”
Cooperation Integration

"Def Design"

A

C

E

S

LCFM
## Decision Matrix

<table>
<thead>
<tr>
<th>aspect</th>
<th>TRANSPARENCY</th>
<th></th>
<th>REUSE</th>
<th></th>
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<tr>
<td></td>
<td>concrete</td>
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<td>Program fulfill</td>
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<td>Response to the context</td>
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<td>Floor to ceiling height</td>
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<td>Construction costs</td>
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<td>Sustainability</td>
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<td>Future design potentials</td>
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</table>

**Rating:** 1 low - 5 high

| sum | 49 | 54 | 62 | 68 |


River Team Presents

ReUse