UCLA Engineering School

TEAM CENTRAL 2009

Eric Kneer (Owner)

Anja Jutraz (Architect, Slovenia)

Ena Tobin (MEP, Ireland)

Pinar Okumus (Structural, USA - Madison)

Jonathan Glassman (Structural, USA - Stanford)

Tobias Wolff (LFCM, Germany)

Andres Beijer Lundberg (CM, Sweden)

Prashant Sharma (CM, USA, Stanford)
The TEAM

Jonathan
E
Stanford
University

Anders
CM
KTH

Pinar
CM
UW Madison

Anja
A
University of Ljubljana

Prashant
CM
Stanford University

Tobi
LCFM
Bauhaus University

Ena
MEP
University College Cork
TEAM CENTRAL: PROJECT STRUCTURE

- Public
- University
- Private
- Owner/Investors
- Project Team
- Contractors
- User/students
- Bank

PARTNERSHIP
LOCATION
LOCAL WEATHER

Summer Temperature
- Avg. Max: 85 F
- Avg. Min: 61 F

Winter Temperature
- Avg. Max: 68 F
- Avg. Min: 48 F
LOCAL - WEATHER

- Rainfall
  Summer: 1.75 inch, Winter: 13.04 inch
- Wind Speed
  Avg. Max. : 8.5 MpH
  Avg. Min. : 6.2 MpH
- Max Humidity
  Summer: 86% (morning)
  Winter: 68% (morning)
- Avg. morning humidity: 79%
- Avg. afternoon humidity: 65%
SURROUNDING

OUR SITE
PARKING GARAGE

OUR SITE

PARKING GARAGE
PHOTOS - courtyard
BIG IDEA 1 - NATURE

...bringing daylight in the building - PATIOS

...connecting outside and inside greener space
BIG IDEA 2 – TWO HANDS

2 GROUPS OF PEOPLE
2 PROGRAMS
need/wish to be alone & together

STUDENTS
VISITORS - AUDITORIUM
FACULTY

PRIVATE
PUBLIC
PUBLIC
PUBLIC
CONCEPT OF ATRIUMS
PARKS IN UCLA
Service access – through the parking garage
LANDSCAPING AND SURROUNDING

PARKING GARAGE

Trees for shading

Outside auditorium (stairs&slope)
ORIENTATION - SUN

Sunlight

Sunset

Sunrise
MAIN ENTRANCE – 2nd storey
2nd STORY

SERVICES
- Corridors
- Mechanical Shaft
- Stairs
- Restrooms

VISITORS
- Auditorium

STUDENTS
- Small Classrooms
- Seminar Rooms
- Student Offices
- Entrance Info & Classroom Equipment
ENTRANCE HALL
3rd STORY

SERVICES
- CORRIDORS
- MECHANICAL SHAFT
- STAIRS
- RESTROOMS

STUDENTS
- LARGE CLASSROOMS

FACULTY
- FACULTY OFFICES
- ADMINISTRATIVE ASSISTANTS
- DEPARTMENT CHAIR'S OFFICE
- SENIOR ADMINISTRATION OFFICE
- FACULTY LOUNGE
INSIDE PATIO
**FLOOR AREAS**

Gross floor area

36,100

Net usable area

25,270

Net assignable area

17,942

Auditorium

2,498

Labs

2,355

Classrooms

6,001

Lounge

1,148

Offices

5,940

Structural area

Non assignable area

7,328

Assignable area

10,830
ROOF

- Green roof
- Solar cells
- Open space
- Wood
- Glass

Diagram showing the components of a green roof system with solar cells.
SECTION a-a

- DAYLIGHT
- Green roof

Inside patio
Outside patio

INSIDE PATIO
SERVICES
CORRIDORS
STORAGE
VISITORS
AUDITORIUM
STUDENTS
INSTRUCTIONAL LABS
LARGE CLASSROOMS
STUDENT OFFICES
FACULTY
FACULTY OFFICES
SECTION b-b

Inside garden  Entrance lobby  Main entrance
ORIENTATION AND SHADING

- MAINTAIN THE VIEWS

W

E
ORIENTATION AND SHADING

- TREES

- OUTSIDE METAL SHADING ELEMENTS

- INSIDE TEXTILE SHADING ELEMENTS

Different programs → different colours

For different projections on the textile
FACADE

1. CONCRETE
2 & 3. GLASS / INOX (to reflect the surrounding)
Lacaton & Vassal: “...floor-to-ceiling glazing, which grants the inhabitants of the apartment for the first time the advantages of the high rise, namely living spaces flooded with daylight and featuring panorama vistas on the surrounding landscape.”
EXPERIENCE IN THE BUILDING

Inside patio

Studying, relaxing

Orestad – Denmark - Gimnasium
INSIDE PATIO – studying, relaxing
COURTYARD ON EAST
NIGHT VIEW

CENTRAL SCHOOL OF ENGINEERING
**Live Loads: (psf)**
- Classrooms: 40
- Offices: 50
- Corridors: 100
- Auditorium: 100
- Roof (green): 100

**Earthquake:**
- Design Category: D
- Occupancy Category: III
- Importance Factor: 1.25
- $S_{DS}$: 1.225
- $S_{D1}$: 0.626

**Wind:**
- Wind Speed: <85mph
- Building Class: III
- Exposure: B

**Soil:**
- Type: Sandy soil
- Bearing pressure: 5000 psf
- Water depth: 15 ft
- Liquefaction: No
COLUMN LAYOUT

First Floor:

- 4 ft cantilever
- Columns closer to shear core
COLUMN LAYOUT

Second Floor:

- Columns
- Rotating Shear Walls
COLUMN LAYOUT

Third Floor:

- Columns
- Rotating Shear Walls
Composite deck:
- W 21 x 50
- W 14 x 26
- W 10 x 19
TYPICAL MEMBERS – GIRDERS & COLUMNS

Girders: W 18 x 46
Columns: W 14 x 43
CANTILEVERS

Cantilevers:
- Balanced
- Symmetrical
Cantilever Design

DL Weight of One Cantilever
507 kips

From SAP Analysis:

Max. Axial Force = 313 kips
Max. Shear Force = 60 kips
Max. Moment = 756 kip-ft
Cantilever Connection

PL 14.1 x 12.6 x 3/4

W14x99

14.1”

12.6”
Cantilever Connection

PL 14.1 x 12.6 x 3/4

W14x99

W14x99

W21x68

W21x68

1/4

1/8

1/8

1/4

14.1”

12.6”
Bearing Capacity: 5 ksf
Sandy Soil
No Liquefaction

\[ k_s = 300 \text{ k/ft}^3 \]
Less than \( \frac{1}{2} \)” max settlement

#6 @ 4” b/w columns
#6 @ 12” midspan

24 in
LATERAL LOAD RESISTING SYSTEM

Rotating Walls around the auditorium

Acknowledgment: GPLA and STANFORD UNIVERSITY
Distribution of Story Shear Forces

- 670 kips on the Roof
- 447 kips on the 3rd Floor
- 223 kips on the 2nd Floor
- 1340 kips at the base
Diaphragm Selection

Story shear/foot

- Roof: 2939 lbs/ft
- 3rd Floor: 1961 lbs/ft
- 2nd Floor: 978 lbs/ft

Maximum Diaphragm Shear/foot

- Roof: 2939 lbs/ft
- 3rd Floor: 1961 lbs/ft
- 2nd Floor: 978 lbs/ft

Type 16 – 36/4 with:

- 6’ joist spacing
- 5/8” puddle weld support fasteners
- Welded sidelap fasteners: 10 for roof, 2 for 2nd and 3rd floors
Cantilever Loads to Diaphragm

Axial Force: 313 kips

→ 3/4” x 2”
→ 2 studs/section
→ 12” o/c

→ ¾” x 2”
→ 2 studs/section
→ 10” o/c
SHEAR WALLS

- Confined Zone: #4 @ 5"
- Vertical bars: #4 @ 4"
- Horizontal bars: #4 @ 5"

- 114 k
- 76 k
- 38 k
- 228 k

Dimensions:
- ~13'
- 39'
- 12''

- 24''
**SHEAR WALL / COLUMN CONNECTION**

- Shear Capacity = 114 k
- 13 ft
- 114 k
- 76 k
- 38 k
- W 14 x 43 Columns
- 12” Walls
- Shear Slit Plates

**Acknowledgment:** GPLA and STANFORD UNIVERSITY
INTERSTORY DRIFT

\[ \Delta = .05\% \]
\[ \Delta = .07\% \]
\[ \Delta = .05\% \]

Acknowledgment: GPLA and STANFORD UNIVERSITY
WINTER SYSTEM REVISITED

Cooling System:
(44F/4C chilled water from CHP plant)
**Dew point cooling humidity control**

Heating System
*CHP plant* (43MW of heating)

Under Floor air diffusers
Concentrated along exterior of the room

Chilled beams – passive
Of various lengths and widths
Of constant height = 147mm
Spanning parallel to beams
WINTER SYSTEM LAYOUT

SOLAR GAIN VALUES

<table>
<thead>
<tr>
<th></th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>10</td>
</tr>
<tr>
<td>South</td>
<td>29.8</td>
</tr>
<tr>
<td>East</td>
<td>52.05</td>
</tr>
<tr>
<td>West</td>
<td>49.8818</td>
</tr>
</tbody>
</table>

ALL AIR

CHILLED BEAMS
**Energy Simulations**

### Solar Gain Values kW

<table>
<thead>
<tr>
<th>Façade</th>
<th>Façade</th>
<th>No Façade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinds Fully Open</td>
<td>Blinds Fully Closed</td>
<td>Double Glazed</td>
</tr>
<tr>
<td>37.29</td>
<td>4.1898</td>
<td>82.8</td>
</tr>
</tbody>
</table>

**Cooling Load - No Façade**

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>Classrooms/Hallways</td>
</tr>
<tr>
<td>811.9 kW</td>
<td>543.0 kW</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1354.9 kW</strong></td>
</tr>
</tbody>
</table>

**Cooling Load - With Shades Fully Closed**

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>Classrooms/Hallways</td>
</tr>
<tr>
<td>567.3 kW</td>
<td>526.8 kW</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1094.2 kW</strong></td>
</tr>
</tbody>
</table>

**Cooling Load - With Shades Fully Open**

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>Classrooms/Hallways</td>
</tr>
<tr>
<td>573.2 kW</td>
<td>531.6 kW</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1104.8 kW</strong></td>
</tr>
</tbody>
</table>

Ducts sizes up to 1.7m
# ENERGY SIMULATION FOR CALCULATIONS

## Cooling Load - With Blinds Fully Open

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>East Side of Building (mainly offices)</td>
<td>170.7</td>
</tr>
<tr>
<td>2</td>
<td>West Side of Building (small classrooms, offices)</td>
<td>240.1</td>
</tr>
<tr>
<td>3</td>
<td>Center/North/South (auditorium/Corridors/Common space)</td>
<td>722.8</td>
</tr>
</tbody>
</table>

Total Cooling Load: 1133.6 kW
Cooling System:
(44F/4C chilled water from CHP plant) Dew point cooling humidity control

Heating System
CHP plant (43MW of heating)

Method of Delivery

• Under Floor Air diffusion for the Auditorium and Large Classrooms.

• All other spaces have Ceiling diffusers

Zones

Zone 1:
East

Zone 2:
West

Zone 3:
Zone 3A – Center
Zone 3B – North and South
### PLANT ROOM DETAILS

#### 3 AHU Units:

<table>
<thead>
<tr>
<th>Zone 1:</th>
<th>East</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AHU Dimensions</strong></td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>1120 mm</td>
</tr>
<tr>
<td>Height</td>
<td>1120 mm</td>
</tr>
<tr>
<td>Length</td>
<td>4030 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>570 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone 2:</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AHU Dimensions</strong></td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>1420 mm</td>
</tr>
<tr>
<td>Height</td>
<td>1420 mm</td>
</tr>
<tr>
<td>Length</td>
<td>4330 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>780 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone 3:</th>
<th>Center/North/South</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AHU Dimensions</strong></td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>2170 mm</td>
</tr>
<tr>
<td>Height</td>
<td>2540 mm</td>
</tr>
<tr>
<td>Length</td>
<td>5530 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>1650 kg</td>
</tr>
</tbody>
</table>

#### AHU Components

- **A** Fan (Return Air)
- **B** Mixing Box
- **C** Filter
- **D** Cooling Coil
- **E** Reheating Coil
- **F** Fan (Supply Air)
PLANT ROOM LAYOUT DIAGRAM

- Supply Duct – Zone 3
- Electrical Controls
- Supply Duct – Zone 1
- Fresh Air Ducts
- Supply Duct – Zone 2
### Plant Room Ducts

<table>
<thead>
<tr>
<th>Plant Room Ducts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Velocity</strong></td>
<td>10</td>
</tr>
<tr>
<td>Air Supply</td>
<td>l/s</td>
</tr>
<tr>
<td>Zone 1</td>
<td>7111.7</td>
</tr>
<tr>
<td>Zone 2</td>
<td>9304.9</td>
</tr>
<tr>
<td>Zone 3</td>
<td>23621.2</td>
</tr>
</tbody>
</table>

### Supply Ducts

<table>
<thead>
<tr>
<th>Supply Ducts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Velocity</strong></td>
<td>6</td>
</tr>
<tr>
<td>Air Supply</td>
<td>l/s</td>
</tr>
<tr>
<td>Zone 1</td>
<td>-</td>
</tr>
<tr>
<td>Floor 00</td>
<td>-</td>
</tr>
<tr>
<td>Floor 01</td>
<td>4481</td>
</tr>
<tr>
<td>Floor 02</td>
<td>2630</td>
</tr>
<tr>
<td>Zone 2</td>
<td>-</td>
</tr>
<tr>
<td>Floor 00</td>
<td>2140</td>
</tr>
<tr>
<td>Floor 01</td>
<td>5010</td>
</tr>
<tr>
<td>Floor 02</td>
<td>2150</td>
</tr>
<tr>
<td>Zone 3A</td>
<td>-</td>
</tr>
<tr>
<td>Floor 00</td>
<td>7140</td>
</tr>
<tr>
<td>Floor 01</td>
<td>2110</td>
</tr>
<tr>
<td>Floor 02</td>
<td>4770</td>
</tr>
<tr>
<td>Zone 3B</td>
<td>-</td>
</tr>
<tr>
<td>Floor 00</td>
<td>950</td>
</tr>
<tr>
<td>Floor 01</td>
<td>6060</td>
</tr>
<tr>
<td>Floor 02</td>
<td>2600</td>
</tr>
</tbody>
</table>

**Maximum Duct Size in Plant Room**: 5.58 ft (1700 mm)

**Maximum Duct Size in Mech. Shaft**: 3.94 ft (1200 mm)
Smaller Beams in Corridor allow for larger duct sizes

### Duct Sizing Details

#### Supply Ducts - Zone 1

<table>
<thead>
<tr>
<th>Velocity</th>
<th>m/s</th>
<th>Air Supply</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor 01</td>
<td></td>
<td>Se</td>
<td>1907</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>510</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>551</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>528</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NE</td>
<td>985</td>
</tr>
</tbody>
</table>

#### Supply Ducts - Zone 2

<table>
<thead>
<tr>
<th>Velocity</th>
<th>m/s</th>
<th>Air Supply</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor 00</td>
<td></td>
<td>Small CR N</td>
<td>1018</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tech Room</td>
<td>88.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small CR S</td>
<td>1037</td>
</tr>
<tr>
<td>Floor 01</td>
<td></td>
<td>bW</td>
<td>530</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cW</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dW</td>
<td>519</td>
</tr>
<tr>
<td></td>
<td></td>
<td>eW</td>
<td>336</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SW</td>
<td>1434</td>
</tr>
<tr>
<td></td>
<td></td>
<td>aNW</td>
<td>1291</td>
</tr>
<tr>
<td>Floor 02</td>
<td></td>
<td>aNW</td>
<td>667</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bW</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cW</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dW</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td></td>
<td>eW</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fW</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td></td>
<td>gW</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hW</td>
<td>111.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iW</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iSW</td>
<td>556</td>
</tr>
</tbody>
</table>

#### Supply Ducts - Zone 3A

<table>
<thead>
<tr>
<th>Velocity</th>
<th>m/s</th>
<th>Air Supply</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor 00</td>
<td></td>
<td>Corridors</td>
<td>1145</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auditorium</td>
<td>5435</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bathroom</td>
<td>124</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Server Room</td>
<td>434</td>
</tr>
<tr>
<td>Floor 01</td>
<td></td>
<td>Corridors</td>
<td>2113</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corridors</td>
<td>2021</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Large Classrooms</td>
<td>2745</td>
</tr>
</tbody>
</table>
DUCT LAYOUT DIAGRAM
CRANE DURING DIFFERENT PHASES

Wheel mounted Hydraulic
Grove RT535E

piping)
CRANE REACH
# STANDARD vs PREFABRICATION

<table>
<thead>
<tr>
<th>Standard</th>
<th>Prefabrication</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Design</td>
<td>• innovative</td>
</tr>
<tr>
<td>• Construction</td>
<td>• Faster</td>
</tr>
<tr>
<td>• Subcontractors</td>
<td>• Efficient</td>
</tr>
<tr>
<td>• Small project</td>
<td>• Less waste</td>
</tr>
<tr>
<td>• Normal difficulties</td>
<td>• Adjusted conditions</td>
</tr>
<tr>
<td>• Cantilever problem</td>
<td>• Earlier move-in</td>
</tr>
<tr>
<td>• Future changes</td>
<td>• Replacebility</td>
</tr>
</tbody>
</table>
Critical construction zone 1: AUDITORIUM
Critical construction zone 2: MECHANICAL ROOM
Critical construction zone 3: ROOF
LEED - Rating

- Conservative estimate
- Later adjustments
- Owners needs
- Realistic estimates
- Need for greater detail

37 / 69 credits
LEED - rating

Sustainable sites
hit: 10
miss: 4

Water efficiency
hit: 2
miss: 5

Energy & atmosphere
hit: 7
miss: 17

Materials & resources
hit: 4
miss: 13

Indoor air quality
hit: 11
miss: 15

Innovation & design
hit: 8
miss: 5
RECYCLING PHASES
RECYCLING PHASES

- Excavation phase
- Structural phase
- Main construction phase
- Carpentry phase
- Finishing phase
- Move-in phase
RECYCLING ON-SITE

- Different zones - different phases
- Metal - recycling
- Non-metal - recycling
- Transports – depending on phase
- Choosing material deliverers
- Small-scale storage
- No unnecessary transports
COST ESTIMATE

- UNIFORMAT
  - Phase to detailed components

- Masterformat
  - RS Means
  - Sage Timberline

- Material
  - wheel mounted Hydraulic crane
# COST ESTIMATE SUMMARY

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 2 Cost</th>
<th>Percent</th>
<th>Level 1 Cost</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substructure</td>
<td>EXCAVATION</td>
<td>326479</td>
<td>6.1</td>
<td>371283</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>FOUNDATION</td>
<td>44804</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shell</td>
<td>SUPERSTRUCTURE</td>
<td>881922</td>
<td>16.6</td>
<td>2431240</td>
<td>45.6</td>
</tr>
<tr>
<td></td>
<td>EXTERIOR CLOSURE</td>
<td>1549318</td>
<td>29.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interiors</td>
<td>INTERIOR CONSTRUCTION</td>
<td>107552</td>
<td>2.0</td>
<td>399164</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>STAIRS</td>
<td>112042</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>INTERIOR FINISHES</td>
<td>179571</td>
<td>3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services (MEP)</td>
<td>CONVEYING SYSTEM</td>
<td>134565</td>
<td>2.5</td>
<td>1357264</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td>PLUMBING</td>
<td>201399</td>
<td>3.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HVAC</td>
<td>423317</td>
<td>7.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fire Protection</td>
<td>196267</td>
<td>3.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ELECTRICAL</td>
<td>401717</td>
<td>7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment &amp;</td>
<td>EQUIPMENT</td>
<td>12560</td>
<td>0.2</td>
<td>297560</td>
<td>5.6</td>
</tr>
<tr>
<td>Furnishing</td>
<td>FURNISHING</td>
<td>285000</td>
<td>5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spl Const</td>
<td>SPECIAL CONSTRUCTION</td>
<td>152000</td>
<td>2.9</td>
<td>152000</td>
<td>2.9</td>
</tr>
<tr>
<td>Site Prep</td>
<td>SITEWORK</td>
<td>320000</td>
<td>6.0</td>
<td>320000</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td></td>
<td><strong>5328512</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INDIRECT COST</strong></td>
<td></td>
<td><strong>1939578</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td><strong>7268090</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
COST SPECIFIC DECISIONS

- **Elevators**
  - machine room less

- **Emergency dewatering**
  - Until foundation & walls are waterproofed

- **Glass Facade**
  - finally single glazed

- **Photos Voltaic**
  - 2800 sq Ft, 16.8 KW

- **Green roof**
  - $ 20 /sf
4 D AND COORDINATION MEETING
## Cash Flow Modelling

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2028</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>$76,079</td>
<td>$87,402</td>
<td>$96,081</td>
</tr>
<tr>
<td>Financial costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity 10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debt 90%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior loan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly loans pay back</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearly loans pay back</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly rent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life cycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated rental fee per month</td>
<td>$64,232</td>
<td>$64,759</td>
<td>$65,301</td>
</tr>
<tr>
<td>Risk charge</td>
<td>$31,844</td>
<td>$31,844</td>
<td>$31,844</td>
</tr>
<tr>
<td>Profit charge</td>
<td>$110,312</td>
<td>$113,600</td>
<td>$116,985</td>
</tr>
<tr>
<td>Real rental fee per year</td>
<td>$912,946</td>
<td>$922,551</td>
<td>$932,439</td>
</tr>
<tr>
<td>Real rental fee per month</td>
<td>$76,079</td>
<td>$76,879</td>
<td>$77,703</td>
</tr>
</tbody>
</table>
## Main cost drivers

<table>
<thead>
<tr>
<th>year</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Construction costs</strong></td>
<td>$7,268,090</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td><strong>financial costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>equity 10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>debt 90%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>senior loan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>debt</td>
<td>$7,129,996</td>
<td>$6,914,367</td>
<td>$6,687,956</td>
<td>$6,450,224</td>
<td>$6,200,606</td>
</tr>
<tr>
<td>interests</td>
<td>$356,500</td>
<td>$345,718</td>
<td>$334,398</td>
<td>$322,511</td>
<td></td>
</tr>
<tr>
<td>monthly loans pay back</td>
<td>$47,677</td>
<td>$47,677</td>
<td>$47,677</td>
<td>$47,677</td>
<td>$47,677</td>
</tr>
<tr>
<td>yearly loans pay back</td>
<td>-$572,129</td>
<td>-$572,129</td>
<td>-$572,129</td>
<td>-$572,129</td>
<td></td>
</tr>
<tr>
<td>monthly rental fee</td>
<td>$64,232</td>
<td>$64,759</td>
<td>$65,301</td>
<td>$65,858</td>
<td></td>
</tr>
<tr>
<td><strong>Life cycle costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>per month</td>
<td>-$14,833</td>
<td>-$15,673</td>
<td>-$16,534</td>
<td>-$17,416</td>
<td></td>
</tr>
<tr>
<td>Service costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>per month</td>
<td>-$113,302</td>
<td>-$116,673</td>
<td>-$120,155</td>
<td>-$123,736</td>
<td></td>
</tr>
<tr>
<td>Maintenance costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>per month</td>
<td>-$4,230</td>
<td>-$4,357</td>
<td>-$4,468</td>
<td>-$4,620</td>
<td></td>
</tr>
<tr>
<td>revenues</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calculated rental fee per month</td>
<td>$64,232</td>
<td>$64,759</td>
<td>$65,301</td>
<td>$65,858</td>
<td></td>
</tr>
<tr>
<td>risk charge</td>
<td>$31,844</td>
<td>$31,844</td>
<td>$31,844</td>
<td>$31,844</td>
<td></td>
</tr>
<tr>
<td>profit charge</td>
<td>$110,312</td>
<td>$113,600</td>
<td>$116,985</td>
<td>$120,471</td>
<td></td>
</tr>
<tr>
<td>real rental fee per year</td>
<td>$912,946</td>
<td>$922,551</td>
<td>$932,439</td>
<td>$942,617</td>
<td></td>
</tr>
<tr>
<td>real rental fee per month</td>
<td>$76,079</td>
<td>$76,879</td>
<td>$77,703</td>
<td>$78,551</td>
<td></td>
</tr>
</tbody>
</table>
Life Cycle Cost development

- Service
- Operation
- Maintenance
### Detailed cost factors

#### Life cycle costs [service]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows/glass surfaces</td>
<td>$-270</td>
<td>$-278</td>
<td>$-286</td>
<td>$-295</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar panels</td>
<td>$-252</td>
<td>$-266</td>
<td>$-269</td>
<td>$-276</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Influences on LCC – Design and construction rules

**Who?** | **Costs** | **What to reduce or to improve?** | **Construction rule (and the effect)**
---|---|---|---
A | Cleaning Costs | Cleaning frequent | Pollution lock and mudflap measure avoid dirt. A protected entrance situation, areas to collect the mud from outside will help.
Implementation of construction rule
Monetary advantage of the protected entrance

on the example of cleaning costs over the life cycle

Total savings over the life cycle: $66,414
Risk allocation

Service risk allocation

Operation risk allocation

Maintenance risk allocation

Construction risk allocation
# Risk charge optimization

on the example of a structural decision

## Rotating walls

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction period</td>
<td>-$181,006</td>
</tr>
<tr>
<td>Operation period</td>
<td>-$412,367</td>
</tr>
<tr>
<td>Maintenance period</td>
<td>-$53,302</td>
</tr>
<tr>
<td>Services</td>
<td>-$149,429</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>-$796,104</strong></td>
</tr>
</tbody>
</table>

## Shear walls

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction period</td>
<td>-$171,413</td>
</tr>
<tr>
<td>Operation period</td>
<td>-$412,367</td>
</tr>
<tr>
<td>Maintenance period</td>
<td>$215,743</td>
</tr>
<tr>
<td>Services</td>
<td>-$149,429</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>-$948,952</strong></td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk charge per year</strong></td>
<td><strong>Risk charge per month</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-$31,844</td>
<td>-$2,654</td>
<td></td>
</tr>
</tbody>
</table>

**Yearly savings:** $6,114  
**Life cycle savings:** $152,850
Sensitivity analysis
SIM VISION : PERSON BACKLOG

With out Intervention

With Intervention
TEAM PROCESS

Speeches

Discussions
TEAM PROCESS – Lateral Load Resisting System

External Braces help the cantilever deflections

Zero waste!

Holes in aud.

Pure transparent facade

CM
A

E

L

MEP

A

CM

E

A

CM

L

UCLA
LESSONS LEARNED
Thank You!

Renate Fruchter
Erik Kneer
Greg Luth
Helmut Krawinklar
Nick Anderson
Adhamina Rodriguez
Andrea Frank-Jungbecker
Daniel Kuron
Henry Tooriyani
Yash Ahuiva