Winter Presentation
March 15th, 2013

Ridge Team 2013
"We are the Ridge Team, which, from now on, stands for awesome."
Ridge Team 2013

Owners: Sinan M., Anirudh R., & Maria S.

Chico, CA
Laura M. (CM)

Stanford, CA
Stephanie C. (SE)
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Puerto Rico
Pablo C. (A)
Jorge S. (A)

Denmark
Kleanthis C. (MEP)

Slovenia
Stefan M. (SE)
Project Overview
SITE UNIVERSITY OF NEVADA, RENO
Climate Challenges

- Sunshine: 3650 hr/yr
- Precipitation: 7.30 inches/yr

Average humidity: 55%

- Heating degrees: 5680 hr/yr
- Cooling degrees: 508 hr/yr
Available Resources

Available in Campus
- Natural Gas for heating and DHW
- Chilled water

Alternative sources
- Ground source heat pump for heating/cooling
- Hybrid Systems

Renewable energy potential
- Photovoltaics
- Wind turbine

Harvest Rainwater
~3.6 gal/sf/yr
1. Reduce energy consumption & use renewable energy

2. Minimize evening building usage

3. Maximize building utilization

4. Winter space temperatures: 68F
   Summer space temperatures: 78F
Big Idea

Industrial Evolution

Architecture
Structure
MEP
Construction

Technology
- Transformation
- Convergent
- Production
- Divergent

Creativity

Flexible Spaces
Rapid Prototyping Labs
Big Idea
Transparent Engineering Building (TEB)

1. Steel
2. Concrete
## Orientation

<table>
<thead>
<tr>
<th></th>
<th>Total EUI (kBtu/sf/yr)</th>
<th>Life Cycle Energy Cost ($)</th>
<th>Net CO₂ (tn/year)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>70</td>
<td>640,000</td>
<td>167</td>
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<tr>
<td>2</td>
<td>67</td>
<td>600,000</td>
<td>140</td>
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<td>3</td>
<td>68</td>
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<tr>
<td>4</td>
<td>67</td>
<td>610,000</td>
<td>144</td>
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</table>
Site/ TEB Concept
Site/ TEB Concept
Level -1 (Basement)

- Rapid Prototyping Labs
- Faculty Offices
- Auditorium
- Bathroom, cores, stairs, elevator...
- Student Offices & area
- Seminar Rooms

Emergency Exit
Entrance
Level -1 (Basement)
Level 0 (Campus Entrance)
Level 0 (Campus Entrance)
Level 1

- Small Classrooms
- Large Classrooms
- Faculty Offices
- Bathroom, cores, stairs, elevator...
- Student Offices & area
- Faculty Lounge

Architecture
Structure
MEP
Construction
Level 2

- Green: Large Classrooms
- Blue: Faculty Offices
- Tan: Bathroom, cores, stairs, elevator...
- Pink: Student Offices & area
- Gray: Faculty Lounge
Level 2
Section aa
Section cc
Dynamic Façade System

Campus Entrance / East Façade / Privacy Glass
Dynamic Façade System

West Façade - Roller Blinds

- Simple device
- Keeps out glare and UV rays
- Easy to operate

South Façade / Parking Entrance
### Load Calculation

<table>
<thead>
<tr>
<th></th>
<th>Steel</th>
<th>Concrete</th>
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<tbody>
<tr>
<td><strong>Roof Dead Load</strong></td>
<td>90 psf</td>
<td>180 psf</td>
</tr>
<tr>
<td><strong>Roof Live Load</strong></td>
<td>20 psf</td>
<td>--</td>
</tr>
<tr>
<td><strong>Roof Snow Load</strong></td>
<td>40 psf</td>
<td>--</td>
</tr>
<tr>
<td><strong>Other Floor Dead Loads</strong></td>
<td>74 psf</td>
<td>150 psf</td>
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<tr>
<td><strong>Other Floor Live Loads</strong></td>
<td>60-100 psf</td>
<td>--</td>
</tr>
<tr>
<td><strong>Wind Shear</strong></td>
<td>100 mph =&gt; 1.5 kips / foot</td>
<td>--</td>
</tr>
<tr>
<td><strong>Earthquake Shear</strong></td>
<td>Sa = 0.4g =&gt; 680 kips</td>
<td>870 k</td>
</tr>
<tr>
<td><strong>Retaining-soil Shear</strong></td>
<td>4.7 kips / foot</td>
<td>--</td>
</tr>
</tbody>
</table>

-- || -- means same load

Per International Building Code (IBC) 2006 with amendments provided by the city of Reno, Nevada
### Soil Conditions

- **Slope:** 7' - 14' above volcanic rock
- 110000 cf excavation

<table>
<thead>
<tr>
<th>Depth of Excavation</th>
<th>Soil Type</th>
<th>Thickness</th>
<th>Bearing Capacity</th>
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</thead>
<tbody>
<tr>
<td>0 inches (0 ft.)</td>
<td>Stony Sandy Loam and Heavy Loam</td>
<td>19 inches (1.58 ft.)</td>
<td>1,500 psf</td>
</tr>
<tr>
<td>19 inches (1.58 ft.)</td>
<td>Sandy Clay Loam</td>
<td>10 inches (0.83 ft.)</td>
<td>1,500 psf</td>
</tr>
<tr>
<td>29 inches (2.42 ft.)</td>
<td>Clay and Clay Loam</td>
<td>27 inches (2.25 ft.)</td>
<td>1,500 psf</td>
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<tr>
<td>56 inches (4.67 ft.)</td>
<td>Very Gravelly Sandy Loam and Very Gravelly Loam</td>
<td>28 inches (2.33 ft.)</td>
<td>5,000 psf</td>
</tr>
<tr>
<td>84 inches (7 ft.)</td>
<td>Volcanic Rock</td>
<td>Unknown</td>
<td>8,000 psf</td>
</tr>
</tbody>
</table>

*Figure from Ridge 2012*
• 6'' - 1' slab & 1' - 2' pad footings
• Idea: to extend horizontally outside the building perimeter for 4' to stabilize
Retaining Walls

- height: 10' - 14'
- Idea: drain the water and collect it
Steel: Level -1

- **BLUE** - Retaining Wall
- **GREEN** – W14x43 Girders
- **ORANGE** – W8x31 Beams @ 4' Spacing
- **RED** – W14x61 Columns
- **PURPLE** – W14x61 Slanted Columns
- **NAVY** – W12x40 Columns
- **Grey** - Slab Openings

**Composite Slab:**
6” Concrete on Steel Deck
Steel: Level 0

Architecture
Structure
MEP
CM

GREEN —
W14x43 Girders
BLUE —
W14x74 Girders
ORANGE —
W8x31 Beams @ 4’ Spacing
RED —
W14x61 Columns
PURPLE —
W14x61 Slanted Columns
NAVY —
W12x40 Columns

- Slab Openings

Composite Slab:
6” Concrete on Steel Deck
Auditorium Slab:
Prefab PT 2’ Slab
Steel : Level 1

GREEN – W14x43 Girders
ORANGE – W8x31 Beams @ 4’ Spacing
BLUE – W8x28 Beams @ 6’ Spacing
RED – W14x61 Columns
PURPLE – W14x61 Slanted Columns
NAVY – W12x40 Columns

Slab Openings

Composite Slab: 6” Concrete on Steel Deck
Steel : Level 2 (Roof)

- **GREEN** – W14x43 Girders
- **ORANGE** – W8x31 Beams @ 4’ Spacing
- **BLUE** – W8x28 Beams @ 6’ Spacing
- **RED** – W14x61 Columns
- **PURPLE** – W14x61 Slanted Columns
- **NAVY** – W12x40 Columns
- Slab Openings

Composite Slab:
6” Concrete on Steel Deck
Lateral Systems

Challenge: Torsion due to irregularity

Cross bracing will be exposed, so aesthetics will also play a role in selection.

RED - Location of cross bracing shown on Level 0 plan
Floor Sandwich: Steel

Total height: 15 inch Distribution

<table>
<thead>
<tr>
<th>Component</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite slab</td>
<td>6 inch</td>
</tr>
<tr>
<td>Steel beams</td>
<td>8 inch</td>
</tr>
<tr>
<td>ducts &amp; instal.</td>
<td>8 inch</td>
</tr>
<tr>
<td>Ceiling panels</td>
<td>1 inch</td>
</tr>
<tr>
<td>Total:</td>
<td>15 inch</td>
</tr>
<tr>
<td>Girders</td>
<td>13 inch</td>
</tr>
</tbody>
</table>

Overhead

- Deck
- Distribution ducts
- Suspended ceiling
- Corridor
- Room
- Main Ducts
- Supply Air
- Return Air
Load Paths
Concrete: Level -1

Architecture
Structure
MEP
CM

BLUE - Retaining Wall
ORANGE - 2’x2’ Columns
GREEN - 1.5’x2’ Beams
RED - Shear Walls & Bracing
- Slab Openings

Floor Slab:
10” Reinforced Concrete Slab
Concrete: Level 0

**Orange** –
2’x2’ Columns

**Green** –
1.5’x2’ Beams

**Red** –
Shear Walls & Bracing

- Slab Openings

Floor Slab:
10” Reinforced Concrete Slab

Auditorium Slab:
Prefab PT 2’ Slab
Concrete: Level 1

**Architecture Structure**

**MEP CM**

**ORANGE** –
2’x2’ Columns

**GREEN** –
1.5’x2’ Beams

**RED** –
Shear Walls & Bracing

Slab Openings

Floor Slab:
10” Reinforced Concrete Slab
Concrete: Level 2 (Roof)

**Orange** – 2’x2’ Columns
**Green** – 1.5’x2’ Beams
**Red** – Shear Walls & Bracing

- Slab Openings

**Floor Slab:**
10” Reinforced Concrete Slab
Floor Sandwich: Concrete

Total height: 20 inch

<table>
<thead>
<tr>
<th>Component</th>
<th>Thickness</th>
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<tbody>
<tr>
<td>Floor finish</td>
<td>1 inch</td>
</tr>
<tr>
<td>Plenum</td>
<td>4 inch</td>
</tr>
<tr>
<td>Reinforced concrete slab</td>
<td>10 inch</td>
</tr>
<tr>
<td>Plenum</td>
<td>4 inch</td>
</tr>
<tr>
<td>Ceiling panels</td>
<td>1 inch</td>
</tr>
<tr>
<td>Total</td>
<td>20 inch</td>
</tr>
<tr>
<td>RC beam</td>
<td>9 inch</td>
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</table>
HVAC Requirements

Heating Set Points: 68 F
Outdoor temperature: 19.9 F

Cooling Set Points: 78 F
Outdoor temperature: 92.2 F

Indoor Relative Humidity: 50%
Ground Source Heat Pump
- Energy efficient with low GHG emissions
- High capital cost and low operational costs (payback ≥5 years, Commercial Buildings Tax Deduction)

**Hybrid Systems**

**Dual Source:**
- Decrease cost & efficiency

**Solar Thermal:**
- Dump excess solar energy to the ground, decrease cost and groundwater well depth ~11%

System ~80 tons
- Boreholes ~300 ft
- Water-to-water system
- Seasonal heat/cold storage
- Energy recovery savings up 9%
Air Distribution

Mechanical Ventilation

- Overhead air distribution - VAV system
- Underfloor air distribution
- Displacement Ventilation

Natural ventilation

- Stack ventilation

Control systems (of occupancy, CO2 concentration, weather provision)
UFAD & DV

UFAD
- Improved thermal comfort
- Improved ventilation efficiency and IAQ
- Reduce energy use
- Fan energy savings
- Reduced electrical demand

UFAD/DV - System
- 4” pressurized supply & return plenum
- Passive floor mounted diffusers
- Dehumidification with portion of return air
- Passive VAV cooling and fin tube heating on perimeter
# Vasari Analysis

<table>
<thead>
<tr>
<th>Glazing</th>
<th>Natural Gas*</th>
<th>GSHP**</th>
<th>UFAD***</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>50%</td>
<td>80%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>kWh/sf/yr</td>
<td>kWh/sf/yr</td>
<td>kWh/sf/yr</td>
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<td>27</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>kBtu/sf/yr</td>
<td>kBtu/sf/yr</td>
<td>kBtu/sf/yr</td>
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<td>HVAC</td>
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<td></td>
<td>kWh</td>
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<td></td>
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<td>kWh</td>
<td>kWh</td>
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<td>Equipment</td>
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<td>L.C. Energy</td>
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<tr>
<td>Cost</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CO2 emissions</td>
<td>107</td>
<td>163</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>tons/yr</td>
<td>tons/yr</td>
<td>tons/yr</td>
</tr>
</tbody>
</table>

* Furnace with gas heat, temperature economizer, DHW unit
** HP system, temperature economizer, DHW unit
*** VAV, Gas fired HW boiler, VV HW pump, HW coil

- **Fuel**: 27 kBtu/sf/yr
- **Electricity**: 9 kWh/sf/yr

- **CO2 emissions**: 107 tons/yr
Duct Network
Natural Ventilation

- Natural stack ventilation in corridor, atriums and perimeter
- Low energy fan during winter
Site Logistics
Cost Estimate

<table>
<thead>
<tr>
<th>Concept</th>
<th>Estimate</th>
<th>Difference From Target</th>
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<tbody>
<tr>
<td>L - Steel</td>
<td>$8,313,600</td>
<td>$(13,600)</td>
</tr>
<tr>
<td>L - Concrete</td>
<td>$8,296,800</td>
<td>$3,200</td>
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</tbody>
</table>
Cost distribution

- **G Building Sitework** $75,000 (1%)
- **H General Conditions** $1,385,600 (17%)
- **F Specialty Construction** $- 0% (0%)
- **E Equipment and Furnishing** $- 0% (0%)
- **D Services** $2,895,000 (35%)
- **A Substructure** $366,000 (4%)
- **B Shell** $2,351,000 (28%)
- **C Interiors** $1,241,000 (15%)
Double Diamond (DD)
1. Central (C)
2. X - Lattice (X)
Orientation

<table>
<thead>
<tr>
<th></th>
<th>Total EUI (kBtu/sf/yr)</th>
<th>Life Cycle Energy Cost ($)</th>
<th>Net CO₂ (tn/year)</th>
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<tbody>
<tr>
<td>1</td>
<td>68</td>
<td>610,000</td>
<td>235</td>
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<td>2</td>
<td>71</td>
<td>650,000</td>
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<td>5</td>
<td>70</td>
<td>630,000</td>
<td>155</td>
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Site/Second Concept
Site/Second Concept
Level -1 (Basement)

- Core
- Prototyping Lab
- Auditorium
- Faculty Offices
- Collaboration Space
Level -1 (Basement)
Level 0 - (Campus Entrance)
Level 0 - (Campus Entrance)
Level 1

Core
Large Classrooms
Small Classrooms
Level 1
Level 2

- Core
- Faculty Lounge
- Faculty Offices
- Administration
- Assistants Offices
Level 2
Flexible Spaces
Section aa

Architecture
Structure
MEP
Construction
Section bb

Architecture
Structure
MEP
Construction

Summer
Winter
Section cc
3d views

East Façade/
  DD Central

South Façade/
  DD Central
3d views

East Facade/
X Lattice

South Façade/
X Lattice
Atrium Design Evolution

Rectangle
+ Easier to fit program
- Concern about shearing along weak axis

Circle
+ Stronger in the weak axis
- More challenging programmatically

Cylinder
+ Simpler form while maintaining circular shape

Hyperboloid
+ Interaction between A + SE
+ Interesting, iconic form
+ Added strength in multiple directions
- More challenging/costly to design & build
- Does not fit architectural scheme well
Hyperboloid Exploration
Central: Level -1

Orange –
1.5’x1.5’ Columns
Green –
4’x1’ Columns
Navy –
1.5’ x2’ Beams
Blue –
Tension Ring
Red –
Shear Walls
Slab Openings

Floor Slab:
10” Reinforced Concrete Slab
Central: Level 0

**ORANGE** –
1.5’x1.5’ Columns

**GREEN** –
4’x1’ Columns

**NAVY** –
1.5’ x2’ Beams

**BLUE** –
Tension Ring

**RED** –
Shear Walls

- Slab Openings

**Floor Slab:**
10” Reinforced Concrete Slab
Central: Level 1

**Orange** – 1.5’x1.5’ Columns
**Green** – 4’x1’ Columns
**Navy** – 1.5’ x2’ Beams
**Blue** – Tension Ring
**Red** – Shear Walls

Slab Openings

Floor Slab: 10” Reinforced Concrete Slab
Central: Level 2 (Roof)

**Structure**
- **ORANGE** – 1.5’x1.5’ Columns
- **GREEN** – 4’x1’ Columns
- **NAVY** – 1.5’ x2’ Beams
- **BLUE** – Tension Ring
- **RED** – Shear Walls
  - Slab Openings

**Floor Slab:**
- 10” Reinforced Concrete Slab
X-Lattice: Level -1

**Architecture Structure**

**MEP CM**

**Orange** –
1.5’x1.5’ Columns

**Navy** –
1.5’ x2’ Beams

**Blue** –
Tension Ring

**Red** –
X-Lattice Wall

Slab Openings

**Floor Slab:**
10” Reinforced Concrete Slab
X-Lattice: Level 0

- Architecture
  - Structure
  - MEP
  - CM

**ORANGE** –
1.5’x1.5’ Columns

**NAVY** –
1.5’ x2’ Beams

**BLUE** –
Tension Ring

**RED** –
X-Lattice Wall

- Slab Openings

**Floor Slab:**
10” Reinforced Concrete Slab
X-Lattice: Level 1

Orange –
1.5’ x 1.5’ Columns

Navy –
1.5’ x 2’ Beams

Blue –
Tension Ring

Red –
X-Lattice Wall

Slab Openings

Floor Slab:
10” Reinforced Concrete Slab
X-Lattice: Level 2 (Roof)

- **ORANGE** – 1.5’x1.5’ Columns
- **NAVY** – 1.5’ x2’ Beams
- **BLUE** – Tension Ring
- **RED** – X-Lattice Wall
- Slab Openings

Floor Slab: 10” Reinforced Concrete Slab
X Lattice Wall

Can also help carry loads from cantilever
ConXTech

Architecture
Structure
MEP
Construction
### Vasari Analysis

<table>
<thead>
<tr>
<th>Input/Output</th>
<th>Natural Gas*</th>
<th>GSHP**</th>
<th>UFAD***</th>
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<tbody>
<tr>
<td>Glazing</td>
<td>50%</td>
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<tr>
<td>80%</td>
<td>80%</td>
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<td>HVAC</td>
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<td>440,000</td>
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<td>Lighting Equipment</td>
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<td>109</td>
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<td>192</td>
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<td>CO2 emissions</td>
<td>tons/yr</td>
<td>tons/yr</td>
<td>tons/yr</td>
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<tr>
<td>109</td>
<td>172</td>
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<tr>
<td>94</td>
<td>181</td>
<td>94</td>
<td>181</td>
</tr>
</tbody>
</table>

*Furnace with gas heat, temperature economizer, DHW unit
**HP system, temperature economizer, DHW unit
***VAV, Gas fired HW boiler, VV HW pump, HW coil
Duct Network

- DV
- Return
- Overhead
Natural Ventilation

- Natural stack ventilation in corridor, atriums and perimeter
- Low energy fan during winter
Double Diamond Site Logistics
## Preliminary Schedule

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitework</td>
<td>35 days</td>
<td>Wed 9/30/15</td>
<td>Tue 11/17/15</td>
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<tr>
<td><strong>Substructure</strong></td>
<td>50 days</td>
<td>Tue 10/20/15</td>
<td>Mon 12/28/15</td>
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<tr>
<td>Mat Slab</td>
<td>5 days</td>
<td>Wed 11/18/15</td>
<td>Tue 11/24/15</td>
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<td>Pile Caps</td>
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<td>Wed 10/21/15</td>
<td>Tue 10/27/15</td>
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<tr>
<td>Grade Beams</td>
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<td>Tue 10/27/15</td>
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<tr>
<td>Slab</td>
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<td>Tue 11/3/15</td>
</tr>
<tr>
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<td>Tue 11/3/15</td>
<td>Mon 11/16/15</td>
</tr>
<tr>
<td>Level 0</td>
<td>10 days</td>
<td>Mon 11/9/15</td>
<td>Fri 11/20/15</td>
</tr>
<tr>
<td>Level 1</td>
<td>10 days</td>
<td>Fri 11/20/15</td>
<td>Thu 12/3/15</td>
</tr>
<tr>
<td>Level 2</td>
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<td>Wed 12/16/15</td>
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<tr>
<td>Level -1</td>
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<td>Wed 1/6/16</td>
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<tr>
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<td>Tue 1/26/16</td>
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<td>Level 2</td>
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<tr>
<td>Interiors</td>
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<td><strong>Interior Construction</strong></td>
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<td>Stairs</td>
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<td>Mon 3/14/16</td>
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<tr>
<td>Services</td>
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<td>Thu 5/19/16</td>
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<td>Elevator</td>
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<td>Thu 5/19/16</td>
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<tr>
<td>Plumbing</td>
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<td>Thu 5/19/16</td>
</tr>
<tr>
<td>HVAC</td>
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<td>Fri 3/25/16</td>
<td>Thu 5/19/16</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>40 days</td>
<td>Fri 3/25/16</td>
<td>Thu 5/19/16</td>
</tr>
<tr>
<td>Electrical</td>
<td>40 days</td>
<td>Fri 3/25/16</td>
<td>Thu 5/19/16</td>
</tr>
<tr>
<td>Site Improvements</td>
<td>25 days</td>
<td>Mon 6/27/16</td>
<td>Fri 7/29/16</td>
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</tbody>
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Cost Estimate

<table>
<thead>
<tr>
<th>Concept</th>
<th>Estimate</th>
<th>Difference From Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-Concrete</td>
<td>$8,744,400</td>
<td>$ (444,400)</td>
</tr>
<tr>
<td>D-Steel</td>
<td>$9,309,600</td>
<td>$ (1,009,600)</td>
</tr>
</tbody>
</table>

Pricier than L due to larger Floor and Facade SF
Cost distribution

- **D Services**: $2,895,000 (31%)
- **A Substructure**: $366,000 (4%)
- **H General Conditions**: $1,551,600 (17%)
- **B Shell**: $3,181,000 (34%)
- **C Interiors**: $1,241,000 (13%)
- **E Equipment and Furnishing**: $- (0%)
- **F Specialty Construction**: $- (0%)
- **G Building Sitework**: $75,000 (1%)
TVD - Concrete

TVD - TARGETS BY CLUSTER Steel

- TARGET VALUE
- ESTIMATED VALUE
- VALUE DELTA

- A Substructure
- B Shell
- C Interiors
- D Services
- E Equipment and Furnishing
- F Specialty Construction
- G Building Sitework
- H General Conditions
Leapfrog Sustainability & Whole Life Cost Challenges
Innovation in Concrete

Use of translucent concrete to allow light in restrooms while maintaining structural integrity of shear walls (L-shape Concrete option)
Structural Health Monitoring

A nervous system for the building, with sensors detecting anomalous strains.

High initial cost --> lower OM cost, better safety, especially after EQ event.

Cost: ~$40/ft²
Smart Operation

- Room controllers with batteryless sensors
- Control of HVAC and lighting
- Thermostats
- Window contacts
- Humidity sensors
- Occupancy sensors
- CO2 sensors
Building Integrated PV
30kW

Mounted On: Roof 30°
Area: 2700 sf
Annual Energy Yield: 51.7 MWh/year
Gross Evaluation: 240,000 $

Mounted On: Atrium 30°
Area: 5400 sf
Annual Energy Yield: 51.7 MWh/year
Gross Evaluation: 290,000 $

Mounted On: Façade 30°
Area: 2700 sf
Annual Energy Yield: 51.7 MWh/year
Gross Evaluation: 260,000 $

Mounted On: BIPV
Area: 2700 sf
Annual Energy Yield: 33.4 MWh/year
Gross Evaluation: 250,000 $
Rainwater Harvesting

- 36000 gal/year rainwater
- Snow melting
- Drain groundwater

Use for:
- Toilet flushing
- Plants irrigation
- Maintenance/cleaning
Building Integrated W/T 18kW

- Operate at low wind speed ~5 mph and up to 120 mph
- Take advantage of ‘chimney effect’
- Low Noise levels

18 W/T Mounted On Roof
Energy produced: 19.4 MWh/year
Gross evaluation: 130,000 $
Electricity Produced: 17,500 $/year
Real Time Positioning

http://www.ekahau.com/products/real-time-location-system/vision.html
Sustainable Target Value

L-Concrete

DD-Central

L-Steel

DD-X
Sustainable Target Value

L-Concrete
*1.013 mtCO2e  $31,000

L-Steel
*993 mtCO2e  $30,000

DD-Cylinder
*1065 mtCO2e  $32,000

DD-X
*934 mtCO2e  $28,000
Sustainability Goals & LEED

Kickoff
-shoot for "net zero" energy
-don't design explicitly for the LEED checklist

Winter Quarter
- Incorporation of passive solar heating & lighting
- Decision to use rainwater harvesting and PV
- Exploration of GSHP & wind turbines

Looking Ahead to Spring Quarter
- Evaluation of design under LEED+ criteria
- Continue to design for sustainability, including Energy & Atmosphere, Indoor Environmental Quality, etc.
Decision Process
Decision Matrix

**Framework provided by LCFM consultants**

1. Team & owners add/modify criteria such as:
   - cost
   - sustainability
   - constructability
   - flexibility
   - innovation
   - efficiency
   - concept clarity

2. Owners choose weight distribution

3. Team rates concepts

4. Scores are calculated
Team's Recommendation to Owners!
LCFM Consulting in Spring

Communicate and consult

1. Establish the context
   - Criteria
   - Stakeholders
   - Alternatives
   - Define key elements

2. Identify the risk
   - What can happen?
   - How can it happen?

3. Analyse the risk
   - Responsibility
   - Costs
   - Duration

4. Evaluate the risk
   - Assessment
   - Evaluation
   - Risk Map
   - Time table

5. Treat the risk
   - Management
   - Identify options
   - Controlling

Monitor and review
Team Process
## Modes of Communication

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text, images, videos, links to other websites, etc.</td>
<td><a href="https://www.facebook.com">Facebook</a></td>
</tr>
<tr>
<td>Instant messaging</td>
<td><a href="https://www.facebook.com">Facebook</a></td>
</tr>
<tr>
<td>Voice</td>
<td><a href="https://www.gotomeeting.com">GoToMeeting</a></td>
</tr>
<tr>
<td>File Sharing</td>
<td><a href="https://drive.google.com">Google Drive</a></td>
</tr>
</tbody>
</table>
Team Design Process

Sketching while on Skype or Gotomeeting to share ideas or receive instant feedback
Example of Interdisciplinary Collaboration

**SE Meetings by Week**

- **Hours**
  - 0
  - 2
  - 4
  - 6
  - 8
  - 10
  - 12
  - 14
  - 16
  - 18

- **Week Starting on**
  - 21-Jan
  - 28-Jan
  - 4-Feb
  - 11-Feb
  - 18-Feb
  - 25-Feb
  - 4-Mar
  - 11-Mar

- **Legend**
  - w/ CM
  - w/ MEP
  - w/ A+MEP
  - w/ A
  - SE Only
  - Team
  - Class

Architecture
Structure
MEP
Construction
Thank You!

Your time and feedback are greatly appreciated!