Communication and Interaction

• **box** -- Permanent files
  • E_CF_Presentation_MAY6_v4.ppt

• **Google docs** -- Co-editing

• **Facebook** -- Inspire, broadcast + forward
Now I will calculate the cost according to a construction like this. Please let me know the sizes of the timber joists or any other changes.
Meeting Protocol
TERF - Online Collaboration
January - Kickoff
March - Winter Presentation
Late February
March - Fishbowl
Decision Matrix

- **Personal Preference**
- **Architecture**
- **Social Responsibility**
- **Economic Prosperity**
- **Environmental Stewardship**
Fullfill client goals = Project Success

“Innovative, efficient, flexible and sustainable. “

“Make nature penetrate the building, make building “floating””

“Value on performance after seismic event.”

“Emphasize the concept of nature.”

“Statement building”

“Access - a lot of people will need to enter and exit the building.”
Total Value Framework
Total Value Framework

Wellbeing
Target Value Design (TVD)
Sustainable Target Value (STV)
Total Value Framework
Total Value Framework

Wellbeing
Productivity
Cooperation
Engagement
Satisfaction
Creativity
Health

Wellbeing ≠ Wellness
Lake Merced Weather

The diagram shows the temperature trends for Lake Merced Weather from January to December. The chart includes the following lines:

- **Record High** (blue line): The highest temperature recorded each month.
- **Avg. High** (orange line): The average high temperature.
- **Avg. Low** (gray line): The average low temperature.
- **Record Low** (dark blue line): The lowest temperature recorded each month.

The y-axis represents the temperature in degrees Fahrenheit, while the x-axis represents the months from January to December.
Lake Merced Weather
Earthquake Information

\[ S_S = 2.177 \text{ g} \]
\[ S_{DS} = 1.451 \text{ g} \]

http://geology.com/articles/images/san-andreas-fault-map.jpg
Soil Profile

- USGS Soil Type C
- Well sorted fine to medium sand
- Water table: 14 ft below grade
- Friction angle = 40 degrees
- $K_a = 0.217$, $K_o = 0.357$, $K_p = 4.599$
- Unit weight = 116 pcf, saturated = 135 pcf
  (from Lindeburg, Civil Engineering Reference Manual for the PE Exam, 8th ed.)
Urban Context

Our Building
University Campus
Lake Merced
Building Access

PUBLIC ACCESS

FROM BUS STOP

STUDENTS FROM CAMPUS
The Fog Catcher
Fog Harvesting Methods
Biomimicry - The Cactus

Water Conservation
- Reduce evaporation
- Provide shade
- Condense moisture for roots
How it Works
How it Works
Fog: 0.05 - 0.5 grams of water per cm³

1 sq. ft. → 0.12 - 0.60 gallons/day
Karl the Fog

Façade ➔ 12,515 gallons/day
Shape Evolution
Site Placement
Elevations
Elevations

SOUTH

EAST
Under the Cantilever
Under the Cantilever
Under the Cantilever
Floor Plan - 2

- Department Chair’s Office
- Faculty Office
- Faculty Lounge
- Seminar Room
- Student Office
- Small Classroom
- Restrooms
- Administrative Office
Faculty Lounge
Student Collaboration Space
Student Collaboration Space
Sections

NORTH - SOUTH

EAST - WEST
Structural Floorplan - 2nd Floor

- Glulam Columns 8“x8”
- Steel Column W14x257
- L-shape Beams 8“x 6”
- Prestressing Cables 2 in^2
- Timber Shear Walls 12”
- Steel Shear Walls 12”
- Truss System (W18x106 for cantilever, W18x86 for interior beams)
Structural Floorplan - 2nd Floor
Structural System
Timber Floors System
## Decision Matrix - Cantilever

<table>
<thead>
<tr>
<th></th>
<th>SE</th>
<th>MEP (STV)</th>
<th>ARCH</th>
<th>CM</th>
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<tbody>
<tr>
<td>Steel</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>CLT Wall</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Hybrid</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
<td>+/-</td>
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# Live Load Requirements

<table>
<thead>
<tr>
<th>Room Function Type</th>
<th>Total Area (Sq-Ft)</th>
<th>Minimum Live Load (psf)</th>
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<tbody>
<tr>
<td>Faculty Offices</td>
<td>3600</td>
<td>50</td>
</tr>
<tr>
<td>Faculty Lounge</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td>Student Offices</td>
<td>1200</td>
<td>50</td>
</tr>
<tr>
<td>Auditorium</td>
<td>3000</td>
<td>100</td>
</tr>
<tr>
<td>Classroom</td>
<td>3600</td>
<td>40</td>
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<tr>
<td>Storage Rooms</td>
<td>1000</td>
<td>150</td>
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</tbody>
</table>

Based on California Building Code
## Lateral Loads

<table>
<thead>
<tr>
<th>System</th>
<th>Base shear (kips)</th>
<th>Overturning Moment (kip-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure shear wall system</td>
<td>7100</td>
<td>135300</td>
</tr>
<tr>
<td>Pure BRBF system</td>
<td>2200</td>
<td>42300</td>
</tr>
</tbody>
</table>

From ASCE 7-10
Truss System Detail

- Vierendeel Truss
  - Beam W18x106
  - Column W14x257
Load Path

Gravity Systems

Lateral Systems

43 ft

30 ft
Load Path

- Gravity Systems
- Lateral Systems
Truss Detail

- Regular prefabricated modules
- Assembled on site with bolts
- Pre-cambered

12’

10’
Cable System

- Cable Systems
  - 7-wire strand pre-stressing wires
  - Cross section area = 2 in^2
Coordination between SE ad Arch
Roof Solutions

- Traditional roof solution

- Waterproof Membrane
- 0.7” Plywood Sheet
- Rigid Foam Insulation
- Timber Joist
Steel Truss

- Assembled while the concrete slab in foundation hardens
- Assembled into 4 pieces, each 40,000 lbs ~ 20 short ton

Mobile Crane 40 ton = $212/hr
1 RED = Assembled on ground
2 ORANGE = Assembled on ground
3 BLUE = Assembled on ground
4 TURQUOISE = Assembled on ground

1, 2, 3, 4 are lifted in place and connected
Truss System Value

Value
Easy to transport
Easy to connect
Reduce stress on the truss
Safer
Less expensive
Architectural freedom

How?
No site welding
Assembly method – fewer lifts
No proprietary connections
Customized design
Increased open space
Timber Floor System
Timber Slab Design

38'x8' Slab Unit

38'x8' Slab Unit
Slab to Slab Connection

- Timber slabs “key” together
- Epoxy + Screws for site connections
Slab to Truss Connection

- Structural Screws in Staggered Pattern
Slab to Truss Connection

- Structural Screws in Staggered Pattern
Structural Layout
Structural Layout
Cable Connection

Suspended from Truss

8x6” L Shape Perimeter Beam

2x Prestressing Cable
0.525” 7-Wire Strand

8x6” L Shape Perimeter Beam
HVAC Design Strategies

50%: Internal gains
40%: Solar gains
Mini Shafts

Mini Vertical Shafts to Access Slabs on either side of the trusses (2.6 square feet each)
Section View of Mini Shafts
MEP Integration

Hollow Slabs → Underfloor air distribution plenum
MEP Integration

Hollow Slabs ➔ Underfloor air distribution plenum
Under Floor Air Distribution using Timber Slab
Prefabrication of floor system

- On-site prefabrication
  - Size of site = 130 000 SF
- 56 slabs
  - Two main versions
Manufacturing plant

Already existing tents on site
Time comparison

Steel concrete composite floor
• 35-40 days

Timber slab
• 110 days to manufacture
• 17 days to lift and install

Time saving ~18-23 days
Cost comparison

Steel concrete composite floor
  • ~$245 000
Prefabricated timber slab incl. Underfloor Air Distribution ductwork
  • ~$290 000

<table>
<thead>
<tr>
<th>Labour</th>
<th>Material</th>
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<tbody>
<tr>
<td>Carpenter Crew</td>
<td>LVL $65 000</td>
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<tr>
<td>Finishes</td>
<td>CLT $60 000</td>
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<tr>
<td>HVAC crew</td>
<td>Ducts $12 000</td>
</tr>
</tbody>
</table>
**Timber Slab**

**Added Value**
- Faster schedule
- Increased quality
- Environmentally advantageous
- Good seismic performance

**How?**
- Prefabricated units
- Integrated MEP and bearing structure
- Timber solution
- Lightweight
Structural Floorplan - Groundfloor

- Glulam Columns 8”x8”
- Steel Column W14x257
- Timber Shear Walls 12”
- Steel Shear Walls 12”
Lateral Load Systems

Wall System
- CLT Mass Timber wall

Frame System
- High Stiffness Wall Equivalent
- Post-tensioning system
- 8.0 sq.in BRB Element
3D View of Lateral Systems
Ground Floor HVAC Solution

Commercial Under Floor Air Distribution System with wood-finish tiles.
Auditorium

- Heating and cooling
- Versatile connections
Ground Floor HVAC Solution

Ventilation and Cooling

Heating
Foundations

- Strip Footings

Depth = 2.16 ft
Width = 7.5 ft
Foundations

• Strip Footings
Foundations

- Use Strip Footings as Pile Caps
Foundations

- Helical Screw Piles
  - No dewatering needed
  - 14” dia. 3-1/2” turbular
**Structural Analysis**

<table>
<thead>
<tr>
<th>Primary Mode</th>
<th>Largest Period</th>
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<td>Torsion</td>
<td>0.20 s</td>
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Structural Analysis - Deflections

<table>
<thead>
<tr>
<th>Points that have largest deflections</th>
<th>Max Deflections (Gravity) - in</th>
<th>Max Deflections (Lateral) - in</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>3.87</td>
<td>1.16</td>
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<tr>
<td>B</td>
<td>1.80</td>
<td>0.96</td>
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</table>
### Structural Analysis

<table>
<thead>
<tr>
<th></th>
<th>Base shear (kips)</th>
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</tr>
<tr>
<td>Pure BRBF system</td>
<td>2200</td>
<td>42300</td>
</tr>
<tr>
<td>ETABS Analysis Results</td>
<td>2800</td>
<td>67000</td>
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</table>

- Hybrid System
Balance Stiffness

- Stiffen the shear walls on one side of the building
BIM Coordination Plan - software

CM
- Terf
- NAVISWORKS
- MS Project
- BIM 360Glue

Model walkthrough
4D BIM
Clash detection

MEP
- Green Building Studio
- REVIT2014-MEP
- VASARI

Dropbox

Architect
REVIT2014-A

SE
- REVIT 2014-SE
- ETABS

Analysis
Software

DATA
App
BIM Coordination Plan - team

- **Early coordination (1-2 weeks)**
  - First Architectural REVIT model \(\rightarrow\) REVIT SE \(\rightarrow\) REVIT MEP
  - Interdisciplinary discussions for decision making

- **Coordination using shared models**
  - Layers
  - Dropbox: model sharing
  - NAVISWORKS: 4D simulation
  - Terf: model walkthrough
  - BIM 360 Glue: model integration, clash detection
Site Access Analysis
Site Layout Plan
Clash Detection-before

April 30

Clashes between architecture vs cables
Clash Detection-after

May 7
Material Access
Health and safety approach

• Adress all risks
  • RED; E.g. falling, squeezing and run-over
  • YELLOW; E.g. dust, noise and chemicals.

• YELLOW most dangerous in long run

• Design for safety

• Fire and safety rounds

• Education;
  • Hand tools, work in elevation, welding, heavy lifting
“Achieve a healthy building through a healthy approach during both the design AND the construction”
Computer lab schedule

Construction Start
September 2019

Computer labs - April 27
Computer Managers Access

Access from N. State Drive for Computer Manager
Computer Managers Entrance

ZONE Auditorium

Separate entrance
Zone 1 - Computer labs
Gantt Schedule
## Milestones

<table>
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<tr>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Apr-Aug</td>
<td>Sep</td>
<td>Oct</td>
<td>Nov</td>
<td>Dec</td>
<td>Jan</td>
<td>Feb</td>
<td>Mar</td>
<td>Apr</td>
<td>Maj</td>
<td>Jun</td>
<td>Jul</td>
<td>Aug</td>
</tr>
</tbody>
</table>

- **Procurement**
- **Site mobilization**
- **Foundation**
- **Structural system**
- **Roof**
- **Enclosure**
- **Interiors and Services**
- **Commissioning**

M1 M2 M3 M4 M5
4D Construction
## Critical Activities

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Predecessors</th>
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</thead>
<tbody>
<tr>
<td>Site work</td>
<td>14 days</td>
<td>Tue 10-05-09</td>
<td>Fri 19-05-09</td>
<td></td>
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<tr>
<td>Site mobilization</td>
<td>8 days</td>
<td>Tue 19-09-08</td>
<td>Thu 19-09-10</td>
<td>Excavation crew B 10</td>
</tr>
<tr>
<td>Grouting</td>
<td>6 days</td>
<td>Fri 19-09-13</td>
<td>Fri 19-09-19</td>
<td>Excavation crew B 10</td>
</tr>
<tr>
<td>Foundation</td>
<td>87 days</td>
<td>Mon 19-09-23</td>
<td>Tue 19-10-17</td>
<td></td>
</tr>
<tr>
<td>Mike 30 psc</td>
<td>8 days</td>
<td>Mon 19-09-23</td>
<td>Wed 19-10-25</td>
<td>Bearing structure crew pilier</td>
</tr>
<tr>
<td>Strip footing formwork and reinforcement</td>
<td>15 days</td>
<td>Thu 19-10-03</td>
<td>Wed 19-10-23</td>
<td>Bearing concrete crew; slater and 5</td>
</tr>
<tr>
<td>Strip footing casting</td>
<td>3 days</td>
<td>Wed 19-10-24</td>
<td>Wed 19-10-27</td>
<td></td>
</tr>
<tr>
<td>Underground MEP and concrete slab works</td>
<td>25 days</td>
<td>Fri 19-11-08</td>
<td>Thu 19-12-12</td>
<td>Water and sewage crew; concrete crew</td>
</tr>
<tr>
<td>Casting concrete slab</td>
<td>2 days</td>
<td>Fri 19-12-13</td>
<td>Tue 19-12-17</td>
<td></td>
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<tr>
<td>Bearing structure</td>
<td>70 days</td>
<td>Wed 19-12-18</td>
<td>Tue 20-03-24</td>
<td></td>
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<tr>
<td>Prefabricated floor + installation</td>
<td>4 days</td>
<td>Thu 20-01-09</td>
<td>Tue 20-01-14</td>
<td>Bearing steel structure 2</td>
</tr>
<tr>
<td>Columns</td>
<td>10 days</td>
<td>Thu 19-12-26</td>
<td>Wed 20-01-03</td>
<td>Bearing steel structure 2</td>
</tr>
<tr>
<td>Beams</td>
<td>10 days</td>
<td>Thu 19-12-26</td>
<td>Wed 20-01-08</td>
<td>1005</td>
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<tr>
<td>Banded formwork</td>
<td>27 days</td>
<td>Wed 20-02-02</td>
<td>Tue 20-02-08</td>
<td></td>
</tr>
<tr>
<td>Insulation, vapor barrier, membrane</td>
<td>15 days</td>
<td>Wed 20-02-09</td>
<td>Tue 20-03-10</td>
<td></td>
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<tr>
<td>Rappel</td>
<td>25 days</td>
<td>Thu 20-02-29</td>
<td>Tue 20-03-24</td>
<td></td>
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<tr>
<td>Ground floor</td>
<td>69 days</td>
<td>Wed 20-03-25</td>
<td>Mon 20-06-29</td>
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<tr>
<td>Zone 1 GFL (MEP + storage)</td>
<td>15 days</td>
<td>Wed 20-03-25</td>
<td>Fri 20-04-17</td>
<td></td>
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<tr>
<td>Interior walls zone 1 DP</td>
<td>2 days</td>
<td>Wed 20-03-25</td>
<td>Thu 20-03-26</td>
<td>Interior crew</td>
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<tr>
<td>Services</td>
<td>13 days</td>
<td>Fri 20-03-27</td>
<td>Tue 20-04-04</td>
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<tr>
<td>HVAC</td>
<td>13 days</td>
<td>Fri 20-03-27</td>
<td>Tue 20-04-14</td>
<td></td>
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<tr>
<td>HVAC installations</td>
<td>3 days</td>
<td>Fri 20-03-27</td>
<td>Thu 20-04-21</td>
<td>HVAC crew</td>
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<td>Dusting Zone 1 DP</td>
<td>8 days</td>
<td>Fri 20-04-01</td>
<td>Fri 20-04-10</td>
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<tr>
<td>HVAC rough in Zone 1 GFL</td>
<td>2 days</td>
<td>Mon 20-04-03</td>
<td>Mon 20-04-13</td>
<td>HVAC crew</td>
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<tr>
<td>HVAC trim out Zone 1 GFL</td>
<td>1 day</td>
<td>Tue 20-04-14</td>
<td>Tue 20-04-16</td>
<td>HVAC crew</td>
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## TVD Winter Quarter

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<th>Winter Estimate</th>
<th>Target Value</th>
<th>Value Delta</th>
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<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>9,260,000</td>
<td>9,800,000</td>
<td>540,000</td>
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<tr>
<td><strong>A Substructure</strong></td>
<td>86,000</td>
<td>710,000</td>
<td>624,000</td>
</tr>
<tr>
<td><strong>B Shell</strong></td>
<td>3,400,000</td>
<td>3,330,000</td>
<td>-70,000</td>
</tr>
<tr>
<td><strong>C Interiors</strong></td>
<td>1,240,000</td>
<td>1,000,000</td>
<td>-240,000</td>
</tr>
<tr>
<td><strong>D Services</strong></td>
<td>3,600,000</td>
<td>3,500,000</td>
<td>-100,000</td>
</tr>
<tr>
<td><strong>E Equipment and Furnishing</strong></td>
<td>140,000</td>
<td>160,000</td>
<td>20,000</td>
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<tr>
<td><strong>F Speciality Construction</strong></td>
<td>200,000</td>
<td>330,000</td>
<td>130,000</td>
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<tr>
<td><strong>G Building Sitework</strong></td>
<td>240,000</td>
<td>270,000</td>
<td>30,000</td>
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<tr>
<td><strong>H General Conditions</strong></td>
<td>350,000</td>
<td>470,000</td>
<td>120,000</td>
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</table>

**WINTER ESTIMATE: $9,260,000**
<table>
<thead>
<tr>
<th>SPRING</th>
<th>ESTIMATED VALUE</th>
<th>TARGET VALUE</th>
<th>VALUE DELTA</th>
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<tr>
<td>TOTAL</td>
<td>10 650 000</td>
<td>9 800 000</td>
<td>-850 000</td>
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<td>A Substructure</td>
<td>260 000</td>
<td>710 000</td>
<td>450 000</td>
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<tr>
<td>B Shell</td>
<td>3 980 000</td>
<td>3 330 000</td>
<td>-650 000</td>
</tr>
<tr>
<td>C Interiors</td>
<td>840 000</td>
<td>1 000 000</td>
<td>160 000</td>
</tr>
<tr>
<td>D Services</td>
<td>3 020 000</td>
<td>3 530 000</td>
<td>510 000</td>
</tr>
<tr>
<td>E Equipment and Furnishing</td>
<td>270 000</td>
<td>160 000</td>
<td>-110 000</td>
</tr>
<tr>
<td>F Specialty Construction</td>
<td>200 000</td>
<td>330 000</td>
<td>130 000</td>
</tr>
<tr>
<td>G Building Sitework</td>
<td>430 000</td>
<td>270 000</td>
<td>-160 000</td>
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<tr>
<td>H General Conditions</td>
<td>1 660 000</td>
<td>470 000</td>
<td>-1 190 000</td>
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SPRING ESTIMATE: $10,650,000
Targets by Cluster

<table>
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<th>Cluster</th>
<th>Target Value</th>
<th>Estimated Value</th>
<th>Value Delta</th>
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<tr>
<td>A Substructure</td>
<td>$1,000,000</td>
<td>$2,500,000</td>
<td>$-1,500,000</td>
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<tr>
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<td>C Interiors</td>
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<td>$3,500,000</td>
<td>$-1,000,000</td>
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<tr>
<td>D Services</td>
<td>$1,500,000</td>
<td>$2,000,000</td>
<td>$-500,000</td>
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<tr>
<td>E Equipment and Furnishing</td>
<td>$500,000</td>
<td>$600,000</td>
<td>$100,000</td>
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<tr>
<td>F Specialty Construction</td>
<td>$500,000</td>
<td>$700,000</td>
<td>$200,000</td>
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<td>G Building Stewwork</td>
<td>$250,000</td>
<td>$350,000</td>
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<tr>
<td>H General Conditions</td>
<td>$1,000,000</td>
<td>$2,000,000</td>
<td>$-1,000,000</td>
</tr>
</tbody>
</table>
Building Performance - STV

better energy and GHG emissions than the median building.
LEED
Previous Swinerton Challenges

- Leapfrog Sustainability
- Biomimicry
- Native
- Sustainable Performance
- Sustainable Design and Construction
Wellbeing - Active Design

• Smoke-free building.
• Stairs, elevators and bathrooms encourage movement.
• Access to take a break or be active.
Wellbeing - Biophilia

• Reduced stress through views of natural landscapes.
• Increased social interactions and sense of community.
• 10 to 25% better mental function and memory.
Wellbeing - Auditorium

- Area for relaxation, quiet, socializing, fitness.
- Quiet room with soft music for times of stress.
- Creativity, self-expression, cooperation, exploration.
Wellbeing - Workspaces

- Opportunity to engage in spontaneous social encounters
- Freedom to move from one social phase to another

- Better ventilation improves productivity by 11%
- Individual temperature control by 3%
Wellbeing - Daylight

- Increased productivity up to 18%.
- 5-14% Higher Test Scores
- Students learn 20-26% faster
A Special Thanks to

Renate Fruchter
Karolina Ostrowska, Mike Miller and Michael Seaman

All mentors that supported and inspired our work

Team Pacific
Learning experiences

“Even if you say green and I say green, I’m thinking blue and you’re thinking orange.”

“Remember to mute your mic/Unmute your mic.”

“What drives project success is a strong interest in everyone's ideas that arise during the project.”

“Maybe I want to be an architect?” // Structural Engineer

“The social interaction is the best – I love you guys.”

“Embrace your differences and take advantage of them”