Our Team
MEET THE TEAM

Meng SE
Catrin CM
Marveliz Ap

Mike, Maria, Enrique, Ana
Owners

Martin A
Marios MEP
Robert SE
Ben CM
Overview
Nearby amenities, green space, and public transit promote Active Transportation!
Client Requirements

- $10.5 Million Budget
- 30,000 GSF, max 30’
- 1-year Max Construction
  - Start Date 5/2/19
  - End Date 8/15/20
- Early Completion of Lab
- Carbon Cap - $5.63 \times 10^6$ CO₂e
- Energy - $1.31 \times 10^8$ MJ
- Water - $1.10 \times 10^8$ kg

New building reflecting UNR’s School of Engineering’s Commitment to Local Impact
UNR’s Initiative new buildings min LEED 2.2 Silver & 30% reduction ASHRAE 90.1 Energy Standard
Important Site Conditions

Highly Seismic Area
Shallow Water Table
Large Fluctuation in Temps. (daily and seasonally)
High desert winds - 60 mph avg
Rain Shadow: 7 in. of rain, 23 in. of snow

Climate Conditions
99% heating design Temperature = 14.9F
1% cooling design Temperature = 92.5F
Average humidity: 60%

Indoor Design Conditions
51 days above 90F, HDD68=5674
166 days below freezing, CDD74=508
Monthly Average Relative Humidity

Mostly Low Relative Humidity
More wind from NORTH. Stronger wind from WEST.
Solar Resources

Roof Radiation ~ 6 KWh/m²/day, 252 Sunny Days per year
Sun Path Visualization

- Summer Solstice
- Fall Equinox

Helped determine orientation and location of spaces
After experimenting with many technologies, we chose to consolidate our tool box into the essential and most effective tools for our particular needs.

- **Revit+Dropbox:** Model creating/sharing/integrating
- **Asana:** Scheduling and Task Tracking
- **TERF:** Virtual Meeting Space. Work Sessions.
- **Facebook:** Frequent messaging, status updates, announcements
- **GotoMeeting:** Smaller/facetoface Meetings. Live Document Editing.
- **Drive:** Collaboration of Deliverables.
Our Team Process

Constant Communication

Generated up to 55 ideas in 10 mins through a timed BrainMerge brainstorming session

Pairwise surveys show owner/member values/priorities

Terf Provided a Virtual Space for Frequent Transatlantic Meetings

Constant feedback
Our Team Process

Example of live feedback, communication, and iteration via Google Drive.
We moved from Asana to Google Drive as a new method of requesting tasks/information and measuring interdependencies of disciplines.

<table>
<thead>
<tr>
<th>Task</th>
<th>Required From</th>
<th>Affected Task</th>
<th>Assigned Date</th>
<th>Due Date</th>
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<tr>
<td>Dewatering for foundation</td>
<td>Catrin</td>
<td>Foundation design</td>
<td>4/28/2015</td>
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<td>Atrium work (special mechanics because of water wall and plants?)</td>
<td>Marios</td>
<td>STV update</td>
<td>4/28/2015</td>
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<td>Martin</td>
<td>Foundation design</td>
<td>4/19/2015</td>
<td>4/24/2015</td>
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</table>

+email, member receives notification of request & link to sheet
Led to further consolidation of tools. **We were ALL already there!** (Email+Drive)
<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Architecture</th>
<th>Construction</th>
<th>Structural Engineering</th>
<th>MEP</th>
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<td>Martin</td>
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<tr>
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</table>

Take into account availability to assign Weekly Discipline Leaders.

Use Time Difference for Round-the-Clock work.

Ensure that each discipline + whole project is moving forward.
Members Evaluating Dynamic TVD Wall on TERF
Decision Matrix
# Weighting Process

1. Expression of Big Idea
   - 2. Site Connection
   - 3. User Comfort
     - 4. Water Challenge
     - 5. Sustainability
       - 6. Floor to Ceiling Height
         - 7. Structural Strength (Seismic Performance)
   - 8. Cost
     - 9. Constructability
       - 10. Duration of Build
         - 11. Innovation
           - 12. Interdisciplinary Integration

## Owner Percentages

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<td>8%</td>
<td>11%</td>
<td>7%</td>
<td>14%</td>
<td>6%</td>
<td>11%</td>
<td>3%</td>
<td>2%</td>
<td>0%</td>
<td>17%</td>
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## Team Percentages

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<td>Percentage</td>
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<td>9%</td>
<td>8%</td>
<td>10%</td>
<td>5%</td>
<td>8%</td>
<td>5%</td>
<td>6%</td>
<td>2%</td>
<td>12%</td>
<td>13%</td>
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</tbody>
</table>

## Combined Outcome

1. Expression of Big Idea | 14%
2. Site Connection | 7%
3. User Comfort | 9%
4. Water Challenge | 8%
5. Sustainability | 10%
6. Floor to Ceiling Height | 5%
7. Structural Strength (Seismic Performance) | 8%
8. Cost | 5%
9. Constructability | 6%
10. Duration of Build | 2%
11. Innovation | 12%
12. Interdisciplinary Integration | 13%
## Decision Diagram Results

<table>
<thead>
<tr>
<th></th>
<th>Average Weighting</th>
<th>Canyon Steel</th>
<th>Canyon Concrete</th>
<th>Oasis Steel</th>
<th>Oasis Timber</th>
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<td>1. Expression of Big Idea</td>
<td>14%</td>
<td>3.26</td>
<td>3.54</td>
<td>2.18</td>
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<td>2. Site Connection</td>
<td>7%</td>
<td>1.74</td>
<td>1.88</td>
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<td>3. User Comfort</td>
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<td>2.19</td>
<td>2.19</td>
<td>2.02</td>
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<td>4. Water Challenge</td>
<td>8%</td>
<td>1.30</td>
<td>1.30</td>
<td>1.30</td>
<td>1.30</td>
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<tr>
<td>5. Sustainability</td>
<td>10%</td>
<td>2.47</td>
<td>1.65</td>
<td>2.58</td>
<td>2.27</td>
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<tr>
<td>6. Floor to Ceiling Height</td>
<td>5%</td>
<td>1.21</td>
<td>1.21</td>
<td>1.21</td>
<td>0.88</td>
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<tr>
<td>7. Structural Strength (Seismic Performance)</td>
<td>8%</td>
<td>1.83</td>
<td>2.25</td>
<td>1.83</td>
<td>1.67</td>
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<td>8. Cost</td>
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<td>1.05</td>
<td>0.84</td>
<td>1.11</td>
<td>1.42</td>
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<td>9. Constructability</td>
<td>6%</td>
<td>1.48</td>
<td>1.07</td>
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<td>1.60</td>
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<td>10. Duration of Build</td>
<td>2%</td>
<td>0.55</td>
<td>0.39</td>
<td>0.55</td>
<td>0.63</td>
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<td>11. Innovation</td>
<td>12%</td>
<td>2.33</td>
<td>2.95</td>
<td>2.33</td>
<td>2.33</td>
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<tr>
<td>12. Interdisciplinary Integration</td>
<td>13%</td>
<td><strong>2.93</strong></td>
<td><strong>3.05</strong></td>
<td>2.54</td>
<td>1.91</td>
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<td><strong>Total</strong></td>
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<td><strong>22.36</strong></td>
<td><strong>22.31</strong></td>
<td><strong>20.36</strong></td>
<td><strong>19.65</strong></td>
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</table>
Decision Matrix
Final Choice: Concrete

Keeping it Local!

Closest Concrete Plant
Sparks, NV
6.5 mi away

Closest Steel Factory:
Las Vegas, NV
450 mi away
SOUTH FACADE
Stairs
Water wall
Water wall implemented in stairs
Building Elevation

6 ft below grade

increase floor-ceiling height

increase user comfort
Soil Profile

(Grade at 4580 ft Elevation) 0 ft

<table>
<thead>
<tr>
<th>Depth of Excavation</th>
<th>Soil Type</th>
<th>Thickness</th>
<th>Bearing Capacity</th>
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<tbody>
<tr>
<td>1.58 ft</td>
<td>Stony Sandy Loam and Heavy Loam</td>
<td>19&quot;</td>
<td>1500 psf</td>
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<tr>
<td>2.42 ft</td>
<td>Sandy Clay Loam</td>
<td>10&quot;</td>
<td>1500 psf</td>
</tr>
<tr>
<td>4.67 ft</td>
<td>Clay and Clay Loam</td>
<td>27&quot;</td>
<td>1500 psf</td>
</tr>
<tr>
<td>7 ft</td>
<td>Very Gravelly Sandy Loam and Very Gravelly Loam</td>
<td>28&quot;</td>
<td>5000 psf</td>
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<tr>
<td></td>
<td>Volcanic Rock</td>
<td>Unknown</td>
<td>8000 psf</td>
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</table>
Foundation

Hydrostatic Forces

125 psf

4000 k

Building

water table (4’ below grade)

first floor (6’ below grade)

1250 k

need thicker base slab

Mat Foundation

5000 psi concrete - 18” thick placed 6’ below grade
Waterproofed Retaining Wall

allow sunlight into first floor

Building

Cost for Value

#5 @ 6"

Surcharge

Backfill

stem

GL

Mat

Hccl

A E MEP C Water Latency
Retaining Wall Location

- Retaining Wall
- Site Boundary

10 ft from the building
3D View Level 1
Level 1

- 9” PT Flat Slab
- 8” RC Shear Wall
- 14” RC Column
- Seismic Separation
3D View Level 2
Level 2

- 9" PT Flat Slab
- 8" RC Shear Wall
- 14" RC Column
- 20" RC Column
- 18 x 36 RC Beam
- Seismic Separation
- 9.5' Cantilever
- Bridges (steel)
3D View Level 3
Level 3

9” PT Flat Slab

- 8” RC Shear Wall
- 14” RC Column
- 20” RC Column
- 16” RC Column
- Seismic Separation
- 9.5’ Cantilever
- Bridges (steel)
# Design Loads

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>E</th>
<th>MEP</th>
<th>C</th>
<th>Water</th>
<th>Latency</th>
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<tbody>
<tr>
<td><strong>Roof</strong></td>
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<tr>
<td>Dead PV Panels</td>
<td>110 psf</td>
<td>5 psf</td>
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<tr>
<td>Live Snow</td>
<td>20 psf</td>
<td>10 psf</td>
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<td><strong>Other Floors</strong></td>
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<tr>
<td>Dead SDL</td>
<td>110 psf</td>
<td>10 psf</td>
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<tr>
<td>Live</td>
<td>65 psf</td>
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</table>

Earthquake Base Shear 320 kips per Wing
## Typical Dimensions

- 5000 psi Concrete
- 9” PT Flat Slab
- 14” Dia. RC Column
- 8” RC Shear Wall
- 9’6” Cantilever
- Seismic Separation

### Adding fly ash:
- Reduce water demand of concrete
- 10% of fly ash → 3% water reduction

### Diagram:

- Material
- Architectural Aspects
- Structural Performance
- Constructibility
- Costs
- Sustainability
- A - SE - MEP - CM Collaboration
- Type of Construction
- Building Services
- Latency
Auditorium PT Slab Analysis
Stress Check - Auditorium

Flexural Stress Check - Long Term:
Dead + PT Final
Dead + 0.5 Live + PT Final

1.71 ksi

Banded Tendons
Distributed Tendons

76’

38’

48’ x 43’
Typical Reinforcement

- Slab top: #6 at 6" #6 at 6"
- Slab bottom: #6 at 6" #6 at 6"
- Column: 8 #7 #3
- Spiral tie: 8 #7 #3
- Wall: 8"
- Cantilever: 9’ 6”
- Primary reinforcement: 9’ 6”
- Column/slab reinforcement: 14”
- Water latency:
- MEP:
- A
- E
- C
- Latency
Non-Auditorium Wing Slab Analysis
### Tendon Layout - Non Auditorium

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<table>
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<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Typical Bay Size</strong></td>
<td>19’ x 19’</td>
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<tr>
<td><strong>Tendon Jacking Stress</strong></td>
<td>216 ksi</td>
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<tr>
<td><strong>Strands</strong></td>
<td>(//6) (B) (//2) (D)</td>
</tr>
<tr>
<td><strong>Stressing Losses</strong></td>
<td>27.0 ksi</td>
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<tr>
<td><strong>Long-Term Losses</strong></td>
<td>13.5 ksi</td>
</tr>
</tbody>
</table>

**Diagram:**
- Banded Tendons
- Distributed Tendons

- **Dimensions:**
  - 76’
  - 38’

**Legend:**
- A
- E
- MEP
- C
- Water
- Latency

**Notes:**
- Long-term losses:
  - 27.0 ksi
  - 13.5 ksi
Deflection - Non Auditorium

Load Combination: 1.0 x Dead + 1.0 x Live + 1.0 x PT Final

Criterion: l/240 = 1.3 in

before: max deflection = 1.18"

Add A Column

after: max deflection = 0.47"
Auditorium Wing Slab Analysis
Tendon Layout - Auditorium Wing

**Typical Bay Size**: 19’ x 19’

**Tendon Jacking Stress**: 216 ksi

**Strands**: \(\frac{6}{6} (B)\) \(\frac{2}{2} (D)\)

**Stressing Losses**
- **Long-Term Losses**: 27.0 ksi
- **Long-Term Losses**: 13.5 ksi
Deflection - Auditorium Wing

Load Combination: 1.0 x Dead + 1.0 x Live + 1.0 x PT Final

Criterion: \( l/240 = 1.6 \) in

- A
- E
- MEP
- C
- Water
- Latency

12 x 24

1.75 in
1.36 in
0.86 in
Deflection - Auditorium Wing

Load Combination: 1.0 x Dead + 1.0 x Live + 1.0 x PT Final

Criterion: $l/240 = 1.4$ in

- 0.96 in
- 0.78 in
- 0.86 in
Punching Shear Reinforcement: Stud Rails

- Max 180 kips
- 6 x 7”
- 24 x JDA-3/12/185/450
- 9”
- 14”

24 x JDA-3/12/185/450
ETABS Response Spectrum Analysis

Auditorium Wing
5% damping SRSS
Non-Auditorium Wing

Separate analysis for each wing
Design Basis Earthquake (DBE)

- Highly seismic area
- Site Class D
- Risk Category II

USGS-Provided Output

- $S_s = 1.963 \, g$
- $S_{MS} = 1.963 \, g$
- $S_{SD} = 1.308 \, g$
- $S_1 = 0.663 \, g$
- $S_{M1} = 0.994 \, g$
- $S_{D1} = 0.663 \, g$
Auditorium Wing

Mode 1
T = 0.19 s
Translational mode in E-W

Mode 2
T = 0.111 s
Translational mode in N-S
Non-Auditorium Wing

Mode 1
T = 0.271 s
translational mode in E-W

Mode 2
T = 0.121 s
translational mode in N-S
Auditorium Wing (1.0E-W + 0.3N-S)

Maximum Story Displacement

- Roof Displ. 0.68”

Maximum Story Drifts

- Max IDR 0.0025
Auditorium Wing (0.3E-W + 1.0N-S)

- **Maximum Story Displacement**: Roof Displ. 0.25”
- **Maximum Story Drifts**: Max IDR 0.001
Non-Auditorium Wing (1.0E-W + 0.3N-S)

Maximum Story Displacement

Roof Displ. 1.5”

Max IDR 0.004
Non-Auditorium Wing (0.3E-W + 1.0N-S)

**Maximum Story Displacement**

- **Roof Displ. 0.5”**

**Maximum Story Drifts**

- **Max IDR 0.0015**
## ETABS Analysis Summary

**Non-Auditorium Wing**

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<th>Scenario</th>
<th>Roof Displacement</th>
<th>Max Story Drift</th>
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<td>1.5 in</td>
<td>0.004</td>
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<tr>
<td>0.3E-W + 1.0N-S</td>
<td>0.5 in</td>
<td>0.0015</td>
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**Auditorium Wing**

<table>
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<th>Scenario</th>
<th>Roof Displacement</th>
<th>Max Story Drift</th>
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<tr>
<td>1.0E-W + 0.3N-S</td>
<td>0.68 in</td>
<td>0.0025</td>
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<tr>
<td>0.3E-W + 1.0N-S</td>
<td>0.25 in</td>
<td>0.001</td>
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</table>

ASCE Design Criterion: 2% story drift
Roof Design

Modified roof slab to reduce cantilever + more daylight

Max cantilever 19’  A + E Integration  Max cantilever 10’
<table>
<thead>
<tr>
<th>A</th>
<th>E</th>
<th>MEP</th>
<th>C</th>
<th>Water</th>
<th>Latency</th>
</tr>
</thead>
</table>

Glass Roof
Roof Design

- **Concrete Slab**
  - Primary HSS 4x4x1/8
  - max span 25’
- **Secondary HSS**
  - typ. glass panel 3’x 3’
Seismic Separation @ Roof

u,x = u,y = 2.5" + 2.5" = 5" < 7"

Glass panel

Primary HSS

Secondary HSS

Welded seam

Teflon slider

Stopper

Galvanized steel plate

Water

Latency

A

E

MEP

C

Water

Latency

3.5"

Galvanized steel plate

Stopper

Teflon Slider

Bolt
Level 2

9” PT Flat Slab

8” RC Shear Wall

14” RC Column

20” RC Column

18 x 36 RC Beam

Seismic Separation

9.5’ Cantilever

Bridges (steel)
Bridge Design

Sliding connection

- Steel beam
- Galvanized steel plate
- Teflon slider
- Steel to concrete connection
Climate

- **Reno Precipitation**
  - **Precipitation (inches)**
    - Jan: 1.1, Feb: 1.0, Mar: 0.7, Apr: 0.4, May: 0.7, Jun: 0.5, Jul: 0.3, Aug: 0.3, Sep: 0.4, Oct: 0.4, Nov: 0.9, Dec: 1.0, **Annual: 7.5**
  - **Days with Precipitation 0.01 inch or More**
    - 5.8, 5.2, 4.3, 1.2, 0.8, 0.0, 0.0, 0.0, 0.0, 0.3, 2.4, **24.3**
  - **Monthly Snowfall (inches)**
    - 5.8, 5.2, 4.3, 1.2, 0.8, 0.0, 0.0, 0.0, 0.0, 0.3, 2.4, **24.3**
Primary Systems:
- District Heating
- Chiller (Mechanical room)

Terminal Systems:
- Radiant Floor
- Chilled Ceiling Panels
UNR Heat Plant

Photovoltaic Panels

Grid

Radiant Floor

Cooling  Ventilation System  Lighting  Equipment

A  E  MEP  C  Water  Latency
Glass Ceiling and Atrium provides Daylight and Night Flush
Natural Ventilation
Natural Ventilation
Natural Ventilation
Natural Ventilation
1st Level Ductwork
2nd Level Ductwork
3rd Level Ductwork
Roof Plan
Auditorium UFAD
Auditorium UFAD
Typical Floor Sandwich
Annual Energy Consumption
Annual Energy Consumption (kWh)

- Initial Simulation: 54%
- Envelope Optimization: 72%
- Controls Optimization: 74%
- External Blinds
- Increasing Thermal Comfort
Heat Island Effect

Cool Roof will mitigate Heat Island Effect.
kWh - PPD evolution

- Consumption (kWh/m²)
- PPD (%)

A E MEP C Water Latency
Auditorium Indoor Air quality - Typical Summer Day

Date: 2015-07-15

- Air age, h
- CO2, ppm (vol)
- Relative humidity, %
Auditorium Indoor Air quality - Typical Winter Day
UNR Heat Plant

Photovoltaic Panels

Campus needs

Grid (backup)

37,000 kWh

98,000 kWh

70,500 kWh

Radiant Floor

Cooling, Ventilation System, Lighting, Equipment

A E MEP C Water Latency
Monthly Electric Demand and Production

Production 174,000 KWh
Demand 98,000 KWh
76,000 KWh of excess energy
Sustainability Target Value

Performance Relative to Life Cycle Impact Targets

<table>
<thead>
<tr>
<th>Impact</th>
<th>Target</th>
<th>Project</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon (kgCO2e)</td>
<td>5.631.313</td>
<td>3.800.274</td>
<td>67%</td>
</tr>
<tr>
<td>Energy (MJ)</td>
<td>131.385.813</td>
<td>53.346.657</td>
<td>41%</td>
</tr>
<tr>
<td>Water (kgH2O)</td>
<td>110.021.918</td>
<td>101.212.463</td>
<td>92%</td>
</tr>
<tr>
<td>Ozone (kgCFC11ε)</td>
<td>-</td>
<td>1.61E-01</td>
<td>-</td>
</tr>
</tbody>
</table>

Carbon (kgCO2e) - Water (kgH2O) - Energy (MJ)
### STV Evolution

<table>
<thead>
<tr>
<th>Date</th>
<th>Rainwater Harvesting</th>
<th>Efficient Water Fixtures</th>
<th>Grey Water Reuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25/2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25/3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22/4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Graph

- **Rainwater Harvesting**
- **Efficient Water Fixtures**
- **Grey Water Reuse**

#### Graph Details

- **Y-axis**: 0 - 450
- **X-axis**: 11/2 - 22/4
- **Lines**:
  - Blue: GWP
  - Red: Energy
  - Green: Water

---

*Note: Graph legend and details are included for clear understanding.*
Namibia Beetle

Enhanced Condensation

Patterned Wettability

"Atmospheric Water Capture Using Advanced Nanomaterials" NSF STTR, UIC - NBD Nano
Using the excess energy provided by the PV’s we will cool 325 SF of Nano-Coated Panel to enhance condensation of humidity in wind.
Annual Water Cycle

-750,000 kg

Nano-coated Panels

1,750,000 kg

Water

1,500,000 kg

Latency

0 kg

2,500,000 kg
## LEED Certification

<table>
<thead>
<tr>
<th>Category</th>
<th>Points</th>
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<tbody>
<tr>
<td>Rainwater Management</td>
<td>3</td>
</tr>
<tr>
<td>Heat Island Reduction</td>
<td>2</td>
</tr>
<tr>
<td>Outdoor Water Use Reduction</td>
<td>2</td>
</tr>
<tr>
<td>Indoor Water Use Reduction</td>
<td>6</td>
</tr>
<tr>
<td>Optimize Energy Performance</td>
<td>18</td>
</tr>
<tr>
<td>Renewable Energy Production</td>
<td>3</td>
</tr>
<tr>
<td>Thermal Comfort</td>
<td>1</td>
</tr>
<tr>
<td>Daylight</td>
<td>1</td>
</tr>
<tr>
<td>Acoustic Performance</td>
<td>1</td>
</tr>
<tr>
<td>Surrounding Density/Diverse Uses</td>
<td>2</td>
</tr>
</tbody>
</table>

79 points
Site Plan
Site Walkthrough
Site Layout
Code of Considerate Practice

- Respect the Community
- Care about site appearance
- Value the workforce
- Secure everyone’s safety
- Protect the environment
Protect the Environment

- Wet Curing Blanket
- Reusable Pallets
- Recycling Water used for Wheel Wash
Care about Appearance

- Maintain cleanliness of site
- Enhance appearance of facilities, stored materials, vehicles and equipment
Respect the Community

- Minimize air & noise pollution
- Keep neighbours updated
Secure Everyone’s Safety

- Health and Safety Plan
- Fencing around the site
- Embed initiatives and attitudes that enhance safety performance
Value the workforce

- Care for the health and well being of the workforce
Keeping it Local!
Keeping it Local!
Equipment

Dozer, 70HP Cat
Class Code: 906-2070

CASE 580N Backhoe

LIEBHERR LR1200SX 275 TON
Supports Local Economy
Scheduling
Exterior walls omitted to show interior activities

South Facade

Top View
Milestone #1 - Building Covered Up

Milestone #1
Building Covered Up
Milestone #2 - Computer Lab Completed by May

Milestone #2 Computer Lab Move-In
Schedule - Milestone #3

Milestone #3
Hand-over to Owners
Construction Starts
1st September 2019

Milestone 1:
Computer lab move-in in may

Milestone 2:
Building covered up before January

Milestone 3:
1 year maximum construction duration

Construction Ends
1st August 2020
Constructability
Constructability - Pre-fabricated Formwork
Constructability - Unitized Curtain Wall
Constructability - Prefab MEP

- 10-15% reduction from RSMeans data
- 20-30% less time spent on site
Constructability - Early Elevator Installation

- Elevator can be used to transport people/material for the remaining construction period.
- Less obstruction for elevator sub-contractor
Cost Estimation Approach

TVD

- Discipline Specific Input
- Quantity Take-Offs
- RSMeans
- Contacting Vendors and Mentors
- TVD Shared with Team
Discipline Specific Input
CostX Quantity Take-Offs
### Contacting Vendors and Mentors

<table>
<thead>
<tr>
<th>A</th>
<th>E</th>
<th>MEP</th>
<th>C</th>
<th>Water</th>
<th>Latency</th>
</tr>
</thead>
</table>

- McTech Group
- accessfloor systems
- Office DEPOT

**RAMMED EARTH WORKS**

*Original Rammed Earth*
Terf TVD
# TVD Sheet Explained

## B. SHELL SUMMARY

| TOTAL TARGET | $10,000,000 |
| B. TARGET   | $2,09,735   |
| B. ESTIMATE | $1,952,544 |

## B: Quantity Reliability

- **Low**: 13%
- **Medium**: 52%
- **High**: 35%

## B: Cost Data Reliability

- **Low**: 28%
- **Medium**: 59%
- **High**: 13%

## B: Overall Reliability

- **Low**: 13%
- **Medium**: 52%
- **High**: 35%

## Table: Line Item Description

<table>
<thead>
<tr>
<th>Category</th>
<th>Line Item Description</th>
<th>Description</th>
<th>Unit</th>
<th>Material Cost</th>
<th>Installation Cost</th>
<th>Total Cost</th>
<th>Quantity</th>
<th>Unit</th>
<th>Quantity Reliability</th>
<th>Cost Data Reliability</th>
<th>Overall Reliability</th>
<th>Estimate</th>
<th>Value Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. SHELL</td>
<td>1010102011120 Floor Construction</td>
<td>Cement-plaster concrete, 15’ round, std, 3000’ foot, 10” slab, height, 150 Gal, L-4000’ pm</td>
<td>V.L.F.</td>
<td>$16.61</td>
<td>$31.42</td>
<td>$48.03</td>
<td>307</td>
<td>V.L.F.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>$14,483</td>
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<tr>
<td></td>
<td>1010102030400 Roof Construction</td>
<td>Cement-plaster concrete beam and slab, 15’ slab, box way, 10” column, 20’ x 20’ box, 123 PSF superimposed load, 220 PSF base load – block in 300 MM concrete</td>
<td>S.F.</td>
<td>$8.06</td>
<td>$5.10</td>
<td>$13.16</td>
<td>35691</td>
<td>S.F.</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>$962,615</td>
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</tr>
<tr>
<td></td>
<td>1010102030501 Roof Construction</td>
<td>Concrete beam, post, 15’ x 25’, 300 FR, 3’x 3’, 1.65’ PSF, superimposed load</td>
<td>L.P.</td>
<td>$79.22</td>
<td>$11.25</td>
<td>$90.47</td>
<td>43</td>
<td>L.P.</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>$16,075</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10102101001 Exterior Walls</td>
<td>Brick wall, composite double wall, roman fancy/ common back-up, 6” thick</td>
<td>S.F.</td>
<td>$11.06</td>
<td>$19.29</td>
<td>$30.35</td>
<td>17124</td>
<td>S.F.</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>$117,550</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10102101002 Exterior Windows</td>
<td>Glazing panel, plate glass, 5/8” thick, clear</td>
<td>S.F.</td>
<td>$10.03</td>
<td>$11.27</td>
<td>$21.30</td>
<td>34523</td>
<td>S.F.</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>$86,011</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10102101003 Exterior Doors</td>
<td>Windows, steel, picture window, standard glass, 7 x 7”</td>
<td>S.A.</td>
<td>$66.89</td>
<td>$113.81</td>
<td>$180.70</td>
<td>49</td>
<td>S.A.</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>$39,255</td>
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<tr>
<td></td>
<td>10102101004 Exterior Doors</td>
<td>Windows, steel, picture window, standard glass, 6 x 4”</td>
<td>S.A.</td>
<td>$119.15</td>
<td>$203.75</td>
<td>$322.90</td>
<td>22</td>
<td>S.A.</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>$34,157</td>
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<tr>
<td></td>
<td>10102101005 Exterior Doors</td>
<td>Door, aluminum &amp; glass, with transom, 2 panels, double door, hardware, 6’ 10” x 10’ 0”</td>
<td>Ong.</td>
<td>$3,055.00</td>
<td>$2,027.13</td>
<td>$4,082.13</td>
<td>2</td>
<td>Ong.</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>$12,955</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10102101006 Exterior Doors</td>
<td>Door, aluminum &amp; glass, with transom, double, standard, hardware, 3’ 0” x 10’ 0”</td>
<td>Ong.</td>
<td>$2,921.80</td>
<td>$1,648.13</td>
<td>$4,569.93</td>
<td>4</td>
<td>Ong.</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>$15,223</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10102101007 Exterior Doors</td>
<td>Roofing, single ply membrane, 70 mil, membrane, flash welded seams, single lap and ballasted</td>
<td>S.A.</td>
<td>$1.13</td>
<td>$1.57</td>
<td>$2.70</td>
<td>10000</td>
<td>S.A.</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>$16,455</td>
<td></td>
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<tr>
<td></td>
<td>10102101008 Exterior Doors</td>
<td>Insulation, rigid roof deck, extruded polystyrene, 40 PSI, compressive strength, 6” thick, R20</td>
<td>S.A.</td>
<td>$2.77</td>
<td>$0.82</td>
<td>$3.59</td>
<td>10000</td>
<td>S.A.</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>$30,990</td>
<td></td>
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<tr>
<td></td>
<td>10102101009 Exterior Doors</td>
<td>Roof edges, aluminum, corrugated, 3/200” thick, 6” base</td>
<td>L.P.</td>
<td>$16.35</td>
<td>$14.71</td>
<td>$31.06</td>
<td>380</td>
<td>L.P.</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>$11,828</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10102101010 Exterior Doors</td>
<td>Chord stop, aluminum, extruded, 6”, mild steel, 375” thick</td>
<td>L.P.</td>
<td>$7.90</td>
<td>$4.82</td>
<td>$12.72</td>
<td>380</td>
<td>L.P.</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>$11,828</td>
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</tbody>
</table>
# TVD Budget and Target

<table>
<thead>
<tr>
<th></th>
<th>Budget</th>
<th>Expected Inflation</th>
<th>5 Year Treasury Bond ROI</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Budget</strong></td>
<td>$10,500,000</td>
<td></td>
<td></td>
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<tr>
<td><strong>Expected Inflation</strong></td>
<td>2.34%</td>
<td></td>
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<tr>
<td><strong>5 Year Treasury Bond ROI</strong></td>
<td>1.51%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Target</strong></td>
<td>$10,000,000</td>
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</table>
## Estimate Summary

### ESTIMATE AND TARGET VALUE - SUMMARY

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Substructure</td>
<td>$445,100</td>
</tr>
<tr>
<td>B Shell</td>
<td>$1,952,500</td>
</tr>
<tr>
<td>C Interiors</td>
<td>$936,300</td>
</tr>
<tr>
<td>D Services</td>
<td>$3,309,600</td>
</tr>
<tr>
<td>E Equipment and Furnishing</td>
<td>$67,300</td>
</tr>
<tr>
<td>F Specialty Construction</td>
<td>$509,700</td>
</tr>
<tr>
<td>G Building Sitework</td>
<td>$65,300</td>
</tr>
<tr>
<td>H General Conditions</td>
<td>$2,428,500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$9,714,300</strong></td>
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Tracking Over Time

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>E</th>
<th>MEP</th>
<th>C</th>
<th>Water</th>
<th>Latency</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Replacing RSMeans Data

- 13-Mar
- 16-Mar
- 23-Mar
- 30-Mar
- 6-Apr
- 10-Apr
- 27-Apr
- 6-May
- 8-May

Solar Panels

- 11-Feb
- 20-Feb

Rammed Earth

- Target
- RS Means Original

Graph showing cost tracking over time with different project phases and cost estimates.
5D Cost Flow Analysis

Cash Flow

- Cost
- Cumulative Cost

Duration

- Week 1 to Week 55
Estimation Targets

**Targets**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substructure</td>
<td>6%</td>
</tr>
<tr>
<td>Shell</td>
<td>21%</td>
</tr>
<tr>
<td>Interiors</td>
<td>16%</td>
</tr>
<tr>
<td>Services</td>
<td>47%</td>
</tr>
<tr>
<td>Equipment and Furnishings</td>
<td>1%</td>
</tr>
<tr>
<td>Specialty Construction</td>
<td>$292,479 (3%)</td>
</tr>
<tr>
<td>Building Sitework</td>
<td>$47,343 (1%)</td>
</tr>
<tr>
<td>General Conditions</td>
<td>$535,122 (5%)</td>
</tr>
<tr>
<td>Substructure</td>
<td>$610,361 (6%)</td>
</tr>
<tr>
<td>Services</td>
<td>$4,682,296 (47%)</td>
</tr>
<tr>
<td>Interiors</td>
<td>$1,640,984 (16%)</td>
</tr>
<tr>
<td>Shell</td>
<td>$2,097,735 (21%)</td>
</tr>
</tbody>
</table>
Water Challenge

Water Wall, A
Fly Ash Concrete, SE
Namib Beetle, MEP
Water Efficient/Waterless Fixtures, MEP
Grey Water Reuse, MEP
Recycled Groundwater Wheel Washer, CM
Curing Blanket, CM
Efficiency and latencies on Predicted vs Actual Timescale.

- **Winter**: Predominant work period.
- **Break**: Occasional transition periods.
- **Spring**: Spring Quarter, noted for dramatically reduced work time.

Switching to Drive and latency tracking in Spring Quarter, significantly reducing work time.
Special Thanks to...

Mentors:
Renate Fruchter (Super Mentor and Super Owner)
Prof. Guido Morgenthal (BUW)
Armin Dariz (SOFiSTiK)
Greg Luth (Gregory P. Luth & Associates)
Eduardo Miranda (Stanford)
Luis Rivera (Arup)
Flavia Grey (AEC Alumni)
Erik Kneer (Holmes Culley)
Mark Barlett (Skanska USA)
Fernando Castillo Cohen (AEC Alumni)
Josh Odelson (AEC Alum)
Willem Kymmel (UCS Chico University)
Michael Lauring (AAU)
Andrej Kurent (AEC Alumni)
John Nelson (UW Madison)
Constantine Megaridis (UIC)
Kyle Adams (Arup)

Owners:
Maria Frank
Mike Muller
Ana Sofia
Enrique Hernandez Delgado
Lessons Learned

“When in doubt, ask.”

“Don’t be shy and don’t forget to mute yourself!”

“The power of understanding is immeasurable”

“Never go to bed angry!”

“Dare to ask for input”

“Colocation rocks!”

“The Imperial System rocks! Not”