09 Site Conditions
Site & Challenges

- Earthquake
- Slope 1:8
- L shape
- Ø waste
- $h_{max} = 30'$
- $7.5m$
Concept 1

1. Main core
2. Entrance
3. Students
4. Auditorium

Floor 1

23.75'

23.5'

47.25'

49.5'
1. Main core
2. Small classroom
3. Large classroom
4. Seminar
5. Lab
6. Server
7. Informal reading
1. Main core
2. Informal reading
3. Administration
4. Faculty office
5. Faculty lounge
6. Cactus collection
09 Concept 1

Section

- 15'-6"
- 5'
- 7'
- 5'

- 30'
- 20'-6"
- 8'-6"
- 0'
Concept 1

Volumetric view
Design Loads and Soil Profile

**Loads**
- **Dead Loads** = 100 psf
- **Live Load** = 80 psf
- **Wind Loads**
- **EQ Loads (govern)**
- **Base Shear** = 1850 k

**Soil Profile**
- **Stony Sandy & Heavy Loam**
- **Building Location**
- **Max Story Drift** = 2.65”
- **Water Table**
- **Distance** = 160’
Seismic Lateral System Rationale

Concrete Shear Walls

**PRO**
- Seismic rigidity and stiffness
- Low redundancy towards Zero Waste

**CON**
- Brittle failure in extreme EQ
- High design shear
- Complex reinforcing details

Steel BRBs or EBFs

**PRO**
- BRB market popularity
- Cheaper connections than MR
- Economical
- EBF-doorway allowance
- Low design shear

**CON**
- BRB buckling in extreme EQ
- Locally available EBF contractors
Concept 1 – Floor 1 – CONCRETE

Lateral resistance from shear core
Gravity resistance beam-column-foundation interaction
Concept 1 – Floor 2

~6” Flat Slab with widened column top
Spread v. Mat Foundation

Zero Waste

Forms

Material

1500 psf

Concept 1 – Floor 3
09 Typical Connections

Concrete

- Column 14”x14” #8 bars
- Beam 20”x15.5” #9 bars
- Beam 21”x10” #9 bars
- Tension reinforcement

Steel

- 3 Bolts @ ends of Beams
- 5 Bolts @ ends of Girders
- Req. Development Length = 21.5”
- Girder W16x67
- Beam W10x49
- A325N bolts
- Steel Angle
Concept 1 Cantilever Solution Exploration

E-W Steel Tension Cables

N-S Steel Dual Story Truss

E-W Steel Truss

N-S Steel Mini Truss

Note: Concrete contribution PT slab and inverted beams
Lateral resistance from braced frames
Gravity resistance floor-beam-girder-column-foundation-soil interaction
Concept 1 – Floor 2

- W16x67 Girders
- W12x72 Columns
- W10x49 Beams
Under-floor Air Circulation

Supplemental/Replacement
- Night Flushing, Natural Vent
- Thermal Mass
- Photovoltaic Energy
- Geothermal Energy

ENERGY MONITORING!
12” Under-floor Plenum + 6” flat slab = 1.5’
Concept 1 – Green Roof

- Skylights
- Native gardens
- PVs on cantilevers
Solar Photovoltaic Considerations

Solar Rooftop – owner recoups costs in 8-10 years

- Tax incentives
- Technology & lifespan
- Model assumptions
It is less expensive to purchase used equipment and use it for multiple jobs than to rent.

Assumptions
Used versus new
Write-offs & depreciation
Zero-waste considerations
09 Zero Waste

Concrete with fly ash & reclaimed aggregate

Off-site prefabrication

Reuse excavated soil for topsoil

Scrap art
Safety and Noise Considerations

Safety training
Inform people
Emergency routes
Alternate pedestrian routes
Noise partitions
Concept 1 – Scheduling

Cast in Place Concrete = 679 calendar days = 1.86 years

Start: June 1, 2015
End: April 10, 2017

Steel Structure = 392 calendar days = 1.07 years

Start: June 1, 2015
End: June 28, 2017
## 09 Concept 1 – Concrete Estimate

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Cost/Sf</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FOUNDATION</strong></td>
<td>$433,500</td>
<td>$12.39</td>
<td>5.07%</td>
</tr>
<tr>
<td><strong>SUBSTRUCTURE</strong></td>
<td>$90,900</td>
<td>$2.60</td>
<td>1.06%</td>
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<tr>
<td><strong>SUPERSTRUCTURE</strong></td>
<td>$1,872,500</td>
<td>$53.50</td>
<td>21.91%</td>
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<tr>
<td><strong>EXTERIOR CLOSURE</strong></td>
<td>$1,099,750</td>
<td>$31.42</td>
<td>13.75%</td>
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<tr>
<td><strong>ROOFING &amp; WATERPROOFING</strong></td>
<td>$563,500</td>
<td>$10.66</td>
<td>4.37%</td>
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<tr>
<td><strong>INTERIOR CONSTRUCTION</strong></td>
<td>$1,165,000</td>
<td>$33.29</td>
<td>13.63%</td>
</tr>
<tr>
<td><strong>CONVEYING SYSTEM</strong></td>
<td>$100,000</td>
<td>$2.86</td>
<td>1.17%</td>
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<tr>
<td><strong>MECH,PLUMB, FP</strong></td>
<td>$1,990,000</td>
<td>$56.86</td>
<td>23.29%</td>
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<tr>
<td><strong>ELECTRICAL</strong></td>
<td>$945,000</td>
<td>$27.00</td>
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<tr>
<td><strong>EQUIPMENT</strong></td>
<td>$0</td>
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<tr>
<td><strong>SITEWORK</strong></td>
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<tr>
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<td>$8,544,755</td>
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</table>

**Total Cost:**

- General Conditions (8%): $678,380 ($19.53)
- Fee (5%): $423,988 ($12.21)
- Contingency (10%): $847,975 ($24.41)

**Total Cost:** $10,500,000 ($300.29)

Inflated to 2015 (3% inflation rate): $12,500,000
## 09 Concept 1 – Steel Estimate

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Cost/Sf</th>
<th>Comments</th>
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<tbody>
<tr>
<td>FOUNDATION</td>
<td>$433,500</td>
<td>$12.39</td>
<td>5.27%</td>
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<tr>
<td>SUBSTRUCTURE</td>
<td>$50,500</td>
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<td>SUPERSTRUCTURE</td>
<td>$1,605,000</td>
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<td>$33.29</td>
<td>14.17%</td>
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<td>$8,217,500</td>
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</table>

**Building Gross Square Footage**: 35,000 GSF

**Total Cost**: $10,100,000

*Inflated to 2015 (3% inflation rate): $12,000,000*
09 Concept 2

Location

116'
58'
Concept 2

1. Vertical core
2. Entrance
3. Students
4. Auditorium
5. Plaza

Floor 1
Concept 2

1. Stair
2. Small classroom
3. Large classroom
4. Seminar
5. Lab
6. Server
7. Mechanical shaft
8. Electric room
9. Elevator

Floor 2
1. Core
2. Balcony
3. Administration
4. Faculty office
5. Faculty lounge
Concept 2

Section
Concept 2

Volumetric view
Concept 2 – Floor 1 – CONCRETE

Uniform 19’ spans

24’ cantilever

23’ cantilever

N

Lateral resistance from shear core
Gravity resistance beam-column-foundation interaction
Concept 2 – Floor 2

Uniform 19' spans

~6” Flat Slab
Concept 2 – Floor 3

Spread v. Mat Foundation

Zero Waste

Forms

Material

1500 psf
Concept 2 – Floor 1 – STEEL

Lateral resistance from braced frame
Gravity Resistance girder-beam-column-foundation interaction
Concept 2 – Floor 3

MEP Layout

Zone 1

Zone 2

DOUBLE HEIGHT

VISIBLE STRUCTURE

136′-4″

81′-10″

plummer.augelli.lock.landmann.delgado.yuen.kode
Concept 2 – Green Roof

- Skylights
- Native gardens
- PV on cantilevers
Concept 2 – Scheduling

Cast in Place Concrete = 503 calendar days = 1.38 years

Start: June 1, 2015
End: November 16, 2017

Steel Structure = 350 calendar days = .96 years

Start: June 1, 2015
End: May 16, 2017
Concept 2 – Concrete Estimate

<table>
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<td>11.79%</td>
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### Concept 2 – Steel Estimates

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<td>$937,000</td>
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<td>inflated to 2015 (3% inflation rate)</td>
<td>$10,800,000</td>
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</table>
Overall Cost Comparison

Budget: $7.5 Million

Concrete 1 – $10.5M

Concrete 2 – $9.4M

Steel 1 – $10.1M

Steel 2 – $9.0M
Overall Cost Comparison

![Cost Comparison Chart]

- **Foundation**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Substructure**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Superstructure**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Ext. Closure**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Roof & Waterproofing**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Interior**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Conveying System & Pumps**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Mechanical, Plumbing, Fire Protection**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Electrical**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
- **Site Work**: C1 Concrete, C2 Concrete, C1 Steel, C2 Steel
Overall Cost Comparison

Cost Comparison (In Today’s Dollars)

<table>
<thead>
<tr>
<th>Concept 1</th>
<th>Concept 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>Steel</td>
</tr>
<tr>
<td>Concrete</td>
<td>Concrete</td>
</tr>
</tbody>
</table>

- Steel Concept 1: $10,100,000
- Concrete Concept 1: $10,500,000
- Steel Concept 2: $9,300,000
- Concrete Concept 2: $9,000,000

Budget: $7.5 Million
Team Process

Logistics
  Naming convention
  Filing
Meetings
  The Process
  Between Meetings
  Working The Plan
  Following up

Working Well
  Collaboration of ideas
  Interdisciplinary understanding
  Group problem solving
  Socializing beyond work

Needs Work
  Effective use of to-do list by everyone
  Reviewing work
  Staying on people about deadlines
1:1, Sub-group, Team Communication

**Asynchronous**
- Think Tank™
- E-mail
- Oslo

**Synchronous**
- Skype
- GogroK
- Windows NetMeeting
- Phone
Team Process – Software Interoperability

Revit Model of Concept 1 after importing in ETABS

ETABS Model of Concept 2
SimVision – Organization Modeling

- Organization (Renate, Owner, Ridge)
- Meetings
- Coordination Links
- Rework Links
- Milestones
- Tasks
SimVision Feedback – Work Breakdown

**Goal:** Reduce Rework and Coordination

- A1 Plans
- A2 Plans
- Revise A1
- Structural Sizes/calcs
- Cost Estimate
- Prepare Presentation

Direct Work (5 days)

Work Days

“Hidden Work” (3+ days)
SimVision Feedback – Backlog

Architect has highest backlog (1.4 days)

CMs have end-loaded backlog

Goal: Evenly distribute tasks to reduce backlog to <1dy
Decision Matrix

- C2 Concrete
- C1 Steel
- C2 Steel
- C1 Concrete

Zero Waste (A,E,C)
Adaptability & Workability of Concept (A,E,C)
Perceived Value & Aesthetics (A, E)
Big Idea & Concept Affinity (A)
Efficient Space Planning (A)
Lowest Overall Cost (CM)
Constructability (CM)
Baseline = 0

(A, E, C)
Final Choice – Moving Forward

Explore integration of natural heating & cooling

Explore local materials & native plants

Cultivate value & design aesthetic

Push sustainability in A/E/C design decisions

Zero Waste
Team Process Improvements

- Rework and Coordination (by ½)
- Member Backlog (everyone <1 day)
- Team Efficiency (Deadlines!)
Questions?