TEAM PACIFIC
Team Pacific

CSU Chico, California

Stanford University, California

UW Madison, Wisconsin

Bauhaus University, Germany

WUoT, Poland

 MEP

 LCF
Site - San Francisco State University

Lake View

San Francisco State Campus

Our Site

Seismic Challenge
Wind Rose
Climate Condition

Mean temperature of around 57 degrees Fahrenheit throughout the year (fairly stable conditions)
Climate Conditions

Wind velocity of around 4 m/s throughout the year (range: 2 m/s to 5 m/s)
# Winter Quarter Decision Matrix

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>ConXtech</td>
<td></td>
</tr>
<tr>
<td>Concrete MF</td>
<td></td>
</tr>
<tr>
<td>Steel MF</td>
<td></td>
</tr>
<tr>
<td>EBF</td>
<td></td>
</tr>
<tr>
<td>Team Pacific</td>
<td>309</td>
</tr>
<tr>
<td>Björn (owner)</td>
<td>411</td>
</tr>
<tr>
<td>Anirudh (owner)</td>
<td>407</td>
</tr>
<tr>
<td>total</td>
<td>1127</td>
</tr>
<tr>
<td>309</td>
<td>277</td>
</tr>
<tr>
<td>344</td>
<td>357</td>
</tr>
<tr>
<td>330</td>
<td>320</td>
</tr>
<tr>
<td>345</td>
<td>323</td>
</tr>
<tr>
<td>1013</td>
<td>1019</td>
</tr>
<tr>
<td>1000</td>
<td></td>
</tr>
</tbody>
</table>

The table above shows the decision matrix for different mechanisms (ConXtech, Concrete MF, Steel MF, EBF) across different houses. The numbers represent the decision scores for each mechanism and house combination.
Mechanism Concept
Houses Concept
Team Pacific
Mechanism
Mechanism: how does it work?
Extruded Footprint
Natural Lighting
Natural Lighting
Views, Terraces
Natural Ventilation
Site Location
Second Floor

- Student Offices
- Restrooms
- Seminar Rooms
- Small Classrooms
- Student Lounge
- Larger Classrooms
First Floor

- Technical Suport / Storage Space
- Restrooms
- Auditorium
- Instructional Lab
Interior Rendering
Sections
Structure
# Loads & Soil Profile

<table>
<thead>
<tr>
<th>Live Load</th>
<th>psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>50</td>
</tr>
<tr>
<td>Classroom</td>
<td>40</td>
</tr>
<tr>
<td>Storage (light)</td>
<td>125</td>
</tr>
<tr>
<td>Large Classroom</td>
<td>60</td>
</tr>
<tr>
<td>Lobby</td>
<td>100</td>
</tr>
<tr>
<td>Construction</td>
<td>20</td>
</tr>
<tr>
<td>Corridors</td>
<td>80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well sorted fine to medium Sand</td>
</tr>
<tr>
<td>Bearing Capacity: 3500psf</td>
</tr>
<tr>
<td>Not in Liquefaction Zone</td>
</tr>
<tr>
<td>Water Table: 14ft below Grade</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Seismic Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{ds} = 1.349$ Site Class D</td>
</tr>
<tr>
<td>$S_{d1} = 1.085$</td>
</tr>
</tbody>
</table>

Seismic Controls over Wind
Initial Radial Grid
Initial “Skewed” Grid
Gravity System Decision Process

Challenge: Assign a functional grid to a very complex building shape

Radial Grid
- Accentuates architecture
- Very complex
- Many constructability issues with non-continuous columns

Skewed Grid
- Somewhat regular grid with high degree of repeatability
- Architectural adjustments needed

Rectangular Grid With Skewed Cantilevers
- Very regular grid
- Allows use of ConXtech
- However, relatively shallow bays required for cantilever attachment
1st Floor Plan

Typical Sections:
- W21X101
- W12X19 / W12X22
- W21X44 / W24X55
- W27X84

Largest: W30X108
2nd Floor Plan

Typical Sections:
- W12X19 / W12X22
- W21X44 / W24X55
- Varies

Largest: W30X173
3rd Floor Plan

Typical Sections:
- W14X22 / W14X26
- W21X44
- W27X84

Dimensions:
- 100 ft
- 52 ft
- 25 ft
- 26.25 ft
- 44 ft
- 21.25 ft

Largest: W30X99
62.5 ft Span Floor-to-Floor Truss

**Typical Sizes**
Top and Bottom Chords: W18 X 35 (ConXtech Connected)

Web Members: 2L4 X 4 X 3/4

Critical Compression Member: 2L8 X 8 X 5/8
Lateral System Decision Process

Challenge: Place lateral system with few continuous frames

- Eccentric Brace Frames
  - Better Performance
  - Blocks Floor Plans

- Traditional Moment Frame
  - No interference with Architecture
  - Lack of Frames
  - W Shapes: No bi-axial bending

- ConXtech: Closed Loop
  - Biaxial bending
  - More Frames
  - Regular Grid, short Spans

- ConXtech: More Frames
  - Uneven Rigidity
  - Creates Torsion

- ConXtech: Rigidity
  - Increased Rigidity
  - Decrease Torsion
Lateral System Decision Process

Challenge: Place lateral system with few continuous frames

Traditional Moment Frame

ConXtech

Short Frames in East-West Direction to avoid bi-axial Bending

Continuous Loop with Columns supporting bi-axial Bending
ConXtech Frame

- Local, innovative structural Steel System
- Prequalified, bolted special Steel Moment Connection
- Moment bearing Collar attaches Ends of Beams to Column
- Precision manufacturing

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Center has regular Floor Plan</td>
<td>• Large Auditorium Span</td>
</tr>
<tr>
<td>• Less Welding</td>
<td>• Lack of continuous Columns</td>
</tr>
<tr>
<td>• Faster Erection Time</td>
<td></td>
</tr>
<tr>
<td>• Allows for open Floor Plans</td>
<td></td>
</tr>
</tbody>
</table>
ConXtech Frame

Photo source: ConXtech
Kaiser Permanente
Lateral System

- **ConXL**
  - **Columns:** Concrete filled HSS 16”x16”x5/8”

Photo source: ConXtech
Dynamic Characteristics

<table>
<thead>
<tr>
<th>Mode</th>
<th>Period (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.7634</td>
</tr>
<tr>
<td>2</td>
<td>0.7204</td>
</tr>
<tr>
<td>3</td>
<td>0.7024</td>
</tr>
</tbody>
</table>
Dynamic Analysis Results

- Time History: El Centro 7.1 Magnitude (1940)
- Limiting Interstory Drift Ratio – 0.025
  - (4 stories or less with consideration of partitions for drift amounts ASCE 7-05 Table 12.12.1)
Enabling Detail: Auditorium Span

- 62.5ft long Span over Auditorium
Enabling Detail: Auditorium Span

- Deep Beam or Floor-to-Floor Truss
Deep Beam

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Member</td>
<td>Block Site Lines in Auditorium</td>
</tr>
<tr>
<td>Bolt Ends</td>
<td>Clash with MEP</td>
</tr>
<tr>
<td></td>
<td>Needs larger Column, Custom</td>
</tr>
</tbody>
</table>
Deep Beam
Enabling Detail: Auditorium Span

- Floor-to-Floor Truss

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiffer, less Deflection</td>
<td>More Fabrication</td>
</tr>
<tr>
<td>Top and bottom Chords small</td>
<td>Blocks Hallway to Classroom</td>
</tr>
<tr>
<td>Does not block Site lines</td>
<td></td>
</tr>
</tbody>
</table>

Enabling Detail: Auditorium Span
Enabling Detail: Auditorium Span

- Floor-to-Floor Truss
  - Doors fit under chevron truss
  - Glass walls expose truss elements
Enabling Detail: Auditorium Span

- Typical Truss Connection

- Simple, Bolted Connections
- 1 1/8” A490 Bolts
- 1 ¼” A36 Steel Gusset Plate
Bridged Entrance Connection

- Objective: connect building to street
- Goal: allow lateral movement during earthquake
- Solution: create a roller connection on street side
- Use: neoprene pads
Foundation and Retaining Wall

Isolated Footings

#7 @ 6” c-c

Retaining Wall

Strip Footings

100ft

100ft

6ft

18”

28”

9ft
MEP Design

- Natural Ventilation Focus
  - Stack Effect
  - Windows
- Mechanical System Back-up
  - Active Multi-Service Chilled Beams
- Daylight Controls
  - Timers, Dimmers, Motion Sensors

Ecotect for Analysis
Natural Ventilation
Stack Effect

Central Atrium:
Automatic Louvers and Fans at the Top
Natural Ventilation
Stack Effect

- Automatic Louvers
  - Open Toward Leeward Side
  - Let Enough Air Out for Stack Effect
  - Prevents Air from Entering

- Fans
  - Help With the Air Flow Up the Building
Natural Ventilation
Stack Effect
Natural Ventilation
Stack Effect

Floor 2

Floor 3
Natural Ventilation

Windows

- Windows that open to corridors: Automatic
  - Facilitate Stack Effect
- Windows that open to rooms: Manual Operable
  - Occupant Control
CA Title 24 Requirements
Natural Ventilation

☐ All spaces within 20 ft of an operable window
☐ Openings at least 5% of floor area

Development of arms helped with natural ventilation reaching more parts of the building
ASHRAE WWR Standard

- Window-to-Wall Ratio: 40 % Limit

Mechanism’s WWR: 60%

Shading → Mechanical System → Lighting Efficiency
Smart Windows

- Architect: “no shading devices”
- Hot Days: (tinted) reflect solar Heat away from Building
- Cold Days: (transparent) allow solar Heat into Building
- Reduce Energy Bills by 30%

![Smart Windows](image)

*In Hot Days, the window absorbs solar energy and reflects it back to the environment.*

*In Cold Days, the window allows solar energy to enter the building.*
ASHRAE
Std 55-2004: Comfort Range

3rd Floor Hallways:
- Mean Monthly Outdoor Air Temp: 57°F
- Indoor Operative Temp: 69°F

Adaptive Comfort Model for Nat Vent Spaces
(Applies when occupants have access to operable windows)
New Requirement in 2010:
- Mechanical ventilation in naturally ventilated spaces

Natural Ventilation with
Active Multi-System Chilled Beams
Mechanical System Distribution Tree

FLOOR 1

Server Room Portable A/C Unit

FLOOR 2

Displacement Ventilation

FLOOR 3

Active Multi-Service Chilled Beams

Supply Return
# Airflow Criteria

<table>
<thead>
<tr>
<th>Space</th>
<th>Cfm/sf</th>
<th>Class</th>
<th>Cfm/sf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>0.667</td>
<td></td>
<td>1.083</td>
</tr>
<tr>
<td>Hall</td>
<td>0.250</td>
<td></td>
<td>0.250</td>
</tr>
<tr>
<td>Lab</td>
<td>1.000</td>
<td></td>
<td>1.000</td>
</tr>
<tr>
<td>Lounge</td>
<td>0.667</td>
<td></td>
<td>1.083</td>
</tr>
<tr>
<td>Mechanical Room</td>
<td>0.042</td>
<td></td>
<td>0.042</td>
</tr>
<tr>
<td>Office</td>
<td>0.667</td>
<td></td>
<td>1.083</td>
</tr>
<tr>
<td>Server Room</td>
<td>1.333</td>
<td></td>
<td>1.333</td>
</tr>
<tr>
<td>Storage/Copy</td>
<td>0.042</td>
<td></td>
<td>0.042</td>
</tr>
<tr>
<td>Toilets</td>
<td>1.667</td>
<td></td>
<td>1.667</td>
</tr>
<tr>
<td>Auditorium</td>
<td>0.85</td>
<td></td>
<td>1.105</td>
</tr>
</tbody>
</table>

Baseline (40% WWR)

Mechanism (60% WWR)
MEP Distribution

AHU:
400 fpm face velocity

Main Vertical Supply Duct Size:
25” diameter

Energy-Saving Design: low-velocity AHU, smooth ductwork
Mechanical System
Active Multi-Service Chilled Beams

- Advantages to entire team:
  - Prefabricated (CM)
  - Less Space in Sandwich Height (A/E)
  - Reduced Installation Cost (CM)
  - Low Maintenance Cost (LCFM)
  - Multiple Systems in One Unit (Save Space)
Mechanical System
Active Multi-Service Chilled Beams

- Thermostats (individual Control)
- Sensor on each Chilled Beam
  - Provide only the required Heating/Cooling
  - Linked to Thermostats
  - Dewpoint Temperature Control
ASHRAE Std 55-2004: Comfort Range

1.0 clo = winter indoor clothing
0.5 clo = summer indoor clothing

Operative temperature = average of air temperature and mean radiant temperature

Ranges correspond to +/-0.5 PMV

~0.96 clo
Trousers, Long-Sleeve Shirt, Suit Jacket
# Lighting Design

## ASHRAE Standard 90.1-2007

<table>
<thead>
<tr>
<th>Space Type</th>
<th>LPD (W/sf)</th>
<th>Mechanism (# lamps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office-Open Plan</td>
<td>1.1</td>
<td>683</td>
</tr>
<tr>
<td>Conference/Multi-Purpose</td>
<td>1.3</td>
<td>107</td>
</tr>
<tr>
<td>Corridor/Transition</td>
<td>0.5</td>
<td>142</td>
</tr>
<tr>
<td>Restroom</td>
<td>0.9</td>
<td>47</td>
</tr>
</tbody>
</table>

32-W T-8’s in the multiservice chilled beams
Lighting Strategies
Dimming Controls

- More daylighting around perimeter and below atrium
- Dimming controls in these areas
  - 9% energy savings
Lighting Strategies
Programmed Schedule

- Building Operation Schedule: 6 am – 11 pm
- Timers in Systems to Shut Down Beyond Schedule
  - Everything must be manually controlled after hours
Ecotect Model

- Compare:
  - Baseline
    - fully air-conditioned spaces
  - Natural Ventilation
    - stack effect in corridors
    - mixed mode in rooms
  - Natural Ventilation + Timers
    - fully operable 6 am – 11 pm

Thermal Zone Settings:

Pink: Hallways

Green: Functional Rooms (Offices, Classrooms)

Purple: Server Room, Storage Rooms

Red (unseen on picture): Auditorium
# Energy Consumption

<table>
<thead>
<tr>
<th></th>
<th>Max Heating (kW)</th>
<th>Max Cooling (kW)</th>
<th>Total Heating/Cooling Load (kWh/m²/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>496 kW January 2(^{nd})</td>
<td>588 kW July 2(^{nd})</td>
<td>289 kWh/m²/yr</td>
</tr>
<tr>
<td><strong>Natural Ventilation</strong></td>
<td>550 kW January 2(^{nd})</td>
<td>680 kW July 2(^{nd})</td>
<td>245 kWh/m²/yr</td>
</tr>
<tr>
<td><strong>Natural Ventilation + Dimming + Timers</strong></td>
<td>556 kW January 2(^{nd})</td>
<td>715 kW July 2(^{nd})</td>
<td>190 kWh/m²/yr</td>
</tr>
</tbody>
</table>

34% Saved
Site Layout

- Crane Location #2
- Sloped elevated Road
- Laydown Area: 2500 S.F.
- Storage for Tools and Equipment
- Access Road: 20’ wide 50’ radius 6000 S.F.
- Mobile Crane
- Parking Areas (32 Spaces)
- Recycling/Waste
- 20’ wide roads

Parking Areas (32 Spaces)
Site Layout
Excavation
Site Layout
Steel Erection

3 different crane locations
Equipment

Wheel Loader:
JCB 426 HT
2.5 CY Bucket

Excavator:
JCB JS 260
1.5 CY Bucket

Mobile Crane:
Grove TM 8690

Other Equipment
Aerial Lifts
Forklift
Trucks
Construction Schedule

Project Duration: 237 Days

- ConXtech Completion: 2/4/2016
- Building Complete: 8/23/2016
Construction Model
Target Value Design: Tracking

<table>
<thead>
<tr>
<th></th>
<th>Target Values</th>
<th>Winter Estimate</th>
<th>Mid-Spring</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Substructure</strong></td>
<td>$500,000</td>
<td>$</td>
<td>$455,054</td>
<td>$694,000</td>
</tr>
<tr>
<td><strong>Shell</strong></td>
<td>$2,100,000</td>
<td>$2,700,000</td>
<td>$1,901,067</td>
<td>$2,362,000</td>
</tr>
<tr>
<td><strong>Interiors</strong></td>
<td>$1,200,000</td>
<td>$1,070,000</td>
<td>$1,056,082</td>
<td>$1,126,000</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>$3,000,000</td>
<td>$2,950,000</td>
<td>$2,944,000</td>
<td>$3,119,000</td>
</tr>
<tr>
<td><strong>Building Sitework</strong></td>
<td>$700,000</td>
<td>$700,000</td>
<td>$700,000</td>
<td>$626,000</td>
</tr>
<tr>
<td><strong>Total Project Estimate</strong></td>
<td>$7,500,000</td>
<td>$7,880,000</td>
<td>$7,056,203</td>
<td>$7,927,000</td>
</tr>
</tbody>
</table>
Target Value Design: Tracking

-$\times$ Target Values

-$\times$ Winter Estimate

-$\times$ Mid-Spring

-$\times$ Final

- Substructure
- Shell
- Interiors
- Services
- Building Sitework
Construction Costs

- Building Sitework: 8%
- Substructure: 9%
- Services: 39%
- Interiors: 14%
- Shell: 30%

Total Estimate: $7,927,000
Natural Ventilation vs. HVAC

return on equity
Regression Coefficients

- cost of construction: -0.94
- electricity: -0.93
- cost of steel: -0.30
- maintenance: -0.13
- heating: -0.12
- cleaning: -0.06
- caretaker: -0.04
- public charges: -0.03
- security: -0.02
- cost of concrete: -0.02
- insurance: -0.01
- others: -0.01
- water: 0.01

@RISK Student Version
For Academic Use Only
Return on Equity

Return on Equity without Natural Ventilation with HVAC ➔ 4%

Return on Equity with Natural Ventilation ➔ 11%
Life Cycle Financial Structure

Rent: $820,000
Break-even Point in year 11
Replacements

25 year Senior Loan
9 year Junior Loan
Vertical Axis Wind Turbines
VAWT – Vertical Axis Wind Turbine

- **Savings:**
  - 10% of total Energy Costs

- **Payback:**
  - After 12 years
**LEED Certification**

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable Site</td>
<td>23 / 26</td>
</tr>
<tr>
<td>Water Efficiency</td>
<td>0 / 10</td>
</tr>
<tr>
<td>Energy and Atmosphere</td>
<td>21 / 35</td>
</tr>
<tr>
<td>Materials and Resources</td>
<td>7 / 14</td>
</tr>
<tr>
<td>Indoor Environmental Quality</td>
<td>13 / 15</td>
</tr>
<tr>
<td>Innovation in Design</td>
<td>6 bonus</td>
</tr>
<tr>
<td>Regional Priority</td>
<td>4 bonus</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>64</strong></td>
</tr>
</tbody>
</table>
Swinerton Challenge: Native

- Site Plan:
  - “Adapting to and Integrating with the Site.”
- ConXtech
  - “Supporting Local Suppliers and Innovators”
- Bridged Entrance
  - “Embracing the City and its Public Transit”
- Vertical Axis Wind Turbines
  - “Integrating with Nature”
- Natural Ventilation
  - “Adapting to and Blending to Our Environment”
Swinerton Challenge: Native

- Site Plan:
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Swinerton Challenge: Native

- Natural Ventilation
  - “Adapting to and Blending to Our Environment”
BIM Coordination

- AUTOCAD
- REVIT ARCH
- REVIT MEP
- ECOTECT
- ETABS
- REVIT STR
- NAVISWORKS
- MS PROJECT
- EXCEL
- VICO CONSTRUCTOR
- ECOTECT
Model Integration

Architecture – Structure clashes
Model Integration

Structure– MEP clashes
Model Integration

Architecture – MEP clashes
Team Communication
Team Communication
Team Communication
Team Communication
It is sort of fun to do the impossible – it just requires communication, communication and communication.

I hear what you are saying but I don’t understand what you are saying.
Final Reflections
Architects, …, Architects

Do you understand what I am doing?
Nothing is delivered on time unless you push for it.

Learn to trust all your teammates. Work to gain their trust as well.
Final Reflections
Yes, yes. I will do that right away.

No, I am not clicking anymore!
Thank You

Renate Fruchter
Björn Wündsch
Anirudh Rao
Greg Luth
Helmut Krawinkler
Eric Borchers
Henry Tooryani
Professor Kolderup
Dennis Kwan
Dustin Rothwell
Matthias Ehrlich
John Nelson
Afaan Naqvi