PROJECT DESCRIPTION:
- San Francisco State University
- Engineering building (new classroom & laboratory facility)
- Home for innovation
- Team approach to engineering
SITE CONTEXT

Lake Merced
Natural Surroundings
High School
Site Slope
Seismic Zone
Shopping center
SFSU Campus

OPPORTUNITIES
CHALLENGES
HAZARDS

Heavy Traffic
SITE CONTEXT CLIMATE

WIND ROSE - SAN FRANCISCO
- Prevailing wind from SW


TEMPERATURE & PRECIPITATION - SAN FRANCISCO
- Moderate climate with low precipitation levels

EXPEDITE
footprint  podiunm & modules  in and out = more light  rainwater collection
BUILDING ENTRANCES
VIEW FROM SOUTH
SECOND FLOOR PLAN

- Instructional Lab (1823 SF tot.)
- Seminar Room (895 SF tot.)
- Small Classroom (2392 SF tot.)
- Stairs (+ Circulation= 2596 SF tot.)
- Student Lounge (294 SF tot.)
- Student Office (1565 SF tot.)

2nd Floor Total Area = 9565 SF
THIRD FLOOR PLAN

Administrative Assistants
Department Chair's Office
Faculty Lounge
Faculty Office
Senior Admin. Office
Stairs
SECOND FLOOR ATRIUM VIEW
TYPICAL FACADE
SITE CONDITIONS

SEISMIC CONDITIONS

SOIL CONDITIONS & WATER TABLE

WELL SORTED MEDIUM SAND

BEARING CAP. 3500 PSF

14 ft
## TYPICAL BUILDING LOADS

### LIVE LOADS

<table>
<thead>
<tr>
<th>USE</th>
<th>UNIFORM LOAD (PSF)</th>
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<tbody>
<tr>
<td>Offices</td>
<td>50</td>
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<tr>
<td>Faculty offices</td>
<td></td>
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<tr>
<td>Department Chair’s offices</td>
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<tr>
<td>Senior Administration Office</td>
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<td>Student Offices</td>
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<td>Administrative Assistants</td>
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<tr>
<td>Corridors (1st Floor)</td>
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<td>Corridors (above 1st Floor)</td>
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<td>Classroom</td>
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<tr>
<td>Large classrooms</td>
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<tr>
<td>Small classrooms</td>
<td></td>
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<tr>
<td>Seminar rooms</td>
<td></td>
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<tr>
<td>Stairs/Exits</td>
<td>100</td>
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<tr>
<td>Auditorium</td>
<td>60</td>
</tr>
<tr>
<td>Lobbies</td>
<td>100</td>
</tr>
</tbody>
</table>

### LATERAL LOADS

- 217 kips
- 374 kips
- 531 kips
- 1,122 kips
STRUCTURAL DESIGN PROCESS

A Design

Non load-bearing modules

Load-bearing modules

Simple frame & facade elements
EXPEDITE SE SOLUTIONS

BOX MODULAR

MAIN STRUCTURE
GRAVITY: conXtech frame w/composite deck
LATERAL: Moment frame

MODULAR STRUCTURE
GRAVITY: concrete podium, light gauge steel frame
LATERAL: podium shear walls, plywood shear walls

SKELETON MODULAR

GRAVITY: conXtech frame w/composite deck
LATERAL: Moment frame
FOUNDATION: Isolated footings
BOX - MODULE DETAILS

MODULE A.1

MODULE A.2

MODULE A.3

Plywood 3/8"
BOX - **LEVEL 1 PLAN**

- **20x20” concrete column** (floors 1-2)
- **16x32” concrete girder**
- **Concrete podium** (load-bearing walls)
- **Elevator core**
BOX - LEVEL 2 PLAN

- **ConXL (16 x 16")** (floors 2-4)
- Concrete podium underlay
- Steel moment frame

**MODULE A**
- 25'-4" x 9.5'

**MODULE B**
- 15' x 12'
  - (bathroom)
**BOX - LEVEL 3 PLAN**

- ConXL (16 x 16")
  (floors 2-4)
- Concrete podium underlay
- Steel moment frame

**MODULE A**
25'-4" x 9.5'

**MODULE B**
15' x 12'
(bathroom)

Windows
A.2
Open

Doors (interior)
A.3
Open
BOX CONNECTION DETAIL

Field bolting

Back-to-back clip angles

Light gauge module joist

Plywood floor panel
BOX - LOAD PATH
SKELETON - LEVEL 1 PLAN

ConXL (16 x 16")
SKELETON - LEVEL 2 PLAN

ConXL (16 x 16")

Typical W30 section

Facade element A.1
(25'-4" x 3')

Facade element B.1
(36' x 6'-4")

Facade element C.1
(12' x 3'
ConXL (16 x 16")

Typical W30 section

Facade element A.1
(25'-4" x 3')

Facade element B.1
(12' x 3')

Facade element B.2
(12' x 6'-4")

Facade element D.1
(19' x 3")
SKELETON - SECTION CUT

- Light-weight metal roof
- ConXtech moment frame
- Elevator core
- Composite floor
- Retaining walls
- Façade panel element
- Isolated footings
SKELETON - CONXTECH DETAIL

conXL connection

Tieback anchored retaining wall
SKELETON - LOAD PATH
Passive HVAC Design Strategies

Comfort Target
Passive HVAC Design Strategies

- Comfort Target
- Windows sun shading
- Thermal mass
- Internal heat gaining
- Passive solar direct gain
- Outdoor wind protection
- Heating
DAYLIGHT FACTOR

Passive HVAC Design Strategies
- Windows sun shading
- Internal heat gaining
- Passive solar gain
DAYLIGHT FACTOR

Passive HVAC Design Strategies
- Windows sun shading
- Internal heat gaining
- Passive solar gain
WATER HARVESTING POTENTIAL

ANNUAL RAINFALL: 504 g/ft²

ROOF AREA: 10,108 g/ft²

HARVEST POTENTIAL 13,940 g/day
5,087,975 g/yr
1. MIXED OVERHEAD

Central AHU (VAV + reheat) + Chiller Plant +

Air-cooled condenser or Water-cooled condenser

Terminals:
Diffusers + Return diffusers

2. Displacement Ventilation (DV)

Central DOAS (VAV + reheat) or roof DOAS (VAV + reheat)

Chiller plant +

Air-cooled condenser Water-cooled condenser

Terminals:
DV diffusers + Return diffusers
MIXED OVERHEAD - LEVEL 2 PLAN

Supply
Return
Centralized atrium exhaust
Inlet
Exhaust
Vertical Duct
MEP room/shaft

Structural Grid
MIXED OVERHEAD - LEVEL 3 PLAN

- Supply
- Return
- Centralized atrium exhaust
- Inlet
- Exhaust
- Vertical Duct
- MEP room/shaft

Structural Grid
MIXED OVERHEAD - SECTION

Central AHU (VAV + reheat) + Chiller plant + Air - cooled condenser
Water - cooled condenser

Terminals: Diffusers + Return diffusers

Supply
Return
Water down pipe
DV - LEVEL 2 PLAN

Supply
Return
Centralized atrium exhaust
Inlet
Exhaust
Vertical Duct
MEP room/shaft

Structural Grid
DV - LEVEL 3 PLAN

- Supply
- Return
- Centralized atrium exhaust
- Inlet
- Exhaust
- Vertical Duct
- MEP room/ shaft
- Structural Grid
DV - SECTION

Central DOAS (reheat) or + Chiller plant + Air - cooled condenser
ROOF DOAS (reheat) Water - cooled condenser

Terminals: DV diffusers + Return diffusers
HVAC DECISION MATRIX

Design aspects

Indoor comfort aspects
- ASHRAE-Building type: Secondary school

- Energy Use Intensity Target: 25 kBtu/sqft-yr
EXPEDITE - PRELIMINARY STV

ARCH BOX MEP

ARCH SKELETON MEP
### EXPEDITE - CURRENT STV

#### BOX

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>TARGET</th>
<th>PROJECT</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARBON</td>
<td>3,714,897</td>
<td>4,754,854</td>
<td>128</td>
</tr>
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<td>ENERGY</td>
<td>120,509,807</td>
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<td>127</td>
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<td>WATER</td>
<td>73,347,945</td>
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#### SKELETON

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<td>CARBON</td>
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<td>394</td>
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</table>
EQUIPMENT LIST

1350-6.1  **LIEBHERR**

Bobcat S630

GEHL DL7-44

**Case Excavator**

Front Loader

Boom Lift
Specialty Contractors

- Site
- Concrete Batch Plant
- Lumber Supplier
- Steel Supplier
- Building Trades Council (Union Labor)
- Modular Fabrication
- Equipment Rental
- ConXTech
- Schedule Savings ~20%
- Safer
- Climate Controlled
ConXtech decreases erection time

Tieback walls for soil retention
CONST. PROGRESSION - BOX

LEVEL 2 MODULE PLACEMENT - 12/20/19
TVD - BOX vs. SKELETON

$9.5 Million

$9.2 Million

G Building Sitework, $490,000, 5%
H General Conditions, $650,000, 7%
A Substructure, $710,000, 7%
F Specialty Construction, $640,000, 7%
E Equipment and Furnishing, $600,000, 6%
D Services, $2,700,000, 28%
C Interiors, $1,500,000, 15%
B Shell, $2,500,000, 25%

G Building Sitework, $490,000, 5%
H General Conditions, $650,000, 7%
A Substructure, $500,000, 5%
F Specialty Construction, $640,000, 7%
E Equipment and Furnishing, $600,000, 6%
D Services, $2,700,000, 29%
C Interiors, $1,600,000, 17%
B Shell, $2,200,000, 24%
SCHEDULE COMPARISON

BOX MODULAR

Start: 9/2/2019
End: 5/6/2020

SKELETON MODULAR

Start: 9/2/2019
End: 5/27/2020
SCHEDULE COMPARISON

TAKEAWAY: Box Alternative is ~3 weeks shorter due to less time on interiors.
EVOLUTION

“Through a process of continuous improvement and evolution...” ~ SF State
footprint 
extrusion

rotation =
evolution

dynamic
shape

second skin
BUILDING ENTRANCES
SECOND FLOOR PLAN

- Instructional Lab
- Circulation and Stairs
- Restrooms
- Seminar Rooms
- Small Classrooms
- Storage
- Student offices
ENTRANCE AREA VIEW
SECOND SKIN STUDY
REFERENCE PROJECTS
STRUCTURAL DESIGN PROCESS

- Vertical Columns
- Triangular Skin
- Steel frame
- Concrete braced shell
STRUCTURAL SOLUTIONS

STEEL
GRAVITY: Internal steel frame w/ composite deck
LATERAL: Buckling restrained brace frame
FOUNDATION: Driven piles

CONCRETE
GRAVITY: Concrete columns w/ post-tensioned slabs
LATERAL: post-tensioned concrete core and perimeter concrete braced frames
FOUNDATIONS: Footings & wall foundation
STEEL - LEVEL 1 PLAN

- Typical W14 column
- Typical W14 slanted Column
STEEL - LEVEL 2 PLAN

- Typical W14 column
- Typical W14 slanted Column
- Typical W21 girders
- Buckling-restrained braces
STEEL - LEVEL 3 PLAN

- Typical W14 column
- Typical W14 slanted Column
- Typical W21 girders
- Buckling-restrained braces
STEEL - LOAD PATH

Gravity Loads
Lateral Loads
Welded as shear connection

Steel plate
CONCRETE - LEVEL 1 PLAN

- 18" concrete columns (w/6 x 6' drop panels)
- Concrete braced shell
- 9' x 9' footings
- 3.6' foundation wall
CONCRETE - LEVEL 2 PLAN

- 18" concrete columns (w/ 6 x 6' drop panels)
- Concrete braced shell
- Precast concrete girders
  - Span < 30ft = 12" x 18"
  - Span > 30ft - 43ft = 12" x 28"
CONCRETE - LEVEL 3 PLAN

18" concrete columns
(w/ 6 x 6’ drop panels)

Concrete braced shell

Precast concrete girders
Span < 30ft = 12” x 18”
Span > 30ft - 43ft = 12” x 28”
POST TENSIONING DETAIL

Anchor bearing plate
Concrete truss frame
Anchor head
Post-tension tendon
CONCRETE - LOAD PATH

Gravity Loads
Lateral Loads
DAYLIGHT FACTOR

Passive HVAC Design Strategies
- Windows sun shading
- Internal heat gaining
- Passive solar gain
DAYLIGHT FACTOR

Passive HVAC Design Strategies
- Windows sun shading
- Internal heat gaining
- Passive solar gain
WATER HARVESTING POTENTIAL

ANNUAL RAINFALL: 504 g/ft²

ROOF AREA: 10,430 g/ft²

HARVEST POTENTIAL
14,380 g/day
5,249,255 g/yr
1. MIXED OVERHEAD

Central DOAS (VAV + reheat) or Roof DOAS

(Central WSHP) Chiller Plant +

Air-cooled condenser or water-cooled condenser

Terminals:
Diffusers + Return diffusers
(Fan coils) (Chill beams)

2. Displacement Ventilation (DV)

Central DOAS (VAV + reheat) or roof DOAS (VAV + reheat)

(Central WSHP) Chiller plant +

Air-cooled condenser
Water-cooled condenser

Terminals:
DV diffusers + Return diffusers
MIXED OVERHEAD - LEVEL 3 PLAN

- Supply
- Return
- Plenum Outline
- Inlet
- Exhaust
- Vertical Duct
- MEP room/ shaft

Structural Grid
MIXED OVERHEAD - SECTION

Central DOAS (VAV + reheat) + Chiller plant + Air - cooled condenser (WSHP) Water - cooled condenser

Terminals: Diffusers + Return diffusers
DV - LEVEL 1 PLAN

- Supply
- Return
- Plenum Outline
- Inlet
- Exhaust
- Vertical Duct
- MEP room/ shaft
DV - LEVEL 2 PLAN

- Supply
- Return
- Plenum Outline
- Inlet
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Structural Grid
DV - LEVEL 3 PLAN

- Supply
- Return
- Plenum Outline
- Inlet
- Exhaust
- Vertical Duct
- MEP room/shaft

Structural Grid
DV - SECTION

Central DOAS (reheat) or Chiller plant + Air - cooled condenser
ROOF DOAS (reheat) (WSHP) Water - cooled condenser

Terminals: DV diffusers + Return diffusers
HVAC DECISION MATRIX

Design aspects

Indoor comfort aspects

Synergy with Architecture/Weather /Site
Constructability /assembling & desassembling
Space impact /floor
Space impact /ceiling
Aesthetics impact
Noise & Vibration
Design Flexibility

Mo [S3]  DV [S5]

Mo [S3]  DV [S5]

Indoor Air Quality
Particulate Control
Temperature Control
Exhaust Capability
Humidity Control
ASHRAE - Building type: Secondary school

Site Energy Use Intensity Target: 25 kBtu/sqft-yr
## EVOLUTION - CURRENT STV

### STEEL

<table>
<thead>
<tr>
<th>Impact</th>
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<tbody>
<tr>
<td>Carbon</td>
<td>3,714,897</td>
<td>4,363,543</td>
<td>117</td>
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<tr>
<td>Energy</td>
<td>120,509,807</td>
<td>138,696,681</td>
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<td>Water</td>
<td>73,347,945</td>
<td>290,754,462</td>
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### CONCRETE

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<tr>
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<tr>
<td>Water</td>
<td>73,347,945</td>
<td>297,310,083</td>
<td>405</td>
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</table>
Concrete Piles

Steel Erection
CONCRETE

Shoring Scaffolding

Precast
SITE ACCESS - EVOLUTION

- Entrance
- Site
- Close N State Dr.
- Re-Route
CONSTRUCTION PROGRESSION

LAST TRIANGLE PLACEMENT - 2/7/20
CONSTRUCTION PROGRESSION

TERRACE/LANDSCAPING - 6/25/20
TVD - Steel vs. Concrete

$9.7 Million

- G Building Sitework, $480,000, 5%
- H General Conditions, $420,000, 4%
- A Substructure, $710,000, 7%
- F Specialty Construction, $1,100,000, 11%
- E Equipment and Furnishing, $680,000, 7%
- D Services, $2,600,000, 27%
- C Interiors, $1,600,000, 16%
- B Shell, $2,300,000, 23%

$9.9 Million

- G Building Sitework, $540,000, 5%
- H General Conditions, $520,000, 5%
- A Substructure, $800,000, 8%
- F Specialty Construction, $1,100,000, 11%
- E Equipment and Furnishing, $680,000, 7%
- D Services, $2,600,000, 26%
- C Interiors, $1,600,000, 16%
- B Shell, $2,240,000, 22%
Schedule Comparison

STEEL

Start: 9/2/2019
End: 8/7/2020

CONCRETE TRIANGLES

Start: 9/2/2019
End: 8/26/2020
TOOLS TO ENSURE SAFETY/QUALITY

Report Hazards

Blueprints and Plans

Task Management

Team Exercises

Backup Plans

Plan of the Day
DECISION
SCHEDULE COMPARISON

- **35WEEKS**
  - Prelim: 3 weeks
  - SubStruct: 10.5 weeks
  - Shell: 10.5 weeks
  - Interior: 7 weeks
  - Closeout: 4 weeks

- **38 WEEKS**
  - Prelim: 3 weeks
  - SubStruct: 11 weeks
  - Shell: 9 weeks
  - Interior: 11 weeks
  - Closeout: 4 weeks

- **48 WEEKS**
  - Prelim: 3 weeks
  - SubStruct: 8 weeks
  - Shell: 11 weeks
  - Interior: 14 weeks
  - Landscape & Façade: 5 weeks
  - Closeout: 5 weeks

- **51 WEEKS**
  - Prelim: 3 weeks
  - SubStruct: 10 weeks
  - Shell: 14 weeks
  - Interior: 14 weeks
  - Landscape & Façade: 5 weeks
  - Closeout: 5 weeks
# Alternatives Summary

<table>
<thead>
<tr>
<th></th>
<th>Box</th>
<th>Skeleton</th>
<th>Steel</th>
<th>Concrete</th>
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<tbody>
<tr>
<td><strong>Construction Time</strong></td>
<td>35 weeks</td>
<td>38 weeks</td>
<td>48 weeks</td>
<td>51 weeks</td>
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<td><strong>Early Occupancy Date</strong></td>
<td>05/06/20</td>
<td>05/27/20</td>
<td>08/07/20</td>
<td>08/26/20</td>
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<tr>
<td><strong>Construction Cost</strong></td>
<td>$9.5 million</td>
<td>$9.2 million</td>
<td>$9.7 million</td>
<td>$9.9 million</td>
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<td><strong>GWP (kg CO2-eq)</strong></td>
<td>4,754,854</td>
<td>5,636,275</td>
<td>4,363,543</td>
<td>9,733,475</td>
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<td><strong>Energy (MJ) 50 Years</strong></td>
<td>153,297,052</td>
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</table>
DECISION MATRICES

EXPEDITE - BOX

EXPEDITE - SKELETON

EVOLVE - STEEL

EVOLVE - CONCRETE
# TEAM PROCESS - PLATFORMS

<table>
<thead>
<tr>
<th>PLATFORM</th>
<th>USERS</th>
<th>PURPOSE</th>
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<tbody>
<tr>
<td>TERF</td>
<td>All team, Renate, owners</td>
<td>Weekly meetings</td>
</tr>
<tr>
<td>SLACK</td>
<td>All team</td>
<td>Formal team communication</td>
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<tr>
<td>GOTOMEETING</td>
<td>All team</td>
<td>Team/subcommittee meetings</td>
</tr>
<tr>
<td>SPAN</td>
<td>All team</td>
<td>Process</td>
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<tr>
<td>REVIT</td>
<td>All team</td>
<td>Graphical documentation</td>
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<tr>
<td>A360</td>
<td>All team</td>
<td>BIM - Revit collaboration</td>
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<tr>
<td>GOOGLE DRIVE</td>
<td>All team, owners</td>
<td>Archive and documentation</td>
</tr>
<tr>
<td>BOX</td>
<td>All A/E/C teams, Renate</td>
<td>Course files &amp; deliverables</td>
</tr>
<tr>
<td>BIM360 GLUE</td>
<td>All team</td>
<td>Clash detection</td>
</tr>
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- **Communication**
- **Collaboration**
- **Coordination**
ZERO CLASHES!
THANK YOU