Middlebury Elementary
By MiddZEST
Introduction

Context
Building
Systems
Energy
Finance
Design Goals

Affordable Efficiency

Visible Engineering

Inspirational Beacon

Experiential Collaboration

Resilient Design
Design Goals

Affordable Efficiency

Visible Engineering

Inspirational Beacon

Experiential Collaboration

Resilient Design
Design Goals

- Affordable Efficiency
- Experiential Collaboration
- Visible Engineering
- Inspirational Beacon
- Resilient Design
Design Goals

Affordable Efficiency

Visible Engineering

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Resilient Design
Design Goals

- Affordable Efficiency
- Visible Engineering
- Inspirational Beacon
- Experiential Collaboration
- Resilient Design
Design Considerations
Visible Engineering

Town Square
Collaboration Spaces
Classrooms
Passive Strategies

3" Concrete thermal mass for absorption and radiation of heat energy

Sunshade to block summer sun

“Daylight” windows allow for light to enter further into room

Summer Solstice
Midday Sun

Winter Solstice
Midday Sun
Summer Solstice Shading
Winter Solstice Shading
Codes and Constructability

NFPA 101
National Electrical Code
Uniform Plumbing Code
International Building Code
Vermont Accessibility Codes
ADA Compliant
NFPA 101
National Electrical Code
Uniform Plumbing Code
International Building Code
Vermont Accessibility Codes
ADA Compliant
NFPA 101
National Electrical Code
Uniform Plumbing Code
International Building Code
Vermont Accessibility Codes
ADA Compliant
Envelope: Wall Assembly

- Interior Paint Finish (Class 3 Vapor Retarder)
- 0.5" Interior Gypsum Board
- 2" x 6" Steel Stud Framing
- 6" Blown-In Cellulose Cavity Insulation in Stud Bay, R-23
- 0.5" Exterior Gypsum Board Sheathing
- Fluid-Applied Air, Water, & Vapor Barrier (R-Guard VB)
- Armatherm Z-Girt Structural Thermal Break
- 7.5" Exterior Mineral Wool Insulation, R-30
- Corrugated Steel Cladding
Envelope: Slab-to-Wall

- 4" Concrete Slab
- 4" PVC Rainwater Drainage
  Pipe Buried Below Grade
- 1'6" Thickened Concrete Edge
- Sill Gasket: Armatherm 500 Structural Thermal Break
- Metal Mesh Between Siding and Insulation: Insect Protection
- Fluid-Applied Air, Water, & Vapor Barrier on 0.5" Exterior Gypsum Board
- 7.5" Exterior Mineral Wool Insulation, R-30
- Corrugated Steel Cladding

Continuous 60-mil Polyethylene Sheet:
Underslab Air and Vapor Barrier
Envelope: Roof

Resilient Design

Coarse Gravel Ballast

60-mil EPDM Roof Membrane

0.5" Exterior OSB

4" Wooden Sleepers

18.75" Exterior Mineral Wool Insulation, R-75

Fluid-Applied Air, Water, & Vapor Barrier (R-Guard VB)

0.5" Exterior Gypsum Board

3" Corrugated Roof Deck

3' Spanning I-Beam
Circulation Pumps
Hydraulic Separator
Expansion Tank
Glycol Refill Tank

ClimateMaster TZ024
ClimateMaster TE049
ClimateMaster TE064

Heating and Cooling
Resilient Design

Most Efficient 2018
Glycol Refill Tank
Expansion Tank
Manifold Vault
Circulation Pumps
Hydraulic Separator
Bore Holes

Heat Pump Types
- ClimateMaster TZ024
- ClimateMaster TE049
- ClimateMaster TE064

Heating and Cooling

Resilient Design
Reduce Electrical Loads

- Thoughtful Daylighting
- Efficient Light Fixtures
- An Intelligent Control System
- Centralized Appliances
Traditional Tank Based Hot Water

- Additional Plumbing And Maintenance Costs
- Constant Energy
- Constant Energy Loss Moving Hot Water Long Distances
Traditional Tank Based Hot Water

- Additional Plumbing And Maintenance Costs
- Constant Energy
- Constant Energy Loss Moving Hot Water Long Distances

Decentralized Point Source Hot Water

- Demand Based Energy Use
- Minimal Energy Loss In Hot Water Delivery
- Longer Lifespan
Energy Efficiency Measures

Source EUI (kbtu/ft²/yr)

- Base
  - 197.5

- Existing School 102.2
Energy Efficiency Measures

Source EUI (kbtu/ft²/yr)

Base
197.5

AEDG
186.8

Existing School 102.2
Energy Efficiency Measures
Energy Efficiency Measures
Energy Efficiency Measures
Energy Efficiency Measures
Energy Efficiency Measures
Design Parameters

Climate Zone 6A

7,186 Heating Degree Days

677 Cooling Degree Days
Panasonic HIT N330
19.7%

1,244 panels
330 W
410.48 kW array

29°
Total Construction Costs: $17.8 Million

Median New England Elementary School Cost\(^1\): $400/ft\(^2\)

Middlebury Elementary Cost: $250/ft\(^2\)
**Financial Analysis**

- $180,000.00
- $160,000.00
- $140,000.00
- $120,000.00
- $100,000.00
- $80,000.00
- $60,000.00
- $40,000.00
- $20,000.00
- $0.00

**Electricity**

**Propane**

**Fuel Oil**

**Water and Sewer**

**Waste**

**Snowplowing**

**Profit**

**Solar Production Credit**

**Affordable Efficiency**

**Mary Hogan Elementary**

**Middlebury Elementary**
ii. Team Information

Zach Berzolla
Physics '18
Team Lead and Project Manager

Amanda Kirkeby
Physics '19
Energy Model

Ben Belinski
Physics '18
MEP

Priyanjali Sinha
SOAN '18
Envelope & Landscape Design

Bennett Doherty
Physics '18
MEP

Tom Buzell, principal of Mary Hogan, provided guidance on programme design and current operating costs.

Max Lutzius
Economics & Physics '20.5
Envelope

Jack Allnut
HARC '20.5
Envelope & Architecture

Greg Sellers provided insight on the structural systems required to support our building.

Karen Kobayashi
HARC '18.5
Architecture

Elliott Friedman
HARC '19
Architecture

Wayne Nelson and Derek Snyder provided guidance on choosing our HVAC system and how to create a system layout.

Alex Browne
Physics '18
Building Codes, MEP

Olivia Ryder
HARC & Studio Art '19
Architecture & Interior Design

Maria Abragan
ES/Geography '18
Interior Design

Gigi Miller
Comp. Sci. & Studio Art '18
Interior Design

Katie Aman
SOAN '19
Deliverables

Ty Storey-Fisher
ES/Policy '18
Deliverables

Thomas Wentworth
ES/Psych '18
PV & Interior Design

Emma McDonagh
HARC '19
Architecture & Interior Design

Jaci Kirby-Miller '14.8 provided envelope design reviews.

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• Middlebury’s President
• Middlebury’s Office of Sustainability Integration
• Middlebury’s Environmental Affairs Department

Works Cited

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• Vermont by Maria Darron from the Noun Project
• Green engine by Attilio Baghino from the Noun Project
• Faucet by Alina Oleynik from the Noun Project
• Faucet by Georgiana Ionescu from the Noun Project
• Dollar coin by Musmellow from the Noun Project
• School by Ayub Irawan from the Noun Project
Appendix: Floor Plan
Appendix: Floor Plan
### South-Facing Windows

<table>
<thead>
<tr>
<th>Specification</th>
<th>Size (l x h)</th>
<th>Quantity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed</td>
<td>4' x 4'</td>
<td>43</td>
<td>Center windows in each South-facing classroom. All windows on the 2nd story South-facing wall.</td>
</tr>
<tr>
<td>Operable Tilt</td>
<td>4' x 4'</td>
<td>32</td>
<td>Two outer-most windows in each South-facing classroom, all exterior windows in the Administration neighborhood.</td>
</tr>
<tr>
<td>Fixed</td>
<td>4' x 2'</td>
<td>77</td>
<td>Above all view windows. One additional window in each South-facing bathroom on the 2nd floor.</td>
</tr>
</tbody>
</table>

### North-Facing Windows

<table>
<thead>
<tr>
<th>Specification</th>
<th>Size (l x h)</th>
<th>Quantity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operable Tilt</td>
<td>4' x 4'</td>
<td>34</td>
<td>Outer-most windows in each North-facing classroom on the 2nd floor. Outer-most windows on the first floor groups of 3.</td>
</tr>
<tr>
<td>Fixed</td>
<td>4' x 2'</td>
<td>63</td>
<td>Above all view windows.</td>
</tr>
<tr>
<td>Fixed</td>
<td>2' x 4'</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

### East-Facing Windows

<table>
<thead>
<tr>
<th>Specification</th>
<th>Size (l x h)</th>
<th>Quantity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed</td>
<td>4' x 4'</td>
<td>1</td>
<td>Multipurpose Room</td>
</tr>
<tr>
<td>Fixed</td>
<td>2' x 4'</td>
<td>2</td>
<td>Stairwell</td>
</tr>
</tbody>
</table>

### West-Facing Windows

<table>
<thead>
<tr>
<th>Specification</th>
<th>Size (l x h)</th>
<th>Quantity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed</td>
<td>4' 2&quot; x 8' 2&quot;</td>
<td>2</td>
<td>2nd floor above the main staircase to view the PV array</td>
</tr>
<tr>
<td>Operable Tilt</td>
<td>4' x 4'</td>
<td>2</td>
<td>Administration neighborhood</td>
</tr>
<tr>
<td>Fixed</td>
<td>4' x 2'</td>
<td>2</td>
<td>Above view windows in Administration neighborhood</td>
</tr>
</tbody>
</table>
1st FLOOR PLAN

SCALE: 1/32" = 1'-0"

Appendix: Furniture Layout
Appendix: Envelope Details
Appendix: Envelope Details

- Door Trim
- 2" x 6" Steel Stud Wall
- 6" Blown-in Cellulose in Stud Bay
- 0.5" Gypsum Exterior Sheathing
- Fluid-Applied Air, Water, & Vapor Barrier
- Z-Shaped Metal Jamb Flashing
- Vertical Armatherm Z-Girt
- 7.5" Mineral Wool Rigid Insulation
- Corrugated Steel Cladding
- Corrugated Steel Cladding
- Steel Flashing
- 0.5" Gypsum Exterior Sheathing
- Fluid-Applied Air, Water, & Vapor Barrier
- 2" x 6" Steel Stud Wall
- 6" Blown-in Cellulose in Stud Bay
- Door Frame Head
- Backer Rod
- Caulk

- Door
- Caulk
- Door Trim
- Backer Rod
- Continuous 60-mil Polyethylene Sheet: Underslab Air and Vapor Barrier
- 4" Concrete Slab
- Drainage Slope
- Sill Gasket; Armatherm 500 Structural Thermal Break
- Steel Flashing
Architectural Drawings

Appendix: Electrical and Light Fixtures

- Lithonia Lighting [B] ‐ GRD ID800LMF 80/20 120 80 27K
  - Light Loss Factor: 1
  - Lamp Lumens: 3172
  - Wattage: 24.9

- Suspension Length: 2 ft
- Lamp Quantity: 1

- 480/277 Feeder Lines to Breaker Panels
- 120/208 Feeder Lines to Breaker Panels
- 20 Amp Lighting Circuit, 10-Gauge Wire
- 20 Amp General Purpose 1 Pole Circuit, 10-Gauge Wire, AFCI Protected
- Dedicated 20 Amp 2 Pole Heat Pump Circuit, 12-Gauge Wire, with Fuse
- Dedicated 40 Amp Heat Pump Circuit, 6-Gauge Wire, with Fuse
- Dedicated 20 Amp Ventilation 2 Pole Circuit, 10-Gauge Wire, with Fuse
- Dedicated 60 Amp Ventilation 3 Pole Circuit, 4-Gauge Wire, with Fuse
- Dedicated 30/40/60 Amp Point Source Water Heating Circuit, 6/4 Gauge Wire
- Dedicated 20 Amp Kitchen Circuit, 10-Gauge Wire
- Dedicated 20 Amp Air Compressor / Sprinkler System Circuit, 10-Gauge Wire, with Fuse

- 3 phase power transformer
- 100 Amp 3 Phase Power 120/208 General Purpose Breaker Panel (each circuit single pole)
- 150 Amp 3 Phase Power 480/277 Lighting Breaker
- 150 Amp 3 Phase Power 120/208 Small Mechanical System Breaker Panel
- 150 Amp 3 Phase Power 120/208 Small Mechanical System Breaker Panel
- 300 Amp 3 Phase Power 480/277 Large Mechanical System Breaker Panel

3/24/2018
Saturday, March 24, 2018

These lighting calculation results are for general informational purposes only and are provided without warranty as to accuracy, completeness, reliability or otherwise. Results are based on user provided data and data provided from publicly available sources; actual field conditions may affect calculated output. Visit www.Visual‐3D.com.
Appendix: Heating and Cooling
## Assembly Category - Name

<table>
<thead>
<tr>
<th>RS Means Line No.</th>
<th>Quantity (units)</th>
<th>Unit</th>
<th>Description</th>
<th>Notes Required?</th>
<th>Justification/Note (for values different than RSMeans Estimate)</th>
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</thead>
</table>

### Building Exterior

#### Exterior Walls

<table>
<thead>
<tr>
<th>RS Means Line No.</th>
<th>Quantity (units)</th>
<th>Unit</th>
<th>Description</th>
<th>Notes Required?</th>
<th>Justification/Note (for values different than RSMeans Estimate)</th>
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#### Exterior Windows

<table>
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<th>RS Means Line No.</th>
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<th>Description</th>
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</table>

#### Roof

<table>
<thead>
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<th>RS Means Line No.</th>
<th>Quantity (units)</th>
<th>Unit</th>
<th>Description</th>
<th>Notes Required?</th>
<th>Justification/Note (for values different than RSMeans Estimate)</th>
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</table>

#### Slab on Grade

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<th>Description</th>
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<th>Justification/Note (for values different than RSMeans Estimate)</th>
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</table>

### Interior

#### Floor

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<th>Description</th>
<th>Notes Required?</th>
<th>Justification/Note (for values different than RSMeans Estimate)</th>
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#### Ceiling

<table>
<thead>
<tr>
<th>RS Means Line No.</th>
<th>Quantity (units)</th>
<th>Unit</th>
<th>Description</th>
<th>Notes Required?</th>
<th>Justification/Note (for values different than RSMeans Estimate)</th>
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</table>

#### Ceiling

<table>
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<tr>
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<th>Description</th>
<th>Notes Required?</th>
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## RSMeans Estimate

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<th>RS Means Line No.</th>
<th>Quantity (units)</th>
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<th>Description</th>
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#### RSMeans Estimated Subtotal

<table>
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<th>RS Means Line No.</th>
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<th>Notes Required?</th>
<th>Justification/Note (for values different than RSMeans Estimate)</th>
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#### Team Estimate Cost

<table>
<thead>
<tr>
<th>RS Means Line No.</th>
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<th>Description</th>
<th>Notes Required?</th>
<th>Justification/Note (for values different than RSMeans Estimate)</th>
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## Notes Required?

- [ ] NO
- [ ] YES

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<table>
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<tr>
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<th>Justification/Note (for values different than RSMeans Estimate)</th>
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## Notes Required?

- [ ] NO
- [ ] YES

## Justification/Note (for values different than RSMeans Estimate)

- [ ] Quote from manufacturer.
- [ ] Needs pricing.
- [ ] Needs reevaluation.
- [ ] Needs additional information.
- [ ] Miscellaneous.

## Assembly Cost

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## Notes Required?

- [ ] NO
- [ ] YES

## Justification/Note (for values different than RSMeans Estimate)

- [ ] Quote from manufacturer.
- [ ] Needs pricing.
- [ ] Needs reevaluation.
- [ ] Needs additional information.
- [ ] Miscellaneous.
## Services

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Cost</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Plumbing: Toto Ultravac 4 toilets</td>
<td></td>
<td>3</td>
<td>$202.00</td>
<td></td>
</tr>
<tr>
<td>Plumbing: Sloan WSS-1000 waterurinals</td>
<td></td>
<td>3</td>
<td>$223.00</td>
<td></td>
</tr>
<tr>
<td>Plumbing: Rohl 1501 No-Rust Stainless Steel Drinking Fountains</td>
<td></td>
<td>3</td>
<td>$472.50</td>
<td></td>
</tr>
<tr>
<td>Plumbing: Escoflet Poor</td>
<td></td>
<td>14</td>
<td>$8,182.27</td>
<td></td>
</tr>
<tr>
<td>Plumbing: Escoflet 11 (1500 page on 49E)</td>
<td></td>
<td>1</td>
<td>$220.00</td>
<td></td>
</tr>
<tr>
<td>Plumbing: Escoflet Eco 27</td>
<td></td>
<td>9</td>
<td>$328.23</td>
<td></td>
</tr>
<tr>
<td>Plumbing: American Standard D555.301.052.05 GPM In-Line Electronic Frosty Faucet</td>
<td></td>
<td>1</td>
<td>$320.00</td>
<td></td>
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<tr>
<td>Plumbing: Lasco wall mounted tall faucet</td>
<td></td>
<td>1</td>
<td>$244.68</td>
<td></td>
</tr>
<tr>
<td>Plumbing: American Standard 4&quot; Centennial Goosneck Faucet</td>
<td></td>
<td>1</td>
<td>$244.68</td>
<td></td>
</tr>
<tr>
<td>Plumbing: High Sierra S5.5 GPM Low Flow Faucet Mist</td>
<td></td>
<td>6</td>
<td>$1,464.32</td>
<td></td>
</tr>
<tr>
<td>Plumbing: Commercial Kitchen Sink NSF-345-3 Compartment</td>
<td></td>
<td>1</td>
<td>$3,650.00</td>
<td></td>
</tr>
<tr>
<td>Plumbing: ABB A-GLT</td>
<td></td>
<td>1</td>
<td>$137.00</td>
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</tr>
<tr>
<td>Electrical: Interior cable wiring</td>
<td></td>
<td>12</td>
<td>$2,031.00</td>
<td></td>
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<tr>
<td>Electrical: Interior Motion Sensor</td>
<td></td>
<td>12</td>
<td>$3,006.00</td>
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</tr>
<tr>
<td>Electrical: Lutron Maestro Sensor Switch</td>
<td></td>
<td>12</td>
<td>$3,006.00</td>
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<tr>
<td>Electrical: Interior Garage door kit</td>
<td></td>
<td>1</td>
<td>$635.00</td>
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<tr>
<td>Electrical: Interior flora</td>
<td></td>
<td>1</td>
<td>$326.00</td>
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<tr>
<td>Electrical: Leviton 20 Amp-125 Volt Duplex Self-Test Tamper Resistant/Rain Weather Resistant GFCI Outlet</td>
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<td>106</td>
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<td>Electrical: 20 Amp Tamper Resistant Duplex Outlet, Wire</td>
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<tr>
<td>Electrical: Homeline 100 Amp 60-Space 40-Circuit Indoor Main Breaker Plug On Neutral Load Center</td>
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<td>60</td>
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<tr>
<td>Electrical: 40 Circuit Indoor Main Breaker</td>
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<td>$8,850.00</td>
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<tr>
<td>Electrical: 20 Amp Commercial Grade Self Grounding Duplex Outlet Floor Box Brass</td>
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<td>Electrical: Homeline 40 Single Pole GFCI Circuit Breaker</td>
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<tr>
<td>Electrical: Transformer, 240V, 6000W/277V, 15A/16A</td>
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<td>$2,224.00</td>
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<td>Electrical: Homeline 20 Amp A-GT Single Pole Circuit Breaker</td>
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<td>$74.00</td>
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<tr>
<td>Elevator: Hydralift passenger elevator options, 46, pipe, base, unit 150 lb. 100' 9 floor 2 stop std 14 24 13 20 130 290</td>
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<td>1</td>
<td>$601,500.00</td>
<td>$59,692.99</td>
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<tr>
<td>Mechanical: Ductwork</td>
<td></td>
<td>4000</td>
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<tr>
<td>Mechanical: Pipe insulation</td>
<td></td>
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<td>$134.00</td>
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<tr>
<td>Mechanical: Equipment</td>
<td></td>
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<td>$18,450.00</td>
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<tr>
<td>Mechanical: Condenser drain</td>
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<td>1</td>
<td>$18,450.00</td>
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<tr>
<td>Mechanical: Roof leak protection and installation</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical: Startup and commissioning services for 1 year</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fire protection: Portable fire extinguishers, CO2, with hose and &quot;H&quot; horns, 15 lb.</td>
<td></td>
<td>10</td>
<td>$880.00</td>
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</tbody>
</table>

**Total Cost:** $730,996.10

## Structure

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure: Bracing, shear wall, bracing, per 10' x 10' beam, one face, metal strap, 20 ga x 6&quot; wide</td>
<td>$265.95</td>
</tr>
<tr>
<td>Structure: Columns, structural, steel, concrete-filled, extra strong pipe, 6&quot; diameter</td>
<td>$262.40</td>
</tr>
<tr>
<td>Structure: Steel structural members, shop fab'd for 100 ton, 1-2 story project, bolted connections, 6'10&quot; x 10' over, 10'9&quot; floor to ceiling, 10'9&quot; ceiling to roof</td>
<td>$241,940.44</td>
</tr>
<tr>
<td>Structure: Open web joists, K series, 30' x 50' spans, ZEKIL, 13/8 lb./ft.</td>
<td>$322.40</td>
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</tbody>
</table>

**Total Cost:** $417,906.44

**Note:** We added this line to include items that are outside of the scope of our design.