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Summary of Changes

Significant changes to the project manual that have occurred between submissions have been outlined below. The Construction Drawings should also be reviewed for relevant revisions.

2-14-2013 Revision

The Project Manual has been updated from the previous issue. Revisions include:

- We have removed one of the three modules making the total number of housing modules two. This reduced our total square footage to 622 sq.ft. as well as reduced the amount of MEP connections between modules to simplify the system and reduce costs.
- Our landscape and foundation designs have been modified. Our deck and landscape now exist strictly between the rails in order to reduce materials and costs as well as to focus jury and visitor attention on that interstitial space. Our foundation is no longer a series of individual piers but rather a continuous grade-beam footing that has been designed with both rapid assembly and timely removal in mind.
- Our canopy and PV integration have been modified and now appear geometrically more rectangular. Each canopy is installed on a series of drawer sliders allowing the canopies to telescope ten feet in both directions. So to summarize, there are two housing modules that move in the East/West direction on rails, and each module has its own canopy that telescopes in the East/West direction on large scale telescoping drawer sliders. As a result of these changes we have revised our safety system and information, as well as our tour and jury schedule in order for movement to occur around the competition schedule. This was done to gain energy and performance benefits.
- Our module delivery and operations strategy has been adjusted to meet our design changes. We are now using a more standard drop-deck transport with crane and spreader bar configuration. We plan to spend the first 3 full days of assembly building our foundation and landscape and then crane the two modules onto the rails around day 4.
- Our MEP systems have changed to respond to the design changes. The amount of plumbing and electrical cable reels was reduced due to the removal of a module from the design. The majority of the MEP system, with the exception of some of the sprinkler system and some electrical, has been focused to the East module, which is the mechanical and plumbing core. The HVAC system is only installed in this module with vents located at what is the center of the house when it is fully closed. We have sourced the appropriate electrical cable and hose types based on the unique requirements of our mobile system and have designed a typical maintenance schedule to be included in our larger narrative.
- Solar Thermal has been added to the South elevation of the East/core module, and is tied directly into our plumbing system. In order to maintain a level of symmetry in terms of design, we have designed in similar looking features on the South elevation of the West module (a hammock) and the North elevations of both modules (a deck to our mechanical room and a removable Thule rack for bike and surfboard storage.)
4-5-2013 Revision
The Project Manual has been updated from the previous issue. Revisions include:

- Added hose reel specs.
- Added outdoor cable information.
- Added Plumbing Sheets.
- Added Instructions/Manuals for Macerator.
- Added Instructions/Manuals for D380 Inverter.
- Added hose reel specs as well as a water maintenance schedule to sheets E-603 and P-602.

5-8-2013 Revision
The Project Manual has been updated from the previous issue. Revisions include:

- Updated E601, E602 to correct indoor grounding wire size error and subpanel breaker rating to reflect NEC 705.12.
- Updated breaker information in Project Manual to include the 75 A breakers for the subpanel, rather than 100 A.

8-22-2013 Revision
The Project Manual has been updated from the previous issue. Revisions include:

- Added tour reconfiguration schedule to Summary of Reconfigurable Features
- Added Engineering Analysis Results and Discussion
- Added info on safety equipment
- Added info on motors
- Added info on motor controllers
- Updated PV Equipment – using Hanwha and Tigo equipment
- Updated Mechanical Equipment – using Mitsubishi equipment
- Replaced cable and hose reels with cable carriers
- Updated smart devices
- Added lights
- Updated bathroom fixtures
- Updated pipes – now using CPVC pipes from Lubrizol
- Updated flexible hoses
- Removed West panelboard
- Updated electrical plans reflecting changes
- Updated main panelboard
- Updated insulation
- Added structural platforms to house on north and south
## Rules Compliance Checklist

<table>
<thead>
<tr>
<th>RULE</th>
<th>RULE DESCRIPTION</th>
<th>LOCATION DESCRIPTION</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 4-2</td>
<td>Construction Equipment</td>
<td>Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site</td>
<td>O-101</td>
</tr>
<tr>
<td>Rule 4-2</td>
<td>Construction Equipment</td>
<td>Specifications for heavy machinery</td>
<td>O-101</td>
</tr>
<tr>
<td>Rule 4-3</td>
<td>Ground Penetration</td>
<td>Drawing(s) showing the locations and depths of all ground penetrations on the competition site</td>
<td>S-401, XC-201</td>
</tr>
<tr>
<td>Rule 4-4</td>
<td>Impact within the Solar Envelope</td>
<td>Drawing(s) showing the location, contact area, and bearing pressure of every component resting directly within the solar envelope</td>
<td>G-101</td>
</tr>
<tr>
<td>Rule 4-5</td>
<td>Generators</td>
<td>Specifications for generators (including sound rating)</td>
<td>O-101</td>
</tr>
<tr>
<td>Rule 4-6</td>
<td>Spill Containment</td>
<td>Drawing(s) showing the locations of all equipment, containers, and pipes that will contain liquids at any point during the event</td>
<td>H-101</td>
</tr>
<tr>
<td>Rule 4-6</td>
<td>Spill Containment</td>
<td>Specifications for all equipment, containers, and pipes that will contain fluids at any point during the event</td>
<td>H-101</td>
</tr>
<tr>
<td>Rule 4-7</td>
<td>Lot Conditions</td>
<td>Calculations showing that the structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists</td>
<td>STAMPED CALCS (ATTACHED)</td>
</tr>
<tr>
<td>Rule 4-7</td>
<td>Lot Conditions</td>
<td>Drawing(s) showing shimming methods and materials to be used if 18 in. (45.7 cm) of vertical elevation change exists on the lot</td>
<td>XC-201</td>
</tr>
<tr>
<td>Rule 5-2</td>
<td>Solar Envelope Dimensions</td>
<td>Drawing(s) showing the location of all house and site components relative to the solar envelope</td>
<td>G-101</td>
</tr>
<tr>
<td>Rule 5-2</td>
<td>Solar Envelope Dimensions</td>
<td>List of solar envelope exemption requests accompanied by justifications and drawing references</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 6-1</td>
<td>Structural Design Approval</td>
<td>List of, or marking on, all drawing and project manual sheets that will be stamped by the qualified, licensed design professional in the stamped structural submission; the stamped submission shall consist entirely of sheets that also appear in the drawings and project manual</td>
<td>STAMPED CALCS (ATTACHED)</td>
</tr>
<tr>
<td>Rule 6-2</td>
<td>Finished Square Footage</td>
<td>Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically</td>
<td>G-101, A-100</td>
</tr>
<tr>
<td>Rule 6-2</td>
<td>Finished Square Footage</td>
<td>Drawing(s) showing all movable components that may increase the finished square footage if operated during contest week</td>
<td>A-100</td>
</tr>
<tr>
<td>Rule 6-3</td>
<td>Entrance and Exit Routes</td>
<td>Drawing(s) showing the accessible public tour route</td>
<td>G-101</td>
</tr>
<tr>
<td>Rule 7-1</td>
<td>Placement</td>
<td>Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system</td>
<td>XC-101</td>
</tr>
<tr>
<td>Rule 7-2</td>
<td>Watering Restrictions</td>
<td>Drawing(s) showing the layout and operation of greywater irrigation systems</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 8-1</td>
<td>PV Technology Limitations</td>
<td>Specifications for photovoltaic components</td>
<td>E-102</td>
</tr>
<tr>
<td>Rule 8-3</td>
<td>Batteries</td>
<td>Drawing(s) showing the location(s) and quantity of all primary and secondary batteries and stand-alone, PV-powered devices</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 8-3</td>
<td>Batteries</td>
<td>Specifications for all primary and secondary batteries and stand-alone, PV-powered devices</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 8-4</td>
<td>Desiccant Systems</td>
<td>Drawing(s) describing the operation of the desiccant system</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 8-4</td>
<td>Desiccant Systems</td>
<td>Specifications for desiccant system components</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 8-5</td>
<td>Village Grid</td>
<td>Completed interconnection application form</td>
<td>(ATTACHED)</td>
</tr>
<tr>
<td>Rule 8-5</td>
<td>Village Grid</td>
<td>Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means</td>
<td>E-102</td>
</tr>
<tr>
<td>Rule 8-5</td>
<td>Village Grid</td>
<td>Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means</td>
<td>E-603</td>
</tr>
<tr>
<td>Rule 8-5</td>
<td>Village Grid</td>
<td>One-line electrical diagram</td>
<td>E-601</td>
</tr>
<tr>
<td>Rule 8-5</td>
<td>Village Grid</td>
<td>Calculation of service/feeder net computed load per NEC 220</td>
<td>E-603</td>
</tr>
<tr>
<td>Rule 8-5</td>
<td>Village Grid</td>
<td>Site plan showing the house, decks, ramps, tour paths, and terminal box</td>
<td>G-101</td>
</tr>
<tr>
<td>Rule 8-5</td>
<td>Village Grid</td>
<td>Elevation(s) showing the meter housing, main utility disconnect, and other service</td>
<td>A-403</td>
</tr>
<tr>
<td>Rule 9-1</td>
<td>Container Locations</td>
<td>Drawing(s) showing the location of all liquid containers relative to the finished square footage</td>
<td>A-100</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Rule 9-1</td>
<td>Container Locations</td>
<td>Drawing(s) demonstrating that the primary supply water tank(s) is fully shaded from direct solar radiation between 9 a.m. and 5 p.m. PDT or between 8 a.m. and 4 p.m. solar time on October 1</td>
<td>A-100</td>
</tr>
<tr>
<td>Rule 9-2</td>
<td>Team-Provided Liquids</td>
<td>Quantity, specifications, and delivery date(s) of all team-provided liquids for irrigation, thermal mass, hydronic system pressure testing, and thermodynamic system operation</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 9-3</td>
<td>Greywater Reuse</td>
<td>Drawing(s) showing the layout and operation of greywater reuse systems</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 9-4</td>
<td>Rainwater Collection</td>
<td>Drawing(s) showing the layout and operation of rainwater collection systems</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 9-6</td>
<td>Thermal Mass</td>
<td>Drawing(s) showing the locations of liquid-based thermal mass systems</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 9-6</td>
<td>Thermal Mass</td>
<td>Specifications for components of liquid-based thermal mass systems</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 9-7</td>
<td>Greywater Heat Recovery</td>
<td>Drawing(s) showing the layout and operation of greywater heat recovery systems</td>
<td>N/A</td>
</tr>
<tr>
<td>Rule 9-8</td>
<td>Water Delivery</td>
<td>Drawing(s) showing the complete sequence of water delivery and distribution events</td>
<td>O-102</td>
</tr>
<tr>
<td>Rule 9-8</td>
<td>Water Delivery</td>
<td>Specifications for the containers to which water will be delivered</td>
<td>O-102, P-104</td>
</tr>
<tr>
<td>Rule 9-9</td>
<td>Water Removal</td>
<td>Drawing(s) showing the complete sequence of water consolidation and removal events</td>
<td>O-102</td>
</tr>
<tr>
<td>Rule 9-9</td>
<td>Water Removal</td>
<td>Specifications for the containers from which water will be removed</td>
<td>O-102, P-104</td>
</tr>
<tr>
<td>Rule 11-4</td>
<td>Public Exhibit</td>
<td>Interior and exterior plans showing entire accessible tour route</td>
<td>G-101</td>
</tr>
</tbody>
</table>
Stamped Structural Calculations

Please See Appendix A for Stamped Structural Calculations.
## Detailed Water Budget

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>WATER USE (GALLONS)</th>
<th>CALCULATIONS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Draws</td>
<td>240</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Water Vaporization</td>
<td>6</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>24</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Clothes Washer</td>
<td>105</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>Vegetation</td>
<td>20</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>50</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>Thermal Storage Tanks</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Testing</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Systems Fill</td>
<td>10</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Solar Thermal Collectors</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aesthetic Purpose</td>
<td>185</td>
<td></td>
<td>185 gal. poured Directly Into Outdoor Water Feature</td>
</tr>
<tr>
<td>Radiant Flooring</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Factor</td>
<td>320</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WATER REQUIRED</strong></td>
<td><strong>985</strong></td>
<td></td>
<td>gallons</td>
</tr>
</tbody>
</table>
Executive Summary

DALE, the Dynamic Augmented Living Environment, welcomes the Solar Decathlon 2013 to sunny southern California. Inspired by the region’s wonderful climate, dramatic geography, and adventurous lifestyle, SCI-Arc/Caltech’s net zero, rail-mounted, active dwelling system carries the architectural tradition of the adobe, bungalow, and Case Study Houses into the twenty-first century. Demonstrating advances in programmatic flexibility, climatic tuning, and size variability – made possible by its unique capability for multi-scale/axis movement – DALE sits lightly but lives large, requiring less space and no net energy consumption to match the unsustainably bloated lifestyle claims of the current investment-driven, supersized housing trends.

DALE is the product of needing a home that is designed to speak to the uniqueness of southern California: a home that is as active as the people who reside in it. Its design takes the residential outdoor connection from visible to tangible and allows the inhabitants the flexibility to configure it to fit their daily needs. DALE is comprised of two modules that work as well in unison as they do individually. These modules come together for conditioning and security purposes when needed but are designed to multiply inhabitable square footage and take advantage of southern California’s ideal climate conditions. Varying configurations allow for the experience of multiple microclimates through drought-tolerant California native landscapes. DALE is an innovative, net-zero energy, solar powered home that will change the way homeowners interact with their environment.

DALE is a dynamic living environment running exclusively on solar power gathered through integrated photovoltaic panels on a performative second skin. This second skin rack telescopes on the same axis as the houses movement, creating a collection configurations that benefit the user both in terms of comfort and energy. The 5.5 kW system works in tandem with an evacuated tube solar thermal collection system for water heating that will ensure a net-zero outcome without sacrificing user comfort or expectations. DALE’s flexibility allows the home to react to climate changes and optimize comfort level through passive systems that reduce its energy footprint. The electrical system relies on the use of day lighting and incorporates the use of energy efficient LED lighting, appliances, and electronics. A sophisticated home monitoring and control system meters every aspect of electricity and water consumption in real time and allows the home and users to regulate their behavior.

DALE learns from two classic California precedents: the super-sized suburban tract home and the compact, sufficient bungalow; amending one and expanding on the other to become a sweet new southern California typology. At 600 square feet it is a micro house with an unprecedented flexible interior that results in the program of a house three times the size. Suspended movable partitions in one module give the occupants two bedrooms, a living room, an office, or an open space for entertaining, while the other module provides a generous kitchen, sand-room, separate bathroom, and a mechanical room where the real energy-efficient magic happens. Couple this interior flexibility with the home’s movement, and the options are nearly unlimited.
Summary of Unlisted Electrical Components

To our knowledge, there are no unlisted electrical components in the present design.
Summary of Reconfigurable Features

House Modules:

DALE is divided into two modules, both of which are situated on a rail system. This allows the house to exist as one connected whole or as separate segments capable of positioning themselves at different locations – across the long axis of the site – depending on the desired configuration or on the varying energy requirements of the house. This reconfigurable feature is supported by a user controlled, motorized end truck system complete with thermal seals and safety sensors between modules. All plumbing and electrical connections are housed in a durable, flexible cable carrier system that runs below the landscape grade at the north end of the site.

Interior Walls:

The West module contains two detachable moving partitions that allow the user to redeem multiple compartmentalized spaces from one larger space. Within each side of each partition is an integrated program surface, where different amenities unfold to accommodate different configurations. This flexible system allows DALE to perform like a house twice its size, all the while providing a comfortable one bedroom house layout when the partitions are in their default position.

Sliding Canopy:

Both the East and West modules of DALE are equipped with highly performative solar sliders that act as a sleeve on each unit. In their default positions, these second skin/canopies hug the modules on three surfaces; the top and the North and South short elevations. These components are installed on 2-way telescoping sliders, allowing them to extend one whole modules length in either direction, creating yet more potential in the variety of spaces in and around DALE, as well as adjusting shade at different times of the day, and on different days of the year. Hanwha photovoltaic panels are attached to the top of the sliders, thus creating comfortable amounts of shade while still allowing subtle rays of California sunshine to spill through. The housing modules can roll apart while the canopy sliders stay in place, creating an enclosed mid-yard and embracing the benign West-coast climate. Additionally, the sliders can move with the sun throughout the day to prevent solar thermal heat gain at the interior spaces. This feature compliments DALE's choreographic design, where residents benefit from the efficiency of a micro-home as well as the unprecedented flexibility of a purely dynamic housing typology.

Reconfigurations During Tour Hours

The team intends to showcase the motion of the home at various times during the day. To reduce tour interruptions, these movements will only take place at the opening and closing of the house and once during the middle of the day.
Morning: Open Modules

Modules start in closed configuration. Modules are then moved apart while watched by team members, temporary ramps are placed and secured, and then tours begin.

Afternoon: Reconfigure Modules

At about 2:25pm the tour line will be halted, and the last tour will exit the house. Team members will remove the temporary ramps. Team members will check to ensure that the area around the modules is clear, and another team member will control the modules to move. After the modules are moved back and forth, they will return to one of the tour configurations. Team members will then restore the temporary ramps, and continue tours. The entire process is expected to take 10 mins, and no more than 15 mins.

Evening: Close Modules

At the end of tours or at the end of a movie/dinner night, the house modules will be closed. Team members will watch the area to ensure it is clear during this process.

Movement Schedule:

<table>
<thead>
<tr>
<th>Day</th>
<th>Open Modules</th>
<th>Reconfigure Modules</th>
<th>Close Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 11</td>
<td>11:00am</td>
<td>2:30pm</td>
<td>7:00pm</td>
</tr>
<tr>
<td>Day 12</td>
<td>11:00am</td>
<td>2:30pm</td>
<td>11:00pm</td>
</tr>
<tr>
<td>Day 13</td>
<td>11:00am</td>
<td>2:30pm</td>
<td>7:00pm</td>
</tr>
<tr>
<td>Day 14</td>
<td>11:00am</td>
<td>2:30pm</td>
<td>7:00pm</td>
</tr>
<tr>
<td>Day 18</td>
<td>11:00am</td>
<td>2:30pm</td>
<td>7:00pm</td>
</tr>
<tr>
<td>Day 19</td>
<td>11:00am</td>
<td>2:30pm</td>
<td>11:00pm</td>
</tr>
<tr>
<td>Day 20</td>
<td>11:00am</td>
<td>2:30pm</td>
<td>11:00pm</td>
</tr>
<tr>
<td>Day 21</td>
<td>11:00am</td>
<td>2:30pm</td>
<td>Disassembly</td>
</tr>
</tbody>
</table>
Interconnection Application Form

SCICAL – LOT 101

PV Systems

<table>
<thead>
<tr>
<th>Module Manufacturer</th>
<th>Short Description of Array</th>
<th>DC Rating of Array (sum of the DC ratings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanwha</td>
<td>West Array</td>
<td>3040 W</td>
</tr>
<tr>
<td>Hanwha</td>
<td>East Array</td>
<td>3040 W</td>
</tr>
</tbody>
</table>

Total DC power of all arrays is 6.1 kW (in tenths)

Inverters

<table>
<thead>
<tr>
<th>Inverter Manufacturer</th>
<th>Model Number</th>
<th>Voltage</th>
<th>Rating (kVA or KW)</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA America</td>
<td>SB6000US</td>
<td>240</td>
<td>6 kW</td>
<td>1</td>
</tr>
</tbody>
</table>

Total AC power of all inverters is 6 kVA or kW (in whole numbers)

Required Information

<table>
<thead>
<tr>
<th>Information</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-Line Electrical Schematic</td>
<td>E-601</td>
</tr>
<tr>
<td>Calculations of service/feeder net computed load and neutral load (NEC 220)</td>
<td>E-603</td>
</tr>
<tr>
<td>Plan view of the lot showing the house, decks, ramps, tour paths, the service point, and the distribution panel or load center</td>
<td>G-102</td>
</tr>
</tbody>
</table>

Provide the Team’s “Electrical Engineer” contact in the “Team Officer Contact Info” database on the Yahoo Group as required per Rule 3-2.
Energy Analysis Results and Discussion

I. Executive Summary

The typical southern California home consumes 40% less electricity than the typical American home (Figure 1), in part because California homeowners can take advantage of our state’s mild climate to reduce HVAC use, but also because state legislature has taught us to be more energy-conscious. Building on the systems we designed for CHIP in the 2011 Solar Decathlon, the 2013 SCI-Arc/Caltech team has designed DALE to take southern California’s green living practices a step further.

![Figure 1 Comparison of average annual energy consumption by typical American homes, typical southern California homes, and DALE. Home entertainment includes televisions, set-top boxes, video game consoles, desktop and laptop computers, monitors, speakers, printers, networking equipment, and uninterruptible power supplies. Miscellaneous includes small electric devices, heating elements, and motors (not electric vehicles).](image)

The following report describes in detail the analysis and simulations we performed to determine our necessary energy production and the engineering strategies we used to minimize our energy consumption.

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1 U.S. Energy Information Administration, 2009
2 California Energy Commission, 2009-2010
II. Electrical Systems

Since we attribute CHIP's success in the Energy Balance Contest in 2011 to a thorough energy analysis using historical weather data and modeling software and a carefully planned energy budget, we approached DALE’s electrical systems in a similar manner.

A. Solar photovoltaic array

To earn full points in the Energy Balance Contest, DALE’s solar photovoltaic (PV) array must generate all of the energy consumed by the home during the ten-day competition. After estimating the power use of every energy sink in the home to calculate the total energy consumption, we used a combination of modeling and simulation, field-testing, and product research to design our PV array. The resulting system is optimized to produce enough energy meet the Solar Decathlon’s net-zero contest requirements in 95% of historical early-October weather conditions in Irvine, CA, while requiring a minimum of panels.

Since the competition will be held in southern California's dry, arid climate this year, we wanted to test the effect of that climate on solar panels. We suspected that these conditions could lead to a significant accumulation of dirt and debris on the panels; this soiling would block incoming light, possibly resulting in costly pre-photovoltaic losses in energy production. We conducted field-testing on solar panels that were left outside to accumulate soiling for eight months and found that panels mounted at an angle saw a smaller decrease in energy production than panels that were flat (Figure 2.1). We thus concluded that tilting our array would be a passive, low-maintenance means of reducing the effects of soiling.

Given that a panel’s energy production is proportional to light intensity, which depends on the angle of incidence, tilting our array to the south provides the additional benefit of increasing the amount of direct sunlight hitting the panels. We used NREL’s System Advisor Model (SAM) to determine that PV arrays should be tilted to the latitude of their location in order to optimize annual energy production (Figure 5.1). Our array would therefore perform best over the course of the entire year if we mounted it at a 33.7° angle toward the south. The competition is held in October, however, and the optimal southern tilt for the month of October is 45°. In either case, such a steep angle poses several problems: DALE’s small roof would cause issues with shading and we have a strict 18 foot height limit for the competition. Given these constraints, we decided that...
mounting our PV array at a 15° angle would best maximize direct sunlight and reduce the effects of soiling while preventing the array from shading itself and keeping the house under the height limit.

In order to properly size our tilted PV array, we compiled a rough, high-level energy budget to estimate the average daily energy consumption of the home. We then used SAM 2012.11.30 and a year of typical weather data to simulate the hourly energy production of the given array. To ensure that our array could perform as needed in any weather conditions, not just those of a typical year, we ran the simulation with 30 years’ worth of data from Weather Analytics for the El Toro Marine base, located in Irvine, California (1982-2011). In addition, we compared the SAM results for CHIP’s array in Washington, D.C., with the 2011 competition data and the SAM results for Caltech’s Wilson array during the second half of 2011 with actual production data (Figure 2.2) to gauge the accuracy of our simulations and adjust them accordingly. We found that SAM typically overestimates the energy production of an array by 5-10%.

![Figure 2.2](image)

**Figure 2.2** SAM predictions vs. actual energy production (a) CHIP array, September – October 2011 (b) Caltech’s Wilson array, May 2011 – December 2011. Soiling effects were taken into account for the Wilson array, which had been washed at the end of July.

After accounting for a margin of error in our energy budget and SAM results, we simulated the energy production for various array sizes and configurations (Table 2.1). We determined that a 32-panel, 5.5kW array mounted at a 15° angle would be net-zero over the course of a ten-day period in Irvine in early October approximately 95% of the time for our 23.1 kWh/day target.
### Table 2.1 Corrected SAM predictions for the likelihood of achieving net-zero during the competition with an array of Y panels mounted at X degrees.

<table>
<thead>
<tr>
<th>Number of Panels</th>
<th>Southern Tilt (degrees)</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>10% 11% 14% 16% 18% 19% 20%</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>37% 46% 53% 59% 64% 67% 68%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>67% 75% 81% 84% 86% 87% 87%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>87% 90% 92% 94% 94% 95% 95%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>93% 95% 96% 97% 97% 98% 98%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>97% 98% 98% 99% 99% 99% 100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>98% 99% 100% 100% 100% 100% 100%</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition to minimizing pre-photovoltaic losses, we have attempted to reduce losses inherent to the solar panels themselves. PV cells are designed to capture as much sunlight as possible, which causes the panels to heat up drastically; this process increases current output but decreases voltage and overall power. We positioned the tilted PV array on DALE’s canopies to take advantage of their ability to move and thereby reconfigure the array to maximize system efficiency throughout the day.

During our field-testing, we analyzed the effects of different air mass heights underneath the PV array. Since the array is mounted on mobile canopies, the panels can be located either one foot above the modules or ten feet above the ground (when the canopies are fully cantilevered). Thermal convection currents coupled with natural air currents produce different effects at these different heights: due to a wind-tunneling effect, airflow around the panels is greater when they are positioned above the house, keeping the panels cooler and resulting in a 2-4% greater efficiency than when the panels are ten feet above the ground.

Thus, the homeowner can optimize system performance by configuring the panels above the house in the early morning and late evening, when the effects of the air currents are greatest. During the day, the canopies can be moved to the inside of the modules to create a shaded area that will keep the space cooler and reduce the energy consumption of the HVAC system. In this way, positioning the PV array on the movable canopies allows us to optimally configure DALE for different environmental conditions while simultaneously increasing energy production.

Additionally, each panel is connected to a Tigo module maximizer, which regulates the output current of each PV module and helps boost energy production. Since the panels in each string of a PV system are wired in series, the current of each string is limited by the lowest current produced – one underperforming panel decreases the energy production of every panel in the string. Tigo module maximizers prevent this current capping by using impedance-matching technology to identify and deactivate underperforming panels.
B. Overview of energy production and consumption

Since we sized our array to be net-zero during October, it would actually produce more energy than the typical inhabitants consume over the course of an entire year in Los Angeles, CA.

According to SAM simulations, our 5.5 kW array should generate an average of 23.1 kWh per day during the competition. When we adjust this value to correct for SAM’s overestimates, we find a more realistic value of 21.0 kWh per day during the competition. To leave ourselves a margin of error, we have budgeted a total of just under 20 kWh per day for the contests. (Figure 2.4).

**Figure 2.3** DALE’s monthly energy production and consumption in Los Angeles, CA. Energy production simulated using SAM; energy consumption based on Energy Star usage estimates.

**Figure 2.4** Comparison of energy and point allocations by contest (a) Maximum possible points (b) Budgeted energy usage for competition.
Our strategy during the competition is based on an analysis of how many points we could earn in each contest and how much energy we would have to use in order to earn those points (Table 2.2). If we are running low on energy, we should stop conditioning the home and not participate and in the cooking contest. If we are running very low on energy, we should use as much energy as we need to maximize our points in the other contests: we would actually earn more points by participating in the other contests than we would lose by not being net-zero.

<table>
<thead>
<tr>
<th>Contest</th>
<th>Points/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water</td>
<td>6.2</td>
</tr>
<tr>
<td>Lighting</td>
<td>3.8</td>
</tr>
<tr>
<td>Washer</td>
<td>3.6</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>3.3</td>
</tr>
<tr>
<td>Dinner Party</td>
<td>2.9</td>
</tr>
<tr>
<td>Home Electronics</td>
<td>2.7</td>
</tr>
<tr>
<td>Movie Night</td>
<td>2.5</td>
</tr>
<tr>
<td>Dryer</td>
<td>2.5</td>
</tr>
<tr>
<td>Refrigerator/Freezer</td>
<td>2.2</td>
</tr>
<tr>
<td>Energy Contest</td>
<td>2.0</td>
</tr>
<tr>
<td>Comfort Zone</td>
<td>1.9</td>
</tr>
<tr>
<td>Cooking</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Table 2.2 Points earned per kWh of energy used.

C. Home electronics, lighting, and appliances

To choose home electronics for DALE, we performed a cost-benefit analysis on a variety of products to find the ones that are least expensive and most efficient. We began by eliminating products that are not readily compatible with Control4 (our home control system) and those that have poor customer reviews (fewer than three stars). Then, using typical retail prices and converting manufacturer-specified maximum power consumptions to kWh, we calculated the average cost and average use cost for each type of device and the monetary and energy cost scores for each product. By selecting the products with the lowest total cost scores among each type of device, we have managed to stay within both our monetary budget and our energy budget for the competition.

We performed a similar cost-benefit analysis on a variety of light fixtures to find an appropriate balance between cost, energy efficiency, illuminance, and color temperature. We also took into consideration customer reviews (to ensure quality), product longevity (to reduce maintenance costs), and thermal output (to limit HVAC demand). In addition, after consulting with lighting experts, we decided to only use light fixtures with a color rendering index (CRI) greater than 80; this allows the homeowners to experience natural-looking light in the evenings and at night, complementing the natural light they enjoy during the day thanks to DALE’s large windows.

Due to budgetary constraints, we had fewer options for our home appliances. Whenever possible, however, we chose appliances that exceed Energy Star requirements for energy and water consumption to keep DALE resource-efficient. For example, our dishwasher uses just 3.5 gallons of water per cycle.¹

¹ Energy Star certification requires ≤ 4.25 gallons/cycle
III. Mechanical Systems

Unlike the typical energy-efficient home, which relies solely on static systems to save energy, DALE utilizes static systems as well as a dynamic mechanical system that embodies our team’s ingenuity and showcases a variety of energy-saving innovations.

A. Module and canopy movement system

Southern California has an agreeable climate that begs homeowners to open their doors and windows and enjoy the pleasant weather. DALE takes this practice a step further by letting homeowners open up the entire house without sacrificing their privacy or shade. Our module and canopy movement system comprises a variety of hardware and software and is responsible for correctly positioning the modules and canopies according to user input while keeping the inhabitants and their belongings safe (please refer to sheet T-101 in the drawing set).

Module and canopy movement begins with the command center, where a touchscreen panel with an intuitive user interface (UI) feeds high-level commands to a programmable logic controller (PLC) located in the mechanical room. Using this touchscreen panel, the homeowner can select one of several preset module and canopy configurations, enter a new configuration manually, or program an additional configuration for the PLC to remember. The PLC checks this input for validity (Table 5.2), computes the necessary module and canopy moves and the order in which they should occur (Figure 5.2), and activates the safety equipment.

The homeowner can also use the command center’s UI to operate the motorized louvers located on both sides of the canopies. Each set of louvers is independently controlled by pressing and holding a touchscreen button until the desired configuration is reached. With so many degrees of freedom, DALE’s inhabitants are able to enjoy an energy-efficient, fully customizable, indoor/outdoor lifestyle.

To make these moves possible, each module is equipped with a variable-frequency drive (VFD) that gradually accelerates and decelerates a pair of one-horsepower end trucks, wheeled motors typically used in gantry cranes (Figure 3.1). This ramping provides two distinct advantages over single-speed operation: smoother starts and stops and less mechanical stress on the motors and modules. In addition, we chose end trucks that are rated for loads much heavier than the modules so they can better handle dynamic loading inside the house. Finally, the modules themselves protect the end trucks from the environment, further reducing maintenance and repair costs for this system. In the unlikely event that power is lost while the home is opened, the end trucks are equipped with a manual brake override to allow the inhabitants to manually close the home.
The modules can move along the entirety of the track’s 54 foot length; the maximum separation between the modules is approximately 34 feet. The maximum separation between the modules during the competition, when we are limited by our solar envelope, is nearly the same at 32 feet.

Figure 3.1 Cutaway view of module with end truck wheel and track.

To make canopy movement possible, a three-stage, ball-based linear telescopic slide system made of stainless steel is attached to the roof support structure of each module (Figure 3.2). Movement during the first and second stages is accomplished by means of a spur gear articulating with a horizontal gear rack. Movement during the third stage is accomplished by means of a tensioned chain running along the sliding rails that is fixed at one point. As with module movement, a VFD gradually accelerates and decelerates a pair of half-horsepower motors equipped with speed reducers and provides the same reduction in maintenance and repair costs for this system. Each canopy slides parallel to the track and can cantilever approximately 10 feet from center in either direction.

Figure 3.2 Linear telescopic slide system for canopy movement.

Having two independently moving modules makes plumbing and electrical wiring difficult since the municipal water supply line and local microgrid are stationary. To accommodate the lines that run between these fixed points and the core module, a durable cable carrier mounted underneath the mechanical room guides flexible cables and hoses along the length of the rails. A second cable carrier mounted underneath each module accommodates the lines that run between them. As with the end trucks, we chose weather-resistant cable carriers and positioned them underneath the modules to protect the lines as much as possible from the environment, thereby reducing maintenance and repair costs. Having canopies that can move in two directions relative to the modules also makes wiring difficult, so we once again chose to use cable carriers. In addition to the solar photovoltaic panels mounted on top of the canopies, small motors for the louvers and various safety sensors are located on the canopies and also necessitate wires running from each module to its canopy.

The PLC uses input from two laser distance sensors to calculate the position of each module relative to the end of the rails, while a third laser distance sensor provides the distance between the
modules as a check. A cost-efficient makeshift encoder comprised of a sprocket and a proximity sensor is attached to each canopy motor; as the motor turns, the teeth of the sprocket spin past the proximity sensor, triggering a pulse. The PLC counts these pulses to calculate the position of each canopy relative its module. A limit switch located at the end of each rail prevents the modules from driving off the rails.

A second pair of limit switches ensures that the modules continue to move together until the gaskets mounted along the perimeters of the opening form an air- and water-tight seal between the modules. We tested the gaskets to determine the minimum compression needed to form an air- and water-tight seal; the limit switches require this amount of compression plus a margin of error. The gaskets have a manufacturer-reported R-value > 11.5, are fire retardant, and provide acoustic dampening.

To keep DALE's inhabitants and their belongings safe during module and canopy movement – and to limit potential liability should damage occur – we have carefully implemented a risk management strategy. We began by identifying the hazards associated with careful operation of our module and canopy movement system and compiling an initial set of safety sensors that address these hazards. We then closely analyzed the coverage of these safety sensors, looked for ways that they could be defeated, and compiled a more robust set of safety sensors. Finally, we consulted with an expert in the field of factory safety to gain a new perspective on our system and to learn about additional safety devices and practices.

The resulting risk management strategy comprises two types of safety measures: preventative and reactive (Table 3.1). Preventative safety measures are used to keep people and objects out of harm’s way, while reactive safety measures are used to stop module and canopy movement in the unlikely event that contact is made. Together, these measures balance safety and cost considerations, offering excellent protection without becoming overly complicated or breaking the bank.
## Preventative Safety Measures

<table>
<thead>
<tr>
<th>Light Curtain</th>
<th>A transmitter on one side of the module emits horizontal beams of low-level visible light and a receiver on the other side of the module senses them. Emergency braking is triggered if one or more beams are interrupted.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Access Control Sensor</td>
<td>Like a miniature light curtain, a transmitter on one side of the module emits a single horizontal beam of low-level visible light and a receiver on the other side of the module senses it. Emergency braking is triggered if the beam is interrupted.</td>
</tr>
</tbody>
</table>

## Reactive Safety Measures

| Sensing Edge | A pressure-sensitive rubber profile lines the vertical canopy edges and multi-use platforms (solar thermal collector, bike rack, hammock, stairs to mechanical room). Emergency braking is triggered on contact. |

Table 3.1 DALE’s preventative and reactive safety measures.

Consider the following scenarios:

- A homeowner parks close to the track and later decides to open DALE to spend a pleasant evening in the mid-yard. The canopy or multi-use platforms on the nearest module might hit the vehicle, possibly causing costly damage to the vehicle, the canopy or appendage, or both. While this scenario cannot be easily prevented by the movement system, our reactive safety measures limit the amount of damage that can occur by stopping all movement as soon as contact is made.

- A homeowner enjoys a picnic between the modules and forgets to move the table before closing DALE. One of the modules might hit the table, possibly pushing it over and causing a small amount of damage to the table, module, or both. While this scenario is unlikely to result in any real harm, it is a nuisance that our light curtains can easily prevent.

- A homeowner wants to move DALE in order to experience a different landscape and is unaware that the family pet is sleeping directly in the path of module movement. The module could run into the animal, possibly causing severe injury or even death. While we hope that this is the rarest of scenarios, we have included area access control sensors as a secondary preventative safety measure in the unlikely event that our light curtains fail to detect a small person, animal, or object.
B. HVAC and DHW systems

We designed DALE’s HVAC and DHW systems to be compatible with module and canopy movement while achieving the same level of functionality and efficiency as the corresponding systems in a more typical home. We addressed our movement concerns by placing the equipment for both systems on just one of the modules – thereby avoiding the complexities associated with flexible, non-standard piping metals – and by choosing units that are well-suited for smaller homes.

Our ductless HVAC system comprises a dual zone heat pump with a single outdoor unit and two indoor units. The outdoor unit is among the most efficient in its size class, rated at a cooling seasonal energy efficiency ratio (SEER) of 18 and a heating seasonal performance factor (HSPF) of 8.9 at 47°F and the indoor units are rated at 15 SEER and 9.6 HSPF. The heat pump cools/heats the refrigerant, R-410a, into a liquid/gaseous form and sends it to the two indoor units, which then drive air cooled/heated by the refrigerant piping into the house.

Since HVAC system size is such an important factor in energy efficiency, we sized our HVAC system to suit its typical load. Given that the majority of the work done by our HVAC system is correcting small temperature swings that are barely outside the desired indoor climate range, we looked for a smaller system that could handle these common loads efficiently. We also wanted our system to be strong enough to handle any larger cooling/heating loads adequately, so we chose ceiling units that can drive air in four directions. This ensures that our indoor units can quickly condition the entire home – no matter how the interior is configured – and keep DALE’s occupants comfortable no matter where they are.

To keep the home conditioned while closed, DALE has fireproof floor, ceiling, and wall insulation that also dampens sound (Table 3.2). Our air exchange ventilator helps maintain proper indoor air quality in accordance with California’s Title 24.

<table>
<thead>
<tr>
<th>Surface</th>
<th>R value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>24</td>
</tr>
<tr>
<td>Walls</td>
<td>23</td>
</tr>
<tr>
<td>Windows/Glass Walls</td>
<td>3</td>
</tr>
<tr>
<td>Roof</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 3.2 DALE’s insulation.

DALE can be opened and closed at any time, so it is possible that the weather might sour while DALE is open. With this in mind, we designed our HVAC system to be capable of handling any inclement weather it might encounter. The system can take a worst-case load and condition the closed space to a comfortable target temperature in less than 30 minutes while still performing at least as efficiently as the typical green home HVAC system.

DALE’s DHW system takes advantage of the cutting-edge heating technology in solar thermal energy collectors, which capture solar energy and convert it to thermal energy. We chose SEER and HSPF ratings as reported by manufacturer. Note that Energy Star does not currently certify ductless HVAC systems; Energy Star certification for split systems requires SEER ≥ 14.5 and HSPF ≥ 8.2 for air-source heat pumps and SEER ≥ 14.5 for central air conditions.

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1 SEER and HSPF ratings as reported by manufacturer. Note that Energy Star does not currently certify ductless HVAC systems; Energy Star certification for split systems requires SEER ≥ 14.5 and HSPF ≥ 8.2 for air-source heat pumps and SEER ≥ 14.5 for central air conditions.
to use a solar thermal collector because its conversion of sunlight into domestic hot water perfectly complements our solar panels’ conversion of sunlight into electricity.

When radiant energy from the sun hits the collector, it heats a transfer fluid contained in heat pipes at the center of the collector tubes. The heat pipe fluid evaporates into a gas that collects at the top of the tubes, where it transfers its thermal energy to the working fluid of a closed loop system flowing through the manifold of the collector. The heated working fluid is pumped through this loop to the heat exchanger of our hot water tank to heat water for domestic use. A backup electric water heater ensures that hot water is always available, even on cloudy days and in high-demand situations.

While solar thermal systems are typically located on the roof, we chose to mount ours on the southern wall of the core module to make room for a larger photovoltaic array on DALE’s roof. Since our collector is in a more accessible location, we chose to use evacuated tubes, which are safe to touch because their exteriors do not heat up significantly. In addition, we chose to orient our solar thermal collector to maximize the amount of sunlight collected in the winter, since there are fewer hours of daylight during those months.

C. Movement and HVAC energy analysis

We performed an extensive analysis of historical southern California weather using ASHRAE Standard 55 equations, which numerically describe how hot or cold an average person would feel given seven parameters: air temperature, mean radiant temperature, relative humidity, wind speed, clothing level, activity level, and metabolic rate. ASHRAE equations also compute a predicted percentage displeased (PPD), representing what percentage of people will be unhappy in a given weather condition. Using these ASHRAE equations, we calculated the hourly PPD given 30 years of weather data for the El Toro Marine base near Irvine, CA to determine when the house could be opened comfortably and how much energy could be saved by doing so.

Since the homeowners can change their clothing level and adjust shading and wind speed by reconfiguring the modules and canopies, we varied these parameters to generate boundary zone estimates for weather conditions in which 90% of people would be happy with the home open (PPD \( \leq 10 \), Figure 3.3) and predict how often the home could be opened comfortably (Figure 3.4).
Figure 3.3 Comfort zones for sunny and cloudy days in southern California; actual data for 2009 – 2011 plotted. Orange and blue dots represent days/weather conditions for which at least 90% of people would have been comfortable outside. Some days/weather conditions outside of the boundaries were still comfortable due to other factors such as sunlight.
We used Energy Pro to estimate how much energy would be consumed by DALE’s HVAC system each hour to keep the inhabitants comfortable if the home was always closed. We then used hourly probabilities that the house could be comfortably opened to estimate how much energy would be consumed by DALE’s HVAC system each month if the inhabitants opened the home strategically to help keep them comfortable (Figure 3.5). We assumed that the home would be closed at night from 10pm to 8am and anytime it was raining, and we considered a variety of homeowner habits:

- Works at home, opens the house during the day: 60% annual HVAC energy savings
- Works away from home from 9am to 5pm five days a week, leaves the house unconditioned during that time: 39% annual HVAC energy savings
- Works away from home from 9am to 5pm five days a week, chooses to condition the house during that time: 23% annual HVAC energy savings
We have made DALE more energy-efficient and affordable by embracing an active mechanical systems approach. Although HVAC heat recovery systems do work, as we showed with CHIP in 2011, we purposefully chose not to implement such a system this year. With the competition being held in southern California’s rather more seasonable climate, we concluded that any energy savings would be merely marginal and thus would not offset the cost of a heat recovery system.

A typical HVAC heat recovery system utilizes an additional heat exchanger in the refrigeration cycle to remove heat from the gas lines of the indoor units and preheat cold municipal water before it enters the water boiler. While the HVAC system is in cooling mode, heat recovery increases the efficiency of the system in two ways. First, it reduces the amount of heat that the outdoor unit has to expel in order to cool the incoming refrigerant. Second, it reduces the workload of the boiler by preheating the incoming water to 70-80°F (municipal water is a cool 50-60°F). Our HVAC heat recovery system in 2011 was capable of reducing the overall energy usage of CHIP’s HVAC and DHW systems by up to 25% compared to the same systems without heat recovery and thus was a worthwhile endeavor.

Such a heat recovery system would not be as beneficial with DALE, however, for several reasons. First, DALE’s HVAC system is already more efficient than CHIP’s and has a higher cooling SEER, which means that the outdoor unit is already using less energy than CHIP’s did and thus would realize smaller energy savings with a heat recovery system. Second, while CHIP utilized an air-to-water heat pump, DALE utilizes a solar thermal system to generate domestic hot water. The
passive heat exchange in DALE’s solar thermal loop results in an equilibrium water temperature warmer than that of CHIP’s passive heat recovery system. Finally, DALE’s HVAC system is less likely to be used during periods of active cooling demand since the house is designed to be opened. Heat recovery systems only work when the house is being actively cooled, so DALE would only infrequently benefit from such a system; the extremely limited temperature gains would not offset the cost of customizing DALE’s refrigeration loop.
IV. Home Control and Monitoring Systems

We designed DALE to boast a southern California philosophy – buy small, live large – and our home control and monitoring systems reflect this ideal.

A. Home control system

By integrating a Control4 system with a Honeywell HVAC control system, DALE Control frees homeowners from having to use multiple applications to control their appliances and HVAC system. The DALE Control application for tablets is intuitive, user-friendly, and easily programmable, allowing the homeowners to store their preferences.

Control4 is a well-known, smart home control system that is commonly used to wirelessly control home appliances. We used a Control4 system with CHIP in the 2011 Solar Decathlon and found it to be extremely reliable and time-saving, hence our decision to use Control4 again this year. DALE Control communicates with a Control4 box through a director application programming interface (API) to determine which devices are connected to DALE’s Control4 server and thus can be controlled through our app.

CHIP’s “big red button” was extremely popular in 2011, so DALE Control likewise has a single button that turns off all non-essential appliances, including lights and televisions. In addition to switching devices between their on and off states, DALE Control can be used to adjust specific device settings; for example, lights can be dimmed or brightened. DALE Control also has an automatic light mode in which the overall light level is fixed by the homeowner; light sensors measure the indoor and outdoor ambient light levels and the app adjusts the lights as needed.

DALE’s HVAC system is controlled via a Honeywell Redlink thermostat, which can be controlled wirelessly from inside the house and monitored over the Internet. We chose to integrate the Redlink thermostat into the DALE Control app rather than use the separate app provided by Honeywell. This gives the homeowners greater control over the HVAC system without complicating the home control process by adding an entirely different user interface.

B. Monitoring system

DALE Control utilizes low-cost, real-time energy monitoring and easy-to-understand data visualization to help homeowners become more aware of how they are using energy and teach them how to run the home more efficiently.

We chose to use Chai Energy’s technology to monitor DALE’s energy consumption. Chai Energy was founded by Caltech alumni who built upon their experiences during the Solar Decathlon 2011 to start a successful business. Their monitoring system utilizes a router to send data from a whole-home smart meter to the cloud every six seconds. Chai Energy software then analyzes this
data, looking for spikes in energy consumption to determine which appliances are on and how much energy each of them is using.

![Chai Energy software uses algorithms and user feedback to identify spikes in total home energy consumption and attribute them to appliances and other energy sinks.](image)

This clever technology offers several distinct advantages over more traditional monitoring systems. First, the Chai Energy system monitors total home energy consumption instead of monitoring at the circuit level; it is thus easier and less expensive to install because it requires very little hardware. The system also takes advantage of the increasing prevalence of smart meters to further lower installation costs. Finally, the Chai Energy system stores current and historical energy usage data for each appliance in an accessible database, allowing homeowners to see changes in their energy consumption over time.

The DALE Control app retrieves energy production data from the Tigo modules and energy consumption data analyzed by Chai Energy from their respective servers and creates an intuitive graphical display of the data. Overall energy production and consumption are plotted against time to show peak energy demands and peak PV array performance, and a pie chart shows the energy consumption of each appliance as calculated by Chai Energy. Together, these user-friendly graphs make the homeowners more aware of their net energy use and help them realize the importance of trying to save energy.

The DALE Control app does more than simply encourage homeowners to be more energy-efficient: it actively helps them develop green habits by offering suggestions and gentle reminders and by identifying potential problems with the house. For example, the app might alert the user if
the bathroom light has been on for several consecutive hours. If the PV array's energy production falls below some threshold, the app might inform the user that maintenance is required.

In addition, the DALE Control app has access to indoor/outdoor temperature and humidity data, which it uses to predict whether or not the occupants would be comfortable outside. Here, the app relies on ASHRAE Standard 55, which defines the range of thermal environmental conditions that are suitable to 90% of the population. We chose to use this standard because it accounts for a tremendous variety of factors, including sunlight, air speed, and clothing levels. The DALE Control app likewise takes these factors into consideration, and when it determines that 90% of the population would be comfortable outside, it will suggest that the occupants open up their home. If the homeowners act on the app's suggestion, they will save energy by not running the HVAC system and they will be able to enjoy a more spacious living environment.

We purposefully chose not to create a completely automated home control system. Instead, DALE Control provides homeowners with the tools they need to make informed decisions on how to run their home. By showing the occupants how they can save energy and money rather than just doing it for them, the DALE Control app helps people live a greener lifestyle that is better for their health and for the environment.
V. Methods and Results

A. Executive summary
Figure 1 Comparison of average annual energy consumption. These data came from:

- US Energy Information Administration 2009 Residential Energy Consumption Survey CE4.1 (end-use consumption by fuel, total U.S. homes)
- California Energy Commission Updated California Energy Demand Forecast 2011-2022 Table B-6 (number of households by planning area, 2010)
- California Energy Commission Energy Almanac California Energy Consumption by End Use (BUGL, LADWP, PASD, SCE, and SDGE)

For each end use, we calculated: \( \frac{\text{electricity consumption per household}}{\text{number of households}} \)

Data rounded to nearest 10 kWh/yr

B. Electrical systems
Figure 2.1 Decrease in energy production due to soiling.
Four Hanwha panels – two that were flat and two that were mounted at a 15° angle – were allowed to accumulate soiling for eight months. On a sunny afternoon, we monitored their instantaneous energy production for ten minutes, cleaned them with a squeegee using dish soap and water, and then monitored their instantaneous energy production for another ten minutes (Table 5.1).

<table>
<thead>
<tr>
<th>Panel Type</th>
<th>Average energy production (W)</th>
<th>Soiled</th>
<th>Clean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Panel 1</td>
<td>122.32</td>
<td>150.41</td>
<td></td>
</tr>
<tr>
<td>Flat Panel 2</td>
<td>118.95</td>
<td>151.82</td>
<td></td>
</tr>
<tr>
<td>Tilted Panel 1</td>
<td>140.14</td>
<td>153.02</td>
<td></td>
</tr>
<tr>
<td>Tilted Panel 2</td>
<td>141.59</td>
<td>156.08</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1 Average instantaneous energy production for soiled and clean panels. The panels produced similar amounts of energy while clean, thus the difference in energy production while soiled must be due to a difference in the amount of accumulated soiling related to the angle at which the panels were mounted.
Determination of optimal tilt.

![Energy production graph](image)

**Figure 5.1** Energy production as a function of an array’s southern tilt. Annual energy production (gray) is maximized when the array is tilted to its location’s latitude; in Irvine, CA, this is 31.7°. Energy production in October (blue) is maximized when the array is tilted to 45.1°. Energy production simulated using SAM.

Home electronics cost-benefit analysis.
To convert manufacturer-specified maximum power consumptions to kWh, we made the following assumptions:

- The laptop, monitor, and television will each be powered on for 35 hours during the competition.
- The Blu-ray player, sound system, and projector will each be powered on for two hours during the competition.

To compute the use cost, monetary cost score, energy cost score, and total cost score, we used the following formulas:

\[
\text{use cost in $} = \text{power consumption in kWh} \times \$6/\text{kWh}
\]

\[
\text{monetary cost score} = \frac{(\text{product cost} - \text{average cost})}{\text{average cost}}
\]

\[
\text{energy cost score} = \frac{(\text{product use cost} - \text{average use cost})}{\text{average use cost}}
\]

\[
\text{total cost score} = \text{monetary cost score} + \text{energy cost score}
\]
C. Mechanical systems
Module and canopy movement.

<table>
<thead>
<tr>
<th>PLC check: canopy moves</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>WestM - 10ft &lt; WestC &lt; WestM + 10ft</td>
<td>The canopy can cantilever only 10 feet from the center in either direction.</td>
</tr>
<tr>
<td>EastM - 10ft &lt; EastC &lt; EastM + 10ft</td>
<td>The canopy can cantilever only 10 feet from the center in either direction.</td>
</tr>
<tr>
<td>WestC + 10ft ≤ EastC</td>
<td>The canopies cannot overlap.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLC check: module moves</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>0ft ≤ WestM ≤ 54ft</td>
<td>The western module must be on the track.</td>
</tr>
<tr>
<td>0ft ≤ EastM ≤ 54ft</td>
<td>The eastern module must be on the track.</td>
</tr>
<tr>
<td>WestM + 10ft ≤ EastM</td>
<td>The modules cannot overlap.</td>
</tr>
<tr>
<td>WestM + 10ft = EastM OR WestM ≤ EastM - 15ft</td>
<td>The distance between the modules must be 0 feet (the house is closed) or greater than 5 feet (a small gap between the modules would be unsafe).</td>
</tr>
</tbody>
</table>

Note: The input position represents the distance between the western end of the track and the western edge of a particular module or canopy. The modules and canopies are 10 feet wide and the track is 54 feet long.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WestM</td>
<td>position of western module</td>
</tr>
<tr>
<td>EastM</td>
<td>position of eastern module</td>
</tr>
<tr>
<td>WestC</td>
<td>position of western canopy</td>
</tr>
<tr>
<td>EastC</td>
<td>position of eastern canopy</td>
</tr>
</tbody>
</table>

Table 5.2 Validity checks for input module and canopy configurations.
We set boundary zone estimates for weather conditions in which 90% of people would be happy with the home open (PPD ≤ 10).

To investigate the effect of shading on temperature, we conducted field-testing using thermocouples placed in the sun and in the shade. We found that shaded areas are significantly cooler than sunny areas during the day (Figure 5.3), and thus it was important for us to take shading into consideration when determining if a given weather condition fell within the 90% comfort zone.

**Figure 5.2** Flowchart used to determine the order of module movements.

Figures 3.3 – 3.5 Energy savings due to movement.
Figure 5.3 Temperature in the sun and shade. Data collected over 2.5 days; peaks occur around noon each day.

To set the comfort zone boundaries for a cloudy day, we used the following parameters:
- Relative humidity = 65% (approximate median for a cloudy day)
- Direct sunlight = 50 W/m^2 (approximate median for a very cloudy day)
- Diffuse sunlight = 200 W/m^2 (approximate median for a very cloudy day)

To set the comfort zone boundaries for a sunny day, we used the following parameters:
- Relative humidity = 52% (approximate median for a sunny day)
- Direct sunlight = 900 W/m^2 (approximate median for a very sunny day)
- Diffuse sunlight = 100 W/m^2 (approximate median for a very sunny day)

We then determined the coldest and warmest a person could feel given hourly weather conditions and the following parameters:
- Metabolic rate = 1.1 (normal adult)
- Activity level = 0 (sitting)

To determine the coldest a person could feel, we used the following parameters:
- Clothing level = 0.3 (shorts and a t-shirt)
- Wind speed = 0.75 * outdoor wind speed (the house is open and only partially blocks the wind)
- Mean radiant temperature = outdoor air temperature (the interior is completely shaded)
To determine the warmest a person could feel, we used the following parameters:

- Clothing level = 1 (sweater and jeans)
- Wind speed = 0.5 * outdoor wind speed (sunny), 0.25 * outdoor wind speed (cloudy)
- Mean radiant temperature > outdoor air temperature (the interior is not shaded; see *Thermal Comfort: Analysis and Applications in Environmental Engineering* by P. O. Fanger for the theory behind this calculation)

We computed the hourly PPD; if PPD ≤ 10 in the region bounded by the coldest and warmest a person could feel given that hour’s weather conditions, the home could be opened comfortably. We then used our hourly yes/no values for 30 years to determine the probability that the homeowners would be comfortable with the house open during a given hour of the year.
Quantity Takeoff of Competition Prototype House

Please See Appendix B for the quantity takeoff.
Construction Specifications

DIVISION 03 – CONCRETE

SECTION 033000 – CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS
A. Submittals: Product Data, concrete mix designs, and submittals required by ACI 301.
B. Ready-Mixed Concrete Producer Qualifications: ASTM C 94/C 94M.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

2.02 MATERIALS
A. Plain Steel Wire: ASTM A 82, as drawn.
B. Plain-Steel Welded Wire Reinforcement: ASTM A 185, as drawn, flat sheet.
C. Portland Cement: ASTM C 150, Type I or II.
D. Fly Ash: ASTM C 618, Class C or F.
E. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
F. Silica Fume: ASTM C 1240, amorphous silica.
G. Aggregates: ASTM C 33, Class 3S, Class 3M, Class 1N, coarse aggregate or better, graded, with at least 10 years' satisfactory service in similar applications.
   1. Maximum Coarse-Aggregate Size: 1 inch nominal.
   2. Maximum Aggregate Size for Concrete in Insulating Concrete Forms: 3/4 inch.
I. Chemical Admixtures: ASTM C 494, water reducing, high-range water reducing, water reducing and accelerating, and water reducing and retarding. Do not use calcium chloride or admixtures containing calcium chloride.
J. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures.
   1. Manufacturers: Quikrete
K. Synthetic Fiber: ASTM C 1116/C 1116M, Type III, polypropylene fibers, 1/2 to 1-1/2 inches long.
L. Vapor Retarder: Reinforced sheet, ASTM E 1745, Class A.
M. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
N. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
O. Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

2.03 CONCRETE MIXTURES
A. Prepare design mixtures, proportioned according to ACI 301.
B. Normal-Weight Concrete:
   1. Minimum Compressive Strength: 4000 psi 28 days.
   2. Maximum Water-Cementitious Materials Ratio: 0.50.
   3. Slump Limit: 5 inches for concrete with verified slump of 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture, plus or minus 1 inch.
4. Air Content: Maintain within range permitted by ACI 301. Do not allow air content of floor slabs to receive troweled finishes to exceed 3 percent.

5. Use fly ash, pozzolan, ground granulated blast-furnace slag, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.

6. For concrete exposed to deicing chemicals, limit use of fly ash to 25 percent replacement of portland cement by weight and granulated blast-furnace slag to 40 percent of portland cement by weight; silica fume to 10 percent of portland cement by weight.

C. Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116.

1. When air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.01 CONCRETING

A. Construct formwork according to ACI 301 and maintain tolerances and surface irregularities within ACI 347R limits of Class A, 1/8 inch for concrete exposed to view and Class B, 1/4 inch for other concrete surfaces.

B. Place vapor retarder on prepared subgrade, with joints lapped 6 inches and sealed.

C. Comply with CRSI’s "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

D. Install construction, isolation, and contraction joints where indicated. Install full-depth joint-filler strips at isolation joints.

E. Place concrete in a continuous operation and consolidate using mechanical vibrating equipment.

F. Protect concrete from physical damage, premature drying, and reduced strength due to hot or cold weather during mixing, placing, and curing.

G. Formed Surface Finish: Smooth-formed finish for concrete exposed to view, coated, or covered by waterproofing or other direct-applied material; rough-formed finish elsewhere.

H. Slab Finishes: Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces. Provide the following finishes:

1. Scratch finish for surfaces to receive mortar setting beds.
2. Float finish for surfaces to receive waterproofing, roofing, or other direct-applied material.
3. Troweled finish for floor surfaces and floors to receive floor coverings, paint, or other thin film-finish coatings.
4. Trowel and fine-broom finish for surfaces to receive thin-set tile.
5. Nonslip-broom finish to exterior concrete platforms, steps, and ramps.


J. Owner will engage a testing agency to perform field tests and to submit test reports.

K. Protect concrete from damage. Repair and patch defective areas.

END OF SECTION 033000
DIVISION 05 – METALS

SECTION 051200 – STRUCTURAL STEEL FRAMING

PART 1 - GENERAL
1.01 SECTION REQUIREMENTS
   A. Submittals: Product data, statement of recycled content, shop drawings, welding procedure specifications (WPSs), mill test reports.

PART 2 - PRODUCTS
2.01 PERFORMANCE REQUIREMENTS
   A. Connections: Provide details of connections required by the Contract Documents to be selected or completed by structural-steel fabricator.
      1. Use [LRFD; data are given at factored-load level] [ASD; data are given at service-load level].
   B. Comply with applicable provisions of the following:
      1. AISC 303.
      2. AISC 341 and AISC 341s1.
      3. AISC 360.
      4. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

2.02 STRUCTURAL STEEL
   A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] [50] <Insert number> percent.
   B. W-Shapes: [ASTM A 992/A 992M] [ASTM A 572/A 572M, Grade 50 (345)].
   C. Channels, Angles, M, S-Shapes: [ASTM A 36/A 36M] [ASTM A 572/A 572M, Grade 50 (345)].
   D. Plate and Bar: [ASTM A 36/A 36M] [ASTM A 572/A 572M, Grade 50 (345)].
   E. Cold-Formed Hollow Structural Sections: ASTM A 500, [Grade B], structural tubing.
   F. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B.

2.03 ACCESSORIES
   A. High-Strength Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C, (ASTM A 563M, Class 8S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers.
   B. Anchor Rods: ASTM F 1554, Grade 36.
      1. Configuration: [Straight] [Hooked].
   C. Primer: Fabricator's standard lead-and chromate-free, nonasphaltic, rust-inhibiting primer.
   D. Grout: ASTM C 1107, nonmetallic, shrinkage resistant, factory packaged.

2.04 FABRICATION
   A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC's "Code of Standard Practice for Steel Buildings and Bridges" and AISC 360.
   B. Weld Connections: Comply with AWS D1.1/D1.1M[ and AWS D1.8/D1.8M] for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
   C. Shop Priming: Prepare surfaces according to SSPC-SP 2, "Hand Tool Cleaning"; or SSPC-SP 3, "Power Tool Cleaning." Shop prime steel to a dry film thickness of at least 1.5 mils (0.038 mm). Do not prime surfaces to be embedded in concrete or mortar or to be field welded.
PART 3 - EXECUTION
3.01 ERECTION
A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.
B. Base [Bearing] [and] [Leveling] Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Weld plate washers to top of base plate.
3. [Snug-tighten] [Pretension] anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure.
C. Align and adjust various members forming part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
D. Do not use thermal cutting during erection[ unless approved by Architect. Finish thermally cut sections within smoothness limits in AWS D1.1/D1.1M].
E. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
1. Joint Type: [Snug tightened] [Pretensioned] [Slip critical].
F. Weld Connections: Comply with AWS D1.1/D1.1M[ and AWS D1.8/D1.8M] for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

END OF SECTION 051200
DIVISION 06 – WOOD, PLASTICS and COMPOSITES

SECTION 061533 – WOOD PATIO DECKING

PART 1 - GENERAL
1.01 SECTION REQUIREMENTS
   A. Submittals: ICC-ES evaluation reports for wood-preservative treated wood, expansion anchors, metal framing anchors and decking fasteners.

PART 2 - PRODUCTS
2.01 WOOD PRODUCTS, GENERAL
   A. Lumber: Provide dressed lumber, S4S, marked with grade stamp of inspection agency.
   B. Certified Wood: Wood-based materials produced from tropical forests shall be certified as "FSC Pure" or "FSC Mixed Credit" according to FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship," and to FSC STD-40-004, "FSC Standard for Chain of Custody Certification."
2.02 TREATED MATERIALS
   A. Preservative-Treated Boards and Dimension Lumber: AWPA U1; Use Category UC3b.
   1. Use treatment containing no arsenic or chromium.
   B. Preservative-Treated Timber and Poles: AWPA U1; Use Category UC4a, waterborne preservative.
   1. Use treatment containing no arsenic or chromium.
   2. Treatment with CCA shall include post-treatment fixation process.
   C. After treatment, redry boards, dimension lumber, timber, and poles to 19 percent maximum moisture content.
   D. Mark treated wood with treatment quality mark of an inspection agency approved by ALSC's Board of Review.
   E. Provide preservative-treated materials for all exterior rough carpentry unless otherwise indicated on Drawings, and the following:
      1. Framing members less than 18 inches above grade.
      2. Sills and ledgers.
      3. Members in contact with masonry or concrete.
      4. Posts.
      5. Round wood poles.
      6. Decking.
      7. Stair treads.
2.03 LUMBER
   A. Dimension Lumber:
      1. Maximum Moisture Content: [15 percent] [19 percent] [15 percent for 2-inch nominal (38-mm actual) thickness or less, 19 percent for more than 2-inch nominal (38-mm actual) thickness] [19 percent for 2-inch nominal (38-mm actual) thickness or less, no limit for more than 2-inch nominal (38-mm actual) thickness].
      2. Deck[ and Stair] Framing: [No. 1] [No. 2] [Construction or No. 2] [Construction, Stud, or No. 3]: [Hem-fir (north): NLGA;] [Southern pine: SPIB] [Douglas fir-larch: WCLIB, or WWPA;] [Spruce-pine-fir: NLGA;] [Douglas fir south: WWPA;] [Hem-fir: WCLIB, or WWPA;] [Douglas fir-larch (north): NLGA;] [or] [Spruce-pine-fir (south): NeLMA, WCLIB, or WWPA].
      3. Dimension Lumber Posts: [No. 2] [Construction or No. 2] [Construction, Stud, or No. 3]: [Hem-fir or hem-fir (north): NLGA, WCLIB, or WWPA;] [Douglas fir-larch, Douglas fir-larch (north), or Douglas fir-south: NLGA, WCLIB, or WWPA;] [or] [Mixed southern pine: SPIB].
4. Dimension Lumber Decking and Stair Treads: [No. 2] [Construction or No. 2]: [Hem-fir or hem-fir (north): NLGA, WCLIB, or WWPA;] [Douglas fir-larch, Douglas fir-larch (north), or Douglas fir-south: NLGA, WCLIB, or WWPA;] [or] [Mixed southern pine: SPIB].

5. Dimension Lumber Decking and Stair Treads: [No. 2] [Construction or No. 2] [Deck Heart or Construction Heart] [Deck Common or Construction Common] redwood; RIS.

6. Dimension Lumber Railing Members and Benches: [No. 1] [No. 2] [Construction or No. 2]: [Hem-fir or hem-fir (north): NLGA, WCLIB, or WWPA;] [Douglas fir-larch, Douglas fir-larch (north), or Douglas fir-south: NLGA, WCLIB, or WWPA;] [or] [Mixed southern pine: SPIB]. Provide material hand selected for freedom from characteristics, that would impair finish appearance, including decay, honeycomb, knot holes, shake, splits, torn grain, and wane.

7. Dimension Lumber Railing Members and Benches: [No. 1] [No. 2] [Construction or No. 2] [Heart B or Select Heart] redwood; RIS.

B. Boards:
2. Board Decking: 1-1/4-inch- (32-mm-) thick, radius-edged decking of any of the following species and grades:
   a. Douglas fir-larch, Douglas fir-larch (north), or Douglas fir-south, WWPA, NLGA, or WCLIB.
   b. Hem-fir or Hem-fir (north), [Patio 1, Select Patio, or Select Dex] [Patio 2, Commercial Patio, or Commercial Dex]; WWPA, NLGA, or WCLIB.
   c. Southern pine, [Premium] [Standard]; SPIB.
3. Board Decking Heart B or Select Heart; RIS.
4. Stair Treads: 1-1/4-inch- (32-mm-) thick stepping with half-round or rounded-edge nosing and any of the following species and grades:
   a. Douglas fir, C & Btr VG (Vertical Grain) stepping; NLGA, WCLIB, or WWPA.
   b. Hem-fir, C & Btr VG (Vertical Grain) stepping; NLGA, WCLIB, or WWPA.
   c. Southern pine, [Edge Grain B & B stepping] [Near Rift B & B stepping] [B & B stepping]; SPIB.
5. Stair Treads: 1-1/4-inch- (32-mm-) thick stepping with half-round or rounded-edge nosing; redwood, [Heart Clear] [Heart B or Select Heart]; RIS.
6. Railing Boards: [Douglas fir, C & Btr finish or C Select; NLGA, WCLIB, or WWPA] [Hem-fir, C & Btr finish or C Select; NLGA, WCLIB, or WWPA] [or] [Southern pine, B & B finish; SPIB].
7. Railing Boards: Redwood, [Heart Clear] [Heart B or Select Heart]; RIS.
8. Boards for Benches: [Douglas fir, C & Btr finish or C Select; NLGA, WCLIB, or WWPA] [Hem-fir, C & Btr finish or C Select; NLGA, WCLIB, or WWPA] [or] [Southern pine, B & B finish; SPIB].
9. Boards for Benches: Redwood, [Heart Clear] [Heart B or Select Heart]; RIS.
10. Board Decking [Stair Treads] [and] [Boards for Benches]: Radius-edged S4S ipe boards, clear one face.

2.04 TIMBER AND POLES
A. Timbers 5-Inch Nominal (117-mm Actual) Size and Thicker: Provide [dressed timber (S4S)] [or] [timber that is rough sawn (Rgh)] unless otherwise indicated.
1. Maximum Moisture Content: [20] [23] <Insert number> percent.
2. Timber Posts: Balsam fir, Douglas fir-larch, Douglas fir-larch (north), eastern hemlock tamarack (north), hem-fir, southern pine, western hemlock, or western hemlock (north); [No. 1] [No. 2]: NeLMA, NLGA, SPIB, WCLIB, or WWPA.
3. Timber Posts: Alaska cedar; [No. 1] [No. 2]; WCLIB.
4. Timber Posts: Southern pine; [No. 1] [No. 2]; SPIB.

B. Round Wood Poles: Clean-peeled wood poles complying with ASTM D 3200; with at least 80 percent of inner bark removed and with knots and limbs cut flush with the surface.
   1. Species: <Insert species required>.

2.05 MISCELLANEOUS PRODUCTS

A. Fasteners: Use [stainless steel] [fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M or ASTM F 2329] unless otherwise indicated.
   1. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches (38 mm) into wood substrate.

B. Postinstalled Anchors: Stainless-steel, [chemical] [or] [torque-controlled expansion] anchors with capability to sustain, without failure, a load equal to six times the load imposed as determined by testing per ASTM E 488.

C. Metal Framing Anchors: Structural capacity, type, and size indicated, made from [hot-dip galvanized steel complying with ASTM A 653/A 653M, G60 (Z180) coating] [hot-dip galvanized steel complying with ASTM A 653/A 653M, G185 (Z550) coating] [stainless steel complying with ASTM A 666, Type 304].
   1. Manufacturers:
      a. Simpson Strong-Tie Co., Inc.

D. Deck Splines: Plastic splines designed to fit in grooves routed into the sides of decking material and be fastened to deck framing with screws. [Splines are made from UV-resistant polypropylene.]
   1. Products:
      a. Blue Heron Enterprises, LLC.; Eb-Ty Hidden Deck Fastener.

E. Deck Clips: Black-oxide-coated stainless-steel clips designed to be fastened to deck framing with screws, and to secure decking material with teeth.
   1. Products:
      a. Tiger Claw Inc.; Tiger Claw Hidden Deck Fasteners.

F. Deck Tracks: Formed metal strips designed to be fastened to deck framing and to secure decking material from underside with screws. Made from [epoxy powder-coated, hot-dip galvanized] [stainless] steel.
   1. Products:

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.

B. Framing Standard: Comply with AF&PA's "Details for Conventional Wood Frame Construction" unless otherwise indicated.

C. Securely attach work to substrates, complying with the following:
   1. CABO NER-272 for power-driven fasteners.
   2. Published requirements of metal framing anchor manufacturer.
   3. [Table 2304.9.1, "Fastening Schedule," in the IBC] [Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC’s International Residential Code for One- and Two-Family Dwellings].
D. Secure decking to framing with concealed decking fasteners.
E. Secure stair treads and risers by gluing and [nailing] [screwing] to carriages. Countersink fastener heads, fill flush, and sand filler. Extend treads over carriages[and finish with bullnose edge].
F. Railing Installation: Countersink fastener heads, fill flush, and sand filler.
   1. Fit balusters to railings, glue, and [nail] [screw] in place.
   2. Secure newel posts to stringers and risers with [through bolts] [lag screws] [countersunk-head wood screws and glue].
   3. Secure wall rails with metal brackets. Fasten freestanding railings to newel posts and to trim at walls with countersunk-head wood screws or rail bolts and glue.

END OF SECTION 061533
SECTION 061600 – SHEATHING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS
A. Submittals: ICC-ES evaluation reports for preservative-treated plywood.

PART 2 - PRODUCTS

2.01 WOOD PANEL PRODUCTS, GENERAL
A. Plywood: DOC PS 1.
B. Certified Wood: Wood-based materials shall be certified as "FSC Pure" or "FSC Mixed Credit" according to FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship," and to FSC STD-40-004, "FSC Standard for Chain of Custody Certification."

2.02 TREATED PLYWOOD
A. Preservative-Treated Plywood: AWPA U1; Use Category UC2.
   1. Use treatment containing no arsenic or chromium.
   2. Kiln-dry plywood after treatment to a maximum moisture content of 15 percent.
B. Provide preservative-treated plywood for items indicated on Drawings and plywood in contact with masonry or concrete or used with roofing, flashing, vapor barriers, and waterproofing.
C. Fire-Retardant-Treated Plywood: Products with a flame-spread index of 25 or less when tested according to ASTM E 84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
   1. Use Exterior type for exterior locations and where indicated.
   2. Use Interior Type A unless otherwise indicated.
   3. For roof sheathing and where high-temperature fire-retardant treatment is indicated, span ratings for temperatures up to 170 deg F shall be not less than span ratings specified.
   4. Identify with appropriate classification marking of a testing and inspecting agency acceptable to authorities having jurisdiction.
D. Provide fire-retardant-treated plywood for items indicated on Drawings.

2.03 WALL SHEATHING
A. Plywood Wall Sheathing: Exterior, Structural I, Exposure 1 sheathing.
B. Plywood Roof Sheathing: Exterior, Structural I, Exposure 1 sheathing.
C. Composite Nail Base Insulated Roof Sheathing: Polyisocyanurate foam with oriented strand board laminated to one face complying with ASTM C 1289, Type V.

2.04 SUBFLOORING AND UNDERLAYMENT
A. Combination Subfloor-Underlayment:
   1. Plywood Combination Subfloor-Underlayment: DOC PS 1, Exterior, Structural I, single-floor panels.
B. Subflooring:
   1. Plywood Subflooring: [Exterior, Structural I [Exterior] [Exposure 1, Structural I] [Exposure 1] single-floor panels or sheathing.
   2. Oriented-Strand-Board Subflooring: Exposure 1[, Structural I sheathing][single-floor panels or sheathing].

2.05 MISCELLANEOUS PRODUCTS
A. Fasteners: Size and type indicated.
   1. For roof and wall sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M of Type 304 stainless steel.
B. Sheathing Joint-and-Penetration Treatment Materials:
1. Sealant for Glass-Mat Gypsum Sheathing: Silicone emulsion sealant, recommended by tape and sheathing manufacturers for application indicated.
2. Sheathing Tape for Glass-Mat Gypsum Sheathing: Self-adhering, glass-fiber tape recommended by sheathing and tape manufacturers for application indicated.

C. Adhesives for Field Gluing Panels to Framing: APA AFG-01.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Securely attach to substrates, complying with the following:
   1. CABO NER-272 for power-driven fasteners.
   2. [Table 2304.9.1, "Fastening Schedule," in the IBC] [Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings].

B. Fastening Methods:
   1. Combination Subfloor-Underlayment:
      a. Nail to wood framing.
      b. Screw to cold-formed metal framing.
   2. Subflooring:
      a. Nail to wood framing.
      b. Screw to cold-formed metal framing.
   3. Wall and Roof Sheathing:
      a. Nail to wood framing.
      b. Screw to cold-formed metal framing.

END OF SECTION 061600
SECTION 061713 – LAMINATED VENNER LUMBER

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data including specifications and installation instructions, ICC-ES evaluation reports the complete furnishings and installation of all Microllam® laminated veneer lumber (LVL) as shown on the drawings herein specified and necessary to complete the work.

B. Code Approvals: These products shall be designed and manufactured to the standards set forth in the ICC Evaluation Service, Inc. report ESR-1387.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Microllam® LVL shall be designed to fit the dimensions and loads indicated on the plans Comply with applicable requirements and recommendations of the following publications:
   1. TPI 1, "National Design Standard for Metal Plate Connected Wood Truss Construction."
   2. TPI DSB, "Recommended Design Specification for Temporary Bracing of Metal Plate Connected Wood Trusses."
   3. TPI BCSI, "Guide to Good Practice for Handling, Installing, Restraining & Bracing Metal Plate Connected Wood Trusses."


2.02 MATERIALS

A. Laminated Veneer Lumber: Materials shall comply with ICC ES ESR-1387.

B. Adhesives: Adhesives shall be of the waterproof type conforming to the requirements of ASTM D2559.

C. Fasteners: Where beams are exposed to weather or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.

D. Metal Framing Anchors: Provide framing anchors made from hot-dip, zinc-coated steel sheet complying with ASTM A 653/A 653M, G60 (Z180) coating designation.

2.03 FABRICATION

A. Microllam® LVL shall be manufactured by Weyerhaeuser in a plant listed in the reports referred to above and under the supervision of an approved third-party inspection agency. It shall be manufactured in a continuous process with all grain parallel with the length of the members. All members are to be free of finger or scarf joints or mechanical connections in full-length members.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install and brace beams according to TPI recommendations and as indicated. Install beams plumb, square, and true to line and securely fasten to supporting construction.

B. Anchor beams securely at bearing points; use metal beam or floor truss hangers as applicable. Install fasteners through each fastener hole in metal framing anchor.

C. Install and fasten permanent bracing during beam erection and before construction loads are applied. Anchor ends of permanent bracing where terminating at walls or beams.
   1. Install bracing to comply with [Section 061000 "Rough Carpentry."] [Section 061053 "Miscellaneous Rough Carpentry."]
   2. Install and fasten strongback bracing vertically against vertical web of parallel-chord floor trusses at centers indicated.

D. Install LVL beams within installation tolerances in TPI 1.

E. Do not alter beams in field.
F. Remove LVL beams that are damaged or do not meet requirements and replace with beams that do meet requirements.

END OF SECTION 061753
SECTION 064100 – ARCHITECTURAL WOOD CASEWORK

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Shop Drawings.
B. Installer Qualifications: Fabricator of products.
C. Environmental Limitations: Do not deliver or install woodwork until building is enclosed, wetwork is completed, and HVAC system is operating.

PART 2 - PRODUCTS

2.01 ARCHITECTURAL CABINETS

A. Quality Standard: AWI, AWMAC, and WI’s "Architectural Woodwork Standards."
B. Certified Wood: Wood-based materials shall be certified as "FSC Pure" or "FSC Mixed Credit" according to FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship," and to FSC STD-40-004, "FSC Standard for Chain of Custody Certification."
C. Plastic-Laminate Cabinets: Economy grade.
   1. Type of Construction: Frameless.
   2. Cabinet and Door and Drawer Front Interface Style: Flush overlay.
   3. Laminate Cladding: Horizontal surfaces other than tops, Grade HGS; postformed surfaces, Grade HGP; vertical surfaces, Grade HGS; edges, Grade HGS PVC tape, PVC edge banding, 0.12 inch thick; semiexposed surfaces, Grade VGS thermoset decorative panels.
   4. Drawer Sides and Backs: Thermoset decorative panels.
   5. Drawer Bottoms: Thermoset decorative panels.

2.02 MATERIALS

A. Wood Moisture Content: 5 to 10 percent.
B. Medium-Density Fiberboard: ANSI A208.2, Grade 130, made with binder containing no urea formaldehyde.
C. Particleboard: ANSI A208.1, Grade M-2, made with binder containing no urea formaldehyde.
D. Veneer-Faced Panel Products (Hardwood Plywood): HPVA HP-1, made with adhesive containing no urea formaldehyde.
E. High-Pressure Decorative Laminate: NEMA LD 3.
   1. Manufacturers:
      a. Formica Corporation.

2.03 CABINET HARDWARE AND ACCESSORY MATERIALS

A. Butt Hinges: 2-3/4-inch, five-knuckle steel hinges made from 0.095-inch thick metal, and as follows:
   1. Semiconcealed Hinges for Flush Doors: BHMA A156.9, B01361.
   2. Semiconcealed Hinges for Overlay Doors: BHMA A156.9, B01521.
B. Frameless Concealed Hinges (European Type): BHMA A156.9, B01602, 170 degrees of opening, self-closing.
C. Wire Pulls: Back mounted, solid [metal] [plastic], [4 inches (100 mm) long, 5/16 inch (8 mm) in diameter] [5 inches (127 mm) long, 2-1/2 inches (63.5 mm) deep, and 5/16 inch (8 mm) in diameter].
D. Catches: [Magnetic catches, BHMA A156.9, B03141] [Push-in magnetic catches, BHMA A156.9, B03131] [Roller catches, BHMA A156.9, B03071] [Ball friction catches, BHMA A156.9, B03013].
E. Adjustable Shelf Standards and Supports: BHMA A156.9, B04071; with shelf rests, B04081
F. Shelf Rests: BHMA A156.9, B04013; metal, two-pin type with shelf hold-down clip.
G. Drawer Slides: BHMA A156.9, B05091.
1. Box Drawer Slides: Grade 1HD-100.
2. Trash Bin Slides: Grade 1HD-100.

H. Drawer Locks: BHMA A156.11, E07041.

I. Exposed Hardware Finishes: Comply with BHMA A156.18 for BHMA code number indicated.
   1. Product: Atlas Homewares Tab Cabinet Pull 4-5/16”
      a. Finish: High Gloss White
      b. Quantity: 15

J. Furring, Blocking, Shims, and Hanging Strips: Fire-retardant-treated hardwood lumber, kiln dried to 15 percent moisture content.

2.04 FABRICATION
A. Complete fabrication to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

2.05 SHOP FINISHING OF WOOD CABINETS
A. Finishes: Same grades as items to be finished.
B. Finish cabinets at the fabrication shop; defer only final touch up until after installation.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Before installation, condition cabinets to average prevailing humidity conditions in installation areas.

B. Install cabinets to comply with referenced quality standard for grade specified.

C. Install cabinets level, plumb, true, and straight. Shim as required with concealed shims. Install level and plumb (including tops) to a tolerance of 1/8 inch in 96 inches.

D. Scribe and cut cabinets to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.

E. Anchor cabinets to anchors or blocking built in or directly attached to substrates. Fasten with countersunk concealed fasteners and blind nailing. Use fine finishing nails or finishing screws for exposed nailing, countersunk and filled flush.

F. Cabinets: Install so doors and drawers are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation.
   1. Fasten wall cabinets through back, near top and bottom, at ends and not more than 16 inches o.c. with No. 10 wafer-head screws sized for 1-inch penetration into wood framing, blocking, or hanging strips.

END OF SECTION 064100
DIVISION 07 – THERMAL AND MOISTURE PROTECTION

SECTION 072120 – THERMAL INSULATION

PART 1- GENERAL
1.1 Summary
A. This section covers thermal insulation

PART 2- PRODUCTS
2.1 Thermal batt insulation
A. Roxul Comfortbatt insulation
   i. Manufacturer: Roxul
   ii. Comfortbatt R30 - 24” Steel Stud
   iii. Comfortbatt R24 - 24” Steel Stud
   iv. Comfortbatt R23 - 16” Wood Stud
   v. Fire resistant, non-combustible
   vi. Chemically inert, non-corrosive

PART 3- EXECUTION
3.1 Install insulation following manufacturer instructions
A. Cut batts with serrated knife
B. Fill between studs

END OF SECTION 072120
SECTION 075000 – MEMBRANE ROOFING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS
A. Submittals: Shop Drawings and ICC-ES evaluation reports for components of membrane roofing system.
B. Warranties: Manufacturer's standard or customized form, without monetary limitation, signed by membrane manufacturer agreeing to repair leaks due to defects in materials or workmanship for period of 10 years.

1.02 DEFINITIONS
A. Exterior unstructured vinyl siding: An architectural siding that provides weather protection and is wholly supported by the building to which it is attached.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS
A. Structural Performance: Provide exterior fabric capable of withstanding the effects of gravity loads and the following loads and stresses within and under conditions indicated.
   1. Wind Loads:
      a. Uniform pressure of 18.6 lbs/sq. ft acting upward or downward.
B. Energy Performance: Initial Solar Reflectance not less than 0.70 and Thermal Emittance not less than 0.75 when tested according to CRRC-1.
C. Solar Reflectance Index: Not less than 78 when calculated according to ASTM E1980.
D. Exterior Fire-Test Exposure: ASTM E108, [Class A] [Class B] [Class C].

2.02 MATERIALS
A. PVC COATED POLYESTER:
   1. Manufacturers:
      a. NAIZIL INC.
   4. Width: 98.5 inches.
   5. Color Fade Resistance: UV resistant. Most colors tested up to 1500 hrs in SAE 1960j fadeometer with minimal or no change. Fade resistant to most chemicals.
   6. Durability: Ten years,
   7. Mildew Resistance: Fabric will not support growth of mildew.
   9. Water Repellency: Excellent
   10. Oil Repellency: AATCC 118-1997 GRADE 5
   11. Bonding: can be heat sealed or sewn

PART 3 - EXECUTION

3.01 INSTALLATION
A. Install substrate board with long joints continuous and perpendicular to roof slopes with end joints staggered. Tightly butt substrate boards together and fasten to wood joist
B. Install roofing membrane system according to roofing system manufacturer's written instructions, applicable recommendations in ARMA/NRCA's "Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing," and as follows:
C. Maintain uniform side and staggered end laps. Bond and seal laps, leaving no voids.

END OF SECTION 075000
SECTION 079100 – PREFORMED JOINT SEALS

PART 1 - GENERAL
1.1 Summary
A. Section Includes:
   i. Seals for module gap

PART 2 - PRODUCTS
A. QuickJoint
   i. Manufacturer: EMSEAL JOINT SYSTEMS
   ii. Self-Extinguising
   iii. Fire-Retardant-acrylic-impregnated foam
   iv. Material Cover: Silicone
   v. Gap sizes: ½" to 6"
   vi. R-value 5.696

PART 3 - EXECUTION
3.1 Installation
A. Ducts shall be installed by a license contractor
B. Ducts prone to condensation shall be insulated to a minimum R-value of R8
C. Follow manufacturer instructions for attachment, support, and sealing
D. Installation shall comply with all applicable codes
E. Ducts shall be routed to reduce the number of bends where possible

END OF SECTION 079100
DIVISION 08 – OPENINGS

SECTION 083213 – SLIDING DOORS

PART 1- GENERAL

1.1 SUMMARY

A. Section includes:
   i. Sliding Metal Doors

B. Shop Drawings
   i. Double Click Icon:

C. Related sections
   i. Section 07270 (07 27 00) - Air Barriers: Water-resistant barrier.
   ii. Section 07920 (07 92 00) - Joint Sealants: Sealants and caulking.

1.2 REFERENCES

A. American Architectural Manufacturers Association (AAMA)
B. American Society for Testing and Materials (ASTM)
C. Aluminum Association (AA)
D. National Wood Window & Door Association (NWWDA)

1.3 SYSTEM DESCRIPTION

A. General: In addition to requirements shown or specified, comply with:


C. Performance Requirements: This product is designed for applications only where AAMA/NWWDA ratings for air, water penetration and structural performance is not required.

1.4 QUALITY ASSURANCE

A. Single Source Responsibility
   i. Obtain entrances, storefronts, ribbon walls, window walls, curtain walls, window systems and finish through one source from a single manufacturer.

B. Provide test reports from AAMA accredited laboratories certifying the performances as specified in 1.3.

1.5 WARRANTY

A. Warranted against failure and/or deterioration of metals due to manufacturing process for a period of one (1) year providing the product was installed in accordance to Arcadia’s installation instructions and maintained in accordance with Arcadia’s operations manual

PART 2- PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

B. Acceptable Products:

2.2 MATERIALS
A. Windows & doors fabricated from aluminum extrusions of 6063-T5 alloy and temper with a minimum wall thickness of 0.090” for the door frame sill member and a minimum of 0.072” for all other members including frame, panel and optional horizontal muntins. The aluminum shall be free of defects which impair strength and appearance.

B. Component parts and accessories shall be of aluminum alloy, stainless steel or non-metallic materials which will neither deteriorate nor promote corrosion.

C. Thermal break barrier (optional) shall provide a continuous uninterrupted thermal separation around the entire perimeter of the panel only which shall consist of a two-part, chemically curing, high-strength urethane.

D. Sill shall have a full-length nylon track cap.

E. Panel members shall have a minimum of 5/8” glass penetration into the aluminum.

F. Operable panel shall be equipped with two adjustable steel tandem ball bearing rollers (all stainless steel tandem rollers and housings optional).

G. Locking device Adams-Rite maximum security lock MS+1850 with stainless steel hook bolt standard. Multi-slider doors & windows including all pocket windows can be supplied with locking flush pulls and an Adams-Rite MS+1847 stainless steel mortise lock-optional.

H. Operating panels shall have an extruded 3/4” diameter – 8” O.C. aluminum wire pull handle set in either clear or black architect finish – other colors available.

I. Operating panels shall contain a bottom rail vinyl sweep.

J. Horizontal members shall have two contact points incorporating silicone treated woven pile with mylar center fins. All vertical members shall have four contact points of silicone treated woven pile with mylar center fins. All shall be held in integral extruded slots and secured to prevent movement or loss while operating sash.

K. Fixed and/or sliding panels shall be constructed to allow for either factory or field glazing. Panel glazing shall be accomplished using a “marine” style reusable, wraparound black flexible PVC or EPDM material per commercial standard CS23060 without the need for separate glazing beads or putty style bedding compounds. The glazing channel shall be provided with the unit for either 1” insulating glass or 3/16” or 1/4” single glazing.

L. All assembly and installation screws shall be 18-8 or 410 stainless steel.

M. Screen made of extruded aluminum frame and screened with 18 x 16 fiber mesh.

2.3 FINISH

A. Finish all exposed areas of aluminum and components as indicated (excluding hardware):
   i. Clear Anodized Class I (215 R1-0.4-0.7 mils thick) meeting AAMA 611.89
   ii. (or) Dark Bronze Anodized Class 1 (0.7 mils thick) meeting AAMA 611.89
   iii. (or) Standard finish is White baked on enamel-Duracron paint PPG UC-UC-42737 meeting AAMA 2603-98
   iv. (or) Standard finish is Quaker Bronze baked on enamel-Duracron paint PPG UC-88426 meeting AAMA 2603-98.
   v. (or) Custom colors in a baked-on enamel or Duranar finish are also available – AAMA 2604.98 and AAMA 2605.98 subject to minimum square footage requirements.

2.4 FABRICATION

A. Primary frame must be a minimum of 2” deep per panel required.
B. Frame sections interlock together to form any number of repetitious sections, each capable of accommodating a panel.

C. Each frame corner joint shall be secured with two stainless steel screws.

D. Profile of the fixed jamb and the latching jamb shall include two weatherstripped pockets to receive the fixed and latching stiles.

E. Fixed and sliding panels shall have a nominal 1-1/2” depth and shall have overlapped joints of the mortise type to provide extra strength and interlocking mechanically fastened hairline joints.

F. Interlocks and latching stiles shall be heavy gauge tubular sections assuring precise alignment and to resist twisting under load conditions.

3.1 EXAMINATIONS
A. Examine conditions and verify substrate conditions are acceptable for product installation.

3.2 INSTALLATION
A. Install in accordance with approved shop drawings and manufacturers installation instructions.

3.3 FIELD QUALITY CONTROL
A. Contractor’s responsibility to make all necessary final adjustments to attain normal operation of each door and its mechanical hardware.

END OF SECTION 083213
DIVISION 09 – FINISHES

SECTION 093000 – TILING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data and Samples.

B. Obtain tile of each type and color or finish from same production run for each contiguous area.

C. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. [Comply with requirements in ANSI A137.1 for labeling ceramic tile packages.]

PART 2 - PRODUCTS

2.01 CERAMIC TILE

A. Ceramic tile that complies with Standard grade requirements in ANSI A137.1, "Specifications for Ceramic Tile."

B. Tile Type: Glazed, square-edged quarry tile.

1. Manufacturers:
   a. Daltile; Division of Dal-Tile International Inc.

2. Face Size: 6 by 3 inches

3. Thickness: 3/8”.


5. Finish: Clear glaze.


8. Trim Units: Coordinated with sizes and coursing of adjoining flat tile
   a. Base: Coved.
   b. Wainscot Cap: Surface bullnose.

C. Cementitious Backer Units: ANSI A118.9 or ASTM C 1325, 1/2 inch (12.7 mm) thick.

1. Products:
   a. USG Corporation; DUROCK Cement Board.

D. Fiber-Cement Underlayment: ASTM C 1288, 1/2 inch thick.

1. Products: [One of the following:]
   a. CertainTeed Corp.; FiberCement Underlayment.

E. Low-Emitting Materials: Adhesives and fluid-applied waterproofing membranes shall have a VOC content of 65 g/L or less.

F. Low-Emitting Materials: Adhesives and fluid-applied waterproofing membranes shall comply with Green Seal's GS-36 and with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. Waterproofing Membranes for Thin-Set Installations: ANSI A118.10, [fabric-faced chlorinated polyethylene, PVC, or polyethylene sheet product] [fabric-reinforced modified bituminous product] [fabric-reinforced liquid-latex or elastomeric polymer product] [unreinforced liquid-latex or elastomeric polymer product] [urethane waterproofing and adhesive].

H. Setting and Grouting Materials: Comply with material standards in ANSI's "Specifications for the Installation of Ceramic Tile" that apply to materials and methods indicated.

1. Thin-Set Mortar Type: Latex-portland cement
   a. Manufacturers:
      1) MAPEI Corporation.

2. Thin-Set Mortar Type for Wood Subfloors: EGP latex-portland cement.
a. Manufacturers:
   1) MAPEI Corporation.

3. Water-Cleanable, Tile-Setting Epoxy:
   a. Manufacturers:
      1) MAPEI Corporation.

4. Grout Type: Standard cement
   a. Manufacturers:
      1) MAPEI Corporation.

5. Grout Type: Polymer modified
   a. Manufacturers:
      1) MAPEI Corporation.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Comply with TCA's "Handbook for Ceramic Tile Installation" for TCA installation methods specified in tile installation schedules. Comply with parts of ANSI A108 Series "Specifications for Installation of Ceramic Tile" that are referenced in TCA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.
   1. For installations indicated below, follow procedures in ANSI's "Specifications for the Installation of Ceramic Tile" for providing 95 percent mortar coverage.
      a. Exterior tile floors.
      b. Tile floors in wet areas.
      c. Tile swimming pool decks.
      d. Tile floors in laundries.
      e. Tile floors composed of tiles 8 by 8 inches or larger.
      f. Tile floors composed of rib-backed tiles.

B. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

C. Lay tile in grid pattern unless otherwise indicated. Align joints where adjoining tiles on floor, base, walls, and trim are the same size.

D. Install cementitious backer units and fiber-cement underlayment and treat joints according to ANSI A108.11.

E. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot toward drains.

F. Install waterproofing to comply with ANSI A108.13.

G. Do not install tile over waterproofing until waterproofing has cured and been tested to determine that it is watertight.

H. Install stone thresholds in same type of setting bed as adjacent floor unless otherwise indicated. At locations where mortar bed (thickset) would otherwise be exposed above adjacent floor finishes, set thresholds in latex-portland cement mortar (thin set).

I. Apply sealer to cleaned stone tile flooring according to sealer manufacturer's written instructions.

J. Interior Floor Tile Installation Method(s):
   1. Over Waterproof Membranes on Concrete Subfloors: [TCA F121 (cement mortar bed)] [TCA F122 (thin-set mortar)].
   2. Over Wood Subfloors: thin-set mortar bonded on cementitious backer units or fiber cement underlayment
3. Over Waterproof Membranes on Wood Subfloors: TCA F121 (cement mortar bed).

K. Interior Wall Tile Installation Method(s):
   1. Bathtub Wall Installations, Wood Studs or Furring: TCA B413 with thin-set mortar
      thin-set mortar on water-resistant gypsum board

END OF SECTION 093000
SECTION 096500 – RESILIENT FLOORING

PART 1 - GENERAL
1.01 SECTION REQUIREMENTS
A. Submittals: Product Data and Samples.
B. Extra Materials:
   1. Resilient Floor Tile: Deliver to Owner one box for every 36 Square feet, 17 boxes or fraction thereof, of each type and color of resilient floor tile installed.

PART 2 - PRODUCTS
2.01 VINYL COMPOSITION FLOOR TILE
A. Products:
   1. Armstrong World Industries, Inc.; Natural living D2404.
B. Color and Pattern: Black Walnut.
C. ASTM F 1066, Class 3 (surface-pattern tile).
D. Fire-Test Response: Critical radiant flux classification of Class I, not less than 0.45 W/sq. cm per ASTM E 648.
E. Wearing Surface: Smooth
F. Thickness: 0.125 inch
G. Size: 4 by 36 inches

2.02 INSTALLATION ACCESSORIES
A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement- or blended hydraulic cement-based formulation provided or approved by flooring manufacturer for applications indicated.
B. Stair-Tread-Nose Filler: Two-part epoxy compound recommended by resilient tread manufacturer to fill nosing substrates that do not conform to tread contours.
C. Adhesives: Water-resistant type recommended by manufacturer to suit floor covering and substrate conditions indicated.
   1. Low-Emitting Materials: Adhesives shall have a VOC content of [50] [60] g/L or less.
   2. Low-Emitting Materials: Adhesives shall comply with Green Seal’s GS-36 and with the testing and product requirements of the California Department of Health Services’ "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
D. Chemical-Bonding Compound: Manufacturer’s product for chemically bonding seams.
   1. Low-Emitting Materials: Chemical-bonding compound shall have a VOC content of 510 g/L or less.
   2. Low-Emitting Materials: Chemical-bonding compound shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
E. Metal Edge Strips: Extruded aluminum with mill finish of width shown, of height required to protect exposed edges of tiles, and in maximum available lengths to minimize running joints.
F. Integral-Flash-Cove-Base Accessories: 1-inch radius cove strip and square metal, vinyl, or rubber cap; both provided or approved by floor covering manufacturer.
   1. Provide metal inside and outside corners and end stops.
G. Floor Polish: Provide protective liquid floor polish products as recommended by manufacturer.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Prepare concrete substrates according to ASTM F 710. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
B. Unroll sheet floor coverings and allow them to stabilize before cutting and fitting.
C. Maintain uniformity of resilient sheet flooring direction, and match edges for color shading at seams.
D. Minimize number of seams; place seams in inconspicuous and low-traffic areas, at least 6 inches away from parallel joints in substrates.
E. Lay out tiles so tile widths at opposite edges of room are equal and are at least one-half of a tile.
F. Match tiles for color and pattern by selecting tiles from cartons in same sequence as manufactured and packaged. Lay tiles [with grain running in one direction] [in basket-weave pattern with grain direction alternating in adjacent tiles] [in patterns indicated].
G. Adhesively install resilient wall base and accessories.
H. Install wall base in maximum lengths possible. Apply to walls, columns, pilasters, casework, and other permanent fixtures in rooms or areas where base is required.
I. Install stair-tread-nose filler to nosing substrates that do not conform to tread contours.
J. Install reducer strips at edges of floor coverings that would otherwise be exposed.
   1. Install metal corners and end stops.
K. Floor Polish: Remove soil, visible adhesive, and surface blemishes from floor covering before applying liquid floor polish.
   1. Apply two coat(s).

END OF SECTION 096500
SECTION 099000 – PAINTING AND COATING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals:
   1. Product Data. Include printout of MPI’s "MPI Approved Products List" with product highlighted.
   2. Samples.

B. Mockups: Full-coat finish Sample of each type of coating, color, and substrate, applied where directed.

PART 2 - PRODUCTS

2.01 PAINT

A. Manufacturers:
   1. Dunn-Edwards Corporation.

B. MPI Standards: Provide materials that comply with MPI standards indicated and listed in its "MPI Approved Products List."

1. Exterior Painting Materials:
   b. Primer, Alkyd: MPI #5.
   c. Latex, Exterior Flat (Gloss Level 1): MPI #10.
   d. Latex, Exterior Low Sheen (Gloss Level 3-4): MPI #15.
   e. Latex, Exterior Semigloss (Gloss Level 5): MPI #11.
   f. Latex, Exterior, Gloss (Gloss Level 6): MPI #119.
   g. Light Industrial Coating, Exterior, Water Based (Gloss Level 3): MPI #161.
   h. Light Industrial Coating, Exterior, Water Based, Semigloss (Gloss Level 5): MPI #163.
   i. Light Industrial Coating, Exterior, Water Based, Gloss (Gloss Level 6): MPI #164.
   j. Alkyd, Exterior Flat (Gloss Level 1): MPI #8.
   k. Alkyd, Exterior, Semigloss (Gloss Level 5): MPI #94.
   m. Alkyd, Quick Dry, Semigloss (Gloss Level 5): MPI #81.
   n. Alkyd, Quick Dry, Gloss (Gloss Level 7): MPI #96.
   o. Floor Paint, Latex, Low Gloss (Maximum Gloss Level 3): MPI #60.
   p. Floor Enamel, Alkyd, Gloss (Gloss Level 6): MPI #27.

2. Interior Painting Materials:
   a. Primer Sealer, Latex: MPI #50.
   b. Primer, Latex, for Interior Wood: MPI #39.
   c. Latex, Interior, Flat, (Gloss Level 1): MPI #53.
   d. Latex, Interior, (Gloss Level 2): MPI #44.
   e. Latex, Interior, (Gloss Level 4): MPI #43.
   f. Latex, Interior, Semigloss, (Gloss Level 5): MPI #54.

3. Staining and Clear Finishing Materials:
   c. Primer, Alkyd for Exterior Wood: MPI #5.
   d. Primer, Oil for Exterior Wood: MPI #7.
   e. Preservative, for Exterior Wood: MPI #37.
   f. Stain, for Exterior Wood Decks: MPI #33.
   g. Stain, Semitransparent, for Interior Wood: MPI #90.
   h. Varnish, Water Based, Clear, Satin (Gloss Level 4): MPI #128.
i. Danish Oil: MPI #92.

4. High-Performance Coating Materials:
   b. Block Filler, Epoxy: MPI #116.
   c. Primer Sealer, Latex: MPI #50.
   e. Primer, Epoxy, Anticorrosive: MPI #101.
   f. Polyurethane, Two-Component, Pigmented, Gloss (Gloss Level 6): MPI #72.

C. Material Compatibility: Provide materials that are compatible with one another and with substrates.
   1. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

D. Use interior paints and coatings that comply with the following limits for VOC content:
   1. Flat Paints and Coatings: [50] <Insert value> g/L.
   2. Nonflat Paints, Coatings: [150] <Insert value> g/L.
   3. Dry-Fog Coatings: [400] <Insert value> g/L.
   4. Primers, Sealers, and Undercoaters: [200] <Insert value> g/L.
   5. Anticorrosive and Antirust Paints Applied to Ferrous Metals: [250] <Insert value> g/L.
   7. Pretreatment Wash Primers: [420] <Insert value> g/L.
   8. Clear Wood Finishes, Varnishes: [350] <Insert value> g/L.
   9. Clear Wood Finishes, Lacquers: [550] <Insert value> g/L.
   10. Floor Coatings: [100] <Insert value> g/L.
   11. Shellacs, Clear: [730] <Insert value> g/L.
   12. Shellacs, Pigmented: [550] <Insert value> g/L.
   13. Stains: [250] <Insert value> g/L.

E. Colors: As [selected] [scheduled].

PART 3 - EXECUTION

3.01 PREPARATION
   A. Comply with recommendations in MPI's "MPI Architectural Painting Specification Manual" applicable to substrates indicated.
   B. Remove hardware, lighting fixtures, and similar items that are not to be painted. Mask items that cannot be removed. Reinstall items in each area after painting is complete.
   C. Clean and prepare surfaces in an area before beginning painting in that area. Schedule painting so cleaning operations will not damage newly painted surfaces.

3.02 APPLICATION
   A. Comply with recommendations in MPI's "MPI Architectural Painting Specification Manual" applicable to substrates indicated.
   B. Paint exposed surfaces, new and existing, unless otherwise indicated.
      1. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces.
      2. Paint surfaces behind permanently fixed equipment or furniture with prime coat only.
      3. Paint the back side of access panels.
      5. Do not paint prefinished items, items with an integral finish, operating parts, and labels unless otherwise indicated.
   C. Apply paints according to manufacturer's written instructions.
1. Use brushes only for exterior painting and where the use of other applicators is not practical.
2. Use rollers for finish coat on interior walls and ceilings.
D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
1. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
E. Apply stains and transparent finishes to produce surface films without color irregularity, cloudines, holidays, lap marks, brush marks, runs, ropiness, or other imperfections. Use multiple coats to produce a smooth surface film of even luster.

3.03 EXTERIOR PAINT APPLICATION SCHEDULE
A. Concrete, Nontraffic Surfaces:
1. Flat Latex: Two coats over primer: MPI EXT 3.1A.
2. Flat Latex: Two coats over alkali-resistant primer: MPI EXT 3.1K.
B. Steel:
1. Semigloss Water-Based, Light-Industrial Coating: Two coats over alkyd anticorrosive primer.
C. Wood: Including wood trim, wood-based panel products.
1. Flat Latex: Two coats over latex primer: MPI EXT 6.3L.

3.04 INTERIOR PAINT APPLICATION SCHEDULE
A. Concrete, Nontraffic Surfaces:
1. Flat Latex: Two coats: MPI INT 3.1E.
2. Flat Latex: Two coats over primer/sealer: MPI INT 3.1A.
B. Steel:
1. Semigloss, Quick-Dry Enamel: Two coats over quick-drying alkyd metal primer: MPI INT 5.1A.
C. Galvanized Metal:
1. Flat Latex: Two coats over waterborne galvanized-metal primer: MPI INT 5.3J.
D. Wood: Including wood trim, door and wood-based panel products.
1. Semigloss Latex: Two coats over latex primer for wood: MPI INT 6.3T.
E. Gypsum Board:
1. Flat and Semigloss Latex: Two coats over latex primer/sealer: MPI INT 9.2A.

3.05 EXTERIOR STAIN AND CLEAR FINISH APPLICATION SCHEDULE
A. Wood, traffic surfaces, including wood decks and stairs.
1. Deck Stain over Wood Preservative: Two coats over preservative: MPI EXT 6.5D.
2. Deck Stain: Two coats: MPI EXT 6.5F.

3.06 INTERIOR STAIN AND CLEAR FINISH APPLICATION SCHEDULE
A. Wood substrates, nontraffic surfaces,
1. Semitransparent Stain: Two coats: MPI INT 6.1G
2. Semitransparent Stain: Two coats: MPI INT 6.3C.
3. Danish Oil: Two coats: MPI INT 6.3M.

3.07 EXTERIOR HIGH PERFORMANCE COATING APPLICATION SCHEDULE
A. Concrete, Nontraffic Surfaces:
1. Gloss Epoxy: Three coats: MPI EXT 3.1D.
B. Concrete, Traffic Surfaces:
1. Epoxy Slip-Resistant Deck Coating: One coat: MPI EXT 3.2C.
C. Steel:
1. Gloss Polyurethane, Pigmented: Two coats over gloss epoxy and epoxy anticorrosive primer: MPI EXT 5.1H.
### Interior High Performance Coating Application Schedule

#### A. Concrete, Nontraffic Surfaces:
1. **Gloss Epoxy:** Two coats: MPI INT 3.1F.
2. **Gloss Epoxy-Modified Latex:** Two coats: MPI INT 3.1G.

#### B. Concrete, Traffic Surfaces:
1. **Gloss Epoxy:** Two coats: MPI INT 3.2C.
2. **Gloss Polyurethane, Pigmented:** Two coat(s) over gloss epoxy: MPI INT 3.2D.
3. **Gloss Polyurethane, Pigmented** Two coat(s) over epoxy primer recommended by topcoat manufacturer.

#### C. Steel:
1. **Gloss Epoxy:** [One] [Two] coat(s) over anticorrosive epoxy primer: MPI INT 5.1L.
2. **Gloss Epoxy:** [One] [Two] coat(s) over epoxy primer recommended by topcoat manufacturer.
3. **Epoxy-Modified Latex:** Two coats over primer recommended by topcoat manufacturer.
4. **Gloss Polyurethane, Pigmented:** [One] [Two] coat(s) over anticorrosive epoxy primer: MPI INT 5.1F.
5. **Gloss Polyurethane, Pigmented:** Two coats over epoxy primer recommended by topcoat manufacturer.

#### D. Galvanized Metal:
1. **Gloss Epoxy:** Two coat(s) over anticorrosive epoxy primer: MPI INT 5.3D.
2. **Gloss Epoxy:** Two coat(s) over epoxy primer recommended by topcoat manufacturer.
3. **Gloss Polyurethane, Pigmented:** Two coats over epoxy primer recommended by topcoat manufacturer.

#### E. Wood:
1. **Gloss Epoxy:** Two coats: MPI INT 6.3L.
2. **Gloss Polyurethane, Pigmented:** Three coats: MPI INT 6.3E.

#### F. Gypsum Board:
1. **Gloss Epoxy:** Two coat(s) over latex primer sealer: MPI INT 9.2E.
2. **Gloss Epoxy-Modified Latex:** Two coats over latex primer sealer: MPI INT 9.2F.

**END OF SECTION 099000**
SECTION 102226 – OPERABLE PARTITIONS

PART 1 - GENERAL
1.01 SECTION REQUIREMENTS
A. Related Sections 064100
B. Submittals: Product Data, Shop Drawings, and Samples.

PART 2 - PRODUCTS
2.01 OPERABLE PANEL PARTITION: SHEET XB101
A. Manufacturers:
   1. Unistrut.
      a. Product: Wheel Trolley P2950
      b. Quantity: 8
   2. Unistrut.
      a. Product: Channel P5000
      b. Quantity: 60 LF
B. Partition Operation and Configuration: Manually operated, individual panels.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
D. Surface-Burning Characteristics: Provide finishes with flame-spread and smoke-developed indexes not more than [25] [75] [200] and 450, respectively, per ASTM E 84.
E. Panel Weight: 2000 LBS maximum.
F. Panel Thickness: 3'X 8'Cabinet
G. Panel Edges: Cap trimmed
H. Panel Face Finish: Formica.
   1. Total Weight: 500lbs.
I. > per ASTM E 90 and ASTM E 413.
J. Suspension System: Steel trolley-system carriers and aluminum track. Limit track deflection to 0.10 inch between supports.
K. Safety Features:

PART 3 - EXECUTION
3.01 INSTALLATION
A. Examine flooring, structural support, and opening, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of operable panel partitions. Proceed with installation only after unsatisfactory conditions have been corrected.
B. Install operable panel partitions to comply with ASTM E 557 after other finishing operations, including painting, had been completed.
C. Adjust operable panel partitions to operate smoothly, without warping or binding. Lubricate hardware, and other moving parts.

END OF SECTION 102226
SECTION 102800 - TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS
   A. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 TOILET AND BATH ACCESSORIES
   A. Manufacturers
      1. Kohler Inc.
   B. Toilet Tissue Dispenser: SHEET P102
      1. Product: K-14444-BN.
      2. Type: Single-roll dispenser.
      4. Material: Brushed Nickel
      6. Capacity: Designed for 4-1/2- or 5-inch diameter-core tissue rolls.
   C. Towel Bar: SHEET P102:
      1. Product: Kohler K-14436-BN
      2. Description: 3/4-inch- square tube with circular end brackets.
      4. Length: 24 inches.
      5. Material and Finish: Brushed Nickel
   D. Towel Bar: SHEET P102:
      1. Product: Kohler K-14435-BN
      2. Description: 3/4-inch- square tube with circular end brackets.
      4. Length: 18 inches.
      5. Material and Finish: Brushed Nickel

PART 3 - EXECUTION

3.01 INSTALLATION
   A. Install accessories using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.
   B. Adjust accessories for unencumbered, smooth operation and verify that mechanisms function properly. Replace damaged or defective items. Remove temporary labels and protective coatings.

END OF SECTION 102800
SECTION 107114 - METAL SUN SHADE

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes: Modular, shop fabricated, metal sun shades to mount on exterior canopy frame.
B. Related Sections:
   1. Section 107313 - AWNINGS

1.2 REFERENCES
A. American Society for Testing and Materials (ASTM) Publications:
   1. ASTM A36 - Structural Steel.
   2. ASTM A500 - Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   3. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
   4. ASTM B221 - Aluminum-Alloy Extruded Bar, Rod, Wire, Shape, and Tube.

1.3 SUBMITTALS
A. Provide in accordance with Section 01 33 00 - Submittal Procedures:
   1. Product data for sun shade components and finish.
   2. Shop drawings showing layout, dimensions, spacing of components, and anchorage and installation details.
   3. Calculations for support system.
   4. Sample: 10 by 10 inches [254 by 254 mm] minimum size sample of sun shade panel illustrating design, fabrication workmanship, and selected color coating.
   5. Copy of warranty specified in Paragraph 1.5 for review by Architect.

1.4 QUALITY ASSURANCE
A. Design structural support framing components for sun shades under direct supervision of professional structural engineer.
B. Installer qualifications: Approved by manufacturer for installation sun shade system.

1.5 WARRANTY
A. Provide in accordance with Section 01 77 00 - Closeout Procedures:
   1. 20 years warranty for factory finish against cracking, peeling, and blistering under normal use.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
A. Apollo Roof opening system
B. Requests to use equivalent products of other manufacturers shall be submitted in accordance with Section 01 63 00 - Product Substitution Procedures.

2.2 MATERIALS
A. Extruded aluminum: ASTM B221, Alloy 6063, Temper T-6.

2.3 SUN SHADE SYSTEM
A. Aluminum sun shades consisting of modular framed panels with louvered infill and outriggers for mounting on canopy frame; Sun Shades as manufactured by Apollo Roof Systems.
   1. Panel size: 126 by 126 inches aluminum frame with louvered infill panel as indicated on Drawings and approved shop drawings.
      i. Quantity: 4
   B. Sun shade panel: Modular infill panel
      2. Panel size: 57 by 126 inches insert panel as indicated on Drawings and approved shop drawings.
         i. Quantity: 26
         a. Incident angle of sun shade: N/A
C. Support system: Provide outriggers or other means for support of sun shade panel fabricated from same material as panel. System shall be designed to resist applicable dead, live, wind, and seismic loads.
   1. Type: Straight projecting outriggers.
   2. Construction: Welded fabrication consisting of attachment plate, double support angles, and tapered plate extension as detailed and dimensioned on Drawings and approved shop drawings.
   3. Size: As required to provide sufficient structural support of panels.
D. Fasteners: Stainless steel bolts, studs, and other types of size and spacing as recommended by manufacturer for specific condition and detailed on approved shop drawings.

2.4 FACTORY FINISH
A. Sun shade panels, outriggers, and other components shall receive electrostatically applied colored polyester powder coating heat cured to chemically bond finish to metal substrate.
   1. Minimum hardness measured in accordance with ASTM D3363: 2H.
   2. Direct impact resistance tested in accordance with ASTM D2794: Withstand 160 inch-pounds.
   3. Salt spray resistance tested in accordance with ASTM B117: No undercutting, rusting, or blistering after 500 hours in 5 percent salt spray at 95 degrees F and 95 percent relative humidity and after 1000 hours less than [3/16 inch] [5 mm] undercutting.
   4. Weatherability tested in accordance with ASTM D822: No film failure and 88 percent gloss retention after 1 year exposure in South Florida with test panels tilted at 45 degrees.
B. Color: Silver with weather resistant clear coating

PART 3 - EXECUTION
3.1 PREPARATION
A. Prior to fabrication, field verify required dimensions.
B. Coordinate sun shade installation with provision of canopy frame structure to ensure proper structural support is provided, attachment of sun shades is compatible with substrate, and weathertightness of exterior envelop is maintained.

3.2 INSTALLATION
A. Install sun shades in accordance with manufacturer’s installation instructions and approved shop drawings.
B. Insulate dissimilar metals to prevent electrolysis with bituminous paint or non-absorptive gasket to prevent contact.
C. Allow for thermal expansion and contraction of metal components.
D. Install shade panels plumb, level, free from distortion, and aligned with building elements and adjacent shade panels.
E. Do not installed bent, bowed, or otherwise damaged panels. Remove damaged components from site and replace.
F. Attach shade panels to outriggers with appropriate fasteners for secure, permanent installation.
G. After installation, touch-up damaged finish with paint supplied by manufacturer and matching original coating.

END OF SECTION 107114
SECTION 107313 – Awnings

PART 1 - GENERAL
1.01 SECTION REQUIREMENTS
   A. Submittals: Product Data, Shop Drawings, and Samples.
   B. Verify dimensions by field measurements before fabrication and indicate on Shop Drawings.

PART 2 - PRODUCTS
2.01 AWNINGS
   A. Performance Requirements: Provide awnings capable of withstanding design loads indicated.
   B. Aluminum Frames: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.
      3. Extruded Structural Pipe and Round Tubing: ASTM B 429/B 429M.
      5. Aluminum Finish: Mill.
   C. Anchors, Fasteners, Fittings, Hardware, and Installation Accessories: Corrosion-resistant, weather-resistant, nonstaining materials. Where exposed to view, provide finish and color as selected.
      1. Expansion Anchors: Stainless steel anchors able to sustain six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete.
   E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
2.02 BALL BEARING SLIDER
   A. Manufacturer
      1. Barnes Engineering Company
         a. Product: HD3B2
         b. Quantity: 10
   B. Manufacturer
      1. Unistrut
         a. Product: Wheel trolley P2750
         b. Quantity: 8
   C. Manufacturer
      1. Unistrut
         a. Product: Channel P1000
         b. Quantity: 40 LF
2.03 CANOPY DRIVE MOTORS
   A. Manufacturer
      1. Baldor
         a. Product: VEM3538
         b. FL Amps 1.54/.77
         c. 60 Hz
         d. 1745 rpm
         e. 0.5 hp
         f. Quantity: 2
2.04 AWNING FABRICATION

A. Frames: Preassemble awning frames in the shop to greatest extent possible.
   1. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
   2. Form exposed work true to line and level with accurate angles and straight edges.
   3. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Provide weep holes where water may accumulate.
   4. Weld corners and connections continuously. At exposed corners and connections, finish exposed welds and surfaces smooth and blended.

B. Colors of Metal and Plastic Components Exposed to View: As indicated by manufacturer's.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install awnings securely connected to supports, free of rack, and in proper relation to adjacent construction.

B. Install awnings after other finishing operations, including joint sealing and painting, have been completed.

C. Slip fit frame connections accurately together to form hairline joints.

D. Weld frame connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.

E. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

F. Galvanized Surfaces: Clean field welds, connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

END OF SECTION 107313
SECTION 107400 – MANUFACTURED EXTERIOR SPECIALTIES

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Variable- and single-frequency drives accelerate and decelerate pairs of motors to move the modules and canopies.

B. Submittals

i. http://ab.com/catalogs/

PART 2 - PRODUCTS

2.1 Single-Phase Drives

A. Allen-Bradley single-phase drive

i. Allen-Bradley 1PH 240 VAC single-phase drives (50/60 Hz)

   a. Catalog number: 22F-A2P5N103
   b. Certification: UL508C, EN 50178
   c. Environment: IP20, -10 to 50 °C
   d. Voltage tolerance: 200 to 240 V ± 10%
   e. Input frequency tolerance: 48 to 63 Hz
   f. Carrier frequency: 2 to 10 kHz
   g. Output frequency: 0 to 400 Hz
   h. Frequency accuracy
      (i) Digital input: within 0.05% of set output frequency
      (ii) Analog input: within 0.5% of maximum output frequency
   i. Speed regulation: open loop with slip compensation
   j. Stop modes: ramp, coast, DC brake, ramp-to-hold, S curve
   k. Output HP: 0.5
   l. Output kW: 0.4
   m. Output current: 2.5 A

2.2 Three-Phase Drives

A. Rockwell Automation three-phase drive

i. PowerFlex 4M

   a. Catalog Number: 22F-RF010-AL
   b. Input Voltage 240 V
   c. Single Phase
   d. Power 0.75 kW
   e. Rating 1.0 hp
   f. Current 10 A
   g. Control output voltage 0-10 V
   h. Control output amperage 4-20 mA
   i. Efficiency 97.5%
   j. UL508 C Listed
   k. CSA 22.2 Listed
   l. Frequency Accuracy +/- 0.05%
   m. Stop Modes: Multiple, including ramp, coast, DC break, S curve

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow Manufacturer Specifications

END OF SECTION 107400
DIVISION 11 – EQUIPMENT

SECTION 113100 – RESIDENTIAL APPLIANCES

PART 1 - GENERAL
1.01 SECTION REQUIREMENTS
A. Allowances: See Section 012000 "Price and Payment Procedures" for appliance allowances.
B. Submittals: Product Data.

PART 2 - PRODUCTS
2.01 RESIDENTIAL APPLIANCES
A. Regulatory Requirements: Comply with the following:
   1. NFPA: Provide electrical appliances listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. ANSI: Provide gas-burning appliances that comply with ANSI Z21 Series standards.
B. Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with [the U.S. Architectural & Transportation Barriers Compliance Board’s Accessibility Guidelines] [ICC A117.1].
C. Electric Cooktop: 30-inch, built-in cooktop with four burner elements.
   1. Manufacturers:
      a. BOSCH Home Appliances.
   2. Product: NET8054UC
D. Electric Wall Oven: Built-in, single electric, self-cleaning wall oven with broiler unit.
   1. Manufacturers:
      a. BOSCH Home Appliances.
   2. Product: HBL8450UC
   1. Manufacturers:
      a. BSH Home Appliances Corporation (Gaggenau).
   2. Product: VL431-707
   3. Color: Stainless Steel
   5. Weatherproof floor cap with backdraft damper and rodent-proof screening.
F. Refrigerator/Freezer: Freestanding, frost-free cycle-defrost, two-door refrigerator with bottom-mounted freezer, ABS thermoplastic-copolymer interior cabinet liners.
   1. Manufacturers:
      a. LIEBHERR.
   2. Product: HC1001
   3. Color: custom panel.
   5. Freezer Compartment Volume: 2.4 cu. Ft.
   6. Shelf Area: four adjustable glass shelves.
   7. Energy Performance: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
G. Dishwasher: Built-in, undercounter, automatic dishwasher drawer, sized to fit in 24-inch base cabinet, nine wash cycles with hot-air and heat-off drying cycles, porcelain-enamel tub and molded-plastic door liner, nylon-coated sliding dish racks.
   1. Manufacturers:
      a. Fisher & Paykel.ffa
2. Product: Model DD36ST12
3. Color: custom panel.
4. Energy Performance: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.

   1. Manufacturers:
      a. BOSCH Home Appliances.
   2. Product: WAS24460UC
   4. Energy Performance: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.

   1. Manufacturers:
      a. BOSCH Home Appliances.
   2. Product: WTE86300US

PART 3 - EXECUTION
3.01 INSTALLATION
A. Built-in Appliances: Securely anchor to supporting cabinetry or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.
B. Freestanding Appliances: Place in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
C. Test each item of residential appliances to verify proper operation. Make necessary adjustments.
D. Verify that accessories required have been furnished and installed.

END OF SECTION 113100
SECTION 115213 - PROJECTION SCREENS

PART 1 - GENERAL
1.01 SECTION REQUIREMENTS
A. Submittals: Product Data.
B. Coordinate layout and installation with ceiling construction.

PART 2 - PRODUCTS
2.01 PROJECTION SCREENS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Surface-Mounted Electrically Operated Screens: UL-labeled units consisting of case, screen, motor, controls, mounting accessories, and other components. Provide units with three-position switch infrared remote control, no ceiling closure, and end-mounted motor.
   1. Manufacturer:
      a. FAVI ENTERTAINMENT
   2. Product: FAVI 16:9/120-Inch Electric Projector Screen (HD-120)
C. Screen Material: Mildew- and flame-resistant fabric with a matte silver, silver lenticular, pearlescent, or high-gain matte neutral viewing surface with a peak gain of at least 1.3 and half-gain angle of at least 40 degrees
   1. Mildew-Resistance Rating: 0 or 1 when tested according to ASTM G 21.
   3. Flame-Spread Index: Not greater than 75 when tested according to ASTM E 84.
   4. Size of Viewing Surface: 105” x 60”

PART 3 - EXECUTION
3.01 INSTALLATION
A. Install projection screens where indicated, securely anchored to supporting substrate in a manner that produces a smoothly operating screen with vertical edges plumb and viewing surface flat when screen is lowered.
B. Test projection screens to verify proper operation. Make necessary adjustments.

END OF SECTION 115213
DIVISION 12 – FURNISHINGS

SECTION 123623 – PLASTIC COUNTERTOPS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Shop Drawings, Samples showing the full range of colors, textures, and patterns available for each type of finish.
B. Fabricator Qualifications: Certified participant in AWI’s Quality Certification Program Licensee of WI’s Certified Compliance Program.
C. Installer Qualifications: Fabricator of products.
D. Environmental Limitations: Do not deliver or install countertops until building is enclosed, wet work is completed, and HVAC system is operating.

PART 2 - PRODUCTS

2.01 PLASTIC-LAMINATE COUNTERTOPS

B. Certified Wood: Wood-based materials shall be certified as "FSC Pure" or "FSC Mixed Credit" according to FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship," and to FSC STD-40-004, "FSC Standard for Chain of Custody Certification."
   1. Laminate Grade: HGS for flat countertops, HGP for post-formed countertops.
   2. Grain Direction: Parallel to cabinet fronts.
   3. Edge Treatment: Same as laminate cladding on horizontal surfaces.

2.02 MATERIALS

A. Wood Moisture Content: 5 to 10 percent.
B. Medium-Density Fiberboard: ANSI A208.2, Grade 130, made with binder containing no urea formaldehyde.
C. Particleboard: ANSI A208.1, Grade M-2, made with binder containing no urea formaldehyde.
D. Softwood Plywood: DOC PS 1.
E. High-Pressure Decorative Laminate: NEMA LD 3.
   1. Manufacturers
      a. Formica Corporation.

2.03 FABRICATION

A. Complete fabrication to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

PART 3 - INSTALLATION

3.01 INSTALLATION

A. Before installation, condition countertops to average prevailing humidity conditions in installation areas.
B. Install countertops to comply with referenced quality standard for grade specified.
C. Install countertops level, plumb, true, and straight. Shim as required with concealed shims. Install level and plumb to a tolerance of 1/8 inch in 96 inches.
D. Scribe and cut countertops to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.
E. Anchor countertops securely to base units. Seal space between backsplash and wall.

END OF SECTION 123623
DIVISION 21 – FIRE PROTECTION

SECTION 210500 – FIRE PREVENTION EQUIPMENT

PART 1 - GENERAL
1.1 Summary
A. This section includes submittals on fire prevention equipment

PART 2 - Products
2.1 Sprinkler Head
A. Tyco Concealed Pendent
   i. Tyco TY2596
   ii. Maximum Coverage Area 12 x 12 ft
   iii. Minimum Flow 13 GPM
   iv. Minimum Pressure 7 PSI
   v. Minimum Spacing 8 FT
   vi. Temperature Rating: 160 F with 139 F Cover Plate
   vii. K-Factor 4.9 GPM/Psi
   viii. Quantity 8

2.2 Hose Material
A. BlazeMaster Pipe and Fittings
   i. Manufacturer: Lubrizol
   ii. Material: CPVC
   iii. Max Pressure 175 psi
   iv. Max Temp 150°F
   v. Service Life 50 years
   vi. Pipe Size 1”

PART 3 - EXECUTION
3.1 Installation

END OF SECTION 210500
DIVISION 22 – PLUMBING

SECTION 220529 – HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 Summary
A. This section includes plumbing equipment related to movement of structures
B. Please Observe Section 260529 HANGARS AND SUPPORTS FOR ELECTRICAL
   i. Cable Carriers are Dual-Use for Hose and Wire Cable

END OF SECTION 220519
SECTION 221116 – DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 Summary

A. This section includes submittals on domestic water piping

PART 2 - Products

2.1 Pipe Material

A. 1/2” FlowGuard Gold CPVC
   i. Company: Lubrizol
   ii. Manufacturer: Charlotte Pipe
   iii. Material: CPVC
   iv. Max Pressure 400 psi
   v. Max Temp 230°F
   vi. Dimensions
      a. Outside diameter: 0.625”
      b. Wall thickness: 0.068”
      c. Copper-tube-size: 1/2”
   vii. Fittings: FlowGuard Gold CPVC solvent weld fittings

B. 3/4” FlowGuard Gold CPVC
   i. Company: Lubrizol
   ii. Manufacturer: Charlotte Pipe
   iii. Material: CPVC
   iv. Max Pressure 400 psi
   v. Max Temp 230°F
   vi. Dimensions
      a. Outside diameter: 0.875”
      b. Wall thickness: 0.080”
      c. Copper-tube-size: 3/4”
   vii. Fittings: FlowGuard Gold CPVC solvent weld fittings

C. 1” FlowGuard Gold CPVC
   i. Company: Lubrizol
   ii. Manufacturer: Charlotte Pipe
   iii. Material: CPVC
   iv. Max Pressure 400 psi
   v. Max Temp 230°F
   vi. Dimensions
      a. Outside diameter: 1.125”
      b. Wall thickness: 0.102”
      c. Copper-tube-size: 1”
   vii. Fittings: FlowGuard Gold CPVC solvent weld fittings

PART 3 - EXECUTION

3.1 Follow manufacturer’s directions.

END OF SECTION 221116
SECTION 221117 – FLEXIBLE HOSES

PART 1 - GENERAL

1.1 Summary
   A. This section contains information on the flexible reels

1.2 Submittals:
   A. Product Information

PART 2 - PRODUCTS

2.1 POTABLE WATER FLEXIBLE HOSES
   A. Ace Hose and Rubber Company
      i. Part 4082-06/3025-AB-Nex
      ii. PVC Potable Water Hose
      iii. NSF 51 Certified
      iv. Black
      v. 1” Diameter
      vi. Max working Pressure: 125 psi for 1” ID hose @70F

2.2 SANITARY WASTE DISPOSAL HOSES
   A. Ace Hose and Rubber Water Hose
      i. Part 4082-06/3025-AB-Nex
      ii. PVC Potable Water Hose
      iii. NSF 51 Certified
      iv. Black
      v. 1” Diameter
      vi. Max working Pressure: 100 psi for 1” ID hose @70F

2.3 FIRE SPRINKLER
   A. Ace Hose and Rubber Company
      i. Part 4082-06/3025-AB-Nex
      ii. PVC Potable Water Hose
      iii. NSF 51 Certified
      iv. Black
      v. 1” Diameter
      vi. Max working Pressure: 125 psi for 1” ID hose @70F

PART 3 - EXECUTION

3.1 Installation
   A. Install with strain relief as needed
   B. Follow manufacturer installation instructions
   C. Ensure proper fitting attachment

END OF SECTION 221117
SECTION 221123 - DOMESTIC WATER PACKAGED BOOSTER PUMPS

Part 1 – GENERAL

1.1 Summary

A. Section includes:
   1. Booster pump for the entire water distribution system

1.2 Related Sections

   1. 223330.13 – Residential Small-Capacity Electric Domestic Water Heaters

1.3 Section Requirements

A. Submittals
   1. Product Data

Part 2 – PRODUCTS

A. Domestic Water booster pump
   1. Grundfos MQ3-45 Flow based pressure boosting system
      a. Product Requirements
         i. UL listed
      b. Product Specifications
         i. System pressure Max 109 psi
         ii. Inlet pressure Max 44 psi
         iii. Suction lift Max 26 ft (8m)
         iv. Liquid Temperature 32 F to 95 F
         v. Main Voltage 120V, 60Hz
         vi. Voltage tolerances: −10% / +6%
         vii. Sound pressure level <55dB
         viii. Flow rate at 75 feet head 4 GPM
      c. Manufacturer Information and Product Link
         i. Manufacturer: Grundfos
         ii. Link: http://noteswww.grundfos.com/web/HOMEus.NSF/Webopslag/PAVA-5CHJE7

Part 3 – EXECUTION

3.1 Installation

   A. Follow manufacturer’s installation instructions

END OF SECTION 221123
SECTION 221223 - WATER STORAGE TANKS

PART 4 - GENERAL
4.1 Summary
A. This section covers info in the water storage tanks

PART 5 - PRODUCTS
5.1 Storage Tank
A. 800 Gallon Fresh Water Bladder Tank
   i. Manufacturer: Go-to tanks
   ii. Size: 8’8” x 10’ x 16”
   iii. Used to store potable water
   iv. 4” PVC fill fitting at top
   v. 1 ½” PVC Flange Fitting with PVC Ball Valve
   vi. Ground Tarp Included
   vii. XR3 FDA/NSF-61 Approved Materials
   viii. 47 lbs

5.2 Wastewater Tank
A. 800 Gallon Fresh Water Bladder Tank
   i. Manufacturer: Go-to tanks
   ii. Size: 8’8” x 10’ x 16”
   iii. Used to store potable water
   iv. 4” PVC fill fitting at top
   v. 1 ½” PVC Flange Fitting with PVC Ball Valve
   vi. Ground Tarp Included
   vii. XR3 FDA/NSF-61 Approved Materials
   viii. 47 lbs

PART 6 - EXECUTION
6.1 Install tanks following manufacturer instructions
6.2 Ensure access to filling hole
6.3 Ensure that PVC outlet pipe is properly connected

END OF SECTION 221223
SECTION 221300 – FACILITY SANITARY SEWERAGE
PART 1 - GENERAL
1.1 Summary
A. This section contains specifications for the macerator unit

PART 2 - PRODUCTS
2.1 Macerator
A. SFA Sanigrind pro
   i. Manufacturer: Saniflo
   ii. Model: 38724.0
   iii. 120 V Macerator Pump
   iv. Dimensions: 10 ½” x 8” x 20 5/16”
   v. Capacity: 30 gpm
   vi. Power: 1 HP
   vii. Anti-siphon backflow prevention
   viii. Requires 15 A dedicated circuit
   ix. Current: 9.0 A
   x. Power: 600 W
   xi. Duty Cycle: 2.5 gpm, 10 foot lift, 1 hour on, 45 mins off
   xii. Vent: 1 ½” Port

2.2 Sump Pump
A. Little Giant Sump/Effluent pump
   i. Manufacturer: Little Giant
   ii. Model Number: 6EN-CIA-SFS
   iv. 1/3 hp PSC motor with thermal overload protection
   v. Cast Iron pump housing
   vi. Stainless Steel screws, bolts, and handle
   vii. Mechanical seals
   viii. Vortex Impellor
   ix. Passes ½ Spherical Solids
   x. 1 ½” FNPT Discharge
   xi. Integral snap action float switch: on level 7” – 10”, off level 2” – 5”
   xii. Fully submersible
   xiii. 115 V
   xiv. 6 A
   xv. 30 GPM at 15’ head

B. Sump Pump Basin
   i. Manufacturer: Topp Industries
   ii. The Sump Box System
   iii. 11 gallon capacity
   iv. 12” x 16” x 14”
   v. Weight: 7 lbs
   vi. Wall Thickness: 3/16”
   vii. 1 1/2” “spin weld” inlet
   viii. Discharge size options: 1 1/2” or 1 1/4”

2.3 Laundry Pump
A.
A. Follow Manufacturer Instructions
B. Install dedicated 15 A circuit for macerators

END OF SECTION 221300
SECTION 223300 – DOMESTIC ELECTRIC HOT WATER HEATERS

PART 1- GENERAL
1.1 SECTION REQUIREMENTS

A. Summary
   i. 76 gal insulated tank for heating and holding hot water. Tank will provide hot water for living needs and for heating the house. Primary heating from heat exchange loop connected to solar thermal system with backup heating provided by integrated electric water heater.

B. Submittals

PART 2- PRODUCTS
2.1 Hot Water Tank

A. 76 Gallon AO Smith Hot Water Tank
   i. Model No SUNX-80
   ii. Specification:
       a. Water Volume 76 gal
       b. Booster heater 4.5 kW
       c. Working Pressure 150 psi
   iii. Piping Connections:
       a. Water inlet H/E Diameter 3/4" (F) BSP
       b. Water outlet H/E Diameter 3/4" (F) BSP
       c. Heat Exchanger in Diameter 1" (F) NPT
       d. Heat Exchanger out Diameter 1" (F) NPT
   iv. Power Supply
       a. V/PH/Hz 240/1/60
   v. Tank Material:
       a. Material outside casing Glass Tank Coating
       b. Heating Element Low-watt density Copper
       c. Insulation 2 in non-CFC foam insulation
   vi. Unit Data:
       a. Dimensions (HxDiam) 63-1/4” x 24”
       b. Shipping weight 257 lbs

PART 3- EXECUTION
3.1 INSTALLATION

A. Follow manufacturer specified instructions

END OF SECTION 223300
SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals:
   1. Product Data for each type of plumbing fixture, including trim, fittings, accessories, appliances, appurtenances, equipment, and supports.
   2. Documentation indicating flow and water consumption requirements.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS


C. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

2.02 WATER CLOSET: SHEET P102

A. Vitreous-China Water Closet: Compact elongated siphon-jet type, floor-mounted outlet with one-piece bowl and tank, flushometer valve.
   1. Manufacturers:
      a. Kohler Co.
   2. Product: Reve K-3797-0
      a. Color: white

2.03 FLUSHOMETERS: SHEET P102

A. Flushometer Valve: Brass body, brass or copper pipe or tubing inlet with wall flange and tailpiece with spud, screwdriver check stop, and vacuum breaker. Polished, chrome-plated, exposed metal parts. Consumption: Dual-flush .8 gal./flush or 1.6 gal./flush.
   1. Manufacturers:
      a. Kohler Co.

2.04 LAVATORY: SHEET P102

A. Vitreous-China Lavatory: Counter mounting, H 7-7/16"x L 23-5/8"x W 18-5/16"
   1. Manufacturers:
      a. Kohler Co.
   2. Product: K-5027-8-0
      a. Color: white

B. ME A112.18.1; solid brass Retain option in "Manufacturers" Subparagraph below to limit manufacturers to those listed.
   1. Manufacturers:
      a. Kohler Co.
   2. Product: K-14406-4-BN
      a. Color: brushed nickel
   3. Type: Widespread faucet with low lever handles and gooseneck spout.
   4. Finish: brushed nickel
   5. Handle(s): Dual lever.
   6. Maximum Flow Rate: 1.5 gpm.

C. Drain: Pop up with NPS 1-1/4 tailpiece, included with faucet.
D. Trap: plastic tubular fittings with slip-joint inlet and wall flange.
E. Supply and Drain Insulation: Soft-plastic covering; removable at stops.
F. Fixture Support: Concealed arm.
2.05 SHOWER: SHEET P102
A. Center drain shower stall with integrated high-dome ceiling, H 90” x L 36” x W 36-1/2”
   1. Manufacturers:
      a. Kohler Co.
   2. Product: Sonata K-1689-0
      a. Color: white
B. Sonata accessory kit (grab bar and shelf kit), L 16” x W 3-1/2”
   1. Manufacturers:
      a. Kohler Co.
   2. Product: Sonata K-9459-BN
      a. Color: brushed nickel
C. Mixing-Valve Faucet and Miscellaneous Fittings: Single-lever, thermostatic and pressure-balance antiscaId-type faucet; maximum 2.5-gpm (0.16-L/s) flow rate.
   1. Manufacturers:
      a. Kohler Co.
   2. Product: K-T14422-4-BN
      a. Color: brushed nickel
   3. pop-up waste and overflow; shower diverter valve; shower head, arm, and flange; and ball, gate, or globe valves on supplies if check stops are not included with faucet.

2.06 SINK: SHEET P102
A. Stainless Sink: Undercounter type, 18-gauge thick, one bowl(s).
   1. Manufacturers:
      a. Kohler Co.
   2. Product: Iron/Tones K-6585-0
      a. Finish: white
B. Bowl:
   1. Dimensions: H 8-1/4” x L 24-1/4” x W 18-3/4”
   3. Drain location: Centered in bowl.
C. Faucet: [Solid brass] [Solid-brass underbody and brass cover plate] [Nonmetal (plastic) underbody and plastic or brass cover plate],[ Maximum 2.5-gpm (0.16-L/s) flow rate.]
   1. Manufacturers:
      a. Kohler Co.
   2. Product: K-7505-BN
   3. Type: Purist with pull-out spout.
   5. Handle(s): Single lever.

PART 3 - EXECUTION
3.01 INSTALLATIONS
A. Install fitting insulation kits on fixtures for people with disabilities.
B. Install fixtures with flanges and gasket seals.
C. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

D. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

E. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified, and to building wall construction where no support is indicated.

F. Fasten floor-mounted fixtures to substrate. Fasten fixtures having holes for securing fixture to wall construction, to reinforcement built into walls.

G. Fasten wall-mounted fittings to reinforcement built into walls.

H. Fasten counter-mounting plumbing fixtures to casework.

I. Secure supplies to supports or substrate within pipe space behind fixture.

J. Set shower receptors and mop basins in leveling bed of cement grout.

K. Install individual supply inlets, supply stops, supply risers, and tubular brass traps with cleanouts at fixture.

L. Install water-supply stop valves in accessible locations.

M. Install traps on fixture outlets. Omit traps on fixtures having integral traps. Omit traps on indirect wastes unless otherwise indicated.

N. Install disposers in sink outlets. Install switch where indicated, or in wall adjacent to sink if location is not indicated.

O. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install [in sink deck] [on countertop at sink] <Insert location>. Connect inlet hose to dishwasher and outlet hose to disposer.

P. Install hot-water dispensers in back top surface of sink or in counter with spout over sink.

Q. Install escutcheons at wall, floor, and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons where required to conceal protruding pipe fittings.

R. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.

S. Install piping connections between plumbing fixtures and piping systems and plumbing equipment. Install insulation on supplies and drains of fixtures for people with disabilities.

T. Ground equipment.

END OF SECTION 224000
DIVISION 23 – HVAC

SECTION 233100 – HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 Summary

A. Section Includes:
   i. Ducting for ventilation and exhaust systems

1.2 Submittals:

A. Product Data

1.3 Related Sections:

A. 23 80 00 Decentralized HVAC Equipment

PART 2 - PRODUCTS

2.1 Metal Ducts

A. Ducts will be used for the range hood, AEV, and bathroom fan

B. Sizes
   i. 4” diameter circular for bathroom ceiling fan
   ii. 5” diameter circular for air exchange ventilator

PART 3 - EXECUTION

3.1 Installation

A. Ducts shall be installed by a license contractor

B. Ducts prone to condensation shall be insulated to a minimum R-value of R8

C. Follow manufacturer instructions for attachment, support, and sealing

D. Installation shall comply with all applicable codes

E. Ducts shall be routed to reduce the number of bends where possible

END OF SECTION 233100
 SECTION 233200 – AIR EXCHANGE VENTILATOR
PART 1- GENERAL
1.1  Summary
   A.  Section Includes:
      i.  Air exchanger for whole house ventilation.
1.2  Submittals:
   A.  Product Sheet: http://fantech.net/download/412123-aev-spec
1.3  Related Sections:
   A.  23 80 00 Decentralized HVAC Equipment

PART 2- PRODUCTS
2.1  Fantech Air Exchanger
   A.  Model Number: AEV 1000
   B.  Specifications
      i.  Speeds (CFM): 25/63/87
      ii.  Power (V/Hz/Phase): 120/60/1
      iii. Max Amps: 0.7
      iv.  Max inlet temp: 140°F
      v.   Dimensions (H x W x D): 14” x 12-1/2” x 18-3/16”

PART 3- EXECUTION
3.1  Installation
   A.  Mounted vertically
   B.  Follow outdoor exhaust/inlet placement requirements
   C.  Install as specified by manufacturer

END OF SECTION 233200
SECTION 233423 – VENTILATORS

PART 1- GENERAL
1.1 Summary

A. Section Includes:
   i. Exhaust fans

1.2 Submittals:

A. Product Data: http://shop.panasonic.com/docs/misc/2012/appliance/FV-08VRL1_Submittal_Sheet.pdf

PART 2- PRODUCTS

A. Bathroom Ventilation Fans
   i. Manufacturer: Panasonic
   ii. Model: FV-08VRL1 WhisperRecessed
   iii. Light: 18 W, GU24
   iv. Power Consumption: 20.5 W
   v. Duct Diameter: 4”
   vi. Voltage: 120 V
   vii. UL Listed for Tub/Shower Enclosure when on GFCI Circuit and enclosed in insulated ceiling

PART 3- EXECUTION

3.1 Installation

A. Ducts shall be installed by a license contractor
B. Follow Manufacturer Instructions

END SECTION 233423
SECTION 235601 – SOLAR THERMAL PUMP STATION

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Summary
   i. Pump station for circulating working fluid through collector to DHW solar kit and back.

B. Submittals

PART 2 - PRODUCTS

2.1 Pump Station

A. Solar Thermal Pump Station
   i. Model No: Wilo Solar pump STAR S 21 U 15 130 PR 3
   ii. Technical Features:
      a. Fluid Type: Water, Glycol solution (50% max glycol)
      b. Safety Valve Calibration: 60 psi
      c. Connection: 3/4” NPT
      d. Operating Temperature Range: 14-230° F
      e. Max Ambient Temp: 104° F
      f. Max Operative Pressure: 145 psi
      g. Insulated Shell Conductibility: 0.041 W/mK
      h. Dimensions (LxWxD): 16.5” x 10.25” x 7”
      i. Center to center connection distance: 5.12 in
      j. Power supply: 115V - 60Hz
      k. Protection level: NEMA 2

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow Manufacturer Specifications

END OF SECTION 235601
SECTION 235613.01 – HEATING, SOLAR, VACUUM TUBE COLLECTORS

PART 1 - GENERAL
1.1 SECTION REQUIREMENTS
A. Summary
   i. Solar Thermal Collector made evacuated tubes with heat pipe cores. The panel collects sunlight to heat a working fluid in the manifold pumped to circulate through the hot water tank to heat water.
B. Submittals

PART 2 - PRODUCTS
2.1 Solar Thermal Collector
A. Solar US Evacuated Tube Collector
   i. Solarus 30
   ii. Model No: SolarUS SL-30
   iii. Dimensions:
        a. Overall Length (in/mm): 76.2/1935
        b. Overall Depth (in/mm): 5.7/145
        c. Overall Width (in/mm): 90.2/2290
        d. Absorber Area (ft²/m²): 26.22/2.436
        e. Net Weight: 216 lbs/98 kg
        f. Volume (Manifold): 0.46 gal/1740 mL
   iv. Performance:
        a. Efficiency (η0G): 74.4%
        b. Peak Power Output: 1917 W/hr/6541 BTU
   v. Tilt: 75° down from horizontal
   vi. Flow Rates:
        a. Max: 2.11 gpm/8 Lpm
        b. Recommended: 0.8 gpm/3 Lpm
        c. Max tubes in series: 150

PART 3 - EXECUTION
3.1 INSTALLATION
A. Follow Manufacturer Specifications

END OF SECTION 235613.01
SECTION 23633 – HEAT PUMP REFRIGERANT CONDENSERS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Summary
   i. Outdoor heat pump split system.

B. Submittals

PART 2 - PRODUCTS

2.1 Outdoor Condensor Unit

A. Mitsubishi Electric Heat Pump
   i. Model No MXZ-2B20NA-1
   ii. Heating Capacity 22,000 Btu/h
   iii. Heating Input Power 2.62 kW
   iv. Cooling Capacity 20,000 Btu/h
   v. Cooling Input Power 2.19 kW
   vi. HSPF 8.9
   vii. SEER 18
   viii. Operating Range
        a. Cooling Temp. (Min/Max) 14/115°F (-10/46°C)
        b. Heating Temp. (Min/Max) 6/75°F (-14/24°C)
   ix. Compressor
        a. DC INVERTER-driven Twin Rotary
   x. Power Supply
        a. V/PH/Hz 208-230/1/60
        b. Minimum Circuit Amps (MCA) 15.0 Amps
        c. Maximum Overcurrent Protection (MOP) 20.0 Amps
   xi. Refrigerant & Piping:
        a. Refrigerant Type/Charge R-410A/5,15
        b. Liquid Piping 1/4"
        c. Gas Piping 3/8"
        d. Max Pipe Length(total) 164 ft
        e. Vertical Limit 49 ft
   xii. Unit Data:
        a. Dimensions (HxWxD) 27-15/16" x 33-1/16" x 13"
        b. Weight 130 lbs

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be designed and completed by trained contractors

END OF SECTION 23633
SECTION 238219 - INDOOR HEAT PUMP UNITS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Summary
   i. Ductless indoor unit heats/cools air over the refrigeration piping from the outdoor unit.

B. Submittals

PART 2 - PRODUCTS

2.1 Indoor Unit

A. Mitsubishi Electric Ceiling-recessed Cassette Ductless Heat Pump
   i. SLZ-KA09NA
      ii. Cooling Performance:
          a. Nominal Capacity 8,400 Btu/h
          b. Capacity Range 3,100-10,900 Btu/h
          c. Total Input 700 W
          d. Energy Efficiency SEER 15
          e. Sensible Heat Factor 0.84
      iii. Heating Performance:
          a. Nominal Capacity 10,900 Btu/h
          b. Capacity Range 3,100-14,100 Btu/h
          c. Total Input 930 W
          d. HSPF (Region IV) 9.6
      iv. Airflow Rate:
          a. Cooling DRY 280-320-350 CFM
          b. Cooling WET 250-290-320 CFM
          c. Heating WET 250-290-320 CFM
          d. External Static Pressure: 0.02-0.06-0.14-0.20 In. WG (5-15-35-50 Pa)
          e. Sound Pressure Level: 29-32-38 dB(A)
   v. Electrical Data:
      a. Power supply 208-230V / 1PH / 60Hz
      b. Min. Circuit Amps (MCA) 1 AMP
   vi. Physical Data:
      a. Dimension (H x W x D) 9-1/4"x22-7/16"x22-7/16"
      b. Grill (H x W x D) 13/16"x25-5/8"x25-5/8"
      c. Weight 36 lbs
   vii. Connection type
      a. Gas Line 3/8"
      b. Liquid Line 1/4"
      c. Field Drain Pipe (OD) 1-1/4"

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow Manufacturer Specifications

END OF SECTION 238219
DIVISION 25 – INTEGRATED AUTOMATION AND CONTROL

SECTION 251400 – MICROPROCESSOR-BASED CONTROL UNIT

PART 1- GENERAL

1.1 SECTION REQUIREMENTS

A. Summary
   i. This section includes information on the Control4 Controller, which is used to receive and send messages between the UI and the house.

B. Submittals

PART 2- PRODUCTS

2.1 Control Equipment

A. Control4 Controller
   i. Home Controller HC-300
      a. Specifications
         (i) Model Number: C4-HC300C-E-B
         (ii) Remote: SR-250 Included
         (iii) Video Outputs: Component (SD/HD), Composite, SVideo
         (iv) Line-Level Audio Outputs: 2 RCA
         (v) Analog Audio Inputs: 1 RCA
         (vi) Num. IR Outputs (Individual Device Control): 6
         (vii) Num. IR Blaster (Multiple Device Control): 1
         (viii) Num. IR Inputs: 1
         (ix) Voltage: 100-240 VAC
         (x) Amps: 0.26 A
         (xi) Hertz: 50-60 Hz
         (xii) Dimensions: 2.8” x 12” x 7.25’ (71mm x 305mm x 184mm)
         (xiii) Weight: 5.2 lbs (2.35kg)
      b. Manufacturer Info
         (i) Manufacturer: Control4 Corporation

PART 3- EXECUTION

3.1 INSTALLATION

A. Follow all manufacturer specifications

END OF SECTION 251400
SECTION 253489 - MITSUBISHI WIRELESS THERMOSTAT

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Summary
   i. This section includes information on the Mitsubishi Wireless Thermostats used to control the HVAC system of the house

B. Submittals
   a. Product link: http://www.mitsubishipro.com/media/448725/mhk1kit.pdf

PART 2 - PRODUCTS

2.1 Control Equipment

A. Mitsubishi Wireless Remote Controller
   i. Model Number: MRCH1
      a. Operation Modes: Cool/Drying/Auto/Heat/Fan Only
      b. Temperature Setting Range 50–87°F
      c. Fan Speed Setting: Hi/Mid-2/Mid-1/Low/Auto
      d. Power Supply: 2 AA batteries
      e. Dimensions: 5-3/16” x 1-1/2” x 3-9/16”

B. Mitsubishi Wireless Receiver
   i. Model Number: MFH1
      a. Receives commands from remote and relays them to the units
      b. Dimensions: 3-1/4” x 1-5/16” x 6-7/16”

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Follow all manufacturer specifications

END OF SECTION 253489
DIVISION 26 – ELECTRICAL

SECTION 260500 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 Related Documents
A. Solar Decathlon 2013 Building Code
B. Solar Decathlon 2013 Rules
C. Drawings and General Provisions of the Contract, including General and Supplementary Conditions, Division 01 Specification Sections, apply to this section and to all following sections within Division 26

1.2 Summary
A. Section Includes
i. Electrical equipment installation
ii. Common electrical installation requirements

1.3 Section Requirements
A. The following specifications apply to all Division 26 Sections as a set of minimum requirements.
   i. Compliance with the following codes:
      c. International Residential Code 2012
   ii. Compliance with local rules and regulations

1.4 Submittals
i. Product data sheets
ii. Manufacturer installation instructions

PART 2 - PRODUCTS

2.1 26 05 19: Low Voltage Electrical Conductors and Cables
2.2 26 05 26: Grounding and Bonding for Electrical Systems
2.3 26 05 33: Raceway and Boxes for Electrical Systems
2.4 26 05 53: Identification for Electrical Systems
2.5 26 05 83: Wiring Connectors

PART 3 - EXECUTION

3.1 INSTALLATION
A. Perform all electrical work in compliance with applicable safety regulations
B. All safety equipment required for compliance shall be provided by the Contractor

3.2 Quality Assurance
A. All work and materials shall be specified in accordance with the requirements and codes listed above and all applicable local regulations applicable to the structure's final location.

END OF SECTION 260500
SECTION 260519 – LOW-VOLTAGE ELECTRICAL CONDUCTORS AND CABLES

PART 1 – GENERAL

1.1 Summary
A. This section covers all conductors and cables used in the house. Refer to Construction Drawings for locations of products

1.2 Related Sections
A. Section 26 05 00: Common Work Results for Electrical

1.3 Submittals
A. Product Data Sheets

PART 2 – PRODUCTS

2.1 Interior Cables
A. NM-B 3-conductor and 4-conductor solid cables
   i. Manufacturer: Southwire
   ii. Insulation Type: NM-B
   iii. Insulation Voltage Rating: 600 V
   iv. Wire type: Solid Copper
   v. Wire colors:
      a. Phase 1: Black
      b. Phase 2: Red
      c. Neutral: White
      d. Ground: Bare

B. NM-B 3-conductor and 4-conductor stranded cables
   i. Manufacturer: Southwire
   ii. Insulation Type: NM-B
   iii. Insulation Voltage Rating: 600 V
   iv. Wire type: Stranded Copper
   v. Wire colors:
      a. Phase 1: Black
      b. Phase 2: Red
      c. Neutral: White
      d. Ground: Bare

2.2 Outdoor Cables
A. SOOW
   i. Manufacturer: Southwire
   ii. Maximum Voltage: 600 V
   iii. Wire color: Black
   iv. Usage: Outdoors

PART 3 – EXECUTION

3.1 Wiring Requirements
A. Verify that raceway work is completed
B. Verify that no further mechanical work is likely do damage cables

3.2 Installation
A. NM-B Solid Cables
   i. Use conductor size AWG 12 for lighting and receptacle branch circuits rated 15-20 A
   ii. Use conductor size AWG-10 for circuits rated up to 30 A
   iii. Pull all conductors through raceway at the same time
   iv. Use suitable wire pulling equipment
v. Support cables using plastic-protected cable fasteners
vi. Protect cables installed through studs with nail plates

B. NM-B Stranded Cables
i. Use conductor size AWG-8 for circuits up to 40 A
ii. Use conductor size AWG-6 for circuits up to 55 A
iii. Use conductor size AWG-2/0 for service entrance cable
iv. Pull all conductors through raceway at the same time
v. Use suitable wire pulling equipment
vi. Support cables using plastic-protected cable fasteners
vii. Protect cables installed through studs with nail plates

C. SOOW Stranded Cables
i. Use conductor size AWG-10, 12
ii. Use conductor size AWG-8 for Ground
iii. Tie cables to PV mounting frame or structure using clips or UV-rated cable ties
iv. Connect to junction boxes via approved watertight connectors
v. Follow Manufacturer Specifications

END OF SECTION 26 05 19
SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS
   A. Summary
      i. This section covers electrical bonding and grounding.
      ii. Related Sections:
          a. 262416: Panelboards
   B. Submittals

PART 2 - PRODUCTS

2.1 Grounding Electrodes
   A. Grounding Rod
      i. Product to be determined based on ground penetration decisions by the Organizers
      ii. Quantity to be determined based on Organizers Building Code Requirements
   2.2 Electrode Fittings
      A. Direct Burial Ground Clamp
      i. Product to be determined based on grounding rod system
      ii. Quantity to be determined based on grounding rod system

PART 3 - EXECUTION

3.1 General
   A. Install in accordance with NEC
   B. Install in locations as shown in Construction Drawings
   C. All metallic equipment, including building structure, ductwork, metallic raceways, junction boxes, and other conductive equipment shall be grounded

3.2 Installation
   A. Grounding Rod system shall be connected to the central panelboard by means of an uninsulated wire of minimum 4 AWG
   B. Grounding Rod and Clamp must be installed where they will not pose a tripping or falling hazard

END OF SECTION 260526
SECTION 260529 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL
1.1 Summary
A. This section includes electric equipment related to movement of structures

PART 2 - PRODUCTS
2.1 Cable Carriers
A. GORTRAC TS-110 Cable Carrier
   i. Outside-Inside Cable Carrier
      a 99 links
      b Outside Dimensions
         (i) 5” Width x 3.24” Height
      c Inside Dimensions
         (i) 3.91” Width x 2.22” Height
      d Link Length 4.06”
      e Bend Radius 10.98”
   ii. Inter-Module Cable Carrier
       a 176 links
       b Outside Dimensions
          (i) 3” Width x 3.24” Height
       c Inside Dimensions
          (i) 2.89” Width x 2.22” Height
       d Link Length 4.06”
       e Bend Radius 10.98”
B. GORTRAC N3-8D Cable Carrier
   i. Canopy Cable Carriers
      a 119 links
      b Outside Dimensions
         (i) 2.95” Width x 1.38” Height
      c Inside Dimensions
         (i) 2.48” Width x 0.91” Height
      d Link Length 4.06”
      e Bend Radius 10.98”

PART 3 - EXECUTION
3.1 INSTALLATION
A. Installation shall be designed and completed by trained contractors
B. Remove all sharp edges prior to installing cables
C. On-site, attach carriers with wires pre-loaded
D. Ensure that hoses and cables can fit in the bend radius

END OF SECTION 260529
SECTION 260533 – RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL
1.1 SECTION REQUIREMENTS
A. Summary
   i. This section covers electrical boxes and raceways for wires
   ii. Related Sections
      a. 26 05 19: Low-Voltage Electrical Conductors and Cables
B. Submittals
   i. Product Data Sheets

PART 2 - PRODUCTS (example is for water systems)
2.1 Metallic boxes
   A. Ceiling Boxes
      i. Manufacturer: Raco or Equivalent
      ii. Size:
          a. 4” square 2-1/8” deep
          b. 4” octagon 2-1/8” deep
      iii. Website:
   B. Wall Boxes
      i. Manufacturer: Raco or Equivalent
      ii. Size:
          a. 4” x 2-1/8” rectangle 2-1/8” deep
          b. 4” square 2-1/8” deep
      iii. Website:
2.2 Nonconductive boxes
2.3 Faceplates and Rings
   A. Faceplates
      i. Approved plastic faceplates shall be used as appropriate for outlets and switches
      ii. Website:
2.4 Raceway
   A. Metallic conduit
   B. Flexible armored cable
   C. Liquidtight flexible conduit
2.5 Cable Carriers
   A. Gortrac KN Series Cable Carriers
      i. Manufacturer: A&A Manufacturing
      ii. Sizes: various

PART 3 - EXECUTION
3.1 INSTALLATION
   A. Follow Manufacturer Specifications
   B. Installation shall be performed by qualified team member or licensed electrician

END OF SECTION 260533
SECTION 260913 – ELECTRICAL POWER MONITORING AND CONTROL

Part 1 - GENERAL

1.1 Summary

A. This section includes information on the monitoring equipment. These include the:
   1. Powerhouse Dynamics eMonitor 4-24 Energy Monitor

Part 2 - PRODUCTS

2.1 Products

A. Energy Consumption Monitor

   1. Product Description and/or Specifications
      i. Power Needs: 120 VAC, 60 Hz
      ii. Operating Temperature: 14 - 140°F
      iii. Operating Humidity: 5 - 95%, non-condensing
      iv. Circuits able to Monitor: 24
   v. Circuit Needs: 120VAC/15A breaker
   vi. Communication Protocols: eLink Wireless 2.4 GHz between circuit probes and Gateway, RS485 link protocol to xPod, WiFi 802.11 and TCP-IP via Ethernet to computer
   vii. Dimensions: 7” x 2.5” x 1.875” (eMonitor), 3.75” x 1.875” x .875” (xPod), 5.25” x 3.25” x 1.5” (Gateway)
   viii. Weight: 4 oz (eMonitor), 2 oz (xPod), 6 oz (Gateway)

2. Manufacturer Information and Product Link

i. Manufacturer: Powerhouse Dynamics
ii. Model: 4 - 24
iii. Product Specifications:
iv. Manufacturer Website:

END SECTION 260913
SECTION 262616 – PANELBOARDS

PART 1 - GENERAL
1.1 SECTION REQUIREMENTS

A. Summary
   i. Panelboards/Circuit breaker panels provide electrical connectivity for the house

B. Submittals

PART 2 - PRODUCTS
2.1 150 A Panelboard

A. Manufacturer: Schenider Electric
   i. Model: HOM24M225RB
   ii. Ampere Rating  225 A
   iii. Bus Material Tim-Plated Aluminum
   iv. Enclosure Type Outdoor/Rainproof
   v. Enclosure Rating NEMA 3R
   vi. Maximum Single-Pole Circuits 42
   vii. Short Circuit Rating  22 kA
   viii. Phase  1-Phase
   ix. Dimensions  39.37 in H x 14.75 in W x 4.52 in D
   x. Voltage Rating  120/240 V

PART 3 - EXECUTION
3.1 INSTALLATION

A. Follow Manufacturer Specifications

B. Products to be installed by a licensed electrician.

END OF SECTION 262616
SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Summary
i. These switches and dimmers receive commands from the Control4 Controller and turn home electronics on and off.

B. Submittals

PART 2 - PRODUCTS

2.1 Switches

A. Outlet Switch
i. Control4 Outlet Switch
   a. Specifications
      (i) Power requirements: 120 VAC +/- 10%; 60/50 Hz
      (ii) Power Consumption: 1.4W (LEDs Off), 1.7W (LEDs On)
      (iii) Maximum One Gang Load (Total across both outlets)
         1. Incandescent/Tungsten/Halogen: 600W
         2. Fluorescent: 7.2
         3. Compact Fluorescent: 7.2
         4. Electronic Low Voltage: 7.2 A
         5. Magnetic Low Voltage: 1000VA
         6. Motor: 1/3 HP (7.2 FLA)
         7. Control Communications: ZigBee (802.15.4)
      (iv) Operational Temperature: 0°C - 40°C
      (v) Humidity: 5%-95% (non-condensing)
      (vi) Storage Temperature: -20°C - 70°C
      (vii) Dimensions: 4.5” x 2.6” x 1.6” (115mm x 67mm x 42mm)
      (viii) Weight: 8.0 oz (227 g)
   b. Manufacturer Info
      (i) Manufacturer: Control4 Corporation

2.2 Dimmers

A. Outlet Dimmer
i. Control4 Outlet Dimmer
   a. Specifications
      (i) Power requirements: 120 VAC +/- 10%; 60/50 Hz
      (ii) Power Consumption: 350 mW
      (iii) Maximum One Gang Load
         1. Incandescent/Tungsten/Halogen: N/A
         2. Fluorescent: 1000W electronic ballast
         3. Compact Fluorescent: 1000VA
         4. Electronic Low Voltage: 1000VA
         5. Magnetic Low Voltage: 1000VA
         6. Control Communications: ZigBee (802.15.4)
      (iv) Operational Temperature: 0°C - 40°C
      (v) Humidity: 5%-95% (non-condensing)
      (vi) Storage Temperature: -20°C - 70°C
      (vii) Dimensions: 4.5” x 2.75” x 1.6” (117mm x 70mm x 41mm)
      (viii) Weight: 4.9 oz (139 g)
   b. Manufacturer Info
(i) Manufacturer: Control4 Corporation

PART 3 - EXECUTION
3.1 INSTALLATION
   A. Follow all manufacturer specifications

END OF SECTION 262726
SECTION 262800 – LOW-VOLTAGE CIRCUIT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Summary
   i. This section contains circuit breaker specifications

B. Submittals
   i. Manufacturer Information

PART 2 - PRODUCTS (example is for water systems)

2.1 Circuit Breakers

A. Square D HOM Line Circuit Breakers
   i. AFCI Breakers
      a. HOM115AFI
         (i) Amperage: 15 A
         (ii) Poles: 1
         (iii) AFCI Protection
   ii. GFCI Breakers
      a. HOM115GFI
         (i) Amperage: 15 A
         (ii) Poles: 1
         (iii) GFCI Protection
      b. HOM120GFI
         (i) Amperage: 20 A
         (ii) Poles: 1
         (iii) GFCI Protection
   iii. Standard Breakers
      a. HOM115
         (i) Amperage: 15 A
         (ii) Poles: 1
      b. HOM215
         (i) Amperage: 15 A
         (ii) Poles: 2
      c. HOM230
         (i) Amperage: 30 A
         (ii) Poles: 2
      d. HOM240
         (i) Amperage: 40 A
         (ii) Poles: 2
      e. HOM240
         (i) Amperage: 50 A
         (ii) Poles: 2
   iv. Panel Breakers
      a. QOM2150VH
         (i) Amperage: 150 A
         (ii) Poles: 2

PART 3 - EXECUTION

3.1 Installation

A. Follow Manufacturer Specifications
B. Installation shall be performed by qualified team member or licensed electrician

END OF SECTION 262800
SECTION 263100 – SOLAR PHOTOVOLTAICS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS
A. This section contains information on the solar array, including:
   i. Hanwha monocrystalline modules
   ii. SMA America inverter
   iii. Tigo module maximizer hubs
B. Submittals
   iii. http://www.tigoenergy.com
   iv. {Shop Drawings}
   v. {Manuf. Instructions}

PART 2 - PRODUCTS

2.1 Photovoltaic modules
A. Hanwha photovoltaic modules
   i. Hanwha monocrystalline modules
      a. Catalog number: SF160-24-1M190
      b. Certification: IEC 61215
      c. Power: 137 W (max at normal cell operating temperature)
      d. Open circuit voltage: 41.2 V
      e. Short circuit current: 4.68 A
      f. Voltage and current at maximum power: 32.2 V, 4.26 A
      g. Module efficiency: 13.4%
      h. Cell efficiency: 17.2%
      i. System voltage: 1,000 V (max)
      j. Series fuse rating: 10 A
      k. Environment: IP65, -40 to 85 °C

2.2 Grid-Tied Inverters
A. SMA America grid-tied inverters
   i. SMA America Sunny Boy 6000 US
      a. Catalog number: SB6000US
      b. Max. recommended PV power: 7500 W
      c. Max. DC power: 6350 W
      d. Max. DC voltage: 600 V
      e. MPP voltage range: 250 to 480 V
      f. Max. input current: 25 A, 20 A per string
      g. MPP trackers: 1
      h. Fused strings per MPP tracker: 4
      i. Max. AC nominal power: 6000 W
      j. Max output current: 29 A
      k. Efficiency: 96.9% (max)
      l. Electronics protection rating: NEMA 3R
      m. Certification: UL1741

2.3 Module Maximizers
A. Tigo Energy module maximizers
   i. Tigo Energy module maximizer
      a. Catalog number: MM-ES50
      b. Maximum power: 350 W
      c. Maximum input DC voltage: 52 V
d  Voltage at maximum power: 16 to 48 V

e  Maximum input current: 10 A

f  Maximum output power: 350 W

g  Maximum continuous output current: 9.5 A

h  Environment: IP65, -30 to 70 °C

i  Certification: UL1741

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow Manufacturer Specifications

END OF SECTION 263100
SECTION 265000 – LIGHTING

PART 1 - GENERAL
1.01 SECTION REQUIREMENTS
A. Submittals: Product Data for each luminaire, including lamps.

PART 2 - PRODUCTS
2.01 PERFORMANCE REQUIREMENTS
A. Fixtures, Emergency Lighting Units, Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS
A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
C. Exterior Luminaires: Comply with UL 1598 and listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
D. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
E. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

2.03 LAMPS
A. Recessed Can Lights
1. Elite Lighting 4” Can
   a. Manufacturer: Elite Lighting
   b. Wattage: 10W
   c. Dimming: Yes
   d. Voltage: 120 V
   e. Housing: LED4IC-AT
   f. Insulation: Yes, can Contact
2. PAR16 GU10 Task Light
   a. Manufacturer: Philips
   b. Yes
B. Outdoor Strip Lights
1. American Lighting LED Rope Light Kit
   a. Model: 120-TL60-30-WW
   b. Color: White
   c. Dimensions: ¼” x 3/8” x 360 in.
   d. Waterproof
   e. Wattage 37 W
C. Deck Recessed Lights
1. Solar LED Recessed Deck Dock Patio Light
   a. Manufacturer: Reusable Revolution
   b. Model: SRroundwhite1
   c. Color: White
   d. Dimensions: 4.75” diameter x 2” x 3” diameter base
   e. Waterproof
   f. Battery: 900 mAh
PART 3 - EXECUTION

3.01 INSTALLATION

A. Coordinate ceiling-mounted luminaires with ceiling construction, mechanical work, and security and fire-prevention features mounted in ceiling space and on ceiling.

B. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

C. Comply with NFPA 70 for minimum fixture supports.

D. Seismic Protection: Luminaire attachments to building walls and ceilings shall comply with seismic criteria in Section 260500 "Common Work Results for Electrical."

E. Adjust aimable lighting fixtures to provide required light intensities.

END OF SECTION 265000
DIVISION 27 – COMMUNICATIONS

SECTION 272200 – DATA COMMUNICATIONS HARDWARE

Part 1 - GENERAL
1.1 Summary
   A. This section includes information on the control equipment. These include the:
      1. Google Nexus 7

Part 2 - PRODUCTS
2.1 Products
   A. Tablets
      1. Google Nexus 7
         a. Product Description and/or specifications
            i. 7" 1280x800 (216ppi) screen
            ii. 198.5 x 120 x 10.45 mm dimension
            iii. 32 GB hard drive
            iv. 340 g
            v. 1.2 MP front-facing camera
            vi. Wi-Fi 802.11 b/g/n
            vii. bluetooth
            viii. 1GB ram
            ix. NVIDIA Tegra 3 quad-core processor
            x. 4,325 mAh battery
            xi. Accelerometer
            xii. GPS
            xiii. Gyroscope
            xiv. Microphone
            xv. Magnetometer

Part 3 - EXECUTION
2.2 Installation
   A. Comply with all manufacturers’ written recommendations and specifications

END OF SECTION 272200
SECTION 274116 – INTEGRATED AUDIO-VISUAL SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. The home entertainment system will contain TV, audio system, projector, projector screen, computer, and monitor. It will be used to entertain guests indoors and outdoors.

B. Submittals

   i. TV: Samsung UN32EH5000
   ii. Blu-Ray player: LG BP220
   Audio system: Panasonic SC-BTT190 Blu-Ray Home Theater System
   Projector: Acer H5360
   Projector screen: FAVI HD150
   Computer: Lenovo H330 (77805RU)
   Monitor: Viewsonic VX2250WM
   iii. {Shop drawings}
   iv. Follow all manufacturer instructions.

PART 2 - PRODUCTS

2.1 TV/blue-ray/audio system

A. TV

   Brand: Samsung
   Model: UN40EH5300
   Type: LED-LCD (LED backlighting)
   Screen size: 40-inch
   Resolution: 1080p HD
   Refresh rate: 60 Hz
   Other: Built-in wifi, Smart Hub

B. Blue-ray

   Brand: LG
   Model: BP220
   Features: Smart TV, Smart phone app
   Connectivity: Wired Internet, DMP (DLNA), SIMPLINK
   Other: HDMI 1.4

C. Audio

   Brand: Panasonic
   Model: SC-BTT190
   Output: 1000W
   Connectivity: Smart phone, VIERA Connect™, Wireless LAN, DLNA (DMP&DMR), BD-Live™
   Other: HDMI

2.2 Projector system:

A. Projector

   Brand: Acer
   Model: H5360
   Brightness: 2500 lumen
   Throw distance: min – 3.2ft, max – 33.4ft
   Max power consumption: 224W
   Resolution: 1080HD
   Other: 3D
   Connectors: HDMI, DVI, VGA

B. Projector screen

   Brand: FAVI
Model: HD-150
Size: 150-inch
Aspect Ratio: 16:9/HD
Viewing Area: 131-inch x 74-inch

2.3 Computer and monitor system

A. Computer
   Brand: Lenovo
   Model: H520s - 57310716
   CPU: 2nd generation Intel Core i3-2130 Processor (3.40GHz)
   RAM: 4GB
   Hard drive: 1TB 7200 rpm

B. Monitor
   Brand: Viewsonic
   Model: VX2250WM
   Resolution: 1080p
   Type: LED backlighting
   Connectivity: VGA, power

PART 3 - EXECUTION
3.1 INSTALLATION
   A. Follow Manufacturer Specifications

END OF SECTION 274116
DIVISION 28 ELECTRONIC SAFETY AND SECURITY

SECTION 281600 – SAFETY MEASURES

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. When a person or other object comes in contact with one or more safety edges, the sensor(s) will trigger a full and immediate stop of module and canopy movement. When a person or other object interrupts the beams of a light curtain, the sensor will trigger a full and immediate stop of module and canopy movement. When a person or other object interrupts the beam of an area access control sensor, the sensor will trigger a full and immediate stop of module and canopy movement. Safety limit switches mute the signal from a light curtain when it is interrupted by the home. Safety relays and safety edge controllers send status inputs to a programmable logic controller and are hard-wired to the module motors.

B. Submittals

i. http://www.ab.com/catalogs

ii. [Shop Drawings]

iii. [Manuf. Instructions]

PART 2 - PRODUCTS

2.1 Safety Edges

A. Allen-Bradley sensitive edge system

i. Allen-Bradley Safedge 0118S

a. Catalog number: 440F-E0118S10

b. Safety rating: IEC/EN 60204-1

c. Environment: IP65, -5 to 55 °C

d. Bend radius: 19.6 in (min)

e. Power supply: 4 VDC (from control unit)

f. Wire size: 18 AWG

g. Cushion factor: 0.15 in

h. Length: 32.8 ft

i. Profile: 0.63 in

j. Mounting rail

   (i) Catalog number: 440F-R1212

   (ii) Material: aluminum

   (iii) Length: 6.5 ft

k. Connector and cable

   (i) Catalog number: 440F-A1185

l. Mini profile resistor

   (i) Catalog number: 440F-A1186

m. Mini profile closing cap

   (i) Catalog number: 440F-A1318

2.2 Safety Edge Controllers

A. Allen-Bradley sensitive edge controller

i. Allen-Bradley Safedge controller

a. Catalog number: 440F-C252D

b. Safety rating: EN 954-1

c. Environment: IP65, -10 to 55 °C

d. Response time: 13 ms (max)

e. Contacts

   (i) Safety: 2 NO
(ii) Auxiliary: 1 NC

2.3 Light Curtains

A. Allen-Bradley safety light curtain
   i. Allen-Bradley Guardmaster Type 4 POC GuardShield Standard
      a. Catalog number: 440L-P4K0320YD
      b. Protected height: 12.6 in
      c. Number of beams: 16
      d. Resolution: 1.18 in
      e. Safety rating: IEC/EN 61496 Parts 1 & 2
      f. Operating voltage: 24 VDC (max)
      g. Power: 0.4 A max (no load)
      h. Response time: 20 to 25 ms
      i. Wavelength: 870 nm
      j. Environment: IP65, -10 to 55 °C
      k. Cordset
         (i) Transmitter
            1. Catalog number: 889D-F4AC-10
            2. 22 AWG
         (ii) Receiver
            1. Catalog number: 889D-F8AB-10
            2. 24 AWG

2.4 Area Access Control Sensors

A. Allen-Bradley area access control sensor
   i. Allen-Bradley area access control single beam – emitter
      a. Catalog number: 440L-T4F2070-Q
      b. Safety rating: IEC/EN 61496 Parts 1 & 2
      c. Input power: 24 VDC ±20%
      d. Power consumption: 8 W (max, 24 VDC)
      e. Outputs: 2 NO relays
      f. Response time: < 22 ms
      g. Beam diameter: 23 mm
      h. Scanning range: 0.5 to 20 m
      i. Wavelength: 950 nm
      j. Environment: IP67, -25 to 55 °C
   ii. Allen-Bradley area access control single beam – receiver
      a. Catalog number: 440L-R4F0020-Q
      b. Safety rating: IEC/EN 61496 Parts 1 & 2
      c. Input power: 24 VDC ±20%
      d. Power consumption: 8 W (max, 24 VDC)
      e. Outputs: 2 NO relays
      f. Response time: < 22 ms
      g. Beam diameter: 23 mm
      h. Scanning range: 0.5 to 20 m
      i. Environment: IP67, -25 to 55 °C

2.5 Safety Limit Switches

A. Allen-Bradley safety limit switch
   i. Allen-Bradley compact safety limit switch
      a. Catalog number: 440P-ARPS11C
      b. Safety rating: UL, CE, marked for all applicable directives
      c. Outputs
(i) Safety contact: 1 NC, snap acting
(ii) Auxiliary contact: 1 NO, snap acting

d  Actuation speed: 250 mm/s (max), 100 mm/min (min)
e  Actuation frequency: 6,000 operations/hour (max)
f  Mechanical life: 10,000,000 operations
g  Environment: IP 66/67, 2 to 70 °C

2.6 Safety Relays
A. Allen-Bradley safety relay
   i. Allen-Bradley muting module safety relay
      a  Catalog number: 440R-P23071
      b  Safety rating: IEC/EN 61496 Parts 1 & 2
      c  Input power: 24 VDC ±20%
      d  Power consumption: 0.4 A max (no load)
      e  Outputs
         (i) Safety: 2 OSSD, 0.5 A
         (ii) Auxiliary: 0.5 A
      f  Response time: 20 ms

PART 3 - EXECUTION
3.1 INSTALLATION
   A. Follow Manufacturer Specifications

END OF SECTION 281600
SECTION 281601 – POSITIONING EQUIPMENT

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Retroreflective laser distance sensors measure the distance between the modules and the distance between each module and the end of the track. Limit switches prevent the modules from driving off the ends of the track and ensure that the modules continue to close until an air- and water-tight seal forms between the modules.

B. Submittals

i. http://ab.com/catalogs/

ii. {Shop Drawings}

iii. {Manuf. Instructions}

PART 2 - PRODUCTS

2.1 Laser Distance Sensors

A. Allen-Bradley photoelectric sensor

i. Allen-Bradley laser measurement photoelectric sensor

a. Catalog number: 45LMS-U8LGC3-D4

b. Sensing mode: retroreflective

c. Light source: Class 1 laser (visible red 660 nm)

d. Sensing distance: 0.2 to 50 m

e. Spot size: < 50mm at a distance of 50 m

f. Precision: accurate to ± 25 mm

g. Environment: IP65, -30 to 50 °C

h. Outputs: one discrete (NPN/PNP), one analog (4 to 20 mA)

i. Mounting bracket

(j) Catalog number: 45LMS-BKT1

j. Cordset

(k) DC Micro quick disconnect, 22 AWG

l. Reflector target

(i) Dimensions: 40.5 x 60 mm

2.2 Limit Switches

A. Allen-Bradley limit switch

i. Allen-Bradley compact limit switch (top push cross roller)

a. Catalog number: 802B-CSAD1XSD4

b. Torque/force to operate: 11.77 N (max)

c. Travel to operate contacts: 1.8 mm (max)

d. Maximum travel: 5 mm

e. Maximum travel to reset contacts: 0.2 mm

f. Output type: standard

2.3 Proximity Sensors

A. Allen-Bradley proximity sensor

i. Allen-Bradley 2W proximity switch

a. Catalog number: 872C-D3NE12-D4

b. Environment: IP67, -25 to 70 °C

c. Barrel Diameter: 12 mm

d. Sensing Distance: 3 mm

e. Load current: < 100 mA

f. Leakage current: < 0.9 mA

g. Operating voltage: 10 to 30 VDC

h. Voltage drop: ±6 V
PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow Manufacturer Specifications

END OF SECTION 281601
SECTION 28160 - COMMAND CENTER EQUIPMENT

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. A programmable logic controller with a touchscreen user interface and manual trigger allow the homeowners to input a desired module and canopy configuration.

B. Submittals
   i. http://ab.com/catalogs/
   ii. {Shop Drawings}
   iii. {Manuf. Instructions}

PART 2 - PRODUCTS

2.1 Programmable Logic Controllers (PLCs)

A. Allen-Bradley PLC
   i. Allen-Bradley MicroLogix 1400 PLC
      a. Catalog number: 1766-L32BWA
      b. Environment: -20 to 60 °C
      c. Line voltage: 120/240 VAC
      d. Memory
         (i) 10 kB user program
         (ii) 10 kB user data
         (iii) Battery-backed RAM
      e. Inputs: 12 (fast 24 VDC), 8 (normal 24 VDC)
      f. Outputs: 12 relay

2.2 PLC Input/Output Modules

A. Allen-Bradley input module
   i. Allen-Bradley four-channel analog input module
      a. Catalog number: 1762-IF4
      b. Environment: -20 to 65 °C
      c. Inputs: four differential (bipolar)
      d. Analog ranges
         (i) Voltage: ±10 V
         (ii) Current: 4 to 20 mA

   ii. Allen-Bradley 16 point digital input module
      a. Catalog number: 1762-IQ16
      b. Environment: -20 to 65 °C
      c. Inputs: 16 (eight points/group)
      d. Operating voltage range: 10 to 26.4 VDC
      e. Maximum on-state current: 12 mA at 30 VDC
      f. Maximum off-state current: 1.5 mA at 5 VDC

B. Allen-Bradley output module
   i. Allen-Bradley 16 point digital output module
      a. Catalog number: 1762-OW16
      b. Environment: -20 to 65 °C
      c. Outputs: 16 (eight points/group)
      d. Operating voltage range: 5 to 265 VAC, 5 to 125 VDC
      e. Maximum continuous current per output: 2.5 A
      f. Maximum off-state leakage current: 0 mA

2.3 User Interface Panels

A. Allen-Bradley touchscreen user interface panels
   i. Allen-Bradley PanelView graphic terminal
a  Catalog number: 2711C-T6T
b  Display type: color transmissive TFT active matrix LCD
c  Display size: 5.7 in
d  Resolution: 320 x 240
e  Backlight: white LED lifetime 40,000 hours (min)
f  Touchscreen type: analog resistive
g  Actuation rating: 1,000,000 presses
h  Communication ports: RS-232 (DH-485), RS-232 (DF1), RS485, Ethernet
i  Programming port: USB device port or Ethernet port
j  Input voltage range: 18 to 30 VDC (24 VDC nom)
k  Power consumption: 10 W (max, 0.42 A at 24 VDC)
l  Environment: IP 65, 0 to 50 °C
m  Certification: c-UL-us, CE marked, C-Tick

2.4 Power Supplies
A. Allen-Bradley power supply
   i. Allen-Bradley 480 W power supply
      a  Catalog number: 1606-XLS480E
      b  Output wattage and voltage: 480 W, 24 to 28 VDC
      c  Input voltage: 100 to 240 VAC or 110 to 150 VDC
      d  Rated input current
         (i) 4.6 A at 100 VAC
         (ii) 2.5 A at 240 VAC
      e  Output current
         (i) 20 A at 24 V
         (ii) 17 A at 28 V
   f  Safety rating: IEC/EN 60950, EN 50178

2.5 Emergency Stop Buttons
A. Allen-Bradley emergency stop button
   i. Allen-Bradley metal mushroom push button
      a  Catalog number: 800FM-MT34
      b  Trigger action: twist to release
      c  Color: red
      d  Size: 30 mm diameter
      e  Environment: IP 65/66, -25 to 70 °C
      f  Mechanical durability: 300,000 cycles
      g  Operating force: 9 N (typical)
      h  Certifications: UR/UL, CSA, CCC, CE
      i  Metal latch
         (i) Catalog number: 800F-ALM
         (ii) Mechanical durability: 10,000,000 cycles
         (iii) Certifications: UR/UL, CSA, CCC, CE
      j  Contact blocks
         (i) Catalog numbers: 800F-X01, 800F-X10

2.6 Unmanaged switches
A. Allen-Bradley unmanaged switch
   i. Allen-Bradley Stratix 2000
      a  Catalog number: 1783-US05T
      b  Inrush current: 2.2 A (max)
      c  Power supply voltage: 24 VDC (10 to 35 VDC)
      d  Isolation voltage: 30 V (continuous)
e Power consumption: 4 W (max, 400 mA at 10 VDC)
f Ethernet connections: category 5 cable (ISO/IEC 24702)
g DC power connections: 16 to 14 AWG
h Environment: open-style enclosure, 0 to 60 °C
i Certification: UL Listed Industrial Control Equipment
j Copper ports per module: 5

PART 3 - EXECUTION
3.1 INSTALLATION
A. Follow Manufacturer Specifications

END OF SECTION 281602
Appendix B: Quantity Takeoff
Sci-Arc Solar Decathlon

Structural Calculations (Construction Documents Phase)
Project #: 3102BD
November 9, 2012
Great Park Irvine, California 92618, USA

Latitude:          N 33.672917
                  N 33° 40' 22.5''
Longitude:        W 117.73172
                  W 117° 43' 54.2''
GENERAL DESIGN CRITERIA:

Structural Design is based on the California Building Code, 2010 Edition, City of Irvine Building Ordinances and Amendments, ASCE (American Society of Civil Engineers), ACI (American Concrete Institute), AISC (American Institute of Steel Construction), AITC (American Institute of Timber Construction), and NDS (National Design Standards) for wood construction.

LOADS:
- **Dead Load:** (As required per calculations)
- **Roof Live Load:** 20 psf
- **Floor Live Load:**
  - Typical Floor: 50 psf *(Reducible per CBC Section 1607.9.1.1)*
  - Decks used for Tour Staging and Egress: 100 psf *(Reducible per CBC Section 1607.9.1.1)*
- **Seismic:** Occupancy Category II; Site class D; Short period spectral response acceleration (S<sub>p</sub>) 143.6%; 1.0 sec period spectral response acceleration (S<sub>r</sub>) 50.7%; Long-period transition period (T<sub>L</sub>) 8.0; Importance factor (I<sub>E</sub>) 1.00;
- **Wind:** Basic wind speed 85 mph; Exposure category C; Importance factor (I<sub>W</sub>) 1.0
- **Snow:** N/A

FOUNDATIONS:
- **Spread and Continuous Footings:** Designed for an allowable bearing pressure of 1,500 psf on paved surfaces.

MATERIALS:

**CONCRETE:**
- Concrete:
  - Spread and Continuous Footings: Minimum compressive strength of 4,500 psi at 28 days.
  - Slab on Grade: Minimum compressive strength of 4,500 psi at 28 days.
- Cement: Type V
- Reinforcing: ASTM A615, Grade 60 (F<sub>y</sub> = 60 ksi)

**STEEL:**
- W-Beams and W-Columns: ASTM A992, Grade 50 (F<sub>y</sub> = 50 ksi)
- HSS-Beams and HSS-Columns (Rectangular): ASTM A500, Grade B (F<sub>y</sub> = 46 ksi)
- Angles and Plates: ASTM A36 (F<sub>y</sub> = 36 ksi)
- Bolt Connections: ASTM A325 (Slip-Critical where occurs).
- Anchor Bolts: Standard: ASTM A307

**WOOD:**
- Visually Graded Dimension Lumber (2" - 4" thick): Douglas Fir-Larch No. 2 Grade.
- Pre-Manufactured Lumber: Truss Joists, a Weyerhaeuser Business or ICBO approved equal.
- Connection Hardware: Simpson Strong Tie or ICBO Approved Equal.
- Shear Walls: As per attached Shear Wall Schedule

**WELDS:**
- E70XX Electrode

**INSPECTION:**
- As required by governing municipality
- Concrete: Required verification and inspection per Table 1704.4
- Steel: Required verification and inspection per Table 1704.3
- Quality Assurance: Section 1705 for Seismic Resistance and 1706 for Wind Requirement
## Shear Wall Schedule

<table>
<thead>
<tr>
<th>Mark</th>
<th>Nominal Panel Thickness</th>
<th>Edge Nailing (E.N.)</th>
<th>Sill Plate Nailing At Steel Floor Member</th>
<th>Sill Plate Nailing At Wood Floor</th>
<th>A35 Or LTP4</th>
<th>16dS</th>
<th>Seismic</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5</td>
<td>3/8&quot; Plywood</td>
<td>10dN @ 6&quot; O.C.</td>
<td>PDP @ 6&quot; O.C.</td>
<td>16dS @ 4&quot; O.C.</td>
<td>4&quot; O.C.</td>
<td>4&quot; O.C.</td>
<td>240 PLF</td>
<td>476 PLF</td>
</tr>
<tr>
<td>A4</td>
<td>3/8&quot; Plywood</td>
<td>10dN @ 4&quot; O.C.</td>
<td>PDP @ 4&quot; O.C.</td>
<td>20dN @ 3&quot; O.C.</td>
<td>3&quot; O.C.</td>
<td>3&quot; O.C.</td>
<td>510 PLF</td>
<td>714 PLF</td>
</tr>
<tr>
<td>A3</td>
<td>3/8&quot; Plywood</td>
<td>10dN @ 3&quot; O.C.</td>
<td>PDP @ 3&quot; O.C.</td>
<td>20dN @ 2&quot; O.C.</td>
<td>2&quot; O.C.</td>
<td>2&quot; O.C.</td>
<td>665 PLF</td>
<td>831 PLF</td>
</tr>
<tr>
<td>A2</td>
<td>3/8&quot; Plywood</td>
<td>10dN @ 2&quot; O.C.</td>
<td>PDP @ 2&quot; O.C.</td>
<td>20dN @ 2&quot; O.C.</td>
<td>1&quot; O.C.</td>
<td>1&quot; O.C.</td>
<td>870 PLF</td>
<td>1218 PLF</td>
</tr>
</tbody>
</table>

### Notes:
1. 10dN = 10d common nail (0.148" dia.)
2. 20dN = 20d common nail (0.182" dia.)
3. 16dS = 16d sinker nail (0.148" dia.)
4. PDP = Hilti X-U (0.157" dia.)
5. P4, P3, P2 and double-sided shear walls shall require the following: A. Nails shall be staggered at all adjoining panel edges.
   B. 3x nominal lumber shall be used at all adjoining panel edges.
   C. Sill plate shall be 2x nominal lumber, 4x nominal lumber may be used at the foundation only.
6. For double-sided shear walls use one-half the spacing shown in the schedule for sill plate connection and hardware connection.
7. All shear wall lengths noted on plan are minimum required and may be increased without review.
8. Allowable shear values are based on the specific gravity of the framing lumber not less than 0.50 and studs are not spaced more than 16' O.C.
9. Multiple end posts shall be stitch nailed together with 16dS per shear wall schedule.

### Comments:
- Wall sheathing shall be structural grade plywood with a span rating of 32/16. All unsupported edges shall be blocked with 12' O.C. field nailing.
- All sill plates shall be 2x nominal lumber and top plate shall be double 2x nominal lumber U.O.N.
- Where Hilti X-U PDP's are used, full penetration into the steel member must be achieved. Install per Mfr specification.
### Roof Dead Loads (Typical Surface Load): Maximum

<table>
<thead>
<tr>
<th>Item</th>
<th>Load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Panels</td>
<td>4.0</td>
</tr>
<tr>
<td>Attachment Steel and Fabric</td>
<td>4.0</td>
</tr>
<tr>
<td>Waterproofing Membrane</td>
<td>1.5</td>
</tr>
<tr>
<td>1/2&quot; Roof Sheathing (O.S.B. Allowance)</td>
<td>1.7</td>
</tr>
<tr>
<td>2x10 Douglas-Fir Floor Joists @ 16&quot; o/c</td>
<td>2.8</td>
</tr>
<tr>
<td>Insulation</td>
<td>0.5</td>
</tr>
<tr>
<td>Mechanical/Electrical/Plumbing</td>
<td>3.0</td>
</tr>
<tr>
<td>Sprinklers</td>
<td>2.0</td>
</tr>
<tr>
<td>5/8&quot; Gypsum Board</td>
<td>2.8</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Total Dead Load</strong></td>
<td><strong>24.0</strong></td>
</tr>
</tbody>
</table>

### Roof Dead Loads (Typical Surface Load): Minimum

<table>
<thead>
<tr>
<th>Item</th>
<th>Load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment Steel and Fabric</td>
<td>3.1</td>
</tr>
<tr>
<td>Waterproofing Membrane</td>
<td>0.5</td>
</tr>
<tr>
<td>1/2&quot; Roof Sheathing</td>
<td>1.5</td>
</tr>
<tr>
<td>2x10 Douglas-Fir Floor Joists @ 16&quot; o/c</td>
<td>2.8</td>
</tr>
<tr>
<td>Insulation</td>
<td>0.3</td>
</tr>
<tr>
<td>5/8&quot; Gypsum Board</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Total Dead Load</strong></td>
<td><strong>11.0</strong></td>
</tr>
</tbody>
</table>
Floor Dead Loads (Typical Surface Load): Maximum

Floor Finish
3/4" Floor Sheathing (O.S.B. Allowance)
2x6 Douglas-Fir Floor Joists @ 16" o/c
Insulation
3/4" Floor Sheathing (O.S.B. Allowance)
Miscellaneous

Total Dead Load 14.0 psf

Floor Dead Loads (Typical Surface Load): Minimum

Floor Finish
3/4" Floor Sheathing
2x6 Douglas-Fir Floor Joists @ 16" o/c
3/4" Floor Sheathing

Total Dead Load 9.0 psf
### Wall Dead Loads (Typical Surface Load): Maximum

<table>
<thead>
<tr>
<th>Item</th>
<th>Load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment Steel and Fabric</td>
<td>4.0</td>
</tr>
<tr>
<td>Waterproofing Membrane</td>
<td>2.5</td>
</tr>
<tr>
<td>1/2&quot; Wall Sheathing (O.S.B. Allowance)</td>
<td>1.7</td>
</tr>
<tr>
<td>2x6 Douglas-Fir Floor Joists @ 16&quot; o/c</td>
<td>1.7</td>
</tr>
<tr>
<td>Insulation</td>
<td>0.5</td>
</tr>
<tr>
<td>Mechanical/Electrical/Plumbing</td>
<td>1.0</td>
</tr>
<tr>
<td>5/8&quot; Gypsum Board</td>
<td>2.8</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Total Dead Load</strong></td>
<td><strong>16.0</strong></td>
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</table>

### Wall Dead Loads (Typical Surface Load): Minimum

<table>
<thead>
<tr>
<th>Item</th>
<th>Load (psf)</th>
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<tbody>
<tr>
<td>Attachment Steel and Fabric</td>
<td>3.2</td>
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<tr>
<td>Waterproofing Membrane</td>
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<tr>
<td>1/2&quot; Wall Sheathing</td>
<td>1.5</td>
</tr>
<tr>
<td>2x6 Douglas-Fir Floor Joists @ 16&quot; o/c</td>
<td>1.7</td>
</tr>
<tr>
<td>Insulation</td>
<td>0.3</td>
</tr>
<tr>
<td>5/8&quot; Gypsum Board</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Total Dead Load</strong></td>
<td><strong>10.0</strong></td>
</tr>
</tbody>
</table>
Line Loads To Exterior Frames:

Trib. Width: 4.50 ft  <<< *Tributary width at all modules*

<table>
<thead>
<tr>
<th></th>
<th>DL (psf)</th>
<th>LL (psf)</th>
<th>DL (plf)</th>
<th>LL (plf)</th>
<th>DL (plf)</th>
<th>LL (plf)</th>
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<tbody>
<tr>
<td>Roof (Max)</td>
<td>24.0</td>
<td>20.0</td>
<td>108</td>
<td>90</td>
<td>110</td>
<td>90</td>
</tr>
<tr>
<td>Roof (Min)</td>
<td>11.0</td>
<td></td>
<td>50</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Floor (Max)</td>
<td>14.0</td>
<td>50.0</td>
<td>63</td>
<td>225</td>
<td>65</td>
<td>225</td>
</tr>
<tr>
<td>Floor (Min)</td>
<td>9.0</td>
<td></td>
<td>41</td>
<td></td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

Point Loads To Exterior Frames:

Wall Height: 9.5 ft  <<< *Constant for all modules*

<table>
<thead>
<tr>
<th></th>
<th>DL (psf)</th>
<th>DL (plf)</th>
<th>DL (lbs)</th>
<th>DL (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall (Max)</td>
<td>16.0</td>
<td>152</td>
<td>684</td>
<td>685</td>
</tr>
<tr>
<td>Wall (Min)</td>
<td>10.0</td>
<td>95</td>
<td>428</td>
<td>430</td>
</tr>
</tbody>
</table>
GRAVITY ANALYSIS AND DESIGN
(MAIN STRUCTURAL SYSTEM)
MEMBER REPORT  Level, Floor: Joist
1 piece(s) 1 3/4" x 5 1/2" 1.9E Microlam® LVL @ 12" OC

Overall Length: 9’ 7”

All Dimensions Are Horizontal; Drawing is Conceptual

<table>
<thead>
<tr>
<th>Design Results</th>
<th>Actual @ Location</th>
<th>Allowed</th>
<th>Result</th>
<th>LDF</th>
<th>Load: Combination (Pattern)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member Reaction (lbs)</td>
<td>288 @ 3 1/2&quot;</td>
<td>1959</td>
<td>Passed</td>
<td>(15%)</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Shear (lbs)</td>
<td>250 @ 9&quot;</td>
<td>1829</td>
<td>Passed</td>
<td>(14%)</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Moment (ft-lbs)</td>
<td>648 @ 4' 9 1/2&quot;</td>
<td>2211</td>
<td>Passed</td>
<td>(29%)</td>
<td>1.000 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Live Load Defl. (in)</td>
<td>0.126 @ 4' 9 1/2&quot;</td>
<td>0.225</td>
<td>Passed</td>
<td>(L/859)</td>
<td>1.000 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Total Load Defl. (in)</td>
<td>0.161 @ 4' 9 1/2&quot;</td>
<td>0.300</td>
<td>Passed</td>
<td>(L/671)</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>TJ-Pro™ Rating</td>
<td>47</td>
<td>40</td>
<td>Passed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Deflection criteria: LL (L/480) and TL (L/360).
- Bracing (Lu): All compression edges (top and bottom) must be braced at 9' o/c unless detailed otherwise. Proper attachment and positioning of lateral bracing is required to achieve member stability.
- A 4% increase in the moment capacity has been added to account for repetitive member usage.
- A structural analysis of the deck has not been performed.
- Deflection analysis is based on composite action with a single layer of 23/32" Weyerhaeuser Edge™ Panel (24" Span Rating) that is glued and nailed down.
- Additional considerations for the TJ-Pro™ Rating Include: None.

Supports

<table>
<thead>
<tr>
<th>Bearne Length</th>
<th>Loads to Supports (lbs)</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Available</td>
<td>Required</td>
</tr>
<tr>
<td>1 - Hanger on 5 1/2&quot; DF beam</td>
<td>3.50&quot;</td>
<td>Hanger</td>
</tr>
<tr>
<td>2 - Hanger on 5 1/2&quot; DF beam</td>
<td>3.50&quot;</td>
<td>Hanger</td>
</tr>
</tbody>
</table>

- At hanger supports, the Total Bearing dimension is equal to the width of the material that is supporting the hanger.
- See Connector grid below for additional information and/or requirements.

Connector: Simpson Strong-Tie Connectors

<table>
<thead>
<tr>
<th>Support</th>
<th>Model</th>
<th>Seat Length</th>
<th>Top Nails</th>
<th>Face Nails</th>
<th>Member Nails</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Face Mount Hanger</td>
<td>Connector not found</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2 - Face Mount Hanger</td>
<td>Connector not found</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Loads

<table>
<thead>
<tr>
<th>Location</th>
<th>Spacing</th>
<th>Dead (0.80)</th>
<th>Floor Live (1.00)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 9’ 7”</td>
<td>12”</td>
<td>14.0</td>
<td>55.0</td>
<td>Residential - Living Areas</td>
</tr>
</tbody>
</table>

Weyerhaeuser Notes

Weyerhaeuser warrants that the sizing of its products will be in accordance with Weyerhaeuser product design criteria and published design values. Weyerhaeuser expressly disclaims any and all liability related to the software. Refer to current Weyerhaeuser literature for installation details. (www.woodbwy.com) Accessories (Rim Board, Blocking Panels and Squash Blocks) are not designed by this software. Use of this software is not intended to document the need for a design professional as determined by the authority having jurisdiction. The designer of record, builder or framer is responsible to assure that this calculation is compatible with the overall project. Products manufactured at Weyerhaeuser facilities are third-party certified to sustainable forestry standards.

The product application, input design loads, dimensions and support information have been provided by Forte Software Operator.

Forte Software Operator
Frank Reppi
BurkRepp pi
(313) 945-4800
frank.reppi@burlkepo.com

<table>
<thead>
<tr>
<th>Job Notes</th>
<th></th>
</tr>
</thead>
</table>
Overall Length: 9'

All Dimensions Are Horizontal; Drawing Is Conceptual

### Design Results

<table>
<thead>
<tr>
<th></th>
<th>Actual @ Location</th>
<th>Allowed</th>
<th>Result (lbs)</th>
<th>LDF</th>
<th>Load: Combination (Pattern)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member Reaction (lbs)</td>
<td>370 @ 3 1/2&quot;</td>
<td>1325</td>
<td>Passed (28%)</td>
<td>1.25</td>
<td>1.0 D + 1.0 Lr (All Spans)</td>
</tr>
<tr>
<td>Shear (lbs)</td>
<td>370 @ 3 1/2&quot;</td>
<td>2738</td>
<td>Passed (14%)</td>
<td>1.25</td>
<td>1.0 D + 1.0 Lr (All Spans)</td>
</tr>
<tr>
<td>Moment (Pt-lbs)</td>
<td>779 @ 4' 6&quot;</td>
<td>7138</td>
<td>Passed (11%)</td>
<td>1.25</td>
<td>1.0 D + 1.0 Lr (All Spans)</td>
</tr>
<tr>
<td>Live Load Defl. (in)</td>
<td>0.011 @ 4' 6&quot;</td>
<td>0.281</td>
<td>Passed (L/999+)</td>
<td>--</td>
<td>1.0 D + 1.0 Lr (All Spans)</td>
</tr>
<tr>
<td>Total Load Defl. (in)</td>
<td>0.025 @ 4' 6&quot;</td>
<td>0.421</td>
<td>Passed (L/999+)</td>
<td>--</td>
<td>1.0 D + 1.0 Lr (All Spans)</td>
</tr>
</tbody>
</table>

* Deflection criteria: LL (L/360) and Tl (L/240).
* Bracing (Lu): All compression edges (top and bottom) must be braced at 8’ 5” o/c unless detailed otherwise. Proper attachment and positioning of lateral bracing is required to achieve member stability.

### Supports

<table>
<thead>
<tr>
<th>Bearing Length</th>
<th>Loads to Supports (lbs)</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Available</td>
<td>Required</td>
</tr>
<tr>
<td>1 - Hanger on 16&quot; DF beam</td>
<td>3.50&quot;</td>
<td>Hanger</td>
</tr>
<tr>
<td>2 - Hanger on 16&quot; DF beam</td>
<td>3.50&quot;</td>
<td>Hanger</td>
</tr>
</tbody>
</table>

* At hanger supports, the Total Bearing dimension is equal to the width of the material that is supporting the hanger
* 1 See Connector grid below for additional information and/or requirements.

### Connector: Simpson Strong-Tie Connectors

<table>
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<tr>
<th>Support</th>
<th>Model</th>
<th>Seat Length</th>
<th>Top Nails</th>
<th>Face Nails</th>
<th>Member Nails</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Top Mount Hanger</td>
<td>TT52.37/16</td>
<td>2.00&quot;</td>
<td>4-10# x 1 x 1/2</td>
<td>2-10# x 1 x 1/2</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>2 - Top Mount Hanger</td>
<td>TT52.37/16</td>
<td>2.00&quot;</td>
<td>4-10# x 1 x 1/2</td>
<td>2-10# x 1 x 1/2</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

### Loads

<table>
<thead>
<tr>
<th>Location</th>
<th>Spacing</th>
<th>Dead (0.90)</th>
<th>Roof Load (non-snow 1.25)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Uniform (PSF)</td>
<td>0 to 9'</td>
<td>24&quot;</td>
<td>24.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

### Weyerhaeuser Notes

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The product application, input design loads, dimensions and support information have been provided by Forte Software Operator.
Floor Joint Hanger Design:

Load from Joint Design = 2.88 k

Load from Tables = 1.81/5 = (1610 lb/yd x .64)

Permitted from Yol to Kid x 1.1

OK = 103# > 288#

Roof Joint Hanger Design:

Load from Joint Design = 37.2 k

Wind uplift on roof: (K = .85 0-15 mph)

\[ q = 600(286)(.85)(1.0)(.85)(85^2)(10) \]
\[ = 13.36 \text{ psi} \]

\[ p = \frac{13.36 \text{ psi} x 1.8}{31.4 \text{ psi}} \]
\[ = 18 \# \]

\[ \text{Uplift Curve} = (31.4 \text{ psi} x 110 \text{ psi} \times 124 \times 0.9^1/2) \]
\[ = 185 \# < 265 \# \text{ OK} \]

BA: 2.37/16 = 2220 # > 370 # \text{ OK} \]
### Face Mount Hangers – Structural Composite Lumber

These products are available with additional corrosion protection. Additional products on this page may also be available with this option. Check with Simpson for details.

#### Codes: See page 12 for Code Reference Key Chart.

<table>
<thead>
<tr>
<th>Actual Joint Size</th>
<th>Model No.</th>
<th>Ga</th>
<th>Dimensions</th>
<th>Fasteners</th>
<th>Allowable Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>1¼ x 5½</td>
<td>HU1.1/5</td>
<td>14</td>
<td>1½% 5% 2½</td>
<td>Min 12-15d</td>
<td>Uplift (16d): 1610 2010 1590</td>
</tr>
<tr>
<td>1¼ x 7¼</td>
<td>HU1</td>
<td>14</td>
<td>1½% 5% 2½</td>
<td>Max 16-15d</td>
<td>1855 2155 2200</td>
</tr>
<tr>
<td>1¼ x 9½</td>
<td>HUS1.1/10</td>
<td>10</td>
<td>1½% 5% 2½</td>
<td>18-15d</td>
<td>1750 2050 2120</td>
</tr>
<tr>
<td>1¼ x 11¼ - 11½</td>
<td>HU11</td>
<td>14</td>
<td>1½% 5% 2½</td>
<td>30-15d</td>
<td>1850 2100 2170</td>
</tr>
<tr>
<td>1¼ x 13</td>
<td>HU31/11-SDS</td>
<td>14</td>
<td>1½% 5% 2½</td>
<td>Max 10-15d</td>
<td>1850 2100 2150</td>
</tr>
<tr>
<td>21½ x 9½</td>
<td>HU2.75/10</td>
<td>14</td>
<td>2½% 9½ 2½</td>
<td>Min 16-15d</td>
<td>1855 2155 2200</td>
</tr>
<tr>
<td>21½ x 11¼ - 11½</td>
<td>HUS2.75/10</td>
<td>12</td>
<td>2½% 9½ 2½</td>
<td>Max 16-15d</td>
<td>1855 2155 2200</td>
</tr>
<tr>
<td>21½ x 13</td>
<td>HU31/12</td>
<td>14</td>
<td>2½% 9½ 2½</td>
<td>Min 16-15d</td>
<td>1855 2155 2200</td>
</tr>
<tr>
<td>21½ x 15</td>
<td>HUS2.75/12</td>
<td>12</td>
<td>2½% 9½ 2½</td>
<td>Max 16-15d</td>
<td>1855 2155 2200</td>
</tr>
<tr>
<td>3½ x 9½</td>
<td>HUS2.75/14</td>
<td>14</td>
<td>2½% 9½ 2½</td>
<td>Min 16-15d</td>
<td>1855 2155 2200</td>
</tr>
<tr>
<td>3½ x 11¼ - 11½</td>
<td>HUS2.75/14</td>
<td>12</td>
<td>2½% 9½ 2½</td>
<td>Max 16-15d</td>
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</tr>
<tr>
<td>3½ x 13</td>
<td>HUS2.75/16</td>
<td>14</td>
<td>2½% 9½ 2½</td>
<td>Min 16-15d</td>
<td>1855 2155 2200</td>
</tr>
<tr>
<td>3½ x 14</td>
<td>HUS2.75/16</td>
<td>12</td>
<td>2½% 9½ 2½</td>
<td>Max 16-15d</td>
<td>1855 2155 2200</td>
</tr>
</tbody>
</table>

1. 10d commons or 18d sinkers may be used instead of the specified 10d at 0.64 of the table load value. 18d at 0.64 of the table load value.
2. 16d commons may be used instead of the specified 16d commons with no load reduction.
3. Uplift loads based on DF/SP lumber and have been increased 60% for wind or earthquake loading with no further increase allowed. For normal loading applications such as caraveller construction refer to Simpson Strong-Tie® Connector Selector software or conservatively divide the uplift load by 1.8.

For DF/SP, use 0.85 x DF/SP Uplift Load and for products requiring rail and 0.72 x DF/SP Uplift Load for products requiring screws.

4. Min nailing quantity and load values—fill all round holes.
5. Max nailing quantity and load values—fill all round holes.
6. Hangers sorted in order of recommended selection for best overall performance and installation values.
**ENGINEERED WOOD & STRUCTURAL COMPOSITE LUMBER CONNECTORS**

**TOP FLANGE HANGERS LBV/BA/B/BB - Joist & Structural Composite Lumber Connectors**

The BA hanger is a cost-effective hanger targeted at high capacity joists and common Structural Composite Lumber applications. A mid-notch nail option gives dual use of this hanger. Minimum values for positive angle nailing are at 1/4 in. without web stiffeners, while the maximum nailing generates higher loads to support structural composite lumber material. The unique top angle provides added stiffness to the top flange.

The newly improved LBV, B and BB hangers offer wider versatility for I-joints and structural composite lumber. The enhanced load capacity further widens the range of applications for these hangers. The LBV still features positive angle nailing and does not require the use of web stiffeners for standard non-modified I-joint installations.

See Flange tables on pages 96 to 105. See Hanger Options on pages 181-183 for hanger modifications, which may result in reduced loads.

**MATERIAL:** See tables, pages 96 to 105.

**FINISH:** LBV, B and BA-Galvanized; all saddle hangers and all welded slotted and special hangers-Simpson Strong-Tie® gray paint. LBV, B and BA may be ordered hot-dip galvanized; specify hot-dip galv.

**INSTALLATION:** Use all specified fasteners. See General Notes and nailer table.

- LBV, B, BA, and BA may be used for weld-on applications. Weld to match material thickness (approximate thickness shown). The minimum required weld to top flange on flanges is 1/8 x 2" fillet weld to each side of each top flange for 6" gauge and 7/8" x 2" fillet weld to each side of each top flange for 7" gauge and 10 gauge. Distribute the weld evenly on both top flanges. Welding can be the top and face nailing requirements. Consult the code for special considerations when welding galvanized steel. The area should be well-ventilated, see page 14 for weld information. Weld on applications produce the maximum allowable down load listed. For uplift loads refer to T-WELDPFLT.

- LBV and B hangers do not require the use of web stiffeners for non-sloped or non-skewed applications.

- B and BA hangers require the use of web stiffeners. BA MIN nailing does not require web stiffeners. BA MAX nailing requires the use of web stiffeners.

- LBV and B hangers must be evaluated for each application separately. Check TF dimension, nail length and nail location on ledger.

- Refer to technical bulletin B-SERIES for information regarding load reductions on selected hangers which can be used without modification to support joints which have shallow slopes (less than 12°).

**OPTIONS:** LBV, B, and BA

- Other widths are available; specify W dimension (minimum W dimension is 1¾in.).
- Other types of hangers will depend on the manufacturing process used. Check with your Simpson Strong-Tie representative for details.
- Hot-dip galvanized available; specify HDG.
- Refer to technical bulletin B-SERIES for the complete line of LBV, BA, and BA hangers, including models not shown here, their available modification combinations and associated reduction factors.
- Modifed hangers have reduced loads, see Hanger Options, pages 181-183.

**CODES:** See page 12 for Code Reference Key Chart.

**BA INSTALLED LVL to LVL Max Nailing**

**Typical Double LBV Hanger Installation**

<table>
<thead>
<tr>
<th>BA Installed LVL to LVL Max Nailing</th>
<th>BA Installed 2X Nailer on Steel Beam Minimum Nailing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nailer attachment Per Designer</td>
<td>BA, HB, and LBV are acceptable for weld-on applications (LBV shown). See Installation Information.</td>
</tr>
</tbody>
</table>

**BA Installed 2X Nailer on Steel Beam Minimum Nailing**

**BA Installed LVL to LVL Max Nailing**

**BA, HB, and LBV are acceptable for weld-on applications (LBV shown). See Installation Information.**

**LBV features positive angle nailing, no web stiffeners are required.**

**BA INSTALLED LVL to LVL Max Nailing**

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<thead>
<tr>
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</tr>
</tbody>
</table>
WALL STUD DESIGN: 2X6

[Diagram of wall stud design]

* USE DOUGLAS FIR LARCH #2

* WALLS ARE NOW BEARING SO ONLY SHOW BEARING CONDITIONS

\[
\begin{align*}
L_{16} &= 10.5 - 0.15 \times 20 \text{ in} \\
&= 10.5 - 3.0 \\
&= 7.5 \\
V_{16} &= 0.00256 \times 0.85 \times 10 	imes 0.85 \times 85^2 \\
&= 13.36 \text{ psi}
\end{align*}
\]

\[
\begin{align*}
p &= V_{16} / A \\
&= 13.36 / 1.5 \\
&= 8.88 \text{ psi}
\end{align*}
\]

\[
\begin{align*}
M &= V_{16} \times d \times 16 / 12 \\
&= 433 \text{ ft-lb}
\end{align*}
\]

\[
\begin{align*}
S &= 26 \times \left( \frac{1}{12} \times \frac{10}{4} \right) \\
&= 173 \text{ ft-lb}
\end{align*}
\]

\[
\begin{align*}
f &= C \times \frac{F_b}{A} \\
&= 1.5 \times \frac{900}{234} \\
&= 677 \text{ psi}
\end{align*}
\]

\[
\begin{align*}
F_b &= \frac{433 \times 12}{7863} \\
&= 687 \text{ psi} < 1872 \text{ psi} \quad \text{OK}
\end{align*}
\]

\[
\begin{align*}
N &= (160 \times 1.22) \\
&= 283 \text{ psi} \quad \text{OK}
\end{align*}
\]

\[
\begin{align*}
\sigma &= \frac{8 \times 8.25}{2 \times 16} \\
&= 3.15 \text{ psi} < 208 \text{ psi}
\end{align*}
\]

\[
\begin{align*}
\text{Deformation} &= \frac{2 \times 12 \times 14.0 \times 10^6 \times 1.25 \times 10^8}{384 \times 1.6 \times 10} \\
&= 0.234 \text{ in} \\
&= 2.86 \text{ in}
\end{align*}
\]
Loads: BLC 3, DL (Min - Center)
Solution: Envelope
Loads: BLC 4, DL (Max - Cantilever)
Solution: Envelope
Loads: BLC 5, DL (Min - Cantilever)
Solution: Envelope
### Hot Rolled Steel Design Parameters

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<td>Section</td>
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<tr>
<td>Size</td>
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<tr>
<td>Flange Thickness</td>
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<td>Web Thickness</td>
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**RISA-3D Version 8.1.2**

**[Image of page and content]**

**Page 13 of 14**
### Envelope Member Section Forces (Continued)

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### Envelope Member Section Forces (Continued)

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<th>Moment</th>
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### Envelope Member Section Forces (Continued)

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### Envelope Member Section Forces (Continued)

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### Envelope Joint Reactions

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<th>Y Rel.</th>
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### Envelope Joint Displacements

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<th>Joint</th>
<th>X Rel.</th>
<th>Y Rel.</th>
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### Envelope AISC 17th ASD Steel Code Checks

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### Material Takeoff

<table>
<thead>
<tr>
<th>Material</th>
<th>Size</th>
<th>Plan</th>
<th>Length (lb)</th>
<th>Weight (lb)</th>
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<tbody>
<tr>
<td>Hot Rolled Steel</td>
<td>10</td>
<td>100</td>
<td>25.6</td>
<td>25.6</td>
</tr>
<tr>
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<tr>
<td>Total Steel</td>
<td></td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Slider Analyses

\[ R_1 = \frac{(4\pi)(33 \times 125 \times 125)}{2 \times 8.5} \]
\[ = 1213 \text{ #} \text{ (Total)} \]
\[ = 606 \text{ #} \text{ (Per Support)} \]

\[ R_2 = \frac{(4\pi)(33 \times 12.5 \times 12.5)(285 + 125)}{2 \times 8.5} \]
\[ = 2863 \text{ #} \text{ (Total)} \]
\[ = 1432 \text{ #} \text{ (Per Support)} \]

Max (up side down care for seismic load compensation

\[ R_2 = 8 \times 606 + 2 \times 606 \]
\[ = 2772 \text{ #} \text{ (R_2)} \]

Will not turn over in earthquake

- Cannot must be closed in high winds
MEMBER REPORT

Level, Floor: Flush Beam

2 piece(s) 1 3/4" x 11 7/8" 1.9E Micromill® LVL

Overall Length: 23' 4 1/2"

All Dimensions Are Horizontal; Drawing is Conceptual

<table>
<thead>
<tr>
<th>Design Results</th>
<th>Actual @ Location</th>
<th>Allowed</th>
<th>Result</th>
<th>LDF</th>
<th>Load: Combination (Pattern)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member Reaction (lbs)</td>
<td>15775 @ 11' 8 1/4&quot;</td>
<td>14438</td>
<td>Failed (100%)</td>
<td>---</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Shear (lbs)</td>
<td>6533 @ 12' 10 7/8&quot;</td>
<td>7897</td>
<td>Passed (85%)</td>
<td>1.00</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Moment (Ft-lbs)</td>
<td>-17511 @ 11' 8 1/4&quot;</td>
<td>17648</td>
<td>Passed (100%)</td>
<td>1.00</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Live Load Defl. (in)</td>
<td>0.330 @ 5' 8 9/16&quot;</td>
<td>0.378</td>
<td>Passed (L/413)</td>
<td>---</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Total Load Defl. (in)</td>
<td>0.354 @ 5' 8 1/16&quot;</td>
<td>0.506</td>
<td>Passed (L/385)</td>
<td>---</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
</tbody>
</table>

* Deflection criteria: Ll (L/360) and Ti (L/240).
* Bracing (Lu): All compression edges (top and bottom) must be braced at 6" o.c. unless detailed otherwise. Proper attachment and positioning of lateral bracing is required to achieve member stability.

<table>
<thead>
<tr>
<th>Supports</th>
<th>Bearing Length</th>
<th>Loads to Supports (lbs)</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Available</td>
<td>Required</td>
</tr>
<tr>
<td>1 - Column Cap - steel</td>
<td>5.50&quot;</td>
<td>5.50&quot;</td>
<td>2.21&quot;</td>
</tr>
<tr>
<td>2 - Column Cap - steel</td>
<td>5.50&quot;</td>
<td>5.50&quot;</td>
<td>6.01&quot;</td>
</tr>
<tr>
<td>3 - Column Cap - steel</td>
<td>5.50&quot;</td>
<td>5.50&quot;</td>
<td>2.21&quot;</td>
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</tbody>
</table>

* Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

<table>
<thead>
<tr>
<th>Loads</th>
<th>Location</th>
<th>Tributary Width</th>
<th>Dead (0.00)</th>
<th>Floor Live (1.00)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Uniform(PLF)</td>
<td>0 to 13' 4 1/2&quot;</td>
<td>N/A</td>
<td>100.0</td>
<td>1000.0</td>
<td>Residential - Living Areas</td>
</tr>
</tbody>
</table>

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The product application, input design loads, dimensions and support information have been provided by Forte Software Operator

---

Forte Software Operator
Frank Reppi
Buckhead Mill (310) 945-4800
frank.reppi@buckhead-mill.com

Job Notes

2/7/2013 7:29:21 PM
Forte v3.5, Design Engine: V6.5.3.2
31023D-20120920-FAR-Deck.4te
Page 1 of 1
**MEMBER REPORT**  
*Level, Floor: Joist*

1-piece(s) 1 3/4" x 7 1/4" 1.9E Microllam® LVL @ 24" OC

**Overall Length: 10' 7"**

![Diagram of member with dimensions and marks]

All Dimensions Are Horizontal; Drawing is Conceptual

<table>
<thead>
<tr>
<th>Design Results</th>
<th>Actual @ Location</th>
<th>Allowed</th>
<th>Result</th>
<th>LDF</th>
<th>Load: Combination (Pattern)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member Reaction (lbs)</td>
<td>1100 @ 3 1/2&quot;</td>
<td>1969</td>
<td>Passed (56%)</td>
<td>--</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Shear (lbs)</td>
<td>967 @ 10 3/4&quot;</td>
<td>2411</td>
<td>Passed (49%)</td>
<td>1.00</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Moment (ft-lbs)</td>
<td>2750 @ 5 3 1/2&quot;</td>
<td>3700</td>
<td>Passed (74%)</td>
<td>1.00</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Live Load Defl. (in)</td>
<td>0.319 5 3 1/2&quot;</td>
<td>0.333</td>
<td>Passed (L/376)</td>
<td>--</td>
<td>1.0 D + 1.0 L (All Spans)</td>
</tr>
<tr>
<td>Total Load Defl. (in)</td>
<td>0.351 @ 5 3 1/2&quot;</td>
<td>0.500</td>
<td>Passed (L/342)</td>
<td>--</td>
<td>1.0 D + 1.0 L (All Spans)</td>
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<tr>
<td>TJ-Pro™ Rating</td>
<td>43</td>
<td>40</td>
<td>Passed</td>
<td>--</td>
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</tr>
</tbody>
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- Deflection criteria: LL (L/360) and TL (L/240).
- Breathing (Lu): All compression edges (top and bottom) must be braced at 10" o/c unless detailed otherwise. Proper attachment and positioning of lateral bracing is required to achieve member stability.
- A 4% increase in the member capacity has been added to account for repetitive member usage.
- A structural analysis of the deck has not been performed.
- Deflection analysis is based on composite action with a single layer of 23/32" Weyerhaeuser edge™ Panel (24" Span Rating) that is glued and nailed down.
- Additional considerations for the T3-Pro™ Rating include: None

### Supports

<table>
<thead>
<tr>
<th>Supports</th>
<th>Bearing Length</th>
<th>Loads to Supports (lbs)</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Available</td>
<td>Required</td>
</tr>
<tr>
<td>1 - Hanger on 7 1/4&quot; DF beam</td>
<td>3.50&quot;</td>
<td>Hanger</td>
<td>1.50&quot;</td>
</tr>
<tr>
<td>2 - Hanger on 7 1/4&quot; DF beam</td>
<td>3.50&quot;</td>
<td>Hanger</td>
<td>1.50&quot;</td>
</tr>
</tbody>
</table>

- At hanger supports, the total Bearing dimension is equal to the width of the material that is supporting the hanger
- See Connector grid below for additional information and/or requirements

### Connector: Simpson Strong-Tie Connectors

<table>
<thead>
<tr>
<th>Support</th>
<th>Model</th>
<th>Seat Length</th>
<th>Top Nails</th>
<th>Face Nails</th>
<th>Member Nails</th>
<th>Accessories</th>
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</thead>
<tbody>
<tr>
<td>1 - Face Mount Hanger</td>
<td>HU7</td>
<td>2.50&quot;</td>
<td>N/A</td>
<td>12-10d common</td>
<td>4-10d x 1-1/2</td>
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</tr>
<tr>
<td>2 - Face Mount Hanger</td>
<td>HU7</td>
<td>2.50&quot;</td>
<td>N/A</td>
<td>12-10d common</td>
<td>4-10d x 1-1/2</td>
<td></td>
</tr>
</tbody>
</table>

### Loads

<table>
<thead>
<tr>
<th>Location</th>
<th>Spacing</th>
<th>Dead (0.00)</th>
<th>Floor Live (1.00)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 10' 7&quot;</td>
<td>24&quot;</td>
<td>10.0</td>
<td>100.0</td>
<td>Residential - Living Areas</td>
</tr>
</tbody>
</table>

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The product application, input design loads, dimensions and support information have been provided by Forte Software Operator.

---

**Forte Software Operator**

**Job Notes**

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BuroHappold  
(310) 945-4800  
frank.reppi@burohappold.com

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2/7/2013 7:28:01 PM  
Forte v3.5, Design Engine: V5.5.3.2  
3102BD-20120920-FAR-Deck.4te  
Page 1 of 1
Deck Design: Flat 2x6's

\[ Dc = \left( \frac{1}{2} \times 2\frac{1}{2} \times 20 \text{ psf} \right) = 20 \text{ psf} \]

\[ Ll = 100 \text{ psf} \]

\[ F_d = (1.0 \times 900 \text{ psf}) + (1.3 \times 1.08 \times 1.5) = 1545 \text{ psf} \]

\[ S_{S credible} = 2606.3 \text{ m}^2 \]

\[ \text{Moment} = (1545 \text{ psf} \times 2606.3 \text{ m}^2) = (0.117 \times 8/12 \times (100 + 20) \times l^2) \]

\[ l = 5.44 \]

\[ A = (4 \times 12) / 360 = (5\pi/8 \times 100 + 20) \times l^3 \]

\[ l = 3.57 \text{ ft} = 4 \text{ ft} \]

2x6 Flat @ 2'-0" O/C max
| PROJECT: |
| SOLAR DECATHALON |
| DESCRIPTION |
| LATERAL ANALYSIS AND DESIGN |
| PROJECT #: |
| 3102BD |
| PAGE #: |
| AUTHOR/DATE: |
| CHECKED BY/DATE: |

LATERAL ANALYSIS AND DESIGN
(MAIN STRUCTURAL SYSTEM)
## Seismic Design Criteria (ASCE 7-05):

- **Occupancy Category:** II
- **Importance Factor:** 1.00
- **Site Class:** D
- **Building Roof Height (h):** 10.00 ft
- **Long-Period Transition (T):** 8.0 sec

### X-Direction

#### Spectral Response Acceleration Parameters:

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Mapped (IMCE)</th>
<th>Site Coefficient</th>
<th>Mapped (IMCE)</th>
<th>Site Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Period</td>
<td>S₁ = 1.436 (Sec. 11.4.1)</td>
<td>F₀ = 1.000 (Sec. 11.4.3)</td>
<td>S₁ = 0.507 (Sec. 11.4.1)</td>
<td>F₀ = 1.500 (Sec. 11.4.3)</td>
</tr>
<tr>
<td>Second Period</td>
<td>S₂ = 1.436</td>
<td></td>
<td>S₂ = 0.761</td>
<td></td>
</tr>
</tbody>
</table>

#### Design Spectral Acceleration:

- S₁ = 2/3 S₁₁ (Eq. 11.4-3)
- S₂ = 0.957

### Y-Direction

#### Spectral Response Acceleration Parameters:

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Mapped (IMCE)</th>
<th>Site Coefficient</th>
<th>Mapped (IMCE)</th>
<th>Site Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Period</td>
<td>S₁ = 0.507 (Sec. 11.4.1)</td>
<td>F₀ = 1.500 (Sec. 11.4.3)</td>
<td>S₁ = 0.507 (Sec. 11.4.1)</td>
<td>F₀ = 1.500 (Sec. 11.4.3)</td>
</tr>
<tr>
<td>Second Period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Design Spectral Acceleration:

- S₁₁ = 2/3 S₁₁ (Eq. 11.4-4)
- S₁₁ = 0.507

### Seismic Base Shear Coefficient: X-Direction

- **Fundamental Period:** T = 0.11 sec (Sec. 12.8.2)
- **Seismic Response Coefficient:** C₁ = S₀₁ / (R / L) (Eq. 12.8-2)  
  C₁ = 0.137
- **Need Not Be Less Than:** C₁ = 0.044 S₀₁ (Supp: Eq. 12.8-3)
  C₁ = 0.044
  C₁ = 0.042
  C₁ = 0.01 (Eq. 12.8-4)

#### Seismic Response Coefficient:

- V = 0.137 x W (Eq. 12.8-1)

### Seismic Base Shear Coefficient: Y-Direction

- **Fundamental Period:** T = 0.11 sec (Sec. 12.8.2)
- **Seismic Response Coefficient:** C₁ = S₀₁ / (R / L) (Eq. 12.8-2)  
  C₁ = 0.137
- **Need Not Be Less Than:** C₁ = 0.044 S₀₁ (Supp: Eq. 12.8-3)
  C₁ = 0.044
  C₁ = 0.042
  C₁ = 0.01 (Eq. 12.8-4)

#### Seismic Response Coefficient:

- V = 0.137 x W (Eq. 12.8-1)

---

Ignore ASCE Equation 12.8-6 when computing story drift.

Seismic Design Category is determined from Table 11.4-1 alone.
Seismic Design Criteria (ASCE 7-05):

Occupancy Category: II
Importance Factor: 1.00
Site Class: D
Building Roof Height (h): 10.00 ft
Long-Period Transition (T): 8.0 sec

Lateral Category: Building Frame Systems
Basic Seismic Force-Resisting System: Ordinary steel concentrically braced frames
Response Modification Factor (R): 3.25

X-Direction

<table>
<thead>
<tr>
<th>Spectral Response Acceleration Parameters</th>
<th>Mapped (MCE):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>Site Coefficient:</td>
</tr>
<tr>
<td></td>
<td>Fs = 1.000</td>
</tr>
<tr>
<td></td>
<td>Fp = 1.500</td>
</tr>
<tr>
<td>Adjusted (MCE):</td>
<td>Sd1 = Fp Ss1</td>
</tr>
<tr>
<td></td>
<td>Sd2 = Fp Ss2</td>
</tr>
<tr>
<td></td>
<td>Sd3 = 1.436</td>
</tr>
</tbody>
</table>

Design Spectral Acceleration:
Sd = 2/3 Sd3 (Eq. 11.4-3)
Sd1 = 0.507
Sd2 = 0.761

Y-Direction

<table>
<thead>
<tr>
<th>Spectral Response Acceleration Parameters</th>
<th>Mapped (MCE):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>Site Coefficient:</td>
</tr>
<tr>
<td></td>
<td>Fs = 1.000</td>
</tr>
<tr>
<td></td>
<td>Fp = 1.500</td>
</tr>
<tr>
<td>Adjusted (MCE):</td>
<td>Sd1 = Fp Ss1</td>
</tr>
<tr>
<td></td>
<td>Sd2 = Fp Ss2</td>
</tr>
<tr>
<td></td>
<td>Sd3 = 1.436</td>
</tr>
</tbody>
</table>

Design Spectral Acceleration:
Sd = 2/3 Sd3 (Eq. 11.4-3)
Sd1 = 0.507
Sd2 = 0.761

Seismic Design Category: D

Seismic Base Shear Coefficient: X-Direction

\[
\text{Seismic Base Shear Coefficient: } F_X = 6.20 \times 0.507 = 3.104 \times 0.285 \text{ kip/ft}
\]

Seismic Base Shear Coefficient: Y-Direction

\[
\text{Seismic Base Shear Coefficient: } F_Y = 0.295 \times W
\]

User Defined Period (T<sub>100</sub>)

Fundamental Period:
T = 0.11 sec (Sec. 12.8.2)
Seismic Response Coefficient:
C<sub>1</sub> = S<sub>d1</sub> / (R / I)
C<sub>2</sub> = 0.295
Need Not Exceed:
C<sub>3</sub> = S<sub>d3</sub> / T (R / I)
C<sub>3</sub> = 1.387
Should Not Be Less Than:
C<sub>4</sub> = 0.044 S<sub>d3</sub>
C<sub>4</sub> = 0.042
C<sub>4</sub> = 0.01 (Eq. 12.8-5)
Seismic Response Coefficient:
V = 0.295 x W (Eq. 12.8-1)
Wind uplift: \( \frac{1200}{4.45} \)

\[ q_2 = \frac{1340 \text{ psi}}{c_p = -0.90} \]

\[ p_v = 1340 \text{ psi} \left[ 0.85 \times (-0.90) + (-0.55) \right] \]

\[ = 17.6 \text{ psi} \]

\[ T_{133} \text{(wind)} = (17.6 \text{ psi}) \times (9.51/12) \]

\[ = 79.2 \text{ psi} \]

See for Module 1.2.3

May uplift:

\[ 0.6 \times \text{ Wind uplift (unknown)} = 240 \text{#} \]

Load combo #71: PSA Analysis

\[ \text{Structure with new load checks: 240# is NEGATIVE.} \]
Seismic MASS: Module 1 and 3

\[ \text{Weight (Roof)} = (24 \times 31 \times 9.81) \]
\[ = 10616 \text{#} \]
\[ = 10616 \text{#} \checkmark \]

\[ \text{Weight (Floor)} = (16 \times 10 \times 2 \times 31 \times 2 \times 9.81) \]
\[ = 7826 \text{#} \checkmark \]

Seismic FORCE: Module 1 and 3

X-Direction

\[ \text{Forced (Roof)} = (10616 \times 137 \times 1 \times 70) \]
\[ = 10418 \text{#} \Rightarrow 3208 \text{#} \]  

\[ \text{Forced (Floor)} = (7826 \times 137 \times 1 \times 70) \]
\[ = 751 \Rightarrow 242 \text{#} \]

Y-Direction

\[ \text{Forced (Roof)} = (10616 \times 295 \times 1 \times 70) \]
\[ = 2192 \Rightarrow 243 \times 6 \text{#} \]

\[ \text{Forced (Floor)} = (7826 \times 295 \times 1 \times 70) \]
\[ = 1616 \Rightarrow 180 \text{#} \]
**LTAR Loads: Module 1 and 3**

\[ q_0 = (0.0025 \times 0.85 \times 1.0 \times 0.80 \times 85^2 / 1.0) \]

\[ = 1340 \text{ psi} \]

**X-Direction (4/3 = 3.3)**

\[ P_{\text{wall}} = (1340 \text{ psi} \times 0.85 \times 0.80 + 0.50) \]

\[ = 14.81 \text{ psi} \]

**Rebars (Roof)**

\[ = (14.81 \text{ psi} \times 0.80 / 2) + (14.81 \text{ psi} \times 0.4) \]

\[ = 142 \text{ psi} \]

**Floor**

\[ = 83 \text{ psi} \]

**Y-Direction (4/3 = 3.3)**

\[ P_{\text{wall}} = (1340 \text{ psi} \times 0.85 \times 0.80 + 0.25) \]

\[ = 120 \text{ psi} \]

**Roof**

\[ = 120 \text{ psi} \]

**Western (Roof)**

\[ = (120 \text{ psi} \times 10^4 / 2) + (120 \text{ psi} \times 0.4) \]

\[ = 1080 \text{ psi} \]

**Western (Floor)**

\[ = (120 \text{ psi} \times 10^4 / 2) = 60 \text{ psi} \]
Roof Diaphragm: Module 1 and 3
Seminar Mass & Module 2

Validated Crosses:
\[ V = 6.4 \text{ psf} \times 31 \text{ ft} \times 9 \text{ ft} \]
\[ + 16 \text{ psf} \times 10.5 \text{ ft} \times 9 \text{ ft} + 9 \text{ ft} \]
\[ = 8136 \text{ #} \]

Validated Floors:
\[ V = 14 \text{ psf} \times 31 \text{ ft} \times 9 \text{ ft} \]
\[ + 16 \text{ psf} \times 10.5 \text{ ft} \times 9 \text{ ft} + 9 \text{ ft} \]
\[ = 5346 \text{ #} \]

Seismic Force & Module 2

X-Direction
\[ F_{ax} = (8136 \text{ #}) \times 0.37 \times 70 \text{ psf} \]
\[ (ROSS) = 780 \text{ kips} \rightarrow 25 \text{ to } 25 \text{ kips} \]

Y-Direction
\[ F_{ay} = (5346 \text{ #}) \times 0.37 \times 70 \text{ psf} \]
\[ (ROSS) = 512 \text{ kips} \rightarrow 16 \text{ to } 16 \text{ kips} \]
where Loads & Module 2

\[ q_r = 0.0256 \times 0.95 \times 10 \times 0.85 \times 85^2 \times 10.5 \]

\[ = 1340 \text{ psi} \]

X-Deflection: \((h/8 = 0.38)\)

\[ P_{awm} = P_{case} = \left(13.40 \text{ psi}\right) \times 0.95 \times 0.85 + 0.50 \]

\[ = 14.81 \text{ psi} \]

W. Transfer to Chords

\[ = (14.81 \text{ psi}) \times 6.0 \times 0.75 \]

\[ = 89 \text{ psi} \]

W. Transfer to (Floor)

\[ = (14.81 \text{ psi}) \times 2.0 \times 0.75 \]

\[ = 30 \text{ psi} \]

Y-Deflection: \((h/8 = 0.38)\)

\[ P_{awm} = P_{case} = \left(13.40 \text{ psi}\right) \times 0.95 \times 0.85 + 0.25 \]

\[ = 120 \text{ psi} \]

W. Chords

\[ = (12.0 \text{ psi}) \times 10.5 \times 0.5 \]

\[ = 108 \text{ psi} \]

W. Chord

\[ = (12.0 \text{ psi}) \times 10/2 \]

\[ = 60 \text{ psi} \]
Diaphragm Design: Module 1 and 3

Roof Diaphragm X-Direction

Wind controls: $p = \frac{245 \text{ psf}}{4} \leq 62 \text{ psf}$

$$T = \frac{420 \text{ psf} \times 31 \text{ ft}^2 \times 9'}{1895} \approx 18.95$$

Steel is adequate for 1.9 kips load.

Floor Diaphragm X-Direction

Wind controls: $p = \frac{281 \text{ psf}}{4} \leq 70.25 \text{ psf}$

$$T = \frac{83 \text{ psf} \times 23\text{ ft}^2 \times 9}{609} \approx 60.9$$

$$T = \frac{83 \text{ psf} \times 4 \text{ ft}^2 \times 2\times 9 + (220 \text{ kips}) \times 4}{9} \approx 1052$$

Steel is adequate for 11 kips load.

By inspection, Module 1 and 3 is critical for Diaphragm Design.
<table>
<thead>
<tr>
<th>PANEL GRADE</th>
<th>COMMON NAIL SIZE OR STAPLE LENGTH AND GAGE</th>
<th>MINIMUM FASTENER PENETRATION IN FRAMING (INCHES)</th>
<th>MINIMUM NOMINAL PANEL THICKNESS (INCH)</th>
<th>MINIMUM NOMINAL WIDTH OF FRAMING MEMBERS AT ADJOINING PANEL EDGES AND BOUNDARIES (INCHES)</th>
<th>BLOCKED DIAPHRAGMS</th>
<th>UNBLOCKED DIAPHRAGMS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fastener spacing (inches) at diaphragm boundaries (all cases) at continuous panel edges parallel to load (Cases 3, 4), and at all panel edges (Cases 5, 6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fastener spacing (inches) at other panel edges (Cases 1, 2, 3 and 4)</td>
<td>Case 1</td>
<td>All other configurations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(No unblocked edges or continuous joints parallel to load)</td>
<td>(Cases 2, 3, 4, 5 and 6)</td>
</tr>
<tr>
<td></td>
<td><strong>6d (2\° x 0.113&quot;)</strong></td>
<td>1\°</td>
<td>1\°</td>
<td>2\°</td>
<td>2 185 250 375 420</td>
<td>165 125 140 140 140</td>
</tr>
<tr>
<td></td>
<td><strong>1½ 16 Gage</strong></td>
<td>1\°</td>
<td>1\°</td>
<td>2\°</td>
<td>2 210 280 420 475</td>
<td>185 140 140 140 140</td>
</tr>
<tr>
<td></td>
<td><strong>8d (2\½ x 0.131&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>2\°</td>
<td>2 155 205 310 350</td>
<td>135 105 105 105 105</td>
</tr>
<tr>
<td><strong>Structural I Grades</strong></td>
<td><strong>8d (2\½ x 0.131&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>3\°</td>
<td>3 175 230 345 390</td>
<td>155 115 115 115 115</td>
</tr>
<tr>
<td></td>
<td><strong>1½ 16 Gage</strong></td>
<td>1\°</td>
<td>1\°</td>
<td>3\°</td>
<td>3 270 360 530 600</td>
<td>240 180 180 180 180</td>
</tr>
<tr>
<td></td>
<td><strong>10d (3\° x 0.148&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>3\°</td>
<td>3 300 400 600 675</td>
<td>265 200 200 200 200</td>
</tr>
<tr>
<td></td>
<td><strong>1½ 16 Gage</strong></td>
<td>1\°</td>
<td>1\°</td>
<td>3\°</td>
<td>3 200 265 395 450</td>
<td>175 130 130 130 130</td>
</tr>
<tr>
<td></td>
<td><strong>6d (2\° x 0.113&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>2\°</td>
<td>2 175 230 350 400</td>
<td>155 115 115 115 115</td>
</tr>
<tr>
<td></td>
<td><strong>1½ 16 Gage</strong></td>
<td>1\°</td>
<td>1\°</td>
<td>3\°</td>
<td>3 200 265 395 450</td>
<td>175 130 130 130 130</td>
</tr>
<tr>
<td><strong>Sheathing, single floor and other grades covered in DOC PS 1 and PS 2</strong></td>
<td><strong>6d (2\° x 0.113&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>2\°</td>
<td>2 170 225 335 380</td>
<td>150 110 110 110 110</td>
</tr>
<tr>
<td></td>
<td><strong>6d (2\° x 0.113&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>3\°</td>
<td>3 190 250 380 430</td>
<td>170 125 125 125 125</td>
</tr>
<tr>
<td></td>
<td><strong>1½ 16 Gage</strong></td>
<td>1\°</td>
<td>1\°</td>
<td>3\°</td>
<td>3 155 205 310 350</td>
<td>140 105 105 105 105</td>
</tr>
<tr>
<td></td>
<td><strong>6d (2\° x 0.113&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>3\°</td>
<td>3 185 250 375 420</td>
<td>165 125 125 125 125</td>
</tr>
<tr>
<td></td>
<td><strong>8d (2\½ x 0.131&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>3\°</td>
<td>3 210 280 420 475</td>
<td>185 140 140 140 140</td>
</tr>
<tr>
<td></td>
<td><strong>6d (2\° x 0.113&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>2\°</td>
<td>2 240 320 480 545</td>
<td>215 160 160 160 160</td>
</tr>
<tr>
<td></td>
<td><strong>8d (2\½ x 0.131&quot;)</strong></td>
<td>1½\°</td>
<td>1½\°</td>
<td>3\°</td>
<td>3 270 360 540 610</td>
<td>240 180 180 180 180</td>
</tr>
</tbody>
</table>

(continued)
Critical Stem Wall: X-DIRECTION

Module 3: Gridline A + E

Wind:

\[ V_{\text{Wind}} = 220 \text{kft} \]

\[ V_{\text{SECC}} = 508 \text{kft} \]

\[ T = c = (220 \text{kft})(9.5 \| / \text{ft}) \]
\[ = 2325 \text{kft} \]

\[ V_c = V_c = 2325 \text{kft} / 9.5 \| \]
\[ = 246 \text{kft} \]

Section E:

\[ T = c = (508 \text{kft})(9.5 \| / \text{ft}) \]
\[ = 536 \text{kft} \]

\[ V_c = V_c = 536 \text{kft} / 9.5 \| \]
\[ = 56.4 \text{kft} \]
<table>
<thead>
<tr>
<th>PANEL GRADE</th>
<th>MINIMUM NOMINAL PANEL THICKNESS (inch)</th>
<th>MINIMUM FASTENER PENETRATION IN FRAMING (inches)</th>
<th>PANELS APPLIED DIRECT TO FRAMING</th>
<th>PANELS APPLIED OVER 1/2&quot; OR 3/4&quot; GYPSUM SHEATHING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fastener spacing at panel edges (inches)</td>
<td></td>
<td>Fastener spacing at panel edges (inches)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

**Structural I Sheathing**

| 7/16 | 1 1/4 | 6d (2 x 0.113" common, 2" x 0.099" galvanized box) | 200 | 300 | 390 | 510 | 200 | 300 | 390 | 510 |
|      |       | 1 1/2 16 Gage                                    | 165 | 245 | 325 | 415 | 125 | 185 | 245 | 315 |
|      |       | 8d (2 1/4" x 0.131" common, 2 1/4" x 0.113" galvanized box) | 230 | 340 | 460 | 610 | 210 | 250 | 350 | 430 |
|      |       | 1 1/2 16 Gage                                    | 155 | 235 | 315 | 400 | 155 | 235 | 310 | 400 |
|      |       | 1 1/4 16 Gage                                    | 170 | 250 | 345 | 440 | 210 | 280 | 360 | 440 |
|      |       | 8d (2 1/4" x 0.131" common, 2 1/4" x 0.113" galvanized box) | 280 | 360 | 450 | 530 | 210 | 280 | 350 | 450 |
|      |       | 1 1/2 16 Gage                                    | 165 | 240 | 320 | 400 | 210 | 280 | 350 | 450 |
|      |       | 10d (3" x 0.148" common, 3" x 0.128" galvanized box) | 340 | 510 | 690 | 870 | 340 | 510 | 690 | 870 |
|      |       | 1 1/2 16 Gage                                    | 180 | 270 | 350 | 450 | 180 | 270 | 350 | 450 |
|      |       | 6d (2" x 0.113" common, 2" x 0.099" galvanized box) | 180 | 270 | 350 | 450 | 180 | 270 | 350 | 450 |
|      |       | 1 1/2 16 Gage                                    | 145 | 220 | 295 | 375 | 145 | 220 | 295 | 375 |
|      |       | 6d (2" x 0.113" common, 2" x 0.099" galvanized box) | 200 | 300 | 390 | 510 | 200 | 300 | 390 | 510 |
|      |       | 1 1/2 16 Gage                                    | 220 | 320 | 410 | 530 | 210 | 280 | 360 | 440 |
|      |       | 8d (2 1/4" x 0.131" common, 2 1/4" x 0.113" galvanized box) | 240 | 350 | 450 | 580 | 240 | 350 | 450 | 580 |
|      |       | 1 1/2 16 Gage                                    | 155 | 230 | 310 | 395 | 210 | 280 | 360 | 440 |
|      |       | 8d (2 1/4" x 0.131" common, 2 1/4" x 0.113" galvanized box) | 260 | 380 | 490 | 620 | 260 | 380 | 490 | 620 |
|      |       | 1 1/2 16 Gage                                    | 140 | 210 | 280 | 360 | 210 | 280 | 360 | 440 |
|      |       | 8d (2 1/4" x 0.131" common, 2 1/4" x 0.113" galvanized box) | 260 | 380 | 490 | 620 | 260 | 380 | 490 | 620 |
|      |       | 1 1/2 16 Gage                                    | 155 | 230 | 310 | 395 | 210 | 280 | 360 | 440 |
|      |       | 8d (2 1/4" x 0.131" common, 2 1/4" x 0.113" galvanized box) | 300 | 460 | 600 | 770 | 300 | 460 | 600 | 770 |
|      |       | 1 1/2 16 Gage                                    | 170 | 250 | 330 | 430 | 210 | 280 | 360 | 440 |
|      |       | 8d (2 1/4" x 0.131" common, 2 1/4" x 0.113" galvanized box) | 340 | 510 | 665 | 870 | 340 | 510 | 665 | 870 |
|      |       | 1 1/2 16 Gage                                    | 185 | 280 | 375 | 475 | 210 | 280 | 360 | 440 |

**Sheathing, plywood siding, except Group 5 Species**

| 5/16 or 1/4" | 1 1/4 | 6d (2 x 0.113" common, 2" x 0.099" galvanized box) | 140 | 210 | 275 | 360 | 140 | 210 | 275 | 360 |
|      |       | 1 1/2 16 Gage                                    | 160 | 240 | 310 | 410 | 160 | 240 | 310 | 410 |

Nail Size (galvanized casing)
Foundation Design:

\[ E_{\text{more}} = E_{\text{mr}}. \]

\[ (2755 \text{ k} \cdot \text{ft} \cdot 20) = (150 \text{ psf} \cdot x/2 \times 18/12 \times 9/12) + (1250 \text{ k} \cdot \text{ft} \cdot x/2) + (2856 \text{ k} \cdot \text{ft} \cdot x/2) \]

\[ x = 15.0 \text{ in.} \]

GD includes 1.5 factor for over-turning. Design is conservative.

From design parameters:

1" x 6 steel bar driven into ground 36"
<table>
<thead>
<tr>
<th><strong>Steel</strong></th>
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<td><strong>WIDE FLANGE</strong></td>
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<table>
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<th>length in ft</th>
<th>weight per LF</th>
<th>total weight</th>
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<tr>
<td>floor face beam</td>
<td>6x6x5/16</td>
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<tr>
<td>Canopy steel HSS</td>
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<td>4&quot;x2&quot;x3/16&quot;</td>
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<td>Solar photovoltaics</td>
<td>SnapNRack</td>
<td>SF160-24-M190</td>
<td>Hanwha Solar</td>
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<td>SnapNRack</td>
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