Re_home

University of Illinois at Urbana-Champaign

Project Manual

As Built Document Submittal
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Re
home

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Rules Compliance Checklist:

RULE	RULE DESCRIPTION	LOCATION DESCRIPTION	LOCATION
Rule 4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site	O-101 O-102
Rule 4-2	Construction Equipment	Specifications for heavy machinery	Division 01 54 19
Rule 4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	C-101
Rule 4-4	Impact on the Turf	Drawing(s) showing the location, contact area, and soil-bearing pressure of every component resting directly on the turf	C-101
Rule 4-5	Generators	Specifications for generators	Division 01 51 13
Rule 4-6	Spill Containment	Drawing(s) showing the locations of all equipment, containers, and pipes that will contain liquids at any point during the event	H-101, P-102, P-103
Rule 4-6	Spill Containment	Specifications for all equipment, containers, and pipes that will contain fluids at any point during the event	Division 22 12 19
Rule 4-7	Lot Conditions	Calculations showing that the structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists	Man Appendix A Pg. 11, 88
Rule 4-7	Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 18 in. (45.7 cm) of vertical elevation change exists on the lot	S-501
Rule 5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	A-101, G-201, G-202, L-101
Rule 6-1	Structural Design Approval	List of, or marking on, all drawing and project manual sheets that have been or 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	Man Appendix A Pg. 1
Rule 6-2	Finished Square Footage	Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically	G-101

Rule 6-3	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route and the ground surface area that will be covered by organizer-provided walkway material	G-102, G-103
Rule 7-1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	L-101
Rule 7-2	Watering Restrictions	Drawing(s) showing the layout and operation of greywater irrigation systems	L-102
Rule 8-1	PV Technology Limitations	Specifications for photovoltaic components	Division 26 31 00 E-602, E-102
Rule 8-5	Village Grid	Completed interconnection application form.	Pg 10
Rule 8-5	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	E-101, E-102, E-602, A-112
Rule 8-5	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	Division 26
Rule 8-5	Village Grid	One-line electrical diagram	E-601
Rule 8-5	Village Grid	Calculation of service/feeder net computed load per NEC 220	E-001, E-602
Rule 8-5	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	E-101
Rule 8-5	Village Grid	Elevation(s) showing the meter housing, main utility disconnect, and other service equipment	E-201
Rule 9-1	Container Locations	Drawing(s) showing the location of all liquid containers relative to the finished square footage	P-101
Rule 9-1	Container Locations	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. EDT or between 8 a.m. and 4 p.m. solar time on October 1	P501 Ref. Manual 22 12 19 for enclosure specs.
Rule 9-3	Greywater Reuse	Drawing(s) showing the layout and operation of greywater reuse systems	L-101
Rule 9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	P-101
Rule 9-7	Greywater Heat Recovery	Drawing(s) showing the layout and operation of greywater heat recovery systems	P-901

Rule 9-8	Water Delivery	Drawing(s) showing the complete sequence of water delivery and distribution events	P-401
Rule 9-8	Water Delivery	Specifications for the containers to which water will be delivered	DIV 22 12 19
Rule 9-9	Water Removal	Drawing(s) showing the complete sequence of water consolidation and removal events	P-402
Rule 9-9	Water Removal	Specifications for the containers from which water will be removed	DIV 22 12 19
Rule 11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	G-103

Detailed Water Budget:

Function	Water Use (Gallons)	Gal	Events	
Hot Water Draws	240	15	16	
Water Vaporization	32	8	4	
Dishwasher	15	3	5	
Clothes Washer	240	30	8	
Vegetation	0	0	0	Greywater Reuse
Fire Protection	250	250	0	Active
Safety Factor 223				
Water Required	750	gallons		

Summary of Unlisted Electrical Components :

There are currently no unlisted electrical components included in the design and construction of the Re_home.

Summary of Reconfigurable Features:

There are currently no reconfigurable features included in the Re_home construction exhibited during the Solar Decathlon competition.

Interconnection Application Form:

University of Illinois Lot#: 305

PV Systems

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
Sunpower Corporation	3 Panels of (8) E18: 230 Modules. 24 modules total.	5520 W
Sanyo	6 HIT Bifacial Modules 195W	1170 W

Total DC power of all arrays is 6.690 kW (in tenths)

INVERTERS

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or KW)	Quantity
Sunpower Corp.	SPR-5000m	240VAC	5kw	1
Kaco	1502xi	240VAC	1.5kw	1

Total AC power of all inverters is 6.5 kVA or kW (in whole numbers)

The following information must be included in the project manual or construction documents. If located in the construction documents, list the drawing locations in this section of the project manual. (Example: B3/E-201)

1. One-Line Electrical schematic – the loads do not have to be detailed (pg. E-601)
2. Calculations of service/feeder net computer load and neutral load (NCE 220) (pg. E-001)
3. Plan view of the lot showing the house, decks, ramps, tour paths, the service point and the distribution panel or load center. (pg. E101)

Electrical Engineer: Stanton Cady: Scady2@illinois.edu. Project Engineer: Chris Cirone: 309 568 4019

Please see the "SD2011_Microgrid_Interconnection_Process_v1" file located the Files/Rules/Team Interconnection Process section of the Yahoo Group for more details on the interconnection process.

Energy Analysis Results and Discussion:

Prevalent throughout mainstream media and sophisticated designs, efficient engineering is a number one priority in building a house. Efficient engineering is an industry-wide standard not only aimed to save people money, but also to promote a healthier life style. In the case of the design for this competition, exceptional elements must be incorporated throughout the house in order to minimize its energy usage and to exemplify its high energy standards. Energy Star, for example, is an international standard for energy efficient consumer products originated in the United States of America. Devices carrying the Energy Star logo, such as computer products and peripherals, kitchen appliances, buildings and other products, generally use 20%–30% less energy than required by federal standards. In order to become an Energy Star qualified product, windows and doors must first be tested and certified by an independent, accredited agency. Window and door products may qualify for Energy Star based on their U-factor. This U-factor is a measure of the rate of non-solar heat loss or gain through a material or assembly. U-values gauge how well a material allows heat to pass through the membrane – the lower the U-value, the greater a product's resistance to heat flow. In order to be accredited as an Energy Star qualified window or door, these products must express a U-factor value of at least 0.35, for implementing its design in the Northern United States. Qualifying U-factor values vary across the nation and may be represented by Table B1 and Figure A1.

As part of this design competition, triple-paned windows are to be used in the house design, which express a U-factor value of 0.204 Btu/h-ft2-F, which may be represented by Figure A2 below. These windows are designed by layering three parallel planes of glass with two inner layers of air insulation. This design greatly inhibits heat conduction, ultimately minimizing the amount of heat loss through the windows. For example, a window in our house design may be five feet long and three feet high, resulting in a glazing area of fifteen feet squared. A window this size, modeled in an environment at 80 °F, may leak 244.8 Btu of energy through this opening per hour, strictly calculated from this U-factor. As a comparison, a substandard house may install standard single-paned windows evaluated at a U-factor value of only 1.004 Btu/h-ft2-F. Under the same design parameters, a substandard house may expect an energy leakage of almost five times that of our triple-paned windows (1204.8 Btu/h for single-paned window). From these results, it appears fundamental why such high quality windows are required as part of an efficient energy analysis.

While windows may seem like the major contributor towards heat loss, doors also play a role in this energy analysis. For this design competition, double-paned doors are to be used in the house design, which express a U-factor value of roughly 0.3 Btu/h-ft2-F, which may be represented by Figure A3 below. Similar to the aforementioned windows, these doors are designed by layering two parallel planes of glass with one inner layer of air insulation. Energy efficient doors, like windows, at-

tempt to minimize heat conduction through its panes in order to respond appropriately to changes in weather. Similar to the windows, a calculation may be done which relates energy loss per unit hour. Assuming a standard door size of three feet long and seven feet high at a temperature of 80 °F, 504 Btu of energy is assumed to leak through this door opening per hour. Ideally, no heat loss or gain should be tolerable through exterior glazing; however, this parameter is hardly ever possible. Not only are perfect efficiencies almost impossible to obtain, but also obtaining these values would introduce a large cost not easily made up for by its savings from energy loss.

On top of windows and doors, another energy saving implementation is incorporated in our design. For years now, large tents have made outdoor events possible, even during the hottest days of summer. While seemingly elementary in nature, these tents have the capability of significantly reducing its encompassing region. While tents are not used in the design, its fundamental principles are applied to the house. In order to duplicate their efforts, “shading structures” encase the house, ultimately aiming to shade and cool the design. These shades are strategically placed so that a majority of the exposed windows and doors are contained within the shading scheme’s extents and are represented by Figure A4. These shades offer protection from the mal-effects of direct sunlight and may even reduce its surrounding region by up to 10 °F. In terms of the door calculations from before, direct shading on the doors may decrease its environment temperature by 10 °F, ultimately resulting in an energy savings of more than 50 Btu per hour. On top of these windows, doors and shading structures, construction materials may also be manipulated to more efficiently construct this house.

An important consideration in the DesignBuilder modeling process was the material composition of the walls, roof, and floor. Each of these components has to be correctly modeled in order to accurately predict the heat losses through the material. For our energy analysis, we referred to the most recent documents provided by the architects showing the section views of each component. The material composition of each component would ultimately give us a thermal resistance which the energy analysis program used to calculate heat losses. Thermal resistance is the temperature difference across an object when a unit of heat energy flows through it in unit time. In our case, we were looking for the absolute maximum thermal resistance we could reasonably obtain. The optimization problem posed to the architects was to get the highest thermal resistance without making the walls too thick. In our case it was decided that the walls would be nine and five-eighths inches thick, the floor would be about eleven and three-eighths inches thick and the roof would be eleven and seven-eighths inches thick. These values are reasonable for a properly air-tight and insulated house.

One material that was considered for the roof, walls and floor was SIP panels. SIP stands for structurally insulated panels. These panels consist of three layers, two outside layers of oriented strand board with a thick layer of insulation foam between them. They come in various thicknesses based primarily on the thickness of foam in the center. The structural performance of the panels is

excellent and they can be used to span around twenty feet. These panels are also highly insulated. The twelve inch panels we explored had a thermal resistance value of just below forty ft2-°F-h/Btu. The major advantage of these panels were that they could be used for the walls the roof and floor giving our house a design unity. The entire house would be highly insulated and construction would be fairly simple. However, the major downfall of these panels was the inability to place components inside the walls. The manufacturer was willing to precut channels in the panels to run pipes however if any modifications were made after the walls were manufactured it would be hard to place things inside the walls. Things such as running a wire would be very difficult. As the team, the architects determined that the disadvantages outweighed the advantages for the SIP panels so an alternative wall composition was formulated.

The walls used in the house are the most important component when considering the heat losses for the house. They occupy the most surface area to the outside extreme temperatures therefore result in the biggest proportion of heat loss compared to the other two components. The walls are composed of six different elements. Starting from outside to inside the first material is a rain screen. The purpose of the rain screen is to provide proper drainage of water away from the interior of the house even if water gets behind the exterior surface. This section of the wall provides very little thermal resistance. The next layer used in the walls is three-quarter inch thick treated furring. This layer is the main moisture barrier for the house. Little moisture should pass through this section of the wall, and this layer does provide a small amount of thermal resistance. After the furring there is a layer of high density wood fiberboard. After the fiberboard comes one of the two main insulation layers. This layer is made of four inch rigid insulation board. This layer adds a lot of thickness to the wall however this material has the highest thermal resistance of the materials used in the wall. After the insulation comes the standard building wrap to provide another vapor barrier and is similar to the wrap required on all houses. After the building wrap is a layer of five-eighths inch oriented strand board (OSB). This material is used for rigidity and its structural properties. After the OSB comes the normal two by four wall frame, followed by five-eighths inch thick drywall. This portion of the wall will be used to run any electricity and pipes necessary for the house. Whatever space is leftover in the two by four frame wall will be filled with spray insulation to add more thermal resistance to the walls. With all of the wall components in place we have calculated that the thermal resistance value is 41.2 ft2-°F-h/Btu.

The roof composition is important because it receives a lot of direct sunlight on its flat surface making it thermally significant and it needs to be able to support the solar panel array placed on top of it making it structurally significant. The most outer layer exposed to the elements is a half inch Sure-White EPDM roof membrane. This layer is the main moisture barrier for the roof and provides minimal thermal resistance. The next layer of the roof is the main structural component. After the roof membrane is a ten inch tapered wooden truss system. The taper on the truss is a quarter inch rise

per linear foot. The taper is used to make sure rain properly drains off of the roof while still giving it the appearance of a flat roof and making it a good base for the solar panels. The triangular truss system provides low thermal resistance so the voids left by the truss are filled with spray insulation. This six inch layer of spay insulation is the main component in the roof providing thermal insulation. Below the truss system is another layer of five-eighths inch OSB. The OSB is followed by the inside finishing layer, five-eighths inch drywall. The last two layers provide a small amount of thermal insulation but are mainly used for ascetics. With all of the roof components in place we have calculated that the thermal resistance value is 37.21 ft2-°F-h/Btu.

The floor in the house is made of a four layer composite. The thermal properties of the floor are important because the entire house is raised on footings and air is allowed to travel under the house. This is important because whenever there is moving air there is heat transfer due to convection. The most outer layer of the floor is a three-quarters inch thick rigid insulation panel. This panel provides a good majority of the floors thermal insulation. The next layer in the floor is the same ten inch truss structure as the roof; however, the floor does not have a taper. This section of the floor does not currently have any spay insulation in it, but it is an option if in later analysis we find it is necessary. On top of the truss system is a five-eighths inch thick OSB board to hold the truss system together and complete the structure of the floor. This layer adds a small amount of thermal resistance to the floor. On top of the OSB is the flooring used in the house. This can either be carpet or tile depending on the need of the room. With all of the floor components in place we have calculated that the thermal resistance value is 40 ft2-°F-h/Btu. A full table of the materials used can be found in Table B2.

After considering each of these factors that go into designing an efficiently designed house, a simulation must be done to evaluate the effectiveness of the implementations. In order to do this, DesignBuilder, which is a state-of-the-art software tool for checking building energy, carbon, lighting and comfort performance, is used. This program allows its user to simplify the process of building simulation and is able to rapidly compare the function and performance of building designs. Furthermore, two design scenarios will be evaluated in DesignBuilder; one located centrally in Champaign, IL and the other located at the competition location in Washington DC. So as to clarify the breakdown of this report, the first half the energy analysis will be done with Champaign, IL as the reference location and the latter half of the energy analysis will be done with Washington DC as our design location.

Prior to running any simulations, the house must first be designed per specification, keeping into consideration each aforementioned energy efficient element for the analysis. These designs may be seen in Figures A4 – A7. After these designs have been rendered, several graphs may be produced to analyze the findings in their data. Pertinent to energy analysis, three graphs, relating time to heating and cooling, time to energy losses and gains and time to inside and outside air tempera-

tures, are investigated. Although the design competition is only during the last week of September in 2011, an energy analysis covering the entire month of September is performed to produce more accurate and relevant data.

As previously mentioned, in a completely ideal environment, no heat loss or gain would occur through a house's exterior glazing or façade construction – including the roof and walls. This, however, is not the case. As shown by Figure A8 and A9, time related to energy losses and gains is graphed for external infiltration and for solar gains through the exterior glazing. As shown by these graphs, a constant solar gain of 10 kBtu per day penetrates through the house's exterior windows. While not desired in the hotter months of the year, this penetration factor is ideal in the winter months. Energy seeps through the windows and doors of the house, providing an external source of heating to the house. This, however, is not desirable in the hotter months. During these hotter months, extra cooling must be provided to make up for this external heating. Figures A8 and A9 also show a variable degree of external infiltration into the house. This infiltration stems from conduction through the construction, windows and doors. As this value becomes greater, a larger degree of heat penetrates into the house. Similarly, to make up for this heat gain, additional cooling would be required to make up for this unnecessary permeation.

An important consideration when designing an HVAC system is the exterior air temperature. For our specific design we are mostly concerned with the temperature during the contest week in Washington DC. However we are also concerned with the conditions that the target user will experience in the Midwest, specifically Champaign, IL. By using exterior temperature data we can more accurately estimate the amount of heating and cooling needed during the contest week. In analyzing the data we found that the temperature distributions for Washington DC and Champaign are extremely similar. For the month of September both cities show the same high and low. Figure A10 shows a graph of the monthly temperature in Washington DC and the corresponding indoor temperature that falls within the heating and cooling contest of 71°F to 76 °F. A similar plot for Champaign can be seen in Figure A11. Some points to note on this figure are the high and low values of temperature for the month of September in both cities. It shows that the possible high for the month is 79°F and the possible low for the month is 52 °F.

These numbers are important because we want to make sure our system can properly perform even if the temperatures for the month are at the extremes. Figure A12 shows the amount of heating and cooling that would be required for the corresponding outdoor temperature to keep the house at the predefined temperatures in Washington DC. The corresponding plot for Champaign can be seen in Figure A13. As expected, the day that requires the most amount of cooling is the hottest day of the month. On this day about 140 kBtu of cooling is required with converts to about a half of ton of cooling. Our system is designed for about two tons of cooling, leaving a factor of safety of four. It may seem that we have overdesigned our system but these numbers are for steady

state heating and cooling. We will need additional capacity when our house needs to dramatically change temperature such as after an open house. On the most extreme cold day in September our house will need approximately 60 kBtu of heating. This translates to 0.2 tons of cooling giving us a factor of safety of 20.

Champaign, IL

Relating time to heating and cooling paints a picture of the total amount of energy used as a function of time. As shown by Figure A14, a significantly larger proportion of September requires cooling in lieu of heating due to the higher outdoor temperatures. In total, a monthly consumption of 495.4 kBtu in heating and 981.7 kBtu in cooling will be required in September.

In order to effectively analyze this energy usage, a detailed energy analysis must be done for both the heating and cooling modes in the house. As previously mentioned, 495.4 kBtu of energy is required to heat the house in September. After calculating the amount of heating used per hour in the month of September (0.69 kBtu/hr), this quantity correlates to a value of 0.057 tons of heating throughout September. Furthermore, 0.057 tons of heating is equal to 202 Watts of energy used on average each day in September. Finally, this wattage may be converted into an average amount of energy used in September, a nominal value of 145 kWh of energy. After calculating this value, a heating operating cost may be tabulated using an average cost of 10¢ per kWh. This results in an overall heating cost requirement of $14.50 in the month of September, after all factors considered. While heating is used during the month of September, a majority of the HVAC effort will be in cooling the house.

As previously mentioned, 981.7 kBtu of energy is required to cool the house in September. After calculating the amount of cooling used per hour in the month of September (1.4 kBtu/hr), this quantity correlates to a value of 0.11 tons of cooling throughout September. Furthermore, 0.11 tons of cooling is equal to 400 Watts of energy used on average each day in September. Finally, this wattage may be converted into an average amount of energy used in September, a nominal value of 288 kWh of energy. Similar to heating, a cooling operating cost may be tabulated using an average cost of 10¢ per kWh. This results in an overall cooling cost requirement of $28.76 in the month of September, after all factors considered. In terms of energy usage in the month of September, 432.78 kWh of energy will be used during the month of September, resulting in a total energy cost of $43.28.

While this aforementioned data provides pertinent information for the design week, ideally, this house will be implemented after the competition is over. Therefore, an energy analysis must be done to cover the scope of an entire year using this HVAC system. As similarly done with the preceding data, Figure A15 shows a display of the total amount of heating and cooling required yearly for this house design. As shown by this figure, 25,146.93 kBtu of heating and 8,082.49 kBtu of cooling is required throughout the year to stay within the specified temperature constraints of 71 to 76 °F. Adding these

two figures and following similar steps in calculating an operating cost, it may be determined that 9,736.22 kWh of energy will be used throughout the year, resulting in a yearly energy cost of $973.62, or $81.14 per month.

Washington DC

As shown by Figure A16, a significantly larger proportion of September requires cooling in lieu of heating due to the higher outdoor temperatures. In total, a monthly consumption of 307.3 kBtu in heating and 1147.5 kBtu in cooling will be required in the month of September. Although minimal, a small degree of heating may be required in the month of September to compensate for any potentially cooler days towards the end of the month.

In order to effectively analyze this energy usage, a detailed energy analysis must be done for both the heating and cooling modes in the house. As previously mentioned, 307.3 kBtu of energy is required to heat the house in September. After calculating the amount of heating used per hour in the month of September (0.43 kBtu/hr), this quantity correlates to a value of 0.036 tons of heating throughout September. Furthermore, 0.036 tons of heating is equal to 125 Watts of energy used on average each day in September. Finally, this wattage may be converted into an average amount of energy used in September, a nominal value of 90 kWh of energy. After calculating this value, a heating operating cost may be tabulated using an average cost of 10¢ per kWh. This results in an overall heating cost requirement of $9.00 in the month of September, after all factors considered. While heating is used during the month of September, a majority of the HVAC effort will be in cooling the house.

As previously mentioned, 1147.5 kBtu of energy is required to cool the house in September. After calculating the amount of cooling used per hour in the month of September (1.6 kBtu/hr), this quantity correlates to a value of 0.13 tons of cooling throughout September. Furthermore, 0.13 tons of cooling is equal to 467 Watts of energy used on average each day in September. Finally, this wattage may be converted into an average amount of energy used in September, a nominal value of 336 kWh of energy. Similar to heating, a cooling operating cost may be tabulated using an average cost of 10¢ per kWh. This results in an overall cooling cost requirement of $33.62 in the month of September, after all factors considered. In terms of energy usage in the month of September, 426.24 kWh of energy will be used during the month of September, resulting in a total energy cost of $42.62.

As similarly done with the preceding data, Figure A17 shows a display of the total amount of heating and cooling required yearly for this house design. As shown by this figure, 18,383.58 kBtu of heating and 10,188.42 kBtu of cooling is required throughout the year to stay within the specified temperature constraints of 71 to 76 °F. Adding these two figures and following similar steps in cal-

culating an operating cost, it may be determined that 8,371.6 kWh of energy will be used throughout the year, resulting in a yearly energy cost of $837.16, or $69.76 per month.

References

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Energy Analysis Appendix A (Figures):

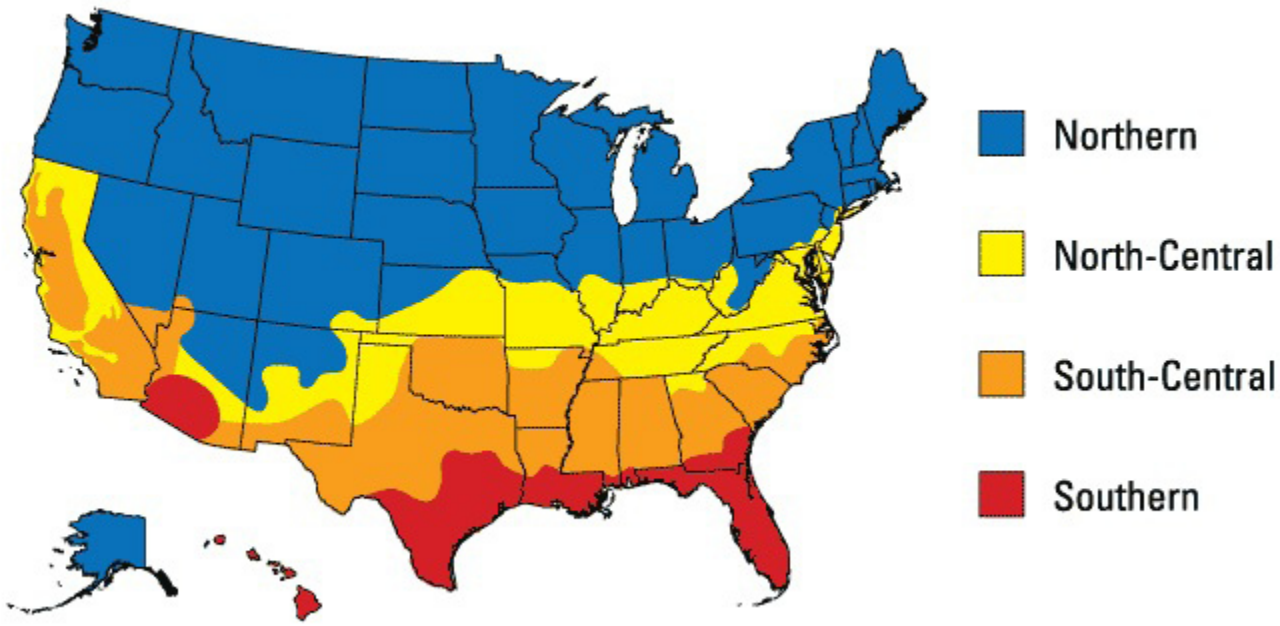


Figure A1: Energy Star Climate Zone Map

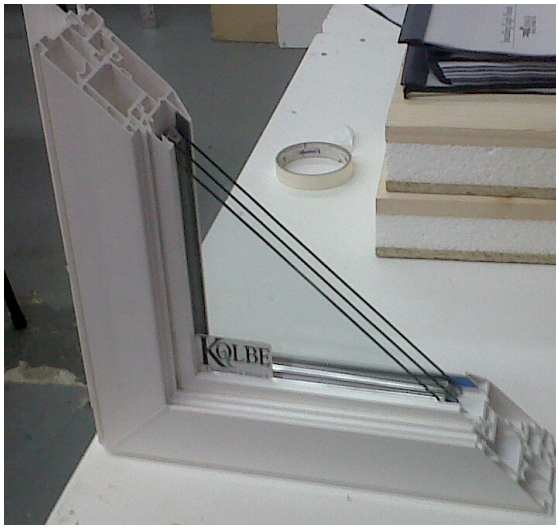


Figure A2: Low E, Argon Filled, Triple Pane Window

Figure A3: Low E, Double Pane Doors with Integral Blind

Figure A4: Shading devices along South facade

Figure A5: Shading devices on East facade

Figure A6: Shading devices along West facade

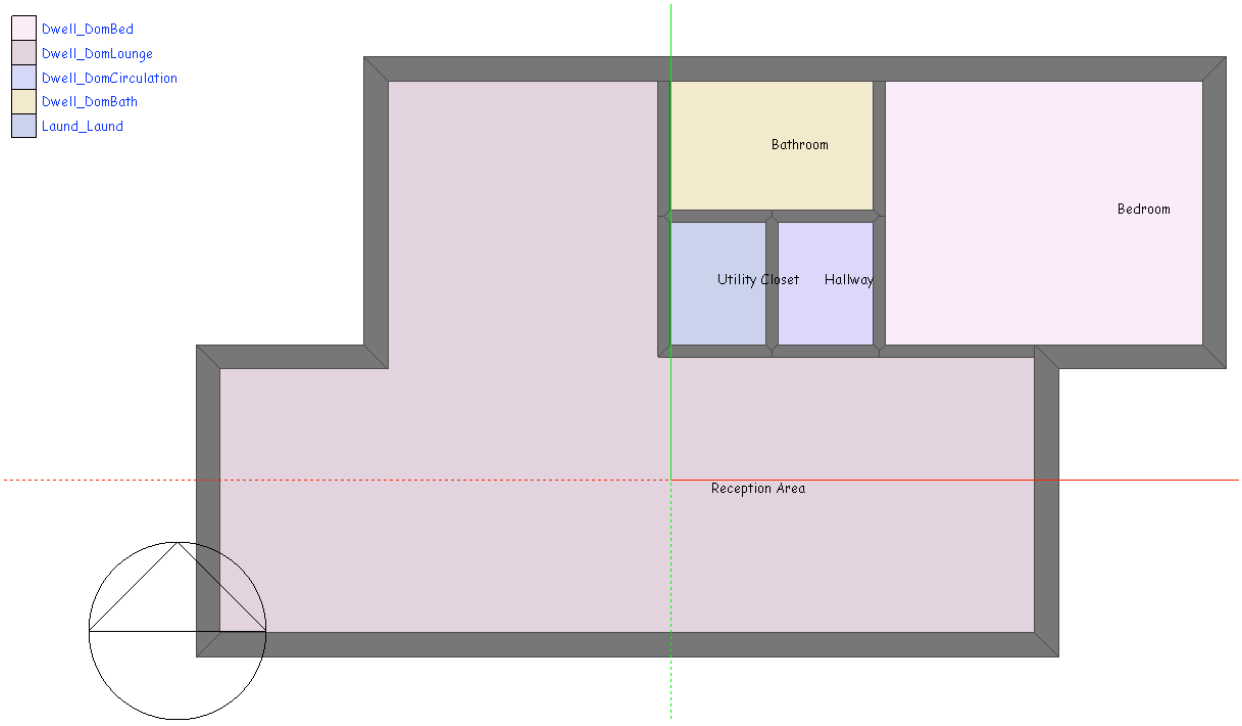


Figure A7: Zoned Floor Plan From Design Builder Energy Modeler

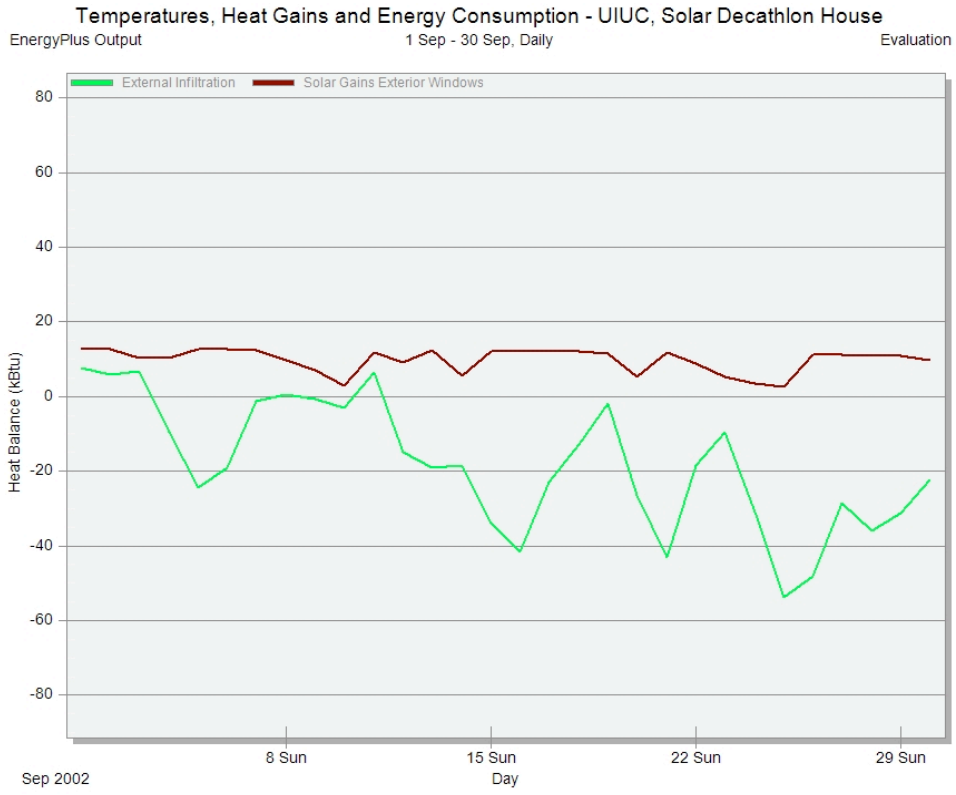


Figure A8: Daily (September) Energy Losses and Gains in Champaign, IL

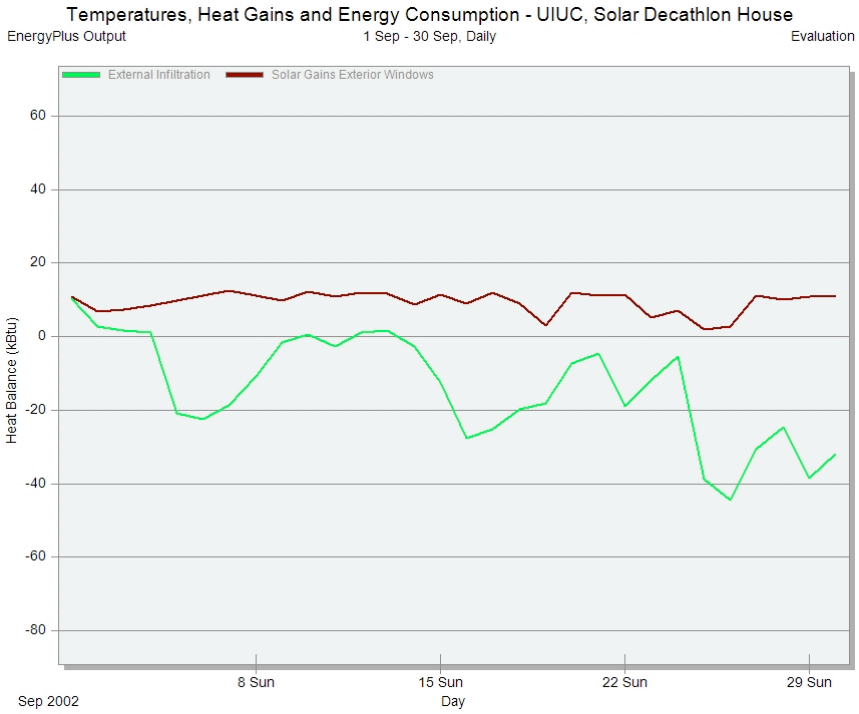


Figure A9: Daily (September) Energy Losses and Gains in Washington DC

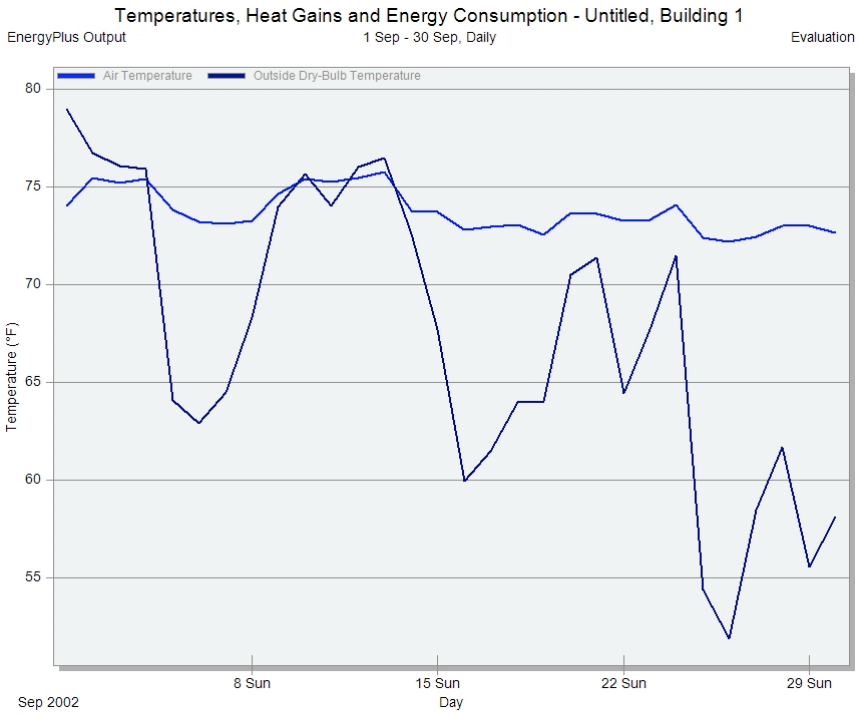


Figure A10: Daily (September) Temperatures in Washington DC

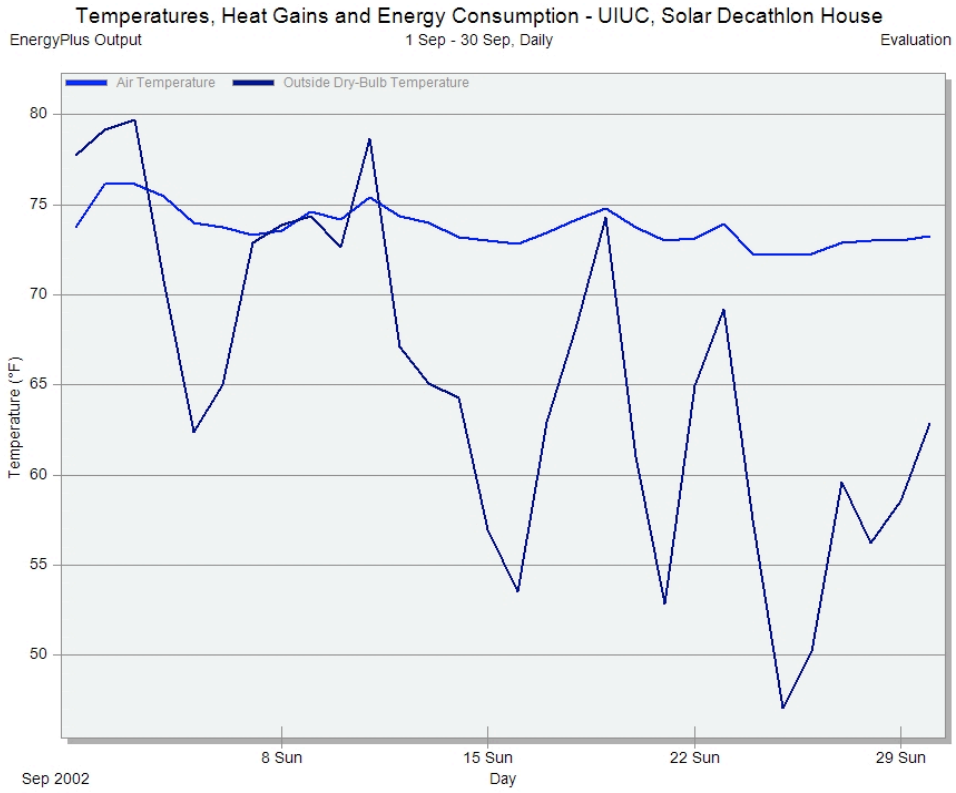


Figure A11: Daily (September) Temperatures in Champaign, IL

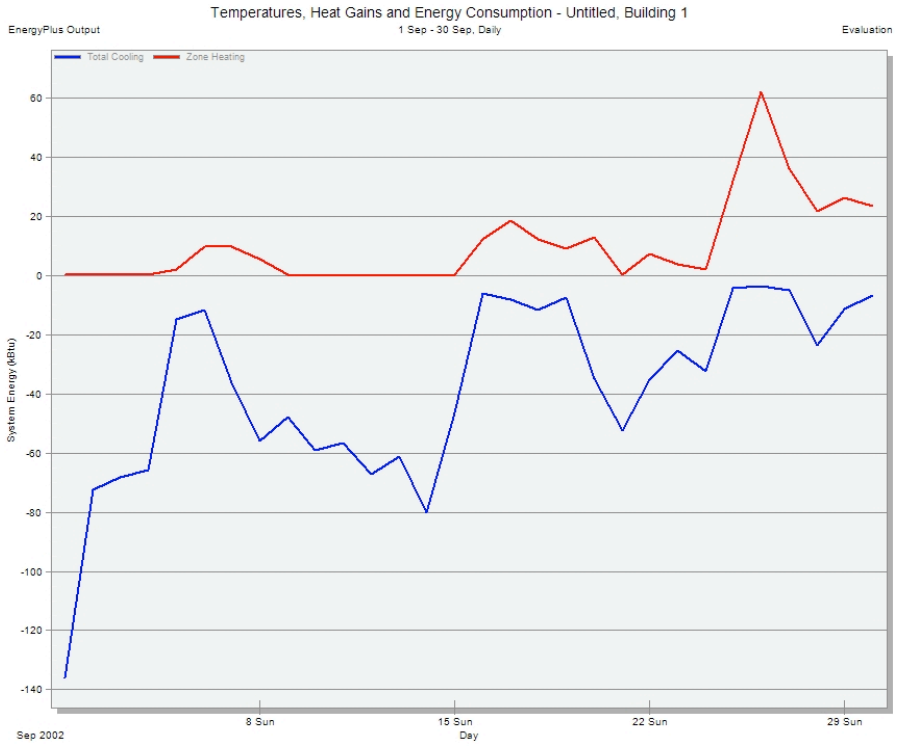


Figure A12: Daily (September) Heating and Cooling in Washington DC

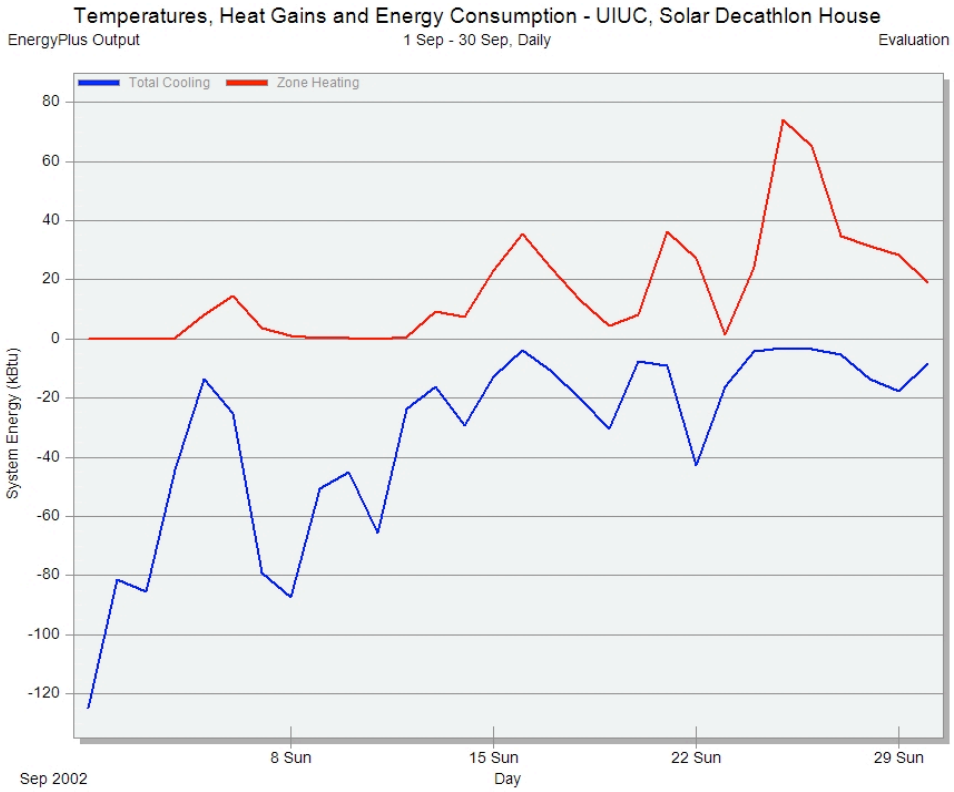


Figure A13: Daily (September) Heating and Cooling in Champaign, IL

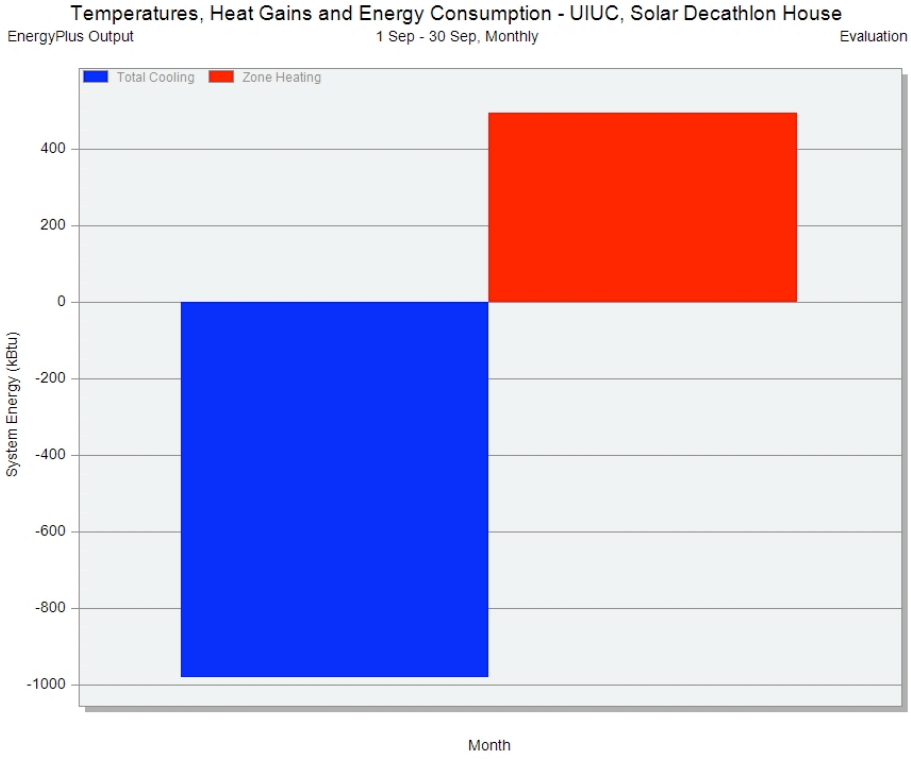


Figure A14: Monthly (September) Heating and Cooling in Champaign, IL

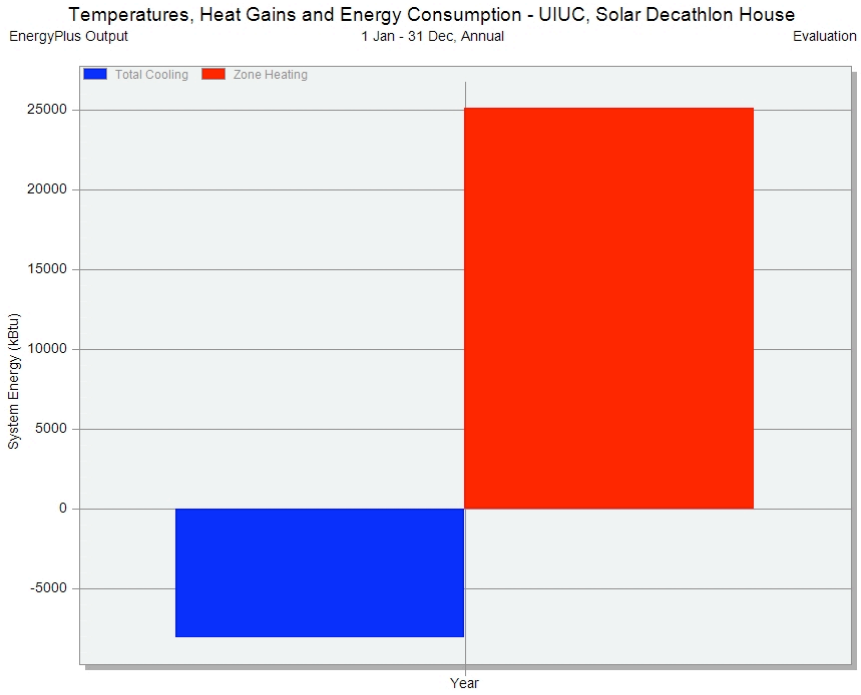


Figure A15: Yearly (September) Heating and Cooling in Champaign, IL

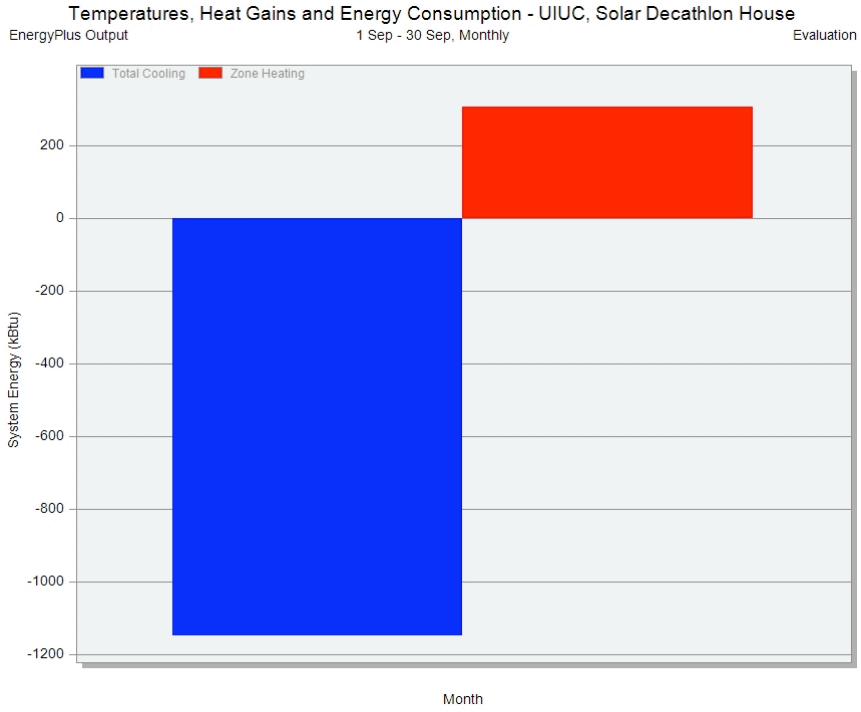


Figure A15: Yearly (September) Heating and Cooling in Champaign, IL

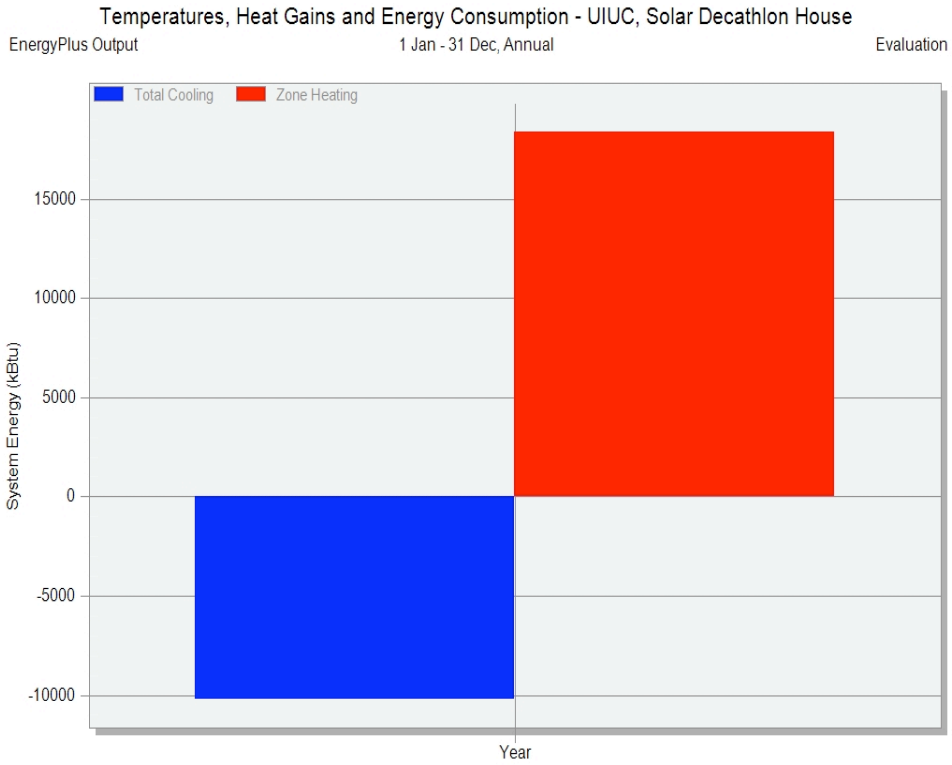


Figure A17: Yearly (September) Heating and Cooling in Washington DC

Energy Analysis Appendix B (Figures):

Windows & Doors

Climate Zone	U-Factor [1]	SHGC [2]	
Northern	≤ 0.35	Any	
North/Central	≤ 0.40	≤ 0.55	
South/Central	≤ 0.40	≤ 0.40	Prescriptive
	≤ 0.41	≤ 0.36	Equivalent Performance *(Excluding CA)*
	≤ 0.42	≤ 0.31	
	≤ 0.43	≤ 0.24	
Southern	≤ 0.65	≤ 0.40	Prescriptive
	≤ 0.66	≤ 0.39	Equivalent Performance
	≤ 0.67		
	≤ 0.68	≤ 0.38	
	≤ 0.69	≤ 0.37	
	≤ 0.70		
	≤ 0.71	≤ 0.36	
	≤ 0.72	≤ 0.35	
	≤ 0.73		
	≤ 0.74	≤ 0.34	
	≤ 0.75	≤ 0.33	

Skylights

Climate Zone	U-Factor [1] 2001 NFRC rated at 20° [3]	U-Factor [1] RES97 rated at 90° [4]	SHGC [2]
Northern	≤ 0.60	≤ 0.45	Any
North/Central	≤ 0.60	≤ 0.45	≤ 0.40
South/Central	≤ 0.60	≤ 0.45	≤ 0.40
Southern	≤ 0.75	≤ 0.75	≤ 0.40

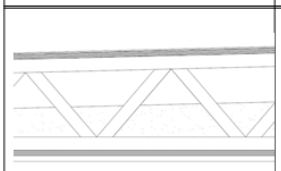
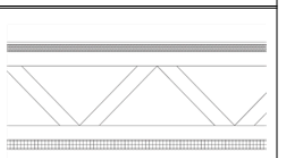
[1] *Btu/h.ft².°F*

[2] *Fraction of incident solar radiation.*

[3] *U-Factor qualification criteria based on 2001 NFRC simulation and certification procedures that rate skylights at a 20-degree angle. Although reported U-Factor is higher than RES97 rated products, energy performance at the ENERGY STAR minimum qualifying level is equivalent.*

[4] *NFRC certification using the 1997 NFRC procedures for residential windows (RES 97) that rated skylights at a 90-degree angle. Skylights rated under this procedure may be present in the marketplace until March 31, 2008. NFRC labels for products using this procedure state: "RES97 rated at 90 degrees."*

Table B1: Energy Star Qualification Criteria

	Roof	Floor
		
Layers Top	Roof Membrane	Flooring Material (Tile Carpet etc.)
	5/8" Oriented Strand Board (OSB)	5/8" Oriented Strand Board (OSB)
	10" Wooden Truss	10" Wooden Truss
Bottom	6" Spray Insulation	3/4" Rigid Insulation
	5/8" Oriented Strand Board (OSB)	
	5/8" Drywall	
R Value	37.21	40

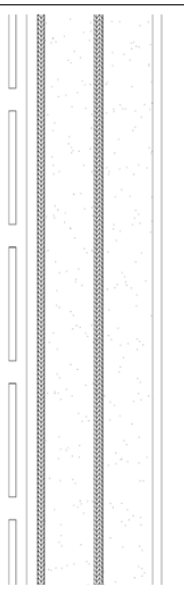
	Walls	
		
	Rainscreen Cladding	
	3/4" Treated Furring	
Outside	5/8" Oriented Strand Board (OSB)	Layers
	4" Rigid Insulation Board	
Inside	5/8" Oriented Strand Board (OSB)	
	3" Spray Foam	
	5/8" Drywall	
	41.2	R Value

Table B2: Construction Specifications

Re_home

University of Illinois at Urbana-Champaign

Construction Specifications

As Built Document Submittal
August 11, 2011

Division 1: General

SECTION 01 25 00
Substitution Requirements and Procedures

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Product Substitution Procedures.

1.2 GENERAL

A. Definition: Proposal by Subcontractor to use manufacturer, product, material, or system different from one required in Contract Documents.

B. Do not substitute Products unless a substitution request has been approved by Design/Builder.

C. In case of non-availability of a specified Product notify Design/Builder in writing as soon as non-availability becomes apparent.

1.3 SUBSTITUTION QUALIFICATIONS

A. All materials to be selected for substitution must meet or exceed the material qualities represented in the original project documents.

B. Solar Decathlon team may make substitutions to the written documents where required for cost considerations and fabrication times.

END OF SECTION

SECTION 01 30 00
Administrative Requirements

PART 1 GENERAL

1.1 SUMMARY

A. Coordinate Construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work.

B. Requests for Information (RFI's): On discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI. Use AIA Document G716-2004.

C. Schedule and conduct progress meetings at Project site at weekly intervals.Notify Owner andArchitect of meeting dates and times. Require attendance of each subcontractor or otherentity concerned with current progress or involved in planning, coordination, or performance of future activities.

1. Architect will record minutes and distribute to everyone concerned, including Owner and Architect.

1.2 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.

1. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
2. Submit three copies of each action submittal. Architect will return two copies.
3. Submit two copies of each informational submittal. Architect will not return copies.
4. Architect will return submittals, without review received from sources other than Contractor.

B. Place a permanent label or title block on each submittal for identification. Provide a

space approximately 6 by 8 inches on label or beside title block to record Contractor's review and
approval markings and action taken by Architect. Include the following information on the label:

1. Project name.
2. Date.
3. Name and address of Contractor.
4. Name and address of subcontractor or supplier.
5. Number and title of appropriate Specification Section.

C. Identify deviations from the Contract Documents on submittals.

D. Contractor's Construction Schedule Submittal Procedure: Submit two copies of schedule within 5 days after date established for Commencement of the Work.

PART 2 PRODUCTS

2.1 Action Submittals

A. Product Data: Mark each copy to show applicable products and options. Include the following:

1. Manufacturer's written recommendations, product specifications, and installation instructions.
2. Wiring diagrams showing factory installed wiring.
3. Printed performance curves and operational range diagrams.
4. Testing by recognized testing agency.
5. Compliance with specified standards and requirements.

B. Shop Drawings: Prepare Project specific information, drawn accurately to scale. Do not base
Shop Drawings on reproductions of the Contract Documents or standard printed data. Submit on sheets at least 8 1/2 by 11 inches but no larger than 30 by 42 inches. Include the

following:

1. Dimensions and identification of products.
2. Fabrication and installation drawings and roughing in and setting diagrams.
3. Wiring diagrams showing field installed wiring.
4. Notation of coordination requirements.
5. Notation of dimensions established by field measurement.

C. Samples: Submit Samples for review of kind, color, pattern, and texture and for a comparison
of these characteristics between submittal and actual component as delivered and installed. Include name of manufacturer and product name on label.

1. If variation is inherent in material or product, submit at least three sets of paired units that show variations.

2.2 INFORMATIONAL SUBMITTALS

A. Qualification Data: Include lists of completed projects with project names and addresses names and addresses of architects and owners, and other information specified.

B. Product Certificates: Prepare written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

2.3 DELEGATED DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.

B. Delegated Design Submittal: In addition to Shop Drawings, Product Data, and other required submittals, submit three copies of a statement, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

2.4 CONTRACTOR'S CONSTRUCTION SCHEDULE

A. Gantt Chart Schedule: Submit a comprehensive, fully developed, horizontal Gantt chart type
schedule within 30 days of date established for commencement of the Work.

B. Preparation: Indicate each significant construction activity separately. Identify first workday of each week with a continuous vertical line.

END OF SECTION

SECTION 01 42 00
References

Part 1 GENERAL

1.1 GENRAL REQUIREMENTS

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. Abbreviations and Acronyms: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. Names, telephone numbers, and Web site addresses are subject to change and are believed to be accurate and up to date as of the date of the Contract Documents.

AA Aluminum Association, Inc. (The)
AAADM American Association of Automatic Door Manufacturers
AABC Associated Air Balance Council
AAMA American Architectural Manufacturers Association
AASHTO American Association of State Highway and Transportation Officials
AATCC American Association of Textile Chemists and Colorists
ABAA Air Barrier Association of America
ABMA American Bearing Manufacturers Association
ACI American Concrete Institute
ACPA American Concrete Pipe Association
AEIC Association of Edison Illuminating Companies, Inc. (The)
AF&PA American Forest & Paper Association
AGA American Gas Association
AGC Associated General Contractors of America (The)
AHA American Hardboard Association
(Now part of CPA)
AHAM Association of Home Appliance Manufacturers
AI Asphalt Institute
AIA American Institute of Architects (The)

AISC American Institute of Steel Construction
AISI American Iron and Steel Institute
AITC American Institute of Timber Construction
ALCA Associated Landscape Contractors of America
(Now PLANET Professional Landcare Network)
ALSC American Lumber Standard Committee, Incorporated
AMCA Air Movement and Control Association International, Inc.
ANSI American National Standards Institute
AOSA Association of Official Seed Analysts, Inc.
APA Architectural Precast Association
APA APA The Engineered Wood Association
APA EWS APA The Engineered Wood Association; Engineered Wood Systems
(See APA The Engineered Wood Association)
API American Petroleum Institute
ARI Air Conditioning & Refrigeration Institute
ARMA Asphalt Roofing Manufacturers Association
ASCE American Society of Civil Engineers
ASCE/SEI American Society of Civil Engineers/Structural Engineering Institute
(See ASCE)
ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME ASME International
(American Society of Mechanical Engineers International)
ASSE American Society of Sanitary Engineering
ASTM ASTM International
(American Society for Testing and Materials International)
AWCI Association of the Wall and Ceiling Industry
AWCMA American Window Covering Manufacturers Association
(Now WCMA)
AWI Architectural Woodwork Institute
AWPA American Wood Protection Association
(Formerly: American Wood Preservers' Association)
AWS American Welding Society
AWWA American Water Works Association
BHMA Builders Hardware Manufacturers Association
BIA Brick Industry Association (The)

BICSI BICSI, Inc.
BIFMA BIFMA International
(Business and Institutional Furniture Manufacturer's Association International)
BISSC Baking Industry Sanitation Standards Committee
BWF Badminton World Federation
(Formerly: IBF International Badminton Federation)
CCC Carpet Cushion Council
CDA Copper Development Association
CEA Canadian Electricity Association
CEA Consumer Electronics Association
CFFA Chemical Fabrics & Film Association, Inc.
CGA Compressed Gas Association
CIMA Cellulose Insulation Manufacturers Association
CISCA Ceilings & Interior Systems Construction Association
CISPI Cast Iron Soil Pipe Institute
CLFMI Chain Link Fence Manufacturers Institute
CRRC Cool Roof Rating Council
CPA Composite Panel Association
CPPA Corrugated Polyethylene Pipe Association
CRI Carpet and Rug Institute (The)
CRSI Concrete Reinforcing Steel Institute
CSA Canadian Standards Association
CSA CSA International
(Formerly: IAS International Approval Services)
CSI Cast Stone Institute
CSI Construction Specifications Institute (The)
CSSB Cedar Shake & Shingle Bureau
CTI Cooling Technology Institute
(Formerly: Cooling Tower Institute)
DHI Door and Hardware Institute
EIA Electronic Industries Alliance
EIMA EIFS Industry Members Association
EJCDC Engineers Joint Contract Documents Committee
EJMA Expansion Joint Manufacturers Association, Inc.
ESD ESD Association

(Electrostatic Discharge Association)
ETL SEMCO Intertek ETL SEMCO
(Formerly: ITS Intertek Testing Service NA)
FIBA Federation Internationale de Basketball
(The International Basketball Federation)
FIVB Federation Internationale de Volleyball
(The International Volleyball Federation)
FM Approvals FM Approvals LLC
FM Global FM Global
(Formerly: FMG FM Global)
FMRC Factory Mutual Research
(Now FM Global)
FRSA Florida Roofing, Sheet Metal & Air Conditioning Contractors Association, Inc.
FSA Fluid Sealing Association
FSC Forest Stewardship Council
GA Gypsum Association
GANA Glass Association of North America
GRI (Part of GSI)
GS Green Seal
GSI Geosynthetic Institute
HI Hydraulic Institute
HI Hydronics Institute
HMMA Hollow Metal Manufacturers Association
(Part of NAAMM)
HPVA Hardwood Plywood & Veneer Association
HPW H. P. White Laboratory, Inc.
IAS International Approval Services
(Now CSA International)
IBF International Badminton Federation
(Now BWF)
ICEA Insulated Cable Engineers Association, Inc.
ICRI International Concrete Repair Institute, Inc.
IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronics Engineers, Inc. (The)
IESNA Illuminating Engineering Society of North America

IEST Institute of Environmental Sciences and Technology
IGCC Insulating Glass Certification Council
IGMA Insulating Glass Manufacturers Alliance
ILI Indiana Limestone Institute of America, Inc.
ISO International Organization for Standardization
Available from ANSI
ISSFA International Solid Surface Fabricators Association
ITS Intertek Testing Service NA
(Now ETL SEMCO)
ITU International Telecommunication Union
KCMA Kitchen Cabinet Manufacturers Association
LMA Laminating Materials Association
(Now part of CPA)
LPI Lightning Protection Institute
MBMA Metal Building Manufacturers Association
MFMA Maple Flooring Manufacturers Association, Inc.
MFMA Metal Framing Manufacturers Association, Inc.
MH Material Handling
(Now MHIA)
MHIA Material Handling Industry of America
MIA Marble Institute of America
MPI Master Painters Institute
MSS Manufacturers Standardization Society of The Valve and Fittings Industry Inc.
NAAMM National Association of Architectural Metal Manufacturers
NACE NACE International
(National Association of Corrosion Engineers International)
NADCA National Air Duct Cleaners Association
NAGWS National Association for Girls and Women in Sport
NAIMA North American Insulation Manufacturers Association
NBGQA National Building Granite Quarries Association, Inc.
NCAA National Collegiate Athletic Association (The)
NCMA National Concrete Masonry Association
NCPI National Clay Pipe Institute
NCTA National Cable & Telecommunications Association
NEBB National Environmental Balancing Bureau

NECA National Electrical Contractors Association
NeLMA Northeastern Lumber Manufacturers' Association
NEMA National Electrical Manufacturers Association
NETA InterNational Electrical Testing Association
NFHS National Federation of State High School Associations
NFPA NFPA
(National Fire Protection Association)
NFRC National Fenestration Rating Council
NGA National Glass Association
NHLA National Hardwood Lumber Association
NLGA National Lumber Grades Authority
NOFMA NOFMA: The Wood Flooring Manufacturers Association
(Formerly: National Oak Flooring Manufacturers Association)
NOMMA National Ornamental & Miscellaneous Metals Association
NRCA National Roofing Contractors Association
NRMCA National Ready Mixed Concrete Association
NSF NSF International
(National Sanitation Foundation International)
NSSGA National Stone, Sand & Gravel Association
NTMA National Terrazzo & Mosaic Association, Inc. (The)
NTRMA National Tile Roofing Manufacturers Association
(Now TRI)
NWWDA National Wood Window and Door Association
(Now WDMA)
OPL Omega Point Laboratories, Inc.
(Now ITS)
PCI Precast/Prestressed Concrete Institute
PDCA Painting & Decorating Contractors of America
PDI Plumbing & Drainage Institute
PGI PVC Geomembrane Institute
PLANET Professional Landcare Network
(Formerly: ACLA Associated Landscape Contractors of America)
PTI Post Tensioning Institute
RCSC Research Council on Structural Connections
RFCI Resilient Floor Covering Institute

RIS Redwood Inspection Service
SAE SAE International
SDI Steel Deck Institute
SDI Steel Door Institute
SEFA Scientific Equipment and Furniture Association
SEI/ASCE Structural Engineering Institute/American Society of Civil Engineers
(See ASCE)
SGCC Safety Glazing Certification Council
SIA Security Industry Association
SIGMA Sealed Insulating Glass Manufacturers Association
(Now IGMA)
SJI Steel Joist Institute
SMA Screen Manufacturers Association
SMACNA Sheet Metal and Air Conditioning Contractors'
National Association
SMPTE Society of Motion Picture and Television Engineers
SPFA Spray Polyurethane Foam Alliance
(Formerly: SPI/SPFD The Society of the Plastics Industry, Inc.; Spray Polyurethane
Foam Division)
SPIB Southern Pine Inspection Bureau (The)
SPRI Single Ply Roofing Industry
SSINA Specialty Steel Industry of North America
SSPC SSPC: The Society for Protective Coatings
STI Steel Tank Institute
SWI Steel Window Institute
SWRI Sealant, Waterproofing, & Restoration Institute
TCA Tile Council of America, Inc.
(Now TCNA)
TCNA Tile Council of North America, Inc.
TIA/EIA Telecommunications Industry Association/Electronic Industries Alliance
TMS The Masonry Society
TPI Truss Plate Institute, Inc.
TPI Turfgrass Producers International
TRI Tile Roofing Institute
UL Underwriters Laboratories Inc.

UNI Uni Bell PVC Pipe Association
USAV USA Volleyball
USGBC U.S. Green Building Council
USITT United States Institute for Theatre Technology, Inc.
WASTEC Waste Equipment Technology Association
WCLIB West Coast Lumber Inspection Bureau
WCMA Window Covering Manufacturers Association
WCSC Window Covering Safety Council
(Formerly: WCMA Window Covering Manufacturers Association)
WDMA Window & Door Manufacturers Association
(Formerly: NWWDA National Wood Window and Door Association)
WI Woodwork Institute (Formerly: WIC Woodwork Institute of California)
WIC Woodwork Institute of California
(Now WI)
WMMPA Wood Moulding & Millwork Producers Association
WSRCA Western States Roofing Contractors Association
WWPA Western Wood Products Association

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 5113
TEMPORARY ELECTRICITY

PART 1 GENERAL

1.1 SUMMARY

A Section Includes:
1. Diesel Generator

2 PRODUCTS

2.1 MATERIALS

A Generator: Gas 20KW Generator, 57db @ 47ft Noise Rating
1 Available Products:
a Multiquip DCA25SSI
i Manufacturers Specifications (http://www.multiquip.com/multiquip/DCA25SSI.htm#no-jump)

3 EXECUTION

3.1 TEMPORARY ELECTRICITY INSTALLATION AND REMOVAL

A Arrange with utility company, Owner, and existing users for a time when service can be interrupted, if necessary, to complete temporary electricity installation.

B Arrange with utility company, Owner, and existing uses for a time when service can be interrupted, if necessary, to complete temporary electricity removal.

END OF SECTION

SECTION 01 5419
TEMPORARY CRANES

PART 1 GENERAL

1.1 SUMMARY

A Section Includes:
1 Crane

2 PRODUCTS

2.1 MATERIALS

A Crane: 70 ton, 65’

Note: Project team is currently in discussion with modular home manufacturer, Homeway Homes, from Deer Creek Illinois about a crane selection to be used in Washington D.C. Full crane specification will be supplied to NREL in the coming weeks.

3 EXECUTION

3.1 TEMPORARY CRANE INSTALLATION AND REMOVAL

A Crane is to be provided and operated by modular home manufacturer or licensed professional.

END OF SECTION

SECTION 01 60 00
Product Requirement

Part 1 GENERAL

1.1 SECTION REQUIREMENTS

A. The term “product” includes the terms “material,” “equipment,” “system,” and terms of similar intent.

B. Comparable Product Requests:

1. Submit request for consideration of each comparable product. Do not submit unapproved products on Shop Drawings or other submittals.
2. Identify product to be replaced and show compliance with requirements for comparable
product requests. Include a detailed comparison of significant qualities of proposed substitution with those of the Work specified.
3. Architect will review the proposed product and notify Contractor of its acceptance or rejection.

C. Basis of Design Product Specification Submittal: Show compliance with requirements.

D. Compatibility of Options: If Contractor is given option of selecting between two or more
products, select product compatible with products previously selected.

E. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft. Comply with manufacturer’s written instructions.

1. Schedule delivery to minimize long term storage at Project site and to prevent overcrowding of construction spaces.
2. Deliver products to Project site in manufacturer’s original sealed container or packaging, complete with labels and instructions for handling, storing, unpacking, protecting,

and installing.
3. Inspect products on delivery to ensure compliance with the Contract Documents and to ensure that products are undamaged and properly protected.
4. Store materials in a manner that will not endanger Project structure.
5. Store products that are subject to damage by the elements, under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.

F. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of the Contract Documents.

PART 2 PRODUCTS

2.1 PRODUCT SELECTION PROCEDURES

A. Provide products that comply with the Contract Documents, are undamaged, and are new at the time of installation.

1. Provide products complete with accessories, trim, finish, and other devices and components needed for a complete installation and the intended use and effect.
2. Descriptive, performance, and reference standard requirements in the Specifications establish salient characteristics of products.

B. Product Selection Procedures:

1. Where Specifications name a single manufacturer and product, provide the named product that complies with requirements.
2. Where Specifications name a single manufacturer or source, provide a product by the named manufacturer or source that complies with requirements.
3. Where Specifications include a list of names of both manufacturers and products, provide one of the products listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will be considered.
4. Where Specifications include a list of names of both available manufacturers and

products, provide one of the products listed, or an unnamed product, that complies with requirements. Comply with requirements for "comparable product requests" for consideration of an unnamed product.

5. Where Specifications include a list of manufacturers' names, provide a product by one of the manufacturers listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will be considered.

6. Where Specifications include a list of available manufacturers, provide a product by one of the manufacturers listed, or a product by an unnamed manufacturer, that complies with requirements. Comply with requirements for "comparable product requests" for consideration of an unnamed manufacturer's product.

7. Where Specifications name a single product, or refer to a product indicated on Drawings, as the "basis of design," provide the named product. Comply with provisions for "comparable product requests" for consideration of an unnamed product by another manufacturer.

C. Where Specifications require "match Architect's sample," provide a product that complies with requirements and matches Architect's sample. Architect's decision will be final on whether a proposed product matches.

D. Unless otherwise indicated, Architect will select color, gloss, pattern, density, or texture from manufacturer's product line that includes both standard and premium items.

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 70 00
Execution and Closeout Requirements

Part 1 GENERAL

1.1 CLOSEOUT SUBMITTALS

A. Record Drawings: Maintain a set of prints of the Contract Drawings as record Drawings. Mark
to show actual installation where installation varies from that shown originally.

1. Identify and date each record Drawing; include the designation “PROJECT RECORD DRAWING” in a prominent location.

B. Operation and Maintenance Data: Submit one copy of manual. Organize data into three ring
binders with identification on front and spine of each binder, and envelopes for folded drawings. Include the following:

1. Manufacturer’s operation and maintenance documentation.
2. Maintenance and service schedules.
3. Maintenance service contracts.
4. Emergency instructions.
5. Spare parts list.
6. Wiring diagrams.
7. Copies of warranties.

1.2 CLOSEOUT PROCEDURES

A. Substantial Completion: Before requesting Substantial Completion inspection, complete the
following:

1. Prepare a list of items to be completed and corrected (punch list), the value of items on

the list, and reasons why the Work is not complete.
2. Advise Owner of pending insurance changeover requirements.
3. Submit specific warranties, maintenance service agreements, and similar documents.
4. Obtain and submit releases permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
5. Submit record Drawings and Specifications, operation and maintenance manuals, and similar final record information.
6. Deliver tools, spare parts, extra materials, and similar items.
7. Make final changeover of permanent locks and deliver keys to Owner.
8. Complete startup testing of systems.
9. Remove temporary facilities and controls.
10. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.
11. Complete final cleaning requirements, including touchup painting.
12. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.

B. Submit a written request for inspection for Substantial Completion. On receipt of request, Architect will proceed with inspection or advise Contractor of unfulfilled requirements. Architect will prepare the Certificate of Substantial Completion after inspection or will advise Contractor of items that must be completed or corrected before certificate will be issued.

C. Request inspection for Final Completion, once the following are complete:

1. Submit a copy of Substantial Completion inspection list stating that each item has been completed or otherwise resolved for acceptance.
2. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems.

D. Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

E. Submit a written request for final inspection for acceptance. On receipt of request, Architect

will proceed with inspection or advise Contractor of unfulfilled requirements. Architect will prepare final Certificate for Payment after inspection or will advise Contractor of items that must be completed or corrected before certificate will be issued.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Verify compatibility with and suitability of substrates.
2. Examine roughing in for mechanical and electrical systems.
3. Examine walls, floors, and roofs for suitable conditions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Take field measurements as required to fit the Work properly. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication.

D. Verify space requirements and dimensions of items shown diagrammatically on Drawings.

3.2 CONSTRUCTION LAYOUT AND FIELD ENGINEERING

A. Before proceeding to lay out the Work, verify layout information shown on Drawings, in relation to the property survey and existing benchmarks.

B. Engage a professional engineer to lay out the Work using accepted surveying practices.

C. Engage a land surveyor prepare a final property survey showing significant features (real property) for Project.

1. At Substantial Completion, have the final property survey recorded by or with authorities having jurisdiction as the official “property survey.”

3.3 INSTALLATION

A. Locate the Work and components of the Work accurately, in correct alignment and elevation,
as indicated. Make vertical work plumb and make horizontal work level.

1. Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections to form hairline joints.
2. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.
3. Maintain minimum headroom clearance of 96 inches in occupied spaces and 90 inches in unoccupied spaces.

B. Comply with manufacturer’s written instructions and recommendations.

C. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

D. Use products, cleaners, and installation materials that are not considered hazardous.

E. Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place. Obtain and distribute to the parties involved templates for work specified to be factory prepared and field installed.

3.4 CUTTING AND PATCHING

A. Provide temporary support of work to be cut. Do not cut structural members or operational elements without prior written approval of Architect.

B. Where existing services/systems are required to be removed, relocated, or aban-

doned, bypass such services/systems before cutting to minimize interruption to occupied areas.

C. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified in other Sections.

1. Restore exposed finishes of patched areas and extend finish restoration into adjoining construction in a manner that will minimize evidence of patching and refinishing.
2. Where patching occurs in a painted surface, prepare substrate and apply primer and intermediate paint coats appropriate for substrate over the patch, and apply final paint coat over entire unbroken surface containing the patch. Provide additional coats until patch blends with adjacent surfaces.

3.5 CLEANING

A. Clean Project site and work areas daily, including common areas. Dispose of materials lawfully.

1. Remove liquid spills promptly.
2. Where dust would impair proper execution of the Work, broom clean or vacuum the entire work area, as appropriate.
3. Remove debris from concealed spaces before enclosing the space.

B. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion:

1. Remove labels that are not permanent.
2. Clean transparent materials, including mirrors. Remove excess glazing compounds. Replace chipped or broken glass.
3. Clean exposed finishes to a dust free condition, free of stains, films, and foreign substances. Sweep concrete floors broom clean.
4. Vacuum carpeted surfaces and wax resilient flooring.
5. Wipe surfaces of mechanical and electrical equipment. Remove excess lubrication. Clean plumbing fixtures. Clean light fixtures, lamps, globes, and reflectors.
6. Clean Project site, yard, and grounds, in areas disturbed by construction activities.

Sweep paved areas; remove stains, spills, and foreign deposits. Rake grounds to a smooth, even textured surface.

3.6 DEMONSTRATION AND TRAINING

A. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system. Include a detailed review of the following:

1. Include instruction for basis of system design and operational requirements, review of documentation, emergency procedures, operations, adjustments, troubleshooting, maintenance, and repairs.

END OF SECTION

Division 3: Concrete

SECTION 03 31 00
Cast In Place Structural Concrete

PART 1 GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals: Product Data, concrete mix designs and submittals required by ACI 301, “Specification for Structural Concrete for Builders” except where noted in drawings.

B. Ready Mixed Concrete Producer Qualifications: ASTM C 94/C 94M.

C. Comply with ACI 301, “Specification for Structural Concrete”; ACI 117, “Specifications for Tolerances for Concrete Construction and Materials”; and CRSI’s “Manual of Standard Practice.”

PART 2 PRODUCTS

2.1 MATERIALS

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

B. Plain Steel Wire: ASTM A 82, as drawn.

C. Plain Steel Welded Wire Reinforcement: ASTM A 185, as drawn, flat sheet.

D. Deformed Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.

E. Portland Cement: ASTM C 150, Type I or II.

F. Fly Ash: ASTM C 618, Type F. Maximum fly ash as a percentage of total weight of cementitious
material shall be 25 percent.

G. Ground Granulated Blast Furnace Slag: ASTM C 989, Grade 100 or 120.

H. Aggregates: ASTM C 33, uniformly graded.

1. Maximum Aggregate Size for Concrete in Insulating Concrete Forms: as listed per drawings, 1" typical.

I. Synthetic Fiber: ASTM C 1116/C 1116M, Type III, polypropylene fibers, 1/2 to 1 1/2 inches long.

J. Air Entraining Admixture: ASTM C 260.

K. Vapor Retarder: Reinforced sheet, ASTM E 1745, Class A.

L. Joint Filler Strips: ASTM D 1751, asphalt saturated cellulosic fiber, or ASTM D 1752, cork or self expanding cork.

M. Moisture Retaining Cover: ASTM C 171, polyethylene film or white burlap polyethylene sheet.

N. Clear, Solvent Borne, Membrane Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

2.2 MIXES

A. Comply with ACI 301 requirements for concrete mixtures.

B. Normal Weight Concrete: Prepare design mixes, proportioned according to ACI 301, as follows:

1. Minimum Compressive Strength: 4500 psi at 28 days.
2. Maximum Water Cementitious Materials Ratio: 0.50.
3. Slump Limit: slumps shall be within +1 inch and 2 inches of the specificed slump per drawings.

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 25 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

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

PART 3 EXECUTION

3.1 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 C, 1/2 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 interior steps and ramps and 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.

I. Cure formed surfaces by moist curing for at least seven days.

J. Begin curing concrete slabs after finishing.

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

L. Protect concrete from damage. Repair surface defects in formed concrete and slabs.

END OF SECTION

Division 5: Metals

SECTION 05 1200
Structural Steel Framing

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Structural steel framing members.
2. Exterior canopy structural members.

PART 2 PRODUCTS

2.1 MATERIALS

A. Steel:
1. Shapes, bars, and plates: ASTM A36/A36M.
2. Hollow structural sections : ASTM A500, Grade B.
3. Pipe: ASTM A53/A53M, Grade B.
4. Shear Connectors: ASTM A108

2.2 ACCESSORIES

A. Anchor Bolts: ASTM A307.

B. High Strength Bolts: ASTM A325, Type 1, uncoated.

C. Standard Bolts: ASTM A307, Grade A.

D. Primer Paint: SSPC Paint 15, Type 1, red oxide.

E. Non Shrink Grout: Premixed, consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; minimum [7,000] [__] PSI compressive strength at 28 days.

F. Welding Materials: AWS D1.1, type required for materials being welded.

2.3 FABRICATION

A. Fabricate structural steel in accordance with AISC Manual.

B. Welding: AWS D1.1. Stress relieve welded assemblies by heat treatment.

C. Where collection of water inside structural tubing could occur, provide drain hole at lowest point.

D. Cap open ends of tubes and seal weld. Wherever practical, weld connections all around. Seal seams that cannot be practically welded with joint sealer.

E. Shop Powdercoating:
1. Shop powdercoat all steel surfaces except:
2. Surface preparation: SSPC Method SP2 - Hand Tool Cleaning or Method SP3 - Power Tool Cleaning.
3. Application: One coat; follow coating manufacturer's instructions.

PART 3 EXECUTION

3.1 ERECTION OF STRUCTURAL STEEL

A. Erect structural steel in accordance with AISC Specifications.

B. Accurately assemble to lines and elevations indicated, within specified erection tolerances.

C. Align and adjust members forming parts of complete frame or structure after assembly but before fastening.

D. Provide temporary shoring and bracing members with connections of sufficient strength to resist imposed loads.

E. Align column bases with leveling plates.

F. Align bearing plates with leveling [plates.

G. Clean bearing surfaces and surfaces that will be in permanent contact before members are assembled.

H. Remove temporary shoring and bracing members after permanent members are in place and final connections have been made.

I. Installation Tolerances:
1. Maximum variation from plumb: 1/4.
2. Maximum variation from level: 1/8 inch in 10 feet, noncumulative.

3.2 ADJUSTING

A. Touch up bolt heads, nuts, field welds, and abrasions in shop coating with same powder coat material used in shop.

END OF SECTION

SECTION 05 5000
Metal Fabrications

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Shop fabricated metal components.
2. Perforated Metal Canopy

B. General Note:
1. Section 05 5000 is being investigated by the project team to detail the top of the canopies.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. McNichols Steel
2. Any qualified steel manufacturer within 100 miles of fabrication location.

2.2 MATERIALS

A. Steel
1. Shapes, bars, and plates: ASTM A36/A36M.
2. Hollow structural sections : ASTM A500, Grade B.

B. Perforated Metal Canopies
1. Material: Bare carbon steel
2. Gauge: 11

3. Perforations: .75” on 1” centers
4. Margins: 2” on all sides

2.3 ACCESSORIES

A. Exposed Screws: Same material as metal being fastened; Phillips flat head, countersunk, unless noted otherwise.

B. Bolts: ASTM A307, hexagonal head type.

C. Primer Paint: SSPC Paint 15, Type 1, red oxide.

2.6 FABRICATION

A. Fit and shop assemble items in largest practical sections, for delivery to site.

B. Fabricate items with joints tightly fitted and secured.

C. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.

D. Exposed Mechanical Fastenings: Flush countersunk screws or bolts, unobtrusively located, consistent with design of component except where specifically noted otherwise.

E. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

F. Conceal fastenings where possible.

G. Welding to conform to AWS [D1.1] [D1.2] [D1.6].
1. Use welds for permanent connections where possible. Grind exposed welds smooth.
2. Tack welds prohibited on exposed surfaces.

2.7 FINISHES

A. Exterior Ferrous Metal: Powder Coat.
1. Color: White

PART 3 EXECUTION

3.1 INSTALLATION

A. Install items in accordance with approved Shop Drawings.

B. Install components plumb, level, and rigid.

C. Welding: Grind and fill exposed welds; finish smooth and flush.

D. Install sleeved components with anchoring cement.

E. Prevent contact of [exterior] aluminum and dissimilar metals by use of zinc rich paint, bituminous coating, or non-absorptive gaskets.

3.2 ADJUSTING

A. Clean and touch up damaged powder coating with same product as applied in shop.

B. Clean and touch up galvanized coatings at welded and abraded surfaces in accordance with ASTM A780.

3.3 SCHEDULE

A. Refer to shop drawings for fabricated material schedules

END OF SECTION

Division 6: Wood, Plastics, and Composites

SECTION 06 1100
Framing And Sheathing

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wall framing.
2. Floor decking.
3. Roof and wall sheathing.
4. Wood blocking and furring.
5. Roof curbs.
6. Exterior Decks

B. Related Sections:

1. Division 06 1733 Open Web Wood Joist.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers - Laminated Veneer Lumber:

1. Any qualified manufacturer within 100 miles of fabrication site

B. Acceptable Manufacturers - Composite Wood:

1. Any qualified manufacturer within 100 miles of fabrication site

2.2 MATERIALS

A. Dimension Lumber:

1. Grading rules: NELMA.
2. Species: Southern Pine
3. Grade: 2 (load bearing partitions and construction), grade 3 (interior partitions).
4. Surfacing: Surfaced four sides (S4S)
5. Maximum moisture content: 19 percent.

B. Composite Joists and Headers:

1. Fabricated by laminating wood veneers to narrow oriented strand board to produce rectangular members with veneers making up not less than 32 percent of total cross section.
2. Made with low-emitting, urea formaldehyde-free adhesives.

C. Composite Wood:

1. Extruded product consisting of recycled polyethylene and industrial waste wood fibers with integral coloring.
2. Color: to be selected from manufacturer's full color range.

D. Panel Products:

1. Type: APA Oriented Strand Board.
2. Panel grade:
   a. Floor, wall and roof sheathing: APA Structural I Rated Sheathing.
   b. Combination subfloor/underlayment: APA Sturd-I-Floor.
   c. Underlayment: APA Underlayment.
3. Exposure:
   a. Exterior applications: Exterior.
   b. Interior applications: Exposure 1.

2.3 ACCESSORIES

A. Fasteners:

1. Screws and Nails as noted in stamped structural drawings

2.4 FABRICATION

A. Preservative Treatment:

1. Treat wood in following locations:
   a. Where in contact with roofing and related flashings.
   b. Where in contact with cementitious materials.
   c. Where in contact with ground.
   d. Exterior
2. Lumber: Treat in accordance with AWPA C1 with retention of 0.25 to 0.40 PCF.
3. Panel products: Treat in accordance with AWPA C9, with retention of 0.25 to 0.40 PCF.

B. Fire Retardant Treatment:

1. Treat exterior wood.
2. Lumber: Treat in accordance with AWPA C20.
3. Panel products: Treat in accordance with AWPA C27, Interior Type A - High Temperature,

PART 3 EXECUTION

3.1 INSTALLATION

A. Set members level, plumb, and rigid.

B. Make provisions for erection loads, and for temporary bracing to maintain structure safe, plumb, and in true alignment until completion of erection and installation of permanent

bracing.

C. Place beams, joists, and rafters with crown edge up.

D. Construct load bearing framing members full length without splices unless noted otherwise

E. Stud Framing:

1. Interior and exterior walls will be 2x4 @ 24" o.c.
2. Provide single bottom plate and double top plates for load bearing partitions.
3. Provide single bottom and top plates for non-load bearing partitions.
4. Double studs at corners and partition intersections.
5. Frame openings with double studs and headers. Space short studs over and under opening to stud spacing.

F. Beams:

1. Provide minimum end bearing of 4 inches.
2. Nail built-up members with two rows of nails spaced 6 inches on center maximum.

G. Roof Sheathing:

1. Roof sheathing will be 7/16" oriented strand board,
2. Place panels perpendicular to framing members with ends staggered and sheet ends over firm bearing.
3. Leave 1/8 " expansion space at panel ends and edges.

H. Wall Sheathing:

1. Exterior wall sheathing will be 1/2" oriented strand board.
2. Place panels perpendicular to framing members, with ends over firm bearing and staggered.
3. Leave 1/8" expansion space at panel ends and edges.
4. Secure to supports with screws spaced maximum 6 inches on center along edges

and maximum 12 inches on center in field of panels.

I. Subflooring:

1. Sub floor will be ¾" oriented strand board, glued and fastened to floor joists.
2. Install flooring underlayment after dust and dirt generating activities have ceased and prior to application of finished flooring.
3. Apply perpendicular to decking; stagger joints of underlayment in adjacent rows.
4. Leave 1/8 inch expansion space at panel ends and edges.

J. Provide blocking, nailers, grounds, furring, and other similar items required to receive and support work.

3.2 TOLERANCES

A. Framing Members: 1/4 inch from true position, maximum.

B. Surface Flatness of Floor: 1/8 inch in 10 feet maximum.

END OF SECTION

SECTION 06 1713
Laminated Veneer Lumber

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Laminated Veneer Lumber for roof and floor framing.

B. Related Sections:

1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 06 1100 – Framing.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Any qualified manufacturer within 100 miles of fabrication site.

2.2 MATERIALS

A. LVL:
1. Graded in accordance with NIST PS 20.

2.3 ACCESSORIES

A. Fasteners: Galvanized steel, type suited to conditions.

2.4 FABRICATION

A. Cut members accurately to length to achieve tight fit.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install joists in accordance with manufacturer's instructions.

B. LVL Joists:
1. 9 ¼" LVL Rim Joist.
2. 22" LVL Joist at Mating Wall.

C. Place level and true to line.

D. Prior to inducing loads, place permanent bridging, bracing, and anchors to maintain joists straight and in correct position.

E. Installation Tolerances: Maximum 1/4" variation from true position.

END OF SECTION

SECTION 06 1733
Open Web Wood Joists

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wood chord oriented strand board open web joists for roof and floor framing.

B. Related Sections:

1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 06 1100 - Framing and Sheathing.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Any qualified fabricator within 100 miles of fabrication site and approved by modular home manufacturer

2.2 MATERIALS

A. Lumber:

1. Graded in accordance with NIST PS 20.

B. Oriented Strand Board

1. APA PRP-108, grade as dictated by design, Exterior Exposure.

2.3 ACCESSORIES

A. Fasteners: Galvanized steel, type suited to conditions.

B. Joist Bridging: Type and size required by joist manufacturer.

2.4 FABRICATION

A. Cut members accurately to length to achieve tight fit.

B. Provide single top and bottom chords.

C. Jig joists during fabrication to obtain tight joint connections.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install joists in accordance with manufacturer's instructions.

B. Floor Joists:

1. 9 ¼" Open Joist 2000 @16" o.c.

C. Roof Joists:

1. 9 1/4"-15 1/4" Open Joist 2000 @ 16" o.c.
2. Roof joists will be sloped at 1/24 with no overhang, eaves, or gables.

D. Place level and true to line.

E. Prior to inducing loads, place permanent bridging, bracing, and anchors to maintain

joists straight and in correct position.

F. Do not field cut joists.

G. Installation Tolerances: Maximum 1/4 inch variation from true position.

END OF SECTION

SECTION 06 4100
Architectural Wood Casework

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Special enclosure constructions for mechanical/laundry space.
2. Prefabricated, component based IKEA kitchen cabinets
3. Prefabricated, component based IKEA storage units for dining room, kitchen, flex space, bathroom, and bedroom.

PART 2 PRODUCTS

2.1 MATERIALS

A. Panel Products:

1. Graded in accordance with AWI Section 200 requirements for quality grade specified.
2. Exposed and semi-exposed veneers:
   a. Birch veneers

B. Hardboard: Pressed wood fiber with resin binder; standard grade, 1/8 inch thick, smooth one side.

C. Lumber:

1. Graded in accordance with AWI Section 100 requirements for quality grade specified, average moisture content of 6 percent.
2. Exposed and semi-exposed locations:
   a. Exterior Grade

2.2 ACCESSORIES

A. Fasteners: Type and size as required by conditions of use.

B. Adhesives:
1. Waterproof, [water based] [solvent release] type, compatible with backing and [veneer] [laminate] materials.

C. Finish Hardware: As scheduled at end of Section.

D. Joint Sealers: Specified in Section 07 9200.

2.3 FABRICATION

A. Shop-assemble for delivery to project site in units easily handled.

B. Prior to fabrication, field-verify dimensions to ensure correct fit.

C. Where field fitting is required, provide ample allowance for cutting. Provide trim for scribing and site conditions.

D. Provide cutouts and reinforcement for plumbing, electrical, appliances, and, accessories. Prime paint surfaces of cut edges.

PART 3 EXECUTION

3.1 PREPARATION

A. Prior to installation, condition cabinets to average humidity that will prevail after installation.

3.2 INSTALLATION

A. Install in accordance with AWI Section 1700, Economy Grade requirements.

B. Set plumb, rigid and level.

C. Scribe to adjacent construction with maximum 1/8 inch gaps.

3.3 FINISH HARDWARE SCHEDULE

DESCRIPTION	MANUFACTURER	MODEL
Door and drawer pull	IKEA	AKB3D
Drawer slide	IKEA	AKB3D
Door hinge	IKEA	AKB3D
Door hinge	IKEA	AKB3D
Shelf standards and brackets	IKEA, ORR & ORR	AKB3D

END OF SECTION

SECTION 06 6116
Solid Surfacing Fabrications

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Solid surfacing countertops with sink bowls.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 07 9200 - Joint Sealers.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Samsung Staron

B. Substitutions: Under provisions of Division 01

2.2 MATERIALS

A. Solid Surfacing:
1. Material: Homogenous sheet material composed of acrylic resins, filler materials, and coloring agents.
2. Thickness: 1 1/2 inch.
3. Color: Arctic Snow
4. Surface finish: Semigloss.

B. Sinks: Same material as solid surfacing, 2 basin undercounter mounted.

2.3 ACCESSORIES

A. Adhesive:
1. Type recommended by solid surfacing manufacturer.

B. Joint Sealer: Specified in Section 07 9200.

2.4 FABRICATION

A. Fabricate components in shop to sizes and shapes indicated, in accordance with manufacturer's instructions and approved Shop Drawings.

B. Fabricate splashes from solid surfacing in color to match countertops.

C. Provide holes and cutouts for mounting of sinks, trim, and accessories.

D. Finish exposed edges to smooth, uniform bullnose profile.

E. Allowable Tolerances:
1. Maximum variation in size: 1/8 inch.
2. Maximum variation in location of openings: 1/8 inch from indicated location.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions and approved Shop Drawings.

B. Set plumb, level, and rigid.

3.2 ADJUSTING

A. Sand out minor scratches and abrasions.

END OF SECTION

Division 7: Thermal and Moisture Protection

SECTION 07 2113
Board Insulation

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Board insulation at exterior walls and between modules.
2. Rigid foam board insulation on roof.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers - Polyisocyanurate Insulation:
1. DOW
2. Owens Corning

B. Acceptable Manufacturers- Rigid Roof Board Insulation
1. DOW
2. Owens Corning

2.2 MATERIALS

A. Polyisocyanurate Insulation:
1. 3.5” closed cell polyisocyanurate foam core bonded in the foaming process to 1⁄2” high-density wood fiberboard on one side and a fiber-reinforced facer on the other

2. Thermal resistance: Minimum R value of 23, calculated in accordance with ASTM C1303.

B. Rigid Roof Board Insulation
1. 2” rigid foam board insulation

2.3 ACCESSORIES

A. Adhesive:
1. Type recommended by insulation manufacturer.

B. Tape: Minimum 4 inches wide, pressure sensitive, [foil faced,] waterproof.

C. Impale Fasteners:
1. Steel impaling fasteners on metal base with lock washers, length to suit insulation thickness.
2. Adhesive: Type recommended by fastener manufacturer.

D. Metal Clips: Galvanized steel, L-shaped, 4 inches long.

E. Fasteners: Type best suited to application

PART 3 EXECUTION

3.1 PREPARATION

A. Substrate:
1. Remove protrusions flush with adjacent surface.
2. Remove dirt, dust, oil, grease, and other materials that could impair adhesion.

3.2 INSTALLATION

A. Polyisocyanurate Insulation:
1. To be fastened to 7/16” OSB on exterior of 2x4 stud wall.
2. To be fastened to LVL’s at connection of modules

B. 2” Rigid Board Insulation:

1. To be attached on top of to 7/16” OSB roof sheathing.

C. Secure insulation with metal clips spaced maximum 24 inches on center and within 6 inches from corners.

D. Apply adhesive in continuous beads.

E. Butt edges and ends tight to adjacent boards and at perimeter.

F. Cut and fit insulation tight to protrusions or interruptions to the insulation plane.

G. Tape seal to perimeter and at joints between insulation pieces.

END OF SECTION

SECTION 07 2119
Foamed-In-Place Insulation

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Foamed-in-place insulation for framed walls, floor cavities, roof cavities.
2. Foamed-in-place insulation at junctions of dissimilar wall and roof materials to achieve a thermal and air seal.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Honeywell

B. Substitutions: Under provisions of Division 01.

2.2 MATERIALS

A. Foamed-In-Place Insulation:
1. Type: NCFI Sprayed-in-Place Polyurethane Foam Insulation System 11-012
2. R-value: Minimum 6.3 per inch

PART 3 EXECUTION

3.1 PREPARATION

A. Protect adjacent surfaces from accidental application.

3.2 APPLICATION

A. Apply insulation in accordance with manufacturer's instructions.
B. Patch access holes, finish flush with adjacent surfaces.

3.3 ADJUSTING

A. Patch damaged areas.

END OF SECTION

SECTION 07 4623
Wood Siding

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Wood siding
2. Composite Siding Material
3. Trim, anchorage, and accessories.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Resysta- http://www.resysta.de/index.php/en
2. Armstrong Lumber

B. Substitutions:
1. Team my substitute equivalent materials where desired.

2.2 MATERIALS

A. Wood Panel Siding:
1. Type: 1x6 Kiln Dried Cedar Siding
2. Veneer grade: To be determined
3. Exposure: Exterior.
4. Size: 7/8” think, 6” nominal tall, varied available widths
5. Surface texture: smooth
6. Surface profile: Ungrooved.

B. Resysta Siding

1. Type: Resysta Wall Cladding 300/35
2. Exposure: Exterior
3. Size: 1.37” thick, 11.8” tall, 5’ wide (trimmed to width on site)
4. Surface Texture: Smooth
5. Surface Profile: As specified by manufacturer.

2.3 ACCESSORIES

A. Fasteners: Type provided when applicable, always type recommended.

B. Sheet Metal Flashings and Trim: Specified in Section 07 6200.

C. Joint Sealers: Specified in Section 07 9200.

PART 3 EXECUTION

3.1 PREPARATION

A. Prior to installation, condition wood to average humidity that will prevail after installation.

B. Back prime siding and trim prior to installation.

3.2 INSTALLATION - WOOD PANEL AND RESYSTA WALL CLADDING

A. Install siding in accordance with manufacturer’s instructions.

B. Butt joints tight.

C. Set plumb and level.

D. Cut siding to fit at perimeter and around penetrations with maximum 1/4 inch gaps. Sand, prime, and paint cut edges.

E. Fasten at maximum 18 inches on center along edges and at intermediate supports in orderly nailing pattern.

F. Install metal flashings at internal and external corners, sills, and heads of wall openings. Fasten at 12 inches on center maximum.

G. Apply joint sealer between siding and trim and adjacent surfaces as specified in Section 07 9200. Ensure watertight condition.

END OF SECTION

SECTION 07 5300
Elastomeric Membrane Roofing

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:.
1. Fully adhered single ply membrane roofing.
2. Roof flashing and metal trim.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 07 6200 - Sheet Metal Flashing and Trim.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Qualified manufacturer within 100 miles of fabrication site.

B. Substitutions: Under provisions of Division 01

2.2 MATERIALS

A. Roof Membrane:
1. Type: EPDM (Ethylene Propylene Diene Terpolymer), fire retardant
2. Physical properties: Conform to ASTM D4637.
3. Size: Maximum sheet size permitted by application and job conditions.
4. Thickness: 45 mils.
5. Color: White

B. Flashing Sheet: Manufacturer's standard flashing sheet, color to match membrane.

2.3 ACCESSORIES

A. Batten Strips or Fastener Plates: Manufacturer's standard.

B. Accessories: By manufacturer of roofing system, including adhesives, tapes, solvents, sealants, water cutoff mastic, and prefabricated pipe flashings.

PART 3 EXECUTION

3.1 PREPARATION

A. Remove projections that could puncture membrane from substrate.

B. Clean substrate of loose and foreign material, oil, and grease.

C. Complete roof penetrations and preparation for drains, flashings, and other penetrations prior to beginning roofing.

D. Protect adjacent and underlying surfaces.

3.2 INSTALLATION - GENERAL

A. Install roofing system in accordance with roofing system manufacturer's instructions, NRCA Manual, and approved Shop Drawings.

3.3 INSTALLATION OF ROOF MEMBRANE

A. Position sheets without stretching; minimize wrinkles. Allow membrane to relax before proceeding.

B. Provide minimum 3 inch lap at joints between adjacent sheets.

C. Splice sheets by contact adhesive method.

D. Bond membrane to substrate with full adhesive bed.

3.4 INSTALLATION OF FLASHINGS

A. Construct in accordance with roofing system manufacturer's standard details.

B. Juncture of Horizontal and Vertical Surfaces:
1. Use longest practical length flashing to minimize joints.
2. Complete splice between flashing and main roof sheet before bonding flashing to vertical surface. Extend splice 3 inches beyond fasteners that attach membrane to horizontal surface.
3. Adhere flashing to substrate with full bed of adhesive.
4. Fasten top of flashing at 12 inches on center maximum, under metal flashing.

C. Penetrations through Membrane:
1. Flash pipe with premolded pipe flashings wherever possible.
2. Where molded pipe flashings cannot be installed, use field fabricated pipe seals.
3. Seal clusters of pipes and unusually shaped penetrations with minimum 2 inch high flashing containing pourable sealer.

D. Expansion Joints:
1. Complete roof membrane and flashing installation prior to installing expansion joint.
2. Set joint cover on top of wood nailers; secure on each side through metal flange.
3. Seal joint cover flanges to membrane as for sheet splice.

E. Roof Drains:
1. Taper insulation around drain to provide smooth transition from roof surface to drain clamping ring.
2. Seal between membrane and drain base with water cutoff mastic.

END OF SECTION

SECTION 07 6200
Sheet Metal Flashing And Trim

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Copings.
2. Edge flashings
3. Gutters and downspouts.
4. Counterflashings over membrane roof base flashings.
5. Counterflashings at roof mounted equipment and utility penetrations.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 07 9200 - Joint Sealers.

PART 2 PRODUCTS

2.1 MATERIALS

A. Precoated Galvanized Steel Sheet:
1. ASTM A653/A653M, Structural Quality, G60 coating class, 24 gage core steel unless noted otherwise.
2. Finish: Precoated with fluoropolymer coating, containing minimum 70 percent PVDF resins, color to be selected from manufacturer's full color range.

2.2 ACCESSORIES

A. Solder: ASTM B32.

B. Fasteners: Same material and finish as sheet metal with neoprene gasketed washers where exposed.

C. Joint Sealers: Specified in Section 07 9200.

2.3 FABRICATION (Specifics to be determined)

A. Fabricate components in accordance with SMACNA Manual.

B. Profiles:
1. Gutters: 4” Rectangular, White.
2. Downspouts: 3.5” Square, Black
3. Fabricate end caps, downspout outlets and headers, straps, brackets, and downspout strainers in profile to suit gutters and downspouts.

C. Solder shop formed joints except at prefinished metal. After soldering, remove flux and wash clean.

D. Fabricate vertical faces with bottom edge formed outward 1/4 inch and hemmed to form drip.

E. Form sections accurate to size and shape, square and free from distortion and defects.

F. Provide for thermal expansion and contraction in sheet metal:
1. Gutters:
   a. Place expansion joints at maximum 50 feet on center.
   b. Locate expansion joints between downspouts; prevent water flow over joint.
2. Other sheet metal:
   a. Provide expansion joints in sheet metal exceeding 15 feet in running length.
   b. Place expansion joints at 10 feet on center maximum and maximum 2 feet from corners and intersections.
3. Joint width: Consistent with types and sizes of materials, minimum width 1/4 inch.

G. Fabricate expansion joints in edge flashings with cover plates formed to flashing profile and minimum 4 inches long.

H. Unless otherwise indicated, provide minimum 3/4 inch wide flat lock seams; lap in direction of water flow.

I. Fabricate cleats and starter strips of same material as sheet metal.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install flashing and sheet metal as indicated and in accordance with SMACNA Manual.

B. Install cleats and starter strips before starting installation of sheet metal.

C. Expansion Joints in Edge Flashings:
1. Seal expansion space between ends of flashing sections.
2. Apply continuous bead of joint sealer between cover plate and flashing sections at each end.

D. Secure flashings with concealed fasteners where possible.

E. Apply plastic cement between metal and bituminous flashings.

F. Fit flashings tight, with square corners and surfaces true and straight.

G. Seam and seal field joints.

H. Separate dissimilar metals with bituminous coating or non-absorptive gaskets.

I. Downspouts:
1. Secure with straps spaced maximum 8 feet on center and within 2 feet of ends and elbows.
2. Flash downspouts minimum 3 inches into gutters and fasten.
3. Flash upper sections into lower sections minimum 2 inches at joints; fasten sections together.

J. Apply joint sealers as specified in Section 07 9200.

3.2 CLEANING

A. Clean sheet metal; remove slag, flux, stains, spots, and minor abrasions without etching surfaces.

END OF SECTION

SECTION 07 9200
Joint Sealants

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Silicone joint sealants.
2. Urethane joint sealants.
3. Polysulfide joint sealants.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

B. VOC Content of Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

1. Architectural Sealants: 250 g/L.
2. Sealant Primers for Nonporous Substrates: 250 g/L.
3. Sealant Primers for Porous Substrates: 775 g/L.

C. Low-Emitting Interior Sealants: Sealants and sealant primers used inside the weatherproofing system 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."

D. Stain-Test-Response Characteristics: Where sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing according to ASTM C

1248 and have not stained porous joint substrates indicated for Project.

E. Suitability for Contact with Food: Where sealants are indicated for joints that will come in repeated contact with food, provide products that comply with 21 CFR 177.2600.

F. Colors of Exposed Joint Sealants: As indicated by manufacturer's designations.

2.2 SILICONE JOINT SEALANTS

A. Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 100/50, for Use NT.

1. Products: Subject to compliance with requirements, available products that may be incorporated but are not limited to, the following:
   a. Dow Corning Corporation; 790
   b. GE Advanced Materials - Silicones; SilPruf LM SCS2700.
   c. Other Qualified Matieral

2.3 URETHANE JOINT SEALANTS

A. Single-Component, Nonsag, Urethane Joint Sealant: ASTM C 920, Type S, Grade NS, Class 100/50, for Use NT.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following
   a. Sika Corporation, Construction Products Division; Sikaflex - 15LM.
   b. Tremco Incorporated; Vulkem 921

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
3. Remove laitance and form-release agents from concrete.
4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
   a. Metal.
   b. Glass.
   c. Glazed surfaces of ceramic tile.

B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for

use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of sealant backings.
2. Do not stretch, twist, puncture, or tear sealant backings.
3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:

1. Place sealants so they directly contact and fully wet joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

1. Remove excess sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
3. Provide concave joint profile per Figure 8A in ASTM C 1193, unless otherwise indicated.
4. Provide flush joint profile where indicated per Figure 8B in ASTM C 1193.
5. Provide recessed joint configuration of recess depth and at locations indicated per Figure 8C in ASTM C 1193.
   a. Use masking tape to protect surfaces adjacent to recessed tooled joints.

G. Installation of Preformed Silicone-Sealant System: Comply with the following require-

ments:

1. Apply masking tape to each side of joint, outside of area to be covered by sealant system.
2. Apply silicone sealant to each side of joint to produce a bead of size complying with preformed silicone-sealant system manufacturer's written instructions and covering a bonding area of not less than 3/8 inch (10 mm). Hold edge of sealant bead 1/4 inch (6 mm) inside masking tape.
3. Within 10 minutes of sealant application, press silicone extrusion into sealant to wet extrusion and substrate. Use a roller to apply consistent pressure and ensure uniform contact between sealant and both extrusion and substrate.
4. Complete installation of sealant system in horizontal joints before installing in vertical joints. Lap vertical joints over horizontal joints. At ends of joints, cut silicone extrusion with a razor knife.

H. Installation of Preformed Foam Sealants: Install each length of sealant immediately after removing protective wrapping. Do not pull or stretch material. Produce seal continuity at ends, turns, and intersections of joints. For applications at low ambient temperatures, apply heat to sealant in compliance with sealant manufacturer's written instructions.

I. Acoustical Sealant Installation: At sound-rated assemblies and elsewhere as indicated, seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and with manufacturer's written recommendations.

J. until test results prove sealants comply with indicated requirements.

3.4 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION

Division 8: Openings

SECTION 08 1416
Flush Wood Doors

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Fiberboard faced flush solid core doors.
2. Factory finishing.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 08 7100 - Door Hardware.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Masonite

B. Subsitutions:
1. Team

2.2 MATERIALS

A. Flush Wood Doors: AWI Section 1300.
1. Core type:
a. Solid Core
2. Fiberboard faces: Minimum 1/8 inch thick high density fiberboard, flush.

2.3 FABRICATION

A. Fabricate doors in accordance with AWI Section 1300.

PART 3 EXECUTION

3.1 PREPARATION

A. Condition doors to average humidity that will be encountered after installation.

3.2 INSTALLATION

A. Install doors in accordance with AWI Section 1700.

B. Install doors plumb and level.

C. Field Fitting to Frames:

1. Non-rated doors:
   a. Width: Cut hinge and lock edges equally.
   b. Height: Cut bottom edge only; maximum 3/4 inch.
2. Edge clearances:
   a. Jambs and head: 1/8 inch maximum between door and frame.
   b. Sills without thresholds: 1/8 inch maximum between door and top of finish floor.
   c. Sills with thresholds: 1/4 inch maximum between door and top of threshold.
3. Lock edge: Bevel 1/8 inch in 2 inches.
4. Do not cut doors down to opening sizes smaller than those for which they were manufactured.

END OF SECTION

SECTION 08 5200
Wood Windows And Glass Doors

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Shop fabricated wood framed glass doors and frames.
2. Operating hardware and insect screens.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Masonite

B. Substitutions: The team may substitute equivalent materials when seen fit.

2.2 MATERIALS

A. Wood:
1. Clear Douglas Fir, preservative treated in accordance with WDMA I.S.4, kiln dried to maximum 12 percent moisture content.

B. Glass and Glazing Accessories:
1. Double Pane Glass with Low E coating on side 2 of exterior light and integral blinds

C. Operating Hardware:
1. Noncorroding material specified by manufacturer.
2. Hinged doors: Butt hinges and lever lockset; keyed outside; furnish four keys.

D. Weatherstripping: Stainless steel.

2.3 ACCESSORIES

A. Fasteners: Stainless steel, hot-dip galvanized steel, or fluoropolymer coated steel; type best suite to application.

2.4 FABRICATION

A. Fabricate to AAMA/WDMA - 101/I.S.2.

2.5 FINISHES

A. Exterior Wood: Factory applied primer.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install glass doors in accordance with manufacturer's instructions and approved Shop Drawings.

B. Set plumb, level, and rigid, free from warpage.

C. Anchor to supporting construction.

D. Installation Tolerances:
1. Maximum variation from plumb or level: 1/8 inch in 3 feet or 1/4 inch in any 10 feet, whichever is less.

3.2 ADJUSTING

A. Touch up minor scratches and abrasions in primer paint.

END OF SECTION

SECTION 08 5300
Plastic Windows And Glass Doors

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Provide high performance vinyl windows with frame and sash members extruded from rigid vinyl formulated for outdoor use. Operating casement complete with hardware, glazing, weatherstripping screens and standard or specified anchorages, trim, attachments, and accessories.

B. Related Sections:

1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 08 8000 - Glazing.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer Units

1. Kolbe Windquest Series Operating Casement and Awning Vinyl Windows as manufactured by Kolbe & Kolbe Millwork Co., Inc. – Vinyl Division. (http://www.kolbe-kolbe.com/)

B. Substitutions: Team may substitute equivalent when desired.

2.2 MATERIALS

A. Frame:

1. Frame members shall be manufactured from multi-chambered extruded unplasticized polyvinylchloride (uPVC). Frame corners shall be fusion welded and cleaned.
2. Frame shall have an overall jamb depth of 3-1/4”.

3. Frame to have exterior and interior accessory groove.

B. Sash

1. Sash members shall be manufactured from multi-chambered extruded unplasticized polyvinylchloride (uPVC). Sash corners shall be fusion welded and cleaned.
2. Sash shall be 2-5/16” in thickness.

C. Operating Hardware:

1. Operator: 100% stainless steel drive worm and gear arm, hinged split arm, and roto gear operator. High-pressure zinc die-cast and folding crank handle. Note: construction handle will be replaced at time of installation.
2. Locks: Manual lever. Stainless steel multipoint sequential lock pulls the sash into a locked position.
3. Hinges Tow concealed stainless steel hinges shall consist of a stainless steel track, steel support arms, stainless steel reinforcing insert in low-friction sliding shoe.
4. Finish: Color to match unit

D. Weather Stripping:

1. Two full perimeter bulb seal weatherstripping on the frame.
2. Full perimeter pile weatherstripping on the sash.

2.3 ACCESSORIES

A. Installation Accessories:

1. Galvanized steel installation clips are required on all units. See manufacturer’s installation instructions.
2. Mull connectors.

2.4 FABRICATION

A. Fabricate to AAMA/WDMA - 101/I.S.2.

B. Fabricate with minimum clearances and shim spaces around perimeter, yet enabling installation and dynamic movement.

C. Fabricate framing, mullions and sash members with fusion welded corners and joints, in rigid jig. Supplement frame sections with internal reinforcement where required for rigidity.

D. Form sills and stools in one piece. Slope sills for wash.

E. Accurately fit and secure joints and intersections. Make joints flush, hairline, and weathertight.

F. Fabricate in largest practical units.

G. Weatherstrip operable sash.

H. Conceal fasteners and attachments from view.

I. Provide internal drainage weep holes and channels to route moisture to exterior.

J. Form snap-in glass stops, closure molds, weather stops, and flashings of extruded PVC for tight fit into window frame section.

K. Form weather stop flange to perimeter of unit.

L. Mount screens in removable, rewireable aluminum frame.

2.5 FINISHES

A. Exterior Surfaces: high performance, heat-reflective polyurethane. Color: colors as selected from manufacturers color spectrum.

B. Interior Surfaces: Color to be selected from manufacturer's full color range.

C. Screens: color to be selected from manufacturer's full color range

D. Hardware: color to be selected from manufacturer's full color range.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install windows and glass doors in accordance with manufacturer's instructions and approved Shop Drawings.

B. Set plumb, level, and rigid, free from warpage.

C. Anchor to supporting construction.

D. Installation Tolerances:
1. Maximum variation from plumb or level: 1/8 inch in 3 feet or 1/4 inch in any 10 feet, whichever is less.
2. Maximum misalignment of members abutting end to end: 1/32 inch.

3.2 ADJUSTING

A. Adjust for smooth operation.

END OF SECTION

SECTION 08 7100
Door Hardware

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Hardware for wood doors.
2. Weatherstripping and thresholds.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers – For all door hardware:
1. Hafele
2. Emtek

B. Substitutions: Team may substitute equivalent when desired

PART 3 EXECUTION

3.1 INSTALLATION

A. Install hardware in accordance with approved hardware schedule and manufacturer's instructions.

B. Install locksets, closers, and trim after finish painting.

C. Mounting Heights - Finished Floor to Center Line of:
1. Locksets: 38 inches.
2. Push and pull plates: 42 inches.

3. Dead locks: 48 inches.
4. Push pad exit devices: 42 inches.
5. Cross bar exit devices: 38 inches.
6. Top hinge: Maximum 10 inches from frame head.
7. Bottom hinge: Maximum 12-1/2 inches from floor.
8. Intermediate hinges: Equally spaced.

3.2 ADJUSTING

A. Test and adjust hardware for quiet, smooth operation, free from binding and rattling.

B. Adjust doors to operate with maximum opening forces in accordance with applicable accessibility code.

3.3 SCHEDULE

SET NO.	QUANTITY	DESCRIPTION	LOCATION
1	3	Emtek Sttutgart Lever Handle	Exterior Doors
	3	Emtek SS Round Single Cylinder Deadbolts	
2	1	Hafele Flatec Barn-Door Hardware	Bathroom
3	2	Hafele Slido Classic 40 P	Bed/Flex Sliding Doors

END OF SECTION

Division 9: Finishes

SECTION 09 2900
Gypsum Board

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Gypsum board.
2. Taping and bedding of gypsum board.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 07 9200 - Joint Sealers.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Any standard Gypsum Board manufacturer

B. Substitutions: Team may make equivalent substitutions when desired.

2.2 MATERIALS - GYPSUM PANELS

A. Fire Resistant Gypsum Board: ASTM C1396; 48 inches wide x 5/8 inch thick, maximum practical length, tapered edge.

2.3 ACCESSORIES

A. Fasteners: ASTM C514, drywall nails, minimum 5/8 inch penetration into framing.

B. Adhesive:
1. Type recommended by gypsum panel manufacturer.

C. Joint Treatment Materials:
1. Reinforcing tape and joint compound; ASTM C475.

PART 3 EXECUTION

3.1 INSTALLATION OF GYPSUM PANELS

A. Install panels and accessories in accordance with ASTM C754, GA-216, and manufacturer's instructions.

B. Accurately cut panels to fit around openings and projections. Do not tear face paper or break gypsum core.

C. Apply panels at non fire-rated assemblies in most economical manner, with ends and edges occurring over supports.

D. Apply panels at fire-rated assemblies as required by design assembly.

E. Stagger joints on opposite sides of partitions.

F. Do not locate joints to align with edges of openings unless a control joint is installed.

G. Mechanically fasten single layer panels to framing. Place fasteners minimum 3/8 inch from edges of panels; drive heads slightly below surface. Stagger fasteners at abutting edges.

H. Apply face layer of double layer applications with joints offset from those in base layer; secure with mechanical fasteners to framing or with adhesive to base layer.

I. Where recessed items occur in fire rated partitions, box item on all sides with gypsum board as required to maintain continuity of fire rating.

3.2 INSTALLATION OF ACCESSORIES

A. Install in accordance with manufacturer's instructions.

B. Install corner reinforcement at outside corners. Use single lengths where length of corner does not exceed standard length.

C. Install casings where indicated and where gypsum board abuts dissimilar materials or stops with edge exposed.

D. Install control joints at ceilings:
1. At maximum 50 feet on center.
2. Where ceiling framing changes direction.

E. Install control joints at walls and partitions:
1. At changes in backup material.
2. At maximum 30 feet on center.
3. Above one jamb of openings in partitions.

3.3 JOINT TREATMENT

A. Treat joints and fasteners in gypsum board in accordance with GA-214.

B. Levels of Finish: TBD
1. Surfaces in plenums: Level 4 finish.
2. Surfaces to receive tile: Level 2 finish.
3. Surfaces to receive flat: Level 5 finish.

END OF SECTION

SECTION 09 3000
Tile

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Ceramic tile floor and wall finishes.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 07 9200 - Joint Sealers.

C. Allowances:
1. Include a unit cost allowance of $5 per square foot for tile.
2. Installation is not included in amount of allowance.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers - Tile:
1. Tile Specialists

B. Acceptable Manufacturers - Setting and Grouting Materials:
1. BASF Corporation. (www.buildingsystems.basf.com)

C. Substitutions: Under provisions of Division 01

2.2 MATERIALS

A. Floor Tile:

1. Size: 2 x 2 inches x 1/4 inch thick.
2. Edge: Square.
3. Color: Dark Grey, To be selected from manufacturer's full color range.
4. Surface finish: Non slip.
5. Trim units: bullnose color to match tile.

B. Wall Tile:
1. Size: 3 x 6 inches x 1/4 inch thick.
2. Edge: Square.
3. Color: White, To be selected from manufacturer's full color range.
4. Surface finish: Glazed
5. Trim units: bullnose color to match tile.

2.3 ACCESSORIES

A. Latex-Portland Cement Mortar: ANSI A118.4, polymer modified dry set type.

B. Water: Clean, potable.

C. Grout:
1. ANSI A118.6, polymer modified dry set type, sanded.
2. Color: To match tile. To be selected from manufacturer's full color range.

D. Joint Sealers: Specified in Section 07 9200.

E. Waterproof Membrane:
1. Type: Load bearing, reinforced self-adhering sheet type.

F. Joint Tape: Waterproof, perforated bedding tape.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean surfaces to remove loose and foreign matter that could impair adhesion.

B. Remove ridges and projections. Fill voids and depressions with patching compound compatible with setting materials.

C. Allowable Substrate Tolerances:
1. Thin set method:
   a. Maximum variation in substrate surface: 1/8 inch in 8 feet.
   b. Maximum height of abrupt irregularities: 1/32 inch.

3.2 INSTALLATION

A. Install waterproof membrane in accordance with manufacturer's instructions.

B. Methods:
1. Walls: ANSI A108.4, thin set with organic adhesive.
2. Floors: ANSI A108.5, thin set with latex-portland cement mortar.
3. Shower walls:
   a. Fill joints between cementitious backer board with mortar. Apply tape centered over joint; skim coat with mortar.
   b. Install tile in accordance with ANSI A108.4, thin set with organic adhesive.
4. Shower floors:
   a. Surround floor drain with broken tile or crushed stone.
   b. Install tile in accordance with ANSI A108.1A, thick set with reinforced portland cement mortar

C. Minimize pieces less than one half size. Locate cuts to be inconspicuous.

D. Lay tile to pattern furnished by Architect. Do not interrupt tile pattern through openings.

E. Joint Widths:
1. Ceramic tile: 1/8 inch, plus or minus 1/16 inch.

F. Make joints watertight, without voids, cracks, excess mortar, or excess grout. Align joints in wall and floor of same-sized tile.

G. Fit tile around projections and at perimeter. Smooth and clean cut edges. Ensure that trim will completely cover cut edges.

H. Install thresholds where tile abuts dissimilar floor finish. Center on door or opening.

I. Allow tile to set for a minimum of 24 hours before grouting.

J. Grout tile joints in accordance with ANSI A108.10 without excess grout.

3.3 ADJUSTING

A. Remove and replace pieces that have been damaged during installation.

3.4 PROTECTION

A. Provide protection for completed work using nonstaining sheet coverings.

B. Prohibit traffic on tile floors for minimum 3 days after installation.

END OF SECTION

SECTION 09 6229
Locking Cork Tile Flooring

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Locking Cork TIle Flooring

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers - Locking Cork Tile Flooring:
1. USFloors

B. Substitutions: Under provisions of Division 01.

2.2 MATERIALS

A. Locking Cork Tile Flooring:
1. Product: Exotic Locking Hardwood Flooring
2. Size: 4 1/8” x 35 4/8” x 13/32” inch tiles
3. Color: Fila Sinza
4. Construction: Engineered Floating
5. Core Type: Moisture Resistant Exterior Grade HDF
6. Integrated Underlayment: Cork

PART 3 EXECUTION

3.1 PREPARATION

A. Clean substrate; remove loose and foreign matter that could impede adhesion or

performance of flooring.

B. Fill cracks, voids, and depressions in substrate with leveling compound.

C. Grind off high spots and projections in substrate; leave smooth and level to 1/4 inch in 10 feet.

D. Install 1/4 hardboard subfloor to bring up to ADA level with door sill.

E. Install waterproof substrate before installation of floor per manufacturers recommendation

3.2 INSTALLATION OF TILE

A. Install in accordance with manufacturer's instructions.

B. Mix tile from container to ensure shade variations are consistent when tile is placed.

C. Lay flooring with joints parallel to building lines to produce symmetrical tile pattern.

D. Scribe flooring to walls, columns, cabinets, and other appurtenances to produce 1/8" joints. Ensure that base, trim, plates, or escutcheons will completely cover cut edges.

3.3 ADJUSTING

A. Correct tiles that are not seated; replace damaged tiles.

3.4 PROTECTION

A. Do not allow traffic on flooring until competition period.

B. Cover areas subject to traffic with protective covering preluding competition period.

END OF SECTION

SECTION 09 6519
Resilient Tile Flooring

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Resilient Marmoleum flooring.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers - Vinyl Composition Tile:
1. Marmoleum (www.themarmoleumstore.com)

B. Substitutions: Under provisions of Division 01.

2.2 MATERIALS

A. Vinyl Plank Flooring:
1. ASTM F1700, Class I – Monolithic.
2. Product: Marmoleum Click
3. Size: 36x12 inch tiles
4. Color: Volcanic Ash

PART 3 EXECUTION

3.1 PREPARATION

A. Clean substrate; remove loose and foreign matter that could impede adhesion or

performance of flooring.

B. Fill cracks, voids, and depressions in substrate with leveling compound.

C. Grind off high spots and projections in substrate; leave smooth and level to 1/4 inch in 10 feet.

D. Install 1/4 hardboard subfloor to bring up to ADA level with door sill.

E. Install waterproof substrate before installation of floor per manufacturers recommendation

3.2 INSTALLATION OF TILE

A. Install in accordance with manufacturer's instructions.

B. Mix tile from container to ensure shade variations are consistent when tile is placed.

C. Lay flooring with joints parallel to building lines to produce symmetrical tile pattern.

D. Install tile to pattern directed by Architect. Allow minimum half-size tiles at room or area perimeter.

E. Scribe flooring to walls, columns, cabinets, and other appurtenances to produce 1/8" joints. Ensure that base, trim, plates, or escutcheons will completely cover cut edges.

F. Extend tile into recesses and under equipment.

G. Terminate flooring at centerline of door openings where adjacent floor finish is dissimilar.

3.3 ADJUSTING

A. Correct tiles that are not seated; replace damaged tiles.

3.4 CLEANING

A. Clean tile and buff in accordance with manufacturer's instructions.

3.5 PROTECTION

A. Do not allow traffic on flooring until competition period.

B. Cover areas subject to traffic with protective covering preluding competition period.

END OF SECTION

SECTION 09 9100
Painting

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Texturing of gypsum board.
2. Surface preparation and field application of paints.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Shermin Williams

B. Subsitutions: Qualified Paint Manufacturer may substitute material of equal qualification when required.

2.2 MATERIALS

A. Paints: As scheduled at end of Section, or approved substitute.

B. Low Volatile Organic Compound (VOC) Content; Interior paints, coatings, and accessories

2.3 ACCESSORIES

A. Accessory Materials: Linseed oil, shellac, turpentine, paint thinners and other materials required to achieve specified finishes; commercial quality.

B. Patching Materials: Latex filler.

C. Fastener Head Cover Materials: Latex filler.

2.4 MIXES

A. Uniformly mix to thoroughly disperse pigments.

B. Do not thin in excess of manufacturer's recommendations.

PART 3 EXECUTION

3.1 EXAMINATION

A. Test shop applied primer for compatibility with subsequent coatings.

3.2 PREPARATION

A. General:
1. Protect adjacent and underlying surfaces.
2. Remove or mask electrical plates, hardware, light fixture trim, escutcheons, and fittings prior to preparing surfaces or finishing.
3. Correct defects and clean surfaces capable of affecting work of this section.
4. Seal marks that may bleed through surface finishes with shellac.

B. Gypsum Board:
1. Fill minor defects with filler compound. Spot prime defects after repair.

C. Uncoated Ferrous Metals:
1. SSPC Method SP2 - Hand Tool Cleaning or Method SP3 - Power Tool Cleaning.
2. Spot prime paint after repairs.

D. Shop Primed Ferrous Metals:
1. SSPC Method SP2 - Hand Tool Cleaning or Method SP3 - Power Tool Cleaning.
2. Feather edges to make patches inconspicuous.
3. Prime bare steel surfaces.

E. Interior Wood:
1. Wipe off dust and grit.
2. Seal knots, pitch streaks, and sappy sections with sealer.
3. Fill nail holes and cracks after primer has dried; sand between coats.

F. Exterior Wood:
1. Remove dust, grit, and foreign matter.
2. Seal knots, pitch streaks, and sappy sections.

3.3 APPLICATION

A. Apply primer or first coat immediately after surface preparation is complete to prevent recontamination.

B. Do not apply finishes to surfaces that are not dry.

C. Apply coatings to minimum dry film thickness recommended by manufacturer.

D. Apply each coat of paint slightly darker than preceding coat unless specified otherwise.

E. Apply coatings to uniform appearance without laps, sags, curtains, holidays, and brush marks.

F. Allow applied coats to dry before next coat is applied.

G. Match final coat to approved color samples.

H. Where clear finishes are specified, tint fillers to match wood. Work fillers into grain

before set. Wipe excess from surface.

I. Prime concealed surfaces of [exterior wood] [and] [interior wood in contact with masonry or cementitious materials] with one coat primer paint.

J. Mechanical and Electrical Components:
1. Paint factory primed equipment.
2. Remove unfinished and primed louvers, grilles, covers, and access panels; paint separately.
3. Paint exposed and insulated pipes, conduit, boxes, ducts, hangers, brackets, collars, and supports unless factory finished.
4. Do not paint name tags or identifying markings.
5. Paint exposed conduit and electrical equipment in finished areas.

K. Do not Paint:
1. Surfaces indicated on Drawings or specified to be unpainted or unfinished.
2. Surfaces with factory applied finish coat or integral finish.
3. Architectural metals, including brass, bronze, stainless steel, and chrome plating.

3.4 ADJUSTING

A. Touch up or refinish disfigured surfaces.

3.5 CLEANING

A. Remove paint from adjacent surfaces.

3.6 PAINT SCHEDULE

A. Types of paint listed herein are set forth as standard of quality and type of coating required for each type of surface.
1. Exposed surfaces of type listed in following schedule are to be painted.
2. Other exposed surfaces not specifically listed shall receive not less than two coats of appropriate type of coating.

B. Prime coat shall consist of touch up only on shop primed [and existing] surfaces.

SUBSTRATE	MANUFACTURER	COLOR
Exterior Surfaces:		
Ferrous and Galvanized Metals	Sherman Williams	
Wood, Semi-Opaque Stain Finish	Sherman Williams	25% White Stain
	Sherman Williams	25% Grey Stain
	Sherman Williams	50% Light Grey Stain
Interior Surfaces:		
Gypsum Board, Latex Flat Finish	Sherman Williams	Painters White

END OF SECTION

Division 10: Specialities

SECTION 10 2813
Toilet Accessories

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Toilet and shower accessories.
2. Framed mirrors.

B. Related Sections:
1. Division 01: Administrative, procedural, and temporary work requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Qualified manufacturer from within 100 miles of fabrication site.

B. Substitutions: Team may substitute when desired

2.2 MATERIALS

A. Stainless Steel:
1. Sheet: ASTM A167, Type 304, rollable temper.
2. Tubing: ASTM A269.

B. Galvanized Steel:
1. ASTM A1008/A1008M.

C. Mirror Glass: ASTM C1036, Type I, Class 1, Quality q1, 3/16 inch thick.

2.3 ACCESSORIES

A. Fasteners: Stainless steel where exposed, hot dip galvanized where concealed; type best suited to substrate conditions.

2.4 FABRICATION

A. Use stainless steel for exposed surfaces; galvanized steel may be used in concealed locations.

B. Form exposed surfaces from single sheet of stock, free from joints, and flat, without distortion.

C. Weld joints of fabricated components and grind smooth.

D. Fabricate grab bars of tubing, free of visible joints, return to wall with end attachment flanges. [Peen grip surfaces.]

E. Provide hangers, adapters, anchor plates, and accessories required for installation.

F. Mirrors:
1. Frame: One piece, roll formed stainless steel channel, 1/2 x 1/2 inch, with corners mitered.
2. Mirror: Apply one coat of silver, one coat of electroplated copper, and one coat of organic mirror backing compound to back surface of glass.
3. Backing: Galvanized steel sheet.
4. Isolate glass from frame and backing with resilient, waterproof padding.

G. Shop assemble units and package complete with anchors and fittings.

2.5 FINISHES

A. Stainless Steel: No. 8 polished.

B. Galvanizing: ASTM A123/A123M to 1.25 ounces per square foot.

C. Chrome Plating: ASTM B456, Type SC 2, polished.

D. Polyethylene: White.

E. Enamel: White.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Set plumb, level, square, and rigid.

C. Install wiring between power supply and accessories.
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END OF SECTION

Division 11: Appliances

SECTION 11 3100
Appliances

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Ranges.
2. Range hoods.
3. Cooktops.
4. Disposers.
5. Microwave ovens.
6. Dishwashers.
7. Refrigerators.
8. Washers and dryers.
9. Connection to utilities.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. GE Appliances. (www.geappliances.com)
2. KitchenAid. (www.kitchenaid.com)
3. Maytag Co. (www.maytag.com)
4. Sears Contract Sales. (www.contractsales.sears.com)
5. Whirlpool. (www.whirlpool.com)
6. Bosch (http://www.bosch-home.com/us)
7. Fisher and Paykel (http://www.fisherpaykel.com)

B. Substitutions: Under provisions of Division 01.

2.2 MANUFACTURED UNITS

A. Appliances: Scheduled at end of Section.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install appliances in accordance with manufacturer's instructions and approved shop Drawings.

B. Set plumb, level, and aligned.

C. Connect to supply water, designated waste water systems.

D. Connect to power supply.

3.2 ADJUSTING

A. Adjust appliances for proper operation.

3.3 SCHEDULE

APPLIANCE DESCRIPTION	MANUFACTURER	MODEL	FINISH
Dryer (Axxis One Condenser)	Bosch	WTC82100US	White
Washer/Dryer	LG	WM3987HW	White
Cooktop (30" Induction)	Bosch	NIT3065UC	Black
Refrigerator (18.1 Cu. Ft.)	Whirlpool	GB9FHDXW	Silver Metallic
Dishwasher (18")	F and P	DD24SI6V2	Stainless Steel
Oven/Microwave (30" Advantium)	Whirlpool	GH7208XRY	Stainless Steel
Stovetop	Bosch	NIT3065UC	Stainless Steel
Television	Samsung	UN46C5000QF	Black

3.4 Details

Appliance Selections

Dishwasher

Brand	Model	Dimensions HxWxD (in)	Energy/cycle	Enregy/week	water use	water/week	price
F & P	DD24SI6V2	16.25x23.5x22.5	0.72KWh	3.58KWh	2.11 G/cyc	10.55 G	$600

http://www.fisherpaykel.com/product/dishwashing/dishwashing/index.cfm?productuid=4F80663B-BA2F-320C-

Washer/Dryer

Brand	Model	Dimensions HxWxD (in)	Energy/load	Energy/week	Water/load	Water/week	Price
LG	WM3987HW	38.69x27x29.75	2.25KWh	18KWh	25 G	200 G	$1,364

http://www.lg.com/us/appliances/washer-dryer-combos/LG-steam-washer-WM3987HW.jsp

Television

Brand	Model	Dimensions HxWxD (in)	Size (in)	Energy use	Energy/Week Cost
Samsung	UN46C5000QF				
26.4x43.6x1.2	46	48 watts	.12 KWh	$1,250	

http://www.samsung.com/us/video/tvs/UN46C5000QFXZA

Stovetop

Brand	Model	Dimensions HxWxD (in)	Energy/load	Energy/Week	# of Burners	Price
Bosch	NIT3065UC	.25+4.13x31x21.25	1.68KWh	13.4KWh	4	$1,600

http://www.bosch-home.com/us/products/cooking/cooktops/induction/NIT3065UC.html?source=browse

Fridge Freezer

Brand	Model	Dimensions HxWxD (in)	Energy/Day	Energy/Week	Price
Whirlpool	GB9FHDXW	67x29.63x33.38	1.074KWh	8.592KWh	$1,150

http://www.whirlpool.com/catalog/product.jsp?src=REFRIGERATORS&cat=96&prod=1851

Microwave/Speedcook Oven/Vent Hood Combination Unit

Brand	Model	Dimensions HxWxD (in)	Capcaity	Price
Whirlpool	GH7208XRY	15.25x29.88x18.13	2.0 Cu. Ft.	$875

http://www.whirlpool.com/catalog/product.jsp?src=MICROWAVES&cat=90&prod=1298

END OF SECTION

Division 21: Fire Suppression

SECTION 21 01 00
Operation And Maintenance Of Water Based Fire Suppression Systems

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Water based sprinkler fire suppression system

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Tyco

B. Substitutions: Team may substitute equivalent when desired.

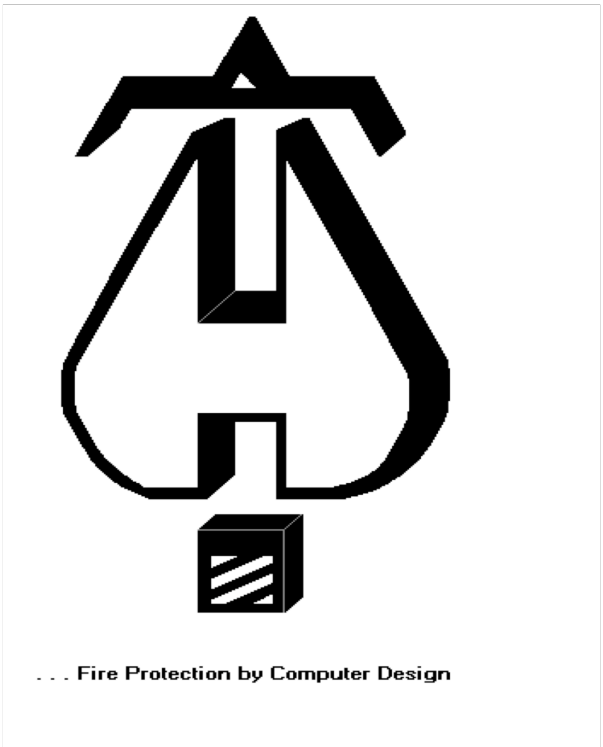
C. Materials:
1. Tyco: Series LFII Residential Flush Horizontal Sidewall Sprinklers

PART 3 EXECUTION

3.1 INSTALATION

A. Sprinklers are to be installed where indicated on drawings.

B. Pump to provide city water pressure equivalent on site in Washington D.C.



CODE Engineering Services
12015 Manchester Road
Suite 141
St. Louis, MO 63131
314-965-8052

Job Name : University of Illinois Solar Decathlon
Building :
Location :
System :
Contract :
Data File : Solar Decathlon.WXF

Computer Programs by Hydratec Inc. Route 111 Windham N.H. USA 03087

Water Supply Curve (C)

CODE Engineering Services
University of Illinois Solar Decathlon

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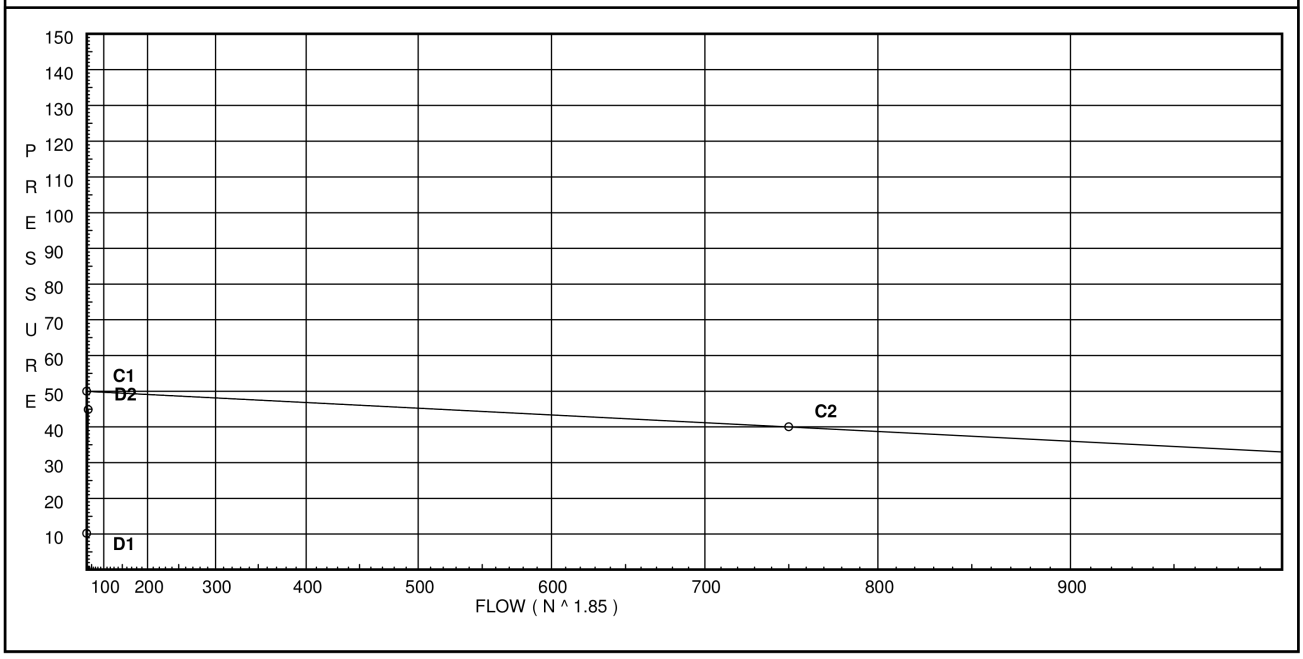
City Water Supply:
C1 - Static Pressure : 50
C2 - Residual Pressure: 40
C2 - Residual Flow : 750

Demand:
D1 - Elevation : 10.178
D2 - System Flow : 28.1067
D2 - System Pressure : 44.873
Hose (Adj City) : _____
Hose (Demand) : _____
D3 - System Demand : 28.1067
Safety Margin : 5.104



Computer Programs by Hydratec Inc. Route 111 Windham N.H. USA 03087

Fittings Used Summary

CODE Engineering Services
University of Illinois Solar Decathlon

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Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
N	CPVC 90'Ell Harvel-Spears	7	7	7	8	9	11	12	13	0	0	0	0	0	0	0	0	0	0	0	0
O	CPVC Tee - Branch	3	3	5	6	8	10	12	15	0	0	0	0	0	0	0	0	0	0	0	0

Pressure / Flow Summary - STANDARD

CODE Engineering Services
University of Illinois Solar Decathlon

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Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
SP1	7.5	4.2	11.11	na	14.0	0.1	140	11.1
AR1	7.5		11.37	na				
SP2	7.5	4.2	11.11	na	14.0	0.1	140	11.1
AR2	7.5		11.3	na				
H1	7.5	K = K @ AR1	11.37	na	14.0			
H2	7.5	K = K @ AR2	11.47	na	14.11			
3	7.5		13.45	na				
4	7.5		14.24	na				
TI	-1.5		18.83	na				
BFP	-6.0		33.14	na				
SRC	-16.0		44.87	na				

The maximum velocity is 9.47 and it occurs in the pipe between nodes H2 and 3

Final Calculations - Hazen-Williams

CODE Engineering Services
University of Illinois Solar Decathlon

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Hyd. Ref. Point	Qa Qt	Dia. "C" Pf/Ft	Fitting or Eqv.	Ln.	Pipe Ftng's Total	Pt Pe Pf	Pt Pv Pn	******* Notes ******
SP1	14.00	1.101	1N	7.0	0.333	11.111		K Factor = 4.20
to		150		0.0	7.000	0.0		
AR1	14.0	0.0352		0.0	7.333	0.258		Vel = 4.72
	0.0							
	14.00					11.369		K Factor = 4.15
SP2	14.00	1.101	1O	5.0	0.333	11.111		K Factor = 4.20
to		150		0.0	5.000	0.0		
AR2	14.0	0.0353		0.0	5.333	0.188		Vel = 4.72
	0.0							
	14.00					11.299		K Factor = 4.16
H1	14.00	1.101		0.0	2.917	11.369		K Factor @ node AR1
to		150		0.0	0.0	0.0		
H2	14.0	0.0353		0.0	2.917	0.103		Vel = 4.72
H2	14.11	1.101	1O	5.0	10.500	11.472		K Factor @ node AR2
to		150		0.0	5.000	0.0		
3	28.11	0.1277		0.0	15.500	1.979		Vel = 9.47
3	0.0	1.394	1N	8.0	11.500	13.451		
to		150		0.0	8.000	0.0		
4	28.11	0.0405		0.0	19.500	0.789		Vel = 5.91
4	0.0	1.394	1N	8.0	9.000	14.240		
to		150		0.0	8.000	3.898		
TI	28.11	0.0405		0.0	17.000	0.688		Vel = 5.91
TI	0.0	1.394	1N	8.0	1.000	18.826		
to		150		0.0	8.000	13.949		* Fixed loss = 12
BFP	28.11	0.0404		0.0	9.000	0.364		Vel = 5.91
BFP	0.0	1.265	1N	8.0	100.000	33.139		
to		150	1O	6.0	14.000	4.331		
SRC	28.11	0.0649		0.0	114.000	7.403		Vel = 7.18
	0.0							
	28.11					44.873		K Factor = 4.20

END OF SECTION

Division 22: Plumbing

SECTION 22 1219
GROUND-MOUNTED, POTABLE-WATER STORAGE TANKS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Potable water storage tanks.
2. Grey water storage tanks.
3. Water Treatment Tanks

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. CMRI
2. The Tank Depot
3. The Tank Store
4. Contico

B. Substitutions: Team may substitute equivalent when desired.

PART 3 EXECUTION

3.1 INSTALLATION

A. Water tanks are to be installed where noted on drawings.

B. Water tanks shall be contained in enclosed deck element in order to ensure shading from 9:00am-5:00pm during the competition period.

C. Water tanks are two be installed on 4x4 wood members to ensure 3.5” resting height above ground level.

3.2 SCHEDULE

SET NO.	QUANTITY	DESCRIPTION
500 RT	2	500 gallon potable water tank. (1:Potable, 1:Greywater Storage)
200 RT	2	200 gallon potable water tank (1:Potable, 1:Blackwater Storage)
GII-RW50	4	50 gallon rainwater catchment tank
Contico 1320BK-1	4	23 gallon rainwater catchment tank
SP0050-RT	1	50 gallon holding tank

3.3 Products

	Product	Model	Size	Capacity
1.	Good Ideas Rain Wizard	GII-RW50	22”x22”x31”	50 Gallons
2.	Contico Storage Locker	1320BK-1	31”x17”x13”	23 Gallons
3.	Tank Store	SP0050-RT	38”x19”x23”	50 Gallons
4.	Tank Store		48”x92”x29”	500 Gallons
5.	Tank Store		48”x40”x29”	250 Gallons

See construction documents for detailed drawings of water tanks.

END OF SECTION

SECTION 22 0500
Common Work Results For Plumbing

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. PEX piping
2. PVC piping

PART 2 PRODUCTS

2.1 MATERIALS

A. PEX piping is to be selected by modular home manufacturer

B. PVC piping is to be selected by modular home manufacturer

C. Substitutions: The team and modular home manufacturer may make equivalent substitutions where appropriate and code compliant.

PART 3 EXECUTION

3.1 INSTALLATION

A. PEX piping:
1. Is to be utilized for all water piping.
2. Pipes to be stubbed from floor system to opening.

B. PVC piping is to be selected by modular home manufacturer
1. Is to be utilized for all waste and vent piping
2. Pipe to be stubbed from floor system or roof to opening.

END OF SECTION

SECTION 22 3200
Domestic Water Filtration Systems

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Greywater pumps
2. Water Filters
3. Supply System Pump
4. Black Water Drainage System Pump
5. Grey Water Drainage System Primary Pump
6. Grey Water Heat Recovery System Heat Exchanger

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers
1. Little Giant
2. Zoeller
3. Atlantic UV
4. Pentek
5. FlatPlate
6. LVM
7. Simer
8. Flotec

B. Substitutions: Team may substitute equivalent when desired.

BRAND	DESCRIPTION	MODEL	COST
LITTLE GIANT	Mag-Drive 720GPH sump pump	566720	80
ZOELLER	115V, Mechanical double-ball float switch	1016864	110
ATLANTIC UV	3GPM, 24W UV Treatment	MIN-3	375

BRAND	DESCRIPTION	MODEL	COST
PENTEK	10” filter housing	3G #10 3/4” CLEAR	100
PENTEK	20” filter housing	3G #20 3/4” CLEAR	50
PENTEK	Stage 1 depth filter	PD-1-934	5
PENTEK	Stage 1 carbon filter	C1	15
PENTEK	Stage 2 UF filtration	MG-10T	160
Guzzler	Water Pump-8 G.P.M 1.25lbs, 10”x5”x4”	400H	70

SUPPLY SYSTEM PUMP:
Shallow Well Jet Pump w/ Pressure Tank
Make: Flotec
Model Number: FP410515H
Power: ½ HP
Voltage: 115 VAC
Pressure Switch: 30/50 psi
Maximum Pressure: 63 psi
Inlet: 1” NPT
Outlet: 1” NPT
Pressure Tank: Pre-charged 15 gallon equivalent diaphragm tank
Heavy-duty cast iron pump housing
Self-priming after pump housing is initially filled

BLACK WATER DRAINAGE SYSTEM PUMP:
Make: Simer
Model:2905 04
Power: ¼ HP, 6A
Switch Type: float
On/Off: 11”/4”

Discharge: 1.25” NPT
Flow: 1260 GPH @ 0’; 1020 GPH @ 10’; 480 GPH @ 20’
Max Lift: 25’

GREY WATER DRAINAGE SYSTEM PRIMARY PUMP:
LVM 141
Flowrate: 3.36 gpm @ 14psi
Max temperature: 60ºC
Submersible/gravity feed.
Intermittently rated.

GREY WATER HEAT RECOVERY SYSTEM HEAT EXCHANGER:
FlatPlate FP3x8 14 (3/4”MPT) MMC
No. of Plates: 14
Width: 3.3 in, 83.82 mm
Length: 7.8 in, 198.12mm
Depth: 1.6 in, 40.64mm
Connections: ¾” MPT
Weight: 3.2 lbs, 1.45 kg
Plate Material: 316L Stainless Steel
Braze Material: Copper
Maximum Working Temperature: 350 F, 176.67 C
Minimum Working Temperature: 320 F, 195.56 C
Maximum Working Pressure: 450 psig, 3102.6 kPa

END OF SECTION

SECTION 22 3300
Electric Domestic Water Heaters

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. General Water Heaters
2. Unitary Heat Pump Booster

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers (Water Heater):
1. Bosch (www.bosch.com)

C. Substitutions: The team may make equivalent substitutions where appropriate.

2.2 MATERIALS

A. Bosch Compress HP 200-1:
1. Type: Hybrid Hot Water Heater
2. Capacity: 50 Gal
3. First Hour Delivery: 58 Gal
4. Height: 64.5”
5. Diameter: 22.4”
5. Heating Power: 1.8 kW
6. Electric Consumption: 0.7 kW
7. Operation Modes: Economic, Electric, Auto, and Vacation

END OF SECTION

Division 23: Heating, Ventilating, and Air Conditioning (HVAC)

SECTION 23 0000
HEATING, VENTILATING, AND AIR CONDITIONING

CERV – Conditioning Energy Recovery Ventilator

The CERV or conditioning energy recovery ventilator is a small, modular, variable capacity air source heat pump system designed to provide comfort conditioning and ventilation for super-insulated, super-sealed structures. The CERV provides the ability to heat, cool, dehumidify, and ventilate within a single system package. It is a self contained, hermetically sealed heat pump unit that does not require refrigerant line-sets or on-site refrigerant charging. This eliminates the need for a specialized refrigeration technician for installation. The system consists of conditioning modules, an air valve module for directing heating, cooling, and fresh air, and a control box. Several conditioning modules can be connected together to build up to a desired capacity. Separate systems can also be installed in a building to provide conditioning in different zones. While smaller in capacity than traditional residential systems, the CERV is the most advanced conditioning system available for home comfort. Internal temperature, humidity, and VOC sensors are used in conjunction with control algorithms to direct the CERV to provide fresh air and comfort conditioning in the most efficient way possible. The configuration of the CERV allows it to provide free cooling, free heating, and energy recovery when necessary. Using components from the appliance industry, the CERV is also among the quietest systems anywhere.

Equipment Cost:

1)	Air valve damper box and blowers	$1,500
2)	Premium control package (T, %RH, and VOC sensing)	500
3)	CERV conditioning module	1,500
	Total	$3,500

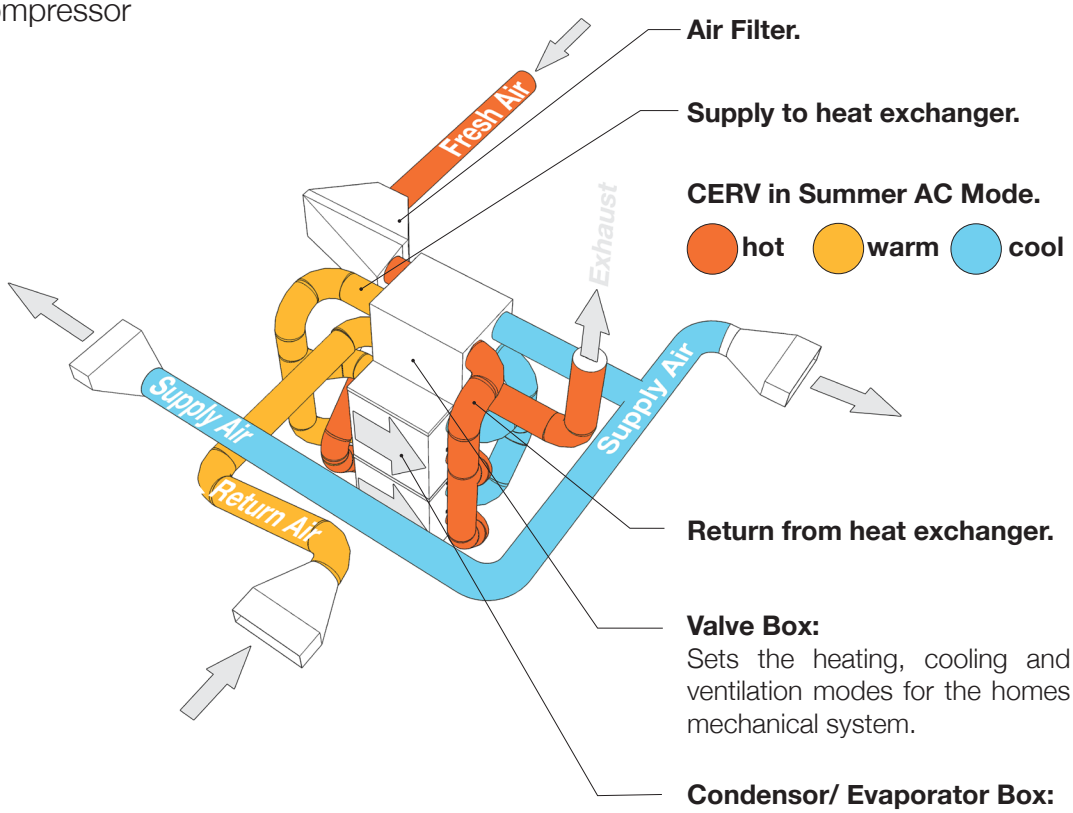
Specifications:

Modes of Operation
Heating (w/ and w/o ventilation)
Cooling (w/ and w/o ventilation)
Dehumidification

1500-2000W heating and cooling capacity
COP 3-5
R-134a Refrigerant
19.5”x17.5”x22.5” (LxWxH)

Variable Speed Compressor
UL Listed
500W
120 VAC

Fans (2)
UL Listed
50 W each
50 CFM



CERV Schematic. See Construction Documents for more information

END OF SECTION

Division 26: Electrical

SECTION 26 0500
Common Work Results For Electrical

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. 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. Comply with NFPA 70

PART 2 PRODUCTS

2.1 GROUNDING MATERIALS

A. Conductors: Solid for No. 8 AWG and smaller, and stranded for No. 6 AWG and larger unless otherwise indicated.
1. Bare, Solid Copper Conductors: Comply with ASTM B 3.

B. Grounding Rod
1. http://www.grainger.com/Grainger/items/2KXL8

PART 3 EXECUTION

3.1 GENERAL ELECTRICAL EQUIPMENT INSTALLATION REQUIREMENTS

A. Install electrical equipment to allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

B. Install electrical equipment to provide for ease of disconnecting the equipment with

minimum interference to other installations.

C. Install electrical equipment to allow right of way for piping and conduit installed at required slope.

D. Install electrical equipment to ensure that connecting raceways, cables, wireways, cable trays, and busways are clear of obstructions and of the working and access space of other equipment.

E. Install required supporting devices and set sleeves in cast in place concrete, masonry walls, and other structural components as they are constructed.

F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Comply with requirements in Division 08 Section "Access Doors and Frames."

G. Install sleeve and sleeve seals of type and number required for sealing electrical service penetrations of exterior walls.

H. Comply with NECA 1.

3.2 RACEWAY AND CABLE INSTALLATION

A. Outdoor Raceway Applications

1. Boxes and Enclosures: Metallic, NEMA 250, Type 3R or Type 4.

B. Indoor Raceway Applications

1. Exposed or Concealed: EMT

a. 26 05 33.A1 1” EMT http://www.grainger.com/Grainger/wwg/productIndex.shtml?L2=EMT&operat or=prodIndexRefinementSearch&originalValue=1%22+EMT+&L1=Conduit%2C

b. 26 05 33.A3 2” EMT http://www.grainger.com/Grainger/items/5ZM23

3.3 GROUNDING

A. Underground Grounding Conductors

1. 26 05 26.A1 Grounding Rod http://www.grainger.com/Grainger/items/2KXL8

END OF SECTION

SECTION 26 0923
Lighting Control Devices

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Light Switches
2. Load Controllers
3. Channel Controllers
4. Room Controllers

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Echoflex
2. Verve Living Solutions
3. Can2Go

B. Substitutions: Team may substitute manufactures when desired

2.2 MATERIALS

Product:	Manufacturer:	Model Number:	Other Info:
Double Rocker Light Switch	Echoflex	PTM265DCW	Two rocker light switches that are wireless and battery-free, using the energy from flipping the switch to send a radio frequency signal.
Single Rocker Light Switch	Echoflex	PTM265C	One rocker light switch that is wireless and battery-free, using the energy from flipping the switch to send a radio frequency signal.
Wireless Load Controller	Echoflex	ERM-DLC	Attachement to light fixture that recieves wireless radio frequency signal to turn light on/off.
10 - Channel Controller	Verve Living Solutions	VLS-10CH	Radio frequency reciever that can turn on/off or dim 10 different groups of lights
Room Controller	CAN2GO	RC1-A0X-00	Room Controller that connects to computer through eithernet and acts as middle man between light switches and load controllers

PART 3 EXECUTION

3.1 INSTALLATION

A. Install per manufacturers recommendations.

END OF SECTION

SECTION 26 2000
Low-Voltage Electrical Distribution

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Meter Housing
2. Utility Feeder Disconnect
3. AC Disconnect from PV
4. Load Center
5. Combiner Box

PART 2 PRODUCTS

2.1 MATERIALS

A. METER HOUSING:

UHTRS213B Meter Socket Ampere Rating 200A
Approvals UL Listed
Wire Binding 1/2 Inch Hex
Wiring Configuration 3-Wire
Depth 4.38 Inches
Height 15.00 Inches
Width 11.00 Inches
Box Number 5R
Bypass Horn
Closing Plate ACP
Hub Opening Series A
Enclosure Material Steel
Socket Type Ringless
Ground Wire Size #14 to #2 AWG (Al/Cu)
Includes Bonded Neutral

Enclosure Rating NEMA 3R
Enclosure Type Rainproof & Ice/Sleet Proof (Indoor/Outdoor)
Jaw Release No
Line/Load/Neutral Wire Size #1/0 to 350 AWG/kcmil (Al/Cu)
Voltage Rating 600VAC
Number of Jaws 4
Number of Sockets 1
Phase 1-Phase
Service Feed Location OH/UG
Type Individual

B. UTILITY FEEDER DISCONNECT:

D224NRB Safety Switch Terminal Type Lugs
Type of Duty General Duty
Maximum Voltage Rating 240VAC
Wire Size #2 to 300 AWG/kcmil(Al) - #4 to 300 AWG/kcmil(Cu)
Depth 8.25 Inches
Height 29.25 Inches
Width 17.25 Inches
Action Single Throw
Ampere Rating 200A
Approvals UL Listed File: E2875
Enclosure Rating NEMA 3R
Enclosure Type Rainproof and Sleet/Ice proof (Indoor/Outdoor)
Enclosure Material Galvannealed Steel
Factory Installed Neutral Yes
Fuse Type Cartridge (Class H, K or R)
Disconnect Type Fusible
Short Circuit Current Rating 100kA (max. depending on fuse type)
Mounting Type Surface
Number of Poles 2-Pole

C. AC DISCONNECT FROM PV:

D223NRB Safety Switch Terminal Type Lugs
Type of Duty General Duty
Maximum Voltage Rating 240VAC
Wire Size #12 to #1/0 AWG(Al) - #14 to #1/0 AWG(Cu)
Depth 6.50 Inches
Height 17.50 Inches
Width 8.50 Inches
Action Single Throw
Ampere Rating 100A
Approvals UL Listed File: E2875
Enclosure Rating NEMA 3R
Enclosure Type Rainproof and Sleet/Ice proof (Indoor/Outdoor)
Enclosure Material Galvannealed Steel
Factory Installed Neutral Yes
Fuse Type Cartridge (Class H, K or R)
Disconnect Type Fusible
Short Circuit Current Rating 100kA (max. depending on fuse type)
Mounting Type Surface
Number of Poles 2-Pole

D. LOAD CENTER:

QO12040M200 Load Center Main Type Convertible - Factory installed main breaker
Maximum Single Pole Circuits 40
Maximum Tandem Circuit Breakers 20
Phase 1-Phase
Spaces 20
Ampere Rating 200A
Voltage Rating 120/240VAC
Application Designed to meet residential, commercial and industrial requirements to protect electrical systems, equipment and people.
Wire Size #4 to 250 AWG/kcmil (Al/Cu)
Wiring Configuration 3-Wire
Depth 3.75 Inches
Height 29.86 Inches

Approvals UL Listed
Cover Type Order separately
Width 14.25 Inches
Bus Material Tin Plated Copper
Enclosure Type Indoor
Box Number 9
Enclosure Rating NEMA 1
Grounding Bar Order separately
Short Circuit Current Rating 22kA

E. COMBINER BOX:

QO612L100TRB Load Center Short Circuit Current Rating 10kA
Main Type Fixed - Factory installed main lugs
Maximum Single Pole Circuits 12
Maximum Tandem Circuit Breakers 6
Phase 1-Phase
Spaces 6
Ampere Rating 100A
Voltage Rating 120/240VAC
Wire Size #8 to 1 AWG(Al/Cu)
Application Designed to meet residential, commercial and industrial requirements to protect electrical systems, equipment and people.
Wiring Configuration 3-Wire
Depth 4.27 Inches
Approvals UL Listed
Height 12.65 Inches
Cover Type Surface
Width 8.88 Inches
Bus Material Tin Plated Aluminum
Enclosure Type Outdoor/Rainproof
Box Number 2R
Enclosure Rating NEMA 3R
Grounding Bar Factory Installed

PART 7 EXECUTION

7.1 INSTALLATION

A. Install per manufacturers recommendations.

END OF SECTION

SECTION 26 3100
Photovoltaic Collectors

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Roof mounted crystalline photovoltaic panels
2. Canopy mounted building integrated bi-facial photovoltaic panels

B. Related Sections:
1. Division 01: Team may make equivalent substitutions where appropriate

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Sunpower Corp. (www.suncorp.com)
2. Sanyo (www.us.sanyo.com)

B. Substitutions: Team may substitute manufactures where desired

2.2 MATERIALS

A. Sunpower E18/230 Photovoltaic Panel (quantity 24)
1. Efficiency: 18.5 %
2. Watts per panel: 230 W
3. System kWs: 5.5 (24 panels @ .23 kW)
4. Rated Voltage: 40.5 V
5. Rated Current: 5.68 A
6. Panel Dimensions: 61.39” x 31.42”

B. Canopy Mounted Sanyo HIT Double 195 Photovoltaic Panel (Quantity: 6)

1. Efficiency: 16.1 %
2. Watts per panel: 195 W
3. System kWs: 1.17 kW (6 panels @ .195 kW)
4. Rated Voltage: 55.8 V
5. Rated Current: 3.5 A
6. Dimensions: 53.2” x 35.35” x 2.36”

PART 3 EXECUTION

3.1 INSTALLATION

A. Install per manufacturers recommendations.

B. Position roof mounted photovoltaics at optimum angle related to location latitude. For Washington D.C. this angle is 43 degrees from horizontal.

C. Secure photovoltaics adequately in order to withstand all wind and dead load forces present at any time.

END OF SECTION

Division 48: Electrical Power Generation

SECTION 48 1916
Electrical Power Control Equipment

PART 1: GENERAL

1.1 SUMMARY

A. Section Includes:
1. Invertors

B. Related Sections:
1. Division 26 3100: Photovoltaic Collectors.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. Sun Power Corp. (www.sunpowercorp.com)
2. Kaco

B. Substitutions: Team may make equivalent substitutions when appropriate.

2.2 PRODUCTS

A. SPR 5000M Inverter:
1. http://us.sunpowercorp.com/downloads/product_pdfs/inverters/SunPower_Inv erters567000m_DS.pdf
2. AC Power 5000 W
3. Efficiency: 96.8%

B. Kaco 1502 XI Inverter
1. http://www.kaco-newenergy.com/

2. AC Power 1500 W
3. Efficiency: 95.5%

PART 3 EXECUTION

3.1 INSTALLATION - GENERAL

A. Install in accordance with manufacturers instructions.

B. Inverters are to be removed during shipment and installed to the pre-wired photovoltaic system once the home is assembled on site.

END OF SECTION

Re_home
University of Illinois at Urbana-Champaign

Appedix A: Stamped Structural Calculations

David Wickersheimer, PESE
MSA Professional Services
(217) 352-6976

As Built Document Submittal
August 11, 2011

MSA
PROFESSIONAL SERVICES
TRANSPORTATION • MUNICIPAL
DEVELOPMENT • ENVIRONMENTAL

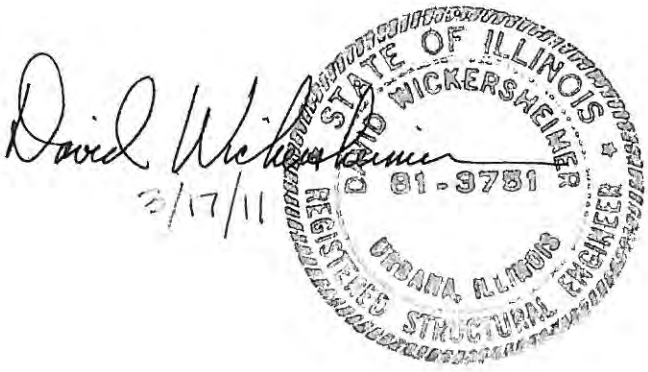
Re_home

University of Illinois
611 Lorado Taft Dr.
Champaign, IL 61820

U.S. Department of Energy

SOLAR DECATHLON 2011

Structural Calculations



David Wickersheimer
Project Engineer

March 17, 2011

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Sheet 1 of 36
Project SOLAR DECATHLON 2011 Comp. by DJW
Date 1/8/11 Ckd. by
Proj. No. 2474004

ROOF DL

SOLAR PANELS
2 SETS/UNIT

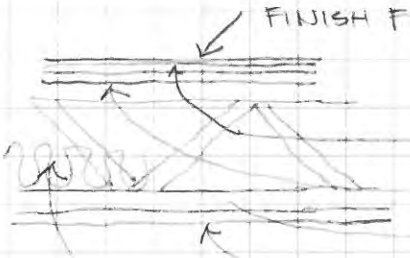
SANYO HIT POWER 215N
WT: ~ 3.0 PSF x 2 = 6 PSF
~ 36 LB x 34/2 = 17 = 612 LB / 408 = 1.5 PSF

ROOF CONSTRUCTION:

EPDM RUBBER RFG : ADHERED : 1 PSF
J/M 2½ FOAM BRD INSUL : 0.75 PSF
7/16 OSB : 1.7 PSF
OPEN JST PITCHED TRUSSES: 2.6 PLF (1'/2') = 1.3 PSF
5/8" DRYWALL : 2.8 PSF
SPRAY FOAM INSUL
2.0 PCF (1') = 2.0 PSF

ΣDL = 11.05 PSF

FLOOR DL



LINOLEUM / ¼" WOOD / TILE : 1 PSF
UNDERLAYMENT 2 PSF
SUBFLOOR: ¾ OSB : 2.5 PSF
OPEN JOIST 2000-9 3/8"
@ 16" O.C. = 2.4 PLF (12/16) = 1.8 PSF
OR ¾" CEMENT BOARD 2.4 (.75/.75) = 3.6 PSF ← either
¾" PLYWOOD (TREATED) 2.3 PSF ← OR
SPRAY FOAM (2 PCF (9/12) = 1.5 PSF

ΣDL = { 11.1 PSF MIN / 12.4 PSF MAX

Johns Manville

ENRGY 3® Plus

INSULATION BOARD

Product Description

ENRGY 3 Plus is a rigid roof insulation board composed of a closed cell polyisocyanurate foam core bonded in the foaming process to ½" (1.27 cm) high-density wood fiberboard on one side and a fiber-reinforced facer on the other. ENRGY 3 Plus is designed for direct application to steel and other roof decks, and is compatible with virtually all roof covering membranes.

ENRGY 3 Plus utilizes an environmentally compliant blowing agent containing pentane hydrocarbon to enhance the thermal performance of the foam insulation. This hydrocarbon has zero ozone depletion potential and conforms to the Montreal Protocol established in 1987.

ENRGY 3 Plus meets the physical property requirements of ASTM C 1289, Type IV and CAN/ULC S704, Type 3, Class 2 (See CCMC Evaluation Report 13058-L).

ENRGY 3 Plus specialty products are also available as tapered panels, precut miters and precut crickets.

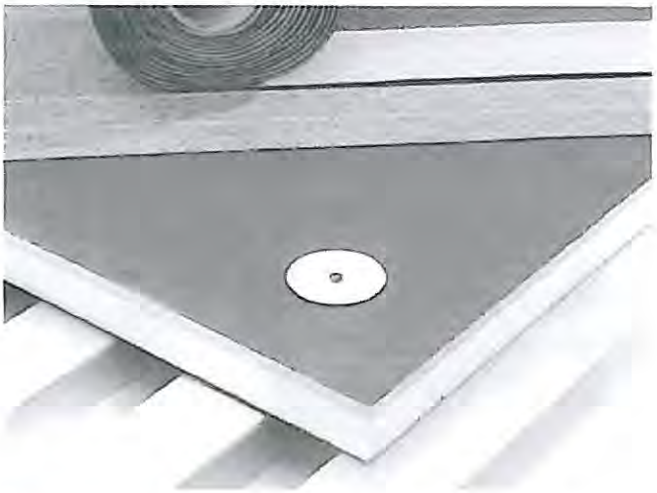
Third-party certification with the PIMA Quality Mark™ for Long-Term Thermal Resistance (LTTR) values.

Applications

- FM Class 1, UL Class A Constructions
- Single Ply Roof Systems:
  Adhered, Mechanically Attached, Ballasted
- Modified Bitumen Roof Systems
- Built-Up Roof Systems

Features and Benefits

ENRGY 3 Plus is a highly efficient thermal insulation with high R-Value and low installed cost. When installed facing up, the coated fiberboard provides an excellent base for conventional built-up roofing, modified bitumen and single ply systems.



Standard Sizes

ENRGY 3 Plus is available in standard 4' x 4' (1.22 m x 1.22 m) or 4' x 8' (1.22 m x 2.44 m) boards and in thicknesses of 1.5" (3.81 cm) to 4" (10.16 cm).

Codes & Compliances

Underwriters Laboratories Inc.

- Component of Class A roof systems: Single Ply (UL 790) – Ballasted, Adhered, Mechanically Attached, Built-Up, Modified Bitumen.
- Hourly Rated P-Series roof assemblies (UL 263).
- Insulated metal deck assemblies (UL 1256).
- ENRGY 3 Plus classified by ULC.

FM Global®

- FM approved for Class 1-60 and 1-90 assemblies with built-up, adhered and mechanically attached single ply roof coverings subject to the conditions of approval described in current FM Global Approval Guide and Supplements (reports available on request).

Typical Physical Properties

	Values	Test Method
Thermal Performance	As required.	ASTM D 518
Dimensional Stability Change	2% max, 7 days (length and width)	ASTM D 2126
Moisture Vapor Transmission*	< 1 perm 57.5 ng/Pa•s•m²	ASTM E 96
Water Absorption	< 2% by volume	ASTM C 209
Service Temperature	-100°F - 250°F (-73°C - 121°C)	

* Foam core only

Refer to the Material Safety Data Sheet and product label prior to using these products.

Thermal Performance

Thickness (nom.) (in.)	(cm)	C-Value (Conductance) BTU/(hr•ft²•°F)	W/m²•°C	LTTR* R-Value (hr•ft²•°F)/BTU	m²•°C/W	Flute Spanability (in.)	(cm)
1.5	3.81	0.137	0.78	7.30	1.29	3⅛	9.21
1.6	4.06	0.127	0.72	7.90	1.39	3⅛	9.21
1.7	4.32	0.118	0.67	8.50	1.50	3⅛	9.21
1.8	4.57	0.110	0.62	9.10	1.60	3⅛	9.21
2.1	5.33	0.092	0.52	10.90	1.92	3⅛	9.21
2.3	5.84	0.082	0.47	12.20	2.15	4⅜	11.11
2.5	6.35	0.075	0.43	13.40	2.36	4⅜	11.11
2.7	6.86	0.068	0.39	14.70	2.59	4⅜	11.11
3.0	7.62	0.060	0.34	16.60	2.92	4⅜	11.11
3.1	7.87	0.050	0.28	19.10	3.37	4⅜	11.11
3.3	8.38	0.054	0.31	18.50	3.26	4⅜	11.11
3.6	9.14	0.049	0.28	20.40	3.60	4⅜	11.11
4.0	10.16	0.043	0.24	23.00	4.05	4⅜	11.11

* The Long-Term Thermal Resistance (LTTR) values were determined in accordance with CAN/ULC S770.

2.5" PANEL: 4x8 · 24 LB ∴ 0.75 PCF

4.0" PANEL 4x8 · 33 LB ∴ 1.03 PCF

6 LB/IN FOR INSUL. + 9 LB FOR WOOD ON 4'x8' SHEET

NCFI POLYURETHANES
Division of BMC
P. O. Box 1528 • Mount Airy, NC 27030
800.346.8229 www.NCFI.com

TECHNICAL DATA SHEET

SPRAY FOAM SYSTEM 11-016

DESCRIPTION:

11-016 is a two component, one-to-one by volume, self-adhering, seamless, high insulating efficiency spray applied closed cell polyurethane foam system. This NCFI system has been formulated with HFC-245fa as the blowing agent and contains an anti-microbial ingredient to inhibit the growth of molds. 11-016 is suitable for use in the NCFI InsulStar® insulation system as well as other insulation applications. 11-016 is certified for application in Type I, II, III, IV & V buildings and is approved for ABAA projects. Complies with ASTM C1029 and AC 377.

DISTINGUISHING CHARACTERISTICS:

- High R-Value
- Zero ODP
- Moisture Vapor Retarder - Class II @ 1.3"
- High Yields
- High Closed Cell Content
- Air Barrier, ABAA Certified
- Good Dimensional Stability
- Meets ASTM E-84, FS ≤25, SD ≤450 @ 4"
- FEMA Flood Resistance - Class 5
- Water Resistive Barrier (AC71)
- Passed NFPA 285
- Approved in multiple UL Fire Resistive Assemblies

For proper use of this NCFI insulating material refer to the NCFI Application Information and any of the following codes or guides:

- International Building Code, (IBC), Chapter 26
- International Residential Code (IRC) Section R316 and R806
- API Fire Safety Guidelines for Use of Rigid Polyurethane and Polyisocyanurate Foam Insulation in Building Construction (AX230)

Installation Limitations
Limits based on NFPA 286

When covered with 1/2" gypsum board	Maximum Thickness in walls	Maximum Thickness in Ceilings
11-016	8"	12"

TYPICAL PHYSICAL PROPERTIES:

Core Density - ASTM 1622	2.0 pcf
Compressive Strength ASTM D 1621	27 psi
Moisture Vapor Transmission - ASTM E 96	1.3 perm·in
Closed Cell Content ASTM D 6226	>90%
R value @ 1 inch ASTM C 518 @3.5 inch	6.8 23.4
Air Permeance - Infiltration ASTM E 283 & 2178 Exfiltration	0.000 cfm/ft² @ 1.57 psf 0.000 cfm/ft² @ 1.57 psf
Bacterial & Fungal Growth ASTM G 21 & E 1428	Negligible*
STC - ASTM E 90 OITC	31** 24**
Flammability ASTM E-84 @ 4 inches	Flame Spread ≤25 Smoke Dev ≤450
Max Service Temperature	180°F
Water Penetration AATCC 127-1998 @ 56 Feet	No Failure

Note: The above values are average values obtained from laboratory experiments and should serve only as guide lines. Free rise core density should not be confused with overall density. Overall densities are always higher than free rise core densities and take into account skin formation, thickness of application, environmental conditions, etc.

*NCFI 11-016 is formulated with an anti-microbial. See back of this page for details.
** As measured in 2" x 4" studwall assembly

11-016 APPLICATION INFORMATION

EQUIPMENT AND COMPONENT RATIOS:

It is preferred that this system be processed with Graco Polyurethane Spray Equipment. 11-016R is connected to the resin pumps with 11-016A being connected to the isocyanate pumps. The proportioning pump ratio is 1 to 1. Graco preheater and hose temperature should be set at 130°F to give a good pattern. For high-pressure equipment, temperature settings may be slightly higher.

STORAGE AND USE OF CHEMICALS:

Keep temperature of chemicals above 70°F for several days before use. Cold chemicals can cause poor mixing, pump cavitations or other process problems due to higher viscosity at lower temperatures. Storage temperature should not exceed 90°F. Do not store in direct sunlight. Keep drums tightly closed when not in use and under nitrogen pressure of 2-3 psi after they have been opened. The shelf life of 11-016 is six months.

SAFE HANDLING OF LIQUID COMPONENTS:

Use caution in removing bungs from the container. Loosen the small bung first and let any built up gas escape before completely removing. **R component will froth at elevated temperatures.** Avoid prolonged breathing of vapors. In case of chemical contact with eyes, flush with water for at least 15 minutes and get medical attention. For further information refer to "MDI-Based Polyurethane Foam Systems: Guidelines for Safe Handling and Disposal" publication AX-119 published by the Center For The Polyurethanes Industry 1300 Wilson Blvd, Suite 800, Arlington, VA 22209.

PREPARATION OF SURFACE TO BE SPRAYED:

11-016 is suitable for application to most construction materials including wood, masonry, concrete, and metal. Application can be to the interior or exterior side of wall surfaces. All surfaces to be sprayed should be clean, dry, and free of dew or frost. All metal to which foam is to be applied must be free of oil, grease, etc. The maximum thickness of each layer or pass of foam should be 2" and allow 10 minutes between each pass for cooling. Multiple layers can be applied to reach the desired R value.

OPTIMUM ADHESION TEMPERATURE OF SURFACE TO BE SPRAYED:

On general work where the surface to be sprayed will remain at ambient temperature or cooler, the surface should be between 10°F and 120°F. In this range the warmer the surface the better the adhesion. NCFI has two grades of 11-016 foam for this application range, G-series for 50°F to 120°F and X-series for temperatures 10°F to 60°F. For best results, when surfaces to be sprayed are cooler than 60°F a flash coat should be applied with the second coat following as soon as the original coat is no longer tacky to the touch. Also, NCFI differentiates between formulas designed to be sprayed at low altitudes (below 4000 ft) versus high altitudes by "L" and "H".

GL— Warm weather at low altitudes
GH— Warm weather at high altitudes
XL— Cold weather at low altitudes
XH— Cold weather at high altitudes

WEATHER PROTECTION OF FINISHED FOAM ON EXTERIOR APPLICATIONS:

The finished surface of sprayed polyurethane foam should be protected from adverse effects of ultraviolet rays of direct sunlight, which can cause dusting and discoloration. Protective coatings designed for use with polyurethane foam are available. Where an exterior masonry veneer or mechanically attached covering is to be installed, the foam surface may be exposed to UV light up to 6 months.

VAPOR BARRIER PROTECTION ON COLD STORAGE APPLICATIONS:

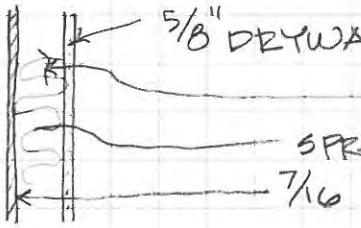
When NCFI sprayed polyurethane foam insulates structures subject to continuous cold temperatures, such as coolers and freezers, a Class I moisture vapor barrier (0.1 perm or less) is normally required on the "warm" side of the foam insulation. Contact NCFI for specific recommendations.

CODE-COMPLIANT FIRE RESISTANCE:

Where foam is sprayed over large areas of building interiors, building codes require the installation of an approved thermal barrier between the foam plastic insulation and the interior of the building. ½" gypsum board or other tested and approved material may be installed as a thermal barrier. Refer to specific building codes for details. Contact NCFI Polyurethanes for specific alternate approvals for 11-016.

*NCFI 11-016 is formulated with an anti-microbial ingredient to inhibit the growth of molds. The anti-microbial properties do not protect occupants of spaces insulated with 11-016 from potential deleterious effects of molds, mold spores, or disease organisms that may be present in the environment.

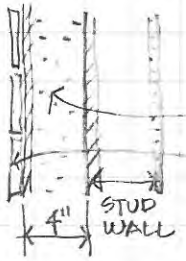
EXTERIOR WALL DL:



5/8" DRYWALL	: 2.8 PSF
2x4 @ 2'-0	: 0.7 PSF
SPRAY FOAM: 2 PCF x (3.5/12)	: 0.58 PSF
7/16 OSB	: 1.7 PSF
ΣDL =	5.78 PSF

9' - 4½" = 8.625 FT @ 8.625' = 49.85 PLF

3 - 2x4 @ 3 (1.3 PLF) =	3.9 PLF
3 - 2x10 @ 3 (3.4 PLF) =	10.2 PLF
INTERM DLΣ =	63.95 PLF



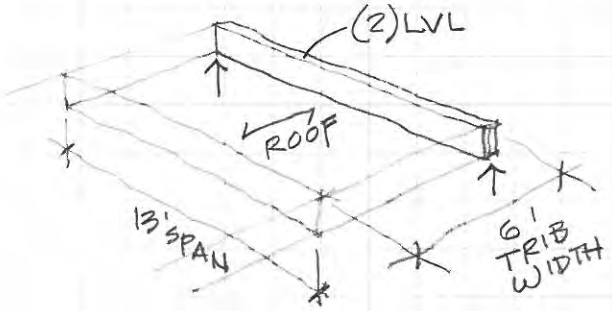
TREATED FURRING: 3/4x2 @ 24: 0.5 PSF (1/2) =	0.25 PSF
JOHN MANVILLE 4" FOAM BRD INSUL =	1.03 PSF
1" CEDAR BEDS + FURRING	1.5 PSF
EXT FIN. DLΣ =	2.78 PSF

@ 10' = 27.8 PLF

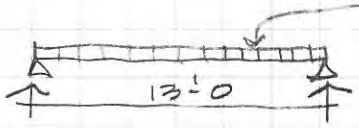
ΣEXT. WALL DL = 91.75 PLF

INTERIOR WALL DL = 63.95 PLF

HEADER DL (ONE SIDE/ONE UNIT)



ROOF DL = 11.05 PSF x 6' = 66.3 PLF



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Sheet 3 of
Project SOLAR DECATHLON 2011 Comp. by DJW
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LIVE LOADS: Washington D.C

SEISMIC CATEGORY: A $\%g = 17$

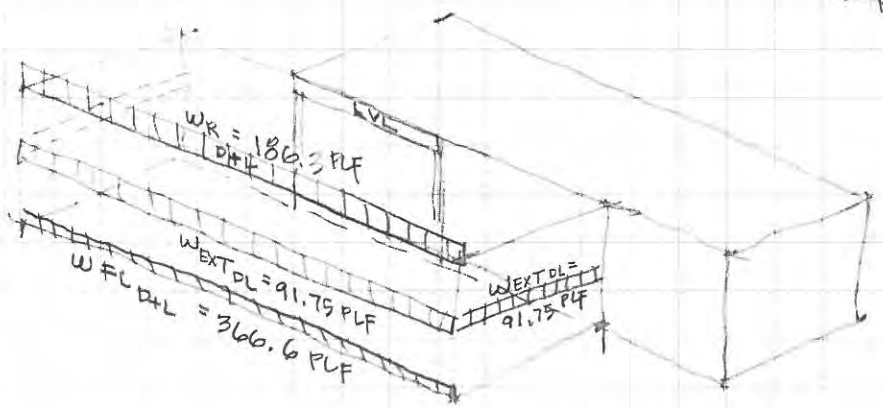
SNOW: $P_g = 20^{PSF}$

WIND: 60 MPH (GIVEN) BASIC WIND SPEED
3 SEC GUST
EXPOSURE C
for 15' adj to C&C values = 1.21

FLOOR LL = 50^{PSF} (GIVEN)

SUMMARY OF GRAVITY LOADS TO FOUNDATION

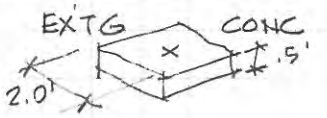
$W_{ROOF_{D+L}} = 11.05^{PSF}_{DL}(6') + 20^{PSF}_{LL}(6')$
$= 66.3^{PLF} + 120^{PLF}$
$= 186.3^{PLF}$



$W_{FL_{D+L}} = 11.1^{PSF}_{DL}(6') + 50^{PSF}_{LL}(6')$
$= 66.6^{PLF} + 300^{PLF}$
$= 366.6^{PLF}$

FOOTING SPACING: ALONG LONG SIDES

$F_{bvg_{ALL}} = 1000^{PSF}$ (GIVEN) TO MITIGATE GRASS IMPACT



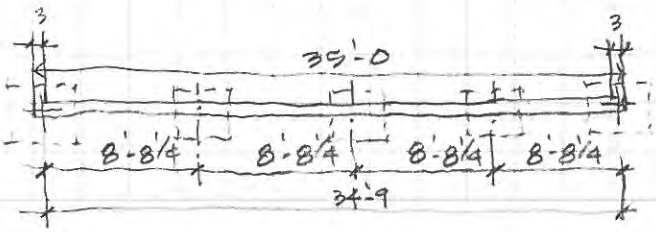
$145^{PCF}(2)(2)0.5 = 290^{LB}$
72.5^{PSF}

if: 2'x2' $P_{ALL} = 4000^{LB} - 290 = 3710^{LB}$
2.5'x2.5' $P_{ALL} = 6250^{LB} - 290 = 5960^{LB}$
3'x3' $P_{ALL} = 9000^{LB} - 290 = 8710^{LB}$

$\Sigma_{D+L} = 186.3 + 91.75 + 366.6 = 644.65^{PLF}$

$S_{2x2} = 5.76'$ $S_{2.5x2.5} = 9.25'$ $S_{3x3} = 13.51'$

2'-6 sq ftg x 0'-6"
WT = 469 LB
75 PSF



USE: 2'-6 x 2'-6

$f_{bvg} = \frac{644.65(8.6875)^1}{2.5^2}$
$= 896.1^{PSF}$
@ INT. FTG

EXT. CORNER FTG:

SHORT WALL: $91.75^{PLF}\left(\frac{12.93'}{2}\right) = 593.2^{LB}$ (DL)

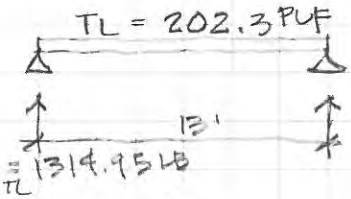
LONG WALL: $\frac{644.65^{PLF}(8.6875)}{2} = 2800.2^{LB}$

$\Sigma DL + LL = 3393.4^{LB}$

$f_{brg} = \frac{3393.4^{LB}}{2.0^2} = \underline{\underline{848.35^{PSF}}}$

LVL HEADER (ONE SIDE) ONE UNIT

ASSUME: (2)-1¾ × 11⅞



$R_{DL} = 534.95^{LB}$

DL = $66.3^{PLF} + 2(6^{PLF}) = 78.3^{PLF}$

LL = $20^{PSF}(6') = 120.0^{PLF}$

198.3^{PLF}

$+(3)2\times8\ (HALF)\ \frac{2.65(3)}{2} = 4.0$

202.3^{PLF}

USING 1¾ × 9½

$M = 202.3(13)^2/8 = 4273.6^{FTLB}$ <

$\ell/240 = 0.65''$

$\Delta_{ACT\ TL} = \frac{5(202.3)13^4(1728)}{384(1900000)125} = 0.547 < .65$ OK

$V = 202.3(13/2) = 1314.95^{LB} < 3160^{LB}$

USE (1) 1¾ × 9½ LVL E1.9

OR

SP#2 (2) 2×10
E = 1.6
I = 98.9 ea.

$S_{req} = \frac{4273.6(12)}{1050(1.15)(2)} = 21.24^{in^3} \sim 21.39$ OK

$\Delta_{ACT} = 0.547\left(\frac{125}{2(98.9)}\right) = .346\left(\frac{1.9}{1.6}\right) = 0.41$ OK

USE: (2) 2×10 S.P.#2
I = 98.9 EA. E = 1,600,000 PSI F_b = 1050 PSI

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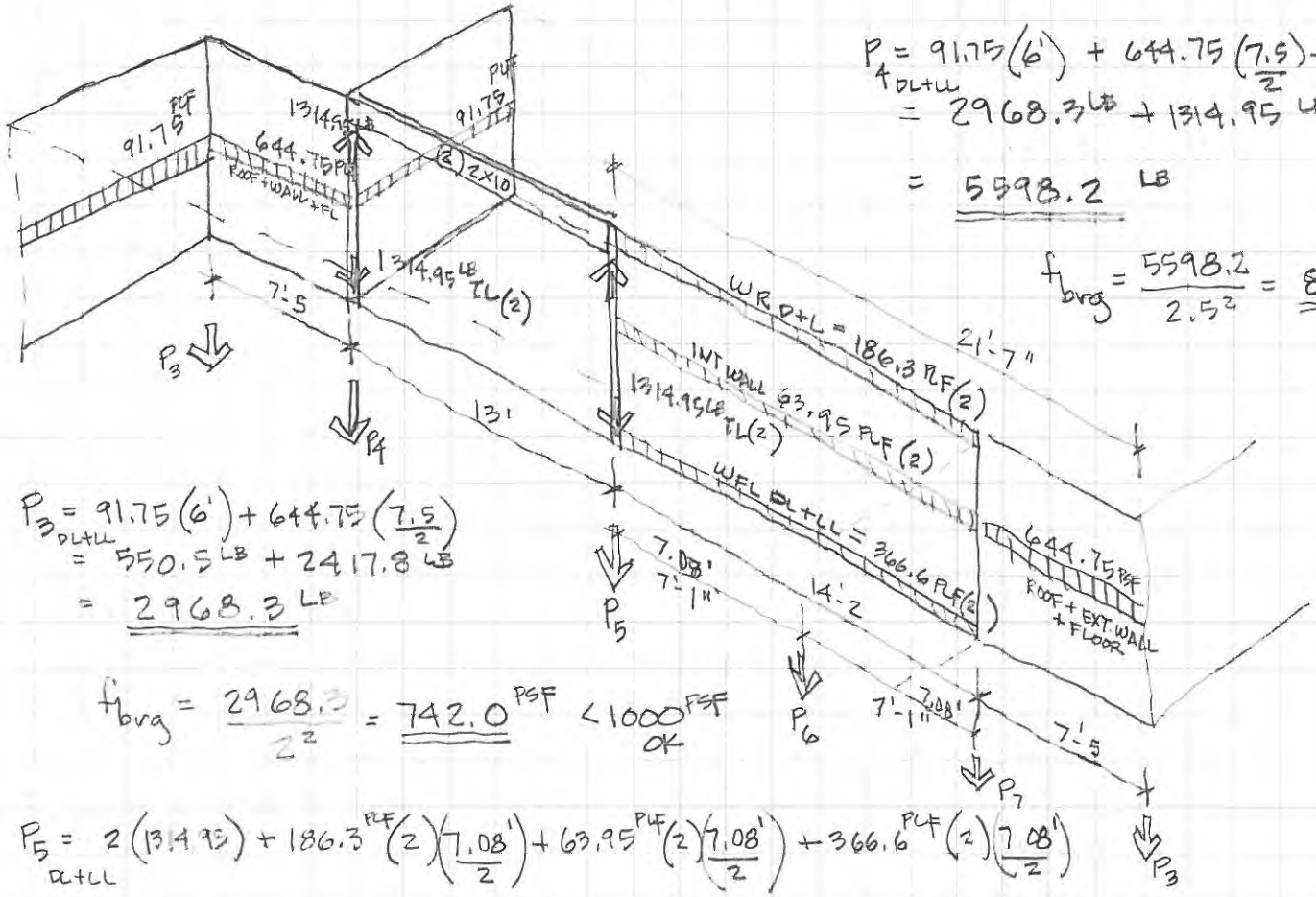

$$P_{4_{DL+LL}} = 91.75(6') + 644.75\left(\frac{7.5}{2}\right) + 1314.95^{LB}$$
$$= 2968.3^{LB} + 1314.95^{LB}(2)$$
$$= \underline{5598.2^{LB}}$$

$$f_{brg} = \frac{5598.2}{2.5^2} = \underline{895.7^{PSF}}$$

$$P_{3_{DL+LL}} = 91.75(6') + 644.75\left(\frac{7.5}{2}\right)$$
$$= 550.5^{LB} + 2417.8^{LB}$$
$$= \underline{2968.3^{LB}}$$

$$f_{brg} = \frac{2968.3}{2^2} = \underline{742.0^{PSF}} < 1000^{PSF}\ OK$$

$$P_{5_{DL+LL}} = 2(1314.95) + 186.3^{PLF}(2)\left(\frac{7.08'}{2}\right) + 63.95^{PLF}(2)\left(\frac{7.08'}{2}\right) + 366.6^{PLF}(2)\left(\frac{7.08'}{2}\right)$$
$$= 2629.9 + 1319.0 + 452.77 + 2595.5 = \underline{6997.2^{LB}}$$

$$f_{brg} = \frac{6997.2^{LB}}{3^2} = \underline{777.5^{PSF}} < 1000^{PSF}\ OK$$

$$P_{6_{DL+LL}} = 186.3(2)7.08' + 63.95(2)7.08' + 366.6(2)7.08'$$
$$= 2638.0 + 905.5 + 5191.1 = \underline{8734.6^{LB}}$$

$$f_{brg} = \frac{8734.6^{LB}}{3^2} = \underline{970.5^{PSF}} < 1000^{PSF}\ OK$$

$$P_{T_{D+L}} = 186.3\left(2\right)\left(\frac{7.08'}{2}\right) + 63.95\left(2\right)\left(\frac{7.08'}{2}\right) + 366.6\left(2\right)\left(\frac{7.08}{2}\right) + 91.75\left(6'\right) + 644.75\left(\frac{7.43'}{2}\right)$$

$$= 1319.0 + 452.8 + 2595.5 + 550.5 + 2395.25$$

$$P_{T_{D+L}} = \underline{5541.27^{LB}}$$

$$f_{brg} = \frac{5541.27}{2.5^2} = \underline{886.6^{PSF}}$$

$< 1000^{PSF}$
OK

CALLED DOE, DETERMINED THAT 1500^{PSF} CRITERIA IS THE CRITICAL BEARING CAPACITY

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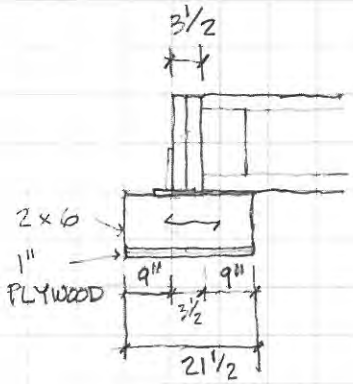
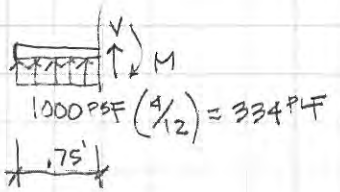




$V = 334(.75) = 250.5^{LB}$

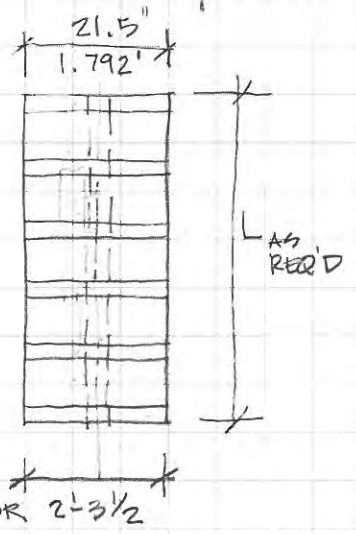
$M = 334\frac{(.75)^2}{2} = 93.94^{FTLB}$

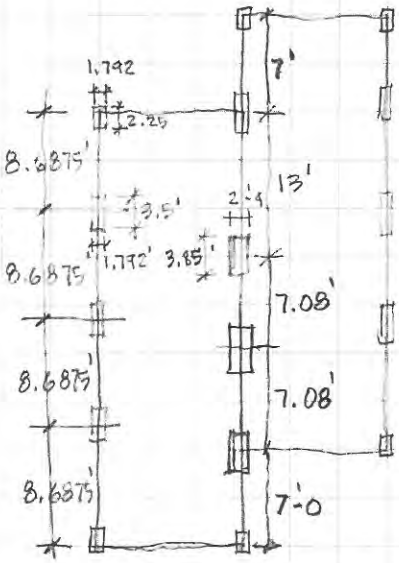
SP #2
2 x 6

$S_{req} = \frac{93.94(12)}{1250} = 0.9^{"3} \ll 7.5^{"3}$ OK

$f_v = \frac{3(250.5)}{2(8.25)} = 45.5^{PSI} \therefore OK$

$\Delta = \frac{334(.75)^4(1728)}{8(1600000)20.8} =$
$= 0.000686"$



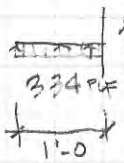


GRAVITY

RECTANGLE :: SQUARE

- $21\frac{1}{2}" \times 3'-6" \approx 2'-6 \times 2'-6$
- $2'-3\frac{1}{2}" \times 3'-10\frac{1}{2}" \approx 3' \times 3'$
- $21\frac{1}{2}" \times 2'-3" \approx 2' \times 2'$

IF : 2'-3½" WIDE



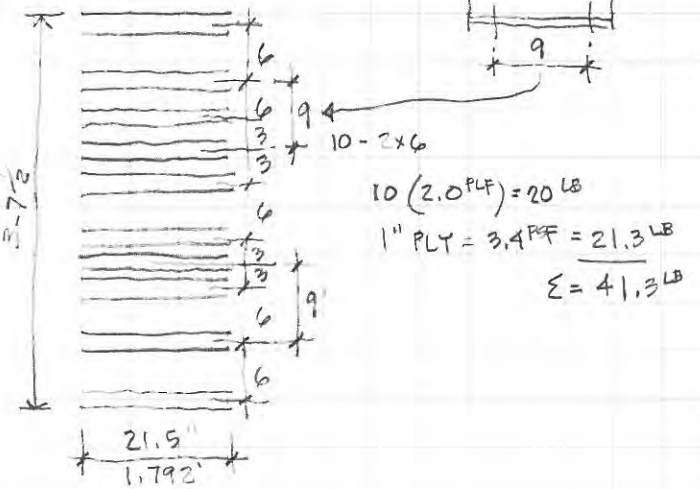
$V = 334^{LB}$

$M = 334\frac{(1)^2}{2} = 167^{FT\,LB}$

$S_{req} = \frac{167(12)}{1250} = 1.6^{"3}$

$f_v = \frac{3(334)}{2(8.25)} = 60.7^{PSI}$

$\Delta = \frac{334(1)^4(1728)}{8(1600000)20.8} = 0.00217"$



$10(2.0^{PLF}) = 20^{LB}$

$1" PLY = 3.4^{PSF} = 21.3^{LB}$

$\Sigma = 41.3^{LB}$

MSA Professional Services Structural Div.
210 W. Springfield Avenue
Champaign, Illinois 61820
(217) 352-0081
(217) 352-8651 (FAX)

JOB TITLE	Solar decathelon 2011		
	U of I		
JOB NO.	12474004	SHEET NO.	1
CALCULATED BY	DJW	DATE	1/8/2011
CHECKED BY		DATE	

STRUCTURAL CALCULATIONS

FOR

Solar decathelon 2011

Washington, D.C.

SA Professional Services Structural Div.
210 W. Springfield Avenue
Champaign, Illinois 61820
(217) 352-0081
(217) 352-8651 (FAX)

JOB TITLE	Solar decathelon 2011 U of I		
JOB NO.	12474004	SHEET NO.	2
CALCULATED BY	DJW	DATE	1/8/11
CHECKED BY		DATE	

Code Search

I. Code: International Building Code 2006

II. Occupancy:

Occupancy Group = R Residential

III. Type of Construction:

Fire Rating:

Roof = 1.0 hr
Floor = 1.0 hr

IV. Live Loads:

Roof angle (θ) 1.00 / 12 4.8 deg

Roof	0 to 200 sf:	20 psf
	200 to 600 sf:	24 - 0.02Area
	over 600 sf:	12 psf
Floor		50 psf
Stairs & Exitways		0 psf
Balcony		N/A
Mechanical		0 psf
Partitions		0 psf

V. Wind Loads : ASCE 7 - 02

Importance Factor	1.00
Wind speed	60 mph
Directionality (Kd)	0.85
Mean Roof Ht (h)	12.0 ft
Parapet ht above grd	0.0 ft
Exposure	C
Enclosure Classif.	Enclosed Building
Internal pressure	+/-0.18
Building length (L)	36.0 ft
Least width (B)	14.0 ft
Kh case 1	0.849
Kh case 2	0.849

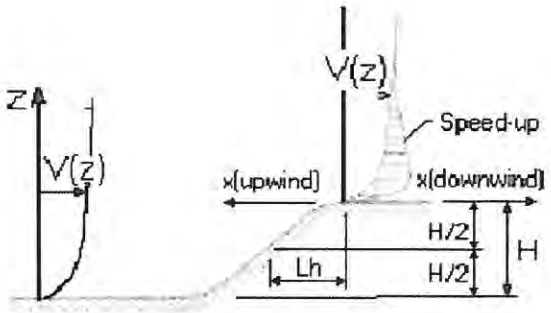
Topographic Factor (Kzt)

Topography	Flat	
Hill Height (H)	0.0 ft	H< 15ft;exp C
Half Hill Length (Lh)	0.0 ft	∴ Kzt=1.0
Actual H/Lh =	0.00	
Use H/Lh =	0.00	
Modified Lh =	0.0 ft	
From top of crest: x=	50.0 ft	
Bldg up/down wind?	downwind	

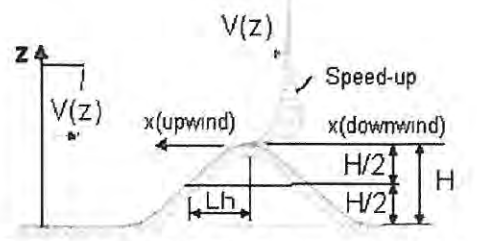
H/Lh= 0.00	K_1 =	0.000
x/Lh = 0.00	K_2 =	0.000
z/Lh = 0.00	K_3 =	1.000

At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2$ = 1.00



ESCARPMENT



2D RIDGE or 3D AXISYMMETRICAL HILL

ISA Professional Services Structural Div.
210 W. Springfield Avenue
Champaign, Illinois 61820
(217) 352-0081
(217) 352-8651 (FAX)

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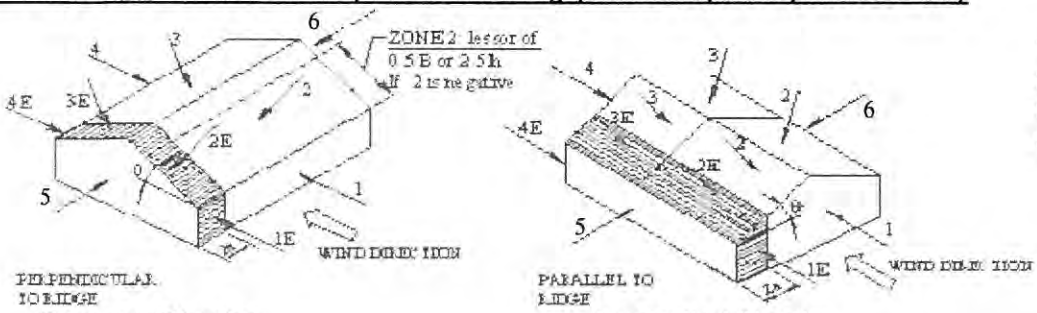
JOB NO.	12474004	**SHEET NO.**	4
CALCULATED BY	DJW	**DATE**	1/8/11
CHECKED BY		**DATE**	

V. Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only



Torsional loads are 25% of zones 1 - 4. See code for loading diagram

Transverse Direction **Longitudinal Direction**

Kz = Kh =	0.85 (case 1)	Edge Strip	(a) 3.0 ft
Base pressure (qh) =	**6.6 psf**	End Zone	(2a) 6.0 ft
GCpi =	+/-0.18	Zone 2 length	= 7.0 ft

	Transverse Direction			Longitudinal Direction			
	Perpendicular θ = 4 8 deg			Parallel θ = 0deg			
Surface	GCpf	w/-GCpi	w/+GCpi	GCpf	w/-GCpi	w/+GCpi	
1	0.40	0.58	0.22	0.40	0.58	0.22	
2	-0.69	-0.51	-0.87	-0.69	-0.51	-0.87	
3	-0.37	-0.19	-0.55	-0.37	-0.19	-0.55	
4	-0.29	-0.11	-0.47	-0.29	-0.11	-0.47	
5	-0.45	-0.27	-0.63	-0.45	-0.27	-0.63	
6	-0.45	-0.27	-0.63	-0.45	-0.27	-0.63	
1E	0.61	0.79	0.43	0.61	0.79	0.43	
2E	-1.07	-0.89	-1.25	-1.07	-0.89	-1.25	
3E	-0.53	-0.35	-0.71	-0.53	-0.35	-0.71	
4E	-0.43	-0.25	-0.61	-0.43	-0.25	-0.61	

Wind Surface pressures (psf) - use 10 psf minimum for zones 1 plus 4 and 5 plus 6

1	3.9	1.5	3.9	1.5	
2	-3.4	-5.8	-3.4	-5.8	
3	-1.3	-3.7	-1.3	-3.7	
4	-0.7	-3.1	-0.7	-3.1	
5	-1.8	-4.2	-1.8	-4.2	
6	-1.8	-4.2	-1.8	-4.2	
1E	5.3	2.9	5.3	2.9	
2E	-5.9	-8.3	-5.9	-8.3	
3E	-2.3	-4.7	-2.3	-4.7	
4E	-1.7	-4.1	-1.7	-4.1	

MWFRS Simple Diaphragm Pressures (psf)

Transverse direction (normal to L)

Interior Zone:	Wall	10.0 psf
	Roof	-2.1 psf
End Zone:	Wall	10.0 psf
	Roof	-3.6 psf

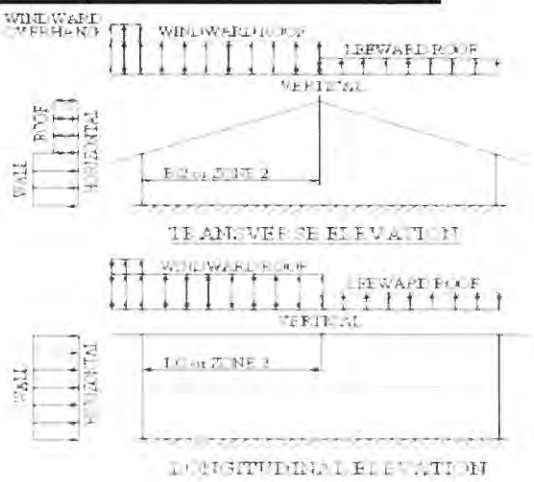
Longitudinal direction (parallel to L)

Interior Zone:	Wall	10.0 psf
End Zone:	Wall	10.0 psf

Windward roof overhangs: 4.5 psf (upward) add to windward roof pressure

Parapet

Windward parapet:	0.0 psf	(GCpn = +1.8)
Leeward parapet:	0.0 psf	(GCpn = -1.1)



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JOB TITLE	Solar decathelon 2011		
	U of I		
JOB NO.	12474004	SHEET NO.	5
CALCULATED BY	DJW	DATE	1/8/11
CHECKED BY		DATE	

V. Wind Loads - Components & Cladding: Low-rise Buildings (h≤60') & Alternate design 60'<h<90'

Kz = Kh (case 1) = 0.85 GCpi = +/-0.18

Base pressure (qh) = **6.6 psf** a = 3.0 ft

Minimum parapet height at building perimeter = 1.2 ft

NOTE: If tributary area is greater than 700sf, MWFRS pressure may be used.

Roof Angle = 4.8 deg

Type of roof = Gable

Roof	GCp +/- GCpi			Surface Pressure (psf)			**User input**	
Area	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	36 sf	70 sf
Negative Zone 1	-1.18	-1.11	-1.08	10 psf	10 psf	10 psf	10 psf	10 psf
Negative Zone 2	-1.98	-1.49	-1.28	-13 psf	10 psf	10 psf	-11 psf	10 psf
Negative Zone 3	-2.98	-1.79	-1.28	-20 psf	-12 psf	10 psf	-14 psf	-10 psf
Positive All Zones	0.48	0.41	0.38	10 psf	10 psf	10 psf	10 psf	10 psf
Overhang Zone 1&2	-1.88	-1.81	-1.78	-13 psf	-12 psf	-12 psf	-12 psf	-12 psf
Overhang Zone 3	-2.98	-1.58	-0.98	-20 psf	-11 psf	10 psf	-12 psf	10 psf

Walls	GCp +/- GCpi			Surface Pressure (psf)			**User input**	
Area	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	36 sf	200 sf
Negative Zone 4	-1.17	-1.01	-0.90	10.0 psf	10.0 psf	10.0 psf	10.0 psf	10.0 psf
Negative Zone 5	-1.44	-1.12	-0.90	10.0 psf	10.0 psf	10.0 psf	10.0 psf	10.0 psf
Positive Zone 4 & 5	1.08	0.92	0.81	10.0 psf	10.0 psf	10.0 psf	10.0 psf	10.0 psf

Note: GCp reduced by 10% due to roof angle <= 10 deg.

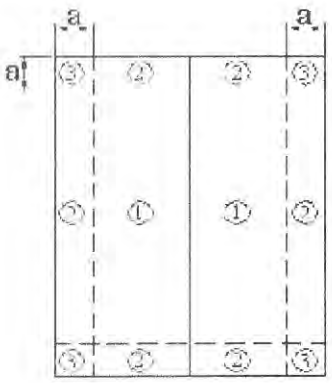
Parapet

qp = 0.0 psf

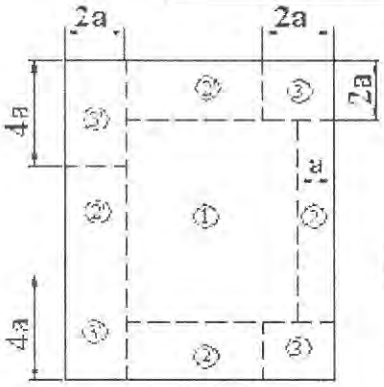
CASE A = pressure towards building

CASE B = pressure away from building

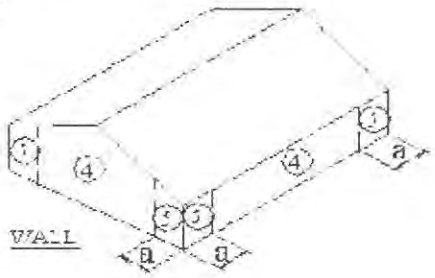
Solid Parapet Pressure		10 sf	100 sf	500 sf
CASE A :	Interior zone :	10.0 psf	10.0 psf	10.0 psf
	Corner zone :	10.0 psf	10.0 psf	10.0 psf
CASE B :	Interior zone :	-10.0 psf	-10.0 psf	-10.0 psf
	Corner zone :	-10.0 psf	-10.0 psf	-10.0 psf

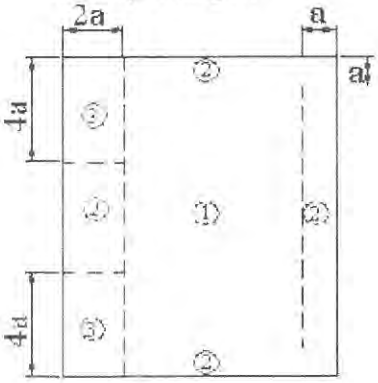


θ ≤ 7 degrees and
Monoslope ≤ 3 degrees

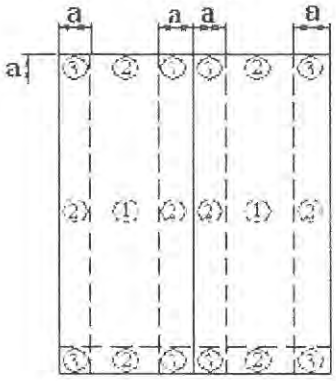


Monoslope roofs
3° < θ ≤ 10°

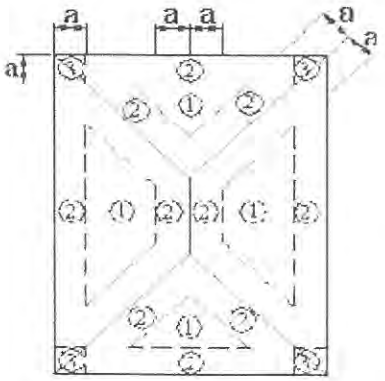




Monoslope roofs 10° < θ ≤ 30°



θ > 7 degrees



θ > 7 degrees

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210 W. Springfield Avenue
Champaign, Illinois 61820
(217) 352-0081
(217) 352-8651 (FAX)

JOB TITLE Solar decathelon 2011
High Roof - Transverse
JOB NO. 12474004 **SHEET NO.** 7
CALCULATED BY DJW **DATE** 1/8/11
CHECKED BY **DATE**

VII. Snow Loads - Flat, Gable & Hip Roofs Only :

Roof slope	=	4.8 deg
Horiz. eave to ridge dist (W)	=	7.0 ft
Roof length parallel to ridge (L)	=	36.0 ft
Type of Roof		Monoslope
Ground Snow Load	Pg =	20.0 psf
Importance Category	=	II
Importance Factor	I =	1.0
Thermal Factor	Ct =	1.00
Exposure Factor	Ce =	1.0
Pf = 0.7*Ce*Ct*I*Pg	=	14.0 psf
Pf min	=	20.0 psf
Flat Roof Snow Load	Pf =	20.0 psf
Rain on Snow Surcharge	=	0.0 psf
Unobstructed Slippery Surface (per Section 7.4)	=	yes
Sloped-roof Factor	Cs =	1.00

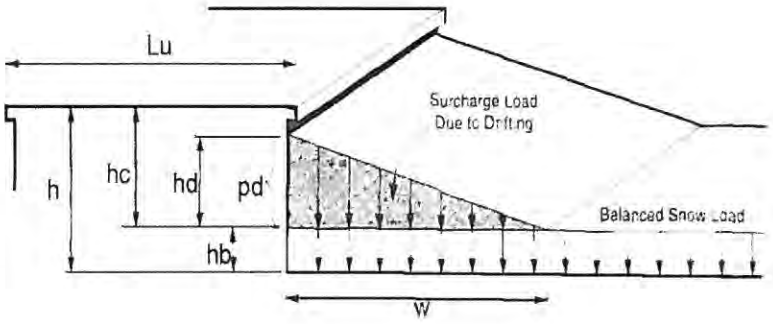
Design Roof Snow load = **20.0 psf** ("balanced" snow load)

Exposure Factor, Ce			
	Exposure of roof		
Terrain	Fully	Partially	Sheltered
A	n/a	1.1	1.3
B	0.9	1.0	1.2
C	0.9	1.0	1.1
D	0.8	0.9	1.0
Above treeline	0.7	0.8	n/a
Alaska-no trees	0.7	0.8	n/a

NOTE. Alternate spans of continuous beams and other areas shall be loaded with half the design roof snow load so as to produce the greatest possible effect - see code.

Leeward Snow Drifts - from adjacent higher roof

Upper roof length	lu =	0.0 ft
Projection height	h =	0.0 ft
Building separation	s =	0.0 ft
Adjacent structure factor		1.00
Snow density	γ =	16.6 pcf
Balanced snow height	hb =	1.20 ft
	hc =	-1.20 ft
hc/hb = -1.0	**Therefore, no drift**	
Drift height	hd =	0.00 ft
Drift width	w =	-9.64 ft
Surcharge load: pd = γ*hd =		**0.0 psf**

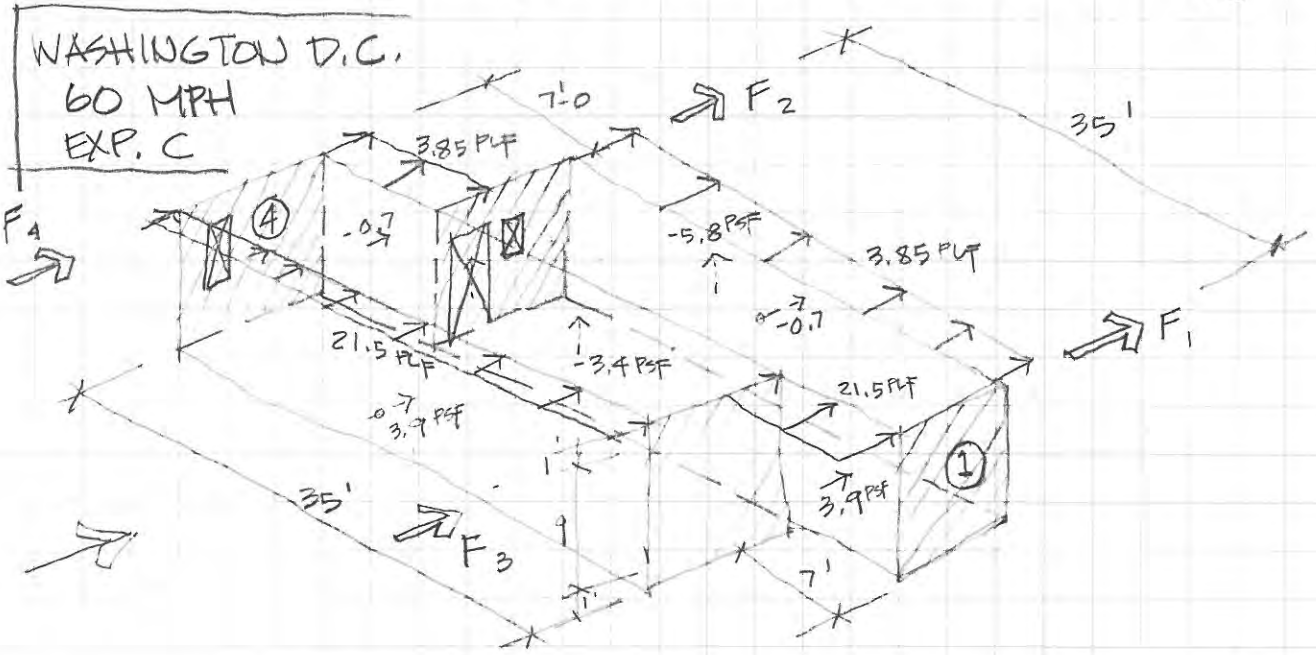


Windward Snow Drifts - Against walls, parapets, etc more than 15' long

Building roof length	lu =	14.0 ft
Projection height	h =	1.0 ft
Snow density	γ =	16.6 pcf
Balanced snow height	hb =	1.20 ft
	hc =	-0.20 ft
hc/hb = -0.2	**Therefore, no drift**	
Drift height	hd =	0.00 ft
Drift width	w =	-22.86 ft
Surcharge load: pd = γ*hd =		**0.0 psf**

TRANSVERSE WIND (WIND FROM LEFT TO RIGHT)(MFRS)

WASHINGTON D.C.
60 MPH
EXP. C



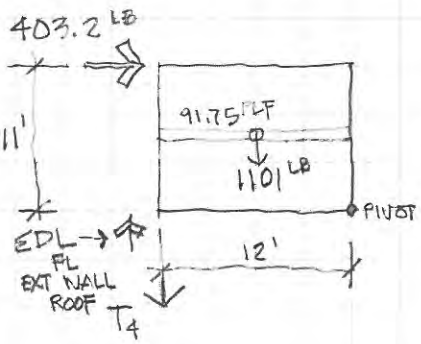
$F_1 = 21.5^{PLF}(7') + 3.85(35'/2) = 150.5 + 67.4 = \underline{217.9^{LB}}$

$F_2 = 3.85^{PLF}(35'/2) = \underline{67.4^{LB}}$

$F_3 = 21.5^{PLF}(35'/2) = \underline{376.25^{LB}}$

$F_4 = 21.5^{PLF}(35'/2) + 3.85(7') = 376.25^{LB} + 26.95 = \underline{403.2^{LB}}$

WALL (4) LC = W + .6DL



$$T_4 = \frac{403.2(11) - .6(1101)6}{12} = 39.3^{LB}\ (\text{TENSION})$$

UPLIFT

$$EDL_{ROOF} = 11.05^{PSF}\left(\frac{8.6875}{2}\right)(6') + 91.75^{PLF}\left(\frac{8.6875'}{2}\right) + 11.1^{PSF}\left(\frac{8.6875}{2}\right)(6')$$

$$EXT\ WALL = 287.99^{LB} + 398.54^{LB} + 289.3^{LB}$$

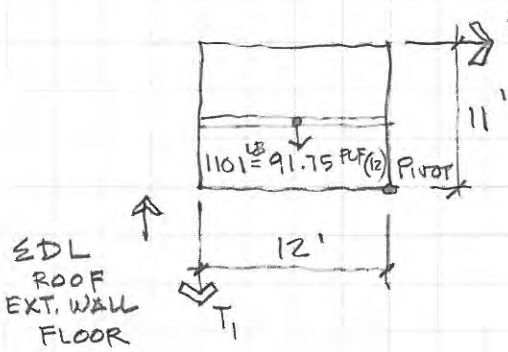
$$FL = 975.8^{LB}(.6) = 585.5^{LB}$$

$$P_4 = 585.5 - 39.3^{LB} = 546.2^{LB}\ (\text{COMP.})$$

.6D+W

TO FTG.

WALL (1) LC = W + 0.6DL



$$T_1 = \frac{217.9(11) - .6(1101)(6)}{12}$$ (2396.9, 3963.6)

$$T_1 = -130.6^{LB} \uparrow \text{(COMP.)}$$

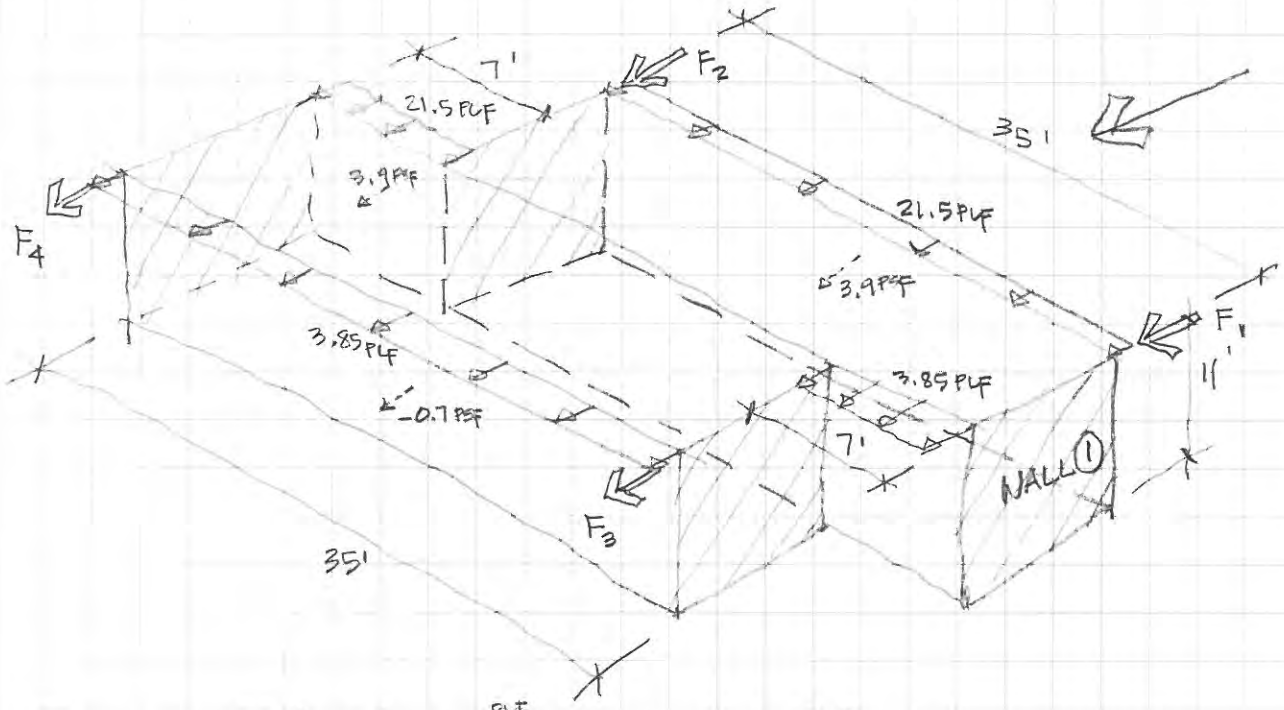
$$\Sigma DL = \underset{\text{ROOF}}{11.05^{PSF}(6')3.5'} + \underset{\text{EXT. WALL}}{91.75^{PLF}(3.5')} + \underset{\text{FLOOR}}{11.1^{PSF}(6')3.5'}$$

$$= 232.05^{LB} + 321.125^{LB} + 233.1^{LB} = 786.3^{LB}(.6) = 471.8^{LB}$$

$$P_{.6D+W} = 602.4^{LB} \text{ (COMP.)}$$

TO FTG.

TRANSVERSE DIRECTION (WIND FROM RIGHT TO LEFT)



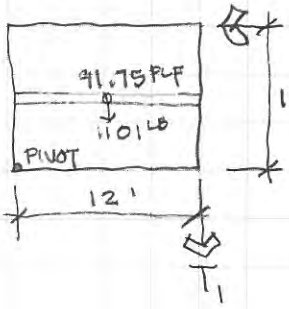
$$F_1 = 21.5^{PLF}(17.5') + 3.85^{PLF}(7') = 403.2^{LB}$$

$$F_2 = 21.5^{PLF}(17.5) = 376.25^{LB}$$

$$F_3 = 3.85^{PLF}(17.5) = 67.4^{LB}$$

$$F_4 = 3.85^{PLF}(17.5) + 21.5^{PLF}(7') = 217.88^{LB}$$

WALL (1) LC = W + 0.6DL

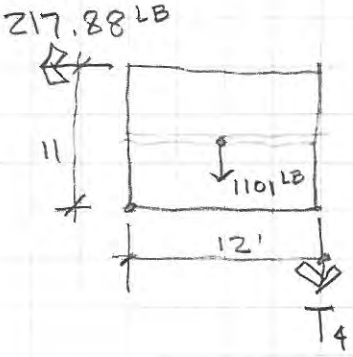


$$T_1 = \frac{\overset{4435.2}{403.2(11)} - \overset{3963.6}{1101(6)(.6)}}{12}$$

$= +39.3^{LB}$ UPLIFT (TENSION)

WILL BE SAME AS WALL #4 FOR WIND FROM LEFT TO RIGHT (PG. 8)

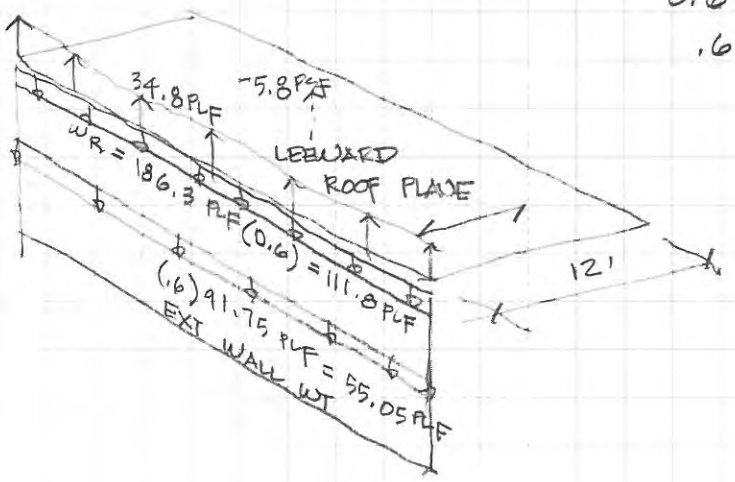
WALL (4) LC = W + 0.6DL



$$T_4 = \frac{217.9(11) - (1101)(6)(.6)}{12} = -130.6^{LB}\ (COMP)$$

SAME AS WALL (1) FOR WIND FROM LEFT TO RIGHT (PG. 9)

TRANSVERSE WIND (DIRECT UPLIFT) (MFRS)



$0.6DL > W_{UPLIFT}$

$.6(11.05) >$

$6.63^{PSF} > 5.8^{PSF}$ @ ROOF

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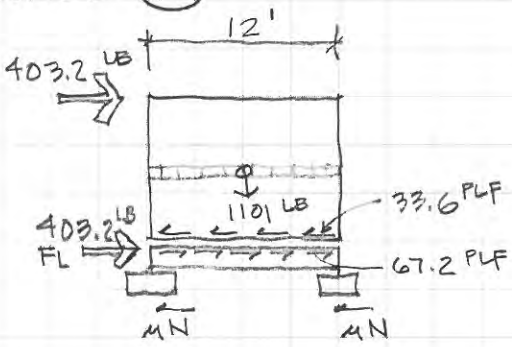
Sheet 11 of _____
Project SOLAR DECATHLON 2011 Comp. by DJW
Date 1/11/11 Ckd. by _____
Proj. No. 12474004

WIND - SLIDING (WIND LEFT TO RIGHT - REF: PG 8)

WALL (4)



$2.4N = 2(403.2^{LB})$ (.5)

$N_{REQ} = \frac{403.2}{.5} = 806.4^{LB}$ FOR F.S. = 1.0

$N_{ACT} = 975.8^{LB} + \frac{1101}{2} = 1526.3$

(2) $1\frac{3}{4} \times 11\frac{7}{8}$ LVL : $12^{PLF} \times \frac{8.6875}{2} =$ 52.1 LB

WOOD FTG: 37.3 LB

1615.7 LB

$> 2(806.4)$

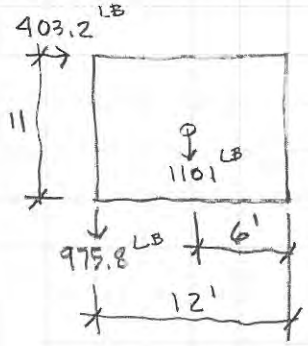
F.S. = 2 → 1612.8

∴ F.S. = 2

AGAINST SLIDING

OK

OVERTURNING



OVER = 403.2(11) = 4435.2 FT LB

RESIST = 1101.(6) + 975.8 (12) = 18315.6 FT LB

$F.S. = \frac{RESIST}{OVER} = \frac{18315.6}{4435.2} = 4.13 > 2$

∴

F.S. AGAINST OVERTURNING > 2.0

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JOB TITLE	Solar decathelon 2011 U of I		
JOB NO.	12474004	SHEET NO.	1
CALCULATED BY	DJW	DATE	1/8/2011
CHECKED BY		DATE	

STRUCTURAL CALCULATIONS

FOR

Solar decathelon 2011

Champaign,IL

SA Professional Services Structural Div.
210 W. Springfield Avenue
Champaign, Illinois 61820
(217) 352-0081
(217) 352-8651 (FAX)

JOB TITLE	Solar decathelon 2011 U of I		
JOB NO.	12474004	SHEET NO.	2
CALCULATED BY	DJW	DATE	1/8/11
CHECKED BY		DATE	

Code Search

I. Code: International Building Code 2003

II. Occupancy:

Occupancy Group = R Residential

III. Type of Construction:

Fire Rating:

Roof = 1.0 hr
Floor = 1.0 hr

IV. Live Loads:

Roof angle (θ) 1.00 / 12 4.8 deg

Roof	0 to 200 sf:	20 psf
	200 to 600 sf:	24 - 0.02Area
	over 600 sf:	12 psf
Floor		50 psf
Stairs & Exitways		0 psf
Balcony		N/A
Mechanical		0 psf
Partitions		0 psf

V. Wind Loads : ASCE 7 - 02

Importance Factor	1.00
Wind speed	90 mph
Directionality (Kd)	0.85
Mean Roof Ht (h)	12.0 ft
Parapet ht above grd	0.0 ft
Exposure	C
Enclosure Classif.	Enclosed Building
Internal pressure	+/-0.18
Building length (L)	36.0 ft
Least width (B)	14.0 ft
Kh case 1	0.849
Kh case 2	0.849

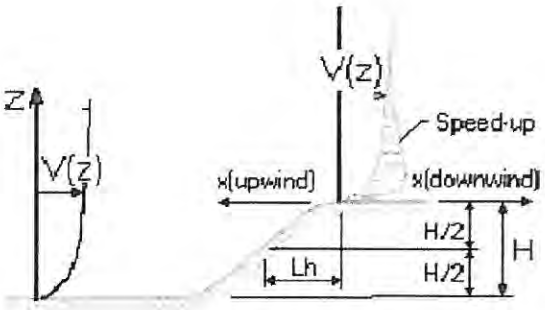
Topographic Factor (Kzt)

Topography	Flat	
Hill Height (H)	0.0 ft	H< 15ft;exp C
Half Hill Length (Lh)	0.0 ft	∴ Kzt=1.0
Actual H/Lh =	0.00	
Use H/Lh =	0.00	
Modified Lh =	0.0 ft	
From top of crest: x=	50.0 ft	
Bldg up/down wind?	downwind	

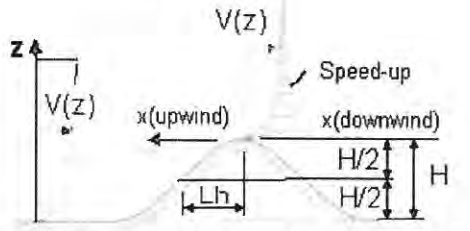
H/Lh= 0.00	K_1 =	0.000
x/Lh = 0.00	K_2 =	0.000
z/Lh = 0.00	K_3 =	1.000

At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2$ = 1.00



ESCARPMENT



2D RIDGE or 3D AXISYMMETRICAL HILL

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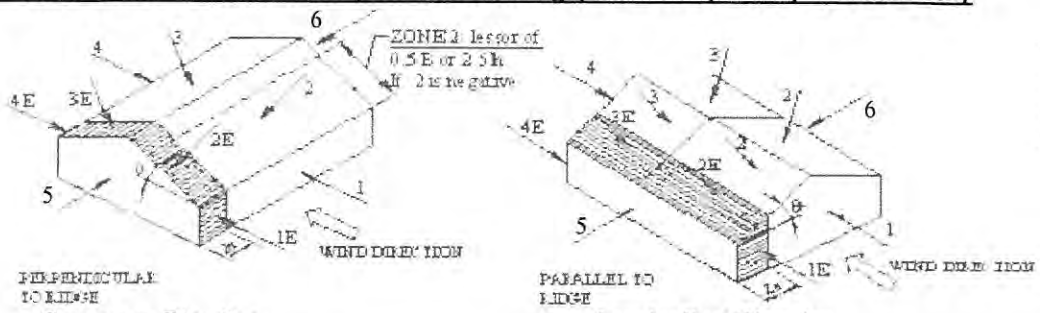
JOB TITLE	Solar decathelon 2011 U of I		
JOB NO.	12474004	SHEET NO.	4
CALCULATED BY	DJW	DATE	1/8/11
CHECKED BY		DATE	

V. Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only



Transverse Direction **Longitudinal Direction**

Torsional loads are 25% of zones 1 - 4. See code for loading diagram

Kz = Kh = 0.85 (case 1)
Base pressure (qh) = **15.0 psf**
GCpi = +/-0.18

Edge Strip (a) 3.0 ft
End Zone (2a) 6.0 ft
Zone 2 length = 7.0 ft

	Transverse Direction			Longitudinal Direction			
	Perpendicular θ = 4 8 deg			Parallel θ = 0deg			
Surface	GCpf	w/-GCpi	w/+GCpi	GCpf	w/-GCpi	w/+GCpi	
1	0.40	0.58	0.22	0.40	0.58	0.22	
2	-0.69	-0.51	-0.87	-0.69	-0.51	-0.87	
3	-0.37	-0.19	-0.55	-0.37	-0.19	-0.55	
4	-0.29	-0.11	-0.47	-0.29	-0.11	-0.47	
5	-0.45	-0.27	-0.63	-0.45	-0.27	-0.63	
6	-0.45	-0.27	-0.63	-0.45	-0.27	-0.63	
1E	0.61	0.79	0.43	0.61	0.79	0.43	
2E	-1.07	-0.89	-1.25	-1.07	-0.89	-1.25	
3E	-0.53	-0.35	-0.71	-0.53	-0.35	-0.71	
4E	-0.43	-0.25	-0.61	-0.43	-0.25	-0.61	

Wind Surface pressures (psf) - use 10 psf minimum for zones 1 plus 4 and 5 plus 6

1	8.7	3.3	8.7	3.3	
2	-7.6	-13.0	-7.6	-13.0	
3	-2.8	-8.2	-2.8	-8.2	
4	-1.6	-7.0	-1.6	-7.0	
5	-4.0	-9.4	-4.0	-9.4	
6	-4.0	-9.4	-4.0	-9.4	
1E	11.8	6.4	11.8	6.4	
2E	-13.3	-18.7	-13.3	-18.7	
3E	-5.2	-10.6	-5.2	-10.6	
4E	-3.7	-9.1	-3.7	-9.1	

MWFRS Simple Diaphragm Pressures (psf)

Transverse direction (normal to L)

Interior Zone: Wall 10.3 psf
Roof -4.8 psf
End Zone: Wall 15.6 psf
Roof -8.1 psf

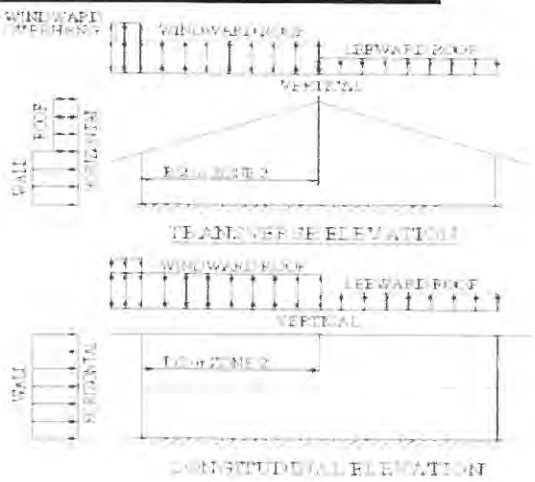
Longitudinal direction (parallel to L)

Interior Zone: Wall 10.3 psf
End Zone: Wall 15.6 psf

Windward roof overhangs: 10.2 psf (upward) add to windward roof pressure

Parapet

Windward parapet: 0.0 psf (GCpn = +1.8)
Leeward parapet: 0.0 psf (GCpn = -1.1)



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JOB TITLE	Solar decathelon 2011 U of I		
JOB NO.	12474004	**SHEET NO.**	5
CALCULATED BY	DJW	**DATE**	1/8/11
CHECKED BY		**DATE**	

V. Wind Loads - Components & Cladding: Low-rise Buildings (h≤60') & Alternate design 60'<h<90'

Kz = Kh (case 1) = 0.85 GCpi = +/-0.18

Base pressure (qh) = **15.0 psf** a = 3.0 ft

Minimum parapet height at building perimeter = 1.2 ft

NOTE: If tributary area is greater than 700sf, MWFRS pressure may be used.

Roof Angle = 4.8 deg

Type of roof = Gable

Roof	GCp +/- GCpi			Surface Pressure (psf)			**User input**	
Area	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	24 sf	2 sf
Negative Zone 1	-1.18	-1.11	-1.08	-18 psf	-17 psf	-16 psf	-17 psf	-18 psf
Negative Zone 2	-1.98	-1.49	-1.28	-30 psf	-22 psf	-19 psf	-26 psf	-30 psf
Negative Zone 3	-2.98	-1.79	-1.28	-45 psf	-27 psf	-19 psf	-35 psf	-45 psf
Positive All Zones	0.48	0.41	0.38	10 psf	10 psf	10 psf	10 psf	10 psf
Overhang Zone 1&2	-1.88	-1.81	-1.78	-28 psf	-27 psf	-27 psf	-28 psf	-28 psf
Overhang Zone 3	-2.98	-1.58	-0.98	-45 psf	-24 psf	-15 psf	-33 psf	-45 psf

Walls	GCp +/- GCpi			Surface Pressure (psf)			**User input**	
Area	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	2 sf	50 sf
Negative Zone 4	-1.17	-1.01	-0.90	-17.5 psf	-15.1 psf	-13.5 psf	-17.5 psf	-15.8 psf
Negative Zone 5	-1.44	-1.12	-0.90	-21.5 psf	-16.8 psf	-13.5 psf	-21.5 psf	-18.2 psf
Positive Zone 4 & 5	1.08	0.92	0.81	16.2 psf	13.8 psf	12.1 psf	16.2 psf	14.5 psf

Note: GCp reduced by 10% due to roof angle <= 10 deg.

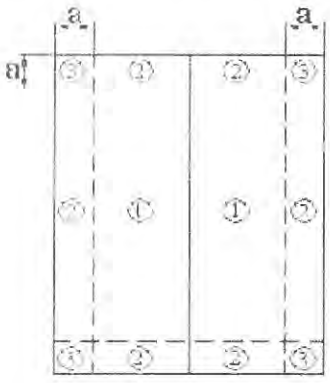
Parapet

qp = 0.0 psf

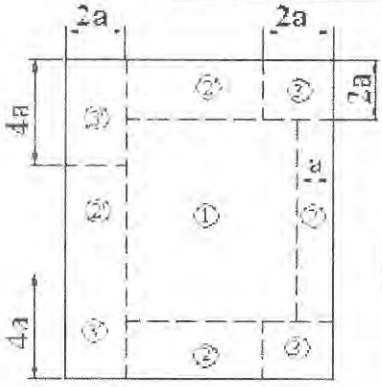
CASE A = pressure towards building

CASE B = pressure away from building

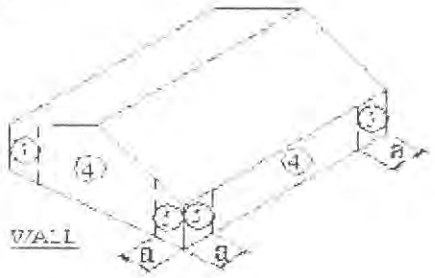
Solid Parapet Pressure	10 sf	100 sf	500 sf
CASE A : Interior zone :	10.0 psf	10.0 psf	10.0 psf
Corner zone :	10.0 psf	10.0 psf	10.0 psf
CASE B : Interior zone :	-10.0 psf	-10.0 psf	-10.0 psf
Corner zone :	-10.0 psf	-10.0 psf	-10.0 psf

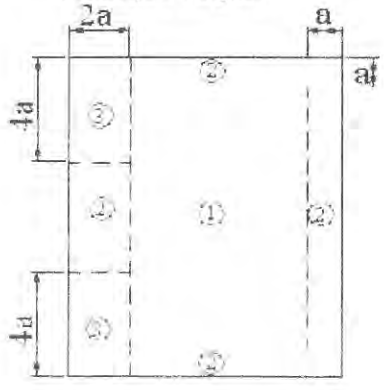


θ ≤ 7 degrees and Monoslope ≤ 3 degrees

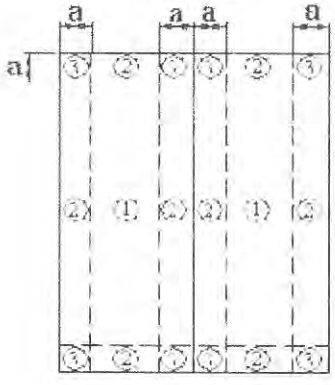


Monoslope roofs 3° < θ ≤ 10°

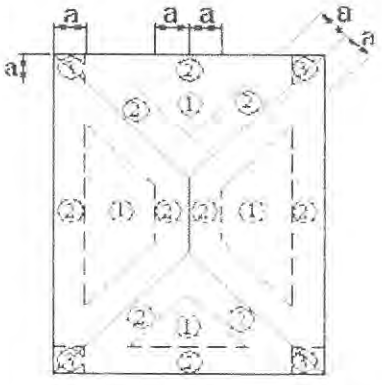




Monoslope roofs 10° < θ ≤ 30°



θ > 7 degrees



θ > 7 degrees

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JOB TITLE Solar decathelon 2011
High Roof - Transverse
JOB NO. 12474004 **SHEET NO.** 7
CALCULATED BY DJW **DATE** 1/8/11
CHECKED BY **DATE**

VII. Snow Loads - Flat, Gable & Hip Roofs Only :

Roof slope	=	4.8 deg
Horiz. eave to ridge dist (W)	=	7.0 ft
Roof length parallel to ridge (L)	=	36.0 ft
Type of Roof		Monoslope
Ground Snow Load	Pg =	20.0 psf
Importance Category	=	II
Importance Factor	I =	1.0
Thermal Factor	Ct =	1.00
Exposure Factor	Ce =	1.0
Pf = 0.7*Ce*Ct*I*Pg	=	14.0 psf
Pf min	=	20.0 psf
Flat Roof Snow Load	Pf =	20.0 psf
Rain on Snow Surcharge	=	0.0 psf
Unobstructed Slippery Surface (per Section 7.4)	=	yes
Sloped-roof Factor	Cs =	1.00

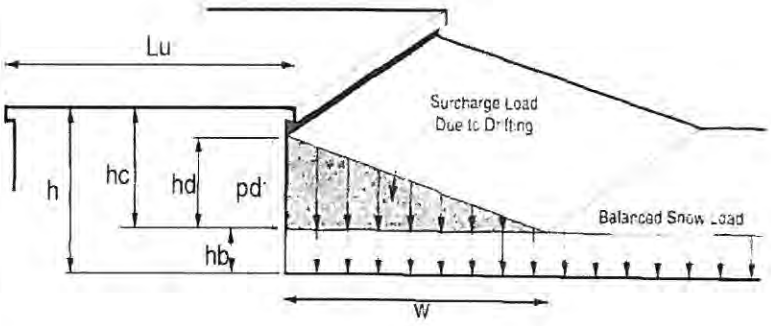
Design Roof Snow load = **20.0 psf** ("balanced" snow load)

Exposure Factor, Ce			
	Exposure of roof		
Terrain	Fully	Partially	Sheltered
A	n/a	1.1	1.3
B	0.9	1.0	1.2
C	0.9	1.0	1.1
D	0.8	0.9	1.0
Above treeline	0.7	0.8	n/a
Alaska-no trees	0.7	0.8	n/a

NOTE: Alternate spans of continuous beams and other areas shall be loaded with half the design roof snow load so as to produce the greatest possible effect - see code

Leeward Snow Drifts - from adjacent higher roof

Upper roof length	lu =	0.0 ft
Projection height	h =	0.0 ft
Building separation	s =	0.0 ft
Adjacent structure factor		1.00
Snow density	γ =	16.6 pcf
Balanced snow height	hb =	1.20 ft
	hc =	-1.20 ft
hc/hb = -1.0	**Therefore, no drift**	
Drift height	hd =	0.00 ft
Drift width	w =	-9.64 ft
Surcharge load pd = γ*hd =		**0.0 psf**



Windward Snow Drifts - Against walls, parapets, etc more than 15' long

Building roof length	lu =	14.0 ft
Projection height	h =	1.0 ft
Snow density	γ =	16.6 pcf
Balanced snow height	hb =	1.20 ft
	hc =	-0.20 ft
hc/hb = -0.2	**Therefore, no drift**	
Drift height	hd =	0.00 ft
Drift width	w =	-22.86 ft
Surcharge load: pd = γ*hd =		**0.0 psf**

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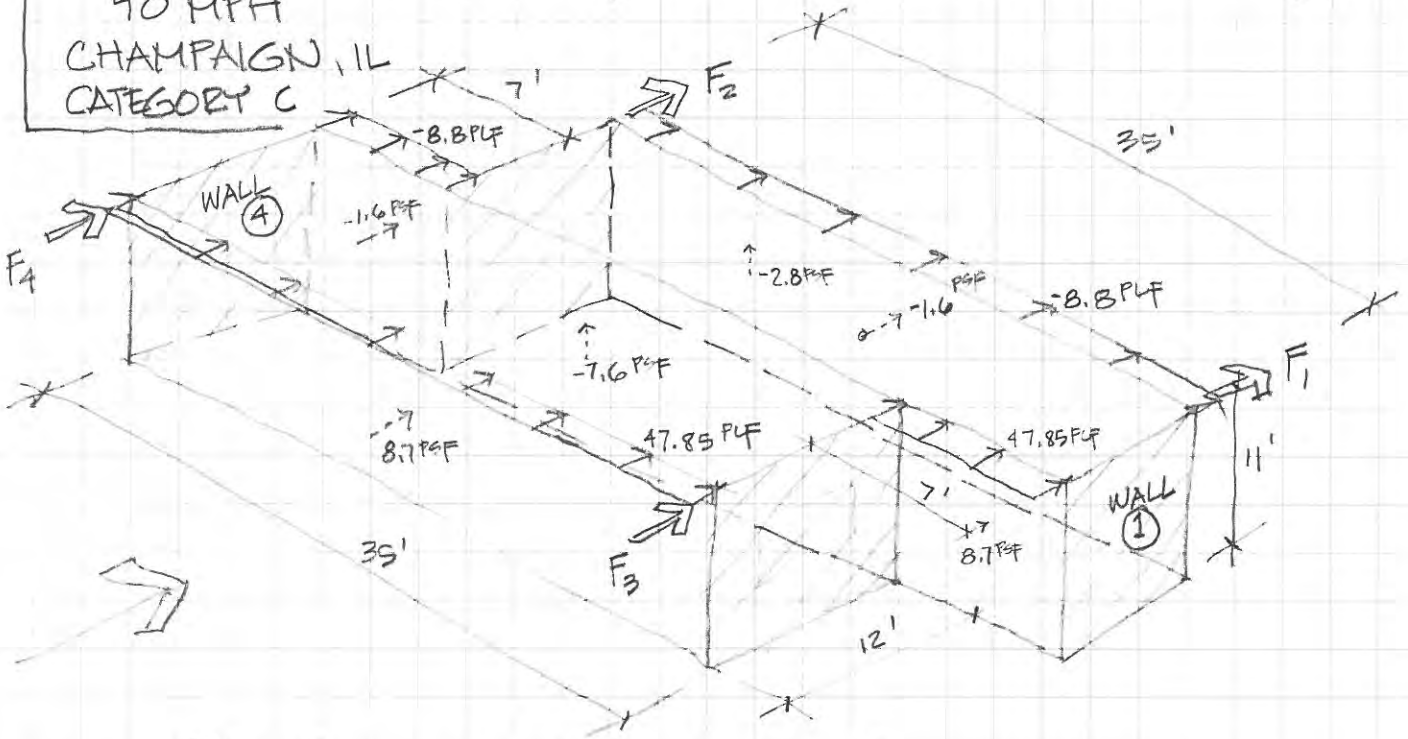
TRANSVERSE WIND (WIND FROM LEFT TO RIGHT) (MWFRS)

90 MPH
CHAMPAIGN, IL
CATEGORY C



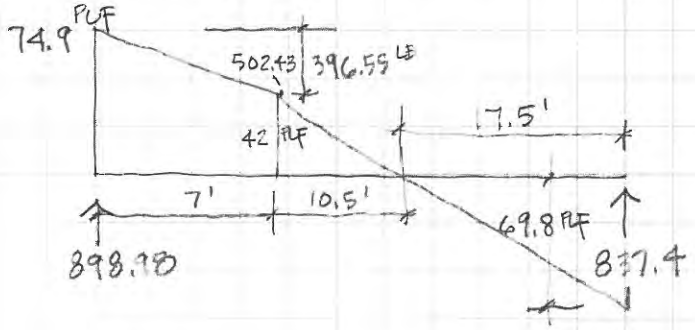
$F_1 = 8.8^{PLF}(17.5') + 47.85^{PLF}(7') = 488.95^{LB}$

$F_2 = 8.8(17.5) = 154^{LB}$

$F_3 = 47.85^{PLF}(17.5) = 837.4^{LB}$

$F_4 = 47.85^{PLF}(17.5') + 8.8^{PLF}(7') = 898.98^{LB}$

ROOF DIAPHRAGM - 7/16 OSB



PANEL GRADE:
- APA STRUCTURAL I
- 16 GA. STAPLES-1 3/4 LG
- UNBLOCKED
- NAILS SPACED 3" O.C @ PERIPHERY EDGES, 6" O.C @ EVERY WHERE ELSE

note pg13 →

- $F_{V_{ALL}} = 165^{PLF}$ CASE 1
  $= 125^{PLF}$ ALL OTHER CASES

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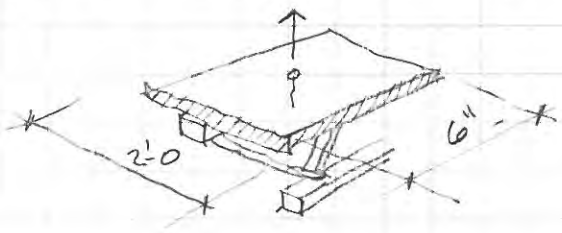
ROOF NAILING : C&C



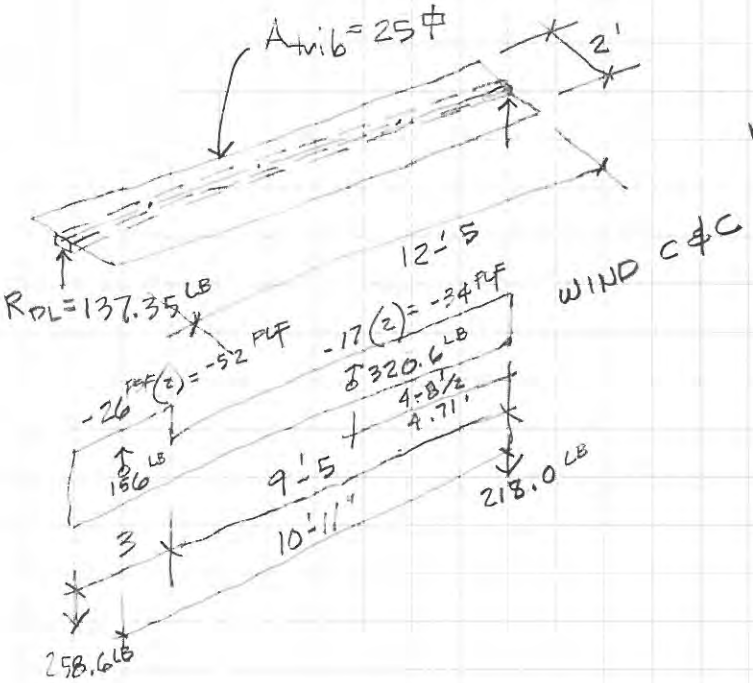
C&C
UPLIFT = -30 PSF ZONE 1 & 2
2.1
-27.9 PSF × 1 Φ = 28 LB ↑

IF 16 GA STAPLE × 1 3/4"
- 7/16
1 5/16 PEN
$P_{ALL} = 30 \frac{LB}{IN}(1.3125") 1.6 = 63 \frac{LB}{LF}$

@ INTERM. MEMBER
2 Φ UPLIFT = -45 PSF
C&C ZONE 3

DL = EPDM 1.0 PSF
7/16 OSB = 1.7 PSF
J/M 2½" = 0.75
3.45 × .6 = 2.1 PSF

∴ NET UPLIFT = 43 PSF ← ZONE 3
× 1 Φ = 43 LB ↑



WIND C&C

DL = 11.05 PSF × 2' = 22.1 PLF

W -.6D
↑ NET UPLIFT = 258.6 - 137.35(.6) = 176.2 LB/TRUSS

HOMEWAY HOMES : USES STAPLES

roof : 7/16 crown width 16 ga
1 3/4 long
3" O.C. edge
6" O.C field

walls : 1¾" long × 16 ga.
staples 3" O.C edge
6" O.C field
7/16 crown width

glue & staple sub fl.
23/32 OSB T&G
16ga staples : 7/16 crown 2" long
4 OC edge
8" OC field

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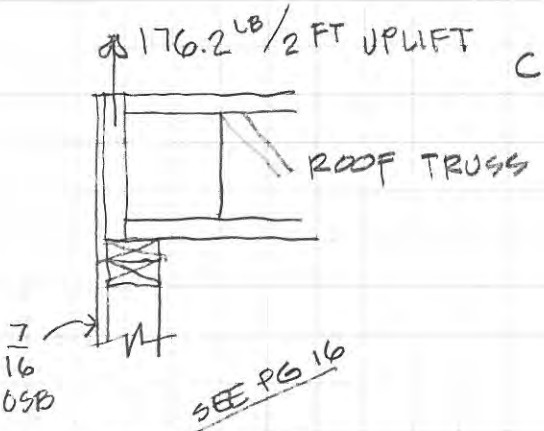
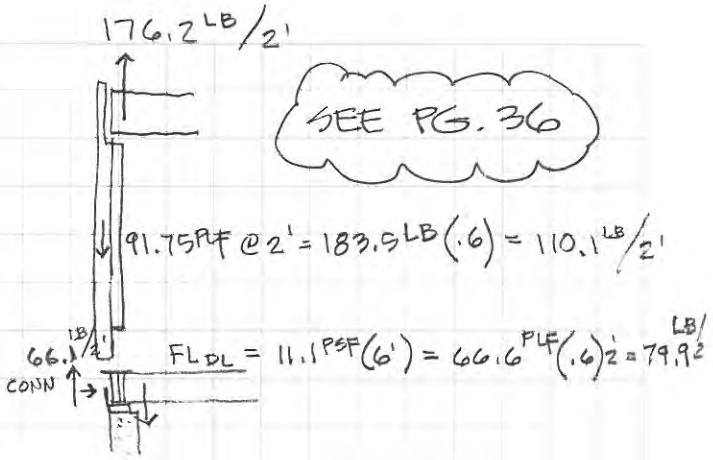
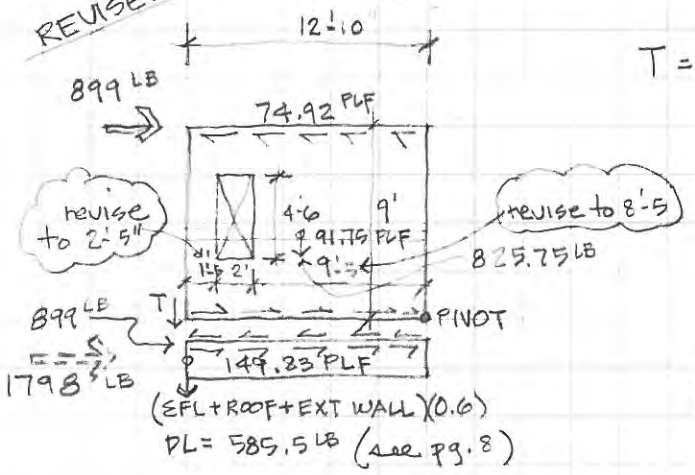




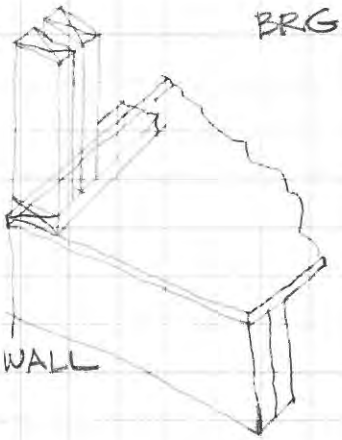
SEE PG 16

SHEAR WALL (4) REVISED



$$T = \frac{825.75(6.42) - 899(9)}{-12.83} = \frac{5301.3 - 8091}{-12.83} = +217.4^{LB} \therefore \downarrow (T)$$

∴ CONNECT TO ALL BRG. WALLS FOR UPLIFT TIE-DOWN @ EA. END



DESIGN AS PERFORATED SHEAR WALL

% FULL HGT SHEATHING:

$$\frac{2.43' + 8.43'}{12.83} = 0.85$$

C_o = Adj. factor = .91 $F_{V_{ALL}} = 155^{PLF}$ $\frac{h}{w} = \frac{9}{2.43} = 3.7 \sim 3.5$ limit OK

$$F_{V_{ALL_{ADJ}}} = .91(155) = 141^{PLF} >> 74.9^{PLF} \therefore OK$$

OR

$$v_{eff} = \frac{899^{LB}}{.91(2.43+8.43)} = 91.0^{PLF} < 155^{PLF} \therefore OK$$

16 ga x 1 3/4" LG STAPLES W/ 7/16 CROWN
SPACING 3" @ EDGES
6" @ OPEN FIELD

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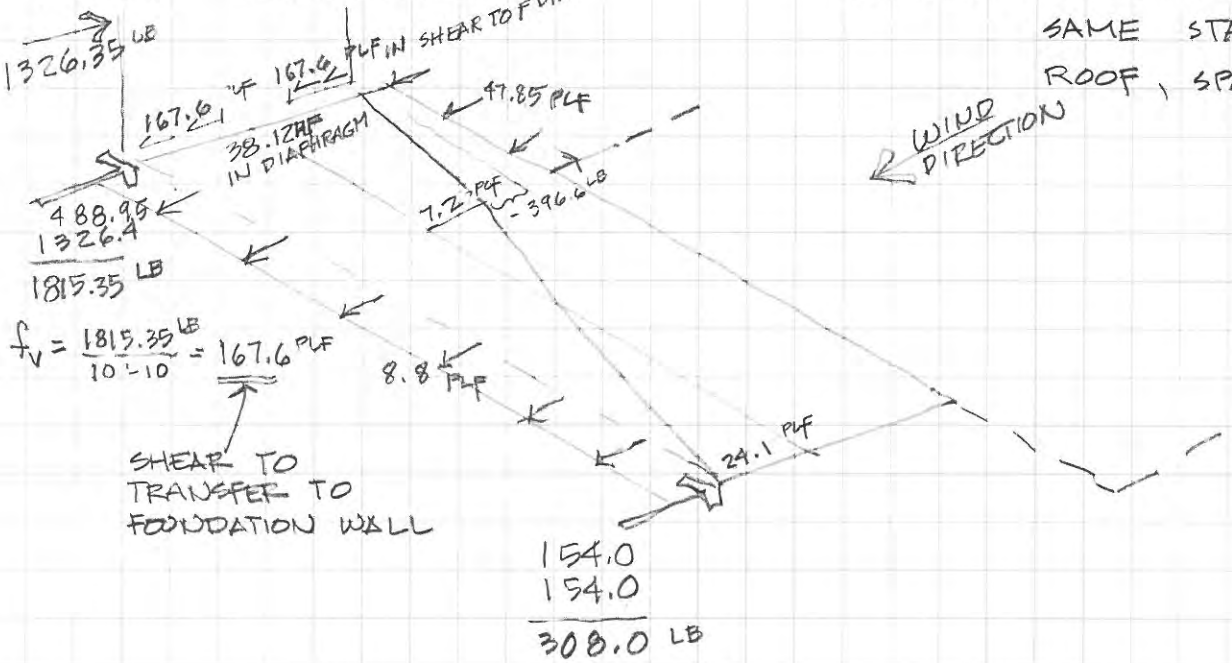
FLOOR DIAPHRAGM

7/16 OSB - APA RATED STRUCT. I
SAME STAPLES AS ROOF, SPACING & SIZE



$f_v = \frac{1815.35\ LB}{10'-10} = 167.6\ PLF$

SHEAR TO TRANSFER TO FOUNDATION WALL

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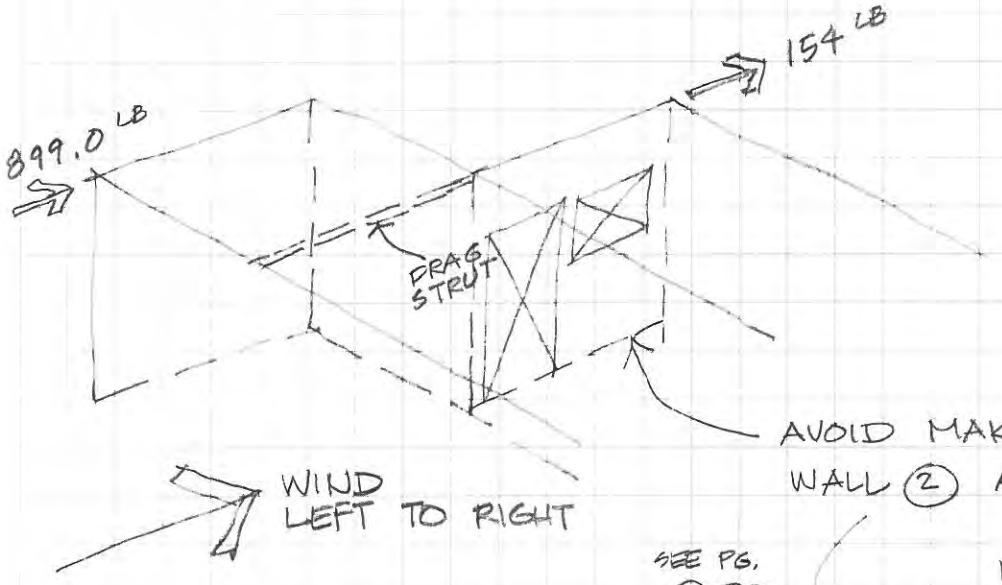

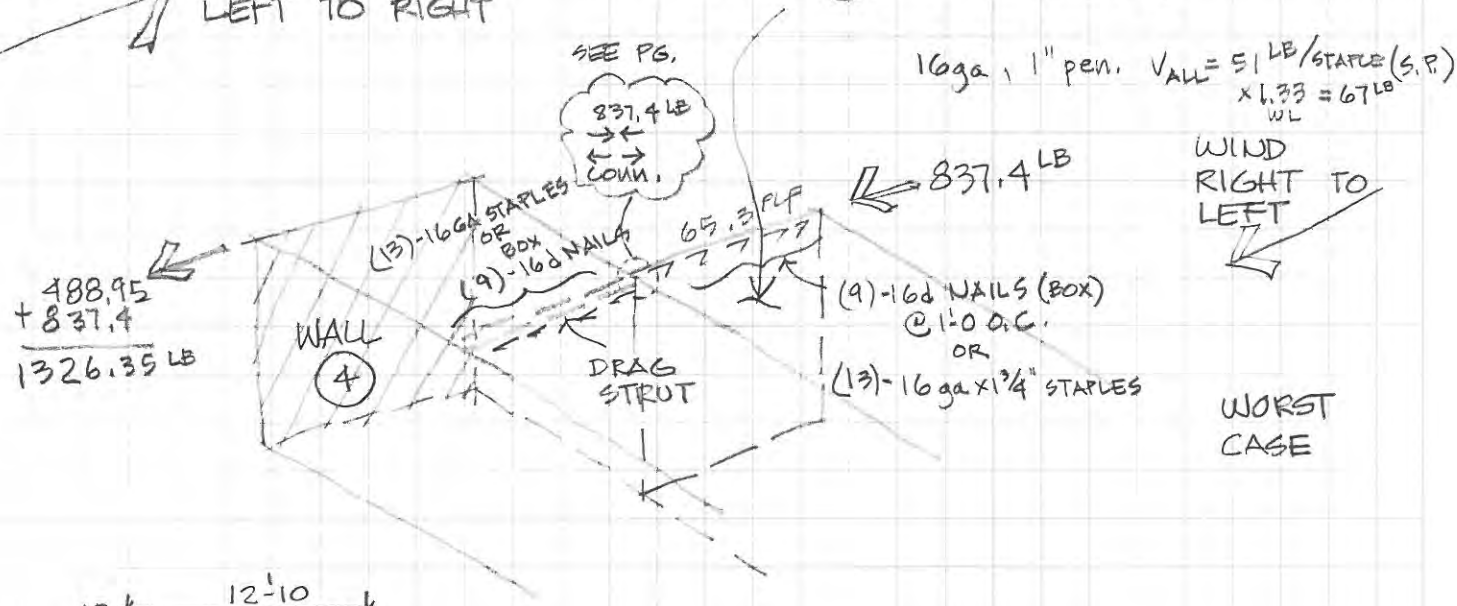

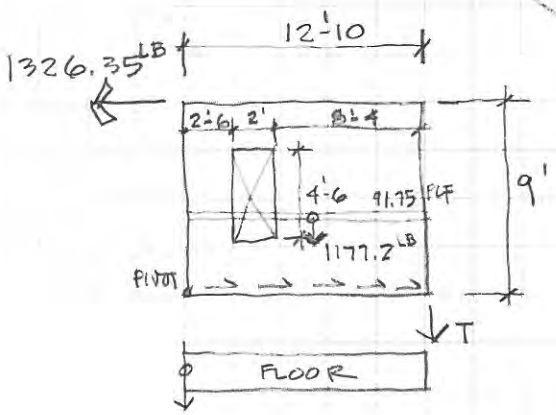

$$T = \frac{1326.35(9) - 1177.2(6.43)(.6)}{12.83} = \frac{11937.15 - 4541.6}{12.83} = 576.4^{LB}\downarrow \text{ UPLIFT}$$

CHECK VALIDITY OF PERFORATED SHEAR WALL SEGMENTS USING IBC METHOD

$h/w = 9/2.5 = 3.6 \approx 3.5$ MAX FOR WIND OK
$= 9/8.33$ 1.1 < 3.5 ∴ OK OK

OPG: .5h & % FULL HGT SHEATHED: $\frac{2.5+8.33}{12.83} = 0.84$

FROM TABLE 2305.3.8.2 $C_o = 0.91$

$$v_{EFF} = \frac{1326.35}{.91(2.5+8.33)} = 134.6^{PLF} < 155^{PLF}_{ALL}$$

∴ OK

DRAG STRUT

NAIL CAPACITIES IN SINGLE SHEAR

NDS 2001 Edition: Breyer Text; 5th Edition Revised:4/13/04

PROJECT: JOB NO: 06058

LOCATION:

Main Member (member receiving nail point):

specific gravity $SG_m := 0.5$

thickness $t_m := 1.5$ inches

(small dowels are considered fasteners < than or = 1/4 inch diameter)

small dowel bearing strength $F_{em} := 16600 \cdot SG_m^{1.84}$ $F_{em} = 4637$ psi

Side Member (member nail passes thru):

thickness $t_s := 0.4375$ inches

If side member is steel, set A=1, otherwise leave as zero. $A := 0.0$

A36 plate: $F_u := 58000$ psi (change "if" statement to 1.5Fu)

ASTM A653 Grade 33 cold formed steel plate: $F_{u1} := 45000$ psi

If wood side member, insert specific gravity $SG_s := 0.5$

$F_{es} := if(A < 1, 16600 \cdot SG_s^{1.84}, 1.375 \cdot F_{u1})$ $F_{es} = 4637$ psi

Nail: 16d com

diameter $D := 0.135$ inches

length $l_w := 3.5$ inches

bending yield $F_{yb} := (130.4 - 213.9 \cdot D) \cdot 1000$ $F_{yb} = 101523.5$ psi

(for low-carbon steel nails and spikes)

(for hardened threaded steel nails multipy Fyb by 1.3)

Minimum nail penetration for full dowel bearing capacity:

$p_{min10} := 10 \cdot D$ $p_{min10} = 1.35$ inches

$p_{min6} := 6D$ $p_{min6} = 0.81$ inches

Toenail Connection

If toenail connection, set theta=30°, otherwise leave as zero: $\theta := 0.0$

$L_{st} := \frac{L}{3}$ $L_{st} = 1.167$ inches

$p_L := L \cdot \cos(\theta \cdot deg) - L_{st}$ $p_L = 2.3$ inches

$L_{mL1} := if(p_L \geq p_{min10}, p_L, p_L - 2 \cdot D \cos(\theta \cdot deg))$ $L_{mL1} = 2.333$ inches

$L_{mL2} := if(L_{mL1} > t_m, t_m, L_{mL1})$ $L_{mL2} = 1.5$ inches

$L_{mL3} := if(L_{mL1} < p_{min6}, 0, L_{mL1})$ $L_{mL3} = 2.333$ inches

$L_{mL4} := if(L_{mL2} < L_{mL3}, L_{mL2}, L_{mL3})$ $L_{mL4} = 1.5$ inches

Dowel Bearing Lengths:

$L_{sd} := t_s$ $L_{sd} = 0.438$ inches

$p := if(L - t_s \leq t_m, L - t_s, t_m)$ $p = 1.5$ inches

$L_{m1} := if[p \geq p_{min10}, p, (L - t_s - 2 \cdot D)]$ $L_{m1} = 1.5$ inches

$L_{m2} := if(L_{m1} > t_m, t_m, L_{m1})$ $L_{m2} = 1.5$ inches

$L_{m3} := if(L_{m2} < p_{min6}, 0, L_{m2})$ $L_{m3} = 1.5$ inches

$L_{m4} := if(L_{m2} < L_{m3}, L_{m2}, L_{m3})$ $L_{m4} = 1.5$ inches

$L_m := if(\theta > 0, L_{mL4}, L_{m4})$ $L_m = 1.5$ inches

Note: Lm is the dowel bearing length in the main member. If Lm=0 this fastener cannot be used. It is too short.

Reduction Coefficient for fastener dia. < 0.25" (Kd):

$K_d := if(D \leq 0.17, 2.2, 10 \cdot D + 0.5)$ $K_d = 2.2$

$R_e := \frac{F_{em}}{F_{es}}$ $R_e = 1$

$L_s := if(\theta > 0, L_{st}, L_{sd})$ $L_s = 0.438$ inches

$R_t := \frac{L_m}{L_s}$ $R_t = 3.429$

$$k_1 := \frac{\left[\sqrt{R_e + 2\cdot R_e^{2}\cdot\left(1 + R_t + R_t^{2}\right) + R_t^{2}\cdot R_e^{3}} - R_e\cdot\left(1 + R_t\right)\right]}{\left(1 + R_e\right)}$$

$k_1 = \mathbf{1.144}$

$$k_2 := -1 + \sqrt{2\cdot\left(1 + R_e\right) + \frac{\left[2\cdot F_{yb}\cdot\left(1 + 2\cdot R_e\right)\cdot D^{2}\right]}{3\cdot F_{em}\cdot L_m^{2}}}$$

$k_2 = \mathbf{1.087}$

$$k_3 := -1 + \sqrt{\left[2\cdot\frac{\left(1 + R_e\right)}{R_e}\right] + 2\cdot F_{yb}\cdot\left(2 + R_e\right)\cdot\frac{D^{2}}{3\cdot F_{em}\cdot L_s^{2}}}$$

$k_3 = \mathbf{1.858}$

Yield Limit Equations:

Mode Im $\quad z_1 := \frac{D\cdot L_m\cdot F_{em}}{K_d}$ $\quad z_1 = \mathbf{427}$ lbs

Mode Is $\quad z_2 := \frac{D\cdot L_s\cdot F_{es}}{K_d}$ $\quad z_2 = \mathbf{124}$ lbs

Mode II $\quad z_3 := \frac{k_1\cdot D\cdot L_s\cdot F_{es}}{K_d}$ $\quad z_3 = \mathbf{142}$ lbs

Mode IIIm $\quad z_4 := \frac{k_2\cdot D\cdot L_m\cdot F_{em}}{K_d\cdot\left(1 + 2\cdot R_e\right)}$ $\quad z_4 = \mathbf{155}$ lbs

Mode IIIs $\quad z_5 := \frac{k_3\cdot D\cdot L_s\cdot F_{em}}{K_d\cdot\left(2 + R_e\right)}$ $\quad z_5 = \mathbf{77}$ lbs

Mode IV $\quad z_6 := \frac{D^{2}}{K_d}\cdot\sqrt{\frac{2\cdot F_{em}\cdot F_{yb}}{3\cdot\left(1 + R_e\right)}}$ $\quad z_6 = \mathbf{103.8}$ lbs

$z := \text{if}\left(z_1 \le z_2, z_1, z_2\right)$ $\quad z_{ww} := \text{if}\left(z \le z_3, z, z_3\right)$

$z_{ww} := \text{if}\left(z \le z_4, z, z_4\right)$ $\quad z_{ww} := \text{if}\left(z \le z_5, z, z_5\right)$

$z_{ww} := \text{if}\left(z \le z_6, z, z_6\right)$

Nominal design value, smallest of all yield equations: $z = \mathbf{77.1}$ lbs/nail

Adjustment factors (VERIFY):

Load Duration Factor: . . . . . $C_D := \underline{\mathbf{1.3}}$

use same as allowable member stresses

Wet Service Factor : . . . . . $C_M := \underline{\mathbf{1.0}}$

See NDS Table 10.3.3

Temperature Factor : . . . . . $C_t := \underline{\mathbf{1.0}}$

See NDS Table 10.3.4

End Grain Factor : . . . . . $C_{eg} := \underline{\mathbf{1.0}}$

Use 0.67 if point is in end grain

Toenail Factor . . . : . . . . . $C_{tn} := \underline{\mathbf{1.0}}$

Use 0.83 if toe-nail and laterally loaded

Diaphragm Factor : . . . . . $C_{di} := \underline{\mathbf{1.0}}$

Use 1.1 if a diaphragm shear connection

Adjusted capacity of one nail:

$Z_a := z \cdot C_D \cdot C_M \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot C_{di}$ $Z_a = \underline{\mathbf{100.2}}$ lbs/nail

Required load to be transferred: $P := \underline{\mathbf{837.4}}$ lbs

Number of nails required:

$N := ceil\left(\frac{P}{Z_a}\right)$ $N = \underline{\mathbf{9}}$ nails

Or, Capacity for number of nails:

number of nails in connection: $n := \underline{\mathbf{9}}$

$P_{all} := n \cdot Z_a$ $P_{all} = \underline{\mathbf{902}}$ lbs

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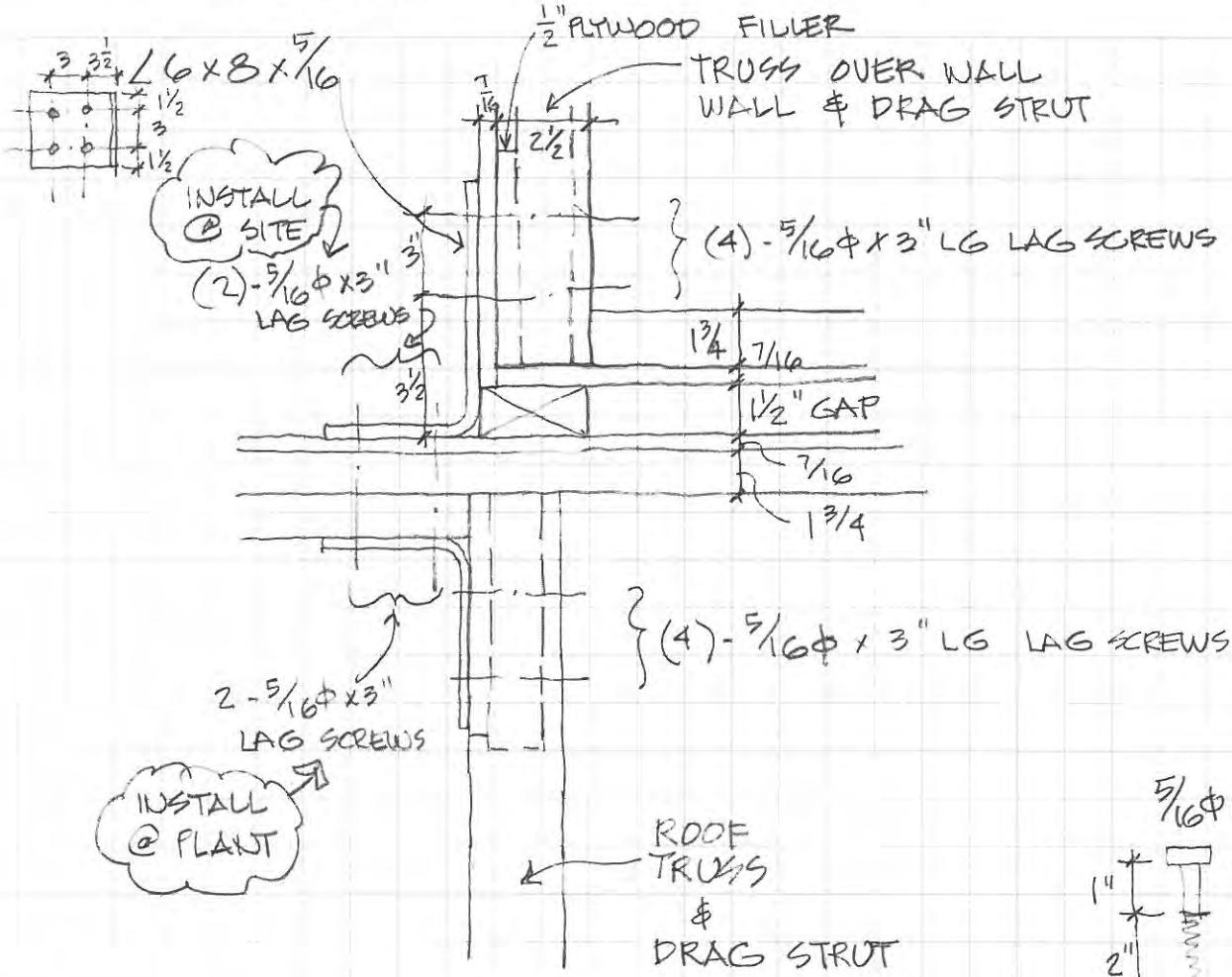
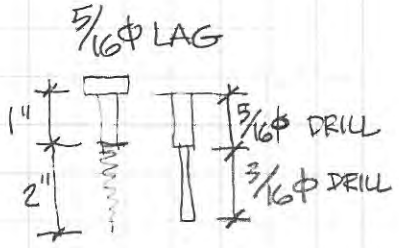
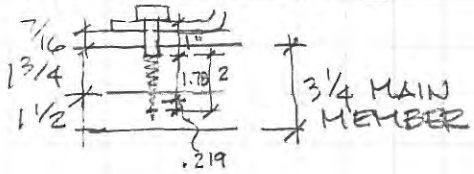
Proj. No. 12474004





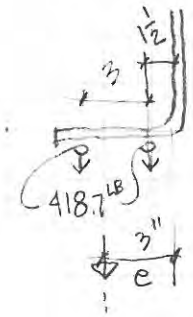
LAG WITHDRAWAL



if 5/16φ x 3" LAG : $p_{EU} = 1.78"$

$\therefore W' = 266^{LB/IN}(1.78^{IN})1.33 = 630^{LB/LAG}$

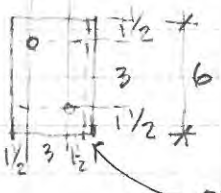
$\therefore$ 2 LAG'S REQ'D



$M = 837.4(3") = 2512.2^{IN\ LB}$

$S_{REQ} = \frac{M/1000}{27\ KSI} = 0.093^{IN^3}$

5/16 MIN BENT ⌀
7/16 MIN AVAILABLE



$S = \frac{bt^2}{6} = \frac{6(.3129)^2}{6} = .0977 > .093 \therefore OK$

OPPOSITE ∠ USES OTHER (2) HOLE LOCATIONS

LAG SCREWS IN SINGLE SHEAR

revised: 04-21-04

NDS 2001: Breyer text 5th Edition

PROJECT: Solar Decathlon 2011, Champaign, IL **JOB NO**: 12474004

LOCATION: drag strut load transfer between units

Lag Bolt Information:

Diameter	$D := 0.3125$	inches
Bending yield for A307 bolts > 3/8" dia.:Fyb = 45 ksi for 1/4" dia. lags: Fyb = 70 ksi, for 5/16" dia. lags: Fyb = 60 ksi	$F_{yb} := 60000$	psi
Length of bolt	$L_w := 3.0$	inches
Root dia. of threaded portion:	$D_r := 0.227$	inches
Length of tapered tip	$E_1 := 0.1875$	inches
Washer thickness or filler	$t_w := 0.9375$	inches

Main Member (receives the point):

Specific gravity	$SG_m := 0.5$	
Thickness	$t_m := 1.5$	inches

If parallel to grain loading, theta = zero; if perpendicular to grain loading, theta = 90°; for any angle in between, insert theta:

$\theta_m := 90.0$

$F_{emp} := 11200 \cdot SG_m$ $F_{emp} = 5600$ psi

$F_{em90} := 6100 \cdot SG_m^{1.45} \cdot D^{-0.5}$ $F_{em90} = 3994$ psi

$$F_{em\theta} := \frac{F_{emp} \cdot F_{em90}}{F_{emp} \cdot \sin(\theta_m \cdot deg)^2 + F_{em90} \cdot \cos(\theta_m \cdot deg)^2}$$

$F_{em\theta} = 3994$ psi

$F_{em} := F_{em\theta}$ $F_{em} = 3994$ psi

Side Member:

Thickness of side member: $t_s := 0.375$ inches

If side member is A36 steel, set A=1; if side member is wood, leave as zero:

$A := 1.0$

If wood side member insert specific gravity: $SG_s := 0.0$

If parallel to grain loading, theta=zero; if perpendicular to grain loading, theta=90o; for any angle in between, insert theta:

$\theta_s := 0.0$

$F_{esp} := 11200 \cdot SG_s$ $F_{esp} = 0$ psi

$F_{es90} := 6100 \cdot SG_s^{1.45} \cdot D^{-0.5}$ $F_{es90} = 0$ psi

$$F_{es\theta} := \frac{F_{esp} \cdot F_{es90}}{F_{esp} \cdot \sin(\theta_s \cdot deg)^2 + F_{es90} \cdot \cos(\theta_s \cdot deg)^2}$$

$F_{es\theta} = 0$ psi $F_{es1} := F_{es\theta}$

for A36 steel plate: $F_u := 58000$ psi

$F_{es} := if(A < 1, F_{es1}, 1.5 \cdot F_u)$ $F_{es} = 87000$ psi

Dowel Bearing Lengths

$L_s := t_s$ $L_s = 0.375$ inches

$p_{min10} := 10 \cdot D$ $p_{min10} = 3.125$ inches

$p_{min4} := 4 \cdot D$ $p_{min4} = 1.25$ inches

$p_{act} := L - t_s - t_w$ $p_{act} = 1.688$ inches

$L_{m1} := if(p_{act} < p_{min10}, L - t_s - t_w - E_1, L - t_s - t_w)$ $L_{m1} = 1.500$

$L_m := if(L_{m1} < p_{min4}, 0, L_{m1})$ $L_m = 1.5$ inches

Note: Lm is the dowel bearing length in the main member. If Lm=0 this fastener cannot be used. It is too short or the bolt dia. is too large.

Coefficients

$$R_t := \frac{L_m}{L_s} \qquad R_t = 4 \qquad R_e := \frac{F_{em}}{F_{es}} \qquad R_e = 0.046$$

$$\theta_s := \text{if}(A > 0, 0.0, \theta_s) \qquad \theta := \text{if}(\theta_m > \theta_s, \theta_m, \theta_s)$$

θ degrees

$$K_\theta := 1 + \frac{\theta}{360} \qquad K_\theta = 1.25$$

$$k_1 := \frac{\sqrt{R_e + 2 \cdot R_e^2 \cdot (1 + R_t + R_t^2) + R_t^2 \cdot R_e^3} - R_e \cdot (1 + R_t)}{(1 + R_e)}$$

$$k_2 := -1 + \sqrt{2 \cdot (1 + R_e) + \frac{2 \cdot F_{yb} \cdot (1 + 2 \cdot R_e) \cdot D_r^2}{3 \cdot F_{em} \cdot t_m^2}}$$

$$k_3 := -1 + \sqrt{\frac{2 \cdot (1 + R_e)}{R_e} + \frac{2 \cdot F_{yb} \cdot (2 + R_e) \cdot D_r^2}{3 \cdot F_{em} \cdot L_s^2}}$$

$k_1 = 0.133$ $k_2 = 0.53$ $k_3 = 6.285$

Yield Limit Equations:

Mode Im $z_1 := \frac{D_r \cdot L_m \cdot F_{em}}{4 \cdot K_\theta}$ $z_1 = 272$ lbs

Mode Is $z_2 := \frac{D_r \cdot L_s \cdot F_{es}}{4 \cdot K_\theta}$ $z_2 = 1481$ lbs

Mode II $z_3 := \frac{k_1 \cdot D_r \cdot L_s \cdot F_{es}}{3.6 \cdot K_\theta}$ $z_3 = 219$ lbs

Mode IIIm $z_4 := \frac{k_2 \cdot D_r \cdot L_m \cdot F_{em}}{3.2 \cdot (1 + 2 \cdot R_e) \cdot K_\theta}$ $z_4 = 165$ lbs

Mode IIIs $z_5 := \frac{k_3 \cdot D_r \cdot L_s \cdot F_{em}}{3.2 \cdot (2 + R_e) \cdot K_\theta}$ $z_5 = 261$ lbs

Mode IV $z_6 := \frac{D_r^2}{3.2 \cdot K_\theta} \cdot \sqrt{\frac{2 \cdot F_{em} \cdot F_{yb}}{3 \cdot (1 + R_e)}}$ $z_6 = 159$ lbs

$z_2 := \text{if}(A > 0, 10000, z_2)$ $\quad z := \text{if}(z_2 \le z_1, z_2, z_1)$

$z := \text{if}(z_3 \le z, z_3, z)$ $\quad z := \text{if}(z_4 \le z, z_4, z)$

$z := \text{if}(z_5 \le z, z_5, z)$ $\quad Z := \text{if}(z_6 \le z, z_6, z)$

$Z = 159$ lbs

Adjustment factors (VERIFY):

Load Duration Factor: . . . . . $C_D := 1.33$

Wet Service Factor: . . . . . $C_m := 1.0$

Temperature Factor: . . . . . $C_t := 1.0$

Group Action Factor:

Number of fasteners in a row: . . . . $n := 2.0$

Center-to-center spacing of fasteners: $s := 3.0$ inches

Gross x-sectional area of **MAIN** member: $A_m := 18$ in²

Modulus of elasticity of **MAIN** member: $E_m := 1600000$ psi

Gross x-sectional area of **SIDE** member: $A_s := 3.00$ in²

Modulus of elasticity of SIDE member: $E_s := 29000000.0$ psi

Load/slip modulus for a connection, lb/in:

$\gamma := \text{if}(A < 1.0, 180000 \cdot D^{1.5}, 270000 \cdot D^{1.5})$ $\quad \gamma = 47167$ lb/in

NOTE: The above equation only covers BOLTS and LAG BOLTS in a wood-to-wood or a wood-to-metal connection.

$u := 1 + \gamma \cdot \left(\frac{s}{2}\right) \cdot \left(\frac{1}{E_m \cdot A_m} + \frac{1}{E_s \cdot A_s}\right)$ $\quad u = 1$

$m := u - \sqrt{u^2 - 1}$ $\quad m = 0.92$

$B := \frac{E_s \cdot A_s}{E_m \cdot A_m}$ $\quad B = 3.02$ $\quad C := \frac{E_m \cdot A_m}{E_s \cdot A_s}$ $\quad C = 0.33$

$R_{ea} := \text{if}(B < C, B, C)$ $\quad R_{ea} = 0.33$

$C_g := \left[\frac{m \cdot \left(1 - m^{2 \cdot n}\right)}{\left[\left(1 + R_{ea} \cdot m^n\right) \cdot (1 + m) - 1 + m^{2 \cdot n}\right] \cdot n}\right] \cdot \left(\frac{1 + R_{ea}}{1 - m}\right)$ $\quad C_g = 1$

BOLT SPACING REQUIREMENTS

	Parallel-to-grain loading:	Perpendicular-to-grain loading:
1.	End Distance-	
	Members in tension:	
	softwoods - 7D (3.5D min) hardwoods - 5D (2.5D min)	4D (2D min)
	Members in compression:	
	4D (2D min)	4D (2D min)
2.	Edge Distance: bolt slenderness= Ls/D and Lm/D	
	a. for L/D <or= 6.0 : 1.5D b. for L/D > 6.0 : 1.5D or 0.5 * row spacing, use larger	Loaded Edge: 4D Unloaded Edge: 1.5D
3.	Center - to - center spacing-	
	s = 4D (3D min)	3D min
4.	Row spacing-	
	1.5D (5D max)	a. for L/D <or= 2.0 : 2.5D b. for L/D >or= 6.0 : 5D c. for 2.0 < L/D < 6.0 : interpolate between 2.5D and 5D

Geometry Factor:

ENTER End distance **EQUATION** to obtain full design value:

$E := 7 \cdot D$ $E = 2.19$ inches

ENTER Minimum edge distance **EQUATION** to obtain full design value:

$F := 2 \cdot D$ $F = 0.63$ inches

ENTER Minimum center-to-center spacing **EQUATION** to obain full design value:

$E_r := 4 \cdot D$ $E_r = 1.25$ inches

ENTER Minimum row spacing **EQUATION** to obtain full design value:

$F_r := 5 \cdot D$ $F_r = 1.563$ inches

ENTER furnished end distance: $G_{end} := 3.0$ inches

ENTER furnished edge distance: $G_{edge} := 2.5$ inches

ENTER furnished center-to-center spacing: $G_{center} := 3.0$ inches

ENTER furnished row spacing: $G_{row} := 3.0$ inches
(if one row enter number greater than Fr)

$$C_{\Delta end1} := if\left(G_{end} > E, 1.0, \frac{G_{end}}{E}\right) \qquad C_{\Delta end1} = 1$$

$$C_{\Delta end2} := if\left(G_{end} < \frac{E}{2}, 0, C_{\Delta end1}\right) \qquad C_{\Delta end2} = 1$$

$$C_{\Delta edge1} := if\left(G_{edge} > F, 1.0, \frac{G_{edge}}{F}\right) \qquad C_{\Delta edge1} = 1$$

$$C_{\Delta center1} := if\left(G_{center} > E_r, 1.0, \frac{G_{center}}{E_r}\right) \qquad C_{\Delta center1} = 1$$

$$C_{\Delta center2} := if\left(G_{center} < 0.75 \cdot E_r, 0, C_{\Delta center1}\right) \qquad C_{\Delta center2} = 1$$

$$C_{\Delta row1} := if\left(G_{row} > F_r, 1.0, \frac{G_{row}}{F_r}\right) \qquad C_{\Delta row1} = 1$$

Check for smallest C_Δ value from all geometry checks:

$$C_\Delta := if\left(C_{\Delta end1} \le C_{\Delta end2}, C_{\Delta end1}, C_{\Delta end2}\right) \qquad C_\Delta = 1$$

$$C_\Delta := if\left(C_{\Delta edge1} \le C_\Delta, C_{\Delta edge1}, C_\Delta\right) \qquad C_\Delta = 1$$

$$C_\Delta := if\left(C_{\Delta center1} \le C_\Delta, C_{\Delta center1}, C_\Delta\right) \qquad C_\Delta = 1$$

$$C_\Delta := if\left(C_{\Delta center2} \le C_\Delta, C_{\Delta center2}, C_\Delta\right) \qquad C_\Delta = 1$$

$$C_\Delta := if\left(C_{\Delta row1} \le C_\Delta, C_{\Delta row1}, C_\Delta\right) \qquad C_\Delta = 1$$

End grain factor: $C_{eg} := 1.0$

When threaded end of lag is in end grain Ceg = 0.67,
and Fem = Fe perpendicular, thus θ = 90 degrees.

Adjusted capacity of one Lag Bolt in single shear:

$$Z_a := Z \cdot \left(C_D \cdot C_m \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg}\right) \qquad Z_a = 211 \text{ lbs}$$

Total capacity of N Lag Bolts:

Number of bolts on one side of the connection-

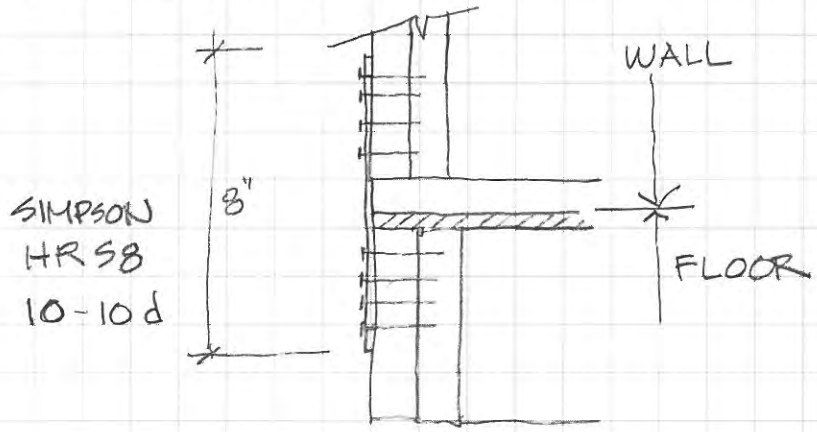
$N := 4$ bolts $\qquad Z_{tot} := Z_a \cdot N \qquad Z_{tot} = 846$ lbs

CONT. FROM PG. 16

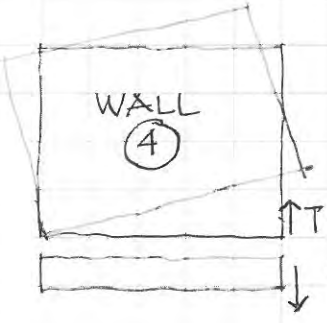
$\therefore F_{V_{ALL}} = 0.91(310\ PLF) = 282\ PLF$

$v_{ACT} = \frac{1326^{LB}}{10.83} = 122.4\ PLF < 282\ PLF \therefore OK$

FOR UPLIFT @ SHEAR WALL



CHECK UPLIFT TO FOOTING:



$\uparrow T = 576.4^{LB}$ NET UPLIFT

$\downarrow$ FLOOR DL + LONG. WALL DL + ROOF DL = $66.3^{PLF} + 66.6^{PLF} + 91.75^{PLF} = \underline{224.65^{PLF}}$

PG. 1 TO 3

$@ \frac{7.43'}{2} = 834.6^{LB} \times .6 = 500.7^{LB}$

$\therefore$ NET UPLIFT TO FDTN IN CHAMPAIGN $= \underline{75.7^{LB}}$

IF UTILIZE FULL LL CAPABILITY OF 'OPEN JOIST' 9¼" DEEP WITH 3" WIDE FLANGE @ 16" O.C FOR 12' CLEAR SPAN:

$LL_{max\ ALL} = 86^{PSF}$

$\therefore w_{FL_{D+L}} = 11.1^{PSF}_{DL}(6') + 86^{PSF}_{LL}(6')$

$= 66.6^{PLF} + 516^{PLF}$

$= \underline{582.6^{PLF}}$

ALSO, ASSUME MAX. ALLOW SOIL BEARING PRESSURE IS $\underline{1500^{PSF}}$

$\Sigma_{D+L} = 186.3^{PLF}_{ROOF} + 91.75^{PLF}_{WALL} + 582.6^{PLF}_{FLOOR} = 860.7^{PLF}$ ← compare w/ pg. 3

FOR 8'-8¼ SPACING OF EXT. LONG SIDE:

$P = 7476.9^{LB}$

$f_{brg} = \frac{860.7(8.6875')}{2.5^2} = \underline{1196.3^{PSF}} << 1500^{PSF}$

∴ OK

EXT. CORNER FTG:

SHORT WALL: DL = 593.2^{LB}

DL+LL: LONG WALL: $860.7\left(\frac{8.6875'}{2}\right) = \underline{3738.7^{LB}}$

DL+LL Σ = 4331.9^{LB}

$f_{brg} = \frac{4331.9^{LB}}{2^2} = \underline{1083.0^{PSF}} < 1500^{PSF}$

∴ OK

REVISED PARTY WALL FOOTING PRESSURES:

from pg 5 $P_{5_{DL+LL}} = 2629.9 + 1319.0 + 452.8 + 582.6(2)\frac{7.08'}{2} = 8526.5^{LB}$

$f_{brg} = \frac{8526.5}{2.5^2} = \underline{1364.2^{PSF}} < 1500$

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Project SOLAR DECATHLON 2011 Comp. by DJW
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$P_{4_{DL+LL}} = 2968.3 + 582.6^{PLF}\left(\frac{7.5'}{2}\right) + 1314.95^{LB} = \underline{6468^{LB}}$

$f_{brg} = \frac{6468^{LB}}{2.5^2} = \underline{1034.9^{PSF}} < 1500$

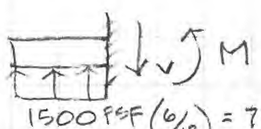
$P_{6_{DL+LL}} = 2638.0^{LB} + 905.5^{LB} + 582.6^{PLF}(2)\,7.08' = 11{,}793.1^{LB}$

$f_{brg} = \frac{11{,}793.1}{3^2} = \underline{1310.3^{PSF}} < 1500$

$P_{7_{DL+LL}} = 1319 + 452.8 + 582.6^{PLF}(2)\left(\frac{7.08'}{2}\right) + 550.5 + 860.7^{PLF}\left(\frac{7.43'}{2}\right) = 9644.6^{LB}$

$f_{brg} = \frac{9644.6}{2.75^2} = \underline{1275\ PSF}$

SEE PG. 7

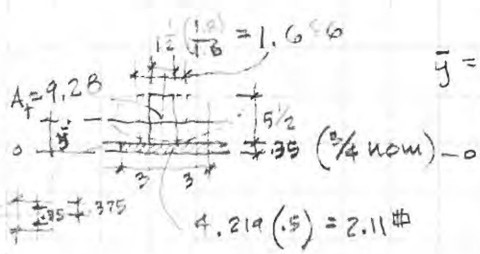


$V = 562.5^{LB}$ $M = \frac{750(.75)^2}{2} = 210.9^{FTLB}$

$1500^{PSF}(6/12) = 750^{PLF}$

9" / .75'

$S_{req} = \frac{M \cdot 12}{1250^{PSI}} = 2.025^{in^3} < 7.5^{in^3}$ OK TRY S.P. # 2x6



$\frac{1}{12}\left(\frac{1.8}{1.6}\right) = 1.686$

$A_t = 9.28$

5 1/2

.35 (3/4 nom)

3 3

.75 .35 .375

$4.219(.5) = 2.11^{in^2}$

$\bar{y} = \frac{9.28(3.5) + 2.11(.375)}{9.28 + 2.11} = 2.92"$

$f_v = \frac{3(562.5)}{2(8.25)} = 102.3^{PSI} < 160^{PSI}$ OK

$\Delta = \frac{750}{334}(.000686) = .0015^{IN}$

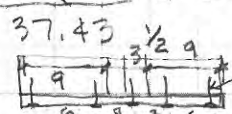
$n = \frac{E_p}{E_w} = \frac{1.8}{1.6} = 1.125$

$I_{tr} = .239(.5) + 2.11(2.92 - .375)^2 + \frac{1.686(5.5)^3}{12} + 9.28(2.92 - 2.75)^2 = .1195 + 13.67 + 23.38 + .268$

$I_{tr} = 37.43^{in^4}$

$Q_a = 2.11(2.92 - .375) = 5.37^{in^3}$

$q = \frac{VQ}{I_{tr}} = \frac{562.5(5.37)}{37.43} = 80.7^{PLI}$



16d COM @ EA 2x6

FOOTING CONN
2x6 TO PLYWOOD

NAIL CAPACITIES IN SINGLE SHEAR

NDS 2001 Edition: Breyer Text; 5th Edition

Revised:4/13/04

PROJECT:

JOB NO: 06058

LOCATION:

Main Member (member receiving nail point):

specific gravity $SG_m := \mathbf{0.5}$

thickness $t_m := \mathbf{5.5}$ inches

(small dowels are considered fasteners < than or = 1/4 inch diameter)

small dowel bearing strength $F_{em} := \mathbf{16600} \cdot SG_m^{\mathbf{1.84}}$ $F_{em} = \mathbf{4637}$ psi

Side Member (member nail passes thru):

thickness $t_s := \mathbf{0.75}$ inches

If side member is steel, set A=1, otherwise leave as zero. $A := \mathbf{0.0}$

A36 plate: $F_u := \mathbf{58000}$ psi (change "if" statement to 1.5Fu)

ASTM A653 Grade 33 cold formed steel plate: $F_{u1} := \mathbf{45000}$ psi

If wood side member, insert specific gravity $SG_s := \mathbf{0.5}$

$F_{es} := \text{if}\left(A < \mathbf{1}, \mathbf{16600} \cdot SG_s^{\mathbf{1.84}}, \mathbf{1.375} \cdot F_{u1}\right)$ $F_{es} = \mathbf{4637}$ psi

Nail: 16d com

diameter $D := \mathbf{0.162}$ inches

length $L := \mathbf{3.5}$ inches

bending yield $F_{yb} := (\mathbf{130.4} - \mathbf{213.9} \cdot D) \cdot \mathbf{1000}$ $F_{yb} = \mathbf{95748.2}$ psi

(for low-carbon steel nails and spikes)

(for hardened threaded steel nails multipy Fyb by 1.3)

Minimum nail penetration for full dowel bearing capacity:

$p_{min10} := \mathbf{10} \cdot D$ $p_{min10} = \mathbf{1.62}$ inches

$p_{min6} := \mathbf{6} D$ $p_{min6} = \mathbf{0.972}$ inches

Toenail Connection

If toenail connection, set theta=30°, otherwise leave as zero: $\theta := 0.0$

$L_{st} := \frac{L}{3}$ $L_{st} = 1.167$ inches

$p_L := L \cdot \cos(\theta \cdot deg) - L_{st}$ $p_L = 2.3$ inches

$L_{mL1} := if(p_L \geq p_{min10}, p_L, p_L - 2 \cdot D \cos(\theta \cdot deg))$ $L_{mL1} = 2.333$ inches

$L_{mL2} := if(L_{mL1} > t_m, t_m, L_{mL1})$ $L_{mL2} = 2.333$ inches

$L_{mL3} := if(L_{mL1} < p_{min6}, 0, L_{mL1})$ $L_{mL3} = 2.333$ inches

$L_{mL4} := if(L_{mL2} < L_{mL3}, L_{mL2}, L_{mL3})$ $L_{mL4} = 2.333$ inches

Dowel Bearing Lengths:

$L_{sd} := t_s$ $L_{sd} = 0.75$ inches

$p := if(L - t_s \leq t_m, L - t_s, t_m)$ $p = 2.8$ inches

$L_{m1} := if[p \geq p_{min10}, p, (L - t_s - 2 \cdot D)]$ $L_{m1} = 2.75$ inches

$L_{m2} := if(L_{m1} > t_m, t_m, L_{m1})$ $L_{m2} = 2.8$ inches

$L_{m3} := if(L_{m2} < p_{min6}, 0, L_{m2})$ $L_{m3} = 2.8$ inches

$L_{m4} := if(L_{m2} < L_{m3}, L_{m2}, L_{m3})$ $L_{m4} = 2.75$ inches

$L_m := if(\theta > 0, L_{mL4}, L_{m4})$ $L_m = 2.75$ inches

Note: Lm is the dowel bearing length in the main member. If Lm=0 this fastener cannot be used. It is too short.

Reduction Coefficient for fastener dia. < 0.25" (Kd):

$K_d := if(D \leq 0.17, 2.2, 10 \cdot D + 0.5)$ $K_d = 2.2$

$R_e := \frac{F_{em}}{F_{es}}$ $R_e = 1$

$L_s := if(\theta > 0, L_{st}, L_{sd})$ $L_s = 0.75$ inches

$R_t := \frac{L_m}{L_s}$ $R_t = 3.667$

$$k_1 := \frac{\left[\sqrt{R_e + 2\cdot R_e^{2}\cdot\left(1 + R_t + R_t^{2}\right) + R_t^{2}\cdot R_e^{3}} - R_e\cdot(1 + R_t)\right]}{(1 + R_e)}$$

$k_1 = \mathbf{1.226}$

$$k_2 := -1 + \sqrt{2\cdot(1 + R_e) + \frac{\left[2\cdot F_{yb}\cdot(1 + 2\cdot R_e)\cdot D^{2}\right]}{3\cdot F_{em}\cdot L_m^{2}}}$$

$k_2 = \mathbf{1.036}$

$$k_3 := -1 + \sqrt{\left[2\cdot\frac{(1 + R_e)}{R_e}\right] + 2\cdot F_{yb}\cdot(2 + R_e)\cdot\frac{D^{2}}{3\cdot F_{em}\cdot L_s^{2}}}$$

$k_3 = \mathbf{1.435}$

Yield Limit Equations:

Mode Im $\quad z_1 := \dfrac{D\cdot L_m\cdot F_{em}}{K_d}$ $\quad z_1 = \mathbf{939}$ lbs

Mode Is $\quad z_2 := \dfrac{D\cdot L_s\cdot F_{es}}{K_d}$ $\quad z_2 = \mathbf{256}$ lbs

Mode II $\quad z_3 := \dfrac{k_1\cdot D\cdot L_s\cdot F_{es}}{K_d}$ $\quad z_3 = \mathbf{314}$ lbs

Mode IIIm $\quad z_4 := \dfrac{k_2\cdot D\cdot L_m\cdot F_{em}}{K_d\cdot(1 + 2\cdot R_e)}$ $\quad z_4 = \mathbf{324}$ lbs

Mode IIIs $\quad z_5 := \dfrac{k_3\cdot D\cdot L_s\cdot F_{em}}{K_d\cdot(2 + R_e)}$ $\quad z_5 = \mathbf{122}$ lbs

Mode IV $\quad z_6 := \dfrac{D^{2}}{K_d}\cdot\sqrt{\dfrac{2\cdot F_{em}\cdot F_{yb}}{3\cdot(1 + R_e)}}$ $\quad z_6 = \mathbf{145.1}$ lbs

$z := \text{if}(z_1 \le z_2, z_1, z_2)$ $\quad z_{ww} := \text{if}(z \le z_3, z, z_3)$

$z_{ww} := \text{if}(z \le z_4, z, z_4)$ $\quad z_{ww} := \text{if}(z \le z_5, z, z_5)$

$z_{ww} := \text{if}(z \le z_6, z, z_6)$

Nominal design value, smallest of all yield equations: $z = \mathbf{122.4}$ lbs/nail

Adjustment factors (VERIFY):

Load Duration Factor: . . . . . $C_D := \underline{1.0}$

use same as allowable member stresses

Wet Service Factor : . . . . . $C_M := \underline{0.7}$

See NDS Table 10.3.3

Temperature Factor : . . . . . $C_t := \underline{1.0}$

See NDS Table 10.3.4

End Grain Factor : . . . . . $C_{eg} := \underline{1.0}$

Use 0.67 if point is in end grain

Toenail Factor . . . : . . . . . $C_{tn} := \underline{1.0}$

Use 0.83 if toe-nail and laterally loaded

Diaphragm Factor : . . . . . $C_{di} := \underline{1.0}$

Use 1.1 if a diaphragm shear connection

Adjusted capacity of one nail:

$Z_a := z \cdot C_D \cdot C_M \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot C_{di}$ $Z_a = \underline{85.7}$ lbs/nail

Required load to be transferred: $P := \underline{81}$ lbs

Number of nails required:

$N := \text{ceil}\left(\frac{P}{Z_a}\right)$ $N = \underline{1}$ nails

Or, Capacity for number of nails:

number of nails in connection: $n := \underline{1}$

$P_{all} := n \cdot Z_a$ $P_{all} = \underline{86}$ lbs

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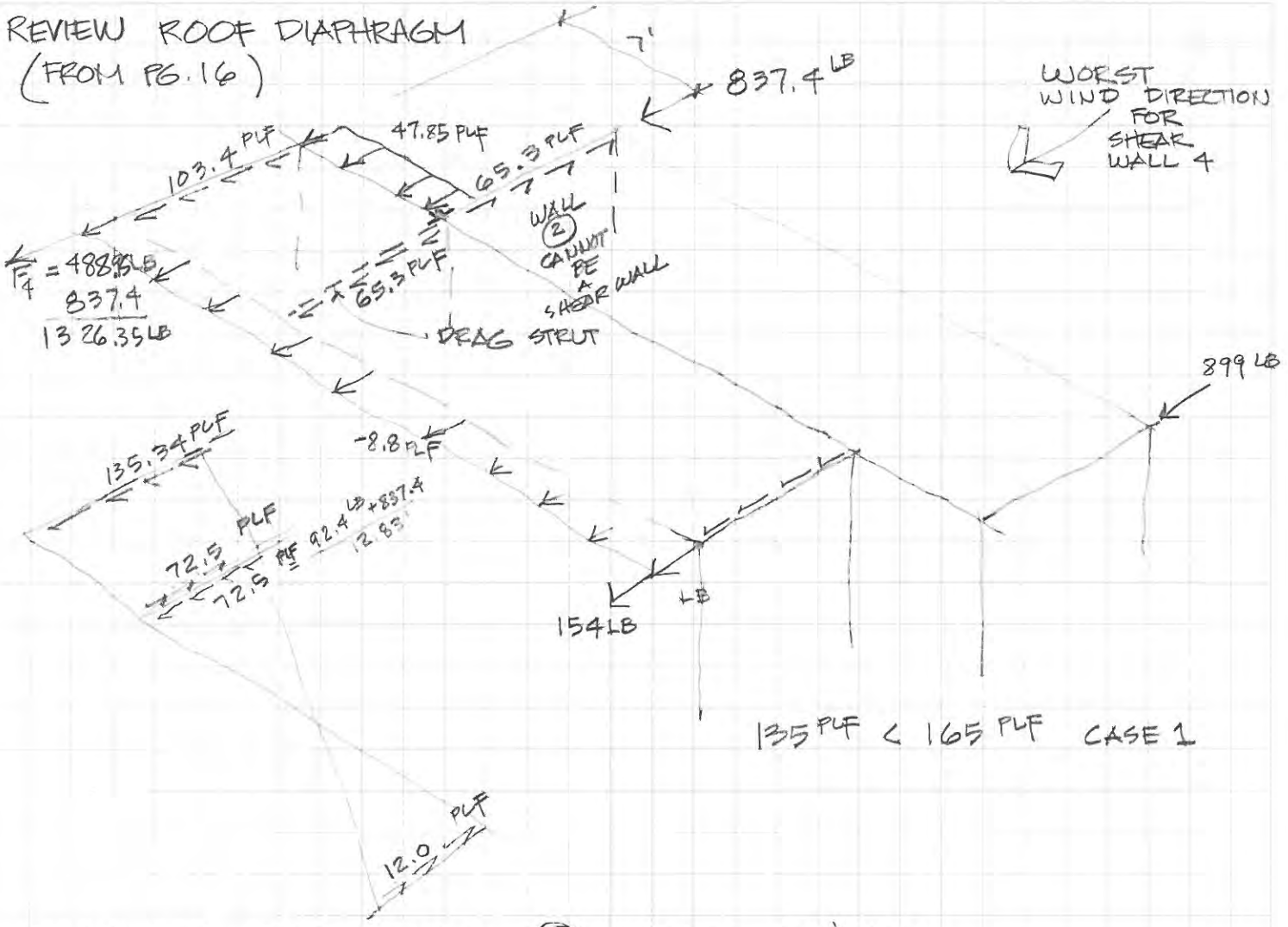
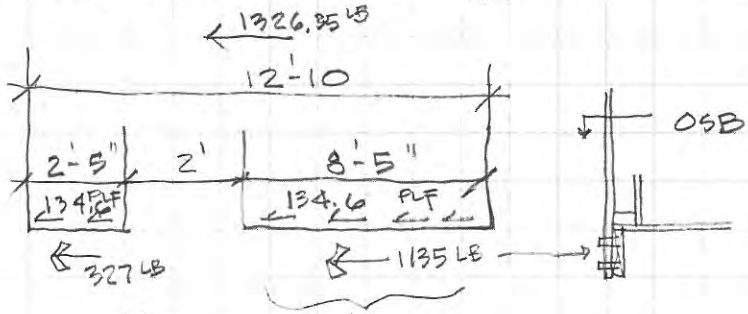
REVIEW ROOF DIAPHRAGM (FROM PG. 16)



COMPLETE SHEAR WALL (4) SHEAR REQ'MTS



OSB SHEAR

$f_v = \frac{134.6^{LB}}{7/16(12")} = 25.7^{PSI}$ very low OK

see pg 16

$\frac{101"}{6} = 16.8 \therefore 16$ staples @ $67^{LB}/STAPLE = 1072^{LB}$ (diaphragm action) $(1.1) = 1179^{LB}$

$\therefore$ OK

∴ 16 GA. STAPLES @ 6" O.C THRU 7/16 WALL SHEATHING INTO BAND BOARD

TABLE 9
ALLOWABLE SHEAR[1] FOR WIND OR SEISMIC LOADING (POUNDS PER FOOT) FOR WOOD STRUCTURAL PANEL HORIZONTAL DIAPHRAGMS WITH FRAMING OF DOUGLAS-FIR, LARCH, OR SOUTHERN PINE[2]
7/16" THICK RATED SHEATHING[3, 11]

Nominal Nail[4] Diameter[6] (in inches) or Staple[5] Gage	Minimum Nominal Fastener Length[6] (in inches)	Minimum Width of Framing Member (in inches)	Blocked Diaphragms				Unblocked Diaphragms	
			Fastener spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3, 4), and at all panel edges (Cases 5 & 6)[7]				Fasteners spaced 6" max. at supported edges[7]	
			6	4	2½[8]	2[8]	Case 1 (No unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)
			Nail spacing at other panel edges (Cases 1, 2, 3 & 4)[7]					
			6	6	4	3		
0.131 smooth or threaded	2 or 2½	2 3	255 285	340 380	505 570	575 645	230 255	170 190
0.120 smooth	3	2 3	215 245	290 325	435 485	490 550	190 215	145 160
0.113 smooth or threaded	2⅜ or 2	2 3	195 220	260 290	390 435	440 490	175 195	130 145
0.099 smooth or threaded	2¼	2 3	155 170	205 230	310 345	350 395	135 155	105 115
0.092 smooth	2¼	2 3	135 155	185 205	275 310	310 350	120 135	90 105
14 Gage	3 or 2½ 2¼ or 2	2 3	240 270	325 365	485 545	550 615	215 240	160 180
15 Gage	2½ 2¼ 2 or 1¾	2 3	205 230	275 310	415 465	470 525	185 205	140 155
16 Gage	2 1¾ or 1½	2 3	165 190	225 250	335 375	380 425	150 165	110 125

See page 18 for footnote explanations and load diagrams.

Footnote Explanations for Horizontal Diaphragm Tables 4 - 11

1. Tabulated values are for short-time loading due to wind or earthquake and shall be reduced by 25 percent for normal loading based on a duration of load factor of 1.33 and a diaphragm factor of 1.3. For diaphragm deflection analysis, deflections in Appendix Table B or C shall be used.

2. The tabulated values are for fasteners installed in Douglas Fir-Larch or Southern Pine. Allowable values for diaphragms framed with wood having a specific gravity equal to or greater than 0.42 but less than 0.50 may be calculated by multiplying the values above by 0.82. For woods with specific gravity less than 0.42 multiply the values above by 0.65.

3. C-D, C-C Exterior Sheathing and other panel grades covered in PS 1 or PS 2.

4. Nails with "T," brad, finish or casing heads are not permitted. A deformed shank nail shall have either a helical (screw) shank or an annular (ring) shank.

5. Staples shall have a $^{7}/_{16}$ inch minimum crown width.

6. Changes to fastener type, size or spacing shall be considered if diaphragms are required to withstand negative pressures of high winds or where prescribed in the model code. Prescriptive fastener schedules are summarized in Tables 28 to 37.

7. Values are based on 24" o.c. spacing of support framing members. Space fasteners maximum 12" o.c. along intermediate framing members (6 in. o.c. when supports are spaced 48" o.c.)

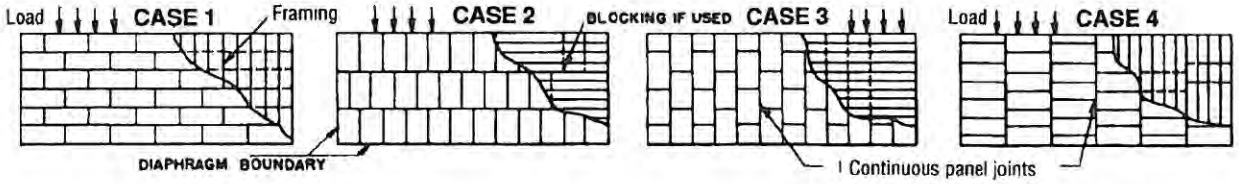
8. Framing at adjoining panel edges shall be 3-inch nominal or wider and nails shall be staggered where nails are spaced 2½" or closer on center.

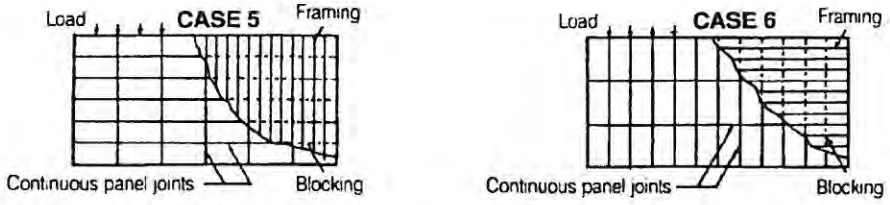
9. Framing at adjoining panel edges shall be 3-inch nominal or wider and nails shall be staggered where nails with shank diameters of 0.148" or greater and penetration of 1⅝ inches or greater are placed 3 inches on center or closer.

10. Plywood not exceeding 1⅛" in thickness is permitted to be attached provided the fastener penetration is at least twelve times the fastener shank diameter.

11. In addition to requirements presented above for fastening of horizontal diaphragms all other requirements of the applicable model code (such as, but not limited to, conditions of use and modification of design values for certain Seismic Design Categories) pertaining to horizontal diaphragm design and construction shall be met.

Load Diagrams for Horizontal Diaphragm Tables 4 - 11.





NOTE: Framing orientation in either direction for diaphragms is permitted provided sheathing is properly designed for vertical loading.

TABLE 18
ALLOWABLE SHEAR[1] FOR WIND OR SEISMIC LOADING (POUNDS PER FOOT) FOR WOOD STRUCTURAL PANEL SHEAR WALLS WITH FRAMING OF DOUGLAS-FIR, LARCH OR SOUTHERN PINE[2] FOR 7/16" THICK RATED SHEATHING[3, 4, 10, 13, 15, 16]

Nominal Nail[5] Diameter (In Inches) or Staple[6] Gage	Minimum Nominal Fastener Length[7] (In inches)		Allowable Wall Shear Values			
	Panels Applied Direct to Framing	Panels Applied Over ½"or ⅝" Gypsum Sheathing	Fastener Spacing at Panel Edges[8] (In inches)			
			6	4	3	2[9]
0.131 smooth or deformed	2 or 2½	-	240[11]	350[11]	450[11]	585[11]
0.148 smooth[12]	3					
0.148 smooth[12]	-	2¾ or 3	255	385	510	650
0.120 smooth	3	-	200	300	400	510
	-	3	180	270	365	460
0.113 smooth or deformed	2⅜ or 2	-	180	270	360	460
	-	2⅜	165	245	325	415
		2	125	185	245	315
0.099 smooth or deformed	2¼	-	145	215	285	365
	-	2¼	130	195	260	330
0.092 smooth	2¼	-	125	190	255	325
	-	2¼	115	170	230	295
14 Gage	3 2½ 2¼ or 2	-	225	335	450	570
15 Gage	2½ or 2¼ 2 or 1¾	-	190	285	380	490
16 Gage	2 1¾ or 1½	-	155	230	310	395
14 Gage	-	3 2½ or 2¼	205	305	405	520
15 Gage	-	2½ or 2¼	175	260	345	445
16 Gage[14]	-	2	140	210	280	360

See pages 27 and 28 for footnote explanations and typical panel layouts.

Footnote Explanations for Shear Wall Tables 12-20

1. Tabulated values are for short-time loading due to wind or earthquake and shall be reduced by 25 percent for normal loading based on a duration of load factor of 1.33 and a diaphragm factor of 1.3. For diaphragm deflection analysis, deflections in Appendix Table B or C shall be used.

2. All panel edges shall be backed by framing members. The tabulated values are for 2-inch nominal or wider framing members of Douglas Fir-Larch or Southern Pine. Allowable values for shear walls framed with wood having a specific gravity equal to or greater than 0.42 but less than 0.50 may be calculated by multiplying the values above by 0.82. For woods with specific gravity less than 0.42 multiply the values above by 0.65.

3. Panel layout: install panels either horizontally or vertically.

4. Fastener spacing intermediate: Space fasteners maximum 6 inches on center along intermediate framing members for 3/8 inch and 7/16 inch panels installed on studs spaces 24 inches on center. For other conditions and panel thicknesses, space fasteners maximum 12 inches on center.

5. Nails with "T," brad, finish or casing heads are not permitted. A deformed shank nail shall have either a helical (screw) shank or an annular (ring) shank.

6. Staples shall have a 7/16 inch minimum crown width.

7. Changes to fastener type, size or spacing shall be considered if shear wall panels are required to withstand negative pressures of high winds or where prescribed in the model code. Prescriptive fastener schedules are summarized in Tables 28 to 37.

8. Where panels are applied to both faces of a wall and fastener spacing is less than 6 inches on center on either side, panel joints shall be offset to fall on different framing members, or framing shall be 3-inch nominal or thicker and fasteners on each side shall be staggered.

9. Framing at adjoining panel edges shall be 3-inch nominal or wider, and fasteners shall be staggered where fasteners are spaced 2 inches on center.

10. C-D, C-C Exterior Sheathing and other panel grades covered in PS 1 or PS 2.

11. The values for 3/8 inch and 7/16 inch panels applied directly to framing may be increased to values shown for 15/32 inch thick panels of the same panel grade, provided studs are spaces a maximum of 16 inches on center or panels are applied with long dimension across studs.

12. Framing at adjacent panel edges shall be 3 inch nominal or wider and fasteners shall be staggered where nails with shank diameters of 0.148" or greater and penetration of 1⅝ inches or greater are placed 3 inches on center or closer.

13. In addition to requirements presented above for fastening of shear walls all other requirements of the applicable model code (such as, but not limited to, conditions of use and modification of design values for certain Seismic Design Categories) pertaining to shear wall design and construction shall be met.

14. Two-inch-long staples have insufficient penetration when wood structural sheathing is applied over 5/8 inch thick gypsum sheathing and shall only be used if wood structural sheathing is applied directly to framing or over gypsum sheathing having a maximum thickness of ½ inch.

15. Where allowable shear values exceed 350 pounds per foot, foundation sill plates and all framing members receiving edge nailing from abutting panels shall not be less than a single 3 inch nominal member. Nails shall be staggered.

16. In structures assigned to Seismic Design Category D, E, or F in areas using the IBC, where shear design values exceed 490 plf (LRFD) or 350 plf (ASD) all framing members receiving edge nailing from abutting panels shall not be less than a single 3-inch nominal member. Plywood joint and sill plate nailing shall be staggered in all cases.

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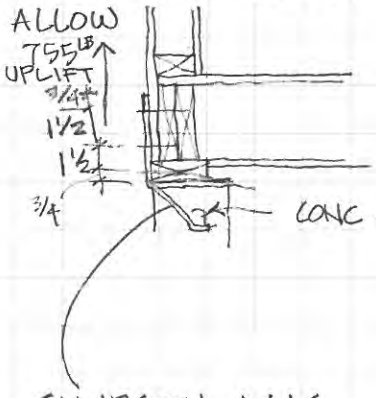
Sheet 23 of
Project SOLAR DECATHLON 2011 Comp. by DJW
Date 1/28/11 Ckd. by
Proj. No. 12474004

CHAMPAIGN FOUNDATION



FROM PG. 14

↑ 66.1.2 LB PER 2' UPLIFT WALL TO FLOOR BAND BOARDS
+
↑ SOLAR PANEL UPLIFT (PG. 24) REACTION @ $\frac{254.4^{LB} \times 6}{35'} =$

$43^{LB/FT} \times 2 = 86^{LB/2'}$

SOLAR FRAME - DL = (6) $14.0^{LB/FT} \times 2 = 16.8^{LB/2'}$

↑ $69^{LB/2'}$ UPLIFT

↑ 61.2

$130.4^{LB/2'}$

FL. DL = $11^{PSF} \times 2 \times 6' (.9) = -79.2^{LB/2'}$

NET UPLIFT = $51.2^{LB/2'}$ TO FDTN

$\div 2 = 25.6^{LB/FT}$

SPACING MAX = $\frac{755}{25.6^{LB/FT}} = 29.5'$

USE MAX AS FOOTING SPACING OR 5'-0 WHICH EVER IS SMALLER

ASSUME CONCRETE FOOTING AS A TRENCH FOOTING CONTINUOUS

LOAD TO FDTN : DL+LL

EXTERIOR WALL

ROOF + FLOOR + EXT. WALL = $186.3^{PLF} + 366.6^{PLF}$ (50 PSF) $+ 91.75^{PLF}$
= 644.7^{PLF}
SOLAR PANEL FRAME = 14.0^{PLF}
658.7^{PLF} TO FDTN MUDSILL

IF USE 86^{PSF} LL @ FLOOR : 582.6^{PLF} DL+LL (FLOOR) (SEE PG 20)
∴ EXT. WALL : ΣDL+LL = 860.7^{PLF}

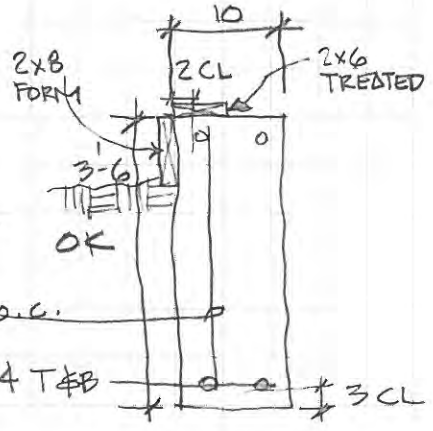
ASSUME: FTG : $\frac{10}{12} \times 3.5 \times 150 =$ 437.5 PLF

14.0

874.7 PLF

1312.2 PLF

$f_{Brg} = \frac{874.7}{10/12(1)} = 1053.9^{PSF} < 1500^{PSF}$ OK



MAS/MASA/MASAP/MASB/MASP *Mudsill Anchors*

SIMPSON Strong-Tie

VALUE ENGINEERED

This product is preferable to similar connectors because of a) easier installation, b) higher loads, c) lower installed cost, or a combination of these features.

MAS style mudsill anchors are easy to install for both the concrete and framing contractor. They are suitable for either stemwall or slab foundations and easily mount on the forms before the pour, simplifying finishing and reducing anchor mislocation problems. The MAS eliminates the need to drill the mudsill and can be installed three different ways to provide flexibility when stud placement or sheathing becomes an issue *(see table below)*.

The new and improved MASA/P provides the installation advantages of mudsill anchors combined with the maximum allowable on-center spacing. The new stronger design provides parallel-to-wall load carrying capacity that meets or exceeds most cast-in-place anchors. This allows for a one-to-one replacement of ½" bolts on 2x or 3x sills and ⅝" bolts on a 2x sill.

The different models of mudsill anchors are designed for specific applications:

MAS/MASA—installed at the top of the form

MASP/MASAP—for panelized forms

MASB—used in concrete masonry units.

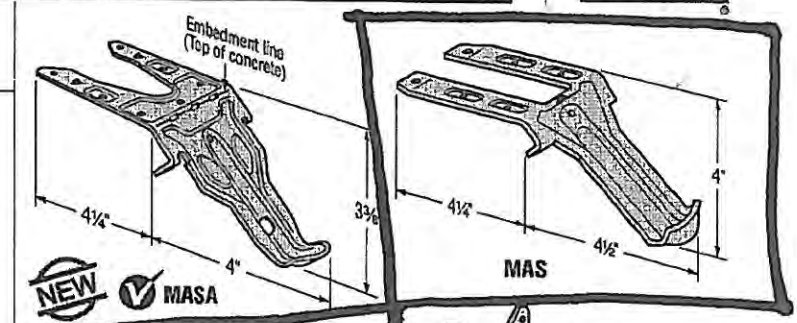
MATERIAL: 16 gauge

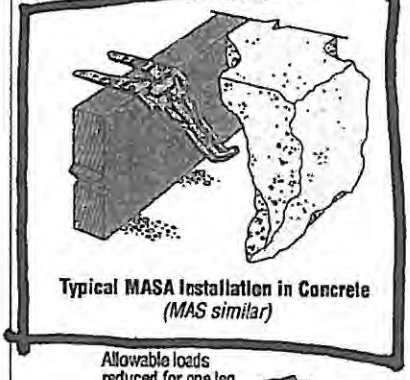
FINISH: Galvanized, all available in ZMAX® coating. See Corrosion Information, page 10-11.

INSTALLATION: • Use all specified fasteners. See General Notes.

- **MAS/MASP/MASA/MASAP**
  - Concrete shall have a minimum f'_c = 2500 psi.
  - Spalling—Full published capacity is achieved so long as a maximum height of 1¼" and a maximum depth of ⅞" is not exceeded. Any exposed portion of the mudsill anchor must be protected against possible corrosion.
  - For prescriptive anchor spacing refer to page 23.
  - Testing shows that these mudsill anchors can be used in lieu of code required anchor bolts and square washer in high seismic zones. Refer to technical bulletin T-MASSW for additional information *(see page 191 for details)*.
- **MASB**—Fill CMU cell with concrete grout first, then place MASB into the grouted cell and adjust into position. Attach mudsill to anchor only after the concrete grout cures.
  - CMU shall have a minimum f'_m = 1500 psi.
  - The MASB Mudsill Anchors were tested in standard 8" CMU.

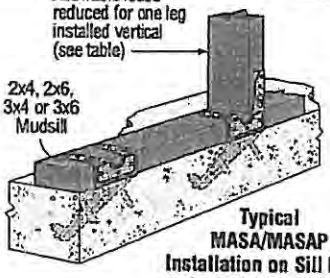
CODES: See page 12 for Code Reference Key Chart.



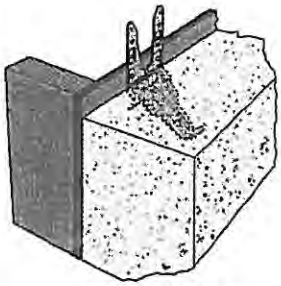


Typical MASA Installation in Concrete *(MAS similar)*

MASAP *(MASP similar)*



Typical MASA/MASAP Installation on Sill Plate *(MAS/MASP similar)*



Typical MASAP Installation in Concrete *(MASP similar)*

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

Model No.	Sill Size	Fasteners[8] Sides	Fasteners[8] Top	Attached to DF/SP Sill Plate Allowable Loads[1] (160) Uplift[2]	Parallel to Plate (F_1)	Perp. to Plate (F_2)	Attached to HF Sill Plate Allowable Loads[1] (160) Uplift[2]	Parallel to Plate (F_1)	Perp. to Plate (F_2)	Code Ref.
TYPICAL INSTALLATION										
MAS or MASP	2x4, 6	2-10dx1½	4-10dx1½	1005	815	575	680	835	255	IL12[6], F24
	3x4, 6	4-10dx1½	2-10dx1½	955	835	465	—	—	—	
MASA or MASAP	2x4, 6	3-10dx1½	6-10dx1½	930	1605	800	930	1440	685	170[6]
	3x4, 6	5-10dx1½	4-10dx1½	930	1570	685	795	1190	495	
MASB	2x4,6x8	2-10dx1½	6-10dx1½	130	930	410	—	—	—	IL5[6]
ONE LEG UP INSTALLATION										
MAS or MASP	2x4, 6	4-10dx1½	2-10dx1½	435	700	240	—	—	—	IL12[6], F24
MASA or MASAP	2x4, 6	6-10dx1½	3-10dx1½	780	1445	380	715	980	380	170[6]
MASB	2x4,6x8	5-10dx1½	3-10dx1½	—	960	360	—	—	—	IL5[6]
BOTH LEGS OVER MAX. ½" PLYWOOD OR OSB INSTALLATION (See page 23)										
MAS or MASP	2x4, 6	6-10dx1½	—	755	785	260	—	—	—	
MASA or MASAP	2x4, 6	9-10dx1½	—	710	930	280	710	930	225	170[6]
MASB	2x4,6x8	8-10dx1½	—	45	295	25	—	—	—	

1. Loads have been increased for short-term loading.
2. For uplift loads, provide attachment from mudsill to building's structural components to prevent cross-grain bending.
3. For stemwall applications, allowable loads are based on a minimum stemwall width of 6".
4. For simultaneous loads in more than one direction, the connector must be evaluated using the Unity Equation. See page 14 under General Instructions for the Designer.
5. Stud-to-plate connectors must be installed on the same side of the plate as the MAS/MASP or MASA/MASAP straps to complete the continuous load path.
6. Testing to new ICC-ES acceptance criteria to be completed in 2009. Reference ***www.strongtie.com*** for latest loads and information.
7. **NAILS:** 10dx1½ = 0.148" dia. x 1½" long. See page 16-17 for other nail sizes and information.

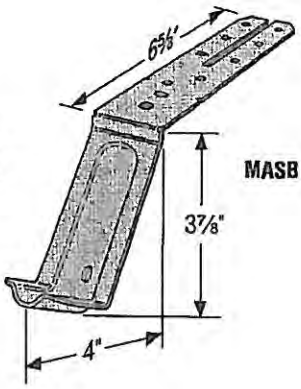
MAS/MASA/MASAP/MASB/MASP *Mudsill Anchors*

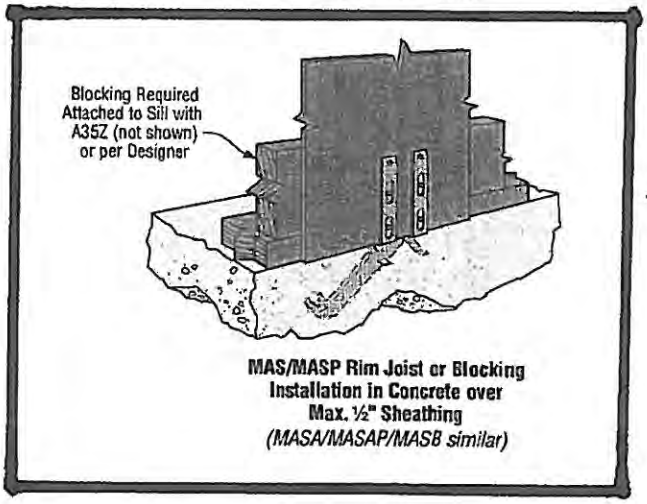
SIMPSON Strong-Tie

Prescriptive Anchor Spacing

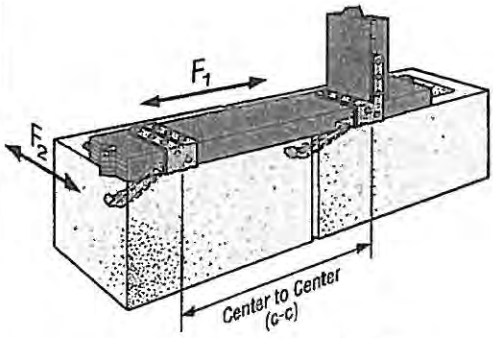
Model No.	O.C. Spacing to replace ½" Anchor Bolt 6' O.C. (160)	O.C. Spacing to replace ⅝" Anchor Bolt 6' O.C. (160)	Min. Concrete End Distance	Min. C-C Spacing
MAS or MASP	5'-0"	4'-0"	4"	8"
MASA or MASAP[6]	6'-0"	6'-0"	4"	8"
MASB	5'-6"	4'-8"	3¾"	7½"

1. Place anchors not more than 12" from the end of each sill per code.
2. Spacing is based on parallel to plate load direction only.
3. CMU shall have a minimum f'_m = 1500 psi and concrete shall have a minimum f'_c = 2500 psi.
4. Spacing applies to DF, SP, and HF 2x sill plates.
5. For installations to rim joist or blocking, MASB spacing is 1'-10" for replacing ½" bolts and 1'-6" for ⅝" bolts. MAS/P and MASA/P remain the same as the table.
6. When replacing ½" sill bolts use 7-10dx1½" nails *(minimum nailing)* and when replacing ⅝" sill bolts use 9-10dx1½" nails *(maximum nailing)*.





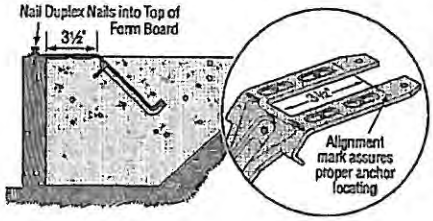
MAS/MASP Rim Joist or Blocking Installation in Concrete over Max. ½" Sheathing
(MASA/MASAP/MASB similar)



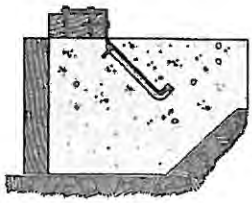
Typical MASB Installation

ALTERNATIVE MUDSILL ANCHOR INSTALLATIONS

ALTERNATE INSTALLATION FOR INSIDE OF WALL CONTINUITY

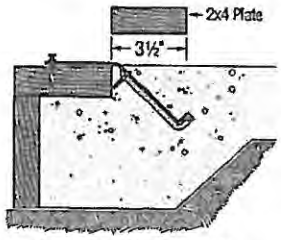


STEP 1:
Attach MAS/MASA 3½" from inside of form. After concrete cures, remove nails and bend straps up 90°



STEP 2:
Place mudsill on concrete and nail MAS/MASA over mudsill

ALTERNATE INSTALLATION FOR BRICK LEDGES



Alternate MAS Installation for Brick Ledges
(MASA similar)

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Sheet 24 of
Project SOLAR DECATHLON 2011 Comp. by DJW
Date 1/31/11 Ckd. by
Proj. No. 12474004

SOLAR PANEL

$A = 17.56^{\#}$

41.18" × 61.39" × 5.12'

3.43' × 5.12' × 328 LB

189 LB

30°

1.715'

WT = 41 LB/PANEL

$w = \frac{41}{3.43(5.12')} = 2.33$ PSF

SOLID FREESTANDING SIGNS

WIND C&C

$v = \frac{h}{w} = \frac{1.715'}{5.12'} = .33$

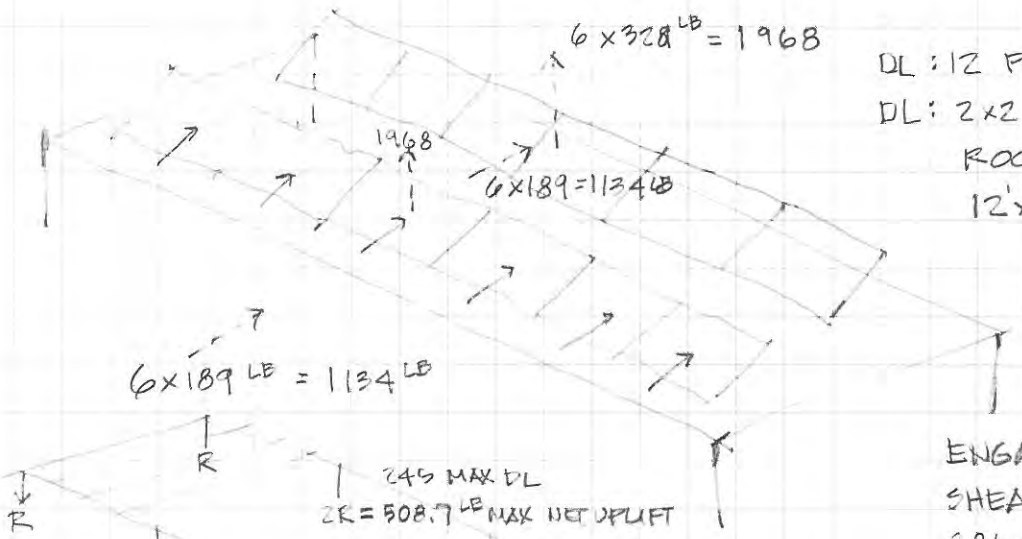
$M = 5.12'$ $N = 1.715'$ $M/N = 2.9$

SINCE $v \leq 3$ $C_f = 1.2$

ABOVE GROUND → $M/N \leq 6$ $C_f = 1.2$

$F = q_z G C_f A_f = 15^{PSF}(1.2)(1.2)(3.43')(5.12) = 379^{LB} \pm$

q_z Champaign



APPROX LC for C&C WIND + .6DL

3936 UPLIFT

DL: 12 PANELS @ 41 LB = 492 LB

DL: 2×2 TUBE FRAME = 981 LB

ROOF DL =

12' × 35' × 11 PSF = 4620 LB

DL 6093 LB

.6DL = 3656.0 LB

NET UPLIFT 281 LB

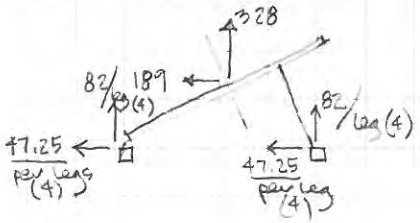
ENGAGING WALLS VIA SHEATHING WILL COVER 281 LB.

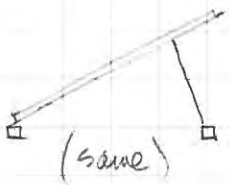
$\Sigma = 12R$

$12R = 2(1968) - 981(.6) - 492(.6)$

$R = \frac{2(1968) - (981) - (492)(6)}{12}$

$R = 254.35 \downarrow$ UPLIFT





Bentley **MSA Professional Services**

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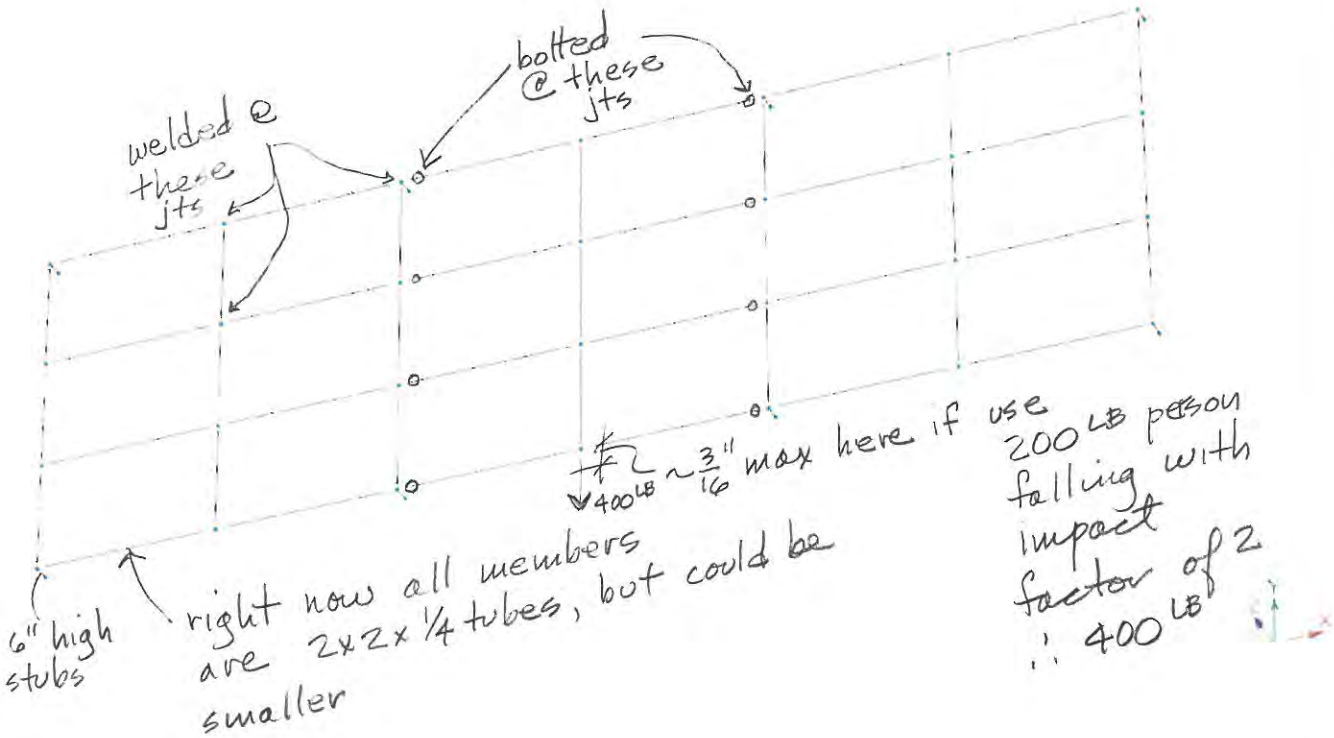


POWER-FAB™
Quality Hardware for the PV Industry

ROOF / GROUND MOUNTS

Power-Fab Roof/Ground Mounts are available in several sizes and styles in both aluminum (AL) and painted steel (PS) versions. In addition to the standard configuration, we offer both low-profile and two-tier designs. Both one-piece (OP) and telescoping-leg (TL) sets are available. This sheet describes our standard line of roof/ground mounts. Power-Fab specializes in custom design and fabrication and can build mounts to meet your exact needs.

SPECIFICATIONS

MATERIALS

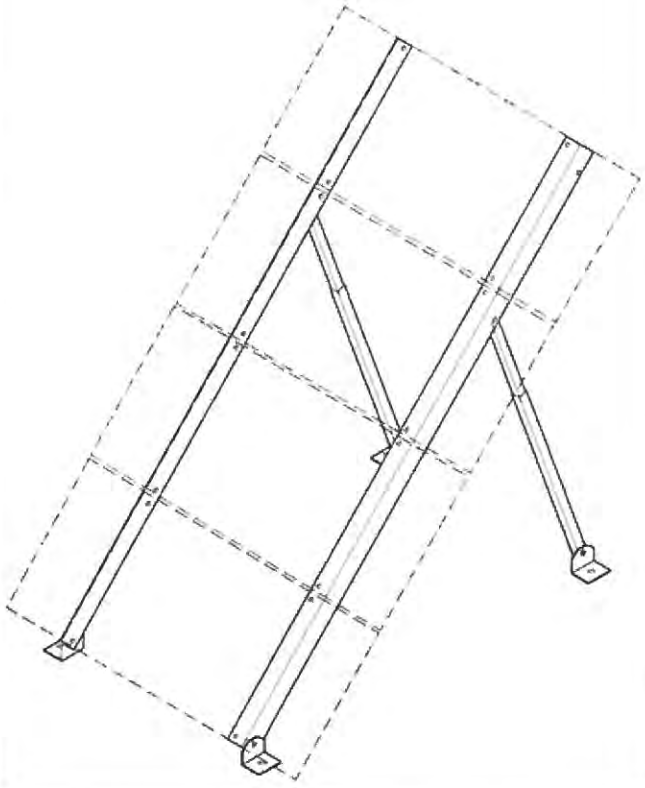
ALUMINUM (AL) ROOF/GROUND MOUNTS: Module rails and legs are made of mill-finish 6061-T6 structural aluminum angle. Some large racks are made of 6061-T6 structural aluminum channel. Clear anodizing is available as an option.

PAINTED STEEL (PS) ROOF/GROUND MOUNTS: Module rails and one-piece legs are made of ASTM A36 steel angle. Telescoping leg sets are made of ASTM A500-Grade B steel square tubing. Steel racks are coated with a minimum of two coats of industrial urethane enamel. Hot-dip-galvanizing is available as an option.

Both aluminum and steel racks come with stainless steel module mounting hardware and Grade 5 zinc-plated rack assembly hardware. Standard mounting feet are made of steel and are hot-dip-galvanized after fabrication.

SRGM STANDARD ROOF/GROUND MOUNTS

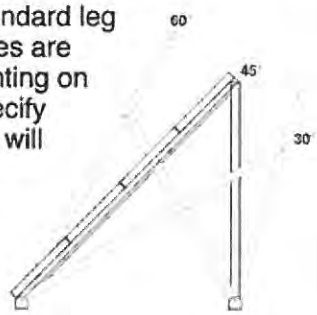
Modules are racked with length horizontal, stacked one above the other. Models are available to hold from 1 to 10 modules (depending on module width).



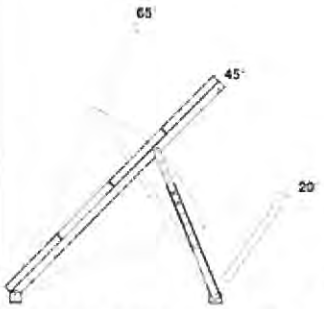
LEG STYLES AND SEASONAL ADJUSTMENT (for all roof ground mounts)

These are Power-Fab standard leg configurations. Other styles are available. If you are mounting on a pitched roof, please specify the slope and Power-Fab will modify the legs to suit.

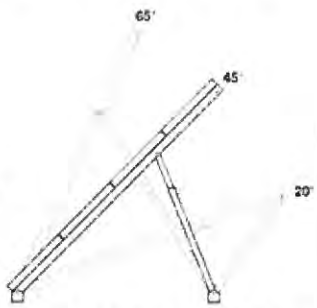
NOTE: All roof/ground mounts can be set at 0° (parallel to mounting surface) by removing the back legs.



ONE-PIECE LEG
Painted Steel & Aluminum
3 Set-Points: 30°, 45°, 60°



TELESCOPING LEG
Aluminum
Tilt Range: 20° to 65°



TELESCOPING LEG
Painted Steel
Tilt Range: 20° to 65°

Bentley **MSA Professional Services**

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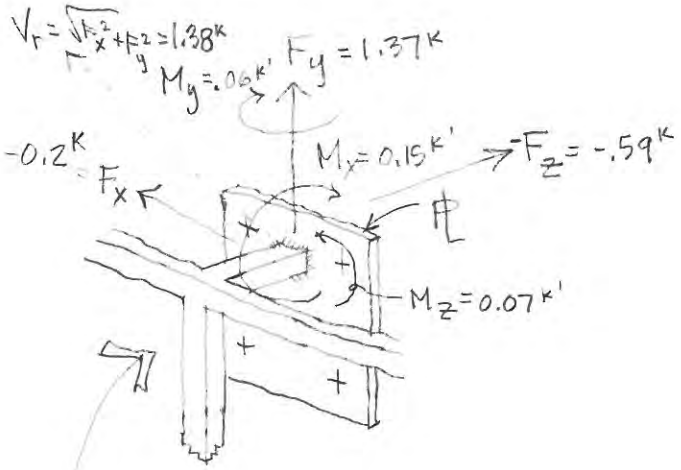

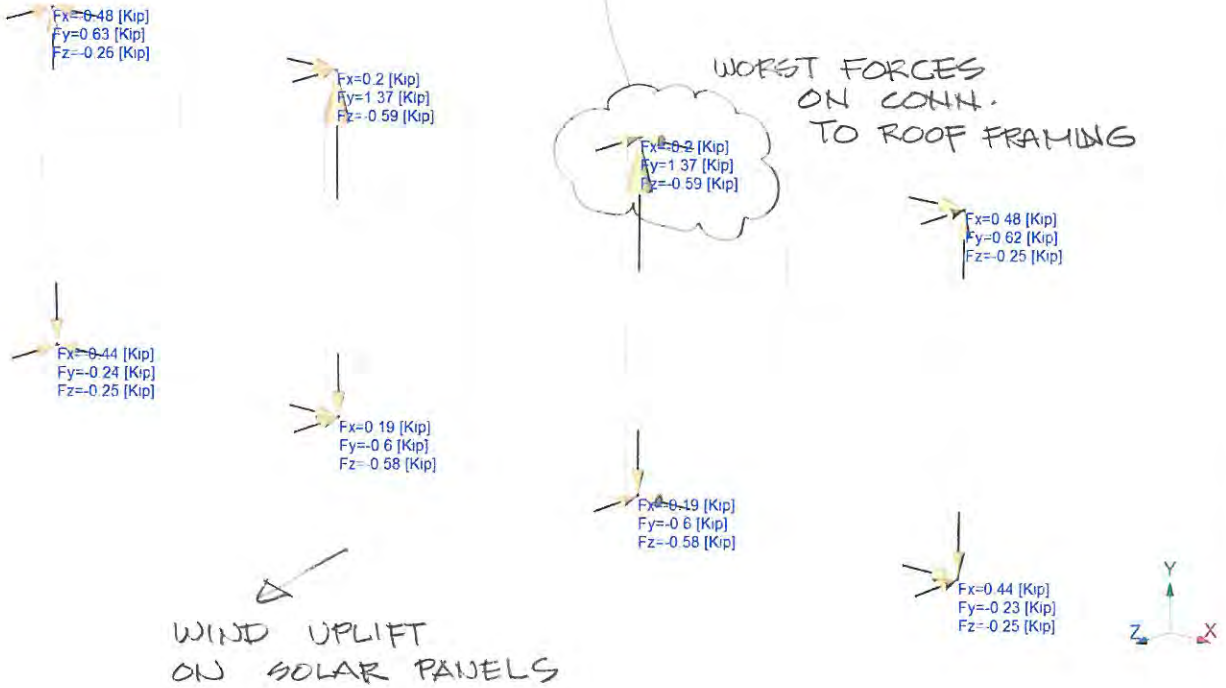

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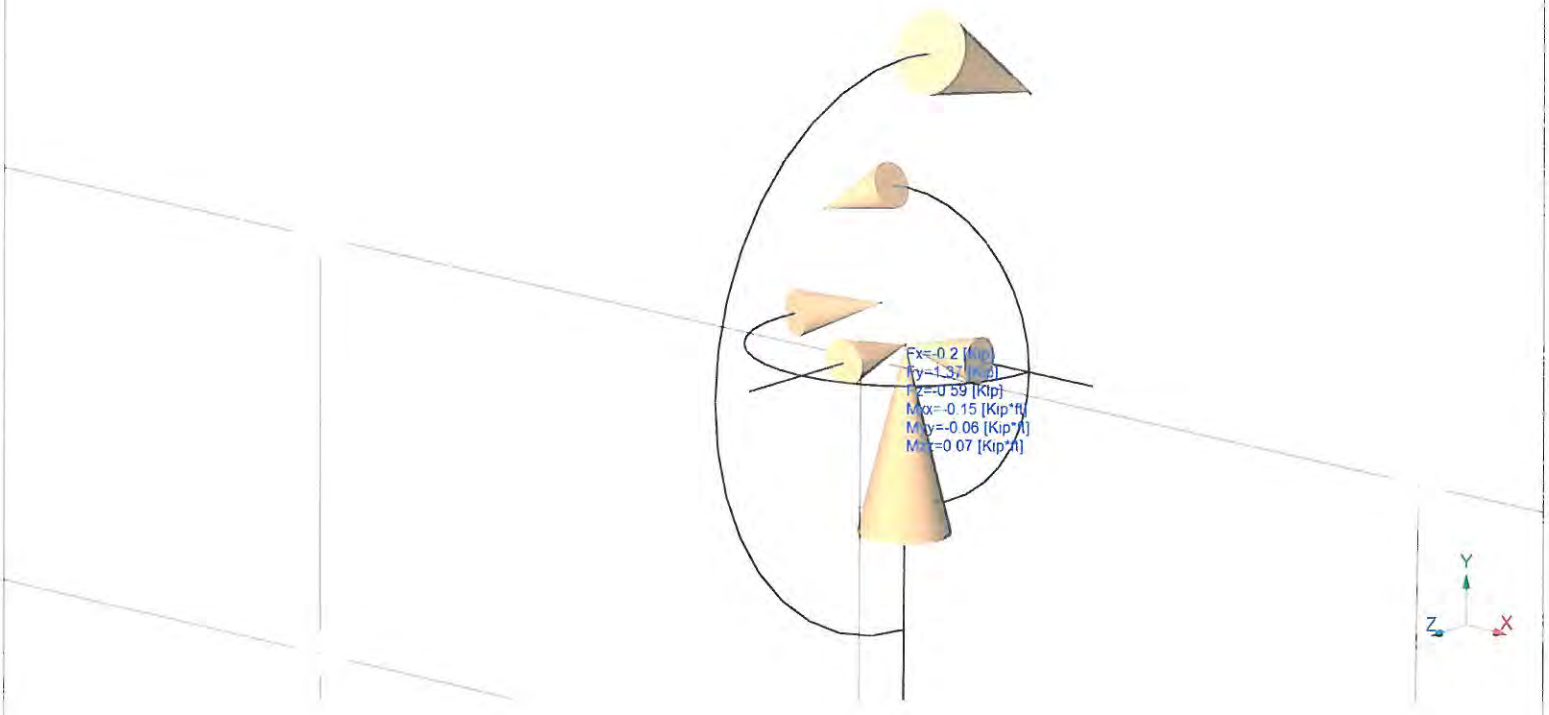
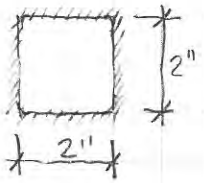
0.6DL+WL



WELD : TUBE TO ℄

$L = 2(2+2) = 8^{IN}$ $J = \frac{(2+2)^3}{6} = 10.67^{IN^3}$

$S = \frac{2}{3}\left(\frac{3(2)+2}{8}\right) = 5.33^{IN^3}$



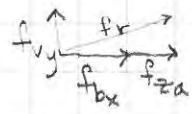
$f_{bx} = \frac{.15(12)}{5.33} = 0.33^{KLI}$

$f_{za} = \frac{.59}{8}$ 0.074^{KLI}

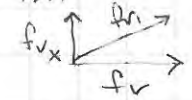
0.404^{KLI}

$f_{vy} = \frac{1.37}{8} = 0.171^{KLI}$

$f_r = .439^{KLI}$

elev. 

$f_{vx} = \frac{.2}{8} = .025^{KLI}$

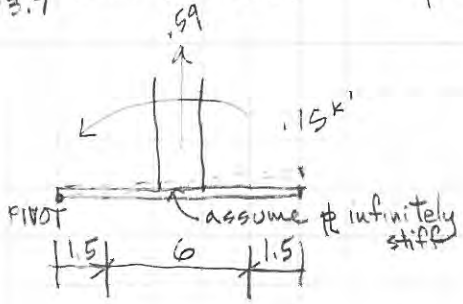
plan 

$f_r = \sqrt{.025^2 + .439^2} = .44^{KLI}$

SHEAR ON DIAPHRAGM

1384 LB/TRUSS 67 LB/STAPLE × 1.1 = 73.7 LB

$n = \frac{1384}{73.7} = 19$ STAPLES



1/8 FILLET OK

1.87 KLI

$T(7.5) = .15(12) + .59(4.5)$

$T = .594$ ← to a pair of anchors

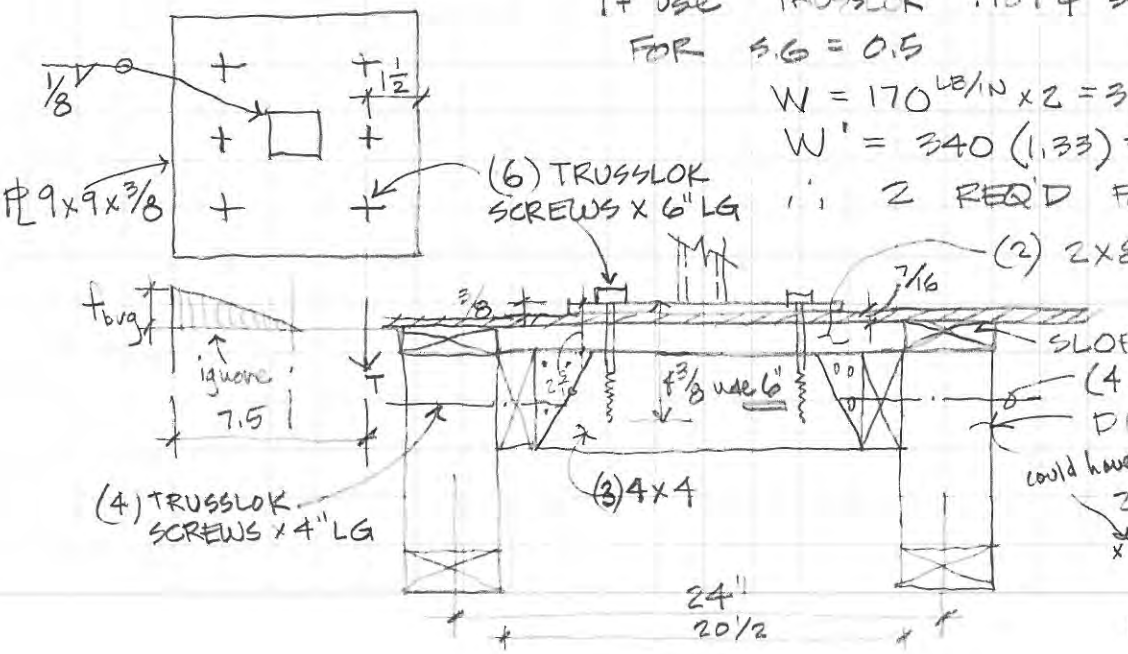
if use TRUSSLOK .139 ϕ SHANK .172 ϕ THREAD ROOT

FOR $S.G = 0.5$

$W = 170^{LB/IN} \times 2 = 340^{LB/SCREW}$

$W' = 340(1.33) = 452.2^{LB/SCREW}$

∴ 2 REQ'D FOR UPLIFT



could have used 1.6 LF

$240^{LB/SCREW} = V_{all\perp}$

$\times 1.33 = 319.2^{LB/SCREW}$

ignored metal ℄

$\frac{594}{1356.6} + \frac{692}{957.6} = 1.16 > 1.0$

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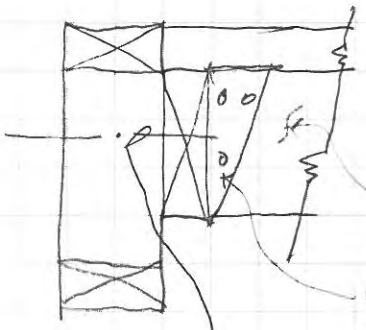
Sheet 25A of _____
Project SOLAR DECATHLON 2011 Comp. by DJW
Date 2/1/11 Ckd. by _____
Proj. No. 12474004



745 LB

$\uparrow \frac{590}{2} = 295^{LB}$

$\frac{1370}{2} = 685$

(3) - 4x4

NOTE: JOIST HANGER PLACED UPSIDE DOWN FOR MAX UPLIFT RESISTANCE

(4) TRUSS LOK SCREWS/SIDE

$V_{all} = 319.2^{LB/SCREW}$

$\frac{745}{319.2} = 2.34$

∴ 3 MIN

USE 4

Job	Truss	Truss Type	Qty	Ply	solar decathlon
B1012023	T01	MONO TRUSS	36	1	Job Reference (optional)

Central Illinois Truss, Morton, Il 61550 — 7.220 s Feb 16 2010 MiTek Industries, Inc. Fri Jan 28 10:25:23 2011 Page 1

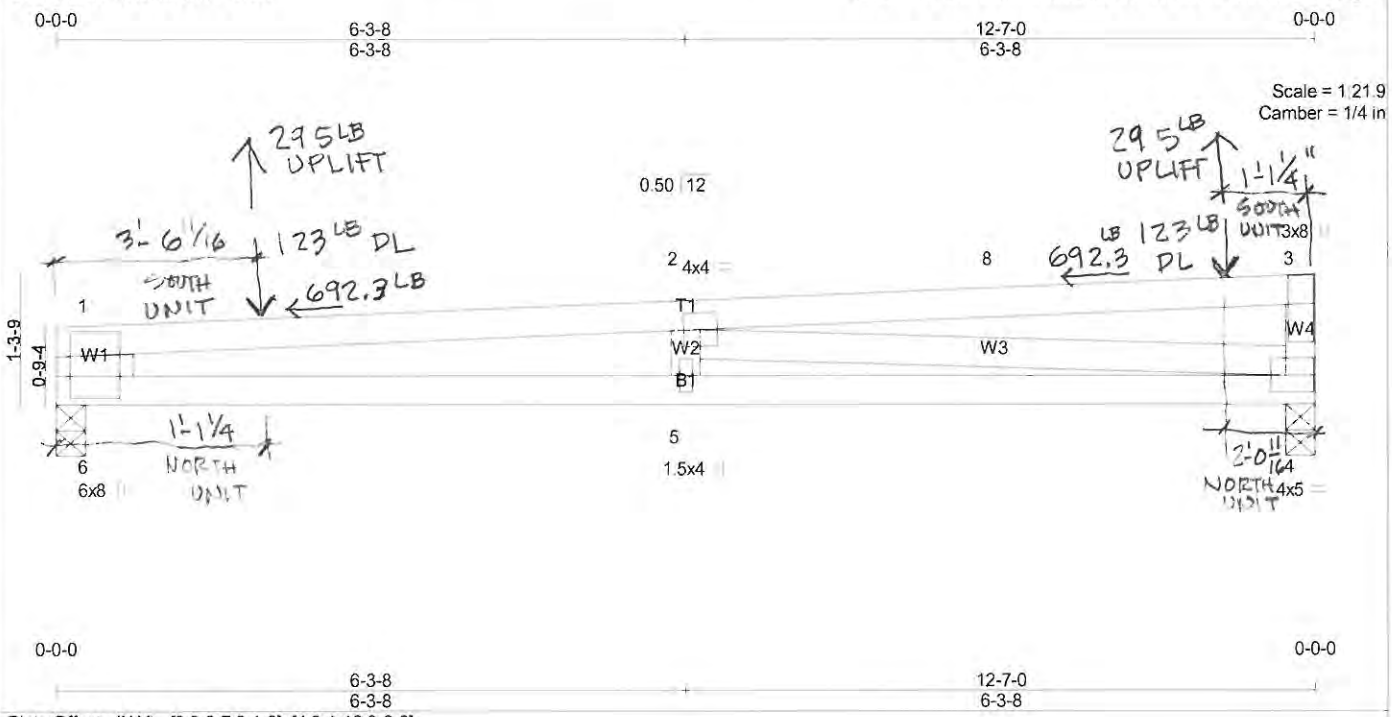
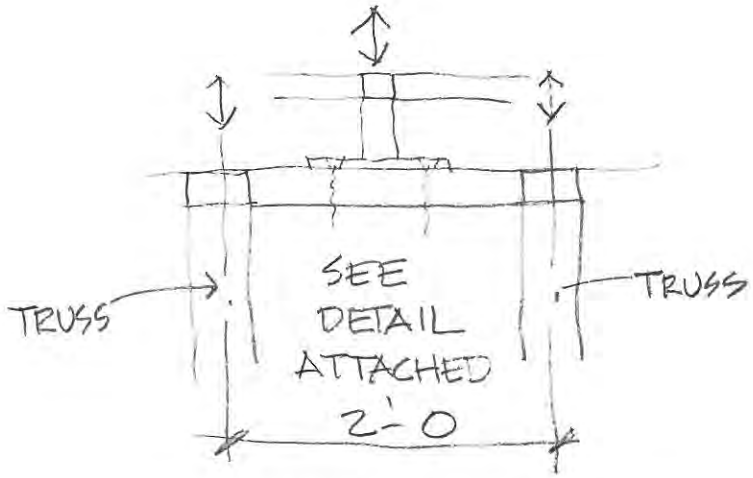


Plate Offsets (X,Y): [3:0-3-7,0-1-8], [4:0-1-12,0-2-0]

LOADING (psf)		SPACING	2-0-0
TCLL	23.1	Plates Increase	
(Ground Snow=30.0)		Lumber Increase	
TCDL	10.0	Rep Stress Incr	YES
BCLL	0.0 *	Code	IBC2006/TPI2002
BCDL	10.0		



4 LOCATIONS THUS 8 TRUSSES W/ ABOVE LOADING ADDED

FastenMaster

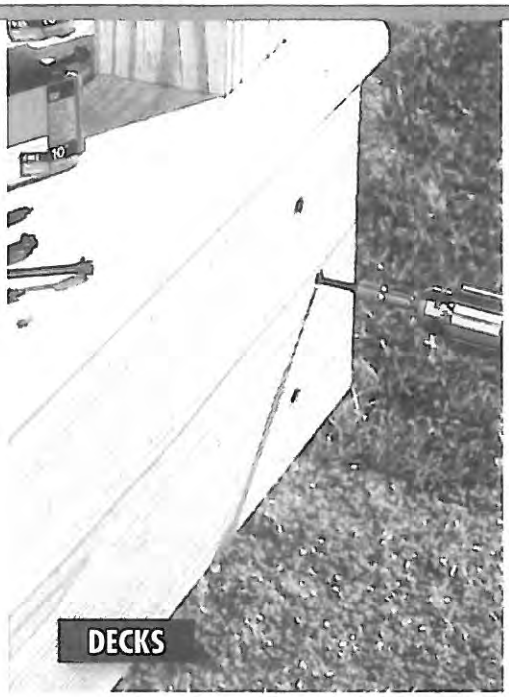
TimberLok®

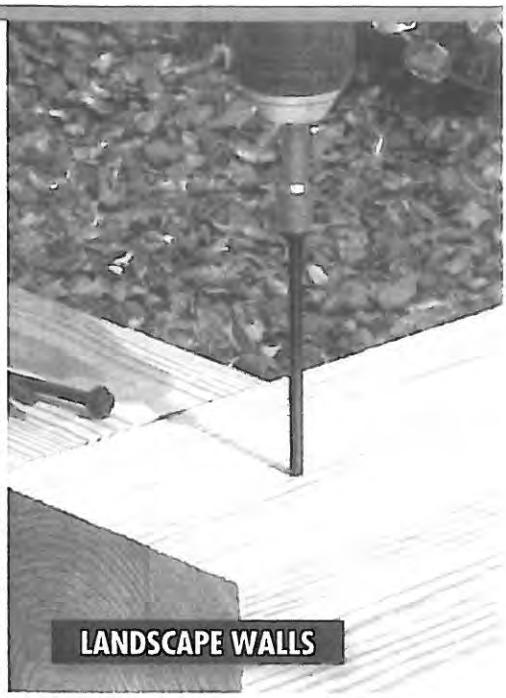
HEAVY DUTY WOOD SCREW

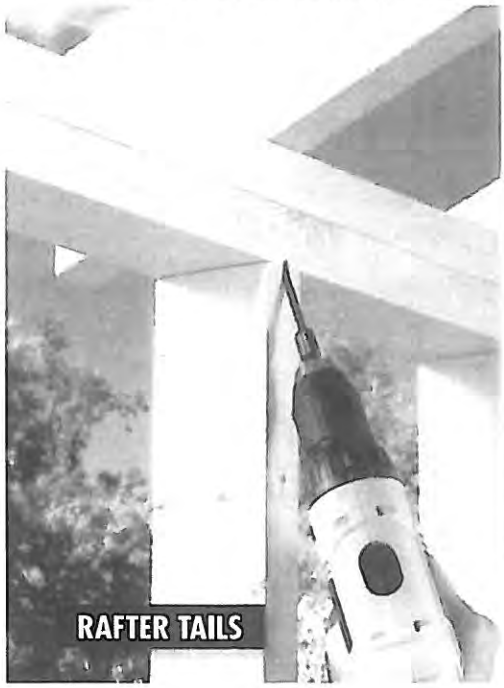
No Predrilling.
Faster, Easier, Stronger than 3/8" lags.

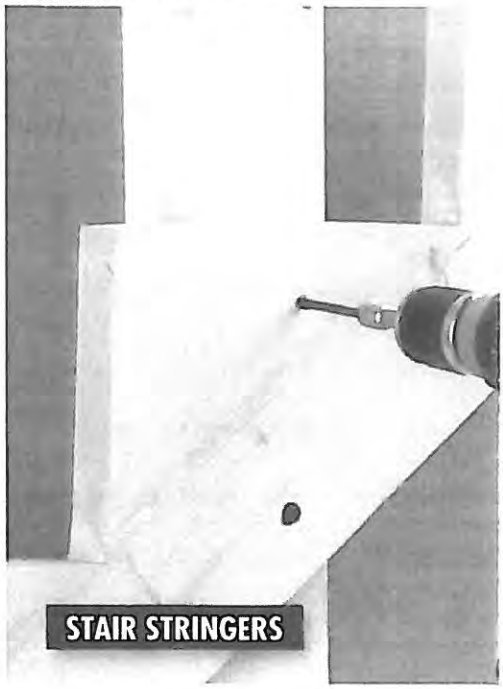
- Stronger design shear values than 3/8" lags
- IBC/IRC code compliant. ESR #1078
- Sharp point and aggressive thread penetrate the densest woods without predrilling
- Unique tapered head countersinks easily into wood for flush appearance
- Variety of lengths, from 2½" to 10", to match every application
- Proprietary three-step coating process protects against corrosion, even in pressure treated wood. ACQ approved
- Free bit in every package

Photographs should not be used as a reference for fastening patterns









For more information or free samples, call FastenMaster at 800-518-3569.

FASTENMASTER, 153 BOWLES ROAD, AGAWAM, MA 01001 WWW.FASTENMASTER.COM

TimberLok
HEAVY DUTY WOOD SCREW

INSTALLATION PROCEDURE

TimberLok should be installed using a high torque, ½" variable speed drill (18V if cordless). Choose the proper length so that threads fully engage the main member or bottom piece. Bring washer head flush to wood surface or countersink head flush.

Guaranteed Corrosion Resistance
TimberLok is guaranteed not to rust or streak for the life of the project. The fastener has also been tested and approved for use in ACQ. A guarantee regarding this can be found on www.FastenMaster.com. TimberLok is not recommended for saltwater applications.

Lateral Design Values (Z) for Single Shear Connections Loaded Perpendicular to Grain

Wood	Specific Gravity**	FastenMaster TimberLok	Nails			Lags	
			10D	16D	20D	¼"	⅜"
Red Oak	0.67	299	154	184	222	140	160
Southern Pine	0.55	257	128	154	185	120	140
Doug. Fir-L, SCL*	0.50	240	118	141	170	110	130
Doug. Fir-S	0.46	226	109	131	157	100	120
Hem. Fir	0.43	215	102	122	147	100	120
E. Spruce, W. Cedar	0.36	189	87	104	126	90	100

*SCL = Structural Composite Lumber (LVL, PSL and LSL)
**Wood species indentified typically have average specific gravity similar to the values shown on this table.

All design values based on 1½" side member thickness and penetration into main member as follows: TimberLok 2", Nails 10x diameter, Lags 8x diameter. Design values may be subject to adjustment factors (section 10.3 in NDS) based on conditions existing during installation as well as those expected during service life.

The lag screw and nail design values included in these tables are compiled directly from the 2005 National Design Specification for Wood Construction (2005 NDS).

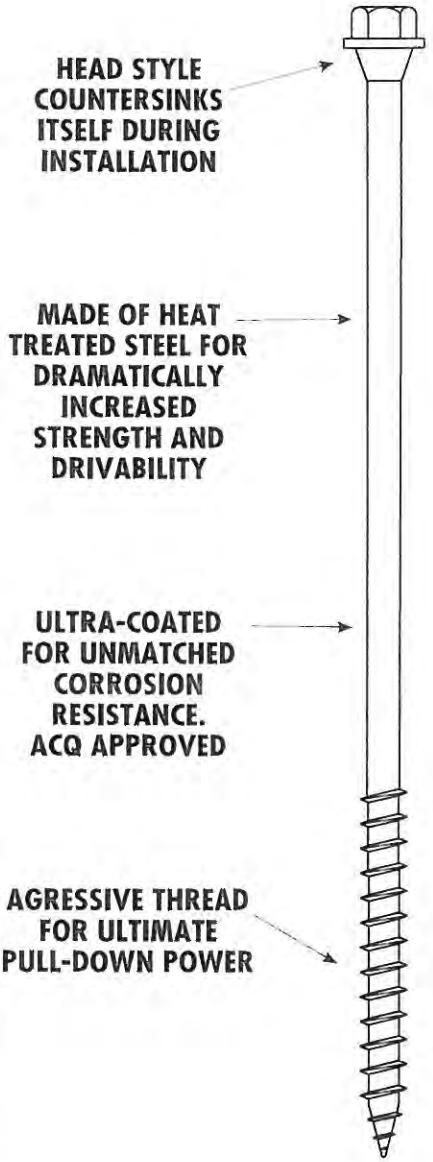
When using in critical applications, please consult a design professional or refer to our technical bulletins for the proper spacing and fastening patterns.

The statement *"Faster, Easier, Stronger than ⅜" lag screws"* refers to the comparison of TimberLok design values in ICC-ES Report #1078 and ⅜" lag screws as published in the current NDS.

For technical assistance or questions regarding proper use of this fastener, please contact FastenMaster Technical Support at 800-518-3569 or visit www.FastenMaster.com.

Item #	Screw Length	Quantity per Pack
FMTLOK04-12	4"	12
FMTLOK06-12	6"	12
FMTLOK08-12	8"	12
FMTLOK10-12	10"	12
FMTLOK212-50	2½"	50
FMTLOK04-50	4"	50
FMTLOK06-50	6"	50
FMTLOK08-50	8"	50
FMTLOK10-50	10"	50
FMTLOK212-500	2½"	500
FMTLOK04-250	4"	250
FMTLOK06-250	6"	250
FMTLOK08-250	8"	250
FMTLOK10-250	10"	250

PRODUCT FEATURES



FMTLOKSHEET (0510)

FastenMaster
FASTER EASIER STRONGER

FASTENMASTER, INC., 153 BOWLES ROAD, AGAWAM, MA 01001
800-518-3569 WWW.FASTENMASTER.COM

TABLE 2—DOWEL BEARING STRENGTH (psi)
(Test results are the 5% offset value)

FASTENER DESIGNATION	DIRECTION OF LOADING	CALCULATED DOWEL BEARING STRENGTH PER REGRESSION EQUATIONS								
		0.67	0.57	0.55	0.5	0.46	0.43	0.42	0.36	0.31
OlyLog® / TimberLok® fasteners	Parallel to grain	7,950	6,400	6,150	5,600	5,150	4,800	4,700	4,050	3,450
	Perpendicular to grain	7,950	6,200	5,900	5,150	4,550	4,150	4,000	3,200	2,550
LogHog® / LedgerLok® / TrussLok® / TrussLok-Z® fasteners	Parallel to grain	7,950	6,400	6,150	5,600	5,150	4,800	4,700	4,050	3,450
	Perpendicular to grain	7,950	5,900	5,550	4,700	4,150	3,750	3,650	2,900	2,350
Wet Service Factor, C_m for lateral loads	*Parallel to grain*	*0.7*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*
	Perpendicular to grain	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*	*0.7*	*0.6*	*0.5*

TABLE 3—DIRECT WITHDRAWAL DESIGN VALUES (*W*)
[Tabulated withdrawal design values (*W*) are in pounds per inch of thread penetration into side grain of main member]

FASTENER DESIGNATION		THREAD LENGTH, *L* (inches)	*W* (lbs./in.) FOR SPECIFIC GRAVITIES OF:								
			0.67	0.57	0.55	0.5	0.46	0.43	0.42	0.36	0.31
OlyLog® / TimberLok® fasteners	TLOK212 or LOG212	1.25	264	207	196	170	150	136	131	104	83
	All other lengths	2									
Wet Service Factor, C_m, for withdrawal loads			*0.7*	*0.7*	*0.7*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*
LogHog® / LedgerLok® fasteners	LL358	2	297	233	221	192	169	153	148	117	94
	All other lengths	3									
TrussLok®	All lengths	$1^1/_2$	—	—	—	153	—	—	—	—	—
TrussLok-Z®	All lengths	$1^1/_4$	—	233	221	192	169	153	148	117	—
Wet Service Factor, C_m, for withdrawal loads			*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*
NDS equation used to calculate design values			11.2-1	11.2-1	11.2-1	11.2-1	11.2-1	11.2-1	11.2-1	11.2-1	11.2-1

For **SI:** 1 inch = 25.4 mm, 1 pound = 4.448 kPa

NOTES

1 Values must be multiplied by all applicable adjust factors (see NDS)
2. Embedded thread length is that portion held by the main member (including tip).

TABLE 4—PULL-THROUGH DESIGN VALUES (*P*)

FASTENER DESIGNATION		THREAD LENGTH, *L* (inches)	*P* (lbs./in.) FOR SPECIFIC GRAVITIES OF:								
			0.67	0.57	0.55	0.5	0.46	0.43	0.42	0.36	0.31
OlyLog® / TimberLok® fasteners	TLOK212 or LOG212	1.25	334	218	200	158	130	112	107	79	62
	All other lengths	2									
LogHog® / LedgerLok® fasteners	LL358	2	471	323	299	243	206	181	173	133	108
	All other lengths	3									
TrussLok®	All lengths	$1^1/_2$	—	—	—	264	—	—	—	—	—
TrussLok-Z®	All lengths	$1^1/_4$	—	366	327	248	199	168	159	114	—

For **SI:** 1 inch = 25.4 mm, 1 pound = 4.448 kPa

NOTES

1 Values must be multiplied by all applicable adjustment factors (see NDS).
2 Embedded thread length is that portion held by the main member (including tip).
3 Tabulated pull-through design values (*P*) are in pounds per inch through side member.

TABLE 5A—LATERAL DESIGN VALUES (*Z*) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS WITH LOADING PARALLEL TO GRAIN

[Tabulated lateral design values (*Z*) are in pounds per fastener into sawn lumber or SCL[3] with both members of identical specific gravity]

FASTENER DESIGNATION		SIDE MEMBER THICKNESS, t_s (inches)	FASTENER PENETRATION, *p* (inches)	Z (lbs.) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS LOADED PARALLEL TO THE GRAIN FOR SPECIFIC GRAVITIES OF:								
				0.67	0.57	0.55	0.5	0.46	0.43	0.42	0.36	0.31
OlyLog® / TimberLok® fasteners	TLOK212 or LOG212	1 1/2	1	265	224	217	203	191	181	179	161	143
	TLOK04 or LOG006	1 1/2	2 1/2	299	268	263	251	240	231	228	228	1788
	TLOK06 or LOG006	4	2						232	230	213	197
	TLOK08 or LOG008	6	2									
	LOG009	7	2									
	TLOK10 or LOG010	8	2									
	LOG012	10	2									
	LOG014	12	2									
	LOG016	14	2									
LedgerLok® fasteners	LL358	1 1/2	2 1/8	373	325	315	292	274	259	255	229	204
	LL005	1 1/2	3 1/2					274	259		229	204
LogHog® fasteners	LHOG009	6	3	357	320	314	299	287	277	274	255	235
	LHOG011	8	3									
	LHOG012	9	3									
	LHOG013	10	3									
	LHOG014	11	3									
	LHOG015	12	3									
TrussLok®	EWS338	1 3/4	1 5/8	—	—	—	318	—	—	—	—	—
	EWS005	1 3/4	3 1/4				333					
	EWS670	1 3/4	5				333					
TrussLok-Z®	TSLZ278	1 1/2	1 3/8	—	306	294	268	246	229	225	194	—
	TSLZ412	1 1/2	3		336	326	303	285	270	266	239	
	TSL006	1 1/2	4 1/2		336	326	303	285	270	266	239	

For **SI:** 1 inch = 25.4 mm, 1 pound = 4.448 kPa

NOTES

1 Values must be multiplied by all applicable adjustment factors (see NDS).
2 Embedded thread length is that portion held by the main member (including tip).
3 SCL is structural composite lumber (laminated veneer lumber is LVL, and parallel strand lumber is PSL). This group also includes all OSB, structural I plywood, and marine-grade plywood panels.
4 *p* = depth of fastener penetration into wood member, in inches.
5 Tabulated values are results of calculations per NDS Section 11.3, where *D* = minor thread diameter.

TABLE 5B—LATERAL DESIGN VALUES (Z) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS WITH LOADING PERPENDICULAR TO GRAIN

[Tabulated lateral design values (Z) are in pounds per fastener into sawn lumber or SCL[3] with both members of identical specific gravity]

FASTENER DESIGNATION		SIDE MEMBER THICKNESS, t_s (inches)	FASTENER PENETRATION, p (inches)	Z (lbs.) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS LOADED PARALLEL TO THE GRAIN FOR SPECIFIC GRAVITIES OF:								
				0.67	0.57	0.55	0.5	0.46	0.43	0.42	0.36	0.31
OlyLog® / TimberLok® fasteners	TLOK212 or LOG212	1 1/2	1	265	219	211	191	175	164	160	133	106
	TLOK04 or LOG006	1 1/2	2 1/2	299	264	257	240	222	206	200	168	142
	TLOK06 or LOG006	4	2					226	216	212	190	166
	TLOK08 or LOG008	6	2									
	LOG009	7	2									
	TLOK10 or LOG010	8	2									
	LOG012	10	2									
	LOG014	12	2									
	LOG016	14	2									
LedgerLok® fasteners	LL358	1 1/2	2 1/8	373	305	290	255	233	216	212	179	145
	LL005	1 1/2	3 1/2			290	255	233	216		180	157
LogHog® fasteners	LHOG009	6	3	357	307	298	274	258	245	242	215	194
	LHOG011	8	3									
	LHOG012	9	3									
	LHOG013	10	3									
	LHOG014	11	3									
	LHOG015	12	3									
TrussLok®	EWS338	1 3/4	1 5/8	—	—	—	267	—	—	—	—	—
	EWS005	1 3/4	3 1/4				290					
	EWS670	1 3/4	5				290					
TrussLok-Z®	TSLZ278	1 1/2	1 3/8	—	282	265	225	198	179	174	139	—
	TSLZ412	1 1/2	3		316	301	266	243	227	222	190	
	TSL006	1 1/2	4 1/2		316	301	266	243	227	222	190	

For **SI:** 1 inch = 25.4 mm, 1 pound = 4.448 kPa.

NOTES

1 Values must be multiplied by all applicable adjustment factors (see NDS).
2 Embedded thread length is that portion held by the main member (including tip).
3 SCL is structural composite lumber (laminated veneer lumber is LVL, and parallel strand lumber is PSL). This group also includes all OSB, structural I plywood, and marine-grade plywood panels.
4 p = depth of fastener penetration into wood member, in inches.
5 Tabulated values are results of calculations per NDS Section 11.3, where D = minor thread diameter.

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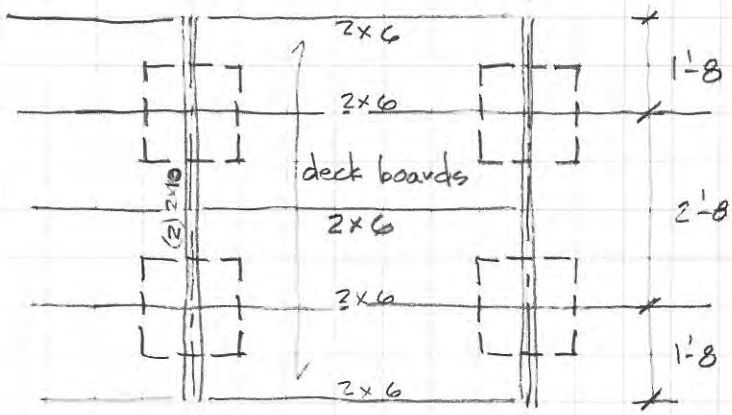
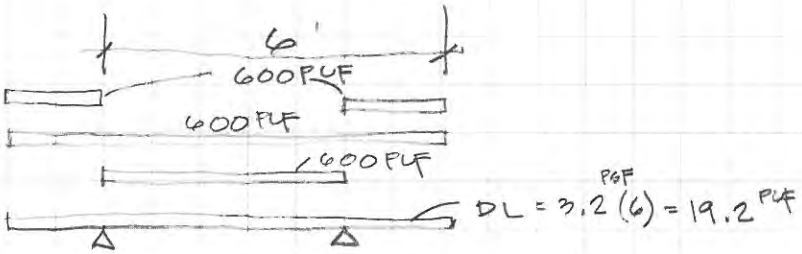
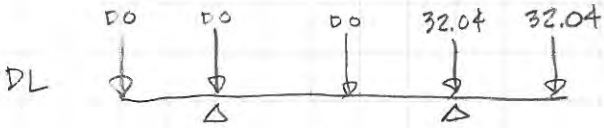
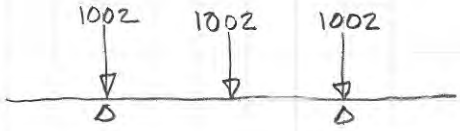
Proj. No. 12474004

WOOD DECKS









typ. 2x6

$DL = 2^{PSF} \times 1.67 = 3.34^{PLF} + 2.0^{PLF}$

$LL = 100 \times 1.67 = 167^{PLF}$

172^{PLF}

$R_{LL} = 501^{LB}$ $R = 516$ $R_{DL} = 16.02^{LB}$ 6'

$\ell/240 = 0.3"$

$M = 172(6)^2/8 = 774^{FT\,LB}$

$S_{req} = \frac{774(12)}{1250} = 7.44^{IN^3} < 7.5$ OK

$I_{req} = \frac{5(172)6^4(1728)}{384(1600000).3} = 10.3^{IN^4}$

$< 20.8^{IN^4}$ OK

$f_v = \frac{3(516)}{2(8.25)} = 93.88^{PSI}$ OK < 175 OK

TYP. JOIST S.P. #2
2x6

$R_{MAX} = 3.23^K$

if 1500^{PSF} ALL SOIL PRESSURE

$A_{req} = \frac{3,230}{1500} = 2.153^{\#}$

$\sqrt{A_{req}} = 1.467^{FT}$

$\therefore$ 1'-6 SQ PADS

FROM COMPUTER OUTPUT (2) 2x10
COULD BE (2) 2x8
S.P. #2

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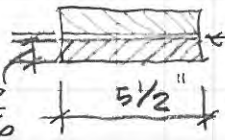
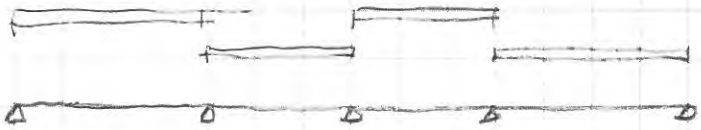
WOOD DECKING



RE-CLAIMED BOARDS
DOUGFIR OF SP.

$S = \frac{.8125^2(5.5)}{6} = 0.605^{in^3}$ $I = \frac{5.5(.8125)^3}{12} = 0.246^{in^4}$ $A = .8125(5.5)$
$A = 4.47$ in

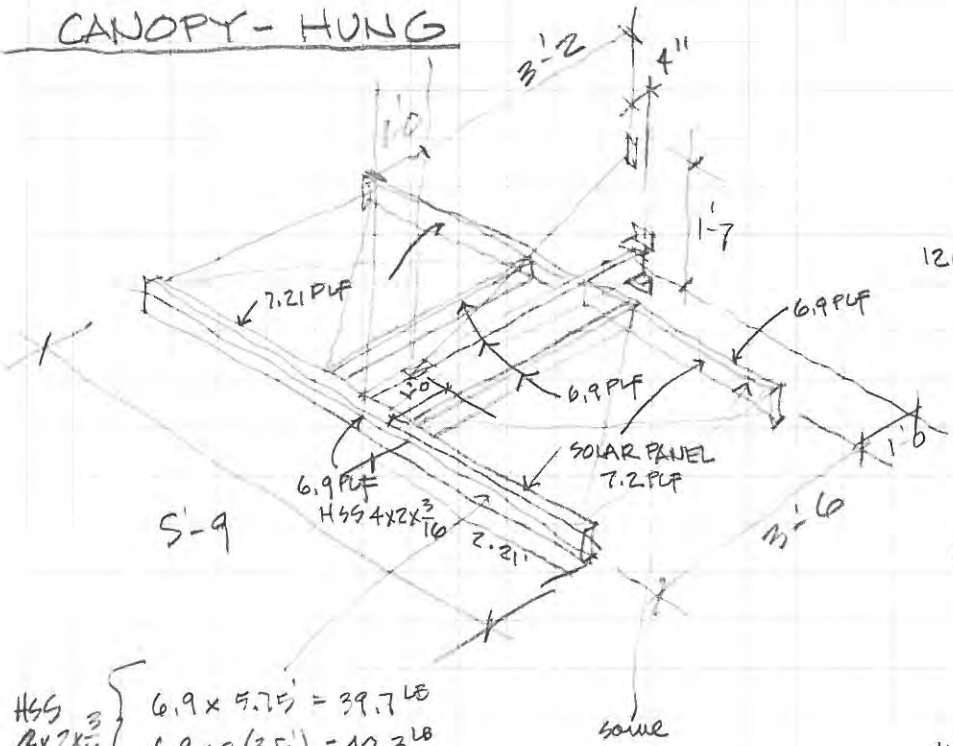


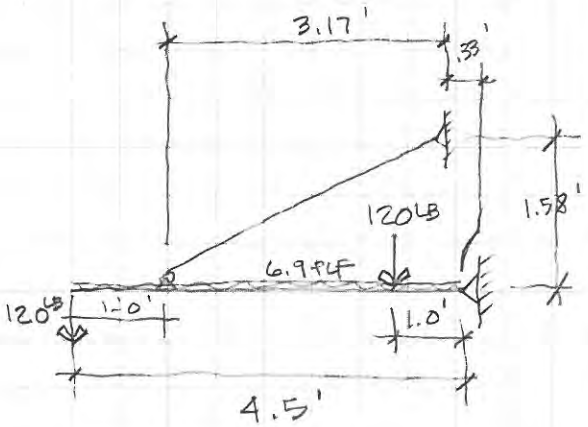
LL = $100^{PSF} \times \frac{55}{12} = 45.8^{PLF}$

STRENGTH RATIO 0.99
$\Delta = .95" \uparrow = .65" \downarrow$

SEE "DECKING BOARDS" MODEL IN RAM ELEMENTS

CANOPY - HUNG





LL = SNOW = $20^{PSF} \times 1.75' = 35^{PLF}$
@ 2 × 2.21' = 154.7 LB

HSS 4x2x3/16
6.9 × 5.75' = 39.7 LB
6.9 × 2(3.5') = 48.3 LB
7.21 PLF (2) 2.21' = 31.9 LB
120 LB

WIND : UPLIFT 14 PSF (WASH DC)
14 PSF (1.75') = 24.5 PLF
@ 2' × 2.21' = 108 LB ↑

HSS 4x2x1/8
4.75 × 5.75' = 27.3 LB
4.75 × 2(3.5) = 33.25 LB
31.9 LB
92.5 LB

ROD : COMP LC2
180 LB
LC1 MAX T = 890 LB

Bentley **MSA Professional Services**

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Units system: English
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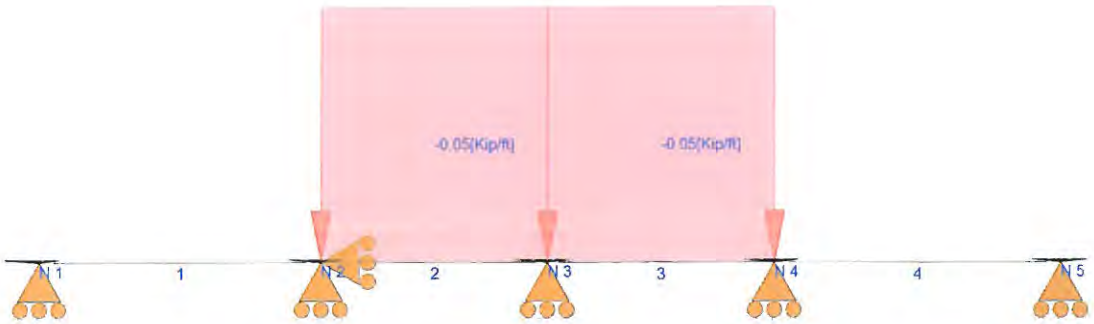
Loads

Global distributed - Members
Local distributed - Members

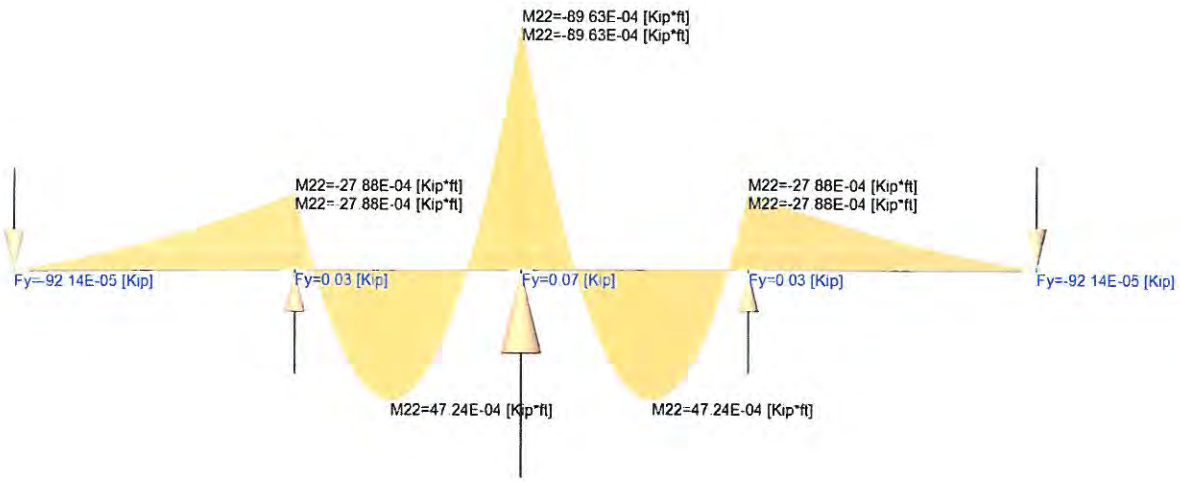
DECKING BOARDS



ONE OF 4 PATTERN LL CASES

Internal forces

Bending moment

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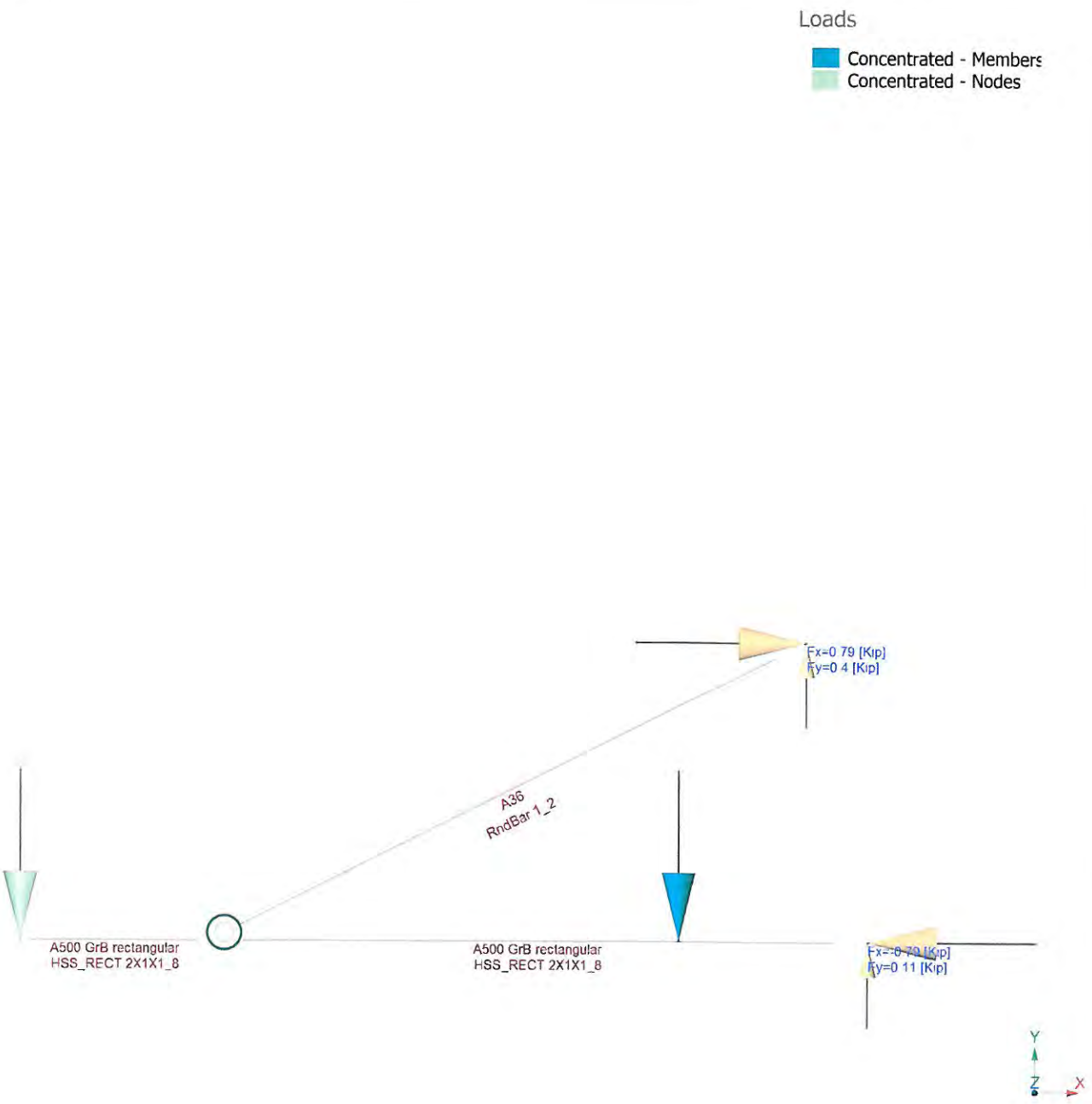
Y
Z
X

Bentley **MSA Professional Services**

Current Date: 2/12/2011 3:48 PM
Units system: English
Load condition: LC1=DL+SL



Bentley **MSA Professional Services**

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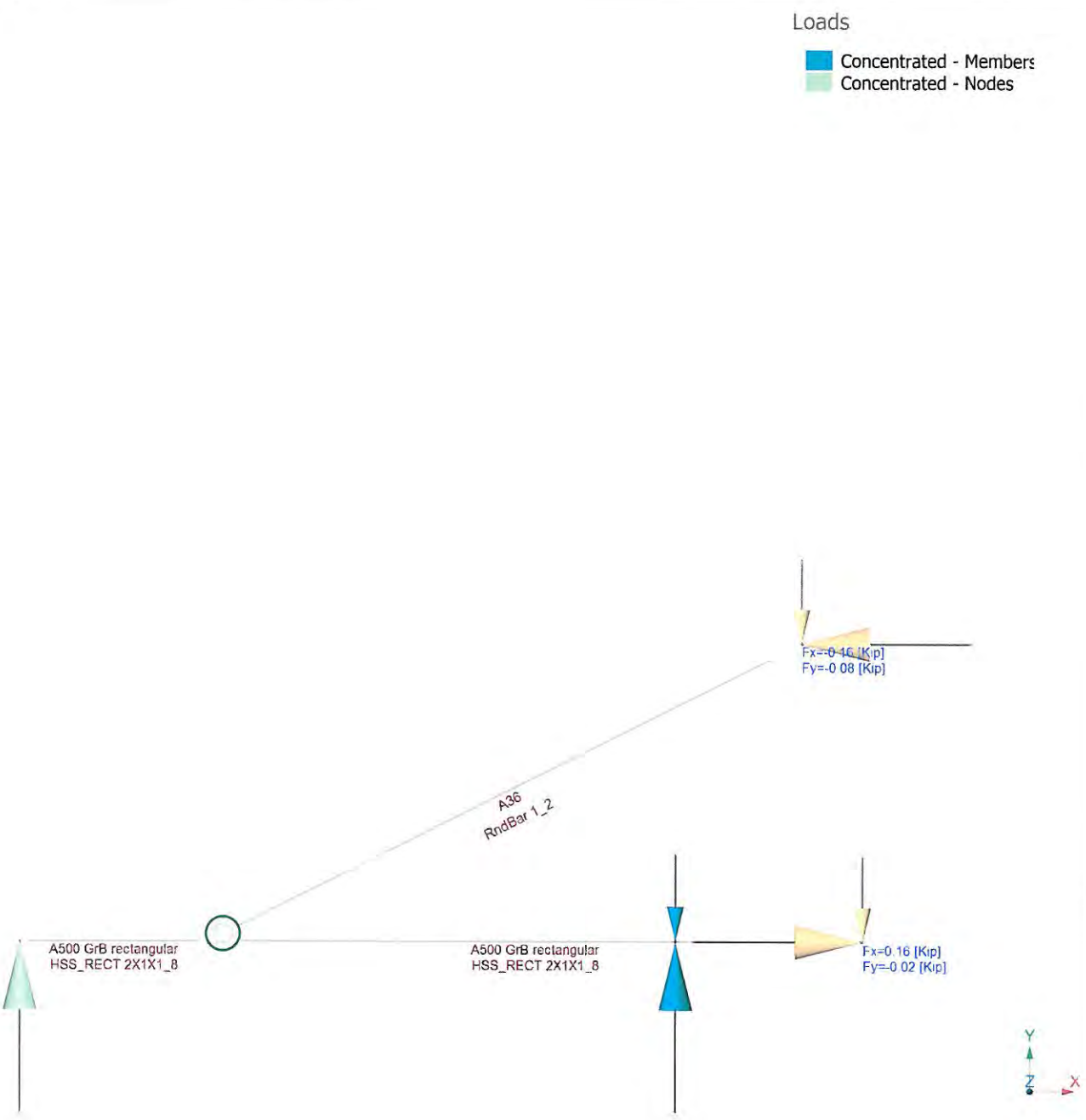
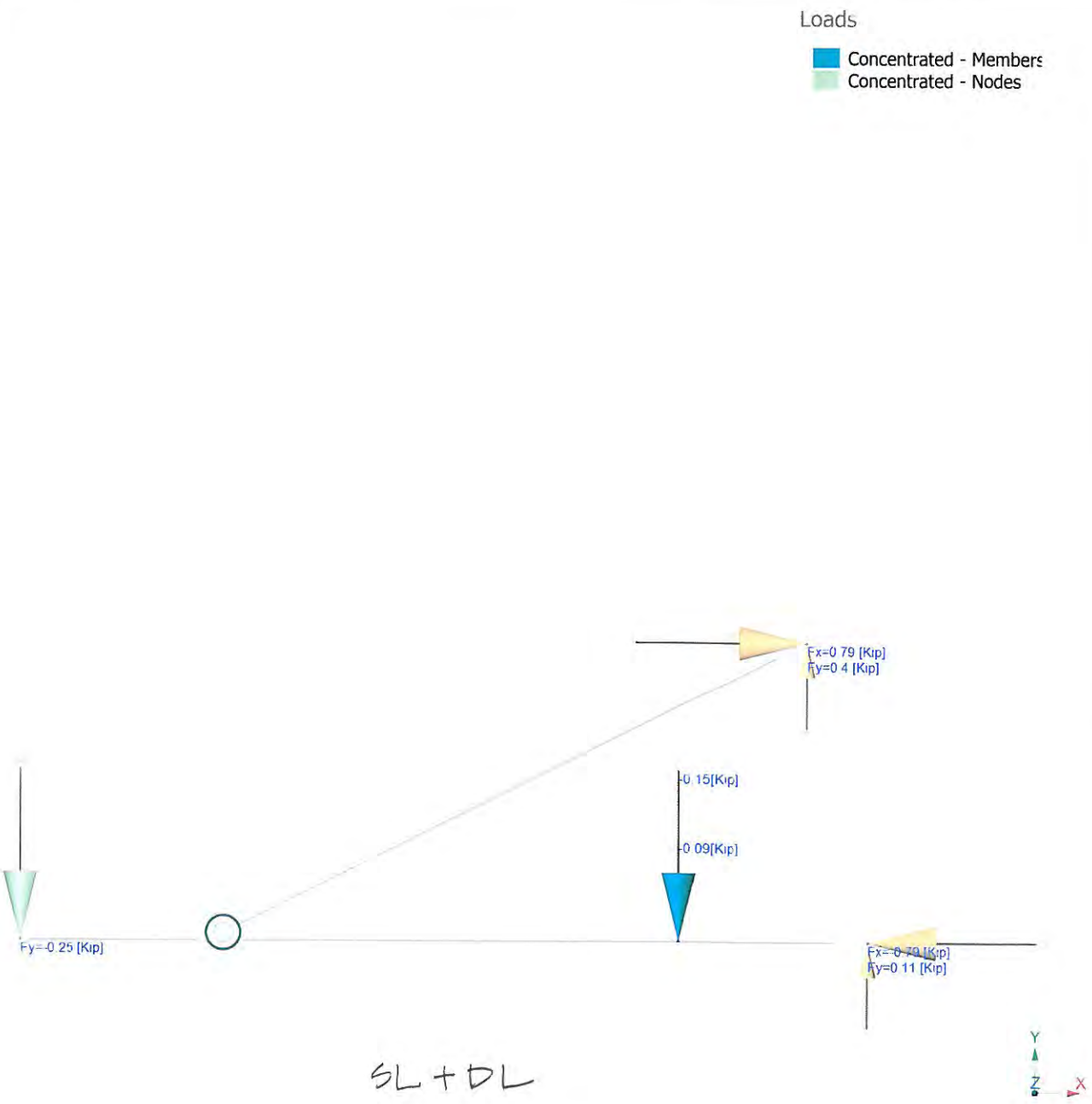


WIND UPLIFT

.6DL + WL

Bentley **MSA Professional Services**

Current Date: 2/12/2011 3:47 PM
Units system: English
Load condition: LC1=DL+SL



SL + DL

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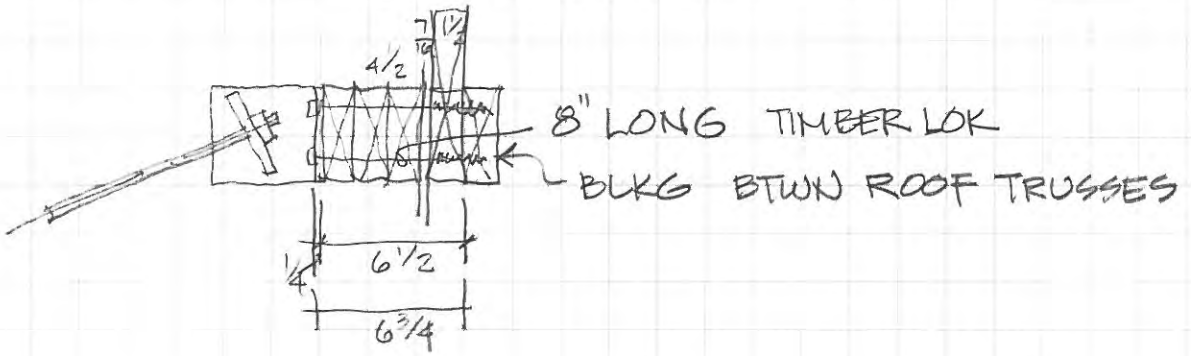
WITHDRAWAL = 790/4 = 197.5 LB/SCREW SHEAR = 400/4 = 100 LB/SCREW

ALLOW = 170 (1.25") (1.33) = 282.6 LB/SCR ALLOW SHEAR = 240 (1.33) = 319.2 LB

$$\frac{197.5}{282.6} + \frac{100}{319.2} = .699 + .313 = 1.01 \quad \therefore OK$$



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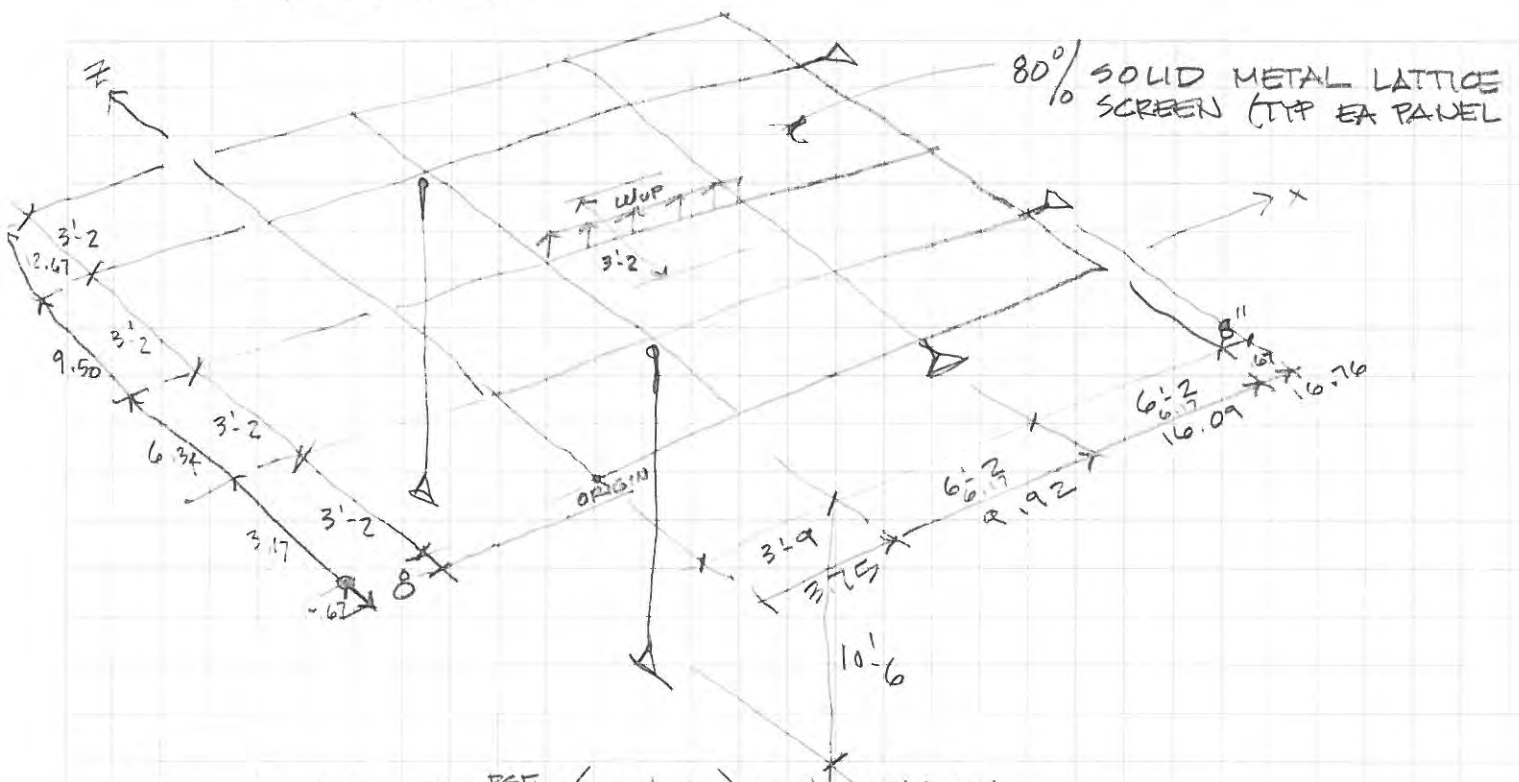


WIND UPLIFT: 35 PSF (C&C) CHAMPAIGN
14 PSF (C&C) WASH. DC.

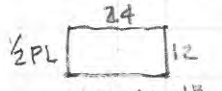
$W_{UP_C} = 3.17' \times 35\ PSF = 111\ PLF$

$W_{UP_W} = 3.17' \times 14\ PSF = 44.4\ PLF$

DL = LATTICE ~ 5 PSF @ 3.17' = 16 PLF + MEMBER WT

SL = 20 PSF × 3.17' = 63.4 PLF

FDTN: MAX UPLIFT TO FTG = 560 LB ↑
WASH. D.C.

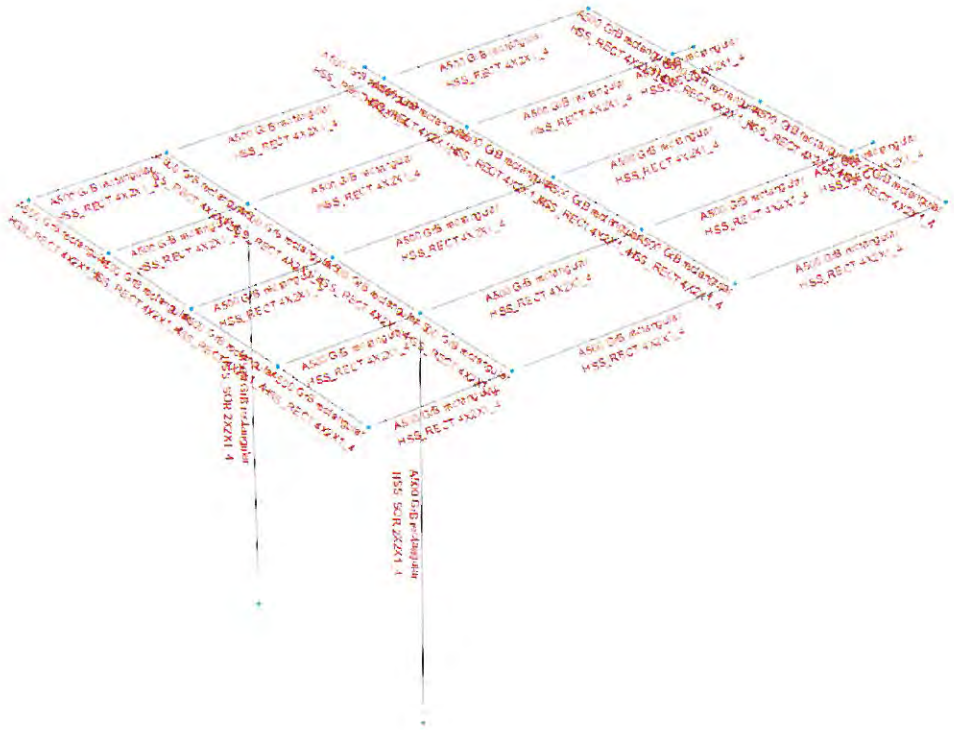


WT = 40.8 LB
62.6
103.4 LB WOOD FTG W/ ₵

560 − 103.4 LB = 456 LB REQD
3.15 CU. FT OF CONC REQD
~1.75' sq. × 1' deep conc.

MAX. GRAVITY = 2800 LB LC3
560 LB CONC
3360 LB

$A_{req} = \frac{3360}{1500} = 2.24\ ft^2$
~1.5' sq
OK



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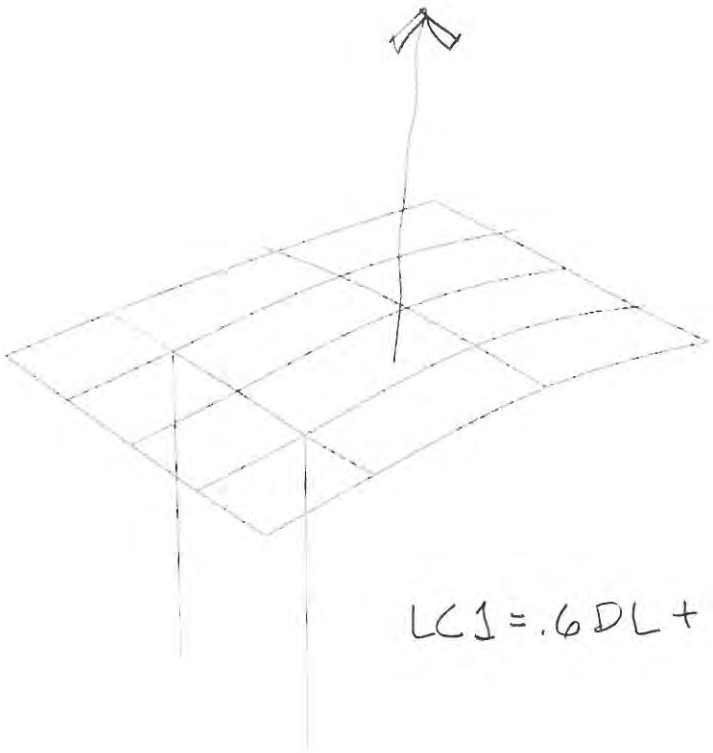

LC1 = .6DL + WL ↑ C&C

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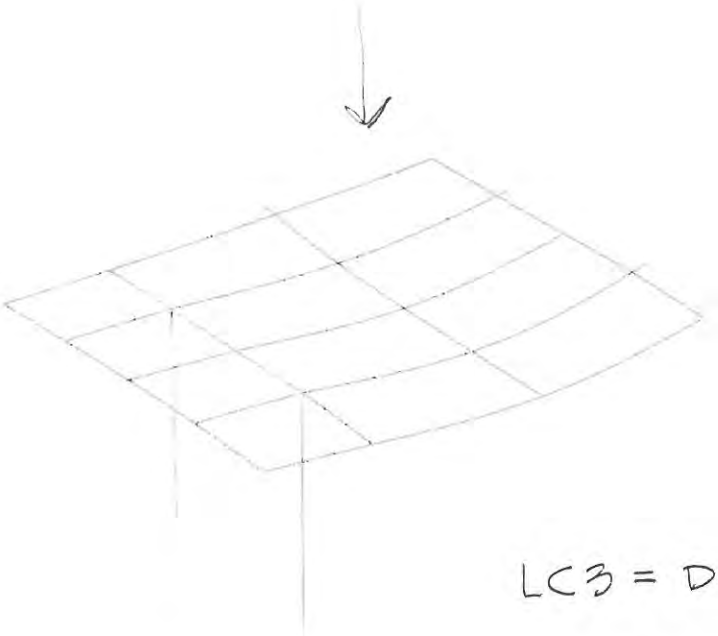
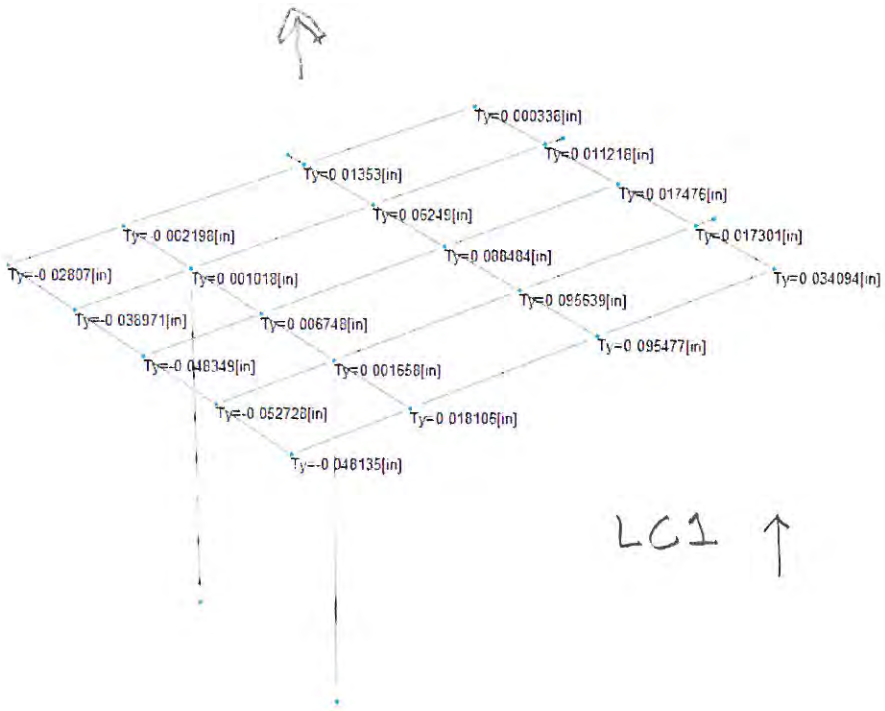


LC3 = DL + .75 (SL + WL↓)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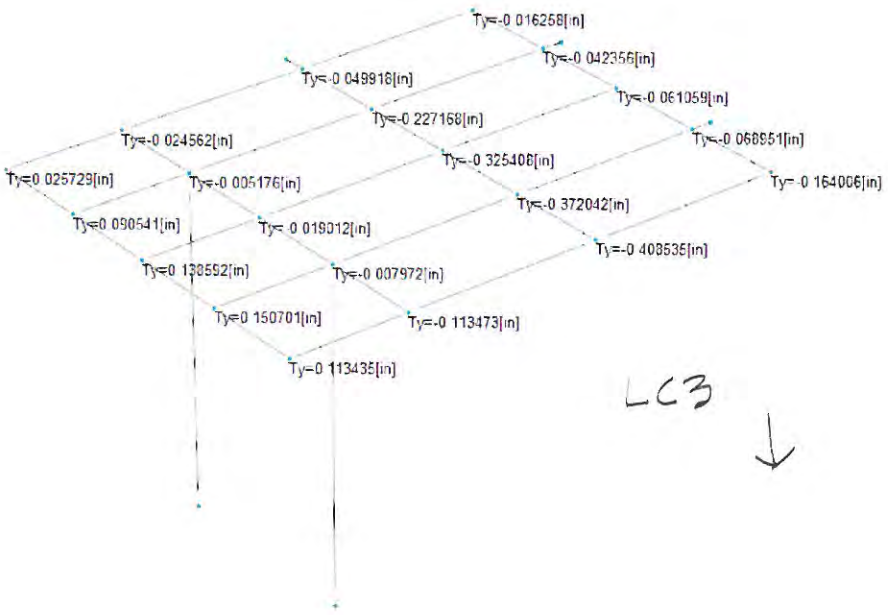
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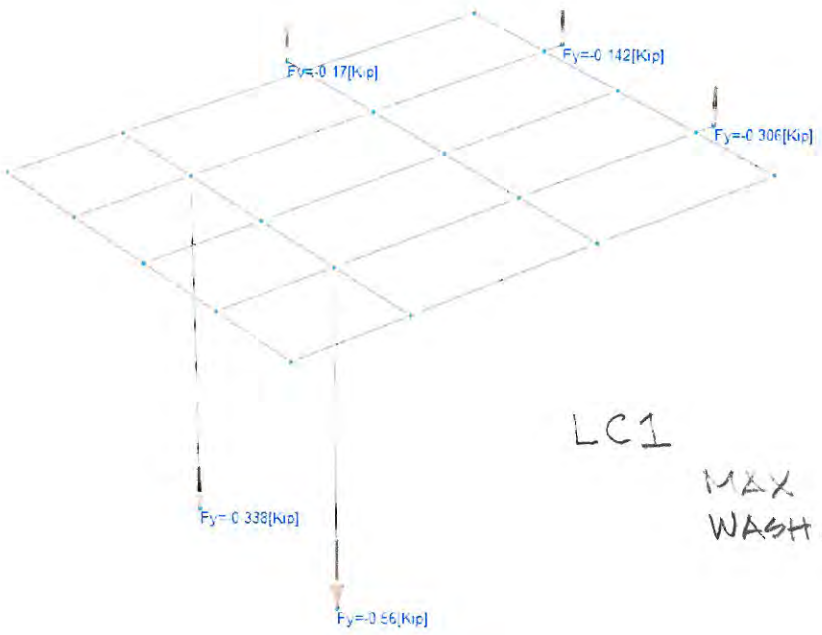
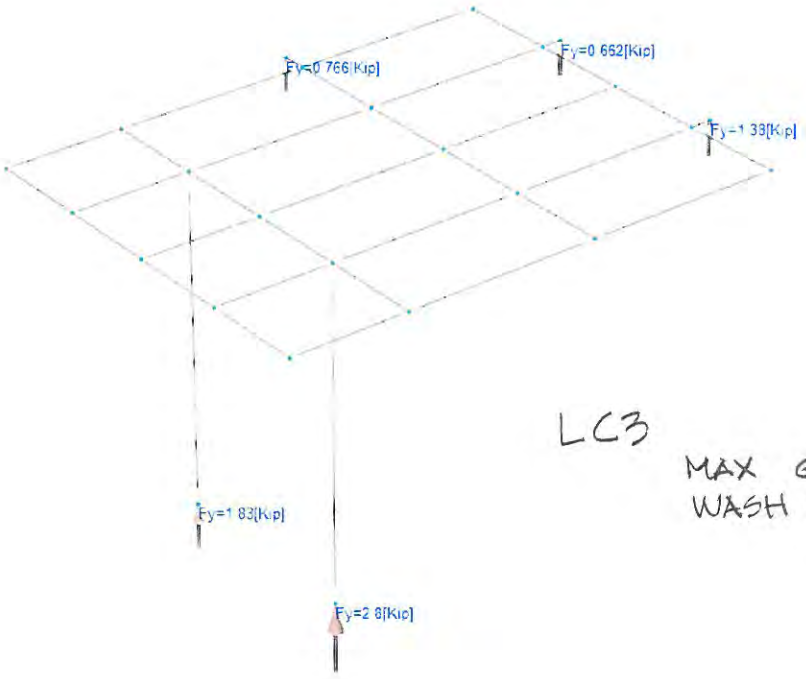
LC3

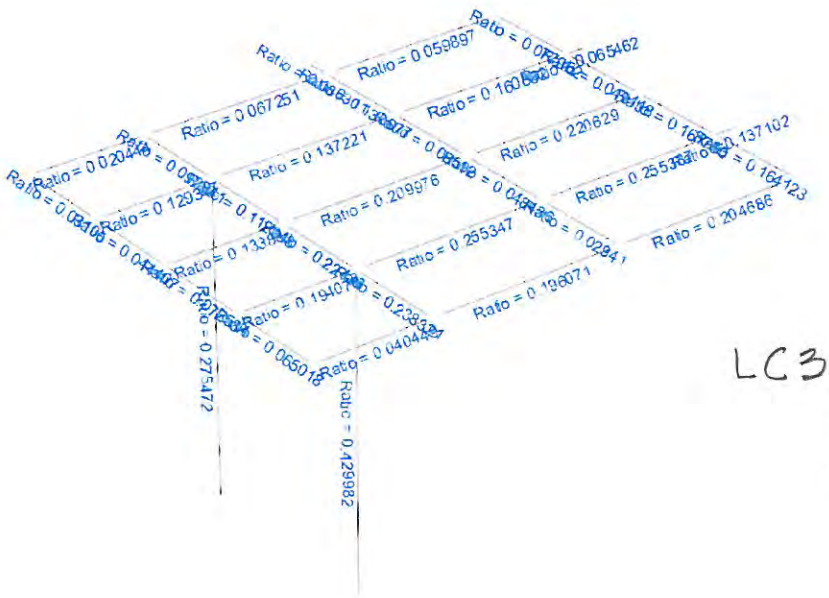


LC1

MAX UPLIFT
WASH. D.C.



LC3
MAX GRAVITY
WASH DC



LC3
MAX
STRESSES
WASH DC

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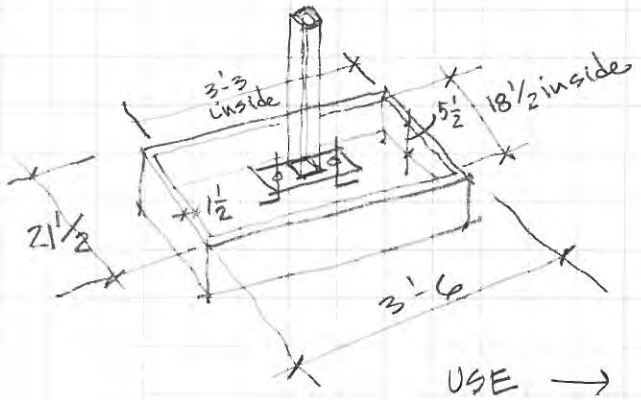


$\left(\frac{18.5(5\frac{1}{2})(39)}{1728}\right)^{FT^3} = 2.3^{CUFT}$

$145^{PCF}(2.3) = 333^{LB}$

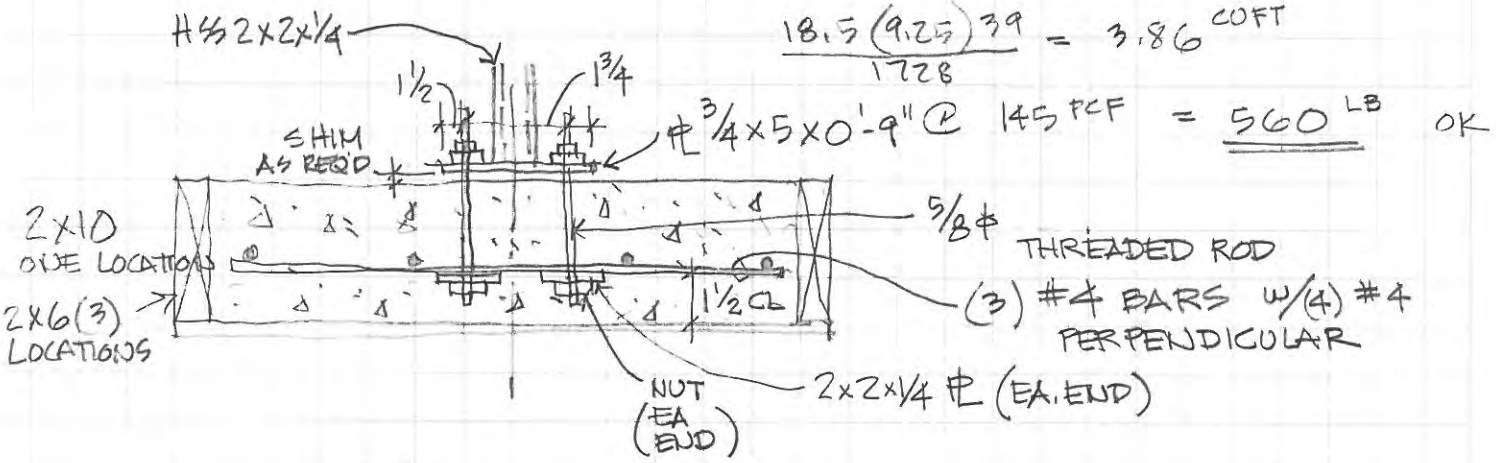
if 2x8 sides

$\frac{18.5(7.25)39}{1728} = 3.03^{CUFT}$

USE → if 2x10 sides

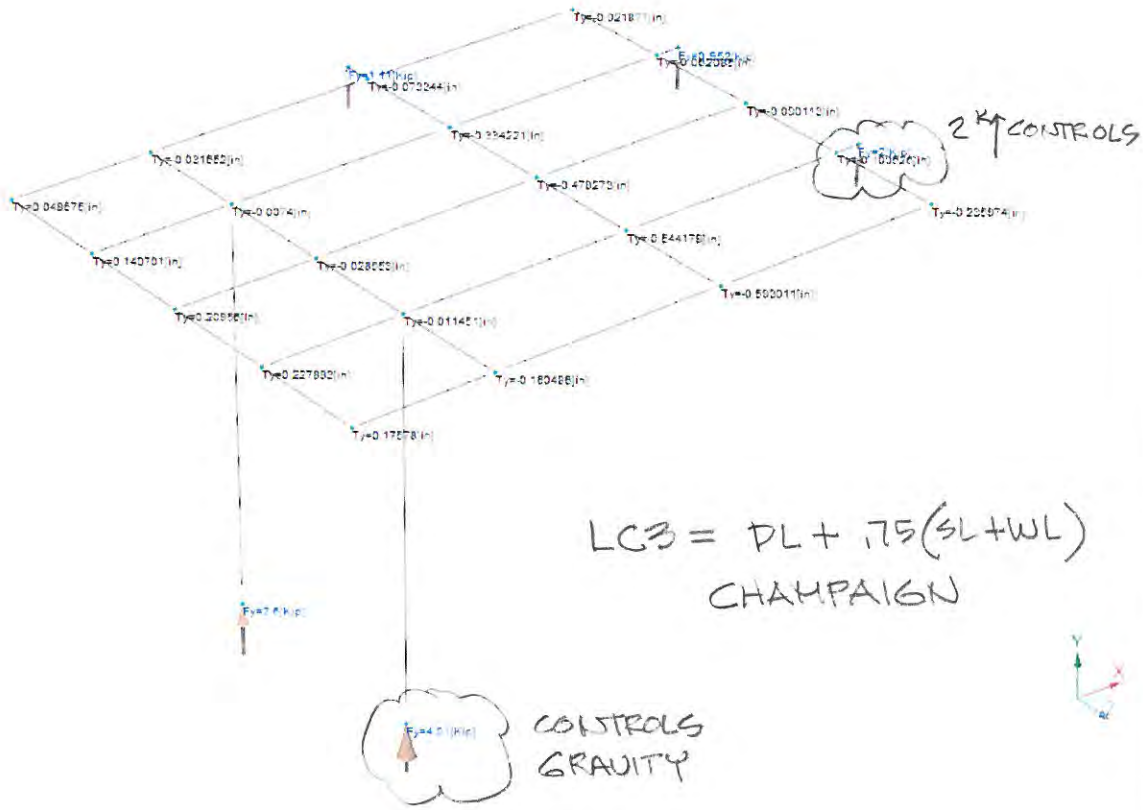
$\frac{18.5(9.25)39}{1728} = 3.86^{CUFT}$

3.86^{CUFT} @ $145^{PCF} = \underline{560^{LB}}$ OK



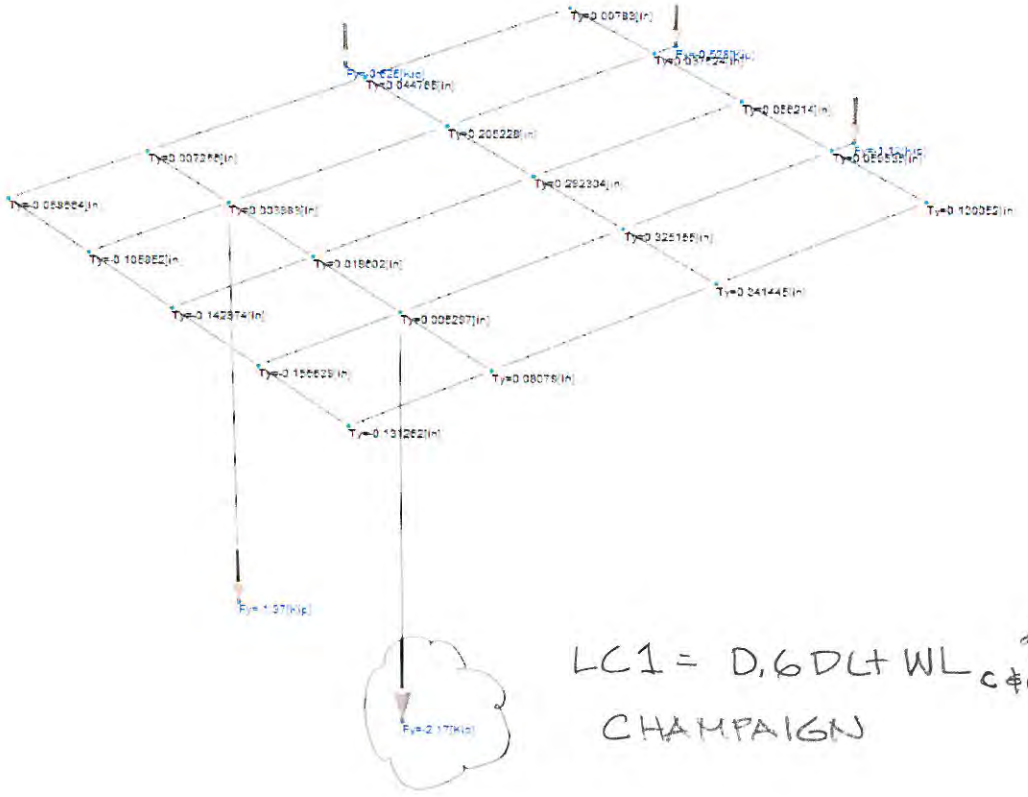
338^{LB} UPLIFT @ OPPOSITE SIDE COLUMN

USE 2x6 SIDE FORMS


2 K CONTROLS
LC3 = DL + .75(SL+WL)
CHAMPAIGN
CONTROLS
GRAVITY

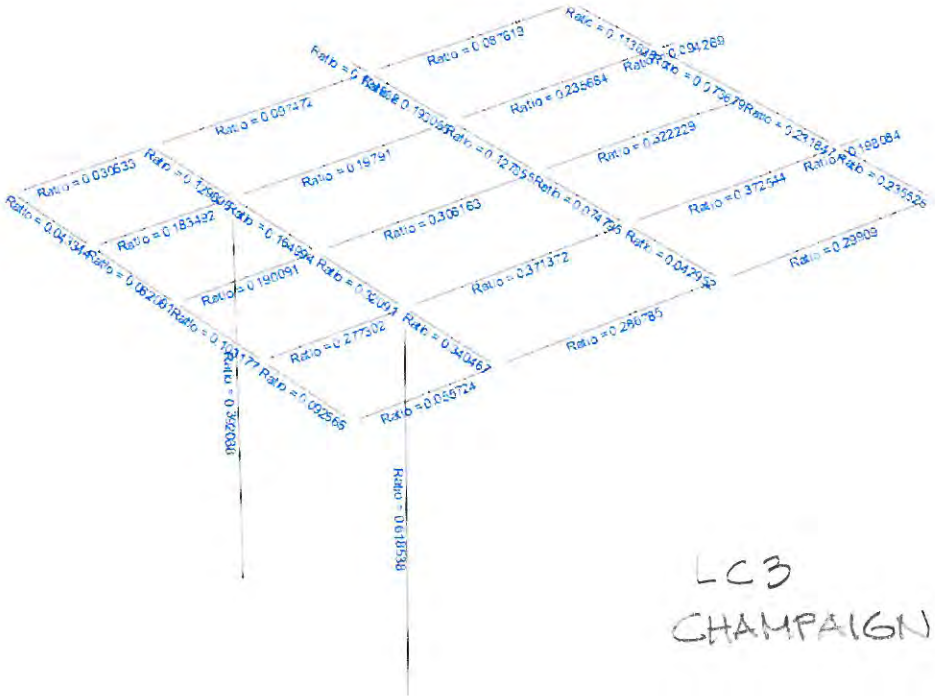
Bentley **MSA Professional Services**

Current Date: 3/13/2011 2:18 PM
Units system: English
File name: C:\Users\dwickersheimer\Desktop\Projects\solar Decathlon 2011\misc calcs and docs\large canopy with columns_Champaign Wind.etz\



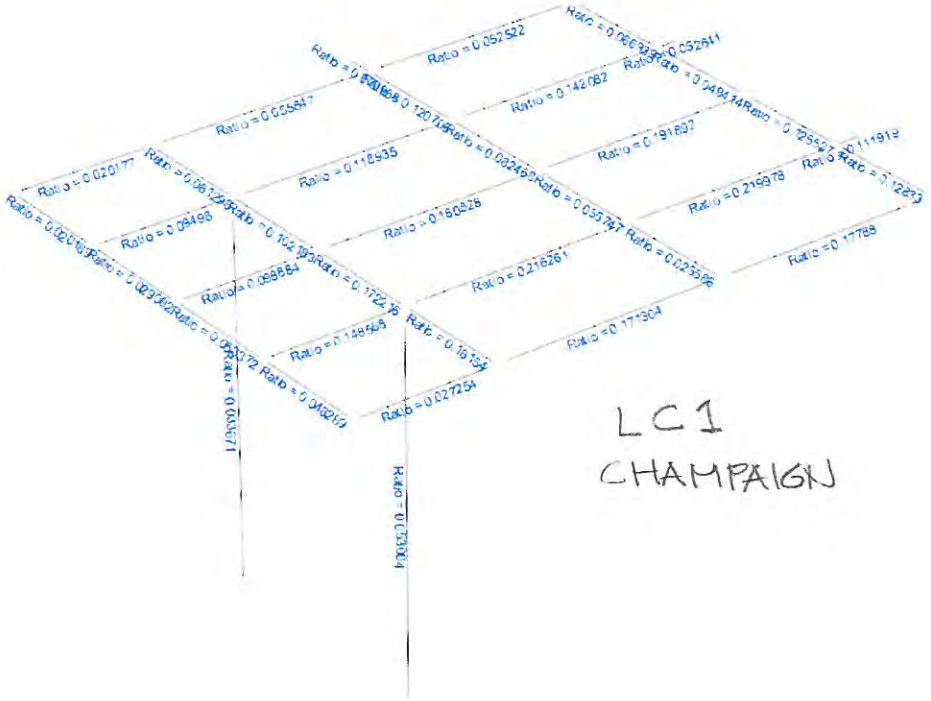
LC1 = D, 6DL + WL c&C

CHAMPAIGN


LC3
CHAMPAIGN

Bentley **MSA Professional Services**

Current Date: 3/13/2011 2:19 PM
Units system: English
File name: C:\Users\dwickersheimer\Desktop\Projects\solar Decathlon 2011\misc calcs and docs\large canopy with columns_Champaign Wind.etz\



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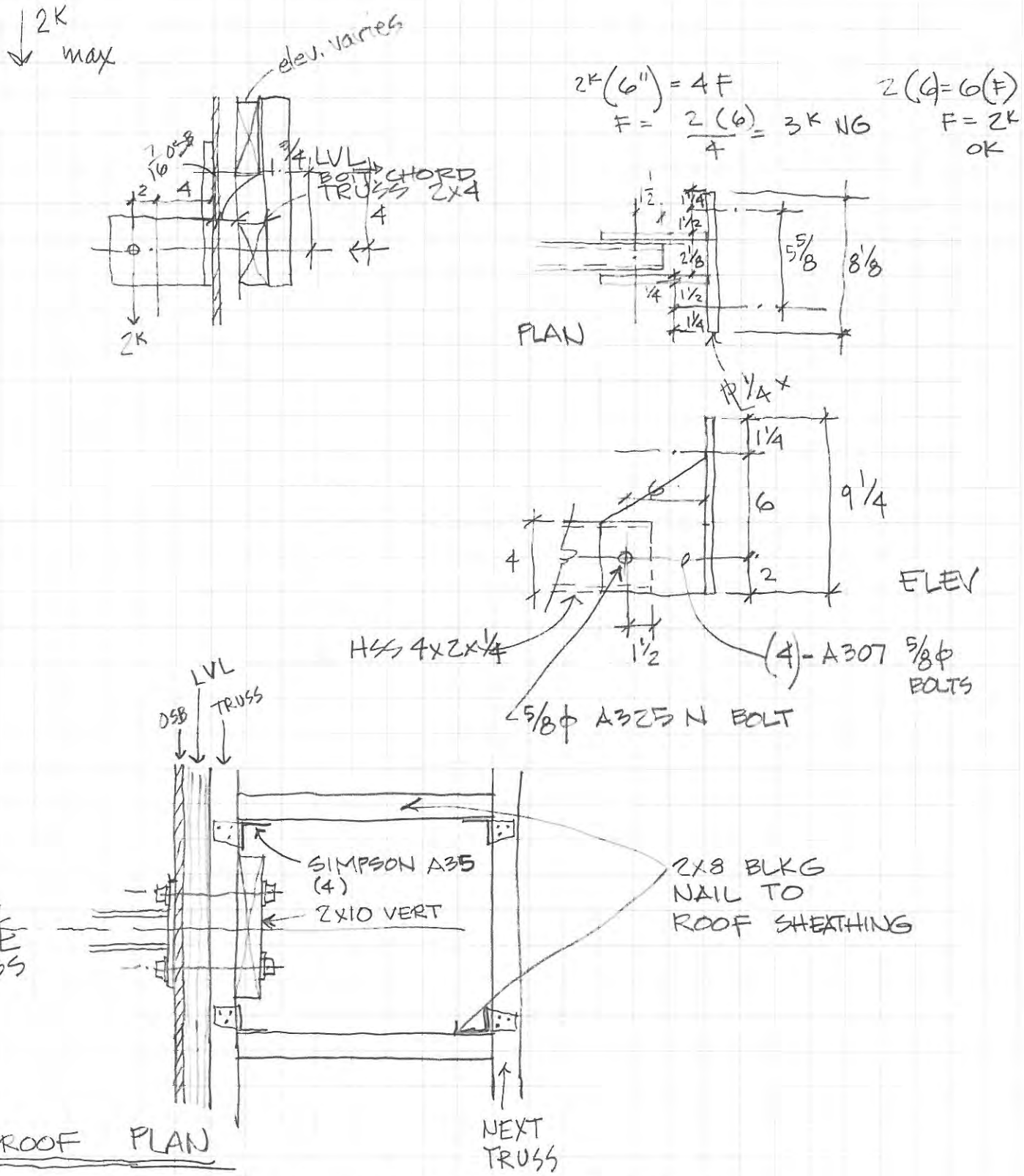
Project SOLAR DECATH 2011 Comp. by DJW
Date 3/14/11 Ckd. by _____
Proj. No. 12474004



TYP. @ 4 LOCATIONS OF CONN.

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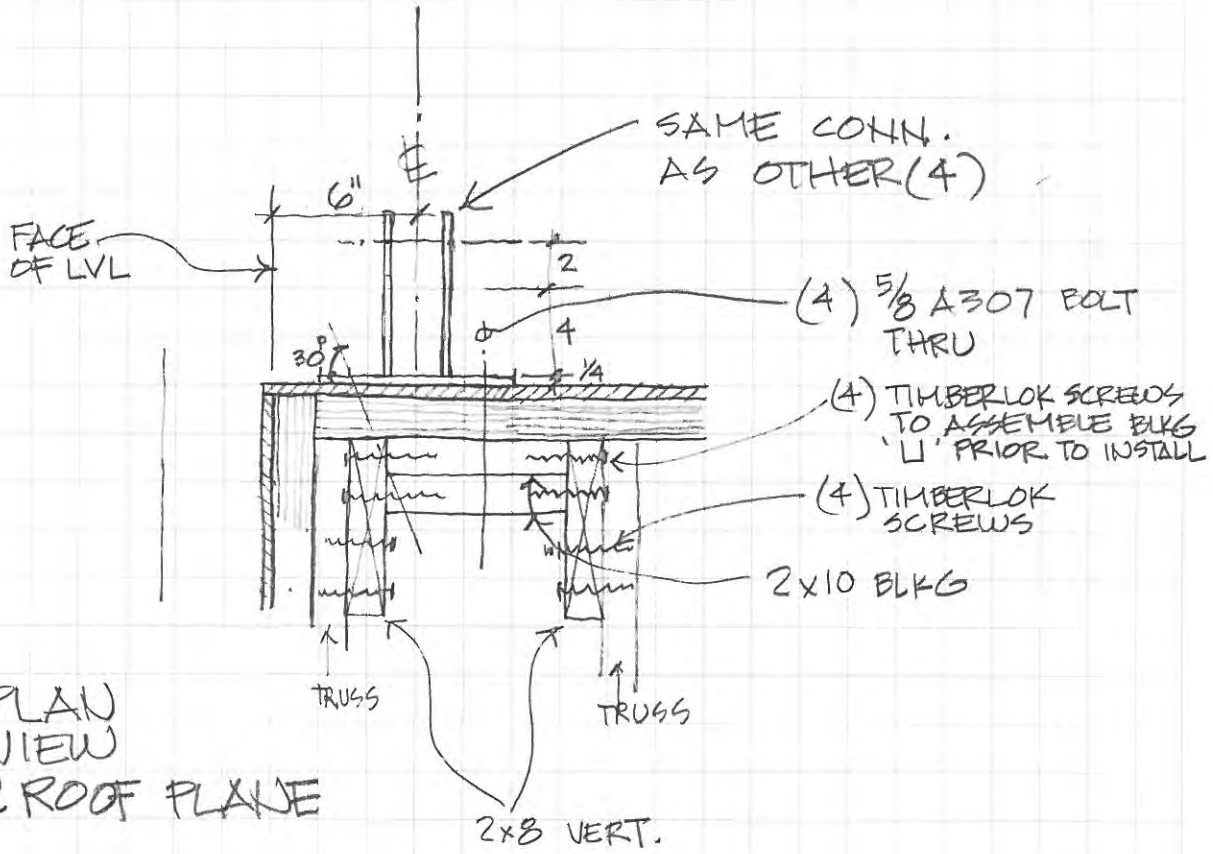
Date 3/14/2011 Ckd. by _____
Proj. No. 12474004



PLAN VIEW @ ROOF PLANE

YOU CAN COVER THESE CONN W/ 4" INSUL PANEL SINCE I ASSUME HOMEWAY WILL INSTALL THESE CONNECTORS.

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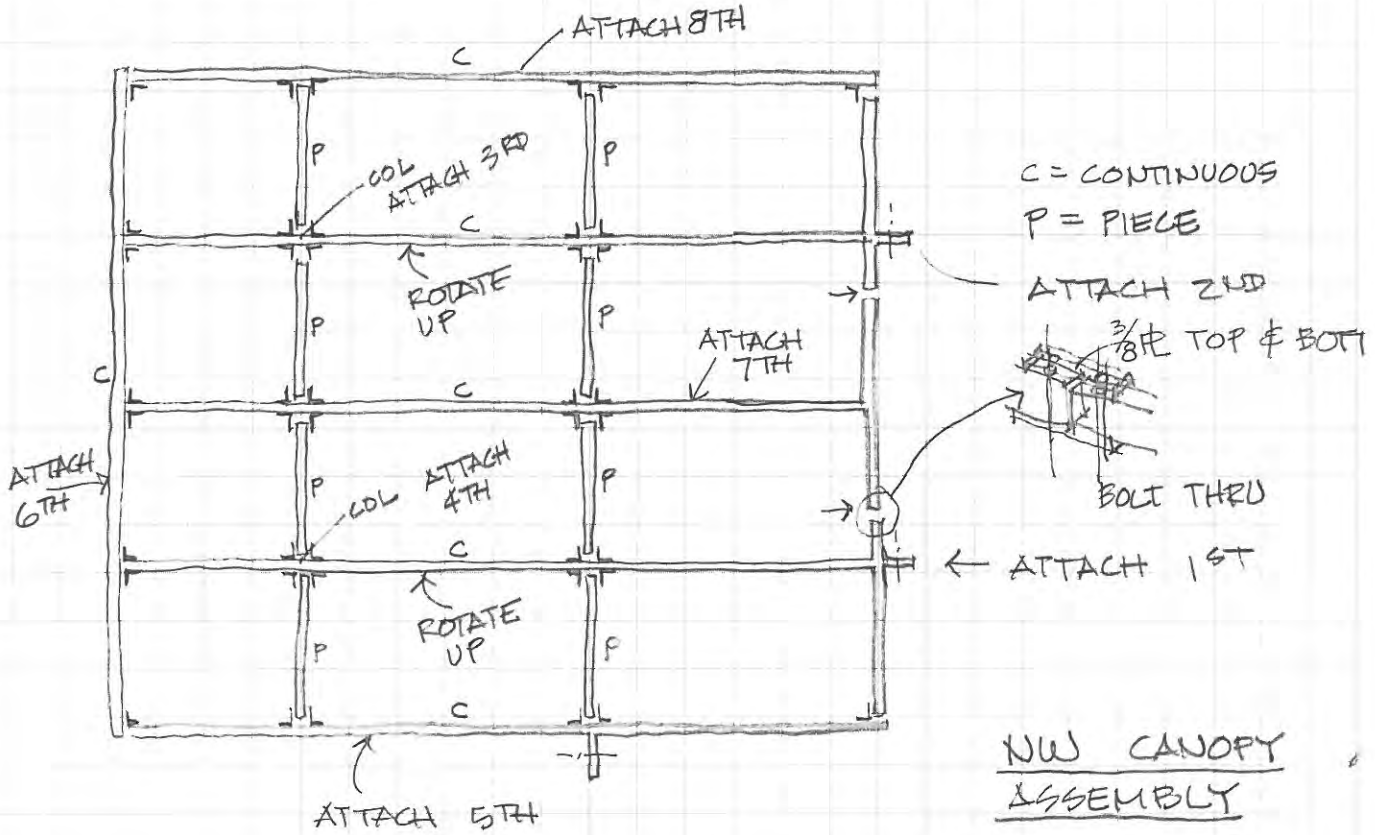
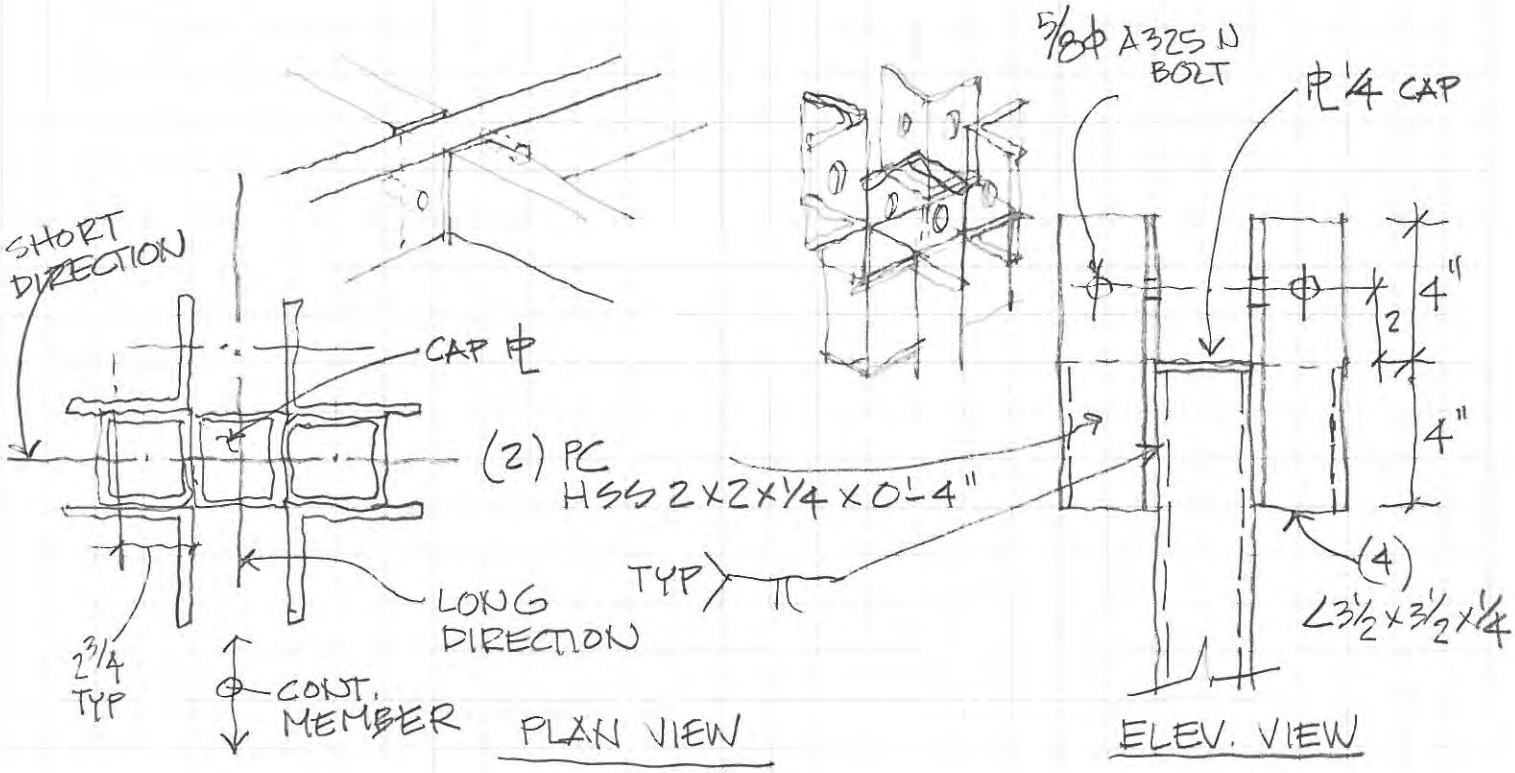
Project SOLAR DECATH 2011 Comp. by DJW
Date 3/14/11 Ckd. by _____
Proj. No. 12474.004



NW CANOPY ASSEMBLY



PLAN VIEW

ELEV. VIEW

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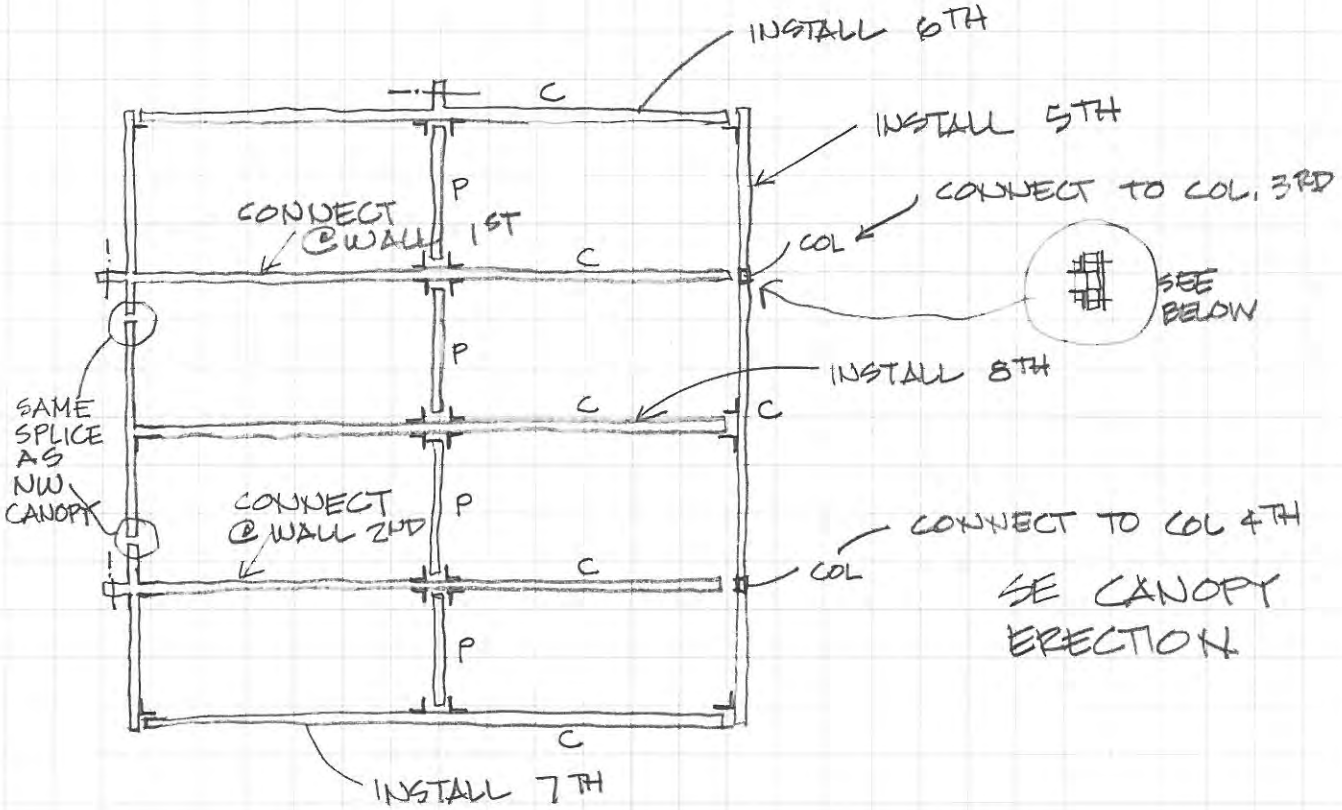
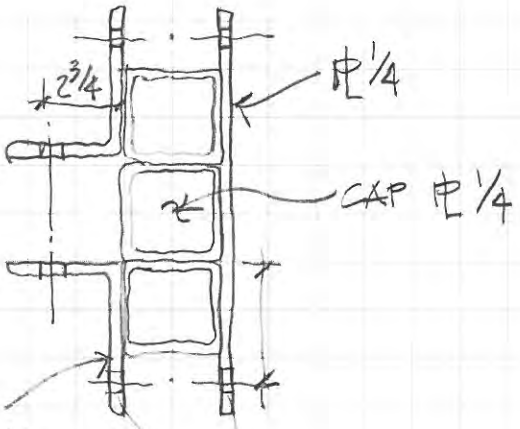
Proj. No. 124744004



PLAN



ELEV. SIMILAR TO NW CANOPY DETAIL

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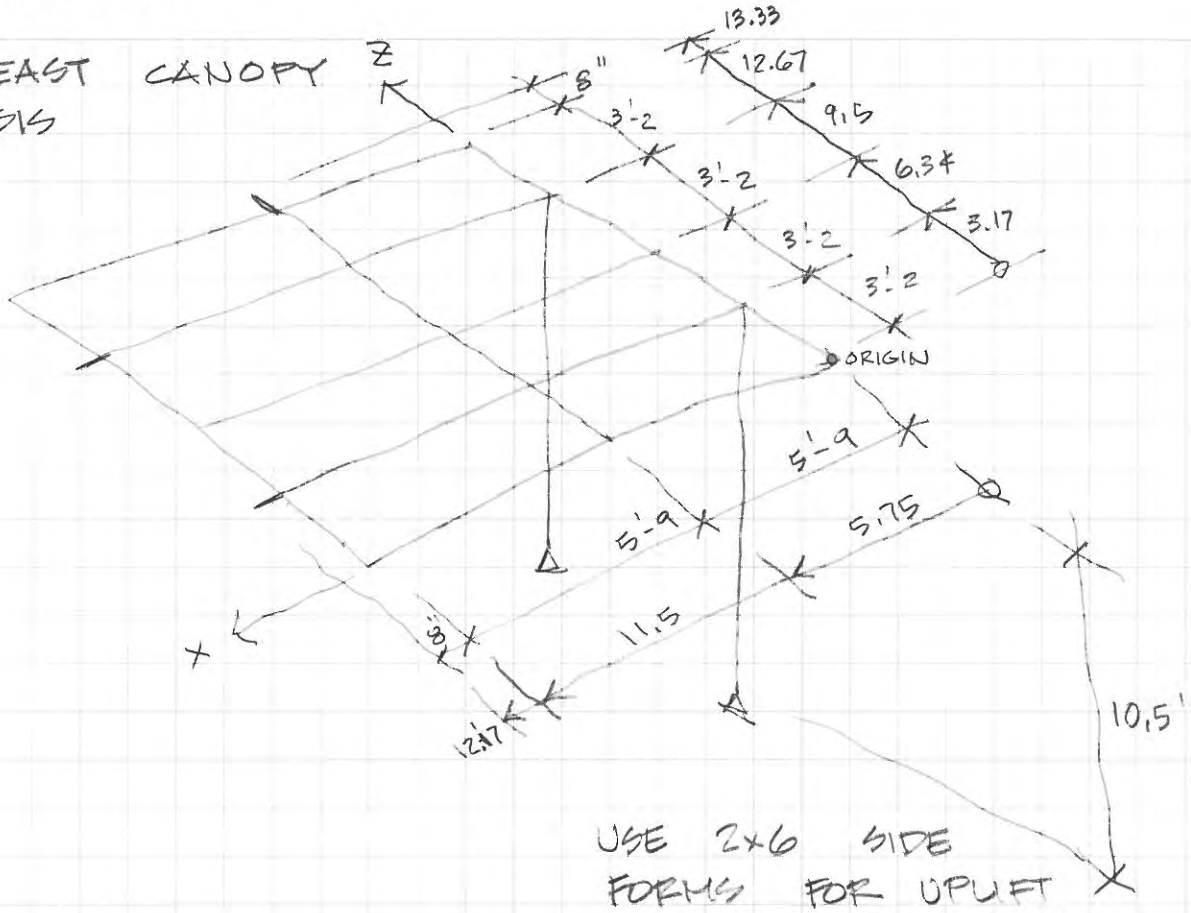
Proj. No. 12474004

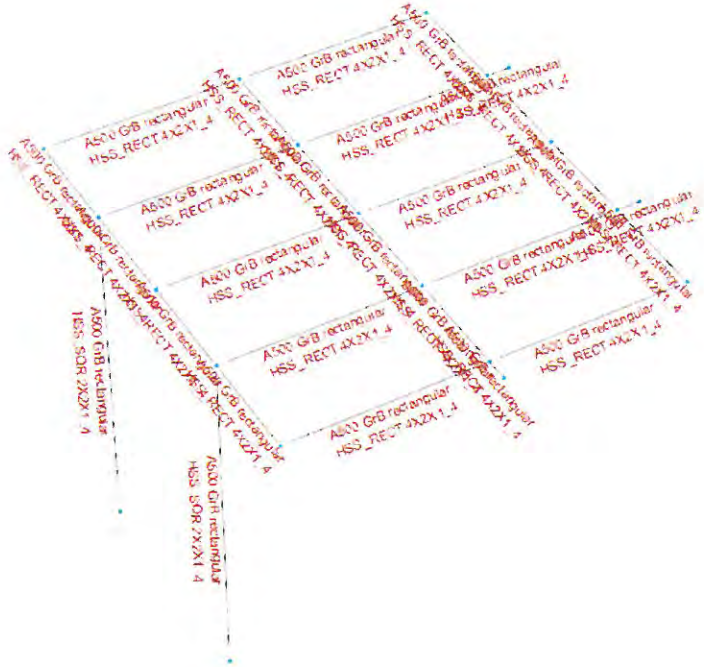
SOUTHEAST CANOPY ANALYSIS

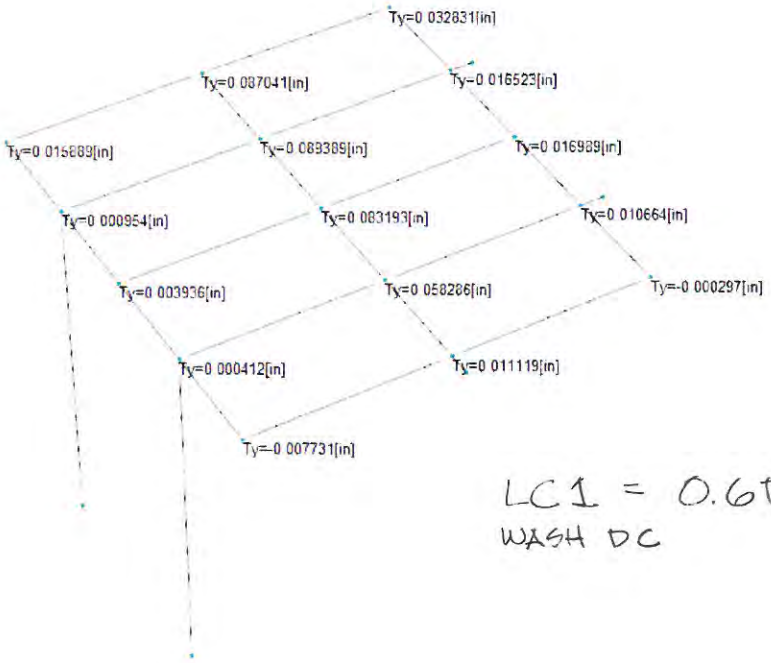


USE 2x6 SIDE FORMS FOR UPLIFT
MAX = 315 LB < 330 LB OK
FOR WASH DC

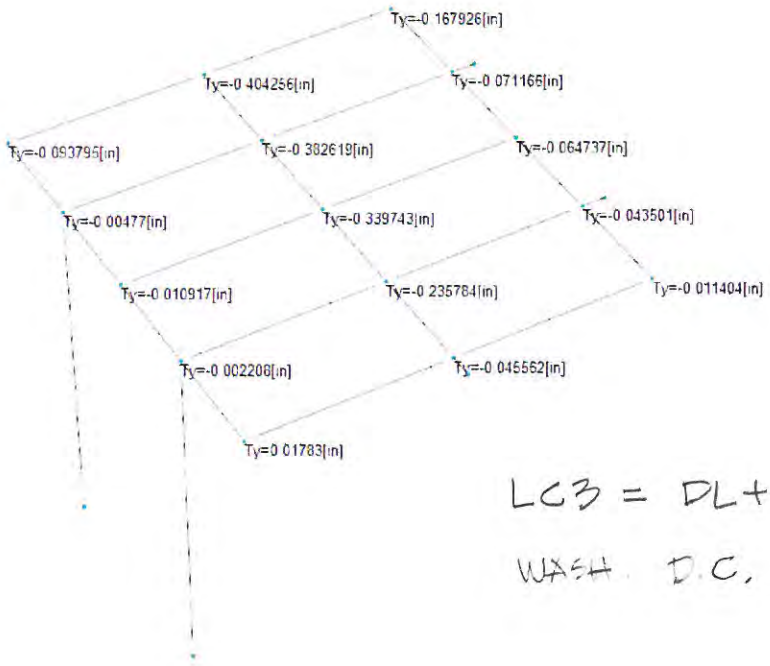
Bentley **MSA Professional Services**

Current Date: 3/12/2011 3:20 PM
Units system: English
File name: C:\Users\dwickersheimer\Desktop\Projects\solar Decathlon 2011\misc calcs and docs\Southeast Canopy.etz\



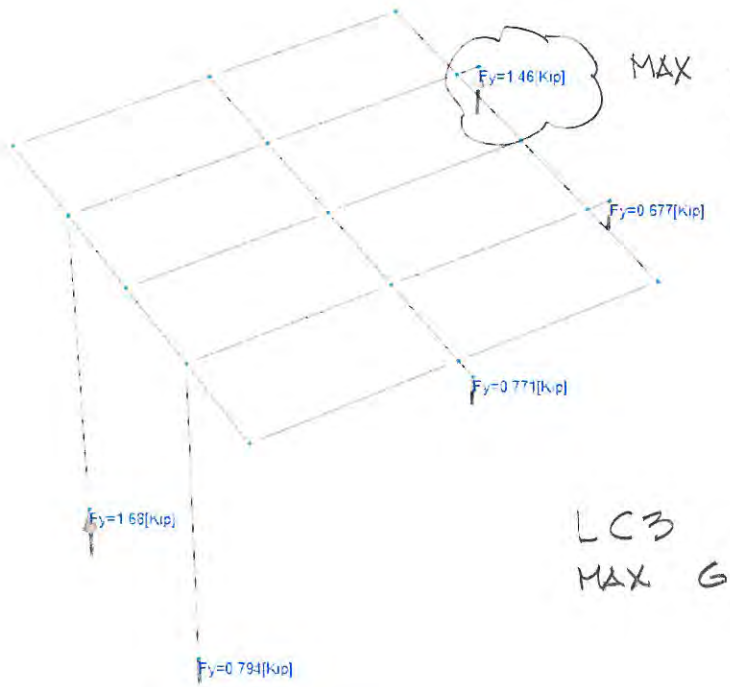


LC1 = 0.6DL + WL C&C ↑
WASH DC



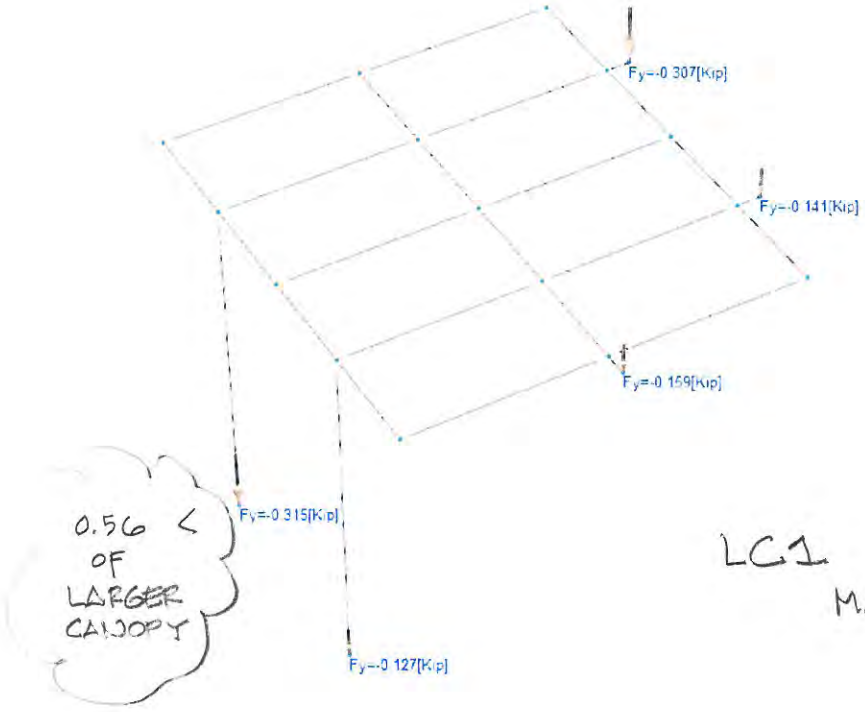
$LC3 = DL + .75(SL + WL\downarrow)$

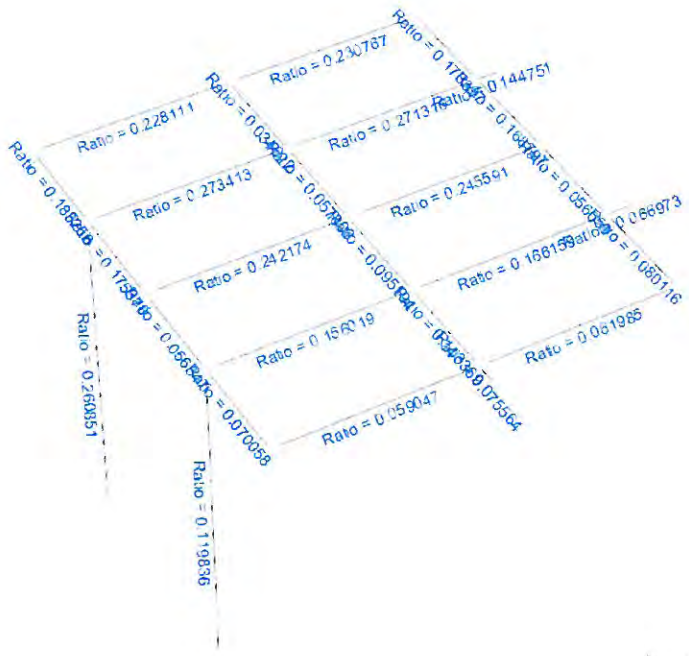
WASH. D.C.



MAX < 2^K OF LARGER CANOPY

LC3
MAX GRAVITY


Fy=-0 307[Kip]
Fy=-0 141[Kip]
Fy=-0 159[Kip]
Fy=-0 315[Kip]
Fy=-0 127[Kip]
0.56 < OF LARGER CANOPY
LC1
MAX UPLIFT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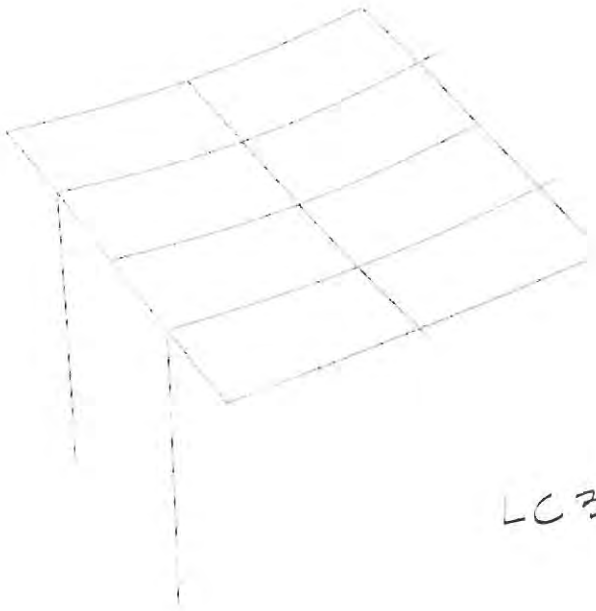
Ratio = 0.228111
Ratio = 0.273413
Ratio = 0.242174
Ratio = 0.156019
Ratio = 0.059047
Ratio = 0.144751
Ratio = 0.271378
Ratio = 0.245591
Ratio = 0.166159
Ratio = 0.061985
Ratio = 0.075564
Ratio = 0.260851
Ratio = 0.119836

LC3

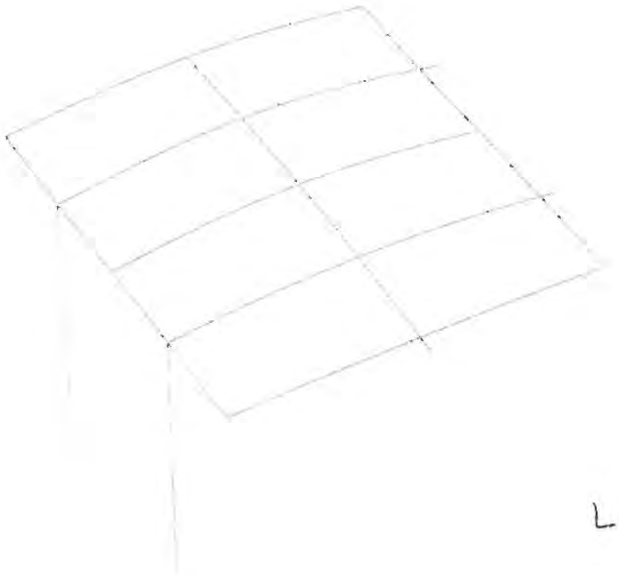
Bentley **MSA Professional Services**

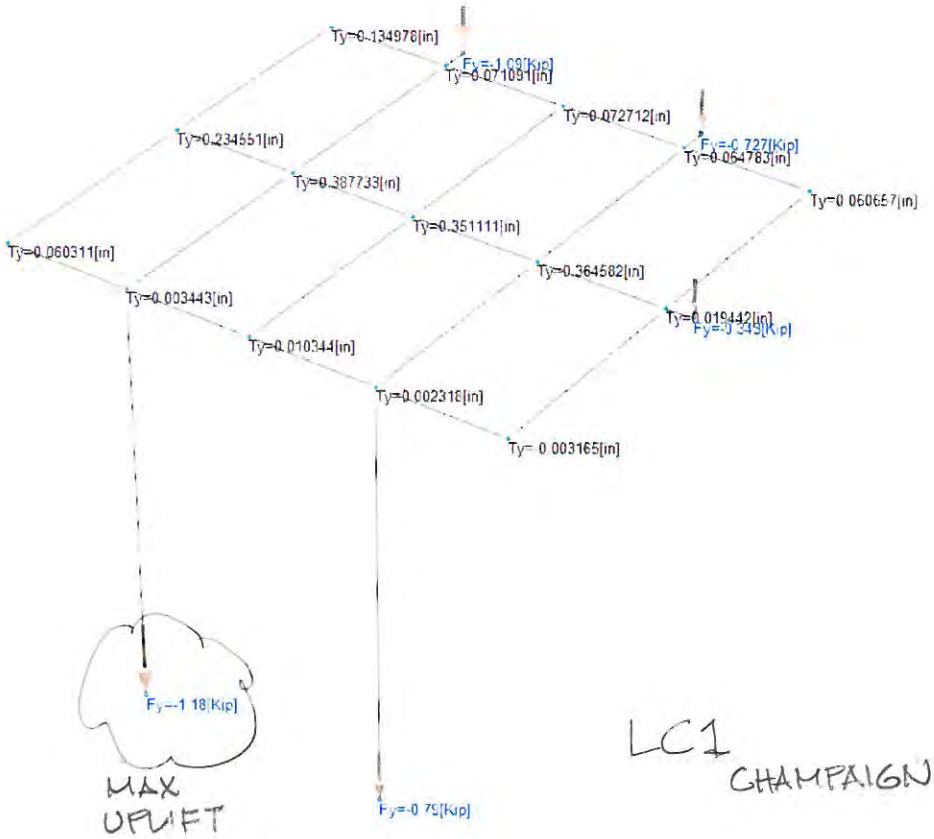
Current Date: 3/12/2011 3:15 PM
Units system: English
File name: C:\Users\dwickersheimer\Desktop\Projects\solar Decathlon 2011\misc calcs and docs\Southeast Canopy.etz\
Load condition: LC3=DL-0.75WL+0.75SL



Bentley **MSA Professional Services**

Current Date: 3/12/2011 3:16 PM
Units system: English
File name: C:\Users\dwickersheimer\Desktop\Projects\solar Decathlon 2011\misc calcs and docs\Southeast Canopy.etz\
Load condition: LC1=0.6DL+WL

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Fx=-0.727[Kip]
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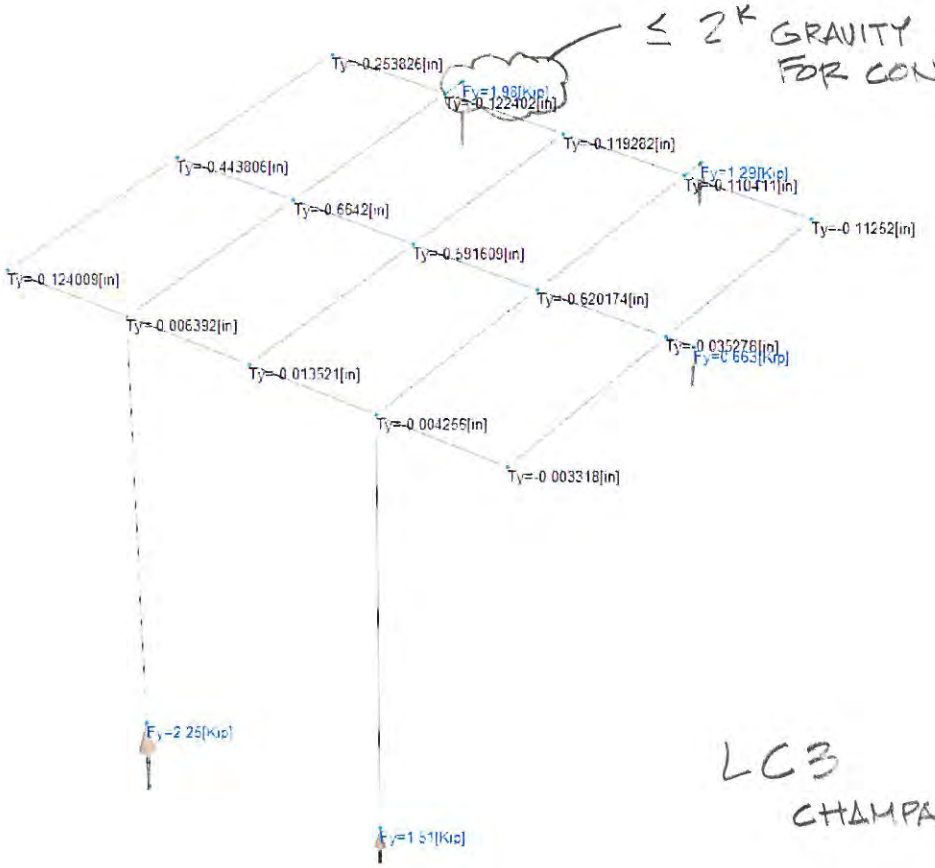
Ty=0.234551[in]
Ty=0.387733[in]
Ty=0.351111[in]
Ty=0.060657[in]
Ty=0.060311[in]
Ty=0.364582[in]
Ty=0.003443[in]
Ty=0.019442[in]
Fy=-0.249[Kip]
Ty=0.010344[in]
Ty=0.002318[in]
Ty=0.003165[in]
Fy=-1.18[Kip]
Fy=-0.75[Kip]
MAX UPLIFT
LC1
CHAMPAIGN


≤ 2K GRAVITY FOR CONN.
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Fy=1.98[Kip]
Ty=-0.122402[in]
Ty=-0.119282[in]
Ty=-0.443806[in]
Fy=1.29[Kip]
Ty=-0.110411[in]
Ty=-0.6642[in]
Ty=-0.11252[in]
Ty=-0.591609[in]
Ty=-0.124009[in]
Ty=-0.520174[in]
Ty=-0.006392[in]
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Ty=-0.013521[in]
Ty=-0.004266[in]
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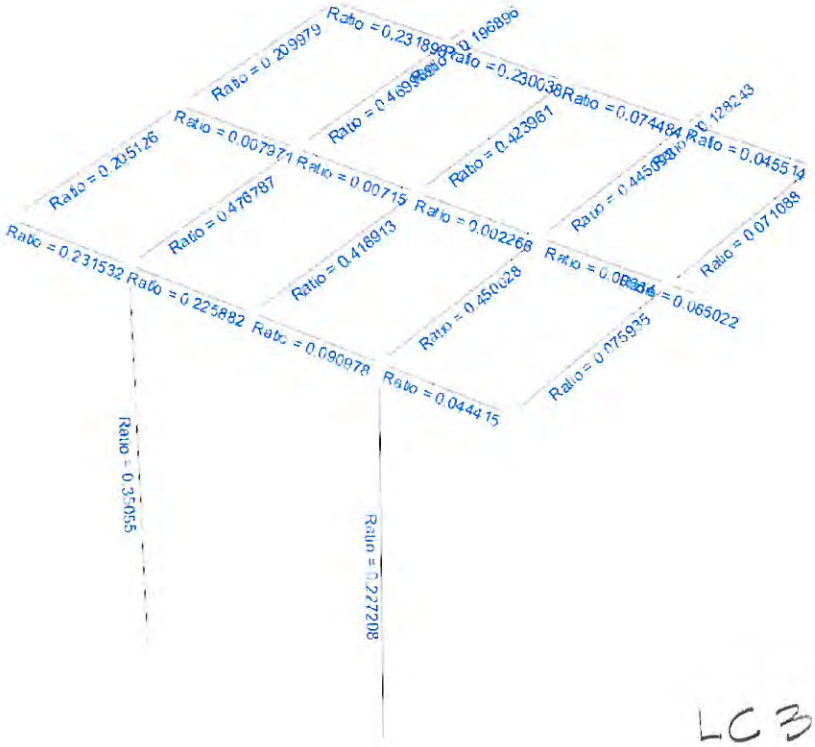
Fy=-2.25[Kip]
Fy=1.51[Kip]
LC3
CHAMPAIGN

Bentley **MSA Professional Services**

Current Date: 3/17/2011 10:45 AM
Units system: English
File name: C:\Users\dwickersheimer\Desktop\Projects\solar Decathlon 2011\misc calcs and docs\Southeast Canopy_Champaign.etz\



LC 3
CHAMPAIGN

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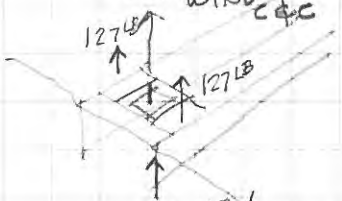
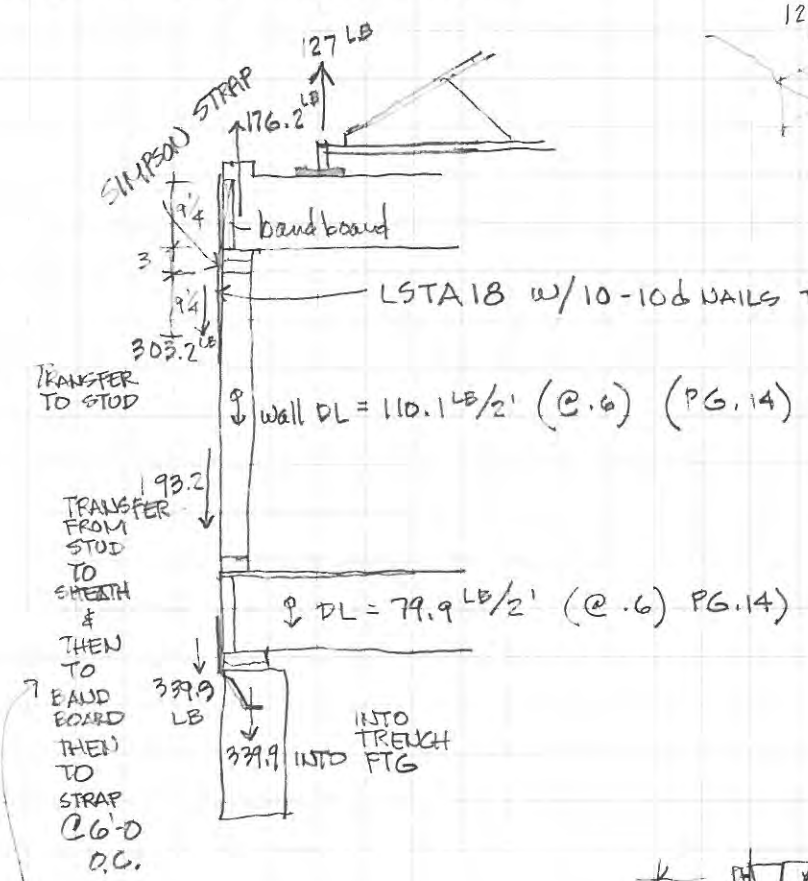
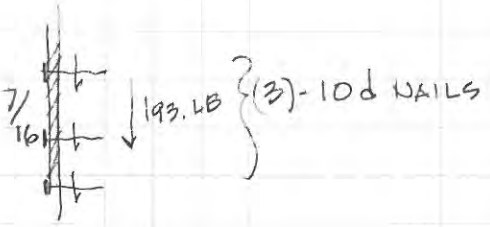
Project SOLAR DECATH 2011 Comp. by DJW
Date 3/17/11 Ckd. by
Proj. No. 12474004

DESIGN FOR CHAMPAIGN

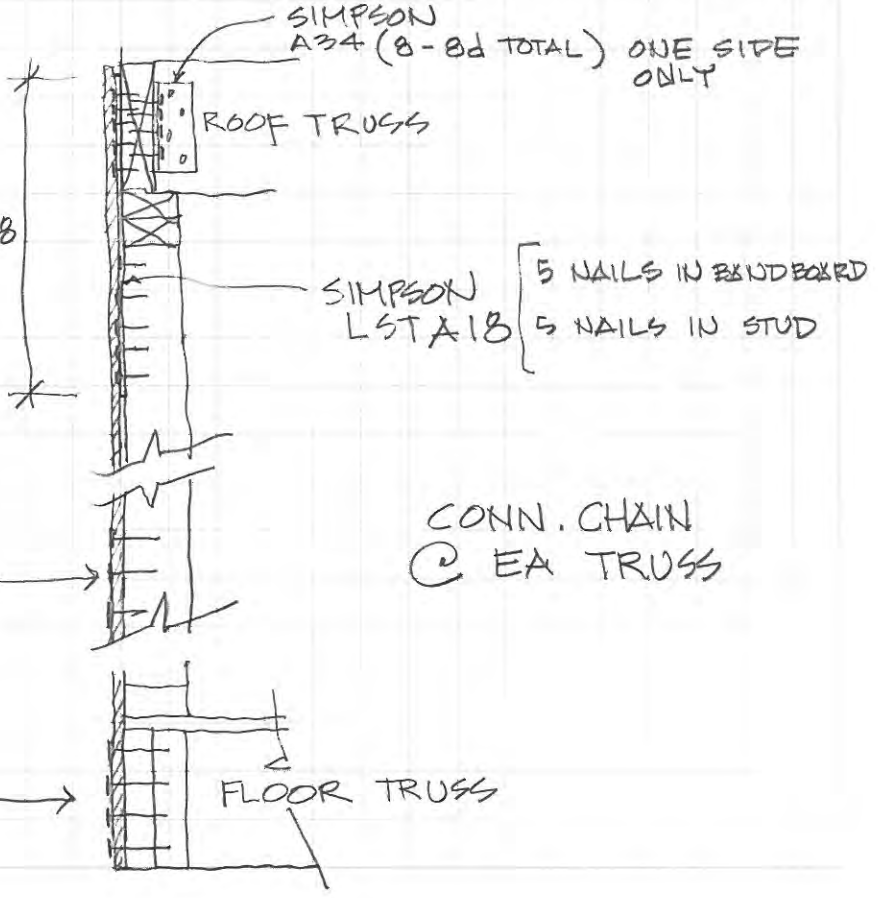
NET UPLIFT 254 LB WIND } NET WIND FROM SOLAR PANEL/FRAME (PG. 24)







CAP: 10d NAIL (WL) = 144 LB/IN



NAIL CAPACITIES IN SINGLE SHEAR

NDS 2001 Edition: Breyer Text; 5th Edition Revised:4/13/04

PROJECT: Solar Decathlon 2011 JOB NO: 06058

LOCATION: exterior wall direct uplift transfer

Main Member (member receiving nail point):

specific gravity $SG_m := 0.5$

thickness $t_m := 3.5$ inches

(small dowels are considered fasteners < than or = 1/4 inch diameter)

small dowel bearing strength $F_{em} := 16600 \cdot SG_m^{1.84}$ $F_{em} = 4637$ psi

Side Member (member nail passes thru):

thickness $t_s := 0.4375$ inches

If side member is steel, set A=1, otherwise leave as zero. $A := 0.0$

A36 plate: $F_u := 58000$ psi (change "if" statement to 1.5Fu)

ASTM A653 Grade 33 cold formed steel plate: $F_{u1} := 45000$ psi

If wood side member, insert specific gravity $SG_s := 0.5$

$F_{es} := if(A < 1, 16600 \cdot SG_s^{1.84}, 1.375 \cdot F_{u1})$ $F_{es} = 4637$ psi

Nail: 40d com

diameter $D := 0.148$ inches

length $L := 3.0$ inches

bending yield $F_{yb} := (130.4 - 213.9 \cdot D) \cdot 1000$ $F_{yb} = 98742.8$ psi

(for low-carbon steel nails and spikes)

(for hardened threaded steel nails multipy Fyb by 1.3)

Minimum nail penetration for full dowel bearing capacity:

$p_{min10} := 10 \cdot D$ $p_{min10} = 1.48$ inches

$p_{min6} := 6D$ $p_{min6} = 0.888$ inches

Toenail Connection

If toenail connection, set theta=30°, otherwise leave as zero: $\theta := \underline{0.0}$

$L_{st} := \frac{L}{\underline{3}}$ $L_{st} = \underline{1}$ inches

$p_L := L \cdot \cos(\theta \cdot deg) - L_{st}$ $p_L = \underline{2}$ inches

$L_{mL1} := if(p_L \geq p_{min10}, p_L, p_L - \underline{2} \cdot D \cos(\theta \cdot deg))$ $L_{mL1} = \underline{2}$ inches

$L_{mL2} := if(L_{mL1} > t_m, t_m, L_{mL1})$ $L_{mL2} = \underline{2}$ inches

$L_{mL3} := if(L_{mL1} < p_{min6}, \underline{0}, L_{mL1})$ $L_{mL3} = \underline{2}$ inches

$L_{mL4} := if(L_{mL2} < L_{mL3}, L_{mL2}, L_{mL3})$ $L_{mL4} = \underline{2}$ inches

Dowel Bearing Lengths:

$L_{sd} := t_s$ $L_{sd} = \underline{0.438}$ inches

$p := if(L - t_s \leq t_m, L - t_s, t_m)$ $p = \underline{2.6}$ inches

$L_{m1} := if[p \geq p_{min10}, p, (L - t_s - \underline{2} \cdot D)]$ $L_{m1} = \underline{2.56}$ inches

$L_{m2} := if(L_{m1} > t_m, t_m, L_{m1})$ $L_{m2} = \underline{2.6}$ inches

$L_{m3} := if(L_{m2} < p_{min6}, \underline{0}, L_{m2})$ $L_{m3} = \underline{2.6}$ inches

$L_{m4} := if(L_{m2} < L_{m3}, L_{m2}, L_{m3})$ $L_{m4} = \underline{2.563}$ inches

$L_m := if(\theta > \underline{0}, L_{mL4}, L_{m4})$ $L_m = \underline{2.56}$ inches

Note: Lm is the dowel bearing length in the main member. If Lm=0 this fastener cannot be used. It is too short.

Reduction Coefficient for fastener dia. < 0.25" (Kd):

$K_d := if(D \leq \underline{0.17}, \underline{2.2}, \underline{10} \cdot D + \underline{0.5})$ $K_d = \underline{2.2}$

$R_e := \frac{F_{em}}{F_{es}}$ $R_e = \underline{1}$

$L_s := if(\theta > \underline{0}, L_{st}, L_{sd})$ $L_s = \underline{0.438}$ inches

$R_t := \frac{L_m}{L_s}$ $R_t = \underline{5.857}$

$$k_1 := \frac{\left[\sqrt{R_e + \underline{2}\cdot R_e^{\underline{2}}\cdot\left(\underline{1} + R_t + R_t^{\underline{2}}\right) + R_t^{\underline{2}}\cdot R_e^{\underline{3}}} - R_e\cdot\left(\underline{1} + R_t\right)\right]}{\left(\underline{1} + R_e\right)}$$

$k_1 = \underline{\mathbf{1.994}}$

$$k_2 := -\underline{1} + \sqrt{\underline{2}\cdot\left(\underline{1} + R_e\right) + \frac{\left[\underline{2}\cdot F_{yb}\cdot\left(\underline{1} + \underline{2}\cdot R_e\right)\cdot D^{\underline{2}}\right]}{\underline{3}\cdot F_{em}\cdot L_m^{\underline{2}}}}$$

$k_2 = \underline{\mathbf{1.035}}$

$$k_3 := -\underline{1} + \sqrt{\left[\underline{2}\cdot\frac{\left(\underline{1} + R_e\right)}{R_e}\right] + \underline{2}\cdot F_{yb}\cdot\left(\underline{2} + R_e\right)\cdot\frac{D^{\underline{2}}}{\underline{3}\cdot F_{em}\cdot L_s^{\underline{2}}}}$$

$k_3 = \underline{\mathbf{1.979}}$

Yield Limit Equations:

Mode Im $\quad z_1 := \dfrac{D\cdot L_m\cdot F_{em}}{K_d}$ $\quad z_1 = \underline{\mathbf{799}}$ lbs

Mode Is $\quad z_2 := \dfrac{D\cdot L_s\cdot F_{es}}{K_d}$ $\quad z_2 = \underline{\mathbf{136}}$ lbs

Mode II $\quad z_3 := \dfrac{k_1\cdot D\cdot L_s\cdot F_{es}}{K_d}$ $\quad z_3 = \underline{\mathbf{272}}$ lbs

Mode IIIm $\quad z_4 := \dfrac{k_2\cdot D\cdot L_m\cdot F_{em}}{K_d\cdot\left(\underline{1} + \underline{2}\cdot R_e\right)}$ $\quad z_4 = \underline{\mathbf{276}}$ lbs

Mode IIIs $\quad z_5 := \dfrac{k_3\cdot D\cdot L_s\cdot F_{em}}{K_d\cdot\left(\underline{2} + R_e\right)}$ $\quad z_5 = \underline{\mathbf{90}}$ lbs

Mode IV $\quad z_6 := \dfrac{D^{\underline{2}}}{K_d}\cdot\sqrt{\dfrac{\underline{2}\cdot F_{em}\cdot F_{yb}}{\underline{3}\cdot\left(\underline{1} + R_e\right)}}$ $\quad z_6 = \underline{\mathbf{123}}$ lbs

$z := \text{if}\left(z_1 \le z_2, z_1, z_2\right)$ $\qquad \underset{\sim}{z} := \text{if}\left(z \le z_3, z, z_3\right)$

$\underset{\sim}{z} := \text{if}\left(z \le z_4, z, z_4\right)$ $\qquad \underset{\sim}{z} := \text{if}\left(z \le z_5, z, z_5\right)$

$\underset{\sim}{z} := \text{if}\left(z \le z_6, z, z_6\right)$

Nominal design value, smallest of all yield equations: $z = \underline{\mathbf{90}}$ lbs/nail

Adjustment factors (VERIFY):

Load Duration Factor: . . . . . $C_D := \underline{\mathbf{1.6}}$

use same as allowable member stresses

Wet Service Factor : . . . . . $C_M := \underline{\mathbf{1.0}}$

See NDS Table 10.3.3

Temperature Factor : . . . . . $C_t := \underline{\mathbf{1.0}}$

See NDS Table 10.3.4

End Grain Factor : . . . . . $C_{eg} := \underline{\mathbf{1.0}}$

Use 0.67 if point is in end grain

Toenail Factor . . . : . . . . . $C_{tn} := \underline{\mathbf{1.0}}$

Use 0.83 if toe-nail and laterally loaded

Diaphragm Factor : . . . . . $C_{di} := \underline{\mathbf{1.0}}$

Use 1.1 if a diaphragm shear connection

Adjusted capacity of one nail:

$Z_a := z \cdot C_D \cdot C_M \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot C_{di}$ $Z_a = \underline{\mathbf{144}}$ lbs/nail

Required load to be transferred: $P := \underline{\mathbf{193}}$ lbs

Number of nails required:

$N := \text{ceil}\left(\frac{P}{Z_a}\right)$ $N = \underline{\mathbf{2}}$ nails

Or, Capacity for number of nails:

number of nails in connection: $n := \underline{\mathbf{2}}$

$P_{all} := n \cdot Z_a$ $P_{all} = \underline{\mathbf{288}}$ lbs