



Team Tidewater Virginia

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U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2013

Project Manual

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HAMPTON UNIVERSITY & OLD DOMINION UNIVERSITY

aDepartment of Architecture
100 East Tyler St.
Hampton, Va 23669

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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
Rule 4-2	Construction Equipment	Specifications for heavy machinery	Section 01 54 19 Section 01 54 23
Rule 4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	None
Rule 4-4	Impact within the Solar Envelope	Drawing(s) showing the location, contact area, and bearing pressure of every component resting directly within the solar envelope	None
Rule 4-5	Generators	Specifications for generators (including sound rating)	N/A
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	P-101 F-101
Rule 4-6	Spill Containment	Specifications for all equipment, containers, and pipes that will contain fluids at any point during the event	Section 22 12 00 Section 22 11 16
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	N/A
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	Pg. 9
Rule 5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	G-201 G-202
Rule 5-2	Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references	N/A
Rule 6-1	Structural Design Approval	List of, or marking on, all drawing and project manual sheets that will be stamped by the qualified, licensed design professional in the stamped structural submission; the stamped submission shall consist entirely of sheets that also appear in the drawings and project manual	See Project Manual



Rule 6-2	Finished Square Footage	Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically	A-101 A-111
Rule 6-2	Finished Square Footage	Drawing(s) showing all movable components that may increase the finished square footage if operated during contest week	None
Rule 6-3	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route	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	C-102
Rule 7-2	Watering Restrictions	Drawing(s) showing the layout and operation of greywater irrigation systems	None
Rule 8-1	PV Technology Limitations	Specifications for photovoltaic components	Section 21 36 00
Rule 8-3	Batteries	Drawing(s) showing the location(s) and quantity of all primary and secondary batteries and stand-alone, PV-powered devices	None
Rule 8-3	Batteries	Specifications for all primary and secondary batteries and stand-alone, PV-powered devices	None
Rule 8-4	Desiccant Systems	Drawing(s) describing the operation of the desiccant system	None
Rule 8-4	Desiccant Systems	Specifications for desiccant system components	None
Rule 8-5	Village Grid	Completed interconnection application form	Pg. 24
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-102 E-201
Rule 8-5	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	Section 26 31 00 Section 26 05 19
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	Pg. 14
Rule 8-5	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	G-103
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. PDT or between 8 a.m. and 4 p.m. solar time on October 1	P-101
Rule 9-2	Team-Provided Liquids	Quantity, specifications, and delivery date(s) of all team-provided liquids for irrigation, thermal mass, hydronic system pressure testing, and thermodynamic system operation	N/A
Rule 9-3	Greywater Reuse	Drawing(s) showing the layout and operation of greywater reuse systems	N/A
Rule 9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	N/A
Rule 9-6	Thermal Mass	Drawing(s) showing the locations of liquid-based thermal mass systems	N/A
Rule 9-6	Thermal Mass	Specifications for components of liquid-based thermal mass systems	N/A
Rule 9-7	Greywater Heat Recovery	Drawing(s) showing the layout and operation of greywater heat recovery systems	N/A
Rule 9-8	Water Delivery	Drawing(s) showing the complete sequence of water delivery and distribution events	P-101
Rule 9-8	Water Delivery	Specifications for the containers to which water will be delivered	Section 22 12 00
Rule 9-9	Water Removal	Drawing(s) showing the complete sequence of water consolidation and removal events	P-101
Rule 9-9	Water Removal	Specifications for the containers from which water will be removed	Section 22 12 19
Rule 11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	G-103



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Detailed Water Budget

FUNCTION	WATER USE (GALLONS)	CALCULATIONS		NOTES
		GAL	EVENTS	
Hot Water Draws	240	15	16	
Water Vaporization	4	1	4	Boil 5 pounds of water ≈0.625 gallons
Dishwasher	50	10	5	Average dishwasher 6-10 gallons per wash
Clothes Washer	160	20	8	Average clothes washer 10-24 gal/wash
Vegetation	0			
Fire Protection	250			Required as per competition rules
Thermal Storage Tanks	125			Hot Water Tank and Phase Change Material Tank
Testing	46			Test each measured contest once
Initial Systems Fill	2			
Solar Thermal Collectors	40			SunDrum collectors, thermal piping, and PCM tank
Aesthetic Purpose	0			
Radiant Flooring	10			927
Safety Factor	73			8%
WATER REQUIRED	1000	gallons		



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Structural Calculations

See Appendix A



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Summary of Unlisted Electrical Components

Team Tidewater does not have any unlisted electrical components.



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Interconnection Application Form

Team Tidewater Lot 108

PV Systems

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
Bosch	CSI M60 MA42117 (255Wp)	10.2kW x 40panels

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

INVERTERS

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or KW)	Quantity
Schneider	Conext 3801	600	3.8kW	3

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

	Location
One-Line Electrical Schematic	E-601
Calculations of service/feeder net computed load and neutral load (NEC 220)	
Plan view of the lot showing the house, decks, ramps, tour paths, the service point, and the distribution panel or load center	E-201
Elevation views showing terminal box, meter, and other service equipment.	E-201



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Calculations of Service/Feeder Net Computed Load and Neutral Load (NEC 220)

SERVICE FEEDER CALCULATIONS			
MAIN SERVICE PANEL			
GENERAL LIGHTING AND RECEPTACLES (NEC 210.11(C))			
GENERAL LIGHTING (NEC 220.12, TABLE 220.12)	843 SQFT X 3 VA/SQFT	2529	VA
SMALL APPLIANCE CIRCUITS (NEC220.52(A))	2 X 1500 VA	3000	VA
LAUNDRY (NEC 220.52(B))	1 CIRCUIT X 1500 VA/CIRCUIT	1500	VA
SUBTOTAL (NEC 220.42, TABLE 220.42)	3000 VA AT 100% + 4029 VA AT 35%	4410	VA
COOKING			
COOKTOP	7200 VA AT 100%	7200	VA
WALL OVEN	5800 VA AT 100%	5800	VA
SUBTOTAL (NEC TABLE 220.55 NOTE (3), COLUMN B)	7200 VA + 5800VA = 1300VA AT 65%	8450	VA
FIXED APPLIANCES			
WATER HEATER (NEC 220.53)	4500 VA AT 75%	3375	VA
DISHWASHER (NEC 220.53)	1300 VA AT 75%	975	VA
RANGE HOOD (NEC 220.53)	580 VA AT 75%	435	VA
VENTILATION FAN (NEC 220.53)	120 VA AT 75%	120	VA
RADIANT FLOOR PUMP (NEC 430.24)	115 VA AT 75%	115	VA
CIRCULATOR PUMP (NEC 430.24)	45 VA AT 100%	45	VA
RE-CIRCULATOR PUMP (NEC 430.24)	75 VA AT 100%	75	VA
KS PUMP STATION (NEC 430.24)	215 VA AT 100%	215	VA
PUMP STATION MODULE SBH (NEC 430.24)	3 VA AT 100%	3	VA
PUMP STATION MODULE SBU (NEC 430.24)	3 VA AT 100%	3	VA
SOLAR CONTROLLER (NEC 430.24)	120 VA AT 100%	120	VA
SUBTOTAL		5366	VA
WASHER AND DRYER (NEC 220.54, ANNEX D2 (B))	2300 VA + 2800 VA = 5100 VA AT 100%	5100	VA
HVAC COMPRESSOR (NEC 220.82 (C), 220.60)	2200 VA AT 100%	2200	VA
LARGEST MOTOR (NEC 430.24 (1))	215 VA AT 25%	54	VA
TOTAL (NEC ANNEX D2 (B))		25580	VA
TOTAL CURRENT		107	A
MAIN SERVICE PANEL BREAKER		150	A
NEUTRAL CONDUCTOR			
GENERAL LIGHTING AND RECEPTACLES (NEC 220.61)	4410 VA AT 100%	4410	VA
COOKING (NEC 220.61(B))	8450 VA AT 70%	5915	VA
FIXED APPLIANCES (NEC 220.61)	5366 VA AT 100%	5366	VA
WASHER AND DRYER (NEC 220.61(B))	5100 VA AT 70%	3500	VA
TOTAL		19191	VA



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TOTAL CURRENT	80	A
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Quantity Takeoff

Specification Number	Brief Description	Detailed Description	Qty	Unit
Division 01 General Requirements				
01 54 19	Temporary Crane	130 ton, telescopic crane	2	Day
Division 02 Existing Conditions				
N/A	None			
Division 03 Concrete				
N/A	None			
Division 04 Masonry				
N/A	None			
Division 05 Metals				
05 10 00	A36 steel Wide Flang	W10x30	373	L.F.
05 10 00	Steel Columns	4"x4"x12'	4	Each
05 10 00	Steel Columns	4"x4"x8'	2	Each
05 10 00	Wide Flange A-36 Steel Beam	W 8x18	12	L.F.
05 12 00	Structural Steel Framing	Cold Formed Steel I-Beams	10.5	Tons
05 14 13	Solar Panels Racking System	UNIRAC ULA	1	Each
05 40 00	Cold Form Stud	18 Gauge 2.5 inches Wide, 16 inch on center	144	L.F.
05 40 00	Cold Form Steel Roof Joists	12in x 2.5in	759	L.F.
Division 06 Wood, Plastics and Composites				
06 09 00	Simpson Strong Tie	Z-maxGalvanized Double Shear Joist Hanger LUS26z	334	Each
06 09 00	Simpson Strong Tie	5 lb Box of 10DHDG Nails 10D5HDG	6	Each
06 09 00	Simpson Strong Tie	2x10 Top Flang Hanger	120	Each
06 09 00	Simpson Strong Tie	5 lb Box of N10 DHDG Nails	1	Each
06 09 00	Simpson Strong Tie	1 lb Box of N10 DHDG Nails	1	Each
06 09 00	OSB Plywood Sheathing (roof)	7/16 in x 4 ft x 8 ft	30	Each
06 09 00	Simpson Strong Tie	Seismic and Hurricane Clip	43	Each
06 10 00	Prime Pressure Treated Pine Board (Foor Joists)	2x10x16 #2	30	Each
06 10 00	Prime Pressure Treated Pine Board (Top Nailer)	Prime Pressure Treated Pine Board (Top Nailer)	24	Each
06 10 00	OSB Plywood Sheathing (subfloor)	OSB Plywood Sheathing (subfloor) 7/16" thickness	28	Each
06 10 00	OSB Plywood Sheathing (Walls)	7/16 in x 4 ft x 8 ft	60	Each
06 12 00	ThermaSteel	Structurally Insulated Panels	1110	S.F.
06 15 33	Deck/Ramp Floor Joists	2x8x16 #2 Prime Pressure Treated Pine Deck/Ramp Floor Joists	63	Each
	Clear Acrylic	48" x 48" Clear Acrylic	2	Each
	Colored Acrylic	36" x 48" Colored Acrylic	2	Each
Division 07 Thermal and Moisture Protection				
		Flashing & sheet metal, unfinished or prefinished, including metal profile gutters, 3" x 4" aluminum downspouts, splash pans, & continuous clear roof coping	300	S.F.
07 62 00	Sheet Metal Flashing & Trim			
07 42 43	Composite Wall Panels	MDO Siding Panels	220	S.F.
	Joint Gaskets	Gap Gasket, cellular EPDM, ASTM D-7465, Type I, 3/4" in width, 164" in length.	200	L.F.
07 91 16				
Division 08 Openings				
N/A	None			
Division 09 Finishes				
		Standard Gypsum Board: ½ thick, maximum available length in place; ends square cut, tapered and beveled edges	2100	S.F.
09 29 00	Gypsum Board			
09 30 00	Tiling	6"x4" Ceramic Technics Porcelain Wood Tile	300	S.F.
09 06 23	Bamboo Flooring	5 1/4"x 72 5/8" x 9/16" Plyboo Stiletto Strand Flooring	788	S.F.
	Ice Stone Countertop	96"x50" Latte Countertops	40	S.F.
	Acrylic Laxtex Paint	Shermin Williams Emerald Paint 350	2100	S.F.
	Bathroom Tile	Ceramic Technics Porcelain 6x24 Tobacco Brown & Sugar Cane Tile	275	S.F.
Division 10 Specialties				
10 28 16.13	Residential Bath Accessories	18" Towel Bar Model Number #4121 (Polished Nickel)	1	Each
10 28 16.13	Residential Bath Accessories	Kohler Recessed Mount Aluminum Medicine Cabinet 16x20x5	1	Each
10 28 16.13	Residential Bath Accessories	18" Chrome Jaclo Luxury Grab Bar	1	Each
Division 11 Equipment				
11 31 13	Ventilation Hood	Bosch, stainless steel hood DKE9665PUC	1	Each
11 31 13	Cooktop	Bosch, black and stainless steel 31 inch wide cooktop NIT5065UC	1	Each
11 31 13	Built-in- Oven	Bosch Stainless Steel oven 29x29 inch HBL3350UC	1	Each
11 31 13	Refrigerator/Freezer	Bosch Stainless Steel 84x30 inch B30BB830SS	1	Each
11 31 13	Dishwasher	Bosch Stainless Steel 32x24 inch dishwasher SGE6E15UC	1	Each
11 31 23	Washer	Bosch White 33x24 inch washer WAS20160UC	1	Each
11 31 23	Dryer	Bosch White 33x24 inch dryer WTV76100US	1	Each
Division 12 Furnishings				
12400	Handles	Valli & Valli	4	Each
12400	Set of 4 robe hooks--- 1"	Vola	1	Each
12400	Toilet Paper Holder	Vola	1	Each
12500	Lexington Medicine Cabinet	Glasscrafters	1	Each
12400	ContempollGrab Bar	Jaclo	6	Each
12500	Tobias Dining Chairs	IKEA	6	Each
12500	Cabinets	Columbia Forest Products	1	Each
Division 13 Special Construction				
Division 14 Conveying Equipment				



N/A	None			
Division 21 Fire Suppression				
21 13 13	Typical Wet Fire Sprinkler System	Pendent Sprinkler, Viking VK457 concealed sprinkler head (5), nominal 1/2" orifice for "Ordinary" temperature classification rating	80	S.F.
21 13 13	TYCO Residential LFII Flush Pendent	Tyco #TY2284 K=4.2, 1/2 NPT (SIN TY2284), 162F/72C, White	8	Each
21 13 13	Smoke and Carbon Monoxide Alarm	Kidde #KN-COSM-B	3	Each
22 11 16	Plumbing Tubing (Non-Barrier) (Blue)	Everhot #NPR3401 3/4" x 100 ft PEX	1	Each
22 11 16	PEX Elbow	Everhot #BPF6805 3/4" PEX x 3/4"	8	Each
22 11 16	Brass PEX Tee	Everhot #BPF6906 3/4" x 3/4" x 3/4"	9	Each
22 11 16	Brass Pex to Female Threaded Adapter	Everhot #BPF7508 x 3/4" x 1/2"	6	Each
Division 22 Plumbing				
22 05 23	Pump Station	Bosch SBH- Pump Station (Re-circ HW or HW to PCM)	1	Each
22 05 23	Pump Station	Bosch SBU- Pump Station (Sundrum to HW or PCM)	1	Each
22 11 23	Circulatory Pump	Grundfos Alpha 15-55SF Circulatory Pump	1	Each
22 12 19	DHW Tank	Bosch WST 50	1	Each
21 13 13	Sprinkler Head	TYCO Residential LFII Flush Pendent, K=4.2, 1/2 NPT (SIN TY2284), 162F/72C, White	6	Each
22 11 19	Manifold	5-port Copper Manifold, 1/2" PEX valves, open ends	1	Each
22 11 19	Manifold	5-port Copper Manifold, 1/2" PEX valves, spin closed	1	Each
22 13 16	Air Ammittance Valve	Oatey Sure-Vent 1-1/2 in. x 2 in. PVC Air Admittance Valve	3	Each
22 12 19	Supply Bladder	Huskey Custom Supply Bladder (Potable)	1	Each
22 12 19	Supply Berm	Huskey Custom Supply Bladder Patriot Angle Berm	1	Each
22 13 53	Return Bladder	Huskey Custom Return Bladder (Non-Potable)	1	Each
22 13 53	Return Berm	Huskey Custom Return Bladder Patriot Angle Berm	1	Each
21 13 13	Smoke Detector	Kidde Smoke and Carbon Monoxide Alarm	3	Each
22 11 19	Outlet Box	Ox Box Washing Machine Outlet Box Standard Pack - 1/2" Male PEX Connection	1	Each
22 11 19	Outlet Box	Ice Maker Box, 1/2" PEX Valve	1	Each
22 11 19	Outlet Box	Ox Box Toilet/Dishwasher Outlet Box Standard Pack - 1/2" Male PEX Connection	1	Each
22 11 16	Tubing	1/2" x 100 ft PEX Plumbing Tubing (Non-Barrier) (Red)	2	Each
22 13 16	Tubing	1/2" x 100 ft PEX Plumbing Tubing (Non-Barrier) (Blue)	2	Each
22 13 16	Tubing	3/4" x 100 ft PEX Plumbing Tubing (Non-Barrier) (Blue)	2	Each
22 13 16	Tubing	7/8" Pipe (O.D.) x 3/8" Wall Insul-Lock Pipe Insulation, 6'	2	Each
22 13 16	Tubing	Charlotte Pipe 3-in x 10-ft Sch 40 PVC DWV Pipe	3	Each
22 13 16	Tubing	1-1/2 in. x 10 ft. PVC Sch. 40 DWV Plain End Pipe	3	Each
22 05 00	Crimp Rings	1/2" PEX Copper Crimp Rings (100/bag)	1	Each
22 05 00	Crimp Rings	3/4" PEX Copper Crimp Rings (100/bag)	1	Each
22 05 00	Bend Supports	1/2" PEX Plastic Bend Support/ bag of 10	3	Each
22 05 00	Bend Supports	3/4" PEX Plastic Bend Support/ bag of 10	3	Each
22 11 16	PEX Elbow	Everhot 3/4" PEX x 3/4" PEX Elbow	5	Each
22 11 16	PEX Tee	Everhot 1/2" x 1/2" x 1/2" Brass PEX Tee	3	Each
22 11 16	PEX Tee	Everhot 3/4" x 3/4" x 3/4" Brass PEX Tee	10	Each
22 11 16	PEX to Female Threaded Adapter	Everhot 3/4" PEX x 1/2" Female Threaded Adapter	6	Each
22 11 16	PEX copper Pipe Adapter	Everhot 3/4" PEX x 3/4" Copper Pipe Adapter	2	Each
22 11 16	PEX to Male Threaded Adapter	Everhot 3/4" PEX x 3/4" Male Threaded Adapter	4	Each
22 11 16	Pump Flange	Grundfos 3/4" Iron Pump Flange (pair)	2	Each
22 11 16	PVC Elbow	Spears 1-1/2" PVC DWV 90° Elbow	8	Each
22 13 16	PVC Elbow	Spears 3" PVC DWV Street 90° Elbow	3	Each
22 13 16	PVC Tee	Spears 1-1/2" PVC DWV Sanitary Tee	4	Each
22 13 16	PVC 45	Spears 1-1/2" PVC DWV 45° Elbow	2	Each
22 13 16	PVC Whe	Spears 1-1/2" PVC DWV Wye	2	Each
22 13 16	PVC Reducer	Spears 3" x 1-1/2" PVC DWV Reducer Coupling	3	Each
22 13 16	P-Trap	Spears 1-1/2" PVC DWV P-Trap	3	Each
22 12 19	Expansion Tank	Logalux Membrane 35L Expansion Tank (Cold Water)	1	Each
22 11 16	Pressure Guage	SharkBite Pressure Guage with 3/4" Tee	4	Each
22 33 00	Water Heater	Bosch WST 50, Logalux SM300	1	Each
	Kitchen Faucet	Kohler Pull Kitchen Faucet Model Number: K-6331	1	Each
	Stainless Kitchen Steel Sink	American Standard ADA Double Bowl 33" 18 Gauge Kitchen Sink	1	Each
	SX5 Basin	Hastings	1	Each
	Drain Trap	Hastings	1	Each
	HV1 Faucet	Vola	1	Each
	Champion Pro Toilet	American Standard	1	Each
	2- Spray Hand Shower Kit in Polished Chrome	Kohler	1	Each
	60" Line Grate Channel Drain	Jaclco	1	Each
Division 23 Heating, Ventilating, and Air-Conditioning				
23 33 00	Roof Cap	6" Roof Cap with Duct Connection and Screened Exhaust Opening	6	Each
24 33 00	Dryer Vent	4" Dryer Vent	1	Each
23 71 00	Phase Change Materail	PureTemp	1	Each
23 71 00	Thermal Storage	Buderus Logalux sm300 Phase Change Material Tank	1	Each
23 21 00	Drain Tubing	#7-58P 5/8" ID Vinyl Drain Tubing	40	L.f.
23 71 13.23	Expansion Tank	Logalux Membrane 35L Expansion Tank (Cold Water)	1	Each
23 72 00	ERV	UltimateAire EV70	1	Each
23 72 00	ERV Ducting	Master Flow 6" x 2'	20	Each
23 72 00	ERV Ducting	Master Flow 3" x 2'	3	Each



23 72 00	ERV Ducting	Speedi-Products 6" elbo 90 deg	13	Each
23 72 00	ERV Ducting	Master Flow 3" elbo 90 deg	1	Each
23 72 00	ERV Ducting	M & G DuraVent 6" elbo 45 deg	2	Each
23 72 00	ERV Ducting	Speedi-Products 3" elbo 45 deg	4	Each
23 72 00	ERV Ducting -Lateral Tee	Speedi-Products 6" x 6" x 3"	1	Each
23 72 00	ERV Ducting -Reducer	Speedi-Products 6" x 3"	1	Each
23 81 26	Wall Mounted Heat Pump Mini Split System	MXZ-2B20/MSZ-FE09/12 , MXZ-2B20NA-1 + MSZ-FE09NA-8 + MSZ-FE12NA-8 Dual Zone Wall Mounted Heat Pump Mini Split System - 21,000 BTU	1	Each
23 81 26	Ductless Mini Split Line Set	50' Length each	3	Each
23 81 26	14/4 Connecting Wire (per foot)	TSW 14/4	100	L.f.
23 81 26	Outdoor Air Sensor For Mitsubishi Mini Split Systems Using the MHK1 Controller	MOS1	1	Each
23 81 26	Indoor Wall Mount AHU - 9 MBH	4MXW8509A10NOBA	2	Each
24 81 26	Indoor Wall Mount AHU - 12 MBH	4MXW8509A10NOBA	1	Each
23 81 26	Remote Controller for AHU	TREMOTE1AHANDAA	3	Each
23 81 26	Disconnect Box + Electrical Whip Kit	Honeywell NFDWHIP	2	Each
23 82 41	Re-Circulator Pump (HW to PCM) 1/25 HP	Grundfos 595916	1	Each
23 83 00	Radiant Flooring	WattsRadiant	1	Each
Division 25 Integrated Automation				
25 81 26	Dual Set Point Wireless Remote Controller Kit	Mitsubishi MHK1	2	Each
25 81 26	SUZ-KA09NA.TH + SLZ-KA09NA.TH Single Zone Mini Split Heat Pump System, 4-Way Ceiling Cassette, Wireless Remote - 8,400 BTU	Mitsubishi SLZ/SUZ-KA09NA.TH	1	Each
Division 26 Electrical				
26 50 00	Six Inch Recessed Light	LR6 6 inch LED Downlight	11	SF/living
26 50 00	Remote phospher dimmable LED module in aluminum & glass casing	DL34ZP [LEDX] Wall Washing Recessed Downlight	7	Each
26 50 00	LED Tape Lighting system	Linkaled LED Tape Lighting	7	Each
26 50 00	Pendant Light	Pulsar 172	4	Each
26 50 00	Light Sconce in Brushed Steel Wall Fixture w/on&off switch	Aqueous 1	5	Each
26 50 00	Landscaping Light	In-Ground Landscaping Light	5	Each
26 50 00	Ventilation Fan with Light	Ventilation Fan with Light	1	Each
26 50 00	Automation Controller Mobile Link	SmartLinc - INSTEON Central Controller	1	Each
26 50 00	Wireless Remote	RemoteLinc 2 Insteon Wireless	1	Each
26 50 00	Andriod Tablet	Galaxy Tab 2	1	Each
26 50 00	Monitoring System Database	DGLux	1	Each
26 50 00	Voice Control Module	EasyVR Speech Recognition Module	1	Each
26 50 00	Microcontroller	Arduino Mega	1	Each
26 50 00	Temperature Sensor	Temperature Sensor - Waterproof	1	Each
26 50 00	Wind and Rain Sensor	Weather Sensor Assembly	1	Each
26 50 00	RGB LED Strip	RGB LED Strip - 60 LED/m - 5m	1	Each
26 24 16	Load Center	QO 200 Amp 40-Space 40-Circuit Indoor Main Breaker Load Center with Cover	1	Each
26 24 16	1P/15A Circuit Breaker	QO 15 Amp Single-Pole Circuit Breaker	9	Each
26 24 16	1P/15A Circuit Breaker GFCI	QO Qwik-Gard 15-Amp Single-Pole GFCI Circuit Breaker	6	Each
26 24 16	1P/20A Circuit Breaker	QO 20-Amp Single Pole Circuit Breaker	2	Each
26 24 16	1P/20A Circuit Breaker GFCI	QO Qwik-Gard 20-Amp Single-Pole GFCI Circuit Breaker	1	Each
26 24 16	2P/25A Circuit Breaker	QO 25-Amp Single-Pole Circuit Breaker	3	Each
26 24 16	2P/30A Circuit Breaker	QO 30-Amp Two-Pole circuit Breaker	3	Each
26 24 16	2P/30A Circuit Breaker GFCI	QO 30 Amp Two-Pole GFCI Breaker	1	Each
26 24 16	2P/40A Circuit Breaker	QO 40 Amp Two-Pole Circuit Breaker	3	Each
26 05 26	Grounding Bar	Load Center Equipment Ground Bar Assy	1	Each
26 05 26	Grounding Rod	Grounding Rod Kit	1	Each
26 05 19	Grounding Wire	200 ft. 4-Gauge Stranded Bare Copper Cable	1	Each
26 05 19	Service Entry Cable	250 ft. 4/0-4/0-4/0-2/0 AL SER Service Entry Electrical Cable	1	Each
26 05 19	Romex	250 ft. Yellow 12-3 Romex NM-B W/G Wire	3	Each
26 05 19	Dryer Cord	3-Prong, 4-ft. 30-Amp Dryer Cord	1	Each
26 05 33	Disconnect for HVAC	Switch Fusible GD 240V 30A 3P NEMA3R	1	Each
26 05 33	Service Disconnect	Switch Fusible GD 240V 200A 3P NEMA3R	1	Each
26 05 33	Meter Socket	Meter Socket Ringless UG 200A	1	Each
26 05 33	1-Gang Junction Box	1-Gang Non-Metallic Old Work Box	2	Each
26 05 33	2-Gang Junction Box	2-Gang 25 cu. In. Zip Box Blue Old Work Non-Metallic Switch and Outlet Box	8	Each
26 05 33	2-Gang Junction Box	2-Gang 21 cu. In. Square Wall Box	4	Each
26 05 33	3-Gang Junction Box	3-Gang 35 cu. In. Switch and Outlet Box	1	Each
26 18 36	Combiner Box	Shoals ST6.CBRH.6.A	1	Each
26 27 26	3-Way Switch	Decora 15-Amp 3-Way Rocker Switch	6	Each
26 27 26	Occupancy Switch	Maestro 2 Amp Single Pole Occupancy Sensing Switch	1	Each
26 27 26	Single Pole Switch	Decora 15-Amp Single Pole AC Quiet Switch	10	Each
27 27 26	Remote Control Light Switch	SwitchLinc On/Off - INSTEON Remote Control Switch (Dual-Band)	11	Each
26 27 26	Standard Duplex Receptacle	20A Tamper Resistant Duplex Outlet	12	Each
26 27 26	GFCI Duplex Receptacle	20A Weather/Tamper Resistant GFCI Duplex Outlet	17	Each
26 27 26	Dryer Receptacle	30-Amp Industrial Flush Mount Single Power Outlet	1	Each



26 27 26	1-Gang Standard Duplex Receptacle Wall Plate	1 Gang Duplex Outlet Wall Plate	1	Each
26 27 26	1-Gang Decorator Wall Plate	Decora 1 Gang Wall Plate	8	Each
26 27 26	2-Gang Quadruplex Receptacle Wall Plate	Leviton 2 Gang Jumbo Duplex Outlet Wall Plate	2	Each
26 27 26	2-Gang Decorator Wall Plate	Decora 2 Gang Wall Plae	6	Each
26 27 26	2-Gang Junction Box Cover Plate	1 - Gang 4 in. Blank Square Box Cover	4	Each
26 27 26	3-Gang Decorator Wall Plate	Decora 3 Gang Wall Plate	1	Each
26 27 26	220V Receptacle Wall Plate	Range and Dryer Wall Plate	1	Each
26 31 00	Solar Panels (255 Wp)	Bosch C-Si M 60 NA42117	39	Each
Division 27 Communications				
	N/A	None		
Division 28 Electronic Safety and Security				
28 XX XX	Fire Alarm System	Fire Detection Systems, remote annunciator, 8 zone lamp, excluding wires & conduits	1	Each
Division 31 Earthwork				
31 66 16	Temporary Foundation	Model J-S-15 Tiger Brand Supper Series Jack Post	50	Each
31 66 16	11" CP Seismic Pier	11" CP Seismic Pier #88	17	Each
31 66 16	Base Plate	3/4" steel base plate #P134	17	Each
Division 48 Electrical Power Generation				
48 19 00	Tigo Maximizer	MM-ES	3	Each
48 19 00	Tigo Maximizer	MME-2ES	18	Each
48 19 16	Inverters	Schneider Model Tx 3800 NA	3	Each



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22 13 16	Sanitary Waste and Vent Piping
22 13 53	Facility Septic Tank
22 33 00	Residential Electrical Domestic Water Heaters
22 33 30.26	Residential, Collector-To-Tank, Heat-Exchanger-Coil, Solar-Electric Domestic Water Heaters
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23 21 00	Hydronic Piping and Pumps
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23 33 13.23	Backdraft Dampers
23 56 13	Solar Energy Heating Equipment
23 71 00	Thermal Storage
23 72 00	Air to Air Recovery Equipment
23 81 26	Split-System Heat Pumps
23 82 41	Water to Water Heat Pumps
23 83 00	Radiant Heating Units
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26 05 19	Low-Voltage Electrical Power Conductors and Cables
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26 09 13.1	Electrical Power Monitoring
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Division 1



SECTION 01 54 19 TEMPORARY CRANES

PART 1 GENERAL

1.01 SUMMARY

- A. Structural Performance: Temporary cranes will withstand structural loads and lifts incurred in lifting, placing, and handling of all modular components.
- B. Submittals: Product Data, and structural analysis data signed and sealed by a qualified professional engineer registered in the state where the project is located.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable Manufacturers
 - 1. Liebherr International.

2.02 TEMPORARY CRANES

- A. Type: 130 ton, Telescopic Crane.
 - 1. Boom extension: 60 m
 - 2. Lattice Jib: 33m
 - 3. Carrier Engine/Output: Liebherr 6-cylinder, Turbo-Diesel 500 hp
 - 4. Crane Engine/Output: Liebherr 4-cylinder, turbo-Diesel, 145 kW
 - 5. Operational Weight: 60,000 kg
 - 6. Total Counterweight: 42 ton



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PART 3 - EXECUTION

3.01 INSTALLATION

- A. Prepare ground by cleaning, removing projections, clearing obstructions, and cordoning off safe working zone, and as otherwise recommended in temporary crane manufacturer's written instructions.
- B. Ground crane securely in place, per operational specifications.
- C. Allow only licensed operators to operate machinery, manage lifts, and issue signals and commands.
- D. Ensure placement of modular components complies with foundational spacing and load requirements.
- E. Coordinate operations with structural requirements per specifications of structural engineer and crane operator.
- F. Correct deficiencies in or remove and reinstall temporary cranes that do not comply with requirements.

END OF SECTION 01 54 19



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SECTION 01 54 23
TEMPORARY SCAFFOLDING AND PLATFORMS

PART 1 GENERAL

1.01 SECTION REQUIREMENTS

- A. Structural Performance: Design, engineer, fabricate, and install staging aids and fall protection equipment to withstand structural loads required by OSHA and ANSI Z359.1 standards.
- B. Submittals: Product Data. Structural analysis data signed and sealed by a qualified professional engineer registered in the state where Project is located.
- C. Structural and Accessory Components shall conform to the following Standards:
 - 1. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
 - 2. Steel Tubing: Cold-formed steel tubing, ASTM A 500.
 - 3. Aluminum Extrusions: ASTM B 221.

PART 2 PRODUCTS

2.01 FALL PROTECTION EQUIPMENT – STANDING SEAM ROOF

- A. Manufacturers
 - 1. Guardian Fall Protection
- B. Models
 - 1. Standing Seam Roof Clamp, Model# 00250
- C. Operation
 - 1. Portable and reusable anchor for use on standing seam roofs



2. Seam spacing range: 24" – 36"
3. Retractable Rotation: 360 degrees
4. Self-retracting lifeline adaptable
5. Meets or exceeds all applicable industry standards, including OSHA and ANSI Z359.1.

2.02 FALL PROTECTION EQUIPMENT - THERMOPLASTIC POLYOLEFIN ROOF

A. Manufacturers

1. Guardian Fall Protection

B. Models

1. CB-12 Roof Anchor, Model# 00485

C. Operation

1. Deck mounted anchor post
2. Load rating: 5000 lbs
3. Base and mount plates flashed into TPO membrane per manufacturer specifications.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in fall protection and deck eye manufacturer's written instructions.
- B. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place, for permanent installation or duration of use.
- C. Fasten fall protection securely in place, with provisions for thermal and structural



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movement.

- D. Correct deficiencies in or remove and reinstall fall protection anchors that do not comply with requirements.
- E. Repair, refinish, or replace fall protection anchors and deck eyes damaged during installation, as directed by Architect.

END OF SECTION 01 54 23



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Division 5



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SECTION 05 14 13
ARCHITECTURALLY-EXPOSED STRUCTURAL ALUMINUM FRAMING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Photovoltaic Mounting System
 - 1. Aluminum Beam
 - 2. Stainless steel hardware

1.02 RELATED SECTIONS

- A. Division 26 31 00 "Photovoltaic Collector System"
- B. Division 22 33 30.26 "Residential, Collector-To-Tank, Heat-Exchanger-Coil, Solar-Electric Domestic Water Heaters"
- C. Division 48 19 16 "Electrical Power Generation Inverters"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. UNIRAC ULA

2.02 COMPONENTS

- A. SolarMount (E)volution Beam = 2.2" Height
- B. Flange Attachment
 - 1. 5/16" x 3-1/2" Zinc Plated Lag Bolt
 - 2. Stainless steel washer
 - 3. Flange Attachment
 - 4. Clip
- C. Beam Splice / Lateral Retainer
 - 1. 4x Self-drilling screws (1-1/4"-20 hex washer head stainless steel)
 - 2. Beam Splice
- D. End Clamp
 - 1. 5/16" - 18 Stainless steel serrated head hex bolt
 - 2. End Clamp
- E. Mid Clamp



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1. 5/16" - 18 Stainless steel serrated head hex bolt
 2. Mid Clamp
- F. Positive Beam Stop
1. Self-drilling screws (1-1/4"-20 hex washer head stainless steel)
- G. Positive Module Stop
1. Stainless Steel 1/4"-20 X 1/2" Socket Head Cap Screw
 2. Serrated Flange Nut

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Tools and instructions required for assembly; UNIRAC ULA installation manual
 1. Self-drilling screws to support the following size hex heads:
 - a. 1-1/4"-20 hex washer head
 - b. 5/16" - 18 Stainless steel serrated head hex bolt
 2. Torque values for dry bolts
 - a. Required torque of 70 ksi for hex washer size of 1-1/4"-20
 - b. Required torque of 10 ft-lbs for bolt size of 5/16-18
- C. <http://unirac.com/sites/default/files/solarmountevolutioninstallguide.pdf>

END OF SECTION 05 14 13



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SECTION 05 40 00
COLD-FORMED METAL FRAMING

PART 1 - - GENERAL

SCHEDULE 0 - SECTION INCLUDES

- PRODUCT DATA SHEET 0 - Cold-formed metal framing for walls.
- PRODUCT DATA SHEET 1 - Roof rafter framing
- PRODUCT DATA SHEET 2 - Bridging, bracing, clips and other accessories.

SCHEDULE 1 - RELATED SECTIONS

- PRODUCT DATA SHEET 0 - Section 07 62 00 - Thermal Protection.
- PRODUCT DATA SHEET 1 - Section 09 29 00 - Gypsum Board Assemblies.

SCHEDULE 2 - REFERENCES

- PRODUCT DATA SHEET 0 - ASTM International (ASTM):
 - 1.01 ASTM A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - 1.02 ASTM A 780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
 - 1.03 ASTM A 1003 - Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic-Coated for Cold-Formed Framing Members.
 - 1.04 ASTM B 633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
 - 1.05 ASTM C 954 - Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 inches to 0.112 inches in thickness.
 - 1.06 ASTM C 955 - Standard Specification for Load-Bearing (Transverse and Axial) Steel Studs, Runners (Tracks), and Bracing or Bridging for Screw Application of Gypsum Panel Products and Metal Plaster Bases.



1.07 ASTM C 1513 - Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections.

1.08 ASTM C 1007 - Standard Specification for Installation of Load Bearing (Transverse and Axial) Steel Studs and Related Accessories.

PRODUCT DATA SHEET 1 - AISI - Standard for Cold-Formed Steel Framing General Provisions.

PRODUCT DATA SHEET 2 - AISI - North American Specification for the Design of Cold-Formed Steel Structural Members.

PRODUCT DATA SHEET 3 - AWS D.1.3 - Structural Welding Code - Sheet Steel.

SCHEDULE 3 - DESIGN REQUIREMENTS

PRODUCT DATA SHEET 0 - Design steel in accordance with American Iron and Steel Institute Publication "Specification for the Design of Cold-Formed Steel Structural Members", except as otherwise shown or specified.

PRODUCT DATA SHEET 1 - Design loads: As indicated on the Structural Drawings.

PRODUCT DATA SHEET 2 - Design framing systems to withstand design loads without deflections greater than the following:

PRODUCT DATA SHEET 3 - Exterior Walls: Lateral deflection of: L/360.

PRODUCT DATA SHEET 4 - Interior Load-Bearing Walls: Lateral deflection of: L/360.

PRODUCT DATA SHEET 5 - Design framing systems to provide for movement of framing members without damage or overstressing, sheathing failure, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change (range) of 67 degrees C (120 degrees F).

PRODUCT DATA SHEET 6 - Design framing system to accommodate deflection of primary building structure and construction tolerances.

PRODUCT DATA SHEET 7 - Design exterior non-load-bearing curtain wall framing to accommodate lateral deflection without regard to contribution of sheathing materials.

SCHEDULE 4 - SUBMITTALS

PRODUCT DATA SHEET 0 - Submit manufacturer's product literature, data sheets and installation



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recommendations for specified products.

PRODUCT DATA SHEET 1 - Manufacturers certification of product compliance with codes and standards.

PRODUCT DATA SHEET 2 - Structural Calculations: Submit structural calculations prepared by manufacturer for approval. Submittal shall be sealed by a professional engineer registered in the state of the project.

1.01 Description of design criteria.

1.02 Engineering analysis depicting stress and deflection (stiffness) requirements for each framing application.

1.03 Selection of framing components, accessories and welded connection requirements.

1.04 Verification of attachments to structure and adjacent framing components.

1.05 Engineer shall have a minimum of 5 years experience with projects of similar scope.

PRODUCT DATA SHEET 3 - Shop Drawings:

1.01 Submit shop drawings prepared by the cold-formed metal framing manufacturer showing plans, sections, elevations, layouts, profiles and product component locations, including anchorage, bracing, fasteners, accessories and finishes.

1.02 Show connection details with screw types and locations, weld lengths and locations, and other fastener requirements.

1.03 Where prefabricated or pre-finished panels are to be provided, provided drawings depicting panel configurations, dimensions and locations.

1.04 Shop Drawings shall be signed and sealed by a registered PE (professional cold-formed specialty engineer) registered in the state of the project.

SCHEDULE 5 - QUALITY ASSURANCE

PRODUCT DATA SHEET 0 - Contractor shall provide effective, full time quality control over all fabrication and erection complying with the pertinent codes and regulations of government agencies having jurisdiction.

PRODUCT DATA SHEET 1 - Installer Qualifications: Installer experienced in performing work of this section who has specialized in installation of work similar to that required for this project.



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PRODUCT DATA SHEET 2 - Pre-installation Meetings: Conduct pre-installation meeting to verify project requirements, substrate conditions, and manufacturer's installation instructions.

PRODUCT DATA SHEET 3 - Welding Standards: Comply with applicable provisions AWS D1.1 Structural Welding Code Steel and AWS D1.3 Structural Welding Code-Sheet Steel.

PRODUCT DATA SHEET 4 - Qualify welding processes and welding operators in accordance with AWS Standard Qualification Procedure.

SCHEDULE 6 - DELIVERY, STORAGE, AND HANDLING

PRODUCT DATA SHEET 0 - Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.

PRODUCT DATA SHEET 1 - Protect and store materials protected from exposure to rain, snow or other harmful weather conditions. Products to be handled per AISI's "Code of Standard Practice" .

SCHEDULE 7 - PROJECT CONDITIONS

PRODUCT DATA SHEET 0 - Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 - PRODUCTS

SCHEDULE 8 - MATERIALS

PRODUCT DATA SHEET 0 - Cold-Formed Steel Sheet: Complying with ASTM A 1003/A 1003M; unless indicated otherwise.

PRODUCT DATA SHEET 1 - Galvanized Coating: G60 coating weight minimum, complying with ASTM C 955.
1.01 Where required: G90 coating weight minimum, complying with ASTM C955.

SCHEDULE 9 - FABRICATION

PRODUCT DATA SHEET 0 - General: Framing components may be pre-assembled into panels prior to erecting.

PRODUCT DATA SHEET 1 - Fabricate panels square, with components attached in a manner so as to prevent racking or distortion.

PRODUCT DATA SHEET 2 - Cut all framing components squarely for attachment to perpendicular members, or as required for an angular fit against abutting members. Hold members positively in

place until properly fastened.

PRODUCT DATA SHEET 3 - Provide insulation as specified elsewhere in all double jamb studs and double header members, which will not be accessible to the insulation contractor.

PRODUCT DATA SHEET 4 - Axially Loaded Studs:

1.01 Install studs to have full bearing against inside track web (1/8 inches (3.2 mm) maximum gap) prior to stud and track attachment.

1.02 Splices in axially loaded studs are not permitted.

PRODUCT DATA SHEET 5 - Fasteners: Fasten components using self-tapping screws or welding.

PRODUCT DATA SHEET 6 - Welding: Welding is permitted on 18 gauge or heavier material only.

1.01 Specify welding configuration and size on the Structural Calculation submittal.

1.02 Qualify welding operators in accordance with Section 6.0 of AWS D.1.3.

1.03 Touch up all welds with zinc-rich paint in compliance with ≈STM A 780.

PART 3 - EXECUTION

SCHEDULE 10 - EXAMINATION

PRODUCT DATA SHEET 0 - Prior to installation, inspect previous work of all other trades. Verify that all work is complete and accurate to the point where this installation may properly proceed in strict accordance with framing shop drawings.

PRODUCT DATA SHEET 1 - If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

SCHEDULE 11 - ERECTION

PRODUCT DATA SHEET 0 - General Erection Requirements:

1.01 Install cold-formed framing in accordance with requirements of ASTM C1007.

1.02 Weld in compliance with AWS D.1.3.

1.03 Install in compliance with applicable sections of the AISI's Standard for Cold-Formed Steel Framing General Provisions.



PRODUCT DATA SHEET 1 - Wall Systems:

- 1.01 Erect framing and panels plumb, level and square in strict accordance with approved shop drawings.
- 1.02 Handle and lift prefabricated panels in a manner so as not to cause distortion in any member.
- 1.03 Anchor runner track securely to the supporting structure as shown on the erection drawings. Install concrete anchors only after full compressive strength has been achieved. Provide a sill sealer or gasket barrier between all concrete and steel connections.
- 1.04 Butt all track joints. Securely anchor abutting pieces of track to a common structural element, or butt-weld or splice them together.
- 1.05 Align and plumb studs, and securely attach to the flanges or webs of both upper and lower tracks except when vertical movement is specified.
- 1.06 Install jack studs or cripples below window sills, above window and door heads, at freestanding stair rails and elsewhere to furnish support, securely attached to supporting members.
- 1.07 Attach wall stud bridging in a manner to prevent stud rotation. Space bridging rows according to manufacturer's recommendations.
- 1.08 Frame wall openings to include headers and supporting studs as shown in the drawings.
- 1.09 Provide temporary bracing until erection is completed.
- 1.10 Provide stud walls at locations indicated on plans as "shear walls" for frame stability and lateral load resistance.
- 1.11 Where indicated in the drawings, provide for structural vertical movement using a vertical slide clip or other means in accordance with manufacturer's recommendations.

PRODUCT DATA SHEET 2 - Steel Joists:

- 1.01 Locate joists directly over bearing studs within 3/4 inch (19 mm) or provide a suitable load distribution member at the top track.
- 1.02 Provide web stiffeners at reaction points where indicated in drawings.



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1.03 Provide joist bridging as shown in drawings.

1.04 Provide end blocking where joist ends are not otherwise restrained from rotation.

SCHEDULE 12 - FIELD QUALITY CONTROL

PRODUCT DATA SHEET 0 - Inspection: Periodic special inspections are required by local code authorities.

1.01 Owner will hire and pay inspection agency.

1.02 Submit schedule showing when the following activities will be performed and resubmit schedule when timing changes.

1.03 Notify inspection agency not less than 3 days before the start of any of the following activities.

1.04 Inspections are required during welding operations, screw attachment, bolting, anchoring and other fastening of components within the force resisting structural system, including struts, braces, and hold-downs.

SCHEDULE 13 - PROTECTION

PRODUCT DATA SHEET 0 - Protect installed products until completion of project.

PRODUCT DATA SHEET 1 - Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION 05 40 00

SECTION 05 41 00
STRUCTURAL METAL STUD FRAMING

PART I GENERAL

1.01 SUMMARY:

- A. These specifications are to be used in preparing details and documentation for projects using the ThermaSteel Building System, manufactured by ThermaSteel Corp. For further product description and usage refer to:

1. ThermaSteel Assembly Manual

1.02 SYSTEM DESCRIPTION:

- A. The ThermaSteel Building System is customized to exact architectural drawings and specifications and can be used for below grade foundation wall systems as well as structural floor, wall and roof systems. (See attached drawing)
- B. Individual panel size and configuration is dependent upon project design requirements. Maximum overall size shall be no greater than 4' x 12'. Panel thickness shall be either 3 1/2", 5 1/2" or 7 1/2". Panel weight shall be no greater than 1.625 lb/sf.
- C. Panels shall be composed of:
1. Integral steel framework of 24ga galvanized G-90 steel.
 2. Exterior sheathing materials as specified by customer. (i.e. brick, lap siding, vinyl, etc.)
 3. Polystyrene core insulation, Class 1 fire rated, is molded into a steel frame to produce a structural composite panel.
- D. Joinery and peripheral components shall be:
1. Footer track shall be 18ga galvanized steel attached per code directly to concrete slab-on-grade or other appropriate foundation. Panel is positioned over track and secured using self-tapping sheet metal screws.

2. Shiplap joints on each panel will be joined using #8, 1/2" self-tapping screws.
3. A header is designed in various configurations to accommodate truss systems for various roof slopes or for parapet on flat roofs.
4. Corner components shall be manufactured using the same materials as the specified wall panels.
5. Other components shall be custom designed as necessary to meet project design as well as structural requirements.

E. Performance requirements: As a minimum the ThermaSteel 4' x 8' panels shall be tested by an independent laboratory to meet the following criteria:

1. Load Criteria:

WALL PANELS (STANDARD-ASSUMES SAFETY FACTOR OF 2.5)

	DIMENSIONS				AXIAL	LATERAL	LATERAL LOAD	RACKING SHEAR	
					LOAD LBS/LF kg/m	LOAD LBS/SF (L/360) kg/m ²	LBS/SF (L/240) kg/m ²	LBS/LF	kg/m 1/8" defl. Max.
W 8-3/24	4'	8'	3 1/2"	24"	1033 lbs/lf	13.6 lbs/sf	20.5 lbs/sf	107 lbs/lf	249 lbs/1 f
	1.2m	2.4m	8.9c m	60c m	1537 kg/m	66.4 kg/m ²	100.1 kg/ m ²	159.2 kg/m	370.5 kg/m
W 8-5/24	4'	8'	5 1/2'	24"	1067 lbs/lf	16.8 lbs/sf	21.8 lbs/sf	93 lbs/lf	243 lbs/1 f
	1.2m	2.4m	13.9 cm	60c m	1587.7 kg/m	82 kg/m ²	106.4 kg/ m ²	138.4 kg/m	361.6 kg/m
W 8-3/16	4'	8'	3 1/2'	16"	1300 lbs/lf	20.5 lbs/sf	27.9 lbs/sf	162 lbs/lf	355 lbs/1 f
	1.2m	2.4m	8.9c m	40c m	1934 kg/m	100.1 kg/ m ²	136.2 kg/ m ²	241.1 kg/m	525.2 kg/m
W 8-5/16	4'	8'	5 1/2"	W	1869 lbs/lf	40.9 lbs/sf	42.3 lbs/sf	125 lbs/lf	312 lbs/1 f
	1.2m	2.4m	13.9 cm	40c m	2781 kg/m	199.7 kg/ m ²	206.6 kg/ m ²	186 kg/m	464.3 kg/m
W 12-5/24	4'	12'	5 1/2"	24"	1104 lbs/lf	55.6 lbs/sf	>55.6 lbs/sf		
	1.2m	3.6m	13.9 cm	60c m	1642.8 kg/m	271.5 kg/ m ²	>271.5 kg/ m ²		
W 12-5/16	4'	17'	5 1/2"	16"	1541 lbs/lf	53.7 lbs/sf	53.6 lbs/sf		
	1.2m	3.6m	13.9 cm	40c m	2293 kg/m	262.2 kg/ m ²	310.6 kg/ m ²		



Wall Description	Rating
3 1/2" ThermaSteel w/steel channels - 1/2" regular gypsum boards - attached with 1" screws 12" o.c.	Minimum
3 1/2" ThermaSteel panel w/ recessed steel channels on exposed side - 5/8" Type X FIRECODE gypsum panels, recessed layer 5/8" gypsum over recessed channels -recessed gypsum board attached with 1" type S screws, 12" o.c., outer board attached with 1 5/8" type S screws, 12" o.c., on exposed side, no. 6 5/8" self- tapping screws 12" o.c., on protected side	1 hour
3 1/2" ThermaSteel panel w/steel channels - double layer 1/2" Type X FIRECODE gypsum boards - panels attached with 1" screws at 24" o.c. on exposed side, 1 5/8" screws at 12" o.c. on protected side	2 hour
5 1/2" ThermaSteel panel w/steel	1 hour Party Wall

2. Fire Resistance: The panels have been tested for surface burning characteristics in accordance with UL 723 procedures (ASTM E84):
 - a. 3 1/2" (8.9cm) thick EPS, 1 1/2" PCF (24 kg/m³):

Flame spread rating:	5-10
Smoke developed:	65-300
 - b. 5 1/2" (13.9cm) thick EPS, 1.0 PCF (16kg/ m³):

Flame spread rating:	5-20
Smoke developed:	125-175

In addition, fire wall assemblies have been tested in accordance with ASTM E119 for 1-hour and 2-hour ratings. Some are shown in the fire resistance table on the next page:

3. Thermal Efficiency:
 - a. 3 1/2" ThermaSteel panel R-Value of 16
 - b. 5 1/2" ThermaSteel panel R-Value of 25

- c. 7 1/2" ThermaSteel panel R-Value of 34

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Panel manufacturer shall be ThermaSteel Corp.
2. Contractor/Installer shall be knowledgeable in the proper installation of the ThermaSteel Building System.
3. All supplied fasteners and other third party supplied components shall be certified by ThermaSteel Corp. as to quality and suitability for use.

B. Regulatory Requirements:

1. The ThermaSteel Building System and panel shall meet or exceed all code requirements for structure and fire safety.
2. The use of the ThermaSteel panel shall be in accordance with all applicable building codes.

C. The ThermaSteel Building System and panel shall be recognized for the intended use by applicable building codes.

D. Third Party Inspection:

1. Manufacture of the building panel and components shall comply with quality assurance standards of a contracted independent third party quality assurance inspection agency.

1.04 DELIVERY, STORAGE, HANDLING

- A. All ThermaSteel panels and components shall be delivered to the job site with labels intact. Questionable panels or parts shall not be used.
- B. Store all panels in a clean and safe area.
- C. Panels shall be handled so as not to damage corners, edges, or channels prior to installation.



1.05 PROJECT CONDITIONS

- A. Application of sealants, primers, elastomeric coatings, brick or stone facings or other forms of exterior sidings or finishes shall be done under the conditions set forth by the manufacturers of those products.

1.06 SEQUENCING AND SCHEDULING

- A. Installation of the ThermaSteel panels shall be coordinated with the other building trades.
- B. Foundations or slab-on-grade must be complete and properly cured, ready to accept the footer track prior to installation of the building panels when they are used as structural wall systems.
- C. Exterior finishing must be accomplished in a timely manner following the installation of the ThermaSteel building panels.
- D. Other building trades may be scheduled as required.

1.07 WARRANTY

- A. ThermaSteel Corp. shall provide a two year warranty against defective material upon written request. See warranty for complete details.

PART II PRODUCT

2.01 MANUFACTURER: The ThermaSteel panel and components are all proprietary products of ThermaSteel Corp. and manufactured under strict quality controls as monitored by a third party independent quality assurance agency.

2.02 MATERIALS

- A. 24ga galvanized G-90 roll formed steel shall comprise the integral framework of the panel. Expandable polystyrene incorporated into the design shall provide a sufficient thermal break to ensure non-conductivity of temperature between surfaces.
- B. The exterior skins of the panel shall be at the discretion of the customer. Specifications for the non-proprietary sheathings shall be available upon request from ThermaSteel Corp.



- C. The panel core shall be Class 1 fire-retardant foam with a minimum density of 1.0 lbs/cf to 1.5 lbs/cf injected into the panel cavity to form a composite panel.
- D. Footer tracks shall be 18ga galvanized G-90 roll-formed steel on all load bearing walls.
- E. Header and other required components shall be custom designed to meet the structural requirements of the architectural design.
- F. Mechanical fasteners and other third party components shall be available from authorized manufacturers and selected by the architect/owner.
- G. Joint sealants, exterior finishes, facings or sidings shall be recommended by ThermaSteel Corp. and selected by the architect/owner.

PART III EXECUTION

3.01 EXAMINATION

- A. Prior to the installation of the ThermaSteel panels, it is the contractor's responsibility to ensure that:
 - 1. The foundation/footer/slab-on-grade is appropriately level and smooth and ready to accept the footer track of the building system.

3.02 PREPARATION

- A. Protection
 - 1. In following good building site practices, it is recommended that the ThermaSteel building panels and components shall be protected from permanent or temporary damage prior to, during, and following installation until proper sealant and exterior finishing are applied.
- B. Foundation Preparation
 - 1. The foundation/footer/slab-on-grade shall be prepared so as to be level and square prior to delivery of the panels.
- C. Wall System Preparation

1. When the ThermaSteel panels are used as a curtain wall, the structural steel wall system shall be prepared so as to provide a level plane for panel installation using construction devices to serve that purpose. All structural systems should be dry and free from extraneous materials which may prevent proper fastening of the panels.

3.03 INSTALLATION

- A. Installation instructions shall be customized for each project. In general, panels are connected:
 1. To the foundation using a footer track bolted to the slab upon which the panel is placed and attached with mechanical fasteners.
 2. At the top using a metal track or wood plate over the top of the panels and attached using mechanical fasteners.
 3. To the structural steel framing using mechanical fasteners of appropriate design and length in a pattern as specified by the ThermaSteel structural engineer.

3.04 FIELD QUALITY CONTROL

- A. The contractor shall be responsible for the proper installation of the ThermaSteel Building System and the necessary sealants and finishes.
- B. Contractors shall be factory trained as to the installation of the system.
- C. A representative of ThermaSteel Corp. shall act as an on-site resource for a period of one day or as negotiated to help ensure proper installation of the system.

3.05 CLEANING

- A. All excess materials, if any, shall be removed from the job site by the contractor in accordance with contract provisions.
- B. All surrounding areas where the panels have been installed and the finish applied shall be left free of debris and foreign substances resulting from the contractor's work.



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END SECTION 05 41 00



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SECTION 06 09 00 WOOD AND PLASTIC FASTENERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Pre-engineered metal or plastic connectors used to support a wood, plated truss or composite wood, from a concrete, masonry, steel, wood, or composite wood supporting member(s).

1.02 RELATED SECTIONS

- A. Section 05 12 00 – Structural Steel Framing – Steel provides support or anchorage.
- B. Section 06 10 00 – Rough Carpentry – Wood supported by fastenings or providing support or anchorage.

1.03 REFERENCES

- A. ASTM A36 – Carbon Structural Steel
- B. ASTM A193 – Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service
- C. ASTM A240 – Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications
- D. ASTM A307 – Carbon Steel Bolts and Studs
- E. ASTM A449 – Hex Cap Screws, Bolts and Studs, Steel, Heat Treated
- F. ASTM A480 – General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
- G. ASTM A493 – Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging

- H. ASTM A500 – Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- I. ASTM A653 – Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- J. ASTM A706 – Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
- K. ASTM A924 – General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
- L. ASTM A1011 – Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability and Ultra-High Strength
- M. ASTM D7147 – Standard Specification for Testing and Establishing Allowable Loads of Joist Hangers.
- N. ASTM D2395 – Standard Test Methods for Specific Gravity of Wood and Wood-Based Materials
- O. ASTM F1554 – Anchor Bolts, Steel
- P. ASTM F1575 – Standard Test Method for Determining Bending Yield Moment of Nails
- Q. ASTM F1667 – Driven Fasteners: Nails, Spikes, and Staples
- R. ICC-ES AC13 – Acceptance Criteria for Joist Hangers and Similar Devices
- S. ICC-ES AC116 – Acceptance Criteria for Nails and Spikes
- T. ICC-ES AC118 – Acceptance Criteria for Tapping Screw Fasteners



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- U. ICC-ES AC120 – Acceptance Criteria for Wood Screws Used in Horizontal Diaphragms and Vertical Shear Walls
- V. ICC-ES AC155 – Acceptance Criteria for Hold-Downs (Tie-Downs) Attached to Wood Members
- W. ICC-ES AC233 – Acceptance Criteria for Alternate Dowel-Type Threaded Fasteners
- X. ICC-ES AC261 – Acceptance Criteria for Connectors Used with Cold-Formed Steel Structural Members
- Y. ICC-ES AC316 – Acceptance Criteria for Shrinkage Compensating Devices
- Z. ICC-ES AC398 – Acceptance Criteria for Cast-In-Place Cold-Formed Steel Connectors in Concrete for Light-Frame Construction
- AA. ICC-ES AC399 Acceptance Criteria for Cast-In-Place Proprietary Bolts in Concrete for Light-Framed Construction
- BB. AISI 2001 – Cold-Formed Steel Specification
- CC. 2005 NDS – National Design Specification

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to job site in manufacturer's or distributor's packaging undamaged, complete with installation instructions.
- B. Protect and handle materials in accordance with manufacturer's recommendations to prevent damage or deterioration.



PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Simpson Strong-Tie Co., Inc.

2.2 MATERIALS

A. Steel:

1. Sheet: ASTM A36, ASTM A653, ASTM A1011
2. Fasteners: ASTM A307, ASTM F1554, ASTM F1667, SAE C1022 (SDS Screws)

B. Stainless Steel:

1. Sheet: ASTM A240, ATT M A480
2. Fasteners: ASTM A493

C. Finishes:

1. Gray paint
2. Hot-dipped galvanized or electro-plated galvanized: G90, G185 (ZMAX or HDG)
3. Powder-coated paint
4. Electro-galvanized, Zinc dichromate and Double Barrier for SD and SDS screws

2.3 FABRICATION

- A. Shop assembly to occur per the manufacturer's approved production drawings.
- B. Fabrication tolerances per manufacturer.
- C. Fabrication requiring welding shall be performed in accordance with the current American Welding Society's standards.
- D. The manufacturer's identification shall be stamped into the metal or wood part and a label may be attached to the part with adhesive.

2.4 TESTING

- A. Allowable loads published in manufacturer's catalog to be determined using the minimum load from static and/or cyclic analysis and one or more of the following test methods:
 - 1. Static load tests in wood assemblies
 - 2. Static load tests in steel jigs
 - 3. Static load tests of products embedded in concrete or masonry
- B. Testing to determine allowable loads shall be performed as per the applicable ICC-ES Acceptance Criteria or ASTM standard.
- C. Allowable loads for hangers are determined by a static load test resulting in not more than a 1/8" deflection of the joist relative to the header, or either the lowest of 3 or average of 6 ultimate load divided by 3, or the fastener allowable load as determined by the NDS, whichever is lowest.
- D. Manufacturer to provide code testing data on all products that have been code tested upon request.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Unless otherwise noted in the manufacturer's catalog, allowable loads are for Douglas Fir-Larch under continuously dry conditions. Allowable loads for other species or conditions must be adjusted according to the code. See manufacturer's catalog for additional notes and requirements.
- B. Built up lumber (multiple members) must be fastened together to act as one unit to resist the applied load.
- C. Verify that the dimensions of the supporting member are sufficient to receive the specified fasteners.

3.2 INSTALLATION

- A. Unless otherwise noted in the manufacturer's catalog, bolts, screws and/or nails shall not be combined.

- B. All nails shall be common unless otherwise noted in the manufacturer's catalog or substituted by the engineer of record with a reduction taken.
- C. Unless otherwise noted in the manufacturer's catalog, bending steel in the field may cause fractures at the bend line. Fractured steel will not carry the allowable load and must be replaced. When bending is allowed or required in the catalog, the connector shall be allowed one cycle bend, one time only.
- D. Galvanized connectors should not be placed in contact with treated wood unless the treated wood is adequately verified to be suitable for such contact. Some wood treatments may accelerate metal deterioration. See the manufacturer's catalog for specific recommendations.
- E. A fastener that splits the wood will not carry the allowable load. Evaluate splits to determine if the connection will perform as required. Dry wood will split more easily and should be evaluated as needed. If wood tends to split, consider pre-boring holes with a diameter not exceeding 0.75 of the nail diameter, for screws in wood with a specific gravity of 0.5 or greater use: 5/32" for SDS, 5/64" for SD9 or SD10, and 1/16" for SD8 (2005 NDS 11.1.4 and 11.1.5.3).
- F. Wood shrinkage will be taken into consideration when designing and installing connections.
- G. Built-up lumber (multiple members) must be fastened together to act as one unit to resist the applied load.
- H. Top flange hangers may cause unevenness. Possible remedies should be evaluated by a professional and include using a face mount hanger, routing the beam, or cutting the subfloor to accommodate the top flange thickness.
- I. Do not overload by exceeding the manufacturer's catalog allowable load values.
- J. Unless otherwise noted in the manufacturer's catalog, fill all fastener holes with fastener types as specified in the manufacturer's catalog.

- K. All specified fasteners must be installed according to the instructions in the manufacturer's catalog.
- L. Bolt holes shall be a minimum of 1/32" and a maximum of 1/16" larger than the bolt diameter (2005 NDS 11.1.2.2).
- M. Install all specified fasteners before loading the connection.
- N. Use proper safety equipment.
- O. Welding shall be in accordance with the Welding Society (AWS) standards.
- P. Welding galvanized steel may produce harmful fumes. Follow proper welding procedures and safety precautions.
- Q. Nail tools with hole-location mechanisms may be used to install connectors, provided the correct quantity and type of nails are properly installed in the nail holes.
- R. The joist shall bear completely on the connector seat the gap between the joist end and the header or back plate of the hanger shall not exceed 1/8".
- S. The installer of ATS systems shall cut rods to length as required.
- T. Anchor bolt nuts should be finger-tight plus 1/3 to 1/2 turn with a wrench. Do not use an impact wrench to tighten nuts on the anchor bolts.
- U. Modifications to products or changes in installation procedures should only be made by a qualified designer. The performance of such modified products or altered installation procedure is the sole responsibility of the designer.



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3.3 FIELD QUALITY CONTROL

- A. Determine that the proper part is being used in the correct application and has been fabricated by the approved manufacturer by observation of the stamp into the metal part and/or the adhesive label on the product denoting part and manufacturer name.

- B. Before substituting another brand, confirm load capacity based on published testing data and calculations per section 2.4. The engineer/designer of record shall evaluate and give written approval for substitution prior to installation.

END OF SECTION 06 09 00



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SECTION 06 10 00 ROUGH CARPENTRY

PART I – GENERAL

1.01 SUMMARY: These specifications are to be used in preparing details and documentation for projects using dimension lumber.

1.02 SYSTEM DESCRIPTION

- A. The rough carpentry of the structure includes:
 - 1. Structural floor and wall with dimension lumber.
 - 2. Built-up structural beams and columns.
 - 3. Structural floor and wall sheathing
 - 4. Wood furring, grounding, and connections.
 - 5. Miscellaneous framing and sheathing
- B. The size and spacing of each member is stated on the structural drawing and should be followed.
- C. All rough carpentry should be constructed using dimensional lumber and wood species to be determined.
- D. Performance Requirements: All materials will meet or exceeded the required information provided by government agencies and an independent laboratory to meet the criteria should test all material.

1.03 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Perform Work in accordance with the following:
 - a. Lumber Grading Agency: Certified by DOC PS 20.



- b. Lumber: Southern Pine #2
- c. Wood Structural Panels: DOC PS 1 or DOC PS 2.

B. Regulatory Requirements:

- 1. Manufacturer's Certificate: Certify products meet or exceed specified sustainable design requirements.
 - a. Certify recycled material content for recycled content products.
 - b. Certify source for local and regional materials and distance from Project site.
 - c. Certify lumber is harvested from Forest Stewardship Council Certified well managed forest.

C. Surface Burning Characteristics:

- 1. Fire Retardant Treated Materials: Maximum 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.

- D. Apply label from agency approved by authority having jurisdiction to identify each preservative treated material.

1.04 DELIVERY, STORAGE, HANDLING

- A. All rough carpentry material should be delivered to job site with labels intact.
- B. Store all materials in a dry, clean, and safe area.
- C. Rough carpentry material should be handled with care as to not damage and materials before installation.

1.05 PROJECT CONDITIONS

- A. Any application of sealants, primers and finishes shall be done in accordance set forth by the manufactures.

1.06 SEQUENCING AND SCHEDULING



- A. Installation of the rough carpentry should be coordinated with the other building trades.
- B. The foundation whether it is temporary or permanent should be erected and ready to accept the rough carpentry elements prior to the installation of rough carpentry material.
- C. Exterior finishes should be accomplished in a timely manner following the construction of the rough carpentry.
- D. Other building trades may be scheduled as required.

PART II – PRODUCTS

2.01 LUMBER MATERIALS

- A. Lumber Grading Rules: SPIB: Southern Pine Inspection Bureau
- B. Beam Framing: Southern Pine species, #2 grade, 2 x 10 size classification, 19 percent maximum moisture content.
- C. Joist Framing: Southern Pine species, #2 grade, 2 x 10 floor Joists, 19 percent maximum moisture content.
- D. Non-structural Light Framing: Southern Pine species, #2 grade, 2 x 4 size classification, 19 percent maximum moisture content.
- E. Studding: Southern Pine species, #2 grade, 2 x 4, 19 percent maximum moisture content.
- F. Studding: Southern Pine species, #2 grade, 2 x 6, 19 percent maximum moisture content.
- G. Miscellaneous Framing: Southern Pine species, 19 percent maximum moisture content.

2.02 SHEATHING MATERIAL

- A. Structural Wall Sheathing:
- B. Gypsum Board Wall Sheathing: ASTM C1177, 5/8 inch thick, 1/2 inch thick.
- C. Wood Structural Panel Floor Sheathing: EWA Rated Sheathing, Structural 1, Oriented Strand Board, Plywood.

2.03 SHEATHING AND UNDERLAYMENT LOCATION

- A. Floor Sheathing: One 7/16 inch thick OSB, 48 x 96 inch sized sheets, square edges, alternating direction.
- B. Wall Sheathing:

2.04 FIREBLOCKING AND DRAFTSTOPPING

- A. Fire blocking: Solid lumber nominal 2 inches thick.
- B. Draft stopping: Gypsum board.
 - 1. Gypsum board, 1/2 inch thick.

2.05 ACCESSORIES

- A. Fasteners and Anchors:
 - 1. Fasteners: ASTM A153/A153M, hot dipped galvanized steel for high humidity and treated wood locations, unfinished steel elsewhere.
 - 2. Nails and Staples: ASTM F1667.
 - 3. Screws: Bugle head, hardened steel, power driven type, length three times thickness of sheathing.
- B. Anchors: No anchors necessary in temporary location.
- C. Structural Framing Connectors:
 - 1. Joist Hangers: Hot dipped galvanized steel, sized to suit framing conditions, manufactured by Simpson Strong Tie.
 - 2. Hurricane Ties: Hot dipped galvanized steel, sized to suit framing conditions, manufactured by Simpson Strong Tie.
 - 3. Structural Straps: Hot dipped galvanized steel, sized to suit framing conditions, manufactured by Simpson Strong Tie.



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D. Subfloor Glue: Waterproof of water base, air cure type, cartridge dispensed.

1. Adhesives: Maximum volatile organic compound content in accordance with SCAQMD Rule 1168.
2. Aerosol Adhesives: Maximum volatile organic compound content in accordance with GS-36.

2.06 FACTORY WOOD TREATMENT

A. Wood Preservative (Pressure Treatment): Factory applied pressure treated preservative, AWWA U1, Commodity Specification A-Sawn Products or F-Wood Composites using water-borne preservative, in accordance with the National Design Specifications for Wood Construction.

B. Moisture Content After Treatment:

1. Lumber: Maximum 19 percent.
2. Structural Panels: Maximum 15 percent.

PART III – EXECUTION

3.01 WOOD GENERAL FRAMING

- A. Install framing members level and plumb, in correct position, of size and spaced as indicated.
- B. Fasten framing in accordance with the Uniform Statewide Building code of Virginia.
- C. Make provisions for erection loads, and for sufficient temporary bracing to maintain structure safe, plumb, and in alignment until completion of erection and installation of permanent bracing.
- D. Place horizontal members, crown side up.
- E. Do not splice structural members between supports.
- F. Space short studs over and under opening to stud spacing.

- G. Construct and install joist headers as indicated.
- H. Bridge floor and ceiling joists in excess of 8 feet span at mid-span. Fit solid blocking at ends of rafters where needed.
- I. Construct corners and partitions with three (3) or more studs. Provide miscellaneous blocking and framing as shown, to support facing materials, fixtures, specialty items, and trim.
- J. Frame openings with multiple studs and headers. Provide nailed header members of thickness equal to width of studs. Set headers on support of jack studs.
 - 1. For load bearing walls, provide double jack studs for all openings. Provide headers of depth as indicated on Contract documents.
- K. Coordinate installation of ThermaSteel panels.
- L. Curb roof openings as indicated.
- M. Coordinate curb installation with installation of roofing vapor retardant.

3.02 FLOOR JOIST FRAMING

- A. General: Install floor joist with crown edge up and support ends of each member on metal joist hanger installed into joist header.
- B. Frame floor joists as indicated on contract documents.
- C. Do not notch in any part of joists. Do not bore holes larger than 1/3 depth of joist; do not locate holes closer than 2 inches from top or bottom.
- D. Provide solid blocking of 2 inch nominal thickness by depth of joist at mid-span of joists.
- E. Under interior partitions, provide double joists directly under partition wall.

3.03 SHEATHING

- A. Install gypsum sheathing in accordance with ASTM C1280.
- B. Fasten sheathing in accordance with the Uniform Statewide Building code of Virginia.



- C. Secure wall sheathing with long dimension perpendicular to wall studs, with ends over firm bearing and staggered.
- D. Place sheathing tape along all joints overlapping where necessary.
- E. Secure 7/16 inch sub-floor sheathing with longer edge perpendicular to floor framing and with end joints staggered and sheet ends over bearing. Attach with sub-floor glue and screws. Secure second 1/2 inch layer plywood perpendicular to first layer of floor sheathing.
- F. Install wall plywood first row level with bottom of joist headers. Install second row level with top of parapet. Finish sheathing wall in center. Nail to framing and space panels 1/8" at edges and ends.
- G. Place building paper between floor underlayment and subflooring.
- H. Install flooring underlayment after dust and dirt generating activities have ceased and prior to application of finished flooring. Apply perpendicular to subflooring, stagger joints of underlayment. Secure with screw type fasteners.

3.04 FIREBLOCKING AND DRAFTSTOPPING

- A. Install fire blocking to cut off concealed draft openings.

3.05 SITE APPLIED WOOD TREATMENT

- A. Brush apply two coats of preservative treatment on wood in contact with cementitious materials.
- B. Allow preservative to dry prior to erecting members.



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3.05 CLEANING

- A. All excess materials, if any, shall be removed from the job site by the contractor in accordance with contract provisions.

- B. All surrounding areas where the panels have been installed and the finish applied shall be left free of debris and foreign substances resulting from the contractor's work.

END SECTION 06 10 00



SECTION 06 12 00
STRUCTURALLY INSULATED PANELS

PART I - GENERAL

1.01 SUMMARY: These specifications are to be used in preparing details and documentation for projects using the ThermaSteel Building System, manufactured by ThermaSteel Corp. For further product description and usage refer to:

A. ThermaSteel Assembly Manual

1.02 SYSTEM DESCRIPTION:

A. The ThermaSteel Building System is customized to exact architectural drawings and specifications and can be used for below grade foundation wall systems as well as structural floor, wall and roof systems. (See attached drawing)

B. Individual panel size and configuration is dependent upon project design requirements. Maximum overall size shall be no greater than 4' x 12'. Panel thickness shall be either 3 1/2", 5 1/2" or 7 1/2". Panel weight shall be no greater than 1.625 lb/sf.

C. Panels shall be composed of:

1. Integral steel framework of 24ga galvanized G-90 steel.
2. Exterior sheathing materials as specified by customer. (i.e. brick, lap siding, vinyl, etc.)
3. Polystyrene core insulation, Class 1 fire rated, is molded into a steel frame to produce a structural composite panel.

D. Joinery and peripheral components shall be:

1. Footer track shall be 18ga galvanized steel attached per code directly to concrete slab-on-grade or other appropriate foundation. Panel is positioned over track and secured using self-tapping sheet metal screws.
2. Shiplap joints on each panel will be joined using #8, 1/2" self-tapping screws.
3. A header is designed in various configurations to accommodate truss systems for

various roof slopes or for parapet on flat roofs.

4. Corner components shall be manufactured using the same materials as the specified wall panels.
 5. Other components shall be custom designed as necessary to meet project design as well as structural requirements.
- E. Performance requirements: As a minimum the ThermaSteel 4' x 8' panels shall be

WALL PANELS (STANDARD-ASSUMES SAFETY FACTOR OF 2.5)

	DIMENSIONS				AXIAL	LATERAL	LATERAL	RACKING SHEAR	
					LOAD	LOAD	LOAD LBS/SF	LBS/LF	kg/m 1/8"
					LBS/LF	LBS/SF	(L/240)	defl. Max.	
					kg/m	(L/360)	kg/m ²		
						kg/m ²			
W 8-3/24	4'	8'	3	24"	1033	13.6 lbs/sf	20.5 lbs/sf	107 lbs/lf	249
			1/2"		lbs/lf				lbs/lf
	1.2	2.4	8.9c	60c	1537	66.4 kg/m ²	100.1 kg/ m ²	159.2	370.5
	m	m	m	m	kg/m			kg/m	kg/m
W 8-5/24	4'	8'	5	24"	1067	16.8 lbs/sf	21.8 lbs/sf	93 lbs/lf	243
			1/2'		lbs/lf				lbs/lf
	1.2	2.4	13.9	60c	1587.7	82 kg/m ²	106.4 kg/ m ²	138.4	361.6
	m	m	cm	m	kg/m			kg/m	kg/m
W 8-3/16	4'	8'	3	16"	1300	20.5 lbs/sf	27.9 lbs/sf	162 lbs/lf	355
			1/2'		lbs/lf				lbs/lf
	1.2	2.4	8.9c	40c	1934	100.1 kg/	136.2 kg/ m ²	241.1	525.2
	m	m	m	m	kg/m	m ²		kg/m	kg/m
W 8-5/16	4'	8'	5	W	1869	40.9 lbs/sf	42.3 lbs/sf	125 lbs/lf	312
			1/2"		lbs/lf				lbs/lf/
	1.2	2.4	13.9	40c	2781	199.7 kg/	206.6 kg/ m ²	186 kg/m	464.3
	m	m	cm	m	kg/m	m ²		kg/m	kg/m
W 12- 5/24	4'	12'	5	24"	1104	55.6 lbs/sf	>55.6 lbs/sf		
			1/2"		lbs/lf				
	1.2	3.6	13.9	60c	1642.8	271.5 kg/	>271.5 kg/		
	m	m	cm	m	kg/m	m ²	m ²		



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W 12-5/16	4`	17'	5 1/2"	16"	1541 lbs/lf	53.7 lbs/sf	53.6 lbs/sf	t
	1.2 m	3.6 m	13.9 cm	40c m	2293 kg/m	262.2 kg/m ²	310.6 kg/m ²	ested by an indepen

dent laboratory to meet the following criteria:

1. Load Criteria:

Wall Description

3 1/2" ThermaSteel w/steel channels - 1/2" regular gypsum boards - attached with 1" screws 12" o.c.

3 1/2" ThermaSteel panel w/ recessed steel channels on exposed side - 5/8" Type X FIRECODE gypsum panels, recessed layer 5/8" gypsum over recessed channels - recessed gypsum board attached with 1" type S screws, 12" o.c., outer board attached with 1 5/8" type S screws, 12" o.c., on exposed side, no. 6 5/8" self-tapping screws 12" o.c., on protected side

3 1/2" ThermaSteel panel w/steel channels - double layer 1/2" Type X FIRECODE gypsum boards - panels attached with 1" screws at 24" o.c. on exposed side, 1 5/8" screws at 12" o.c.

Rating
Minimum

1 hour

2. Fire Resistance: The panels have been tested for surface burning characteristics in accordance with UL 723 procedures (ASTM E84):

- a. 3 1/2" (8.9cm) thick EPS, 1 1/2" PCF (24 kg/m³):
 Flame spread rating: 5-10
 Smoke developed: 65-300
- b. 5 1/2" (13.9cm) thick EPS, 1.0 PCF (16kg/ m³):
 Flame spread rating: 5-20
 Smoke developed: 125-175

In addition, fire wall assemblies have been tested in accordance with ASTM E119 for 1-hour and 2-hour ratings. Some are shown in the fire resistance table on the next page:

3. Sound Rating:

* Improved sound rating values may be accomplished by the use of any of the following:



- 5 1/2" Panels
- Fiberglass sound blankets between walls
- Dynamat sound proofing films
- The use of lead oil on one or both interior surfaces.
- Changing the density of the EPS on either side.

- 4. Thermal Efficiency:
 - a. 5 1/2" ThermaSteel panel R-Value of 25

1.03 QUALITY ASSURANCE

A. Qualifications:

- 1. Panel manufacturer shall be ThermaSteel Corp.
- 2. Contractor/Installer shall be knowledgeable in the proper installation of the ThermaSteel Building System.
- 3. All supplied fasteners and other third party supplied components shall be certified by ThermaSteel Corp. as to quality and suitability for use.

B. Regulatory Requirements:

- 1. The ThermaSteel Building System and panel shall meet or exceed all code requirements for structure and fire safety.
- 2. The use of the ThermaSteel panel shall be in accordance with all applicable building codes.

C. The ThermaSteel Building System and panel shall be recognized for the intended use by applicable building codes.

D. Third Party Inspection:

- 1. Manufacture of the building panel and components shall comply with quality assurance standards of a contracted independent third party quality assurance inspection agency.

1.04 DELIVERY, STORAGE, HANDLING



- A. All ThermaSteel panels and components shall be delivered to the job site with labels intact. Questionable panels or parts shall not be used.
- B. Store all panels in a clean and safe area.
- C. Panels shall be handled so as not to damage corners, edges, or channels prior to installation.

1.05 PROJECT CONDITIONS

- A. Application of sealants, primers, elasotmeric coatings, brick or stone facings or other forms of exterior sidings or finishes shall be done under the conditions set forth by the manufacturers of those products.

1.06 SEQUENCING AND SCHEDULING

- A. Installation of the ThermaSteel panels shall be coordinated with the other building trades.
- B. Foundations or slab-on-grade must be complete and properly cured, ready to accept the footer track prior to installation of the building panels when they are used as structural wall systems.
- C. Exterior finishing must be accomplished in a timely manner following the installation of the ThermaSteel building panels.
- D. Other building trades may be scheduled as required.

1.07 WARRANTY

- A. ThermaSteel Corp. shall provide a two year warranty against defective material upon written request. See warranty for complete details.

PART II - PRODUCT

2.01 MANUFACTURER: The ThermaSteel panel and components are all proprietary products of ThermaSteel Corp. and manufactured under strict quality controls as monitored by a third party independent quality assurance agency.

2.02 MATERIALS



- A. 24ga galvanized G-90 roll formed steel shall comprise the integral framework of the panel. Expandable polystyrene incorporated into the design shall provide a sufficient thermal break to ensure non-conductivity of temperature between surfaces.
- B. The exterior skins of the panel shall be at the discretion of the customer. Specifications for the non-proprietary sheathings shall be available upon request from ThermaSteel Corp.
- C. The panel core shall be Class 1 fire-retardant foam with a minimum density of 1.0 lbs/cf to 1.5 lbs/cf injected into the panel cavity to form a composite panel.
- D. Footer tracks shall be 18ga galvanized G-90 roll-formed steel on all load bearing walls.
- E. Header and other required components shall be custom designed to meet the structural requirements of the architectural design.
- F. Mechanical fasteners and other third party components shall be available from authorized manufacturers and selected by the architect/owner.
- G. Joint sealants, exterior finishes, facings or sidings shall be recommended by ThermaSteel Corp. and selected by the architect/owner.

PART III - EXECUTION

3.01 EXAMINATION

- A. Prior to the installation of the ThermaSteel panels, it is the contractor's responsibility to ensure that:
 - 1. The foundation/footer/slab-on-grade is appropriately level and smooth and ready to accept the footer track of the building system.

3.02 PREPARATION

- A. Protection
 - 1. In following good building site practices, it is recommended that the ThermaSteel building panels and components shall be protected from permanent or temporary damage prior to, during, and following installation until proper sealant and exterior finishing are applied.

B. Foundation Preparation

1. The foundation/footer/slab-on-grade shall be prepared so as to be level and square prior to delivery of the panels.

C. Wall System Preparation

1. When the ThermaSteel panels are used as a curtain wall, the structural steel wall system shall be prepared so as to provide a level plane for panel installation using construction devices to serve that purpose. All structural systems should be dry and free from extraneous materials which may prevent proper fastening of the panels.

3.03 INSTALLATION

A. Installation instructions shall be customized for each project. In general, panels are connected:

1. To the foundation using a footer track bolted to the slab upon which the panel is placed and attached with mechanical fasteners.
2. At the top using a metal track or wood plate over the top of the panels and attached using mechanical fasteners.
3. To the structural steel framing using mechanical fasteners of appropriate design and length in a pattern as specified by the ThermaSteel structural engineer.

3.04 FIELD QUALITY CONTROL

- A. The contractor shall be responsible for the proper installation of the ThermaSteel Building System and the necessary sealants and finishes.
- B. Contractors shall be factory trained as to the installation of the system.
- C. A representative of ThermaSteel Corp. shall act as an on-site resource for a period of one day or as negotiated to help ensure proper installation of the system.



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3.05 CLEANING

- A. All excess materials, if any, shall be removed from the job site by the contractor in accordance with contract provisions.
- B. All surrounding areas where the panels have been installed and the finish applied shall be left free of debris and foreign substances resulting from the contractor's work.

END SECTION 06 12 00



SECTION 06 15 33
WOOD PATIO DECKING

PART I – GENERAL

1.01 SUMMARY: Section includes softwood lumber structural wood decking and preservative treatment of wood.

1.02 SYSTEM DESCRIPTION

- A. A pressure treated wood decking system will be used on the outdoor structures to include the decks and ramps.
- B. The size of the decking material will be determined upon the project design requirements. The dimensions and weight of material will be determined based upon the chosen material.
- C. Joinery and peripheral components shall be:
 - 1. Floor joist should be pressure treated 2x8" wood.
 - 2. The decking system will use the appropriate decking screws to connect the decking material to the exterior floor joists.
- D. Performance requirements: As a minimum an independent laboratory should test all pressure treated wood decking material to make sure that the material chosen meets the criteria specified for the chosen wood specimen.

1.03 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
 - 2. Design decking under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of Virginia.
- B. Regulatory Requirements:
 - 1. Materials Resource Certificates:

- a. Certify recycled material content for recycled content products.
 - b. Certify source for local and regional materials and distance from Project Site.
 - c. Certify lumber is harvested from Forest Stewardship Council Certified well managed forest.
2. Perform Work in accordance with the following:
 - a. Lumber Grading Agency: Certified by DOC PS 20.
 - b. Lumber: DOC PS 20.
 3. Perform Work in accordance with AITC A190.1.
 4. Surface Burning Characteristics:
 - a. Fire Retardant Materials: Maximum 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.
 5. Apply label from agency approved by authority having jurisdiction to identify each preservative treated material.

1.04 DELIVERY, STORAGE, HANDLING

- A. All wood decking material and components should be delivered to the job site with labels intact.
- B. Store decking material in a dry, clean and safe area.
- C. Decking material should be handle with care to insure that the material does not get damaged before installation.

1.05 PROJECT CONDITIONS

- A. Applicant of sealants, primers and any other finishes shall be done under the conditions set forth by the manufactures.

1.06 SEQUENCING AND SCHEDULING



- A. The installation of all wood decking material shall be coordinated with the other building trades.
- B. The foundation must be completed and ready to accept the floor joist prior to the installation of the wood decking material.
- C. Any sealants must be completed in a timely manner following the installation of the wood decking.
- D. Other building trades may be schedule as required.

PART II – PRODUCTS

2.01 MANUFACTURERS

- A. Generic treated lumber decking. Milled and ripped to sizes as indicated.

2.02 MATERIALS

- A. Lumber Grading Rules: SPIB – Southern Pine Inspection Bureau.
- B. Lumber Decking: Southern Pine species, #2 grade, 5/4 inch x 6 inch size classification, 19 percent maximum moisture content.

2.03 ACCESSORIES

- A. Fasteners and Anchors:
 - 1. Screws: Bugle head, hardened steel, power driven type, length three times thickness of decking.
- B. Sealer: Thompsons water seal or equivalent sealer.

2.04 WOOD TREATMENT

- A. Wood Preservative (Pressure Treatment): Factory applied pressure treated preservative, AWWA U1, Commodity Specification A-Sawn Products or F-Wood Composites using water-borne preservative, in accordance with the National Design Specifications for Wood Construction.



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- B. Wood Preservative (Surface Application): Colored, manufactured by Thompsons water seal.

2.03 SOURCE QUALITY CONTROL

- A. Section 01 00 00 - Quality Requirements: Testing, inspection and analysis requirements.
- B. Inspect Work performed at fabricator's facility to verify conformance to Contract Documents.
- C. When fabricator is approved by authority having jurisdiction, submit certificate of compliance indicating work performed at fabricator's facility conforms to Contract Documents.
 - 1. Specified shop inspections are not required for Work performed by approved fabricator.

PART III - EXECUTION

3.01 EXAMINATION

- A. Verify support framing is ready to receive decking.

3.02 PREPERATION

- A. Coordinate placement of support items.

3.03 SITE APPLIED WOOD TREATMENT

- A. Brush apply two coats of preservative treatment on wood.
- B. Treat site-sawn cuts. Apply preservative to site-sawn cuts in accordance with AWPA M4.
- C. Allow preservative to dry prior to erecting members.

3.04 INSTALLATION- LUMBER DECKING

- A. Install decking perpendicular to framing members, with ends staggered, over firm



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bearing.

- B. Secure with fasteners.
- C. Maintain decking joint space of 1/16 inch maximum.
- D. Cut decking to accommodate roof drain and flange.

3.05 CLEANING

- A. All excess materials, if any, shall be removed from the job site by the contractor in accordance with contract provisions.
- B. All surrounding areas where the wood decking has been installed and the finish applied shall be left free of debris and foreign substances resulting from the contractor's work.

END OF SECTION 06 15 33



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SECTION 06 16 23 SUBFLOORING

PART 1 GENERAL

1.01 SECTION REQUIREMENTS

- A. Submittals: Product Data.

PART 2 PRODUCTS

2.01 SUBFLOORING AND UNDERLAYMENT

- A. Subflooring:
 - 1. Plywood Subflooring: 1-1/8" thick tongue and groove, 48/24 span rating Advantech subfloor. Glue and screw sheathing to floor beams.
 - 2. Plywood Underlayment for Ceramic Tile: DOC PS 1, Exterior, C-C Plugged, not less than 5/8-inch (15.9-mm) nominal thickness.

2.02 MISCELLANEOUS PRODUCTS

- A. Fasteners: 8d common nails at 4" o.c. at each sheet perimeter and 12" o.c.
- B. Adhesives for Field Gluing Panels to Framing: BF Goodrich PL400 or equal

PART 3 EXECUTION

3.01 INSTALLATION

- A. Securely attach to substrates, complying with "Alternate Attachments," in ICC's International Residential Code for One- and Two- Family Dwellings.
- B. Fastening Methods:
 - 1. Combination Subfloor-Underlayment:
 - a. Glue and nail to wood framing.
 - b. Screw to cold-formed metal framing.



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2. Subflooring:
 - a. Glue and nail to wood framing.
 - b. Screw to cold-formed metal framing.

3. Underlayment:
 - a. Nail to subflooring.

END OF SECTION 06 16 23



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SECTION 06 20 00 FINISH CARPENTRY

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Exterior Finish Carpentry:
 - a. Standing and running trim.
 - b. Ramps
 - c. Handrails
 - d. Decking.
 - e. Sunshades.
 - f. Pergola.
2. Interior Finish Carpentry:
 - a. Standing and running trim.
 - b. Door frames.
 - c. Shelving.
 - d. Clothes rods.
 - e. Interior Casework

1.02 SUBMITTALS



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A. Product Data:

1. Submit data on fire retardant treatment materials and application instructions.
2. Submit data on preservative treatment materials and application instructions.
3. Submit data on plastic finish carpentry products.
4. Submit data on attachment hardware, finish hardware, and specific design casework.

B. Shop Drawings:

1. Indicate materials, component profiles, fastening methods, jointing details, finishes, and accessories.

C. Samples:

1. Submit two 6 x 6 inch size samples illustrating wood grain and specified finish.

1.03 QUALITY ASSURANCE

A. Perform work in accordance with Custom Grade.

- B. Surface Burning Characteristics: Maximum 25/45 flame spread/smoke developed index when tested in accordance with ASTM E84.

PART 2 PRODUCTS

2.01 EXTERIOR FINISH CARPENTRY

A. Manufacturer and Product List:

1. Hardwood Manufacturers Southern Cypress Manufacturer Association.
2. Substitutions permitted.

B. Exterior Running Trim: Cypress.

1. Cornice Trim: Sizes 2 X 12 nominal wood



- 2. String Course: Sizes 2 X 3 nominal wood
- D. Exterior Decking: Treated Southern Yellow Pine
 - 1. Profile: Sizes and profiles as indicated on Drawings.
- E. Sunshade: Cypress
 - 1. Profile: Sizes and profiles as indicated on Drawings.
- F. Pergola: Cypress
 - 1. Profile: Sizes and profiles as indicated on Drawings.
- G. Performance / Design Criteria:
 - 1. Design handrails stairs, pergola, and sunshade under direct supervision of licensed professional.

2.02 INTERIOR FINISH CARPENTRY

- A. Interior Standing and Running Trim: Poplar lumber.
 - 1. Profile: Sizes and profiles as indicated on Drawings.
- B. Interior Door Frames: Poplar lumber.
 - 1. Profile: Sizes and profiles as indicated on Drawings.
- C. Shelving: MDO plywood.
 - 1. Profile: Sizes and profiles as indicated on Drawings.
- D. Interior Clothes Rod: Pine lumber.
 - 1. Profile: Sizes and profiles as indicated on Drawings.

2.03 EXTERIOR MATERIALS



- A. Exterior Softwood Lumber: Cyprus species.
 - 1. Cut: Plain sawn.
 - 2. Finger Jointing: Permitted with waterproof adhesives.
- B. Lumber Moisture Content Range: 10-15 percent.

2.04 INTERIOR MATERIALS

- A. Interior Hardwood Lumber: Poplar species.
 - 1. Cut: Plain sawn.
 - 2. Finger Jointing: Permitted.
- B. Lumber Moisture Content Range: 10 percent.

2.05 WOOD TREATMENT

- A. Fire Retardant Treatment: Chemically treated and pressure impregnated, having flame spread of 25 or less when tested in accordance with ASTM E 84 and showing no evidence of significant progressive combustion when test is continued for an additional 20 minute period, Exterior Type.
- B. Wood Preservative Pressure Treatment: WDMA I.S.4
- C. Provide identification on fire retardant treated material.
- D. Deliver fire retardant treated materials cut to required sizes. Minimize field cutting.
- E. Moisture Content after Treatment: Redried.
 - 1. Lumber: As specified for exterior and interior lumber.
 - 2. Plywood: Maximum 15 percent.

2.06 FABRICATION



- A. Fabricate finish carpentry to AWI AWS Section 6 Custom Premium Grade.
- B. Fabricate handrails, balustrades, pergola, and sunshade to AWI AWS Section 7 Custom Grade.

2.07 FINISHES

- A. Sand work smooth and set exposed nails and screws.
- B. Apply wood filler in exposed nail and screw indentations.
- C. On items to receive transparent finishes, use wood filler matching surrounding surfaces and of types recommended for applied finishes.
- D. Stain, seal, and varnish exposed to view surfaces.
- E. Seal internal surfaces and semi-concealed surfaces.
- F. Prime paint surfaces in contact with cementitious materials.

2.08 ACCESSORIES

- A. Fasteners and Anchors:
 - 1. Fasteners: ASTM A153/A153M, hot dipped galvanized steel for high humidity and treated wood locations, unfinished steel elsewhere.
 - 2. Nails and Staples: ASTM F1667.
- B. Contact Adhesives: Water Base type.
- C. Wall Adhesive: Cartridge type, compatible with wall substrate, capable of achieving durable bond.
- D. Primer: Acrylic primer sealant type.
- E. Wood Filler: Solvent base, tinted to match surface finish color.

PART 3 EXECUTION

3.01 EXAMINATION



- A. Verify field conditions are acceptable and are ready to receive work.

3.02 PREPARATION

- A. Prime paint surfaces of wood items and assemblies to be in contact with cementitious materials.
- B. Prime paint surfaces of exterior wood items and assemblies.

3.03 INSTALLATION

- A. Install work in accordance with AWI AWS Section 6 and Custom] Grade and manufacturer's instructions.
- B. Set and secure materials and components in place, plumb and level.
- C. Install trim with screws
- D. Install prefinished paneling with screws
- E. Install hardware supplied by Section 08 71 00.
- F. Site Applied Wood Treatment:
 - 1. Brush apply one coat of preservative treatment on wood in contact with cementitious materials
 - 2. Treat site-sawn cuts. Apply preservative to site-sawn cuts in accordance with WDMA I.S.4.
 - 3. Allow preservative to dry prior to erecting members.
- G. Preparation For Finish:
 - 1. Sand work smooth and set exposed fasteners. Apply wood filler in exposed fastener indentations.



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3.04 ATTACHMENTS

A. Exterior Finish Carpentry:

1. Brackets, Finials, and Pediments: Clear fir, prepare for paint finish.
2. Handrails Cyprus: Prepare for stained and sealed finish.
3. Soffits and Facias: Cyprus, prepare for paint finish.

B. Interior Finish Carpentry:

1. Window Sills: Plastic laminate finish.
2. Balustrades, and Handrails: Clear fir, prepare for stained finish.
3. Moldings, Bases, Casings, and Miscellaneous Trim: Clear Cyprus, prepare for paint finish.

END OF SECTION 06 20 00



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SECTION 06 20 23 INTERIOR FINISH CARPENTRY

PART 1 GENERAL

- 1.01 Grades of interior architectural woodwork shall comply with AWI's "Architectural Woodwork Quality Standards."
- 1.02 Submittals: Product Data.

PART 2 - PRODUCTS

2.01 STANDING AND RUNNING TRIM

- A. Douglas Fir trim to be installed to conceal LVL in modules as indicated in drawings.
 - 1. AWI 300
 - 2. Transparent Finish: Premium
- B. Baseboard
 - 1. Poplar
 - 2. Finish: Painted Black

PART 3 - EXECUTION

3.01 INSTALLATION

- A. All woodwork shall comply with Custom grade, per AWI section 400.
- B. Wood to be conditioned to ambient level of humidity in installation area before time of fabrication for no less than 24 hours. Moisture content of wood to meet manufacturer's recommendations for finish carpentry.
- C. Woodwork to comply with quality standard for Grade 1. Substrate to be inspected for plumb and rigidity before installation.



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- D. Woodwork shall be installed level, plumb, true and straight, with use of shims as required. Level and plumb shall be inspected for a tolerance of 1/8 inch in 8 feet.
- E. Carpentry shall be scribed and cut to fit adjoining framing. Nails to be countersunk, then surfaces filled, sanded and refinished to match adjoining work. Blind nailing used where possible, as in interior shelving.

END OF SECTION 06 20 23



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Division 7



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SECTION 07 62 00 SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes flashings, gutters and downspouts and fabricated sheet metal items.

1.02 SYSTEM DESCRIPTION

- A. Sheet Metal System: Conform to criteria of SMACNA "Architectural Sheet Metal Manual."
 - 1. Gutters: SMACNA Details as indicated on drawings.
 - 2. Downspouts: SMACNA Details as indicated on drawings.
 - 3. Flashings: SMACNA Details as indicated on drawings.
 - 4. Splash Plan: SMACNA Details as indicated on drawings.
 - 5. Roof Coping: SMACNA Details as indicated on drawings.
- B. Gutters and Downspouts: Size components for rainfall intensity determined by storm occurrence of 1 in 5 years in accordance with SMACNA recommendations.

1.03 SUBMITTALS

- A. Shop Drawings: Indicate material profile, jointing pattern, jointing details, fastening methods, flashings, termination, and installation details.

1.04 WARRANTY

- A. Furnish two year manufacturer warranty for finishes.

PART 2 PRODUCTS

2.01 SHEET METAL FLASHING AND TRIM



A. Fabricators:

1. Gutters. Englert Inc.
2. Downspouts. Englert Inc.
3. Splash Pan.
4. Flashing.
5. Roof Coping.
6. Substitutions: Not Permitted.

- B. Product Description: Flashing and sheet metal; unfinished or prefinished, including gutters, downspouts, splash pans and roof copings.

2.02 COMPONENTS

- A. Seal joints watertight.
- B. Install snow guards as indicated on Drawings.

2.03 ACCESSORIES

- A. Fasteners: Galvanized steel
- B. Gutter and Downspout Anchorage Devices: recommended by fabricator.
- C. Gutter Supports: Brackets Downspout Supports: Brackets

2.04 FABRICATION

- A. Gutter Accessories: Profiled to suit gutters and downspouts.
- B. Gutters: Metal profile as indicated on Drawings.
 1. Manufacturer: Englert Inc



2. Model: RainPro
3. Color: Charcoal
- C. Downspouts: Aluminum 3 inch x 4 inch profile as indicated on Drawings.
 1. Manufacturer: Englert
- D. Roof Coping: profile as indicated on Drawings.
 1. Manufacturer: Englert Continuous Cleat Coping.
 2. 24 ga. Steel Color: Charcoal.
- E. Form components to shape indicated on Drawings, accurate in size, square, and free from distortion or defects. Form pieces in longest practical lengths.

2.05 SHOP FINISHING

- A. Class I Natural Anodized Finish: AAMA 611 Clear anodic coating not less than 0.7 mils thick.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set, cant strips and reglets in place, and nailing strips located.
- B. Verify membrane termination and base flashings are in place, sealed, and secure.

3.02 PREPARATION

- A. Paint concealed metal surfaces and surfaces in contact with dissimilar metals with protective backing paint to minimum dry film thickness of 15 mil.

3.03 INSTALLATION

- A. Install starter and edge strips, and cleats.



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- B. Install surface mounted reglets. Seal top of reglets with sealant. Insert flashings to form tight fit. Seal flashings into reglets with sealant.
- C. Secure flashings, gutters and downspouts in place using concealed fasteners.

END OF SECTION 07 62 00



SECTION 07 91 16
JOINT GASKETS

PART 1 GENERAL

1.01 SECTION REQUIREMENTS

- A. Submittals: Product Data.

PART 2 PRODUCTS

2.01 BUILDING GASKET FOR USE IN ROOF SEPARATION JOINT:

A. Conservation Technology

1. Structural Gasket, Cellular EPDM (Ethylene propylene diene monomer); ASTM D-7465, Type I; 5" wide, 82' lengths
2. Part number: BG65
3. http://www.conservationtechnology.com/building_gaskets.html

2.02 BUILDING GASKET FOR USE IN MODULE SEPARATION JOINT

A. Conservation Technology

1. Gap Gasket, Cellular EPDM (Ethylene propylene diene monomer); ASTM D-7465, Type I; 3/4" wide, 164' lengths
2. Part number: BG46
3. http://www.conservationtechnology.com/building_gaskets.html

B. Conservation Technology

1. Gap Gasket, Cellular EPDM (Ethylene propylene diene monomer); ASTM D-7465, Type I; 1" wide, 82' lengths
2. Part number: BG48



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3. http://www.conservationtechnology.com/building_gaskets.html

PART 3 EXECUTION

3.01 INSTALLATION

- A. Prepare substrate by cleaning, removing projections and filling voids and as otherwise recommended by manufacturer's written instructions.
- B. Install joint gaskets in accordance with reviewed product data, manufacturer's written recommendations, and as indicated on the Drawings. Install joint gaskets at the depth recommended by the sealant manufacturer. Do not use with hot-applied sealants.

3.02 COMPATIBILITY

- A. Closed cell polyethylene foam is basically an inert material; and therefore, it is compatible, both physically and chemically, with virtually all known cold-applied sealants, including, but not limited to, self-leveling types.

END OF SECTION 07 91 16



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SECTION 07 92 00
JOINT SEALANTS

PART 1 GENERAL

1.01 SECTION REQUIREMENTS

- A. Submittals: Product Data and color Samples.
- B. Environmental Limitations: Do not proceed with installation of joint sealants when ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (4.4 deg C).
- C. Compatibility: Provide joint sealants, joint fillers, and other related materials that are compatible with one another and with joint substrates under service and application conditions.

PART 2 PRODUCTS

2.01 Gap Filler:

- A. DOW
 - 1. GREAT STUFF™ Gaps & Cracks Insulating Foam Sealant. Single-component, closed cell polyurethane post-expanding foam. UL Classified
 - 2. <http://building.dow.com/na/en/products/sealants/gapcracks.htm>
- B. DOW
 - 1. GREAT STUFF™ Window & Door. Single-component closed cell polyurethane foam sealant. UL Classified.
 - 2. <http://building.dow.com/na/en/products/sealants/windowdoor.htm> Joint Filler
- C. TREMCO
 - 1. Tremflex 834 gun-grade general purpose acrylic latex sealant. It can be used indoors and outdoors and is tack-free in 15 minutes and ready to paint in 30-45 minutes with

latexes or oil-based paint.

2. <http://www.tremcosealants.com/filesshare/pds/tflex834.pdf>

2.02 Sealant for TPO Roof Penetrations:

A. FIRESTONE:

1. Water-Block Seal (S-20) Butyl Rubber Sealant. Designed to provide a seal when used in compression as required by Firestone Details.
2. <http://www.firestonebpco.com/templateFiles/includes/common/displayFile.ashx?fileId=2242>

B. RED DEVIL

1. Butyl Rubber Sealant. A high quality, tough, butyl rubber sealant, ideal for jobs requiring a durable watertight seal
2. http://www.reddevil.com/msds-tds/tds_0698.pdf

2.03 Sealant for Use in Interior Joints in Ceramic Tile and Other Hard Surfaces in Kitchens and Toilet Rooms and Around Plumbing Fixtures:

A. GE

1. SCS1700 Sanitary single-component, mildew-resistant silicone sealant.
2. http://www.siliconeforbuilding.com/pdf/speciality/Data_Sheet_SCS1700_Sanitary.pdf

2.04 Sealant for Exterior Use at Perimeters of Translucent Wall Panels:

A. TREMCO

1. Spectrem® 1. Ultra low modulus, high performance, one-part, moisture curing silicone joint sealant.
2. <http://www.tremcosealants.com/filesshare/pds/Spectrem1DSEnglish.pdf>

2.05 Fire Protection Sealant:

A. TREMCO

1. Fyre-Caulk intumescent acrylic sealant. Designed for use in commonly encountered applications where both combustible and noncombustible through penetrations are present. To be used with Roxul insulation where needed to fill larger gaps in penetrations.
2. http://www.tremcosealants.com/fileshare/pds/FyreCaulk_DS.pdf

2.06 Sealant for Use on Galvanized Aluminum Flashing and Gutters:

A. DAP

1. Silicone Sealant. An all-purpose, one component, acetoxycure sealant ideal for indoor/outdoor use. It provides a watertight, flexible seal that won't crack, crumble or shrink. It meets ASTM Specification C 920, Class 25, Type S, Grade NS and has a 50 year durability guarantee.
2. <http://www.dap.com/docs/tech/00000683.pdf>

2.07 MISCELLANEOUS MATERIALS

- A. Provide sealant backings of material that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C 1330, of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.
- D. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 - EXECUTION



3.01 INSTALLATION

- A. Sealants must be installed and maintained according to the manufacturer's current instructions.
- B. Prepare substrate by cleaning, removing projections, and as otherwise recommended in manufacturer's written instructions.
- C. Install sealant backings to support sealants during application and to produce cross-sectional shapes and depths of installed sealants that allow optimum sealant movement capability.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Acoustical Sealant Installation: At sound-rated assemblies and elsewhere as indicated, seal perimeters, control joints, openings, and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions. Comply with ASTM C 919.

END OF SECTION 07 92 00



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Division 8



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SECTION 08 32 16
SLIDING PLASTIC-FRAMED GLASS DOORS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Vinyl sliding patio doors.

1.02 RELATED REQUIREMENTS

- A. Section 07 27 00 – Air Barriers: Water-resistant barrier.
- B. Section 07 92 00 – Joint Sealants: Sealants.

1.03 REFERENCE STANDARDS

- A. American Architectural Manufacturers Association (AAMA):
 - 1. AAMA 502 – Voluntary Specification for Field Testing of Newly Installed Fenestration Products.
- B. ASTM International (ASTM):
 - 1. ASTM C 1036 – Standard Specification for Flat Glass.
 - 2. ASTM C 1048 – Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass.
 - 3. ASTM E 330 – Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.
 - 4. ASTM F 588 – Standard Test Methods for Measuring the Forced Entry Resistance of Window Assemblies, Excluding Glazing Impact.
- C. Screen Manufacturers Association (SMA):
 - 1. SMA 1201 – Specifications for Insect Screens for Windows, Sliding Doors and Swinging Doors.

- D. Window and Door Manufacturers Association (WDMA):
 - 1. AAMA/WDMA/CSA 101/I.S.2/A440 – North American Fenestration Standard/Specification for Windows, Doors, and Skylights.

1.04 SUBMITTALS

- A. Comply with Section 01 33 00 – Submittal Procedures.
- B. Product Data: Submit manufacturer's product data, including installation instructions.
- C. Shop Drawings: Submit manufacturer's shop drawings, indicating dimensions, construction, component connections and locations, anchorage methods and locations, hardware locations, and installation details.
- D. Samples: Submit full-size or partial full-size sample of vinyl sliding patio doors illustrating glazing system, quality of construction, and color of finish.
- E. Manufacturer's Certification: Submit manufacturer's certification that materials comply with specified requirements and are suitable for intended application.
- F. Cleaning and Maintenance Instructions: Submit manufacturer's cleaning and maintenance instructions.
- G. Warranty Documentation: Submit manufacturer's standard warranty.

1.05 QUALITY ASSURANCE

- A. Installer's Qualifications:
 - 1. Installer regularly engaged, for past 5 years, in installation of vinyl sliding patio doors of similar type to that specified.
 - 2. Employ persons trained for installation of vinyl sliding patio doors.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Delivery:



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1. Deliver doors to site undamaged in manufacturer's or sales branch's original, unopened containers and packaging, with labels clearly identifying manufacturer and product name.
 2. Include installation instructions.
- B. Storage and Handling:
1. Store and handle doors in accordance with manufacturer's instructions.
 2. Store doors off ground and under cover.
 3. Provide full support under framework when storing, handling, and installing doors.
 4. Allow sufficient spacing between doors during storage for ventilation.
 5. Do not lift doors by head member only.
 6. Protect doors from weather, direct sunlight, and construction activities.
 7. Protect doors and finish during handling and installation to prevent damage.

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. Pella Corporation, 102 Main Street, Pella, Iowa 50219. Toll Free 800-54-PELLA. Phone 641-621-1000. Website www.pella.com.

2.02 PERFORMANCE REQUIREMENTS

- A. Performance:
1. Meets or exceeds AAMA/WDMA/CSA 101/I.S.2/A440 Ratings: SD-R50, WDMA Hallmark Certified.
 2. Air Infiltration, 1.57 psf wind pressure: 0.30 cfm/ft² of frame.
 3. Design Pressure: 50 psf.



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4. Water Resistance: 7.5 psf.
- B. Forced Entry Resistance, ASTM F 842, Minimum Security Grade: 10.
- C. Maximum Operating Force:
 1. Initiate Motion: 30 lbs.
 2. Maintain Motion: 20 lbs.
- D. Meets U.S. ENERGY STAR guidelines.

2.03 VINYL SLIDING PATIO DOORS

- A. Vinyl Sliding Patio Doors: Pella 350 Series.
- B. Frame:
 1. Interior and Exterior Frame Surfaces: Extruded, rigid, polyvinyl chloride (PVC).
 2. Overall Frame Depth: 6 inches.
 3. Frame Members: Mitered and heat fused to provide fully welded corner assembly with "SmoothSeam" virtually invisible corner welds.
 4. Sill: Fitted with weeps.
 5. Frame Type:
 - a. Setback Nail Fin, 1-3/8 inches: For 4-9/16-inch wall depth.
 - b. Setback Nail Fin, 1 inch: For 4-15/16-inch wall depth.
 - c. Block Frame: For 6-inch wall depth.
 - d. Double Wall Flush Flange: For 5-1/2-inch wall depth.
- C. Door Panels:

1. Door Panel: Extruded, rigid, PVC.
 2. Panel Members: Mitered and heat fused to provide fully welded corner assembly with "SmoothSeam" virtually invisible corner welds.
 3. Vent Panels:
 - a. Fully operable for ventilation.
 - b. Two adjustable rollers, set on stainless steel track cap.
 4. Contains sealed insulating glass.
 5. Wet glazed with polyurethane-reactive hotmelt.
- D. Insulating Glazing:
1. Float Glass: ASTM C 1036.
 2. Exterior face-glazed sealed insulating glass.
 4. Triple-Pane Insulating Glass:
 - a. Total Thickness: 1-3/8 inches.
 - b. Tempered Safety Glass: ASTM C 1048.
 - c. Advanced Low-E coated, with argon.
 - d. "NaturalSun" Low-E coated, with argon.
 - e. High-Altitude Low-E coated.
 - f. Obscure.
- E. Single-Glass Impact-Resistant Glazing: "HurricaneShield".
1. Total Thickness: 7/16 inch.

2. Laminated Clear, ASTM C 1172.
 3. Laminated "SunDefense" Low-E.
 4. Laminated Bronze Tint.
 5. Laminated Gray Tint.
- F. Weatherstripping: Fin-type pile around perimeter of vent panel.

2.04 HARDWARE

- A. Interior Handle and Thumb Lock:
1. Finish: [Match door interior] [Bright Brass] [Satin Nickel] [Oil-Rubbed Bronze].
- B. Exterior Handle:
1. Finish: Match door exterior.
- C. Exterior Keylock: Schlage configured "C" key-way pin-lock cylinder.
- D. Multipoint Lock: [Electroplated steel] [Stainless steel].
- E. Door Rollers:
1. Adjustable.
 2. Permanently sealed.
 3. Material: [Electroplated steel with organic-coated ball-bearing rollers] [Corrosion-resistant stainless steel with precision ball-bearing rollers].
- F. Fasteners: Corrosion-resistant, PVC-compatible material.

2.05 SCREENS

A. Screens:

1. Sliding.
2. Full size.
3. Screen Cloth: Black, vinyl-coated, 18/14 mesh, fiberglass screen cloth, SMA 1201.
4. Set in extruded aluminum frame.
5. Four self-adjustable rollers.
6. Latch.
7. Latch handle.

2.06 OPTIONS

A. Blinds: Blinds-between-the-glass.

1. Aluminum blinds sealed between Low-E dual-pane insulating glass.
2. Operation: Cordless tilt, raise, and lower.
3. Color: White.

B. Shades: Shades-between-the-glass.

1. Light-filtering fabric cellular shades sealed between Low-E dual-pane insulating glass.
2. Operation: Cordless raise and lower.
3. Color: Linen.

2.07 TOLERANCES

A. Doors shall accommodate the following opening tolerances:

1. Horizontal Dimensions Between High and Low Points: Plus 1/4 inch, minus 0 inch.



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2. Width Dimensions: Plus 1/4 inch, minus 0 inch.
3. Building Columns or Masonry Openings: Plus or minus 1/4 inch from plumb.

2.08 FINISH

- A. Exposed PVC Surfaces: Smooth, glossy, and uniform in appearance.
- B. Frame Colors:
 1. Exterior/Interior:
 - a. White: Integral color extruded throughout profiles.
 - b. Almond: Integral color extruded throughout profiles.
 - c. Brown: Color-capped perimeter with White integral interior color.

2.09 INSTALLATION ACCESSORIES

- A. Flashing/Sealant Tape: Pella "SmartFlash".
 1. Aluminum-foil-backed butyl window and door flashing tape.
 2. Maximum Total Thickness: 0.013 inch.
 3. UV resistant.
 4. Verify sealant compatibility with sealant manufacturer.
- B. Interior Insulating-Foam Sealant: Low-expansion, low-pressure polyurethane insulating window and door foam sealant.
- C. Exterior Perimeter Sealant: "Pella Window and Door Installation Sealant" or equivalent high quality, multi-purpose sealant as specified in the joints sealant section.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine rough opening to receive vinyl sliding patio doors.
 - 1. Verify rough opening is plumb, level, square, and of proper dimensions.
 - 2. Verify a minimum of 1-1/2 inches of solid wood blocking is installed around perimeter of rough opening.
- B. Notify Architect of conditions that would adversely affect installation or subsequent use.
- C. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 INSTALLATION

- A. Install vinyl sliding patio doors in accordance with manufacturer's instructions.
- B. Install doors plumb, level, square, and without distortion.
- C. Maintain alignment with adjacent work.
- D. Install doors to be weather tight.
- E. Install doors to be freely operating.
- F. Verify proper operation of operating hardware.
- G. Integrate door installation with exterior weather-resistant barrier using flashing/sealant tape.
 - 1. Apply and integrate flashing/sealant tape with weather-resistant barrier using watershed principles in accordance with door manufacturer's instructions.
- H. Seal doors to exterior wall cladding with sealant and related backing materials at perimeter of assembly.
- I. Place interior seal around door perimeter to maintain continuity of building thermal and air barrier using insulating-foam sealant.
- J. Leave doors closed and locked.

3.03 FIELD QUALITY CONTROL



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- A. Field Testing: Field test vinyl sliding patio doors in accordance with AAMA 502.

3.04 CLEANING

- A. Clean vinyl sliding patio doors in accordance with manufacturer's instructions.
- B. Do not use harsh cleaning materials or methods that could damage finish, vinyl, or glass.
- C. Remove labels and visible markings.
- D. Keep door tracks clear of dirt and debris.
- E. Keep weep holes open and clear of obstructions.

3.05 PROTECTION

- A. Protect installed vinyl sliding patio doors to ensure that, except for normal weathering, doors will be without damage or deterioration at time of substantial completion.

END OF SECTION 08 32 16



SECTION 08 41 13
ALUMINUM – FRAMED ENTRANCES AND STOREFRONTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Engineered sliding/folding aluminum and glass door system, including aluminum frame, threshold, panels, sliding/folding and locking hardware, weather stripping, glass and glazing; designed to provide an opening glass wall, with sizes and configurations as shown on drawings and specified herein, NanaWall SL60, Thermally Broken Aluminum Framed Folding System as supplied by NANA WALL SYSTEMS, INC.

1.02 REFERENCES

A. American Architectural Manufacturers Association (AAMA):

1. AAMA 611, Voluntary Specification for Anodized Architectural Aluminum.
2. AAMA 2604, Voluntary Specifications, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels.
3. AAMA 1304, Voluntary Specifications for Forced Entry Resistance of Side-Hinged Door Systems.

B. American National Standards Institute (ANSI):

1. ANSI Z97.1, Safety Performance Specifications and Methods of Test for Safety Glazing Material Used In Buildings.

C. American Society for Testing and Materials (ASTM):

1. ASTM E 283, Test Method for Rate of Air Leakage through Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference.
2. ASTM E 330, Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference.



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3. ASTM E 547, Test Method for Water Penetration of Exterior Windows, Curtain Walls, and Doors by Cyclic Static Air Pressure Differential.

4. ASTM E 331, Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.

D. Consumer Product Safety Commission (CPSC):

1. CPSC 16CFR-1201, Safety Standard for Architectural Glazing Materials.

E. National Fenestration Rating Council (NFRC):

1. NFRC 100, Procedure for Determining Fenestration Product Thermal Materials.

2. NFRC 200, Procedure for Determining Solar Heat Gain Coefficient.

3. NFRC 400, Procedure for Determining Fenestration Product Air Leakage

1.03 SUBMITTALS

A. Detail Drawings: Indicate dimensioning, direction of swing, configuration, swing panels, typical head jamb, side jambs and sill details, type of glazing material, and handle height.

B. Product Data: Manufacturer's literature including independently tested data listing performance criteria and Owner's Manual with installation instructions.

C. Contract Closeout Submittal: Submit Owner's Manual from manufacturer. Identify with project name, location and completion date, type and size of unit installed.

1.04 QUALITY ASSURANCE

A. Manufacturer: Provide complete, precision built, engineered, pre-fitted unit by a single source manufacturer with at least 20 years experience in providing folding/sliding door systems for large openings in the North American market.

1. The manufacturer must have a quality management system registration to the ISO 9001:2008 standard.



B. Performance Requirements: Provide from manufacturer that has independently tested typical units. Testing results to include air infiltration in accordance with ASTM E 283 and NFRC 400, water penetration in accordance with ASTM E 547 and E 331, structural loading in accordance with ASTM E 330, and forced entry in accordance with AAMA 1304.

SPECIFIER'S NOTE: Air infiltration and water penetration testing results can only be applicable if the unit matches the test unit in the direction of opening and the type of sill. Structural load testing results are only applicable for the test unit size, type of locking and type of mounting. (Comparative analysis charts published by manufacturer show which panel sizes (if any) would meet structural loading design pressures specifically required for the project. Check for limitations on the use of these charts in the jurisdiction of the project). Forced entry testing results are only applicable for the test unit type of locking. See manufacturer's latest published data.

C. Thermal Performance U factor: Unit to be rated, certified and labeled in accordance with NFRC 100, shown in manufacturer's latest published data for the glazing, sill, and direction of opening specified.

D. Solar Heat Gain Coefficient: Unit to be rated, certified and labeled in accordance with NFRC 200, shown in manufacturer's latest published data for the glazing, sill, and direction of opening specified.

SPECIFIER'S NOTE: If desired, Energy Star ratings can be achieved by the use of proper glass with the unit. See NanaWall's Performance data for details.

E. Installer Qualifications: Installer experienced in the installation of manufacturer's products or other similar products for large openings. Installer to provide reference list of at least 3 projects of similar scale and complexity successfully completed in the last 3 years.

1.05 WARRANTY

A. Provide manufacturer's standard warranty against defects in materials and workmanship.

B. Warranty Period: Ten years for rollers and for seal failure of insulated glass supplied. For all other components, one year (two years if unit is installed by manufacturers certified trained installer) from date of delivery by manufacturer.

1.06 SITE CONDITIONS, DELIVERY, STORAGE AND HANDLING



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A. In addition to general delivery, storage and handling requirements specified in Section 01600, comply with the following:

1. Deliver materials to job site in sealed, unopened cartons or crates. Protect units from damage. Store material under cover, protected from weather and construction activities.

PART 2 - PRODUCTS

2.01 SUPPLIER

NANA WALL SYSTEMS, INC.
100 Meadowcreek Drive #250
Corte Madera, CA 94925
Toll Free: (800) 873-5673
Telephone: (415) 383-3148
Fax: (415) 383-0132
Website: www.nanawall.com
Email: info@nanawall.com

2.02 MATERIALS

A. Frame and Panels: From manufacturer's standard profiles, provide head track, side jambs, and panels with dimensions shown on drawings.

1. Provide panels with:

Standard one lite

[OR with horizontal mullion(s) at specified height(s) from the bottom of the panel]

[OR with simulated divided lites in pattern as shown on drawings].

2. Provide standard bottom rail.

3. Aluminum Extrusion: Extrusions with nominal thickness of .078" (2.0 mm). Alloy specified as AlMgSi0.5 with strength rated as 6063-T5 or F-22 (European standard). Anodized conforming to AAMA 611 or powder coated conforming to AAMA 2604.

4. Thermally broken with a wide Polyamide plastic reinforced with glass fibers. Polyamide plastic less than 7/8 (22 mm) wide or pour and de-bridge thermal break will not be accepted.

5. Aluminum Finish:

Select from NanaWall Powder Coating Finish Chart

[OR clear anodized]

[OR select from range of RAL high gloss powder coated finishes available from manufacturer]

[OR select from range of RAL matte powder coated finishes available from manufacturer]

[OR custom finish]

Same [OR different] finishes on inside and outside

B. Glass:

1. All glass to comply with safety glazing requirements of ANSI Z97.1 and CPSC 16CFR 1201. Provide manufacturer's standard glass with dry glazing:

15/16" (24 mm) insulating clear safety

[OR 15/16" (24 mm) insulating argon filled Low-E safety]

[OR 15/16" (24 mm) insulating krypton filled Heat Mirror TC88 safety]

[OR 1 1/2" (38 mm) triple insulating argon filled Low-E safety]

[OR other glass available from manufacturer, including glass with other total thickness]

2. Provide manufacturer's standard glass spacers. Provide without capillary tubes [OR with capillary tubes].

C. Locking Hardware and Handles:

1. Main entry panel:

On the main entry panel for models with a pair of swing panels, provide manufacturer's standard lever handles on the inside and outside, a Schlage compatible lock set with lockable latch, multi-point locking with a dead bolt and rods at the top and bottom on primary panel. Rods to be concealed and not edge mounted. After turn of key or thumbturn, depression of handles withdraws latch. Lifting of handles engages rods and turn of key or thumb turn engages deadbolt and operates lock. On the secondary swing panel, provide matching dummy lever handles on both sides and concealed flush bolts that operate the rods at the top and the bottom for the secondary swing panel.

Stainless steel lever handles in a titanium black finish

[OR stainless steel lever handles in a brushed satin finish]

[OR oil rubbed bronze solid brass lever handles]

[OR satin nickel solid brass lever handles]

[OR white solid brass lever handles]

[OR on the main entry panel for models with a swing panel, provide manufacturer's standard lever handles on the inside and outside, a Schlage compatible lock set with lockable latch, multi-point locking with a dead bolt and rods at the top and bottom on primary panel only. Rods to be concealed and not edge mounted. After turn of key or thumbturn, depression of handles withdraws latch. Lifting of handles engages rods and turn of key or thumb turn engages dead bolt and operates lock. If there is a secondary swing panel, provide two point locking with flat handles on inside only for the secondary swing panel.

Stainless steel lever handles in a titanium black finish

[OR stainless steel lever handles in a brushed satin finish]

[OR oil rubbed bronze solid brass lever handles]

[OR satin nickel solid brass lever handles]

[OR white solid brass lever handles]

[OR on main entry pair of panels on in swing models without a swing panel, provide manufacturer's standard L-shaped handle on the inside, flat handle on the outside and lock set with profile cylinder. Operation of lock set is by turn of key from the outside and with a thumbturn from the inside with a two point locking hardware operated by 180° turn of the handle.]

Stainless steel L shaped handles in a titanium black finish

[OR stainless steel L shaped handles in a brushed satin finish]

[OR L shaped handles in a brown nylon finish]

[OR L shaped handles in a gray nylon finish]

[OR L shaped handles in a white nylon finish]

[OR on main entry pair of panels on outswing models without a swing panel, provide manufacturer's standard flat handle on the inside and on the outside and a lock set with a profile cylinder. Operation of lock set is by turn of key from the outside and from the inside with a two point locking hardware operated by 180° turn of the handle.

SPECIFIER'S NOTE: Key operation from the inside may not meet egress requirements.]

[OR on main entry panel, provide manufacturer's standard flat handle on inside only with concealed two point locking hardware operated by 180° turn of handle.

SPECIFIER'S NOTE: Note that with this option, the main entry panel is operable from inside only and that there is no latch.]

SPECIFIER'S NOTE: Note that other compatible lever handle styles and finishes are available from other suppliers.]

2. On all other secondary swing panels and pairs of folding panels, provide manufacturer's standard flat handles and concealed two point locking hardware operated by 180° turn of handle between each pair. Face applied flush bolt locking will not be allowed.

3. Flat Handle Finish:

Stainless steel in a titanium black finish

[OR stainless steel in a brushed satin finish]

[OR closest powder coat match to aluminum profile finish]

Provide handle height centered at 41 3/8" [OR as specified] from bottom of panel.

Aluminum locking rods with fiber glass reinforced polyamide end caps at top and bottom. Rods to have a stroke of 15/16" (24 mm).

If there are more than one unit, keyed alike [OR keyed differently].

D. Sliding/Folding Hardware: Provide manufacturer's standard combination sliding and folding hardware with top, bottom tracks and threshold. All running carriages to be with sealed, self-lubrication, ball bearing multi-rollers. Surface mounted hinges and running carriages will not be allowed. Weight of panels to be borne by the bottom of the guide channel in the sill will not be allowed.

1. For each pair of folding panels:

For top hung system SL60/o, provide cardanic, independently suspended, four wheeled coated with fiber glass reinforced polyamide upper running carriage and lower guide carriage. Running carriage to be adjustable in height, 1/4" (6 mm) up and down.

[OR for floor mounted system SL60/u, provide upper guide carriage and lower running carriage with two vertical stainless steel wheels and two horizontal wheels. The vertical wheels to ride on stainless steel guide track covers over the full length of sill track and lie above the water run-off level. Carrying capacity of lower running carriage to be 220 lbs. (100 kgs) Wheels rolling below the water run off level and/or riding on aluminum surfaces will not be accepted.]

2. Threshold:

Thermally broken with polyamide raised sill in the same finish as panel finish

[OR clear anodized flush sill]

[OR dark bronze anodized flush sill]

[OR clear anodized thermally broken with polyamide low profile saddle sill]

[OR dark bronze anodized thermally broken with polyamide low profile saddle sill]

[OR clear anodized Surface Mounted Interior Sill (not thermally broken)]

[OR bronze anodized Surface Mounted Interior Sill (not thermally broken)]

A cover plate over the sill will not be allowed.

3. Provide on all four corners of panels, thermally broken, die cast zinc multi-functional corner fittings with carriage connectors, hinges and hinge pins as required. Finish: Powder coated, closest match to finish of frame and panels.

SPECIFIER'S NOTE: Note that as corner connectors are only available in powder coated finishes, if anodized panel and frame finishes are selected, there may be aesthetic issues.

4. Adjustment: Provide system capable of specified amount of adjustments without removing panels from tracks, 5/32" (4 mm) in width per side jamb hinge.

E. Other Components:

1. Weather stripping: Provide manufacturer's standard double layer EPDM or brush seals with a two layer polyamide fin at both the inner and outer edge of door panels or on frame for sealing between panels and between panel and frame. Single layer weather stripping will not be allowed.

2. Provide tapered pins or machine screws for connecting frame components.

2.03 FABRICATION

A. Use extruded aluminum frame and panel profiles with male-female interlocking, corner connectors and hinges, sliding and folding hardware, locking hardware and handles, glass and glazing and weather stripping as specified herein to make a folding glass wall. Factory pre-assemble as is standard for manufacturer and ship with all components and installation instructions.

B. Sizes and Configurations: See drawings for selected custom dimensions within maximum frame sizes possible as indicated in manufacturer's literature. See drawings for selected number of panels and configuration. Inward [OR outward] opening unit. On configurations with a pair of swing panels, looking from inside, primary swing panel on the left [OR right].

2.04 ACCESSORIES (Edit for project requirements.)

A. Provide the NanaScreen, a series of vertical, collapsible, pleated screen panels. Provide pleated screen material with floor tracking chain with 1/4" (5 mm) floor track. See drawings for selected number of panels and configuration.

Provide aluminum top track, side jambs, and vertical struts:

White powder coated

[OR clear anodized]



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[OR dark bronze anodized]

[OR powder coated select from range of RAL powder coated finishes available from manufacturer].

NanaScreen installation within opening [OR extended beyond opening]

B. Provide other side lites, transoms, corner posts, or single or double doors as per drawings provided.

PART 3 - EXECUTION

3.01 ERECTION

A. Because of the large dimensions involved and the weight and movement of the panels, verify the structural integrity of the header such that the deflection with live load and dead loads is limited to the lesser of $L/720$ of the span and $1/4$ (6 mm). Structural support for lateral loads (both wind load and eccentric load when the panels are stacked open) must be provided. It is recommended that all building dead loads be applied to the header prior to installing the NanaWall. If so and if a reasonable amount of time has been allowed for the effect of this dead load on the header, then only the building's live load can be used to meet the above requirements of $L/720$ or $1/4$ (6 mm). If not, both the dead and live loads need to be considered.

It is recommended that all building dead loads be applied to the header prior to installing the NanaWall. If so and if a reasonable amount of time has been allowed for the effect of this dead load on the header, then only the building's live load can be used to meet the above requirements of $L/720$ or $1/4$ (6 mm). If not, both the dead and live loads need to be considered.

B. Examine surfaces of openings and verify dimensions; verify rough openings are level, plumb, and square with no unevenness, bowing, or bumps on the floor.

C. Installation of units constitutes acceptance of existing conditions.

3.02 INSTALLATION

A. Install frame in accordance with manufacturer's recommendations and installation instructions. Properly flash and waterproof around the perimeter of the opening.



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- B. Installer to provide appropriate anchorage devices and to securely and rigidly fit frame in place, absolutely level, straight, plumb and square. Install frame in proper elevation, plane and location, and in proper alignment with other work.
- C. If necessary, provide drain connections from lower track.
- D. Install panels, handles and lock set in accordance with manufacturer's recommendations and installation instructions.
- E. If necessary, adjust hardware for proper operation.
- F. Accessories: Screens; install in accordance with screen manufacturer's recommendations and installation instructions.

END OF SECTION 08 41 13



SECTION 08 53 13
VINYL WINDOWS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Vinyl casement windows.

1.02 RELATED REQUIREMENTS

- A. Section 07 27 00 – Air Barriers: Water-resistant barrier.
- B. Section 07 92 00 – Joint Sealants: Sealants.

1.03 REFERENCE STANDARDS

- A. American Architectural Manufacturers Association (AAMA):
 - 1. AAMA 502 – Voluntary Specification for Field Testing of Newly Installed Fenestration Products.
- B. ASTM International (ASTM):
 - 1. ASTM C 1036 – Standard Specification for Flat Glass.
 - 2. ASTM C 1048 – Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass.
 - 3. ASTM E 330 – Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.
 - 4. ASTM F 588 – Standard Test Methods for Measuring the Forced Entry Resistance of Window Assemblies, Excluding Glazing Impact.
- C. Screen Manufacturers Association (SMA):
 - 1. SMA 1201 – Specifications for Insect Screens for Windows, Sliding Doors and Swinging



Doors.

- D. Window and Door Manufacturers Association (WDMA):
 - 1. AAMA/WDMA/CSA 101/I.S.2/A440 – North American Fenestration Standard/ Specification for Windows, Doors, and Skylights.

1.04 SUBMITTALS

- A. Comply with Section 01 33 00 – Submittal Procedures.
- B. Product Data: Submit manufacturer's product data, including installation instructions.
- C. Shop Drawings: Submit manufacturer's shop drawings, indicating dimensions, construction, component connections and locations, anchorage methods and locations, hardware locations, and installation details.
- D. Samples: Submit full-size or partial full-size sample of vinyl casement windows illustrating glazing system, quality of construction, and color of finish.
- E. Manufacturer's Certification: Submit manufacturer's certification that materials comply with specified requirements and are suitable for intended application.
- F. Cleaning and Maintenance Instructions: Submit manufacturer's cleaning and maintenance instructions.
- G. Warranty Documentation: Submit manufacturer's standard warranty.

1.05 QUALITY ASSURANCE

- A. Installer's Qualifications:
 - 1. Installer regularly engaged, for past 5 years, in installation of vinyl casement windows of similar type to that specified.
 - 2. Employ persons trained for installation of vinyl casement windows.

1.06 DELIVERY, STORAGE, AND HANDLING



A. Delivery:

1. Deliver windows to site undamaged in manufacturer's or sales branch's original, unopened containers and packaging, with labels clearly identifying manufacturer and product name.
2. Include installation instructions.

B. Storage and Handling:

1. Store and handle windows in accordance with manufacturer's instructions.
2. Store windows off ground and under cover.
3. Provide full support under framework when storing, handling, and installing windows.
4. Allow sufficient spacing between windows during storage for ventilation.
5. Do not lift windows by head member only.
6. Protect windows from weather, direct sunlight, and construction activities.
7. Protect windows and finish during handling and installation to prevent damage.

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. Pella Corporation, 102 Main Street, Pella, Iowa 50219. Toll Free 800-54-PELLA. Phone 641-621-1000. Website www.pella.com.

2.02 PERFORMANCE REQUIREMENTS

A. Standard Performance:

1. Meets or exceeds AAMA/WDMA/CSA 101/I.S.2/A440 Ratings: LC-PG40, WDMA Hallmark Certified.
2. Unit assembly shall withstand both positive and negative uniform static air pressure difference without damage when tested according to ASTM E 330.



3. Air Infiltration, 1.57 psf wind pressure: 0.05 cfm/ft² of frame.
4. Design Pressure: 40 psf.
5. Water Penetration Resistance: 6.06 psf.

B. Performance Upgrade:

1. Meets or exceeds AAMA/WDMA/CSA 101/I.S.2/A440 Ratings: LC-PG60, WDMA Hallmark Certified.
2. Unit assembly shall withstand both positive and negative uniform static air pressure difference without damage when tested according to ASTM E 330.
3. Air Infiltration, 1.57 psf wind pressure: 0.05 cfm/ft² of frame.
4. Design Pressure: 60 psf.
5. Water Penetration Resistance: 9.20 psf.

C. Forced Entry Resistance, ASTM F 588, Minimum Security Grade: 40.

D. Maximum Operating Force:

1. Initiate Motion: 15 lbs.
2. Maintain Motion: 6 lbs.

E. Meets U.S. ENERGY STAR guidelines.

2.03 VINYL CASEMENT WINDOWS

A. Vinyl Casement Windows: Pella 350 Series.

B. Frame:

1. Interior and Exterior Frame Surfaces: Extruded, rigid, polyvinyl chloride (PVC).
2. Overall Frame Depth: 4-1/2 inches.

3. Frame Members: Mitered and heat fused to provide fully welded corner assembly with “SmoothSeam” virtually invisible welds.
4. Frame Type:
 - a. Setback Nail Fin, 1-7/16 inches: For 3-1/16-inch wall depth.
 - b. Block Frame: For 4-1/2-inch wall depth.
 - c. Block Frame: For 3-1/4-inch pocket install.
 - d. Flush Flange: For 4-1/16-inch wall depth.
 - e. Integral Flange: For 3-7/8-inch wall depth.
- C. Sash:
 1. Sash Members: Extruded, rigid, PVC [with foam insulation].
 2. Panel Members: Mitered and heat fused to provide fully welded corner assembly with “SmoothSeam” virtually invisible welds.
 3. Contains sealed insulating glass.
 4. Wet glazed with polyurethane-reactive hotmelt.
- D. Glazing:
 1. Float Glass: ASTM C 1036.
 - a. Glass Type: [Annealed] [Tempered safety glass, ASTM C 1048].
 2. Exterior face-glazed sealed insulating glass.
 4. Triple-Pane Insulating Glass:
 - a. Total Thickness: [1-1/4 inches] [1-7/16 inches].

- b. Advanced Low-E coated, with argon.
- c. "NaturalSun" Low-E coated, with argon.
- d. High-Altitude Advanced Low-E coated.
- e. High-Altitude "NaturalSun" Low-E coated.
- f. Obscure: [Standard] [Fern].

E. Weatherstripping:

- 1. Vent: Weatherstripped around sash and frame perimeter with TPE bulb weatherstrip in 2 locations and foam-filled Santoprene rainstrip in 1 location

2.04 HARDWARE

- A. Lock: Factory-installed, single-handle, zinc-die-cast, multipoint unison lock.
- B. Roto Operator:
 - 1. Dual Arm: [DYAD] [Reverse DYAD].
 - 2. Fold-down crank on sill.
- C. Fasteners: Corrosion-resistant, PVC-compatible material.
- D. Hardware Finish: [Match window interior] [Bright Brass] [Satin Nickel] [Oil-Rubbed Bronze].

2.05 SCREENS

- A. Screens: Standard.
 - 1. Screen Cloth: Black, vinyl-coated, 18/14 mesh, fiberglass screen cloth, SMA 1201.
 - 2. Set in extruded aluminum frame and fitted to interior of windows.
 - 3. Screen Frame Finish: Baked enamel.

- a. Color: Match window interior.

2.07 TOLERANCES

- A. Windows shall accommodate the following opening tolerances:
 1. Horizontal Dimensions Between High and Low Points: Plus 1/4 inch, minus 0 inch.
 2. Width Dimensions: Plus 1/4 inch, minus 0 inch.
 3. Building Columns or Masonry Openings: Plus or minus 1/4 inch from plumb.

2.08 FINISH

- A. Exposed PVC Surfaces: Smooth, glossy, and uniform in appearance.
- B. Frame Colors:
 1. Exterior/Interior:
 - a. White: Integral color extruded throughout profiles.
 - b. Almond: Integral color extruded throughout profiles.
 - c. Brown: Solar reflective coating on PVC on exterior and White integral color on the interior.

2.09 INSTALLATION ACCESSORIES

- A. Flashing/Sealant Tape: Pella "SmartFlash".
 1. Aluminum-foil-backed butyl window and door flashing tape.
 2. Maximum Total Thickness: 0.013 inch.
 3. UV resistant.
 4. Verify sealant compatibility with sealant manufacturer.
- B. Interior Insulating-Foam Sealant: Low-expansion, low-pressure polyurethane insulating

window and door foam sealant.

- C. Exterior Perimeter Sealant: "Pella Window and Door Installation Sealant" or equivalent high quality, multi-purpose sealant as specified in the joints sealant section.
- D. Jamb Extensions: Factory-applied, [primed-wood] [unfinished] jamb extensions for [4-9/16-inch] [6-9/16-inch] wall depth.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine rough opening to receive vinyl casement windows.
 - 1. Verify rough opening is plumb, level, square, and of proper dimensions.
 - 2. Verify a minimum of 1-1/2 inches of solid wood blocking is installed around perimeter of rough opening.
- B. Notify Architect of conditions that would adversely affect installation or subsequent use.
- C. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 INSTALLATION

- A. Install vinyl casement windows in accordance with manufacturer's instructions.
- B. Install windows plumb, level, square, and without distortion.
- C. Maintain alignment with adjacent work.
- D. Install windows to be weather tight.
- E. Install windows to be freely operating.
- F. Verify proper operation of operating hardware.
- G. Integrate window installation with exterior weather-resistant barrier using flashing/sealant tape.
 - 1. Apply and integrate flashing/sealant tape with weather-resistant barrier using watershed



principles in accordance with window manufacturer's instructions.

- H. Seal windows to exterior wall cladding with sealant and related backing materials at perimeter of assembly.
- I. Place interior seal around window perimeter to maintain continuity of building thermal and air barrier using insulating-foam sealant.
- J. Leave windows closed and locked.

3.03 FIELD QUALITY CONTROL

- A. Field Testing: Field test vinyl casement windows in accordance with AAMA 502.

3.04 CLEANING

- A. Clean vinyl casement windows in accordance with manufacturer's instructions.
- B. Do not use harsh cleaning materials or methods that could damage finish, vinyl, or glass.
- C. Remove labels and visible markings.
- D. Keep window tracks clear of dirt and debris.
- E. Keep weep holes open and clear of obstructions.

3.05 PROTECTION

- A. Protect installed vinyl casement windows to ensure that, except for normal weathering, windows will be without damage or deterioration at time of substantial completion.

END OF SECTION 08 53 13



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SECTION 08 62 00 UNIT SKYLIGHTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Solar Tube.
2. Roof Flashings.
3. Accessories.

1.02 SYSTEM DESCRIPTION

A.

1.03 SUBMITTALS

A. General: Submit listed submittals in accordance with Conditions of the Contract and Division 01 Submittal Procedures Section.

B. Product Data: Submit manufacturer's product data and installation guides.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Provide products from the following manufacturer:

1. Tom Burke
Architectural Systems of Virginia
PO Box 70351
Richmond, VA 23255
Tel: 804.437.0006
tburke@arch-system.net



2.02 HARDWARE

- A. Model number: 290 DS/290 DSe
- B. Tube Size: 10 in. (250 mm)
- C. Light Coverage Area: 150 – 200 ft² (14 – 19 m²)
- D. Potential Tube Length: 20 ft. (6 m)

A.

2.03 Roof Flashing

A. Flashing

1. For fast and easy installation, Solartube flashings are available for nearly all roof types and pitches. The flashings provide complete protection, fabricated as a single, seamless piece to ensure leakproof performance.

B. No Pitch Flashing

1. 290 DS / 290 DSe
2. Use on low pitched or flat roofs. Available in 4 in. (100 mm) or 6 in. (150 mm) heights
3. Use 6 in. (150 mm) for areas prone to heavy snow loads and on commercial roofs.

2.04 ACCESSORIES

A. Flashing Turret Extensions

- a. Use to raise the height of the Solartube dome on a roof to avoid snow, water, or shading from roof obstructions. Order additional Spectralight infinity Tubing to accommodate turret height. Available in 2 in. (50 mm), 4 in. (100 mm), 12 in. (300 mm), 24 in. (600 mm), 36 in. (900 mm), and 48 in. (1200 mm) sizes.

3.01 INSTALLATION

- A. Install frame using mounting brackets provided with Solartube.
- B. Install flashing in accordance with SolarTube manufacturer's installation guidelines.



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END OF SECTION 08 62 00



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Division 9



SECTION 09 06 23
Bamboo Flooring

PART 1 - GENERAL

1.01 SUMMARY/DESCRIPTION

- A. Stiletto is a collection of natural, amber and color-stained, prefinished bamboo solid strand strip flooring manufactured with no urea formaldehyde and is FSC-certified.
- B. click-lock flooring system, it can be installed with the floating method over an approved underlayment system, or by direct glue down method on concrete, wood, or wood subfloor surfaces. The flooring is suitable for high traffic retail and commercial environments and residential installations and is compatible with radiant floor systems.

C. RELATED SECTIONS

- 1. Section 03 30 00 – Cast-In-Place Concrete
- 2. Section 06 16 23 – Subflooring
- 3. Section 06 16 26 – Underlayment
- 4. Section 06 16 29 – Acoustical Underlayment
- 5. Section 06 46 19 -- Wood Base and Shoe Moldings
- 6. Section 01 04 00 -- Submittals
- 7. Section 01 35 63 – Sustainability Certification Project Requirements

1.02 REFERENCES

- A. ASTM - American Society for Testing and Materials International.
 - 1. ASTM E 648: Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source.



2. ASTM D1037: Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials.
 3. ASTM D3359: Standard Test Method for Measuring Adhesion by Tape Test
 4. ASTM D3501: Standard Test Methods for Wood-Based Structural Panels in Compression.
 5. ASTM D4060: Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
 6. ASTM D4442: Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials.
 7. ASTM D5116-06: Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products [Guidelines also set by the California Department of Health Services (CDHS) Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers (CA/DHS/EHLB/R-174, 2004); also known as, chamber testing portion of CA Section 01350.]
- B. FSC – Forest Stewardship Council
- C. Green Building Rating Systems:
1. LEED® -- Leadership in Energy & Environmental Design
 2. UKGBC – United Kingdom Green Building Council
 3. Green Globes® -- Building Certification
 4. BREEM – BRE Environmental Assessment Method
- D. Green building rating system guidelines: [no added urea formaldehyde], [rapidly renewable], [low emitting].
- E. 2009 International Residential Building Code (IRC)
- F. 2012 International Building Code (ICB)
- G. State and Local Building Codes

1.02 QUALITY ASSURANCE



A. Qualifications

1. MANUFACTURER:

Bamboo Flooring Manufacturer's Qualifications:

- a. Minimum twenty (20) years continuous experience producing bamboo flooring and minimum ten (10) years producing bamboo strand products.
- b. Bamboo flooring must be FSC-certified and manufactured at an ISO 9001 certified facility.

2. Installer Qualifications:

- a. Minimum five (5) years documented experience installing bamboo and hardwood flooring.
- b. Installer shall be liable for all matters related to installation for a minimum period of one (1) year after the floor has been substantially installed and completed.

3. Performance Testing:

- a. Strand bamboo flooring must meet or exceed the specified ASTM physical property performance requirements.

1.04 SUBMITTALS

Submit under the provisions of Section 00 62 11, Submittal Transmittal Form.

A. Specification:

1. Submit strand bamboo specification sheets, FSC certification, and independent laboratory test results for CA 01350.

B. Samples:

1. Submit [#] 6-inch (152 mm) samples of flooring material in color(s) specified.
2. [Submit [#] 4-inch (100 mm) samples of the [PLYBOOQUIET®][PLYBOOFIT®] padded sub-floor system specified.]

C. Quality Assurance Submittals / Certificates

1. Submit Proof of Manufacturer Qualifications.



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2. Submit Proof of Installing Contractor's Qualifications.
3. Submit FSC certification.
4. Submit LEED submittals for MR and IEQ credit contributions.
 - a. MRc6, Rapidly Renewable Materials: [bamboo flooring]
 - b. MRc4, Recycled Content [crumb rubber underlayment] (95% recycled content) [PLYBOOQUIET] [PLYBOOFIT]
 - c. MRc5, Regional Materials [PLYBOOQUIET] [PLYBOOFIT]
 - d. MRc7, Certified Wood: Forest Stewardship Council (100% FSC)
 - e. IEQc4.3, Low-Emitting Materials – Flooring Systems (CA Section 01350 tested) [manufacturer's product data]
 - f. Installer Supplied Adhesive(s):
 - (i) IEQc4.1, Low-Emitting Materials – Adhesives [manufacturer's product data]
5. Submit independent laboratory certification for CA 01350 testing for flooring
6. Submit independent laboratory test results for PlybooQuiet [ASTM E2179-09, "Standard Test Method for Laboratory Measurement of the Effectiveness of Floor Coverings in Reducing Impact Sound Transmission Through Concrete Floors; ASTM E492-09, ASTM E989-06, "Standard Test Method for Laboratory Measurement of the Effectiveness of Floor Coverings in Reducing Impact Sound Transmission Through Concrete Floors with a Drop Ceiling]
7. Submit Manufacturer's recommended installation instructions
8. Submit Maintenance Guidelines as requested by Specifier
 - a. MSDS data



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- b. Care, Maintenance and Service Guidelines
 - c. HVAC temperature and humidity requirements
9. Submit strand bamboo product flooring warranty

1.05 WORKING CONDITIONS, DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in original unopened cartons until ready for installation.
- B. Reference Section 01 66 00: Product Handling and Storage Requirements.
 - 1. Cartons are to be opened and flooring materials stored in open cartons for a minimum seventy-two (72) hours.
 - 2. Do not store directly on concrete or near outside walls.
- C. Anticipate and schedule work to assure environmental conditions (temperature, humidity and ventilation) are within limits recommended by manufacturer for optimum results.

1.06 WARRANTY

- A. Smith & Fong warrants that products sold under this warranty are at the time of sale, free of defects in material and manufacture. The full warranty is available at <http://www.plyboo.com/downloads/smith-fong-flooring-warranty>.

PART 2 – PRODUCTS

2.01 MANUFACTURER

- A. Acceptable Manufacturer: Smith & Fong Company, which is located at 475 Sixth Street, San Francisco, CA 94103; Toll Free Tel: (866) 835-9859; Email: sales@plyboo.com; Web: www.plyboo.com
- B. Substitutions: Not permitted.
- C. Requests for substitution will be considered in accordance with provisions of Section 00 63 25.

2.02 MATERIALS

- A. Products: Stiletto Bamboo Flooring by Smith & Fong Company

1. Species: Moso (Phyllostachys Pubescens) Bamboo
2. Non-urea formaldehyde resin system
3. FSC certified
4. Finish: Factory applied multi-coat, polyurethane and sealer finish system formulated specifically for Plyboo Stiletto
5. Color: [Brushed Pearl] [Brushed Sahara Sand] [Brushed Eclipse] [Brushed Amber] [Brushed Barnwood] [Cerused Taupe]
6. Back: Channeled
7. Edge Configuration: Floating System – Click-Locking configuration on four-sides
8. Type: Strand Prefinished: 5 inches (127mm) wide by 9/16 (14mm) inches thick by 72 inches (1830mm) in length
9. Physical Mechanical Properties:
 - a. ASTM E648: Critical Radiant Flux, Class 1
 - b. ASTM D1037:
 - i. Dimensional Stability, 50% to 20% RH; Linear Expansion:
Parallel -0.02%, Perpendicular -0.23%; Thickness Swell -0.25%.
 - ii. Hardness (Janka Ball Test): 3,500 lbf (avg)
 - c. ASTM D3359: Adhesion by Tape Test, Class 4B
 - d. ASTM D3501: Compressive Strength / Max Load, 9,340 lbs / 13,140 lbs.
 - e. ASTM D4060: Taber Abrasion: Avg. Wear-through / Wear rate, 11,000 cycles / 5,000 cycles per 0.001 inch
 - f. ASTM D4442: Moisture Content, 6 – 9% (average range)



g. ASTM D5116-06: Organic Emissions (CA Section 01350), Office scenario/ Classroom
scenario: Pass/Pass

(i) (0.00 ug/m3 formaldehyde detected)

2.03 ACCESSORIES

A. Underlayment:

1. PlybooQuiet, SKU# PQR-45B, Recycled Rubber Padding: 1/8 inch (3mm) x 48 inches (1220mm) wide x
50 feet (15.24m) long as supplied by Smith & Fong Company

B. Flooring Accessories and Trim

1. Accessories and trim pieces, as specified in [color], as listed at
http://www.plyboo.com/downloads/plybostrand-accessories

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine substrates for compliance with requirements for installation tolerances, and other conditions
affecting performance of flooring.

B. Verify substrate is dry, clean, and free of loose material.

Specifier Note: DELETE PARAGRAPH BELOW AND TWO SUBPARAGRAGHS (SECTION C AND SUBSESTIONS 1
AND 2) IF SUBSTRATE IS NOT CONCRETE.

C. Substrate Moisture Testing: Use Calcium Chloride Test and Tramex Moisture Encounter Meter.
Moisture abatement measures must be taken following industry standard procedures and post
abatement test measurement taken to confirm effectiveness.

- 1. In multiple story buildings, test each floor level scheduled to receive bamboo flooring.
2. Mark test location(s) on As-Built Drawings.



Specifier Note: DELETE PARAGRAPH BELOW (SECTION D) IF SUBSTRATE IS NOT WOOD.

- D. Do not install bamboo flooring if wood substrate (NFWA reference) exceeds 12% moisture.
E. Verify HVAC System is operating and maintaining temperature and humidity conditions in compliance with Manufacturer's Installation Instructions.
F. Coordinate with responsible entity to correct unsatisfactory conditions.
G. Commencement of work by installer is acceptance of substrate and environmental conditions.

3.02 PREPARATION

- A. Humidity: maintain indoor air humidity levels between 35% and 55% for two weeks before installation and continually thereafter.
B. Temperature: maintain temperature of materials and installation area between 50 degrees and 80 degrees during installation and thereafter.
C. Acclimatization: Seventy-two (72) hours prior to installation place opened boxes on a flat, even surface in the center of the work-space.
D. Grind and fill subfloor using methods and materials appropriate to the subfloor construction to eliminate high spots and depressions exceeding 3/16 inch (5 mm) in 10 feet (3048 mm) diameter.

3.03 INSTALLATION

- A. Flooring: Comply with Manufacturer's Installation Instructions.

3.04 CLEANING: Reference Section 01 74 00: Cleaning and Waste Management

- A. Repair or replace damaged installed products.
B. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance.



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3.05 PROTECTION

- A. Protect installed product from damage during construction by covering with heavy kraft-paper or other suitable covering. Do not use non-breathable sheet or film that could cause condensation to form. Maintain covering throughout remainder of construction period.

END OF SECTION 09 64 19



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SECTION 09 29 00 GYPSUM BOARD

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Gypsum board and joint treatment.
2. Predecorated gypsum board.
3. Gypsum sheathing.
4. Tile backer board.
5. Acoustic insulation.
6. Textured finishes.

1.02 QUALITY ASSURANCE

- A. Perform Work in accordance with ASTM C840. GA-201 - Gypsum Board for Walls and Ceilings.
- B. Furnish framing materials in accordance with SSMA - Product Technical Information.
- C. Fire Rated Wall Construction: 1 rating in conjunction with Section 06 10 00 Tested Rating: Determined in accordance with ASTM E119.
- D. Surface Burning Characteristics:
 1. Textile Wall Coverings: Comply with one of the following:
 - a. Maximum 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.



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PART 2 PRODUCTS

2.01 GYPSUM BOARD ASSEMBLIES

A. Manufacturer List:

1. CertainTeed
2. No substitutions permitted.

B. Performance / Design Criteria:

1. Acoustic Attenuation for [Identified] Interior Partitions: 35 STC in accordance with ASTM E90.
2. Seismic Loads: Design and size components to withstand seismic loads and sway displacement as calculated according to ASCE 7 and applicable codes.

2.02 COMPONENTS

A. Gypsum Board Materials: ASTM C1396/C1396M ; Type X fire resistant where indicated on Drawings.

1. Standard Gypsum Board: ½ thick, maximum available length in place; ends square cut, tapered and beveled edges.
2. Moisture Resistant Gypsum Board: ½ thick, maximum available length in place; ends square tapered and beveled edges.

B. Tile Backer Boards:

1. Fiber Cement Tile Backer Board: ASTM C1288; 1/4 inch thick; mold resistant.

2.3 ACCESSORIES

A. Gypsum Board Accessories: ASTM C1047; metal and paper combination; corner beads, edge trim, and expansion joints.

1. Metal Accessories: Galvanized steel.
2. Plastic Accessories: PVC plastic.



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3. Edge Trim: Type L bead.
- B. Joint Materials: GA-216, reinforcing tape, joint compounds, and water.
- C. Fasteners: GA-216; length to suit application.
- D. Gypsum Board Screws: ASTM C1002; length to suit application.
 1. Screws for Wood Framing: Type W.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify site conditions are ready to receive work.

3.02 INSTALLATION

- A. Gypsum Board:
 1. Install gypsum board in accordance with GA-216.
 2. Fasten gypsum board to furring or framing with screws. Staples may only be used when securing first layer of double layer applications.
 3. Place control joints consistent with lines of building spaces as directed by Architect/Engineer.
 4. Place corner beads at external corners. Use longest practical length. Place edge trim where gypsum board abuts dissimilar materials.
 5. Seal cut edges and holes in moisture resistant gypsum board with sealant.
- B. Joint Treatment:
 1. Finish in accordance with GA-214 3.

END OF SECTION 09 29 00

SECTION 09 30 00
TILING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
1. ceramic, ceramic mosaic tile for interior floor and wall applications; cementitious backer board as tile substrate; and thresholds at door openings.
 2. Resin infused composite countertops.
 3. Setting materials and accessories.

1.02 REFERENCES

1. ASTM International (ASTM):
 - a. D1037 - Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials.
 - b. D2395 - Standard Test Methods for Specific Gravity of Wood and Wood-Based Materials.\
 - c. D4442 - Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials.
 - d. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
2. Forest Stewardship Council (FSC) STD-40-004 - Chain of Custody Standard.

SUBMITTALS

- A. Refer to Section 01 00 00 – General Requirements for Submittal Procedures.
- B. Shop Drawings: Indicate patterned applications and thresholds.
- C. Product Data: Submit instructions for using grouts and adhesives.
- D. Samples: Submit mounted tile and grout on two 48 inch plywood panels, size illustrating pattern, color variations, and grout joint size variations.



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E. Submittals for Review:

- a. Shop Drawings: Include layout, dimensions, materials, finishes, cutouts, and attachments.

1.03 CLOSEOUT

- A. Operation and Maintenance Data: Submit recommended cleaning methods, cleaning materials, stain removal methods, and polishes and waxes.

- B. Maintenance Data: Include recommended cleaning materials and procedures, and list of materials detrimental to resin infused composite panels.

1.04 QUALITY ASSURANCE

- A. Perform Work in accordance with TCA Handbook and ANSI A108.1 Series/A118.1 Series.

- B. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

- C. Installer: Company specializing in performing Work of this section with minimum three documented experience approved by manufacturer.

1.05 ENVIRONMENTAL REQUIREMENTS

- A. Do not install adhesives in unventilated environment.

- B. Maintain ambient and substrate temperature of 50 degrees F during installation of mortar materials.

PART 2 PRODUCTS

2.01 Products

A. Manufacturers:

1. Bathroom Floor Tile: Ceramic Tile – Fondovalle Le Pietre Naturali 13x13 African Blue Tile

- a. Substitutions: Not permitted.

2. Contract Documents are based on products by TorZo Surfaces.

2.02 COMPONENTS

A. Base: Same as floor tile.

1. Length: 16'
2. Height: 4"
3. Top Edge: Beveled
4. Moisture Absorption: TBD percent.
5. Surface Finish: Porcelain.
6. Color: Gray.

B. Mortar Materials:

1. Ceramic Tile

a. Mortar Bed Materials: ANSI A108.1A Portland cement, sand, and water; proportioned in accordance with International Building code.

b. Mortar Bond Coat Materials:

i. Dry-Set Portland Cement type: ANSI A118.1.

ii. Latex-Portland Cement type: ANSI A118.4.

2. Resin Infused Composite Panels:

a. Product: Durum.

b. Sustainable content: 70 percent pre-consumer recycled and rapidly renewable wheat straw.

c. Free from added urea formaldehyde.

d. Color: [emerald.] [To be selected from manufacturer's full color range.]

- e. Thickness: [3/8] [5/8] [7/8] inch, tested to ASTM D1037.
- f. Physical characteristics:
 - i. Density: 72, tested to ASTM D2395.
 - ii. Internal bond: 325, tested to ASTM D1037.
 - iii. Modulus of rupture: 7432, tested to ASTM D1037.
 - iv. Modulus of elasticity: 897,792, tested to ASTM D1037.
 - v. Hardness, Janka ball: 4225, tested to ASTM D1037.
 - vi. Screw holding; tested to ASTM D1037:
 - 1) Face: 672.
 - 2) Edge: 681.
 - vii. Linear expansion: 0.13, tested to ASTM D1037.
 - viii. Moisture content: 2.5, tested to ASTM D4442.
 - ix. Fire rating: Class B, tested to ASTM E84.

C. Grout Materials:

- 1. Standard Grout: Commercial Portland cement type as specified in ANSI A118.6; Raven color as selected.
 - 2. Silicone Rubber Grout: Silicone sealant, moisture and mildew resistant type, complying with ANSI A118.6, TBD color as selected.
 - a. Interior Sealants and Sealant Primers: Maximum volatile organic compound content in accordance with SCAQMD Rule 1168.
- D. Cementitious Backer Board: ANSI A118.9; High density, glass fiber reinforced, 5/16 inch thick; 2 inch wide coated glass fiber tape for joints and corners; manufactured by Durock.

E. Thresholds: Extruded aluminum with integral edge strip.

F. Tile Floor Edging: TBD.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify surfaces are ready to receive work.

3.02 PREPARATION

A. Ceramic Tile:

1. Install cementitious backer board. Tape joints and corners, cover with skim coat of thin-set mortar to feather edge.

B. Resin Infused Composite Panels:

1. Clean surfaces to receive fabrications; remove loose and foreign matter than could interfere with adhesion.

3.03 INSTALLATION

A. Ceramic Tile:

1. Install tile, thresholds, and grout in accordance with applicable requirements of ANSI A108.1 through A108.10, and TCA Handbook recommendations.

2. Cut and fit tile to penetrations through tile, leaving sealant joint space. Form corners and bases neatly. Align floor, base and wall joints.

3. Place tile joints uniform in width, subject to variance in tolerance allowed in tile size. Make joints watertight, without voids, cracks, excess mortar, or excess grout.

4. Grout tile joints. Use standard grout unless otherwise indicated.

5. Floors:

a. wood substrates, install in accordance with TCA Handbook Method F142, with standard grout.

b. Over FRP grate, position BioPCM mat inverted over grate such that PCM pockets are inserted into grate openings. Apply construction adhesive suitable for plastic and cementitious substrates to PCM backing, then install cementitious backer board, securing the backer board to the wooden subfloor beneath the FRP grate for added rigidity.

B. Resin Infused Composite Panels:

3. Install fabrications in accordance with manufacturer's instructions and approved Shop Drawings.
4. Adhere fabrications with continuous beads of adhesive.
5. Set plumb and level. Align adjacent pieces in same plane.
6. Install with hairline joints.
7. Fill joints between fabrications and adjacent construction with joint sealer; finish smooth and flush.

F. Wall Tile:

1. Over cementitious backer units install in accordance with TCA Handbook Method W244, using membrane at toilet rooms, kitchens.
2. Over gypsum wallboard on wood or metal studs install in accordance with TCA Handbook Method W243, thin-set with dry-set or latex-Portland cement bond coat.

3.04 PROTECTION

A. Protect installed fabrications with non-staining sheet coverings.

END OF SECTION 09 30 00



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SECTION 10 28 16 Residential Bath Accessories

PART 1 GENERAL

1.01 SECTION REQUIREMENTS

- A. Submittals: Product Data

PART 2 PRODUCTS

2.01 Hotel Handshower Kit

- A. Model Number: K-8487
- B. Dimensions: The handshower kit shall be 24-3/4" (629 mm) in length offering a custom shower at various heights. Kit shall feature a finish engineered to resist corrosion and daily wear. Kit shall feature black or grey handshower handle depending on finish ordered. Handshower shall rotate to select wide coverage or concentrated spray options. Handshower offers 2.5 gal/min (9.5 l/min) maximum flow rate. Kit shall feature MasterClean spray nozzles to prohibit mineral build-up for easy cleaning. Kit shall include handshower, slidebar, supply elbow, vacuum breaker, and 60" (1524 mm) metal shower hose. Kit shall be covered by the KOHLER lifetime limited warranty. Handshower kit shall be Kohler Model K-8487.
- C. Finishes:
 - 1. CP: Polished Chrome
 - 2. Other: Refer to Price Book for additional colors/finishes

- D. Product Manual: http://www.us.kohler.com/webassets/kpna/catalog/pdf/en/1214789_4.pdf

2.02 18" Towel Bar

- A. Model Number: #4021 (Satin Nickel), #4121 (Polished Nickel)

2.03 Toilet Roll Holder

- A. VOLA product



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- B. Model Number: T12
- C. Dimensions: length 6", height 3-1/8", screw holes 3-7/8" apart.
- D. Color Number: 16 – Polished Chrome.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Assemble and install product in accordance with manufacturer's instructions
- B. Test each product to verify proper operation. Make necessary adjustments.

END OF SECTION 10 28 16



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SECTION 11 30 00 RESIDENTIAL EQUIPMENT

PART 1 – GENERAL

1.02 SECTION REQUIREMENTS

- B. Submittals: Product Data

PART 2 – PRODUCTS

2.01 Television

- E. Samsung 60" LED – 1080p – 240 Hz – Smart – 3D HDTV
- F. Model Number: UN60ES7100
- G. Dimensions: 31.5" x 53.9" x 12.25"
- H. Smart Device Capabilities:
 - a. Web Browser
 - b. Multimedia Search
- I. Finishes: Black
- J. Product Manual: http://www.managemylife.com/mmh/owner_manuals/139473/SAMSUNG-LCD-Television-1204321L?brand_name_search=Samsung+60+LED+Smart+HDTV+UN60ES7100FXZA

2.02 Computer

- B. Apple MacBook Pro 15.4"
- C. Model Number: MC118LLA
- D. Dimensions: 1" x 14.3" x 9.8"

2.03 Router

- E. Belkin N600 Dual-Band Wireless N Router



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F. Model Number: F9K1102

G. Dimensions: 7.5" x 2.5" x 2.5"

PART 3 – EXECUTION

3.01 INSTALLATION

- C. Assemble and install product in accordance with manufacturer's instructions
- D. Test each product to verify proper operation. Make necessary adjustments.

END OF SECTION 11 30 00



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SECTION 11 31 13 RESIDENTIAL KITCHEN APPLIANCES

PART 1 – GENERAL

1.03 SECTION REQUIREMENTS

C. Submittals: Product Data

D. Regulatory Requirements:

1. ADA compliant: Americans with Disabilities Act (ADA), the single most important piece of legislation to improve the lives of people with disabilities.
2. Energy Star compliant: Meets the energy efficiency requirements set forth in ENERGY STAR product specifications.
3. NFPA: Provide electrical appliances listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. UL and NEMA: Provide electrical components required as part of residential appliances that are listed and labeled by UL and that comply with applicable NEMA standards.
5. NAECA: Provide residential appliances that comply with NAECA standards.

PART 2 – PRODUCTS

2.01 Countertop Microwave

K. GE Microwave

L. Model Number: JES0736SPSS

M. Dimensions: 10.25" x 18.25" x 13.5"

N. Capacity: 0.7 cu ft.

O. Wattage: 700W

P. Finishes: Stainless Steel, Black, White



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2.02 Ventilation Hood

- A. Bosch 36" Wall Mount Hood
- B. Model Number: DKE9665PUC
- C. Dimensions: 28.125-43.3125" x 35.375" x 20.4375"
- D. Capability: 600 CFM Blower with 4-Speed Fan
- E. Finishes: Stainless Steel
- F. Product Manual: [https://portal.bsh-partner.com/portal\(bD1kZSZjPTAwOQ==\)/PORTALFRAME.HTM](https://portal.bsh-partner.com/portal(bD1kZSZjPTAwOQ==)/PORTALFRAME.HTM)

2.03 Cooktop

- A. Bosch 30" Full Induction 4 Burner Cooktop
- B. Model Number: NIT5065UC
- C. Dimensions: 4.4375" x 31" x 21.25"
- D. Cooktop: Black Ceramic Glass
- E. Finishes: Black/Stainless Steel
- F. Product Manual: http://www.managemylife.com/mmh/owner_manuals/20945/BOSCH-Counter-Unit-Electric-L0908301?brand_name_search=bosch+NIT5065UC

2.04 Electric Oven

- E. Bosch 30" Built-In Wall Oven
- F. Model Number: HBL3350UC
- G. Dimensions: 29.0625" x 29.75" x 23.875"



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H. Capabilities: Self-Cleaning, 4 Cooking Modes

I. Finishes: Stainless Steel/Black

J. Product Manual: http://www.managemylife.com/mmh/owner_manuals/10893/BOSCH-Built-In-Oven-Electric-L0708274?brand_name_search=bosch+HBL3350UC

2.05 Refrigerator/Freezer

A. Bosch Built-In Refrigerator

B. Product Number: B30BB830SS

C. Dimensions: 83.75" x 29.75" x 24"

D. Capacity: 16 cu ft.

E. Freezer: Bottom door with ice maker

F. Finishes: Stainless Steel, Black

G. Product Manual: [https://portal.bsh-partner.com/portal\(bD1kZSZjPTAwOQ==\)/PORTALFRAME.HTM](https://portal.bsh-partner.com/portal(bD1kZSZjPTAwOQ==)/PORTALFRAME.HTM)

2.06 Dishwasher

A. Bosch 24" Built-In Dishwasher

B. Product Number: SGE63E15UC

C. Dimensions: 32.0625" x 23.563" x 22.563"

D. Finishes: Stainless Steel, Black

E. Product Manual: http://www.managemylife.com/mmh/owner_manuals/10626/BOSCH-Dishwasher-L0910012?brand_name_search=Bosch+24%E2%80%9D+Built-In+Dishwasher

PART 3 – EXECUTION

3.01 INSTALLATION



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- E. Built-in Appliances: Securely anchor to supporting cabinetry or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.
- F. Freestanding Appliances: Place in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
- G. Verify that accessories required have been furnished and installed.
- H. Test each product to verify proper operation. Make necessary adjustments.
- I. Find parts at Sears Parts Direct, if needed.

END OF SECTION 11 31 13



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SECTION 11 31 13 Residential Kitchen Appliances

PART 1 GENERAL

1.04 SECTION REQUIREMENTS

E. Submittals: Product Data

PART 2 PRODUCTS

2.01 Pull-Out Kitchen Sink Faucet

A. Manufacturer: Kohler

F. Model Number: K-6331

G. Dimensions: The contemporary pull-out kitchen sink faucet shall be of metal construction. Product shall have a maximum flow rate of 2.2 gallons (8.3 L) per minute with lower flow aerator options available (refer to the Kohler Price Book). Product shall feature a one-piece, self-contained ceramic disc valve, allowing volume and temperature control. Product shall feature temperature memory, allowing the faucet to be turned on and off at any temperature setting. Product shall feature a high-temperature limit setting for added safety. Product shall feature a 360° spout rotation. Product shall feature a three-function sprayhead with spray, aerated stream, and pause settings. Product shall feature Promotion technology with nylon hose and ball joint for easy operation. Product shall be available with a 9" (229 mm) or 8" (203 mm) swing spout reach. Pull-out kitchen faucet shall be Kohler Model K-6331.

2.02 Finishes:

1. CP: Polished Chrome

2. Other: Refer to Price Book for additional colors/finishes

H. Product Manual:

https://mailattachment.googleusercontent.com/attachment/u/0/?ui=2&ik=3b3f4ca400&view=att&th=140a380d602ae031&attid=0.1&disp=inline&safe=1&zw&saduie=AG9B_P8auThZU4Uesvebs7MoRmYK&sadet=1377135232623&sads=TWu-cdjcmN_j7AFpSirOYngkDM0



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2.03 Codes/Standards Applicable

A. Specified model meets or exceeds the following at date of manufacture:

1. ADA
2. ASME A112.18.1/CSA B125.1
3. ICC/ANSI A117.1
4. Energy Policy Act of 2005
5. NSF 61
6. All applicable US Federal and State material regulations

PART 3 EXECUTION

3.01 INSTALLATION

J. Install this product according to the installation guide.

- a. ADA compliant when installed to the specific requirements of the regulation. END OF

END OF SECTION 11 31 13



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SECTION 11 31 23 RESIDENTIAL LAUNDRY APPLIANCES

PART 1 – GENERAL

1.05 SECTION REQUIREMENTS

I. Submittals: Product Data

J. Regulatory Requirements:

1. ADA compliant: Americans with Disabilities Act (ADA), the single most important piece of legislation to improve the lives of people with disabilities.
2. Energy Star compliant: Meets the energy efficiency requirements set forth in ENERGY STAR product specifications.
3. NFPA: Provide electrical appliances listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. UL and NEMA: Provide electrical components required as part of residential appliances that are listed and labeled by UL and that comply with applicable NEMA standards.
5. NAECA: Provide residential appliances that comply with NAECA standards.

PART 2 – PRODUCTS

2.01 Clothes Washer

Q. Bosch Electric Washing Machine

R. Model Number: WAS20160UC

S. Dimensions: 33.18" x 23.56" x 24.6"

T. Capacity: 2.2 cu ft.

U. Front Loader

V. Finishes: White

W. Product Manual: http://www.managemylife.com/mmh/owner_manuals/7687/BOSCH-Residential-Washers-L0805203?brand_name_search=bosch+washer



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2.02 Clothes Dryer

K. Bosch Electric Dryer

L. Model Number: WTV76100US

M. Dimensions: 33.18" x 23.56" x 24.6"

N. Capacity: 3.9 cu ft.

O. Front Loader

P. Finishes: White

Q. Product Manual: http://www.managemylife.com/mmh/owner_manuals/21675/BOSCH-Residential-Dryer-L0902082?brand_name_search=bosch+dryer

2.03 Dryer Vent

A. Speedi-Products 4 in. White Micro Louver Eave Vent

B. Model # EX-EVML 04

C. Dimensions: 4"x 5.6"x 5.6"

PART 3 – EXECUTION

3.01 INSTALLATION

K. Place in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.

L. Verify that accessories required have been furnished and installed.

M. Test each product to verify proper operation. Make necessary adjustments.

N. Find parts at Sears Parts Direct, if needed.



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END OF SECTION 11 31 23



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SECTION 21 13 13 WET PIPE SPRINKLER SYSTEM

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

- A. Submittals: Product Data for valves, sprinklers, specialties, and alarms.
 - 1. Submit sprinkler system drawings identified as "working plans" and calculations according to NFPA 13. Submit required number of sets to authorities having jurisdiction for review, comment, and approval. Include system hydraulic calculations.
 - 2. Submit test reports and certificates as described in NFPA 13.
- B. Design and Installation Approval: Acceptable to authorities having jurisdiction.
- C. Hydraulically design sprinkler systems according to NFPA 13.
- D. Comply with Section P2904.
- E. UL-listed and -labeled and FM-approved pipe and fittings.
- F. Verify dimensions in field measurements before fabrication & indicate on shop drawings.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

- A. PEX Tubing: UL 1821, 175-psig rating, made in NPS for sprinkler service. Include "Listed" and "CPVC Sprinkler Pipe" marks on pipe.
- B. PEX Tubing Fittings: ASTM F 438 for NPS 3/4 to NPS 1-1/2 and ASTM F 439 for NPS 2, UL listed, 175-psig rating, for sprinkler service. Include "Listed" and "CPVC Sprinkler Fitting" marks on fittings.
- C. Copper piping shall be provided in all exposed areas.
- D. Provide hangers, supports, and seismic restraints with UL listing and FM approval for

fire-protection systems.

2.02 VALVES

- A. Fire-Protection Service Valves: UL listed and FM approved, with 175-psig nonshock minimum working-pressure rating. Indicating valves shall be butterfly or ball type, bronze body, and integral indicating device with 115-V ac, electric, single-circuit supervisory switch indicator.

2.03 SPRINKLERS

- A. Automatic Sprinklers: With heat-responsive element complying with the following:
 - 1. UL 1626, for residential applications.
- B. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- C. Sprinkler types include the following:
 - 1. Pendent Sprinkler: Tyco Rapid Response LFII Flush Residential Sprinkler Head
- D. Sprinkler Escutcheons: steel, one piece, with finish to match sprinklers.
- E. Sprinklers shall be low flow residential hidden pendent sprinklers engineered to provide a minimum design density of 0.05 gpm/ft² over the listed coverage area.
- F. Sprinkler frame and deflector shall be of bronze frame construction having a 1/2" NPT thread.
- G. Waterseal assembly shall consist of a Teflon-coated Belleville spring washer with top loaded extruded or cold head cup with 3 mm glass bulb containing no plastic parts, and having a temperature rating of 155°F, 165°F or 175°F.
- H. Sprinklers shall have a nominal K-factor of as designed in the hydraulic sprinkler design.

PART 3 - EXECUTION

3.01 INSTALLATION



- A. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.
- B. Correct deficiencies in or remove and reinstall sprinkler that does not comply with requirements. C. Repair, refinish, or replace sprinklers damaged during installation, as directed by Architect.
- D. Adjust operating parts and hardware for smooth, quiet operation and weathertight closure. Lubricate hardware and moving parts.

3.02 PIPE AND FITTING APPLICATION

- A. Use steel pipe with threaded, press-seal, roll-grooved, or cut-grooved joints; copper tube with wrought-copper fittings and brazed joints; metal-to-plastic transition fittings with solvent-cemented joints; PEX piping and fittings with manufactures connections.

3.03 PIPING INSTALLATION

- A. Install "Inspector's Test Connections" in sprinkler piping, complete with shutoff valve.

3.04 TESTING

- A. Flush, test, and inspect sprinkler piping systems according to NFPA 13.

END OF SECTION 21 13 13



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Division 22



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SECTION 22 05 00 COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

- A. This section Includes:
 - 1. Plumbing hangers and supports
 - 2. Miscellaneous

1.02 REFERENCE STANDARDS

- A. NSF Standard 61-G Drinking Water System Components - Health Effects

1.03 SUBMITTALS

- A. Product Data.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Everhot
- B. Sioux Chief
- C. Other approved manufacturer that is equal or better than the one above.

2.02 HANGERS AND SUPPORTS

- A. Hanger and Pipe Attachments:
 - a. Factory fabricated with galvanized coatings; nonmetallic plastic bend support for PEX tubing.
 - i. PEX Wall Support Brackets 1/2". Uponor A5750500.
 - b. 1/2" PEX Copper Crimp Rings
 - c. 3/4" PEX Copper Crimp Rings

PART 3 - EXECUTION

3.01 GENERAL PIPING INSTALLATIONS

- A. Install Piping free of sags and bends.
- B. Install fittings to account for branch connections and changes in direction.
- C. Install sleeves for all pipes passing through roof slabs, walls, and concrete floors.
- D. Exterior Wall, Pipe Penetrations: Mechanical sleeve seals inserted in cast-iron or steel pipes for wall sleeves.
- F. Install unions at final connection to each piece of equipment.



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3.02 GENERAL EQUIPMENT INSTALLATIONS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Install mechanical equipment to facilitate service, maintenance, repair, and replacement of components. Connect equipment for ease of disconnecting with minimum interference to other installations.
- D. Install equipment to allow right of way for piping installed at required pitch.

3.03 GENERAL METERS AND GAUGES INSTALLATIONS

- A. General: Comply with the PHCC National Standard Plumbing Code and manufacturer's recommendations.

END OF SECTION 22 05 00



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SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Bosch Pump Station Modules

1.02 RELATED SECTIONS

- A. Division 23 71 00 "Thermal Storage"
- B. Division 22 33 30.26 "Residential, Collector-to-Tank, Heat Exchanger Coil, Solar Electric Domestic Water Heaters"
- C. Division 22 11 19 "Domestic Water Piping"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. Bosch

2.02 COMPONENTS

- A. Bosch Pump Station Modules
 - a. SBU
 - i. SBU is a change over tank that allows the direction of the incoming and outgoing Sun Drum water to be directed to either the water heater or phase change tank.

PART 3 EXECUTION

3.01 INSTALLATION

- A. SBU
 - a. Steps:
 - i. Install in accordance with manufacturer's instructions.

END OF SECTION 22 05 23



SECTION 22 11 16 DOMESTIC WATER PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. This section Includes:

1. Domestic water piping
2. Domestic water pipe fittings
3. Domestic water pipe sleeves
4. Domestic water manifold
5. Special duty valves for domestic water

1.02 REFERENCES

- A. Comply with NSF 14 for plastic, potable domestic water piping and components.
- A. Comply with NSF 61-G for potable domestic water piping and components.

PART 2 - PRODUCTS

2.01 PIPING

A. Everhot

1. PEX Tubing: ½" Type B
2. Part#: NPR1201 (Red) and NPR1201 (Blue)
3. PEX Tubing: ¾" Type B
4. Part#: NPR3401 (Blue)

2.02 FITTINGS

A. Lav Adapter

1. Connects 3/4" PEX tubing directly to lavatory faucets
2. Materials: Bronze construction
3. Nut: Metal construction
4. Basis of design: Provide lav adapter equal or equivalent to:
5. Viega Bronze PEX Press Lav Adapter. Stock code: 57002.

B. Pipe Insulation

1. Slide over fit for PEX tubing.
2. Material: Foam construction
3. Pipe size: For 3/4" PEX. ASTM F1960, NSF, ASTM F877.
4. Basis of design: Provide Protection from UV rays.

C. Manifold

1. ASTM F 877 plastic or corrosion-resistant-metal assembly, with a plastic corrosion-resistant metal valve for each outlet.

2. (5) x ½" ports
 3. Basis of design:
 4. Viega PureFlow Dual Temperature MINIBLOC - PEX Press Model # V5065ZL
- D. Special-Duty Valves
1. ½" PEX Angle Stop (1/4 Turn): Complies with ASTM F 1087.
 2. Union Ball Valves: MSS SP-122, with full-port ball, socket, or threaded detachable end connectors, and pressure rating not less than 125 psi at 73°.
 3. ½" PEX Straight Stop: Complies with ASTM F 1087.1 ½" threaded check valve, 150 psi
 4. ¾" threaded check valve, 150 psi: Complies with ANSI B1.20
 5. ¾" PROFLOW 10-D hose bib.
- E. Transition Fittings: Manufactured piping coupling or specified piping system fitting. Same size as pipes to be joined and pressure rating at least equal to pipes to be joined. IAPMO 3558; ANSI/NSF 14- and NSF 61-G certified; HUD MR 1269; ICC ESR 1099.
1. 1/2" PEX x 1/2" NPT Brass Male Adapter: Connects PEX tubing to NPT thread.
 2. 1/2" PEX x 1/2" NPT Brass Female Adapter: Use with ring for connection.
 3. ¾" NPT Viega Pro Press Copper Male Adapter: Viega 79230
 4. 90° ¾" Copper Elbow: Viega 77322
 5. ¾" Dielectric unions, Viega 79160: Complies with ASME B 16.18, ASME B 16.22
 6. ¾" Iron Pump Flange(Pair): Grundfos 519601

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install PEX tubing in accordance with the manufacturer's recommendations and as indicated in the installation handbook.
- B. Do not install PEX tubing within 6 inches of gas appliance vents or within 12 inches of any recessed light fixtures.
- C. Do not expose PEX tubing to direct sunlight for more than 30 days.
- D. Ensure no glues, solvents, sealants or chemicals come in contact with the tubing without prior permission from the tubing manufacturer.
- E. Protect PEX tubing with sleeves where abrasion may occur.
- F. Use strike protectors where PEX tubing penetrates a stud or joist and has the potential for being struck with a screw or nail.
- G. Use tubing manufacturer-supplied bend supports where bends are less than six times the outside tubing diameter.
- H. Horizontal supports are installed not less than 32 inches between hangers in accordance with plumbing codes and the installation handbook.
- I. Vertical supports are installed not less than 10 ft between hangers in accordance with plumbing codes and the installation handbook.

- J. Maximum length of individual runs is 60 ft.
- K. Allow 1/8" in slack per foot of tubing to allow for thermal expansion.
- L. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.
- M. Install domestic water piping without pitch for horizontal piping and plumb for vertical piping.
- N. Rough-in domestic water piping for water-meter installation accordingly to utility company's requirements.

3.02 INSPECTING AND CLEANING

- A. Inspect and test piping systems as follows:
 - 1. Fill domestic and fire suppression piping. Check components to determine that they are not air bound and that piping is full of water.
 - 2. Test for leaks and defects in new piping and all other piping that have been altered extended, or repaired.
- B. Disinfect and clean potable domestic water piping by filling system with water/chlorine solution with no less than 50 mg/L of chlorine. Isolate and allow to stand for 24 hours. Flush system with clean, potable water until water exiting stream contains no chlorine from system after the stand time.

3.03 PIPING SCHEDULE

- A. Above ground Distribution Piping: PEX Piping.
- B. Outside Distribution: Insulated PEX Piping.

3.04 VALVE SCHEDULE

- A. Install gate valves close to main on each branch and riser serving two or more plumbing fixtures or equipment connections and where indicated.
- B. Install gate or ball valves on inlet to each plumbing equipment item, on each supply to each plumbing fixture not having stops on supplies, and elsewhere as indicated.
- C. Ball, butterfly, and check valves may be used in matching piping materials.
- D. Install drain valve at base of each riser, at low points of horizontal runs, and where required to drain water distribution piping system.
- E. Install swing check valve on discharge side of each pump and elsewhere as indicated.
- F. Install ball valves in each hot-water circulating loop and discharge side of each pump.

END OF SECTION 22 11 16



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SECTION 22 11 19 DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.01 Section Includes

- A. SunDrum Collectors
- B. Backflow prevention
- C. Clothes washer outlet boxes
- D. Expansion tank

1.02 RELATED REQUIREMENTS

- A. Division 22 33 30.26 "Residential, Collector-To-Tank, Heat-Exchanger-Coil, Solar-Electric (1) Domestic Water Heaters"
- B. Division 22 12 00 "Facility Potable Water Storage"

1.03 SUBMITTALS

- A. Product Data.

PART 2 - MANUFACTURED UNITS

2.01 BACKFLOW PREVENTION

- A. Check valve is installed within Grundfos Pump. See Section 22 11 23 for more information.

2.02 CLOTHES WASHER OUTLET BOXES:

- A. Washing machine outlet Box with 1/2" Press Valves.
- B. Complies with ASTM F 877 and ASTM F1960.
- C. Basis of design: provide outlet box equal or equivalent to:
 - 1. Viega Pureflow Washing Machine Box. Model # V5073.5.
 - 2. Any other approved washing machine box that is equal or better than the one above.

2.03 ICE-MAKER OUTLET BOXES

- A. Ice-maker outlet box with 3/8" Press Valves.
- B. Complies with ASTM F 877 and ASTM F1960.
- C. Basis of design: provide outlet box equal or equivalent to:
 - 1. Viega Pureflow Ice-Maker Box. Model #.V 5073.
 - 2. Any other approved Ice-Maker Box box that is equal or better than the one above.

2.04 PEX Manifolds



- A. Sioux Chief
 - 1. Cold Water Manifold: Copper construction with one $\frac{3}{4}$ " inlet and five $\frac{1}{2}$ " outlets with $\frac{3}{4}$ " open end.
 - 2. Part #: 672XV0599
- B. Sioux Chief
 - 1. Hot Water Manifold: Copper construction with one $\frac{3}{4}$ " inlet and five $\frac{1}{2}$ " outlets with spin closed end.
 - 2. Part #: 672XV0590
- C. Or any other approved PEX Manifold that is equal or better than the one above.

2.05 EXPANSION TANK

- A. Capacity: 20 gallon
- B. Rugged flexible butyl diaphragm
- C. Basis of design: Provide tank equal or equivalent to
 - 1. Watts 20-Gallon Tank. Model # PLT-20-M1.
 - 2. Any other approved expansion tank that is equal or better than the one above.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Follow installation instructions outlines in 22 11 16 DOMESTIC WATER PIPING.
- B. Adhere to manufacturer's recommendation and installation instructions.

END OF SECTION 22 11 19



SECTION 22 11 23 DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.01 SUMMARY

- A. This section includes:
 - 1. Domestic water pump.
 - 2. Hot water tank re-circulatory pump.

1.02 SUBMITTALS

- A. Product Data. Include performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.03 REFERENCES

- A. Comply with UL 778 for motor-operated water pumps.
- B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 MAIN PRESSURIZING DOMESTIC WATER PUMP

- A. In-Line, Centrifugal Pumps: Factory-assembled and –tested, in-line, close-coupled, canned-motor, centrifugal pumps. Motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal. Rated for 145 psi maximum working pressure and 230° F maximum operating temperature.
 - 1. Basis of design: provide outlet box equal or equivalent to:
 - a. Grundfos ALPHA 15-55SF Stainless Steel Circulator Pump
 - 1. 1/16 Horse Power, 115 Volts, with integrated check-valve.
 - b. Grundfos UP15-10SU7P/TLC
 - 1. 3/4" NPT, Comfort System w/Comfort Valve & Connectors.
 - 2. 1/25 Horse Power, 115 Volts.
 - c. Sundrum Solar Pump Package

2.02 MOTORS

- A. NEMA MG 1, "Standard for Motors and Generators." Include NEMA listing and labeling.
- B. Motor Sizes: Minimum size indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.



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- C. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.
- C. Support pumps and piping so weight of piping is not supported by pump volute.
- D. Install electrical connections for power, controls, and devices.
- E. Suspend in-line pumps independent from piping. Use continuous-thread hanger rods and vibration isolation hangers. Fabricate brackets or supports as required for pumps.
- F. Install vertical in-line pumps on concrete bases.
- G. Connect piping with valves that are at least the same size as piping connecting to pumps.
- H. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- I. Install shutoff valve(s) and strainer on suction side of pumps.
- J. Install non-slam check valve(s) and throttling valve(s) on discharge side of pumps.
- K. Install pressure sensor in buffer tank outlet piping.
- L. Install pressure gauges on suction and discharge of each pump. Install at integral pressure gage tapings where provided.

END OF SECTION 22 11 23



Section 22 12 19
FACILITY POTABLE- WATER STORAGE TANK

PART 1 - GENERAL

1.03 SECTION INCLUDES

- A. Domestic Hot Water Tank

1.04 RELATED SECTIONS

- A. Division 22 33 30 "Residential, Collector-to-Tank, Heat Exchanger Coil, Solar Electric Domestic Water Heaters"
- B. Division 23 71 00 "Thermal Storage"
- C. Division 22 11 16 "Domestic Water Piping"
- D. Division 22 11 23 "Domestic Water Pumps"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Bosch
- B. Husky Portable
- C. Logalux

2.02 COMPONENTS

- A. Bosch
 - a. Bosch WST 50
 - i. <http://www.bosch-climate.us/products-bosch-thermotechnology/indirect-storage-tanks/wst-indirect-storage-tank.html>
- B. Husky Portable
 - a. Husky Custom Water Bladder Tank
 - i. Location: Underneath deck within patriot berm
 - ii. Dimensions [L x W x H]: 270" x 86" x 12"
 - iii. Weight: 90 pounds
 - iv. Capacity: 1200 gallons
 - b. Husky Custom Patriot Berm
 - i. Location: Under deck surrounding berm for support and containment.
 - ii. Dimensions [L x W x H]: 270" x 86" x 12"
 - iii. Weight: 130 pounds while in bag



- c. Accessories
 - i. ¾" Flange it, nipple and ball valve 300oz PVC
 - ii. 4" Fill cap
- C. Logalux
 - a. Expansion Tank
 - i. Membrane Expansion tank
 - ii. 35L capacity

PART 3 - EXECUTION

3.02 Placement

- A. The supply water bladder will be located within the patriot angle berm underneath the deck for support and containment as shown in the drawings.

3.03 USES

- A. Tanks will house potable water pumped to appliances and fixtures in the house.

3.04 INSTALLATION

- A. Bosch
 - a. Install in accordance with manufacturer's instructions.
- B. Husky Portable
 - a. Install in accordance with manufacturer's recommendations.
 - b. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.
 - i. Adequately support all pipe and valves. Do not apply excess weight on water tanks.
 - ii. Tanks are not designed for storage of fluid in vacuum conditions or higher pressure above atmospheric.
 - iii. Use caution when handling bladder.
- C. Fill potable-water storage tank with water.

END OF SECTION 22 12 19



SECTION 22 13 16
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 SUMMARY

- A. This section Includes:
1. Sanitary waste piping

1.02 SECTION REQUIREMENTS

- A. Minimum Pressure Requirement for Soil, Waste, and Vent: 4.5 psi.
B. Comply with NSF 14, "Plastic Piping Components and Related Materials," for plastic piping components.

PART 2 - PRODUCTS

2.01 PIPING

- A. PVC Pipe and Fittings: ASTM D 2665, Schedule 40, plain ends.
1. 1-1/2" diameter, ABS Pipe
 2. 3" diameter, ABS Pipe

2.02 FITTINGS

- A. Air admittance valve
1. 1-1/2" NPT Threads
 2. Tensions membrane: Neoprene
 3. Sensitivity: -0.1psi
 4. Basis of design:
 - a. Oatey 20 DFU Sure-Vent Air Admittance Valve with Schedule 40 Adapter. Product no. 39016.
 - b. Any other Air Admittance Valve that is equal or better than the one above.
- B. ABS P-Trap
1. ASTM D 2665, Schedule 40
 2. 1.5"

PART 3 - EXECUTION

3.01 PIPING INSTALLATION



- A. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for basic piping installation requirements, piping joint construction, pipe hanger, and support devices.
- B. Install wall penetration system at each pipe penetration through foundation wall. Make installation watertight.
- C. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- D. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated.
 - 1. Horizontal Sanitary Drain: 1/4" per ft slope downward in direction of flow for piping NPS 2" and smaller; 1/8" per ft slope downward in direction of flow for piping NPS 4" and larger.
 - 2. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- E. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- F. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.02 PIPE SCHEDULE

- A. Aboveground Applications: PVC, DWV pipe and fittings with solvent-cemented joints.

END OF SECTION 22 13 16

SECTION 22 13 53
FACILITY SEPTIC TANK

PART 1 - GENERAL

1.05 SUMMARY

- B. This is a temporary facility that is only used for the purposes of the competition in Irvine, CA and does not apply to the affordability contest of Canopy House.
- C. This section includes the waste water storage tanks used for Canopy House.

1.06 RELATED SECTIONS

- A. Section 22 11 16 "Domestic Water Piping"

1.03 SUBMITTALS

- A. Product Data

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Husky Portable
 - Husky Custom Waste Water Bladder Tank [CSI 22 13 53.A1]
 1. Location: Underneath Deck within return patriot bladder.
 2. Dimensions [L x W x H]: 222" x 86" x 12"
 3. Weight: 85 pounds
 4. Capacity: 991 gallons
- B. Husky Custom Patriot Berm
 1. Location: Under deck surrounding berm for support and containment.
 2. Dimensions [L x W x H]: 270" x 86" x 12"
 3. Weight: 103 pounds total
- C. Accessories
 1. 3" PVC bulkhead fitting [CSI 22 13 53.D1]
 2. 4" Fill cap [CSI 22 13 53.E1]

PART 3 - EXECUTION

3.05 Placement

- A. Husky Custom Patriot Berm will be placed on location as specified on the drawings.



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- B. Husky Portable Water Bladder will be placed within the Husky Custom Patriot Berm per manufactures instructions.
- C. Decking will be placed over the Husky Custom Patriot Berm and Husky Portable Water Bladder as specified in the drawings.

3.06 USES

- A. Tanks will house waste water drained from residential appliances and fixtures in the house

3.07 INSTALLATION

- A. Set septic tanks level, plumb, and true in line and anchor securely in place according to manufactures specifications.
- B. Plumb with 3" PVC piping [Refer to Section 22 11 16 - Domestic Water Piping] unless otherwise specified
- C. Install in accordance with manufacturer's recommendations.

END OF SECTION 22 13 53



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SECTION 22 33 00
RESIDENTIAL ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.01 SUMMARY

- A. This section includes:
1. Water heaters

1.02 SUBMITTALS

- A. Product Data. Including capacity, temperature setting range, control type, dimensions, and power ratings.

PART 2 - PRODUCTS

2.01 ELECTRIC WATER HEATERS

- A. Electrical Requirements
1. 2 dedicated 40 Amp min 2-pole circuit breakers and 4 #8 AWG wires plus ground, min 120 Amp breaker panel required.
 2. 2 x 240V
 3. 17/13 kW max.
- B. Energy Factor: .95
- C. Unit capacity: Endless
- D. Dimensions:
1. Depth: 4 1/2 in.
 2. Height: 15 1/2 in.
 3. Width 15 1/4 in.
- E. Operating pressure: 15-150 PSI
- F. Basis of design: Provide electric water heater equal or equivalent to:
1. Bosch WST 50
 2. Bosch Logalux SM300



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PART 3 - EXECUTION

3.01 INSTALLATION

- A. Water heaters shall be installed level and plumb.
- B. Water heaters shall be installed and connected in accordance with manufacture's written instructions.
- C. Water heaters shall be set at 120 degrees F.

END OF SECTION 22 33 30



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SECTION 22 33 30.26

RESIDENTIAL, COLLECTOR-TO-TANK, HEAT-EXCHANGER-COIL, SOLAR-ELECTRIC DOMESTIC WATER HEATERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hybrid Solar Water Heating and Energy System
- B. Solar-heated hot water tank storage tank

1.02 RELATED SECTIONS

- A. Division 05 14 13 "Architecturally-Exposed Structural Aluminum Framing"
- B. Division 22 11 19 "Domestic Water Piping"
- C. Division 22 33 30.26 "Residential, Collector-to-Tank, Heat Exchanger Coil, Solar Electric Domestic Water Heaters"
- D. Division 23 71 00 "Thermal Storage"
- E. Division 26 31 00 "Photovoltaic Collector System"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. SunDrum Solar

2.02 COMPONENTS

- A. SDM100 Collectors (650 W)
- B. SDM100 Connection Kit
 - 1. 2x 3/8" barbs
 - 2. 2x plugs
 - 3. 2x stainless steel hose clamps
 - 4. 5' of industrial hose
 - 5. 5' of UV resistant insulation
- C. Header Kit
- D. Controller with Thermistor's + Sleeve
- E. Pump Station
- F. Propylene glycol

PART 3 EXECUTION



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3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. SunDrum collectors are constructed with sheet metal and may have sharp edges. Gloves should be worn when handling.
- C. SunDrum collectors may be attached on the roof or other elevated locations. Installers should wear an adequate safety harness secured per manufacturer's guidelines.
- D. Link to Installation Manual
 - 1. <http://gncre.com/wp-content/uploads/2011/08/SunDrum-Solar-SDM300-series-Owners-manual-approved-version.pdf>

END OF SECTION 22 33 30.26



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Division 23

SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ball Valve.
2. Hangers and Supports.
3. Identification Tags and Sleeves.

1.2 INCLUDED SECTIONS

- A. Section 23 05 23 General Duty Valves for HVAC Piping.
- B. Section 23 05 29 Hangers and Supports for HVAC Piping and Equipment.
- C. Section 23 05 53 Identification for HVAC Piping and Equipment.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturers catalog information with valve data and ratings for each service.
- B. Shop Drawings:
 1. Manufacturer supplied drawings and cut sheets for all types of General Duty Valves used.
 2. Detailed description and drawings of hangers and supports for HVAC Piping and Equipment.
 3. Shop drawings and orientation of Identification for HVAC Piping and Equipment.
- C. Informational Submittals:
 1. Manufacturer's Installation Instructions: Submit hanging and support methods, joining procedures.
 2. Operation and Maintenance Data: Submit installation instructions, spare parts lists, exploded assembly views.
- D. Material Samples:
 1. Samples of the identification tags and sleeves for the HVAC Piping and Equipment.

PART 2 – PRODUCTS

2.1 BALL VALVES

A. Manufacturers:

1. Crane Valve, North America.
2. Hammond Valve Model.
3. Milwaukee Valve Company.
4. NIBCO, Inc.
5. Stockham Valves & Fittings.
6. Other approved vendor.
7. Approved equal or better than above manufacturer's

2.2 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electro galvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- C. Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- D. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.3 IDENTIFICATION TAGS AND SLEEVES

A. NAMEPLATES

1. Manufacturers:

- a. Craftmark.
- b. Seton.
- c. Kolbi.
- d. Approved equal or better than above manufacturer's
2. Product Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.
3. Metal Labels for Equipment:
 - a. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - b. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. PIPE MARKERS

1. Plastic Pipe Markers:
 - a. Manufacturers:
 - i. Seton.
 - ii. Brady.
 - iii. Kolbi.
 - iiii. Approved equal or better than above manufacturer's
 - b. Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener.
2. Plastic Tape Pipe Markers:
 - a. Manufacturers:
 - i. Seton.
 - ii. Brady.
 - iii. Kolbi.
 - iiii. Approved equal or better than above manufacturer's
 - b. Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

C. LABELS

1. Manufacturers:
 - a. Seton.
 - b. Brady.
 - c. Kolbi.
 - d. Approved equal or better than above manufacturer's
2. Pipe Labels:
 - a. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

- b. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - i. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - ii. Lettering Size: At least 1-1/2 inches high.
 - c. Maximum Temperature: Able to withstand temperatures up to 180 deg F (83 deg C).
3. Duct Labels:
- a. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - b. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - c. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
 - d. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
 - i. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
 - ii. Lettering Size: At least 1-1/2 inches high.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with stems upright or horizontal, not inverted.
- B. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- C. Install 3/4 inch ball valves with cap for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment.
- D. Install valves with clearance for installation of insulation and allowing access.
- E. Provide access where valves and fittings are not accessible.

3.2 VALVE APPLICATIONS

- A. Install shutoff and drain valves at locations indicated on drawings in accordance with this section.
- B. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- C. Install ball or globe valves for throttling, bypass, or manual flow control services.
- D. Install spring loaded check valves on discharge of water pumps unless otherwise specified in pump section.
- E. Install ball valves in heating water systems for shut-off service.
- F. Install ball valves in heating water systems for throttling service.

3.3 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- E. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 IDENTIFICATION TAGS AND SLEEVES INSTALLATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.



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- B. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.
- C. Install labels with sufficient adhesive; for permanent adhesion seal with clear lacquer.

END OF SECTION 23 05 00



SECTION NUMBER 23 07 00
HVAC INSULATION

PART 1 — GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Insulation Materials:
 - a. Piping insulation, jacketing and accessories
 - b. Equipment insulation and jacketing or coatings
 - c. Laminated self-adhesive water and weather seal: such as Venture Clad
2. References
 - a. ASTM International (ASTM)
 - b. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE)
 - c. North American Insulation Manufacturers Association (NAIMA)
 - d. National Fire Protection Association (NFPA)
 - e. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
 - f. Underwriter's Laboratories (UL)
 - g. GREENGUARD Environmental Institute (GEI)
3. Related Sections:
 - a. Division 22 Section "Plumbing Insulation"

1.3 SUBMITTALS FOR INFORMATION

- A. Product data: To include product description, manufacturer's installation instructions, types and recommended thicknesses for each application, and location of materials.
- B. Samples and mock-ups of systems shall be provided upon engineer's request.

1.4 QUALITY ASSURANCE



- A. Surface Burning Characteristics: Insulation and related materials shall have surface burning characteristics determined by test performed on identical products per ASTM E 84 mounted and installed as per ASTM E 2231. All testing shall be performed by a testing and inspecting agency acceptable to authorities having jurisdiction. Insulation, jacket materials, adhesives, mastics, tapes and cement material containers shall be labeled with appropriate markings of applicable testing and inspecting agency.
- B. Store tapes, adhesives, mastics, cements, and insulation materials in ambient conditions in accordance with the recommendations of the manufacturer.
- C. Follow manufacturer's recommended handling practices.
- D. Supply fiber glass products that are manufactured using a minimum of 60% "post-consumer"
 - a. recycled bottle glass material.
- E. Supply fiber glass products that have been verified to be formaldehyde free by the GEI.
- F. Fiber Glass and Mold: Contractor shall take precaution to protect insulation. Any fiber glass insulation that becomes wet or torn should be replaced at no additional cost. Air handling insulation used in the air stream must be discarded if exposed to water.

PART 2 — PRODUCTS

2.1 INSULATION MATERIALS

- A. Products shall not contain asbestos, lead, formaldehyde, mercury or mercury compounds.
- B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 parts per million (ppm) when tested according to ASTM C 871.
- C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- D. Manufacturers: Knauf Insulation, Proto Corporation, or pre-approved substitute.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that all piping, ductwork, and equipment are tested and approved prior to insulation installation.



- B. Verify that all surfaces are clean, dry and without foreign material before applying insulation materials.

3.2 GENERAL INSULATION REQUIREMENTS

- A. All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards.
- B. Locate insulation and cover seams in the least visible location. All surface finishes shall be extended in such a manner as to protect all raw edges, ends and surfaces of insulation.
- C. On cold surfaces where a vapor seal must be maintained, insulation shall be applied with a continuous, unbroken moisture and vapor retarder. All hangers, supports, anchors, or other projections secured to cold surfaces shall be insulated and vapor sealed to prevent condensation.
- D. All pipe insulation shall be continuous through walls, ceiling or floor openings or sleeves except where firestop or firesafing materials are required.
- E. Install multiple layers of insulation with longitudinal and circumferential joints staggered.

3.3 PIPING INSULATION: PIPE & TANK INSULATION

- A. Apply on clean, dry surfaces.
- B. Cut to appropriate length using manufacturers' stretchout guide for the specific pipe size. Add an additional 2 inches (51 mm) to 4 inches (102 mm) for a staple flap.
- C. Wrap around the pipe to ensure proper fit. Staple the lap on 3 inch (76 mm) centers with outward clinching staples.
- D. On systems operating below ambient, appropriate UL approved vapor retarder shall be applied to all longitudinal and circumferential joints.
- E. For piping exposed to the elements, jacketing shall be UV resistant PVC with a minimum thickness of 0.020 inches, or 0.016 inches (0.406) thick aluminum with factory applied moisture barrier or 0.010 inches (0.254mm) thick stainless steel with a factory applied moisture barrier or laminated self-adhesive water and weather seals. Fitting covers shall be of similar materials. The insulation and jacketing shall be held firmly in place with a friction type Z lock or a minimum 2" overlap joint. For systems operating below ambient, all PVC joints shall be sealed completely

along the longitudinal and circumferential seams and installed so as to shed water. When required, all PVC circumferential joints shall be sealed by use of preformed butt strips; minimum 2" wide or a minimum 2" overlap. Butt strips shall overlap the adjacent jacketing a minimum ½ inch and be completely weather sealed. PVC Jacketing shall be limited to a maximum 20-inch OD of the insulation when exposed to direct sunlight. For systems operating above ambient, circumferential joints should overlap a minimum of 2" and not be sealed. Insulation thickness for piping covered by PVC Jacketing shall be such that the surface temperature of the PVC does not exceed 125°F (52°C).

- F. On below ambient piping, vapor retarder mastic shall be applied to the ends at every fourth section and at each fitting before taping.

3.4 FLEXIBLE FIBER GLASS BLANKET

- A. Install Duct Wrap using manufacturer's stretch-out tables to obtain specified R-value using a maximum compression of 25%.
- B. Installed R-value shall be per ASHRAE 90.1; UCC Code; or other design criteria.
- C. Firmly butt all joints.
- D. The longitudinal seam of the vapor retarder must be overlapped a minimum of 2 inches.
- E. A 2-inch tab is provided on Knauf Insulation Friendly Feel[®] Duct Wrap for the circumferential seam.
- F. Where vapor retarder performance is required, all penetrations and damage to the facing shall be repaired using pressure-sensitive tape matching the facing, or mastic prior to system startup. Pressure-sensitive tapes shall be a minimum 3 inches wide and shall be applied with moving pressure using a squeegee or other appropriate sealing tool. Closure shall have a 25/50 Flame Spread/Smoke Developed Rating per UL 723.
- G. Duct Wrap shall be additionally secured to the bottom of round ductwork over 24 inches wide using mechanical fasteners on 18-inch centers. Care should be exercised to avoid over-compression of the insulation during installation. Unfaced Duct Wrap shall be overlapped a minimum of 2 inches and fastened using 4-inch to 6-inch nails or skewers spaced 4 inches apart, or secured with a wire/banding system. Care should be exercised to avoid damage to the Duct Wrap.

3.4 DUCTWORK



- A. Apply on clean, dry surfaces.
- B. Cut to appropriate length using manufacturers’ stretch-out guide for the specific duct size. Add an additional 2 inches (51 mm) to 4 inches (102 mm) for a staple flap.
- C. Wrap around the duct to ensure proper fit. Staple the lap on 3 inch (76 mm) centers with outward clinching staples.
- D. Ends shall be firmly butted and secured with matching butt strip material at each joint.
- E. On below ambient ductwork, appropriate UL approved vapor retarder shall be applied to all longitudinal and circumferential joints before application of butt strip material.

3.5 INSULATION SCHEDULES

- A. ASHRAE 90.1 – 2010 Requirements, Pipe Insulation

Minimum Pipe Insulation Thickness ^a

Insulation Conductivity			Nominal Pipe or Tube Size (in.)				
Fluid Design			<1	1 to < 1½	1½ to < 4	4 to <8	≥8
Operating Temp. Range (° F.)	Conductivity Btu·in./((hr·ft ² ·°F)	Mean Rating Temp. °F.					
Heating Hot Water Systems (Steam, Steam Condensate, Hot Water Heating and Domestic Water Systems)^{b,c}							
>350	0.32 – 0.34	250	4.5	5.0	5.0	5.0	5.0
251 – 350	0.29 – 0.31	200	3.0	4.0	4.5	4.5	4.5
201 – 250	0.27 – 0.30	150	2.5	2.5	2.5	3.0	3.0
141 – 200	0.25 – 0.29	125	1.5	2.0	2.0	2.0	2.0
105 – 140	0.22 – 0.28	100	1.0	1.0	1.5	1.5	1.5



- ^a For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r\{(1 + t/r)^{K/k} - 1\}$. Where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature {Btu·in.(hr·ft²·°F)}; and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.
- ^b These thicknesses are based on energy *efficiency* considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.
- ^c For piping smaller than 1.5" and located in partitions within conditioned spaces, reduction of these thicknesses by 1" shall be permitted (before thickness adjustment required in footnote a) but not to thicknesses below 1".
- ^d These thicknesses are based on energy *efficiency* considerations only. **Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.**
- ^e The table is based on steel pipe. Non-metallic pipes scheduled 80 thickness or less shall use the table values. For other non-metallic pipes having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown on the table.

B. Necessary pipe insulation to prevent condensation:

Pipe Size	Relative Humidity & Operating Temperature 70% RH					Relative Humidity & Operating Temperature 80% RH					Relative Humidity & Operating Temperature 90% RH				
	35° F	40° F	45° F	50° F	55° F	35° F	40° F	45° F	50° F	55° F	35° F	40° F	45° F	50° F	55° F
0.5	0.5"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	0.5"	0.5"	1.5"	1.5"	1.5"	1.0"	1.0"
1	0.5"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	0.5"	0.5"	1.5"	1.5"	1.5"	1.5"	1.0"
1.5	0.5"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	1.0"	0.5"	2.0"	2.0"	1.5"	1.5"	1.5"
2	0.5"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	1.0"	0.5"	2.0"	2.0"	1.5"	1.5"	1.5"
4	1.0"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	1.0"	0.5"	2.0"	2.0"	2.0"	1.5"	1.5"
6	1.0"	0.5"	0.5"	0.5"	0.5"	1.5"	1.0"	1.0"	1.0"	0.5"	2.5"	2.5"	2.0"	2.0"	1.5"
8	1.0"	0.5"	0.5"	0.5"	0.5"	1.5"	1.0"	1.0"	1.0"	0.5"	2.5"	2.5"	2.0"	2.0"	1.5"
10	1.0"	0.5"	0.5"	0.5"	0.5"	1.5"	1.0"	1.0"	1.0"	0.5"	2.5"	2.5"	2.0"	2.0"	1.5"



12	1.0"	1.0"	1.0"	1.0"	0.5"	1.5"	1.0"	1.0"	1.0"	1.0"	2.5"	2.5"	2.0"	2.0"	1.5"
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Pipe Size	Relative Humidity & Operating					Relative Humidity &					Relative Humidity &				
	70% RH					80% RH					90% RH				
	35° F	40° F	45° F	50° F	55° F	35° F	40° F	45° F	50° F	55° F	35° F	40° F	45° F	50° F	55° F
0.5	0.5"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	0.5"	0.5"	2.0"	1.5"	1.5"	1.0"	1.0"
1	0.5"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	1.0"	0.5"	2.0"	2.0"	2.0"	1.5"	1.5"
1.5	1.0"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	1.0"	1.0"	2.0"	2.0"	2.0"	2.0"	1.5"
2	1.0"	0.5"	0.5"	0.5"	0.5"	1.0"	1.0"	1.0"	1.0"	1.0"	2.5"	2.0"	2.0"	2.0"	1.5"
4	1.0"	0.5"	0.5"	0.5"	0.5"	1.5"	1.0"	1.0"	1.0"	1.0"	3.0"	2.5"	2.5"	2.0"	2.0"
6	1.0"	1.0"	0.5"	0.5"	0.5"	1.5"	1.0"	1.0"	1.0"	1.0"	3.0"	3.0"	2.5"	2.5"	2.0"
8	1.0"	1.0"	1.0"	0.5"	0.5"	1.5"	1.0"	1.0"	1.0"	1.0"	3.0"	3.0"	2.5"	2.5"	2.0"
10	1.0"	1.0"	1.0"	0.5"	0.5"	1.5"	1.5"	1.0"	1.0"	1.0"	3.5"	3.0"	2.5"	2.5"	2.0"
12	1.0"	1.0"	1.0"	1.0"	0.5"	1.5"	1.5"	1.0"	1.0"	1.0"	3.5"	3.0"	2.5"	2.5"	2.0"

C. ASHRAE 90.1 – 2010 REQUIREMENTS – DUCT INSULATION
Minimum Duct Insulation R-Value ^{a,b,c}

Energy Recovery Supply and Exhaust Ventilation Ducts

Duct Location							
Climate Zone	Ventilated Exterior	Unvented Attic	Unvented Attic Above Ceiling	Unvented Attic with Roof Insulation ^a	Unconditioned Space ^b	Indirectly Conditioned Space ^c	Buried
Supply & Exhaust Ducts							
1	R – 6.0	R – 6.0	R – 8.0	R – 3.5	R – 3.5	none	R – 3.5
2	R – 6.0	R – 6.0	R – 6.0	R – 3.5	R – 3.5	none	R – 3.5
3	R – 6.0	R – 6.0	R – 6.0	R – 3.5	R – 3.5	none	R – 3.5
4	R – 6.0	R – 6.0	R – 6.0	R – 3.5	R – 3.5	none	R – 3.5
5	R – 6.0	R – 6.0	R – 6.0	R – 1.9	R – 3.5	none	R – 3.5



6	R – 8.0	R – 6.0	R – 6.0	R – 1.9	R – 3.5	none	R – 3.5
7	R – 8.0	R – 6.0	R – 6.0	R – 1.9	R – 3.5	none	R – 3.5
8	R – 8.0	R – 8.0	R – 8.0	R – 1.9	R – 6.0	none	R – 6.0

^a Insulation R – values, measured in (hr· ft²· °F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be required by the most restrictive condition of Section 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a Mean temperature of 75° F at the installed thickness.

^b Includes crawlspaces, both ventilated and non-ventilated.

^c Includes return air plenum with or without exposed roofs above.

E. MINIMUM DUCT WRAP INSULATION (INSTALLED) TO PREVENT CONDENSATION

Jacket: Aged Aluminum Foil or Galvanized Sheet Metal ($\epsilon = 0.2$) Wind Speed = 0 mph

Operating Temperature: 45°F					
Rel. Humidity	Ambient Temperature				
	70°F	80°F	90°F	100°F	110°F
60%	2.2	3.3	4.3	4.3	5.4
70%	3.3	5.4	6.5	7.6	**
80%	7.0	**	**	**	**

Operating Temperature: 55°F					
Rel. Humidity	Ambient Temperature				
	70°F	80°F	90°F	100°F	110°F
60%	1.1	2.2	3.3	3.3	4.3



70%	1.1	3.3	4.3	6.5	6.5
80%	3.3	6.5	**	**	**

Operating Temperature: 65°F					
Rel. Humidity	Ambient Temperature				
	70°F	80°F	90°F	100°F	110°F
60%	1.1	1.1	2.2	3.3	4.3
70%	1.1	1.1	3.3	5.4	6.5
80%	2.2	3.3	6.5	**	**
90%	6.5	**	**	**	**

** Necessary R-value is greater than one typically supplied in duct wrap. Please consult manufacturer.

END OF SECTION 23 07 00



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SECTION 23 09 00
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1 Specification Sections apply to this Section.
- B. Division 22
- C. Division 23 (Multiple Sections)
- D. Division 26

1.2 SCOPE

- A. The BAS/ATC (Building Automation System/Automatic Temperature Control) systems as specified herein shall be provided in their entirety by the BAS/ATC Contractor. The BAS/ATC Contractor shall complete the installation of the system as specified by the sequence of operations, the points list, and Contract Documents. Regardless of the points listed in these documents, the Contractor shall provide the number of points, the types of points, and other controls as required for the sequence of operations.
- B. It shall be the responsibility of the BAS/ATC Contractor to fully coordinate with all equipment suppliers, and with the fire alarm system designer/installer to provide a complete functional control system.
- C. All Direct Digital Controllers shall be factory mounted, programmed, and commissioned. Where factory mounting, programming, or commissioning is not possible, it shall be the responsibility of BAS/ATC Contractor to provide verification of operation of non-factory installed controls. It shall be the responsibility of the Mechanical Equipment Supplier and the ATC Contractor to ensure that the entire system (Mechanical Equipment and Automatic Temperature Controls) be free of defects and function as specified. Any control devices required by the "Mechanical General Provisions" specification or the "Automatic Temperature Control" specification shall be furnished without any additional cost to Owner.



- D. The BAS/ATC Contractor shall provide trending of HVAC points during a 90-day period following installation. The Contractor shall analyze the trends and report any unusual conditions to the General Contractor, Mechanical Contractor, Project Manager, and Engineers. Trends and status reports shall be emailed to all listed parties for records and actions required.

1.3 SUBMITTALS

- A. The following data/information shall be submitted for approval in conjunction with the Mechanical Equipment Submittal (separate Control and Equipment submittals will be rejected):
 1. Complete sequence of operation.
 2. Provide a detailed Performance Verification Testing procedure
 3. Control system CAD-generated drawings, including all pertinent data to provide a functional operating system.
 4. Damper and valve schedules showing size, configuration, etc.
 5. Data sheets for all hardware and software control components.
 6. A description of the installation materials, including conduit, wire, flex, etc.
 7. Computer and DDC controller panel locations.
 8. Provide as part of the submittal four (4) copies of all data and control drawings.

1.4 QUALIFICATIONS

- A. The BAS/ATC Contractor shall be the local office of a nationally recognized organization within a 75-mile radius of the job site. This office shall be staffed with four (4) factory trained engineers and four (4) factory trained service technicians fully capable of providing instruction, routine maintenance and 24-hour emergency maintenance service on all system components. The ATC Contractor shall have a 5-year experience record in the design and installation of computerized building systems similar in scope and performance to that specified herein, and shall provide evidence of this history as condition of acceptance.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All materials and equipment used shall be standard components, of regular manufacture for this application. All systems and components shall have been thoroughly tested and proven in actual use.
 1. Acceptable Manufacturers: Trane
 2. Substitutions: Sundrum, BuildingLogix (Tridium-based, Niagra Framework), DGLogic
 3. No other manufacturers are acceptable

2.2 GENERAL

- A. Building Automation System shall include but not be limited to the following components.
1. The Operator Interface shall consist of hardware and software that allows full user monitoring and adjustment of system parameters.
 2. Building Control Unit (BCU) shall manage the Energy and Building Management capabilities of the automation system as well as facilitate remote communications and central monitoring.
 3. The Data Communications capability shall allow data to be shared between the various controllers in the architecture.
 4. The system software shall include software for global application functions, application software for distributed controllers, and operator interface software.
 5. End devices such as sensors, actuators, dampers, valves, and relays.
 6. The failure of any single component shall not interrupt the control strategies of other operational devices. System expansion shall be through the addition of end devices, controllers, and other devices described in this specification.
 7. Communication between the control panels and all workstations shall be over a high-speed Local Area Network. All nodes on this network shall be peers. The operator shall not have to know the panel identifier or location to view or control an object. Application Specific Controllers shall be constantly scanned by the network controllers to update point information and alarm information.

2.3 OPERATOR INTERFACE

- A. Furnish one (1) dedicated DDC System computer. The Building Automation System supplier shall provide all cables, connectors, software, and hardware required to monitor, modify, upload, and download all DDC Controllers furnished on the project.
1. Intel Core i5-520M (2.4Ghz, 3M cache) with Turbo Boost Technology
 2. 21" HD Anti-Glare LED display
 3. 2GB, DDR3-1333 SDRAM, 2 DIMMS
 4. 160GB 5400RPM Hard Drive
 5. 1 expansion slot
 6. Touchpad and Trackstick dual Pointing
 - 7.. Wireless Lan (802.11) Half mini card
 8. Windows 7 enterprise
 9. 8X dvd+/-RW
 10. Internal Keyboard
 11. Internal 56K Modem
 12. DDC System Manufacturer's proprietary software (Complete with licensing)



2.4 WEB-BASED OPERATOR INTERFACE

- A. The Building Control Unit is to have an on-board web server to allow remote web accessibility for system accessibility, monitoring, and parameter modification. The Building Control Unit should be compatible with the following PC and Mobile web browsers:
1. Internet Explorer 8.0+
 2. Firefox 4.0+
 3. Chrome 10.0+
 4. OS (iPad/iPhone) V4.0+
 5. Android (Tablet) V4.0+
 6. Android (Phone) V2.3+

2.5 BUILDING CONTROL UNIT (BCU)

- A. General: Provide Building Controllers that are BACnet ready and meet the following requirements:
1. The Building Automation System shall be composed of one (1) independent, stand-alone, microprocessor based Building Controller to manage the global strategies described in System software section.
 2. The Building Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 3. The Building Controller shall provide a communications port for connection of the Portable Operators Terminal using Point to Point BACnet physical/data link layer protocol or a connection to the inter-network.
 4. The operating system of the Building Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
 5. Controllers that perform scheduling shall have a real-time clock.
 6. Data shall be shared between networked Building Controllers (if applicable).
 7. The Building Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - a. Assume a predetermined failure mode.
 - b. Generate an alarm notification.
 8. The Building Controller shall be BACnet Class 3 device and perform the following BACnet Functional Group Services: Clock, Reinitialize.
 9. All Building Control shall be wired to emergency power if applicable



- B. Communications: The Building Controller Unit shall reside on the Local Area Network. The Local Area Network will be provided by Division 26 and supports the Internet Protocol (IP). Local connections of the Building Controller shall be on ISO 8802-3 (Ethernet). Communications shall use Annex J of ASHRAE Standard 135-95. Each Building Controller shall also perform routing to a network of Custom Application and Application Specific Controllers.
- C. Environment: Controller's hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at 0°C to 50°C [32°F to 120°F].
- D. Serviceability: Provide diagnostic LEDs for power, communications, and processor. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connection by a ribbon cable.
- E. Memory: The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
- F. Immunity to Power and Noise: Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2.6 COMMUNICATIONS

- A. This project shall comprise a BACnet inter-network. All PC Workstations and Building Controller components shall meet ASHRAE/ANSI Standard 135-1995, BACnet.
- B. Each BACnet device shall operate on the BACnet physical/data link protocols specified for that device as defined earlier in this Section.
- C. Division 26 is to provide all communication media, connectors, repeaters, hubs, and routers necessary for the internetwork. A 10 BaseT jack will be provided adjacent to the Building Control Panel and PC Workstation for connection to this network.
- D. All Building Controllers shall have a communications port for connections with the operator interfaces. This may be either an RS-232 port for Point to Point connection or a network interface node for connection to the Ethernet network.

- E. Remote operator interface via a 56KB or faster modem shall allow for communication with any and all controllers on this network as described in 2.06.F below.
- F. Communications services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:
 - 1. Connection of an operator interface device to any one controller on the internetwork will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the internetwork.
 - 2. All database value (i.e. points, software variable, custom program variables) of any one controller shall be readable by any other controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to a point name not located in that controller is entered into the controller's database. An operator/ installer shall not be required to set up any communications services to perform internetwork value passing.
- G. The time clocks in all controllers shall be automatically synchronized daily.
- H. Provide communication gateways for devices without native BACnet capabilities. This includes, but not limited to, the following:
 - 1. Solar Panel Power Monitoring System as supplied by Division 26
 - 2. Schneider Electric BCPM components
 - 3. Any Additional Power Monitoring Equipment as supplied by Division 26
 - 4. INSTEON Lighting Controls

2.7 UNIT CONTROL MODULE (UCM)

- A. Unit Control Modules (UCM) shall be stand-alone, microprocessor based Direct Digital Controllers with sufficient memory to handle its operating system, database and programming requirements. Provide full English, Color LCD display for all Custom Application Controllers.
- B. The UCM shall be pre-programmed, tested and factory mounted on the mechanical equipment to ensure reliability. Under no circumstance shall more than one UCM be utilized to control any specific piece of mechanical equipment.
- C. Where factory mounting is not possible, the Controllers shall be factory programmed and tested prior to shipment to the jobsite. The Controllers shall be clearly labeled as to controller type, where it is to be installed, and software address (if applicable). The Controller shall be fully tested upon installation to ensure that it is properly matched to the equipment it is controlling.

- D. The Controller shall communicate with other devices on the communication network and be fully integrated with the other system components.
- E. The hardware shall be suitable for the anticipated ambient conditions.
 - 1. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at -40°F to 155°F.
 - 2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32°F to 120°F.

2.8 INPUT/OUTPUT INTERFACE

- A. Hardwired inputs and outputs may tie into the system through Building Control Unit (BCU), or Unit Control Module (UCM). Slave devices are also acceptable. Any critical points requiring immediate reaction shall be tied directly into the controller hosting the control software algorithm for the critical function.
- B. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of 12mA at 12VDC to be compatible with commonly available control devices.
- C. All status points shown on the point list shall be positive proof differential pressure or current sensing binary switches.
- D. Analog inputs shall allow the monitoring of low voltage, current, or resistance signals and shall have a minimum resolution of 0.1% of the sensing range. Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.
- E. Binary outputs shall provide a continuous low voltage signal for on/off control of remote devices.
- F. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device.

2.9 DAMPERS

- A. The Building Automation System supplier shall provide all automatic control dampers not specified to be supplied integral to any HVAC equipment.



- B. Dampers shall be low leakage or high velocity low leakage as specified in the sequence of operations. All proportional dampers shall be opposed blade type. Two position dampers may be opposed or parallel blade type.
- C. Damper frames and blades shall be galvanized steel and a minimum of 16 gauge. Blade width shall not exceed 8". Dampers and seals shall be suitable for temperature ranges of -50 to 250°F.
- D. Standard low leakage dampers shall be provided to conserve energy. Dampers shall be equipped with neoprene edge seals and compressible metal jamb seals. Leakage shall not exceed 10 CFM/Sq. Ft. at 4" W.G. differential.

2.10 DAMPER OPERATORS

- A. Damper operators shall be electronic, spring return, low voltage (24VAC) and shall be properly sized so as to stroke the damper smoothly and efficiently throughout its range. Actuator response shall be linear in response to sensed load.

2.11 TEMPERATURE SENSORS

- A. Temperature sensors shall be Resistance Temperature Detector (RTD) or Thermistor as dictated by the requirements of this Specification.
- B. All space temperature sensors shall have an LCD Display, setpoint adjustment, and two integral pushbuttons which shall override and cancel the space from unoccupied to occupied. In lieu of cancel button, furnish LED which shall illuminate whenever the system is overridden.
- C. Duct sensors shall be rigid or averaging as specified in the sequence of operations. Averaging sensors shall be a minimum of 5 feet in length.
- D. Accuracies shall be $\pm 1^{\circ}\text{F}$ for standard applications. Where high accuracy is required, accuracies shall be $\pm 0.2^{\circ}\text{F}$.

2.12 DIFFERENTIAL PRESSURE SWITCHES

- A. Differential Pressure Switches shall be furnished as indicated for status purposes in air and water applications. Provide single pole double throw switch with fully adjustable differential pressure settings.

2.13 LOW LIMIT THERMOSTATS (If Applicable)

- A. Safety low limit thermostats shall be vapor pressure type with a 20-foot minimum element. Element shall respond to the lowest temperature sensed by any one foot section.
- B. Low limit shall be auto reset only.

2.14 FIRE PROTECTION DEVICES

- A. UL-Listed, ionization-type smoke detectors shall be provided per code, per the International Mechanical Code, or as indicated on the drawings, whichever is most demanding. Locations indicated on the drawings are general; final locations shall be consistent with manufacturer recommendations in regard to access, air velocity, distance from elbows and the like. Upon detection of products of combustion, the unit supply fan shall stop. The detectors shall be furnished by Division 26 and installed by the Mechanical Contractor. Smoke detectors shall be wired to the BAS/ATC system under this Section.
- B. Power wiring to the smoke detector and signal wiring from the smoke detector to the Fire Alarm Control Panel shall be furnished under Division 26. Unit shutdown wiring and control shall be the responsibility of the Mechanical Contractor.

2.15 STATIC PRESSURE SENSORS

- A. Static pressure sensors shall be differential pressure type. The sensor range shall be closely matched to the system static pressure, -.5 to .5", -1 to 1", 0 to 2.5".
- B. Sensor accuracy shall be $\pm 5\%$ of the sensing range.

2.16 CONTROL VALVES (Where Field-Supplied)

- A. Valve bodies shall be 2-way normally open or closed, or 3-2 way mixing as specified. Valve bodies 2" and smaller shall be bronze, screwed type and shall be rated at 250 psig. Valve bodies 2-1/2" and larger shall be iron, flanged and rated at 125 psig except where otherwise noted.
 - 1. Acceptable Manufacturers: Belimo, No Substitutions
- B. Valves shall have stainless-steel stems and allow for servicing, including packing, stem and disk replacement.

2.17 VALVE ACTUATORS

- A. Valve actuators shall be electronic, spring return, low voltage (24VAC) and properly selected for the valve body and service.
- B. Actuators shall be fully proportioning and be spring return for normally open or normally closed operation as called out in the Sequence of Operation.
- D. The Automatic Temperature Controls Contractor SHALL NOT supply the control valves specified as intergral components to the Solar Water Pump Packages or Hydronic Radiant Floor Heating distribution panels (Valves will be provided as integral components from the factory).
- E. The ATC Contractor SHALL supply control valves which are not integral to a packaged solution.

2.18 HUMIDITY SENSORS

- A. Humidity sensors shall be capacitance or bulk polymer resistance type.
- B. Duct and room sensors have a sensing range of 0 to 95% with accuracy of $\pm 3.0\%$ R.H. Duct sensors shall be provided with a sampling chamber.

2.19 CURRENT SENSING SWITCH

- A. Sensor supply voltage and supply current shall be induced from monitored conductor. Contact rating shall be 0.2 amperes at 30 volts DC/AC. Trip setpoint shall be adjustable to $\pm 1\%$ of range. Current sensing switch wiring shall not be polarity sensitive.

2.20 CARBON DIOXIDE SENSOR (If Applicable)

- A. Solid-state infrared sensor, calibrated for 0 to 2%, with continuous or averaged reading, 4-20 mA output, duct mounted.

2.21 DIFFERENTIAL PRESSURE SENSOR

- A. Provide self-contained, variable capacitance type differential pressure transmitters equal to a Rosemount No. 1151DPS. Design range shall be as required by system. External zero and span adjustments, over pressure to 2,000 PSI, and no humidity effects. Minimum accuracy shall be $\pm 0.25\%$ of upper range limit for 6 months. No internal mechanical linkages shall be used in the transmitter(s).

2.22 UNINTERRUPTED POWER SOURCE (UPS)



- A. Provide UPS for all Building Control Units. UPS must be a minimum APC No. SUA1500 rated a 1440VA/980W and provide a minimum backup time of 20 minutes.
- B. Mount UPS on wall beside Building Control Unit.

2.23 ENERGY CONSUMPTION METER

- A. The Energy Meter shall consist of digital electronic circuitry.
- B. The Energy Meter shall conform to ANSI C12.1 metering accuracy standards.
- C. The Energy Meter shall consist of a meter and include CT(s) calibrated together as a system.
- D. The Energy Meter's accuracy shall be $\pm 1\%$ from 2% to 100% of the rated current over a temperature range of 0-50°C.
- E. The Energy Meter shall require no annual recalibration by users in the field.
- F. The Energy Meter shall derive operating power from its metering connections, and shall not require a separate control power connection.
- G. The Energy Meter CTs shall be factory assembled.
- H. The Energy Meter shall have a backlit LCD display measuring 1.2" X 3.8" that is direct read without the need for multipliers.
- I. The Energy Meter LCD Display shall show accumulated kWh on the top half of display while the bottom half of the display scrolls through Amps, Voltage, PF, KVAR, KVA, KW Real Power, as stated in point Q below.



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- J. The Energy Meter shall meet UL and cUL specifications as listed in 3111-1.
- K. The Energy Meter shall directly accept any voltage input from 120-480VAC.
- L. The Energy Meter shall be internally isolated to 2500 VAC.
- M. The Energy Meter shall have an N.O. pulse output with selectable pulse output rates of 0.10, 0.25, 0.50, or 1.00kWh per pulse.
- N. The Energy Meter shall have an N.C. phase-loss alarm output operating at 100mA @ 24VAC/DC.
- O. Using the optional communications board, the Energy Meter shall be networkable via an RS485 connection to a Modbus RTU network. Provide Modbus-to-BACnet gateway as required by this specification. Gateway shall be provided as a component by the Energy Meter manufacturer.
- P. The information and capabilities provided by the Energy Meter shall include the following:
 - 1. Current, per phase & three phase total.
 - 2. Voltage, per phase & three phase total, phase to phase & neutral.
 - 3. Real Power (KW), per phase & three phase total.
 - 4. Reactive Power (kVAR), three phase total.
 - 5. Apparent Power (kVA), three phase total.
 - 6. Power Factor, per-phase & three phase total.
 - 7. Real Energy (kWh), three phase total.
- Q. The Energy Meter shall be the H8163 Series by VERIS INDUSTRIES, or approved equal.

2.24 SOFTWARE SECURITY SYSTEM

- A. User access shall be secured using individual security passwords for a minimum of eight users.
- B. Passwords shall have at least three levels of user access with data entry restrictions being assignable by password.
- C. User logon/logoff attempts shall be recorded.



- D. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.

2.25 ALARMS

- A. The Building Automation System shall provide audio, visual, contact closure, and remote telephone annunciation for:
 - 1. Remote equipment failure
 - 2. Equipment run time
 - 3. Number of start/stops
 - 4. Program failure
 - 5. Communication failure
 - 6. Sensor failure
- B. Each analog sensor and binary point shall be individually alarmed for values in excess of individual high/low limits or status.
- C. Ethernet Communications: A communications utility shall allow standalone Building Control Unit (BCU) to communicate with remote operator stations over Ethernet/WAN/LAN data lines.
- D. Remote Alarm/Reporting:
 - 1. Controllers shall automatically call operator stations to report alarms, and upload historical data and reports.
 - 2. In the event that the controller is unable to connect with the remote station, it shall continue to attempt communication on a predetermined interval until communication is successful. The capability shall exist to automatically switch to a backup phone number in the event communications is unsuccessful with the first number.
- E. Remote Operator Communications:
 - 1. Web-based accessibility shall allow access to the Building Control Unit (BCU) and gain the full control, reporting, and system modification capabilities described in this specification.

2.26 ENERGY MANAGEMENT SOFTWARE

- A. The following Energy Management programs shall be furnished standard as part of the Building Automation System. The programs shall be enabled or disabled as directed by Owner.

1. Scheduling:
 - a. The scheduling program shall have a minimum of 32 named master schedules. Each master schedule shall have a minimum of 8 day schedules (seven plus holiday).
 - b. To these master schedules, a minimum of 24 system loads (HVAC equipment etc) or groups of loads can be assigned.
 - c. The master schedule shall be individually editable for each day of the week and holiday.
 - d. On any day, a minimum of six time of day events may be edited, including:
 - (1) equipment start/stop
 - (2) optimum start/stop
 - (3) occupied/unoccupied
 - (4) duty cycle start/stop
 - (5) night purge cycle start
2. Optimum Start/Stop:
 - a. An optimum start/stop program shall determine the required equipment start/stop timing by applying inside/outside temperature information to the user's time of day schedule.
 - b. The optimum start/stop program shall run independently for each controlled load or zone.
 - c. The program shall automatically make adjustments to itself based on historical data.
3. Duty Cycling:
 - a. The duty cycle program shall cycle a minimum of 32 pieces of equipment according to user-defined on/off patterns.
 - b. User editable parameters are to include period length, off time and delay time. Program shall incorporate temperature and humidity overrides to ensure that Indoor Air Quality and occupant comfort is not compromised.
4. Demand Limiting:
 - a. The demand limiting program shall monitor building power consumption from signals generated by a pulse generator (future) mounted at the building power meter or from a watts transducer or current transformer attached to the building feeder lines.
 - b. The demand-limiting program shall be based on a predictive sliding window algorithm. The program shall be self-adjusting and shall control a minimum of two independent demand limiting applications.
 - c. Demand limiting parameters shall include 15 or 30 minute intervals, shed/restore dead band width as well as maximum off-time and temperature limits for each load to ensure that Indoor Air Quality and occupant comfort are not compromised.
 - d. The HVAC equipment shall be protected by an anti-recycle timer.
 - e. Input capability shall also be provided for an end-of-billing period indication.

2.27 BUILDING MANAGEMENT SOFTWARE

- A. The following Building Management programs shall be furnished standard as part of the Building Automation System. The programs shall be enabled or disabled as directed by Owner.
1. Timed Override:
 - a. A timed override program shall be provided to enable the building operator to set up devices or groups of devices to be temporarily turned on for a defined period of time based on binary inputs or analog inputs.
 - b. The override time shall be adjustable from 1 to 720 minutes.
 - c. A standard weekly and monthly report shall be provided for easy documentation of timed override operation.
 2. Direct Digital Control:
 - a. The Direct Digital Control program shall allow modulating control of remote devices based on sensed data.
 - b. Standard control strategies shall include proportional, proportional plus integral, and proportional plus integral plus derivative control.
 - c. Control routines shall be flexible enough to allow operator to set parameters and make adjustments.
 - d. Direct Digital Control loop setup and modification shall be done through pre-formatted edit screens, with parameters listed in English language.
 - e. Program shall include a dynamic graphic display printout routine to indicate the status and real-time performance of the control loop.
 3. Custom Programming Language:
 - a. A custom control language capability shall be provided to allow the operator to create real time, equation based, custom control routines.
 - b. All binary and analog points in the Building Automation System shall be available as inputs to the custom routines.
 - c. Equation operations shall include math functions, such as addition, subtraction, multiplication, division, square root, minimum, maximum, and average. Logical functions such as greater than, less than, equal to, not equal to, less than or equal to, greater than or equal to, variable timing and delays shall also be allowed.
 4. Run Time Maintenance:
 - a. The system shall monitor equipment status and generate maintenance messages based upon user designated run time, starts and/or calendar date limits.
 - b. A minimum of 32 separate devices shall be monitored under this function.
 5. Expanded Messages: The user shall be able to define a minimum of ten 40-character messages for automatic printing in the event of system alarm and/or run time and maintenance events.
 6. Reports and Logs: The system shall include the capability to store, review and print the following reports and logs. In addition, if a PC interface is specified, these reports shall be saved to diskette as an ASCII file for use by other Owner-furnished software packages.



- a. Current Summary Report - An instantaneous summary of building status, including heating and cooling degree days, on and off peak electrical demand performance, current electrical kWh consumption, and summary for critical temperature sensors listing today's minimum and maximum values.
- b. Monthly Summary Report - An end of the month summary of building status including heating and cooling degree days, on and off peak electrical demand performance, current electrical kWh consumption, and summary for critical temperature sensors listing this month's minimum and maximum values.
- c. Monthly Demand Limiting Report - A report for logging the electrical demand performance (both on and off peak) and the kWh consumption for each of the two utility meter programs shall be provided to the building operator. Included shall be the times of today and yesterday's demand peaks as well as the time and date of the monthly demand peaks. This report shall log electrical performance for the present day and previous 32 days.
- d. Yearly Demand Limiting Report - A report for logging the electrical demand performance (both on and off peak) and kWh consumption for each of the two utility meter programs. This report shall log electrical performance for the present month and previous 12 months.
- e. Yearly Meter Report - A report for logging the electrical kWh consumption for up to 6 submeters. This report shall log electrical performance for the present month and previous 12 months.
- f. Yearly Degree-Day Report - A current month and previous 12-month summary of heating and cooling degree-days.
- g. Weekly Temperature Report - A previous 7-day summary of the minimum and maximum temperatures for the critical zone temperature sensors.
- h. Weekly Override Time Report - A previous 7-day summary of after hours override usage (in hours and minutes) for the timed override groups.
- i. Monthly Override Time Report - A current and previous month summary of after hours override usage (in hours and minutes) for the timed override groups).
- j. Trend Logs - A custom report generator allowing the user to trend and store at least 24 sample points based on a user-defined schedule.
- k. Event Logs - The system shall track system events including alarms, logons and diagnostics.
- l. Input/Output Status Reports - This reporting tool shall allow the operator to review the status of all system points.
- m. HVAC Equipment Reports - Reports shall be provided which indicate the HVAC equipment status as well as the status of all input/output points of connected HVAC equipment.
- n. Custom Report Capability - The building operator shall be provided with a simple method of creating custom reports.



2.28 ANTI-RECYCLE TIMER PROTECTION

- A. A software program shall be provided to allow each individual piece of HVAC equipment to be individually programmable with “minimum on,” and “minimum off” timers to protect HVAC equipment from rapid cycling due to system or operator error.
- B. Minimum on/off timer program shall have priority over all application software functions except fire shutdown and smoke evacuation modes.
- C. For system start-up purposes, timers shall be set at 15 minutes or at an acceptable time as documented by the HVAC equipment supplier.
- D. Timers shall be individually programmable from 0 to 120 minutes.

2.29 CUSTOM PROGRAMMING REQUIREMENTS

- A. A user-friendly custom DDC programming utility shall be provided to allow the building operator to tailor the system to meet individual needs and respond to changing building requirements.
- B. The building operator shall be able to create custom DDC routines using analog and binary point values, alarm states, constants, and shared variables to perform calculations. The results of these calculations shall be used to perform analog control, binary control, DDC loop enable/disable, and other control functions.
- C. Custom routines in distributed controllers shall be maintained in nonvolatile memory to prevent loss in a power outage. Custom routines hosted in Building Control Unit (BCU) may use battery backup so long as a quick method of system downloading is provided.

2.30 WORKSTATION SOFTWARE

- A. Operating System: Furnish a commercially available, concurrent multi-tasking operating system. The operating system shall also support the use of other common software applications that operate under DOS or Microsoft Windows. Acceptable operating systems are Windows XP.
- B. System Graphics: The Operator Workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the

size and location of graphic displays on the screen. The system graphics shall be able to be modified while on line. An operator with the proper password level shall be able to add, delete, or change dynamic points on a graphic. Dynamic points shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation of equipment.

1. Custom Graphics: Custom graphic files shall be created with the use of commonly available graphics packages, such as PC Paint. The graphics generation package shall create and modify graphics that are saved in industry standard formats, such as PCX, BMP, GIF and JPEG. The graphics generation package shall also provide the capability of capturing or converting graphics from other programs, such as Designer, or AutoCAD.
 2. Graphics Library: Furnish a complete library of standard HVAC equipment, such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library shall also include standard symbols for other equipment, including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
 3. Engineering Units: Allow for selection of the desired engineering units (i.e., Inch pound or SI) in the system. Unit selection shall be able to be customized by locality to select the desired units for each measurement.
- C. System Applications: Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation.
1. Automatic System Database Save and Restore: Each workstation shall store on the hard disk a copy of the current database of the Building Controller. This database shall be updated whenever a change is made in any panel in the system. The storage of this data shall be automatic and not require operator intervention. In the event of a database loss in a building management panel, the first workstation to detect the loss shall automatically restore the database for that panel.
 2. Manual Database Save and Restore: A system operator with the proper password clearance shall be able to archive the database from any system panel and store on magnetic media. The operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
 3. System Configuration: The workstation software shall provide a graphical method of configuring the system. The user with proper security shall be able to add new devices, and assign modems to devices. This shall allow for future system changes as additions.
 4. On-line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

5. Security: Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time shall be set per operator password. All system security data shall be stored in an encrypted format.
6. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
7. Alarm Processing: Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.
 - a. Alarm Reactions: The operator shall be able to determine what actions, if any, are to be taken, by object (or point), during an alarm. Actions shall include logging, printing, starting programs, displaying messages, and dialing out to remote stations, paging, providing audible annunciation or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day. An object in alarm that has not been acknowledged within an operator specified time period shall be re-routed to an alternate operator specified alarm receipt device.
 - b. Binary Alarms: Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to disable alarming when the associated equipment is turned off or is being serviced.
 - c. Analog Alarms: Each analog object shall have both high and low alarm limits and warning limits. Alarming must be able to be automatically and manually disabled.
8. Trend Logs: The operator shall be able to define a custom trend log for any data in the system. This definition shall include interval, start-time, and stop-time. Trend intervals of 1, 5, 15, 30, and 60 minutes, once a day, once a week, and once a month shall be selectable. All trends shall start based on the hour. Each trend shall accommodate up to 64 system objects. The system operator with proper password shall be able to determine how many samples are stored in each trend. Trend data shall be sampled and stored on the Building Controller panel and be archived on the hard disk. Trend data shall be able to be viewed and printed from the operator interface software. They shall also be storable in a tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages.
9. Alarm and Event Log: The operator shall be able to view all logged system alarms and events from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the workstation.

10. Object and Property Status and Control: Provide a method for the operator with proper password protection to view, and edit if applicable, the status of any object and property in the system. These statuses shall be available by menu, on graphics, or through custom programs.
 11. Clock Synchronization: The real-time clocks in all Building Control panels and workstations shall be synchronized on command of an operator. The system shall also be able to automatically synchronize all system clocks; daily from any operator designated device in the system. The system shall automatically adjust for Daylight Savings and Standard Time if applicable.
 12. Reports and Logs: Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archived on the hard disk for historical reporting. Provide the ability for the operator to obtain real-time logs of designated lists of objects. Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications, including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer. The operator shall be able to designate reports that shall be printed or stored to disk at selectable intervals.
 - a. Custom Reports: Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. These reports shall be time and date stamped and shall contain a report title and the name of the facility.
 - b. Standard Reports. The following standard system reports shall be provided for this project. These reports shall be readily customized to the project by the Owner.
 - (1) Electrical Meter Report: Provide a monthly report showing the daily electrical consumption and peak electrical demand for each building meter. Provide an annual (12 month) summary report showing the monthly electrical consumption and peak demand for each meter.
 - (2) Weather Data Report: Provide a monthly report showing the daily minimum, maximum and average outdoor air temperature and the number of heating and cooling degree days for each day. Provide an annual (12 month) report showing the minimum, maximum and average outdoor air temperature for the month and the number of heating and cooling degree days for the month.
- D. Workstation Applications Editors: Each PC Workstation shall support full screen editing of all system applications. Provide editors for each application at the PC workstation via the web browser. The applications shall be downloaded and executed at the appropriate controller panels.
1. Controller: Provide a full screen editor for each type controller and application that shall allow the operator with proper password to view and change the configuration, name, control parameters, and system set points.

2. Scheduling: An editor for the scheduling application shall be provided at each workstation. Provide a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. The advance and delay time for each object shall be adjustable from this master schedule.
 - a. An operator with proper password level shall be able to modify the schedule. Schedules shall be able to be easily copied between objects and/or dates.
 3. Equipment Coordination: Provide a full screen editor that allows equipment to be grouped for proper operation as specified in the sequence of operations.
 4. Solar Hot Water/Hydronic Radiant Hot Water: The Solar/Hot Water control application shall be configured using a full screen editor and shall provide operating status for the system. The display shall include:
 - System mode of the Solar & Radiant Hot Water Systems
 - System enable/disable status
 - Radiant Hot Water System supply water setpoint
 - Solar/Radiant System supply and return water temperature
 - Solar/Radiant water pump station
 - Solar/Radiant water flow (Proof of Flow or Rate in GPM)
 - Bypass pipe flow rate (if applicable)
 - Current system control operation
 - System failure information
 - Pump or System failure information
 - Override capabilities to force an add control, subtract control, or change of sequence.
- E. Custom Application Programming: Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded. The programming language shall have the following features:
1. The language shall be English language oriented and be based on the syntax of programming languages such as BASIC. It shall allow for free form or fill in the Blank programming. Alternatively, the programming language can be graphically-based using function blocks as long as blocks are available that directly provide the functions listed below, and that custom or compound function blocks can be created.
 2. A full screen character editor/programming environment shall be provided. The editor shall be cursor/mouse driven and allow the user to insert, add, modify, and delete code from the custom programming. It shall also incorporate word processing features such as cut/paste and find/replace.



3. The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.
4. The editor/programming environment shall have a debugging/ simulation capability that allows the user to step through the program and to observe any intermediate values and or results. The debugger shall also provide error messages for syntax and execution errors.
5. The programming language shall support conditional statements (IF/THEN/ELSE/ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
6. The programming language shall support floating-point arithmetic using the following operators: +, -, /, x square root, and xy. The following mathematical functions shall also be provided: natural log, log, absolute value, and minimum/maximum value from a list of values.
7. The programming language shall have pre-defined variables that represent clock time, day of the week, and date. Variables that provide interval time shall also be available. The language shall allow for computations using these values.
8. The programming language shall have ability to predefined variables representing the status and results of the System Software, and shall be able to enable, disable, and change the values of BACnet objections in the system.

PART 3 - EXECUTION

3.1 INSTALLATION REQUIREMENTS

- A. All electrical work performed in the installation of the BAS/ATC system as described in this specification shall be per the National Electrical Code (NEC) and per applicable state and local codes. Where exposed, conduit shall be run parallel to building lines properly supported and sized at a maximum of 40% fill. In no cases shall field installed conduit smaller than 1/2" trade size be allowed.

3.2 ELECTRIC WIRING

- A. The Control Contractor shall provide all electrical control and interlock wiring required for the Automatic Temperature Control System furnished hereunder. All power wiring shall be furnished and installed per Division 26. Where electric power is supplied to a DDC Controller by this Contractor, a suitable circuit breaker will be furnished and installed by this Contractor.
- B. All electrical work performed under this Section shall comply with the National Electrical Code, Underwriters' Laboratories where applicable, and the Electrical Division of these Specifications.

- C. Class II wiring for the Automatic Temperature Control System in plenum ceiling spaces or in corridor ceiling spaces shall be run in EMT or with plenum-rated cable. All control wiring in exposed locations must be installed in metallic conduit. Power line carrier devices or RF signaling devices may not be used. All system components and sensors must be hard-wired. Minimum size conduit shall be 3/4". All cable shall be bundled and neatly strapped to roof joists. Laying wire on top of ceiling shall NOT be allowed.
- D. Where wiring in exposed, occupied spaces cannot be concealed, wire mold shall be used.
- E. For installation of wall sensor control wiring, use the existing conduit where applicable.

3.3 INSTALLATION OF SENSORS

- A. Install sensors in accordance with the manufacturer's recommendations.
- B. Mount sensors rigidly and adequate for the environment within which the sensor operates.
- C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
- D. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.
- E. Install duct static pressure tap with tube and facing directly down-stream of airflow.
- F. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
- G. All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.
- H. Wiring for space sensors shall be concealed in building walls. EMT conduit is acceptable within mechanical and service rooms.
- I. Install outdoor air temperature sensors on north wall complete with sun shield at designated location.

3.4 OWNER TRAINING



- A. The BAS/ATC Contractor shall provide three copies of an operator's manual describing all operating and routine maintenance service procedures to be used with the temperature control and Building Automation System supplied. This Contractor shall instruct the Owner's designated representatives in these procedures during the startup and test period. The duration of the instruction period shall be no less than four 4-hour sessions during normal working hours.

3.5 Performance Verification Testing (PVT)

- A. The BAS/ATC Contractor shall submit for approval with their shop drawings, a detailed procedure for testing the entire Automatic Temperature Control System. As a minimum, the following items shall be included in the PVT Procedure:
 - 1. Software
 - a. Sequence of Operation
 - b. Control Loops
 - c. Inputs/Outputs
 - d. Building Management Software
 - e. Energy Management Software
 - 2. Hardware
 - a. Direct Digital Control Panels
 - b. Remote Communications
 - c. Inputs/Outputs
 - d. Testing procedures for control devices that are not factory-mounted and tested with their respective equipment.

3.6 ACCEPTANCE PROCEDURE

- A. Upon completion of commissioning, the Contractor shall submit Operation and Maintenance Manuals, including, but not limited to, as-built control drawings, all software routines and all test results of the Commissioning Procedure. Before Final Acceptance, the BAS/ATC Contractor shall mount a detailed Automatic Temperature Control Wiring Diagram on each individual piece of HVAC equipment.

3.7 WARRANTY

- A. All BAS/ATC devices and installation shall be warranted to be free from defects in workmanship and material for a period of one (1) year from the date of Substantial Completion. Any equipment, software, or labor found to be defective during this period should be repaired or replaced without



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expense to the Owner. Factory authorized warranty service shall be available within 50 miles of job site.

PART 4 - SEQUENCE OF OPERATION ****FINAL SEQUENCE UNDER DEVELOPMENT****

- A. Ductless Mini-Split Heat Pumps
- B. Energy Recovery Ventilation Unit
- C. Solar Hot Water System (SunDrum)
- D. Hydronic Radiant Floor Heating System
- E. Kitchen Exhaust Fans
- F. Mechanical Room Fan

END OF SECTION 23 09 00

SECTION 23 21 00
HYDRONIC PIPING AND PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Flexible, pre-insulated piping system that incorporates cross-linked polyethylene (PEX) service tubing for hot and cold fluid distribution systems.
- B. Radiant floor heating systems for various applications and control strategies, using PEX-Aluminum-PEX (PAP) tubing and appropriate fittings.
- C. Bosch Solar pump station Modules for cross-linked solar thermal applications (SBU/SBH/SBT)

1.2 RELATED SECTIONS

- A. Section 230900 – Instrumentation & Controls for HVAC
- B. Section 232113 – Hydronic Piping
- C. Section 072100 – Thermal Insulation

1.3 REFERENCES

- A. General: Standards listed by reference, including revisions by issuing authority, form a part of this specification section to the extent indicated. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.
- B. ASTM International:
 - 1. ASTM F2165 Standard Specification for Flexible Pre-Insulated Piping
 - 2. ASTM F1281 Standard Specification for Cross-linked Polyethylene/ Aluminum/ Cross-linked Polyethylene (PEX/AL/PEX) Pressure Pipe

3. ASTM F1335 Standard Specification for Pressure-Rated Composite Pipe for Elevated Temperature Service
- C. German Institute for Standards (Deutsches Institut für Normung e.V., DIN):
 1. DIN 4726 Pipelines of Plastic Materials Used in Warm Water Floor Heating Systems; General Requirements
 2. DIN 16892 Crosslinked Polyethylene Pipes – General Quality Requirements and Testing
 3. DIN 16893 Crosslinked Polyethylene Pipes - Dimensions
- D. Certified to International Association of Plumbing and Mechanical Officials (IAPMO) by NSF:
 1. Uniform Mechanical Code (UMC)
- E. Watts Radiant
 1. RadiantPEX, RadiantPEX+, and RadiantPEX-AL Installation Manual
 2. Watts Radiant R-flex™ Pre-Insulated PEX Installation Manual
 3. RadiantWorks Professional Software

1.4 SYSTEM DESCRIPTION

- A. RAUPEX® O2 Barrier Pipe, SDR9 Design Requirements:
 1. RAUPEX pipe is produced using the high pressure peroxide method for crosslinked polyethylene (PEXa) in accordance with ASTM F876, F877, CSA.
 2. RAUPEX pipe is manufactured by REHAU using a quality management system which has been certified to the latest version of ISO 9001.
 3. RAUPEX O2 Barrier pipe has a co-extruded oxygen diffusion barrier that exceeds the strict requirements of DIN 4726. RAUPEX O2 Barrier pipe is copper tube size SDR9, red in color, and compatible with RAUPEX compression nut fittings and EVERLOC® compression-sleeve fittings in accordance with ASTM F2080 and CSA B137.5.
 4. The PEX service tubing has hydrostatic ratings in accordance with the temperatures and pressures listed below. The hydrostatic ratings are:
 - a. 200 degrees F (93 degrees C) at 80 psi (551 kPa)
 - b. 180 degrees F (38 degrees C) at 100 psi (689 kPa)
 - c. 73.4 degrees F (23 degrees C) at 160 psi (1102 kPa)
- B. RAUPEX® O2 Barrier Pipe, SDR9 Performance requirements: Provide pre-insulated piping system that is manufactured, fabricated, and installed to comply with regulatory agencies and authorities

with jurisdiction, and maintain performance criteria stated by the tubing manufacturer without defects, damage or failure.

1. Show compliance with DIN 16892
2. Show compliance with DIN 16893
3. Show compliance with DIN 4726 regarding oxygen diffusion
4. Insulation of all carrier tubing shall consist of a microcellular, cross-linked polyethylene foam in multi-layer arrangements. The insulation's closed cell structure shall ensure minimal water absorption at all times to preserve insulating effect against thermal loss.
5. Insulation shall not crush, break, or pulverize.
6. All materials shall be CFC free.
7. The outer jacket shall be cast with a corrugated pattern along its entire length. The corrugation pattern shall provide flexibility in the longitudinal direction and rigidity against radial forces.
8. The corrugation shall employ a double-walled closed-cell construction to provide an extra layer of protection from piercing of the outer jacket.
9. Single wall exterior jackets shall be deemed not equal for the long-term protection of the Owner.

C. PEX-AL (PAP) Tubing Design Requirements:

1. Cross-linked Polyethylene-Aluminum-Cross-linked Polyethylene Composite Pipe (PAP): Standard Grade hydrostatic pressure ratings. The following four standard-grade hydrostatic ratings are required:
 - a. 200 degrees F (93 degrees C) at 100 psi (689 kPa).
 - b. 180 degrees F (82 degrees C) at 125 psi (862 kPa).
 - c. 140 degrees F (60 degrees C) at 160 psi (1102 kPa).
 - d. 73.4 degrees F (23 degrees C) at 200 psi (1379 kPa).

D. PEX-AL (PAP) Performance requirements: Provide Hydronic system that is manufactured, fabricated and installed to comply with regulatory agencies and authorities with jurisdiction, and maintain performance criteria stated by the tubing manufacturer without defects, damage, or failure.

1. Cross-linked Polyethylene-Aluminum-Cross-linked Polyethylene Composite Tubing (PAP):
 - a. Show compliance with ASTM F1281

1.5 SUBMITTALS

- A. General: Submit listed submittals in accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.

- B. Product Data: Submit manufacturer's product submittal data and installation instructions for each product.

- C. Shop Drawings – Hydronic Heating System & Pre-Insulated Piping System
 - 1. Provide engineering analysis using manufacturer's proprietary software.
 - 2. Provide installation drawings indicating tubing layout, manifold locations, zoning requirements, and manifold schedules with details required for installation of the system.
 - 3. Provide mechanical schematic indicating heat source, mechanical piping and accessories from heat source to manifolds, circulators, water tempering, and zone controls. Indicate supply water temperatures and flow rates to manifolds.

- D. Samples: Submit selection and verification samples of primary materials.

- E. Documentation:
 - 1. Provide manufacturer's detailed instructions for site preparation and product installation.
 - 2. Provide manufacturer's electrical power requirements and heat output in watts delivered to the structure.
 - 3. Provide documentation indicating the installer is trained to install the manufacturer's products, as needed.

- F. Quality Assurance and Control Submittals:
 - 1. Upon request, submit test reports from recognized testing laboratories.

- G. Closeout Submittals – Submit the following:
 - 1. Warranty documents specified
 - 2. Operation and maintenance data
 - 3. Manufacturer's field reports as specified in this document
 - 4. Final as-built piping layout drawing

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Manufacturer shall have a minimum of ten years experience in similar systems.

2. Manufacturer shall provide products of consistent quality in appearance and physical properties.
3. Manufacturer shall use the highest quality products in the production of systems and components referenced in this document.
4. Materials shall be from a single manufacturer to ensure consistent quality and compatibility.

B. Installer Qualifications:

1. Use and installer with demonstrated experience on projects of similar size and complexity and/or documentation proving successful completion of familiarization training hosted/approved in writing by the system manufacturer.
2. Electrical rough-in and connections shall be done by a licensed electrician.

C. Certifications: Provide letters of certification as follows:

1. Installer employs skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed trades person.

D. Regulatory Requirements and Approvals: Ensure the pre-insulated piping system complies with all applicable codes and regulations.

E. Pre-installation meetings

1. Verify project requirements, substrate conditions, excavation conditions, system performance requirements, coverings, manufacturer's installation instructions, and warranty requirements.
2. Review project construction timeline to ensure compliance or discuss modifications as required.
3. Coordinate with other trade representatives to verify areas of responsibility.
4. Establish the frequency (during construction phase of the project) the engineer intends for site visits and inspections by the manufacturer's representative.

F. Mock-up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.

1. Finish areas designated by Architect
2. Do not proceed with remaining work until workmanship, color, and sheen are approved by Architect.
3. Refinish mock-up area as required to produce acceptable work

1.7 DELIVERY, STORAGE, AND HANDLING

- A. General: Comply with Division 1 Product Requirements Section.
- B. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- C. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.
- D. Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer:
 - 1. Store pre-insulated piping coils under cover or supply plugs to prevent dirt or foreign material from entering the service tubing.
 - 2. Do not expose the PEX service tubing to direct sunlight for more than 30 days. If construction delays are encountered, cover the tubing that is exposed to direct sunlight.

1.8 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.9 WARRANTY

- A. Project Warranty: Refer to Conditions of the Contract for project warranty provisions.
- B. Manufacturer's Warranty – Pre-insulated Piping Systems:
 - 1. Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official.
 - 2. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under contract documents.
 - a. Warranty covers the repair or replacement of any piping or fittings proven defective.
 - b. Warranty may transfer to subsequent owners.

- c. The manufacturer's warranty shall be a minimum of 10 years, non-prorated, on the carrier tubing and 10 years on the fittings, insulation, and cover beginning with the date of substantial completion.

C. Manufacturer's Warranty – Hydronic Systems

1. Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official.
2. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under contract documents.
 - a. Warranty covers the repair or replacement of any tubing or fittings proven defective.
 - b. Warranty may transfer to subsequent owners.
 - c. Warranty Period for Tubing is 25-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.
 - d. Warranty Period for Manifolds and Fittings is 2-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.
 - e. Warranty period for Controls and Electrical components is a 2-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.

1.10 SYSTEM START-UP

- A. Verify all electrical components are installed per local and National Electrical Code (NEC) prior to start-up.

1.11 OWNER'S INSTRUCTIONS

- A. Instruct Owner about operation and maintenance of installed system.
- B. Provide Owner with manufacturer's installation instructions for installed components within the system.
- C. Provide Owner with all operating instructions/documents for sensors and controls.

- D. Provide Owner with copies of any detailed layout drawings and photos of installed product before coverings are installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. REHAU

2.2 PRE-INSULATED PIPING PRODUCT CHARACTERISTICS

A. Service Tubing:

1. Material: Cross-linked polyethylene (PEX) manufactured by PEX-a or Engel method
2. Material Standard: Manufactured in accordance with DIN 16892 and 16893
3. Pressure Ratings: Hydrostatic design and pressure ratings are in accordance with the manufacturer.
4. The PEX service tubing in R-flex has an oxygen diffusion barrier that does not exceed an oxygen diffusion rate of 0.10 grams per cubic meter (0.000062 lb/cu. ft.) per day at 104 degrees F (40 degrees C) water temperature in accordance with German DIN 4726.
5. Nominal Inside Diameter: Provide tubing with nominal outside diameter in accordance with DIN 16892, as indicated:
 - a. Single R-flex
 - 1) 40 mm (approximately 1½ inch)
 - 2) 50 mm (approximately 2 inch)
 - 3) 63 mm (approximately 2½ inch)
 - 4) 75 mm (approximately 3 inch)
 - 5) 90 mm (approximately 3½ inch)
 - 6) 110 mm (approximately 4 inch)
 - b. Dual R-flex
 - 1) 28.58 mm (approximately 1⅛ inch)
 - 2) 32 mm (approximately 1¼ inch)
 - 3) 40 mm (approximately 1½ inch)
 - 4) 50 mm (approximately 2 inch)
 - 5) 63 mm (approximately 2½ inch)

B. Outer Jacket

1. Material is corrugated seamless high-density polyethylene (HDPE)
2. The HDPE jacket completely encompasses and protects the insulation from moisture and damage.

3. The outer jacket shall be cast with a corrugated pattern along its entire length. The corrugation pattern shall provide flexibility in the longitudinal direction and rigidity against radial forces.
4. The corrugation shall employ a double walled closed cell construction to provide an extra layer of protection from piercing of the outer jacket.
5. Single wall exterior jackets shall be deemed not equal for the long-term protection of the Owner.
6. The outer jacket shall contain two percent carbon black to provide protection from UV degradation.
7. Minimum Bend Radius:
 - a. Single R-flex:
 - 1) 40 mm (approximately 1½ inch) pre-insulated tubing with a 6.3 inch (160 mm) jacket has a bend radius of 13.8 inches (350 mm).
 - 2) 50 mm (approximately 2 inch) pre-insulated tubing with a 6.3 inch (160 mm) jacket has a bend radius of 17.8 inches (450 mm).
 - 3) 63 mm (approximately 2½ inch) pre-insulated tubing with a 6.3 inch (160 mm) jacket has a bend radius of 21.7 inches (550 mm).
 - 4) 75 mm (approximately 3 inch) pre-insulated tubing with a 7.9 inch (200 mm) jacket has a bend radius of 31.5 inches (800 mm).
 - 5) 90 mm (approximately 3½ inch) pre-insulated tubing with a 7.9 inch (200 mm) jacket has a bend radius of 43.4 inches (1100 mm).
 - 6) 110 mm (approximately 4 inch) pre-insulated tubing with a 7.9 inch (200 mm) jacket has a bend radius of 47.3 inches (1200 mm).
 - b. Dual R-flex:
 - 1) 28.58 mm (approximately 1⅛ inch) pre-insulated tubing with 4.9 inch (125 mm) jacket has a bend radius of 11.8 inches (300 mm).
 - 2) 32 mm (approximately 1¼ inch) pre-insulated tubing with 4.9 inch (125 mm) jacket has a bend radius of 11.8 inches (300 mm).
 - 3) 40 mm (approximately 1½ inch) pre-insulated tubing with 6.3 inch (160 mm) jacket has a bend radius of 23.7 inches (600 mm).
 - 4) 50 mm (approximately 2 inch) pre-insulated tubing with 7.9 inch (200 mm) jacket has a bend radius of 31.5 inches (800 mm).
 - 5) 63 mm (approximately 2½ inch) pre-insulated tubing with 7.9 inch (200 mm) jacket has a bend radius of 47.3 inches (1200 mm).

C. Insulation

1. The insulation shall be cross-linked polyethylene closed cell foam with a water absorption after 28 days of less than 1.04 percent.
2. All seams of the insulation shall be sealed.
3. Insulation shall not be bonded to the service tubing.

4. Insulation shall not crush, break or pulverize.

D. End Seals

1. The piping manufacturer will supply all end caps.
2. End caps are to be installed on each end prior to connecting the service pipes and insulating the field joints.
3. Where necessary, the end caps will heat shrink onto the piping outer jacket forming a watertight seal.

E. Compression Fittings for PEX Service Tubing

1. For system compatibility, use fittings offered by the tubing manufacturer.
2. Fittings are to be manufactured from brass.
3. The fitting assembly must comply with performance requirements of DIN 16892.
4. The fittings will consist of a compression fitting with a coupling sleeve, a fitting body insert with o-ring(s) and a bolt and a nut.
5. All buried fittings will be installed, insulated, and sealed in accordance with the piping manufacturer's instructions.

2.3 PRE-INSULATED PIPING ACCESSORIES

- #### A. Use accessories associated with the installation of the pre-insulated piping system as recommended by or available from the piping manufacturer.

B. Protective Casings

1. Protective casings will be manufactured of high density polyethylene shells with insulation, bolts, nuts, and a sealant compound.

C. Protective Inspection Chambers

1. The piping manufacturer will provide the inspection chambers when required by the project construction.
2. Inspection chambers shall be constructed of shock-resistant high density polyethylene.
3. Heat shrink seals as provided by the piping manufacturer shall be installed to prevent introduction of water into the vault.

D. Anchors

1. The use of anchors, if required, within the piping system will be determined by the project engineer.

2.4 HYDRONIC RADIANT HEAT PRODUCT CHARACTERISTICS

A. Material:

1. Cross-linked polyethylene with an aluminum middle core.
2. Manufactured by PEX-b or Silane method.

B. Material Standard:

1. Manufactured in accordance with ASTM F1281.
2. Tested for compliance by an independent third-party agency.

C. Temperature/Pressure Ratings: shall be capable of withstanding temperatures of:

1. 73.4°F (23°C) at 160 psi (1.10 MPa)
2. 180°F (82.2°C) at 100 psi (0.69 MPa)
3. 200°F (93.3°C) at 80 psi (0.55 MPa).

D. Minimum Bend Radius (Cold Bending):

1. No less than five times the outside diameter.
2. Use the tubing manufacturer's bend supports if radius is less than stated.

2.5 HYDRONIC RADIANT HEAT MANIFOLDS AND FITTINGS

A. Manifolds (Residential and light Commercial, Stainless Steel)

1. For system compatibility, use 1 or 1½" (25 – 38mm) Stainless Steel manifolds offered by the respective tubing manufacturer.
2. Manifolds shall provide individual flow control for each loop of the manifold through valve actuators available from the manifold supplier.
3. Manifolds shall feature manual flow balancing capability within the manifold body for balancing unequal loop lengths across the manifold. Balance valves shall not be ball valves.
4. Manifolds accommodate ½ - ¾" (12.7 – 19 mm) Radiant PEX-AL tubing.
5. Each manifold location shall have the ability to vent air manually from the system.
6. Stainless Steel 1" (25 mm) Manifolds
 - a. Heavy-duty, DIN Standard, 304 stainless steel
 - b. Matching fittings and accessories are made of solid brass and are heavily plated with nickel to match the appearance of the manifold trunk.
 - c. Internal balancing valves
 - d. 0 - 2½ gpm (0 – 0.16 L/sec) flow meters
 - e. Manifold brackets
 - f. All connections are BSP (British Standard Pipe) or straight thread and require the use of the included gasket.

- g. 2½" (54 mm) OC circuit spacing
 - h. 12 gpm (.75 L/sec) maximum flow rate
 - i. 194°F (90°C) maximum operating temperature
 - j. 87 psi (600 kPa) maximum operating pressure
 - k. 2½ gpm (0.16 L/sec) per circuit maximum flow rate
7. Stainless Steel 1½" (38 mm) Manifolds
- a. Heavy-duty, DIN Standard, 304 stainless steel
 - b. Matching fittings and accessories are made of solid brass and are heavily plated with nickel to match the appearance of the manifold trunk.
 - c. Internal balancing valves
 - d. 0 - 4 gpm (0 – 0.25 L/sec) flow meters
 - e. Manifold brackets
 - f. All connections are BSP (British Standard Pipe) or straight thread and require the use of the included gasket.
 - g. 2½" (54 mm) OC circuit spacing
 - h. 22 gpm (1.4 L/sec) maximum flow rate
 - i. 194°F (90°C) maximum operating temperature
 - j. 87 psi (600 kPa) maximum operating pressure
 - k. 4 gpm (0.25 L/sec) per circuit maximum flow rate

B. Manifolds (Commercial, Copper)

- 1. Provide 1" (25 mm) or larger Copper manufactured from L-copper and offered by the respective tubing manufacturer for system compatibility.
 - a. Install manifolds with optional isolation valves located on both the supply and return manifold.
 - b. Each manifold location shall have the ability to vent air manually from the system.
- 2. Provide Copper manifolds approved for use in systems free of ferrous materials, or isolate ferrous material to eliminate corrosion damage due to oxygen diffusion.
- 3. Balancing:
 - a. Design individual loop lengths across the manifold with 10% of each other in length.
 - b. Install supply and return piping to the manifold in a reverse-return configuration to ensure self-balancing.
 - c. Where the supply and return piping is in direct-return configuration, use manifolds with balancing valves or balance flow setters on the return leg of each manifold to the mains.

C. Manifold Mounting Boxes

- 1. Sizes – Watts Radiant manifold mounting boxes come in 3 sizes:
 - a. 15¾" by 28½" by 4¼" (400mm by 724 mm by 108 mm)

- b. 24½" by 28½" by 4¾" (622mm by 724 mm by 111 mm)
- c. 39½" by 28½" by 4¾" (1003mm by 724 mm by 111 mm)
2. Each box shall be designed to be recessed into a 4" or 6" (102 mm or 152 mm) stud wall.
3. Included elevators can raise the box from 1½" to 4½" (38 – 114 mm) off of the floor.
4. Each manifold box is constructed of powder-coated sheet metal, providing increased resistance to corrosion and job-site abuse.
5. Inside Manifold Mounting Brackets:
 - a. Manifold boxes come with 2 fixed horizontal attachment rails and 2 adjustable rails.
 - b. Each Watts Radiant manifold option will utilize different rail positions, depending on the bracket used.

D. Fittings

1. For system compatibility, use fittings offered by the tubing manufacturer.
 - a. The fitting assembly shall comply with ASTM F1281.
 - b. Only REHAU stainless steel Press Fittings or Compression Fittings are approved.
 - c. Available connections:
 - 1) Sweat
 - 2) NPT
 - 3) BSP

2.6 HYDRONIC RADIANT HEAT SUPPLY AND RETURN PIPING

A. Supply-and-Return Piping to the Manifolds (above ground piping):

1. Properly size supply and return distribution piping for the given volume and velocities required at system design.
2. Use compatible distribution pipe material for all supply fluid temperatures and flows in systems with ferrous components.
 - a. When using RAUPEX, do not exceed 200 degrees F (93 degrees C) at 100 psi (689 kPa).
3. Do not expose RAUPEX tubing to direct sunlight.
 - a. Where PEX tubing is exposed, install suitable pipe insulation around the exposed tubing.
4. Use fittings compatible with piping material. Fittings shall transition from distribution piping to system manifolds.

PART 3 - EXECUTION

3.1 GENERAL EXAMINATION

A. Site Verification of Conditions:

1. Verify that site conditions are acceptable for installation of the system. Refer to manufacturer's installation manual for information.
2. Do not proceed with installation of the system until unacceptable conditions are corrected.

3.2 PRE-INSULATED PIPING FIELD QUALITY CONTROL AND TESTING

A. Site tests:

- a. To ensure system integrity, pressure-test the system before and during backfilling or when other trades are working near the piping.
- b. The service tubing will be water-tested at 1 ½ times the operating pressure for a minimum of 3 hours prior to system burial.

3.3 INSTALLATION OF RADIANT FLOOR HEATING SYSTEMS

A. Comply with manufacturer's product data, including product technical bulletins, installation instructions and design drawings, including the following:

1. Installation manuals
2. Design software engineering and analysis

B. Wood Floor Construction with REHAU:

1. Install Raupanel Aluminum Panel, Return Bends, and Furring Strips on top of the wood sub-floor according to the tubing manufacturer's instructions.
2. Coordinate the finished floor covering layout direction with the direction of the Aluminum panels layout. Comply with the tubing manufacturer's instructions.
3. Install insulation in the joist cavity below the floor according to the submitted radiant floor design. Install the insulation tight against the wood sub-floor. Refer to Section 072100.
4. Use the recommended amount of insulation in the joist cavity below the floor in accordance with the submitted radiant floor design. Refer to Section 072100.
5. Use edge insulation equal to the amount of underfloor insulation if the heated panel directly contacts an exterior wall or panel. Refer to Section 072100.

3.4 HYDRONIC RADIANT HEAT FIELD QUALITY CONTROL AND TESTING

A. Site tests:



1. To ensure system integrity, pressure test the system before covering tubing in concrete or when other trades are working in the vicinity of the tubing.
2. Test all electrical controls in accordance with respective installation manuals.
3. System shall be checked after 3 years of operation and every year thereafter. System shall be checked for pH levels to ensure that it is operating within suggested guidelines.

3.5 GENERAL CLEANING

- A. Remove temporary coverings and protection of adjacent work areas.
- B. Repair or replace damaged installed products.
- C. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance.
- D. Remove construction debris from project site and legally dispose of debris.

3.6 GENERAL DEMONSTRATION

- A. Pre-insulated and Hydronic Piping Systems
 1. Demonstrate operation of system to Owner or Owner's personnel.
 2. Instruct Owner or Owner's personnel about operation and maintenance of the installed system.
 3. Provide Owner or Owner's personnel with manufacturer's installation, operation, and maintenance instructions for installed components within the system.

3.7 GENERAL PROTECTION

- A. Protect installed work from damage caused by subsequent construction activity on the site. Provide Owner with copy of photos and drawings of product locations to assist.

END OF SECTION 23 21 00



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SECTION 23 31 00 HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Single-wall circular ducts and fittings.
 - 2. Sheet metal materials.
 - 3. Sealants and gaskets.

1.2 INCLUDED SECTIONS

- A. Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
- B. Section 23 07 13 "HVAC Insulation."
- C. Section 23 31 13 "Metal Ducts."
- D. Section 23 33 00 "Duct Accessories."

1.3 SUBMITTALS

- A. Product Data.
- B. Shop Drawings: detailed duct layout reflected from the mechanical drawings.

PART 2 - PRODUCTS

2.1 SINGLE-WALL CIRCULAR DUCTS AND FITTINGS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. In conformance with ASTM A90/A90M.
- B. General Material Requirements: Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 SHEET METAL MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. In conformance with ASTM A90/A90M.
- B. General Material Requirements: Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 SEALANT AND GASKETS

- A. Water-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Water resistant.
 - 3. Mold and mildew resistant.
 - 4. Substrate: Compatible with galvanized sheet steel, stainless steel, or aluminum sheets.

2.4 DRAIN TUBING

- A. 5/8" ID Vinyl Drain Tubing

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts.

- C. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- D. Install ducts in maximum practical lengths with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with enough clearance to allow for insulation thickness plus space for maneuverability.
- I. Route ducts to avoid complications with piping and electrical wiring as well as accounting for intelligent placement within the equipment room.
- J. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 DUCT SEALING

- A. Seal ducts for duct static-pressure and leakage prevention.

3.3 CONNECTIONS

- A. Make secure and sealed connections to equipment with flexible connectors.



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3.4 DUCT CLEANING

- A. Clean new duct system before starting up the system.

END OF SECTION 23 31 00



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SECTION 23 33 00 AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Volume and Control Dampers
2. Flexible Connectors
3. Flexible Ducts
4. Self-sealing, round fittings

1.2 RELATED SECTIONS

- A. Section 23 07 00 "HVAC Insulation"
- B. Section 23 31 00 "HVAC Ducts and Casings"

1.3 SUBMITTALS

- A. Product Data

PART 2 - PRODUCTS

2.1 VOLUME DAMPERS AND CONTROL DAMPERS

A. Single and multiple opposed-blade dampers

1. Standard leakage rating and suitable for horizontal or vertical applications
2. Factory fabricated and complete with required hardware and accessories

2.2 FLEXIBLE CONNECTORS

1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1

2.3 FLEXIBLE DUCTS

1. Corrugated aluminum complying with UL 181, Class 1

2.4 SELF-SEALING GASKETS



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A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible

B. Connector: Woven Fiberglass

1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric conforming to NFPA 90A, minimum density 24 oz per sq yd

2.5 ROOF CAPS

A. 6 " Roof Cap

B. Duct Connection and Screened Exhaust Opening

C. Speedi-Products model #EX-RCGC 06

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before installation, verify ducts and equipment installations are ready for accessories
- B. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement

3.2 INSTALLATION

- A. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
 1. Outdoor, Supply-Air Ducts: Seal Class A
 2. Outdoor, Exhaust Ducts: Seal Class C
 3. Outdoor, Return-Air Ducts: Seal Class C
 4. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B
 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A
 6. Unconditioned Space, Exhaust Ducts: Seal Class C
 7. Unconditioned Space, Return-Air Ducts: Seal Class B

8. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C
9. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher than 2-Inch wg (500 Pa): Seal Class B
10. Conditioned Space, Exhaust Ducts: Seal Class B
11. Conditioned Space, Return-Air Ducts: Seal Class C

C. Conceal ducts from view in finished and occupied spaces

D. Avoid passing through electrical equipment spaces and enclosures

E. Support ducts to comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Ch. 4, "Hangers and Supports"

F. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts

G. Install volume and control dampers in lined duct with methods to avoid damage to liner and to avoid erosion of duct liner

H. Install fire dampers according to UL listing

I. Install fusible links in fire dampers

J. Clean new duct system(s) before testing, adjusting, and balancing

3.3 TESTING, ADJUSTING, AND BALANCING

- A. Balance airflow within distribution systems, including submains, branches, and terminals to indicated quantities

END OF SECTION 23 33 00



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SECTION 23 33 13.23 BACKDRAFT DAMPERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Vent Cover with Damper

1.2 RELATED SECTIONS

- A. Section 23 07 00 " HVAC Insulation"
- B. Section 23 31 00 "HVAC Ducts and Casings"

1.3 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 PRODUCTS

2.1 MANUFACTURER

- A. Speedi-Products 6 in. Black Galvanized Flush Roof Cap with Removable Screen, Backdraft Damper

2.2 COMPONENTS

- A. 6 Inch Roof Cap With Duct Connection
- B. Screened Exhaust Opening

PART 3 EXECUTION

3.1 INSTALLATION

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



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END OF SECTION 23 33 13.23



SECTION 23 56 13 SOLAR ENERGY HEATING EQUIPMENT

PART 1 – GENERAL

1.1 SUMMARY

- A. Section includes solar collectors, controls, pipe and fittings, valves, tanks, pumps, cabinet fans, cleaning and chemical treatment of systems.
- B. Related Sections:
 - 1. Section 08 31 13 "Access Doors and Frames"
 - 2. Section 23 05 13 "Common Motor Requirements for HVAC Equipment"
 - 3. Section 23 31 00 "HVAC Ducts and Casings"
 - 4. Section 26 05 03 "Equipment Wiring Connections"

1.2 REFERENCES

- A. American Society of Mechanical Engineers:
 - 1. ASME Section VIII - Boiler and Pressure Vessel Code - Pressure Vessels.
- B. ASTM International:
 - 1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 2. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

1.3 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures.
- B. Shop Drawings: Indicate manufactured assembly's system and control schematics, solar collector installation, layout, weights, mounting and support details, and piping connections.
- C. Product Data: Submit data on specialties, including manufacturers catalog information. Indicate chemical treatment materials, chemicals, and equipment. Submit certified pump performance and NPSH curve. Submit performance ratings and rough-in details for solar collectors.
- D. Manufacturer's Installation Instructions: Submit mounting and other structural requirements.



- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- F. Manufacturer's Field-Reports: Indicate start-up of treatment systems and include analysis of system water after cleaning and treatment.
- a. CLOSEOUT SUBMITTALS
 - A. Section 01 70 00 - Execution and Closeout Requirements.
 - B. Operation and Maintenance Data: Spare parts lists, procedures, and treatment programs.
- b. QUALITY ASSURANCE
 - A. Light Transmitting Plastics: Class defined by applicable code when tested in accordance with ASTM D635 in thickness for intended use.
 - 1. Self-Ignition Temperature: Minimum 650 degrees F (343 degrees C) when tested in accordance with ASTM D1929.
 - 2. Smoke Developed Index: Maximum 450 when tested in accordance with ASTM E84 or maximum 75 when tested in accordance with ASTM D2843 in thickness for intended use.
 - B. Surface Burning Characteristics:
 - 1. Foam Insulation: Maximum 75/450 flame spread/smoke developed index when tested in accordance with ASTM E84.
 - C. Apply label from agency approved by authority having jurisdiction to identify each foam plastic insulation board.
- a. QUALIFICATIONS
 - A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience, and with service facilities within 100 miles of Project.
 - B. Installer: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer.
- b. PRE-INSTALLATION MEETINGS
 - A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.



B. Convene minimum one week prior to commencing work of this section.

c. DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.

B. Accept and store solar collectors and valves in shipping containers and maintain in place until installation.

C. Protect piping from debris and other foreign matter by using caps on piping connections.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Section 01 70 00 - Execution and Closeout Requirements: Product warranties and product bonds.

B. Furnish five year manufacturer warranty for collectors.

1.11 MAINTENANCE SERVICE

A. Section 01 70 00 - Execution and Closeout Requirements: Maintenance service.

B. Furnish monthly technical service visits for one years starting with date of substantial completion to perform field inspections and make water analysis on site. Detail findings in writing. Submit two copies of report after each visit.

1.12 EXTRA MATERIALS

A. Section 01 70 00 - Execution and Closeout Requirements: Spare parts and maintenance products.

B. Furnish supply of chemicals for treatment and testing during warranty period.

C. Furnish one extra set of mechanical seals for pumps.

D. Furnish 1 year supply of chemicals for treatment.



PART 2 – PRODUCTS

a. SOLAR COLLECTORS

A. Manufacturers:

1. Sundrum

B. Construction: Unit consisting of manufacturers standard assembly of frame, cover, back cover with insulation, absorber plate assembly, and accessories.

C. Frame:

1. Aluminum: Extrusion shapes including I-beam, top battens, double battens, strips, channels, or angles, assembled with stainless steel screws with self sealing neoprene washers.

D. Cover: Fiberglass reinforced polymer sheet.

1. Solar energy transmittance: 90 percent at 0-degree angle of incidence.
2. Heat transmittance: $-0.865 \text{ Btu/hr} \times \text{sq ft} \times \text{degrees F}$ ($-4.9099 \text{ W/sq m} \times \text{K}$).
3. Index of refraction: 1.55.
4. Tensile strength: 10,000 psi (68,950 kPa).
5. Flexural strength: 17,150psi (118,250 kPa).
6. Flexural modulus: 1,000,000 psi (689,500kPa).
7. Shear strength: 12,800 psi (88,250 kPa).
8. Water absorption: 0.6 percent by weight.
9. Thermal expansion: 1.36in/in/degree F
10. Thermal conductivity: 0.713 Btu/hr sq ft degree F/in.
11. Weight: 4.7 oz/sq ft (1435 kg/sq meter).
12. Thickness 0.060inches 0.15 mm).
13. Nominal size: 48 x 120 inches (1219.2 x 3048 mm).

E. Back Cover: Galvanized steel with 2 inch (50 mm) thick rigid fiberglass insulation.

F. Plate and Tube Assembly: Copper sheet bonded to copper tubes.

1. Tubes: 0.375 diameter, 0.013 inch ([0.016 mm]) wall, copper.
2. Sheet: 0.0032 to 0.0035 inch ([0.081 to 0.089] mm) thick copper alloy sheet.
3. Working pressure: 150 psig (1034 kPa).
4. Paint: Selective-absorptivity 0.94, emissivity 0.47.
5. Construction: Tubes brazed to header, sheet soldered to tubes.
6. Headers: [0.75 inch (20 mm)] Type M copper tube.
7. Sheet width: [48] inches [1219.2] mm).



8. Sheet length: [120 inches ([3048] mm).
9. Area: [40] sq ft ([3.71] sq meters).

b. DIFFERENTIAL CONTROLLERS

A. Manufacturers:

1. Sundrum

B. Description: Solid-state differential temperature thermostat with two low resistance thermistors and SPDT relay contactor, and field adjustable differential.

C. Functions:

1. Standard: When collector outlet temperature exceeds storage temperature, close contacts.
2. Ambient Override: When collector temperature is less than 80 degrees F (26 degrees C), open contacts.
3. High Limit Off: When storage temperature rises above 160 degrees F (71 degrees C), open contacts.

c. PIPING

A. Copper Tubing: ASTM B88 (ASTM B88M), Type [M,] drawn.

1. Fittings: Cast brass or wrought copper.
2. Joints: Grade 95TA solder joint.

a. GATE VALVES

A. Up to 2 inches (50 mm): Bronze body, bronze trim, non- rising stem, hand wheel, inside screw, single wedge or disc, solder or threaded ends.

b. ISOLATION BALL VALVES

A. Up to 2 inches (50 mm): Bronze one piece body, stainless steel ball, teflon seats and stuffing box ring, lever handle, solder or threaded ends.

c. SPRING CHECK VALVES

A. Up to 2 inches (50 mm): Br swing disc, solder or screwed ends.

d. RELIEF VALVES

- A. Bronze body, Teflon seat, stainless steel stem and springs, automatic, direct pressure actuated capacities ASME certified and labeled.

e. PUMPS

A. Manufacturers:

1. Armstrong Model: ASTRO-30B. Potable water loop circulation pump.
2. Armstrong Model: ASTRO-230CI. Drainback/collector loop heat transfer fluid pump.

B. General Construction Requirements:

1. Balance: Rotating parts, statically and dynamically.
2. Construction: To permit servicing without breaking piping or motor connections.
3. Motors: Operate at 1750 rpm unless specified otherwise.
4. Connections: Flanged.

C. Close Coupled Pumps:

1. Type: [Horizontal] [Vertical] shaft, single stage, close coupled, radial split casing, for [125 psig (860 kPa)] maximum working pressure.
2. Construction: Cast iron casing with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge, bronze, fully enclosed impeller keyed to motor shaft extension, non-mechanical seal.

a. TANKS

A. Manufacturers:

1. Bosch WST 50 and Logalux SM300

- B. Tank: 50 and 77 gal Drainback Heat Exchanging reservoir. $\frac{3}{4}$ " NPT fittings for collector loop, $\frac{1}{2}$ " NPT fittings for heat exchanger.

PART 3 – EXECUTION

a. PREPARATION

- A. Ream pipe and tube ends. Remove burrs.
- B. Remove scale and dirt on inside and outside before assembly.



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- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean, and treat systems.
- b. INSTALLATION
 - A. Route piping in orderly manner, installing plumb and parallel to building structure, and maintain gradient.
 - B. Install piping to conserve building space, and not interfere with use of space and other work. Group piping whenever practical at common elevations.
 - C. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
 - D. Maintain clearance for installation of insulation, and access to valves and fittings.
 - E. Install access doors where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 31 13.
 - F. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
 - G. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
 - H. Prepare pipe, fittings, supports, and accessories for finish painting. Refer to Section 09 90 00.
 - I. Install valves with stems upright or horizontal.
 - J. Support tanks inside building from building structure.
 - K. Install drain with valve and hose connection on strainer blow down connection.
 - L. Select system relief valve capacity greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment. Pipe relief valve outlet to nearest floor drain.



- M. Verify pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
 - N. Make changes in piping size with reducing fittings. Support piping adjacent to pump so no weight is carried on pump casings.
 - O. Install line sized shut-off valve and strainer on pump suction, and line sized check valve and balancing valve on pump discharge. Install air vent and drain connection on horizontal pump casings.
 - P. Install unions downstream of valves and at equipment or apparatus connections.
 - Q. Install threaded brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.
 - R. Install [gate] [ball] [butterfly] valves for shut-off and to isolate equipment, part of systems, or vertical risers.
 - S. Install [globe] [ball] [butterfly] valves for throttling, bypass, or manual flow control services.
 - T. Install 3/4 inch (20 mm) [gate] [ball] drain valves at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. [Pipe to nearest drain.]
 - U. Install [manual] [automatic] air vents at system high points. [Install vent tubing to nearest drain.]
 - V. Install relief valves on system at expansion tanks.
 - W. Connect air collectors and fans with flexible connectors and ductwork. Refer to Section 23 31 00.
- c. CLEANING
- A. Section 01 70 00 - Execution and Closeout Requirements: Final cleaning.
 - B. After completion, fill, start, and vent prior to cleaning. Use water meter to record capacity in each system. Place terminal control valves in open position during cleaning.
 - C. Add cleaner to closed systems at concentration as recommended by manufacturer.



- D. Circulate for 48 hours, then drain systems as quickly as possible. Refill with clean water, circulate for 24 hours, then drain. Refill with clean water and repeat until system cleaner is removed.
- E. Use neutralizer agents on recommendation of system cleaner supplier and acceptance of Architect/Engineer.
- F. Flush open systems with clean water for one-hour minimum. Drain completely and refill.
- G. Remove, clean, and provide new strainer screens. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed.
- H. Closed System Treatment:
 - 1. Install one bypass feeder on each system. Install isolating and drain valves and interconnecting piping. Install around globe valve downstream of circulating pumps [as indicated on Drawings].
 - 2. Introduce closed system treatment through bypass feeder.
- I. Open System Treatment:
 - 1. Install two glass mesh feeder bags for each unit, suspended in sump, filled with sequestering agent.
 - 2. Install drip feeder to feed sequestering agent into sump. Interlock solenoid valve on drip system with circulating pump.
 - 3. Install 1/2 inch (13 mm) bleed-off complete with globe valve piped to drain. Install bleed-off above flood line.

END OF SECTION 23 56 13



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SECTION 23 71 00 THERMAL STORAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submittals: Manufacturers Specifications.

1.2 RELATED SECTIONS

- A. Section 22 35 00 "Domestic Water Heat Exchangers"
- B. Section 23 56 00 "Solar Energy Heating Equipment"

1.3 SUBMITTALS

- A. Product Data
- B. Material Safety Data Sheet [MSDS]

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Entropy Solutions Inc. Worldwide
151 Cheshire Lane, Suite 400
Plymouth MN 55441
Phone: 952-941-0306
www.puretemp.com

2.2 PRODUCTS

- A. Team Tidewater Thermal Storage Tank
Location: Mechanical Room
 - a. Design by Old Dominion University students and faculty.
 - b. Bosch Logalux SM300
 - c. Dimensions [H]: 47" [W]: 22 ¾" [L]: 24"



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1. Phase Change Material

- A. Model Number: PureTemp 53
- B. Oil based phase change material with a peak melting point at approximately 127.4° F [43°C].
- C. Stored in auxiliary storage tank to be used as a passive cooling and heating device.
- D. Latent heat storage capacity: 200 J/g

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Phase change material is integrated with the auxiliary storage tank.
- B. Installation instructions are proprietary of Team Tidewater.

END OF SECTION 23 71 00



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SECTION 23 71 13.23
PRESSURIZED-WATER STORAGE THERMAL TANKS

PART 1 - GENERAL

1.07 SECTION INCLUDES

- B. 35L Expansion Tank Membrane

1.08 RELATED SECTIONS

- A. Division 22 33 30.26 "Residential, Collector-to-Tank, Heat Exchanger Coil, Solar Electric Domestic Water Heaters"
- B. Division 23 71 00 "Thermal Storage"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- D. Logalux

2.02 COMPONENTS

- A. Expansion Tank 35L, 6 Bar White
- B. http://www.bosch-climate.us/files/201108242103190.Expansion_Tanks_ES_v1.5_062910.pdf

PART 3 - EXECUTION

3.08 INSTALLATION

- D. Install in accordance with manufacturer's instructions.

END OF SECTION 23 71 13.23



SECTION 23 72 00
AIR TO AIR RECOVERY EQUIPMENT

PART I – GENERAL

1.1 SUMMARY

- A. Selection Includes:
 - 1. Energy Recovery Ventilator EV70 shall be a packaged unit as manufactured by RenewAire and shall transfer both heat and humidity using static plate core technology.

1.2 INCLUDED SECTIONS

- A. Section 23 09 00 “Instrumentation and Controls for HVAC.”
- B. Section 23 31 13 “Metal Ducts”

1.3 SUBMITTALS

- A. Product Data
- B. Shop Drawings: detailed duct layout reflected from the mechanical drawings.

1.4 QUALITY ASSURANCE

- A. The energy recovery ventilator shall be certified by the Home Ventilating Institute (HVI) under CSA 439. Both a heating and a cooling test must be run to demonstrate year round energy recovery.
- C. Manufacturer shall be able to provide evidence of independent testing of the core by Underwriters Laboratory (UL), verifying a maximum flame spread index (FSI) of 25 and a maximum smoke developed index (SDI) of 50 thereby meeting NFPA 90A and NFPA 90B requirements for materials in a compartment handling air intended for circulation through a duct system. The method of test shall be UL Standard 723.
- D. Unit shall be listed under UL 1812 Standard for Ducted Air to Air Heat Exchangers. The unit must pass commercial flammability requirements and shall not be labeled “For Residential Use Only”.



- E. The ERV core shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of ten years from the date of purchase. The balance-of-unit shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of two years from the date of purchase.

PART II – PRODUCTS

2.1 CONSTRUCTION

- A. The energy recovery component shall be of fixed-plate cross-flow construction, with no moving parts.
- B. No condensate drain pans or drains shall be allowed and unit shall be capable of operating in both winter and summer conditions without generating condensate.
- C. The unit case shall be constructed of 24-gauge steel, with lapped corners and zinc plated screw fasteners. case shall be finished with textured, powder coat paint.
- D. Access doors shall provide easy access to blowers, ERV cores, and filters. Doors shall have an airtight compression seal using closed cell foam gaskets.
- E. Case walls and doors shall be fully insulated with 1 inch, expanded polystyrene foam insulation faced with a cleanable foil face on all exposed surfaces.
- F. The ERV cores shall be protected by a MERV-8 rated, spun polyester, disposable filter in both airstreams.
- G. The unit shall have a line cord power connection and be supplied with an internal 24 VAC transformer and relay.
- H. Standby power draw shall not exceed 1 Watt for the unit along with an optional automatic control.

2.2 OPTIONS

- A. For EV-Series: Controls including proportional run time, push button and furnace interlock and a variety of weather hoods.



- B. **OPTIONAL** in lieu of stand-alone controls, integrate to the DDC System as specified under specification section 23 09 00.

PART III – EXECUTION

3.1 UNIT LOCATION

- A. Locate and orient unit to provide the shortest and most straight duct connections. Provide service clearances as indicated on the plans. Locate units distant from sound critical occupancies.
- B. Use integral mounting flange and hanging bar system to mount the unit to a structurally suitable surface. The units may be mounted in any orientation.

3.2 VIBRATION ISOLATION

- A. Utilize factory supplied vibration isolation kit following instructions.

3.3 DUCT DESIGN

- A. All ductwork shall be designed, constructed, supported and sealed in accordance with SMACNA HVAC Duct Construction Standards and pressure classifications.
- B. At a minimum all duct runs to the outdoors shall be thermally insulated at levels appropriate to the local climate. A continuous vapor barrier shall also be provided on warm surface of the insulation.

3.4 SOUND CONTROL

- A. To control sound radiated from the unit:
 - 1. Provide acoustic treatment in mechanical room walls and ceilings.

3.5 TEST AND BALANCING

- A. Test and Balancing may not begin until 100% of the installation is complete and fully functional.
- B. Follow National Comfort Institute (NCI) air test and balance procedures specific to Heat Recovery Ventilator Balancing Procedure including standard reports to the owner's representative.

Part IV - PERFORMANCE

- A. Energy Transfer: The ERV shall be capable of transferring both sensible and latent energy between airstreams. Latent energy transfer shall be accomplished by direct water vapor transfer from one



airstream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air.

- B. Passive Frost Control: The ERV core shall perform without condensing or frosting under normal operating conditions (defined as outside temperatures above -10°F and inside relative humidity below 40%). Occasional more extreme conditions shall not affect the usual function, performance or durability of the core. No condensate drains will be allowed.
- C. Continuous Ventilation: Unit shall have the capacity to operate continuously without the need for bypass, recirculation, pre-heaters, or defrost cycles under normal operating conditions.
- D. Positive Air stream Separation: Water vapor transfer shall be through molecular transport by hydroscopic resin and shall not be accomplished by “porous plate” mechanisms. Exhaust and fresh airstreams shall travel at all times in separate passages, and airstreams shall not mix.
- E. Laminar Flow: Airflow through the ERV core shall be laminar over the products entire operating airflow range, avoiding deposition of particulates on the interior of the energy exchange plate material.

END OF SECTION 23 72 00



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SECTION 23 81 26 SPLIT-SYSTEM HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes packaged indoor and outdoor unit heat pumps with related equipment, accessories, and controls

1.2 REFERENCES

- A. Comply with NFPA 70, National Electrical Code
- B. Warranties: Provide standard manufacturer's written warranty, without monetary limitation, signed by manufacturer agreeing to promptly repair or replace products that fail in materials or workmanship for the period of 7 years for compressor, 5 years for parts

1.3 SUBMITTALS

- A. Product Data
 - 1. Published literature: indicate capacities, ratings, gages, and finishes of materials, and electrical characteristics and connection requirements

1.4 RELATED SECTIONS

- A. SECTION 23 09 00 "INSTRUMENTATION AND CONTROL FOR HVAC"
- B. DIVISION 26 00 00 "ELECTRICAL"

PART 2 – PRODUCTS

2.1 MANUFACTURER

- A. Trane

2.2 OUTDOOR UNIT

- A. Heat Pump - 24 MBH, 3-zone System
 - 1. Model #: 4TXM6524A1030BA



2.3 INDOOR UNIT

- A. Indoor Wall Mount AHU - 9 MBH
 - 1. Model #: 4MXW8509A10N0BA

- B. Indoor Wall Mount AHU - 12 MBH
 - 1. Model #: 4MXW8512A10N0BA

2.4 SPLIT SYSTEM HEAT PUMP CONTROLS (MINIMUM REQUIREMENT)

- A. Trane Remote Controller for AHU

2.5 ACCESSORIES

- A. Drain Pipe

- B. Trane Line Sets - 50' Length each

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be executed as per installation manuals provided by the Manufacturer and all local and national mechanical and electrical codes.

- B. Set units level, plumb, and true to line, without warp or rack of products and anchor securely in place as described in manufacturer's specifications.

- C. Correct deficiencies in or remove and reinstall units that do not comply with requirements.

- D. Repair, refinish, or replace products or finishes damaged during installation or transit, as directed by Architect.

END OF SECTION 23 81 26



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SECTION 23 82 41 WATER-TO-WATER HEAT PUMPS

PART 1 - GENERAL

1.09 SECTION INCLUDES

- A. Grundfos Recirculator Pump

1.10 RELATED SECTIONS

- A. Division 22 33 30.26 "Residential, Collector-to-Tank, Heat Exchanger Coil, Solar Electric Domestic Water Heaters"
- B. Division 23 71 00 "Thermal Storage"
- C. Division 48 19 00 "Electrical Power Control Equipment"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- E. Grundfos

2.02 COMPONENTS

- A. Grundfos UP15-10SU7/TLC circulator
 - a. Model # 595916
 - b. The Grundfos circulator pumps, Series UP, are specifically designed for heating systems.
 - c. The pumps are also suitable for circulation of hot domestic water and for circulation of liquid in cooling and air-conditioning systems.
- B. Revolutionary Comfort Valve

PART 3 - EXECUTION

3.09 INSTALLATION

- A. The stainless steel circulator, complete with timer and 10-foot power cord, is installed directly to the hot water discharge on the water heater.
- B. The Comfort Valve is installed under the sink at the fixture furthest from the water heater
- C. The Grundfos UP15-10SU7/TLC circulator system uses the existing cold water line to return hot water to the water heater.

END OF SECTION 23 82 41

SECTION 23 83 00

RADIANT HEATING UNITS

PART 1 - GENERAL

1.12 SECTION INCLUDES

- A. Submittals: Product Data
- B. Comply with NFPA 70, "National Electrical Code."
- C. Verify dimensions by field measurements before fabrication.
- D. Pre-piped mechanical primary and distribution panels for use in radiant floor heating and snow melting systems.

1.13 RELATED SECTIONS

- A. Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping"
- B. Section 23 21 12 "Hydronic Piping"

1.14 REFERENCES

- A. Rehau Pro Balance Mixing Module Installation and Operations Manual

1.15 SUBMITTALS

- A. General: Submit listed submittals in accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.
- B. Product Data: Submit manufacturer's product submittal data and installation instructions for each product.
- C. Shop Drawings – Hydronic System
 - 1. Provide engineering analysis using manufacturer's proprietary software.
 - 2. Provide mechanical schematic indicating heat source, mechanical piping and accessories from heat source to manifolds, circulators, water tempering, and zone controls. Indicate supply water temperatures and flow rates to manifolds.
- D. Documentation:



1. Provide manufacturer's detailed instructions for site preparation and product installation.
2. Provide manufacturer's electrical power requirements.

E. Closeout Submittals – Submit the following:

1. Operation and maintenance data
2. Manufacturer's field reports as specified in this document
3. Final as-built mechanical and electrical drawings

1.16 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Manufacturer shall provide products of consistent quality in appearance and physical properties.
2. Manufacturer shall use the highest quality products in the production of systems and components referenced in this document.

B. Installer Qualifications:

1. Use and installer with demonstrated experience on projects of similar size and complexity and/or documentation proving successful completion of familiarization training hosted/approved in writing by the system manufacturer.
2. Electrical rough-in and connections shall be done by a licensed electrician.

C. Pre-installation meetings

1. Verify project requirements, substrate conditions, excavation conditions, system performance requirements, coverings, manufacturer's installation instructions, and warranty requirements.
2. Review project construction timeline to ensure compliance or discuss modifications as required.
3. Coordinate with other trade representatives to verify areas of responsibility.
4. Establish the frequency (during construction phase of the project) the engineer intends for site visits and inspections by the manufacturer's representative.

1.17 DELIVERY, STORAGE, AND HANDLING

A. General: Comply with Division 1 Product Requirements Section.

B. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

C. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.



- D. Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer:
 - 1. Store in cartons or under cover to avoid dirt or foreign material from entering the panel.

1.18 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.19 SYSTEM START-UP

- A. Verify all electrical components are installed per local and National Electrical Code (NEC) prior to start-up.

1.20 OWNER'S INSTRUCTIONS

- A. Instruct Owner about operation and maintenance of installed system.
- B. Provide Owner with manufacturer's installation instructions for installed components within the system.
- C. Provide Owner with all operating instructions/documents for sensors and controls.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturer: REHAU

2.2 REHAU PRO_BALANCE Mixing Module

- A. Intended for relatively small radiant heating applications using a fixed "set point" temperature supply.
- B. The supply temperature to the manifold may be adjusted gradually between 68 F and 158 F, by means of temperature controlled injection valve.
- C. The injection valve has features that can limit the manual adjustment of the valve to prevent tampering and/or over-heating.



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2.3 RAUPANEL Aluminum Panel

- A. Extruded aluminum RAUPANEL sections conduct heat from 3/8" RAUPEX® pipe to provide even floor surface temperatures and quick response time, with minimal downward heat transfer for efficient operation.

2.4 RAUPANEL Plywood Return Bends

- A. Precision-machined plywood return bends allow for maximum flexibility during installation.

2.5 RAUPANEL Furring Strips

- A. Precision-machined plywood furring strips allow for maximum flexibility during installation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Site Verification of Conditions:
 - 1. Verify that site conditions are acceptable for installation of the system. Refer to manufacturer's installation manual for information.
 - 2. Do not proceed with installation of the system until unacceptable conditions are corrected.

3.2 FIELD QUALITY CONTROL AND TESTING

- A. Site tests:
 - 1. Test all electrical controls in accordance with respective installation manuals.
 - 2. System shall be checked after 3 years of operation and every year thereafter. System shall be checked for pH levels to ensure that it is operating within suggested guidelines.

3.3 SYSTEM ADJUSTING

- A. Balancing Across Manifold: Balance all loops across each manifold for equal flow resistance based on actual loop lengths and total manifold flow.
- B. Balancing between manifolds is accomplished with a flow control device installed on the return piping leg from each manifold when direct return piping is used for the supply and return mains or the circuits deviate by more than 10%.

3.4 CLEANING



- A. Remove temporary coverings and protection of adjacent work areas.
- B. Repair or replace damaged installed products.
- C. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance.
- D. Remove construction debris from project site and legally dispose of debris.

3.5 DEMONSTRATION

- A. Demonstrate operation of system to Owner or Owner's personnel.
- B. Instruct the Owner or Owner's personnel about the type, concentration and maintenance of the glycol and water solution.
- C. Provide Owner or Owner's personnel with manufacturer's installation, operation, and maintenance instructions for installed components within the system.

3.6 PROTECTION

- A. Protect installed work from damage caused by subsequent construction activity on the site. Provide Owner with copy of photos and drawings of product locations to assist.

END OF SECTION 23 83 00



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Division 26



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SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

- 1.01 SECTION INCLUDES
 - A. Multi-conductor Building Wires
 - B. Dryer Cord
- 1.02 RELATED SECTION
 - A. SECTION 26 50 00 "Lighting"
 - B. SECTION 26 27 26 "Wiring Devices"
- 1.03 SUBMITTALS
 - A. Schematic drawings and product specifications

PART 2 PRODUCTS

- 2.01 MANUFACTURER
 - A. Southwire
 - B. GE
- 2.02 COMPONENTS
 - A. Southwire
 - a. MULTICONDUCTOR BUILDING WIRE TYPE NM-B
 - i. 250 ft per unit
 - ii. 3 Conductors
 - iii. Estimated amount used 700 ft.
 - iv. Used for power circuits
 - B. GE
 - a. Dryer Cord
 - i. 3 Prong
 - ii. 4 ft.
 - iii. 30-Amp

PART 3 EXECUTION

- 3.01 INSTALLATION
 - A. Install according to NEC 2011 and manufacturers rated load specifications.



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END OF SECTION 26 05 19



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Section 26 05 33
Raceway and Boxes for Electrical Systems

PART 1 - GENERAL

1.11 SECTION INCLUDES

- C. Disconnect
- D. Junction boxes

1.12 RELATED SECTIONS

- A. 26 05 19 "Low-Voltage Wires"
- B. 26 27 26 "Wiring Devices"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- F. Schneider Electric
- G. Carlon
- H. Steel City

2.02 COMPONENTS

- A. Schneider Electric
 - a. Disconnect for HVAC
 - i. Switch Fusible
 - ii. GD 240V
 - iii. 200A 3P NEMA3R
 - b. Service Disconnect
 - i. Switch Fusible
 - ii. GD 240V
 - iii. 200A 3P NEMA3R
- B. Carlon
 - a. Gang Junction Box
 - i. Model - B114R B
 - 1. Non-Metallic Old Work Box
 - ii. Model - B225R-UPC
 - 1. 25 cu. In.
 - 2. Zip Box Blue Old Work



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- 3. Non-Metallic Switch and Outlet Box
 - iii. Model - B355R
 - 1. 35 cu. In. Switch and Outlet Box
- C. Steel City
 - a. Gang Junction Box
 - i. Model - 521511234-30R
 - 1. 21 cu. In.
 - 2. Square Wall Box

PART 3 - EXECUTION

3.10 INSTALLATION

- A. Junction boxes for the purposes of housing receptacles and switches shall be installed at 1.5' and 4' from finished floor and flush with the wall surface.
- B. Disconnect switches shall be installed between 3' and 5' from grade level however up to 6' 7" may be permitted as per NEC.

END OF SECTION 26 05 33



SECTION 26 09 13.10
ELECTRICAL POWER MONITORING

PART I GENERAL

A. SYSTEM DESCRIPTION

1. Furnish and install a complete Power Monitoring and Control System (PMCS) as detailed on the drawings and as described in this specification. The system is defined to include, but not be limited to, remote devices for monitoring, control and protection, device communication interface hardware, inter-communication wiring, personal computer workstations, software, printer where specified, and ancillary equipment.
2. The manufacturer shall demonstrate the system is not a prototype and that similar systems have been field installed and successfully operated for at least five years. The PMCS vendor shall have full responsibility for insuring that the PMCS system performs as specified.
3. The PMCS shall utilize Ethernet as the high-speed backbone network that supports direct connection of an unlimited number of personal computer workstations anywhere on the network.
4. Each Personal Computer Workstation (PCW) connected to the network shall have equal access to information provided by the power monitoring devices for centralizing data display, data logging, alarming, event recording, and other power monitoring operations. Each PCW shall be independent of the other PCWs with its own software to allow the user to retrieve and configure the information based on the user's needs.
5. The high-speed network shall allow direct access to data provided by the power monitoring devices for implementing automatic control.
6. Application software for personal computer workstations shall be provided as described in Article 2.11 of this specification.
7. The PMCS shall be POWERLOGIC as manufactured by Square D Company [or approved equal].
8. All products shall not violate any U. S. patents.

B. REFERENCES

1. All Power Meters and Circuit Monitors shall be UL 508 Listed, CSA approved, and have CE marking. They shall also have certified revenue accuracy as per ANSI C12.20 and IEC 60687 class 0.5S or better.
2. The system shall comply with the applicable portions of NEMA standards. In addition, the control unit shall comply with FCC Emission Standards specified in Part 15, Sub-part J for Class A application.

C. SUBMITTALS

1. PMCS Drawings: Drawings shall show all field monitoring devices, key networking components, and cabling required to complete the system. Drawings shall identify network connections and protocols. Drawings shall identify device room location and recommended installation notations. Specific locations and mounting details are subject to the discretion and responsibilities of the installation Contractor.
2. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements of each device supplied under the PMCS scope of work.

D. QUALITY

1. The PMCS vendor shall be ISO 9000 registered to demonstrate quality compliance.
2. PMCS components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

E. CIRCUIT MONITORS – Advanced (CM4000&CM4000T)

1. Measured Values

- a) The following metered values shall be measured by the Circuit Monitor. In addition, the circuit monitor shall record and save in nonvolatile memory the minimum and maximum values of all listed values since last reset. The circuit monitor shall also record and save in nonvolatile memory the interval minimum, maximum, and average of any of the values pre-defined over a user specified interval.

(1) Real-Time Readings

- (a) Current (Per-Phase, N, G, 3-Phase Avg, Apparent rms, % Unbalanced)

(b) Voltage (L–L Per-Phase, L-L 3-Phase Avg, L–N Per-Phase, 3-Phase Avg, Neutral to Ground, % unbalanced)

(c) Real Power (Per-Phase, 3-Phase Total)

(d) Reactive Power (Per-Phase, 3-Phase Total)

(e) Apparent Power (Per-Phase, 3-Phase Total)

(f) Power Factor (True)(Per-Phase, 3-Phase Total)

(g) Power Factor (Displacement)(Per-Phase, 3-Phase Total)

(h) Frequency

(i) Temperature (Internal Ambient)

(j) THD (Current and Voltage)

(k) K-Factor (Per-Phase)

(2) Energy Readings

(a) Accumulated Energy (Real kWh, Reactive kVARh, Apparent kVAh) (Signed/Absolute)

(b) Incremental Energy (Real kWh, Reactive kVARh, Apparent kVAh) (Signed/Absolute)

(c) Conditional Energy (Real kWh, Reactive kVARh, Apparent kVAh) (Signed/Absolute)

(d) Reactive Energy by Quadrant

(3) Demand Readings

(a) Demand Current (Per-Phase present, 3-Phase Avg, Neutral)

(i) Last complete interval

(ii) Peak



(b) Demand Voltage (L-N, L-L, Per-Phase, 3-Phase avg.)

(i) Last complete interval

(ii) Minimum

(iii) Peak

(4) Average Power Factor (True), (3-Phase total)

(i) Last complete interval

(ii) Coincident with kW peak

(iii) Coincident with kVAR peak

(iv) Coincident with kVA peak

(5) Demand Real Power (3-Phase Total)

(i) Last complete interval

(ii) Predicted

(iii) Peak

(iv) Coincident kVA Demand

(v) Coincident kVAR Demand

(6) Demand Reactive Power (3-Phase Total)

(i) Last complete interval

(ii) Predicted

(iii) Peak

(iv) Coincident kVA demand

(v) Coincident kW demand

(7) Demand Apparent Power (3-Phase Total)

- (i) Last complete interval
- (ii) Predicted
- (iii) Peak
- (iv) Coincident kVA demand
- (v) Coincident kW demand

(8) Power Analysis Values

- (a) THD – Voltage, Current (3-Phase, Per-Phase, Neutral)
- (b) thd - Voltage, Current (3-Phase, Per-Phase, Neutral)
- (c) Total Demand Distortion
- (d) K-Factor (Per-Phase)
- (e) Crest Factor (Per-Phase)
- (f) Displacement Power Factor (Per-Phase, 3-Phase)
- (g) Fundamental Voltage, Magnitude and Angle (Per-Phase)
- (h) Fundamental Currents, Magnitude and Angle (Per-Phase)
- (i) Fundamental Real Power (Per-Phase, 3-Phase)
- (j) Fundamental Reactive Power (Per-Phase)
- (k) Harmonic Power ((Per-Phase, 3-Phase)
- (l) Phase Rotation
- (m) Unbalance (Current and Voltage)
- (n) Harmonic Magnitudes & Angles (Per-Phase)
- (o) Distortion Power
- (p) Distortion Power Factor

b) The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 255th harmonic (based on fundamental of 50/60 Hz).

c) The following metered values as well as the minimum and maximum instantaneous readings since last reset shall be communicated by the Circuit Monitor:

- (1) Frequency
- (2) Temperature
- (3) Current, per phase rms and neutral (if applicable)
- (4) Current, 3-phase average rms
- (5) Current, apparent rms
- (6) Voltage, phase-to-phase and phase-to-neutral
- (7) Voltage unbalance, phase-to-phase and phase-to-neutral
- (8) Power factor, per phase
- (9) Power factor, 3-phase total
- (10) Real power, per phase and 3-phase total
- (11) Reactive power, per phase and 3-phase total
- (12) Apparent power, per phase and 3-phase total
- (13) Demand current, per phase and three-phase average
- (14) Demand real power, three-phase average
- (15) Demand reactive power, three-phase average
- (16) Demand apparent power, three-phase average
- (17) Accumulated energy, (MWh, MVAh, and MVARh)
- (18) Reactive energy, (VARh by quadrant)

(19) Total Harmonic Distortion (THD), voltage and current, per phase

(20) K-factor, per phase

2. Demand

a) All power demand calculations shall be done by any one of the following calculation methods, selectable by the user:

(1) Thermal demand is calculated using a sliding window and is updated every second. The sliding window length shall be defined by the user from 1-60 minutes, with 1-minute increments.

(2) Block interval, with optional sub-intervals. The window length shall be set by the user from 1-60 minutes in 1-minute intervals. The user shall be able to set the sub-interval length from 1-30 minutes in 1-minute intervals.

(3) External Pulse Synchronization, utilizing a synch pulse provided externally. An optional status input shall be used to sense the pulse.

(4) Sliding block interval with continuous sliding 1 second subintervals.

b) The default demand calculation method shall be a 15-minute continuous sliding block.

c) The following demand readings shall be reported by the Circuit Monitor:

(1) Average demand current, per phase

(2) Peak demand current, per phase

(3) Average demand for real power, reactive power, and apparent power

(4) Predicted demand for real power, reactive power, and apparent power

(5) Peak demand for real power, reactive power, and apparent power

d) The Circuit Monitor shall also provide a generic demand capability to provide demand calculation on any metered parameter.

e) Each Circuit Monitor shall be capable of receiving a broadcast message over the communications network that can be used to synchronize demand calculations by

several Circuit Monitors. This message need not be addressed specifically to any one Circuit Monitor.

3. Sampling

a) The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 255th harmonic (fundamental of 60 Hz).

b) (CM4000)The circuit monitor shall provide continuous sampling at a minimum of up to 512 samples/cycle, simultaneously on all voltage and current channels in the meter.

c) (CM4000T)The circuit monitor shall have a 5 MHz per channel (83,333 points per cycle at 60 Hz or 100,000 points per cycle at 50 Hz) sampling rate.

4. Harmonics

a) Advanced harmonic information shall be available via the Circuit Monitor. This shall include the calculation of the harmonic magnitudes and angles for each phase voltage and current through the 255th harmonic.

b) This information shall be available for all three phases, current and voltage, plus the neutral current. To ensure maximum accuracy for analysis, the current and voltage information for all phases shall be obtained simultaneously from the same cycle.

c) The Circuit Monitor shall have a minimum of 16k of on board memory to log harmonic magnitudes and angles.

d) The harmonic magnitude shall be reported as a percentage of the fundamental or as a percentage of any Circuit Monitor may be applied in three-phase, three- or four-wire systems. A fourth CT input shall be available to measure neutral or ground current. If the fourth CT is not used, then a residual current shall be calculated by vectoral addition of the phase currents. In four-wire connections the Circuit Monitor shall utilize the circuit neutral common reference and not earth ground, to provide metering accuracy.

e) Harmonic power flows will be provided up to the 41st harmonic for real, reactive and apparent power.

5. Transients

a) The Circuit Monitor shall be able to detect and capture transients up to 10,000 V_{peak} line to line with a duration as short as 200 nanoseconds when equipped with a Transient Module.

6. Flicker

a) The Circuit Monitor shall detect and measure the flicker (50Hz or 60Hz) of an electrical system based on the IEC Standard 61000-4-15 (or IEEE 1453) when equipped with a Transient Module.

b) The Circuit Monitor shall measure three levels of Flicker:

(1) Instantaneous

(2) Short-term

(3) Long-term

c) The user shall have the ability to view the graphical time-trend of Flicker magnitude in a semi-logarithmic format when equipped with a communications card.

7. EN50160 Evaluation

a) The Circuit Monitor shall include EN50160 evaluations. This capability is characterized by the evaluation of certain power quality parameters: frequency, magnitude of the supply voltage, supply voltage variations, rapid voltage changes, supply voltage dips, short interruptions of the supply voltage, long interruptions of the supply voltage, temporary power frequency overvoltages, transient overvoltages, supply voltage unbalance, and harmonic voltage.

b) The Circuit Monitor shall be capable of reporting EN50160 evaluation data in the following formats: summary of active evaluations, summary of evaluation status, detailed information for each evaluated parameter, detailed information for each abnormal event

c) The user shall be able to reset EN50160 evaluations statistics as required.

8. Accuracy

a) The Circuit Monitors shall accept metering inputs of up to 600Vac direct connection or from industry standard instrument transformers (120 VAC secondary PTs and 5 A

secondary CTs). Connection to 480Y/277 VAC circuits shall be possible without use of PTs.

b) PT primaries through 1.2 MV shall be supported

c) CT primaries through 32 kA shall be supported

d) The Circuit Monitor shall be accurate to 0.04% of reading plus/minus 0.025% of full scale for voltage and current metering and 0.08% of reading plus 0.025% for power.

e) The Circuit Monitor's energy readings shall meet the revenue accuracy requirements of ANSI C12.20 0.2 class and IEC 60687 0.2S class metering.

f) No annual re-calibration by users shall be required to maintain published accuracy.

g) Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions (harmonics).

9. Waveform Capture

a) All Circuit Monitors shall include current and voltage waveform capture capability. Waveform capture shall be user selectable for 16 to 512 cycles of data. Or can be user specified up to 30 seconds.

b) Waveform capture shall be initiated either from a Personal Computer Workstation (PCW) running the Power Monitoring and Control Systems software, or by the circuit monitor as a user defined response to an alarm condition.

c) Waveform capture manually triggered from the Power Monitoring and Control System software shall be captured at 512 samples/cycle for one cycle providing harmonic content up to the 255th harmonic for Ia, Ib, Ic, I4, Va, Vb, Vc, Vg.

d) Three types of waveform capture shall be available for response to an alarm condition:

(1) Steady State shall be manually initiated and provide a resolution of 512 samples/cycle

(2) Disturbance shall be initiated manually or by an alarm condition and allow the user to select a resolution of 16 to 512 samples/cycle and a duration of 915 to 1 cycle.

(3) Adaptive shall be initiated manually or by an alarm condition and allow the user to select a resolution of 16 to 512 samples/cycle and a duration of 1320 to 1 second.

e) The Circuit Monitor shall transmit the waveform samples over the network to the personal computer workstation for display, archival, and analysis.

f) Each voltage and current of all the phases shall be sampled concurrently so that proper phase relationships are maintained, so that harmonic flow analysis can be performed, and so that the effect of a disturbance can be observed on all phase voltages and currents.

g) Harmonic analysis performed on the captured waveforms shall resolve harmonics through the 255th using Power Monitoring and Control Software.

h) All waveforms must reflect actual circuit performance. Waveforms synthesized or composed over time shall not be acceptable.

10. Logging

a) Data logging may be accomplished either within the circuit monitor or at the PC Workstation, or both. Each circuit monitor shall be able to log data, alarms and events, and multiple waveforms. The monitors shall contain a minimum of 8MB of on-board nonvolatile memory, which can be field upgraded without requiring disassembly or removal the Circuit Monitor. On board data logs shall be communicated to the PC Workstation upon demand or at scheduled intervals. Logged information to be stored in each Circuit Monitor includes:

(1) Up to 14 separate data logs shall be configurable by the user. Each log entry shall be date and time stamped. The type of data for the log shall be selected from a list of over 150 monitored values. Each log entry shall be user configurable to consist of from one to over 75 values of instantaneous data. It shall be possible to set up each log to record data at independent user defined intervals. In addition, it shall be possible for a user to define an event or new min/max condition that will trigger log file entries.

(2) Data logs can be configured by users to be Fill & Hold or Circular (FIFO).

(3) A Min/Max log file shall include the time, date, and value for the minimum and maximum of each of the instantaneous metered values since last reset. As

well as a Min/Max/Avg. log that records the minimum/maximum/average readings for pre-defined quantities at a user-specified interval.

(4) An alarm and event log shall contain time, date, event information, and coincident information for each user defined alarm or event. This log shall have a capacity of up to 1,000 events.

(5) Waveform logs shall store captured waveforms as defined by the user. Waveform log entries shall be scheduled at user defined interval, externally triggered, or forced in response to a user defined event. Waveform logs shall be either Fill & Hold or Circular (FIFO) as defined by the user.

(6) The Power Monitoring and Control System software shall be available to enable the user to allocate onboard Circuit Monitor memory for each logging function.

11. Alarming

a) Alarm events shall be a combination of pre-configured from the factory events and user definable events. Multiple levels of alarms can be configured for each metered parameter.

b) The following classes of events shall be available as alarm events:

- (1) Over/under current
- (2) Over/under voltage
- (3) Current imbalance
- (4) Phase loss, current
- (5) Phase loss, voltage
- (6) Wave Shape Alarm
- (7) Voltage imbalance
- (8) Over kVA
- (9) Over kW or kVAR into/out of load

- (10) Over/under frequency
 - (11) Under power factor, true or displacement
 - (12) Over THD
 - (13) Over K-factor
 - (14) Over demand, current or power
 - (15) Reverse power
 - (16) Phase reversal
 - (17) Status Input change
 - (18) End of incremental energy interval
 - (19) End of demand interval
 - (20) Over/under analog inputs
 - (21) Current sag/swell
 - (22) Voltage sag/swell
 - (23) Transients (CM4000T)
- c) For each over/under metered value alarm, the user shall be able to define a pick-up, drop-out, and delay.
- d) The user will have the ability to alarm using a Waveshape Alarm feature based on user set thresholds by defining the following parameters:
- (1) Phase Voltage
 - (2) Neutral Ground Voltage
 - (3) Phase Current
 - (4) Neutral Current

e) There shall be four alarm severity levels in order make it easier for the user to respond to the most important events first.

f) Indication of an alarm condition shall be given on the local display as well as reported to the Power Monitoring and Control System software.

g) The Circuit Monitor shall calculate key electrical parameters at 100ms intervals for the purpose of alarming and recording of data during an event. The recorded data shall be comprised of RMS readings for I, V, kW, kVAR, kVA, and True PF. 1-10 seconds of pre-event and up to 5 minutes of post event data can be recorded.

12. Waveshape Alarm

a) The Circuit Monitor shall include waveshape alarm capability. This capability is characterized by the following features:

(1) The Circuit Monitor shall be capable of continuously monitoring waveform anomalies in the following:

- (a) Phase voltages
- (b) Neutral to ground voltages
- (c) Phase currents
- (d) Neutral currents

b) Anomalous waveshape events less than 1/2 cycle in length shall be detected.

c) The user shall be able to set a threshold value and upper limit in the circuit monitor to determine if a waveshape event has occurred. The threshold and upper limit shall be user-defined values between 0-100. The threshold value is the limit at which a waveshape alarm will trigger. The upper limit defines the highest waveshape value that will trigger a waveshape alarm.

d) Upon detecting a disturbance, the Circuit Monitor shall be capable of:

(1) Logging a waveform of the event all phase currents and voltages and/or a high-speed 100ms RMS event recording.

(2) Recording the disturbance into an event log with a date and time stamp to the millisecond.

(3) Causing an operator alarm at the PCW workstation.

(4) Determining the source of the disturbance (upstream or downstream from the meter) and a statistical level of confidence (low, medium, high) of the accuracy of the source location.

13. Alarm Setpoint Learning (ASL)

a) Using SMS software (3.3.2 or greater), the user can enable the Series 4000 Circuit Monitor to learn the characteristics of normal operation of metered values and select alarm setpoints based on this data.

b) The user is able to determine the quantities to be learned and the period of time for the learning process for standard-speed and high-speed analog alarms, disturbance alarms, and waveshape alarms.

c) The user can configure this feature using one of two modes:

(1) Fixed Learning — Initially configured user setpoints are used during the entire learning period.

(2) Dynamic Learning — Initially configured user setpoints are temporarily replaced by learned setpoints at the interval specified by the user in SMS. The setpoints continue to be updated at the specified interval until the learning period expires.

d) The user can configure the duration of the learning period. If the learned setpoints do not change over a predefined period, the process can be stopped and the setpoints either installed or held for review.

14. Communications

a) The Circuit Monitor shall communicate via RS-232, RS-485, and Ethernet simultaneously.

b) The Circuit Monitor shall provide Modbus communications using Modbus TCP via an Ethernet network at 10/100Mbaud using UTP or Fiber connections. The Circuit Monitor shall provide the capability to communicate to 31 additional Modbus devices existing on

RS-485 daisy chains and report data back to the PMCS application software or across the Ethernet network to other software applications.

c) The Circuit Monitor display shall provide an RS-232 communications port on board the metering module as well as an IR RS-232 communications port located on the display. The display port shall be completely accessible during normal operation and shall not require exposure of the operator to life-threatening voltage when in use. The operator shall be able to quickly connect a small Personal Computer (PC) to either the module port or the display port without use of tools or splices. Both the metering module port and the display port shall have all of the communication functionality of the standard hard-wired port. When a connection is made to either the metering module port or the display port, the Circuit Monitor shall continue simultaneous operation of all communication ports associated with the Circuit Monitor.

d) It shall be possible to field upgrade the firmware in the Circuit Monitor to enhance functionality. These firmware upgrades shall be done through either the display port or communication connection. No Circuit Monitor disassembly or changing of integrated circuit chips shall be required. It shall not be necessary to de-energize the circuit or the equipment to upgrade the firmware.

e) The circuit monitor shall allow communication to all ports simultaneously.

f) The circuit monitor shall have the option to serve data over the Ethernet network accessible through a standard web browser. Information shall be available from the circuit monitor and from Modbus slave devices connected downstream from the monitor. The monitor shall contain default pages from the factory and also have the ability for the user to create custom pages as needed.

g) The circuit monitor shall provide e-mail notification of any alarm condition that it detects.

h) Time synchronization to 1 millisecond between monitors via GPS synchronization.

15. I/O Options

a) Circuit Monitor Input/Output Options: Input/Output options/modules shall be field replaceable. Circuit Monitors shall provide pre-configured I/O options and also provide I/O options to be configured as applicable to each installation as shown on the project drawings:

- (1) One solid state output suitable for KYZ pulse initiation; four solid state status inputs; three (10A) mechanical output relays
- (2) Four solid state status inputs; four analog inputs (4-20 mA)
- (3) Four inputs (32Vdc); 2 solid state outputs (60Vdc); 1 analog input (0-5Vdc); 1 analog output (4-20mA)
- (4) Eight solid state status inputs (120Vac)
- (5) Circuit Monitor shall provide configurable I/O options to include solid state input modules for 120Vac, 200Vac, and 32Vdc; solid state outputs modules for 120Vac, 240Vac, 60Vdc, 240Vdc; analog input modules for 0-5Vdc, 4-20mA; analog output module for 4-20mA.

16. Output Relay Control

- a) Relay outputs shall operate either by user command sent over the communication link, or set to operate in response to user defined alarm event.
- b) Output relays shall close in either a momentary or latched mode as defined by the user.
- c) Each output relay used in a momentary contact mode shall have an independent timer that can be set by the user.
- d) It shall be possible for individual relay outputs to be controlled by multiple alarms in a wired "OR" configuration.

17. Disturbance Detection

- a) All Circuit Monitors noted on the project drawings shall include sag and swell detection capability. This capability is characterized by the following features:
 - (1) The Circuit Monitor shall continuously monitor for disturbances in the currents and incoming voltage. There shall be zero blind time; each cycle shall be individually monitored.
 - (2) Disturbance events less than 1/2 cycle in length shall be detected.

(3) The user shall be able to set a threshold and delay which shall be used by the circuit monitor to determine if an event has occurred. The threshold shall be user defined as either a fixed set point or relative set point. When using the relative set point, the Circuit Monitor will set the nominal current or voltage equal to its present average value. The Circuit Monitor will automatically adjust the nominal current and voltage values to avoid nuisance alarms caused by gradual daily variations of currents and voltages.

b) Upon detecting a disturbance, the Circuit Monitor shall be capable of :

(1) Logging a waveform of the event all phase currents and voltages and/or a high-speed 100ms RMS event recording.

(2) Operating any output relay on an optional I/O module.

(3) Recording the disturbance into an event log with a date and time stamp to the millisecond.

(4) Determining the direction of the cause of disturbance and categorize as "Upstream" from the meter or "Downstream" from the meter with an assigned confidence factor in the algorithm, then annunciate this determination through software.

(5) Causing an operator alarm at the PCW workstation.

c) The user shall have the ability to display the voltage sag/swell events on ITIC or SEMI graphs to quantify the event with respect to accepted industry standards. If so desired the user shall also have the ability to view this information on custom web pages over the Internet when used with a communications card.

d) All data and waveform logs shall be communicated over the local area network or through the front panel communications port so that the user may view and analyze the data using the PMCS software and workstation.

e) The location of the source of the disturbance (upstream or downstream from the meter) may be provided for each event. A statistical level of confidence (low, medium, high) will be provided of the accuracy of the source's location.

18. Display

a) The Circuit Monitor display shall allow the user to select one of six languages to view on the screen:

- (1) English
- (2) French
- (3) Spanish.
- (4) Italian
- (5) Polish
- (6) German

b) The Circuit Monitor display shall also allow the user to select a date/time format and the ability to create additional screens for user-specified views and/or custom quantities without overwriting existing standard screens.

c) The Circuit Monitor display shall provide local access to the following metered quantities as well as the minimum and maximum value of each instantaneous quantity since last reset of min/max:

- (1) Current, per phase rms, 3-phase average and neutral (if applicable)
- (2) Voltage, phase-to-phase, phase-to-neutral, and 3-phase average (phase-to-phase and phase-to-neutral)
- (3) Real power, per phase and 3-phase total
- (4) Reactive power, per phase and 3-phase total
- (5) Apparent power, per phase and 3-phase total
- (6) Power factor, 3-phase total and per phase
- (7) Frequency
- (8) Demand current, per phase and three phase average
- (9) Demand real power, three phase total

(10) Demand apparent power, three phase total

(11) Accumulated Energy, (MWh and MVARh)

(12) THD, current and voltage, per phase

(13) K-factor, current, per phase

d) Reset of the following electrical parameters shall also be allowed from the Circuit Monitor display:

(1) Peak demand current

(2) Peak demand power (kW) and peak demand apparent power (kVA)

(3) Energy (MWh) and reactive energy (MVARh)

(4) Setup for system requirements shall be allowed from the Circuit Monitor display. Setup provisions shall include:

(5) CT rating

(6) PT rating

(7) System type [three-phase, 3-wire] [three-phase, 4-wire]

(8) Demand interval (5-60 min.)

(9) Watt-hours per pulse

e) For ease in operator viewing, two displays are offered for local viewing of Circuit Monitor data. The liquid crystal display (LCD) shall include back lighting. The enhanced vacuum fluorescent display (VFD) shall be automatically activated by a proximity sensor as the operator approaches.

19. Programming

a) Where indicated on the drawings, the Circuit Monitors shall be designed to run customized programs to greatly expand the Circuit Monitor's functionality for the particular installation.

b) These programs shall be written in a circuit monitor programming language similar to a compiled "BASIC" language. It shall include the following capabilities:

- (1) Scheduled tasks
- (2) Event Tasks
- (3) Math functions including: add, subtract, multiple, divide, sine, cosine, square root, etc.
- (4) Logical functions including: AND, OR, XOR, NOT, shift, etc.
- (5) Loop commands
- (6) Compare statements
- (7) Counters and timers

c) The circuit monitor manufacturer shall offer custom programming services.

d) Changing programs shall not require any physical modifications to the Circuit Monitor, such as changing computer chips or cards. All changes shall be done via either of the communications ports.

e) Examples of custom programs would include:

- (1) Metering of specialized utility rate structures, including real time pricing and curtailable rates
- (2) Data reduction using smart data logging
- (3) Automatic monthly logging/reset of kWh and Peak Demand
- (4) Statistical profile analysis of metered quantities
- (5) ITIC/SEMI power quality analysis
- (6) Calculations for IEEE-519 verification
- (7) Metering of combined utilities: gas, water, steam, electric

(8) Non-critical control schemes, such as load control or power factor correction, based on multiple conditions e.g. time of day and input status

20. Current/Voltage Inputs

- a) The Circuit Monitors shall accept metering inputs of up to 600Vac direct connection or from industry standard instrument transformers (120 VAC secondary PTs and 5 A secondary CTs). Connection to 480Y/277 VAC circuits shall be possible without use of PTs.
- b) PT primaries through 1.2 MV shall be supported
- c) CT primaries through 32 kA shall be supported
- d) The Circuit Monitor shall be accurate to 0.04% of reading plus/minus 0.025% of full scale for voltage and current metering and 0.08% of reading plus 0.025% for power.
- e) The Circuit Monitor's energy readings shall meet the revenue accuracy requirements of ANSI C12.20 0.2 class metering.
- f) No annual re-calibration by users shall be required to maintain published accuracy.

21. Feature Additions

- a) It shall be possible to field upgrade the firmware in the Circuit Monitor to enhance functionality. These firmware upgrades shall be done through the communication connection and shall allow upgrades of individual meters or groups. No disassembly or changing of integrated circuit chips shall be required and it will not be necessary to de-energize the circuit or the equipment to perform the upgrade.
- b) The Circuit Monitors shall be rated for an operating temperature range of -25° C to 70° C and have an over current withstand rating of 500 amps for 1 second.
- c) All setup parameters required by the Circuit Monitors shall be stored in nonvolatile memory and retained in the event of a control power interruption.
- d) The Circuit Monitor shall be capable of being applied without modification at nominal frequencies of 50, 60, or 400 Hz.



e) The Circuit Monitor (CM4250) shall include anti-aliasing filters on both voltage and current metering inputs. These anti-aliasing filters are capable of having the corner frequency adjusted between 50Hz, 60Hz, or "off" modes.

f) The Circuit Monitor (CM4250) shall have a Cat IV overvoltage withstand rating on the voltage metering inputs.

22. The Circuit Monitor shall operate properly over a wide range of control power including 100-305 VAC or 100-300 VDC. Connections to 18-60 VDC shall also be available.

23. Ride through capability shall be available for backup control power for up to 2 seconds, the rms values, as selected by the user.

24. The Circuit Monitor shall provide a hardware security switch to protect all revenue related metering configuration from unauthorized/accidental changes. The Circuit Monitor shall support the use of a wire seal to further deter inadvertent configuration changes and provide visual tamper indication.

25. The Circuit Monitor shall be a PowerLogic CM4000(T) manufactured by Square D Company or equal.

III. EXECUTION

A. INSTALLATION

1. PMCS components, including Circuit Monitors, Electronic Trip Units, Transformer Temperature Monitors, Motor Protection Devices, and Digital Relays, included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

2. All control power, CT, PT and data communications wire shall be factory wired and harnessed within the equipment enclosure.

3. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.

4. All wiring required to externally connect equipment lineups shall be installed by the electrical contractor.



5. Contractor interconnection wiring requirements shall be clearly identified on the PMCS system drawings.

B. SYSTEM START-UP AND TRAINING

1. On-site start-up and training of the PMCS shall be included in the project bid.
2. Start-up shall include a complete working demonstration of the PMCS with simulation of possible operating conditions that may be encountered.
3. Training shall include any documentation and hands-on exercises necessary to enable electrical operations personnel to assume full operating responsibility for the PMCS after completion of the training period.
4. The project bid shall include [] days start-up assistance and [] days training to include [] trip(s).
5. The power monitoring vendor shall offer regularly scheduled factory training for customers on all aspects of power monitoring and control, including:
 - a) Comprehensive software and hardware setup, configuration, and operation
 - b) Advanced monitoring and data reporting
 - c) Advanced power quality and disturbance monitoring
6. The power monitoring manufacturer shall provide a full time telephone technical help center for customers.

C. POWER QUALITY/ENERGY MANAGEMENT SERVICES

1. Manufacturer shall offer complete power quality and analytical services, including:
 - a) Energy Savings
 - (1) Bill and tariff analysis
 - (2) Power Factor Improvement
 - (3) Mechanical Equipment Optimization

b) Power Quality Evaluation

- (1) IEEE-519 Harmonic Compliance
- (2) Circuit and Transformer Loading
- (3) Harmonic Mitigation

c) Power System Troubleshooting

- (1) Equipment Problems
- (2) Wiring and Grounding Evaluation
- (3) Short Circuit Analysis
- (4) Load Flow and Harmonic Flow Studies

2. Engineers performing these studies shall be employees of manufacturer, have engineering degrees, and be licensed professional engineers. They shall demonstrate proficiency by demonstrating past studies and projects similar to those to be undertaken.

D. DESIGN SERVICES

1. The energy monitoring system vendor shall make all alterations and changes needed to make the system perform as needed at each location. These changes may include:

- a) Custom enclosures and panels
- b) Modifications to existing switchgear and equipment, including installation
- c) Configuration of software, servers, and workstations
- d) Communication interface installation and configuration
- e) Communication network design

2. The energy monitoring system vendor can provide development, integration, and installation services required to complete and turn over a fully functional system. This shall include:

- a) Project management - A project manager shall be assigned to each plant EMS implementation. Typical responsibilities shall include coordination of personnel,



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information and on-site supervision for the various levels and functions of suppliers required for completion of the project. The Project Manager shall provide strategic direction for the entire team. Responsibilities include daily operational and tactical implementation of projects, provide logistics and ensure follow up and closure of site related issues.

b) All technical coordination, installation, integration and testing of all components

c) Detailed system design

d) System drawings

END OF SECTION 26 09 13.10



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SECTION 26 18 36
MEDIUM-VOLTAGE ENCLOSED FUSES

PART 1 - GENERAL

1.13 SECTION INCLUDES

- A. Combiner Box

1.14 RELATED SECTIONS

- A. Division 48 19 16 "Electrical Power Generation Inverters"
- B. Division 26 05 19 "Low-Voltage Electrical Power Conductors and Cables"
- C. Division 48 19 16 "Electrical Power Generation Inverters"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- I. Shoals

2.02 COMPONENTS

- A. Combiner box
 - a. Model # ST6.CBRH.6.A
 - b. Is a fuse box that allows the electrical connection on the roof to be connected and disconnected for safe user access.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Steps:
 - ii. Install in accordance with manufacturer's instructions.
 - iii. Read Installation and Safety Manual.

END OF SECTION 26 18 36



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SECTION 26 24 16 PANELBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. DESCRIPTION OF WORK

1. Extent of panelboard, load-center, and enclosure work, including cabinets and cutout boxes, is indicated by drawings and schedules.
2. Types of panelboards and enclosures in this section include the following:
 - a. Power-distribution panelboards.
 - b. Lighting and appliance panelboards.
3. Refer to other Electrical work sections for cable/wire, connectors and electrical work required in conjunction with panelboards and enclosures.

B. STANDARDS AND CODES

1. Comply with NEC 2011.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Product

1. Main Panel Board
 - a. Manufacturer Square D
 - b. Model Number QO140M200C
 - c. Phase Single
 - d. 120/240V
 - e. 200A
 - f. Main Circuit Breaker
 - g. 40 Space

B. Panel boards



1. General: Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials, design and construction in accordance with published product information; equip with number of unit panelboard devices as required for complete installation.
2. Panelboard Accessories: Provide panelboard accessories and devices including, but not necessarily limited to, cartridge and plug time-delay type fuses, circuit breakers, ground-fault protection units, etc., as recommended by panelboard manufacturer for ratings and applications indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of Panelboards:

1. General: Install panelboards and enclosures where indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.
2. Anchor enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically secure.
3. Provide electrical connections within enclosures.
4. Fill out panelboard's circuit directory card upon completion of installation work. Directory shall be type written.

END OF SECTION 26 24 16



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SECTION 26 27 26 WIRING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Receptacles
- B. Switches
- C. Other wiring devices indicated on the drawings

1.02 RELATED SECTIONS

- A. SECTION 26 50 00 "Lighting"
- B. SECTION 26 05 19 "Low-Voltage Electrical Power Conductors And Cables"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. Leviton
- B. Smarthome

2.02 COMPONENTS

- A. Leviton
 - a. STANDARD DUPLEX RECEPTICAL
 - i. Straight Blade Wiring Devices
 - ii. Leviton Model R52-05320-00W
 - b. SMARTLOCK PRO GFCI OUTLET
 - i. GFCI Duplex Receptacle
 - ii. Leviton Model R72-N7599-0RW
 - c. 30-AMP INDUSTRIAL FLUSH MOUNT SINGLE POWER OUTLET
 - i. 120/240V Dryer Receptacle
 - ii. Leviton Model R50-00278-000
 - d. 50-AMP RANGE RECEPTICAL
 - i. 120/240V Range Receptacle
 - ii. Leviton R50-00279-000
- B. Smarthome
 - a. SwitchLinc On/Off Switch



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- i. 3-Way Light Switch
- ii. 2477S

PART 3 EXECUTION

3.01 INSTALLATION

- A. Wiring Devices shall be installed according to the NEC 2012 with respect to mounting height, location and distribution along the floor line.
- B. Wiring Devices shall be installed according to manufacturer's specifications.

END OF SECTION 26 27 26



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SECTION 26 31 00 PHOTOVOLTAIC COLLECTS

PART 1 - GENERAL

1.15 SECTION INCLUDES

- A. Solar Panels

1.16 RELATED SECTIONS

- A. Division 05 14 13 "Architecturally-Exposed Structural Aluminum Framing"
- B. Division 22 11 19 "Domestic Water Piping Specialties"
- C. Division 22 33 30.26 " Residential, Collector-To-Tank, Heat –Exchanger-Coil, Solar-Electric Domestic Water Heater"
- D. Division 48 19 16 "Electrical Power Generation Inverters"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- J. Bosch

2.02 COMPONENTS

- B. Crystalline silicon photovoltaic modules for electricity generation
- C. Bosch Solar Module c-Si M60 NA 42117
- D. <http://www.bosch-solarenergy.com/en/bosch-se-online/produkte/uebersichtseite-kristalline-module-1/Kristalline-Solar-Module.html>

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Prepare Unirac system per manufacturer's instructions.
- B. Place panels on the Unirac system and ensure the panels are level.
- C. Affix panels to the Unirac system as described in the written instructions provided by the manufacturer.

END OF SECTION 26 31 00



SECTION 26 50 00
LIGHTING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Interior and Exterior Lighting Fixtures

1.02 RELATED SECTIONS

- A. SECTION 26 27 26 "Wiring Devices"
- A. SECTION 26 05 19 "Low-Voltage Electrical Power Conductors And Cables"

1.03 SUBMITTALS

- A. Product Data for all luminaries.

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. CREE
- B. Lucifer Lighting Co.
- C. LITON Lighting
- D. Louis Poulsen
- E. Access
- F. Allscape
- G. Boran

2.02 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Recessed Features: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Features: Comply with UL 1598. Where LER is specified test according to NEMA LE 5A.
- C. Exterior Luminaries: Comply with UL 1598.

2.02 REQUIREMENTS FOR INDIVIDUAL LIGHTING FIXTURES

- A. CREE
 - a. Recessed Light

- i. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.
- ii. Input Power: 10.5 Watts
- iii. Mounting: Recessed Ceiling
- iv. Nominal Dimensions: 6.00" H x 7.375" W

B. Lucifer Light Co.

a. Wall Washing Light

- i. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.
- ii. Input Power: 18.0 Watts
- iii. Mounting: Placed in aluminum channel at base of wall panels
- iv. Nominal Dimensions: 5.75" H x 4.00" W

C. LITON lighting

a. Under Cabinet Light

- i. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.
- ii. Input Power: 2.4 Watts
- iii. Mounting: Under cabinetry
- iv. Nominal Dimensions: 1/8" H x 12 1/4" W

D. Louis Poulsen

a. Pendant Light

- i. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.
- ii. Input Power: 19.0 Watts
- iii. Mounting: Suspended from ceiling
- iv. Nominal Dimensions: 7.3" H x 7.1" W

E. Access

a. Wall Sconce Light

- i. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.
- ii. Input Power: 60 Watts (max)
- iii. Mounting: Wall mounted
- iv. Nominal Dimensions: 14.50" H x 4.40" W

F. ALLSCAPE

a. Landscape Light

- i. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.
- ii. Input Power: 25W
- iii. Mounting: Recessed in Deck
- iv. Nominal Dimensions: 21.5" H x 12.25" Dia.

G. Broan

a. Ventilation Fan with Light

- i. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.
- ii. Input Power: 40W
- iii. Mounting: Recessed Ceiling
- iv. Nominal Dimensions: 13.75" W x 13" L x 7.625" T

PART 3 EXECUTION

3.01 INSTALLATION

- B. Install according to NEC 2011 and manufacturers rated load specifications.
- C. Set units level, plumb, and square with ceiling and walls, and secure.
- D. Correct deficiencies in or remove and reinstall mountings and modules that do not comply with requirements.
- E. Repair, refinish, or replace mountings and modules damaged during installation or transit, as directed by Architect.



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END OF SECTION 26 50 00



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Division 31



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SECTION 31 66 16 TEMPORARY FOUNDATIONS

PART I - GENERAL

1.01 SUMMARY: This section includes the temporary foundation construction for a single story, multiple module building and decking components.

- A. Central Piers Seismic Piers Instruction Manual
- B. Tiger Brand Super Series Jack Post Instruction Manual

1.02 SYSTEM DESCRIPTION

- A. Temporary Foundation: Design and construct temporary foundation system for support of structure as required, meeting Solar Decathlon competition code.
- B. The size and dimension of the required foundation pier or jack post are determined based on the site characteristics to obtain the correct height from grade to finished floor.
- C. The foundation system shall be composed of:
 - 1. Central Piers Seismic Piers: made from hot rolled mild steel and attached to a $\frac{3}{4}$ steel plate.
 - 2. Tiger Brand Jack Post: prefabricated adjustable steel columns made from ASTM A 500.
- D. The temporary foundation should be placed and level before any of the modules are placed and attached to the foundation.
- E. Performance requirements: The piers and jack posts should be placed so that the load distributed to the surface is within code requirements.

1.03 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Pier manufacturer should be Central Piers Inc.
 - 2. Contractor/Installer should be familiar with the proper installation of temporary foundation piers.



3. All supplied fasteners and other third party supplied components shall be certified by Central Piers Inc. as to quality and suitability for use.

B. Regulatory Requirements:

1. The Central Pier and Tiger Brand Jack Post shall meet or exceed all code requirements for the structure.

- C. The Central Piers and Tiger Brand Jack Posts should be recognized for the intended use by applicable building codes.

D. Third Party Inspection:

1. The manufacturer of the piers, concrete blocks and components shall comply with quality assurance standards of a contracted independent third party quality assurance inspection agency.

1.04 DELIVERY, STORAGE, HANDLING

- A. All central piers, jack posts and components shall be delivered to the job site with labels intact.
- B. All required material shall be stored in a clean and safe area.
- C. All temporary foundation material shall be handled with care as to not damage the material prior to installation.

1.05 PROJECT CONDITIONS

- A. Application of any sealants, primers, or finishes shall be done under the conditions set forth by the manufacture of those products.

1.06 SEQUENCING AND SCHEDULING

- A. Installation of the temporary foundation shall be coordinated with other building trades.
- B. The site shall be completely clear of any obstacles and debris before the foundation is placed.
- C. Other building trades may be schedule as required.



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PART II – PRODUCTS

2.01 MANUFACTURER: The seismic piers, super series jack posts, and components are all proprietary products of Central Piers Inc., Tiger Brand Jack Post, and manufactured under strict quality controls as monitored by a third party independent quality assurance agency.

2.02 MATERIALS

A. Central Piers Seismic Pier:

1. The CP Seismic Pier is a Powder Coated Steel Pier, mounted to a $\frac{3}{4}$ steel plate (Above ground).
2. Available for mobile home permanent foundations, commercial foundations, tie-downs, earthquake bracing, and 2-story fleetwood foundations.

B. Super Series Jack Post:

1. Steel prefabricated adjustable columns made from ASTM A 500.

PART III - EXECUTION

3.01 EXAMINATION

- A. Verify grade and levelness of site.
- B. Locate footprint of building location and determine lowest point of grade and required elevation for the finished floor of structure.

3.02 TEMPORARY FOUNDATION PLACEMENT

- A. Starting at the lowest point on site, place temporary foundation units in accordance with placement drawings. Level foundations from the lowest point on site.
- B. Place the foundation elements at the locations specified in the foundation plan.
 1. Seismic Pier
 - a. Attach the seismic pier to the $\frac{3}{4}$ inch steel plate in accordance with the instruction manual.



- b. Orient the seismic pier and the $\frac{3}{4}$ inch steel plate in accordance with the foundation plan.
- c. Adjust the height of the pier to the correct elevation so that the distance between grade and finish floor is 2'.

2. Super Series Jack Post

- a. Attach the jack post to the 2x8 base plate.
- b. Orient the jack post in accordance to the foundation plan.
- c. If the jack post is not level, use wood shims to make the jack post level.
- d. Adjust the post to obtain the correct elevation.

- C. Continue to place the temporary foundation members at the rest of the locations according to the above process.
- D. Confirm that the temporary foundation is all at the same elevation before any modules are installed to ensure the structure will be placed on a level surface.
- E. Assemble the house on temporary foundation piers as indicated on drawings.
- F. Connect modules to piers and jacks in accordance with the instruction manual for the given pier or jack post.

3.05 CLEANING

- A. All excess materials, if any, shall be removed from the job site by the contractor in accordance with contract provisions.
- B. All surrounding areas where the foundation has been installed shall be left free of debris and foreign substances resulting from the contractor's work.

END SECTION 31 66 1



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Division 33



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Section 33 71 73.11
Meter Centers Gangable

PART 1 - GENERAL

1.17 SECTION INCLUDES

- E. Meter Socket

1.18 RELATED SECTIONS

- A. 26 05 19 "Low-Voltage Wires"
- B. 26 27 26 "Wiring Devices"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- K. Schneider Electric

2.02 COMPONENTS

- D. Meter Socket Ringless UG 200A
 - a. UTRS213A

PART 3 - EXECUTION

3.11 INSTALLATION

- C. The meter center shall be installed between 3 and 5 feet above grade level so that it may be readily accessible in the event of an emergency

END OF SECTION 33 71 73.11



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Division 48



SECTION 48 19 00
ELECTRICAL POWER CONTROL EQUIPMENT

PART 1 - GENERAL

1.19 SECTION INCLUDES

- A. Module Maximizer

1.20 RELATED SECTIONS

- A. Division 26 31 00 "Photovoltaic Collectors"
- B. Division 26 05 19 "Low-Voltage Electrical Power Conductors and Cables"
- C. Division 48 19 16 "Electrical Power Generation Inverters"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- L. Tigo Energy

2.02 COMPONENTS

- D. Tigo Energy
 - a. Dual Maximizer
 - i. Make sure voltage of module is within voltage rating of Maximizer. Each unit can be used with up to two solar modules (can use configuration tool on the Tigo Energy website)
 - b. Gateway
 - i. The Gateway communicates (wirelessly) with up to 150 Maximizers, with maximum radius of 50 ft. (15 m)
 - c. Management Unit
 - i. Description: The Tigo Energy Maximizer Management Unit calculates the optimization points for each of the Maximizers, and collects data to be sent to Tigo Energy's Datacenter.

PART 3 - EXECUTION

3.12 INSTALLATION

- B. Tigo Energy



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- a. Steps:
 - i. Install in accordance with manufacturer's instructions.
 - ii. Read Installation and Safety Manual
 - iii. Configure the system online
 - iv. Connect Maximizers to the PV modules
 - v. Connect Maximizers in series
 - vi. Record location of Maximizer Mac IDs on system map
 - vii. Mount the Gateway(s) in the center of the array
 - viii. Install Maximizer Management Unit (MMU) and connect to Gateways
 - ix. Initiate Discovery and Power On
 - x. Verify RSSI and Gateway location
 - xi. Test PV-Safe and string polarity

END OF SECTION 48 19 10



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SECTION 48 19 16
ELECTRICAL POWER GENERATION INVERTERS

PART 1 - GENERAL

1.21 SECTION INCLUDES

- A. Schneider Electric Inverters

1.22 RELATED SECTIONS

- A. Division 26 31 00 "Photovoltaic Collectors"
- B. Division 26 05 33 "Raceway and Boxes for Electrical Systems"
- C. Division 26 05 19 "Low-Voltage Electrical Power Conductors and Cables"
- D. Division 48 19 00 "Electrical Power Control Equipment"

1.03 SUBMITTALS

- A. Product datasheets from manufacturer

PART 2 - PRODUCTS

2.01 MANUFACTURER

- M. Schneider Electric

2.02 COMPONENTS

- C. Conext Tx 878-3801
- D. http://www2.schneider-electric.com/sites/corporate/en/products-services/renewable-energies/products-offer/range-presentation.page?c_filepath=/templatedata/Offer_Presentation/3_Range_Datasheet/data/en/shared/solar/conext.xml&p_function_id=15210&p_family_id=15211&p_range_id=61159&f=F13%3ASolar~!NNM1:Solar+Grid+Tie+Systems~!NNM2:Single+Phase+Solar~!NNM3:Conext+TX

PART 3 - EXECUTION

3.13 INSTALLATION

- E. Install in accordance with manufacturer's instructions.

END OF SECTION 48 19 16

Canopy House
Irvine, California

STRUCTURAL DESIGN CRITERIA

March 26, 2013



Engineer: Edward C. Westerman, P.E.

Comm. No.: 4.0

Canopy House

Irvine, California

Design Criteria and Reference Codes & Standards

- 2012 International Building Code
- ASCE 7-10, “Minimum Design Loads for Buildings and Other Structures”
- AISC 360-10, “Specification for Structural Steel Buildings”
- AISC 303-10, “Code of Standard Practice for Steel Buildings and Bridges”
- AISI, “Specification for the Design of Cold-Formed Steel Structural Members”, 2007
- AISI, “North American Standard for Cold-Formed Steel Framing – Lateral Design”, 2007 edition with Supplement No. 1
- AF&PA, “National Design Specification for Wood Construction”, 2005 edition
- AF&PA, “Special Design Provisions for Wind and Seismic”, 2008 edition

Dead Loads

Roof Loads

Plywood sheathing	1.5 PSF
Cold-formed roof joists	4.5 PSF
Insulation	1 PSF
½” Gypsum board ceiling	2 PSF
Lights	0.5 PSF
Mechanical allowance	2 PSF
Roof membrane	1 PSF
Solar panels	6.5 PSF

Floor Loads

Floor finish	2 PSF
Plywood sheathing	2.5 PSF
2x10 wood joists at 16” OC	3.5 PSF
2x6 wood nailer	1 PSF
W10x30 spandrel beams	8 PSF
ThermaSteel wall panels (including gypsum board)	4 PSF
Exterior wall siding (including plywood sheathing)	4 PSF

Canopy House

Irvine, California

Live Loads

Roof	20 PSF
Interior living areas	50 PSF
Exterior decks and ramps	100 PSF
Mechanical room	125 PSF

Snow Loads

Ground Snow Load, p_g	0 PSF
Importance Factor, I	1.0
Exposure Factor, C_e	1.0
Thermal Factor, C_t	1.0
(I) p_g (minimum value)	0 PSF
Flat Roof Snow Load, p_f	0 PSF

Wind Loads

Basic Wind Speed, V	110 MPH
Risk Category	II
Exposure Category	C
Internal Pressure Coefficient, GC_{pi}	+/- 0.18
Gust Effect Factor, G	0.85
Components and Cladding Pressures	See Calculations

Canopy House

Irvine, California

Seismic Loads

Risk Category	II
Importance Factor, I	1.00
Site Class	D (Assumed)
Mapped Spectral Response Accelerations:	
Short-period Response, S_s	1.493g
One-second Response, S_1	0.554g
Design Spectral Response Accelerations:	
Short-period Response, S_{DS}	0.995g
One-second Response, S_{D1}	0.554g
Seismic Design Category	D
Basic Seismic-Force-Resisting System	Light-frame (cold-formed steel) walls sheathed with wood structural panels rated for shear resistance or steel sheets
Response Modification Factor, R	6.5
Design Base Shear, V	$V = 0.153W$
Analysis Procedure	Equivalent Lateral Force

USGS Design Maps Summary Report

User-Specified Input

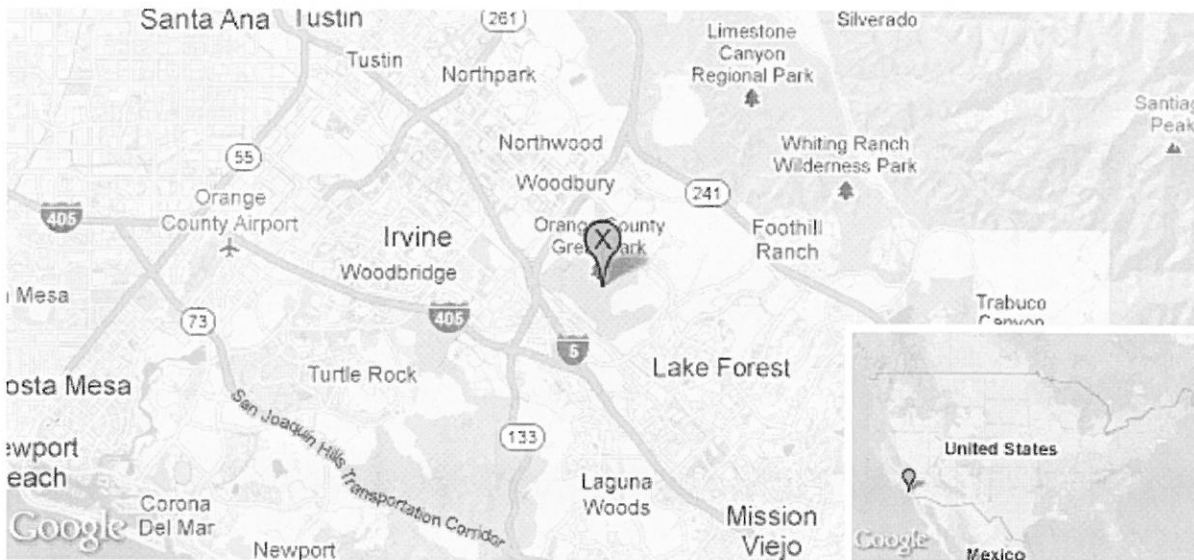
Report Title Solar Decathlon Canopy House - Irvine, CA
Thu February 14, 2013 15:45:03 UTC

Building Code Reference Document ASCE 7-10 Standard
(which makes use of 2008 USGS hazard data)

Site Coordinates 33.67°N, 117.73°W

Site Soil Classification Site Class D - "Stiff Soil"

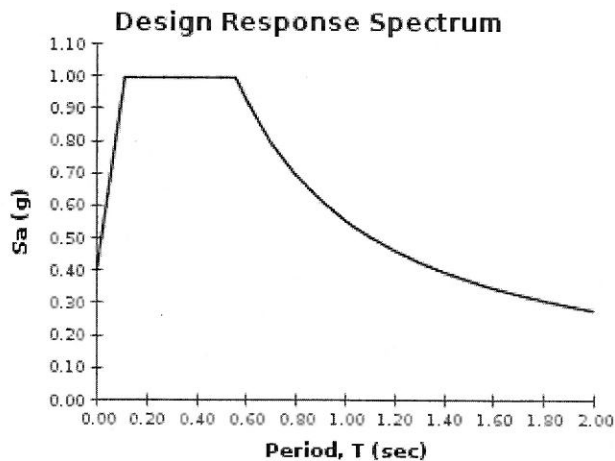
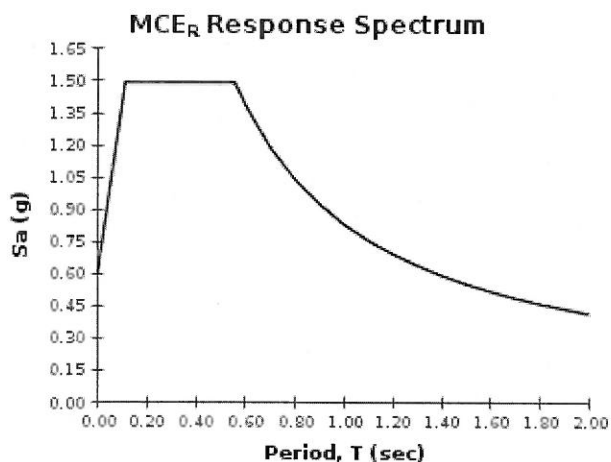
Risk Category I/II/III



USGS-Provided Output

$S_s = 1.493 \text{ g}$	$S_{MS} = 1.493 \text{ g}$	$S_{DS} = 0.995 \text{ g}$
$S_1 = 0.554 \text{ g}$	$S_{M1} = 0.831 \text{ g}$	$S_{D1} = 0.554 \text{ g}$

For information on how the S_s and S_1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.



For PGA_M , T_L , C_{RS} , and C_{R1} values, please [view the detailed report](#).

Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.

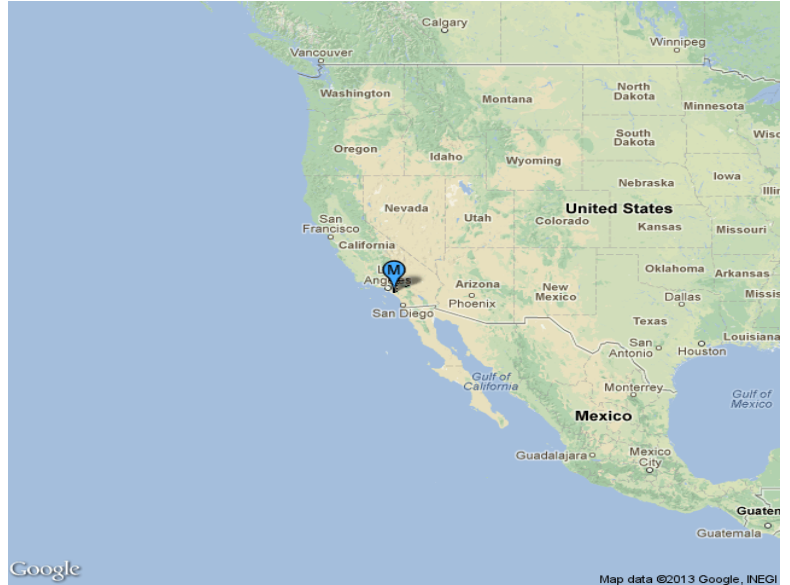
Search Results

Latitude: 33.6700
Longitude: -117.7300

**ASCE 7-10 Wind Speeds
(3-sec peak gust MPH*):**

Risk Category I: 100
Risk Category II: 110
Risk Category III-IV: 115
MRI 10 Year:** 72
MRI 25 Year:** 79
MRI 50 Year:** 85
MRI 100 Year:** 91

ASCE 7-05: 85
ASCE 7-93: 70



*MPH(Miles per hour)

**MRI Mean Recurrence Interval (years)

Users should consult with local building officials to determine if there are community-specific wind speed requirements that govern.

WIND SPEED WEB SITE DISCLAIMER:

While the information presented on this web site is believed to be correct, ATC assumes no responsibility or liability for its accuracy. The material presented in the wind speed report should not be used or relied upon for any specific application without competent examination and verification of its accuracy, suitability and applicability by engineers or other licensed professionals. ATC does not intend that the use of this information replace the sound judgment of such competent professionals, having experience and knowledge in the field of practice, nor to substitute for the standard of care required of such professionals in interpreting and applying the results of the wind speed report provided by this web site. Users of the information from this web site assume all liability arising from such use. Use of the output of this web site does not imply approval by the governing building code bodies responsible for building code approval and interpretation for the building site(s) described by latitude/longitude location in the wind speed report.

CLARK • NEXSEN

Architecture & Engineering

6160 Kempsville Circle
Suite 200A
Norfolk, VA 23502

Project: ODU Solar Decathlon Canopy House
Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

Snow Loads per ASCE 7-10

A. General Requirements

Location = Irvine, CA
Latitude = 33.67
Longitude = -117.73
ZIP Code = 92618

Risk category = II (Table 1.5-1)
Roof profile = Monoslope
Roof slope, θ = 3.58 deg

B. Ground Snow Load, p_g

$$p_g = 0 \text{ psf}$$

Note:

- 1.) Ground snow load, p_g , may be obtained from Figure 7-1

C. Snow Load Parameters

Exposure factor, C_e = 1.0 (Table 7-2) (Partially Exposed)
Thermal factor, C_t = 1.0 (Table 7-3)
Importance factor, I_s = 1.00 (Table 1.5-2)

D. Flat Roof Snow Load, p_f

$$p_f = 0.7C_eC_tI_s p_g \quad (\text{Equation 7.3-1})$$
$$p_f = 0.0 \text{ psf}$$

E. Minimum Snow Load for Low-Slope Roofs, p_m

$$p_m = 0.0 \text{ psf} \quad (\text{Section 7.3.4})$$

F. Rain-on-Snow Surcharge Load (Section 7.10)

$$W_1 = 18.0 \text{ ft}$$

$$W_2 = 23.0 \text{ ft}$$

$$\text{Surcharge load} = 0 \text{ psf}$$

G. Ponding Instability (Section 7.11)

Result = Ponding instability analysis not required

H. Snow Drift Load At Roof Projection (Section 7.8)

$$l_u = 22.83 \text{ ft}$$

$$\gamma = 14.00 \text{ pcf}$$

$$h_b = 0.00 \text{ ft}$$

$$\text{Height of roof projection} = 3.00 \text{ ft}$$

$$h_c = 3.00 \text{ ft}$$

$$h_{d, \text{nominal}} = 1.25 \text{ ft}$$

$$h_{d, \text{design}} = 0.94 \text{ ft}$$

(Figure 7-9)

(= 0.75 * $h_{d, \text{nominal}}$)

Is $h_{d, \text{design}} \leq h_c$? **Yes**

$$\text{Drift height, } h_d = 0.00 \text{ ft}$$

$$\text{Drift width, } w = 0.00 \text{ ft}$$

$$\text{Balanced + drift height} = 0.00 \text{ ft}$$

$$\text{Drift pressure, } p_d = 0.0 \text{ psf}$$

$$\text{Max. snow load, } p_{\text{max}} = 0.0 \text{ psf}$$

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Architecture & Engineering

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Suite 200A
Norfolk, VA 23502

Project: ODU Solar Decathlon Canopy House
Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

Design Wind Pressures per ASCE 7-10 Main Wind-Force Resisting System (MWFRS) - Directional Procedure

A. General Requirements

Location = Irvine, CA
Latitude = 33.67
Longitude = -117.73
ZIP Code = 92618

Risk category = II (Table 1.5-1)
Mean roof height, h = 11.5 ft (Eave height since $\theta \leq 10$ degrees)

B. Basic Wind Speed, V

V = 110 MPH

Note:

- 1.) Basic wind speed, V may be obtained from Figures 26.5-1A, B, or C; or
- 2.) From Applied Technology Council (ATC) website at:
<http://www.atcouncil.org/windspeed/index.php>

C. Wind Load Parameters

Exposure category = **C** (Section 26.7)
 Wind directionality factor, K_d = **0.85** (Table 26.6-1)
 Topographic factor, K_{zt} = **1.0** (Section 26.8)
 Gust effect factor, G = **0.85** (Section 26.9)
 Enclosure classification = **Enclosed** (Sections 26.10 and 26.2)
 Internal pressure coefficients: (Table 26.11-1)
 GC_{pi} (+) = **0.18**
 GC_{pi} (-) = **-0.18**

D. Velocity Pressure Exposure Coefficient, K_z (Table 27.3-1)

K_z = See table below
 K_h = **0.85**

E. Velocity Pressure, q_z or q_h

$$q_z = 0.00256K_zK_{zt}K_dV^2 \quad (\text{Equation 27.3-1})$$

$$q_h = 22.4 \text{ psf}$$

F. External Pressure Coefficients, C_p

a.) Walls - Wind Blowing North-South (Figure 27.4-1)

L = **23.0 ft**
 B = **41.75 ft**
 L/B = **0.6**

Surface	C_p
Windward Wall	0.8
Leeward Wall	-0.5
Side Wall	-0.7

b.) Walls - Wind Blowing East-West (Figure 27.4-1)

$$L = 41.75 \text{ ft}$$

$$B = 23.0 \text{ ft}$$

$$L/B = 1.8$$

Surface	C_p
Windward Wall	0.8
Leeward Wall	-0.34
Side Wall	-0.7

c.) Roof - Normal to Ridge (Figure 27.4-1)

$$\theta = 4.76 \text{ deg}$$

$$L = 23.0 \text{ ft}$$

$$h/L = 0.500$$

Horiz Distance to Windward Edge	C_p	
0 to h/2	-0.9	-0.18
h/2 to h	-0.9	-0.18
h to 2h	-0.5	-0.18
> 2h	-0.3	-0.18

d.) Roof - Parallel to Ridge (Figure 27.4-1)

$$\theta = 4.76 \text{ deg}$$

$$L = 48.0 \text{ ft}$$

$$h/L = 0.240$$

Horiz Distance to Windward Edge	C_p	
0 to h/2	-0.9	-0.18
h/2 to h	-0.9	-0.18
h to 2h	-0.5	-0.18
> 2h	-0.3	-0.18

G. Wall Design Wind Pressure

$$p = qGC_p - q_i(GC_{pi}) \quad (\text{Equation 27.4-1})$$

a.) Walls - Wind Blowing North-South

z	K _z	q _z	P _{windward}		P _{leeward}		P _{windward} + P _{leeward}
			GC _{pi} (+)	GC _{pi} (-)	GC _{pi} (+)	GC _{pi} (-)	
0-15 ft	0.85	22.4 psf	11.2 psf	19.2 psf	-13.5 psf	-5.5 psf	24.7 psf
20 ft	0.90	23.7 psf	12.1 psf	20.1 psf	-13.5 psf	-5.5 psf	25.6 psf
25 ft	0.94	24.7 psf	12.8 psf	20.9 psf	-13.5 psf	-5.5 psf	26.3 psf
30 ft	0.98	25.8 psf	13.5 psf	21.6 psf	-13.5 psf	-5.5 psf	27.1 psf
40 ft	1.04	27.4 psf	14.6 psf	22.6 psf	-13.5 psf	-5.5 psf	28.1 psf
50 ft	1.09	28.7 psf	15.5 psf	23.5 psf	-13.5 psf	-5.5 psf	29.0 psf
60 ft	1.13	29.8 psf	16.2 psf	24.3 psf	-13.5 psf	-5.5 psf	29.7 psf
70 ft	1.17	30.8 psf	16.9 psf	25.0 psf	-13.5 psf	-5.5 psf	30.5 psf
80 ft	1.21	31.9 psf	17.6 psf	25.7 psf	-13.5 psf	-5.5 psf	31.2 psf

b.) Walls - Wind Blowing East-West

z	K _z	q _z	P _{windward}		P _{leeward}		P _{windward} + P _{leeward}
			GC _{pi} (+)	GC _{pi} (-)	GC _{pi} (+)	GC _{pi} (-)	
0-15 ft	0.85	22.4 psf	11.2 psf	19.2 psf	-10.5 psf	-2.4 psf	21.7 psf
20 ft	0.90	23.7 psf	12.1 psf	20.1 psf	-10.5 psf	-2.4 psf	22.6 psf
25 ft	0.94	24.7 psf	12.8 psf	20.9 psf	-10.5 psf	-2.4 psf	23.3 psf
30 ft	0.98	25.8 psf	13.5 psf	21.6 psf	-10.5 psf	-2.4 psf	24.0 psf
40 ft	1.04	27.4 psf	14.6 psf	22.6 psf	-10.5 psf	-2.4 psf	25.1 psf
50 ft	1.09	28.7 psf	15.5 psf	23.5 psf	-10.5 psf	-2.4 psf	26.0 psf
60 ft	1.13	29.8 psf	16.2 psf	24.3 psf	-10.5 psf	-2.4 psf	26.7 psf
70 ft	1.17	30.8 psf	16.9 psf	25.0 psf	-10.5 psf	-2.4 psf	27.4 psf
80 ft	1.21	31.9 psf	17.6 psf	25.7 psf	-10.5 psf	-2.4 psf	28.1 psf

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Suite 200A
Norfolk, VA 23502

Project: ODU Solar Decathlon Canopy House
Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

**Design Wind Pressures per ASCE 7-10
Components & Cladding (C&C) - Part 1: Low-Rise Buildings ($h \leq 60$ ft)**

A. General Requirements

Location = Irvine, CA
Latitude = 33.67
Longitude = -117.73
ZIP Code = 92618

Risk category = II (Table 1.5-1)
Mean roof height, h = 11.5 ft (Eave height since $\theta \leq 10$ degrees)

B. Basic Wind Speed, V

$V = 110$ MPH

Note:

- 1.) Basic wind speed, V may be obtained from Figures 26.5-1A, B, or C; or
- 2.) From Applied Technology Council (ATC) website at:
<http://www.atccouncil.org/windspeed/index.php>

C. Wind Load Parameters

Exposure category = **C** (Section 26.7)
 Wind directionality factor, $K_d = 0.85$ (Table 26.6-1)
 Topographic factor, $K_{zt} = 1.0$ (Section 26.8)
 Gust effect factor, $G = 0.85$ (Section 26.9)
 Enclosure classification = **Enclosed** (Sections 26.10 and 26.2)
 Internal pressure coefficients: (Table 26.11-1)
 $GC_{pi} (+) = 0.18$
 $GC_{pi} (-) = -0.18$

D. Velocity Pressure Exposure Coefficient, K_h (Table 30.3-1)

$$K_h = 0.85$$

E. Velocity Pressure, q_z or q_h

$$q_z = 0.00256K_zK_{zt}K_dV^2 \quad (\text{Equation 30.3-1})$$

$$q_h = 22.4 \text{ psf}$$

F. External Pressure Coefficients, GC_p

a.) Walls (Figure 30.4-1)

Least horizontal dimension = **18.0 ft**
 $a = 3.0 \text{ ft}$

Effective Wind Area	$GC_p (+)$	
	Zone 4	Zone 5
10 ft ²	1.0	1.0
20 ft ²	0.95	0.95
50 ft ²	0.88	0.88
100 ft ²	0.82	0.82
200 ft ²	0.78	0.78

Effective Wind Area	GC _p (-)	
	Zone 4	Zone 5
10 ft2	-1.1	-1.4
20 ft2	-1.05	-1.3
50 ft2	-0.98	-1.16
100 ft2	-0.92	-1.05
200 ft2	-0.88	-0.95

b.) Monoslope Roof

(Figure 30.4-5A)

Effective Wind Area	GC _p (+)
	All Zones
10 ft2	0.3
20 ft2	0.28
50 ft2	0.22
100 ft2	0.20
200 ft2	0.20

Effective Wind Area	GC _p (-)				
	Zone 1	Zone 2	Zone 2'	Zone 3	Zone 3'
10 ft2	-1.1	-1.3	-1.6	-1.8	-2.6
20 ft2	-1.1	-1.28	-1.57	-1.63	-2.3
50 ft2	-1.1	-1.23	-1.54	-1.38	-1.9
100 ft2	-1.1	-1.2	-1.5	-1.2	-1.6
200 ft2	-1.1	-1.2	-1.5	-1.2	-1.6

G. Wall and Roof Design Wind Pressure (C&C)

$$p = q_h[(GC_p) - (GC_{pi})] \quad (\text{Equation 30.4-1})$$

a.) Windward Wall Components and Cladding Pressures

Effective Wind Area	Windward Wall Component Pressure (p_{windward})			
	$GC_{pi} (+)$		$GC_{pi} (-)$	
	Zone 4	Zone 5	Zone 4	Zone 5
10 ft2	18.4 psf	18.4 psf	26.4 psf	26.4 psf
20 ft2	17.2 psf	17.2 psf	25.3 psf	25.3 psf
50 ft2	15.7 psf	15.7 psf	23.7 psf	23.7 psf
100 ft2	14.3 psf	14.3 psf	22.4 psf	22.4 psf
200 ft2	13.4 psf	13.4 psf	21.5 psf	21.5 psf

b.) Leeward Wall Components and Cladding Pressures

Effective Wind Area	Leeward Wall Component Pressure (p_{leeward})			
	$GC_{pi} (+)$		$GC_{pi} (-)$	
	Zone 4	Zone 5	Zone 4	Zone 5
10 ft2	-28.6 psf	-35.4 psf	-20.6 psf	-27.3 psf
20 ft2	-27.5 psf	-33.1 psf	-19.5 psf	-25.1 psf
50 ft2	-26.0 psf	-30.0 psf	-17.9 psf	-21.9 psf
100 ft2	-24.6 psf	-27.5 psf	-16.6 psf	-19.5 psf
200 ft2	-23.7 psf	-25.3 psf	-15.7 psf	-17.2 psf

c.) Roof Components and Cladding Pressures - Positive Pressure

Effective Wind Area	Roof Component Pressure (p_{positive})	
	$GC_{pi} (+)$	$GC_{pi} (-)$
	All Zones	All Zones
10 ft2	2.7 psf	10.7 psf
20 ft2	2.2 psf	10.3 psf
50 ft2	0.9 psf	9.0 psf
100 ft2	0.4 psf	8.5 psf
200 ft2	0.4 psf	8.5 psf

d.) Roof Components and Cladding Pressures - Negative Pressure with Postive Internal Pressure

Effective Wind Area	Roof Component Pressure (p_{negative})				
	$GC_{pi} (+)$				
	Zone 1	Zone 2	Zone 2'	Zone 3	Zone 3'
10 ft2	-28.6 psf	-33.1 psf	-39.8 psf	-44.3 psf	-62.2 psf
20 ft2	-28.6 psf	-32.7 psf	-39.2 psf	-40.5 psf	-55.5 psf
50 ft2	-28.6 psf	-31.6 psf	-38.5 psf	-34.9 psf	-46.6 psf
100 ft2	-28.6 psf	-30.9 psf	-37.6 psf	-30.9 psf	-39.8 psf
200 ft2	-28.6 psf	-30.9 psf	-37.6 psf	-30.9 psf	-39.8 psf

e.) Roof Components and Cladding Pressures - Negative Pressure with Negative Internal Pressure

Effective Wind Area	Roof Component Pressure (p_{negative})				
	$GC_{pi} (-)$				
	Zone 1	Zone 2	Zone 2'	Zone 3	Zone 3'
10 ft2	-20.6 psf	-25.1 psf	-31.8 psf	-36.3 psf	-54.2 psf
20 ft2	-20.6 psf	-24.6 psf	-31.1 psf	-32.5 psf	-47.4 psf
50 ft2	-20.6 psf	-23.5 psf	-30.4 psf	-26.9 psf	-38.5 psf
100 ft2	-20.6 psf	-22.8 psf	-29.5 psf	-22.8 psf	-31.8 psf
200 ft2	-20.6 psf	-22.8 psf	-29.5 psf	-22.8 psf	-31.8 psf

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Project: ODU Solar Decathlon Canopy House
Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

Seismic Base Shear Calculation (ASCE 7-10)

Location: Irvine, CA

Latitude: 33.67
Longitude: -117.73
ZIP Code: N/A

A. Seismic Design Criteria

Risk Category = II (Table 1.5-1)
Seismic Importance Factor, I_e = 1.00 (Table 1.5-2)
Site Class = D (Table 20.3-1)

B. Determine Design Spectral Response Accelerations

Mapped risk-targeted maximum considered earthquake (MCE_R) spectral
response acceleration parameter at short period, S_s = 1.493 g
Mapped risk-targeted maximum considered earthquake (MCE_R) spectral
response acceleration parameter at 1-second period, S_1 = 0.554 g

Note:

- 1.) S_s and S_1 may be obtained from ASCE 7-10 Chapter 22, or:
- 2.) USGS website: <http://geohazards.usgs.gov/designmaps/us/>

C. Determine Site Coefficients

F_a = 1.0 (Table 11.4-1) - Interpolation permitted
 F_v = 1.5 (Table 11.4-2) - Interpolation permitted

D. Calculate Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameters

S_{MS} = 1.493 g (Equation 11.4-1)
 S_{M1} = 0.831 g (Equation 11.4-2)

E. Calculate Design Spectral Response Acceleration Parameters

$$S_{DS} = 0.995 \text{ g} \quad (\text{Equation 11.4-3})$$

$$S_{D1} = 0.554 \text{ g} \quad (\text{Equation 11.4-4})$$

F. Determine Seismic Design Category

Based on short period response acceleration: **D** (Table 11.6-1)
Based on 1-second period response acceleration: **D** (Table 11.6-2)
Seismic Design Category = **D**

Note:
Risk Category I, II, or III structures with S_1 greater than or equal to 0.75g shall be assigned to **Seismic Design Category E**.
Risk Category IV structures with S_1 greater than or equal to 0.75g shall be assigned to **Seismic Design Category F**.

G. Calculate Seismic Base Shear, V (Equivalent Lateral Force Procedure from Chapter 12.8 of ASCE 7-10)

$$V = C_s W \quad (\text{Equation 12.8-1})$$

$$R = 6.5 \quad (\text{Table 12.2-1})$$

$$C_t = 0.02 \quad (\text{Table 12.8-2})$$

$$x = 0.75 \quad (\text{Table 12.8-2})$$

$$T_L = 8 \text{ sec} \quad (\text{Figures 22-15 through 22-20})$$

$$h_n = 14.000 \text{ ft}$$

$$\text{Approximate period, } T_a = 0.145 \text{ sec} \quad (\text{Equation 12.8-7})$$

$$C_s = 0.1531 \quad (\text{Equation 12.8-2})$$

$$C_s = 0.5888 \quad (\text{Equation 12.8-3 or 12.8-4})$$

$$C_s = 0.0438 \quad (\text{Equation 12.8-5})$$

$$C_s = 0.0426 \quad (\text{Equation 12.8-6})$$

$$\text{Design } C_s = 0.1531$$

$$\text{Base Shear, } V = 0.1531 W$$

$$\text{Effective Seismic Weight, } W = 52.5 \text{ k}$$

$$\text{Base Shear, } V = 8.04 \text{ k}$$

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Engineer: Edward C. Westerman, P.E.

Vertical Distribution of Seismic Forces ASCE 7-10 Chapter 12.8.3

Base shear, $V = 8.04 \text{ k}$

$$w_{\text{roof}} = 26.62 \text{ k}$$

$$w_{\text{floor}} = 25.88 \text{ k}$$

Approximate period, $T_a = 0.145 \text{ sec}$

$$k = 1$$

$$F_x = C_{vx} V \quad (\text{Equation 12.8-11})$$

$$C_{vx} = \frac{w_x h_x^k}{\sum w_i h_i^k} \quad (\text{Equation 12.8-12})$$

Level	w_i	h_i	h_i^k	$w_i h_i^k$	C_{vx}	F_x
Roof	26.62 k	13.0 ft	13.0 ft	346.10 k-ft	0.870	6.99 k
First floor	25.88 k	2.0 ft	2.0 ft	51.75 k-ft	0.130	1.05 k
			$\Sigma =$	397.85 k-ft	1.000	8.04 k



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Project: ODU Solar Decathlon Canopy House
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Horizontal Distribution of Seismic Forces at Roof Shear Wall Design Forces

A.) Seismic Forces Acting in East-West Direction

$$F_x = 6.99 \text{ k} \quad (\text{ASCE 7-10 Equation 12.8-11})$$

$$E_h = \rho Q_E \quad (\text{ASCE 7-10 Equation 12.4-3})$$

$$\rho = 1.0$$

$\rho = 1.0$ since removal of a shear wall with a height-to-length ratio greater than 1.0 within any story would not result in a 33% or greater reduction in story strength. Nor would such removal result in an extreme torsional irregularity.

$$E_h = 0.7\rho Q_E \quad (\text{Allowable Stress Design})$$

$$E_h = 4.89 \text{ k}$$

i.) Diaphragm Flexibility (ASCE 7-10 Section 12.3)

Diaphragm classification = **Flexible**

The diaphragm is permitted to be idealized as flexible per ASCE 7-10 12.3.1.1 since this is a one- or two-family dwelling.

$$\text{Diaphragm width} = 24.0 \text{ ft}$$

$$w_x = 203.9 \text{ lb/ft}$$

Shear Wall	Shear Wall Length	Tributary Width	v_w	V_w
1	5.5 ft	9.0 ft	175 lb/ft	961 lb
2	5.0 ft	9.0 ft	175 lb/ft	874 lb
3	3.0 ft	12.0 ft	188 lb/ft	565 lb
4	10.0 ft	12.0 ft	188 lb/ft	1882 lb
5	2.5 ft	2.9 ft	234 lb/ft	586 lb

B.) Seismic Forces Acting in North-South Direction

$$F_x = 6.99 \text{ k} \quad (\text{ASCE 7-10 Equation 12.8-11})$$

$$E_h = \rho Q_E \quad (\text{ASCE 7-10 Equation 12.4-3})$$

$$\rho = 1.0$$

$\rho = 1.0$ since removal of a shear wall with a height-to-length ratio greater than 1.0 within any story would not result in a 33% or greater reduction in story strength. Nor would such removal result in an extreme torsional irregularity.

$$E_h = 0.7\rho Q_E \quad (\text{Allowable Stress Design})$$

$$E_h = 4.89 \text{ k}$$

i.) Diaphragm Flexibility (ASCE 7-10 Section 12.3)

Diaphragm classification = **Flexible**

The diaphragm is permitted to be idealized as flexible per ASCE 7-10 12.3.1.1 since this is a one- or two-family dwelling.

Diaphragm width = **40.0 ft**

$$w_x = 122.3 \text{ lb/ft}$$

Shear Wall	Shear Wall Length	Tributary Width	v_w	V_w
A	8.0 ft	20.0 ft	144 lb/ft	1151 lb
B	9.0 ft	20.0 ft	144 lb/ft	1295 lb
C	8.0 ft	20.0 ft	175 lb/ft	1398 lb
D	6.0 ft	20.0 ft	175 lb/ft	1049 lb



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Diaphragm Design Forces ASCE 7-10 Chapter 12.10.1

$$F_{px} = \frac{\sum F_i(w_{px})}{\sum w_i} \quad (\text{Equation 12.10-1})$$

$$S_{DS} = 0.995 g$$

$$I_e = 1.00$$

$$F_{px, \min} = 0.2S_{DS}I_e w_{px} \quad (\text{Equation 12.10-2})$$

$$F_{px, \max} = 0.4S_{DS}I_e w_{px} \quad (\text{Equation 12.10-3})$$

Level	w_{px}	w_i	F_i	F_{px}	$F_{px, \min}$	$F_{px, \max}$
Roof	26.62 k	26.62 k	6.99 k	4.08 k	5.30 k	10.60 k
First floor	25.88 k	25.88 k	1.05 k	3.96 k	5.15 k	10.30 k
	$\Sigma =$	52.50 k	8.04 k			

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Roof Diaphragm Shear Check

A.) Seismic Forces Acting in East-West Direction

$$F_{px} = 5.30 \text{ k} \quad (\text{ASCE 7-10 Equation 12.10-2})$$

$$\begin{aligned} \text{Diaphragm width} &= 24.0 \text{ ft} \\ w_{px} &= 220.8 \text{ lb/ft} \end{aligned}$$

$$\begin{aligned} R_n &= 565 \text{ lb/ft} \\ \Omega &= 2.5 \end{aligned} \quad (\text{AISI S213-07-S1-09 Table D2-1})$$

Location	Tributary Width	Collector Length	v_D	R_n/Ω	Result
SW 1 & 2	9.0 ft	40.0 ft	49.7 lb/ft	226 lb/ft	OKAY
SW 3 & 4	12.0 ft	40.0 ft	66.3 lb/ft	226 lb/ft	OKAY
SW 5	2.9 ft	17.0 ft	37.3 lb/ft	226 lb/ft	OKAY

B.) Seismic Forces Acting in North -South Direction

$$F_{px} = 5.30 \text{ k} \quad (\text{ASCE 7-10 Equation 12.10-2})$$

$$\begin{aligned} \text{Diaphragm width} &= 40.0 \text{ ft} \\ w_{px} &= 132.5 \text{ lb/ft} \end{aligned}$$

$$\begin{aligned} R_n &= 565 \text{ lb/ft} \\ \Omega &= 2.5 \end{aligned} \quad (\text{AISI S213-07-S1-09 Table D2-1})$$

Location	Tributary Width	Collector Length	v_D	R_n/Ω	Result
SW A & B	20.0 ft	23.0 ft	115.2 lb/ft	226 lb/ft	OKAY
SW C & D	20.0 ft	17.0 ft	155.9 lb/ft	226 lb/ft	OKAY

Table D2-1
United States and Mexico
Nominal Shear Strength (R_n) for Diaphragms with Wood Sheathing^{1, 4}
(Pounds Per Foot)

Membrane Material	Screw Size	Thick-ness (in.)	Blocked				Unblocked	
			Screw spacing at diaphragm boundary edges and at all continuous panel edges (in.)				Screws spaced maximum of 6" on all supported edges	
			6	4	2.5	2	Load perpendicular to unblocked edges and continuous panel joints	All other configurations
			Screw spacing at all other panel edges (in.)					
6	6	4	3					
Structural I	See note 2	3/8	768	1022	1660	2045	685	510
		7/16	768	1127	1800	2255	755	565
		15/32	925	1232	1970	2465	825	615
C-D, C-C and other graded wood structural panels ³	See note 2	3/8	690	920	1470	1840	615	460
		7/16	760	1015	1620	2030	680	505
		15/32	832	1110	1770	2215	740	555

- For SI: 1" = 25.4 mm, 1 foot = 0.305 m, 1 lb = 4.45 N.
- No. 8 screws (minimum) shall be used when framing members have a *designation thickness* of 54 mils or less and No. 10 screws (minimum) shall be used when framing members have a *designation thickness* greater than 54 mils.
- Wood structural panels shall conform to DOC PS-1 and PS-2.
- For wood structural panel sheathed diaphragms, tabulated R_n values shall be applicable for short-term load duration (wind or seismic loads). For other in-plane lateral loads of normal or permanent load duration as defined by the AF&PA NDS, the values in the table above for wood structural panel sheathed diaphragms shall be multiplied by 0.75 (normal) or 0.67 (permanent).

D3 Special Seismic Requirements

D3.1 General

Where the seismic response modification coefficient, R , used to determine the lateral forces is taken greater than 3, the requirements of this section shall apply in addition to the requirements of Sections D1 and D2.

Diaphragms shall be defined as flexible or rigid, in accordance with the *applicable building code*.

D3.2 Wood Diaphragms

The aspect ratio (length/width) of a *diaphragm* sheathed with wood structural sheathing shall be limited to 4:1 where all edges of the wood structural panel sheathing are attached to framing members or to intermittent *blocking*. Where there is no intermittent *blocking*, the aspect ratio shall be limited to 3:1. Wood structural panel sheathing shall be arranged so that

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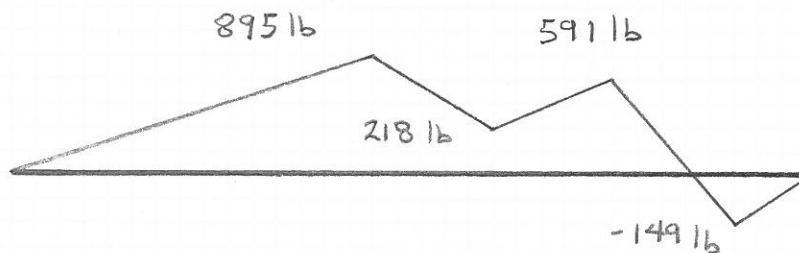
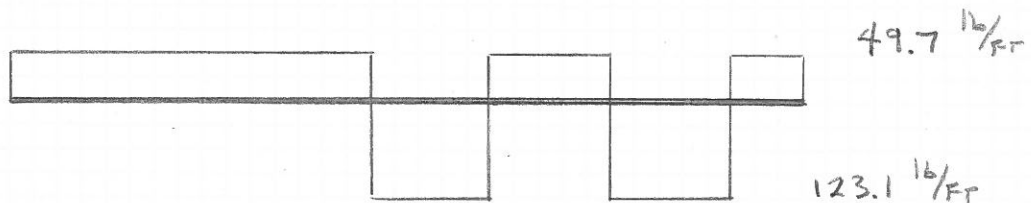
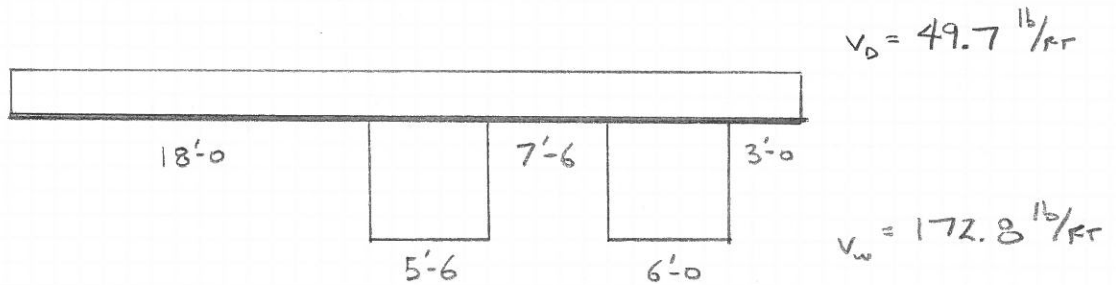
PROJECT ODU SOLAR DECATHLON SHEET NO. 1 OF _____ SHEETS

(A) COLLECTOR AT SHEAR WALL (1) AND (2)

COLLECTOR FORCE DIAGRAM:

$$v_d = 49.7 \text{ lb/ft} \quad (\text{FROM EXCEL SPREADSHEET})$$

$$v_w = \frac{220.8 \text{ lb/ft} (9')}{(5.5' + 6')} = 172.8 \text{ lb/ft}$$



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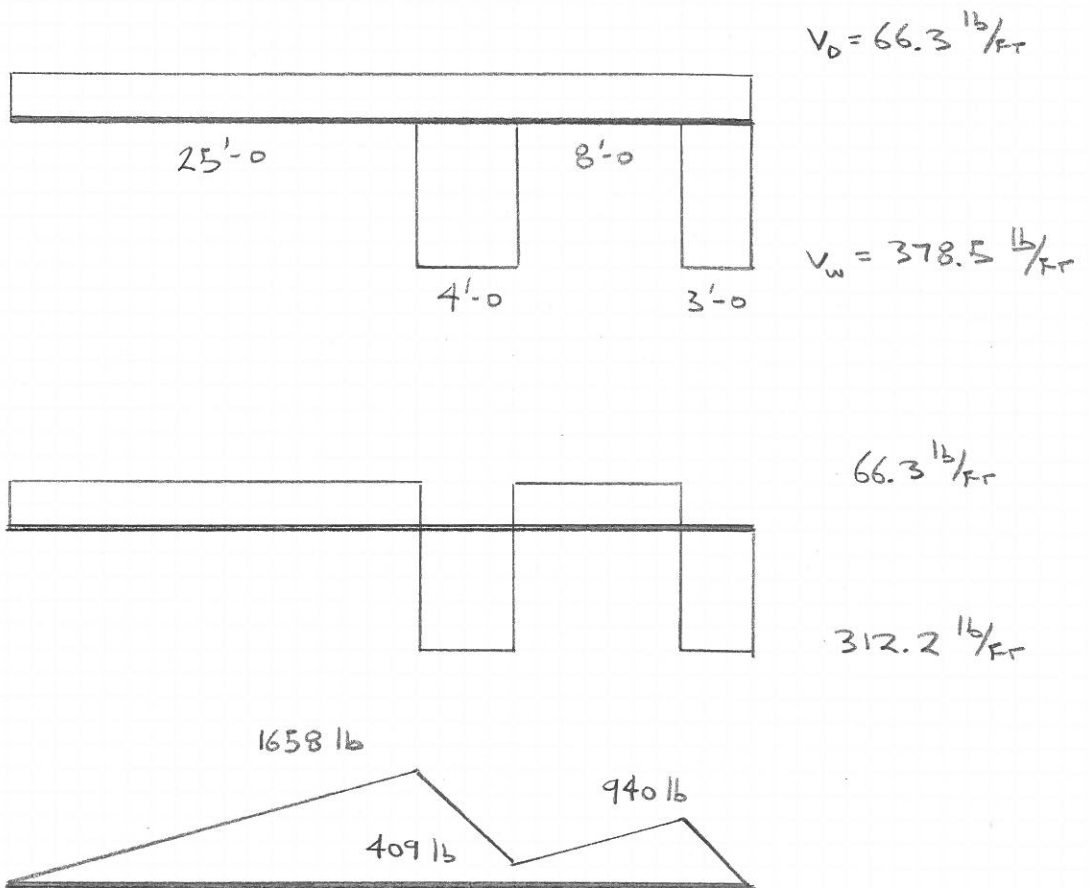
PROJECT ODU SOLAR DECATHLON SHEET NO. 2 OF _____ SHEETS

(B) COLLECTOR AT SHEAR WALLS (3) AND (4)

COLLECTOR FORCE DIAGRAM :

$V_D = 66.3 \text{ lb/ft}$ (FROM EXCEL SPREADSHEET)

$V_w = \frac{220.8 \text{ lb/ft} (12')}{(3' + 4')} = 378.5 \text{ lb/ft}$



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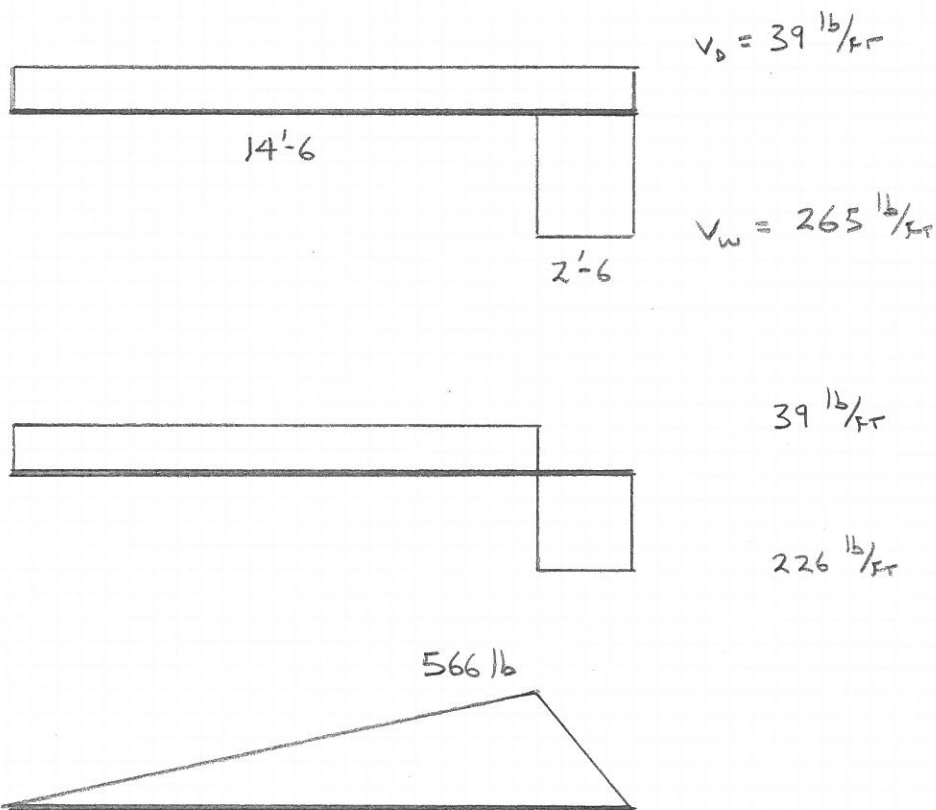
PROJECT ODU SOLAR DECATHLON SHEET NO. 3 OF _____ SHEETS

(C) COLLECTOR AT SHEAR WALL (S)

COLLECTOR FORCE DIAGRAM:

$V_D = 39 \text{ lb/ft}$ (FROM EXCEL SPREADSHEET)

$V_W = \frac{220.8 \text{ lb/ft} (3')}{2.5'} = 265 \text{ lb/ft}$



ROOF COLLECTORS

DATE 3 FEB 13 COMPUTED BY ECW

COMM. NO. 4.0 CHECKED BY _____

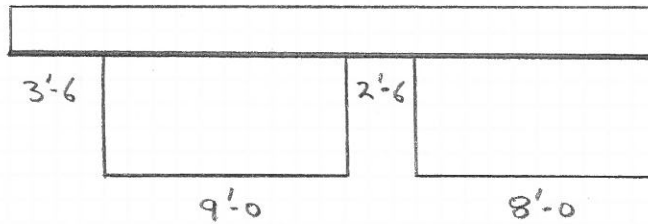
PROJECT ODU SOLAR DECATHLON SHEET NO. 4 OF _____ SHEETS

Ⓓ. COLLECTOR AT SHEAR WALLS Ⓐ AND Ⓑ

COLLECTOR FORCE DIAGRAM:

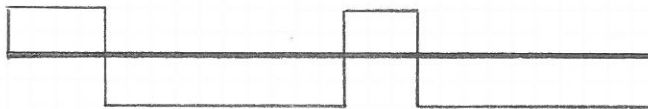
$$V_D = 115.2 \text{ lb/ft} \quad (\text{FROM EXCEL SPREADSHEET})$$

$$V_W = \frac{132.5 \text{ lb/ft} (20')}{(8' + 9')} = 155.9 \text{ lb/ft}$$



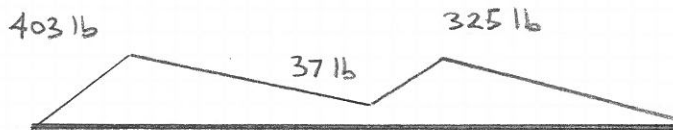
$$V_D = 115.2 \text{ lb/ft}$$

$$V_W = 155.9 \text{ lb/ft}$$



$$115.2 \text{ lb/ft}$$

$$40.7 \text{ lb/ft}$$



ROOF COLLECTORS

DATE 3 FEB 13 COMPUTED BY ECW

COMM. NO. 4.0 CHECKED BY _____

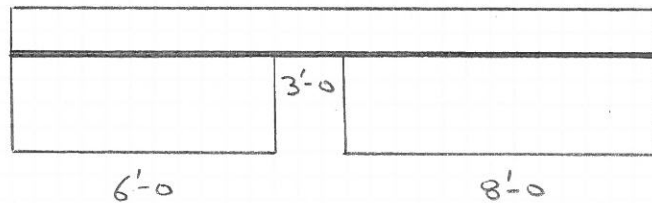
PROJECT ODU SOLAR DECATHLON SHEET NO. 5 OF _____ SHEETS

(E) COLLECTOR AT SHEAR WALL (C) AND (D)

COLLECTOR FORCE DIAGRAM:

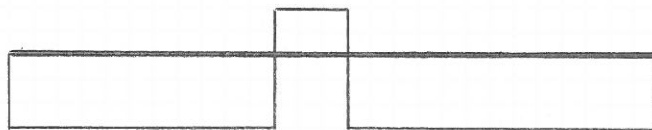
$$V_D = 155.9 \text{ lb/ft} \quad (\text{FROM EXCEL SPREADSHEET})$$

$$V_W = \frac{132.5 \text{ lb/ft} (20')}{(6' + 8')} = 189.3 \text{ lb/ft}$$



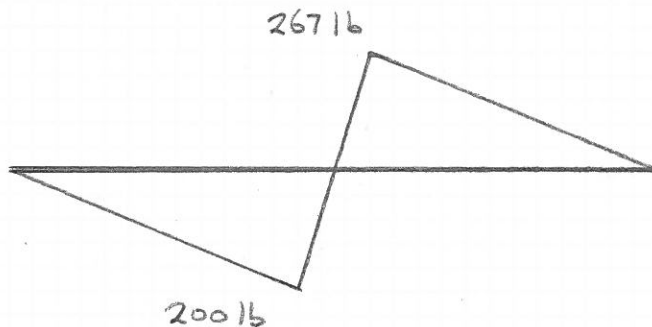
$$V_D = 155.9 \text{ lb/ft}$$

$$V_W = 189.3 \text{ lb/ft}$$



$$155.9 \text{ lb/ft}$$

$$33.4 \text{ lb/ft}$$





6160 Kempsville Circle
Suite 200A
Norfolk, VA 23502

Project: ODU Solar Decathlon Canopy House
Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

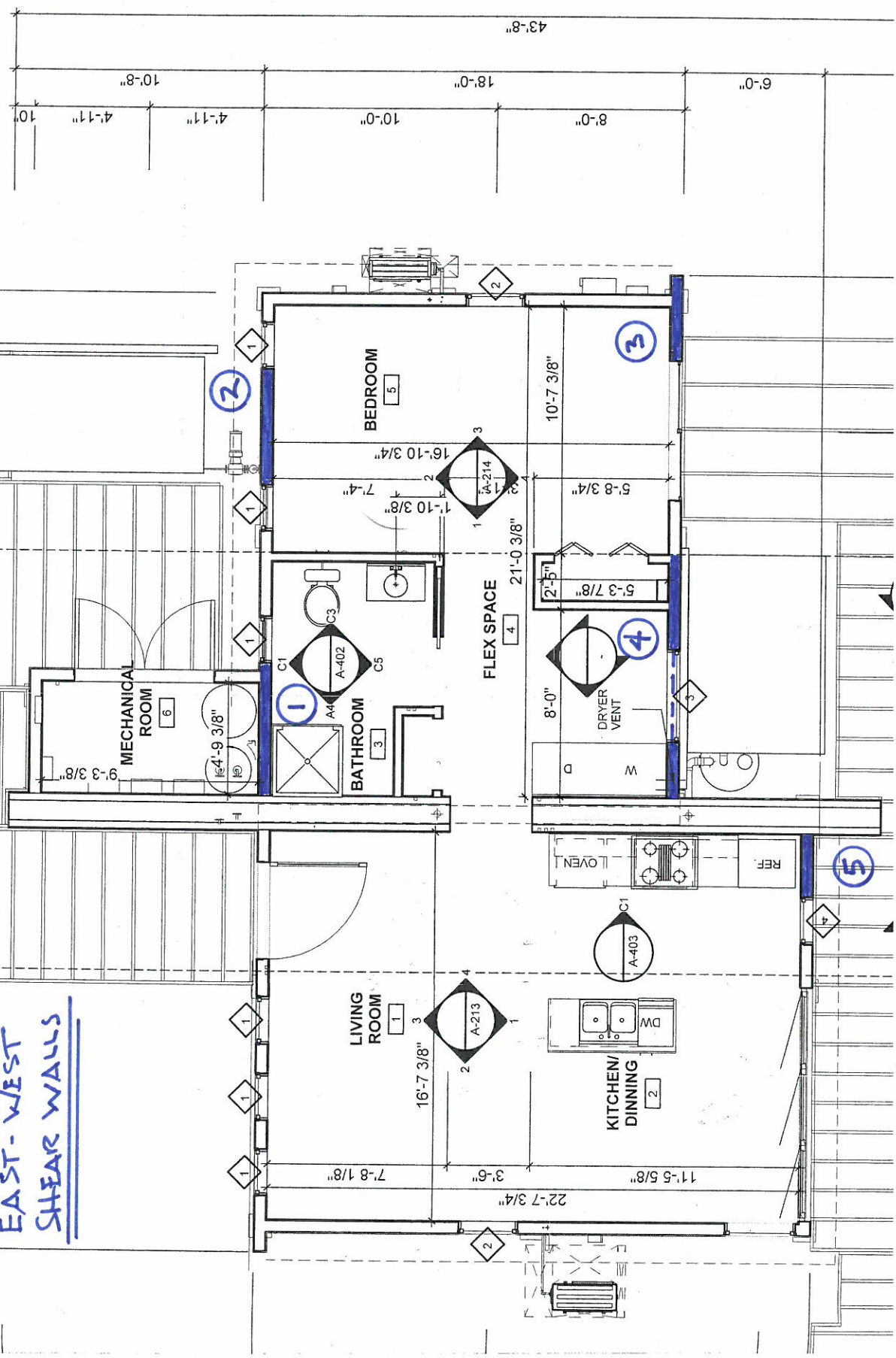
Shear Wall Design
AISI S213-07-S1-09 Chapter C2

R_n = From Table C2.1-3
 Ω = 2.50

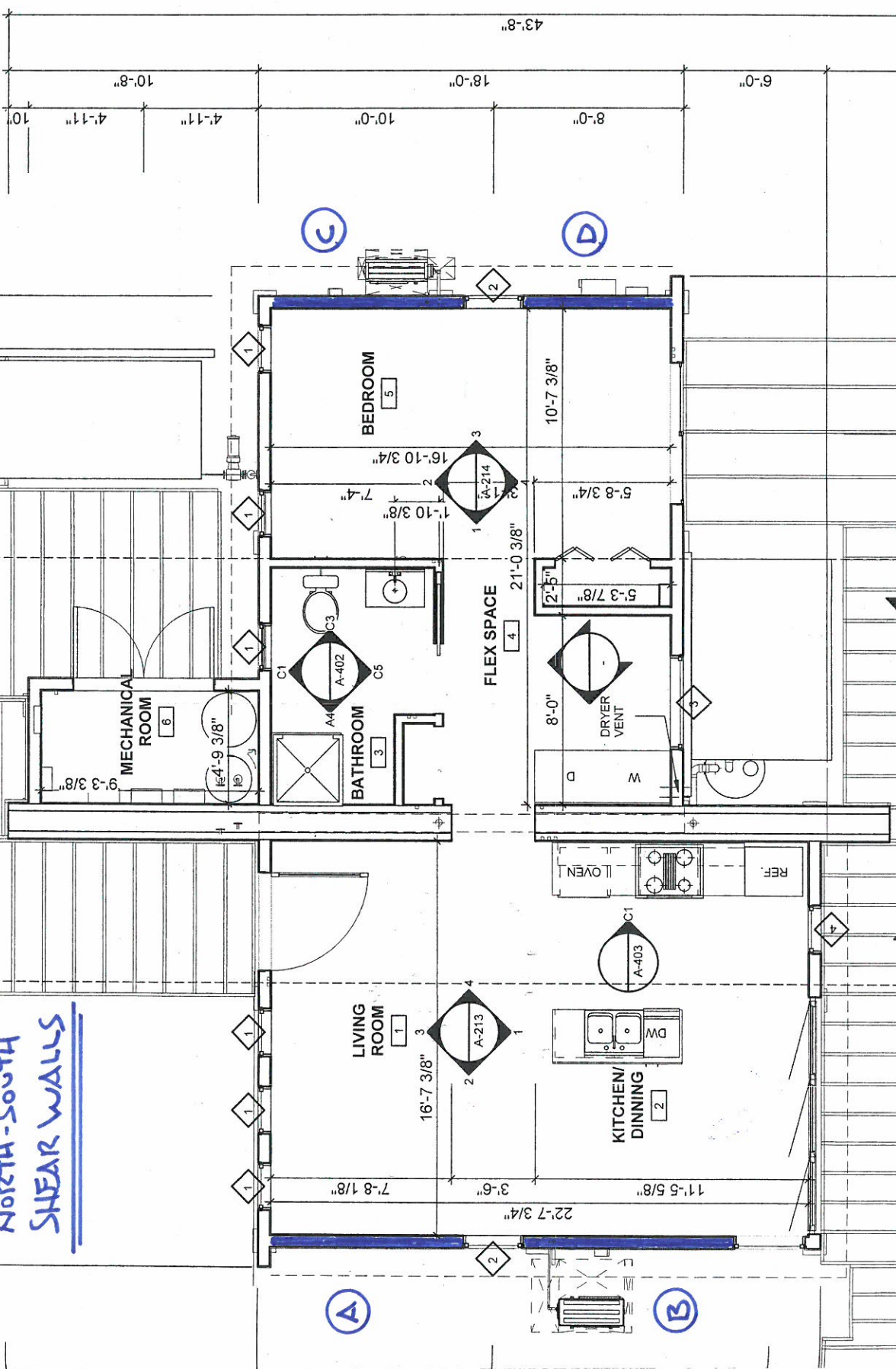
Shear Wall Type = Type I
Sheathing Thickness = 15/32" Structural 1 (one side of shear wall)

Wall No.	Height, h_w	Length, L_w	h_w/L_w	v_w	T/C Reaction	V	R_n	R_n/Ω
1	9.67 ft	5.5 ft	1.76	175 lb/ft	1692 lb	963 lb	780 lb/ft	312 lb/ft
2	9.67 ft	5.0 ft	1.93	175 lb/ft	1692 lb	875 lb	780 lb/ft	312 lb/ft
3	8.25 ft	3.0 ft	2.75	188 lb/ft	1551 lb	564 lb	780 lb/ft	227 lb/ft
4	8.25 ft	10.0 ft	0.83	188 lb/ft	1551 lb	1880 lb	780 lb/ft	312 lb/ft
5	8.25 ft	2.5 ft	3.30	234 lb/ft	1931 lb	585 lb	990 lb/ft	240 lb/ft
A	9.00 ft	8.0 ft	1.13	144 lb/ft	1296 lb	1152 lb	780 lb/ft	312 lb/ft
B	9.00 ft	9.0 ft	1.00	144 lb/ft	1296 lb	1296 lb	780 lb/ft	312 lb/ft
C	9.00 ft	8.0 ft	1.13	175 lb/ft	1575 lb	1400 lb	780 lb/ft	312 lb/ft
D	9.00 ft	6.0 ft	1.50	175 lb/ft	1575 lb	1050 lb	780 lb/ft	312 lb/ft

EAST-WEST
SHEAR WALLS



NORTH-SOUTH
SHEAR WALLS



43'-8"
18'-0"
6'-0"
8'-0"
10'-0"
4'-11"
4'-11"
10'-8"

Table C2.1-3
United States and Mexico
Nominal Shear Strength (R_n) for Seismic and Other In-Plane Loads for Shear Walls^{1,4,7,8}
(Pounds Per Foot)

Assembly Description	Max. Aspect Ratio (h/w)	Fastener Spacing at Panel Edges ² (inches)				Designation Thickness ^{5,6} of Stud, Track and Blocking (mils)	Required Sheathing Screw Size
		6	4	3	2		
15/32" Structural 1 sheathing (4-ply), one side	2:1 ³	780	990	-	-	33 or 43	8
	2:1	890	1330	1775	2190	43 or 54 68	8 10
7/16" OSB, one side	2:1 ³	700	915	-	-	33	8
	2:1 ³	825	1235	1545	2060	43 or 54	8
	2:1	940	1410	1760	2350	54	8
	2:1	1232	1848	2310	3080	68	10
0.018" steel sheet, one side	2:1	390	-	-	-	33 (min.)	8
0.027" steel sheet, one side	4:1	-	1000	1085	1170	43 (min.)	8
	2:1 ³	647	710	778	845	33 (min.)	8

1. Nominal strength shall be multiplied by the resistance factor (ϕ) to determine design strength or divided by the safety factor (Ω) to determine allowable strength as set forth in Section C2.1.
2. Screws in the field of the panel shall be installed 12 inches (305 mm) o.c. unless otherwise shown.
3. Shear wall height to width aspect ratios (h/w) greater than 2:1, but not exceeding 4:1, shall be permitted provided the nominal strength values are multiplied by 2w/h. See Section C2.1.
4. See Section C2.1 for requirements for sheathing applied to both sides of wall.
5. Unless noted as (min.), substitution of a stud or track of a different designation thickness is not permitted.
6. Wall studs and track shall be of ASTM A1003 Structural Grade 33 (Grade 230) Type H steel for members with a designation thickness of 33 and 43 mils, and A1003 Structural Grade 50 (Grade 340) Type H steel for members with a designation thickness equal to or greater than 54 mils.
7. For wood structural panel sheathed shear walls, tabulated R_n values applicable for short-term load duration (seismic loads). For other in-plane lateral loads of normal or permanent load duration as defined by the AF&PA NDS, the values in the table above for wood structural panel sheathed shear walls shall be multiplied by 0.63 (normal) or 0.56 (permanent).
8. For SI: 1" = 25.4 mm, 1 foot = 0.305 m, 1 lb = 4.45 N.



6160 Kempsville Circle
Suite 200A
Norfolk, VA 23502

Project: ODU Solar Decathlon Canopy House
Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

Base Shear Comparison Seismic and Wind MWFRS per ASCE 7-10

Seismic Base Shear, $V = 8.04 \text{ k}$

$$F_{x, \text{roof}} = 6.99 \text{ k}$$

$$F_{x, \text{first flr}} = 1.05 \text{ k}$$

$$E_h = 0.7\rho Q_E$$

(Note: 0.7 factor utilized for allowable stress design format)
($\rho = 1.0$)

$$E_{h, \text{roof}} = 4.89 \text{ k}$$

$$E_{h, \text{first flr}} = 0.74 \text{ k}$$

Level	North-South Direction				East-West Direction			
	Seismic Force	Tributary Area	Wind Pressure	Wind Force	Seismic Force	Tributary Area	Wind Pressure	Wind Force
Roof	4.89 k	322 ft ²	14.8 psf	4.77 k	4.89 k	178 ft ²	13.0 psf	2.32 k
First Floor	0.74 k	253 ft ²	14.8 psf	3.75 k	0.74 k	140 ft ²	13.0 psf	1.82 k
	$\Sigma = 5.63 \text{ k}$		$\Sigma = 14.8 \text{ psf}$	$\Sigma = 8.52 \text{ k}$	$\Sigma = 5.63 \text{ k}$		$\Sigma = 13.0 \text{ psf}$	$\Sigma = 4.14 \text{ k}$

Note:
Calculated MWFRS wind pressures in table above have been multiplied by 0.6 to convert to allowable stress design format.



6160 Kempsville Circle
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Project: ODU Solar Decathlon Canopy House
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Foundation Design Diagonal Tension Anchors

Anchor angle, $\theta = 45 \text{ deg}$ (Angle is measured from the ground surface)

Turnbuckle tension, $F = V / \cos \theta$

$V_{\text{anchor}} = F \cdot \cos \theta$

$T_{\text{anchor}} = F \cdot \sin \theta$

$F_{\text{allow}} = 2100 \text{ lb}$

$V_{\text{allow}} = 1500 \text{ lb}$

$T_{\text{allow}} = 1250 \text{ lb}$

$$\text{Interaction Ratio} = \frac{T_{\text{anchor}}}{T_{\text{allow}}} + \frac{V_{\text{anchor}}}{V_{\text{allow}}} \leq 1.0$$

Seismic base shear, $V = 5.45 \text{ k}$ (based on revised effective seismic weight, $W = 50.9 \text{ k}$)

Wind base shear, $V_w = 8.52 \text{ k}$

Foundation Location	Shear Force, V	Anchor Quantity	Turnbuckle Tension, F	$F_{\text{actual}} / F_{\text{allow}}$	V_{anchor}	$V_{\text{anchor}} / V_{\text{allow}}$	T_{anchor}	$T_{\text{anchor}} / T_{\text{allow}}$	Interaction Ratio
North wall	2065 lb	4	730 lb	0.35	516 lb	0.34	516 lb	0.41	0.76
South wall 1	2754 lb	4	974 lb	0.46	689 lb	0.46	689 lb	0.55	1.01
South wall 2	631 lb	1	892 lb	0.42	631 lb	0.42	631 lb	0.50	0.93
West wall	4260 lb	7	861 lb	0.41	609 lb	0.41	609 lb	0.49	0.89
East wall	4260 lb	7	861 lb	0.41	609 lb	0.41	609 lb	0.49	0.89

Cleveland City Forge

46950 State Route 18 West

Wellington, Ohio 44090

Toll Free: 1.800.431.4350 • Tel: 440.647.5400 • Fax: 440.647.4185

E-Mail: info@clevelandcityforge.com • Web site: www.clevelandcityforge.com

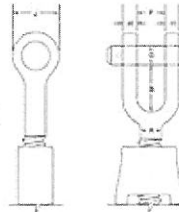
Item # TBJJ008, Assembly: JAW & JAW

List Price

Material: C-1030, 316 Stainless Steel

Threads: U.N.C. Class 2A, Right or Left Hand

Finish: Galvanized



SPECIFICATIONS

A - Thread Dia.	1/2 in
T - Take Up	6 in
F - Jaw	5/8 in
B - Jaw	1 in
G - Jaw	7/16 in
H - Jaw	3/8 in
J - Jaw	1 in
Overall Closed Length	13 in
Rated Capacity	2100 Lbs.
Unit Weight	1.64 Lbs.

DATE 21 FEB 13COMPUTED BY ECWCOMM. NO. 4.0

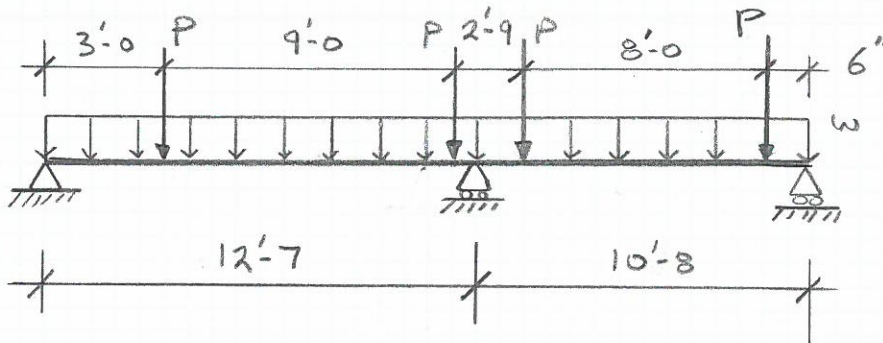
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PROJECT ODU SOLAR DECATHLON

SHEET NO. _____ OF _____ SHEETS

MODULE ONE

① BEAM No. 1



i) ROOF

$$\text{DEAD LOAD} = 19 \text{ PSF} (1.83') = 35 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 20 \text{ PSF} (1.83') = 37 \text{ lb/ft}$$

ii) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (11\frac{1}{2}') = 110 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (11\frac{1}{2}') = 275 \text{ lb/ft}$$

iii) WALL

$$\text{DEAD LOAD} = 8 \text{ PSF} (9') = 72 \text{ lb/ft}$$

$$w_D = 217 \text{ lb/ft}$$

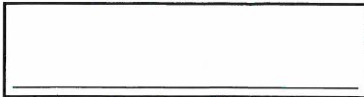
$$w_L = 312 \text{ lb/ft}$$

SHEAR WALL CHORD FORCE :

$$T = \frac{1296 \text{ lb}}{0.7} = 1852 \text{ lb}$$

$$C = \frac{1296 \text{ lb}}{0.7} = 1852 \text{ lb}$$

$$P = P_{EQ} = 1852 \text{ lb}, -1852 \text{ lb}$$



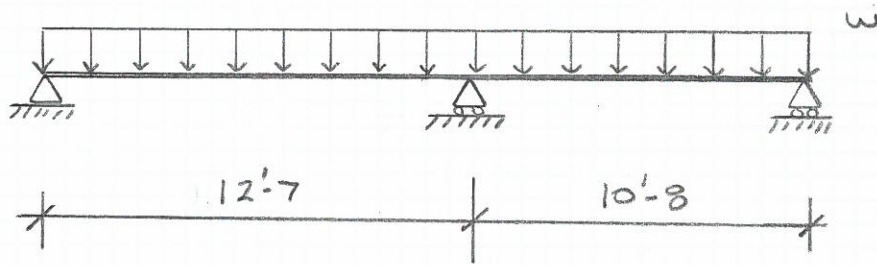
DATE 21 FEB 13 COMPUTED BY ECW

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PROJECT ODU SOLAR DECATHLON SHEET NO. _____ OF _____ SHEETS

MODULE ONE

② BEAM No. 2



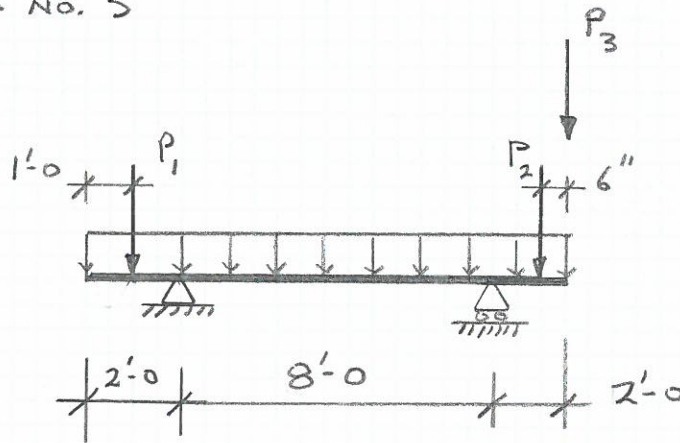
i) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (11\frac{1}{2} + 0.5') = 120 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (11\frac{1}{2} + 0.5') = 300 \text{ lb/ft}$$

MODULE ONE

③ BEAM No. 3



i) ROOF

$$\text{DEAD LOAD} = 19 \text{ PSF} (23.25'/2) = 221 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 20 \text{ PSF} (23.25'/2) = 233 \text{ lb/ft}$$

ii) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (1.33'/2) = 14 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (1.33'/2) = 34 \text{ lb/ft}$$

iii) WALL LOAD

$$\text{DEAD LOAD} = 8 \text{ PSF} (9.67') = 77 \text{ lb/ft}$$

$$P_{1,D} = 0.9 \text{ k}$$

$$P_{2,D} = 0.6 \text{ k}$$

$$P_{1,L} = 1 \text{ k}$$

$$P_{2,L} = 1.1 \text{ k}$$

$$P_{1,RL} = 0.1 \text{ k}$$

$$P_{3,D} = -1 \text{ k}$$

$$P_{1,EQ} = 1.6 \text{ k}$$

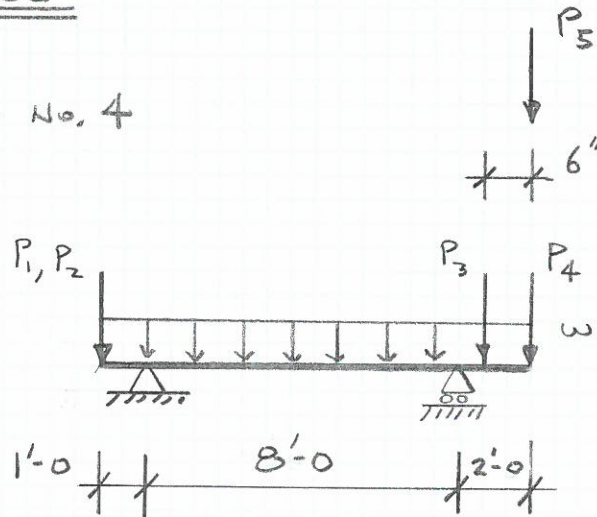
$$P_{3,L} = -0.1 \text{ k}$$

$$P_{3,RL} = 0 \text{ k}$$

$$P_{3,EQ} = -1 \text{ k} (+1 \text{ k})$$

MODULE ONE

④ BEAM No. 4



i) ROOF

$$P_{1,D} = 19 \text{ PSF } (23.25'/2) (11'/2) = 1215 \text{ lb}$$

$$P_{1,L} = 20 \text{ PSF } (23.25'/2) (11'/2) = 1279 \text{ lb}$$

ii) FLOOR

$$w_D = 14 \text{ lb/ft}$$

$$w_L = 34 \text{ lb/ft}$$

iii) WALL

$$\text{DEAD LOAD} = 8 \text{ PSF } (8.25') = 66 \text{ lb/ft}$$

$$P_{2,D} = 1.2 \text{ k}$$

$$P_{3,D} = 0.7 \text{ k}$$

$$P_{2,L} = 1.4 \text{ k}$$

$$P_{3,L} = 1.5 \text{ k}$$

$$P_{2,RL} = 0.2 \text{ k}$$

$$P_{4,D} = 1.215 \text{ k}$$

$$P_{2,ER} = -1.2 \text{ k}$$

$$P_{4,L} = 1.279 \text{ k}$$

$$P_{5,D} = 0.1 \text{ k}$$

$$P_{5,ER} = -2.2 \text{ k } (+2.2 \text{ k})$$

$$P_{5,L} = 0.4 \text{ k}$$

$$P_{5,RL} = 0.3 \text{ k}$$



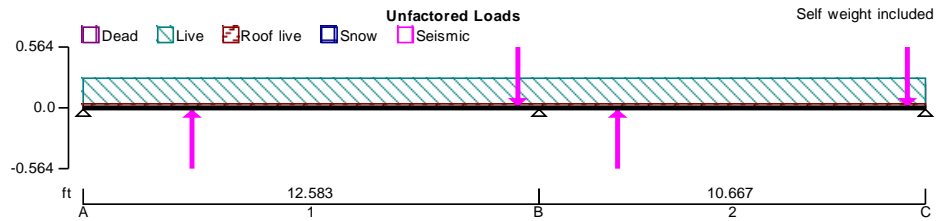
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6160 Kempsville Circle
Suite 200A
Norfolk, VA 23502

Project ODU Solar Decathlon				Job Ref.	
Section Module 1, Beam No. 1				Sheet no./rev. 1	
Calc. by ECW	Date 2/24/2013	Chk'd by	Date	App'd by	Date

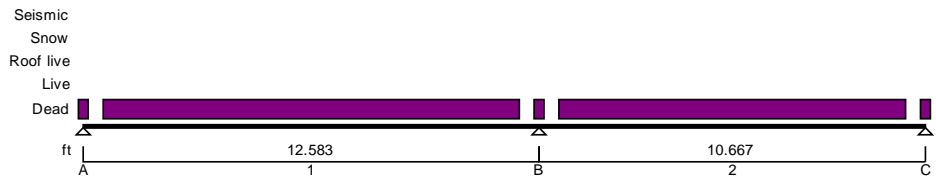
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

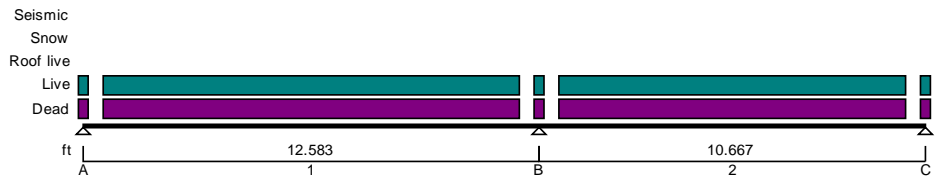
Tedds calculation version 3.0.06



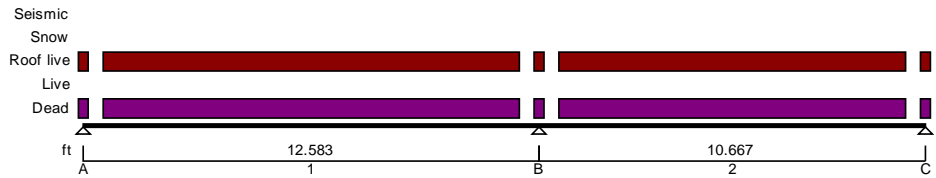
Load Combination 1 (shown in proportion)



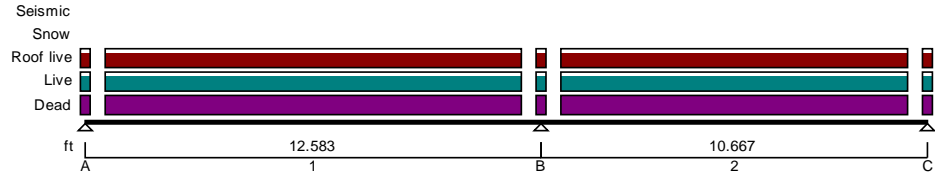
Load Combination 2 (shown in proportion)



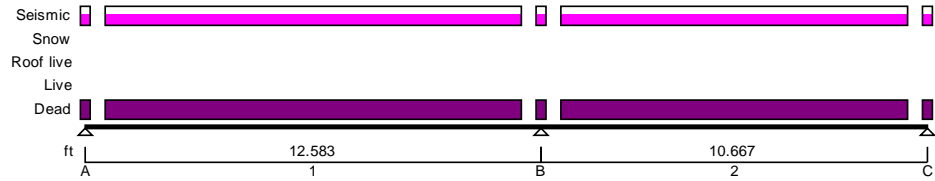
Load Combination 3 (shown in proportion)



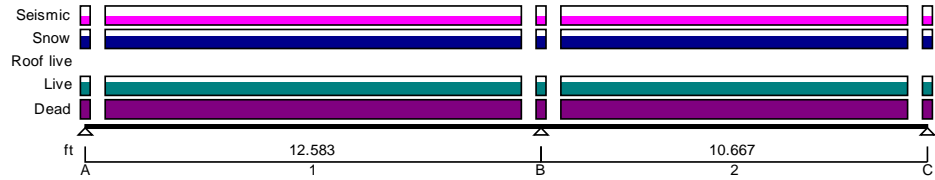
Load Combination 4 (shown in proportion)



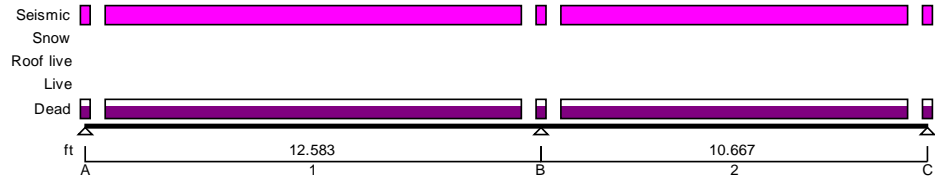
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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Project
ODU Solar Decathlon

Section
Module 1, Beam No. 1

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Sheet no./rev.
3

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2/24/2013

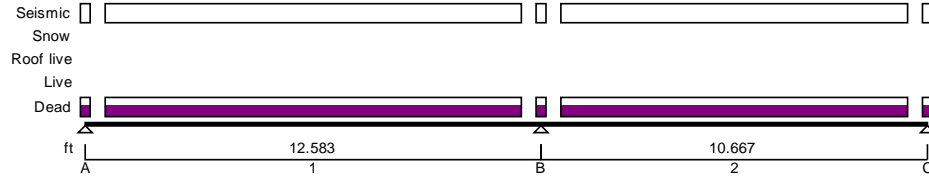
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Date

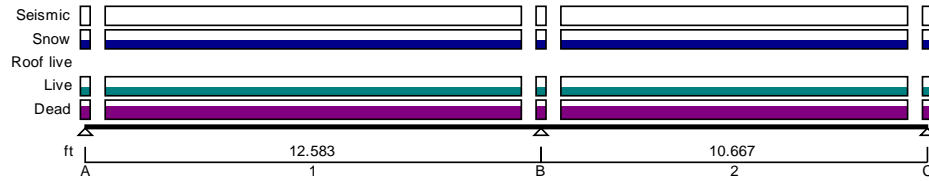
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Date

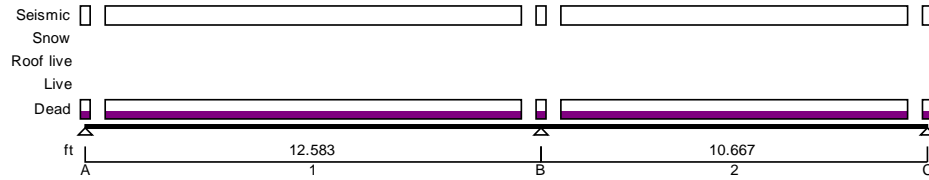
Load Combination 8 (shown in proportion)



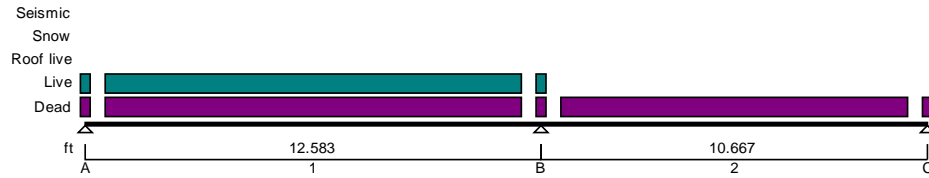
Load Combination 9 (shown in proportion)



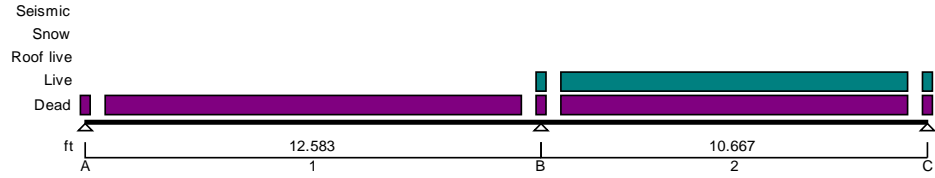
Load Combination 10 (shown in proportion)



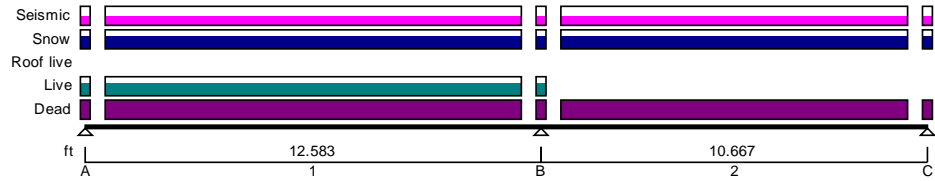
Load Combination 11 (shown in proportion)



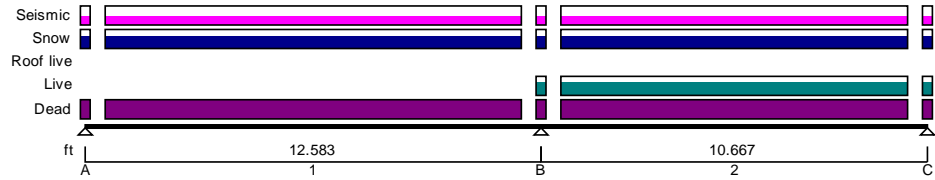
Load Combination 12 (shown in proportion)



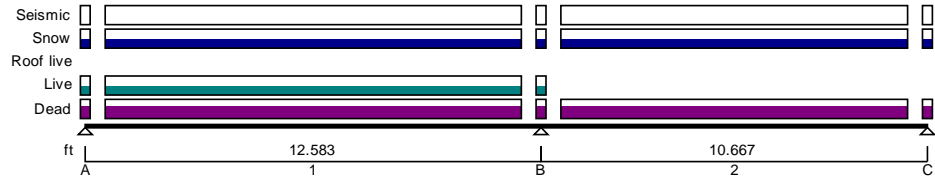
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)

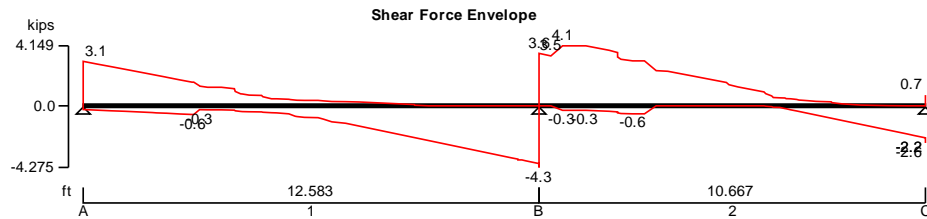
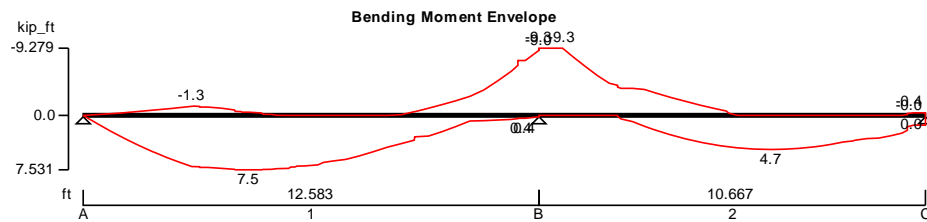
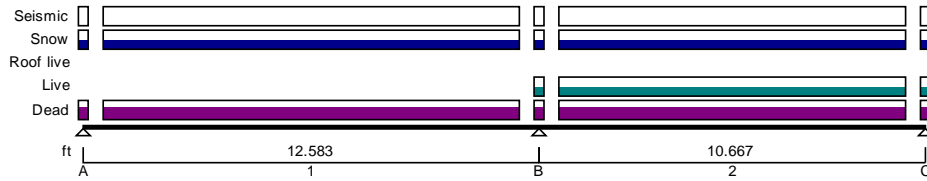




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Project ODU Solar Decathlon				Job Ref.	
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Load Combination 16 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.217 kips/ft Live load - Live full UDL 0.275 kips/ft Roof live load - Roof live full UDL 0.037 kips/ft Dead self weight of beam \times 1 EQ 1 - Seismic point load -1.852 kips at 36.00 in EQ 2 - Seismic point load 1.852 kips at 144.00 in EQ 3 - Seismic point load -1.852 kips at 177.00 in EQ 4 - Seismic point load 1.852 kips at 273.00 in
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Calc. by ECW	Date 2/24/2013	Chk'd by	Date	App'd by	Date

Analysis results

Maximum moment	$M_{max} = 7.5$ kips_ft	$M_{min} = -9.3$ kips_ft
Maximum moment span 1	$M_{s1_max} = 7.5$ kips_ft	$M_{s1_min} = -9.3$ kips_ft
Maximum moment span 2	$M_{s2_max} = 4.7$ kips_ft	$M_{s2_min} = -9.3$ kips_ft
Maximum shear	$V_{max} = 4.1$ kips	$V_{min} = -4.3$ kips
Maximum shear span 1	$V_{s1_max} = 3.1$ kips	$V_{s1_min} = -4.3$ kips
Maximum shear span 2	$V_{s2_max} = 4.1$ kips	$V_{s2_min} = -2.8$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 3.1$ kips	$R_{A_min} = -0.3$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = 1.2$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 1.4$ kips	
Unfactored roof live load reaction at support A	$R_{A_Roof\ live} = 0.2$ kips	
Unfactored seismic load reaction at support A	$R_{A_Seismic} = -1.2$ kips	
Maximum reaction at support B	$R_{B_max} = 7.6$ kips	$R_{B_min} = 1.4$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 3.6$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 4$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 0.5$ kips	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = -0.4$ kips	
Maximum reaction at support C	$R_{C_max} = 2.8$ kips	$R_{C_min} = -0.7$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 0.9$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 1$ kips	
Unfactored roof live load reaction at support C	$R_{C_Roof\ live} = 0.1$ kips	
Unfactored seismic load reaction at support C	$R_{C_Seismic} = 1.6$ kips	

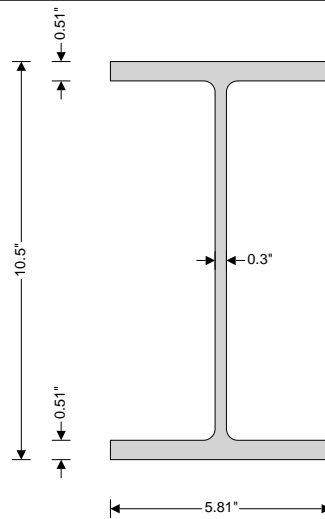
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{[E / F_y]} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{[E / F_y]} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{[E / F_y]} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{[E / F_y]} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 4.275$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
Allowable shear strength	$V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength



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Design of members for flexure in the major axis at span 2 - Chapter F

Required flexural strength $M_r = \max(\text{abs}(M_{s2_max}), \text{abs}(M_{s2_min})) = 9.279 \text{ kips_ft}$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = 152.5 \text{ kips_ft}$

Lateral-torsional buckling - Section F2.2

Unbraced length $L_b = L_{s2} = 128.004 \text{ in}$

Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 \times r_y \times \sqrt{E / F_y} = 58.069 \text{ in}$

Distance between flange centroids $h_o = d - t_f = 9.99 \text{ in}$

$c = 1$

$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602 \text{ in}$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + ((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)]} = 193.716 \text{ in}$$

Cross-section mono-symmetry parameter $R_m = 1.000$

Moment at quarter point of segment $M_A = 2.950 \text{ kips_ft}$

Moment at center-line of segment $M_B = 4.399 \text{ kips_ft}$

Moment at three quarter point of segment $M_C = 4.056 \text{ kips_ft}$

Maximum moment in segment $M_{abs} = 9.279 \text{ kips_ft}$

Lateral torsional buckling modification factor - eq F1-1 $C_b = 12.5 \times M_{abs} / [2.5 \times M_{abs} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = 1.876$

Nominal flexural strength for lateral torsional buckling - eq F2-2 $M_{nlbt} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] = 230.053 \text{ kips_ft}$

Nominal flexural strength $M_n = \min(M_{nyld}, M_{nlbt}) = 152.500 \text{ kips_ft}$

Allowable flexural strength $M_c = M_n / \Omega_b = 91.317 \text{ kips_ft}$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection $\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = 0.419 \text{ in}$

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = 0.031 \text{ in}$

PASS - Maximum deflection does not exceed deflection limit



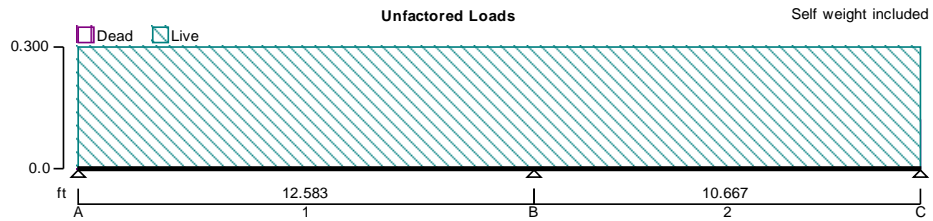
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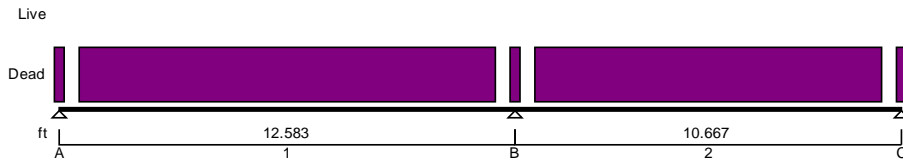
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

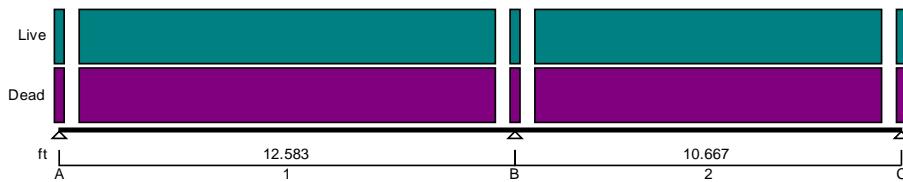
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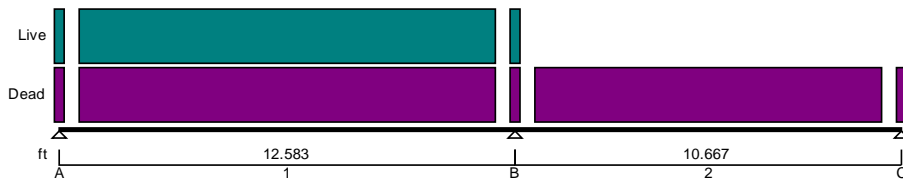
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)



Load Combination 3 (shown in proportion)

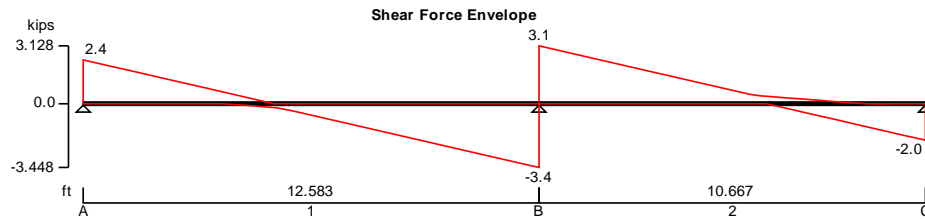
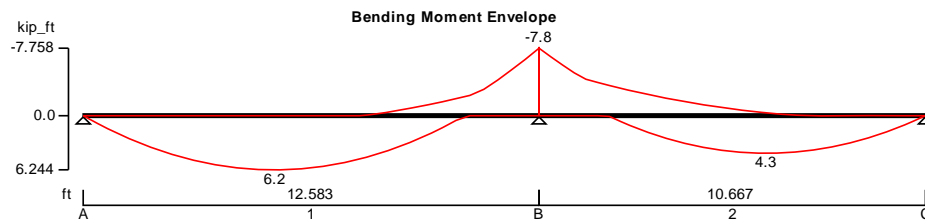
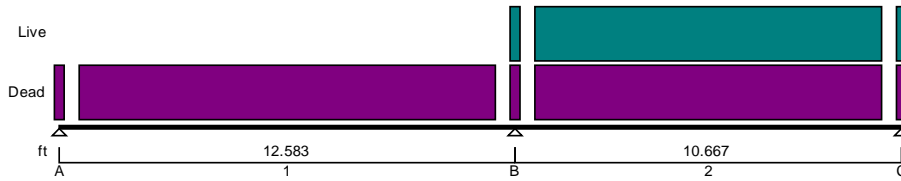




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Load Combination 4 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.12 kips/ft Live load - Live full UDL 0.3 kips/ft Dead self weight of beam \times 1
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Analysis results

Maximum moment	$M_{max} = 6.2$ kips_ft	$M_{min} = -7.8$ kips_ft
Maximum moment span 1	$M_{s1_max} = 6.2$ kips_ft	$M_{s1_min} = -7.8$ kips_ft
Maximum moment span 2	$M_{s2_max} = 4.3$ kips_ft	$M_{s2_min} = -7.8$ kips_ft
Maximum shear	$V_{max} = 3.1$ kips	$V_{min} = -3.4$ kips
Maximum shear span 1	$V_{s1_max} = 2.4$ kips	$V_{s1_min} = -3.4$ kips



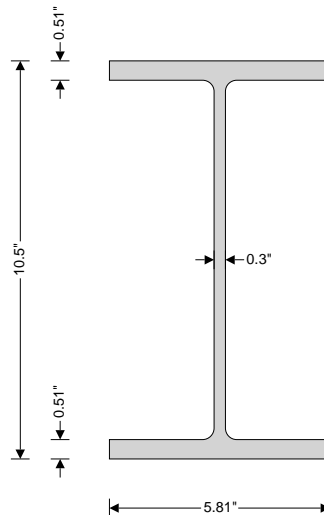
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Maximum shear span 2	$V_{s2_max} = 3.1$ kips	$V_{s2_min} = -2$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 2.4$ kips	$R_{A_min} = 0.6$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = 0.7$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 1.5$ kips	
Maximum reaction at support B	$R_{B_max} = 6.6$ kips	$R_{B_min} = 2.2$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 2.2$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 4.4$ kips	
Maximum reaction at support C	$R_{C_max} = 2$ kips	$R_{C_min} = 0.3$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 0.6$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 1.1$ kips	

Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only



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Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{[E / F_y]} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{[E / F_y]} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{[E / F_y]} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{[E / F_y]} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 3.448$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
Allowable shear strength	$V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 2 - Chapter F

Required flexural strength	$M_r = \max(\text{abs}(M_{s2_max}), \text{abs}(M_{s2_min})) = 7.758$ kips_ft
----------------------------	--

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1	$M_{nyld} = M_p = F_y \times Z_x = 152.5$ kips_ft
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Lateral-torsional buckling - Section F2.2

Unbraced length	$L_b = L_{s2} = 128.004$ in
Limiting unbraced length for yielding - eq F2-5	$L_p = 1.76 \times r_y \times \sqrt{[E / F_y]} = 58.069$ in
Distance between flange centroids	$h_o = d - t_f = 9.99$ in
	$c = 1$
	$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602$ in

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = 193.716 \text{ in}$$

Cross-section mono-symmetry parameter	$R_m = 1.000$
Moment at quarter point of segment	$M_A = 2.749$ kips_ft
Moment at center-line of segment	$M_B = 4.129$ kips_ft
Moment at three quarter point of segment	$M_C = 3.665$ kips_ft
Maximum moment in segment	$M_{\text{abs}} = 7.758$ kips_ft
Lateral torsional buckling modification factor - eq F1-1	$C_b = 12.5 \times M_{\text{abs}} / [2.5 \times M_{\text{abs}} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = 1.758$
Nominal flexural strength for lateral torsional buckling - eq F2-2	$M_{ntlb} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] = 215.555$ kips_ft
Nominal flexural strength	$M_n = \min(M_{nyld}, M_{ntlb}) = 152.500$ kips_ft
Allowable flexural strength	$M_c = M_n / \Omega_b = 91.317$ kips_ft

PASS - Allowable flexural strength exceeds required flexural strength



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Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = \mathbf{0.419 \text{ in}}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.025 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit



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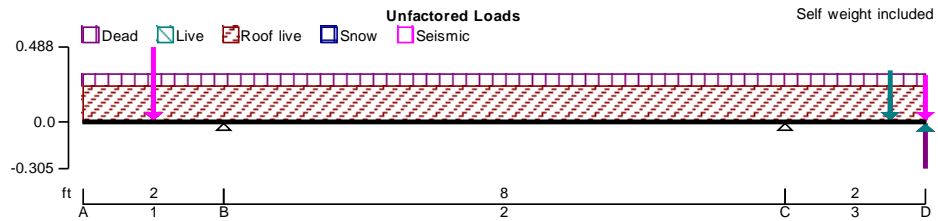
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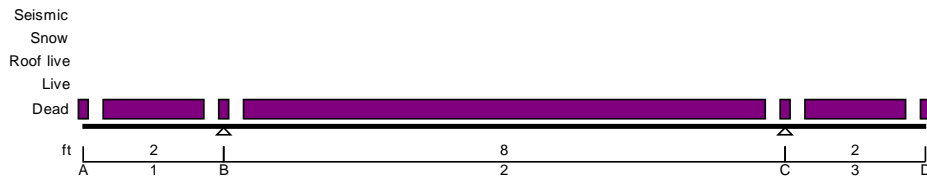
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

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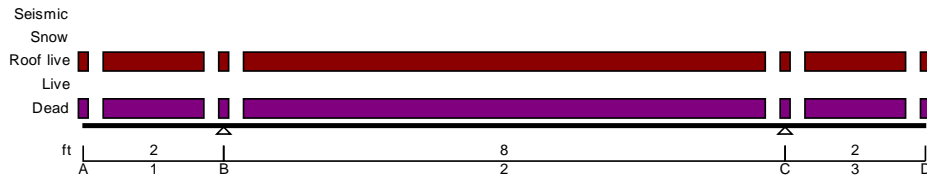
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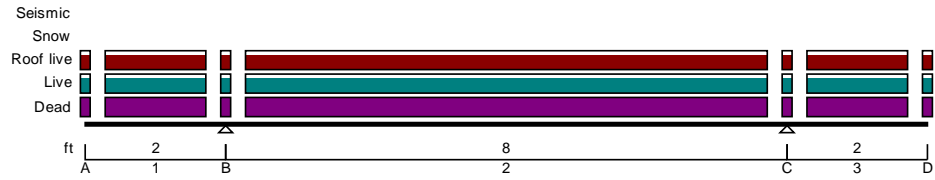
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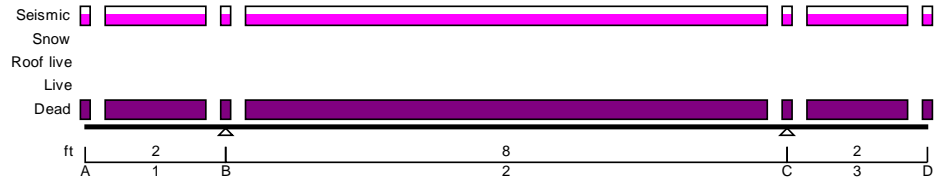
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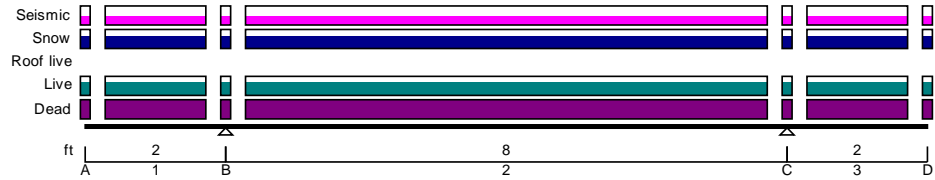
Load Combination 4 (shown in proportion)



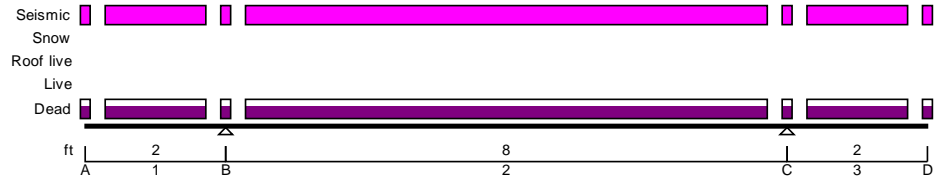
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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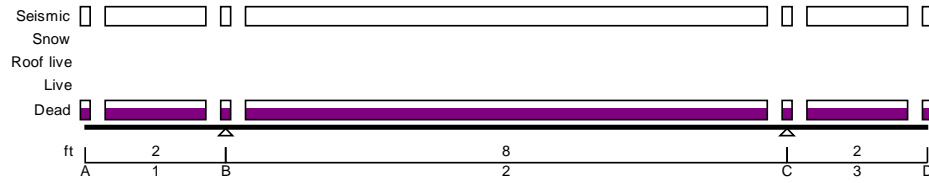
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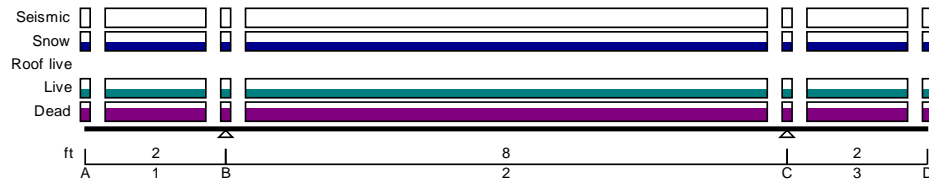
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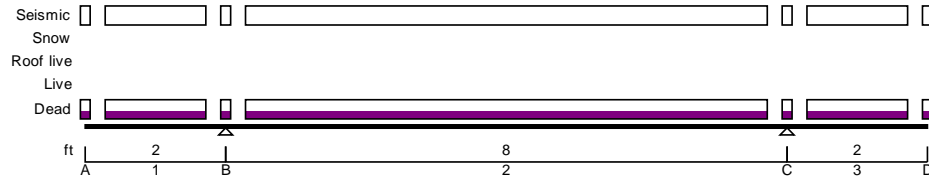
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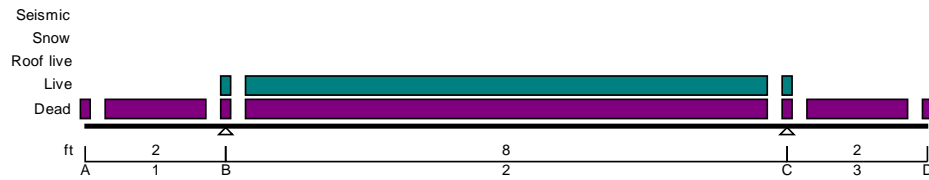
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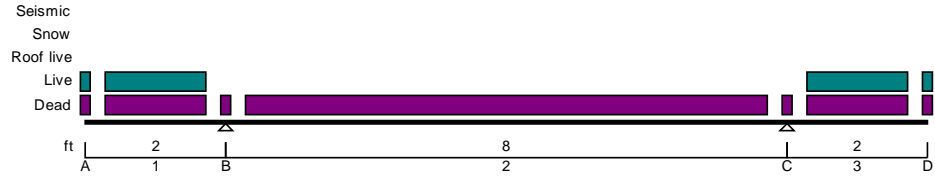
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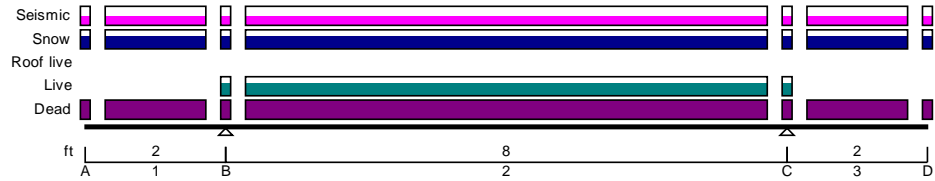
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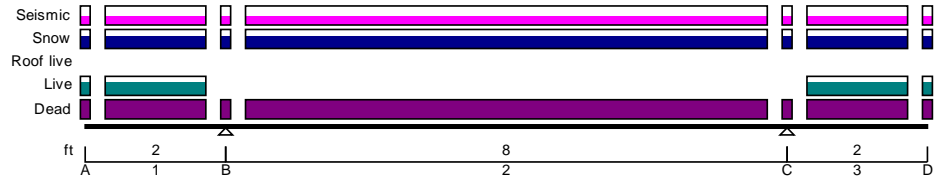
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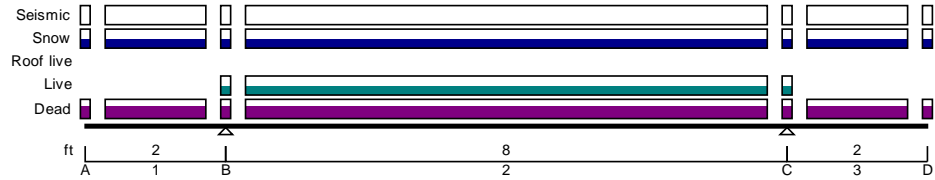
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)





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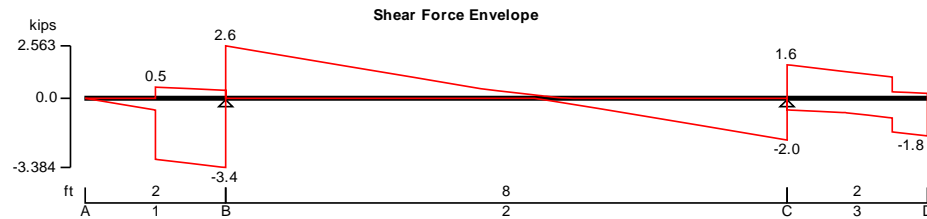
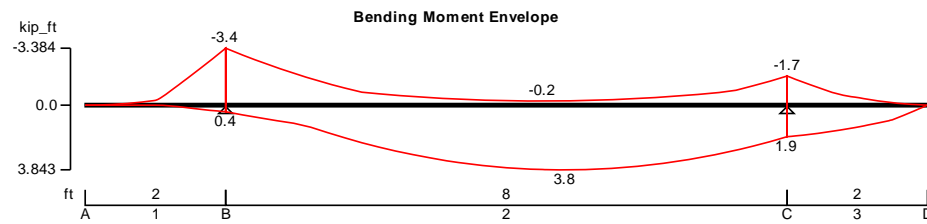
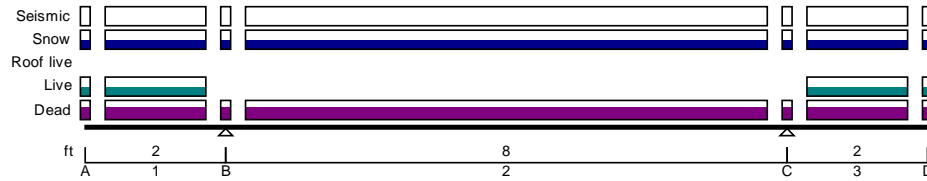
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Load Combination 16 (shown in proportion)



Support conditions

- Support A: Vertically free, Rotationally free
- Support B: Vertically restrained, Rotationally free
- Support C: Vertically restrained, Rotationally free
- Support D: Vertically free, Rotationally free

Applied loading

- Beam loads:
 - Dead load - Dead full UDL 0.312 kips/ft
 - Live load - Live full UDL 0.034 kips/ft
 - Roof live load - Roof live full UDL 0.233 kips/ft
 - Dead self weight of beam $\times 1$
 - Dead load - Dead point load 0.9 kips at 12.00 in
 - Live load - Live point load 1 kips at 12.00 in
 - Roof live load - Roof live point load 0.1 kips at 12.00 in



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EQ 1 - Seismic point load 1.6 kips at 12.00 in
Dead load - Dead point load 0.6 kips at 138.00 in
Live load - Live point load 1.1 kips at 138.00 in
Dead load - Dead point load -1 kips at 144.00 in
Live load - Live point load -0.1 kips at 144.00 in
Seismic load - Seismic point load 1 kips at 144.00 in

Analysis results

Maximum moment	$M_{max} = 3.8$ kips_ft	$M_{min} = -3.4$ kips_ft
Maximum moment span 1	$M_{s1_max} = 0.4$ kips_ft	$M_{s1_min} = -3.4$ kips_ft
Maximum moment span 2	$M_{s2_max} = 3.8$ kips_ft	$M_{s2_min} = -3.4$ kips_ft
Maximum moment span 3	$M_{s3_max} = 1.9$ kips_ft	$M_{s3_min} = -1.7$ kips_ft
Maximum shear	$V_{max} = 2.6$ kips	$V_{min} = -3.4$ kips
Maximum shear span 1	$V_{s1_max} = 0.5$ kips	$V_{s1_min} = -3.4$ kips
Maximum shear span 2	$V_{s2_max} = 2.6$ kips	$V_{s2_min} = -2$ kips
Maximum shear span 3	$V_{s3_max} = 1.6$ kips	$V_{s3_min} = -1.8$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Deflection span 3	$\delta_{s3_max} = 0$ in	$\delta_{s3_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 0$ kips	$R_{A_min} = 0$ kips
Maximum reaction at support B	$R_{B_max} = 5.2$ kips	$R_{B_min} = 0.4$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 3.2$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 1.1$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 1.5$ kips	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = 1.5$ kips	
Maximum reaction at support C	$R_{C_max} = 3.4$ kips	$R_{C_min} = -0.1$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 1.4$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 1.3$ kips	
Unfactored roof live load reaction at support C	$R_{C_Roof\ live} = 1.4$ kips	
Unfactored seismic load reaction at support C	$R_{C_Seismic} = 1.1$ kips	
Maximum reaction at support D	$R_{D_max} = 0$ kips	$R_{D_min} = 0$ kips

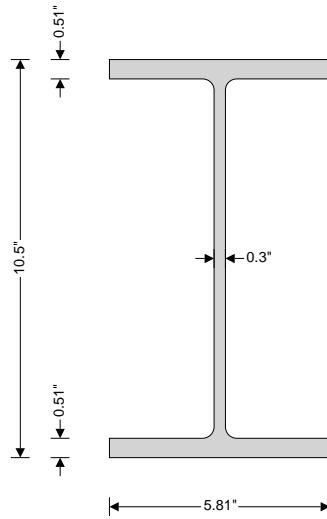
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only
Span 3 has lateral bracing at supports only
Cantilever tip is free
Cantilever support is continuous with lateral and torsional restraint

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{[E / F_y]} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{[E / F_y]} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{[E / F_y]} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{[E / F_y]} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 3.384 \text{ kips}$
Web area	$A_w = d \times t_w = 3.15 \text{ in}^2$
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500 \text{ kips}$



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Allowable shear strength

$$V_c = V_n / \Omega_v = \mathbf{63.000 \text{ kips}}$$

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 2 - Chapter F

Required flexural strength

$$M_r = \max(\text{abs}(M_{s2_max}), \text{abs}(M_{s2_min})) = \mathbf{3.843 \text{ kips_ft}}$$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1

$$M_{nyld} = M_p = F_y \times Z_x = \mathbf{152.5 \text{ kips_ft}}$$

Lateral-torsional buckling - Section F2.2

Unbraced length

$$L_b = L_{s2} = \mathbf{96 \text{ in}}$$

Limiting unbraced length for yielding - eq F2-5

$$L_p = 1.76 \times r_y \times \sqrt{E / F_y} = \mathbf{58.069 \text{ in}}$$

Distance between flange centroids

$$h_o = d - t_f = \mathbf{9.99 \text{ in}}$$

$$c = \mathbf{1}$$

$$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = \mathbf{1.602 \text{ in}}$$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = \mathbf{193.716 \text{ in}}$$

Cross-section mono-symmetry parameter

$$R_m = \mathbf{1.000}$$

Moment at quarter point of segment

$$M_A = \mathbf{2.293 \text{ kips_ft}}$$

Moment at center-line of segment

$$M_B = \mathbf{3.712 \text{ kips_ft}}$$

Moment at three quarter point of segment

$$M_C = \mathbf{3.572 \text{ kips_ft}}$$

Maximum moment in segment

$$M_{abs} = \mathbf{3.843 \text{ kips_ft}}$$

Lateral torsional buckling modification factor - eq F1-1

$$C_b = 12.5 \times M_{abs} / [2.5 \times M_{abs} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = \mathbf{1.142}$$

Nominal flexural strength for lateral torsional buckling - eq F2-2

$$M_{ntlb} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] =$$

$$\mathbf{155.688 \text{ kips_ft}}$$

Nominal flexural strength

$$M_n = \min(M_{nyld}, M_{ntlb}) = \mathbf{152.500 \text{ kips_ft}}$$

Allowable flexural strength

$$M_c = M_n / \Omega_b = \mathbf{91.317 \text{ kips_ft}}$$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, L_{s2} / 360) = \mathbf{0.267 \text{ in}}$$

Maximum deflection span 2

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.008 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit



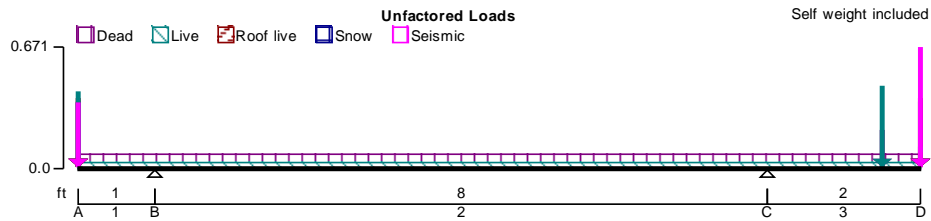
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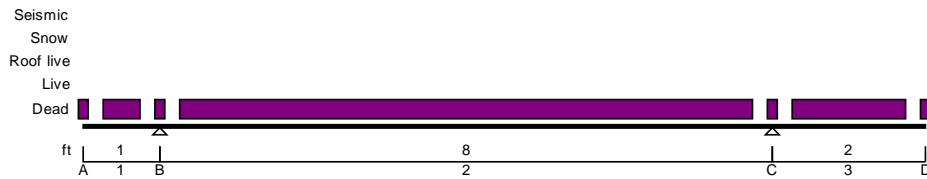
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

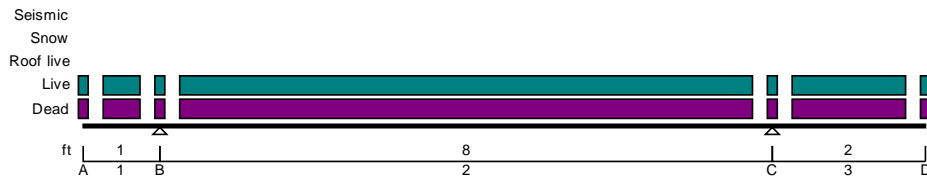
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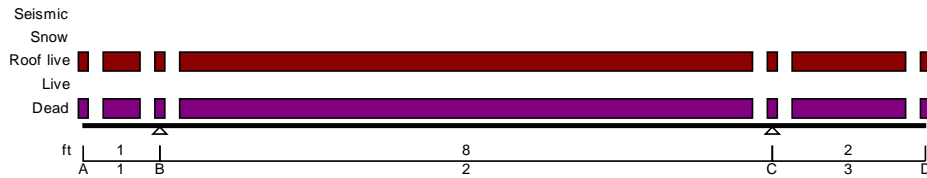
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)

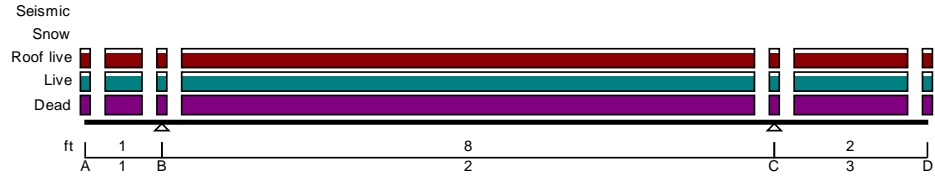


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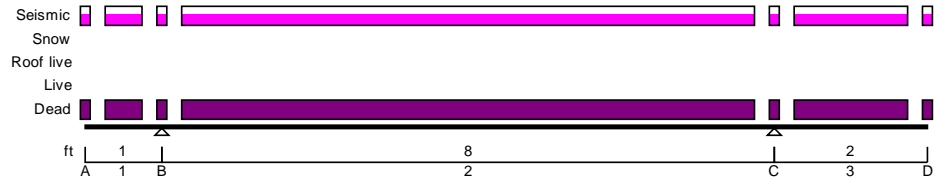


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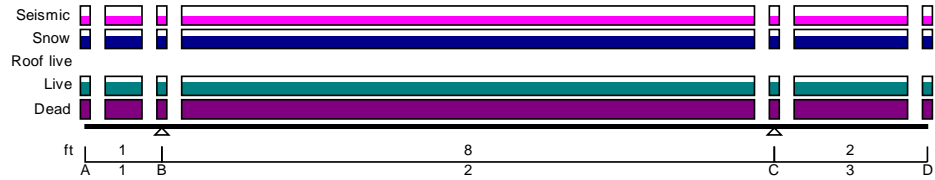
Load Combination 4 (shown in proportion)



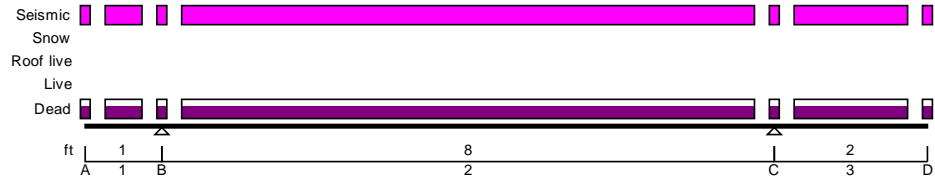
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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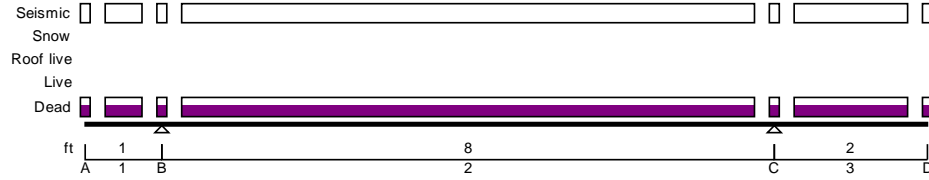
Job Ref.

Sheet no./rev.
3

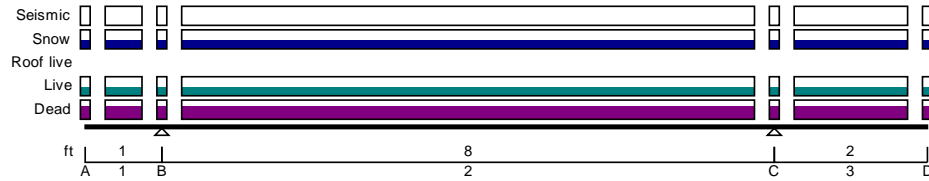
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Date

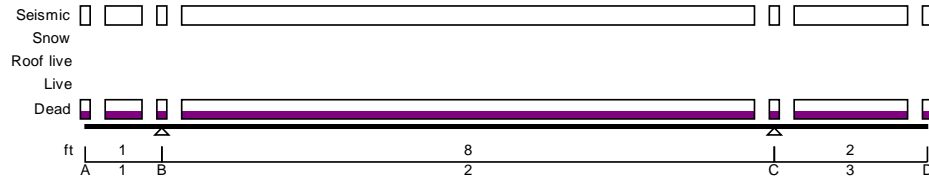
Load Combination 8 (shown in proportion)



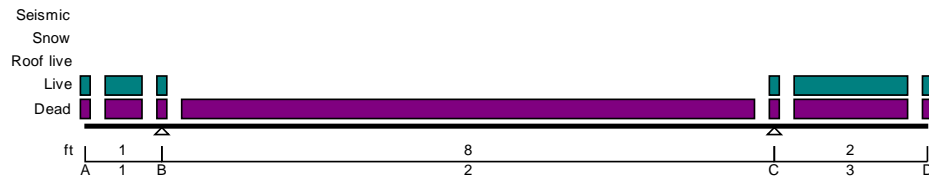
Load Combination 9 (shown in proportion)



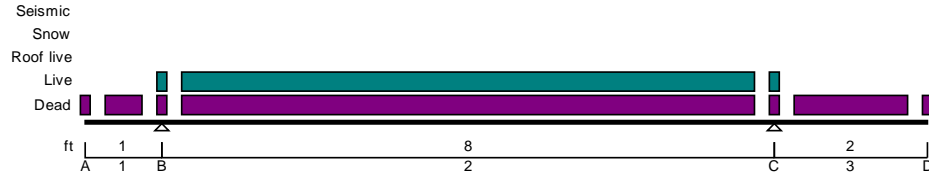
Load Combination 10 (shown in proportion)



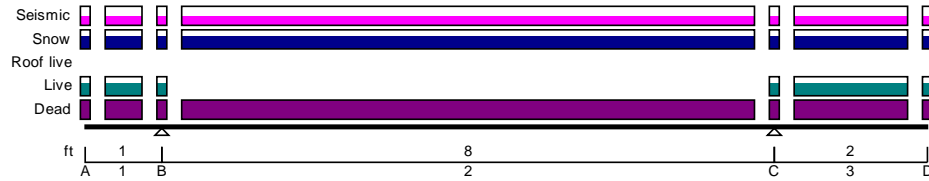
Load Combination 11 (shown in proportion)



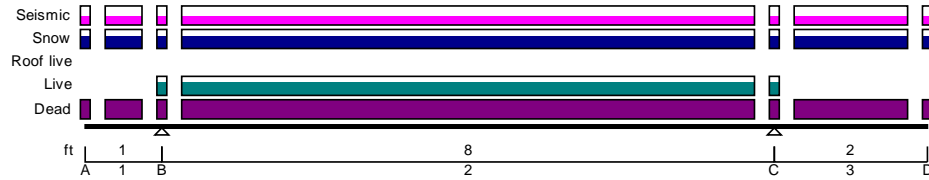
Load Combination 12 (shown in proportion)



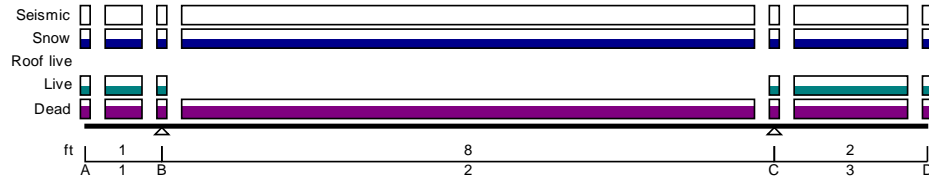
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)

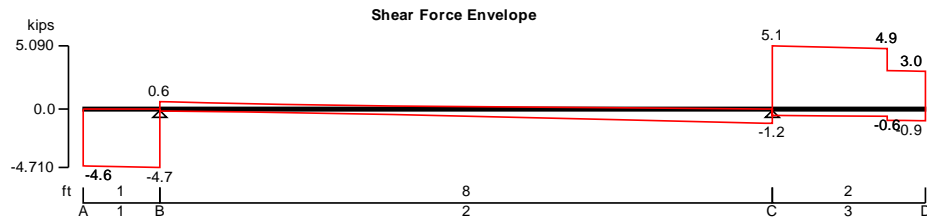
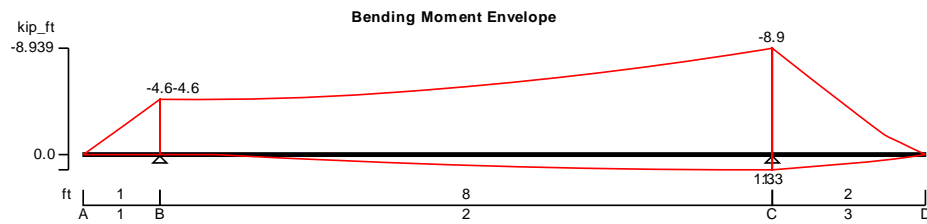
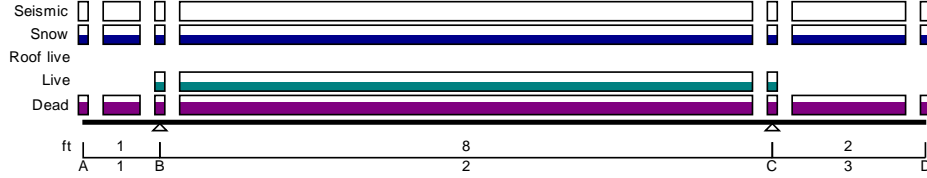




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Load Combination 16 (shown in proportion)



Support conditions

- Support A: Vertically free, Rotationally free
- Support B: Vertically restrained, Rotationally free
- Support C: Vertically restrained, Rotationally free
- Support D: Vertically free, Rotationally free

Applied loading

- Beam loads:
 - Dead load - Dead full UDL 0.08 kips/ft
 - Live load - Live full UDL 0.034 kips/ft
 - Roof live load - Roof live point load 1.279 kips at 0.00 in
 - Roof dead load - Dead point load 1.215 kips at 0.00 in
 - Dead self weight of beam × 1
 - Dead load - Dead point load 1.2 kips at 0.00 in
 - Live load - Live point load 1.4 kips at 0.00 in



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Roof live load - Roof live point load 0.2 kips at 0.00 in
EQ 1 - Seismic point load 1.2 kips at 0.00 in
Dead load - Dead point load 0.7 kips at 126.00 in
Live load - Live point load 1.5 kips at 126.00 in
Dead load - Dead point load 1.215 kips at 132.00 in
Roof live load - Roof live point load 1.279 kips at 132.00 in
Dead load - Dead point load 0.1 kips at 132.00 in
Live load - Live point load 0.4 kips at 132.00 in
Roof live load - Roof live point load 0.3 kips at 132.00 in
EQ 2 - Seismic point load 2.2 kips at 132.00 in

Analysis results

Maximum moment	$M_{max} = 1.3$ kips _{ft}	$M_{min} = -8.9$ kips _{ft}
Maximum moment span 1	$M_{s1_max} = 0$ kips _{ft}	$M_{s1_min} = -4.6$ kips _{ft}
Maximum moment span 2	$M_{s2_max} = 1.3$ kips _{ft}	$M_{s2_min} = -8.9$ kips _{ft}
Maximum moment span 3	$M_{s3_max} = 1.3$ kips _{ft}	$M_{s3_min} = -8.9$ kips _{ft}
Maximum shear	$V_{max} = 5.1$ kips	$V_{min} = -4.7$ kips
Maximum shear span 1	$V_{s1_max} = -0.3$ kips	$V_{s1_min} = -4.7$ kips
Maximum shear span 2	$V_{s2_max} = 0.6$ kips	$V_{s2_min} = -1.2$ kips
Maximum shear span 3	$V_{s3_max} = 5.1$ kips	$V_{s3_min} = -0.9$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Deflection span 3	$\delta_{s3_max} = 0$ in	$\delta_{s3_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 0$ kips	$R_{A_min} = 0$ kips
Maximum reaction at support B	$R_{B_max} = 4.8$ kips	$R_{B_min} = 0.7$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 2.8$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 1.4$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 1.3$ kips	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = 0.8$ kips	
Maximum reaction at support C	$R_{C_max} = 6.2$ kips	$R_{C_min} = -0.5$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 2.9$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 2.3$ kips	
Unfactored roof live load reaction at support C	$R_{C_Roof\ live} = 1.8$ kips	
Unfactored seismic load reaction at support C	$R_{C_Seismic} = 2.6$ kips	
Maximum reaction at support D	$R_{D_max} = 0$ kips	$R_{D_min} = 0$ kips

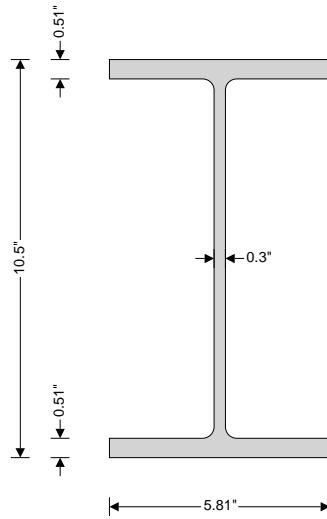
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only
Span 3 has lateral bracing at supports only
Cantilever tip is free
Cantilever support is continuous with lateral and torsional restraint

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{[E / F_y]} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{[E / F_y]} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{[E / F_y]} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{[E / F_y]} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 5.090$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips



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Allowable shear strength

$$V_c = V_n / \Omega_v = \mathbf{63.000 \text{ kips}}$$

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 3 - Chapter F

Required flexural strength

$$M_r = \max(\text{abs}(M_{s3_max}), \text{abs}(M_{s3_min})) = \mathbf{8.939 \text{ kips_ft}}$$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1

$$M_{nyld} = M_p = F_y \times Z_x = \mathbf{152.5 \text{ kips_ft}}$$

Lateral-torsional buckling - Section F2.2

Unbraced length

$$L_b = L_{s3} = \mathbf{24 \text{ in}}$$

Limiting unbraced length for yielding - eq F2-5

$$L_p = 1.76 \times r_y \times \sqrt{E / F_y} = \mathbf{58.069 \text{ in}}$$

Distance between flange centroids

$$h_o = d - t_f = \mathbf{9.99 \text{ in}}$$

$$c = \mathbf{1}$$

$$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = \mathbf{1.602 \text{ in}}$$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = \mathbf{193.716 \text{ in}}$$

Nominal flexural strength

$$M_n = M_{nyld} = \mathbf{152.500 \text{ kips_ft}}$$

Allowable flexural strength

$$M_c = M_n / \Omega_b = \mathbf{91.317 \text{ kips_ft}}$$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, 2 \times L_{s3} / 360) = \mathbf{0.133 \text{ in}}$$

Maximum deflection span 3

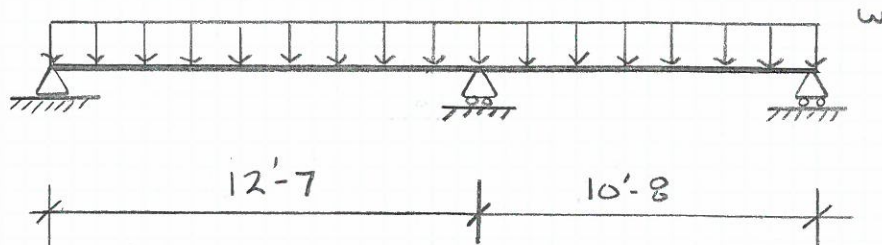
$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.026 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit

Architecture & Engineering

 ARCHITECTURAL MECHANICAL CIVIL ELECTRICAL STRUCTURAL
DATE 22 FEB 13 COMPUTED BY ECWCOMM. NO. 4.0 CHECKED BY _____PROJECT ODU SOLAR DECATHLON SHEET NO. _____ OF _____ SHEETSMODULE TWO

① BEAM No. 1 AND BEAM No. 2



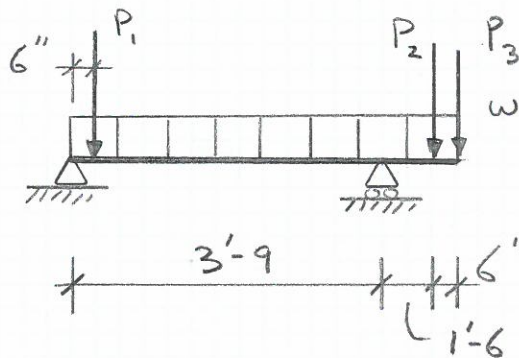
i) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (5.75' / 2) = 58 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (5.75' / 2) = 144 \text{ lb/ft}$$

DATE 22 FEB 13 COMPUTED BY ECWCOMM. NO. 4.0 CHECKED BY _____PROJECT ODU SOLAR DECATHLON SHEET NO. _____ OF _____ SHEETSMODULE TWO

② BEAM NO. 3



i) ROOF

$$\text{DEAD LOAD} = 19 \text{ PSF} (23.25' / 2) = 221 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 20 \text{ PSF} (23.25' / 2) = 233 \text{ lb/ft}$$

ii) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (1.33' / 2) = 14 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (1.33' / 2) = 34 \text{ lb/ft}$$

iii) WALL LOAD

$$\text{DEAD LOAD} = 8 \text{ PSF} (9.67') = 77 \text{ lb/ft}$$

$$P_{1D} = 0.3 \text{ k}$$

$$P_{2D} = 0.3 \text{ k}$$

$$P_{1L} = 0.5 \text{ k}$$

$$P_{2L} = 0.5 \text{ k}$$

$$P_{3D} = 3 \text{ k}$$

$$P_{3L} = 0.7 \text{ k}$$

$$P_{3RL} = 0.5 \text{ k}$$

$$P_{3ER} = -1.8 \text{ k} \quad (\text{INPUT AS POSITIVE VALUE})$$

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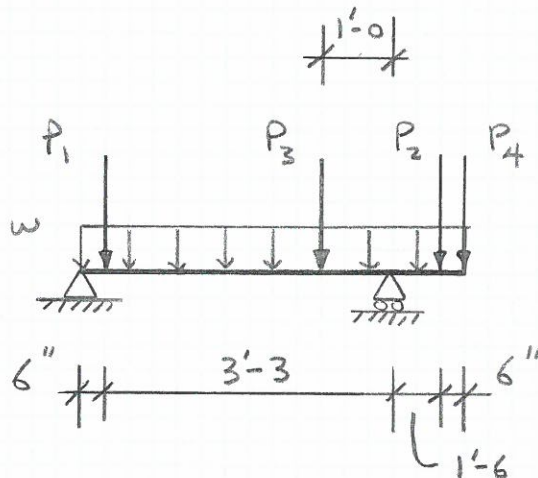
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PROJECT ODU SOLAR DECATHLON

SHEET NO. _____ OF _____ SHEETS

MODULE TWO

③ BEAM No. 4



i) ROOF

DEAD LOAD = 221 lb/ft

LIVE LOAD = 233 lb/ft

ii) FLOOR

DEAD LOAD = 14 lb/ft

LIVE LOAD = 34 lb/ft

iii) WALL LOAD

DEAD LOAD = 8 psf (8.25') = 66 lb/ft

$P_{1D} = 0.4k$

$P_{1L} = 0.7k$

$P_{2D} = 0.4k$

$P_{2L} = 0.7k$

$P_{3EQ} = \frac{1931lb}{0.7} = -2760lb$

$P_{4EQ} = \frac{1931lb}{0.7} = 2760lb$

$P_{4D} = 1000lb$ (WALL)



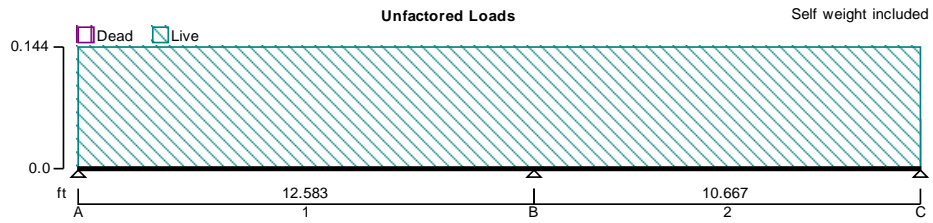
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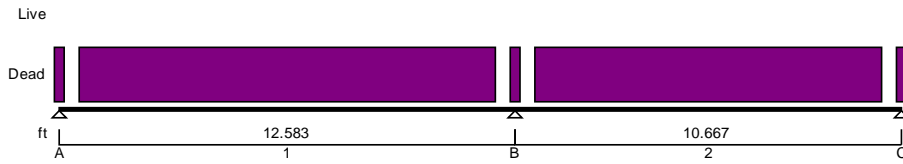
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

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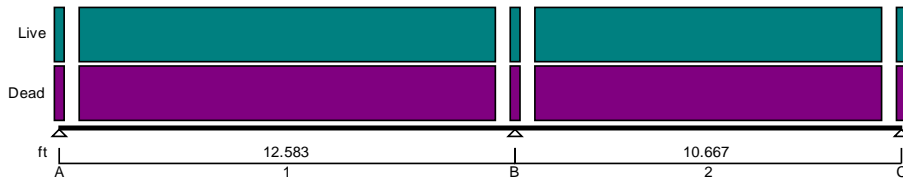
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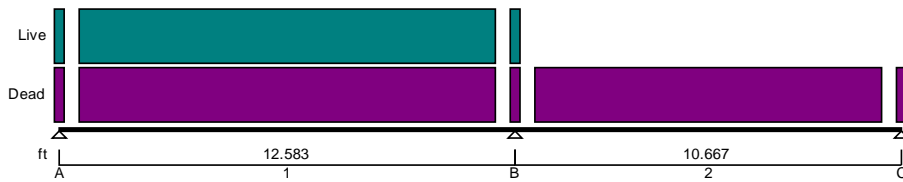
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)



Load Combination 3 (shown in proportion)

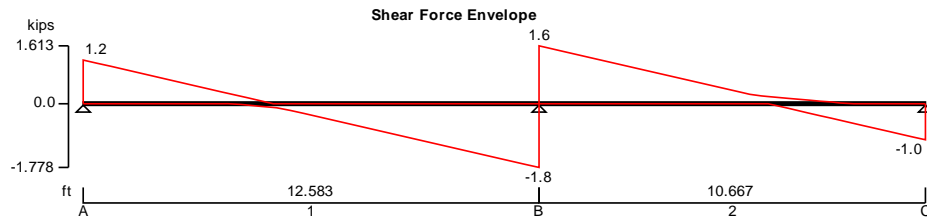
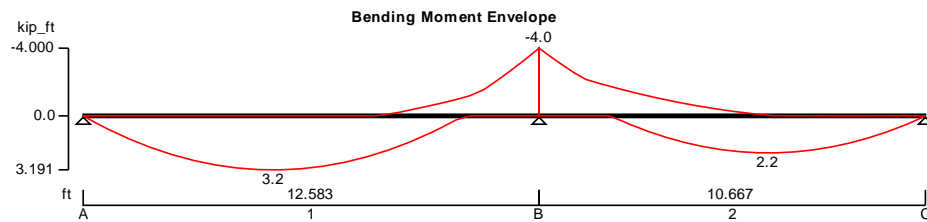
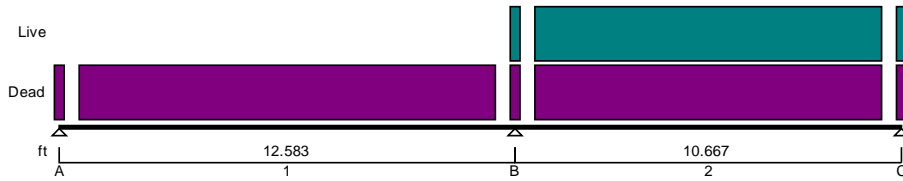




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Load Combination 4 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.058 kips/ft Live load - Live full UDL 0.144 kips/ft Dead self weight of beam × 1
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Analysis results

Maximum moment	$M_{max} = 3.2$ kips_ft	$M_{min} = -4$ kips_ft
Maximum moment span 1	$M_{s1_max} = 3.2$ kips_ft	$M_{s1_min} = -4$ kips_ft
Maximum moment span 2	$M_{s2_max} = 2.2$ kips_ft	$M_{s2_min} = -4$ kips_ft
Maximum shear	$V_{max} = 1.6$ kips	$V_{min} = -1.8$ kips
Maximum shear span 1	$V_{s1_max} = 1.2$ kips	$V_{s1_min} = -1.8$ kips



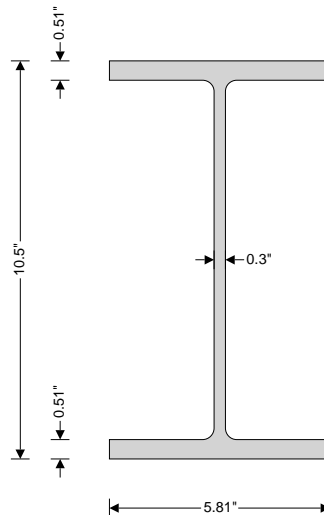
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Maximum shear span 2	$V_{s2_max} = 1.6$ kips	$V_{s2_min} = -1$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 1.2$ kips	$R_{A_min} = 0.4$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = 0.4$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 0.7$ kips	
Maximum reaction at support B	$R_{B_max} = 3.4$ kips	$R_{B_min} = 1.3$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 1.3$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 2.1$ kips	
Maximum reaction at support C	$R_{C_max} = 1$ kips	$R_{C_min} = 0.2$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 0.3$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 0.5$ kips	

Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only



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Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{[E / F_y]} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{[E / F_y]} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{[E / F_y]} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{[E / F_y]} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 1.778$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
Allowable shear strength	$V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 1 - Chapter F

Required flexural strength	$M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 4$ kips_ft
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Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1	$M_{nyld} = M_p = F_y \times Z_x = 152.5$ kips_ft
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Lateral-torsional buckling - Section F2.2

Unbraced length	$L_b = L_{s1} = 151$ in
Limiting unbraced length for yielding - eq F2-5	$L_p = 1.76 \times r_y \times \sqrt{[E / F_y]} = 58.069$ in
Distance between flange centroids	$h_o = d - t_f = 9.99$ in
	$c = 1$
	$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602$ in

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = 193.716 \text{ in}$$

Cross-section mono-symmetry parameter	$R_m = 1.000$
Moment at quarter point of segment	$M_A = 2.680$ kips_ft
Moment at center-line of segment	$M_B = 3.063$ kips_ft
Moment at three quarter point of segment	$M_C = 1.150$ kips_ft
Maximum moment in segment	$M_{\text{abs}} = 4.000$ kips_ft
Lateral torsional buckling modification factor - eq F1-1	$C_b = 12.5 \times M_{\text{abs}} / [2.5 \times M_{\text{abs}} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = 1.482$
Nominal flexural strength for lateral torsional buckling - eq F2-2	$M_{ntlb} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] = 167.117$ kips_ft
Nominal flexural strength	$M_n = \min(M_{nyld}, M_{ntlb}) = 152.500$ kips_ft
Allowable flexural strength	$M_c = M_n / \Omega_b = 91.317$ kips_ft

PASS - Allowable flexural strength exceeds required flexural strength



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Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = \mathbf{0.419 \text{ in}}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.013 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit



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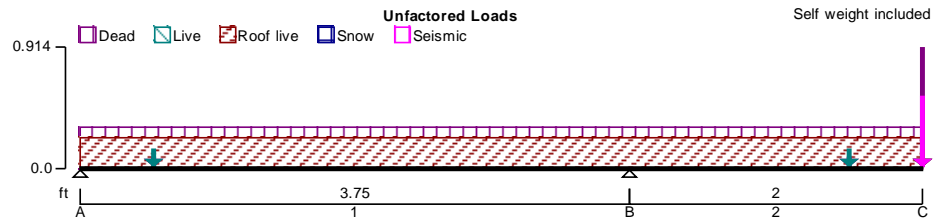
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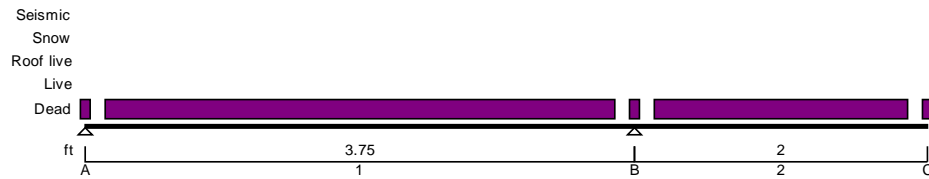
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

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Tedds calculation version 3.0.06



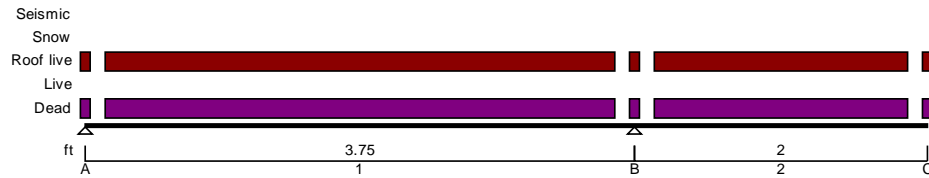
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)



Load Combination 3 (shown in proportion)

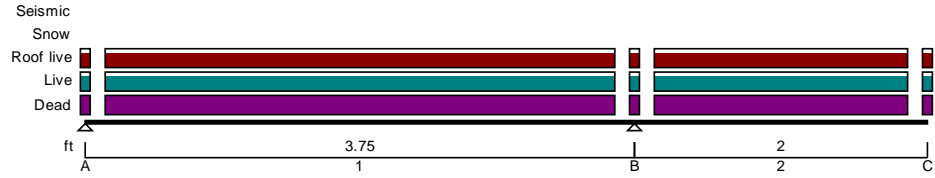




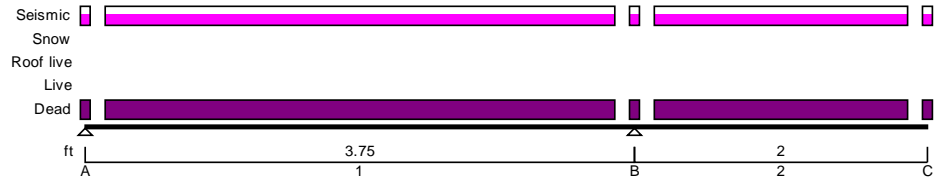
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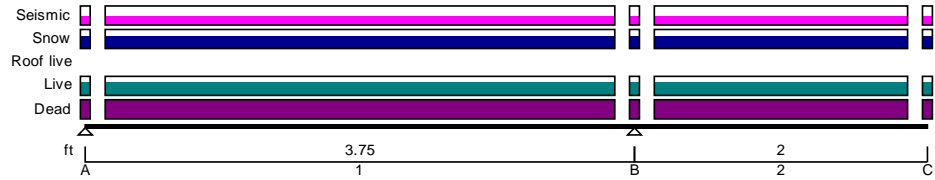
Load Combination 4 (shown in proportion)



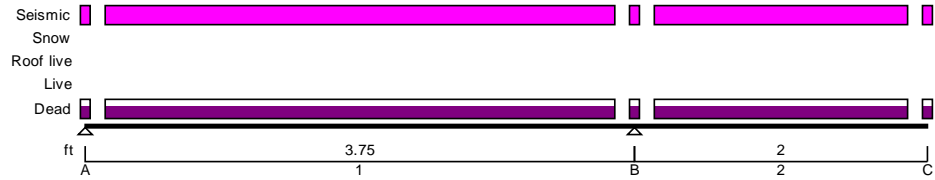
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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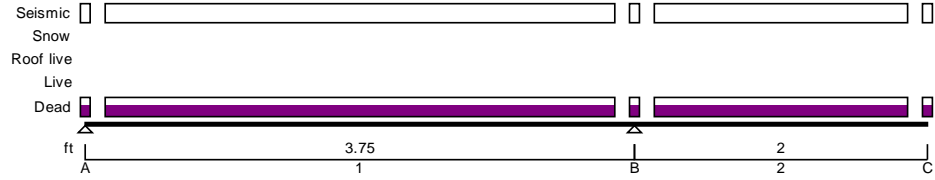
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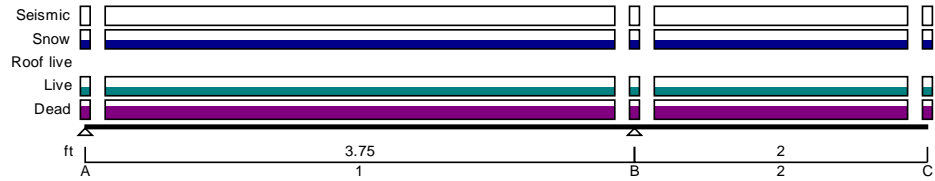
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Load Combination 8 (shown in proportion)



Load Combination 9 (shown in proportion)



Load Combination 10 (shown in proportion)



Load Combination 11 (shown in proportion)





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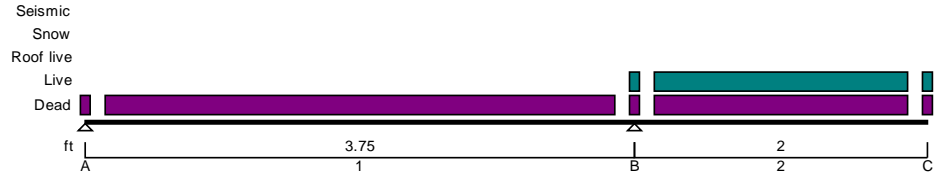
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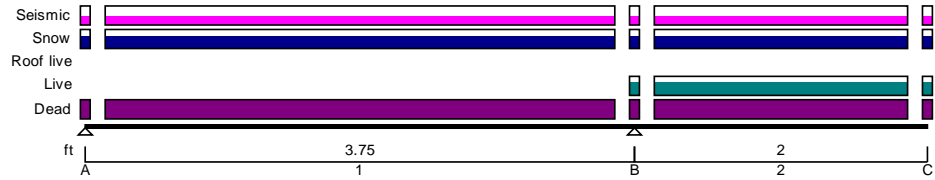
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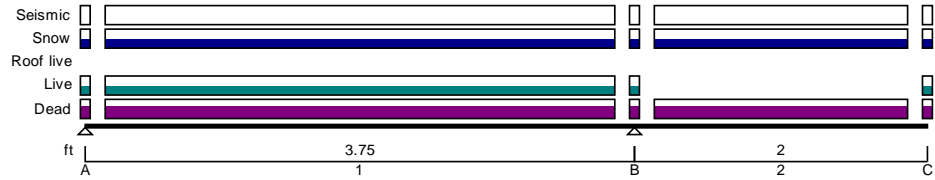
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)

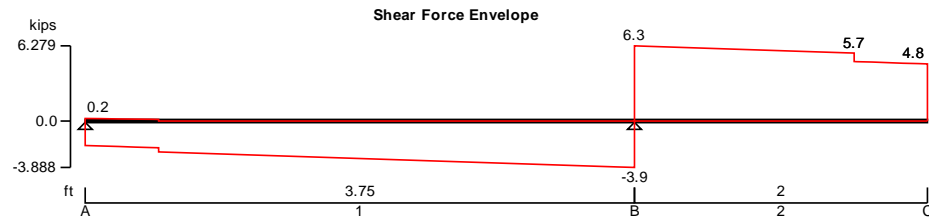
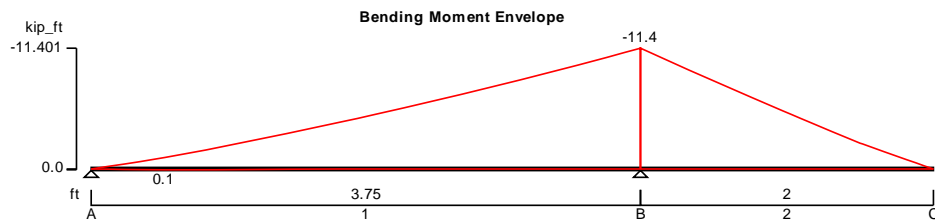
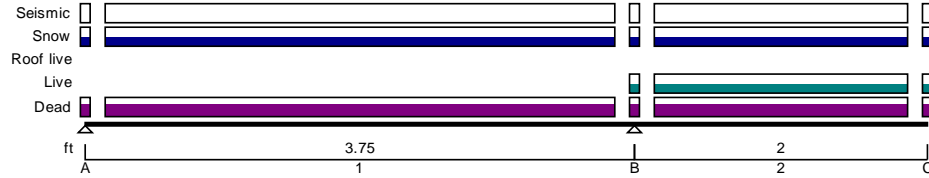




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Load Combination 16 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically free Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.312 kips/ft Live load - Live full UDL 0.034 kips/ft Roof live load - Roof live full UDL 0.233 kips/ft Dead load - Dead point load 0.3 kips at 6.00 in Live load - Live point load 0.5 kips at 6.00 in Dead load - Dead point load 0.3 kips at 63.00 in Live load - Live point load 0.5 kips at 63.00 in Dead load - Dead point load 3 kips at 69.00 in Live load - Live point load 0.7 kips at 69.00 in
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Roof live load - Roof live point load 0.5 kips at 69.00 in
Seismic load - Seismic point load 1.8 kips at 69.00 in
Dead self weight of beam $\times 1$

Analysis results

Maximum moment	$M_{max} = 0.1$ kips_ft	$M_{min} = -11.4$ kips_ft
Maximum moment span 1	$M_{s1_max} = 0.1$ kips_ft	$M_{s1_min} = -11.4$ kips_ft
Maximum moment span 2	$M_{s2_max} = 0$ kips_ft	$M_{s2_min} = -11.4$ kips_ft
Maximum shear	$V_{max} = 6.3$ kips	$V_{min} = -3.9$ kips
Maximum shear span 1	$V_{s1_max} = 0.2$ kips	$V_{s1_min} = -3.9$ kips
Maximum shear span 2	$V_{s2_max} = 6.3$ kips	$V_{s2_min} = 0.1$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 0.2$ kips	$R_{A_min} = -2$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = -1$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = -0.1$ kips	
Unfactored roof live load reaction at support A	$R_{A_Roof\ live} = 0$ kips	
Unfactored seismic load reaction at support A	$R_{A_Seismic} = -1$ kips	
Maximum reaction at support B	$R_{B_max} = 10.2$ kips	$R_{B_min} = 1.1$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 6.6$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 2$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 1.8$ kips	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = 2.8$ kips	
Maximum reaction at support C	$R_{C_max} = 0$ kips	$R_{C_min} = 0$ kips

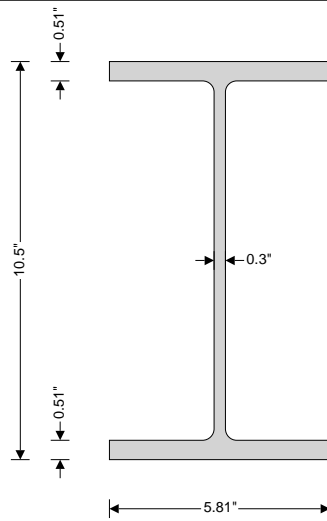
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only
Cantilever tip is free
Cantilever support is continuous with lateral and torsional restraint

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 6.279$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
Allowable shear strength	$V_c = V_n / \Omega_v = 63.000$ kips



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PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 2 - Chapter F

Required flexural strength $M_r = \max(\text{abs}(M_{s2_max}), \text{abs}(M_{s2_min})) = 11.401 \text{ kips_ft}$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = 152.5 \text{ kips_ft}$

Lateral-torsional buckling - Section F2.2

Unbraced length $L_b = L_{s2} = 24 \text{ in}$

Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 \times r_y \times \sqrt{E / F_y} = 58.069 \text{ in}$

Distance between flange centroids $h_o = d - t_f = 9.99 \text{ in}$

$$c = 1$$

$$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602 \text{ in}$$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = 193.716 \text{ in}$$

Nominal flexural strength $M_n = M_{nyld} = 152.500 \text{ kips_ft}$

Allowable flexural strength $M_c = M_n / \Omega_b = 91.317 \text{ kips_ft}$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection $\delta_{lim} = \min(0.75 \text{ in}, 2 \times L_{s2} / 360) = 0.133 \text{ in}$

Maximum deflection span 2 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = 0.013 \text{ in}$

PASS - Maximum deflection does not exceed deflection limit



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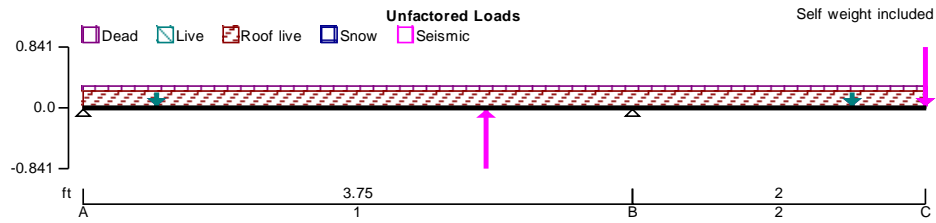
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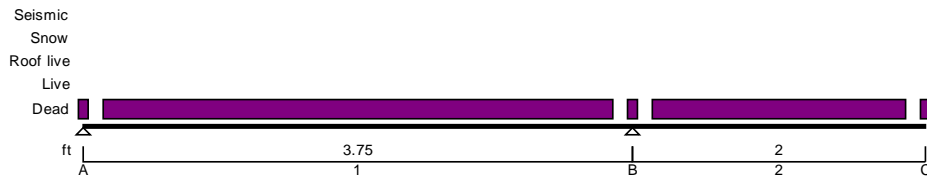
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

Tedds calculation version 3.0.06



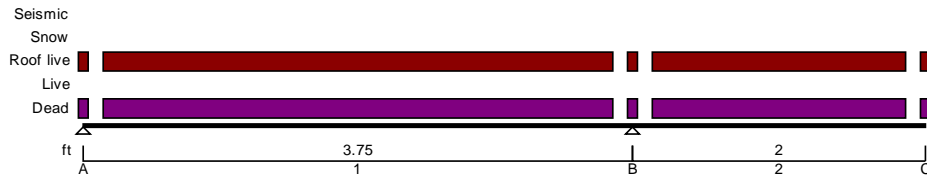
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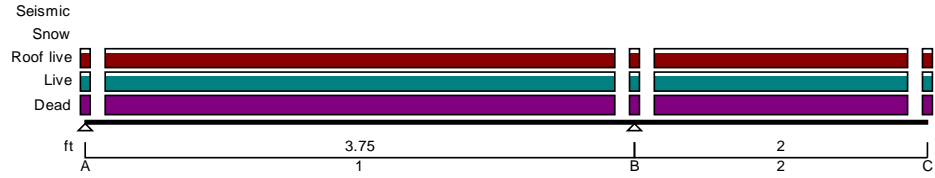
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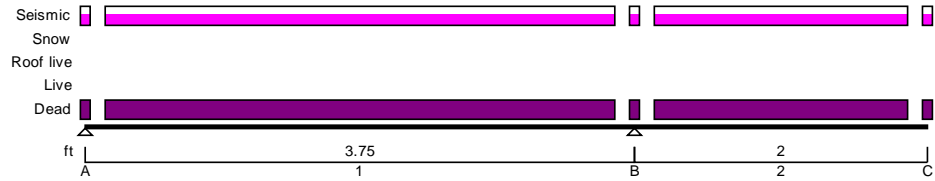
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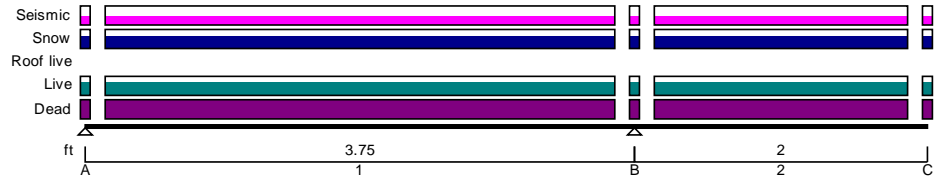
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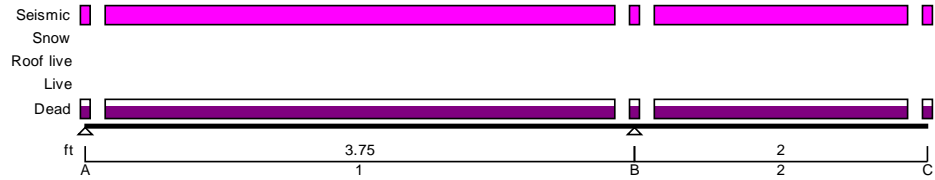
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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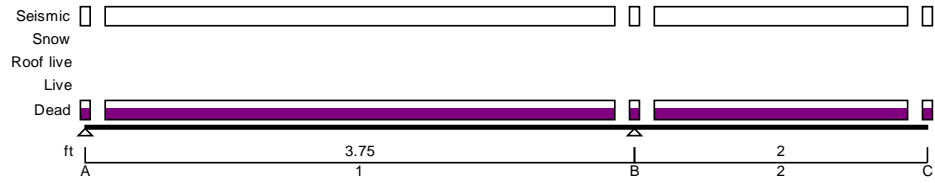
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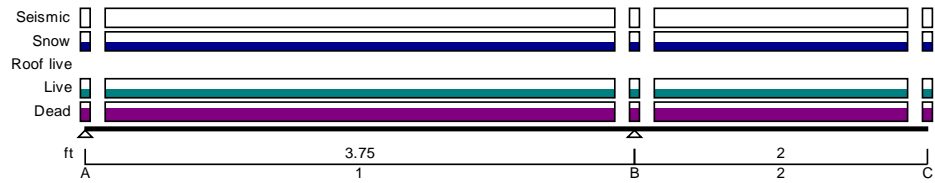
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Load Combination 8 (shown in proportion)



Load Combination 9 (shown in proportion)



Load Combination 10 (shown in proportion)



Load Combination 11 (shown in proportion)



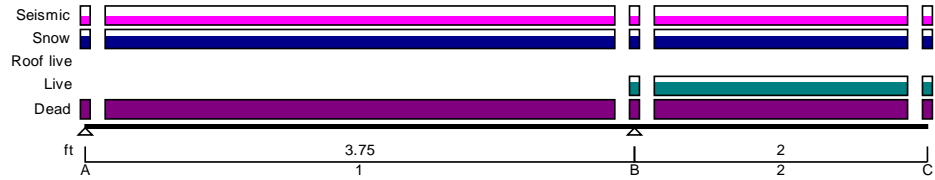
Load Combination 12 (shown in proportion)



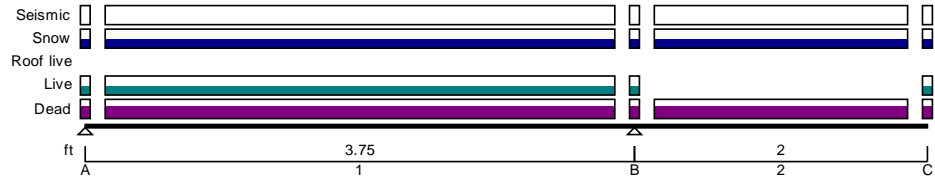
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)

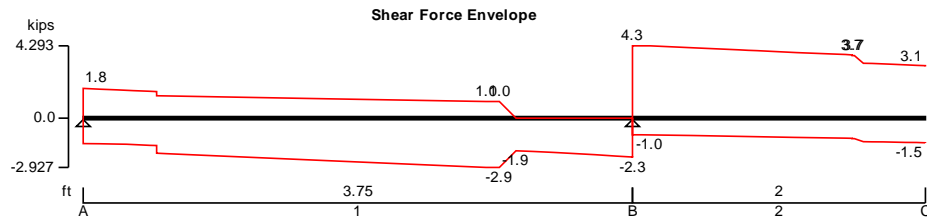
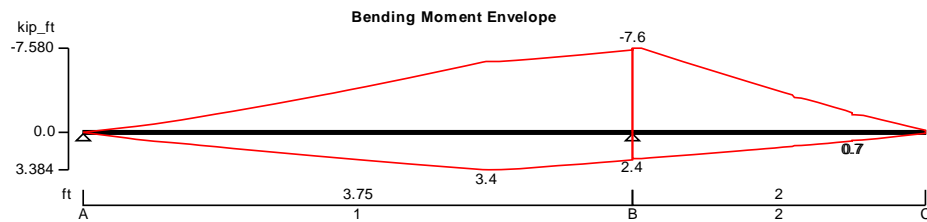
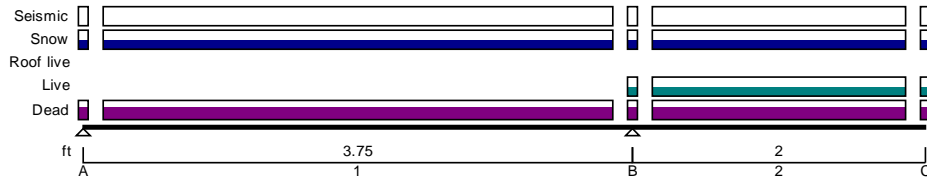




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Load Combination 16 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically free Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.301 kips/ft Live load - Live full UDL 0.034 kips/ft Roof live load - Roof live full UDL 0.233 kips/ft Dead load - Dead point load 0.4 kips at 6.00 in Live load - Live point load 0.7 kips at 6.00 in Dead load - Dead point load 0.4 kips at 63.00 in Live load - Live point load 0.7 kips at 63.00 in Dead load - Dead point load 1 kips at 69.00 in Seismic load - Seismic point load -2.76 kips at 33.00 in
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Seismic load - Seismic point load 2.76 kips at 69.00 in
Dead self weight of beam \times 1

Analysis results

Maximum moment

$M_{max} = 3.4$ kips_{ft}

$M_{min} = -7.6$ kips_{ft}

Maximum moment span 1

$M_{s1_max} = 3.4$ kips_{ft}

$M_{s1_min} = -7.6$ kips_{ft}

Maximum moment span 2

$M_{s2_max} = 2.4$ kips_{ft}

$M_{s2_min} = -7.6$ kips_{ft}

Maximum shear

$V_{max} = 4.3$ kips

$V_{min} = -2.9$ kips

Maximum shear span 1

$V_{s1_max} = 1.8$ kips

$V_{s1_min} = -2.9$ kips

Maximum shear span 2

$V_{s2_max} = 4.3$ kips

$V_{s2_min} = -1.5$ kips

Deflection

$\delta_{max} = 0$ in

$\delta_{min} = 0$ in

Deflection span 1

$\delta_{s1_max} = 0$ in

$\delta_{s1_min} = 0$ in

Deflection span 2

$\delta_{s2_max} = 0$ in

$\delta_{s2_min} = 0$ in

Maximum reaction at support A

$R_{A_max} = 1.8$ kips

$R_{A_min} = -1.5$ kips

Unfactored dead load reaction at support A

$R_{A_Dead} = 0.1$ kips

Unfactored live load reaction at support A

$R_{A_Live} = 0.4$ kips

Unfactored roof live load reaction at support A

$R_{A_Roof\ live} = 0.3$ kips

Unfactored seismic load reaction at support A

$R_{A_Seismic} = -2.2$ kips

Maximum reaction at support B

$R_{B_max} = 6$ kips

$R_{B_min} = 0.1$ kips

Unfactored dead load reaction at support B

$R_{B_Dead} = 3.6$ kips

Unfactored live load reaction at support B

$R_{B_Live} = 1.2$ kips

Unfactored roof live load reaction at support B

$R_{B_Roof\ live} = 1$ kips

Unfactored seismic load reaction at support B

$R_{B_Seismic} = 2.2$ kips

Maximum reaction at support C

$R_{C_max} = 0$ kips

$R_{C_min} = 0$ kips

Section details

Section type

W 10x30 (AISC 13th Edn 2005)

ASTM steel designation

A992

Steel yield stress

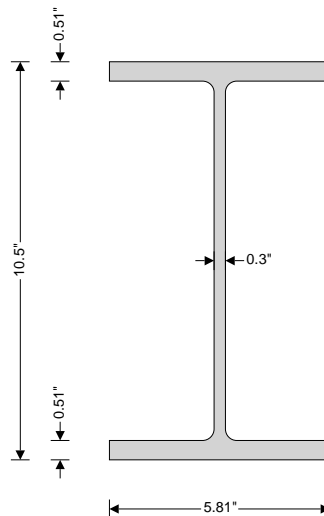
$F_y = 50$ ksi

Steel tensile stress

$F_u = 65$ ksi

Modulus of elasticity

$E = 29000$ ksi





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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only
Cantilever tip is free
Cantilever support is continuous with lateral and torsional restraint

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 4.293$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
Allowable shear strength	$V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 1 - Chapter F

Required flexural strength	$M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 7.58$ kips_ft
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Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1	$M_{nyld} = M_p = F_y \times Z_x = 152.5$ kips_ft
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Lateral-torsional buckling - Section F2.2

Unbraced length	$L_b = L_{s1} = 45$ in
Limiting unbraced length for yielding - eq F2-5	$L_p = 1.76 \times r_y \times \sqrt{E / F_y} = 58.069$ in
Distance between flange centroids	$h_o = d - t_f = 9.99$ in
	$c = 1$
	$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602$ in

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = 193.716 \text{ in}$$

Nominal flexural strength	$M_n = M_{nyld} = 152.500$ kips_ft
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Allowable flexural strength

$$M_c = M_n / \Omega_b = \mathbf{91.317 \text{ kips_ft}}$$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, 2 \times L_{s2} / 360) = \mathbf{0.133 \text{ in}}$$

Maximum deflection span 2

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.005 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit

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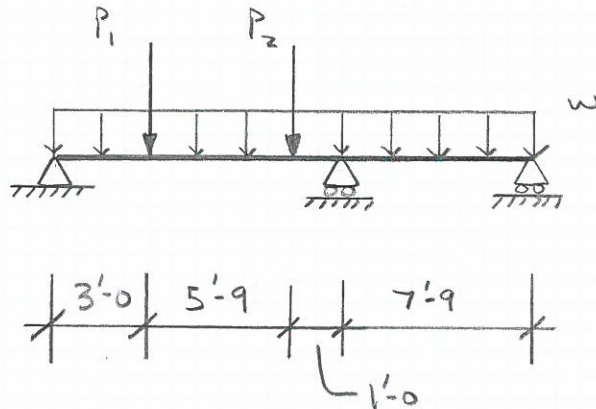
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PROJECT ODU SOLAR DECATHLON

SHEET NO. _____ OF _____ SHEETS

MODULE THREE

① BEAM No. 1



i) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (1.167') = 24 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (1.167') = 59 \text{ lb/ft}$$

$$P_{2D} = 20 \text{ PSF} (8.75') (10.167') / 2 = 890 \text{ lb}$$

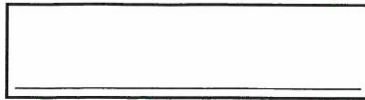
$$P_{2L} = 50 \text{ PSF} (8.75') (10.167') / 2 = 2224 \text{ lb}$$

ii) WALL

$$\text{DEAD LOAD} = 8 \text{ PSF} (10') = 80 \text{ lb/ft}$$

$$P_{1D} = 60 \text{ lb/ft} (15') = 900 \text{ lb}$$

$$P_{1RL} = 20 \text{ PSF} (0.75') (15') = 225 \text{ lb}$$



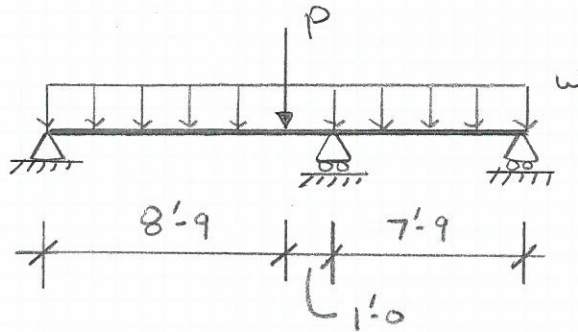
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PROJECT DDU SOLAR DECATILLO SHEET NO. _____ OF _____ SHEETS

MODULE THREE

② BEAM No. 2



i) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (1.167') = 24 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (1.167') = 59 \text{ lb/ft}$$

$$P_D = 890 \text{ lb}$$

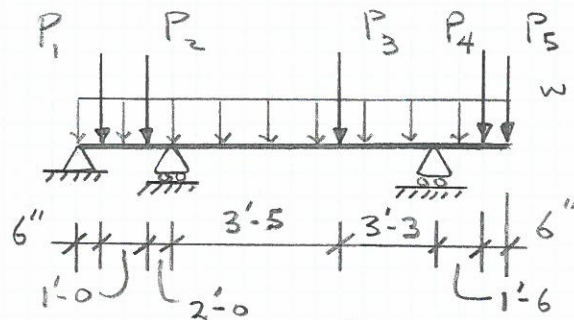
$$P_L = 2224 \text{ lb}$$

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PROJECT ODU SOLAR DECATILLOW SHEET NO. _____ OF _____ SHEETSMODULE THREE

③ BEAM No. 3



i) ROOF

$$\text{DEAD LOAD} = 19 \text{ PSF} (17.5'/2) = 167 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 20 \text{ PSF} (17.5'/2) = 175 \text{ lb/ft}$$

$$P_{1RL} = 225 \text{ lb}$$

$$P_{2D} = 315 \text{ lb}$$

$$P_{2RL} = 330 \text{ lb} + 225 \text{ lb} = 555 \text{ lb}$$

$$P_{3D} = 315 \text{ lb}$$

$$P_{3RL} = 330 \text{ lb}$$

ii) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (8.75'/2) = 88 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (8.75'/2) = 219 \text{ lb/ft}$$

$$P_{1D} = 175 \text{ lb}$$

$$P_{2D} = 330 \text{ lb} + 200 \text{ lb} = 530 \text{ lb}$$

$$P_{2L} = 2065 \text{ lb}$$

$$P_{4D} = 100 \text{ lb}$$

$$P_{4L} = 0 \text{ lb}$$

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③ CONT'D

$$P_{3D} = 330 \text{ lb}$$

$$P_{3L} = 2065 \text{ lb}$$

iii) WALL

$$\text{DEAD LOAD} = 8 \text{ PSF} (9.67') = 77 \text{ lb/ft}$$

$$P_{1D} = 1780 \text{ lb}$$

$$P_{2D} = 1780 \text{ lb}$$

$$P_{3D} = 430 \text{ lb}$$

iv) SEISMIC

$$P_{2EQ} = \frac{-1692 \text{ lb}}{0.7} = -2420 \text{ lb}$$

$$P_{3EQ} = \frac{1692 \text{ lb}}{0.7} = 2420 \text{ lb}$$

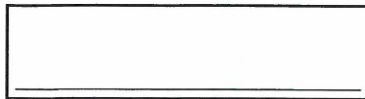
P_5 = REACTIONS FROM BEAM No. 3 OF MODULE FOUR

$$P_{5D} = 0.1 \text{ k}$$

$$P_{5L} = 0 \text{ k}$$

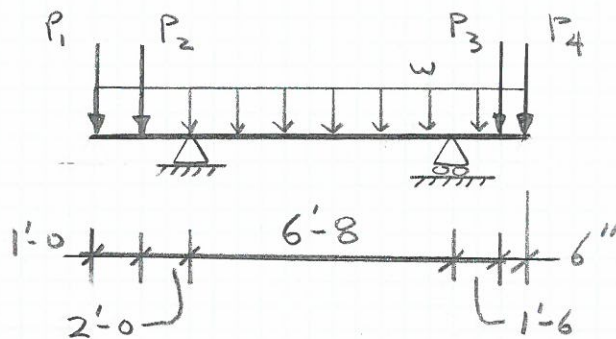
$$P_{5RL} = 0 \text{ k}$$

$$P_{5EQ} = -0.3 \text{ k} \quad (\text{INPUT AS POSITIVE VALUE})$$



MODULE THREE

④ BEAM No. 4



i) ROOF

DEAD LOAD = 19 PSF (17.5'/2) = 167 lb/ft ✓

LIVE LOAD = 20 PSF (17.5'/2) = 175 lb/ft ✓

$P_{1RL} = 175 \text{ lb}$ ✓

$P_{2RL} = 175 \text{ lb}$ ✓

ii) FLOOR

$P_{1D} = 400 \text{ lb}$ ✓

$P_{1L} = 200 \text{ lb}$ ✓

$P_{1RL} = 100 \text{ lb}$

$P_{2D} = 400 \text{ lb}$ ✓

$P_{2L} = 200 \text{ lb}$ ✓

$P_{2RL} = 100 \text{ lb}$ ✓

DEAD LOAD = 88 lb/ft ✓

LIVE LOAD = 219 lb/ft ✓

$P_{3D} = 300 \text{ lb}$ ✓

$P_{3L} = 300 \text{ lb}$ ✓

Architecture & Engineering

 ARCHITECTURAL MECHANICAL CIVIL ELECTRICAL STRUCTURALDATE 23 FEB 13COMPUTED BY ECWCOMM. NO. 4.0

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④ CONT'D

iii) WALL

$$\text{DEAD LOAD} = 8 \text{ PSF} (8.25') = 66 \text{ lb/ft} \quad /$$

$$P_{1D} = 800 \text{ lb}$$

$$P_{2D} = 800 \text{ lb}$$

iv) SEISMIC

$$P_{2EQ} = \frac{-1551 \text{ lb}}{0.7} = -2216 \text{ lb} \quad /$$

$$P_{3EQ} = \frac{1551 \text{ lb}}{0.7} = 2216 \text{ lb} \quad /$$

P_4 = REACTIONS FROM BEAM NO. 4 OF MODULE FOUR

$$P_{4D} = -0.2 \text{ k}$$

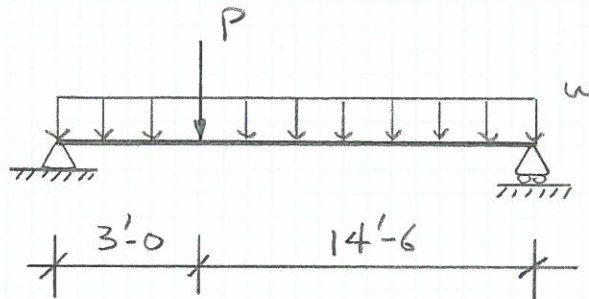
$$P_{4L} = 0.1 \text{ k}$$

$$P_{4RL} = -0.2 \text{ k}$$

$$P_{4EQ} = 0.9 \text{ k}$$

Architecture & Engineering ARCHITECTURAL MECHANICAL CIVIL ELECTRICAL STRUCTURALDATE 23 FEB 13 COMPUTED BY ECWCOMM. NO. 4.0 CHECKED BY _____PROJECT ODU SOLAR DECATHLON SHEET NO. _____ OF _____ SHEETSMODULE THREE

⑤ BEAM No. 5



i) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (1') = 20 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (1') = 50 \text{ lb/ft}$$

ii) WALL

$$\text{DEAD LOAD} = 8 \text{ PSF} (10') = 80 \text{ lb/ft}$$

$$P_D = 900 \text{ lb}$$

$$P_{RL} = 225 \text{ lb}$$



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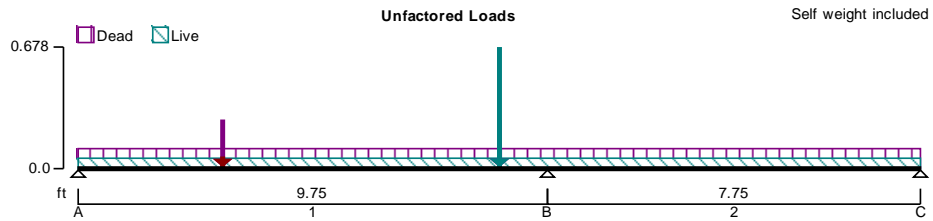
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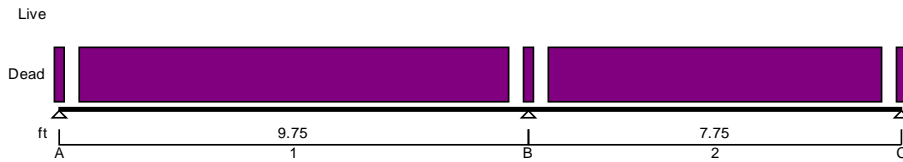
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

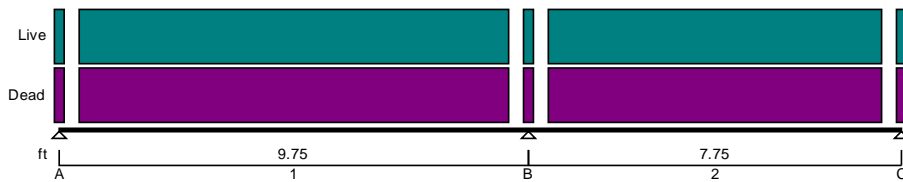
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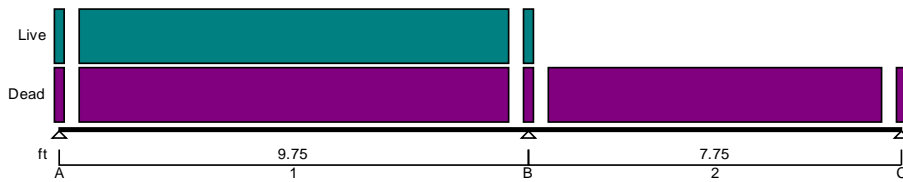
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)



Load Combination 3 (shown in proportion)

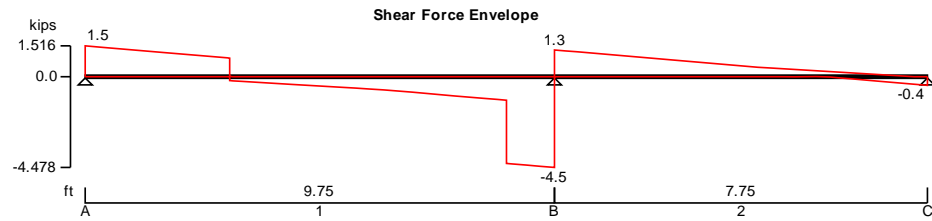
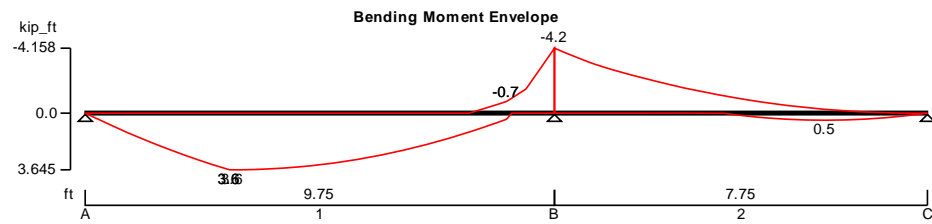
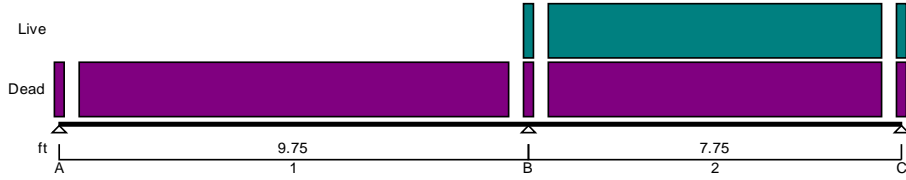




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Load Combination 4 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.112 kips/ft Live load - Live full UDL 0.059 kips/ft Dead self weight of beam × 1 Dead load - Dead point load 0.9 kips at 36.00 in Roof live load - Roof live point load 0.225 kips at 36.00 in Dead load - Dead point load 0.89 kips at 105.00 in Live load - Live point load 2.224 kips at 105.00 in
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Analysis results

Maximum moment	$M_{max} = 3.6$ kips_ft	$M_{min} = -4.2$ kips_ft
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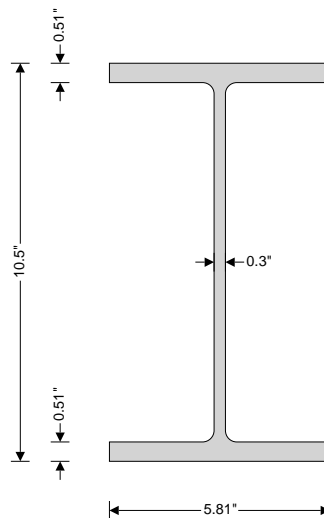
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Maximum moment span 1	$M_{s1_max} = 3.6$ kips_ft	$M_{s1_min} = -4.2$ kips_ft
Maximum moment span 2	$M_{s2_max} = 0.5$ kips_ft	$M_{s2_min} = -4.2$ kips_ft
Maximum shear	$V_{max} = 1.5$ kips	$V_{min} = -4.5$ kips
Maximum shear span 1	$V_{s1_max} = 1.5$ kips	$V_{s1_min} = -4.5$ kips
Maximum shear span 2	$V_{s2_max} = 1.3$ kips	$V_{s2_min} = -0.4$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 1.5$ kips	$R_{A_min} = 1.1$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = 1.1$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 0.3$ kips	
Unfactored roof live load reaction at support A	$R_{A_Roof\ live} = 0.1$ kips	
Maximum reaction at support B	$R_{B_max} = 5.8$ kips	$R_{B_min} = 2.9$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 2.9$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 2.9$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 0.1$ kips	
Maximum reaction at support C	$R_{C_max} = 0.4$ kips	$R_{C_min} = 0$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 0.2$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 0$ kips	
Unfactored roof live load reaction at support C	$R_{C_Roof\ live} = 0$ kips	

Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
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Safety factor for tensile rupture $\Omega_{tr} = 2.00$
 Safety factor for compression $\Omega_c = 1.67$
 Safety factor for flexure $\Omega_b = 1.67$
 Safety factor for shear $\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
 Span 2 has lateral bracing at supports only

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio $b_f / (2 \times t_f) = 5.70$
 Limiting ratio for compact section $\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$
 Limiting ratio for non-compact section $\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$ Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio $(d - 2 \times k) / t_w = 29.60$
 Limiting ratio for compact section $\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$
 Limiting ratio for non-compact section $\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$ Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength $V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 4.478$ kips
 Web area $A_w = d \times t_w = 3.15$ in²
 Web plate buckling coefficient $k_v = 5$
 Web shear coefficient - eq G2-2 $C_v = 1.000$
 Nominal shear strength - eq G2-1 $V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
 Allowable shear strength $V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 1 - Chapter F

Required flexural strength $M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 4.158$ kips_ft

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = 152.5$ kips_ft

Lateral-torsional buckling - Section F2.2

Unbraced length $L_b = L_{s1} = 117$ in
 Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 \times r_y \times \sqrt{E / F_y} = 58.069$ in
 Distance between flange centroids $h_o = d - t_f = 9.99$ in
 $c = 1$
 $r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602$ in

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = 193.716 \text{ in}$$

Cross-section mono-symmetry parameter $R_m = 1.000$
 Moment at quarter point of segment $M_A = 3.099$ kips_ft
 Moment at center-line of segment $M_B = 3.316$ kips_ft
 Moment at three quarter point of segment $M_C = 1.831$ kips_ft
 Maximum moment in segment $M_{\text{abs}} = 4.158$ kips_ft



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Lateral torsional buckling modification factor - eq F1-1 $C_b = 12.5 \times M_{abs} / [2.5 \times M_{abs} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = \mathbf{1.352}$
 Nominal flexural strength for lateral torsional buckling - eq F2-2 $M_{nlb} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] = \mathbf{172.09 \text{ kips_ft}}$
 Nominal flexural strength $M_n = \min(M_{nyld}, M_{nlb}) = \mathbf{152.500 \text{ kips_ft}}$
 Allowable flexural strength $M_c = M_n / \Omega_b = \mathbf{91.317 \text{ kips_ft}}$
PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection $\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = \mathbf{0.325 \text{ in}}$

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.012 \text{ in}}$

PASS - Maximum deflection does not exceed deflection limit



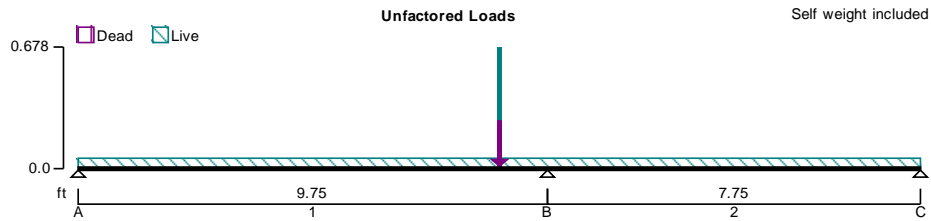
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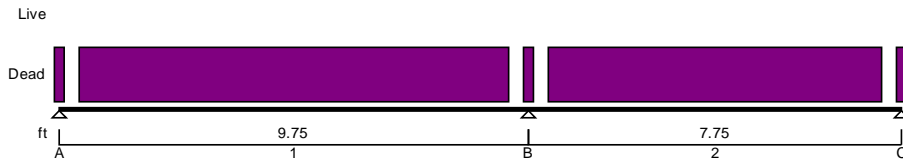
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

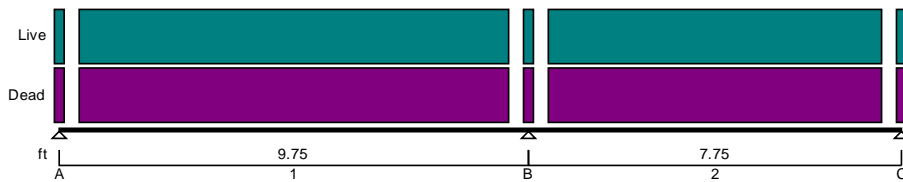
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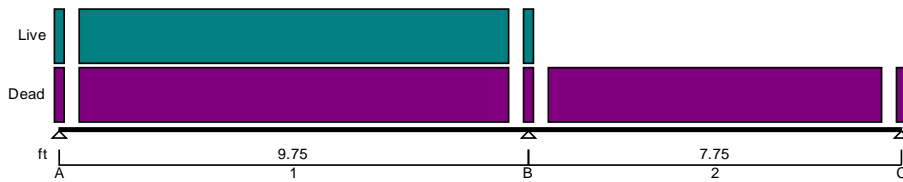
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)



Load Combination 3 (shown in proportion)

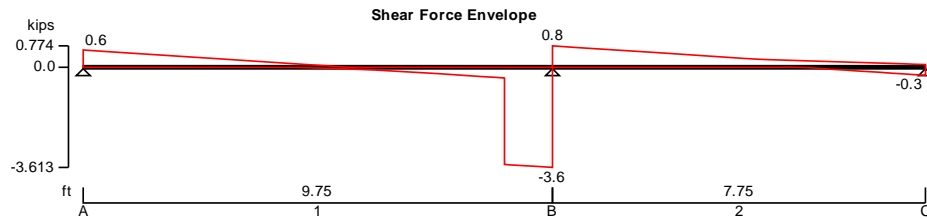
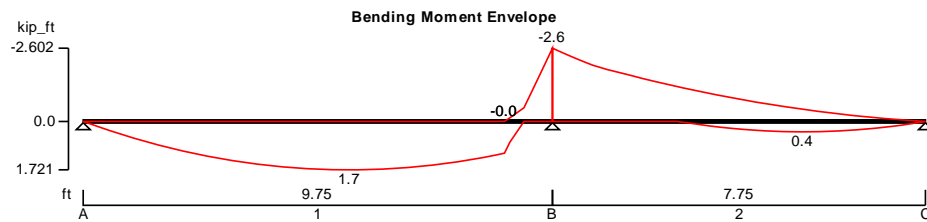
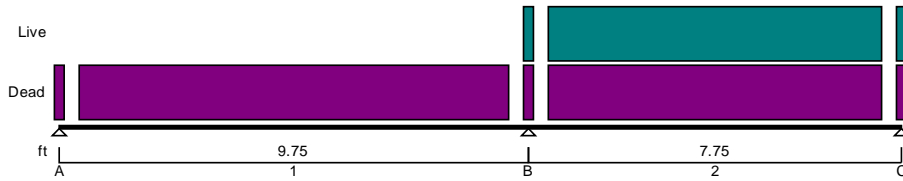




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Load Combination 4 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.024 kips/ft Live load - Live full UDL 0.059 kips/ft Live load - Live point load 2.224 kips at 105.00 in Dead load - Dead point load 0.89 kips at 105.00 in Dead self weight of beam \times 1
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Analysis results

Maximum moment	$M_{max} = 1.7$ kips_ft	$M_{min} = -2.6$ kips_ft
Maximum moment span 1	$M_{s1_max} = 1.7$ kips_ft	$M_{s1_min} = -2.6$ kips_ft
Maximum moment span 2	$M_{s2_max} = 0.4$ kips_ft	$M_{s2_min} = -2.6$ kips_ft



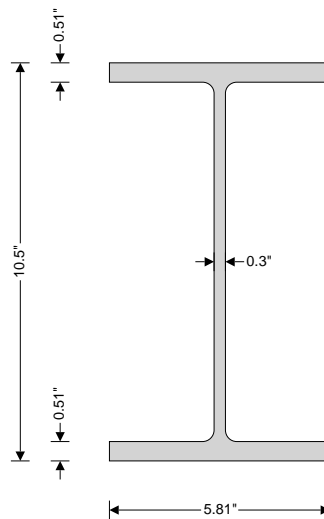
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Maximum shear	$V_{max} = 0.8$ kips	$V_{min} = -3.6$ kips
Maximum shear span 1	$V_{s1_max} = 0.6$ kips	$V_{s1_min} = -3.6$ kips
Maximum shear span 2	$V_{s2_max} = 0.8$ kips	$V_{s2_min} = -0.3$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 0.6$ kips	$R_{A_min} = 0.2$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = 0.3$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 0.3$ kips	
Maximum reaction at support B	$R_{B_max} = 4.4$ kips	$R_{B_min} = 1.5$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 1.5$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 2.9$ kips	
Maximum reaction at support C	$R_{C_max} = 0.3$ kips	$R_{C_min} = -0.1$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 0.1$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 0$ kips	

Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$



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Lateral bracing

Span 1 has lateral bracing at supports only

Span 2 has lateral bracing at supports only

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio $b_f / (2 \times t_f) = 5.70$
 Limiting ratio for compact section $\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$
 Limiting ratio for non-compact section $\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$ Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio $(d - 2 \times k) / t_w = 29.60$
 Limiting ratio for compact section $\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$
 Limiting ratio for non-compact section $\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$ Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength $V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 3.613$ kips
 Web area $A_w = d \times t_w = 3.15$ in²
 Web plate buckling coefficient $k_v = 5$
 Web shear coefficient - eq G2-2 $C_v = 1.000$
 Nominal shear strength - eq G2-1 $V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
 Allowable shear strength $V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 1 - Chapter F

Required flexural strength $M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 2.602$ kips_ft

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = 152.5$ kips_ft

Lateral-torsional buckling - Section F2.2

Unbraced length $L_b = L_{s1} = 117$ in
 Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 \times r_y \times \sqrt{E / F_y} = 58.069$ in
 Distance between flange centroids $h_o = d - t_f = 9.99$ in
 $c = 1$
 $r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602$ in

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + ((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)]} = 193.716 \text{ in}$$

Cross-section mono-symmetry parameter $R_m = 1.000$

Moment at quarter point of segment $M_A = 1.185$ kips_ft

Moment at center-line of segment $M_B = 1.698$ kips_ft

Moment at three quarter point of segment $M_C = 1.539$ kips_ft

Maximum moment in segment $M_{\text{abs}} = 2.602$ kips_ft

Lateral torsional buckling modification factor - eq F1-1 $C_b = 12.5 \times M_{\text{abs}} / [2.5 \times M_{\text{abs}} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = 1.515$

Nominal flexural strength for lateral torsional buckling - eq F2-2 $M_{nlbt} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] = 192.852$ kips_ft

Nominal flexural strength $M_n = \min(M_{nyld}, M_{nlbt}) = 152.500$ kips_ft



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Allowable flexural strength

$$M_c = M_n / \Omega_b = \mathbf{91.317 \text{ kips_ft}}$$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = \mathbf{0.325 \text{ in}}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.006 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit



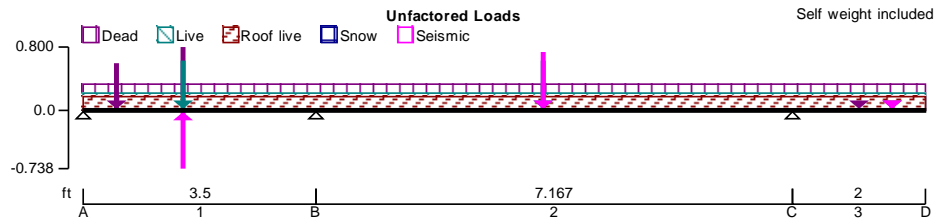
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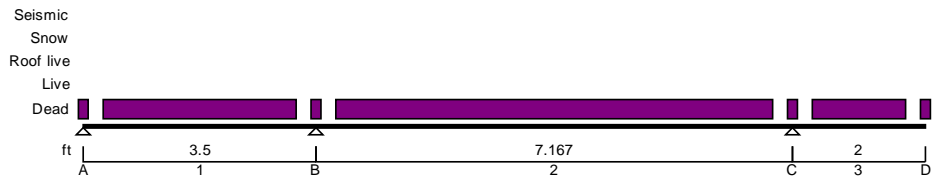
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

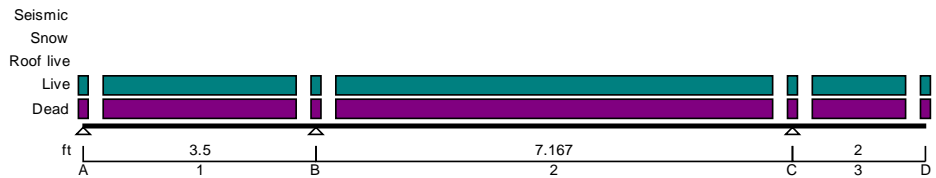
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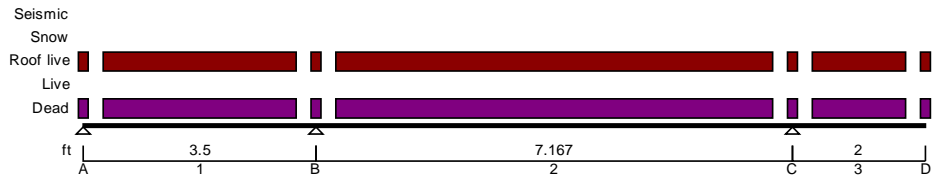
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)

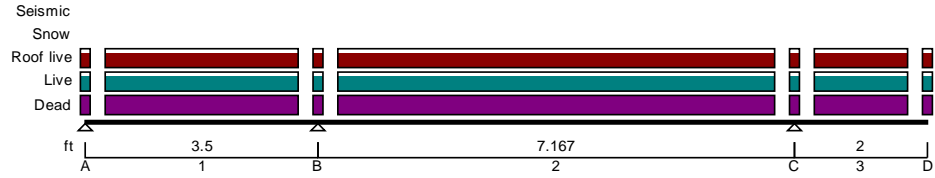


Load Combination 3 (shown in proportion)

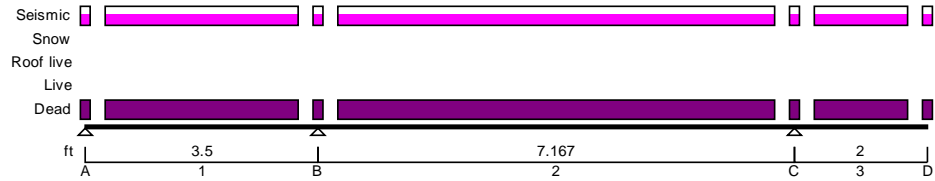


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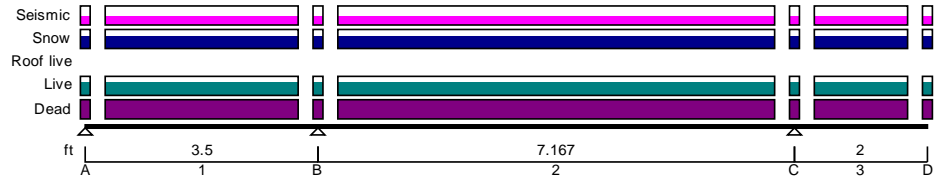
Load Combination 4 (shown in proportion)



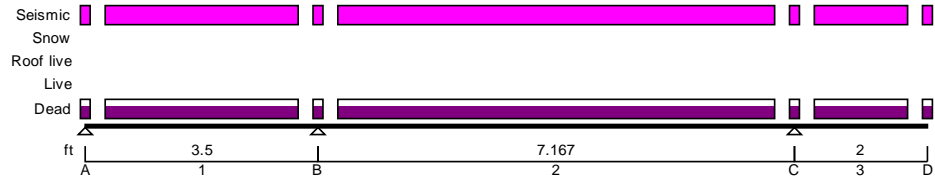
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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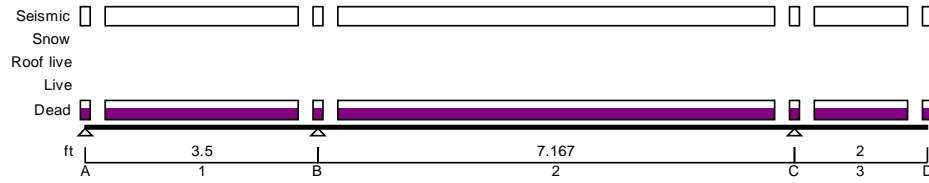
Job Ref.

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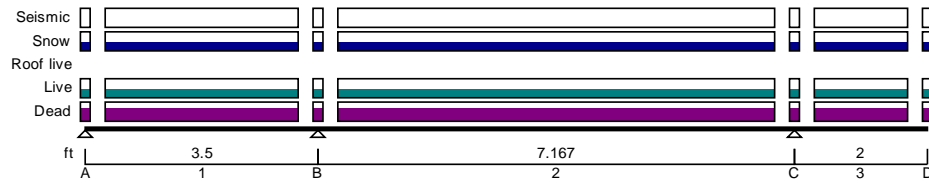
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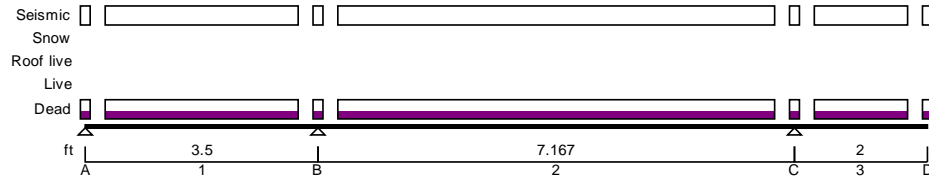
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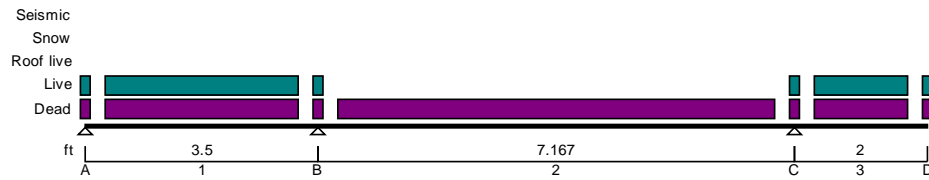
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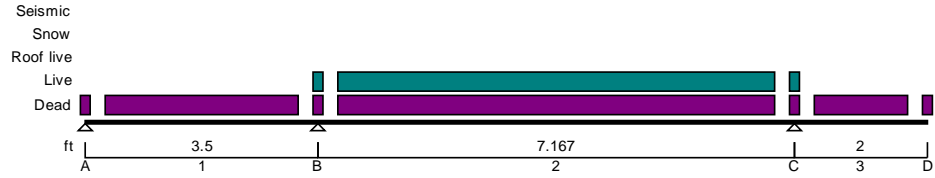
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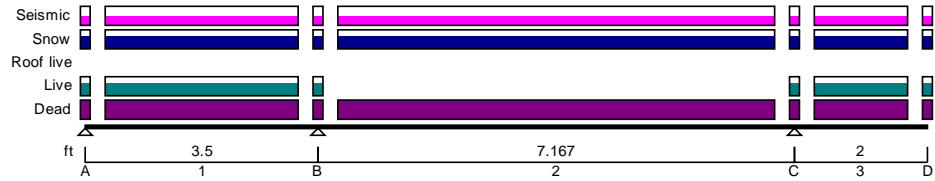
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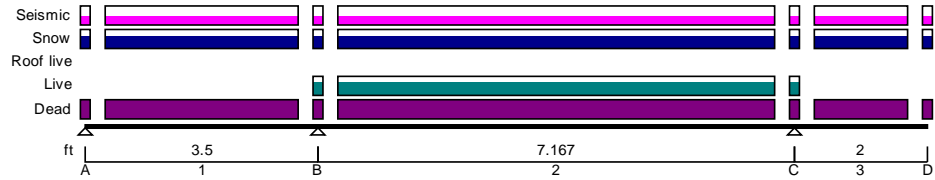
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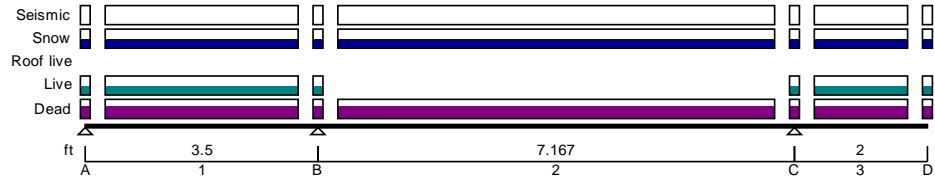
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)

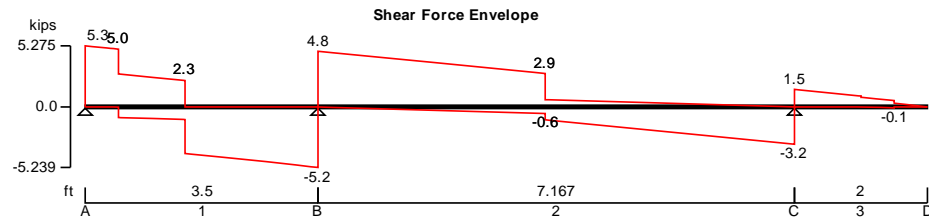
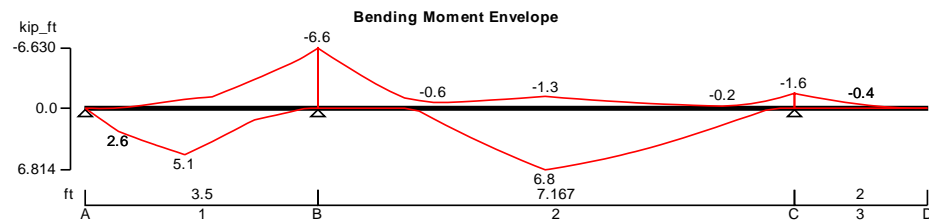
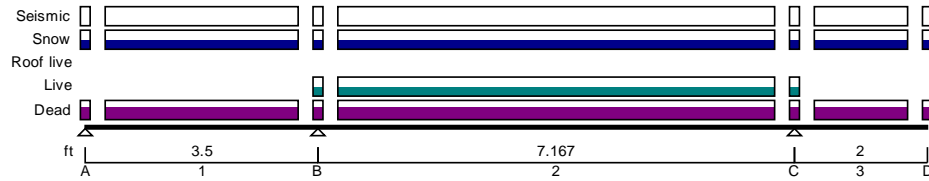




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Load Combination 16 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free
Support D	Vertically free Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.332 kips/ft Live load - Live full UDL 0.219 kips/ft Roof live load - Roof live point load 0.225 kips at 6.00 in Dead load - Dead point load 2.625 kips at 18.00 in Roof live load - Roof live point load 0.555 kips at 18.00 in Dead load - Dead point load 1.075 kips at 83.00 in Roof live load - Roof live point load 0.33 kips at 83.00 in
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Roof live load - Roof live full UDL 0.175 kips/ft
 Dead self weight of beam \times 1
 Dead load - Dead point load 1.955 kips at 6.00 in
 Live load - Live point load 2.065 kips at 18.00 in
 Dead load - Dead point load 0.1 kips at 140.00 in
 Live load - Live point load 2.065 kips at 83.00 in
 EQ 1 - Seismic point load -2.42 kips at 18.00 in
 EQ 2 - Seismic point load 2.42 kips at 83.00 in
 Dead load - Dead point load 0.1 kips at 146.00 in
 Seismic load - Seismic point load 0.3 kips at 146.00 in

Analysis results

Maximum moment	$M_{max} = 6.8$ kips _{ft}	$M_{min} = -6.6$ kips _{ft}
Maximum moment span 1	$M_{s1_max} = 5.1$ kips _{ft}	$M_{s1_min} = -6.6$ kips _{ft}
Maximum moment span 2	$M_{s2_max} = 6.8$ kips _{ft}	$M_{s2_min} = -6.6$ kips _{ft}
Maximum moment span 3	$M_{s3_max} = 0$ kips _{ft}	$M_{s3_min} = -1.6$ kips _{ft}
Maximum shear	$V_{max} = 5.3$ kips	$V_{min} = -5.2$ kips
Maximum shear span 1	$V_{s1_max} = 5.3$ kips	$V_{s1_min} = -5.2$ kips
Maximum shear span 2	$V_{s2_max} = 4.8$ kips	$V_{s2_min} = -3.2$ kips
Maximum shear span 3	$V_{s3_max} = 1.5$ kips	$V_{s3_min} = -0.1$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Deflection span 3	$\delta_{s3_max} = 0$ in	$\delta_{s3_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 5.3$ kips	$R_{A_min} = 0.1$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = 2.9$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 0.6$ kips	
Unfactored roof live load reaction at support A	$R_{A_Roof\ live} = 0.5$ kips	
Unfactored seismic load reaction at support A	$R_{A_Seismic} = -1.8$ kips	
Maximum reaction at support B	$R_{B_max} = 9.8$ kips	$R_{B_min} = 1.7$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 5.1$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 4.4$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 1.8$ kips	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = 0.8$ kips	
Maximum reaction at support C	$R_{C_max} = 4.7$ kips	$R_{C_min} = 0.2$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 2.4$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 1.8$ kips	
Unfactored roof live load reaction at support C	$R_{C_Roof\ live} = 1$ kips	
Unfactored seismic load reaction at support C	$R_{C_Seismic} = 1.3$ kips	
Maximum reaction at support D	$R_{D_max} = 0$ kips	$R_{D_min} = 0$ kips

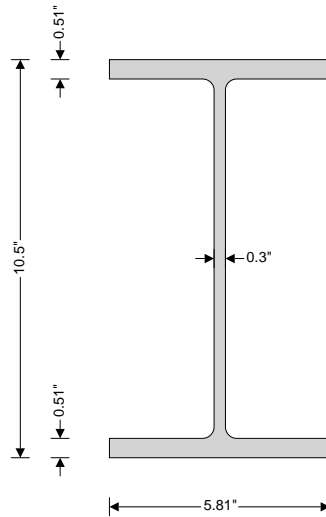
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

- Span 1 has lateral bracing at supports only
- Span 2 has lateral bracing at supports only
- Span 3 has lateral bracing at supports only
- Cantilever tip is free
- Cantilever support is continuous with lateral and torsional restraint

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 5.275$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$



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Nominal shear strength - eq G2-1

$$V_n = 0.6 \times F_y \times A_w \times C_v = \mathbf{94.500 \text{ kips}}$$

Allowable shear strength

$$V_c = V_n / \Omega_v = \mathbf{63.000 \text{ kips}}$$

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 2 - Chapter F

Required flexural strength

$$M_r = \max(\text{abs}(M_{s2_max}), \text{abs}(M_{s2_min})) = \mathbf{6.814 \text{ kips_ft}}$$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1

$$M_{nyld} = M_p = F_y \times Z_x = \mathbf{152.5 \text{ kips_ft}}$$

Lateral-torsional buckling - Section F2.2

Unbraced length

$$L_b = L_{s2} = \mathbf{86.004 \text{ in}}$$

Limiting unbraced length for yielding - eq F2-5

$$L_p = 1.76 \times r_y \times \sqrt{[E / F_y]} = \mathbf{58.069 \text{ in}}$$

Distance between flange centroids

$$h_o = d - t_f = \mathbf{9.99 \text{ in}}$$

$$c = \mathbf{1}$$

$$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = \mathbf{1.602 \text{ in}}$$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = \mathbf{193.716 \text{ in}}$$

Cross-section mono-symmetry parameter

$$R_m = \mathbf{1.000}$$

Moment at quarter point of segment

$$M_A = \mathbf{1.374 \text{ kips_ft}}$$

Moment at center-line of segment

$$M_B = \mathbf{6.621 \text{ kips_ft}}$$

Moment at three quarter point of segment

$$M_C = \mathbf{3.560 \text{ kips_ft}}$$

Maximum moment in segment

$$M_{abs} = \mathbf{6.814 \text{ kips_ft}}$$

Lateral torsional buckling modification factor - eq F1-1

$$C_b = 12.5 \times M_{abs} / [2.5 \times M_{abs} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = \mathbf{1.460}$$

Nominal flexural strength for lateral torsional buckling - eq F2-2

$$M_{nlbt} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] =$$

$$\mathbf{205.281 \text{ kips_ft}}$$

Nominal flexural strength

$$M_n = \min(M_{nyld}, M_{nlbt}) = \mathbf{152.500 \text{ kips_ft}}$$

Allowable flexural strength

$$M_c = M_n / \Omega_b = \mathbf{91.317 \text{ kips_ft}}$$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, L_{s2} / 360) = \mathbf{0.239 \text{ in}}$$

Maximum deflection span 2

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.008 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit



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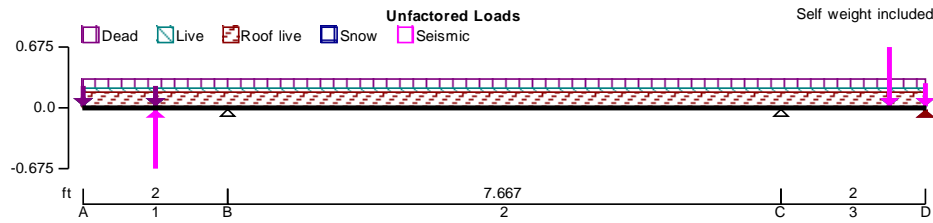
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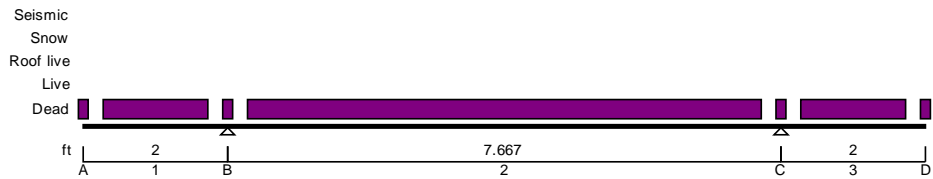
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

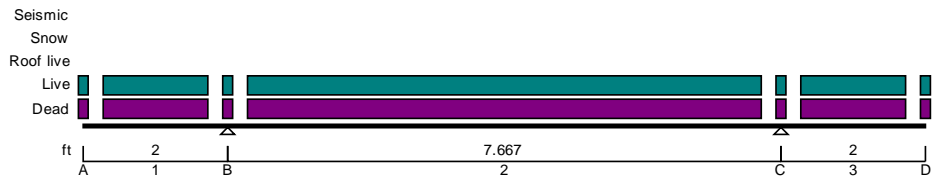
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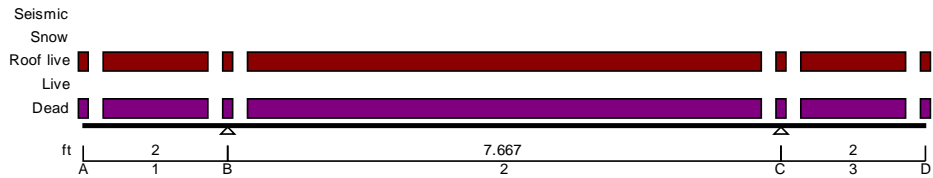
Load Combination 1 (shown in proportion)



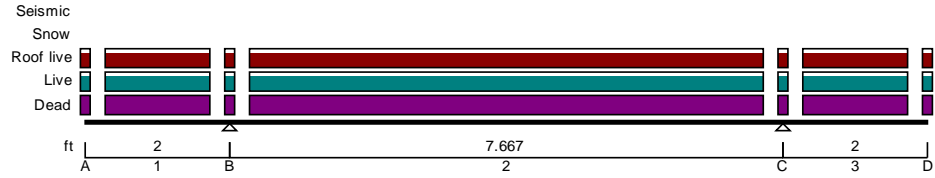
Load Combination 2 (shown in proportion)



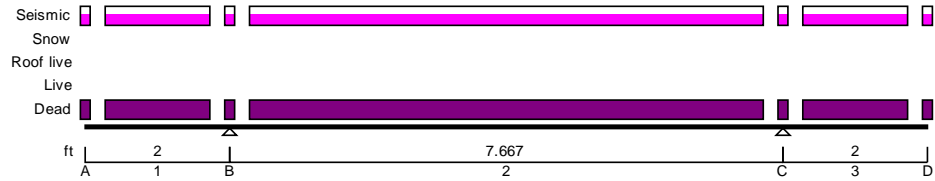
Load Combination 3 (shown in proportion)



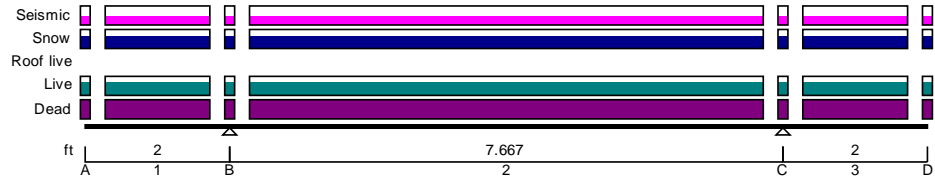
Load Combination 4 (shown in proportion)



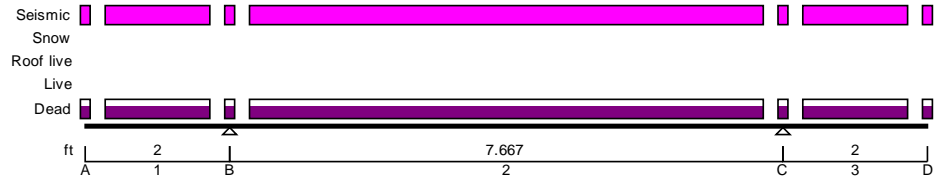
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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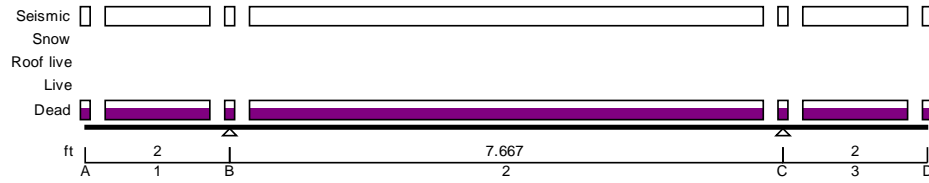
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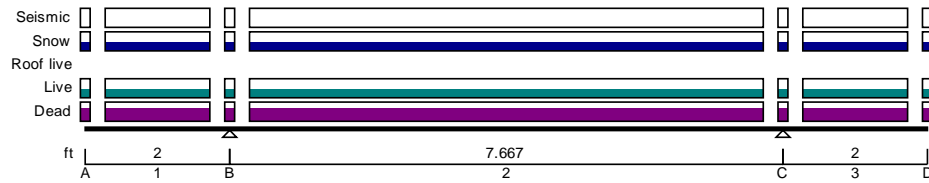
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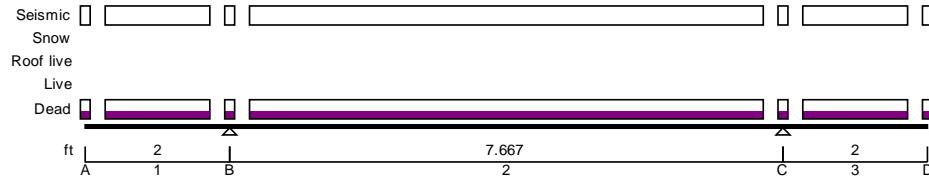
Load Combination 8 (shown in proportion)



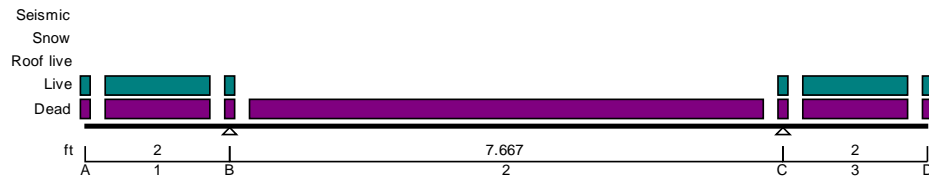
Load Combination 9 (shown in proportion)



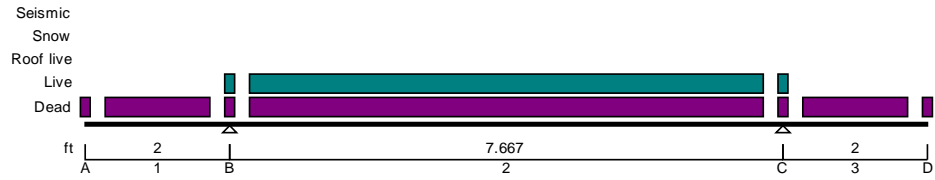
Load Combination 10 (shown in proportion)



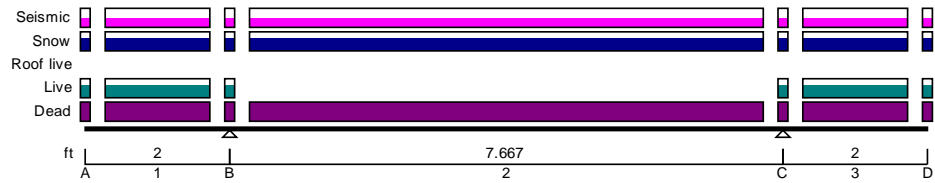
Load Combination 11 (shown in proportion)



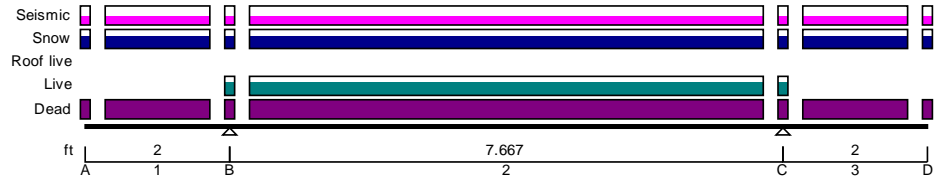
Load Combination 12 (shown in proportion)



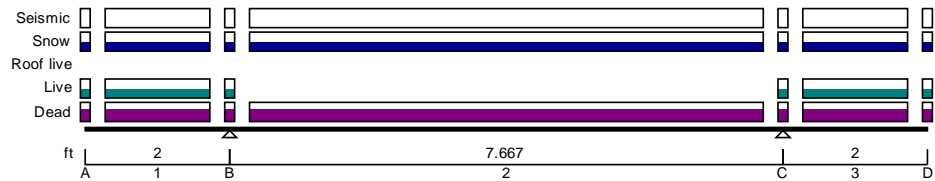
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)





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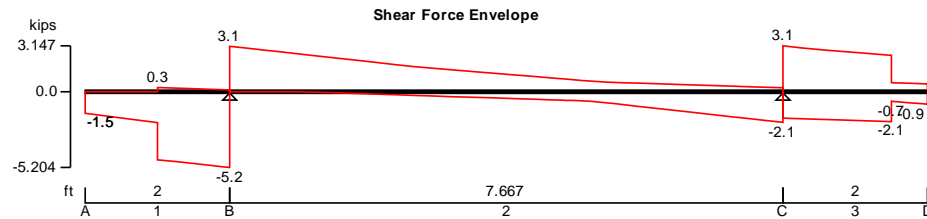
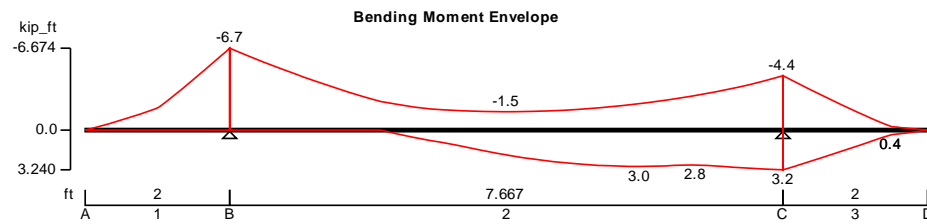
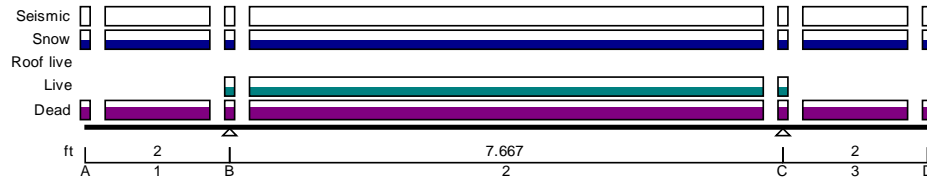
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Load Combination 16 (shown in proportion)



Support conditions

- | | |
|-----------|--|
| Support A | Vertically free
Rotationally free |
| Support B | Vertically restrained
Rotationally free |
| Support C | Vertically restrained
Rotationally free |
| Support D | Vertically free
Rotationally free |

Applied loading

- Beam loads
- Dead load - Dead full UDL 0.321 kips/ft
 - Live load - Live full UDL 0.219 kips/ft
 - Roof live load - Roof live full UDL 0.175 kips/ft
 - Roof live load - Roof live point load 0.175 kips at 0.00 in
 - Roof live load - Roof live point load 0.275 kips at 12.00 in
 - Dead load - Dead point load 0.4 kips at 0.00 in
 - Live load - Live point load 0.2 kips at 0.00 in



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Dead load - Dead point load 0.4 kips at 12.00 in
Dead self weight of beam \times 1
Live load - Live point load 0.2 kips at 12.00 in
Dead load - Dead point load 0.3 kips at 134.00 in
Live load - Live point load 0.3 kips at 134.00 in
Dead load - Dead point load 0.8 kips at 0.00 in
Dead load - Dead point load 0.8 kips at 12.00 in
EQ 1 - Seismic point load -2.216 kips at 12.00 in
EQ 2 - Seismic point load 2.216 kips at 134.00 in
Dead load - Dead point load -0.2 kips at 140.00 in
Live load - Live point load 0.1 kips at 140.00 in
Roof live load - Roof live point load -0.2 kips at 140.00 in
Seismic load - Seismic point load 0.9 kips at 140.00 in

Analysis results

Maximum moment	$M_{max} = 3.2$ kips_ft	$M_{min} = -6.7$ kips_ft
Maximum moment span 1	$M_{s1_max} = 0$ kips_ft	$M_{s1_min} = -6.7$ kips_ft
Maximum moment span 2	$M_{s2_max} = 3.2$ kips_ft	$M_{s2_min} = -6.7$ kips_ft
Maximum moment span 3	$M_{s3_max} = 3.2$ kips_ft	$M_{s3_min} = -4.4$ kips_ft
Maximum shear	$V_{max} = 3.1$ kips	$V_{min} = -5.2$ kips
Maximum shear span 1	$V_{s1_max} = 0.3$ kips	$V_{s1_min} = -5.2$ kips
Maximum shear span 2	$V_{s2_max} = 3.1$ kips	$V_{s2_min} = -2.1$ kips
Maximum shear span 3	$V_{s3_max} = 3.1$ kips	$V_{s3_min} = -2.1$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Deflection span 3	$\delta_{s3_max} = 0$ in	$\delta_{s3_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 0$ kips	$R_{A_min} = 0$ kips
Maximum reaction at support B	$R_{B_max} = 8.3$ kips	$R_{B_min} = 0$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 4.9$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 1.7$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 1.6$ kips	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = -3.2$ kips	
Maximum reaction at support C	$R_{C_max} = 5.3$ kips	$R_{C_min} = -2.1$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 1.7$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 1.7$ kips	
Unfactored roof live load reaction at support C	$R_{C_Roof\ live} = 0.7$ kips	
Unfactored seismic load reaction at support C	$R_{C_Seismic} = 4.1$ kips	
Maximum reaction at support D	$R_{D_max} = 0$ kips	$R_{D_min} = 0$ kips

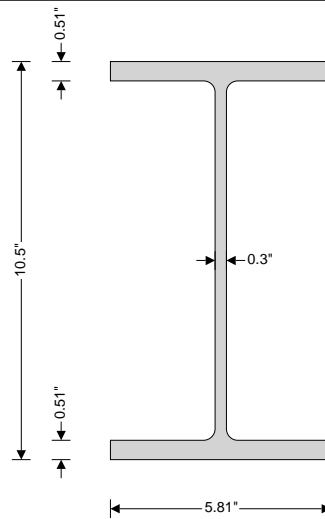
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only
Span 3 has lateral bracing at supports only
Cantilever tip is free
Cantilever support is continuous with lateral and torsional restraint

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 5.204$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips



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Allowable shear strength

$$V_c = V_n / \Omega_v = \mathbf{63.000 \text{ kips}}$$

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 1 - Chapter F

Required flexural strength

$$M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = \mathbf{6.674 \text{ kips_ft}}$$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1

$$M_{nyld} = M_p = F_y \times Z_x = \mathbf{152.5 \text{ kips_ft}}$$

Lateral-torsional buckling - Section F2.2

Unbraced length

$$L_b = L_{s1} = \mathbf{24 \text{ in}}$$

Limiting unbraced length for yielding - eq F2-5

$$L_p = 1.76 \times r_y \times \sqrt{E / F_y} = \mathbf{58.069 \text{ in}}$$

Distance between flange centroids

$$h_o = d - t_f = \mathbf{9.99 \text{ in}}$$

$$c = \mathbf{1}$$

$$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = \mathbf{1.602 \text{ in}}$$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = \mathbf{193.716 \text{ in}}$$

Nominal flexural strength

$$M_n = M_{nyld} = \mathbf{152.500 \text{ kips_ft}}$$

Allowable flexural strength

$$M_c = M_n / \Omega_b = \mathbf{91.317 \text{ kips_ft}}$$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, 2 \times L_{s1} / 360) = \mathbf{0.133 \text{ in}}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.006 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit



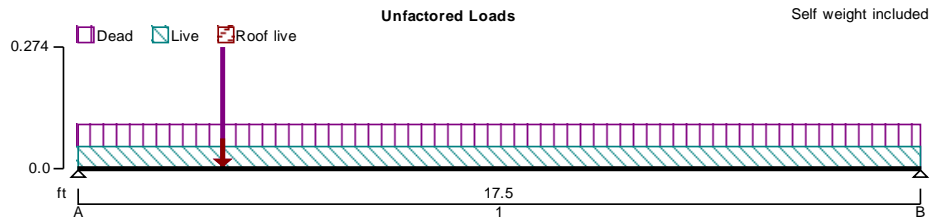
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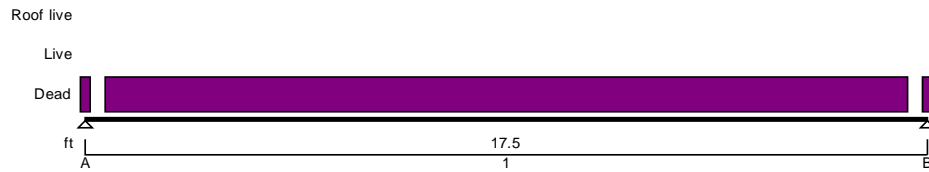
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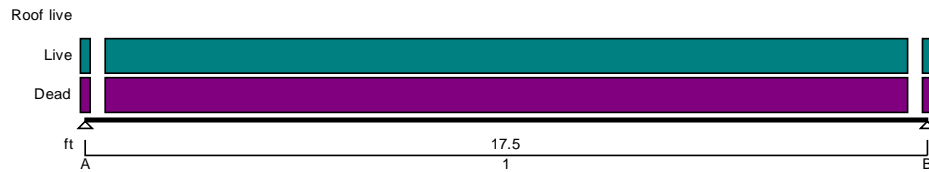
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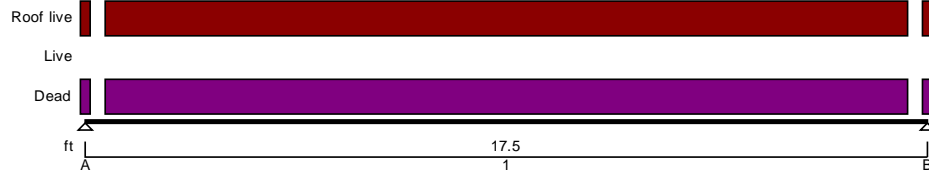
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)



Load Combination 3 (shown in proportion)





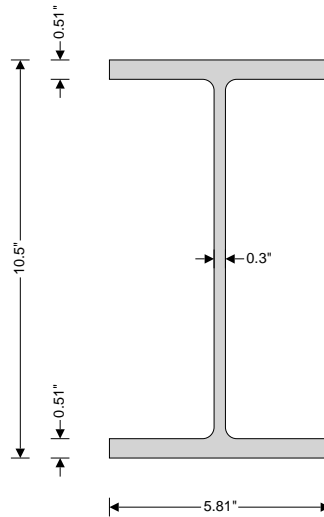
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Unfactored live load reaction at support A	$R_{A_Live} = 0.4$ kips	
Unfactored roof live load reaction at support A	$R_{A_Roof\ live} = 0.2$ kips	
Maximum reaction at support B	$R_{B_max} = 1.7$ kips	$R_{B_min} = 1.3$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 1.3$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 0.4$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 0$ kips	

Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has continuous lateral bracing

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$
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Limiting ratio for compact section $\lambda_{pwf} = 3.76 \times \sqrt{[E / F_y]} = \mathbf{90.55}$
 Limiting ratio for non-compact section $\lambda_{rnf} = 5.70 \times \sqrt{[E / F_y]} = \mathbf{137.27}$ Compact
Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength $V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = \mathbf{2.352}$ kips
 Web area $A_w = d \times t_w = \mathbf{3.15}$ in²
 Web plate buckling coefficient $k_v = \mathbf{5}$
 Web shear coefficient - eq G2-2 $C_v = \mathbf{1.000}$
 Nominal shear strength - eq G2-1 $V_n = 0.6 \times F_y \times A_w \times C_v = \mathbf{94.500}$ kips
 Allowable shear strength $V_c = V_n / \Omega_v = \mathbf{63.000}$ kips
PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis - Chapter F

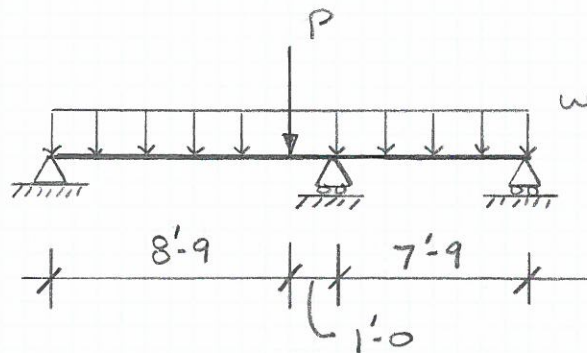
Required flexural strength $M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = \mathbf{8.31}$ kips_ft
Yielding - Section F2.1
 Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = \mathbf{152.5}$ kips_ft
 Nominal flexural strength $M_n = M_{nyld} = \mathbf{152.500}$ kips_ft
 Allowable flexural strength $M_c = M_n / \Omega_b = \mathbf{91.317}$ kips_ft
PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads
 Limiting deflection $\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = \mathbf{0.583}$ in
 Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{\max}), \text{abs}(\delta_{\min})) = \mathbf{0.099}$ in
PASS - Maximum deflection does not exceed deflection limit

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① BEAM No. 1



i) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (1.167') = 24 \text{ lb/ft}$$

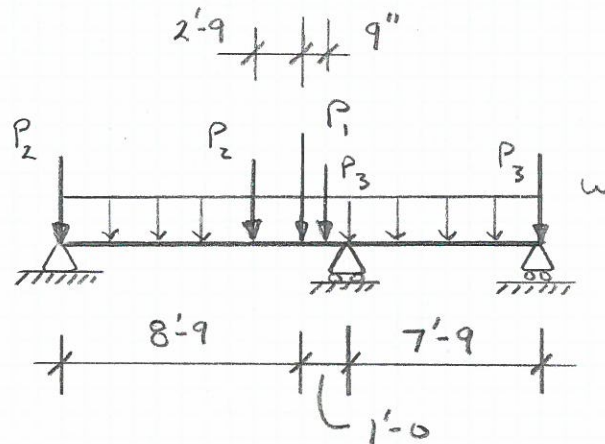
$$\text{LIVE LOAD} = 50 \text{ PSF} (1.167') = 59 \text{ lb/ft}$$

$$P_D = 955 \text{ lb}$$

$$P_L = 2390 \text{ lb}$$

DATE 22 FEB 13 COMPUTED BY ECWCOMM. NO. 4.0 CHECKED BY _____PROJECT ODU SOLAR DECATHLON SHEET NO. _____ OF _____ SHEETSMODULE FOUR

② BEAM No. 2



i) ROOF

$$\text{DEAD LOAD} = 19 \text{ PSF} (1.167') = 22 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 20 \text{ PSF} (1.167') = 23 \text{ lb/ft}$$

ii) FLOOR

$$\text{DEAD LOAD} = 24 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 59 \text{ lb/ft}$$

$$P_0 = 955 \text{ lb}$$

$$P_L = 2390 \text{ lb}$$

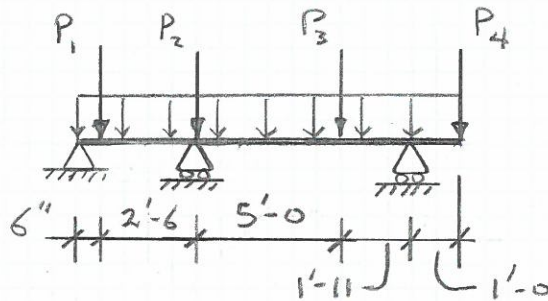
iii) WALL

$$\text{DEAD LOAD} = 8 \text{ PSF} (9') = 72 \text{ lb/ft}$$

$$P_{2EQ} = P_{3EQ} = \frac{1575 \text{ lb}}{0.7} = 2250 \text{ lb}, -2250 \text{ lb}$$

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③ BEAM No. 3



i) ROOF

$$\text{DEAD LOAD} = 19 \text{ PSF} (23.25'/2) = 221 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 20 \text{ PSF} (23.25'/2) = 233 \text{ lb/ft}$$

ii) FLOOR

$$\text{DEAD LOAD} = 20 \text{ PSF} (8.75'/2) = 88 \text{ lb/ft}$$

$$\text{LIVE LOAD} = 50 \text{ PSF} (8.75'/2) = 219 \text{ lb/ft}$$

iii) WALL

$$\text{DEAD LOAD} = 8 \text{ PSF} (9.67') = 77 \text{ lb/ft}$$

$$P_{1D} = 0.1 \text{ k}$$

$$P_{1L} = 0 \text{ k}$$

$$P_{4D} = 0.3 \text{ k}$$

$$P_{4L} = 0 \text{ k}$$

$$P_{4R} = 0.1 \text{ k}$$

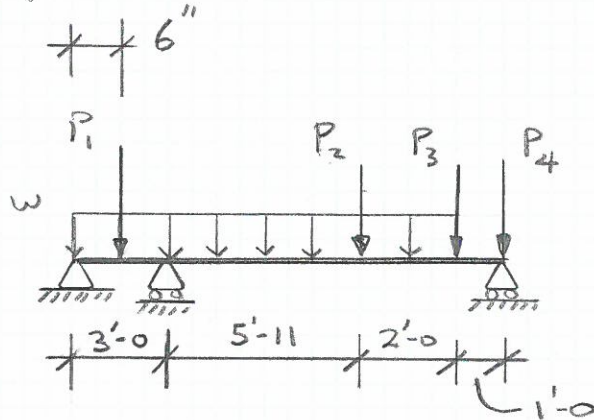
$$P_{4EQ} = 2 \text{ k}$$

$$P_{2EQ} = \frac{1692 \text{ lb}}{0.7} = 2417 \text{ lb}$$

$$P_{3EQ} = -2417 \text{ lb}$$

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④ BEAM No. 4



i) ROOF

DEAD LOAD = 221 ^{lb}/ft

LIVE LOAD = 233 ^{lb}/ft

ii) FLOOR

DEAD LOAD = 88 ^{lb}/ft

LIVE LOAD = 219 ^{lb}/ft

iii) WALL

DEAD LOAD = 8 psf (8.25') = 66 ^{lb}/ft

$P_{1D} = 0.3 \text{ k}$

$P_{1L} = 0.4 \text{ k}$

$P_{3D} = 0.6 \text{ k}$

$P_{3L} = 0.4 \text{ k}$

$P_{3RL} = 0.1 \text{ k}$

$P_{3EQ} = -1.7 \text{ k}$

$P_{2EQ} = \frac{1551 \text{ lb}}{0.7} = 2216 \text{ lb}$

$P_{4EQ} = -2216 \text{ lb}$



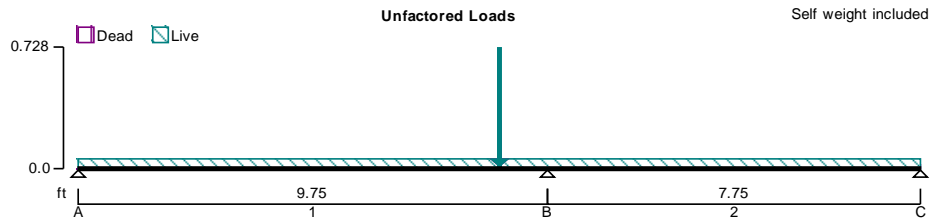
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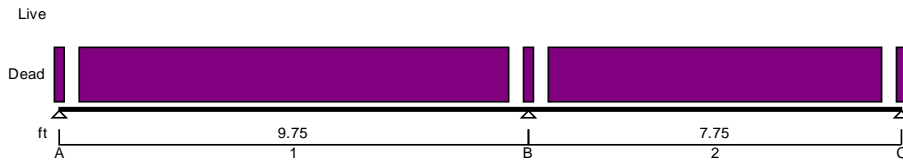
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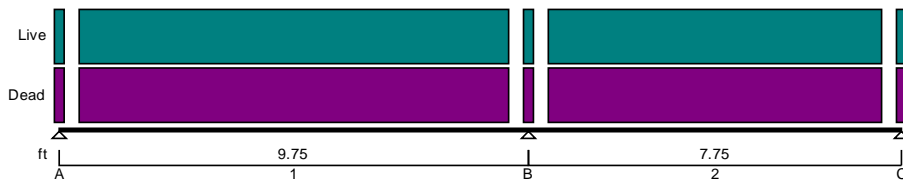
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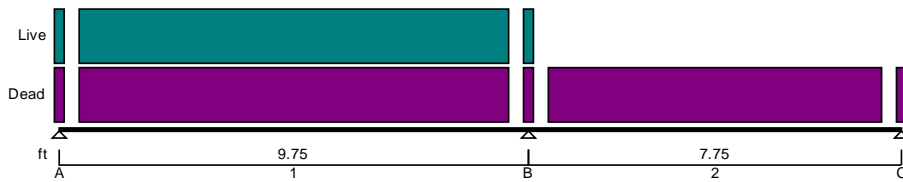
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)



Load Combination 3 (shown in proportion)

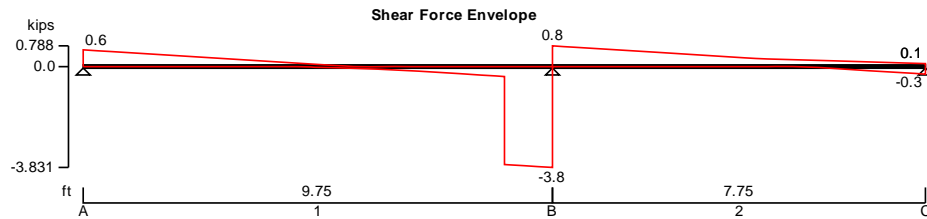
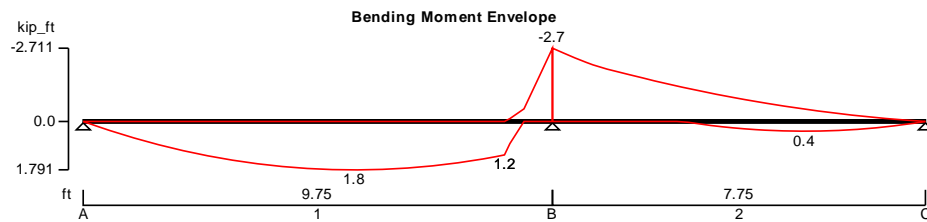
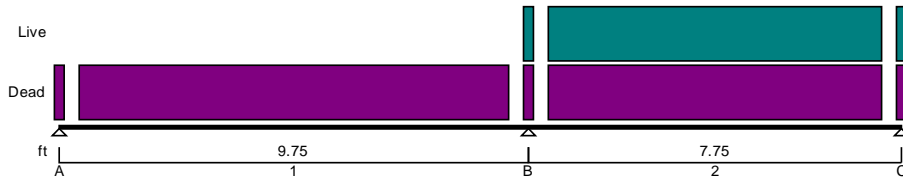




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Load Combination 4 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.024 kips/ft Live load - Live full UDL 0.059 kips/ft Dead self weight of beam \times 1 Dead load - Dead point load 0.955 kips at 105.00 in Live load - Live point load 2.39 kips at 105.00 in
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Analysis results

Maximum moment	$M_{max} = 1.8$ kips_ft	$M_{min} = -2.7$ kips_ft
Maximum moment span 1	$M_{s1_max} = 1.8$ kips_ft	$M_{s1_min} = -2.7$ kips_ft
Maximum moment span 2	$M_{s2_max} = 0.4$ kips_ft	$M_{s2_min} = -2.7$ kips_ft



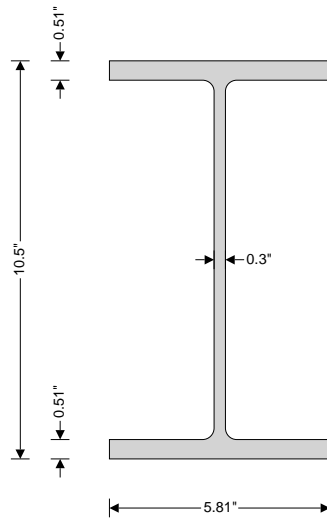
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Maximum shear	$V_{max} = 0.8$ kips	$V_{min} = -3.8$ kips
Maximum shear span 1	$V_{s1_max} = 0.6$ kips	$V_{s1_min} = -3.8$ kips
Maximum shear span 2	$V_{s2_max} = 0.8$ kips	$V_{s2_min} = -0.3$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 0.6$ kips	$R_{A_min} = 0.2$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = 0.3$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 0.4$ kips	
Maximum reaction at support B	$R_{B_max} = 4.6$ kips	$R_{B_min} = 1.6$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 1.6$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 3.1$ kips	
Maximum reaction at support C	$R_{C_max} = 0.3$ kips	$R_{C_min} = -0.1$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 0.1$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 0$ kips	

Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$



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Lateral bracing

Span 1 has lateral bracing at supports only

Span 2 has lateral bracing at supports only

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio $b_f / (2 \times t_f) = 5.70$
 Limiting ratio for compact section $\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$
 Limiting ratio for non-compact section $\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$ Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio $(d - 2 \times k) / t_w = 29.60$
 Limiting ratio for compact section $\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$
 Limiting ratio for non-compact section $\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$ Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength $V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 3.831$ kips
 Web area $A_w = d \times t_w = 3.15$ in²
 Web plate buckling coefficient $k_v = 5$
 Web shear coefficient - eq G2-2 $C_v = 1.000$
 Nominal shear strength - eq G2-1 $V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
 Allowable shear strength $V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 2 - Chapter F

Required flexural strength $M_r = \max(\text{abs}(M_{s2_max}), \text{abs}(M_{s2_min})) = 2.711$ kips_ft

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = 152.5$ kips_ft

Lateral-torsional buckling - Section F2.2

Unbraced length $L_b = L_{s2} = 93$ in
 Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 \times r_y \times \sqrt{E / F_y} = 58.069$ in
 Distance between flange centroids $h_o = d - t_f = 9.99$ in
 $c = 1$
 $r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602$ in

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + ((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)]} = 193.716 \text{ in}$$

Cross-section mono-symmetry parameter $R_m = 1.000$

Moment at quarter point of segment $M_A = 1.582$ kips_ft

Moment at center-line of segment $M_B = 0.852$ kips_ft

Moment at three quarter point of segment $M_C = 0.340$ kips_ft

Maximum moment in segment $M_{\text{abs}} = 2.711$ kips_ft

Lateral torsional buckling modification factor - eq F1-1 $C_b = 12.5 \times M_{\text{abs}} / [2.5 \times M_{\text{abs}} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = 2.125$

Nominal flexural strength for lateral torsional buckling - eq F2-2 $M_{nlbt} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] = 292.305$ kips_ft

Nominal flexural strength $M_n = \min(M_{nyld}, M_{nlbt}) = 152.500$ kips_ft



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Allowable flexural strength

$$M_c = M_n / \Omega_b = \mathbf{91.317 \text{ kips_ft}}$$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = \mathbf{0.325 \text{ in}}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.006 \text{ in}}$$

PASS - Maximum deflection does not exceed deflection limit



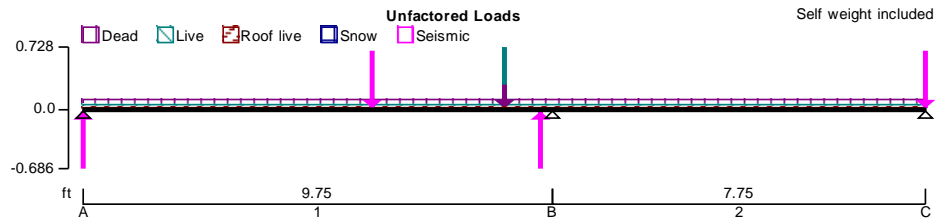
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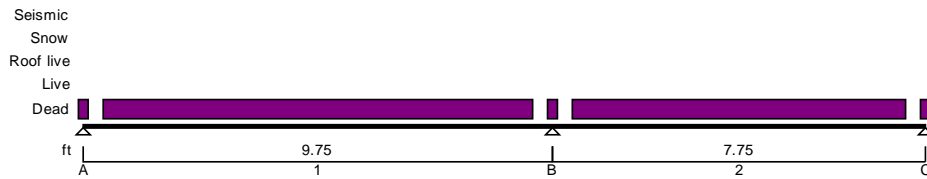
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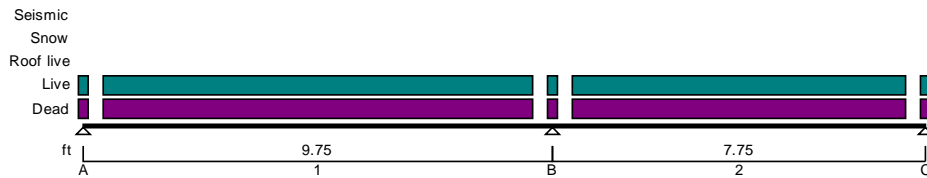
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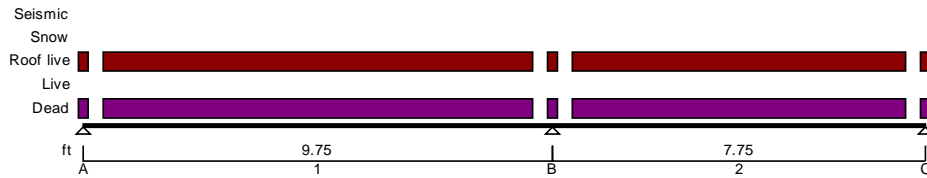
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)

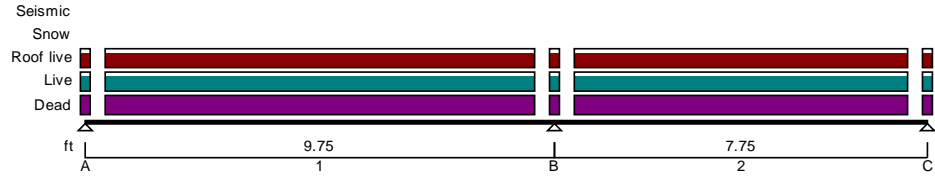


Load Combination 3 (shown in proportion)

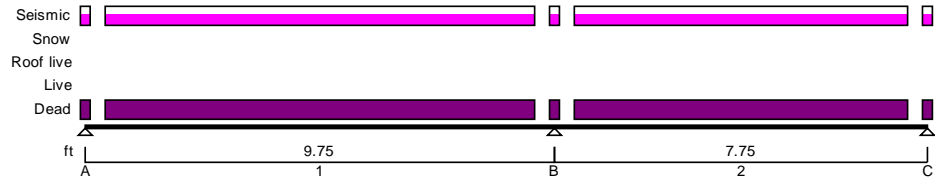


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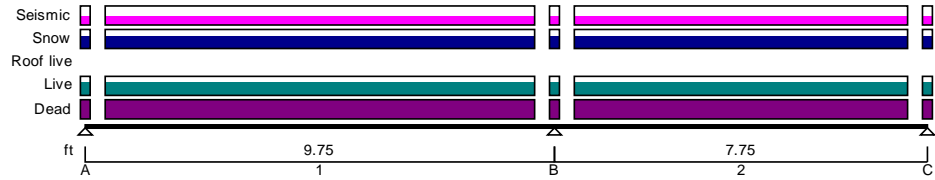
Load Combination 4 (shown in proportion)



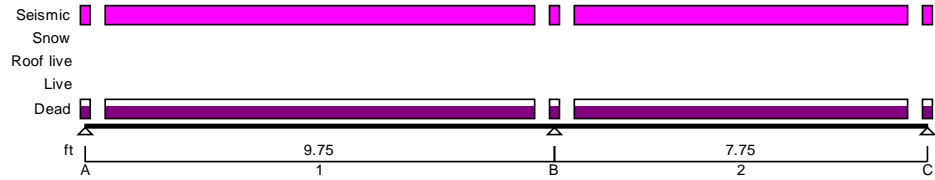
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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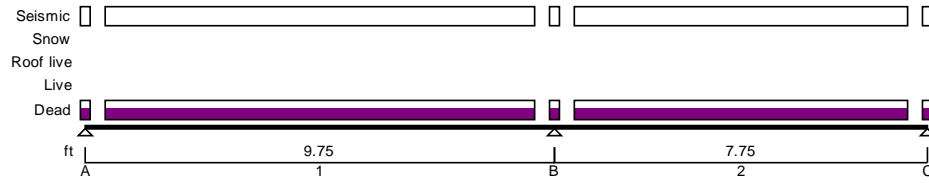
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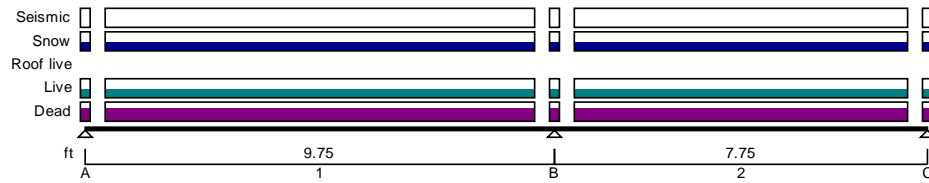
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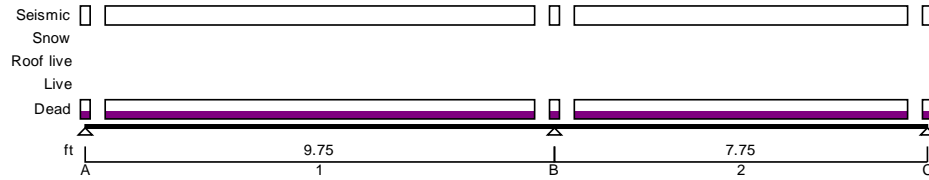
Load Combination 8 (shown in proportion)



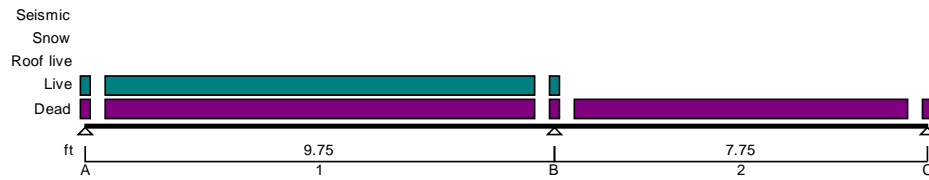
Load Combination 9 (shown in proportion)



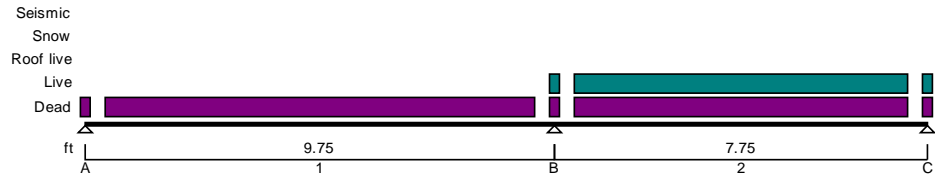
Load Combination 10 (shown in proportion)



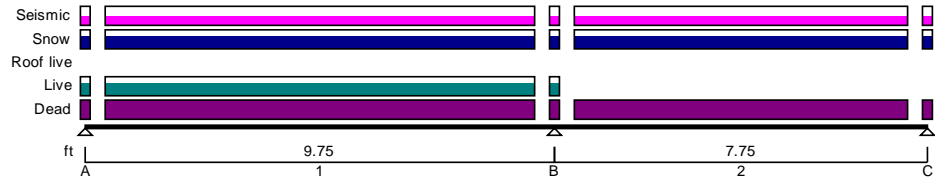
Load Combination 11 (shown in proportion)



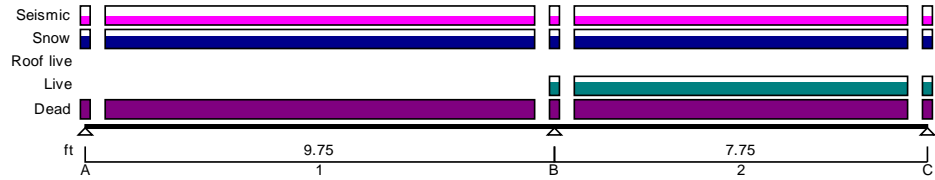
Load Combination 12 (shown in proportion)



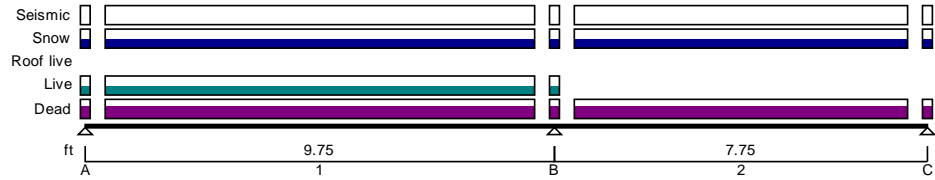
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)

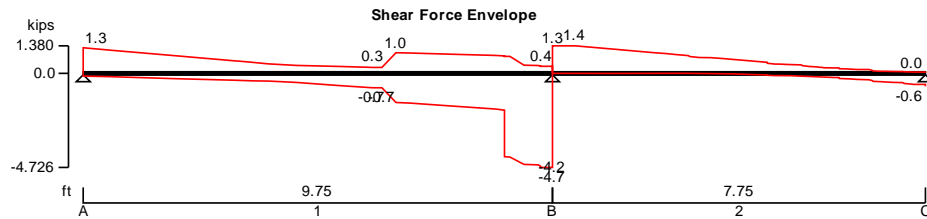
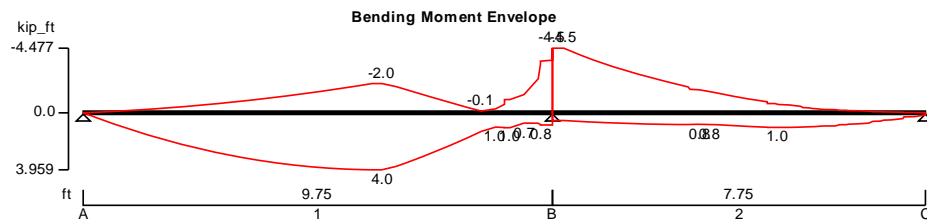
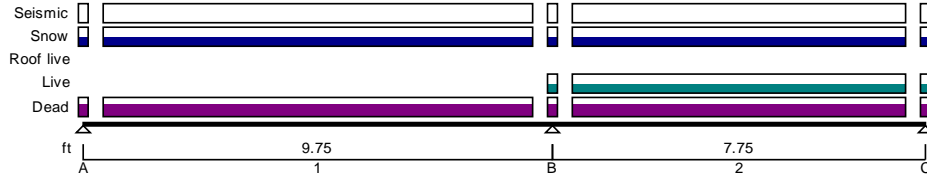




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Load Combination 16 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.118 kips/ft Live load - Live full UDL 0.059 kips/ft Live load - Live point load 2.39 kips at 105.00 in Dead load - Dead point load 0.955 kips at 105.00 in Roof live load - Roof live full UDL 0.023 kips/ft Dead self weight of beam $\times 1$ EQ 1 - Seismic point load -2.25 kips at 0.00 in EQ 2 - Seismic point load 2.25 kips at 72.00 in EQ 3 - Seismic point load -2.25 kips at 114.00 in
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EQ 4 - Seismic point load 2.25 kips at 210.00 in

Analysis results

Maximum moment	$M_{max} = 4 \text{ kips_ft}$	$M_{min} = -4.5 \text{ kips_ft}$
Maximum moment span 1	$M_{s1_max} = 4 \text{ kips_ft}$	$M_{s1_min} = -4.5 \text{ kips_ft}$
Maximum moment span 2	$M_{s2_max} = 1 \text{ kips_ft}$	$M_{s2_min} = -4.5 \text{ kips_ft}$
Maximum shear	$V_{max} = 1.4 \text{ kips}$	$V_{min} = -4.7 \text{ kips}$
Maximum shear span 1	$V_{s1_max} = 1.3 \text{ kips}$	$V_{s1_min} = -4.7 \text{ kips}$
Maximum shear span 2	$V_{s2_max} = 1.4 \text{ kips}$	$V_{s2_min} = -0.6 \text{ kips}$
Deflection	$\delta_{max} = 0 \text{ in}$	$\delta_{min} = 0 \text{ in}$
Deflection span 1	$\delta_{s1_max} = 0 \text{ in}$	$\delta_{s1_min} = 0 \text{ in}$
Deflection span 2	$\delta_{s2_max} = 0 \text{ in}$	$\delta_{s2_min} = 0 \text{ in}$
Maximum reaction at support A	$R_{A_max} = 1.9 \text{ kips}$	$R_{A_min} = -0.9 \text{ kips}$
Unfactored dead load reaction at support A	$R_{A_Dead} = 0.6 \text{ kips}$	
Unfactored live load reaction at support A	$R_{A_Live} = 0.4 \text{ kips}$	
Unfactored roof live load reaction at support A	$R_{A_Roof live} = 0.1 \text{ kips}$	
Unfactored seismic load reaction at support A	$R_{A_Seismic} = -1.7 \text{ kips}$	
Maximum reaction at support B	$R_{B_max} = 5.7 \text{ kips}$	$R_{B_min} = 1 \text{ kips}$
Unfactored dead load reaction at support B	$R_{B_Dead} = 2.6 \text{ kips}$	
Unfactored live load reaction at support B	$R_{B_Live} = 3.1 \text{ kips}$	
Unfactored roof live load reaction at support B	$R_{B_Roof live} = 0.3 \text{ kips}$	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = -0.3 \text{ kips}$	
Maximum reaction at support C	$R_{C_max} = 1.8 \text{ kips}$	$R_{C_min} = -1.2 \text{ kips}$
Unfactored dead load reaction at support C	$R_{C_Dead} = 0.3 \text{ kips}$	
Unfactored live load reaction at support C	$R_{C_Live} = 0 \text{ kips}$	
Unfactored roof live load reaction at support C	$R_{C_Roof live} = 0.1 \text{ kips}$	
Unfactored seismic load reaction at support C	$R_{C_Seismic} = 2 \text{ kips}$	

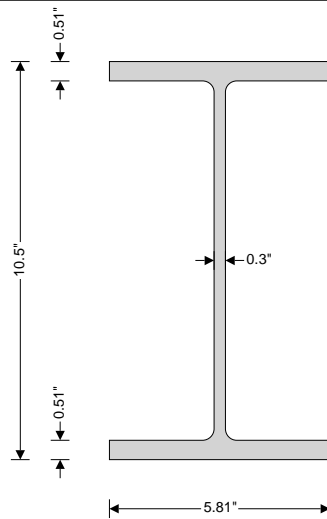
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50 \text{ ksi}$
Steel tensile stress	$F_u = 65 \text{ ksi}$
Modulus of elasticity	$E = 29000 \text{ ksi}$



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{[E / F_y]} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{[E / F_y]} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{[E / F_y]} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{[E / F_y]} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 4.726$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
Allowable shear strength	$V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength



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Design of members for flexure in the major axis at span 1 - Chapter F

Required flexural strength $M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 4.477 \text{ kips_ft}$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = 152.5 \text{ kips_ft}$

Lateral-torsional buckling - Section F2.2

Unbraced length $L_b = L_{s1} = 117 \text{ in}$

Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 \times r_y \times \sqrt{E / F_y} = 58.069 \text{ in}$

Distance between flange centroids $h_o = d - t_f = 9.99 \text{ in}$

$c = 1$

$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602 \text{ in}$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + ((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)]} = 193.716 \text{ in}$$

Cross-section mono-symmetry parameter $R_m = 1.000$

Moment at quarter point of segment $M_A = 2.508 \text{ kips_ft}$

Moment at center-line of segment $M_B = 3.785 \text{ kips_ft}$

Moment at three quarter point of segment $M_C = 2.281 \text{ kips_ft}$

Maximum moment in segment $M_{abs} = 4.477 \text{ kips_ft}$

Lateral torsional buckling modification factor - eq F1-1 $C_b = 12.5 \times M_{abs} / [2.5 \times M_{abs} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = 1.375$

Nominal flexural strength for lateral torsional buckling - eq F2-2 $M_{nlbt} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] = 175.042 \text{ kips_ft}$

Nominal flexural strength $M_n = \min(M_{nyld}, M_{nlbt}) = 152.500 \text{ kips_ft}$

Allowable flexural strength $M_c = M_n / \Omega_b = 91.317 \text{ kips_ft}$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection $\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = 0.325 \text{ in}$

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = 0.008 \text{ in}$

PASS - Maximum deflection does not exceed deflection limit



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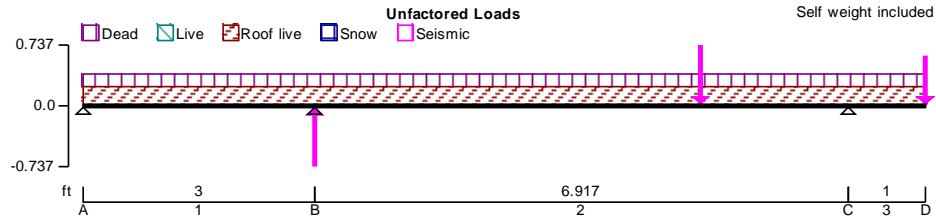
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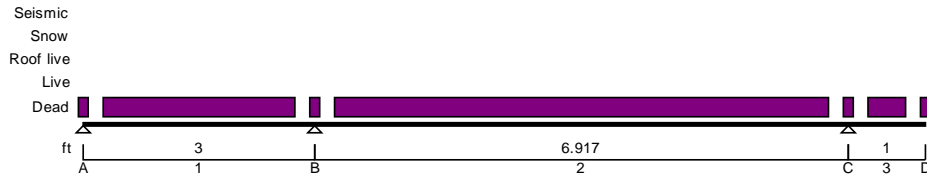
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

Tedds calculation version 3.0.06



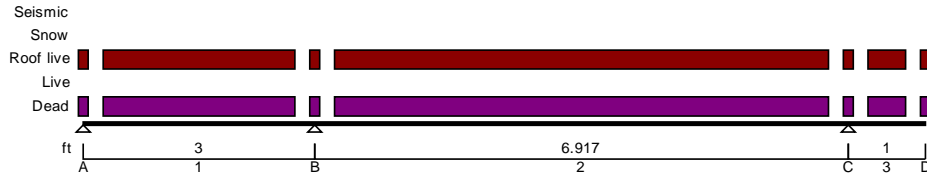
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)

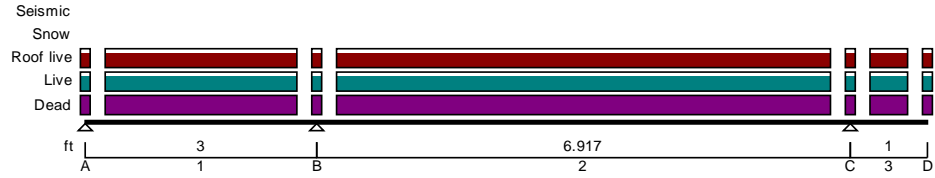


Load Combination 3 (shown in proportion)

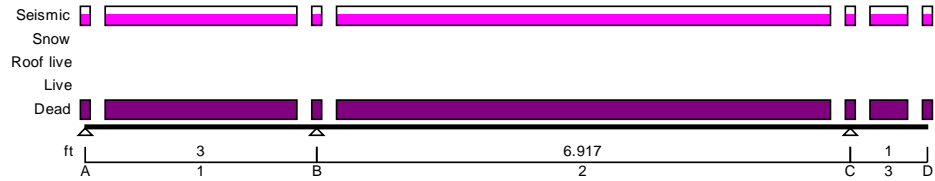


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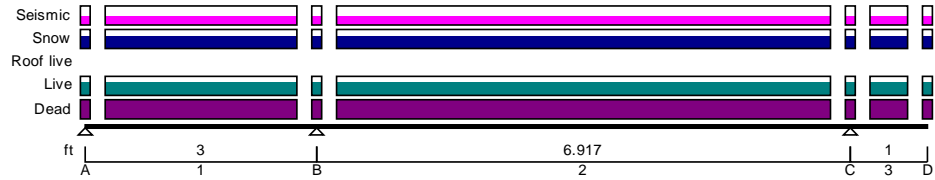
Load Combination 4 (shown in proportion)



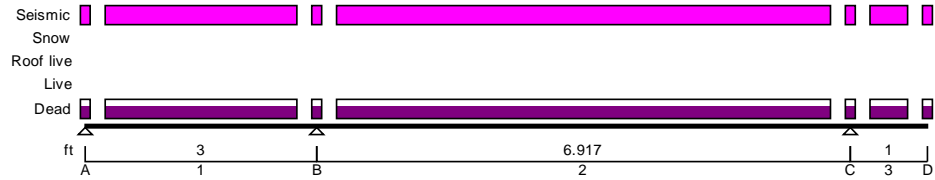
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)

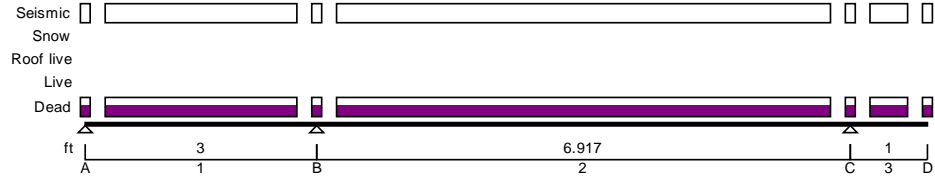


Load Combination 7 (shown in proportion)

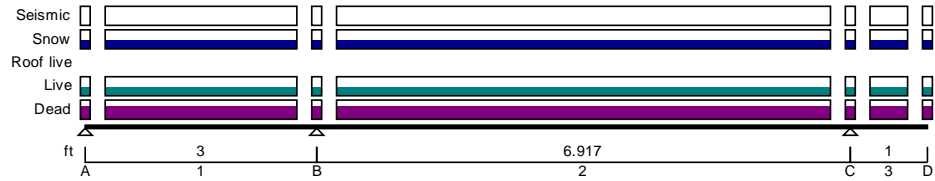


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Load Combination 8 (shown in proportion)



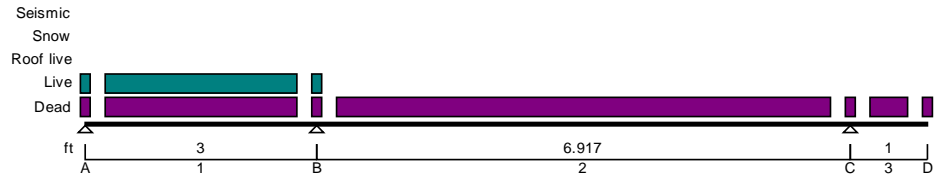
Load Combination 9 (shown in proportion)



Load Combination 10 (shown in proportion)



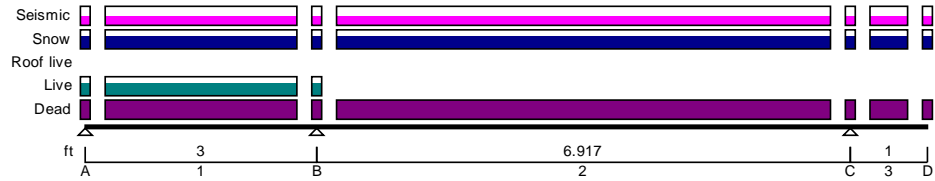
Load Combination 11 (shown in proportion)



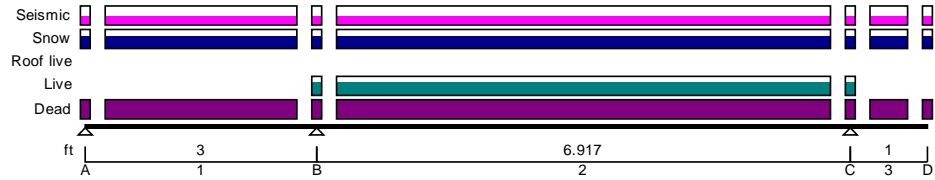
Load Combination 12 (shown in proportion)



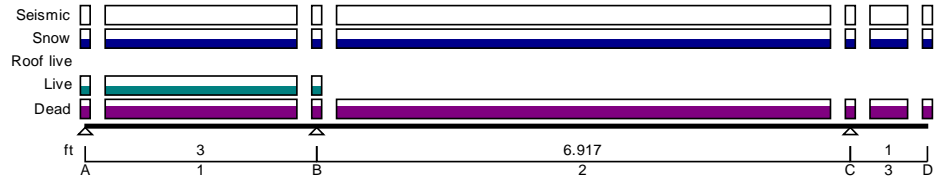
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)

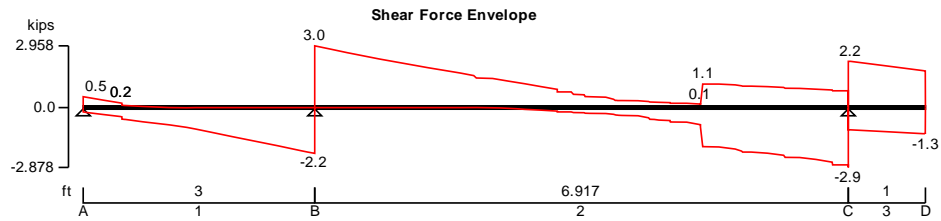
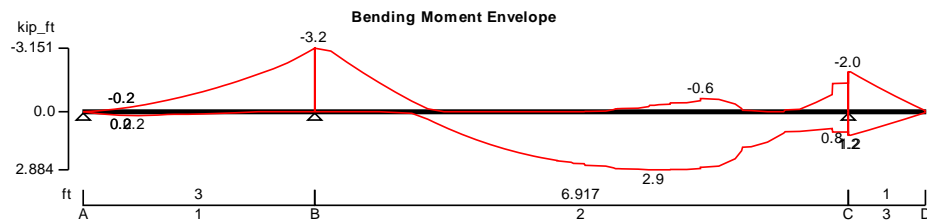
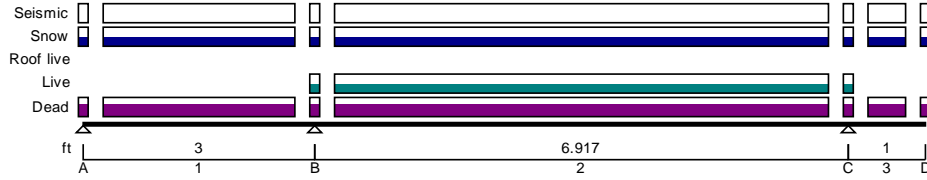




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Load Combination 16 (shown in proportion)



Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free
Support C	Vertically restrained Rotationally free
Support D	Vertically free Rotationally free

Applied loading

- Beam loads
- Dead load - Dead full UDL 0.386 kips/ft
 - Live load - Live full UDL 0.219 kips/ft
 - Dead load - Dead point load 0.1 kips at 6.00 in
 - Dead load - Dead point load 0.3 kips at 130.99 in
 - Roof live load - Roof live full UDL 0.233 kips/ft
 - Roof live load - Roof live point load 0.1 kips at 130.99 in
 - Dead self weight of beam × 1



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EQ 1 - Seismic point load -2.417 kips at 36.00 in

EQ 2 - Seismic point load 2.417 kips at 96.00 in

EQ 3 - Seismic point load 2 kips at 130.99 in

Analysis results

Maximum moment	$M_{max} = 2.9$ kips_ft	$M_{min} = -3.2$ kips_ft
Maximum moment span 1	$M_{s1_max} = 0.2$ kips_ft	$M_{s1_min} = -3.2$ kips_ft
Maximum moment span 2	$M_{s2_max} = 2.9$ kips_ft	$M_{s2_min} = -3.2$ kips_ft
Maximum moment span 3	$M_{s3_max} = 1.2$ kips_ft	$M_{s3_min} = -2$ kips_ft
Maximum shear	$V_{max} = 3$ kips	$V_{min} = -2.9$ kips
Maximum shear span 1	$V_{s1_max} = 0.5$ kips	$V_{s1_min} = -2.2$ kips
Maximum shear span 2	$V_{s2_max} = 3$ kips	$V_{s2_min} = -2.9$ kips
Maximum shear span 3	$V_{s3_max} = 2.2$ kips	$V_{s3_min} = -1.3$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Deflection span 3	$\delta_{s3_max} = 0$ in	$\delta_{s3_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 0.5$ kips	$R_{A_min} = -0.2$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = 0.1$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 0$ kips	
Unfactored roof live load reaction at support A	$R_{A_Roof\ live} = 0$ kips	
Unfactored seismic load reaction at support A	$R_{A_Seismic} = -0.3$ kips	
Maximum reaction at support B	$R_{B_max} = 5.2$ kips	$R_{B_min} = 0.1$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 2.8$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 1.5$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 1.6$ kips	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = -1.7$ kips	
Maximum reaction at support C	$R_{C_max} = 5$ kips	$R_{C_min} = -1.8$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 2$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 0.9$ kips	
Unfactored roof live load reaction at support C	$R_{C_Roof\ live} = 1$ kips	
Unfactored seismic load reaction at support C	$R_{C_Seismic} = 3.9$ kips	
Maximum reaction at support D	$R_{D_max} = 0$ kips	$R_{D_min} = 0$ kips

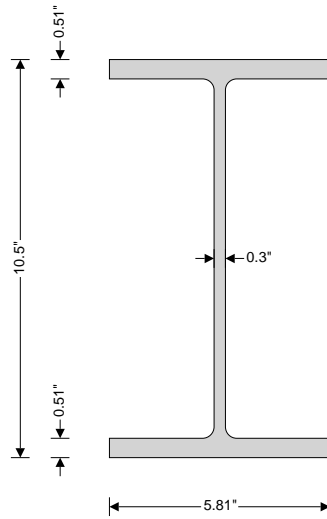
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports only
Span 2 has lateral bracing at supports only
Span 3 has lateral bracing at supports only
Cantilever tip is free
Cantilever support is continuous with lateral and torsional restraint

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 2.958 \text{ kips}$
Web area	$A_w = d \times t_w = 3.15 \text{ in}^2$
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500 \text{ kips}$



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Allowable shear strength

$$V_c = V_n / \Omega_v = \mathbf{63.000} \text{ kips}$$

PASS - Allowable shear strength exceeds required shear strength

Design of members for flexure in the major axis at span 1 - Chapter F

Required flexural strength

$$M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = \mathbf{3.151} \text{ kips_ft}$$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1

$$M_{nyld} = M_p = F_y \times Z_x = \mathbf{152.5} \text{ kips_ft}$$

Lateral-torsional buckling - Section F2.2

Unbraced length

$$L_b = L_{s1} = \mathbf{36} \text{ in}$$

Limiting unbraced length for yielding - eq F2-5

$$L_p = 1.76 \times r_y \times \sqrt{E / F_y} = \mathbf{58.069} \text{ in}$$

Distance between flange centroids

$$h_o = d - t_f = \mathbf{9.99} \text{ in}$$

$$c = \mathbf{1}$$

$$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = \mathbf{1.602} \text{ in}$$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + \sqrt{((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)}]} = \mathbf{193.716} \text{ in}$$

Nominal flexural strength

$$M_n = M_{nyld} = \mathbf{152.500} \text{ kips_ft}$$

Allowable flexural strength

$$M_c = M_n / \Omega_b = \mathbf{91.317} \text{ kips_ft}$$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection

$$\delta_{lim} = \min(0.75 \text{ in}, L_{s2} / 360) = \mathbf{0.231} \text{ in}$$

Maximum deflection span 2

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{0.004} \text{ in}$$

PASS - Maximum deflection does not exceed deflection limit



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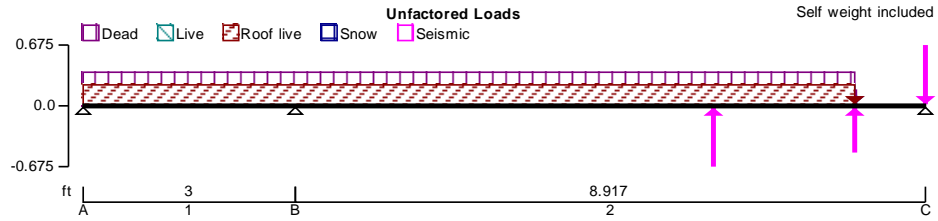
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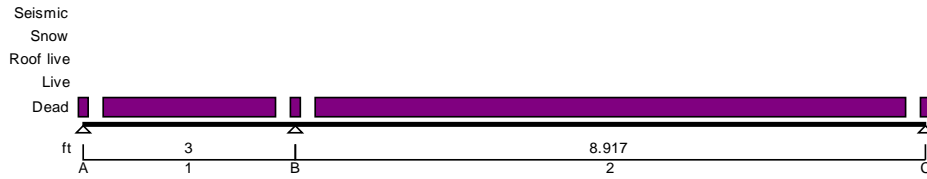
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

Tedds calculation version 3.0.06



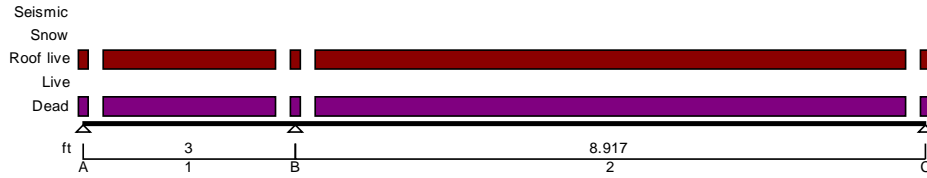
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)

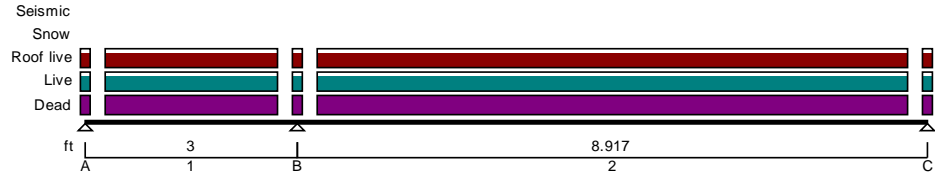


Load Combination 3 (shown in proportion)

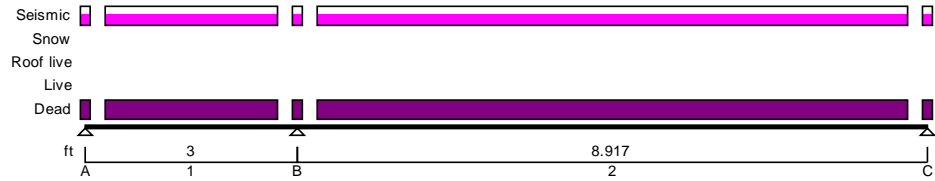


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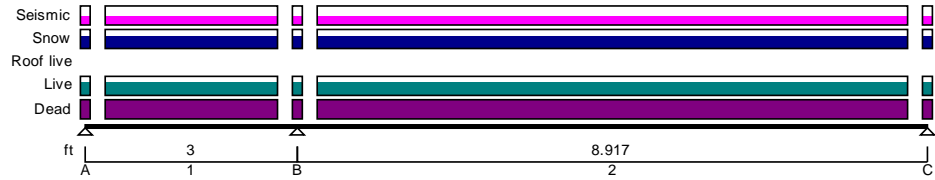
Load Combination 4 (shown in proportion)



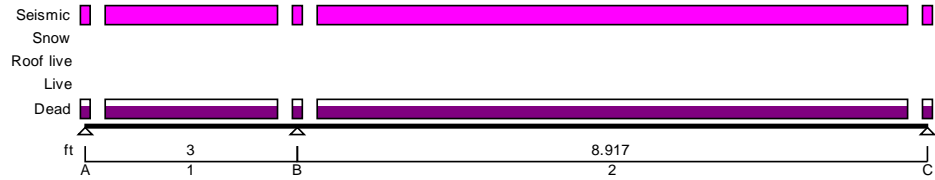
Load Combination 5 (shown in proportion)



Load Combination 6 (shown in proportion)



Load Combination 7 (shown in proportion)





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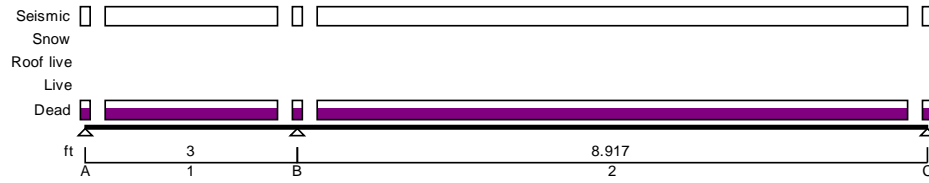
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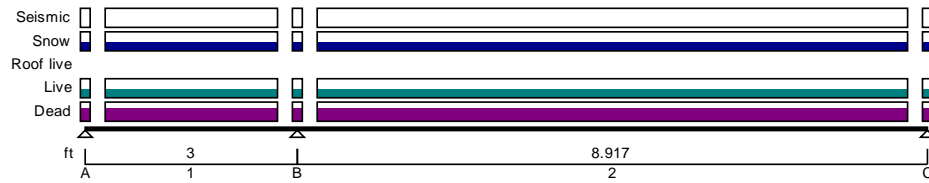
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Load Combination 8 (shown in proportion)



Load Combination 9 (shown in proportion)



Load Combination 10 (shown in proportion)



Load Combination 11 (shown in proportion)

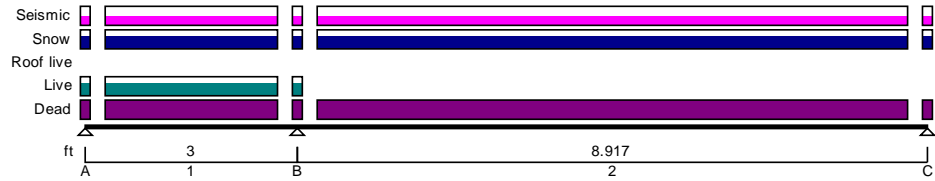


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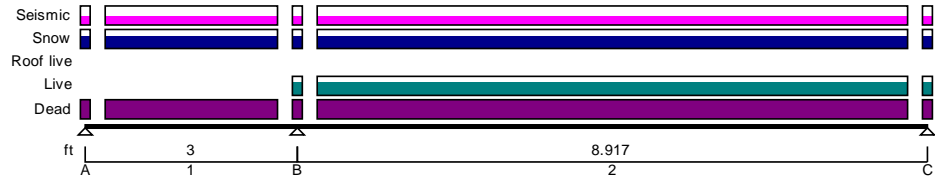
Load Combination 12 (shown in proportion)



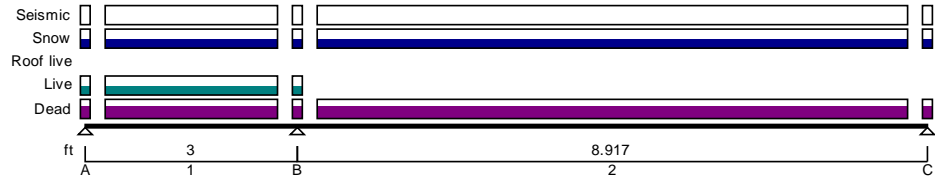
Load Combination 13 (shown in proportion)



Load Combination 14 (shown in proportion)



Load Combination 15 (shown in proportion)





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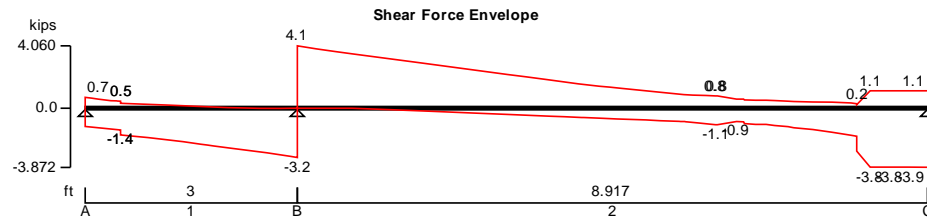
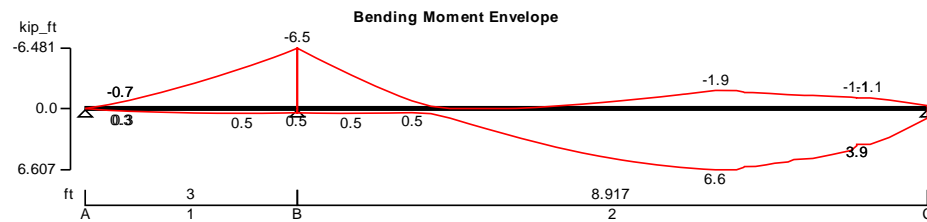
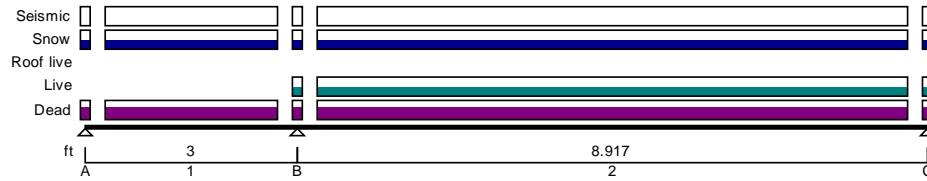
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Load Combination 16 (shown in proportion)



Support conditions

- Support A: Vertically restrained, Rotationally free
- Support B: Vertically restrained, Rotationally free
- Support C: Vertically restrained, Rotationally free

Applied loading

- Beam loads
 - Dead load - Dead partial UDL 0.375 kips/ft from 0.00 in to 131.00 in
 - Live load - Live partial UDL 0.219 kips/ft from 0.00 in to 131.00 in
 - Live load - Live point load 0.4 kips at 6.00 in
 - Live load - Live point load 0.4 kips at 131.00 in
 - Dead load - Dead point load 0.3 kips at 6.00 in
 - Dead load - Dead point load 0.6 kips at 131.00 in
 - Roof live load - Roof live partial UDL 0.233 kips/ft from 0.00 in to 131.00 in
 - Roof live load - Roof live point load 0.1 kips at 131.00 in
 - Dead self weight of beam $\times 1$



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EQ 1 - Seismic point load -2.216 kips at 107.00 in

EQ 2 - Seismic point load 2.216 kips at 143.00 in

EQ 3 - Seismic point load -1.7 kips at 131.00 in

Analysis results

Maximum moment	$M_{max} = 6.6$ kips_ft	$M_{min} = -6.5$ kips_ft
Maximum moment span 1	$M_{s1_max} = 0.5$ kips_ft	$M_{s1_min} = -6.5$ kips_ft
Maximum moment span 1 segment 1	$M_{s1_seg1_max} = 0.3$ kips_ft	$M_{s1_seg1_min} = -1.1$ kips_ft
Maximum moment span 1 segment 2	$M_{s1_seg2_max} = 0.5$ kips_ft	$M_{s1_seg2_min} = -2.6$ kips_ft
Maximum moment span 1 segment 3	$M_{s1_seg3_max} = 0.5$ kips_ft	$M_{s1_seg3_min} = -4.4$ kips_ft
Maximum moment span 1 segment 4	$M_{s1_seg4_max} = 0.5$ kips_ft	$M_{s1_seg4_min} = -6.5$ kips_ft
Maximum moment span 2	$M_{s2_max} = 6.6$ kips_ft	$M_{s2_min} = -6.5$ kips_ft
Maximum shear	$V_{max} = 4.1$ kips	$V_{min} = -3.9$ kips
Maximum shear span 1	$V_{s1_max} = 0.7$ kips	$V_{s1_min} = -3.2$ kips
Maximum shear span 1 segment 1	$V_{s1_seg1_max} = 0.7$ kips	$V_{s1_seg1_min} = -1.9$ kips
Maximum shear span 1 segment 2	$V_{s1_seg2_max} = 0.3$ kips	$V_{s1_seg2_min} = -2.3$ kips
Maximum shear span 1 segment 3	$V_{s1_seg3_max} = 0.1$ kips	$V_{s1_seg3_min} = -2.7$ kips
Maximum shear span 1 segment 4	$V_{s1_seg4_max} = 0$ kips	$V_{s1_seg4_min} = -3.2$ kips
Maximum shear span 2	$V_{s2_max} = 4.1$ kips	$V_{s2_min} = -3.9$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Deflection span 1	$\delta_{s1_max} = 0$ in	$\delta_{s1_min} = 0$ in
Deflection span 2	$\delta_{s2_max} = 0$ in	$\delta_{s2_min} = 0$ in
Maximum reaction at support A	$R_{A_max} = 0.7$ kips	$R_{A_min} = -1.2$ kips
Unfactored dead load reaction at support A	$R_{A_Dead} = -0.2$ kips	
Unfactored live load reaction at support A	$R_{A_Live} = 0.1$ kips	
Unfactored roof live load reaction at support A	$R_{A_Roof\ live} = -0.2$ kips	
Unfactored seismic load reaction at support A	$R_{A_Seismic} = 0.9$ kips	
Maximum reaction at support B	$R_{B_max} = 7.3$ kips	$R_{B_min} = 0.3$ kips
Unfactored dead load reaction at support B	$R_{B_Dead} = 4$ kips	
Unfactored live load reaction at support B	$R_{B_Live} = 2.2$ kips	
Unfactored roof live load reaction at support B	$R_{B_Roof\ live} = 2.2$ kips	
Unfactored seismic load reaction at support B	$R_{B_Seismic} = -2.2$ kips	
Maximum reaction at support C	$R_{C_max} = 2.8$ kips	$R_{C_min} = 0.4$ kips
Unfactored dead load reaction at support C	$R_{C_Dead} = 1.6$ kips	
Unfactored live load reaction at support C	$R_{C_Live} = 0.9$ kips	
Unfactored roof live load reaction at support C	$R_{C_Roof\ live} = 0.7$ kips	
Unfactored seismic load reaction at support C	$R_{C_Seismic} = -0.4$ kips	

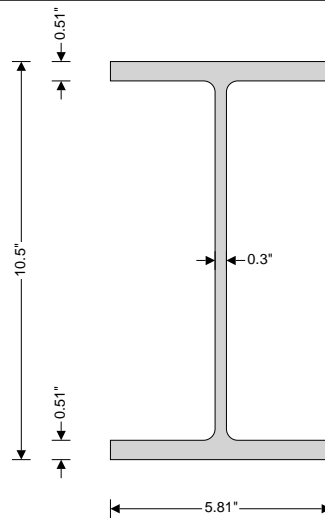
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has lateral bracing at supports plus quarter points
Span 2 has lateral bracing at supports only

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 4.060$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
Allowable shear strength	$V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength



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Design of members for flexure in the major axis at span 2 - Chapter F

Required flexural strength $M_r = \max(\text{abs}(M_{s2_max}), \text{abs}(M_{s2_min})) = 6.607 \text{ kips_ft}$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = 152.5 \text{ kips_ft}$

Lateral-torsional buckling - Section F2.2

Unbraced length $L_b = L_{s2} = 107 \text{ in}$

Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 \times r_y \times \sqrt{E / F_y} = 58.069 \text{ in}$

Distance between flange centroids $h_o = d - t_f = 9.99 \text{ in}$

$c = 1$

$r_{ts} = \sqrt{[(I_y \times C_w) / S_x]} = 1.602 \text{ in}$

Limiting unbraced length for inelastic LTB - eq F2-6

$$L_r = 1.95 \times r_{ts} \times E / (0.7 \times F_y) \times \sqrt{[(J \times c / (S_x \times h_o)) + ((J \times c / (S_x \times h_o))^2 + 6.76 \times (0.7 \times F_y / E)^2)]} = 193.716 \text{ in}$$

Cross-section mono-symmetry parameter $R_m = 1.000$

Moment at quarter point of segment $M_A = 1.195 \text{ kips_ft}$

Moment at center-line of segment $M_B = 5.380 \text{ kips_ft}$

Moment at three quarter point of segment $M_C = 5.835 \text{ kips_ft}$

Maximum moment in segment $M_{abs} = 6.607 \text{ kips_ft}$

Lateral torsional buckling modification factor - eq F1-1 $C_b = 12.5 \times M_{abs} / [2.5 \times M_{abs} + 3 \times M_A + 4 \times M_B + 3 \times M_C] = 1.397$

Nominal flexural strength for lateral torsional buckling - eq F2-2 $M_{nlbt} = C_b \times [M_p - (M_p - 0.7 \times F_y \times S_x) \times (L_b - L_p) / (L_r - L_p)] = 183.794 \text{ kips_ft}$

Nominal flexural strength $M_n = \min(M_{nyld}, M_{nlbt}) = 152.500 \text{ kips_ft}$

Allowable flexural strength $M_c = M_n / \Omega_b = 91.317 \text{ kips_ft}$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection $\delta_{lim} = \min(0.75 \text{ in}, L_{s2} / 360) = 0.297 \text{ in}$

Maximum deflection span 2 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = 0.014 \text{ in}$

PASS - Maximum deflection does not exceed deflection limit



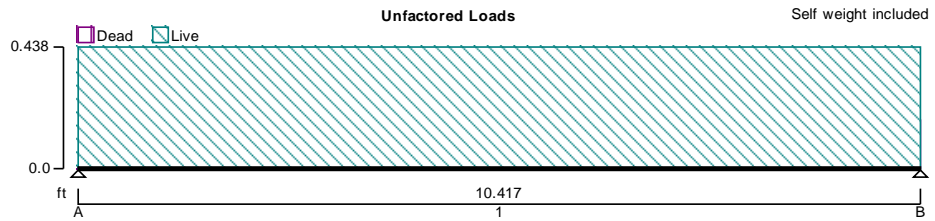
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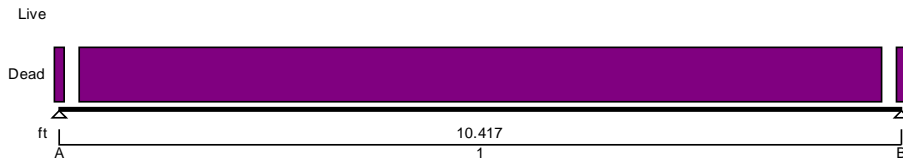
STEEL BEAM ANALYSIS & DESIGN (AISC360-10)

In accordance with AISC360 14th Edition published 2010 using the ASD method

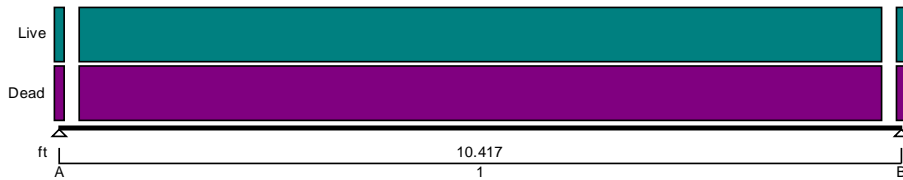
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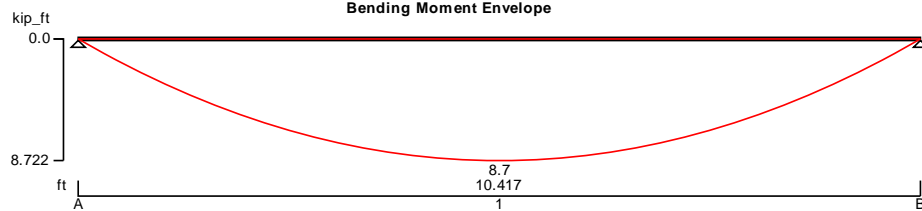
Load Combination 1 (shown in proportion)



Load Combination 2 (shown in proportion)



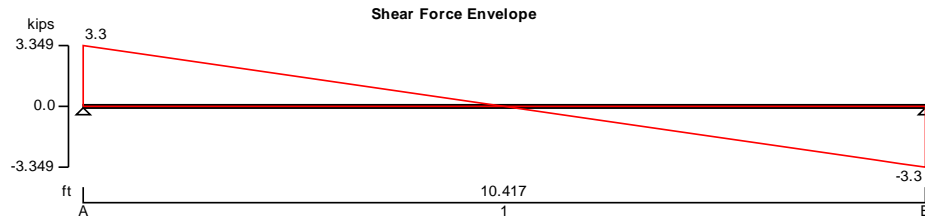
Bending Moment Envelope





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Support conditions

Support A	Vertically restrained Rotationally free
Support B	Vertically restrained Rotationally free

Applied loading

Beam loads	Dead load - Dead full UDL 0.175 kips/ft Live load - Live full UDL 0.438 kips/ft Dead self weight of beam $\times 1$
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Analysis results

Maximum moment	$M_{max} = 8.7$ kips _{ft}	$M_{min} = 0$ kips _{ft}
Maximum shear	$V_{max} = 3.3$ kips	$V_{min} = -3.3$ kips
Deflection	$\delta_{max} = 0$ in	$\delta_{min} = 0$ in
Maximum reaction at support A	$R_{A,max} = 3.3$ kips	$R_{A,min} = 1.1$ kips
Unfactored dead load reaction at support A	$R_{A,Dead} = 1.1$ kips	
Unfactored live load reaction at support A	$R_{A,Live} = 2.3$ kips	
Maximum reaction at support B	$R_{B,max} = 3.3$ kips	$R_{B,min} = 1.1$ kips
Unfactored dead load reaction at support B	$R_{B,Dead} = 1.1$ kips	
Unfactored live load reaction at support B	$R_{B,Live} = 2.3$ kips	

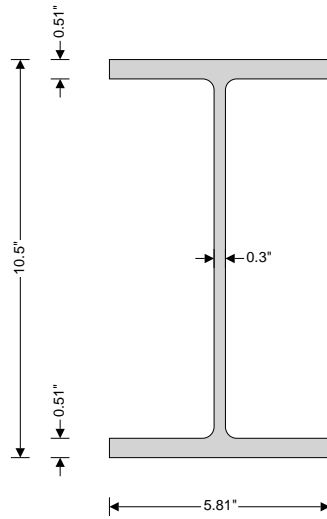
Section details

Section type	W 10x30 (AISC 13th Edn 2005)
ASTM steel designation	A992
Steel yield stress	$F_y = 50$ ksi
Steel tensile stress	$F_u = 65$ ksi
Modulus of elasticity	$E = 29000$ ksi



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Safety factors

Safety factor for tensile yielding	$\Omega_{ty} = 1.67$
Safety factor for tensile rupture	$\Omega_{tr} = 2.00$
Safety factor for compression	$\Omega_c = 1.67$
Safety factor for flexure	$\Omega_b = 1.67$
Safety factor for shear	$\Omega_v = 1.50$

Lateral bracing

Span 1 has continuous lateral bracing

Classification of sections for local bending - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 \times t_f) = 5.70$	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 \times \sqrt{E / F_y} = 9.15$	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 \times \sqrt{E / F_y} = 24.08$	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio	$(d - 2 \times k) / t_w = 29.60$	
Limiting ratio for compact section	$\lambda_{pwf} = 3.76 \times \sqrt{E / F_y} = 90.55$	
Limiting ratio for non-compact section	$\lambda_{rwf} = 5.70 \times \sqrt{E / F_y} = 137.27$	Compact

Section is compact in flexure

Design of members for shear - Chapter G

Required shear strength	$V_r = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 3.349$ kips
Web area	$A_w = d \times t_w = 3.15$ in ²
Web plate buckling coefficient	$k_v = 5$
Web shear coefficient - eq G2-2	$C_v = 1.000$
Nominal shear strength - eq G2-1	$V_n = 0.6 \times F_y \times A_w \times C_v = 94.500$ kips
Allowable shear strength	$V_c = V_n / \Omega_v = 63.000$ kips

PASS - Allowable shear strength exceeds required shear strength



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Design of members for flexure in the major axis - Chapter F

Required flexural strength $M_r = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 8.722 \text{ kips_ft}$

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{nyld} = M_p = F_y \times Z_x = 152.5 \text{ kips_ft}$

Nominal flexural strength $M_n = M_{nyld} = 152.500 \text{ kips_ft}$

Allowable flexural strength $M_c = M_n / \Omega_b = 91.317 \text{ kips_ft}$

PASS - Allowable flexural strength exceeds required flexural strength

Design of members for vertical deflection

Consider deflection due to dead, live, roof live and snow loads

Limiting deflection $\delta_{lim} = \min(0.75 \text{ in}, L_{s1} / 360) = 0.347 \text{ in}$

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = 0.035 \text{ in}$

PASS - Maximum deflection does not exceed deflection limit



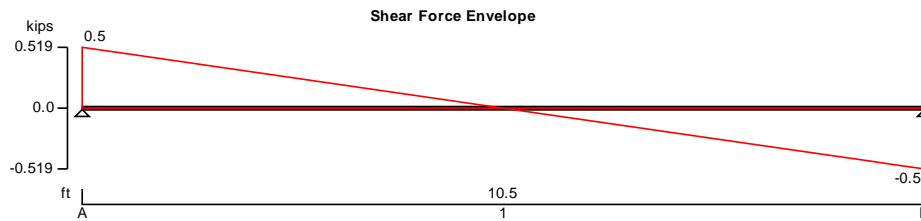
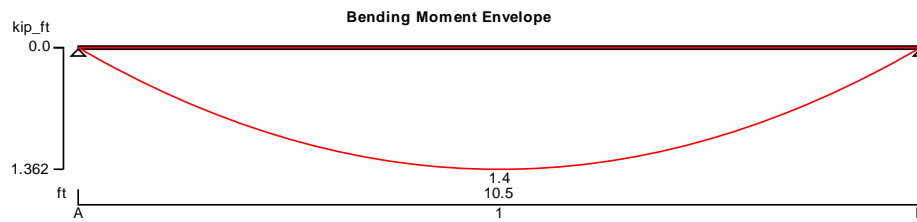
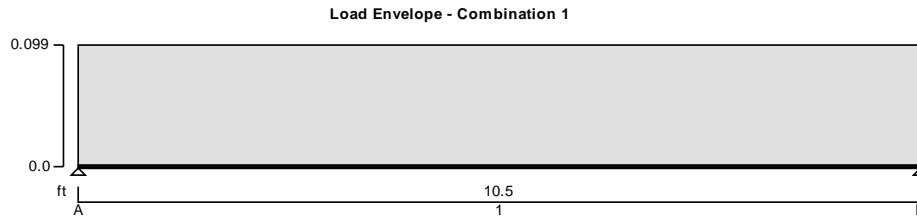
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STRUCTURAL WOOD BEAM ANALYSIS & DESIGN (NDS 2005)

In accordance with the ASD method

TEDDS calculation version 1.5.07



Applied loading

Beam loads

Dead load	Dead self weight of beam × 1
Live load	Dead full UDL 27 lb/ft
	Live full UDL 67 lb/ft

Load combinations

Load combination 1	Support A	Dead × 1.00
		Live × 1.00
	Span 1	Dead × 1.00
		Live × 1.00
	Support B	Dead × 1.00
		Live × 1.00

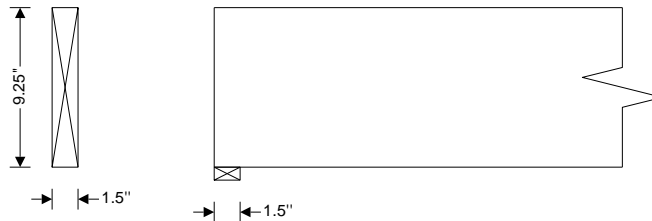


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Analysis results

Maximum moment	$M_{max} = 1362 \text{ lb_ft}$	$M_{min} = 0 \text{ lb_ft}$
Design moment	$M = \max(\text{abs}(M_{max}), \text{abs}(M_{min})) = 1362 \text{ lb_ft}$	
Maximum shear	$F_{max} = 519 \text{ lb}$	$F_{min} = -519 \text{ lb}$
Design shear	$F = \max(\text{abs}(F_{max}), \text{abs}(F_{min})) = 519 \text{ lb}$	
Total load on member	$W_{tot} = 1038 \text{ lb}$	
Reaction at support A	$R_{A_max} = 519 \text{ lb}$	$R_{A_min} = 519 \text{ lb}$
Unfactored dead load reaction at support A	$R_{A_Dead} = 167 \text{ lb}$	
Unfactored live load reaction at support A	$R_{A_Live} = 352 \text{ lb}$	
Reaction at support B	$R_{B_max} = 519 \text{ lb}$	$R_{B_min} = 519 \text{ lb}$
Unfactored dead load reaction at support B	$R_{B_Dead} = 167 \text{ lb}$	
Unfactored live load reaction at support B	$R_{B_Live} = 352 \text{ lb}$	



Sawn lumber section details

Nominal breadth of sections	$b_{nom} = 2 \text{ in}$
Dressed breadth of sections	$b = 1.5 \text{ in}$
Nominal depth of sections	$d_{nom} = 10 \text{ in}$
Dressed depth of sections	$d = 9.25 \text{ in}$
Number of sections in member	$N = 1$
Overall breadth of member	$b_b = N \times b = 1.5 \text{ in}$

Table 4B - Reference design values for visually graded Southern Pine dimension lumber (2"-4" thick)

Species, grade and size classification	Southern Pine, No.2 grade, 10" wide
Bending parallel to grain	$F_b = 1050 \text{ lb/in}^2$
Tension parallel to grain	$F_t = 575 \text{ lb/in}^2$
Compression parallel to grain	$F_c = 1500 \text{ lb/in}^2$
Compression perpendicular to grain	$F_{c_perp} = 565 \text{ lb/in}^2$
Shear parallel to grain	$F_v = 175 \text{ lb/in}^2$
Modulus of elasticity	$E = 1600000 \text{ lb/in}^2$
Mean shear modulus	$G_{def} = E / 16 = 100000 \text{ lb/in}^2$

Member details

Service condition	Dry
Length of bearing	$L_b = 1.5 \text{ in}$
Load duration	Ten years
The beam is one of three or more repetitive members	

Section properties

Cross sectional area of member	$A = N \times b \times d = 13.87 \text{ in}^2$
--------------------------------	--



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Section modulus $S_x = N \times b \times d^2 / 6 = 21.39 \text{ in}^3$
 $S_y = d \times (N \times b)^2 / 6 = 3.47 \text{ in}^3$
 Second moment of area $I_x = N \times b \times d^3 / 12 = 98.93 \text{ in}^4$
 $I_y = d \times (N \times b)^3 / 12 = 2.60 \text{ in}^4$

Adjustment factors

Load duration factor - Table 2.3.2 $C_D = 1.00$
 Temperature factor - Table 2.3.3 $C_t = 1.00$
 Size factor for bending - Table 4B $C_{Fb} = 1.00$
 Size factor for tension - Table 4B $C_{Ft} = 1.00$
 Size factor for compression - Table 4B $C_{Fc} = 1.00$
 Flat use factor - Table 4B $C_{fu} = 1.20$

Incising factor for modulus of elasticity - Table 4.3.8 $C_{iE} = 1.00$

Incising factor for bending, shear, tension & compression - Table 4.3.8

$C_i = 1.00$

Incising factor for perpendicular compression - Table 4.3.8

$C_{ic_perp} = 1.00$

Repetitive member factor - cl.4.3.9

$C_r = 1.15$

Bearing area factor - eq.3.10-2

$C_b = 1.00$

Depth-to-breadth ratio

$d_{nom} / (N \times b_{nom}) = 5.00$

- Beam is fully restrained

Beam stability factor - cl.3.3.3

$C_L = 1.00$

Bearing perpendicular to grain - cl.3.10.2

Design compression perpendicular to grain $F_{c_perp}' = F_{c_perp} \times C_t \times C_i \times C_b = 565 \text{ lb/in}^2$

Applied compression stress perpendicular to grain $f_{c_perp} = R_{B_max} / (N \times b \times L_b) = 231 \text{ lb/in}^2$

$f_{c_perp} / F_{c_perp}' = 0.408$

PASS - Design compressive stress exceeds applied compressive stress at bearing

Strength in bending - cl.3.3.1

Design bending stress

$F_b' = F_b \times C_D \times C_t \times C_L \times C_{Fb} \times C_i \times C_r = 1208 \text{ lb/in}^2$

Actual bending stress

$f_b = M / S_x = 764 \text{ lb/in}^2$

$f_b / F_b' = 0.633$

PASS - Design bending stress exceeds actual bending stress

Strength in shear parallel to grain - cl.3.4.1

Design shear stress

$F_v' = F_v \times C_D \times C_t \times C_i = 175 \text{ lb/in}^2$

Actual shear stress - eq.3.4-2

$f_v = 3 \times F / (2 \times A) = 56 \text{ lb/in}^2$

$f_v / F_v' = 0.320$

PASS - Design shear stress exceeds actual shear stress

Deflection - cl.3.5.1

Modulus of elasticity for deflection

$E' = E \times C_{ME} \times C_t \times C_{iE} = 1600000 \text{ lb/in}^2$

Design deflection

$\delta_{adm} = \min(0.75 \text{ in}, 0.003 \times L_{s1}) = 0.378 \text{ in}$

Bending deflection

$\delta_{b_s1} = 0.171 \text{ in}$

Shear deflection

$\delta_{v_s1} = 0.014 \text{ in}$

Total deflection

$\delta_a = \delta_{b_s1} + \delta_{v_s1} = 0.185 \text{ in}$

$\delta_a / \delta_{adm} = 0.489$



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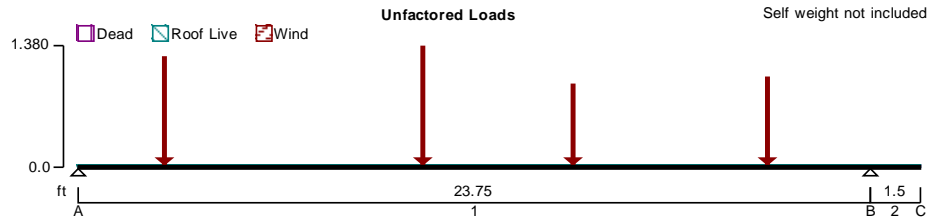
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PASS - Design deflection is less than total deflection



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CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = 2

Material Properties:

Modulus of elasticity = 29000 ksi

Material density = 490 pcf

Support Conditions:

Support A Vertically "Restrained"

Rotationally "Free"

Support B Vertically "Restrained"

Rotationally "Free"

Support C Vertically "Free"

Rotationally "Free"

Span Definitions:

Span 1 Length = 23.750 ft

Cross-sectional area = 3 in²

Moment of inertia = 60.8 in⁴

Span 2 Length = 1.500 ft

Cross-sectional area = 3 in²

Moment of inertia = 60.8 in⁴

LOADING DETAILS

Beam Loads:

Load 1 UDL Dead load 0.027 kips/ft

Load 2 UDL Roof Live load 0.027 kips/ft

Load 3 Point Wind load 1.3 kips at 2.583 ft

Load 4 Point Wind load 1.4 kips at 10.333 ft

Load 5 Point Wind load 1.0 kips at 14.833 ft

Load 6 Point Wind load 1.0 kips at 20.666 ft

LOAD COMBINATIONS

Load combination 1 - Dead + Roof live load

Span 1 1×Dead + 1×Roof Live

Span 2 1×Dead + 1×Roof Live

Load combination 2 - Dead + Wind load

Span 1 1×Dead + 1×Wind

Span 2 1×Dead + 1×Wind

Load combination 3 - Dead + Roof live load + wind load

Span 1 1×Dead + 0.75×Roof Live + 0.75×Wind

Span 2 1×Dead + 0.75×Roof Live + 0.75×Wind

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

Support A Max react = -0.64 kips Min react = -2.71 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Support B Max react = -0.72 kips Min react = -2.59 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Support C Max react = 0.00 kips Min react = 0.00 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Beam Max/Min results - Combination Summary



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Maximum shear = **2.7** kips

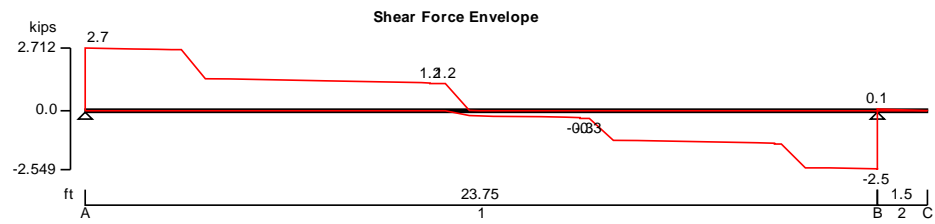
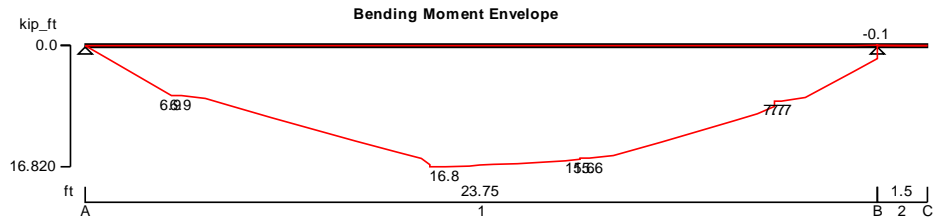
Minimum shear = **-2.5** kips

Maximum moment = **16.8** kip_ft

Minimum moment = **-0.1** kip_ft

Maximum deflection = **0.932** in

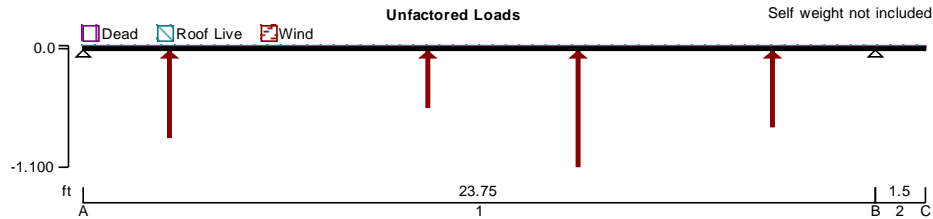
Minimum deflection = **-0.188** in





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CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = 2

Material Properties:

Modulus of elasticity = 29000 ksi

Material density = 490 pcf

Support Conditions:

Support A Vertically "Restrained"

Rotationally "Free"

Support B Vertically "Restrained"

Rotationally "Free"

Support C Vertically "Free"

Rotationally "Free"

Span Definitions:

Span 1 Length = 23.750 ft Cross-sectional area = 3 in²

Moment of inertia = 60.8 in⁴

Span 2 Length = 1.500 ft Cross-sectional area = 3 in²

Moment of inertia = 60.8 in⁴

LOADING DETAILS

Beam Loads:

Load 1 UDL Dead load 0.027 kips/ft

Load 2 UDL Roof Live load 0.027 kips/ft

Load 3 Point Wind load -0.8 kips at 2.583 ft

Load 4 Point Wind load -0.5 kips at 10.333 ft

Load 5 Point Wind load -1.1 kips at 14.833 ft

Load 6 Point Wind load -0.7 kips at 20.666 ft

LOAD COMBINATIONS

Load combination 1 - Dead + Roof live load

Span 1 1×Dead + 1×Roof Live

Span 2 1×Dead + 1×Roof Live

Load combination 2 - 0.6 Dead - Wind load

Span 1 0.6×Dead + 1×Wind

Span 2 0.6×Dead + 1×Wind

Load combination 3 - Dead + Roof live load + wind load

Span 1 1×Dead + 0.75×Roof Live + 0.75×Wind

Span 2 1×Dead + 0.75×Roof Live + 0.75×Wind

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

Support A Max react = 1.37 kips Min react = -0.64 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Support B Max react = 1.43 kips Min react = -0.72 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Support C Max react = 0.00 kips Min react = 0.00 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Beam Max/Min results - Combination Summary



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Maximum shear = 1.5 kips

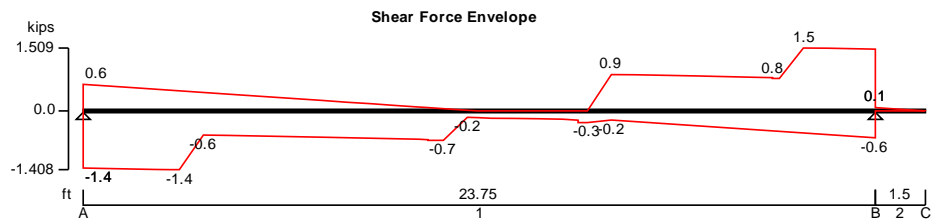
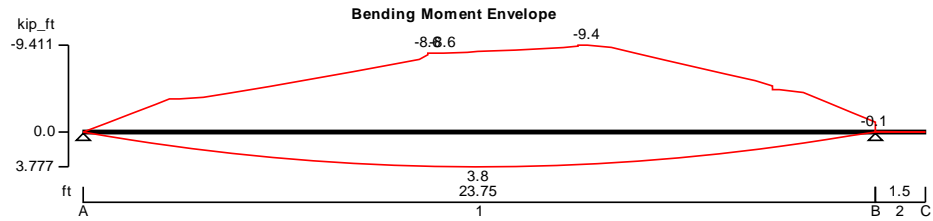
Minimum shear = -1.4 kips

Maximum moment = 3.8 kip_ft

Minimum moment = -9.4 kip_ft

Maximum deflection = 0.217 in

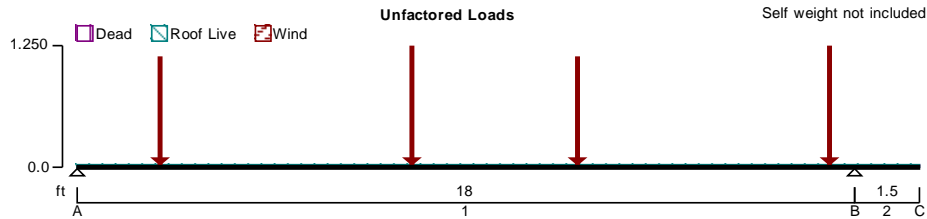
Minimum deflection = -0.506 in





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CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = 2

Material Properties:

Modulus of elasticity = 29000 ksi

Material density = 490 pcf

Support Conditions:

Support A Vertically "Restrained"

Rotationally "Free"

Support B Vertically "Restrained"

Rotationally "Free"

Support C Vertically "Free"

Rotationally "Free"

Span Definitions:

Span 1 Length = 18.000 ft

Cross-sectional area = 2 in²

Moment of inertia = 43.9 in⁴

Span 2 Length = 1.500 ft

Cross-sectional area = 2 in²

Moment of inertia = 43.9 in⁴

LOADING DETAILS

Beam Loads:

Load 1 UDL Dead load 0.027 kips/ft

Load 2 UDL Roof Live load 0.027 kips/ft

Load 3 Point Wind load 1.1 kips at 1.917 ft

Load 4 Point Wind load 1.3 kips at 7.750 ft

Load 5 Point Wind load 1.1 kips at 11.583 ft

Load 6 Point Wind load 1.3 kips at 17.417 ft

LOAD COMBINATIONS

Load combination 1 - Dead + Roof live load

Span 1 1×Dead + 1×Roof Live

Span 2 1×Dead + 1×Roof Live

Load combination 2 - Dead + Wind load

Span 1 1×Dead + 1×Wind

Span 2 1×Dead + 1×Wind

Load combination 3 - Dead + Roof live load + wind load

Span 1 1×Dead + 0.75×Roof Live + 0.75×Wind

Span 2 1×Dead + 0.75×Roof Live + 0.75×Wind

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

Support A Max react = -0.48 kips Min react = -2.42 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Support B Max react = -0.57 kips Min react = -2.89 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Support C Max react = 0.00 kips Min react = 0.00 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Beam Max/Min results - Combination Summary



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Maximum shear = **2.4** kips

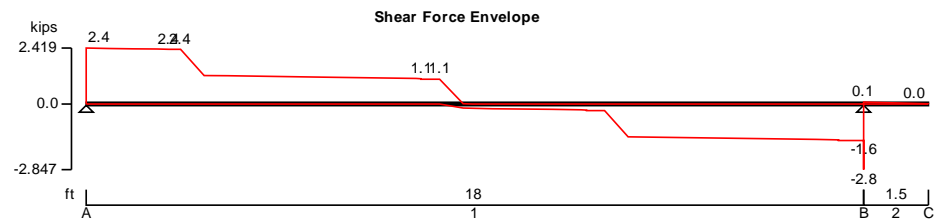
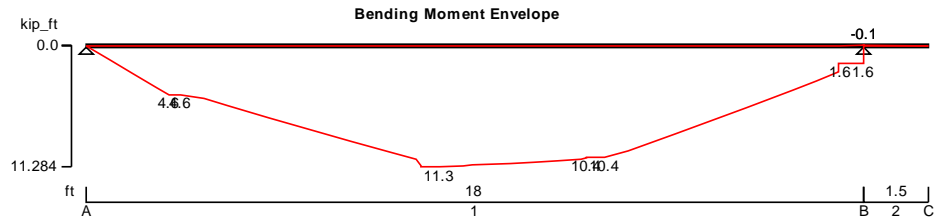
Minimum shear = **-2.8** kips

Maximum moment = **11.3** kip_ft

Minimum moment = **-0.1** kip_ft

Maximum deflection = **0.496** in

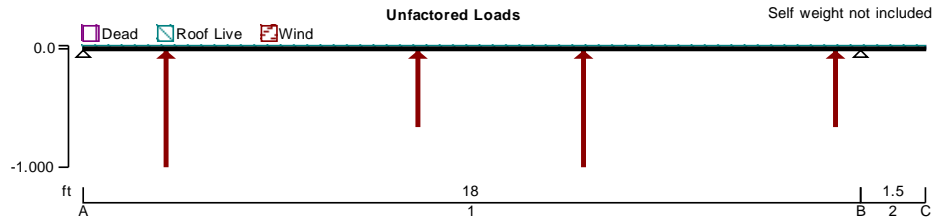
Minimum deflection = **-0.130** in





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CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = 2

Material Properties:

Modulus of elasticity = 29000 ksi

Material density = 490 pcf

Support Conditions:

Support A Vertically "Restrained"

Rotationally "Free"

Support B Vertically "Restrained"

Rotationally "Free"

Support C Vertically "Free"

Rotationally "Free"

Span Definitions:

Span 1 Length = 18.000 ft

Cross-sectional area = 2 in²

Moment of inertia = 43.9 in⁴

Span 2 Length = 1.500 ft

Cross-sectional area = 2 in²

Moment of inertia = 43.9 in⁴

LOADING DETAILS

Beam Loads:

Load 1 UDL Dead load 0.027 kips/ft

Load 2 UDL Roof Live load 0.027 kips/ft

Load 3 Point Wind load -1.0 kips at 1.917 ft

Load 4 Point Wind load -0.7 kips at 7.750 ft

Load 5 Point Wind load -1.0 kips at 11.583 ft

Load 6 Point Wind load -0.7 kips at 17.417 ft

LOAD COMBINATIONS

Load combination 1 - Dead + Roof live load

Span 1 1×Dead + 1×Roof Live

Span 2 1×Dead + 1×Roof Live

Load combination 2 - 0.6 Dead - Wind load

Span 1 0.6×Dead + 1×Wind

Span 2 0.6×Dead + 1×Wind

Load combination 3 - Dead + Roof live load + wind load

Span 1 1×Dead + 0.75×Roof Live + 0.75×Wind

Span 2 1×Dead + 0.75×Roof Live + 0.75×Wind

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

Support A Max react = 1.50 kips Min react = -0.48 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Support B Max react = 1.50 kips Min react = -0.57 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Support C Max react = 0.00 kips Min react = 0.00 kips Max mom = 0.00 kip_ft Min mom = 0.00 kip_ft

Beam Max/Min results - Combination Summary



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Maximum shear = 1.5 kips

Minimum shear = -1.5 kips

Maximum moment = 2.2 kip_ft

Minimum moment = -6.3 kip_ft

Maximum deflection = 0.099 in

Minimum deflection = -0.285 in

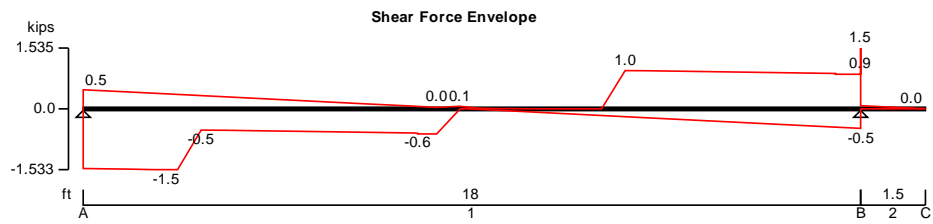
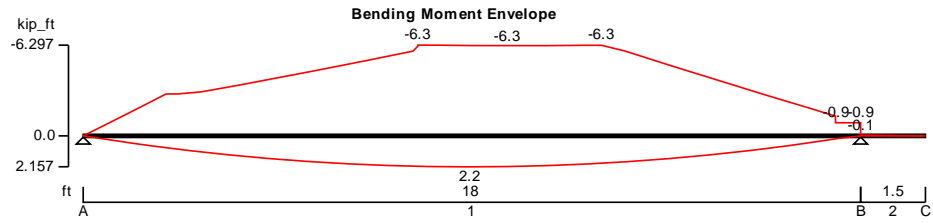
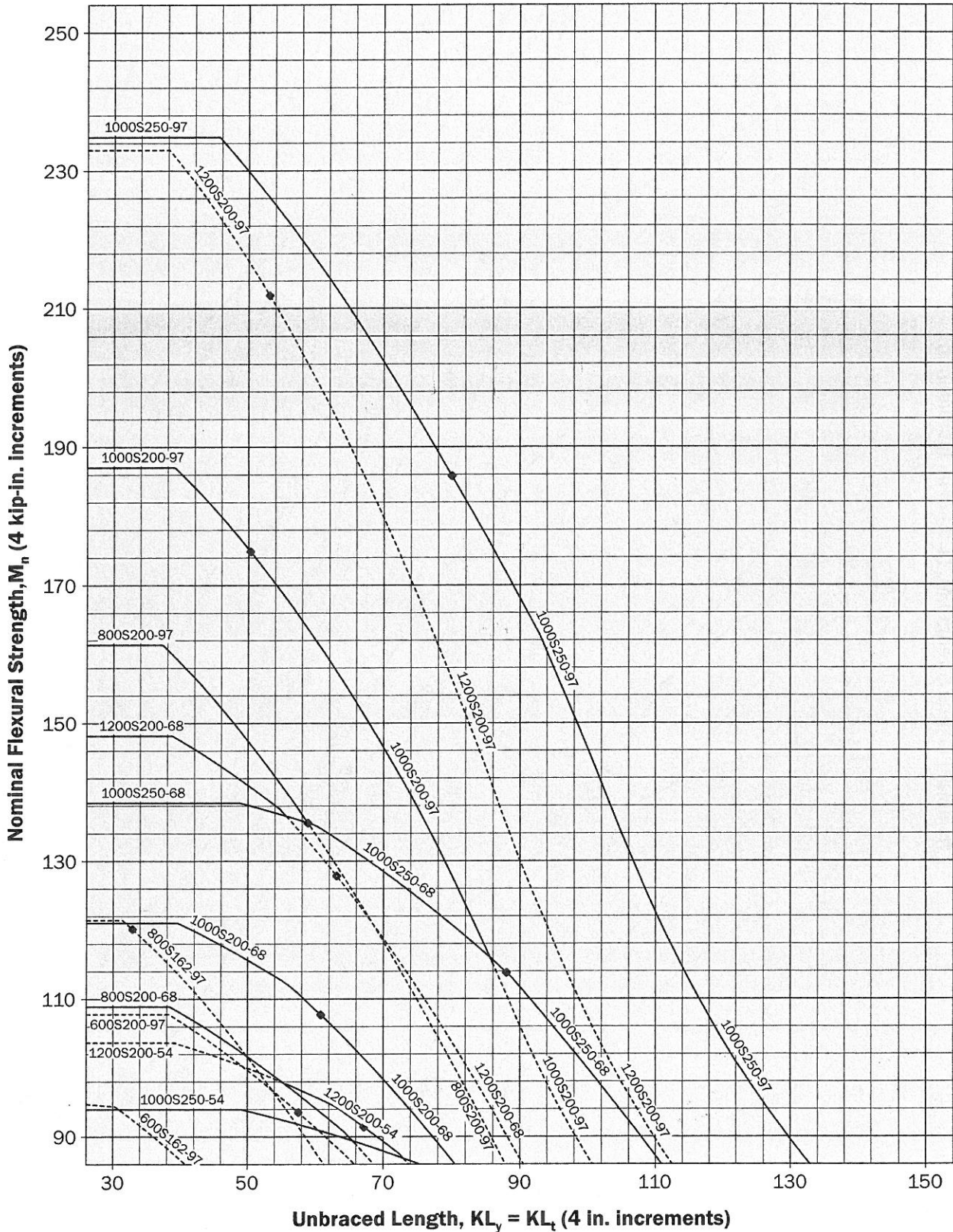
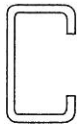


Chart II-2b

**Nominal Flexural Strength
SSMA Studs
C-Sections with Lips ($F_y = 50$ ksi, $C_b = 1$)**

$\Omega_b = 1.67$ (ASD)
 $\phi_{bY} = 0.95$ (LRFD)
 $\phi_{bLTB} = 0.90$ (LRFD)





Custom Solutions Quotation

Quote Number: **AMS-LA-130204-1014**
Revision: **3**

Quoted By: **Adam Saidel**

Customer Information

Customer: **Richmond Bysolar**
Address:
City, State Zip:

Contact: **Dave Stets**
Phone: **(804) 222-4420**
Email: **dave.stets@bysolar.net**

Project Information

Project: **Solar Decathlon**
Address:
City, State Zip:

Description:

Module Specification

Module Model: **Bosch - c-Si M60 NA30119 245W**
Height: **38.98**
Width: **64.96**

Module Quantity: **9**
Module Power: **245** Watts (DC Rated)
Project Power: **2.205** Kilowatts (DC Rated)

Racking Specifications

Pipe Selection: **2 in. Schedule 40**
Rail Selection: **SolarMount HD**
Brace Selection: **2" x 2" Aluminum Square Tube**

Pipe Cap Selection: **Aluminum- 2" Front Cap**
Number of Rows: **3**
Number of Columns: **3** Arrays: **1**

Bill of Materials

Category	Quantity	Part #	Description	Unit Price	Total
Module Racking					
	6	410144M	SMHD RAIL 144" MILL	\$146.00	\$876.00
	12	403213C	ULA RAIL BRACKET, 2"	\$18.98	\$227.76
Module Attachment					
	36	302000C	SM BOTTOM UP CLIPS W/HDW, CLR	\$1.30	\$46.80
ULA Connections					
	5	403211C	ULA FRONT CAP, 2", AL	\$43.00	\$215.00
	5	403214C	ULA REAR CAP, 2", AL	\$43.00	\$215.00
	5	403215C	ULA SLIDER, 2", AL	\$20.48	\$102.40
	5	403200C	ULA BRACE, 2"@ 7 FT	\$68.00	\$340.00
Racking Attachments					
	10	403216S	ULA THREADED FOOT, 2", STL	\$41.00	\$410.00
Seismic Bracing Materials					
	0			\$0.00	\$0.00
	0			\$0.00	\$0.00
	0			\$0.00	\$0.00
Grounding					
	15	008002S	GROUND WEEBLUG #1	\$11.15	\$167.25
Other					
	44		Pipe Req. (Feet, above ground)	\$0.00	\$0.00
Totals					
Total List Price for all components (\$USD)					\$2,600.21
List price per watt (\$USD)					\$1.18
List price per module (\$USD)					\$288.91

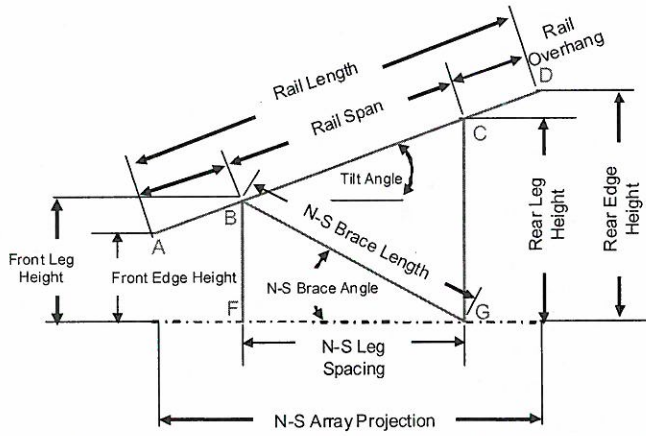
Custom Solutions Quotation

Quote Number: **AMS-LA-130204-1014**
 Revision: **3**

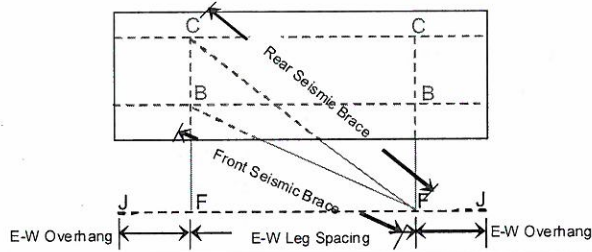
Quoted By: **Adam Saidel**

ULA Geometry

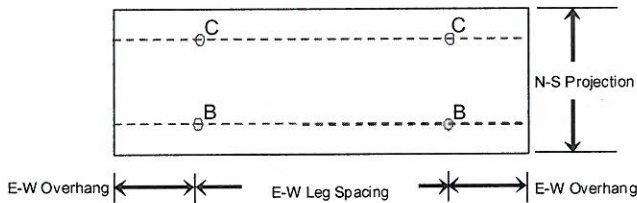
Side Elevation



Front Elevation



Plan View



Member Description	Maximum	Revised	Units
Rail Length (in):	118	118	in
Tilt Angle (deg):	10	10	degrees
Rail Span:	70.8	71.08	in
Rail Overhang:	23.6	23.46	in
Front Edge Height:	3	3	in
Rear Edge Height:	23.49	23.49	in
Front Leg Length:	7.1	7.07	in
Rear Leg Length:	19.39	19.41	in
N-S Cross Brace Length:	116.43	70.36	in
N-S Cross Brace Angle:	3.5	5.77	degrees
N-S Leg Spacing:	116.21	70	in
E-W Leg Spacing:	74	48	in
E-W Overhang (in):		2	in

Module Specification

Mfr:		Mod:	Bosch - c-Si M60 NA30
N-S Dim (in):	38.98	N-S Spacing (in):	0.25
E-W Dim (in):	64.96	E-W Spacing (in):	0.25
Thickness (in):	1.65	Power Rating (W):	245
Orientation:	L	Weight (lbs):	41.89

Sub-Array Configuration

# Rows:	3
# Columns:	3
SubArray Modules:	9
Rails Per Module:	2
Extended Rail (in):	0
Seismic Brace Pairs:	
Column N-S Length (in):	118
Array E-W Dimension (in):	196
Array N-S Projection (in):	116
Number of Leg Pairs:	5
Footing Diameter:	12 in.
Footing Depth:	18 in.

ULA Array Totals

# SubArrays:	1
Total Modules:	9
ULA Power Rating (kW):	2.205



Custom Solutions Quotation

Quote Number: **AMS-LA-130204-1014**
Revision: **3**

Quoted By: **Adam Saidel**

Inputs

Wind Load Variables

Array Height above ground:
Exposure Category:
Basic Wind Speed, V (mph):
Importance Factor:
Roof Zone Multiplier:

Load Combination Variable (psf)

Snow Load:

Pipe Design Inputs

Pipe Span (E-W Leg Spacing):
Number of Leg Pairs:

Pipe Material Specifications

Pipe Selection:

Rail Material Specifications

Rail Selection:

E-W Cross Brace Design

Cross Brace Selection:

Seismic Analysis Inputs

Latitude:
Longitude:
Site Class:
Importance Factor:
Roof Height:
Component Height:
Ss: Mapped Accel. Parameter
S1: Mapped Accel. Parameter
Fa: Table 1613.5.3(1)
Fv: Table 1613.5.3(2)

**ASCE7-05
Methodology**

- OR -

Seismic Zone:
Cross Brace Pairs:

Direct Methodology

Footing Design Inputs

Footing Diameter: in.
Footing Depth: in.
Concrete Density: Kcf
Soil Density: KcF

Footing guideline
only! Consult a
geotechnical
engineer for final
footing design!

Front Cap Design

Cap Selection:



Custom Solutions Quotation

Quote Number: **AMS-LA-130204-1014**

Quoted By: **Adam Saidel**

Revision: **3**

Terms and Conditions

Please note that the quote, specifications, and product warranty are subject to the following conditions:

1. This PV system has been designed with Unirac proprietary computer software. Use of this design with products other than Unirac is prohibited.
2. This quotation is based on information provided to Unirac. Customer is responsible for accuracy of the information provided. Any problems that develop as the result of inaccurate information about the system or site are the responsibility of the installer or customer.
3. The system must be installed per Unirac's specifications in the quote in order to be covered by Unirac's warranty.
4. Multiple revisions to this quote, which are the result of customer requests (i.e. site changes, module changes, layout, wind conditions, etc.), require a fee, based on an hourly engineering rate of \$75.00 per hour. If more than one revision is required, contact us for an estimated cost.
5. Any change to product specifications may result in the need for a re-quote.
6. Change Order, Cancellations & Returns Policy
 - a) Rush orders cannot be changed, cancelled or returned
 - b) For stocking orders only, the order may be modified up to 10 working days prior to the committed ship date; stocking orders may not be cancelled after 10 working days from date of order acknowledgement.
 - c) All other orders may not be cancelled or modified after 10 working days from date of order acknowledgement.
 - d) All order cancellations will incur a \$50 processing fee

Ordering

Please refer to www.Unirac.com for a list of stocking distributors. If you have an established account with Unirac, please place your order in the following manner:

1. Email your order, and attach the entire Unirac PDF quotation to order@Unirac.com.
2. Fax a copy of your purchase order, along with the quotation # or the itemized list page from the quotation, Attention: Order Entry Department at 505-242-6412.

Due to fluctuating raw material costs, pricing is subject to change. Please check at time of order for the most current pricing.

Quotation Notes

1. This quote is an exact material take-off. The installer may wish to have extra quantities of module mounting and grounding hardware on hand during installation.
2. Customer to provide pipe for array structure and, when applicable, concrete for ground mount footings.
3. Footing design specification is for information only and does not include soil type or frost line considerations. Please check with a local geotechnical engineer for accurate footing size and specifications.
4. Calculated pipe requirement is above ground only. Per Figure 8 in the ULA installation manual, the customer must add pipe so that the front and rear legs extend to the bottom of the footings.
5. Please note that the figures in the ULA installation manuals may not accurately reflect the actual part quantities.

Quotation Contacts

Quotation Approval and Acceptance

By signing this quotation, the customer agrees to and accepts all of the terms and conditions listed above. Customers must comply with all of the conditions and instructions specified in UniRac's Installation Manuals in order to preserve UniRac's Limited Warrantee.

Signature:

Date:

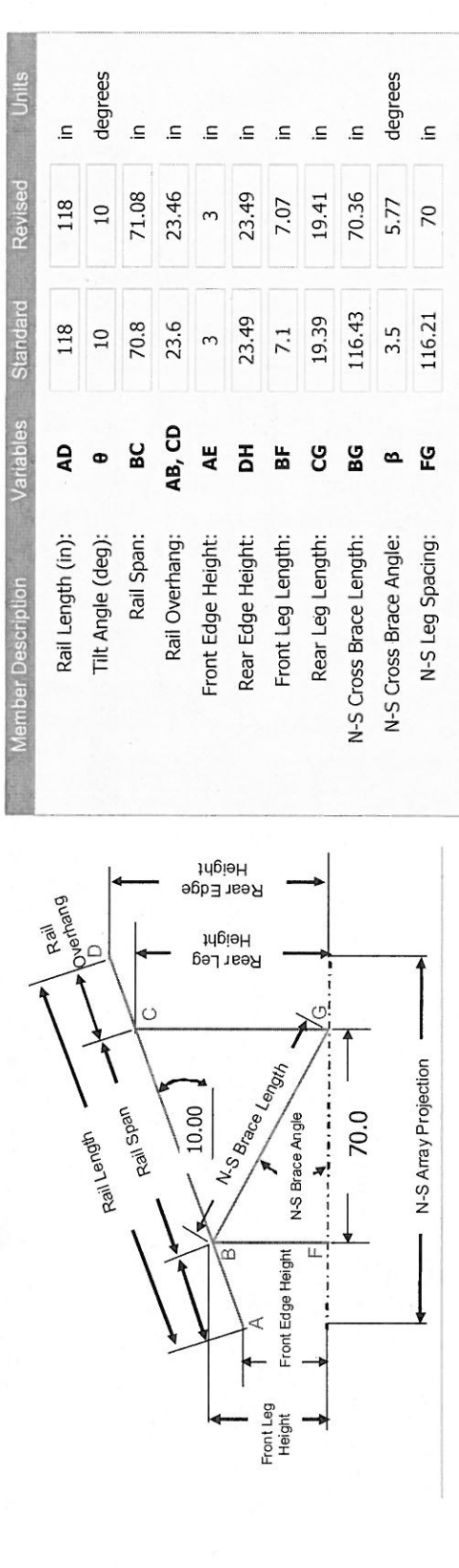
Title:

Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident: Richmond Bysolar **Contact:** Dave Stets Revision 3
Address1: **Address:** **Phone:** (804) 222-4420 Preparer adams
Address2: **Address2:** **Phone2:** **Email:** dave.stets@bysolar.net
City, ST, Zip: **City, ST, Zip:**

Module Specification		Sub-Array Configuration		ULA Totals	
Bosch - c-Si M60 NA30119 245W					
N-S Dim (in):	38.98	N-S Spacing (in):	0.25	# Rows:	3
E-W Dim (in):	64.96	E-W Spacing (in):	0.25	# Columns:	3
Thickness (in):	1.65	Power Rating (W):	245	SubArray Modules:	9
Orientation:	L	Weight (lbs):	41.89	Rails Per Module:	2
				Extended Rail (in):	0
				Column N-S Length (in):	118
				Array E-W Dimension (in):	196
				Array N-S Projection (in):	116
				# SubArrays:	1
				Total Modules:	9
				ULA Power Rating (kW):	2.205



Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident:
Address1:
Address2:
City, ST, Zip:

Customer: Richmond Bysolar
Address:
Address2:
City, ST, Zip:

Contact: Dave Stets
Phone: (804) 222-4420
Phone2:
Email: dave.stets@bysolar.net

Revision 3
Preparer adams

Wind Load Calculations

Wind Load Variables

Tilt Angle (deg): 10
Array Height above ground: 15
Exposure Category: C
Basic Wind Speed, V (mph): 110.00
Importance Factor: 1.00
Roof Zone Multiplier: 1.4

MWFRS Wind Load Calculation

$$q_h = 0.00256 K_z K_{zt} K_d V^2 I (lb / ft^2)$$

Adjustment Factor for height and Exposure Category Kz: 0.85
Topographic Factor (assumed to be 1 for level ground) Kzt: 1
Directionality Factor Kd: 0.85
Wind Load (psf) qh: 31.33

Maximum Loads (psf)

Uplift Front Leg: -32.49 Rear Leg: -47.14
Down Force Front Leg: 46.6 Rear Leg: 41.81

ASCE 7-05 Open Building Unobstructed Wind Flow Coefficients, Cn



	Load Case A	Load Case B	Load Case A	Load Case B
Front Leg	-1.22	0	1.19	1.75
Rear Leg	-0.82	-1.77	1.57	0.52
Average	1.02	-0.89	1.38	1.14

ASCE 7-05 MWFRS Open Buildings Wind Load

$$p = q_h GC_n$$

	Load Case A	Load Case B	Load Case A	Load Case B
Gust Effect Factor (G):	0.85	0.85	0.85	0.85
Cn (Front Leg):	-32.49	10	31.69	46.6
Cn (Rear Leg):	-21.84	-47.14	41.81	13.85
Cn (Avg):	27.16	-23.7	36.75	30.36

Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident: Customer: Richmond Bysolar Contact: Dave Stets Revision 3
Address1: Address: Phone: (804) 222-4420 Preparer adams
Address2: Address2: Phone2:
City, ST, Zip: City, ST, Zip: Email: dave.stets@bysolar.net

Combination Load Analysis

Complete

Load Combination Variable (psf)			
Dead Load:	6.89	Assumed	
Snow Load:	11.3		
Max Load Results (psf)			
Down Force		Uplift	
Front Leg:	53.6		-28.29
Rear Leg:	48.81		-42.94
Max (Absolute):	48.81		
Load Combination Factors			
Dead Load	1	Snow Load	0
Load Case 1 (downforce):	1	1	0
Load Case 2 (downforce):	1	0	1
Load Case 3 (downforce):	1	0.75	0.75
Load Case 4 (uplift):	0.6		1

Front Leg Load Combinations (psf)		
	Wind Load Case A	Wind Load Case B
Load Case 1 (downforce):	18.3	18.3
Load Case 2 (downforce):	38.69	53.6
Load Case 3 (downforce):	39.24	50.43
Max Downforce:	39.24	53.6
Load Case 4 (uplift):	-28.29	14.2

Rear Leg Load Combinations (psf)		
	Wind Load Case A	Wind Load Case B
Load Case 1 (downforce):	18.3	18.3
Load Case 2 (downforce):	48.81	20.85
Load Case 3 (downforce):	46.83	25.86
Max Downforce:	48.81	25.86
Load Case 4 (uplift):	-17.64	-42.94

Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident:
Address1:
Address2:
City, ST, Zip:

Customer: Richmond Bysolar
Address:
Address2:
City, ST, Zip:

Contact: Dave Stets
Phone: (804) 222-4420
Phone2:
Email: dave.stets@bysolar.net

Revision 3
Preparer adams

Horizontal Pipe Design

Complete

Pipe Design Inputs

Pipe Span (E-W Leg Spacing):

Number of Leg Pairs:

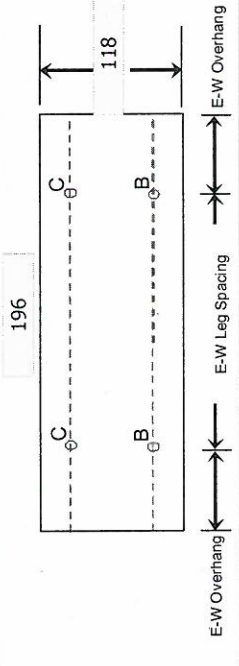
Horizontal Pipe Overhang (in):

Pipe Design Loads (psf)

Front Leg (psf):

Rear Leg (psf):

Maximum absolute value of Load Combination Loads



Pipe Material Specifications

Pipe Selection:

Modulus of Elasticity, E (psf):

Moment of Inertia, I (ft^4):

Section Modulus, Z (ft^3):

Yield Stress, Fy (psf):

Array Width (in):

Rail Length (in):

Description	Front Horizontal Pipe		Rear Horizontal Pipe	
	Max	Revised	Max	Revised
Max Distributed Load (plf):	263.53	263.53	239.98	239.98
Pipe Span (in):	73.81	48	73.81	48
Allowable Bending Moment (lb-ft):	1246.42	1246.42	1246.42	1246.42
Actual Bending Moment (lb-ft):	1246.26	527.06	1134.89	479.96
Actual/Allowable Moment:	100%	42%	91%	39%
Allowable Total Deflection L/70 (in):	1.05	0.69	1.05	0.69
Actual Deflection (in):	0.47	0.08	0.43	0.08
Actual/Allowable Deflection:	45%	12%	41%	12%

Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer: adams

Address2:

Phone2:

City, ST, Zip:

City, ST, Zip: ,
Email: dave.stets@bysolar.net

Rail Bending

Complete

Rail Design Variables

Rail Length (in): 118
 Rail Overhang (in): 23.46
 Rail Span (in): 71.08

Rail Distributed Load Calculation

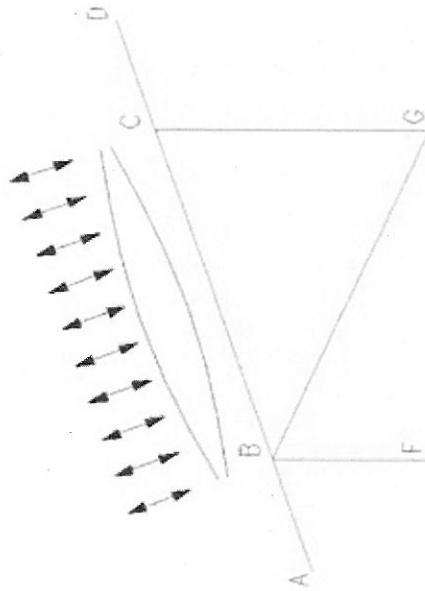
Maximum Average Design Load (psf): 43.75
 Module Dim Perpendicular to Rails (in): 64.96
 Rails Per Module: 2
 Distributed Load (plf): 118.42

Rail Material Specifications

Rail Selection:
 SolarMount HD
 E (psf): 1.45E+09
 I (ft⁴): 0.0000697
 Z (ft³): 0.000522
 Fy (psf): 2736000

Rail Bending Calculations

Allowable Bending Moment (lb-ft): 1428.19
 Actual Bending Moment (lb-ft): 519.36
 Actual/Allowable Moment: 36%
 Allowable Deflection (in): 1.01
 Actual Deflection (in): 0.23
 Actual/Allowable Deflection: 23%



Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer adams

Address2:

Address2:

Phone2:

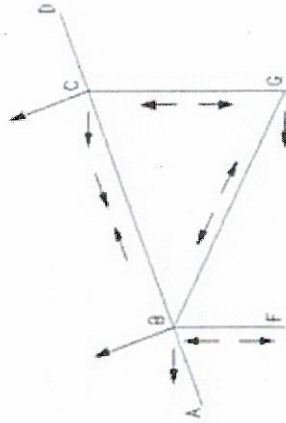
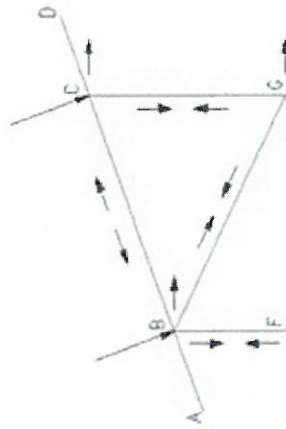
City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Force Analysis

Angles		Design Loads	
Tilt Angle (deg):	10	Downforce	Uplift
Cross Brace Angle (deg):	5.77	Front Leg (psf / kip):	53.6 1.05
E-W Leg Spacing	48	Rear Leg (psf / kip):	48.81 0.96
Rail Length:	118		



Complete

Maximum Component Forces (kips)	
Axial Force in Front Leg:	1.03
Axial Force in Front Cap:	1.39
Shear Force Front Cap:	0.36
Axial Force in Rear Leg:	0.95
Axial Force in Rear Cap:	0.78
Shear Force Rear Cap:	0.17
Shear Force Rear Foot:	0.36
Axial Force in N-S Brace:	0.36
Resultant Shear N-S Brace:	0.36
Resultant Axial N-S Brace:	0.04
Axial Force Rail:	0.17
Resultant Shear Rail:	0.03
Resultant Axial Rail:	0.17
Down Force	1.03
Uplift	-0.55
Max Magnitude	-0.65
Max Magnitude	-0.83
Max Magnitude	-0.68
Max Magnitude	0.17
Max Magnitude	0.36
Max Magnitude	-0.1
Max Magnitude	0.36
Max Magnitude	-0.01
Max Magnitude	-0.15
Max Magnitude	0.03
Max Magnitude	0.17

Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident: Richmond Bysolar **Contact:** Dave Stets Revision 3
Address1: **Address:** Phone: (804) 222-4420 Preparer adams
Address2: **Address2:** Phone2:
City, ST, Zip: **City, ST, Zip:** Email: dave.stets@bysolar.net

Column Buckling Analysis

Complete

Front Leg Design	Rear Leg Design	Rail Design	N-S - Cross Brace Design
Pipe Selection: 2 in. Schedule 40 E (ksi): 29 Fy (ksi): 35 r (in): 0.791	Pipe Selection: 2 in. Schedule 40 E (ksi): 29 Fy (ksi): 35 r (in): 0.791	Rail Selection: SolarMount HD E (ksi): 10.1 Fy (ksi): 19 r (in): 1.1679 Rails per EW Leg: 1.47	Cross Brace Selection: 2" x 2" Aluminum Square Tube E (ksi): 10.1 Fy (ksi): 19 r (in): 0.7672
Front Leg Column Calculations	Rear Leg Column Calculations	Rail Column Calculations	Cross Brace Column Calculations
Length: 7.07 Eff. Column Len. Fac: 1 Eff. Column Length: 7.07 Slenderness Ratio: 8.94 Critical Force: 20.87 Actual Force: 1.03 Ratio To Allowable: 4.94%	Length: 19.41 Eff. Column Len. Fac: 1 Eff. Column Length: 19.41 Slenderness Ratio: 24.54 Critical Force: 20.32 Actual Force: 0.95 Ratio To Allowable: 4.68%	Length: 71.08 Eff. Column Len. Fac: 1 Eff. Column Length: 71.08 Slenderness Ratio: 60.86 Critical Force: 19.55 Actual Force: 0.17 Ratio To Allowable: 0.87%	Length: 70.36 Eff. Column Len. Fac: 1 Eff. Column Length: 70.36 Slenderness Ratio: 91.71 Critical Force: 5.68 Actual Force: 0.36 Ratio To Allowable: 6.34%

Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident: Richmond Bysolar Contact: Dave Stets Revision 3
 Address1: Address: Phone: (804) 222-4420 Preparer adams
 Address2: Address2: Phone2:
 City, ST, Zip: City, ST, Zip: Email: dave.stets@bysolar.net

Seismic Design and Analysis

Complete

Seismic Analysis Inputs	ASCE7-05 Methodology	Seismic Analysis Results	E-W - Cross Brace Design
Latitude: <input type="text" value="0"/>	ASCE7-05 Methodology	Sms: <input type="text" value="0"/> Eq # 16 -37	Cross Brace Selection: 2" x 2" Aluminum Square Tube E (ksi): <input type="text" value="10.1"/> Fy (ksi): <input type="text" value="19"/> r (in): <input type="text" value="0.7672"/> Area (sq in): <input type="text" value="0.9375"/> Cross Brace Column Calculations Max CB Length: <input type="text" value="51.78"/> Eff. Column Len. Fac: <input type="text" value="2"/> Eff. Column Length: <input type="text" value="103.56"/> Slenderness Ratio: <input type="text" value="67.49"/> Critical Force: <input type="text" value="5.68"/> Kip Actual Force: <input type="text" value="0.00"/> Kip Margin Ratio: <input type="text" value="0.0%"/>
Longitude: <input type="text" value="0"/>		Sms1: <input type="text" value="0"/> Eq # 16 -38	
Site Class: <input type="text" value="A"/>		Sds: <input type="text" value="0"/> Eq # 16 -39	
Importance Factor: <input type="text" value="0"/>		Sd1: <input type="text" value="0"/> Eq # 16 -40	
Roof Height: <input type="text" value="0"/>		Ap, Rp: <input type="text" value="1.0, 1.5"/> Table 13.6 - 1	
Component Height: <input type="text" value="0"/>		Fp LRFD: <input type="text" value="0"/> Eq 13.3 - 1	
Ss: <input type="text" value="0"/> Mapped Accel. Parameter		Fp ASD: <input type="text" value="0"/> per 13.1.7	
S1: <input type="text" value="0"/> Mapped Accel. Parameter			
Fa: <input type="text" value="0"/> Table 1613.5.3(1)			
Fv: <input type="text" value="0"/> Table 1613.5.3(2)			
- OR - Seismic Zone: <input type="text"/>	Direct Methodology	Fp ASD: <input type="text" value="0"/>	
Cross Brace Pairs: <input type="text"/>	Array Weight: <input type="text" value="1124"/>	Total Axial Force: <input type="text" value="0"/> lbs	

Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer adams

Address2:

Address2:

Phone2:

City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Footing Design

Complete

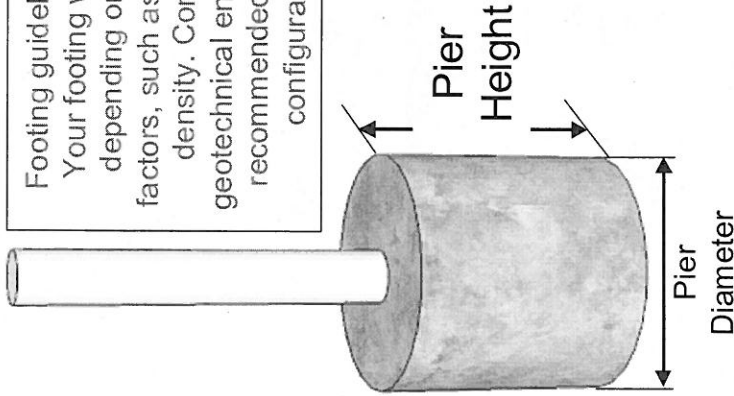
Footing Design Inputs

Footing Diameter: in.
 Footing Depth: in.
 Concrete Density: Kcf
 Soil Density: Kcf

Footing Design Calculations

Max Uplift Force: Kip
 Safety Factor:
 Required Resisting Force: Kip
 Concrete Volume: cf
 Concrete Weight: Kip
 Soil Volume: cf
 Soil Weight: Kip
 Total Weight: Kip
 Margin Ratio:

Footing guideline only.
 Your footing will vary depending on many factors, such as your soil density. Consult a geotechnical engineer for recommended footing configuration



Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer: adams

Address2:

Address2:

Phone2:

City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Cap and Foot Design

Complete

Front Cap Design

Cap Selection: Aluminum- 2" Front Cap
 Pipe Selection: 2 in. Schedule 40

Allowable:	Axial Compression (kip)	Axial Tension (kip)	Shear (kip)
Actual:	7.272	-2.4	2.424
Margin Ratio:	19.11%	-0.65	0.36
		27.08%	14.85%

Rear Cap Design

Cap Selection: Aluminum- 2" Front Cap

Allowable:	Axial Compression (kip)	Axial Tension (kip)	Shear (kip)
Actual:	7.272	-2.4	2.424
Margin Ratio:	13.06%	-0.83	0.17
		34.58%	7.01%

Front Foot Design

Actual:	Axial Compression (kip)	Axial Tension (kip)	Shear (kip)
	1.39	-0.65	0

Rear Foot Design

Actual:	Axial Compression (kip)	Axial Tension (kip)	Shear (kip)
	0.95	-0.83	0.36

Project Solar Decathlon

Quote AMS-LA-130204-1014

Project Ident: **Customer:** Richmond Bysolar
Address1: **Address:**
Address2: **Address2:**
City, ST, Zip: **City, ST, Zip:**

Contact: Dave Stets
Phone: (804) 222-4420
Phone2:
Email: dave.stets@bysolar.net

Revision 3
Preparer: adams

Design Margin Ratios

Design Specifications and Ratios		
Horizontal Pipe: 2 in. Schedule 40		
Front		Rear
Pipe Moment: 42%	Pipe Moment: 39%	39%
Pipe Deflection: 12%	Pipe Deflection: 12%	12%

Vertical Pipe Specifications and Column Design Ratios	
Front Leg Buckling:	4.94%
Rear Leg Buckling:	4.68%
N-S Brace Buckling:	6.34%

Connection Specifications and Design Ratios		
Cap Selection: Aluminum- 2" Front Cap		
Front		Rear
Axial Compression: 19.11%	Axial Compression: 13.06%	13.06%
Axial Tension: 27.08%	Axial Tension: 34.58%	34.58%
Shear: 14.85%	Shear: 7.01%	7.01%

Rail Specification, Beam and Column Design Ratios	
Rail Selection: SolarMount HD	
Rail Bending Moment: 36%	
Rail Bending Deflection: 23%	
Rail Buckling: 0.87%	

Seismic Design Ratios	
Margin Ratio: 0.0%	
Margin Ratio: 277.22%	



Custom Solutions Quotation

Quote Number: **AMS-LA-130204-2014**
Revision: **3**

Quoted By: **Adam Saidel**

Customer Information

Customer: **Richmond Bysolar**
Address:
City, State Zip:

Contact: **Dave Stets**
Phone: **(804) 222-4420**
Email: **dave.stets@bysolar.net**

Project Information

Project: **Solar Decathlon**
Address:
City, State Zip:

Description:

Module Specification

Module Model: **Bosch - c-Si M60 NA30119 245W**
Height: **38.98**
Width: **64.96**

Module Quantity: **12**
Module Power: **245** Watts (DC Rated)
Project Power: **2.94** Kilowatts (DC Rated)

Racking Specifications

Pipe Selection: **2 in. Schedule 40** Pipe Cap Selection: **Aluminum- 2" Front Cap**
Rail Selection: **SolarMount HD** Number of Rows: **4**
Brace Selection: **2" x 2" Aluminum Square Tube** Number of Columns: **3** Arrays: **1**

Bill of Materials

Category	Quantity	Part #	Description	Unit Price	Total
Module Racking					
	6	410168M	SMHD RAIL 168" MILL	\$166.00	\$996.00
	12	403213C	ULA RAIL BRACKET, 2"	\$18.98	\$227.76
Module Attachment					
	48	302000C	SM BOTTOM UP CLIPS W/HDW, CLR	\$1.30	\$62.40
ULA Connections					
	5	403211C	ULA FRONT CAP, 2", AL	\$43.00	\$215.00
	5	403214C	ULA REAR CAP, 2", AL	\$43.00	\$215.00
	5	403215C	ULA SLIDER, 2", AL	\$20.48	\$102.40
	5	403201C	ULA BRACE, 2"@ 10.5 FT	\$99.00	\$495.00
Racking Attachments					
	10	403216S	ULA THREADED FOOT, 2", STL	\$41.00	\$410.00
Seismic Bracing Materials					
	0			\$0.00	\$0.00
	0			\$0.00	\$0.00
	0			\$0.00	\$0.00
Grounding					
	18	008002S	GROUND WEEBLUG #1	\$11.15	\$200.70
Other					
	64		Pipe Req. (Feet, above ground)	\$0.00	\$0.00
Totals					
Total List Price for all components (\$USD)					\$2,924.26
List price per watt (\$USD)					\$0.99
List price per module (\$USD)					\$243.69

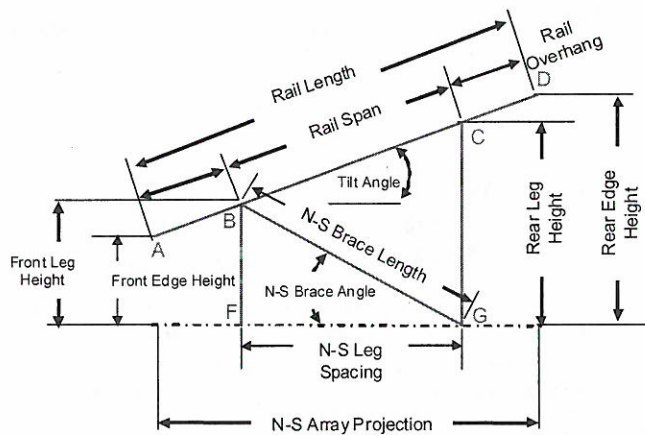
Custom Solutions Quotation

Quote Number: **AMS-LA-130204-2014**
 Revision: **3**

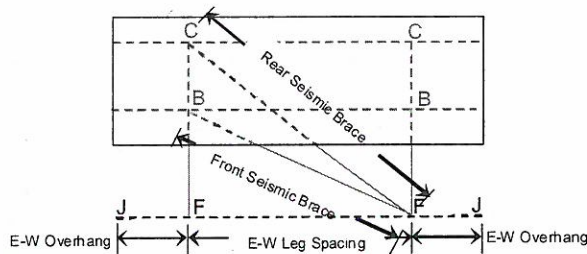
Quoted By: **Adam Saidel**

ULA Geometry

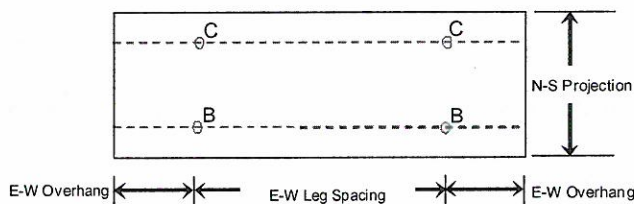
Side Elevation



Front Elevation



Plan View



Member Description	Maximum	Revised	Units
Rail Length (in):	157	157	in
Tilt Angle (deg):	10	10	degrees
Rail Span:	94.2	94.43	in
Rail Overhang:	31.4	31.29	in
Front Edge Height:	23.5	23.5	in
Rear Edge Height:	50.76	50.76	in
Front Leg Length:	28.95	28.93	in
Rear Leg Length:	45.31	45.33	in
N-S Cross Brace Length:	157.31	97.4	in
N-S Cross Brace Angle:	10.6	17.28	degrees
N-S Leg Spacing:	154.62	93	in
E-W Leg Spacing:	64	48	in
E-W Overhang (in):		2	in

Module Specification

Mfr:		Mod:	Bosch - c-Si M60 NA30
N-S Dim (in):	38.98	N-S Spacing (in):	0.25
E-W Dim (in):	64.96	E-W Spacing (in):	0.25
Thickness (in):	1.65	Power Rating (W):	245
Orientation:	L	Weight (lbs):	41.89

Sub-Array Configuration

# Rows:	4
# Columns:	3
SubArray Modules:	12
Rails Per Module:	2
Extended Rail (in):	0
Seismic Brace Pairs:	
Column N-S Length (in):	157
Array E-W Dimension (in):	196
Array N-S Projection (in):	155
Number of Leg Pairs:	5
Footing Diameter:	12 in.
Footing Depth:	18 in.

ULA Array Totals

# SubArrays:	1
Total Modules:	12
ULA Power Rating (kW):	2.94



Custom Solutions Quotation

Quote Number: AMS-LA-130204-2014

Quoted By: Adam Saidel

Revision: 3

Inputs

Wind Load Variables

Array Height above ground:
Exposure Category:
Basic Wind Speed, V (mph):
Importance Factor:
Roof Zone Multiplier:

Load Combination Variable (psf)

Snow Load:

Pipe Design Inputs

Pipe Span (E-W Leg Spacing):
Number of Leg Pairs:

Pipe Material Specifications

Pipe Selection:

Rail Material Specifications

Rail Selection:

E-W Cross Brace Design

Cross Brace Selection:

Seismic Analysis Inputs

Latitude:
Longitude:
Site Class:
Importance Factor:
Roof Height:
Component Height:
Ss: Mapped Accel. Parameter
S1: Mapped Accel. Parameter
Fa: Table 1613.5.3(1)
Fv: Table 1613.5.3(2)

**ASCE7-05
Methodology**

- OR -

Seismic Zone:

Direct Methodology

Cross Brace Pairs:

Footing Design Inputs

Footing Diameter: in.
Footing Depth: in.
Concrete Density: Kcf
Soil Density: KcF

Footing guideline only! Consult a geotechnical engineer for final footing design!

Front Cap Design

Cap Selection:



Custom Solutions Quotation

Quote Number: **AMS-LA-130204-2014**

Quoted By: **Adam Saidel**

Revision: **3**

Terms and Conditions

Please note that the quote, specifications, and product warranty are subject to the following conditions:

- 1.This PV system has been designed with Unirac proprietary computer software. Use of this design with products other than Unirac is prohibited.
- 2.This quotation is based on information provided to Unirac. Customer is responsible for accuracy of the information provided. Any problems that develop as the result of inaccurate information about the system or site are the responsibility of the installer or customer.
- 3.The system must be installed per Unirac's specifications in the quote in order to be covered by Unirac's warranty.
- 4.Multiple revisions to this quote, which are the result of customer requests (i.e. site changes, module changes, layout, wind conditions, etc.), require a fee, based on an hourly engineering rate of \$75.00 per hour. If more than one revision is required, contact us for an estimated cost.
- 5.Any change to product specifications may result in the need for a re-quote.
- 6.Change Order, Cancellations & Returns Policy
 - a)Rush orders cannot be changed, cancelled or returned
 - b)For stocking orders only, the order may be modified up to 10 working days prior to the committed ship date; stocking orders may not be cancelled after 10 working days from date of order acknowledgement.
 - c)All other orders may not be cancelled or modified after 10 working days from date of order acknowledgement.
 - d)All order cancellations will incur a \$50 processing fee

Ordering

Please refer to www.Unirac.com for a list of stocking distributors. If you have an established account with Unirac, please place your order in the following manner:

- 1.Email your order, and attach the entire Unirac PDF quotation to order@Unirac.com.
- 2.Fax a copy of your purchase order, along with the quotation # or the itemized list page from the quotation, Attention: Order Entry Department at 505-242-6412.

Due to fluctuating raw material costs, pricing is subject to change. Please check at time of order for the most current pricing.

Quotation Notes

1. This quote is an exact material take-off. The installer may wish to have extra quantities of module mounting and grounding hardware on hand during installation.
2. Customer to provide pipe for array structure and, when applicable, concrete for ground mount footings.
3. Footing design specification is for information only and does not include soil type or frost line considerations. Please check with a local geotechnical engineer for accurate footing size and specifications.
4. Calculated pipe requirement is above ground only. Per Figure 8 in the ULA installation manual, the customer must add pipe so that the front and rear legs extend to the bottom of the footings.
5. Please note that the figures in the ULA installation manuals may not accurately reflect the actual part quantities.

Quotation Contacts

Quotation Approval and Acceptance

By signing this quotation, the customer agrees to and accepts all of the terms and conditions listed above. Customers must comply with all of the conditions and instructions specified in UniRac's Installation Manuals in order to preserve UniRac's Limited Warrantee.

Signature:

Date:

Title:

Project Solar Decathlon

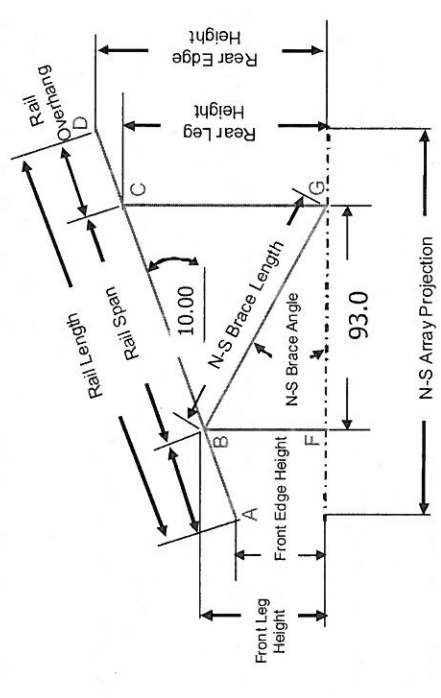
Quote AMS-LA-130204-2014

Project Ident: Customer: Richmond Bysolar Contact: Dave Stets Revision 3
Address1: Address: Phone: (804) 222-4420 Preparer adams
Address2: Address2: Phone2:
City, ST, Zip: City, ST, Zip: Email: dave.stets@bysolar.net

ULA Geometry

Module Specification		Sub-Array Configuration		ULA Totals	
Bosch - c-Si M60 NA30119 245W					
N-S Dim (in):	38.98	N-S Spacing (in):	0.25	# Rows:	4
E-W Dim (in):	64.96	E-W Spacing (in):	0.25	# Columns:	3
Thickness (in):	1.65	Power Rating (W):	245	SubArray Modules:	12
Orientation:	L	Weight (lbs):	41.89	Rails Per Module:	2
				Extended Rail (in):	0
				Column N-S Length (in):	157
				Array E-W Dimension (in):	196
				Array N-S Projection (in):	155
				# SubArrays:	1
				Total Modules:	12
				ULA Power Rating (kW):	2.94

Member Description	Variables	Standard	Revised	Units
Rail Length (in):	AD	157	157	in
Tilt Angle (deg):	θ	10	10	degrees
Rail Span:	BC	94.2	94.43	in
Rail Overhang:	AB, CD	31.4	31.29	in
Front Edge Height:	AE	23.5	23.5	in
Rear Edge Height:	DH	50.76	50.76	in
Front Leg Length:	BF	28.95	28.93	in
Rear Leg Length:	CG	45.31	45.33	in
N-S Cross Brace Length:	BG	157.31	97.4	in
N-S Cross Brace Angle:	β	10.6	17.28	degrees
N-S Leg Spacing:	FG	154.62	93	in



Project Solar Decathlon

Quote AMS-LA-130204-2014

Project Ident:
Address1:
Address2:
City, ST, Zip:

Customer: Richmond Bysolar
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City, ST, Zip:

Contact: Dave Stets
Phone: (804) 222-4420
Phone2:
Email: dave.stets@bysolar.net

Revision 3
Preparer adams

Wind Load Calculations

Wind Load Variables

Tilt Angle (deg): 10
Array Height above ground: 15
Exposure Category: C
Basic Wind Speed, V (mph): 110.00
Importance Factor: 1.00
Roof Zone Multiplier: 1.4

MWFRS Wind Load Calculation

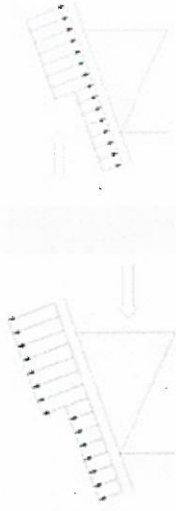
$$q_h = 0.00256 K_z K_{zt} K_d V^2 I (lb/ft^2)$$

Adjustment Factor for height and Exposure Category Kz: 0.85
Topographic Factor (assumed to be 1 for level ground) Kzt: 1
Directionality Factor Kd: 0.85
Wind Load (psf) qh: 31.33

Maximum Loads (psf)

Uplift
Front Leg: -32.49
Rear Leg: -47.14
Down Force
Front Leg: 46.6
Rear Leg: 41.81

ASCE 7-05 Open Building Unobstructed Wind Flow Coefficients, Cn



	Load Case A	Load Case B	Load Case A	Load Case B
Front Leg	-1.22	0	1.19	1.75
Rear Leg	-0.82	-1.77	1.57	0.52
Average	1.02	-0.89	1.38	1.14

ASCE 7-05 MWFRS Open Buildings Wind Load

$$\text{Gust Effect Factor (G): } 0.85 \quad p = q_h G C_n$$

	Load Case A	Load Case B	Load Case A	Load Case B
Gust Effect Factor (G)	0.85	0.85	0.85	0.85
Cn (Front Leg)	-32.49	10	31.69	46.6
Cn (Rear Leg)	-21.84	-47.14	41.81	13.85
Cn (Avg)	27.16	-23.7	36.75	30.36

Complete

Project Solar Decathlon

Quote AMS-LA-130204-2014

Project Ident: Richmond Bysolar **Contact:** Dave Stets Revision 3
Address1: **Address:** **Phone:** (804) 222-4420 Preparer adams
Address2: **Address2:** **Phone2:** **Email:** dave.stets@bysolar.net
City, ST, Zip: **City, ST, Zip:**

Combination Load Analysis

Complete

Load Combination Variable (psf)

Dead Load:	6.89	Assumed
Snow Load:	11.3	

Max Load Results (psf)

Down Force	Uplift
Front Leg: 53.6	-28.29
Rear Leg: 48.81	-42.94
Max (Absolute): 48.81	

Front Leg Load Combinations (psf)

	Wind Load Case A	Wind Load Case B
Load Case 1 (downforce):	18.3	18.3
Load Case 2 (downforce):	38.69	53.6
Load Case 3 (downforce):	39.24	50.43
Max Downforce:	39.24	53.6
Load Case 4 (uplift):	-28.29	14.2

Load Combination Factors

	Dead Load	Snow Load	Wind Load
Load Case 1 (downforce):	1	1	0
Load Case 2 (downforce):	1	0	1
Load Case 3 (downforce):	1	0.75	0.75
Load Case 4 (uplift):	0.6		1

Rear Leg Load Combinations (psf)

	Wind Load Case A	Wind Load Case B
Load Case 1 (downforce):	18.3	18.3
Load Case 2 (downforce):	48.81	20.85
Load Case 3 (downforce):	46.83	25.86
Max Downforce:	48.81	25.86
Load Case 4 (uplift):	-17.64	-42.94

Project Solar Decathlon

Quote AMS-LA-130204-2014

Project Ident:
Address1:
Address2:
City, ST, Zip:

Customer: Richmond Bysolar
Address:
Address2:
City, ST, Zip:

Contact: Dave Stets
Phone: (804) 222-4420
Phone2:
Email: dave.stets@bysolar.net

Revision 3
Preparer adams

Horizontal Pipe Design

Pipe Design Inputs

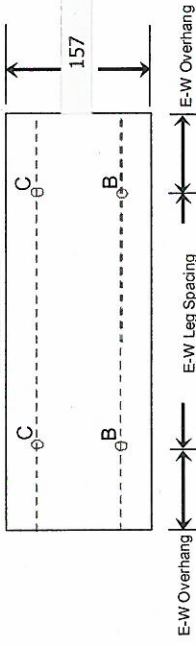
Pipe Span (E-W Leg Spacing):
 Number of Leg Pairs:
 Horizontal Pipe Overhang (in):

Pipe Design Loads (psf)

Front Leg (psf):
 Rear Leg (psf):
 Maximum absolute value of Load Combination Loads

Complete

196



Pipe Material Specifications

Pipe Selection:
 Modulus of Elasticity, E (psf):
 Moment of Inertia, I (ft⁴):
 Section Modulus, Z (ft³):
 Yield Stress, Fy (psf):
 Array Width (in):
 Rail Length (in):

Description

Max Distributed Load (plf):
 Pipe Span (in):
 Allowable Bending Moment (lb-ft):
 Actual Bending Moment (lb-ft):
 Actual/Allowable Moment:
 Allowable Total Deflection L/70 (in):
 Actual Deflection (in):
 Actual/Allowable Deflection:

Description	Front Horizontal Pipe		Rear Horizontal Pipe	
	Max	Revised	Max	Revised
Max Distributed Load (plf):	350.63	350.63	319.3	319.3
Pipe Span (in):	63.99	48	63.99	48
Allowable Bending Moment (lb-ft):	1246.42	1246.42	1246.42	1246.42
Actual Bending Moment (lb-ft):	1246.3	701.26	1134.93	638.6
Actual/Allowable Moment:	100%	56%	91%	51%
Allowable Total Deflection L/70 (in):	0.91	0.69	0.91	0.69
Actual Deflection (in):	0.35	0.11	0.32	0.1
Actual/Allowable Deflection:	38%	16%	35%	14%

Project Solar Decathlon

Quote AMS-LA-130204-2014

Project Ident: Richmond Bysolar
 Contact: Dave Stets
 Address1: Address:
 Address2: Address2:
 City, ST, Zip: City, ST, Zip: ,
 Phone: (804) 222-4420
 Phone2:
 Email: dave.stets@bysolar.net

Revision 3

Preparer adams

Rail Bending

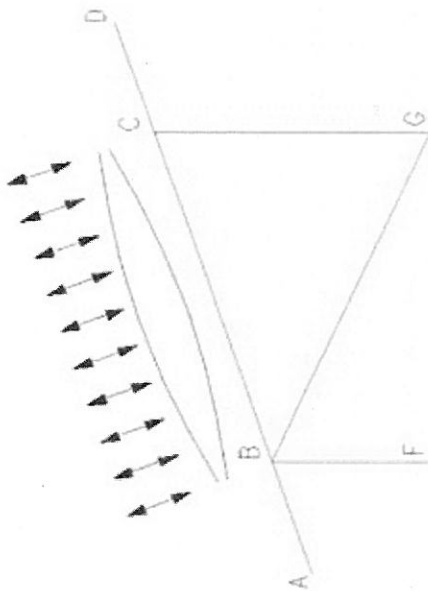
Complete

Rail Design Variables	
Rail Length (in):	157
Rail Overhang (in):	31.29
Rail Span (in):	94.43

Rail Material Specifications	
Rail Selection:	SolarMount HD
E (psf):	1.45E+09
I (ft ⁴):	0.0000697
Z (ft ³):	0.000522
Fy (psf):	2736000

Rail Distributed Load Calculation	
Maximum Average Design Load (psf):	43.75
Module Dim Perpendicular to Rails (in):	64.96
Rails Per Module:	2
Distributed Load (plf):	118.42

Rail Bending Calculations	
Allowable Bending Moment (lb-ft):	1428.19
Actual Bending Moment (lb-ft):	916.63
Actual/Allowable Moment:	64%
Allowable Deflection (in):	1.35
Actual Deflection (in):	0.7
Actual/Allowable Deflection:	52%



Project Solar Decathlon

Quote AMS-LA-130204-2014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer: adams

Address2:

Phone2:

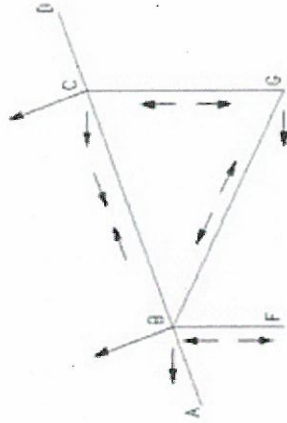
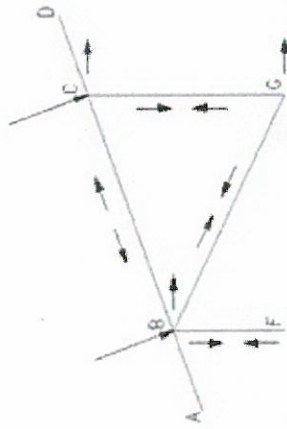
City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Force Analysis

Angles		Design Loads		
Tilt Angle (deg):	10	Downforce	Uplift	
Cross Brace Angle (deg):	17.28	Front Leg (psf / kip):	53.6	1.4
E-W Leg Spacing	48	Rear Leg (psf / kip):	48.81	1.28
Rail Length:	157			



Complete

Maximum Component Forces (kips)	
Axial Force in Front Leg:	1.38
Axial Force in Front Cap:	1.87
Shear Force Front Cap:	0.49
Axial Force in Rear Leg:	1.26
Axial Force in Rear Cap:	1.04
Shear Force Rear Cap:	0.22
Shear Force Rear Foot:	0.49
Axial Force in N-S Brace:	0.49
Resultant Shear N-S Brace:	0.47
Resultant Axial N-S Brace:	0.15
Axial Force Rail:	0.22
Resultant Shear Rail:	0.04
Resultant Axial Rail:	0.22
Uplift	-0.73
Max Magnitude	-0.86
Max Magnitude	-1.1
Max Magnitude	-0.91
Max Magnitude	Max Magnitude
Max Magnitude	Max Magnitude
Max Magnitude	-0.13
Max Magnitude	Max Magnitude
Max Magnitude	-0.04
Max Magnitude	-0.19
Max Magnitude	Max Magnitude
Max Magnitude	-0.19

Project Solar Decathlon

Quote AMS-LA-130204-2014

Project Ident: Customer: Richmond Bysolar Contact: Dave Stets Revision 3
Address1: Phone: (804) 222-4420 Preparer adams
Address2: Phone2:
City, ST, Zip: City, ST, Zip: Email: dave.stets@bysolar.net

Column Buckling Analysis

Complete

Front Leg Design	Rear Leg Design	Rail Design	N-S - Cross Brace Design
Pipe Selection: 2 in. Schedule 40 E (ksi): 29 Fy (ksi): 35 r (in): 0.791	Pipe Selection: 2 in. Schedule 40 E (ksi): 29 Fy (ksi): 35 r (in): 0.791	Rail Selection: SolarMount HD E (ksi): 10.1 Fy (ksi): 19 r (in): 1.1679 Rails per EW Leg: 1.47	Cross Brace Selection: 2" x 2" Aluminum Square Tube E (ksi): 10.1 Fy (ksi): 19 r (in): 0.7672
Front Leg Column Calculations Length: 28.93 Eff. Column Len. Fac: 1 Eff. Column Length: 28.93 Slenderness Ratio: 36.57 Critical Force: 19.57 Actual Force: 1.38 Ratio To Allowable: 7.05%	Rear Leg Column Calculations Length: 45.33 Eff. Column Len. Fac: 1 Eff. Column Length: 45.33 Slenderness Ratio: 57.31 Critical Force: 17.72 Actual Force: 1.26 Ratio To Allowable: 7.11%	Rail Column Calculations Length: 94.43 Eff. Column Len. Fac: 1 Eff. Column Length: 94.43 Slenderness Ratio: 80.85 Critical Force: 8.28 Actual Force: 0.22 Ratio To Allowable: 2.66%	Cross Brace Column Calculations Length: 97.4 Eff. Column Len. Fac: 1 Eff. Column Length: 97.40 Slenderness Ratio: 126.96 Critical Force: 2.97 Actual Force: 0.49 Ratio To Allowable: 16.50%

Project Solar Decathlon

Quote AMS-LA-130204-2014

Project Ident: Richmond Bysolar **Contact:** Dave Stets **Revision** 3
Address1: **Phone:** (804) 222-4420 **Preparer** adams
Address2: **Phone2:**
City, ST, Zip: **Email:** dave.stets@bysolar.net

Seismic Design and Analysis

Complete

Seismic Analysis Inputs		Seismic Analysis Results		E-W - Cross Brace Design	
ASCE7-05 Methodology Latitude: <input type="text" value="0"/> Eq # 16 -37 Longitude: <input type="text" value="0"/> Eq # 16 - 38 Site Class: <input type="text" value="A"/> Eq # 16 -39 Importance Factor: <input type="text" value="0"/> Eq # 16 -40 Roof Height: <input type="text" value="0"/> Table 13.6 - 1 Component Height: <input type="text" value="0"/> Eq 13.3 - 1 Ss: <input type="text" value="0"/> Mapped Accel. Parameter S1: <input type="text" value="0"/> Mapped Accel. Parameter Fa: <input type="text" value="0"/> Table 1613.5.3(1) Fv: <input type="text" value="0"/> Table 1613.5.3(2)		Sms: <input type="text" value="0"/> Eq # 16 -37 Sm1: <input type="text" value="0"/> Eq # 16 - 38 Sds: <input type="text" value="0"/> Eq # 16 -39 Sd1: <input type="text" value="0"/> Eq # 16 -40 Ap, Rp: <input type="text" value="1.0, 1.5"/> Table 13.6 - 1 Fp LRFD: <input type="text" value="0"/> Eq 13.3 - 1 Fp ASD: <input type="text" value="0"/> per 13.1.7		Cross Brace Selection: 2" x 2" Aluminum Square Tube E (ksi): <input type="text" value="10.1"/> Fy (ksi): <input type="text" value="19"/> r (in): <input type="text" value="0.7672"/> Area (sq in): <input type="text" value="0.9375"/> Cross Brace Column Calculations Max CB Length: <input type="text" value="66.02"/> Eff. Column Len. Fac: <input type="text" value="2"/> Eff. Column Length: <input type="text" value="132.04"/> Slenderness Ratio: <input type="text" value="86.05"/> Critical Force: <input type="text" value="2.97"/> Kip Actual Force: <input type="text" value="0.00"/> Kip Margin Ratio: <input type="text" value="0.0%"/>	
- OR - Seismic Zone: <input type="text"/>		Fp ASD: <input type="text" value="0"/>			
Cross Brace Pairs: <input type="text"/>		Array Weight: <input type="text" value="1496"/> lbs Total Axial Force: <input type="text" value="0"/> lbs			

Project Solar Decathlon

Quote AMS-LA-130204-2014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer adams

Address2:

Address2:

Phone2:

City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Footing Design

Complete

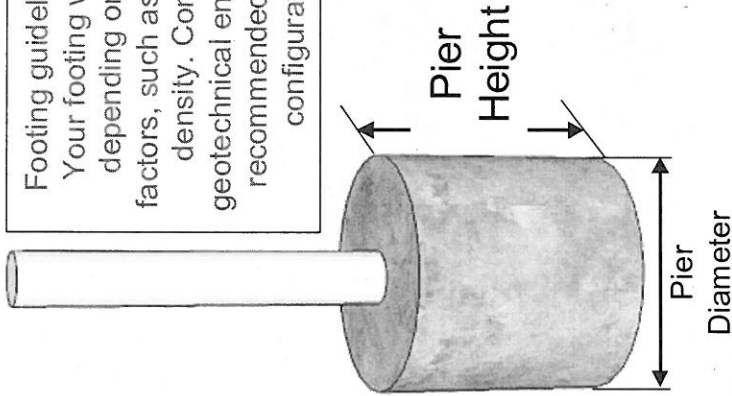
Footing Design Inputs

Footing Diameter: in.
 Footing Depth: in.
 Concrete Density: Kcf
 Soil Density: Kcf

Footing Design Calculations

Max Uplift Force: Kip
 Safety Factor:
 Required Resisting Force: Kip
 Concrete Volume: cf
 Concrete Weight: Kip
 Soil Volume: cf
 Soil Weight: Kip
 Total Weight: Kip
 Margin Ratio:

Footing guideline only.
 Your footing will vary depending on many factors, such as your soil density. Consult a geotechnical engineer for recommended footing configuration



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Preparer adams

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Address2:

Phone2:

City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Cap and Foot Design

Complete

Front Cap Design

Cap Selection: Aluminum- 2" Front Cap
Pipe Selection: 2 in. Schedule 40

Axial Compression (kip)	7.272	Axial Tension (kip)	-2.4	Shear (kip)	2.424
Allowable:	7.272	Actual:	1.87	Actual:	0.49
Margin Ratio:	25.72%		35.83%		20.21%

Front Foot Design

Axial Compression (kip)	1.87	Axial Tension (kip)	-0.86	Shear (kip)	0
Actual:	1.87		-0.86		0

Rear Cap Design

Cap Selection: Aluminum- 2" Front Cap

Axial Compression (kip)	7.272	Axial Tension (kip)	-2.4	Shear (kip)	2.424
Allowable:	7.272	Actual:	1.26	Actual:	0.22
Margin Ratio:	17.33%		45.83%		9.08%

Rear Foot Design

Axial Compression (kip)	1.26	Axial Tension (kip)	-1.1	Shear (kip)	0.49
Actual:	1.26		-1.1		0.49

Project Solar Decathlon

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Address2:

Phone2:

City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Design Margin Ratios

Design Specifications and Ratios

Horizontal Pipe: 2 in. Schedule 40

Front

Rear

Pipe Moment: 56%

Pipe Moment: 51%

Pipe Deflection: 16%

Pipe Deflection: 14%

Vertical Pipe Specifications and Column Design Ratios

Front Leg Buckling: 7.05%

Rear Leg Buckling: 7.11%

N-S Brace Buckling: 16.50%

Connection Specifications and Design Ratios

Cap Selection: Aluminum- 2" Front Cap

Front

Rear

Axial Compression: 25.72%

Axial Compression: 17.33%

Axial Tension: 35.83%

Axial Tension: 45.83%

Shear: 20.21%

Shear: 9.08%

Rail Specification, Beam and Column Design Ratios

Rail Selection: SolarMount HD

Rail Bending Moment: 64%

Rail Bending Deflection: 52%

Rail Buckling: 2.66%

Seismic Design Ratios

Margin Ratio: 0.0%

Footing Design Ratios

Margin Ratio: 367.40%



Custom Solutions Quotation

Quote Number: **AMS-LA-130204-3014**
 Revision: **3**

Quoted By: **Adam Saidel**

Customer Information

Customer: **Richmond Bysolar**
 Address:
 City, State Zip:

Contact: **Dave Stets**
 Phone: **(804) 222-4420**
 Email: **dave.stets@bysolar.net**

Project Information

Project: **Solar Decathlon**
 Address:
 City, State Zip:

Description:

Module Specification

Module Model: **Bosch - c-Si M60 NA30119 245W**
 Height: **38.98**
 Width: **64.96**

Module Quantity: **12**
 Module Power: **245** Watts (DC Rated)
 Project Power: **2.94** Kilowatts (DC Rated)

Racking Specifications

Pipe Selection: **2 in. Schedule 40**
 Rail Selection: **SolarMount HD**
 Brace Selection: **2" x 2" Aluminum Square Tube**

Pipe Cap Selection: **Aluminum- 2" Front Cap**
 Number of Rows: **3**
 Number of Columns: **4** Arrays: **1**

Bill of Materials

Category	Quantity	Part #	Description	Unit Price	Total
Module Racking					
	8	410144M	SMHD RAIL 144" MILL	\$146.00	\$1,168.00
	16	403213C	ULA RAIL BRACKET, 2"	\$18.98	\$303.68
Module Attachment					
	48	302000C	SM BOTTOM UP CLIPS W/HDW, CLR	\$1.30	\$62.40
ULA Connections					
	5	403211C	ULA FRONT CAP, 2", AL	\$43.00	\$215.00
	5	403214C	ULA REAR CAP, 2", AL	\$43.00	\$215.00
	5	403215C	ULA SLIDER, 2", AL	\$20.48	\$102.40
	5	403200C	ULA BRACE, 2"@ 7 FT	\$68.00	\$340.00
Racking Attachments					
	10	403216S	ULA THREADED FOOT, 2", STL	\$41.00	\$410.00
Seismic Bracing Materials					
	0			\$0.00	\$0.00
	0			\$0.00	\$0.00
	0			\$0.00	\$0.00
Grounding					
	20	008002S	GROUND WEEBLUG #1	\$11.15	\$223.00
Other					
	66		Pipe Req. (Feet, above ground)	\$0.00	\$0.00
Totals					
Total List Price for all components (\$USD)					\$3,039.48
List price per watt (\$USD)					\$1.03
List price per module (\$USD)					\$253.29

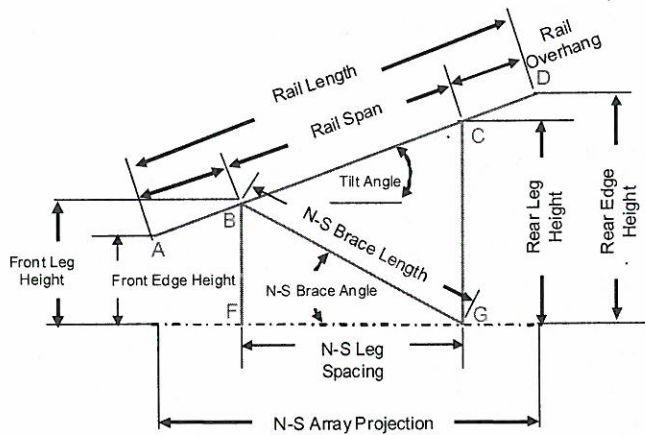
Custom Solutions Quotation

Quote Number: **AMS-LA-130204-3014**
 Revision: **3**

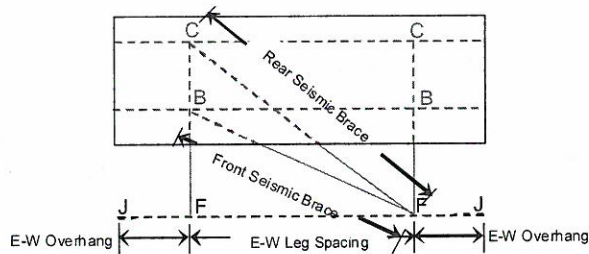
Quoted By: **Adam Saidel**

ULA Geometry

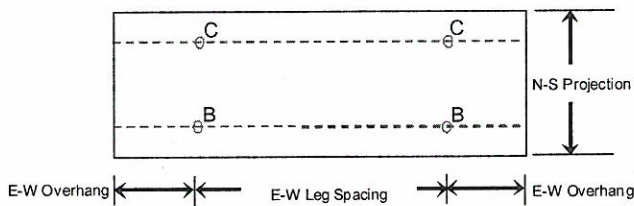
Side Elevation



Front Elevation



Plan View



Member Description	Maximum	Revised	Units
Rail Length (in):	118	118	in
Tilt Angle (deg):	10	10	degrees
Rail Span:	70.8	71.08	in
Rail Overhang:	23.6	23.46	in
Front Edge Height:	16.55	16.55	in
Rear Edge Height:	37.04	37.04	in
Front Leg Length:	20.65	20.62	in
Rear Leg Length:	32.94	32.96	in
N-S Cross Brace Length:	118.03	72.97	in
N-S Cross Brace Angle:	10.08	16.41	degrees
N-S Leg Spacing:	116.21	70	in
E-W Leg Spacing:	74	58	in
E-W Overhang (in):		14.5	in

Module Specification

Mfr:		Mod:	Bosch - c-Si M60 NA30
N-S Dim (in):	38.98	N-S Spacing (in):	0.25
E-W Dim (in):	64.96	E-W Spacing (in):	0.25
Thickness (in):	1.65	Power Rating (W):	245
Orientation:	L	Weight (lbs):	41.89

Sub-Array Configuration

# Rows:	3
# Columns:	4
SubArray Modules:	12
Rails Per Module:	2
Extended Rail (in):	0
Seismic Brace Pairs:	
Column N-S Length (in):	118
Array E-W Dimension (in):	261
Array N-S Projection (in):	116
Number of Leg Pairs:	5
Footing Diameter:	12 in.
Footing Depth:	18 in.

ULA Array Totals

# SubArrays:	1
Total Modules:	12
ULA Power Rating (kW):	2.94



Custom Solutions Quotation

Quote Number: **AMS-LA-130204-3014**
Revision: **3**

Quoted By: **Adam Saidel**

Inputs

Wind Load Variables

Array Height above ground:
Exposure Category:
Basic Wind Speed, V (mph):
Importance Factor:
Roof Zone Multiplier:

Load Combination Variable (psf)

Snow Load:

Pipe Design Inputs

Pipe Span (E-W Leg Spacing):
Number of Leg Pairs:

Pipe Material Specifications

Pipe Selection:

Rail Material Specifications

Rail Selection:

E-W Cross Brace Design

Cross Brace Selection:

Seismic Analysis Inputs

Latitude: **ASCE7-05 Methodology**
Longitude:
Site Class:
Importance Factor:
Roof Height:
Component Height:
Ss: Mapped Accel. Parameter
S1: Mapped Accel. Parameter
Fa: Table 1613.5.3(1)
Fv: Table 1613.5.3(2)

- OR - Seismic Zone:

Direct Methodology

Cross Brace Pairs:

Footing Design Inputs

Footing Diameter: in. Footing guideline only! Consult a geotechnical engineer for final footing design!
Footing Depth: in.
Concrete Density: Kcf
Soil Density: KcF

Front Cap Design

Cap Selection:



Custom Solutions Quotation

Quote Number: **AMS-LA-130204-3014**
Revision: **3**

Quoted By: **Adam Saidel**

Terms and Conditions

Please note that the quote, specifications, and product warranty are subject to the following conditions:

1. This PV system has been designed with Unirac proprietary computer software. Use of this design with products other than Unirac is prohibited.
2. This quotation is based on information provided to Unirac. Customer is responsible for accuracy of the information provided. Any problems that develop as the result of inaccurate information about the system or site are the responsibility of the installer or customer.
3. The system must be installed per Unirac's specifications in the quote in order to be covered by Unirac's warranty.
4. Multiple revisions to this quote, which are the result of customer requests (i.e. site changes, module changes, layout, wind conditions, etc.), require a fee, based on an hourly engineering rate of \$75.00 per hour. If more than one revision is required, contact us for an estimated cost.
5. Any change to product specifications may result in the need for a re-quote.
6. Change Order, Cancellations & Returns Policy
 - a) Rush orders cannot be changed, cancelled or returned
 - b) For stocking orders only, the order may be modified up to 10 working days prior to the committed ship date; stocking orders may not be cancelled after 10 working days from date of order acknowledgement.
 - c) All other orders may not be cancelled or modified after 10 working days from date of order acknowledgement.
 - d) All order cancellations will incur a \$50 processing fee

Ordering

Please refer to www.Unirac.com for a list of stocking distributors. If you have an established account with Unirac, please place your order in the following manner:

1. Email your order, and attach the entire Unirac PDF quotation to order@Unirac.com.
2. Fax a copy of your purchase order, along with the quotation # or the itemized list page from the quotation, Attention: Order Entry Department at 505-242-6412.

Due to fluctuating raw material costs, pricing is subject to change. Please check at time of order for the most current pricing.

Quotation Notes

1. This quote is an exact material take-off. The installer may wish to have extra quantities of module mounting and grounding hardware on hand during installation.
2. Customer to provide pipe for array structure and, when applicable, concrete for ground mount footings.
3. Footing design specification is for information only and does not include soil type or frost line considerations. Please check with a local geotechnical engineer for accurate footing size and specifications.
4. Calculated pipe requirement is above ground only. Per Figure 8 in the ULA installation manual, the customer must add pipe so that the front and rear legs extend to the bottom of the footings.
5. Please note that the figures in the ULA installation manuals may not accurately reflect the actual part quantities.

Quotation Contacts

Quotation Approval and Acceptance

By signing this quotation, the customer agrees to and accepts all of the terms and conditions listed above. Customers must comply with all of the conditions and instructions specified in UniRac's Installation Manuals in order to preserve UniRac's Limited Warrantee.

Signature:

Date:

Title:

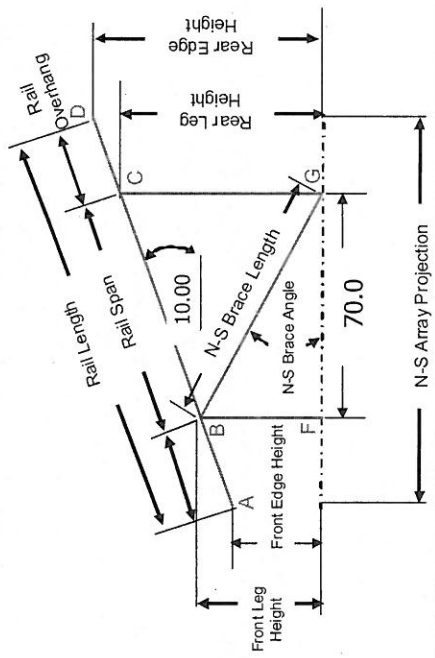
Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident: Customer: Richmond Bysolar Contact: Dave Stets Revision 3
Address1: Address: Phone: (804) 222-4420 Preparer adams
Address2: Address2: Phone2:
City, ST, Zip: City, ST, Zip: Email: dave.stets@bysolar.net

ULA Geometry

Module Specification		Sub-Array Configuration		ULA Totals	
Bosch - c-Si M60 NA30119 245W					
N-S Dim (in):	38.98	N-S Spacing (in):	0.25	Column N-S Length (in):	118
E-W Dim (in):	64.96	E-W Spacing (in):	0.25	Array E-W Dimension (in):	261
Thickness (in):	1.65	Power Rating (W):	245	SubArray Modules:	12
Orientation:	L	Weight (lbs):	41.89	Rails Per Module:	2
				Extended Rail (in):	0
				# Rows:	3
				# Columns:	4
				Array N-S Projection (in):	116
				ULA Power Rating (kW):	2.94
				# SubArrays:	1
				Total Modules:	12



Member Description	Variables	Standard	Revised	Units
Rail Length (in):	AD	118	118	in
Tilt Angle (deg):	θ	10	10	degrees
Rail Span:	BC	70.8	71.08	in
Rail Overhang:	AB, CD	23.6	23.46	in
Front Edge Height:	AE	16.55	16.55	in
Rear Edge Height:	DH	37.04	37.04	in
Front Leg Length:	BF	20.65	20.62	in
Rear Leg Length:	CG	32.94	32.96	in
N-S Cross Brace Length:	BG	118.03	72.97	in
N-S Cross Brace Angle:	β	10.08	16.41	degrees
N-S Leg Spacing:	FG	116.21	70	in

Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer adams

Address2:

Address2:

Phone2:

City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Wind Load Calculations

Complete

Wind Load Variables

Tilt Angle (deg):	10
Array Height above ground:	15
Exposure Category:	C
Basic Wind Speed, V (mph):	110.00
Importance Factor:	1.00
Roof Zone Multiplier:	1.4

MWFRS Wind Load Calculation

$$q_h = 0.00256 K_z K_{zt} K_d V^2 I (lb / ft^2)$$

Adjustment Factor for height and Exposure Category	Kz:	0.85
Topographic Factor (assumed to be 1 for level ground)	Kzt:	1
Directionality Factor	Kd:	0.85
Wind Load (psf)	qh:	31.33

Maximum Loads (psf)

Uplift	Down Force
Front Leg: -32.49	Front Leg: 46.6
Rear Leg: -47.14	Rear Leg: 41.81

ASCE 7-05 Open Building Unobstructed Wind Flow Coefficients, Cn



	Load Case A	Load Case B	Load Case A	Load Case B
Front Leg	-1.22	0	1.19	1.75
Rear Leg	-0.82	-1.77	1.57	0.52
Average	1.02	-0.89	1.38	1.14

ASCE 7-05 MWFRS Open Buildings Wind Load

Gust Effect Factor (G):	0.85	$p = q_h G C_n$	
Load Case A	Load Case B	Load Case A	Load Case B
Cn (Front Leg): -32.49	10	31.69	46.6
Cn (Rear Leg): -21.84	-47.14	41.81	13.85
Cn (Avg): 27.16	-23.7	36.75	30.36

Project Solar Decathlon

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Address1: Address: Phone: (804) 222-4420 Preparer adams
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City, ST, Zip: City, ST, Zip: Email: dave.stets@bysolar.net

Combination Load Analysis

Complete

Load Combination Variable (psf)	
Dead Load:	6.89 Assumed
Snow Load:	11.3

Max Load Results (psf)	
Down Force	Uplift
Front Leg: 53.6	-28.29
Rear Leg: 48.81	-42.94
Max (Absolute):	48.81

Front Leg Load Combinations (psf)		
	Wind Load Case A	Wind Load Case B
Load Case 1 (downforce):	18.3	18.3
Load Case 2 (downforce):	38.69	53.6
Load Case 3 (downforce):	39.24	50.43
Max Downforce:	39.24	53.6
Load Case 4 (uplift):	-28.29	14.2

Load Combination Factors			
	Dead Load	Snow Load	Wind Load
Load Case 1 (downforce):	1	1	0
Load Case 2 (downforce):	1	0	1
Load Case 3 (downforce):	1	0.75	0.75
Load Case 4 (uplift):	0.6		1

Rear Leg Load Combinations (psf)		
	Wind Load Case A	Wind Load Case B
Load Case 1 (downforce):	18.3	18.3
Load Case 2 (downforce):	48.81	20.85
Load Case 3 (downforce):	46.83	25.86
Max Downforce:	48.81	25.86
Load Case 4 (uplift):	-17.64	-42.94

Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident: Richmond Bysolar **Contact:** Dave Stets **Revision 3**
Address1: **Phone:** (804) 222-4420 **Preparer:** adams
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City, ST, Zip: **City, ST, Zip:**

Horizontal Pipe Design

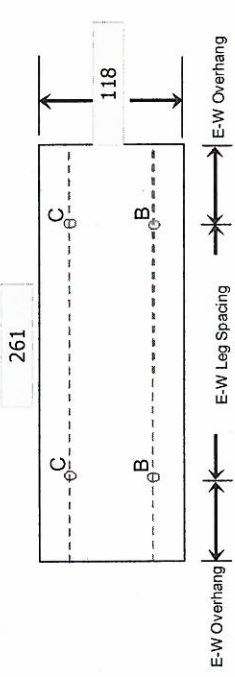
Complete

Pipe Design Inputs

Pipe Span (E-W Leg Spacing):
 Number of Leg Pairs:
 Horizontal Pipe Overhang (in):

Pipe Design Loads (psf)

Front Leg (psf):
 Rear Leg (psf):
 Maximum absolute value of Load Combination Loads



Pipe Material Specifications

Pipe Selection:
 Modulus of Elasticity, E (psf):
 Moment of Inertia, I (ft^4):
 Section Modulus, Z (ft^3):
 Yield Stress, Fy (psf):
 Array Width (in):
 Rail Length (in):

Description	Front Horizontal Pipe		Rear Horizontal Pipe	
	Max	Revised	Max	Revised
Max Distributed Load (plf):	263.53	263.53	239.98	239.98
Pipe Span (in):	73.81	58	73.81	58
Allowable Bending Moment (lb-ft):	1246.42	1246.42	1246.42	1246.42
Actual Bending Moment (lb-ft):	1246.26	769.54	1134.89	700.77
Actual/Allowable Moment:	100%	62%	91%	56%
Allowable Total Deflection L/70 (in):	1.05	0.83	1.05	0.83
Actual Deflection (in):	0.47	0.18	0.43	0.16
Actual/Allowable Deflection:	45%	22%	41%	19%

Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident:

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Contact: Dave Stets

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Rail Bending

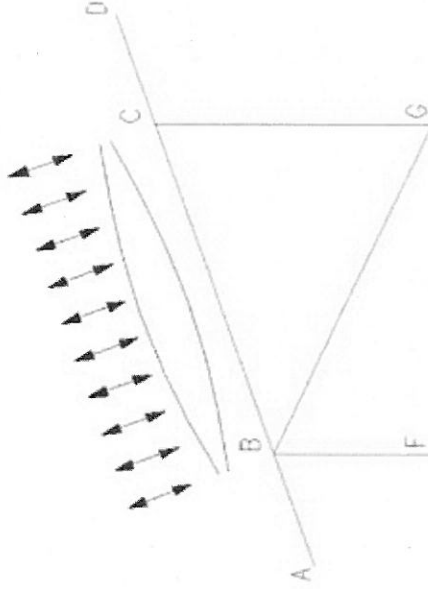
Complete

Rail Design Variables	
Rail Length (in):	118
Rail Overhang (in):	23.46
Rail Span (in):	71.08

Rail Material Specifications	
Rail Selection:	SolarMount HD
E (psf):	1.45E+09
I (ft ⁴):	0.0000697
Z (ft ³):	0.000522
Fy (psf):	2736000

Rail Distributed Load Calculation	
Maximum Average Design Load (psf):	43.75
Module Dim Perpendicular to Rails (in):	64.96
Rails Per Module:	2
Distributed Load (plf):	118.42

Rail Bending Calculations	
Allowable Bending Moment (lb-ft):	1428.19
Actual Bending Moment (lb-ft):	519.36
Actual/Allowable Moment:	36%
Allowable Deflection (in):	1.01
Actual Deflection (in):	0.23
Actual/Allowable Deflection:	23%



Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident:
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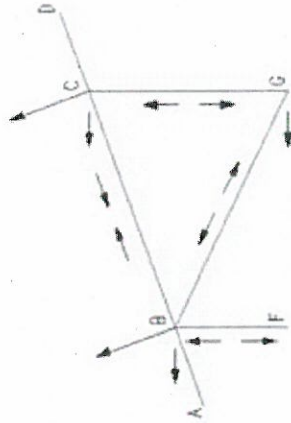
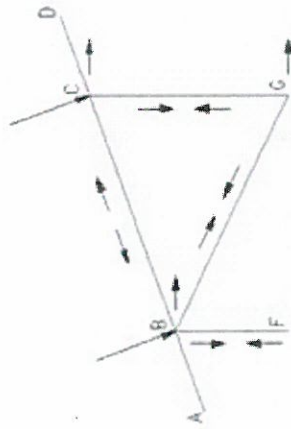
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Contact: Dave Stets
Phone: (804) 222-4420
Phone2:
Email: dave.stets@bysolar.net

Revision 3
Preparer adams

Force Analysis

Angles		Design Loads	
Tilt Angle (deg):	10	Downforce	Uplift
Cross Brace Angle (deg):	16.41	Front Leg (psf / kip):	53.6 1.27
E-W Leg Spacing)	58	Rear Leg (psf / kip):	48.81 1.16
Rail Length:	118		-28.29 -0.67
			-42.94 -1.02



Maximum Component Forces (kips)			
Axial Force in Front Leg:	1.25	Down Force	Uplift
Axial Force in Front Cap:	1.69		-0.66
Shear Force Front Cap:	0.44	Max Magnitude	
Axial Force in Rear Leg:	1.14		-1
Axial Force in Rear Cap:	0.94		-0.82
Shear Force Rear Cap:	0.2	Max Magnitude	
Shear Force Rear Foot:	0.44	Max Magnitude	
Axial Force in N-S Brace:	0.44		-0.12
Resultant Shear N-S Brace:	0.42	Max Magnitude	
Resultant Axial N-S Brace:	0.12		-0.03
Axial Force Rail:	0.2		-0.18
Resultant Shear Rail:	0.03	Max Magnitude	
Resultant Axial Rail:	0.2		-0.18

Project Solar Decathlon

Quote AMS-LA-130204-3014

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 Revision 3
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 City, ST, Zip: City, ST, Zip: ,
 Email: dave.stets@bysolar.net

Column Buckling Analysis

Complete

Front Leg Design	
Pipe Selection:	2 in. Schedule 40
E (ksi):	29
Fy (ksi):	35
r (in):	0.791
Front Leg Column Calculations	
Length:	20.62
Eff. Column Len. Fac:	1
Eff. Column Length:	20.62
Slenderness Ratio:	26.07
Critical Force:	20.24
Actual Force:	1.25
Ratio To Allowable:	6.18%

Rear Leg Design	
Pipe Selection:	2 in. Schedule 40
E (ksi):	29
Fy (ksi):	35
r (in):	0.791
Rear Leg Column Calculations	
Length:	32.96
Eff. Column Len. Fac:	1
Eff. Column Length:	32.96
Slenderness Ratio:	41.67
Critical Force:	19.18
Actual Force:	1.14
Ratio To Allowable:	5.94%

Rail Design	
Rail Selection:	SolarMount HD
E (ksi):	10.1
Fy (ksi):	19
r (in):	1.1679
Rails per EW Leg:	1.78
Rail Column Calculations	
Length:	71.08
Eff. Column Len. Fac:	1
Eff. Column Length:	71.08
Slenderness Ratio:	60.86
Critical Force:	23.67
Actual Force:	0.2
Ratio To Allowable:	0.84%

N-S - Cross Brace Design	
Cross Brace Selection:	2" x 2" Aluminum Square Tube
E (ksi):	10.1
Fy (ksi):	19
r (in):	0.7672
Cross Brace Column Calculations	
Length:	72.97
Eff. Column Len. Fac:	1
Eff. Column Length:	72.97
Slenderness Ratio:	95.11
Critical Force:	5.29
Actual Force:	0.44
Ratio To Allowable:	8.32%

Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident: **Customer:** Richmond Bysolar Contact: Dave Stets Revision 3
Address1: **Address:** Phone: (804) 222-4420 Preparer adams
Address2: **Address2:** Phone2:
City, ST, Zip: **City, ST, Zip:** Email: dave.stets@bysolar.net

Seismic Design and Analysis

Complete

Seismic Analysis Inputs		Seismic Analysis Results		E-W - Cross Brace Design	
ASCE7-05 Methodology				Gross Brace Selection:	
Latitude: 0	Sms: 0	Eq # 16 -37	2" x 2" Aluminum Square Tube		
Longitude: 0	Sm1: 0	Eq # 16 - 38	E (ksi): 10.1		
Site Class: A	Sds: 0	Eq # 16 -39	Fy (ksi): 19		
Importance Factor: 0	Sd1: 0	Eq # 16 -40	r (in): 0.7672		
Roof Height: 0	Ap, Rp: 1.0, 1.5	Table 13.6 - 1	Area (sq in): 0.9375		
Component Height: 0	Fp LRFD: 0	Eq 13.3 - 1	Cross Brace Column Calculations		
Ss: 0	Fp ASD: 0	per 13.1.7	Max CB Length: 66.71		
S1: 0			Eff. Column Len. Fac: 2		
Fa: 0			Eff. Column Length: 133.42		
Fv: 0			Slenderness Ratio: 86.95		
- OR - Seismic Zone:	Fp ASD: 0		Critical Force: 5.29	Kip	
Direct Methodology	Array Weight: 1497		Actual Force: 0.00	Kip	
Cross Brace Pairs:	Total Axial Force: 0	lbs	Margin Ratio: 0.0%		

Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident:
Address1:
Address2:
City, ST, Zip:

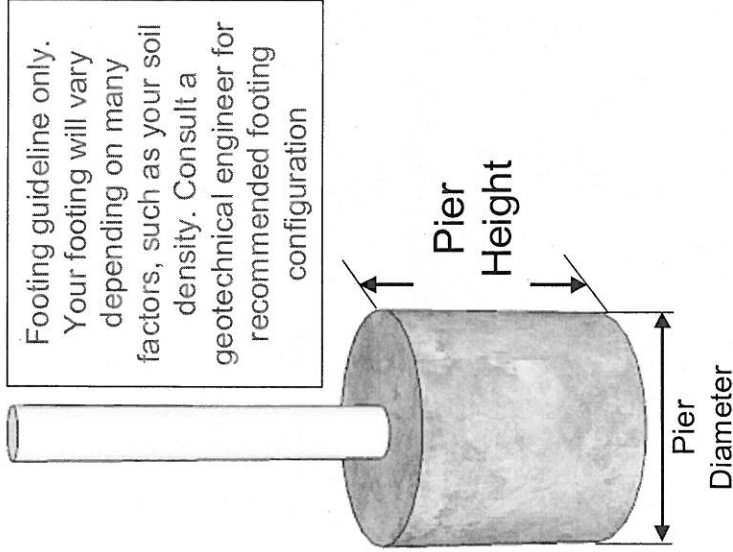
Customer: Richmond Bysolar
Address:
Address2:
City, ST, Zip:

Contact: Dave Stets
Phone: (804) 222-4420
Phone2:
Email: dave.stets@bysolar.net
Revision 3
Preparer adams

Footling Design

Complete

Footling Design Inputs	
Footling Diameter:	12 in.
Footling Depth:	18 in.
Concrete Density:	0.15 Kcf
Soil Density:	0.1 Kcf
Footling Design Calculations	
Max Uplift Force:	1.00 Kip
Safety Factor:	1.67
Required Resisting Force:	1.67 Kip
Concrete Volume:	1.18 cf
Concrete Weight:	0.18 Kip
Soil Volume:	6.44 cf
Soil Weight:	0.32 Kip
Total Weight:	0.5 Kip
Margin Ratio:	334.00%



Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident:

Address1:

Address2:

City, ST, Zip:

Customer: Richmond Bysolar

Address:

Address2:

City, ST, Zip:

Contact: Dave Stets

Phone: (804) 222-4420

Phone2:

Email: dave.stets@bysolar.net

Revision 3

Preparer adams

Cap and Foot Design

Complete

Front Cap Design

Cap Selection: Aluminum- 2" Front Cap
 Pipe Selection: 2 in. Schedule 40

Axial Compression (kip)	7.272	Axial Tension (kip)	-2.4	Shear (kip)	2.424
Allowable:	7.272	Actual:	1.69	Actual:	0.44
Margin Ratio:	23.24%		32.50%		18.15%

Front Foot Design

Axial Compression (kip)	1.69	Axial Tension (kip)	-0.78	Shear (kip)	0
Actual:	1.69		-0.78		0

Rear Cap Design

Cap Selection: Aluminum- 2" Front Cap

Axial Compression (kip)	7.272	Axial Tension (kip)	-2.4	Shear (kip)	2.424
Allowable:	7.272	Actual:	1.14	Actual:	0.2
Margin Ratio:	15.68%		41.67%		8.25%

Rear Foot Design

Axial Compression (kip)	1.14	Axial Tension (kip)	-1	Shear (kip)	0.44
Actual:	1.14		-1		0.44

Project Solar Decathlon

Quote AMS-LA-130204-3014

Project Ident: Customer: Richmond Bysolar
Address1: Address:
Address2: Address2:
City, ST, Zip: City, ST, Zip:
Contact: Dave Stets
Phone: (804) 222-4420
Phone2:
Email: dave.stets@bysolar.net
Revision 3
Preparer: adams

Design Margin Ratios

Design Specifications and Ratios		
Horizontal Pipe: 2 in. Schedule 40		
Front		Rear
Pipe Moment: 62%	Pipe Moment: 56%	
Pipe Deflection: 22%	Pipe Deflection: 19%	

Vertical Pipe Specifications and Column Design Ratios	
Front Leg Buckling: 6.18%	
Rear Leg Buckling: 5.94%	
N-S Brace Buckling: 8.32%	

Connection Specifications and Design Ratios		
Cap Selection: Aluminum- 2" Front Cap		
Front		Rear
Axial Compression: 23.24%	Axial Compression: 15.68%	
Axial Tension: 32.50%	Axial Tension: 41.67%	
Shear: 18.15%	Shear: 8.25%	

Rail Specification, Beam and Column Design Ratios	
Rail Selection: SolarMount HD	
Rail Bending Moment: 36%	
Rail Bending Deflection: 23%	
Rail Buckling: 0.84%	

Seismic Design Ratios	
Margin Ratio: 0.0%	
Margin Ratio: 334.00%	

Project Solar Decathlon

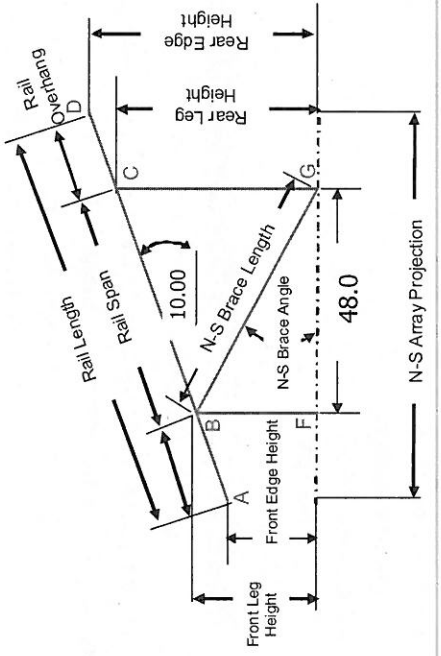
Quote AMS-LA-130204-4014

Project Ident: Customer: Richmond Bysolar Contact: Dave Stets Revision 3
Address1: Address: Phone: (804) 222-4420 Preparer adams
Address2: Address2: Phone2:
City, ST, Zip: City, ST, Zip: Email: dave.stets@bysolar.net

ULA Geometry

Complete

Module Specification		Sub-Array Configuration		ULA Totals		
Bosch - c-Si M60 NA30119 245W	# Rows:	2	Column N-S Length (in):	79	# SubArrays:	1
N-S Dim (in): 38.98	N-S Spacing (in):	0.25	Array E-W Dimension (in):	261	Total Modules:	8
E-W Dim (in): 64.96	E-W Spacing (in):	0.25	Array N-S Projection (in):	78	ULA Power Rating (kW):	1.96
Thickness (in): 1.65	Power Rating (W):	245	Rails Per Module:	2		
Orientation: L	Weight (lbs):	41.89	Extended Rail (in):	0		



Member Description	Variables	Standard	Revised	Units
Rail Length (in):	AD	79	79	in
Tilt Angle (deg):	θ	10	10	degrees
Rail Span:	BC	47.4	48.74	in
Rail Overhang:	AB, CD	15.8	15.13	in
Front Edge Height:	AE	37.04	37.04	in
Rear Edge Height:	DH	50.76	50.76	in
Front Leg Length:	BF	39.78	39.67	in
Rear Leg Length:	CG	48.01	48.13	in
N-S Cross Brace Length:	BG	87.38	62.27	in
N-S Cross Brace Angle:	β	27.08	39.57	degrees
N-S Leg Spacing:	FG	77.8	48	in

Project Solar Decathlon

Quote AMS-LA-130204-4014

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Customer: Richmond Bysolar
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 Phone2:
 Email: dave.stets@bysolar.net

Revision 3
 Preparer adams

Wind Load Calculations

Complete

Wind Load Variables

Tilt Angle (deg): 10
 Array Height above ground: 15
 Exposure Category: C
 Basic Wind Speed, V (mph): 110.00
 Importance Factor: 1.00
 Roof Zone Multiplier: 1.4

MWFRS Wind Load Calculation

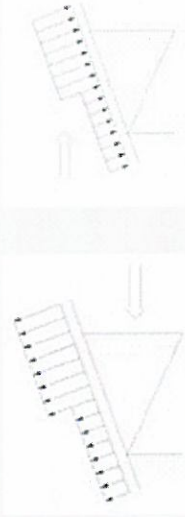
$$q_h = 0.00256 K_z K_{zt} K_d V^2 I (lb/ft^2)$$

Adjustment Factor for height and Exposure Category Kz: 0.85
 Topographic Factor (assumed to be 1 for level ground) Kzt: 1
 Directionality Factor Kd: 0.85
 Wind Load (psf) qh: 31.33

Maximum Loads (psf)

Uplift
 Front Leg: -32.49 Down Force
 Rear Leg: -47.14 Front Leg: 46.6
 Rear Leg: 41.81

ASCE 7-05 Open Building Unobstructed Wind Flow Coefficients, Cn



	Load Case A	Load Case B	Load Case A	Load Case B
Front Leg	-1.22	0	1.19	1.75
Rear Leg	-0.82	-1.77	1.57	0.52
Average	1.02	-0.89	1.38	1.14

ASCE 7-05 MWFRS Open Buildings Wind Load

Gust Effect Factor (G): 0.85 $p = q_h G C_n$

	Load Case A	Load Case B	Load Case A	Load Case B
Cn (Front Leg):	-32.49	10	31.69	46.6
Cn (Rear Leg):	-21.84	-47.14	41.81	13.85
Cn (Avg):	27.16	-23.7	36.75	30.36

Project Solar Decathlon

Quote AMS-LA-130204-4014

Project Ident: Customer: Richmond Bysolar Contact: Dave Stets Revision 3
Address1: Address: Phone: (804) 222-4420 Preparer adams
Address2: Address2: Phone2:
City, ST, Zip: City, ST, Zip: Email: dave.stets@bysolar.net

Combination Load Analysis

Complete

Load Combination Variable (psf)

Dead Load:	6.89	Assumed
Snow Load:	11.3	

Max Load Results (psf)

Down Force	Uplift
Front Leg: 53.6	-28.29
Rear Leg: 48.81	-42.94
Max (Absolute): 48.81	

Front Leg Load Combinations (psf)

	Wind Load Case A	Wind Load Case B
Load Case 1 (downforce):	18.3	18.3
Load Case 2 (downforce):	38.69	53.6
Load Case 3 (downforce):	39.24	50.43
Max Downforce:	39.24	53.6
Load Case 4 (uplift):	-28.29	14.2

Load Combination Factors

	Dead Load	Snow Load	Wind Load
Load Case 1 (downforce):	1	1	0
Load Case 2 (downforce):	1	0	1
Load Case 3 (downforce):	1	0.75	0.75
Load Case 4 (uplift):	0.6		1

Rear Leg Load Combinations (psf)

	Wind Load Case A	Wind Load Case B
Load Case 1 (downforce):	18.3	18.3
Load Case 2 (downforce):	48.81	20.85
Load Case 3 (downforce):	46.83	25.86
Max Downforce:	48.81	25.86
Load Case 4 (uplift):	-17.64	-42.94

Project Solar Decathlon

Quote AMS-LA-130204-4014

Project Ident:
Address 1:
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City, ST, Zip:

Customer: Richmond Bysolar
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Contact: Dave Stets
Phone: (804) 222-4420
Phone 2:
Email: dave.stets@bysolar.net

Revision 3
Preparer adams

Horizontal Pipe Design

Complete

Pipe Design Inputs

Pipe Span (E-W Leg Spacing):

Number of Leg Pairs:

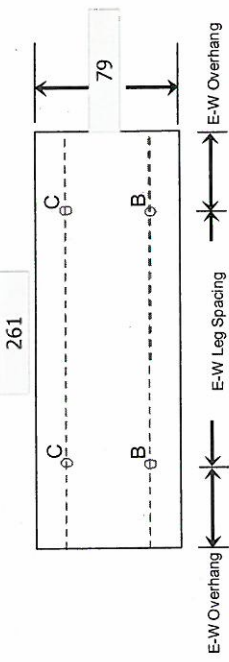
Horizontal Pipe Overhang (in): 0

Pipe Design Loads (psf)

Front Leg (psf):

Rear Leg (psf):

Maximum absolute value of Load Combination Loads



Pipe Material Specifications

Pipe Selection:

Modulus of Elasticity, E (psf):

Moment of Inertia, I (ft^4):

Section Modulus, Z (ft^3):

Yield Stress, Fy (psf):

Array Width (in):

Rail Length (in):

Description	Front Horizontal Pipe		Rear Horizontal Pipe	
	Max	Revised	Max	Revised
Max Distributed Load (pf):	176.43	176.43	160.67	160.67
Pipe Span (in):	90.21	64	90.21	64
Allowable Bending Moment (lb-ft):	1246.42	1246.42	1246.42	1246.42
Actual Bending Moment (lb-ft):	1246.32	627.31	1134.99	571.27
Actual/Allowable Moment:	100%	50%	91%	46%
Allowable Total Deflection L/70 (in):	1.29	0.91	1.29	0.91
Actual Deflection (in):	0.7	0.18	0.64	0.16
Actual/Allowable Deflection:	54%	20%	50%	18%

Project Solar Decathlon

Quote AMS-LA-130204-4014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer adams

Address2:

Address2:

Phone2:

City, ST, Zip:

City, ST, Zip:

Email: dave.stets@bysolar.net

Rail Bending

Complete

Rail Design Variables

Rail Length (in): 79
 Rail Overhang (in): 15.13
 Rail Span (in): 48.74

Rail Distributed Load Calculation

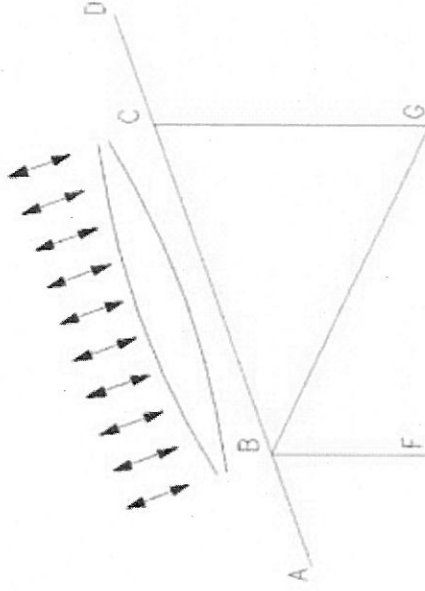
Maximum Average Design Load (psf): 43.75
 Module Dim Perpendicular to Rails (in): 64.96
 Rails Per Module: 2
 Distributed Load (plf): 118.42

Rail Material Specifications

Rail Selection:
 SolarMount
 E (psf): 1.45E+09
 I (ft^4): 0.0000222
 Z (ft^3): 0.000214
 Fy (psf): 2736000

Rail Bending Calculations

Allowable Bending Moment (lb-ft): 585.5
 Actual Bending Moment (lb-ft): 244.2
 Actual/Allowable Moment: 42%
 Allowable Deflection (in): 0.68
 Actual Deflection (in): 0.16
 Actual/Allowable Deflection: 24%



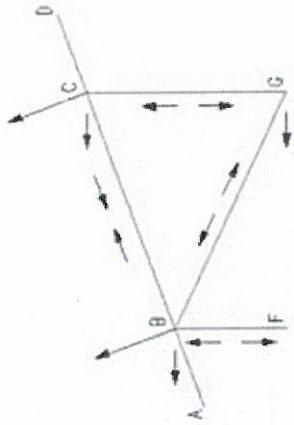
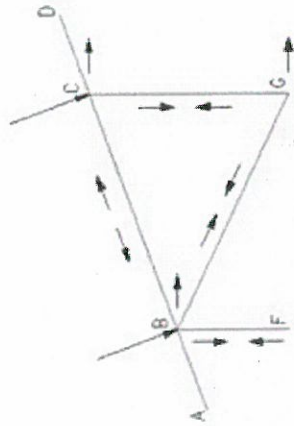
Project Solar Decathlon

Quote AMS-LA-130204-4014

Project Ident: Richmond Bysolar **Contact:** Dave Steits **Revision 3**
Address1: **Phone:** (804) 222-4420 **Preparer:** adams
Address2: **Phone2:** **City, ST, Zip:** **Email:** dave.steits@bysolar.net

Force Analysis

Angles		Design Loads		
Tilt Angle (deg):	10	Downforce	Uplift	
Cross Brace Angle (deg):	39.57	Front Leg (psf / kip):	53.6 0.94	-28.29 -0.5
E-W Leg Spacing)	64	Rear Leg (psf / kip):	48.81 0.86	-42.94 -0.75
Rail Length:	79			



Maximum Component Forces (kips)					
Axial Force in Front Leg:	0.93	Down Force	0.93	Uplift	-0.49
Axial Force in Front Cap:	1.26	Axial Force in Rear Leg:	0.85	Axial Force in Rear Cap:	0.7
Shear Force Front Cap:	0.33	Max Magnitude		Shear Force Rear Cap:	0.15
		Axial Force in Rear Cap:	0.7	Max Magnitude	
		Shear Force Rear Foot:	0.33	Max Magnitude	
		Axial Force in N-S Brace:	0.33	Max Magnitude	
		Resultant Shear N-S Brace:	0.25	Max Magnitude	
		Resultant Axial N-S Brace:	0.21	Max Magnitude	
		Axial Force Rail:	0.15	Max Magnitude	
		Resultant Shear Rail:	0.03	Max Magnitude	
		Resultant Axial Rail:	0.15	Max Magnitude	

Complete

Project Solar Decathlon

Quote AMS-LA-130204-4014

Project Ident:

Customer: Richmond Bysolar

Contact: Dave Stets

Revision 3

Address1:

Address:

Phone: (804) 222-4420

Preparer adams

Address2:

Address2:

Phone2:

City, ST, Zip :

City, ST, Zip :

Email: dave.stets@bysolar.net

Column Buckling Analysis

Complete

Front Leg Design	
Pipe Selection:	2 in. Schedule 40
E (ksi):	29
Fy (ksi):	35
r (in):	0.791
Front Leg Column Calculations	
Length:	39.67
Eff. Column Len. Fac:	1
Eff. Column Length:	39.67
Slenderness Ratio:	50.15
Critical Force:	18,43
Actual Force:	0.93
Ratio To Allowable:	5.05%

Rear Leg Design	
Pipe Selection:	2 in. Schedule 40
E (ksi):	29
Fy (ksi):	35
r (in):	0.791
Rear Leg Column Calculations	
Length:	48.13
Eff. Column Len. Fac:	1
Eff. Column Length:	48.13
Slenderness Ratio:	60.85
Critical Force:	17.35
Actual Force:	0.85
Ratio To Allowable:	4.90%

Rail Design	
Rail Selection:	SolarMount
E (ksi):	10.1
Fy (ksi):	19
r (in):	0.829
Rails per EW Leg:	1.96
Rail Column Calculations	
Length:	48.74
Eff. Column Len. Fac:	1
Eff. Column Length:	48.74
Slenderness Ratio:	58.79
Critical Force:	16.8
Actual Force:	0.15
Ratio To Allowable:	0.89%

N-S - Cross Brace Design	
Cross Brace Selection:	2" x 2" Aluminum Square Tube
E (ksi):	10.1
Fy (ksi):	19
r (in):	0.7672
Cross Brace Column Calculations	
Length:	62.27
Eff. Column Len. Fac:	1
Eff. Column Length:	62.27
Slenderness Ratio:	81.17
Critical Force:	7.26
Actual Force:	0.33
Ratio To Allowable:	4.55%

Project Solar Decathlon

Quote AMS-LA-130204-4014

Project Ident: Richmond Bysolar **Contact:** Dave Stets Revision 3
Address1: **Phone:** (804) 222-4420 Preparer adams
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Complete

Seismic Design and Analysis

Seismic Analysis Inputs		Seismic Analysis Results		E-W - Cross Brace Design	
ASCE7-05 Methodology				Cross Brace Selection:	
Latitude: <input type="text" value="0"/>	Sms: <input type="text" value="0"/>	Eq # 16 -37	2" x 2" Aluminum Square Tube		
Longitude: <input type="text" value="0"/>	Sm1: <input type="text" value="0"/>	Eq # 16 - 38	E (ksi): <input type="text" value="10.1"/>		
Site Class: <input type="text" value="A"/>	Sds: <input type="text" value="0"/>	Eq # 16 -39	Fy (ksi): <input type="text" value="19"/>		
Importance Factor: <input type="text" value="0"/>	Sd1: <input type="text" value="0"/>	Eq # 16 -40	r (in): <input type="text" value="0.7672"/>		
Roof Height: <input type="text" value="0"/>	Ap, Rp: <input type="text" value="1.0, 1.5"/>	Table 13.6 - 1	Area (sq in): <input type="text" value="0.9375"/>		
Component Height: <input type="text" value="0"/>	Fp LRFD: <input type="text" value="0"/>	Eq 13.3 - 1	Cross Brace Column Calculations		
Ss: <input type="text" value="0"/>	Fp ASD: <input type="text" value="0"/>	per 13.1.7	Max CB Length: <input type="text" value="80.08"/>		
S1: <input type="text" value="0"/>			Eff. Column Len. Fac: <input type="text" value="2"/>		
Fa: <input type="text" value="0"/>			Eff. Column Length: <input type="text" value="160.16"/>		
Fv: <input type="text" value="0"/>			Slenderness Ratio: <input type="text" value="104.38"/>		
- OR - Seismic Zone: <input type="text"/>		Fp ASD: <input type="text" value="0"/>	Critical Force: <input type="text" value="7.26"/>	Kip	
Cross Brace Pairs: <input type="text"/>		Array Weight: <input type="text" value="1002"/>	Actual Force: <input type="text" value="0.00"/>	Kip	
		Total Axial Force: <input type="text" value="0"/>	Margin Ratio: <input type="text" value="0.0%"/>		
				lbs	

Project Solar Decathlon

Quote AMS-LA-130204-4014

Project Ident:
Address1:
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Customer: Richmond Bysolar
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Contact: Dave Stets
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Revision 3
Preparer adams

Footing Design

Complete

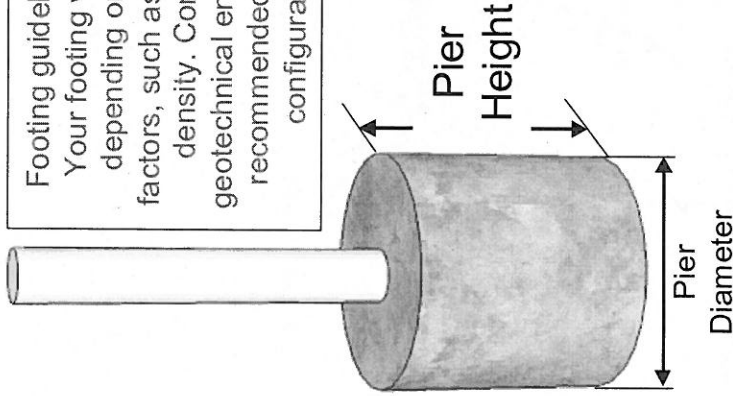
Footing Design Inputs

Footing Diameter: in.
 Footing Depth: in.
 Concrete Density: Kcf
 Soil Density: Kcf

Footing Design Calculations

Max Uplift Force: Kip
 Safety Factor:
 Required Resisting Force: Kip
 Concrete Volume: cf
 Concrete Weight: Kip
 Soil Volume: cf
 Soil Weight: Kip
 Total Weight: Kip
 Margin Ratio:

Footing guideline only.
 Your footing will vary depending on many factors, such as your soil density. Consult a geotechnical engineer for recommended footing configuration



Project Solar Decathlon

Quote AMS-LA-130204-4014

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Contact: Dave Steits

Revision 3

Address1:

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Preparer adams

Address2:

Address2:

Phone2:

City, ST, Zip:

City, ST, Zip:

Email: dave.steits@bysolar.net

Cap and Foot Design

Complete

Front Cap Design

Cap Selection: Aluminum- 2" Front Cap
 Pipe Selection: 2 in. Schedule 40

Axial Compression (kip)	7.272	Axial Tension (kip)	-2.4	Shear (kip)	2.424
Allowable:	1.26		-0.58		0.33
Margin Ratio:	17.33%		24.17%		13.61%

Rear Cap Design

Cap Selection: Aluminum- 2" Front Cap

Axial Compression (kip)	7.272	Axial Tension (kip)	-2.4	Shear (kip)	2.424
Allowable:	0.85		-0.74		0.15
Margin Ratio:	11.69%		30.83%		6.19%

Front Foot Design

Axial Compression (kip)	1.26	Axial Tension (kip)	-0.58	Shear (kip)	0
Actual:					

Rear Foot Design

Axial Compression (kip)	0.85	Axial Tension (kip)	-0.74	Shear (kip)	0.33
Actual:					

Project Solar Decathlon

Quote AMS-LA-130204-4014

Project Ident:

Address1:

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City, ST, Zip:

Customer: Richmond Bysolar

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Contact: Dave Stets

Phone: (804) 222-4420

Phone2:

Email: dave.stets@bysolar.net

Revision 3

Preparer adams

Design Margin Ratios

Design Specifications and Ratios

Horizontal Pipe: 2 in. Schedule 40

Front

50%

Pipe Moment:

20%

Pipe Deflection:

Rear

46%

Pipe Moment:

18%

Pipe Deflection:

Vertical Pipe Specifications and Column Design Ratios

Front Leg Buckling: 5.05%

Rear Leg Buckling: 4.90%

N-S Brace Buckling: 4.55%

Connection Specifications and Design Ratios

Cap Selection: Aluminum- 2" Front Cap

Front

17.33%

Axial Compression:

24.17%

Axial Tension:

13.61%

Shear:

Rear

11.69%

Axial Compression:

30.83%

Axial Tension:

6.19%

Shear:

Rail Specification: Beam and Column Design Ratios

Rail Selection: SolarMount

Rail Bending Moment: 42%

Rail Bending Deflection: 24%

Rail Buckling: 0.89%

Seismic Design Ratios

Margin Ratio: 0.0%

Footling Design Ratios

Margin Ratio: 247.16%

Canopy House
Irvine, California

STRUCTURAL DESIGN CRITERIA

Engineer: Edward C. Westerman, P.E.

Comm. No.: 4.0

Canopy House

Irvine, California

Design Criteria and Reference Codes

- 2012 International Building Code
- ASCE 7-10, “Minimum Design Loads for Buildings and Other Structures”
- AISC 360-10, “Specification for Structural Steel Buildings”
- AISC 303-10, “Code of Standard Practice for Steel Buildings and Bridges”
- AISI, “Specification for the Design of Cold-Formed Steel Structural Members”, 2007
- AISI, “North American Standard for Cold-Formed Steel Framing – Lateral Design”, 2007 edition with Supplement No. 1
- AF&PA, “National Design Specification for Wood Construction”, 2005 edition
- AF&PA, “Special Design Provisions for Wind and Seismic”, 2008 edition

Dead Loads

Roof Loads

Plywood sheathing	1.5 PSF
Cold-formed roof joists	4.5 PSF
Insulation	1 PSF
½” Gypsum board ceiling	2 PSF
Lights	0.5 PSF
Mechanical allowance	2 PSF
Roof membrane	1 PSF
Solar panels	6.5 PSF

Floor Loads

Floor finish	2 PSF
Plywood sheathing	2.5 PSF
2x10 wood joists at 16” OC	3.5 PSF
2x6 wood nailer	1 PSF
W10x30 spandrel beams	8 PSF
ThermaSteel wall panels (including gypsum board)	4 PSF
Exterior wall siding (including plywood sheathing)	4 PSF

Canopy House

Irvine, California

Live Loads

Roof	20 PSF
Interior living areas	50 PSF
Exterior decks and ramps	100 PSF
Mechanical room	125 PSF

Snow Loads

Ground Snow Load, p_g	0 psf
Importance Factor, I	1.0
Exposure Factor, C_e	1.0
Thermal Factor, C_t	1.0
$I \times p_g$ (minimum value)	0 psf
Flat Roof Snow Load, p_f	0 psf

Wind Loads

Basic Wind Speed, V	110 mph
Risk Category	II
Exposure Category	C
Internal Pressure Coefficient, GC_{pi}	+/- 0.18
Gust Effect Factor, G	0.85
Components and Cladding Pressures	See Calculations

Canopy House

Irvine, California

Seismic Loads

Risk Category	II
Importance Factor, I	1.00
Site Class	D (assumed)
Mapped Spectral Response Accelerations:	
Short-period Response, S_s	1.493g
One-second Response, S_1	0.554g
Design Spectral Response Accelerations:	
Short-period Response, S_{DS}	0.995g
One-second Response, S_{D1}	0.554g
Seismic Design Category	D
Basic Seismic-Force-Resisting System	Light-frame (cold-formed steel) walls sheathed with wood structural panels rated for shear resistance or steel sheets
Response Modification Factor, R	6.5
Design Base Shear, V	$V = 0.153W$
Analysis Procedure Used	Equivalent lateral force

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Architecture & Engineering

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Suite 200A
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Project: ODU Solar Decathlon Canopy House
Comm. No.: 5.0
Engineer: Edward C. Westerman, P.E.

Snow Loads per ASCE 7-10

A. General Requirements

Location = Irvine, CA
Latitude = 33.67
Longitude = -117.73
ZIP Code = 92618

Risk category = II (Table 1.5-1)
Roof profile = Monoslope
Roof slope, θ = 3.58 deg

B. Ground Snow Load, p_g

$$p_g = 0 \text{ psf}$$

Note:

- 1.) Ground snow load, p_g , may be obtained from Figure 7-1

C. Snow Load Parameters

Exposure factor, C_e = 1.0 (Table 7-2) (Partially Exposed)
Thermal factor, C_t = 1.0 (Table 7-3)
Importance factor, I_s = 1.00 (Table 1.5-2)

D. Flat Roof Snow Load, p_f

$$p_f = 0.7C_eC_tI_s p_g \quad (\text{Equation 7.3-1})$$
$$p_f = 0.0 \text{ psf}$$

E. Minimum Snow Load for Low-Slope Roofs, p_m

$$p_m = 0.0 \text{ psf} \quad (\text{Section 7.3.4})$$

F. Rain-on-Snow Surcharge Load (Section 7.10)

$$W_1 = 18.0 \text{ ft}$$

$$W_2 = 23.0 \text{ ft}$$

$$\text{Surcharge load} = 0 \text{ psf}$$

G. Ponding Instability (Section 7.11)

Result = Ponding instability analysis not required

H. Snow Drift Load At Roof Projection (Section 7.8)

$$l_u = 22.83 \text{ ft}$$

$$\gamma = 14.00 \text{ pcf}$$

$$h_b = 0.00 \text{ ft}$$

$$\text{Height of roof projection} = 3.00 \text{ ft}$$

$$h_c = 3.00 \text{ ft}$$

$$h_{d, \text{nominal}} = 1.25 \text{ ft}$$

$$h_{d, \text{design}} = 0.94 \text{ ft}$$

(Figure 7-9)

(= 0.75 * $h_{d, \text{nominal}}$)

Is $h_{d, \text{design}} \leq h_c$? **Yes**

$$\text{Drift height, } h_d = 0.00 \text{ ft}$$

$$\text{Drift width, } w = 0.00 \text{ ft}$$

$$\text{Balanced + drift height} = 0.00 \text{ ft}$$

$$\text{Drift pressure, } p_d = 0.0 \text{ psf}$$

$$\text{Max. snow load, } p_{\text{max}} = 0.0 \text{ psf}$$

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Project: ODU Solar Decathlon Canopy House
Comm. No.: 5.0
Engineer: Edward C. Westerman, P.E.

**Design Wind Pressures per ASCE 7-10
Main Wind-Force Resisting System (MWFRS) - Directional Procedure**

A. General Requirements

Location = Irvine, CA
Latitude = 33.67
Longitude = -117.73
ZIP Code = 92618

Risk category = II (Table 1.5-1)
Mean roof height, h = 11.5 ft (Eave height since $\theta \leq 10$ degrees)

B. Basic Wind Speed, V

V = 110 MPH

Note:

- 1.) Basic wind speed, V may be obtained from Figures 26.5-1A, B, or C; or
- 2.) From Applied Technology Council (ATC) website at:
<http://www.atcouncil.org/windspeed/index.php>

C. Wind Load Parameters

Exposure category = **C** (Section 26.7)
 Wind directionality factor, $K_d = 0.85$ (Table 26.6-1)
 Topographic factor, $K_{zt} = 1.0$ (Section 26.8)
 Gust effect factor, $G = 0.85$ (Section 26.9)
 Enclosure classification = **Enclosed** (Sections 26.10 and 26.2)
 Internal pressure coefficients: (Table 26.11-1)
 $GC_{pi} (+) = 0.18$
 $GC_{pi} (-) = -0.18$

D. Velocity Pressure Exposure Coefficient, K_z (Table 27.3-1)

$K_z =$ See table below
 $K_h = 0.85$

E. Velocity Pressure, q_z or q_h

$$q_z = 0.00256K_zK_{zt}K_dV^2 \quad (\text{Equation 27.3-1})$$

$$q_h = 22.4 \text{ psf}$$

F. External Pressure Coefficients, C_p

a.) Walls - Wind Blowing North-South (Figure 27.4-1)

$L = 23.0 \text{ ft}$
 $B = 41.75 \text{ ft}$
 $L/B = 0.6$

Surface	C_p
Windward Wall	0.8
Leeward Wall	-0.5
Side Wall	-0.7

b.) Walls - Wind Blowing East-West (Figure 27.4-1)

$$L = 41.75 \text{ ft}$$

$$B = 23.0 \text{ ft}$$

$$L/B = 1.8$$

Surface	C_p
Windward Wall	0.8
Leeward Wall	-0.34
Side Wall	-0.7

c.) Roof - Normal to Ridge (Figure 27.4-1)

$$\theta = 4.76 \text{ deg}$$

$$L = 23.0 \text{ ft}$$

$$h/L = 0.500$$

Horiz Distance to Windward Edge	C_p	
0 to h/2	-0.9	-0.18
h/2 to h	-0.9	-0.18
h to 2h	-0.5	-0.18
> 2h	-0.3	-0.18

d.) Roof - Parallel to Ridge (Figure 27.4-1)

$$\theta = 4.76 \text{ deg}$$

$$L = 48.0 \text{ ft}$$

$$h/L = 0.240$$

Horiz Distance to Windward Edge	C_p	
0 to h/2	-0.9	-0.18
h/2 to h	-0.9	-0.18
h to 2h	-0.5	-0.18
> 2h	-0.3	-0.18

G. Wall Design Wind Pressure

$$p = qGC_p - q_i(GC_{pi}) \quad (\text{Equation 27.4-1})$$

a.) Walls - Wind Blowing North-South

z	K _z	q _z	P _{windward}		P _{leeward}		P _{windward} + P _{leeward}
			GC _{pi} (+)	GC _{pi} (-)	GC _{pi} (+)	GC _{pi} (-)	
0-15 ft	0.85	22.4 psf	11.2 psf	19.2 psf	-13.5 psf	-5.5 psf	24.7 psf
20 ft	0.90	23.7 psf	12.1 psf	20.1 psf	-13.5 psf	-5.5 psf	25.6 psf
25 ft	0.94	24.7 psf	12.8 psf	20.9 psf	-13.5 psf	-5.5 psf	26.3 psf
30 ft	0.98	25.8 psf	13.5 psf	21.6 psf	-13.5 psf	-5.5 psf	27.1 psf
40 ft	1.04	27.4 psf	14.6 psf	22.6 psf	-13.5 psf	-5.5 psf	28.1 psf
50 ft	1.09	28.7 psf	15.5 psf	23.5 psf	-13.5 psf	-5.5 psf	29.0 psf
60 ft	1.13	29.8 psf	16.2 psf	24.3 psf	-13.5 psf	-5.5 psf	29.7 psf
70 ft	1.17	30.8 psf	16.9 psf	25.0 psf	-13.5 psf	-5.5 psf	30.5 psf
80 ft	1.21	31.9 psf	17.6 psf	25.7 psf	-13.5 psf	-5.5 psf	31.2 psf

b.) Walls - Wind Blowing East-West

z	K _z	q _z	P _{windward}		P _{leeward}		P _{windward} + P _{leeward}
			GC _{pi} (+)	GC _{pi} (-)	GC _{pi} (+)	GC _{pi} (-)	
0-15 ft	0.85	22.4 psf	11.2 psf	19.2 psf	-10.5 psf	-2.4 psf	21.7 psf
20 ft	0.90	23.7 psf	12.1 psf	20.1 psf	-10.5 psf	-2.4 psf	22.6 psf
25 ft	0.94	24.7 psf	12.8 psf	20.9 psf	-10.5 psf	-2.4 psf	23.3 psf
30 ft	0.98	25.8 psf	13.5 psf	21.6 psf	-10.5 psf	-2.4 psf	24.0 psf
40 ft	1.04	27.4 psf	14.6 psf	22.6 psf	-10.5 psf	-2.4 psf	25.1 psf
50 ft	1.09	28.7 psf	15.5 psf	23.5 psf	-10.5 psf	-2.4 psf	26.0 psf
60 ft	1.13	29.8 psf	16.2 psf	24.3 psf	-10.5 psf	-2.4 psf	26.7 psf
70 ft	1.17	30.8 psf	16.9 psf	25.0 psf	-10.5 psf	-2.4 psf	27.4 psf
80 ft	1.21	31.9 psf	17.6 psf	25.7 psf	-10.5 psf	-2.4 psf	28.1 psf

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Project: ODU Solar Decathlon Canopy House
Comm. No.: 5.0
Engineer: Edward C. Westerman, P.E.

**Design Wind Pressures per ASCE 7-10
Components & Cladding (C&C) - Part 1: Low-Rise Buildings ($h \leq 60$ ft)**

A. General Requirements

Location = Irvine, CA
Latitude = 33.67
Longitude = -117.73
ZIP Code = 92618

Risk category = II (Table 1.5-1)
Mean roof height, h = 11.5 ft (Eave height since $\theta \leq 10$ degrees)

B. Basic Wind Speed, V

$V = 110$ MPH

Note:

- 1.) Basic wind speed, V may be obtained from Figures 26.5-1A, B, or C; or
- 2.) From Applied Technology Council (ATC) website at:
<http://www.atccouncil.org/windspeed/index.php>

C. Wind Load Parameters

Exposure category = **C** (Section 26.7)
 Wind directionality factor, $K_d = 0.85$ (Table 26.6-1)
 Topographic factor, $K_{zt} = 1.0$ (Section 26.8)
 Gust effect factor, $G = 0.85$ (Section 26.9)
 Enclosure classification = **Enclosed** (Sections 26.10 and 26.2)
 Internal pressure coefficients: (Table 26.11-1)
 $GC_{pi} (+) = 0.18$
 $GC_{pi} (-) = -0.18$

D. Velocity Pressure Exposure Coefficient, K_h (Table 30.3-1)

$$K_h = 0.85$$

E. Velocity Pressure, q_z or q_h

$$q_z = 0.00256K_zK_{zt}K_dV^2 \quad (\text{Equation 30.3-1})$$

$$q_h = 22.4 \text{ psf}$$

F. External Pressure Coefficients, GC_p

a.) Walls (Figure 30.4-1)

Least horizontal dimension = **18.0 ft**
 $a = 3.0 \text{ ft}$

Effective Wind Area	$GC_p (+)$	
	Zone 4	Zone 5
10 ft ²	1.0	1.0
20 ft ²	0.95	0.95
50 ft ²	0.88	0.88
100 ft ²	0.82	0.82
200 ft ²	0.78	0.78

Effective Wind Area	GC _p (-)	
	Zone 4	Zone 5
10 ft2	-1.1	-1.4
20 ft2	-1.05	-1.3
50 ft2	-0.98	-1.16
100 ft2	-0.92	-1.05
200 ft2	-0.88	-0.95

b.) Monoslope Roof (Figure 30.4-5A)

Effective Wind Area	GC _p (+)
	All Zones
10 ft2	0.3
20 ft2	0.28
50 ft2	0.22
100 ft2	0.20
200 ft2	0.20

Effective Wind Area	GC _p (-)				
	Zone 1	Zone 2	Zone 2'	Zone 3	Zone 3'
10 ft2	-1.1	-1.3	-1.6	-1.8	-2.6
20 ft2	-1.1	-1.28	-1.57	-1.63	-2.3
50 ft2	-1.1	-1.23	-1.54	-1.38	-1.9
100 ft2	-1.1	-1.2	-1.5	-1.2	-1.6
200 ft2	-1.1	-1.2	-1.5	-1.2	-1.6

G. Wall and Roof Design Wind Pressure (C&C)

$$p = q_h[(GC_p) - (GC_{pi})] \quad (\text{Equation 30.4-1})$$

a.) Windward Wall Components and Cladding Pressures

Effective Wind Area	Windward Wall Component Pressure (p_{windward})			
	$GC_{pi} (+)$		$GC_{pi} (-)$	
	Zone 4	Zone 5	Zone 4	Zone 5
10 ft2	18.4 psf	18.4 psf	26.4 psf	26.4 psf
20 ft2	17.2 psf	17.2 psf	25.3 psf	25.3 psf
50 ft2	15.7 psf	15.7 psf	23.7 psf	23.7 psf
100 ft2	14.3 psf	14.3 psf	22.4 psf	22.4 psf
200 ft2	13.4 psf	13.4 psf	21.5 psf	21.5 psf

b.) Leeward Wall Components and Cladding Pressures

Effective Wind Area	Leeward Wall Component Pressure (p_{leeward})			
	$GC_{pi} (+)$		$GC_{pi} (-)$	
	Zone 4	Zone 5	Zone 4	Zone 5
10 ft2	-28.6 psf	-35.4 psf	-20.6 psf	-27.3 psf
20 ft2	-27.5 psf	-33.1 psf	-19.5 psf	-25.1 psf
50 ft2	-26.0 psf	-30.0 psf	-17.9 psf	-21.9 psf
100 ft2	-24.6 psf	-27.5 psf	-16.6 psf	-19.5 psf
200 ft2	-23.7 psf	-25.3 psf	-15.7 psf	-17.2 psf

c.) Roof Components and Cladding Pressures - Positive Pressure

Effective Wind Area	Roof Component Pressure (p_{positive})	
	$GC_{pi} (+)$	$GC_{pi} (-)$
	All Zones	All Zones
10 ft2	2.7 psf	10.7 psf
20 ft2	2.2 psf	10.3 psf
50 ft2	0.9 psf	9.0 psf
100 ft2	0.4 psf	8.5 psf
200 ft2	0.4 psf	8.5 psf

d.) Roof Components and Cladding Pressures - Negative Pressure with Postive Internal Pressure

Effective Wind Area	Roof Component Pressure (p_{negative})				
	$GC_{pi} (+)$				
	Zone 1	Zone 2	Zone 2'	Zone 3	Zone 3'
10 ft2	-28.6 psf	-33.1 psf	-39.8 psf	-44.3 psf	-62.2 psf
20 ft2	-28.6 psf	-32.7 psf	-39.2 psf	-40.5 psf	-55.5 psf
50 ft2	-28.6 psf	-31.6 psf	-38.5 psf	-34.9 psf	-46.6 psf
100 ft2	-28.6 psf	-30.9 psf	-37.6 psf	-30.9 psf	-39.8 psf
200 ft2	-28.6 psf	-30.9 psf	-37.6 psf	-30.9 psf	-39.8 psf

e.) Roof Components and Cladding Pressures - Negative Pressure with Negative Internal Pressure

Effective Wind Area	Roof Component Pressure (p_{negative})				
	$GC_{pi} (-)$				
	Zone 1	Zone 2	Zone 2'	Zone 3	Zone 3'
10 ft2	-20.6 psf	-25.1 psf	-31.8 psf	-36.3 psf	-54.2 psf
20 ft2	-20.6 psf	-24.6 psf	-31.1 psf	-32.5 psf	-47.4 psf
50 ft2	-20.6 psf	-23.5 psf	-30.4 psf	-26.9 psf	-38.5 psf
100 ft2	-20.6 psf	-22.8 psf	-29.5 psf	-22.8 psf	-31.8 psf
200 ft2	-20.6 psf	-22.8 psf	-29.5 psf	-22.8 psf	-31.8 psf

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Project: ODU Solar Decathlon Canopy House
Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

Seismic Base Shear Calculation (ASCE 7-10)

Location: Irvine, CA

Latitude: 33.67

Longitude: -117.73

ZIP Code: N/A

A. Seismic Design Criteria

Risk Category = II (Table 1.5-1)
Seismic Importance Factor, I_e = 1.00 (Table 1.5-2)
Site Class = D (Table 20.3-1)

B. Determine Design Spectral Response Accelerations

Mapped risk-targeted maximum considered earthquake (MCE_R) spectral
response acceleration parameter at short period, S_s = 1.493 g
Mapped risk-targeted maximum considered earthquake (MCE_R) spectral
response acceleration parameter at 1-second period, S_1 = 0.554 g

Note:

- 1.) S_s and S_1 may be obtained from ASCE 7-10 Chapter 22, or:
- 2.) USGS website: <http://geohazards.usgs.gov/designmaps/us/>

C. Determine Site Coefficients

F_a = 1.0 (Table 11.4-1) - Interpolation permitted
 F_v = 1.5 (Table 11.4-2) - Interpolation permitted

D. Calculate Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameters

S_{MS} = 1.493 g (Equation 11.4-1)
 S_{M1} = 0.831 g (Equation 11.4-2)

E. Calculate Design Spectral Response Acceleration Parameters

$$S_{DS} = 0.995 \text{ g} \quad (\text{Equation 11.4-3})$$

$$S_{D1} = 0.554 \text{ g} \quad (\text{Equation 11.4-4})$$

F. Determine Seismic Design Category

Based on short period response acceleration: **D** (Table 11.6-1)
Based on 1-second period response acceleration: **D** (Table 11.6-2)
Seismic Design Category = **D**

Note:
Risk Category I, II, or III structures with S_1 greater than or equal to 0.75g shall be assigned to **Seismic Design Category E**.
Risk Category IV structures with S_1 greater than or equal to 0.75g shall be assigned to **Seismic Design Category F**.

G. Calculate Seismic Base Shear, V (Equivalent Lateral Force Procedure from Chapter 12.8 of ASCE 7-10)

$$V = C_s W \quad (\text{Equation 12.8-1})$$

$$R = 6.5 \quad (\text{Table 12.2-1})$$

$$C_t = 0.02 \quad (\text{Table 12.8-2})$$

$$x = 0.75 \quad (\text{Table 12.8-2})$$

$$T_L = 8 \text{ sec} \quad (\text{Figures 22-15 through 22-20})$$

$$h_n = 14.000 \text{ ft}$$

$$\text{Approximate period, } T_a = 0.145 \text{ sec} \quad (\text{Equation 12.8-7})$$

$$C_s = 0.1531 \quad (\text{Equation 12.8-2})$$

$$C_s = 0.5888 \quad (\text{Equation 12.8-3 or 12.8-4})$$

$$C_s = 0.0438 \quad (\text{Equation 12.8-5})$$

$$C_s = 0.0426 \quad (\text{Equation 12.8-6})$$

$$\text{Design } C_s = 0.1531$$

$$\text{Base Shear, } V = 0.1531 W$$

$$\text{Effective Seismic Weight, } W = 52.5 \text{ k}$$

$$\text{Base Shear, } V = 8.04 \text{ k}$$

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Project: ODU Solar Decathlon Canopy House
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Engineer: Edward C. Westerman, P.E.

Vertical Distribution of Seismic Forces ASCE 7-10 Chapter 12.8.3

Base shear, $V = 8.04 \text{ k}$

$$w_{\text{roof}} = 26.62 \text{ k}$$

$$w_{\text{floor}} = 25.88 \text{ k}$$

Approximate period, $T_a = 0.145 \text{ sec}$

$$k = 1$$

$$F_x = C_{vx} V \quad (\text{Equation 12.8-11})$$

$$C_{vx} = \frac{w_x h_x^k}{\sum w_i h_i^k} \quad (\text{Equation 12.8-12})$$

Level	w_i	h_i	h_i^k	$w_i h_i^k$	C_{vx}	F_x
Roof	26.62 k	13.0 ft	13.0 ft	346.10 k-ft	0.870	6.99 k
First floor	25.88 k	2.0 ft	2.0 ft	51.75 k-ft	0.130	1.05 k
			$\Sigma =$	397.85 k-ft	1.000	8.04 k



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Project: ODU Solar Decathlon Canopy House
Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

Horizontal Distribution of Seismic Forces at Roof Shear Wall Design Forces

A.) Seismic Forces Acting in East-West Direction

$$F_x = 6.99 \text{ k} \quad (\text{ASCE 7-10 Equation 12.8-11})$$

$$E_h = \rho Q_E \quad (\text{ASCE 7-10 Equation 12.4-3})$$

$$\rho = 1.0$$

$\rho = 1.0$ since removal of a shear wall with a height-to-length ratio greater than 1.0 within any story would not result in a 33% or greater reduction in story strength. Nor would such removal result in an extreme torsional irregularity.

$$E_h = 0.7\rho Q_E \quad (\text{Allowable Stress Design})$$

$$E_h = 4.89 \text{ k/ft}$$

i.) Diaphragm Flexibility (ASCE 7-10 Section 12.3)

Diaphragm classification = **Flexible**

The diaphragm is permitted to be idealized as flexible per ASCE 7-10 12.3.1.1 since this is a one- or two-family dwelling.

$$\text{Diaphragm width} = 24.0 \text{ ft}$$

$$w_x = 203.9 \text{ lb/ft}$$

Shear Wall	Shear Wall Length	Tributary Width	v_w	V_w
1	5.5 ft	9.0 ft	175 lb/ft	961 lb
2	5.0 ft	9.0 ft	175 lb/ft	874 lb
3	3.0 ft	12.0 ft	188 lb/ft	565 lb
4	10.0 ft	12.0 ft	188 lb/ft	1882 lb
5	3.0 ft	3.0 ft	204 lb/ft	612 lb

B.) Seismic Forces Acting in North-South Direction

$$F_x = 6.99 \text{ k} \quad (\text{ASCE 7-10 Equation 12.8-11})$$

$$E_h = \rho Q_E \quad (\text{ASCE 7-10 Equation 12.4-3})$$

$$\rho = 1.0$$

$\rho = 1.0$ since removal of a shear wall with a height-to-length ratio greater than 1.0 within any story would not result in a 33% or greater reduction in story strength. Nor would such removal result in an extreme torsional irregularity.

$$E_h = 0.7\rho Q_E \quad (\text{Allowable Stress Design})$$

$$E_h = 4.89 \text{ k/ft}$$

i.) Diaphragm Flexibility (ASCE 7-10 Section 12.3)

Diaphragm classification = **Flexible**

The diaphragm is permitted to be idealized as flexible per ASCE 7-10 12.3.1.1 since this is a one- or two-family dwelling.

$$\begin{aligned} \text{Diaphragm width} &= 40.0 \text{ ft} \\ w_x &= 122.3 \text{ lb/ft} \end{aligned}$$

Shear Wall	Shear Wall Length	Tributary Width	v_w	V_w
A	8.0 ft	20.0 ft	144 lb/ft	1151 lb
B	9.0 ft	20.0 ft	144 lb/ft	1295 lb
C	8.0 ft	20.0 ft	175 lb/ft	1398 lb
D	6.0 ft	20.0 ft	175 lb/ft	1049 lb



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Comm. No.: 4.0
Engineer: Edward C. Westerman, P.E.

Shear Wall Design
AISI S213-07-S1-09 Chapter C2

R_n = From Table C2.1-3
 Ω = 2.50

Shear Wall Type = Type I
Sheathing Thickness = 15/32" Structural 1 (one side of shear wall)

Wall No.	Height, h_w	Length, L_w	h_w/L_w	v_w	T/C Reaction	V	R_n	R_n/Ω
1	9.67 ft	5.5 ft	1.76	175 lb/ft	1692 lb	963 lb	780 lb/ft	312 lb/ft
2	9.67 ft	5.0 ft	1.93	175 lb/ft	1692 lb	875 lb	780 lb/ft	312 lb/ft
3	8.25 ft	3.0 ft	2.75	188 lb/ft	1551 lb	564 lb	780 lb/ft	227 lb/ft
4	8.25 ft	10.0 ft	0.83	188 lb/ft	1551 lb	1880 lb	780 lb/ft	312 lb/ft
5	8.25 ft	3.0 ft	2.75	204 lb/ft	1683 lb	612 lb	780 lb/ft	227 lb/ft
A	9.00 ft	8.0 ft	1.13	144 lb/ft	1296 lb	1152 lb	780 lb/ft	312 lb/ft
B	9.00 ft	9.0 ft	1.00	144 lb/ft	1296 lb	1296 lb	780 lb/ft	312 lb/ft
C	9.00 ft	8.0 ft	1.13	175 lb/ft	1575 lb	1400 lb	780 lb/ft	312 lb/ft
D	9.00 ft	6.0 ft	1.50	175 lb/ft	1575 lb	1050 lb	780 lb/ft	312 lb/ft

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Diaphragm Design Forces ASCE 7-10 Chapter 12.10.1

$$F_{px} = \frac{\sum F_i(w_{px})}{\sum w_i} \quad (\text{Equation 12.10-1})$$

$$S_{DS} = 0.995 \text{ g}$$

$$I_e = 1.00$$

$$F_{px, \min} = 0.2S_{DS}I_e w_{px} \quad (\text{Equation 12.10-2})$$

$$F_{px, \max} = 0.4S_{DS}I_e w_{px} \quad (\text{Equation 12.10-3})$$

Level	w_{px}	w_i	F_i	F_{px}	$F_{px, \min}$	$F_{px, \max}$
Roof	26.62 k	26.62 k	6.99 k	4.08 k	5.30 k	10.60 k
First floor	25.88 k	25.88 k	1.05 k	3.96 k	5.15 k	10.30 k
	$\Sigma =$	52.50 k	8.04 k			

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Roof Diaphragm Shear Check

A.) Seismic Forces Acting in East-West Direction

$$F_{px} = 5.30 \text{ k} \quad (\text{ASCE 7-10 Equation 12.10-2})$$

$$\begin{aligned} \text{Diaphragm width} &= 24.0 \text{ ft} \\ w_{px} &= 220.8 \text{ lb/ft} \end{aligned}$$

$$\begin{aligned} R_n &= 565 \text{ lb/ft} \\ \Omega &= 2.5 \end{aligned} \quad (\text{AISI S213-07-S1-09 Table D2-1})$$

Location	Tributary Width	Collector Length	v_D	R_n/Ω	Result
SW 1 & 2	9.0 ft	40.0 ft	49.7 lb/ft	226 lb/ft	OKAY
SW 3 & 4	12.0 ft	40.0 ft	66.3 lb/ft	226 lb/ft	OKAY
SW 5	3.0 ft	17.0 ft	39.0 lb/ft	226 lb/ft	OKAY

B.) Seismic Forces Acting in North -South Direction

$$F_{px} = 5.30 \text{ k} \quad (\text{ASCE 7-10 Equation 12.10-2})$$

$$\begin{aligned} \text{Diaphragm width} &= 40.0 \text{ ft} \\ w_{px} &= 132.5 \text{ lb/ft} \end{aligned}$$

$$\begin{aligned} R_n &= 565 \text{ lb/ft} \\ \Omega &= 2.5 \end{aligned} \quad (\text{AISI S213-07-S1-09 Table D2-1})$$

Location	Tributary Width	Collector Length	v_D	R_n/Ω	Result
SW A & B	20.0 ft	23.0 ft	115.2 lb/ft	226 lb/ft	OKAY
SW C & D	20.0 ft	17.0 ft	155.9 lb/ft	226 lb/ft	OKAY

ROOF COLLECTORS

DATE 3 FEB 13 COMPUTED BY ECW

COMM. NO. 4.0 CHECKED BY _____

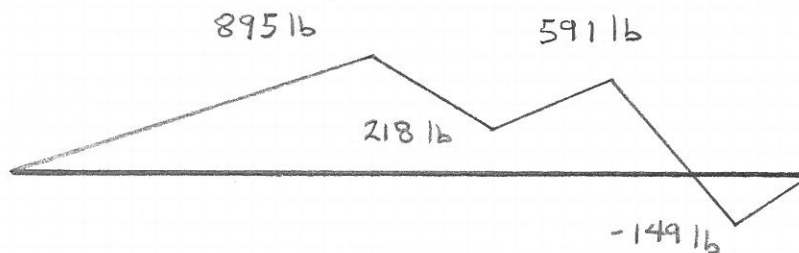
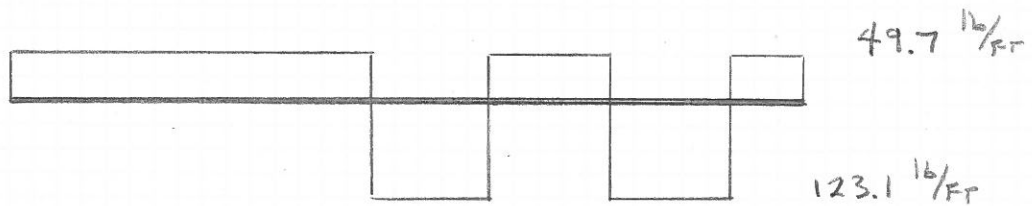
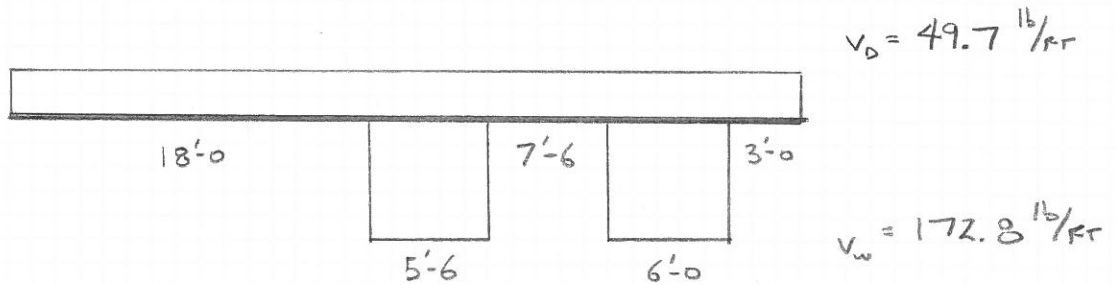
PROJECT ODU SOLAR DECATHLON SHEET NO. 1 OF _____ SHEETS

(A) COLLECTOR AT SHEAR WALL (1) AND (2)

COLLECTOR FORCE DIAGRAM:

$$V_D = 49.7 \text{ lb/ft} \quad (\text{FROM EXCEL SPREADSHEET})$$

$$V_W = \frac{220.8 \text{ lb/ft} (9')}{(5.5' + 6')} = 172.8 \text{ lb/ft}$$



ROOF COLLECTORS

DATE 3 FEB 12 COMPUTED BY ECW

COMM. NO. 4.0 CHECKED BY _____

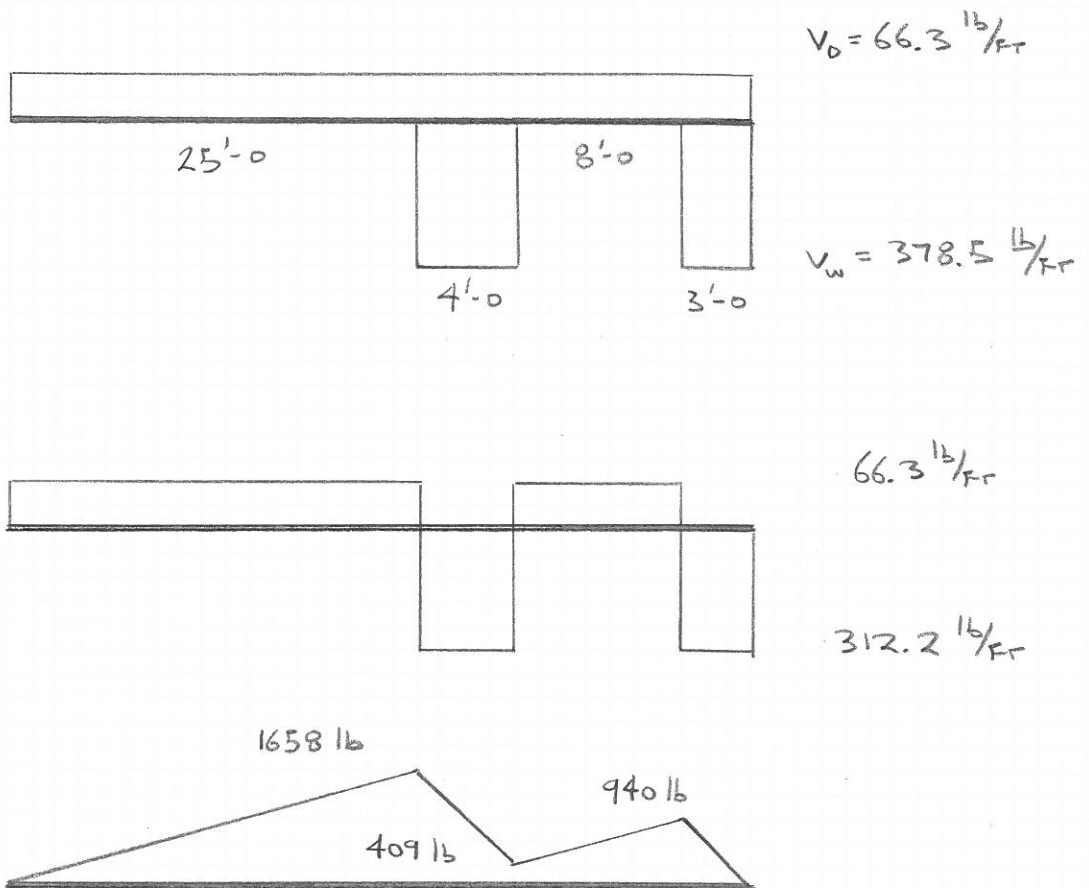
PROJECT ODU SOLAR DECATHLON SHEET NO. 2 OF _____ SHEETS

Ⓑ. COLLECTOR AT SHEAR WALLS ③ AND ④

COLLECTOR FORCE DIAGRAM :

$V_D = 66.3 \text{ lb/ft}$ (FROM EXCEL SPREADSHEET)

$V_w = \frac{220.8 \text{ lb/ft} (12')}{(3' + 4')} = 378.5 \text{ lb/ft}$



ROOF COLLECTORS

DATE 3 FEB 13 COMPUTED BY ECW

COMM. NO. 4.0 CHECKED BY _____

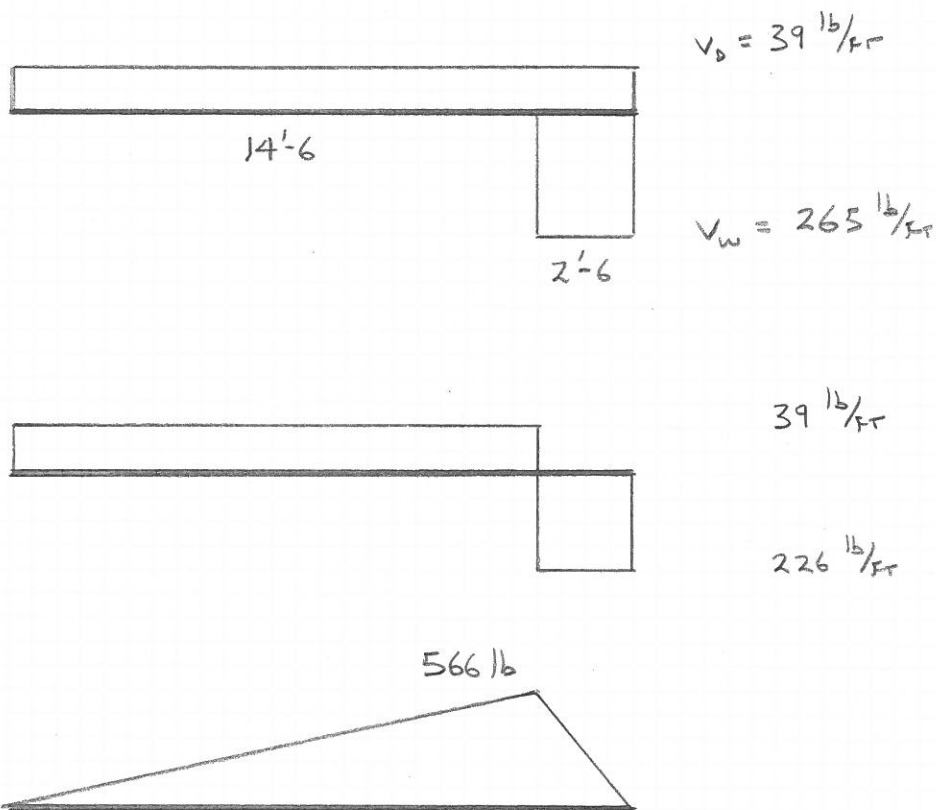
PROJECT ODU SOLAR DECATHLON SHEET NO. 3 OF _____ SHEETS

(C) COLLECTOR AT SHEAR WALL (S)

COLLECTOR FORCE DIAGRAM:

$V_D = 39 \text{ lb/ft}$ (FROM EXCEL SPREADSHEET)

$V_W = \frac{220.8 \text{ lb/ft} (3')}{2.5'} = 265 \text{ lb/ft}$



ROOF COLLECTORS

DATE 3 FEB 13 COMPUTED BY ECW

COMM. NO. 4.0 CHECKED BY _____

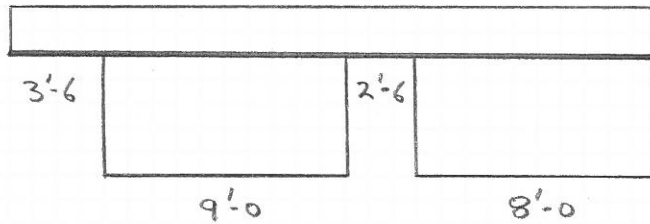
PROJECT ODU SOLAR DECATHLON SHEET NO. 4 OF _____ SHEETS

Ⓓ. COLLECTOR AT SHEAR WALLS Ⓐ AND Ⓑ

COLLECTOR FORCE DIAGRAM:

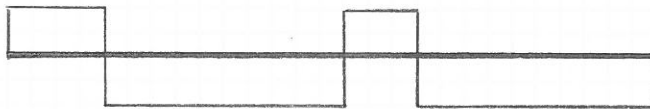
$$V_D = 115.2 \text{ lb/ft} \quad (\text{FROM EXCEL SPREADSHEET})$$

$$V_W = \frac{132.5 \text{ lb/ft} (20')}{(8' + 9')} = 155.9 \text{ lb/ft}$$



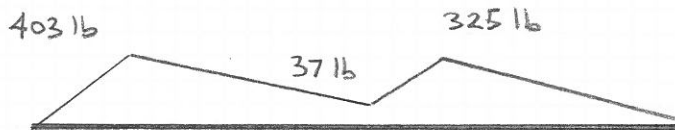
$$V_D = 115.2 \text{ lb/ft}$$

$$V_W = 155.9 \text{ lb/ft}$$



$$115.2 \text{ lb/ft}$$

$$40.7 \text{ lb/ft}$$



403 lb

37 lb

325 lb

ROOF COLLECTORS

DATE 3 FEB 13 COMPUTED BY ECW

COMM. NO. 4.0 CHECKED BY _____

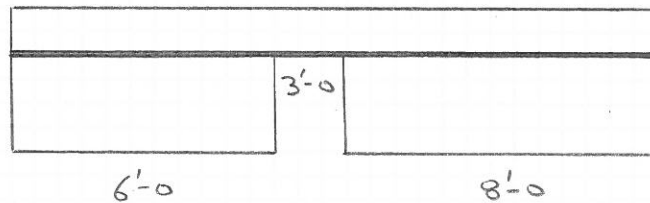
PROJECT ODU SOLAR DECATHLON SHEET NO. 5 OF _____ SHEETS

(E) COLLECTOR AT SHEAR WALL (C) AND (D)

COLLECTOR FORCE DIAGRAM:

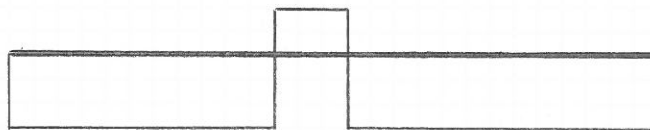
$$V_D = 155.9 \text{ lb/ft} \quad (\text{FROM EXCEL SPREADSHEET})$$

$$V_W = \frac{132.5 \text{ lb/ft} (20')}{(6' + 8')} = 189.3 \text{ lb/ft}$$



$$V_D = 155.9 \text{ lb/ft}$$

$$V_W = 189.3 \text{ lb/ft}$$



$$155.9 \text{ lb/ft}$$

$$33.4 \text{ lb/ft}$$

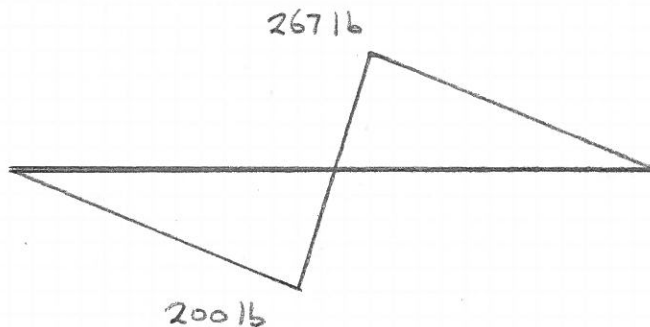


Table C2.1-3
United States and Mexico
Nominal Shear Strength (R_n) for Seismic and Other In-Plane Loads for Shear Walls^{1,4,7,8}
(Pounds Per Foot)

Assembly Description	Max. Aspect Ratio (h/w)	Fastener Spacing at Panel Edges ² (inches)				Designation Thickness ^{5,6} of Stud, Track and Blocking (mils)	Required Sheathing Screw Size
		6	4	3	2		
15/32" Structural 1 sheathing (4-ply), one side	2:1 ³	780	990	-	-	33 or 43	8
	2:1	890	1330	1775	2190	43 or 54 68	8 10
7/16" OSB, one side	2:1 ³	700	915	-	-	33	8
	2:1 ³	825	1235	1545	2060	43 or 54	8
	2:1	940	1410	1760	2350	54	8
	2:1	1232	1848	2310	3080	68	10
0.018" steel sheet, one side	2:1	390	-	-	-	33 (min.)	8
0.027" steel sheet, one side	4:1	-	1000	1085	1170	43 (min.)	8
	2:1 ³	647	710	778	845	33 (min.)	8



1. Nominal strength shall be multiplied by the resistance factor (ϕ) to determine design strength or divided by the safety factor (Ω) to determine allowable strength as set forth in Section C2.1.
2. Screws in the field of the panel shall be installed 12 inches (305 mm) o.c. unless otherwise shown.
3. Shear wall height to width aspect ratios (h/w) greater than 2:1, but not exceeding 4:1, shall be permitted provided the nominal strength values are multiplied by $2w/h$. See Section C2.1.
4. See Section C2.1 for requirements for sheathing applied to both sides of wall.
5. Unless noted as (min.), substitution of a stud or track of a different designation thickness is not permitted.
6. Wall studs and track shall be of ASTM A1003 Structural Grade 33 (Grade 230) Type H steel for members with a designation thickness of 33 and 43 mils, and A1003 Structural Grade 50 (Grade 340) Type H steel for members with a designation thickness equal to or greater than 54 mils.
7. For wood structural panel sheathed shear walls, tabulated R_n values applicable for short-term load duration (seismic loads). For other in-plane lateral loads of normal or permanent load duration as defined by the AF&PA NDS, the values in the table above for wood structural panel sheathed shear walls shall be multiplied by 0.63 (normal) or 0.56 (permanent).
8. For SI: 1" = 25.4 mm, 1 foot = 0.305 m, 1 lb = 4.45 N.

Table D2-1
United States and Mexico
Nominal Shear Strength (R_n) for Diaphragms with Wood Sheathing^{1, 4}
(Pounds Per Foot)

Membrane Material	Screw Size	Thick-ness (in.)	Blocked				Unblocked	
			Screw spacing at diaphragm boundary edges and at all continuous panel edges (in.)				Screws spaced maximum of 6" on all supported edges	
			6	4	2.5	2	Load perpendicular to unblocked edges and continuous panel joints	All other configurations
			Screw spacing at all other panel edges (in.)					
6	6	4	3					
Structural I	See note 2	3/8	768	1022	1660	2045	685	510
		7/16	768	1127	1800	2255	755	565
		15/32	925	1232	1970	2465	825	615
C-D, C-C and other graded wood structural panels ³	See note 2	3/8	690	920	1470	1840	615	460
		7/16	760	1015	1620	2030	680	505
		15/32	832	1110	1770	2215	740	555

- For SI: 1" = 25.4 mm, 1 foot = 0.305 m, 1 lb = 4.45 N.
- No. 8 screws (minimum) shall be used when framing members have a *designation thickness* of 54 mils or less and No. 10 screws (minimum) shall be used when framing members have a *designation thickness* greater than 54 mils.
- Wood structural panels shall conform to DOC PS-1 and PS-2.
- For wood structural panel sheathed diaphragms, tabulated R_n values shall be applicable for short-term load duration (wind or seismic loads). For other in-plane lateral loads of normal or permanent load duration as defined by the AF&PA NDS, the values in the table above for wood structural panel sheathed diaphragms shall be multiplied by 0.75 (normal) or 0.67 (permanent).

D3 Special Seismic Requirements

D3.1 General

Where the seismic response modification coefficient, R , used to determine the lateral forces is taken greater than 3, the requirements of this section shall apply in addition to the requirements of Sections D1 and D2.

Diaphragms shall be defined as flexible or rigid, in accordance with the *applicable building code*.

D3.2 Wood Diaphragms

The aspect ratio (length/width) of a *diaphragm* sheathed with wood structural sheathing shall be limited to 4:1 where all edges of the wood structural panel sheathing are attached to framing members or to intermittent *blocking*. Where there is no intermittent *blocking*, the aspect ratio shall be limited to 3:1. Wood structural panel sheathing shall be arranged so that