WaterShed

AT THE UNIVERSITY OF MARYLAND

U.S. Department of Energy Solar Decathlon 2011

Team Maryland

As-Built Project Manual

Primary Faculty Contact:
Amy Gardner
School of Architecture, Planning, and Preservation
College Park, MD 20742
turbine@umd.edu
301.405.6303

Primary Student Contact:
Allison Wilson
School of Architecture, Planning, and Preservation
College Park, MD 20742
amwilson@umd.edu
973.978.8941

11 August 2011

TABLE OF CONTENTS

SUMMARY OF CHANGES

Team Maryland's document set has been revised twice since its initial design development set to the Solar Decathlon. Find below two sets of changes, the first changes between the 100% Construction Documents set and this As-Built Document set and second changes between the 80% Design Development set and the 100% Construction Documents set.

CHANGES BETWEEN THE 100% CONSTRUCTION DOCUMENTS SET AND THE AS-BUILT DOCUMENT SET:

CHANGES TO THE DRAWING SET:

G-102, G-103, C-102 – Ramp Slope
Slope of ramp/walking surface was decreased to 1:21 or less.

S-Series – Structural Carrying Beams
Four triple pack beams, composed of (3)2x10 wood members, added across foundation pads in the east/west direction for lifting during transport.

A-Series – Interior Wall Reveal
Wall reveal at 3'6" above finish floor was deleted. Upper wall reveal expanded from 6" to 9 ½".

A-Series – Interior Baseboard
Baseboard changed from extruded base to recessed base with trim detail.

A-Series – Exterior Trim Material Change
Doug Fir used on exterior finish carpentry on Module B (middle).

A-Series – Interior Trim Material
Doug Fir trim added at LVL roof joint, baseboard and around all fenestration.

C-102 – Site Plan and A-100 SERIES
Removed railing and gate on south and west sides of pergola deck. Added 36" platform, 18" grade.

A-111 – Bathroom Material Changes
Bathroom ceiling changed from corrugated metal to MDO plywood. Bathroom walls, ceiling and floor in toilet and lavatory niche changed from drywall to vertical grain bamboo panels. Shower floor changed to milled, woven strand bamboo flooring.

A-301, A-313 – Interior Parapet Wall Added
Parapet wall added above desk niche in Module C.

A-314 – Shade Pockets Added
Recessed shade pocket added in ceiling above both windows in Module B.

A-200s, A300s – Foundations
Perimeter jackstand footings changed to adjustable lock deck foundation pads.

A-402 – Kitchen Changes
Kitchen cabinet dimensions and layout changed slightly to meet typical cabinet sizing.

A-401, A-402 – Countertop Material
Kitchen and bathroom countertops changed to concrete.

A-411, A-412 – Wetland Finish Material
Wetland modules wrapped in corrugated metal and poplar trim.

A-516, E-401 – Weatherhead
Din rail box changed to weatherhead on Module B roof.

A-518, S-500 – Pergola Structure
Pergola framing changed from aluminum to structural steel tubes.

F-101 – Fire Protection
Fire protection drawings replaced with drawings from “Absolute, Fire Protection, Inc” engineer.

O-Series – Operations
Site operation plans updated per new site information.

F-SERIES – Fire Suppression Layout
Third Party Fire Suppression Contractor updated fire suppression plan to comply with 2009 IRC.

P-Series – LDW
Added lighting to LDW specification.

P-101 – Supply Tank Water Piping
Updated supply tank piping to 4” PVC.

P-101 – Domestic Water Piping
Added Hose Bibb to West Exterior Wall of Module C.

P-102 – Heating Solar Collectors
Changed glycol loop piping from PEX tubing to copper piping.

P-102 – Regenerator
Changed location of Regenerator, updated specifications and increased size of regenerator.

P-104 – HXEST Water Piping
Changed mechanical room piping from PEX tubing to copper piping.

P-111 – Domestic Water Piping
Changed dishwasher piping to connect to kitchen sink hot water piping.

P-112 – Sanitary Waste and Vent Piping
Deleted Air Admittance Valves.

P-112 – Sanitary Waste and Vent Piping

Changed waste and vent piping layout.

P-112 – Waste Filtration System
Added pumps and piping for waste filtration system.

P-401 – Water Storage Tanks
Changed expansion tank layout and products.

P-401 – PEX Manifold
Changed PEX Manifold Layout and added copper piping.

M-SERIES – HVAC Insulation
Added insulted flex duct to mechanical room.

M-SERIES – Metal Ducts
Spiral Duct substituted for hard ducting.

M-SERIES – Duct Layout
Revised supply and return runs.

M-SERIES – Diffusers, Registers and Grilles
Added and updated interior and exterior grilles.

E-101 – Interior Electrical Distribution Plan
Adjustments to quantity and location of outlets throughout house.

E-102 – Exterior Electrical Distribution Plan
Sheet added. Outlets added beneath house.

E-104 – Lighting Plan
Updated lighting schedule and added fixtures. Removed dimmer panel and added button stations.

CHANGES TO THE PROJECT MANUAL:
XX XX XX
Where multiple manufacturers or products were listed, divisions have been updated to reflect product actually install in Project.

01 54 19 Temporary Cranes
Crane specification changed to 130 ton model.

05 05 23 Metal Fastenings
Division deleted and products listed as accessories under 26 31 00.

05 15 16 Steel Wire Rope Assemblies
Division deleted to reflect changes to the scope of work.

05 05 23 Metal Fastenings
Division deleted and products listed as accessories under 26 31 00.

06 20 23 Interior Finish Carpentry
Division added to describe finish trim materials throughout house.

07 71 23 Manufactured Gutters and Downspouts
Eliminated from project. Materials consolidated into 07 62 00 Sheet Metal Flashing and Trim.

11 31 XX Residential Appliance
Appliance selections updated to different manufacturers and models.

22 41 26 Residental Disposers
Division added to describe garbage disposal element.

26 05 26 Grounding and Bonding for Electrical Systems
Division added to describe grounding rod.

26 32 00 Packaged Generator Assemblies
Division added to describe generator to be used during competition construction.

22 41 26 Residential Disposers
Division added to reflect changes to the scope of work.

25 XX XX Integrated Automated
Changes in manufacturer and product selection to accommodate changes in design.

25 30 00 Integrated Automation Instrumentation and Terminal Devices
Division deleted to reflect changes to the scope of work.

CHANGES BETWEEN THE 80% DESIGN DEVELOPMENT SET AND THE 100% CONSTRUCTION DOCUMENTS SET:

CHANGES TO THE DRAWING SET:
A-SERIES – Stair
Exterior stair off west deck was deleted per competition requirements.

A-SERIES – Module B Floor
Extents of wood and tile flooring were changed.

A-SERIES – Shower Floor
Shower floor grated added to the shower.

A-SERIES – Murphy Bed
Murphy Bed removed.

A-101, A-302 – Pergola Structure
Columns and frame become 4” x 4” aluminum tubing. Columns are clad with 3/4” of exterior finish wood material. Details were added to document changes.

A-103 – PFAS

Fall arrested updated on Module C Roof; Added to Module B Roof.

A-202, A-303 – Exterior Wall Cladding
Exterior finish at mechanical room and solar thermal wall changed from corrugated metal panel to shiplap siding with splines.

A-312, A-515 – South Wall
South wall moved adjacent to house on the east deck where structure lines up with south module's southernmost wall. Details updated to document changes. Top of wall elevated to roof break. Solar tubes moves up on wall. Bottom of tubes are above the 36" knee wall that was added below to act as a railing/barrier.

C-101 – Site Location
Solar Village drawing, including layout and lot numbers was updated in response to latest information provided.

F-101 – Sprinkler
Addition of sprinkler head in Mechanical Closet.

M-101 – Mechanical
Dryer Duct and Electric Radiant Floor Mat in bathroom added.

P-SERIES – PEX
PEX tubing runs are updated throughout the drawings.

P-112 – Greywater Cistern
Greywater Cistern with pumps and piping added.

P-112 – Plumbing
Settling Tank and Waste Water Pump added.

E-101 – Receptacles
Added Office Receptacles, 4 GFCI Mechanical Room Receptacles, and Weather Proof Exterior Receptacles on West wall of Module C.

E-103 – Lighting
Added Two "M" lights to Northwest Deck, two "M" lights to Entrance Deck, "F" rope lights to Entrance Deck, and "R" lights to South wall of Module C. Removed "A" light, three "J" lights in Kitchen, two lights in Bathroom and one in ceiling.

E-104 – Hardwired Electrical
Added Thermostat and switch for Radiant Floor Mat in Bathroom.

E-401 – Grounding Rod
Grounding Rod was added.

E-6XX – Schedules
Updated Schedules and included required information.

T-101 – Dimmer Panel
Dimmer Panel was removed and remaining panels were relocated.

CHANGES TO THE PROJECT MANUAL:
05 12 00 – Structural Steel Framing
This section was removed from the scope of WaterShed's design.

05 14 00 – Structural Aluminum Framing
This section was added to the project manual to identify the structural elements of the pergola at the northwest deck.

05 15 16 – Steel Wire Rope Assemblies
This section was added to the project manual to identify elements that will support plants on the green walls of the southeast deck.

06 10 00 – Rough Carpentry
Section was significantly revised in order to clarify WaterShed's carpentry specifications. Siding moved to section 06 20 13. Decking moved to section 06 15 33. All structural wood members moved to section 06 11 00. Furring strips added to this section.

06 11 00 – Wood Framing
This section was added to identify wood members used for structural purposes.

06 11 13 – Engineered Wood Products
Subflooring and LVL's were removed from this section and new sections 06 16 23 and 06 17 13 were created.

06 15 33 – Wood Deck
This section was added to identify exterior decking assemblies.

06 16 23 – Subflooring
This section was added to identify the ¾" ceramic tile underlayment and the 1 1/8" Advantek subfloor.

06 17 13 – LVL
This section added to identify the Laminated Veneer Lumber locations in WaterShed.

07 21 13 – Board Insulation
This section was expanded to include the addition of Extruded Polystyrene for use on exterior of walls, and the addition of Composite Board Insulation for use on North Roof.

07 21 16 – Blanket Insulation
This section added to include fiberglass-free batt insulation for use as an acoustical barrier at bathroom and washer/dryer closet.

07 21 29 – Sprayed Insulation
This section expanded to include addition of Open Cell Spray Insulation for use in interior cavities of walls and ceilings.

07 25 00 – Weather Barriers
This section was removed from the scope of WaterShed's design.

07 46 23 – Wood Siding
This section was removed, and elements from this section were consolidated in to division 06 20 13.

07 71 00 – Roof Specialties
This section expanded to include Fall Arrest Anchors and Siding Vents.

07 91 16 – Joint Gaskets
This section was added to include information about sill seal and neoprene tape.

08 10 00 – Doors and Frames
This section was removed in order to provide better clarity between door types. New sections with greater specificity were created in its stead.

08 14 00 – Wood Doors
This section was created to specify interior and exterior wooden doors throughout WaterShed.

08 14 23 – Clad Doors
This section was created to specify exterior metal clad doors.

09 28 13 – Cementitious Boards
This section was created to lend greater specificity to interior finish board materials.

09 29 00 – Gypsum Board
Cementitious Board removed from this section and moved to section 09 28 13.

10 28 16.13 – Residential Bath Accessories
Some content within this section was moved to Division 22 – Plumbing Fixtures.

10 71 13 – Exterior Sun Control Devices
This section was eliminated and information was consolidated with section 08 14 00.

12 20 00 – Window Treatments
This section was revised to reflect changes in window treatment types, and addition of hidden blind pocket assembly.

21 10 00 – Suppression Systems
Section number and name changed to reflect more appropriate designation for system. Information moved to new section 21 13 13.

21 13 13 – Wet Pipe Sprinkler System
This section created for better designation of fire suppression system.

21 11 00 – Facility Fire-Suppression Water-Service Piping
Updated ¾" CPVC pipe to 1 ½" pipe for fire suppression system.

21 41 00 – Storage Tanks for Fire-Suppression Water
This section was eliminated and information regarding the fire-suppression water storage has been included with section 22 12 19.

22 11 16 – Domestic Water Piping
All valves in this section moved to section 22 11 19. PVC pipe moved to section 22 13 16. PEX changed to Uponor Type A.

22 11 19 – Domestic Water Piping Specialties
Valves added from section 22 11 16. Ball Valve and PEX manifold manufacturers also updated.

22 12 19 – Facility Potable-Water Storage Tanks
Manufacturer and size of pre-heat tank updated. Also added a statement noting reserves for fire suppression system to be included with main potable storage tanks.

22 14 29.16 – Submersible Sump Pumps
This section was eliminated and information regarding the submersible sump pump has been included with section 32 71 00.

22 35 00 – Domestic Water Heat Exchangers
This section was eliminated and information was moved to section 23 57 00.

22 41 13 – Residential Water Closets, Urinals, and Bidets
In-wall plumbing system added.

22 41 00 – Residential Plumbing Fixtures
Shower head moved to section 22 41 39.

22 41 23 – Residential Shower Receptors and Basins
This section was added to include information about the shower drain assembly.

22 41 39 – Residential Faucets, Supplies, and Trim
Shower head and shower mixing valve added to this section.

23 34 13 – Mechanical Room Ventilation Fans
This section was added to describe ventilation fans to be used in mechanical room.

23 56 13.19 – Heating Solar Vacuum-Tube Collectors
Glycol fluid and pump added to this section.

23 83 13.16 – Radiant Heating Units
This section was added to describe the radiant flooring to be installed in WaterShed's bath module.

26 05 33 – Raceway and Boxes for Electrical Systems
ENT and NEMA 4 box for PV wiring on roof added.

26 24 16 – Panel Boards
Main and sub panels were changed, and a surge breaker was added.

26 28 13 – Fuses
This section was removed from the scope of WaterShed's design.

26 31 00 – Photovoltaic Collectors
Roof and Trellis mounting systems added.

28 31 46 – Smoke Detection Sensors
This section added for Smoke Detectors to be used in WaterShed.

31 66 00 – Special Foundations
Added post and precast concrete footing foundation systems.

RULES COMPLIANCE CHECKLIST

	RULE DESCRIPTION	LOCATION DESCRIPTION	LOCATION
Rule 4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site	O-101, O-102
Rule 4-2	Construction Equipment	Specifications for heavy machinery	01 54 19 and O-101
Rule 4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	S-500, E-401
Rule 4-4	Impact on the Turf	Drawing(s) showing the location, contact area, and soil-bearing pressure of every component resting directly on the turf	C-104
Rule 4-5	Generators	Specifications for generators	26 32 00
Rule 4-6	Spill Containment	Drawing(s) showing the locations of all equipment, containers, and pipes that will contain liquids at any point during the event	H-101, P-SERIES
Rule 4-6	Spill Containment	Specifications for all equipment, containers, and pipes that will contain fluids at any point during the event	07 33 63 07 71 23, 11 31 13, 11 31 23, 21 13 13, 22 XX XX, 23 20 00, 23 23 00, 23 56 13.19, 23 57 00, 23 84 00, 32 71 00
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	S-000, Appendix 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	S-400
Rule 5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	C-102, C-201, C-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 have been or will be stamped by the qualified, licensed design professional in the stamped structural submission; the stamped submission shall consist entirely of sheets that also appear in the drawings and project manual	S-SERIES, Appendix A Stamped drawings & calculations submitted 7/27/11
Rule 6-2	Finished Square Footage	Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically	G-101
Rule 6-2	Finished Square Footage	Drawing(s) showing all movable components that may increase the finished square footage if operated during contest week	n/a
Rule 6-3	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route and the ground surface area that will be covered by organizer-provided walkway material	G-103
Rule 7-1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	L-101
Rule 7-2	Watering Restrictions	Drawing(s) showing the layout and operation of greywater irrigation systems	A-412, P-112
Rule 8-1	PV Technology Limitations	Specifications for photovoltaic components	26 31 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	n/a
Rule 8-3	Batteries	Specifications for all primary and secondary batteries and stand-alone, PV-powered devices	n/a
Rule 8-4	Desiccant Systems	Drawing(s) describing the operation of the desiccant system	P-103
Rule 8-4	Desiccant Systems	Specifications for desiccant system components	23 84 00
Rule 8-5	Village Grid	Completed interconnection application form.	Page 19
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-103, E-401, 26 05 26, 26 05 33
Rule 8-5	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	26 31 00, 48 19 16, 26 24 16
Rule 8-5	Village Grid	One-line electrical diagram	E-602
Rule 8-5	Village Grid	Calculation of service/feeder net computed load per NEC 220	Pages 20-22

Rule 8-5	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	E-102
Rule 8-5	Village Grid	Elevation(s) showing the meter housing, main utility disconnect, and other service equipment	E-401
Rule 9-1	Container Locations	Drawing(s) showing the location of all liquid containers relative to the finished square footage	H-101
Rule 9-1	Container Locations	Drawing(s) demonstrating that the primary supply water tank(s) is fully shaded from direct solar radiation between 9 a.m. and 5 p.m. EDT or between 8 a.m. and 4 p.m. solar time on October 1	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	Page 15, 23 84 00
Rule 9-3	Greywater Reuse	Drawing(s) showing the layout and operation of greywater reuse systems	P-112
Rule 9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	A-411, A-412
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	O-111
Rule 9-8	Water Delivery	Specifications for the containers to which water will be delivered	22 12 19
Rule 9-9	Water Removal	Drawing(s) showing the complete sequence of water consolidation and removal events	O-111
Rule 9-9	Water Removal	Specifications for the containers from which water will be removed	22 13 53
Rule 11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	G-103

STRUCTURAL CALCULATIONS

Structural calculations are attached in Appendix A of this document.

DETAILED WATER BUDGET

FUNCTION	WATER USE (GALLONS)	CALCULATIONS		NOTES
		GAL	EVENTS	
Hot Water Draws	240	15	16	
Water Vaporization	3	0.75	4	
Dishwasher	25	5	5	
Clothes Washer	48	6	8	
Vegetation	150	30	5	assume daily watering; usage may decrease if rain events happen during competition. Demand will be met by greywater recycling.
Fire Protection	300	300	1	
Testing	0	0	0	
Initial Systems Fill	575	575	1	150 gallons - east rainwater cistern; 200 gallons - west rainwater filtration system; 185 gallons - hot water tank initial fill; 40 gallons - piping fill
Safety Factor	134.1			
WATER REQUIRED	**1475.1**	gallons		

SUMMARY OF UNLISTED ELECTRICAL COMPONENTS

WaterShed is not using any unlisted electrical components.

SUMMARY OF RECONFIGURABLE FEATURES

Reconfigurable features of WaterShed are as follows:

1. Kitchen table
   This element is a combination of table and rolling cart components that can be configured as a table, a countertop, or various combinations thereof. The kitchen table consists of rolling carts supported on locking casters nested underneath and supporting table components. The cart components have space within their frames that is used to store dining stools. The entire kitchen table can be used as a wall or island counter or can be pulled apart, allowing the rolling carts and table components to be used separately.

   For Public Tours the typical location and configuration of the kitchen table will be as shown Figure 1.

Figure 1: Kitchen Table in Public Exhibit Configuration

The kitchen table will be located against the north wall of Module A between the refrigerator and the Liquid Desiccant Waterfall. The rolling carts will be in their nested positions under the table components with casters locked.

During the Dinner Party sub-contest the tables will be located in the center of the kitchen/dining space and the rolling carts will remain against the north wall of Module A with casters locked. As shown in Figure 2.

Figure 2: Kitchen Table in Dinner Party Configuration

During Public Tours and Juries information about this reconfigurable feature will be communicated through signage that has been submitted and approved as part of Team Maryland's Public Exhibit deliverable.

2. Bed and table
   This element is a piece of furniture that can be configured as a table or a bed through manual manipulation. For Public Tours, the typical location and configuration of this element will be in the table configuration as shown in figure 3.

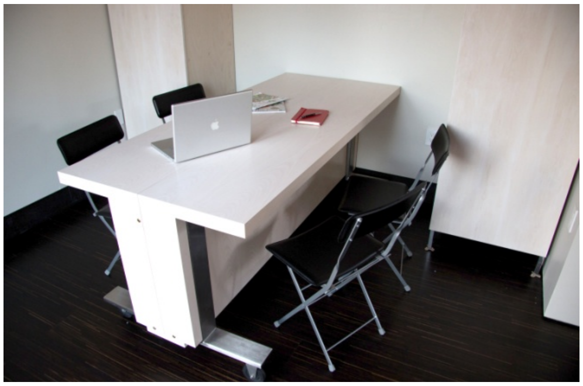


Figure 3: Bed and Table Element Shown as Table

For Public Tours and the duration of the competition this element will be configured in its table configuration demonstrating the unit as a 6 foot long table adjacent to cabinet storage. The table cannot be change into a bed by curious members of the touring public by virtue of locked hinges that require a key to release.

Information about this element will be communicated during both Public Tours and Juries through signage that has been submitted and approved as part of Team Maryland's Public Exhibit deliverable.

INTERCONNECTION APPLICATION FORM

Team Maryland, Lot 304

PV Systems

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
Sanyo	36 Sanyo HIT Power 220A's on a standing seam metal roof	7920 Watts
Sanyo	6 Sanyo HIT Power 220A's integrated in trellis roof	1320 Watts

Total DC power of all arrays is 9.2 kW.

Inverters

Inverter Manufacturer	Model Number	Voltage	Rating (kW)	Quantity
Enphase	M210	240	0.210	42

Total AC power of all inverters is 8.8 kW.

1. WaterShed's one-line electrical schematic can be found on sheet E-602 of the drawing set.
2. Calculations of service/feeder net computer load and neutral load are described in the chart on the following page.
3. A plan view of the lot showing the house, decks, walking surface, tour paths and the service point can be found on sheet G-103 of the drawing set.
4. Elevation views showing the terminal box, meter, and other service equipment can be found on sheet E-401 of the drawing set.

Team Maryland's Electrical Engineer is Steve Emling. His contact information can be found in the Team Officer Contact Information database on the Solar Decathlon Yahoo Group.

Calculations of Service/Feeder, Net Computer Load, and Neutral Load

SERVICE FEEDER CALCS			
MAIN SERVICE PANEL			
GENERAL LIGHTING AND RECEPTICLES (NEC210.11(C))			
GENERAL LIGHTING	876 SQFT X 3VA/SQFT	2628	VA
SMALL APPLIANCE CIRCUITS	2 CIRCUITS X 1500VA/CIRCUIT	3000	VA
LAUNDRY	1 CIRCUIT X 1500VA/CIRCUIT	1500	VA
SUBTOTAL	3000 VA AT 100% + 4128 VA AT 35%	**4445**	VA
COOKING			
COOKTOP	7700 VA AT 100%	7700	VA
WALL OVEN	2400 VA AT 100%	2400	VA
SUBTOTAL (NEC TABLE 220.55 NOTE (4), COLUMN C)	7700VA+2400VA=10100VA	**8000**	VA
FIXED APPLIANCES			
WATER HEATER (NEC 220.53)	4500 VA AT 75%	3375	VA
DISHWASHER (NEC 220.53)	1500 VA AT 75%	1125	VA
RANGE HOOD (NEC 220.53)	300 VA AT 75%	225	VA
DESSICANT REGENERATOR AND WALLS (NEC 220.53)	400 VA AT 75%	300	VA
RADIENT FLOOR (NEC 220.53)	360 VA AT 75%	270	VA
WATER TANK PUMP (NEC 430.24)	1150 VA AT 100%	1150	VA
GARBAGE DISPOSAL (NEC 430.24)	560 VA AT 100%	560	VA
SPRINKLER PUMP (NEC 430.24)	800 VA AT 100%	800	VA
LIVING SYSTEMS PUMPS (NEC 430.24)	(6) 45 VA AT 100%	270	VA
RADIENT FLOOR (NEC 220.51)	360 VA AT 100%	360	VA
SUBTOTAL		**8435**	VA
DRYER (W=VA FROM NEC 220.54)	7200 VA AT 100%	**7200**	VA
HVAC COMPRESSOR AND UNITS	1800 VA AT 100%	**1800**	VA
LARGEST MOTOR (NEC 220.14(C))	1150 VA AT 25%	**288**	VA
TOTAL		**30167**	VA
TOTAL CURRENT		**126**	A
MAIN SERVICE PANEL BREAKER		**150**	A
NEUTRAL CONDUCTOR			
GENERAL LIGHTING AND RECEPTICLES (NEC220.61(A))	4445 VA AT 100%	4445	VA
COOKING (NEC 220.61(B))	8000 VA AT 70%	5600	VA
FIXED APPLIANCES (NEC 220.61(A))	8435 VA AT 100%	8165	VA
DRYER (NEC 220.619(B))	7200 VA AT 70%	5040	VA
TOTAL		**23250**	VA
TOTAL CURRENT		**97**	A

NORTH SUB SERVICE PANEL			
GENERAL LIGHTING AND RECEPTICLES (NEC210.11(C))			
GENERAL LIGHTING	450 SQFT X 3VA/SQFT	1350	VA
SMALL APPLIANCE CIRCUITS	2 CIRCUITS X 1500 VA/CIRCUIT	3000	VA
SUBTOTAL	3000 VA AT 100% + 1350 VA AT 35%	**3473**	VA
COOKING			
COOKTOP	7700 VA AT 100%	7700	VA
WALL OVEN	2400 VA AT 100%	2400	VA
SUBTOTAL (NEC TABLE 220.55 NOTE (4), COLUMN C)	7700VA+2400VA=10100VA	**8000**	VA
FIXED APPLIANCES			
DISHWASHER (NEC 220.53)	1500 VA AT 100%	1500	VA
RANGE HOOD (NEC 220.53)	300 VA AT 100%	300	VA
DESSICANT WALL (NEC 220.53)	75 VA AT 100%	75	VA
GARBAGE DISPOSAL (NEC 430.24)	560 VA AT 100%	560	VA
LIVING SYSTEMS PUMPS (NEC 430.24)	(6) 45 VA AT 100%	270	VA
SUBTOTAL		**2705**	VA
LARGEST MOTOR (NEC 220.14(C))	560 VA AT 25%	**140**	VA
TOTAL		**14178**	VA
TOTAL CURRENT		**59**	A
NORTH SUB SERVICE PANEL BREAKER		**100**	A
NEUTRAL CONDUCTOR			
GENERAL LIGHTING AND RECEPTICLES (NEC220.61(A))	3473 VA AT 100%	3473	VA
COOKING (NEC 220.61(B))	8000 VA AT 70%	5600	VA
FIXED APPLIANCES (NEC 220.61(A))	2705 VA AT 75%	2029	VA
TOTAL		**10595**	VA
TOTAL CURRENT		**44**	A

SOUTH SUB SERVICE PANEL			
GENERAL LIGHTING AND RECEPTICLES (NEC210.11(C))			
GENERAL LIGHTING	426 SQFT X 3 VA/SQFT	1278	VA
SMALL APPLIANCE CIRCUITS	2 CIRCUITS X 1500 VA/CIRCUIT	3000	VA
LAUNDRY	1 CIRCUIT X 1500 VA/CIRCUIT	1500	VA
SUBTOTAL (NEC TABLE 220.55 NOTE (4), COLUMN C)	3000 VA AT 100% + 2778 VA AT 35%	**3525**	VA
FIXED APPLIANCES			
WATER HEATER (NEC 220.53)	4500 VA AT 100%	4500	VA
DESSICANT REGENERATOR AND WALL (NEC 220.53)	325 VA AT 100%	325	VA
WATER TANK PUMP (NEC 430.24)	1150 VA AT 100%	1150	VA
SPRINKLER PUMP (NEC 430.24)	800 VA AT 100%	800	VA
RADIENT FLOOR (NEC 220.51)	360 VA AT 100%	360	VA
SUBTOTAL		**7135**	VA
DRYER (W=VA FROM NEC 220.54)	7200 VA AT 100%	**7200**	VA
HVAC COMPRESSOR AND UNITS	1800 VA AT 100%	**1800**	VA
LARGEST MOTOR (NEC 220.14(C))	1150 VA AT 25%	**288**	VA
TOTAL		**19948**	VA
TOTAL CURRENT		**83**	A
SOUTH SUB SERVICE PANEL BREAKER		**100**	A
NEUTRAL CONDUCTOR			
GENERAL LIGHTING AND RECEPTICLES (NEC220.61(A))	3525 VA AT 100%	3525	VA
FIXED APPLIANCES (NEC 220.61(A))	7135 VA AT 100%	7135	VA
DRYER (NEC 220.619(B))	7200 VA AT 70%	5040	VA
TOTAL		**15700**	VA
TOTAL CURRENT		**65**	A

ENERGY ANALYSIS AND RESULTS

1.0 Introduction

1.1 Background

As part of the U.S. Department of Energy's Solar Decathlon 2011, the University of Maryland will compete with 19 other colleges and universities from around the globe to demonstrate the application of sustainable designs to today's residential building market. The University's entry into the competition, WaterShed, incorporates passive strategies with advanced technology to achieve an integrated design that is both comfortable and resource efficient.

In order to maximize energy efficiency, students, guided by faculty and mentors, have completed numerous iterations of energy modeling to guide key design decisions pertaining to system design, envelope construction, and equipment sizing. Our modeling process is summarized as follows:

- Create a baseline model of the house incorporating the geometry, preliminary envelope constructions, expected internal gains, and a preliminary HVAC system
- Perform parametric studies on the baseline house to determine the ideal envelope construction that minimizes annual cooling and heating loads
- Determine optimum HVAC size
- Predict annual electricity demand and determine optimum size of the photovoltaic array
- Predict house performance in competition scenarios

Our approach to energy modeling incorporates the house with all of its systems, losses, and gains into a single model. This method allows the designer to observe how individual changes to an aspect of the model, such as lighting levels or U-values, impact the overall energy consumption of the house. Parametric studies performed on these individual aspects of the model have helped guide the team towards the current design of the house.

2.0 Tools

The team has used several computer tools to build models, run parametric studies, and analyze results. These programs and a brief description of their uses are as follows:

2.1 Revit (2011)

Revit is an architectural drawing and design tool that is used in the project as the primary documentation tool and repository of information about the house design. The Revit file contains the most up-to-date geometry of the house. The geometry is exported to other tools for analysis purposes as described below.

2.2 SketchUp – OpenStudio (Version 1.0.6)

The OpenStudio plugin to Google SketchUp dramatically streamlines the task of defining 3D geometry for EnergyPlus analysis. OpenStudio also provides an interface for visualizing the output from EnergyPlus

Model views of the house, rendered in SketchUp, can be found in Appendix A.

2.3 EnergyPlus (Version 6.0)

Parametric energy simulation studies on the house are performed using EnergyPlus, a program distributed for free by the U.S. Department of Energy (DOE) for energy studies on residential and commercial buildings. To develop a model, the user defines the geometry of the house using SketchUp. The user then inputs a detailed array of parameters into EnergyPlus including envelope material properties, internal gains and schedules, equipment, lights, the HVAC system(s), and the photovoltaic array. The simulation uses averaged weather data for a specific region to closely estimate the building's energy usage at user-specified intervals.

2.4 Microsoft Excel (2010)

Results from EnergyPlus are output to Excel spreadsheets. The energy analysis process makes extensive use of Excel's graphical analysis capabilities.

2.5 PVWatts (Version 2)

Solar photovoltaic array sizing simulations are performed using PVWatts, a tool provided online for free by the National Renewable Energy Laboratory (NREL). The tool predicts the array's electricity production for any region in the United States based on its nominal wattage, angle, and inverter efficiency. The calculator can be found on the PVWatts website: http://rredc.nrel.gov/solar/calculators/PVWATTS/version2/.

3.0 Geometry and Systems – A Brief Explanation

3.1 Geometry

Model views of the house can be found in Appendix A (the EnergyPlus model, viewed in SketchUp) as figures A-1 to A-4.

WaterShed is comprised of three linked modules. The two largest modules, the public and private modules, face one another. The third module, containing the bathroom, links the two. The roofs of the larger modules slope towards the center of the house, creating the home's signature split-butterfly roof form. The south-facing roof of the public module, angled at 12.8°, supports the home's photovoltaic (PV) system. The north-facing roof, angled at 10.0°, supports the home's green roof.

Shaded by the overhanging roofs, the upper portions of the two large modules are comprised of gable end-walls facing east and west and clerestory windows facing north and south. Four partially shaded glass doors connect the interior and exterior spaces. Next to the bedroom's south-facing glass door is the entrance to the unconditioned mechanical room.

Extending east from the south wall of the bedroom, a wall of vertically mounted solar thermal tubes define the boundary for the southeast entry deck and help shade the space. Extending west from the living room, vertical gardens and a photovoltaic-covered trellis shade the northwest garden deck.

3.2 Systems

Closely integrated with one another and with the house architecture, the engineering systems are outlined below:

Heating, Ventilation, & Air Conditioning Systems (HVAC):

- Mini Splits: Two indoor Mitsubishi MSZ-FE09NA mini-split heat pump units condition the space. One mini-split is housed in the public module and the other is housed in the private module. They connect to a single outdoor compressor unit.
- Energy Recovery Ventilator (ERV): WaterShed's Ultimate Air RecoupAerator 200 DX ERV provides ventilation at 70 CFM and maintains indoor air quality. The ERV saves heating and cooling energy by tempering the incoming ventilation air stream. It exchanges energy and moisture between the incoming and outgoing air streams, retaining indoor heat during the heating season and limiting incoming heat during the cooling season.

Solar Energy Systems:

- Solar Thermal: Two Paradigma CPC 45 Star Azzurro solar thermal evacuated tube collectors gather thermal energy from the Sun to heat the home's hot water tanks and regenerate the liquid desiccant solution (explained below).
- Photovoltaic (PV): Photovoltaic panels on the roof and trellis convert sunlight into electricity to feed back to the grid. WaterShed supports a 9.24 kW system of 42 Sanyo 220A panels.

Fluid Systems:

- Liquid Desiccant Waterfall (LDW): The LDW is the home's unique humidity control mechanism. Liquid desiccant dehumidification is an appealing alternative to the traditional, electricity-intensive practice of cooling air to the dew point. Rather than using electricity for latent cooling, desiccant dehumidification uses primarily thermal energy, a much more efficiently obtained form of energy. Two liquid desiccant waterfalls inside the house dehumidify household air by providing a site for interaction between air and lithium chloride brine. Outside, in a desiccant regeneration unit, heat captured by the solar thermal system concentrates the brine to be reused in the waterfalls.
- Heat Exchange for Excess Solar Thermal (HXEST): Heat exchangers, mounted on the LDW indoor units, heat the indoor air during the heating season with energy captured by the solar thermal tubes that is not needed to heat domestic hot water.

Control System:

- Smart House Adaptive Control (SHAC): SHAC provides user control, feedback, and data collected from its various sensors inside and outside the house. It also provides automation for systems like the LDW and HXEST.

4.0 Envelope, Electrical Loads, & Internal Gain Analysis

The discussion and results presented in this section refer to the EnergyPlus model of WaterShed.

4.1 Weather Data

The DOE provides weather data for over 2100 locations around the world specifically intended for EnergyPlus simulations. EnergyPlus requires these data in order to calculate building loads. For the purposes of WaterShed's analysis, Team Maryland used the weather data for the Washington Dulles Airport region. Annual profiles for outdoor temperature (Figure 4.1a) and direct solar insolation (Figure 4.1b) are shown below as examples:

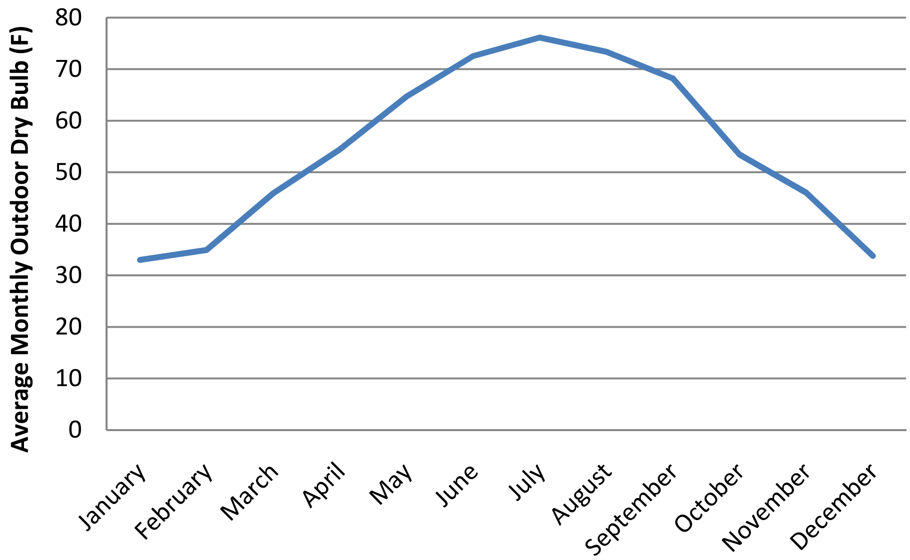


Figure 4.1a: Average Monthly Outdoor Temperature

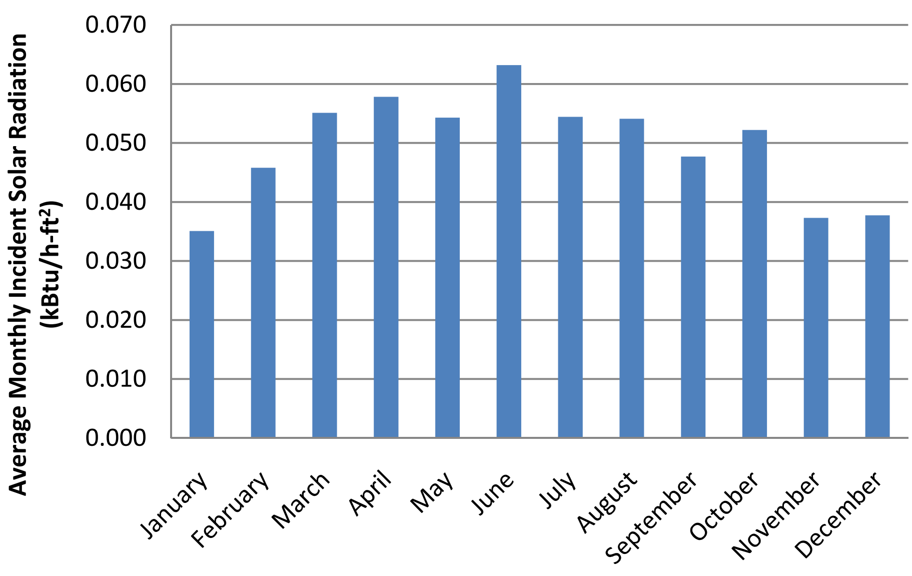


Figure 4.1b: Average Monthly Incident Solar Radiation

For further information on the sources of these data, refer to the DOE website, http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_sources.cfm.

4.2 Preliminary Studies

4.2.1 Envelope Studies

Given the weather data and the geometry outlined in Section 3.1, EnergyPlus was used to perform parametric studies on a range of building characteristics such as wall R-value and building performance issues such as HVAC load. Some of the key studies explored the impact of wall, roof, floor, and overhang characteristics on heating and cooling loads. The following figures illustrate the trends these studies revealed.

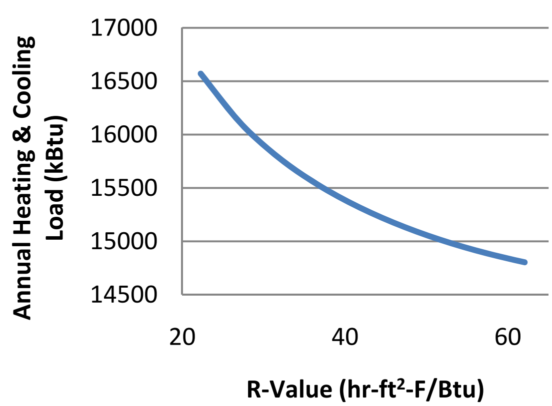


Figure 4.2.1a: Relationship Between Wall R-Value and Annual HVAC Load

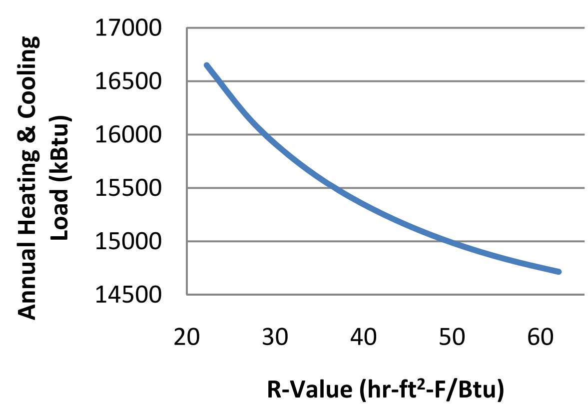


Figure 4.2.1b: Relationship Between Roof R-Value and Annual HVAC Load

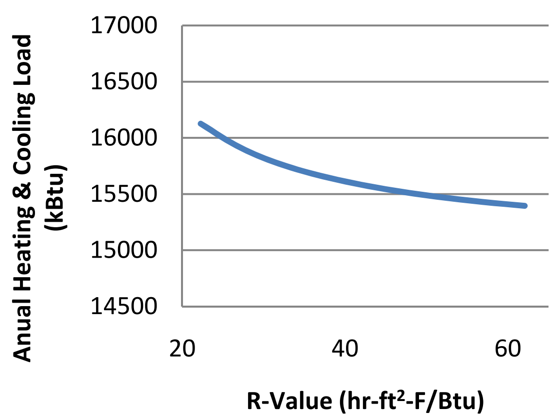


Figure 4.2.1c: Relationship Between Floor R-Value and Annual HVAC Load

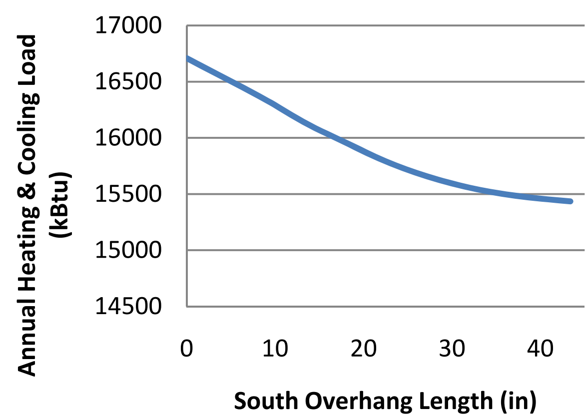


Figure 4.2.1d: Relationship Between Bedroom Roof Overhang Length and Annual HVAC Load

In each of these studies, one building characteristic was varied, while the rest of the model's parameters were held fixed. The above figures illustrate the resulting impact of the changed characteristic on the annual HVAC load (the total heating and cooling load over the course of a year). The results shown here indicate that increasing envelope insulation beyond a certain point will produce diminishing returns in overall energy efficiency. These envelope studies also reveal several other important points:

- Increasing the roof and wall insulation has a greater impact on load reduction than increasing floor insulation.
- R-50 insulation provides a good balance between envelope thermal efficiency and the various construction costs of using thicker insulation. The final design R-values of WaterShed's solid walls and roof are 48 and 51 (hr-ft2-F/Btu) respectively.
- A 40-inch overhang over the bedroom clerestory provides a good balance between HVAC efficiency and the various construction costs and solar-envelope issues associated with deeper overhangs. The designed length of WaterShed's southern overhang is 40 inches.

Using these simulations, Team Maryland could readily identify the effect of building characteristics on energy performance, establishing goals for the architecture team in designing the envelope. This process has helped make WaterShed's envelope optimized for energy efficient.

4.2.2 HVAC Sizing

EnergyPlus uses extreme yearly conditions from the weather data to calculate the necessary sizes for the heating and cooling elements of the HVAC system. According to competition requirements, the HVAC system must maintain a comfort zone between 71°F and 76°F. In order to meet the comfort zone requirements, even on the most extreme days of the year, the simulation suggests the following:

- Cooling Coil Rated Total Capacity: 17.5 kBtu/hr
- Heating Coil Rated Total Capacity: 17.5 kBtu/hr

This recommendation provided a basis for the final design sizes of the HVAC system. WaterShed's two indoor mini-split heat pumps provide a combined cooling capacity of 18 kBtu/hr and a combined heating capacity of 21.8 kBtu/hr.

4.3 WaterShed Simulation Results

Independent research by students, with input from faculty and mentors, has helped guide the choice of parameters for the EnergyPlus model. The primary parameters included in the model are outlined below.

4.3.1 Envelope Constructions

EnergyPlus models surfaces as layers of materials. In cases where a layer may be composed of multiple materials, such as stud walls with foam insulation, accurate modeling is difficult to achieve. In order to provide flexibility in our parametric modeling, we modeled the actual envelope construction with a simpler layered system with easily-defined R-values. The following envelope assemblies include the most thermally significant layers from the actual design of WaterShed, listed from outside to inside.

Public and Private Modules:

Lower Wall Assembly: 0.75” cooked ash wood siding, 4” XPS board insulation, 1.5” Lock-Deck sheathing, 5.5” open-cell spray foam insulation, and 0.5” gypsum board
Wall R-Value: 48 hr-ft^2-F/Btu

Gable Wall Assembly: 0.03” metal cladding, 0.5” wood sheathing, 3.5” closed-cell spray foam insulation, and 0.5” gypsum board
Gable Wall R-Value: 25 hr-ft^2-F/Btu

Exterior Floor Assembly: 6” closed-cell spray foam insulation, 1-1/8” subfloor, 9/16” hardwood flooring
Floor R-Value: 42 hr-ft^2-F/Btu

Exterior Roof Assembly: 0.03” metal roofing, 4” Polyiso board insulation, 1.5” Lock-Deck sheathing, 3.5” closed-cell spray foam insulation, and 0.5” gypsum board
Roof R-Value: 51 hr-ft^2-F/Btu

The green roof provides an additional insulation value of approximately R-2 to the bedroom roof.

Bath Module:

Wall Assembly: Exterior walls are glazed

Floor Assembly: 6” closed-cell spray foam insulation, 0.75” subfloor, 0.75” ceramic tile
Floor R-Value: 41 hr-ft^2-F/Btu

Roof Assembly: 4” XPS rigid board insulation, 1.5” Lock-Deck sheathing, 7.25” open-cell spray foam insulation, and 0.5” gypsum board
Roof R-Value: 59 hr-ft^2-F/Btu

Glass Fenestration Characteristics:

	U-Value (Btu/hr-ft^2-F)	**Solar Heat Gain Coefficient (SHGC)**
Fixed Windows[1]	0.27	0.23
Clerestory Windows	0.22	0.14
North Window[2]	0.28	0.23
Glass Doors[3]	0.30	0.32

[1]The two fixed windows face east and west and are located on either side of the central bathroom module
[2]The north window is located on the north wall of the public module
[3]All other fenestration (East, West, and South exposures) is in doors, selected to facilitate the public tours and extend the interior spaces.

4.3.2 Internal Gains

Any sources of energy dissipated inside the house, unrelated to environmental gains such as direct solar or temperature, are considered internal gains. The model includes gains due to occupants, lighting, and electric equipment. A more detailed spreadsheet of internal gains can be found in Appendix B.

4.3.2.1 Occupancy Loads

The model includes two working occupants. We assumed each occupant contributes an average of 100W of internal gain and is absent from the house for 8 hours each day between 9:00AM and 5:00PM.

4.3.2.2 Lighting Loads

The model includes 1175W of internal lights. These run for 4 hours each evening.

4.3.2.3 Electric Equipment Loads

The model accounts for all electrical equipment expected to run in the house. This includes appliances, electronics, SHAC controls, and miscellaneous loads. The electric loads are based on EnergyStar data from individual appliance specifications or on careful estimates for each specific product. Data for the total gain of each piece of equipment and the daily schedules for each can be found in greater detail in Appendix B.

4.3.3 Modeled HVAC System

We simulated the heating and cooling equipment of the HVAC system as a heat pump with a coil in the air stream (the air stream is recirculated indoor air). In the cooling mode, WaterShed's two mini-split heat pumps have a SEER rating of 16 and a rated capacity of 18 kBtu/hr. In heating mode, the system has a COP of 4.22 and a rated capacity of 21.8 kBtu/hr. In the model, the HVAC system runs under setpoint control, maintaining an indoor air temperature range of 72.5 °F to 74.5 °F, a range well within the competition requirements.

The home's ERV provides ventilation at a rate of 70 cfm. WaterShed's ERV efficiently tempers incoming air with a sensible and latent effectiveness of 95%.

4.4 Simulation Results

The results of these simulations illustrate a number of useful points that have impacted the design process. Three major pieces of information resulting from the simulation are:

- Predicted performance of the envelope, guiding architectural design to an optimized envelope design.

- Predicted overall electricity use of the house & necessary PV array size required to fulfill needs.
- Predicted external and internal gains to guide selection of HVAC system.

This information allowed Team Maryland to assess the energy efficiency of the building, determine areas of the design that could be improved, and develop strategies for the competition.

4.4.1 Electricity Usage

Energy Plus calculates the total predicted electricity usage over the course of the year (Table 4.4.1). Using Excel, we can visually represent the relative breakdown of electricity use (Figure 4.4.1).

Table 4.4.1: Annual Electricity Usage by Subcategory

End Use	End Use Breakdown	Electricity Demand (kWh)	Total Electricity (kWh)
Lights			
	Internal	643	
	External	137	
			780
Equipment			
	Dryer	718	
	Washer	52	
	Fridge/Freezer	392	
	Stove	333	
	Dishwasher	117	
	TV	193	
	Computer	77	
	SHAC	350	
	Misc	500	
			2731
HVAC			
	ERV	686	
	Heating Coil	1763	
	Cooling Coil	1126	
	Mini Split Fans	1085	
			4660
Solar Thermal Glycol Pump			**153**
Main Water Pump			**137**
LDW Pumps & Fans			**83**
HEXST Pumps & Fans			**36**
Living Systems Pumps			**228**
Total:			**8809**

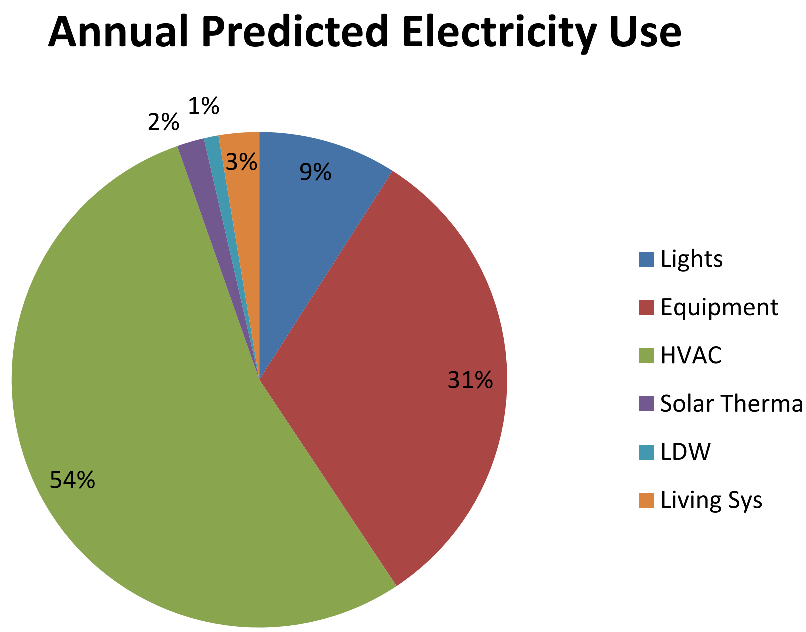


Figure 4.4.1: Annual Relative Electricity Use by Subcategory

These predictions indicate that the primary electricity draw will be the HVAC system. For typical buildings in the DC metropolitan area, energy use is dominated by heating. The EnergyPlus model for WaterShed, however, predicts that because of its highly-insulated envelope and energy-saving ERV, this will not be the case for WaterShed. The ERV alone reduces heating demand by 36% (discussion of the ERV can be found in Section 4.4.1.1). WaterShed also uses high-efficiency lights and appliances, limiting the draws from these areas as well.

4.4.1.1 Energy Recovery Ventilator (ERV)

The ERV is an important energy-saving component of the HVAC system. Compared to an equivalent home without an ERV, WaterShed saves 605 kWh annually on HVAC electricity demand. Table 4.4.1.1a illustrates the simulation results of such an equivalent home; all characteristics of the home are the same as WaterShed, but the ventilation air is not tempered by an ERV. A breakdown of the home's HVAC electricity use (with and without an ERV) is as follows:

Table 4.4.1.1a: HVAC Electricity Breakdown for an Equivalent House with No ERV

HVAC Component	Electricity Demand (kWh)
Mechanical Ventilation	248
Heating Coil	2736
Cooling Coil	1197
Mini Split Fans	1085
Total	**5265**

Table 4.4.1.1b: HVAC Electricity Breakdown for WaterShed (with ERV)

HVAC Component	Electricity Demand (kWh)
ERV	686
Heating Coil	1763
Cooling Coil	1126
Mini Split Fans	1085
Total	**4660**

The total HVAC electricity demand for an equivalent house with no ERV (Table 4.4.1.1a) is notably greater than that of WaterShed (Table 4.4.1b), especially in the heating season. The ERV saves WaterShed 36% on heating electricity (1763 kWh with an ERV, compared to 2736 kWh without one) and 11% on total HVAC electricity (5265 kWh with an ERV, compared to 4660 kWh without one). It is an indispensible component of WaterShed's modern, energy-efficient HVAC system.

4.4.1.2 Solar PV Array Size

Based on the characteristics of the model, EnergyPlus predicts that WaterShed will consume 8809 kWh of electricity over the course of a year. Using PVWatts, we predicted the necessary PV array size to meet this electricity demand.

WaterShed's PV array is comprised of 42 Sanyo 220A PV panels, totaling 9.24 kW. 36 of those panels are fixed to the south-facing roof, angled at 12.8° from the ground. The remaining 6 panels are fixed to the trellis, parallel to the ground. PVWatts predicts the following output from the system while on the competition site in Washington DC:

Table 4.4.1.2: Predicted Annual AC Electricity Production by the PV Array

	Annual AC Electricity Production (kWh)
Rooftop Panels	9128
Trellis Panels	1383
Total:	10511

Under the simulation conditions, this annual production of 10511 kWh will meet all of WaterShed's electricity demands. The size of the array provides a 19% margin of safety, allowing for weather fluctuations, additional electricity use, and any other factors not accounted for in the model.

4.4.2 Liquid Desiccant Waterfall (LDW)

Liquid desiccant dehumidification offers an elegant and effective solution to the seasonal humidity of the mid-Atlantic region. For homes like WaterShed, with limited electricity-producing rooftop area, using solar thermal energy rather than electricity to dehumidify household air is an appealing prospect.

As the team designed the LDW, latent cooling load predictions from EnergyPlus provided design criteria. Table 4.4.2 illustrates the annual cooling load breakdown:

Table 4.4.2: Predicted Annual Sensible & Latent Cooling Loads

	Annual Cooling Load (kBtu)
Sensible Cooling Load	12936
Latent Cooling Load	1760
Total	14696

The LDW has been designed to handle as much of the latent cooling load as possible, reducing the electricity used by the mini-splits in cooling by as much as 12%.

4.4.3 Internal & External Gains

It has been an important part of the design process to reduce or control unnecessary gains into the house during the cooling season and maximize gains during the heating season. Doing so places less demand on the HVAC system.

4.4.3.1 Internal Gains

Any energy that enters the house due to day-to-day activities by the house's inhabitants constitutes an internal gain. Sources of gains accounted for in this model include people, lights, and electric equipment. These gains are constant throughout the year and their relative daily contributions to household energy are illustrated in Figure 4.4.3.1.

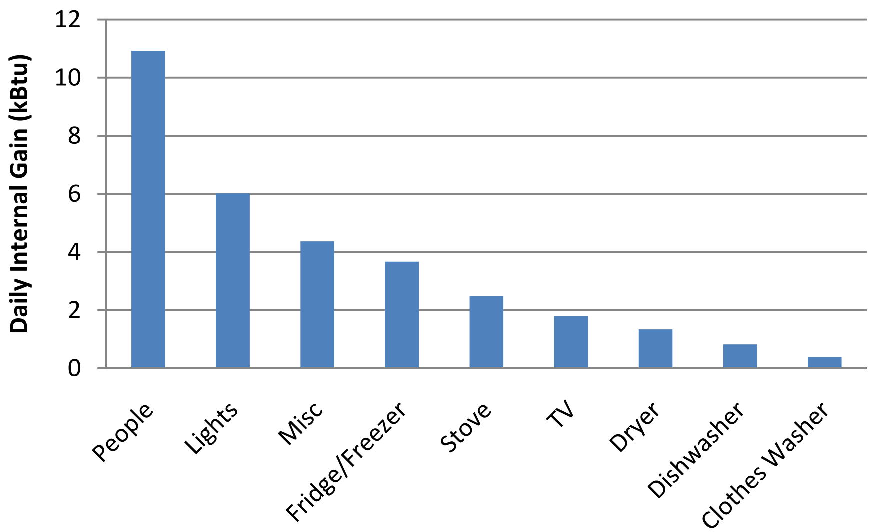


Figure 4.4.3.1: Daily Internal Gains

Appliances such as the clothes dryer, dishwasher, and clothes washer do not contribute significant internal gains because they are drained or vented to the outdoors. Other appliances, lights, and electronics however, contribute significantly to the internal gain. These gains must then be removed in the cooling season by the HVAC system, creating energy inefficiency. In the heating season, the gains reduce the required heat input, but since the house operation will be dominated by cooling during the competition, cooling season conditions dominate design considerations. Part of the design process for WaterShed includes obtaining energy efficient appliances, lights, and electronics in order to limit unnecessary internal gain.

4.4.3.2 Windows

Windows are both a visual connection to the outdoors and an energy bridge between the interior and exterior of the building. They constitute one of the greatest sources of heat gain in WaterShed. As illustrated in Figure 4.4.3.2a, windows contribute a much larger percentage of heat gain to the building than do the internal gains, especially during the cooling season.

WaterShed employs strategic shading and thermally insulated window materials to limit unwanted gains. Compared to an equivalent home with no shading devices (no trellis, solar thermal wall, or overhangs) and less insulating glass (U value of 0.35 Btu/hr-ft^2-F and SHGC of 0.35), WaterShed takes in 37% less unwanted thermal energy through windows in July, the peak cooling month, than the equivalent home. Figure 4.4.3.2b illustrates the gains of such a house for comparison.

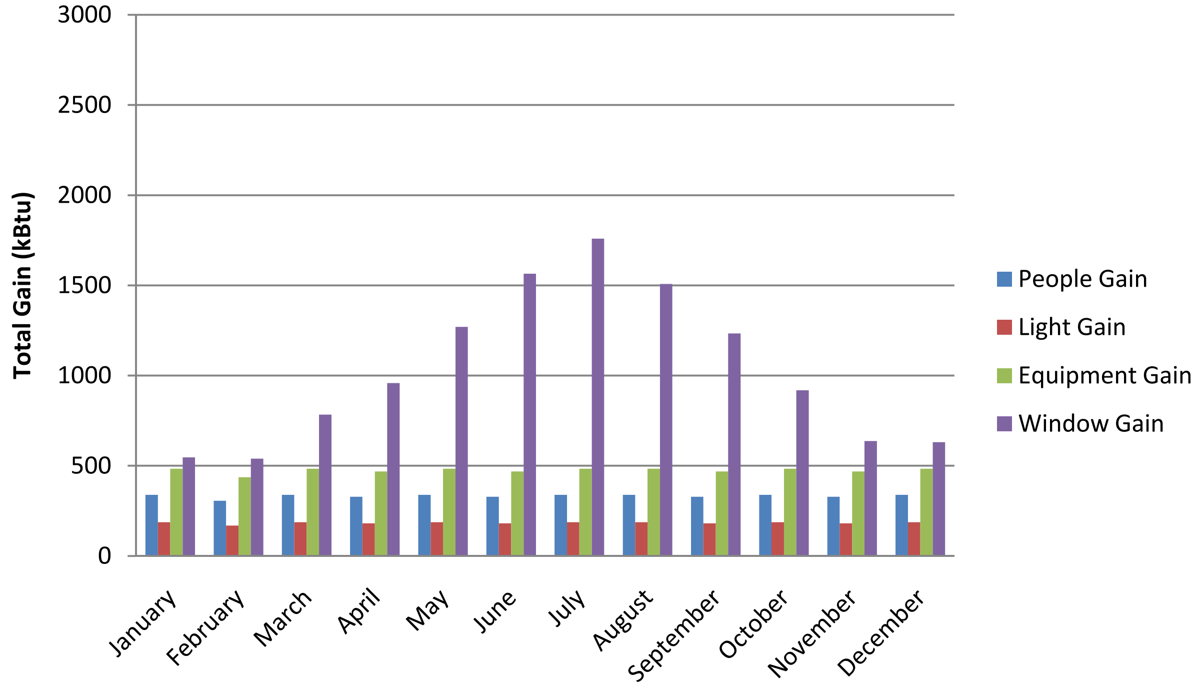


Figure 4.4.3.2a: Window Gains Relative to Internal Gains for WaterShed

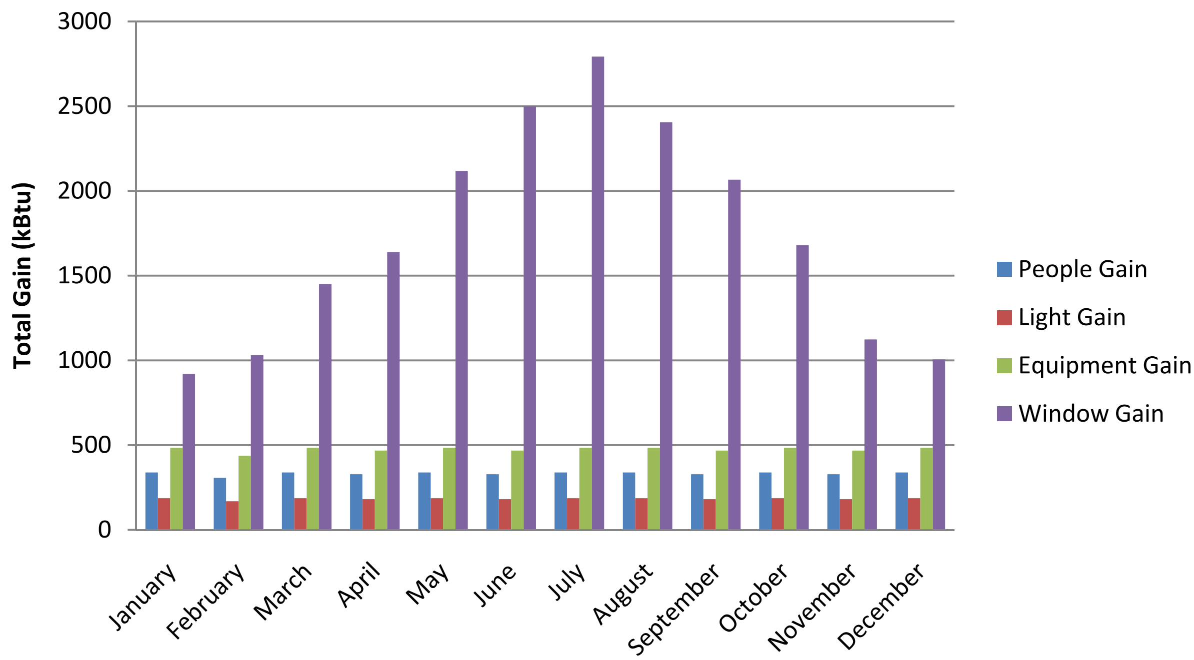


Figure 4.4.3.2b: Window Gains Relative to Internal Gains for an Equivalent House with no Shading Devices and Less Insulating Window Characteristics

In order to minimize the building's HVAC demand, gains are controlled to the extent possible. While gains due to people, lights, and equipment will be relatively constant throughout the year, proper window placement and shading limit the cooling load in the summer and heating load in the winter.

Understanding the expected heat gains and losses through the fenestrations on each surface of the house has played a role in the design process for the windows, affecting choices in size, placement, and treatments. The gains and losses through WaterShed's cardinal faces are illustrated below in Figures 4.4.3.2c – 4.4.3.2f. Red indicates monthly heat loss and blue indicates

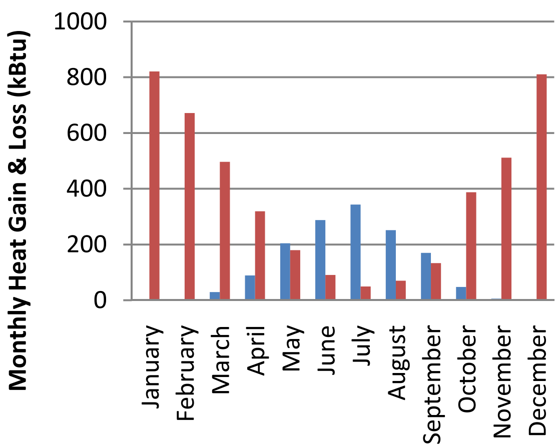


Figure 4.4.3.2c: North Fenestrations Monthly Heat Gains (Blue) & Losses (Red)

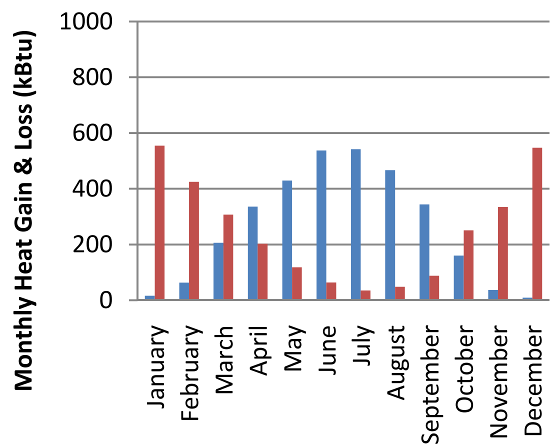


Figure 4.4.3.2d: East Fenestrations Monthly Heat Gains (Blue) & Losses (Red)

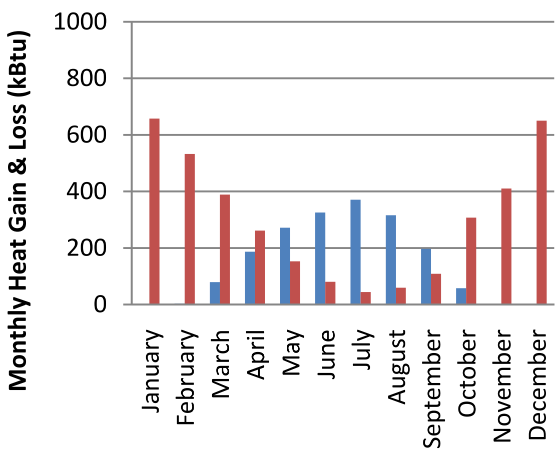


Figure 4.4.3.2e: West Fenestrations Monthly Heat Gains (Blue) & Losses (Red)

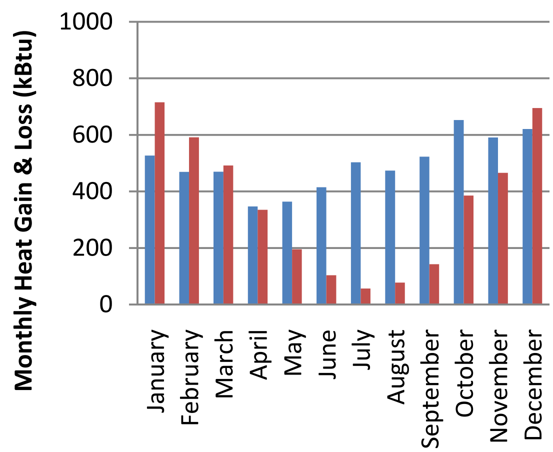


Figure 4.4.3.2f: South Fenestrations Monthly Heat Gains (Blue) & Losses (Red)

monthly heat gain.

These studies confirm conventional wisdom about window placement and reveal several important points:

- Heat gains are optimized for passive heating on the south face. On this face, gains are greatest in the winter and lowest in the summer, reducing HVAC demand. For this reason, WaterShed maximizes south-facing window area.
- Heat gains on the east and west faces are not optimized for passive heating. These faces are good design targets for shading and window treatments that reduce undesirable summer gains. For this reason, WaterShed employs shading on east and west doors and treatments on the east and west picture windows.
- Heat losses are correlated to glass fenestration area. WaterShed's north and south faces have the greatest fenestration area, and thus, winter heat losses are greater on these faces than on the east and west faces. Low U-value glass reduces undesirable winter heat losses. For this reason, WaterShed's north and south clerestories are made of Kalwall, the most thermally insulating window material in the home.

5.0 Competition Simulation

In an effort to predict WaterShed's energy performance during the competition, Team Maryland ran EnergyPlus simulations that mimicked competition conditions.

5.1 Competition Weather

The competitions will occur over a nine day span in the fall. Team Maryland chose to simulate the performance of the house between September 23 and October 2. An analysis of the weather given in the weather file through September and October indicated that this nine day period places the most demanding load on the HVAC system. This period acts as the design criteria for the house during the competition. Profiles of the hourly temperature (Figure 5.1a) and direct solar (Figure 5.1b) during this period are shown below:

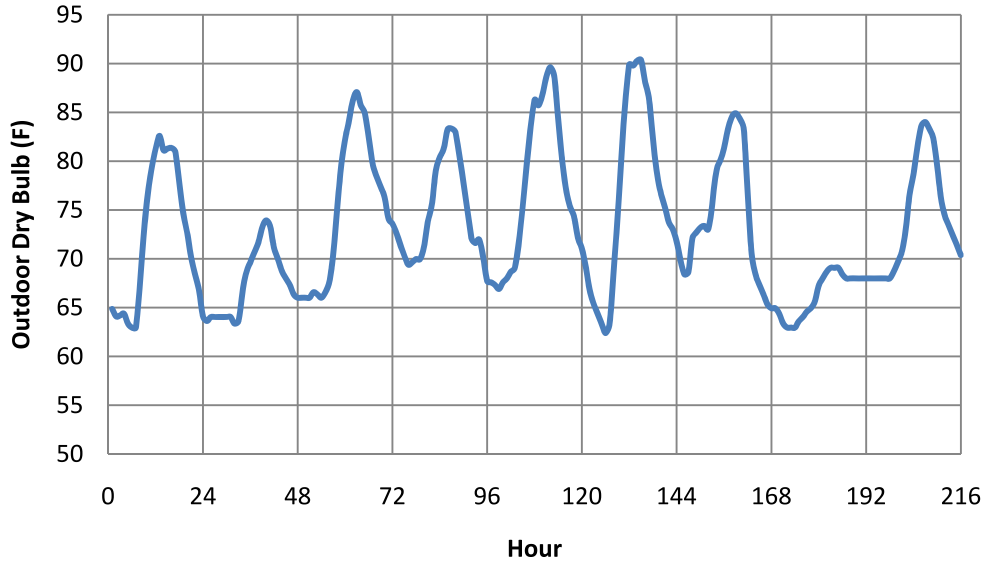


Figure 5.1a: Hourly Outdoor Temperature (September 23 – October 2)

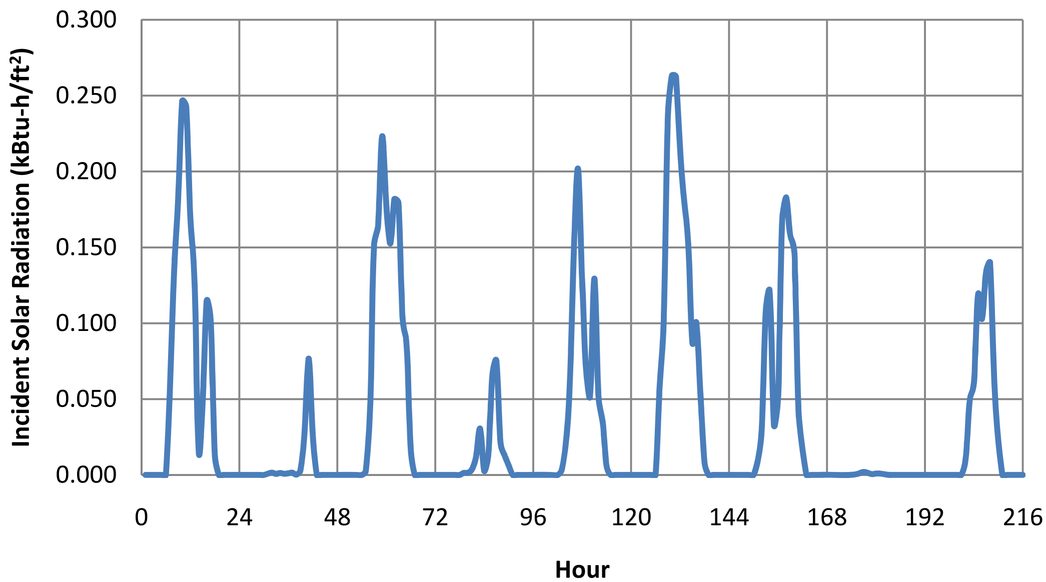


Figure 5.1b: Hourly Direct Solar Radiation (September 23 – October 2)

5.2 The Competition Model

A simulation of the WaterShed model during this nine day period helped Team Maryland prepare for how the house might react to the environment of the competition. The competition imposes rules on how the house will be run which differ from the conditions used in the annual model. The same geometry and envelope construction outlined in

Section 4.3.1 were used in this model; however, we redefined the internal gains and their schedules.

5.2.1 Internal Gains

The peak power and the relative gain fractions remain unchanged for each source of gain. The schedules however, approximate as closely as possible, the competition schedules over the course of the Solar Decathlon. The competition period model includes six occupants throughout the day and zero at night to account for impound hours.

5.2.2 HVAC and Tour Simulation

In order to simulate the most demanding and unusual aspect of the competition, the model incorporates tour periods. The following parameters were used to approximate these periods:

- During the times of the day when a tour is scheduled, the ERV, mechanical ventilation, and mini-splits are shut off.
- The building infiltration increases to 10 air exchanges/hour.
- The number of occupants rises to 20 people.

At the end of the tour, these parameters are returned to their normal state. This simulation approximates the impact of the public exhibit hours on WaterShed's ability to return to the comfort zone temperatures during the Solar Decathlon.

5.3 Results

The competition simulation yielded a number of interesting results that guide Team Maryland's strategy for operating the house during the competition week.

5.3.1 Tour Effect

The tour period causes a significant disruption of the house air temperature and humidity. When the HVAC turns off and infiltration increases, the indoor air conditions approximately equalize with the outdoor air conditions. As such, Team Maryland expects that the HVAC load following a public exhibit period will be primarily dependent on the outdoor temperature. This effect is illustrated in Figure 5.3.1.

Figure 5.3.1 displays the hourly results of the competition simulation (occurring over the nine day span of September 23 to October 2). The chart illustrates predicted indoor and outdoor temperatures. For reference, the comfort zone is indicated by two horizontal lines at 71 ^{o}F and 76 ^{o}F. Periods when the indoor air temperature leaves the bounds of the comfort zone indicate the shutoff of the HVAC system during a public exhibit period. These large indoor air temperature changes are a major design consideration for the HVAC system size.

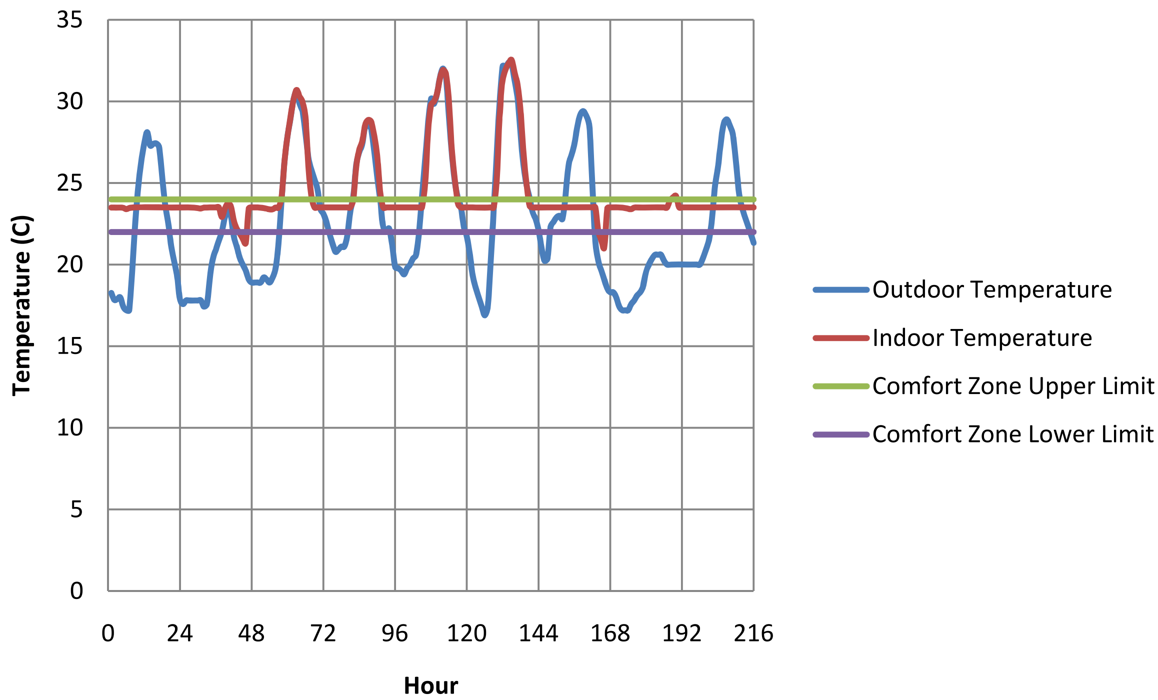


Figure 5.3.1: Competition Week Indoor Temperature Fluctuations

According to the rules and competition event schedule, each team has one hour to return their house to the comfort zone following the tours, creating an extreme design criterion for the HVAC system size. In order to meet the post-tour cooling demand, EnergyPlus calculates that the size of the cooling component of the HVAC be 37 kBtu/hr which is larger than the corresponding size calculated without the tours.

These results indicate the necessity of limiting unnecessary gains during the hour after the tour. Simple strategies such as emptying the house of people, turning off electronic equipment, and shading windows will be employed.

5.3.2 Electricity Usage

A prediction of household electricity use over the course of the competition is illustrated in Table 5.3.2a. Team Maryland anticipates that the 9.2 kW PV array will be able to meet the competition demand. PVWatts predicts that the array will produce 274 kWh (Table 5.3.2b) over a 9 day span in September. The size of the array leaves a 43% margin of safety to account for unpredictable weather conditions over the competition period. Although the array is oversized for the competition period, the safety factor for the annual simulation is only 19%.

Table 5.3.2a: Competition Week Electricity Usage by Subcategory

End Use	End Use Breakdown	Electricity Demand (kWh)	Total Electricity (kWh)
Lights			
	Internal	33	
	External	7	
			40
Equipment			
	Dryer	8	
	Washer	2	
	Fridge	10	
	Stove	4	
	Dishwasher	2	
	TV	7	
	Computer	3	
	SHAC	9	
			43
HVAC			
	ERV	13	
	Heating Coil	0	
	Cooling Coil	57	
	Mini Split Fans	21	
			91
Solar Thermal Glycol Pump			**4**
Main Water Pump			**1**
LDW Pumps & Fans			**6**
HEXST Pumps & Fans			**0**
Living Systems Pumps			**6**
Total:			**191**

Table 5.3.2b: Predicted Nine Day AC Electricity Production by the PV Array in September

	AC Electricity Production (kWh)
Rooftop Panels	238
Trellis Panels	36
Total:	274

6.0 Conclusions

These computer models offer the team a prediction of WaterShed's behavior annually and during the competition. Iterations of energy modeling have helped guide the design process and continue to impact competition strategy.

The necessity of controlling the flow of energy through the house is important to Team Maryland's strategy. This means using passive concepts that limit electricity demand and lessen the load on the HVAC. This will be especially true during and immediately after the tour periods. Team Maryland expects to continue exploring ways to limit undesirable internal gains and fenestration gains as much as possible during the hour following the tours.

Appendix A: Model Views

The following are views of the EnergyPlus model of WaterShed as viewed in SketchUp. Yellow surfaces are walls, blue surfaces are glass fenestrations, red surfaces are roofs, and purple surfaces are shading groups (ie: the trellis, solar thermal, PV array, and roof overhangs). The solid axis colors correspond to north (green) and east (red).

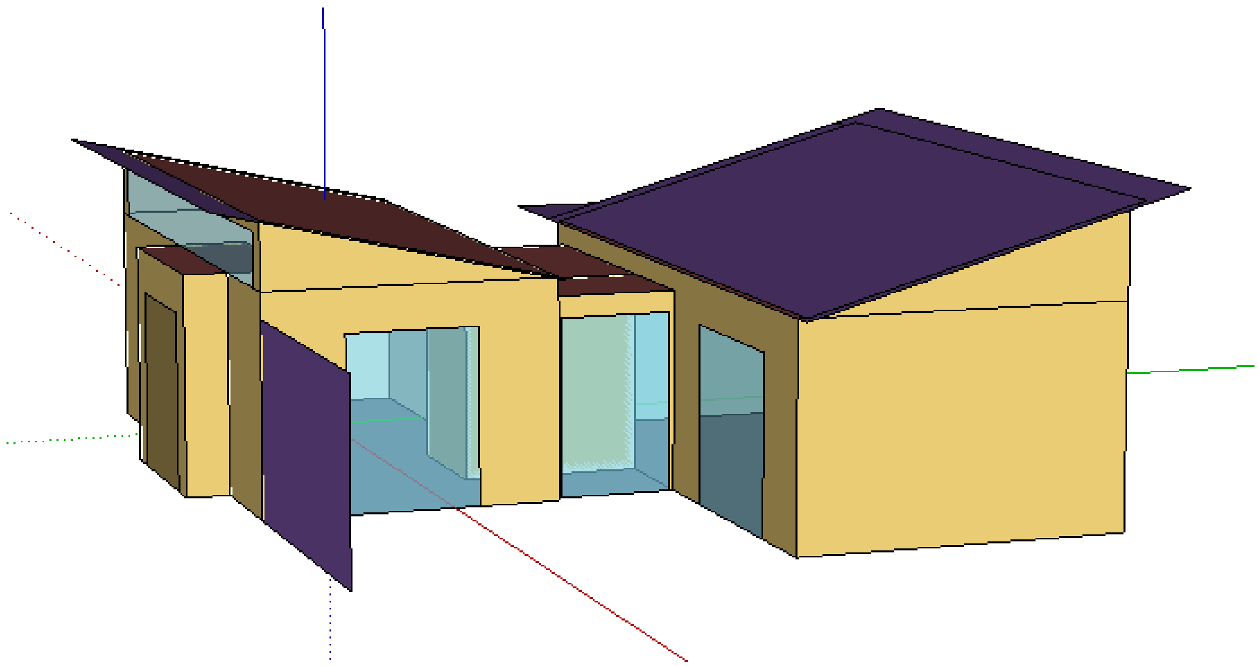


Figure A- 1: South-East View

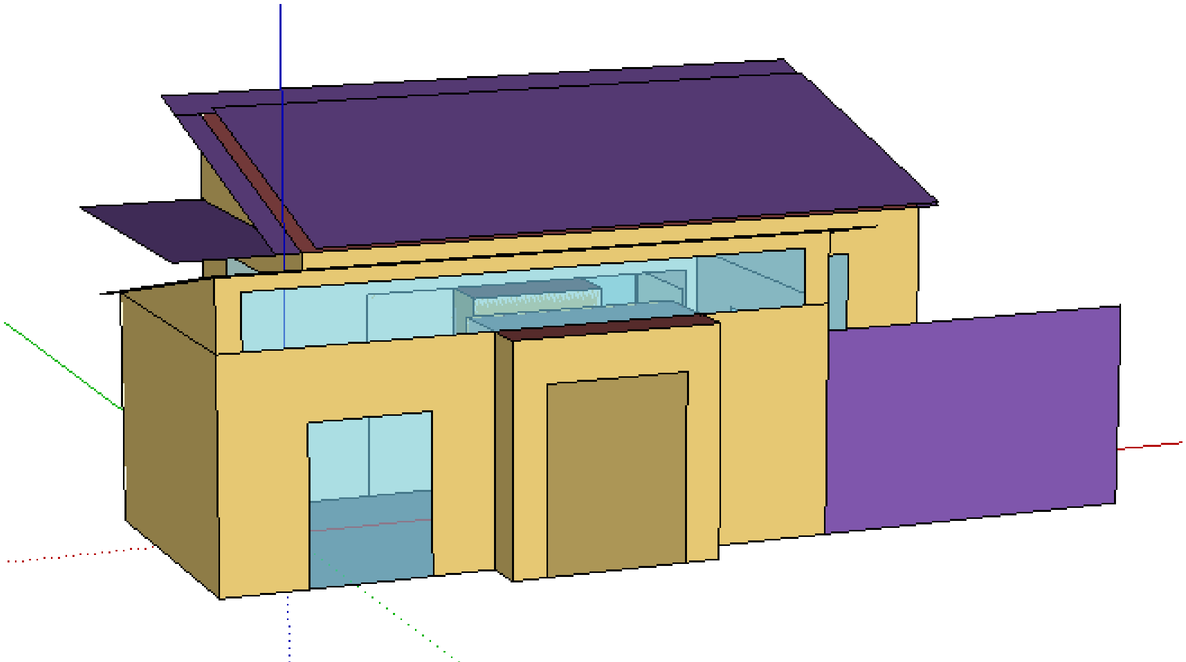


Figure A- 2: South-West View

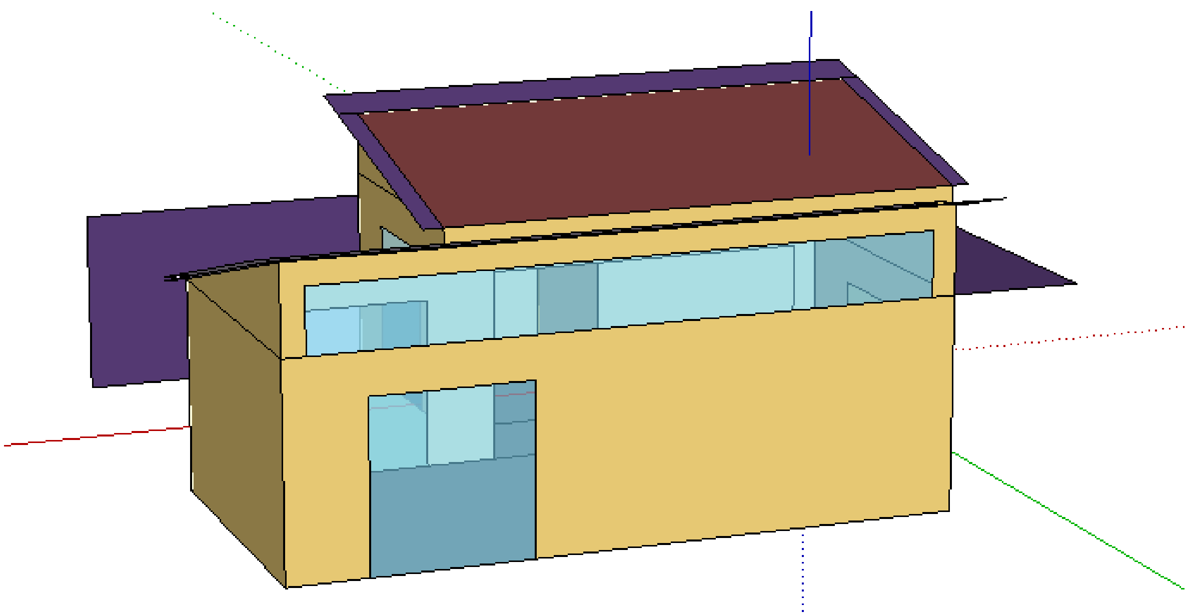


Figure A- 3: North-East View

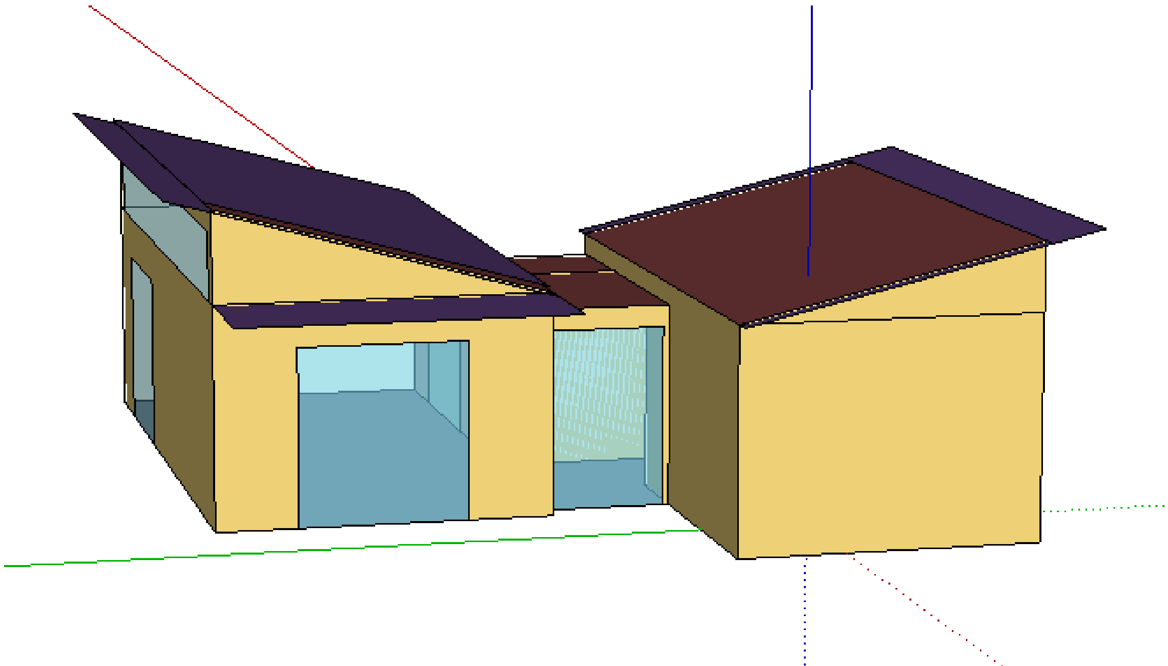


Figure A- 4: North-West View

Appendix B: Internal Gains Spreadsheet (Annual, No Tour Simulation)

		Activity Level ea. (W)	No. of People	Fraction Radiant			Hours Active per Day	Total Gain per Day (kBtu)	
People		100	2	1			16	10.92	
		Lighting Level (W)	**Fraction Radiant**	**Fraction Visible**	**Fraction Convected**	**Fraction Lost**	**Hours Active per Day**	**Total Gain per Day (kBtu)**	**Total Electric per Day (kWh)**
Lights									
	Internal	1175	0.78	0.12	0	0	1.5	6.01	1.76
	External	380	0	0	0	1	1.5	0	0.57
		Design Level (W)	**Fraction Latent**	**Fraction Radiant**	**Fraction Convected**	**Fraction Lost**	**Hours Active per Day**	**Total Gain per Day (kBtu)**	**Total Electric per Day (kWh)**
Electric Equipment									
	Dryer	1966	0.05	0.15	0	0.8	1	1.34	1.97
	Washer	141.6	0	0.8	0	0.2	1	0.39	0.14
	Fridge/Freezer	44.75	0	1	0	0	24	3.66	1.07
	Stovetop	3649.3	0.3	0.5	0	0.2	0.25	2.49	0.91
	Dishwasher	320.5	0.15	0.6	0	0.25	1	0.82	0.32
	TV	176	0	0.5	0.5	0	3	1.80	0.53
	Computer	70	0	0.5	0.5	0	3	0.72	0.21
	SHAC	40	0	0	0	1	24	0	0.96
	Glycol Pump	60	0	0	0	1	7	0	0.42
	HXEST Pumps	106	0	0	0	1	2 (4 mo)	0	0.21
	HXEST Fans	60	0	1	0	0	2 (4 mo)	0.41	0.12
	Desiccant Wall Pumps	150	0	0.5	0	0.5	2 (4 mo)	0.51	0.30
	Desiccant Wall Fans	60	0	1	0	0	2 (4 mo)	0.41	0.12
	Desiccant Regen Pumps	70	0	0	0	1	2 (4 mo)	0	0.14
	Desiccant Regen Fans	60	0	0	0	1	2 (4 mo)	0	0.12
	East Wetland Circulation Pumps	22.5	0	0	0	1	10	0	0.23
	West Wetland Circulation Pumps	33.75	0	0	0	1	8	0	0.27
	Wetland Sump Pump	131	0	0	0	1	1	0	0.13
	Main Water Pump	500	0	0	0	1	0.75	0	0.38
	Misc	57.08	0.2	0.734	0	0.066	24	4.37	1.37

Values included in the model come from a variety of sources. Where applicable, we have derived values from EnergyStar predictions for annual electricity. In many cases, Team Maryland followed the guidelines for internal gains required for a BuildingAmerica Building Technologies Program benchmark home. More information on this program can be found at http://www1.eere.energy.gov/buildings/building_america/.

LIQUID DESICCANT SYSTEM DESCRIPTION

The University of Maryland was the first school to include a liquid desiccant system in their U.S. Department of Energy Solar Decathlon 2007 submission, LEAFHouse. Now a patent-pending innovation, the LEAFHouse liquid desiccant waterfall (LDW) has paved the way for subsequent iterations. In the 2009 competition, two schools used liquid desiccant systems and now in 2011 the University of Maryland will be showcasing an improved liquid desiccant waterfall design.

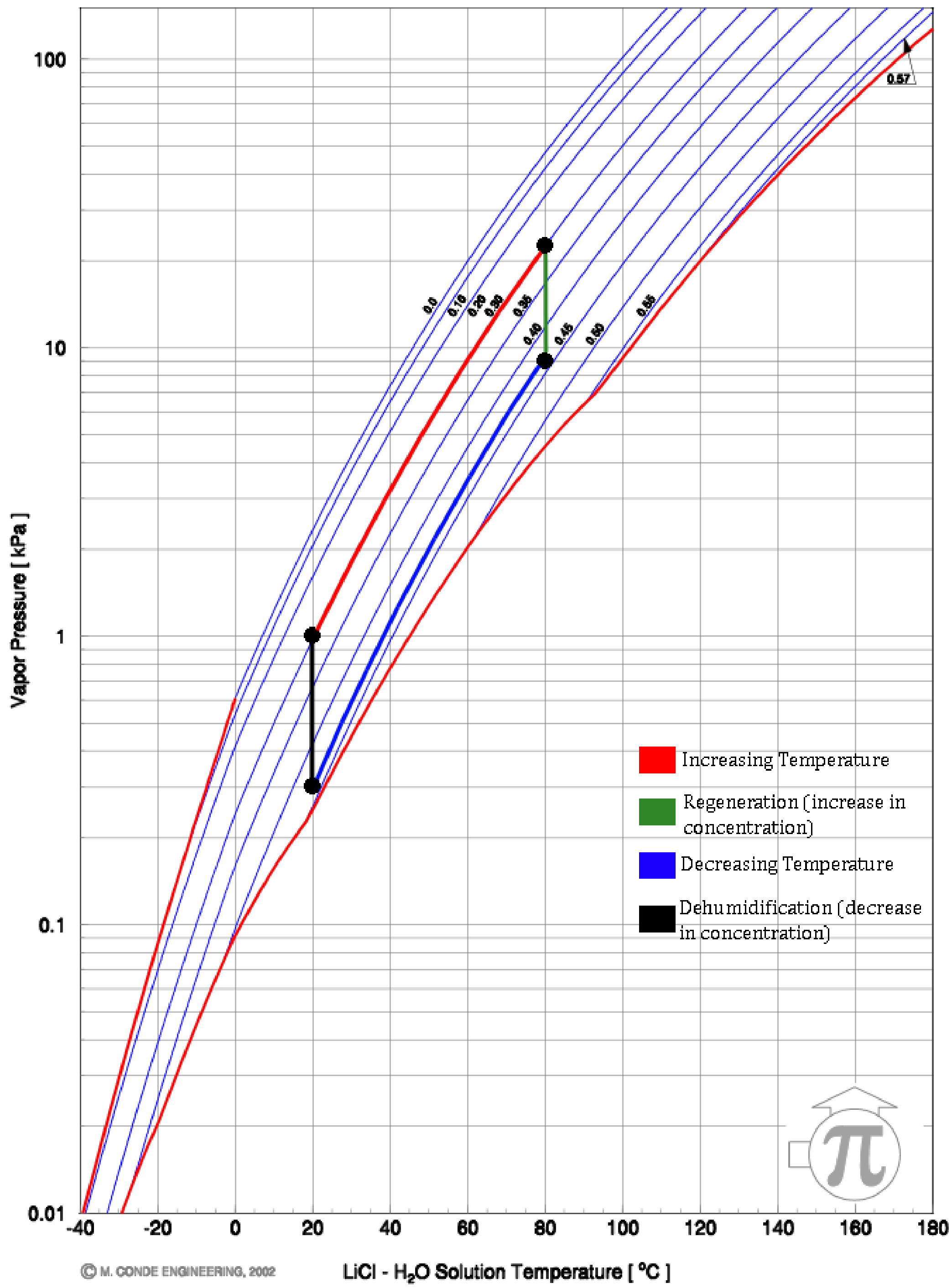
The liquid desiccant dehumidifier works based on the ability of saline solutions to absorb humidity from the surrounding air. The more salt dissolved in solution, the higher its propensity to capture water from the air. By using a saline solution of 42% by weight Lithium Chloride (LiCl), WaterShed's system will be able to dehumidify air to very dry conditions. The dehumidification process occurs within two indoor wall units; one unit is in each of WaterShed's two primary modules. Each unit will have a Plexiglas spillway where LiCl solution is pumped through packing media while air flows in the opposite direction, releasing its moisture in the process. The packing media, comprised of spherical raschig rings, is a new component added for the 2011 model; it allows the liquid to be dispersed over a wider surface area so there is more contact between the desiccant solution and the air and thus a higher rate of moisture transfer. The air is pulled through the system by a fan in each wall unit and then expelled into the room.

The more moisture taken out of the air, the more dilute the desiccant solution becomes. As the solution gains water, the ratio of LiCl to water decreases, as does its ability to capture moisture from the air. Once the solution becomes too dilute to function as a desiccant, it is pumped to the outdoor regenerator where the excess water is evaporated. To make water leave the solution – as opposed to being absorbed by it – the working fluid must be heated until its vapor pressure is greater than that of the atmosphere. When the desiccant solution is heated, the water in the solution boils and evaporates off of the desiccant solution leaving a fully regenerated salt-rich solution that is pumped back into the house to absorb moisture from WaterShed's conditioned spaces.

The regenerator operates in a reverse manner to the indoor units, at a higher temperature. The desiccant is heated to 180 °F using heat generated from the evacuated solar thermal tube array. It is then sprayed down a Plexiglas spillway while air passes in the opposite direction. Because the desiccant solution is heated, instead of picking up moisture from the air, the solution evaporates it into the passing air.

Industrial desiccant systems use natural gas or electricity to produce the heat required for regeneration. The WaterShed LDW uses renewable heat energy from the solar thermal system to regenerate, but this heat source is non-continuous on an hour-to-hour, day-to-day, and even month-to-month basis. Team Maryland created the regeneration design to work with this energy source by using a unique batch approach instead of continuous regeneration. The industry standard is for the desiccant to go through the dehumidifier once, then directly to the regenerator, then back to the dehumidifier in a continuous cyclical process. In WaterShed's system however, the indoor solution constantly dehumidifies until it becomes dilute. At this point it is exchanged with the regenerated solution as a batch. Half of the working fluid is contained in the regenerator and the other half is split evenly between the two indoor units. Because there is always a batch of solution both inside and out, the dehumidifying process is independent from the regeneration process. This allows the indoor units to be dehumidifying even when there is no sunlight to power the regenerator, a large advantage to the system because the sun shines less than half the day. More importantly, this gives the system the ability to dehumidify during rainy days when humidity increases but there is little sunlight. This is also useful when the solar thermal heat energy is needed by another system such as the hot water heater.

Graph Describing Vapor Pressure of LiCl Solutions Based on Temperature and Concentration



This graph, from M. Conde Engineering, 2001, shows the entire cycle of the desiccant solution. Based on these vapor pressures, it can be shown that the desiccant will either absorb or expel water depending on the vapor pressure of the surrounding air: whichever substance has the higher vapor pressure will expel the water. From the graph we can gather the following important information:

Concentration (% by weight)	Temperature of Desiccant (°F)	Vapor Pressure (kPa)
43	68	0.3
30	68	1.0
30	176	22.0
43	176	9.0

For the indoor units, Team Maryland used figures based on the Solar Decathlon competition rules for the comfort zone contest. WaterShed must maintain an indoor environment at 71-76°F at <60% relative humidity. For the dehumidification process, the vapor pressure of the desiccant must be *lower* than that of the indoor air.

Various Indoor Air Conditions

Temperature (°F)	Relative Humidity (%)	Vapor Pressure (kPa)
76	60	1.85
76	40	1.23
76	20	0.62
71	60	1.56
71	40	1.04
71	20	0.52

As an example, when the desiccant is at 30% conc. and 68 °F, the desiccant vapor pressure is less than the air water vapor pressure at 71 °F 40% RH to 76 °F 60% RH. 1.0 kPa < (1.04 to 1.85 kPa). Thus, the desiccant will extract water vapor from the air.

These figures, when compared to those from the graph above, clearly show that the desiccant will absorb moisture from the air even when at the lowest concentration (30% concentration). For the regeneration process the vapor pressure of the desiccant must be *higher* than that of the outdoor air.

Various Outdoor Air Conditions

Situation	Temperature (°F)	Relative Humidity (%)	Vapor Pressure (kPa)
Spring (humid)	70	80	2.02
Spring (avg)	70	50	1.26
Summer (humid)	88	85	3.86
Summer (avg)	88	55	2.49
Fall (humid)	68	85	1.99
Fall (avg)	68	55	1.29

As an example, when the desiccant is at 43% conc. and 176 °F, the desiccant vapor pressure is greater than the air water vapor pressure under all outdoor conditions. 9.0 kPais greater than > (1.26 to 3.86). Thus, the desiccant will expel water vapor into the air.

These figures show that the desiccant will evaporate water out of solution under any outdoor conditions, even very hot and humid days. As can be seen in the graph and tables, if the desiccant is at a very high temperature (above 60 °C/140 °F) it will always successfully regenerate.

There are multiple precautions that were taken while constructing this project. LiCl is not much different than regular table salt, but any highly concentrated salt solution has to be handled with care because it absorbs moisture from any source. The side effects of human contact with the desiccant are mild. Dermal contact can result in a mile to severe rash while eye contact results in irritation, redness, and pain. Ingestion can cause nausea, vomiting, and diarrhea. WaterShed's system uses 40 gallons of fully regenerated 42% (by weight) solution: 10 gallons in each indoor unit and 20 in the regenerator.

During construction, elbow length rubber gloves and protective glasses were worn at all times. Each unit has been thoroughly tested to make sure there are no leaks or splashes that could result in any solution leaving the apparatus. All pipe and tube connections have been made with secure plastic fittings. All parts touching the solution are made of plastic or titanium to eliminate the possibility of corrosion and material degradation. Metal has been eliminated from construction in all applicable situations. All piping that touches the heated solution in the regenerator is made of CPVC which can handle temperatures up to 200 °F. All air outlets have been equipped with demisters to eliminate any droplets of desiccant from escaping the units.

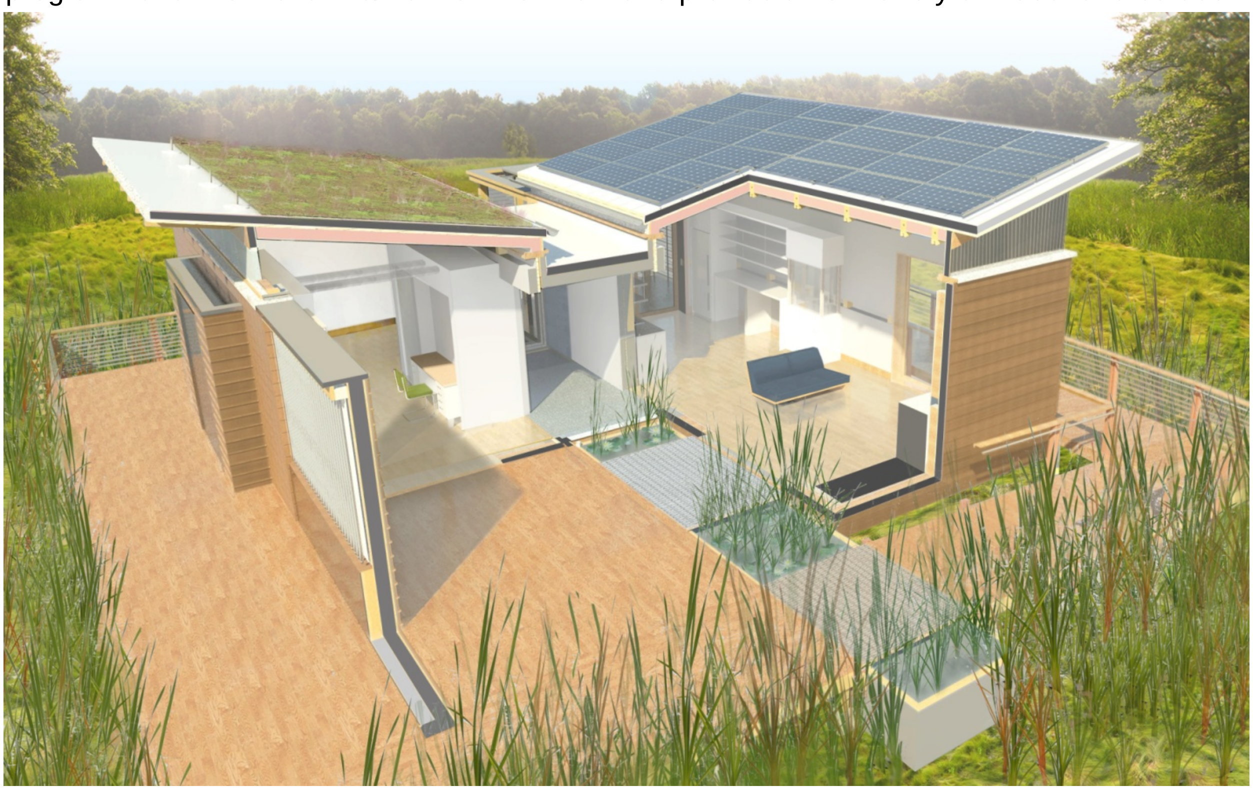
ARCHITECTURAL DESIGN NARRATIVE

WaterShed's architectural design responds to both the challenges of rethinking energy use in the built environment and concerns over American attitudes toward water. Inspired by the Chesapeake Bay, WaterShed's architectural design is derived from four guiding principles:

- water is a precious resource and should be handled conscientiously.
- homes should function as micro ecosystems.
- a sustainable house should both conserve and produce resources.
- merging the best of passive and active energy strategies is the most effective way to create a house that is in tune with its environment.

The forms of the house, in plan and in section, highlight the path of water – falling from clouds to highlands, trickling down waterways, seeping into groundwater, and ultimately evaporating back into our atmosphere. WaterShed's split-butterfly roofline, comprised of two sheds sloping towards each other, is intended to highlight storm water runoff from each module, directing and collecting it into the celebrated water axis at the core of the home. Water used within the house intersects this axis through a consolidated mechanical core. The design physically and visually connects the home and its residents with their surroundings while demonstrating the interconnected nature of an ecosystem.

Spatially, the house is designed as two shed modules slid apart along the central water axis and connected by a third module – the bridge. The two larger modules express the programmatic intent of a live/work environment and provide a rich variety of indoor and outdoor



WaterShed takes inspiration from the Chesapeake Bay ecosystem and seeks to interconnect the house, the landscape, and the residents who live there.

spaces. The bridging module houses the bathroom, highlighting the connection between interior water uses and the wetland axis outside while concurrently linking the public and private spaces.

WaterShed's design showcases the potential of living systems to improve water management. The green roof slows rainwater runoff to the landscape while simultaneously improving the house's energy efficiency by providing added thermal insulation. Storm water runoff is also collected from the solar array in a cistern on the east side of the water axis where it is stored for reuse in landscape irrigation. Grey water from the shower, lavatory, clothes washer, and dishwasher are collected and filtered through a constructed wetland on the west side of the water axis, nourishing the landscape without consuming potable water.

WaterShed's design also demonstrates the potential for architecture to contribute to healthy carbon cycles through the gardens and composting station. The process of growing vegetables in the garden, cooking and consuming those vegetables in the house, and returning the discarded food scraps to compost for gardening, directly and clearly illustrates the potential for improved health, energy and cost savings inherent in a complete carbon cycle program.

The holistic design features integrated architecture and engineering as evidenced in the sloping forms of the modules. The sloped forms create soaring living spaces that are daylit using translucent clerestories and also allow the solar array to most efficiently create power. This energy is used by the mechanical systems to condition the space and a robust envelope ensures that once energy is used in space conditioning its value is retained.

Through integrated architecture, engineering, and living systems, WaterShed creates inspiring spaces which bring delight to life's every day activities.

MARKET VIABILITY JUSTIFICATION

WaterShed is intended for a working couple who can use the house as both a home and as an office. This demographic is highly prevalent within the Baltimore and Washington, DC markets, where many sole proprietorships exist in consulting, law, architecture and other professions. WaterShed is affordable to such residents because the upfront investment in energy-saving and water-saving technologies eventually provide cost-savings to the consumer given the increasing prices of utilities. For people in the Washington, DC corridor specifically, WaterShed is affordable because it provides them the opportunity to telecommute, thus reducing commuting expenses in one of the most congested areas in the country.

Simplified Target Market Identification:

- Geographical Market: Baltimore – Washington, DC corridor (primary); Other Mid-Atlantic states (secondary)
- Housing Configuration: For sale product: one bedroom, plus work den / one bathroom
- Occupant Demographic: Self-employed couple, no kids living at home
- Household Income: $75,000-$115,000 (based on 2009 FHFA AMI figures of our primary demographic market)

To demonstrate WaterShed's livability, a typical week for the house's residents might include a standard work week Monday through Friday where the house functions as an office during the day and a resting place at night. One partner telecommutes three days each week, while the other manages his or her own business at an urban office. The reconfigurable furniture in the south module allows the space to easily transform from a productive workspace to a comfortable bedroom. In the evenings they spend time cooking with produce from their gardens.

On the weekends, they often host potluck dinners for friends in the north module, maximizing usage of the full-sized dining table and transformable living room furniture. Weekends are spent participating in social and community activities because WaterShed's low-maintenance, durable materials require limited time input from the owners. The couple enjoys spending time outdoors as well as time in the city and chose not to move into an urban apartment because of their desire to control their own water and energy consumptions, a desire that is aided by WaterShed's intuitive home automation system. The system provides the residents information about their resource consumption, allowing them to customize settings for maximum efficiency.

Water management is integrated seamlessly into daily life. Rainwater that lands on the house takes one of two paths: it travels off the photovoltaic roof, enters a collection cistern and is later filtered through the constructed wetlands or is absorbed by the green roof. The constructed wetlands also filter grey water from the shower, dishwasher, and bathroom sink. The constructed wetlands allow the residents to minimize their potable water usage because the filtered water is able to be reused onsite to irrigate the landscape.

On the technological side of the house, an appropriately-sized solar array powers the house year round and allows the residents to earn the best return on their initial investment. Solar thermal tubes use heat energy from the sun to heat all domestic hot water, regenerate the desiccant solution, and provide supplemental space heating. These renewable energy technologies are paired with high-efficiency systems throughout the house resulting in energy and cost savings.

WaterShed's unique design, technology, and environmental balance make the home appealing in today's Baltimore-Washington, DC market area. The flexible design suits a wide demographic that looks for long-term value and support for a live-work lifestyle. There is a relationship between the house, the owners, and the environment – an important balance that few homes accomplish with such simplicity. WaterShed moves the concept of housing forward into the next decade of environmental awareness and responsibility through integrated architecture, engineering, and living systems.

ENGINEERING DESIGN NARRATIVE

WaterShed's engineering design features an integrated set of systems that achieve robust functionality and keep WaterShed comfortable under a wide range of climatic conditions. Like the components of the Chesapeake Bay ecosystem, the engineering systems work in harmony, each acting to increase the effectiveness of the others.

Innovative combinations of technology and passive strategies can greatly reduce energy and material waste. WaterShed's engineering approach begins with a tight, well-insulated envelope that reduces the need for mechanical heating and cooling. An envelope with a thermal resistance of over R-40 paired with high-efficiency technologies throughout the structure to minimize the size of the photovoltaic and solar thermal arrays.

WaterShed harnesses the Sun's power through monocrystalline photovoltaic (PV) panels and evacuated-tube solar thermal collectors. The 9.2 kW PV system is sized to fulfill the home's annual energy needs, but is limited to a practical size to optimize the homeowners' return on investment. WaterShed's 106 square foot array of evacuated-tube solar thermal collectors allows the home to meet 100% of its domestic hot-water needs, 100% of the energy required to regenerate the liquid desiccant, and provides supplemental space heating in winter through an innovative system dubbed HXEST that transfers solar thermal energy to the house air.

The indoor environment is conditioned using two mini-split heat pumps. With one unit in each of WaterShed's primary modules, the homeowners can independently control temperature of the spaces. An energy recovery ventilator or ERV exchanges indoor and outdoor air to maintain air quality while conserving energy with 96% effectiveness. A free-cooling mechanism in the ERV can be activated to cool the house with outdoor air when the temperature drops below indoor temperature resulting in energy and cost savings.

The innovative Liquid Desiccant Waterfall (LDW) originally developed by the University of Maryland's Solar Decathlon 2007 team is improved in the 2011 iteration in three significant ways:

- a more effective desiccant solution with Lithium Chloride
- increased contact between the working fluid and air flow using spherical raschig rings as packing media
- stronger integration with the solar thermal array for desiccant regeneration.

This next-generation system provides the independent humidity control necessary for Maryland's typically harsh, humid summers. Independent humidity control reduces the latent heat load on the mini split air conditioning units and improves the overall efficiency of the entire HVAC system. By considering systems holistically and looking for ecosystem-like synergies between components, WaterShed's engineering systems are able to be more effective and efficient than conventional systems.

Inspired by the Chesapeake Bay ecosystem, WaterShed's constructed wetlands are engineered to harvest rainwater from the two shed roofs of the house and filter grey water from the shower, clothes washer, and dishwasher. The wetlands system is also connected to the mini-split units as the condensate line drains into the wetland. Once water in the wetlands has been properly filtered through the plants, the water can be reused to nourish the landscape, decreasing potable water usage.

WaterShed is the embodiment of a way of life that is in tune with the natural processes that surround us. The engineering design supports this relationship between nature and humans by using technology to inform homeowners about the impacts their actions within the home have on the surrounding landscape. WaterShed's home automation system, called Smart House/Adaptive Control or SHAC, is an integrated network of sensors, controllers and software. SHAC automatically monitors and adjusts the temperature, humidity, brightness, and other parameters of the engineering systems to provide maximum function with the least amount of energy use and impact on the environment. The control system informs the homeowners of their energy and water consumption and provides suggestions for reducing unnecessary use of these important resources.

WaterShed is a house as ecosystem, an answer to today's many questions about how to build a more sustainable future. The house's engineering systems act as a unified, synergistic system which is as much a part of the environment as the water that flows through it.

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

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

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 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

SECTION 05 12 00 - STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Design, engineer, fabricate, and install structural steel framing and weldments to withstand structural loads required by International Residential Code 2006 and all applicable codes.

B. Submittals: Shop Drawings.

C. All structural steel work shall conform to the following governing standards:

1. American Society for Testing and Materials:
    a. ASTM Specifications for Structural Steel
    b. ASTM Specification for Pipe, Welded and Seamless
    c. ASTM Specification for Cold-Formed Welded and Seamless Steel Structural Tubing in Rounds and Shapes
    d. ASTM Specification for Hot-Formed Welded and Seamless Steel Structural Tubing
2. American Welding Society:
    a. AWS Structural Welding Code
    b. AWS Specifications for Welding Rods and Bare Electrodes
3. Industrial Fasteners Institute:
    a. IFS Handbook on Bolt, Nut, and Rivet Standards

PART 2 - PRODUCTS

2.01 PRE-FABRICATED STRUCTURAL STEEL FRAMING

A. Hot Rolled Steel Provided by Gutierrez Studios

1. 4” x 4” and 6” x 4”, 1/4” thick structural steel tube to be used in fabrication of primary load-bearing structure for deck pergola.
2. System to be constructed per drawings, using appropriate fastenings and hardware.
3. Steel components will support 6 photovoltaic panels mounted to unirac system, and shall mount onto primary structural members of pergola decking system.

2.02 FINISHES

A. Hot Rolled Steel, Prime Only

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare ground surface by cleaning, removing projections, filling voids, and as otherwise recommended in steel 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 using appropriate fastening methods.

C. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

D. Correct deficiencies in or remove and reinstall any steel framing that does not comply with requirements.

E. Repair, refinish, or replace aluminum extrusions and connecting hardware damaged during installation, as directed by Architect.

END OF SECTION 05 12 00

SECTION 05 52 13 – PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Design, engineer, fabricate, and install pipe and tube railings to withstand a uniform load of 50 lbf/ft. (0.73 kN/m) and a concentrated load of 200 lbf (0.89 kN) applied to handrails of guards in any direction. Uniform and concentrated loads need not be assumed to act concurrently.

B. Submittals: Product Data. Shop Drawings.

PART 2 - PRODUCTS

2.01 SPEED-RAIL RAILING SYSTEMS

A. Manufacturer: Hollaender Manufacturing Company

B. Material: Aluminum 6005-T5 meeting or exceeding the requirements of ASTM B 429.

2.02 FINISHES

Aluminum Finishes: Anodized.

PART 3 - EXECUTION

3.01 FABRICATION

A. Assemble railing system in shop to the greatest extent possible. Use connections that maintain structural value of joined pieces.

B. Form changes in direction of railing members by use of prefabricated fittings.

C. Fabricate railing systems and handrails for connecting members with concealed mechanical fasteners and fittings.

D. Provide manufacturer's standard wall brackets, flanges, miscellaneous fittings, and anchors to connect handrail and railing members to other construction.

3.02 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.03 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Once installed, all handrails must be in compliance with the requirements of the all federal, state and local building codes.

C. Correct deficiencies in or remove and reinstall railings that do not comply with requirements.

END OF SECTION 05 52 13

SECTION 05 53 00 - METAL GRATINGS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Design, engineer, fabricate, and install metal grating to withstand structural loads required by International Residential Code 2009, and per ADA Accessibility Guidelines for Buildings and Facilities.

B. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 METAL GRATING

A. Manufacturer: McNichols Company

1. McNichols Quality SAFE-T-GRID® Bar Grating, Aluminum Type 6063-T6, TB-940 Grooved, Locked by Swaging Construction, 1" x .94" Bearing Bars, 1-3/16" on Center, Regular Cross Bars 4" on Center, 36.5630" Width x 288.0000" Length (Span)
2. Item #6710316324
3. http://www.mcnichols.com/product/6710316324?navCode=cc:bar&navCode=avc:safe-t-grid
4. Aluminum Finishes: Anodized.

2.02 STRUCTURAL ALUMINUM

A. Manufacturer: BMG Metals

B. Product Description
1. Aluminum tubing to be used in fabrication of structural bracing for metal grating. System to be constructed per drawings, using appropriate fastenings and hardware. Aluminum components will support metal grating system and shall mount onto primary structural members.
2. 6063-T5 Aluminum Extruded Channel
3. 1-1/2” x 1-1/2” Tubing

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in metal grating 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.

C. Fasten metal gratings securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

D. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

E. Correct deficiencies in or remove and reinstall metal grating that does not comply with requirements.

F. Repair, refinish, or replace metal grating damaged during installation, as directed by Architect.

END OF SECTION 05 53 00

SECTION 05 58 00 - FORMED METAL FABRICATIONS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Design, engineer, fabricate, and install aluminum channel and angles to withstand structural loads required by International Residential Code 2009.

B. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 ALUMINUM CHANNELS, ANGLES AND ROD

A. Manufacturer: BMG Metals
   1. Aluminum channel and angles to be used in fabrication of screen element on north side of pergola.
   2. System to be constructed per drawings using appropriate fastenings and hardware.
   3. Aluminum components will support light-weight wooden screen system and shall mount to primary structural members of exterior pergola framing system.
   4. 6063-T5 Aluminum Extruded Channel
   5. 1-1/2” x 1-1/8” channel
   6. 1” x 3/4” channel
   7. 1” x 1” aluminum angle
   8. 1/2” aluminum rod

2.02 FINISHES

Mill Finish, typical for all exterior applications

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in aluminum channel and angle 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.

C. Fasten aluminum framework securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

D. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

E. Correct deficiencies in or remove and reinstall any aluminum extrusion that does not comply with requirements.

F. Repair, refinish, or replace aluminum extrusions and connecting hardware damaged during installation, as directed by Architect.

END OF SECTION 05 58 00

SECTION 06 05 23 - WOOD, PLASTIC, AND COMPOSITE FASTENINGS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

PART 2 - PRODUCTS

2.01 MATERIALS

A. Sheathing nails: 8d common nails

B. Frame screws: 4”

C. Simpson Strong-Tie Company Inc.
1. Joist Hangers for 2x10: Simpson LUS210-3 and Simpson HU9
2. Source: Simpson Strong-Tie Company Inc.
3. http://www.strongtie.com

B. Simpson Strong-Tie Company Inc.
1. Inverted JH: Simpson HUS210-3
2. Source: Simpson Strong-Tie Company Inc.
3. http://www.strongtie.com

C. Simpson Strong-Tie Company Inc.
1. Inverted JH: Simpson HUS210-3
2. Source: Simpson Strong-Tie Company Inc.
3. http://www.strongtie.com

D. Simpson Strong-Tie Company Inc.
1. Twist Strap: Simpson TS18
2. Source: Simpson Strong-Tie Company Inc.
3. http://www.strongtie.com

E. Simpson Strong-Tie Company Inc.
1. Module Connector: SS All-thread PCS ¾” x 15”
2. Source: Simpson Strong-Tie Company Inc.
3. http://www.strongtie.com

F. Simpson Strong-Tie Company Inc.
1. SS Nuts: ¾”
2. Source: Simpson Strong-Tie Company Inc.
3. http://www.strongtie.com

G. Simpson Strong-Tie Company Inc.
1. SS Washers: for ¾”
2. Source: Simpson Strong-Tie Company Inc.
3. http://www.strongtie.com

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide 2”x6” blocking at all free edges.

B. Soil anchors shall not penetrate more than 18” into the soil of the competition site.

C. All sill plates shall be p.t. and anchored to foundation walls with 1/2” diameter headed anchor bolts (ASTM F1554) at 4’-0” o.c. and within 12” of all sill plate slices (min. 7” embed.).

D. Joist Hangers shall be a minimum of 18 gauge steel.

E. Built-up beams less than 8” deep shall be spiked together with two (2) 16d nails at 16” o.c.

F. Built-up beams greater than 8” deep shall be spiked together with three (3) 16d nails at 16” o.c.

END OF SECTION 06 05 23

SECTION 06 10 00 - ROUGH CARPENTRY

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data. Shop Drawings.

B. Refer to drawings for nominal size specifications.

C. Provide dressed lumber marked with grade stamp of inspection agency.

PART 2 - PRODUCTS

2.01 WOOD BLOCKING

A. Miscellaneous Blocking
1. Blocking will be provided as needed.
2. Standard, Stud, or No. 3 grade with 19 percent maximum moisture content of any species.

B. Finish Framing / Drywall Blocking
1. Provide blocking for drywall and finish framing.
2. Drywall shall be supported at a minimum at 16” on center.

2.02 PRESERVATIVE-TREATED MATERIALS

A. Adhere to AWPA C2, except that lumber not in ground contact and not exposed to the weather may be treated according to AWPA C31 with inorganic boron (SBX).
1. Use treatment containing no arsenic or chromium.
2. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent.
3. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

B. Provide preservative-treated materials for all rough carpentry in connection with roofing, flashing, vapor barriers, and waterproofing.

C. Provide preservative-treated materials for all rough carpentry that is less than 18 inches (460 mm) above the ground.

D. Wood Battens: 1 x 4 nom. preservative-treated furring strip provided 16” on center.

2.04 PLYWOOD BACKING PANELS

E. Plywood, Exterior, AC, fire-retardant treated, not less than 3/4-inch (19-mm) nominal thickness.

2.05 MISCELLANEOUS PRODUCTS

F. Fasteners: Size and type indicated. Where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M
   1. Power-Driven Fasteners: CABO NER-272.
   2. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where indicated, flat washers.

G. Sill Sealer Closed-cell neoprene foam, 1/4 inch (6.4 mm) thick.

H. Use ply clips or other edge support as required for plywood sheathing.

PART 3 - EXECUTION

3.01 INSTALLATION

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

B. All plywood shall be glued and screwed to floor joists at 1/8” space at all panel edge joints using an APA approved adhesive (B.F. Goodrich PL400 or equal).

C. Leave 1/16” space at all plywood panel end joists and 1/8” space at all panel edge joints.

D. Unless noted otherwise, plywood wall sheathing shall be fastened to shear wall stud framing with 8d common nails at 4” o.c. at each sheet perimeter and 12” o.c. elsewhere. Provide 2”x6” nom. blocking at all free edges.

E. Fastening shall be in accordance with the most restrictive of: The International Building Code 2009, the 1992 CABO for 1 and 2 family dwelling, or the manufacturer’s recommended fastening schedules.

F. Lap all plates at corners and at intersection of partitions.

G. Stagger all top and bottom plate splices a minimum of 32 inches.

H. Bridging for spans up to 14 ft., provide 1 row. Bridging for spans over 14 ft., provide 2 rows.

I. No joists shall be cut or notched without approval.

J. All light-gauge hangers supporting preservative treated wood shall meet or exceed G185 (1.85 oz of zinc per square foot). Alternatively, stainless steel connectors may be used. Fasteners shall match the selected hanger finish and material.

K. Wood furring strips shall be installed with 6” flute head screws.

END OF SECTION 06 10 00

SECTION 06 11 00 - WOOD FRAMING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data. Shop Drawings.

B. Provide dressed lumber marked with grade stamp of inspection agency.

C. All wood framing including details for bridging, blocking, fire stopping, etc., shall conform to the latest edition of the "National Design Specification for Wood Construction" and its supplements and shall be installed in accordance with the NFPA "Manual for House Framing".

D. Fastening shall be in accordance with the most restrictive of: The International Building Code 2009, the 1992 CABO for 1 and 2 family dwelling, or the manufacturer's recommended fastening schedules.

PART 2 - PRODUCTS

2.01 LUMBER

A. Dimensional Lumber:
   1. Maximum Moisture Content: 19 percent
   2. Non-Load-Bearing Interior Partitions: Standard, Stud, or No. 3
   3. Framing Other Than Non-Load-Bearing Interior Partitions: Douglas fir-larch: WCLIB or WWPA
   4. Exposed Framing: Provide material hand-selected for uniformity of appearance and freedom from characteristics on exposed surfaces and edges that would impair finish appearance, including decay, honeycomb, knot-holes, shake, splits, torn grain, and wane.
      a. Species:
         1) Rafters and Joists: Southern Yellow Pine
         2) Beams, Girders, and Headers: Southern Yellow Pine
         3) Studs and Plates: Southern Yellow Pine

B. Timbers 5-Inch Nominal (117-mm Actual) Size and Thicker:
   1. Species
      a. Douglas fir-larch,
      b. Douglas fir-larch (north), or
      c. Douglas fir-south
      d. NLGA, WCLIB, or WWPA
   2. Maximum Moisture Content: 23 percent

C. Miscellaneous Lumber:

1. Standard, Stud, or No. 3 grade with 19 percent maximum moisture content of any species.
2. Provide for nailers, blocking, and similar members.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All flush-framed connections shall be made with approved galvanized steel joist or beam hangers, minimum 18 gauge, installed according to manufacturer's recommendations.

B. Where framing lumber is flush framed to microlam, steel or flitch-plate girder, set these girders 1/4" clear (min.) below top of framing lumber, to allow for shrinkage.

C. Stud walls are to be constructed of 2"x4" at 16" o.c. at the interior and 2"x6" at 16" o.c. at the exterior, unless noted otherwise on plan.

D. Use double studs at ends of wall and ends of wall openings.

E. Use double trimmers and headers at all floor openings where beams are not designated.

F. Bridging for spans up to 14 ft., provide 1 row.

G. Bridging for spans over 14 ft., provide 2 rows.

H. Built-up beams less than 8" deep shall be spiked together with two (2) 16d nails at 16" o.c.

I. Built-up beams greater than 8" deep shall be spiked together with three (3) 16d nails at 16" o.c.

J. No joists shall be cut or notched without approval.

END OF SECTION 06 11 00

SECTION 06 11 13 - ENGINEERED WOOD PRODUCTS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Manufacturer's published values of allowable design stresses shall be demonstrated by comprehensive testing.

PART 2 - PRODUCTS

2.01 LOCK DECK

A. Dimensions: 2” x 6” nominal, 1-1/2” x 5-1/2” actual

B. Provide continuously supported, random length laminated decking in one of the following species:
1. Douglas Fir
2. Larch
3. Southern Pine

2.02 Parrallam PSL Column

A. Dimension: 6” x 6” nominal, 5 1/4” x 5 1/2” actual

B. Solid, one-piece column members used in dry-service conditions (SC1 and SC2).

C. Loads are based on simple axial-loaded columns using the design provisions of BS5268: Part 2, 2002 edition.

D. The modification factor for compression members K12 is calculated using the equation in Annex B.

E. The eccentricity factor (d) is taken as 0.01 of the slenderness ratio (h).

F. For side loads or other combined bending and axial loads, see provisions of BS 5268: Part 2, 2002 edition

2.03 FINISHES

A. Lock Deck: Factory clear matte sealer, natural finish.

B. Parrallam PSL Column: Wolmanized

PART 3 - EXECUTION

3.01 INSTALLATION

A. Lock Deck:
1. The deck must be continuous over three or more spans of approximately equal length, with each piece of deck over at least one support. Other situations require special design.
2. Place decking to disperse end-joints as randomly as possible.
3. The distance between end-joints in adjacent rows of decking is at least two feet.
4. The distance between end-joints in rows of decking separated by only one row is at least one foot.
5. End spans shall be carefully planned and placed. To ensure that end spans perform as indicated by the Span Tables, follow one of these practices:
   a. Eliminate end-joints in one-third of the decking courses, or
   b. Provide a cantilevered overhang, free of end-joints, equal to 20% of the end span, or shorten the end span by 10%.
   c. Where one of these practices cannot be applied, end span deflection may exceed the values shown.
6. Toenailing along courses: 8d at 30” o.c. for 2” nominal thickness
7. Face Nailing to Supports 20d for 2” nominal thickness

B. Parallam PSL Column:
1. Install to full compliance with specifications and details of manufacturer.

END OF SECTION 06 11 13

SECTION 06 15 33 - WOOD DECK

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data. Shop Drawings.

PART 2 - PRODUCTS

2.01 DECKS AND FRAMING STRUCTURE

A. Provide heat treated materials (“cooked wood”) treated as follows: heated wood up to 250c, using a water vapor as shielding gas.

B. Heat treated materials do not need to be stamped by WWPA as qualifying lumber, with the KD - HT mark.

C. Exterior Decks
1. 5/4” x 6” Heat-Treated Ash
2. Manufacturer: Heister House, Inc.
3. http://www.hhmillworks.com/

B. Deck Framing Structure:
1. 2”x8” nom. Preservative-Treated Pine Lumber

2.03 PERGOLA

A. Provide heat treated materials (“cooked wood”) treated as follows: heated wood up to 250c, using a water vapor as shielding gas.

B. Heat treated materials do not need to be stamped by WWPA as qualifying lumber, with the KD - HT mark.

C. 5/4” x 6” Heat Treated Ash
1. Manufacturer: Heister House, Inc.
2. Provide product matching same specifications as all exterior decking

2.07 MISCELLANEOUS PRODUCTS

1. IQ Hidden Fastening System
   a. Manufacturer: FastenMaster
   b. http://www.fastenmaster.com

PART 3 - EXECUTION

3.01 INSTALLATION

A. Fastening shall be in accordance with the most restrictive of: The International Building Code 2009, the 1992 CABO for 1 and 2 family dwelling, or the manufacturer's recommended fastening schedules.

B. IQ Hidden Fastening System shall be installed on deck boards prior to being fastened to preservative treated 2 x 8 nom. structure.

C. Decking shall run perpendicular to substructure and end on a girder. Deck boards will be fastened together at butt joints with IQ Hidden Fastening System prior to installation.

D. All light-gauge hangers supporting preservative treated wood shall meet or exceed G185 (1.85 oz of zinc per square foot). Alternatively, stainless steel connectors may be used. Fasteners shall match the selected hanger finish and material.

END OF SECTION 06 15 33

SECTION 06 16 00 - SHEATHING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 WOOD PANEL PRODUCTS, GENERAL

A. Plywood: DOC PS 1.

2.02 WALL SHEATHING

A. Plywood Wall Sheathing: 1/2" thick, 32/16 span rating

2.03 ROOF SHEATHING

A. Plywood Roof Sheathing: 5/8" thick, 48/24 span rating

2.04 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 the following:
   1. "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.

B. Fastening Methods:
   1. Wall and Roof Sheathing:
      a. Nail to wood framing.
      b. Screw to cold-formed metal framing.

END OF SECTION 06 16 00

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.
   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

SECTION 06 17 13 - LAMINATED VENEER LUMBER

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

PART 2 - PRODUCTS

2.01 MATERIALS

2.02 ENGINEERED WOOD PRODUCTS

A. Rim Boards: Provide continuous 1-3/4" thick rim boards, microlam LVL as manufactured by Trusjoist Macmillan, or approved equal. Install in compliance with the manufacturer's recommendations at the perimeter of all floor platforms.

B. Microlam Beams: Provide engineered beams, sizes as shown in drawings, microlam LVL (Fb=2600 PSI, E=1,900,00 PSI) or parallam PSL (Fb=2900 PSI, E=2,000,000 PSI) as manufactured by Trusjoist Macmillan or approved equal. Install in compliance with the manufacturer's standard recommendations and details.

C. Laminated-Veneer Lumber: Manufactured with exterior-type adhesive complying with ASTM D 2559. Allowable design values determined according to ASTM D 5456.
   1. Extreme Fiber Stress in Bending, Edgewise: 2250 psi (15.5 MPa) for 12-inch nominal - (286-mm actual) depth members.
   2. Modulus of Elasticity, Edgewise: 1,500,000 psi (10 300 MPa**).**

PART 3 - EXECUTION

3.01 INSTALLATION

A. Microlam LVL:
   1. Install to full compliance with specifications and details of manufacturer.

END OF SECTION 06 17 13

SECTION 06 20 13 - EXTERIOR FINISH CARPENTRY

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 WOOD SHIPLAP SIDING

A. Milled 1” x 8”, heat-treated poplar
B. Manufacturer: Heister House, Inc.
C. http://www.hhmillworks.com/

2.02 SIDING SPLINES

A. For north façade and mechanical room bump out as indicated in drawings.
B. Milled 1”x2”, heat-treated poplar with milled drip edge
C. Manufacturer: Heister House
D. http://www.hhmillworks.com/

2.02 RAILINGS AND GUARDS

A. Deck Posts
1. Triple-member post, comprised of two (2) 2” x 6” nom. members on sides and one (1) 2” x 4” nom. member in center.
2. Heat-treated ash.
3. Manufacturer: Heister House, Inc.
4. http://www.hhmillworks.com/

B. Deck Post Top Rail
1. 1”x6” nom.
2. Heat-treated ash.
3. Manufacturer: Heister House
4. http://www.hhmillworks.com/

C. Deck Railing Guard Infill
1. Milled 1” x 2” with milled drip edge
2. Heat-treated poplar.
3. Manufacturer: Heister House
4. http://www.hhmillworks.com/

2.03 WINDOW AND DOOR TRIM

A. Douglas Fir, 1” x 4” nom.
B. Manufacturer: TW Perry
C. http://www.twperry.com

2.04 EXTERIOR PAINTED TRIM
A. Douglas Fir, 1” x 4” nom. or 1” x 8” nom. as indicated in drawings.
B. Manufacturer: TW Perry
C. http://www.twperry.com

2.05 ACCESSORIES

A. Fasteners at Wood Stud Framing:
1. Nails: Galvanized steel
a. Type: Ring shank nails with a blunt or diamond point and a box or siding type head
b. Length: Sufficient to penetrate tongue and groove sheathing, not less than 1 1/4”
2. Screws: Corrosion resistant coating
a. Type: Phillips bugle head Rock-On screw fastener
b. Length: Sufficient to penetrate wood studs not less than 1”
3. Fasteners used with copper preservative treated woods shall be coated or corrosion resistant metal (hot-dipped galvanized or stainless steel) sized to suit application.
a. Plates and Connectors: Hot Dip Galvanized: ASTM A653; G185 coating class
b. Bolts, Shims, and Washers: Hot Dip Galvanized: ASTM A153; G185 coating

PART 3 - EXECUTION

3.01 INSTALLATION

A. Shilap Siding and Splines:
1. Follow installation of furring strips and initial finish of siding material.
2. Set siding and spline level, plumb, and true to line, allowing inconsistencies in plumbness of no more than 1/4” over 20’ and anchor securely in place as required in manufacturer’s specifications
3. Correct deficiencies in or remove and reinstall siding and splines that do not comply with requirements.
4. Repair, refinish, or replace siding and splines damaged during installation or transit, as directed by Architect

B. Railings and Guards:

1. Construct railings and guards to meet required safety standards.
2. Railing and guards should be constructed parallel to deck and sloped walking surface as indicated in drawings.
3. Set railings and guards level, plumb, and true to line, allowing inconsistencies in plumbness of no more than 1/4” over 20’ and anchor securely in place as required in manufacturer’s specifications
4. Correct deficiencies in or remove and reinstall siding and splines that do not comply with requirements.
5. Repair, refinish, or replace siding and splines damaged during installation or transit, as directed by Architect

C. Trim:
1. Following installation of flexible flashing around wall openings, install wood trim in compliance with manufacturer’s instructions.
2. Fasteners shall be installed no more than 2” from end of each board.
3. Pre-drill nail holes if necessary to prevent breakage.
4. Touch up field cut edges before installing.
5. After installation, seal joints except lap joints of lap siding. Seal around penetrations. Seal exposed cut edges.

END SECTION 06 20 13

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. Doug 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.

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

SECTION 06 40 16 - INTERIOR ARCHITECTURAL WOODWORK

PART 1 - GENERAL

1.01 CERTIFICATION OF WOOD STANDARDS

A. Grades of interior architectural woodwork shall comply with AWI's "Architectural Woodwork Quality Standards."

B. Submittals: Product Data.

PART 1 - PRODUCTS

1.01 MATERIALS

A. Lumber (solid stock):
1. AWI 100.
2. Wood Species and Grade: Doug Fir, select clear.
3. Refer also to Schedule of Finishes on drawings.

B. Particleboard:
1. ANSI A208.1, Grade M-2.

C. Softwood veneer plywood:
1. Type DOC PS 1

D. Hardwood plywood and face veneers
1. Type HPVA HP-10, using adhesive with no urea formaldehyde.
2. Species: Birch

E. Bamboo Panels
1. Installed in bathroom niche.
2. Vertical grain carmelized bamboo flooring.

F. Shower Grate
1. Milled woven strand bamboo flooring.
2. Custom fabrication.

1.02 DOOR HARDWARE AND ACCESSORY MATERIALS

A. CRL anodized extruded aluminum track for OT series, top-hung bi-fold door
1. Manufacturer: C.R. Laurence
2. Part no. OTTR120SA, Technology LK
3. Source: C.R. Laurence Co., Inc. http://www.crlaurence.com

1.03 INTERIOR WOODWORK

A. Woodwork to be sized according to dimensions given in plan and elevation drawings. Edges of shelving to be eased up to radius of 1/16 inch

B. Species of Wood:
1. Casework: Birch Veneer Plywood
2. Casing for sliding and bi-fold doors: select clear Douglas Fir
3. Shelves fixed to walls: Birch Veneer Plywood
4. Interior door frames: select clear Douglas Fir

PART 2 - EXECUTION

2.01 INSTALLATION

A. Fabrication shall be completed to maximum extent possible before shipment to site.

B. All woodwork shall comply with Custom grade, per AWI section 400.

C. 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.

D. Woodwork to comply with quality standard for Grade 1 as specified above. Walls and other substrata to be inspected for plumb and rigidity before installation.

E. 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.

F. 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.

G. Shelves to be offset from cabinetry no more than maximum of 1/16".

H. Cabinets: door hinges shall be installed with a maximums of 1/32" tolerance of vertical and horizontal alignment. Adjust hardware to true doors after installation and to provide for ease of operation.

END OF SECTION 06 40 16

SECTION 07 21 13 – BOARD INSULATION

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Applicable standards: ASTM C1289 – Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board, Type II, Class 1; ASTM C 1289, Type IV or V; ASTM C578, Type IV – Standard Specification for Rigid Cellular Polystyrene Thermal Insulation; E84 – Standard Test Method for Surface Burning Characteristics of Building Materials

C. Related sections: 079200 JOINT SEALANTS

PART 2 - PRODUCTS

2.01 POLYISOCYANURATE THERMAL INSULATION BOARD

A. Firestone Building Products ISO 95+ GL
1. Fiber-Reinforced Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, faced on both sides with fiber reinforced facers. Thermal resistance R-25; thickness 4 in., or as indicated on drawings.
2. http://www.firestonebpco.com/roofing/insulation/iso95/

2.02 TAPERED POLYISOCYANURATE THERMAL INSULATION BOARD

A. Firestone Building Products ISO 95+ GL
1. Tapered Fiber-Reinforced Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, faced on both sides with fiber reinforced facers. Tapered ¼"/ft, 4' x 4' boards tapering from 2" to 3" and 3" to 4."
2. http://www.firestonebpco.com/roofing/insulation/iso95/

2.03 EXTRUDED POLYSTYRENE FOAM INSULATION

A. Dow Styrofoam Square Edge insulation
1. Extruded Polystyrene Foam Insulation: ASTM C578, Type IV. Thermal resistance R-10; thickness 2 in., or as indicated in drawings.
2. http://building.dow.com/na/en/products/insulation/squareedge.htm

2.04 ACCESSORIES

A. Vapor Retarder: Fire-retardant, reinforced polyethylene, 6 mils (0.15 mm) thick.

B. Dow WEATHERMATE Construction Tape
   1. Clear acrylic adhesive tape with polypropylene UV-treated film. Width 2 7/8”
   2. http://building.dow.com/na/en/products/specialty/wmtape.htm

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install 2 layers of 2 in. extruded polystyrene foam insulation board on all exterior walls to a total thickness of 4 in., unless otherwise indicated on drawings. All joints to be staggered and sealed with construction tape.

B. Extruded polystyrene foam insulation board to be attached using silicon sealant approved by manufacturer and mechanically fastened with cap nails as recommended by manufacturer.

C. Where indicated on drawings, install tapered polyisocyanurate insulation to allow for positive drainage per manufacturer’s instructions.

END OF SECTION 07 21 13

SECTION 07 21 16 – BLANKET INSULATION

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Applicable Standards: C518 – Standard Test Method for Steady-State Thermal Transmission Properties by means of the Heat Flow Meter Apparatus; ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials

PART 2 - PRODUCTS

2.01 BATT THERMAL INSULATION

A. Knauf Insulation EcoBatt Insulation
   1. Thermo-Acoustic Quilt manufactured from glasswool fibers. Unfaced; Thermal Resistance, R-19; Thickness, 6.25 in.; width, 15 in., unless otherwise indicated in drawings
   2. http://www.ecobatt.us/eco_batt.html

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install insulation in areas and in thicknesses indicated in drawings.

B. Insulation to be friction fit between wood framing members.

END OF SECTION 07 21 16

SECTION 07 21 29 – SPRAYED INSULATION

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Applicable standards: ASTM C 518

C. Sustainability credentials: CAN/ULC 5774 – VOC Emissions from Polyurethane Foam; ASTM D 6866 – Bio-based content

PART 2 - PRODUCTS

2.01 CLOSED CELL RIGID, SPRAY APPLIED POLYURETHANE FOAM INSULATION

A. Demilec HEATLOK SOY

1. Two component spray applied rigid polyurethane foam having a nominal density 2lbs/ft^3. Thermal resistance R-6.6/in.
2. http://www.demilecusa.com/Default.aspx?ip=3&sip=47

2.02 OPEN CELL SEMI-RIGID, SPRAY APPLIED POLYURETHANE FOAM INSULATION

A. Demilec *SEAL*ECTION Agribalance

1. Two component, open cell, spray applied, semi-rigid polyurethane foam. Fully water blown system having a low in-place density. Thermal resistance R-4.45/in.
2. http://www.demilecusa.com/Repository/File/TDS_SEALECTION_Agribalance_082508.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Mask all finish surfaces and areas not to receive insulation prior to spray process.

B. Install insulation in areas and in thicknesses indicated in drawings.

END OF SECTION 07 21 29

SECTION 07 27 26 – FLUID-APPLIED MEMBRANE AIR BARRIERS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Applicable standards: ASTM E-2178 Standard Test Method for Air Permeance of Building Materials; ASTM E-2357 Standard Test Method for Determining Air Leakage of Air Barrier Assemblies

C. Related sections: 07 92 00 JOINT SEALANTS

PART 2 - PRODUCTS

2.01 FLUID-APPLIED MEMBRANE AIR BARRIER

A. Tremco ExoAir 220 Fluid Applied Vapor Permeable Air Barrier Membrane
   1. Fluid-Applied, Vapor-Permeable Air Barrier membrane: monolithic elastomeric membrane, rolled on. Air permeance not greater than 0.00120 L/s/m^2 pressure difference per ASTM E 2178-01 and water-vapor permeance not less than 12 perms per ASTM E 96.
   2. http://www.tremcosealants.com/commercial/products/product_detail.asp?id=298

2.02 ACCESSORIES – SELF-ADHERED MEMBRANE FLASHING

A. Tremco ExoAir 110 Self-Adhered Air & Vapor Barrier Membrane
   1. 36 mil, self-adhering SBS rubber asphalt air and vapor membrane laminated to a 4 mil cross laminated polyethylene film with a siliconized release liner. 75 ft rolls, width as indicated in drawings.
   2. http://www.tremcosealants.com/commercial/products/product_detail.asp?id=211

B. Tremco ExoAir Primer
   1. VOC-Compliant adhesive primer designed for use with Tremco 110 Self-Adhered Air & Vapor Barrier Membrane
   2. http://www.tremcosealants.com/commercial/products/product_detail.asp?selected_type=1&product_id=246

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in manufacturer's written instructions.

B. Fill gaps in perimeter frame surfaces of windows, curtain walls, storefronts, and doors, and miscellaneous penetrations of air-barrier membrane with foam sealant.

C. Using roller or brush, apply primer to substrates at required rate and allow to dry. Limit priming to areas that will be covered by air-barrier membrane in same day. Reprime areas exposed for more than 24 hours.

D. Install termination strips and auxiliary materials according to air-barrier manufacturer's written instructions to form a seal with adjacent construction and maintain a continuous air barrier. Install termination strips so that a minimum of 4 inches (102 mm) of coverage is achieved over both substrates.

E. Apply termination mastic at all seams of membrane flashing

F. Apply air-barrier membrane to form a seal with termination strips and to achieve a continuous air barrier according to air-barrier manufacturer's written instructions.

G. Roller apply fluid-applied air barrier to a wet thickness not less than 80 mil.

END OF SECTION 07 27 26

SECTION 07 33 63 - VEGETATED ROOFING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, color charts showing the full range of colors available for factory-applied finishes

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 1 year.

C. LEED Credits
1. SS 5.1 Site Development, Protect or Restore Habitat
2. SS 5.2 Site Development, Maximize Open Space
3. SS 6.1 Quantity Control
4. SS 6.2 Quality Control
5. SS 7.2 Heat Island Effect–Roof
6. WE 1.1 Water Efficient Landscaping, Reduce by 50 %
7. WE 1.2 Water Efficient Landscaping, No Potable Use or No Irrigation
8. MR 4.1-4.2 Recycled Content
9. MR 5.1-5.2 Regional Materials
10. MR 6 Rapidly Renewable Materials

PART 2 - PRODUCTS

2.01 VEGETATED ROOFING

A. LiveRoof LITE
1. Modular Vegetated Roofing, manufactured in 1' x 2' trays. Saturated weight of system to be approximately 15 – 17 lbs/sf.
   a. Trays will be 100 mil thick recycled polypropylene and colored black, gray or clear. Tray dimensions 12 inches wide by 24 inches long and 1 ¾ inches deep. Total soil height to be 2 ½ inches.
   b. Growing medium - Engineered blend of inorganic and organic components based upon German FLL granulometric guidelines modified so as to contain ecologically sustainable levels of organic content.
   c. Recommended plant mixes consisting of highly drought resistant ground covers. Local horticulturalists should be consulted for specific recommendations.
2. http://www.liveroof.com/?parent=System_Specifications&page=cad_drawings#Lite

2.02 ACCESSORIES

A. Permaloc Corporation LiveRoof Edge
   1. Extruded .25” aluminum green roof edge manufactured in 8’-0” lengths. Leg dimensions 3” x 3.25”
   2. http://www.liveroof.com/?parent=System_Specifications&page=cad_drawings#RoofEdge

B. EPDM Slip Sheet
   1. Conservation Technology EPDM Rubber
   2. 40 mil thickness, min. 7.5 ft membrane width.
   3. http://www.conservationtechnology.com/waterproofing_epdm.html

2.03 FINISHES

A. Trays – Black

B. Roof Edge – mill finish

PART 3 - EXECUTION

3.01 PREPARATION OF ROOF SURFACE

A. Slip sheet/roof barrier, specified by architect and approved by manufacturer, of 40 mil thickness with overlapped and effectively bonded seams to ward against roof penetration and to keep waterproofing layer safe and clean from soil during installation. Slip sheet/roof barrier typified as follows:
   1. Glued seam types (40 mil thickness)
      a. EPDM, with seams overlapped a minimum of 3 inches and glued with roll out adhesive or double sided tape adhesive of the type that is impervious to and not affected by moisture, and recommended by the manufacturer.

3.02 INSTALLATION

A. Installation season: Module installation to be conducted when plants are:
   1. Properly adapted and acclimatized to local weather conditions.
   2. When weather is above 35 degrees F and there is no ice on the roof and vegetated roof soil is unfrozen.
   3. When plants cover 95% or more of soil surface.

B. Establish perimeter of green roof area with extruded aluminum roof edge

C. Interlock LiveRoof modules moving from low slope of roof to high slope until desired roof area is covered

END OF SECTION 07 33 63

SECTION 07 42 13 – METAL WALL PANELS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data and color Samples.

B. Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of item indicated.

C. Warranties: Provide manufacturer's standard written warranty, signed by manufacturer agreeing to promptly repair or replace metal wall panels that show evidence of deterioration of factory-applied finishes within 20 years from date of Substantial Completion.

D. Related sections: 07 62 00 SHEET METAL FLASHING AND TRIM; 07 92 00 JOINT SEALANTS

PART 2 - PRODUCTS

2.01 CORRUGATED METAL WALL PANELS

A. Fabral Corrugated ½"
1. Corrugated Panel for Commercial-Industrial Metal Roofing and Wall Cladding. Exposed-fastener, lap seam ½ in. corrugated metal wall panel, 2.667 in. ridge to ridge, 40 in. net coverage.
2. http://www.fabral.com/products/1-2-corrugated#specs

2.02 FLASHING AND TRIM

A. Head Flashing
1. Galvalume steel sheet; Nominal Metal Thickness: 24 ga.; 0.028 inch (0.71 mm).

B. Endwall Flashing
1. Galvalume steel sheet, Nominal Metal Thickness: 24 ga.; 0.028 inch (0.71 mm).

C. Closure Flashing
1. Galvalume steel sheet, Nominal Metal Thickness: 26 ga.; 0.022 inch (0.55 mm).

2.03 FINISHES

1. Clear organic polymer surface treatment; material thickness as specified in drawings

PART 3 - EXECUTION

3.01 FABRICATION

A. Custom fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, geometry, metal thickness and other characteristics of item indicated. Fabricate items at the shop to greatest extent possible.

B. Obtain field measurements for accurate fit before shop fabrication.

3.02 INSTALLATION

A. Anchor panels securely in place, with provisions for thermal and structural movement. Field cutting exterior panels by torch is not permitted. Exposed fasteners finished to match wall panels.

B. Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of wall panel assemblies. Provide types of gaskets, fillers, and sealants as indicated, or as recommended by panel manufacturer.

C. Separate dissimilar metals and metal panels from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

END OF SECTION 07 42 13

SECTION 07 54 23 - THERMOPLASTIC-POLYOLEFIN ROOFING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, and manufacturer's color charts showing the full range of colors available for factory-applied finishes.

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 20 years.

PART 2 - PRODUCTS

2.01 THERMOPLASTIC POLYOLEFIN ROOFING MEMBRANE

A. Tremco TPO Single Ply Roof System
1. Mechanically fastened Thermoplastic Polyolefin roofing membrane, thickness 60 mil, 10 ft width
2. http://www.tremcoroofing.com/fileshare/specs/tpo_single_ply_roof_system_REV_8_2009.pdf

2.02 FIBERGLASS-MAT FACED GYPSUM ROOF BOARD

A. Georgia-Pacific DensDeck Prime Roof Board
1. ½ inch (12.7 mm) thick, 4' x 8' gypsum roof board, fiberglass-mat surfacing; R-Value (ASTM C518): Not less than 0.56; Compressive Strength (Applicable sections of ASTM C472): 500 – 900 psi
2. http://www.gp.com/build/product.aspx?pid=4664

2.03 ACCESSORIES – TPO FLASHING

A. Tremco TPO Unreinforced Membrane
1. Thermoplastic Polyolefin non-reinforced flashing membrane, 55 mil membrane, 8" width.
2. http://www.tremcoroofing.com/fileshare/msds/TPO055_503_U.pdf

2.04 ACCESSORIES – TERMINATION BAR

A. 0.100 inch x 1 inch mill finish aluminum bar stock.

2.05 FINISHES

A. Colors - white

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in manufacturer's written instructions.

B. Lay out roof substrate and fasten through to roof substrate. Fasteners to be installed of type and quantity as recommended by manufacturer.

C. Fasten membrane securely in place, with provisions for thermal and structural movement.

D. Correct deficiencies in or remove and reinstall roof membrane that does not comply with requirements.

E. Install with appropriate heat welding equipment in accordance with specifications, details and workmanship requirements.

END OF SECTION 07 54 23

SECTION 07 61 13 – STANDING SEAM SHEET METAL ROOFING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, Shop Drawings, manufacturer's color charts showing the full range of colors available for factory-applied finishes

B. Comply with SMACNA's "Architectural Sheet Metal Manual" unless otherwise indicated.

C. Warranties: Provide manufacturer's standard written warranty, signed by manufacturer agreeing to promptly repair or replace roofing sheet metal that shows evidence of deterioration of factory-applied finishes within 20 years from date of Substantial Completion.

D. Warranties: Standard form in which roofing Installer agrees to repair or replace sheet metal roofing that fails in materials or workmanship within 5 years from date of Substantial Completion.

E. Related Sections: 07 62 00 – Sheet Metal Flashing and Trim; 07 92 00 – Joint Sealants

PART 2 - PRODUCTS

2.01 STANDING SEAM SHEET METAL ROOFING

A. Tremco TremLock VP
   1. Factory formed double-lock, architectural standing seam metal roof panel utilizing mechanical seaming.
   2. Energy Performance of Roofing Sheet Metal: Initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC-1.
   3. 2" seam height, 16" panel width, panel length to be determined by drawings. No stiffening ribs or striations.
   4. Metallic-Coated Steel Sheet: AZ-55 Hot Dipped Galvalume structural-steel sheet, ASTM E 111-04, AZ-55; 24 ga. [0.025 in. (0.64 mm)] nominal thickness.
   5. http://www.tremcoroofing.com/fileshare/specs/TremLock_VP.pdf

2.02 ACCESSORIES

A. Panel Clips
   1. Firestone UNA-CLAD UC-6 Fixed Clip

c. http://www.firestonebpco.com/templateFiles/includes/common/displayFile.ashx?fileId=12977

B. Metal Roof Trim:
1. Firestone UNA-CLAD ACRYLUME Steel Architectural Sheet
a. Matching sheet metal roofing in finish and material required for a complete weathertight roofing system, including clips, flashings, ridge closure strips, trim, copings, fasciae, gutters, and louvers.
b. Metallic-Coated Steel Sheet: AZ-55 Hot Dipped Galvalume structural-steel sheet, ASTM E 111-04, AZ-55; 24 ga. [0.025 in. (0.64 mm)] nominal thickness.
c. Profiles to be shop fabricated to thickness, material thickness and profiles as indicated in drawings; fabricated in 10' lengths.
d. http://www.firestonebpco.com/templateFiles/includes/common/displayFile.ashx?fileId=15783

C. Roof Substrate
1. 1/2" Exterior Grade Plywood, 4' x 8' sheets

D. Self-Adhering Sheet Underlayment, High Temperature:
1. Met-Fab MetShield High Temperature Waterproof Underlayment Membrane
a. Rubberized asphalt; slip-resisting-polyethylene surfaced; with release paper backing; cold applied. Stable after testing at 250 deg F (121 deg C) and passes after testing at minus 40 deg F (-40 deg C); ASTM D 1970.
b. http://www.met-fab.com/products/metshield-waterproof-underlayment/

E. Slip Sheet: Red Rosin Building paper, 3-lb/100 sq. ft. (0.16-kg/sq. m) minimum, rosin sized.

F. Fasteners: Wood screws, annular-threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners.
1. Fasteners for Metallic-Coated Steel Sheet: Hot-dip galvanized steel or Series 300 stainless steel.

G. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.

H. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.03 FINISHES

A. Steel Architectural Sheet, AZ-55 Hot Dipped Galvalume, thickess as specified. All metal exposed to view to have Clear Organic Polymer Surface Treatment.

PART 3 - EXECUTION

3.01 FABRICATION

A. Fabricate sheet metal roofing to comply with details shown and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of installation indicated.
   1. Standing-Seam Roofing: Form standing-seam pans with finished seam height of 2 inches (38 mm) and pan width of 16 inches (406 mm).

3.02 INSTALLATION

A. Install plywood substrate in a staggered pattern and fasten to roof deck below using fasteners in quantity and pattern recommended by manufacturer.

B. Apply self-adhering sheet underlayment over entire roof area

C. Apply slip sheet over self-adhering sheet underlayment before installing metal roof panels.

D. Anchor roofing securely in place, with provisions for thermal and structural movement. Install with concealed panel clips at 16" o.c. and fasten to roof decking unless otherwise indicated.

E. Separate dissimilar metals with a bituminous coating or polymer-modified, bituminous sheet underlayment.

F. Install work with lines and corners of exposed units true and accurate. Form exposed faces flat and free of buckles, excessive waves, and avoidable tool marks, considering temper and reflectivity of metal. Provide uniform, neat seams with minimum exposure of solder and sealant. Fold back sheet metal to form a hem on concealed side of exposed edges unless otherwise indicated.

   1. Install cleats to hold sheet metal panels in position. Attach each cleat with two fasteners to prevent rotation.
   2. Nail cleats at 12 inches (300 mm) o.c.

G. Seal joints as shown and as required for leakproof construction. Provide low-slope transverse seams using cleats where backup of moisture may occur.

END OF SECTION 07 61 13

SECTION 07 62 00 – SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, Shop Drawings, Product Samples.

B. Comply with SMACNA's "Architectural Sheet Metal Manual." Conform to dimensions and profiles shown unless more stringent requirements are indicated.

C. Verify dimensions by field measurements before fabrication and indicate on Shop Drawings

D. Related Sections: 07 71 00 – ROOF SPECIALTIES; 07 92 00 – JOINT SEALANTS

PART 2 - PRODUCTS

2.01 SHEET METAL

A. Galvalume Steel Sheet: Galvalume structural-steel sheet, ASTM E111-04, AZ-55, 24 ga.; 0.025-inch (0.64-mm) nominal thickness, 26 ga.; 0.019-inch (0.48 mm) nominal thickness.

B. Galvalume Steel Sheet: Galvalume structural-steel sheet, ASTM E111-04, AZ-50, 26 ga.; 0.019-inch (0.48 mm) nominal thickness

C. Galvanized structural-steel sheet, ASTM A 653/A 653M, G90, 24 ga.; 0.025-inch (0.64-mm) nominal thickness.

D. Aluminum sheet, ASTM B209; .032 inch nominal thickness.

2.02 ACCESSORIES

A. Self-Adhering Sheet Underlayment, High Temperature: Butyl or SBS-modified asphalt; slip-resisting-polyethylene surfaced; with release paper backing; cold applied. Stable after testing at 250 deg F (121 deg C) and passes after testing at minus 40 deg F (-40 deg C); ASTM D 1970.

B. Slip Sheet: Building paper, 3-lb/100 sq. ft. (0.16-kg/sq. m) minimum, rosin sized.

C. Fasteners: Wood screws, annular-threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners.

1. Exposed Fasteners: Heads matching color of sheet metal roofing using plastic caps or factory-applied coating..
2. Fasteners for Metallic-Coated Steel Sheet: Hot-dip galvanized steel or Series 300 stainless steel.

D. Butyl Sealant: ASTM C 1311, solvent-release butyl rubber sealant.

E. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.03 FINISHES

A. Galvalume Steel Sheet – AZ-55 Galvalume Coating with Clear Organic Polymer Surface Coating

B. Galvalume Steel Sheet – bare AZ-50 Galvalume mill finish

C. Galvanized Structural-Steel Sheet – bare G90 mill finish

D. Aluminum Sheet – Kynar/Hylar 5000 pre-finished
1. Color – medium bronze

PART 3 - EXECUTION

3.01 FABRICATION

A. Fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of the item indicated.

B. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."

C. Window Sill flashing – fabricated from 26 ga. Galvalume

D. Window and door head flashing – fabricated from .032 aluminum

E. Clerestory sill flashing – fabricated from 24 ga. Galvalume

F. Receiver flashings and counter flashings – fabricated from 26 ga. Galvalume

G. Module C roof flashings - fabricated from 24 ga. Galvalume

H. Drip edges - fabricated from 26 ga. Galvalume

I. Fasciae - fabricated from 24 ga. Galvalume

J. 6” Half-Round Gutters – fabricated from 24 ga. Galvalume

K. 4” Round Downspouts - fabricated from 24 ga. Galvalume

L. Copings – fabricated from 24 ga. Galvalume

M. Concealed Cleats – fabricated from 24 ga. Galvanized

3.02 INSTALLATION

A. Comply with SMACNA's "Architectural Sheet Metal Manual." Allow for thermal expansion; set true to line and level. Install Work with laps, joints, and seams permanently watertight and weatherproof; conceal fasteners where possible.

B. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.

1. Do not solder metallic-coated steel

C. Separate dissimilar metals with a bituminous coating or polymer-modified, bituminous sheet underlayment.

D. Coordinate installation of sheet metal flashing and trim with interfacing and adjoining construction to provide a leakproof, secure, and noncorrosive installation.

E. Apply Self Adhering Sheet Underlayment over all pressure treated lumber prior to installing flashings.

END OF SECTION 07 62 00

SECTION 07 71 00 – ROOF SPECIALTIES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data and Product Samples.

B. Warranties: Provide manufacturer's standard written warranty, signed by manufacturer agreeing to promptly repair or replace roof specialties that show evidence of deterioration of factory-applied finishes within 5 years from date of Substantial Completion.

C. SPRI Wind Design Standard: Provide roof-edge flashings tested according to SPRI ES-1 and capable of resisting the following design pressures:

1. Design Pressure: ANSI/SPRI ES-1 Test Method RE-1 Test for Roof Edge Termination of Single-Ply Roofing Membranes: The fascia system shall be tested to secure the membrane to minimum 100 lbs/ft

PART 2 - PRODUCTS

2.01 ROOF SPECIALTIES

A. Bar-Type Snow Guards: Rail-type assembly consisting of two 1 inch outside diameter stainless-steel bars or pipe held in place by stainless-steel clamps attached to roof substrate through insulation.

1. Alpine Snow Guards 115R Pipe SnowGuard for Membrane Roofs with Insulation – two rail version.
    a. Snow Guard Bracket – 6000 Series Aluminum.
    b. Base Plate – 11 gage 304 stainless steel with two 5/16 inch (8 mm) 304 stainless steel machine screws welded into countersinks.
    c. Tubing - Stainless Steel – 304 alloy, 1 (25.4 mm) inch outside diameter and .120 (3 mm) inch wall thickness, welded.
    d. Couplings - Stainless Steel – 304 alloy, internal and concealed coupling 3 inches (76.2 mm) long.
    e. End Caps – 304 Stainless Steel
    f. Ferrules – 6000 Series Aluminum 1 inch (25.4 mm) o.c. 1/8 inch (3.1 mm) wall thickness x 24 inch (609.6 mm) long. Cut to length on site.
    g. http://www.alpinesnowguards.com/pdf/115r-snow-guard-spec.pdf

B. Siding Vents: heat resistant polypropylene

1. Cor-A-Vent SV-5 Siding Vent

a. ¾" x 3" x 4' heat resistant polypropylene siding vent, 8.5 sq. in. NFVA per lineal foot
b. http://www.cor-a-vent.com/siding-vent-sv-3.cfm

2.02 ACCESSORIES

A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy and temper as recommended by manufacturer for use and finish indicated.

B. Aluminum Finish: Mill finish

C. Fasteners: Manufacturer's recommended fasteners, suitable for application and designed to meet performance requirements.

1. Exposed Penetrating Fasteners: Gasketed screws with heads matching color of metal.
2. Fasteners for Aluminum: Aluminum or Series 300 stainless steel.
3. Fasteners for Zinc-Coated (Galvanized) Steel Sheet: Series 300 stainless steel or hot-dip zinc-coated steel.

D. Butyl Sealant: ASTM C 1311, solvent-release butyl rubber sealant.

E. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.03 FINISHES

A. Finish to be selected by Architect from manufacturer's full range of standard colors.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install roof specialties according to manufacturer's written instructions. Anchor roof specialties securely in place, with provisions for thermal and structural movement.

B. Coat back side of aluminum and stainless-steel roof specialties with bituminous coating where they will contact wood, ferrous metal, or cementitious construction.

C. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof specialties for waterproof performance.

D. Space movement joints at a maximum of 12 feet (3.6 m) with no joints within 24 inches (609.6 mm) of corners or intersections unless indicated.

E. Fastener Sizes: Use fasteners of sizes that will penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.

END OF SECTION 07 71 00

SECTION 07 71 00 – ROOF SPECIALTIES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data and Product Samples.

B. Warranties: Provide manufacturer's standard written warranty, signed by manufacturer agreeing to promptly repair or replace roof specialties that show evidence of deterioration of factory-applied finishes within 5 years from date of Substantial Completion.

C. SPRI Wind Design Standard: Provide roof-edge flashings tested according to SPRI ES-1 and capable of resisting the following design pressures:

1. Design Pressure: ANSI/SPRI ES-1 Test Method RE-1 Test for Roof Edge Termination of Single-Ply Roofing Membranes: The fascia system shall be tested to secure the membrane to minimum 100 lbs/ft

PART 2 - PRODUCTS

2.01 ROOF SPECIALTIES

A. Bar-Type Snow Guards: Rail-type assembly consisting of two 1 inch outside diameter stainless-steel bars or pipe held in place by stainless-steel clamps attached to roof substrate through insulation.

1. Alpine Snow Guards 115R Pipe SnowGuard for Membrane Roofs with Insulation – two rail version.
   a. Snow Guard Bracket – 6000 Series Aluminum.
   b. Base Plate – 11 gage 304 stainless steel with two 5/16 inch (8 mm) 304 stainless steel machine screws welded into countersinks.
   c. Tubing - Stainless Steel – 304 alloy, 1 (25.4 mm) inch outside diameter and .120 (3 mm) inch wall thickness, welded.
   d. Couplings - Stainless Steel – 304 alloy, internal and concealed coupling 3 inches (76.2 mm) long.
   e. End Caps – 304 Stainless Steel
   f. Ferrules – 6000 Series Aluminum 1 inch (25.4 mm) o.c. 1/8 inch (3.1 mm) wall thickness x 24 inch (609.6 mm) long. Cut to length on site.
   g. http://www.alpinesnowguards.com/pdf/115r-snow-guard-spec.pdf

B. Siding Vents: heat resistant polypropylene

1. Cor-A-Vent SV-5 Siding Vent

a. ¾” x 3” x 4’ heat resistant polypropylene siding vent, 8.5 sq. in. NFVA per lineal foot
b. http://www.cor-a-vent.com/siding-vent-sv-3.cfm

2.02 ACCESSORIES

A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy and temper as recommended by manufacturer for use and finish indicated.

B. Aluminum Finish: Mill finish

C. Fasteners: Manufacturer's recommended fasteners, suitable for application and designed to meet performance requirements.

1. Exposed Penetrating Fasteners: Gasketed screws with heads matching color of metal.
2. Fasteners for Aluminum: Aluminum or Series 300 stainless steel.
3. Fasteners for Zinc-Coated (Galvanized) Steel Sheet: Series 300 stainless steel or hot-dip zinc-coated steel.

D. Butyl Sealant: ASTM C 1311, solvent-release butyl rubber sealant.

E. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.03 FINISHES

A. Finish to be selected by Architect from manufacturer’s full range of standard colors.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install roof specialties according to manufacturer's written instructions. Anchor roof specialties securely in place, with provisions for thermal and structural movement.

B. Coat back side of aluminum and stainless-steel roof specialties with bituminous coating where they will contact wood, ferrous metal, or cementitious construction.

C. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof specialties for waterproof performance.

D. Space movement joints at a maximum of 12 feet (3.6 m) with no joints within 24 inches (609.6 mm) of corners or intersections unless indicated.

E. Fastener Sizes: Use fasteners of sizes that will penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.

END OF SECTION 07 71 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

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

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/gapscracks.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/fileshare/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 jobsrequiring 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/fileshare/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, acetoxy cure 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

SECTION 08 14 00 – WOOD DOORS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Provide doors engineered, fabricated, and installed to withstand normal thermal movement, wind loading, and impact loading without failure, as demonstrated by testing manufacturer's standard door assemblies representing types, grades, and sizes required for this Project according to test methods indicated.

B. Submittals: Product Data. Shop Drawings.

C. Standards: Performance requirements for operating force, air infiltration, water penetration, structural performance, and forced-entry resistance for doors are those specified in NWWDA I.S. 2, "Industry Standard for Wood Window Units."

D. Test Criteria: Testing shall be performed by a qualified independent testing agency based on the following criteria:
   1. Design wind velocity at Project site is 60 mph.
   2. Test Procedures: Test door units according to ASTM E 283 for air infiltration, ASTM E 547 for water penetration, and ASTM E 330 for structural performance.

E. Performance Requirements: Testing shall demonstrate compliance with requirements indicated in NWWDA I.S. 2 for water penetration and structural performance for the type and performance grade of window and door units required. Where required design pressure exceeds the minimum for the specified window grade, comply with requirements of NWWDA I.S. 2, Article 6, "Optional Performance Classifications," for higher than minimum performance grades.
   1. Air-Infiltration Rate for Doors: Not more than 0.15 cfm/sq. ft. for an inward test pressure of 1.57 lbf/sq. ft. (75 Pa).
   2. Water Penetration for Doors: No water penetration as defined in the test method at a static pressure of 4.16 p.s.f. after 15 minutes with water applied at a rate of five gallons per hour per square foot.
   3. Structural Performance: No failure or permanent deflection in excess of 0.4 percent of any member's span after removing the imposed load, for a positive (inward) and negative (outward) test pressure of 22.5 lbf/sq. ft. (1077 Pa).

PART 2 - PRODUCTS

2.01 WOODEN EXTERIOR DOORS

A. Loewen Windows and Doors
1. Description: Swinging French Terrace, Heat Smart X, Clear Finish exterior, Vertical Grain Douglas Fir with Clear Finish, ADA Compliant Flat Thresholds, Manual Multi-Point Locking hardware, Clear Tempered Glass.
2. Item Numbers: FD2 2224 LRA, FD2 1824 LRA, and FD2 1520 LRA
3. http://www.loewen.com/sites/default/loewen/downloads/TechGuide/TG-TerraceDoor.pdf

B. Custom Manufactured Doors
1. Description: French Outswing Solid Wood Doors, Vertical Grain Douglas Fir with Clear Finish, Manual Multi-Point Locking hardware

2.02 EXTERIOR DOOR HARDWARE

A. Provide manufacturer's standard hardware necessary to operate, tightly close, limit travel, and to securely doors. Do not use aluminum in frictional contact with other metals.
1. Provide hardware with a special coating finish and plated steel or brass/bronze operating bars and rods in finish as selected by Architect.

2. Handles and escutcheon plates: Active handle, inactive handle, interior and exterior escutcheon plates currently specified as brushed chrome.

B. Gaskets: Black Neoprene
C. Locking hardware shall have a 1 inch (25 mm) throw deadbolt with Schlage key lock cylinder. Color: Brushed aluminum.
D. All components are corrosion resistant.
E. Five Point locking system on primary active panels of high performance units. Stainless steel.
F. Head and sill strike plates to be made of aluminum. Color: brushed aluminum with aluminum strike.
G. Two Point flush bolt on secondary active panel. Top and bottom threaded shoot rods are made of steel and die cast parts. Level face plate has a lacquer-coated Bright Brass finish. Head and sill strike plates are made of Light Bronze anodized aluminum.
H. Commercial grade hinges, 4-1/2" x 4-1/2" ball bearing square corner with non-removable pin in satin nickel finish.
I. Weatherstripping to meet manufacturer's standards for performance.

2.01 WOODEN INTERIOR DOORS

A. Custom Manufactured Doors

1. Interior Doors to be both track-mounted sliding and hinged outswing. Door hardware to be purchased from Grant Hardware distributor, door structure to be of standard birch or maple veneer type.

2.02 INTERIOR DOOR HARDWARE

A. Grant Hardware
1. Top Line Grant 71-034 Hardware Set for Sliding Door
2. Wing Line Grant 1260 Series for Folding Doors
3. Grant Single Track 7001 Aluminum Extruded

2.03 EXTERIOR WOODEN DOORS FOR SUN SHADING

A. Manufacturers
1. Custom shop production based on shop drawings and field measurements

B. Description
1. Exterior wooden screen to be constructed from solid wood stiles and rails and louvers.

2.04 EXTERIOR SUN SHADING DOOR HARDWARE

A. Grant Hardware
1. Wing Line Grant 1260 Series for Bi-Fold Doors
2. Grant Single Track 7001 Aluminum Extruded

2.05 MATERIALS

A. Wooden Framing Systems – Douglas Fir

B. Glass and Glazing Materials
1. General: Provide manufacturer's standard 5/8" Argon filled Low-E sealed clear insulating glass units complying with the following minimum requirements:
2. Provide tempered or laminated glass insulated units for all locations.
   a. Indoor Lite: Type I (transparent glass, flat), Class 1 (clear) float glass.
   b. Outdoor Lite: Type I (transparent glass, flat), Class 1 (clear) float glass.
   c. Total Unit “U” Factor: 0.29
   d. Solar Heat Gain Coefficient: .40
3. Glazing Seal: Provide manufacturer's standard extruded, vinyl, or butyl glazing gasket providing weather-tight seal.
4. Safety Glazing: Provide tempered or laminated glass insulating units at doors and other locations immediately adjacent to doors and walking paths.

2.06 FINISHES
1. Clear Coat on Douglas Fir Frame

2. Handles and Hinges: Satin Nickel Finish
3. ADA Threshold: Bronze Anodized Aluminum
4. Glass: Clear Tempered Glass
5. See 09 93 13 - EXTERIOR STAINING AND FINISHING

PART 3 - EXECUTION

3.01 FABRICATION

A. General: Fabricate wood door units to comply with indicated standards. Include a complete system for assembly of components and anchorage of door units.
   1. Comply with requirements of NWWDA I.S. 2 , I.S. 610, and I.S. 620 for moisture content of lumber at time of fabrication.
   2. Fabricate doors to produce units that are reglazable without dismantling sash framing. Provide openings and mortises precut, where possible, to receive hardware and other items.

B. Factory-Glazed Door Units: Except for light sizes in excess of 100 united inches (2500 mm width plus length), glaze window and door units in the shop before delivery, unless factory glazing is not available from manufacturer. Comply with requirements of NWWDA I.S. 2.

C. Complete fabrication, assembly, finishing, hardware application, and other work before shipment to the Project site, to the maximum extent possible. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

3.02 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in 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.

C. Fasten door frames securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

D. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

E. Correct deficiencies in or remove and reinstall doors, glazing, or hardware that does not comply with requirements.

F. Repair, refinish, or replace doors damaged during installation, as directed by Architect.

G. Adjust operating parts and hardware for smooth, quiet operation and weathertight closure. Lubricate hardware and moving parts.

END OF SECTION 08 14 00

SECTION 08 45 00 – TRANSLUCENT WALL AND ROOF ASSEMBLIES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Design, engineer, fabricate, and install translucent wall panels to withstand structural loads required by local codes.

B. Submittals: Product Data.

C. Design Loads: Framing components shall be designed to support following loads:
1. Live Load
   a. 3 psf
   b. As indicated on the drawings
2. Wind Load
   a. 90 mph per ICC maps
3. Deflection of a Framing Member in a Direction Normal to Plane of Glazing: Shall not exceed L/100.
4. Safety Factors: Allowable Stresses shall incorporate following safety factors, unless otherwise specified:
   a. Load Carrying Members: 1.65
   b. Load Carrying Fasteners: 2.0

D. Warranties
1. Major warranties the merchandise to be equal to its established standards of manufacture as to material and workmanship.

PART 2 - PRODUCTS

2.01 TRANSLUCENT WALL PANEL SYSTEMS

A. Major Industries
1. Description: Fiberglass translucent panels set into thermally broken aluminum vertical-lite framing system for higher U-value performance. Wall panel thickness of 2.75," panel lengths and widths vary per design specifications. Meets testing and certification criteria per ASTM, AAMA, ICC, and NFRC agencies.
2. Guardian 275 Wall Panel System
3. http://www.majorskylights.com/products/guardian/

2.02 FINISHES

A. Glazing: White/White .070" Ultimate Series "Silver Edition"

B. Frame: 70% Kynar Standard Black

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in translucent wall panel 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.

C. Framing: size framing and blocking in accordance with load-bearing requirements and manufacturer specifications. Install manufacturer framing assembly per manufacturer specifications.

D. Fasten translucent wall panel securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

E. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

F. Correct deficiencies in or remove and reinstall translucent wall panels that do not comply with requirements.

G. Repair, refinish, or replace wall panels and framing assembly damaged during installation, as directed by Architect.

END OF SECTION 08 45 00

SECTION 08 50 00 – WINDOWS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Provide wood windows engineered, fabricated, and installed to withstand normal thermal movement, wind loading, and impact loading without failure, as demonstrated by testing manufacturer's standard window and door assemblies representing types, grades, and sizes required for this Project according to test methods indicated.

B. Submittals: Product Data. Shop Drawings

C. Standards: Performance requirements for operating force, air infiltration, water penetration, structural performance, and forced-entry resistance for wood windows are those specified in NWWDA I.S. 2, "Industry Standard for Wood Window Units."

D. Test Criteria: Testing shall be performed by a qualified independent testing agency based on the following criteria:
   1. Design wind velocity at Project site is 60 mph.
   2. Test Procedures: Test window units according to ASTM E 283 for air infiltration, ASTM E 547 for water penetration, and ASTM E 330 for structural performance.

E. Performance Requirements: Testing shall demonstrate compliance with requirements indicated in NWWDA I.S. 2 for water penetration, and structural performance for the type and performance grade of window units required. Where required design pressure exceeds the minimum for the specified window grade, comply with requirements of NWWDA I.S. 2, Article 6, "Optional Performance Classifications," for higher than minimum performance grades.
   1. Air-Infiltration Rate for Windows: Not more than 0.05 cfm/sq. ft. for an inward test pressure of 6.24 lbf/sq. ft. (295 Pa).
   2. Water Penetration for Windows: No water penetration as defined in the test method at a static pressure of 12 p.s.f. after 15 minutes with water applied at a rate of five gallons per hour per square foot.
   3. Structural Performance: No failure or permanent deflection in excess of 0.4 percent of any member's span after removing the imposed load, for a positive (inward) and negative (outward) test pressure of 22.5 lbf/sq. ft. (1077 Pa).

PART 2 - PRODUCTS

2.01 DOUGLAS FIR WINDOWS

A. Loewen Windows and Doors
1. Description and Operation
a. Fabricate windows to produce units that are reglazible without dismantling sash framing. Provide openings and mortises precut, where possible, to receive hardware and other items
b. Window Types: As indicated on drawings
1) Wood Casement, Operable
2) Wood Picture
3) Wood Awning
c. Performance Grades and Class: LC 25
d. Condensation Resistance Factor (CRF): Provide wood windows tested for thermal performance according to AAMA 15001, showing CRF of 45 minimum.
2. Window Models
a. Casement: CA1 0815 L
b. Picture: PS1 1824
c. Awning: AW1 0809
3. http://www.loewen.com/windows/windowStyles/casement/relatedLinks/DouglasFir/index.html

2.02 FINISHES

A. Frame: Clear Coat on Douglas Fir Vertical Grain

B. Hardware: Satin Nickel

C. Glazing: Clear Finish

PART 3 - EXECUTION

3.01 FABRICATION

A. General: Fabricate wood window units to comply with indicated standards. Include a complete system for assembly of components and anchorage of window and door units.
1. Comply with requirements of NWWDA I.S. 2 , I.S. 610, and I.S. 620 for moisture content of lumber at time of fabrication.
2. Fabricate.

B. Provide weather stripping at perimeter of each operating sash.

C. Factory-Glazed Window and Door Units: Except for light sizes in excess of 100 united inches (2500 mm width plus length), glaze window and door units in the shop before delivery, unless factory glazing is not available from manufacturer. Comply with requirements of NWWDA I.S. 2.

D. Complete fabrication, assembly, finishing, hardware application, and other work before shipment to the Project site, to the maximum extent possible. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

E. Mullions: Provide mullions and cover plates as shown, matching window units, complete with anchors for support to structure and installation of window units. Allow for erection tolerances and provide for movement of window units due to thermal expansion and building deflections, as indicated. Provide mullion and cover plates capable of withstanding design loads of window units.

3.02 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in 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.

C. Fasten door and window frames securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

D. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

E. Correct deficiencies in or remove and reinstall windows, doors, glazing, or hardware that does not comply with requirements.

F. Repair, refinish, or replace windows and doors damaged during installation, as directed by Architect.

G. Adjust operating parts and hardware for smooth, quiet operation and weathertight closure. Lubricate hardware and moving parts.

END OF SECTION 08 50 00

SECTION 08 95 16 – WALL VENTS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. American Society for Testing and Materials (ASTM) Publications:
1. ASTM B26 – Aluminum-Alloy Sand Castings.
2. ASTM B85 – Aluminum-Alloy Die Castings.

PART 2 - PRODUCTS

2.01 WALL VENTS

A. Seiho
1. Material: Aluminum; Finish: Anodized; Mounting: Flush
2. Seiho SX-N 6 Aluminum Vent Caps and Seiho SB Dryer Vent
3. http://www.seiho.com/pdf/submittal/sb.pdf; http://www.seiho.com/pdf/submittal/sx.pdf

B. Type: Anodized aluminum, fixed louver wall vent with insect screen and operable hinged flap type damper.

C. Nominal vent size: 3 inches deep with 8 inch diameter.

D. Construction: Framed vent with overlapping lover blades fabricated as cast aluminum unit.
1. Louver blades: fixed, horizontal blades deep set at 45 degrees.
2. Top frame: Flat surface with toe drip on front edge.
3. Bottom Frame: Flat surface with back water stop and front drip edge.

E. Insect Screen: Mesh aluminum screen riveted to vent behind louvers.

2.02 MATERIALS

A. Description: Anodized aluminum wall vents with fixed louvers, backdraft preventer, and insect screens for installation in wood frame exterior wall, to provide ventilation for mechanical spaces and dryer exhaust.

B. Aluminum castings: ¼” minimum thickness cast aluminum complying with ASTM B26 or ASTM B85, Alloy No. 319

C. Fasteners: Type, size, and spacing as recommended by vent manufacturer for project conditions.

D. Joint sealants as recommended by vent manufacturer.

2.03 FINISHES

A. Wall vent finish: anodized aluminum.

PART 3 - EXECUTION

3.01 COORDINATION

A. Coordinate supply of vents with construction of walls to ensure proper sizing and placement of vent openings.

3.02 INSTALLATION

A. Install vents and dampers in accordance with manufacturer’s installation instructions and approved shop drawings.

B. Do not install bent, scratched, or otherwise damaged vents. Remove damaged components from site and replace

C. Install vents secure, level, plumb, and flush with wall surface.

3.03 CLEANING

A. Remove excess sealant by moderate use of mineral spirits or other solvent acceptable to sealant manufacturer.

B. Wash exposed surfaces with solution of mild detergent applied with soft cloth. Take care to remove dirt from corners. Wipe surfaces clean.

END OF SECTION 08 95 16

SECTION 09 29 00 - GYPSUM BOARD

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Product Certificate for GREENGUARD Indoor Air Quality for products and materials required to comply with requirements for minimum chemical emission.

C. ASTM C 1396 standards applicable.

PART 2 - PRODUCTS

2.01 GYPSUM BOARD

A. STANDARD GYPSUM BOARD
1. Core: Regular
2. Surface Paper: 100% recycled content paper on front, back and long edges.
3. Long Edges: Square.
4. Overall thickness: 1/2 inch.

B. MOLD AND MOISTURE RESISTANT GYPSUM BOARD
1. Core: Mold and moisture resistant gypsum core
2. Surface paper: 100% recycled content moisture/mold/mildew resistant paper on front, back, and long edges
3. Long Edges: square
4. Overall thickness: 5/8 inch
5. Mold/Mildew Resistance: 10 when tested in accordance with ASTM D 3273 Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber
6. Environmental Requirements: Provide products that comply with testing and product requirements for low emitting materials

2.02 TILE BACKER BOARD

A. CEMENTITIOUS BACKER BOARD
1. Panel of lightweight concrete core with coated glass fiber mesh reinforcement and high-density Portland cement surface. Long Edges: square
2. ASTM C1325 or ANSI A118.9 compliant
3. Overall thickness: 1/2 inch

B. ACCESSORY PRODUCTS
1. Tape:

a. Paper Tape: 2-1/16 inches wide
b. Paper Tape: 2 inches wide with metal strips laminated along the center crease to form inside and outside corners
c. Fiberglass Tape: Nominal 2 inches wide self adhering tape

2. Trims and Beads: Material: Zinc-coated steel; 26 gauge minimum, ASTM C10472
   a. Corner Bead: Use at outside corners
   b. Control Joint: Use where indicated and specified
   c. J-Bead: Use where indicated and specified

3. Drying Type Compound:
   a. Ready Mix vinyl base compound.
   b. Ready Mix vinyl base compound formulated for enhanced mold and mildew resistance.
   c. Ready Mix vinyl base compound formulated to reduce airborne dust during sanding.
   d. Ready Mix vinyl base topping compound for finish coating.
   e. Ready Mix vinyl base compound for embedding joint tape, cornerbeads or other accessories.
   f. Field Mix vinyl base compound.

4. Setting Compound:
   a. Field mixed hardening compound.
   b. Field mixed hardening compound for fire resistance rated construction and penetrations.

PART 3 - EXECUTION

3.01 INSTALLATION: GYPSUM BOARD

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in gypsum board manufacturer's written instructions.
   1. Single Layer - 5-1/2 inch wood stud construction.
      a. Apply 1/2 inch, Gypsum Panel to each side of wood studs.
      b. Space screws 16” (400 mm) o.c. in field and along abutting end joints. Parallel application, space screws 16” (400 mm) o.c. in field of panels and along vertical abutting edges.

3.02 INSTALLATION: TILE BACKER BOARD

A. Cementitious backer board shall be used as a base on walls for thin set application of ceramic tile, plastic tile, and natural stone tile in areas defined as wet areas.

B. Fasten backer boards to framing members with screws 8” (200 mm) o.c. Perimeter fasteners to be at least 3/8” (10 mm) and less than 5/8” (16 mm) from ends and edges.

END OF SECTION 09 29 00

SECTION 09 30 13 - CERAMIC TILING

PART 1 - GENERAL

1.01 SUBMITTALS

A. Product Data. Product Samples.

PART 2 - PRODUCTS

2.01 PORCELAIN TILE

A. Manufacturer: Emil Ceremica

B. Product line: Fashion

C. Size: nominal 6" x 24" rectangular, cut to nominal 3" x 24"

D. Thickness: 3/8"

E. Color/Finish: Minimal

F. Factory Blending: For tile exhibiting color variations within ranges selected during sample submittals, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved samples.

G. http://www.emilamerica.com/CM/EmilProducts.aspx?ModuleId=23

2.02 SETTING AND GROUTING MATERIALS

A. REQUIREMENTS
1. Select materials which are rated as low-VOC.
2. Verify that setting and grouting materials are compatible with tile and adjacent membranes and materials.
3. Verify that setting and grouting materials are approved by tile manufacturer.

B. MATERIALS
1. Thin Set Mortar
   a. Portland Cement – ASTM C150, Type 1
   b. Hydrated Lime – ASTM C207, Type S
   c. Sand – ASTM C144
   d. Latex additive : as approved
   e. Water: clean and potable.
2. Polymer modified cement grout, sanded or unsanded, as specified in ANSI A118.7

a. Color as specified by Architect from manufacturer's full range of available colors.

3. Silicone sealant : moisture and mildew resistant type.
   a. Color as specified by Architect from manufacturer's full range of products.
4. Slate Sealer : Clear penetrating type, matte finish.

2.03 DECOUPLING MEMBRANE

A. PRODUCTS & MANUFACTURERS
1. DTIRA – Schuter Systems
2. ANSI A118.10
3. Thickness: 1/8"
4. Material: high-density polyethylene membrane with a grid structure of 1/2" x 1/2" square cavities each cut back in a dovetail configuration, and a polypropylene anchoring fleece laminated to its underside

2.04 WATERPROOF MEMBRANE

A. APPROVED PRODUCTS & MANUFACTURERS
1. KERDI - Schlüter Systems
2. ANSI A118.10
3. Description: 0.008" thick, orange polyethylene membrane, with polypropylene fleece laminated on both sides

2.05 SHOWER WATERPROOFING SYSTEM

A. APPROVED PRODUCTS & MANUFACTURERS
1. KERDI-DRAIN-SHOWER ST/SC - Schlüter Systems
2. Thickness : 0.008"
3. Description : orange polyethylene membrane, with polypropylene fleece laminated on both sides

2.08 THRESHOLD STRIPS

A. APPROVED PRODUCTS & MANUFACTURERS
1. Metal edging strips by Schluter Systems.
2. Profile as selected by Architect

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that substrate is clean and free of debris and surface contaminants.

3.02 INSTALLATION

A. GENERAL REQUIREMENTS:

1. Comply with manufacturer’s instructions for installation of each material needed as well as ANSI and TCNA requirements. Installation of tile shall be in compliance with requirements as set forth in TCNA *Handbook for Ceramic Tile Installation*.
2. Structure Supported Floors: Thin set; TCNA F148
3. Walls : Cementitious Backer Board: Thin set; TCNA W244
4. Thresholds: TCNA TH611
5. Accurately form intersections and returns. Carefully grind edges of tile abutting trim, finish or built in items. Fit tile closely to outlets, piping and other penetration so that plates, collars, or covers overlap tile.
6. Lay tile in patterns as indicated on Drawings. Align joints when adjoining tiles on floor, base, walls and trim are same size.
7. Layout tile work and center tile sites in both directions in each space or on each wall area. Adjust to minimize tile cutting to avoid tiles less than one half size.
8. Provide uniform joint widths as recommended by tile manufacturer.
9. Unless otherwise specifically indicated, trowel patterns, regardless of depth, shall be square-notched and not “v” or rounded type.
10. Where tile abuts softer flooring materials, provide metal edge protection device to help prevent edge chipping caused by impact.

END OF SECTION 09 30 13

SECTION 09 64 19 - WOOD COMPOSITION FLOORING

PART 1 - GENERAL

1.01 QUALITY ASSURANCE

A. Installer Qualifications: Company or person specializing in performing the work of this section with minimum 10 years experience.

B. Quality Assurance Submittals: Submit manufacturer’s installation procedures that shall be basis for accepting or rejecting actual installation procedures.

1.02 SECTION REQUIRMENTS

A. Submittals: Product Data. Samples not less than 12” x 12”.

1.03 PROJECT CONDITIONS

A. Materials shall be delivered to Project in advance of installation to permit moisture content to stabilize to ambient conditions.

B. Do not install engineered wood flooring until wet construction activities are completed and ambient air at installation space has moisture content stabilized.

C. Maintain a minimum room temperature of 65°F for a period starting 7 days prior to delivery of materials to after installation.

D. Deliver and store products in manufacturer's unopened packaging until ready for installation. Boxes should be stored in protected and dry place.

PART 2 - PRODUCTS

2.01 WOOD FLOORING

A. Manufacturer: Oregon Lumber Company

B. Bellagio Microline White Oak-Fumed
   1. Description: Engineered multi-ply laminated construction using non-formaldehyde laminating adhesive
   2. Planks shall meet or exceed Hardwood Plywood Veneer Association (HPVA) Type II bond test
   3. Species/Color/Finish/Pattern: Fumed White Oak with UV Polyurethane Finish
   4. Width: 7” tongue and groove

5. Length: random lengths up to 86.6”
6. Thickness: 3-ply, 9/16” minimum
7. Wear-layer: 3 mm
8. Installation: Glue
9. http://www.oregonlumber.com/engineered-and-solid-engineered/bellagio-microline-56-engineered

2.02 ACCESSORY MATERIALS

A. Adhesives: Water resistive, formaldehyde-free type as recommended by flooring manufacturer. VOC Content: Not more than 100 g/L when calculated according to CFR 40, Part 59, Subpart D (EPA Method 24)

B. Fasteners: As recommended by manufacturer, but not less than that recommended in NWFA's "Installation Guidelines: Wood Flooring."

C. Sub-Floor Filler: Latex cement patching compound

D. Rosin paper, as recommended by manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All sub-floors must be clean, level, and dry. Scrape and smooth any debris off of the surface. Sand high areas or joints. Fill lower areas and cracks with proper compound.

B. Open box just before installation. Each floor board must be properly checked before installation. Never install damaged boards.

C. Color variation in boards may occur. It is recommended to work out of several boxes at once to create a color blend and balanced appearance of the boards.

D. Always begin installation with the groove side of the floorboard facing to the closest wall.

E. Allow a minimum ½” distance between flooring edges and the wall on all sides to accommodate for any expansions. Use temporary spacing wedges for this purpose. Remember to remove all spacing wedges once installation is complete.

F. Place floorboards alongside each other staggering their joints at least 20” apart.

G. Refer to manufactures instructions for specific steps related to floating, glue-down or nail down installation. http://www.oregonlumber.com/sites/default/files/downloads/Bellagio%20Installation%20101705.pdf

END OF SECTION 09 64 19

SECTION 09 91 23 – INTERIOR PAINTING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals:

1. Product Data. Include printout of MPI's "MPI Approved Products List" with product highlighted.
2. Samples.

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

C. Extra Materials: Deliver to Owner 1 gal. of each color and type of finish coat paint used on Project, in containers, properly labeled and sealed.

D. Compliance:
1. Product complies with MPI standards, indicated and listed in "MPI Approved Products List."
2. Interior paints and coatings shall comply with the following limits for VOC content:
    a. Flat Paints and Coatings: 50 g/L.
    b. Nonflat Paints, Coatings: 50 g/L.
    c. Primers, Sealers, and Undercoaters: 100 g/L.
    d. Pretreatment Wash Primers: 300 g/L.

PART 2 - PRODUCTS

2.01 PAINTS

A. Primer
1. Benjamin Moore & Co. Classic Colors (Pristine® Eco-Spec®)
2. Paint Line: Natura Paints

B. Wall Paint
1. Benjamin Moore & Co. Classic Colors (Pristine® Eco-Spec®)
2. Paint Line: Natura Paints
3. Color: No. 970, “White Down” (Eggshell)
4. Description: off-white, premium-quality, odorless, zero-VOC paint,
5. Resin Type: 100% Acrylic Latex
6. <http://www.benjaminmoore.com/en-us/for-architects-and-designers/natura-interior-waterborne-paint-eggshell-513>

C. Gabel Wall Paint

1. Benjamin Moore & Co. Classic Colors (Pristine® Eco-Spec®)
2. Paint Line: Natura Paints
3. Color: No. 971, “Olympic mountains” (Flat)
4. Description: off-white, premium-quality, odorless, zero-VOC paint
5. Resin Type: 100% Acrylic Latex
6. <http://www.benjaminmoore.com/en-us/for-architects-and-designers/natura-interior-waterborne-paint-flat-512>

D. Ceiling Paint
   1. Benjamin Moore & Co. Classic Colors (Pristine® Eco-Spec®)
   2. Paint Line: Natura Paints
   3. Color: No. 971, “Olympic mountains” (Flat)
   4. Description: off-white, premium-quality, odorless, zero-VOC paint
   5. Resin Type: 100% Acrylic Latex
   6. <http://www.benjaminmoore.com/en-us/for-architects-and-designers/natura-interior-waterborne-paint-flat-512>

E. Material Compatibility:
   1. Materials are compatible with one another and with substrates.

PART 3 - EXECUTION

3.01 PREPARATION

A. Comply with recommendations in MPI's "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

B. Remove hardware, lighting fixtures, and similar items that are not to be painted. Mask items that cannot be removed. Reinstall items in each area after painting is complete.

C. Clean and prepare surfaces before beginning painting in that area. Schedule painting so cleaning operations will not damage newly painted surfaces.

3.02 APPLICATION

A. Comply with recommendations in MPI's "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

B. Paint exposed surfaces, new and existing, unless otherwise indicated.
   1. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces.
   2. Paint surfaces behind permanently fixed equipment or furniture with prime coat only.
   3. Paint the back side of access panels.
   4. Color-code mechanical piping in accessible ceiling spaces.
   5. Do not paint prefinished items, items with an integral finish, operating parts, and labels unless otherwise indicated.

C. Apply paints according to manufacturer's written instructions.
   1. Use rollers for finish coat on interior walls and ceilings except where impractical.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
   1. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

END OF SECTION 09 91 23

SECTION 09 93 13 – EXTERIOR STAINING AND FINISHING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Submittal: Product Data. Selection Samples. Verification Samples.

B. Quality Assurance
   1. Installer qualifications: A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.
   2. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship. Provide samples that designate primer and finish coats.

C. Project Conditions
   1. 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.

D. Extra Materials
   1. Furnish one percent of each material and color to the Owner, but not less than 1 gal (3.8 l) or 1 case, as appropriate.

PART 2 - PRODUCTS

2.01 STAINS

A. Siding & Decking Stain
   1. Materials: wood siding (poplar), railings (poplar), and decking (ash)
   2. Manufacturer: Sikkins
   3. Stain: Cetol Water based SRD translucent wood finish
      a. Finish: Clear, No. SIK77000
      b. Color: Natural, No.78
      c. Coats: 2
      d. Description: contains an optimal amount of translucent iron oxide pigments and UV light stabilizers
      e. http://www.sikkens.us/en/Products/Exteriors/Pages/CetolWBSRD.aspx

B. Rafters & Roof Decking Stain
   1. Materials: Southern Yellow Pine, tongue & groove lock deck
   2. Manufacturer: Sikkins
   3. Stain: Cetol Water based SRD translucent wood finish

a. Finish: Clear, No. SIK77000
b. Color: Butternut, No.072
c. Coats: 2
d. <http://www.sikkens.us/en/Products/Exteriors/Pages/CetolWBSRD.aspx>

C. Door and Window (Doug Fir) Exterior Stain
1. Materials: Douglas Fir
2. Manufacturer: ZAR
3. Stain: Ultra Exterior Oil-Based Fast Drying Polyurethane
a. Finish: Clear Satin
b. Coats: 3
c. http://www.ugl.com/zarWoodFinishing/zarExteriorPolyurethane/zarUltraExteriorPoly.php

PART 3 - EXECUTION

3.01 EXAMINATION

A. Do not begin installation until substrates have been properly prepared; notify Architect of unsatisfactory conditions before proceeding. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

B. Proceed with work only after conditions have been corrected and approved by all parties, otherwise application of coatings will be considered as an acceptance of surface conditions.

3.02 SURFACE PREPARATION

A. General: Surfaces shall be dry and in sound condition. Remove oil, dust, dirt, loose rust, peeling paint or other contamination to ensure good adhesion.

3.03 INSTALLATION

A. Apply all coatings and materials with manufacture specifications in mind. Mix and thin coatings according to manufacturer's recommendations.

B. Do not apply to wet or damp surfaces.

C. Apply coatings using methods recommended by manufacturer.

D. Uniformly apply coatings without runs, drips, or sags, without brush marks, and with consistent sheen.

E. The coated surface must be inspected and approved by the Architect immediately prior to each coat.

3.04 PROTECTION

A. Protect finished coatings from damage until completion of project.

B. Touch-up damaged coatings after substantial completion, following manufacturer's recommendation for touch up or repair of damaged coatings. Repair any defects that will hinder the performance of the coatings.

END OF SECTION 09 93 13

SECTION 09 93 23 – INTERIOR STAINING AND FINISHING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product data. Selection Samples. Verification Samples.

PART 2 - PRODUCTS

2.01 STAINS AND FINSHES

A. Door and Window Interior Stain
   1. ZAR Ultra Max Waterborne Oil Modified Polyurethane
   2. Satin Finish
   3. http://www.ugl.com/zarWoodFinishing/zarInteriorPolyurethane/zarUltraMax.php

B. Interior Trim and Casework
   1. ZAR Ultra Max Waterborne Oil Modified Polyurethane
   2. Satin Finish
   3. http://www.ugl.com/zarWoodFinishing/zarInteriorPolyurethane/zarUltraMax.php

C. Rafters
   1. General Finishes Water-Based Stain
   2. Color: Butternut

D. Casework
   1. Stains
      a. General Finishes Water-Based Whitewash
      b. Minwax Gel Stain
         1) Honey Maple 604
   2. Topcoat
      a. General Finishes High Performance Water-Based Topcoat
      b. Satin Finish
      c. Color: Clear

E. Baseboard
   1. Benjamin Moore
   2. Line: Neutra
   3. Finish: Semi-gloss
   4. Color: Black Beauty

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrates by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in manufacturer's written instructions.

B. Remove or protect hardware, electrical equipment plates, mechanical grilles and louvers, lighting fixture trim, and other items not indicated to receive coatings that are adjacent to surfaces to receive coatings.

C. Prepare surfaces in compliance with manufacturer’s instructions for specified coatings and indicated materials, using only methods and materials recommended by coating manufacturer.

D. Surfaces shall be clean, dry, sound, and adequately profiled prior to application of coating systems.

E. Sand wood surfaces and edges smooth and even before finishing. Remove dust after sanding.

F. Countersink nails and fill nail holes, cracks, open joints and other defects with tinted putty or wood filler.

G. Apply coating systems in compliance with manufacturer’s instructions and using application method best suited for obtaining full, uniform coverage of surfaces to be coated.

H. Apply each coat to uniform coating thickness not exceeding manufacturer’s specified maximum spread rate for indicated surface; thins, brush marks, roller marks, orange-peel, or other application imperfections are not acceptable.

I. Make edges of finish application adjoining other materials sharp and clean, without overlapping.

J. Finish tops, bottoms and edges of doors same as faces of doors.

K. Finish all cut ends and backs of exterior siding before installation; apply second coat after installation.

L. Correct deficiencies in or remove and re-apply product that does not comply with requirements.

END OF SECTION 09 93 23

SECTION 10 28 16.13 – RESIDENTIAL BATH ACCESSORIES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. ASTM A, B, & C standards applicable.

PART 2 - PRODUCTS

2.01 TOILET TISSUE DISPENSER

A. Toto Soiree Toilet Paper Holder
1. Model No: YP960#CP
2. Type: Single-roll dispenser
3. Mounting: Surface mounted with concealed anchorage
4. Material/Finish: Polished Chrome
5. Shipping Dimensions: 7-3/4"L x 5-1/4"W x 4-1/2"D
6. Capacity**:** Designed for 4-1/2- or 5-inch- (114- or 127-mm-) diameter-core tissue rolls
7. <http://www.totousa.com/Default.aspx?TabId=75&ProductId=4457f979-1bf5-4332-8a85-bd91d12d82c7&SearchId=c679ed34-66b8-4396-a246-b8ffae20afc2&PTab=0&STab=0>

2.02 MIRROR UNIT

A. Pegasus Jameson 20 in. x 26 in. Rectangular Mirror
1. Frame: Brushed nickel, adjustable tilt
2. Manufacturer Model # : 130-26-121-25
3. Manufacturer Part # : 130-26-121-25
4. <http://www.homedepot.com/webapp/wcs/stores/servlet/ProductDisplay?storeId=10051&productId=202075100&langId=-1&catalogId=10053&N=10000003%2090043%20524255%201471>

2.03 ROBE HOOK

A. Toto Soiree Robe Hook
1. Model No: YH960#CP
2. Material/Finish: Polished Chrome
3. Shipping Dimensions: 6-1/2"L x 5-3/4"W x 2-3/4"D

4. <http://www.totousa.com/Default.aspx?TabId=75&ProductId=6b1fe419-9a92-48d8-a80d-642e3321d2f2&SearchId=c679ed34-66b8-4396-a246-b8ffae20afc2&PTab=0&STab=0>

2.04 TOWEL BAR

A. Toto Soiree Towel Bar
   1. Model No: YB960#CP
   2. Material/Finish: Polished Chrome
   3. Mounting: Flanges with concealed fasteners.
   4. Shipping Weight: 2.0 lbs
   5. Shipping Dimensions: 26-1/2"L x 4-3/4"W x 2-3/4"D
   6. Install Length: 25.4 inches
   7. <http://www.totousa.com/Default.aspx?TabId=75&ProductId=81eb2e34-1ab8-47f8-bb82-6df6d7a93e13&SearchId=c679ed34-66b8-4396-a246-b8ffae20afc2&PTab=0&STab=0>

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install accessories using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated in drawings.

   1. Install grab bars to withstand a downward load of at least 250 lbf (1112 N), when tested according to method in ASTM F 446.

B. Adjust accessories for unencumbered, smooth operation and verify that mechanisms function properly. Replace damaged or defective items. Remove temporary labels and protective coatings.

C. Repair, refinish, or replace finishes damaged during installation or transit, as directed by Architect.

END OF SECTION 10 28 16.13

SECTION 11 30 00 - RESIDENTIAL EQUIPMENT

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 CEILING FAN

A. Modern Fan Company

B. Product Name: Lapa

C. Finish: Bright Nickel

D. Blade length: 42”

E. Blade color: Nickel

F. No light

G. http://www.modernfan.com/pdf/lapa_cutsheet.pdf

2.02 ACCESSORIES

A. Downrod
   1. Use appropriate length downrod to have blade height at 8’-0” above finished floor.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install per manufacturer’s instructions.

END OF SECTION 11 30 00

SECTION 11 31 13 - RESIDENTIAL KITCHEN APPLIANCES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Regulatory Requirements: Comply with provisions of the following product certifications:

1. 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.
2. 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.
3. NAECA: Provide residential appliances that comply with NAECA standards.

PART 2 - PRODUCTS

2.01 ELECTRIC COOKTOP

A. Miele Touch Control Induction Cooktop

B. Product Number: KM5753

C. Dimensions: 31-1/4" x 20-1/4"

D. Finish: Stainless steel

E. http://www.mieleusa.com/pdf/cooktops/KM5753.pdf

F. http://www.mieleusa.com/manuals_pdf/Residential/Cooktops/English_manuals/Operating_instructions/KM5753_5758_us.pdf

2.02 ELECTRIC WALL OVEN

A. Miele Combination Microwave Oven

B. Product Number: H 4082 BM

C. Dimensions: 23-7/16" x 21-5/16" x 17-15/16"

D. Finish: Stainless steel

E. http://www.mieleusa.com/pdf/bm/H4082BM.pdf

F. http://www.mieleusa.com/manuals_pdf/Residential/Ovens/H4082BM_us.pdf

2.03 EXHAUST HOOD

A. Miele Built-in Ventilation System

B. Product Number: DA3180

C. Dimensions: 10-3/16” x 19-11/16” x 13-3/4”

D. Finish: Stainless steel

E. http://www.mieleusa.com/pdf/Hoods/DA3180.pdf

F. http://www.mieleusa.com/manuals_pdf/Residential/Hoods/DA3160_3180_3190_us.pdf

2.04 REFRIGERATOR-FREEZER

A. Summit Full-Size Refrigerator-Freezer

B. Product Number: FFBF285SS

C. Dimensions: 75.25” x 27.63” x 23.5”

D. Capacity: 13.81 cubic feet

E. Finish: Stainless steel

F. http://www.summitappliance.com/catalog/model/FFBF285SS

2.05 Dishwasher

A. Miele Slimline Dishwasher

B. Product Number: G1262SCVi

C. Dimensions: 17-5/8” x 22-1/2” x 34-5/8”

D. http://www.mieleusa.com/pdf/dishwashers/G1262SCVi.pdf

E. http://www.mieleusa.com/manuals_pdf/Residential/Dishwashers/English_manuals/Operating_Instructions/G1262_us.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Built-in Appliances: Securely anchor to supporting cabinetry or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.

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

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

D. Repair, refinish, or replace finishes damaged during installation or transit, as directed by Architect.

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

END OF SECTION 11 31 13

SECTION 11 31 23 - RESIDENTIAL LAUNDRY APPLIANCES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Regulatory Requirements: Comply with provisions of the following product certifications:

1. 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.
2. 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.
3. NAECA: Provide residential appliances that comply with NAECA standards.

PART 2 - PRODUCTS

2.01 CLOTHES WASHER

A. LG Front Load Washer

B. Product Number: WM2140CW

C. Stackable

D. 4.0-cu. ft. capacity

E. Stainless steel tub

F. http://www.lg.com/us/appliances/washers/LG-WM2140CW.jsp

2.02 ELECTRIC CLOTHES DRYER

A. LG Front Load Electric Dryer

B. Product Number: DLE2140W

C. Stackable

D. 7.1-cu. ft. capacity

E. http://www.lg.com/us/appliances/dryers/LG-electric-dryer-DLE2140W.jsp

PART 3 - EXECUTION

3.01 INSTALLATION

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

B. Stack clothes dryer securely on top of clothes washer and fasten appropriately.

C. Test each residential appliance to verify proper operation. Make necessary adjustments.

D. Repair, refinish, or replace finishes damaged during installation or transit, as directed by Architect.

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

END OF SECTION 11 31 23

SECTION 12 20 00 - WINDOW TREATMENTS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

PART 2 - PRODUCTS

2.01 ROLLER SHADE SYSTEM

A. Solar Screen Roller Shade
1. Manufacturer: Next Day Blinds
2. Model: Solar Screen 1% Roller Shade
3. Fabric: Woven PVC and Polyester
4. Edge: Hemmed
5. Light Transmittance: 1%
6. Operation: Clutch Lift System
7. Color: Cream
8. http://www.nextdayblinds.com/product_NRSolarScreens.asp

B. Extruded Aluminum Roller Shade Pocket
1. Manufacturer: Lutron
2. Model: Lutron Roller 100
3. Material: Extruded aluminum with removable closure panel
4. http://www.lutron.com

PART 3 - EXECUTION

3.01 FABRICATION

A. Shade panels shall be 100% visually inspected to ensure there are no frayed edges or defects in the cut.

B. Where applicable, shade fabric will be ultrasonically cut and friction sealed to minimize fraying.

C. Woven yarn fabrics will be interlocking and heat-treated so that all material is securely bonded.

D. Shade fabric panels shall be 100% visually inspected for defects using a light box integrated into the manufacturing line.

E. 100% visual inspections shall be performed on each shade seam and hem bar welds and compared to strict aesthetic standards.

F. Shade seam weld strength process shall be tested on a daily basis to ensure controlled consistency of weld quality.

G. Shade panels shall be 100% checked for square (±1/16”).

3.02 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in Roller Shade 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.

C. Install shades in windows level and plumb to provide smooth operation.

D. Install in accordance with manufacturer’s product data and approved shop drawings

E. Correct deficiencies in or remove and reinstall Roller Shade that does not comply with requirements.

F. Repair, refinish, or replace Roller Shade damaged during installation, as directed by Architect.

G. Adjust operating parts and hardware for smooth, quiet operation. Lubricate hardware and moving parts.

END OF SECTION 12 20 00

SECTION 12 35 30.13 - KITCHEN CASEWORK

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, Shop Drawings, and Material Samples.

B. Verify dimensions by field measurements, measure for countertops after base cabinets are installed.

PART 2 - PRODUCTS

2.01 CASEWORK

A. Manufacturer: Décor Cabinet Company
   1. http://www.decorkit.com

B. Comply with KCMA A161.1.

C. Cabinets:

   1. Model: Talora
   2. Face Style: Flush overlay
   3. Cabinet Style: Frameless
   4. Door and Drawer Fronts: Wood stiles and rails, with MDF core construction.
   5. Door and Drawer Fronts: Laminate-faced particleboard
   6. Exposed Cabinet End Finish: Countertop material
   7. Door and Drawer Pulls: Inset flush pulls
   8. Hinges: Concealed European-style self-closing hinges.
   9. Drawer Guides: Epoxy-coated-metal, self-closing drawer guides with nylon-tired, ball-bearing rollers.
   10. Color: White

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install cabinets with no variations in flushness of adjoining surfaces by using concealed shims. Where casework abuts other finished work, scribe and cut for accurate fit. Provide filler strips, scribe strips, and moldings in finish to match casework face.

B. Install cabinets without distortion so doors and drawers fit openings properly and are aligned.

C. Install level and plumb to a tolerance of 1/8 inch in 8 feet (3.2 mm in 2.4 m).

D. Fasten each cabinet to adjacent unit and to structural members of wall construction. Fasten wall cabinets through back, near top and bottom, at ends and not less than 24 inches (600 mm) o.c.

1. Use No. 10 wafer-head screws sized for 1-inch (25-mm) penetration into wood framing, blocking, or hanging strips.
2. Use toggle bolts through metal backing behind gypsum board.

END OF SECTION 12 35 30.13

SECTION 12 36 13 – CONCRETE COUNTERTOPS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Shop Drawings, Samples at least 12 inches square.

B. Verify dimensions of countertops by field measurements and indicate on shop drawings.

PART 2 - PRODUCTS

2.01 Concrete Countertops

A. Manufacturer: LukeWorks

B. http://www.lukeworks.com

C. Type: Factory pre-fabricated concrete countertop composed of 80% recycled content including minerals, cement, resin, glass, reinforcing fibers and admixtures.

D. Casting: Individual melamine, rubber or extruded polystyrene molds

E. Reinforcing: Steel and fiberglass mesh

F. Size and Configuration: As indicated on the drawings

G. Thickness: 1.25”

H. Integral Color: Sheddy Black

I. Finish: Polished

J. Edge: Square

K. Compressive Strength: 7000 psi

PART 3 - EXECUTION

3.01 INSTALLING COUNTERTOPS

A. Install countertops no variations in flushness of adjoining surfaces; use concealed shims.

B. Install countertop level and plumb to a tolerance of 1/8 inch in 8 feet.

C. Adhere countertop to substrate using construction adhesive. Maintain temperatures above 40 degrees F (9 degrees C) for at least 12 hours.

D. Form openings for grommets, sinks, plumbing and electrical fixtures and other countertop mounted fixtures. Use templates or patterns furnished by manufacturer. Form cut-outs to smooth, even curves.

3.02 CLEANING

A. Clean countertops as work progresses. Remove adhesive and sealant smears immediately.

B. Clean countertops with a damp cloth and ordinary soap or household ammoniated liquid detergent.

END OF SECTION 12 36 13

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 NFPA 13D and NFPA 70, and IRC 2009 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. CPVC Plastic Pipe: ASTM F 442/F 442M, UL 1821, 175-psig rating, made in NPS for sprinkler service. Include "Listed" and "CPVC Sprinkler Pipe" marks on pipe.

B. CPVC Plastic Pipe 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. Black steel 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

2. Pendent Sprinkler: Viking VK457 Concealed Sprinkler Head

3. Pendant Sprinkler: Viking VK468 Semi-Recessed 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 ½” NPT thread.

G. Waterseal assembly shall consist of a Teflon-coated Belleville springwasher 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; or CPVC plastic pipe and fittings and metal-to-plastic transition fittings with solvent-cemented joints.

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

SECTION 22 11 16 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

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

B. Comply with NSF 61 for potable domestic water piping and components.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

A. Hard Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Types B and C), water tube, drawn temper with wrought-copper, solder-joint fittings and ProPress fittings.

1. Copper Unions: Cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint ends.
2. Joining Materials: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder.

B. Uponor

1. PEX tubing: ½" type A
2. Part #: F2060500 (red) and F3060500 (blue)
3. PEX tubing: ¾" type A
4. Part #: F1060750

C. PVC Pipe: ASTM D 1785, Schedule 40.

1. PVC Fittings: ASTM D 2466, Schedule 40, socket type.

D. 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.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for basic piping installation requirements.

B. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for wall penetration systems.

C. 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.

D. Install domestic water piping without pitch for horizontal piping and plumb for vertical piping.

E. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

F. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.

1. Soldered Joints: Comply with procedures in ASTM B 828 unless otherwise indicated.

G. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for pipe hanger and support devices.

3.02 INSPECTING AND CLEANING

A. Inspect and test piping systems as follows:

1. Fill domestic water 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 parts of existing piping that have been altered, extended, or repaired by visual inspection of all joints.

B. Clean and disinfect potable domestic water piping by filling system with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time by flushing out a volume equal to the system volume, then stopping the flow of water for one hour, and then flushing the system.

3.03 PIPING SCHEDULE

A. Aboveground Distribution Piping: PEX piping

B. Mechanical Room Piping: Copper pipe

3.04 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use bronze ball valve
2. Throttling Duty: Use bronze ball valve
3. Hot-Water-Piping, Balancing Duty
4. Drain Duty: Hose-end drain valves

B. Install 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. PVC 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 spring 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

SECTION 22 11 19 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 BACKFLOW PREVENTER

A. Watts

1. Bronze construction. Temperature Range: 33 °F – 180 °F. Max pressure: 150 psi.
2. Part #: 7U2-2
3. http://media.wattswater.com/ES-7.pdf

2.02 THERMOSTATIC MIXING VALVE

A. Caleffi

1. Manually adjustable, bronze body. Includes integral temperature guage. Maximum pressure: 200 psi, Maximum temperature: 200 ˚F
2. Part #: 521519A
3. http://www.caleffi.us/en_US/Technical_brochures/01050/01050.pdf

2.03 BALL VALVES

A. Viega

1. 3/4" Ball Valve with full-port, Propress end connectors, and pressure rating of 200 PSI.
2. Part #: 22058
3. www.viega.net/cps/rde/xbcr/fr-us/TDPPBrzBVMetal0309.pdf

2.04 PEX MANIFOLDS

A. Uponor

1. Cold Water Manifold: Copper construction with one 1" inlet and eight ½" outlets.

2. Part #: Q2500800

B. Uponor

1. Hot Water Manifold: Copper construction with one 1" inlet and six ½" outlets.
2. Part #: Q2500600

2.05 PRESSURE REDUCING VALVE

A. Wilkins

1. Max. working water pressure: 400 psi, Reduced pressure range: 25 – 75 PSI, FNPT connectors ANSI B1.20.1
2. Part #: NR3
3. www.airdelights.com/specifications/wilkins/NR3_spec_sheet.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install backflow preventers at each water-supply connection to mechanical equipment and where required by authorities having jurisdiction.

B. Install hose bibs with integral or field-installed vacuum breaker.

END OF SECTION 22 11 19

SECTION 22 11 23 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

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

B. Comply with NFPA 70, "National Electrical Code."

C. Comply with UL 778 for motor-operated water pumps.

PART 2 - PRODUCTS

2.01 MAIN PRESSURIZING DOMESTIC WATER PUMP

A. Little Giant

1. 1/2 Horsepower, 115 Volt, A.O. Smith higher than standard NEMA service factor dual compartment motor
2. Part #: JPC-050-C
3. www.pexuniverse.com/docs/pdf/JPC-specs.pdf

2.02 MOTORS

A. NEMA MG 1, "Standard for Motors and Generators." Include NEMA listing and labeling.

B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

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

2.03 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Settings: Pump turned on and off by SHAC.

B. Square D

1. Type: Pressure sensing pump controller
2. Settings: 5-65 PSI on/off setting, 15-30 PSI differential, 220 PSI max pressure
3. Part #: 9013FSG2J20M4
4. http://ecatalog.squared.com/datasheet.cfm?partnumber=9013FSG2J20M4

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. Connect piping with valves that are at least the same size as piping connecting to pumps.

F. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

G. Install shutoff valve and strainer on suction side of pumps.

H. Install nonslam check valve and throttling valve on discharge side of pumps.

I. Install thermostats in hot-water return piping.

J. Install test plugs on suction and discharge of each pump. Install at integral pressure gauge tappings where provided.

END OF SECTION 22 11 23

SECTION 22 12 19 - FACILITY POTABLE-WATER STORAGE TANKS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data. Shop Drawings.

B. Warranties: SunMaxx Solar – 3-year warranty if installed by a certified SunMaxx Solar installer. Amtrol – 5 year limited warranty, non-transferable, covering all defects in material and workmanship.

PART 2 - PRODUCTS

2.01 105 GALLON PREHEAT TANK

A. SunMaxx Solar

1. 2” insulation thickness, Maximum T: 203 °F at 145 PSI, Maximum coil T: 320 °F at 363 PSI
2. Part #: StorMaxxPTec-105-2HX
3. http://www.siliconsolar.com/admin/kt_download.php?document_id=44935

2.02 DOMESTIC HOT WATER EXPANSION TANK

A. Amtrol

1. 10 gal. capacity, factory pre-charge 40 PSI, max P 150 PSI, max temp 200 °F
2. Part #: Therm-X-Trol ST-25V
3. http://s3.pexsupply.com/manuals/1260456430463/20373_PROD_FILE.pdf

2.03 HXEST EXPANSION TANK

A. ProFlo

1. 2 gal. capacity, factory pre-charge 12 PSI, max P 100 PSI, max temp 240 °F
2. Part #: PFXT5

2.04 WATER SUPPLY TANKS

A. Fol-Da-Tank

1. Three 525 gallon pillow tanks. Potable water fabric NSF/ANSI 61 standard, 4” FNPT PVC opening
2. Part #: PW-525
3. Will provide the necessary 300 gallons of water to the fire suppression pump and system

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.

B. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

C. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

D. Correct deficiencies in or remove and reinstall products that do not comply with requirements.

E. Repair, refinish, or replace products damaged during installation, as directed by Architect.

F. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 22 12 19

SECTION 22 13 16 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Minimum Pressure Requirement for Soil, Waste, and Vent: 10-foot head of water (30 kPa).

B. Comply with NSF 14, "Plastic Piping Components and Related Materials," for plastic piping components.

PART 2 - PRODUCTS

2.01 PIPES AND FITTINGS

A. PVC Pipe

1. 2" pipe, ASTM D 1785, Schedule 40.
2. 1-1/2" pipe, ASTM D 1785, Schedule 40.
3. 3" pipe, ASTM D 1785, Schedule 40.

B. PVC Fittings

1. ASTM D 2466, Schedule 40, socket type.

PART 3 - EXECUTION

3.01 PIPING INSTALLATION

A. Install wall penetration system at each pipe penetration through foundation wall. Make installation watertight.

B. 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.

C. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

D. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.

E. 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 plastic, DWV pipe and fittings with solvent-cemented joints

END OF SECTION 22 13 16

SECTION 22 13 53 - FACILITY SEPTIC TANKS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 SEPTIC TANKS

A. Fol-Da-Tank

1. Two 525 gallon pillow tanks. Fabric NSF/ANSI 61 standard, 4” FNPT PVC opening
2. Part #: GW-525

2.02 DISTRIBUTION PIPES AND FITTINGS

A. PVC Sewer Pipe and Fittings: ASTM D 3034, SDR 35, nonperforated, for solvent-cement or elastomeric gasket joints.

1. Solvent Cement: ASTM D 2564.
2. Gaskets: ASTM F 477, elastomeric seal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set septic tanks level, plumb, and true to line and anchor securely in place according to manufacturer’s specifications.

END OF SECTION 22 13 53

SECTION 22 33 30 – RESIDENTIAL ELECTRIC DOMESTIC WATER HEATER

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Comply with NFPA 70, "National Electrical Code."

C. Warranty: 6-year limited tank and parts warranty.

PART 2 - PRODUCTS

2.01 80 GALLON HOT WATER HEATER

A. A.O. Smith

1. Foam Insulation – R-Value of 16, Glass-Lined Tank, Dielectric Nipples
2. Heating Element –4500 watt immersion type heating element for heating system back-up.
3. Part #: SUNX-80
4. http://s3.pexsupply.com/manuals/1277918330238/33850_PROD_FILE.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.

B. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

C. Separate dissimilar metals and metal products from contact with wood or cementations materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

D. Correct deficiencies in or remove and reinstall products that do not comply with requirements.

E. Repair, refinish, or replace products damaged during installation, as directed by Architect.

F. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 22 33 30

SECTION 22 41 13 – RESIDENTIAL WATER CLOSETS, URINALS, AND BIDETS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Warranties: Toto – one year limited warranty. Geberit – limited lifetime warranty on tank and carrier, 10-year warranty on fill valve and flush valve, one year warranty on actuator plate

C. ASME A112.19.2/CSA B45.1, ASME A112.19.14, ASME A112.6.2 ASME 112.19.6, ASSE 1002, CSA B125-98

PART 2 - PRODUCTS

2.01 WALL MOUNTED CERAMIC TOILET

A. Toto

1. Wall Hung, mounted to in-wall tank system, elongated front bowl and wall-mounted push-button type trip lever. Dual flush not to exceed 1.6 GPF/6.0LPF.
2. Part #: CT418FG
3. http://admin.totousa.com/Product%20Downloads/SS-00456,%20CT418FG,%20V.03.pdf

2.02 IN-WALL TANK SYSTEM

A. Geberit

1. Adjustable 15”-19” mounting height, support up to 880 lbs, pc blow molded polyethylene tank to prevent leaks
2. Commercial 2 x 6 or optional residential installation with 2 x 4 wall studs with waste outlet kit
3. Part #: 111.335.00.5
4. http://www.geberit.us/pdf/installation/111335005.pdf

2.03 FINISHES

A. Toto CT418FG: White ceramic interior and exterior, smooth, non-porous

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install per manufacturer’s installation guide.

B. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.

C. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

D. Repair, refinish, or replace products damaged during installation, as directed by Architect.

E. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 22 41 13

SECTION 22 41 16 – RESIDENTIAL LAVATORIES AND SINKS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Warranties: Delta – Lifetime Faucet and Finish Limited Warranty to the original consumer purchaser to be free from defects in material and workmanship. Kraus – Limited lifetime warranty.

C. ADA compliant, WaterSense® Labeled Product, CA/VT compliant, ASME A112.18.1, CSA B125.1

PART 2 - PRODUCTS

2.01 ABOVE COUNTER MOUNTED CERAMIC SINK

A. Kraus

1. 1.75-inch standard drain opening, sol3id brass umbrella pop-up drain
2. White ceramic interior and exterior, smooth, non-porous
3. Part #: KVC-120
4. http://www.krausproducts.com/pdf/bathroom/ceramic-sinks/KCV-120.pdf

2.02 INSTALLATION MATERIALS

A. Sealant: White

2.03 KITCHEN SINK

A. Kraus
1. 30” Undermount Single Bowl 16 Gauge Stainless Steel Kitchen Sink
2. KHU100-30
3. http://www.krausproducts.com/kraus-30-inch-undermount-single-bowl-16-gauge-stainless-steel-kitchen-sink-khu100-30_2706.html

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install per manufacturer's installation guide.

B. Set units level, plumb, and true to line, and anchor securely in place.

C. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

D. Repair, refinish, or replace products damaged during installation, as directed by Architect.

E. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 22 41 16

SECTION 22 41 23 - RESIDENTIAL SHOWER RECEPTORS AND BASINS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product

B. ANSI A118.10: Meets the American National Standard for Load Bearing, Bonded, Waterproof Membranes for Thin-Set Ceramic Tile and Dimension Stone Installations

PART 2 - PRODUCTS

2.01 SHOWER TRAY

A. Schluter

1. Trapezoid-imprinted, prefabricated, sloped tiled shower tray base, made of 2.75 lb/ft3 (44 kg/m3) density, self-extinguishing (HF-1 rating per UL-94) expanded polystyrene, with 12-5/16 inch (313 mm) diameter removable recessed section with 1/8 inch (3 mm) wide ribs on top and channels on the underside.
2. Schluter®-KERDI-SHOWER-ST
3. http://www.schluter.com/8_3_kerdi_st_sc_sr.aspx

B. Schluter

1. 0.008 inch (0.2 mm) thick, orange polyethylene membrane,with polypropylene fleece laminated on both sides, which meet or exceed the requirements of the “American national standard specifications for load bearing, bonded, waterproof membranes for thin-set ceramic tile and dimension stone installation A118.10,” and is listed by cUPC®, and is evaluated by ICC-ES (see Report No. ESR-2467).
2. Schluter®-KERDI
3. http://www.schluter.com/8_1_kerdi.aspx

2.02 MISCELLANEOUS MATERIALS

A.

1. Provide compatible KERDI-FIX sealant that are approved for applications indicated by manufacturer based on field experience and laboratory testing.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in KERDI manufacturer's written instructions.

B. The substrate must be clean, even, and load bearing. Any leveling must be done prior to placing the tray. If necessary, cut the KERDI tray or sheets to size prior to application.

C. Apply unmodified thin-set mortar to the substrate using a 1/4" x 3/8" (6 mm x 10 mm) square- or U-notched trowel. Place the KERDI product making certain to solidly embed the tray in the mortar. Check the underside of the tray to ensure that full coverage is achieved.

D. Correct deficiencies in or remove and reinstall KERDI that does not comply with requirements.

E. Repair, refinish, or replace KERDI damaged during installation, as directed by Architect.

END OF SECTION 22 41 23

SECTION 22 41 26 – RESIDENTIAL DISPOSERS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 GARBAGE DISPOSAL

A. Manufacturer: Insinkerator

B. Model: Evolution Compact

C. http://www.insinkerator.com/pdf/SpecSheet_COM.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in garbage disposal manufacturer’s written instructions.

B. Set units level, plumb, and true to line, without warp or rack of unit and anchor securely in place to torque pressures required in manufacturer’s specifications.

C. Correct deficiencies in or remove and reinstall unit that does not comply with requirements.

D. Repair, refinish, or replace finishes damaged during installation or transit, as directed by Architect.

END OF SECTION 22 41 26

SECTION 22 41 39 – RESIDENTIAL FAUCETS, SUPPLIES, AND TRIM

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. ASTM A, B, & C standards applicable.

PART 2 - PRODUCTS

2.01 BATHROOM FAUCET

A. Delta

1. Addison Single Handle Centerset Lavatory Faucet with Riser, counter mount
2. Part #: 792-SS-DST
3. http://www.deltafaucet.com/media/Product_Tech_Docs/Spec_Sheets/DSP-L-792-DST_Rev_A_12cc3.pdf

2.02 KITCHEN FAUCET

A. Delta Addison Touch20 Pull-Down
1. Finish: Stainless steel
2. Model Number: 9192T-SS-DST
3. http://www.deltafaucet.com/kitchen/details/9192T-SS-DST.html

B. Delta Addison Pull-Down
1. Finish: Stainless steel
2. Model Number: 9192-SS-DST
3. http://www.deltafaucet.com/kitchen/details/9192-SS-DST.html

2.03 SHOWER HEAD

A. Grohe Relexa Rustic Shower Set
1. Wall mounted
2. Material: Brushed nickel
3. Reference No: 27140 EN0
4. http://www.groheamerica.com/m/25_7926/page/modules/pn/article.php?part=view&action=view&product=27140G173&offset=0&amount=15

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install showerhead using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Adjust accessories for unencumbered, smooth operation and verify that mechanisms function properly. Replace damaged or defective items. Remove temporary labels and protective coatings.

END OF SECTION 22 41 39

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Quality Assurance: Labeled with maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to ASTM E 84.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Flexible Elastomeric
1. Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
2. Ferguson R6RX038038
3. http://www.ferguson.com/FergusonSearch/RecordDetails.action?R=273021&search=true

B. Flexible Elastomeric and Polyolefin Adhesive:
1. Comply with MIL-A-24179A, Type II, Class I.

C. Vapor-Barrier Mastic
1. Water based
2. Suitable for indoor and outdoor use on below ambient services.

D. ASJ Tape
1. Black vapor-retarder tape matching factory-applied jacket with acrylic adhesive
2. Comply with ASTM C 1136.

E. Insulated Fiberglass Flex Duct
1. 6 inch (15 cm) diameter; R-Value 6.0. Comply with UL 181.
2. Atco13602506
3. http://www.lowes.com/pd_82445-62931-13602506_0__?productId=3397992&Ntt=flex+duct&pl=1&currentURL=%2Fpl__0__s%3FNtt%3Dflex%2Bduct&facetInfo=

PART 3 - EXECUTION

3.01 INSULATION INSTALLATION

A. Comply with requirements of the Midwest Insulation Contractors Association's "National Commercial & Industrial Insulation Standards" for insulation installation on pipes and equipment.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall, Partition, and Floor Penetrations: Install insulation continuously through penetrations. Seal penetrations. Comply with requirements in Division 07 Section "Penetration Firestopping."

D. Flexible Elastomeric Insulation Installation:

1. Seal longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

E. Plenums and Ducts Not Insulated:

1. Metal ducts with duct liner.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

F. Piping Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawlspaces.
2. Chrome-plated pipes and fittings unless there is a potential for injury.

3.02 HVAC PIPING INSULATION SCHEDULE

A. Heating-Hot-Water Supply and Return: Insulation shall be the following:

1. Flexible Elastomeric: 3/8 inch (9.5 mm) thick.

B. Refrigerant Suction and Hot-Gas Piping: Insulation shall be the following:

1. Flexible Elastomeric: 3/8 inch (9.5 mm) thick.

END OF SECTION 23 07 00

SECTION 23 09 13 - INSTRUCTIONS AND CONTROL FOR HVAC

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Shop Drawings, Product Data

B. Comply with NFPA 70, "National Electrical Code."

C. Must be compatible with Crestron house control systems, and Mitsubishi Spilt-type Heat Pumps.

PART 2 - PRODUCTS

2.01 M-NET CONVERTER

A. Mitsubishi
1. Connects MSZ Series Indoor Heat Pumps to CITY MULTI Controls network
2. M-NET Control Adaptor MAC-399IF
3. http://www.mylinkdrive.com/MrSlim/Accessories/R410a/MAC-399IF-E/MAC-399IF_Submittal.pdf

2.02 CENTRAL CONTROLLER

A. Mitsubishi
1. Connects to the SHAC system and is able to manage the Indoor Heat Pumps in terms of monitoring, operation, scheduling, and maintenance diagnostics.
2. GB-24 Central Controller
3. http://www.ductfree.com/UploadedFiles/Resource/GB-24A_SP_Submittal.pdf

2.03 POWER SUPPLY

A. Mitsubishi
1. Provides power to the central controller
2. PAC-SC50KUA Power Supply
3. http://www.ductfree.com/UploadedFiles/Resource/GB-24A_SP_Submittal.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Connect Indoor Heat Pump to M-Net interface per manufacturer's instructions.

B. Install control wiring concealed, except in mechanical rooms, and according to requirements specified in Division 26 Sections.

END OF SECTION 23 09 13

SECTION 23 20 00 - HVAC PIPING AND PUMPS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product data. Shop Drawings.

B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 PIPING

A. PEX Tube and Fittings
1. Comply with: ASTM F 877, SDR 9 PEX tubing and ASTM F 1807, metal insert-type fittings with copper or stainless-steel crimp rings.
2. Uponor F2060750 PEX-a
3. http://www.pexsupply.com/Wirsbo-Uponor-F2060750-3-4-AQUAPEX-Red-300-ft-coil-2188000-p

B. PEX Tubing
1. 3/4" type A
2. Uponor F1060750
3. http://www.pexsupply.com/Wirsbo-Uponor-F2060750-3-4-AQUAPEX-Red-300-ft-coil-2188000-p

2.02 PUMP FOR HEAT EXCHANGER

A. Taco
1. Cast Iron construction, 0-20 GPM, 40° - 240° F water temperature, 125 psi.
2. Model 007 Cartridge Circulator
3. http://www.taco-hvac.com/en/products/Model+007+Cartridge+Circulator/products.html?view=ProdDetail&current_category=52&Product=10

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with requirements for basic piping installation.

B. Install wall penetration system at each service pipe penetration through exterior wall. Make installation watertight.

C. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance.

D. Install domestic water piping with 0.25 percent slope downward toward drain for horizontal piping and plumb for vertical piping.

E. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

END OF SECTION 23 20 00

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Comply with ASME B31.5, "Refrigerant Piping," and with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

PART 2 - PRODUCTS

2.01 TUBES AND FITTINGS

A. Copper Tube: ASTM B 88, Types K and L (ASTM B 88M, Types A and B) and ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

D. Brazing Filler Metals: AWS A5.8.

2.02 VALVES

A. Thermostatic Expansion Valve: Comply with ARI 750; forged brass or steel body, stainless-steel internal parts, copper tubing filled with refrigerant charge for 46 deg F (8 deg C) heating and 71 deg F (22 deg C) cooling suction temperature; 102-411 psig (710-2834 kPa) working pressure, and 240 deg F (116 deg C) operating temperature.

B. Solenoid Valves: Comply with ARI 760; 240 deg F (116 deg C) temperature rating, 400-psig (2760-kPa) working pressure, 240 deg F (116 deg C) operating temperature; and 24-V normally closed holding coil.

2.03 REFRIGERANT PIPING SPECIALTIES

A. Strainers: Welded steel with corrosion-resistant coating and 100-mesh stainless-steel screen with socket ends; 500-psig (3450-kPa) working pressure and 275 deg F (135 deg C) working temperature.

B. Moisture/Liquid Indicators: 500-psig (3450-kPa) operating pressure, 240 deg F (116 deg C) operating temperature; with replaceable, polished, optical viewing window and color-coded moisture indicator.

C. Mufflers: Welded steel with corrosion-resistant coating and socket ends; 500-psig (3450-kPa) operating pressure; 240 deg F (116 deg C) operating temperature.

D. Refrigerant: ASHRAE 34; R-410A.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install wall penetration system at each pipe penetration through foundation wall. Make installation watertight.

B. Install refrigerant piping and charge with refrigerant according to ASHRAE 15.

C. Belowground, install copper tubing in PVC conduit. Vent conduit outdoors.

D. Insulate suction lines to comply with Division 23 Section "HVAC Insulation."

E. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

F. Install solenoid valves upstream from each thermostatic expansion valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporator coils.

H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

I. Install strainers upstream from and adjacent to solenoid valves, thermostatic expansion valves, and compressors unless they are furnished as an integral assembly for device being protected:

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

3.02 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.

B. Hot-Gas and Liquid Lines: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.

END OF SECTION 23 23 00

SECTION 23 23 23 - REFRIGERANTS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

PART 2 - PRODUCTS

2.01 REFRIGERANT

A. R-410A, ASHRAE 34.
   1. Non-ozone depleting refrigerant

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install refrigerant piping and charge with refrigerant according to ASHRAE 15.

END OF SECTION 23 23 23

SECTION 23 31 13 – METAL DUCTS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data for fire and smoke dampers and Shop Drawings detailing duct layout and including locations and types of duct accessories, duct sizes, transitions, radius and vaned elbows, special supports details, and inlets and outlet types and locations.

B. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Comply with NFPA 96 for ducts connected to commercial kitchen hoods.

D. Comply with UL 181 for ducts and closures.

PART 2 - PRODUCTS

2.01 DUCTS

A. Galvanized-Steel Sheet and Spiral Duct: ASTM A 653/A 653M, with G60 (Z180) hot-dip galvanized coating.

B. Joint and Seam Tape, and Sealant: Comply with UL 181A.

2.02 ACCESSORIES

A. Volume Dampers and Control Dampers: Single-blade and multiple opposed-blade dampers, standard leakage rating, and suitable for horizontal or vertical applications; factory fabricated and complete with required hardware and accessories.

B. Fire Dampers: Rated and labeled according to UL 555 by an NRTL; factory fabricated and complete with required hardware and accessories.

C. Ceiling Fire Dampers: Labeled according to UL 555C by an NRTL and complying with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory." Provide factory-fabricated units complete with required hardware and accessories.

D. Smoke Dampers: Labeled according to UL 555S by an NRTL. Combination fire and smoke dampers shall also be rated and labeled according to UL 555. Provide factory-fabricated units complete with required hardware and accessories.

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

F. Flexible Ducts: Corrugated aluminum complying with UL 181, Class 1.

G. The *EDGE™* Gasketed Spiral Duct Connectors and Turns: Meets SMANCA Class 3 leakage standards.

PART 3 - EXECUTION

3.01 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.

3.02 TESTING, ADJUSTING, AND BALANCING

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

END OF SECTION 23 31 13

SECTION 23 34 13 - AXIAL HVAC FANS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, Shop Drawings, manufacturer's color charts showing the full range of colors available for factory-applied finishes.

B. Comply with NFPA 70, "National Electrical Code."

C. Verify dimensions by field measurements before fabrication and indicate on Shop Drawings.

D. 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 1 year.

PART 2 - PRODUCTS

2.01 THROUGH-THE-WALL VENTILATION FAN

A. Broan
   1. Interior to exterior ventilation fan for mechanical room conditioning; 70CFM, 3.5 Sones
   2. Broan 6” Through Wall Ventilation Fan 512M
   3. http://www.broan.com/ImageLibrary/broan/pdf/Specifications/99042567.pdf

B. Honeywell
   1. Medium duty line voltage heat-cool thermostat
   2. Honeywell T651A 3018
   3. http://customer.honeywell.com/techlit/pdf/63-0000s/63-2051.pdf

2.02 FINISHES

A. Seiho SX 6; Anodized aluminum finish.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install per manufacturer’s instructions.

B. http://www.broan.com/ImageLibrary/broan/pdf/InstallGuides/99043228.pdf

END OF SECTION 23 34 13

SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data and color charts for factory finishes.

PART 2 - PRODUCTS

2.01 GRILLES

A. Nailor
   1. Material: Steel; Finish: Appliance White; Mounting: Flush.
   2. Nailor 61CD (2B) Curved Blade Directional Grilles
   3. http://www.nailor.com/onlineCatalog09/CAD-08/CADGGR.pdf

B. Nailor
   1. Material: Steel; Finish: Appliance White; Mounting: Flush.
   2. Nailor 51CD (1A) Curved Blade Directional Grilles
   3. http://www.nailor.com/onlineCatalog09/CAD-08/CADGGR.pdf

C. Nailor
   1. Material: Steel; Finish: Appliance White; Mounting: Flush.
   2. Nailor 67PR (-O) Type S Perforated Face Return Grilles
   3. http://www.nailor.com/onlineCatalog09/CAD-08/CADGGR.pdf

D. Seiho
   1. Material: Aluminum; Finish: Anodized; Mounting: Flush
   2. Seiho SX-N 6, SX 6, SX 4 Aluminum Vent Caps and Seiho SB Dryer Vent
   3. http://www.seiho.com/pdf/submittal/sb.pdf;
      http://www.seiho.com/pdf/submittal/sx.pdf

E. Seiho
   1. Material: Aluminum; Finish: Anodized; Mounting: Flush
   2. Seiho SX 6
   3. http://www.seiho.com/pdf/submittal/sx.pdf

F. Seiho
   1. Material: Aluminum; Finish: Anodized; Mounting: Flush
   2. Seiho SX 4 Aluminum Vent Caps
   3. http://www.seiho.com/pdf/submittal/sx.pdf

G. Seiho
   1. Material: Aluminum; Finish: Anodized; Mounting: Flush

2. Seiho SB Dryer Vent
3. http://www.seiho.com/pdf/submittal/sb.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel unless otherwise indicated. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

SECTION 23 56 13.19 – HEATING SOLAR VACUUM-TUBE COLLECTORS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Design, engineer, fabricate, and install PARADIGMA CPC 45 STAR AZZURROS according to manufacturer specifications.

B. Submittals: Product Data Sheets; installation guidelines including preparation instructions, handling requirements & installation methods; Shop Drawings; Operation and Maintenance Instructions; Manufacturer's Certificates

C. Verify dimensions by field measurements before fabrication and indicate on Shop Drawings.

D. Warranties: Taco - Taco, Inc. will repair or replace any Taco 00 Series circulator or circulator part that is proven defective under normal use within three (3) years from the date of manufacture.

E. Extra Materials: Deliver to owner two (2) sets of mount rail systems and collector connector packs of each color and type used on Project, securely packaged and labeled.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

B. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy 6063-T6.

C. Stainless Steel Sheet: ASTM A 666, Type 302 or 304.

D. Plastic Laminate: NEMA LD 3, color, texture, and pattern as selected.

2.02 EVACUATED TUBE SOLAR PANELS

A Paradigma

1. Two 30-tube Arrays
2. Supply / return Compression fitting: mm Cu 15, max pressure: 150 psi
3. Part #: CPC 45 Star Azzurro

2.03 GLYCOL PUMP

A Taco

1. Universal flanged connections, cast-iron casing, stainless steal cartdrige with a non-metallic impeller, 115VAC 1/25 HP
2. Part #: 008-F6
3. http://s3.pexsupply.com/manuals/1249544537780/101-031.pdf

2.04 GLYCOL FLUID

A DYN-O-FLO

1. 100% concentrate, high temperature [325ºF], non-toxic, propylene glycol antifreeze. Recommend one gallon per collector.
2. Part #: DFLO-004-004
3. https://shop.solardirect.com/pdf/water-heaters/solar-hot-water/active-solar/collectors/dyn-o-flo-hd-fluid.pdf

2.05 PIPE AND FITTINGS

A. Hard Copper Tubing: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper with wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

1. Copper Unions: Cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint ends.
2. Joining Materials: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in PARADIGMA CPC 45 STAR AZZURRO 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, according to manufacturer’s instructions & shop drawings.

C. Fasten PARADIGMA CPC 45 STAR AZZURRO securely in place as outlined in manufacturer’s instructions, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

D. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

E. Correct deficiencies in or remove and reinstall PARADIGMA CPC 45 STAR AZZURRO that does not comply with requirements.

F. Repair, refinish, or replace PARADIGMA CPC 45 STAR AZZURRO damaged during installation, as directed by Project Architect.

END OF SECTION 23 56 13.19

SECTION 23 57 00 – HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Comply with NFPA 70, "National Electrical Code."

C. 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 5 years.

PART 2 - PRODUCTS

2.01 WATER-TO-AIR HEAT EXCHANGER

A. Eastlake Alternative Energy
1. 3/8" copper tubes with a high density of aluminum fins. Fins are spaced at 12 fins per inch. Pressure tested to exceed 250 psi.
2. Eastlake Alternative Energy 12x12 HE.
3. http://water-to-air-heat-exchanger.com/assets/Uploads/CoilInfo.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Water-to-air heat exchanger is installed within the LDW.

B. Install heat exchanger according to drawings and manufacturer's specifications.

END OF SECTION 23 57 00

SECTION 23 72 00 – AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, Shop Drawings.

B. Comply with NFPA 70, "National Electrical Code."

C. 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 5 years.

PART 2 - PRODUCTS

2.01 ENERGY RECOVERY VENTILATOR

A. UltimateAir
1. Variable speed energy recovery ventilator providing filtration and ventilation, removing particles from both incoming and outgoing air. The Econocool feature brings in cool filtered night air during the summer to reduce A/C loads.
2. Ultimate Air RecoupAerator 200 DX
3. http://www.ultimateair.com/product.php

2.02 MOUNTING KIT

A. UltimateAir
1. Ceiling mount kit allows for suspended, horizontal mounting of the RecoupAerator 200DX.
2. Ceiling Mounting Kit for RecoupAerator 200 DX
3. http://www.ultimateair.com/product.php

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install unit per Manufacturer’s inststructions under supervision of HVAC contractor.

B. Connect and install ducts as described in Section 23 31 13.

END OF SECTION 23 72 00

SECTION 23 81 26 – SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, Shop Drawings.

B. Comply with NFPA 70, "National Electrical Code."

C. 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.

PART 2 - PRODUCTS

2.01 OUTDOOR COMPRESSOR

A. Mitsubishi MXZ-2B20NA Compressor
  1. 18,000-22,000 BTU capacity, 16.5 SEER, Variable Speed Compressor that supports up to 2 (two) indoor units.
  2. http://www.mitsubishicomfort.com/media/336793/m_p_catalog.pdf

2.02 INDOOR HEAT PUMP

A. Mitsubishi MSZ-FE09NA Split-type Heat Pumps
  1. 9,000-10,900 BTU capacity, 2.1 pints/hr dehumidification, variable airflow, independently controlled units with thermal detection of uneven conditioning.
  2. http://www.mitsubishicomfort.com/media/336793/m_p_catalog.pdf

2.03 INSTALLATION MATERIALS

A. MSZ-FE09NA unit comes with wall-mount installation plates, remote control holder, hardware, and Anti-Allergen and deodorizing filters.

B. DiversiTech Ultralite Equipment Pad
  1. 26”x36”x2” equipment pad to be placed under outdoor compressor unit. Withstands environmental stresses such as freezing/thawing, UV light, and fire.
  2. DiversiTech UC2636-2
  3. http://www.pexsupply.com/DiversiTech-UC2636-2-2-UltraLite-Equipment-Pad-26-x-36

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall be executed as per installation manuals provided by the Manufacturer.

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

SECTION 23 83 13.16 - RADIANT HEATING UNITS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data, Shop Drawings.

B. Comply with NFPA 70, "National Electrical Code."

C. UL listed and CSA approved.

D. Verify dimensions by field measurements before fabrication and indicate on Shop Drawings.

E. 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 25 years.

F. EnergyStar qualified.

PART 2 - PRODUCTS

2.01 RADIANT HEAT MAT

A. NuHeat
   1. Electric radiant heating unit for tile floor applications, 12 watts per square foot, custom shape.
   2. NuHeat Custom Shaped Mat.
   3. http://www.nuheat.com/products/electric-floor-heat/custom-mats.html

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install before tile flooring system per Manufacturer's instructions by a qualified Installer.
   1. http://www.nuheat.com/customer-care/manuals.html

END OF SECTION 23 83 13.16

SECTION 23 84 00 - HUMIDITY CONTROL EQUIPMENT

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 MATERIALS

A. 2"x4" planks of pine wood

B. Medium density fiberboard

C. Silicone adhesive: designed for plastic sheets

D. Epoxy fast set adhesive

E. Plastic mesh: ½" square cut openings

F. PVC pipe

G. PVC tubing

H. Plexiglas sheets: 3/16" clear acrylic

I. Screws, course threaded drywall type, 2.5"

J. Adjustable furniture levels, 600 lb capacity

K. Caulk, industrial strength

2.02 LITHIUM CHLORIDE SALT SOLUTION

A. FMC

1. 40% LiCl solution by weight
2. Part #: 7447-41-8
3. http://www.fmclithium.com/Portals/FMCLithium/content/docs/DataSheet/QS-PDS-1057%20r0.pdf

2.03 PUMP

A. March

1. Epoxy, polypropylene, ceramic, Viton®, 316 stainless steel. 1/40 HP, 3450 rpm, 115 Volt
2. Part #: AC-2CP-MD
3. www.pumpagents.com/pdf/MarchPumps/AC-2CP-MD.pdf

2.04 FAN

A. Sunon

1. 172 mm, 115VAC, RoHS compliant
2. Part #: A1175-HBL TC.GN
3. http://www.farnell.com/datasheets/13362.pdf

2.05 HOLDING TANK

A. Den Hartog

1. 20 Gallon Rectangle Applicator Tank 14" x 28" x 12" with a 3/4" FPT w/EPDM Fitting
2. Part #: SP0020-LC
3. http://www.usplastic.com/catalog/files/drawings/9687.pdf

2.06 PACKING MEDIA

A. Jaeger

1. Polypropylene 1" spherical packing media
2. Part #: 1" Tri-Packs®
3. http://www.jaeger.com/Brochure/Series600-09.pdf

2.07 SOLENOID VALVES

A. McMaster-Carr

1. 3/8" port, normally closed, 120 VAC, 250 PSI max, with wire leads
2. Part #: 7876K12

2.08 PEX TUBING

A. Rifeng

1. ½" diameter tubing
2. Part #: 050-100-B

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install unit plumb and anchor to walls.

B. Make plumbing connections as indicated in drawings.

C. Make electrical connections as indicated in drawings. Ensure that all metal and electrical components are grounded.

D. Test liquid connections for leak free operation.

E. Avoid contact between liquid desiccant solution and metals parts since liquid is highly corrosive to most metals.

F. In the event of a spill of the liquid desiccant solution, cleanup must include triple rinsing with water to minimize corrosion of metals.

END OF SECTION 23 84 00

SECTION 25 05 00 – COMMON WORK RESULTS FOR INTEGRATED AUTOMATION

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 FINGER DUCT

A. McMaster Carr 75835K83

B. Narrow slotted finger duct 2-1/4” x 2-1/4” x 6’-6”.

C. Color: Gray

2.02 RACKS

A. Middle Atlantic HPM-4-915

B. 4U 9-15” adjustable depth hinged panel mount.

2.03 RACK SHELF

A. Middle Atlantic UTR1

B. 1U device mounting shelf 10” deep

2.04 CABLE ORGANIZER

A. Middle Atlantic PHCM-1-2

B. 1U cable management bracket

2.05 RACK POWER STRIP

A. Geist SPTN064-10

B. 1U 6 outlet power strip.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in manufacturer’s written instructions.

B. Install materials according to manufacturer’s specifications.

C. Set units level, plumb, and true to line and anchor securely in place.

D. Correct deficiencies in or remove and reinstall materials that do not comply with requirements.

E. Repair, refinish, or replace substrate damaged during installation or transit, as directed by Architect.

END OF SECTION 25 05 00

SECTION 25 10 00 – INTEGRATED AUTOMATION NETWORK EQUIPMENT

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 PATCH PANELS

A. 12 Port Patch Panel
   1. Tripp Lite N050-012
   2. 12 port C5E vertical patch panel

B. 24 Port Patch Panel
   1. Tripp Lite N052-024
   2. 24 port C5E 1U patch panel

2.02 NETWORK SWITCH

A. D-Link DSS-16+

B. 16 port 1U 10/100 network switch

2.03 ANALOG OUTPUT MODULE

A. Weeder Tech WTDAC-M

B. http://www.weedtech.com/wtdac-m.pdf

2.04 12V POWER SUPPLY

A. LTS AT1207M-D09

2.05 UPS

A. Minuteman EN-900

B. Wall mount 500W UPS

2.06 LEVEL SENSOR

A. Milone Technologies PN-6573P-8

B. Etape level sensor

2.07 FLOAT SWITCH

A. Omega LVK-131

B. Liquid level switch

2.08 STEP UP RELAY BOXES

A. Taco SR504-2
   1. Step up relay box, 4 relay

B. Taco SR506-2
   1. Step up relay box, 6 relay

2.09 COUNTER

A. Weeder WTPCT-M

B. Counter module

2.10 DATABASE COMPUTER

A. FoxConn NTA350-OHOW-B-A-NA

B. Barebones computer

2.11 FIREWALL/ROUTER

A. Linksys WRT54GL

2.12 MICROCONTROLLERS

A. Ocean Control KTA-225

B. Arduino boxes with 8 A/D and 8 relays

2.13 ENVOY PHOTOVOLTAIC MONITOR

A. Enphase Envoy

B. Photovoltaic system communications gateway

2.14 NETWORK SWITCH

A. Crestron CEN-SW-POW-5

B. 5-port ethernet switch

2.15 CONTROL COMPUTER

A. Crestron PRO2

B. Main datalogging computer

2.16 TEMPERATURE SENSOR

A. Analog Devices AD22100KTZ-ND

B. http://www.analog.com/static/imported-files/Data_Sheets/AD22100.pdf

2.17 HUMIDITY SENSOR

A. Honeywell 785-HIH-4010-001

B. http://sensing.honeywell.com/index.cfm/ci_id/142534/la_id/1/document/1/re_id/0

2.18 CURRENT METER

A. Eaton EAC205SP

B. http://datasheet.octopart.com/EAC205SP-Eaton-datasheet-9596518.pdf

2.19 FLOW METER

A. Grundfos VFS 5-100

B. http://www.google.com/url?sa=t&source=web&cd=1&ved=0CBkQFjAA&url=http%3A%2F%2Fnet.grundfos.com%2FAppl%2FWebCAPS%2FGrundfosliterature-145876.pdf&rct=j&q=Grundfos%20VFS%205-100&ei=SntDTu3UHqTx0gHUsd3DCQ&usg=AFQjCNH3bA2BG6rht6D5FS-Qxk6BzvrLng&sig2=_qorpvMc30Rsq0PtFetunA&cad=rja

2.20 LEVEL SENSOR

A. Milone PN-6573P-8

B. http://www.sparkfun.com/datasheets/Sensors/Flex/eTape%20Datasheet%206573P-8_030611.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in manufacturer’s written instructions.

B. Network equipment to be installed according to manufacturer’s specifications.

C. Set units level, plumb, and true to line and anchor securely in place.

D. Correct deficiencies in or remove and reinstall materials that do not comply with requirements.

E. Repair, refinish, or replace substrate damaged during installation or transit, as directed by Architect.

END OF SECTION 25 10 00

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 THHN/THWN Copper Wire

A. Republic Wire
1. Used for Line Voltage power transfer to electrical device located throughout the house.
2. Solid and Stranded Copper
3. AWG: 14/12/10/6/1
4. http://www.republicwire.com/pdf/thhn-thwnCopperConductor.pdf

2.02 CAT5E Shielded Cable

A. CableWholesale
1. Required to support both network and sensor communications (analog) runs parallel with power lines, up to 1000 ft.
2. 10X6-521SH
3. http://www.cablewholesale.com/pdfspecs/10x6-5xxsh.pdf

2.03 Crestron Communications

A. Crestron
1. Required to facilitate 4 wire communications using Crestron Cresnet protocol, up to 1000 ft.
2. CRESNET-NP-TL-SP1000
3. http://www.crestron.com/resources/product_and_programming_resources/catalogs_and_brochures/online_catalog/default.asp?jump=1&model=cresnet-np

2.04 18/2

A. Americord

1. Required to facilitate analog signal carrying over short distances, up to 500ft of cable.
2. SKU 597
3. http://www.americord.com/18-2-bulk-wire-2-prod-621.html

2.05 Disconnects

A. Svideo
1. Inline shielded coupler required to support disconnects in CAT5e cabling.
2. CAT5e-Coupler
3. http://www.svideo.com/cat5ecoupler.html

2.06 Connectors

A. Leviton
1. Modular snap in connectors required to support cabling/terminations of CAT5e
2. 5G108-RW5
3. http://www.leviton.com/OA_HTML/ibeCCtpItmDspRte.jsp?item=156537&section=10234&minisite=10026

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install according to manufacturer's specification inside flexible ENT.

END OF SECTION 26 05 19

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

A. 2.01 Ground Rod
   1. Ground electric system
   2. Erico 615800UPC
   3. http://www.thegreathardwarestore.com/Erico-5-8x10-Bonded-GreenD-Rod-615800UPC-p/255953.htm

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare grounding location by clearing debris and other obstructions.

B. Drive grounding rod 8' into soil.

C. Bond Main Service Panel and PV circuit bare ground copper wires to grounding rod.

D. Correct deficiencies in or remove and reinstall wires and connectors that do not comply with requirements.

END OF SECTION 26 05 26

SECTION 26 05 33 – RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals: Product Data

B. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.1 RACEWAY AND CONDUIT

A. Carlon
   1. Electrical Nonmetallic Tubing used as raceway or conduit walls of house
   2. Flex-Plus Blue ENT
   3. http://www.carlon.com/Master%20Catalog/ENT_2B43.pdf

2.2 BOXES

A. Carlon
   1. Single, Double, and Four Gang Non Metallic junction box for residential and light commercial use
   2. http://www.carlon.com/Master%20Catalog/Zip%20Boxes_2B1.pdf

B. Cooper Wiring Devices
   1. Single weather proof cover for outdoor receptacles
   2. http://www.cooperindustries.com/content/dam/public/wiringdevices/literature/lit_pdf/CWD_WeatherBox_Broch.pdf

2.3 METER HOUSING

A. Schneider Electric
   1. UTRS202B Meter Socket
   2. http://products.schneider-electric.us/products-services/product-detail/?event=productDetail&partNumber=UTRS202B&countryCode=us

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.

B. Fasten raceway and boxes securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

C. Repair, refinish, or replace raceway or boxes damaged during installation, as directed by Electrician.

END OF SECTION 26 05 33

SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA PB 1.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush and Surface-mounted cabinets; NEMA 250, Type 1.
   1. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

B. Incoming Mains Location: Side

C. Phase, Neutral, and Ground Buses: Tin-plated aluminum.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

   1. Material: Tin-plated copper.
   2. Main and Neutral Lugs: Mechanical type.
   3. Ground Lugs and Bus Configured Terminators: Mechanical type.

E. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, and listed and labeled for series-connected short-circuit rating by an NRTL.

F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.02 DISTRIBUTION PANELBOARDS

A. Mains: Circuit breaker

B. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers.

C. Main Service Panel
   1. Service panel for connecting grid, PV array and house sub panels
   2. Schneider Electric QO12040M200
   3. http://products.schneider-electric.us/products-services/product-detail/?event=productDetail&countryCode=us&partNumber=QO12040M200

D. Sub Service Panels
   1. Service panels for house electrical wiring in each module
   2. Schneider Electric QO124M125
   3. http://ecatalog.squared.com/fulldetail.cfm?partnumber=QO124M125

E. LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

F. Mains: Circuit breaker

G. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

H. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.03 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

   1. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

C. Surge Breaker
   1. Protect house electric system from voltage spikes
   2. Schneider Electric QO2175SB
   3. http://ecatalog.squared.com/fulldetail.cfm?partnumber=QO2175SB

D. Arc Fault Breaker
   1. Schneider Electric QO120CAFIC
   2. http://ecatalog.squared.com/fulldetail.cfm?partnumber=QO120CAFIC

PART 3 - EXECUTION

3.01 INSTALLATION

A. Receive, inspect, handle, store and install panelboards and accessories according to NECA 407 and NEMA PB 1.1.

B. Mount bottom of trim 55 inches above finished floor unless otherwise indicated.

C. Arrange conductors into groups; bundle and wrap with wire ties.

D. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory.

END OF SECTION 26 24 16

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 DEVICES

A. Convenience Receptacles: NEMA WD 1, NEMA WD 6, Configuration 5-20R, and UL 498.

1. Products:

a. Leviton

b. TWR15-W

c. http://www.platt.com/CutSheets/Leviton/TDR15W.pdf

B. Duplex GFCI Convenience Receptacles: 125 V, 15 A, straight blade, feed-through type. NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

1. Products:

a. Leviton

b. X7599-W

c. http://www.leviton.com/OA_HTML/ibeCCtpItmDspRte.jsp?item=680338&section=33614&minisite=10051&language=US

C. Switches: NEMA WD 1 and UL 20. Single-pole, double-throw, momentary contact, center-off switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Products:

    a. Leviton

    b. 5601-2W

    c. http://www.leviton.com/OA_HTML/ibeCCtpItmDspRte.jsp?item=865319&section=10053&minisite=10026

D. Wall Plates, Finished Areas: Smooth, high-impact thermoplastic fastened with metal screws having heads matching plate color.

1. Leviton
    a. Snap-on double gang faceplate
    b. 30809-SA
    c. http://www.smarthome.com/8582A/Leviton-80309-SA-Double-Gang-Screwless-Decora-Wall-Plate-Almond/p.aspx
2. Leviton
    a. Single gang snap-on faceplate
    b. 80301-S0
    c. http://www.leviton.com/OA_HTML/ibeCCtpItmDspRte.jsp?item=10219&section=11002

E. Wall Plates, Unfinished Areas: Smooth, high-impact thermoplastic with metal screws.

F. Wall Plates, Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet locations.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Install devices and assemblies plumb, level, and square with building lines.

C. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

D. Install unshared neutral conductors on line and load side of dimmers.

E. Mount devices flush, with long dimension vertical, and grounding terminal of receptacles on top unless otherwise indicated. Group adjacent devices under single, multigang wall plates.

END OF SECTION 26 27 26

SECTION 26 31 00 – PHOTOVOLTAIC COLLECTORS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Comply with NFPA 70, "National Electrical Code."

C. Related sections: 48 19 16 Electrical Power Generation Inverters

PART 2 - PRODUCTS

2.01 MODULES

A. Manufacturer: Sanyo

B. Mono-crystalline photovoltaic module for electricity generation

C. Sanyo HITPower 220A

D. http://us.sanyo.com/dynamic/LinkListingItems/Files/HIT%20Power%20220A%20web-1.pdf

2.02 ACCESSORIES

A. ROOF MOUNTING CLIPS
   1. S-5!
      a. Required to fasten photovoltaic modules to standing seam sheet metal roof
      b. PV Kit and Type U-mini clamps
      c. http://www.s-5.com/common/downloads/S-5-PV_101510.pdf
      d. http://www.s-5.com/clamps/index_929.cfm
      e. Stainless steel finishes: No. 6, dull satin

B. PERGOLA MOUNTING
   1. Unirac
      a. Required to mount PV modules on trellis
      b. Sun Frame, Slot Rail, Cap Strip, Cap strip Screws, End Caps, Splices
      c. Product Numbers: 302018, 321130, 321159, 310229, 310226, 310067
      d. http://www.civicsolar.com/sites/default/files/library/collateral/Sunframe_Brochure.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in photovoltaic mounting clip manufacturer’s written instructions.

B. Affix S-5! U-mini clamps to standing seam metal roof per manufacturer instructions with provisions for thermal and structural movements.

C. Set units level, plumb, and true to line, without warp or rack of frames or panels and anchor securely in place to torque pressures required in manufacturer’s specifications.

D. Make connections between S-5! U-mini clamps and PV Kit per manufacturer instructions.

E. Correct deficiencies in or remove and reinstall mountings and modules that do not comply with requirements.

F. Repair, refinish, or replace mountings and modules damaged during installation or transit, as directed by Architect.

END OF SECTION 26 31 00

SECTION 26 32 00 – PACKAGED GENERATOR ASSEMBLIES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Comply with NFPA 54, “National Fuel Gas Code.”

C. Comply with NFPA 70, "National Electrical Code."

PART 2 - PRODUCTS

2.01 GENERATOR ASSEMBLY

A. Honda Inverter Deluxe Generator Model EM5000isAB

B. 120/240 Single-Phase, 60 Hertz gasoline-powered generator

C. Maximum AC Output 5000 Watts (41.7A @ 240 V / 20.8A @ 120V)

D. Operating Noise (at 7m) 62 dB(A) (Without Load), 68 dB(A) (Full Load)

E. http://www.advancedmower.com/honda/generators/delux/em5000is.htm

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set unit level on a stable surface during use. Store in a weather-protected location when not in use.

B. Adjust operating parts and hardware for smooth, quiet operation. Lubricate hardware and moving parts.

END OF SECTION 26 32 00

SECTION 26 50 00 – LIGHTING

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data for each luminaire, including lamps.

B. Fixtures, Emergency Lighting Units, Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with IEEE C2, "National Electrical Safety Code."

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

PART 2 - PRODUCTS

2.01 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

D. Exterior Luminaires: Comply with UL 1598 and listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

E. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

F. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

2.02 REQUIREMENTS FOR INDIVIDUAL LIGHTING FIXTURES

A. Fixture 1: Flood Light

1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

   a. Hadco Floodlyte WAMLD1 W 3H

2. Voltage: 12 AC
3. Mounting: Exterior ground with mounting stake
4. Nominal Dimensions: 4 7/8” H x 6 7/8” W
5. Lamps: : 6.4W LED
6. External Finish: Bronze
7. Transformer: Hadco TC151-12

B. Fixture 2: Exterior Door Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

   a. CSL SS2010A-SA

2. Voltage: 120V AC
3. Mounting: Exterior Surface wall centered over doorway
4. Nominal Dimensions: 3” cylinder x 6 1/4” H
5. Lamps: (2) 75 W MR16
6. External Finish: Satin Aluminum

C. Fixture 3: Wetland Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

   a. Hadco UWL1 A

2. Voltage: 12V AC
3. Mounting: Submersible in Constructed Wetlands
4. Nominal Dimensions: 5” circle x 3” H
5. Lamps: 10 W T3
6. External Finish: Black
7. Transformer: Hadco TC151-12

D. Fixture 4: Cable Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

   a. TechLighting 700KHELLO3

2. Voltage: 12V AC
3. Mounting: Fixtures clipped onto cable suspended by turnbuckles attached to house structure. Adjustable standoffs support cables over long distances.
4. Nominal Dimensions: 3.5” W x 2.3” H
5. Lamps: 37 W MR16
6. External Finish: Satin Aluminum

7. Transformer: TechLighting 700-AT300T
8. Hardware
    a. Kable Lite Bare Cable: 700KLABAREC
    b. Kable Light Center Power Feed Single Feed: 700KPCENS
    c. Kable Light Universal Turnbuckles: 700PARTTS
    d. Kable Light Adjustable Standoff: 700PRTD33S

E. Fixture 5: Undercabinet Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

    a. CSL AEBO XL-22-SA/XL-16-SA

2. Voltage: 12V AC
3. Mounting: Under cabinetry
4. Nominal Dimensions: 22" L (16" L) x 1" W x 1" H
5. Lamps: 10 W Xenon; CSL L-105
6. External Finish: Satin Aluminum
7. Transformer: CSL T-118

F. Fixture 6: Shower Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

    a. CSL EDL-ADJ-WW

2. Voltage: 120V AC
3. Mounting: Recessed ceiling
4. Lamps: 16 W LED
5. Trim: CSl EDL-1200; Glass, Round Frost Shower

G. Fixture 7: Hallway Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

    a. CSL EDL-ADJ-WW

2. Voltage: 120V AC
3. Mounting: Recessed ceiling
4. Lamps: 16 W LED
5. Trim: CSl EDL-1200; Glass, Round Frost Shower

H. Fixture 8: Translucent Wall Panel Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

    a. CSL LRL-OD-20-WW

2. Voltage: 12V DC

3. Mounting: Placed in aluminum channel at base of translucent wall panels
4. Nominal Dimensions: 1/2” W x 3/16” H
5. Lamps: 1.5 W/ft LED
6. Transformer: CSL D-111
7. Hardware
   a. Power Connector: LRP-OD-10

I. Fixture 9: Bathroom Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

   a. Millenium 8090-01

2. Voltage: 120V AC
3. Mounting: Wall mounted above bathroom mirror
4. Nominal Dimensions: 27” L x 3 1/2” W x 1” H
5. Lamps: 24 W T5
6. External Finish: Chrome

J. Fixture 10: Mechanical Room Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

   a. Stonco VWXL11GCN

2. Voltage: 120V AC
3. Mounting: Wall mounted
4. Nominal Dimensions: 7 1/4” D x 9 3/4” H
5. Lamps: 13 W CFL
6. External Finish: Die-cast Aluminum

K. Fixture 11: Laundry Room Light
1. Basis-of-Design Product: product indicated in Lighting Schedule or comparable product subject to approval by architect.

   a. Leviton 9860-LHG

2. Voltage: 120V AC
3. Mounting: Ceiling Mounted
4. Lamps: 13 W CFL
5. External Finish: White

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set units level, plumb, and square with ceiling and walls, and secure.

B. Terminate appropriate fixtures with corresponding transformer and secure transformer.

C. Wire fixtures and transformers to scheduled Crestron Dimmer Panel and Button Station switch leg.

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.

END OF SECTION 26 50 00

SECTION 28 31 46 – SMOKE DETECTION SENSORS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data and system operating description.

B. Submittals to Authorities Having Jurisdiction: In addition to distribution requirements for submittals, make an identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations.

C. Comply with NFPA 72.

D. UL listed and labeled.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2 - PRODUCTS

2.01 SMOKE DETECTORS

A. Kidde PI2010 Dual Sensor, 120V AC with Battery Backup Smoke Alarm

B. Sensors: Ionization and Photoelectric

C. High-Level Chimes: 85 dBA at 10ft

2.02 WIRE AND CABLE

A. UL listed and labeled as complying with NFPA 70, Article 760.

B. Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation. No. 12 AWG or larger as required by local codes.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install and test systems according to NFPA 72. Comply with NECA 1.

B. Install wiring "fished" in concealed spaces and exposed on ceilings and walls where indicated.

C. Wire system per manufacturer specifications.

END OF SECTION 28 31 46

SECTION 31 66 00 – SPECIAL FOUNDATIONS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Design, engineer, fabricate, and install foundation system to withstand structural loads required by the U.S. Department of Energy Solar Decathlon Building Code.

B. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 ADJUSTABLE FOUNDATION POSTS

A. Pylex Adjustable Deck Posts
1. Model# 12105
2. Adjustable height, steel plate and post with threaded adjustment.
3. Load Rating: 2,725 lbs.
4. Minimum/Maximum Height: 6.5”/10”
5. U-plate size: 3.625” x 3” x 5.25”
6. Color: Khaki
7. Website: http://24.226.222.37/pylex/html/page_07-en.html

B. Ellis Adjustable Screw Jack
1. Model# MJ-6
2. Adjustable height, steel plate and post with threaded adjustment.
3. Load Rating: 15,000 lbs.
4. Minimum/Maximum Height: 9.5”/15”
5. Anchor plate size: 4” x 4” x .25”
6. Color: Red
7. Website: http://www.ellisok.com/ellisok/products_miniscrewjack.html

C. Ellis Adjustable Steel Shore
1. Model# STL-19
2. Adjustable height, steel plate and post with threaded adjustment.
3. Load Rating: 18,000 lbs.
4. Minimum/Maximum Height: 19”/27”
5. Anchor plate size: 6” x 6” x .375”
6. Color: Red
7. Website: http://www.ellisok.com/ellisok/products_36screw.html#SS-36

2.02 PRECAST CONCRETE FOOTINGS WITH POSTS

A. Precast Concrete Footings
1. Size: 11.5 ” x 8” x 11.5”
2. Compressive Strength: 1,900 psi
3. Color: Gray
4. ASTM Standard: C90

2.03 FINISHES

A. Steel Finishes: Cleaned, primed, and painted by manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Prepare ground by cleaning, removing projections, and as otherwise recommended in stand manufacturer's written instructions and DOE Solar Decathlon Building Code foundation provisions.

B. Set units level, plumb, and true to line, without warp or rack of materials. Adjust products to achieve level foundation within manufacturer’s specified minimum and maximum heights. Provide appropriate blocking if necessary.

C. Fasten stands securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated in drawings. Adjust as needed to integrate stability throughout system.

D. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

E. Correct deficiencies in or remove and reinstall products that do not comply with requirements.

F. Repair, refinish, or replace products damaged during installation, as directed by Architect.

G. Lubricate hardware and moving parts.

H. Secure with approved anchoring system.

END OF SECTION 31 66 00

SECTION 32 71 00 – CONSTRUCTED WETLANDS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Structural Performance: Design, engineer, fabricate, and install the constructed wetland to withstand structural loads.

B. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 PRE-FABRICATED WOOD STRUCTURAL TRUSS

A. Fabricator: Blue Ridge Truss.

B. Design, engineer, fabricate, and install wood structural trusses to withstand structural loads.

C. Wood structural trusses have varying cross-member heights per wetlands section in drawings.

2.02 SHEATHING

A. 1/2” Grade C Plywood.

2.03 FASTENINGS

A. Wood fastenings.

2.04 PIPING AND FITTINGS

A. PVC Piping
   1. Use 11/2” and 2” PVC piping for module-to-module connections as per drawings.

B. PVC Fittings
   1. Use 1-1/2” and 2” PVC fittings to connect PVC piping in module-to-module connections.

C. Corrugated black hose
   1. 1-1/2” diameter hose connecting house outlet to constructed wetlands inlet.

2. Install such that house outlet elevation is higher than wetlands inlet.

D. Slotted black Pipe
   1. 2” diameter slotted black pipe for rainwater distribution at end of east wetland as per drawings.

2.05 PUMPS

A. 500 gph, PM5 In-Line Submersible Pump
   1. Conservation Technology.
   2. Magnetic-driven.
   3. Supply Voltage: 115V.
   4. Current Rating: 0.39A.
   5. Pumps serve to circulate within each of the systems themselves helping to prevent water from becoming stagnant, and the growth of insects.

B. 300 gph, PM5 In-Line Submersible Pump
   1. Conservation Technology.
   2. Supply Voltage: 115V, Current Rating: 0.39A, Magnetic-driven.
   3. Pumps serve the purpose of circulation within each of the systems themselves helping to prevent water from becoming stagnant, and the growth of insects.

2.06 WATERPROOFING MEMBRANE

A. Tremco Vulkem 116
   1. One-part polyurethane sealant for joints.
   2. Use over all connection points between structural trusses and sheathing.
   3. Allow minimum 30 hours cure time.

B. Tremco Vulkem Primer 171
   1. Urethane sealant
   2. Coat over entire sheathing surface.
   3. Allow minimum 30 minutes cure time.

C. Tremco Vulkem 350NF
   1. Single-component polyurethane basecoat.
   2. First coat applied in a 4” diameter around joints.
   3. Allow minumim 4 hours cure time between first and second coat.
   4. Second coat over entire sheathing surface has 40 mil thickness.
   5. Allow minimum 6 hours cure time after second coat.

D. Vulkem 951NF Topcoat
   1. High-performance, two-part polyurethane coating.
   2. Two coats at 12 mil each; allow minimum 6 hours cure time.

2.07 SETTLING TANK

A. TetraPond: Clear Choice PF-2 Biofilter.

B. Filtration type: Gravity/Trickle, Fittings: 3/4” and 1-1/4”, max flow: 500gph, Diameter: 4’5.5”, Height:2’5.5”.

2.08 OUTDOOR TIMER

A. UtiliTech.

B. Supply Voltage: 125 V.

C. Current Rating: 15A.

D. Used to regulate recirculation pumps in wetlands.

2.09 PLANT BAGS

A. Conservation Technology.

B. Fabric planting pot.

C. Diameter: 8” and 10”.

D. Material: Fabric.

E. Bags help to contain the growing medium, but still allow water to pass through so the root to water contact is still possible.

2.10 BIO BARRELS

A. Koiphen Aquatic-BF44.

B. Length: 1-1/2”.

C. 44’ surface area per cubic foot.

D. Barrels help to provide extra surface area for microbial organisms to grow, helping with the overall filtration process. The weight of the rocks is also supported by the bio-barrels.

2.11 FINISHES

A. River Rocks
   1. The Stone Store

2. 1”-2” Black Polished Pebbles.

B. Corrugated Metal
   1. Firestone Building Products UNVA-CLAD UC-601.
      a. Corrugated Panel for Commerical-Industrial Metal Roofing and Wall Cladding. Exposed-fastener, lap seam1/2” corrugated metal wall panel, 2” ridge to ridge, 40” net coverage.
      b. http://www.firestonebpco.com/templateFiles/includes/common/displayFile.ashx?fileId=10451

C. Cooked Poplar Trim
   1. Heister House, Inc.
      a. Milled, heat-treated poplar.
      b. http://www.hhmillworks.com/

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install pre-fabricated wood structural trusses 16” o.c. maximum per drawings.

B. Connect all structural trusses to sheathing using appropriate fastenings. Install plywood sheathing Grade C face up.

C. Make plumbing penetrations in locations indicated in drawings.

D. Set units level, plumb, and true to line, without warp or rack of frames. Securely in place using appropriate fastenings.

E. Connect PVC piping to modules where indicated in drawings with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated in drawings.

F. Install pumps in locations indicated on drawings.

G. Prepare substrate as recommended in waterproofing membrane manufacturer’s specifications.

H. Apply waterproofing membrane in the following order: Tremco Vulkem 116, Tremco Vulkem Primer 171, Tremco Vulkem 350NF, Tremco Vulkem 951NF Topcoat. Apply layers to locations indicated in accordance with manufacturer’s specifications allowing indicated curing times between coats.

I. Repair, refinish, or replace damaged parts during installation, as directed by Architect.

J. Adjust operating parts and hardware for smooth, quiet operation. Lubricate hardware and moving parts.

K. Install settling tank and outdoor timer according accrording to manufacturer’s written instructions.

L. Place wetland plants in plant bags and bio-barrels within the respective parts of the wetland.

M. Finish wetland by placing river rocks above bio-barrels. Bio-barrels should not be visible when installation is complete.

N. Trim wetland modules in cooked ash and corrugated metal as indicated in drawings.

END OF SECTION 32 71 00

SECTION 48 19 16 - ELECTRICAL POWER GENERATION INVERTERS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Comply with NFPA 70, "National Electrical Code."

C. Related sections: 26 31 00 Photovoltaic Collectors.

PART 2 - PRODUCTS

2.01 Microinverter

A. Enphase M210
1. DC to AC transformer for an individual photovoltaic module.
2. Provide one microinverter per installed photovoltaic module.
3. Warranty: 15 Years.
4. http://www.enphaseenergy.com/downloads/Enphase_M210_Datasheet.pdf

PART 3 - EXECUTION

3.01 INSTALLATION

A. Measure service entrance conductors to confirm AC service at the site.

B. Mark approximate centers of each PV module on mounting surface.

C. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place using S5! U-mini clamps on standing seam metal roof. On pergola attach to structure using appropriate fastenings.

D. Fasten M210 securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated on drawings.

E. Correct deficiencies in or remove and reinstall Enphase M210 microinverters that do not comply with requirements.

END SECTION 48 19 16

APPENDIX A: STRUCTURAL CALCULATIONS

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS

STRUCTURAL CALCULATIONS

Watershed

University of Maryland, Solar Decathlon Entry

March 18, 2011

PREPARED FOR:
University of Maryland
College Park, MD 20742

BY:
ROBERT SILMAN ASSOCIATES, PLLC
1053 31st Street, NW
Washington, DC 20007

Contents: **Page**

Signed:

ROBERT SILMAN ASSOCIATES, PLLC

PRINCIPALS
Robert Silman
Joseph F. Tortorella
Kirk Mettam
Nat Oppenheimer
Edmund Meade

1053 31st Street, NW
Washington, DC 20007
P 202.333.6230
F 202.318.3015
www.silman.com

STRUCTURAL DESIGN NARRATIVE

General Description

The project is conceived as a custom-designed, highly energy efficient, single-family residence. The majority of the structure consists of mono-slope framed roofs supported by small grid (approx. 48” o.c.) of fixed base posts, integral with the floor framing. The expectations of material and energy efficiency are high, in keeping with the life-cycle energy efficiency of the remainder of its systems.

Foundations

The design of adjustable micro footings will comply with limitations on differential movement appropriate to the competition duration and variability of surface strata.

It is anticipated that uplift and overturning forces will be resisted by building weight and footing stance, supplemented by drill-in-place soil screws.

Superstructure

The design of the superstructure will be driven by two factors: constructability and economy. As such, it is anticipated that the gravity and lateral forces will be resisted by the same system of elements.

SUPERSTRUCTURE DETAIL:

1. Roof framing will utilize engineered and solid sawn (as visibility dictates) lumber to create the desired roof configurations and framed with spacers to allow the fixed top post interaction.
2. Roof diaphragms will consist of engineered 2x (1 7/16” true) timber decking spanning approximately 4’-0” and fastened directly to the rafters in a random layup configuration.
3. Floor framing will utilize engineered lumber framed with spacers to allow the fixed base post interaction.
4. Floor diaphragms will consist of 3x (2 3/16” true) engineered timber decking spanning approximately 8’-0” and fastened directly to the floor girders in a random layup configuration. As the top surface will be exposed to view, the material selection of the top lamination will likely be of very high quality. Additionally, all screws will be plugged and sanded where visible.
5. Tightly spaced (4’-0”), fixed base posts will be used to support gravity and lateral loads. Posts may be comprised of (3) 2x laminations whose center lamination is splined down into the

girder and up into the doubled rafter.

6. The lateral system will utilize exterior shear walls, where possible. In-plane bracing is not anticipated, but could be employed in less visible areas.

STRUCTURAL DESIGN GUIDELINES

Applicable Codes and Standards

The following codes and standards are specified:

A. 2011 Solar Decathlon Building Code (SDBC)
B. 2009 International Residential Code (IRC), as modified by COMAR 05.02.07 (Maryland Building Performance Standard for Modular Building Construction).
C. ASCE 7-05, Minimum Design Loads for Buildings and Other Structures
D. EPA Comprehensive Procurement Guidelines as they relate to recycled content of construction materials, if necessary.

The following structural design codes will be followed as specified by the governing codes and standards:

A. NDS, National Design Specification for Wood Construction (NDS)
B. AA-ADM 1-05 Aluminum Design Manual
C. AISC 360 Specification for Structural Steel Buildings
D. AISC 341 Seismic Provisions for Structural Steel Buildings, including Supplement No.1 dated 2006.

Structural Loading

Uniformly Distributed Live Loading
The following values are specified by the applicable codes and standards or are higher values selected for use on this project.

Occupancy or Use Live Loading

	Uniform[2] (psf)	Concentrated (pounds)	Linear (# / lin.ft.)
Uninhabitable attics without storage	10		
Uninhabitable attics with storage	20		
Habitable attics and sleeping areas	30		
All other areas except balconies	40		
Balconies not exceeding 100 sf	60		
Balconies exceeding 100 sf	100		
Assembly Areas	100	2000[1]	
Roof	20	250[1]	
Special Floor Finishes	15-20		

[1] Non-concurrent with uniform live load
[2] 20 psf CMEP, unless noted otherwise

Live Load Reduction

The 2009 IBC allows a reduction in live loads applied to members having an influence area of 400 ft^2 or more in accordance with the following equation:

$$L = L_0 + \left[.025 + \frac{15}{\sqrt{A_i}} \right]$$

- Maximum reduction for members supporting one floor is 50% and more than one floor is 60%.
- Live Load reduction is not permitted for roof loads or areas where the live load exceeds 100 psf.
- The contributory area for a column is defined as "the loaded area directly supported by the column". The loaded area is the cumulative total area of all the floors that are supported.
- For the design of flat plate or flat slab construction, the contributory area is half the area of the panel.
- No live load reduction is permitted for calculating shear stresses at the heads of columns in flat slab or flat plate construction.

Snow Loading

Flat Roof Snow Load: 40 psf*

* Sloped roof snow loads, snowdrift, and sliding snow will be accounted for in accordance with ASCE 7.

Design Earth Bearing Pressure

Competition Design: 1500 psf (Reduced Factor of Safety)
Permanent Design: 1500 psf (Min 5:1 Factor of Safety)

Wind Loading

Building Frame

The 2010 IBC Section on wind loads is used to calculate the design forces. The design base shear is found using the static force procedure with the following factors:

Basic Wind Speed	90 mph
Wind Load Importance Factor	1.00
Wind Exposure	C

Seismic Parameters

The 2009 IRC Section on earthquake loads is used to calculate the design forces. The design base shear is found using the equivalent lateral force procedure with the following factors:

Short period map value (SS)	18.0% g
1-Sec period map value (S1)	6.3% g
Assumed Site Class (Soil Factor)	D
Seismic Design Category	C

Basic Structural System	Load-bearing post elements with base-fixity
Seismic Resisting System	Load-bearing post elements with base-fixity and cap rigidity, composite with wood shear walls
Lateral Bracing System	Load-bearing post elements with base-fixity and cap rigidity, composite with wood shear walls

Design Considerations:

Stability

1. Dead Load = 2.0 x overturning [Competition - 60mph]
2. Dead Load = 2.0 x sliding [Competition - 60mph]
3. Dead Load + anchorage = 2.0 x overturning [Competition - 60mph]

Lateral Deflection

1. Design (amplified) story drift due to seismic loads shall not exceed 0.007 x story height.
2. Design story drift due to wind shall not exceed 0.002 x story height.

Floor Deflections

1. The live load deflection of wood floor framing supporting tile or stone finishes shall not exceed 1/600 times the span length.
2. The live load deflection of wood floor framing supporting standard wood floor finishes shall not exceed 1/480 times the span length.
3. The live load deflection of steel beams and girders shall not exceed 1/360 times the span length.
4. Roof deflection under snow or wind loads shall not exceed

1/360 times the span length.

5. The live load deflection of floor spandrels supporting exterior wall elements shall not exceed 0.3”

Vibrations

Where human comfort is the criteria for limiting pedestrian induced motion, floor-framing vibration due to footfall vibrations will be verified. Where running machinery causes vibrations, the machinery shall be isolated by damping devices or by the use of independent foundations.

Steel floor framing members will be designed to perform within the recommended acceleration thresholds for residential framing, as defined by AISC Design Guide 11 (Murray, Allen, and Ungar, 2003)

Engineered wood joists will be designed so that the assembly receives at least 45 TJ-Pro Rating Points or equivalent perception/acceptance criteria.

Non-Structural Components

Provisions for the support of non-structural components are as follows:

Seismic provisions of the 2009 IBC require minimum detailing requirements for non-load bearing walls, supports for mechanical/ electrical/plumbing equipment, etc.

Future Use/ Expansion Provisions

Except provisions noted above, no provisions for future changes in use or expansion will be included in the structural design.

- ROOF

  - DEAD

    - BASE DL 15 PSF
    - GREEN ROOF MODULES 17 PSF
    - P.V. PANELS 2 PSF

  - LIVE

    - COMPETITION 20 PSF

    - SNOW

$p_g = 40\text{psf}$

$p_f = 0.7 C_e C_t I p_g = 0.7(1.0)(1.1)(1.0)(40\text{psf}) = 30.8 \text{ PSF}$

$p_s = C_s p_f = (1.0)(30.8\text{psf}) = \boxed{30.8 \text{ PSF}}$

- DRIFTING SNOW (ASCE 7.7)

$h_c/h_b = 15'/1.6' = \boxed{0.94 > 0.2}$

$h_b = p_s/\gamma = 30.8\text{PSF}/19.2 \text{ PCF} = 1.60'$

- $\gamma = 0.13 p_g + 14 = 0.13(40\text{PSF}) + 14 = \boxed{19.2\text{PCF} < 30\text{PCF}}$ ✓ (7-3)

$p_d = h_d \gamma = 0'(19.2\text{PCF}) = \underline{\underline{0}}$ $\quad h_b > h_c \therefore h_d = 0$

- SLIDING SNOW (ASCE 7.9)

$0.4 p_f W = 0.4(30.8\text{PSF})(18') = \boxed{222 \text{ PLF}}$

- LENGTH OF LOWER ROOF = 6'

$6/15 \,(222\text{PLF}) = 88.8\text{PLF}$

$\dfrac{88.8\text{PLF}}{6'} = \boxed{14.8 \text{PSF}}$ ← ADD'L LOAD DUE TO SLIDING (PER ROOF)

⇒ $\underline{29.6 \text{PSF}}$ TOTAL SLIDING LOAD ON LOW ROOF

PROJECT ______ JOB NO. ______ PAGE ______

SUBJECT PROJECT LOADS BY KP DATE ______

- FLOOR
  - DEAD
    - BASE DL (INTERIOR) 15 PSF
    - BASE DL (EXTERIOR) 7 PSF
  - LIVE
    - INTERIOR FLOORS, DECKS, & RAMPS 50 PSF
    - MEANS OF EGRESS 100 PSF
    - EXTERIOR DECKS (RESIDENTIAL) 60 PSF
    - RAILINGS 200 # CONCENTRATED LOAD
- SOIL
  - BEARING CAPACITY (HOUSE) 1500 PSF (MAX.)
    1000 PSF (MIN.)
  - DECK & RAMP FOUNDATIONS 250 PSF (MIN.)
  - WATER TANK 1000 PSF (MIN.)

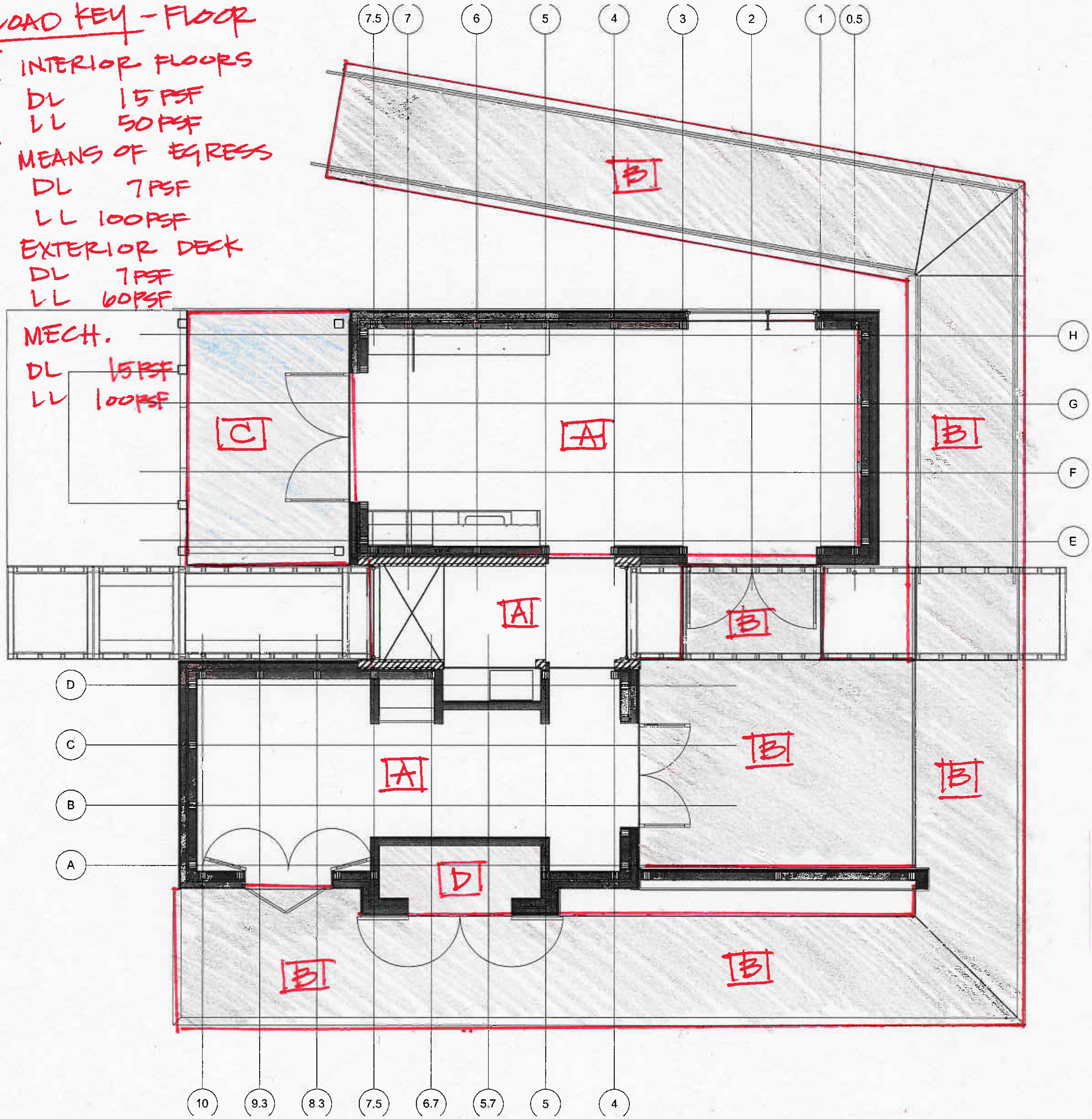
LOAD KEY - FLOOR

A — INTERIOR FLOORS
- DL 15 PSF
- LL 50 PSF

B — MEANS OF EGRESS
- DL 7 PSF
- LL 100 PSF

C — EXTERIOR DECK
- DL 7 PSF
- LL 60 PSF

D — MECH.
- DL 15 PSF
- LL 100 PSF

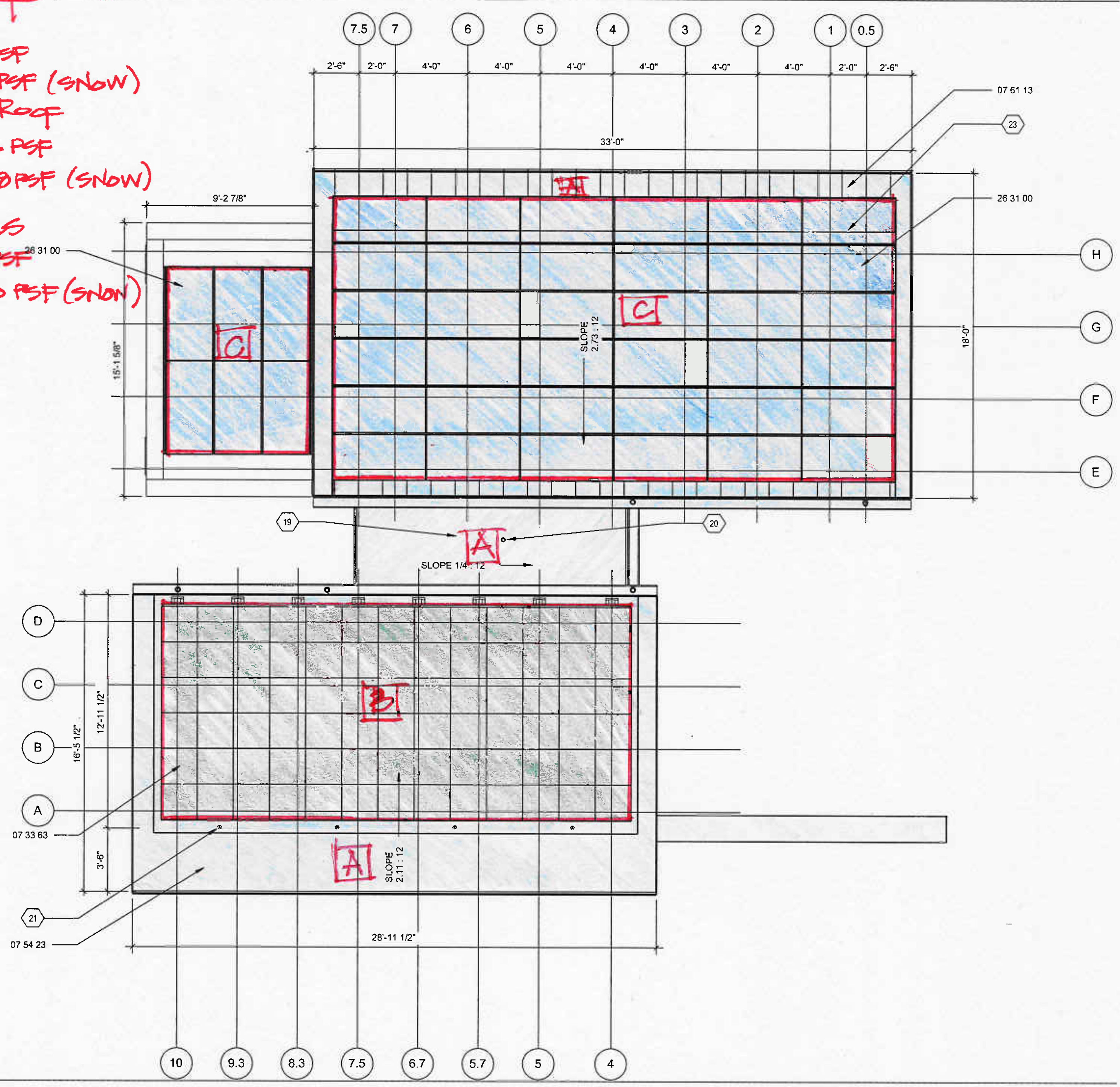


LOAD KEY - ROOF

A ROOF
DL 15 PSF
LL 30.8 PSF (SNOW)

B GREEN ROOF
DL 32 PSF
LL 30.8 PSF (SNOW)

C PV PANELS
DL 17 PSF
LL 30.8 PSF (SNOW)



ROBERT SILMAN ASSOCIATES, PLLC

STRUCTURAL ENGINEERS

1053 31ST NW, WASHINGTON DC 20007

PROJECT ____ JOB NO. ____ PAGE ____

SUBJECT PROJECT LOADS BY KP DATE 03.09.11

- WIND
  - BASIC WIND SPEED
    - COMPETITION 60 MPH
    - PERMANENT 90 MPH
  - EXPOSURE CATEGORY: C
  - SAFETY FACTOR: 2.0
    - APPLIES FOR O.T., UPLIFT, SLIDING
  - MWFRS - METHOD 1 (ASCE 7 FIG. 6.2)
    - $p_s = \lambda K_{zt} I p_{s30}$ (6-1)

      $\lambda = 1.21$

      $K_{zt} = 1.0$

      $I = 1.0$

ZONE		p_{s30} (PSF)	p_s (PSF)	p_s (PSF)
HORIZONTAL	A	16.1	19.5	8.58
	B	-5.4	-6.5	-2.86
	C	10.7	12.9	5.7
	D	-3.0	-3.6	-1.6
VERTICAL	E	-15.4	-18.6	-8.21
	F	-10.1	-12.2	-5.4
	G	-10.7	-12.9	-5.7
	H	-7.7	-9.3	-4.1
OVERHANGS	E_{OH}	-21.6	-26.1	-11.51
	G_{OH}	-16.9	-20.4	-8.98
		90MPH	90MPH	60MPH

* FACTORED TO APPROPRIATE VALUES @ 60MPH

TO GET FROM 90MPH VALUES TO 60MPH VALUES USE MULTIPLIER EQUAL TO: $60^2/90^2 = 0.44$

ROBERT SILMAN ASSOCIATES, PLLC
STRUCTURAL ENGINEERS
1053 31ST NW, WASHINGTON DC 20007

PROJECT ______ JOB NO. ______ PAGE ______

SUBJECT ______ BY ______ DATE ______

- COMPONENTS & CLADDING (FOR 90 MPH) (6-2)

$P_{net} = \lambda K_{zt} I P_{net30}$

$\lambda = 1.21$

$K_{zt} = 1.0$

$I = 1.0$

ZONE	E.W.A.	P_{net30} (PSF)		P_{net} (PSF)	
1 (ROOF)	10	8.4	-13.3	10.2	-16.1
	20	7.7	-13.0	9.32	-15.7
	50	6.7	-12.5	8.12	-15.1
	100	5.9	-12.1	7.14	-14.6
2 (ROOF)	10	8.4	-23.2	10.2	-28.1
	20	7.7	-21.4	9.32	-25.9
	50	6.7	-18.9	8.12	-22.9
	100	5.9	-17.0	7.14	-20.6
3 (ROOF)	10	8.4	-34.3	10.2	-41.5
	20	7.7	-32.1	9.32	-38.8
	50	6.7	-29.1	8.12	-35.2
	100	5.9	-26.9	7.14	-32.5
2OH	10	-27.2		-32.9	
	20	-27.2		-32.9	
	50	-27.2		-32.9	
	100	-27.2		-32.9	
3OH	10	-45.7		-55.3	
	20	-41.2		-49.9	
	50	-35.3		-42.7	
	100	-30.9		-37.4	

ROBERT SILMAN ASSOCIATES, PLLC
STRUCTURAL ENGINEERS
1053 31ST NW, WASHINGTON DC 20007

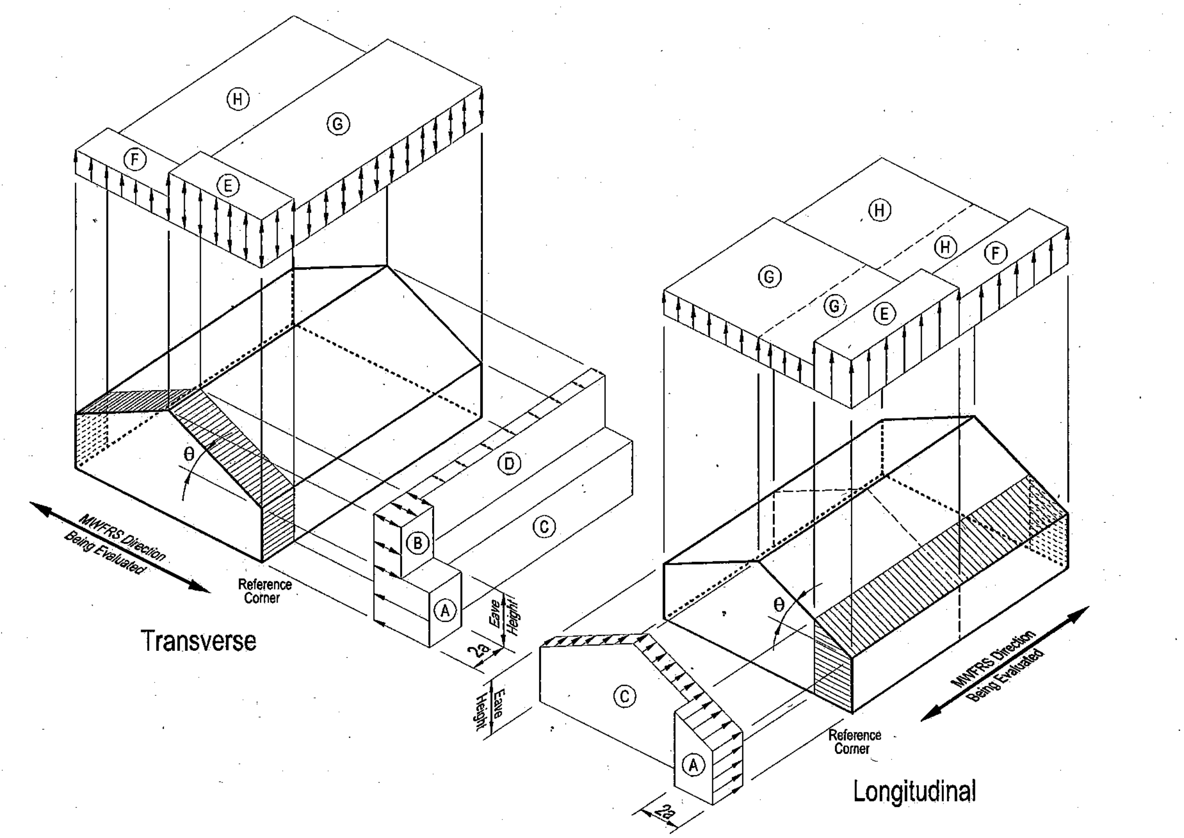
PROJECT ______ JOB NO. ______ PAGE ______

SUBJECT ______ BY ______ DATE ______

- COMPONENTS & CLADDING (CONT.)

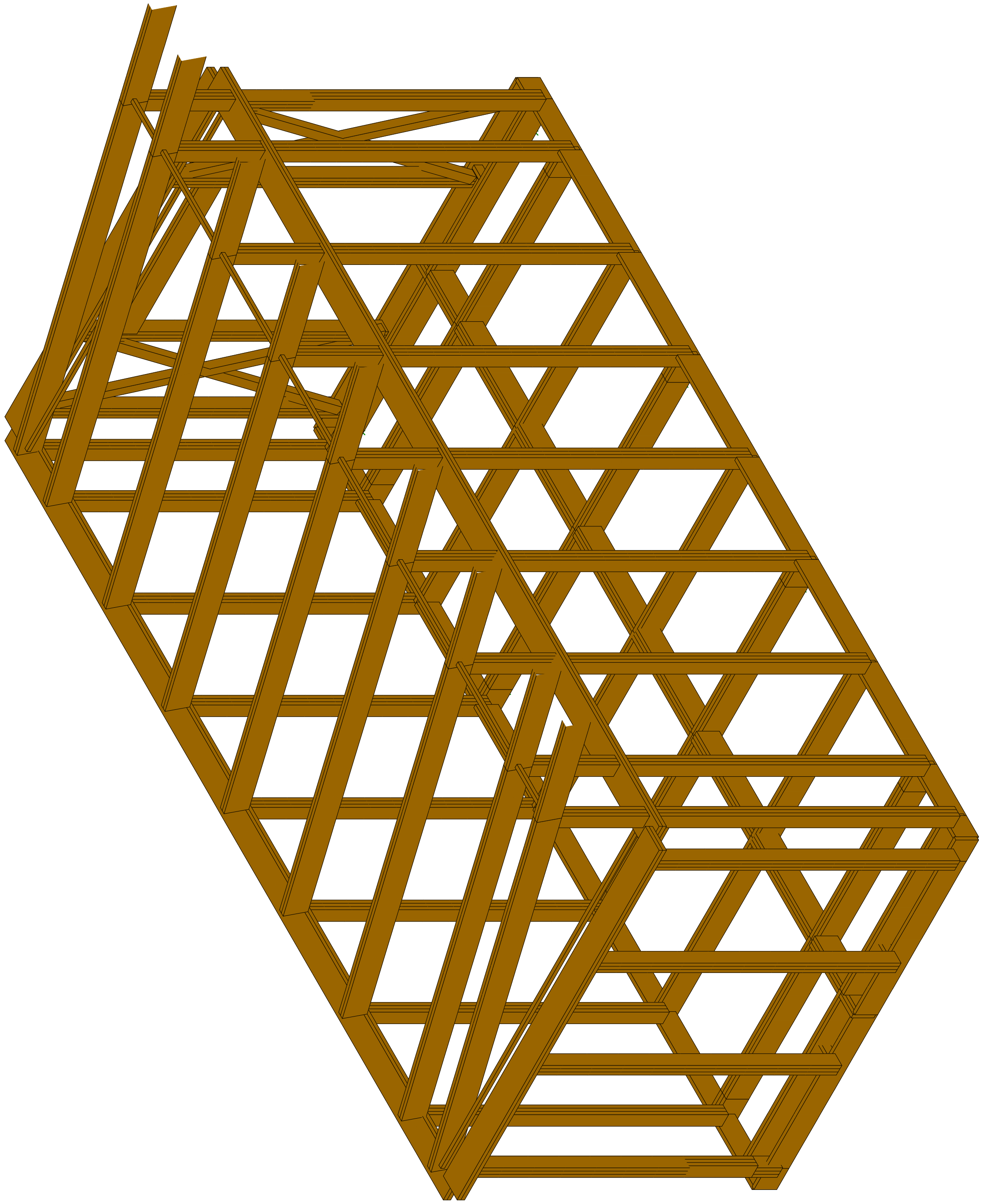
ZONE	E.W.A.	Pnet30 (PSF)		Pnet (PSF)	
4 (WALL)	10	14.6	-15.8	17.7	-19.1
	20	13.9	-15.1	16.8	-18.3
	50	13.0	-14.3	15.7	-17.3
	100	12.4	-13.6	15.0	-16.5
	500	10.9	-12.1	13.2	-14.6
5 (WALL)	10	14.6	-19.5	17.7	-23.6
	20	13.9	-18.2	16.8	-22.0
	50	13.0	-16.5	15.7	-20.0
	100	12.4	-15.1	15.0	-18.3
	500	10.9	-12.1	13.2	-14.6

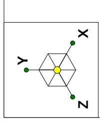
Main Wind Force Resisting System – Method 1		$h \leq 60$ ft.
Figure 6-2	Design Wind Pressures	Walls & Roofs
Enclosed Buildings		



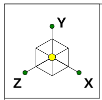
Notes:

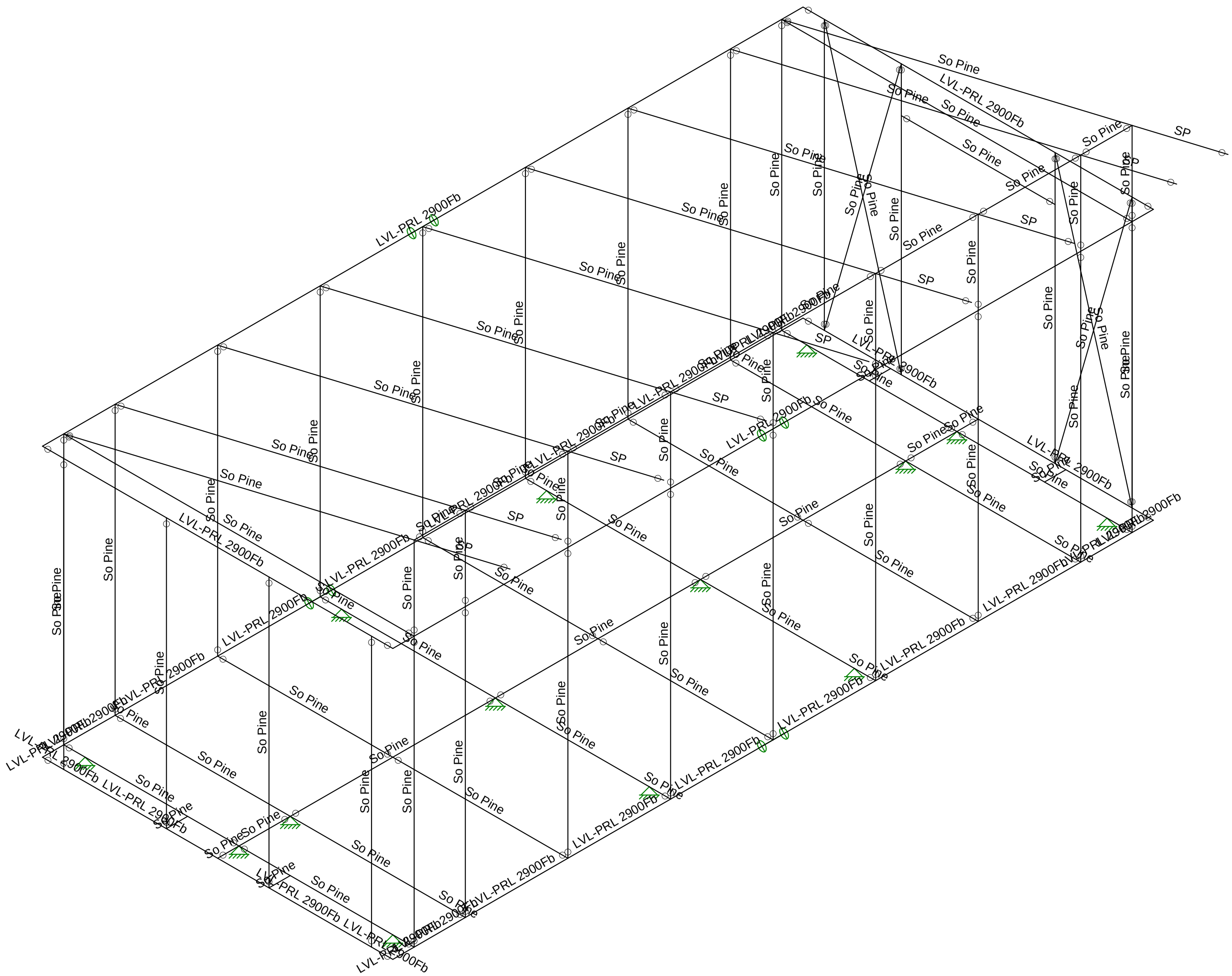
1. Pressures shown are applied to the horizontal and vertical projections, for exposure B, at h=30 ft (9.1m), I=1.0, and $K_{zt} = 1.0$. Adjust to other conditions using Equation 6-1.
2. The load patterns shown shall be applied to each corner of the building in turn as the reference corner. (See Figure 6-10)
3. For the design of the longitudinal MWFRS use $\theta = 0°$, and locate the zone E/F, G/H boundary at the mid-length of the building.
4. Load cases 1 and 2 must be checked for $25° < \theta \leq 45°$. Load case 2 at 25° is provided only for interpolation between 25° to 30°.
5. Plus and minus signs signify pressures acting toward and away from the projected surfaces, respectively.
6. For roof slopes other than those shown, linear interpolation is permitted.
7. The total horizontal load shall not be less than that determined by assuming $p_S = 0$ in zones B & D.
8. The zone pressures represent the following:
   Horizontal pressure zones – Sum of the windward and leeward net (sum of internal and external) pressures on vertical projection of:
   A - End zone of wall C - Interior zone of wall
   B - End zone of roof D - Interior zone of roof
   Vertical pressure zones – Net (sum of internal and external) pressures on horizontal projection of:
   E - End zone of windward roof G - Interior zone of windward roof
   F - End zone of leeward roof H - Interior zone of leeward roof
9. Where zone E or G falls on a roof overhang on the windward side of the building, use E_{OH} and G_{OH} for the pressure on the horizontal projection of the overhang. Overhangs on the leeward and side edges shall have the basic zone pressure applied.
10. Notation:
    a: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
    h: Mean roof height, in feet (meters), except that eave height shall be used for roof angles <10°.
    θ: Angle of plane of roof from horizontal, in degrees.



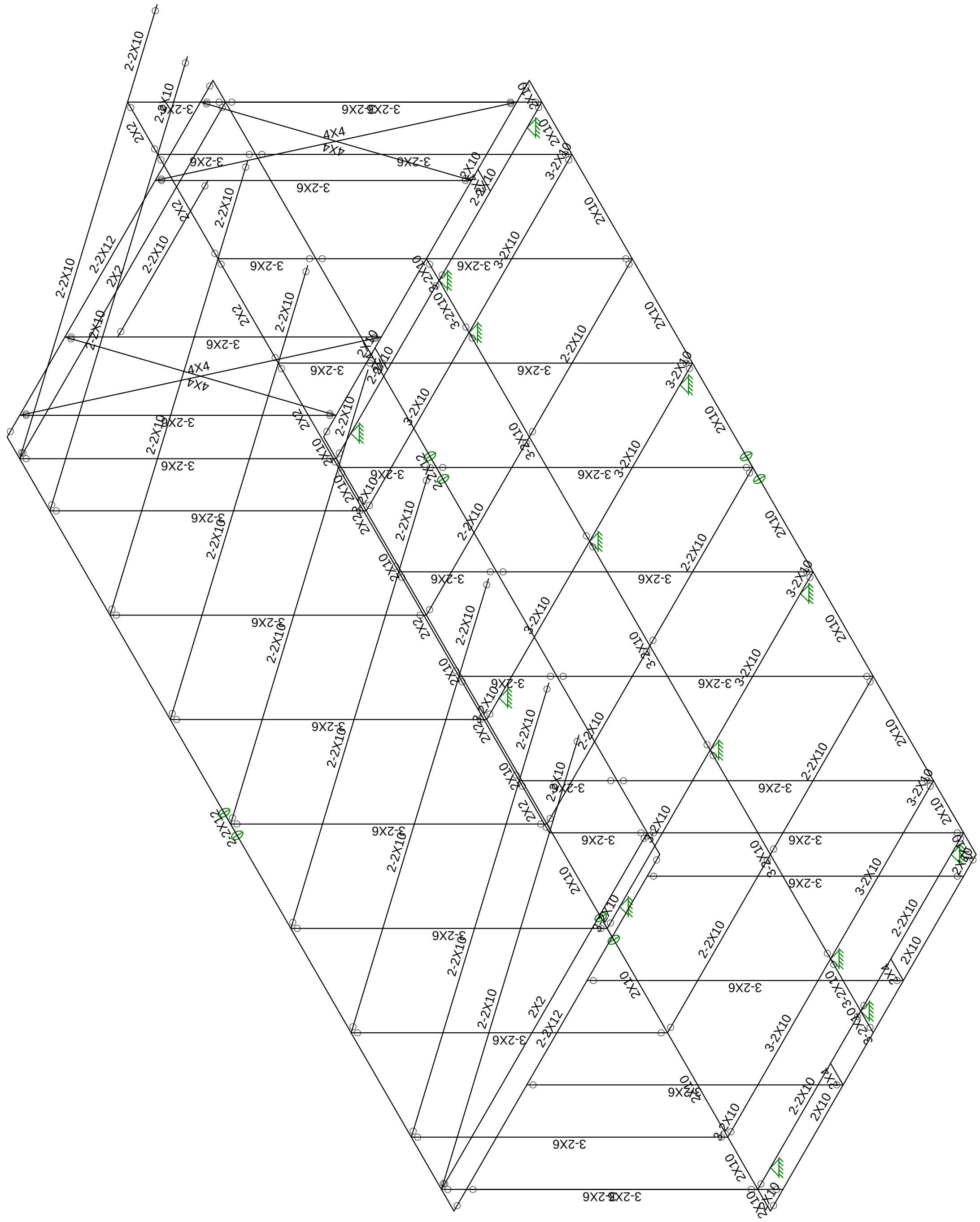


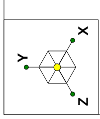
Results for LC 1, IBC 16-8 (a)

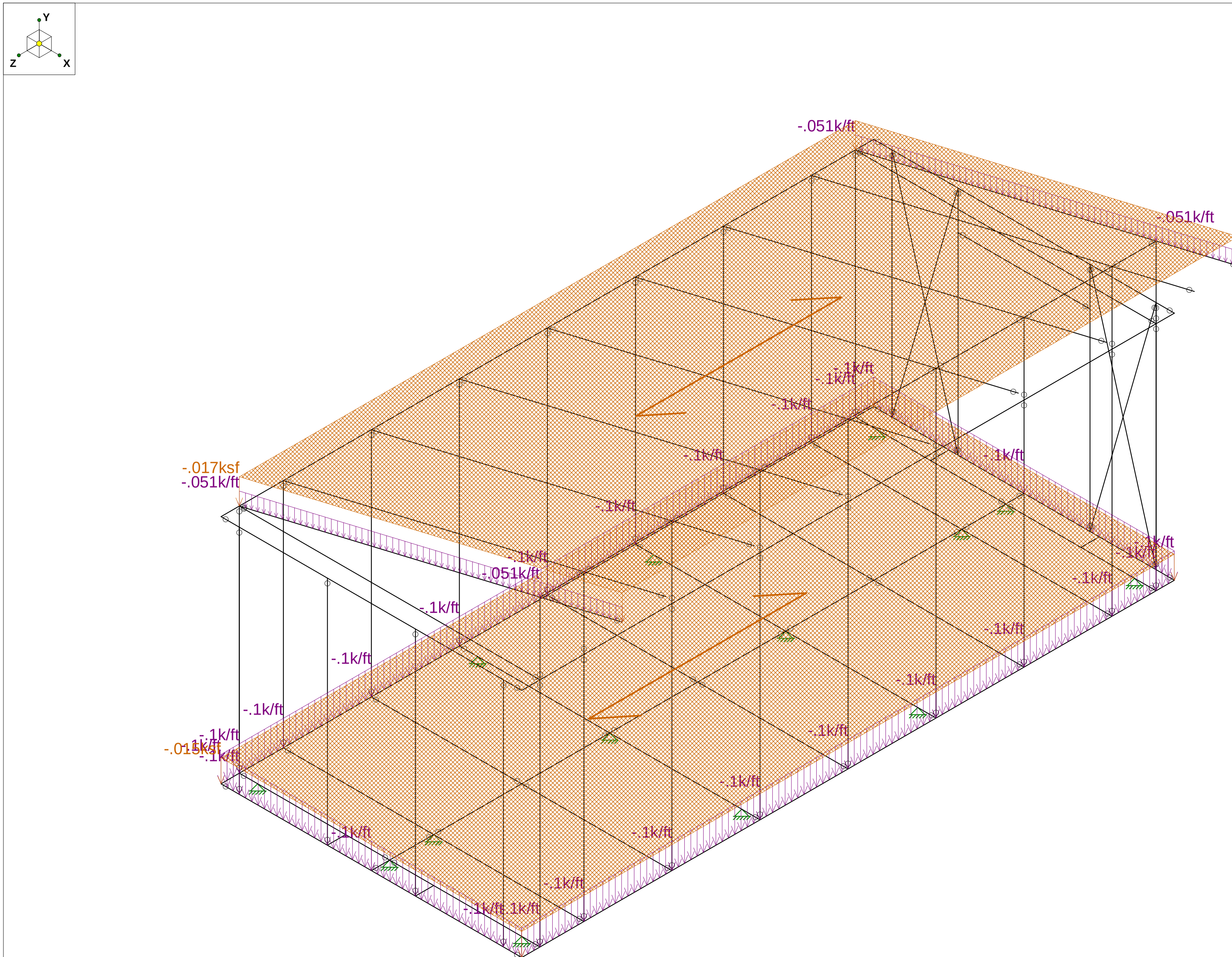




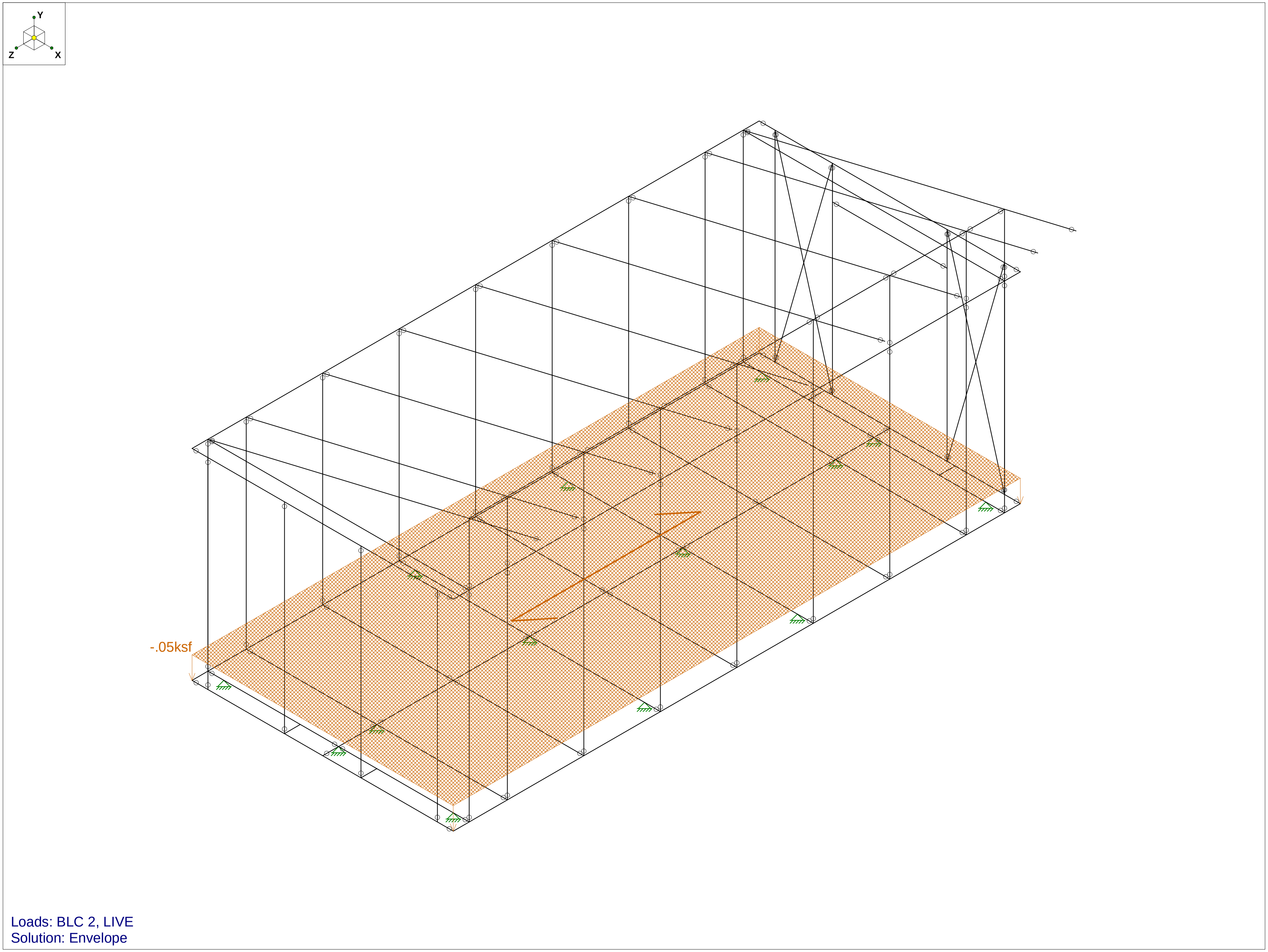
Results for LC 1, IBC 16-8 (a)

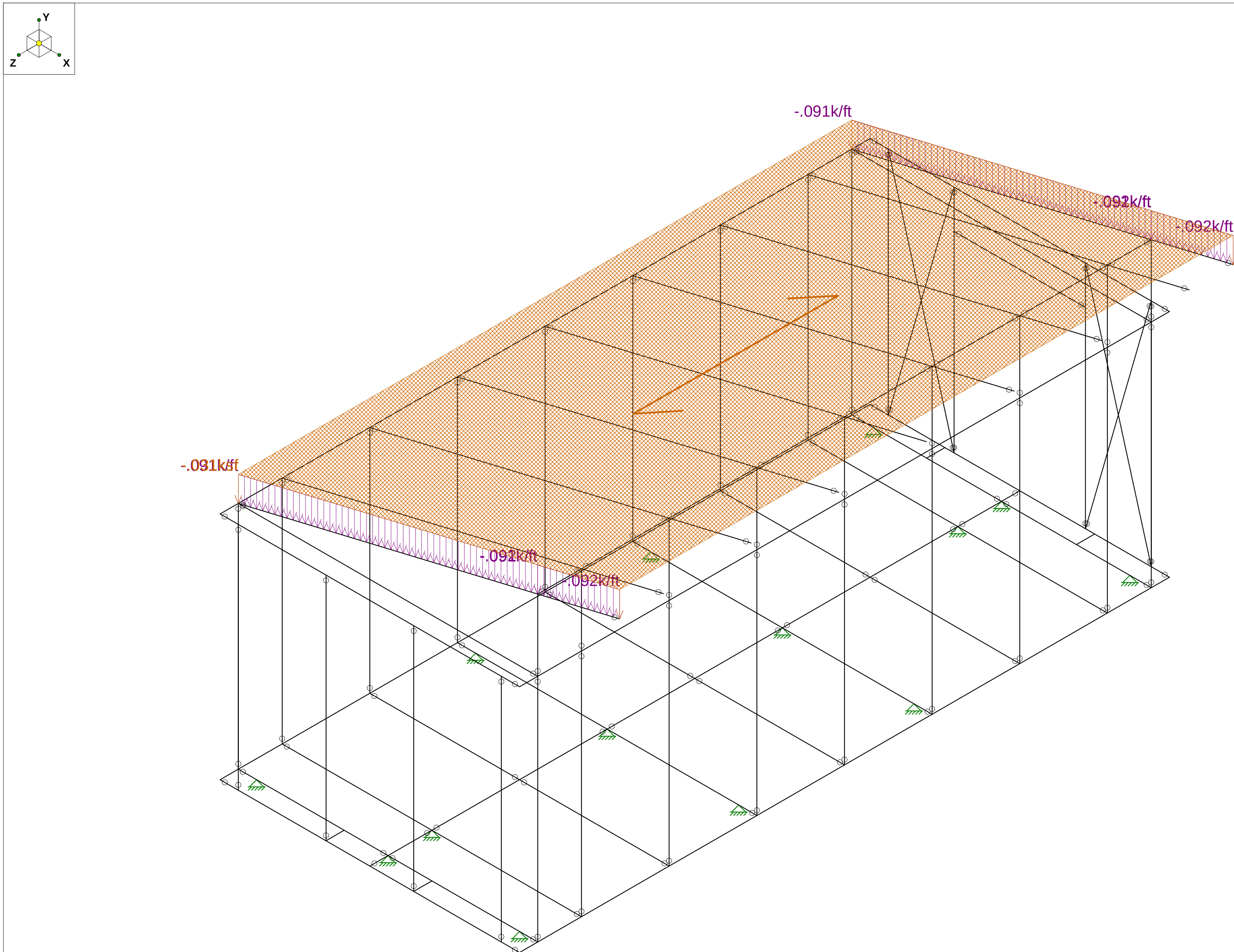

2-2X10
2-2X12
2X2
2X10
3-2X10
3-2X6
4X4


Y
X
Z

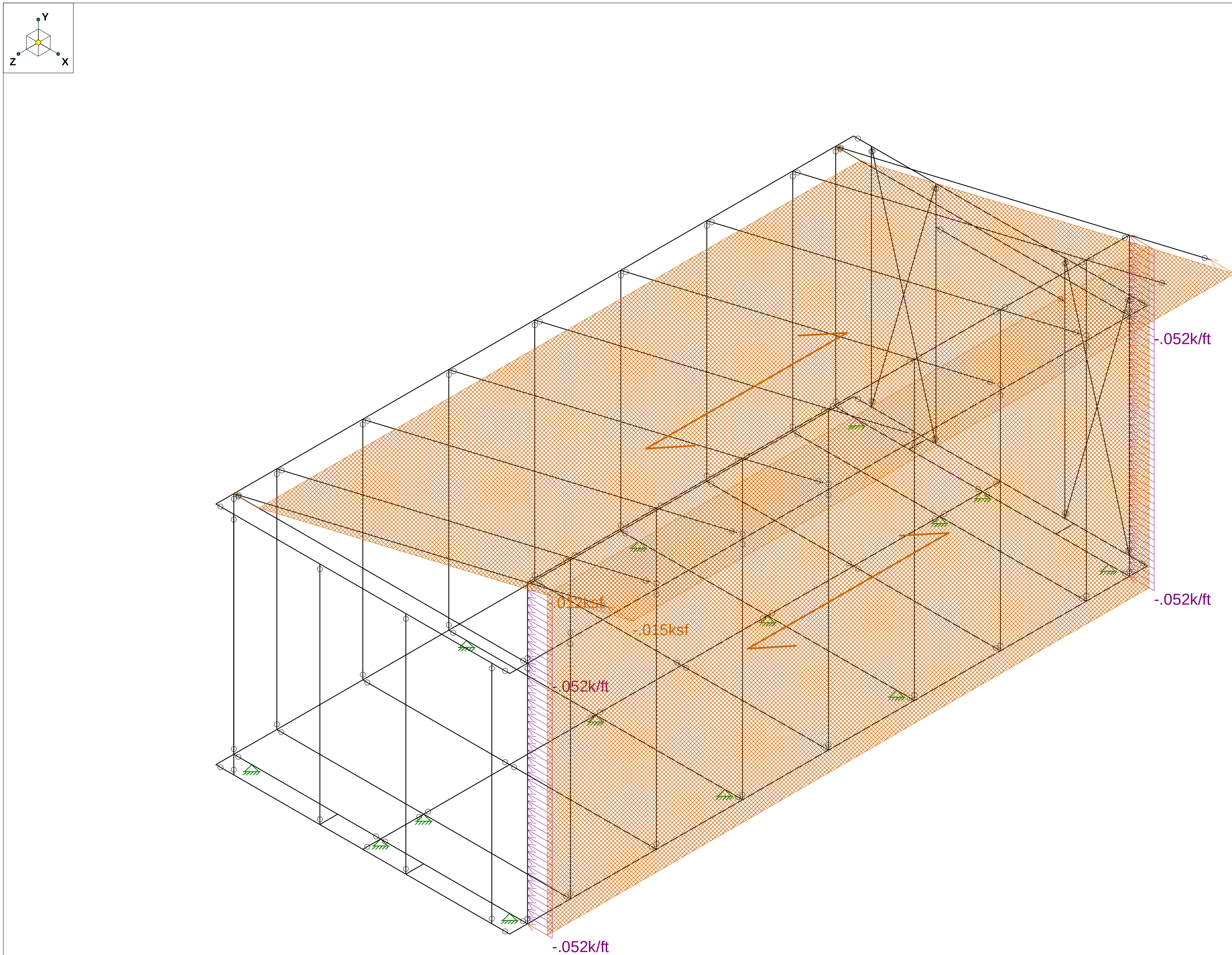


Loads: BLC 1, DEAD
Solution: Envelope

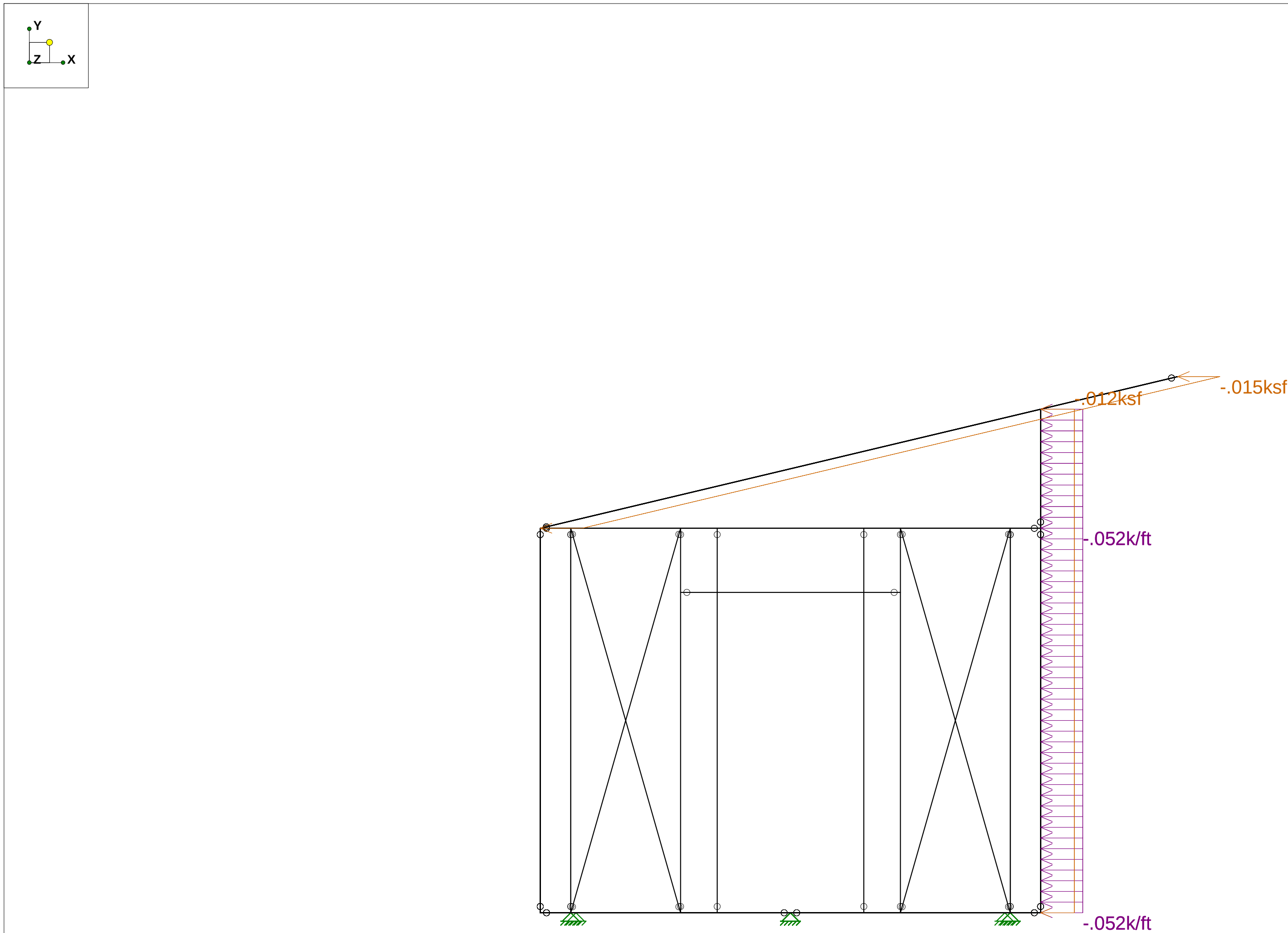

Y
Z
X
-.05ksf
Loads: BLC 2, LIVE
Solution: Envelope



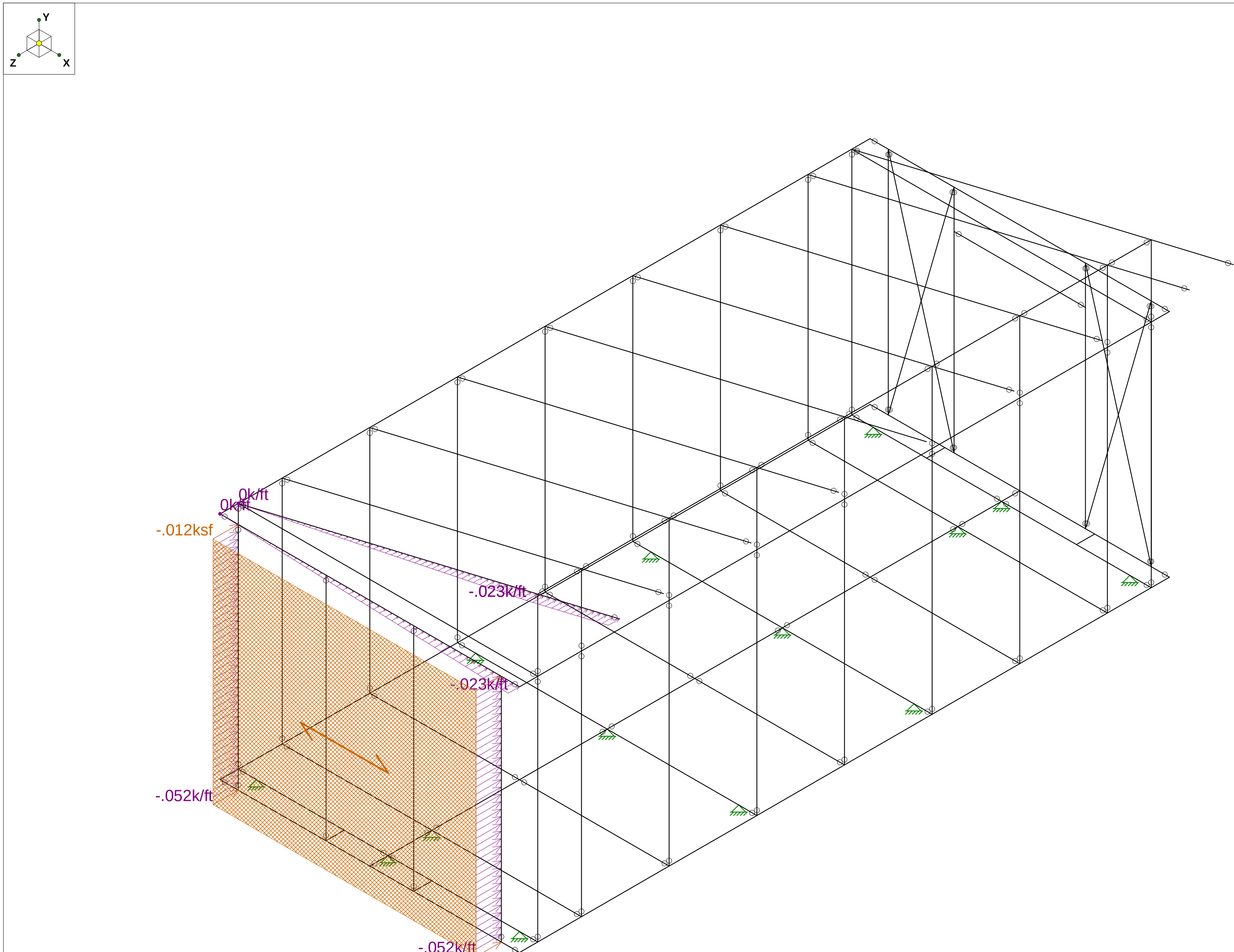
Loads: BLC 3, SNOW
Solution: Envelope



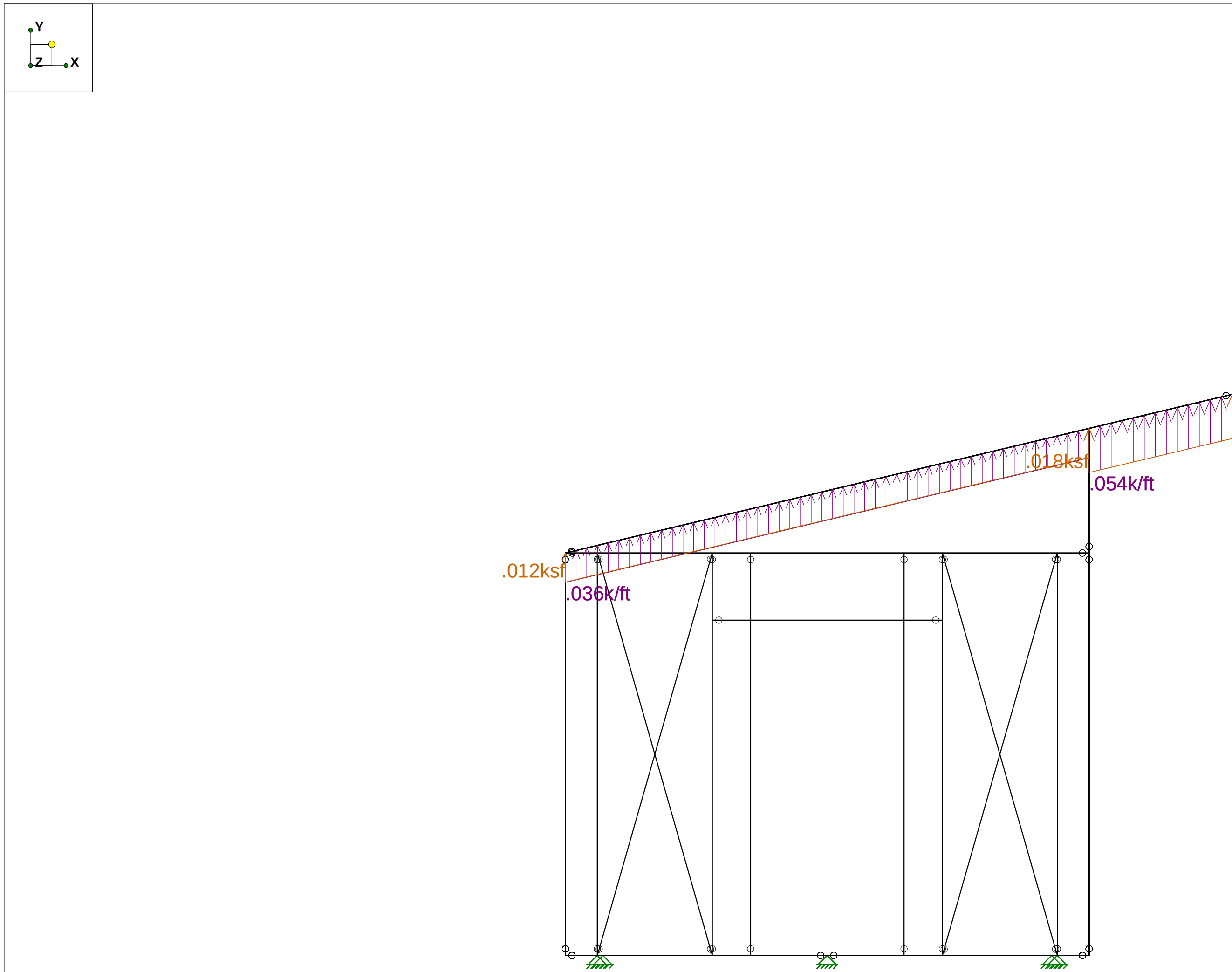
Loads: BLC 4, WIND FR NORTH
Solution: Envelope



Loads: BLC 4, WIND FR NORTH
Solution: Envelope



Loads: BLC 6, WIND TO EAST
Solution: Envelope



Loads: BLC 7, RF WIND TO EAST
Solution: Envelope

Global

Display Sections for Member Calcs	5
Max Internal Sections for Member Calcs	97
Include Shear Deformation	Yes
Include Warping	Yes
Area Load Mesh (in^2)	144
Merge Tolerance (in)	.12
P-Delta Analysis Tolerance	0.50%
Vertical Axis	Y

Hot Rolled Steel Code	AISC 360-05: ASD (Direct Analysis Method)
Cold Formed Steel Code	AISI NAS-01: ASD
Wood Code	AF&PA NDS-05: ASD
Wood Temperature	< 100F
Concrete Code	ACI 318-05
Masonry Code	ACI 530-05: ASD
Aluminum Code	AA ADM1-05: ASD

Number of Shear Regions	4
Region Spacing Increment (in)	4
Biaxial Column Method	PCA Load Contour
Parme Beta Factor (PCA)	.65
Concrete Stress Block	Rectangular
Use Cracked Sections	Yes
Bad Framing Warnings	No
Unused Force Warnings	Yes

Seismic Code	UBC 1997
Seismic Base Elevation (ft)	Not Entered
Ct X	.035
Ct Z	.035
T X (sec)	Not Entered
T Z (sec)	Not Entered
R X	8.5
R Z	8.5
Ct Exp. X	.75
Ct Exp. Z	.75
Ca	.36
Cv	.54
Nv	1
SD1	1
SDS	1
S1	1
Occupancy Code	4
Seismic Zone	3
Use Group	I
Use Gravity Self Wt in Diaphragm Mass	Yes
Use Deck Self Wt in Diaphragm Mass	Yes
Use Lateral Self Wt in Diaphragm Mass	Yes
Seismic Detailing Code	None
Om X	1
Om Z	1
Rho X	1
Rho Z	1

Wood Material Properties

	Label	Species	Grade	Cm	Emod	Nu	Therm (\1...	Dens[k/ft^3]
1	DF Larch	Douglas Fir-Larch	No.1		1	.3	.3	.035
2	So Pine	Southern Pine	No.2		1	.3	.3	.035
3	DF/SPine	Com Species Group ...	No.1		1	.3	.3	.035
4	HF/Spruce Fir	Com Species Group ...	No.1		1	.3	.3	.035
5	DF	Douglas Fir-Larch	No.1		1	.3	.3	.035
6	SP	Southern Pine	No.1		1	.3	.3	.035
7	HF	Hem-Fir	No.1		1	.3	.3	.035
8	SPF	Spruce-Pine-fir	No.1		1	.3	.3	.035
9	24F-1.8E DF Balanced	24F-1.8E_DF_BAL	na		1	.3	.3	.035
10	24F-1.8E DF Unbalanced	24F-1.8E_DF_UNBAL	na		1	.3	.3	.035
11	24F-1.8E SP Balanced	24F-1.8E_SP_BAL	na		1	.3	.3	.035
12	24F-1.8E SP Unbalanced	24F-1.8E_SP_UNBAL	na		1	.3	.3	.035
13	LVL-PRL 2250Fb	LVL_PRL_1.5E_225...	na		1	.3	.3	.035
14	LVL-PRL 2900Fb	LVL_PRL_2.0E_290...	na		1	.3	.3	.035

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Z [k/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
1	N34							
2	N35	Reaction	Reaction	Reaction				
3	N36							
4	N37	Reaction	Reaction	Reaction				
5	N38	Reaction	Reaction	Reaction				
6	N39	Reaction	Reaction	Reaction				
7	N40	Reaction	Reaction	Reaction				
8	N41							
9	N42							
10	N43	Reaction	Reaction	Reaction				
11	N44	Reaction	Reaction	Reaction				
12	N45	Reaction	Reaction	Reaction				
13	N46	Reaction	Reaction	Reaction				
14	N47	Reaction	Reaction	Reaction				
15	N10							
16	N9							
17	N77							
18	N15							
19	N20							
20	N16							
21	N21							
22	N26							
23	N30							
24	N11							
25	N12							
26	N56							
27	N57							
28	N72							
29	N73							
30	N13							
31	N71							
32	N74							
33	N14							
34	N17							
35	N23						Reaction	
36	N28							
37	N63						Reaction	
38	N52						Reaction	

Joint Boundary Conditions (Continued)

	Joint Label	X [k/in]	Y [k/in]	Z [k/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
39	N24						Reaction	
40	N1							
41	N2							
42	N3							
43	N4							
44	N5							
45	N6							
46	N7							
47	N8							
48	N18							
49	N19							
50	N22							
51	N25							
52	N27							
53	N29							
54	N31							
55	N32							
56	N33							
57	N78							
58	N79							
59	N80							
60	N81							
61	N82							
62	N83							
63	N84							
64	N85							
65	N87							
66	N89							
67	N91							
68	N93							
69	N95							
70	N97							
71	N1967	Reaction	Reaction	Reaction				
72	N1968	Reaction	Reaction	Reaction				
73	N1919	Reaction	Reaction	Reaction				
74	N1882	Reaction	Reaction	Reaction				

Wood Design Parameters

	Label	Shape	Length[...	le2[ft]	le1[ft]	le-bend to...	le-bend bo...	Kyy	Kzz	CV	Cr	y sway	z sway
1	M1	3-2X10	.83	1.333		1.333	1.333						
2	M2	3-2X10	6	1.333		1.333	1.333						
3	M3	3-2X10	6	1.333		1.333	1.333						
4	M4	3-2X10	.83	1.333		1.333	1.333						
5	M5	3-2X10	.83	1.333		1.333	1.333						
6	M6	3-2X10	6	1.333		1.333	1.333						
7	M7	3-2X10	6	1.333		1.333	1.333						
8	M8	3-2X10	.83	1.333		1.333	1.333						
9	M9	3-2X10	.83	1.333		1.333	1.333						
10	M10	3-2X10	6	1.333		1.333	1.333						
11	M11	3-2X10	6	1.333		1.333	1.333						
12	M12	3-2X10	.83	1.333		1.333	1.333						
13	M13	3-2X10	.83	1.333		1.333	1.333						
14	M14	3-2X10	6	1.333		1.333	1.333						
15	M15	3-2X10	6	1.333		1.333	1.333						
16	M16	3-2X10	.83	1.333		1.333	1.333						
17	M17	3-2X10	.83	1.333		1.333	1.333						

Wood Design Parameters (Continued)

	Label	Shape	Length[...	le2[ft]	le1[ft]	le-bend to...	le-bend bo...	Kyy	Kzz	CV	Cr	y sway	z sway
18	M18	3-2X10	2	1.333		1.333	1.333						
19	M19	3-2X10	8	1.333		1.333	1.333						
20	M20	3-2X10	8	1.333		1.333	1.333						
21	M21	3-2X10	8	1.333		1.333	1.333						
22	M22	3-2X10	2	1.333		1.333	1.333						
23	M23	3-2X10	.83	1.333		1.333	1.333						
24	M24	2-2X10	6.83	1.333		1.333	1.333						
25	M25	2-2X10	6.83	1.333		1.333	1.333						
26	M26	2-2X10	6.83	1.333		1.333	1.333						
27	M27	2-2X10	6.83	1.333		1.333	1.333						
28	M28	2-2X10	6.83	1.333		1.333	1.333						
29	M29	2-2X10	6.83	1.333		1.333	1.333						
30	M30	2-2X10	6.83	1.333		1.333	1.333						
31	M31	2-2X10	6.83	1.333		1.333	1.333						
32	M32	2-2X10	6.83	1.333		1.333	1.333						
33	M33	2-2X10	6.83	1.333		1.333	1.333						
34	M34	2X10	6.83	1.333		1.333	1.333						
35	M35	2X10	6.83	1.333		1.333	1.333						
36	M36	2X10	.83	1.333		1.333	1.333						
37	M37	2X10	2	1.333		1.333	1.333						
38	M38	2X10	4	1.333		1.333	1.333						
39	M39	2X10	4	1.333		1.333	1.333						
40	M40	2X10	4	1.333		1.333	1.333						
41	M41	2X10	4	1.333		1.333	1.333						
42	M42	2X10	4	1.333		1.333	1.333						
43	M43	2X10	4	1.333		1.333	1.333						
44	M44	2X10	2	1.333		1.333	1.333						
45	M45	2X10	.83	1.333		1.333	1.333						
46	M46	2X10	.83	1.333		1.333	1.333						
47	M47	2X10	6	1.333		1.333	1.333						
48	M48	2X10	6	1.333		1.333	1.333						
49	M49	2X10	.83	1.333		1.333	1.333						
50	M50	2X10	.83	1.333		1.333	1.333						
51	M51	2X10	2	1.333		1.333	1.333						
52	M52	2X10	4	1.333		1.333	1.333						
53	M53	2X10	4	1.333		1.333	1.333						
54	M54	2X10	4	1.333		1.333	1.333						
55	M55	2X10	4	1.333		1.333	1.333						
56	M56	2X10	4	1.333		1.333	1.333						
57	M57	2X10	4	1.333		1.333	1.333						
58	M58	2X10	2	1.333		1.333	1.333						
59	M59	2X10	.83	1.333		1.333	1.333						
60	M60	2-2X12	29.66	4		4	4	1					
61	M61	2-2X12	13.66	4		4	4	1					
62	M62	2-2X12	29.66	4		4	4	1					
63	M63	2-2X12	13.66	4		4	4	1					
64	M64	3-2X6	10.5	1.333		1.333	1.333						
65	M65	3-2X6	10.5	1.333		1.333	1.333						
66	M66	3-2X6	10.5	1.333		1.333	1.333						
67	M67	3-2X6	10.5	1.333		1.333	1.333						
68	M68	3-2X6	10.5	1.333		1.333	1.333						
69	M69	3-2X6	10.5	1.333		1.333	1.333						
70	M70	3-2X6	10.5	1.333		1.333	1.333						
71	M71	3-2X6	10.5	1.333		1.333	1.333						
72	M72	3-2X6	10.5	1.333		1.333	1.333						
73	M73	3-2X6	10.5	1.333		1.333	1.333						
74	M74	3-2X6	10.5	1.333		1.333	1.333						

Wood Design Parameters (Continued)

	Label	Shape	Length[...	le2[ft]	le1[ft]	le-bend to...	le-bend bo...	Kyy	Kzz	CV	Cr	y sway	z sway
75	M75	3-2X6	10.5	1.333		1.333	1.333						
76	M76	3-2X6	10.5	1.333		1.333	1.333						
77	M77	3-2X6	10.5	1.333		1.333	1.333						
78	M78	3-2X6	10.5	1.333		1.333	1.333						
79	M79	3-2X6	10.5	1.333		1.333	1.333						
80	M80	3-2X6	10.5	1.333		1.333	1.333						
81	M81	3-2X6	10.5	1.333		1.333	1.333						
82	M82	3-2X6	3.25										
83	M83	3-2X6	3.25										
84	M84	3-2X6	3.25	1.333		1.333	1.333						
85	M85	3-2X6	3.25										
86	M86	3-2X6	3.25										
87	M87	3-2X6	3.25										
88	M88	3-2X6	3.25										
89	M89	3-2X6	3.25										
90	M90	3-2X6	3.25										
91	M91	2-2X10	14.041	1.33		1.33	1.33	1					
92	M92	2-2X10	14.041	1.33		1.33	1.33	1					
93	M93	2-2X10	14.041	1.33		1.33	1.33	1					
94	M94	2-2X10	14.041	1.33		1.33	1.33	1					
95	M95	2-2X10	14.041	1.33		1.33	1.33	1					
96	M96	2-2X10	14.041	1.33		1.33	1.33	1					
97	M97	2-2X10	14.041	1.33		1.33	1.33	1					
98	M98	2-2X10	14.041	1.33		1.33	1.33	1					
99	M99	2-2X10	14.041	1.33		1.33	1.33	1					
100	M100	3-2X6	10.5	1.333		1.333	1.333						
101	M101	3-2X6	10.5	1.333		1.333	1.333						
102	M102	2X2	2										
103	M103	2X2	4										
104	M104	2X2	4										
105	M105	2X2	4										
106	M106	2X2	4										
107	M107	2X2	4										
108	M108	2X2	4										
109	M109	2X2	2										
110	M110	2X2	28										
111	M111	2-2X10	3.844	1.33		1.33	1.33	1					
112	M112	2-2X10	3.844	1.33		1.33	1.33	1					
113	M113	2-2X10	3.844	1.33		1.33	1.33	1					
114	M114	2-2X10	3.844	1.33		1.33	1.33	1					
115	M115	2-2X10	3.844	1.33		1.33	1.33	1					
116	M116	2-2X10	3.844	1.33		1.33	1.33	1					
117	M117	2-2X10	3.844	1.33		1.33	1.33	1					
118	M118	2-2X10	3.844	1.33		1.33	1.33	1					
119	M119	2-2X10	3.844	1.33		1.33	1.33	1					
120	M120	3-2X6	10.5	1.333		1.333	1.333						
121	M121	3-2X6	10.5	1.333		1.333	1.333						
122	M122	3-2X6	10.5	1.333		1.333	1.333						
123	M123	3-2X6	10.5	1.333		1.333	1.333						
124	M124	3-2X6	10.5	1.333		1.333	1.333						
125	M125	3-2X6	10.5	1.333		1.333	1.333						
126	M126	2X4	.83										
127	M127	2X4	.83										
128	M128	2-2X10	6										
129	M129	2X4	.83										
130	M130	2X4	.83										
131	M131	2X2	13.66	1.333	1.333	1.333	1.333						

Wood Design Parameters (Continued)

	Label	Shape	Length[...	le2[ft]	le1[ft]	le-bend to...	le-bend bo...	Kyy	Kzz	CV	Cr	y sway	z sway
132	M132	2X2	13.66	1.333	1.333	1.333	1.333						
133	M133	2X2	2	1.333	1.333	1.333	1.333						
134	M134	2X2	4	1.333	1.333	1.333	1.333						
135	M135	2X2	4	1.333	1.333	1.333	1.333						
136	M136	2X2	4	1.333	1.333	1.333	1.333						
137	M137	2X2	4	1.333	1.333	1.333	1.333						
138	M138	2X2	4	1.333	1.333	1.333	1.333						
139	M139	2X2	4	1.333	1.333	1.333	1.333						
140	M140	2X2	2	1.333	1.333	1.333	1.333						
141	M143	4X4	10.92	5.5	5.5	5.5	5.5						
142	M144	4X4	10.92	5.5	5.5	5.5	5.5						
143	M143A	4X4	10.92	5.5	5.5	5.5	5.5						
144	M144A	4X4	10.92	5.5	5.5	5.5	5.5						

Member Distributed Loads (BLC 1 : DEAD)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M45	Y	-.1	-.1	0	0
2	M44	Y	-.1	-.1	0	0
3	M43	Y	-.1	-.1	0	0
4	M42	Y	-.1	-.1	0	0
5	M41	Y	-.1	-.1	0	0
6	M40	Y	-.1	-.1	0	0
7	M39	Y	-.1	-.1	0	0
8	M38	Y	-.1	-.1	0	0
9	M37	Y	-.1	-.1	0	0
10	M36	Y	-.1	-.1	0	0
11	M48	Y	-.1	-.1	0	0
12	M49	Y	-.1	-.1	0	0
13	M47	Y	-.1	-.1	0	0
14	M46	Y	-.1	-.1	0	0
15	M58	Y	-.1	-.1	0	0
16	M59	Y	-.1	-.1	0	0
17	M57	Y	-.1	-.1	0	0
18	M56	Y	-.1	-.1	0	0
19	M55	Y	-.1	-.1	0	0
20	M54	Y	-.1	-.1	0	0
21	M53	Y	-.1	-.1	0	0
22	M52	Y	-.1	-.1	0	0
23	M51	Y	-.1	-.1	0	0
24	M50	Y	-.1	-.1	0	0
25	M34	Y	-.1	-.1	0	0
26	M35	Y	-.1	-.1	0	0
27	M91	Y	-.051	-.051	0	0
28	M99	Y	-.051	-.051	0	0
29	M111	Y	-.051	-.051	0	0
30	M119	Y	-.051	-.051	0	0

Member Distributed Loads (BLC 3 : SNOW)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M91	Y	-.091	-.092	0	0
2	M99	Y	-.091	-.092	0	0
3	M111	Y	-.091	-.092	0	0
4	M119	Y	-.091	-.092	0	0

Member Distributed Loads (BLC 4 : WIND FR NORTH)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]

Member Distributed Loads (BLC 4 : WIND FR NORTH) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M81	X	-.052	-.052	0	0
2	M82	X	-.052	-.052	0	0
3	M70	X	-.052	-.052	0	0
4	M90	X	-.052	-.052	0	0

Member Distributed Loads (BLC 5 : RF WIND FR NORTH)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M91	Y	.033	.033	0	0
2	M99	Y	.033	.033	0	0
3	M111	Y	.054	.054	0	0
4	M119	Y	.054	.054	0	0

Member Distributed Loads (BLC 6 : WIND TO EAST)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M101	Z	-.052	-.052	0	0
2	M100	Z	-.052	-.052	0	0
3	M63	Z	-.023	0	0	0
4	M91	Z	0	-.023	0	0
5	M111	Z	-.023	-.023	0	0

Member Distributed Loads (BLC 7 : RF WIND TO EAST)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M91	Y	.036	.036	0	0
2	M99	Y	.036	.036	0	0
3	M111	Y	.054	.054	0	0
4	M119	Y	.054	.054	0	0

Member Distributed Loads (BLC 8 : BLC 1 Transient Area Loads)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	-.052	-.052	0	.83
2	M2	Y	-.044	-.044	.146	6
3	M3	Y	-.044	-.044	0	5.854
4	M4	Y	-.052	-.052	0	.83
5	M5	Y	-.07	-.07	0	.83
6	M6	Y	-.059	-.059	.146	6
7	M7	Y	-.059	-.059	4.996e-16	5.854
8	M8	Y	-.07	-.07	0	.83
9	M9	Y	-.07	-.07	0	.83
10	M10	Y	-.059	-.059	.146	6
11	M11	Y	-.059	-.059	2.387e-15	5.854
12	M12	Y	-.07	-.07	0	.83
13	M13	Y	-.052	-.052	0	.83
14	M14	Y	-.044	-.044	.146	6
15	M15	Y	-.044	-.044	2.22e-16	5.854
16	M16	Y	-.052	-.052	0	.83
17	M24	Y	-.059	-.059	1.11e-16	6.83
18	M25	Y	-.059	-.059	8.327e-16	6.83
19	M26	Y	-.059	-.059	8.882e-16	6.83
20	M27	Y	-.059	-.059	0	6.83
21	M28	Y	-.059	-.059	3.331e-16	6.83
22	M29	Y	-.059	-.059	2.22e-16	6.83
23	M30	Y	-.03	-.03	5.551e-16	6.83
24	M31	Y	-.03	-.03	1.665e-15	6.83
25	M32	Y	-.03	-.03	6.106e-16	6.83
26	M33	Y	-.03	-.03	1.332e-15	6.83
27	M91	Y	-.017	-.017	0	13.911

Member Distributed Loads (BLC 8 : BLC 1 Transient Area Loads) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
28	M92	Y	-.051	-.051	1.221e-15	13.911
29	M93	Y	-.068	-.068	1.055e-15	13.911
30	M94	Y	-.068	-.068	1.055e-15	13.911
31	M95	Y	-.068	-.068	1.499e-15	13.911
32	M96	Y	-.068	-.068	1.499e-15	13.911
33	M97	Y	-.068	-.068	6.106e-16	13.911
34	M98	Y	-.051	-.051	5.551e-16	13.911
35	M99	Y	-.017	-.017	9.992e-16	13.911
36	M111	Y	-.018	-.018	0	3.844
37	M112	Y	-.053	-.053	0	3.844
38	M113	Y	-.07	-.07	0	3.844
39	M114	Y	-.07	-.07	0	3.844
40	M115	Y	-.07	-.07	0	3.844
41	M116	Y	-.07	-.07	0	3.844
42	M117	Y	-.07	-.07	0	3.844
43	M118	Y	-.053	-.053	0	3.844
44	M119	Y	-.018	-.018	0	3.844

Member Distributed Loads (BLC 9 : BLC 2 Transient Area Loads)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	-.174	-.174	0	.83
2	M2	Y	-.148	-.148	.146	6
3	M3	Y	-.148	-.148	0	5.854
4	M4	Y	-.174	-.174	0	.83
5	M5	Y	-.232	-.232	0	.83
6	M6	Y	-.198	-.198	.146	6
7	M7	Y	-.198	-.198	4.996e-16	5.854
8	M8	Y	-.232	-.232	0	.83
9	M9	Y	-.232	-.232	0	.83
10	M10	Y	-.198	-.198	.146	6
11	M11	Y	-.198	-.198	2.387e-15	5.854
12	M12	Y	-.232	-.232	0	.83
13	M13	Y	-.174	-.174	0	.83
14	M14	Y	-.148	-.148	.146	6
15	M15	Y	-.148	-.148	2.22e-16	5.854
16	M16	Y	-.174	-.174	0	.83
17	M24	Y	-.198	-.198	1.11e-16	6.83
18	M25	Y	-.198	-.198	8.327e-16	6.83
19	M26	Y	-.198	-.198	8.882e-16	6.83
20	M27	Y	-.198	-.198	0	6.83
21	M28	Y	-.198	-.198	3.331e-16	6.83
22	M29	Y	-.198	-.198	2.22e-16	6.83
23	M30	Y	-.099	-.099	5.551e-16	6.83
24	M31	Y	-.099	-.099	1.665e-15	6.83
25	M32	Y	-.099	-.099	6.106e-16	6.83
26	M33	Y	-.099	-.099	1.332e-15	6.83

Member Distributed Loads (BLC 10 : BLC 3 Transient Area Loads)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M91	Y	-.031	-.031	0	13.911
2	M92	Y	-.092	-.092	1.221e-15	13.911
3	M93	Y	-.123	-.123	1.055e-15	13.911
4	M94	Y	-.123	-.123	1.055e-15	13.911
5	M95	Y	-.123	-.123	1.499e-15	13.911
6	M96	Y	-.123	-.123	1.499e-15	13.911
7	M97	Y	-.123	-.123	6.106e-16	13.911
8	M98	Y	-.092	-.092	5.551e-16	13.911

Member Distributed Loads (BLC 10 : BLC 3 Transient Area Loads) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
9	M99	Y	-.031	-.031	9.992e-16	13.911
10	M111	Y	-.032	-.032	0	3.844
11	M112	Y	-.096	-.096	0	3.844
12	M113	Y	-.127	-.127	0	3.844
13	M114	Y	-.127	-.127	0	3.844
14	M115	Y	-.127	-.127	0	3.844
15	M116	Y	-.127	-.127	0	3.844
16	M117	Y	-.127	-.127	0	3.844
17	M118	Y	-.096	-.096	0	3.844
18	M119	Y	-.032	-.032	0	3.844

Member Distributed Loads (BLC 11 : BLC 4 Transient Area Loads)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M68	X	-.049	-.049	4.441e-16	10.5
2	M69	X	-.037	-.037	7.772e-16	10.5
3	M70	X	-.012	-.012	1.943e-15	10.5
4	M72	X	-.049	-.049	4.441e-16	10.5
5	M74	X	-.049	-.049	8.882e-16	10.5
6	M75	X	-.049	-.049	8.882e-16	10.5
7	M77	X	-.049	-.049	4.441e-16	10.5
8	M79	X	-.037	-.037	1.388e-15	10.5
9	M81	X	-.012	-.012	1.443e-15	10.5
10	M82	X	-.012	-.012	.304	3.25
11	M83	X	-.036	-.036	.304	3.25
12	M84	X	-.048	-.048	.304	3.25
13	M85	X	-.048	-.048	.304	3.25
14	M86	X	-.048	-.048	.304	3.25
15	M87	X	-.048	-.048	.304	3.25
16	M88	X	-.048	-.048	.304	3.25
17	M89	X	-.036	-.036	.304	3.25
18	M90	X	-.012	-.012	.304	3.25
19	M91	X	-.015	-.015	1.11e-15	13.911
20	M92	X	-.045	-.045	3.331e-16	13.911
21	M93	X	-.06	-.06	1.055e-15	13.911
22	M94	X	-.06	-.06	2.831e-15	13.911
23	M95	X	-.06	-.06	1.943e-15	13.911
24	M96	X	-.06	-.06	1.665e-16	13.911
25	M97	X	-.06	-.06	1.055e-15	13.911
26	M98	X	-.045	-.045	1.055e-15	13.911
27	M99	X	-.015	-.015	0	13.911
28	M111	X	-.016	-.016	0	3.844
29	M112	X	-.047	-.047	0	3.844
30	M113	X	-.062	-.062	0	3.844
31	M114	X	-.062	-.062	0	3.844
32	M115	X	-.062	-.062	0	3.844
33	M116	X	-.062	-.062	0	3.844
34	M117	X	-.062	-.062	0	3.844
35	M118	X	-.047	-.047	0	3.844
36	M119	X	-.016	-.016	0	3.844

Member Distributed Loads (BLC 12 : BLC 5 Transient Area Loads)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M111	Y	.021	.021	0	3.844
2	M112	Y	.049	.049	0	3.844
3	M113	Y	.077	.077	0	3.844
4	M114	Y	.07	.07	3.775e-15	3.844
5	M115	Y	.07	.07	0	3.844

Member Distributed Loads (BLC 12 : BLC 5 Transient Area Loads) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
6	M116	Y	.07	.07	0	3.844
7	M117	Y	.077	.077	0	3.844
8	M118	Y	.049	.049	2.748e-15	3.844
9	M119	Y	.021	.021	3.608e-15	3.844
10	M91	Y	.008	.008	2.109e-15	14.041
11	M92	Y	.025	.025	2.109e-15	14.041
12	M93	Y	.033	.033	7.772e-16	14.041
13	M94	Y	.033	.033	3.331e-16	14.041
14	M95	Y	.033	.033	1.221e-15	14.041
15	M96	Y	.033	.033	1.221e-15	14.041
16	M97	Y	.033	.033	3.331e-16	14.041
17	M98	Y	.025	.025	2.109e-15	14.041
18	M99	Y	.008	.008	1.11e-16	14.041

Member Distributed Loads (BLC 13 : BLC 6 Transient Area Loads)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M100	Z	-.023	-.023	5.551e-16	10.5
2	M101	Z	-.023	-.023	0	10.5
3	M124	Z	-.046	-.046	6.661e-16	10.5
4	M125	Z	-.046	-.046	6.661e-16	10.5

Member Distributed Loads (BLC 14 : BLC 7 Transient Area Loads)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M111	Y	.021	.021	0	3.844
2	M112	Y	.05	.05	0	3.844
3	M113	Y	.078	.078	0	3.844
4	M114	Y	.071	.071	3.775e-15	3.844
5	M115	Y	.071	.071	0	3.844
6	M116	Y	.071	.071	0	3.844
7	M117	Y	.078	.078	0	3.844
8	M118	Y	.05	.05	2.748e-15	3.844
9	M119	Y	.021	.021	3.608e-15	3.844
10	M91	Y	.012	.012	2.109e-15	14.041
11	M92	Y	.036	.036	2.109e-15	14.041
12	M93	Y	.048	.048	7.772e-16	14.041
13	M94	Y	.048	.048	3.331e-16	14.041
14	M95	Y	.048	.048	1.221e-15	14.041
15	M96	Y	.048	.048	1.221e-15	14.041
16	M97	Y	.048	.048	3.331e-16	14.041
17	M98	Y	.036	.036	2.109e-15	14.041
18	M99	Y	.012	.012	1.11e-16	14.041

Member Area Loads (BLC 1 : DEAD)

	Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[ksf]
1	N74	N71	N72	N73	Y	A-B	-.015
2	N14	N15	N77	N78	Y	A-B	-.017

Member Area Loads (BLC 2 : LIVE)

	Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[ksf]
1	N74	N71	N72	N73	Y	A-B	-.05

Member Area Loads (BLC 3 : SNOW)

	Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[ksf]
1	N14	N15	N77	N78	Y	A-B	-.031

Member Area Loads (BLC 4 : WIND FR NORTH)

	Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[ksf]
1	N1	N9	N68	N70	X	A-B	-.012
2	N78	N77	N15	N14	X	A-B	-.015

Member Area Loads (BLC 5 : RF WIND FR NORTH)

	Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[ksf]
1	N1	N9	N77	N78	Y	A-B	.018
2	N14	N15	N9	N1	Y	A-B	.008

Member Area Loads (BLC 6 : WIND TO EAST)

	Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[ksf]
1	N33	N32	N76	N75	Z	A-B	-.012

Member Area Loads (BLC 7 : RF WIND TO EAST)

	Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[ksf]
1	N1	N9	N77	N78	Y	A-B	.018
2	N14	N15	N9	N1	Y	A-B	.012

Basic Load Cases

	BLC Description	Category	X Gra...	Y Gra...	Z Gra...	Joint	Point	Distributed	Area (Me...	Surfac...
1	DEAD	DL						30	2	
2	LIVE	LL							1	
3	SNOW	SL						4	1	
4	WIND FR NORTH	WLX						4	2	
5	RF WIND FR NORTH	WLX+R						4	2	
6	WIND TO EAST	WLZ						5	1	
7	RF WIND TO EAST	WLZ+R						4	2	
8	BLC 1 Transient Are...	None						44		
9	BLC 2 Transient Are...	None						26		
10	BLC 3 Transient Are...	None						18		
11	BLC 4 Transient Are...	None						36		
12	BLC 5 Transient Are...	None						18		
13	BLC 6 Transient Are...	None						4		
14	BLC 7 Transient Are...	None						18		

Load Combinations

	Descripti...	Solve	PDelta	SRSS	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...
1	SD/IBC 1...	Yes			DL	1														
2	SD/IBC 1...	Yes			DL	1	LL	1												
3	SD/IBC 1...	Yes			DL	1	SL	1												
4	IBC 16-1...				DL	1	WLX	1	WLX...	1										
5	SD11 16-...	Yes			DL	1	WLX	.44	WLX...	.44										
6	IBC 16-1...				DL	1	WLZ	1	WLZ+R	1										
7	SD11 16-...	Yes			DL	1	WLZ	.44	WLZ+R	.44										
8	IBC 16-1...				DL	1	WLX	.75	LL	.75	LLS	.75	WL...	.75						
9	SD11 16-...	Yes			DL	1	WLX	.33	LL	.75			WL...	.33						
10	IBC 16-1...				DL	1	WLX	.75	LL	.75	LLS	.75	SL	.75	W...	.75				
11	SD11 16-...	Yes			DL	1	WLX	.33	LL	.75			SL	.75	W...	.33				
12	IBC 16-1...				DL	1	WLZ	.75	LL	.75	LLS	.75	SL	.75	W...	.75				
13	SD11 16-...	Yes			DL	1	WLZ	.33	LL	.75			SL	.75	W...	.33				
14	IBC 16-1...				DL	.6	WLX	1	WLX...	1										
15	SD11 16-...	Yes			DL	.6	WLX	.44	WLX...	.44										
16	IBC 16-1...				DL	.6	WLZ	1	WLZ+R	1										
17	SD11 16-...	Yes			DL	.6	WLZ	.44	WLZ+R	.44										

Load Combinations (Continued)

	Descripti...	Solve	PDelta	SRSS	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...
18	SD11 OT...				DL	1	WLX	.88	WLX...	.88										
19	SD11 OT...				DL	1	WLZ	.88	WLZ+R	.88										

Envelope Joint Reactions

	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
1	N35	max	.801	15	2.217	13	.011	17	0	1	0	1	0	1
2		min	-.015	2	.792	15	-.035	3	0	1	0	1	0	1
3	N37	max	.127	11	7.72	3	.382	5	0	1	0	1	0	1
4		min	.018	17	.158	15	.071	1	0	1	0	1	0	1
5	N38	max	.019	7	4.556	11	.113	17	0	1	0	1	0	1
6		min	-.062	15	.628	17	-.375	5	0	1	0	1	0	1
7	N39	max	.109	15	6.034	3	.055	17	0	1	0	1	0	1
8		min	-.032	13	.933	17	-.3	3	0	1	0	1	0	1
9	N40	max	0	17	5.41	11	.006	17	0	1	0	1	0	1
10		min	-.047	11	1.24	17	-.254	3	0	1	0	1	0	1
11	N43	max	1.183	5	5.209	3	.121	13	0	1	0	1	0	1
12		min	-.007	17	1.392	17	.016	15	0	1	0	1	0	1
13	N44	max	.229	15	2.014	2	.049	7	0	1	0	1	0	1
14		min	-.027	3	-.115	3	.012	1	0	1	0	1	0	1
15	N45	max	.013	2	2.479	2	.134	13	0	1	0	1	0	1
16		min	-.075	15	-.998	3	.023	15	0	1	0	1	0	1
17	N46	max	-.01	17	2.398	2	.048	17	0	1	0	1	0	1
18		min	-.094	11	-.967	3	-.141	11	0	1	0	1	0	1
19	N47	max	.253	15	1.558	2	.103	17	0	1	0	1	0	1
20		min	-.029	3	-.938	3	-.064	11	0	1	0	1	0	1
21	N23	max	0	1	0	1	0	1	0	1	0	1	0	3
22		min	0	1	0	1	0	1	0	1	0	1	0	15
23	N63	max	0	1	0	1	0	1	0	1	0	1	.005	3
24		min	0	1	0	1	0	1	0	1	0	1	-.043	15
25	N52	max	0	1	0	1	0	1	0	1	0	1	0	2
26		min	0	1	0	1	0	1	0	1	0	1	0	5
27	N24	max	0	1	0	1	0	1	0	1	0	1	.032	5
28		min	0	1	0	1	0	1	0	1	0	1	0	17
29	N1967	max	1.331	11	4.885	3	.044	17	0	1	0	1	0	1
30		min	.084	17	-1.694	15	-.803	11	0	1	0	1	0	1
31	N1968	max	.689	15	5.271	11	.149	15	0	1	0	1	0	1
32		min	-.572	3	.811	17	-.447	3	0	1	0	1	0	1
33	N1919	max	.673	15	5.354	11	.837	13	0	1	0	1	0	1
34		min	-.442	13	1.547	17	-.407	15	0	1	0	1	0	1
35	N1882	max	1.129	11	5.753	3	1.242	11	0	1	0	1	0	1
36		min	.116	17	.502	15	.235	17	0	1	0	1	0	1
37	Totals:	max	5.967	5	52.14	11	1.303	7						
38		min	0	17	11.477	17	0	15						

Envelope Wood Code Checks

	Member	Shape	Code C...	Loc[ft]	LC	Shear C...	Loc[ft]	Dir	LC	Fc' [ksi]	Ft' [ksi]	Fb1' [ksi]	Fb2' [ksi]	Fv' [ksi]	Eqn
1	M1	3-2X10	.053	.83	2	.098	0	y	2	.893	.575	1.05	1.26	.175	3.9-1
2	M2	3-2X10	.312	6	11	.187	6	y	2	1.436	.575	1.05	1.26	.175	3.9-1
3	M3	3-2X10	.275	0	13	.188	0	y	2	1.436	.575	1.05	1.26	.175	3.9-1
4	M4	3-2X10	.052	0	2	.099	.83	y	9	.893	.575	1.05	1.26	.175	3.9-1
5	M5	3-2X10	.499	.83	11	.708	.83	y	11	.893	.575	1.05	1.26	.175	3.9-3
6	M6	3-2X10	.501	0	11	.249	0	y	11	1.436	.575	1.05	1.26	.175	3.9-1
7	M7	3-2X10	.850	6	13	.330	5.875	y	13	1.436	.575	1.05	1.26	.175	3.9-1
8	M8	3-2X10	.847	0	13	1.211	0	y	13	.893	.575	1.05	1.26	.175	3.9-3
9	M9	3-2X10	.605	.83	11	.881	.83	y	11	.893	.575	1.05	1.26	.175	3.9-3

Envelope Wood Code Checks (Continued)

	Member	Shape	Code C...	Loc[ft]	LC	Shear C...	Loc[ft]	Dir	LC	Fc' [ksi]	Ft' [ksi]	Fb1' [ksi]	Fb2' [ksi]	Fv' [ksi]	Eqn
10	M10	3-2X10	.607	0	11	.294	0	y	13	1.436	.575	1.05	1.26	.175	3.9-1
11	M11	3-2X10	.646	6	11	.302	5.875	y	13	1.436	.575	1.05	1.26	.175	3.9-3
12	M12	3-2X10	.646	0	11	.938	0	y	11	.893	.575	1.05	1.26	.175	3.9-3
13	M13	3-2X10	.053	.83	2	.099	0	y	2	.893	.575	1.05	1.26	.175	3.9-1
14	M14	3-2X10	.263	6	2	.187	6	y	2	1.436	.575	1.05	1.26	.175	3.9-3
15	M15	3-2X10	.263	0	2	.187	0	y	2	1.436	.575	1.05	1.26	.175	3.9-1
16	M16	3-2X10	.054	0	2	.099	.83	y	2	.893	.575	1.05	1.26	.175	3.9-1
17	M17	3-2X10	.227	.83	11	1.187	0	y	5	.893	.575	1.05	1.26	.175	3.9-1
18	M18	3-2X10	.302	0	11	1.094	0	y	5	.893	.575	1.05	1.26	.175	3.9-1
19	M19	3-2X10	.626	4	2	.218	3	y	2	1.377	.575	1.05	1.26	.175	3.9-3
20	M20	3-2X10	.626	4	2	.217	3	y	2	1.377	.575	1.05	1.26	.175	3.9-1
21	M21	3-2X10	.627	4	2	.184	4	y	2	1.377	.575	1.05	1.26	.175	3.9-3
22	M22	3-2X10	.552	2	11	.343	1	y	11	.893	.575	1.05	1.26	.175	3.9-1
23	M23	3-2X10	.517	0	11	.736	0	y	11	.893	.575	1.05	1.26	.175	3.9-1
24	M24	2-2X10	.402	3.415	2	.290	6.83	y	2	1.415	.575	1.05	1.26	.175	3.9-1
25	M25	2-2X10	.402	3.415	2	.280	0	y	2	1.415	.575	1.05	1.26	.175	3.9-1
26	M26	2-2X10	.401	3.415	2	.272	6.83	y	2	1.415	.575	1.05	1.26	.175	3.9-1
27	M27	2-2X10	.402	3.415	2	.280	0	y	2	1.415	.575	1.05	1.26	.175	3.9-1
28	M28	2-2X10	.401	3.415	2	.291	6.83	y	2	1.415	.575	1.05	1.26	.175	3.9-1
29	M29	2-2X10	.401	3.415	2	.295	0	y	2	1.415	.575	1.05	1.26	.175	3.9-1
30	M30	2-2X10	1.095	.996	11	1.739	.925	y	13	1.415	.575	1.05	1.26	.175	3.9-3
31	M31	2-2X10	1.094	5.834	13	2.179	5.905	y	11	1.415	.575	1.05	1.26	.175	3.9-1
32	M32	2-2X10	.933	.854	11	1.696	.783	y	11	1.415	.575	1.05	1.26	.175	3.9-3
33	M33	2-2X10	.864	5.976	13	1.477	6.047	y	13	1.415	.575	1.05	1.26	.175	3.9-1
34	M34	2X10	.517	3.842	15	.955	3.771	y	15	2.68	1.9	2.9	2.9	.285	3.9-1
35	M35	2X10	.607	2.988	5	1.622	3.415	y	11	2.68	1.9	2.9	2.9	.285	3.9-3
36	M36	2X10	.057	.83	15	.158	0	y	5	2.684	1.9	2.9	2.9	.285	3.9-1
37	M37	2X10	.066	0	13	.220	0	y	13	2.684	1.9	2.9	2.9	.285	3.9-3
38	M38	2X10	.046	4	11	.055	3	y	11	2.684	1.9	2.9	2.9	.285	3.9-1
39	M39	2X10	.078	4	11	.194	4	y	11	2.684	1.9	2.9	2.9	.285	3.9-3
40	M40	2X10	.077	0	11	.215	1	y	11	2.684	1.9	2.9	2.9	.285	3.9-3
41	M41	2X10	.434	4	13	.779	4	y	13	2.684	1.9	2.9	2.9	.285	3.9-3
42	M42	2X10	.455	4	13	.494	0	y	13	2.684	1.9	2.9	2.9	.285	3.9-1
43	M43	2X10	.453	0	13	.452	4	y	11	2.684	1.9	2.9	2.9	.285	3.9-1
44	M44	2X10	.359	0	11	.775	0	y	11	2.684	1.9	2.9	2.9	.285	3.9-1
45	M45	2X10	.066	0	15	.126	.83	y	5	2.684	1.9	2.9	2.9	.285	3.9-1
46	M46	2X10	.209	.83	15	.715	0	y	15	2.684	1.9	2.9	2.9	.285	3.9-3
47	M47	2X10	.221	0	15	.584	1	y	5	2.684	1.9	2.9	2.9	.285	3.9-1
48	M48	2X10	.303	6	11	.649	6	y	11	2.684	1.9	2.9	2.9	.285	3.9-3
49	M49	2X10	.299	0	11	.848	0	y	11	2.684	1.9	2.9	2.9	.285	3.9-1
50	M50	2X10	.062	.83	5	.162	.83	y	5	2.684	1.9	2.9	2.9	.285	3.9-3
51	M51	2X10	.067	0	11	.216	0	y	11	2.684	1.9	2.9	2.9	.285	3.9-3
52	M52	2X10	.023	4	5	.052	2	y	11	2.684	1.9	2.9	2.9	.285	3.9-1
53	M53	2X10	.174	4	11	.221	4	y	11	2.684	1.9	2.9	2.9	.285	3.9-1
54	M54	2X10	.174	0	11	.221	0	y	11	2.684	1.9	2.9	2.9	.285	3.9-3
55	M55	2X10	.354	4	11	.645	4	y	11	2.684	1.9	2.9	2.9	.285	3.9-3
56	M56	2X10	.350	0	11	.375	0	y	11	2.684	1.9	2.9	2.9	.285	3.9-3
57	M57	2X10	.282	0	11	.302	4	y	13	2.684	1.9	2.9	2.9	.285	3.9-1
58	M58	2X10	.200	0	13	.441	0	y	13	2.684	1.9	2.9	2.9	.285	3.9-1
59	M59	2X10	.064	0	5	.132	0	y	5	2.684	1.9	2.9	2.9	.285	3.9-3
60	M60	2-2X12	.220	.927	5	.668	0	y	5	.939	1.9	2.9	2.9	.285	3.9-1
61	M61	2-2X12	.200	9.818	15	.128	12.949	z	11	2.471	1.9	2.9	2.9	.285	3.9-1
62	M62	2-2X12	.226	18.846	13	.547	0	y	3	.939	1.9	2.9	2.9	.285	3.9-3
63	M63	2-2X12	.227	.854	11	.180	0	z	11	2.471	1.9	2.9	2.9	.285	3.9-3
64	M64	3-2X6	.114	0	11	.032	.875	z	15	.772	.725	1.25	1.438	.175	3.6.3
65	M65	3-2X6	.106	0	11	.021	0	z	15	.772	.725	1.25	1.438	.175	3.6.3
66	M66	3-2X6	.104	.875	13	.065	.875	z	15	.772	.725	1.25	1.438	.175	3.9-1

Envelope Wood Code Checks (Continued)

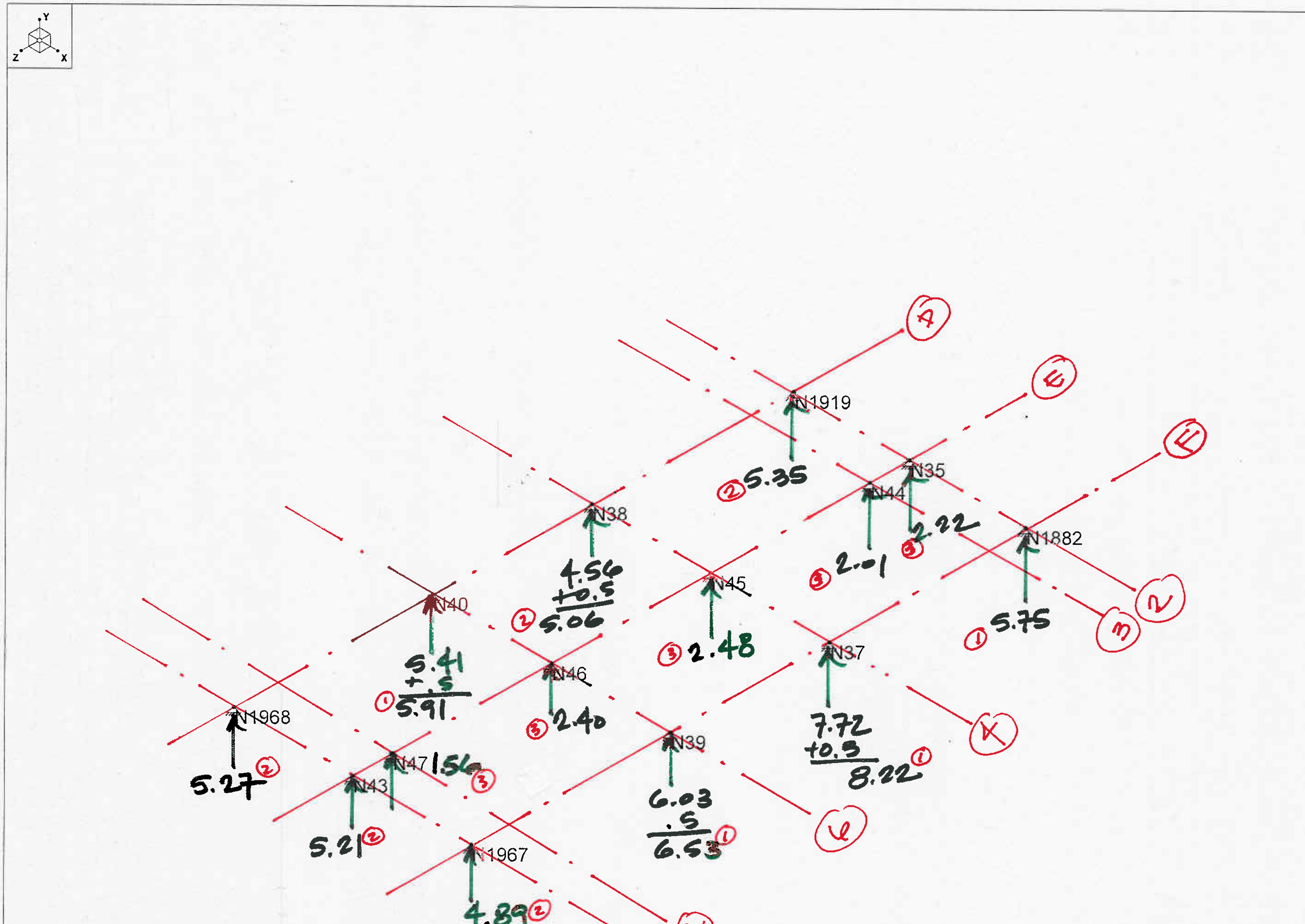
	Member	Shape	Code C...	Loc[ft]	LC	Shear C...	Loc[ft]	Dir	LC	Fc' [ksi]	Ft' [ksi]	Fb1' [ksi]	Fb2' [ksi]	Fv' [ksi]	Eqn
67	M67	3-2X6	.030	0	3	.071	0	z	5	.795	.834	1.438	1.653	.201	3.6.3
68	M68	3-2X6	.128	5.25	15	.162	0	y	11	.772	.725	1.25	1.438	.175	3.9-1
69	M69	3-2X6	.095	5.25	5	.107	0	y	11	.772	.725	1.25	1.438	.175	3.9-3
70	M70	3-2X6	.168	5.25	5	.062	10.5	y	15	.772	.725	1.25	1.438	.175	3.9-3
71	M71	3-2X6	.076	9.625	3	.072	9.625	z	5	.795	.834	1.438	1.653	.201	3.6.3
72	M72	3-2X6	.151	0	3	.141	0	y	11	.795	.834	1.438	1.653	.201	3.6.3
73	M73	3-2X6	.026	9.625	3	.064	9.625	z	15	.795	.834	1.438	1.653	.201	3.6.3
74	M74	3-2X6	.126	5.25	5	.117	9.625	y	5	.772	.725	1.25	1.438	.175	3.9-3
75	M75	3-2X6	.128	5.25	5	.152	10.5	y	15	.772	.725	1.25	1.438	.175	3.9-3
76	M76	3-2X6	.065	0	11	.064	9.625	z	5	.772	.725	1.25	1.438	.175	3.6.3
77	M77	3-2X6	.128	5.25	5	.128	0	z	3	.772	.725	1.25	1.438	.175	3.9-3
78	M78	3-2X6	.027	9.625	3	.058	9.625	y	15	.795	.834	1.438	1.653	.201	3.6.3
79	M79	3-2X6	.183	.875	11	.113	.875	z	3	.772	.725	1.25	1.438	.175	3.9-1
80	M80	3-2X6	.022	9.625	3	.058	9.625	z	15	.795	.834	1.438	1.653	.201	3.6.3
81	M81	3-2X6	.169	5.141	5	.059	0	y	11	.772	.725	1.25	1.438	.175	3.9-3
82	M82	3-2X6	.672	3.25	3	.259	0	y	3	1.029	.834	1.438	1.653	.201	3.9-3
83	M83	3-2X6	.461	3.25	3	.438	0	y	3	1.029	.834	1.438	1.653	.201	3.9-3
84	M84	3-2X6	.434	3.25	3	.527	0	y	3	1.76	.834	1.438	1.653	.201	3.9-3
85	M85	3-2X6	.292	3.25	11	.385	3.25	y	15	.904	.725	1.25	1.438	.175	3.9-3
86	M86	3-2X6	.290	3.25	11	.386	3.25	y	5	.904	.725	1.25	1.438	.175	3.9-3
87	M87	3-2X6	.360	3.25	11	.511	3.25	y	11	.904	.725	1.25	1.438	.175	3.9-3
88	M88	3-2X6	.513	3.25	11	.622	3.25	y	11	.904	.725	1.25	1.438	.175	3.9-3
89	M89	3-2X6	.481	3.25	11	.447	0	y	3	.904	.725	1.25	1.438	.175	3.9-3
90	M90	3-2X6	.673	3.25	3	.260	0	y	3	1.029	.834	1.438	1.653	.201	3.9-3
91	M91	2-2X10	.774	14.041	3	.517	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-1
92	M92	2-2X10	.559	5.851	3	.411	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-3
93	M93	2-2X10	.792	5.851	3	.542	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-1
94	M94	2-2X10	.848	6.289	3	.531	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-3
95	M95	2-2X10	.863	6.289	3	.507	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-3
96	M96	2-2X10	.848	6.289	3	.515	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-3
97	M97	2-2X10	.796	5.997	3	.502	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-3
98	M98	2-2X10	.558	5.851	3	.424	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-3
99	M99	2-2X10	.777	14.041	3	.514	14.041	y	11	1.083	.661	1.208	1.449	.201	3.9-1
100	M100	3-2X6	.198	5.25	7	.121	10.5	y	17	.772	.725	1.25	1.438	.175	3.9-1
101	M101	3-2X6	.198	5.25	7	.130	10.5	y	7	.772	.725	1.25	1.438	.175	3.9-1
102	M111	2-2X10	.271	0	3	.193	0	y	3	1.08	.834	1.495	1.794	.201	3.9-3
103	M112	2-2X10	.244	0	3	.149	0	y	3	1.08	.834	1.495	1.794	.201	3.9-1
104	M113	2-2X10	.323	0	3	.199	0	y	3	1.08	.834	1.495	1.794	.201	3.9-3
105	M114	2-2X10	.299	0	3	.199	0	y	3	1.08	.834	1.495	1.794	.201	3.9-3
106	M115	2-2X10	.270	0	3	.199	0	y	3	1.08	.834	1.495	1.794	.201	3.9-3
107	M116	2-2X10	.305	0	3	.199	0	y	3	1.08	.834	1.495	1.794	.201	3.9-3
108	M117	2-2X10	.327	0	3	.199	0	y	3	1.08	.834	1.495	1.794	.201	3.9-3
109	M118	2-2X10	.246	0	3	.149	0	y	3	1.08	.834	1.495	1.794	.201	3.9-1
110	M119	2-2X10	.271	0	3	.193	0	y	3	1.08	.834	1.495	1.794	.201	3.9-3
111	M120	3-2X6	.035	9.625	15	.016	5.25	z	5	.772	.725	1.25	1.438	.175	3.6.3
112	M121	3-2X6	.052	.875	5	.016	0	z	11	.772	.725	1.25	1.438	.175	3.9-1
113	M122	3-2X6	.050	8.75	15	.016	8.75	y	5	.772	.725	1.25	1.438	.175	3.9-1
114	M123	3-2X6	.066	8.75	11	.024	5.25	y	11	.772	.725	1.25	1.438	.175	3.6.3
115	M124	3-2X6	.120	5.25	7	.068	10.5	y	7	.772	.725	1.25	1.438	.175	3.9-3
116	M125	3-2X6	.120	5.25	7	.060	10.5	y	17	.772	.725	1.25	1.438	.175	3.9-3
117	M126	2X4	1.100	0	13	1.173	0	y	13	1.595	.825	1.5	1.65	.175	3.9-1
118	M127	2X4	1.902	0	11	1.839	0	y	11	1.595	.825	1.5	1.65	.175	3.9-1
119	M128	2-2X10	.000	5	3	.012	0	z	11	.437	.661	1.208	1.449	.201	3.9-1
120	M129	2X4	.751	.83	3	1.035	0	y	3	1.824	.949	1.725	1.898	.201	3.9-1
121	M130	2X4	.829	.83	5	1.274	0	y	5	1.595	.825	1.5	1.65	.175	3.9-3
122	M131	2X2	.000	0	11	.004	0	z	11	1.488	.825	1.5	1.5	.175	3.9-1
123	M132	2X2	.000	0	3	.009	0	z	5	1.677	.949	1.725	1.725	.201	3.9-1

Envelope Wood Code Checks (Continued)

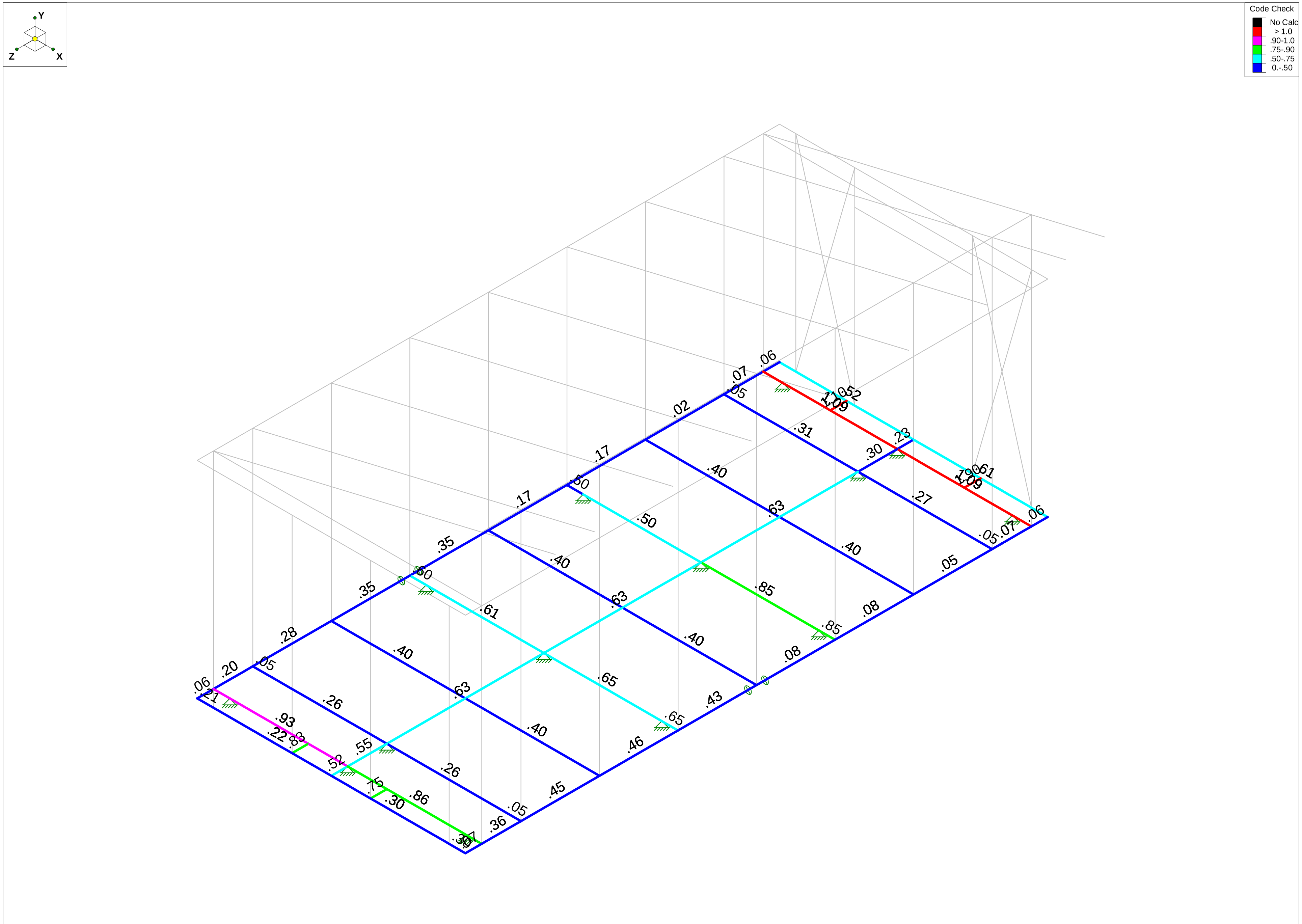
	Member	Shape	Code C...	Loc[ft]	LC	Shear C...	Loc[ft]	Dir	LC	Fc' [ksi]	Ft' [ksi]	Fb1' [ksi]	Fb2' [ksi]	Fv' [ksi]	Eqn
124	M133	2X2	.005	1.5	3	.051	.5	z	3	1.677	.949	1.725	1.725	.201	3.9-1
125	M134	2X2	.005	3	15	.106	2	y	3	1.488	.825	1.5	1.5	.175	3.6.3
126	M135	2X2	.007	3	15	.094	2	y	3	1.488	.825	1.5	1.5	.175	3.6.3
127	M136	2X2	.008	3	5	.025	1	y	3	1.488	.825	1.5	1.5	.175	3.6.3
128	M137	2X2	.008	3	5	.033	3	y	11	1.488	.825	1.5	1.5	.175	3.6.3
129	M138	2X2	.006	3	11	.069	1	y	3	1.488	.825	1.5	1.5	.175	3.6.3
130	M139	2X2	.004	1	3	.125	1	y	3	1.677	.949	1.725	1.725	.201	3.9-1
131	M140	2X2	.006	.5	3	.086	1.5	z	11	1.677	.949	1.725	1.725	.201	3.9-1
132	M143	4X4	.131	8.19	15	.061	5.46	z	13	1.02	.825	1.5	1.5	.175	3.6.3
133	M144	4X4	.219	5.46	5	.112	5.46	z	11	1.02	.825	1.5	1.5	.175	3.9-1
134	M143A	4X4	.181	5.46	15	.150	5.46	y	13	1.02	.825	1.5	1.5	.175	3.9-1
135	M144A	4X4	.173	2.73	5	.219	5.46	y	11	1.02	.825	1.5	1.5	.175	3.6.3

Material Takeoff

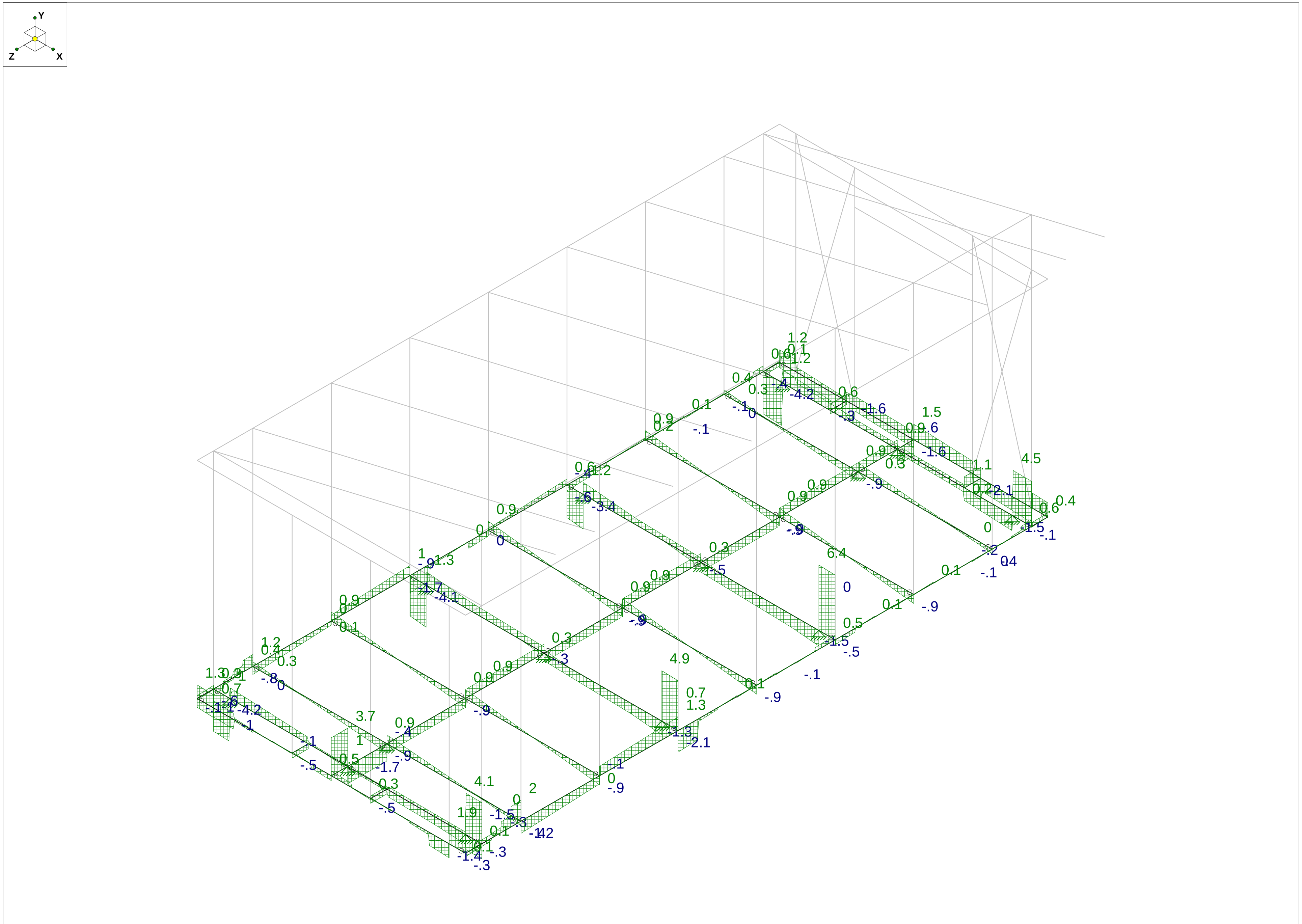
	Material	Size	Pieces	Length[ft]	Weight[K]
1	Wood				
2	LVL-PRL 2900Fb	2X10	26	86.6	.3
3	LVL-PRL 2900Fb	2-2X12	4	86.6	.7
4	So Pine	2-2X10	20	200.7	1.4
5	So Pine	2X2	19	111.3	0
6	So Pine	2X4	4	3.3	0
7	So Pine	3-2X10	23	84.3	.9
8	So Pine	3-2X6	35	302.3	1.8
9	So Pine	4X4	4	43.7	.1
10	SP	2-2X10	9	34.6	.2
11	Total Wood		144	953.4	5.5



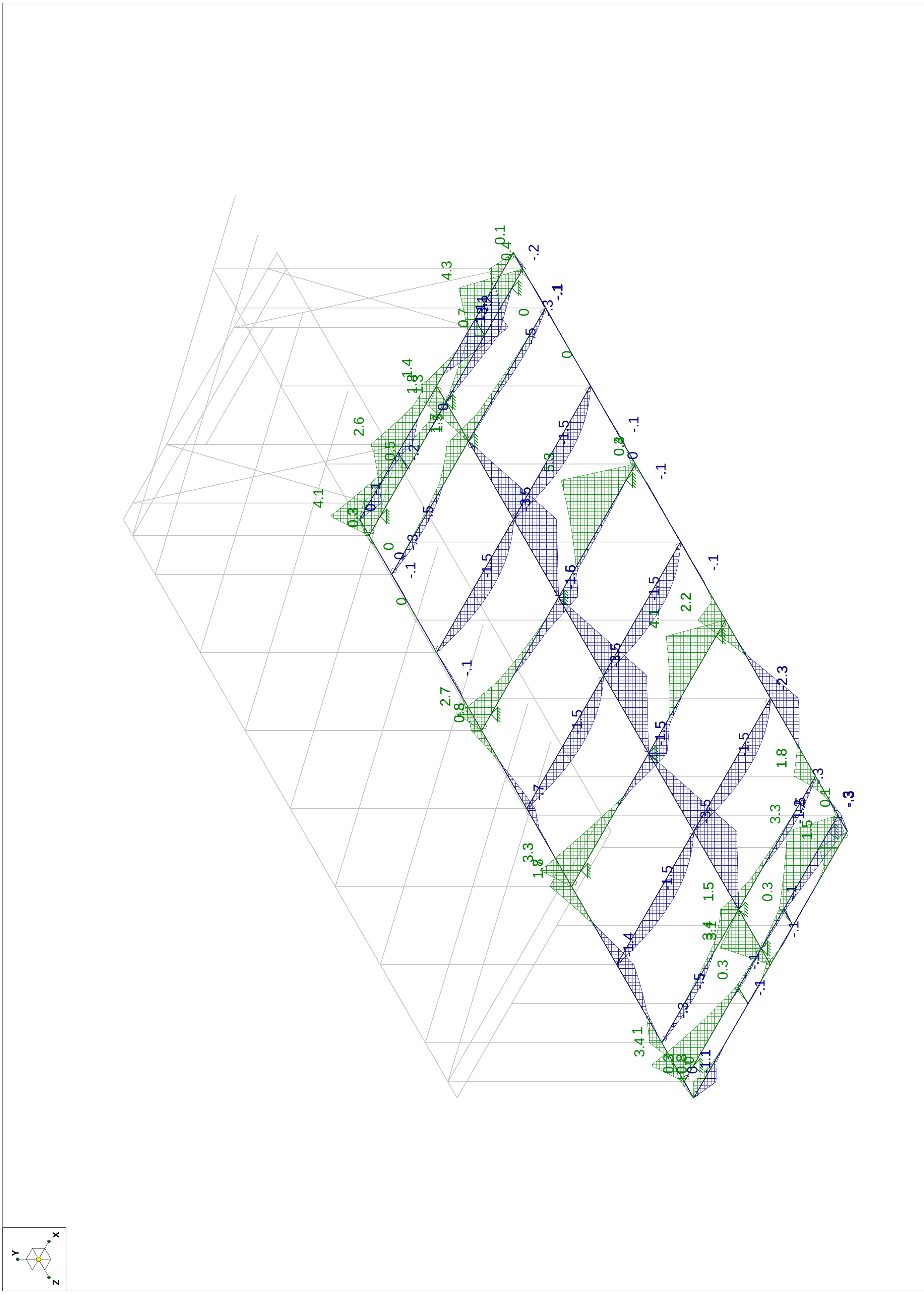
Solution: Envelope
Member Axial Forces (k) ← DESIGN FOOTING LOADS (F ≤ 1500 psF)



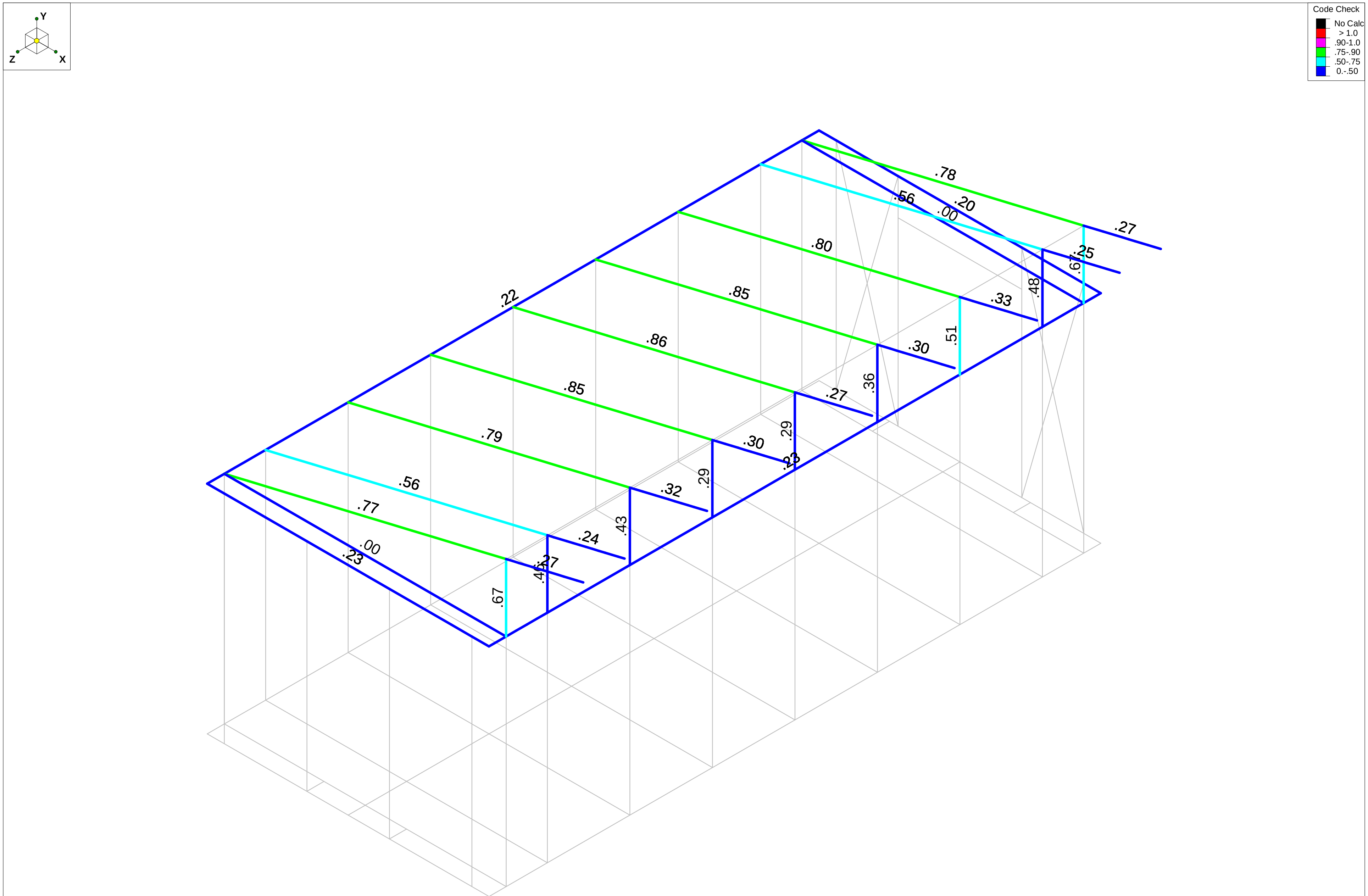
Member Code Checks Displayed
Solution: Envelope



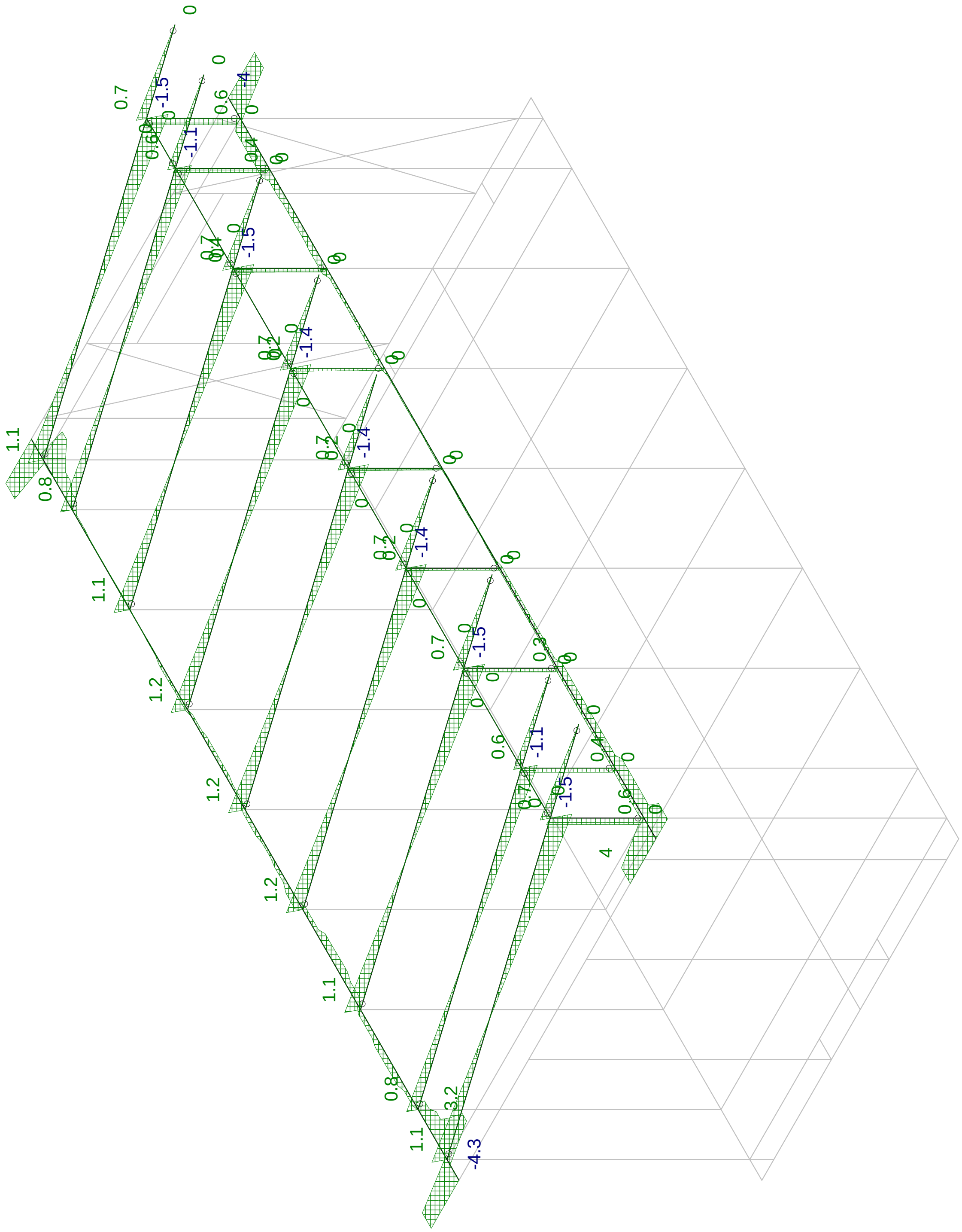
Solution: Envelope
Member y Shear Forces (k)



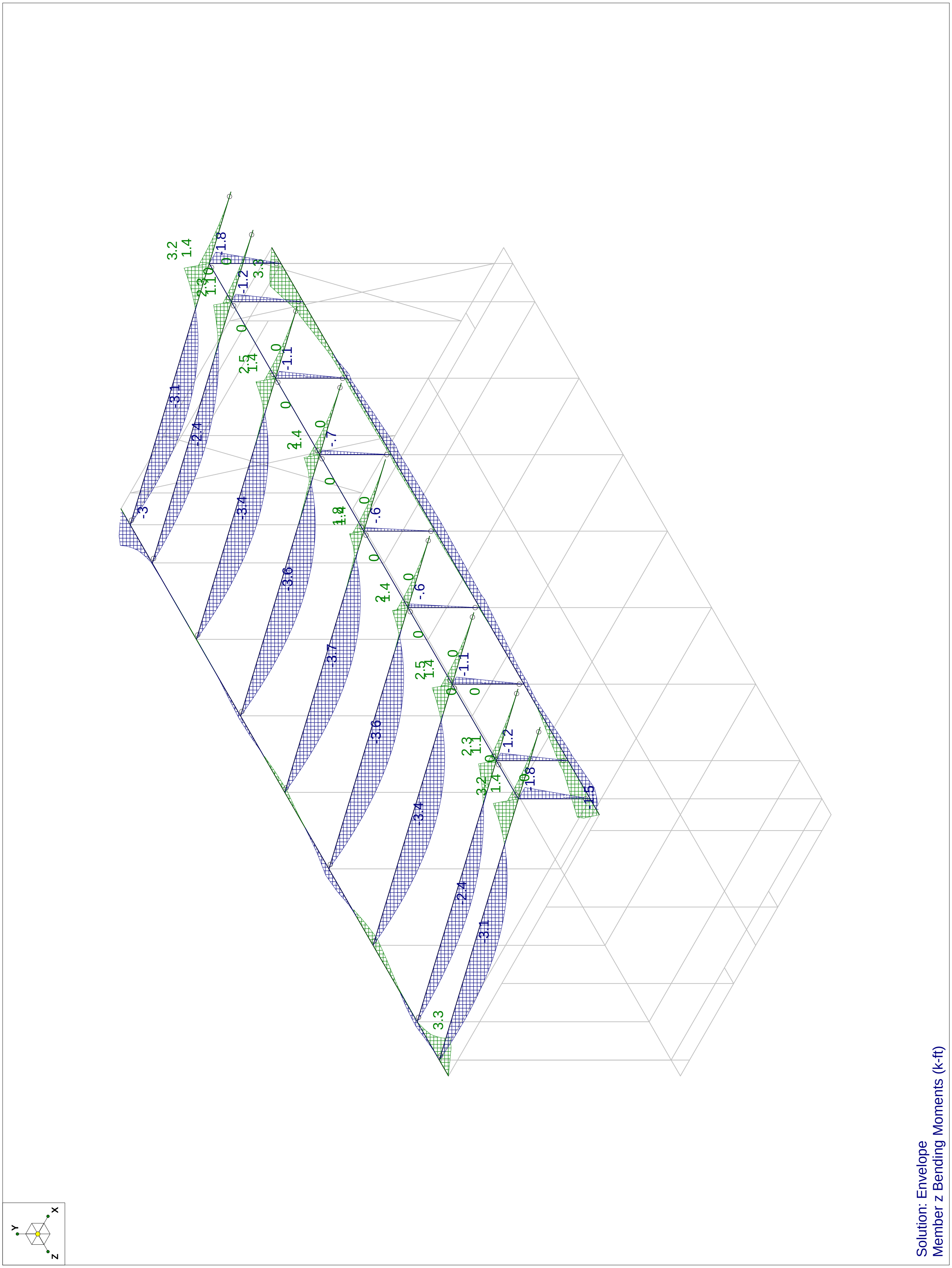
Solution: Envelope
Member z Bending Moments (k-ft)

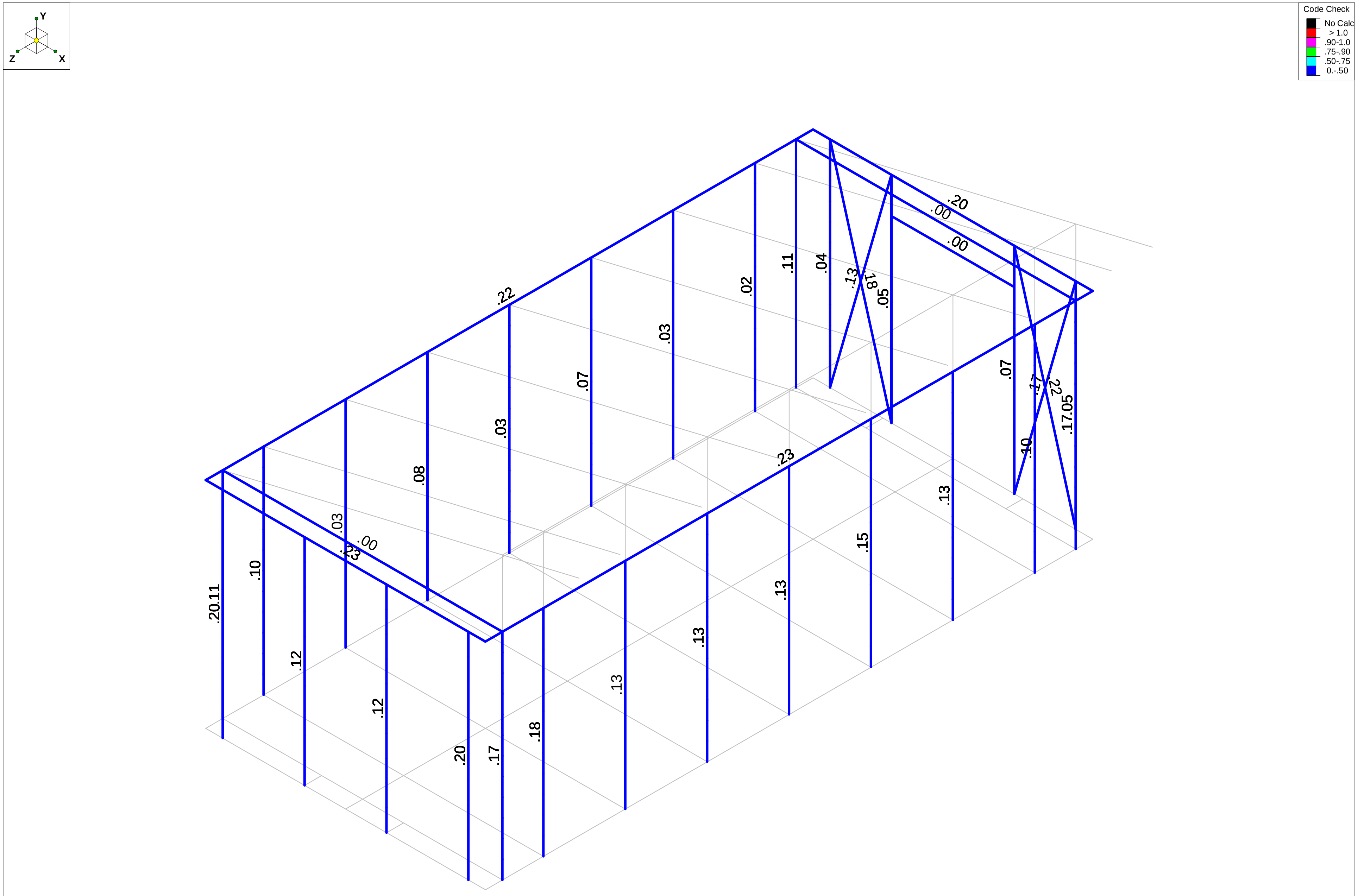


Member Code Checks Displayed
Solution: Envelope

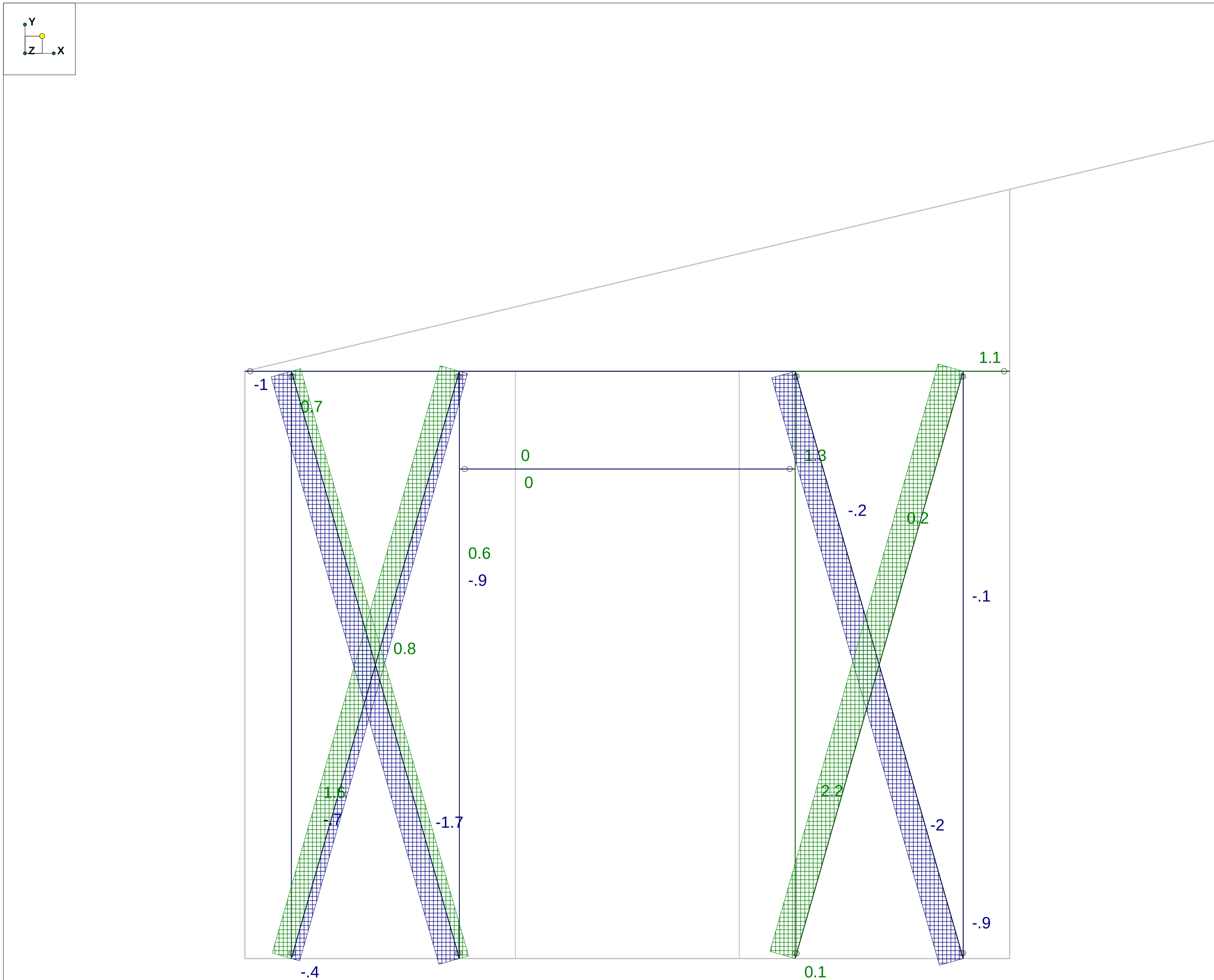


Solution: Envelope
Member y Shear Forces (k)

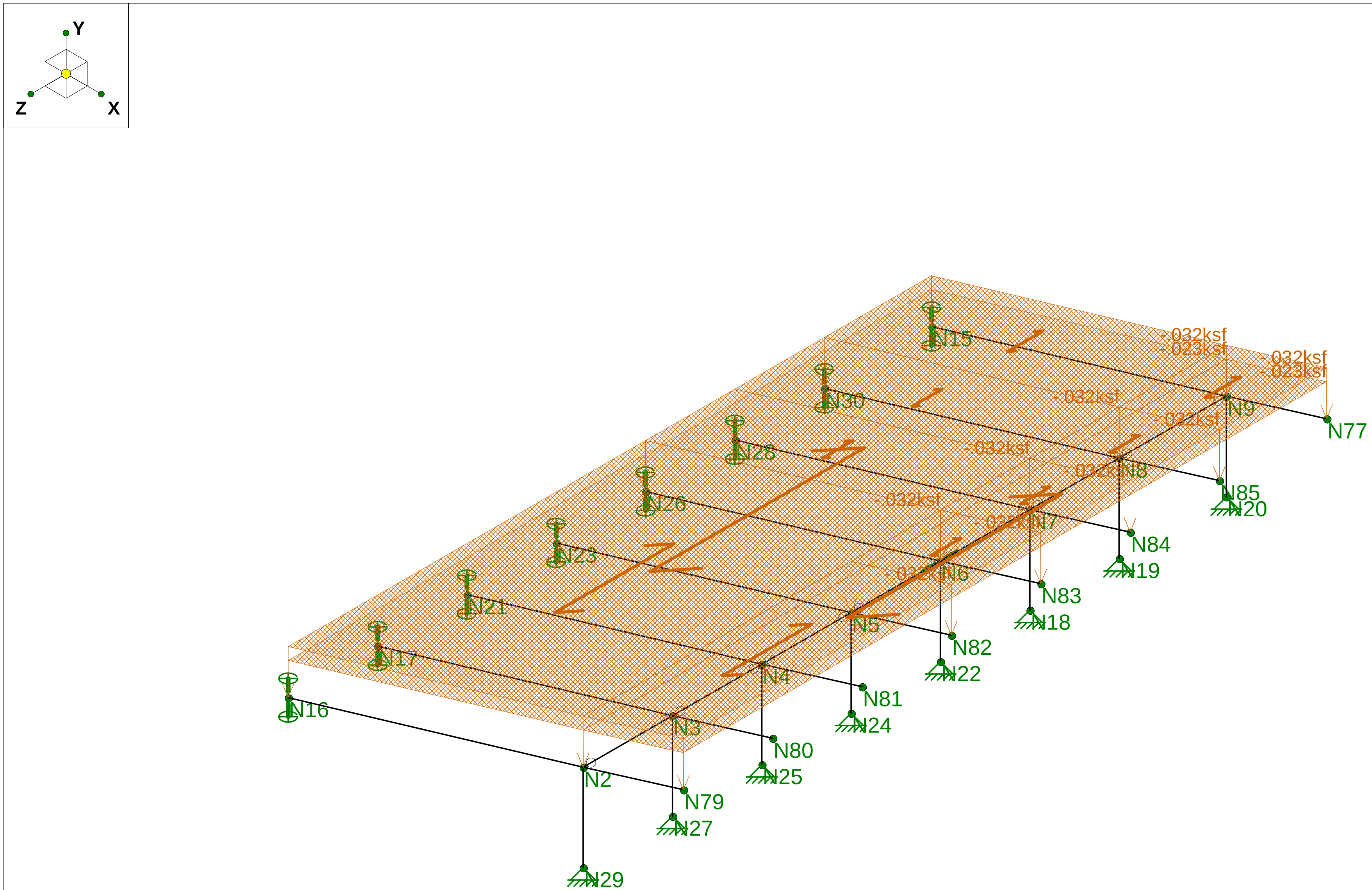

Solution: Envelope
Member z Bending Moments (k-ft)



Member Code Checks Displayed
Solution: Envelope

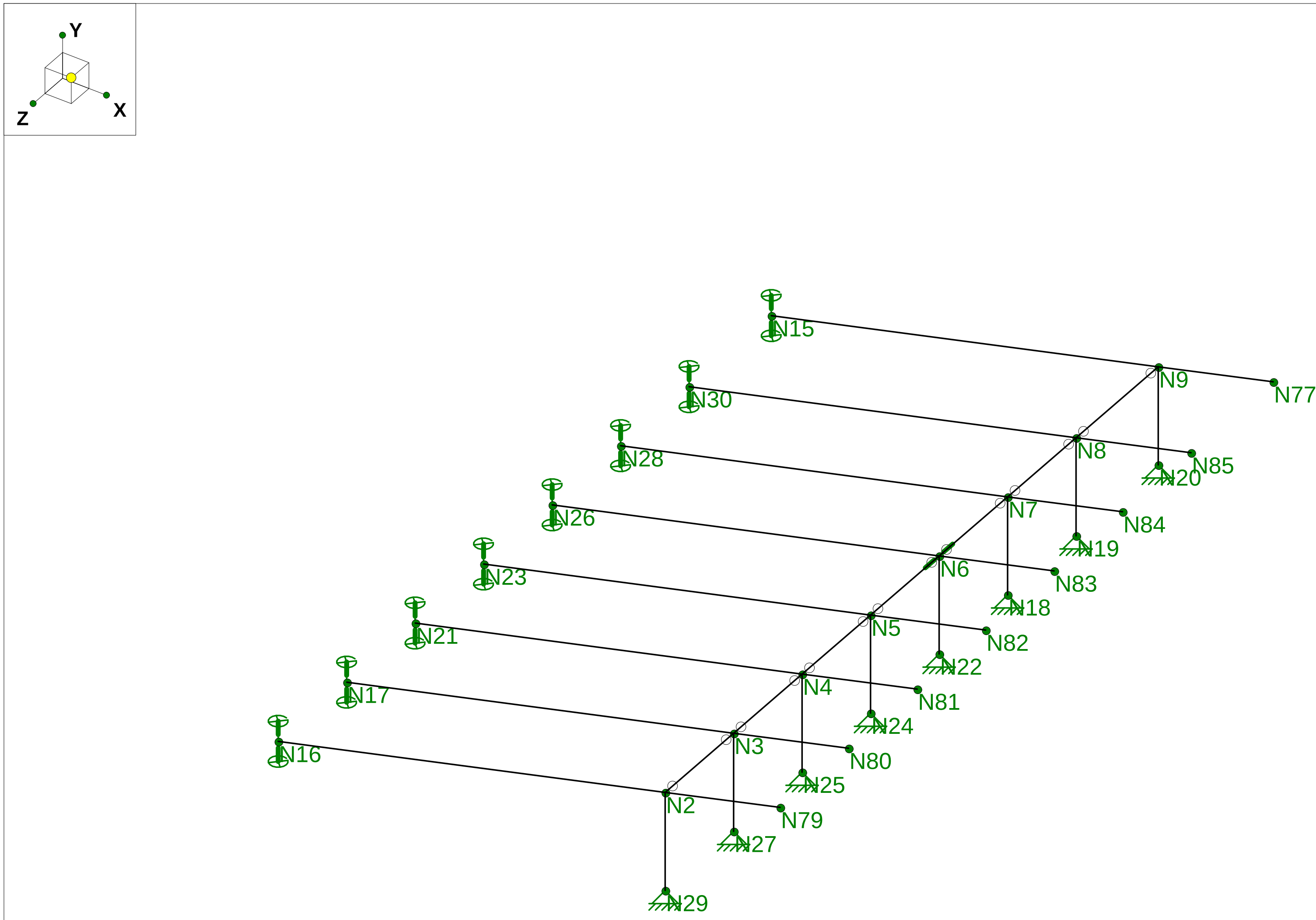


Solution: Envelope
Member Axial Forces (k)



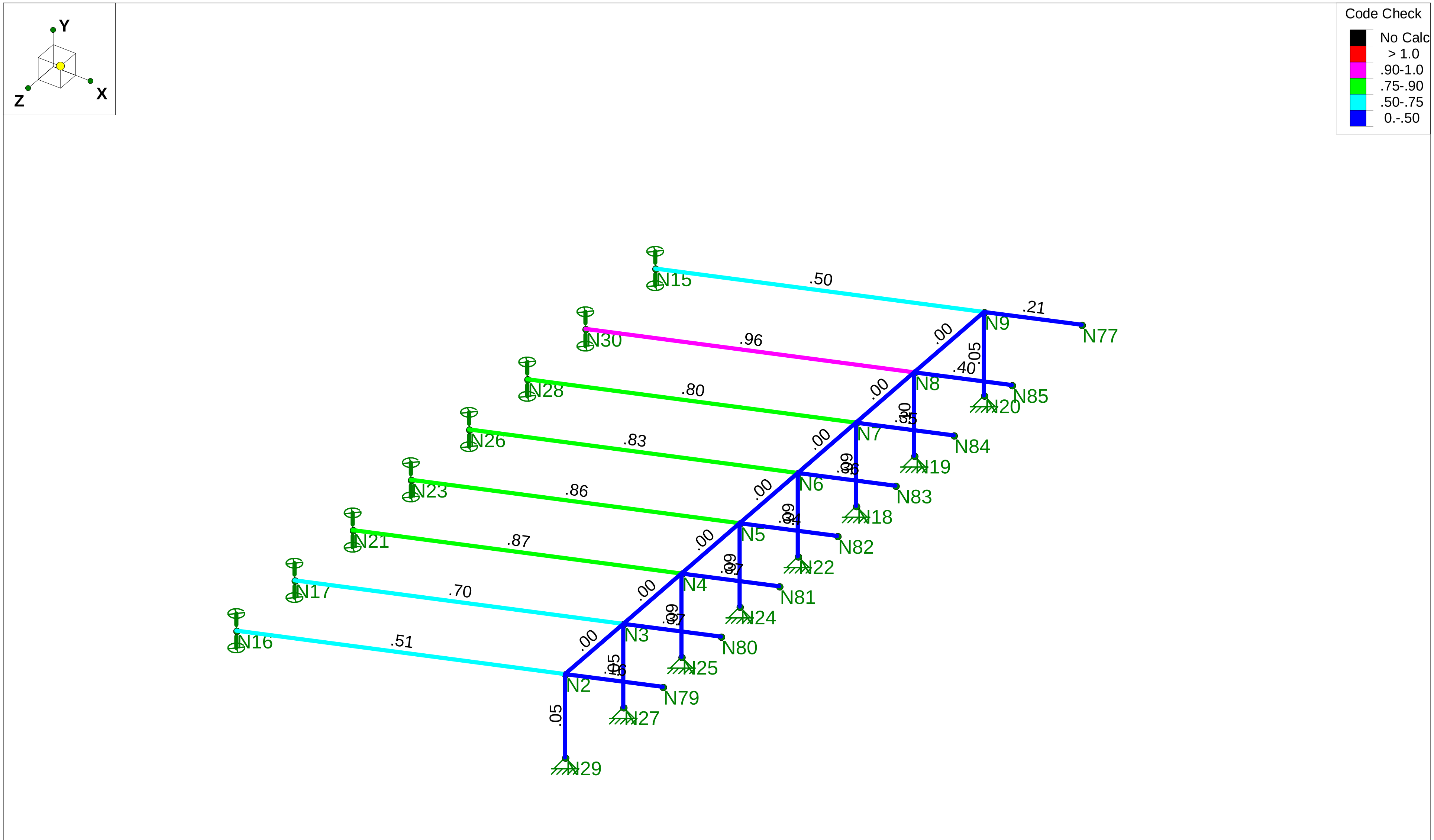
Loads: LC 11, SD11 16-13 ca
Solution: Envelope

Robert Silman Associates		SK - 1
C. Allan Cobb	UMd SD2011 - North Module	Mar 16, 2011 at 5:04 PM
	Applied Loads - South Module	RSA SD2011 Modules - South Roof.r3d



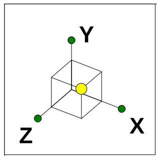
Solution: Envelope

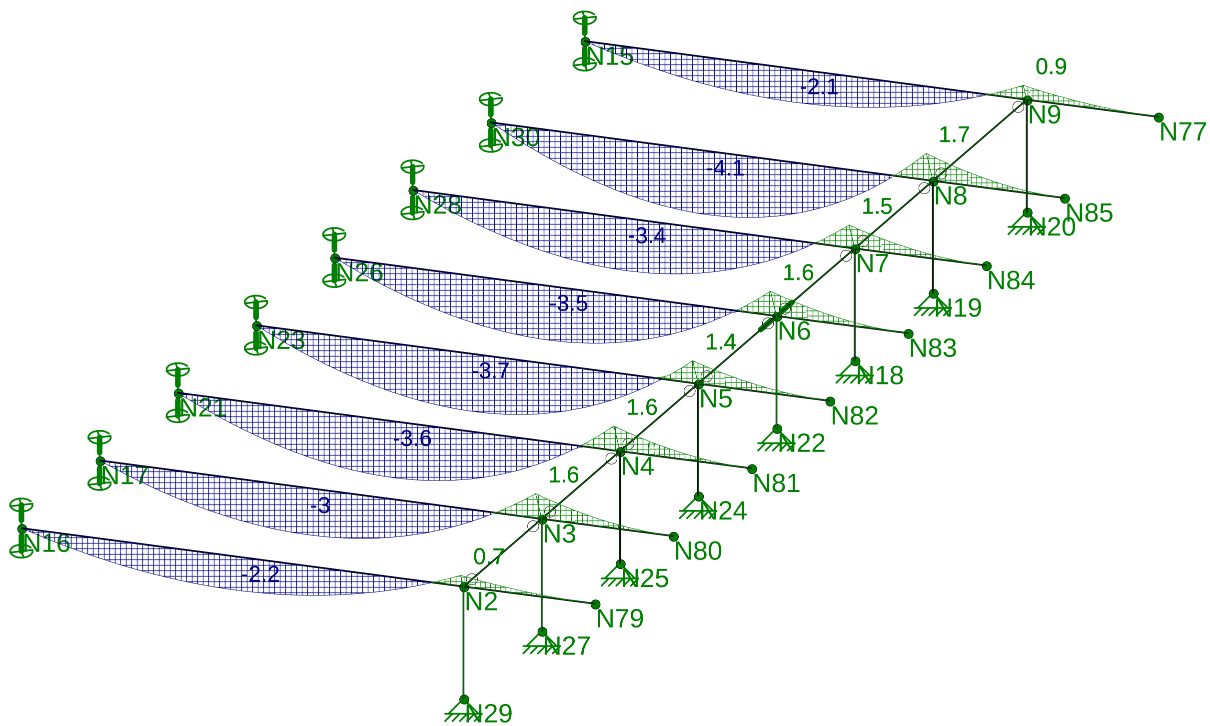
Robert Silman Associates		SK - 2
C. Allan Cobb	UMd SD2011 - North Module	Mar 16, 2011 at 5:06 PM
	Nodes - South Module Roof	RSA SD2011 Modules - South Roof.r3d



Member Code Checks Displayed
Solution: Envelope

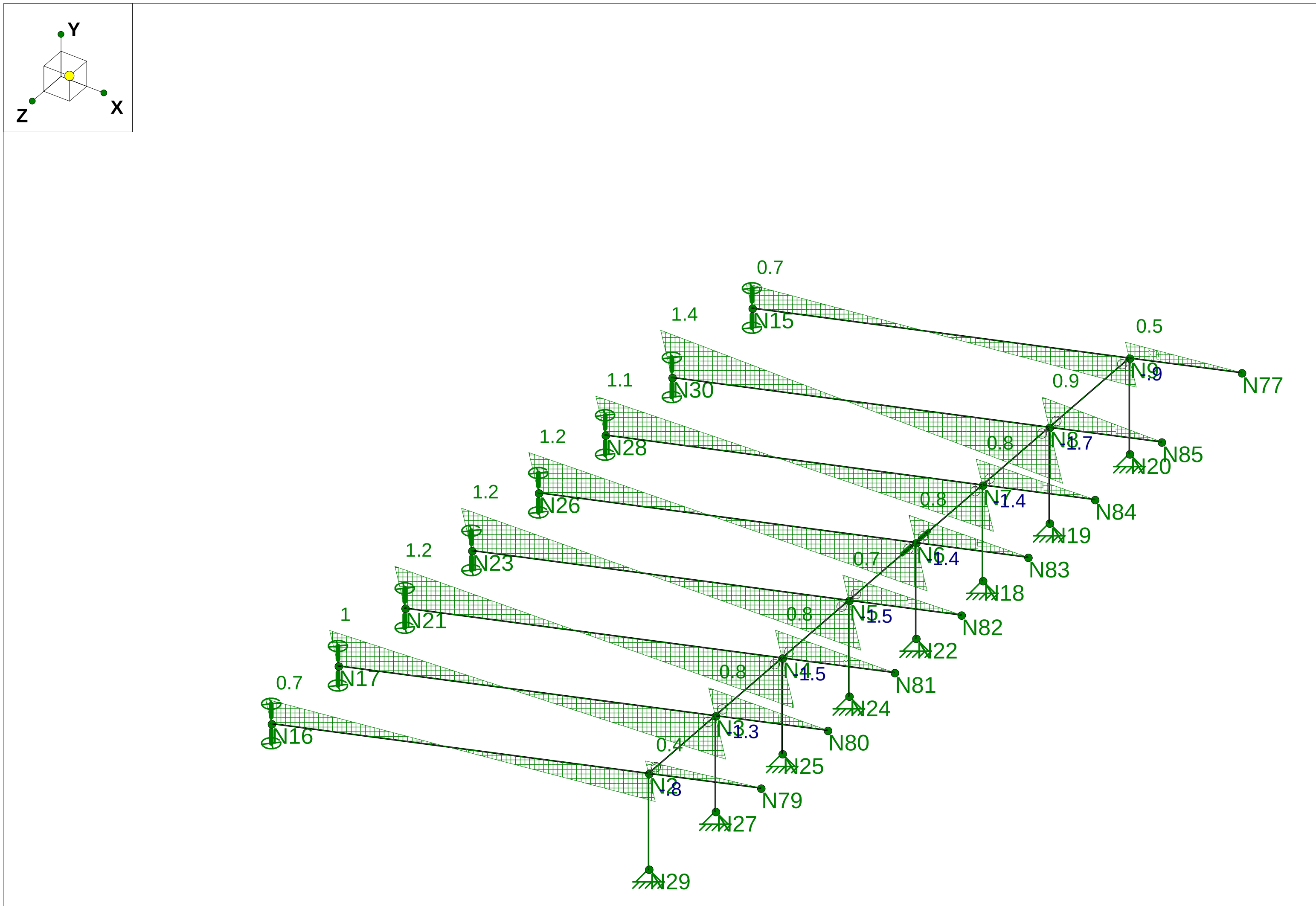
Robert Silman Associates		SK - 3
C. Allan Cobb	UMd SD2011 - North Module	Mar 16, 2011 at 5:06 PM
	Code Check - South Module Roof	RSA SD2011 Modules - South Roof.r3d





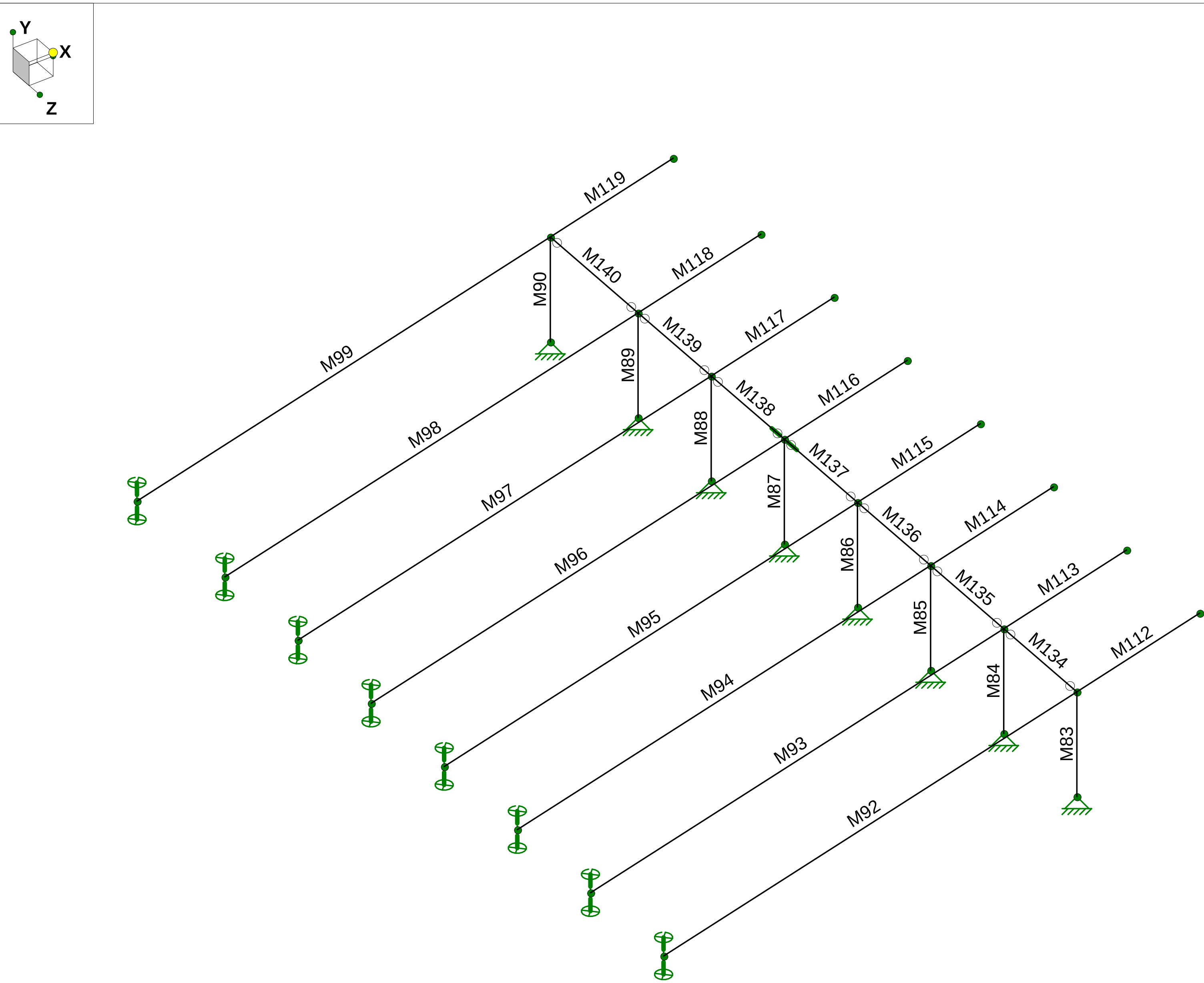
Solution: Envelope
Member z Bending Moments (k-ft)

Robert Silman Associates		SK - 4
C. Allan Cobb	UMd SD2011 - North Module	Mar 16, 2011 at 5:07 PM
	Bending Moment Diagram - South Module Roof	RSA SD2011 Modules - South Roof.r3d



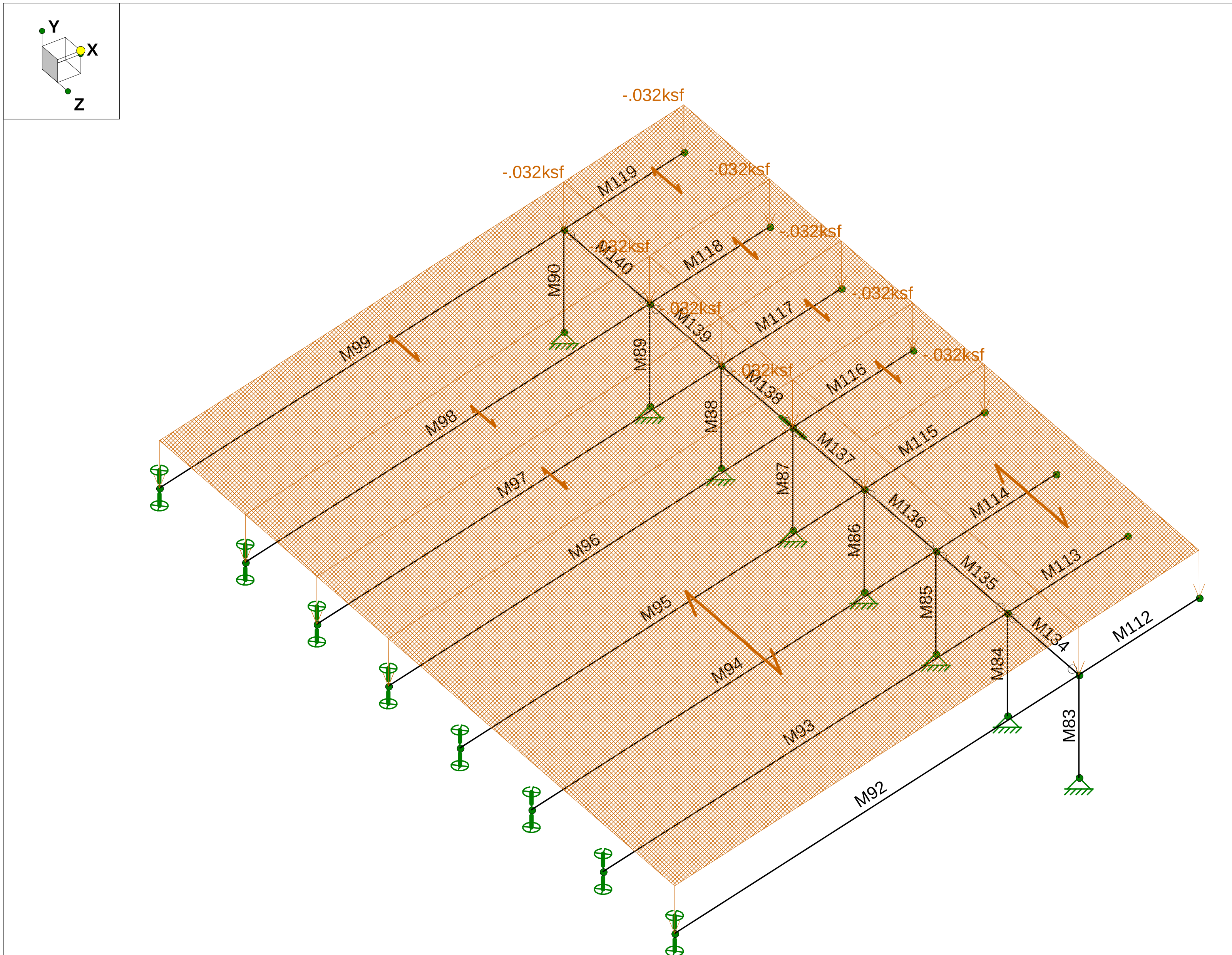
Solution: Envelope
Member y Shear Forces (k)

Robert Silman Associates		SK - 5
C. Allan Cobb	UMd SD2011 - North Module	Mar 16, 2011 at 5:08 PM
	Shear Diagram - South Module Roof	RSA SD2011 Modules - South Roof.r3d

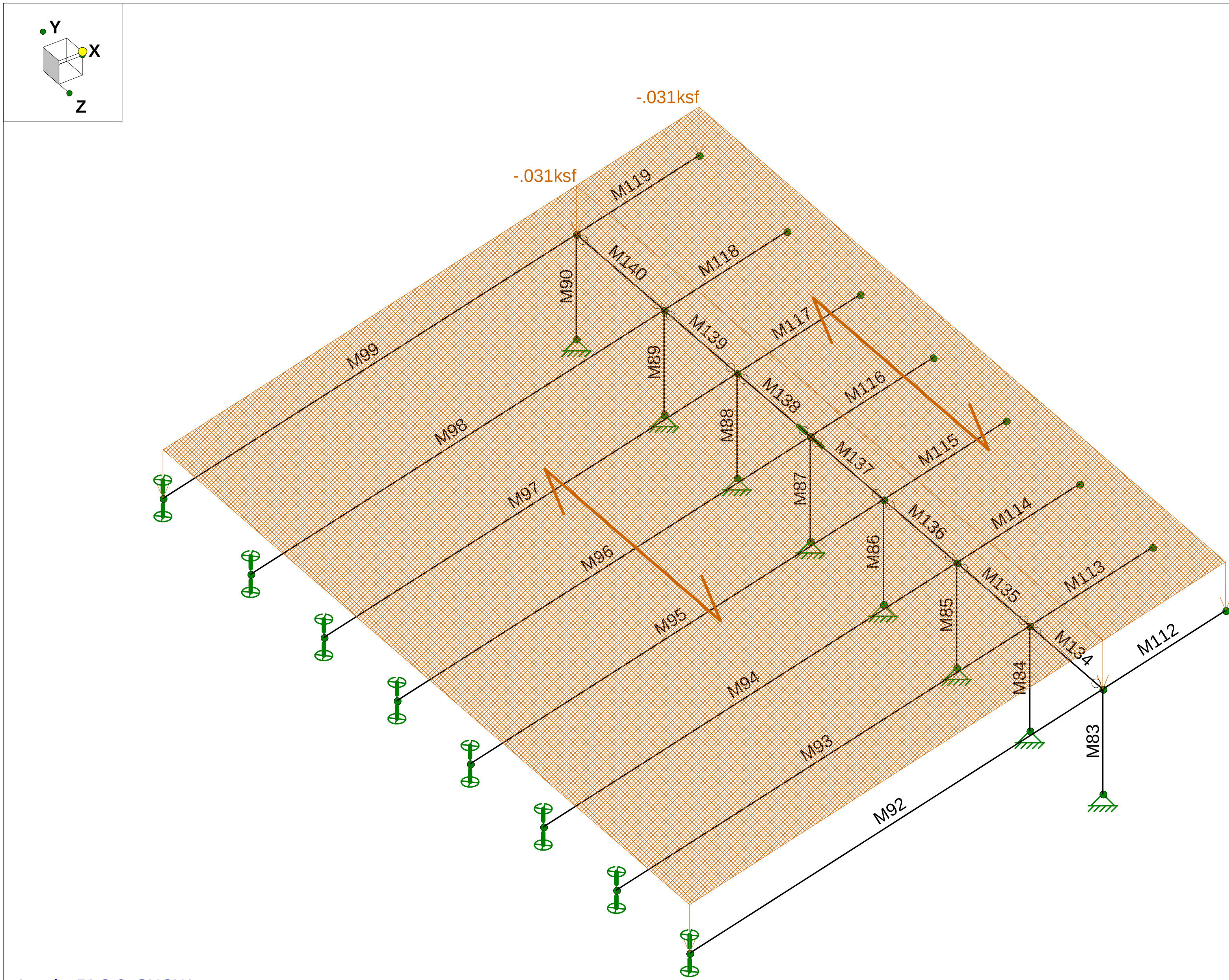


Solution: Envelope

Robert Silman Associates		SK - 6
C. Allan Cobb	UMd SD2011 - North Module	Mar 16, 2011 at 5:09 PM
	Member Numbers - South Module Roof	RSA SD2011 Modules - South Roof.r3d



Robert Silman Associates		SK - 7
C. Allan Cobb	UMd SD2011 - North Module	Mar 16, 2011 at 5:09 PM
	Dead Load - South Module Roof	RSA SD2011 Modules - South Roof.r3d



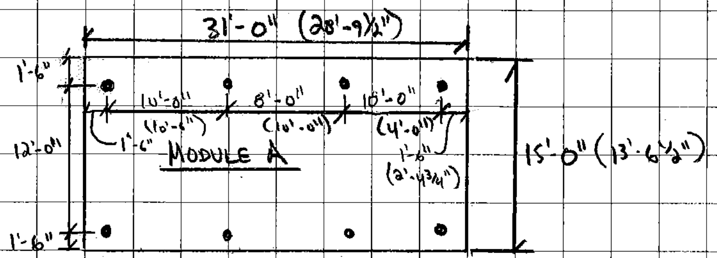
Loads: BLC 3, SNOW
Solution: Envelope

Robert Silman Associates		SK - 8
C. Allan Cobb	UMd SD2011 - North Module	Mar 16, 2011 at 5:10 PM
	Snow Load - South Module Roof	RSA SD2011 Modules - South Roof.r3d

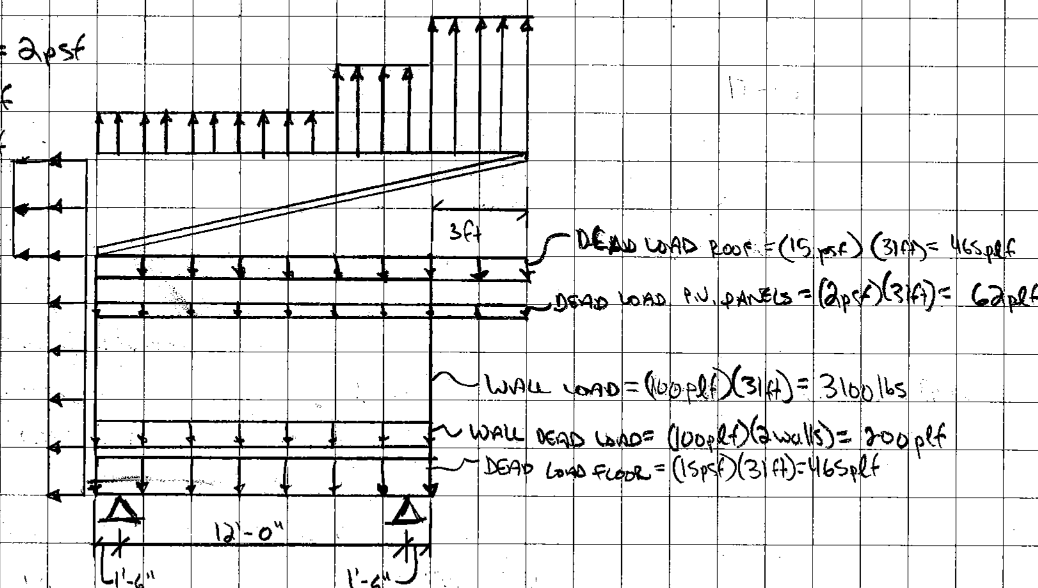
Envelope Wood Code Checks

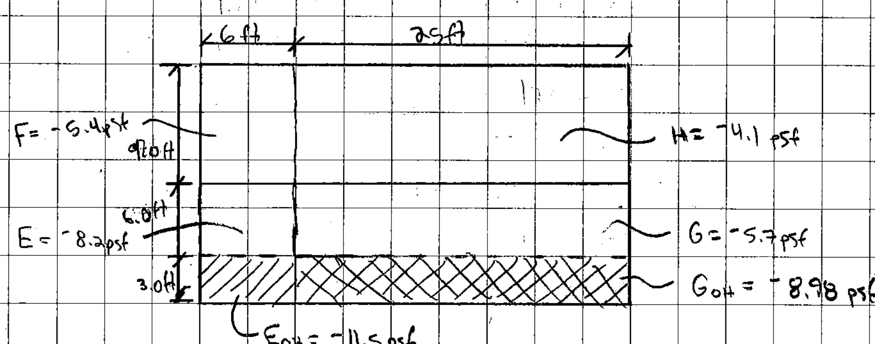
	Member	Shape	Code C...	Loc[in]	LC	Shear C...	Loc[in]	Dir	LC	Fc' [ksi]	Ft' [ksi]	Fb1' [ksi]	Fb2' [ksi]	Fv' [ksi]	Eqn
1	M83	3-2X6	.048	0	3	.000	0	z	1	1.029	.834	1.438	1.653	.201	3.6.3
2	M84	3-2X6	.050	0	3	.000	0	z	1	1.76	.834	1.438	1.653	.201	3.6.3
3	M85	3-2X6	.094	0	13	.000	0	z	1	.904	.725	1.25	1.438	.175	3.6.3
4	M86	3-2X6	.090	0	3	.000	0	z	1	1.029	.834	1.438	1.653	.201	3.6.3
5	M87	3-2X6	.091	0	13	.000	0	z	1	.904	.725	1.25	1.438	.175	3.6.3
6	M88	3-2X6	.087	0	13	.000	0	z	1	.904	.725	1.25	1.438	.175	3.6.3
7	M89	3-2X6	.103	0	3	.000	0	z	1	1.029	.834	1.438	1.653	.201	3.6.3
8	M90	3-2X6	.054	0	3	.000	0	z	1	1.029	.834	1.438	1.653	.201	3.6.3
9	M92	2-2X10	.508	73.104	13	.223	155.9...	y	13	1.096	.575	1.05	1.26	.175	3.9-1
10	M93	2-2X10	.705	69.855	13	.346	155.9...	y	13	1.096	.575	1.05	1.26	.175	3.9-1
11	M94	2-2X10	.870	71.479	13	.405	155.9...	y	13	1.096	.575	1.05	1.26	.175	3.9-1
12	M95	2-2X10	.863	71.479	3	.394	155.9...	y	3	1.18	.661	1.208	1.449	.201	3.9-3
13	M96	2-2X10	.832	71.479	13	.390	155.9...	y	13	1.096	.575	1.05	1.26	.175	3.9-1
14	M97	2-2X10	.799	71.479	13	.374	155.9...	y	13	1.096	.575	1.05	1.26	.175	3.9-1
15	M98	2-2X10	.957	71.479	13	.444	155.9...	y	13	1.096	.575	1.05	1.26	.175	3.9-1
16	M99	2-2X10	.503	71.479	13	.233	155.9...	y	13	1.096	.575	1.05	1.26	.175	3.9-1
17	M112	2-2X10	.165	0	13	.098	0	y	13	1.475	.575	1.05	1.26	.175	3.9-3
18	M113	2-2X10	.370	0	13	.222	0	y	13	1.475	.575	1.05	1.26	.175	3.9-3
19	M114	2-2X10	.370	0	13	.222	0	y	13	1.475	.575	1.05	1.26	.175	3.9-3
20	M115	2-2X10	.337	0	13	.202	0	y	13	1.475	.575	1.05	1.26	.175	3.9-3
21	M116	2-2X10	.362	0	13	.217	0	y	13	1.475	.575	1.05	1.26	.175	3.9-3
22	M117	2-2X10	.345	0	13	.206	0	y	13	1.475	.575	1.05	1.26	.175	3.9-3
23	M118	2-2X10	.400	0	13	.240	0	y	13	1.475	.575	1.05	1.26	.175	3.9-3
24	M119	2-2X10	.210	0	13	.126	0	y	13	1.475	.575	1.05	1.26	.175	3.9-3
25	M134	2X2	.000	0	1	.057	0	z	3	1.357	.743	1.35	1.35	.158	3.9-3
26	M135	2X2	.000	0	1	.121	0	z	1	1.357	.743	1.35	1.35	.158	3.9-3
27	M136	2X2	.000	0	1	.109	0	z	1	1.357	.743	1.35	1.35	.158	3.9-3
28	M137	2X2	.000	0	1	.085	0	z	1	1.357	.743	1.35	1.35	.158	3.9-3
29	M138	2X2	.000	0	1	.030	0	z	1	1.357	.743	1.35	1.35	.158	3.9-3
30	M139	2X2	.000	0	1	.091	0	z	3	1.357	.743	1.35	1.35	.158	3.9-3
31	M140	2X2	.000	0	1	.194	0	z	3	1.357	.743	1.35	1.35	.158	3.9-3

MODULE A



ROOF ∢ 13°
ROOF DEAD LOAD = 15psf
P.V. PANELS DEAD LOAD = 2psf
FLOOR DEAD LOAD = 15psf
WALL DEAD LOAD = 100 plf





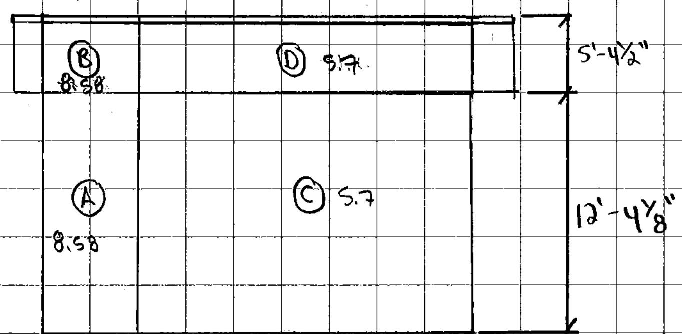
ROOF LOADS FROM WIND

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street, NW Washington, DC 20007

PROJECT SD-2011 JOB NO. PAGE 2/5

SUBJECT TIE DOWN CALCS BY SMB DATE 3/15/2011

WALL LOADS @ NORTH MODULE



BECAUSE (B) AND (D) ARE A WALL USE SAME PRESSURE AS (A) AND (C)

ZONE	TRIB WIDTH	TRIB. HEIGHT/LENGTH	LOAD, P (lbs)	MOMENT ARM (ft)	MOMENT lb-ft
A	6	12.34375	635.5	6.2	3940
B	6	5.375	277	15.03	4159
C	25	12.34375	1759	6.2	10,906
D	25	5.375	766	15.03	11512
E	46	6	297	10.5	3119
F	9	6	292	4.5	1314
G	6	25	855	10.5	8978
H	9	25	923	4.5	4154
E_{OH}	3	6	207	15	3105
G_{OH}	3	25	674	15	10,110

M_o = 61,297 lb-ft

DETERMINE RIGHTING MOMENT

DEAD LOAD ROOF = (465 lb/ft)(18 ft)(9 ft − 1.5 ft) = 62,775 lb-ft

DEAD LOAD P.V. = ((62 lb/ft)(18 ft)(9 ft − 1.5 ft) = 8,370 lb-ft

Wall LOAD = (3100 lbs)(13.5 ft) = 41,850 lbs

WALL DEAD LOAD = (200 lb/ft)(15 ft)(7.5 ft − 1.5 ft) = 18,000 lb-ft

DEAD LOAD FLOOR = (465 lb/ft)(15 ft)(7.5 ft − 1.5 ft) = 41,850 lb-ft

TOTAL RIGHTING MOMENT = 172,845 lb-ft

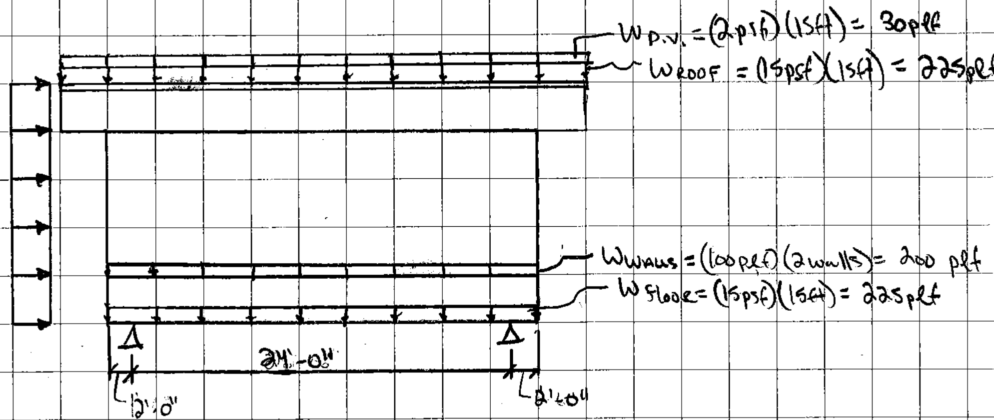
RATIO M_r/M_o = 2.82 > 2.0 ok

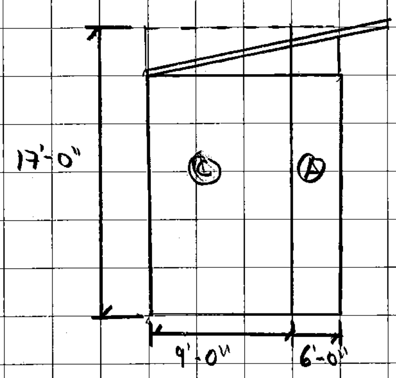
ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street, NW Washington, DC 20007

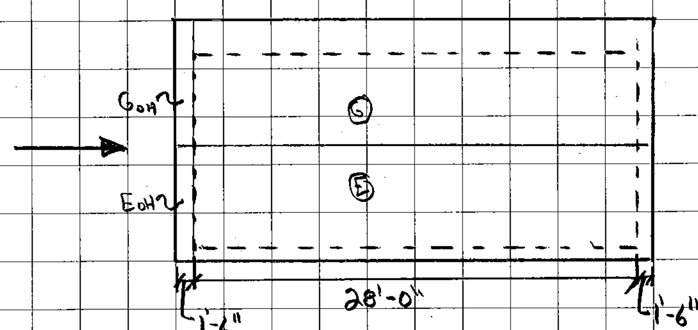
PROJECT SD-2011 JOB NO. PAGE 3/5

SUBJECT TIE DOWN CALCS BY SMB DATE 3/15/2011

CHECK SHORT DIRECTION WIND FROM EAST - WEST







ZONE	TRIB WIDTH	TRIB. HEIGHT/LENGTH	LOAD, P (lbs)	Moment Arm (ft)	Moment (ft-lbs)
A	6	17	875	8.5	7438
C	9	17	872	8.5	7412
E	19	29.5	3750	14.75	55312
G	19	29.5	1513	14.75	22317
Eoh	9	1.5	155	14.75	2286
Goh	19	1.5	121	14.75	1785

M_o = 96,550 lb-ft

DEAD LOAD ROOF = (225 plf)(31ft)(13.5ft) = 94,162 lb-ft
DEAD LOAD P.V. = (30plf)(31ft)(13.5ft) = 12,555 lb-ft
WALL LOAD = (100 plf)(15ft)(30ft) = 45,000 lb-ft
WALL DEAD LOAD = (200plf)(28ft)(12ft) = 67,200 lb-ft
FLOOR DEAD LOAD = (225plf)(28ft)(12ft) = 75,600 lb-ft
M_R = 294,517 lb-ft

RATIO = M_R/M_o = 3.05 > 2.0 OK

SOUTH MODULE, SOUTH WIND

LAYOUT OF STRUCTURE SIMILAR TO DIAGRAMS ON PREVIOUS PAGES

ZONE	TRIB WIDTH	TRIB HEIGHT	LOAD, P(lbs)	MOMENT ARM (ft)	MOMENT (lb-ft)
A	6	16.5	849.	8.25	7004
C	22.79	16.5	2144	8.25	17688
E	5.22	6	257	9.33	2398
F	8.22	6	266	2.61	694
G	5.22	22.79	678	9.33	6326
H	8.22	22.79	768	2.61	2005
E_{OH}	3	6	207	13.44	2782
G_{OH}	3	22.79	614	13.44	8252

M_o = 47,149 lb-ft

DEAD LOAD ROOF = (15psf)(16.46ft)(6.73ft)(28.75ft) = 47,772 lb-ft
GREEN ROOF LOAD = (17psf)(10.5ft)(5.25ft)(24ft) = 22491 lb-ft
WALL LOAD = (100plf)(24ft)(10.5ft) = 25,200 lb-ft
WALL DEAD LOAD = (200 lb/ft)(10.5ft)(5.25ft) = 11,025 lb-ft
DEAD LOAD FLOOR = (15psf)(24ft)(10.5ft)(10.5ft/2) = 19,845 lb-ft
M_e = 126,333 lb-ft

RATIO = M_e/M_o = 126,333 lb-ft / 47,149 lb-ft = 2.68 > 2.0 ok

SOUTH MODULE EAST-WEST WIND

ZONE	TRIB WIDTH	TRIB HEIGHT	LOAD, P(lbs)	MOMENT ARM (ft)	MOMENT (ft-lbs)
A	6	16.5	849	8.25	7004
C	7.42	16.5	698	8.25	5759
E	8.23	26.4	1782	12.89	22970
G	8.23	26.4	1238	12.89	15958
E_{OH}	8.23	2.4	227	28.04	6365
G_{OH}	8.23	2.4	177	28.04	4963

M_o = 63,019 lb-ft

DEAD LOAD ROOF = (15psf)(16.46ft)(28.75ft)(12.89ft) = 91,498 lb-ft
GREEN ROOF LOAD = (17psf)(10.5ft)(24ft)(24ft/2) = 51,408 lb-ft
WALL LOAD = (100plf)(13.46ft)(24ft) = 32,300 lb-ft
WALL DEAD LOAD = (200plf)(24ft)(12ft) = 57,600 lb-ft
DEAD LOAD FLOOR = (15psf)(24ft)(10.5ft)(12ft) = 45,360 lb-ft
M_e = 278,166 lb-ft

RATIO = M_e/M_o = 4.4 > 2.0 ok

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street, NW Washington, DC 20007

PROJECT SD-2011 JOB NO. PAGE 5/5

SUBJECT TIE DOWN CALCS BY SMB DATE 3/15/2011

CHECK SLIDING
NORTH MODULE

WIND FORCE = 3438 lbs

$\mu = 0.3$

WEIGHT OF BUILDING = 22,561 lbs

$F_f = \mu F_n = (0.3)(22{,}561 \text{ lbs}) = 6{,}768$ lbs

RATIO = 1.97 (CLOSE BUT DOES NOT COUNT GLOBAL SLIDING)

CHECK SLIDING OF WHOLE STRUCTURE

ASSUME ZONE A WIND = 8.58 psf ≈ 9.0 psf (CONSERVATIVE MOST OF AREA PRESSURE IS 5.7 psf

WIND BLOWING NORTH, AREA = (38 ft)(17.72 ft) = 673.36 ft^2 ≈ 674 ft^2

WIND FORCE = (674 ft^2)(9.0 psf) = 6,066 lbs

Weight of Module A = 22,561 lbs

Weight of Module B = 21,308 lbs

TOTAL WEIGHT = 43,869 lbs

$\mu = 0.3$

$F_f = \mu F_N = (0.3)(43{,}869 \text{ lbs}) = 13{,}160.7$ lbs

SLIDING RATIO = 13,160.7 lbs / 6,066 lbs = 2.17 > 2.0 ok

- DESIGN OF PV PANEL SUPPORT FOR UPLIFT
  - Demand uplift on each 5'-0" x 2'-6" PV Panel: (Components + Cladding, Reference Fig. 6-3 of ASCE 7-05)
    - In zone 1 (interior zone of roof), effective wind area = (216"-22"·2)(396"-22"·2) = 60,544 in² = 420 ft²

      a = (.10) 18' = 22"

      ∴ for zone 1, uplift = -12.1 psf
    - In zone 2 (end zone of roof), effective wind area = (22"(396"-22")·2) + (22"(216"-22")·2)

      = 24,992 in² = 173 ft²

      ∴ for zone 2, uplift = -17.0 psf
    - In zone 3 (corner zone of roof), effective wind area = 22"·22"·4 = 1936 in² = 13 ft²

      ∴ for zone 3, uplift = -34.3 psf

  *note: Reference p. 6 of project load calculations to see where components and cladding forces came from.
  - The worst case will be at zone 1, as you will have the edge of four PV panels being resisted per clip as opposed to 2 edges at zone 2 and one edge at zone 3.
  - Uplift force = 5'(2.5')·12.1 psf = 151#

    ∴ 151# must be resisted at each roof clip.
  - Per the Firestone Building Products, Metal Roof System Design Guide, the minimum fastener resistance is 300# for pullout [See A1]
  - Based on the technical information sheet for the UC-3 Expansion Clip and UC Bearing Plate the maximum ∅ of the fasteners is .22" [See A2 + A3]

  ∴ Will try Firestone 'W56 RAC 4416' HD Hail Gard Fastener. [See A4]

  The pullout force in new ½" plywood is 360# > 300# required in design guide.

$$\boxed{\text{∴ USE (2) 'W56 RAC 4416' HD Hail Gard Fasteners @ each UC-3 Expansion Clip.}}$$

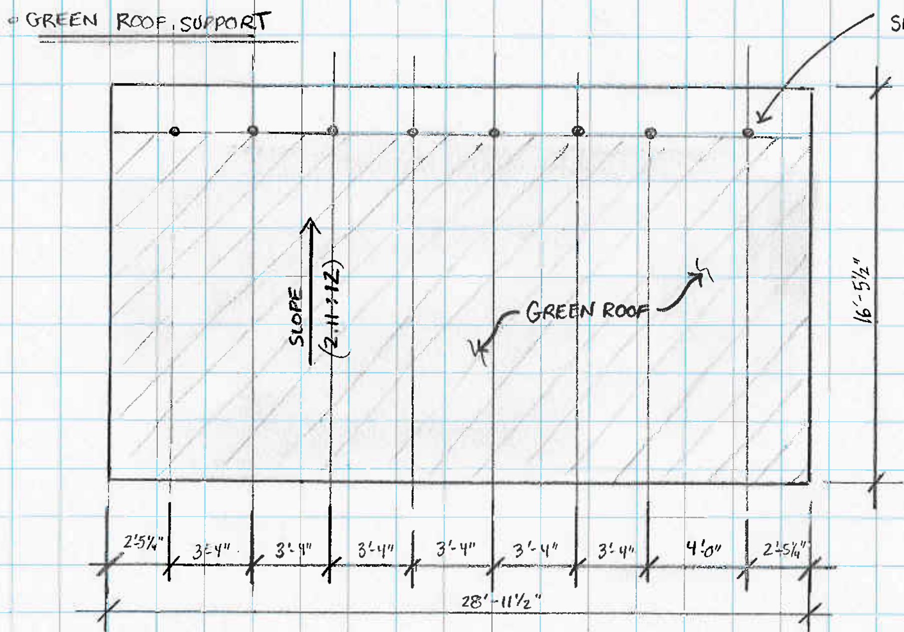
*note: UC Bearing Plate should be added below UC-3 Expansion Clip.

ROBERT SILMAN ASSOCIATES, PLLC
STRUCTURAL ENGINEERS
1053 31ST NW, WASHINGTON DC 20007

PROJECT SOLAR DECATHALON JOB NO. —— PAGE 1/2

SUBJECT GREEN ROOF SUPPORT BY NATHAN DATE 3/11/2011

- GREEN ROOF SUPPORT



*note Green Roof is assumed to be Live Roof Lite (17 psf)

- Based on manufacturer's specifications (see Live Roof Catalog, Arch + Engineering Tables) the force [See A1] against the roof edge for LiveRoof Lite (17 psf) plus 30 psf snow load is:
  - 77 plf for 2:12 roof w/ 10' horiz. run distance
  - 99 plf for 2.5:12 roof w/ 10' horiz. run distance
  - 156 plf for 2:12 roof w/ 20' horiz. run distance
  - 195 plf for 2.5:12 roof w/ 20' horiz. run distance.
- Interpolating these values from the tables for 2.11:12 roof w/ 15' horiz run distance:
  124 plf for 2.11:12 roof w/ 15' run
- Looking at the worst-case trib. width that any one snow guard must take:
  Trib. width = 4'/2 + 2'-5¼" = 4'-5¼" ∴ F_{Guard} = 124 plf (4'-5¼") = 550#
- Snow guards will be from Alpine Snow Guards (#115 two-pipe):
  - For the two-pipe system w/ a bracket spacing of 48" (worst-case) the pipes can support 320 plf > 1.6 (124 plf) = 198 plf = demand (w/ load factor for snow) at pipe ∴ pipe is ok to support green roof system [See A1]
- Design of base plate fasteners [See A3]
  - Based on manufacturer's website will assume there are (7)-5/16" ø fasteners between base plate and wood blocking.
  - Note: will assume wood blocking is ~4" deep and the base plate is 1/8" thick based on manufacturer's cut sheet.

ROBERT SILMAN ASSOCIATES, PLLC
STRUCTURAL ENGINEERS
1053 31ST NW, WASHINGTON DC 20007

PROJECT SOLAR DECATHALON JOB NO. — PAGE 2/2

SUBJECT GREEN ROOF SUPPORT BY NATHAN DATE 03/15/2011

- Will use SDS screws to provide connection between base plate and wood block:
  - Using (7) Simpson 'SDS25300':
    - Checking Shear: Shear/fastener = $550^{\#}/7 = 79^{\#} < 200^{\#} = V_{all}$ [see A4] (w/ 1½" wood side plate)
    - Checking Uplift: Looking at the uplift the guard was exposed to a pullout force of $800^{\#}$/fastener for 6 fasteners when a $2000^{\#}$ force was applied ∴ for 7 fasteners and $550^{\#}$ force:

      Uplift/fastener = $(550^{\#}/2000^{\#})(6/7) \cdot 800^{\#} = 188^{\#}$/fastener $< 240^{\#}$/fastener

∴ USE (7) 'SDS25300' SIMPSON WOOD SCREWS @ BASE PL.

- Will use SDS screws to provide connection between wood block and 2x10.
  - Using (4) Simpson 'SDS25800':
    - threaded length in 2x10 = 8" - 4" - 1.5" + .25" = 2.75", thread length = 3.25"

      ∴ must reduce allow. load by $(.5/1)(121^{\#}) = 60^{\#}$
    - Checking Shear: Shear/fastener = $550^{\#}/4 = 138^{\#} < (250^{\#} - 60^{\#})$ [see A4]
    - Checking Uplift: Uplift/fastener = $(550^{\#}/2000^{\#})(6/4) \cdot 800^{\#} = 330^{\#} < 335^{\#} = 395^{\#} - 60^{\#}$ [See A4]

∴ USE (4) 'SDS25800' SIMPSON WOOD SCREWS @ WOOD BLOCK

ROBERT SILMAN ASSOCIATES, PLLC

STRUCTURAL ENGINEERS

1053 31ST NW, WASHINGTON DC 20007

PROJECT Solar Decathalon JOB NO. —— PAGE A1

SUBJECT Green Roof Support BY Nathan DATE 3/11/2011

ALPINE SNOWGUARDS

A Division of Vermont Slate & Copper Services, Inc.

* From website of alpine snow guards, test results for 2 pipe system (#115)

Following numbers are based on test data from the pipe style snowguards test done by Vermont Testing on July 25, 1996.

The following numbers are for a 2-pipe system.

Bracket Spacing	Load per Foot	Load at which pipes start to fail
48"	320	1280
36"	773	2319
30"	1344	3360
24"	1480	2960

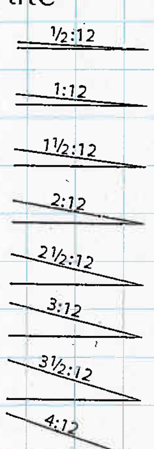
Fasteners holding the brackets to the decking must exceed the "Total Load on Bracket" for the system to be properly designed.

Force Against Roof Edge For 17 PSF (LiveRoof Lite)
Plus 30 PSF Snowload Expressed in pounds per lineal foot

(From LiveRoof Catalog)

Coefficient of friction (μ) assumed to equal zero

LiveRoof® Lite



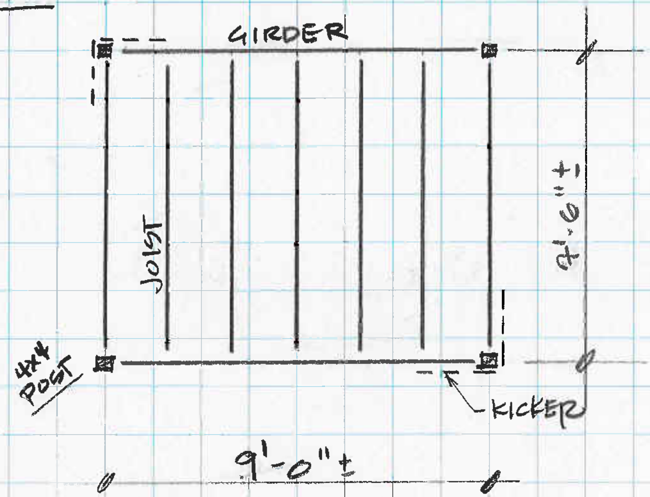
Roof Slope			Force Against Roof Edge, F (plf)				
			Horizontal Run Distance (ft)				
			10	20	30	40	50
1/2:12	4.20%	2.4°	19	39	58	80	99
1:12	8.30%	4.8°	39	80	118	156	195
1 1/2:12	12.50%	7.1°	58	115	176	233	291
2:12	16.70%	9.5°	77	156	233	313	390
2 1/2:12	21.00%	11.8°	99	195	294	390	490
3:12	25.00%	14.0°	115	235	349	467	583
3 1/2:12	29.20%	16.3°	137	272	409	547	684
4:12	33.30%	18.4°	156	310	467	621	778

ROBERT SILMAN ASSOCIATES, PLLC
STRUCTURAL ENGINEERS
1053 31ST NW, WASHINGTON DC 20007

PROJECT UMD SOLAR DECATHLON JOB NO. PAGE 1/

SUBJECT DECK BY KP DATE 11.16.2010

• PLAN



• LOAD FACTORS

$C_D = 1.0$

$C_M = 0.85$ (for F_b)

$F_b = 1250\text{psi}(.85) = 1063\text{ PSI}$ (SPF)

$1063\text{psi} \le 1150\text{PSI}$

$\therefore \boxed{C_M = 1.0}$

$F_b = 1500\text{psi}(.85) = 1275\text{psi}$ (SoP.)

$1275\text{psi} \ge 1150\text{psi}$

$\therefore \boxed{C_M = 0.85}$

• LOADS

DL

DECK 1 1/2" THICK	5 PSF
2x8 FRAMING @ 16" O.C.	1.5 PSF

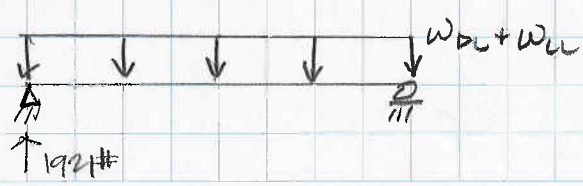
LL

PUBLIC ASSEMBLY	100 PSF

• FOR 2x8 JOIST @ 16" O.C.:

TW = 16"

• FOR 2x8 GIRDER:



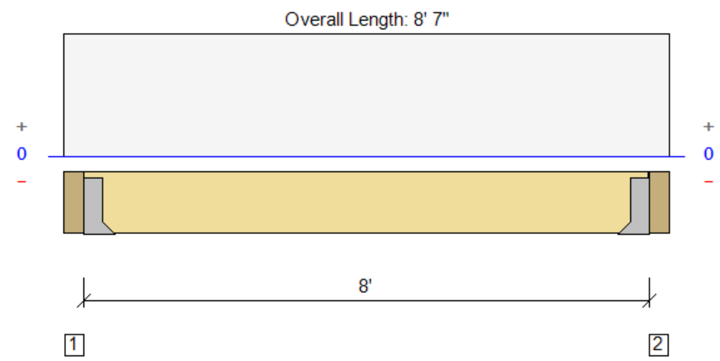
TW = 3'-9" ±

iLevel Forte software

MEMBER REPORT *Exterior Deck, Deck: Typ. Joist*

PASSED

1 piece(s) 2 x 8 Spruce-Pine-Fir No. 1 / No. 2 @ 16" OC



All Dimensions are Horizontal; Drawing is Conceptual

Design Results	Actual @ Location	Allowed	Result	LDF
Member Reaction (lbs)	568 @ 3 1/2"	3825	Passed (15%)	- -
Shear (lbs)	482 @ 10 3/4"	881	Passed (55%)	0.90
Moment (Ft-lbs)	1136 @ 4' 3 1/2"	1190	Passed (95%)	0.90
Live Load Defl. (in)	0.126 @ 4' 3 1/2"	0.267	Passed (L/762)	- -
Total Load Defl. (in)	0.134 @ 4' 3 1/2"	0.400	Passed (L/715)	- -
TJ Pro Rating	N/A	N/A	- -	- -

System : Floor
Member Type : Joist
Building Use : Residential
Building Code : IBC
Design Methodology : ASD

- Deflection criteria: LL (L/360) and TL (L/240).
- Design results assume a fully braced condition where sheathing is properly nailed to all compression edges at the top of the joist and that the compression edges at the bottom of the joist are properly braced to provide lateral stability.
- Bracing (Lu): All compression edges (top and bottom) must be braced at 3' 7 5/16" o/c unless detailed otherwise. Proper attachment and positioning of lateral bracing is required to achieve member stability.
- A 15% increase in the moment capacity has been added to account for repetitive member usage.
- Deflection analysis is based on composite action with a single layer of 23/32" iLevel® Edge Panel (24" Span Rating) that is glued and nailed down.
- Dimension lumber analysis is in accordance with 2005 NDS methodology.

Supports	Total Bearing	Available Bearing	Required Bearing	Support Reactions (lbs) Dead / Floor / Roof / Snow / Wind / Seismic	Accessories
1 - 7 1/4" Beam - Spruce Pine Fir	3.50"	Hanger	Hanger	37 / 572 / 0 / 0 / 0 / 0	None
2 - 7 1/4" Beam - Spruce Pine Fir	3.50"	Hanger	Hanger	37 / 572 / 0 / 0 / 0 / 0	None

Connector: Simpson Strong-Tie Connectors

Support	Model	Top Nails	Face Nails	Member Nails	Accessories
1 - Face Mount Hanger	LU28	N/A	8-10d common	6-10d x 1-1/2	
2 - Face Mount Hanger	LU28	N/A	8-10d common	6-10d x 1-1/2	

Loads	Location	Spacing	Dead (0.90)	Floor Live (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Wind (1.60)	Seismic (1.60)	Comments
1 - Uniform(PSF)	0 to 8' 7"	16"	6.5	100.0	0.0	0.0	0.0	0.0	Public Assembly Areas: Deck

iLEVEL® Notes

iLevel® warrants that the sizing of its products will be in accordance with iLevel® product design criteria and published design values. iLevel® expressly disclaims any other warranties related to the software. Refer to current iLevel® literature for installation details. (www.iLevel.com) Accessories (Rim Board, Blocking Panels and Squash Blocks) are not designed by this software. Use of this software is not intended to circumvent the need for a design professional as determined by the authority having jurisdiction. The designer of record, builder or framer is responsible to assure that this calculation is compatible with the overall project. iLevel® products manufactured at Weyerhaeuser facilities are third-party certified to sustainable forestry standards.
The product application, input design loads, dimensions and support information have been provided by Forte Software Operator

SUSTAINABLE FORESTRY INITIATIVE

Forte™ Software Operator	Job Notes
Kristin Potterton Robert Silman Associates (202) 333-6230 potterton@silman.com	TYP. DECK MODULE DESIGN

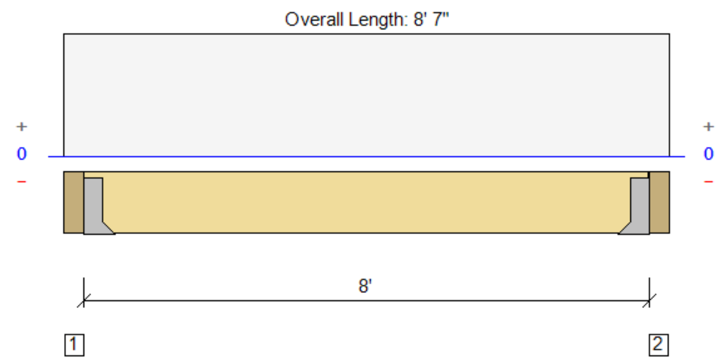
3/15/2011 8:33:59 AM
iLevel® Forte™ v2.0, Design Engine: V5.1.0.3
DECKAN~1.4TE

iLevel Forte software

MEMBER REPORT *Exterior Deck, Deck: Typ. Girder*

3 piece(s) 2 x 8 Douglas Fir-Larch No. 1

PASSED



All Dimensions are Horizontal; Drawing is Conceptual

Design Results	Actual @ Location	Allowed	Result	LDF
Member Reaction (lbs)	1737 @ 3 1/2"	16875	Passed (10%)	- -
Shear (lbs)	1475 @ 10 3/4"	3524	Passed (42%)	0.90
Moment (Ft-lbs)	3474 @ 4' 3 1/2"	3548	Passed (98%)	0.90
Live Load Defl. (in)	0.152 @ 4' 3 1/2"	0.267	Passed (L/633)	- -
Total Load Defl. (in)	0.165 @ 4' 3 1/2"	0.400	Passed (L/583)	- -

System : Floor
Member Type : Flush Beam
Building Use : Residential
Building Code : IBC
Design Methodology : ASD

- Deflection criteria: LL (L/360) and TL (L/240).
- Design results assume a fully braced condition where all compression edges (top and bottom) are properly braced to provide lateral stability.
- Bracing (Lu): All compression edges (top and bottom) must be braced at 5' 9 3/4" o/c unless detailed otherwise. Proper attachment and positioning of lateral bracing is required to achieve member stability.
- Dimension lumber analysis is in accordance with 2005 NDS methodology.

Supports	Total Bearing	Available Bearing	Required Bearing	Support Reactions (lbs) Dead / Floor / Roof / Snow / Wind / Seismic	Accessories
1 - 7 1/4" Beam - Spruce Pine Fir	3.50"	Hanger	Hanger	145 / 1717 / 0 / 0 / 0 / 0	None
2 - 7 1/4" Beam - Spruce Pine Fir	3.50"	Hanger	Hanger	145 / 1717 / 0 / 0 / 0 / 0	None

Connector: Simpson Strong-Tie Connectors					
Support	**Model**	**Top Nails**	**Face Nails**	**Member Nails**	**Accessories**
1 - Face Mount Hanger	Connector not found	N/A	N/A	N/A	
2 - Face Mount Hanger	Connector not found	N/A	N/A	N/A	

Loads	Location	Tributary Width	Dead (0.90)	Floor Live (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Wind (1.60)	Seismic (1.60)	Comments
1 - Uniform(PSF)	0 to 8' 7"	4'	6.5	100.0	0.0	0.0	0.0	0.0	Public Assembly Areas: Deck

iLEVEL® Notes

iLevel® warrants that the sizing of its products will be in accordance with iLevel® product design criteria and published design values. iLevel® expressly disclaims any other warranties related to the software. Refer to current iLevel® literature for installation details. (www.iLevel.com) Accessories (Rim Board, Blocking Panels and Squash Blocks) are not designed by this software. Use of this software is not intended to circumvent the need for a design professional as determined by the authority having jurisdiction. The designer of record, builder or framer is responsible to assure that this calculation is compatible with the overall project. iLevel® products manufactured at Weyerhaeuser facilities are third-party certified to sustainable forestry standards.
The product application, input design loads, dimensions and support information have been provided by Forte Software Operator

SUSTAINABLE FORESTRY INITIATIVE

Forte™ Software Operator	Job Notes
Kristin Potterton Robert Silman Associates (202) 333-6230 potterton@silman.com	TYP. DECK MODULE DESIGN

3/15/2011 8:35:38 AM
iLevel® Forte™ v2.0, Design Engine: V5.1.0.3
DECKAN~1.4TE

ROBERT SILMAN ASSOCIATES, PLLC
STRUCTURAL ENGINEERS
1053 31ST NW, WASHINGTON DC 20007

PROJECT Solar Decathlon 2011 JOB NO. — PAGE 1/

SUBJECT Evacuated Tube Wall BY KP DATE 03.11.2011

- LOADS

  - EVACUATED TUBES: ~168# / PANEL
  - SELF WT: (WALL) 12PSF (100FT²) = 1200# (600# RXN @ end)
    (BASE) 16.4PLF (x length)
  - WIND: SOLID SIGN / FREESTANDING WALL

    $F = q_h G C_f A_s$

    $q_h = 0.00256 (90MPH)^2 (1.0) = 20.7 PSF$
    $G = 0.85$
    $C_f = 1.45$
    $A_s = 10' \times 10' = 100SF$ (APPROX.)

    $F = 20.7psf (0.85)(1.45)(100SF)$
    $= 25.5psf (100SF)$
    $= 2550\#$

- WALL CONSTR. (SO. PINE #2) (3) 2x6 POSTS ✓ ok
  stud grade? wet use

  - LOAD TO POST (WORST CASE @ CTR)
    - END 1275# (127.5plf)
    - MID. 2550# (255plf)

  - $M_{max} = 1275\#FT$ (FIXED BASE)

    $M_{allow} = F_b' S_x = 1250PSI (1.6)(3 \cdot 7.563 in^3) = 45378\# \cdot in = \boxed{3782\#FT}$

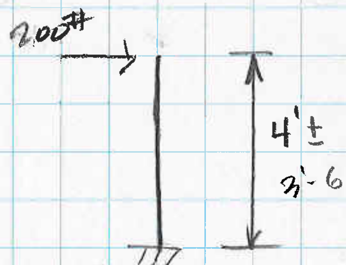
    $M_{allow} = \boxed{3782\#FT > 1275\#FT}$ ✓ ok!

PROJECT SD 2011 JOB NO. — PAGE 1

SUBJECT HANDRAIL BY KP DATE 03.05.2011

∘ LOADS

· $200^{\#}$ LOAD IN ANY DIRECTION @ T/RAIL



· RAIL IS (2) 2x4 "THERMO-TREATED WOOD"

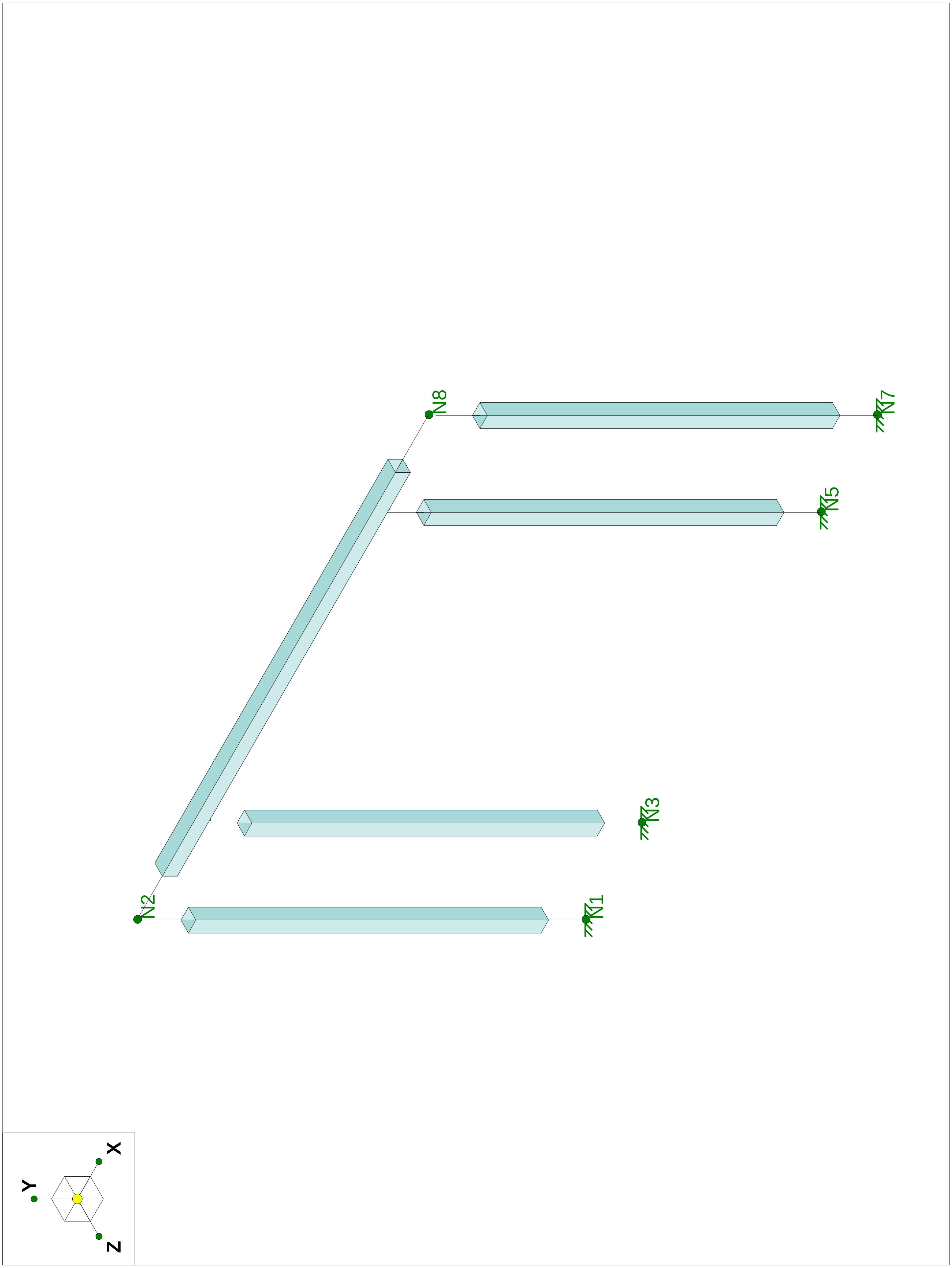
· $f_b' = 500psi \underset{C_F}{(1.3)} \underset{C_D}{(2.0)} = \underline{1300\,PSI}$

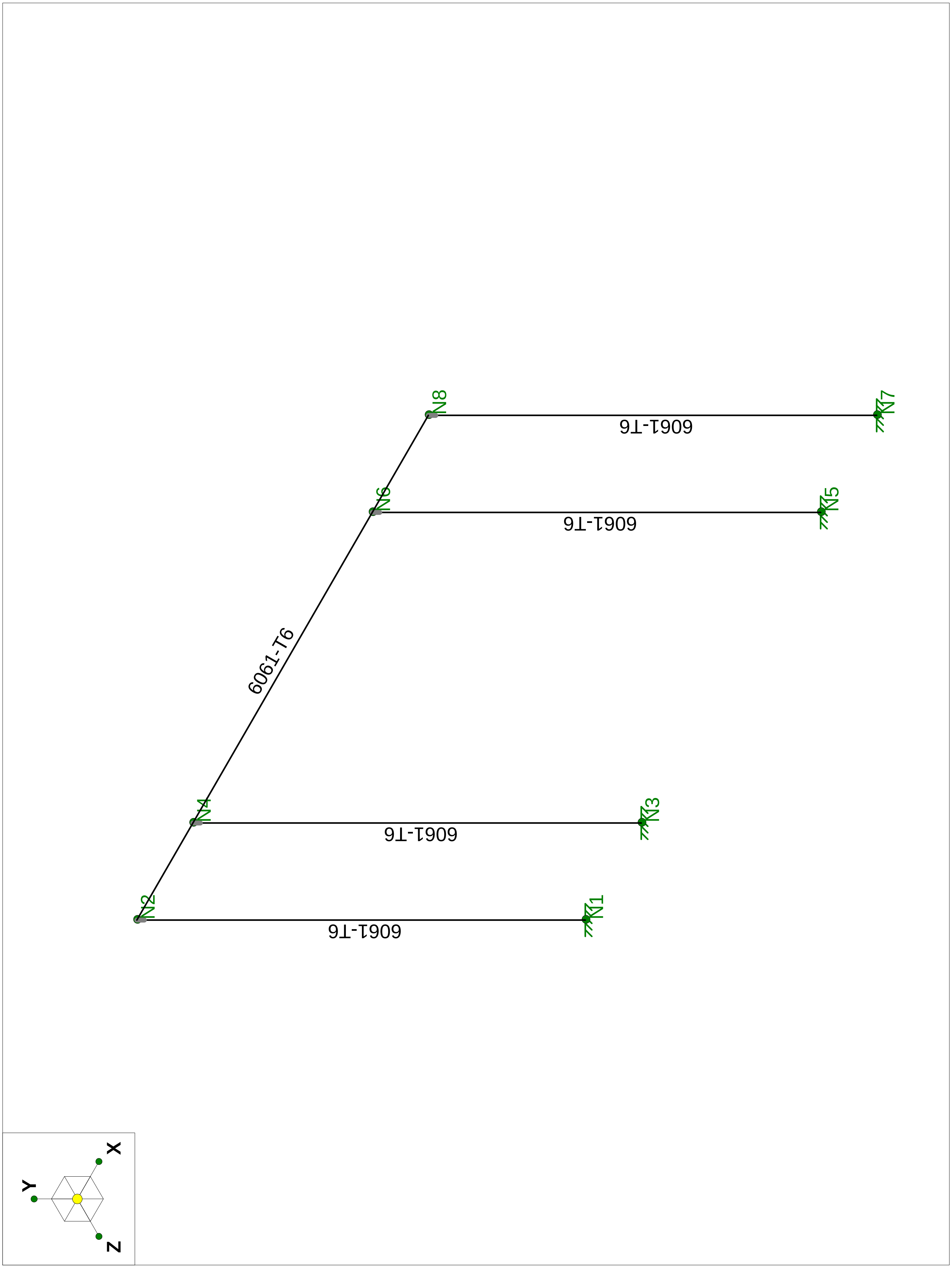
· $A = 2(8.25\,IN^2) = 16.5\,IN^2$

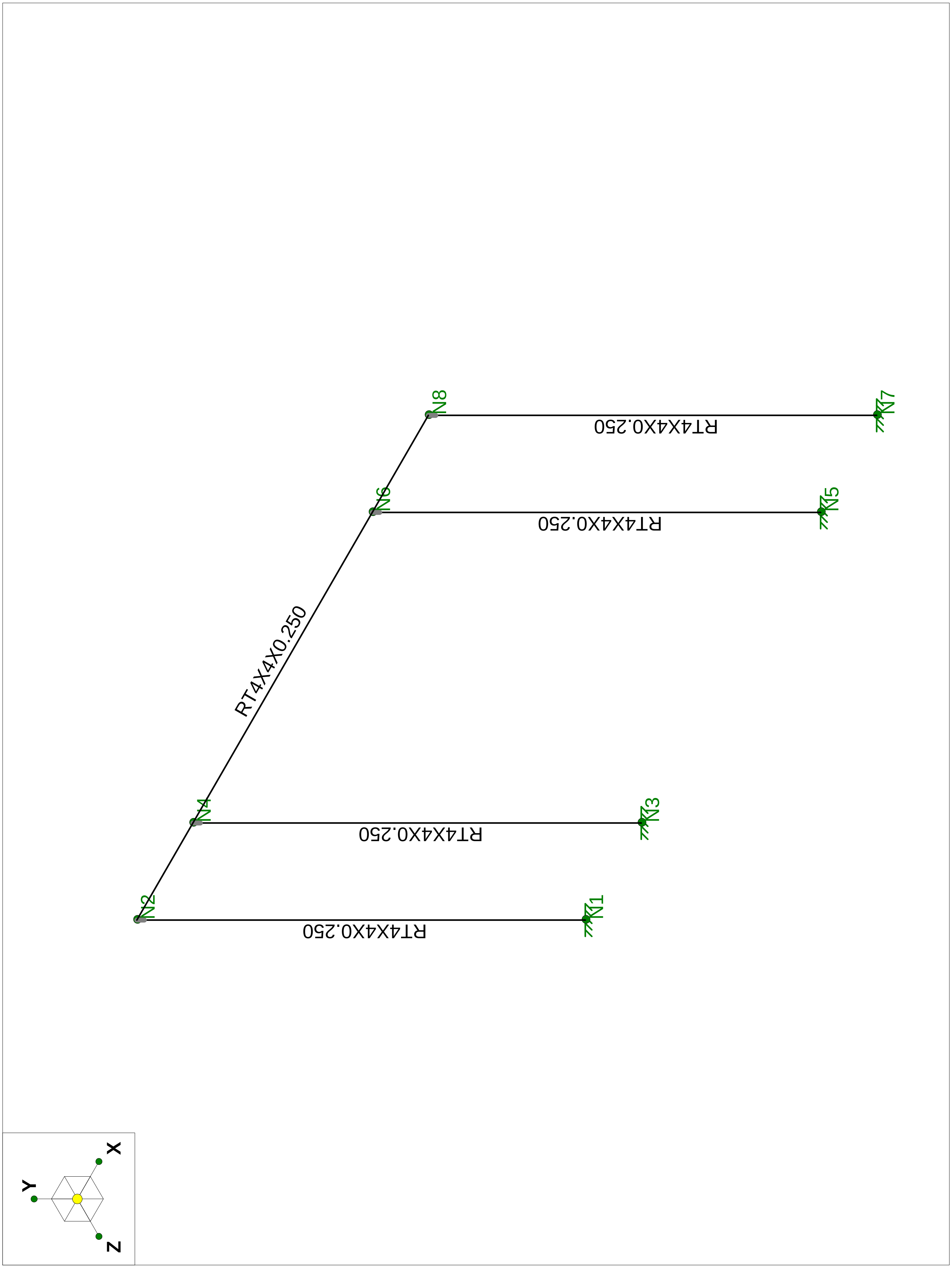
· $S_x = bd^2/6 = 2(7.563\,IN^3) = \underline{15.13\,IN^3}$

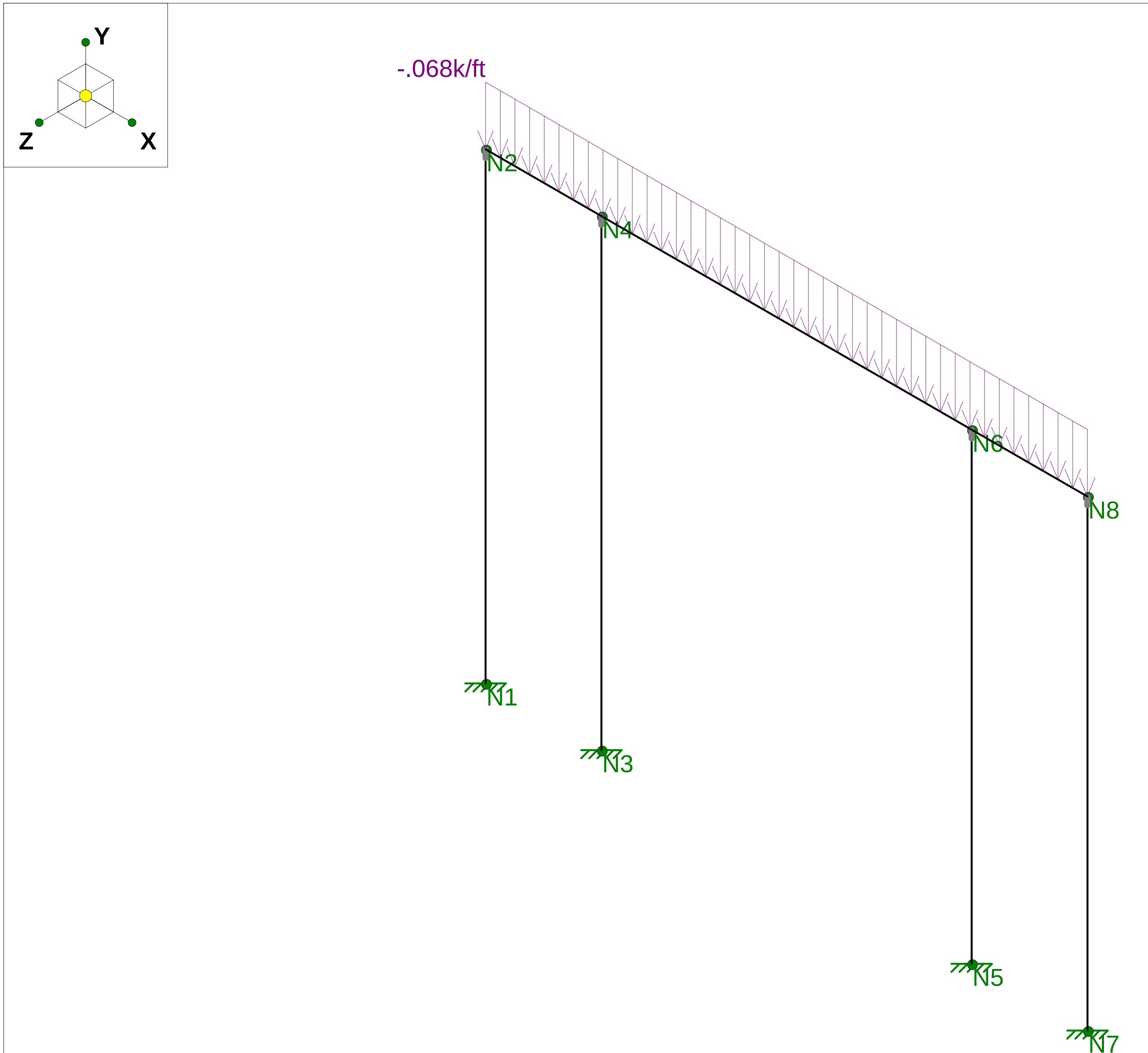
· $M_{max} = 200^{\#}(4') = \boxed{800\,\#FT}$ 700

· $M_{allow} = f_b' S_x = 750psi(15.13\,IN^3) = 11348\#IN = \boxed{946\#FT}$ ✓ OK

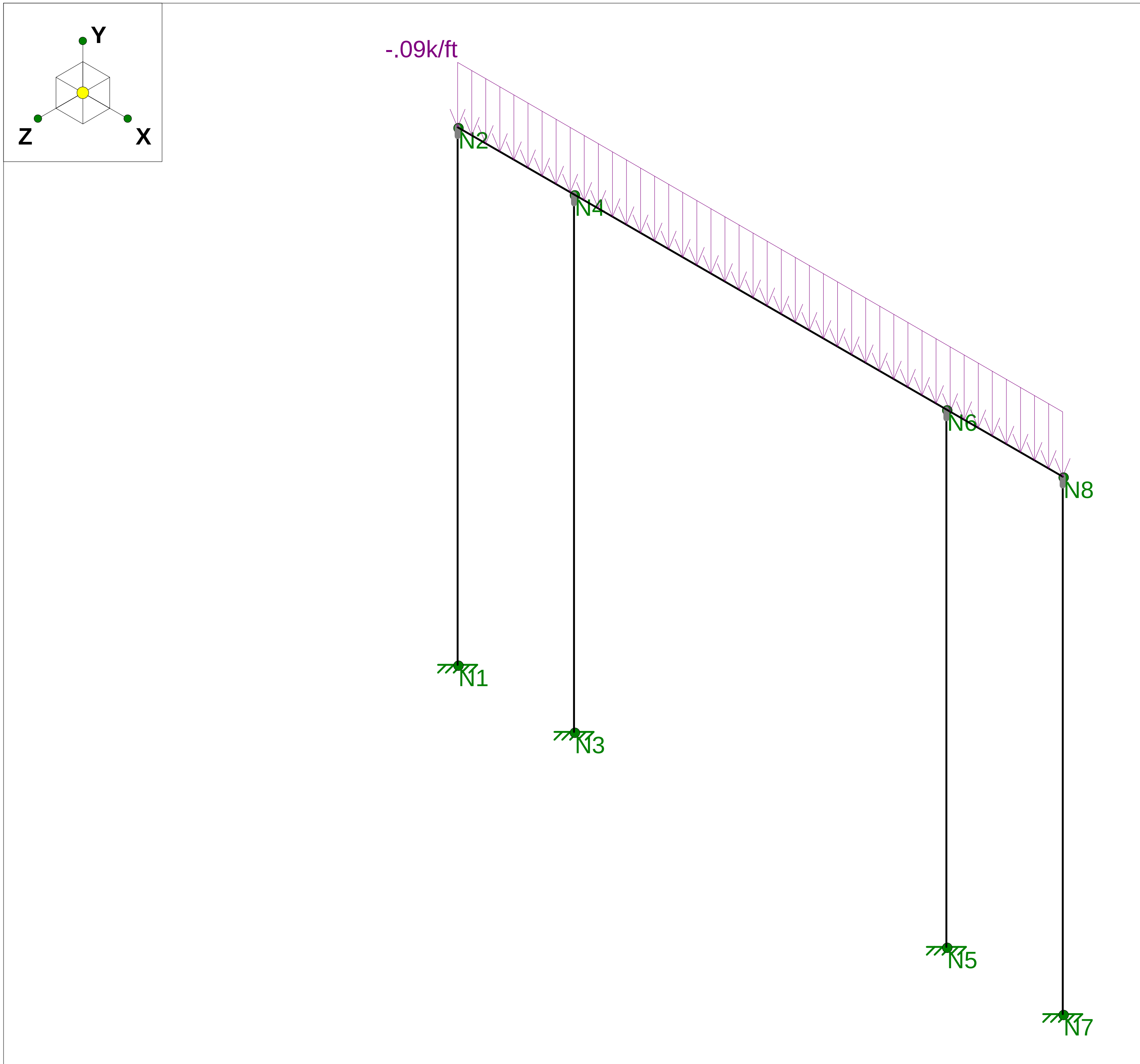

N8
N7
N5
N3
N2
N1
Y
X
Z


N1
N2
N3
N4
N5
N6
N7
N8
6061-T6
6061-T6
6061-T6
6061-T6
6061-T6
X
Y
Z

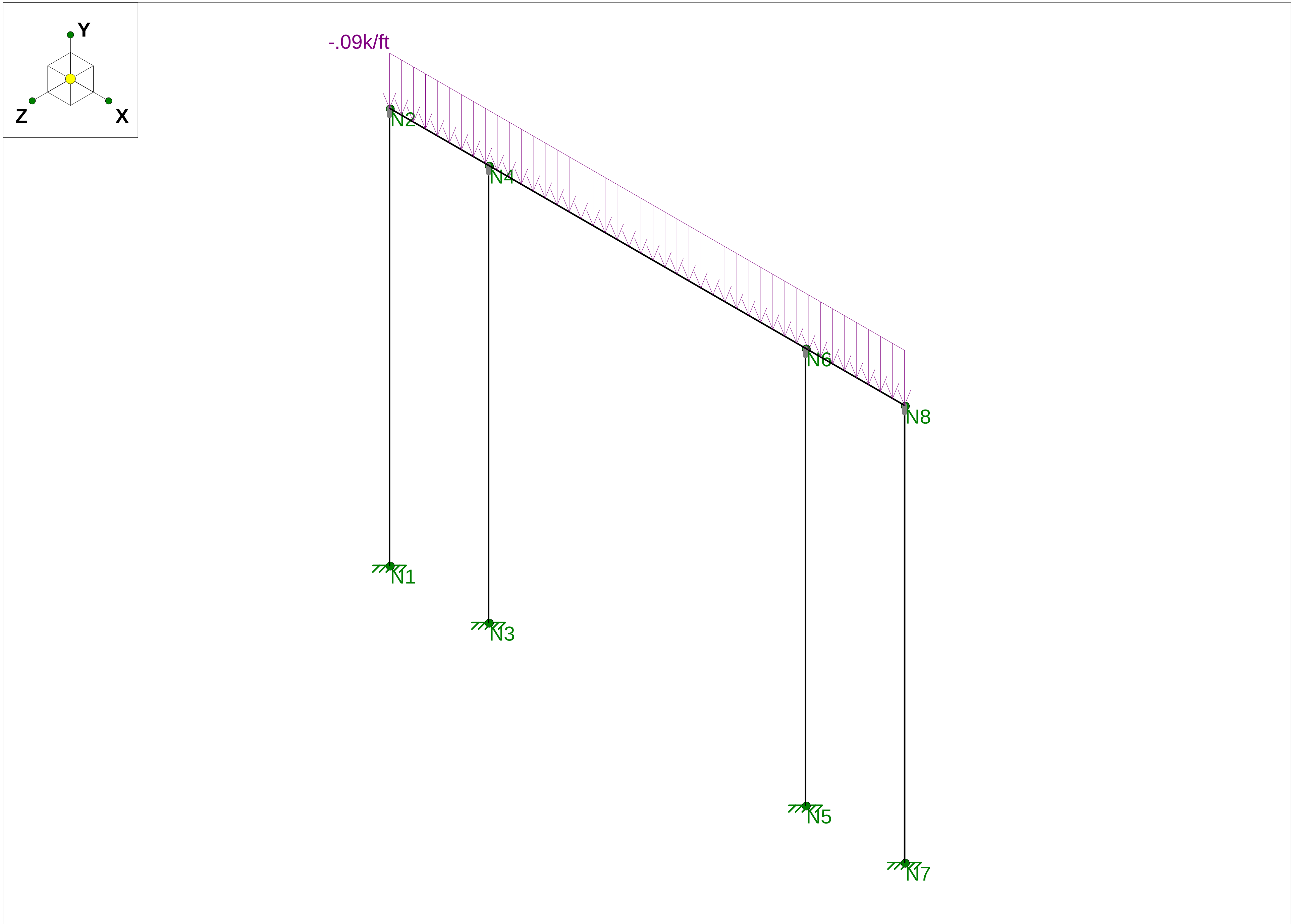

N8
N7
RT4X4X0.250
N6
N5
RT4X4X0.250
RT4X4X0.250
N4
N3
RT4X4X0.250
N2
N1
RT4X4X0.250
Y
X
Z



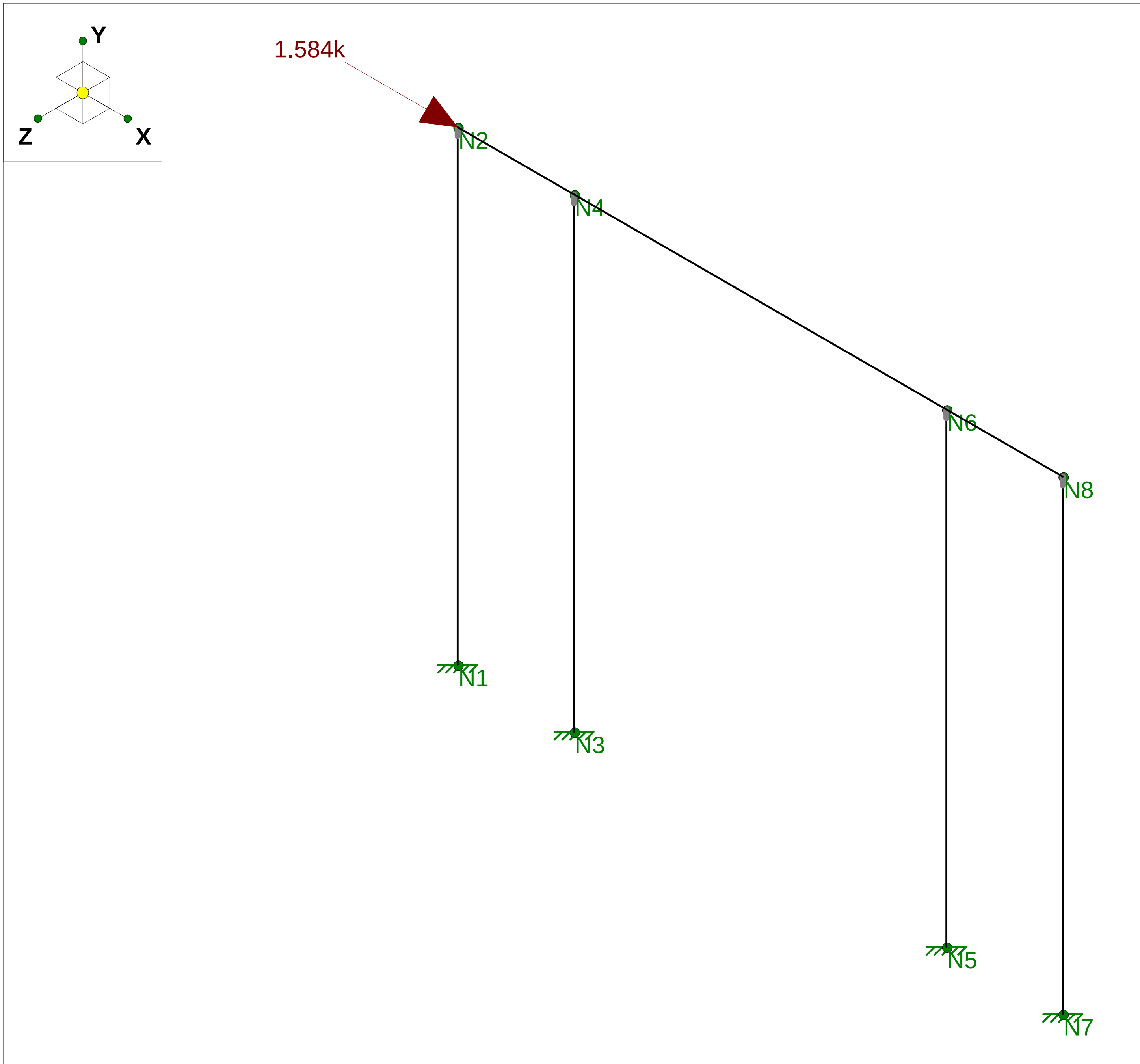
Loads: BLC 1, Roof Dead Load



Loads: BLC 2, Roof Live Load



Loads: BLC 3, Roof Snow Load



Loads: BLC 4, Wind Load

Global

Display Sections for Member Calcs	5
Max Internal Sections for Member Calcs	97
Include Shear Deformation	Yes
Include Warping	Yes
Area Load Mesh (in^2)	144
Merge Tolerance (in)	.12
P-Delta Analysis Tolerance	0.50%
Vertical Axis	Y

Hot Rolled Steel Code	AISC 360-05: ASD (Direct Analysis Method)
Cold Formed Steel Code	AISI NAS-01: ASD
Wood Code	AF&PA NDS-05: ASD
Wood Temperature	< 100F
Concrete Code	ACI 318-05
Masonry Code	ACI 530-05: ASD
Aluminum Code	AA ADM1-05: ASD

Number of Shear Regions	4
Region Spacing Increment (in)	4
Biaxial Column Method	Exact Integration
Parme Beta Factor (PCA)	.65
Concrete Stress Block	Rectangular
Use Cracked Sections	Yes
Bad Framing Warnings	No
Unused Force Warnings	Yes

Seismic Code	ASCE 7-05
Seismic Base Elevation (ft)	Not Entered
Ct X	.035
Ct Z	.035
T X (sec)	Not Entered
T Z (sec)	Not Entered
R X	8.5
R Z	8.5
Ct Exp. X	.75
Ct Exp. Z	.75
Ca	.36
Cv	.54
Nv	1
SD1	1
SDS	1
S1	1
TL (sec)	Not Entered
Occupancy Code	4
Seismic Zone	3
Occupancy Cat	I or II
Use Gravity Self Wt in Diaphragm Mass	Yes
Use Deck Self Wt in Diaphragm Mass	Yes
Use Lateral Self Wt in Diaphragm Mass	Yes
Seismic Detailing Code	None
Om X	1
Om Z	1
Rho X	1
Rho Z	1

Aluminum Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (...	Density[...	Table 3.3	kt	Ftu[ksi]	Fty[ksi]	Fcy[ksi]	Fsu[ksi]	Ct
1	3003-H14	10100	3787.5	.33	1.3	.173	Table 3....	1	19	16	13	12	141
2	6061-T6	10100	3787.5	.33	1.3	.173	Table 3....	1	38	35	35	24	141
3	6063-T5	10100	3787.5	.33	1.3	.173	Table 3....	1	22	16	16	13	141
4	6063-T6	10100	3787.5	.33	1.3	.173	Table 3....	1	30	25	25	19	141
5	5052-H34	10200	3787.5	.33	1.3	.173	Table 3....	1	34	26	24	20	141
6	6061-T6 W	10100	3787.5	.33	1.3	.173	Table 3....	1	24	15	15	15	141

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Z [k/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
1	N1	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
2	N3	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
3	N5	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
4	N7	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	

Aluminum Design Parameters

	Label	Shape	Length...	Lbyy[ft]	Lbzz[ft]	Lcomp to...	Lcomp b...	Kyy	Kzz	Cm-yy	Cm-zz	Cb	y sway	z sway	Function
1	M1	RT4X4X0...	10												Lateral
2	M2	RT4X4X0...	10												Lateral
3	M3	RT4X4X0...	10												Lateral
4	M4	RT4X4X0...	10												Lateral
5	M5	RT4X4X0...	13												Lateral

Member Distributed Loads (BLC 1 : Roof Dead Load)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.068	-.068	0	0

Member Distributed Loads (BLC 2 : Roof Live Load)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.09	-.09	0	0

Member Distributed Loads (BLC 3 : Roof Snow Load)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.09	-.09	0	0

Joint Loads and Enforced Displacements (BLC 4 : Wind Load)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N2	L	X	1.584

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distributed	Area (Me...	Surface (...
1	Roof Dead Load	DL		-1				1		
2	Roof Live Load	LL						1		
3	Roof Snow Load	SL						1		
4	Wind Load	WL				1				

Load Combinations

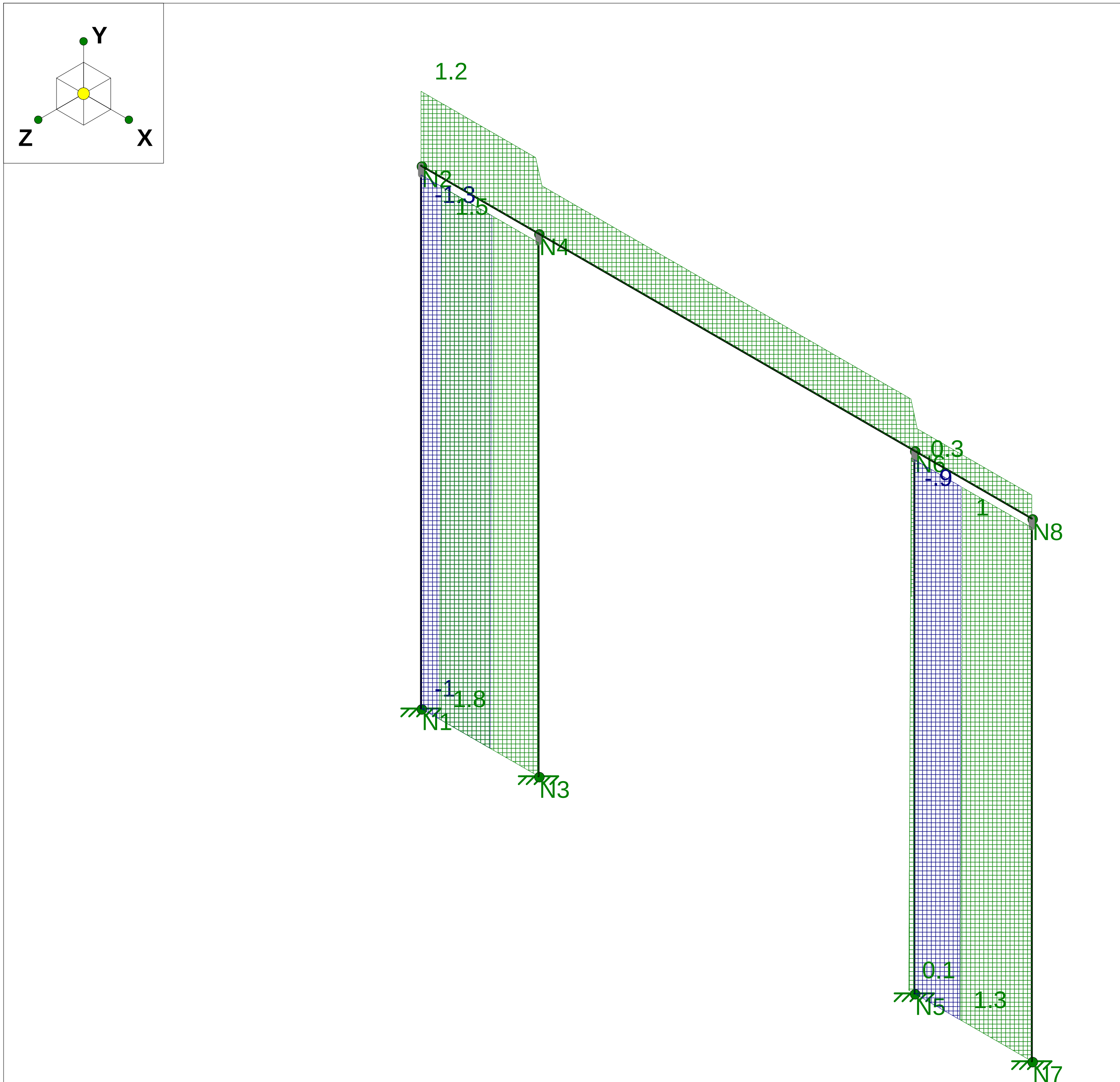
	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	D+W	Yes			1	1	4	1												
2	D+0.75W+0....	Yes			1	1	4	.75	2	.75										
3	D+0.75W+0....	Yes			1	1	4	.75	3	.75										
4	0.6D+W	Yes			1	.6	4	1												

Envelope Joint Reactions

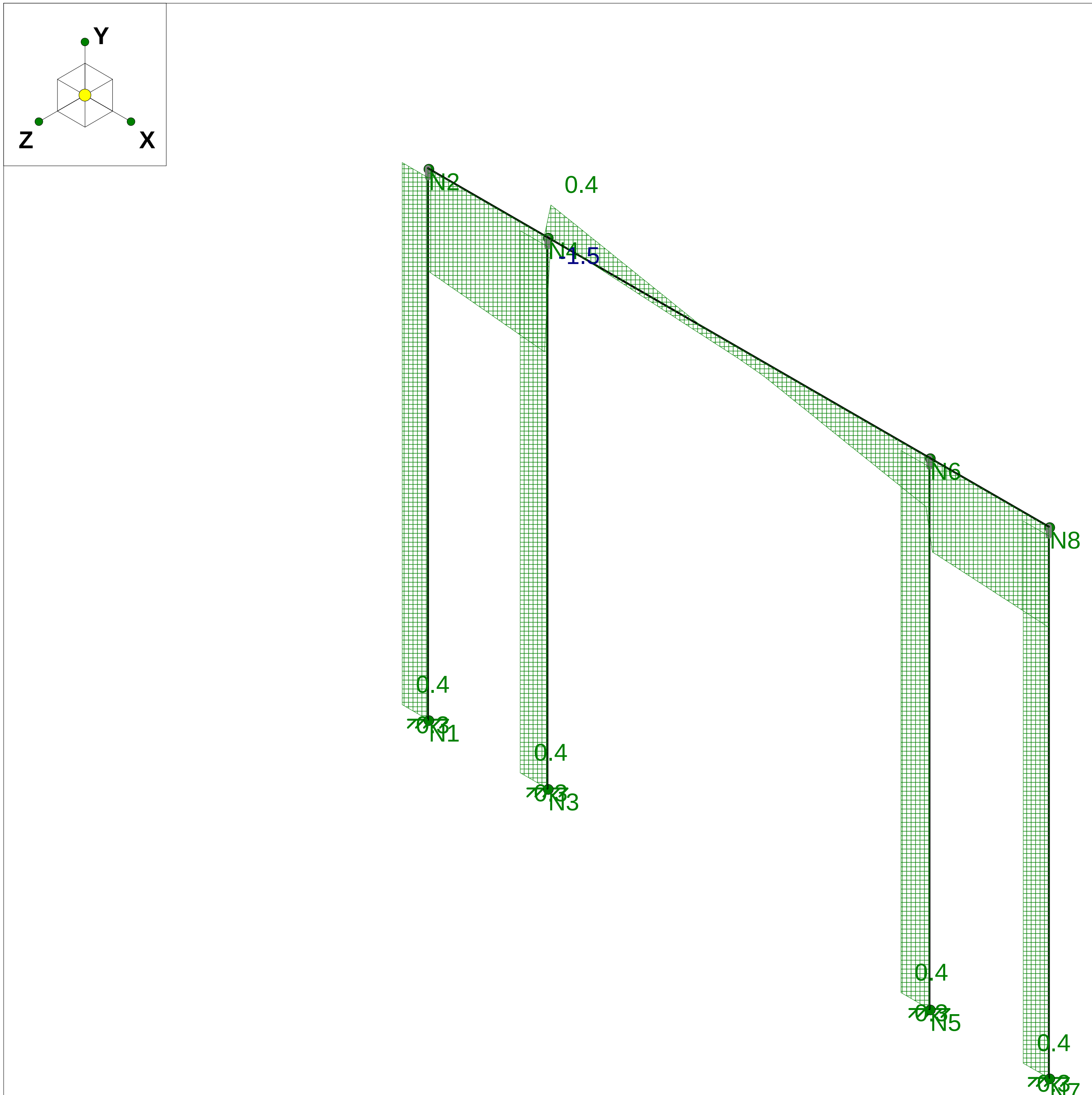
	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
1	N1	max	-.288	2	-.959	2	0	1	0	1	0	1	2.003	1
2		min	-.383	1	-1.288	4	0	1	0	1	0	1	1.505	2
3	N3	max	-.284	2	1.848	2	0	1	0	1	0	1	2.071	4
4		min	-.404	4	1.48	4	0	1	0	1	0	1	1.491	2
5	N5	max	-.332	2	.104	2	0	1	0	1	0	1	2.132	1
6		min	-.423	1	-.845	4	0	1	0	1	0	1	1.649	2
7	N7	max	-.284	2	1.335	1	0	1	0	1	0	1	1.99	4
8		min	-.38	4	.998	2	0	1	0	1	0	1	1.489	2
9	Totals:	max	-1.188	2	1.99	2	0	1						
10		min	-1.584	1	.668	4	0	1						

Envelope ADM 05 ASD Aluminum Code Checks

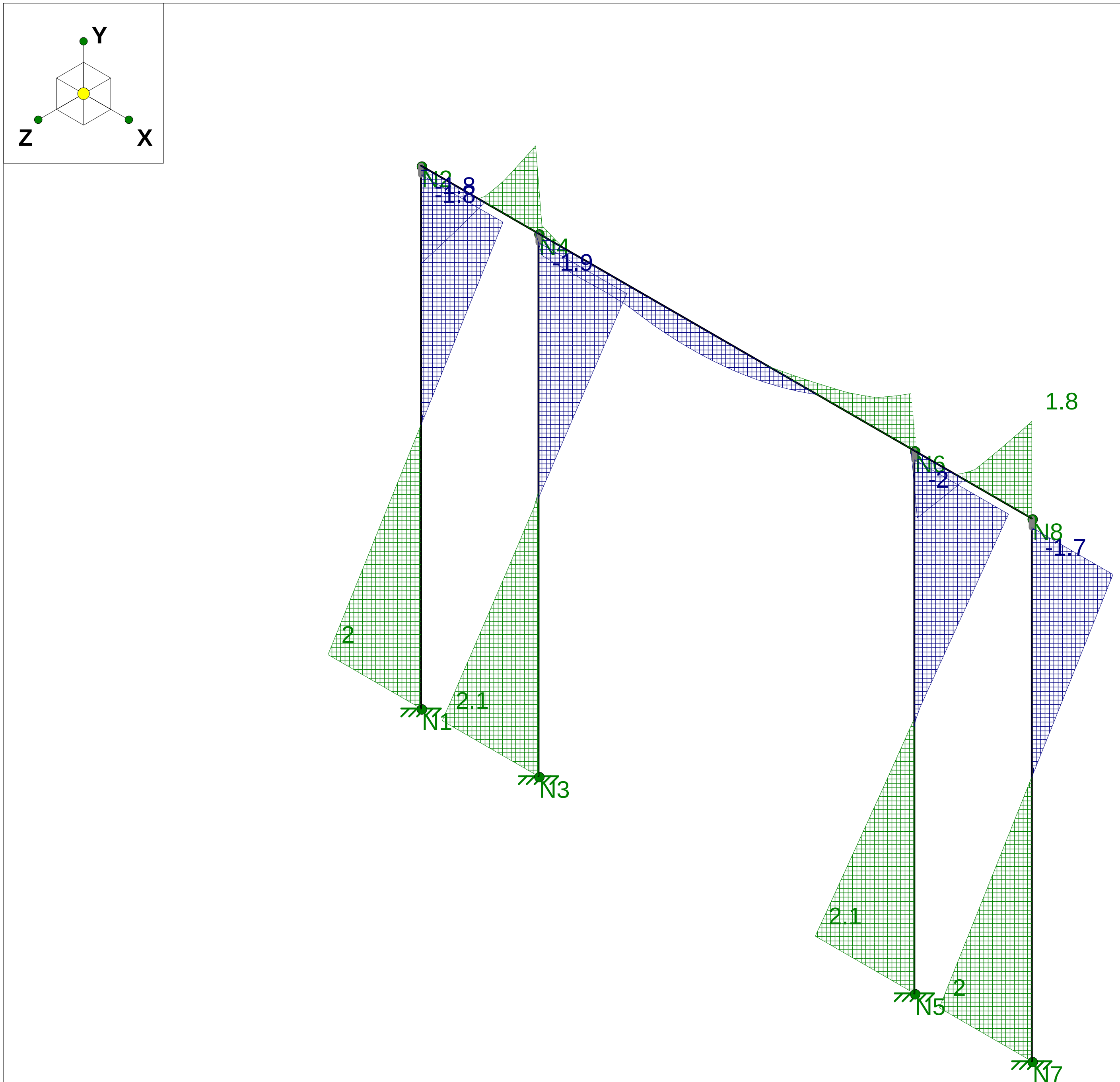
	Member	Shape	Code ...	Loc[ft]	LC	Shear ...	Loc[ft]	Dir	LC	Ft [ksi]	Fc [ksi]	Fb y-y ...	Fb z-z ...	Fs y-y ...	Fs z-z ...	Cb	Cmy	Cmz	Eqn
1	M1	RT4X4X...	.297	0	4	.016	0	y	1	19.487	8.645	21.212	21.212	12.247	12.247	2....	.6	.248	4.1.2-1
2	M2	RT4X4X...	.315	0	1	.016	0	y	4	19.487	8.645	21.212	21.212	12.247	12.247	2....	.6	.237	4.1.1-3
3	M3	RT4X4X...	.307	0	4	.017	0	y	1	19.487	8.645	21.212	21.212	12.247	12.247	2....	.6	.223	4.1.2-1
4	M4	RT4X4X...	.296	0	1	.016	0	y	4	19.487	8.645	21.212	21.212	12.247	12.247	2....	.6	.249	4.1.1-3
5	M5	RT4X4X...	.299	0	1	.061	2.438	y	1	19.487	4.946	21.212	21.212	12.247	12.247	2....	.6	.204	4.1.1-3



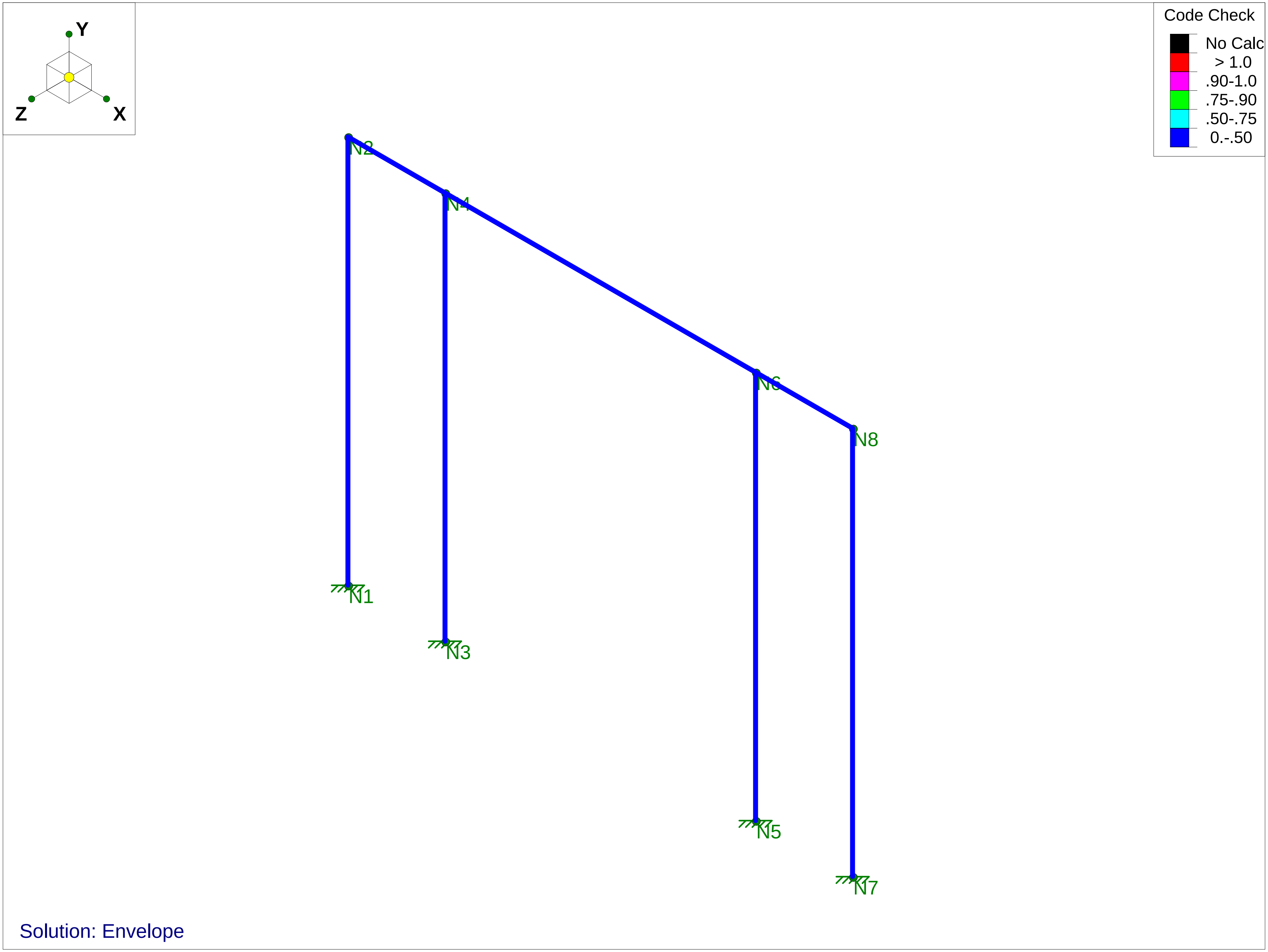
Solution: Envelope
Member Axial Forces (k)

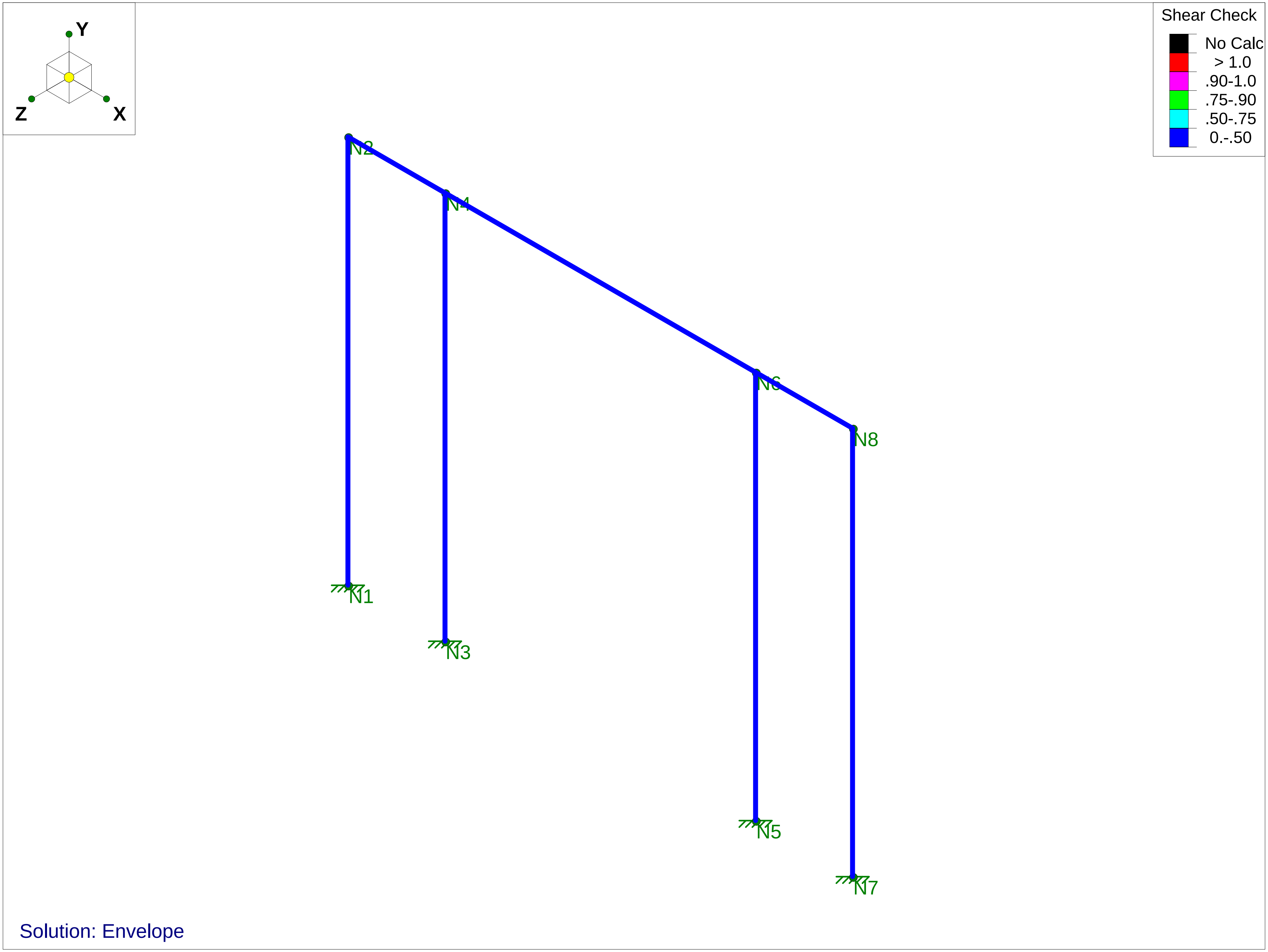


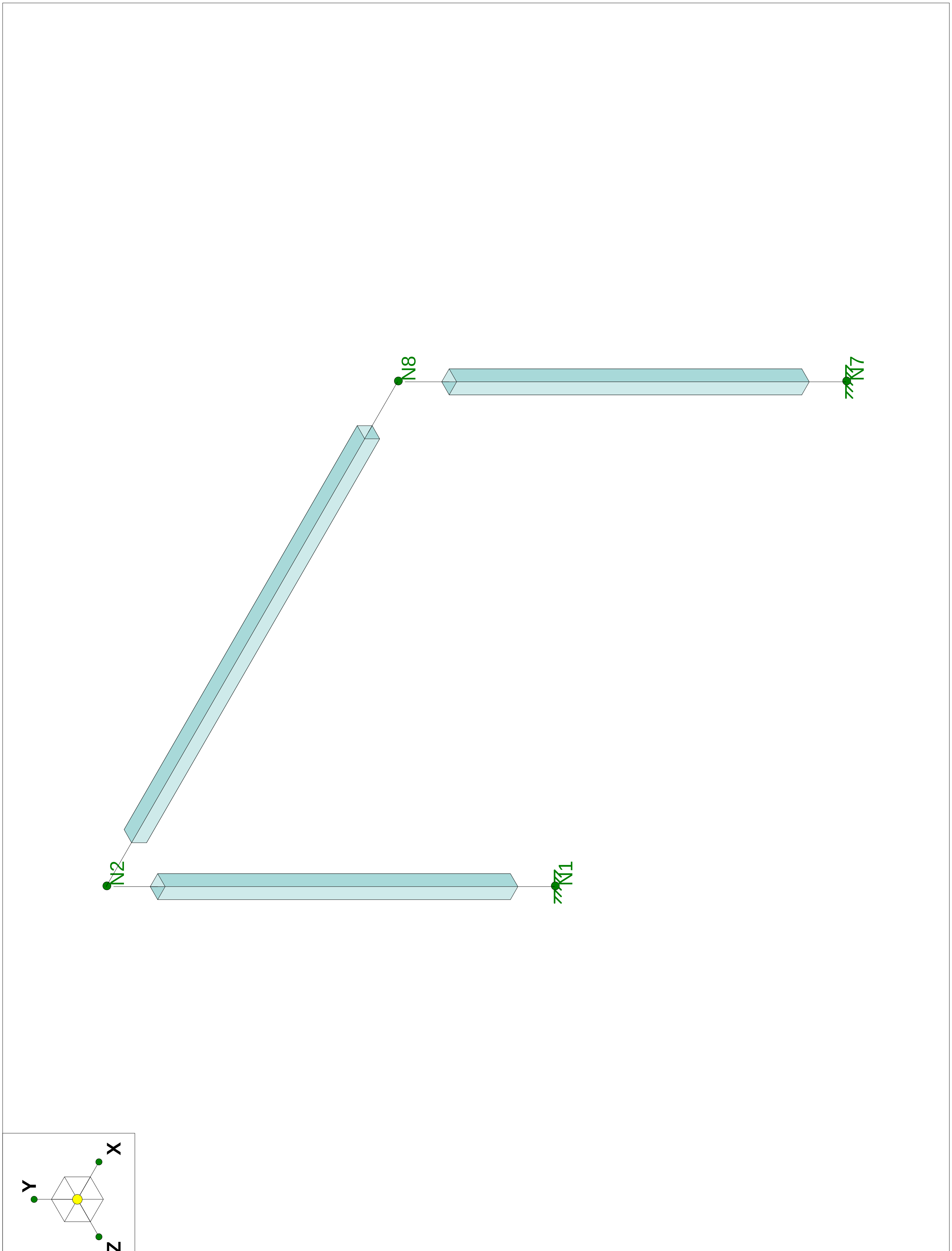
Solution: Envelope
Member y Shear Forces (k)

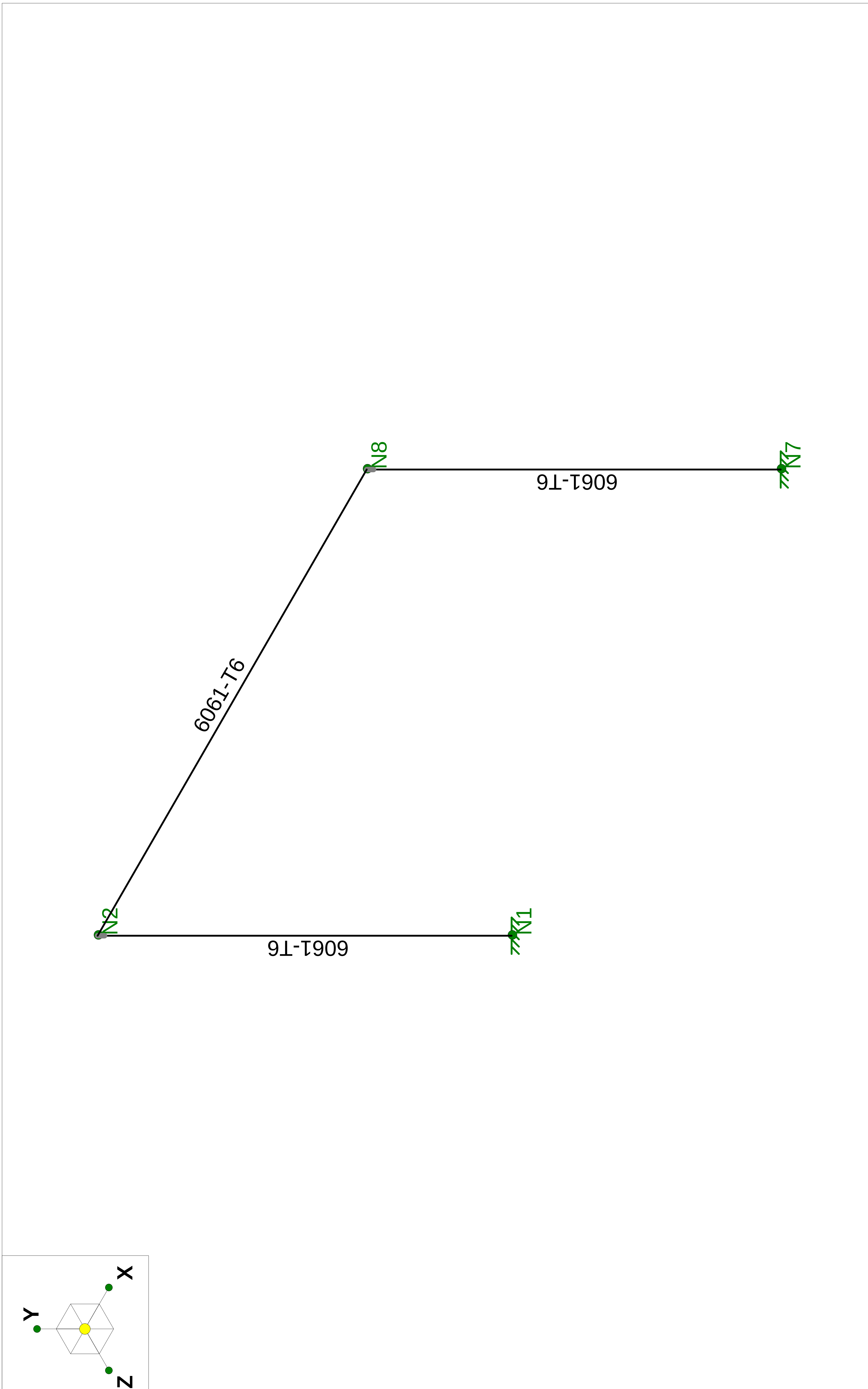


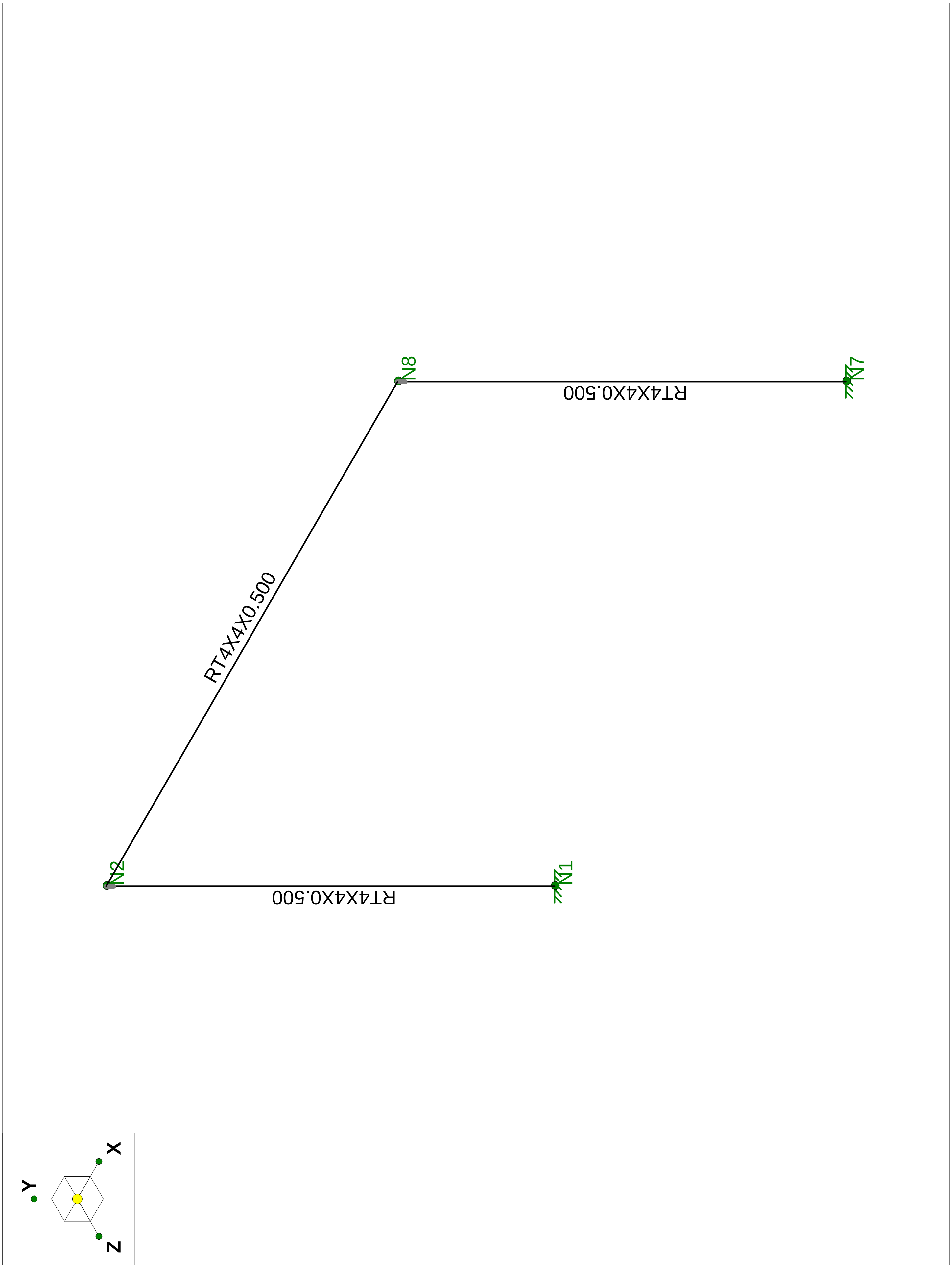
Solution: Envelope
Member z Bending Moments (k-ft)

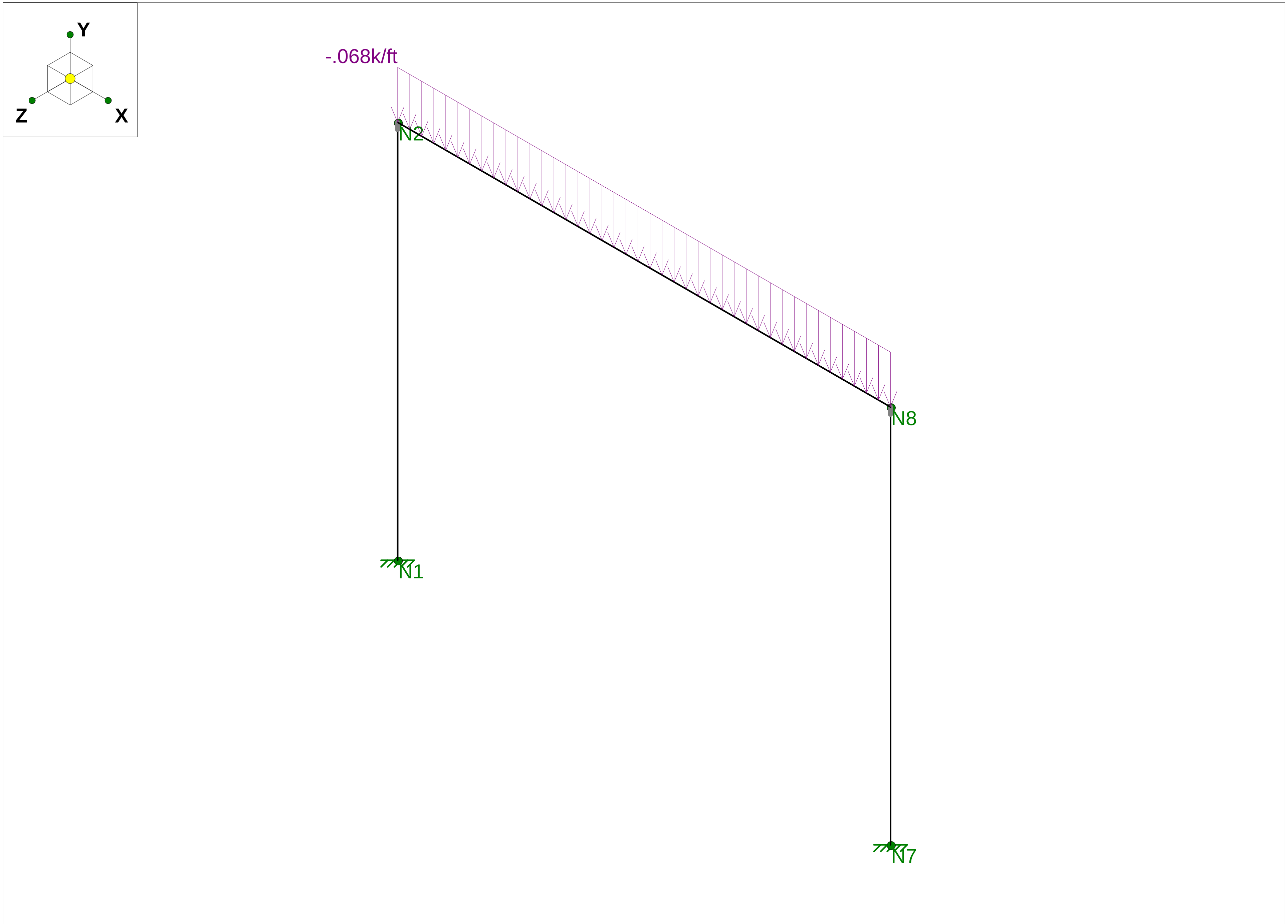

Y
Z
X
Code Check
No Calc
> 1.0
.90-1.0
.75-.90
.50-.75
0.-.50
N2
N4
N6
N8
N1
N3
N5
N7
Solution: Envelope


Y
Z
X
Shear Check
No Calc
> 1.0
.90-1.0
.75-.90
.50-.75
0.-.50
N2
N4
N6
N8
N1
N3
N5
N7
Solution: Envelope

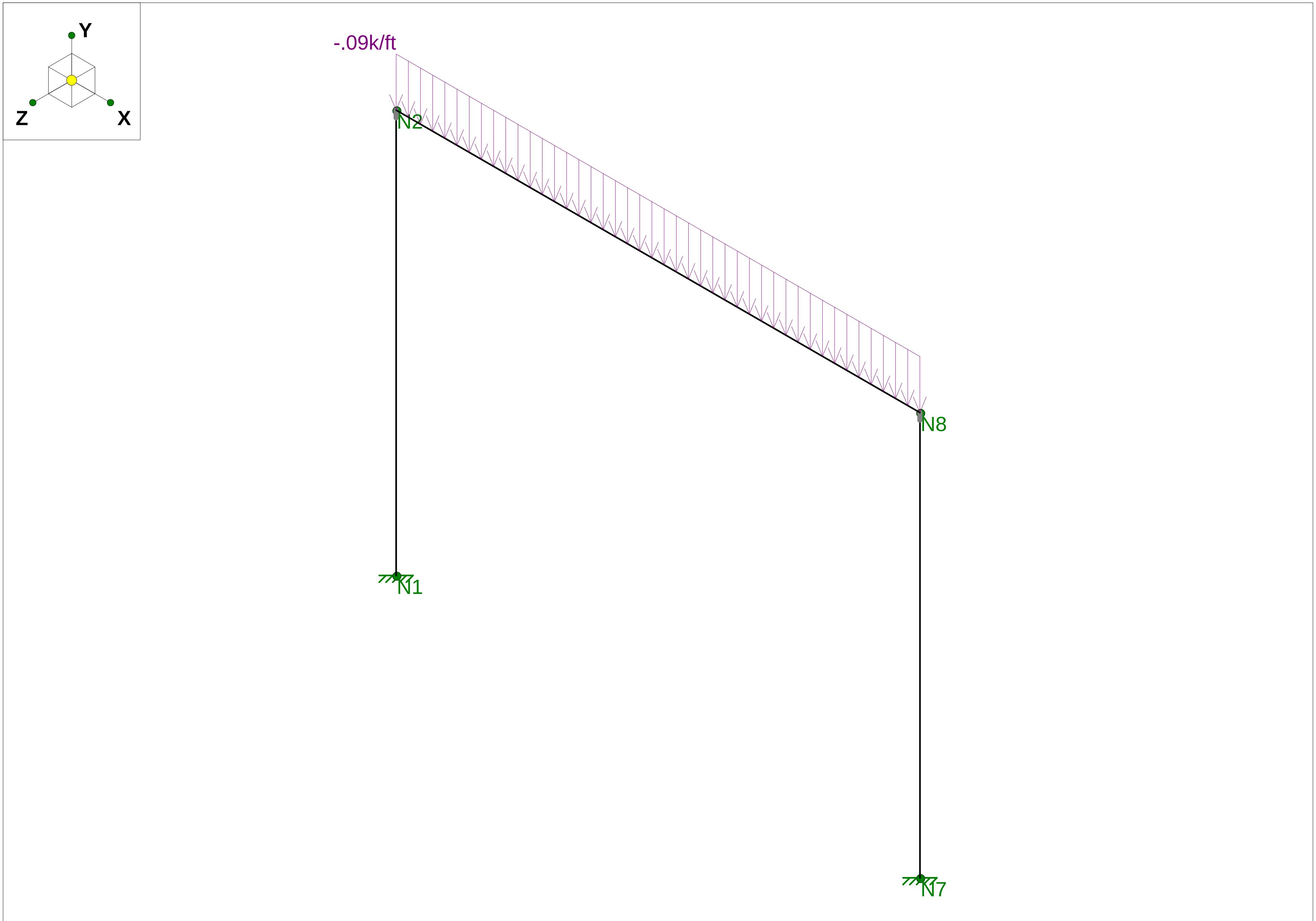

N8
N7
N2
N1
X
Y
Z


N8
N7
6061-T6
6061-T6
N2
N1
6061-T6
Y
X
Z

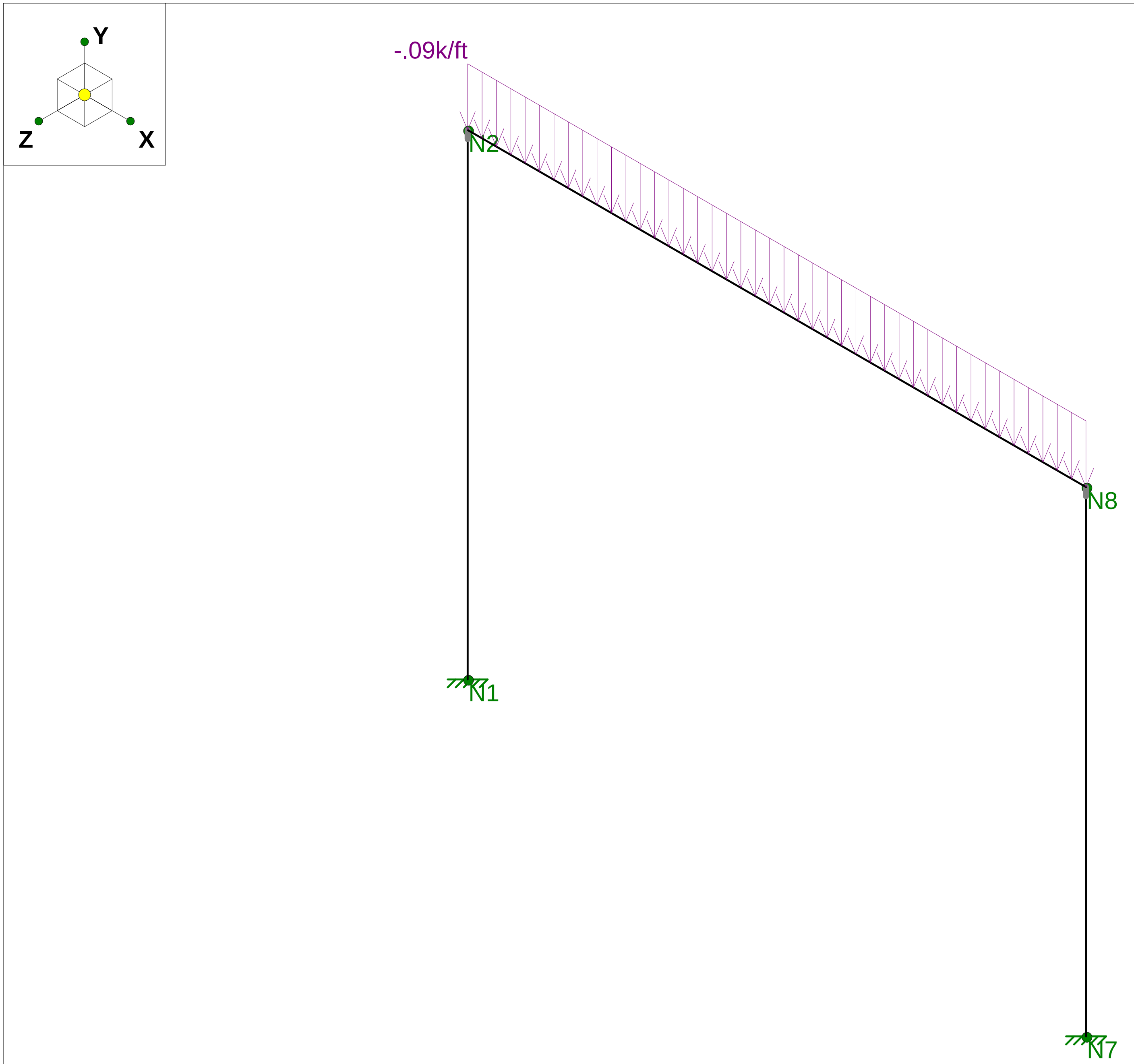

N8
N7
RT4X4X0.500
RT4X4X0.500
N2
N1
RT4X4X0.500
Y
X
Z



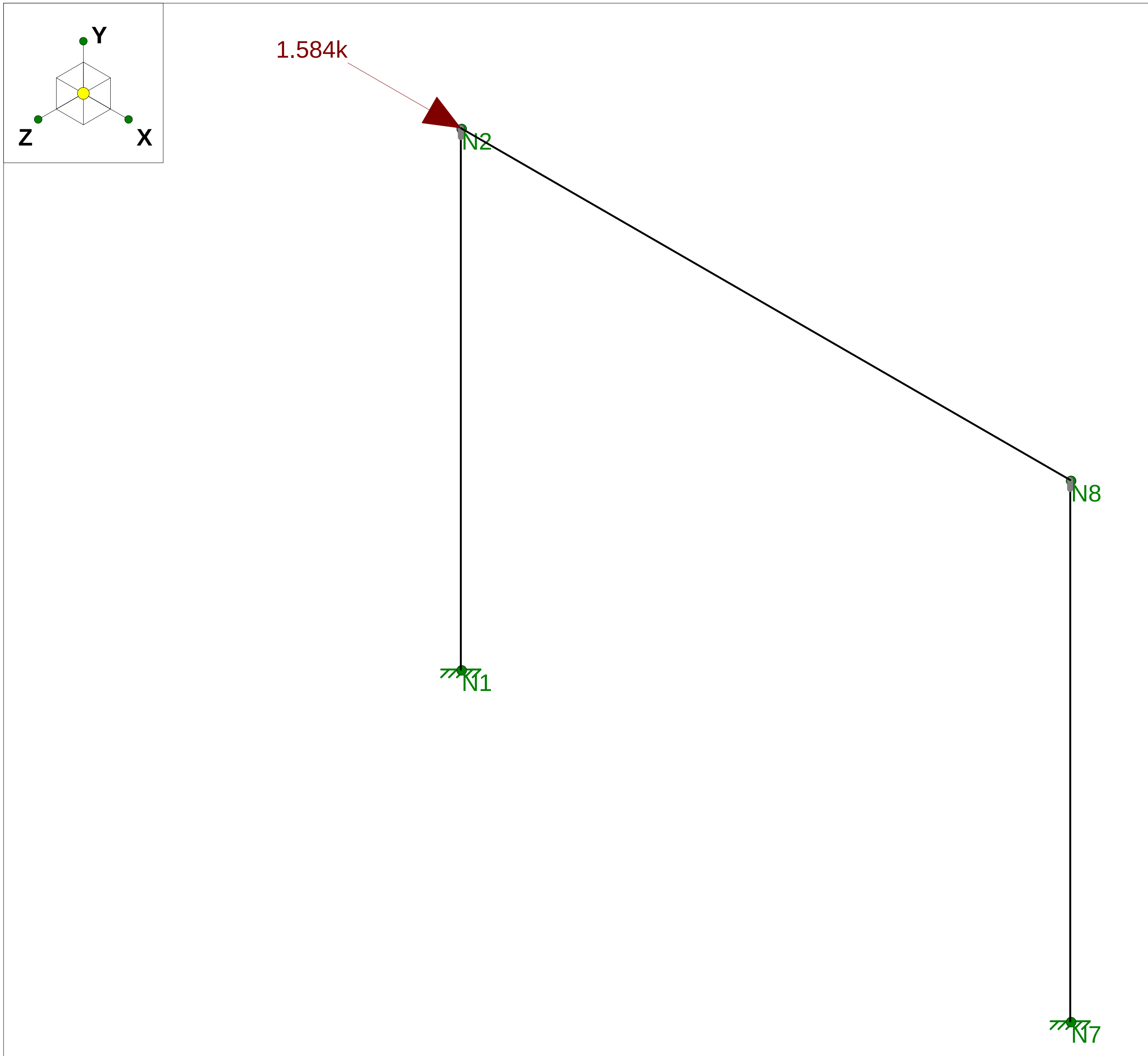
Loads: BLC 1, Roof Dead Load



Loads: BLC 2, Roof Live Load



Loads: BLC 3, Roof Snow Load



Loads: BLC 4, Wind Load

Global

Display Sections for Member Calcs	5
Max Internal Sections for Member Calcs	97
Include Shear Deformation	Yes
Include Warping	Yes
Area Load Mesh (in^2)	144
Merge Tolerance (in)	.12
P-Delta Analysis Tolerance	0.50%
Vertical Axis	Y

Hot Rolled Steel Code	AISC 360-05: ASD (Direct Analysis Method)
Cold Formed Steel Code	AISI NAS-01: ASD
Wood Code	AF&PA NDS-05: ASD
Wood Temperature	< 100F
Concrete Code	ACI 318-05
Masonry Code	ACI 530-05: ASD
Aluminum Code	AA ADM1-05: ASD

Number of Shear Regions	4
Region Spacing Increment (in)	4
Biaxial Column Method	Exact Integration
Parme Beta Factor (PCA)	.65
Concrete Stress Block	Rectangular
Use Cracked Sections	Yes
Bad Framing Warnings	No
Unused Force Warnings	Yes

Seismic Code	ASCE 7-05
Seismic Base Elevation (ft)	Not Entered
Ct X	.035
Ct Z	.035
T X (sec)	Not Entered
T Z (sec)	Not Entered
R X	8.5
R Z	8.5
Ct Exp. X	.75
Ct Exp. Z	.75
Ca	.36
Cv	.54
Nv	1
SD1	1
SDS	1
S1	1
TL (sec)	Not Entered
Occupancy Code	4
Seismic Zone	3
Occupancy Cat	I or II
Use Gravity Self Wt in Diaphragm Mass	Yes
Use Deck Self Wt in Diaphragm Mass	Yes
Use Lateral Self Wt in Diaphragm Mass	Yes
Seismic Detailing Code	None
Om X	1
Om Z	1
Rho X	1
Rho Z	1

Aluminum Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (...	Density[...	Table 3.3	kt	Ftu[ksi]	Fty[ksi]	Fcy[ksi]	Fsu[ksi]	Ct
1	3003-H14	10100	3787.5	.33	1.3	.173	Table 3....	1	19	16	13	12	141
2	6061-T6	10100	3787.5	.33	1.3	.173	Table 3....	1	38	35	35	24	141
3	6063-T5	10100	3787.5	.33	1.3	.173	Table 3....	1	22	16	16	13	141
4	6063-T6	10100	3787.5	.33	1.3	.173	Table 3....	1	30	25	25	19	141
5	5052-H34	10200	3787.5	.33	1.3	.173	Table 3....	1	34	26	24	20	141
6	6061-T6 W	10100	3787.5	.33	1.3	.173	Table 3....	1	24	15	15	15	141

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Z [k/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
1	N1	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
2	N7	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	

Aluminum Design Parameters

	Label	Shape	Length...	Lbyy[ft]	Lbzz[ft]	Lcomp to...	Lcomp b...	Kyy	Kzz	Cm-yy	Cm-zz	Cb	y sway	z sway	Function
1	M1	RT4X4X0...	10												Lateral
2	M4	RT4X4X0...	10												Lateral
3	M5	RT4X4X0...	13												Lateral

Member Distributed Loads (BLC 1 : Roof Dead Load)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.068	-.068	0	0

Member Distributed Loads (BLC 2 : Roof Live Load)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.09	-.09	0	0

Member Distributed Loads (BLC 3 : Roof Snow Load)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.09	-.09	0	0

Joint Loads and Enforced Displacements (BLC 4 : Wind Load)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N2	L	X	1.584

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distributed	Area (Me...	Surface (...
1	Roof Dead Load	DL		-1				1		
2	Roof Live Load	LL						1		
3	Roof Snow Load	SL						1		
4	Wind Load	WL				1				

Load Combinations

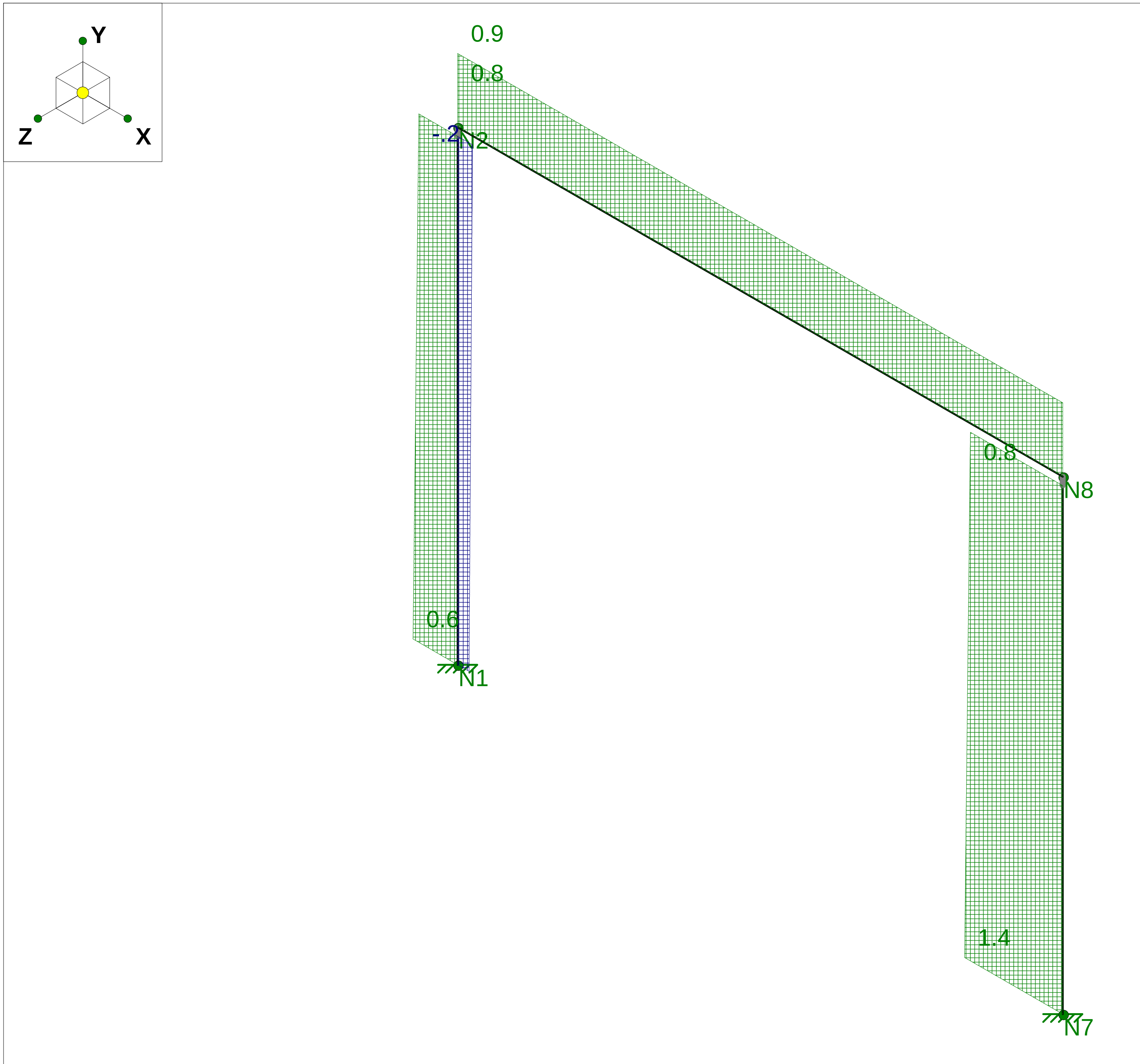
	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	D+W	Yes			1	1	4	1												
2	D+0.75W+0....	Yes			1	1	4	.75	2	.75										
3	D+0.75W+0....	Yes			1	1	4	.75	3	.75										
4	0.6D+W	Yes			1	.6	4	1												

Envelope Joint Reactions

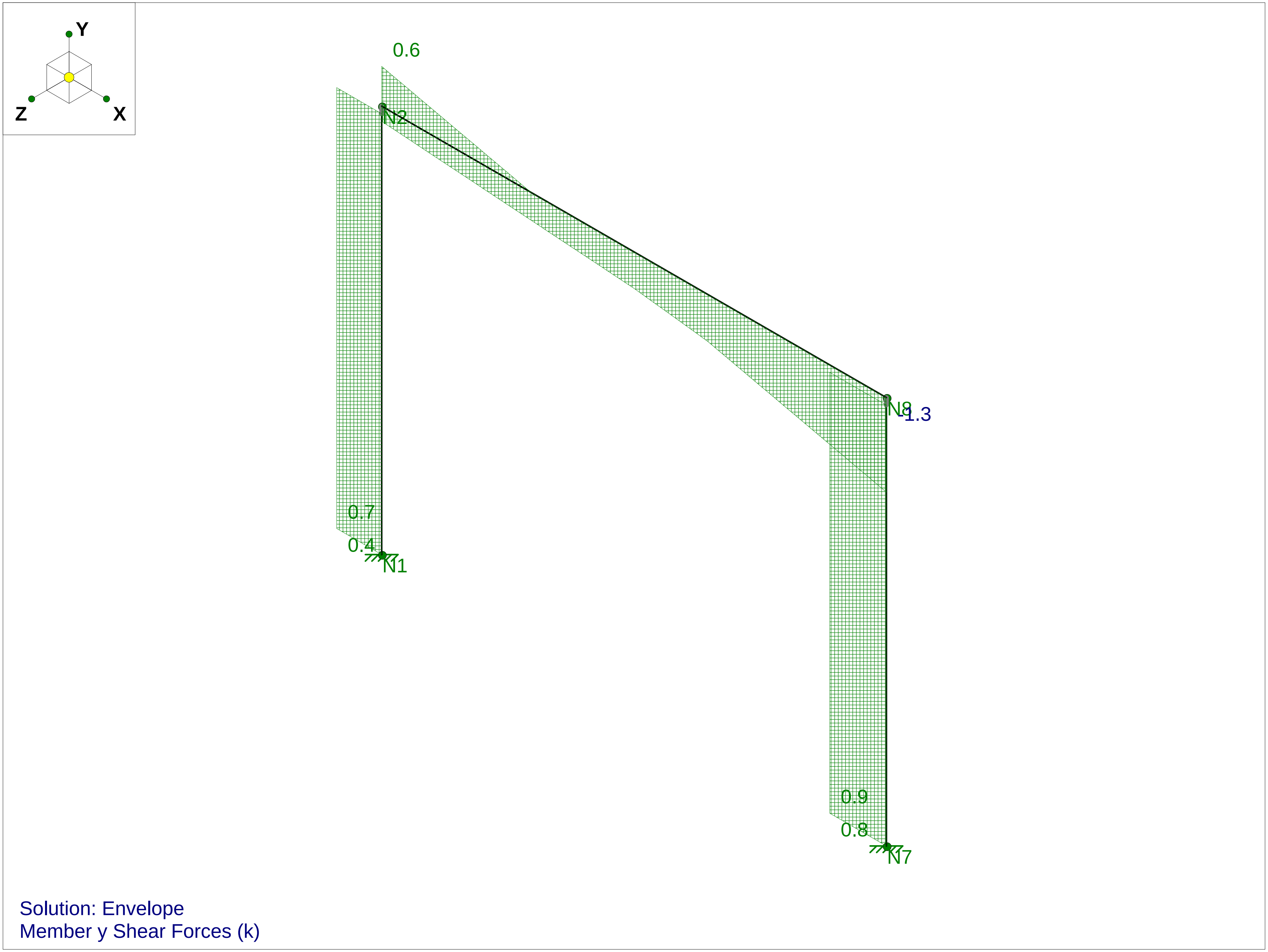
	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
1	N1	max	-.373	2	.635	2	0	1	0	1	0	1	4.394	4
2		min	-.722	4	-.161	4	0	1	0	1	0	1	2.736	2
3	N7	max	-.815	2	1.395	2	0	1	0	1	0	1	5.011	1
4		min	-.909	1	.852	4	0	1	0	1	0	1	4.202	2
5	Totals:	max	-1.188	2	2.029	2	0	1						
6		min	-1.584	1	.691	4	0	1						

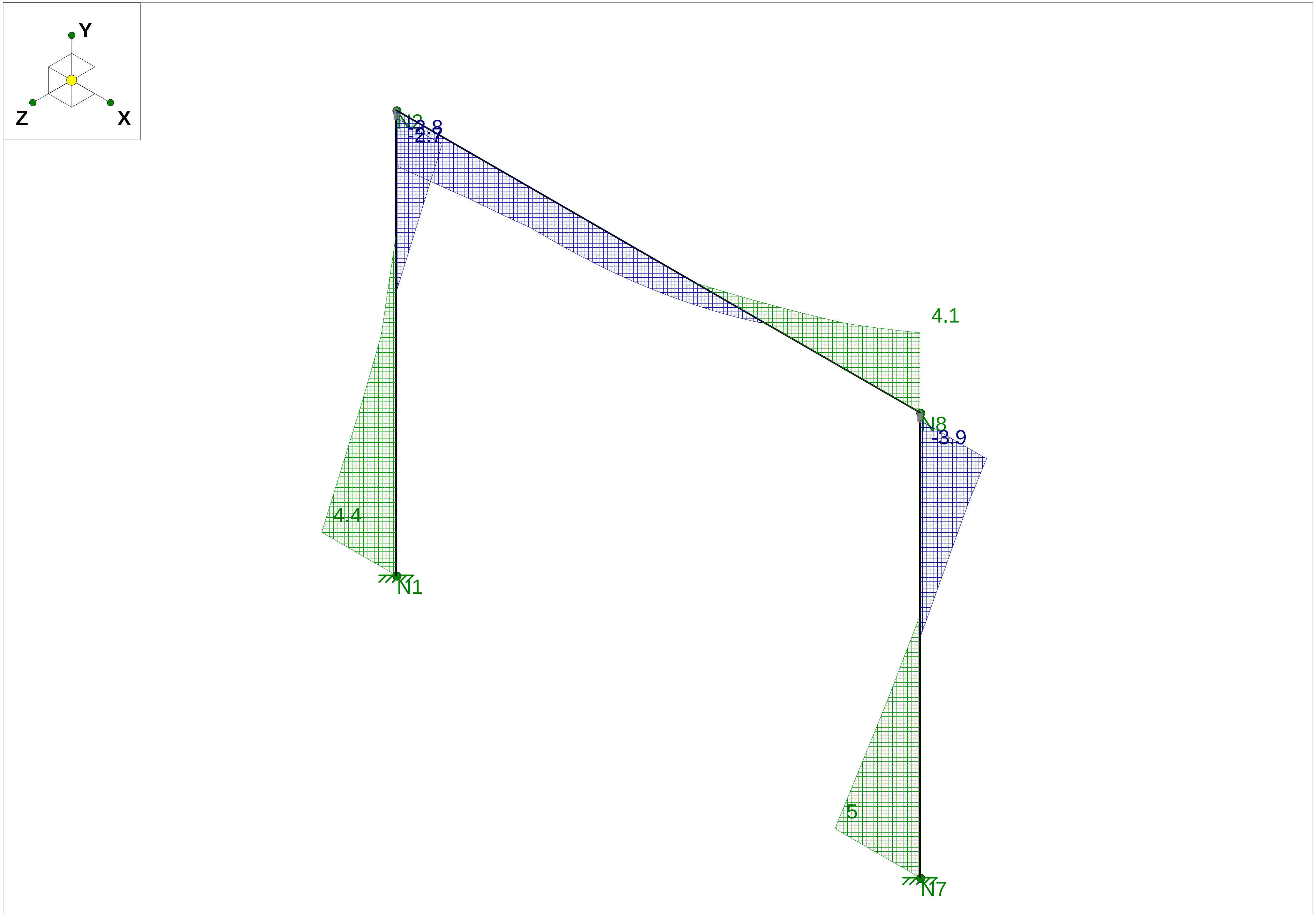
Envelope ADM 05 ASD Aluminum Code Checks

	Member	Shape	Code ...	Loc[ft]	LC	Shear ...	Loc[ft]	Dir	LC	Ft [ksi]	Fc [ksi]	Fb y-y ...	Fb z-z ...	Fs y-y ...	Fs z-z ...	Cb	Cmy	Cmz	Eqn
1	M1	RT4X4X...	.372	0	4	.015	0	y	4	19.487	7.657	21.212	21.212	12.247	12.247	2....	.6	.354	4.1.2-1
2	M4	RT4X4X...	.423	0	1	.019	0	y	1	19.487	7.657	19.487	19.487	12.247	12.247	2....	.6	.287	4.1.2-1
3	M5	RT4X4X...	.346	13	1	.027	13	y	2	19.487	4.381	21.212	21.212	12.247	12.247	2....	.6	.354	4.1.1-3

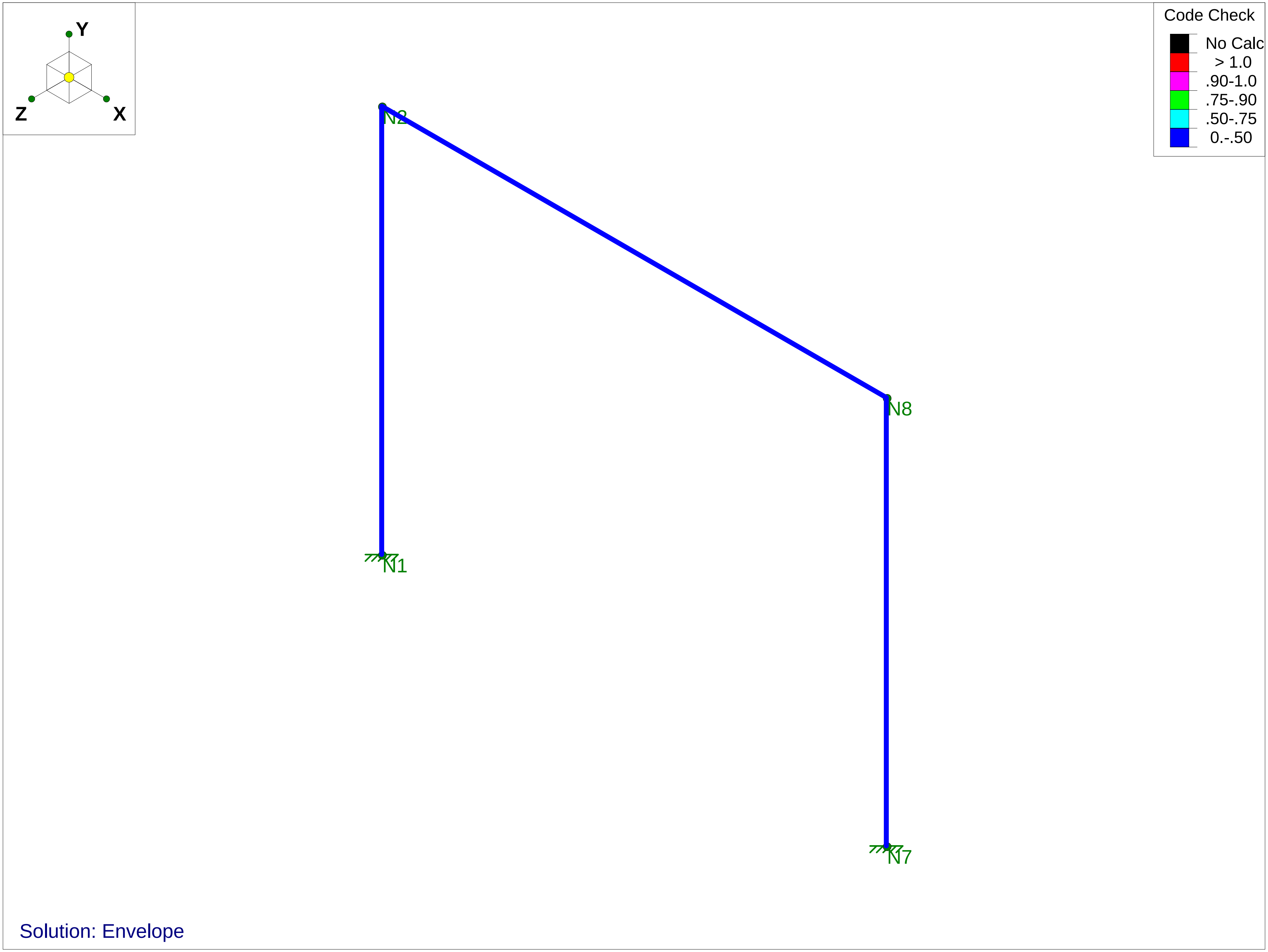


Solution: Envelope
Member Axial Forces (k)

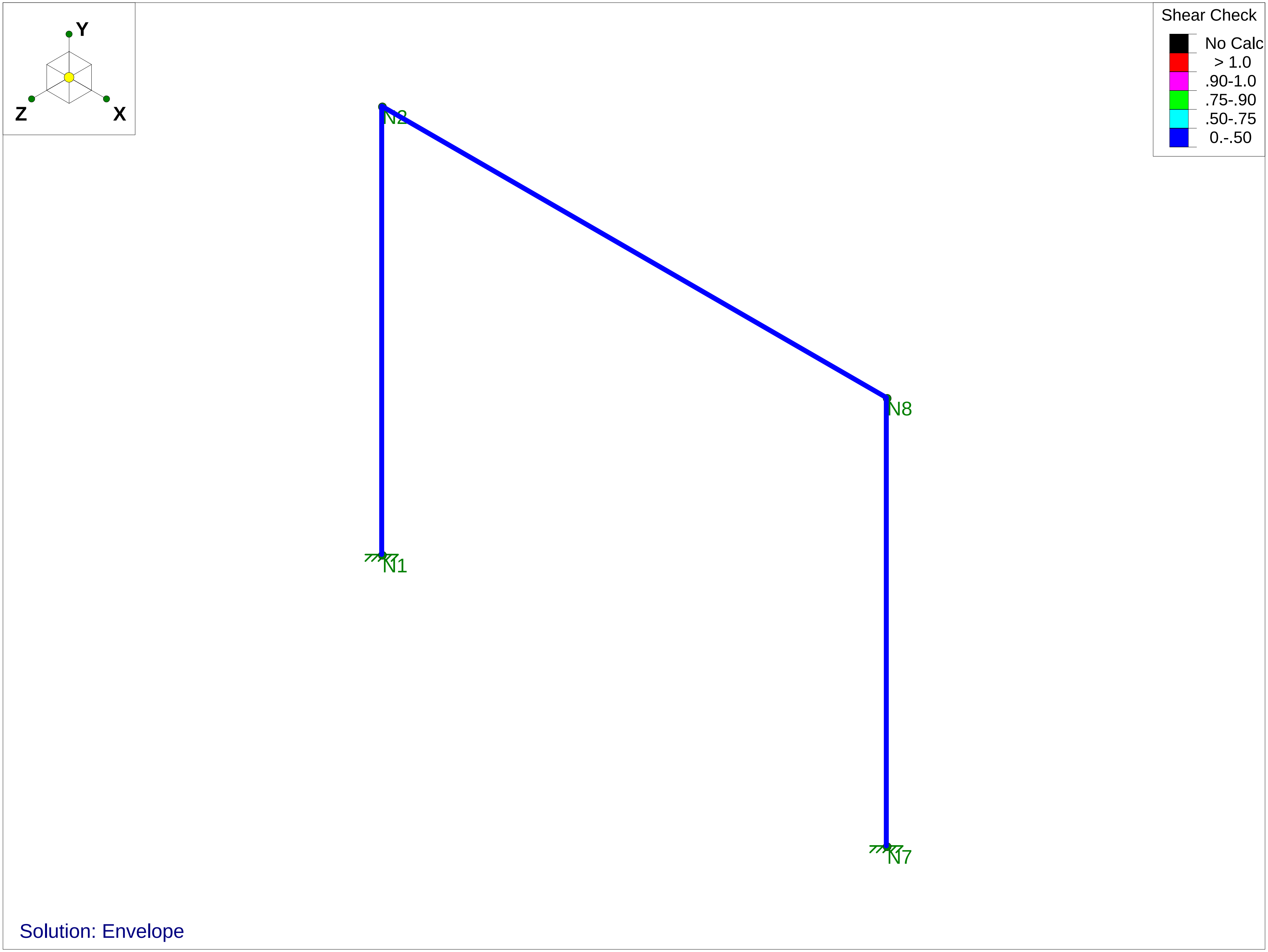

Y
Z
X
0.6
N2
N8
-1.3
0.7
0.4
N1
0.9
0.8
N7
Solution: Envelope
Member y Shear Forces (k)



Solution: Envelope
Member z Bending Moments (k-ft)



Y
Z
X
N2
N8
N1
N7
Code Check
No Calc
> 1.0
.90-1.0
.75-.90
.50-.75
0.-.50
Solution: Envelope


Y
Z
X
Shear Check
No Calc
> 1.0
.90-1.0
.75-.90
.50-.75
0.-.50
N2
N8
N1
N7
Solution: Envelope

INTRODUCTION

Diaphragms are common and economical structural systems to resist lateral forces. These forces develop from wind and earthquakes most frequently, although they can originate from blasts, or other causes.

A diaphragm consists of a thin, rigid and strong sheet between chords. The sheet acts as the web of an I beam thus a stiff system develops due to efficient use of the available material. Stiffness characteristics of the web can be achieved in various ways. Description of different systems is beyond the scope of this brochure since they are well publicized in the technical literature. Attention will be given here only to the glued Lock-Deck® diaphragm which combines the well proven structural characteristics of the laminated decking with the strong glue joints between decking courses. Special advantages of this diaphragm are the excellent deflection recovery quality following loading, and favorable economics.

Basics of the diaphragm design and construction are discussed in detail in this publication. Also included is a design example intended to provide a guide to engineers and architects familiar with diaphragms.

DIAPHRAGM CONSTRUCTION AND CHARACTERISTICS

The glued Lock-Deck decking diaphragm is developed from the basic Lock-Deck roof system by applying 3M 5230 elastomeric adhesive in the tongue and groove joint as will be described later. Thus the basic roof system is adapted into a diaphragm with a relatively small labor and materials cost. It is therefore advisable for the architect and designer to become familiar with the roof system from the Potlatch Engineered Structural Wood Products brochure and use this literature as a supplement to design a diaphragm.

MATERIAL:

All Lock-Deck laminated decking furnished by Potlatch Corporation is suitable for diaphragm construction regardless of species and size. These deckings are manufactured of dried lumber laminations to maintain dimensional stability in place under normal uses. The glue line which develops the diaphragm action is designed to take 100% elongation safely, however, the occurrance of such elongation in a well designed diaphragm is very unlikely.

The adhesive shall be 3M 5230 (3M Company). It is moisture curing, durable and has a remarkable recovery property which is reflected by the diaphragm deflection and its recovery characteristics. It also has an excellent energy absorbing, damping quality as an added advantage over many other diaphragm systems.

Potlatch decking and the adhesive combination is efficient in the sense that the glue line thickness and shape result in a strong, adequately rigid, yet flexible glue joint which absorbs much of the shock wave energy from dynamic loads such as wind gust or earthquake. Figure 1 is an illustration of the glue joint between two adjacent decking courses.

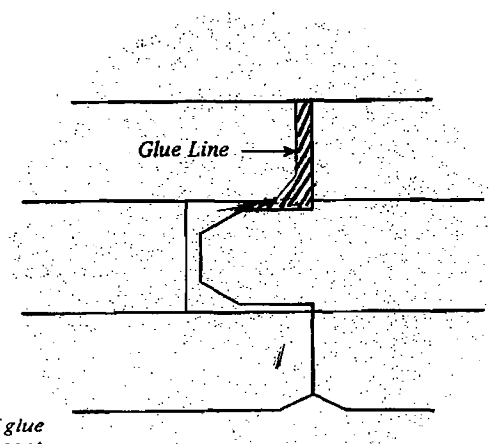


Fig. 1. Illustration of glue joint between adjacent decking courses.

102

CONSTRUCTION:

Random Length Continuous (over 3 or more spans) decking layup construction was adapted to diaphragm construction. All specifications regarding the decking, end joint spacing and nailing must be followed as given in the ICBO Research Committee Recommendation Report No. 1379 or in the appropriate technical literature published by Potlatch Corporation. Additional requirements are the following:

1. Glue Application

A 3/8 in. diameter glue bead is to be applied on the tongue of each piece of decking, as shown on Figure 2 prior to the placement of the next course of decking fitted to it. The glue so placed will fill the gap between the adjacent courses as shown in Figure 1. Filling the gap is a basic requirement and should always be maintained. The glue line may be continuous along the diaphragm length or spaced at specified intervals. Spacing is determined by shear requirements of the design and is governed by the required minimum glue line ratio (p). A 60 percent glue line of the total length has p = 0.6. For example, 3 ft. long glue lines spaced 2 ft. apart would be acceptable for a "p" of 0.6. Longer glue lines and greater spacing is possible but care must be taken to assure glue line on each plank or piece of decking. Shorter planks will require closer spacing. Also, glue lines should begin in each course at both diaphragm ends. It is advisable to have the glue lines and any spacings systematically lined up perpendicular to the decking length for ease in controlling the required amount of glue in the diaphragm.

Minimum glue line length and maximum spacing between glued sections are 1-ft. and 4-ft. respectively.

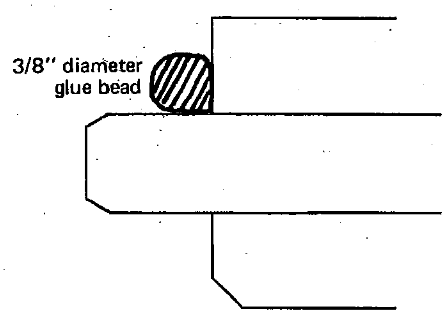


Fig. 2. Adhesive Application

2. Diaphragm Chords and Headers.

The diaphragm should have continuous chords and headers along the sides and ends respectively. They are designed to resist the external moment developing on the diaphragm from the lateral load from any direction.

Standard engineering practice must be followed in designing chords and headers. Type of the chords or headers, and construction details depend on the wall and roof structure. Chords must be structurally continuous and can be dimension lumber, laminated timber, or other suitable material. Each specific solution will be adapted to the trusses or beams supporting the roof. The decking should in each case be nailed to the chords and headers following the nailing schedule per design (see item 4 later). Figure 3 shows a chord detail with a laminated roof support.

3. End Stiffening.

Stiffening the diaphragm corners and ends is recommended. Corner stiffening can be done easily by bolting dimension lumber to the headers and chords with the use of angle iron. The stiffener (dimension lumber or other material) should run perpendicular to the decking length for best performance. In the example shown later under "Design", the stiffener is parallel to the header. Figure 4 shows a chord and header detail with corner stiffening.

4. Nailing.

Nailing of the decking to the roof supporting trusses or beams and slant nailing should follow specifications in the Lock-Deck decking brochure. Nailing to the chords and headers must be designed to resist shear load but cannot be less than required for the Lock-Deck decking roof.

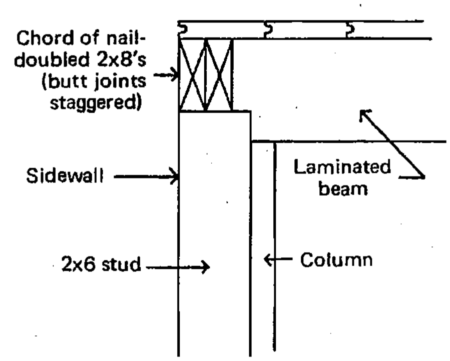


Fig. 3. A chord construction solution without connection and other construction details.

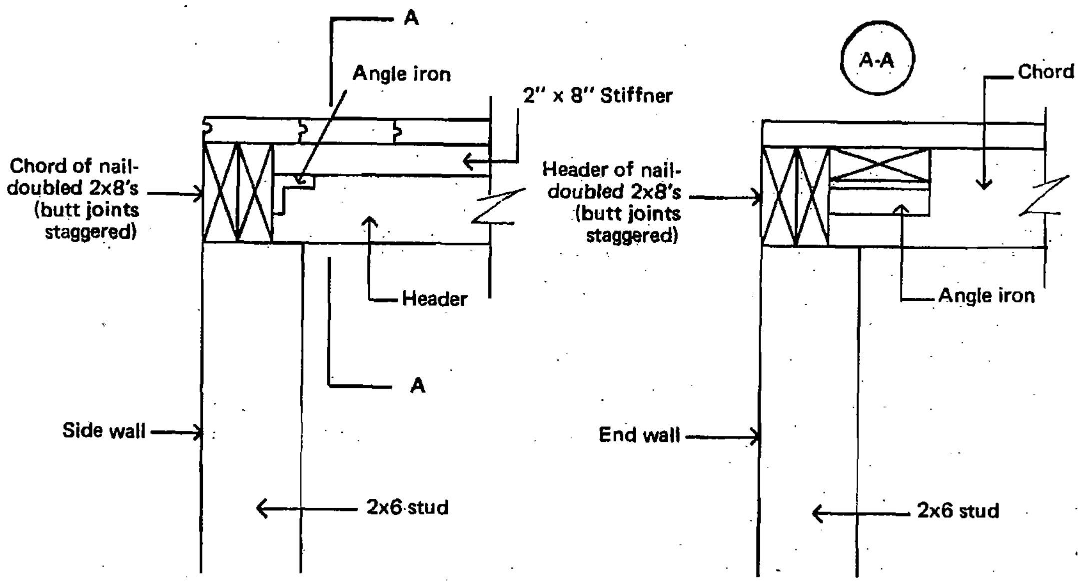


Fig. 4. Corner stiffening example. Connection and wall construction details are not shown.

SUMMARY

There are a number of special features of a glued Lock-Deck diaphragm related to material and construction. All must be considered, so they are summarized below:

1. The dry laminated Potlatch decking assures dimensional stability, a requirement for diaphragm application. Other deckings should not be substituted.
2. Thickness and shape of the glue line in the specifically designed machined tongue and groove joint of Potlatch Lock-Deck decking results in an efficient joint for strength and stiffness. Other joints are not likely to be equivalent, although similarity may exist.
3. Only Potlatch Lock-Deck laminated decking regardless of species and size is suitable for diaphragm application.
4. Only Random Length Continuous (RLC) layup of decking is adaptable to diaphragm construction.
5. A 3/8" diameter 3M 5230 adhesive bead must be applied on the top of the tongue continuously or spaced per design. Other adhesives are not acceptable without Potlatch's recommendation.
6. Continuous chords and headers must be provided to resist the external moment imposed on the diaphragm.
7. The nailing schedule should follow specifications described in the Lock-Deck decking brochure, but it should be checked to resist shear load in any section.
8. Corner stiffening is recommended.

DESIGN

The design is based on the assumption that the diaphragm acts as a deep I beam for which the decking with glue between the courses functions as the web. Needed properties in design are a) allowable shear load level, and b) deflection characteristics due to lateral load. Both were determined through full size diaphragm testing.[1] The design method features mechanics of the I beam in bending and test data regarding ultimate strength and deflection. Thus the method follows a traditional approach but has one new aspect which results from the effect of the relationship between decking length direction and acting lateral force direction on diaphragm deflection. Thus the glued decking courses tend to bend when load is perpendicular to their length but are primarily in shear when these directions are parallel. The example below will demonstrate the design for both cases.

[1] *Test was carried out by Oregon State University as reported in Report T-25 July 1968.*

1. Basic Structure and Wind Force Distribution Diagram.

A rectangular shape flat roof building with 5x6 Idaho White Pine Lock-Deck decking will be considered. Other types of roof such as curved or pitched are also adaptable to the diaphragm design. Consult your Potlatch representative in case of curved roof. This paper doesn't address itself to the wall construction, but assumes that it will transfer half of the lateral load acting on it to the diaphragm. Figure 5 shows a structure with dimensions while Figure 6 is the illustration of forces on the structure due to wind load.

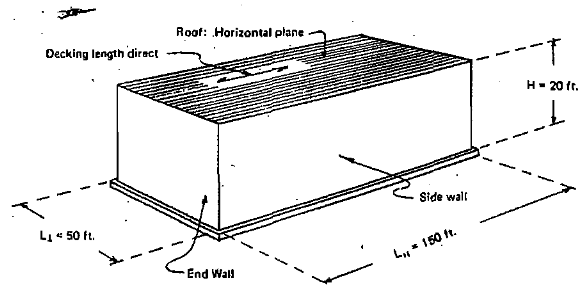


Fig. 5. Force resisting planes.

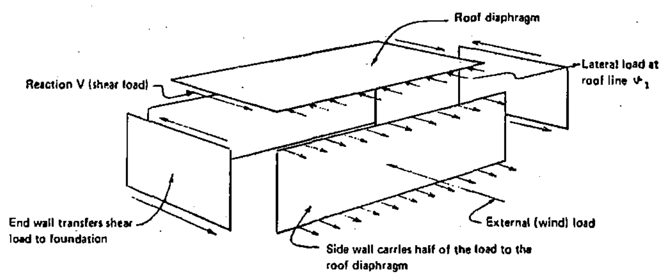


Fig. 6. Distribution of wind forces acting perpendicular to decking length.

2. Calculating forces Acting on the Diaphragm

Wind can blow from any direction. It is evident that maximum wind force will develop when wind blows perpendicular to the 150 ft. long side wall. However, a design will also be made for the case of wind force acting on the end wall to demonstrate the design for both cases.

A. Wind Force Perpendicular to Decking Length.

a) Wind load (w) is 25 pounds per square foot (psf)

b) Lateral load (v_1) acting on the wall and reacting on the diaphragm:

$$v_1 = \frac{wH}{2} = \frac{25 \times 20}{2} = 250 \text{ plf}$$

c) Reaction (V) at end wall:

$$V = \frac{v_1 L_{\parallel}}{2} = \frac{250 \times 150}{2} = 18750 \text{ lbs}$$

d) Unit shear load (v_s) at diaphragm ends:

$$v_s = \frac{V}{L_1} = \frac{18750}{50} = 375 \text{ plf}$$

Allowable shear load is 500 plf from Table 1 when glue line ratio (p) is 1.0. Thus a lower glue line ratio would be acceptable. A p = 0.7 in Table 1 shows v_s = 395 plf, exceeds that of the design one.

B. Wind Load Parallel to Decking Length

Allowable shear load (v_s) and shear in the glue lines (τ) should be checked. Steps are the same as under "A", thus w and v_1 are unchanged.

c) $V = \frac{v_1 \times L_1}{2} = \frac{250 \times 50}{2} = 6250$ lbs

d) $v_s = \frac{V}{L_{\parallel}} = \frac{6250}{150} = 41.7$ plf < 395 plf

e) Maximum shear stress in the glue line (τ)

$$\tau = \frac{V}{p L_{\parallel}} = \frac{6250}{0.5 \times 150 \times 12} = 6.94 \text{ pli} < 41$$

pli allowable (See Table 1)

3. Nailing Schedule Design

Decking is 3-21/32" x 5-1/4". Minimum lateral nail holding strength needed is 375 plf along the end wall and 41.7 plf along the side wall. Current specification for nailing Lock-Deck decking to each support requires two 50-penny nails (5-1/2" long and 0.244" diameter) per course. Allowable lateral load of one nail with 11 times diameter penetration (11 x 0.244 = 2.684 in.) for Group II species per NDS[1/] is 202 lbs. Actual penetration in this case is length of the nail minus decking thickness (5.50 - 3.656 = 1.844 in.). Thus the two nails have to have minimum of $\frac{5.250}{12}$ 375 = 164 lbs. lateral load holding strength while they have $\frac{1.844}{2.684}$ x 202 x 2 = 277 lbs. at the diaphragm ends.

This allowable load increases to 277 x 1.33 = 368 lbs. due to duration of loading adjustment. Thus: 164 < 368 O.K.

Nail spacing along the diaphragm length is allowable load per nail load over 41.7 lbs. which is: $\frac{368}{2 \times 41.7}$ = 4.41 ft. ~ 53 ins.

Slant nailing between courses is required as specified in the Potlatch Lock-Deck Laminated Decking Brochure.

[1] *National Design Specification for Stress-Grade Lumber and Its Fastening by the National Forest Products Association.*

4. Designing Chords and Headers.

Considering the same size members for chords and headers, design should be made for the chords along the diaphragm length as this is exposed to higher load. These members will resist tension and compression forces due to the external moment as the result of the uniform lateral load along the diaphragm length. The load distributed may be other than uniform depending on the building structure. This will change the value of the k_2 factor in the formula. A list of these factors is given in Table 2 for various types of loading.

The tension or compression force (P_t or P_c) in the chord assuming uniform lateral load is:

$$P_t = P_c = \frac{k_2 v_1 L_{\parallel}^2}{L_{\perp}} = \frac{250 \times 150^2}{8 \times 50} = 14{,}062 \text{ lbs}$$

A continuous 2 x 10 of No. 2 Douglas Fir and Larch or Southern Pine MG dimension having tension parallel to grain F_t = 825 psi would be satisfactory (assumes 1/3 increase for duration of loading).

5. Deflection Calculation

A. Wind Force Acts Perpendicular to Decking Length.

Modulus of elasticity (E) for the chord material is 1,700 ksi.

$$\Delta = \left[\frac{24 k_1 P_{\perp} L_{\parallel}^3}{E A_c L_{\perp}^2} + 20{,}000 \frac{k_2 P_{\perp} L_{\parallel}}{A_d L_{\perp} G}\right]\left[1 + m\right]$$

$$= \left[\frac{24 \times 5 \times 37.5 \times 150^3}{384 \times 1700 \times 13.875 \times 50^2} + \frac{20{,}000 \times 37.5 \times 150}{8 \times 43.13 \times 50 \times 15{,}010}\right]\left[1 + 0.51\right]$$

$$= \left[0.671 + 0.434\right]\left[1.51\right] = 1.669 \text{ in.}$$

B. Wind Force Acts Parallel to Decking Length.

$$= \frac{6P_{\parallel}}{L_{\parallel}}\left[\frac{k_1 L_{\perp}^3}{E A_c L_{\parallel}} + \frac{5.1\, n}{p} 10^{-4}\right]\left[1 + m\right]$$

$$= \frac{6 \times 12.5}{150}\left[\frac{5 \times 50^3}{384 \times 1700 \times 13.875 \times 150} + \frac{5.1 \times 111}{0.7} \times 10^{-4}\right]\left[1 + 0.51\right]$$

$$= 0.50 \left[0.00046 + 0.0809\right]\left[1.51\right] = 0.061 \text{ in.} < 1.669 \text{ in.}$$

$$n = \frac{12 L_{\perp}}{b} = \frac{12 \times 50}{5.376} \sim 111; \qquad b = \text{actual width of a plank *}$$

Symbols:

- k_1 = deflection constant from Table 2
- k_2 = moment constant from Table 2
- $P_{\perp}$ = total load (2V) acting perpendicular to decking length - kip
- $P_{\parallel}$ = total load acting parallel to decking length - kip
- $L_{\parallel}$ = diaphragm dimension parallel to decking length - ft.
- $L_{\perp}$ = diaphragm dimension perpendicular to decking length - ft.
- A_c = area of one chord (header) - in.^{2}
- A_d = area of 1 ft wide decking - in.^{2}.*
- G = modulus of rigidity constant from Table 1.
- m = nonlinear but recoverable deflection constant from Table 1.
- n = $\dfrac{12 L_{\perp}}{b}$
- b = decking width - in.

**This area is given in the section property table of the Potlatch Lock-Deck Laminated Decking Brochure.*

The total deflection of 1.669 in. for the 20 ft. height corresponds to 0.084 inch/foot, slightly more than 1/16 in.

As expected, deflection was greater when load acted perpendicular to decking axis. Thus the later calculation could be avoided since diaphragm shape made the choice of critical case obvious.

The calculated deflection should be compared to the allowable one specified by the code governing in the area for the type of building in question. If deflection is large, glue line ratio (p) or chord size can be increased to meet code requirements.

6. Construction Specification

Since the diaphragm is designed a construction specification can be prepared. It should cover:

a) Lock-Deck® decking size, species, and layup construction (Random Length Continuous).
b) Adhesive (3M 5230) application should follow manufacturer's instruction.
c) Glue bead size and glue line ratio (p) and spacing in case of less than 100 percent glue line coverage.
d) Lumber size and grade for chords.
e) Splice joint detail for achieving continuous chord.
f) Nailing schedule.
g) Inspection regarding all items listed above.

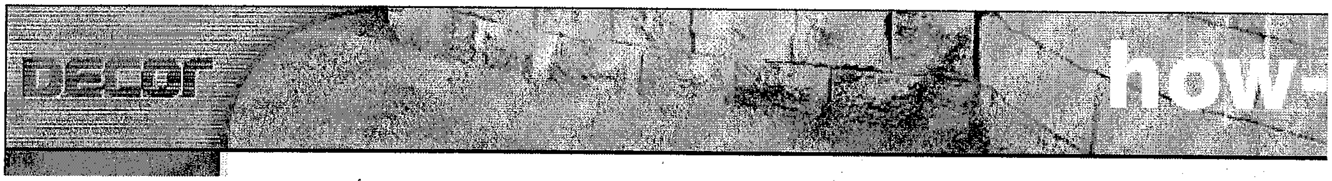
TABLE 1.
CONSTANTS PERTINANT TO DIAPHRAGM DESIGN

Sum of glue-line lengths as portion of total length p	Constant m	Modulus of rigidity constant G 10^3	Allowable[1] shear load level v_s plf	Allowable[1] shear stress in the glue-line $\tilde{\tau}$ pli
1.00	0.23	19.30	500	
0.90	0.32	17.90	465	
0.80	0.42	16.49	430	
0.70	0.51	15.01	395	41.00
0.60	0.60	13.69	360	
0.50	0.69	12.29	325	
0.40	0.79	10.88	290	
0.30	0.88	9.48	255	
0.20	0.97	8.08	220	

1. These values should always be used regardless of duration of loading.

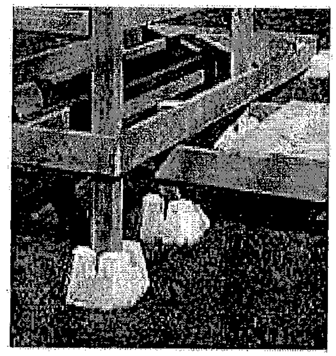
TABLE 2.
CONSTANTS FOR DEFLECTION CALCULATION

Loading condition	Deflection constant k_1	Moment constant k_2
Uniformly distributed	5/384	1/8
Center point concentrated	1/48	1/4
Third point	1/56.3	1/6
Fifth point	0.0137	6/40
Twelfth point	0.0141	6/44



4 WAY DEK-BLOCK+™

build the deck of your dreams in just one day!



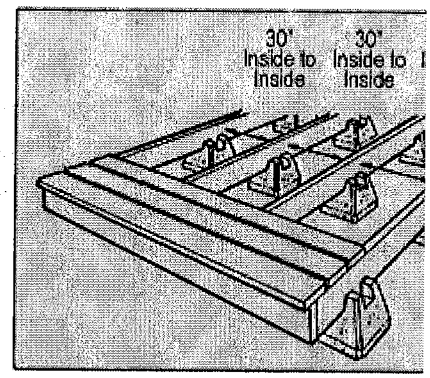
Tools Needed

• shovel • level • tape measure • 1/4" dowel • drill with screwdriver bit • saw (required only when using 4x4's to level or elevate deck, or for adding handrail posts)

Choose the 4 WAY Dek-Block+™ deck plan that's right for you:

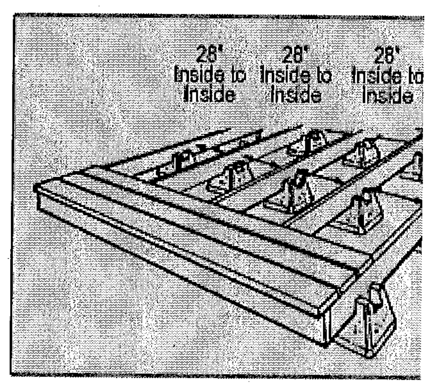
8' x 8' • 8' x 10' • 8' x 12' • 8' x 16' • 8' x 20'

Materials	8'x8'	8'x10'	8'x12'	8'x16'	8'x20'
4 way dek-block+ piers	12	12	12	20	20
8' 2x6 treated lumber	24	24	28	44	45
10' 2x6 treated lumber	-	4	-	-	8
12' 2x6 treated lumber	-	-	4	-	-
8' 4x4 treated lumber	2	2	2	4	4
2-1/2" galv. deck screws	3lbs	4lbs	5lbs	7lbs	7lbs
construction adhesive-tubes	1	1	1	2	2
stain or sealer, gallons	1	1	1	2	2
metal truss plates	-	-	-	8	8
1/4" dowel	1	1	1	1	1



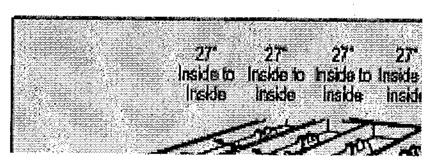
10' x 10' • 10' x 12' • 10' x 16' • 10' x 20'

Materials	10'x10'	10'x12'	10'x16'	10'x20'
4 way dek-block+ piers	15	15	25	25
8' 2x6 treated lumber	-	-	10	-
10' 2x6 treated lumber	29	28	36	55
12' 2x6 treated lumber	-	5	-	-
8' 4x4 treated lumber	3	3	5	5
2-1/2" galv. deck screws	5lbs	5lbs	8lbs	8lbs
construction adhesive-tubes	1	1	1	2
stain or sealer, gallons	1	1	1	2
metal truss plates	-	-	10	10
1/4" dowel	1	1	1	1



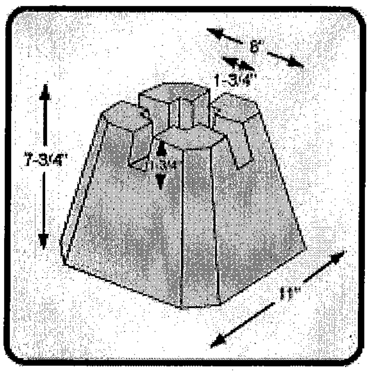
12' x 12' • 12' x 16' • 12' x 20'

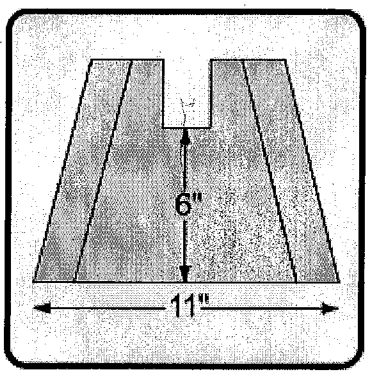
Materials	12'x12'	12'x16'	12'x20'
4 way dek-block+ piers	18	30	30
8' 2x6 treated lumber	-	12	-
10' 2x6 treated lumber	-	-	12



What is the Dek-Block® Pier?

Dek-Block® piers are solid, pre-formed concrete foundation blocks designed specifically for the Floating Foundation Deck System.

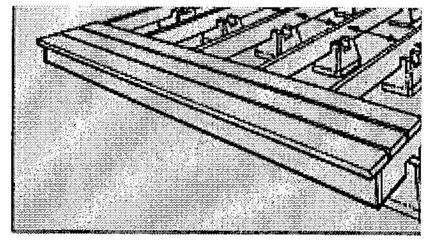


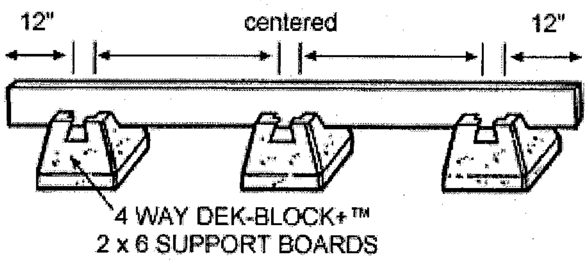


Dek-Block® Pier Specs

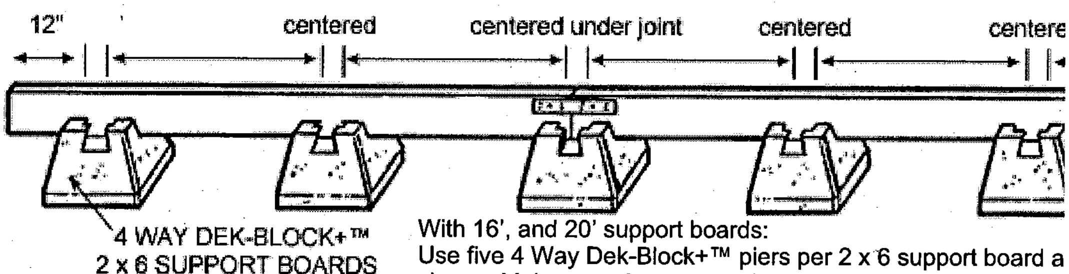
- 1-3/4" wide x 1-3/4" deep slot accepts 2" thick (1-1/2" net) lumber horizontally
- 3-3/4" square x 1-3/4" deep socket accepts 4x4 (3-1/2" x 3-1/2" net) posts vertically
- 42 lbs per block average. Weight varies slightly by region
- 6" distance from bottom of block to bottom of lumber slot
- Block porosity wicks moisture from slot/lumber to ground.
- Each block is manufactured from 5,000 psi concrete to ensure the greatest strength and durability.

12' 2x6 treated lumber	34	34	45
8' 4x4 treated lumber	3	5	5
2-1/2" galv. deck screws	6lbs	8lbs	9lbs
construction adhesive-tubes	2	2	3
stain or sealer, gallons	2	2	3
metal truss plates	-	12	12
1/4" dowel	1	1	1





How to space 4 WAY Dek-Block+™
With 8', 10' and 12' support boards:
Use three 4 WAY Dek-Block+™ piers per :
support board as shown.



With 16', and 20' support boards:
Use five 4 Way Dek-Block+™ piers per 2 x 6 support board a shown. Make sure that center pier is directly under center joir support board.

Build the 4 WAY Dek-Block+™ deck of your dreams in 4 easy steps

Step 1: Position and level 4 Way Dek-Block+™ piers. Use a 2 x 6 support board and the spacing measurements shown in the plans for the deck of your choice. Adjust 4 Way Dek-Block+™ piers until the top edge of the 2 x 6 support board is level. (NOTE: For 16 and 20-foot deck lengths, connect two 8 or 10-foot support boards end-to-end by nailing a perforated metal truss plate to both sides of the joint as shown. Make sure that a 4 Way Dek-Block+™ pier is positioned directly under the joint).

Step 2: Position and level all 2 x 6 support boards. Make sure that the top edges of all the support boards are level with each other.

Step 3: Square up 2 x 6 deck support boards and add 2 x 6 boards to finish both open ends.

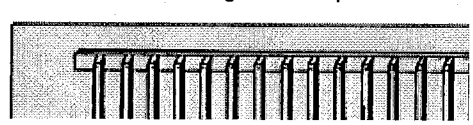
To square up support boards, measure diago form ends of outside support boards (corner t corner). Adjust position of outside support bo: until diagonal distance between opposite corr EQUAL. Screw a 2 x 6 board across one ope adjusting all inside support boards so they bu flush against the finish board. Screw the secc finish board across the other open end.

Step 4: Add 2 x 6 decking surface. Place AL decking on the deck before screwing. Space decking board 1/4" apart on support boards u 1/4" dowel as a guide. Adjust as necessary tc ensure that the decking boards overlap the fi boards on each end by the same amount. Wh decking is in position, remove each board an apply a bead of construction adhesive to the edge of the support board beneath it. Put boa back in place and secure with 2-1/2" deck scr (two screws per support board).

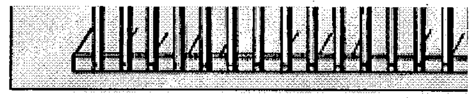
How to add a handrail

Step 1
Position centers of outer 2 x 2 boards 5" in from each end of 2 x 6 handrail board, and attach with one 2-1/2" decking screw at the top. Attach bottom ends of 2 x 2's to deck support or facing board with two decking screws, using a

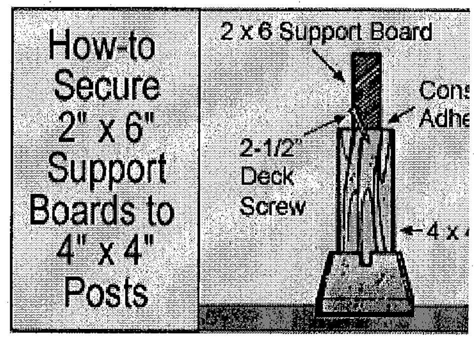
Step 2
Position remaining 2 x 2 boards on 5" centers, with two 2-1/2" decking screws top and bottom.



level to ensure that 2 x 2's are plumb and that 2 x 6 handrail board is level with deck. Secure top of each 2 x 2 with a second screw.

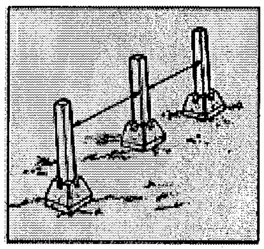


Materials (per Side)	8'	10'	12'	16'	20'
8' 2x6 treated lumber	1	-	-	2	-
10' 2x6 treated lumber	-	2	-	-	2
12' 2x6 treated lumber	-	-	1	-	-
42 inch 2x2 treated lumber - beveled at both ends	20	25	30	40	49
2-1/2" galv. deck screws	1lbs	1lbs	2lbs	2lbs	2lbs



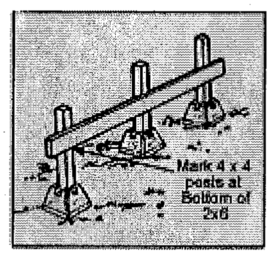
how to level or elevate your 4 WAYDek-Block+™ deck

Step 1
Position first row of 4 Way Dek-Block+™ piers and 4 x 4 posts.



Level the top of each 4 Way Dek-Block+™ pier, then insert 4 x 4 posts. Get the inside measurement for the distance between posts from the plan for the deck size you've chosen.

Step 2
Determine height of deck with 2 x 6 leveler.

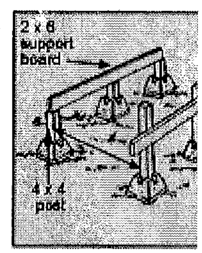


Mark desired height of completed deck on 4 x 4 post positioned on highest ground. Mark post 1-3/4" below original mark to allow for thickness of decking. Position top edge of 2 x 6 leveler flush with second mark and nail to post. Place spirit level on top edge of leveler, nailing other end to opposite 4 x 4 post when level. Mark all posts clearly along bottom edge of leveler.

Step 3
Cut 4 x 4 posts to length and position 2 x 6 support board.

Remove 4 x 4 posts from 4 Way Dek-Block+™ piers. Cut to length at marks made in Step 2. Reinsert posts in piers. Center 2 x 6 support board along top of post

Step 4
Position remaining 2 x 6 support boards, square up, and secure to 4 x 4 posts.



Position remaining 2 x 6 support boards by repeating Steps 1, 2 & 3. Distance between posts is 2" less than the distance between support boards shown on the plan for your deck. Squ by adjusting outside support boards until dia distance between opposite corners is EQUA ends of all support boards are flush. Secure support boards to posts as shown.

A1

3. Three techniques are currently available to evaluate the roof by indirect / non-invasive means. Results of these studies must still be correlated with roof cores. These techniques provide measurements of factors that can be associated with the presence of moisture.
   - Nuclear moisture detection
   - Infrared thermography
   - Electric capacitance

1.04 SUBSTRATE AND SUBSTRATE REQUIREMENTS

A. General

1. The Firestone Metal roof system depends on a suitable substrate to perform its intended function of weatherproofing the building.

> **It is the roofing contractor's responsibility for ensuring that the substrate is acceptable for the Firestone metal roof system.**

2. The substrate to which the Firestone roof system is installed must:
   - Be continuous and monolithic within a defined area.
   - Be structurally sound
   - Be dry, smooth, flat and clean
   - Be free of sharp fins, or foreign materials that could damage the roof system
   - Meet the minimum requirements for the system performance being installed
   - Not be out of plane more than ¼" (6.35 mm)in 10' (3048 mm)in any direction

B. Fastener/ Pullout Requirements

1. Substrates for insulation attachment are required to provide sufficient pullout resistance for the fasteners and roof system.
2. In the case where the structural deck does not meet the minimum fastener pullout requirements contact the Roof Solutions Group at Firestone Building Products

Table 1.04-1
The Minimum Fastener Pullout Resistances For Insulation Attachment

System	Minimum Fastener Resistance
Metal Roof Systems with mechanically attached insulation or approved cover board	300 LBS. (136.1 KG) **Minimum Pullout** Contact the Roofing Solutions Group at Firestone Building Products when the structural deck does not meet the minimum fastener pullout requirements.

3. Pullout Tests: Due to the variety of physical conditions that can affect pullout resistance, Firestone recommends that on-site tests be conducted by an independent testing laboratory, the manufacturer's representative or the roofing contractor, to determine actual pullout values. The following deck type are those which may not provide sufficient pullout resistance:
   - Steel decks thinner than 22 gauge (0.76 mm)
   - Plywood or oriented strand board less than 7/16" (11.1 mm) thickness
   - Tongue and Grove Decks less than 1" (25.4 mm) thick.

TECHNICAL INFORMATION SHEET

2066
2/4/2010

Firestone
BUILDING PRODUCTS COMPANY

UNA-CLAD UC Bearing Plate

Firestone Item Number: W683400P20 (Galvanized)
W683400P22 (Stainless)

DESCRIPTION:
Firestone UNA-CLAD UC Bearing Plates are specially designed to be used in the attachment of the Firestone UNA-CLAD standing seam roof panel clips over insulation and cover boards as required by Firestone Specifications.

METHOD OF APPLICATION:
Position UC Bearing Plates over the insulation or cover board. Attach the standing seam panel clip & plate using the appropriate Firestone fastener. UC Bearing Plates may be fastened independent of the clip, using the outside corner fastener holes, or along with the clip using the clip fasteners. Install plates with the beveled edge down.

Note: Install assembly according to Firestone Metal Design and Application Guides found on the Firestone website. Follow approved installation details.

STORAGE:
Store in unopened original containers protected from the weather.

PACKAGING:
Per Piece; Maximum of 600 per carton

PRECAUTIONS:
1. Do not overdrive or under drive fastener. Use a variable speed clutched driver.
2. Bearing Plates are for use with UNA-CLAD standing seam roof panel clips only.
3. Can not bė used with fasteners larger than No. 14.
4. Eye protection must be worn during the installation of fasteners.

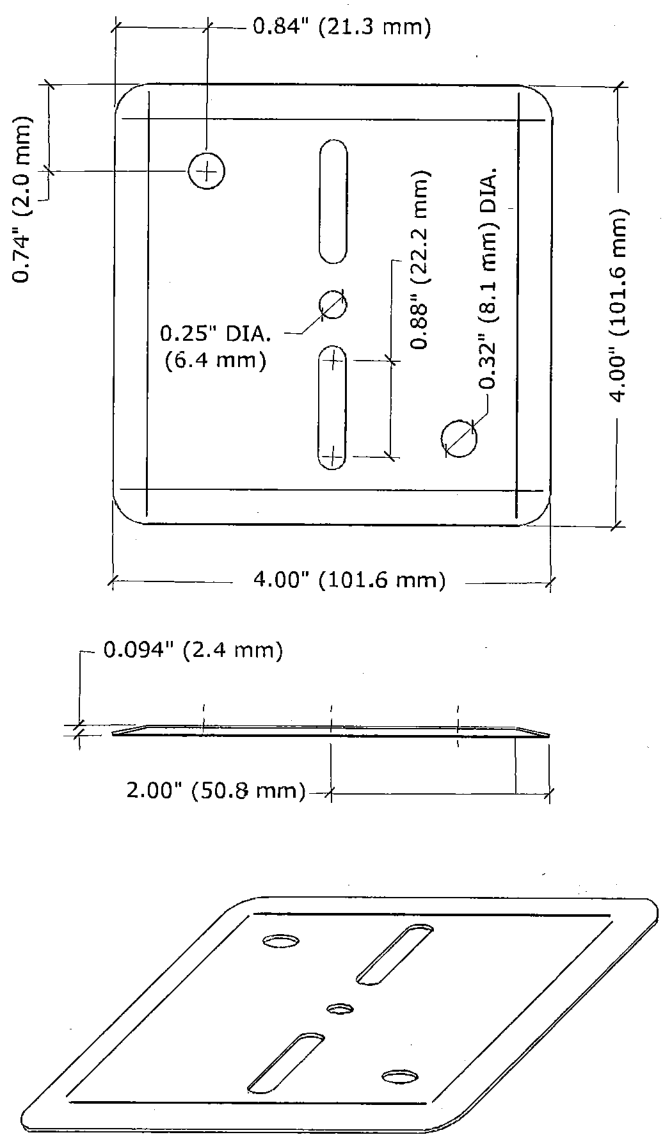
LEED INFORMATION:

Stocking Locations: Anoka, MN
Jackson, MS
Morrisville, PA
Miramar, FL
Reno, NV
Warren, MI

PRODUCT DATA

Property:	**Minimum Performance:**
Material:	G-90 Galvanized Steel 300 Series Stainless Steel
Material Thickness:	
Galvanized Steel	20 ga.; 0.037" (0.97 mm)
Stainless Steel	22 ga.; 0.032" (0.46 mm)
Dimensions:	4.0" x 4.0" (101.6 x 101.6 mm)

PRODUCT DETAIL



Firestone Building Products Company, LLC
250 West 96th Street • Indianapolis, IN 46260
Sales (800) 428-4442 • Technical (800) 428-4511
http://www.firestonebpco.com

A3

TECHNICAL INFORMATION SHEET

2054
8/9/2010

Firestone
BUILDING PRODUCTS COMPANY

UNA-CLAD UC-3 Expansion Clip

Firestone Item Number:
W6810C0300 (1.5" Stainless Steel)
W6810C0310 (1.0" Stainless Steel)

DESCRIPTION:
Firestone UNA-CLAD UC-3 Expansion Clips are specially designed to be used in the attachment of the Firestone UNA-CLAD UC-3 Standing Seam Roof Panel. The design of the clip allows the upper tab to be mechanically integrated into the double lock seam. The two-piece construction allows for thermal movement of the panel while providing positive securement to the deck.

METHOD OF APPLICATION:

1. Position the clips flush against the vertical seam.
2. Ensure proper location of tab relative to base location.
3. Attach clips to roof deck using the appropriate Firestone fastener for desired performance or warranty.
4. Position adjacent panel flush against installed clip.
5. Secure panel by folding outer vertical female leg 90° under head of male leg at clip location.

   Note: Install assembly according to Firestone Metal Design and Application Guides found on the Firestone website. Follow approved installation details.

STORAGE:
Store in unopened original containers protected from the weather.

PACKAGING:
1000 Clips per carton

PRECAUTIONS:

1. Do not overdrive or under drive fastener. Use a variable speed clutched driver.
2. Clips are designed to anchor UC-3 standing seam roof panels only
3. Can not be used with Firestone HD, HD Plus, or fasteners larger than No. 12.
4. Eye protection must be worn during the installation of fasteners.

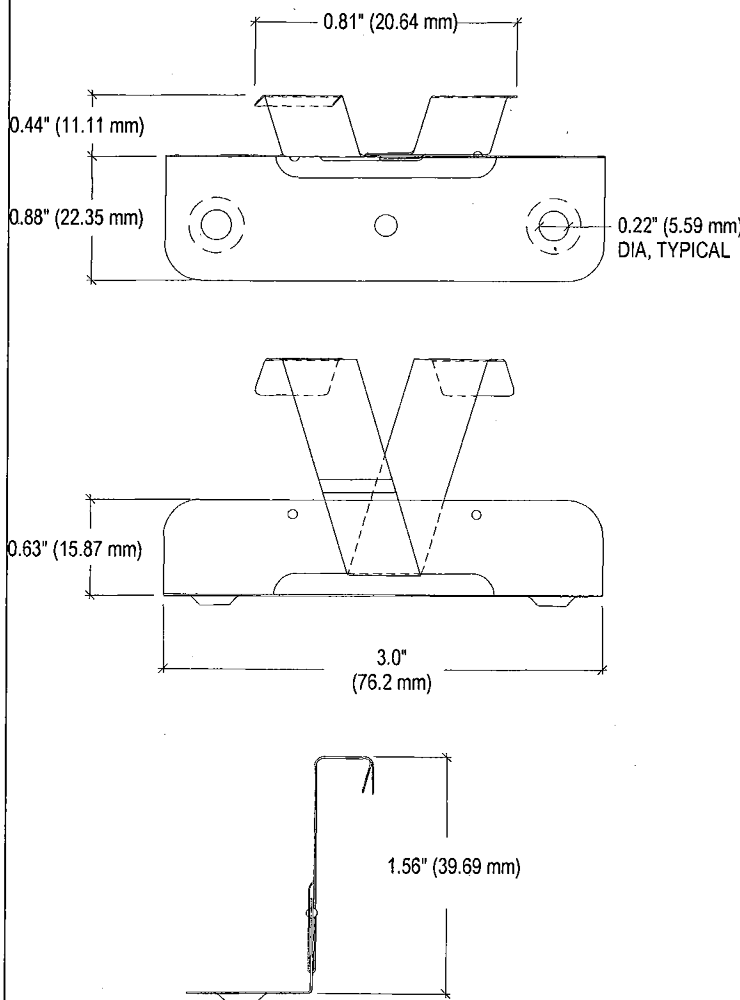
LEED INFORMATION:

Stocking Locations: Anoka, MN
College Station, GA
Jackson, MS
Miramar, FL
Morrisville, PA
Reno, NV
Warren, MI

PRODUCT DATA

Property:	Minimum Performance:
Material:	Stainless Steel
Material Thickness:	0.016" (0.41 mm); 28ga.
Base:	3.0" x 0.63" (76.20 x 15.87 mm);
Tab:	1.50" x 0.81" (38.10 x 20.64 mm) 1.0" x 0.81" (25.4 x 20.64 mm)
Hole Diameter:	0.22" (5.59 mm)

PRODUCT DETAIL



Firestone Building Products Company, LLC
250 West 96th Street • Indianapolis, IN 46260
Sales (800) 428-4442 • Technical (800) 428-4511
http://www.firestonebpco.com

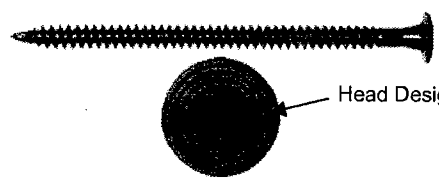
A1

TECHNICAL INFORMATION SHEET

1019
3/8/2011

Firestone
BUILDING PRODUCTS

HD HailGard™ Fastener



Head Design

Firestone Item Number

2-1/2"	W56RAC4405	5-1/2"	W56RAC4411
3"	W56RAC4406	6"	W56RAC4412
3-1/2"	W56RAC4407	6-1/2"	W56RAC4413
4"	W56RAC4408	7"	W56RAC4414
4-1/2"	W56RAC4409	7-1/2"	W56RAC4415
5"	W56RAC4410	8"	W56RAC4416

DESCRIPTION:
The Firestone HD HailGard Fastener is specifically designed to be used in roofing applications where HailGard insulation or an OSB or plywood overlay is used and fastened into 22 ga. steel*, concrete* or wood decking. The HD HailGard bugle-head design allows the head to be installed flush with the top layer of oriented strand board. The HD HailGard Fastener is also an ideal fastener for attaching HailGard insulation when used as a substrate for roofing shingles or metal roofing.

METHOD OF APPLICATION:
The Firestone HD HailGard fastener has a #3 Square Drive Type III recess in the head and comes with two #3 Square Drive bits in each pail. Install the fasteners using the special bit and a variable speed drill so that the top of the fastener is flush with the top of the OSB or plywood. Care should be taken to not overdrive the fastener, which may result in damage to the OSB, plywood or stripping of the fastener in the deck. A drill with a clutch is recommended to facilitate installation.

Contact your Firestone Technical Coordinator at 1-800-428-4511 for specific application information.

PRECAUTIONARY DATA:
Eye protection must be worn during the installation of the fasteners and during any drilling operation.

PRODUCT DATA:

Property	Minimum Performance
Material:	SAE 1022, heat treated steel
Thread Size:	0.265" (6.7 mm) nom. diameter
Threads/Inch:	13
Thread Design:	Buttress thread
Fastener Tip:	X-point
Fastener Head:	#3 Square Drive, Type III Recess, Bugle Head design, 0.500" - 0.520" (12.7 mm – 13.2 mm) diameter

Property	Minimum Performance
Fastener Head Pull-Through in HailGard or 7/16" OSB:	400 lb (181.4 kg) min.
Pullout in New 22 ga.* (0.76 mm):	
Steel Deck (22 ga.):	
Grade C (Grade 33):	595 lb (270 kg) min.
Grade E (Grade 80):	650 lb (295 kg) min.
Pullout in New Structural Concrete Decks*:	700 lb (317 kg) min.
Pullout in New 1/2" (12.7 mm) Plywood/OSB:	360 lb (163 kg) min.
Corrosion Coating:	Red epoxy applied by Electrocoating
Color:	Red (PMS 185)

**20 ga. or heavier steel decking will require pre-drilling of the deck using a 3/16" (4.8 mm) drill bit.*

In concrete, use a rotary hammer or hammer drill in hammer mode to drill a pilot hole with a 7/32" (5.56 mm) carbide tip masonry drill bit. The hole must be a minimum of 1/2" (12.7 mm) deeper than the final depth of the fastener. Install fasteners using a variable speed drill at a maximum of 1,500 RPM, taking care not to over or under drive the fastener.

Screw Length	Thread Length	Pieces/ Plastic Pail
2-1/2" (63.5 mm)	1.75" (44.0 mm)	1,000
3" (76.2 mm)	2.25" (57.0 mm)	1,000
3-1/2" (88.9 mm)	2.75" (69.8 mm)	1,000
4" (101.6 mm)	3.00" (76.2 mm)	1,000
4-1/2" (114.3 mm)	4.00" (101.6 mm)	1,000
5" (127.0 mm)	4.00" (101.6 mm)	1,000
5-1/2" (139.7 mm)	4.00" (101.6 mm)	500
6" (152.4 mm)	4.00" (101.6 mm)	500
6-1/2" (165.0 mm)	4.00" (101.6 mm)	500
7" (177.8 mm)	4.00" (101.6 mm)	500
7-1/2" (190.5 mm)	4.00" (101.6 mm)	500
8" (203.2 mm)	4.00" (101.6 mm)	500

Determine Required Screw Length As Follows:

Steel Decks:	Select fastener length to penetrate through the deck a minimum of 3/4" (19.1 mm).
Wood Decks:	Select fastener length to penetrate into or through deck a minimum of 1" (25.4 mm).
Concrete Decks:	Select fastener length to penetrate into deck a minimum of 1" (25.4 mm).

LEED INFORMATION:

Post Consumer Recycled Content:	0%
Post Industrial Recycled Content:	30%
Manufacturing Location:	Itasca, IL

FM APPROVED

Firestone Building Products Company
250 W. 96th Street, Indianapolis, IN 46260
Sales: (800) 428-4442 • Technical (800) 428-4511
www.firestonebpco.com

Vermont Testing
P.O. Box 420 • Waterbury, Vermont 05676
1-800-244-6131 • FAX (802) 244-5097

A2

DIVISION OF GEISSER ENGINEERING CORPORATION

Date: 09/20/2002
Job: 02-008
Project: Snow Guard Testing
Re: **PART NO. 115-3P**

Attn: Mr. Alan Stearns
Alpine SnowGuards
P.O. Box 430
Stowe, VT 05672
Ph: (888)766 4273 Fax: (888)-766 9994

Re: Shear Force and Pull-out Force to resist a 2000 Pound load at 3.875 inch from Base.

Dear Mr. Stearns:

As you requested, we have determined the shear force and pull-out force needed to resist a Ton or 2000 pound load at the most critical location of the SnowGuard Part # 115-3P. The load is assumed to be applied at the most far pipe connection which is at 3.875 inches from the base.

Each fastener holding the system to the roof at six locations should resist a shear force of at least 350-Pounds and a pullout force of at least 800-Pounds.
{TO RESIST 2000 #[SHEAR/FASTENER=350#]--PULLOUT/FASTENER=800#]}

Please feel free to contact me at 1-800 244 6131, if you have any questions or need further information.

STATE OF VERMONT
BERNARD K. CHE[illegible]
No. 3569
REGISTERED
PROFESSIONAL ENGINEER

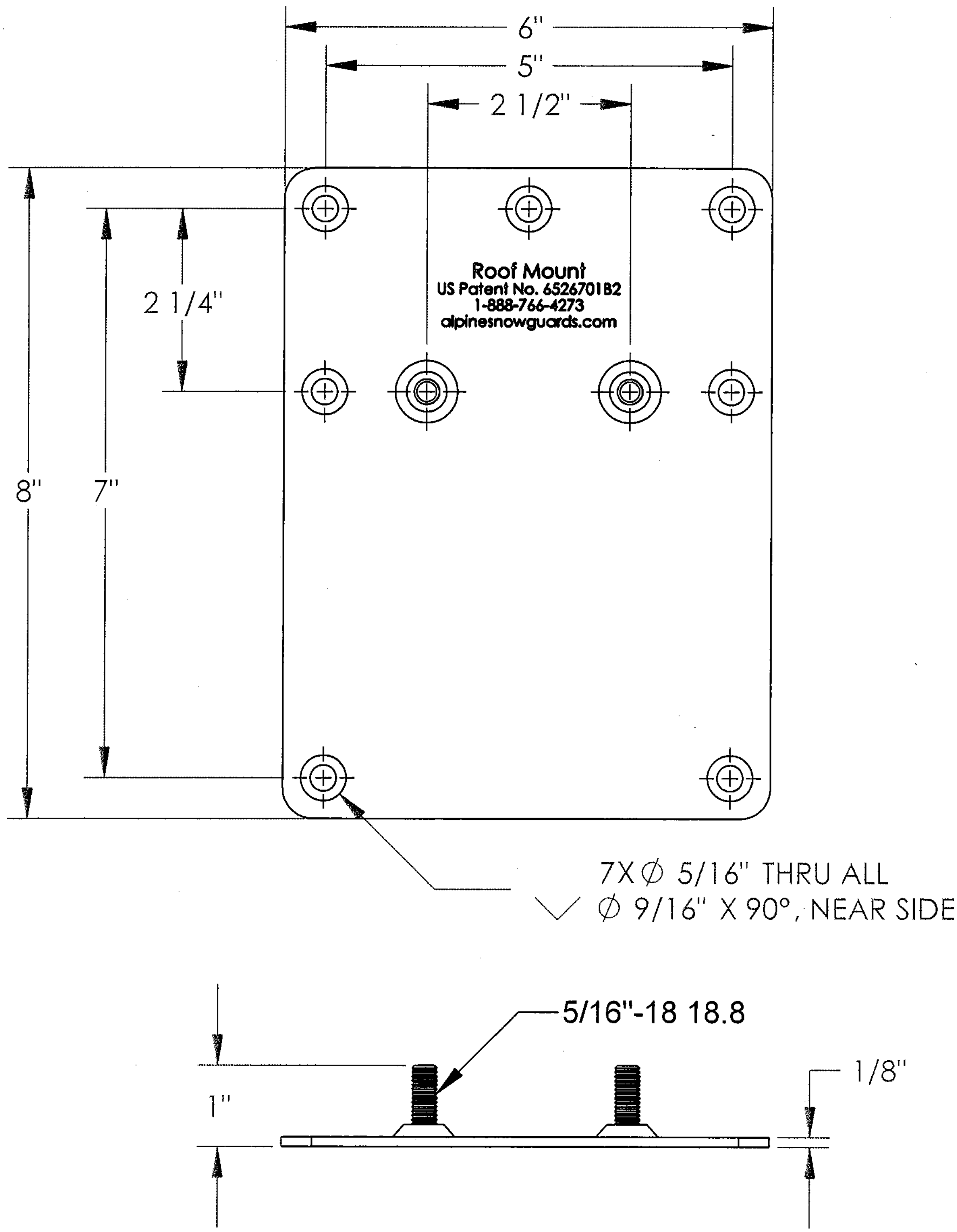
Yours Truly,

Jacques B. Bouramia, V.P.

Cut Sheet - #115 Base Plate

A3

1. Installation to be completed in accordance with manufacturer's written specifications and installation instructions.
2. See spec sheet or contact manufacturer for detailed material, finishes, and configuration options.
3. Contact manufacturer for detailed layout.
4. Do not scale drawings.
5. Subject to change without notice.



ALPINE SNOWGUARDS®
www.alpinesnowguards.com

289 Harrel Street
Morrisville, VT 05661
Toll Free Phone 1.888.766.4273
Toll Free Fax 1.888.766.9994

Material: 11 gage 304 Stainless Steel

Scale: 1:2 | 7/19/2010 | 07 72 53 Snow Guards

SIMPSON Strong-Tie®

SDS & SD Wood Screws

The Simpson Strong-Tie® Strong-Drive® screw (SDS) is a ¼" diameter structural wood screw ideal for various connector installations as well as wood-to-wood applications. It installs with no predrilling and has been extensively tested in various applications. The new SDS is improved with a patented easy driving 4CUT™ tip and a corrosion resistant double-barrier coating.

The SD8 #8x1¼" wafer head screw is ideal for miscellaneous fastening applications. The needle point ensures fast starts and deep #2 Phillips drive reduces cam-out and stripping.

SDS FEATURES:

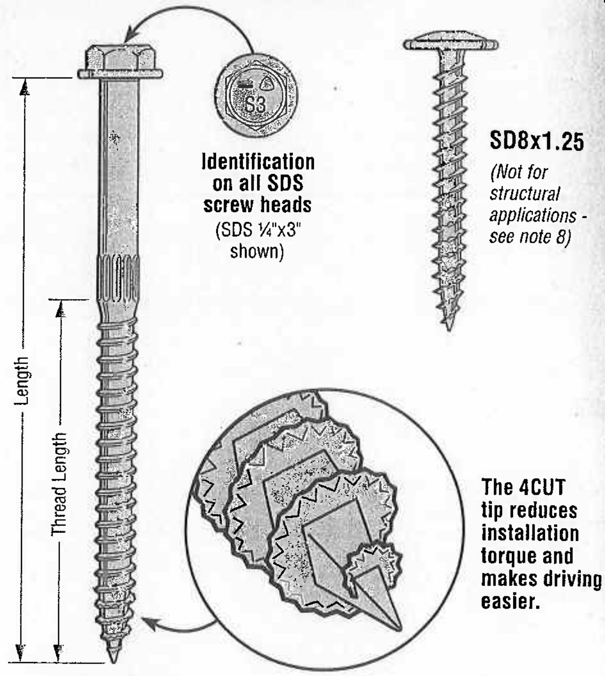
- The patented 4CUT tip has a square core and serrated threads to reduce installation torque and make driving easier with no predrilling and minimal wood splitting.
- A double-barrier coating finish provides corrosion resistance equivalent to hot-dip galvanization. Now one screw can handle interior, exterior and certain pressure-treated wood applications *(see Corrosion Information on page 18-19 for more information).*
- ⅜" hex washer head is stamped with the No-Equal sign and fastener length for easy identification after installation.

MATERIAL: Heat-treated carbon steel, Type-316 stainless steel

FINISH: SDS—New double-barrier coating. SDS screws may also be available yellow zinc dichromate or HDG *(Not all sizes are available in all coatings – Contact Simpson Strong-Tie for product availability and ordering information)*; SD8x1.25—Electro Galvanized.

CODES: See page 20 for Code Reference Key Chart.

WARNING: Industry studies show that hardened fasteners can experience performance problems in wet or corrosive environments. Accordingly, the SD8 should be used in dry, interior, and noncorrosive environments only.



SDS ¼"x3"
U.S. Patent 6,109,850; 5,897,280; 7,101,133

These products feature additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

SDS and SD Wood Screws

• Can use Timberlock if longer self-tapping screw needed

Size (in.)	Model No.	Thread Length (in.)	Fasteners per Carton[6]	DF/SP Shear (100)[1] Wood Side Plate[3] 1½"	DF/SP Shear Wood Side Plate 1¾" SCL	DF/SP Shear Steel Side Plate 16 ga	DF/SP Shear Steel Side Plate 14 ga & 12 ga	DF/SP Shear Steel Side Plate 10 ga or Greater	DF/SP Withdrawal[5] (100) Wood or Steel Side Plate	SPF/HF Shear (100) Wood Side Plate[3] 1½"	SPF/HF Shear Wood Side Plate 1¾" SPF LVL	SPF/HF Shear Steel Side Plate 16 ga	SPF/HF Shear Steel Side Plate 14 ga & 12 ga	SPF/HF Shear Steel Side Plate 10 ga or Greater	SPF/HF Withdrawal[5] (100) Wood or Steel Side Plate	Code Ref.
5/32 x 1¼	SD8x1.25[8]	—	—	—	—	50	50	50	—	—	—	45	45	45	—	170
¼ x 1½	SDS25112	1	1500	—	—	250	250	250	170	—	—	180	180	180	120	I5, L1, F20
¼ x 2	SDS25200	1¼	1300	—	—	250	290	290	215	—	—	180	210	210	150	
¼ x 2½	SDS25212	1½	1100	190	—	250	390	420	255	135	—	180	280	300	180	
¼ x 3	SDS25300	2	950	280	—	250	420	420	345	200	—	180	300	300	240	
¼ x 3½	SDS25312	2¼	900	340	340	250	420	420	385	245	245	180	300	300	270	
¼ x 4½	SDS25412	2¾	800	350	340	250	420	420	475	250	245	180	300	300	330	
¼ x 5	SDS25500	2¾	500	350	340	250	420	420	475	250	245	180	300	300	330	
¼ x 6	SDS25600	3¼	600	350	340	250	420	420	560	250	245	180	300	300	395	
¼ x 8	SDS25800	3¼	400	350	340	250	420	420	560	250	245	180	300	300	395	

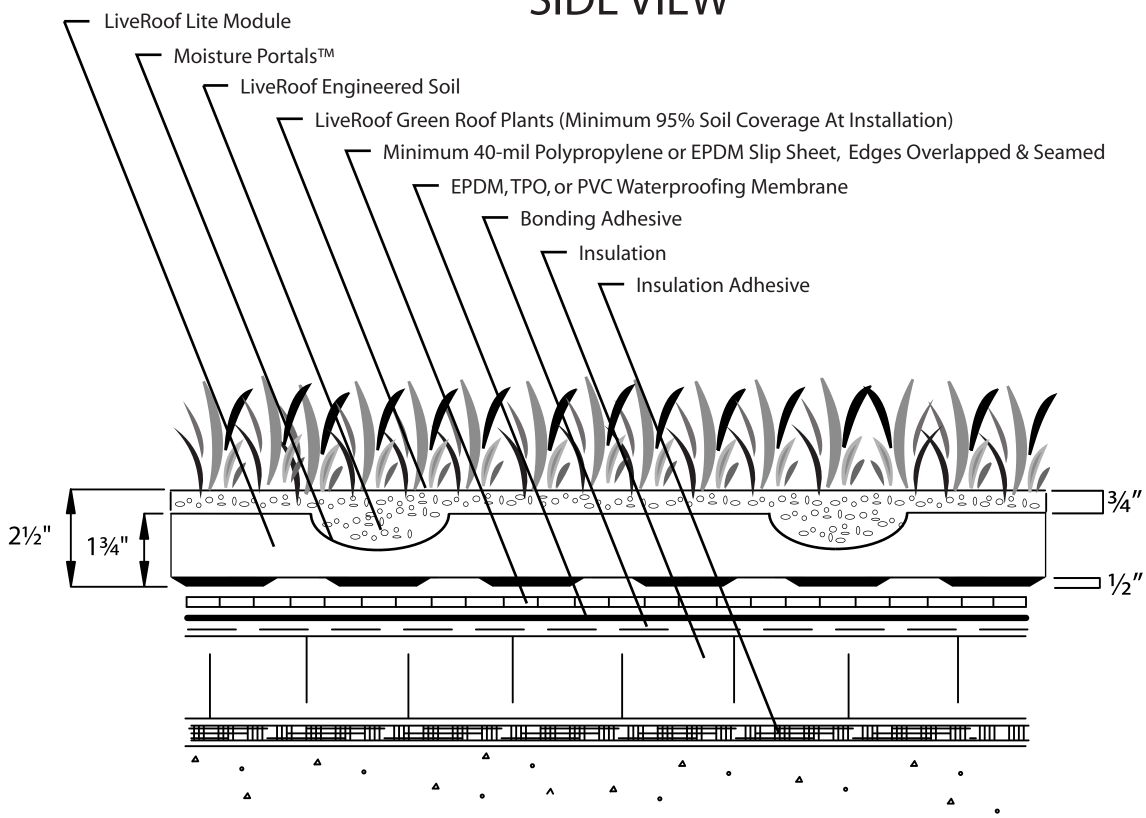
Stainless-Steel SDS Wood Screws

Size (in.)	Model No.	Thread Length (in.)	Fasteners per Carton[6]	DF/SP Shear (100) Wood Side Plate 1½"	DF/SP Shear Wood Side Plate 1¾" SCL	DF/SP Shear Steel Side Plate 16 ga	DF/SP Shear Steel Side Plate 14 ga & 12 ga	DF/SP Shear Steel Side Plate 10 ga or Greater	DF/SP Withdrawal[5] (100) Wood or Steel Side Plates	SPF/HF Shear (100) Wood Side Plate 1½"	SPF/HF Shear Wood Side Plate 1¾" SCL	SPF/HF Shear Steel Side Plate 16 ga	SPF/HF Shear Steel Side Plate 14 ga & 12 ga	SPF/HF Shear Steel Side Plate 10 ga or Greater	SPF/HF Withdrawal[5] (100) Wood or Steel Side Plates	Code Ref.
¼ x 1½	SDS25112SS	1	1500	—	—	250	250	250	170	—	—	180	180	180	120	I5, L1, F20
¼ x 2	SDS25200SS	1¼	1300	—	—	250	290	290	215	—	—	180	210	210	150	
¼ x 2½	SDS25212SS	1½	1100	190	—	250	390	420	255	135	—	180	280	300	180	
¼ x 3	SDS25300SS	2	950	280	—	250	420	420	345	200	—	180	300	300	240	
¼ x 3½	SDS25312SS	2¼	900	340	340	250	420	420	385	245	245	180	300	300	270	

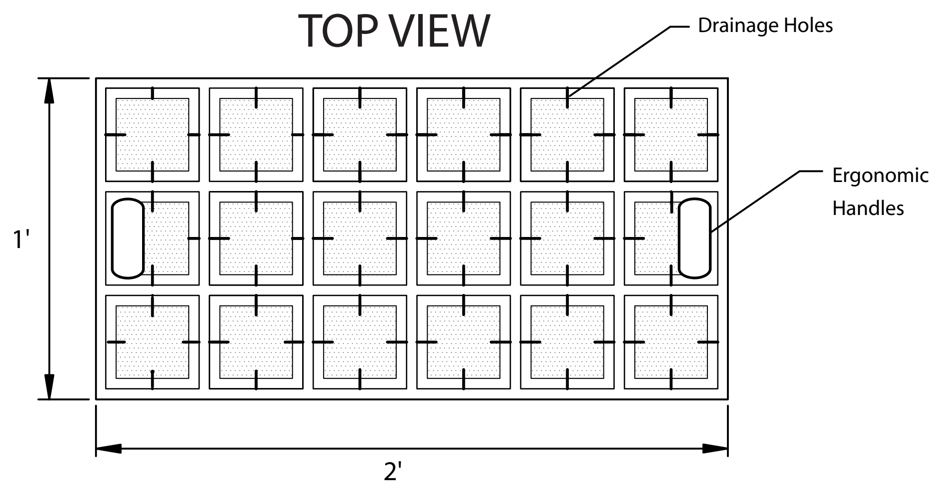
1. Screws may be provided with the 4CUT or Type 17 tip.
2. SDS screws install best with a low speed ½" drill with a ⅜" hex head driver.
3. All applications are based on full penetration into the main member.
4. Allowable loads are shown at the wood load duration factor of C_D=1.00. Loads may be increased for load duration per the building code up to a C_D=1.60.
5. Withdrawal loads shown are in pounds (lbs.) and are based on the entire threaded section installed into the main member. If thread penetration into the main member is less than the Thread Length as shown in the table, reduce allowable load by 172 lbs. x inches of thread not in main member. Use 121 lbs./inch for SPF.
6. Fasteners per Carton represent the quantity of screws which are available in bulk packaging. Screws are also available in mini bulk and retail packs. Refer to Simpson Strong-Tie® List Price book. Contact Simpson Strong-Tie for more information.
7. LSL wood-to-wood applications that require 4½", 5", 6" or 8" SDS screws are limited to interior-dry use only.
8. SD8x1.25 requires 3/4" minimum penetration. DO NOT USE SD8x1.25 wood screws with structural connectors unless specified and stated in this catalog.

LiveRoof LITE SYSTEM

SIDE VIEW



TOP VIEW



NOT TO SCALE

LITE A

ILLUSTRATIONS ARE TO CONCEPTUALLY ASSIST PROFESSIONALS IN DESIGNING LIVEROOF INSTALLATIONS. LIVEROOF DOES NOT ACCEPT RESPONSIBILTY FOR ENGINEERING BASED ON ILLUSTRATIONS. A QUALIFIED ROOFING SPECIALIST SHOULD BE CONSULTED TO DETERMINE APPROPRIATE WATERPROOFING AND ROOF DECK MATERIALS AND SUITABLE DESIGN.

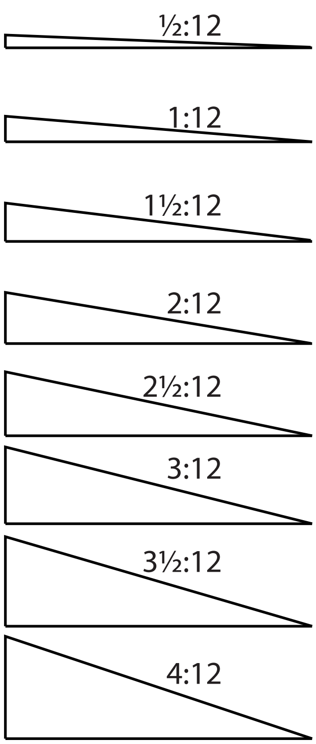
LiveRoof, LLC
P.O. Box 533
Spring Lake, MI 49456

(800) 875-1392
www.liveroof.com

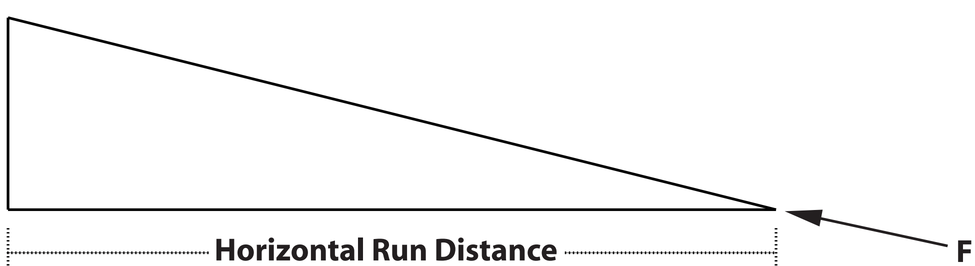
LiveRoof®

FORCE AGAINST ROOF EDGE FOR 17PSF GREEN ROOF LOAD

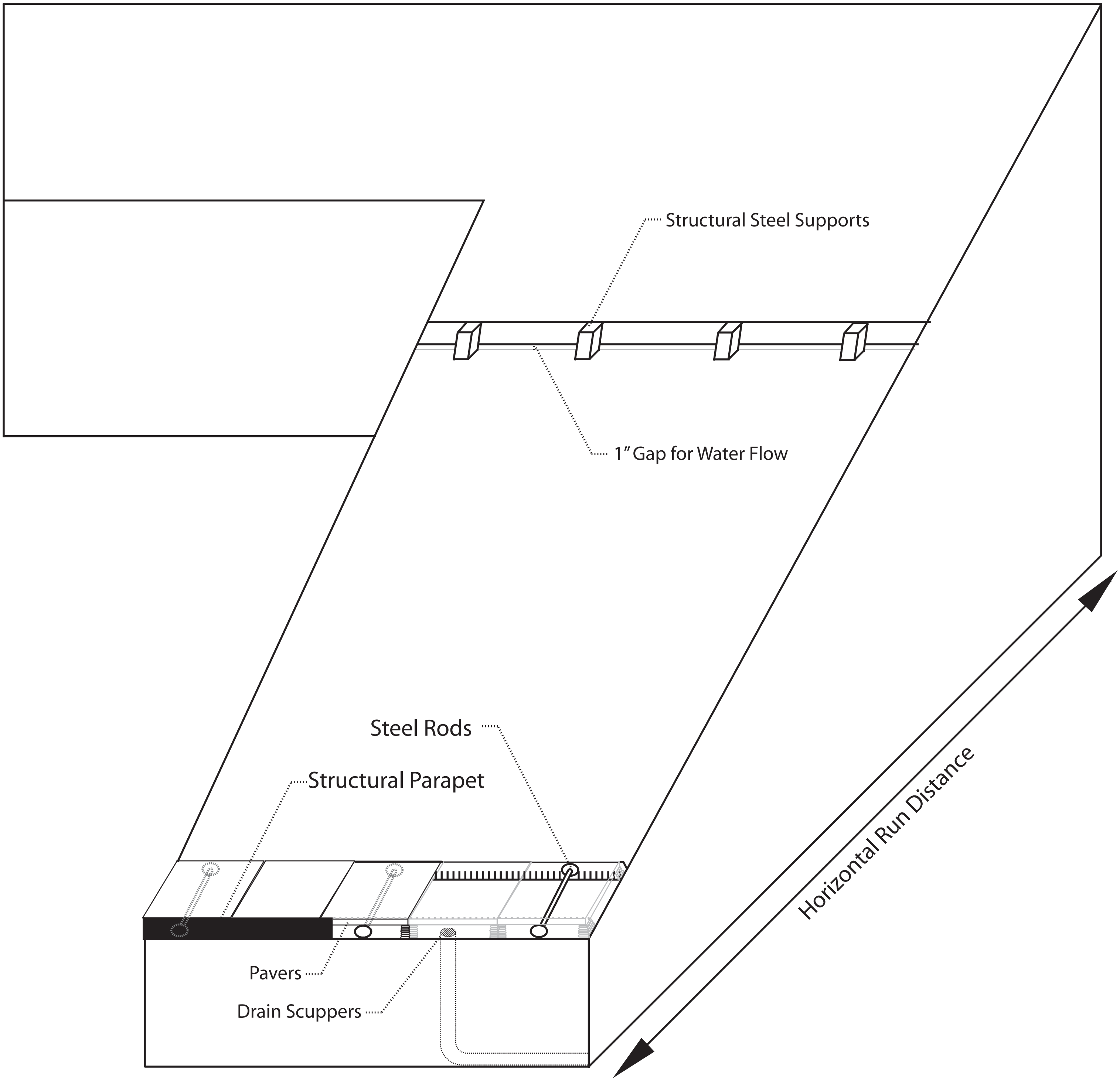
NOTE: Coefficient of friction (μ) is assumed to equal zero.



Roof Slope			Force Against Roof Edge, F (plf)				
			Horizontal Run Distance (ft)				
			10	**20**	**30**	**40**	**50**
1/2:12	4.20%	2.4°	7	14	21	29	36
1:12	8.30%	4.8°	14	29	43	57	71
1 1/2:12	12.50%	7.1°	21	42	64	85	106
2:12	16.70%	9.5°	28	57	85	114	142
2 1/2:12	21.00%	11.8°	36	71	107	142	178
3:12	25.00%	14.0°	42	85	127	170	212
3 1/2:12	29.20%	16.3°	50	99	149	199	249
4:12	33.30%	18.4°	57	113	170	226	283



LOADING 17PSF



For sloping roofs, LiveRoof suggests a conservative model that assumes "zero" coefficient of friction during winter (as might be the case when ice forms underneath the modules). During freezing temperatures, the green roof is capable of exerting substantial downward force against the lower edge of the roof. Such force should be resisted with appropriate engineering and design. For some roofs, a structural parapet may suffice. On very long roofs, structural steel supports are sometimes incorporated into the roof design.

See Loading Tables for Slope Force.
See Detail Drawings SLOPE-A, SLOPE-B, & SLOPE-C.

NOT TO SCALE

LiveRoof®

LiveRoof Edge™

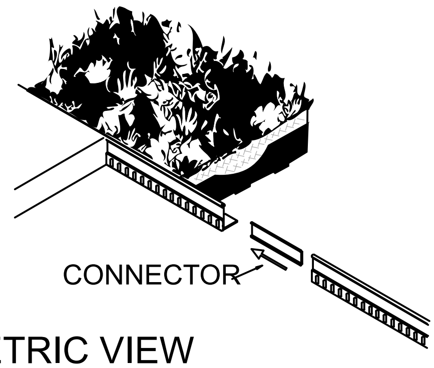
PERMALOC CORPORATION, 13505 BARRY STREET HOLLAND, MI 49424
(800) 356-9660 PHONE: (616) 399-9600 FAX: (616) 399-9770 WWW.PERMALOC.COM

FOR USE WITH: LiveRoof

ARCHITECT NOTE: CHECK OFF APPLICABLE SIZE & FINISH DESIRED

SIZE: ALL 8' (2.44M) LENGTHS w/ 0.250" (6.35MM) THICK EXPOSED TOP LIP

☐	3" x 3.25"	(76MM x 83MM)	☐MF	☐BL
☐	4.25" x 3.25"	(108MM x 83MM)	☐MF	☐BL
☐	6.5" x 5.5"	(165MM x 140MM)	☐MF	☐BL



ISOMETRIC VIEW
NTS

FINISH LEGEND:

(MF) MILL FINISH-NATURAL ALUMINUM
(BL) BLACK DURAFLEX-ELECTROSTATICALLY APPLIED BAKED ON PAINT, MEETS AAMA 2603

PERMALOC LIVEROOF EDGE ALUMINUM RESTRAINT

GREENROOF MODULE

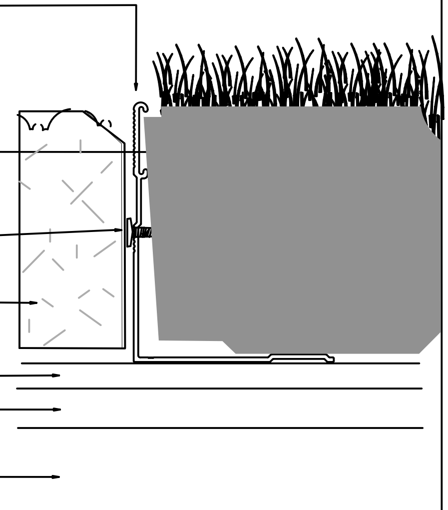
TEKS 10-16 X 1" WAFER HEAD GRAY SPEX FINISH**

PAVER OR BALLAST

SLIP SHEET

WATERPROOF LAYER

CONCRETE ROOF (NEW OR EXISTING)

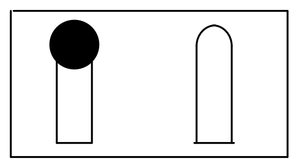


NOTES:

1. INSTALLATION PER MANUFACTURER'S RECOMMENDED "INSTALLATION GUIDELINES" IN ACCORDANCE WITH DESIGNER'S INSTRUCTIONS.*
2. 8'-0" (2.44M) SECTIONS CONNECTED WITH 2 - 2.75" (70MM) SLIDING CONNECTORS.
3. CORNERS: REMOVE BASE TABS AND FORM A CONTINUOUS CORNER.
4. PERMALOC GEOEDGE AS MANUFACTURED BY PERMALOC CORPORATION, HOLLAND MI. (800) 356-9660 (616) 399-9600
5. CONTRACTOR'S NOTE: FOR PRODUCT AND PURCHASING INFORMATION VISIT: WWW.PERMALOC.COM

*DESIGNER MAINTAINS ULTIMATE RESPONSIBILITY FOR VALIDITY AND SAFETY OF THE INSTALLATION.

PLACE TEK SCREW AT TOP OF DRAINAGE HOLE AS SHOWN.



SPACE SCREWS EQUALLY- MINIMUM OF TWO PER TRAY

MANUFACTURER RECOMMENDS EDGING BE FASTENED TO TRAYS FOR ALL APPLICATIONS.

**AVAILABLE FROM FASTENAL (507)454-5374. MODEL #32091.

EDGING FOR LIVEROOF MODULES

SCALE: 3"=1'-0"

LR1.dwg

FINNISH
ThermoWood
ASSOCIATION

ThermoWood®
Handbook

Finnish Thermowood Association
c/o Wood Focus Oy, P.O. Box 284 (Snellmaninkatu 13), FIN-00171 Helsinki, FINLAND,
tel. +358 9 6865 4522, fax +358 9 6865 4530
www.thermowood.fi

Preface

This handbook has been produced by the members of the Finnish Thermowood Association. When new products and methods of production enter the various markets, it is very important to offer as much information as possible concerning the product and process so as to raise and maintain the level of knowledge as efficiently as possible. Therefore, we hope that this handbook will act as a good information source for specifiers, end users in industry, construction companies, timber merchants, etc.

The aim of the handbook is to present a good mix between theoretical material, laboratory results, information from field testing, and, finally, practical advice for working with the product. The results have been collected from a wide range of sources, most of which are of research institute or university status; experiences of industrial manufacturers have been included too. The results and experiences presented in this handbook should only be used as a guide and are subject to change.

One of the roles of the Finnish Thermowood Association will involve updating this handbook on a regular basis. As new results and experiences become available, new editions will be published outlining the areas that have been updated.

The name ThermoWood is a registered trademark, and may be used only by members of the Finnish ThermoWood Association.

We hope that the readers of this handbook will find it both informative and useful.

CONTENTS

1. Introduction

1.1. Background

It has been known for centuries that burning the surface of wood in open fire will make it more durable in exterior use. Even the Vikings used this method in outdoor structures such as fences.

Heat treatment of wood was scientifically studied by Stamm and Hansen in the 1930s in Germany and by White in the 1940s in the United States. In the 1950s, Germans Bavendam, Runkel, and Buro continued research into the subject. Kollman and Schneider published their findings in the 1960s, and Rusche and Burmester in the 1970's. More recently, research work was carried out in Finland, France, and the Netherlands in the 1990s. The most intensive and comprehensive research work was conducted by VTT in Finland. Significant practical research is also being done by YTI (the Institute of Environmental Technology).

ThermoWood is manufactured using a method developed by VTT. The wood material is heated to a temperature of at least 180 degrees Celsius while it is protected with steam. Besides providing protection, the steam also affects the chemical changes taking place in the wood. As a result of the treatment, environmentally friendly ThermoWood is created. Its colour darkens, it is more stable than normal wood in conditions of changing humidity, and its thermal insulation properties are improved. If carried out at a sufficiently high temperature, treatment also makes the wood resistant to decay. On the other hand, this has a decrease in the bending strength.

1.2. The ThermoWood process in brief

An industrial scale heat-treatment process for wood has been developed at VTT in co-operation with the Finnish wood product industry. The ThermoWood process is licensed to the members of the Finnish Thermowood Association.

The ThermoWood process can divided into three main phases:

– **Phase 1.** Temperature increase and high-temperature drying
  Using heat and steam, the kiln temperature is raised rapidly to a level of around 100 ºC. Thereafter, the temperature is increased steadily to 130 ºC, during which time the high-temperature drying takes place and the moisture content in the wood decreases to nearly zero.
– **Phase 2.** Heat treatment
  Once high-temperature drying has taken place, the temperature inside the kiln is increased to between 185 ºC and 215 ºC. When the target level has been reached, the temperature remains constant for 2–3 hours depending on the end-use application.
– **Phase 3.** Cooling and moisture conditioning
  The final stage is to lower the temperature by using water spray systems; when the temperature has reached 80–90 ºC, re-moisturising takes place to bring the wood moisture content to a useable level, 4–7%.

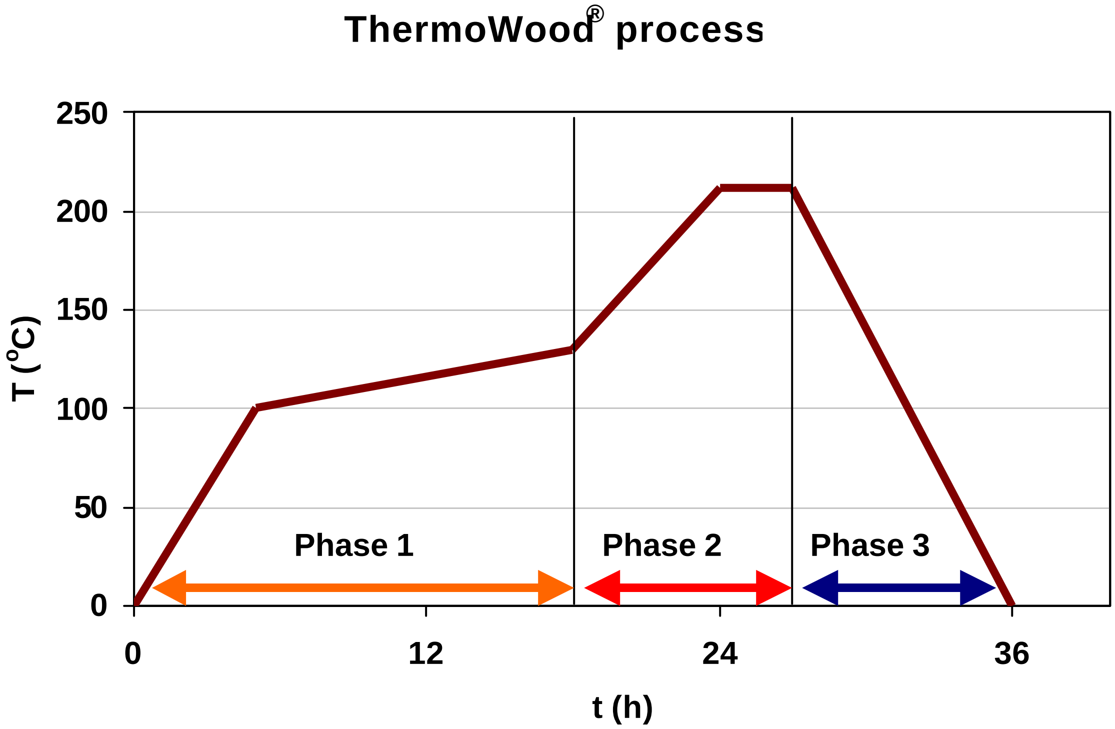


Figure 1-1. Diagram of the production process

When the temperature is raised or lowered, a special adjustment system is used in order to prevent surface and inside splitting and checking. Customised adjustment values are used for different wood species and dimensions.

The raw material can be green or kiln-dried wood. If the process is begun with green wood, the wood can be dried in a very fast high-temperature drying process. The method is suitable for softwood and hardwood species. However, the process must be optimised separately for each wood species.

For more specific details on the ThermoWood process, see chapter 3.

1.3. Changes in wood structure and chemical reactions

As a result of the heat treatment process the wood structure is re-formed, the following pictures show how the structure differs between normal untreated pine and heat treated pine.

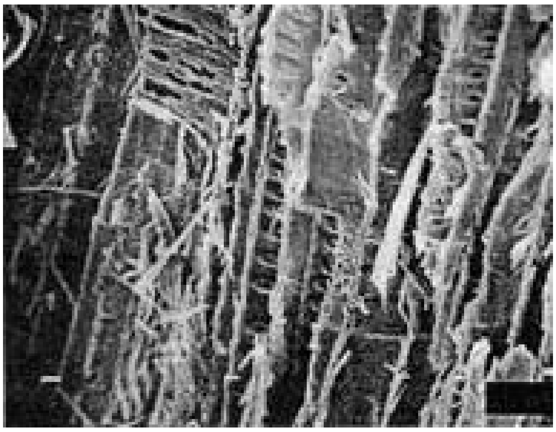


Figure 2-1. Untreated pine

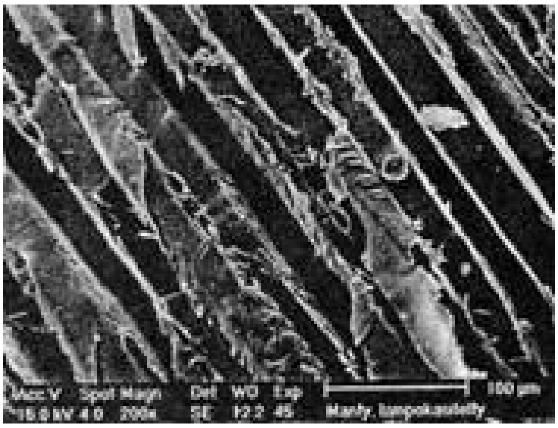


Figure 3-1. Heat-treated pine

Heating wood permanently changes several of its chemical and physical properties. The change in properties is mainly caused by thermic degrading of hemicelluloses. Desired changes start to appear already at about 150 ºC, and the changes continue as the temperature is increased in stages. As a result, swelling and shrinkage due to moisture is decreased, biological durability is improved, colour darkens, several extractives flow from the wood, the wood becomes lighter, equilibrium moisture content decreases, pH decreases, and thermal insulation properties are improved. However, the wood's rigidity and strength properties are also changed.

1.4. Standard ThermoWood treatment classification

Softwood and hardwood species have a separate classification since their properties clearly differ. There are two classes of heat treatment. Having more than two classes is not reasonable since wood properties change slowly at first as the temperature increases. Once the treatment temperature exceeds 200 ^{o}C, the properties change rapidly. Using more than two classes would generate a risk of mixing properties of different classes. 215 ^{o}C is sufficient as a maximum temperature value yet is not so high that the effects of heat treatment on the wood's structural properties would be significant.

In the standard class of ThermoWood treatment, swelling and shrinkage of wood due to moisture, colour change, and biological durability are emphasised as key properties.

Since the ThermoWood material to be supplied to industrial customers is heat-treated in accordance with the agreements between the purchaser and producer, the processing level can be carefully optimised according to the end use application. In this case, the material will be ThermoWood that is not categorised according to the standard treatment classification scheme.

Standard ThermoWood treatment classes
ThermoWood has two standard treatment classes, Thermo-S and Thermo-D.

Thermo-S
The letter 'S' in 'Thermo-S' stands for 'stability'. Along with appearance, stability is a key property in the end use applications of the products in this treatment class. The average tangential swelling and shrinkage due to moisture for Thermo-S class treated wood is 6–8%. Thermo-S class ThermoWood is classified as relatively durable according to the standard EN 113; i.e., its natural resistance to decay meets class 3 requirements.

Recommended end use applications for Thermo-S class heat-treated timber:

Thermo-S Softwood	Thermo-S Hardwood
- building components - furnishing in dry conditions - fixtures in dry conditions - furniture - garden furniture - sauna benches - door and window components	- furnishing - fixtures - furniture - flooring - sauna structures - garden furniture

Thermo-D
The letter 'D' in 'Thermo-D' stands for 'durability'. Along with appearance, biological durability is a key property in the end use applications of products in this treatment class. The average tangential swelling and shrinkage due to moisture for Thermo-D class treated wood is 5–6%. Thermo-D class ThermoWood is classified as durable according to the EN 113 standard; i.e., its natural resistance to decay meets class 2 requirements.

Recommended end use applications for Thermo-D class heat-treated timber:

Thermo-D Softwood	Thermo-D Hardwood
- cladding - outer doors - shutters - environmental constructions - sauna and bathroom furnishing - flooring - garden furniture	End use applications as in Thermo-S. If a darker colour is desired, Thermo-D should be used.

Summary of the effects of the ThermoWood process on wood properties, by treatment class

Softwoods (pine and spruce)

	Thermo-S	Thermo- D
Treatment temperature	190 °C	212 °C
Weather resistance	+	++
Dimensional stability	+	++
Bending strength	no change	-
Colour darkness	+	+ +

Hardwoods (birch and aspen)

	Thermo-S	Thermo- D
Treatment temperature	185 °C	200 °C
Weather resistance	no change	+
Dimensional stability	+	+
Bending strength	no change	-
Colour darkness	+	+ +

1.5. List of standards

– EN 20 – 1	Wood preservatives. Determination of the protective effectiveness against Lyctus Brunneus (Stephens). Part 1: Application by surface treatment (laboratory method)
– EN 21	Wood preservatives. Determination of the toxic values against Anobium punctatum (De Geer) by larval transfer (Laboratory method)
– EN 46	Wood preservatives. Determination of the preventive action against recently hatched larvae of Hylotrupes bajulus (Linnaeus) (Laboratory method)
– EN 47	Wood preservatives. Determination of the toxic values against Hylotrupes bajulus (Linnaeus) larvae (Laboratory method)
– EN 84	Wood preservatives. Accelerated ageing of treated wood prior to biological testing. Leaching procedure
– EN 113	Wood preservatives. Test method for determining the protective effectiveness against wood destroying basidiomycetes. Determination of the toxic values
– EN 117	Wood preservatives. Determination of toxic values against Reticulitermes santonensis de Feytaud (Laboratory method)
– EN 252	Field test method for determining the relative protective effectiveness of a wood preservative in ground contact
– EN 302-2	Adhesives for load-bearing timber structures; test methods; part 2: determination of resistance to delamination (laboratory method)
– EN 335 – 1	Durability of wood and wood-based products - Definition of hazard classes of biological attack - Part 1: General
– EN 335 – 2	Durability of wood and wood-based products - Definition of hazard classes of biological attack - Part 2: Application to solid wood
– EN 350 – 1	Durability of wood and wood-based products. Natural durability of solid wood. Part 1: Guide to the principles of testing and classification of the natural durability of wood
– EN 350 – 2	Durability of wood and wood-based products. Natural durability of solid wood. Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe
– EN 392	Glued laminated timber - Shear test glue lines
– EN 408	Timber structures. Structural timber and glued laminated timber. Determination of some physical and mechanical properties
– EN 460	Durability of wood and wood-based products - Natural durability of solid wood - Guide to the durability requirements for wood to be used in hazard classes
– ENV 807	Wood preservatives. Determination of the effectiveness against soft rotting micro-fungi and other soil inhabiting micro-organisms
– EN 927 – 1	Paints and varnishes. Coating materials and coating systems for exterior wood. Part 1: Classification and selection

– EN 927 – 3 Paints and varnishes. Coating materials and coating systems for exterior wood. Part 3: Natural weathering test
– EN 927 – 4 Paints and varnishes. Coating materials and coating systems for exterior wood. Part 4: Assessment of the water-vapour permeability
– EN 927 – 5 Paints and varnishes. Coating materials and coating systems for exterior wood. Part 5: Assessment of the liquid water permeability
– EN 12037 Wood preservatives - Field test method for determining the relative protective effectiveness of a wood preservative exposed out of ground contact - Horizontal lap-joint method
– ISO 5660 – 1 Fire tests; reaction to fire; part 1: rate of heat release from building products (cone calorimeter method)
– ISO 6341 Water quality -- Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) -- Acute toxicity test
– ASTM D 3273 Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings In an Environmental Chamber

2. Raw material

2.1. Factors affecting the quality of heat-treated wood

2.1.1. General

The quality of raw material has a significant effect on the quality of the final heat-treated wood product. In principle, all wood species can be heat-treated. However, the parameters used for the process must be optimised separately for each wood species.

2.1.2. Wood species

In Finland, the species used for heat treatment are pine (*Pinus sylvestris*), spruce (*Picea abies*), birch (*Betula pendula*), and aspen (*Populus tremula*). In addition, some experience has been gained in the treatment of Radiata pine (*Pinus radiata*), ash (*Fraxinus excelsior*), larch (*Larix sibirica*), alder (*Alnus glutinosa*), beech (*Fagus silvativa*), and eucalyptus.

There are differences between wood species in terms of annual growth, wood cells, wood pores, the number of chemical components, etc. Moreover, different wood species have, for example, different fibre length properties: the softwoods feature a wide distribution in fibre length compared with hardwoods which on average have much shorter fibre length and less variance.

2.2. Sawn timber quality

2.2.1. General Nordic Softwood timber quality grades

The quality of sawn timber as raw material is controlled with a general quality grading system. The quality grades are divided into three groups according to the number, quality, location, and size of the knots and other features. These are A, B, and C grades, with Grade A divided further into sub-grades A1, A2, A3, and A4. In addition, sawmills use several customer-specific grading applications.

2.2.2. Knots

The figures below show different knot types, which are taken into account when selecting the raw material. For the most part, only sawn timber grades with sound knots are selected for heat-treatment.

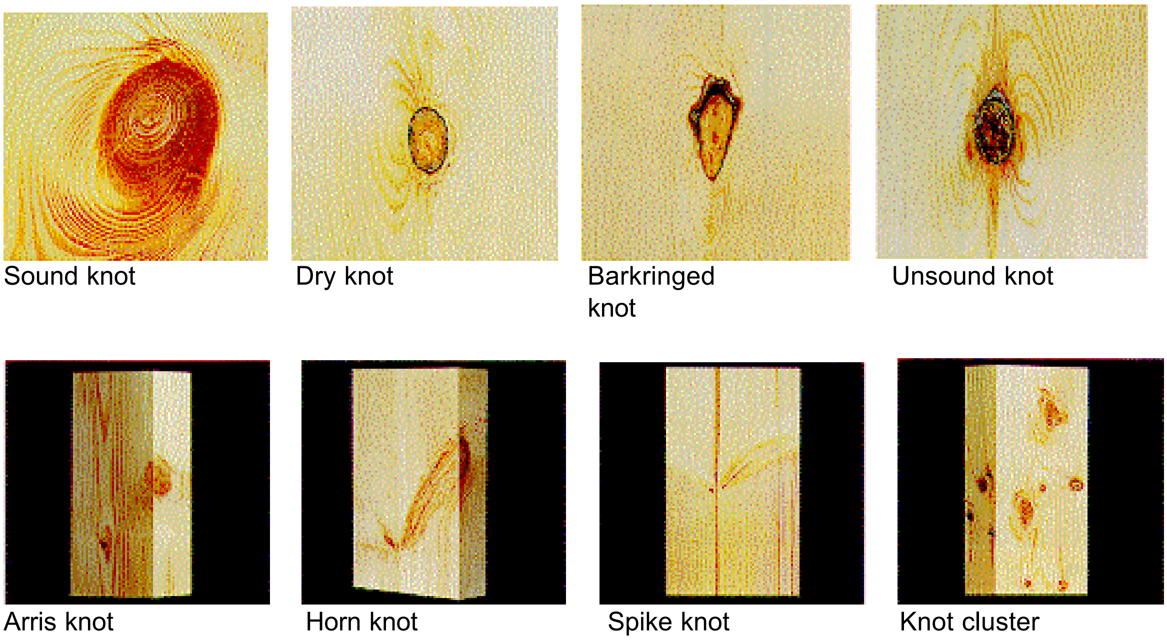


Figure 1-2. Knot types

2.2.3. Minimum requirements for raw material

The Finnish Thermowood Association has established quality level thresholds for pine, spruce, and hardwood timber used as raw material for ThermoWood. These minimum quality requirements are presented in tables 1 to 3 below.

Table 1-2. Quality requirements for pine timber used for heat-treatment

QUALITY			**A+B furniture**
KNOTS [1] on the worst 2 metres of length			pcs
Sound/dead		On face	8/2
		On edge	4/1
Knots with bark			Not permitted
Knot hole or loose knot			Not permitted
Maximum size of a sound knot on the face			Knot size, mm
Dimension	16, 19, 22, 25 * 75, 100, 115		35
	125, 150		55
	175, 200, 225		55
	32, 38, * 75, 100, 115		55
	125, 150		55
	175, 200, 225		60
	44, 50, *75, 100, 115		60
	125, 150		60
	175, 200, 225		70
	63, 75, * 75, 100, 115		60
	125, 150		60
	175, 200, 225		65
Maximum size of a sound knot on the edge			Knot size, mm
Timber thickness, mm		16,19	= thickness
		22, 25	22
		32, 38	30
		44, 50	40
		63, 75	50
Other knots Tight knots in grades A and B			Maximum size in % of sound knot size
Knot cluster, per knot [2]			70
Dead knot [3]			20
Bark ringed knot [4]			Not permitted
Unsound knot			Not permitted
Other faults			
Top rupture			Max. 20% of width
Exposed pith			Permitted

1	If the knot size is smaller than the value given in the table, the higher number of knots is permitted. However, the sum of knot sizes in mm (= the number of knots * diameter) may not be exceeded for the respective types of knots.
2	A knot cluster consists of a minimum of 4 knots with a diameter exceeding 12 mm, with all located within 150 mm of length on the outside face and the edges. If the knots are not clearly separated by undisturbed grain, they are classified as one knot and evaluated accordingly.
3	If a knot is intergrown to more than ¾ with the surrounding wood, it is considered a sound knot.
4	If less than ¼ of a knot is encircled by bark, it is classified as a dead knot.

Table 2-2. Quality requirements for spruce timber used for heat-treatment

QUALITY			ST 1-5
KNOTS [1] on the worst 2 metre of length			pcs
Sound/dead		On face	8/2
		On edge	4/1
Knots with bark			Not permitted
Knot hole or loose knot			Not permitted
Maximum size of a sound knot on the face			Knot size, mm
Dimension	16, 19, 22, 25 * 75, 100, 115		35
	125, 150		40
	175, 200, 225		45
	32, 38, * 75, 100, 115		40
	125, 150		45
	175, 200, 225		50
	44, 50, *75, 100, 115		45
	125, 150		50
	175, 200, 225		55
	63, 75, * 75, 100, 115		50
	125, 150		55
	175, 200, 225		60
Maximum size of a sound knot on the edge			Knot size, mm
Timber thickness, mm		16,19	= thickness
		22, 25	22
		32, 38	30
		44, 50	40
		63, 75	50
Other knots Tight knots in grades A and B			Maximum size in % of sound knot size
Knot cluster, per knot [2]			The sum of knots may not be exceeded
Dead knot [3]			20
Bark ringed knot [4]			Not permitted
Unsound knot			Not permitted
Other faults			
Top rupture			Max. 20% of width
Exposed pith			Permitted

1	If the knot size is smaller than the value given in the table, the higher number of knots is permitted. However, the sum of knot sizes in mm (= the number of knots * diameter) may not be exceeded for the respective types of knots.
2	A knot cluster consists of a minimum of 4 knots with a diameter exceeding 12 mm, with all located within 150 mm of length on the outside face and the edges. If the knots are not clearly separated by undisturbed grain, they are classified as one knot and evaluated accordingly.
3	If a knot is intergrown to more than ¾ with the surrounding wood, it is considered a sound knot.
4	If less than ¼ of a knot is encircled by bark, it is classified as a dead knot.

Table 3-2. Quality requirements for hardwood timber used for heat-treatment

QUALITY REQUIREMENTS (applies to all hardwood timber used for heat-treatment)		
	GRADE E Definition: 4-side knot-free, fully faultless side cut	**GRADE A** Definition: 3-side knot-free side cut
Minimum dimensions at delivery moisture content (about 18%)		
Width	Nominal dimension + 6%, with a few millimetres more permitted	
Thickness	Nominal dimension + 3%, with a few millimetres more permitted	
Splits / fissures	Not permitted	
Wane	Not permitted	
Spring	= 8 mm / 3 m	
Bow	= 15 mm / 3 m	
Twist	= 10 mm / 3 m	
Moisture content	< 20%, even in whole batch	
Blue stain	Not permitted	
Delivery length	> 2 100 mm, can be shorter if separately agreed	
Packaging	According to lengths, at 100 mm intervals	
Heartwood Dark or light	Not permitted	Not permitted
Discoloration caused by seasoning	Not permitted	
Discoloration caused by sawing time or storage	Not permitted	
Even discoloration	As agreed	
Species-specific quality instructions	**Birch** Flame and mineral spots permitted.	**Birch** On the worse face, two knots, max. size 10 mm, or one dead knot, max. size 10 mm per timber metre is permitted. Grey heartwood is permitted on single timber pieces max. 20 mm width on 0.5 m of length. **Aspen** On the worse face, some surface knots and discolorations permitted on single timber pieces.
	Aspen No wetwood or cell collapse permitted.	

2.2.4. Wood moisture

With regard to the success of heat-treatment, the wood's starting moisture content has no significance. Treatment can be undertaken with either green or dried wood. In any case, the wood is dried until absolutely dry in the first phase of the treatment. Drying is the longest phase in the heat-treatment process.

Green wood contains water in two forms: free water in cell lumens and bound water in cell walls. During drying, some of the water in the cell lumens travels via capillaries in the direction of the grain due to surface tension and steam pressure differences. If the pores between one cell lumen and another enable its free travel, water can travel several metres. Otherwise, capillary drying reaches only a few cells from the ends of the wood. The great majority of the water is removed by diffusion through the cell walls in the form of steam. This occurs through the cell lumens perpendicular to the grain.

3. The ThermoWood prosess

3.1. Equipment

In the heat treatment process, water, steam, and high temperatures are used. The process conditions are corrosive, as are the constituent compounds evaporating from the wood.

Heat-treatment equipment is made of stainless steel. In addition, high temperature requires non-standard blower and radiator solutions and safety devices.

To generate the required heat in the ThermoWood process hot oil heating systems can be used and fuelled by biofuel, fuel oil, or gas. Other heating solutions, such as direct electric heating, are utilised too. In addition, the equipment used must feature a steam generator for generating the steam required by the process.

Gases evaporating from the wood during the process are processed by such methods as burning. The primary purpose of the processing is to prevent an odour nuisance being imposed on the environment due to compounds evaporating from the wood.

3.2. Phases

Drying

Drying is the most time-consuming phase in the heat-treatment process. This phase is also called high-temperature drying. During this phase, the moisture content in the wood is reduced to nearly zero before the heat-treatment phase begins. The duration of the drying phase depends on the initial moisture content of the wood, wood species, and timber thickness. Raw material can be green or dried wood.

Successful drying is important in order to avoid internal checks. Since the wood becomes elastic at high temperatures, its resistance to deformation is better than in traditional kiln drying.

Heat treatment

The heat treatment is carried out in a closed chamber in which the temperature is increased to 185–215 ºC, depending on the processing level. The heat treatment phase starts immediately after the high-temperature drying phase. Steam is used during the drying and heat treatment as a protective vapour. Protective gas prevents the wood from burning and also affects the chemical changes taking place in the wood. The heat-treatment phase takes 2–3 hours.

Conditioning

Conditioning is carried out after the heat treatment. The wood is cooled down in a controlled way after heat treatment. Care must be taken in this stage as the high temperature difference between the wood and outside air can cause splitting. In addition, the wood must be re-moisturised in order to bring it to an appropriate moisture level for end use. The final moisture level of the wood has a significant effect on its working properties – it is difficult to work with wood that is too dry. After the conditioning, the final moisture of the wood should be 5–7%. Depending on the treatment temperature and timber, the conditioning phase takes 5–15 hours.

3.3. Energy

Energy is needed mainly for drying the wood, which accounts for 80% of the heat energy used. The total energy demand is only 25% higher than that of the ordinary timber drying process. The electricity requirement is the same as for ordinary timber drying.

3.4. Environmental issues

Since no chemicals are required and only water and heat are used, the ThermoWood process is environmentally friendly. As the process releases extractives from the wood, these must be processed - for example, by burning to avoid an odour nuisance.

No significant amount of waste water is generated by the ThermoWood process. The solid components of the generated waste water are separated out in a special settling basin, and the rest is processed at waste water works.

4. ThermoWood properties

All the properties described in this chapter are based on the results of a range of tests, conducted over a period of several years, concerning heat treatment of wood. These properties should be used as a guide only and are subject to variation due to the natural differences between timber pieces. The information is based on current knowledge. Further testing is constantly underway in order to verify previous test results and to accumulate a statistically significant database concerning the most important ThermoWood properties.

Most of the tests that have been carried out are on softwoods (pine, spruce), but some tests have also been carried out on hardwoods (birch, aspen). The differences between spruce and pine are not great, but natural differences such as density and knot type obviously exist.

4.1. Chemical changes

4.1.1. General

VTT, the Helsinki University of Technology, and the University of Helsinki have published several scientific papers about chemical changes in heat-treated wood as part of their joint project entitled ‘Reaction Mechanisms of Modified Wood’ during 1998–2001. In addition, Risto Kotilainen from the University of Jyväskylä has written a dissertation called ‘Chemical Changes in Wood during Heating at 150–260 ºC’.

Understanding the numerous changes that take place in the physical and chemical structure of wood during the heating process requires a good basic knowledge of its chemical composition, structure, and physical properties.

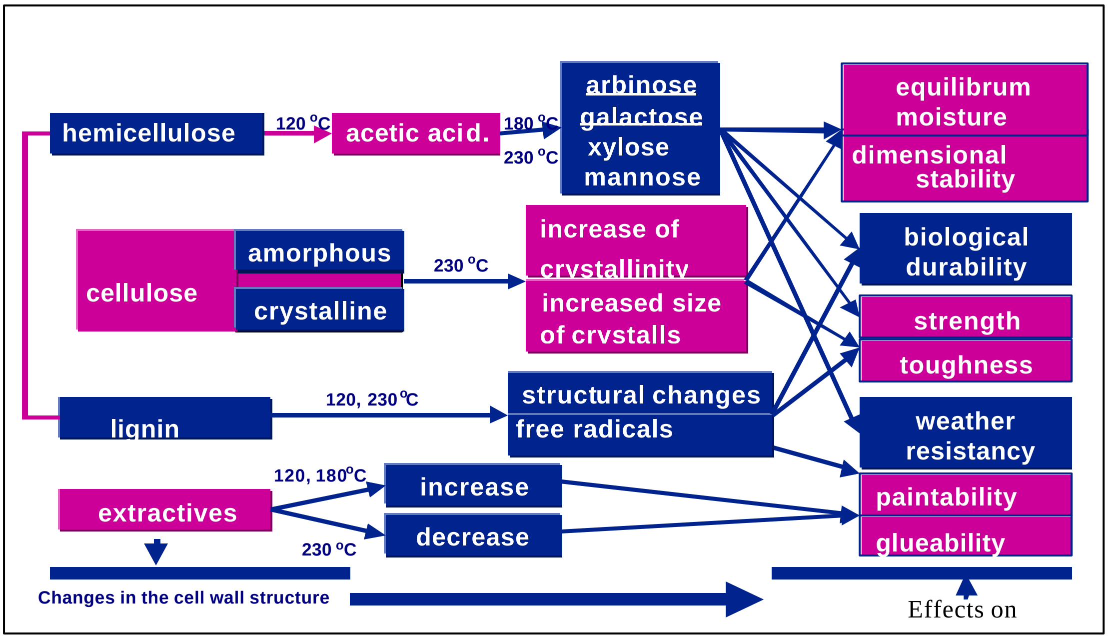


Figure 1-4. Reaction mechanisms of heat-treated wood (source: VTT).

The main components of wood (cellulose, hemicelluloses, and lignin) degrade in different ways under heat. Cellulose and lignin degrade more slowly and at higher temperatures than the hemicelluloses. The extractives in the wood degrade more easily, and these compounds evaporate from the wood during the heat treatment.

4.1.2. Carbohydrates

Cellulose and hemicelluloses are carbohydrates that are structural components in wood. Cellulose constitutes 40–50% and hemicelluloses 25–35% of wood. Cellulose is a long chain (DP 5000–10000) made up of units of glucose, while hemicelluloses are shorter chains (DP 150–200) made up of various monosaccharides. The composition and contents of hemicelluloses vary from one wood species to another. During the heat treatment, both groups undergo changes, but the majority of the changes occur in hemicelluloses with high oxygen content.

Cellulose components, β-D-glycopyranoses, are joined by (1→4)-glycoside bonds. Cellulose chains are joined by bonds between hydroxyl groups. At temperatures under 300 ºC, the degree of polymerisation in cellulose decomposition decreases; water is eliminated; and free radicals, carbonyl, carboxyl, and hydroperoxide groups, as well as carbon monoxide, carbon dioxide, and reactive wood charcoal, are generated.

The components of the hemicelluloses include D-glucose, D-mannose, D-galactose, D-xylose, L-arabinose, and small amounts of L-rhamnose, 4-O-methyl-D-glucuronic acid, and D-galacturonic acid. They are joined by (1→4)- or (1→6)-bonds.

As wood is heated, acetic acid is formed from acetylated hemicelluloses by hydrolysis. The released acid serves as a catalyst in the hydrolysis of hemicelluloses to soluble sugars. In addition, the acetic acid that has formed depolymerises the cellulose microfibrils in the amorphous area. The acid hydrolises the bonds joining the units of glucose, breaking cellulose into shorter chains.

After the heat treatment, the wood contains a substantially lower amount of hemicelluloses. As a result of this, the amount of fungi susceptible material is significantly lower, providing one reason for heat-treated woods improved resistance to fungal decay compared with normal kiln dried softwood. With the degrading of the hemicelluloses, the concentration of water-absorbing hydroxyl groups decreases and the dimensional stability of treated wood is also improved compared to normal kiln dried softwood.

The decomposition temperature of the hemicelluloses is about 200–260 ºC, and the corresponding temperature for cellulose is about 240–350 ºC. Since the amount of hemicelluloses in hardwood species is higher than in softwood species, degrading is also easier in hardwoods than softwoods. However, the breaking of a hemicellulose chain does not reduce as much the strength of the wood as breaking of cellulose chains would do. Instead, breaking of a hemicellulose chain improves the pressability of wood and reduces the generation of stresses and resilience of wood.

4.1.3. Lignin

Lignin holds the wood cells together. The dark matter of wood cells' middle lamellae is mainly lignin. It is also found at the primary and secondary cell walls. Lignin constitutes 25–30% and 20–25% of softwoods and hardwoods, respectively. The precise chemical structure of lignin has not yet been determined, but its precursors - i.e., components - have been known for decades. Lignin is primarily composed of these phenylpropane units, which are typically joined by ether- and carbon-carbon bonds (DP 10–50). Softwoods contain mainly guaiacyl units of phenylpropane, and hardwoods contain almost equal amount of guaiacyl and syringyl units of phenylpropane. Both contain minor amounts of p-hydroxyl phenylpropane.

During the heat treatment, bonds between phenylpropane units are partly broken. Aryl ether bonds between syringyl units break more easily than bonds between guaiacyl units. Thermochemical reactions are more common for allylic side chains than aryl-alkyl ether bonds. The longer the autohydrolysis time is, the more condensation reactions occur. Products of condensation reaction include β-ketone groups and conjugated carboxylic acid groups.

Of all wood's constituents, lignin has the best ability to withstand heat. Lignin's mass starts to decrease only when the temperature exceeds 200 ºC, when the β-aryl ether bonds start to break. At high temperatures, lignin's methoxy content decreases and some of lingnin's non-condensed units are transformed into diphenylmethane-type units. Accordingly, diphenylmethane-type condensation is the most typical reaction at the 120–220 ºC temperature range. This reaction has a significant effect on lignin's properties in heat treatment, such as its colour, reactivity, and dissolution.

4.1.4. Extractives

Wood contains minor amounts of small-molecule constituents. Extractives constitute less than 5% of wood. This group includes, for example, terpenes, fats, waxes, and phenoles. Extractives are of heterogenic nature in various wood species, and the number of compounds is very high. Extractives are not structural components in wood, and most of the compounds evaporate easily during the heat treatment.

4.1.5. Toxicity

The ecotoxicity of the leachates of heat-treated spruce has been tested at CTBA (an EU project - Upgrading of non-durable wood species by appropriate pyrolysis thermal treatment, 1998). The tests were carried out on leachates obtained after an EN 84 test. This test is applied to evaluate the fixation of the biosides in wood cells. Small specimens were leached with water, and the water was tested according to NF-EN ISO 506341 against Daphnia magna (small freshwater shellfish) and microtoxicity tests on marine luminescent bacteria. The test results showed that leachates do not contain toxic substances for Daphnia magna and are harmless to bacteria.

ThermoWood has been tested as a bone substitute material (VTT & Surgical Clinic of University Hospital in Turku). Preliminary tests have shown good results: heat-treated birch has similar properties to bone. ThermoWood is sterile, and no toxic substances have been found.

4.2. Physical changes

4.2.1. Density

Density is determined by measuring the weight and the dimensions of the sample. ThermoWood has a lower density than untreated wood. This is mainly due to the changes of the sample mass during the treatment when wood loses its weight. As can be seen from the figure below, the density decreases as higher treatment temperatures are used. However, deviation is high and the coefficient of determination is low, due to natural variation in wood density.

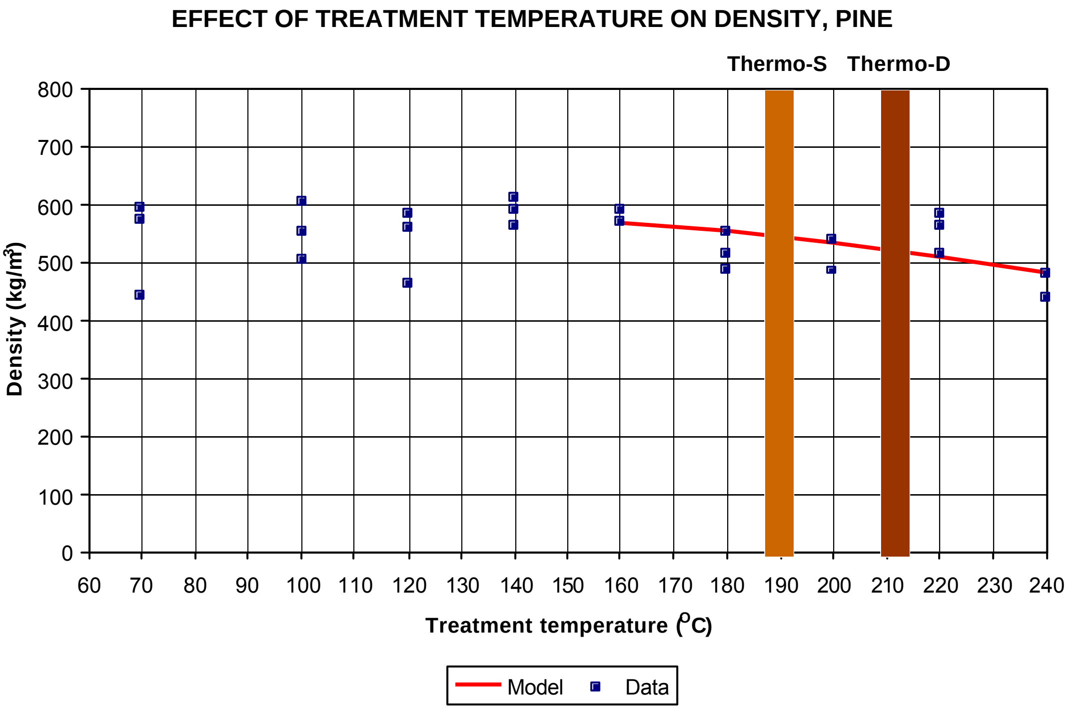


Figure 2-4. The effect of treatment temperature on the density of pine treated for 3 hours at 160–240 °C. The average density in the temperature range T < 160 °C is 560 kg/m3. The test material was conditioned at RH 65% (source: VTT).

4.2.2. Strength

Strength of wood material in general has a strong correlation with density, and ThermoWood has slightly lower density after the treatment. Therefore, it is obvious that ThermoWood in some cases has lower strength values. However, the weight-to-strength ratio can remain practically unchanged. The strength of wood is also highly dependent on the moisture content and its relative level below the grain saturation point. ThermoWood can benefit due to its lower equilibrium moisture content.

<u>Bending strength</u>

Two methods for testing bending strength have been used, one using defect-free material over a short span and the other utilising pieces having natural defects over a longer span. The results (Figure 3-4) show that substantial strength loss in pine starts at temperatures over 220 °C.

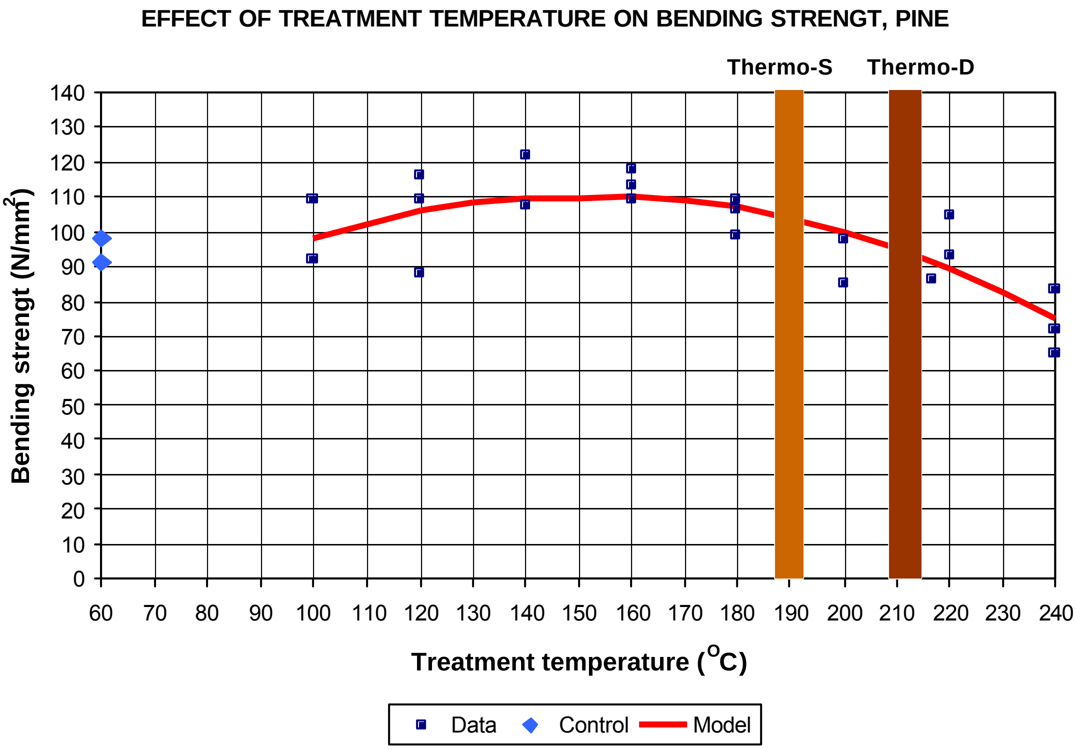


Figure 3-4. The effect of heat treatment temperature on the bending strength of pine, average density 560 kg/m3 (source: VTT)

The results show that heat treatment does not significantly change the modulus of elasticity of wood (Figure 4-4).

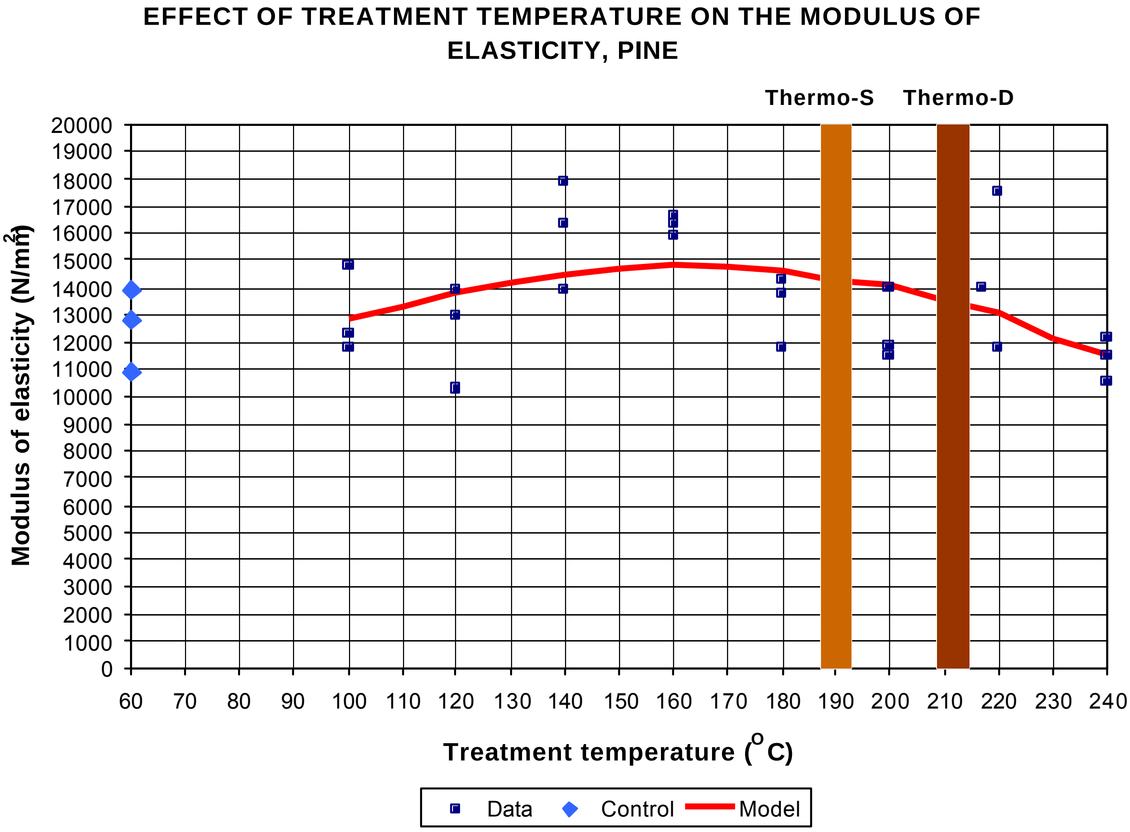


Figure 4-4. Effect of heat treatment temperature on the modulus of elasticity of pine, average density 560 kg/m3 (source: VTT)

The strength of heat-treated (230 °C, 5 hours) spruce was studied with larger test pieces according to EN 408. Prior to testing, the test pieces were conditioned at 45% and 65% relative humidity. The results are presented in table 1-4. With timber containing knots, the strength values for heat-treated wood are lower than those of untreated wood. This is due to, among other factors, the resins being extracted from the wood.

Table 1-4. Bending strength and modulus of elasticity of heat-treated spruce.

Series	width (mm)	height (mm)	length (mm)	RH (%)	density	bending strength 1) N/mm^2	modulus of elasticity 1) N/mm^2	apparent modulus of elasticity 1) N/mm^2
1	38	100	1800	45	425±45	23.0 ± 11.2	11015 ±3142	9495 ±2823
2	38	100	1800	65	392±40	22.5 ± 9.2	12326 ± 1681	11494 ±1280
3	100	38	1800	45	392±25	19.0 ± 5.4	10486 ±1649	9537 ± 1705
4	100	38	1800	65	397±17	27.9 ± 5.9	11913 ±1422	11230 ± 1224

1) mean value and standard deviation

The reference values for untreated spruce at 12% moisture content are: bending strength 40–50 N/mm^2 and modulus of elasticity 9,700–12,000 N/mm^2.

In tests conducted on ungraded timber with defects and a span of 1,800 mm treated at 230 °C for 4 hours (Table 1-4), the bending strength was reduced by up to 40% compared with normal untreated wood. This was due to weakening of areas around the defects. However, with wood treated at lower temperatures of about190 °C for 4 hours, the difference in bending strength was far less.

The majority of testing so far has been performed on small, defect-free pieces. More testing is needed on full-size test pieces and with varying numbers of knots and different knot types. In the absence of sufficient information, we recommend that ThermoWood **NOT** be employed in load-bearing structural usage for the time being.

Screw holding strength

Results from the 'heat treatment of timber' study performed by the Institute of Environmental technology in 1999 showed that the major impact on screw holding strength was due more to the general variations in wood density than to the heat treatment itself. The study revealed that in lower-density material the results were better when smaller, pre-drilled holes were used.

Compression strength parallel to grain

According to tests conducted by VTT with timber treated at 195 °C for 3 hours, the compression strength parallel to the grain of the heat-treated timber was about 30% higher than that of normal untreated timber. The test pieces in this study had been submerged in water before testing.

Compression strength is mainly dependent on the actual density of the wood. Tests show that the heat treatment process does not have a negative effect on compression strength values. Actually, the results indicate that the compression strength values were better than with untreated wood even when a higher treatment temperature was used (Figure 5-4).

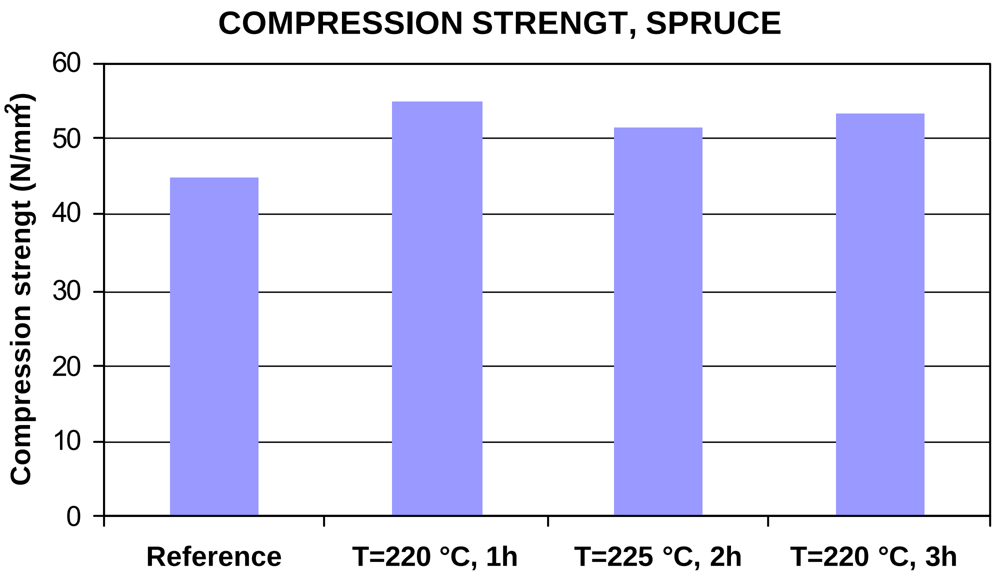


Figure 5-4. The compression strength (N/mm2) of spruce. Average density 420 kg/m^3 (source: VTT).

Tests show that when the maximum compression load was achieved, the pieces broke into smaller sections but didn't buckle like normal kiln-dried timber. This revealed clearly that heat-treated timber is not as elastic as normally kiln-dried timber.

Impact bending strength (dynamic bending)

From test results (CTBA), it can be understood that the impact strength value for ThermoWood is less than that of normal kiln-dried timber. In testing spruce that had been treated for 3 hours at 220 °C, it was found that the impact strength was reduced by about 25 per cent.

Shear strength

The tests were performed (by VTT) by measuring both radial and tangential directions. It was found that with higher-temperature treatments (at 230 °C for 4 hours) the strength properties were reduced in radial tests from 1 to 25% and in tangential tests form 1 to 40%. However, lower-temperature treatments (at 190 °C) had very little effect on pine, although spruce showed a 1–20% decrease in both radial and tangential tests.

Splitting strength

The splitting tests were performed at the Institute of Environmental Technology with spruce, pine, and birch using an extensive range of treatment temperatures. From the test results, it can be concluded that the splitting strength is reduced by 30-40% and the decrease in strength is greater with treatment at higher temperatures.

4.2.3. Hardness

Brinell hardness has been tested according to prEN 1534. The results show that the hardness increases as the treatment temperature increases (Figure 6-4). However, the relative change is very small, therefore having no effect in practice. As with all wood species, the Brinell hardness is highly dependent on the density.

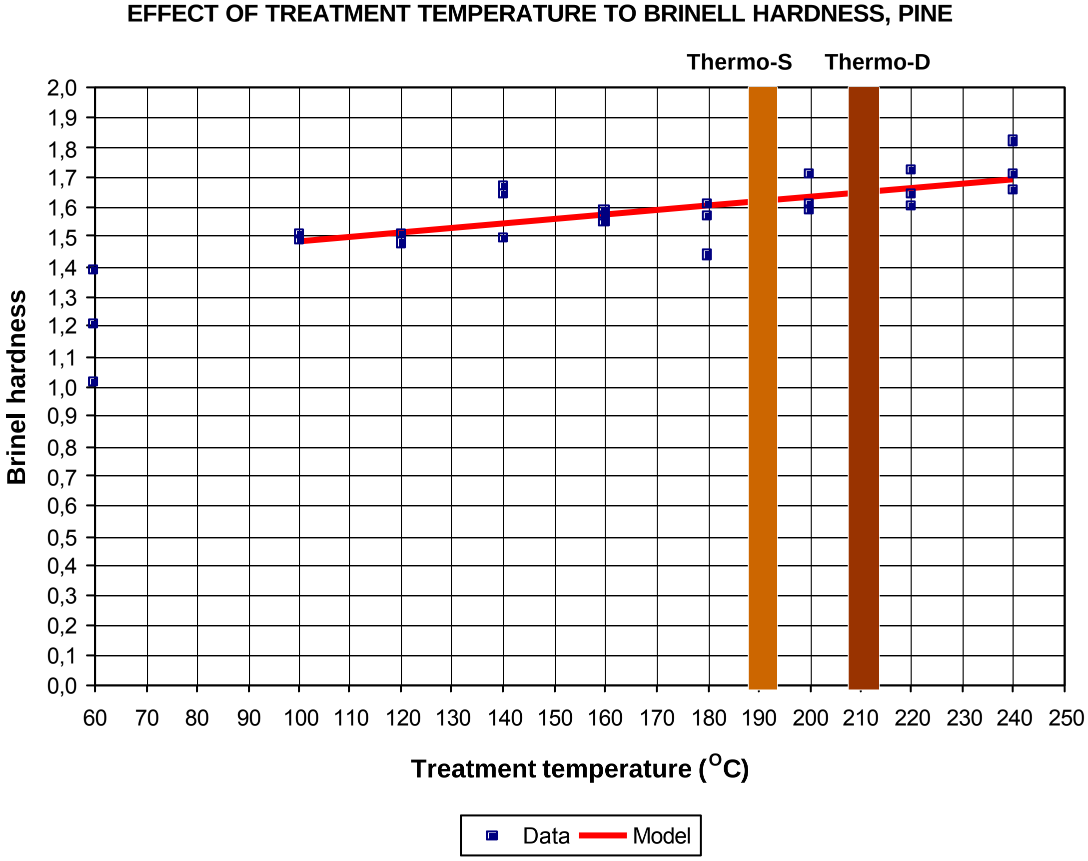


Figure 6-4. The effect of heat treatment on the Brinell hardness of pine. Treatment time of 3 hours (source: VTT).

4.2.4. Equilibrium moisture content

Heat treatment of wood reduces the equilibrium moisture content. Comparisons have been made of heat-treated wood with normal untreated wood at various relative humidities.

Heat treatment clearly reduces the equilibrium moisture content of wood, and at high temperatures (220 °C) the equilibrium moisture content is about half that of untreated wood. The difference in wood moisture values is higher when the relative humidity is higher. The figure below shows the effects on material treated at 220–225 °C for 1–3 hours and at varying humidities.

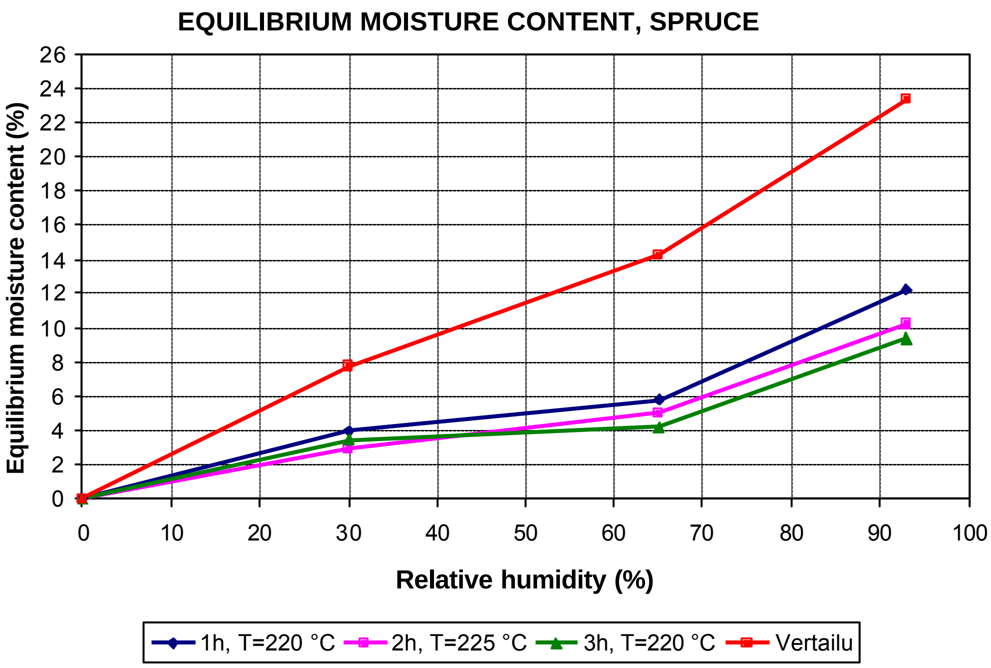


Figure 7-4. The effect of relative humidity on moisture content of heat-treated spruce (source: VTT).

4.2.5. Swelling and shrinkage due to moisture

Heat treatment significantly reduces the tangential and radial swelling (Figures 8-4 and 9-4).

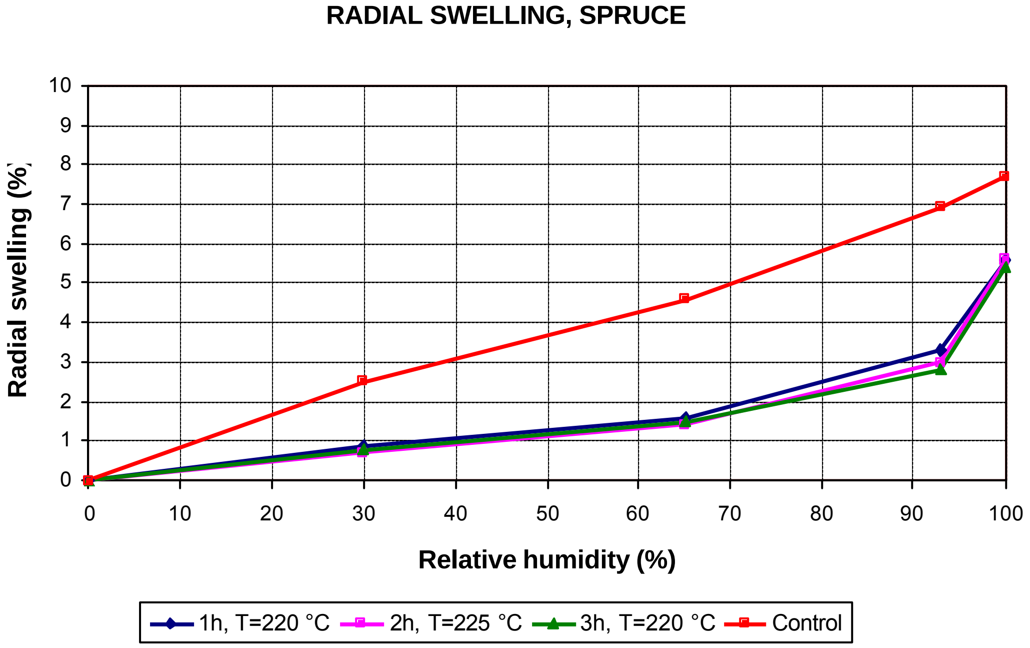


Figure 8-4. The radial swelling of spruce as a function of relative humidity (source: VTT).

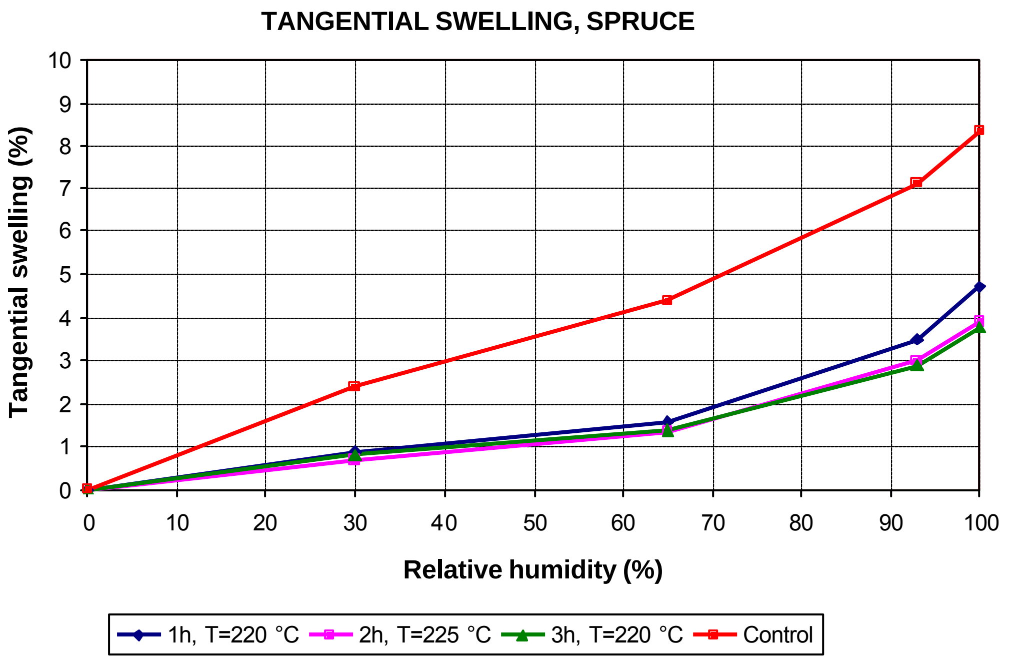


Figure 9-4. The tangential swelling of spruce as a function of relative humidity (source: VTT).

The effect of heat treatment in terms of reduced swelling and shrinkage of wood was clearly shown in relation to cupping of the final product. According to VTT tests, heat-treated wood both with and without a coating maintained its form but CCA-treated and untreated wood were affected by cupping.

Unlike timber in general, heat-treated wood does not feature drying stress. This is a clear advantage, seen when, for example, splitting the material and manufacturing carpentry products. In addition, the wood's swelling and shrinkage is very low.

4.2.6. Permeability

The water permeability of heat-treated wood has been tested by CTBA, examining end grain penetration. This feature is important in, for example, windows. Samples were dipped in demineralised water and then kept in a room with a relative humidity of 65% and a temperature of 20 °C. The samples were periodically weighed over a period of 9 days. The conclusion was that during a short period the water permeability of heat-treated spruce was 20–30 per cent lower than that of normal kiln dried spruce.

VTT has tested the steam permeability of heat-treated wood according to EN 927-4. The results are shown in the figure below (Figure 10-4).

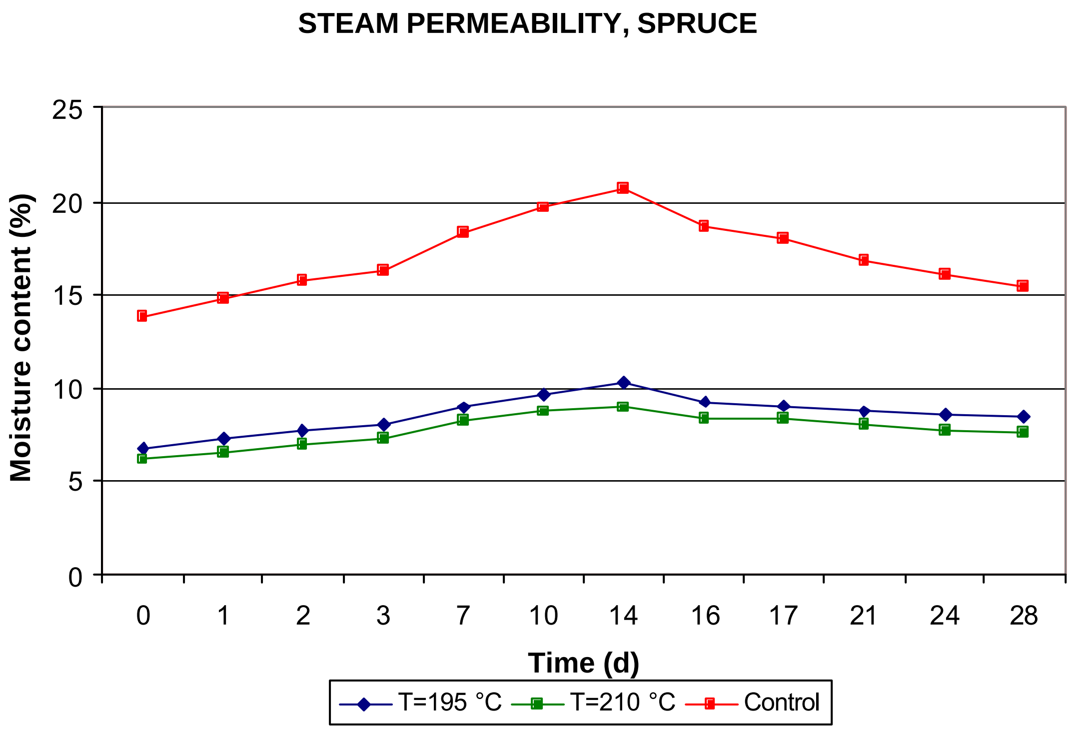


Figure 10-4. The effect of heat treatment on steam permeability (source: VTT).

Water permeability was tested by VTT according to EN 927-5 too. Permeability was determined after the pieces soaked in water for 72 hours with their end surfaces sealed. Untreated spruce gained a moisture content of 22%, while the moisture contents of wood treated at 195 °C and at 210 °C were about 12% and 10%, respectively.

4.2.7. Thermal conductivity

Tests have shown that the thermal conductivity of heat treated wood is reduced by 20–25% when compared with normal untreated softwoods (Taple 2-4). Therefore, ThermoWood is well-suited for applications like outer doors, cladding, windows, and saunas.

According to the VTT tests, the thermal conductivity λ_{10} of Thermo-D class ThermoWood is 0.099 W/(m K). The corresponding value for untreated timber according to Section C4 of the Finnish building code is 0.12 W/(m K).

Table 2-4. Thermal conductivity

Dimension (mm)	**Treatment time at 230 °C (h)**	**Weight loss (%)**	**Density (kg/m^3)**	**Moisture content (%)**	**Thermal conductivity l10 W/mK**
			Pine		
25 x 125	3	8,7	525	4,5	0,107
25 x 125	5	12,1	474	3,6	0,101
	0		505		0,130
			Spruce		
22 x 100	3	5,8	445	5,5	0,097
22 x 100	5	9,3	405	4,4	0,082
	0		432		0,110

4.2.8. Fire safety

<u>SBI test (EN 13823)</u>

The fire resistance of construction products according to the new Euroclasses was assessed with a SBI (Single Burning Item) test. In this test, a specimen consisting of two vertical wings forming a right-angled corner is exposed to flames from a gas burner. The height of the specimen wings is 1.5 m, and their widths are 0.5 and 1.0 m. The gas burner placed at the bottom of the corner stands for a single burning item producing a heat attack with a maximum of about 40 kW/m^2 on the product tested.

The effect of heat treatment on RHR (Rate of Heat Release) is shown in Figure 11-4. The RHR level of heat-treated pine was about 10 kW greater than that of untreated pine. The earlier increase of RHR towards the end of the test for the specimen without heat treatment was due to its smaller thickness. In THR, an increase of about 15% due to heat treatment was observed. Smoke production was roughly doubled. In addition, the ignition time (based on a 5 kW increase in

RHR) was shortened by 30%. In conclusion, heat treatment seems to degrade the fire resistance of wood. This is probably related to release of volatile compounds during the heat treatment. Although the temperature during the treatment is not near the ignition temperature of wood, the constituents of wood can still gradually disintegrate. Consequently, the material properties change, leading to slightly degraded fire resistance.

The number of tests made on ThermoWood has been too low to establish exact values. However it can be stated that ThermoWood does not differ significantly from normal wood when it comes to fire safety. ThermoWood is in fire class D.

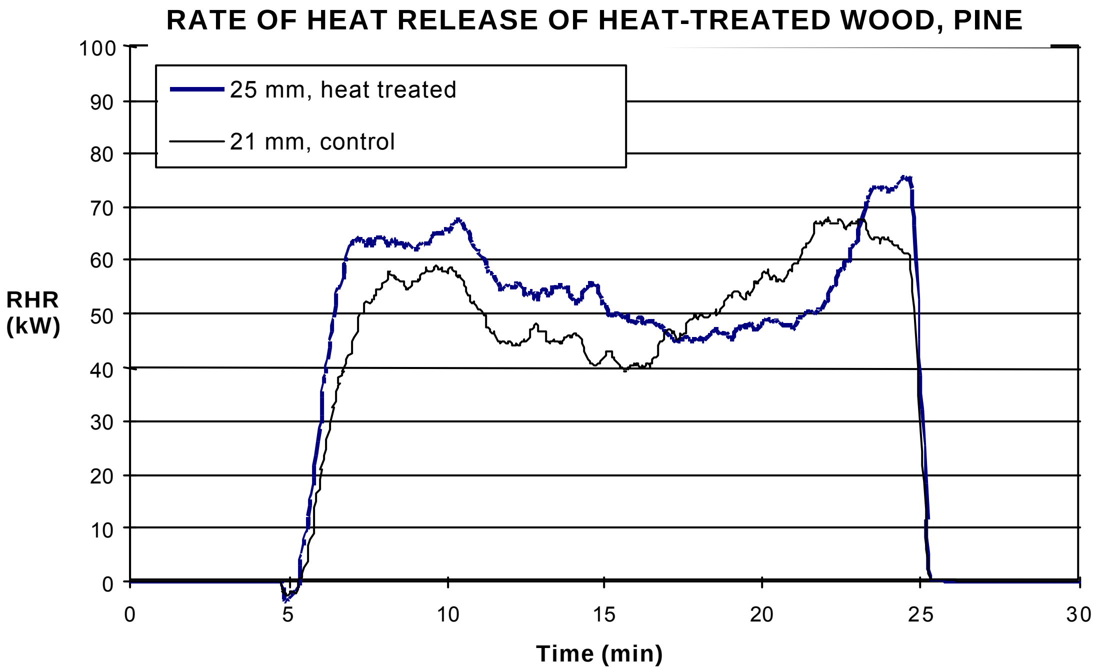


Figure 11-4. Rate of heat release of pine specimens with (2/1) and without (3/1) heat treatment. The specimen thickness was 21 and 25 mm for untreated and heat-treated pine boards, respectively.

Table 3-4. Brandsäkra Trähus – Fas 2: SBI test results for wood-based products

Product	**Thick-ness (mm)**	**FIGRA (W/s)**	**THR_{600s} (MJ)**	**SMOGRA (m^2/s^2)**	**TSP_{600s} (m^2)**
Spruce	18	419	18.0	4	36.3
Pine (heat-treated)	25	581	32.8	6	62.5
Pine	21	321	23.2	3	15.0
Pine (with cavity of 22 mm)	21	329	22.3	4	35.5
Pine	15	361	26.6	4	17.5
Pine	45	587	23.9	12	54.4
Spruce (tongue and groove), vertical	15	452	17.0	3	34.0
Spruce (tongue and groove), horizontal	15	494	18.4	4	50.0
Plywood (spruce)	12	596	15.8	3	45.0
Plywood (pine surface)	12	437	16.6	1	21.0

ISO 5660 test

VTT tested the fire resistance properties of ThermoWood were tested according to ISO 5660. Heat treatment decreased the ignition time for both pine and spruce samples (Tables 4-4 and 5-4) to half that of untreated wood. With pine samples, the rate of heat release (RHR) decreased 32%. The heat-treated spruce samples showed no difference. The production of smoke was small with heat-treated pine and spruce samples in comparison to untreated samples.

Table 4-4. Cone calorimetric test ISO 5660, radiation level 50 kW/ m2, pine.

Dimension (mm)	**Treatment time at 230 °C (h)**	**Weight loss (%)**	**Ignition time (s)**	**RHR (60 s,ave) (kW/m^2)**	**Smoke (m^2/kg)**
50 x 150	5	7.2	12	137	180
50 x 150	8	11.8	13	136	47
50 x 150	10	14.4	16	160	120
50 x 150	0		19–25	150–200	25–100 (200)

Table 5-4. Cone calorimetric test ISO 5660, radiation level 25 kW/m2, spruce.

Dimension (mm)	**Treatment time at 230 °C (h)**	**Ignition time (s)**	**RHR (60 s,ave) (kW/m^2)**	**Smoke (m^2/kg)**
50 x 150	8	97	112	21
50 x 150	0	193	113	72

Test according to NF B 52501 standard

Tests were carried out by CTBA according to the NF B 52501 standard. All samples studied can be classified in Class M_3. The tests indicate that the fire resistance of heat-treated wood has to be considered to be the same as that of untreated wood of corresponding species.

Test to British Standard, surface spread of flame, BS 476 Part 7

A very limited number of pine and spruce pieces treated at 210 °C were tested in the United Kingdom in accordance with Class 1 surface spread of flame standard BS 476, Part 7. The results showed that both heat-treated wood species attained a class 4 rating. The standard rating for normally treated wood is class 3. The heat-treated wood exceeded the limit for class 3 within the first minute.

Due to the very small number of test pieces used, it is concluded that the results cannot be relied upon and more extensive testing is needed using material treated at varying temperatures and moisture contents. The BS tests and results only focused on flame spread speed, and this element is only one part of the testing procedure set forth in new EN standards. The heat-treated wood had a clearly shorter ignition time but was better than the normally dried softwoods in terms of heat and smoke release.

Performance of ThermoWood in relation to the Finnish building codes

The fire safety requirements for structures and the products used in them are defined in section E1, 'Structural fire safety in buildings', 1997, of the National Building Code of Finland. Structural fire design is performed according to section B1, 'Structural safety and loads', 1998, and section B10, 'Timber structures', 1983, amended 1990, of the National Building Code of Finland.

The test methods and acceptance criteria used for defining the fire reaction characteristics of construction materials, construction elements, and devices are presented in 'Ympäristöopas 35 1998, Rakennustuotteiden palotekninen hyväksyntä' (Environment guide 35, 1998; Fire-engineering acceptance of construction products) published by the Ministry of the Environment.

ThermoWood can be regarded as meeting the inflammability Class 2 requirements laid out in the publication mentioned above.

4.2.9. Biological durability

VTT carried out three tests to determine the biological durability of heat-treated timber. The tests were carried out in accordance with the EN 113 standard, with a 16-week decay time. In addition, a modification of the EN 113 test was used; the test time was accelerated by using smaller test pieces and a shorter decay time (6 weeks). The third test was made in soil contact according to ENV 807, the test times being 8, 16, 24, and 32 weeks. The test fungi were *Coniophora puteana* and *Poria placenta* since these are regarded as the most common and problematic fungi.

The results revealed a remarkable ability of the heat-treated wood to resist decay by brown rot. Against the two fungi, the heat-treated wood showed varying results. The heat-treated wood required a higher treatment temperature in order to gain maximum resistance against *Poria placentia* compared to resistance against *Coniophora puteana* (Figure 12-4).

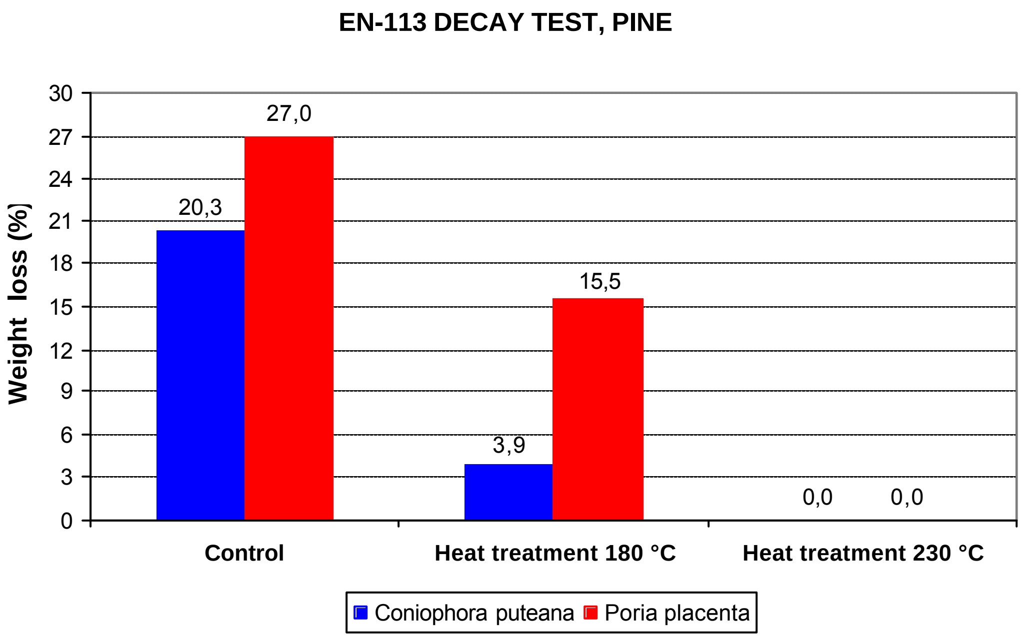


Figure 12-4. The effect of heat treatment on decay by brown rot in a modified EN 113 test. Heat-treated pine, treatment time of 4 hours (source: VTT).

The biological resistance test in accordance with EN 113 revealed very good durability depending on the treatment temperature and time. In order to treat the wood to meet the class 1 (very durable) requirements, temperatures of over 220 °C for 3 hours are required, and to gain class 2 (durable) status, the desired result is achieved at about 210 °C (Figure 13-4).

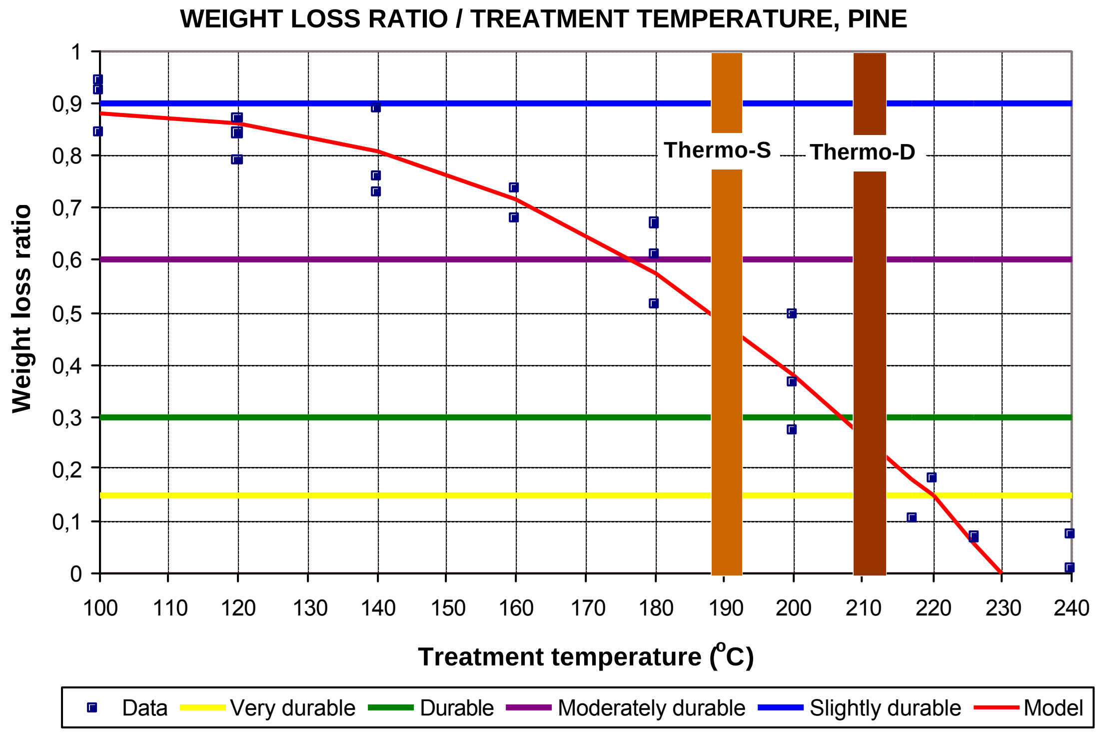


Figure 13-4. The effect of temperature on the weight loss ratio. Pine, treatment time of 3 hours. Standard EN 350-1. Natural durability (source: VTT).

Based on the results of the field test (EN 252), it is **recommended that ThermoWood not be used in deep ground applications where structural performance is required.** It is assumed that the indicated loss of strength is due to a moisture and not caused by any micro-organism. Establishing the reason behind this phenomenon will require further study. However practical experience has found that usage of Thermo-D material in ground contact where structural performance is not critical and periodic drying of the surfaces is allowed does not cause any significant deterioration to the material. This is especially apparent when the ground has good drainage and is made up of sand or shingle.

4.2.10. Resistance to insects

Tests were carried out by the CTBA in France. Longhorn beetles are found in sapwood of softwoods. The common furniture beetle (*Anobium punctatum*) attacks hardwoods in particular. *Lyctus Bruneus* is found in some hardwood species. The tests showed that ThermoWood was resistant to all three of the above insects.

Tests made at the University of Kuopio also prove that ThermoWood has good resistance against longhorn beetles. The test report concludes that beetles recognise pine from its terpene emissions to be a suitable place for egg laying. Because terpene emissions from ThermoWood are drastically reduced in comparison to normal wood (see Section 4.2.13), it is expected that beetles will choose normal wood over ThermoWood, whenever possible. According to the report, the same phenomena can apply also to termites. However, more testing is needed in this area.

Figure 14-4. Longhorn beetle and a larva in tested ThermoWood (photos: Jarmo Holopainen, University of Kuopio).

Concerning termites, the problem is currently more apparent in Southern hemisphere locations, but termites have already spread through France and cases have also been reported in countries further north in Europe. Termites attack buildings from the earth below, avoiding direct sunlight whenever possible. Termites will attack both wood and concrete-based materials in their quest for nutrition. Various measures have been developed to control the problem; these include polythene membranes being installed in the foundations of the building. Also, various bituminous paint products are available to seal possible routes up the building. So far, the test results indicate that ThermoWood is unable to resist attack from termites. However, local tests are recommended since termite types vary from one region to another. In addition, more research into termite attack is needed.

4.2.11. Weather resistance

Weather resistance without surface treatment

Rain

Various field tests have been carried out to study the performance of ThermoWood against natural weathering. Material that had been treated at 225 °C for 6 hours had about half the moisture content of untreated wood; this difference remained after five years' exposure. The following diagram describes the moisture content development in natural weather conditions of untreated wood, ThermoWood, and CCA-treated wood.

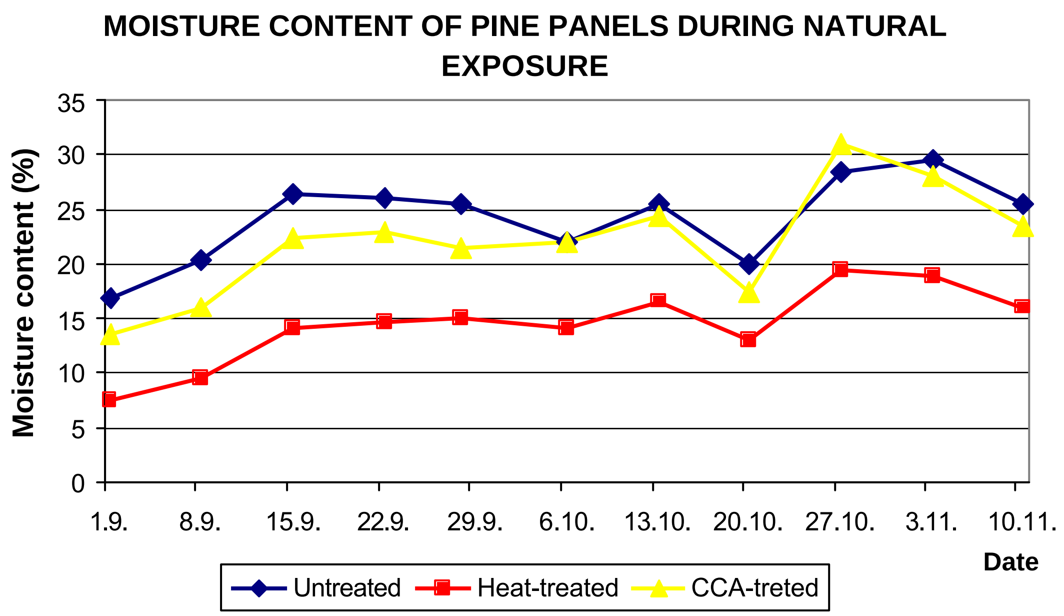


Figure 15-4. The moisture content of planed pine panels during natural exposure, 1994 (source: VTT).

As with all materials exposed to the natural environment, surface mould growth can appear on ThermoWood. Due to bacteria in the air or dirt carried in the rain, fungi can grow on the untreated surface. However, this is on the surface only and can be removed by wiping or scraping.

Sunlight

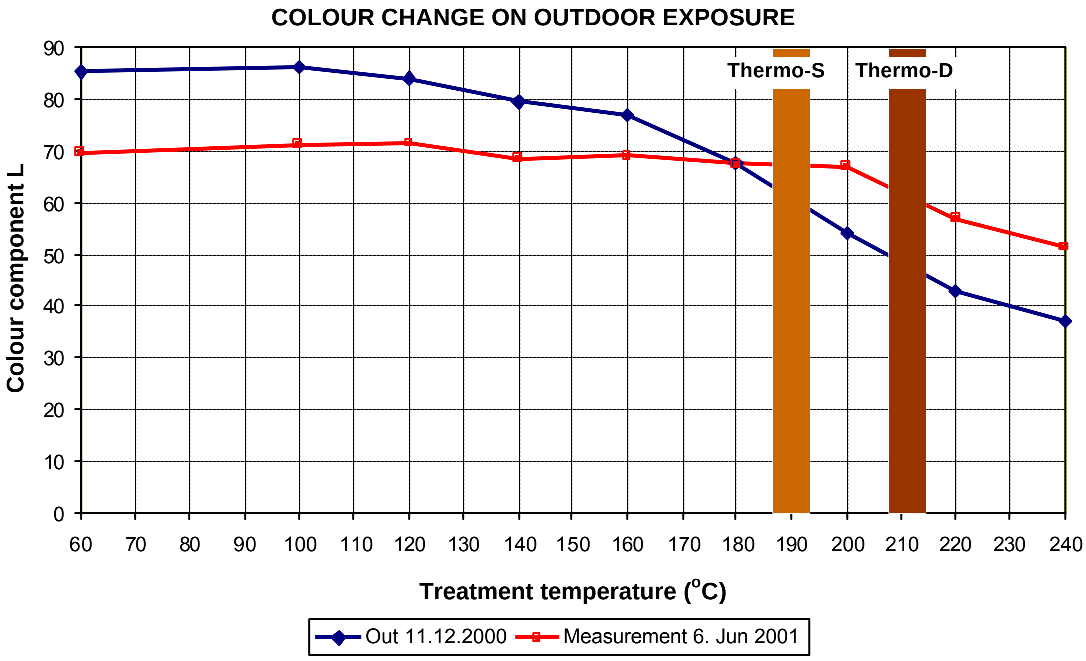


Figure 16-4. The effect of heat treatment temperature on colour changes due to outdoor exposure. Pine, treatment time 3 hours (source: VTT).

Field tests have been conducted to measure ThermoWood's resistance to the effect of sunlight (ultraviolet radiation). As with most natural materials, ThermoWood is unable to resist UV radiation. As a result, the colour changes over a period of time from the original brown appearance to a grey weathered colour when exposed to direct sunlight. The above diagram shows the change in colour component L over a six-month period. The original ThermoWood colour can be preserved with pigmented or UV-protective preservatives.

Although moisture content and swelling and shrinkage due to moisture are greatly reduced with ThermoWood, the ultraviolet radiation causes small surface shakes to occur on uncoated panels when exposed. Levels of surface shakes in ThermoWood did show signs of improvement over the untreated control material when higher temperatures were used (Figure 17-4).

The effect of the heat treatment process on surface shakes and surface fungal growth is shown in the following diagram. The shakes were graded as follows:

- size (0–5):
  - 0 no shakes
  - 1 the shake is seen with the loop, 10 times enlargement
  - 2 the shake is just seen by the eye
  - 3 the shake is clearly detectable
  - 4 shakes where the width is under 1 mm
  - 5 large shakes, with width over 1 mm

– density (0–5):
1 one shake
5 the surface is full of shakes

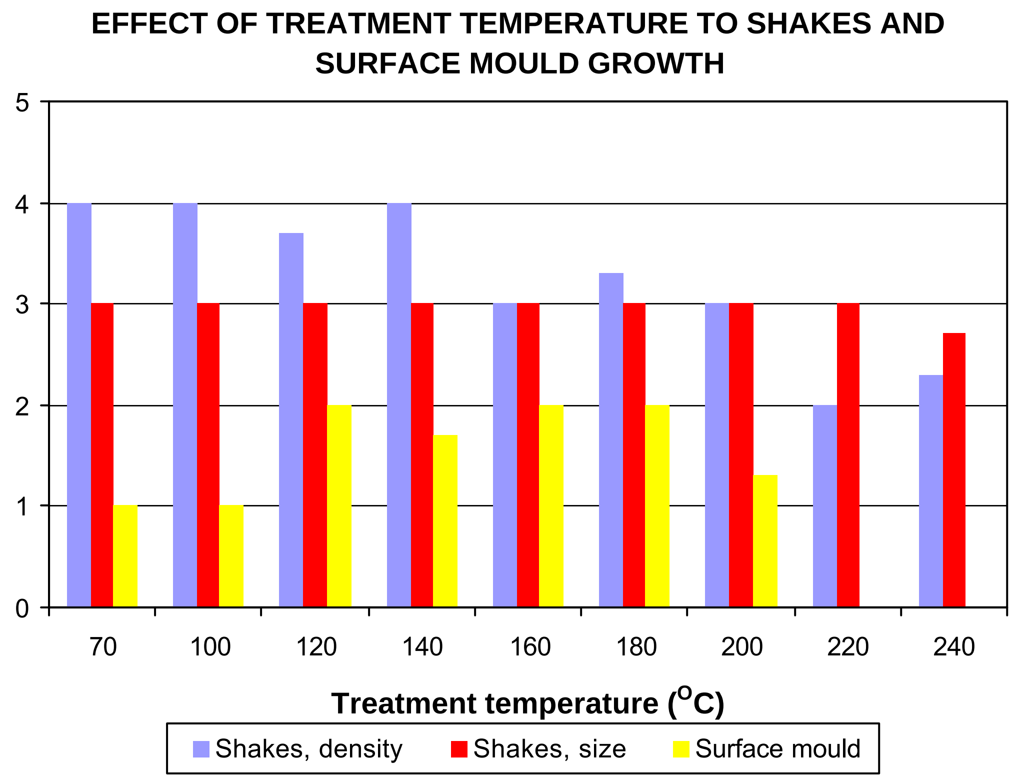


Figure 17-4. Effect of heat treatment temperature on surface shakes and fungal growth of pine panels. Heat treatment time of 3 hours. Outdoor exposure time of 6 months (source: VTT).

It can be easily concluded from the effects of sunlight (ultraviolet radiation) that, with the application of surface treatments containing pigment ThermoWood performs to a good level with respect to surface shakes. Surface treatment is therefore highly recommended.

Weather resistance of surface-treated ThermoWood

Field testing with five years' outdoor exposure was carried out by VTT to study the performance of coatings on the surface of ThermoWood and to compare it with untreated wood. The panels were visually graded in accordance with the ISO 4628 series during weathering.

It was found that the moisture content of ThermoWood was about half that of untreated wood. The unpigmented or low-build stains and oils protected neither ThermoWood nor untreated wood. These coatings wore away and annual rings started to loosen just as in the panels without coating. The panels coated with the low-build stains showed a strong tendency to crack.

The effect of the ThermoWood substrate on the joinery paint performance was observed after five years of exposure. The acid-curable and water-borne acrylic paint had better performance on the heat-treated panels than on the untreated panels. The panels coated with these paints showed no flaking on the ThermoWood substrate (Figure 18-4).

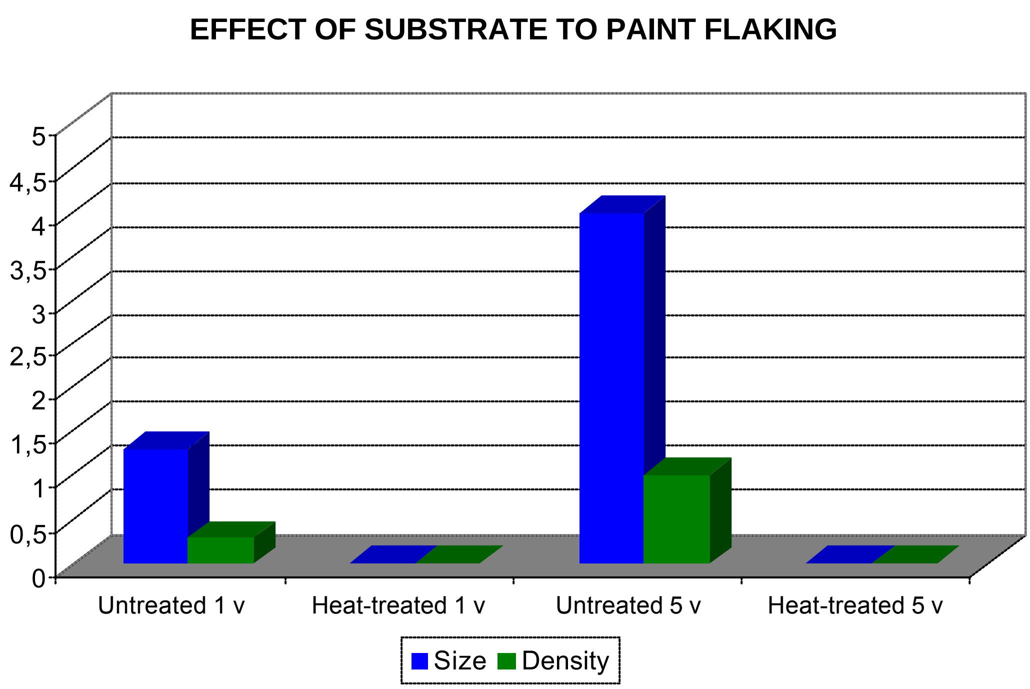


Figure 18-4. The effect of substrate on flaking of water-based joinery paint on pine (source: VTT)

The exterior wall paints performed well on both ThermoWood and an untreated substrate, and no significant effects could be found. The results indicated that the best coating systems for ThermoWood consisted of the priming oil and solvent-based alkyd or water-based acrylic topcoat.

4.2.12. Colour

The colour of ThermoWood is affected by the treatment temperature and time. The higher the temperature, the darker the appearance. As with all softwoods, the colour consistency is affected by normal variation due to density and also depends on whether springwood or latewood is used. In principle, the colour can be well replicated in the process and is measured using the L component. The possibility of including measurement of the L component value in process quality control criteria is being studied.

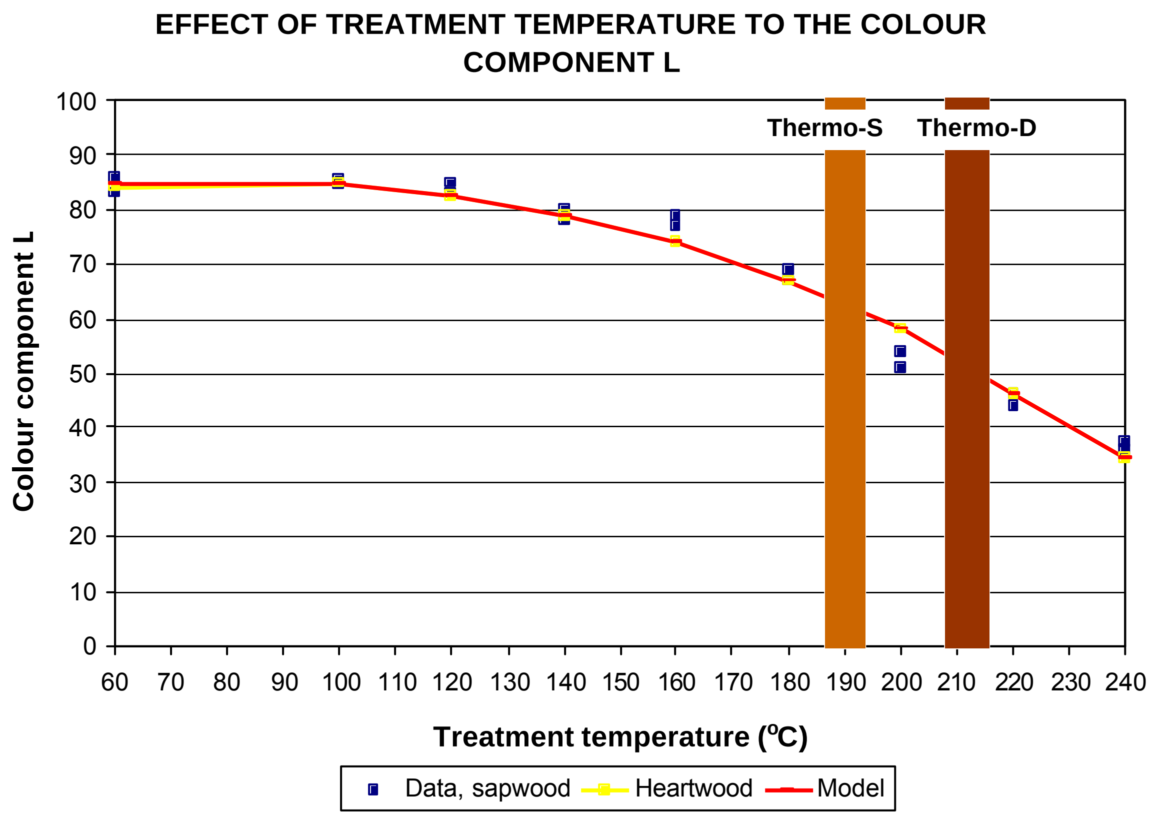


Figure 19-4. The effect of heat treatment temperature on colour component L. Pine boards, treatment time of 3 hours (source: VTT)

The following picture shows the colours of pine boards treated at different temperatures.

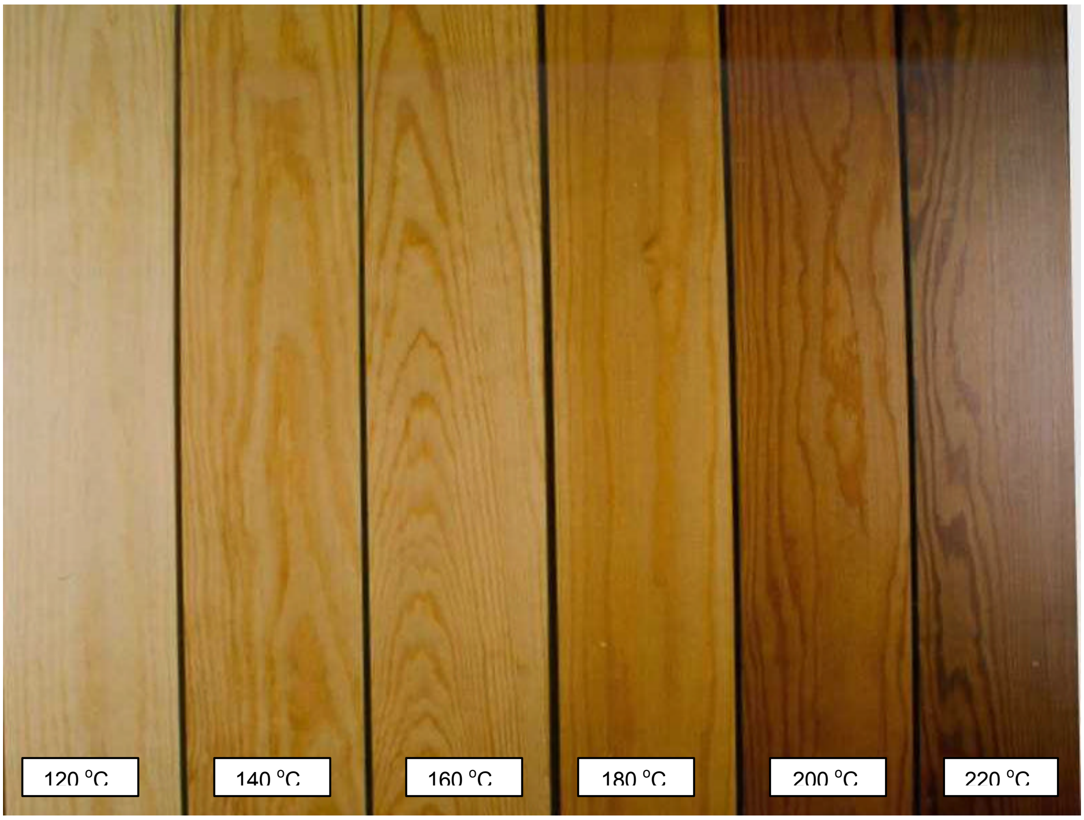


Figure 20-4. The colour of heat-treated pine. Treatment temperatures from 120 to 220°C at 20°C intervals. Treatment time (photo: VTT).

4.2.13. Emissions

Emissions were measured from heat-treated pine boards. The samples were heat-treated at 180 °C and 230 °C for 4 hours. The test was carried out for 7 weeks (180 °C) or 8 weeks (230 °C) after the treatment.

The emission measurements were carried out at the VTT chemical technology unit according to the KET 3300495 test method. Untreated pine showed the largest quantity of volatile organic compounds, 1486 $\mu g/m^2h$. The majority of this consisted of terpenes, and significant amounts of alpha-pinene, camphene, and limonene were found. Untreated pine contained hexanal and small amounts of furfural and acetic acid too.

The total emission for heat-treated pine treated at 180 °C was 828 $\mu g/m^2h$. The sample contained terpenes, furfurals, hexanal, and acetic acid. The total emission of heat-treated pine treated at 230 °C was the lowest, at 235 $\mu g/m^2h$. This consisted mostly of acetic acid (110 $\mu g/m^2h$). This sample contained only small amounts of terpenes. The emissions are presented in Figure 21-4.

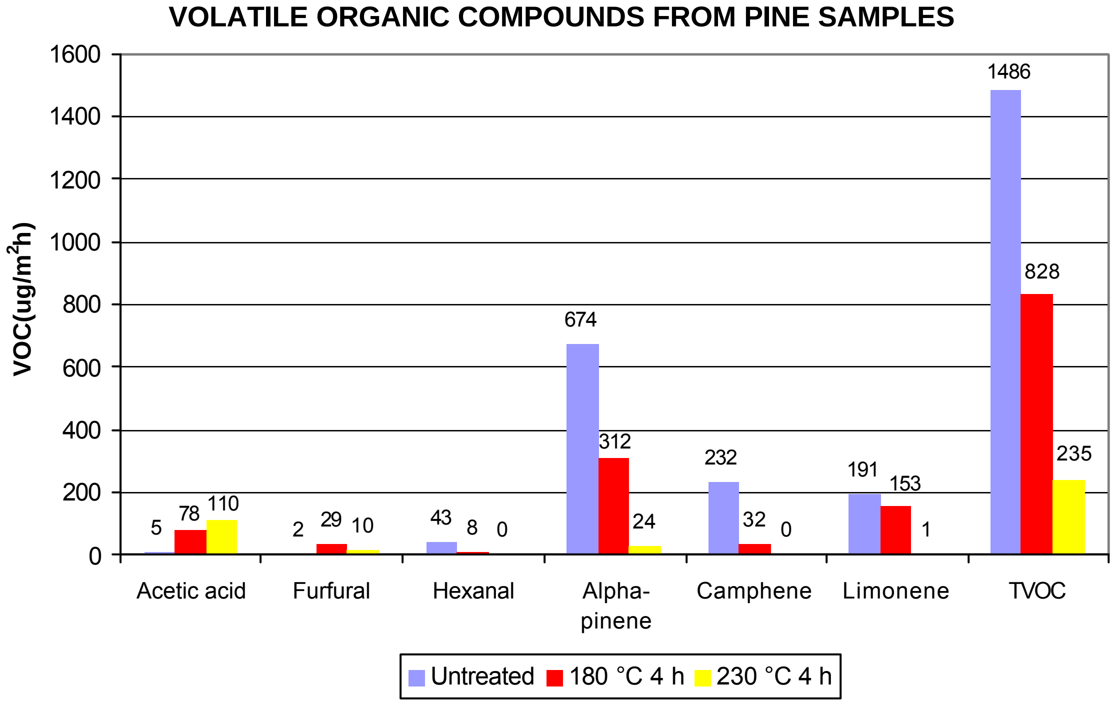


Figure 21-4. Volatile organic compounds from pine samples, age 2 months (source: VTT).

The smoke-like smell of heat-treated wood most likely comes from furfural. Results of tests have not yet been published concerning the smell. The smell has been found to disappear over time, and when surface treatments are applied the smell is removed.

5. Working with ThermoWood in industrial plants

5.1. General

In principle, the handling of ThermoWood requires a bit more care than that of normal kiln dried softwood, it is more susceptible to mechanical damage when it undergoes further processing. Similar handling procedures as when working with hardwoods is recommended. Sharp tools are highly recommended when working with ThermoWood. As when working with all wood materials pre-conditioning of the moisture content in relation to the sites relative humidity improves the results.

5.2. Sawing

The internal stresses of wood are released during an appropriate heat-treatment process, and therefore no distortion occurs after the pieces are split.

Since ThermoWood does not contain resin, the power requirement for cutting equipment is reduced and the life span of the equipment is significantly increased.

Sawing of ThermoWood does not differ from sawing of untreated wood. Where knots are concerned, no special tearing is distinguishable compared with normal kiln dried softwood. The only problem encountered thus far in sawing is the wood dust. Since ThermoWood is very dry, the wood dust is very fine and spreads easily to the environment.

For the reasons mentioned above, special attention has to be paid to the operation of an appropriate dust extraction system. The system must be well-sealed and sufficiently effective.

Since gap-toothed saw blades can cause chipping in the edges of ThermoWood pieces, fine-toothed blades are recommended. Blades with carbide or similar tips extend the saw blade’s maintenance and sharpening intervals.

5.3. Planing

As a result of the ThermoWood heat-treatment process, cupping can occur in the pieces although, as referred to in the section discussing stretching and contracting of wood due to moisture, post-treatment movement is very limited. As a result of cupping, it is recommended that when planing timber pieces which have not been re-cut before planing, the infeed roller be changed to one that has two narrow wheels so the contact with the piece is at the outer edges of the convex face - see figure below. Alternatively, a single narrow wheel could be used so that the piece is turned with the convex face down. Both methods enable a flat surface to be formed as the piece proceeds through the planer, thus reducing the risk of surface cracking and enabling higher infeed roller pressure.

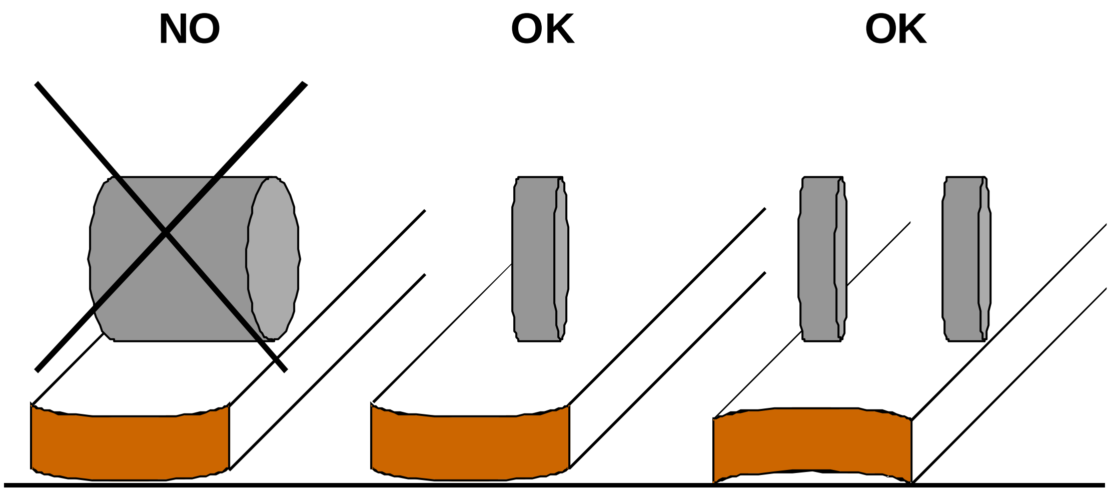


Figure 1-5. Recommended infeed rollers to avoid cracking of the boards.

In order to avoid cracking of the boards, it is advisable to make a flat base surface with a planer or band saw first before profiling. Seinäjoki Polytechnic has performed a series of tests concerning the planing of ThermoWood. Several cutter angles were tested. In these tests, all angles worked well and the surface quality was good too. The best results are achieved with carbide-tipped cutters, as when working with hard types of wood.

It has also been reported that ThermoWood pieces cause less friction during infeed and enable a smoother planing process. This is due to the lack of resin in the wood. On the other hand, since the strength of the material is lower, the infeed rollers must be adjusted to lower pressures to avoid cracking of the boards. Good results have been achieved by replacing the rollers as shown in the picture above. In some planing lines, the speed must also be decreased - for example, in one case from 80 m/min to 60 m/min and in another case from 100 m/min to 80 m/min. If the infeed speed is decreased, the rotation speed of the cutters must be decreased accordingly. Too high a ratio of rotation speed to infeed speed can cause the wood surface to burn.

The pressure of rollers, as well as speed and other parameters, is highly dependent on the planing line and machinery. Therefore, no general values can be cited. In the planing of ThermoWood, the parameters are set separately for each planing machine.

It has been reported that machines (cutters and other surfaces) are very clean after working with ThermoWood due to the lack of resin in the wood. ThermoWood can even clean the machines of the resin-containing dust from previous production lots.

To achieve the best possible planing results and minimise loosening of the wood's annual rings, it is recommended to use material that has been cut as parallel to the grain as possible. In addition, considering the best face of the board when planing improves the result. There is a close connection between the infeed roller type and pressure, the grain direction, cupping, cutter sharpness, and throughput speed. When these variables are carefully harmonised, the best results are achieved.

5.4. Milling

Milling tests were performed by VTT using a CNC machine. In order to achieve a good surface quality – especially in milling – the cutters must be sharp; otherwise tearing will occur. A higher level of tearing was observed when the wood was milled across the grain. The greatest problems with tearing occurred at the start of the milling and at the end, when the cutter comes out of the wood. Milling heat-treated wood can be regarded as similar to working with hard, brittle hardwoods.

It was found that the working order has an influence on the working properties of wood. The best results were achieved when there was enough solid wood material behind the cutter. Therefore, working must be planned carefully beforehand.

The cutters wear more slowly than with normal wood.

5.5. Sanding

General working is equivalent to working with untreated wood; no problems have been reported. In many cases there is no need for sanding, as ThermoWood has a good surface quality after planing or milling.

The dust generated has a small particle size, which is to be taken into account in planning dust extraction. On the other hand, it is a light and dry dust which does not impose any special requirements for dust extraction systems. As in working with any type of wood dust, there is a risk of dust explosion in certain conditions.

5.6. Industrial gluing and jointing

Gluing

In gluing ThermoWood, the adhesive manufacturer's specific instructions must always be followed. Appendix 1 presents the recommendations of one manufacturer.

VTT has studied the glueability of heat-treated wood with 1- and 2-component PVAc adhesives, 1- and 2-component polyurethane adhesives (PU), resorsinol-phenol adhesives (RF), and emulsion-polymer-isocyanate adhesives (EPI). The glueability test was carried out in accordance with DIN 68603. The strength of the glue line was determined in accordance with EN 392 (block shear test). The moisture durability was determined in accordance with the delamination test EN 302-2. The penetration of the adhesive into ThermoWood was studied with a microscope.

The glueability is dependent on the heat-treatment class. The shear strength of the glue line decreases with increased treatment temperatures. This is due to change in the strength properties of the material. It also explains the high wood failure percentages (90–100%). The glue line broke up from the wood, not from the adhesive.

The penetration of the EPI adhesive into heat-treated wood was high, which can have some effect on the strength values. The EPI adhesive is mildly alkaline, and also a long cold pressing time of several hours can improve the penetration of the adhesive.

Experiences in one glulam beam plant using heat-treated pine as raw material were good. Both MUF and RF adhesives worked well. Normal production parameters (pressing time, pressure, etc.) were used. Finger joints were made with MUF adhesive.

With regard to gluing, the results are better with wood treated at lower temperatures. In working with PVAc adhesives, the water content in adhesive should be minimised. Since the heat-treatment process changes wood's water-bonding capability, the absorption rate of adhesive and water into the wood is decreased.

Some PVAc adhesives can cause problems in the form of significantly prolonged drying times due to the requirement for the water to penetrate the wood, i.e,. the curing of the adhesive is based on the absorption of water into the wood. Chemically curing adhesives have a normal drying time.

All tests carried out with PU adhesives have been successful, but it must be kept in mind that the curing reaction of PU requires water. The water can be absorbed from either the wood or the surrounding air. The required amount of moisture is dependent on the adhesive, but if both wood and air are very dry, there exists a chance of unsuccessful gluing.

As always in wood gluing operations, attention has to be paid to correct working conditions when working with ThermoWood. These include wood temperature, the wood’s moisture content, and surface cleanliness.

Finger jointing

The Seinäjoki Institute of Technology has performed finger-jointing tests with

- Four different adhesives: MUF, PVAc, 2 x PU;
- Three open times: 15 s, 30 s, and 60 s;
- Six pressures between 1.3 and 7.8 N/mm^2 (corresponding pressure in the glue line 0.2–1.2 Mpa).

The joints were firm with all tested parameters. According to the tests, the maximum pressure was 22 N/mm^2, which is over ten times the pressure that a firm glue line needs.

Carbide-tipped cutters are recommended for machining the fingers for the joints. It is also recommended that adhesive be applied to both ends in order to ensure a firm joint.

Since working with blunt cutters can easily lead to chipping of the finger joints, sharp cutters are essential. It was also found that using slightly lower speeds caused less chipping of the joint fingers.

Various finger jointing methods have been tested successfully.
Industrial tests have shown that due to the cupping of ThermoWood caused by the treatment process, pre-planing of the material before finger jointing yields a much better result and allows for higher throughput speed and fewer stoppages. In addition, pre-planing improves the performance of machine vision devices in automated cutting lines.

Mechanical joints
Splitting of the material can be avoided by using self-tapping and countersinking screws or by pre-drilling the holes.

Figure 2-5. Self-tapping screw.

The hardware must be selected according to the application. For outdoor applications and similar conditions, stainless steel hardware is recommended.

Good jointing results are achieved with pneumatic nailers. Attention must be paid to the correct pressure and the nailer’s drive length.

The decreased splitting strength and also slightly decreased bending strength of the material is to be taken into account when designing the joints. It is recommended that the critical joints and the details of the products be tested before production. Big knots (especially with respect to the size of the cross-section) are always a risk factor with ThermoWood because the wood lacks the resinous substances that in normal wood act as an adhesive between knot and the surrounding area.

The better dimensional stability of ThermoWood allows joints to be designed with smaller tolerances than joints using normal wood.

5.7. Industrial surface treatment

In terms of its material properties, ThermoWood is comparable to untreated wood as a substrate for coatings. Since the resins have come out of the heat-treated timber, the risk of resin flow from the surroundings of the knots to the paint surface is reduced. Therefore, knot sealer is not required before surface treatment.

In the application of surface treatment products to ThermoWood, the paint manufacturer’s specific instructions must always be followed. Appendix 2 presents manufacturers' recommendations.

Better surface adhesion for ThermoWood occurs with a smooth planed finish, or if springwood is brushed. Otherwise, small splinters are easily detached from the surface sawn with a bandsaw. Surfaces must be clean, as with any other material.

Oil-based substances work as with normal wood. When one works with water-based substances, it has to be taken into account that ThermoWood has a lower water-absorption capacity than normal wood. However, no problems have been reported. Water-based treatment products seem to work well, when they dry slowly and have enough time to penetrate the wood. UV-hardening paints and lacquers have shown good results, as have oils and waxes.

We are still awaiting the results of outdoor tests of Dyrup/Gori paints. In addition, a comprehensive series of water-based industrial application systems with varying colours has been tested. Dyrup has also carried out accelerated weathering tests on ThermoWood with one surface coating without impregnation as well as normally impregnated softwood with a surface coating. These samples have already been in the accelerated weathering test chamber for 2000 hours, and they show no difference in performance. The test will continue for a further 2000 hours to see if any differences will appear.

The tests have shown that there is a larger consumption of primer, but apart from this there are no other significant findings other than the excellent surface results and aesthetic appearance gained with ThermoWood. Paint products which can already be recommend for ThermoWood are mentioned in the appendices.

As always in surface treatment operations, working with ThermoWood requires attention to be paid to correct working conditions, such as appropriate wood temperature, moisture content, and surface cleanliness.

5.8. Fire protection

ThermoWood (made of pine) has shown good results in preliminary fire retardant tests. They have been carried out using Moelven Fireguard IV and Injecta F exterior fire retardants. For both substances, the uptake is higher than with normal untreated wood, the reason for that being the lack of resin in ThermoWood. Further testing will be carried out.

5.9. Practical experiences from a Finnish joinery company

The following results are comments by a technical engineer at a Finnish purpose-made joinery company. The company has been working with ThermoWood successfully for several years.

Raw material

The company has worked with heat-treated pine, spruce, aspen, and birch.

- Aspen: the results have been good but availability is poor
- Birch: good results and better availability
- Pine and spruce: small fresh-knotted material good; larger dead knots a problem; availability good
- In most cases, they purchase the timber one dimension module larger than is usual, to ensure sufficient allowance, the problem being distortions due to the heat-treatment process

Sawing

- Normal machines/tools work but must be sharp
- No significant problems with split or cross-cut sawing
- No internal stresses are present in heat-treated wood
- The wood structure is more like that of hardwood, and tools wear accordingly

Planing

- The company uses normal machines/cutters
- The machines and cutters must be well maintained and sharp
- The working result can be affected by cutter techniques
- The cutters wear down in the same way as when working with hardwoods
- Aspen, birch, and pine are very good to work with
- Spruce needs slightly more attention, but the results can be good

Milling

- Risk of breaking when tennoning
- The sharpness of the cutters, correct cutting angles, and cutting speed affect the result

Sanding

- No significant problems when using sanding machines
- Paper wears at a similar rate as when sanding hardwood

Nailing and screwing

- A pneumatic nailer is best for nailing
- For nailing with a hammer, pre-drilled holes are recommended
- For screwing, pre-drilled holes are required
- Handle the wood as with hardwood

Gluing

- Adhesive drying and pressing time notably longer
- Several adhesive options
- Drying time can be shortened with higher temperatures

Surface treatment

- Normal methods are suitable
- Without pigment, the colour becomes light grey after a period
- Good adhesion of surface treatment
- The material is a good base for water-based paints

Storing the raw material

- Do not store where exposed to snow or rain
- Protect the packages with paper wrapping or store in a warehouse
- No need for special warehouse conditions
- Conditioning suggested before use

5.10. Health and safety

There is no major difference in health and safety considerations for ThermoWood as compared to normal softwood or hardwood species. There are still two detectable differences: the smell of the material and the dust generated in the processing of ThermoWood.

ThermoWood has a smoke-like smell, which likely comes from chemical compounds called furfurals. Although the smell is easily detectable by the human senses and seems stronger than that of untreated wood, the tests show opposite results. As mentioned in section 4.2.13, the volatile organic compound (VOC) emissions from ThermoWood are only a fraction of those of normal pine.

There have been no toxic or harmful components found in ThermoWood. It has even been tested as a bone substitute material. In any case, if a wood splinter penetrates the skin, it should be removed as soon as possible, as with normal wood.

The Tampere University of Technology has studied, in co-operation with the Lappeenranta Regional Institute of Occupational Health, the health effects of working with ThermoWood. ThermoWood dust has a slightly smaller particle size than normal softwoods. It is comparable to MDF (although the density is lower) or hardwood dust. No correlation to a risk of cancer was observed when studying ThermoWood dust.

In processing ThermoWood, special attention has to be paid to the operation of an appropriate dust extraction system. The system must be well-sealed and sufficiently effective.

The standard dust extraction systems in industrial environments meet this requirement without requiring special adjustments. Since the dust is fine, light, and resin-free, it is easily sucked into the extraction piping. Persons who are exposed to the dust on a daily basis should protect themselves with, for example, dust masks.

When gluing or painting ThermoWood, always follow the paint or adhesive manufacturers' specific health and safety instructions.

6. Use of ThermoWood

6.1. Working

Sawing ThermoWood is like sawing untreated wood. Where knots are concerned, no special tearing distinct from that of normal wood has been noticed.

Working with all kinds of hand tools - for example, in sanding, drilling, and milling - is easy. Sanding gives excellent results, and drilling – even of knots - is easy.

Because of the brittleness of ThermoWood, attention must be paid to its handling. Dropping the pieces may damage the edges. Long pieces shouldn't be lifted by only one end.

The only problem in working with hand tools is the dust. Because ThermoWood is normally very dry, the wood dust is fine and spreads easily to the environment. The best solution would be an efficient dust extraction system, but that is often not possible; therefore, the use of a dust mask in these cases is highly recommended.

6.2. Joining

Nailing
A pneumatic nailer is recommended for nailing ThermoWood. The pressure must be tested in order to adjust the nail penetration - see the figure below. The best result is achieved by using a small pneumatic nailer with adjustable drive depth.

The use of a normal hammer increases the risk of splitting when the hammer hits the wood. The final 2 to 3 mm of the nail length should be hit with a punch.

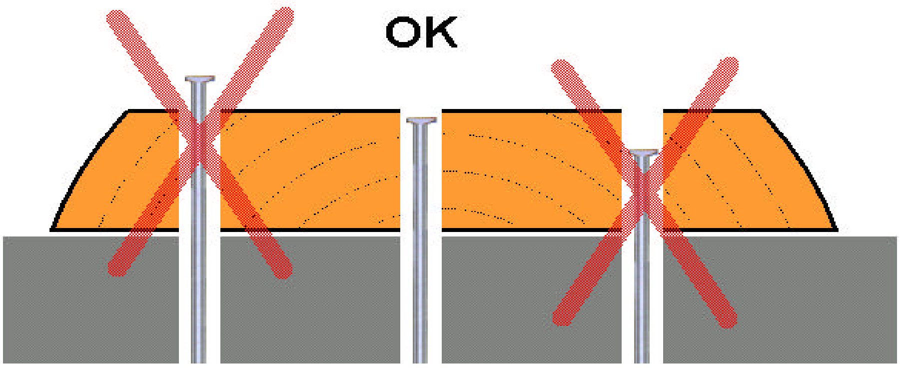


Figure 1-6. Drawing showing the correct nail penetration depth. The correct penetration depth is about 1 mm below the surface of the piece.

Nail types

To reduce the risk of discoloration of the wood, stainless steel nails should be used. However, if a pneumatic nailer is used, galvanised nails are suitable since in this method no metal-to-metal contact occurs and breaks the galvanised surface. Galvanised nails are also best if a topcoat is applied to the cladding. To prevent splitting, small oval-head nails would be the most suitable.

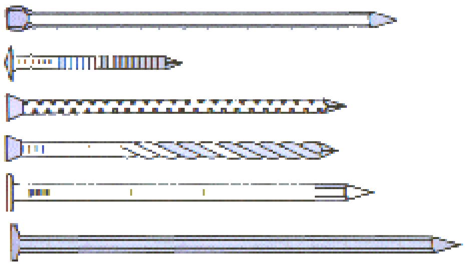


Figure 2-6. Some suitable nail types, the most recommended being the small oval-head nail shown at the top.

Screwing

Pre-drilling (close to ends) and countersinking is essential, just as when working with hardwood, MDF, or other brittle materials. Stainless steels screws with countersunk heads are most suitable in outdoor usage or other humid environments. For the best holding strength, coarse-thread screws perform best. Self-tapping screws can be used in ThermoWood without pre-drilling.

Figure 3-6. Self-tapping screw.

6.3. Gluing on-site

In gluing ThermoWood, the adhesive manufacturer's instructions must always be followed. Appendix 1 presents recommendations from one manufacturer.

Where gluing is concerned, the results are better with wood treated at lower temperatures, such as the ThermoWood class for interior applications. In assembly, high compression pressures cannot be used, as the material is more brittle than untreated wood.

Heat-treated wood absorbs water and water-based adhesives, such as PVAc, slowly. That is why longer pressing times than normal are needed when using water-based adhesives. Some PVAc adhesives can cause problems in the form of significantly prolonged drying times due to the requirement for the water to be absorbed by the wood, i.e., the curing of the adhesive depends on the wood's absorption of water. When one works with PVAc adhesives, the water content in adhesive should be minimised.

It is reported that PU (polyurethane) adhesives work well with ThermoWood. Although all tests carried out with PU adhesives have been successful, it must be kept in mind that the curing reaction of PU requires water. The water can be absorbed from either the wood or the surrounding air. The required amount of moisture is dependent on the adhesive, but if both wood and air are very dry, there exists the possibility of unsuccessful gluing.

Chemically curing adhesives, such as MUF and RF resins, allow drying times and other gluing parameters to remain unchanged.

As always in wood gluing operations, attention has to be paid to correct working conditions when working with ThermoWood; these include wood temperature, moisture content, and surface cleanliness.

6.4. Surface treatment

As a general rule, ThermoWood® is analogous to normal wood as a base for surface treatment. However, the ThermoWood® process affects some properties related to surface treatment. The decreased equilibrium moisture content of the wood improves its stability, which in turn reduces the cracking and flaking of the surface coating in changing environmental conditions. Water-based surface treatment products require slightly longer drying/absorbing times since ThermoWood's water-absorbing capacity has decreased along with the equilibrium moisture content. Since the high temperature of the treatment process removes the resin from the wood, knots do not necessarily require special procedures during the surface treatment.

Without surface treatment, the surface of ThermoWood acts like the surface of untreated wood. Due to the UV radiation in sunlight, the surface turns grey, microscopic cracks are formed on the surface, and the surface ages to an antique appearance over time. To retain the original colour and surface quality, surface treatment is recommended. If priming paint is to be applied manually, the best surface treatment results are achieved by using oil-based paints. If the material has been delivered to the site primed, the corresponding topcoats can be applied without problems manually with a brush using either oil- or water-based paint, depending on the primer type and the manufacturer's recommendations.

To prevent colour changes, the treatment substance should contain pigment. In most cases, the surface treatment is done with a transparent wood preservative with brown pigment added to match the original ThermoWood colour as closely as possible. This usually results in a slightly darker appearance. Different surface treatments have different maintenance intervals. The more pigment used, the longer the maintenance interval. If opaque paint is used, the original ThermoWood colour and features are obscured.

It is recommended that the material be treated once before installation, with the finishing treatment applied after the installation. If vegetable-oil-based surface treatment products are used for applications exposed to the elements, it is recommended that products containing anti-mould agents be used.

In carrying out surface treatment of ThermoWood, the instructions of the surface treatment product manufacturers must always be followed.

6.5. ThermoWood in sauna benches

Due to its highly hygienic nature, colour, and decreased thermal conductivity, ThermoWood® is well suited for sauna benches. However, fast wetting and drying cycles in a high-temperature environment can cause benches to split at the ends. To avoid this, it is recommended to seal the ends with oil, wax, or varnish.

6.6. Product maintenance

Different surface treatments have different maintenance intervals. The more pigment used, the longer the maintenance interval. However, if opaque paint is used, the original ThermoWood colour and appearance are obscured. As a rule of thumb, pigment-containing transparent surface treatment has a doubled or tripled maintenance interval in comparison to a treatment product without pigment. Furthermore, opaque paints have maintenance intervals twice as long as pigment-containing transparent paints.

The environment and climate have a crucial effect on the life span of a surface treatment. UV radiation from sunlight and moisture are major obstacles that must be surmounted by surface treatment. These factors mean that, for example, the south side of a building needs maintenance more often than the north side. Moreover, buildings in a continental climate have a longer life span for their surface treatment than buildings by the sea.

To ensure maximum performance of coating and avoid damages, the surfaces should be cleaned and checked annually, with any defects repaired immediately.
Always refer to the paint manufacturer's specific maintenance instructions, if available.

6.7. Health and safety

There is no significant difference between the health and safety considerations for ThermoWood and those for normal softwood or hardwood species. There are still two detectable differences: the smell of the material and the dust resulting from the processing of ThermoWood.

ThermoWood has a smoke-like smell, which likely comes from chemical compounds called furfurals. Although the human senses can easily recognise the smell and it appears stronger than that of untreated wood, the volatile organic compound (VOC) emissions from ThermoWood are only a fraction of those of normal pine.

There have been no toxic or harmful components found in ThermoWood. It has even been tested as a bone substitute material. However, if a wood splinter penetrates the skin, it should be removed as soon as possible, just as with normal wood.

ThermoWood dust has a smaller particle size than dust from normal softwoods. It is comparable to MDF (although the density is lower) or hardwood dust. The dust can cause problems for people suffering from asthma. For the reasons mentioned above, one has to pay special attention to the utilisation of an appropriate dust extraction system.

If the dust extraction system is not sufficient, a dust mask must be used.

When gluing or painting ThermoWood, always follow the paint or adhesive manufacturers' specific health and safety instructions.

7. Handling and storage of ThermoWood

7.1. General

ThermoWood must be stored in a dry place. Since no special storage temperature is required, cold warehouses are among the suitable locations. The product should be carefully covered or stored in a covered warehouse.

The packages should be stored horizontally with a sufficient number of supports under the packages to prevent the lowest boards from distortion. The packages must be stored so they do not touch the ground

Before use or further working where gluing and/or surface treatment is taking place, the material must be allowed sufficient time for conditioning to the suitable MC and temperature as per the manufacturer's recommendations. When ThermoWood packages are lifted with a crane, forklift, or similar device, the forks should be adjusted to their maximum distance apart because of the slightly decreased bending strength of the material.

The bundles are not to be opened before use.

7.2. Handling of residual and discarded products

ThermoWood is a natural wood product without any chemicals added to it. When not glued or painted, ThermoWood waste can be handled like any other untreated wood waste.

ThermoWood can be burned. It produces about 30% less energy than untreated wood because the majority of the energy containing extractives has already been removed in the heat-treatment process. ThermoWood burns with a smaller flame and produces less smoke and harmful gases because of the factors mentioned above. Flammability is normally better due to the lower equilibrium moisture content of the wood; i.e., the wood is drier. There is no significant difference between the compounds in smoke from ThermoWood and those in the smoke from normal wood.

Pelletising and briquetting is possible, if a mixture with normal sawdust is used. Due to the dryness and lack of resin with ThermoWood, normal softwood dust is required to hold the pellets together.

ThermoWood can be taken to the landfill. It is non-toxic.

8. Frequently asked questions and answers

1. Can you heat-treat different wood species?

The manufacturing and use of both softwood and hardwood species, such as pine, spruce, birch, and aspen, has produced highly positive results.

2. How long does ThermoWood last?

Although evidence from long-term experience of the use of ThermoWood is not yet available, tests have shown that the material's resistance to decay is far superior to that of untreated softwoods and equal that of many tropical hardwoods. In addition, good dimensional stability increases the wood's life span. The service life can be affected by many factors other than resistance to decay - such as the level of maintenance, especially for the surface treatment, and general wear and tear. Following the guidelines presented in this handbook should also assist in lengthening the life expectancy of the product.

3. What are the guarantees?

Although there are no specific guarantees for the product, tests conducted by several independent research institutes have shown consistently positive results where durability is concerned.

4. Why is ThermoWood so durable despite the resin and extractives having boiled away?

The durability of ThermoWood is based on the changes in chemical compounds in the wood. Wood's hemicellulose (sugar compound) is degraded, leaving no nutritive matter for fungi.

5. Are any chemicals added as part of the process?

No chemical additives are used in the ThermoWood production process; only energy and steam are required. Hence, ThermoWood can be utilised/discarded like normal wood after its life span is complete.

6. Can ThermoWood be used in contact with the ground?

Results have shown that even in ground contact ThermoWood does not decay; however, when constantly immersed in water or making soil contact, it loses its strength properties due to certain chemical reactions. The mechanisms are yet unknown, and further research is needed. This is why it is recommended that ThermoWood not be used in continuous direct contact with moist soil.

7. What kind of surface treatment is needed for outdoor use?

ThermoWood can be used outdoors without surface treatment, but this will lead to greying and shaking of the surface, as with normal wood. The type of surface treatment desired varies with the end use application. Products that require the original ThermoWood appearance should be treated with transparent paint containing some brown pigment.

8. Is the smell of ThermoWood harmful?

Tests have shown that there are no harmful emissions from ThermoWood, but the smell might not be appreciated by everyone.

9. Does the smell disappear?

If surface treatment is applied to a product made of ThermoWood, the smell will disappear and not return. If ThermoWood is used without surface treatment, the smell will gradually dissipate until reaching a level where it is no longer noticed except when smelled from a very close distance.

10. Can ThermoWood be glued?

Practical experience has shown that gluing of ThermoWood is possible with all adhesive types. If water-based adhesives, such as PVAc adhesive, are used, the decreased water absorption capacity of ThermoWood must be taken into account where drying time is concerned. In the case of PVAc in particular, the adhesive manufacturer's specific instructions for the product and its use with ThermoWood must always be followed.

11. Can ThermoWood be used in load-bearing structures?

So far, most of the strength tests have been carried out with small, defect-free test pieces. Further testing is required with larger test pieces and with varying numbers of knots and different knot types. Due to insufficient information, we recommend that ThermoWood **NOT** be used structurally for load-bearing purposes for the time being.

References

Alén, R., Puun rakenne ja kemiallinen koostumus, luentomuistiinpanot luentosarjasta, Jyväskylän yliopisto, Kemian laitos, Soveltava kemia, Jyväskylä, 1998.

Brunow, G., Lundquist, K. ja Gellerstedt, G., Ligniini. Kirjassa: Sjöström, E. ja Alén, R., (toim.), Analythical methods in wood chemistry, pulping, and papermaking, Springer-Verlag, Berliini, Saksa, 1999, s. 77-92.

Fengel, D. ja Wegener, G., Wood - Chemistry, Ultrastructure, Reactions, Walter de Gruyter, Berliini, Saksa, 1989, s. 26-344.

Funaoka, M., Kako, T. ja Abe, I., Condenasation of lignin during heating of wood, Wood Sci. Technol., 24(1990)277-288.

Hietala, S., Maunu, S.L., Sundholm, F., Jämsä, S. and Viitaniemi, P. Structure of Thermally Modified Wood Studied by Liquid State NMR Measurements. Holzforschung, submitted, 2001.

Ilvessalo-Pfäffli, M.-S., Puun rakenne, kirjassa: Puukemia (toim. W.Jensen), Teknillisten Tieteiden Akatemia, suomi, 1977, s. 7-81.

Juppi, T., Työilman puupölypitoisuus lämpökäsiteltyä ja muulla tavalla kuivattua puuta hiottaessa, Projekti- ja seminaarityö, Mikkelin ammattikorkeakoulu, 1999, 24 s.

Jämsä, S., Ahola, P., Viitaniemi, P. 2000. 2000. Long-term natural weathering of coated ThermoWood. Pigment & Resin Technology . Vol. 29 (2000) No: 2, 68 - 74.

Jämsä, S., Ahola, P., Viitaniemi, P. 1999. Performance of coated heat-treated wood. Surface Coatings International JOCCA Journal of the oil & colour chemists' association. Vol. 82 (1999) No: 6, 297 - 300.

Jämsä, S., Ahola, P., Viitaniemi, P. 1988. Moisture behaviour of coated thermowood. 5th Conference on Wood - Coatings - Moisture. VTT, Espoo, 20 march, 1998.

Jämsä, S., Ahola, P., Viitaniemi, P. 1988. Performance of the coated Thermowood. Advances in exterior wood coatings and CEN standardisation. Brussels, BE, 19 - 21 Oct. 1998. Paint Research Association, Teddington. 9 p. Paper : 22.

Jämsä, S., Viitaniemi, P. 1998. Heat treatment of wood. Better durability without chemicals Nordiske Trebeskyttelsedager. Lofoten, NO, 13 - 16 Aug. 1998. Nordiske Trebeskyttelseråd (1998), p. 47 - 51.

Kotilainen, R., Chemical changes in wood during heating at 150-260 ºC, Väitöskirja, Jyväskylän yliopisto, Kemian laitos, Soveltava kemia, Jyväskylä, 2000.

Kotilainen, R., Alén, R., Puhakka, I. ja Peltola, P., A rapid spectrometric /PLS method for evaluating rotting test results from heat-treated wood products, posteri, CAC-2000, 7th Inernational Conference on chemometrics in Analytical chemistry, Antwerpen, Belgia, 16.-20.10. 2000.

Kärkkäinen, T., Männyn lämpökäsittelyssä haihtuvien reaktiotuotteiden koostumus ja niiden poistaminen kondenssivesistä, Erikoistyö, Jyväskylän yliopisto, Kemian laitos, Soveltava kemia, Jyväskylä, 2000.

Liitiä,T., Maunu, S.-L. ja Hortling, B., Solid-state NMR studies of residual lignin and its association with carbohydrates, J. Pulp Paper Sci., 16(2000)323-330.

Mali, J., Koskela, K. ja Kainulainen, K., Stellac®Wood- prosessilla lämpökäsitellyn puun ominaisuudet, Tutkimusraportti, Valtion teknillinen tutkimuskeskus, Rakennustekniikka, Puutekniikka, Espoo, 2000.

Marttinen, J., Lämpökäsitellyn puun laadunvalvontajärjestelmän jatkokehittäminen, insinöörityö, Mikkelin ammattikorkeakoulu, Tekniikan koulutusyksikkö, metsätalouden ja puutekniikan koulutusohjelma, puutuotetekniikan suuntautumisvaihtoehto, Mikkeli, 2001.

Mikkola, E. ja Hakkarainen, T., Effect of thermal treatment on reaction to fire classification of wood, Tutkimusraportti RTE896/01, Valtion teknillinen tutkimuskeskus, Rakennustekniikka, Espoo, 2001.

Myllynen, T., Lämpökäsitellyn puun höyläystesti, tutkimusseloste, Ympäristötekniikan instituutti, Mikkeli, 2000.

Möller, K. ja Otranen L., Puun lämpökäsittely, Ympäristötekniikan instituutin julkaisuja 4, Ympäristötekniikan instituutti, Mikkeli, 1999.

Nuopponen, M., Vuorinen, T., Jämsä, S., Viitaniemi, P. Effects of heat treatment on the behaviour of extractives in softwood. Wood Science and Technology, submitted 2001.

Peltomäki, J., Lämpökäsitellyn puun ulkokenttätestaus eri maalisysteemeillä, tutkimusseloste, Teknos Winter Oy, 1998.

Pouru, M., Peräkorpi, K. ja Lehtonen, J., Testausseloste 00/16, Mikkelin ammattikorkeakoulu, ympäristölaboratorio, Mikkeli, 2000.

Puhakka, I., Sulfaattimassan jäännösligniinin kemiallinen rakenne, Pro gradu, Jyväskylän yliopisto, Kemian laitos, Soveltava kemia, Jyväskylä, 2001.

Puhakka, I. ja Peltola, P., Spektroskopisten mittausten ja kaasunläpäisyn soveltuvuus lämpökäsitellyn puun laadunvalvontaan ja prosessinohjaukseen, Erikoistyö, Jyväskylän yliopisto, Kemian laitos, Soveltavan kemian osasto, Jyväskylä, 2000.

Rusche, H., Die Thermisch Zersetzung von Holz bei Temperaturen bis 200 ºC-Erste Mitteilung: Festigkeitseigenshaften von Trockenem Holz Nach Thermischer Behandlung, Holz Roh Werkst, 31(1973)273-281.

Sailer, M., Rapp, A.O. ja Leithoff, H., Improved resistance of Scots pine and spruce by application of an oil-heat treatment, 31st Annual Meeting of the international research group on wood preservation, Kona, Hawaii, USA, 14.-19.2000, IRG/WP 00-40162, s. 3-17.

Sakakibara, A., Chemistry of lignin. Kirjassa: Hon, D.N.-S. ja Shiraishi, N., (toim.), Wood and Cellulosic Chemistry, Marcel Dekker, New York, USA, 1991, s. 113-120.

Shafizadeh, F., The chemistry of pyrolysis and combustion. Kirjassa: Comstock, M.J., (toim.), Chemistry of solid wood, American chemical society, Washington D.C., USA, 1984, s. 489-529.

Sivonen, H., Maunu, S.L., Sundholm, F., Jämsä, S. and Viitaniemi, P. Magnetic Resonance Studies of Thermally Modified Wood. Holzforschung, submitted 2001.

Sjöström, E., Wood Chemistry- Fundamentals and Applications, 2. painos, Academic Press, San Diego, USA, 1993, 293 s.

Syrjänen, T. ja Kangas, E., Heat treated timber in Finland, 31st Annual Meeting of the international research group on wood preservation, Kona, Hawaii, USA, 14.-19.2000, IRG/WP 00-40158, s. 2-10.

Tarvainen, V., Forsén, H. ja Hukka, A., Männyn ja kuusen kuumakuivauskaavojen kehittäminen ja kuivatun sahatavaran ominaisuudet, VTT julkaisuja 812, Valtion teknillinen tutkimuskeskus, Espoo, 1996, 99 s.

Torniainen, P., Lämpökäsittelyn vaikutus koivun kovuuteen, Ympäristötekniikan instituutin julkaisuja, Ympäristötekniikan instituutti, Mikkeli, 2000.

Up-grading of non durable wood species by appropriate pyrolysis treatment (PYROW). Confidential, a brief summary of the results is published at Up-grading of non durable wood species by appropriate pyrolysis thermal treatment. EU Brite-Euram III-program, project BRE-CT-5006. 30.3.1998.

Viitanen, H., Jämsä, S., Paajanen, L., Viitaniemi, P. 1994. The effect of heat treatment on the properties of spruce. Apreliminary report. Paper prepared for the 25th Annual Meeting, Bali, Indonesia May 29 - June 3. 1994.

Viitaniemi, P. ja Jämsä, S., Heat treatment of wood, esitelmä Puu ja Metsä 2001- messujen yhteydessä järjestetyssä seminaarissa 6.9.2001.

Viitaniemi, P. ja Jämsä, S., Puun modifiointi lämpökäsittelyllä, VTT julkaisuja 814, Valtion teknillinen tutkimuskeskus, Espoo, 1996.

Viitaniemi, P., Jämsä, S. Paajanen, L. Modifioidun puun reaktiomekanismit. Metsäalan tutkimusohjelma Wood Wisdom. Vuosikirja 1999. Raportti 2. Paavilainen, L. (toim). Metsäalan tutkimusohjelma. Helsinki (2000), s.121 - 125 ISBN952-9621-88-4.

Viitaniemi, P., Jämsä, S., Paajanen, L. Modifioidun puun reaktiomekanismit. Metsäalan tutkimusohjelma Wood Wisdom. Vuosikirja 1998. Raportti 1/1999. Paavilainen, L. (toim). Metsäalan tutkimusohjelma. Helsinki (1999), s.103 - 105 ISBN 951-53-1434-8.

Viitaniemi, P., Jämsä, S., Vuorinen, T.Sundholm, F., Maunu, S-L., Paakkari, T. Modifioidun puun reaktiomekanismit, hanke-esittely. Wood Wisdom Metsäalan tutkimusohjelman tiedotuslehti (1999) No: 2, 3 - 5.

Patents and patent applications

Patent application FI 20000101.2000. Menetelmä lämpömodifioidun puun modifiointiasteen toteamiseksi. VTT, Finland, (Viitaniemi, P., Jämsä, S. ja Sundholm, F.).Appl.. 20000101, 18.1.2000. 13 p.

Pat. FI 104285 1999. Menetelmä selluloosapohjaisten tuotteiden biohajoamiskestävyyden ja mittapysyvyyden parantamiseksi. VTT (Viitaniemi, Pertti; Jämsä, Saila; Ek, Pentti; Viitanen, Hannu). Hakemusnumero 955391, hakemispäivä 09.11.95. Julkaisupäivä 15.12.99. 17 s. + liitteet 12 s.

Pat.US-5678324, 1997. Method for improving biodegradation resistance and dimensional stability of cellulosic products. VTT (Viitaniemi, P., Jämsä, S., Ek, P. and Viitanen H.) Appl.545791, 13.5.1994. Publ. 21.10.1997. 18 p.

Pat. EP 0695408 (BE,DE,FR,ES,IT,AT,GR,PT,NL,IE,GB,CH), 2001. Method for improving biodegradation resistance and dimensional stability of cellulosic products. VTT (Viitaniemi, P., Jämsä, S., Ek, P. and Viitanen H.). Appl. 94915166.6, 13.5.1994. Publ. 10.1.2001.

Pat. FI 104286. 1999. Menetelmä puun sisähalkeamien estämiseksi. VTT (Viitaniemi, Pertti; Jämsä, Saila; Ek, Pentti ja Ranta-Maunus Alpo). Hakemusnumero 942209, 11.05.94. Julkaisupäivä 15.12.99. 6 s. + liitt. 4 s.

Pat. FI 103834, 1999. Menetelmä puun kuivaamiseksi. VTT (Viitaniemi, Pertti; Jämsä, Saila; Ek, Pentti). Hakemusnumero 942210, hakemispäivä 11.05.1994. Julk. 30.09.99. 6 s. + liitt. 4 s.

Pat. EP-0759137 (SE, DK, NL, GB, FR, DE), 1998. Method for processing of wood at elevated temperatures. VTT (Viitaniemi, P., Ranta-Maunus, A., Jämsä, S. and Ek, P). Appl. EP95918005, 11.5.1995. Publ.4.2.1998. 10 p.

PE18 PENETRATOR

REUSABLE SCREW ANCHOR

2,500 pounds of holding power.

NSN # 4030-01-528-5749

AMERICAN EARTH ANCHORS, Inc
"THE PENETRATOR"
www.americanea.com

Tie Off Cable

Developed specifically for the United States Army, the PE18 & PE18-SQ Penetrators are an 18" long, ***reusable*** screw anchor made of high quality, lightweight heat treated aluminum. The PE18 1" hex head, PE18-SQ 1/2" square drive flat head all are easy to install with either an impact wrench or ratcheting T-Handle. The 2" wide cast-in lip or optional tie-off cable makes guying or tying-off exceptionally convenient.

PE-18 PE-18-SQ

Low Profile With No Sharp Edges!
Great in Asphalt!

Impact Wrench

T-Handle

Great for Theft Deterrence, Weather Security and All Around Stability

		Pullout Resistance In Pounds				
Anchor Size	Minimum Vertical Depth - Feet	Hard Pan Soil	Class 1 Soil Dense Sand & Gravel	Class 2 Soil Medium Sandy Gravel	Class 3 Soil Loose Medium To Fine Sand	Class 4 Soil Loose Fine Uncompacted Sand
18" Penetrator	18"	2,500	1,700	600	350	200

APPLICATIONS

OUR CUSTOMERS HAVE USED THE PENETRATORS FOR SECURING:
Solar Panels - Enclosures - Shelters - Portable Buildings - Sheds -Towers - Winches Antennas - Canopies - Carports - Sports Goals - Inflatable Play Structures - Fencing - Playground Equipment - Air Conditioners - Portable Shelters - Construction Equipment MUCH MORE!

Re-Usable Anchoring System - Holds 2,500 Lbs

PE18

1" Hex Head

> Use a 1" socket with our "T" handle or impact wrench

> Screw anchor straight down - do not over tighten and strip the soil.

Z bracket

Tie Off Cable

2" Pipe hold down

Dry Lake Bed Install

PE18-SQ

Flat Head 1/2" Drive

> Use a 1/2" drive with our "T" handle or impact wrench

> Screw anchor straight down - do not over tighten and strip the soil.

Ordering Instructions

PE18 -

Anchor Classification

Volume Packaging:
Bag of (12) anchors

Call For Quantity Pricing

Examples:

- **PE18** 18" Penetrator screw anchor with 1" Hex Head
- **PE18-SQ** 18" Penetrator screw anchor with Flat Head & 1/2" Sq Drive
- **PE18-B12** (12) 18" Penetrator screw anchors with 1" Hex Head
- **PE18-SQ - B12** (12) 18" Penetrator screw anchor with Flat Head & 1/2" Sq Drive
- **PE-RTH** Ratcheting "T" Handle for installation

Bracket Hole Size
PE18 & PE18-SQ

Plate Thickness	1/4"	1/2"	3/4"
Hole Diameter	1-1/2"	1-5/8"	1-5/8"

Tower Anchoring Plate

US Cellular - Portable Antenna

American Earth Anchors is a producer of high quality innovative anchoring products and accessories for the military, commercial, government and residential markets.

FastenMaster

ThruLok™

SCREW BOLT FASTENING SYSTEM

The speed of a LOK fastener. The strength of a through-bolted connection.

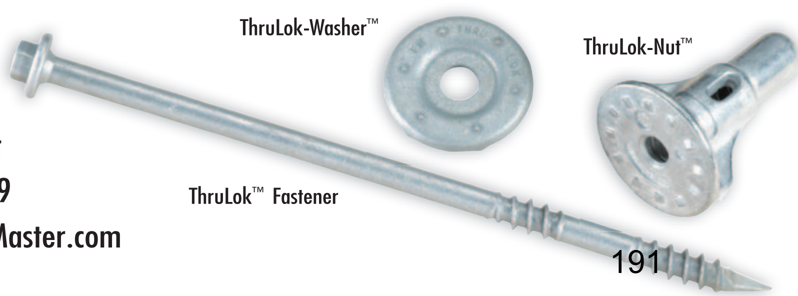
- **No Predrilling**
- **Installs with an 18 volt cordless drill**
- **No drill bits or wrenches required**
- **Galvanized coating meets IRC ACQ corrosion requirement**
- **Lifetime performance guarantee**

Photographs should not be used as a reference for fastening patterns.

4x4 Post to Single Rim: 6¼" ThruLok

4x4 Post to Rim and Blocking: 8" ThruLok

6x6 Notched Carrying Beam: 7" ThruLok



FastenMaster
800·518·3569
www.FastenMaster.com

FastenMaster

ThruLok™

SCREW BOLT FASTENING SYSTEM

INSTALLATION PROCEDURE

Put the ThruLok-Washer on the ThruLok screw with the teeth of the washer facing away from the head of the fastener. No predrilling required when properly installed. Using a ½" high torque variable speed drill (18V if cordless), drive the ThruLok until washer and hex head are just above the wood surface (approx ¼") and point of screw protrudes out other side of connection. Thread the ThruLok-Nut onto point of fastener. Hand tighten nut until flush with wood. Tighten screw with drill. Repeat to match code-compliant fastening pattern.

NOTE: Point of fastener must engage in ThruLok-Nut to "MIN" line or beyond.

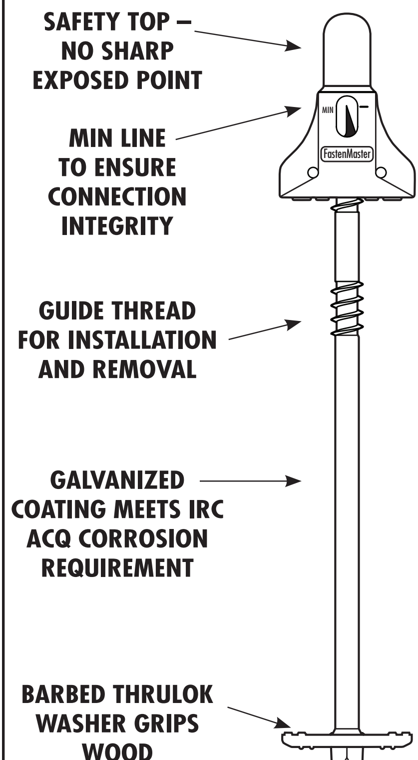
Lifetime ACQ and Performance Guarantee
ThruLok is coated with mechanically applied zinc in accordance with ASTM B695, Class 55. This is compliant with the 2006 International Residential Code® (R319.3) and 2009 IRC (R317.1.3) for use in ACQ pressure treated wood.

The structural and corrosion-resistant performance of the ThruLok System is guaranteed for the life of the project. Please see our written warranty at www.FastenMaster.com.

Code Approvals and Fastening Patterns
The ThruLok Technical bulletins must be reviewed and followed in order to make code approved connections. These can be found in each ThruLok package and online at www.fastenmaster.com

For technical assistance or questions regarding proper use of this fastener, please contact FastenMaster Technical Support at 800·518·3569 or visit www.FastenMaster.com.

PRODUCT FEATURES



Item #	Screw Length	Quantity per Pack	Primary Application	Wood Dimension Range	
FMTHR614-6	6¼"	6	4X4 Deck Post to Single Rim Joist	4½"	5¼"
FMTHR614-24	6¼"	24			
FMTHR007-6	7"	6	Notched 6X6 Carrying Beam to two 2Xs	5¼"	6"
FMTHR007-24	7"	24			
FMTHR008-6	8"	6	4X4 Deck Post to Double Rim Joist or Rim Joist and 2X Blocking	6¼"	7"
FMTHR008-24	8"	24			

FASTENMASTER, 153 BOWLES ROAD, AGAWAM, MA 01001
800·518·3569 WWW.FASTENMASTER.COM

FMTHRCARD (1010)

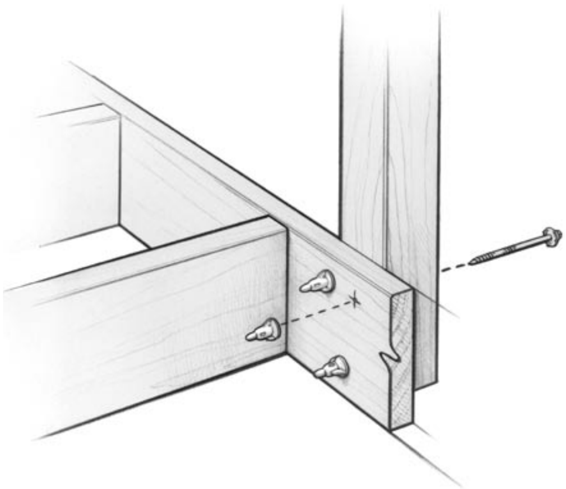
DECK RAIL POST TO RIM BOARD

CONNECTION DETAILS

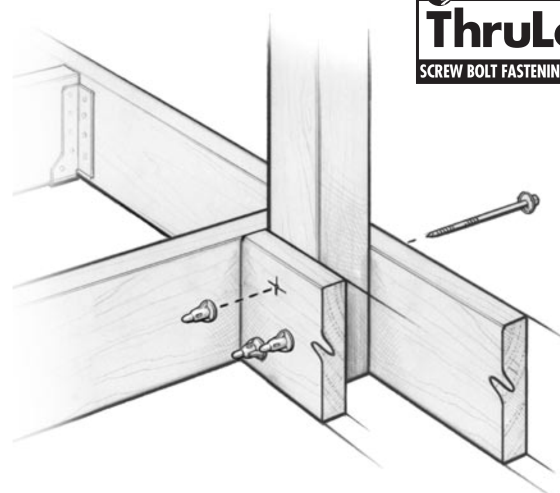
According to the 2009 *International Residential Code for One and Two-Family Dwellings,* Table R301.5 (ICC, 2009), guardrails and handrails must be designed to withstand a single concentrated load of 200 pounds in any direction. A critical part of this connection is making a strong connection between the guardrail post and the rim board of the deck. In most cases, a ½" through-bolt or carriage bolt is used to make this connection. When installed as instructed in this bulletin, the ThruLok System can replace ½" bolts, meeting the 200 pound design load for this part of the connection.

APPLICATIONS

FastenMaster ThruLok™ SCREW BOLT FASTENING SYSTEM



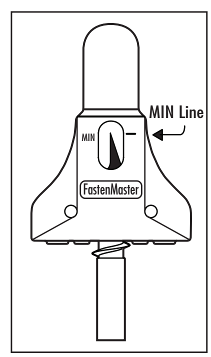
DECK POST TO SINGLE RIM JOIST



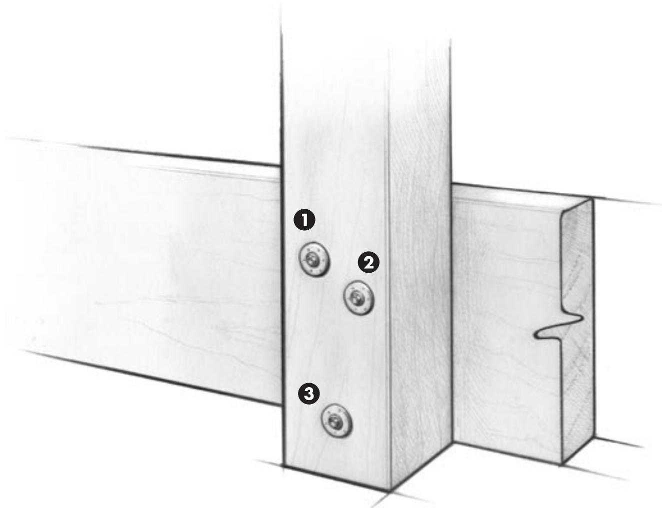
DECK POST TO DOUBLE RIM OR SINGLE RIM WITH BLOCKING

INSTALLATION INSTRUCTIONS

1. Choose the correct length (6¼" or 8") and fastening pattern for each post to rim application based on the illustrated conditions.
2. Mark the surface of the wood with the correct pattern.
3. If a flush mounted head is required, use a 1¼" spade bit to create a ¼" deep recess in the rim or post.
4. Remove the pre-assembled ThruLok nut from the screw and using a ½" drill on low speed/high torque setting, install the ThruLok screw and washer into the outside face of the application until the screw is ¼" to ⅛" from being flush.
5. Thread the ThruLok nut onto the exposed threaded end of the fastener. Firmly twist on the nut by hand until snug.
6. Return to driving the screw in the remaining ¼" to ⅛" until the washer and nut are firmly drawn together.
7. Make sure that the point of the ThruLok fastener has passed the "MIN LINE" printed on the nut.
8. Repeat until all of the fasteners are installed correctly according to the specifications contained in this bulletin.



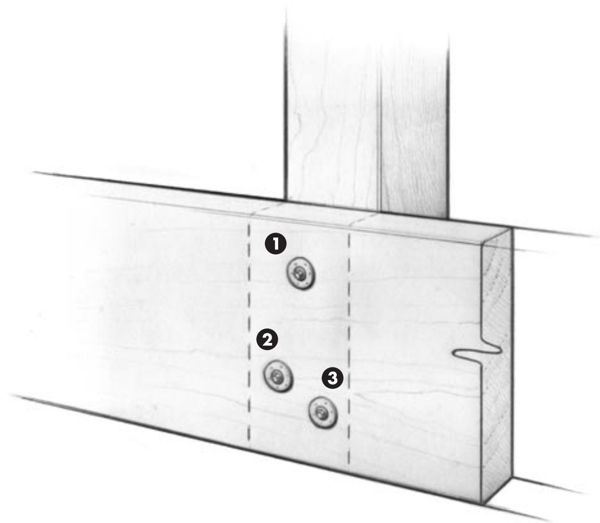
CONDITION 1 – EXTERIOR MOUNTED 4X4 POST TO 2X RIM



For this condition, use the 6¼" ThruLok fastener

1. Install first screw 1" in from the edge of the post and 2" (+/- ¼") from the top of the rim board
2. Install second screw 1" in from the to other edge of the post and 3" (+/- ¼") from the top of the rim board
3. Install third screw in the center of the post and 2" (+/- ¼") from the bottom of the rim board

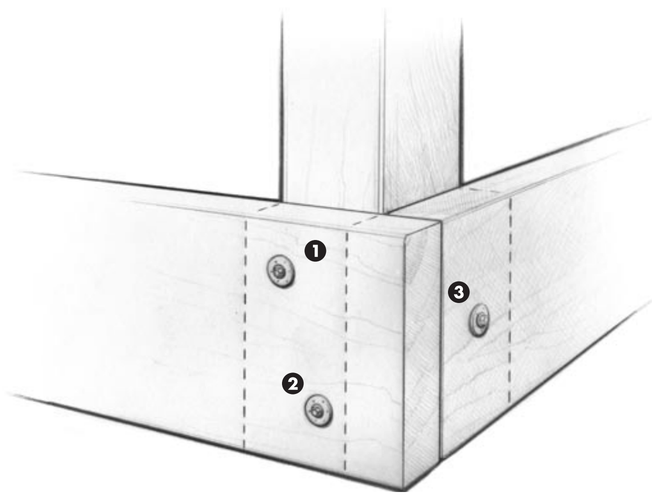
CONDITION 2 – INTERIOR MOUNTED 4X4 POST TO 2X RIM



For this condition, use the 6¼" ThruLok fastener

1. Install first screw in the center of the post and 2" (+/- ¼") from the top of the rim board
2. Install second screw 1" in from the other edge of the post and 3" (+/- ¼") from the bottom of the rim board
3. Install third screw 1" in from the edge of the post and 2" (+/- ¼") from the bottom of the rim board

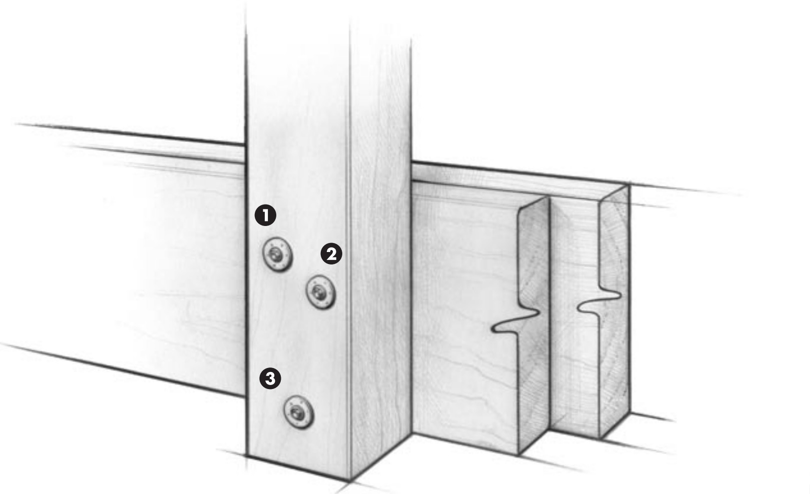
CONDITION 3 – INTERIOR MOUNTED 4X4 CORNER POST TO 2X RIM



For this condition, use the 6¼" ThruLok fastener

1. Install first screw 1" in from the edge of the post and 2" (+/- ¼") from the top of the rim board
2. Install second screw 1" in from the other edge of the post and 2" (+/- ¼") from the bottom of the rim board
3. Install third screw centered on both the post and the rim board

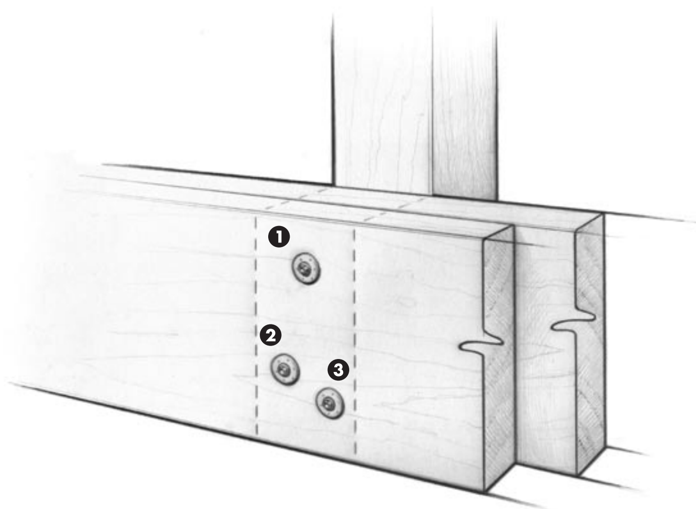
CONDITION 4 – EXTERIOR MOUNTED 4X4 POST TO DOUBLE 2X RIM



For this condition, use the 8" ThruLok fastener

1. Install first screw 1" in from the edge of the post and 2" (+/- ¼") from the top of the rim board
2. Install second screw 1" in from the other edge of the post and 3" (+/- ¼") from the top of the rim board
3. Install third screw in the center of the post and 2" (+/- ¼") from the bottom of the rim boards

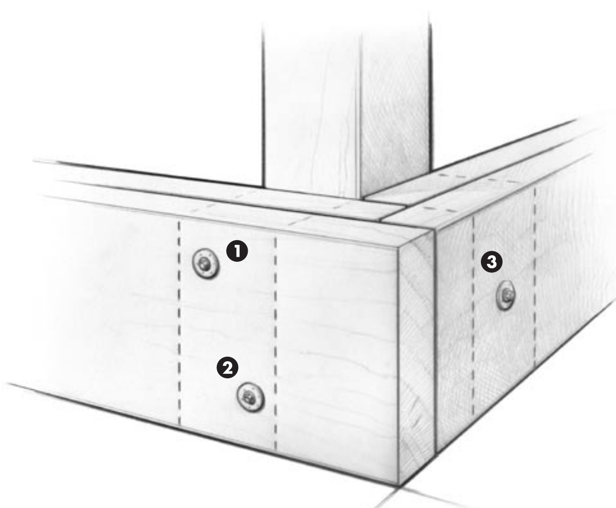
CONDITION 5 – INTERIOR MOUNTED 4X4 POST TO DOUBLE 2X RIM



For this condition, use the 8" ThruLok fastener

1. Install first screw in the center of the post and 2" (+/- ¼") from the top of the rim board
2. Install second screw 1" in from the edge of the post and 3" (+/- ¼") from the bottom of the rim board
3. Install third screw 1" in from the other edge of the post and 2" (+/- ¼") from the bottom of the rim boards

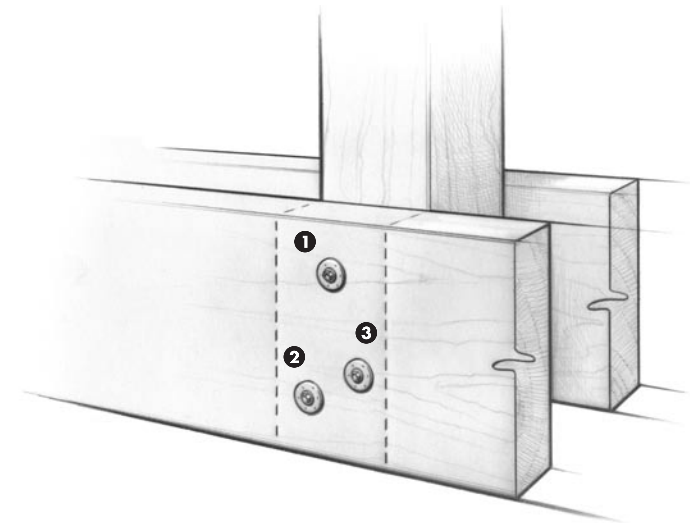
CONDITION 6 – INTERIOR MOUNTED 4X4 CORNER POST TO DOUBLE 2X RIM



For this condition, use the 8" ThruLok fastener

1. Install first screw 1" in from the edge of the post and 2" (+/- ¼") from the top of the rim board
2. Install second screw 1" in from the other edge of the post and 2" (+/- ¼") from the bottom of the rim board
3. Install third screw centered on both the post and the rim board

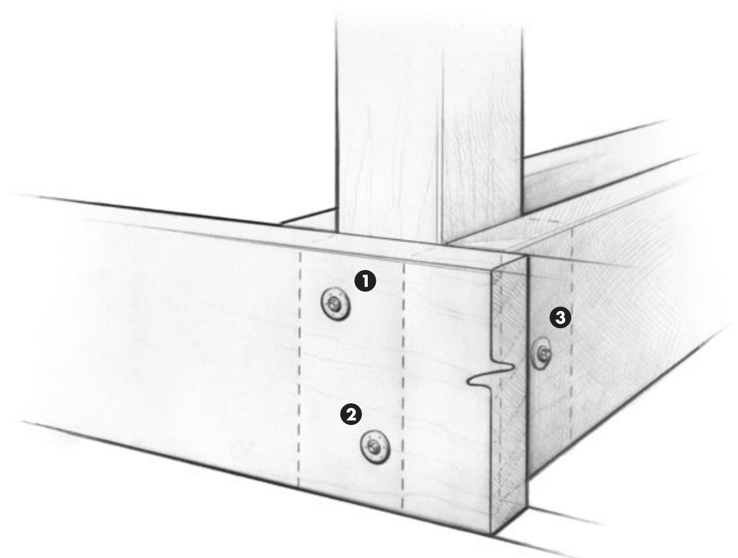
CONDITION 7 – INTERIOR MOUNTED 4X4 POST TO 2X RIM WITH BLOCKING



For this condition, use the 8" ThruLok fastener

1. Install first screw in the center of the post and 2" (+/- ¼") from the top of the rim board
2. Install second screw 1" in from the edge of the post and 2" (+/- ¼") from the bottom of the rim board
3. Install third screw 1" in from the other edge of the post and 3" (+/- ¼") from the bottom of the rim board

CONDITION 8 – INTERIOR MOUNTED 4X4 POST TO 2X RIM WITH SIDE BLOCKING



For this condition, use two, 6¼" and one, 8" ThruLok fasteners

1. Install first 6¼" screw 1" in from the edge of the post and 2" (+/- ¼") from the top of the rim board
2. Install second 6¼" screw 1" in from the other edge of the post and 2" (+/- ¼") from the bottom of the rim board
3. Install 8" screw centered on both the post and the rim board

GENERAL FASTENING GUIDELINES

Third party testing in accordance with ASTM D1761 and ICC Acceptance Criteria AC233 was conducted to determine the proper placement and number of fasteners to meet code.

The connection details shown in this bulletin apply specifically to 4x4 posts and 2x8, 2x10 or 2x12 rims and/or joists.

For different dimension lumber, wood species of lower density than Hem Fir (SYP and DF are higher density and therefore approved), or post heights greater than 37.5" off the top of the joists, please contact FastenMaster to determine the proper fastening solution.

ThruLok is coated with mechanically applied zinc in accordance with ASTM B695, Class 55. This is compliant with the 2006 International Residential Code® (R319.3) and 2009 IRC (R317.1.3) for use in ACQ pressure treated wood.

As with other bolted connections using wet treated wood, the nut should be inspected and tightened if needed after initial drying period.

The connection details in this bulletin are an acceptable means of transferring the load from guard post to rim joist only. Additional blocking or hardware may be required to transfer loads from the rim to deck joists.

Fastening patterns assume the following: All components are used (screw, washer and nut), holes are not pre-drilled, and posts are loaded in an outward direction from the deck.

For questions regarding these or other connections, please contact FastenMaster Technical Support at www.fastenmaster.com or by calling 800·518·3569.

FMTECH-THRPOST (1010)

ESR-1078

Reissued February 1, 2007

This report is subject to re-examination in two years.

ICC Evaluation Service, Inc.
www.icc-es.org

Business/Regional Office ■ 5360 Workman Mill Road, Whittier, California 90601 ■ (562) 699-0543
Regional Office ■ 900 Montclair Road, Suite A, Birmingham, Alabama 35213 ■ (205) 599-9800
Regional Office ■ 4051 West Flossmoor Road, Country Club Hills, Illinois 60478 ■ (708) 799-2305

DIVISION: 06—WOOD AND PLASTICS
Section: 06090—Wood and Plastic Fastenings

REPORT HOLDER:

OMG, INC.
153 BOWLES ROAD
AGAWAM, MASSACHUSETTS 01001
(413) 789-0252
www.fastenmaster.com
mguthrie@olyfast.com

EVALUATION SUBJECT:

FASTENMASTER® THREADED WOOD FASTENERS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2006 *International Building Code®* (IBC)
- 2006 *International Residential Code®* (IRC)

Properties evaluated:

Structural

2.0 USES

The FastenMaster Series fasteners described in this report are alternate dowel-type threaded fasteners used for wood-to-wood connections.

3.0 DESCRIPTION

3.1 General:

The FastenMaster Series fasteners described in this report are manufactured using a standard cold-forming process and are heat-treated. The fasteners have a proprietary coating with a lubricious clear top coat. The FastenMaster series includes three different fastener diameters that are available in lengths ranging from $2^1/_2$ to 16 inches (63.5 to 406.4 mm), inclusive of thread. (See Tables 1A through 1D of this report for fastener dimensions.) The fasteners have a hex-head design with integral washer, rolled threads and a gimlet point.

These fasteners depart from ANSI B18.2.1 and B18.6.1 in thread design, exceed the bending yield strengths documented in Table 6 of American Forest & Paper Association (AF&PA) Technical Report 12, and are not installed with lead holes in accordance with the National Design Specification for Construction (NDS).

3.2 Materials:

The fasteners are made of carbon steel grade 1022 wire, conforming to ASTM A 510, with a minimum ultimate tensile strength of 60 ksi (414 MPa), and have a proprietary finish. Minimum bending yield strengths of the fasteners are listed in Tables 1A, 1B, 1C and 1D of this report.

4.0 DESIGN AND INSTALLATION

4.1 Design:

Design values for dowel bearing strengths are specified in Table 2 of this report. Design values for withdrawal connections are specified in Table 3 of this report. Design values for pull-through shall be as specified in Table 4 of this report. Design values for lateral resistance in wood-to-wood connections loaded parallel and perpendicular to the grain, are noted in Tables 5A and 5B of this report, using the applicable fastener diameter (minor thread diameter).

4.2 Installation:

The fasteners must be installed with a $^1/_2$-inch (12.7 mm), low RPM/high torque electric drill (450 rpm) using the special hex-head driver bit included in each box. Lead holes are not required at the minimum end and edge distances listed in Table 6 of this report.

5.0 CONDITIONS OF USE

The fasteners described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 When the capacity of a connection is controlled by fastener metal strength, rather than wood strength, allowable strength of the connection are not permitted to be multiplied by the adjustment factors specified in the NDS.

5.2 When designing a connection, the connection shall be checked against Appendix E in the NDS to ensure the capacity of the connection and fastener group.

5.3 This evaluation report does not address fastener corrosion when the fastener is installed in chemically treated wood.

5.4 The fasteners are produced by OMG, Inc. at their facility located in Agawam, Massachusetts; under a quality control program with inspections by FM Approvals (AA-653).

6.0 EVIDENCE SUBMITTED

Data and test reports in accordance with the ICC-ES Acceptance Criteria for Alternate Dowel-type Threaded Fasteners Part A: Fasteners Less Than $^1/_4$ Inch in Diameter (AC233), dated October 2006.

7.0 IDENTIFICATION

The fasteners are identified by the designation "TrussLok®," "TrussLok-Z®," "TimberLok®," "LedgerLok®," "OlyLog®," or "LogHog®" on the packaging. Head markings consist of "F" followed by the length of the fastener. Each container of fasteners must have a label noting OMG's name and address, fastener size, inspection agency name (FM Approvals) and the evaluation report number (ICC-ES ESR-1078).

TABLE 1A—FASTENER SPECIFICATIONS: OLYLOG AND TIMBERLOK FASTENERS

OLYLOG® / TIMBERLOK® FASTENER DESIGNATION	HEAD MARKING	OVERALL LENGTH[1] (inches)	LENGTH OF THREAD (inches)[2,5]	UNTHREADED SHANK DIAMETER[3] (inch)	MINOR THREAD (ROOT) DIAMETER (inch)	ALLOWABLE STEEL STRENGTH		
						Bending Yield (Fyb, psi)[4,6]	Tensile (psi)	Single Shear (psi)
TLOK212 or LOG212	F2.5	$2\frac{1}{2}$	$1\frac{1}{4}$	0.189 [0.187 - 0.189]	0.172 (design diameter)	189,700	45,600	29,900
TLOK04 or LOG004	F4.0	4	2					
TLOK06 or LOG006	F6.0	6	2					
TLOK08 or LOG008	F8.0	8	2					
LOG009	F9.0	9	2					
TLOK10 or LOG010	F10.0	10	2					
LOG012	F12.0	12	2					
LOG014	F14.0	14	2					
LOG016	F16.0	16	2					

For **SI:** 1 inch = 25.4 mm, 1 psi = 6.895 kPa.

NOTES:

1. For purposes of measuring overall fastener length, fasteners must be measured from the underside of head to bottom of tip.
2. Length of thread includes tip. See detailed illustration.
3. Unthreaded shank diameters are shown in table with manufacturing tolerances in brackets [ ].
4. Bending yield strength determined per methods specified in ASTM D 1575 and based on the minor thread diameter.
5. Fastener installation and design values require complete threaded portion to be embedded in the main member.
6. Fastener bending yield strength is determined by the 5% diameter (0.05D) offset method of analyzing load-displacement curves developed from bending tests.

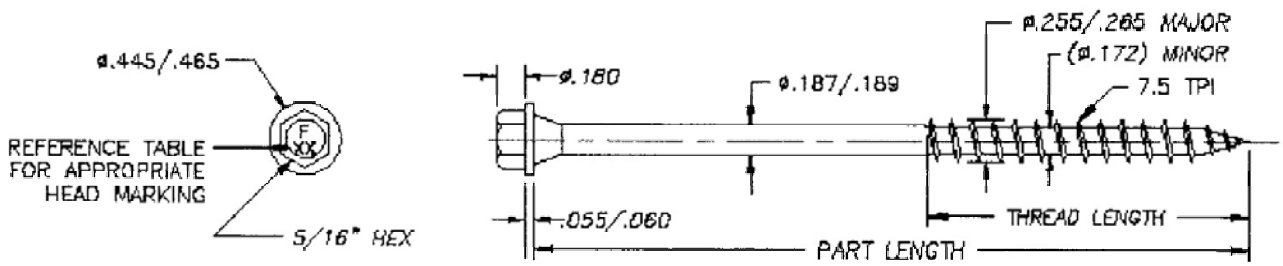


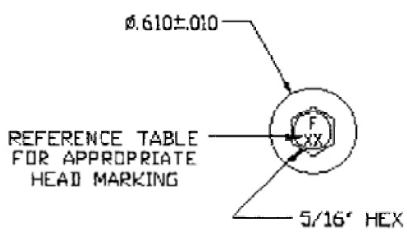
TABLE 1B—FASTENER SPECIFICATIONS: LOGHOG AND LEDGERLOK FASTENERS

LEDGERLOK® / LOGHOG® FASTENER DESIGNATION	HEAD MARKING	OVERALL LENGTH[1] (inches)	LENGTH OF THREAD (inches)[2,5]	UNTHREADED SHANK DIAMETER[3] (inch)	MINOR THREAD (ROOT) DIAMETER (inch)	ALLOWABLE STEEL STRENGTH		
						Bending Yield (Fyb, psi)[4,6]	Tensile (psi)	Single Shear (psi)
LL358	F3.6	$3^5/_8$	2	0.228 [.227 - 0.229)	0.202 (design diameter	200,700	49,800	32,800
LL005	F5.0	5	3					
LHOG009	F9.0	9	3			183,200	32,700	21,800
LHOG011	F11.0	11	3					
LHOG012	F12.0	12	3					
LHOG013	F13.0	13	3					
LHOG014	F14.0	14	3					
LHOG015	F15.0	15	3					

For **SI:** 1 inch = 25.4 mm, 1 psi = 6.895 kPa.

NOTES:

1. For purposes of measuring overall fastener length, fasteners must be measured from the underside of head to bottom of tip.
2. Length of thread includes tip. See detailed illustration.
3. Unthreaded shank diameters are shown in table with manufacturing tolerances in brackets [ ].
4. Bending yield strength determined per methods specified in ASTM D 1575 and based on the minor thread diameter.
5. Fastener installation and design values require complete threaded portion to be embedded in the main member.
6. Fastener bending yield strength is determined by the 5% diameter (0.05D) offset method of analyzing load-displacement curves developed from bending tests.



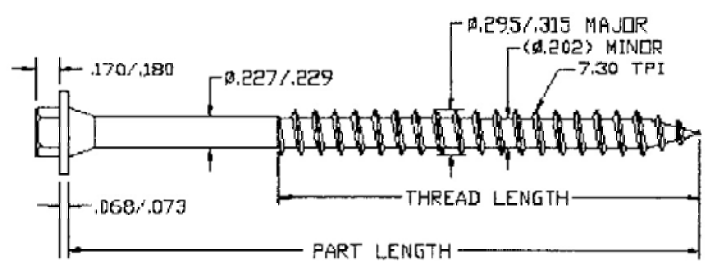


TABLE 1C—FASTENER SPECIFICATIONS: TRUSSLOK FASTENERS

TRUSSLOK® FASTENER DESIGNATION	HEAD MARKING	OVERALL LENGTH[1] (inches)	LENGTH OF THREAD (inches)[2,5]	UNTHREADED SHANK DIAMETER[3] (inch)	MINOR THREAD (ROOT) DIAMETER (inch)	ALLOWABLE STEEL STRENGTH		
						Bending Yield (Fyb, psi)[4,6]	Tensile (psi)	Single Shear (psi)
EWS338	F3.3	$3^3/_8$	$1^1/_2$	0.228 [0.227 - 0.229]	0.215 (design diameter)	202,200	49,800	32,800
EWS005	F5.0	5						
EWS670	F6.7	6.7						

For **SI:** 1 inch = 25.4 mm, 1 psi = 6.895 kPa.

NOTES:

1. For purposes of measuring overall fastener length, fasteners must be measured from the underside of head to bottom of tip.
2. Length of thread includes tip. See detailed illustration.
3. Unthreaded shank diameters are shown in table with manufacturing tolerances in brackets [ ].
4. Bending yield strength determined per methods specified in ASTM D 1575 and based on the minor thread diameter.
5. Fastener installation and design values require complete threaded portion to be embedded in the main member.
6. Fastener bending yield strength is determined by the 5% diameter (0.05D) offset method of analyzing load-displacement curves developed from bending tests.

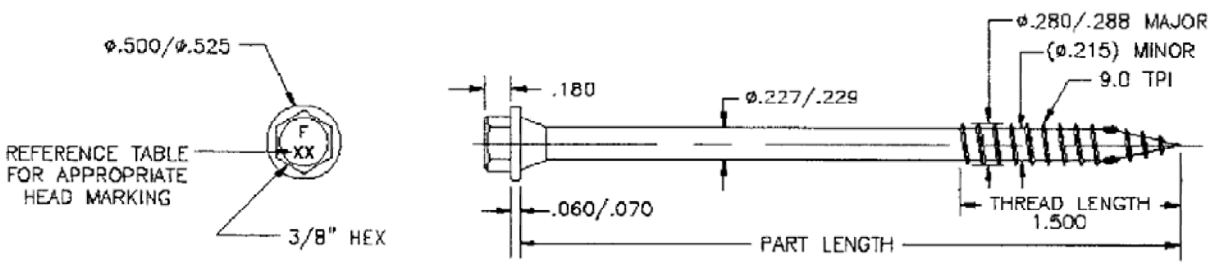


TABLE 1D—FASTENER SPECIFICATIONS: TRUSSLOK-Z FASTENERS

TRUSSLOK-Z® FASTENER DESIGNATION	HEAD MARKING	OVERALL LENGTH[1] (inches)	LENGTH OF THREAD (inches)[2,5]	UNTHREADED SHANK DIAMETER[3] (inch)	MINOR THREAD (ROOT) DIAMETER (inch)	ALLOWABLE STEEL STRENGTH		
						Bending Yield (Fyb, psi)[4,6]	Tensile (psi)	Single Shear (psi)
TSLZ278	F2.8	$2^7/_8$	$1^1/_4$	0.228 [0.227 - 0.229]	0.202 (design diameter)	236,300	49,800	32,800
TSLZ412	F4.5	$4^1/_2$						
TSLZ006	F6.0	6						

For **SI:** 1 inch = 25.4 mm, 1 psi = 6.895 kPa.

NOTES:

1. For purposes of measuring overall fastener length, fasteners must be measured from the underside of head to bottom of tip.
2. Length of thread includes tip. See detailed illustration.
3. Unthreaded shank diameters are shown in table with manufacturing tolerances in brackets [ ].
4. Bending yield strength determined per methods specified in ASTM D 1575 and based on the minor thread diameter.
5. Fastener installation and design values require complete threaded portion to be embedded in the main member.
6. Fastener bending yield strength is determined by the 5% diameter (0.05D) offset method of analyzing load-displacement curves developed from bending tests.

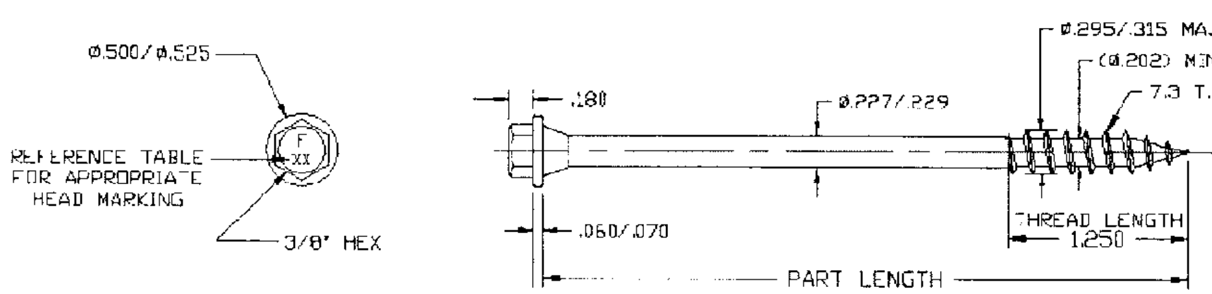


TABLE 2—DOWEL BEARING STRENGTH (psi)
(Test results are the 5% offset value)

FASTENER DESIGNATION	DIRECTION OF LOADING	CALCULATED DOWEL BEARING STRENGTH PER REGRESSION EQUATIONS								
		0.67	**0.57**	**0.55**	**0.5**	**0.46**	**0.43**	**0.42**	**0.36**	**0.31**
OlyLog® / TimberLok® fasteners	Parallel to grain	7,950	6,400	6,150	5,600	5,150	4,800	4,700	4,050	3,450
	Perpendicular to grain	7,950	6,200	5,900	5,150	4,550	4,150	4,000	3,200	2,550
LogHog® / LedgerLok® / TrussLok® / TrussLok-Z® fasteners	Parallel to grain	7,950	6,400	6,150	5,600	5,150	4,800	4,700	4,050	3,450
	Perpendicular to grain	7,950	5,900	5,550	4,700	4,150	3,750	3,650	2,900	2,350
Wet Service Factor, C_m, for lateral loads	*Parallel to grain*	*0.7*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*
	Perpendicular to grain	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*	*0.7*	*0.6*	*0.5*

TABLE 3—DIRECT WITHDRAWAL DESIGN VALUES (*W*)
[Tabulated withdrawal design values (*W*) are in pounds per inch of thread penetration into side grain of main member]

FASTENER DESIGNATION		THREAD LENGTH, *L* (inches)	*W* (lbs./in.) FOR SPECIFIC GRAVITIES OF:								
			0.67	**0.57**	**0.55**	**0.5**	**0.46**	**0.43**	**0.42**	**0.36**	**0.31**
OlyLog® / TimberLok® fasteners	TLOK212 or LOG212	1.25	264	207	196	170	150	136	131	104	83
	All other lengths	2									
Wet Service Factor, C_m, for withdrawal loads			*0.7*	*0.7*	*0.7*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*
LogHog® / LedgerLok® fasteners	LL358	2	297	233	221	192	169	153	148	117	94
	All other lengths	3									
TrussLok®	All lengths	$1^1/_2$	—	—	—	153	—	—	—	—	—
TrussLok-Z®	All lengths	$1^1/_4$	—	233	221	192	169	153	148	117	—
Wet Service Factor, C_m, for withdrawal loads			*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*
NDS equation used to calculate design values			11.2-1	11.2-1	11.2-1	11.2-1	11.2-1	11.2-1	11.2-1	11.2-1	11.2-1

For **SI:** 1 inch = 25.4 mm, 1 pound = 4.448 kPa.

NOTES:

1. Values must be multiplied by all applicable adjust factors (see NDS).
2. Embedded thread length is that portion held by the main member (including tip).

TABLE 4—PULL-THROUGH DESIGN VALUES (*P*)

FASTENER DESIGNATION		THREAD LENGTH, *L* (inches)	*P* (lbs./in.) FOR SPECIFIC GRAVITIES OF:								
			0.67	**0.57**	**0.55**	**0.5**	**0.46**	**0.43**	**0.42**	**0.36**	**0.31**
OlyLog® / TimberLok® fasteners	TLOK212 or LOG212	1.25	334	218	200	158	130	112	107	79	62
	All other lengths	2									
LogHog® / LedgerLok® fasteners	LL358	2	471	323	299	243	206	181	173	133	108
	All other lengths	3									
TrussLok®	All lengths	$1^1/_2$	—	—	—	264	—	—	—	—	—
TrussLok-Z®	All lengths	$1^1/_4$	—	366	327	248	199	168	159	114	—

For **SI:** 1 inch = 25.4 mm, 1 pound = 4.448 kPa.

NOTES:

1. Values must be multiplied by all applicable adjustment factors (see NDS).
2. Embedded thread length is that portion held by the main member (including tip).
3. Tabulated pull-through design values (*P*) are in pounds per inch through side member.

TABLE 5A—LATERAL DESIGN VALUES (*Z*) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS WITH LOADING PARALLEL TO GRAIN

[Tabulated lateral design values (*Z*) are in pounds per fastener into sawn lumber or SCL[3] with both members of identical specific gravity]

<table>
<tr><th colspan="2" rowspan="2">FASTENER DESIGNATION</th><th rowspan="2">SIDE MEMBER THICKNESS, t_s (inches)</th><th rowspan="2">FASTENER PENETRATION, p (inches)</th><th colspan="9">Z (lbs.) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS LOADED PARALLEL TO THE GRAIN FOR SPECIFIC GRAVITIES OF:</th></tr>
<tr><th>0.67</th><th>0.57</th><th>0.55</th><th>0.5</th><th>0.46</th><th>0.43</th><th>0.42</th><th>0.36</th><th>0.31</th></tr>
<tr><td rowspan="10">OlyLog® / TimberLok® fasteners</td><td>TLOK212 or LOG212</td><td>1 1/2</td><td>1</td><td>265</td><td>224</td><td>217</td><td>203</td><td>191</td><td>181</td><td>179</td><td>161</td><td>143</td></tr>
<tr><td>TLOK04 or LOG006</td><td>1 1/2</td><td>2 1/2</td><td rowspan="9">299</td><td rowspan="9">268</td><td rowspan="9">263</td><td rowspan="9">251</td><td rowspan="9">240</td><td>231</td><td>228</td><td>228</td><td>1788</td></tr>
<tr><td>TLOK06 or LOG006</td><td>4</td><td>2</td><td rowspan="8">232</td><td rowspan="8">230</td><td rowspan="8">213</td><td rowspan="8">197</td></tr>
<tr><td>TLOK08 or LOG008</td><td>6</td><td>2</td></tr>
<tr><td>LOG009</td><td>7</td><td>2</td></tr>
<tr><td>TLOK10 or LOG010</td><td>8</td><td>2</td></tr>
<tr><td>LOG012</td><td>10</td><td>2</td></tr>
<tr><td>LOG014</td><td>12</td><td>2</td></tr>
<tr><td>LOG016</td><td>14</td><td>2</td></tr>
<tr><td rowspan="2">LedgerLok® fasteners</td><td>LL358</td><td>1 1/2</td><td>2 1/8</td><td rowspan="2">373</td><td rowspan="2">325</td><td rowspan="2">315</td><td rowspan="2">292</td><td>274</td><td>259</td><td rowspan="2">255</td><td>229</td><td>204</td></tr>
<tr><td>LL005</td><td>1 1/2</td><td>3 1/2</td><td>274</td><td>259</td><td>229</td><td>204</td></tr>
<tr><td rowspan="6">LogHog® fasteners</td><td>LHOG009</td><td>6</td><td>3</td><td rowspan="6">357</td><td rowspan="6">320</td><td rowspan="6">314</td><td rowspan="6">299</td><td rowspan="6">287</td><td rowspan="6">277</td><td rowspan="6">274</td><td rowspan="6">255</td><td rowspan="6">235</td></tr>
<tr><td>LHOG011</td><td>8</td><td>3</td></tr>
<tr><td>LHOG012</td><td>9</td><td>3</td></tr>
<tr><td>LHOG013</td><td>10</td><td>3</td></tr>
<tr><td>LHOG014</td><td>11</td><td>3</td></tr>
<tr><td>LHOG015</td><td>12</td><td>3</td></tr>
<tr><td rowspan="3">TrussLok®</td><td>EWS338</td><td>1 3/4</td><td>1 5/8</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">—</td><td>318</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">—</td></tr>
<tr><td>EWS005</td><td>1 3/4</td><td>3 1/4</td><td>333</td></tr>
<tr><td>EWS670</td><td>1 3/4</td><td>5</td><td>333</td></tr>
<tr><td rowspan="3">TrussLok-Z®</td><td>TSLZ278</td><td>1 1/2</td><td>1 3/8</td><td rowspan="3">—</td><td>306</td><td>294</td><td>268</td><td>246</td><td>229</td><td>225</td><td>194</td><td rowspan="3">—</td></tr>
<tr><td>TSLZ412</td><td>1 1/2</td><td>3</td><td>336</td><td>326</td><td>303</td><td>285</td><td>270</td><td>266</td><td>239</td></tr>
<tr><td>TSL006</td><td>1 1/2</td><td>4 1/2</td><td>336</td><td>326</td><td>303</td><td>285</td><td>270</td><td>266</td><td>239</td></tr>
</table>

For **SI:** 1 inch = 25.4 mm, 1 pound = 4.448 kPa.

NOTES:

1. Values must be multiplied by all applicable adjustment factors (see NDS).
2. Embedded thread length is that portion held by the main member (including tip).
3. SCL is structural composite lumber (laminated veneer lumber is LVL, and parallel strand lumber is PSL). This group also includes all OSB, structural I plywood, and marine-grade plywood panels.
4. p = depth of fastener penetration into wood member, in inches.
5. Tabulated values are results of calculations per NDS Section 11.3, where D = minor thread diameter.

TABLE 5B—LATERAL DESIGN VALUES (*Z*) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS WITH LOADING PERPENDICULAR TO GRAIN

[Tabulated lateral design values (*Z*) are in pounds per fastener into sawn lumber or SCL[3] with both members of identical specific gravity]

<table>
<tr><th colspan="2" rowspan="2">FASTENER DESIGNATION</th><th rowspan="2">SIDE MEMBER THICKNESS, t_s (inches)</th><th rowspan="2">FASTENER PENETRATION, p (inches)</th><th colspan="9">Z (lbs.) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS LOADED PARALLEL TO THE GRAIN FOR SPECIFIC GRAVITIES OF:</th></tr>
<tr><th>0.67</th><th>0.57</th><th>0.55</th><th>0.5</th><th>0.46</th><th>0.43</th><th>0.42</th><th>0.36</th><th>0.31</th></tr>
<tr><td rowspan="9">OlyLog® / TimberLok® fasteners</td><td>TLOK212 or LOG212</td><td>$1\frac{1}{2}$</td><td>1</td><td>265</td><td>219</td><td>211</td><td>191</td><td>175</td><td>164</td><td>160</td><td>133</td><td>106</td></tr>
<tr><td>TLOK04 or LOG006</td><td>$1\frac{1}{2}$</td><td>$2\frac{1}{2}$</td><td rowspan="8">299</td><td rowspan="8">264</td><td rowspan="8">257</td><td rowspan="8">240</td><td>222</td><td>206</td><td>200</td><td>168</td><td>142</td></tr>
<tr><td>TLOK06 or LOG006</td><td>4</td><td>2</td><td rowspan="7">226</td><td rowspan="7">216</td><td rowspan="7">212</td><td rowspan="7">190</td><td rowspan="7">166</td></tr>
<tr><td>TLOK08 or LOG008</td><td>6</td><td>2</td></tr>
<tr><td>LOG009</td><td>7</td><td>2</td></tr>
<tr><td>TLOK10 or LOG010</td><td>8</td><td>2</td></tr>
<tr><td>LOG012</td><td>10</td><td>2</td></tr>
<tr><td>LOG014</td><td>12</td><td>2</td></tr>
<tr><td>LOG016</td><td>14</td><td>2</td></tr>
<tr><td rowspan="2">LedgerLok® fasteners</td><td>LL358</td><td>$1\frac{1}{2}$</td><td>$2\frac{1}{8}$</td><td rowspan="2">373</td><td rowspan="2">305</td><td>290</td><td>255</td><td>233</td><td>216</td><td rowspan="2">212</td><td>179</td><td>145</td></tr>
<tr><td>LL005</td><td>$1\frac{1}{2}$</td><td>$3\frac{1}{2}$</td><td>290</td><td>255</td><td>233</td><td>216</td><td>180</td><td>157</td></tr>
<tr><td rowspan="6">LogHog® fasteners</td><td>LHOG009</td><td>6</td><td>3</td><td rowspan="6">357</td><td rowspan="6">307</td><td rowspan="6">298</td><td rowspan="6">274</td><td rowspan="6">258</td><td rowspan="6">245</td><td rowspan="6">242</td><td rowspan="6">215</td><td rowspan="6">194</td></tr>
<tr><td>LHOG011</td><td>8</td><td>3</td></tr>
<tr><td>LHOG012</td><td>9</td><td>3</td></tr>
<tr><td>LHOG013</td><td>10</td><td>3</td></tr>
<tr><td>LHOG014</td><td>11</td><td>3</td></tr>
<tr><td>LHOG015</td><td>12</td><td>3</td></tr>
<tr><td rowspan="3">TrussLok®</td><td>EWS338</td><td>$1\frac{3}{4}$</td><td>$1\frac{5}{8}$</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">—</td><td>267</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">—</td><td rowspan="3">—</td></tr>
<tr><td>EWS005</td><td>$1\frac{3}{4}$</td><td>$3\frac{1}{4}$</td><td>290</td></tr>
<tr><td>EWS670</td><td>$1\frac{3}{4}$</td><td>5</td><td>290</td></tr>
<tr><td rowspan="3">TrussLok-Z®</td><td>TSLZ278</td><td>$1\frac{1}{2}$</td><td>$1\frac{3}{8}$</td><td rowspan="3">—</td><td>282</td><td>265</td><td>225</td><td>198</td><td>179</td><td>174</td><td>139</td><td rowspan="3">—</td></tr>
<tr><td>TSLZ412</td><td>$1\frac{1}{2}$</td><td>3</td><td>316</td><td>301</td><td>266</td><td>243</td><td>227</td><td>222</td><td>190</td></tr>
<tr><td>TSL006</td><td>$1\frac{1}{2}$</td><td>$4\frac{1}{2}$</td><td>316</td><td>301</td><td>266</td><td>243</td><td>227</td><td>222</td><td>190</td></tr>
</table>

For **SI:** 1 inch = 25.4 mm, 1 pound = 4.448 kPa.

NOTES:

1. Values must be multiplied by all applicable adjustment factors (see NDS).
2. Embedded thread length is that portion held by the main member (including tip).
3. SCL is structural composite lumber (laminated veneer lumber is LVL, and parallel strand lumber is PSL). This group also includes all OSB, structural I plywood, and marine-grade plywood panels.
4. p = depth of fastener penetration into wood member, in inches.
5. Tabulated values are results of calculations per NDS Section 11.3, where *D* = minor thread diameter.

TABLE 6—CONNECTION GEOMETRY

CONNECTION GEOMETRY/CRITERIA	DIAMETERS	OLYLOG® / TIMBERLOK® FASTENERS (inches)	LOGHOG® / LEDGERLOK® / TRUSSLOK® / TRUSSLOK-Z® FASTENERS (inches)
Minimum edge distance (2.5 diameters per NDS Commentary Table C11.4-1):	8	$1^1/_2$	$1^3/_4$
From edge (4 diameters per NDS Table 11.5.1A), loaded edge:	8	$1^1/_2$	$1^3/_4$
Minimum end distance, tension load parallel to grain (per NDS Commentary Table C11.4-1):	16	3	$3^3/_4$
Compression load parallel to grain (NDS Commentary Table C11.4-1):	10	2	$2^3/_8$
Spacing (pitch) between fasteners in a row, parallel to grain:	15	$2^3/_4$	$3^1/_2$
Perpendicular to grain:	10	2	$2^3/_8$
Spacing (gage) between rows of fasteners, in-line:	5	1	$1^1/_4$
Spacing (gage) between rows of fasteners, staggered:	2.5	$^1/_2$	$^5/_8$
Minimum penetration into the main member for single shear connections	6	$1^1/_4$	$1^3/_8$

For **SI:** 1 inch = 25.4 mm.

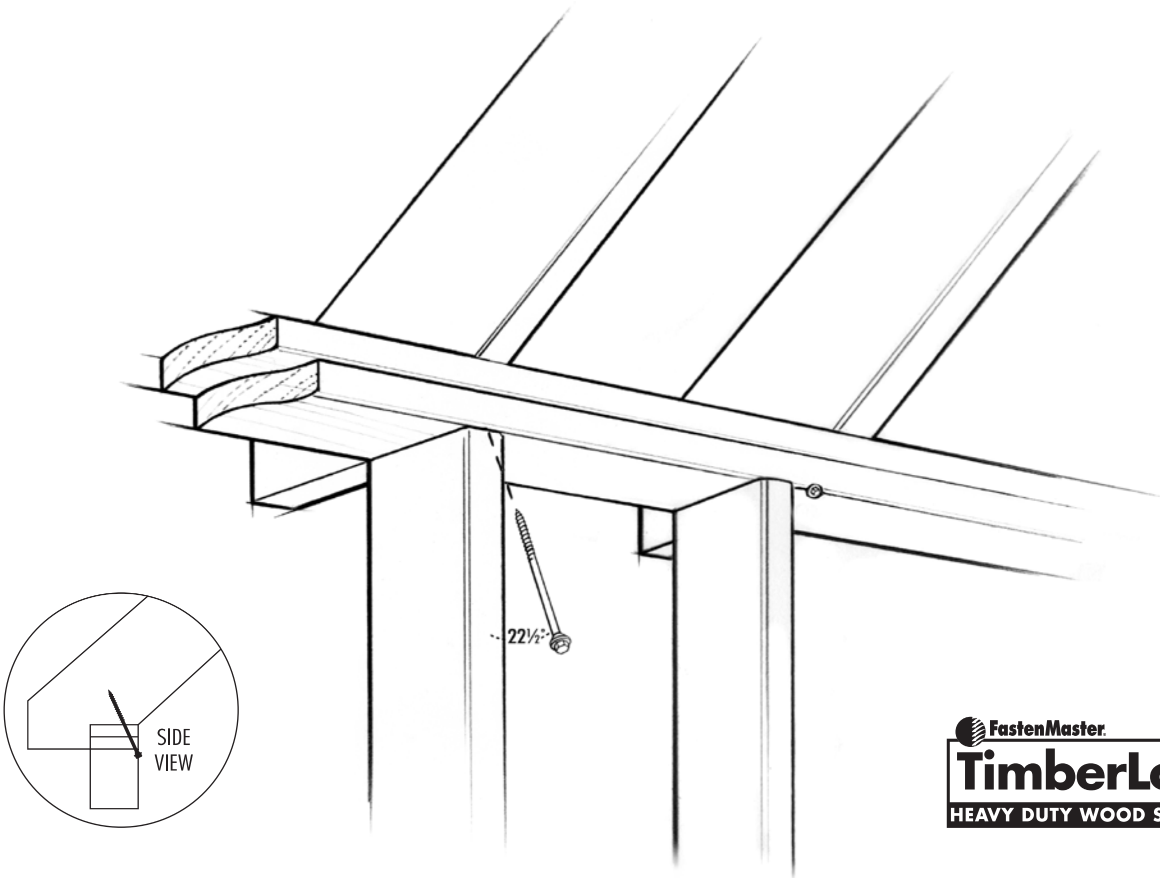
RAFTER TAIL TO TOP PLATE

CONNECTION DETAILS

The minimum fastening requirements for the rafter to top plate connection in the 2006/2009 International Residential Code (Table R602.3) require 2-16d nails toenailed. The 2006/2009 International Building Code (Table 2304.9.1) requires 3-8d nails toenailed. Both of these codes can be met by installing the FastenMaster TimberLok when the guidelines on this technical bulletin are followed. In many cases where increased wind uplift or seismic conditions require a stronger rafter to top plate connection, this fastening method may also be used to replace metal ties and straps.

FASTENING METHOD

CAN BE USED WHEN RAFTER IS ALIGNED OVER OR BETWEEN WALL STUDS



FastenMaster
TimberLok
HEAVY DUTY WOOD SCREW

- Use a 6" FastenMaster TimberLok.
- Where the rafter is directly over the wall stud, insert fastener point between the bottom of the top plate and the top of the stud.
- Where the rafter is located between two studs, insert fastener point on bottom surface of the top plate no greater than ½" from the inside edge of the plate.
- Drive fastener through double top plate at a 22½° angle (+/– 5°)and into the center of the rafter.
- Fastener must be driven into the center of the 1½" rafter edge (+/– ¼") with the threads fully embedded into the rafter.
- Bring the fastener head flush with the wood surface.

FASTENER DESIGN LOADS

The FastenMaster TimberLok load values in Table 1 can be used by a design professional to determine suitability of these fasteners in a rafter to top plate connection.

- Where the uplift and/or lateral design loads have been provided on the building plans, the allowable loads in Table 1 can be compared to the plan values to make sure they are met or exceeded by use of this fastening method.
- If ties or straps have been called for to resist uplift and lateral forces, the allowable loads in Table 1 should be compared to the manufacturer's published values for the specified connector to ensure that this fastening method meets or exceeds these loads.
- In cases where the above two methods are not available and the wind speed from IRC Figure 301.2(4) equals or exceeds 100 mph in hurricane-prone regions, or 110 mph elsewhere, the design loads of this connection can be determined by a design professional from one of the following three sources and compared to Table 1:

TABLE 1

TimberLok Design Loads for Rafter to Top Plate Connections						
Wood Species	SPF/HF		Douglas Fir		Southern Pine	
Load Type	Uplift	Lateral/ Shear	Uplift	Lateral/ Shear	Uplift	Lateral/ Shear
Allowable Load	420	320	540	380	620	410

- TimberLok values above are based on ICC-ES Report #1078 and independently verified through testing to ASTM D-1761.
- A standard wind load duration factor has been applied to these values per NDS Table 2.3.2. Other applicable NDS adjustment factors are at the discretion of a design professional.
- These values apply only to the top plate to rafter connection and assume that the fastener is properly installed per the instructions on this bulletin.

1. American Forest and Paper Association (AF&PA) Wood Frame Construction Manual for One- and Two-Family Dwellings (WFCM). A sample of this chart is shown below.
2. International Code Council (ICC) Standard for the Residential Construction in High Wind Regions (ICC-600).
3. Minimum Design Loads for Buildings and Other Structures (ASCE-7).

Sample Wind Loads

Table 2 below represents common design wind loads on rafter to top plate connections taken from the AF&PA Wood Frame Construction Manual, High Wind Zone Exposure B, Wall Connections at Load Bearing Walls.

TABLE 2

		Roof Framing Span (ft.)								
		12	**16**	**20**	**24**	**28**	**32**	**36**		
WIND ZONE (MPH)	**RAFTER SPACING**	**UPLIFT (lb.)**							**LATERAL (LB.)**	**SHEAR (LB.)**
90	16" o.c.	82	96	110	125	139	154	168	119	52
90	24" o.c.	123	144	165	187	209	230	252	178	78
100	16" o.c.	124	147	170	193	217	240	264	145	64
100	24" o.c.	186	220	255	290	325	360	396	218	96
110	16" o.c.	170	203	236	269	303	336	370	176	77
110	24" o.c.	255	304	354	404	454	504	554	264	116
120	16" o.c.	220	264	308	352	397	441	486	209	93
120	24" o.c.	331	396	462	528	595	661	728	314	140
130	16" o.c.	275	331	386	442	499	555	611	247	109
130	24" o.c.	413	496	580	664	748	833	917	370	164

This chart is used as an example only and should not be the sole source to design the connection.

FMTECH-RAFTTAIL (1210)