Welcome to the ICON Solar House

project manual

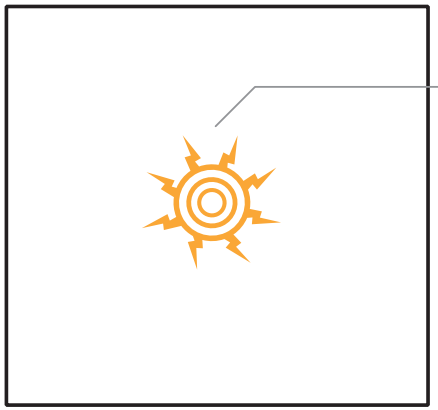
Architecture | Engineering | Market Viability | Lighting Design | Communications

This document is designed to help you learn about the ICON Solar House design and intentions. We have created a naviagation system for you to follow, whether you print this out or read it digitally.

Find the icon associated with the subjective contest you're interested in, and you can follow that icon through this massive document. It'll show you what we think are highlights of each topic.

The number on left of the icon is one page previous in your specific path, and the number on the right of the icon is the next page in your specific path. When a page has multiple paths associated with it, all icons are shown.

Navigation Scheme



Follow the Icon

ICON SOLAR HOUSE

UNIVERSITY OF MINNESOTA

COMMENTS

REV DATE 05/15/2009

COVER

AUTHORED BY Meaghan Tessman

PM-001

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AUTHORED BY Simona Fischer

PM-002

Executive Summary

This document contains and introduction to the University of Minnesota, ICON Solar House Team, and the ICON concept. From there, each of the five subjective contests are addressed - architectural design, market viability, engineering, lighting design, and communications. Narratives explaining the intent and approaches to each subjective contest can be found in the main body of this document. Also, as discussed on the cover page, the navigation icons will travel between this document, the construction drawings and communications plan to highlight the main ideas of each topic. The next-use plan, to be implemented after the 2009 U.S. Department of Energy Solar Decathlon, is discussed in the final narrative.

The appendices of the document contain reference documents and required content, such as the construction specifications, and the structural calculations. To aid in navigation through the required documentation, the following chart locates specific content by the U.S. Department of Energy Solar Decathlon rules.

	Rule	Location
4-2	Construction Equipment	O-102, O-601
4-2	Construction Equipment - Specs	PM-Appendix C
4-3	Ground penetration	S-501, PM-Appendix B
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4-7	Lot Conditions - Elevation Change	L-201, L-202
4-7	Lot Conditions - Foundation	S-101
5-2	Solar Envelope - Dimensions	L-101, L-201, L-202
5-2	Solar Envelope - Exemptions	NA
6-1	Structural Design Approval	S series stamped
6-2	Max Architectural Footprint	X-103

	Rule	Location
6-2	Max Architectural Footprint - Moveable Components	X-103
6-2	Max Architectural Footprint - Shading	X-103
6-3	Minimum Conditioned Space	X-103
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8-4	Batteries	NA
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8-5	Desiccant Systems - drawings	M-603
8-5	Desiccant Systems - Datasheets	PM-Appendix C, linked to online database
8-6	Village Grid - Interconnection Form	PM-Appendix D
8-6	Village Grid - Drawings	L-101, E-101, E-201
8-6	Village Grid - Datasheets	PM-Appendix C, linked to online database
8-6	Village Grid - One Line	E-603
8-6	Village Grid - NEC 220 Calc	E-001, E-002
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9-4	Rainwater collection	L-601

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AUTHORED BY Shengyin Xu

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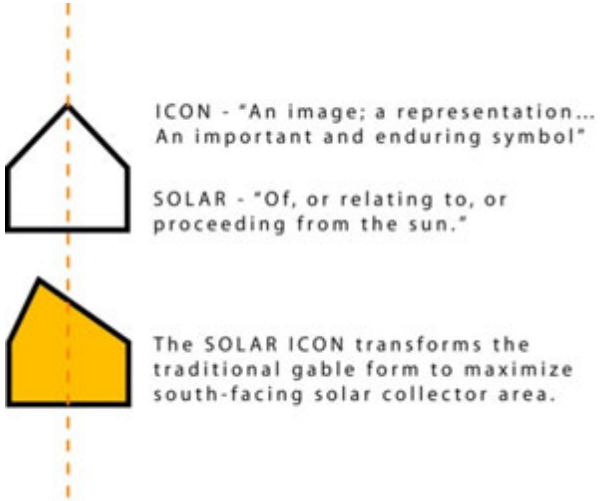
The University of Minnesota ICON House



Overview

Design Concept
The design of the ICON House is rooted in the familiar shape of an American family home. The gabled roof is a traditional form that has long been associated with the concept of home. We believe that merging new technology with familiar imagery is a vital symbolic step in the transition from traditional building methods to a zero-energy use future.

The gabled shape provides challenges in optimization for solar collection. It limits the surface area for collectors, and it restricts the angles at which we can mount the panels. Thus, our team has modified the abstract gabled form into one that is optimized for solar gain. By adjusting the geometry, we have achieved a gabled form that is both familiar, yet with sufficient surface area and appropriate angles for solar collection.

The ICON House combines unfamiliar technology with the popularly accepted imagery, in order to create a new tradition. We hope that this adjusted gable form will become a new icon of solar and sustainable homes.

Integrated Design Process & Nutrient Concept
The Project is organized around an integrated design process that utilizes many disciplines and points of view at every stage of the process in order to arrive at synergistic and satisfying results. This was an explicit goal from early in the project and has been reinforced by the way the teams are structured, the design and charrette process, the formation of integrated task groups to resolve specific issues and the primary decision making process that involves student leaders from all disciplines.

There is an underlying "nutrient" concept in the way ICON House team members discuss the life of the house. The Decathlon dictates many of the decisions for materials and products in the house, however; the members of our Project were aware from the beginning, of the different set of challenges that face sustainable housing over the lifetime of the house, versus during the short period of the competition. To address this issue, we have established a goal of analyzing the sustainability of the materials by using Life Cycle Assessments at various stages of design and development. In doing so, we will consider the environmental impact of a product or material by calculating its energy and material inputs from cradle to grave.

Ideally, LCA tools would be used at every stage of the design process to make choices about the materials used in the house. In practice, the construction schedule and timing of the project led to the necessity of making many decisions prior to running an LCA. Despite this, we believe our material sustainability goals should be incorporated into the education process. Thus, we have developed a process for running an LCA on our final house design, then using this data to compare to other equivalent materials that we had considered during the design process. The outcome will be an outreach tool in the form of a database that communicates to the general public issues raised by life cycle assessment.

An example of the LCA tool in our process is in the selection of our insulation. Given the necessity of maintaining a high R-value, we were concerned about the environmental impact of choosing high-petroleum content insulation, the content of which increases proportionately with R value. We considered icynene foams due to the fact that the blowing agents are generally less harmful than those of closed-cell foams, and there is less embodied energy within

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the product. Further, the open-celled icynene would allow more breathability for moisture vapor in our wall structure, helping to prevent mold growth or rotting of the structure if moisture makes its way into the wall cavity. However, to get the same R-50 performance, we would have had to have 12" or thicker walls. The lower impact, breathable insulation would require over 12" of wall structure, and offered many challenges in how to safely transport the house. In the end, we chose to use polyurethane, closed-cell insulation. It offered the high R-value, and additional rigidity for shipping and transport. Further, with careful design, we were able to study the moisture retention potential of the wall (see Architecture Narrative), and maintain breathability for moisture vapor. We may have chosen the more energy intensive closed-cell insulation, but our particular needs seemed to dictate this decision. However, our LCA research and our own decision making process will be documented in a database of materials, which will allow people to learn and select materials based on their particular needs.

"Traditionally, many disciplines provide a specialized technical service that is not always well coordinated with other aspects of the project. "Whole building design" or integrated design as a process requires the various stakeholders and disciplines to coordinate and interact as early as possible in the process, and throughout the life cycle of the project to achieve a holistic solution that may yield multiple benefits."

Whole Building Design Guide, 2006

"An integrated team reaches its potential if it can rise above the specialties of its members in order to arrive at innovative solutions. For the team to achieve this, it must develop true dialogue that encourages members to grasp complex issues as well as focus on a course of action and conclusion...the following conditions allow for true dialogue within a group exploring new ideas:

- *All participants must be aware of and let go of their preconceptions.*
- *All participants must consider each other as colleagues.*
- *A facilitator must keep the group interacting by these conditions."*

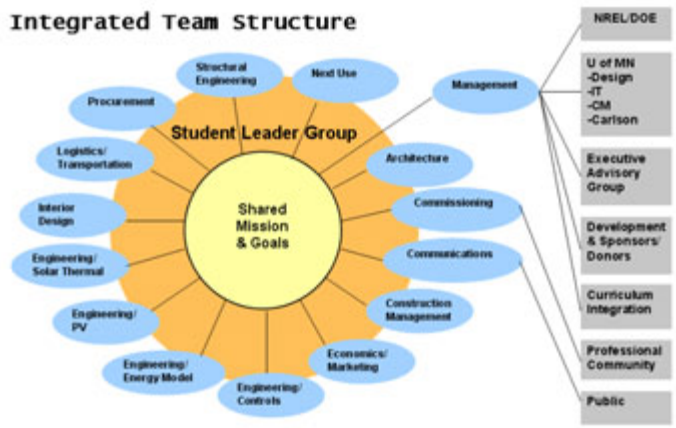
Kulman, Jonee & J. Schurke. Sustainable Design. 2001

Mission and Goals

The mission of the University of Minnesota ICON House is to further innovation and popular acceptance of sustainable housing by creating a zero-energy, solar-integrated prototype house and associated educational materials for the 2009 Solar Decathlon Competition. The house and educational materials shall not only meet the criteria of the competition, but embody a regional approach tailored to a target area, express creative thinking about sustainability, and strive to receive recognition for excellence in each component. The project will provide opportunities for hands-on interdisciplinary learning, promote the University of Minnesota, and raise awareness for sustainable strategies in the wider, non-academic community.

Project Goals

- Market Transformation: To plant a seed that will further encourage widespread acceptance of solar-integrated, sustainable housing by 2015.
- Competition: To build a zero-energy house that places in the top three in the 2009 Solar Decathlon.
- Innovative Sustainability: To create a prototype that demonstrates innovative thinking about sustainability.
- Regionalism: To create a prototype that demonstrates regionally-appropriate approaches to sustainable design, differentiating the ICON house from its competitors.
- Learning: To provide opportunities for hands-on interdisciplinary learning among project participants.



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Performance-Based Design Tools

Commissioning
Recognizing the strong performance-driven nature of this project, and the critical need to have systems running interactively very quickly after construction, the ICON House Student Leadership Group established a Commissioning Team. In this project, commissioning is interpreted broadly to encompass early goal setting and to be inclusive of both objective and subjective criteria for success. Using the Solar Decathlon Competition's Contest Criteria and Rules, the Commissioning Team created a set of guiding documents to facilitate the process of reviewing the design, establishing project deliverables, and testing the finished product.

More of a process than a tool, the comprehensive commissioning process is one of the key strategies for achieving the mission and goals of the team, clarifying intentions, and reviewing progress towards those goals and metrics throughout the design and construction process.

Role of BIM (Building Information Modeling)
Building Information Modeling is often advertised as a tool for integrated practice and sustainability. Our team's integrated process, involving 13 teams from engineering, design, business, and communications, promotes the use of BIM to communicate design issues between teams. ArchiCAD by Graphisoft was used to produce construction documents, coordinate drawings in 3D across teams, and as an interactive tool for public relations events. The ArchiCAD model was used to generate geometries to input into TRNSYS and IES for comprehensive energy modeling.

Energy Models (TRNSYS , spreadsheets and IES)
Quick energy calculations for rapid iterations of design alternatives made use of several energy spreadsheet calculators. TRNSYS models were added for more sophisticated and integrated energy analysis. IES was used by the commissioning team during the construction and refinements phase, making use of lighting levels and other metrics to test and hone the design.

The ICON House Team
The strength of the ICON House team comes from our technical and design knowledge, and our diversity. In addition to being highly competent in each of their respective fields, team members bring a variety of perspectives that are reflected in the design of the house. Differing viewpoints are taken into consideration through the use of a team structure that values input from all members, and requires a consensus approach to decision-making.

Our Project's integrated process involves 13 subsidiary teams from engineering, design, business, and communications. The larger team is made up of over 150 graduate and undergraduate students, faculty, staff, and professional or trade advisors at any given time, representing a broad range of backgrounds. Students and faculty involved in the project draw from many colleges and departments at the University of Minnesota, including the College of Design, the Institute of Technology, the College of Continuing Education's Construction Management Program, and Carlson School of Business's Innovation by Design Program. In addition, interested students from outside majors including Journalism, Education and others have contributed their time and varied perspectives

Leadership
The project is led by a project management team consisting of Project Manager and Principal Investigator Ann Johnson, Student Project Manager Shengyin Xu, Assistant Project Manager Dan Handeen, Construction Manager Craig Hohensee, and student group advisor and commissioning advisor Jonee Kulman Brigham.

The ICON House is a student-driven project, with one or more leaders from each integrated sub-team serving on the overarching Student Leadership Group. This group meets at least weekly to discuss issues of common concern and to keep informed of each team's activities and coordination issues. This group is the central decision-making body for issues that affect the whole team or the major direction of the project.

Student Leader Table

Team	Student Leader	Program/ Degree	College
Architecture Design	Shengyin Xu	Master of Architecture	College of Design
Engineering Controls	Andrew McCain	Electrical Engineering	Institute of Technology
Engineering Energy Model	Josh Quinnel/ Peter Leeman	Mechanical Engineering	Institute of Technology
Engineering PV	Brian Henke	Electrical Engineering	Institute of Technology
Engineering Solar Thermal	Julia Haltiwanger	Mechanical Engineering	Institute of Technology
Communications	Meag Tessman	Graphics Design	College of Design
Interior Design	Shona Mosites	Interior Design	College of Design
Structural Engineering	Matt Bechle	Civil Engineering	Institute of Technology
Logistics and Transportation	Jake Wollensak	Master of Architecture	College of Design
Construction Management	Craig Hohensee	Construction Management	College of Continuing Education
Next Use	David Saddoris	Master of Science Civil Engineering	Institute of Technology
Commissioning	Joe Messier	Master of Architecture	College of Design

Faculty Advisor Roles

Faculty Advisors and Project Managers offer their perspective and guidance to the student team. They work with administrative and procurement issues, and liaison to development staff. They gather resources to support student work.

Faculty Advisors	Ann Johnson		PI & Project Manager
	Dan Handeen		A. Project Manager
	Jonee Kulman Brigham	Commissioning / Next-Use	Student Group Advisor
	Jim Lutz	Architectural Design	Faculty Advisor
	Jane Davidson	Energy Modeling	Faculty Advisor
	Paul Imbertson	PV / Controls	Faculty Advisor
	David Williams	Solar/Energy - ALL TEAMS	Faculty Advisor
	Geoffrey Warner	Logistics / Transportation	Faculty Advisor
	Steven McCarthy	Communications	Faculty Advisor
	Peter Hilger	Construction Management	Faculty Advisor
	Dave McDonald	Structural Engineering	Faculty Advisor
	Pam Enz	Interior Design	Faculty Advisor
	Garrett Mosiman	Economics/ Marketing	Faculty Advisor

Staff Support Roles

Additionally, the Project is supported by University of Minnesota communications and development staff who regularly meet with our Project Management team and students to provide University resources and talent in assisting our efforts.

Full Team Credits

The full team is listed here by sub teams. Team members in grey represent student, faculty or professional leadership, or advisors to each group.

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AUTHORED BY Shengyin Xu, Simona Fischer

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Subjective Contest Support Documents

Architectural Design

The Solar Icon

The design concept of the house is based on the idea that a singular form can be the basis for cultural allusion as well as functional performance. The form of the home carries historical and emotional meaning. Whitaker (1996) discusses the symbolic significance behind the stand-alone, single family house as a construct of American independence. Within the language of the American family home, the gabled roof is perhaps the most recognizable and enduring symbol.

Most gabled roof forms are symmetrical, designed for shedding water and snow. By definition, these forms orient half of the roof area towards the north, or both sides towards the non-optimal east and west. The angles are high, usually 45 degree pitches, but the surface area for collectors are minimal, often resulting in large portions of roof being unsuited for solar collectors.

The ICON House references the cultural significance of the single family home, classically identified by the gabled roof, and employs this form with modifications for solar technology. Pulling the ridge towards the north expands the surface area, while not lowering the angle to compromise optimal collection. In Minnesota, a range of 35 degrees to 45 degrees is ideal, however, according to initial estimates, lowering the roof to 28 degrees and gaining surface area for collectors actually produces more power. The addition of solar collectors to the south wall, integrated into the glass and wall itself, further increases power production. In particular, solar thermal panels on the roof at 28 degrees and on the south wall at 90 degrees help to achieve higher production under varied weather conditions.

The ICON House design provides the intermediary step towards the fusion of traditional style and new technology, a fusion that is necessary for a more energy-efficient future. Although the original gable roof is not ideal for solar power, our demonstrated incorporation of solar technology into the form of the house provides strong support for the use of building-integrated photovoltaics in the broader context of the American residential neighborhood. Our modifications to the roof line—and the fully integrated livable nature of the ICON House—have created what we hope will become an icon for solar housing that respects both the idea of a house and the need for solar energy.

Technology and Architecture: Performance and Meaning

It has been said that technology and architectural meaning cannot be reconciled. However, this interpretation does not take into account the functions of elements that work to create meaning (Lavine 2001). If a building is unable to incorporate its functional thermal system into the larger meaning, how then can the structural walls and posts be said to factor into meaning in a more relevant way?

The ICON House has a particular advantage when incorporating architectural meaning into the technology used. The integrated design team incorporated engineering expertise into the design process at an early stage, resulting in a design that developed with the twin notions of solar collectors as part of the structural system, while creating that iconic shape, at its core.

Every move references both cultural meaning in housing and functional performance. The use of photovoltaic laminated glass on insulated glass units provide energy, ventilation, and insulation, but also satisfy the human need for connection to nature and the outside.

The integrated shelving system supports the idea that technology and function can be an integral part of architectural meaning. It runs the entire length of the house, incorporating lighting, HVAC ductwork, partitions and doors. This shelving unit is a meaningful presence as well, acting as the threshold for entry, and serving as the partition that defines public and private boundaries.
The design of the envelope further demonstrates the integration of performance and aesthetics. Over the course of the design process, the insulation value of the wall was increased from R-40 to R-50, and the roof from R-50 to R-70. The high insulation levels of the shell of the house results in added energy savings in heating and cooling loads (see energy report). However, increasing wall insulation, especially with the impermeable polyurethane and polyisocyanurate types, will cause condensation to occur in the cavity.

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Architectural Design Narrative

COMMENTS

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By simulating the moisture behavior within the wall over the course of several years, the ICON House's durability is tested. Our double 2x4 stud walls are split by a 1" layer of foil-faced polyisocyanurate, which acts as the air barrier. Towards the interior, the drying potential and permeability of the materials increase, allowing for vapor to escape inward from the center. Moving from the center towards the outside of the wall, much of the drying potential comes from the use of rainscreen instead of siding, and a particular membrane material that has a high permeability rating, which allows air movement to occur behind the cladding material, helping to draw away moisture from the membrane and plywood sheathing while still allowing the wall to permeate moisture vapor (see G-703 of the Construction Drawings).

At the same time, the wall addresses the aesthetic goals of the house and the project concept. The rainscreen takes the form of horizontal slats that have a similar pattern as traditional wood siding, but represents a different type of construction. These spaced slats, as opposed to lapped siding, create the appearance of a more delicate screen, which becomes an important aesthetic element of the house.

Market Viability

Livability

Features and Design Considerations

Throughout the design of the ICON House, we have created a living environment that is both innovative and familiar by referencing the iconic home and our goals for the integration of technology. The livability of the ICON House is addressed in several ways. Small, but functionally distinct areas for entertainment, dining, cooking, and private activities are open to each other, creating the illusion that the house is bigger than it is, while providing a special place for each activity. Coordinated, natural material finishes in each area creates a harmonious effect.

The prominence of the sheltering ICON roof form, expressed in the interior, provides a cohesive identity to the whole. Traffic patterns are planned for both exhibit and living accessibility. Together, these features create a safe, functional, convenient, and enjoyable space for our target market home owners – upper- income professional couples who identify themselves as environmentalists, and technological early adopters, with a desire to live simply, but well. The target market is described in more detail in the following sections.

Public Areas

The kitchen is frequently considered the heart of the home, and in the ICON House this holds true. With its traditional L-shaped layout, the kitchen is compact in design, but large in accommodation. The main traffic flow is directed outside of the work zones to allow those working to be undisturbed, creating a kitchen that is designed for safety, comfort and convenience. With divided cooking and prep areas, the kitchen allows for two cooks, while also providing multi-¬use storage for changing culinary interests.

Technological needs are met with energy efficient kitchen appliances that match the compact design of the kitchen, enabling the preparation of a full range of foods and encouraging the purchase of fresh, local ingredients to complement the container garden on the deck, just outside the kitchen. The kitchen is located close to the side deck entrance for entertaining access and landing after shopping, making it a convenient and informal entrance area similar to that of the "side door" area in many of today's homes. The dining area combines ease of use with aesthetic pleasures. The area is separated from the main traffic flow, but maintains visual

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PM-009

access to all other public, social zones. The intimate dining area is designed for everyday use, or can expand to seat up to eight when the dining table is configured to its full size.

The living room is the space for entertainment and excitement. Configured to optimize both socializing and entertainment viewing, the living room also boasts plenty of electrical receptacles for mobile technology. Here the modern worker will find convenience and comfort. The sofa accommodates the occasional overnight guest or an alternate sleeping location by turning into a bed, and the coffee table functions symbiotically, nesting below the open bed. The storage in the seating area supports the many possible uses of the space.

The office is adjacent to the living space, making use of this corner area. The office is designed not only as a work area, but also for the storage of electronics and entertainment devices for the living area. The shelving and mobile filing drawers address the unique and specific storage needs of each individual's working style. The use of sliding panels allows for items on the desk to be shut away from visitors' view. A nearby window provides daylight and a view outside.

The deck expands the living space and provides ample area for Minnesotans, eager for the outdoors after a long winter, to stretch out and enjoy the sun, putter in their container garden, or grill and entertain outdoors with easy access to the kitchen. As busy professionals, homeowners can enjoy a key benefit of home ownership with a small, easily cared for outdoor area. In winter, the deck provides a large, bright snow covered surface to reflect extra sunlight in, or a place to build a snow man—or even a place to grill, as Minnesotans have been known to do year round.

Private Areas

Unique storage opportunities paired with easily maintained materials and fixtures creates a bathroom that is streamlined and water conscious, including a low-flow toilet and shower head. Due to the compact size of the room, an open shower and reflective finishes on the fixtures were utilized to create a space that appears larger than it is. One of these fixtures is the full-length mirrored medicine cabinet. Partially recessed, the medicine cabinet was moved from the traditional sink area to the wall, creating greater storage possibilities.

The alcove sleeping area is an intimate space that gives the user a small place of sanctuary. Utilizing the shelving system gives the alcove many storage possibilities while maintaining separation from entertainment area.

Marketability

> *"You know you have reached perfection of design not when you have nothing more to add, but when you have nothing more to take away."*
>
> - Antoine de Saint Exupéry

Small is Beautiful

The ICON House is small. At 800 sq feet with only one bedroom, the space is not suitable for every family. Fortunately, Minnesotans were some of the first homebuyers to turn their back on the trend of cathedral–like spaces that may or may not offer the comforts of home.

In her practice, Minneapolis architect Sarah Susanka found many local clients interested in small homes. In The Not So Big House, she explores home value from the perspective of comfortable spaces rather than the traditional dollar-per-square foot metric. Small homes designed with personality, spatial variety and durability where every space is used are now the basis for a new movement (Susanka 2000). NSBH (Not So Big House) designs generally contain 1,500 square feet of living space and are considered suitable for an entire family. The ICON House is half that size, designed for a couple without children.

Cost comparisons between the NSBH and ICON House indicate that ICON is more expensive per square foot, but the added benefit of extreme energy efficiency supplemented by subsidized technologies, none of which are incorporated in NSBH designs, narrow the price difference.

The ICON House Value Proposition

At more than $1,200 per square foot, the ICON House has a higher square footage cost than the average single family home in the Twin Cities market. However, its sustainability features offer homeowners added value over traditionally designed and constructed homes.

Green building is catching on with homeowners as they look for ways to conserve energy and recycle waste. Green buildings' expected share of the 2008 U.S. residential housing market is 6%, up 50% since 2005. Seventy percent of buyers surveyed by McGraw Hill Construction are either "more" or "much more" inclined to purchase a green home over a conventional home in a down housing market (McGraw Hill Construction, 2008). Recent studies show that square footage sale prices of certified sustainable homes exceed those of non-certified homes by more than 10% (Johnson, 2008).

Market trends illustrate that consumers are commonly willing to trade-off upfront costs for these immediate and long-term, future benefits. "Green buildings are clearly achieving higher rents and higher occupancy, they have lower operating costs, and they're achieving higher sale prices" (Burr 2008). Prospective homeowners' willingness to pay for the added value of ICON House's sustainable features is a notion supported by growing market demand and changing consumer preferences for increasingly efficient housing choices.

But for the target market of the ICON House, efficiency is only part of the value proposition. With the ICON House's leading edge, net-zero design, homeowners are buying an idea and a lifestyle, just as some other upper income segments pay over $1,000 per square foot for a luxury condominium overlooking Las Vegas. In a posting on Private Equity HUB, a website for private equity investors, a self-proclaimed early adopter notes one important motivation for high-end green, the "Icon" factor.

> *"…Toyota's first version of the Prius was a dud, a bland hybrid version of a cheap economy model. The car took off when it was completely redesigned with its own unique, iconic style. The car has since become a highly visible symbol of a clean and green mind-set…the Prius is successful because it is iconic, while its predecessor model and its main competitor, the Honda Civic, are not. Having an iconic product shows that one is a thought leader."*
>
> - Ben Dubin, technological early adopter

Like the identifiably green Prius, the ICON House expresses its owners' values of sustainable energy use.

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Market Viability

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PM-011

Meeting Upfront Costs
Use of high-tech sustainable systems and materials with extended life cycle value account for higher upfront costs, but owners' return on investment is improved through grants given for sustainable building, and through reduced operating costs.
(see Energy Options and Incentives Table)

Energy Savings over Time
Upfront investment in sustainable building systems provides immediate benefits to ICON House owners in the form of lower energy bills. Average monthly residential energy usage in Minnesota is 815 kWh home, translating to monthly bills of approximately $70 /month (U.S. Average Monthly Bill by Sector, 2007). Integration of solar thermal systems to heat, dehumidify and produce hot water reduces reliance on utility-supplied energy, and minimizes monthly expenses. The Icon House is projected to have an annual net positive energy balance throughout a Minnesota year.

Further Benefits
Further value for the Icon House owner is added when occupant health and lifecycle benefits of the home's materials and systems are considered. Non-VOC paints, finishes and adhesives contribute to better indoor air quality, a significant health benefit to the home's inhabitants. Durable, high quality materials can be recycled and reused. The wall construction has been studied for durability and longevity (see Architecture narrative). The extended life of materials in the ICON House provides economic benefit to homeowners, as their costs can be amortized over a longer period of time. This extended value, coupled with reduced need for more frequent repair and replacement of such materials and systems, provides long term economic benefit to the homeowner in both reducing future expenditures and in contributing to a higher future resale value.

Prospective Buyer: Target Market
(see Target Market Profile Table next page)

The ICON House is a small, yet comfortable and stylish residence for the eco-conscious urban dweller. A number of trends indicate that there is an emerging market for smaller more energy efficient housing in Minnesota. The seven-county Minneapolis area has had steady population growth since the 1990s, which is expected to continue and approximately double by the year 2030 (Sasaki 2006). In fact, household growth has been at a faster rate than population, although the average household size has fallen. Future housing development is expected to be consistent in Minnesota; largely single family, with some shifts toward housing that is oriented to smaller, older households (Sasaki 2006).

These trends indicate that the ICON House would be very attractive to our target market: upper income Gen-X professional couples who identify themselves as environmentalists and technological early adopters, with a desire to live simply, but well.

The upper-income Generation X professional, member of a demographic that is known for seeking alternatives to mainstream

offerings, is "on the leading edge of home and garden trends" and is often among early adaptors of products offering technology (Tergenza, 2008). This target market segment also tends to favor alternative housing typologies to traditional single-family homes in suburban settings (Asturias, 2008). Style-conscious younger buyers are asking themselves: Of what use is more house if you can't afford to fill it in style? (Iconoculture, 2005)

The ICON House is also affordable for affluent Gen X professionals with rising incomes, a market segment that is willing to spend for convenience and for environmentally sustainable products. These consumers will continue to focus spending on residential investments and seek to integrate "workable green solutions into daily life" (Tergenza, 2008). Offering immediate enjoyment and future energy savings, the ICON House meets the trends, values and needs of this market (Tergenza, 2008).
At a total cost of $600,000, the owners would need a combined income of $177,000 to finance a 30-year mortgage. A number of dual income professionals would meet this affordability threshold; for example, two lawyers making the Minnesota median income for their profession in 2008 would have a combined income of approximately $200,000 per year (calculations based on data from Minnesota Department of Employment and Economic Development at http://www.deed.state.mn.us).

ICON SOLAR HOUSE
UNIVERSITY OF MINNESOTA

Market Viability

COMMENTS

REV DATE 03/26/09

AUTHORED BY IbD, Shona Mosites, Simona Fischer, Jonee Kulman-Brigham

PM-012

Energy Options and Incentives Table

Type	Name	Citation	Eligibility	Max Amount
Federal Tax Credit	Residential Renewable Energy Tax Credit	DSIREusa.org	Solar installs, post 2008	30% total install, no max
Federal Tax Credit	Residential Energy Efficiency Tax Credit		Equipment and envelope improvements - windows, doors w U<=.3, air source heat pump w seer >-15	30% on equipment up to $1,500
Federal Subsidy Exclusion	Residential Energy Conservation Subsidy Exclusion		Tax on utility rebates waived	
MN Rebate	MN Solar Hot Water Rebate	Office of Energy Security, MN Dept of Commerce	Solar thermal systems Rated by SRCC, domestic hot water	25% or $2,500
MN Rebate	MN State solar Electric Rebate Program		PV system between .5-10 kW	$2/watt, max $2,000
MN Tax Exemptions	MN State Exemption from Property Tax		PV, wind, commercial, residential	Exclude value added by PV system from property tax
MN Tax Exemption	MN State Sales Tax Exemption on All Solar Energy Components			
Local Utility Incentives	Xcel Energy for Energy Efficient appliances		Airsource heat pump	$180-$330
State loans	Home Energy Loan Program		Windows, insulation, AC	$10,000, 6.25 APR, 5 years
	NEC MN Energy Loan Program		Ceiling fans, lighting, AC, insulation, windows, PV, ST	$25,000, 6.25 APR, 20 year (max $93,100 income)
PENDING	Xcel Solar Rewards	Xcel energy website	Small sys (up to 10kW)	(CO) Rebate of $2 per watt; 1.50 per watt energy credit for 20 years
				(NM) Rebate of .2 / kWh for 14 years

Target Market Profile

Occupant Demographic	Eco-Conscious Gen-X Professionals (singles and couples)
Primary Motivations	Green consciousness Early Adopter Simplicity and Ease of use Community Living Accessibility to Workplace
Number of Occupants	2
Location of Permanent Site	University of Minnesota Outreach, Research, and Education (UMore) Park, Rosemont, MN
Housing Type	Single Family
Homeowner Annual Income	177,000
Number of Bedrooms	0 (two alternate sleeping areas: Alcove and Sofa Bed in Living/ Master Bed Area)

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REV DATE
03/26/09

Market Viability

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PM-013

Required Income Calculator - Solar Decathlon House		
Assumption: Only one mortage (no second mortgage or home equity line of credit (HELOC))		
Directions: Populate the grey fields only (the blue fields are automatically calculated)		
Item	**Amount**	**Notes**
House price (fabrication)	$560,000	
Transportation and site installation	$30,000	Include costs that are not part of a normal lot setup (i.e. foundation)
Land	$25,000	
Infrastructure	$25,000	Include costs that are part of a normal lot setup (i.e. roads and utilities to site)
Total cost =	$640,000	Excludes developer fees, permits, construction period interest, etc...
Down payment (%)	10%	
Down payment ($)	$64,000	Closing costs not included
Loan amount	$576,000	
Interest rate	5.25%	
Property taxes (per year)	$6,000	
Insurance (per year)	$2,000	
Mortgage insurance (per month)	$288	Not required for 20% or greater down, assume 0.60%/yr if required
Amortization (years)	30	
Monthly principal + interest	$3,181	
Total mortgage payment =	$4,135	Assume taxes and insurance are escrowed
Front end ratio	28%	Monthly housing payment/monthly gross income
Back end ratio (debt to income ratio)	36%	Monthly total debt payments/monthly gross income
Car payments (per month)	$500	
Student loan payments (per month)	$0	
Credit card payments (per month)	$200	Minimum monthly payments
Child support payments (per month)	$0	
Total non-mortgage debt =	$700	
Required annual income (front end ratio) =	$177,230	
Required annual income (back end ratio) =	$161,179	
Required annual income =	**$177,230**	

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Market Viability

AUTHORED BY IbD, Shona Mosites, Simona Fischer, Jonee Kulman-Brigham

PM-014

Subjective Contest Support Documents

Engineering Design

The engineering systems of the ICON House were designed with Minnesota in mind. Solar-thermal panels and multiple photovoltaic technologies are integrated into the architecture so that the house stands out as a high performance solar home while still maintaining a traditional aesthetic. Passive techniques such as walls with a high insulation value were used to reduce heating and cooling energy requirements.

Due to the high variability of the Minnesota climate, we use efficient active systems to meet the remaining energy loads. The modularity of our active systems allows for great flexibility throughout the seasons. Because of this, we will remain highly competitive for the competition in Washington, DC. The engineering systems are a true product of a multidisciplinary design team. We believe we have fused engineering and architecture in an elegant and efficient way.

Thermal Technologies

Brutally cold Minnesota winters lead to very high heating loads—significantly higher than would occur in even the worst case weather during the competition in Washington, DC. This is parallel to a challenge all thermal system designers face: in order to meet winter heating loads, systems must be sized such that a lot of solar thermal energy is wasted during the summer months. To meet this challenge we need a thermal system that is both optimally sized for the Solar Decathlon competition and for Minnesota winters. We have designed a system that is as unique as the challenges posed by our cold, northern location.

Veissmann flat plate solar thermal panels and tanks form the heart of the solar-thermal system's collection and storage. The panels are located on the south roof and wall. The system will use that thermal energy to meet not only domestic hot water loads and heating loads, but also to meet the home's latent cooling loads. During summer months in Minnesota and humid days at the competition, an open-cycle liquid desiccant dehumidification system will use thermal energy to latently cool. Latent cooling is the process of taking humidity out of the air. In essence, we will be using heat to cool. During the winters in Minnesota and cold nights at the competition, the solar-thermal system will supply heat to a radiant floor heating system. In short, the thermal system is flexible enough to be close to optimal during both the summer and the winter, and in locations as different as Washington, DC and Minneapolis, MN.

The liquid desiccant dehumidification system is a custom experimental system. It utilizes the material properties of desiccants to remove the water vapor in the air. A desiccant is a material, usually a solution or a solid, that attracts and holds water, and then releases that water when it is heated. This is how we will use heat to latently cool. The liquid desiccant solution we are using is an aqueous salt solution of Lithium Chloride (LiCl) and Calcium Chloride (CaCl) at .4 mass concentration before dehumidification. We are using a mixture because LiCl performs well but is very expensive. CaCl performs adequately and is comparatively much less expensive. In order to facilitate the transfer of water vapor to and from the liquid desiccant we are using randomly packed columns with a counter flow arrangement.

The desiccant dehumidification system consists of two main steps: dehumidification and regeneration. For dehumidification, the desiccant solution is sprayed into the packed column and the air from the house is brought in from the bottom. The liquid desiccant draws in water vapor, and the now dehumidified air leaves the top of the column and goes back to the house at a lower relative humidity. The desiccant from the dehumidifier is pumped to a heat exchanger and heated before it enters the regenerator. In the regenerator, the process works in reverse. Outside air goes up through the column and takes water vapor with it. The desiccant, now ready to be used again, is then pumped back to the dehumidifier to complete the cycle.

The sensible cooling is handled by a Daikin Quaternity wall mounted, mini-split heat pump air conditioning (AC) unit while the ventilation of the house is done with a RenewAire Energy Recovery Ventilator (ERV). In general, the addition of an ERV improves efficiency by transferring energy from conditioned exhaust air to new outside intake air prior to entering the house. By using the ERV and liquid desiccant dehumidification system to remove the latent cooling load, we can improve the efficiency of the AC unit. In a regular home, the AC unit is required to cool the air below the dew point (condensation) and then reheat it to the set temperature. This process requires a significant amount of energy. Also, by choosing a variable-speed modular system, we can accommodate the changing cooling loads expected during the competition and have flexibility throughout the seasons.

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COMMENTS

REV DATE
05/30/09

Engineering Narratives

AUTHORED BY
Peter Leeman, Brian Henke, Andrew McCain

PM-015

Due to the small size of our house and the very open floor plan, the Uponor radiant floor heating system required only a single water loop to meet both the large heating loads of a Minnesota winter and the small heating loads of the cool Washington, DC nights. This level of performance is a testament to the efficiency and flexibility of the radiant floor system, which delivers heat at low temperature by utilizing the superb energy storage capacity of water compared to air. Delivering heat at low temperature, just degrees above the desired comfort zone temperature, means that the radiant floor system heats the house using less energy. To further compliment this efficiency, we have selected the Baunach RendeMIX for mixing down the temperature of the hot water from the storage tank to the operating temperature of the radiant floor. This innovative mixer selectively draws water from the middle or top of the storage tank in order to maintain stratification in the tank, which improves the efficiency of the solar thermal system as a whole.

Photovoltaic Technologies

Multiple photovoltaic technologies are integrated into the ICON House. Our challenge is to use highly integrated collection systems while maintaining the high efficiency level needed to place well in the net metering competition. Traditional solar panels serve as roof cladding for most of the south roof while Building Integrated Photovoltaic (BIPV) glazing is located on the east end of the south wall and roof.

The main array, composed of thirty BP SX3190 traditional PV panels, will yield the majority of the electric power generation. The panels are arranged in 2 strings while each string consists of fifteen panels each. The main array will employ one Sunnyboy SB-6000US inverter. An inverter converts DC current into AC current. The SB-6000US can accommodate up to 4 strings with a maximum combined DC input current of 30 Amperes. Since the PV panels will serve as roof cladding, all wiring will be internal to the house. This will be run through conduit to the DC disconnect, inverters, AC disconnect and finally to the main service panel. Each string will be individually fused.

The BIPV glazing makes up the other two arrays. We will have 1 string of 6 modules and 1 string of 5 modules, all will be Sanyo HIT Double 195 Photovoltaic Modules. There will be a total of 11 Sanyo modules. The Sanyo modules on the roof and south wall allow passage of some light for natural illumination while also converting some light to electricity. The Sanyo HIT module is a bifacial photovoltaic module and is semi-transparent. The bifacial capability of the module increases the power generation potential by converting light energy from ambient light on the back of the panel to electrical energy. For our house, the Sanyo panels will be approximately 15% transparent. Aesthetics, lighting, and technical considerations dictate those parameters. A StarInverter PVP-2000EVR inverter will service each Sanyo string at the east end of the south-facing roof and the south wall.

The maximum system voltage of each string was computed according to National Electric Code (NEC) 690.7(A). This section of the NEC calls for predicting the expected minimum ambient temperature for purposes of choosing an appropriate voltage multiplication factor. The choice was made to design the system for Minnesota temperatures. Thus, worst case, lowest ambient temperature is -40°F and the corresponding voltage multiplication factor is 1.25. The resulting maximum system voltage was calculated to be 391.5 V for the main array.

Conductors were sized to meet or exceed the NEC 2008 code requirements. Maximum current and amperage were calculated for the PV source circuits, PV output circuits, and inverter output circuits as specified in NEC 690.8. The system was designed for the record ambient temperature of 114° F. This is the highest atmospheric temperature on record for Minnesota. For any conductor installed in conduit exposed to direct sunlight the temperature correction factor was adjusted according to NEC 310.15(B)(2)(c). Conduit will be 1 inch electrical metallic tubing (EMT), unless specified otherwise. Conduit fill is limited in accordance with NEC 2008 Annex C Table C.1.

See Construction Drawings for full calculations and explanation.

AUTHORED BY
Peter Leeman, Brian Henke, Andrew McCain

Module Specifications		
Physical Dimensions	BP SX3195	Sanyo HIT Double 195
Length	66.14 in	53.2 in
Width	32.95 in	35.35 in
V_{oc}	30.7 V	68.7 V
I_{sc}	8.6 A	3.73 A
$V_{sys\ max}$	600 V	600 V
P_{max}	195 W	195 W
V_{Pmax}	24.4 V	55.8 V
I_{Pmax}	7.96 A	3.5 A
Temp Coefficients		
Power	-.5 % / deg C	-.2 %/deg C
Voltage	-111 mV/ deg C	-172 mV/deg C
Current	.065 %/ deg C	.87 mA/deg C
Series Fuse Rating	15 A	15 A
Peak Power per Unit Area	12.7 W/ft^2	14.9 W/ft^2
CEC PTC Rating	207.1 W	

Array Specifications	Rooftop BP Array	South Wall Sanyo	Roof Top Sanyo
Module Count	30	6	5
Modules per string	15	6	5
Strings	2	1	1
Operating Voltage	366 V	334.8 V	279 V
Operating Current	7.96 A	3.5 A	3.5 A
Power at STC (P_{max})	5850 W	1170 W	975 W
Voltage Correction Factor (NEC 2008 table 690.7)	1.25	1.25	1.25
Max Sys Voc	568.73 V	479.28 V	399.4 V
Max Isc	8.6 A	3.73 A	3.73 A
NEC 690.8(A) (1)	1.25	1.25	1.25
NEC 690.8(B) (1)	1.25	1.25	1.25
Ambient Temp. (°C) Correction Factor (NEC Table 310.16)	.58	.58	.58
Max Sys Current	26.83 A	5.82 A	5.82 A

Conductor Sizes (AWG)			
System Section	BP SX3190	South Wall Sanyo	Roof Top Sanyo
PV Source Circuits	10	10	10
PV Output Circuits	8	8	8
Inverter Output Circuits	8	8	8

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COMMENTS

REV DATE
05/30/09

Engineering Narratives

AUTHORED BY
Peter Leeman, Brian Henke, Andrew McCain

PM-017

Passive Technologies + Energy Use

The ICON house takes advantage of a number of passive technologies to achieve energy efficiency. By coupling this with high efficiency appliances, lights, and engineering systems, we can further insure that the house will produce more energy than it needs.

The primary passive technology is the high performance building envelope which minimizes the space conditioning energy loads. External wall sections are insulated with R-values between 50-60 BTU/hr-ft2, to reduce conductive heat loss. An R-value is a measure of how well something resists heat transfer. Windows are installed with high performance triple-pane glazing that uses low-emittance (low-e) coatings and are filled with inert gas to minimize convective and radiative heat loss. A large fraction of the south wall is comprised of this glazing in order to maximize winter insolation and minimize summer insolation. Finally, an eastern eave and louvers reduce the direct solar heat gain through the east kitchen window.

The ICON House also implements user-operable passive technology, allowing the resident to control comfort. A sliding panel along the south window-wall adds an R20 BTU/hr-ft2 thermal barrier to reduce radiative heat loss at night during the winter. During the summer it reflects insolation to reduce passive solar heat gain. The panels conveniently collapse into the south west corner of the home when not in use. Double hung windows on the south wall and motorized awning windows on the high northwest wall utilize the chimney effect to passively cool the house.

Because of the advanced passive technology in the ICON House, the energy requirements for active space conditioning are significantly reduced. The active systems that meet this reduced load run on solar thermal and electrical energy, collected from solar thermal and photovoltaic (PV) technologies. The PV system will be hooked up to the local electrical grid, so it cannot meet the electrical load, the grid will. If the PV array has excess energy, it will feed it back to the grid and the house will then be generating power. Solar thermal energy is used to heat potable water and to meet the heating load via a radiant floor system. It is stored locally in two tanks, one for domestic hot water and one for radiant floor heating. Enough solar thermal storage is available to provide approximately 1-3 days of hot potable water and 0-5 days of radiant floor heating. Solar thermal energy is also used to meet the latent cooling load via open-cycle liquid desiccant dehumidification. Auxiliary inline electric heaters provide backup for the solar thermal system in the unlikely event that the solar thermal storage is depleted.

The annual operational strategy for the heating, ventilation and air conditioning systems in Minnesota will be quite different than during the competition period in Washington, DC. In Washington, DC, the cooling load will primarily be latent in the morning and afternoon and sensible cooling in the afternoon. It will be driven by the sun and the high occupancy during public tours. There is a possibility for low temperatures at night, requiring radiant heat, but probably only between 10PM and 8AM. Passive ventilation is not viable due to the narrow requirements of temperature and humidity during the competition. In Minnesota, the conflicting overlap between heating and cooling will be less of a concern. Passive strategies will be more favorable due to less rigid thermal environment requirements.

Control System

Typical building and home automation systems are implemented primarily for increasing comfort, security, and functionality of the building. However, rising energy prices and environmental concerns are creating a desire to monitor and reduce energy consumption. The first step to reducing energy consumption is awareness of where energy is being consumed, and the second step is to use automated functions that save energy. The most vital part of home automation is the ability to be useful by any user, so that the home will do what you want it to do, while not being intimidating to the user.

The Control system of the ICON House involves an energy and environmental monitoring system that may be implemented in a Cortexa 7202 commercial automated system, which will interface to varying degrees with several subsystems. Additionally, the Cortexa unit will act as an interface between the internet and the house, providing forecasting abilities as well as web-based views and controls for the house. Connectivity to this unit will be with wireless as well as wired IP, as well as RS232 serial port connections. Additionally, IR connections may be used for remote controlled applications. Data control and output will be multifaceted, using a touch screen control panel in the kitchen, the in-home computer, and also available from the Web.

Controlling the home will be user friendly so that, for example, one can either use a standard light switch when walking into a room, or to be able to program the exterior lights to turn on at dusk for the

exterior lighting. If the owner goes on vacation, the schedule for the lights can even be controlled while away from the home.

The primary subsystem incorporates the Campbell CR1000 datalogger, which will provide information to Cortexa by using low-power sensors in collecting air and water temperature, humidity and system pressure and liquid levels for the desiccant system, power measurement from the PV arrays and usage by some specific loads (Stove, Dryer, etc.) and other systems. The information will be stored and organized in the data-logger and then sent to Cortexa for control and information.

Additional subsystems include a lighting control by Lutron Lighting or equivalent, which will encompass lighting and operations for Sage glass windows. The Irrigation system for the house will be controlled by a Toro IBOC plus series controller including PC Link, which may be directly integrable to Coretxa as well. NuVo systems provide the subsystem for the A/V controller. Daikin and Renewaire have internal controls for the air handling system which will be integrated with the overall system.

Lighting Design

The ICON House is designed with features that offer maximum efficiency of light around the house, interior and exterior, natural and artificial. Integration of technology and sustainability is balanced with traditional lighting strategies by using electric lighting with a clearly defined purpose, and selective use of daylight to enhance areas within the home. As a result of the selectivity, the entire electric lighting budget is under 500 watts for both interior and exterior.

The exterior of the house includes both public and private spaces with various lighting strategies. These spaces include a north entry sequence, a large east porch for gathering and entertaining guests, and seating spaces within the vegetated planters of the south deck. Each of these provides a different relationship with sunlight. The north entry is predominantly shaded by the house and vegetation that welcomes residents and guests along the ramp. The outdoor dining area on the east can be a great place to welcome the morning sun with breakfast outdoors. However the east icon shaped overhang shades this area in the afternoon and evening creating a cool place to retreat from the late afternoon sun. The south deck seating areas accommodate residents who want to take in the sun while sitting amongst vegetation. These three spaces demonstrate three different approaches for users to interact with sunlight.

The electric lighting strategies for the exterior are efficient in their use of light while allowing residents to continue using the aforementioned spaces into the twilight hours. Efficiency is achieved by both the technology of the LED fixtures, but also in the way that they are deployed with hoods and at specific angles to illuminate down on key surfaces without wasteful light pollution . Along the main entry, two different LED fixtures are integrated into the deck and vegetation to wash the ramp and the base of the vegetation. At the front and rear entrances of the house, LED fixtures are integrated into the exterior cladding of the house to safely light the doorway. A small number of these same LED fixtures are arranged around the outdoor dining porch to provide enough light for guests and residents to navigate around the deck. Given the close spatial relationship between the outdoor dining space and the indoor kitchen, three pendants are placed in the large east windows as luminous objects that visually connect the spaces. These large east windows also provide a glimpse of the additional lighting strategies that are utilized within the house.

Beginning with daylighting, the narrow form of the house allows light penetration into most of the interior spaces. Along this east west axis a variety of daylighting approaches are taken from dramatic to tranquil, creating three zones that reflect the living activities within each zone.

Starting in the east, the kitchen is a dynamic space in the house. This dynamism is reflected in the treatment of the large east windows. They allow the morning light to wash into the kitchen, filtered through exterior louvers, interior light shelf, and integrated electrochomic shading devices. These windows also serve to visually connect residents to the exterior east porch dining area.

In the middle zone of the house large south windows allow generous amounts of light to fall on the dining room table. Again these large apertures capture direct daylight which changes throughout the day as the sun travels east to west. The details of the window mullions and shading devices are strategically designed to provide views of the south deck for residents seated at the table.

In the west most zone, the living room and workstation functions are paired with calm north clerestory windows. This diffuse northern light reflects off the ceiling above, avoiding direct light that would cause glare on work surfaces or video screens. Furthermore windows on the west south walls still maintain views out for residents who are seated on the couch, or working at the desk. The operable low south windows, the sloped ceiling, and the north clerestory windows combine to create passive stacked ventilation across this primary living space.

See Construction Drawings for images.

Lighting Design

AUTHORED BY
Rose Lin, Joe Messier

REV DATE
05/30/09

COMMENTS

While the daylighting strategies focus on controlling the way the exterior light sources pass through the exterior shell of the house, the electrical lighting strategies reverse this relationship. The soffit structure of the interior is the main horizontal element, containing integrated lighting, HVAC, and storage. This core element of the house serves as the primary electric light source with several LED fixtures that up light the ceiling reflecting diffuse light back down to the living spaces below. Not only does the soffit lighting highlight the iconic structure of the house above, but also showcases the design details of the spaces below. Passageways through the shelving core are lit with LED recessed down-lighting.

Though the core provides general ambient illumination, task lighting is placed in work spaces that require more attention and focus. In the kitchen LED lighting fixtures are provided under the cabinets to illuminate the counter tops for food preparation. The same LED fixtures are used under the shelving around the workstation area to illuminate the desk surface. In the living room, a familiar table lamp is provided to accommodate activities while seated on the couch. In the bed alcove small adjustable reading fixtures are also provided. In the dining room a single fixture is suspended above the table. Utilizing a warm colored T5 lamp, this fixture focuses light at the table in the center of the space.

To achieve the small electric lighting energy budget of 500 watts, the ICON Solar Home utilizes the latest in LED lighting technology. However, as concept describes, this new technology is carefully considered within a context of the traditional home. This balance is achieved in two ways. First, the color temperatures of all lamps were carefully selected to maintain a warm illumination. While LED and compact fluorescents achieve great reductions in energy consumption, these lamps historically create light with cool color temps (above 4000K) which can be at odds with a comfortable living environment. However, with the improvement of the technology, this design was able to utilize efficient fixtures and lamps while achieving color temperatures around 3000 Kelvin.

The second strategy that balances new technology and traditional experiences of home is in the way that residents control light in the house. The majority of interior and exterior electric lighting can be controlled from typical switches located strategically at high traffic areas within the house. Additionally all lights are wired to the home control system and are programmed into zones of activity. Each zone will has different settings for different activities. The sleeping area, bathroom, task lighting and freestanding fixtures can be individually controlled to fit the user's need. Most of the lights in the house are dimmable and most are set as permanent dimmed to reduce energy use and extend the life of the lamp. Control of the daylighting also spans from the traditional use of fixed louvers and interior shades to electronically controlled tinting glass. Thus the ICON Solar Home integrates these progressive lighting technologies without abandoning historic notions of home to create a new tradition.

See Construction Drawings for Images.

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UNIVERSITY OF MINNESOTA

Lighting Design

COMMENTS

REV DATE 05/30/09

AUTHORED BY Rose Lin, Joe Messier

PM-021

Subjective Contest Support Documents

Communications

The driving concepts behind the University of Minnesota ICON House are the iconic nature of home, and the importance of sustainable living.

We value the beauty of a traditional house, and we want our visitors to know that solar can be beautiful. It can also coexist with present technologies, aesthetics, and the comforts of tradition.

The role of the Communications Team is to promote sustainable living to our target audiences by integrating iconic and familiar forms and materials with cutting edge solar technology.

Please see Communication Plan for further details, and visit the ICON House website at www.solardecathlon.umn.edu.

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Communications

COMMENTS

REV DATE 05/30/09

AUTHORED BY Meaghan Tessman, Dan Handeen

PM-022

ICON House Next-Use Discussion

A Next-Use Team was formed almost as soon as the University of Minnesota was accepted into the 2009 Solar Decathlon. This team took ideas and queues from early design charrettes about potential location-concepts for the house, and developed these in conjunction with the Student Leadership Group. The Next-Use Team's work led to the adoption of a resolution for the next use of the house.

Resolution for Next Use

The ICON House has been designed as a fully functional dwelling.

One of the missions of the Solar Decathlon competition project is to advance the awareness and science of solar-integrated housing within the University community and greater public. As primary sponsor, the University of Minnesota has the authority to determine the next use for the ICON House following the Solar Decathlon Competition.

The Student Leadership Group recognizes that the ICON House has substantial value for continuation of our mission after the competition, and believes:

1. The educational mission of the house can be served by the following:
   - A site in close proximity to campus for easy student access
   - The house made accessible to a large public audience for educational purposes
   - The house kept open to the public for a maximum number of hours
   - Utilizing the house for research projects by students and faculty
   - Maximizing exposure of the house to the affordable housing sector

2. The market transformation mission of the project can be served by demonstrating the viability and functionality of the house and its sustainability features by placing it in private service.

Recommendations by Student Leadership Group

- Following the Solar Decathlon competition in Washington, DC in the fall of 2009, the house should come back to Minnesota.
- The University of Minnesota should place the ICON House at a publicly accessible site for use as a public exhibit for 3-5 years following the competition, as a 3-5 year time frame is the likely period of peak public and educational interest in the project before it no longer represents the most current technologies and approaches.
- Following its use as an exhibit, the ICON House should be donated to a non-profit affordable housing agency for use as a permanent private residence.
- The University of Minnesota should place the ICON House at a publicly accessible site for use as a public exhibit for 3-5 years following the competition, as a 3-5 year time frame is the likely period of peak public and educational interest in the project before it no longer represents the most current technologies and approaches.
- Following its use as an exhibit, the ICON House should be donated to a non-profit affordable housing agency for use as a permanent private residence.

The Solar Decathlon Student Leadership Group also recommends to the University of Minnesota to include in their fundraising efforts for the Solar Decathlon project funding for transportation of the house to the post-decathlon exhibit location and funding for utility connections, foundation systems, site work and house installation expenses at the exhibit site.

Future Home

The ICON Solar House has captured the imaginations of many, and discussions have begun regarding the house being just the first of a larger development of leading-edge solar homes.
A truly sustainable house depends upon its surroundings. Current plans call for the house to be permanently sited at the University of Minnesota Outreach and Research (UMore) Park, a new planned community near Rosemont, Minnesota, designed for 20,000 to 30,000 residents. Planned development typologies, ranging from New Urbanism to traditional planned communities, are proven viable models, successfully serving markets that desire the benefits

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Next-Use

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of community living with access to work, education, entertainment and social engagement within a compact, walkable setting. With the U.S. population and consequent need for housing continuing to grow, analysts forecast increased demand for master planned communities (Sasaki 2006).

According to this plan, the ICON House will serve for 2-3 years as a public demonstration at UMore Park, followed by permanent installation of the house as part of the residential development of UMore.

This location is an ideal site for the permanent placement of the ICON House, since one of the three core missions of the development will be the advancement of energy efficiency and protection of the natural environment. It is expected that UMore Park will be a place for public-private partnerships with the University to design and create new community technologies, and to research forms of renewable energy and energy conservation systems for cold climates.

Originally the home of an industrial complex supplying munitions to the Allied troops during World War II, UMore is now owned by the University of Minnesota and currently serves as an agricultural research station. However, the Board of Regents has approved development of this 5,000 acre site. The master plan for the community calls for phased development that spans several years so that the 263,000 tons of concrete remaining on the property and any necessary remediation can be addressed.

The first development will serve as a hallmark of the sustainable community and will contain a full range of housing types, and in the next decade, the University of Minnesota will oversee the planning and construction of one of the nation's most forward-looking sustainable communities (Sasaki 2006).
Among these, the ICON House will be a leading example.

The UMore Park website may be found at
http://www.umorepark.umn.edu/

Extended Research Opportunities

At its next-use site the house can continue to be a source of learning. Extended research can be conducted on several topics.

Waste Stream Documentation

To fully capture the energy and resource usage of the house, we could track the amount of waste we have generated in construction, as well as during the process of each disassembly, shipment to a new site, and reassembly. This type of research might lead to proposals in how to minimize waste at these various states of the house, during construction and during each move from site to site. This research would have particular relevance to the Decathlon competition, as these methods to minimize waste could be adopted by all future schools participating.

Post Occupancy

Health of Wall & Indoor Air Quality

With our very high insulation levels, there is a higher chance for condensation and water trapping within the wall. This leads to rotting in the structure, as well as indoor air quality problems if mold grow occurs. Our project worked with Building Science faculty at the U to model and attempt to design a highly-insulated wall that would avoid this type of damage. We have utilized a membrane material that has high permeability for moisture vapor, while still acting as the membrane for the wall. Further, we have selected materials, like plywood sheathing, to allow for additional breathability of the wall. In theory, our models indicate that our walls should remain healthy, however, additional study of this wall system would reveal any building practices or materials selections that are particularly susceptible to damage in the long term.

Performance of Building and Systems

Many of our systems are highly efficient, such as our solar thermal system. and some are even custom designed, our desiccant system. Monitoring the performance of these systems over time will produce important data that can allow us to understand best practices in designing, implementing, and controlling these systems.

Maintenance Issues

Many of the systems used in the ICON House are uncommon and new in residential construction. We would like to see how well systems hold up, and what kind of maintenance issues occur through the seasons. Our study could produce a user-friendly operations manual for adopting some of these new technologies.

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Market

Effectiveness of Communication Strategies

In this study, we could continue exhibits at the house and study how well people receive or retain information about solar and sustainable strategies.

Effectiveness as Youth Outreach Tool

We have several graduate students in education who have been developing curriculum around solar and sustainable information. Our house could serve as a lab for young students to come and learn about technologies and low-tech strategies to limit resource use.

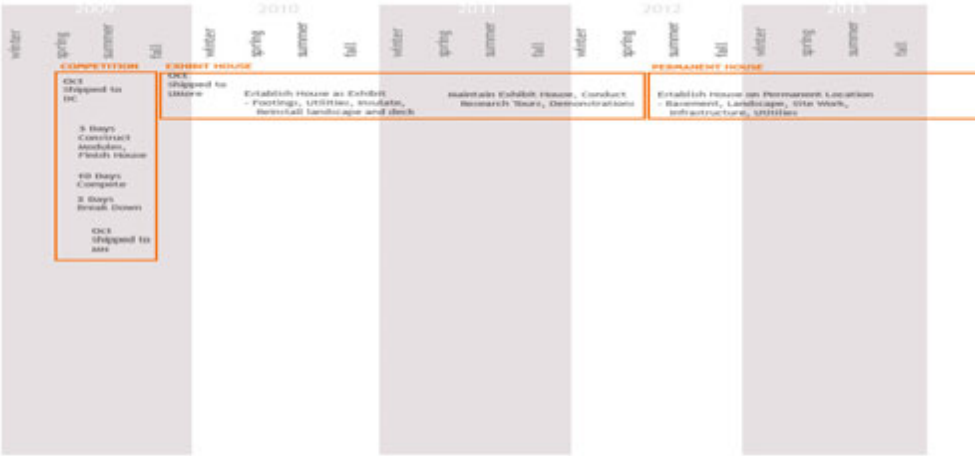
Transformation: Construction Industry and Manufacturers

We are planning a database that compares the choices of materials or products considered during the design process of the ICON House, and gives Life Cycle Assessment information for each option. We could work with industry to make this database for construction and design professionals to find sustainable alternatives to building materials.

Certification Potential

Specific certifications could be pursued, in order to educate the public on the process and result of a residence that is qualified under LEED for Homes, or Minnesota Greenstar, or others.

Timeline



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Article I. Appendix B: Full Energy Report

Section 1.01 Introduction

In this report we discuss the major energy-related elements of the design of the ICON Solar House, and describe our strategy for estimating the energy performance. We present and discuss results for this energy performance for sample competition periods and annually in two climates.

The ICON Solar House resulted from a balance between the requirements of the competition and those imposed by the Minnesota climate. A variety of design and engineering student backgrounds contributed to the design of the envelope and the engineered systems. By developing the ICON Solar House in this integrated fashion we aimed to create a solar house that performs well in varied climates and appeals to the traditional concepts of the home. The performance metrics at the end of the report show that we honored these goals and the varied student perspectives without compromising the energy performance.

Section 1.02 Energy in Design

Minnesota's varied climate and unique energy requirements are the main drivers for the ICON solar home design. The average temperature and incident radiation on the collection surfaces of the ICON Solar House are shown in Figure 1. While it has its share of overcast days, Minnesota also receives intense sunlight year round, but solar gains are hampered in the winter months due to short days, precisely when the energy demand is largest. The large variation in the solar zenith causes daylight hours to range from just 9 in the winter to nearly 16 in the summer. This variation also complicates the collector orientation.

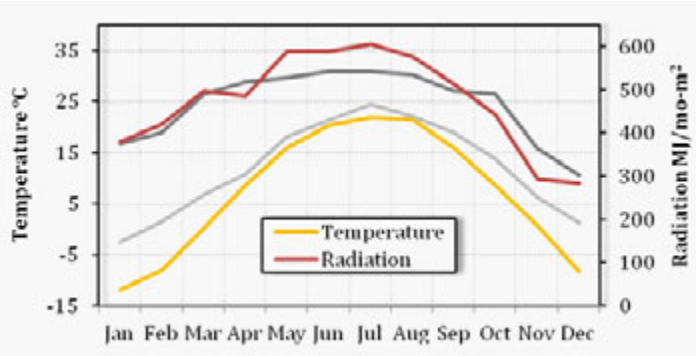

Figure 1: Temperature and incident radiation on active collector surface in Minnesota. Washington, DC shown in gray

The competition also played a strong role in the design because one of our stated objectives is to score well in the energy competitions. The competition's emphasis on producing an energy surplus, its narrow comfort parameters, and specialized appliance tasks are elements in contrast to a more typical approach to energy-conserving design in Minnesota. We paired these considerations with a traditional iconic house shape to enforce the notion that solar energy is accessible to the traditional home. In this section we document several features of the ICON Solar House that resulted from this balance of goals.

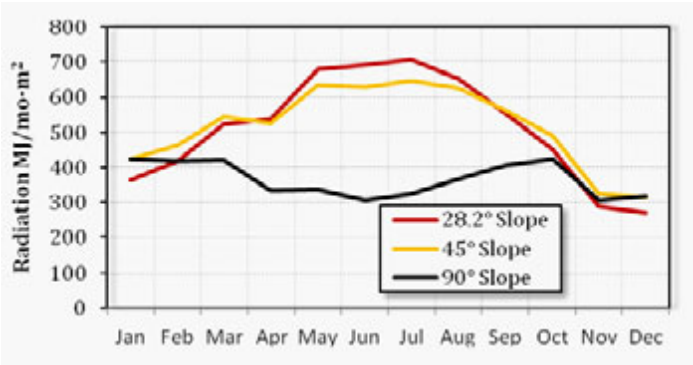

Figure 2: Incident monthly radiation for three collector slopes (Minneapolis, MN). The collector area is constant.

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(a) Roof Slope: Performance vs. Design

Collectors are typically placed at latitude (45° for Minneapolis, MN) to maximize annual solar radiation. Such a steep slope is architecturally difficult, especially for the competition size envelope. A study of roof slope revealed that a 30° roof slope has a marginal reduction of annual solar gains (Figure 2). Annually, the ICON house collects 0.5% less electricity and 4.4% less solar thermal energy with a roof slope of 28.2° compared to 45° for the same collector area. This energy deficit is exaggerated during November through February due to the low zenith angle of the sun. We compensated by adding vertically oriented solar collectors on the south wall. The 90° slope has a small incidence angle with the sun during winter months, allowing us to increase the winter solar fraction for heating. The added collector area on the south wall introduced flexibility into the envelope design without sacrificing winter performance.

(b) Winter Envelope Loads

Heating loads are a primary concern due to the low winter temperatures experienced in Minneapolis (Figure 1). Minimizing the loads with a well insulated envelope was the primary strategy. Triple pane, argon filled insulated windows are used throughout the house. The building integrated photovoltaic (BIPV) south curtain wall is double-paned and krypton-filled. The wall sections are R-50 and roof is R-60 to compensate for its large surface area. The choices for insulation exceed Minnesota code considerably. This comparison is shown in Figure 3, where the ICON Solar House is compared to the minimum insulation to meet code on the same envelope geometry. In both scenarios, the average heating load is significantly reduced because of the added insulation. It is noted that we had to reduce the percentage of glazing on the south wall from 43% to 35% to meet code with the minimally insulated wall section. In each case, the heating load through ICON Solar House envelope is reduced by about 20% compared to minimum residential code in Minnesota.

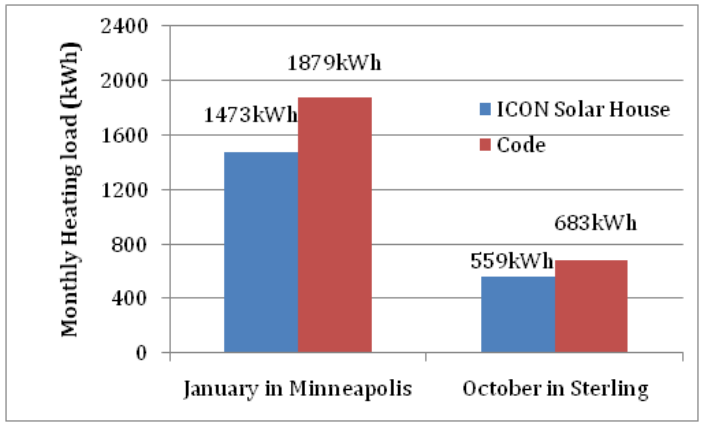

Figure 3: Reduction of heat loss through the footprint due to extra insulation.

(c) Glazing and Passive Absorption

The main glazing for solar is on the south wall to maximize passive gains during the winter and minimize them during the summer. External shading also lessens the passive gains when the sun is high in the sky during summer. The large east window is largely shaded from the overhang and permanent louvers except during early morning hours. These ideas are shown in Figure 4, respectively.

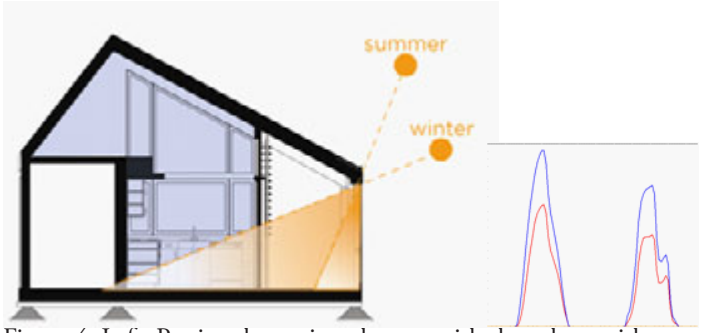

Figure 4: Left: Passive absorption changes with the solar zenith. Right: Shading reduces the magnitude of unwanted summer gains

(d) Day-Lighting

Ample glazing on east, west, and south surfaces ensures that the ICON Solar House is well lit by natural light throughout daylight

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hours. The floor plan follows the position of the sun so that portions of the home are likely occupied when sunlight is incident upon them. This strategy acknowledges that unlike an office setting where patches of sun may be distracting, in a residential setting, people tend to gravitate toward sunlight, especially in northern climates. High north windows provide extra diffuse light for the space. Some examples of the day-lighting are given in Figure 5.

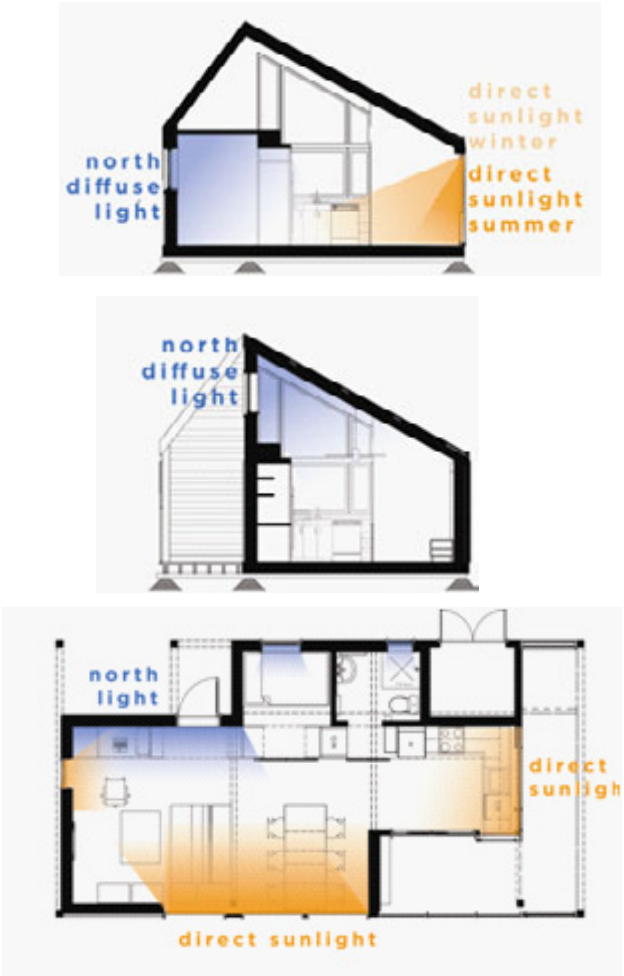

Figure 5: The first diagram shows effective daylight depth using the 2.5 window head height rule of thumb. The other various floor plans show sun penetration from the windows for a few different times of day and times of year.

(e) Solar Thermal Radiant Heat

The heating is supplied by a hydronic radiant floor system. The radiant floor provides comfortable, uniform heating to the small space by pumping warm fluid through pipes embedded in the floor (Figure 6). The low temperature hydronic system is ideally suited to the flat plate solar thermal collectors. The low temperature requirements allow the heating system to piggy-back off the DHW system to improve panel efficiency. An auxiliary inline electric heater pulls back stored electricity from the grid to heat the fluid when the solar buffer is depleted. Surplus energy from the DHW tank can also be used to heat the home.

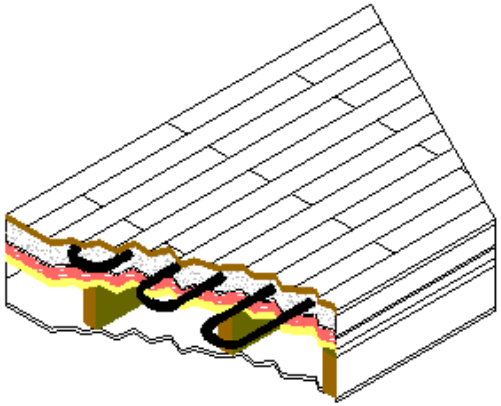

Figure 6: Warm fluid, 26-32 °C, circulates through the floor to warm the house.

(f) Desiccant Dehumidification

Solar thermal systems often overheat during summer because the demand for heat is low and solar collection is large. This overheat is exaggerated for solar thermal systems designed to meet winter heating loads. To improve the year-round utility of the solar thermal equipment, the excess thermal energy is used for dehumidification as shown in Figure 7. This additional draw on the solar thermal system minimizes the overheat, makes use of excess summer capacity, and provides finer humidity control compared to electric A/C as described in the next energy feature. The packed column approach, detailed in Figure 8, gives a large surface area for

the desiccant-air contact, which allows for smaller components. The absorption in the conditioner removes humidity from the conditioned space, while the desorption in the regenerator exhausts excess water vapor to the environment.

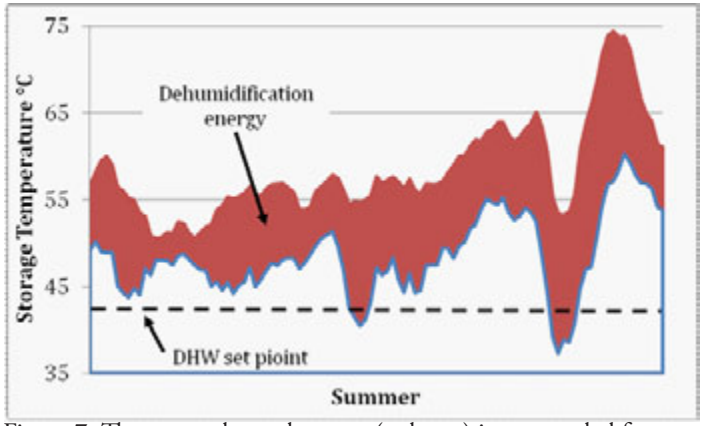

Figure 7: The excess thermal energy (red area) is not needed for DHW. This energy is used for desiccant dehumidification.

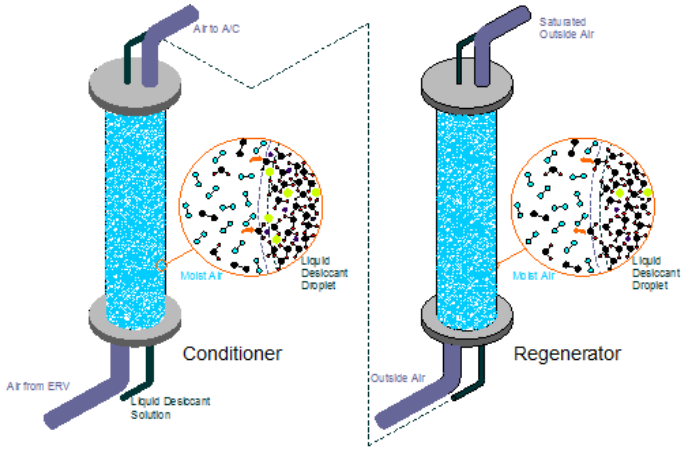

Figure 8: The packed column facilitates contact between air and desiccant to absorb moisture indoors and expel it outside.

(g) Separate Humidity and Temperature Control

The split A/C improves HVAC performance with variable speed compression and adjustable refrigerant throttling. These technologies allow for improved efficiency in small systems. The A/C system efficiency is further increased by the implementation of the desiccant dehumidifier described above. The dehumidifier is capable of removing a large portion of latent loads. Because of this, the A/C evaporator temperature can be increased and the requirement to reheat is eliminated compared to an A/C system that must run colder in order to both cool and dehumidify. Better comfort is maintained by independent temperature and humidity control, particularly in swing months where humidity may be large but sensible cooling is small. As shown in Figure 9, less energy is needed with this hybrid-cooling system with approximately 60% energy savings at 50% RH and 40% savings at 80% RH assuming an interior RH set point of 45%.

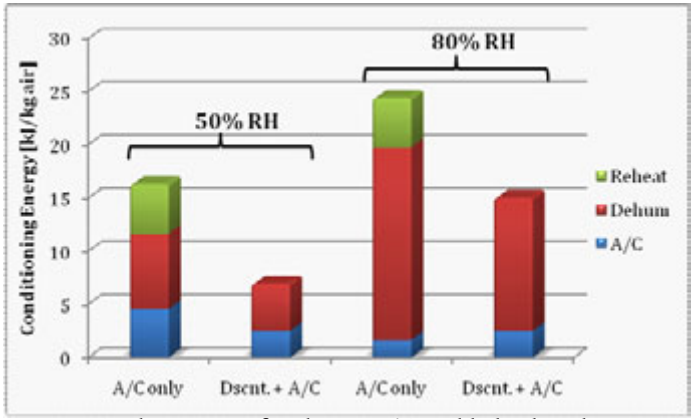

Figure 9: Cooling energy for electric A/C and hybrid cooling systems.

(h) Form, Envelope, and Glazing Balance: Design with Performance

The original ICON Solar House was a much tighter design compared to the final design. It had thicker walls and significantly less glazing. However, the energy performance of the original design came at the expense of aesthetics, livability, and general appeal.

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During our internal and external reviews, we realized that energy performance alone cannot drive the design of a solar home. In order to spread sustainable design and renewable technology in the marketplace, we must include elements that appeal to a wider audience. The final envelope opened up the house by adding significantly more surface area and glazing. These changes increased the envelope loads by about 30%, but the final design represents a compromise between good energy performance and aesthetic appeal. The difference in the two designs is reflected best in these renderings of the south east corner in Figure 10.

Figure 10: A comparison of the southwest corner of the final CD Set design to the initial DD Set design.

Section 1.03 Energy Model

(a) Energy Modeling Software

The energy modeling software used was TRNSYS (TRaNsient SYstem Simulation) software suite. TRNSYS is a transient equation solver that can be adapted for any type of transient calculation, but it includes many components for simulating the energy performance of buildings and renewable energy systems.

We use the software to study the energy performance of the ICON Solar House. The majority of model is built from internal TRNSYS components. We extended the software to create simple models of the desiccant dehumidification and control systems. Our model results are conservative for this final assessment of the CD design. We expect that many assumptions will be relaxed based on the construction and commissioning of the ICON Solar House.

(b) Modular Modeling Approach

Our approach in modeling the energy performance of the ICON Solar House depended on the decentralized nature of the TRNSYS software suite. TRNSYS contains a collection of independent components that connect together to model a real system, much like the physical parts of the real home. The componentized model is demonstrated in Figure 11, where the main systems are labeled. The many interconnections in this figure confuse the fundamental nature of the model but demonstrates the complexity. A simpler diagram, Figure 12, shows the communication among the main model components. The environment imposes itself on the building envelope and the solar collection systems, while the engineered systems interface meet the loads with solar energy.

TRNSYS model. The main model/system components are labeled. The green boxes condense many components into a single symbol. There are two distinct advantages to the modular approach. The first advantage allowed us to split the complete model into manageable parts. Three models naturally developed; the electrical system, solar thermal system, and the building envelope. These models

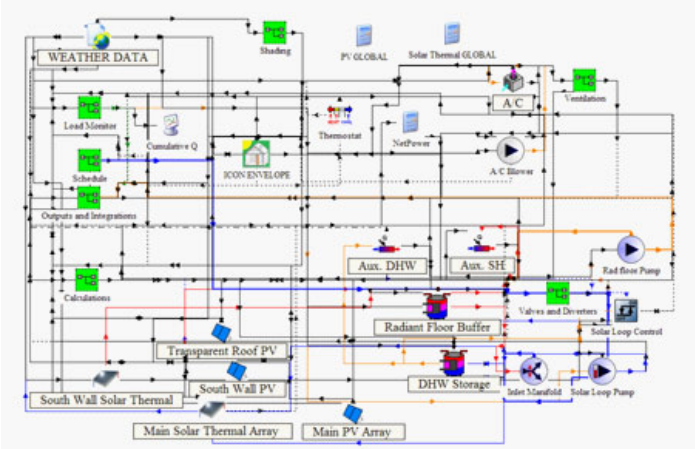

Figure 11: The GUI representation of the ICON Solar House

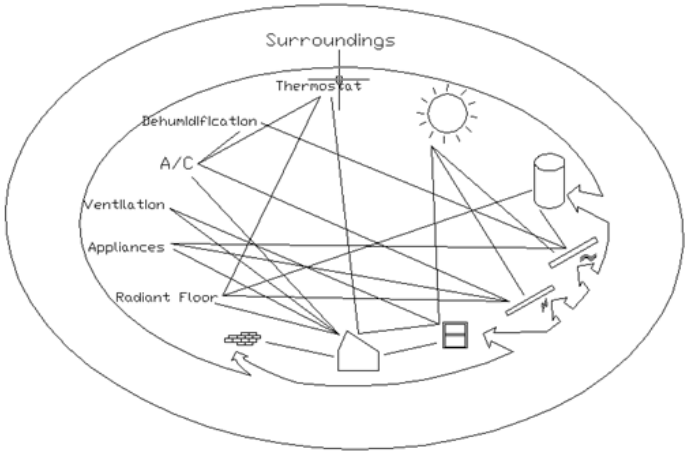

Figure 12: Diagram of model communication among main components.

were configured independently to separately guide design of each part of the project. This choice improved feedback between modeling and design in terms of the response time and the number of opportunities for feedback. It also provided an opportunity for students of different skill sets to participate in the modeling of the ICON Solar House. TRNSYS allowed us to quickly couple the models to estimate total performance. Coupling the models together introduced second order effects such as parasitic energy use and internal gains. The complete, integrated model was used to develop results presented in this report.

The ability to quickly change components and variables proved to be the second important advantage to our approach. Changes were often isolated to single components or groups of components. This factor reduced the effort needed to study the influence of a variable on specific performance metrics.

(c) Model Inputs and Solver

The TRNSYS software solves a transient energy balance on a collection of components representing the house and its systems. We coupled these component terms with the boundary conditions imposed by the competition and the environment. The initial conditions to the competition model were of vital importance due to the short-time nature of that transient solution. They depend on our ability to quickly construct the ICON Solar House on the mall and operate our systems before the competition begins. On the other hand, annual performance of the ICON Solar House is insensitive with respect to the initial conditions. A three minute time step was selected for accurate thermostat control and to achieve accurate transient heat transfer calculations, such as those on heat exchangers, thermal storage, and natural convection from envelope surfaces.

(d) Schedule of loads

The competition imposed a strict load schedule on the model. The time and duration of each of the competitions were fixed. The static load schedule was estimated from requirements for each of the competition tasks. These estimates enabled us to establish an expectation of total electricity consumption, hot water usage, and conditioning period. These static inputs are given in the competition results section.

Simulating annual performance required a different approach. The scheduling of a typical 2-person dwelling proved to be very different than the specific profiles we generated for the competition. Standard (2-person) occupancy and looser thermostat control were used in the annual simulation. Hot water profiles were taken from

ASHRAE and adjusted for 2-person occupancy to be about 208 l/day. Electricity consumption was estimated from the DOE 2001 Residential Energy Consumption Survey. The average consumption for a two occupancy dwelling between 500 and 999 ft2 is approximately 13.5 kWh/day.

We applied location specific TMY2 weather and climate data to each model. Over long time periods, the TMY data gives a reasonable expectation for radiation and weather data. Due to its statistical nature, the TMY weather dataset is increasingly inaccurate as the length of the simulation is decreased. This tendency was of particular concern when modeling the short competition period. We learned to expect variations of up to 20% for TMY data when used in periods less than one month through consultation and experience. We applied this statistical variance in our sizing calculations. In order to assess the TMY data we collected live weather data during October 2008 for comparison. For temperature and humidity we found very good agreement, well inside the uncertainly bounds we predicted. We determined radiation figures from an empirical model and found this comparison and determined it to be significantly less than the TMY2 data.

(e) Model Description

By choice and necessity, our model does not capture every physical feature of the ICON Solar House. Part of our duty as modelers is to identify those features of the design which have a strong impact on the energy performance of the model. There are many physical features to which the energy performance is insensitive. Including them consumes a disproportionate amount of time, but also adds to the computational resources required to run the model. For instance, we used fixed natural heat transfer coefficients in most cases because computing these dynamically added considerable computation time. We also used a rule of thumb to guess the internal thermal capacitance (12X thermal capacitance of the air) instead of calculating the actual value from the internal mass.

Our model also misses some elements that may be important to the design. Our solar thermal system allows heat transfer from the DHW storage to the radiant heating system, but the model does not include this. The optional insulation panel for the curtain wall is also not included in the model. The control system and thermostat are also simplified from what we will eventually implement. Care was taken in our choices such that we expect all of these inaccuracies to reduce the energy performance of the model compared to the real house.

(i) Solar Thermal Model

The principal components of the solar thermal model are the collector array, storage vessels, heat exchangers, and inline auxiliary heaters. These components match those specified in the CD set, with the exception that the model does not allow heat transfer between the storage tanks. The collectors are modeled according to the quadratic efficiency model used by the Solar Rating and Certification Corporation (SRCC). The storage tank models use five nodes to model thermal stratification. The internal heat exchangers are modeled using empirical correlations for submerged coil heat exchangers. The pump electricity contributes to the parasitic electrical load. The control for the solar thermal system is based on a differential temperature controller between the domestic hot water temperature and the outlet flow of the collector array.

(ii) Photovoltaic Model

The photovoltaic (PV) electricity model is split up into the generation side and the demand side. The demand loads on the electrical system are further divided into the appliance loads, parasitic loads, A/C, auxiliary heating, and lighting. Of these, the appliance and lighting loads are from a predetermined schedule while the remaining loads are dynamic according to the specific simulation. The parasitic load is the electricity used by the ventilation, ERV, radiant floor, desiccant dehumidification, and solar thermal systems.

The main components of the electricity generation system are the PV arrays. The array models are based on the 4-parameter circuit model. Open circuit voltage, short circuit current, and voltage and current at the maximum power point are fixed for each array. The number of cells per panel and the voltage and current temperature coefficients are also specified. An inverter efficiency of 85% is used to incorporate inverter and line losses. A 10°C temperature penalty is assigned to the roof array to account for the reduced heat transfer from the flush mounted system.

(iii) Envelope and Internal Gains Model

The model of the building envelope is a detailed construction that interfaces in a variety of ways with the solar thermal and PV models. The structure is simulated by describing each "wall" (roof and floor included) and window, as well as energy sources and sinks. Categories such as ventilation, infiltration, equipment gains, occupancy gains, and heating and cooling each describe an important phenomenon in the energy balance.

As the word 'envelope' implies, the main features of this model describe the outer shell of the ICON home. Wall and roof sections have been adjusted and readjusted over the course of the design process to match R-values with the current design. The density and heat capacity of the materials in the wall sections were of secondary importance.

Similarly, all conventional windows were modeled as triple pane according to the design specification. Another important energy flow occurring at the boundary between inside and outside is solar radiation. We learned early in the modeling process that solar gains could make or break the performance of the ICON home. Radiation is largely a one-way process in this setting, so control of the solar gain is achieved through shading where possible, without compromising collector area. Modeling of realistic shading was done rigorously and several components work together to provide the best estimate for the fraction of solar radiation reaching the inside.

Ventilation, infiltration, and conditioning are the final paths by which energy can move across the envelope. Infiltration flow is set 0.2 air change/hr, except during public tours when it is set at 5 air change/hr. The ventilation air is supplied by an external component that is adjusted independent of the envelope. The envelope determines the load on the conditioning systems, including the A/C, desiccant dehumidification, and radiant floor heat described in the next section.

In addition to all these trans-"envelope" phenomena, this sub-model accounts for internal gains. These are broken down into people, lighting, and appliance gains. Energy gains from occupancy are based on a static schedule that estimates the number of people that will be in the house at any given time. The sensible and latent heat loads from occupancy are determined from the competition circumstances. Lighting wattage was added to the total internal gain. Finally, appliance gains were estimated for such essential items as the refrigerator/freezer, range, computer, television, and the home control system.

(iv) HVAC Models

The desiccant system, radiant floor heating, A/C system, and ventilation systems were modeled within the home. An energy recovery system and an ambient cooling strategy were also implemented within the energy model.

The model for the desiccant system is based on the performance of a specific packed column system which we emulated in our design. Our model assumes a constant coefficient of performance of 0.4. The thermal load for the regeneration of the desiccant system draws from the DHW tank when the temperature is high enough. We expect this simple model to give an accurate total energy balance at the expense of the correct recharging schedule. The electrical consumption of the desiccant blowers and pumps contributes to the parasitic electrical load.

The A/C system is modeled as a standard 1.25-ton central unit. Care was taken to operate the A/C within an environment of controlled humidity, such that the efficiency gains of a higher evaporator temperature were realized. The model interpolates data from a performance map a of a real 2-ton unit based on the indoor temperature, outdoor temperature, and the latent load. We expect the actual COP of our mini split unit to exceed the performance of the reference A/C unit.

The radiant floor model was included within the envelope model as an active heating element. This empirical model essentially treats the floor as a heat exchanger with the conditioned zone. The model takes as parameters the physical attributes of the radiant floor design including floor section, pipe size and material, as well as flow rate and loop count. The flow rate is adjusted to correspond to the maximum heating load of the simulation in order to

maintain the correct floor temperature. This variation differentiates the radiant floor model in each of the annual simulations from the competition simulation.

Ventilation is modeled at the lowest continuous rate to meet code, determined to be 0.85 m3/min. The ventilation air is brought in through an energy recovery unit that has a fixed latent efficiency (0.5) and sensible efficiency (0.6). These efficiencies are based on annual averages. During the competition we expect a more efficient sensible exchange and about the same efficiency for latent energy exchange. The electrical consumption of these units is included in the parasitic energy load.

Due to the large area of glazing on the house, the temperature of the conditioned zone often exceeds that of the outdoor ambient temperature. This occurrence is particularly evident in the swing months, which includes the competition. We developed an ambient cooling control strategy to bring in fresh air through the ventilation unit rather than use the A/C system under this circumstance. This choice increases the dehumidification load while reducing the A/C load. This option was used more heavily in the annual simulations than during the competition because of the very tight temperature and humidity boundaries in the competition.

The main HVAC control is a simple thermostat that enables heating and cooling. This thermostat is combined with the conditioning flag during the competition period. The conditioning flag alerts the control system to the timing of the Decathlon conditioning contests. Humidity sensing is absent to facilitate the simple desiccant dehumidification model. The only calculated quantity is the thermal energy needed to maintain 45% RH. The ambient cooling strategy is implemented entirely within the control framework. If the ambient temperature is less than the house temperature and cooling is needed, a high flow of fresh air is brought into the ventilation system and the A/C is not used. The time step of our simulation is fixed at 3 minutes. This period is the shortest length of time over which control decisions are made. The electricity consumption of the control and sensing systems were not modeled because they have a relatively small impact on the energy balance.

Section 1.04 Results

We present selected outputs to demonstrate the performance of the ICON Solar House during the Solar Decathlon competition and for two annual cases, Minneapolis, MN, and Sterling, VA., the closest available weather file to the competition site in Washington DC. The loads vary according to each type of simulation, but the systems and building envelope are constant. The important inputs are described and followed by the presentation of the results. All other parameters are fixed according to the ICON Solar House design as of May 26, 2008. The model parameters match the description Project Manual and CD as closely as possible.

We break down the total energy consumption for each of the main types of load: electricity, solar thermal, envelope loads, and HVAC energy. We present cumulative load and energy production data on a daily basis for the competition and a monthly basis for the annual simulations. Two performance metrics are given at the conclusion of each section: the solar fraction and the net energy performance. All results are presented in SI units.

(a) Competition

(i) Competition Environment

The energy model is used to simulate three competition scenarios. The first scenario corresponds to the TMY2 weather profile for the scheduled competition in October 2009 based on weather from Sterling, VA. Two other scenarios were selected based on TMY2 weather patterns ±14 days from the start of the actual competition. In each case, a 10-day October competition period is simulated. These simulations are a few among an infinite number of possibilities for the actual weather during competition. They also neglect real-time changes that can be made by students during the competition. The climate data for these periods is average with respect to October radiation in Washington, DC. Temperatures in this dataset are considerably cooler than those measured in Washington, D.C. during October 2008. Temperature and total horizontal radiation from the TMY2 data set are given for the 10-day competition period in Figure 13 and Figure 14.

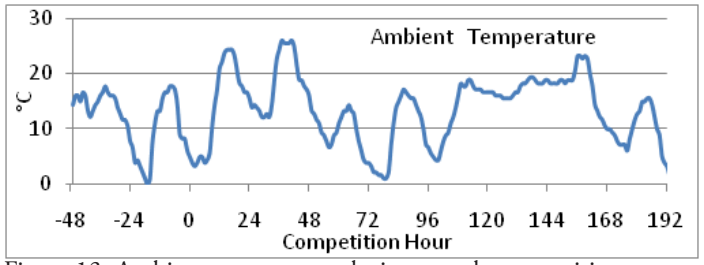

Figure 13: Ambient temperature during sample competition period.

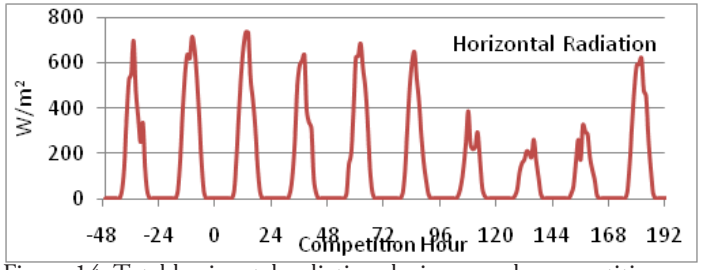

Figure 14: Total horizontal radiation during sample competition period.

(ii) Initial Conditions

The house and all surfaces are initialized at 20°C. The storage tanks have an initial temperature of 20°C. We assume that we have 1.5 days to collect solar thermal energy prior to the start of the competition. Competition days begin on Thursday and end on the following Thursday. The competition begins at hour zero. Net-metering for the electricity and all cumulative loads are reset at this time. Energy in the form of hot water storage is exempt from the energy reset.

(iii) Competition Schedule Inputs

The static inputs that have been estimated according to the competition schedule are presented in Figure 15-Figure 20. These loads are competition appliance electrical draw, lighting electricity, hot water draw, occupancy of conditioned zone, total internal gains, and the conditioning flag corresponding to temperature and humidity monitoring. Additional dynamic loads occur throughout the competition based on the operation of systems in the home.

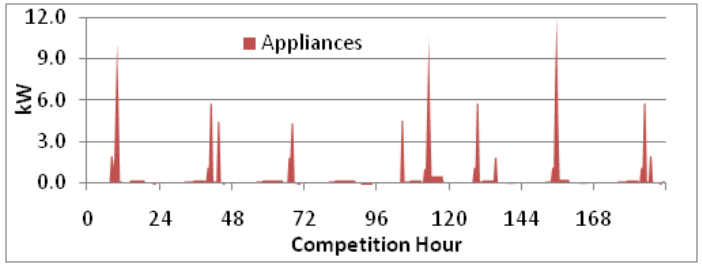

Figure 15: The electricity draw of competition appliances.

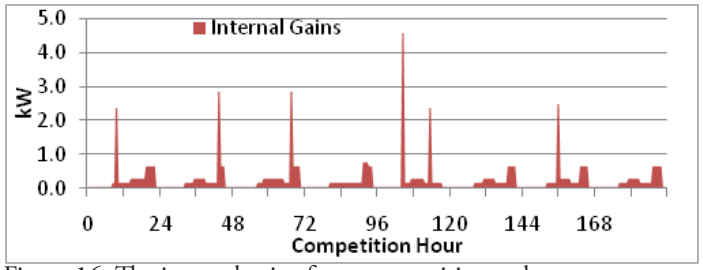

Figure 16: The internal gains from competition tasks.

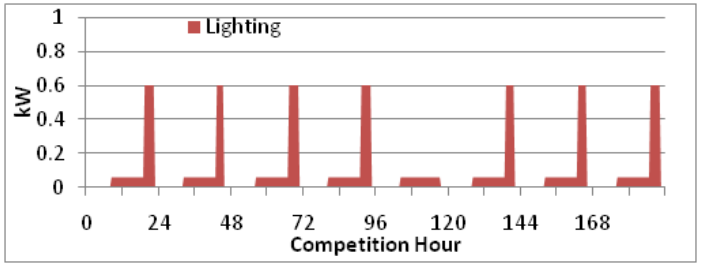

Figure 17: The competition lighting schedule.

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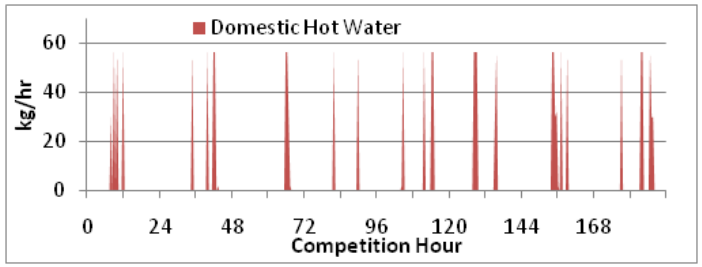

Figure 18: The hot water loads are determined from the competition schedule.

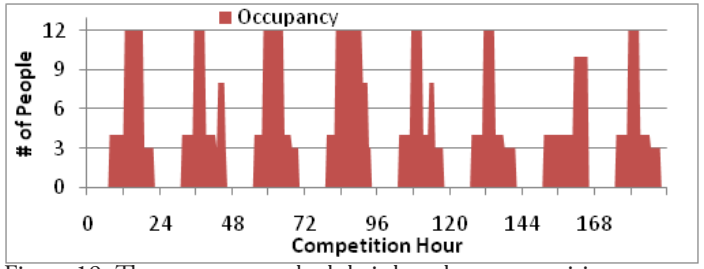

Figure 19: The occupancy schedule is based on competitions, hosted events, and public tours.

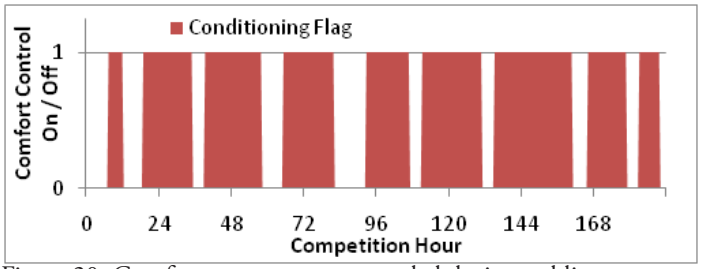

Figure 20: Comfort contests are suspended during public tour periods.

(iv) Results – Loads

The breakdown of the total energy consumption for electricity, solar thermal, envelope loads, and HVAC energy for the competition period are detailed in Figure 21-Figure 24. The percentage and total amount in units of kWh are listed.

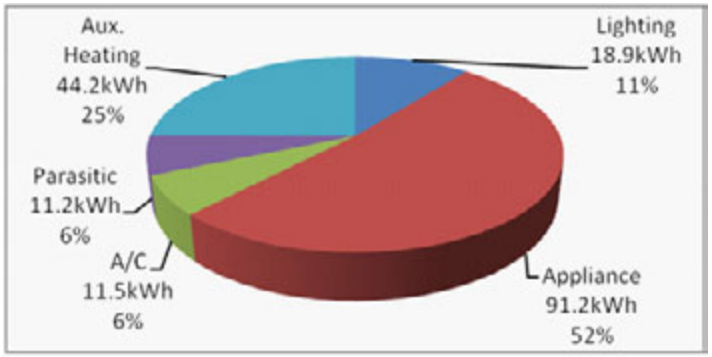

Figure 21: Breakdown of the total electricity consumption (177kWh) for the simulated competition period.

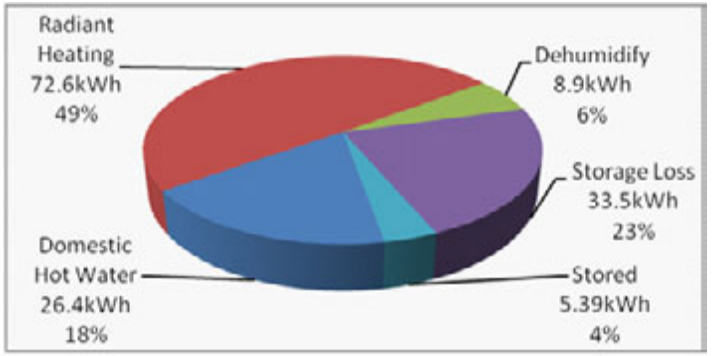

Figure 22: Breakdown of the total solar thermal energy consumption (147kWh) for the simulated competition period.

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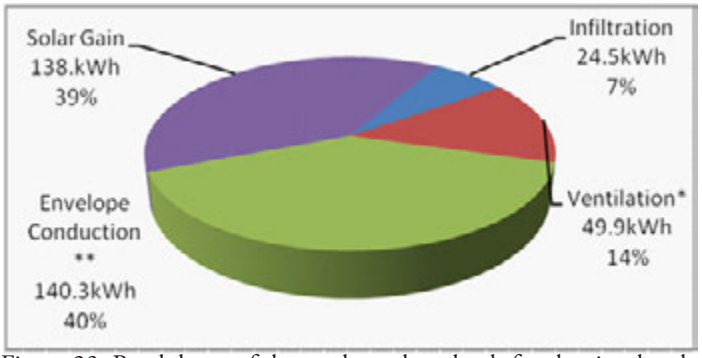

Figure 23: Breakdown of the total envelope loads for the simulated competition period. *Ventilation loads include cold ambient air for cooling. **During daylight, solar gain mainly offsets envelope conduction until active cooling is required.

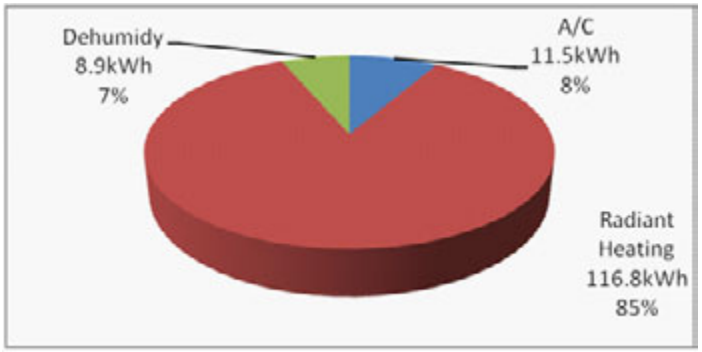

Figure 24: Breakdown of total HVAC energy consumption (137.2kWh) for the simulated competition period.

Daily numbers for the consumption of electricity and solar thermal energy are given in Figure 25 and Figure 26. The results from each of the three competition periods are presented.

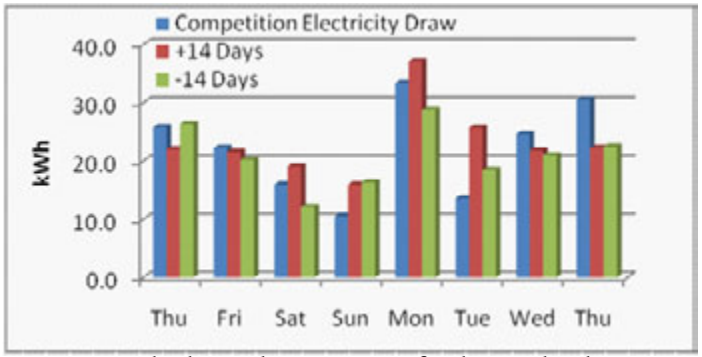

Figure 25: Daily electrical consumption for the simulated competition periods.

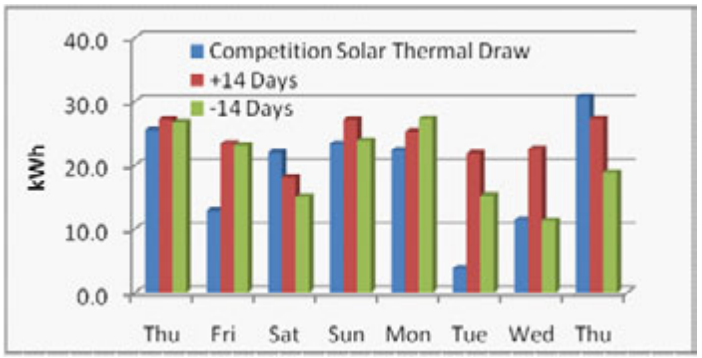

Figure 26: Daily thermal energy consumption for the simulated competition periods.

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(v) Results – Generation

The output of the photovoltaic system (including inverter loss) and the solar thermal array are given in Figure 27 and Figure 28. The losses from the solar thermal storage tanks are also shown in Figure 28.

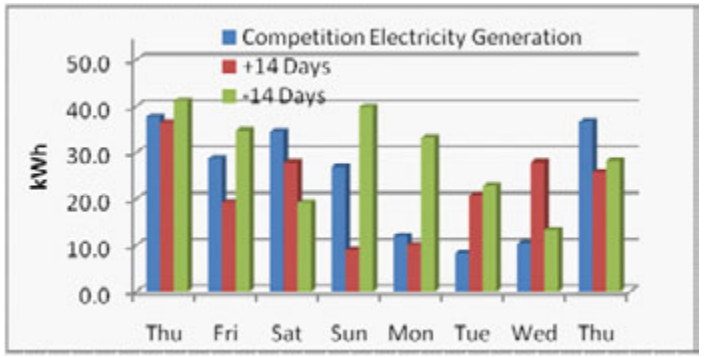

Figure 27: Daily electricity generation during competition periods.

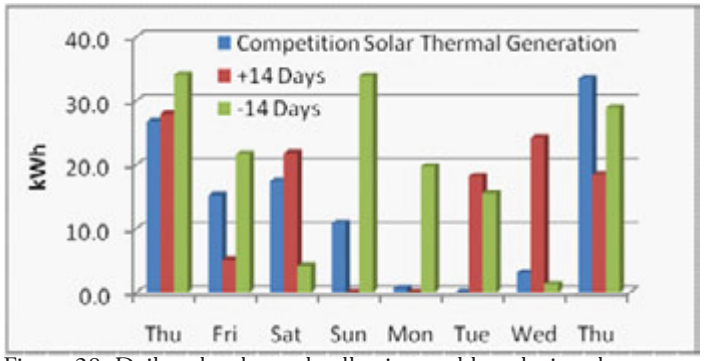

Figure 28: Daily solar thermal collection and loss during the competition periods.

(vi) Results – Performance Metrics

Two performance metrics are calculated to compare the energy performance of the ICON home. The solar fraction gives the fraction of the load that is met by the active solar systems. The net-zero metric gives the hourly net-energy balance on the home for each the solar thermal system and the photovoltaic system for the three simulated competition periods.

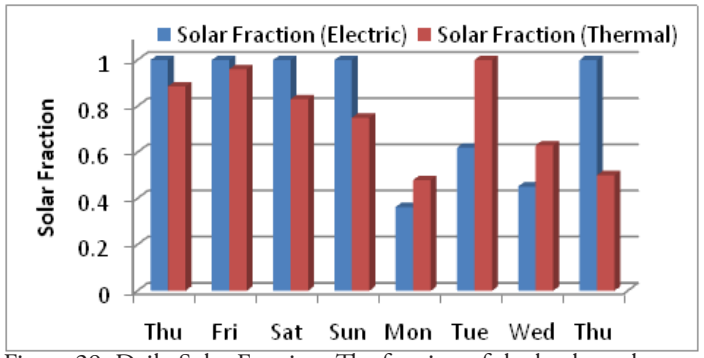

Figure 29: Daily Solar Fraction: The fraction of the load met by solar resource per day for the competition period.

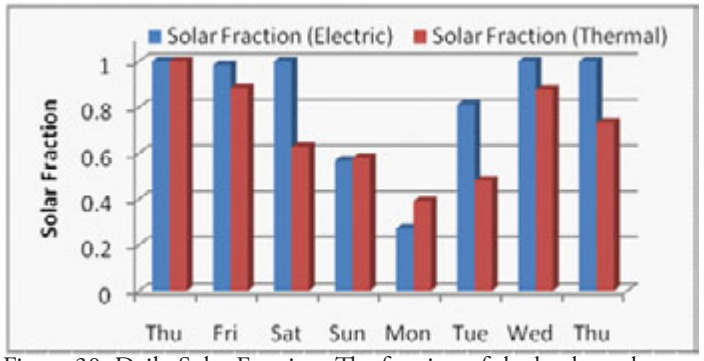

Figure 30: Daily Solar Fraction: The fraction of the load met by solar resource per day for the competition period +14 days.

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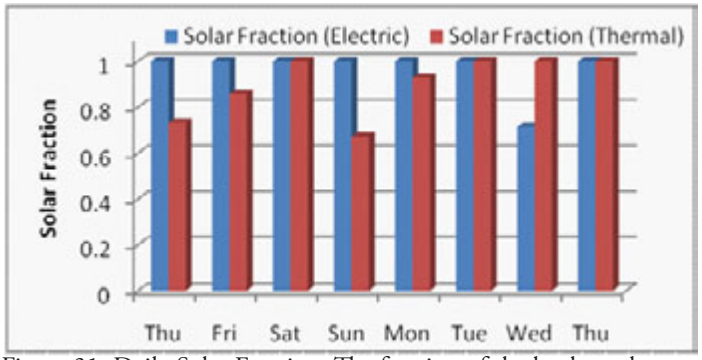

Figure 31: Daily Solar Fraction: The fraction of the load met by solar resource per day for the competition period -14 days.

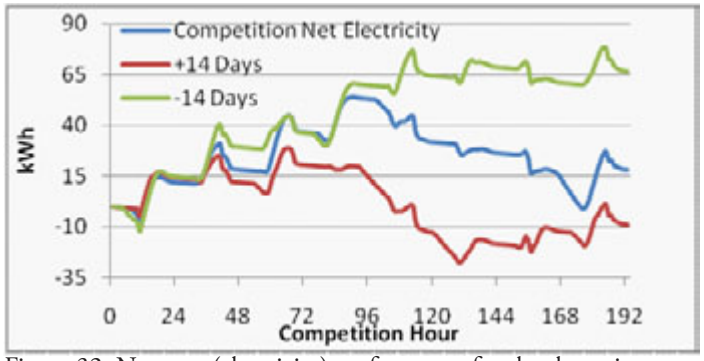

Figure 32: Net-zero (electricity) performance for the three simulated competition periods.

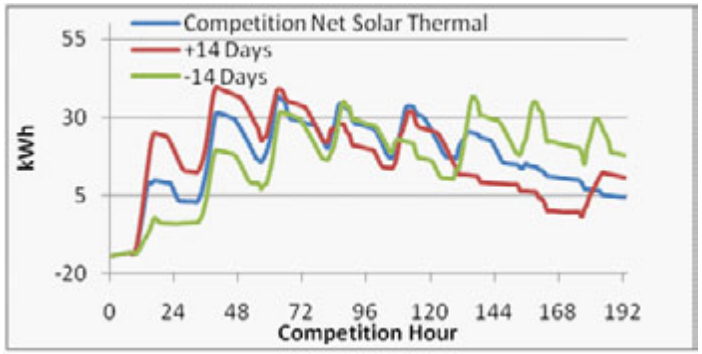

Figure 33: Net-zero (solar thermal) performance for the three simulated competition periods.

(b) Annual Results

Annual results are provided for the TMY2 data set from Minneapolis, MN and Sterling, VA climates. This section contains the same organization of results as presented above. The results are compared side by side where possible to illustrate how climate impacts the performance of the design. The lighting, electricity, occupancy, internal gains, and hot water schedules are the same for each location.

The main differences between the Minneapolis and Sterling climate are:

The latitude in Minneapolis (45°) is 6° N of the latitude of Sterling, Va (39°).

Minnesota has a longer heating season and a larger heating load. Sterling has a longer cooling season and a larger portion of the cooling is latent.

(i) Competition Environment

TMY2 weather data was used for climate data in Minneapolis, MN and Sterling, VA. We assume for the annual simulation that the solar thermal storage is not placed outside. Losses from the tanks are calculated at the temperature of the conditioned space and function to increase or decrease the home heating load.

(ii) Initial Conditions

The initial conditions from the competition period were reused for these simulations. The simulation begins in January assuming that the house and the storage tanks are at 20 °C. The influence of the initial values is minor in the annual simulations.

(iii) Annual Schedule Inputs

The lighting and non-occupant internal gains schedules were reused from the competition. The other energy consumption characteristics were adjusted to represent a 2 person occupancy swelling. The domestic hot water consumption was estimated at 208 l/day from the ASHRAE standard. Electrical consumption was estimated to be 15.3 kWh/day from the DOE 2001 Residential Energy Consumption Survey. The occupancy assumed two working (full time) individuals who entertained guests on average of one time per week.

(iv) Results – Loads

The breakdown of the total energy consumption for electricity, solar thermal, envelope loads, and HVAC energy are detailed in Figure 34-Figure 41. The percentage and total amount in kWh are given. The daily consumption of electricity and solar thermal energy are given per month in Figure 42-Figure 43.

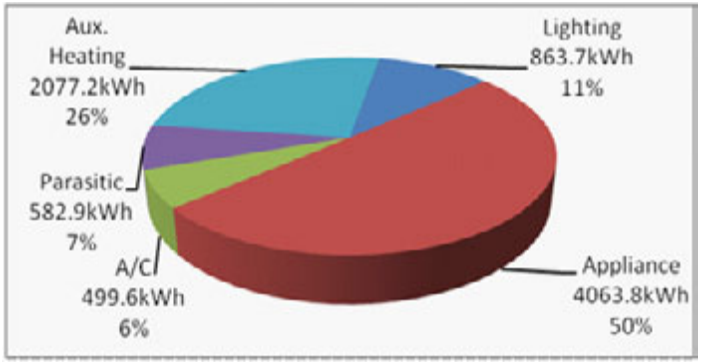

Figure 34: Breakdown of the total electricity consumption (8087 kWh) for 1 year in Minneapolis, MN.

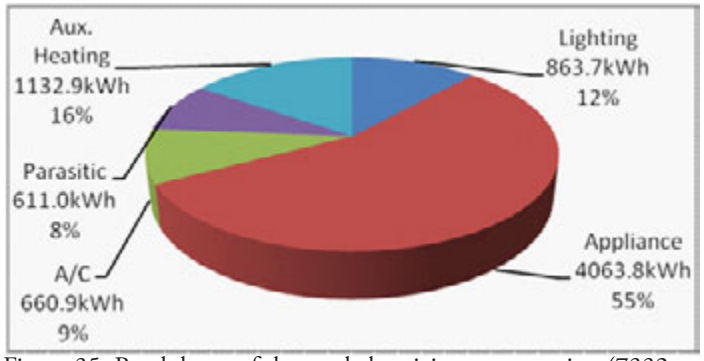

Figure 35: Breakdown of the total electricity consumption (7332 kWh) for 1 year in Sterling, VA.

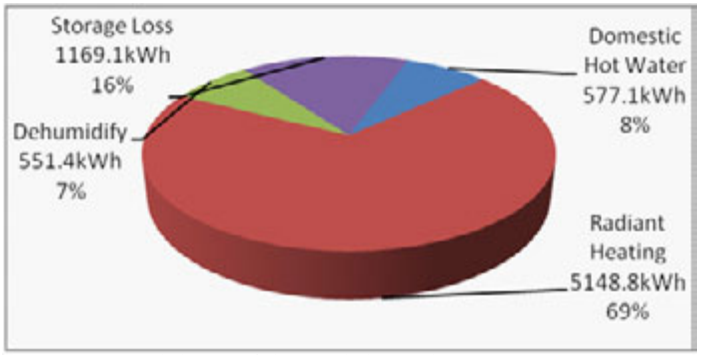

Figure 36: Breakdown of the total thermal energy consumption (7446 kWh)for 1 year in Minneapolis, MN.

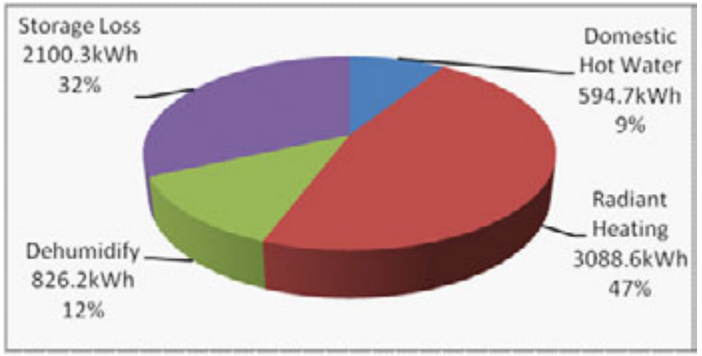

Figure 37: Breakdown of the total thermal energy consumption (6610 kWh) for 1 year in Sterling, VA.

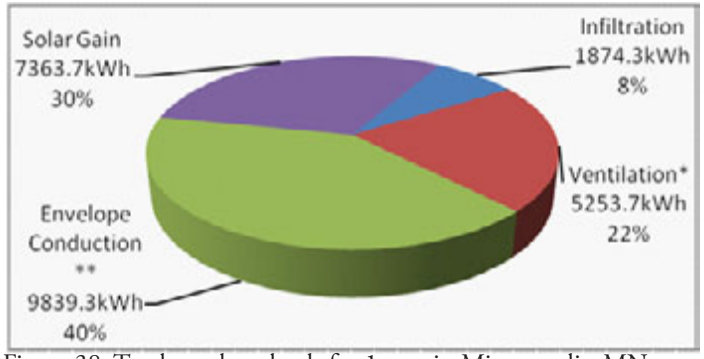

Figure 38: Total envelope loads for 1 year in Minneapolis, MN. *Ventilation loads include cold ambient air for cooling. **During daylight, passive solar mainly offsets envelope conduction until active cooling is required.

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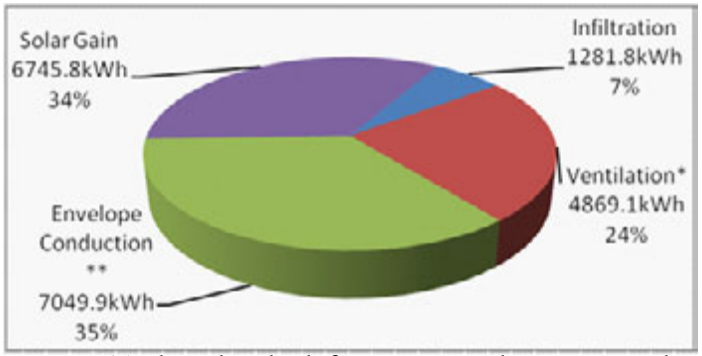

Figure 39: Total envelope loads for 1 year in Sterling, VA. *Ventilation loads include cold ambient air for cooling. **During daylight, passive solar mainly offsets envelope conduction until active cooling is required.

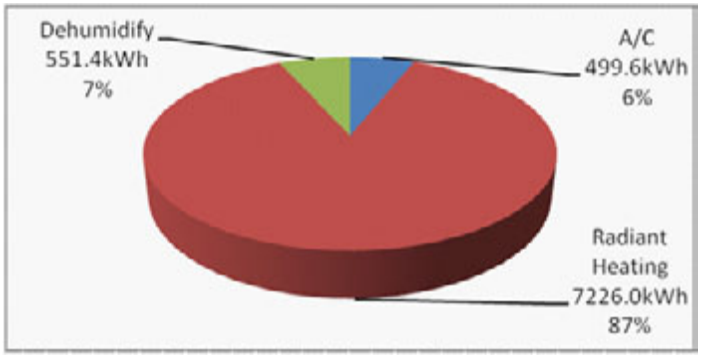

Figure 40: Breakdown of the total HVAC energy consumption (8277 kWh) for 1 year in Minneapolis, MN.

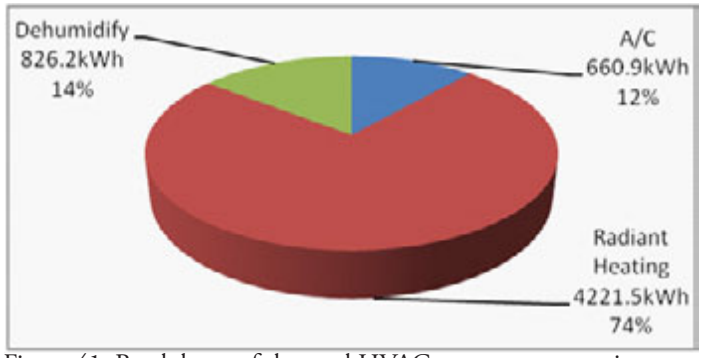

Figure 41: Breakdown of the total HVAC energy consumption (5709 kWh) for 1 year in Sterling, VA.

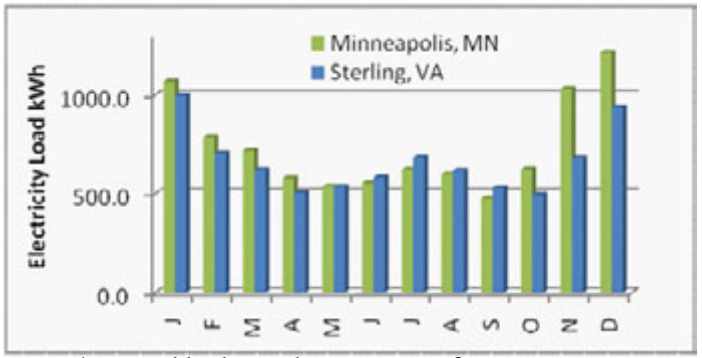

Figure 42: Monthly electrical consumption for 1 year in Minneapolis, MN and Sterling, VA.

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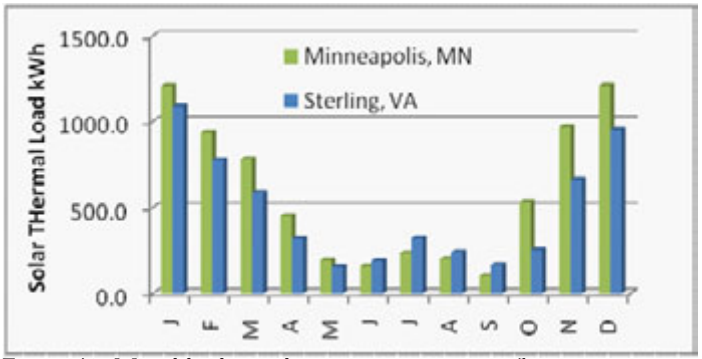

Figure 43: Monthly thermal energy consumption for 1 year in Minneapolis, MN and Sterling, VA.

(v) Results – Generation

The monthly generation of electricity is given for Minneapolis and Sterling in Figure 44. In Figure 45, the monthly collection of solar thermal energy is given for each climate.

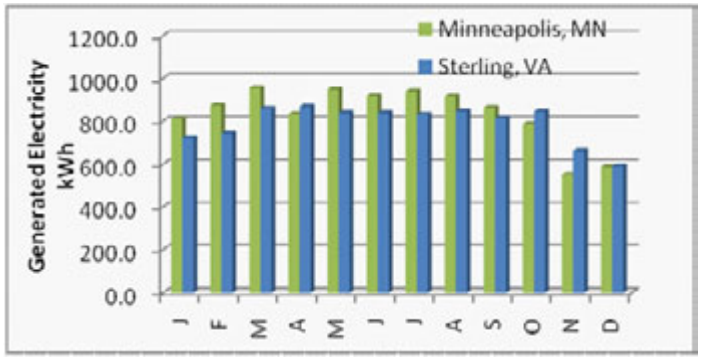

Figure 44: Monthly electrical generation for 1 year in Minneapolis, MN and Sterling, VA.

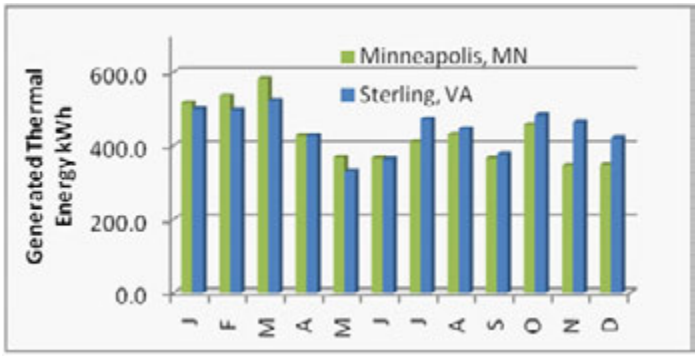

Figure 45: Monthly solar thermal collection for 1 year in Minneapolis, MN and Sterling, VA.

(vi) Results – Performance Metrics

The same performance metrics calculated for the simulated competition are presented for the annual results. The metrics are computed for each month of the year instead of each day of the competition. The net-thermal energy balance is inconsequential on the seasonal timescale so it is not included for the annual results. The solar fraction and net-energy performance are given in Figure 47 and Figure 48.

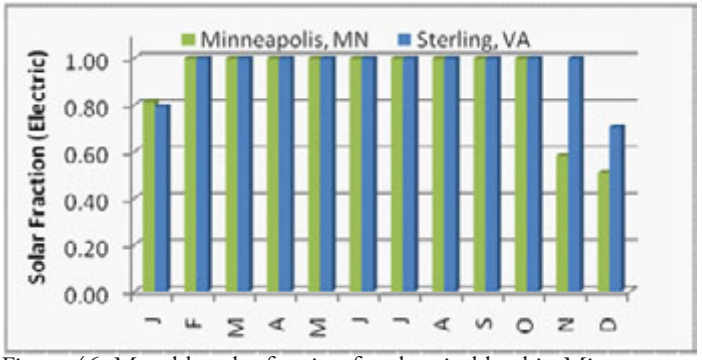

Figure 46: Monthly solar fraction for electrical load in Minneapolis, MN and Sterling, VA.

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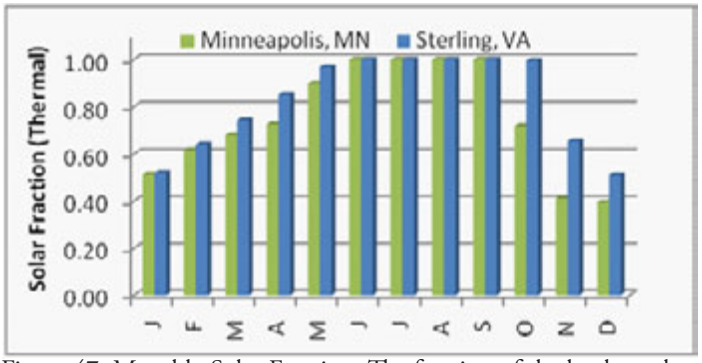

Figure 47: Monthly Solar Fraction: The fraction of the load met by solar resource per month in Minneapolis, MN and Sterling, VA.

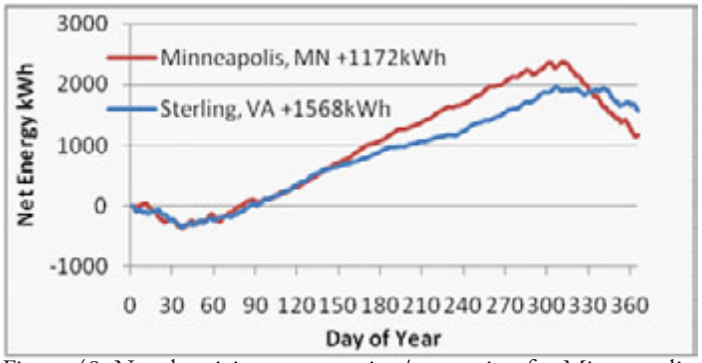

Figure 48: Net electricity consumption/generation for Minneapolis, MN and Sterling, VA.

Section 1.05 Conclusions

This section provides a brief reflection on the results presented in the previous section.

(a) Competition

From our modeling of multiple competition scenarios, we have shown a range of possibilities for the competition. In two of the three scenarios we are net-energy positive, while in one scenario we end with an energy deficit. In the competition period we end with about 1 extra day of electricity. In the earlier period we end with 3-4 extra days of electricity, while in the late period we end with a deficit of just under 1 day worth of electricity.

The variations among these results show the dependency of a solar house on the weather. This is especially true when constrained to time periods as short as the 10-day competition period. The direct consequence of this is the need for annual simulation. By adjusting our design for the average weather over an entire year, we can plan to generate surpluses for the times when solar energy cannot meet the loads.

(b) Annual

Our annual simulation has successfully shown that the ICON house is a true cold weather solar home. From Figure 48, we see that although it is much colder in Minneapolis than Sterling during January, the ICON house gets through the month without using any more energy than in Sterling. Furthermore we see that with the arrival of February, the ICON house transitions to net-energy positive in both climates. By April and May we see that the rate of energy production becomes higher in Minneapolis than Sterling. Finally, in both climates, the ICON house ends the year, conclusively, in net-positive territory. In both cases, the ICON house has generated about an extra 1-2 months worth of electricity.

In Figure 46 and Figure 47, the solar performance in each climate is broken down by the month. Beginning with the electric solar fraction, we see that in both climates, the PV array generates a surplus of electricity from February through October. In Sterling, this surplus is extended into November, but the solar fraction falls off in Minneapolis due to the cloudy weather during that time.

The electric solar fraction falls off during January and December for both climates mainly due to the high incidence angle between the PV array and the sun during that time.

The solar fraction for the solar thermal systems shows a slightly different story. In both climates, the solar thermal system meets the thermal loads during June through September. The solar fraction falls off in the remaining months. However, between February and October, the auxiliary electric heaters are able to maintain the total solar thermal fraction at unity. During November – January, the

heating loads cannot be met by the combined effort of the solar thermal and PV systems and we rely on excess electricity from the summer months to meet the load.

The main limitation on the performance of the ICON Solar House is the inability to weather extended periods of bad solar resource. The PV essentially has a free and unlimited storage because it is connected to the grid. We leverage this resource for seasonal storage by generating a massive surplus during the summer. However we use the majority of the surplus for inefficient resistance heating during the winter because of the limitation of solar thermal storage (for heating). The solar thermal storage is limited by size. The PV system would essentially suffer the same problem if it required local storage. Thus, one of the basic limitations of residential solar is the inability to store enough energy to overcome the extended (weeks, months) bad weather during winter. Using the free storage of the grid is a questionable and expensive strategy for overcoming this limitation.

(c) Final Conclusions

We believe from our conservative modeling procedure that we will be net-energy positive during the competition. We have also demonstrated that the ICON Solar House can achieve net-positive energy in both Minneapolis and Sterling climates. We recognize here that a key aspect to sustainable design is a corresponding lifestyle that considers the value of energy and resources. We firmly expect that there is sufficient opportunity to further increase the net-energy performance annually in Minnesota when the ICON Solar House is paired with occupants that value sustainability, renewable energy, and who are willing to embrace a greener lifestyle than that supposed by using average consumption statistics. The application of the night insulation/privacy barrier and inclusion of the DHW tank into the radiant heating system will also improve the performance of the ICON Solar House.

The performance speaks for itself; we have proven with our design that we can achieve good energy performance without sacrificing the appealing concept of a home. Moreover, we hope to demonstrate this success on the National Mall by showcasing the ICON Solar House for the public and having them leave with a vision of the technology and design that is emblematic of the future solar house for cold climates.

Structural Calculations

for the

Solar Decathlon House Competition Washington, DC

March 24, 2009

Solar Decathlon Structures Team

Matthew Bechle
Scott Merth
Joanna Campbell

David Macdonald, Advisor

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly licensed Professional Engineer under the laws of the State of Minnesota.

David H Macdonald

David H. Macdonald P.E.

3/24/2009 MN Reg. No. 14751

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Date 7 Dec 08	SHT
Project Solar Decath	1
By DHM 08171	

Roof Loads

DL

Roofing	5
Struct	5
Clg+Ins	5
Solar Cell	10
	25 psf

LL:

Ground Snow Load = 50psf

$C_e = 1.0$ Terrain B

$C_t = 1.0$

$I = 1.0$

$P_f = .7(50)(1)(1) = 35$ psf

Sloped Roof

Roof 1 Slope = 52°

$C_s = .42$

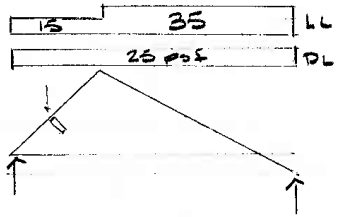
$P_s = 35 \times .42 = 14.7$

Roof 2 Slope = 28°

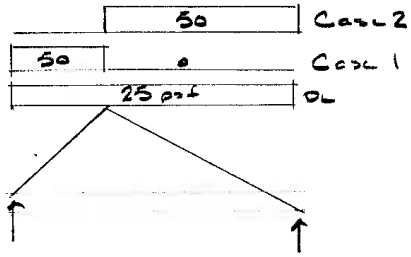
$C_s = 1.0$

$P_s = 35 \times 1.0 = 35$ psf

Balanced Snow load

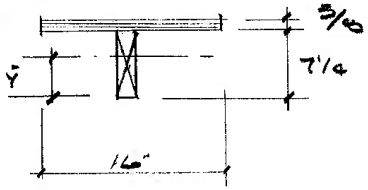


Unbalanced



Roof Joists:

2x8 @ 16" w/ 5/8 Plywd

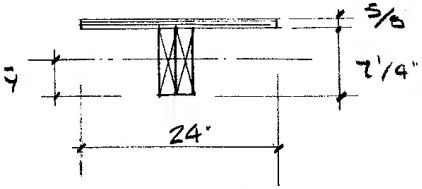


$A = 20.9 \text{ in}^2$ $\bar{y} = 5.51$

$I_{xx} = 126.7 \text{ in}^4$

$S_t = 51.7$ $S_b = 23.3$

Dbl 2x8 @ 24 w/ 5/8 Plywd



$A = 36.75 \text{ in}^2$ $\bar{y} = 5.23$

$I_{xx} = 233.4 \text{ in}^4$

$S_t = 84.3$ $S_b = 44.6$

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Structural Calculations

COMMENTS

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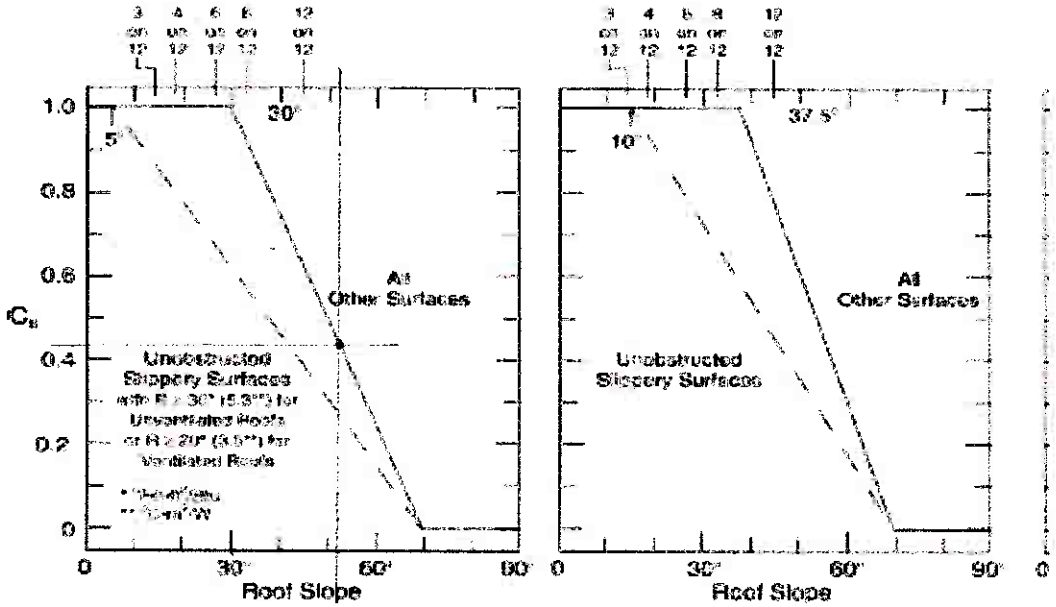
PM-B002



7-2a: Warm roofs with $C_t = 1.0$ 7-2b: Cold roofs with $C_t = 1.1$

FIGURE 7-2 GRAPHS FOR DETERMINING ROOF SLOPE FACTOR C_s, FOR WARM AND COLD ROOFS (SEE 1

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Date 7 Dec 08	SHT
Project Solar Decath	2
By DHM	

Roof Panels

1) Span = 12'-9" 16" o/c

w: DL = 1.33 × 25 = 33
LL = 1.33 × 50 = 67
100 #/ft

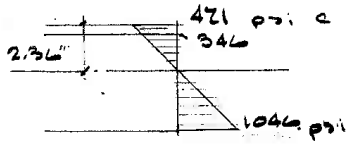
V = 638 #
M = 2032 ft#

Shear taken by 2×8

$f_{vn} = \frac{638(1.5)}{10.9} = 88$ psi

$F_{vn} = 150(1.15) = 173$ psi ok

Fb:



Fb 2×8: = 850(1.15)1.15(1.2)
= 1348 psi ok

Check Plywood:

$C = \frac{471+346}{2} \times .625 \times 12 = 3063$ #/ft

For 5/8 Plywood Group 1
(not AC or Marine)

Allowable Capacity C = 3800 #/ft width

3800# > 3063# ok

Shear Flow

Q = 16(.625)(2.36 - .31) = 20.5

$V_{n\,max} = \frac{638(20.5)}{128.7^{n}} = 102$ #/in max

$\Delta = \frac{100/12\,(12.75 \times 12)^4}{1.3 \times 10^6 (128.7)} \frac{5}{384} = .36"$

$\Delta_{LL} = .24"$ l/642

2) Span = 11'-6"
16" o/c w = 100 #/ft

V = 575 #
M = 1653 ft# 2×8 @ 16"

Shear in 2×8

$f_{vn} = \frac{575(1.5)}{10.9} = 79 < 173$ psi

Bending in 2×8

$f_b = \frac{1653 \times 12}{23.3} = 1021$ psi

Fb = 1348 psi ok

Comp in Plywood

C: 383
281

$C = \frac{383+281}{2}(.625) \times 12 = 2490$ #/ft

Allow = 3800 > 2490 # ok

$\Delta = \frac{5}{384} \frac{\frac{100}{12}(11.5 \times 12)^4}{1.3 \times 10^6 (128.7)} = .23"$

$\Delta_{LL} = .15"$ l/875

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Date 7 Dec 08
Project Solar Decath
By DMM
SHT 3

Shear Flow

$Q = .625(16)(2.365 - .3125)$
$= 20.5$

$V_{h\,max} = \frac{575(20.5)}{128.7} = 91.6$ #/in max

3) 10'-7" Span
2x8 @ 16" w/ 5/8"

$w = 100$ #/ft
$V = 529$#
$M = 1400$ ft#

Shear in 2x8

$f_{vn} = \frac{529(1.5)}{10.9} = 72$ psi < 173 ok

Bending in 2x8

$f_b = \frac{1400(12)}{23.3} = 721$ psi
< 1348 ok

Comp in Plywood

C = 324, 237

$= \frac{324+237}{2}(16)(.625) = 2805$#

Callow = 3800 > 2805 ok

$\Delta = \frac{5}{384}\frac{\frac{100}{12}(10.58 \times 12)^4}{1.3 \times 10^6 (128.7)} = .16$"

$\Delta_{TL} = .16' = L/793$
$\Delta_{LL} = .10$" " $L/1184$

Shear Flow

$Q = 16(.625)(2.64 - .3125)$
$= 20.5$

$F_{vn} = \frac{529(20.5)}{128.7} = 84$ #/in max

Need Adhesive to Resist
102 #/in max

Check Tension in Plywood Panel

Shear to Sides
$= 46\text{psf}\left(\frac{11 \times 9.74}{2}\right) = 2464$#

$v = \frac{2464}{9.74'} = 253$ #/ft

for Blocked Sheathing
19/32 min 10d nails 6/6
v' = 320 #/ft ok

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PM-B005

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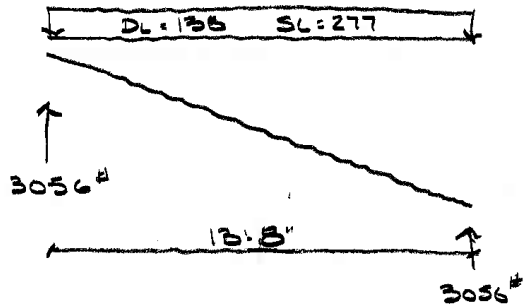
Date 3/16/09
Project Solar Decath
By DHM
SHT

Bm @ East Edge



2-1¾ x 11⅞ LVL OK

Area Req'd Fe = 405 psi
Ar = 7.5 in²
= 3½" x 2.15"
Use 2-2x Min

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Structural Calculations

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PM-B006

WoodWorks®	COMPANY	PROJECT
	Mar. 16, 2009 11:55	Beam1.wwb

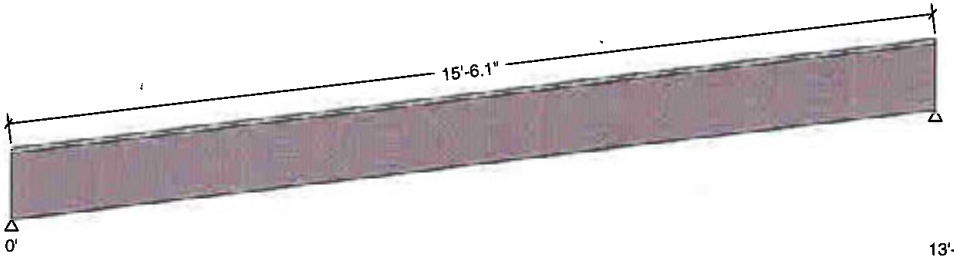
Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start	Magnitude End	Location [ft] Start	Location [ft] End	Pat-tern
Load1	Dead	Full UDL	138.0				No
Load2	Snow	Full UDL	277.0				No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :



Dead	1163		1163
Live	1893		1893
Total	3056		3056
Bearing:			
LC number	2		2
F'theta	893		2643
Length	1.00		1.00

LVL n-ply, 1.8E, 2600Fb, 1-3/4x11-7/8", 2-Plys

Slope: 28.2 deg; Total length: 15'-6.1"; Self Weight of 11.98 plf automatically included in loads;
Lateral support: top= full, bottom= at supports; Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	fv = 85	Fv' = 328	fv/Fv' = 0.26
Bending(+)	fb = 1523	Fb' = 2993	fb/Fb' = 0.51
Live Defl'n	0.32 = L/584	0.52 = L/360	0.62
Total Defl'n	0.61 = L/304	0.78 = L/240	0.79

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CV	Cfu	Cr	Cfrt	Ci	Cn	LC#
Fb'+	2600	1.15	-	1.00	1.000	1.00	-	1.00	1.00	-	-	2
Fv'	285	1.15	-	1.00	-	-	-	-	1.00	-	1.00	2
Fcp'	750	-	-	1.00	-	-	-	-	1.00	-	-	-
E'	1.8 million		-	1.00	-	-	-	-	1.00	-	-	2

```
Bending(+): LC# 2 = D+S, M =  10441 lbs-ft
Shear     : LC# 2 = D+S, V =   2693, V design =   2348 lbs
Deflection: LC# 2 = D+S   EI=    440e06 lb-in2/ply
Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.
Bearing: Allowable bearing at an angle F'theta  calculated for each support
as per NDS 3.10.3
  (D=dead  L=live  S=snow  W=wind  I=impact  C=construction  CLd=concentrated)
  (All LC's are listed in the Analysis output)
```

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. SCL-BEAMS (Structural Composite Lumber): the attached SCL selection is for preliminary design only. For final member design contact your local SCL manufacturer.
3. Size factors vary from one manufacturer to another for SCL materials. They can be changed in the database editor.
4. BUILT-UP SCL-BEAMS: contact manufacturer for connection details when loads are not applied equally to all plys.
5. SLOPED BEAMS: level bearing is required for all sloped beams.

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REV DATE 03/26/09

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PM-B007

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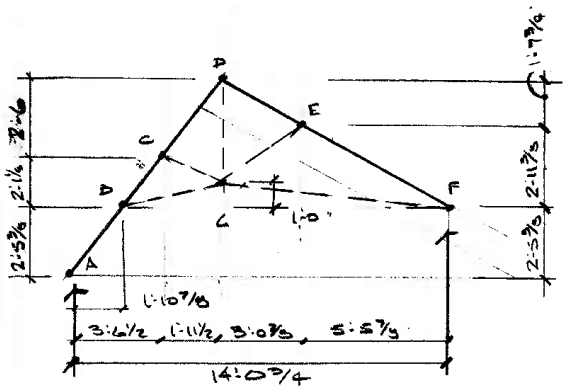
Date 3/11/09	SHT
Project Solar Decath	
By DHM	

Roof Truss 1



Truss	Coord x	Coord y
A	0	0
B	1.9063	2.4479
C	3.5417	4.5417
D	5.500	7.0417
E	8.5729	5.3935
F	14.0625	2.4479
G	5.500	3.4479

Top Chord
2 - 1 3/4 x 1 1 7/8 L's

Webs
2" x 2" x 3/16" Tube

Loading: Trib width = 10'-9"

DL:

263 #/ft

SL balanced

161 #/ft | 376 #/ft

SL Unbal Right & Left

0 | 538 #/ft

538 #/ft | 0

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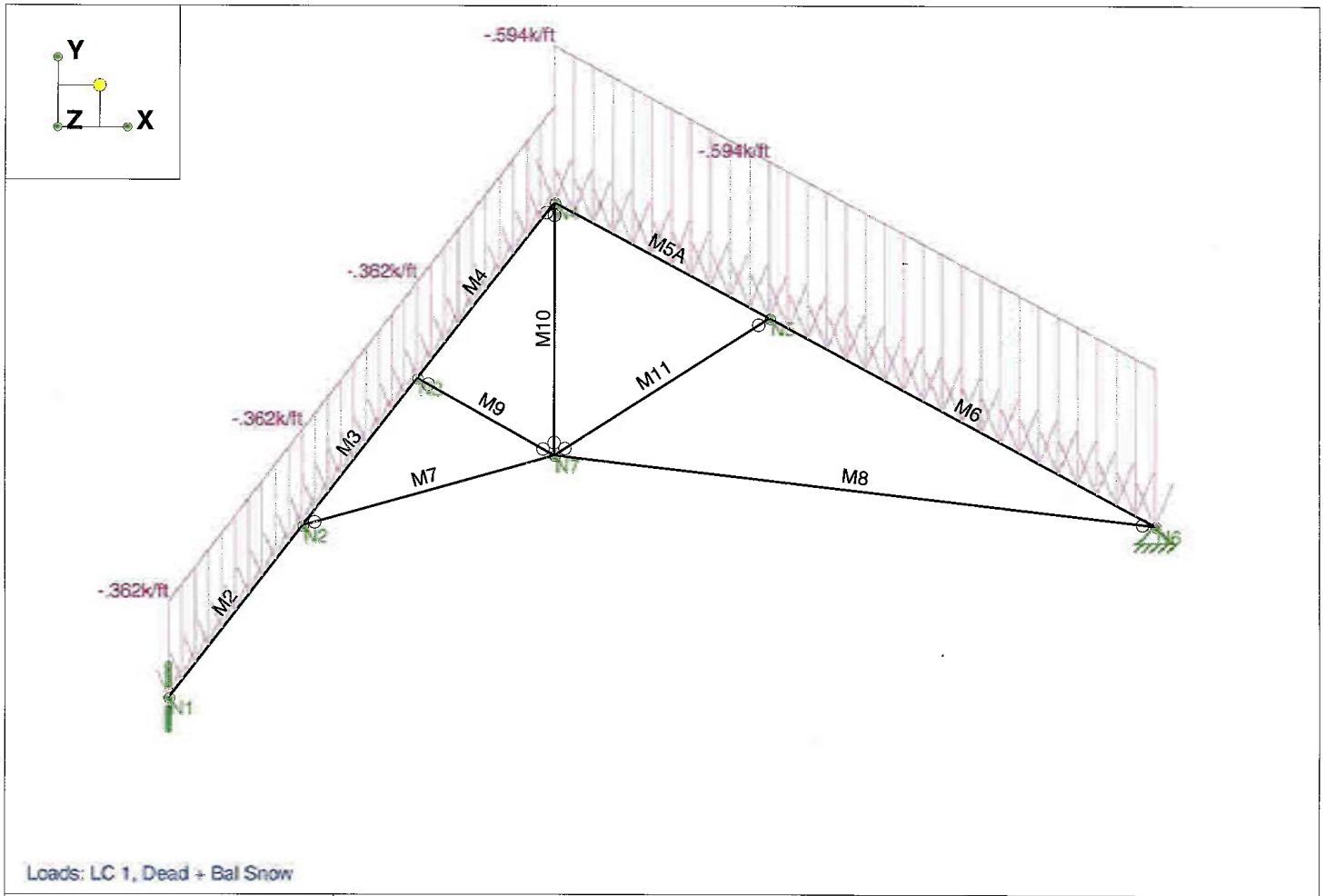
PM-B008



Loads: LC 1, Dead + Ball Snow

		Mar 17, 2009 at 7:26 AM
		truss.r2d

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PM-B009

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	1.9063	2.4479	0
3	N3	3.5417	4.5417	0
4	N4	5.5	7.0417	0
5	N5	8.5729	5.3958	0
6	N6	14.0625	2.4479	0
7	N7	5.5	3.4479	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N6	Reaction	Reaction		
2	N1		Reaction		

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	Dead Load	DL		-1			5
2	Snow Load Bal	SL					5
3	Snow Load Unbal Right	SL					2
4	Snow Load Unbal Left	SL					3

Load Combinations

	Description	Sol...	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	Dead + Bal Snow	Yes			1	1	2	1												
2	Dead + Unbal Right	Yes			1	1	3	1												
3	Dead + Unbal Left	Yes			1	1	4	1												
4	Dead Only				1	1														

Member Distributed Loads (BLC 1 : Dead Load)

	Member Label	Direction	Start Magnitude[k/ft,d...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.263	-.263	0	0
2	M3	Y	-.263	-.263	0	0
3	M4	Y	-.263	-.263	0	0
4	M5A	Y	-.263	-.263	0	0
5	M6	Y	-.263	-.263	0	0

Member Distributed Loads (BLC 2 : Snow Load Bal)

	Member Label	Direction	Start Magnitude[k/ft,d...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M2	V	-.161	-.161	0	0
2	M3	V	-.161	-.161	0	0
3	M4	V	-.161	-.161	0	0
4	M5A	V	-.376	-.376	0	0
5	M6	V	-.376	-.376	0	0

Member Distributed Loads (BLC 3 : Snow Load Unbal Right)

	Member Label	Direction	Start Magnitude[k/ft,d...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M5A	V	-.533	-.533	0	0
2	M6	V	-.533	-.533	0	0

Member Distributed Loads (BLC 4 : Snow Load Unbal Left)

Member Label	Direction	Start Magnitude[k/ft,d...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]

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Structural Calculations

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PM-B010

Member Distributed Loads (BLC 4 : Snow Load Unbal Left) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,d...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M2	V	-.533	-.533	0	0
2	M3	V	-.533	-.533	0	0
3	M4	V	-.533	-.533	0	0

Joint Loads and Enforced Displacements

Joint Label	L,D,M	Direction	Magnitude[k,k-ft in,rad k*s^2/ft]
No Data to Print ...			

Member Point Loads

Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
No Data to Print ...			

Wood Design Parameters

	Label	Shape	Length[ft]	Le-out[ft]	Le-in[ft]	le-bend to...	le-bend bo...	K-out	K-in	CV	Cr	Out sway	In sway
1	M2	Truss Chord	3.103	1		1							
2	M3	Truss Chord	2.657	1		1							
3	M4	Truss Chord	3.176	1		1							
4	M5A	Truss Chord	3.486	1		1							
5	M6	Truss Chord	6.231	1		1							

Hot Rolled Steel Design Parameters

	Label	Shape	Length[...	Lb-out[ft]	Lb-in[ft]	Lcomp top...	Lcomp bot...	K-out	K-in	Cm	Cb	Out s...	In sway	Functi...
1	M7	Web Mem...	3.73											Lateral
2	M8	Web Mem...	8.621											Lateral
3	M9	Web Mem...	2.243											Lateral
4	M10	Web Mem...	3.594											Lateral
5	M11	Web Mem...	3.638											Lateral

Wood Material Properties

	Label	Species	Grade	Cm	Emod	Nu	Therm (\1E...	Dens[k/ft^3]
1	Hem Fir	Hem-Fir	No.2		1	.3	.3	.035
2	So Pine	Southern Pine	No.2		1	.3	.3	.035
3	LVL	1.9E Lvl	na		1	.3	.3	.035
4	PSL	2.0E PSL	na		1	.3	.3	.035

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A500 Gr.46	29000	11154	.3	.65	.49	46

Wood Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	Truss Chord	2-1.75X11.87...	Beam	Rectangular	LVL	Typical	41.563	42.428	488.413
2	PSL Chord	2-1.75X11.87...	Beam	Rectangular	PSL	Typical	41.563	42.428	488.413

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UNIVERSITY OF MINNESOTA

Structural Calculations

COMMENTS

REV DATE 03/26/09

AUTHORED BY Dave MacDonald, P.E.

PM-B011

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	Web Member	TU2X2X3	Column	Tube	A500 Gr.46	Typical	1.27	.668	.668

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M2	N1	N2		Truss Chord	Beam	Rectangular	LVL	Typical
2	M3	N2	N3		Truss Chord	Beam	Rectangular	LVL	Typical
3	M4	N3	N4		Truss Chord	Beam	Rectangular	LVL	Typical
4	M5A	N4	N5		Truss Chord	Beam	Rectangular	LVL	Typical
5	M6	N5	N6		Truss Chord	Beam	Rectangular	LVL	Typical
6	M7	N2	N7		Web Member	Column	Tube	A500 Gr.46	Typical
7	M8	N7	N6		Web Member	Column	Tube	A500 Gr.46	Typical
8	M9	N3	N7		Web Member	Column	Tube	A500 Gr.46	Typical
9	M10	N4	N7		Web Member	Column	Tube	A500 Gr.46	Typical
10	M11	N5	N7		Web Member	Column	Tube	A500 Gr.46	Typical

Member Advanced Data

	Label	I Release	J Release	I Offset[in]	J Offset[in]	T/C Only	Physical	TOM	Inactive
1	M2						Yes		
2	M3						Yes		
3	M4		PIN				Yes		
4	M5A						Yes		
5	M6						Yes		
6	M7	PIN					Yes		
7	M8		PIN				Yes		
8	M9	PIN	PIN				Yes		
9	M10	PIN	PIN				Yes		
10	M11	PIN	PIN				Yes		

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N6	0	4.782	0
2	1	N1	0	4.511	0
3	1	Totals:	0	9.293	
4	1	COG (ft):	X: 7.237	Y: 4.298	
5	2	N6	0	5.544	0
6	2	N1	0	4.208	0
7	2	Totals:	0	9.752	
8	2	COG (ft):	X: 7.995	Y: 4.43	
9	3	N6	0	2.943	0
10	3	N1	0	5.177	0
11	3	Totals:	0	8.12	
12	3	COG (ft):	X: 5.097	Y: 3.925	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	-.141	0	-3.889e-3
2	1	N2	-.044	-.077	-1.996e-3
3	1	N3	-.027	-.094	-5.741e-5
4	1	N4	-.037	-.09	-1.614e-4
5	1	N5	-.039	-.088	2.756e-4
6	1	N6	0	0	2.201e-3

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Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
7	1	N7	-.03	-.096	-2.605e-4
8	2	N1	-.143	0	-3.816e-3
9	2	N2	-.047	-.076	-2.015e-3
10	2	N3	-.029	-.095	-1.291e-4
11	2	N4	-.037	-.092	-2.767e-4
12	2	N5	-.041	-.093	1.961e-4
13	2	N6	0	0	2.447e-3
14	2	N7	-.033	-.099	-3.057e-4
15	3	N1	-.134	0	-4.02e-3
16	3	N2	-.035	-.079	-1.93e-3
17	3	N3	-.022	-.093	1.116e-4
18	3	N4	-.037	-.085	1.113e-4
19	3	N5	-.034	-.075	4.597e-4
20	3	N6	0	0	1.599e-3
21	3	N7	-.024	-.09	-1.537e-4

Member Section Deflections

	LC	Member Label	Sec	x [in]	y [in]	(n) L/y Ratio
1	1	M2	1	-.087	.111	299.668
2			2	-.087	.074	425.186
3			3	-.087	.04	699.752
4			4	-.088	.01	1594.917
5			5	-.088	-.013	NC
6	1	M3	1	-.088	-.013	NC
7			2	-.089	-.026	4960.636
8			3	-.09	-.033	4097.745
9			4	-.09	-.036	6104.38
10			5	-.091	-.037	NC
11	1	M4	1	-.091	-.037	NC
12			2	-.092	-.036	NC
13			3	-.093	-.034	NC
14			4	-.093	-.03	NC
15			5	-.094	-.026	NC
16	1	M5A	1	.01	-.097	NC
17			2	.009	-.099	NC
18			3	.008	-.099	NC
19			4	.008	-.098	NC
20			5	.007	-.096	NC
21	1	M6	1	.007	-.096	NC
22			2	.005	-.088	4677.34
23			3	.004	-.07	3416.767
24			4	.002	-.039	4861.573
25			5	0	0	NC
26	1	M7	1	-.063	-.063	NC
27			2	-.061	-.07	NC
28			3	-.059	-.076	NC
29			4	-.057	-.081	NC
30			5	-.055	-.085	NC
31	1	M8	1	-.019	-.099	NC
32			2	-.014	-.1	4004.2
33			3	-.009	-.084	2986.456
34			4	-.005	-.049	4299.827
35			5	0	0	NC
36	1	M9	1	.022	-.096	NC
37			2	.022	-.096	NC
38			3	.022	-.097	NC

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Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	(n) L/y Ratio
39			4	.021	-.098	NC
40			5	.021	-.099	NC
41	1	M10	1	.09	-.037	NC
42			2	.092	-.036	NC
43			3	.093	-.034	NC
44			4	.095	-.032	NC
45			5	.096	-.03	NC
46	1	M11	1	.08	.053	NC
47			2	.079	.057	NC
48			3	.079	.06	NC
49			4	.078	.063	NC
50			5	.077	.065	NC
51	2	M2	1	-.088	.113	303.466
52			2	-.088	.077	429.448
53			3	-.089	.043	704.005
54			4	-.089	.014	1595.727
55			5	-.089	-.01	NC
56	2	M3	1	-.089	-.01	NC
57			2	-.09	-.023	5123.821
58			3	-.091	-.03	4218.922
59			4	-.092	-.034	6254.045
60			5	-.092	-.036	NC
61	2	M4	1	-.092	-.036	NC
62			2	-.093	-.036	NC
63			3	-.094	-.034	NC
64			4	-.095	-.031	NC
65			5	-.096	-.027	NC
66	2	M5A	1	.011	-.099	NC
67			2	.01	-.102	NC
68			3	.009	-.103	NC
69			4	.009	-.103	NC
70			5	.008	-.102	NC
71	2	M6	1	.008	-.102	NC
72			2	.006	-.095	3997.211
73			3	.004	-.077	2895.939
74			4	.002	-.044	4101.641
75			5	0	0	NC
76	2	M7	1	-.066	-.061	NC
77			2	-.064	-.069	NC
78			3	-.062	-.076	NC
79			4	-.06	-.082	NC
80			5	-.058	-.086	NC
81	2	M8	1	-.021	-.102	NC
82			2	-.016	-.103	3827.565
83			3	-.011	-.087	2873.428
84			4	-.005	-.05	4152.831
85			5	0	0	NC
86	2	M9	1	.021	-.097	NC
87			2	.021	-.098	NC
88			3	.02	-.1	NC
89			4	.02	-.101	NC
90			5	.02	-.102	NC
91	2	M10	1	.092	-.037	NC
92			2	.094	-.036	NC
93			3	.095	-.035	NC
94			4	.097	-.034	NC
95			5	.099	-.033	NC

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Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	(n) L/y Ratio
96	2	M11	1	.085	.057	NC
97			2	.084	.06	NC
98			3	.082	.062	NC
99			4	.081	.064	NC
100			5	.08	.066	NC
101	3	M2	1	-.082	.106	294.038
102			2	-.083	.068	419.702
103			3	-.083	.033	697.008
104			4	-.084	.002	1609.5
105			5	-.084	-.021	NC
106	3	M3	1	-.084	-.021	NC
107			2	-.085	-.032	4659.733
108			3	-.085	-.038	3875.919
109			4	-.086	-.04	5836.05
110			5	-.087	-.039	NC
111	3	M4	1	-.087	-.04	NC
112			2	-.088	-.037	NC
113			3	-.088	-.034	NC
114			4	-.089	-.029	NC
115			5	-.09	-.023	NC
116	3	M5A	1	.007	-.092	NC
117			2	.007	-.091	NC
118			3	.006	-.089	NC
119			4	.005	-.086	NC
120			5	.005	-.082	NC
121	3	M6	1	.005	-.082	NC
122			2	.004	-.071	7929.002
123			3	.002	-.053	6024.885
124			4	.001	-.029	8769.826
125			5	0	0	NC
126	3	M7	1	-.055	-.067	NC
127			2	-.053	-.071	NC
128			3	-.051	-.075	NC
129			4	-.049	-.078	NC
130			5	-.047	-.08	NC
131	3	M8	1	-.013	-.092	NC
132			2	-.01	-.092	4525.575
133			3	-.006	-.077	3311.658
134			4	-.003	-.045	4716.613
135			5	0	0	NC
136	3	M9	1	.026	-.092	NC
137			2	.025	-.092	NC
138			3	.024	-.091	NC
139			4	.024	-.091	NC
140			5	.023	-.09	NC
141	3	M10	1	.085	-.037	NC
142			2	.086	-.034	NC
143			3	.087	-.03	NC
144			4	.089	-.027	NC
145			5	.09	-.024	NC
146	3	M11	1	.069	.045	NC
147			2	.069	.05	NC
148			3	.069	.055	NC
149			4	.068	.059	NC
150			5	.068	.063	NC

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Member Section Forces

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	1	M2	1	3.559	2.772	0
2			2	3.331	2.594	-2.081
3			3	3.104	2.417	-4.024
4			4	2.876	2.24	-5.83
5			5	2.648	2.062	-7.499
6	1	M3	1	7.996	-1.903	-7.499
7			2	7.801	-2.055	-6.185
8			3	7.607	-2.207	-4.769
9			4	7.412	-2.359	-3.253
10			5	7.217	-2.511	-1.635
11	1	M4	1	6.849	-.15	-1.635
12			2	6.616	-.333	-1.444
13			3	6.383	-.515	-1.107
14			4	6.15	-.697	-.626
15			5	5.918	-.88	0
16	1	M5A	1	4.345	1.083	0
17			2	4.594	.618	-.741
18			3	4.843	.154	-1.078
19			4	5.091	-.311	-1.009
20			5	5.34	-.775	-.536
21	1	M6	1	6.668	1.573	-.536
22			2	7.113	.743	-2.34
23			3	7.559	-.086	-2.852
24			4	8.004	-.915	-2.072
25			5	8.45	-1.745	0
26	1	M7	1	-6.662	.012	0
27			2	-6.663	.008	-.01
28			3	-6.664	.005	-.016
29			4	-6.665	0	-.018
30			5	-6.666	-.003	-.017
31	1	M8	1	-6.666	.017	-.017
32			2	-6.664	.007	-.043
33			3	-6.663	-.002	-.048
34			4	-6.662	-.011	-.034
35			5	-6.661	-.02	0
36	1	M9	1	2.38	.004	0
37			2	2.381	.002	-.002
38			3	2.382	0	-.002
39			4	2.384	-.002	-.002
40			5	2.385	-.004	0
41	1	M10	1	-5.213	0	0
42			2	-5.209	0	0
43			3	-5.206	0	0
44			4	-5.202	0	0
45			5	-5.198	0	0
46	1	M11	1	2.692	-.007	0
47			2	2.694	-.003	.005
48			3	2.696	0	.006
49			4	2.698	.003	.005
50			5	2.7	.007	0
51	2	M2	1	3.32	2.585	0
52			2	3.153	2.455	-1.955
53			3	2.986	2.325	-3.809
54			4	2.818	2.195	-5.562
55			5	2.651	2.065	-7.214
56	2	M3	1	7.913	-1.838	-7.214

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Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
57			2	7.77	-1.949	-5.956
58			3	7.627	-2.061	-4.624
59			4	7.484	-2.173	-3.218
60			5	7.341	-2.284	-1.738
61	2	M4	1	7.028	-.28	-1.738
62			2	6.858	-.414	-1.463
63			3	6.687	-.547	-1.081
64			4	6.516	-.681	-.594
65			5	6.345	-.815	0
66	2	M5A	1	4.49	1.262	0
67			2	4.796	.692	-.852
68			3	5.102	.121	-1.206
69			4	5.407	-.45	-1.062
70			5	5.713	-1.021	-.422
71	2	M6	1	7.404	1.971	-.422
72			2	7.951	.952	-2.698
73			3	8.498	-.068	-3.386
74			4	9.046	-1.087	-2.487
75			5	9.593	-2.106	0
76	2	M7	1	-6.555	.013	0
77			2	-6.557	.009	-.011
78			3	-6.558	.005	-.017
79			4	-6.559	.002	-.021
80			5	-6.56	-.002	-.02
81	2	M8	1	-7.508	.016	-.02
82			2	-7.506	.007	-.045
83			3	-7.505	-.002	-.05
84			4	-7.504	-.012	-.035
85			5	-7.503	-.021	0
86	2	M9	1	2.019	.004	0
87			2	2.02	.002	-.002
88			3	2.021	0	-.002
89			4	2.022	-.002	-.002
90			5	2.024	-.004	0
91	2	M10	1	-5.5	0	0
92			2	-5.496	0	0
93			3	-5.492	0	0
94			4	-5.489	0	0
95			5	-5.485	0	0
96	2	M11	1	3.43	-.007	0
97			2	3.432	-.003	.005
98			3	3.434	0	.006
99			4	3.436	.003	.005
100			5	3.439	.007	0
101	3	M2	1	4.084	3.181	0
102			2	3.717	2.894	-2.356
103			3	3.349	2.608	-4.49
104			4	2.982	2.322	-6.402
105			5	2.614	2.036	-8.092
106	3	M3	1	8.11	-2.036	-8.092
107			2	7.795	-2.282	-6.658
108			3	7.481	-2.527	-5.061
109			4	7.166	-2.773	-3.301
110			5	6.851	-3.019	-1.377
111	3	M4	1	6.356	.156	-1.377
112			2	5.98	-.139	-1.384
113			3	5.604	-.434	-1.156

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Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
114			4	5.228	-.728	-.695
115			5	4.852	-1.023	0
116	3	M5A	1	3.96	.649	0
117			2	4.072	.439	-.474
118			3	4.184	.23	-.766
119			4	4.297	.02	-.875
120			5	4.409	-.19	-.8
121	3	M6	1	4.871	.621	-.8
122			2	5.073	.246	-1.476
123			3	5.274	-.128	-1.568
124			4	5.475	-.503	-1.076
125			5	5.676	-.878	0
126	3	M7	1	-6.844	.01	0
127			2	-6.845	.006	-.008
128			3	-6.847	.002	-.012
129			4	-6.848	-.001	-.012
130			5	-6.849	-.005	-.009
131	3	M8	1	-4.619	.017	-.009
132			2	-4.618	.008	-.037
133			3	-4.617	-.001	-.044
134			4	-4.615	-.01	-.032
135			5	-4.614	-.02	0
136	3	M9	1	3.204	.004	0
137			2	3.205	.002	-.002
138			3	3.207	0	-.002
139			4	3.208	-.002	-.002
140			5	3.209	-.004	0
141	3	M10	1	-4.486	0	0
142			2	-4.482	0	0
143			3	-4.478	0	0
144			4	-4.474	0	0
145			5	-4.47	0	0
146	3	M11	1	.929	-.007	0
147			2	.931	-.003	.005
148			3	.934	0	.006
149			4	.936	.003	.005
150			5	.938	.007	0

Member Section Stresses

	LC	Member Label	Sec	Axial[ksi]	Shear[ksi]	Top Bending[ksi]	Bot Bending[ksi]
1	1	M2	1	.086	.1	0	0
2			2	.08	.094	.304	-.304
3			3	.075	.087	.587	-.587
4			4	.069	.081	.851	-.851
5			5	.064	.074	1.094	-1.094
6	1	M3	1	.192	-.069	1.094	-1.094
7			2	.188	-.074	.902	-.902
8			3	.183	-.08	.696	-.696
9			4	.178	-.085	.475	-.475
10			5	.174	-.091	.239	-.239
11	1	M4	1	.165	-.005	.239	-.239
12			2	.159	-.012	.211	-.211
13			3	.154	-.019	.162	-.162
14			4	.148	-.025	.091	-.091
15			5	.142	-.032	0	0
16	1	M5A	1	.105	.039	0	0

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Member Section Stresses (Continued)

	LC	Member Label	Sec	Axial[ksi]	Shear[ksi]	Top Bending[ksi]	Bot Bending[ksi]
17			2	.111	.022	.108	-.108
18			3	.117	.006	.157	-.157
19			4	.123	-.011	.147	-.147
20			5	.128	-.028	.078	-.078
21	1	M6	1	.16	.057	.078	-.078
22			2	.171	.027	.341	-.341
23			3	.182	-.003	.416	-.416
24			4	.193	-.033	.302	-.302
25			5	.203	-.063	0	0
26	1	M7	1	-5.246	.016	0	0
27			2	-5.247	.011	.175	-.175
28			3	-5.247	.006	.284	-.284
29			4	-5.248	0	.329	-.329
30			5	-5.249	-.004	.308	-.308
31	1	M8	1	-5.248	.022	.308	-.308
32			2	-5.248	.01	.768	-.768
33			3	-5.247	-.003	.87	-.87
34			4	-5.246	-.015	.614	-.614
35			5	-5.245	-.027	0	0
36	1	M9	1	1.874	.006	0	0
37			2	1.875	.003	.032	-.032
38			3	1.876	0	.043	-.043
39			4	1.877	-.003	.032	-.032
40			5	1.878	-.006	0	0
41	1	M10	1	-4.105	0	0	0
42			2	-4.102	0	0	0
43			3	-4.099	0	0	0
44			4	-4.096	0	0	0
45			5	-4.093	0	0	0
46	1	M11	1	2.12	-.009	0	0
47			2	2.121	-.004	-.081	.081
48			3	2.123	0	-.108	.108
49			4	2.125	.004	-.081	.081
50			5	2.126	.009	0	0
51	2	M2	1	.08	.093	0	0
52			2	.076	.089	.285	-.285
53			3	.072	.084	.556	-.556
54			4	.068	.079	.811	-.811
55			5	.064	.075	1.052	-1.052
56	2	M3	1	.19	-.066	1.052	-1.052
57			2	.187	-.07	.869	-.869
58			3	.184	-.074	.675	-.675
59			4	.18	-.078	.469	-.469
60			5	.177	-.082	.254	-.254
61	2	M4	1	.169	-.01	.254	-.254
62			2	.165	-.015	.213	-.213
63			3	.161	-.02	.158	-.158
64			4	.157	-.025	.087	-.087
65			5	.153	-.029	0	0
66	2	M5A	1	.108	.046	0	0
67			2	.115	.025	.124	-.124
68			3	.123	.004	.176	-.176
69			4	.13	-.016	.155	-.155
70			5	.137	-.037	.062	-.062
71	2	M6	1	.178	.071	.062	-.062
72			2	.191	.034	.394	-.394
73			3	.204	-.002	.494	-.494

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Member Section Stresses (Continued)

	LC	Member Label	Sec	Axial[ksi]	Shear[ksi]	Top Bending[ksi]	Bot Bending[ksi]
74			4	.218	-.039	.363	-.363
75			5	.231	-.076	0	0
76	2	M7	1	-5.162	.018	0	0
77			2	-5.163	.012	.189	-.189
78			3	-5.163	.007	.314	-.314
79			4	-5.164	.002	.373	-.373
80			5	-5.165	-.003	.367	-.367
81	2	M8	1	-5.911	.022	.367	-.367
82			2	-5.911	.009	.813	-.813
83			3	-5.91	-.003	.9	-.9
84			4	-5.909	-.015	.629	-.629
85			5	-5.908	-.028	0	0
86	2	M9	1	1.59	.006	0	0
87			2	1.591	.003	.032	-.032
88			3	1.592	0	.043	-.043
89			4	1.592	-.003	.032	-.032
90			5	1.593	-.006	0	0
91	2	M10	1	-4.331	0	0	0
92			2	-4.328	0	0	0
93			3	-4.325	0	0	0
94			4	-4.322	0	0	0
95			5	-4.319	0	0	0
96	2	M11	1	2.701	-.009	0	0
97			2	2.703	-.004	-.081	.081
98			3	2.704	0	-.108	.108
99			4	2.706	.004	-.081	.081
100			5	2.708	.009	0	0
101	3	M2	1	.098	.115	0	0
102			2	.089	.104	.344	-.344
103			3	.081	.094	.655	-.655
104			4	.072	.084	.934	-.934
105			5	.063	.073	1.18	-1.18
106	3	M3	1	.195	-.073	1.18	-1.18
107			2	.188	-.082	.971	-.971
108			3	.18	-.091	.738	-.738
109			4	.172	-.1	.481	-.481
110			5	.165	-.109	.201	-.201
111	3	M4	1	.153	.006	.201	-.201
112			2	.144	-.005	.202	-.202
113			3	.135	-.016	.169	-.169
114			4	.126	-.026	.101	-.101
115			5	.117	-.037	0	0
116	3	M5A	1	.095	.023	0	0
117			2	.098	.016	.069	-.069
118			3	.101	.008	.112	-.112
119			4	.103	0	.128	-.128
120			5	.106	-.007	.117	-.117
121	3	M6	1	.117	.022	.117	-.117
122			2	.122	.009	.215	-.215
123			3	.127	-.005	.229	-.229
124			4	.132	-.018	.157	-.157
125			5	.137	-.032	0	0
126	3	M7	1	-5.389	.014	0	0
127			2	-5.39	.008	.138	-.138
128			3	-5.391	.003	.21	-.21
129			4	-5.392	-.002	.218	-.218
130			5	-5.393	-.007	.161	-.161

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Member Section Stresses (Continued)

	LC	Member Label	Sec	Axial[ksi]	Shear[ksi]	Top Bending[ksi]	Bot Bending[ksi]
131	3	M8	1	-3.637	.023	.161	-.161
132			2	-3.636	.011	.658	-.658
133			3	-3.635	-.001	.797	-.797
134			4	-3.634	-.014	.577	-.577
135			5	-3.633	-.026	0	0
136	3	M9	1	2.523	.006	0	0
137			2	2.524	.003	.032	-.032
138			3	2.525	0	.043	-.043
139			4	2.526	-.003	.032	-.032
140			5	2.527	-.006	0	0
141	3	M10	1	-3.532	0	0	0
142			2	-3.529	0	0	0
143			3	-3.526	0	0	0
144			4	-3.523	0	0	0
145			5	-3.52	0	0	0
146	3	M11	1	.732	-.009	0	0
147			2	.733	-.004	-.081	.081
148			3	.735	0	-.108	.108
149			4	.737	.004	-.081	.081
150			5	.738	.009	0	0

Member Wood Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear...	Loc[ft]	Fc'[ksi]	Ft'[ksi]	Fb'[ksi]	Fv'[ksi]	RB	CL	CP	Eqn
1	1	M2	2-1.75X11.8...	.422	3.103	.351	0	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
2	1	M3	2-1.75X11.8...	.428	0	.318	2.657	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
3	1	M4	2-1.75X11.8...	.096	0	.111	3.176	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
4	1	M5A	2-1.75X11.8...	.064	2.033	.137	0	2.496	1.55	2.6	.285	3.411	1	.994	3.9-3
5	1	M6	2-1.75X11.8...	.168	2.986	.221	6.231	2.459	1.55	2.6	.285	3.411	1	.98	3.9-3
6	2	M2	2-1.75X11.8...	.406	3.103	.327	0	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
7	2	M3	2-1.75X11.8...	.412	0	.289	2.657	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
8	2	M4	2-1.75X11.8...	.102	0	.103	3.176	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
9	2	M5A	2-1.75X11.8...	.071	1.925	.160	0	2.496	1.55	2.6	.285	3.411	1	.994	3.9-3
10	2	M6	2-1.75X11.8...	.200	3.051	.267	6.231	2.459	1.55	2.6	.285	3.411	1	.98	3.9-3
11	3	M2	2-1.75X11.8...	.455	3.103	.403	0	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
12	3	M3	2-1.75X11.8...	.461	0	.382	2.657	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
13	3	M4	2-1.75X11.8...	.083	.397	.130	3.176	2.496	1.55	2.6	.285	3.411	1	.995	3.9-3
14	3	M5A	2-1.75X11.8...	.051	2.687	.082	0	2.496	1.55	2.6	.285	3.411	1	.994	3.9-3
15	3	M6	2-1.75X11.8...	.093	2.596	.111	6.231	2.459	1.55	2.6	.285	3.411	1	.98	3.9-3

Member AISC ASD Steel Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear ...	Loc[ft]	Fa[ksi]	Ft[ksi]	Fb[ksi]	Cb	Cm	Eqn
1	1	M7	TU2X2X3	.201	2.992	.001	0	21.025	27.6	30.36	1	1	H2-1
2	1	M8	TU2X2X3	.222	3.861	.001	8.621	7.34	27.6	27.6	1	1	H2-1
3	1	M9	TU2X2X3	.079	1.145	.000	2.243	24.319	27.6	30.36	1	1	H1-3
4	1	M10	TU2X2X3	.149	0	.000	0	21.36	27.6	30.36	1.75	.6	H2-1
5	1	M11	TU2X2X3	.103	1.857	.000	3.638	21.251	27.6	30.36	1	1	H1-3
6	2	M7	TU2X2X3	.200	3.186	.001	0	21.025	27.6	30.36	1	1	H2-1
7	2	M8	TU2X2X3	.247	3.772	.002	8.621	7.34	27.6	27.6	1	1	H2-1
8	2	M9	TU2X2X3	.067	1.145	.000	2.243	24.319	27.6	30.36	1	1	H1-3
9	2	M10	TU2X2X3	.157	0	.000	0	21.36	27.6	30.36	1.75	.6	H2-1
10	2	M11	TU2X2X3	.131	1.857	.000	0	21.251	27.6	30.36	1	1	H1-3
11	3	M7	TU2X2X3	.203	2.448	.001	0	21.025	27.6	30.36	1	1	H2-1
12	3	M8	TU2X2X3	.161	4.041	.001	8.621	7.34	27.6	27.6	1	1	H2-1
13	3	M9	TU2X2X3	.105	1.145	.000	2.243	24.319	27.6	30.36	1	1	H1-3
14	3	M10	TU2X2X3	.128	0	.000	0	21.36	27.6	30.36	1.75	.6	H2-1

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Member AISC ASD Steel Code Checks (By Combination) (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear ...	Loc[ft]	Fa[ksi]	Ft[ksi]	Fb[ksi]	Cb	Cm	Eqn
15	3	M11	TU2X2X3	.038	1.857	.000	0	21.251	27.6	30.36	1	1	H1-3

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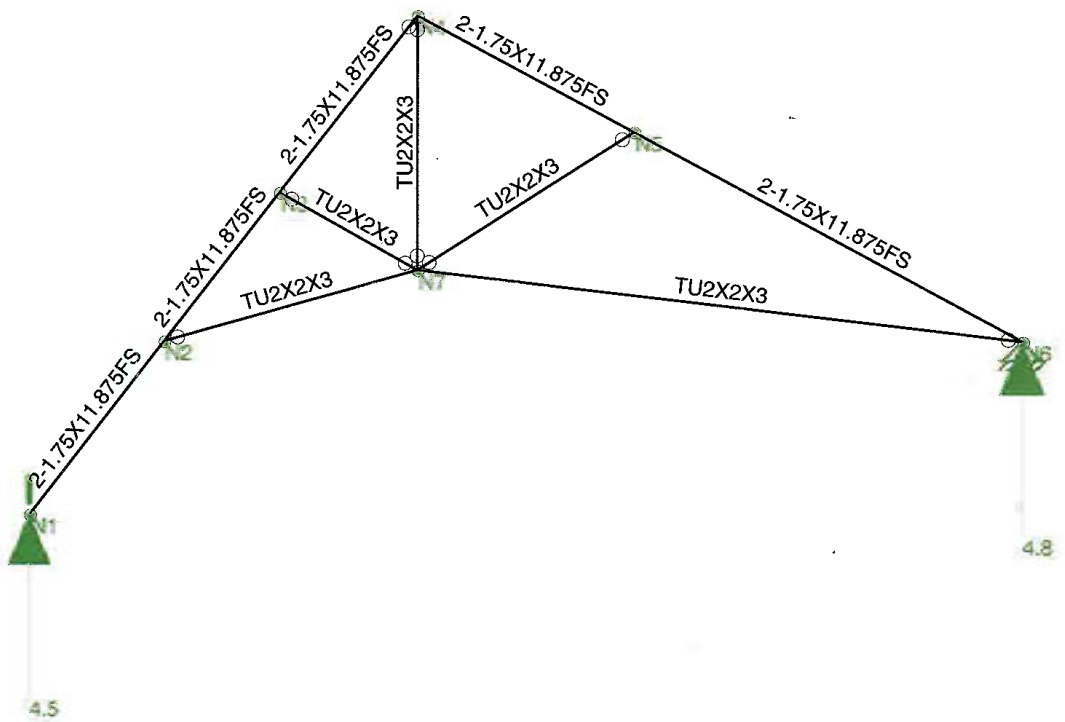

Results for LC 1, Dead + Bal Snow
Reaction units are k and k-ft

Mar 17, 2009 at 7:30 AM
truss.r2d

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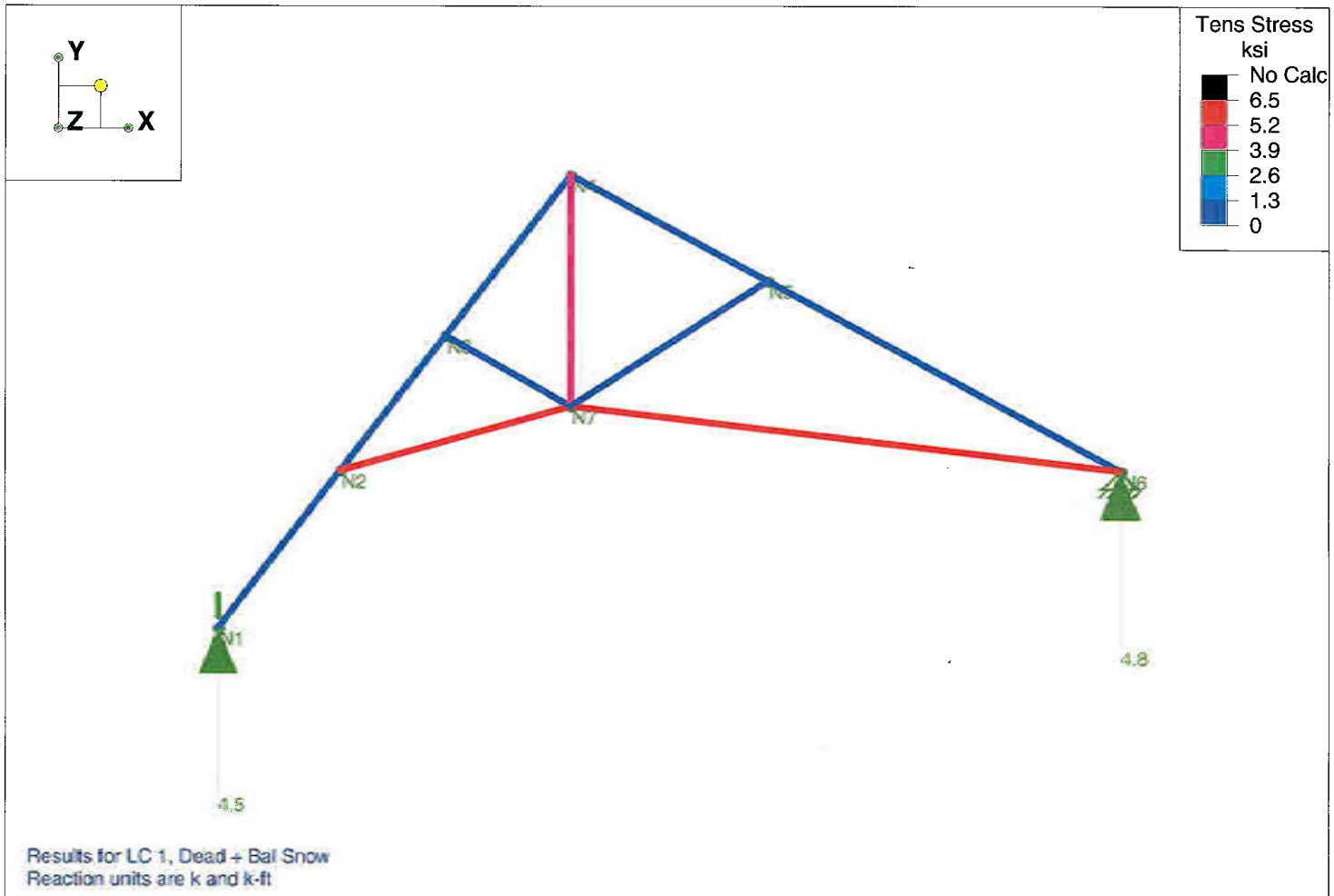

Results for LC 1, Dead + Bal Snow
Reaction units are k and k-ft

Mar 17, 2009 at 7:31 AM

truss.r2d

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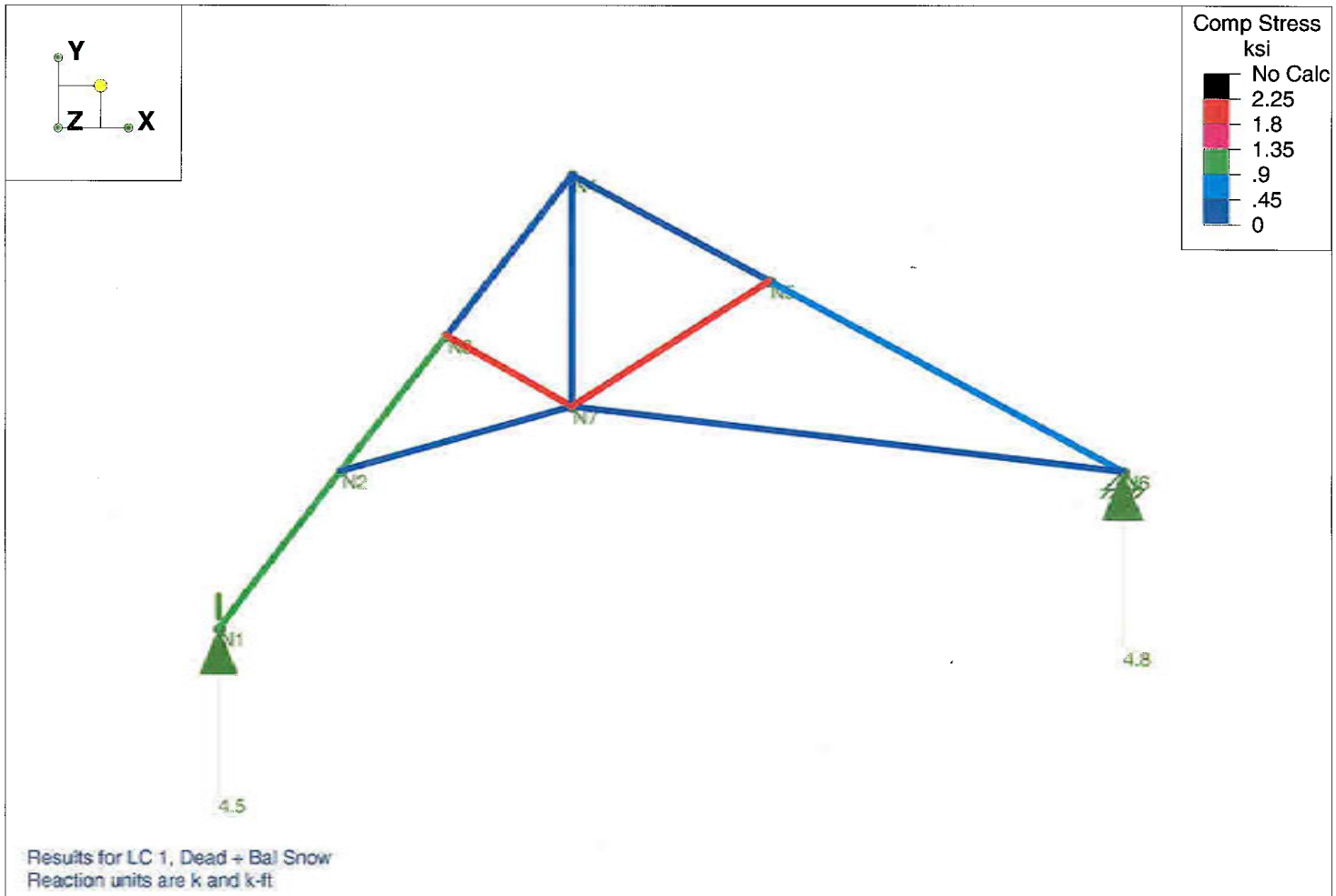

Results for LC 1, Dead + Bal Snow
Reaction units are k and k-ft

Mar 17, 2009 at 7:32 AM

truss.r2d

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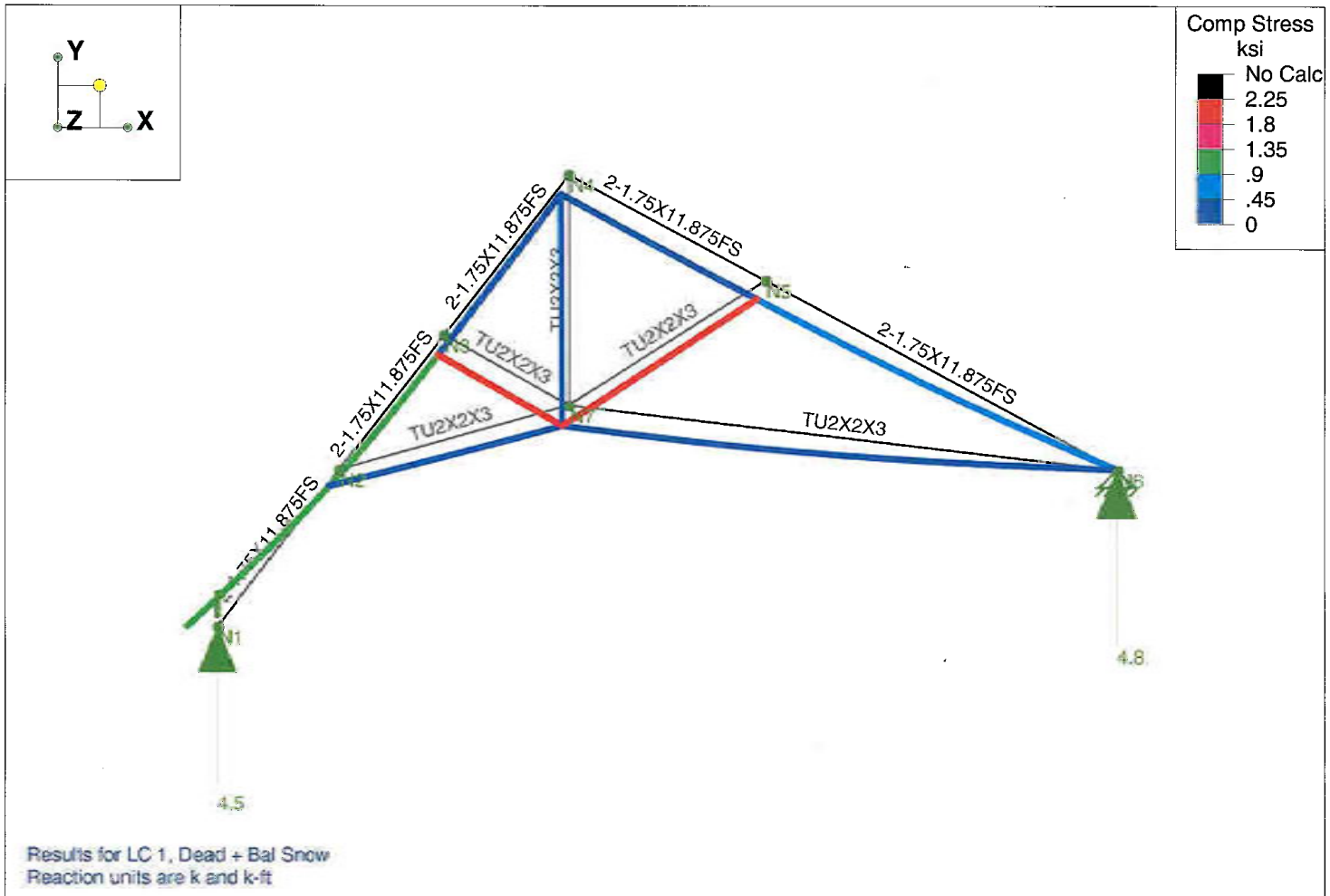

Mar 17, 2009 at 7:32 AM

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PM-B026

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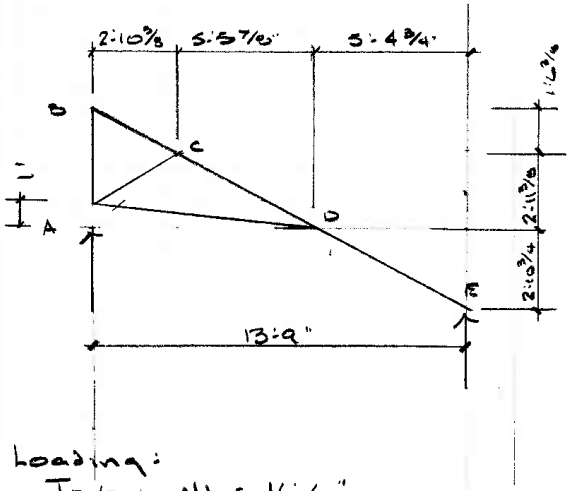
Date	SHT
Project	
By	

Roof Truss 2



Joint	Coordinates X	Y
A	0	3.8958
B	0	7.375
C	2.8646	5.8437
D	8.3542	2.8958
E	13.75	0

Top Chord:
2-1 3/4x11 7/16 LVL

Webs
2"x2"x 3/16" Tubes

Loading:
Trib width = 16'-6"

Dead Load

288 #/ft

Snow Bal

403 #/ft

Snow Unbal

575 #/ft

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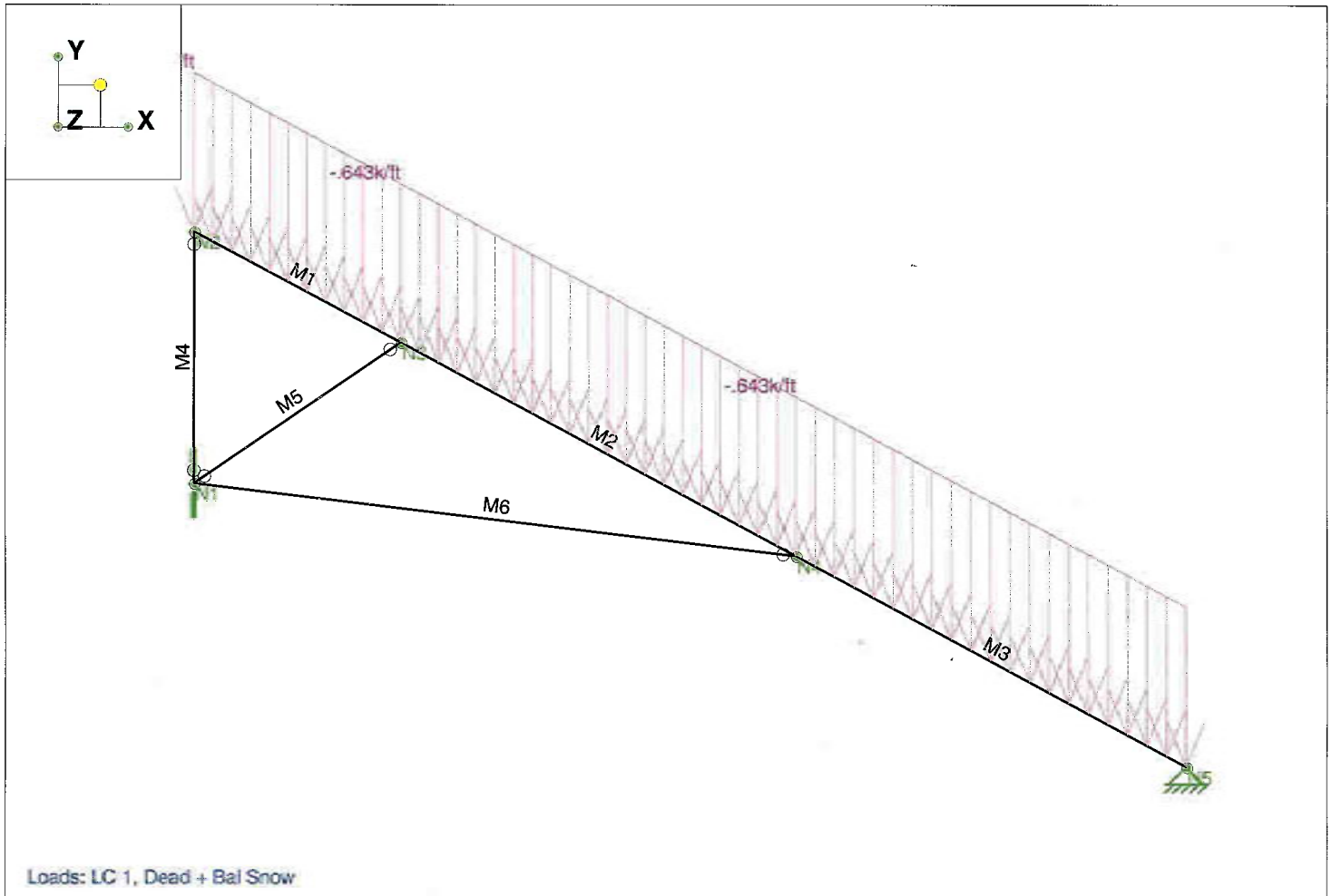

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Mono truss.r2d

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Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	3.8958	0
2	N2	0	7.375	0
3	N3	2.8646	5.8437	0
4	N4	8.3542	2.8958	0
5	N5	13.75	0	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1		Reaction		
2	N5	Reaction	Reaction		

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	Dead Load	DL		-1			3
2	Snow Load Bal	SL					3
3	Snow Load Unbal Right	SL					3

Load Combinations

	Description	Sol...	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	Dead + Bal Snow	Yes			1	1	2	1												
2	Dead + Unbal Right	Yes			1	1	3	1												
3	Dead Only				1	1														

Member Distributed Loads (BLC 1 : Dead Load)

	Member Label	Direction	Start Magnitude[k/ft,d...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	-.288	-.288	0	0
2	M2	Y	-.288	-.288	0	0
3	M3	Y	-.288	-.288	0	0

Member Distributed Loads (BLC 2 : Snow Load Bal)

	Member Label	Direction	Start Magnitude[k/ft,d...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M1	V	-.403	-.403	0	0
2	M2	V	-.403	-.403	0	0
3	M3	V	-.403	-.403	0	0

Member Distributed Loads (BLC 3 : Snow Load Unbal Right)

	Member Label	Direction	Start Magnitude[k/ft,d...	End Magnitude[k/ft,d...	Start Location[ft,%]	End Location[ft,%]
1	M1	V	-.575	-.575	0	0
2	M2	V	-.575	-.575	0	0
3	M3	V	-.575	-.575	0	0

Joint Loads and Enforced Displacements

Joint Label	L,D,M	Direction	Magnitude[k,k-ft in,rad k*s^2/ft]
No Data to Print ...			

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Member Point Loads

Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
No Data to Print ...			

Wood Design Parameters

	Label	Shape	Length[ft]	Le-out[ft]	Le-in[ft]	le-bend to...	le-bend bo...	K-out	K-in	CV	Cr	Out sway	In sway
1	M1	Truss Chord	3.248	1		1							
2	M2	Truss Chord	6.231	1		1							
3	M3	Truss Chord	6.124	1		1							

Hot Rolled Steel Design Parameters

	Label	Shape	Length[...	Lb-out[ft]	Lb-in[ft]	Lcomp top...	Lcomp bot...	K-out	K-in	Cm	Cb	Out s...	In sway	Functi...
1	M4	Web Mem...	3.479											Gravity
2	M5	Web Mem...	3.464											Gravity
3	M6	Web Mem...	8.414											Gravity

Wood Material Properties

	Label	Species	Grade	Cm	Emod	Nu	Therm (\1E...	Dens[k/ft^3]
1	Hem Fir	Hem-Fir	No.2		1	.3	.3	.035
2	So Pine	Southern Pine	No.2		1	.3	.3	.035
3	LVL	1.9E Lvl	na		1	.3	.3	.035
4	PSL	2.0E PSL	na		1	.3	.3	.035

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A500 Gr.46	29000	11154	.3	.65	.49	46

Wood Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	Truss Chord	2-1.75X11.87...	Beam	Rectangular	LVL	Typical	41.563	42.428	488.413
2	PSL Chord	2-1.75X11.87...	Beam	Rectangular	PSL	Typical	41.563	42.428	488.413

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	Web Member	TU2X2X3	Column	Tube	A500 Gr.46	Typical	1.27	.668	.668

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N2	N3		Truss Chord	Beam	Rectangular	LVL	Typical
2	M2	N3	N4		Truss Chord	Beam	Rectangular	LVL	Typical
3	M3	N4	N5		Truss Chord	Beam	Rectangular	LVL	Typical
4	M4	N1	N2		Web Member	Column	Tube	A500 Gr.46	Typical
5	M5	N1	N3		Web Member	Column	Tube	A500 Gr.46	Typical
6	M6	N1	N4		Web Member	Column	Tube	A500 Gr.46	Typical

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Member Advanced Data

	Label	I Release	J Release	I Offset[in]	J Offset[in]	T/C Only	Physical	TOM	Inactive
1	M1						Yes		
2	M2						Yes		
3	M3						Yes		
4	M4	PIN	PIN				Yes		
5	M5	PIN	PIN				Yes		
6	M6		PIN				Yes		

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	0	5.15	0
2	1	N5	0	5.109	0
3	1	Totals:	0	10.259	
4	1	COG (ft):	X: 6.848	Y: 3.693	
5	2	N1	0	6.332	0
6	2	N5	0	6.292	0
7	2	Totals:	0	12.624	
8	2	COG (ft):	X: 6.853	Y: 3.692	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	-.222	0	-5.647e-3
2	1	N2	.009	0	-5.605e-3
3	1	N3	-.098	-.199	-6.478e-3
4	1	N4	-.261	-.489	1.268e-3
5	1	N5	0	0	1.095e-2
6	2	N1	-.273	0	-6.77e-3
7	2	N2	.011	0	-6.901e-3
8	2	N3	-.121	-.245	-7.976e-3
9	2	N4	-.321	-.602	1.561e-3
10	2	N5	0	0	1.348e-2

Member Section Deflections

	LC	Member Label	Sec	x [in]	y [in]	(n) L/y Ratio
1	1	M1	1	.007	.005	NC
2			2	.007	-.05	719.268
3			3	.007	-.105	357.282
4			4	.007	-.161	235.013
5			5	.007	-.222	172.411
6	1	M2	1	.007	-.222	NC
7			2	.006	-.349	1674.235
8			3	.004	-.465	976.07
9			4	.003	-.54	1088.861
10			5	.002	-.554	NC
11	1	M3	1	.001	-.554	NC
12			2	.001	-.494	941.533
13			3	0	-.37	791.502
14			4	0	-.198	1230.004
15			5	0	0	NC
16	1	M4	1	0	.222	NC
17			2	0	.164	NC
18			3	0	.107	NC
19			4	0	.049	NC

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PM-B031

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	(n) L/y Ratio
20			5	0	-.009	NC
21	1	M5	1	-.183	.125	177.867
22			2	-.186	.066	237.734
23			3	-.188	.007	357.563
24			4	-.191	-.051	716.693
25			5	-.193	-.109	NC
26	1	M6	1	-.22	-.026	NC
27			2	-.215	-.167	5673.59
28			3	-.211	-.296	4042.433
29			4	-.206	-.412	5673.59
30			5	-.201	-.517	NC
31	2	M1	1	.009	.006	NC
32			2	.009	-.061	584.185
33			3	.009	-.129	290.183
34			4	.009	-.199	190.877
35			5	.008	-.273	140.032
36	2	M2	1	.009	-.273	NC
37			2	.007	-.43	1359.752
38			3	.005	-.572	792.741
39			4	.004	-.665	884.369
40			5	.002	-.682	NC
41	2	M3	1	.002	-.682	NC
42			2	.001	-.608	764.699
43			3	0	-.456	642.83
44			4	0	-.244	998.95
45			5	0	0	NC
46	2	M4	1	0	.273	NC
47			2	0	.202	NC
48			3	0	.131	NC
49			4	0	.06	NC
50			5	0	-.011	NC
51	2	M5	1	-.226	.154	144.465
52			2	-.229	.081	193
53			3	-.232	.009	290.135
54			4	-.235	-.063	581.3
55			5	-.238	-.134	NC
56	2	M6	1	-.271	-.032	NC
57			2	-.265	-.201	5673.59
58			3	-.259	-.359	4042.433
59			4	-.253	-.503	5673.59
60			5	-.247	-.636	NC

Member Section Forces

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	1	M1	1	.237	-.442	0
2			2	.487	-.91	.549
3			3	.737	-1.378	1.479
4			4	.987	-1.846	2.788
5			5	1.237	-2.315	4.478
6	1	M2	1	5.169	5.204	4.478
7			2	5.651	4.307	-2.93
8			3	6.132	3.411	-8.942
9			4	6.613	2.515	-13.558
10			5	7.095	1.618	-16.777
11	1	M3	1	.525	-.977	-16.777
12			2	.997	-1.858	-14.606

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Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
13			3	1.47	-2.74	-11.086
14			4	1.943	-3.621	-6.218
15			5	2.416	-4.502	0
16	1	M4	1	-.487	0	0
17			2	-.49	0	0
18			3	-.494	0	0
19			4	-.498	0	0
20			5	-.502	0	0
21	1	M5	1	8.489	.006	0
22			2	8.487	.003	-.004
23			3	8.485	0	-.005
24			4	8.482	-.003	-.004
25			5	8.48	-.006	0
26	1	M6	1	-7.068	.018	0
27			2	-7.067	.009	-.028
28			3	-7.066	0	-.038
29			4	-7.065	-.009	-.028
30			5	-7.064	-.018	0
31	2	M1	1	.291	-.544	0
32			2	.599	-1.121	.676
33			3	.907	-1.697	1.82
34			4	1.216	-2.274	3.433
35			5	1.524	-2.851	5.513
36	2	M2	1	6.365	6.408	5.513
37			2	6.958	5.304	-3.609
38			3	7.551	4.199	-11.01
39			4	8.144	3.095	-16.692
40			5	8.737	1.991	-20.653
41	2	M3	1	.645	-1.202	-20.653
42			2	1.227	-2.287	-17.983
43			3	1.81	-3.373	-13.65
44			4	2.393	-4.458	-7.656
45			5	2.975	-5.544	0
46	2	M4	1	-.602	0	0
47			2	-.606	0	0
48			3	-.609	0	0
49			4	-.613	0	0
50			5	-.617	0	0
51	2	M5	1	10.451	.006	0
52			2	10.449	.003	-.004
53			3	10.447	0	-.005
54			4	10.445	-.003	-.004
55			5	10.443	-.006	0
56	2	M6	1	-8.703	.018	0
57			2	-8.702	.009	-.028
58			3	-8.701	0	-.038
59			4	-8.7	-.009	-.028
60			5	-8.698	-.018	0

Member Section Stresses

	LC	Member Label	Sec	Axial[ksi]	Shear[ksi]	Top Bending[ksi]	Bot Bending[ksi]
1	1	M1	1	.006	-.016	0	0
2			2	.012	-.033	-.08	.08
3			3	.018	-.05	-.216	.216
4			4	.024	-.067	-.407	.407
5			5	.03	-.084	-.653	.653

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Member Section Stresses (Continued)

	LC	Member Label	Sec	Axial[ksi]	Shear[ksi]	Top Bending[ksi]	Bot Bending[ksi]
6	1	M2	1	.124	.188	-.653	.653
7			2	.136	.155	.427	-.427
8			3	.148	.123	1.304	-1.304
9			4	.159	.091	1.978	-1.978
10			5	.171	.058	2.447	-2.447
11	1	M3	1	.013	-.035	2.447	-2.447
12			2	.024	-.067	2.131	-2.131
13			3	.035	-.099	1.617	-1.617
14			4	.047	-.131	.907	-.907
15			5	.058	-.162	0	0
16	1	M4	1	-.383	0	0	0
17			2	-.386	0	0	0
18			3	-.389	0	0	0
19			4	-.392	0	0	0
20			5	-.395	0	0	0
21	1	M5	1	6.684	.008	0	0
22			2	6.682	.004	.072	-.072
23			3	6.681	0	.096	-.096
24			4	6.679	-.004	.072	-.072
25			5	6.677	-.008	0	0
26	1	M6	1	-5.566	.024	0	0
27			2	-5.565	.012	.512	-.512
28			3	-5.564	0	.682	-.682
29			4	-5.563	-.012	.512	-.512
30			5	-5.562	-.024	0	0
31	2	M1	1	.007	-.02	0	0
32			2	.014	-.04	-.099	.099
33			3	.022	-.061	-.266	.266
34			4	.029	-.082	-.501	.501
35			5	.037	-.103	-.804	.804
36	2	M2	1	.153	.231	-.804	.804
37			2	.167	.191	.526	-.526
38			3	.182	.152	1.606	-1.606
39			4	.196	.112	2.435	-2.435
40			5	.21	.072	3.013	-3.013
41	2	M3	1	.016	-.043	3.013	-3.013
42			2	.03	-.083	2.623	-2.623
43			3	.044	-.122	1.991	-1.991
44			4	.058	-.161	1.117	-1.117
45			5	.072	-.2	0	0
46	2	M4	1	-.474	0	0	0
47			2	-.477	0	0	0
48			3	-.48	0	0	0
49			4	-.483	0	0	0
50			5	-.486	0	0	0
51	2	M5	1	8.229	.008	0	0
52			2	8.228	.004	.072	-.072
53			3	8.226	0	.096	-.096
54			4	8.224	-.004	.072	-.072
55			5	8.223	-.008	0	0
56	2	M6	1	-6.853	.024	0	0
57			2	-6.852	.012	.512	-.512
58			3	-6.851	0	.682	-.682
59			4	-6.85	-.012	.512	-.512
60			5	-6.849	-.024	0	0

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Member Wood Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear...	Loc[ft]	Fc'[ksi]	Ft'[ksi]	Fb'[ksi]	Fv'[ksi]	RB	CL	CP	Eqn
1	1	M1	2-1.75X11.8...	.252	3.248	.293	3.248	2.496	1.55	2.6	.285	6.147	1	.995	3.9-3
2	1	M2	2-1.75X11.8...	.957	6.231	.659	0	2.459	1.55	2.6	.285	3.411	1	.98	3.9-3
3	1	M3	2-1.75X11.8...	.942	0	.570	6.124	2.461	1.55	2.6	.285	3.411	1	.981	3.9-3
4	2	M1	2-1.75X11.8...	.310	3.248	.361	3.248	2.496	1.55	2.6	.285	6.147	1	.995	3.9-3
5	2	M2	2-1.75X11.8...	1.183	6.231	.811	0	2.459	1.55	2.6	.285	3.411	1	.98	3.9-3
6	2	M3	2-1.75X11.8...	1.160	0	.702	6.124	2.461	1.55	2.6	.285	3.411	1	.981	3.9-3

Member AISC ASD Steel Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear ...	Loc[ft]	Fa[ksi]	Ft[ksi]	Fb[ksi]	Cb	Cm	Eqn
1	1	M4	TU2X2X3	.014	3.479	.000	0	21.636	27.6	30.36	1.75	.6	H2-1
2	1	M5	TU2X2X3	.312	1.696	.000	3.464	21.672	27.6	30.36	1	1	H1-1
3	1	M6	TU2X2X3	.226	4.207	.001	0	7.705	27.6	27.6	1	1	H2-1
4	2	M4	TU2X2X3	.018	3.479	.000	0	21.636	27.6	30.36	1.75	.6	H2-1
5	2	M5	TU2X2X3	.383	1.696	.000	3.464	21.672	27.6	30.36	1	1	H1-1
6	2	M6	TU2X2X3	.273	4.207	.001	8.414	7.705	27.6	27.6	1	1	H2-1

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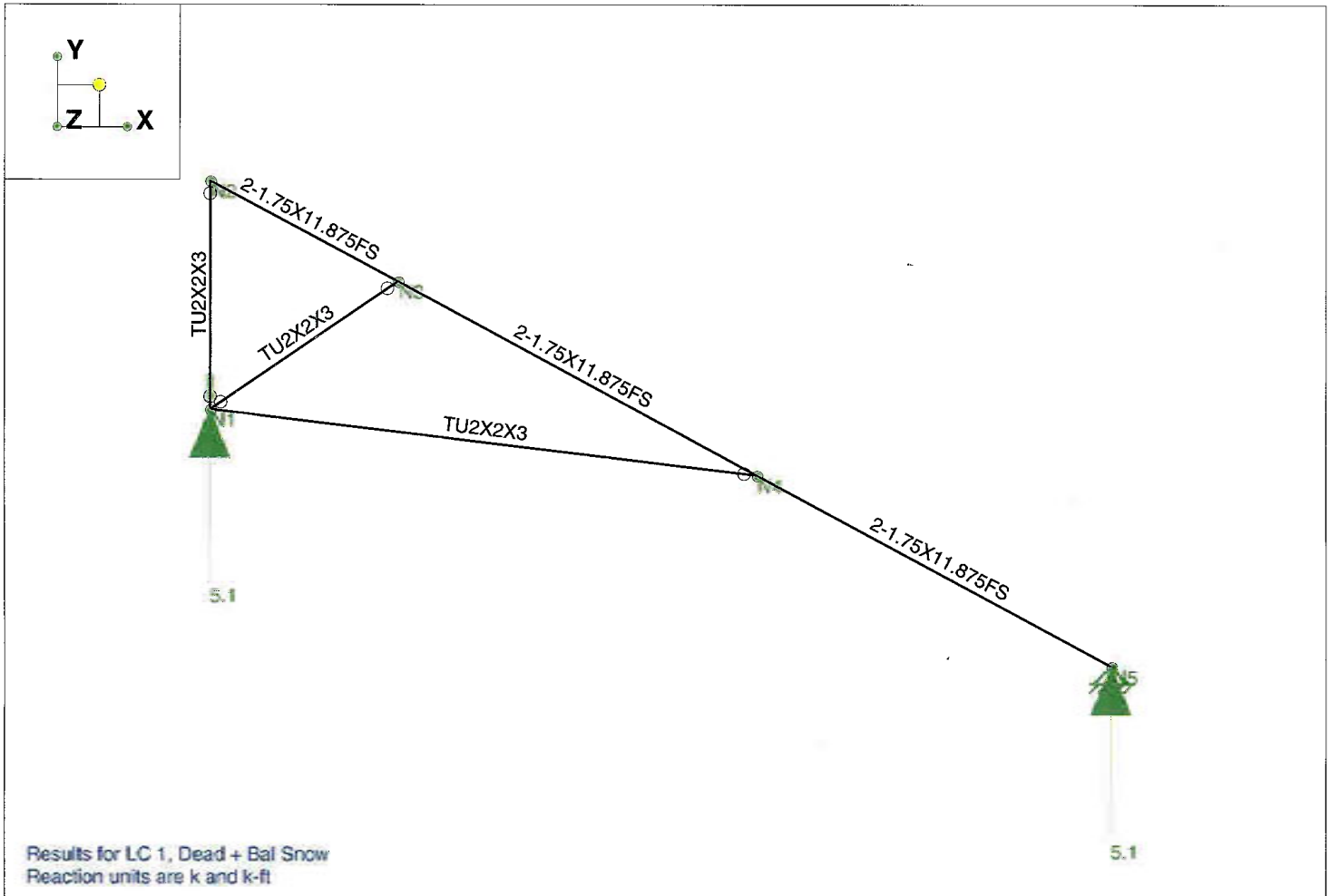

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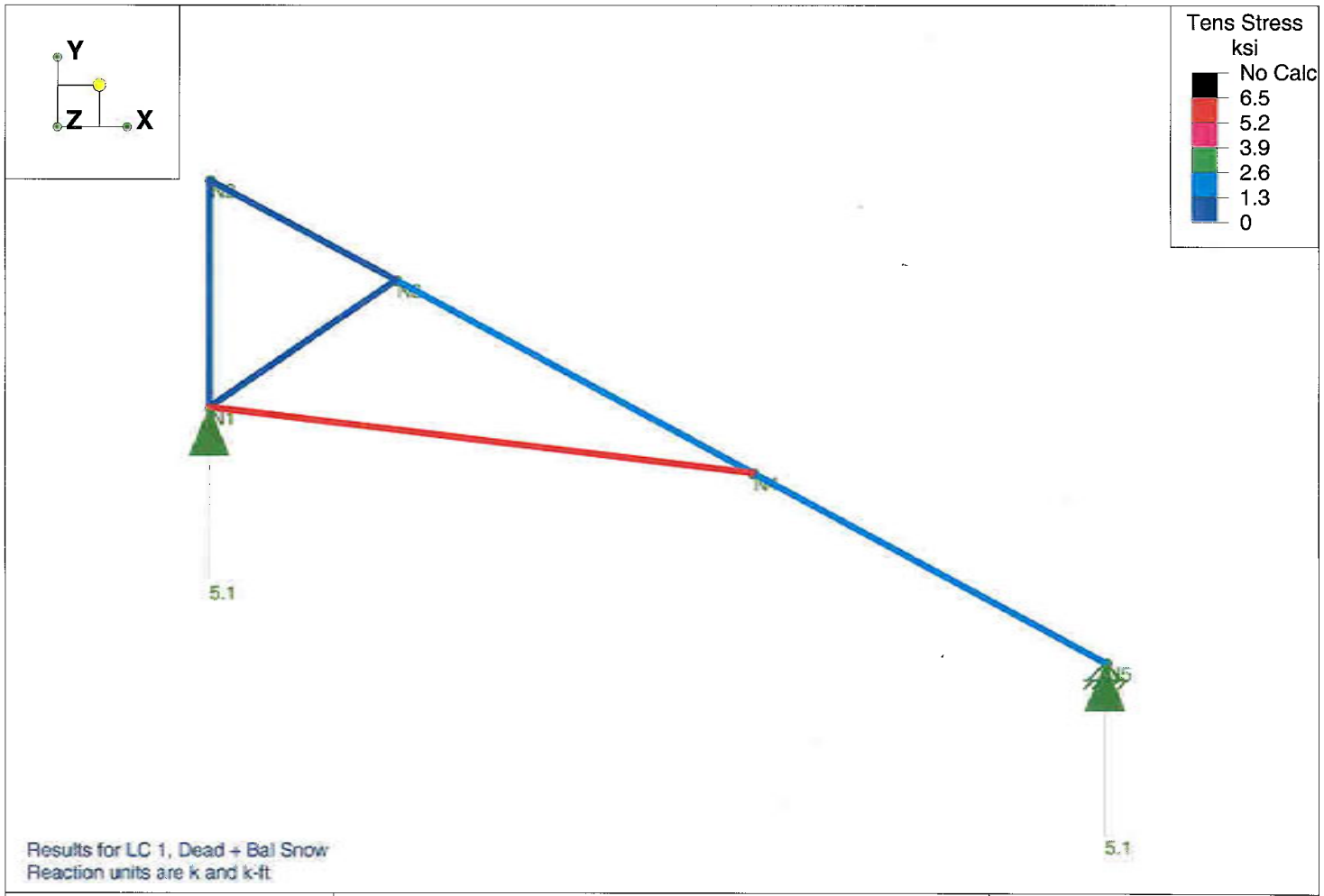

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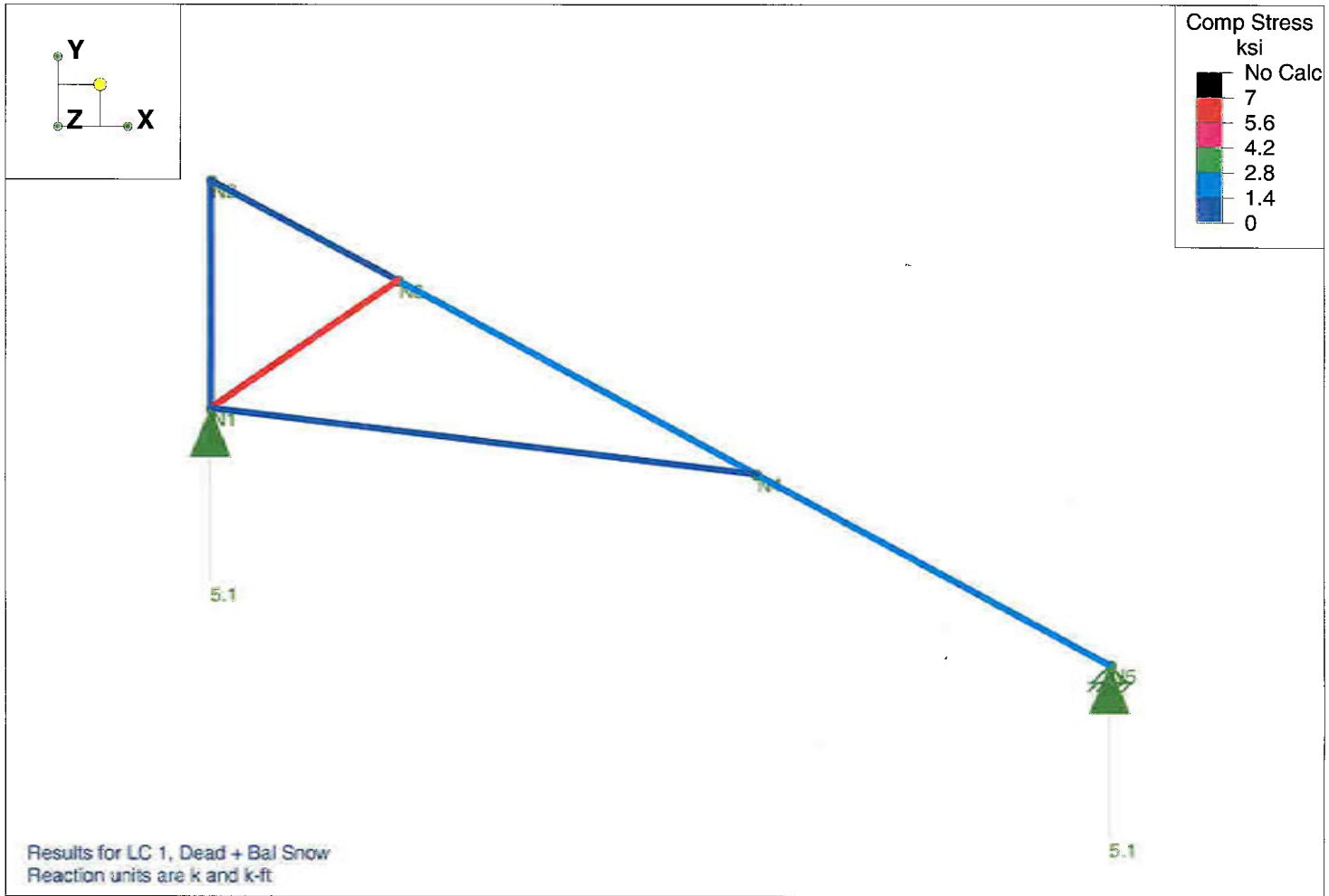

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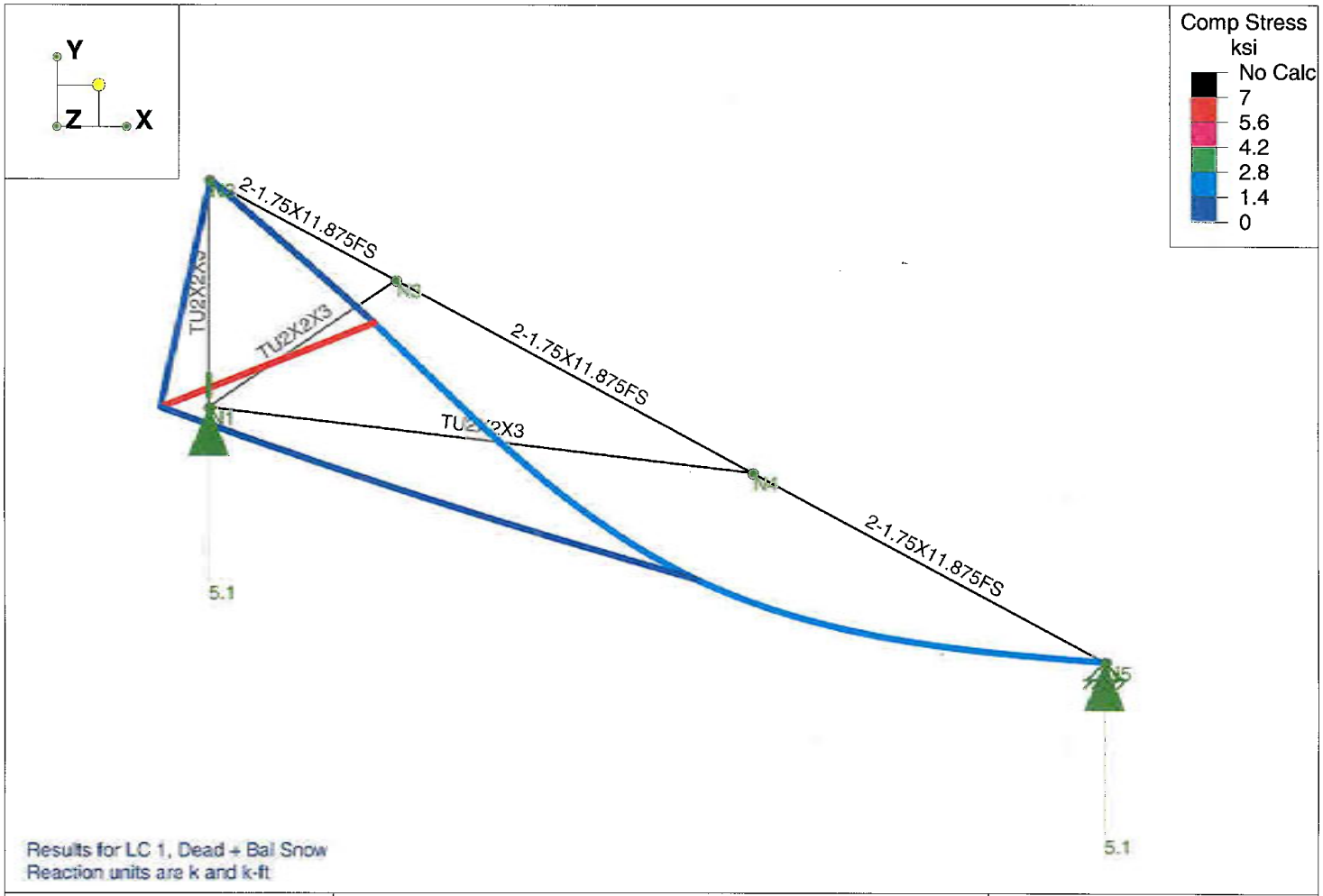

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PM-B039

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Date 3/17/09
Project Solar Decath
By DHM
SHT W1

Bldg Wind Loads

MWFRS		Net Bldg
Wall	16.0 + 11.5	21.5 psf
Sidewall	-12.35 - 12.35	0
Roof	$\frac{-10 - 12.21}{2}$	-11.1 psf

∴ Net Pressure on Bldg:

Windward pressure = 21.5 psf × Wall Area

Sidewall pressure cancels 0 psf

Roof Uplift = Avg 11.1 psf uplift × Roof Area

Components & Cladding

Wall Elements

P: 20.4 psf Main Wall
24.1 psf Corners

Roof Elements

-18.6 psf Main Roof
-21.1 psf Edge & Sides
21.1 psf Corners

Roof

Net Uplift on Roof - MWFRS

11.1 psf uplift - 15 psf DL = No Net Uplift on Bldg

Net Uplift on Roof Elements

21.1 psf uplift - 15 psf DL = 6.1 psf Uplift

Check Roof Elements for 6.1 psf Uplift

2x8 @ 16" Max Span = 13'-0

2x8 @ 16" ok See A

Uplift on Trusses:

Truss 1 Trib width = 10'-9"

Wup = 21.1 × 10.75 = 227 #/ft up

Net Load to Truss results in no uplift See B

Truss 2

Wup = 21.1 × 11.5 = 243 #/ft

Net Load to Truss Results in no uplift See C

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PM-B040

Project :
Subject :
Location :

File :
Date : 3/17/2009
Eng. :

Design Wind Pressure, p, Equation 6-18 (ASCE 7-05)

Design wind pressures and forces are determined per equations given in section 6.5.12

System Type	Structure Type	Equation
Main Wind-Force Resisting System	Low-Rise Buildings Gable Roof	*p* : qh·[(GCpf) - (GCpi)] qh : at mean roof height h GCpf : given in Figure 6-10 GCpi : given in Figure 6-5

Velocity Pressure Calculations, qh

Velocity pressure qh is calculated in accordance with section 6.5.10

qh = Velocity pressure @ mean roof height (h) (Eq. 6-15)
qh = Constant · Kh · Kzt · Kd · V^2 ·I
qh = Velocity pressure @ height (h)

Where : Constant = Numerical constant (Section C6.5.10)
= ½ · [(Air density lb/ cu ft) / (32.2 ft/s^2)] · [(mi/h)(5280 ft/mi) · (1 hr/3600 s)] ^{2}
= 0.00256

Mean Sea Level = 0.00 ft
Air Density @ MSL = 0.0765 lb/cu ft (Table C6-13)

Category = II (Table 1-1)
Importance Factor = 1 (Table 6-1)

Exposure Category = B (Urban areas)
Alpha = 7.00 (Table 6-2)
Zg = 1,200.00 ft (Table 6-2)

Basic Wind Speed = 90.00 mph (Figure 6-1)
Mean Roof Height = 16.00 ft

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PM-B041

Project	:	**File**	:
Subject	:	**Date**	: 3/17/2009
Location	:	**Eng.**	:

Velocity Pressure Calculations, qz (Cont.)

Where : Kh = Velocity pressure coefficient @ height z (Eq. C6-4a)
= 2.01·(Z/Zg) ^ (2/Alpha) for 15 ft <= Z <= Zg (Eq. C6-4b)
= 2.01 · (15/Zg) ^ (2/Alpha) for Z < 15 ft
= 0.70

Kzt = Topographic factor obtained from Fig. 6-4
= (1 + K1 · K2 · K3) ²

Kzt @ h = 1.00

Topography = None

Kd = Wind directionality factor obtained from Table 6-4
= 0.85

qh = **12.35** (psf)

Internal Pressure Coefficient, GCpi, Figure 6-5

The internal pressure coefficients are given in Figure 6-5

Enclosure Classification	GCpi+	GCPi-	Ri	GCpi+	GCPi-
Partially enclosed buildings	0.55	-0.55	1.00	0.55	-0.55

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PM-B042

Project :
Subject :
Location :

File :
Date : 3/17/2009
Eng. :

External Pressure Coefficient, Cp, Figure 6-10

The pressure force coefficient are given in Figure 6-10

Roof Angle	Building Surface									
	1	2	3	4	5	6	1E	2E	3E	4E
28.20 deg.	0.55	0.05	-0.44	-0.38	-0.45	-0.45	0.71	0.03	-0.56	-0.51

Design Wind Pressure, p, (psf) Equation 6-18

Design wind pressures and forces are determined per equations given in section 6.5.12

Building Surface	Cp	qh (psf)	GCpi+	GCpi-	p+ (psf)	p- (psf)
1	0.55	12.35	0.55	-0.55	10.00	13.64
2	0.05	12.35	0.55	-0.55	-10.00	10.00
3	-0.44	12.35	0.55	-0.55	-12.21	10.00
4	-0.38	12.35	0.55	-0.55	-11.49	10.00
5	-0.45	12.35	0.55	-0.55	-12.35	10.00
6	-0.45	12.35	0.55	-0.55	-12.35	10.00
1E	0.71	12.35	0.55	-0.55	10.00	15.56
2E	0.03	12.35	0.55	-0.55	-10.00	10.00
3E	-0.56	12.35	0.55	-0.55	-13.69	-10.00
4E	-0.51	12.35	0.55	-0.55	-13.07	10.00

p+ uses GCpi+ *p- uses GCpi-*

Design Wind Pressure for Overhang, p, Equation 6-18

The design equation has been modified to qh·[(GCpf) - G·(Underside Cp)] for overhang pressures
0.80 is used for Underside Cp instead of GCpi (G = .85)

	Roof Zone	
	2	2E
For roof only	-7.80	-8.04

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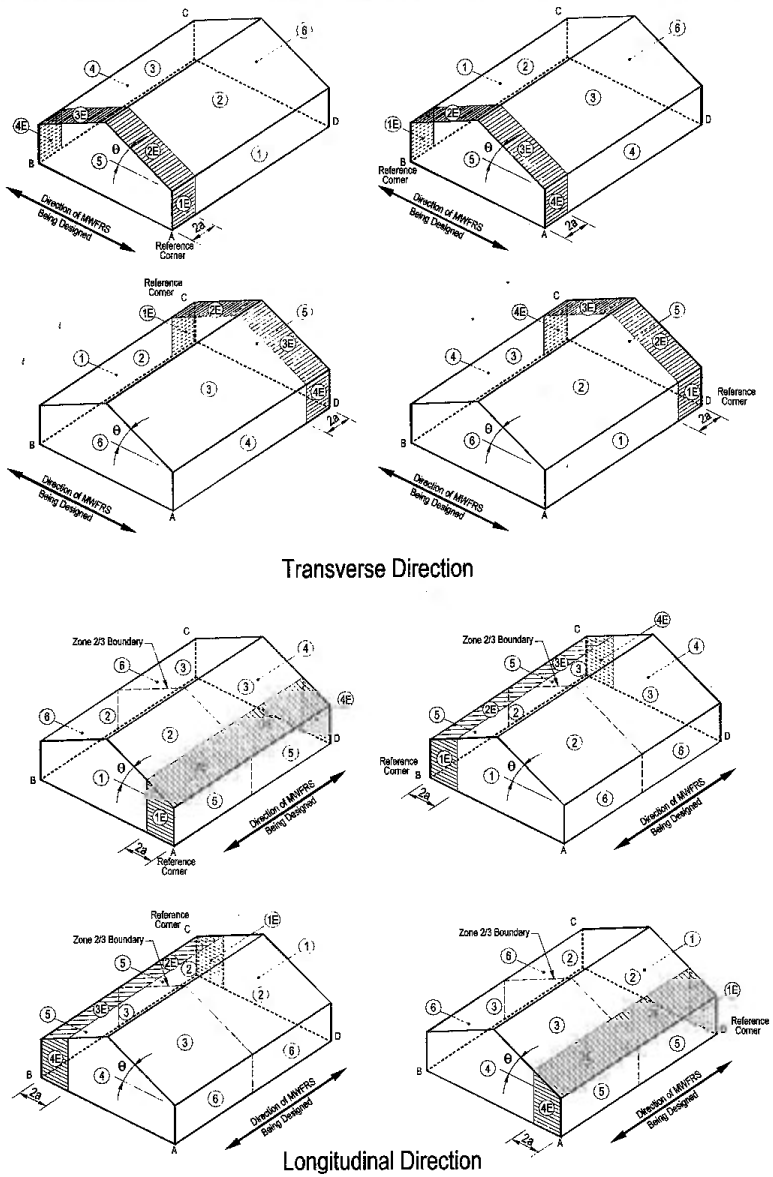
Main Wind Force Resisting System – Method 2		h ≤ 60 ft.
Figure 6-10	External Pressure Coefficients, GC_{pf}	Low-rise Walls & Roofs
Enclosed, Partially Enclosed Buildings		



Basic Load Cases

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PM-B044

Project	:	**File**	:
Subject	:	**Date**	: 3/17/2009
Location	:	**Eng.**	:

Design Wind Pressure, p, Equation 6-22 (ASCE 7-05)

Design wind pressures and forces are determined per equations given in section 6.5.12

System Type	Structure Type	Equation
Components and Cladding	Low-Rise Buildings and Buildings with h <= 60 ft Gabled, Hipped and Stepped Roofs	*p* : qh·[(GCp) - (GCpi)] qh : at mean roof height GCp : given in Figure 6-11, 6-12 GCpi : given in Figure 6-5

Velocity Pressure Calculations, qh

Velocity pressure qh is calculated in accordance with section 6.5.10

qh = Velocity pressure @ mean roof height (h) (Eq. 6-15)
qh = Constant · Kh · Kzt · Kd · V^2 ·I
qh = Velocity pressure @ mean roof height (h)

Where :	Constant	= Numerical constant = ½ · [(Air density lb/ cu ft) / (32.2 ft/s²)] · [(mi/h)(5280 ft/mi) · (1 hr/3600 s)] ² = 0.00256	(Section C6.5.10)
	Mean Sea Level	= 0.00 ft	
	Air Density @ MSL	= 0.0765 lb/cu ft	(Table C6-13)
	Category	= II	(Table 1-1)
	Importance Factor	= 1.00	(Table 6-1)
	Exposure Category	= B (Urban areas)	
	Alpha	= 7.00	(Table 6-2)
	Zg	= 1,200.00 ft	(Table 6-2)
	Basic Wind Speed	= 90.00 mph	(Figure 6-1)
	Mean Roof Height	= 16.00 ft	

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PM-B045

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Location	:	**Eng.**	:

Velocity Pressure Calculations, qz (Cont.)

Where : Kh = Velocity pressure coefficient @ height z (Eq. C6-4a)
= 2.01·(Z/Zg) ^ (2/Alpha) for 15 ft <= Z <= Zg (Eq. C6-4b)
= 2.01 · (15/Zg) ^ (2/Alpha) for Z < 15 ft
= 0.70

Kzt = Topographic factor obtained from Fig. 6-4
= (1 + K1 · K2 · K3) ²

Kzt @ h = 1.00

Topography = None

Kd = Wind directionality factor obtained from Table 6-4
= 0.85

qh = **12.35** (psf)

Internal Pressure Coefficient, GCpi, Figure 6-5

The internal pressure coefficients are given in Figure 6-5

Enclosure Classification	GCpi+	GCPi-	Ri	GCpi+	GCPi-
Partially enclosed buildings	0.55	-0.55	1.00	0.55	-0.55

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PM-B046

Project :
Subject :
Location :

File :
Date : 3/17/2009
Eng. :

External Pressure Coefficient, GCp, Figure 6-11 and Figure 6-12

The pressure force coefficient are given in Figure 6-11 and Figure 6-12

Zone	Area (sq. ft.)	Angle (deg)	GCp+	GCp-	GCp R.O.
1	16.00	28.20	0.88	-0.96	-
2	16.00	28.20	0.88	-1.16	-1.96
3	16.00	28.20	0.88	-1.16	-1.96
4	8.00	All	1.00	-1.10	-
5	8.00	All	1.00	-1.40	-

Design Wind Pressure, p, Equation 6-22

Design wind pressures and forces are determined per equations given in section 6.5.12
Values of external and internal pressures shall be combined algebraically

Zone	qh (psf)	GCp+	GCp-	GCpi+	GCpi-	p1+ (psf)	p2+ (psf)	p1- (psf)	p2- (psf)
1	12.35	0.88	-0.96	0.55	-0.55	10.00	17.65	-18.64	-10.00
2	12.35	0.88	-1.16	0.55	-0.55	10.00	17.65	-21.11	-10.00
3	12.35	0.88	-1.16	0.55	-0.55	10.00	17.65	-21.11	-10.00
4	12.35	1.00	-1.10	0.55	-0.55	10.00	19.14	-20.37	-10.00
5	12.35	1.00	-1.40	0.55	-0.55	10.00	19.14	-24.08	-10.50

p1+ uses GCp+ and GCpi+ *p1- uses GCp- and GCpi+*
p2+ uses GCp+ and GCpi- *p2- uses GCp- and GCpi-*

Roof overhang wind pressures

Zone	qh (psf)	GCp- (R.O.)	p (R.O.) (psf)
1	-	-	-
2	12.35	-1.96	-24.19
3	12.35	-1.96	-24.19

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COMMENTS

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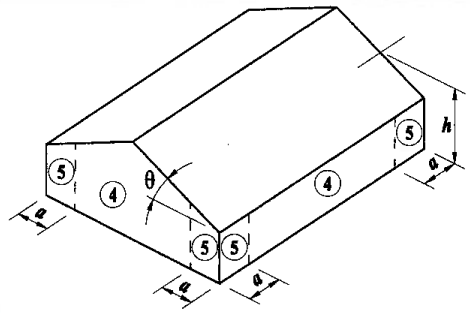
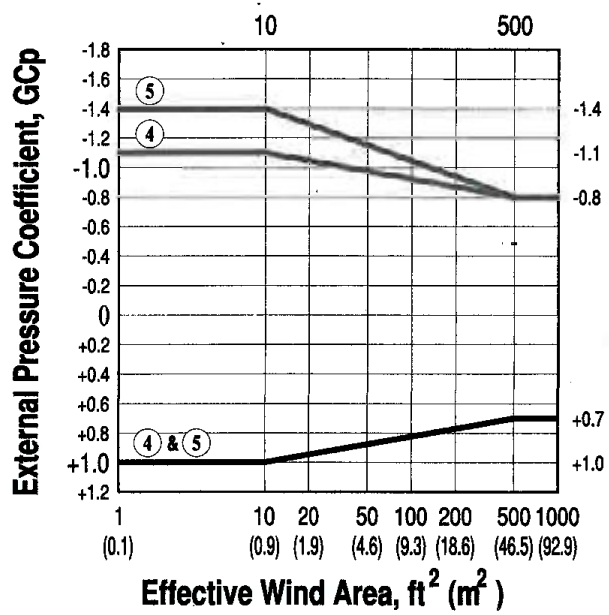
Components and Cladding – Method 2		h ≤ 60 ft.
Figure 6-11A	External Pressure Coefficients, GC_p	**Walls**
Enclosed, Partially Enclosed Buildings		





Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for walls shall be reduced by 10% when $\theta \leq 10°$.
6. 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 $\theta \leq 10°$.
   - θ: Angle of plane of roof from horizontal, in degrees.

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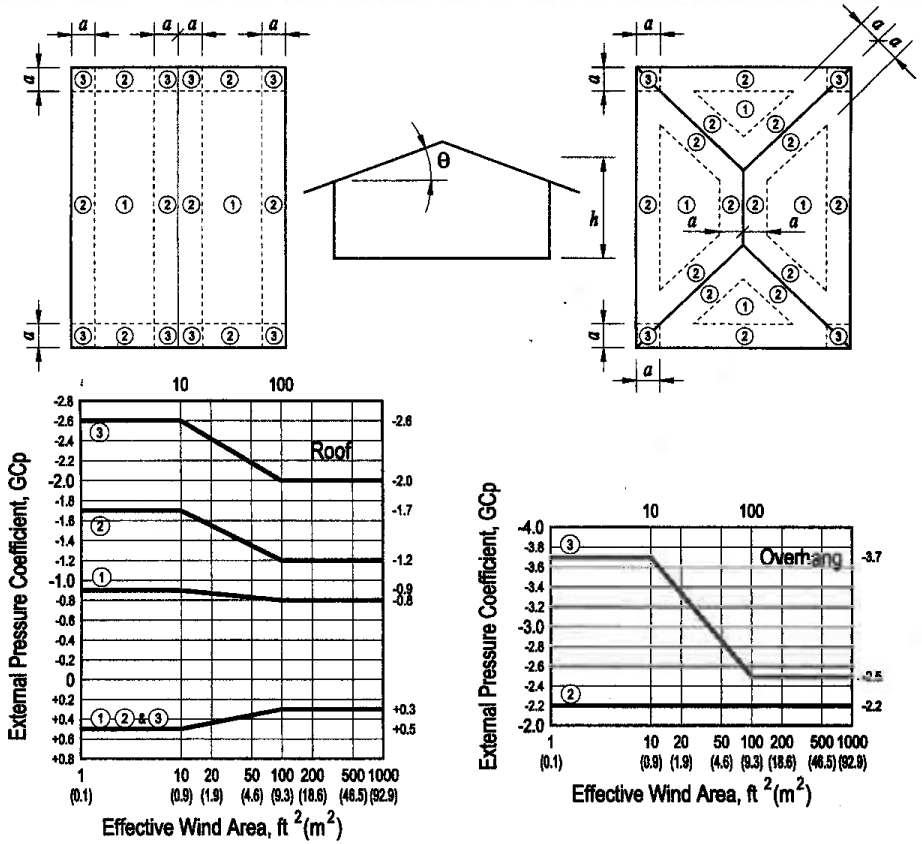
PM-B048

Components and Cladding – Method 2		h ≤ 60 ft.
Figure 6-11C	**External Pressure Coefficients, GC_p**	**Gable/Hip Roofs 7°< θ ≤ 27°**
Enclosed, Partially Enclosed Buildings		



Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
6. For hip roofs with 7° < θ ≤ 27°, edge/ridge strips and pressure coefficients for ridges of gabled roofs shall apply on each hip.
7. For hip roofs with θ ≤ 25°, Zone 3 shall be treated as Zone 2.
8. 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 θ ≤ 10°.
   - θ: Angle of plane of roof from horizontal, in degrees.

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Structural Calculations

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PM-B049

WoodWorks® SOFTWARE FOR WOOD DESIGN	COMPANY	PROJECT
	Mar. 17, 2009 10:03	Beam1.wwb

Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start	Magnitude End	Location [ft] Start	Location [ft] End	Pat-tern
Load1	Wind	Full Area	6.10	(16.0)*			No

*Tributary Width (in)

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :

Dead	15		15
Live	53		53
Total	67		67
Bearing:			
LC number	2		2
Length	1.00		1.00

Lumber-soft, Hem-Fir, No.2, 2x8"

Spaced at 16" c/c; Self Weight of 2.25 plf automatically included in loads;
Lateral support: top= full, bottom= at supports; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	fv = 8	Fv' = 240	fv/Fv' = 0.04
Bending(+)	fb = 200	Fb' = 1877	fb/Fb' = 0.11
Live Defl'n	0.08 = <L/999	0.65 = L/240	0.13
Total Defl'n	0.12 = <L/999	0.87 = L/180	0.14

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfrt	Ci	Cn	LC#
Fb'+	850	1.60	1.00	1.00	1.000	1.200	1.00	1.15	1.00	1.00	-	2
Fv'	150	1.60	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
Fcp'	405	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.3 million		1.00	1.00	-	-	-	-	1.00	1.00	-	2

```
Bending(+): LC# 2 = .6D+W, M =    219 lbs-ft
Shear     : LC# 2 = .6D+W, V =     67, V design =     61 lbs
Deflection: LC# 2 = .6D+W   EI=     62e06 lb-in2
Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.
  (D=dead  L=live  S=snow  W=wind  I=impact  C=construction  CLd=concentrated)
  (All LC's are listed in the Analysis output)
```

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.

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Structural Calculations

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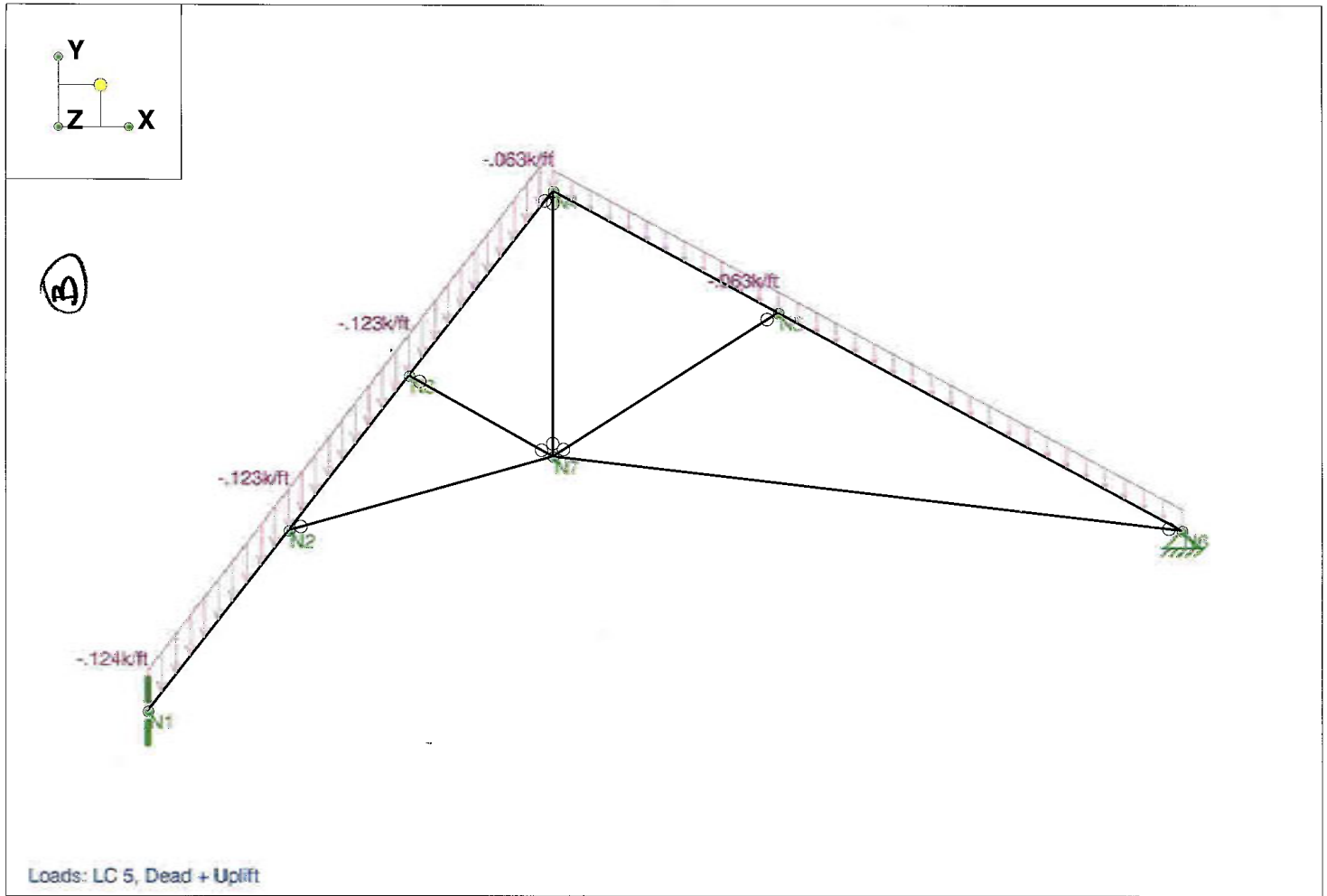
PM-B050



Loads: LC 5, Dead + Uplift

Mar 17, 2009 at 10:09 AM

truss.r2d

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Structural Calculations

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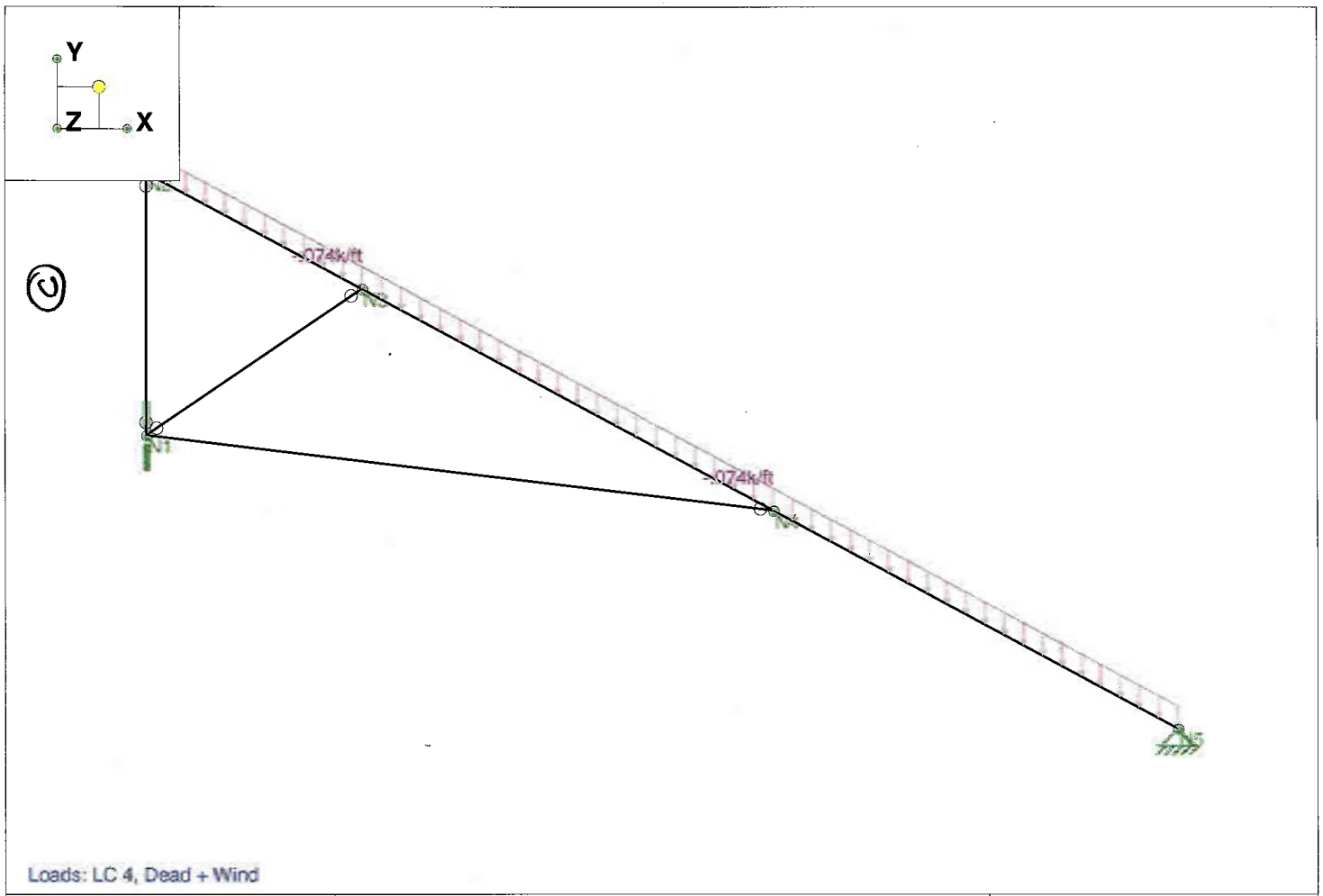
PM-B051



Loads: LC 4, Dead + Wind

Mar 17, 2009 at 10:13 AM

Mono truss.r2d

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Structural Calculations

COMMENTS

REV DATE 03/26/09

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PM-B052

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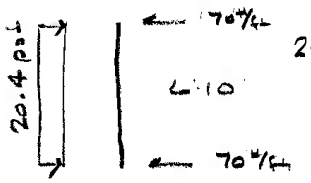
Date 3/20/09	SHT
Project Solar Decath	W2
By DHM	

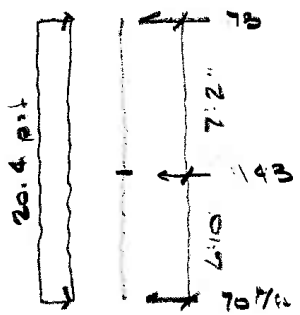
Wind Loads to Bldg Walls

North Wall



2x4 @ 24" o.c.
OK (A)

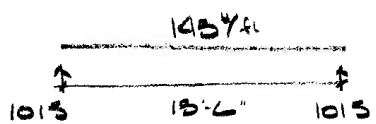
Side Wall



2x4 @ 24" o.c.
OK (B)

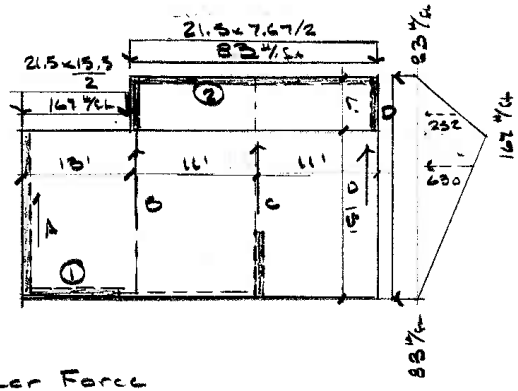
Check Module Break as Transfer Bm:

2 - 1½" x 8" NLG



Use 2 - 1¾ x 9" LVL (C)

Wind Loads to Bldg Diaphragms MWFRS



Shear Force

		✓	leff	~
A	167(13/2) =	1086#	15'	72#/ft
B	167(13/2) + 83(1/2) =	1543#	22'	70#/ft
C	83(11) =	913#	22'	42#/ft
D	83(11/2) =	457#	6'	76#/ft
1	83(21/2) + 630(11/21) + 252(4/21) =	1249#	35'	36#/ft
2	83(21/2) 630(10/21) 252(17/21) =	1375	22'	63#/ft

Max Roof Deck Shear
= 76#/ft
19/32 APA Rated Panel
8d nails @ 6" edges, 12" interior
~' = 180 x .82 = 148#/ft ok

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Structural Calculations

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PM-B053

WoodWorks®	COMPANY	PROJECT
	Mar. 20, 2009 12:46	Column1.wwc

Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start	Magnitude End	Location [ft] Start	Location [ft] End	Pat-tern
Load1	Wind	Full Area	20.40	(24.0)*			No

*Tributary Width (in)

MAXIMUM REACTIONS (lbs):

0' 6'-10"

Dead			
Live	139		139
Total	139		139

Lumber Stud, S-P-F, Stud, 2x4"

Spaced at 24" c/c; Self Weight of 1.06 plf automatically included in loads;
Pinned base; Loadface = width(b); Ke x Lb: 1.00 x 0.00= 0.00 [ft]; Ke x Ld: 1.00 x 6.83= 6.83 [ft]; Lateral support: top = Lb, bottom = Lb; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	fv = 40	Fv' = 216	fv/Fv' = 0.18
Bending(+)	fb = 933	Fb' = 1366	fb/Fb' = 0.68
Axial	fc = 1	Fc' = 463	fc/Fc' = 0.00
Axial Bearing	fc = 1	Fc* = 685	fc/Fc* = 0.00
Combined (axial compression + side load bending)			Eq.3.9-3 = 0.68
Live Defl'n	0.31 = L/263	0.46 = L/180	0.68
Total Defl'n	0.31 = L/263	0.46 = L/180	0.68

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfrt	Ci	Cn	LC#
Fb'+	675	1.60	1.00	1.00	1.000	1.100	1.00	1.15	1.00	1.00	-	2
Fv'	135	1.60	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
Fcp'	425	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
Fc'	725	0.90	1.00	1.00	0.676	1.050	-	-	1.00	1.00	-	1
Fc'comb	725	1.60	-	-	0.461	-	-	-	-	-	-	2
E'	1.2 million		1.00	1.00	-	-	-	-	1.00	1.00	-	2
Fc*	725	0.90	1.00	1.00	-	1.050	-	-	1.00	1.00	-	1

```
Bending(+): LC# 2 = .6D+W, M =    238 lbs-ft
Shear     : LC# 2 = .6D+W, V =    139, V design =    139 lbs
Deflection: LC# 2 = .6D+W   EI=      6e06 lb-in2
Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.
Axial     : LC# 1 = D only,  P =     7 lbs
Combined  : LC# 2 = .6D+W;   (1 - fc/FcE) = 1.00
  (D=dead  L=live  S=snow  W=wind  I=impact  C=construction  CLd=concentrated)
  (All LC's are listed in the Analysis output)
```

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.

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Structural Calculations

COMMENTS

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PM-B054

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	Mar. 20, 2009 12:56	Beam1.wwb

B

Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start	Magnitude End	Location [ft] Start	Location [ft] End	Pat-tern
Load1	Wind	Full UDL	41.6				No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :

Dead	3		9		3
Live	105		364		113
Total	107		373		116
Bearing:					
LC number	2		2		2
Length	1.00		1.00		1.00
Cb	1.00		2.78		1.00

Lumber-soft, S-P-F, No.1/No.2, 2x4"

Self Weight of 1.06 plf automatically included in loads;
Lateral support: top= full, bottom= at supports; Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	fv = 51	Fv' = 216	fv/Fv' = 0.23
Bending(+)	fb = 622	Fb' = 2100	fb/Fb' = 0.30
Bending(-)	fb = 1026	Fb' = 2068	fb/Fb' = 0.50
Live Defl'n	0.14 = L/612	0.36 = L/240	0.39
Total Defl'n	0.15 = L/589	0.36 = L/240	0.41

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfrt	Ci	Cn	LC#
Fb'+	875	1.60	1.00	1.00	1.000	1.500	1.00	1.00	1.00	1.00	-	2
Fb'-	875	1.60	1.00	1.00	0.985	1.500	1.00	1.00	1.00	1.00	-	2
Fv'	135	1.60	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
Fcp'	425	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.4 million		1.00	1.00	-	-	-	-	1.00	1.00	-	2

```
Bending(+): LC# 2 = .6D+W, M =    159 lbs-ft
Bending(-): LC# 2 = .6D+W, M =    262 lbs-ft
Shear     : LC# 2 = .6D+W, V =    189, V design =    177 lbs
Deflection: LC# 2 = .6D+W   EI=      8e06 lb-in2
Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.
  (D=dead  L=live  S=snow  W=wind  I=impact  C=construction  CLd=concentrated)
  (All LC's are listed in the Analysis output)
```

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. Continuous or Cantilevered Beams: NDS Clause 4.2.5.5 requires that normal grading provisions be extended to the middle 2/3 of 2 span beams and to the full length of cantilevers and other spans.
3. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.

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Structural Calculations

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PM-B055

WoodWorks®	COMPANY	PROJECT
	Mar. 20, 2009 13:03	Beam1.wwb

Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start	Magnitude End	Location [ft] Start	Location [ft] End	Pat-tern
Load1	Wind	Full UDL	143.0				No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :

Dead	49		49
Live	965		965
Total	1015		1015
Bearing:			
LC number	2		2
Length	1.00		1.00

LVL n-ply, 1.8E, 2600Fb, 1-3/4x7-1/4", 2-Plys

Self Weight of 7.31 plf automatically included in loads;
Lateral support: top= full, bottom= full; Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	fv = 55	Fv' = 456	fv/Fv' = 0.12
Bending(+)	fb = 1340	Fb' = 4455	fb/Fb' = 0.30
Live Defl'n	0.53 = L/303	0.67 = L/240	0.79
Total Defl'n	0.58 = L/281	0.67 = L/240	0.85

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CV	Cfu	Cr	Cfrt	Ci	Cn	LC#
Fb'+	2600	1.60	-	1.00	1.000	1.07	-	1.00	1.00	-	-	2
Fv'	285	1.60	-	1.00	-	-	-	-	1.00	-	1.00	2
Fcp'	750	-	-	1.00	-	-	-	-	1.00	-	-	-
E'	1.8 million		-	1.00	-	-	-	-	1.00	-	-	2

```
Bending(+): LC# 2 = .6D+W, M =   3424 lbs-ft
Shear     : LC# 2 = .6D+W, V =   1015, V design =    924 lbs
Deflection: LC# 2 = .6D+W   EI=    100e06 lb-in2/ply
Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.
  (D=dead  L=live  S=snow  W=wind  I=impact  C=construction  CLd=concentrated)
  (All LC's are listed in the Analysis output)
```

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. SCL-BEAMS (Structural Composite Lumber): the attached SCL selection is for preliminary design only. For final member design contact your local SCL manufacturer.
3. Size factors vary from one manufacturer to another for SCL materials. They can be changed in the database editor.
4. BUILT-UP SCL-BEAMS: contact manufacturer for connection details when loads are not applied equally to all plys.

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Structural Calculations

COMMENTS

REV DATE 03/26/09

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PM-B056

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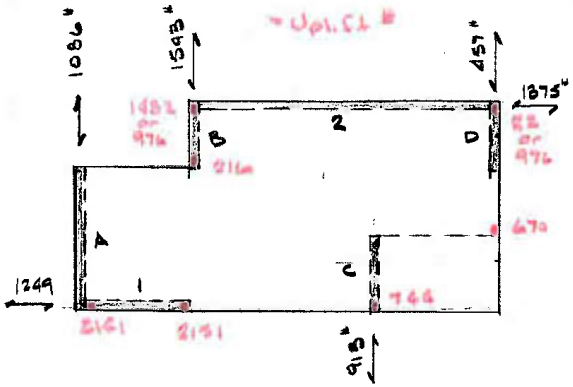
612-827-0805 fax

Date 3/20/09	SHT
Project Solar Death	W3
By DMM	

Diaphragm Loads to Shear Walls



See Results (A)

All walls:
2x4 @ 24" o/c ok
15/32 APA Rated Panels
10d nails 6/12 spacing

Largest Uplift Force =
2151#

Use HDU2 6-SD 1/4x2 1/2
Y's 2215#

Anchor to Floor Framing
1- 5/8" ϕ Lag G=.50
T= 447(1.6) = 715 #/in pen
3" Pen Req'd
Use 5/8" ϕ x 8" Lag Screw

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Structural Calculations

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03/26/09

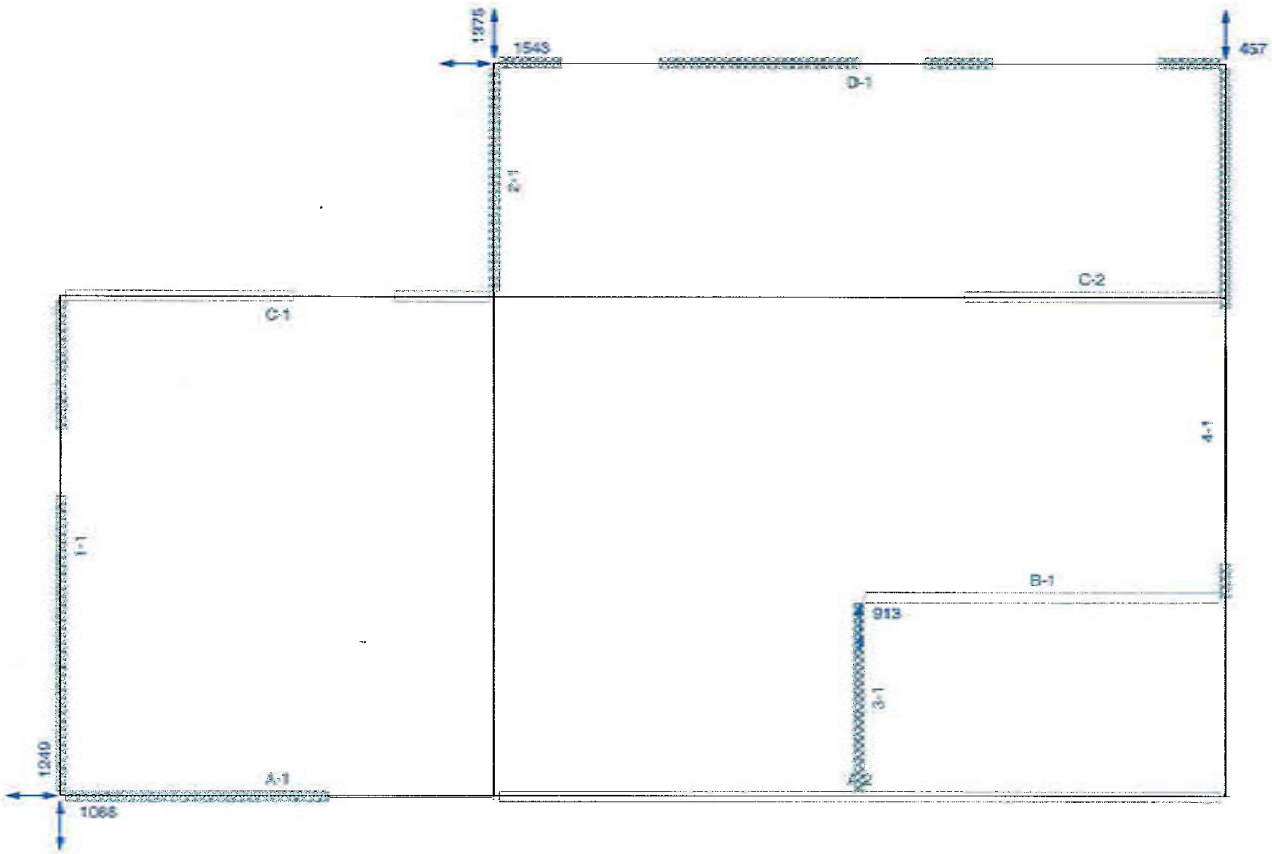
AUTHORED BY
Dave MacDonald, P.E.

PM-B057

WoodWorks® Shearwalls SOFTWARE FOR WOOD DESIGN

Shear wall.wsw WoodWorks® Shearwalls 2004b Mar. 20, 2009 13:51:05

Level 1 of 1



Loads Shown: W; Forces: W + 0.6D.

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Structural Calculations

COMMENTS

REV DATE 03/26/09

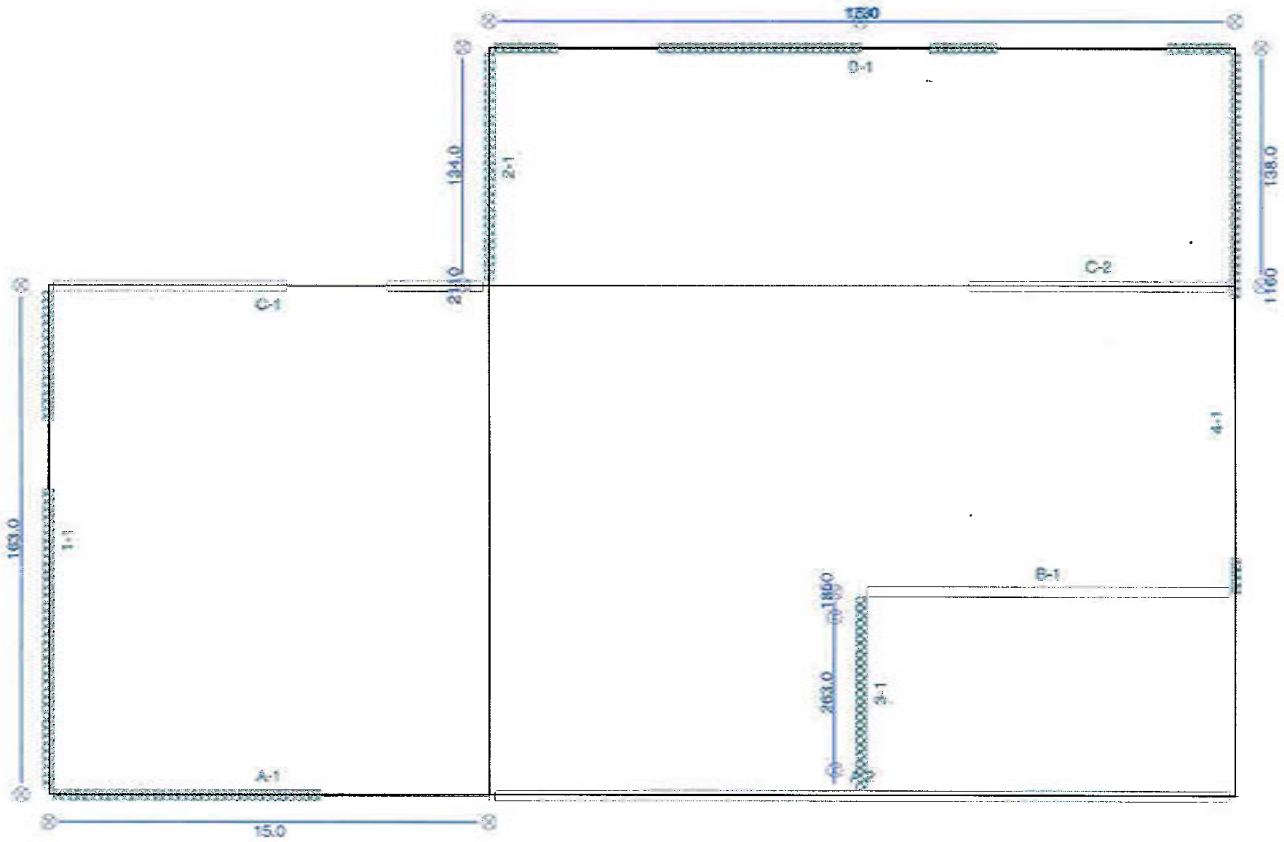
AUTHORED BY Dave MacDonald, P.E.

PM-B058

WoodWorks® Shearwalls	SOFTWARE FOR WOOD DESIGN

Shear wall.wsw | **WoodWorks® Shearwalls 2004b** | **Mar. 20, 2009 13:51:05**

Level 1 of 1



Loads Shown: W; Forces: W + 0.6D.

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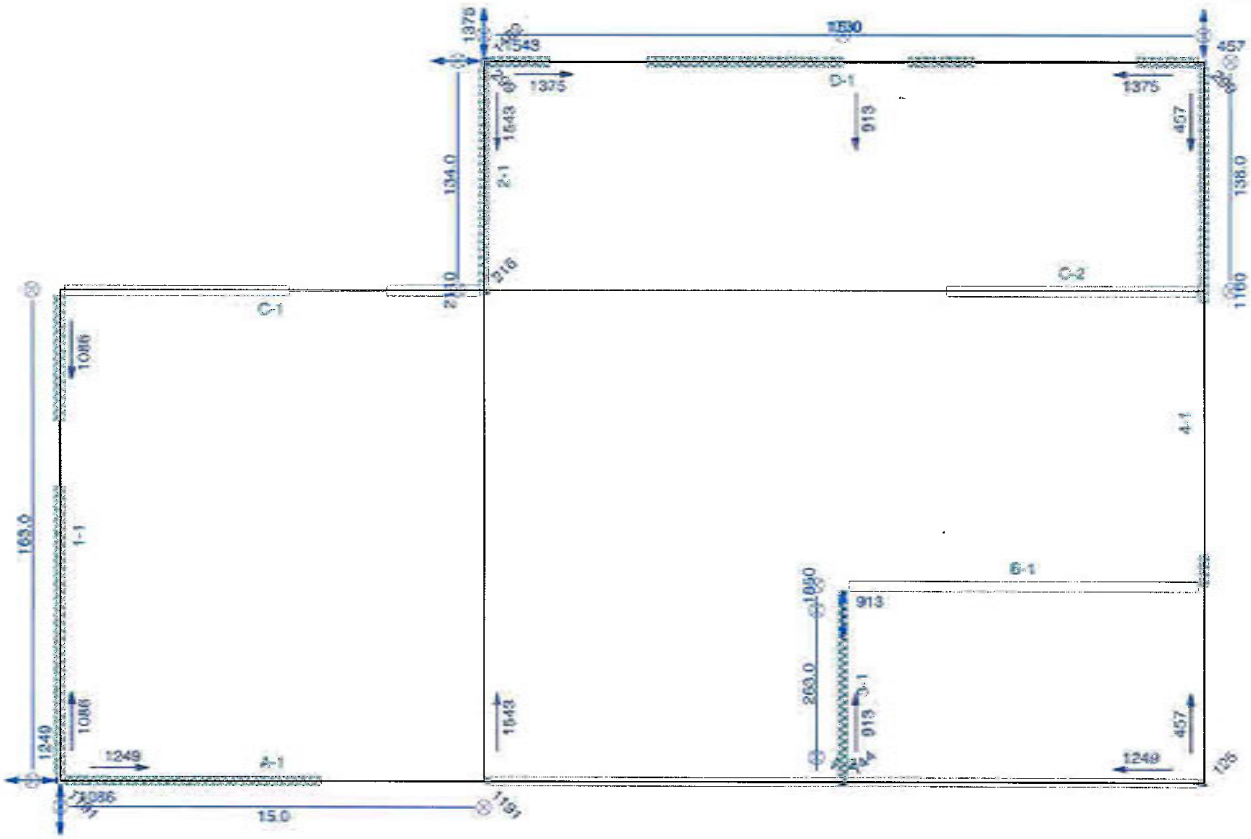
PM-B059

WoodWorks® Shearwalls SOFTWARE FOR WOOD DESIGN

Shear wall.wsw **WoodWorks® Shearwalls 2004b** **Mar. 20, 2009 13:51:05**

Level 1 of 1



Loads Shown: W; Forces: W + 0.6D.

ICON SOLAR HOUSE

UNIVERSITY OF MINNESOTA

Structural Calculations

COMMENTS

REV DATE 03/26/09

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PM-B060

WoodWorks® Shearwalls — SOFTWARE FOR WOOD DESIGN

WoodWorks® Shearwalls 2004b

Shear wall.wsr

Mar. 20, 2009 14:11:05

Project Information

COMPANY AND PROJECT INFORMATION

Company	Project
Mattson Macdonald Young, Inc. 901 North 3rd Street Suite 100 Minneapolis, MN 55401	Solar Decathlon DHM

DESIGN SETTINGS

Design Code	Wind Standard	Seismic Standard
IBC 2003	ASCE-7 98	ASCE-7 98

Wind Capacity Increase		Load Combinations	Building Code Capacity Reduction	
Shear	C&C Panels		Wind	Seismic
1.40	-	1.00 Wind + 0.60 Dead	1.00	1.00

Nail Withdrawal Modification				Max Shearwall Offset [ft]	
Duration Factor	Temperature Range	Moisture Content Fabrication	Moisture Content Service	Plan (within story)	Elevation (between stories)
-	-	-	-	0.50	-

Maximum Height-to-width Ratio						
Plywood		Fiberboard	Lumber		Gypsum	
Wind	Seismic		Wind	Seismic	Blocked	Unblocked
-	-	-	-	-	-	-

Shearwall Relative Rigidity: Designed capacity using flexible distribution

Hold-down Forces: Based on applied shearline force

Seismic Materials: -

SITE INFORMATION

IBC Occupancy	ASCE-7 Equivalent
Category II - All others	Category II - All others

Wind		Seismic	
ASCE-7 98 general analytic method for all bldgs		-	
Design Wind Speed	90mph	Use Group	-
Exposure	Exposure B	Design Category	-
Enclosure	Partly Enclosed	Site Profile Class	-

Topographic Information [ft]			Spectral Response Acceleration		
Shape	Height	Length	S1: -	Ss: -	
-	-	-	Fundamental Period	E-W	N-S
Site Location: -			T Used	-	-
-			Approximate Ta	-	-
-			Maximum T	-	-
			Response Factor R	-	-

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COMMENTS

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Structural Data

STORY INFORMATION

	Story Elev [ft]	Floor/Ceiling Depth [in]	Wall Height [ft]
Ceiling	10.67	0.0	
Level 1	2.67	8.0	8.00
Foundation	2.00		

BLOCK and ROOF INFORMATION

Block Dimensions [ft]			Roof Panels Face	Type	Slope	Overhang [ft]
Block 1	1 Story	E-W Ridge				
Location X,Y =	0.00	0.00	**North**	Side	90.0	0.00
Extent X,Y =	13.00	15.00	**South**	Side	28.2	0.00
Ridge Y Location, Offset	15.00	7.50	**East**	Joined	90.0	0.00
Ridge Elevation, Height	10.67	0.00	**West**	Gable	90.0	0.00
Block 2	1 Story	E-W Ridge				
Location X,Y =	13.00	0.00	**North**	Side	45.8	0.00
Extent X,Y =	22.00	22.00	**South**	Side	25.7	0.00
Ridge Y Location, Offset	15.00	4.00	**East**	Gable	90.0	0.00
Ridge Elevation, Height	17.88	7.21	**West**	Gable	90.0	0.00

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PM-B062

WoodWorks® Shearwalls

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MATERIALS by WALL GROUP

Wall		Sheathing [in]			Fasteners		Spcg [in]		Framing Members [in]				Apply
Grp	Surf	Material	Thick	Orient	Size	Type	Edg	Fld	Blkg	Species	G	Spc	Notes
1	Ext	Structural I	5/16	Vert	8d	Nail	6	12	yes	D.Fir-L	0.50	16	
	Int	Gyp WB 1-ply	1/2	Horz	5d	Nail	7	7	no	D.Fir-L	0.50	16	
2	Ext	SS incl. OSB	15/32	Horz	10d	Nail	6	12	yes	S-P-F	0.42	16	1
	Int	Gyp WB 1-ply	1/2	Horz	5d	Nail	7	7	no	S-P-F	0.42	16	
3	1	Structural I	15/32	Horz	10d	Nail	6	12	yes	S-P-F	0.42	16	1
	2	Gyp WB 1-ply	1/2	Horz	5d	Nail	7	7	no	S-P-F	0.42	16	

Notes:
1. Capacity has been reduced according to IBC specific gravity adjustment.

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PM-B063

WoodWorks® Shearwalls

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SHEARLINE, WALL and OPENING DIMENSIONS

North-South Shearlines	Type	Wall Group(s)	Location X [ft]	Extent [ft] Start	Extent [ft] End	Length [ft]	FHS [ft]	Height [ft]
Line 1								
Level 1								
Line 1, Level 1	Prf	2	0.00	0.00	15.00	15.00	13.00	8.00
Wall 1-1	Prf	2	0.00	0.00	15.00	15.00	13.00	
Opening 1				9.00	11.00	2.00		3.00
Line 2								
Level 1								
Line 2, Level 1	Prf	2	13.00	0.00	22.00	22.00	7.00	8.00
Wall 2-1	Prf	2	13.00	15.00	22.00	7.00	7.00	
Line 3								
Level 1								
Line 3, Level 1	Prf	3	24.00	0.00	22.00	22.00	6.00	8.00
Wall 3-1	Prf	3	24.00	0.00	6.00	6.00	6.00	
Line 4								
Level 1								
Line 4, Level 1	Prf	2	35.00	0.00	22.00	22.00	8.33	8.00
Wall 4-1	Prf	2	35.00	0.00	22.00	22.00	8.33	
Opening 1				0.00	6.00	6.00		8.00
Opening 2				7.00	14.67	7.67		5.00

East-West Shearlines	Type	Wall Group(s)	Location Y [ft]	Extent [ft] Start	Extent [ft] End	Length [ft]	FHS [ft]	Height [ft]
Line A								
Level 1								
Line A, Level 1	Prf	1	0.00	0.00	35.00	35.00	8.00	8.00
Wall A-1	Prf	1	0.00	0.00	13.00	13.00	8.00	
Opening 1				8.00	13.00	5.00		8.00
Wall A-2	NSW		0.00	13.00	35.00	22.00	22.00	
Line B								
Level 1								
Line B, Level 1	NSW		6.00	24.00	35.00	11.00	0.00	8.00
Wall B-1	NSW		6.00	24.00	35.00	11.00	11.00	
Line C								
Level 1								
Line C, Level 1	NSW		15.00	0.00	35.00	35.00	0.00	8.00
Wall C-1	NSW		15.00	0.00	13.00	13.00	10.00	
Opening 1				7.00	10.00	3.00		7.00
Wall C-2	NSW		15.00	27.00	35.00	8.00	8.00	
Line D								
Level 1								
Line D, Level 1	Prf	2	22.00	13.00	35.00	22.00	12.00	8.00
Wall D-1	Prf	2	22.00	13.00	35.00	22.00	12.00	
Opening 1				15.00	18.00	3.00		3.00
Opening 2				24.00	26.00	2.00		2.00
Opening 3				28.00	33.00	5.00		7.00

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Structural Calculations

COMMENTS

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PM-B064

Loads

WIND SHEAR LOADS

Level 1 Block	F	Element	Load Case	Wnd Dir	Surf Dir	Prof	Location [ft] Start	Location [ft] End	Magnitude [lbs,plf,psf] Start	Magnitude [lbs,plf,psf] End	Trib Ht [ft]
Manual	W	Face		W->E	Both	Point	0.00	0.00	1249		
Manual	W	Face		W->E	Both	Point	22.00	22.00	1375		
Manual	S	Face		S->N	Both	Point	0.00	0.00	1086		
Manual	S	Face		S->N	Both	Point	24.00	24.00	913		
Manual	N	Face		N->S	Both	Point	13.00	13.00	1543		
Manual	N	Face		N->S	Both	Point	35.00	35.00	457		

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PM-B065

DEAD LOADS (for hold-down calculations)

Name	Shear Line	Level	Profile	Tributary Width [ft]	Location [ft] Start	Location [ft] End	Mag [lbs,psf,psi] Start	Mag [lbs,psf,psi] End
Line A	A	1	Line		0.00	13.00	15.0	
Line D	D	1	Line		13.00	35.00	15.0	
Line D	D	1	Point		24.00	24.00	1730	
Line 1	1	1	Line		0.00	15.00	163.0	
Line 2	2	1	Point		15.00	15.00	2110	
Line 2	2	1	Line		15.00	22.00	134.0	
Line 3	3	1	Line		0.00	6.00	263.0	
Line 3	3	1	Point		6.00	6.00	1850	
Line 4	4	1	Point		15.00	15.00	1160	
Line 4	4	1	Line		15.00	22.00	138.0	

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PM-B066

WoodWorks® Shearwalls

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Flexible Diaphragm Wind Design

SHEAR RESULTS

North-South Shearlines	W Gp	For Dir	Ld. Case	Shear Force [plf] V [lbs]	V/L	V/FHS	Allowable Shear [plf] Int	Ext	Co	C	Total	V [lbs]	Crit. Resp.
Line 1													
Level 1													
Ln1, Lev1	2	Both		1086	72.4	83.5	100	399	0.98	A	491	6384	0.17
Line 2													
Ln2, Lev1	2	Both		1543	70.1	220.4	100	399	1.00	A	499	3495	0.44
Line 3													
Ln3, Lev1	3	Both		913	41.5	152.2	100	438	1.00	A	538	3228	0.28
Line 4													
Ln4, Lev1	2	Both		457	20.8	54.8	100	399	0.45	A	223	1855	0.25
East-West Shearlines	**W Gp**	**For Dir**	**Ld. Case**	**Shear Force [plf] V [lbs]**	**V/L**	**V/FHS**	**Allowable Shear [plf] Int**	**Ext**	**Co**	**C**	**Total**	**V [lbs]**	**Crit. Resp.**
Line A													
Level 1													
LnA, Lev1	1	Both		1249	35.7	156.1	100	280	0.57	A	215	1718	0.73
Line D													
LnD, Lev1	2	Both		1375	62.5	114.6	100	399	0.58	A	287	3446	0.40

C- Sheathing Combination: A- Add capacities; S- Strongest only; X- Strongest or twice weakest.

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Structural Calculations

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PM-B067

DRAGSTRUT AND HOLDDOWN FORCES

Level 1 Line-Wall	Position on Wall Or Opening	Location [ft] X	Location [ft] Y	Ld. Case	Holddown Force [lbs] Shear	Holddown Force [lbs] Dead	Holddown Force [lbs] Uplift	Holddown Force [lbs] Cmb'd	Dragstrut Force [lbs]
Line 1									
1-1	Left Wall End	0.00	0.00		679	1223			
1-1	Left Opening 1	0.00	9.00						100
1-1	Right Opening 1	0.00	11.00						45
1-1	Right Wall End	0.00	15.00		679	1223			
Line 2									
2-1	Left Wall End	13.00	15.00		1763	2579		216	1052
2-1	Right Wall End	13.00	22.00		1763	469		1482	
Line 3									
3-1	Left Wall End	24.00	0.00		1217	789		744	
3-1	Right Wall End	24.00	6.00		1217	2639			664
Line 4									
4-1	Left Wall End	35.00	0.00		984	523		670	
4-1	Right Opening 1	35.00	6.00						125
4-1	Left Opening 2	35.00	7.00						91
4-1	Right Opening 2	35.00	14.67						250
4-1	Right Wall End	35.00	22.00		984	1603		22	
Line A									
A-1	Left Wall End	0.00	0.00		2210	98		2151	
A-1	Left Opening 1	8.00	0.00						964
A-1	Right Wall End	13.00	0.00		2210	98		2151	785
Line D									
D-1	Left Wall End	13.00	22.00		1594	1030		976	
D-1	Left Opening 1	15.00	22.00						104
D-1	Right Opening 1	18.00	22.00						83
D-1	Left Opening 2	24.00	22.00						229
D-1	Right Opening 2	26.00	22.00						104
D-1	Left Opening 3	28.00	22.00						208
D-1	Right Opening 3	33.00	22.00						104
D-1	Right Wall End	35.00	22.00		1594	1030		976	

Dead load contribution to combined force is factored by 0.60 load combination factor

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PM-B068

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COMMENTS

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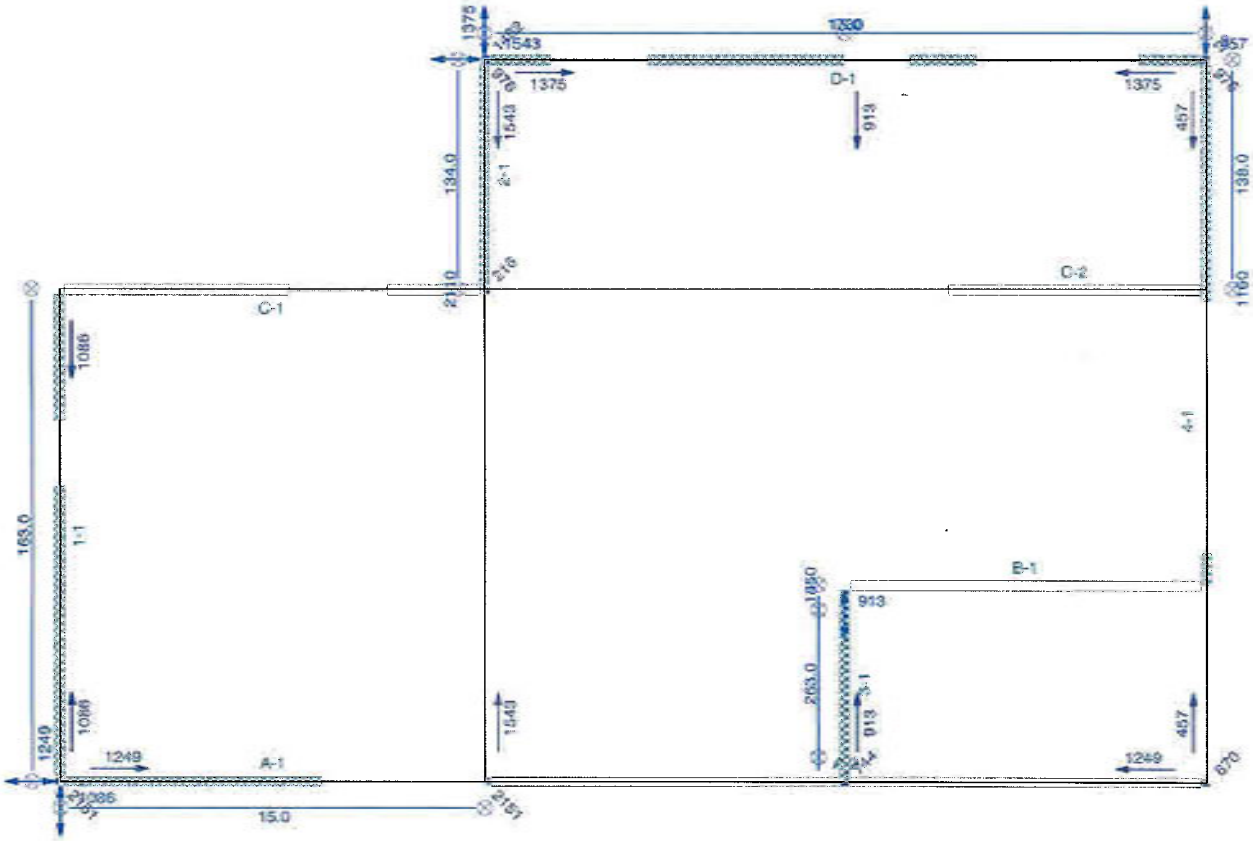
PM-B069

WoodWorks® Shearwalls | **SOFTWARE FOR WOOD DESIGN**

Shear wall.wsw | **WoodWorks® Shearwalls 2004b** | **Mar. 20, 2009 14:07:21**

Level 1 of 1



Loads Shown: W; Forces: W + 0.6D.

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Structural Calculations

COMMENTS

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PM-B070

WoodWorks® Shearwalls | **SOFTWARE FOR WOOD DESIGN**

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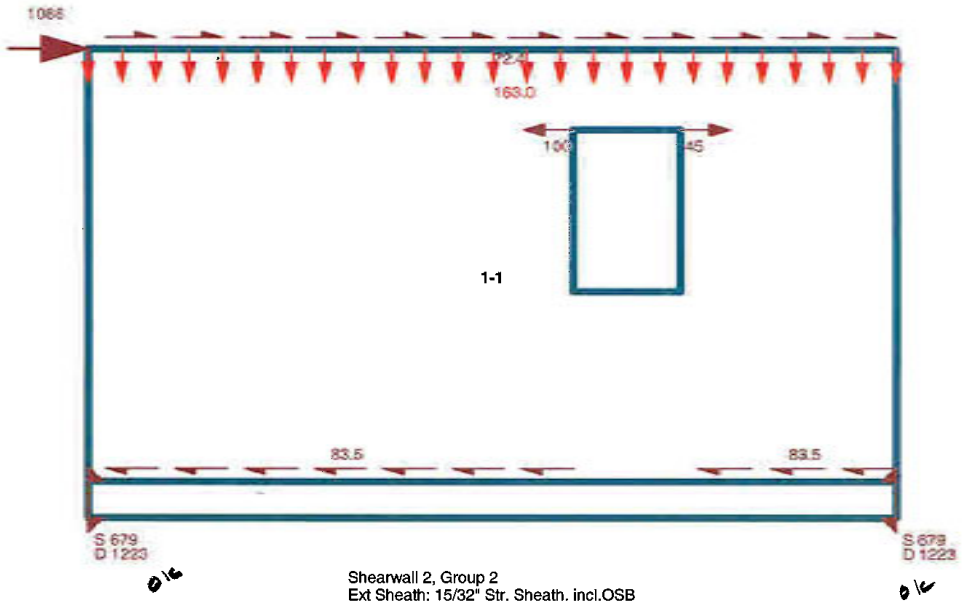
WALL A

Elevation View, Shearline 1, at X = 0 ft, Level 1.
Flexible Diaphragm Wind Design.
Units = lbs, plf



Shearwall 2, Group 2
Ext Sheath: 15/32" Str. Sheath. incl.OSB
Nails: 10d @ 6/12"
Shear: 392.7 plf
Withdr: Load 0 lbs Cap 93.66 lbs
Int Sheath: 1/2" Gypsum WBoard 1-ply
Nails: 5d @ 7/7"
Shear: 73.8 plf
Frame S-P-F @ 24" Blocked

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Structural Calculations

COMMENTS

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PM-B071

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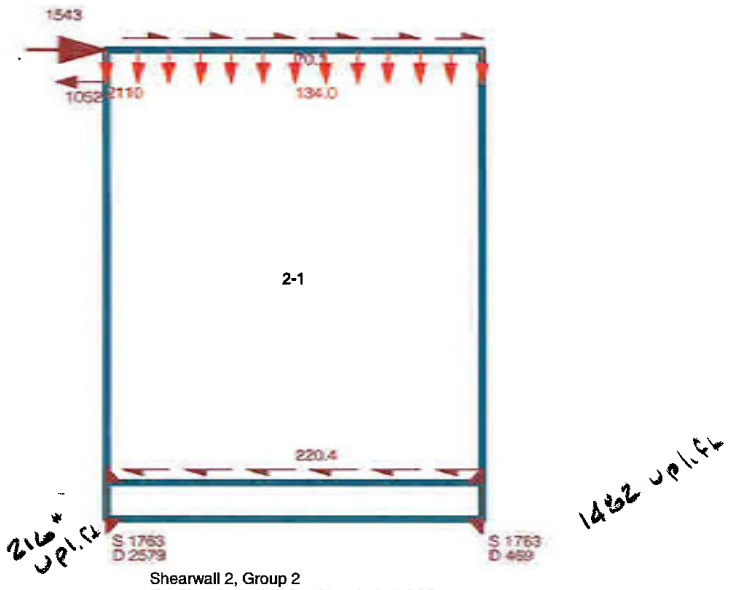
Elevation View, Shearline 2, at X = 13 ft, Level 1.
Flexible Diaphragm Wind Design.
Units = lbs, plf

wall 2



Shearwall 2, Group 2
Ext Sheath: 15/32" Str. Sheath. incl.OSB
Nails: 10d @ 6/12"
Shear: 399.3 plf
Withdr: Load 0 lbs Cap 93.66 lbs
Int Sheath: 1/2" Gypsum WBoard 1-ply
Nails: 5d @ 7/7"
Shear: 75 plf
Frame S-P-F @ 24" Blocked

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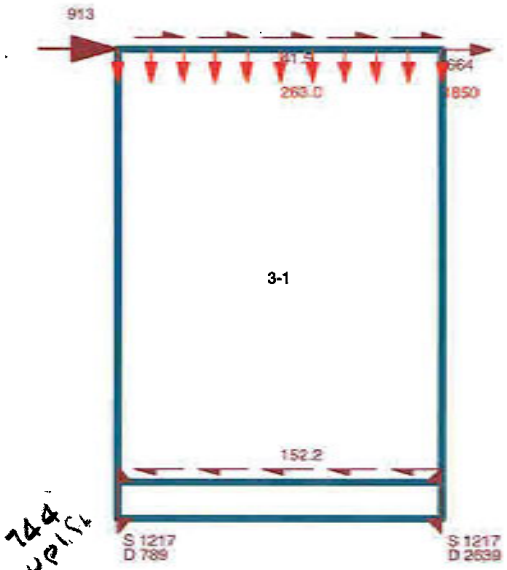
Elevation View, Shearline 3, at X = 24 ft, Level 1.
Flexible Diaphragm Wind Design.
Units = lbs, plf



Shearwall 3, Group 3
Ext Sheath: 15/32" Structural I
Nails: 10d @ 6/12"
Shear: 437.9 plf
Withdr: Load 0 lbs Cap 0 lbs
Int Sheath: 1/2" Gypsum WBoard 1-ply
Nails: 5d @ 7/7"
Shear: 75 plf
Frame S-P-F @ 24" Blocked

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PM-B073

WoodWorks® Shearwalls | **SOFTWARE FOR WOOD DESIGN**

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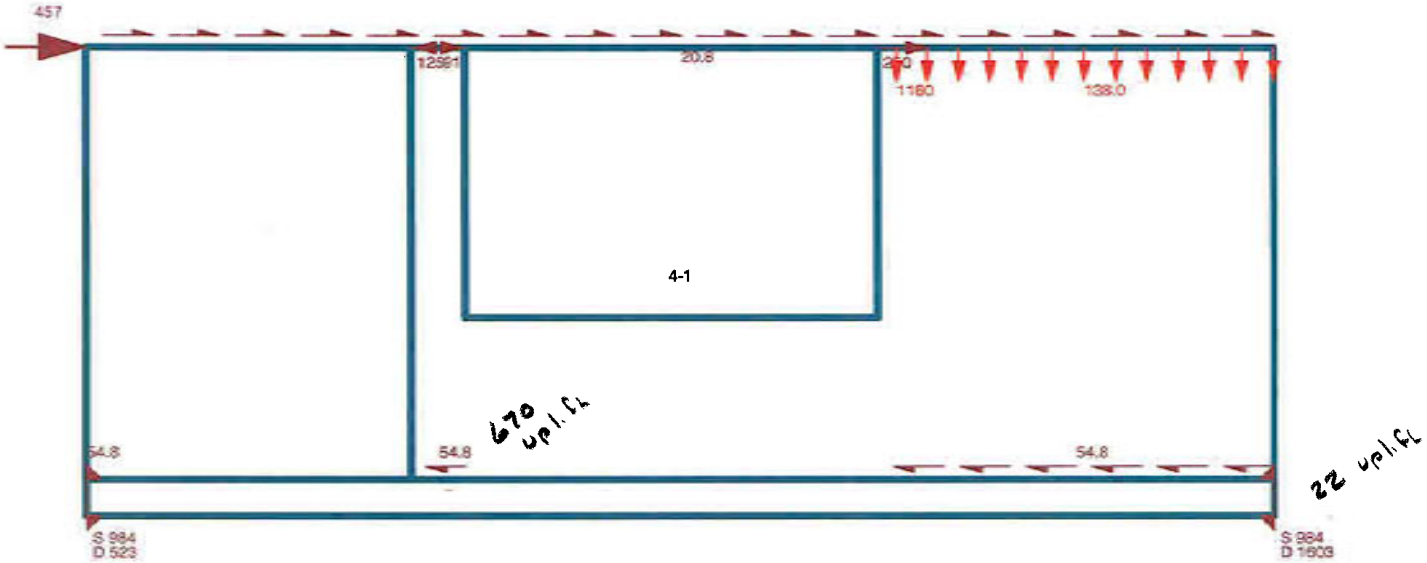
Elevation View, Shearline 4, at X = 35 ft, Level 1.
Flexible Diaphragm Wind Design.
Units = lbs, plf



Shearwall 2, Group 2
Ext Sheath: 15/32" Str. Sheath. incl.OSB
Nails: 10d @ 6/12"
Shear: 178.1 plf
Withdr: Load 0 lbs Cap 93.66 lbs
Int Sheath: 1/2" Gypsum WBoard 1-ply
Nails: 5d @ 7/7"
Shear: 33.4 plf
Frame S-P-F @ 24" Blocked

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Structural Calculations

COMMENTS

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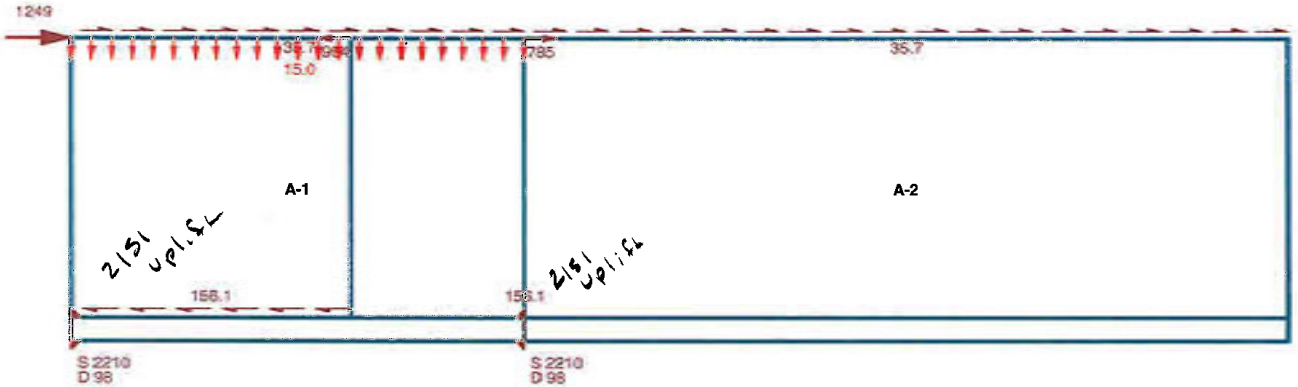
PM-B074

Elevation View, Shearline A, at Y = 0 ft, Level 1.
Flexible Diaphragm Wind Design.
Units = lbs, plf



Shearwall 1, Group 1
Ext Sheath: 5/16" Structural I
Nails: 8d @ 6/12"
Shear: 158.3 plf
Withdr: Load 0 lbs Cap 107.19 lbs
Int Sheath: 1/2" Gypsum WBoard 1-ply
Nails: 5d @ 7/7"
Shear: 42.4 plf
Frame D.Fir-L @ 24" Blocked

Shearwall A-2, Group 0
Ext Sheath: Unknown thickness of Structural I
Nails: 8d @ Unknown spacing/Unknown spacing
Withdr: Load 0 lbs Cap 0 lbs
Int Sheath: 1/2" Gypsum WBoard 1-ply
Nails: 5d @ 7/7"
Frame D.Fir-L @ 16" Blocked

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PM-B075

WoodWorks® Shearwalls SOFTWARE FOR WOOD DESIGN

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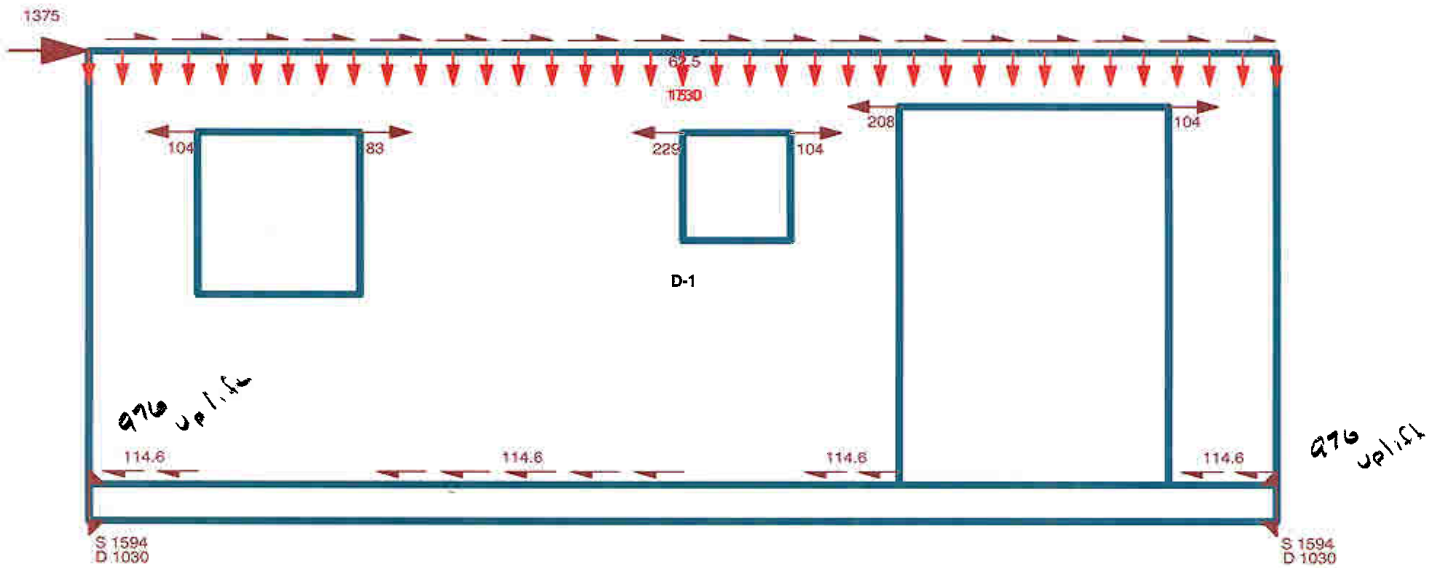
Elevation View, Shearline D, at Y = 22 ft, Level 1.
Flexible Diaphragm Wind Design.
Units = lbs, plf



Shearwall 2, Group 2
Ext Sheath: 15/32" Str. Sheath. incl.OSB
Nails: 10d @ 6/12"
Shear: 229.7 plf
Withdr: Load 0 lbs Cap 93.66 lbs
Int Sheath: 1/2" Gypsum WBoard 1-ply
Nails: 5d @ 7/7"
Shear: 43.1 plf
Frame S-P-F @ 24" Blocked

/est Eas

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Structural Calculations

COMMENTS

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PM-B076

Mattson Macdonald Young
structural engineers
Basset Creek Business Center
901 North 3rd Street, Suite 100
Minneapolis, MN 55401
612-827-7825 voice
612-827-0805 fax

Date 3/23/09
Project Solar Decath
By DHM
SHT F-1

Floor Framing

DL = 15 psf Uniform Floor
LL = 50 psf

See Dtl (F1A) For Superimposed Loads from roof & Walls

Typical Floor Joists
Bay 1 - 2x8 @ 12
all others 2x8 @ 16"
Rim Members = 2-1 3/4 x 7 1/4 LVL
Bms @ Int = 4-1 3/4 x 7 1/4 LVL

Results of Risa Floor see attached
Note: Bay 1 Purlins Overstressed by 4% ok
Deflection by 2% ok

See (F1b) for Summary

Col Reactions = Loads to Ftgs.
See (F1c)
Soil Brg = 1500 psf

Ftg Type			
	A	16x16	2666#
	B	20x20	4166#
	C	30x30	9375#
	D	40x40	16666#

Check Fndn for Uplift Forces

See (F1d) for uplift Loading in comb w/ Dead Loads

See (F1e) for resultant Uplift Forces @ Fnd'n

Holdowns Req'd to Grade

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COMMENTS

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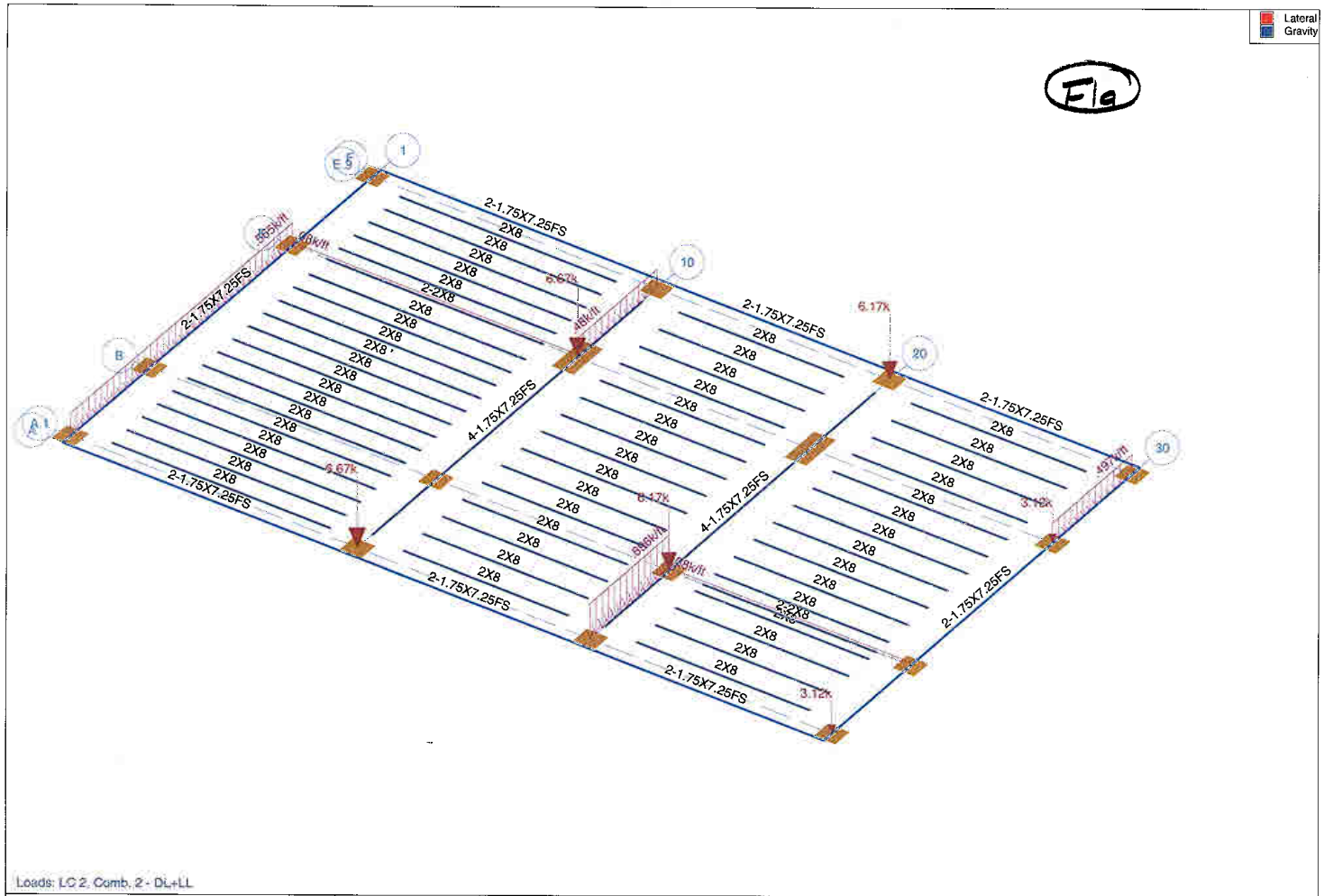
PM-B077



Loads: LC 2, Comb. 2 - DL+LL

Floor 1	
Mar 24, 2009 at 9:11 AM	
Floor.rfl	

ICON SOLAR HOUSE

UNIVERSITY OF MINNESOTA

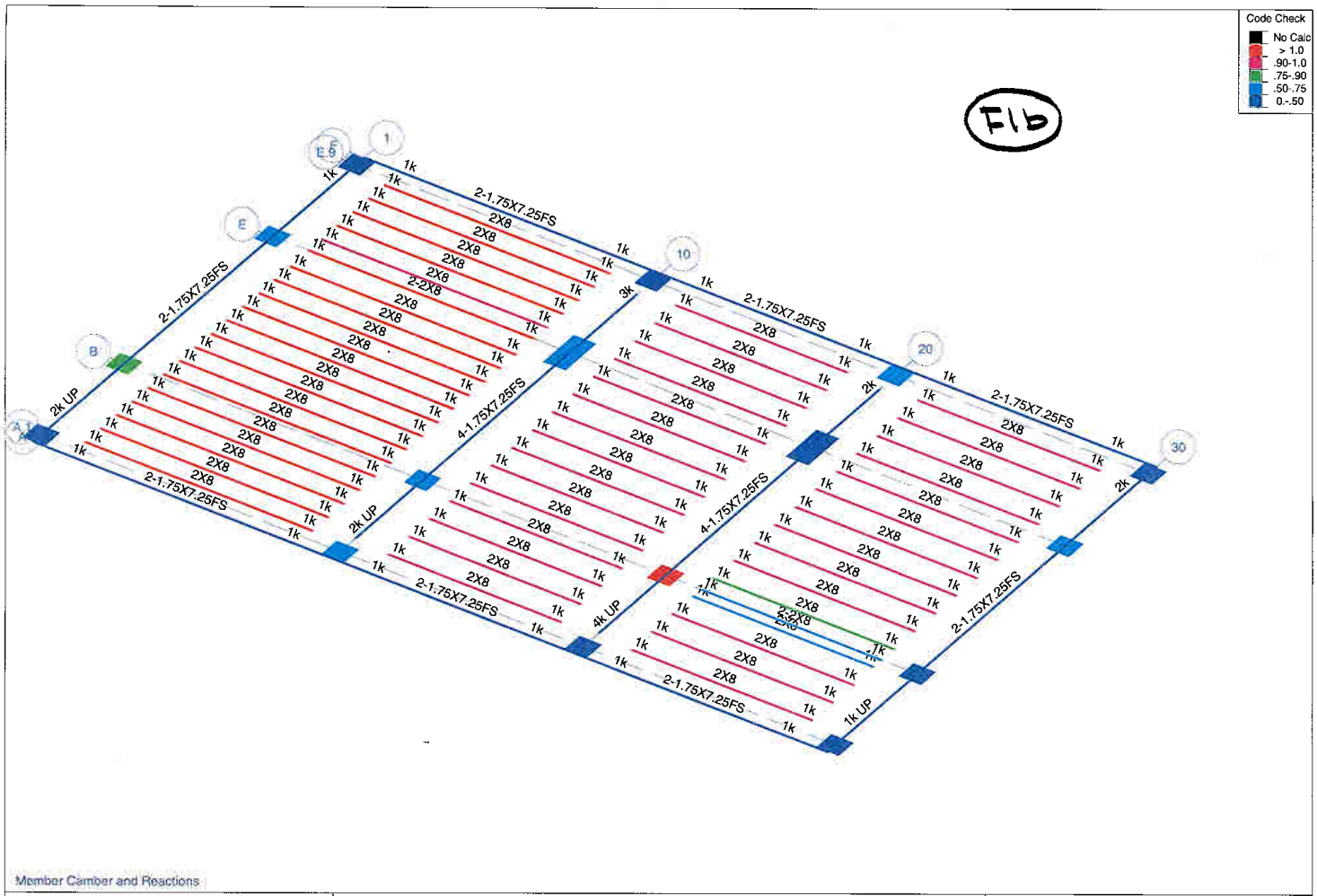
Structural Calculations

COMMENTS

REV DATE 03/26/09

AUTHORED BY Dave MacDonald, P.E.

PM-B078



		Floor 1
		Mar 24, 2009 at 9:17 AM
		Floor.rfl

ICON SOLAR HOUSE

UNIVERSITY OF MINNESOTA

Structural Calculations

COMMENTS

REV DATE 03/26/09

AUTHORED BY Dave MacDonald, P.E.

PM-B079

Company :
Designer :
Job Number :

Mar 24, 2009
9:19 AM
Checked By:_____

Solution Warning Log

	Message
1	Floor 1: Floor 1 - Column L1 CS16 (B-20) (Stack L1 CS16 (B-20)) has failed for Bending Cols no Consideration
2	Floor 1 : Floor 1 - Member PUR11 has failed for Deflection and Bending
3	Floor 1 : Floor 1 - Member PUR12 has failed for Deflection and Bending
4	Floor 1 : Floor 1 - Member PUR13 has failed for Deflection and Bending
5	Floor 1 : Floor 1 - Member PUR14 has failed for Deflection and Bending
6	Floor 1 : Floor 1 - Member PUR15 has failed for Deflection and Bending
7	Floor 1 : Floor 1 - Member PUR16 has failed for Deflection and Bending
8	Floor 1 : Floor 1 - Member PUR17 has failed for Deflection and Bending
9	Floor 1 : Floor 1 - Member PUR18 has failed for Deflection and Bending within 4% ok
10	Floor 1 : Floor 1 - Member PUR19 has failed for Deflection and Bending
11	Floor 1 : Floor 1 - Member PUR20 has failed for Deflection and Bending
12	Floor 1 : Floor 1 - Member PUR21 has failed for Deflection and Bending
13	Floor 1 : Floor 1 - Member PUR22 has failed for Deflection and Bending
14	Floor 1 : Floor 1 - Member PUR23 has failed for Deflection and Bending
15	Floor 1 : Floor 1 - Member PUR24 has failed for Deflection and Bending
16	Floor 1 : Floor 1 - Member PUR27 has failed for Deflection and Bending
17	Floor 1 : Floor 1 - Member PUR28 has failed for Deflection and Bending
18	Floor 1 : Floor 1 - Member PUR29 has failed for Deflection and Bending
19	Floor 1 : Floor 1 - Member PUR30 has failed for Deflection and Bending
20	Floor 1 : Floor 1 - Member M61 has failed for Deflection and Bending Changed to 2 Lrg

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COMMENTS

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03/26/09

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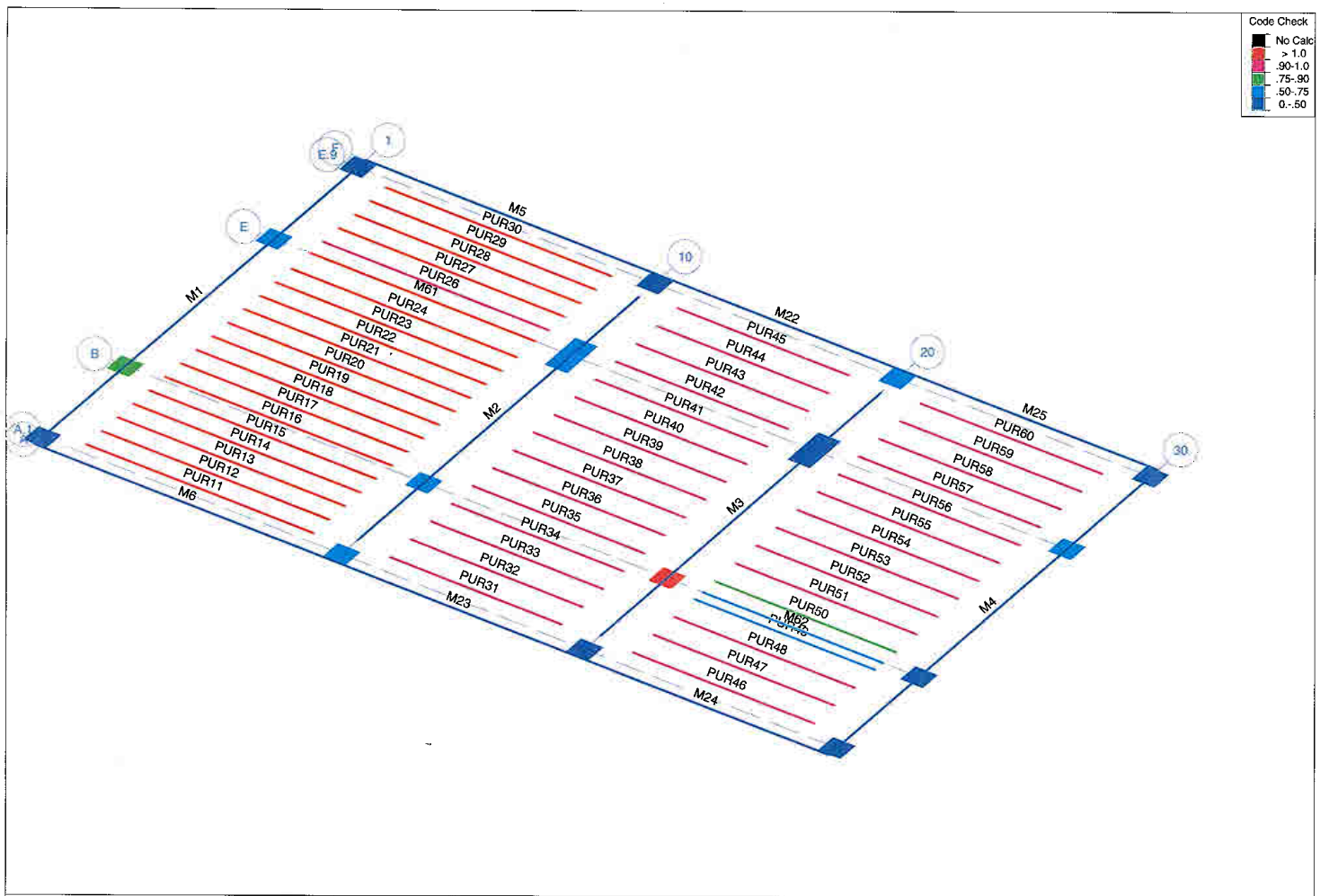
PM-B080



Floor 1	
Mar 24, 2009 at 9:21 AM	
Floor.rfl	

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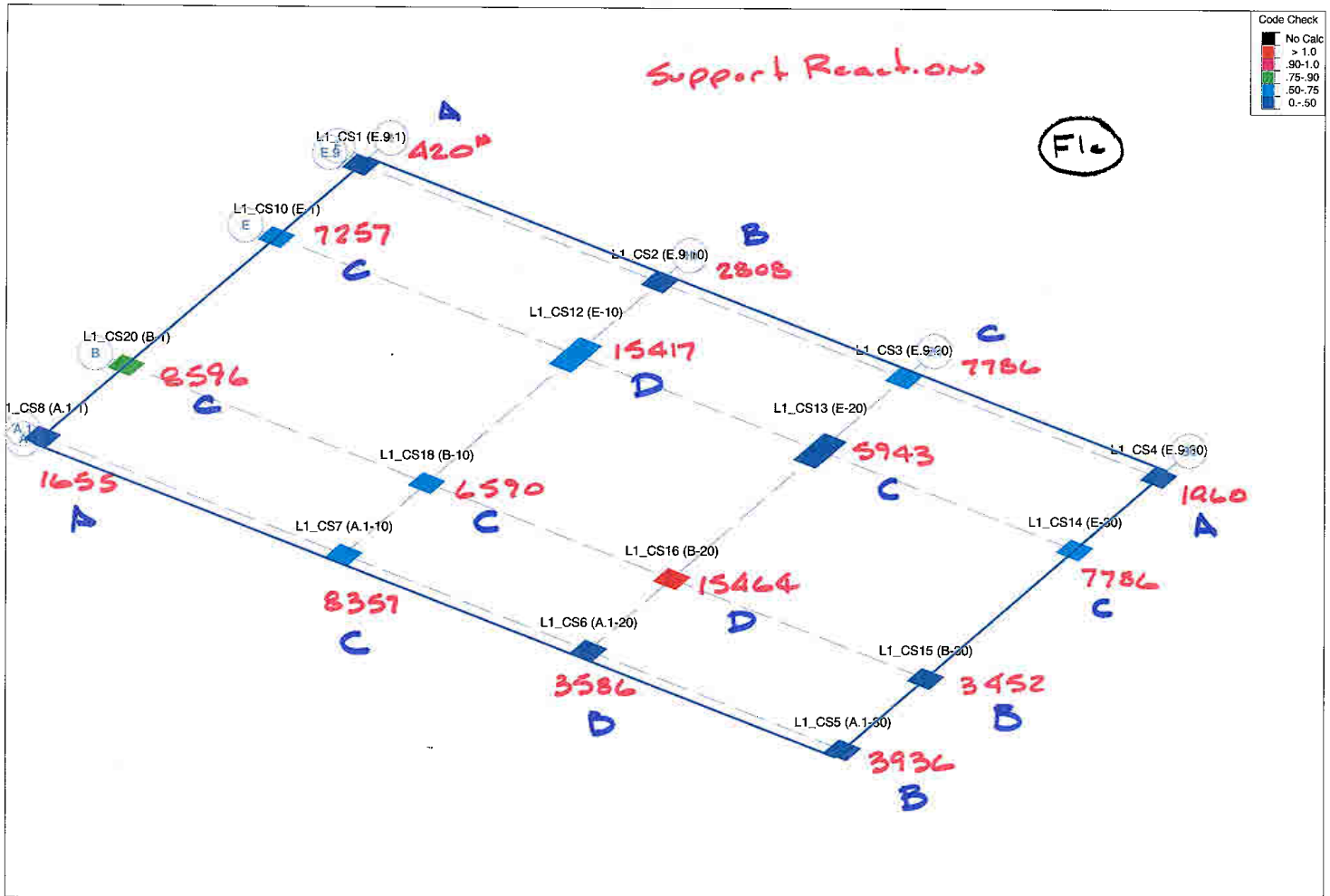
PM-B081



Floor 1	
Mar 24, 2009 at 9:24 AM	
Floor.rfl	

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Structural Calculations

COMMENTS

REV DATE 03/26/09

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PM-B082

Column Forces/Moments, Dead & Other Categories : Floor 1

	Column Stack	Lift No.	Floor Label	Coordinat...	Max Base Reaction[k]	Max Ba...	DLPre[k]	DL[k]	OL1[k]	OL2[k]	OL3[k]	OL4[k]
1	CS1 (E.9-1)	1	Floor 1	0,20.083	.42	2	.131	.098	0	0	0	0
2	CS2 (E.9-10)	1	Floor 1	12.438,20...	2.808	2	.222	1.051	0	0	0	0
3	CS3 (E.9-20)	1	Floor 1	22.615,20...	7.786	2	.199	2.588	0	0	0	0
4	CS4 (E.9-30)	1	Floor 1	33.188,20...	1.96	2	.109	.783	0	0	0	0
5	CS5 (A.1-30)	1	Floor 1	33.188,.5	3.936	2	.107	1.319	0	0	0	0
6	CS6 (A.1-20)	1	Floor 1	22.615,.5	3.586	2	.196	1.311	0	0	0	0
7	CS7 (A.1-10)	1	Floor 1	12.438,.5	8.357	2	.218	2.786	0	0	0	0
8	CS8 (A.1-1)	1	Floor 1	0,.5	1.655	2	.129	.625	0	0	0	0
9	CS10 (E-1)	1	Floor 1	0,14.875	7.257	2	.375	2.93	0	0	0	0
10	CS12 (E-10)	1	Floor 1	12.438,14...	15.417	2	.654	5.428	0	0	0	0
11	CS13 (E-20)	1	Floor 1	22.615,14...	5.943	2	.565	1.768	0	0	0	0
12	CS14 (E-30)	1	Floor 1	33.188,14...	7.786	2	.286	2.659	0	0	0	0
13	CS15 (B-30)	1	Floor 1	33.188,5....	3.452	2	.313	1.334	0	0	0	0
14	CS16 (B-20)	1	Floor 1	22.615,5....	15.464	2	.575	5.394	0	0	0	0
15	CS18 (B-10)	1	Floor 1	12.438,5....	6.59	2	.619	1.97	0	0	0	0
16	CS20 (B-1)	1	Floor 1	0,5.646	8.596	2	.357	3.205	0	0	0	0

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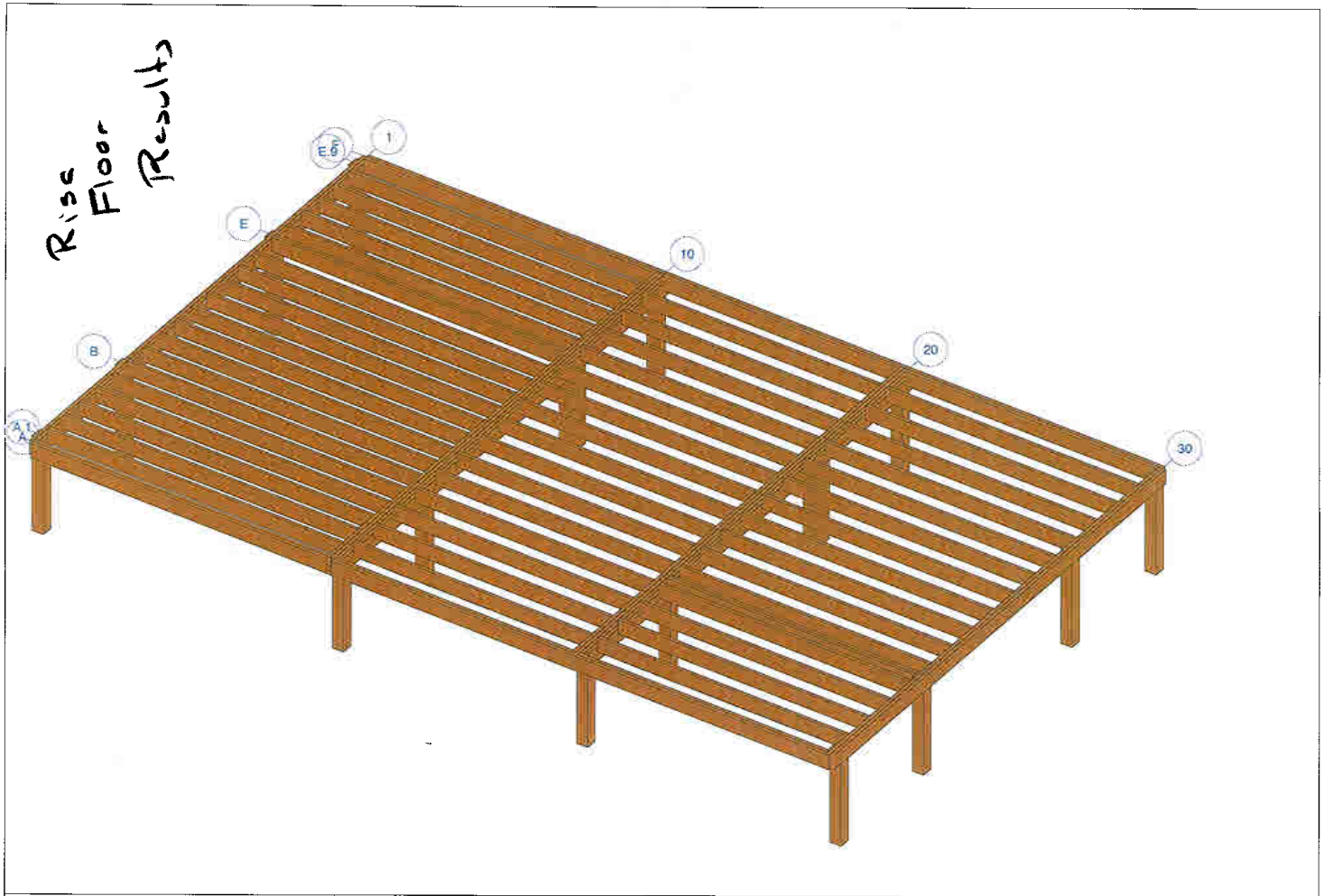
PM-B083

Rise Floor Results



Floor 1	
Mar 24, 2009 at 9:45 AM	
Floor.rfl	

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Structural Calculations

AUTHORED BY
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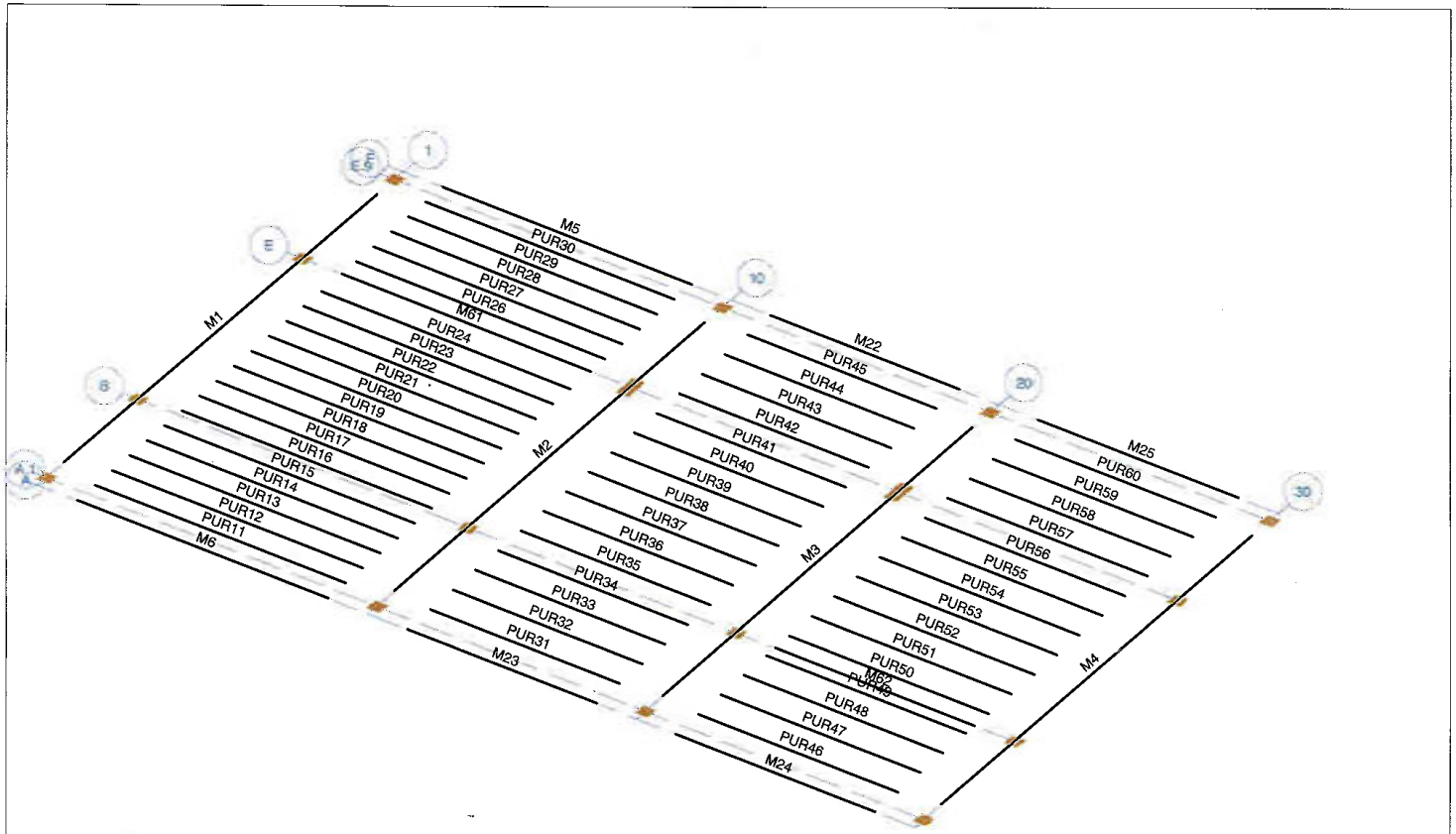
REV DATE
03/26/09

COMMENTS

PM-B084



Floor 1	
Mar 24, 2009 at 10:01 AM	
Floor.rfl	

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Structural Calculations

COMMENTS

REV DATE 03/26/09

AUTHORED BY Dave MacDonald, P.E.

PM-B085

Horizontal Project Grid Locations

	Label	Distance [ft]	Increment [ft]
1	1	0	0
2	10	12.438	12.438
3	20	22.615	10.177
4	30	33.188	10.573

Vertical Project Grid Locations

	Label	Distance [ft]	Increment [ft]
1	A	0	0
2	A.1	.5	.5
3	B	5.646	5.146
4	E	14.875	9.229
5	E.9	20.083	5.208
6	F	20.583	.5

Wood Material Properties

	Label	Species	Grade	Cm	Emod	Nu	Therm (\1E5 F)	Dens[k/ft^3]
1	Hem Fir No 2	Hem-Fir	No 2		1	.3	.3	.035
2	1.3 Lsl Joist	1.3 Lsl	na		1	.3	.3	.035
3	1.9 Lvl Beam	1.9 Lvl	na		1	.3	.3	.035

Deck General Properties

	Label	Thickness [in]	f'c [ksi]	Wt [k/ft^3]	Elastic Modulus [ksi]	Max Span[ft]	Unbraced[ft]
1	Plywood Deck	0	1	0	0	2.5	2.5

Deck Loads

	Label	Two Way	Self Wt [ksf]	Const DL [ksf]	Const LL [ksf]
1	Plywood Deck		.003	0	.02

Design Deflection Parameters

	Label	DL Defl[in]	DL Ratio	LL Defl[in]	LL Ratio	DL+LL Defl[...	DL+LL Ratio	Category	Defl[in]	Ratio	Category	Defl[in]	Ratio
1	Typical		240		360		240	None		360	None		360

Uniform Area Loads

	Label	Additive	PreDL[ksf]	PostDL[ksf]	LL[ksf]	LL Type	VL[ksf]	Dyn Load[ksf]
1	Residential			.015	.05	LL		

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Structural Calculations

COMMENTS

REV DATE 03/26/09

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PM-B086

Beam Primary Data : Floor 1

	Label	Start Point	End Point	Shape	Material	Design Rules	Function	Orientation	Start Release	End Release
1	M1	N9	N10	2-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Fixed	Pinned
2	M2	N12	N11	4-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Fixed	Fixed
3	M3	N13	N16	4-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Fixed	Fixed
4	M4	N14	N15	2-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Fixed	Fixed
5	M5	N9	N12	2-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Pinned	Pinned
6	M6	N10	N11	2-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Pinned	Pinned
7	M22	N12	N13	2-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Pinned	Pinned
8	M23	N11	N16	2-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Pinned	Pinned
9	M24	N16	N15	2-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Pinned	Pinned
10	M25	N13	N14	2-1.75X7.25FS	1.9 Lvl Beam	Typical	Gravity	Strong Axis	Pinned	Pinned
11	PUR11	N77	N78	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
12	PUR12	N125	N126	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
13	PUR13	N127	N128	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
14	PUR14	N129	N130	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
15	PUR15	N131	N132	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
16	PUR16	N133	N134	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
17	PUR17	N135	N136	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
18	PUR18	N137	N138	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
19	PUR19	N139	N140	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
20	PUR20	N141	N142	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
21	PUR21	N143	N144	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
22	PUR22	N145	N146	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
23	PUR23	N147	N148	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
24	PUR24	N149	N150	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
25	PUR26	N153	N154	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
26	PUR27	N155	N156	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
27	PUR28	N157	N158	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
28	PUR29	N159	N160	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
29	PUR30	N161	N162	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
30	PUR31	N18	N47	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
31	PUR32	N163	N164	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
32	PUR33	N165	N166	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
33	PUR34	N167	N168	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
34	PUR35	N169	N170	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
35	PUR36	N171	N172	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
36	PUR37	N173	N174	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
37	PUR38	N175	N176	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
38	PUR39	N177	N178	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
39	PUR40	N179	N180	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
40	PUR41	N181	N182	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
41	PUR42	N183	N184	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned

ICON SOLAR HOUSE
UNIVERSITY OF MINNESOTA

Structural Calculations

COMMENTS

REV DATE
03/26/09

AUTHORED BY
Dave MacDonald, P.E.

PM-B087

Beam Primary Data : Floor 1 (Continued)

	Label	Start Point	End Point	Shape	Material	Design Rules	Function	Orientation	Start Release	End Release
42	PUR43	N185	N186	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
43	PUR44	N187	N188	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
44	PUR45	N189	N190	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
45	PUR46	N47	N62	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
46	PUR47	N164	N191	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
47	PUR48	N166	N192	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
48	PUR49	N168	N193	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
49	PUR50	N170	N194	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
50	PUR51	N172	N195	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
51	PUR52	N174	N196	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
52	PUR53	N176	N197	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
53	PUR54	N178	N198	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
54	PUR55	N180	N199	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
55	PUR56	N182	N200	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
56	PUR57	N184	N201	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
57	PUR58	N186	N202	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
58	PUR59	N188	N203	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
59	PUR60	N190	N204	2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
60	M61	N117	N118	2-2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned
61	M62	N122	N121	2-2X8	Hem Fir No 2	Typical	Gravity	Strong Axis	Pinned	Pinned

Beam Primary Data : Floor 2

	Label	Start Point	End Point	Shape	Material	Design Rules	Function	Orientation	Start Release	End Release
No Data to Print ...										

Wood : Floor 1

	Label	Length[ft]	le-bend Top[ft]	le-bend Bot[ft]	CV	Repetitive
1	M1	20.583	1.33	1.33		No
2	M2	20.583	1.33	1.33		Yes
3	M3	20.583	1.33	1.33		Yes
4	M4	20.583	1.33	1.33		No
5	M5	12.438	1.33	1.33		Yes
6	M6	12.438	1.33	1.33		Yes
7	M22	10.177	1.33	1.33		Yes
8	M23	10.177	1.33	1.33		Yes
9	M24	10.573	1.33	1.33		Yes
10	M25	10.573	1.33	1.33		Yes
11	PUR11	12.438	1.33	1.33		Yes
12	PUR12	12.438	1.33	1.33		Yes
13	PUR13	12.438	1.33	1.33		Yes

ICON SOLAR HOUSE
UNIVERSITY OF MINNESOTA

Structural Calculations

COMMENTS

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PM-B088

Wood : Floor 1 (Continued)

	Label	Length[ft]	le-bend Top[ft]	le-bend Bot[ft]	CV	Repetitive
14	PUR14	12.438	1.33	1.33		Yes
15	PUR15	12.438	1.33	1.33		Yes
16	PUR16	12.438	1.33	1.33		Yes
17	PUR17	12.438	1.33	1.33		Yes
18	PUR18	12.438	1.33	1.33		Yes
19	PUR19	12.438	1.33	1.33		Yes
20	PUR20	12.438	1.33	1.33		Yes
21	PUR21	12.438	1.33	1.33		Yes
22	PUR22	12.438	1.33	1.33		Yes
23	PUR23	12.438	1.33	1.33		Yes
24	PUR24	12.438	1.33	1.33		Yes
25	PUR26	12.438	1.33	1.33		Yes
26	PUR27	12.438	1.33	1.33		Yes
27	PUR28	12.438	1.33	1.33		Yes
28	PUR29	12.438	1.33	1.33		Yes
29	PUR30	12.438	1.33	1.33		Yes
30	PUR31	10.177	1.33	1.33		Yes
31	PUR32	10.177	1.33	1.33		Yes
32	PUR33	10.177	1.33	1.33		Yes
33	PUR34	10.177	1.33	1.33		Yes
34	PUR35	10.177	1.33	1.33		Yes
35	PUR36	10.177	1.33	1.33		Yes
36	PUR37	10.177	1.33	1.33		Yes
37	PUR38	10.177	1.33	1.33		Yes
38	PUR39	10.177	1.33	1.33		Yes
39	PUR40	10.177	1.33	1.33		Yes
40	PUR41	10.177	1.33	1.33		Yes
41	PUR42	10.177	1.33	1.33		Yes
42	PUR43	10.177	1.33	1.33		Yes
43	PUR44	10.177	1.33	1.33		Yes
44	PUR45	10.177	1.33	1.33		Yes
45	PUR46	10.573	1.33	1.33		Yes
46	PUR47	10.573	1.33	1.33		Yes
47	PUR48	10.573	1.33	1.33		Yes
48	PUR49	10.573	1.33	1.33		Yes
49	PUR50	10.573	1.33	1.33		Yes
50	PUR51	10.573	1.33	1.33		Yes
51	PUR52	10.573	1.33	1.33		Yes
52	PUR53	10.573	1.33	1.33		Yes
53	PUR54	10.573	1.33	1.33		Yes
54	PUR55	10.573	1.33	1.33		Yes

ICON SOLAR HOUSE
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PM-B089

Wood : Floor 1 (Continued)

	Label	Length[ft]	le-bend Top[ft]	le-bend Bot[ft]	CV	Repetitive
55	PUR56	10.573	1.33	1.33		Yes
56	PUR57	10.573	1.33	1.33		Yes
57	PUR58	10.573	1.33	1.33		Yes
58	PUR59	10.573	1.33	1.33		Yes
59	PUR60	10.573	1.33	1.33		Yes
60	M61	12.438	1.33	1.33		Yes
61	M62	10.573	1.33	1.33		Yes

Wood : Floor 2

	Label	Length[ft]	le-bend Top[ft]	le-bend Bot[ft]	CV	Repetitive
No Data to Print ...						

Point Loads : Floor 1

	Point Label	PreDL[k]	PostDL[k]	LL[k]	LL Type	Dyn Load[k]
1	N7		2.22	4.45	LL	
2	N118		2.22	4.45	LL	
3	N122		2.05	4.12	LL	
4	N3		2.05	4.12	LL	
5	N5		1.04	2.08	LL	
6	N120		1.04	2.08	LL	

Point Loads : Floor 2

	Point Label	PreDL[k]	PostDL[k]	LL[k]	LL Type	Dyn Load[k]
No Data to Print ...						

Line Loads : Floor 1

	Start Point	End Point	Start PreDL[...	End PreDL[k/...	Start PostDL[k/ft]	End PostDL[k/ft]	Start LL[k/ft]	End LL[k/ft]	LL Type	St Dyn Load[k/ft]	End Dyn Load[k/ft]
1	N117	N8			.24	.24	.325	.325	LL		
2	N118	N2			.21	.21	.27	.27	LL		
3	N122	N6			.35	.35	.546	.546	LL		
4	N4	N120			.22	.22	.277	.277	LL		
5	N117	N118			.08	.08			LL		
6	N122	N121			.08	.08			LL		

Line Loads : Floor 2

Start Point	End Point	Start PreDL[...	End PreDL[k/...	Start PostDL[k/ft]	End PostDL[k/ft]	Start LL[k/ft]	End LL[k/ft]	LL Type	St Dyn Load[k/ft]	End Dyn Load[k/ft]
No Data to Print ...										

ICON SOLAR HOUSE
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REV DATE 03/26/09

AUTHORED BY Dave MacDonald, P.E.

PM-B090

Combinations

	Label	Solve	Category	Factor	Category	Factor	Category	Factor	Category	Factor	Category	Factor	Category	Factor	Category	Factor	Category	Factor
1	Comb. 1 - DL		DL	1														
2	Comb. 2 - DL+LL	Yes	DL	1	LL	1												
3	Comb 3 - LL		LL	1														

Combination Design

	Label	ASIF	CD	Hot Rolled Steel	Cold Formed Steel	Wood	Wood Products	Concrete
1	Comb. 1 - DL					Yes	Yes	
2	Comb. 2 - DL+LL					Yes	Yes	
3	Comb 3 - LL					Yes	Yes	

Floors

	Label	Elevation[ft]	Area Load Default	Deck Default	Deck Angle Default ...	Parent	Inactive	Splice Distance Below...	Splice Type
1	Floor 1	0	Residential	Plywood Deck	0	None		10	Moment
2	Floor 2	6.667	Residential	Plywood Deck	0	None		5	Moment

Custom Wood Properties

	Label	Fb [ksi]	Ft [ksi]	Fv [ksi]	Fc [ksi]	E [ksi]	SCL
1	1.3 Lsl	1.7	1.075	.4	1.4	1300	Yes
2	1.9 Lvl	2.6	1.555	.285	2.51	1900	Yes

Beam Design for Wood : Floor 1

	Label	Size	Explicit	Material	Max Start Reac...	Max End Reacti...	Min Start Reacti...	Min End Reactio...
1	M1	2-1.75X7.25FS	Yes	1.9 Lvl Beam	.404	-1.558	.404	-1.558
2	M2	4-1.75X7.25FS	Yes	1.9 Lvl Beam	2.722	-1.67	2.722	-1.67
3	M3	4-1.75X7.25FS	Yes	1.9 Lvl Beam	1.599	-3.441	1.599	-3.441
4	M4	2-1.75X7.25FS	Yes	1.9 Lvl Beam	1.873	-.8	1.873	-.8
5	M5	2-1.75X7.25FS	Yes	1.9 Lvl Beam	.246	.246	.246	.246
6	M6	2-1.75X7.25FS	Yes	1.9 Lvl Beam	.247	.247	.247	.247
7	M22	2-1.75X7.25FS	Yes	1.9 Lvl Beam	.254	.254	.254	.254
8	M23	2-1.75X7.25FS	Yes	1.9 Lvl Beam	.255	.255	.255	.255
9	M24	2-1.75X7.25FS	Yes	1.9 Lvl Beam	.265	.265	.265	.265
10	M25	2-1.75X7.25FS	Yes	1.9 Lvl Beam	.264	.264	.264	.264
11	PUR11	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
12	PUR12	2X8	Yes	Hem Fir No 2	.43	.43	.43	.43
13	PUR13	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
14	PUR14	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
15	PUR15	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
16	PUR16	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
17	PUR17	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431

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Beam Design for Wood : Floor 1 (Continued)

	Label	Size	Explicit	Material	Max Start Reac...	Max End Reacti...	Min Start Reacti...	Min End Reactio...
18	PUR18	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
19	PUR19	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
20	PUR20	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
21	PUR21	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
22	PUR22	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
23	PUR23	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
24	PUR24	2X8	Yes	Hem Fir No 2	.467	.467	.467	.467
25	PUR26	2X8	Yes	Hem Fir No 2	.394	.394	.394	.394
26	PUR27	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
27	PUR28	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
28	PUR29	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
29	PUR30	2X8	Yes	Hem Fir No 2	.431	.431	.431	.431
30	PUR31	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
31	PUR32	2X8	Yes	Hem Fir No 2	.455	.455	.455	.455
32	PUR33	2X8	Yes	Hem Fir No 2	.456	.456	.456	.456
33	PUR34	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
34	PUR35	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
35	PUR36	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
36	PUR37	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
37	PUR38	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
38	PUR39	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
39	PUR40	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
40	PUR41	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
41	PUR42	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
42	PUR43	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
43	PUR44	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
44	PUR45	2X8	Yes	Hem Fir No 2	.459	.459	.459	.459
45	PUR46	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
46	PUR47	2X8	Yes	Hem Fir No 2	.472	.472	.472	.472
47	PUR48	2X8	Yes	Hem Fir No 2	.474	.474	.474	.474
48	PUR49	2X8	Yes	Hem Fir No 2	.335	.335	.335	.335
49	PUR50	2X8	Yes	Hem Fir No 2	.387	.387	.387	.387
50	PUR51	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
51	PUR52	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
52	PUR53	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
53	PUR54	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
54	PUR55	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
55	PUR56	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
56	PUR57	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
57	PUR58	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
58	PUR59	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476

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Beam Design for Wood : Floor 1 (Continued)

	Label	Size	Explicit	Material	Max Start Reac...	Max End Reacti...	Min Start Reacti...	Min End Reactio...
59	PUR60	2X8	Yes	Hem Fir No 2	.476	.476	.476	.476
60	M61	2-2X8	Yes	Hem Fir No 2	.945	.945	.945	.945
61	M62	2-2X8	Yes	Hem Fir No 2	.682	.682	.682	.682

Beam Design for Wood : Floor 2

Label	Size	Explicit	Material	Max Start Reac...	Max End Reacti...	Min Start Reacti...	Min End Reactio...
No Data to Print ...							

Beam Design for Wood Products : Floor 1

Label	Size	Explicit	Vmax[k]	V'[k]	Mmax[k-ft]	M'r[k-ft]	Max Start Rea...	Max End Reac..	Min Start Rea...	Min End React...
No Data to Print ...										

Beam Design for Wood Products : Floor 2

Label	Size	Explicit	Vmax[k]	V'[k]	Mmax[k-ft]	M'r[k-ft]	Max Start Rea...	Max End Reac..	Min Start Rea...	Min End React...
No Data to Print ...										

Beam Code Summary for Wood : Floor 1

	Label	Size	Explicit	Material	Bending Check	Loc[ft]	LC	Defl Check	Loc[ft]	Cat	Shear Check	Loc[ft]	LC
1	M1	2-1.75X7.25FS	Yes	1.9 Lvl Be...	.763	15.009	2	.604	10.292	DL+LL	.996	14.794	2
2	M2	4-1.75X7.25FS	Yes	1.9 Lvl Be...	.316	5.789	2	.217	10.506	LL	.432	5.575	2
3	M3	4-1.75X7.25FS	Yes	1.9 Lvl Be...	.315	15.009	2	.18	10.292	LL	.534	15.009	2
4	M4	2-1.75X7.25FS	Yes	1.9 Lvl Be...	.354	5.789	2	.196	0	DL+LL	.577	5.575	2
5	M5	2-1.75X7.25FS	Yes	1.9 Lvl Be...	.092	6.219	2	.162	6.219	DL+LL	.051	0	2
6	M6	2-1.75X7.25FS	Yes	1.9 Lvl Be...	.093	6.219	2	.163	6.219	DL+LL	.051	0	2
7	M22	2-1.75X7.25FS	Yes	1.9 Lvl Be...	.078	5.089	2	.112	5.089	DL+LL	.053	0	2
8	M23	2-1.75X7.25FS	Yes	1.9 Lvl Be...	.078	5.089	2	.113	5.089	DL+LL	.053	0	2
9	M24	2-1.75X7.25FS	Yes	1.9 Lvl Be...	.085	5.286	2	.126	5.286	DL+LL	.055	10.573	2
10	M25	2-1.75X7.25FS	Yes	1.9 Lvl Be...	.084	5.286	2	.126	5.286	DL+LL	.055	10.573	2
11	PUR11	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
12	PUR12	2X8	Yes	Hem Fir N...	1.04	6.219	2	1.025	6.219	LL	.395	0	2
13	PUR13	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
14	PUR14	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
15	PUR15	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
16	PUR16	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
17	PUR17	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
18	PUR18	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
19	PUR19	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
20	PUR20	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2
21	PUR21	2X8	Yes	Hem Fir N...	1.043	6.219	2	1.028	6.219	LL	.396	0	2

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Beam Code Summary for Wood : Floor 1 (Continued)

	Label	Size	Explicit	Material	Bending Check	Loc[ft]	LC	Defl Check	Loc[ft]	Cat	Shear Check	Loc[ft]	LC
22	PUR22	2X8	Yes	Hem Fir N..	1.043	6.219	2	1.028	6.219	LL	.396	0	2
23	PUR23	2X8	Yes	Hem Fir N..	1.043	6.219	2	1.028	6.219	LL	.396	0	2
24	PUR24	2X8	Yes	Hem Fir N..	1.132	6.219	2	1.118	6.219	LL	.43	0	2
25	PUR26	2X8	Yes	Hem Fir N..	.955	6.219	2	.937	6.219	LL	.363	0	2
26	PUR27	2X8	Yes	Hem Fir N..	1.043	6.219	2	1.028	6.219	LL	.396	0	2
27	PUR28	2X8	Yes	Hem Fir N..	1.043	6.219	2	1.028	6.219	LL	.396	0	2
28	PUR29	2X8	Yes	Hem Fir N..	1.043	6.219	2	1.028	6.219	LL	.396	0	2
29	PUR30	2X8	Yes	Hem Fir N..	1.043	6.219	2	1.028	6.219	LL	.396	0	2
30	PUR31	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
31	PUR32	2X8	Yes	Hem Fir N..	.9	5.089	2	.732	5.089	LL	.418	0	2
32	PUR33	2X8	Yes	Hem Fir N..	.903	5.089	2	.735	5.089	LL	.419	0	2
33	PUR34	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
34	PUR35	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
35	PUR36	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
36	PUR37	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
37	PUR38	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
38	PUR39	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
39	PUR40	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
40	PUR41	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
41	PUR42	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
42	PUR43	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
43	PUR44	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
44	PUR45	2X8	Yes	Hem Fir N..	.908	5.089	2	.739	5.089	LL	.422	0	2
45	PUR46	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
46	PUR47	2X8	Yes	Hem Fir N..	.972	5.286	2	.821	5.286	LL	.434	10.573	2
47	PUR48	2X8	Yes	Hem Fir N..	.975	5.286	2	.824	5.286	LL	.436	10.573	2
48	PUR49	2X8	Yes	Hem Fir N..	.689	5.286	2	.575	5.286	LL	.308	10.573	2
49	PUR50	2X8	Yes	Hem Fir N..	.795	5.286	2	.668	5.286	LL	.355	10.573	2
50	PUR51	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
51	PUR52	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
52	PUR53	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
53	PUR54	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
54	PUR55	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
55	PUR56	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
56	PUR57	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
57	PUR58	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
58	PUR59	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
59	PUR60	2X8	Yes	Hem Fir N..	.98	5.286	2	.829	5.286	LL	.438	10.573	2
60	M61	2-2X8	Yes	Hem Fir N..	1.144	6.219	2	1.062	6.219	DL+LL	.434	0	2
61	M62	2-2X8	Yes	Hem Fir N..	.702	5.286	2	.554	5.286	DL+LL	.314	10.573	2

Beam Code Summary for Wood : Floor 2

Label	Size	Explicit	Material	Bending Check	Loc[ft]	LC	Defl Check	Loc[ft]	Cat	Shear Check	Loc[ft]	LC
No Data to Print ...												

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Beam Shear Results for Wood : Floor 1

	Label	Size	F'v[ksi]	fv[ksi]	Shear Check	Loc[ft]	LC
1	M1	2-1.75X7.25FS	.285	.284	.996	14.794	2
2	M2	4-1.75X7.25FS	.285	.123	.432	5.575	2
3	M3	4-1.75X7.25FS	.285	.152	.534	15.009	2
4	M4	2-1.75X7.25FS	.285	.164	.577	5.575	2
5	M5	2-1.75X7.25FS	.285	.015	.051	0	2
6	M6	2-1.75X7.25FS	.285	.015	.051	0	2
7	M22	2-1.75X7.25FS	.285	.015	.053	0	2
8	M23	2-1.75X7.25FS	.285	.015	.053	0	2
9	M24	2-1.75X7.25FS	.285	.016	.055	10.573	2
10	M25	2-1.75X7.25FS	.285	.016	.055	10.573	2
11	PUR11	2X8	.15	.059	.396	0	2
12	PUR12	2X8	.15	.059	.395	0	2
13	PUR13	2X8	.15	.059	.396	0	2
14	PUR14	2X8	.15	.059	.396	0	2
15	PUR15	2X8	.15	.059	.396	0	2
16	PUR16	2X8	.15	.059	.396	0	2
17	PUR17	2X8	.15	.059	.396	0	2
18	PUR18	2X8	.15	.059	.396	0	2
19	PUR19	2X8	.15	.059	.396	0	2
20	PUR20	2X8	.15	.059	.396	0	2
21	PUR21	2X8	.15	.059	.396	0	2
22	PUR22	2X8	.15	.059	.395	0	2
23	PUR23	2X8	.15	.059	.396	0	2
24	PUR24	2X8	.15	.064	.43	0	2
25	PUR26	2X8	.15	.054	.363	0	2
26	PUR27	2X8	.15	.059	.396	0	2
27	PUR28	2X8	.15	.059	.396	0	2
28	PUR29	2X8	.15	.059	.396	0	2
29	PUR30	2X8	.15	.059	.396	0	2
30	PUR31	2X8	.15	.063	.422	0	2
31	PUR32	2X8	.15	.063	.418	0	2
32	PUR33	2X8	.15	.063	.419	0	2
33	PUR34	2X8	.15	.063	.422	0	2
34	PUR35	2X8	.15	.063	.422	0	2
35	PUR36	2X8	.15	.063	.422	0	2
36	PUR37	2X8	.15	.063	.422	0	2
37	PUR38	2X8	.15	.063	.422	0	2
38	PUR39	2X8	.15	.063	.422	0	2
39	PUR40	2X8	.15	.063	.422	0	2
40	PUR41	2X8	.15	.063	.422	0	2
41	PUR42	2X8	.15	.063	.422	0	2

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Beam Shear Results for Wood : Floor 1 (Continued)

	Label	Size	F'v[ksi]	fv[ksi]	Shear Check	Loc[ft]	LC
42	PUR43	2X8	.15	.063	.422	0	2
43	PUR44	2X8	.15	.063	.422	0	2
44	PUR45	2X8	.15	.063	.422	0	2
45	PUR46	2X8	.15	.066	.438	10.573	2
46	PUR47	2X8	.15	.065	.434	10.573	2
47	PUR48	2X8	.15	.065	.436	10.573	2
48	PUR49	2X8	.15	.046	.308	10.573	2
49	PUR50	2X8	.15	.053	.355	10.573	2
50	PUR51	2X8	.15	.066	.438	10.573	2
51	PUR52	2X8	.15	.066	.438	10.573	2
52	PUR53	2X8	.15	.066	.438	10.573	2
53	PUR54	2X8	.15	.066	.438	10.573	2
54	PUR55	2X8	.15	.066	.438	10.573	2
55	PUR56	2X8	.15	.066	.438	10.573	2
56	PUR57	2X8	.15	.066	.438	10.573	2
57	PUR58	2X8	.15	.066	.438	10.573	2
58	PUR59	2X8	.15	.066	.438	10.573	2
59	PUR60	2X8	.15	.066	.438	10.573	2
60	M61	2-2X8	.15	.065	.434	0	2
61	M62	2-2X8	.15	.047	.314	10.573	2

Beam Shear Results for Wood : Floor 2

Label	Size	F'v[ksi]	fv[ksi]	Shear Check	Loc[ft]	LC
No Data to Print ...						

Beam Bending Results for Wood : Floor 1

	Label	Size	Lb Top[ft]	Lb Bot[ft]	Rb	CL	CP	F'b[ksi]	fb[ksi]	Bending Ch...	Loc[ft]	LC	Equation
1	M1	2-1.75X7.25FS	1.33	1.33	3.073	1	.99	3.12	2.38	.763	15.009	2	3.9-3
2	M2	4-1.75X7.25FS	1.33	1.33	1.537	1	.998	3.245	1.024	.316	5.789	2	3.9-3
3	M3	4-1.75X7.25FS	1.33	1.33	1.537	1	.998	3.245	1.022	.315	15.009	2	3.9-3
4	M4	2-1.75X7.25FS	1.33	1.33	3.073	1	.99	3.12	1.103	.354	5.789	2	3.9-3
5	M5	2-1.75X7.25FS	1.33	1.33	3.073	1	.469	3.245	.299	.092	6.219	2	3.9-3
6	M6	2-1.75X7.25FS	1.33	1.33	3.073	1	.469	3.245	.3	.093	6.219	2	3.9-3
7	M22	2-1.75X7.25FS	1.33	1.33	3.073	1	.645	3.245	.253	.078	5.089	2	3.9-3
8	M23	2-1.75X7.25FS	1.33	1.33	3.073	1	.645	3.245	.254	.078	5.089	2	3.9-3
9	M24	2-1.75X7.25FS	1.33	1.33	3.073	1	.611	3.245	.274	.085	5.286	2	3.9-3
10	M25	2-1.75X7.25FS	1.33	1.33	3.073	1	.611	3.245	.273	.084	5.286	2	3.9-3
11	PUR11	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
12	PUR12	2X8	1.33	1.33	7.171	1	.545	1.173	1.22	1.04	6.219	2	3.9-3
13	PUR13	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3

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REV DATE 03/26/09

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PM-B096

Beam Bending Results for Wood : Floor 1 (Continued)

	Label	Size	Lb Top[ft]	Lb Bot[ft]	Rb	CL	CP	F'b[ksi]	fb[ksi]	Bending Ch...	Loc[ft]	LC	Equation
14	PUR14	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
15	PUR15	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
16	PUR16	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
17	PUR17	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
18	PUR18	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
19	PUR19	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
20	PUR20	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
21	PUR21	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
22	PUR22	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
23	PUR23	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
24	PUR24	2X8	1.33	1.33	7.171	1	.545	1.173	1.327	1.132	6.219	2	3.9-3
25	PUR26	2X8	1.33	1.33	7.171	1	.545	1.173	1.12	.955	6.219	2	3.9-3
26	PUR27	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
27	PUR28	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
28	PUR29	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
29	PUR30	2X8	1.33	1.33	7.171	1	.545	1.173	1.224	1.043	6.219	2	3.9-3
30	PUR31	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
31	PUR32	2X8	1.33	1.33	7.171	1	.694	1.173	1.056	.9	5.089	2	3.9-3
32	PUR33	2X8	1.33	1.33	7.171	1	.694	1.173	1.059	.903	5.089	2	3.9-3
33	PUR34	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
34	PUR35	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
35	PUR36	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
36	PUR37	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
37	PUR38	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
38	PUR39	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
39	PUR40	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
40	PUR41	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
41	PUR42	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
42	PUR43	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
43	PUR44	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
44	PUR45	2X8	1.33	1.33	7.171	1	.694	1.173	1.066	.908	5.089	2	3.9-3
45	PUR46	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
46	PUR47	2X8	1.33	1.33	7.171	1	.667	1.173	1.14	.972	5.286	2	3.9-3
47	PUR48	2X8	1.33	1.33	7.171	1	.667	1.173	1.143	.975	5.286	2	3.9-3
48	PUR49	2X8	1.33	1.33	7.171	1	.667	1.173	.809	.689	5.286	2	3.9-3
49	PUR50	2X8	1.33	1.33	7.171	1	.667	1.173	.933	.795	5.286	2	3.9-3
50	PUR51	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
51	PUR52	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
52	PUR53	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
53	PUR54	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
54	PUR55	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3

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Beam Bending Results for Wood : Floor 1 (Continued)

	Label	Size	Lb Top[ft]	Lb Bot[ft]	Rb	CL	CP	F'b[ksi]	fb[ksi]	Bending Ch...	Loc[ft]	LC	Equation
55	PUR56	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
56	PUR57	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
57	PUR58	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
58	PUR59	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
59	PUR60	2X8	1.33	1.33	7.171	1	.667	1.173	1.15	.98	5.286	2	3.9-3
60	M61	2-2X8	1.33	1.33	3.586	1	.545	1.173	1.341	1.144	6.219	2	3.9-3
61	M62	2-2X8	1.33	1.33	3.586	1	.667	1.173	.823	.702	5.286	2	3.9-3

Beam Bending Results for Wood : Floor 2

Label	Size	Lb Top[ft]	Lb Bot[ft]	Rb	CL	CP	F'b[ksi]	fb[ksi]	Bending Ch...	Loc[ft]	LC	Equation
No Data to Print ...												

Beam Absolute Deflections : Floor 1

	Beam	PreDL[in]	DL[in]	LL[in]	DL+LL[in]
1	M1	.011	.105	.175	.28
2	M2	.01	.027	.067	.094
3	M3	.008	.022	.056	.077
4	M4	.009	.02	.057	.077
5	M5	.02	.039	.064	.103
6	M6	.02	.038	.062	.101
7	M22	.009	.019	.035	.054
8	M23	.009	.019	.034	.053
9	M24	.011	.022	.04	.062
10	M25	.011	.021	.04	.061
11	PUR11	.049	.177	.427	.604
12	PUR12	.048	.176	.425	.601
13	PUR13	.048	.175	.423	.598
14	PUR14	.048	.172	.419	.591
15	PUR15	.048	.172	.418	.59
16	PUR16	.049	.179	.432	.611
17	PUR17	.052	.197	.463	.66
18	PUR18	.055	.217	.499	.716
19	PUR19	.057	.233	.529	.762
20	PUR20	.059	.243	.546	.789
21	PUR21	.058	.243	.546	.789
22	PUR22	.057	.234	.529	.763
23	PUR23	.055	.217	.499	.716
24	PUR24	.054	.21	.5	.71
25	PUR26	.046	.157	.379	.536
26	PUR27	.048	.17	.415	.584

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Beam Absolute Deflections : Floor 1 (Continued)

	Beam	PreDL[in]	DL[in]	LL[in]	DL+LL[in]
27	PUR28	.048	.171	.419	.59
28	PUR29	.048	.174	.423	.597
29	PUR30	.049	.176	.425	.601
30	PUR31	.025	.103	.255	.359
31	PUR32	.025	.105	.256	.36
32	PUR33	.025	.103	.252	.355
33	PUR34	.025	.1	.249	.35
34	PUR35	.027	.104	.26	.365
35	PUR36	.03	.113	.284	.397
36	PUR37	.033	.122	.304	.426
37	PUR38	.034	.125	.312	.437
38	PUR39	.033	.122	.304	.426
39	PUR40	.03	.114	.284	.398
40	PUR41	.027	.104	.26	.364
41	PUR42	.025	.1	.249	.349
42	PUR43	.025	.102	.251	.354
43	PUR44	.025	.104	.255	.359
44	PUR45	.025	.103	.254	.356
45	PUR46	.029	.12	.297	.417
46	PUR47	.029	.121	.297	.418
47	PUR48	.029	.12	.294	.414
48	PUR49	.024	.085	.202	.287
49	PUR50	.028	.1	.244	.344
50	PUR51	.034	.128	.323	.451
51	PUR52	.037	.135	.341	.477
52	PUR53	.038	.138	.348	.486
53	PUR54	.037	.135	.34	.475
54	PUR55	.034	.127	.321	.449
55	PUR56	.031	.119	.3	.419
56	PUR57	.029	.118	.291	.409
57	PUR58	.029	.122	.297	.419
58	PUR59	.029	.124	.301	.425
59	PUR60	.03	.121	.297	.418
60	M61	.036	.447	.213	.661
61	M62	.016	.22	.073	.293

Beam Absolute Deflections : Floor 2

Beam	PreDL[in]	DL[in]	LL[in]	DL+LL[in]
No Data to Print ...				

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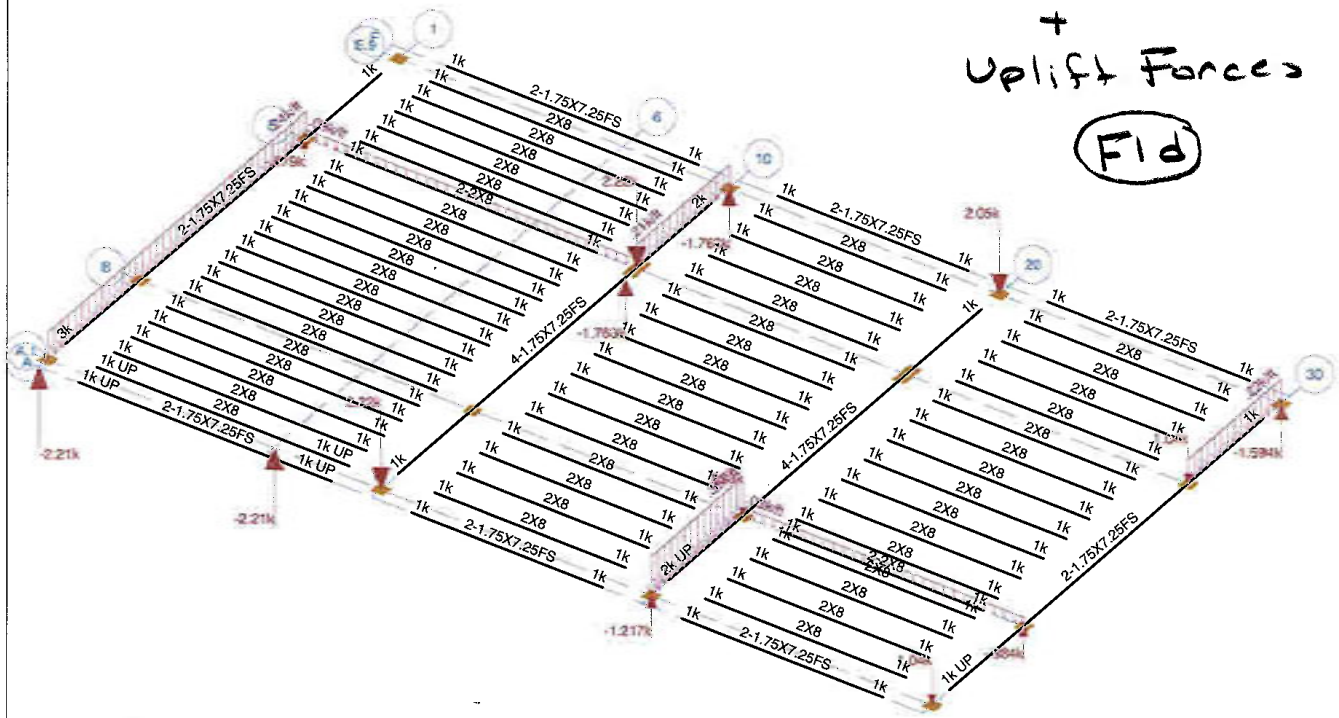
Dead Loads
+
Uplift Forces
(F1d)



Member Camber and Reactions
Loads: LC 1, Comb. 1 - DL+ Uplift

Floor 1	
Mar 24, 2009 at 10:23 AM	
FloorUplift.rfl	

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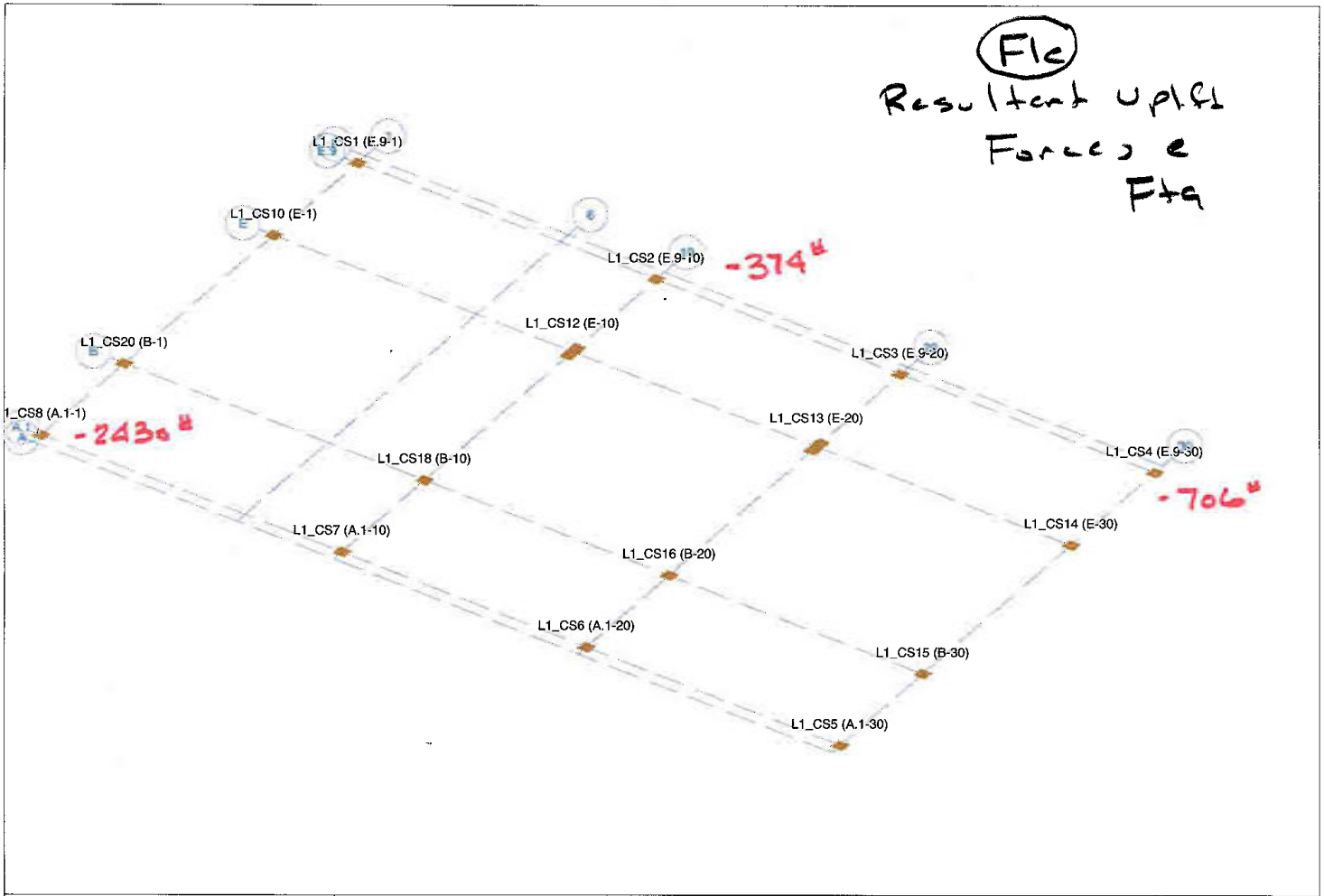

Floor 1	
Mar 24, 2009 at 10:25 AM	
FloorUplift.rfl	

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Column Forces/Moments, Dead & Other Categories : Floor 1

	Column Stack	Lift No.	Floor Label	Coordinat...	Max Base Reaction[k]	Max Ba...	DLPre[k]	DL[k]	OL1[k]	OL2[k]	OL3[k]	OL4[k]
1	CS1 (E.9-1)	1	Floor 1	0,20.083	.241	1	.131	.098	0	0	0	0
2	CS2 (E.9-10)	1	Floor 1	12.438,20...	-.374	1	.222	1.051	0	0	0	0
3	CS3 (E.9-20)	1	Floor 1	22.615,20...	2.795	1	.199	2.588	0	0	0	0
4	CS4 (E.9-30)	1	Floor 1	33.188,20...	-.706	1	.109	.783	0	0	0	0
5	CS5 (A.1-30)	1	Floor 1	33.188,.5	1.422	1	.107	1.319	0	0	0	0
6	CS6 (A.1-20)	1	Floor 1	22.615,.5	.296	1	.196	1.311	0	0	0	0
7	CS7 (A.1-10)	1	Floor 1	12.438,.5	1.539	1	.218	2.786	0	0	0	0
8	CS8 (A.1-1)	1	Floor 1	0,.5	-2.43	1	.129	.625	0	0	0	0
9	CS10 (E-1)	1	Floor 1	0,14.875	2.724	1	.375	2.93	0	0	0	0
10	CS12 (E-10)	1	Floor 1	12.438,14...	4.571	1	.654	5.428	0	0	0	0
11	CS13 (E-20)	1	Floor 1	22.615,14...	2.632	1	.565	1.768	0	0	0	0
12	CS14 (E-30)	1	Floor 1	33.188,14...	3.099	1	.286	2.659	0	0	0	0
13	CS15 (B-30)	1	Floor 1	33.188,5....	.789	1	.313	1.334	0	0	0	0
14	CS16 (B-20)	1	Floor 1	22.615,5....	5.038	1	.575	5.394	0	0	0	0
15	CS18 (B-10)	1	Floor 1	12.438,5....	2.799	1	.619	1.97	0	0	0	0
16	CS20 (B-1)	1	Floor 1	0,5.646	4.004	1	.357	3.205	0	0	0	0

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PM-B102

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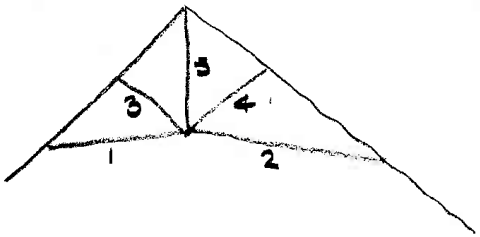
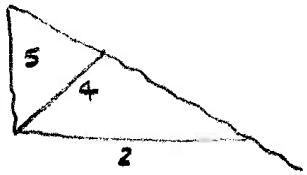
Date 3/23/09	SHT
Project Solar Decathlon	T-1
By DHM	

Truss Connections
Web members
Roof Truss 1



Roof Truss 2



Members 3 + 4
2 - 1"x1"x3/16" Tubes

Member 3 Truss 1
Bal P = 2.39k
Unbal R = 2.02k
Unbal L = 3.20k

Member 4 Truss 1
Bal 2.7k
Unbal R 3.44k
Unbal L .938k

Truss 2 Member 4
Bal P = 8.489k
Unbal = 10.451k ←

P = 10.451k Controls

For Each Conn
P = 5.275k

Brg on Lug
A = 1 3/4 x 6" x 500 psi = 5250k

Check HSS 1x1x3/16
A = .6094 in²
r = .3904 l_{max} = 3.6'
kl/r = 126 Fa = 9.41
Cc = 111.6
Fa = 9.41
fa = 8.61 ok

Member 5
Truss 1
Bal 5k Tens
Unbal R 5.4k Tens
Unbal L 4.97k Tens

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PM-B103

Title :
Dsgnr:
Description :

Scope :

Job #
Date: 10:59AM, 24 MAR 09

Built-Up Section Properties

Description

General Information

	Type...					X cg	Y cg
#1	Rectangular	Height	0.1875 in	Width	1.0000 in	0.5000 in	0.0938 in
#2	Rectangular	Height	0.1875 in	Width	1.0000 in	0.5000 in	0.9063 in
#3	Rectangular	Height	0.6250 in	Width	0.1875 in	0.0938 in	0.5000 in
#4	Rectangular	Height	0.6250 in	Width	0.1875 in	0.9063 in	0.5000 in

Summary

Total Area	0.6094 in2	Ixx	0.071 in4	r xx	0.3404 in
		Iyy	0.071 in4	r yy	0.3404 in
X cg Dist.	0.5000 in	Edge Distances from CG...			
Y cg Dist.	0.5000 in	+X	0.5000 in	S left	0.1412 in3
		-X	-0.5000 in	S right	0.1412 in3
		+Y	0.5000 in	S top	0.1412 in3
		-Y	-0.5000 in	S bottom	0.1412 in3

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REV DATE
03/26/09

AUTHORED BY
Dave MacDonald, P.E.

PM-B104

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612-827-0805 fax

Date 3/23/09	SHT
Project Solar Decath	T-2
By	

Max load ea Tube
T = 2.7k
f_t = 4.4 ksi ok

Connection to Lum
$Z_\perp$ for 5/8" ϕ bolts
$Z_\perp$ = 600×1.15 690#/bolt
4-bolts Req'd
Spacing 1.875" min
Edge Dis 2 1/2"

Tension Cable
Tmax

Truss 2
Unbal T = 8.7k

Truss 1
Bal 6.66k
Unbal L 6.0k
Unbal R 7.5k

Worst Case = 8.7k Tens
for 2 cables:
T = 4.4k/cable

3/8" ϕ Aircraft wire strand
Nominal Strength = 12k
F.S = 2.72 ok

Bolts Req'd @ Conn
= 2720/690 = 3.9
Use 4 - 5/8" ϕ Bolts

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SECTION 01 3000
ADMINISTRATIVE REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Submittals for review, information, and project closeout.
- B. Number of copies of submittals.
- C. Submittal procedures.

1.02 RELATED REQUIREMENTS
- A. Section 01 7800 - Closeout Submittals: Project record documents.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 SUBMITTALS FOR REVIEW
- A. When the following are specified in individual sections, submit them for review:
  1. Product data.
  2. Shop drawings.
  3. Samples for selection.
  4. Samples for verification.
  5. Professional engineer certification.
  6. Calculations.
  7. Warranties.
- B. Submit to Architect for review for the limited purpose of checking for conformance with information given and the design concept expressed in the contract documents.
- C. Samples will be reviewed only for aesthetic, color, or finish selection.
- D. After review, provide copies and distribute in accordance with SUBMITTAL PROCEDURES article below and for record documents purposes described in Section 01 7800 - CLOSEOUT SUBMITTALS.

3.02 SUBMITTALS FOR INFORMATION
- A. When the following are specified in individual sections, submit them for information:
  1. Design data.
  2. Certificates.
  3. Test reports.
  4. Inspection reports.
  5. Manufacturer's instructions.
  6. Manufacturer's field reports.
  7. Other types indicated.
- B. Submit for Architect's knowledge as contract administrator or for Owner. No action will be taken.

3.03 SUBMITTALS FOR PROJECT CLOSEOUT
- A. When the following are specified in individual sections, submit them at project closeout:
  1. Project record documents.
  2. Operation and maintenance data.
  3. Warranties.
  4. Bonds.
  5. Other types as indicated.
- B. Submit for Owner's benefit during and after project completion.

3.04 NUMBER OF COPIES OF SUBMITTALS
- A. Documents for Review:
  1. Small Size Sheets, Not Larger Than 280 x 432 mm (11 x 17 inches): Submit two copies; the Contractor shall make his own copies from one original copy returned by the Architect.
  2. Larger Sheets, Not Larger Than 910 x 1220 mm (36 x 48 inches): Submit one original on mylar, vellum, or bond and one opaque reproduction. The Contractor shall make his own copies from one original copy returned by the Architect.
- B. Documents for Information: Submit two copies.
- C. Documents for Project Closeout: Make one reproduction of submittal originally reviewed. Submit one extra of submittals for information.
- D. Samples: Submit the number specified in individual specification sections; one of which will be retained by Architect.
  1. Retained samples will not be returned to Contractor unless specifically so stated.

3.05 SUBMITTAL PROCEDURES
- A. Transmit each submittal with one of the following:
  1. Contractor's own transmittal form.
  2. AIA Form G810.
- B. Sequentially number the transmittal form. Revise submittals with original number and a sequential alphabetic suffix.
- C. Identify Project, Contractor, Subcontractor or supplier; pertinent drawing and detail number, and specification section number, as appropriate on each copy.
- D. Apply Contractor's stamp, signed or initialed certifying that review, approval, verification of Products required, field dimensions, adjacent

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construction Work, and coordination of information is in accordance with the requirements of the Work and Contract Documents.

E. Deliver submittals to Architect at business address.

F. It is Contractor's sole responsibility to schedule submittals to expedite the Project, and coordinate submission of related items; include accommodation of specified submittal review period.

G. For each submittal for review, allow 15 days excluding delivery time to and from the Contractor.

H. Identify variations from Contract Documents and Product or system limitations that may be detrimental to successful performance of the completed Work.

I. Provide space for Contractor and Architect review stamps.

J. When revised for resubmission, identify all changes made since previous submission.

K. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report any inability to comply with requirements.

L. Submittals not requested will not be recognized or processed.

M. Incomplete submittals shall include those that do not include all documents indicated in the Submittals article of each Specification Section; incomplete submittals will be Rejected by Architect and returned for re-submittal.

1. Pay particular attention to Submittal requirements that include calculations and/or Licensed Design Professional certification. Submission of shop drawings without specified calculations or certifications constitute incomplete submittals and are grounds for Rejection and Re-submittal action.

END OF SECTION

SECTION 01 4000
QUALITY REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. References and standards.
- B. Quality assurance submittals.
- C. Control of installation.
- D. Tolerances.
- E. Manufacturers' field services.

1.02 RELATED REQUIREMENTS
- A. Section 01 6000 - Product Requirements: Requirements for material and product quality.

1.03 SUBMITTALS
- A. Design Data: Submit for Architect's knowledge as contract administrator for the limited purpose of assessing conformance with information given and the design concept expressed in the contract documents, or for Owner's information.
- B. Certificates: When specified in individual specification sections, submit certification by the manufacturer and Contractor to Architect, in quantities specified for Product Data.
  1. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
  2. Certificates may be recent or previous test results on material or product, but must be acceptable to Architect.
- C. Manufacturer's Instructions: When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, for the Owner's information. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.
- D. Manufacturer's Field Reports: Submit reports for Architect's benefit as contract administrator or for Owner.
  1. Submit for information for the limited purpose of assessing conformance with information given and the design concept expressed in the contract documents.

1.04 REFERENCES AND STANDARDS
- A. For products and workmanship specified by reference to a document or documents not included in the Project Manual, also referred to as reference standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.
- B. Conform to reference standard of date of issue current on date of Contract Documents, except where a specific date is established by applicable code.
- C. Obtain copies of standards where required by product specification sections.
- D. Maintain copy at project site during submittals, planning, and progress of the specific work, until Substantial Completion.
- E. Should specified reference standards conflict with Contract Documents, request clarification from Architect before proceeding.
- F. Neither the contractual relationships, duties, or responsibilities of the parties in Contract nor those of Architect shall be altered from the Contract Documents by mention or inference otherwise in any reference document.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 CONTROL OF INSTALLATION
- A. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.
- B. Comply with manufacturers' instructions, including each step in sequence.
- C. Should manufacturers' instructions conflict with Contract Documents, request clarification from Architect before proceeding.
- D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- E. Have Work performed by persons qualified to produce required and specified quality.
- F. Verify that field measurements are as indicated on shop drawings or as instructed by the manufacturer.
- G. Secure products in place with positive anchorage

devices designed and sized to withstand stresses, vibration, physical distortion, and disfigurement.

3.02 TOLERANCES

A. Monitor fabrication and installation tolerance control of products to produce acceptable Work. Do not permit tolerances to accumulate.

B. Comply with manufacturers' tolerances. Should manufacturers' tolerances conflict with Contract Documents, request clarification from Architect before proceeding.

C. Adjust products to appropriate dimensions; position before securing products in place.

3.03 MANUFACTURERS' FIELD SERVICES

A. When specified in individual specification sections, require material or product suppliers or manufacturers to provide qualified staff personnel to observe site conditions, conditions of surfaces and installation, quality of workmanship, start-up of equipment, test, adjust and balance of equipment as applicable, and to initiate instructions when necessary.

B. Report observations and site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturers' written instructions.

3.04 DEFECT ASSESSMENT

A. Replace Work or portions of the Work not conforming to specified requirements.

B. If, in the opinion of Architect, it is not practical to remove and replace the Work, Architect will direct an appropriate remedy or adjust payment.

END OF SECTION

SECTION 01 6000
PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. General product requirements.
- B. Transportation, handling, storage and protection.
- C. Product option requirements.
- D. Substitution limitations and procedures.
- E. Maintenance materials, including extra materials, spare parts, tools, and software.

1.02 RELATED REQUIREMENTS
- A. Section 01 4000 - Quality Requirements: Product quality monitoring.

1.03 REFERENCE STANDARDS
- A. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.04 SUBMITTALS
- A. Product Data Submittals: Submit manufacturer's standard published data. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this Project.
- B. Shop Drawing Submittals: Prepared specifically for this Project; indicate utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.
- C. Sample Submittals: Illustrate functional and aesthetic characteristics of the product, with integral parts and attachment devices. Coordinate sample submittals for interfacing work.
  1. For selection from standard finishes, submit samples of the full range of the manufacturer's standard colors, textures, and patterns.

PART 2 PRODUCTS

2.01 NEW PRODUCTS
- A. Provide new products unless specifically required or permitted by the Contract Documents.
- B. Do not use products having any of the following characteristics:
- C. Where all other criteria are met, Contractor shall give preference to products that:
  1. Are extracted, harvested, and/or manufactured closer to the location of the project.
  2. Have longer documented life span under normal use.
  3. Result in less construction waste.
  4. Are made of vegetable materials that are rapidly renewable.
- D. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Size terminal lugs to NFPA 70, include lugs for terminal box.
- E. Cord and Plug: Provide minimum 2 m (6 foot) cord and plug including grounding connector for connection to electric wiring system. Cord of longer length is specified in individual specification sections.

2.02 PRODUCT OPTIONS
- A. Products Specified by Reference Standards or by Description Only: Use any product meeting those standards or description.
- B. Products Specified by Naming One or More Manufacturers: Use a product of one of the manufacturers named and meeting specifications, no options or substitutions allowed.
- C. Products Specified by Naming One or More Manufacturers with a Provision for Substitutions: Submit a request for substitution for any manufacturer not named.

2.03 MAINTENANCE MATERIALS
- A. Furnish extra materials, spare parts, tools, and software of types and in quantities specified in individual specification sections.
- B. Deliver to Project site; obtain receipt prior to final payment.

PART 3 EXECUTION

3.01 TRANSPORTATION AND HANDLING
- A. Coordinate schedule of product delivery to designated prepared areas in order to minimize site storage time and potential damage to stored materials.
- B. Transport and handle products in accordance with manufacturer's instructions.
- C. Transport materials in covered trucks to prevent contamination of product and littering of surrounding areas.
- D. Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.
- E. Provide equipment and personnel to handle products

by methods to prevent soiling, disfigurement, or damage.

F. Arrange for the return of packing materials, such as wood pallets, where economically feasible.

3.02 STORAGE AND PROTECTION

A. Designate receiving/storage areas for incoming products so that they are delivered according to installation schedule and placed convenient to work area in order to minimize waste due to excessive materials handling and misapplication.

B. Store and protect products in accordance with manufacturers' instructions.

C. Store with seals and labels intact and legible.

D. Store sensitive products in weather tight, climate controlled, enclosures in an environment favorable to product.

E. For exterior storage of fabricated products, place on sloped supports above ground.

F. Provide off-site storage and protection when site does not permit on-site storage or protection.

G. Cover products subject to deterioration with impervious sheet covering. Provide ventilation to prevent condensation and degradation of products.

H. Store loose granular materials on solid flat surfaces in a well-drained area. Prevent mixing with foreign matter.

I. Prevent contact with material that may cause corrosion, discoloration, or staining.

J. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.

K. Arrange storage of products to permit access for inspection. Periodically inspect to verify products are undamaged and are maintained in acceptable condition.

END OF SECTION

SECTION 01 7800
CLOSEOUT SUBMITTALS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Operation and Maintenance Data.
- B. Warranties and bonds.

1.02 RELATED REQUIREMENTS
- A. Section 01 3000 - Administrative Requirements: Submittals procedures, shop drawings, product data, and samples.
- B. Individual Product Sections: Specific requirements for operation and maintenance data.
- C. Individual Product Sections: Warranties required for specific products or Work.

1.03 SUBMITTALS
- A. Operation and Maintenance Data:
  1. Submit two copies of preliminary draft or proposed formats and outlines of contents before start of Work. Architect will review draft and return one copy with comments.
  2. For equipment, or component parts of equipment put into service during construction and operated by Owner, submit completed documents within ten days after acceptance.
  3. Submit one copy of completed documents 15 days prior to final inspection. This copy will be reviewed and returned after final inspection, with Architect comments. Revise content of all document sets as required prior to final submission.
  4. Submit two sets of revised final documents in final form within 10 days after final inspection.
- B. Warranties and Bonds:
  1. For equipment or component parts of equipment put into service during construction with Owner's permission, submit documents within 10 days after acceptance.
  2. Make other submittals within 10 days after Date of Substantial Completion.
  3. For items of Work for which acceptance is delayed beyond Date of Substantial Completion, submit within 10 days after acceptance, listing the date of acceptance as the beginning of the warranty period.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 OPERATION AND MAINTENANCE DATA
- A. For Each Product or System: List names, addresses and telephone numbers of Subcontractors and suppliers, including local source of supplies and replacement parts.
- B. Product Data: Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Delete inapplicable information.
- C. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams. Do not use Project Record Documents as maintenance drawings.
- D. Typed Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions.

3.02 OPERATION AND MAINTENANCE DATA FOR MATERIALS AND FINISHES
- A. For Each Product, Applied Material, and Finish:
  1. Product data, with catalog number, size, composition, and color and texture designations.
  2. Information for re-ordering custom manufactured products.
- B. Instructions for Care and Maintenance: Manufacturer's recommendations for cleaning agents and methods, precautions against detrimental cleaning agents and methods, and recommended schedule for cleaning and maintenance.
- C. Moisture protection and weather-exposed products: Include product data listing applicable reference standards, chemical composition, and details of installation. Provide recommendations for inspections, maintenance, and repair.
- D. Additional information as specified in individual product specification sections.

3.03 OPERATION AND MAINTENANCE DATA FOR EQUIPMENT AND SYSTEMS
- A. For Each Item of Equipment and Each System:
  1. Description of unit or system, and component parts.
  2. Identify function, normal operating characteristics, and limiting conditions.
  3. Include performance curves, with engineering

data and tests.

4. Complete nomenclature and model number of replaceable parts.

B. Operating Procedures: Include start-up, break-in, and routine normal operating instructions and sequences. Include regulation, control, stopping, shut-down, and emergency instructions. Include summer, winter, and any special operating instructions.

C. Maintenance Requirements: Include routine procedures and guide for preventative maintenance and trouble shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.

D. Provide servicing and lubrication schedule, and list of lubricants required.

E. Include manufacturer's printed operation and maintenance instructions.

F. Include sequence of operation by controls manufacturer.

G. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.

H. Provide control diagrams by controls manufacturer as installed.

I. Provide list of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.

J. Include test and balancing reports.

K. Additional Requirements: As specified in individual product specification sections.

3.04 OPERATION AND MAINTENANCE MANUALS

A. Prepare instructions and data by personnel experienced in maintenance and operation of described products.

B. Prepare data in the form of an instructional manual.

C. Binders: Commercial quality, 216 by 280 mm (8-1/2 by 11 inch) three D side ring binders with durable plastic covers; 50 mm (2 inch) maximum ring size. When multiple binders are used, correlate data into related consistent groupings.

D. Cover: Identify each binder with typed or printed title OPERATION AND MAINTENANCE INSTRUCTIONS; identify title of Project; identify subject matter of contents.

E. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, in three parts as follows:

1. Part 1: Directory, listing names, addresses, and telephone numbers of Architect, Contractor, Subcontractors, and major equipment suppliers.

2. Part 2: Operation and maintenance instructions, arranged by system and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:

   a. Significant design criteria.
   b. List of equipment.
   c. Parts list for each component.
   d. Operating instructions.
   e. Maintenance instructions for equipment and systems.
   f. Maintenance instructions for special finishes, including recommended cleaning methods and materials, and special precautions identifying detrimental agents.

3. Part 3: Project documents and certificates, including the following:

   a. Shop drawings and product data.
   b. Air and water balance reports.
   c. Certificates.
   d. Photocopies of warranties and bonds.

3.05 WARRANTIES AND BONDS

A. Obtain warranties and bonds, executed in duplicate by responsible Subcontractors, suppliers, and manufacturers, within 10 days after completion of the applicable item of work. Except for items put into use with Owner's permission, leave date of beginning of time of warranty until the Date of Substantial completion is determined.

B. Verify that documents are in proper form, contain full information, and are notarized.

C. Co-execute submittals when required.

D. Retain warranties and bonds until time specified for submittal.

E. Manual: Bind in commercial quality 216 by 279 mm (8-1/2 by 11 inch) three D side ring binders with durable plastic covers.

F. Cover: Identify each binder with typed or printed title WARRANTIES AND BONDS, with title of Project; name, address and telephone number of Contractor and equipment supplier; and name of responsible company principal.

G. Table of Contents: Neatly typed, in the sequence of the Table of Contents of the Project Manual, with

each item identified with the number and title of the specification section in which specified, and the name of product or work item.

H. Separate each warranty or bond with index tab sheets keyed to the Table of Contents listing. Provide full information, using separate typed sheets as necessary. List Subcontractor, supplier, and manufacturer, with name, address, and telephone number of responsible principal.

END OF SECTION

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SECTION 05 5000
METAL FABRICATIONS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Shop fabricated steel items.

1.02 RELATED REQUIREMENTS
- A. Section 06 1753 - Shop-Fabricated Wood Trusses: Truss assemblies that incorporate metal fabrications provided by Section 05 5000.

1.03 REFERENCE STANDARDS
- A. ASTM A 53/A 53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2007.
- B. ASTM A 123/A 123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2002.
- C. ASTM A 283/A 283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates; 2003 (Reapproved 2007).
- D. ASTM A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength; 2007a.
- E. ASTM A 325M - Standard Specification for Structural Bolts, Steel, Heat Treated 830 MPa Tensile Strength (Metric); 2007.
- F. ASTM A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes; 2007.
- G. AWS D1.1/D1.1M - Structural Welding Code - Steel; American Welding Society; 2006 and Errata.
- H. SSPC-Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic"); Society for Protective Coatings; 2002 (Ed. 2004).
- I. SSPC-SP 2 - Hand Tool Cleaning; Society for Protective Coatings; 1982 (Ed. 2004).

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories. Include erection drawings, elevations, and details where applicable.
- C. Welders' Certificates: Submit certification for welders employed on the project, verifying AWS qualification within the previous 12 months.

PART 2 PRODUCTS

2.01 MATERIALS - STEEL
- A. Steel Tubing: ASTM A 500, Grade B cold-formed structural tubing.
- B. Plates: ASTM A 283.
- C. Pipe: ASTM A 53/A 53M, Grade B Schedule 40, hot-dip galvanized finish.
- D. Cable: Galvanized, steel woven wire rope, coated aircraft cable wire strand type, 7 x 19 construction, 4.76 mm (3/16 inch) diameter, 1900 kg (4200 lbs) normal breaking strength and 9.5 mm (3/8 inch), 5430 kg (12,000 lbs) normal breaking strength, as indicated.
- E. Cable Fittings: Thimbles, sleeves, and end fittings; size to match cable; galvanized finish.
- F. Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1.
- G. Soil Anchors: American Industries, Inc. EARTH ANCHORS, sized for 18 inch penetration into soil.
- H. Welding Materials: AWS D1.1/D1.1M; type required for materials being welded.
- I. Touch-Up Primer for Galvanized Surfaces: SSPC-Paint 20, Type I - Inorganic, complying with VOC limitations of authorities having jurisdiction.

2.02 FABRICATION
- A. Fit and shop assemble items in largest practical sections, for delivery to site or wood truss fabricator, as required.
- B. Fabricate items with joints tightly fitted and secured.
- C. Continuously seal joined members by continuous welds.
- D. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.
- E. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

2.03 FABRICATED ITEMS
- A. Shop-Fabricated Wood Truss Components: As detailed; prime paint finish.
- B. Floor Platform Lifting Pipes and Related Brackets: Steel pipe and plate, as detailed; galvanized finish.

2.04 FINISHES - STEEL

A. Prepare surfaces to be primed in accordance with SSPC-SP2.
B. Clean surfaces of rust, scale, grease, and foreign matter prior to finishing.
C. Prime Painting: One coat.
D. Galvanizing of Non-structural Items: Galvanize after fabrication to ASTM A 123/A 123M requirements.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install items plumb and level, accurately fitted, free from distortion or defects.
B. Install soil anchors in accordance with manufacturer's instructions.
C. Provide for erection loads, and for sufficient temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.
D. Obtain approval prior to site cutting or making adjustments not scheduled.
E. After erection, prime welds, abrasions, and surfaces not shop primed or galvanized, except surfaces to be in contact with concrete.

END OF SECTION

SECTION 05 5305
METAL GRATINGS AND FLOOR PLATES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Formed metal floor gratings.
- B. Perimeter closure.

1.02 RELATED REQUIREMENTS
- A. Section 05 5000 - Metal Fabrications: Supports for gratings.

1.03 REFERENCE STANDARDS
- A. ASTM A 36/A 36M - Standard Specification for Carbon Structural Steel; 2005.
- B. ASTM A 123/A 123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2002.
- C. ASTM A 153/A 153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2005.
- D. AWS D1.1/D1.1M - Structural Welding Code - Steel; American Welding Society; 2006 and Errata.
- E. NAAMM MBG 532 - Heavy Duty Metal Bar Grating Manual; The National Association of Architectural Metal Manufacturers; 2000 (ANSI/ NAAMM MBG 532).
- F. SSPC-Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic"); Society for Protective Coatings; 2002 (Ed. 2004).

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide span and deflection tables.
- C. Shop Drawings: Indicate details of component supports, openings, perimeter construction details, and tolerances.
- D. Manufacturer's Installation Instructions: Indicate special requirements for opening and perimeter framing.

PART 2 PRODUCTS

2.01 MATERIALS
- A. Steel Framing: ASTM A 36/A 36M shapes, galvanized per ASTM A 123/A 123M.
- B. Welding Materials: AWS D1.1; type required for materials being welded.
- C. Touch-Up Primer for Galvanized Surfaces: SSPC-Paint 20, Type I - Inorganic, complying with VOC limitations of authorities having jurisdiction.

2.02 ACCESSORIES
- A. Fasteners and Saddle Clips: Galvanized steel:
- B. Perimeter Closure: Of same material as grating.

2.03 FABRICATION
- A. Grating Type: NAAMM MBG 532, Pressure Locked Type.
- B. Weld joints of intersecting metal sections.
- C. Fabricate gratings for openings.
- D. Top Surface: Plain.
- E. Bearing Bar: 38 x 3 mm (1-1/2 x 1/8 inch) size, spaced 11 mm (7/16 inches) on center.
- F. Cross Bars: Spaced 101 mm (4 inches) on center.

2.04 FINISHES
- A. Galvanizing for Steel Shapes: ASTM A 123/A 123M.
- B. Galvanizing for Steel Hardware: ASTM A 153/A 153M.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify that field measurements are as indicated on shop drawings.
- B. Verify that opening sizes and dimensional tolerances are acceptable.
- C. Verify that supports are correctly positioned.

3.02 INSTALLATION
- A. Install components in accordance with manufacturer's instructions.
- B. Mechanically cut galvanized finish surfaces. Do not flame cut.
- C. Anchor by bolting through saddle clips.
- D. Secure to prevent movement.

3.03 TOLERANCES
- A. Maximum Space Between Adjacent Sections: 13 mm (1/2 inch).
- B. Maximum Variation From Top Surface Plane of Adjacent Sections: 3 mm (1/8 inch)

END OF SECTION

SECTION 06 1000
ROUGH CARPENTRY

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Structural dimension lumber framing.
B. Non-structural dimension lumber framing.
C. Rough opening framing for doors, windows, and roof openings.
D. Sheathing.
E. Subflooring.
F. Roof-mounted curbs.
G. Roofing nailers.
H. Preservative treated wood materials.
I. Miscellaneous framing and sheathing.
J. Concealed wood blocking, nailers, and supports.
K. Miscellaneous wood nailers, furring, and grounds.
L. Exterior wood decking and landscape related timbers and other wood components.

1.02 RELATED REQUIREMENTS

A. Section 05 5000 - Metal Fabrications: Steel lifting pipes and hold-down cables for wood floor platform framing.
B. Section 06 1753 - Shop-Fabricated Wood Trusses.
C. Section 07 2500 - Weather Barriers: Air barrier over sheathing.
D. Section 23 8316 - Radiant-Heating Hydronic Piping: Plywood underlayment accessory for radiant floor heating system.

1.03 REFERENCE STANDARDS

A. AFPA (WFCM) - Wood Frame Construction Manual for One- and Two-Family Dwellings; American Forest and Paper Association; 2001.
B. ASTM A 153/A 153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2005.
C. ASTM A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2007
D. AWPA C2 - Lumber, Timber, Bridge Ties and Mine Ties -- Preservative Treatment by Pressure Processes; American Wood-Preservers' Association; 2003.
E. AWPA U1 - Use Category System: User Specification for Treated Wood; American Wood-Preservers' Association; 2007.
F. PS 1 - Structural Plywood; 2007.
G. PS 20 - American Softwood Lumber Standard; National Institute of Standards and Technology (Department of Commerce); 2005.

1.04 DELIVERY, STORAGE, AND HANDLING

A. General: Cover wood products to protect against moisture. Support stacked products to prevent deformation and to allow air circulation.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Dimension Lumber: Comply with PS 20 and requirements of specified grading agencies.
   1. Species: Spruce-Pine-Fir (South), unless otherwise indicated.
   2. If no species is specified, provide any species graded by the agency specified; if no grading agency is specified, provide lumber graded by any grading agency meeting the specified requirements.
   3. Grading Agency: Any grading agency whose rules are approved by the Board of Review, American Lumber Standard Committee (www.alsc.org) and who provides grading service for the species and grade specified; provide lumber stamped with grade mark unless otherwise indicated.
   4. Lumber of other species or grades is acceptable provided structural and appearance characteristics are equivalent to or better than products specified.
B. Lumber fabricated from old growth timber is not permitted.

2.02 DIMENSION LUMBER FOR CONCEALED APPLICATIONS

A. Sizes: Nominal sizes as indicated on drawings, S4S.
B. Moisture Content: S-dry or MC19.
C. Stud Framing (50 by 50 mm through 50 by 150 mm (2 by 2 through 2 by 6)):
   1. Grade: No. 2.
D. Joist, Rafter, and Small Beam Framing (50 by 150 mm through 100 by 400 mm (2 by 6 through 4 by 16)):
   1. Grade: No. 2.
E. Miscellaneous Framing, Blocking, Nailers, Grounds, and Furring:
   1. Lumber: S4S, No. 2 or Standard Grade.

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2. Boards: Standard or No. 3.

2.03 EXPOSED DIMENSION LUMBER

A. Sizes: Nominal sizes as indicated on drawings, S4S.

B. Moisture Content: S-dry or MC19.

C. Joist, Rafter, and Small Beam Framing (50 by 150 through 100 by 400 mm (2 by 6 through 4 by 16)):

1. Species: Western Cedar.

2. Grade: D Clear.

D. Deck Boards; 31 x 150 mm (5/4 x 6 inches), unless otherwise indicated:

1. Species: Western Cedar.

2. Grade: Architect Knotty.

2.04 EXPOSED TIMBERS

A. Submit manufacturer's certificate that products meet or exceed specified requirements, in lieu of grade stamping.

B. Moisture Content: Kiln-dry (20 percent maximum).

C. Surfacing: S4S.

D. Species: Western Cedar.

E. Grade: D and Better Clear.

2.05 MANUFACTURED DIMENSION LUMBER & TIMBER PRODUCTS

A. Laminated Veneer Lumber (LVL) Beams: Manufactured structural lumber; E = 1,900,000 psi and Fb = 2,600 psi (for 12 inch depth); as manufactured by Georgia Pacific Corp., Louisiana-Pacific Corp., Trus Joist, APA EWS trademarked manufacturers, or approved equivalent.

B. Parallel Strand Lumber (PSL) Columns and Posts: Manufactured parallel strand lumber; E = 1,800,000 psi, Fb = 2,400 psi (for 12 inch depth), and Fcll = 2,500 psi; TrusJoist PARALLAM or approved equivalent.

2.06 CONSTRUCTION PANELS

A. Subfloor/Underlayment Combination: APA PRP-108, Rated Sturd-I-Floor.

1. Exposure Class: Exposure 1.

2. Span Rating: 610 mm (24 inches).

3. Thickness: 32 mm (1-1/8 inches), nominal.

B. Roof Sheathing: APA PRP-108/APA PRPR-108, Form B455, Structural I Rated Sheathing, Exposure 1, and as follows:

1. Span Rating: 812/406 (32/16).

C. Wall Sheathing: APA PRP-108/APA PRP-108, Form B455 Structural I Rated Sheathing, veneer plywood only, Exterior Exposure Class, and as follows:

1. Span Rating: 812/406 (32/16).

D. Other Applications:

1. Plywood Concealed From View But Located Within Exterior Enclosure: PS 1, C-C Plugged or better, Exterior grade.

2. Plywood Exposed to View But Not Exposed to Weather: PS 1, A-C, or better.

3. Other Locations: PS 1, C-D Plugged or better.

2.07 ACCESSORIES

A. Fasteners and Anchors:

1. Metal and Finish: Hot-dipped galvanized steel per ASTM A 153/A 153M for high humidity and preservative-treated wood locations, unfinished steel elsewhere.

2. Screws: Bugle head, hardened steel, power driven type, length three times thickness of sheathing.

B. Die-Stamped Connectors: Hot dipped galvanized steel, sized to suit framing conditions. Provide type as indicated manufactured by Simpson Strong-Tie or approved equivalent.

1. For contact with preservative treated wood in exposed locations, provide minimum Z550 (G185) galvanizing per ASTM A 653/A 653M.

C. Joist Hangers: Hot dipped galvanized steel, sized to suit framing conditions.

1. For contact with preservative treated wood in exposed locations, provide minimum Z550 (G185) galvanizing per ASTM A 653/A 653M.

D. Sill Gasket to Seal Module-to-Module Joints: 6 mm (1/4 inch) thick, 150 mm (6 inch) wide, closed cell plastic foam from continuous rolls.

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

2.08 FACTORY WOOD TREATMENT

A. Treated Lumber and Plywood: Comply with requirements of AWPA U1 - Use Category System for wood treatments determined by use categories, expected service conditions, and specific applications.

1. Preservative-Treated Wood: Provide lumber and plywood marked or stamped by an ALSC-accredited testing agency, certifying level and type of treatment in accordance with AWPA standards.

B. Preservative Treatment:

C. Preservative Pressure Treatment of Lumber Above Grade: AWPA Use Category UC3B, Commodity Specification A (Treatment C2) using waterborne preservative to 4.0 kg/cu m (0.25 lb/cu ft) retention.

1. Kiln dry lumber after treatment to maximum

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moisture content of 19 percent.

a. Treat lumber exposed to weather.

PART 3 EXECUTION

3.01 PREPARATION

A. Install sill gasket at framed walls joining adjacent building modules together to ensure air tightness; puncture gasket cleanly to fit tightly around any protrusions.

B. Coordinate installation of rough carpentry members specified in other sections.

3.02 INSTALLATION - GENERAL

A. Select material sizes to minimize waste.

B. Reuse scrap to the greatest extent possible; clearly separate scrap for use on site as accessory components, including: shims, bracing, and blocking.

C. Where treated wood is used on interior, provide temporary ventilation during and immediately after installation sufficient to remove indoor air contaminants.

3.03 FRAMING INSTALLATION

A. Set structural members level, plumb, and true to line. Discard pieces with defects that would lower required strength or result in unacceptable appearance of exposed members.

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

C. Install structural members full length without splices unless otherwise specifically detailed.

D. Comply with member sizes, spacing, and configurations indicated, and fastener size and spacing indicated, but not less than required by applicable codes and AFPA Wood Frame Construction Manual.

E. Install horizontal spanning members with crown edge up and not less than 38 mm (1-1/2 inches) of bearing at each end.

F. Construct double joist headers at floor and ceiling openings and under wall stud partitions that are parallel to floor joists; use metal joist hangers unless otherwise detailed.

G. Provide bridging at joists in excess of 2.3 m (8 feet) span as detailed. Provide solid lumber bridging in joists at beam bearing points as indicated. Fit solid blocking at ends of members.

H. Frame wall openings with two or more studs at each jamb; support headers on cripple studs.

3.04 BLOCKING, NAILERS, AND SUPPORTS

A. Provide framing and blocking members as indicated or as required to support finishes, fixtures, specialty items, and trim.

B. In framed assemblies that have concealed spaces, provide solid wood fireblocking as required by applicable local code, to close concealed draft openings between floors and between top story and roof/attic space; other material acceptable to code authorities may be used in lieu of solid wood blocking.

C. In walls, provide blocking attached to studs as backing and support for wall-mounted items, unless item can be securely fastened to two or more studs or other method of support is explicitly indicated.

D. Where ceiling-mounting is indicated, provide blocking and supplementary supports above ceiling, unless other method of support is explicitly indicated.

3.05 INSTALLATION OF CONSTRUCTION PANELS

A. Subflooring/Underlayment Combination: Glue and nail to framing; staples are not permitted.

B. Roof Sheathing: Secure panels with long dimension perpendicular to framing members, with ends staggered and over firm bearing.

1. Screw panels to framing; nails and staples are not permitted.

C. Wall Sheathing: Secure with long dimension parallel to wall studs, with ends over firm bearing and staggered, using nails, screws, or staples.

3.06 SITE APPLIED WOOD TREATMENT

A. Apply preservative treatment compatible with factory applied treatment at site-sawn cuts, complying with manufacturer's instructions.

B. Allow preservative to dry prior to erecting members.

3.07 TOLERANCES

A. Framing Members: 6 mm (1/4 inch) from true position, maximum.

B. Surface Flatness of Floor: 1 mm/m (1/8 inch in 10 feet) maximum, and 7 mm in 10 m (1/4 inch in 30 feet) maximum.

C. Variation from Plane (Other than Floors): 2 mm/m (1/4 inch in 10 feet) maximum, and 7 mm in 10 m (1/4 inch in 30 feet) maximum.

3.08 CLEANING

A. Waste Disposal:
   1. Comply with applicable regulations.
   2. Do not burn scrap on project site.
   3. Do not burn scraps that have been pressure treated.
   4. Do not send materials treated with pentachlorophenol, CCA, or ACA to co-generation facilities or "waste-to-energy" facilities.

B. Do not leave any wood, shavings, sawdust, etc. on the ground or buried in fill.

C. Prevent sawdust and wood shavings from entering the storm drainage system.

END OF SECTION

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SECTION 06 1753
SHOP-FABRICATED WOOD TRUSSES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Shop fabricated wood trusses for roof framing.
- B. Bridging, bracing, and anchorage.

1.02 RELATED REQUIREMENTS
- A. Section 05 5000 - Metal Fabrications: Metal components and cables that are part of shop-fabricated wood trusses.
- B. Section 06 1000 - Rough Carpentry: Installation requirements for miscellaneous framing.
- C. Section 06 1000 - Rough Carpentry: Material requirements for blocking, bridging, plates, and miscellaneous framing.

1.03 REFERENCE STANDARDS
- A. TPI 1 - National Design Standard for Metal Plate Connected Wood Truss Construction; Truss Plate Institute; 2002 and errata (ANSI/TPI 1).
- B. TPI DSB-89 - Recommended Design Specification for Temporary Bracing of Metal Plate Connected Wood Trusses; Truss Plate Institute; 1989.
- C. BCSI 1 - Building Component Safety Information Booklet: The Guide to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses; joint publication of the Truss Plate Institute and the Wood Trust Council of America; 2006.

1.04 DESIGN REQUIREMENTS
- A. Comply with applicable code and information indicated on drawings for structural loading criteria.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Show truss configurations, sizes, spacing, size and type of connectors, cambers, framed openings, bearing and anchor details, and bridging and bracing.
  1. Include identification of engineering software used for design.
  2. Provide shop drawings stamped or sealed by design engineer.

1.06 QUALITY ASSURANCE
- A. Truss Design, Fabrication, and Installation: In accordance with TPI 1, TPI DSB-89, and BCSI 1.
- B. Designer Qualifications: Perform design by or under direct supervision of a Qualified Professional Engineer experienced in design of this Work and licensed in the State of Minnesota.
- C. Fabricator Qualifications: Company specializing in manufacturing the products specified in this section with minimum 5 years of experience.

1.07 DELIVERY, STORAGE, AND HANDLING
- A. Handle and erect trusses in accordance with BCSI 1.
- B. Store trusses in vertical position resting on bearing ends.

PART 2 PRODUCTS

2.01 MATERIALS
- A. Lumber:
  1. Species and Grade: As required by truss design calculations.
  2. Moisture Content: Between 7 and 9 percent.
  3. Lumber fabricated from old growth timber is not permitted.
- B. Steel Connectors and Components: As provided by Section 05 5000; coordinate requirements.

2.02 ACCESSORIES
- A. Wood Blocking, Bridging, Plates, and Miscellaneous Framing: Softwood lumber, any species, construction grade, 19 percent maximum and 7 percent minimum moisture content.
- B. Fasteners: Electrogalvanized steel, type to suit application.

2.03 FABRICATION
- A. Fabricate trusses to achieve structural requirements specified.
- B. Brace wood trusses in accordance with TPI DSB-89 and BCSI 1.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify that field measurements are as indicated on shop drawings.
- B. Verify that supports and openings are ready to receive trusses.

3.02 ERECTION
- A. Install trusses in accordance with manufacturer's instructions and TPI DSB-89 and BCSI 1.
- B. Set members level and plumb, in correct position.
- C. Make provisions for erection loads, and for sufficient temporary bracing to maintain structure plumb, and in true alignment until completion of erection and

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installation of permanent bracing.

D. Do not field cut or alter structural members without approval of Architect.

E. Install permanent bridging and bracing.

3.03 TOLERANCES

A. Framing Members: 12 mm (1/2 inch) maximum, from true position.

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SECTION 06 2000
FINISH CARPENTRY

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Finish carpentry items.
- B. Wood casings and moldings.
- C. Hardware and attachment accessories.

1.02 RELATED REQUIREMENTS
- A. Section 06 1000 - Rough Carpentry: Support framing, grounds, and concealed blocking.
- B. Section 06 4100 - Architectural Wood Casework: Shop fabricated custom cabinet work.
- C. Section 08 3200 - Sliding and Swinging Glass Doors: Clad wood patio and entry doors.
- D. Section 08 5200 - Wood Windows.
- E. Section _____-_____: Cabinet hardware.
- F. Section 09 6429 - Wood Strip and Plank Flooring.
- G. Section 09 9000 - Painting and Coating: Painting and finishing of finish carpentry items.

1.03 REFERENCE STANDARDS
- A. AWI/AWMAC (QSI) - Architectural Woodwork Quality Standards Illustrated; Architectural Woodwork Institute and Architectural Woodwork Manufacturers Association of Canada; 2005, 8th Ed., Version 2.0.
- B. NHLA G-101 - Rules for the Measurement & Inspection of Hardwood & Cypress; National Hardwood Lumber Association; 2007.

1.04 QUALITY ASSURANCE
- A. Grade materials in accordance with the following:
  1. Softwood Lumber: In accordance with rules certified by ALSC; www.alsc.org.
  2. Plywood: Certified by the American Plywood Association.
  3. Hardwood Lumber: In accordance with NHLA Grading Rules; www.natlhardwood.org.

1.05 DELIVERY, STORAGE, AND HANDLING
- A. Protect work from moisture damage.

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL
- A. Unless otherwise indicated provide products of quality specified by AWI Architectural Woodwork Quality Standards Illustrated for Custom grade.

2.02 WOOD-BASED COMPONENTS
- A. Wood fabricated from old growth timber is not permitted.

2.03 LUMBER MATERIALS
- A. Hardwood Lumber: Species as indicated on drawings, plain sawn, maximum moisture content of 6 percent; with vertical grain, of quality suitable for transparent finish, with knots, weather checks, splits and similar defects graded out.

2.04 FASTENERS
- A. Fasteners: Of size and type to suit application; plain finish in interior locations and hot dip galvanized finish in exterior locations.

2.05 ACCESSORIES
- A. Lumber for Shimming, Blocking, and Alignment: Softwood lumber of any commercial softwood species.
- B. Wood Filler: Solvent base, tinted to match surface finish color.

2.06 HARDWARE
- A. Shelf Standards: Wall standard and resilient rest style, zinc plated finish; #255/256R manufactured by Knape and Vogt (KV) or approved equivalent.

2.07 FABRICATION
- A. Shop assemble work for delivery to site, permitting passage through building openings.
- B. Standing and Running Trim: Fabricate from specified hardwood to profiles indicated, minimum 18 knife cuts per inch; grade for uniformity of color when transparent finish is indicated.
- C. When necessary to cut and fit on site, provide materials with ample allowance for cutting. Provide trim for scribing and site cutting.

2.08 SHOP FINISHING
- A. Sand work smooth and set exposed nails and screws.
- B. Apply wood filler in exposed nail and screw indentations.
- C. On items to receive transparent finishes, use wood filler that matches surrounding surfaces and is of type recommended for the applicable finish.
- D. Finish work in accordance with AWI Architectural Woodwork Quality Standards Illustrated, Section 1500:

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify adequacy of backing and support framing.
- B. Verify mechanical, electrical, and building items

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affecting work of this section are placed and ready to receive this work.

3.02 INSTALLATION

A. Set and secure materials and components in place, plumb and level.

B. Carefully scribe work abutting other components, with maximum gaps of 1 mm (1/32 inch). Do not use additional overlay trim to conceal larger gaps.

C. Anchor finish carpentry work securely to supports and substrates, using concealed fasteners and blind nailing where possible. Use fine finishing nails for exposed nailing, except as indicated, set below finish surface and filled flush with finished surface.

D. Finish work shall be free of defects including hammer marks. Exposed joints shall be coped and mitered.

E. Make exterior joints water resistant by careful fitting. Prime end cuts during installation.

F. Standing and Running Trim: Install with minimum number of joints possible, using full-length pieces from maximum length of lumber available. Cope at returns, miter at corners to produce tight fitting joints. Use scarf joints for end-to-end joints. Provide miter returns at all ends of pre-finished materials.

G. Install hardware in accordance with manufacturer's instructions.

3.03 PREPARATION FOR SITE FINISHING

A. Set exposed fasteners. Apply wood filler in exposed fastener indentations. Sand work smooth.

B. Site Finishing: See Section 09 9000.

3.04 TOLERANCES

A. Maximum Variation from True Position: 1.5 mm (1/16 inch).

B. Maximum Offset from True Alignment with Abutting Materials: 0.7 mm (1/32 inch).

END OF SECTION

SECTION 06 4100
ARCHITECTURAL WOOD CASEWORK

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Specially fabricated cabinet units.
- B. Cabinet hardware.
- C. Factory finishing.
- D. Interior, sliding, visual screen panels and track support system.

1.02 RELATED REQUIREMENTS
- A. Section 06 1000 - Rough Carpentry: Support framing, grounds, and concealed blocking.
- B. Section 12 3600 - Countertops.
- C. Section 08 8000 - Glazing: Glass for casework.

1.03 REFERENCE STANDARDS
- A. ANSI A135.4 - American National Standard for Basic Hardboard; 2004.
- B. ANSI A208.2 - American National Standard for Medium Density Fiberboard for Interior Use; 2002.
- C. AWI/AWMAC (QSI) - Architectural Woodwork Quality Standards Illustrated; Architectural Woodwork Institute and Architectural Woodwork Manufacturers Association of Canada; 2005, 8th Ed., Version 2.0.
- D. BHMA A156.9 - American National Standard for Cabinet Hardware; Builders Hardware Manufacturers Association; 2003 (ANSI/BHMA A156.9).
- E. HPVA HP-1 - American National Standard for Hardwood and Decorative Plywood; Hardwood Plywood & Veneer Association; 2004 (ANSI/HPVA HP-1).
- F. NHLA G-101 - Rules for the Measurement & Inspection of Hardwood & Cypress; National Hardwood Lumber Association; 2007.
- G. PS 20 - American Softwood Lumber Standard; National Institute of Standards and Technology (Department of Commerce); 2005.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate materials, component profiles and elevations, assembly methods, joint details, fastening methods, accessory listings, hardware location and schedule of finishes.
- C. Product Data: Provide data for hardware accessories.
- D. Samples: Submit actual samples of architectural cabinet construction, minimum 300 mm (12 inches) square, illustrating proposed cabinet and shelf unit substrate and finish.

1.05 QUALITY ASSURANCE
- A. Perform work in accordance with AWI/AWMAC Architectural Woodwork Quality Standards Illustrated, Custom quality, unless other quality is indicated for specific items.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Protect units from moisture damage.

1.07 FIELD CONDITIONS
- A. During and after installation of custom cabinets, maintain temperature and humidity conditions in building spaces at same levels planned for occupancy.

PART 2 PRODUCTS

2.01 WOOD-BASED COMPONENTS
- A. Wood fabricated from old growth timber is not permitted.

2.02 LUMBER MATERIALS
- A. Softwood Lumber: NIST PS 20; Graded in accordance with AWI/AWMAC Architectural Woodwork Quality Standards Illustrated, Grade II/Custom; average moisture content of 5-10 percent; any commercial softwood species.
  - 1. Use for concealed locations only.
- B. Hardwood Lumber: NHLA; Graded in accordance with AWI/AWMAC Architectural Woodwork Quality Standards Illustrated, Grade II/Custom; average moisture content of 5-10 percent; species as follows:
  - 1. Exposed and Semi-Exposed Surfaces: Baltic Birch or Apple Ply, as selected by Architect.

2.03 PANEL MATERIALS
- A. Veneer Faced Plywood Finish: HPVA HP-1; graded in accordance with AWI/AWMAC Architectural Woodwork Quality Standards Illustrated, core of veneer (wood plies), medium density fiberboard, or strawboard; type of glue recommended for specific application; thickness as required; face veneer as follows:
  - 1. Exposed and Semi-Exposed Surfaces: Baltic Birch or Apple Ply, as selected by Architect.

B. Medium Density Fiberboard (MDF): ANSI A208.2; type as specified in AWI/AWMAC Architectural Woodwork Quality Standards Illustrated; composed of wood fibers pressure bonded with moisture resistant adhesive to suit application; sanded faces; thickness as required.
   1. Use for concealed components.
C. Plywood for Non-Decorative Purposes: NIST PS 1, Interior rated adhesives, core of wood plies from listed species unless otherwise indicated, thickness as indicated or as required by application.
   1. Use for concealed components.
D. Hardboard: AHA A135.4; Pressed wood fiber with resin binder, Class 1 - Tempered, 6 mm (1/4 inch) thick, smooth two sides (S2S); use for drawer bottoms, dust panels, and other components indicated on drawings.
E. Hardwood Edgebanding: Use solid hardwood edgebanding matching species, color, grain, and grade for exposed portions of cabinetry.

2.04 ACCESSORIES
A. Adhesive: Type recommended by fabricator to suit application.
B. Glass: Tempered or laminated as suitable for use in cabinets and conforming to Product requirements specified in Section 08 8000.
C. Interior, Sliding, Visual Screen Panels: Visually decorative finished panels with dynamic interlayer system allowing the designer to custom select the color, pattern, texture, interlayer and finish of the material, produced from ECORESIN, a specially-formulated co-polyester resin that is both environmentally responsible and high-performing and has been engineered to incorporate 40 percent pre-consumer re-grind content, 12 mm (1/2 inch) thick, unframed; provide 3form VARIA ECORESIN panels: www.3-form.com, style as selected by Interior Designer.
   1. Track System: Package of all basic hardware for a single ceiling mounted door, including 2 top roller assemblies, 2 top brackets, 1 96 inch top track, 2 stiffener handles, 1 U-Guide with rollers, 1 U-Guide receiver, and 1 valance; provide 3form model 3-15-1759-P.
   2. Ceiling to Wall Mount Adapter: L-shaped aluminum profile to mount top track to wall, pre-drill track to fit wall mount profile, anchors by installer; provide 3form Model 3-15-1768.
D. Fasteners: Size and type to suit application.
E. Bolts, Nuts, Washers, Lags, Pins, and Screws: Of size and type to suit application; galvanized or chrome-plated finish in concealed locations and stainless steel, or chrome-plated finish in exposed locations.
F. Concealed Joint Fasteners: Threaded steel.

2.05 HARDWARE
A. Hardware: BHMA A156.9, types as recommended by fabricator for quality grade specified.
B. Adjustable Shelf Supports: Standard side-mounted system using recessed metal shelf standards or multiple holes for pin supports and coordinated self rests, polished chrome finish, for nominal 25 mm (1 inch) spacing adjustments.
C. Door Pulls: "U" shaped wire pull, steel with chrome finish, 100 mm centers ("U" shaped wire pull, steel with chrome finish, 4 inch centers).
D. Drawer Slides:
   1. Type: Full extension.
   2. Static Load Capacity: Commercial grade.
   3. Mounting: Bottom mounted.
   4. Stops: Integral type.
   5. Features: Provide self closing/stay closed type, including opening of drawer by lightly touching drawer front; no pull allowed.
   6. Manufacturers:
      a. Blum; Product TIP-ON opening system with TANDEM PLUS runners without BLUMOTION: www.blum.com.
E. Door Opening System:
   1. Type:
      a. For Vertically Stacked Doors, 2 Same Size: Bi-fold, vertical lift and hold system. Provide Blum AVENTOS HF bi-fold lift system.
      b. For Single Doors: Concealed, vertical opening hinge and holder system. Provide Blum AVENTOS HK vertical lift system.

2.06 FABRICATION
A. Cabinet Style: Flush overlay.
B. Cabinet Doors and Drawer Fronts: Flush style, including stile and rail style with glass "panel" as indicated.
C. Drawer Construction Technique: In accordance with reference Quality Standard.
D. Assembly: Shop assemble cabinets for delivery to site in units easily handled and to permit passage through building openings.

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E. Edging: Fit shelves, doors, and exposed edges with specified edging. Do not use more than one piece for any single length.
F. Fitting: When necessary to cut and fit on site, provide materials with ample allowance for cutting. Provide matching trim for scribing and site cutting.
G. Matching Wood Grain: Comply with requirements of quality standard for specified Grade exclusively.
H. Shop glaze glass materials using the Interior Wet method specified in Section 08 8000.

2.07 FACTORY FINISHING
A. Sand work smooth and set exposed nails and screws.
B. On items to receive transparent finishes, use wood filler matching or blending with surrounding surfaces and of types recommended for applied finishes.
C. Finish work in accordance with AWI/AWMAC Architectural Woodwork Quality Standards Illustrated, Section 1500, Conversion Varnish, Transparent.

PART 3 EXECUTION

3.01 EXAMINATION
A. Verify adequacy of backing and support framing.
B. Verify location and sizes of utility rough-in associated with work of this section.

3.02 INSTALLATION
A. Install hardware in accordance with manufacturers' instructions.
B. Set and secure custom cabinets in place, assuring that they are rigid, plumb, and level.
C. Use fixture attachments in concealed locations for wall mounted components.
D. Use concealed joint fasteners to align and secure adjoining cabinet units.
E. Carefully scribe casework abutting other components, with maximum gaps of 1 mm (1/32 inch). Do not use additional overlay trim for this purpose.
F. Secure cabinets and counter bases to floor using appropriate angles and anchorages.

3.03 ADJUSTING
A. Adjust installed work.
B. Adjust moving or operating parts to function smoothly and correctly.

3.04 CLEANING
A. Clean casework, counters, shelves, hardware, fittings, and fixtures.

END OF SECTION

SECTION 07 2100
THERMAL INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Board insulation at exterior wall behind _____ wall finish and wall and roof assemblies.

B. Batt insulation for filling perimeter window and door shim spaces and crevices in exterior wall and roof.

1.02 RELATED REQUIREMENTS

A. Section 06 1000 - Rough Carpentry: Supporting construction for rigid board insulation.

B. Section 07 2119 - Foamed-In-Place Insulation.

C. Section 07 2500 - Weather Barriers: Separate air barrier materials.

1.03 REFERENCE STANDARDS

A. ASTM C 665 - Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing; 2006.

B. ASTM C 1289 - Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board; 2007.

C. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2008.

D. ASTM E 136 - Standard Test Method for Behavior of Materials in a Vertical Tube Furnace At 750 Degrees C; 2004.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on product characteristics, performance criteria, and product limitations.

PART 2 PRODUCTS

2.01 BOARD INSULATION MATERIALS

A. Polyisocyanurate Board Insulation: Rigid cellular foam, complying with ASTM C 1289; Type I, aluminum foil both faces; Class 1, non-reinforced foam core.

1. Flame Spread Index: 75 or less, when tested in accordance with ASTM E 84.
2. Smoke Developed Index: 450 or less, when tested in accordance with ASTM E 84.
3. Compressive Strength: 25 psi minimum.
4. Board Size: 1220 x 2440 mm (48 x 96 inch).
5. Board Thickness: 25 mm (1 inch).
6. Long-Term Thermal Resistance (ASTM C518, measured at Mean Temp of 75F): R-value of 6.5 per 1 inch.
7. Board Edges: Square.
8. Manufacturer: The Dow Chemical Company THERMAX™ ci Exterior Insulation.

2.02 BATT INSULATION MATERIALS

A. Batt Insulation: ASTM C 665; preformed batt; friction fit, conforming to the following:

1. Material: Glass fiber.
2. Flame Spread Index: 25 or less, when tested in accordance with ASTM E 84.
3. Combustibility: Non-combustible, when tested in accordance with ASTM E 136, except for facing, if any.
4. Facing: Unfaced.
5. Manufacturers:

a. CertainTeed Corporation: www.certainteed.com.

b. Johns Manville Corporation: www.jm.com.

c. Owens Corning Corp: www.owenscorning.com.

6. Substitutions: See Section 01 6000 - Product Requirements.

2.03 ACCESSORIES

A. Tape: Bright aluminum self-adhering type, mesh reinforced, 50 mm (2 inch) wide.

B. Nails or Staples: Steel wire; electroplated, or galvanized; type and size to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that substrate, adjacent materials, and insulation materials are dry and that substrates are ready to receive insulation.

B. Verify substrate surfaces are flat, free of honeycomb, fins, irregularities, or materials or substances that may impede adhesive bond.

3.02 BOARD INSTALLATION AT EXTERIOR WALLS AND ROOF

A. Install boards vertically on walls and perpendicular to framing on roofs.

1. Install in running bond pattern on roofs.
2. Butt edges and ends tightly to adjacent boards and to protrusions.

B. Cut and fit insulation tightly to protrusions or interruptions to the insulation plane.

C. Nail or staple to framing to retain in position until covering material is placed and to ensure that edges remain in a common plane.
D. Tape seal insulation board joints to ensure continuity of vapor retarder and air seal.

3.03 BATT INSTALLATION

A. Install insulation in accordance with manufacturer's instructions.
B. Trim insulation neatly to fit spaces. Insulate miscellaneous gaps and voids.
C. Fit insulation tightly in cavities and tightly to exterior side of mechanical and electrical services within the plane of the insulation.

3.04 PROTECTION

A. Do not permit installed insulation to be damaged prior to its concealment.

END OF SECTION

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SECTION 07 2119
FOAMED-IN-PLACE INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Foamed-in-place insulation, typically installed in stud and joist cavity spaces.

1.02 REFERENCE STANDARDS
- A. ASTM C 177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2004.
- B. ASTM D 1621 - Standard Test Method for Compressive Properties of Rigid Cellular Plastics; 2004a.
- C. ASTM D 1622 - Standard Test Method for Apparent Density of Rigid Cellular Plastics; 2003.
- D. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2008.

1.03 ADMINISTRATIVE REQUIREMENTS
- A. Preinstallation Meeting: Convene one week prior to commencing work of this section.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, insulation properties, and preparation requirements.
- C. Manufacturer's Installation Instructions: Indicate special procedures, and perimeter conditions requiring special attention

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with not less than 10 years of experience.
- B. Applicator Qualifications: Company specializing in performing work of the type specified, and approved by manufacturer.

1.06 REGULATORY REQUIREMENTS
- A. Conform to applicable code for flame and smoke and concealment limitations.

1.07 FIELD CONDITIONS
- A. Do not install insulation when ambient temperature is lower than 21 degrees C (70 degrees F).

PART 2 PRODUCTS

2.01 MANUFACTURERS
- A. Foamed-In-Place Insulation:
  1. BASF Polyurethane Foam Enterprises LLC; Product SPRAYTITE 178 Series: www.foamenterprises.com.
  2. Substitutions: Not permitted.

2.02 MATERIALS
- A. Insulation: Closed-cell polyurethane system utilizing an EPA approved, zero ozone-depleting, blowing agent.
  1. Thermal Conductivity: When tested in accordance with ASTM C 177:
  2. Permeability: 1.82 perm inch, when tested in accordance with ASTM E 96.
  3. Permeance: 0.91 perms @ 2" SPF, when tested in accordance with ASTM E 96.
  4. Air Leakage: 0.00025 L/s/m2 @ 75Pa, when tested in accordance with ASTM E 283.
  5. Compressive Strength: 152 kPa (22 psi), when tested in accordance with ASTM D 1621.
  6. Density: 34.4 kg/cu m (2.15 lb/cu ft) at 2 inch lift, when tested in accordance with ASTM D 1622.
  7. Closed Cell Content: > 90 percent, when tested in accordance with ASTM D 6226.
  8. Surface Burning Characteristics: Flame spread/ Smoke developed index of 25 / 350, when tested in accordance with ASTM E 84.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify work within construction spaces or crevices is complete prior to insulation application.
- B. Verify that surfaces are clean, dry, and free of matter that may inhibit insulation adhesion.

3.02 PREPARATION
- A. Mask and protect adjacent surfaces from over spray or dusting.

3.03 APPLICATION
- A. Apply insulation in accordance with manufacturer's instructions.
- B. Apply insulation by spray method, to a uniform monolithic density without voids.
- C. Apply to fill void areas, typically stud and joist spaces, as indicated on drawings.
- D. Patch damaged areas.

3.04 CLEANING
- A. Remove, overspray, markings and residue from

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finished surfaces.

B. In areas where finished surfaces are soiled by work of this section, consult manufacturer of surfaces for cleaning advice and conform to their documented instructions.

C. Repair or replace defaced or damaged finishes caused by work of this section.

3.05 PROTECTION

A. Do not permit subsequent construction work to disturb applied insulation.

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SECTION 07 2500
WEATHER BARRIERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Air Barriers: Materials to stop passage of air through exterior walls.

1.02 RELATED REQUIREMENTS

A. Section 07 6200 - Sheet Metal Flashing and Trim: Metal flashings installed in conjunction with weather barriers.

B. Section 07 9005 - Joint Sealers: Sealant materials and installation techniques.

1.03 DEFINITIONS

A. Weather Barrier: Assemblies that form either water-resistive barriers, air barriers, vapor retarders, or water-resistive barriers.

B. Air Barrier: Air-tight barrier made of material that is relatively air impermeable but water vapor permeable, both to the degree specified, with sealed seams and with sealed joints to adjacent surfaces.

1.04 REFERENCE STANDARDS

A. AATCC Test Method 127 - Water Resistance: Hydrostatic Pressure Test; 2003.

B. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2008.

C. ASTM E 96/E 96M - Standard Test Methods for Water Vapor Transmission of Materials; 2005.

D. ASTM E 2178 - Standard Test Method for Air Permeance of Building Materials; 2003.

1.05 PERFORMANCE REQUIREMENTS

A. Provide an air and water barrier system to perform as a continuous barrier to air infiltration/exfiltration and to act as a liquid water drainage plane flashed to discharge any incidental condensation or water penetration. Additionally, the non-permeable air barrier shall be a continuous barrier to water vapor transmission.

B. All penetrations of the air barrier and paths of air infiltration/exfiltration shall be made airtight.

1.06 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on material characteristics.

C. Shop Drawings: Provide drawings of special joint conditions.

D. Manufacturer's Installation Instructions: Indicate preparation.

1.07 FIELD CONDITIONS

A. Maintain temperature and humidity recommended by the materials manufacturers before, during and after installation.

B. Coordinate installation schedule and sequence of exterior weather barriers so that manufacturer's recommended maximum UV exposure time limit of such barriers is not exceeded prior to covering with finish materials.

PART 2 PRODUCTS

2.01 WEATHER BARRIER ASSEMBLIES

A. Air Barrier:

1. On outside surface of sheathing of exterior walls use air barrier sheet, mechanically fastened type.

2.02 AIR BARRIER MATERIALS (WATER VAPOR PERMEABLE AND WATER-RESISTIVE)

A. Air Barrier Sheet, Mechanically Fastened:

1. Type: Triple layer spunbond polypropylene, non-woven, non-perforated.
2. Air Permeance: 0.01 liters per second per square meter (0.002 cubic feet per square foot), maximum, when tested in accordance with ASTM E 2178.
3. Water Vapor Permeance: 2873 ng/(Pa s sq m) (50 perms), minimum, when tested in accordance with ASTM E96/E 96M Procedure A (desiccant method).
4. Water Penetration Resistance: Withstand a water head of 55 cm (21 inches), minimum, for minimum of 5 hours, when tested in accordance with AATCC 127.
5. Ultraviolet and Weathering Resistance: Approved in writing by manufacturer for minimum of 9 months weather exposure.
6. Surface Burning Characteristics: Flame spread index of 25 or less, smoke developed index of 50 or less, when tested in accordance with ASTM E 84.
7. Products:
   a. VaproShield, LLC; WrapShield: www.vaproshield.com.
   b. Substitutions: Not permitted.

2.03 SEALANTS

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A. Silicone Sealant: As specified in Section 07 9005.

2.04 ACCESSORIES

A. Self-Adhesive Tape and Sheet Flashings: As recommended by sheet membrane manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that surfaces and conditions are ready to accept the work of this section.

3.02 PREPARATION

A. Remove projections, protruding fasteners, and loose or foreign matter that might interfere with proper installation.

3.03 INSTALLATION

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

B. Install air barriers as whole building envelope "wrap" prior to installation of glazing systems, doors, louvers, and exterior wall finishes.

C. Air Barriers: Install continuous air-tight barrier over surfaces indicated, with sealed seams and with sealed joints to adjacent surfaces.

D. Apply sealants and adhesives within recommended application temperature ranges. Consult manufacturer if temperature is out of this range.

E. Mechanically Fastened Sheets - On Exterior:

1. Install sheets shingle-fashion to shed water, with seams generally horizontal.
2. Overlap seams as recommended by manufacturer but at least 6 inches.
3. Overlap at outside and inside corners as recommended by manufacturer but at least 305 mm (12 inches).
4. Attach to framed construction with fasteners extending through sheathing into framing. Space fasteners at 305 to 460 mm (12 to 18 inches) on center along each framing member supporting sheathing.
5. For applications specified to be air-tight, seal seams, laps, penetrations, tears, and cuts with self-adhesive tape; use only large-headed, gasketed fasteners recommended by the manufacturer.
6. Install air barrier and vapor retarder UNDER jamb flashings.
7. Install head flashings under weather barrier.

F. Openings and Penetrations in Exterior Weather Barriers:

1. Install self-adhesive flashing over sills, covering entire sill frame member, extending at least 125 mm (5 inches) onto weather barrier and at least 150 mm (6 inches) up jambs; mechanically fasten stretched edges.
2. At openings to be filled with frames having nailing flanges, seal head and jamb flanges using a continuous bead of sealant compressed by flange and cover flanges with self-adhesive flashing at least 100 mm (4 inches) wide; do not seal sill flange.
3. At openings to be filled with non-flanged frames, seal weather barrier to all sides of opening framing, using self-adhesive flashing at least 230 mm (9 inches) wide, covering entire depth of framing.
4. At head of openings, install self-adhesive flashing under weather barrier extending at least 50 mm (2 inches) beyond face of jambs; seal weather barrier to flashing.
5. At interior face of openings, seal gap between window/door frame and rough framing, using joint sealant over backer rod.
6. Service and Other Penetrations: Form self-adhesive flashing around penetrating item and seal to weather barrier surface.

3.04 FIELD QUALITY CONTROL

A. Do not cover installed weather barriers until required inspections have been completed.

3.05 PROTECTION

A. Do not leave materials exposed to weather longer than recommended by manufacturer.

END OF SECTION

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SECTION 07 4243
COMPOSITE WALL PANELS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Labor, material, transportation, tools and other apparatus and supervision required to perform Work specified in this Section.

B. Solid composite exterior wall and roof strip systems. Work includes exterior wall finish and roof finish as indicated.

1. Refer to Drawings for locations and extent of Work.

1.02 RELATED SECTIONS

A. Section 06 1000 - Rough Carpentry: Wall and roof panel substrate.

B. Section 06 2000 - Finish Carpentry.

C. Section 07 2100 - Thermal Insulation.

D. Section 07 2500 - Weather Barriers: Weather barrier under wall panels.

1.03 REFERENCES

A. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2005.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's product data, including SPEC-DATA sheets for specified products.

C. Shop Drawings: Indicate layout, profiles and product components, including edge conditions, panel joints, fixture locations, anchorage, accessories, finish colors, patterns, and textures.

D. Samples: Submit two finish samples, 100 x 100 mm (4 x 4 inch) in size, illustrating each color and thickness of material used.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than 10 years of experience.

1.06 DELIVERY, STORAGE, AND PROTECTION

A. Deliver and store materials in an enclosed shelter providing protection from damage and exposure to the elements.

1.07 COORDINATION

A. Field Measurements: Secure field measurements before preparation of shop drawings and fabrication for proper fabrication and installation of the Work.

1.08 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

B. Provide 10 year manufacturer warranty against delamination and against discoloration, Gray Scale 4-5 when tested in accordance to ISO 105A02-87.

1. Manufacturer, factory authorized fabricator, and qualified product installer shall sign the Warranty documents and submit a copy to the Contractor for submission to the Owner.

C. Provide 3 year installer warranty for defects in material and workmanship. Include replacement of Work found defective during the warranty period.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Solid Phenolic Panels:

1. Trespa International; Product METEON panels distributed by Trespa North America, Ltd., Poway, CA, 92604: 800-487-3772.

a. Represented locally by Tegan Marketing, Inc. 763-475-1340 or 800-510-5836.

b. A list of approved fabricators that provide the system specified in this section may be acquired by contacting Trespa North America or Tegan Marketing.

B. Substitutions: See Section 01 6000 - Product Requirements.

2.02 MATERIALS

A. Panels: Solid phenolic flat panel, based on thermosetting resins, homogeneously reinforced with cellulose fibers and manufactured under high pressure and temperature.

B. Panel Face: Pigmented resin, decorative surface, electron-beam cured for superior chemical and dirt resistance.

C. Panel Core: Bakelized Type FR fire retardant black core.

D. Exposed fastening.

E. Panel Thickness: 10 mm (3/8 inch).

F. Strip Size: Cut panels to 2 inch wide strips x longest length possible to fill wall area between constraints.

G. Color and Finish: As selected by Architect from manufacturer's standards.

H. Performance Testing Requirements:

1. Physical Properties:

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a. Specific Gravity: 87 lbs per cubic foot, minimum.
b. Dimensional Stability: 0.03 in/ft, maximum.
c. Water Absorption: 3 percent by weight, maximum.
d. Vapor Diffusion: 30,000
e. Do not support micro-organic growth.

2. Optical Properties:
a. Color Stability: Gray scale 4 – 5 when tested in accordance with ISO 105A02-87, (3000 hours Xenon test 1200).
b. Dioxide Resistance: Gray scale 4 – 5 (50 cycles 0.0067 percent).

3. Mechanical Properties:
a. Flame Spread Index: 5 when tested in accordance with ASTM E 84.
b. Smoke Development Index: 5 when tested in accordance with ASTM E 84
c. Modulus of Elasticity: 1,200,000 psi minimum.
d. Tensile Strength: 13,000 psi, minimum.
e. Flexural Strength: 16,000 psi minimum.
f. Surface Impact Resistance: 9 lb.
g. Scratch Resistance: 0.8 lb.

2.03 SUB-FRAME ASSEMBLY

A. Sub-Frame Furring: Extruded aluminum, 6063-T6, 1/8 inch minimum thickness; extrude to "hat" and channel profiles, as recommended by manufacturer; paint black.

2.04 ACCESSORIES

A. Exposed Fastening Fasteners:
1. Manufacturer's standard type to suit application; with soft neoprene washer, stainless steel, fastener cap same color as exterior panel.

B. Joint Closures: None; install with open joints as rain-screen system.

2.05 FABRICATION

A. Fabricate solid phenolic panels and accessory items in accordance with manufacturer's recommendations and approved shop drawings.
B. Sand and round smooth all panel exposed edges.
C. Fabricate for exposed fastening.

2.06 SOURCE QUALITY CONTROL

A. Panels: Material specifically designed for exterior wall panels. Fabricated work surfaces shall comply with all current codes and regulations.
B. Panel Tolerance:
1. Thickness: Uniform thickness of +0.03 inch for a 10 foot span maximum.
2. Flatness: Maximum difference of 0.08 inch for 3 foot span.
3. Fabricated Panel Length: +/- 0.03 inch maximum.
4. Width: +/- 0.03 inch maximum.

C. Panels to be U.L. registered and labeled for quality consistency.

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to installing sub-frame, verify that substrate alignment is flat and uniform and meets manufacturer's installation requirements; do not proceed until any defects are corrected by responsible contractor. .

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions and approved shop drawings.
B. See Section 07 2500 for installation of weather barrier over face of sheathing.
C. Install sub-frame, fasteners and composite wall panel system in accordance with approved shop drawings.
D. Install sub-frame and anchoring system true, plumb, and secure to provide support for the wall panels.
E. Install panel strips with open joints.
1. All fabricated joints to allow a minimum 1/2" of free space for movement of panels.
2. Install sub-frame directly behind and in line with vertical joints.
3. Exact sizes and dimensions to be coordinated with the drawings, field conditions and approved shop drawings.

3.03 FIELD QUALITY CONTROL

A. Repair or replace all damaged material to the satisfaction of the Architect.
B. Installed portions of the Work shall be inspected by Architect and approved immediately following completion of such areas.

3.04 CLEANING

A. Do not use of abrasive cleaners or cleaning tools.
B. Installer shall dry wipe down clean all work as it is erected and prior to moving to the next portion or area.
C. Contractor shall be responsible for the subsequent and final cleaning of the wall system.

3.05 PROTECTION

A. After installation, Contractor shall protect the wall

panel system from damage. Keep panels free from paint, plaster, cement, scratches, or any other destructive forces.

END OF SECTION

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SECTION 07 5300
ELASTOMERIC MEMBRANE ROOFING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Elastomeric roofing membrane, mechanically fastened conventional and adhered conventional application.
- B. Membrane flashings.

1.02 RELATED REQUIREMENTS
- A. Section 06 1000 - Rough Carpentry: Wood roof deck.
- B. Section 07 6200 - Sheet Metal Flashing and Trim: Counterflashings and perimeter flashings.
- C. Section 23 5613.13 - Heating Solar Flat-Plate Collectors: Panels to be mounted off from and above roofing system.

1.03 REFERENCE STANDARDS
- A. ASTM D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension; 2006a.
- B. ASTM D 624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers; 2000 (Reapproved 2007).
- C. ASTM D 4637 - Standard Specification for EPDM Sheet Used in Single-Ply Roof Membrane; 2004.
- D. NRCA ML104 - The NRCA Roofing and Waterproofing Manual; National Roofing Contractors Association; Fifth Edition, with interim updates.

1.04 ADMINISTRATIVE REQUIREMENTS
- A. Coordinate with installation of associated counterflashings installed under other sections.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data indicating membrane materials, flashing materials, fasteners, and adhesives.
- C. Shop Drawings: Indicate joint or termination detail conditions and conditions of interface with other materials.
- D. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE
- A. Perform work in accordance with NRCA Roofing and Waterproofing Manual and manufacturer's instructions.
- B. Applicator Qualifications: Company specializing in performing the work of this section with minimum three years experience and approved by manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING
- A. Deliver products in manufacturer's original containers, dry, undamaged, with seals and labels intact.
- B. Store products in weather protected environment, clear of ground and moisture.
- C. Protect foam insulation from direct exposure to sunlight.

1.08 FIELD CONDITIONS
- A. Do not apply roofing membrane during unsuitable weather.
- B. Do not apply roofing membrane when ambient temperature is below 5 degrees C (40 degrees F).
- C. Do not apply roofing membrane to damp or frozen deck surface or when precipitation is expected or occurring.
- D. Do not expose materials vulnerable to water or sun damage in quantities greater than can be weatherproofed the same day.

1.09 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide 10 year manufacturer's material and labor warranty to cover failure to prevent penetration of water.

PART 2 PRODUCTS

2.01 MANUFACTURERS
- A. EPDM Membrane Materials:
  1. Carlisle SynTec: www.carlisle-syntec.com.
  2. Firestone Building Products Co: www.firestonebpco.com.
  3. GenFlex Roofing Systems: www.genflex.com.
  4. Substitutions: Not permitted.

2.02 ROOFING - UNBALLASTED APPLICATIONS
- A. Elastomeric Membrane Roofing: One ply membrane, fully adhered.
- B. Roofing Assembly Requirements:
  1. Roof-Ceiling Fire Resistance Rating: No rating required.
  2. Factory Mutual Classification: No rating

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required.

2.03 ROOFING MEMBRANE AND ASSOCIATED MATERIALS

A. Membrane: Ethylene-propylene-diene-terpolymer (EPDM); non-reinforced; complying with minimum properties of ASTM D 4637.
   1. Thickness: 1.5 mm (0.060 inch).
   2. Color: Black.
   3. Tensile Strength: 8.96 MPa (1300 psi), measured in accordance with ASTM D 412.
   4. Ultimate Elongation: 300 percent, measured in accordance with ASTM D412.
   5. Tear Strength: 26.3 kN/m (150 lbf/in), measured in accordance with ASTM D 624.

B. Seaming Materials: Seam tape, As recommended by membrane manufacturer.

C. Flexible Flashing Material: EPDM sheet; conforming to the following:
   1. Thickness: 1.1 mm (45 mil).
   2. Tensile Strength: 8.3 MPa (1,200 psi).
   3. Color: Black.

2.04 ACCESSORIES

A. Stack Boots: Prefabricated flexible boot and collar for pipe stacks through membrane; same material as membrane.

B. Membrane Adhesive: As recommended by membrane manufacturer.

C. Surface Conditioner for Adhesives: Compatible with membrane and adhesives.

D. Thinners and Cleaners: As recommended by adhesive manufacturer, compatible with membrane.

E. Sealants: As recommended by membrane manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that surfaces and site conditions are ready to receive work.

B. Verify deck is supported and secure.

C. Verify deck is clean and smooth, flat, free of depressions, waves, or projections, properly sloped and suitable for installation of roof system.

D. Verify deck surfaces are dry and free of snow or ice.

E. Verify that roof openings, curbs, and penetrations through roof are solidly set, and nailing strips are in place.

3.02 WOOD DECK PREPARATION

A. Verify flatness and tightness of joints of wood decking. Fill knot holes with latex filler.

B. Confirm that deck fasteners are fully driven and not protruding above deck top surface. If not satisfactory, do not proceed until corrected.

3.03 MEMBRANE APPLICATION

A. Roll out membrane, free from wrinkles or tears. Place sheet into place without stretching.

B. Shingle joints on sloped substrate in direction of drainage.

C. Fully Adhered Application: Apply adhesive to substrate at rate recommended by manufacturer. Fully embed membrane in adhesive. Fully adhere one roll before proceeding to adjacent rolls.

D. Overlap edges and ends and seal seams by contact tape, minimum 75 mm (3 inches). Seal permanently waterproof.

E. At intersections with vertical surfaces:
   1. Extend membrane over cant strips and up a minimum of 200 mm (8 inches) onto vertical surfaces.
   2. Fully adhere flexible flashing over membrane and up to nailing strips.

F. At open roof edges, extend membrane under sheet metal flashings and to the outside face of the wall; turn down over roof edge and secure as recommended by membrane manufacturer.

G. Around roof penetrations, seal flanges and flashings with flexible flashing.

H. Coordinate installation of roof mounted solar heat collectors and related flashings.

3.04 CLEANING

A. Remove markings from finished surfaces.

B. In areas where finished surfaces are soiled by work of this section, consult manufacturer of surfaces for cleaning advice and conform to their documented instructions.

C. Repair or replace defaced or damaged finishes caused by work of this section.

3.05 PROTECTION

A. Protect installed roofing and flashings from construction operations.

B. Where traffic must continue over finished roof membrane, protect surfaces using durable materials.

END OF SECTION

SECTION 07 6200
SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Fabricated sheet metal items, including flashings, counterflashings, gutters, and downspouts.

1.02 RELATED REQUIREMENTS
- A. Section 06 1000 - Rough Carpentry: Wood nailers.
- B. Section 07530 - Elastomeric Membrane Roofing: Roofing system.
- C. Section 07 9005 - Joint Sealers.

1.03 REFERENCE STANDARDS
- A. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum; American Architectural Manufacturers Association; 1998.
- B. AAMA 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels; 2005.
- C. ASTM A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2007.
- D. ASTM B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2007.
- E. ASTM B 209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric]; 2007.
- F. SMACNA (ASMM) - Architectural Sheet Metal Manual; Sheet Metal and Air Conditioning Contractors' National Association; 2003.

1.04 QUALITY ASSURANCE
- A. Perform work in accordance with SMACNA Architectural Sheet Metal Manual requirements and standard details, except as otherwise indicated.

1.05 DELIVERY, STORAGE, AND HANDLING
- A. Stack material to prevent twisting, bending, and abrasion, and to provide ventilation. Slope metal sheets to ensure drainage.
- B. Prevent contact with materials that could cause discoloration or staining.

PART 2 PRODUCTS

2.01 SHEET MATERIALS
- A. Galvanized Steel: ASTM A 653/A 653M, with G90/Z275 zinc coating; 22 gauge thick.
  1. Use for concealed work.
- B. Pre-Finished Galvanized Steel: ASTM A 653/A 653M, with G90/Z275 zinc coating; 24 gauge thick base metal, shop pre-coated with PVDF coating.
  1. PVDF (Polyvinylidene Fluoride) Coating: Superior Performance Organic Finish, AAMA 2605; multiple coat, thermally cured fluoropolymer finish system; color as scheduled.
- C. Aluminum: ASTM B 209 (ASTM B 209M); 0.8 mm (0.032 inch) thick; anodized finish of dark bronze color.
  1. Color Anodized Finish: AAMA 611 AA-M12C22A42/44 Class I integrally or electrolytically colored anodic coating not less than 0.018 mm (0.7 mils) thick.

2.02 ACCESSORIES
- A. Fasteners: Galvanized steel, with soft neoprene washers, except aluminum fasteners for aluminum flashing material.
- B. Primer: Zinc chromate type.
- C. Sealant: Silicone Type specified in Section 07 9005.

2.03 FABRICATION
- A. Form sections true to shape, accurate in size, square, and free from distortion or defects.
- B. Fabricate cleats of unfinished galvanized steel type sheet metal, interlocking with sheet.
- C. Form pieces in longest possible lengths.
- D. Hem exposed edges on underside 13 mm (1/2 inch); miter and seam corners.
- E. Form material with flat lock seams, except where otherwise indicated. At moving joints, use sealed lapped, bayonet-type or interlocking hooked seams.
- F. Fabricate corners from one piece with minimum 450 mm (18 inch) long legs; seam for rigidity, seal with sealant.
- G. Fabricate vertical faces with bottom edge formed outward 1/4 inch (6 mm) and hemmed to form drip.

2.04 GUTTER AND DOWNSPOUT FABRICATION
- A. Gutters: Profile as indicated; built-in type.
- B. Downspouts: Rectangular profile.
- C. Accessories: Profiled to suit gutters and downspouts.
  1. Downspout Supports: Brackets.
- D. Seal metal joints.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 PREPARATION

A. Install starter and edge strips, and cleats before starting installation.

3.03 INSTALLATION

A. Conform to drawing details indicated and to requirements of single ply membrane roofing manufacturer.
B. Secure flashings in place using concealed fasteners.
C. Fit flashings tight in place. Make corners square, surfaces true and straight in planes, and lines accurate to profiles.
D. Seal metal joints watertight.
E. Provide prefinished aluminum drip cap flashing at window heads, door heads, and other exposed exterior locations as necessary to shed water to the exterior.
F. Secure gutters and downspouts in place using fasteners.
G. Slope gutters 20 mm/m (1/4 inch per foot) minimum.

END OF SECTION

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SECTION 07 9005
JOINT SEALERS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Sealants and joint backing.

1.02 RELATED REQUIREMENTS
- A. Section 07 2500 - Weather Barriers: Sealants required in conjunction with air barriers and vapor retarders:
- B. Section 07 53 00 - Elastomeric Membrane Roofing: Sealants required in conjunction with roofing.
- C. Section 08 8000 - Glazing: Glazing sealants and accessories.

1.03 REFERENCE STANDARDS
- A. ASTM C 834 - Standard Specification for Latex Sealants; 2005.
- B. ASTM C 920 - Standard Specification for Elastomeric Joint Sealants; 2005.
- C. ASTM C 1193 - Standard Guide for Use of Joint Sealants; 2005a.

1.04 ADMINISTRATIVE REQUIREMENTS
- A. Coordinate the work with other sections referencing this section.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data:
  1. Provide data indicating sealant chemical characteristics, performance criteria, substrate preparation, limitations, and color availability.
  2. Provide data indicating physical properties of sealant backer rod and bond breaker tape.
- C. Samples:
  1. Selection Samples: Submit two samples, 10 x 50 mm (3/8 x 2 inch) in size illustrating sealant colors for selection.
  2. Verification Samples: Provide 3 in-place sealant color samples, 18 inches long each, for each installation condition, for Architect's final color verification/selection.

1.06 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum 10 years experience.
- B. For the project, each type of sealant and related primer and backing shall be products provided by a single manufacturer.
- C. Do not use sealants and primers after manufacturer's stated shelf life.
- D. Product Selection: When window seam sealant tape has been used to seal exterior wall openings, select sealant products at those locations that are approved by seam sealant tape manufacturer and/or take precautions to ensure no contact between sealant and seam sealing tape.

1.07 FIELD CONDITIONS
- A. Maintain temperature and humidity recommended by the sealant manufacturer during and after installation.
- B. Do not install sealants when temperature is 5 degrees F or more below dewpoint.
- C. Do not install sealants during inclement weather or when such conditions are expected. Allow wet surfaces to dry.

1.08 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective work within a 1 year period after Date of Substantial Completion.
- C. Warranty:
  1. Provide 1 year installer's workmanship warranty for installed sealants and accessories which fail to achieve airtight seal and watertight seal, exhibit loss of adhesion or cohesion, or do not cure.
  2. Provide 20 year manufacturer's material and weatherseal limited warranty for properly installed silicone sealants.

PART 2 PRODUCTS

2.01 MANUFACTURERS
- A. Silicone Sealants:
  1. Dow Corning Corp: www.dowcorning.com.
  2. Momentive Performance Materials, Inc (formerly GE Silicones): www.momentive.com.
  3. Pecora Corporation: www.pecora.com.
  4. Tremco Global Sealants: www.tremcosealants.com.
  5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Butyl Sealants:
  1. Bostik Inc: www.bostik-us.com.
  2. Pecora Corporation: www.pecora.com.

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3. Tremco Global Sealants: www.tremcosealants.com.
4. Substitutions: See Section 01 6000 - Product Requirements.

C. Acrylic Emulsion Latex Sealants:
1. Bostik Inc: www.bostik-us.com.
2. Pecora Corporation: www.pecora.com.
3. BASF Construction Chemicals-Building Systems: www.chemrex.com.
4. Tremco Global Sealants: www.tremcosealants.com.
5. Substitutions: See Section 01 6000 - Product Requirements.

2.02 SEALANTS

A. General Purpose Exterior Sealant: Silicone; ASTM C 920, Type S, Grade NS, Class 50, Uses NT, M, G, A, and O; single component, pre-pigmented, medium-modulus, neutral cure for weatherproofing porous stone, metal panels, curtainwall framing, and other above-grade expansion and control joints for both new and remedial construction where staining and residue rundown streaking must be minimized.
1. Color: Standard colors matching finished surfaces.
2. Product: DOW CORNING 756 SMS Building Sealant manufactured by Dow Corning Corp. or equivalent of other approved manufacturers.
3. Applications: Use for:
a. Joints between and within exterior finish materials and between exterior finish materials and adjacent dissimilar materials.
b. Joints between metal, wood, and plastic frames in exterior walls and other materials.
c. Joints in exterior wood trim.
d. Joints around penetrations in exterior walls.
e. Lap joints in sheet metal components.
f. Other exterior joints required to provide a weather and water tight enclosure.
g. Other exterior joints for which no other sealant is indicated.

B. General Purpose Interior Sealant: Acrylic emulsion latex; ASTM C 834, Type OP, Grade NF single component, paintable.
1. Applications: Use for:
a. Joints in interior materials other than concrete and masonry.

C. Bathtub/Tile Sealant: Silicone; ASTM C 920, Uses M and A; single component, mildew resistant.
1. Applications: Use for:
a. Joints between plumbing fixtures and floor and wall surfaces, if not specified in Division 22; white color.
b. Joints between kitchen and bath countertops and wall surfaces; color as selected to match/complement adjacent finish materials.

D. Butyl Sealant: ASTM C 920, Grade NS, Class 12-1/2, Uses NT, M, A, G, O; single component, solvent release, non-skinning, non-sagging.
1. Color: Standard colors matching finished surfaces.
2. Applications: Use for:
a. Setting door thresholds.

2.03 ACCESSORIES

A. Primer: Non-staining type, when recommended by sealant manufacturer to suit application.

B. Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Cleaning Clothes: Clean, soft, absorbent, lint-free cloths.

D. Joint Backing: Round foam rod compatible with sealant; closed cell polyethylene; oversized 30 to 50 percent larger than joint width; SOF ROD manufactured by Namaco Inc.

E. Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that substrate surfaces and joint openings are ready to receive work.

B. Ensure surfaces are clean, dry, and free of frost, dust, dirt, grease, oil, curing compounds, form release agents, laitance, efflorescence, mildew, and existing sealant.

C. Verify that joint backing and release tapes are compatible with sealant.

3.02 PREPARATION

A. Remove loose materials and foreign matter that could impair adhesion of sealant.

B. Clean and prime joints in accordance with manufacturer's instructions.
1. Clean non-porous surfaces with 2-cloth wipe with solvent wipe in accordance with ASTM C 1193.

a. Pour cleaning solvent onto clean cloth. Wipe vigorously to remove contaminants.
b. Immediately wipe cleaned area with separate cloth before solvent has evaporated.

C. Perform preparation in accordance with manufacturer's instructions and ASTM C 1193.
D. Protect elements surrounding the work of this section from damage or disfigurement.

3.03 INSTALLATION

A. Perform work in accordance with sealant manufacturer's requirements for preparation of surfaces and material installation instructions.
B. Perform installation in accordance with ASTM C 1193.
C. Measure joint dimensions and size joint backers to achieve width-to-depth ratio, neck dimension, and surface bond area as recommended by manufacturer, except where specific dimensions are indicated.
D. Install joint backers without gaps, twisting, stretching, or puncturing. Use gage to ensure uniform depth to achieve correct profile, coverage, and performance.
E. Install bond breaker where joint backing is not used.
F. Install sealant free of air pockets, foreign embedded matter, ridges, and sags.
G. Fill joint opening to full and proper configuration. Apply in continuous operation.
H. Ensure sealant fills entire joint and firmly contacts all surfaces.
I. Complete horizontal joints before vertical joints. Lap vertical sealant over horizontal joints.
J. DO NOT seal joints between the top side of sheet metal drip flashings and the finish material/product above the flashing, except at both ends, form an end dam of sealant to prevent water from rolling off the end of the flashing.
K. Apply sealant within recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.
L. Tool joints concave with metal spatula before skinning or curing begins. Provide smooth, uniform, sealant finish. Tool joints with one continuous stroke.

3.04 CLEANING

A. Clean adjacent soiled surfaces.|

3.05 PROTECTION

A. Protect sealants until cured.

END OF SECTION

SECTION 08 1113
HOLLOW METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Non-fire-rated steel doors and frames.
- B. Thermally insulated steel doors.

1.02 RELATED REQUIREMENTS
- A. Section 08 3200 - Sliding Glass Doors.
- B. Section 08 7100 - Door Hardware.
- C. Section 09 9000 - Painting and Coating: Field painting.

1.03 REFERENCE STANDARDS
- A. ANSI A250.8 - SDI-100 Recommended Specifications for Standard Steel Doors and Frames; 2003.
- B. ANSI A250.10 - Test Procedure and Acceptance Criteria for Prime Painted Steel Surfaces for Steel Doors and Frames; 1998 (R2004).
- C. ASTM A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2007.
- D. BHMA A156.115 - Hardware Preparation in Steel Doors and Steel Frames; 2006.
- E. NAAMM HMMA 840 - Guide Specifications for Installation and Storage of Hollow Metal Doors and Frames; The National Association of Architectural Metal Manufacturers; 2007.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Materials and details of design and construction, hardware locations, reinforcement type and locations, anchorage and fastening methods, and finishes.
- C. Shop Drawings: Details of each opening, showing elevations, glazing, frame profiles, and identifying location of different finishes, if any.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Store in accordance with NAAMM HMMA 840.
- B. Protect with resilient packaging; avoid humidity build-up under coverings; prevent corrosion.

PART 2 PRODUCTS

2.01 DOORS AND FRAMES
- A. Requirements for All Doors and Frames:
  1. Door Top Closures: Flush with top of faces and edges.
  2. Door Texture: Smooth faces.
  3. Hardware Preparation: In accordance with BHMA A156.115, with reinforcement welded in place, in addition to other requirements specified in door grade standard.
  4. Galvanizing for Units Installed in Exterior Openings: All components hot-dipped zinc-iron alloy-coated (galvannealed), manufacturer's standard coating thickness.
  5. Finish: Factory primed, for field finishing.
- B. Combined Requirements: If a particular door and frame unit is indicated to comply with more than one type of requirement, comply with all the specified requirements for each type; for instance, an exterior door that is also indicated as being sound-rated must comply with the requirements specified for exterior doors and for sound-rated doors; where two requirements conflict, comply with the most stringent.

2.02 STEEL DOORS
- A. Exterior Doors:
  1. Grade: ANSI A250.8 Level 3, physical performance Level A, Model 2, seamless.
  2. Core: Polystyrene foam.
  3. Galvanizing: All components hot-dipped zinc-iron alloy-coated (galvannealed) in accordance with ASTM A 653/A 653M, with manufacturer's standard coating thickness.
  4. Weatherstripping: Separate, see Section 08 7100.

2.03 STEEL FRAMES
- A. General:
  1. Comply with the requirements of grade specified for corresponding door, except:
     - a. ANSI A250.8 Level 3 Doors: 14 gage frames.
  2. Finish: Same as for door.
  3. Provide mortar guard boxes for hardware cut-outs in frames to be installed in masonry or to be grouted.

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4. Frames Wider than 1200 mm (48 Inches): Reinforce with steel channel fitted tightly into frame head, flush with top.

B. Exterior Door Frames: Face welded, seamless with joints filled.

1. Galvanizing: All components hot-dipped zinc-iron alloy-coated (galvannealed) in accordance with ASTM A 653/A 653M, with manufacturer's standard coating thickness.
2. Finish: Factory primed, for field finishing.
3. Weatherstripping: Separate, see Section 08 7100.

2.04 ACCESSORY MATERIALS

A. Silencers: Resilient rubber, fitted into drilled hole; 3 on strike side of single door, 3 on center mullion of pairs, and 2 on head of pairs without center mullions.

B. Temporary Frame Spreaders: Provide for all factory- or shop-assembled frames.

2.05 FINISH MATERIALS

A. Primer: Rust-inhibiting, complying with ANSI A250.10, door manufacturer's standard.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that opening sizes and tolerances are acceptable.

3.02 INSTALLATION

A. Install in accordance with the requirements of the specified door grade standard and NAAMM HMMA 840.

B. Coordinate frame anchor placement with wall construction.

C. Fill frames in exterior openings with foamed-in-place insulation as specified in Section 07 2119.

D. Coordinate installation of hardware.

3.03 TOLERANCES

A. Clearances Between Door and Frame: As specified in ANSI A250.8.

B. Maximum Diagonal Distortion: 1.5 mm (1/16 in) measured with straight edge, corner to corner.

3.04 ADJUSTING

A. Adjust for smooth and balanced door movement.

END OF SECTION

SECTION 08 3200
SLIDING AND SWINGING GLASS DOORS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Sliding and swinging entry doors and frames of wood construction.
- B. Glazing; site glazed.
- C. Operating hardware and insect screens.

1.02 RELATED REQUIREMENTS
- A. Section 06 1000 - Rough Carpentry: Rough opening framing.
- B. Section 07 2100 - Thermal Insulation: Fibrous stuffing insulation at door frame perimeter.
- C. Section 07 2500 - Weather Barriers: Perimeter air and vapor seal between sliding door frame and adjacent construction.
- D. Section 07 9005 - Joint Sealers: Perimeter sealant and backup materials.

1.03 REFERENCE STANDARDS
- A. AAMA 2605 - Voluntary Specification , Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels; 1998.
- B. ASTM E 2190 - Standard Specification for Insulating Glass Unit Performance and Evaluation; 2002.
- C. WDMA I.S.4: Industry Standard for Water Repellent Preservative Treatment for Millwork.

1.04 PERFORMANCE REQUIREMENTS
- A. Performance Requirements: As specified in PART 2, with the following additional requirements:
- B. Lintel Deflection: Accommodate deflection of lintel without damage to components, deterioration of seals, or movement between door frame and perimeter framing.
- C. Air and Vapor Seal: Maintain continuous air barrier and vapor retarder throughout assembly.
- D. System Internal Drainage: Drain to the exterior by means of a weep drainage network any water entering joints, condensation occurring in glazing channel, or migrating moisture occurring within system.
- E. Thermal Movement: Design sections to permit thermal expansion and contraction of components to match perimeter opening construction.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide component dimensions and descriptions of hardware and accessories.
- C. Shop Drawings: Indicate opening dimensions, elevations of different types, framed opening tolerances, installation requirements, and installation details including those unique to project.
- D. Manufacturer's Installation Instructions: Include complete preparation, installation, and cleaning requirements.

1.06 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in fabrication of commercial sliding and swinging doors with not fewer than 10 years of experience.

1.07 DELIVERY, STORAGE, AND HANDLING
- A. Deliver products to project site and store in manufacturer's protective cartons until openings are ready for door installation.

1.08 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide 10 year manufacturer warranty against failure of glass seal on insulating glass units, including interpane dusting or misting. Include provision for replacement of failed units.
- C. Provide 10 year manufacturer warranty against excessive degradation of exterior finish. Include provision for replacement of units with excessive fading, chalking, or flaking.

PART 2 PRODUCTS

2.01 MANUFACTURERS

2.02 COMPONENTS - WOOD DOORS
- A. Sliding Doors: Wood framed, factory fabricated; vision glass, threshold, related flashings, anchorage and attachment devices.
  1. Performance Requirements: AAMA/NWWDA 101/I.S.2 SGD-LC35.
  2. Configuration: One fixed panel and one horizontal sliding panel.
  3. Exterior Finish: Extruded aluminum, 1.4mm (0.055 inch) thick, Architectural Bronze color.
  4. Aluminum Clad Finish: Superior performance organic coating.
  5. Interior Finish: Unfinished, for field finishing.
- B. Fixed and Sliding Door Frame:
  1. Profile: 116 x 27 mm (4-9/16 x 1-1/16 inch)

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minimum size.

2. Construction: Wood with mortise and tenon or slot mortise joint construction.
   a. Interior: Finger jointed pine cores with vertical grain Douglas fir veneer.
      1) Kiln dried to a moisture content no greater than twelve (12) percent at the time of fabrication.
      2) Water repellent, preservative treated in accordance with WDMA I.S.4.
3. Sill: Bronze fiberglass reinforced pultruded sill, 3.0 mm (0.115 inch) thick, with polycarbonate thermoplastic roller track 1.3 mm (0.050 inch) thick.

C. Swinging Door Frame:
1. Profile: 116 x 27 mm (4-9/16 x 1-1/16 inch) size.
2. Construction: Finger jointed, edge-glued vertical grain Douglas fir core with clear vertical grain Douglas fir veneer.
   a. Kiln dried to a moisture content no greater than twelve (12) percent at the time of fabrication.
   b. Water repellent, preservative treated in accordance with WDMA I.S.4.
3. Exterior Finish: Extruded aluminum, 1.3 mm (0.050 inch) thick, Architectural Bronze color.
4. Aluminum Clad Finish: Superior performance organic coating.
5. Sill: Low profile, ADA compliant.

D. Sliding and Swinging Door Panels:
1. Laminated Veneer Lumber (LVL) cores with vertical grain Douglas fir veneer.
   a. Kiln dried to a moisture content no greater than twelve (12) percent at time of fabrication.
   b. Water repellent, preservative treated in accordance with WDMA I.S.4.
2. Thickness: 44 mm (1-3/4 inch).
3. Construction: Wood with mortise and tenon joint construction.

E. Glass Stops: Formed extruded PVC to match cladding, sloped for wash. Form weather stop flange.

F. Glazing Seal: Silicone bedding, interior.

G. Insect Screen Frame: Extruded aluminum frame of rectangular sections, 1.4 mm (0.055 inch) thick; fit with adjustable hardware; nominal size similar to operable glazed unit; finish to match door.

H. Insect Screens: Woven aluminum mesh; 14/18 mesh size, charcoal color.

I. Weatherstripping: Hollow vinyl type profiled to create positive weather seal.
1. Sliding Doors: Stationary panel interlock weather strip between sliding panel and meeting stile on stationary panel. Continuous slip coat weather strip along sill, head jamb and meeting stiles. Two sets of bulb weather strip on operating jamb.
2. Swinging Doors: Head jamb and side jambs shall have two sets of bulb weather strip, locking stiles shall have pile weather strip maintaining contact with door panels.

2.03 MATERIALS

A. Wood: Clear fir, clear preservative treated, of type suitable for transparent finish.
1. Metal Cladding: Extruded aluminum factory fit to profile of exterior exposed surfaces.

B. Insulating Glass: Sealed triple pane units at swinging doors and double pane units at sliding doors.
1. Durability: Certified as complying with ASTM E 2190 by an independent testing agency.
2. Outer Pane: Clear tempered float glass.
3. Middle Pane: Clear tempered float glass.
4. Inner Pane: Clear tempered float glass.
5. Pane Thickness: 38 mm (1-1/2 inch) at triple pane units and 19 mm (3/4 inch) at double pane units.
6. Coating: Low-E type on number 2 and 5 surfaces at triple pane units and on number 2 surface at double pane units.
7. See Section 08 8000 for additional requirements.

2.04 HARDWARE

A. Sliding Doors:
1. Pull Handles: Manufacturer's standard type, Zinc die cast.
   a. Color: As selected.
   b. Include integral locking mechanism.
2. Locking System: Multi-point zinc plated locking system operated at handle assembly. Key lock cylinder.
3. Threshold: Extruded aluminum, sloped to exterior; mill finish.
4. Sliding Panel Bottom Rollers: Two Stainless steel roller assemblies per operating panel; two ball bearing wheels per roller assembly; adjustable from interior. Maximum vertical

adjustment: 8 mm (5/16 inch).

5. Limit Stops: Resilient rubber.

B. Swinging Doors:

1. Hinges: 4-½ x 4-½ inch square corner ball bearing hinges. Finish: Bronze.
2. Locking System: Schlage L series entrance lock.

2.05 FABRICATION

A. Size and fabricate door assembly to allow for tolerances of rough framed openings, clearances, and shims around perimeter of assemblies.
B. Factory fabricate door assembly complete with main frame and glazed door panels in one unit.
C. Ensure joints and connections are flush, hairline width, and waterproof.
D. Scarf joints are permitted if wood matches in color and grain texture. Finger joints are not permitted in units intended for transparent finish.
E. Form sills and stools in one piece. Slope sills for wash.
F. Assemble insect screen frames with mesh set into frame and secured. Fit frames with adjustable roller hardware.
G. Accurately and rigidly fit joints and corners.
H. Match components to ensure continuity of line.
I. Provide drainage to exterior for moisture entering joints and glazing spaces and condensation occurring within frame construction.
J. Factory install glass in fixed and sliding units in accordance with manufacturer's standard method.

2.06 FINISHES

A. Superior Performance Organic Coating System: AAMA 2605 multiple coat, thermally cured polyvinylidene fluoride system; color as scheduled.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that openings are ready to receive work and opening dimensions and clearances are as indicated on shop drawings.

3.02 PREPARATION

A. Prepare opening to permit correct installation of door unit in conjunction with air and vapor seal.

3.03 INSTALLATION

A. Install door unit assembly, glass and glazing, and hardware in accordance with manufacturer's instructions.
B. Attach frame and shims to perimeter opening to accommodate construction tolerances and other irregularities.
C. Use anchorage devices to securely fasten sliding door assembly to wall construction without distortion or imposed stresses.
D. Coordinate installation with placement of vapor seal at frame perimeter as specified in Section 07 25 00.
E. Coordinate installation with placement of air seal at frame perimeter as specified in Section 07 2500.
F. Coordinate installation of loose fibrous thermal insulation at shim spaces at frame perimeter as specified in Section 07 2100.
G. Place threshold in bed of butyl sealant.

3.04 TOLERANCES

A. Maintain dimensional tolerances and alignment with adjacent work.
B. Maximum Variation from Plumb: 1.5 mm (1/16 inch).
C. Maximum Variation from Level: 1.5 mm (1/16 inch).
D. Longitudinal or Diagonal Warp: Plus or minus 3 mm (1/8 inch) from 3 m (10 foot) straight edge.

3.05 ADJUSTING

A. Adjust hardware for smooth operation.

3.06 CLEANING

A. Remove protective material from factory finished surfaces.
B. Remove labels and visible markings.
C. Wash surfaces by method recommended and acceptable to sealant and window manufacturer; rinse and wipe surfaces clean.

3.07 PROTECTION

A. Protect installed products from damage during subsequent construction activities.

END OF SECTION

SECTION 08 4413
GLAZED ALUMINUM CURTAIN WALLS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Aluminum-framed curtain wall, with vision and photovoltaic glazing.
- B. Perimeter sealant.

1.02 RELATED REQUIREMENTS
- A. Section 07 2500 - Weather Barriers: Perimeter air and vapor seal between glazing system and adjacent construction.
- B. Section 07 9005 - Joint Sealers: Perimeter sealant and back-up materials.
- C. Section 08 8000 - Glazing: Vision glass and glazing accessories.
- D. Section 26 3100 - PhotoVoltaic Collector System: PhotoVoltaic glass panels.

1.03 REFERENCE STANDARDS
- A. AAMA CW-10 - Care and Handling of Architectural Aluminum From Shop to Site; American Architectural Manufacturers Association; 2004.
- B. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum; American Architectural Manufacturers Association; 1998.
- C. ASCE 7 - Minimum Design Loads for Buildings and Other Structures; American Society of Civil Engineers; 2005.
- D. ASTM A 36/A 36M - Standard Specification for Carbon Structural Steel; 2005.
- E. ASTM A 123/A 123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2002.
- F. ASTM B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2007.
- G. ASTM B 209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric]; 2007.
- H. ASTM B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes; 2006.
- I. ASTM B 221M - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes [Metric]; 2007.
- J. ASTM E 283 - Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen; 2004.
- K. ASTM E 330 - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference; 2002.
- L. ASTM E 331 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference; 2000.
- M. SSPC-Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic"); Society for Protective Coatings; 2002 (Ed. 2004).

1.04 ADMINISTRATIVE REQUIREMENTS
- A. Coordinate with installation of other components that comprise the exterior enclosure.

1.05 PERFORMANCE REQUIREMENTS
- A. Design and size components to withstand the following load requirements without damage or permanent set:
  1. Design Wind Loads: Comply with requirements of ASCE 7 and applicable code.
  2. Member Deflection: Limit member deflection to flexure limit of glass in any direction, and maximum of 19 mm (3/4 inch), with full recovery of glazing materials.
  3. Measure performance by testing in accordance with ASTM E 330, using test loads equal to 1.5 times the design wind loads and 10 second duration of maximum pressure.
- B. Movement: Accommodate the following movement without damage to components or deterioration of seals:
  1. Movement of curtain wall relative to perimeter framing.
  2. Deflection of structural support framing, under permanent and dynamic loads.
- C. Air Infiltration: Limit air infiltration through assembly to 0.3 L/s/sq m (0.06 cu ft/min/sq ft) of wall area, measured at a reference differential pressure across assembly of 300 Pa (6.24 psf) as measured in accordance with ASTM E 283.
- D. Water Leakage: None, when measured in accordance with ASTM E 331 at a test pressure difference of 730 Pa (15 lbf/sq ft.
- E. System Internal Drainage: Drain to the exterior by

means of a weep drainage network any water entering joints, condensation occurring in glazing channel, and migrating moisture occurring within system.

F. Air and Vapor Seal: Maintain continuous air barrier and vapor retarder throughout assembly, primarily in line with inside pane of glazing and heel bead of glazing compound.

G. Expansion/Contraction: Provide for expansion and contraction within system components caused by cycling temperature range of 95 degrees C (170 degrees F) over a 12 hour period without causing detrimental effect to system components, anchorages, and other building elements.

H. Design system to eliminate noises caused by wind and thermal movement, to prevent vibration harmonics, and to prevent "stack effect" in internal spaces.

1.06 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide component dimensions, describe components within assembly, anchorage and fasteners, glazing and infill, internal drainage details and connection method.

C. Shop Drawings: Indicate system dimensions, framed opening requirements and tolerances, affected related Work, installation details including those unique to project, expansion and contraction joint location and details, and field welding required.

1. If installer drawn shop drawings are included, indicate curtain wall manufacturer's approval of the drawings.

D. Samples: Submit two samples 50 x 150 mm (2 x 6 inches) in size illustrating finished aluminum surface materials; illustrated maximum range of possible finish color and texture variation.

E. Test Reports: Submit results of full-size mock-up testing. Reports of tests previously performed on the same design are acceptable.

F. Design Data: Provide framing member structural and physical characteristics and engineering calculations, and identify dimensional limitations.

G. Manufacturer's Certificate: Certify that the products supplied meet or exceed the specified requirements.

1.07 QUALITY ASSURANCE

A. Designer Qualifications: Design structural support framing components under direct supervision of a Qualified Professional Engineer experienced in design of this Work and licensed at the State of Minnesota.

B. Manufacturer: Company specializing in manufacturing aluminum framed glazing systems with minimum 10 years of experience.

C. Installer: Company specializing in installing aluminum glazing systems with minimum 5 years of experience.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Handle products of this section in accordance with AAMA CW-10.

B. Protect finished aluminum surfaces with wrapping. Do not use adhesive papers or sprayed coatings that bond to aluminum when exposed to sunlight or weather.

1.09 FIELD CONDITIONS

A. Do not install sealants when ambient temperature is less than 5 degrees C (40 degrees F). Maintain this minimum temperature during and 48 hours after installation.

PART 2 PRODUCTS

2.01 COMPONENTS

A. Aluminum-Framed Curtain Wall: Factory fabricated, factory finished aluminum framing members with infill, and related flashings, anchorage and attachment devices.

1. Outside glazed, with pressure plate and mullion cover.
2. Finish: Class I color anodized.
3. Color: Dark bronze.

B. Aluminum Framing Members: Tubular aluminum sections, drainage holes and internal weep drainage system.

1. Cross-Section: 63 x 150 mm (2-1/2 x 6 inch) nominal dimension.
2. Structurally Reinforced Members: Extruded aluminum with internal reinforcement of structural steel member where required by windload design.
   a. Match size of non-reinforced members.

2.02 MATERIALS

A. Extruded Aluminum: ASTM B 221 (ASTM B 221M).

B. Sheet Aluminum: ASTM B 209 (ASTM B 209M).

C. Structural Steel Sections: ASTM A 36/A 36M; galvanized in accordance with requirements of ASTM A 123/A 123M.

D. Structural Supporting Anchors Attached to Wood:

Design for bolted attachment.

E. Fasteners: Stainless steel.

F. Exposed Flashings: 1 mm (0.040 inch) thick aluminum sheet, except 2 mm (0.080 inch) thick aluminum sheet if used for sill flashing; finish to match framing members.

G. Concealed Flashings: 0.5 mm (0.018 inch) thick stainless steel.

H. Perimeter Sealant: Silicone Type specified in Section 07 9005.

I. Glazing: As specified in Section 08 8000 and Section 26 3100.

1. Glass in Exterior Framing:

a. PhotoVoltaic Glass: Laminated type, 17 mm (5/8 inch) thick.

b. Vision Glass: Monolithic type, 6 mm (1/4 inch) thick.

J. Glazing Gaskets: Type to suit application to achieve weather, moisture, and air infiltration requirements.

K. Glazing Accessories: As specified in Section 08 8000.

L. Touch-Up Primer for Galvanized Steel Surfaces: SSPC-Paint 20, zinc rich.

2.03 FINISHES

A. Class I Color Anodized Finish: AAMA 611 AA-M12C22A42 Integrally colored anodic coating not less than 0.018 mm (0.7 mils) thick.

B. Touch-Up Materials: As recommended by coating manufacturer for field application.

2.04 FABRICATION

A. Fabricate components with minimum clearances and shim spacing around perimeter of assembly, yet enabling installation and dynamic movement of perimeter seal.

B. Accurately fit and secure joints and corners. Make joints flush, hairline, and weatherproof.

C. Prepare components to receive anchor devices. Fabricate anchors.

D. Coat concealed metal surfaces that will be in contact with cementitious materials or dissimilar metals with bituminous paint.

E. Arrange fasteners and attachments to conceal from view.

F. Reinforce framing members for imposed loads when required by the windload design.

G. Finishing: Apply factory finish to all surfaces that will be exposed in completed assemblies.

1. Touch-up surfaces cut during fabrication so that no natural aluminum is visible in completed assemblies, including joint edges.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify dimensions, tolerances, and method of attachment with other work.

B. Verify that wall openings are ready to receive work of this section.

C. Verify that anchorage devices have been properly installed and located.

3.02 INSTALLATION

A. Install wall system in accordance with manufacturer's instructions.

B. Attach to structure to permit sufficient adjustment to accommodate construction tolerances and other irregularities.

C. Provide alignment attachments and shims to permanently fasten system to building structure.

D. Align assembly plumb and level, free of warp or twist. Maintain assembly dimensional tolerances, aligning with adjacent work.

E. Provide thermal isolation where components penetrate or disrupt building insulation.

F. Install sill flashings. Turn up ends and edges; seal to adjacent work to form water tight dam.

G. Coordinate attachment and seal of perimeter air and vapor barrier materials.

H. Pressure Plate Framing: Install glazing in accordance with Section 08 8000, using exterior dry glazing method.

I. Install perimeter sealant in accordance with Section 07 9005.

J. Touch-up minor damage to factory applied finish; replace components that cannot be satisfactorily repaired.

3.03 TOLERANCES

A. Maximum Variation from Plumb: 1.5 mm/m (0.06 inches every 3 ft) non-cumulative or 12 mm/30 m (0.5 inches per 100 ft), whichever is less.

B. Maximum Misalignment of Two Adjoining Members Abutting in Plane: 0.8 mm (1/32 inch).

C. Sealant Space Between Curtain Wall Mullions and Adjacent Construction: Maximum of 19 mm (3/4 inch) and minimum of 6 mm (1/4 inch).

3.04 CLEANING

A. Remove protective material from pre-finished aluminum surfaces.

B. Wash down surfaces with a solution of mild

detergent in warm water, applied with soft, clean wiping cloths. Take care to remove dirt from corners. Wipe surfaces clean.

C. Remove excess sealant by method acceptable to sealant manufacturer.

3.05 PROTECTION

A. Protect installed products from damage during subsequent construction.

END OF SECTION

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SECTION 08 5200
WOOD WINDOWS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Factory fabricated metal clad wood windows with fixed, and operating sash, including extruded aluminum frame to accept photovoltaic glass when installed outboard of wood windows.
- B. Operating hardware.
- C. Insect screens.

1.02 RELATED REQUIREMENTS
- A. Section 06 1000 - Rough Carpentry: Rough opening framing.
- B. Section 07 2100 - Thermal Insulation: Fibrous stuffing insulation at door frame perimeter.
- C. Section 07 2500 - Weather Barriers: Perimeter air and vapor seal between window frame and adjacent construction.
- D. Section 07 6200 - Sheet Metal Flashing and Trim: Sheet metal drip flashing.
- E. Section 07 9005 - Joint Sealers: Perimeter sealant and back-up materials.
- F. Section 08 3200 - Sliding Glass Doors.
- G. Section 08 4413 - Glazed Aluminum Curtain Walls.
- H. Section 08 80 00 - Glazing: Product requirements.
- I. Section 09 9000 - Painting and Coating: Site finishing wood surfaces.
- J. Section 26 3100 - PhotoVoltaic Collector System: PhotoVoltaic glass panels.

1.03 REFERENCE STANDARDS
- A. AAMA/WDMA/CSA 101/I.S.2/A440 - Voluntary Specifications for Aluminum, Vinyl (PVC) and Wood Windows and Glass Doors; American Architectural Manufacturers Association; 2005.
- B. FS L-S-125 - Screening, Insect, Nonmetallic; Federal Specifications and Standards; Revision B, 1972.
- C. WDMA I.S.4 - Water-Repellent Preservative Non-Pressure Treatment for Millwork; National Wood Window and Door Association; 2007a.

1.04 PERFORMANCE REQUIREMENTS
- A. Performance Requirements: As specified in PART 2, with the following additional requirements:
- B. Deflection: Limit member deflection to flexure limit of glass with full recovery of glazing materials.
- C. Design windows to accommodate, without damage to components or deterioration of seals, movement between window and perimeter framing and deflection of lintel.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Show component dimensions.
- C. Shop Drawings: Indicate opening dimensions, framed opening tolerances, installation requirements, and installation details including those unique to project.

1.06 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing commercial wood windows with minimum 10 years of experience.

1.07 DELIVERY, STORAGE, AND HANDLING
- A. Protect factory finished surfaces with wrapping. Do not use adhesive papers or sprayed coatings that bond when exposed to sunlight or weather.

1.08 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide 10 year manufacturer warranty for insulated glass units from seal failure, interpane dusting or misting, and replacement of same.

PART 2 PRODUCTS

2.01 MANUFACTURERS
- A. Marvin Windows and Doors; Product Wood ULTIMATE DOUBLE HUNG MAGNUM and related casement and fixed units: www.marvin.com.

2.02 WINDOW COMPONENTS
- A. Windows: Wood frame and sash, factory fabricated and assembled.
  1. Performance Requirements: AAMA/WDMA/CSA 101/I.S.2/A440 C50.
  2. Exterior Surfaces: Metal clad,, Architectural Bronze finish.
  3. Interior Surfaces: Unfinished, for transparent finish specified in Section 09 9000.
  4. Configuration: As indicated on drawings, Fixed, non-operable, Outward projecting awning, Outward opening casement, and Double hung.
  5. Factory glazed; wet-dry glazing method.
- B. Insect Screen Frame: Extruded aluminum frame of rectangular sections; fit with adjustable hardware; nominal size similar to operable glazed unit.

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C. Insect Screens: Woven nonmetallic mesh; 18/16 mesh, glass fiber strands; black color.
D. Operable Sash Weatherstripping: Wool pile; permanently resilient, profiled to effect weather seal.
E. Window Assembly Fasteners: Stainless steel.
F. Window Installation Fasteners: Galvanized steel.
G. Accessories: Provide all related flashings, and anchorage and attachment devices.

2.03 MATERIALS

A. Wood: Clear vertical grain Douglas Fir, clear preservative treated in accordance with WDMA I.S.4 using treatment type suitable for transparent or opaque finish.
   1. Exception: Bathroom window shall be Mahogany species.
B. Metal Cladding: Extruded aluminum, factory finished, factory attached to wood members.
C. Glass and Glazing Materials: As specified in Section 08 8000 of Types described below:
   1. Sealed insulating triple pane, low-E glass .
   2. Provide tempered sealed insulated glass where required by code including, but not limited to, windows within code defined proximity to operable doors and walking surfaces.
D. Seam Sealing Tape: Polyethylene backed synthetic butyl rubber or rubberized asphalt based self-adhering membrane, 35 mil thick minimum; provide SAF-SEAL 6610 or BT-20XL both as manufactured by Protecto Wrap Co., FORTI-FLASH (40 mil) as manufactured by Fortifiber Building Systems Group, or equivalent.
E. Sealant Materials: As specified in Section 07 9005 of Type recommended by seam sealing tape manufacturer.

2.04 HARDWARE

A. Double Hung Sash: Metal and nylon spiral friction slide cylinder, each sash, each jamb.
B. Sash lock: Lever handle with cam lock.
C. Casement Operator: Geared rotary handle fitted to projecting sash arms with limit stops; baked enamel finish.
D. Projecting Sash Arms: Cadmium plated steel, friction pivot joints with nylon bearings, removable pivot clips for cleaning.

2.05 FABRICATION

A. Fabricate frame and sash members with mortise and tenon joints. Glue and steel pin joints to hairline fit, weather tight.
B. Transparent Finish: Finger joints not permitted in units intended for transparent finish.
C. Factory glaze window units.
D. Install operating hardware.
1. Provide two lift handles on operating sash bottom rail.
E. Fabricate components with minimum clearances and shim spacing around perimeter of assembly, yet allowing installation and dynamic movement of perimeter seal.
F. Arrange fasteners to be concealed from view.
G. Provide internal drainage of glazing spaces to exterior through weep holes.
H. Assemble insect screen frame, miter and reinforce frame corners. Fit mesh taut into frame and secure. Fit frame with four spring loaded steel pin retainers.
I. Double weatherstrip operable units.
J. Provide no or minimum width jamb extension to provide finished appearance as detailed.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify wall openings and adjoining air and vapor seal materials are ready to receive work of this section.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.
   1. Confirm manufacturer's installation instructions. Compare to installation requirements specified below; if there is a difference, follow the more stringent requirements.
B. Coordinate window installation with weather barrier opening preparation specified in Section 07 2500.
C. Install sill flashing of seam sealing tape. Install on horizontal surface of rough sill covering full depth of sill, extend 6 inches minimum up both jambs, and extend downward 4 inches minimum unto outside face of weather barrier. Provide additional pieces of tape applied diagonally at corners to complete sealing.
D. Attach window frame and shims to perimeter opening to accommodate construction tolerances and other irregularities.
E. Align window plumb and level, free of warp or twist. Maintain dimensional tolerances and alignment with adjacent work.
F. Install, or coordinate installation, of sheet metal drip flashing, specified in Section 07 6200, at head of

window.

G. Provide thermal isolation where components penetrate or disrupt building insulation.

H. Coordinate installation of loose fibrous thermal insulation at shim spaces at frame perimeter as specified in Section 07 2100.

I. Coordinate attachment and seal of perimeter air and vapor barrier materials.

J. Install screens just prior to Substantial Completion.

3.03 ADJUSTING

A. Adjust hardware for smooth operation and secure weathertight closure.

3.04 CLEANING

A. Remove protective material from factory finished surfaces.

B. Wash surfaces by method recommended and acceptable to sealant and window manufacturer; rinse and wipe surfaces clean.

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

END OF SECTION

SECTION 08 7100
DOOR HARDWARE

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Hardware for hollow steel doors.
- B. Thresholds.
- C. Weatherstripping, seals and door gaskets.

1.02 RELATED REQUIREMENTS
- A. Section 08 1113 - Hollow Metal Doors and Frames.

1.03 PRICE AND PAYMENT PROCEDURES
- A. See Section 01 2100 - Allowances, for allowances affecting this section.

1.04 REFERENCE STANDARDS
- A. ANSI/ICC A117.1 - American National Standard for Accessible and Usable Buildings and Facilities; International Code Council; 2003.
- B. DHI (LOCS) - Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames; Door and Hardware Institute; 2004.

1.05 ADMINISTRATIVE REQUIREMENTS
- A. Coordinate the manufacture, fabrication, and installation of products onto which door hardware will be installed.

1.06 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Samples: Prior to preparation of hardware schedule:
  1. Submit 1 sample of hinge, latchset, lockset, closer, and _____ illustrating style, color, and finish.
  2. Samples will be incorporated into the Work.
- C. Maintenance Data: Include data on operating hardware, lubrication requirements, and inspection procedures related to preventative maintenance.

1.07 QUALITY ASSURANCE
- A. Hardware Supplier Qualifications: Company specializing in supplying commercial door hardware with five years of experience.

1.08 DELIVERY, STORAGE, AND HANDLING
- A. Package hardware items individually; label and identify each package with door opening code to match hardware schedule.

PART 2 PRODUCTS

2.01 MANUFACTURERS
- A. Hinges:
  1. Assa Abloy McKinney: www.assaabloydss.com.
  2. Bommer Industries, Inc: www.bommer.com.
  3. Hager Companies: www.hagerco.com.
  4. Stanley Hardware: www.stanleyworks.com.
- B. Lock and Latch Sets:
  1. Schlage: www.schlage.com.
- C. Overhead Holders/Stops:
  1. Assa Abloy Rixson or Sargent: www.assaabloydss.com.
  2. DORMA Group North America: www.dorma-usa.com/usa.
  3. Glynn-Johnson: www.glynn-johnson.com.
- D. Manual Bolts:
  1. Assa Abloy McKinney: www.assaabloydss.com.
  2. Ives: www.ives.com.
  3. Hager Companies: www.hagerco.com.
  4. Triangle Brass Manufacturing Co., Inc: www.trimcobbw.com.
- E. Gasketing and Thresholds:
  1. Assa Abloy McKinney: www.assaabloydss.com.
  2. National Guard Products, Inc: www.ngpinc.com.
  3. Pemko Manufacturing Co: www.pemko.com.
  4. Zero International, Inc: www.zerointernational.com.
  5. Reese Enterprises..

2.02 GENERAL REQUIREMENTS FOR DOOR HARDWARE PRODUCTS
- A. Provide products that comply with the following:
  1. Applicable provisions of Federal, State, and local codes.
  2. ANSI/ICC A117.1, American National Standard for Accessible and Usable Buildings and Facilities.
- B. Finishes: Identified in schedule in Part 2.

2.03 KEYING
- A. Door Locks: Master keyed.
- B. Supply keys in the following quantities:
  1. 3 master keys.
  2. 3 change keys for each lock.

2.04 HINGES
- A. General: Polished and plated contract grade material, 5-knuckle type, fabricated to template for use with metal doors or frames, with flat button tips, non-rising loose steel pins, and beveled or non-beveled inner edge.

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1. Non-removable loose pin hinges for exterior outswing doors.
2. Non-ferrous base metal for exterior doors.
3. Hinges of proper size and weight for doors.

B. Hinge Sizes: 1-3/4 inch doors / 4-1/2 inches x 4-1/2 inches
1. Width of hinges: Sufficient to clear trim.

C. Quantities:
1. One pair (2 hinges) on doors 60 inches high or less, 1/2 pair (1 hinge) for every additional 30 inches or fraction thereof.

D. Type 3 Hinge: Extra heavy, ball bearing, steel.
1. Interior doors wider than 41 inches.
2. Doors higher than 96 inches.
3. Vestibule doors.
4. In-swing exterior doors.
5. Products:
a. Bommer BB5004.
b. Hager BB1168.
c. McKinney T4B3786.
d. Stanley FBB168.

E. Type 4 Hinge: Extra heavy, ball bearing, brass, bronze or stainless steel.
1. Out-swing exterior doors.
2. When specified in group or suffix.
3. Products:
a. Bommer BB5005.
b. Hager BB1199.
c. McKinney T4B3386.
d. Stanley FBB199.

2.05 FLUSH BOLTS

A. Manual Flush Bolts: Two 12 inch bolts on inactive door of pairs where used with locks and latches, with dustproof strike for bottom bolts, and 24 inch top rod for high doors.
1. Acceptable manufacturers and products:
a. Ives (numbers specified in groups or suffixes).
b. Comparable products of other manufacturers specified above are acceptable.

2.06 LOCKSETS / LATCHSETS

A. Provide sets which are uniform in size, regardless of function, permitting interchanging locksets and latchsets, with 6 pin tumbler cylinder cores.
1. Backset for locks, deadbolts, and latches to be 2-3/4 inches.
2. Provide wrought boxes and curved lip strikes with proper lip length to protect trim (projecting not more than 1/8 inch beyond trim).

B. Standard Duty Cylindrical Type: Lever Design (Schlage numbers specified) Series 4000, Grade 2; provide Schlage AL series with JUP lever design.

2.07 STOPS AND HOLDERS

A. Supply a stop for every door which will prevent damage to the door, hardware, and surrounding surfaces. Use an overhead type stop GJ 450S Series for doors that are capable of swinging more than 145 degrees before striking a wall and where a door strikes a fixed object like a sink, cabinet. Wall stops must be wall mounted.

B. Stop/Holders: GJ 450H series, as required by surrounding conditions, for interior doors scheduled for a stop and holder, unless others are specified. GJ 80, 90 or 100 series, as required by surrounding conditions, for all exterior doors scheduled for "stop and holder".

2.08 THRESHOLDS AND WEATHERSTRIPPING

A. Thresholds: Aluminum 5 inch saddle, 1/2 inch high, unless specified or detailed otherwise.
1. Reese No. S205 specified.
2. Comparable products of other manufacturers specified above are acceptable.

B. Weatherstripping: Closed cell 3/16 inch sponge neoprene with 1 inch aluminum extrusion.
1. Reese No. DS70 specified.
2. Comparable products of other manufacturers specified above are acceptable.

C. Door Sweeps: Neoprene with 1/2 inch sweep at the door bottom with 1-1/4 inch aluminum extrusion.
1. Reese No. 323 specified.
2. Comparable products of other manufacturers specified above are acceptable.

2.09 FINISHES

A. Exposed Metal Finishes: US26D = Satin Chrome

B. US32D = Satin Stainless Steel
1. Hinges-Exterior: US26D or US32D
2. Hinges-Interior: US26D
3. Locksets: US26D
4. Overhead Holders: US26D
5. Door Stops: US26D (US32D for wrought material)
6. Miscellaneous Items: US26D

C. US32 and US32D: Solid 18-8 chromium-nickel, 300 series, "Austenitic", non-magnetic. Straight chrome-

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irons (magnetic), is not acceptable, except as hinge pins. Items showing magnetic properties will be rejected. For items not available in US32 or US32D provide US26 or US26D.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that doors and frames are ready to receive work and dimensions are as indicated on shop drawings.

3.02 INSTALLATION

A. Install hardware in accordance with manufacturer's instructions and applicable codes.

B. Use templates provided by hardware item manufacturer.

C. Mounting heights for hardware from finished floor to center line of hardware item:

1. For steel doors and frames: Comply with DHI "Recommended Locations for Architectural Hardware for Steel Doors and Frames."

3.03 ADJUSTING

A. Adjust work under provisions of Section 01 7000.

B. Adjust hardware for smooth operation.

3.04 SCHEDULE

A. Hardware Group 1 - Pair of Doors, Exterior Mechanical Room

1. Hinges as specified.
2. 1 Lockset Schlage AL53PD.
   a. Function: Inside always by lever. Outside by lever, except when outside lever is set by inside turn button, then, outside by key. Deadlocking latch bolt.
3. 1 Set Manual Flush Bolts Ives
4. 2 Overhead Stops/Holders GJ90H.
5. 1 Set Weatherstrip
6. 1 Astragal Set Reese 95 x 95P, for the meeting edge of the door leaves
7. 1 Threshold
8. 1 Door Sweep

B. Hardware Group 2 - Single Door, Exterior Mechanical Room

1. Hinges as specified.
2. 1 Lockset Schlage AL53PD.
   a. Function: Inside always by lever. Outside by lever, except when outside lever is set by inside turn button, then, outside by key. Deadlocking latch bolt.
3. 1 Overhead Stop/Holder GJ90H.
4. 1 Set Weatherstrip
5. 1 Threshold
6. 1 Door Sweep

C. Hardware Group 3 - Entry Door

1. 1 Overhead Stop/Holder GJ90H.
2. Remainder of hardware by door and supplier.

END OF SECTION

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SECTION 08 8000
GLAZING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Glass.
- B. Privacy glass.
- C. Glazing compounds and accessories.

1.02 RELATED REQUIREMENTS
- A. Section 06 4100 - Architectural Wood Casework: Cabinets with requirements for glass shelves and _____.
- B. Section 08 3200 - Sliding Glass Doors: Sliding glass doors referencing glass performance requirements in Section 08 8000.
- C. Section 08 5200 - Wood Windows: Glazed windows referencing glass performance requirements in Section 08 8000.
- D. Section 08 4413 - Glazed Aluminum Curtain Walls.
- E. Section 26 3100 - PhotoVoltaic Collector System: PhotoVoltaic glass panels.

1.03 REFERENCE STANDARDS
- A. 16 CFR 1201 - Safety Standard for Architectural Glazing Materials; current edition.
- B. ASTM C 864 - Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers; 2005.
- C. ASTM C 920 - Standard Specification for Elastomeric Joint Sealants; 2005.
- D. ASTM C 1036 - Standard Specification for Flat Glass; 2006.
- E. ASTM C 1048 - Standard Specification for Heat-Treated Flat Glass--Kind HS, Kind FT Coated and Uncoated Glass; 2004.
- F. ASTM C 1172 - Standard Specification for Laminated Architectural Flat Glass; 2003.
- G. ASTM C 1193 - Standard Guide for Use of Joint Sealants; 2005a.
- H. ASTM E 1300 - Standard Practice for Determining Load Resistance of Glass in Buildings; 2007.
- I. ASTM E 2190 - Standard Specification for Insulating Glass Unit Performance and Evaluation; 2002.
- J. GANA (GM) - GANA Glazing Manual; Glass Association of North America; 2004.
- K. GANA (SM) - FGMA Sealant Manual; Glass Association of North America; 1990.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data on Glass Types: Provide structural, physical and environmental characteristics, size limitations, special handling or installation requirements.
- C. Product Data on Glazing Compounds: Provide chemical, functional, and environmental characteristics, limitations, special application requirements. Identify available colors.

1.05 QUALITY ASSURANCE
- A. Perform Work in accordance with GANA Glazing Manual and FGMA Sealant Manual for glazing installation methods.

1.06 FIELD CONDITIONS
- A. Do not install glazing when ambient temperature is less than 10 degrees C (50 degrees F).
- B. Maintain minimum ambient temperature before, during and 24 hours after installation of glazing compounds.

1.07 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Sealed Insulating Glass Units: Provide a ten (10) year warranty to include coverage for seal failure, interpane dusting or misting, including replacement of failed units.
- C. Laminated Glass: Provide a ten (10) year warranty to include coverage for delamination, including replacement of failed units.

PART 2 PRODUCTS

2.01 GLAZING TYPES
- A. Sealed Insulating Glass Units: Vision glazing, Low-E.
  1. Application(s): All exterior glazing unless otherwise indicated.
  2. Outboard Lite: Annealed float glass, 3 mm (1/8 inch) thick, minimum.
     - a. Tint: Clear.
     - b. Coating: Low-E type, on #2 surface.
  3. Middle Lite: Annealed float glass, 3 mm (1/8 inch) thick, minimum.
     - a. Tint: Clear.
  4. Inboard Lite: Annealed float glass, 3 mm (1/8 inch) thick, minimum.

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a. Tint: Clear.
b. Coating: Low-E type, on #5 surface.

5. Total Thickness: 38 mm (1-1/2 inch) for awning, casement, and fixed window units and 22 mm (7/8 inch) for double hung units.
   a. Exception: For sliding glass door units, provide 2 light, sealed insulating glass units, 19 mm (3/4 inch) thick, with Low-E type coating on #2 surface.
6. Total Visible Light Transmittance: 39 percent, nominal.
7. Total Solar Heat Gain Coefficient: 0.24, nominal.

B. Privacy Glass Units: Electrically tintable insulating glass units for dynamic light and heat control.
   1. Provide SAGE Electrochromics, Inc. SAGEGLASS CLASSIC Laminated Sealed Insulating Glass Units (IGUs):
      a. Outboard Lite:
         1) Glass Type: SageGlass® coated clear float glass.
         2) Glass Tint: Variable.
         3) Nominal Thickness: 6 mm (0.25 inch) per industry standards.
         4) Heat Treatment: Tempered.
         5) Coating Orientation: Surface No. 2.
      b. Air Space:
         1) Spacer Material: Austenitic standard stainless steel.
         2) b. Nominal Thickness: 12.5 mm plus/minus 0.5mm (0.50 plus/minus 0.02 in).
         3) Wall Thickness: 0.2 cm (0.008 inch).
         4) Gas Fill: 90 percent Argon.
         5) Desiccant: 4 sides filled with 100 percent molecular sieve and silica gel blend desiccant.
      c. Laminated Inboard Lite:
         1) Outer Ply (Surface 4):
            (a) Glass Type: Clear float glass.
            (b) Glass Tint: Clear.
            (c) Nominal Thickness: 3 mm (0.125 inch).
            (d) Heat Treatment: Heat-strengthened.
         2) Interlayer:
            (a) Interlayer Type: Polyvinyl Butyral.
            (b) Interlayer Tint: None.
            (c) Nominal Thickness: 1.52 mm (0.06 inch).
         3) Inner Ply (Surface 3): 1) 2) 3) 4)
            (a) Glass Type: Clear float glass.
            (b) Glass Tint: Clear.
            (c) Nominal Thickness: 3 mm (0.125 inch).
            (d) Heat Treatment: Heat-strengthened.
      d. Pigtail:
         1) 2-conductor sheathed cable type CM/CL2, 0.15 inch nominal OD.
         2) Molex 52213-0211 2-pin connector.
      e. Untinted Performance Characteristics (Center of Glass):
         1) Visible Transmittance: 62 percent.
         2) Interior Visible Reflectance: 14 percent.
         3) Exterior Visible Reflectance: 21 percent.
         4) Summer U-factor (U-value): 0.28.
         5) Winter U-factor (U-value): 0.28.
         6) Krochman Damage Function (KDF): 15 percent.
         7) Solar Heat Gain Coefficient (SHGC): 0.48.
      f. Tinted Performance Characteristics (Center of Glass):
         1) Visible Transmittance: 3.5 percent.
         2) Interior Visible Reflectance: 10 percent.
         3) Exterior Visible Reflectance: 6 percent.
         4) Summer U-factor (U-value): 0.28.
         5) Winter U-factor (U-value): 0.28.
         6) Krochman Damage Function (KDF): 1.7 percent.
         7) Solar Heat Gain Coefficient (SHGC): 0.09.

2.02 EXTERIOR GLAZING ASSEMBLIES

A. Structural Design Criteria: Select type and thickness to withstand dead loads and wind loads acting normal to plane of glass at design pressures calculated in accordance with applicable code.
   1. Use the procedure specified in ASTM E 1300 to determine glass type and thickness.
   2. Limit glass deflection to 1/200 or flexure limit of glass, whichever is less, with full recovery of glazing materials.

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3. Thicknesses listed are minimum.

2.03 GLASS MATERIALS

A. Float Glass: All glazing is to be float glass unless otherwise indicated.
   1. Annealed Type: ASTM C 1036, Type I, transparent flat, Class 1 clear, Quality Q3 (glazing select).
   2. Heat-Strengthened and Fully Tempered Types: ASTM C 1048.
   3. Thicknesses: As indicated; for exterior glazing comply with specified requirements for wind load design regardless of specified thickness.

B. Laminated Glass: Float glass laminated in accordance with ASTM C 1172.
   1. Laminated Safety Glass: Comply with 16 CFR 1201 test requirements for Category II.
   2. Plastic Interlayer: 1.52 mm (0.060 inch) thick, minimum.
   3. Where fully tempered is specified or required, provide glass that has been tempered by the tong-less horizontal method.

2.04 SEALED INSULATING GLASS UNITS

A. Sealed Insulating Glass Units: Types as indicated above.
   1. Durability: Certified by an independent testing agency to comply with ASTM E 2190.
   2. Edge Spacers: Aluminum, bent and soldered corners.
   3. Edge Seal: Glass to elastomer with supplementary silicone sealant.
   4. Purge interpane space with dry hermetic air.
   5. Fill interpane space with argon gas.

2.05 GLAZING COMPOUNDS

A. Butyl Sealant: Single component; Shore A hardness of 10 to 20; black color; non-skinning.

B. Silicone Sealant: Single component; chemical curing; capable of water immersion without loss of properties; non-bleeding, non-staining; ASTM C 920, Type S, Grade NS, Class 25, Uses M, A, and G; cured Shore A hardness of 15 to 25; color as selected.

2.06 GLAZING ACCESSORIES

A. Setting Blocks: Neoprene, 80 to 90 Shore A durometer hardness, ASTM C 864 Option I. Length of 25 mm for each square meter (0.1 inch for each square foot) of glazing or minimum 100 mm (4 inch) x width of glazing rabbet space minus 1.5 mm (1/16 inch) x height to suit glazing method and pane weight and area.

B. Spacer Shims: Neoprene, 50 to 60 Shore A durometer hardness, ASTM C 864 Option I. Minimum 75 mm (3 inch) long x one half the height of the glazing stop x thickness to suit application, self adhesive on one face.

C. Glazing Tape: Preformed butyl compound with integral resilient tube spacing device; 10 to 15 Shore A durometer hardness; coiled on release paper; size as required by application; black color.

D. Glazing Gaskets: Resilient silicone extruded shape to suit glazing channel retaining slot; ASTM C 864 Option I; black color.

E. Glazing Clips: Manufacturer's standard type.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean contact surfaces with solvent and wipe dry.

B. Prime surfaces scheduled to receive sealant.

C. Install sealants in accordance with ASTM C 1193 and FGMA Sealant Manual.

D. Install sealant in accordance with manufacturer's instructions.

3.02 INSTALLATION - EXTERIOR DRY METHOD (TAPE AND GASKET SPLINE GLAZING)

A. Cut glazing tape to length; install on glazing pane. Seal corners by butting tape and sealing junctions with butyl sealant.

B. Place setting blocks at 1/4 points with edge block no more than 150 mm (6 inches) from corners.

C. Rest glazing on setting blocks and push against fixed stop with sufficient pressure to attain full contact.

D. Install removable stops without displacing glazing spline. Exert pressure for full continuous contact.

E. Trim protruding tape edge.

3.03 INSTALLATION - EXTERIOR WET/DRY METHOD (PREFORMED TAPE AND SEALANT)

A. Cut glazing tape to length and set against permanent stops, 5 mm (3/16 inch) below sight line. Seal corners by butting tape and dabbing with butyl sealant.

B. Apply heel bead of butyl sealant along intersection of permanent stop with frame ensuring full perimeter seal between glass and frame to complete the continuity of the air and vapor seal.

C. Place setting blocks at 1/4 points with edge block no more than 150 mm (6 inches) from corners.

D. Rest glazing on setting blocks and push against tape and heel bead of sealant with sufficient pressure to

attain full contact at perimeter of pane or glass unit.

E. Install removable stops, with spacer strips inserted between glazing and applied stops, ____ mm (____ inch) below sight line. Place glazing tape on glazing pane or unit with tape flush with sight line.

F. Fill gap between glazing and stop with _____ type sealant to depth equal to bite of frame on glazing, but not more than 9 mm (3/8 inch) below sight line.

G. Apply cap bead of _____ type sealant along void between the stop and the glazing, to uniform line, flush with sight line. Tool or wipe sealant surface smooth.

3.04 INSTALLATION - INTERIOR WET METHOD (COMPOUND AND COMPOUND)

A. Install glazing resting on setting blocks. Install applied stop and center pane by use of spacer shims at 600 mm (24 inch) centers, kept 6 mm (1/4 inch) below sight line.

B. Locate and secure glazing pane using glazers' clips.

C. Fill gaps between glazing and stops with glazing compound until flush with sight line. Tool surface to straight line.

3.05 ELECTRICAL CONNECTIONS

A. Coordinate connection of electrified glazing products to electrical supply or electrical collection system as appropriate.

3.06 CLEANING

A. Remove glazing materials from finish surfaces.

B. Remove labels after Work is complete.

C. Once electronically tintable IGUs have been removed from manufacturer's packaging, remove protective film within 90 days of exposure to sunlight or other UV light sources.

D. Clean glass and adjacent surfaces.

3.07 SCHEDULE

A. Wood Windows: Exterior wet/dry method with silicone compound.

B. Metal-Framed Storefronts and Curtain Wall: Exterior dry method.

C. Hollow Steel Frames - Interior: Interior wet method.

END OF SECTION

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SECTION 09 2116
GYPSUM BOARD ASSEMBLIES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Cementitious backing board.
- B. Gypsum wallboard.
- C. Joint treatment and accessories.

1.02 RELATED REQUIREMENTS
- A. Section 06 1000 - Rough Carpentry: Building framing and sheathing.
- B. Section 07 2500 - Weather Barriers: Water-resistive barrier over sheathing.

1.03 REFERENCE STANDARDS
- A. ANSI A108.11 - American National Standard for Interior Installation of Cementitious Backer Units; 1999 (R2005).
- B. ANSI A118.9 - American National Standard Specifications for Test Methods and Specifications for Cementitious Backer Units; 1999 (R2005).
- C. ASTM C 475/C 475M - Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board; 2002 (Reapproved 2007).
- D. ASTM C 840 - Standard Specification for Application and Finishing of Gypsum Board; 2007.
- E. ASTM C 1002 - Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs; 2007.
- F. ASTM C 1047 - Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base; 2005.
- G. ASTM C 1325 - Standard Specification for Non-Asbestos Fiber-Mat Reinforced Cement Substrate Sheets; 2004.
- H. ASTM C 1396/C 1396M - Standard Specification for Gypsum Board; 2006a.

PART 2 PRODUCTS

2.01 BOARD MATERIALS
- A. Wallboard: Paper-faced gypsum wallboard as defined in ASTM C 1396/C 1396M; sizes to minimize joints in place; ends square cut.
  1. Application: Use for vertical surfaces and ceilings, unless otherwise indicated.
  2. Thickness:
     - a. Vertical Surfaces: 13 mm (1/2 inch).
     - b. Ceilings: 13 mm (1/2 inch).
- B. Backing Board For Wet Areas: One of the following products:
  1. Application: Locations as noted and surfaces behind tile in wet areas including shower surrounds.
  2. ANSI Cement-Based Board: Non-gypsum-based; aggregated portland cement panels with glass fiber mesh embedded in front and back surfaces complying with ANSI A118.9 or ASTM C 1325.
     - a. Thickness: 12.7 mm (1/2 inch).

2.02 ACCESSORIES
- A. Finishing Accessories: ASTM C 1047, galvanized steel or rolled zinc, unless otherwise indicated.
  1. Types: As detailed or required for finished appearance.
  2. Special Trims: Where indicated on drawings, wall trims shall be manufactured by GorDon, Inc. of drywall J-Edge trim or F-Reveal style as indicated.
     - a. Trims: Extruded aluminum, alloy 6063-T5, .050" thick with clear anodized 200-r1 finish.
- B. Joint Materials: ASTM C 475 and as recommended by gypsum board manufacturer for project conditions.
  1. Ready-mixed vinyl-based joint compound.
- C. Screws for Attachment to Steel Members Less Than 0.7 mm (0.03 inch) In Thickness, to Wood Members, and to Gypsum Board: ASTM C 1002; self-piercing tapping type.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify that project conditions are appropriate for work of this section to commence.

3.02 BOARD INSTALLATION
- A. Comply with ASTM C 840. Install to minimize butt end joints, especially in highly visible locations.
- B. Single-Layer Non-Rated: Install gypsum board in most economical direction, with ends and edges occurring over firm bearing.
  1. Exception: Tapered edges to receive joint treatment at right angles to framing.
- C. Cementitious Backing Board: Install over wood

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framing members and plywood substrate where indicated, in accordance with ANSI A108.11 and manufacturer's instructions.

D. Installation on Framing: Use screws for attachment of all gypsum board.

3.03 INSTALLATION OF TRIM AND ACCESSORIES

A. Control Joints: Place control joints consistent with lines of building spaces and as indicated.
   1. Not more than 10 meters (30 feet) apart on walls and ceilings over 10 meters (30 feet) long.

B. Corner Beads: Install at external corners, using longest practical lengths.

C. Edge Trim: Install at locations where gypsum board abuts dissimilar materials and as indicated.

D. Special Trims: Secure 10'-0" lengths of material to framing with screws at 12" o.c. Make butt joints neat and tight; miter intersecting corners. Wipe excess plaster from surfaces immediately.

3.04 JOINT TREATMENT

A. Finish gypsum board in accordance with levels defined in ASTM C 840, as follows:
   1. Level 4: Walls and ceilings to receive paint finish or wall coverings, unless otherwise indicated.

B. Tape, fill, and sand exposed joints, edges, and corners to produce smooth surface ready to receive finishes.
   1. Feather coats of joint compound so that camber is maximum 0.8 mm (1/32 inch).

C. Fill and finish joints and corners of cementitious backing board as recommended by manufacturer.

3.05 TOLERANCES

A. Maximum Variation of Finished Gypsum Board Surface from True Flatness: 3 mm in 3 m (1/8 inch in 10 feet) in any direction.

END OF SECTION

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SECTION 09 3000
TILING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Tile for floor applications.
- B. Tile for wall applications.

1.02 RELATED REQUIREMENTS
- A. Section 09 2116 - Gypsum Board Assemblies: Installation of tile backer board.

1.03 REFERENCE STANDARDS
- A. ANSI A108 Series/A118 Series/A136.1 - American National Standard Specifications for the Installation of Ceramic Tile (Compendium); 2005.
  1. ANSI A108.1a - American National Standard Specifications for Installation of Ceramic Tile in the Wet-Set Method, with Portland Cement Mortar; 2005.
  2. ANSI A108.1b - American National Standard Specifications for Installation of Ceramic Tile on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex Portland Cement Mortar; 1999 (R2005).
  3. ANSI A108.1c - Specifications for Contractors Option: Installation of Ceramic Tile in the Wet-Set Method with Portland Cement Mortar or Installation of Ceramic Tile on a Cured Portland Cement Mortar Bed with Dry-Set or Latex Portland Cement Mortar; 1999 (R2005).
  4. ANSI A108.4 - American National Standard Specifications for Installation of Ceramic Tile with Organic Adhesives or Water Cleanable Tile-Setting Epoxy Adhesive; 1999 (R2005).
  5. ANSI A108.5 - American National Standard Specifications for Installation of Ceramic Tile with Dry-Set Portland Cement Mortar or Latex-Portland Cement Mortar; 1999 (R2005).
  6. ANSI A108.6 - American National Standard Specifications for Installation of Ceramic Tile with Chemical Resistant, Water Cleanable Tile-Setting and -Grouting Epoxy; 1999 (R2005).
  7. ANSI A108.8 - American National Standard Specifications for Installation of Ceramic Tile with Chemical Resistant Furan Resin Mortar and Grout; 1999 (R2005).
  8. ANSI A108.9 - American National Standard Specifications for Installation of Ceramic Tile with Modified Epoxy Emulsion Mortar/Grout; 1999 (R2005).
  9. ANSI A108.10 - American National Standard Specifications for Installation of Grout in Tilework; 1999 (R2005).
  10. ANSI A118.4 - American National Standard Specifications for Latex-Portland Cement Mortar; 1999 (R2005).
  11. ANSI A118.6 - American National Standard Specifications for Standard Cement Grouts for Tile Installation; 1999 (R2005).
  12. ANSI A118.7 - American National Standard Specifications for Polymer Modified Cement Grouts for Tile Installation; 1999 (R2005).
  13. ANSI A136.1 - American National Standard for Organic Adhesives for Installation of Ceramic Tile; 1999 (R2005).
  14. ANSI A137.1 - American National Standard Specifications for Ceramic Tile; 2008.
- B. ASTM C 1028 - Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method; 2007.
- C. TCA (HB) - Handbook for Ceramic Tile Installation; Tile Council of North America, Inc.; 2007/2008.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturers' data sheets on tile, mortar, grout, and accessories. Include instructions for using grouts and adhesives.
- C. Samples: Mount tile and apply grout on two plywood panels, minimum 450 x 450 mm (18 x 18 inches) in size illustrating pattern, color variations, and grout joint size variations.
- D. Maintenance Data: Include recommended cleaning methods, cleaning materials, stain removal methods, and polishes and waxes.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the types of products specified in this section, with minimum 10 years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Protect adhesives from freezing or overheating in accordance with manufacturer's instructions.

1.07 FIELD CONDITIONS

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A. Do not install adhesives in an unventilated environment.
B. Maintain ambient and substrate temperature of 10 degrees C (50 degrees F) during installation of mortar materials.

PART 2 PRODUCTS

2.01 TILE

A. Glass Mosaic Wall Tile: ANSI A137.1, and as follows:
1. Moisture Absorption: 0 to 0.5 percent.
2. Size and Shape: 25 mm square (1 inch square).
3. Edges: Cushioned.
4. Surface Finish: High Gloss.
5. Colors: As selected by Interior Designer.

B. Porcelain Floor Tile: Through-body color type; ANSI A137.1, and as follows:
1. Moisture Absorption: 0 to 0.5 percent.
2. Chemical Resistance: Resistant when tested in accordance with ASTM C 650.
3. Coefficient of Friction: > 0.6 COF when tested in accordance with ASTM C 1028.
4. Size and Shape: 150 mm square (6 inch square).
5. Thickness: 9.5 mm (3/8 inch)
6. Face: Plain.
7. Edges: Cushioned.
8. Surface Finish: Unglazed.
9. Colors: As scheduled.

2.02 ADHESIVE MATERIALS

A. Organic Adhesive: ANSI A136.1, thinset bond type; use Type I in areas subject to prolonged moisture exposure.

2.03 MORTAR MATERIALS

A. Manufacturers:
1. Bonsal American, Inc: www.sakrete.com
2. Bostik Inc: www.bostik-us.com.
3. Custom Building Products: www.custombuildingproducts.com.
4. Substitutions: See Section 01 6000 - Product Requirements.

B. Mortar Bond Coat Materials:
1. Latex-Portland Cement type: ANSI A118.4.
   a. For setting glass mosaic tile, use bright white colored product specifically recommended by manufacturer for use with glass mosaic tile.

2.04 GROUT MATERIALS

A. Manufacturers:
1. Bonsal American, Inc: www.sakrete.com
2. Bostik Inc: www.bostik-us.com.
3. Custom Building Products: www.custombuildingproducts.com.
4. Laticrete International, Inc.: www.laticrete.com.
5. Substitutions: See Section 01 6000 - Product Requirements.

B. Standard Grout: Any type specified in ANSI A118.6 or A118.7.
1. Color: As selected by Interior Designer.

2.05 ACCESSORY MATERIALS

A. Tile Floor Edging: Terrazzo divider strip; 1/8 inch thick zinc exposed top strip, zinc coated steel concealed bottom strip, with anchoring features.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that sub-floor surfaces are smooth and flat within the tolerances specified for that type of work and are ready to receive tile.
B. Verify that wall surfaces are smooth and flat within the tolerances specified for that type of work, are dust-free, and are ready to receive tile.
C. Verify that sub-floor surfaces are dust-free and free of substances that could impair bonding of setting materials to sub-floor surfaces.

3.02 PREPARATION

A. Protect surrounding work from damage.
B. Vacuum clean surfaces and damp clean.
C. Seal substrate surface cracks with filler. Level existing substrate surfaces to acceptable flatness tolerances.
D. Place edge strips at exposed tile edges.

3.03 INSTALLATION - GENERAL

A. Install tile and grout in accordance with applicable requirements of ANSI A108.1 through A108.13, manufacturer's instructions, and TCA Handbook recommendations.
B. Request tile pattern. Do not interrupt tile pattern through openings.
C. Cut and fit tile to penetrations through tile, leaving sealant joint space. Form corners and bases neatly. Align floor joints.
D. Place tile joints uniform in width, subject to variance in tolerance allowed in tile size. Make joints watertight, without voids, cracks, excess mortar, or excess grout.
E. Form internal angles square and external angles bullnosed.

F. Sound tile after setting. Replace hollow sounding units.
G. Allow tile to set for a minimum of 48 hours prior to grouting.
H. Grout tile joints. Use standard grout unless otherwise indicated.
I. Apply sealant to junction of tile and dissimilar materials and junction of dissimilar planes.

3.04 INSTALLATION - FLOORS - THIN-SET METHODS

A. Over wood substrates, install in accordance with TCA Handbook Method F142, with standard grout, unless otherwise indicated.

3.05 INSTALLATION - SHOWERS AND BATHTUB WALLS

A. At shower walls install in accordance with TCA Handbook Method B419, over tile backer boards.
B. Grout with standard grout as specified above.
C. Seal joints between tile work and other work with silicone sealant specified in Section 07 9005.

3.06 INSTALLATION - WALL TILE

A. Over cementitious backer units on studs, install in accordance with TCA Handbook Method W244.
B. Over gypsum wallboard on wood or metal studs install in accordance with TCA Handbook Method W243, thin-set with dry-set or latex-portland cement bond coat, unless otherwise indicated.

3.07 CLEANING

A. Clean tile and grout surfaces.

3.08 PROTECTION

A. Do not permit traffic over finished floor surface for 4 days after installation.

END OF SECTION

SECTION 09 6429
WOOD STRIP AND PLANK FLOORING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Wood strip flooring, nailed.
- B. Surface finishing.

1.02 RELATED REQUIREMENTS
- A. Section 06 1000 - Rough Carpentry: Wood subfloor surface.

1.03 REFERENCE STANDARDS
- A. MFMA (SPEC) - Guide Specifications for Maple Flooring Systems; Maple Flooring Manufacturers Association; current edition.

1.04 QUALITY ASSURANCE
- A. Perform work of this section in accordance with MFMA (SPEC).

1.05 FIELD CONDITIONS
- A. Do not install wood flooring until wet construction work is complete and ambient air at installation space has moisture content stabilized at maximum moisture content of 40 percent.
- B. Provide heat, light, and ventilation prior to installation.
- C. Store materials in area of installation for minimum period of 24 hours prior to installation.
- D. Maintain minimum room temperature of 18 degrees C (65 degrees F) for a period of two days prior to delivery of materials to installation space, during installation, and after installation.

PART 2 PRODUCTS

2.01 MATERIALS
- A. Wood Strip Flooring: Reclaimed and re-used material.
  1. Species: Northern Hard Maple.
  2. Moisture Content: 7 to 9 percent.
  3. Actual Thickness: 20 mm (25/32 inch).
  4. Edge: Tongue and Groove.
  5. End: End matched.
  6. Length: Random, minimum of 230 mm (9 inches).
- B. Flooring Nails: Spiral shank type.
- C. Sheathing Paper: Waxed kraft paper.

2.02 ACCESSORIES
- A. Floor Finish: Polyurethane, to achieve satin sheen surface; type recommended by flooring manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify existing conditions before starting work.
- B. Verify wood subfloor is properly secured, smooth and flat to plus or minus 6 mm in 3 m (1/4 inch in 10 feet).
- C. Verify that required floor-mounted utilities are in correct location.

3.02 PREPARATION
- A. Reclaimed and Re-Used Flooring:
  1. Inspect and identify damaged pieces; discard severely damaged pieces or cut-out defective area and salvage usable portion.
  2. Remove any remaining nails or other metal fasteners.
  3. Plane a minimum amount to remove existing finish and any minor surface surface scratches.
- B. Prepare substrate to receive wood flooring in accordance with MFMA instructions.
- C. Broom clean substrate.

3.03 INSTALLATION
- A. Sheathing Paper: Place over wood subfloor; lap edges and ends 50 mm (2 inches), staple in place.
- B. Wood Flooring:
  1. Install in accordance with MFMA instructions; predrill and blind nail to wood sub-floor.
  2. Lay flooring parallel to length of room areas. Verify alignment as work progresses.
  3. Arrange flooring with end matched grain set flush and tight.
  4. Terminate flooring at centerline of door openings where adjacent floor finish is dissimilar; provide divider strips and transition strips in accordance with flooring manufacturer's recommendations and as indicated..
  5. Install edge strips at unprotected or exposed edges, and where flooring terminates.
  6. Secure edge strips before installation of flooring with stainless steel screws.
  7. Install flooring tight to floor access covers.
  8. Provide 13 mm (1/2 inch) expansion space at fixed walls and other interruptions.
- C. Finishing:
  1. Mask off adjacent surfaces before beginning sanding.

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2. Sand flooring to smooth even finish with no evidence of sander marks. Take precautions to contain dust. Remove dust by vacuum.
3. Apply finish in accordance with floor finish manufacturer's instructions.
4. Apply three finish coats.
5. Apply first coat, allow to dry, then buff lightly with steel wool to remove irregularities. Vacuum clean and wipe with damp cloth before applying succeeding coat.
6. Lightly buff between coats with steel wool and vacuum clean before applying succeeding coat.
7. Apply last coat of finish.

3.04 PROTECTION

A. Prohibit traffic on floor finish for 48 hours after installation.
B. Place protective coverings over finished floors; do not remove coverings until Substantial Completion.

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SECTION 09 9000
PAINTING AND COATING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Surface preparation.
- B. Field application of paints, stains, varnishes, and other coatings.
- C. Scope: Finish all interior and exterior surfaces exposed to view, unless fully factory-finished and unless otherwise indicated, including the following:
  1. Mechanical and Electrical:
     - a. In finished areas, paint all insulated and exposed pipes, conduit, boxes, insulated and exposed ducts, hangers, brackets, collars and supports, mechanical equipment, and electrical equipment, unless otherwise indicated.
     - b. In finished areas, paint shop-primed items.
     - c. On the roof and outdoors, paint all equipment that is exposed to weather or to view, including that which is factory-finished.
- D. Do Not Paint or Finish the Following Items:
  1. Items fully factory-finished unless specifically so indicated; materials and products having factory-applied primers are not considered factory finished.
  2. Items indicated to receive other finishes.
  3. Items indicated to remain unfinished.
  4. Fire rating labels, equipment serial number and capacity labels, and operating parts of equipment.
  5. Non-metallic roofing and flashing.
  6. Stainless steel, anodized aluminum, bronze, terne, and lead items.
  7. Floors, unless specifically so indicated.
  8. Ceramic and other tiles.
  9. Glass.
  10. Concealed pipes, ducts, and conduits.

1.02 RELATED REQUIREMENTS
- A. Section 05 5000 - Metal Fabrications: Shop-primed items.

1.03 DEFINITIONS
- A. Conform to ASTM D 16 for interpretation of terms used in this section.

1.04 REFERENCE STANDARDS
- A. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings; U.S. Environmental Protection Agency; current edition.
- B. ASTM D 16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications; 2007.
- C. ASTM D 4442 - Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials; 1992 (Reapproved 2003).

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on all finishing products, including VOC content.

1.06 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified, with minimum 10 years experience.

1.07 DELIVERY, STORAGE, AND HANDLING
- A. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.
- B. Container Label: Include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
- C. Paint Materials: Store at minimum ambient temperature of 7 degrees C (45 degrees F) and a maximum of 32 degrees C (90 degrees F), in ventilated area, and as required by manufacturer's instructions.

1.08 FIELD CONDITIONS
- A. Do not apply materials when surface and ambient temperatures are outside the temperature ranges required by the paint product manufacturer.
- B. Follow manufacturer's recommended procedures for producing best results, including testing of substrates, moisture in substrates, and humidity and temperature limitations.
- C. Do not apply exterior coatings during rain or snow, or when relative humidity is outside the humidity ranges required by the paint product manufacturer.
- D. Minimum Application Temperatures for Latex Paints: 7 degrees C (45 degrees F) for interiors; 10 degrees C (50 degrees F) for exterior; unless required otherwise by manufacturer's instructions.

E. Provide lighting level of 860 lx (80 ft candles) measured mid-height at substrate surface.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide all paint and coating products used in any individual system from the same manufacturer; no exceptions.

B. Paints:

1. Benjamin Moore & Co: www.benjaminmoore.com.

C. Substitutions: Not permitted.

2.02 PAINTS AND COATINGS - GENERAL

A. Paints and Coatings: Ready mixed, unless intended to be a field-catalyzed coating.

1. Provide paints and coatings of a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating, with good flow and brushing properties, and capable of drying or curing free of streaks or sags.

2. Supply each coating material in quantity required to complete entire project's work from a single production run.

3. Do not reduce, thin, or dilute coatings or add materials to coatings unless such procedure is specifically described in manufacturer's product instructions.

B. Primers: Where the manufacturer offers options on primers for a particular substrate, use primer categorized as "best" by the manufacturer.

C. Volatile Organic Compound (VOC) Content: Provide interior-use coatings that contain 0 percent VOC content, including after tinting.

1. Provide exterior-use coatings that comply with the most stringent requirements specified in the following:

a. 40 CFR 59, Subpart D--National Volatile Organic Compound Emission Standards for Architectural Coatings.

2. Determination of VOC Content: Testing and calculation in accordance with 40 CFR 59, Subpart D (EPA Method 24), exclusive of water added at project site; or other method acceptable to authorities having jurisdiction.

2.03 PAINT SYSTEMS - EXTERIOR

A. Wood, Opaque, Latex, 3 Coat:

1. One coat of latex primer sealer; Fresh Start Acrylic Primer (023).

2. Semi-gloss: Two coats of latex enamel; AURA Waterborne Exterior Paint Semi Gloss Finish 632.

B. Wood, Semi-Transparent, Stain:

1. Two coats of stain; ALKYD SEMI TRANSPARENT Stain 328/C328.

C. Ferrous Metals, Unprimed, Latex, 3 Coat:

1. One coat of latex primer; IRONCLAD Latex Low Lustre Metal & Wood Enamel.

2. Semi-gloss: Two coats of latex enamel; AURA Waterborne Exterior Paint Semi Gloss Finish 632.

D. Ferrous Metals, Primed, Latex, 2 Coat:

1. Touch-up with rust-inhibitive primer recommended by top coat manufacturer.

2. Semi-gloss: Two coats of latex enamel; AURA Waterborne Exterior Paint Semi Gloss Finish 632.

E. Galvanized Metals, Latex, 2 Coat:

1. No primer required, but thoroughly clean with mineral spirits to remove contaminants. To promote adhesion, dull with very fine sandpaper or a synthetic steel wool pad new shiny non-ferrous metal surfaces that will be subject to abrasion.

2. Semi-gloss: Two coats of latex enamel; AURA Waterborne Exterior Paint Semi Gloss Finish 632.

2.04 PAINT SYSTEMS - INTERIOR

A. Wood, Opaque, Latex, 3 Coat:

1. One coat of latex primer sealer; NATURA Interior Waterborne Paint, Primer 511.

2. Semi-gloss: Two coats of latex enamel; NATURA Interior Waterborne Paint, Semi-Gloss 514.

B. Paint WI-TR-V - Wood, Transparent, Varnish, No Stain:

1. One coat sealer.

2. Satin: Two coats of varnish; BENWOOD Polyurethane Finish Low Lustre C435.

C. Paint MI-OP-2L - Ferrous Metals, Primed, Latex, 2 Coat:

1. Touch-up with latex primer.

2. Semi-gloss: Two coats of latex enamel; NATURA Interior Waterborne Paint, Semi-Gloss 514.

D. Paint MgI-OP-3L - Galvanized Metals, Latex, 3

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Coat:
1. One coat galvanize primer.
2. Semi-gloss: Two coats of latex enamel; NATURA Interior Waterborne Paint, Semi-Gloss 514.

E. Paint GI-OP-3L - Gypsum Board/Plaster, Latex, 3 Coat:
1. One coat of latex primer sealer; NATURA Interior Waterborne Paint, Primer 511.
2. Eggshell: Two coats of latex enamel; for walls; NATURA Interior Waterborne Paint, Eggshell 513.
3. Flat: Two coats of latex enamel; for ceilings; NATURA Interior Waterborne Paint, Flat 512.

2.05 ACCESSORY MATERIALS

A. Accessory Materials: Provide all primers, sealers, cleaning agents, cleaning cloths, sanding materials, and clean-up materials required to achieve the finishes specified whether specifically indicated or not; commercial quality.
B. Patching Material: Latex filler.
C. Fastener Head Cover Material: Latex filler.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that surfaces are ready to receive work as instructed by the product manufacturer.
B. Examine surfaces scheduled to be finished prior to commencement of work. Report any condition that may potentially affect proper application.
C. Test shop-applied primer for compatibility with subsequent cover materials.
D. Measure moisture content of surfaces using an electronic moisture meter. Do not apply finishes unless moisture content of surfaces are below the following maximums:
1. Gypsum Wallboard: 12 percent.
2. Interior Wood: 15 percent, measured in accordance with ASTM D 4442.
3. Exterior Wood: 15 percent, measured in accordance with ASTM D 4442.

3.02 PREPARATION

A. Clean surfaces thoroughly and correct defects prior to coating application.
B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
C. Remove surface appurtenances, including electrical plates, hardware, light fixture trim, escutcheons, and fittings, prior to preparing surfaces or finishing.
D. Seal surfaces that might cause bleed through or staining of topcoat.
E. Remove mildew from impervious surfaces by scrubbing with solution of tetra-sodium phosphate and bleach. Rinse with clean water and allow surface to dry.
F. Gypsum Board Surfaces to be Painted: Fill minor defects with filler compound. Spot prime defects after repair.
G. Galvanized Surfaces to be Painted: Remove surface contamination and oils and wash with solvent. Apply coat of etching primer, unless otherwise indicated.
H. Uncorroded Uncoated Steel and Iron Surfaces to be Painted: Remove grease, mill scale, weld splatter, dirt, and rust. Where heavy coatings of scale are evident, remove by hand wire brushing or sandblasting; clean by washing with solvent. Apply a treatment of phosphoric acid solution, ensuring weld joints, bolts, and nuts are similarly cleaned. Prime paint entire surface; spot prime after repairs.
I. Shop-Primed Steel Surfaces to be Finish Painted: Sand and scrape to remove loose primer and rust. Feather edges to make touch-up patches inconspicuous. Clean surfaces with solvent. Prime bare steel surfaces.
J. Interior Wood Surfaces to Receive Opaque Finish: Wipe off dust and grit prior to priming. Seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after primer has dried; sand between coats. Back prime concealed surfaces before installation.
K. Interior Wood Surfaces to Receive Transparent Finish: Wipe off dust and grit prior to sealing, seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after sealer has dried; sand lightly between coats. Prime concealed surfaces with gloss varnish reduced 25 percent with thinner.
L. Exterior Wood Surfaces to Receive Opaque Finish: Remove dust, grit, and foreign matter. Seal knots, pitch streaks, and sappy sections. Fill nail holes with tinted exterior calking compound after prime coat has been applied. Back prime concealed surfaces before installation.
M. Exterior Wood to Receive Semi-Transparent Finish: Remove dust, grit, and foreign matter; seal knots,

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pitch streaks, and sappy sections with sealer. Fill nail holes with tinted exterior calking compound after sealer has been applied. Prime concealed surfaces.

N. Metal Doors to be Painted: Prime metal door top and bottom edge surfaces.

3.03 APPLICATION

A. Remove unfinished louvers, grilles, covers, and access panels on mechanical and electrical components and paint separately.

B. Exterior Wood to Receive Opaque Finish: If final painting must be delayed more than 2 weeks after installation of woodwork, apply primer within 2 weeks and final coating within 4 weeks.

C. Apply products in accordance with manufacturer's instructions.

D. Do not apply finishes to surfaces that are not dry. Allow applied coats to dry before next coat is applied.

E. Apply each coat to uniform appearance.

F. Dark Colors and Deep Clear Colors: Regardless of number of coats specified, apply as many coats as necessary for complete hide.

G. Sand wood and metal surfaces lightly between coats to achieve required finish.

H. Vacuum clean surfaces of loose particles. Use tack cloth to remove dust and particles just prior to applying next coat.

I. Wood to Receive Transparent Finishes: Tint fillers to match wood. Work fillers into the grain before set. Wipe excess from surface.

J. Reinstall electrical cover plates, hardware, light fixture trim, escutcheons, and fittings removed prior to finishing.

3.04 CLEANING

A. Collect waste material that could constitute a fire hazard, place in closed metal containers, and remove daily from site.

3.05 PROTECTION

A. Protect finished coatings until completion of project.

B. Touch-up damaged coatings after Substantial Completion.

END OF SECTION

SECTION 10 2800
TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Accessories for toilet rooms, showers, and residential bathrooms.
- B. Medicine cabinet.

1.02 REFERENCE STANDARDS
- A. ASTM B 456 - Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium; 2003.

1.03 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on accessories describing size, finish, details of function, attachment methods.

PART 2 PRODUCTS

2.01 MANUFACTURERS
- A. Products listed are made by Toto Ltd; Product LLOYD Bath Accessories: www.totousa.com.
- B. All items of each type to be made by the same manufacturer.

2.02 MATERIALS
- A. Accessories - General: Shop assembled, free of dents and scratches and packaged complete with anchors and fittings, steel anchor plates, adapters, and anchor components for installation.
  1. Grind welded joints smooth.
  2. Fabricate units made of metal sheet of seamless sheets, with flat surfaces.
- B. Fasteners, Screws, and Bolts: Hot dip galvanized, tamper-proof, security type.
- C. Expansion Shields: Fiber, lead, or rubber as recommended by accessory manufacturer for component and substrate.

2.03 FINISHES
- A. Stainless Steel: No. 4 satin brushed finish, unless otherwise noted.
- B. Chrome/Nickel Plating: ASTM B 456, SC 2, polished finish, unless otherwise noted.

2.04 TOILET ROOM ACCESSORIES
- A. Toilet Paper Dispenser: Single roll, surface mounted bracket type, chrome-plated zinc alloy brackets with flat, rectangular cross section, bar stock tissue roll holder.
  1. Product: YP930CP manufactured by Toto.
- B. Mirrors: Stainless steel framed, 6 mm thick float glass mirror.
  1. Size: As indicated on drawings.
  2. Frame: 1.3 mm (0.05 inch) angle shapes, with mitered and welded and ground corners; No.4 finish.
  3. Backing: Full-mirror sized, minimum 0.8 mm (0.03 inch) galvanized steel sheet and nonabsorptive filler material.

2.05 SHOWER AND TUB ACCESSORIES
- A. Shower Curtain Rod: Stainless steel tube, 25 mm (1 inch) outside diameter, 1.0 mm (0.04 inch) wall thickness, satin-finished, with 75 mm (3 inch) outside diameter, minimum 1.0 mm (0.04 inch) thick satin-finished stainless steel flanges, for installation with exposed fasteners.
  1. Provide 90 degree bend in shower rod to accommodate continuous rod for 2 adjacent sides of shower; include adjustable height overhead hanger at 90 degree corner.
- B. Shower Curtain:
  1. Material: Semi-transparent, "clear" vinyl, 0.2 mm (0.008 inch) thick, matte finish, with antibacterial treatment, flameproof and stain-resistant.
  2. Size: 1830 mm (72 inches) tall, hemmed edges.
  3. Grommets: Stainless steel; pierced through top hem on 150 mm (6 inch) centers.
  4. Shower curtain hooks: Chrome-plated or stainless steel spring wire designed for snap closure.

2.06 RESIDENTIAL ACCESSORIES
- A. Medicine Cabinet: One-piece construction of heavy-gage aluminum with clear anodized finish, size as indicated on drawings; semi-recess mounted.
  1. Shelves: Adjustable, glass; provide 1 for each approximately 10 inches of cabinet height.
  2. Door: Frameless, side hinged, mirror door; 3-way adjustable hinge system.
  3. Product: M-Series manufactured by Robern, Inc: www.robern.com.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify existing conditions before starting work.

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B. Verify exact location of accessories for installation.

3.02 INSTALLATION

A. Install accessories in accordance with manufacturers' instructions.

B. Install plumb and level, securely and rigidly anchored to substrate.

C. Mounting Heights and Locations: as indicated on drawings

END OF SECTION

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SECTION 11 3100
RESIDENTIAL APPLIANCES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Kitchen appliances.
- B. Laundry appliances.
- C. Ceiling fans.

1.02 RELATED REQUIREMENTS
- A. Section 22 1005 - Plumbing Piping: Plumbing connections for appliances.
- B. Section 26 2717 - Equipment Wiring: Electrical connections for appliances.

1.03 REFERENCE STANDARDS
- A. UL (EAUED) - Electrical Appliance and Utilization Equipment Directory; Underwriters Laboratories Inc.; current edition.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Manufacturer's data indicating dimensions, capacity, and operating features of each piece of residential equipment specified.
- C. Copies of Warranties: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than 10 years of experience.
- B. Electric Appliances: Listed and labeled by UL and complying with NEMA standards.

1.06 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five (5) year manufacturer warranty on refrigeration system of refrigerators.
- C. Provide ten (10) year manufacturer warranty on tub and door liner of dishwashers.

PART 2 PRODUCTS

2.01 KITCHEN APPLIANCES
- A. Refrigerator: Built-in, bottom-mounted freezer, frost-free, 24 inches wide.
  1. Capacity: Total minimum storage of 0.26 cu m (9.2 cubic ft); minimum 15 percent freezer capacity.
  2. Energy Usage: Minimum 20 percent more energy efficient than energy efficiency standards set by DOE.
  3. Features: Include LED lighting, glass shelves, light in freezer compartment, and dual refrigeration system.
  4. Finish: Porcelain enameled steel, color as selected by Interior Designer.
  5. Manufacturers:
     - a. Liebherr; Product HC 1011: www.liebherr-appliances.com.
- B. Modular Cooktop: Electric, unframed, induction cooktop.
  1. Size: 762 mm (30 inches).
  2. Elements: 4; 2 at 1800 W with 3000 W boost and 2 at 1200 W.
  3. Features: Include cookware sensing and temperature limiter.
  4. Finish: Glass, black ceramic.
  5. Manufacturers:
     - a. Wolf; Product CT30IU: www.wolfappliance.com.
- C. Wall Oven: Electric, single convection steam oven.
  1. Size: 762 mm (30 inches).
  2. Oven: Manual cleaning.
  3. Controls: Solid state electronic, multi-lingual LCD display.
  4. Features: Include 1.2 L (1.25 qt) water reservoir, oven light and stainless steel interior.
  5. Finish: Porcelain enameled steel, color as indicated.
  6. Manufacturers:
     - a. Miele; Product DG4080 (replaces earlier model DG155); www.miele.com.
- D. Cooking Exhaust: Range hood.
  1. Size: 762 mm (30 inches).
  2. Fan: Two- speed, 76 L/s (160 cfm), permanently lubricated.
  3. Exhaust: Recirculating.
  4. Features: Include cooktop light and removable grease filter.
  5. Finish: Painted steel, color as selected by Interior Designer.
  6. Manufacturers:
     - a. Broan; Product F40000: www.broan.com.
- E. Dishwasher: Undercounter, double drawer.

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1. Controls: Solid state electronic.
2. Wash Levels: 3.
3. Cycles: 9, including normal, rinse and hold, short, china/crystal, and pot and pan.
4. Features: Include rinse aid dispenser, optional no-heat dry, optional water temperature boost, adjustable upper rack, adjustable lower rack, and up to 12 hour delayed start.
5. Finish: Porcelain enameled steel, color as indicated by Interior Designer.
6. Manufacturers:
   a. Fisher & Paykel; Product Double DishDrawer DD605I Integrated: www.fp.com.au.

2.02 LAUNDRY APPLIANCES

A. Clothes Washer: Front-loading, stackable.
1. Size: Large capacity.
2. Controls: Solid state electronic.
3. Cycles: Include normal and permanent press.
4. Motor Speed: Two-speed.
5. Features: Include stainless steel drum, optional second rinse, bleach dispenser, fabric softener dispenser, self-cleaning lint filter, sound insulation, end of cycle signal, and Energy Star rated.
6. Finish: Painted steel, color as indicated.
7. Accessory: Include Asko HIDDEN HELPER Single Shelf accessory for stacked washer and dryer.
8. Manufacturers:
   a. ASKO Appliances, Inc; Product W6222: www.askousa.com.

B. Clothes Dryer: Electric, stationary, stackable.
1. Size: Large capacity.
2. Controls: Solid state electronic, with electronic moisture-sensing dry control.
3. Temperature Selections: Three.
4. Cycles: Include normal, permanent press, knit/delicate, and air only.
5. Features: Include interior light, reversible door, stationary rack, sound insulation, end of cycle signal, and stainless steel drum.
6. Finish: Painted steel, color as indicated.
7. Manufacturers:
   a. ASKO Appliances, Inc; Product T712: www.askousa.com.

2.03 CEILING FANS

A. Appearance: Contemporary.
B. Blade Diameter: 1270 mm (50 inches).
C. Blade Quantity: 3
D. Blade Finish: Nickel.
E. Motor Housing, Canopy, and Drop Rod Finish: Bright Nickel.
F. Motor: 3 speed, reversible.
G. Light: None.
H. Mounting: Capable of mounting to sloped ceiling and supply with 24 inch minimum length drop rod.
I. Control: Allow for wall switch and remote control both. Supply necessary controls and switches.
J. Manufacturer: Provide The Modern Fan Co; Product VELO: www.modernfan.com.

2.04 ACCESSORIES

A. Provide cord and plug for each appliance.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify utility rough-ins are present and correctly located.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Level appliances to manufacturer's recommended tolerance; use adjustable legs of appliances when available.
C. Anchor built-in equipment in place.
D. Connect to utilities.

3.03 ADJUSTING

A. Adjust operating equipment to efficient operation.
B. Balance ceiling fan blades to ensure fan operates without excessive vibration.

3.04 CLEANING

A. Remove packing materials from equipment.
B. Wash and clean equipment.

END OF SECTION

SECTION 12 2413
WINDOW SHADES

PART 1 - GENERAL

1.01 SCOPE
- A. Commercial honeycomb shades (Premium Quality).

1.02 RELATED WORK:
- A. Section 06 1000: Rough Carpentry
- B. Section 08 5200: Wood Windows

1.03 REFERENCES
- A. Flame-resistant fabrics shall pass or exceed one or more of the following tests:
  1. National Fire Protection Association (NFPA) 701 (small scale for horizontal applications).
  2. Department of Transportation Motor Vehicle Safety Standard 302 Flammability of Interior Materials.
  3. California Administrative Code Title 19.
  4. Federal Standard 191 Method 5903 (used by Port Authority of New York and New Jersey for drapery, curtain, and upholstery material).
  5. Boston Fire Department Test BFD IX-1.
  6. New York State Uniform Fire Prevention and Building Code.

1.04 SUBMITTALS
- A. Product Data: Manufacturer's descriptive literature shall be submitted indicating materials, finishes, construction and installation instructions and verifying that product meets requirements specified. Manufacturers recommendations for maintenance and cleaning shall be included.
- B. Drawings and Diagrams: Wiring diagrams of any motorized components or units, working and assembly drawings shall be supplied as requested.
- C. Samples: Supply one sample shade of each type specified in this contract for approval. Supplied units shall be furnished complete with all required components, mounting and associated hardware, instructions and warranty.

1.05 QUALITY ASSURANCE:
- A. Supplier: Manufacturer, subsidiary or licensed agent shall be approved to supply the products specified, and to honor any claims against product presented in accordance with warranty.
- B. Installer: Installer or agent shall be qualified to install specified products by prior experience, demonstrated performance and acceptance of requirements of manufacturer, subsidiary, or licensed agent. Installer shall be responsible for an acceptable installation.
- C. Uniformity: Provide Commercial Honeycomb Shades of only one manufacturer for entire project.

1.06 DELIVERY, STORAGE AND HANDLING:
- A. Product shall be delivered to site in manufacturer's original packaging.
- B. Product shall be handled and stored to prevent damage to materials, finishes and operating mechanisms.

1.07 JOB CONDITIONS:
- A. Prior to shade installation, building shall be enclosed.
- B. Interior temperature shall be maintained between 60 and 90 degrees F. during and after installation; relative humidity shall not exceed 80 percent. Wet work shall be complete and dry.

1.08 WARRANTY:
- A. Lifetime Limited Warranty. Warrant fabrics and cords for three years. Specific product warranties available from manufacturer or its authorized agent.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

2.02 Hunter Douglas Contract; Product DUETTE Standard Commercial 3/4 Inch Semi-Opaque Honeycomb Shades: www.hunterdouglascontract.com.

2.03 COMMERCIAL HONEYCOMB SHADES
- A. Materials:
  1. Fabric: Permanent flame-resistant textured, non-woven polyester formed into translucent 3/4" hexagonal double honeycomb cells creating 3 air chambers in stacked tubular construction. Single cell construction; with each cell an independent piece of fabric. Provide ARCHITELLA fabric in color as selected by Interior Designer from manufacturer's available colors.
  2. Head/Bottom Rail: Standard type measuring 1.875 x 0.460 inch, 0.040 inch thick constructed of aluminum alloy 6063. Internally fit with components required for specified performance and designed for smooth, quiet, trouble-free operation. Finish to be standard polyester based paint and to coordinate with fabric. Fit ends with polycarbonate end caps color coordinated with fabric.
  3. Lifting Mechanism: Molded engineering plastic

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cordlock, color coordinated to fabric with stainless steel components providing durable and crash-proof operation. Color coordinated braided polyester 0.035 inch lift cord and 0.086 inch tassel cord, tassel, and stop-ball. Located on either side of individual shade unit as per Interior Designer's request.

4. Mounting Hardware: Manufacturer's standard polycarbonate universal hidden brackets, provide a sleek, unobtrusive appearance.

2.04 FABRICATION

A. Blind measurements shall be accurate to within + 1/8 inch or as recommended in writing by manufacturer.

2.05 2.04 FINISHES

A. Fabric finish to be duotone with neutral tone facing the exterior and color selection facing the interior.

PART 3 - EXECUTION

3.01 INSPECTION:

A. Installer shall be responsible for inspection on site, approval of mounting surfaces, installation conditions and field measurement for this work.

B. Other interacting trades shall receive drawings of shade systems, dimensions, assembly and installation methods from subcontractor upon request.

3.02 INSTALLATION:

A. Installation shall comply with manufacturer's specifications, standards and procedures as detailed on contract drawings.

B. Adequate clearance shall be provided to permit unencumbered operation of shade and hardware.

C. Clean finish installation of dirt and finger marks. Leave work area clean and free of debris.

3.03 DEMONSTRATION:

A. Demonstrate operation method and instruct owner's personnel in the proper operation and maintenance of the blinds.

END OF SECTION

SECTION 12 3600
COUNTERTOPS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Countertops for architectural cabinetwork.

1.02 RELATED REQUIREMENTS
- A. Section 06 4100 - Architectural Wood Casework.
- B. Section 22 4000 - Plumbing Fixtures: Sinks.

1.03 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
  1. Preparation instructions and recommendations.
  2. Storage and handling requirements and recommendations.
  3. Specimen warranty.
- C. Shop Drawings: Complete details of materials and installation; combine with shop drawings of cabinets and casework specified in other sections.
- D. Verification Samples: For each finish product specified, minimum size 150 mm (6 inches) square, representing actual product, color, and patterns.
- E. Maintenance Data: Manufacturer's instructions and recommendations for maintenance and repair of countertop surfaces.

1.04 QUALITY ASSURANCE
- A. Fabricator Qualifications: Use fabricator certified and approved by countertop material manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING
- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.06 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide manufacturer's standard 10 year warranty that the surface products will be free from manufacturing defects, provided the surface products are fabricated and installed by a manufacturer's certified fabricator.

PART 2 PRODUCTS

2.01 COUNTERTOP ASSEMBLIES
- A. Recycled Glass Countertops: Monolithic composition that combines up to 85 percent recycled glass with Portland cement, water and proprietary inert ingredients such as minerals, pigments and other non-VOC substances.
  1. Finish: High-gloss, polished and sealed, similar to terrazzo.
  2. Thickness: Approximately 30 mm (1-3/16 inches).
  3. Color: As selected by Interior Designer.
  4. Edge Profile: Standard, eased edge with 3/16 inch radius profile; edge finished same as top.

2.02 ACCESSORY MATERIALS
- A. Adhesives: Chemical resistant waterproof adhesive as recommended by manufacturer of materials being joined.
- B. Joint Sealant: Mildew-resistant silicone sealant, color as selected to complement countertop color.
- C. Surface Sealer: As recommended by countertop manufacturer.

2.03 FABRICATION
- A. Fabricate tops in accordance with manufacturer's recommendations.
- B. Fabricate tops and splashes in the largest sections practicable, with top surface of joints flush.
  1. Join lengths of tops using best method recommended by manufacturer.
  2. Fabricate to overhang fronts and ends of cabinets 25 mm (1 inch) except where top butts against cabinet or wall.
  3. Prepare all cutouts accurately to size; replace tops having improperly dimensioned or unnecessary cutouts or fixture holes.
- C. Provide back/end splash wherever counter edge abuts vertical surface unless otherwise indicated.
  1. Secure to countertop with concealed fasteners or contact surfaces set in waterproof glue.
  2. Height: 102 mm (4 inches), unless otherwise indicated.
- D. Recycled Glass:
  1. Fabricate tops up to 2740 mm (108 inches) long in one piece; join pieces with adhesive sealant in accordance with manufacturer's recommendations and instructions.
  2. Fabricate entire project from one production run

of countertop material to ensure highest quality of color consistency.

PART 3 EXECUTION

3.01 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

C. Verify that wall surfaces have been finished and mechanical and electrical services and outlets are installed in proper locations.

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. Securely attach countertops to cabinets using concealed fasteners or adhesive. Make flat surfaces level; shim where required.

B. Seal joint between back/end splashes and vertical surfaces.

C. Seal countertop exposed surfaces, using number of coats recommended by countertop manufacturer, to provide enhanced stain resistance.

3.04 CLEANING

A. Clean countertops surfaces thoroughly.

3.05 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

SECTION 22 0716
PLUMBING EQUIPMENT INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Equipment insulation.

1.02 RELATED REQUIREMENTS
- A. Section 22 1005 - Plumbing Piping: Placement of hangers and hanger inserts.
- B. Section 23 2113 - Hydronic Piping: Placement of hangers and hanger inserts.
- C. Section 23 2114 - Hydronic Specialties.

1.03 REFERENCE STANDARDS
- A. ASTM B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2007.
- B. ASTM B 209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric]; 2007.
- C. ASTM C 177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2004.
- D. ASTM C 518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2004.
- E. ASTM C 553 - Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2002.
- F. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2008.
- G. ASTM E 96/E 96M - Standard Test Methods for Water Vapor Transmission of Materials; 2005.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with not less than 10 years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.07 FIELD CONDITIONS
- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION
- A. Surface Burning Characteristics: Flame spread/ Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.

2.02 GLASS FIBER, FLEXIBLE
- A. Insulation: ASTM C 553; flexible, noncombustible.
  1. 'Ksi' ('K') Value: 0.052 at 24 degrees C (0.36 at 75 degrees F), when tested in accordance with ASTM C 177 or ASTM C 518.
  2. Maximum Service Temperature: 121 degrees C (250 degrees F).
  3. Maximum Water Vapor Sorption: 5.0 percent by weight.
- B. Vapor Barrier Jacket: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
  1. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E 96/E 96M.
  2. Secure with self-sealing longitudinal laps and butt strips.

2.03 JACKETS
- A. PVC Plastic:
  1. Jacket: Sheet material, off-white color.
     - a. Minimum Service Temperature: -40 degrees C (-40 degrees F).
     - b. Maximum Service Temperature: 66 degrees C (150 degrees F).
     - c. Moisture Vapor Permeability: 0.04 perm inch (0.058 ng/Pa s m), when tested in accordance with ASTM E 96/E 96M.
     - d. Thickness: 0.25 mm (10 mil).
     - e. Connections: Brush on welding adhesive.
- B. Aluminum Jacket: ASTM B 209 (ASTM B 209M) formed aluminum sheet.

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1. Thickness: 0.64 mm (0.025 inch) sheet.
2. Finish: Embossed.
3. Joining: Longitudinal slip joints and 50 mm (2 inch) laps.
4. Metal Jacket Bands: 10 mm (3/8 inch) wide; 0.38 mm (0.015 inch) thick aluminum.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that equipment has been tested before applying insulation materials.
B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Factory Insulated Equipment: Do not insulate.
C. Exposed Equipment: Locate insulation and cover seams in least visible locations.
D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
F. Insulated equipment containing fluids below ambient temperature: Insulate entire system.
G. Fiber glass insulated equipment containing fluids below ambient temperature: Provide vapor barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapor barrier adhesive.
H. For hot equipment containing fluids over 60 degrees C (140 degrees F), insulate flanges and unions with removable sections and jackets.
I. Fiber glass insulated equipment containing fluids above ambient temperature: Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
J. Finish insulation at supports, protrusions, and interruptions.
K. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with PVC jacket and fitting covers.
L. Exterior Applications: Provide vapor barrier jacket or finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal equipment.
M. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
N. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

END OF SECTION

SECTION 22 0719
PLUMBING PIPING INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Piping insulation.
- B. Jackets and accessories.

1.02 RELATED REQUIREMENTS
- A. Section 22 1005 - Plumbing Piping: Placement of hangers and hanger inserts.

1.03 REFERENCE STANDARDS
- A. ASTM C 177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus; 2004.
- B. ASTM C 195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007.
- C. ASTM C 449/C 449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement; 2000.
- D. ASTM C 534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2007a.
- E. ASTM C 547 - Standard Specification for Mineral Fiber Pipe Insulation; 2007.
- F. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2008.
- G. ASTM E 96/E 96M - Standard Test Methods for Water Vapor Transmission of Materials; 2005.
- H. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association; 2006.
- I. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Underwriters Laboratories Inc.; 2003.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than 10 years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.07 FIELD CONDITIONS
- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.01 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION
- A. Surface Burning Characteristics: Flame spread/ Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.

2.02 GLASS FIBER
- A. Insulation: ASTM C 547; rigid molded, noncombustible.
  1. 'Ksi' ('K') value: ASTM C 177, 0.035 at 24 degrees C (0.24 at 75 degrees F).
  2. Maximum service temperature: 454 degrees C (850 degrees F).
  3. Maximum moisture absorption: 0.2 percent by volume.
- B. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E 96/E 96M of 0.029 ng/Pa s m (0.02 perm-inches).
- C. Vapor Barrier Lap Adhesive:
  1. Compatible with insulation.
- D. Insulating Cement/Mastic:
  1. ASTM C 195; hydraulic setting on mineral wool.
- E. Fibrous Glass Fabric:
  1. Cloth: Untreated; 305 g/sq m (9 oz/sq yd) weight.
  2. Blanket: 16 kg/cu m (1.0 lb/cu ft) density.
  3. Weave: 5x5.
- F. Indoor Vapor Barrier Finish:
  1. Cloth: Untreated; 305 g/sq m (9 oz/sq yd) weight.
  2. Vinyl emulsion type acrylic, compatible with insulation, black color.

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G. Outdoor Vapor Barrier Mastic:
   1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
H. Outdoor Breather Mastic:
   1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
I. Insulating Cement:
   1. ASTM C 449/C 449M.

2.03 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

A. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C 534 Grade 3; use molded tubular material wherever possible.
   1. Minimum Service Temperature: -40 degrees C (-40 degrees F).
   2. Maximum Service Temperature: 104 degrees C (220 degrees F).
   3. Connection: Waterproof vapor barrier adhesive.
B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.04 JACKETS

A. PVC Plastic.
   1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
      a. Minimum Service Temperature: -18 degrees C (0 degrees F).
      b. Maximum Service Temperature: 66 degrees C (150 degrees F).
      c. Moisture Vapor Permeability: 0.0029 ng/Pa s m (0.002 perm inch), maximum, when tested in accordance with ASTM E 96/E 96M.
      d. Thickness: 0.25 mm (10 mil).
      e. Connections: Brush on welding adhesive.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.
B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Install in accordance with NAIMA National Insulation Standards.
C. Exposed Piping: Locate insulation and cover seams in least visible locations.
D. Insulated pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
E. Glass fiber insulated pipes conveying fluids below ambient temperature:
   1. Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
   2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
F. Glass fiber insulated pipes conveying fluids above ambient temperature:
   1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
   2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
G. Inserts and Shields:
   1. Application: Piping 40 mm (1-1/2 inches) diameter or larger.
   2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
   3. Insert location: Between support shield and piping and under the finish jacket.
   4. Insert configuration: Minimum 150 mm (6 inches) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
   5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
H. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions.
I. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier

cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.03 SCHEDULES

A. Plumbing Systems:

1. Domestic Hot and Cold Water Supply:
   a. Glass Fiber Insulation:
      1) Pipe Size Range: All sizes.
      2) Thickness: 13 mm (1 inch).
2. Solar Heating System Piping:
   a. Glass Fiber Insulation:
      1) Interior locations only.
      2) Pipe Size Range: All sizes.
      3) Thickness: 25 mm (1 inch).
   b. Cellular Foam Insulation:
      1) Exterior locations.
      2) Pipe Size Range: All sizes.
      3) Thickness: 25 mm (1 inch).

END OF SECTION

SECTION 22 1005
PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Pipe, pipe fittings, valves, and connections for piping systems.

1.02 RELATED REQUIREMENTS
- A. Section 09 9000 - Painting and Coating.
- B. Section 22 0719 - Plumbing Piping Insulation.

1.03 REFERENCE STANDARDS
- A. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2005) (ANSI B16.18).
- B. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2005).
- C. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2004 (ANSI/ASME B31.9).
- D. ASTM B 32 - Standard Specification for Solder Metal; 2004.
- E. ASTM B 88 - Standard Specification for Seamless Copper Water Tube; 2003.
- F. ASTM B 88M - Standard Specification for Seamless Copper Water Tube (Metric); 2005.
- G. ASTM D 2855 - Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings; 1996 (Reapproved 2002).
- H. AWWA C651 - Disinfecting Water Mains; American Water Works Association; 2005 (ANSI/AWWA C651).
- I. MSS SP-80 - Bronze Gate, Globe, Angle and Check Valves; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.
- J. MSS SP-85 - Cast Iron Globe & Angle Valves, Flanged and Threaded Ends; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2002.
- K. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 1996.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- C. Project Record Documents: Record actual locations of valves.

1.05 QUALITY ASSURANCE
- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.06 REGULATORY REQUIREMENTS
- A. Perform Work in accordance with State of Minnesota plumbing code.
- B. Conform to applicable code for installation of backflow prevention devices.

1.07 DELIVERY, STORAGE, AND HANDLING
- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 SANITARY SEWER PIPING, ABOVE GRADE
- A. PVC or ABS Pipe, Schedule 40, conforming to Minnesota Plumbing Code.
  1. Joints, contrasting color primer and solvent cement per Minnesota Plumbing Code.

2.02 WATER PIPING, ABOVE GRADE
- A. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), Drawn (H).
  1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
  2. Joints: ASTM B 32, alloy Sn95 solder or grooved mechanical couplings.
- B. Crosslinked Polyethylene pipe with compatible fitting.
  1. Compression ring fittings, IAMPO approved.

2.03 PIPE HANGERS AND SUPPORTS
- A. Plumbing Piping - Drain, Waste, and Vent:
  1. Conform to ASME B31.9.
  2. PVC "hook" hangers, specifically made compatible with PVC pipe; allow 360 degree swivel for alignment of pipe regardless of hanger

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orientation.
3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

B. Plumbing Piping - Water:
1. Conform to ASME B31.9.
2. Insulated "staples" specifically compatible with flexible PEX tubing.

2.04 BALL VALVES

A. Construction, 100 mm (4 Inches) and Smaller: MSS SP-110, Class 150, 2760 kPa (400 psi) CWP, bronze, two piece body, chrome plated brass ball, regular port, teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, threaded ends.

2.05 SPRING LOADED CHECK VALVES

A. Class 125, iron body, bronze trim, stainless steel springs, bronze disc, Buna N seals, wafer style ends.

2.06 WATER PRESSURE REDUCING VALVES

A. Up to 50 mm (2 Inches):
1. MSS SP-80, bronze body, stainless steel and thermoplastic internal parts, fabric reinforced diaphragm, strainer, threaded single union ends.

B. Over 50 mm (2 Inches):
1. MSS SP-85, cast iron body, bronze fitted, elastomeric diaphragm and seat disc, flanged.

2.07 STRAINERS

A. Size 50 mm (2 inch) and Under:
1. Threaded brass body for 1200 kPa (175 psi) CWP, Y pattern with 0.8 mm (1/32 inch) stainless steel perforated screen.
2. Class 150, threaded bronze body 2070 kPa (300 psi) CWP, Y pattern with 0.8 mm (1/32 inch) stainless steel perforated screen.

B. Size 40 mm (1-1/2 inch) to 100 mm (4 inch):
1. Class 125, flanged iron body, Y pattern with 1.6 mm (1/16 inch) stainless steel perforated screen.

PART 3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

C. Route piping in orderly manner and maintain gradient.

D. Install piping to maintain headroom, conserve space, and not interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 0719.

H. Provide access where valves and fittings are not exposed.

I. Install vent piping penetrating roofed areas to maintain integrity of roof assembly; refer to Section 07 5300.

J. Install bell and spigot pipe with bell end upstream.

K. Install valves with stems upright or horizontal, not inverted.

L. Install water piping to ASME B31.9 and the Minnesota State Plumbing Code.

M. PVC Pipe: Make solvent-welded joints in accordance with ASTM D 2855.

N. Pipe Hangers and Supports:
1. Install in accordance with ASME B31.9.
2. Support horizontal piping as required by Minnesota State Plumbing Code.
3. Install hangers to provide minimum 15 mm (1/2 inch) space between finished covering and adjacent work.
4. Place hangers within 300 mm (12 inches) of each horizontal elbow.
5. Use hangers with 40 mm (1-1/2 inch) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
6. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
8. Provide copper plated hangers and supports for copper piping.

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9. Provide hangers adjacent to motor driven equipment with vibration isolation.

3.03 APPLICATION

A. Install unions downstream of valves and at equipment or apparatus connections.

B. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.

C. Install ball valves for throttling, bypass, or manual flow control services.

3.04 TOLERANCES

A. Drainage Piping: Establish invert elevations within 10 mm (1/2 inch) vertically of location indicated and slope to drain at minimum of 1:100 (1/8 inch per foot) slope.

B. Water Piping: Slope at minimum of 1:400 (1/32 inch per foot) and arrange to drain at low points.

3.05 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Prior to starting work, verify system is complete, flushed and clean.

B. Ensure Ph of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).

C. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.

D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.

E. Maintain disinfectant in system for 24 hours.

F. If final disinfectant residual tests less than 25 mg/L, repeat treatment.

G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.

H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

END OF SECTION

SECTION 22 1006
PLUMBING PIPING SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Cleanouts.
- B. Hose bibbs.
- C. Hydrants.
- D. Backflow preventers.
- E. Thermostatic mixing valves.

1.02 RELATED REQUIREMENTS
- A. Section 22 1005 - Plumbing Piping.
- B. Section 22 4000 - Plumbing Fixtures.

1.03 REFERENCE STANDARDS
- A. ASSE 1011 - Hose Connection Vacuum Breakers; American Society of Sanitary Engineering; 2004 (ANSI/ASSE 1011).
- B. ASSE 1019 - Vacuum Breaker Wall Hydrants, Freeze Resistant Automatic Draining Type; American Society of Sanitary Engineering; 2004, and Errata 2005 (ANSI/ASSE 1019).

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- C. Project Record Documents: Record actual locations of equipment, cleanouts, and backflow preventers.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than 10 years experience.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Accept specialties on site in original factory packaging. Inspect for damage.

PART 2 PRODUCTS

2.01 CLEANOUTS
- A. Cleanouts at Interior Finished Wall Areas:
  1. Line type with PVC body and threaded plug, and round stainless steel access cover secured with machine screw.
- B. Cleanouts at Interior Unfinished Accessible Areas: Line type with PVC body and threaded plug

2.02 HOSE BIBBS
- A. Interior Hose Bibbs:
  1. Bronze or brass with integral mounting flange, replaceable hexagonal disc, hose thread spout, with handwheel, integral vacuum breaker in conformance with ASSE 1011.

2.03 HYDRANTS
- A. Wall Hydrants:
  1. ASSE 1019; freeze resistant, self-draining type with chrome plated wall plate hose thread spout, handwheel, and integral vacuum breaker.

2.04 WASHING MACHINE BOXES AND VALVES
- A. Description: Plastic preformed rough-in box with brass long shank valves with wheel handles, socket for 50 mm (2 inch) waste, slip in finishing cover.

2.05 BACKFLOW PREVENTERS
- A. Reduced Pressure Backflow Preventers:
  1. ASSE 1013; bronze body with bronze internal parts and stainless steel springs; two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve that opens under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.

2.06 MIXING VALVES
- A. Thermostatic Mixing Valves:
  1. Valve: Chrome plated cast brass body, stainless steel or copper alloy bellows, integral temperature adjustment.
  2. Accessories:
     - a. Volume control shut-off valve on outlet.
     - b. Stem thermometer on outlet.
     - c. Strainer stop checks on inlets.

PART 3 EXECUTION

3.01 INSTALLATION
- A. Install in accordance with manufacturer's instructions.
- B. Extend cleanouts to finished wall surface. Lubricate threaded cleanout plugs with Teflon tape. Ensure clearance at cleanout for rodding of drainage system.
- C. Install approved portable water protection devices on plumbing lines where contamination of domestic water may occur; on solar heating water feed water lines, premise isolation, irrigation systems, interior and exterior hose bibbs or wall hydrants.

END OF SECTION

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SECTION 22 3313
INSTANTANEOUS ELECTRIC DOMESTIC WATER HEATERS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. In-line tankless electric domestic water heaters.
- B. Connection to utilities.
- C. Service fittings and outlets.

1.02 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide equipment dimensions and construction, equipment capacities, physical dimensions, utility and service requirements and locations, and point loads.
- C. Manufacturer's Installation Instructions: Indicate special installation requirements.
- D. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.03 QUALITY ASSURANCE
- A. Manufacturer: Company specializing in manufacturing the types of products specified in this section, with minimum 10 years of experience.

1.04 REGULATORY REQUIREMENTS
- A. Conform to applicable code for plumbing equipment.
- B. Conform to UL requirements for fabrication and installation of electrically powered equipment.

1.05 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide 3 year manufacturer warranty for defects in workmanship and material including delivery of heated water.

PART 2 PRODUCTS

2.01 MANUFACTURERS
- A. Water Heaters: As indicated on drawings.

2.02 COMPONENTS
- A. Equipment: Compact design, tankless, instantaneous water heater; filter incoming water supply, maintain consistent heated water temperature output with microprocessor control, digital thermometer and control allowing user to set temperature desired.
  1. Power: 240 V, single phase.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify that rough-in piping and electric supply are accurately placed.

3.02 INSTALLATION
- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with standards required by authority having jurisdiction.
- C. Anchor equipment securely in place; provide supplemental mounting backboard, brackets, or accessories as needed to provide solid, secure mounting.
- D. Sequence installation to ensure utility connections are achieved in an orderly and expeditious manner.
- E. Touch-up minor damaged surfaces caused during installation. Replace damaged components as directed by Architect.

3.03 INTERFACE WITH OTHER PRODUCTS
- A. Coordinate installation of domestic water and hydronic in-floor heating systems with water heater installation.

3.04 ADJUSTING
- A. Adjust operating equipment to efficient operation.

3.05 CLOSEOUT ACTIVITIES
- A. Demonstrate equipment operation and maintenance requirements.

END OF SECTION

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SECTION 22 4000
PLUMBING FIXTURES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Water closets.
- B. Lavatories.
- C. Sinks.
- D. Showers.
- E. Towel warmer.

1.02 RELATED REQUIREMENTS
- A. Section 07 9005 - Joint Sealers: Seal fixtures to walls and floors.
- B. Section 22 1005 - Plumbing Piping.
- C. Section 22 1006 - Plumbing Piping Specialties.

1.03 REFERENCE STANDARDS
- A. ASME A112.18.1 - Plumbing Supply Fittings; The American Society of Mechanical Engineers; 2005.
- B. ASME A112.19.2 - Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals; The American Society of Mechanical Engineers; 2003.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- C. Maintenance Data: Include fixture trim exploded view and replacement parts lists.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum 10 years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Accept fixtures on site in factory packaging. Inspect for damage.
- B. Protect installed fixtures from damage.

PART 2 PRODUCTS

2.01 TANK TYPE WATER CLOSETS
- A. Water Closet Manufacturers:
  1. Toto USA, Inc; Model MS853113E; www.totousa.com.
- B. Bowl:
  1. ASME A112.19.2; high profile, one piece, low consumption (1.28Gpf/4.8Lpf), floor mounted, siphon jet, vitreous china, 420 mm (16.5 inches) high, with round rim, vitreous china closet tank with fittings and lever flushing valve, bolt caps.
- C. Seat Manufacturers:
  1. Toto USA, Inc; Model SS113 (Centoco); www.totousa.com.
- D. Seat:
  1. Solid white plastic, closed front, soft close, brass bolts, with cover.

2.02 LAVATORIES
- A. Manufacturers:
  1. Toto USA, Inc; Model LF930MCP (LLOYD Metal Console Lavatory); www.totousa.com.
- B. Metal Console with Vitreous China Basin:
  1. ASME A112.19.2; vitreous china exposed sides lavatory complete with mounting hardware, 28 inches wide (nominal) with single hole drilling, rear overflow. Metal console of tubular steel open construction, height adjustable leveling legs, factory finished.
- C. Sensor Operated Faucet: Cast brass, chrome plated, deck mounted with sensor located on neck of spout.
  1. Spout Style: Standard, contemporary style.
  2. Power Supply: Self-generating, hydro-powered turbine charge with backup battery supply.
  3. Mixing Valve: None, single line for tempered water.
  4. Water Supply: 13 mm (1/2 inch) male threaded connections.
  5. Aerator: Vandal resistant, 1.89 LPM (0.5 GPM), laminar flow device.
  6. Automatic Shut-off: 30 seconds.
  7. Sensor range: Factory set at a minimum of 76 mm (3 inch) adjustable up to 610 mm (24 inch).
  8. Finish: Polished chrome.
  9. Sensor Operated Faucet Manufacturers:
     a. Toto USA; Model TEL3GKCN-10: www.totousa.com.
- D. Accessories:
  1. Chrome plated 1.3 mm (17 gage) brass P-trap with clean-out plug and arm with escutcheon.
  2. Waste with perforated open strainer.
  3. Flexible supplies.

2.03 SINKS
- A. Manufacturers:

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1. Blanco; Model 513-829: www.blancoamerica.com.

B. Double Compartment Bowl:

1. ASME A112.19.3; 1-1/2 Prep Sink, 555 x 460 x 190 mm (21-7/8 x 18-1/8 x 7-1/2 inch) outside dimensions 7.1 mm (1/4 inch) thick, SILGRANITE (80 percent rock hard granite), undermount bowl with mounting hardware.
   a. Drains: 90 mm (3-1/2 inch) crumb cup and tailpiece.

C. Trim: ASME A112.18.1; chrome plated brass supply with high rise swing spout, vandal proof water economy aerator with maximum 0.14 L/s (2.2 gpm) flow, single lever handle.

1. Manufacturer: Provide KWC ONO series as scheduled on drawings.

D. Accessories: Chrome plated 1.3 mm (17 gage) brass P-trap and arm with escutcheon, wheel handle stop, flexible supplies.

2.04 SHOWERS

A. Base:

1. Terrazzo receptor with shoulder not less than 2-1/2 inch high, inside. Cast flange integral, of galvanized-bonderized steel and extend not less than one inch above shoulder on four sides for installation.
2. Manufacture receptor of tan and white marble chips cast in white Portland cement to produce a compressive strength of not less than 3,000 PSI, seven days after casting. Grind and polish terrazzo surface, and seal the entire unit to resist stains and moisture after any air holes and/or pits are grouted.
3. Reinforce receptor with 16 gauge wire.
4. Drain Body: Cast integral, and provide for a non-caulked connection not less than one inch deep to a two inch pipe. Provide removable type stainless steel strainer plate.
5. Manufacturer: Florestone Products Company, Inc; Model 100: www.florestone.com.

B. Trim:

1. ASME A112.18.1; concealed shower supply with pressure balanced mixing valves, integral service stops, single lever user control, polished chrome finish; provide Toto USA Model TSPTR with TS930#CP trim: www.totousa.com.

C. Shower Head:

1. ASME A112.18.1; chrome plated square head, 8 inch size, with integral wall bracket and escutcheon, built-in 0.16 L/s (2.5 gpm) flow control, polished chrome finish; provide Toto USA Model TS930A1: www.totousa.com.

2.05 TOWEL WARMER

A. Hydronic Towel Warmer: Myson, Inc: www.mysoninc.com Model Saxby B34-1, chrome finish.

1. One inch tubing, 27 x 27 inch overall size, 5-3/8 inch projection from wall.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
B. Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks.

3.02 PREPARATION

A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.03 INSTALLATION

A. Install all products in accordance with manufacturers' instructions.
B. Install each fixture with trap, easily removable for servicing and cleaning.
C. Provide chrome plated rigid or flexible supplies to fixtures with wheel-type stops, reducers, and escutcheons.
D. Install components level and plumb.
E. Secure fixtures in place.
F. Seal fixtures to wall and floor surfaces with sealant as specified in Section 07 9005, color to match fixture.

3.04 INTERFACE WITH WORK OF OTHER SECTIONS

A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.05 ADJUSTING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.06 CLEANING

A. Clean plumbing fixtures and equipment.

3.07 PROTECTION

A. Protect installed products from damage due to subsequent construction operations.
B. Do not permit use of fixtures by construction personnel.

C. Repair or replace damaged products before Date of Substantial Completion.

END OF SECTION

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SECTION 23 0713
DUCT INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Duct insulation.
- B. Duct Liner.

1.02 REFERENCE STANDARDS
- A. ASTM C 518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2004.
- B. ASTM C 553 - Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2002.
- C. ASTM C 612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2004.
- D. ASTM C 1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2005.
- E. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2008.
- F. SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.03 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.04 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than 10 years of experience.

1.05 DELIVERY, STORAGE, AND HANDLING
- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.06 FIELD CONDITIONS
- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION
- A. Surface Burning Characteristics: Flame spread/ Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.

2.02 GLASS FIBER, FLEXIBLE
- A. Insulation: ASTM C 553; flexible, noncombustible blanket.
  1. 'Ksi' ('K') value: 0.052 at 24 degrees C (0.36 at 75 degrees F), when tested in accordance with ASTM C 518.
  2. Maximum Service Temperature: 232 degrees C (450 degrees F).
  3. Maximum Water Vapor Sorption: 5.0 percent by weight.
- B. Vapor Barrier Jacket:
  1. Kraft paper with glass fiber yarn and bonded to aluminized film.
  2. Secure with pressure sensitive tape.
- C. Vapor Barrier Tape:
  1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

2.03 GLASS FIBER, RIGID
- A. Insulation: ASTM C 612; rigid, noncombustible blanket.
  1. 'Ksi' ('K') value: 0.036 at 24 degrees C (0.24 at 75 degrees F), when tested in accordance with ASTM C 518.
  2. Maximum service temperature: 232 degrees C (450 degrees F).
  3. Maximum Water Vapor Sorption: 5.0 percent.
- B. Vapor Barrier Jacket:
  1. Kraft paper with glass fiber yarn and bonded to aluminized film.
  2. Secure with pressure sensitive tape.
- C. Vapor Barrier Tape:
  1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

2.04 DUCT LINER
- A. Insulation: Incombustible glass fiber complying with

ASTM C 1071; rigid board and preformed round liner board; impregnated surface and edges coated with poly vinyl acetate polymer.

1. Apparent Thermal Conductivity: Maximum of 0.045 at 24 degrees C (0.31 at 75 degrees F).
2. Service Temperature: Up to 121 degrees C (250 degrees F).
3. Rated Velocity on Coated Air Side for Air Erosion: 25.4 m/s (5,000 fpm), minimum.
4. 13 mm (1/2 inch) Thickness: 0.30.

B. Adhesive: Waterproof, fire-retardant type.

C. Liner Fasteners: Galvanized steel, self-adhesive pad with integral head.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that ducts have been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Insulated ducts conveying air below ambient temperature:

1. Provide insulation with vapor barrier jackets.
2. Finish with tape and vapor barrier jacket.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
4. Insulate entire system including fittings, joints, flanges, flexible connections, and expansion joints.

D. Insulated ducts conveying air above ambient temperature:

1. Provide with or without standard vapor barrier jacket.
2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

E. Duct and Plenum Liner Application:

1. Adhere insulation with adhesive for 90 percent coverage.
2. Secure insulation with mechanical liner fasteners. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for spacing.
3. Seal and smooth joints. Seal and coat transverse joints.
4. Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

3.03 SCHEDULES

A. Exhaust Ducts Within 3 m (10 ft) of Exterior Openings: Flexible glass fiber duct insulation, 50 mm (2 inches) thick.

B. Exhaust Ducts Exposed to Outdoor Air: Rigid glass fiber duct insulation, 50 mm (2 inches) thick.

C. Outside Air Intake Ducts: Flexible glass fiber duct insulation, 50 mm (2 inches) thick.

D. Return and Relief Ducts in Mechanical Rooms: Rigid glass fiber duct liner.

END OF SECTION

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SECTION 23 2113
HYDRONIC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Pipe and pipe fittings for:
  1. Heating water piping system.
  2. Glycol water piping system.
- B. Valves:

1.02 RELATED REQUIREMENTS
- A. Section 22 0719 - Plumbing Piping Insulation.
- B. Section 22 0516 - Expansion Fittings and Loops for Plumbing Piping.
- C. Section 23 5613.13 - Heating Solar Flat-Plate Collectors.
- D. Section 23 8316 - Radiant-Heating Hydronic Piping: In-floor heating system.

1.03 REFERENCE STANDARDS
- A. ASME B16.3 - Malleable Iron Threaded Fittings; The American Society of Mechanical Engineers; 1998 (R2006).
- B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2005) (ANSI B16.18).
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2005).
- D. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2004 (ANSI/ASME B31.9).
- E. ASTM A 53/A 53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2007.
- F. ASTM A 234/A 234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2007.
- G. ASTM B 32 - Standard Specification for Solder Metal; 2004.
- H. ASTM B 88 - Standard Specification for Seamless Copper Water Tube; 2003.
- I. ASTM B 88M - Standard Specification for Seamless Copper Water Tube (Metric); 2005.
- J. ASTM F 876 - Standard Specification for Crosslinked Polyethylene (PEX) Tubing; 2007.
- K. ASTM F 877 - Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems; 2007.
- L. AWS A5.8/A5.8M - Specification for Filler Metals for Brazing and Braze Welding; American Welding Society; 2004 and errata.
- M. AWS D1.1/D1.1M - Structural Welding Code - Steel; American Welding Society; 2006 and Errata.

1.04 SYSTEM DESCRIPTION
- A. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- B. Use grooved mechanical couplings and fasteners in accessible locations only.
- C. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- D. Use non-conducting dielectric connections whenever jointing dissimilar metals.
- E. Provide pipe hangers and supports in accordance with ASME B31.9 unless indicated otherwise.
- F. Use ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- C. Project Record Documents: Record actual locations of valves.

1.06 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum 10 years of experience.

1.07 REGULATORY REQUIREMENTS
- A. Conform to ASME B31.9 code for installation of piping system.

1.08 DELIVERY, STORAGE, AND HANDLING
- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary protective coating on cast iron

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and steel valves.

C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 HEATING WATER AND GLYCOL PIPING, ABOVE GROUND

A. Steel Pipe: ASTM A 53/A 53M, Schedule 40, black.
   1. Fittings: ASTM B 16.3, malleable iron or ASTM A 234/A 234M, wrought steel welding type fittings.
   2. Joints: Threaded, or AWS D1.1 welded.

B. Copper Tube: ASTM B 88 (ASTM B 88M), Type K (A), drawn.
   1. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
   2. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.
   3. Joints: Solder, lead free, 95-5 tin-antimony, or tin and silver.

2.02 RADIANT HEATING PIPING

A. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B) annealed.
   1. Fittings: ASME B16.22, wrought copper.
   2. Joints: Solder, lead free, ASTM B 32, HB alloy (95-5 tin-antimony), or tin and silver.

B. Polyethylene Pipe: ASTM F 876 or ASTM F 877, cross-linked polyethylene, 690 kPa (100 psig) operating pressure at 82 degrees C (180 degrees F).
   1. Joints: Mechanical compression fittings.

2.03 PIPE HANGERS AND SUPPORTS

A. Conform to ASME B31.9.

B. Hangers for Pipe Sizes 13 to 38 mm (1/2 to 1-1/2 Inch): Malleable iron, adjustable swivel, split ring.

C. Hangers for Hot Pipe Sizes 50 to 100 mm (2 to 4 Inches): Carbon steel, adjustable, clevis.

D. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

E. Vertical Support: Steel riser clamp.

F. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

G. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

2.04 UNIONS, FLANGES, AND COUPLINGS

A. Unions for Pipe 50 mm (2 Inches) and Under:
   1. Ferrous Piping: 1034 kPa (150 psig) malleable iron, threaded.
   2. Copper Pipe: Bronze, soldered joints.

B. Flanges for Pipe Over 50 mm (2 Inches):
   1. Ferrous Piping: 1034 kPa (150 psig) forged steel, slip-on.
   2. Copper Piping: Bronze.
   3. Gaskets: 1.6 mm (1/16 inch) thick preformed neoprene.

C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.05 BALL VALVES

A. Up To and Including 50 mm (2 Inches):
   1. Bronze one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder or threaded ends to suit pipe style served.

B. Over 50 mm (2 Inches):
   1. Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, flanged.

2.06 SPRING LOADED CHECK VALVES

A. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer or threaded lug ends.

2.07 FLOW CONTROLS

A. Construction: Class 125, Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.

B. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 24 kPa kPa (3.5 psi psi).

PART 3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

E. After completion, fill, clean, and treat systems.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install heating water and glycol piping to ASME B31.9 requirements.
C. Route piping in orderly manner, parallel to building structure, and maintain gradient.
D. Install piping to conserve building space and to avoid interfere with use of space.
E. Group piping whenever practical at common elevations.
F. Slope piping and arrange to drain at low points.
G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
H. Pipe Hangers and Supports:
   1. Install in accordance with ASME B31.9.
   2. Install hangers to provide minimum 13 mm (1/2 inch) space between finished covering and adjacent work.
   3. Place hangers within 300 mm (12 inches) of each horizontal elbow.
   4. Use hangers with 38 mm (1-1/2 inch) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
   5. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
   6. Provide copper plated hangers and supports for copper piping.
I. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 0719.
J. Provide access where valves and fittings are not exposed.
K. Use eccentric reducers to maintain top of pipe level.
L. Install valves with stems upright or horizontal, not inverted.

END OF SECTION

SECTION 23 2114
HYDRONIC SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Expansion tanks.
- B. Air vents.
- C. Strainers.
- D. Flow indicators, controls, meters.
- E. Relief valves.
- F. Glycol specialties.

1.02 RELATED REQUIREMENTS
- A. Section 23 2113 - Hydronic Piping.

1.03 REFERENCE STANDARDS
- A. ASME (BPV VIII, 1) - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers; 2007.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
- C. Project Record Documents: Record actual locations of flow controls.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum 10 years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 DIAPHRAGM-TYPE EXPANSION TANKS
- A. Construction: Welded stainless steel, tested and stamped in accordance with ASME (BPV VIII, 1); supplied with National Board Form U-1, rated for working pressure of 860 kPa (125 psi), with flexible EPDM diaphragm sealed into tank, and steel support stand.
- B. Accessories: Pressure gage and air-charging fitting, tank drain; precharge to 80 kPa (12 psi).
- C. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.

2.02 AIR VENTS
- A. Float Type:
  1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

2.03 STRAINERS
- A. Size 50 mm (2 inch) and Under:
  1. Screwed brass or iron body for 1200 kPa (175 psi) working pressure, Y pattern with 0.8 mm (1/32 inch) stainless steel perforated screen.
- B. Size 65 mm (2-1/2 inch) to 100 mm (4 inch):
  1. Flanged iron body for 1200 kPa (175 psi) working pressure, Y pattern with 1.2 mm (3/64 inch) stainless steel perforated screen.

2.04 FLOW CONTROLS
- A. Construction: Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet with blowdown/backflush drain.
- B. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 24 kPa (3.5 psi).
- C. Control Mechanism: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring.
- D. Accessories: In-line strainer on inlet and ball valve on outlet.

2.05 RELIEF VALVES
- A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

2.06 GLYCOL SYSTEM
- A. Storage Tank: Closed type, welded steel constructed, tested and stamped in accordance with ASME (BPV VIII, 1); 690 kPa (100 psi) rating; cleaned, prime coated, and supplied with steel support saddles. Construct with tappings for installation of

accessories.

B. Expansion Tank: Diaphragm type with vent fitting with air separator, and automatic air vent.

C. Air Pressure Reducing Station: Pressure reducing valve with shut-off valves, strainer, check valve and needle valve bypass.

D. Glycol Solution:

1. Inhibited ethylene glycol and water solution mixed 50 percent glycol - 50 percent water, suitable for operating temperatures from -40 degrees C (-40 degrees F) to 121 degrees C (250 degrees F).

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Where large air quantities can accumulate, provide enlarged air collection standpipes.

C. Provide manual air vents at system high points and as indicated.

D. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.

E. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

F. Clean and flush glycol system before adding glycol solution.

G. Feed glycol solution to system through make-up line with pressure regulator, venting system high points.

END OF SECTION

SECTION 23 2123
HYDRONIC PUMPS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. In-line circulators.

1.02 RELATED REQUIREMENTS
- A. Section 22 0719 - Plumbing Piping Insulation.
- B. Section 22 0716 - Plumbing Equipment Insulation.
- C. Section 23 2113 - Hydronic Piping.
- D. Section 23 2114 - Hydronic Specialties.
- E. Section 26 2717 - Equipment Wiring: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS
- A. UL 778 - Standard for Motor-Operated Water Pumps; Underwriters Laboratories Inc.; 2002.

1.04 PERFORMANCE REQUIREMENTS
- A. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.

1.06 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacture, assembly, and field performance of pumps, with minimum 10 years of experience.

1.07 REGULATORY REQUIREMENTS
- A. Products Requiring Electrical Connection: Listed and classified by UL 778 as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 SYSTEM LUBRICATED CIRCULATORS
- A. Type: Horizontal shaft, single stage, direct connected with multiple speed wet rotor motor for in-line mounting, for 965 kPa (140 psi) maximum working pressure, 110 degrees C (230 degrees F) maximum water temperature.
- B. Casing: Cast iron with flanged pump connections.
- C. Impeller, Shaft, Rotor: Stainless Steel.
- D. Bearings: Metal Impregnated carbon (graphite) and ceramic.
- E. Motor: Impedance protected, multiple speed, with external speed selector.

PART 3 EXECUTION

3.01 PREPARATION
- A. Verify that electric power is available and of the correct characteristics.

3.02 INSTALLATION
- A. Install in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than minimum space recommended by manufacturer.
- C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 102 mm (4 inches) and over.
- D. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
- E. Provide air cock and drain connection on horizontal pump casings.
- F. Lubricate pumps before start-up.

END OF SECTION

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SECTION 23 3100
HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Metal ductwork.
- B. Duct cleaning.

1.02 RELATED REQUIREMENTS
- A. Section 23 0713 - Duct Insulation: External insulation and duct liner.
- B. Section 23 3700 - Air Outlets and Inlets.

1.03 REFERENCE STANDARDS
- A. ASTM A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2007.
- B. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems; National Fire Protection Association; 2006.
- C. SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.04 PERFORMANCE REQUIREMENTS
- A. No variation of duct configuration or sizes permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.05 REGULATORY REQUIREMENTS
- A. Construct ductwork to NFPA 90B standards.

1.06 FIELD CONDITIONS
- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 PRODUCTS

2.01 MATERIALS
- A. Galvanized Steel Ducts: Hot-dipped galvanized steel sheet, ASTM A 653/A 653M FS Type B, with G60/Z180 coating.
- B. Insulated Flexible Ducts:
  1. UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound spring steel wire; fiberglass insulation; polyethylene vapor barrier film.
     - a. Pressure Rating: 2.50 kPa (10 inches WG) positive and 250 Pa (1.0 inches WG) negative.
     - b. Maximum Velocity: 20.3 m/sec (4000 fpm).
     - c. Temperature Range: -28 degrees C to 99 degrees C (-20 degrees F to 210 degrees F).

2.02 DUCTWORK FABRICATION
- A. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
- C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

2.03 MANUFACTURED METAL DUCTWORK AND FITTINGS
- A. Manufacture in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gages,reinforcing, and sealing for operating pressures indicated.

PART 3 EXECUTION

3.01 INSTALLATION
- A. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- B. Install and seal metal and flexible ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- C. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

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D. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
E. Use crimp joints with or without bead for joining round duct sizes 200 mm (8 inch) and smaller with crimp in direction of air flow.
F. Use double nuts and lock washers on threaded rod supports.
G. Connect terminal units to supply ducts directly or with 300 mm (one foot) maximum length of flexible duct. Do not use flexible duct to change direction.
H. Connect flexible ducts to metal ducts with draw bands.
I. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
J. At exterior wall louvers, seal duct to louver frame and install blank-out panels.

3.02 CLEANING

A. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment that could be harmed by excessive dirt with temporary filters, or bypass during cleaning.

3.03 SCHEDULES

A. Ductwork Material:
   1. Low Pressure Supply: Galvanized steel and insulated flexible duct.
   2. Return and Relief: Galvanized steel.
   3. General Exhaust: Galvanized steel.
   4. Outside Air Intake: Galvanized steel.
B. Ductwork Pressure Class:
   1. Supply: 500 Pa (2 inch).
   2. Return and Relief: 250 Pa (1 inch).
   3. General Exhaust: 250 Pa (1 inch).
   4. Outside Air Intake: 500 Pa (2 inch).

END OF SECTION

SECTION 23 3700
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Registers/grilles.

1.02 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittal procedures.

B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum 10 years of experience.

PART 2 PRODUCTS

2.01 WALL AND CEILING SUPPLY REGISTERS/ GRILLES

A. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille with one-way deflection.

B. Frame: 32 mm (1-1/4 inch) margin with countersunk screw mounting and gasket.

C. Fabrication: Aluminum extrusions with factory off-white enamel finish.

D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.02 WALL AND CEILING EXHAUST AND RETURN REGISTERS/GRILLES

A. Type: Streamlined blades, 19 mm (3/4 inch) minimum depth, 19 mm (3/4 inch) maximum spacing, with spring or other device to set blades, vertical face.

B. Frame: 32 mm (1-1/4 inch) margin with countersunk screw mounting.

C. Fabrication: Steel frames and blades, with factory off-white enamel finish, color to be selected.

D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.03 LINEAR FLOOR SUPPLY REGISTERS/GRILLES

A. Type: Streamlined blades with 0 degree deflection, 3 x 19 mm (1/8 x 3/4 inch) on 6 mm (1/4 inch) centers, assembled on expanded tubes mandrel construction.

B. Frame: 32 mm (1-1/4 inch) heavy margin frame with countersunk screw mounting, and mounting frame.

C. Fabrication: Aluminum extrusions with factory clear lacquer finish.

D. Damper: Integral gang-operated opposed blade damper with removable key operator, operable from face.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

C. Install diffusers to ductwork with air tight connection.

D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers.

3.02 SCHEDULES

3.03 AIR OUTLET AND INLET SCHEDULE - ON DRAWINGS

END OF SECTION

SECTION 23 5613.13
HEATING SOLAR FLAT-PLATE COLLECTORS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Solar Collectors.
- B. Pipe and pipe fittings.
- C. Valves.
- D. Pumps.

1.02 RELATED REQUIREMENTS
- A. Section 23 3100 - HVAC Ducts and Casings.
- B. Section 23 8316 - Radiant-Heating Hydronic Piping: Under-floor radiant heating system.
- C. Section 26 2717 - Equipment Wiring.

1.03 REFERENCE STANDARDS
- A. ASME (BPV VIII, 1) - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers; 2007.
- B. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2004 (ANSI/ASME B31.9).
- C. ASTM B 88 - Standard Specification for Seamless Copper Water Tube; 2003.
- D. ASTM B 88M - Standard Specification for Seamless Copper Water Tube (Metric); 2005.

1.04 SUBMITTALS
- A. Shop Drawings: Provide for manufactured assemblies. Indicate system and controls schematics. Indicate solar collector installation, layout, weights, mounting and support details, and piping connections.
- B. Product Data: Provide data on specialties, including manufacturers' catalog information. Indicate chemical treatment materials, chemicals, and equipment. Submit certified pump performance and NPSH curve. Submit performance ratings for solar collectors, rough-in details, weights, support requirements, and piping connections.
- C. Operation and Maintenance Instructions: Include installation instruction, spare parts lists, procedures, and treatment programs.

1.05 QUALITY ASSURANCE
- A. Conform to ASME B31.9.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Deliver and store solar collectors in shipping containers and maintain in place until installation. Provide caps on piping connections.
- B. Deliver and store valves in shipping containers with labelling in place.

PART 2 PRODUCTS

2.01 SOLAR COLLECTORS
- A. Construction: Unit consisting of manufacturer's standard assembly of frame, cover, back cover with insulation, absorber plate assembly, and accessories.
- B. Efficiency: 78.4 percent.
- C. Frame:
  1. Aluminum: Extrusion shapes including I-beam, top battens, double battens, strips, channels, or angles, silver anodized finish, assembled with stainless steel screws with self sealing neoprene washers.
- D. Cover: Low-iron, high transparency tempered glass, 4 mm (0.16 inch) thick.
  1. Solar energy transmittance: 91 percent at 0 degree angle of incidence.
  2. Nominal size: 2152 x 1252 mm (84.7 x 49.3 inches).
- E. Back Cover: Galvanized steel with 20 mm (0.79 Inch) thick rigid mineral wool insulation.
- F. Plate and Tube Assembly: Copper sheet bonded to copper tubes.
  1. Tubes: 12 mm (1/2 inch) diameter, copper.
  2. Sheet: 0.081 to 0.089 mm (0.0032 to 0.0035 inch) thick copper alloy sheet.
  3. Working Pressure: 3.2 bar (46.4 psi).
  4. Pressure Drop (0.66 gal./min. solar fluid): 75.0 mbar (1.1 psi).
  5. Area: 2.67 sq m (28.7 sq ft).

2.02 DIFFERENTIAL CONTROLLERS
- A. Description: Solid state differential temperature thermostat with two low resistance thermistors and SPDT relay contactor, and field adjustable differential.
- B. Functions:
  1. Standard: When collector outlet temperature exceeds storage temperature, close contacts.
  2. Ambient Override: When collector temperature

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is less than 26 degrees C (80 degrees F), open contacts.

3. Freeze Recirculation: When collector temperature drops below 5.5 degrees C (42 degrees F), close contacts and open at 11 degrees C (52 degrees F).
4. High Limit Off: When storage temperature rises above 71 degrees C (160 degrees F), open contacts.

2.03 THERMOSTATS

A. Electric Thermostat: Low voltage type with setback/setup temperature control for cooling and heating.

2.04 PIPING

A. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), drawn.
   1. Fittings: Cast brass or wrought copper.
   2. Joints: Grade 95TA solder joints.

2.05 VALVES

A. Ball Valves Up to 50 mm (2 Inches): Bronze or stainless steel one piece body, stainless steel ball, teflon seats and stuffing box ring, lever handle, solder or threaded ends.

2.06 DIAPHRAGM-TYPE COMPRESSION TANKS

A. Construction: Welded steel, tested and stamped in accordance with ASME (BPV VIII,1); rated for working pressure of 860 kPa (125 psi), with flexible diaphragm sealed into tank, and steel legs or saddles.

2.07 PIPING SPECIALTIES

A. Manual Air Vents: Short vertical sections of 50 mm (2 inch) diameter pipe to form air chamber, with 3 mm (1/8 inch) brass needle valve at top of chamber.
B. Float Type Air Vents: Brass or semi-steel body, copper float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
C. Control Valves: Angle or straight pattern, rising stem, globe valve for 860 kPa (125 psi) working pressure, with bronze body and integral union for screwed connections, renewable composition disc, general purpose solenoid enclosure with continuous duty coil.

2.08 PUMPS

A. General Construction Requirements
   1. Balance: Rotating parts, statically and dynamically.
   2. Construction: To permit servicing without breaking piping or motor connections.
   3. Motors: Operate at 1750 rpm unless specified otherwise.
   4. Connections: Flanged.
B. In-Line Circulators:
   1. Type: Horizontal shaft, single stage, direct connected to multiple speed motor for in-line mounting, oil lubricated, for 860 kPa (125 psi) maximum working pressure.
   2. Construction: Cast iron casing, bronze impeller keyed to alloy steel shaft, oil lubricated bronze sleeve bearings.

2.09 TANKS

A. Tank: SS tank with dual heat exchanger coils and foam insulation suitable for solar energy collection.

PART 3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs.
B. Prepare piping connections to equipment with flanges or unions.
C. After completion, fill, clean, and treat systems.

3.02 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.
B. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
C. Install piping to conserve building space,and not interfere with use of space and other work. Group piping whenever practical at common elevations.
D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
E. Provide clearance for installation of insulation, and access to valves and fittings.
F. Provide access where valves and fittings are not exposed.
G. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
H. Install valves with stems upright or horizontal.
I. Support tanks inside building from building structure.
J. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment. Pipe relief valve outlet to nearest floor drain.
K. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation,

are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

L. Change line size with reducing fittings. Support piping adjacent to pump such that no weight is carried on pump casings.

M. Provide line sized shut-off valve and strainer on pump suction, and line sized check valve and balancing valve on pump discharge. Provide air cock and drain connection on horizontal pump casings.

N. Install unions downstream of valves and at equipment or apparatus connections.

O. Install threaded brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.

P. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.

Q. Install ball valves for throttling, bypass, or manual flow control services.

R. Provide 20 mm (3/4 inch) ball drain valves at main shut-off valves, low points of piping, bases of vertical risers, and at equipment.

S. Provide manual air vents at system high points.

T. Provide relief valves on system at expansion tanks.

3.03 CLEANING SEQUENCE

A. After completion, fill, start, and vent prior to cleaning. Use water meter to record capacity in each system. Place terminal control valves in open position during cleaning.

B. Add cleaner to closed systems at concentration as recommended by manufacturer.

C. Circulate for 48 hours, then drain systems as quickly as possible. Refill with clean water, circulate for 24 hours, then drain. Refill with clean water and repeat until system cleaner is removed.

D. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect.

E. Flush open systems with clean water for one hour minimum. Drain completely and refill.

F. Remove, clean, and replace strainer screens. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.04 CLOSED SYSTEM TREATMENT

A. Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around globe valve downstream of circulating pumps unless indicated otherwise.

B. Introduce closed system treatment through bypass feeder when required or indicated by test.

END OF SECTION

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SECTION 23 7223
PACKAGED AIR-TO-AIR ENERGY-RECOVERY UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Wall exhausters, heat recovery type.

1.02 RELATED REQUIREMENTS
- A. Section 26 2717 - Equipment Wiring: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS
- A. UL 705 - Power Ventilators; Underwriters Laboratories Inc.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Indicate installation instructions.
- D. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum 10 years of experience.

1.06 FIELD CONDITIONS
- A. Permanent ventilators may not be used for ventilation during construction.

PART 2 PRODUCTS

2.01 POWER VENTILATORS - GENERAL
- A. Performance Ratings:
  1. Certified by the Home Ventilating Institute (HVI) under CSA 439. Both a heating and an air conditioning test shall be run to demonstrate year round energy recovery.
  2. Meet NFPA 90A and 90B requirements for flame spread, not to exceed 25, and smoke generation, not to exceed 50, through an on going testing and verification program using UL Standard 723.
- B. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 1812, Standard for Ducted Air to Air Heat Exchangers.
- C. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.02 WALL EXHAUSTERS, ENERGY RECOVERY TYPE
- A. Performance:
  1. Energy Transfer:
     - a. The energy recovery core shall be capable of transferring both sensible and latent energy between air streams. Latent energy transfer shall be accomplished by direct water vapor transfer using molecular transport by hydroscopic resin.
  2. Passive Frost Control:
     - a. The energy recovery core shall perform without the occurrence of condensation or frosting under normal operating conditions (defined as outside temperatures above -10°F and inside relative humidity below 40%). Occasional extreme conditions shall not affect the usual function or performance of the energy recovery core.
  3. Continuous Ventilation:
     - a. The unit shall accomplish energy recovery in both heating and cooling seasons and shall have the capacity to operate continuously without the need for bypass, recirculation, pre-heaters or other defrost cycles under normal operating conditions.
  4. Positive Air Stream Separation:
     - a. Exhaust and fresh airstreams shall at all times travel in separate passages, and airstreams shall not mix.
  5. Laminar Flow:
     - a. Airflow through the energy recovery core shall be laminar, avoiding deposition of particulates on the interior of the exchange plate material.
- B. Construction
  1. The energy recovery core shall be of static plate, cross-flow construction, with no moving parts.
  2. No condensate pan or drain shall be required.
  3. The unit shall be supplied with an internal 24 VAC transformer and relay.
  4. The unit shall have line cord for easy plug-in

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operation.

5. A latched and hinged door shall provide access to blowers, energy recovery core, and filters.
6. Cabinet walls and doors shall be insulated with 1 inch thick FSK high-density board insulation, with additional ¼ inch thick foam insulation on access door for thermal and sound insulation.
7. The energy exchange element and blowers shall be protected by a polyester filter in both exhaust air and fresh air streams.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Hung or Overhead Mounted Fans:

1. Install fans with resilient mountings and flexible electrical leads.
2. Install flexible connections between fan and ductwork. Ensure metal bands of connectors are parallel with minimum 25 mm (one inch) flex between ductwork and fan while running.

C. Provide backdraft dampers on outlet from wall exhauster fans and as indicated.

END OF SECTION

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SECTION 23 8127
SMALL SPLIT-SYSTEM HEATING AND COOLING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Air cooled condensing units.
- B. Indoor ductless fan & coil units.
- C. Refrigerant piping.
- D. Controls.

1.02 RELATED REQUIREMENTS
- A. Section 22 1005 - Plumbing Piping: Indoor coil condensate drain.
- B. Section 26 2717 - Equipment Wiring: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

1.03 REFERENCE STANDARDS
- A. ARI 210/240 - Standard for Performance Rating of Unitary Air Conditioning and Air-Source Heat Pump Equipment; Air-Conditioning, Heating, and Refrigeration Institute; 2006.
- B. ARI 520 - Positive Displacement Condensing Units; Air-Conditioning, Heating, and Refrigeration Institute; 2004.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2007.
- D. ASHRAE Std 23 - Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2005.
- E. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems; National Fire Protection Association; 2006.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- D. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- E. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner s name and registered with manufacturer.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum 10 years of experience.

1.06 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturers warranty for condensing units and compressors.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN
- A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
  1. Heating: None.
  2. Cooling: Outdoor electric condensing unit with evaporator coil in central ducted indoor unit.
  3. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B. Performance Requirements: See Drawings for additional requirements.

2.02 INDOOR UNITS FOR DUCTLESS SYSTEMS
- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.
- B. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
  1. Construction and Ratings: In accordance with ARI 210/240 and UL listed.
  2. Manufacturer: System manufacturer.
- C. Remote Actuators:

2.03 OUTDOOR UNITS
- A. Outdoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, with compressor and condenser.
  1. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety

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interlock switches, glass fiber insulation with reflective liner.

2. Construction and Ratings: In accordance with ARI 210/240 with testing in accordance with ASHRAE Std 23 and UL listed.

B. Compressor: ARI 520; hermetic, two speed 1800 and 3600 rpm, resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.

C. Air Cooled Condenser: ARI 520; Aluminum fin and copper tube coil, with direct drive axial propeller fan resiliently mounted, galvanized fan guard.

D. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gage ports, thermometer well (in liquid line).

1. Provide thermostatic expansion valves.

E. Refrigerant Piping: Copper tube, ASTM B 280, H58 had drawn or O60 soft annealed.

1. Fittings: ASME B16.22 wrought copper.
2. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy.

F. Operating Controls:

1. Control by room thermostat to maintain room temperature setting.

2.04 ACCESSORY EQUIPMENT

A. Room Thermostat: Wall-mounted, electric solid state microcomputer based room thermostat with remote sensor to maintain temperature setting; low-voltage; with following features:

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from setpoint.
3. Set-up for four separate temperatures per day.
4. Instant override of setpoint for continuous or timed period from one hour to 31 days.
5. Short cycle protection.
6. Programming based on weekdays, Saturday and Sunday.
7. Selection features including degree F or degree C display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on-auto.
8. Battery replacement without program loss.
9. Thermostat display:
   a. Time of day.
   b. Actual room temperature.
   c. Programmed temperature.
   d. Day of week.
   e. System mode indication: heating, cooling, fan auto, off, and on, auto or on, off.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.

B. Verify that proper power supply is available and in correct location.

C. Verify that proper fuel supply is available for connection.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.

B. Install in accordance with NFPA 90B.

C. Install refrigeration systems in accordance with ASHRAE Std 15.

END OF SECTION

SECTION 23 8316
RADIANT-HEATING HYDRONIC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Radiant floor heating system for floor construction and control strategy, using crosslinked polyethylene (PEX) tubing and applicable fittings.

1.02 RELATED SECTIONS
- A. Section 06 1000 - Rough Carpentry: Floor framing and sheathing.

1.03 REFERENCES
- A. ASTM International
  1. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
  2. ASTM E 119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
  3. ASTM E 814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
  4. ASTM F 876 - Standard Specification for Crosslinked Polyethylene (PEX) Tubing.
  5. ASTM F 877 - Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
  6. ASTM F 1960 - Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Tubing.
- B. American National Standards Institute (ANSI)/ Underwriters Laboratories, Inc. (UL)
  1. ANSI/UL 263 Standard for Safety for Fire Tests of Building Construction and Materials.
- C. Canadian Standards Association (CSA)
  1. CAN/CSA B137.5 Cross-Linked Polyethylene (PEX) Tubing Systems for Pressure. Applications
- D. German Institute for Standards (Deutsches Institut fur Normung e.V., DIN)
  1. DIN 4726 Pipelines of Plastic Materials Used in Warm Water Floor Heating Systems; General Requirements.
- E. International Code Council (ICC)
  1. International Mechanical Code (IMC).
  2. International Building Code (IBC).
  3. ICC Evaluation Service (ES) Evaluation Report No. ESR 1099.
- F. Plastics Pipe Institute (PPI)
  1. Technical Report TR-3 Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials.
  2. Technical Report TR-4 Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Piping and Fitting Compounds.
- G. International Association of Plumbing and Mechanical Officials (IAPMO)
  1. Uniform Mechanical Code.
- H. Uponor
  1. Complete Design Assistance Manual (CDAM), 5th edition.
  2. Radiant Floor Installation Handbook, 6th edition.
  3. Uponor System Design Software (USDS) or Advanced Design Suite™ (ADS) Software.

1.04 SYSTEM DESCRIPTION
- A. Design Requirements
  1. Standard Grade hydrostatic pressure ratings from Plastics Pipe Institute in accordance with TR-3 as listed in TR-4. The following three standard-grade hydrostatic ratings are required.
     - a. 200 degrees F (93 degrees C) at 80 psi (551 kPa)
     - b. 180 degrees F (82 degrees C) at 100 psi (689 kPa)
     - c. 73.4 degrees F (23 degrees C) at 160 psi (1102 kPa)
     - d. Certification of flame spread/smoke development rating of 25/50 in accordance with ASTM E84 for the following PEX tubing sizes when encased with ½ inch fiberglass insulation at tube spacing of not less than 4 inches apart.
       1) 5/16 inch [7.94mm]
       2) 3/8 inch [9.53mm]
       3) 1/2 inch [12.7mm]
       4) 5/8 inch [15.88mm]
       5) 3/4 inch [19.05mm]
       6) 1 inch [25.4mm]
       7) 1-1/4 inch [31.75mm]
       8) 1-1/2 inch [38.1mm]
       9) 2 inch [50.8mm]
- B. Performance Requirements: Provide hydronic radiant floor heating system that is manufactured, fabricated and installed to comply with regulatory agencies

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

1. Show compliance with ASTM F877.
2. Show compliance with DIN 4726 regarding oxygen diffusion concerns where applicable.
3. Show compliance with ASTM E119 and ANSI/UL 263 through certification listings with Underwriters Laboratories, Inc. (UL).
   a. UL Design No. L557 - 1 hour wood frame floor/ceiling assemblies
   b. UL Design No. K913 - 2 hour concrete floor/ceiling assemblies
   c. UL Design No. U372 - 1 hour wood stud/gypsum wallboard wall assemblies
   d. UL Design No. V444 - 1 hour steel stud/gypsum wallboard wall assemblies

1.05 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

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

C. Shop Drawings
   1. Provide installation drawings indicating tubing layout, manifold locations, zoning requirements and manifold schedules with details required for installation of the system.
   2. Provide mechanical schematic indicating heat source, mechanical piping and accessories from heat source to manifolds, circulators, water tempering and zone controls. Indicate supply water temperatures and flow rates to manifolds.

D. Samples: Submit selection and verification samples of piping.

E. Quality Assurance and Control Submittals: Submit the following.
   1. Test Reports: Upon request, submit test reports from recognized testing laboratories.
   2. Documentation: Submit the following.
      a. Manufacturer's certificate indicating products comply with specified requirements
      b. Manufacturer's detailed room-by-room heat-loss analysis for the structure
      c. Documentation indicating that the installer has been trained to install the manufacturer's products

F. Closeout Submittals: Submit the following.
   1. Warranty documents specified herein
   2. Operation and maintenance data
   3. Manufacturer's field reports specified herein
   4. Final as-built tubing layout drawing

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Use an installer with demonstrated experience on projects of similar size and complexity and possessing documentation proving successful completion of radiant floor heating training by the PEX tubing manufacturer.

B. Regulatory Requirements and Approvals: Provide a radiant floor heating system that complies with the following requirements.
   1. International Code Council (ICC)
      a. International Mechanical Code (IMC)
      b. International Residential Code (IRC)
      c. ICC Evaluation Service (ES) Evaluation Report No. ESR 1099
      d. International Association of Plumbing and Mechanical Officials (IAPMO)
         1) Uniform Mechanical Code (UMC)

C. Certifications: Provide letters of certification as follows.
   1. Installer is trained by the PEX tubing manufacturer to install the radiant floor heating system.
   2. Installer uses skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed trades person.

1.07 DELIVERY, STORAGE AND HANDLING

A. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

B. Delivery: Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.

C. Storage and Protection: Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer.
   1. Store PEX tubing in cartons or under cover to avoid dirt or foreign material from entering the tubing.
   2. Do not expose PEX tubing to direct sunlight for more than 30 days. If construction delays are encountered, cover the tubing that is exposed to direct sunlight.

1.08 WARRANTY

A. Manufacturer's Warranty: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under contract documents.

1. Warranty covers the repair or replacement of any tubing or fittings proven defective.
2. Warranty may transfer to subsequent owners.
3. Warranty Period for PEX Tubing: 30-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion when installed by a factory-trained Uponor Home Comfort Team (HCT) contractor.
4. Warranty Period for Manifolds and Fittings: 5-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with Date date of Substantial substantial Completion completion when installed by a factory-trained Uponor HCT HCT contractor.
5. Warranty Period for Controls and Electrical Components: 2-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion when installed by a factory-trained Uponor HCT HCT contractor.
6. If a factory-trained Uponor HCT contractor does not install the system, then the most recent limited warranty published by the PEX tubing manufacturer takes precedence.

1.09 SYSTEM STARTUP

A. Prior to Substantial Completion, when work related to the radiant floor heating system is complete, start up the system and ensure that it is operating as intended. Make adjustments as may be needed.

1.10 OWNER'S INSTRUCTIONS

A. Instruct Owner's personnel about operation and maintenance of installed system. Provide manufacturer's installation, operation and maintenance instructions for installed components within the system.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Uponor, Inc.: www.uponor-usa.com.

2.02 HYDRONIC RADIANT FLOOR HEATING SYSTEM MATERIALS

A. Tubing

1. Material: Crosslinked polyethylene (PEX) manufactured by PEX-a or Engle method
2. Material Standard: Manufactured in accordance with ASTM F876 and ASTM F877 and tested for compliance by an independent third-party agency.
3. Pressure Ratings: Standard Grade hydrostatic design and pressure ratings as issued by the Plastics Pipe Institute (PPI), a division of the Society of the Plastics Industry (SPI).
4. Show compliance with ASTM E119 and ANSI/UL 263 through certification listings through UL.
   a. UL Design No. L557 - 1 hour wood frame floor/ceiling assemblies
   b. UL Design No. K913 - 2 hour concrete floor/ceiling assemblies
   c. UL Design No. U372 - 1 hour wood stud/gypsum wallboard wall assemblies
   d. UL Design No. V444 - 1 hour steel stud/gypsum wallboard wall assemblies
5. Minimum Bend Radius (Cold Bending): No less than six times the outside diameter. Use the PEX tubing manufacturer's bend supports if radius is less than stated.
6. Barrier Tubing Type: Wirsbo hePEX™ plus
   a. Wirsbo hePEX plus tubing with an oxygen diffusion barrier does not exceed an oxygen diffusion rate of 0.10 grams per cubic meter per day at 104 degrees F (40 degrees C) water temperature in accordance with German DIN 4726.
   b. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated.
      1) 5/16 inch [7.94mm]
      2) 3/8 inch [9.53mm]
      3) 1/2 inch [12.7mm]
      4) 5/8 inch [15.88mm]
      5) 3/4 inch [19.05mm]
      6) 1 inch [25.4mm]
7. Non-Barrier Tubing Type: Wirsbo AQUAPEX® or Wirsbo AQUAPEX plus
   a. Wirsbo AQUAPEX tubing does not feature an oxygen diffusion barrier.
   b. Nominal Inside Diameter: Provide tubing

with nominal inside diameter in accordance with ASTM F876, as indicated.
1) 3/8 inch [9.53mm]
2) 1/2 inch [12.7mm]
3) 5/8 inch [15.88mm]
4) 3/4 inch [19.05mm]
5) 1 inch [25.4mm]
6) 1-1/4 inch [31.75mm]
7) 1-1/2 inch [38.1mm]
8) 2 inch [50.8mm]

8. An oxygen diffusion barrier tubing is not required if one of the following design strategies is used.
   a. Isolate the ferrous materials in the boiler and other components within the primary side of the mechanical system with a heat exchanger.
      1) Use non-ferrous components within the secondary system side (e.g., pumps, expansion tanks, etc.).
   b. Use non-ferrous components within the entire fluid pathway.
9. Use Wirsbo hePEX plus tubing when oxygen diffusion barrier tubing is required. Use Wirsbo AQUAPEX when non-barrier tubing is required.

B. Manifolds (residential and light commercial, valved brass).
1. For system compatibility, use 1-1/4-inch brass manifolds offered by the respective PEX tubing manufacturer.
2. Use manifold mounting brackets offered by the respective PEX tubing manufacturer.
3. Manifolds must provide individual flow control for each loop of the manifold through valve actuators available from the manifold supplier.
4. Manifolds must feature manual flow balancing capability within the manifold body for balancing unequal loop lengths across the manifold.
5. Manifolds support 5/16 inch to 3/8 inch PEX tubing.
6. Each manifold location should have the ability to vent air manually from the system.

C. Fittings
1. For system compatibility, use fittings offered by the PEX tubing manufacturer.
2. The fitting assembly must comply with ASTM F877 and CAN/CSA B137.5 requirements.
3. Use Uponor QS20 compression fittings or Uponor ProPEX fittings as applicable.
4. Uponor QS20 Compression Fittings
   a. Fitting assembly manufactured from UNS C3600 series brass material.
   b. The fitting assembly consists of a barbed insert, a compression ring and a compression nut. The barbed insert is manufactured with an o-ring to facilitate air pressure testing.
5. Uponor ProPEX Fittings
   a. Fittings manufactured in accordance with ASTM F1960.
   b. Fitting assembly manufactured from material listed in paragraph 5.1 of ASTM F1960.
   c. The fitting assembly consists of a barbed adapter and an applicable sized PEX ring. The barbed insert may include an o-ring to facilitate pressure testing with air.

D. Supply-and-return Piping to the Manifolds (above ground piping)
1. Properly size supply and return distribution piping for the given volume and velocities required at system design.
2. Use suitable distribution piping material (i.e., metric dimensioned Wirsbo hePEX plus, type M copper or black iron piping) for all supply fluid temperatures in systems with ferrous components.
   a. When using 32mm through 63mm dimensioned Wirsbo hePEX plus tubing, do not exceed 194 degrees F (90 degrees C) at 58 psi (400 kPa).
   b. Use suitable distribution piping material (i.e., Wirsbo AQUAPEX or HDPE) for systems free of or isolated from ferrous components.
      1) When using HDPE mains, do not exceed 140 degrees F (60 degrees C) at 80 psi (551 kPa).
      2) When using Wirsbo AQUAPEX mains, do not exceed 200 degrees F (93 degrees C) at 80 psi (551 kPa).
   c. Do not expose Wirsbo AQUAPEX and metric dimensioned Wirsbo hePEX plus tubing to direct sunlight or install near overhead fluorescent lighting. If PEX tubing

is exposed, install suitable pipe insulation around the exposed tubing.

d. Use fittings compatible with piping material. Fittings must transition from distribution piping to system manifolds.

E. Room Temperature Controls

1. All thermostats shall operate within a 1 degree F differential temperature incorporating pulse-width modulation action.
2. Install an Uponor Radiant Thermostat (heat and cool) with digital display for one room or heating zone and one cooling zone. Centrally locate the thermostat for the respective heating and cooling zones.
3. For multiple-zoning control, install the loop(s) per zone and install the individual valve actuators on the respective loop(s) at the manifold.
4. The Uponor Zone Control Module supplies 24VAC to the thermostats and actuators. With end-switch capability, the Zone Control Module activates other relays or controls as required by system control strategy.

F. Supply Water Temperature Control (Single-temperature with Floating Action)

1. Design the control strategy and install the components to meet or exceed the system performance requirements as stated in the system design.
2. Use the PEX tubing manufacturer's supply water temperature controls and sensors.
3. Temper supply water temperature to the radiant floor panel via a three-way floating action valve controlled by the Uponor proMIX 101.
4. The proMIX 101 resets the supply water temperature to the radiant floor system as it relates to outdoor temperature.
   a. Install the outdoor sensor (S4) on the north face of the building out of direct sunlight.
   b. On receiving a heat demand, the proMIX 101 energizes the system circulator (P1).
   c. The proMIX 101 initiates the boiler call for heat.
   d. Install a 24VAC transformer to power the circuit between the Zone Control Module end switch and the mix demand terminal of the proMIX 101.
   e. Install the outdoor sensor (S4), the system supply sensor (S1) and the boiler return sensor (S3) for proper operation of the control.
   f. Review the Uponor proMIX 101 Installation Manual for testing, startup and application drawings.

G. QUIK TRAK Panels: Plywood panels, 7 x 48 inches (W x L), 1/2 inch thick, attached to an aluminum transfer sheet with a groove down the center of each panel to hold 5/16 inch Wirsbo hePEX™ plus tubing. Fasten panels together with reinforced strapping tape to provide a strong, secure link.

1. To facilitate tubing turns, include return panels with U-shaped grooves to ensure total Quik Trak coverage and ensure the proper turning radius.

H. Accessories

1. Use accessories associated with the installation of the radiant floor heating system as recommended by or available from the PEX tubing manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that site conditions are acceptable for installation of the radiant floor heating system.

B. Do not proceed with installation of the radiant floor heating system until unacceptable conditions are corrected.

3.02 INSTALLATION

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

1. Uponor Complete Design Assistance Manual (CDAM), 5th edition
2. Uponor Radiant Floor Installation Handbook

B. Wood Floor Construction with Quik Trak Panels

1. Install Quik Trak panels on top of the wood subfloor according to the PEX tubing manufacturer's instructions.
2. Apply a thin bead of 100 percent silicone sealant in the Quik Trak groove prior to installing the 5/16-inch Wirsbo hePEX plus tubing in the panel.
3. The finished floor covering determines the direction of the Quik Trak panel layout. Refer to the tubing manufacturer's instructions.
4. Due to the small diameter of the 5/16-inch PEX tubing, do not exceed 250 linear feet for any loop.

5. Install insulation in the joist cavity below the floor according to the submitted radiant floor design.
6. Use edge insulation if the heated panel directly contacts an exterior wall or panel.

C. Glycol and Water Solution
1. PEX tubing manufacturer recommends premixed glycol and water solutions.
   a. PEX tubing manufacturer allows site-mixed solutions if mixed to the proper concentration before entering the system.
   b. Mix the glycol and water solution to proper concentration levels to protect the system freezing during operation shutdown.
   c. System circulators must operate continuously for a minimum of 30 days after the system is filled to ensure the glycol and water does not separate in a static system.
   d. Do not use ethylene glycol due to toxicity issues. The PEX tubing manufacturer recommends the use of inhibited propylene glycol for hydronic radiant floor heating systems. Refer to the boiler manufacturer's recommendations.

3.03 FIELD QUALITY CONTROL

A. Site Tests
1. To ensure system integrity, pressure test the system before covering tubing or when other trades are working in the vicinity of the tubing.
2. Test all electrical controls in accordance with respective installation manuals.

3.04 ADJUSTING

A. Balancing Across the Manifold
1. Balance all loops across each manifold for equal flow resistance based on actual loop lengths and total manifold flow.
2. Balancing is unnecessary when all loop lengths across the manifold are within 3 percent of each other in length. Install the supply and return piping to the manifold in a reverse-return configuration to ensure self-balancing.

B. Balancing between manifolds is accomplished with a flow control device installed on the return piping leg from each manifold when direct return piping is used for the supply and return mains.

3.05 CLEANING

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

3.06 DEMONSTRATION

A. Demonstrate operation of hydronic radiant floor heating system to Owner's personnel.
B. Advise the owner's representative about the type and concentration of glycol and water solution if used in the hydronic radiant floor heating system.
1. The Owner monitors the solution effectiveness through an established maintenance program as outlined by the glycol manufacturer.

3.07 PROTECTION

A. Protect installed work from damage caused by subsequent construction activity on the site.

END OF SECTION

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SECTION 26 0519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 V AND LESS)

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Wire and cable for 600 volts and less.
- B. Wiring connectors and connections.

1.02 RELATED REQUIREMENTS
- A. Section 26 0553 - Identification for Electrical Systems.

1.03 REFERENCE STANDARDS
- A. NECA 1 - Standard for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.
- B. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide for each cable assembly type.

1.05 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum 10 years experience.
- C. Products: Furnish products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 WIRING REQUIREMENTS
- A. Concealed Dry Interior Locations: Use only building wire in raceway, nonmetallic-sheathed cable, armored cable, or metal clad cable.
- B. Exposed Dry Interior Locations: Typically, use only building wire in raceway.
  1. At equipment rooms use building wire in raceway, nonmetallic-sheathed cable, armored cable, or metal clad cable
- C. Wet or Damp Interior Locations: Use only building wire in raceway, direct burial cable, armored cable with jacket, or metal clad cable.
- D. Exterior Locations: Use only building wire in raceway, direct burial cable, service-entrance cable, armored cable with jacket, or metal clad cable.
- E. Underground Installations: Use only building wire in raceway, direct burial cable, or service-entrance cable.
- F. Use solid conductor for feeders and branch circuits 10 AWG and smaller.
- G. Use stranded conductors for control circuits.
- H. Use conductor not smaller than 12 AWG for power and lighting circuits.
- I. Use conductor not smaller than 16 AWG for control circuits.
- J. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 25 m (75 feet).
- K. Use 10 AWG conductors for 20 ampere, 240 volt branch circuits longer than 60 m (200 feet).

2.02 BUILDING WIRE
- A. Description: Single conductor insulated wire.
- B. Conductor: Copper.
- C. Insulation Voltage Rating: 600 volts.

2.03 NONMETALLIC-SHEATHED CABLE
- A. Description: NFPA 70, Type NMC.
- B. Conductor: Copper.
- C. Insulation Voltage Rating: 600 volts.

2.04 DIRECT BURIAL CABLE
- A. Description: NFPA 70, Type UF.
- B. Conductor: Copper.
- C. Insulation Voltage Rating: 600 volts.

2.05 SERVICE ENTRANCE CABLE
- A. Description: NFPA 70, Type SE.
- B. Conductor: Copper.
- C. Insulation Voltage Rating: 600 volts.
- D. Insulation: Type RH.

2.06 ARMORED CABLE
- A. Description: NFPA 70, Type AC.
- B. Conductor: Copper.
- C. Insulation Voltage Rating: 300 volts.

2.07 METAL CLAD CABLE
- A. Description: NFPA 70, Type MC.
- B. Conductor: Copper.
- C. Insulation Voltage Rating: 600 volts.
- D. Insulation Temperature Rating: 60 degrees C.
- E. Insulation Material: Thermoplastic.
- F. Armor Material: Steel.
- G. Armor Design: Interlocked metal tape.

2.08 WIRING CONNECTORS
- A. In accordance with UL a;and NEC.
- B. Branch Circuits No. 10 AWG and Smaller:
  1. Connectors: Solderless, screw-on, pressure cable

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type, 600 volt, 105 degrees C, with integral insulation; approved for copper and aluminum conductors, and be reusable.

2. Integral Insulator: Have skirt to completely cover stripped wires.
3. Comply with manufacturer's listing/labeling as to the number, size, and combination of conductors that may be joined.

C. Feeder Circuits: Connectors shall be indent, hex screw, or bolt-clamp type. Material shall be high conductivity and corrosion resistant.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that interior of building has been protected from weather.
B. Verify that mechanical work likely to damage wire and cable has been completed.
C. Verify that raceway installation is complete and supported.

3.02 PREPARATION

A. Completely and thoroughly swab raceway before installing wire.

3.03 INSTALLATION

A. Install wire and cable securely, in a neat and workmanlike manner, as specified in NECA 1.
B. Route wire and cable as required to meet project conditions.
   1. Wire and cable routing indicated is approximate unless dimensioned.
   2. Where wire and cable destination is indicated and routing is not shown, determine exact routing and lengths required.
C. Use wiring methods indicated.
D. Pull all conductors into raceway at same time.
E. Use suitable wire pulling lubricant for building wire 4 AWG and larger.
F. Protect exposed cable from damage.
G. Use suitable cable fittings and connectors.
H. Neatly train and lace wiring inside boxes, equipment, and panelboards.
I. Clean conductor surfaces before installing lugs and connectors.
J. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
K. Trench and backfill for direct burial cable installation. Install warning tape along entire length of direct burial cable, within 75 mm (3 inches) of grade.
L. Identify and color code wire and cable under provisions of Section 26 0553. Identify each conductor with its circuit number or other designation indicated.

END OF SECTION

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SECTION 26 0534
CONDUIT

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Conduit, fittings and conduit bodies.

1.02 RELATED REQUIREMENTS
- A. Section 26 0553 - Identification for Electrical Systems.
- B. Section 26 0537 - Boxes.

1.03 REFERENCE STANDARDS
- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC); 2005.
- B. ANSI C80.3 - American National Standard for Steel Electrical Metallic Tubing (EMT); 2005.
- C. ANSI C80.5 - American National Standard for Electrical Rigid Aluminum Conduit (ERAC); 2005.
- D. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.
- E. NECA 101 - Standard for Installing Steel Conduit (Rigid, IMC, EMT); National Electrical Contractors Association; 2006.
- F. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; National Electrical Manufacturers Association; 2007.
- G. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Tubing and Conduit; National Electrical Manufacturers Association; 2003.
- H. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing; National Electrical Manufacturers Association; 2004.
- I. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide for metallic conduit, flexible metal conduit, liquidtight flexible metal conduit, metallic tubing, nonmetallic conduit, fittings, and surface metal raceways.

1.05 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.
- B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for purpose specified and shown.

1.06 DELIVERY, STORAGE, AND HANDLING
- A. Accept conduit on site. Inspect for damage.
- B. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.
- C. Protect PVC conduit from sunlight.

PART 2 PRODUCTS

2.01 CONDUIT REQUIREMENTS
- A. Conduit Size: Comply with NFPA 70.
  1. Minimum Size: 13 mm (1/2 inch) unless otherwise specified.
- B. Underground Installations: Use PVC or high density PE.
  1. Minimum Size: 19 mm (3/4 inch).
- C. Outdoor Locations Above Grade: Use rigid steel conduit, intermediate metal conduit, or liquid-tight flexible metal conduit.
- D. Wet and Damp Locations: Use rigid steel conduit, intermediate metal conduit, or liquid-tight flexible metal conduit.
- E. Dry Locations:
  1. Concealed: Use rigid steel conduit, rigid aluminum conduit, intermediate metal conduit, or electrical metallic tubing.
  2. Exposed: Use rigid steel conduit, rigid aluminum conduit, intermediate metal conduit, electrical metallic tubing, or surface metal raceways.
     - a. At exposed, finished locations, use only surface metal raceways.

2.02 METAL CONDUIT
- A. Rigid Steel Conduit: ANSI C80.1.
- B. Rigid Aluminum Conduit: ANSI C80.5.
- C. Intermediate Metal Conduit (IMC): Rigid steel.
- D. Fittings and Conduit Bodies: NEMA FB 1; material to match conduit.

2.03 FLEXIBLE METAL CONDUIT
- A. Description: Interlocked steel construction.
- B. Fittings: NEMA FB 1.

2.04 LIQUIDTIGHT FLEXIBLE METAL CONDUIT
- A. Description: Interlocked steel construction with PVC jacket.
- B. Fittings: NEMA FB 1.

2.05 ELECTRICAL METALLIC TUBING (EMT)
- A. Description: ANSI C80.3; galvanized tubing.

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B. Fittings and Conduit Bodies: NEMA FB 1; steel or malleable iron compression type.

2.06 NONMETALLIC CONDUIT

A. Description: NEMA TC 2; Schedule 40 PVC or high density polyethylene.

B. Fittings and Conduit Bodies: NEMA TC 3.

2.07 SURFACE METAL RACEWAYS

A. Description: Sheet metal channel with fitted cover, suitable for use as surface metal raceway, zinc plated or galvanized steel with baked enamel finish. Comply with UL - 5 and accommodate pulling conductors through raceway.

B. Fittings: Full complement of corners, tees, adapters, transitions, boxes, etc.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify routing and termination locations of conduit prior to rough-in.

B. Conduit routing is shown on drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

3.02 INSTALLATION

A. Install conduit securely, in a neat and workmanlike manner, as specified in NECA 1.

B. Install steel conduit as specified in NECA 101.

C. Install nonmetallic conduit and surface metal raceway in accordance with manufacturer's instructions.

D. Arrange supports to prevent misalignment during wiring installation.

E. Support conduit using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.

F. Group related conduits; support using conduit rack. Construct rack using steel channel; provide space on each for 25 percent additional conduits.

G. Fasten conduit supports to building structure and surfaces.

H. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.

I. Arrange conduit to maintain headroom and present neat appearance.

J. Route exposed conduit parallel and perpendicular to walls.

K. Maintain adequate clearance between conduit and piping.

L. Cut conduit square using saw or pipecutter; de-burr cut ends.

M. Bring conduit to shoulder of fittings; fasten securely.

N. Install no more than equivalent of three 90 degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic one shot bender to fabricate bends in metal conduit larger than 50 mm (2 inch) size.

O. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.

P. Provide suitable fittings to accommodate expansion and deflection where conduit crosses seismic.

Q. Provide suitable pull string in each empty conduit except sleeves and nipples.

R. Use suitable caps to protect installed conduit against entrance of dirt and moisture.

S. Ground and bond conduit.

T. Identify conduit under provisions of Section 26 0553.

END OF SECTION

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SECTION 26 0537
BOXES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Wall and ceiling outlet boxes.
- B. Floor boxes.
- C. Pull and junction boxes.

1.02 REFERENCE STANDARDS
- A. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.
- B. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; National Electrical Manufacturers Association; 2007.
- C. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports; National Electrical Manufacturers Association; 2003.
- D. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports; National Electrical Manufacturers Association; 2003.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association; 2003.
- F. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

PART 2 PRODUCTS

2.01 OUTLET BOXES
- A. Sheet Metal Outlet Boxes: NEMA OS 1, galvanized steel.
  1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 13 mm (1/2 inch) male fixture studs where required.
- B. Nonmetallic Outlet Boxes: NEMA OS 2.
- C. Cast Boxes: NEMA FB 1, Type FD, aluminum. Provide gasketed cover by box manufacturer. Provide threaded hubs.
- D. Wall Plates for Finished Areas: As specified in Section 26 2726.

2.02 FLOOR BOXES
- A. Floor Boxes: NEMA OS 1, fully adjustable, 38 mm (1-1/2 inches) deep.
- B. Material: Formed steel.
- C. Shape: Rectangular.
- D. Service Fittings: As specified in Section 26 2726.

2.03 PULL AND JUNCTION BOXES
- A. Sheet Metal Boxes: NEMA OS 1, galvanized steel.
- B. Surface Mounted Cast Metal Box: NEMA 250, Type 4; flat-flanged, surface mounted junction box:
  1. Material: Cast aluminum.
  2. Cover: Furnish with ground flange, neoprene gasket, and stainless steel cover screws.
- C. In-Ground Cast Metal Box: NEMA 250, Type 6, outside flanged, recessed cover box for flush mounting:
  1. Material: Galvanized cast iron.
  2. Cover: Smooth cover with neoprene gasket and stainless steel cover screws.
  3. Cover Legend: "ELECTRIC".
- D. Fiberglass Handholes: Die molded glass fiber hand holes:
  1. Cable Entrance: Pre-cut 150 x 150 mm (6 x 6 inch) cable entrance at center bottom of each side.
  2. Cover: Glass fiber weatherproof cover with nonskid finish.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify locations of floor boxes prior to rough-in.

3.02 INSTALLATION
- A. Install boxes securely, in a neat and workmanlike manner, as specified in NECA 1.
- B. Install in locations as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and as required by NFPA 70.
- C. Coordinate installation of outlet boxes for equipment connected under Section 26 2717.
- D. Set wall mounted boxes at elevations to accommodate mounting heights indicated.
- E. Electrical boxes are shown on Drawings in approximate locations unless dimensioned.
- F. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726.
- G. Maintain headroom and present neat mechanical appearance.
- H. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.
- I. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

J. Locate outlet boxes to allow luminaires positioned as shown on reflected ceiling plan.
K. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.
L. Use flush mounting outlet box in finished areas.
M. Do not install flush mounting box back-to-back in walls; provide minimum 150 mm (6 inches) separation. Provide minimum 600 mm (24 inches) separation in acoustic rated walls.
N. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
O. Use stamped steel bridges to fasten flush mounting outlet box between studs.
P. Install flush mounting box without damaging wall insulation or reducing its effectiveness.
Q. Use adjustable steel channel fasteners for hung ceiling outlet box.
R. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 305 mm (12 inches) of box.
S. Use gang box where more than one device is mounted together. Do not use sectional box.
T. Use gang box with plaster ring for single device outlets.
U. Use cast outlet box in exterior locations exposed to the weather and wet locations.
V. Set floor boxes level.

3.03 ADJUSTING

A. Adjust floor boxes flush with finish flooring material.
B. Install knockout closures in unused box openings.

3.04 CLEANING

A. Clean interior of boxes to remove dust, debris, and other material.
B. Clean exposed surfaces and restore finish.

END OF SECTION

SECTION 26 0553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Nameplates and labels.
- B. Wire and cable markers.
- C. Conduit markers.

1.02 REFERENCE STANDARDS
- A. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.03 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.

PART 2 PRODUCTS

2.01 NAMEPLATES AND LABELS
- A. Nameplates: Engraved three-layer laminated plastic, black letters on white background.
- B. Locations:
  1. Each electrical distribution and control equipment enclosure.
- C. Letter Size:
  1. Use 6 mm (1/4 inch) letters for identifying grouped equipment and loads.
- D. Labels: Embossed adhesive tape, with 5 mm (3/16 inch) white letters on black background. Use only for identification of individual wall switches and receptacles, and control device stations.

2.02 WIRE MARKERS
- A. Description: Cloth or tape type wire markers.
- B. Locations: Each conductor at panelboard gutters, pull boxes, outlet boxes, and junction boxes each load connection.

2.03 CONDUIT MARKERS
- A. Location: Furnish markers for each conduit longer than 2 m (6 feet).
- B. Spacing: 6 m (20 feet) on center.

2.04 UNDERGROUND WARNING TAPE
- A. Description: 100 mm (4 inch) wide plastic tape, detectable type colored red with suitable warning legend describing buried electrical lines.

PART 3 EXECUTION

3.01 PREPARATION
- A. Degrease and clean surfaces to receive nameplates and labels.

3.02 INSTALLATION
- A. Install nameplates and labels parallel to equipment lines.
- B. Secure nameplates to equipment front using screws.
- C. Secure nameplates to inside surface of door on panelboard that is recessed in finished locations.
- D. Identify underground conduits using underground warning tape. Install one tape per trench at 75 mm (3 inches) below finished grade.

END OF SECTION

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SECTION 26 0917
PROGRAMMABLE CONTROLLERS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Programmable controllers.
- B. Remote input/output units.
- C. Programmer/loader unit.

1.02 REFERENCE STANDARDS
- A. NEMA ICS 1 - General Standards for Industrial Control and Systems; National Electrical Manufacturers Association; 2005.
- B. NEMA ICS 3 - Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC; 2005.
- C. NEMA ICS 6 - Industrial Control and Systems: Enclosures; National Electrical Manufacturers Association; 1993 (R2006).
- D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.03 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements, including layout of completed assemblies, interconnecting cabling, dimensions, weights, and external power requirements.
- C. Product Data: Provide data for each component specified showing electrical characteristics and connection requirements.

1.04 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.
- C. Furnish products listed and classified by Underwriters Laboratories Inc. as suitable for purpose specified and indicated.

1.05 DELIVERY, STORAGE, AND HANDLING
- A. Store products in clean, dry area; maintain temperature to NEMA ICS 1.

1.06 FIELD CONDITIONS
- A. Maintain temperature above 0 degrees C (32 degrees F) and below 40 degrees C (104 degrees F) during and after installation of products.
- B. Maintain area free of dirt and dust during and after installation of products.

PART 2 PRODUCTS

2.01 PROGRAMMABLE CONTROLLER
- A. Description: Programmable controller manufactured to NEMA ICS 3 Part 2. Capable of controlling multiple systems, receiving input data from multiple on-site monitors and/or sensors, being monitored or controlled from off-site location via inter-net enabled connection, having at-location digital screen programmable display; suitable for interior mounting and use.
- B. Configuration:
  1. Processor Unit: Include processor, power supply, random access memory and input/output modules.
  2. Remote Input/Output Unit: Include input/output modules, interface module and power supply for system inputs and outputs.
- C. Power Supply: Input voltage of 120 volts, 60 Hz.
- D. Enclosure: NEMA ICS 6; Type 12.
- E. Programmer/Loader Unit: Manual graphic display type.

PART 3 EXECUTION

3.01 INSTALLATION
- A. Install in accordance with manufacturer's instructions.
- B. Do not install products until major construction is complete and building interior is enclosed and heated.
- C. Connect input and output devices as indicated.

3.02 CLOSEOUT ACTIVITIES
- A. Demonstrate operation and programming of controller.

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SECTION 26 2416
PANELBOARDS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Lighting and appliance panelboards.

1.02 RELATED REQUIREMENTS
- A. Section 26 0553 - Identification for Electrical Systems.

1.03 REFERENCE STANDARDS
- A. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.
- B. NEMA PB 1 - Panelboards; National Electrical Manufacturers Association; 2006.
- C. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less; National Electrical Manufacturers Association; 2007.
- D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.
- B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 LIGHTING AND APPLIANCE PANELBOARDS
- A. Description: NEMA PB1, circuit breaker type, lighting and appliance branch circuit panelboard.
- B. Panelboard Bus: Copper, ratings as indicated. Provide copper ground bus in each panelboard; provide insulated ground bus where scheduled.
- C. Minimum Integrated Short Circuit Rating: As indicated.
  1. 240 Volt Panelboards: 10,000 amperes rms symmetrical.
- D. Molded Case Circuit Breakers: Thermal magnetic trip circuit breakers, bolt-on type, with common trip handle for all poles; UL listed.
  1. Type SWD for lighting circuits.
  2. Type HACR for air conditioning equipment circuits.
  3. Class A ground fault interrupter circuit breakers where scheduled.
- E. Enclosure: NEMA PB 1, Type 1.
- F. Cabinet Box: 153 mm (6 inches) deep, 508 mm (20 inches) wide for 240 volt and less panelboards, 508 mm (20 inches) wide for 480 volt panelboards.
- G. Cabinet Front: Flush cabinet front with concealed trim clamps, concealed hinge, metal directory frame, and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

PART 3 EXECUTION

3.01 INSTALLATION
- A. Install panelboards in accordance with NEMA PB 1.1 and NECA 1.
- B. Install panelboards plumb. Install recessed panelboards flush with wall finishes.
- C. Height: 1800 mm (6 feet) to top of panelboard; install panelboards taller than 1800 mm (6 feet) with bottom no more than 100 mm (4 inches) above floor.
- D. Provide filler plates for unused spaces in panelboards.
- E. Provide typed circuit directory for each branch circuit panelboard. Revise directory to reflect circuiting changes required to balance phase loads.
- F. Provide engraved plastic nameplates under the provisions of Section 26 0553.
- G. Ground and bond panelboard enclosure in accordance with NFPA 70.

3.02 ADJUSTING
- A. Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads to within 20 percent of each other. Maintain proper phasing for multi-wire branch circuits.

END OF SECTION

SECTION 26 2716
ELECTRICAL CABINETS AND ENCLOSURES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Hinged cover enclosures.
- B. Cabinets.
- C. Terminal blocks.

1.02 REFERENCE STANDARDS
- A. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association; 2003.
- C. NEMA ICS 4 - Industrial Control and Systems: Terminal Blocks; National Electrical Manufacturers Association; 2005.
- D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.03 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard data for enclosures and cabinets.
- C. Cabinet Keys: Deliver to Owner in accordance with Section 01 6000 for maintenance materials.

1.04 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.
- B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 HINGED COVER ENCLOSURES
- A. Construction: NEMA 250, Type 1 steel enclosure.
- B. Covers: Continuous hinge, held closed by flush latch operable by key.
- C. Provide interior plywood panel for mounting terminal blocks and electrical components; finish with white enamel.
- D. Enclosure Finish: Manufacturer's standard enamel.
- E. Keys: Provide two of each different key.

2.02 CABINETS
- A. Boxes: Galvanized steel.
- B. Box Size: As indicated, or if not indicated, as required by use.
- C. Backboard: Provide 19 mm (3/4 inch) thick plywood backboard for mounting terminal blocks. Paint matte white.
- D. Fronts: Steel, flush type with concealed trim clamps, door with concealed hinge, and flush lock keyed to match branch circuit panelboard. Finish with gray baked enamel.
- E. Provide metal barriers to form separate compartments wiring of different systems and voltages.
- F. Keys: Provide two of each different key.

2.03 TERMINAL BLOCKS
- A. Terminal Blocks: NEMA ICS 4.
- B. Power Terminals: Unit construction type with closed back and tubular pressure screw connectors, rated 600 volts.
- C. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with tubular pressure screw connectors, rated 300 volts.
- D. Provide ground bus terminal block, with each connector bonded to enclosure.

PART 3 EXECUTION

3.01 INSTALLATION
- A. Install securely, in a neat and workmanlike manner, as specified in NECA 1.
- B. Install enclosures and boxes plumb. Anchor securely to wall and structural supports at each corner.
- C. Install cabinet fronts plumb.

3.02 CLEANING
- A. Clean electrical parts to remove conductive and harmful materials.
- B. Remove dirt and debris from enclosure.
- C. Clean finishes and touch up damage.

END OF SECTION

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SECTION 26 2717
EQUIPMENT WIRING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Electrical connections to equipment.

1.02 RELATED REQUIREMENTS
- A. Section 26 0534 - Conduit.
- B. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables (600 V and Less).
- C. Section 26 0537 - Boxes.
- D. Section 26 2726 - Wiring Devices.

1.03 REFERENCE STANDARDS
- A. NEMA WD 1 - General Color Requirements for Wiring Devices; National Electrical Manufacturers Association; 1999 (R 2005).
- B. NEMA WD 6 - Wiring Devices - Dimensional Requirements; National Electrical Manufacturers Association; 2002.
- C. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.04 ADMINISTRATIVE REQUIREMENTS
- A. Coordination:
  1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
  2. Determine connection locations and requirements.
- B. Sequencing:
  1. Install rough-in of electrical connections before installation of equipment is required.
  2. Make electrical connections before required start-up of equipment.

1.05 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.
- B. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 MATERIALS
- A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
  1. Colors: Conform to NEMA WD 1.
  2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
  3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit over-current protection.
- B. Disconnect Switches: As specified in Section _____ and in individual equipment sections.
- C. Wiring Devices: As specified in Section 26 2726.
- D. Flexible Conduit: As specified in Section 26 0534.
- E. Wire and Cable: As specified in Section 26 0519.
- F. Boxes: As specified in Section 26 0537.

2.02 EQUIPMENT CONNECTIONS
- A. As indicated on drawings:
  1. Electrical Connection: Flexible conduit.
  2. Electrical Connection: Cord and plug (NEMA 6-20R).
  3. Provide field-installed disconnect switch when using flexible conduit connection.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.02 ELECTRICAL CONNECTIONS
- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment

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wiring requirements.

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SECTION 26 2726
WIRING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Wall switches.
- B. Wall dimmers.
- C. Receptacles.
- D. Device plates and decorative box covers.
- E. Floor box service fittings.
- F. Combination smoke detectors/carbon monoxide detectors.

1.02 RELATED REQUIREMENTS
- A. Section 26 0537 - Boxes.

1.03 REFERENCE STANDARDS
- A. NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006.
- B. NEMA WD 1 - General Color Requirements for Wiring Devices; National Electrical Manufacturers Association; 1999 (R 2005).
- C. NEMA WD 6 - Wiring Device -- Dimensional Requirements; National Electrical Manufacturers Association; 2002.
- D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

1.05 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.
- C. Products: Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 WALL SWITCHES
- A. Wall Switches: Heavy Duty, AC only general-use snap switch, complying with NEMA WD 6 and WD 1.
  1. Body and Handle: Ivory plastic with toggle handle.
  2. Ratings: Match branch circuit and load characteristics.
- B. Switch Types: Single pole, double pole, and 3-way.

2.02 WALL DIMMERS
- A. Wall Dimmers: Semiconductor dimmer for incandescent lamps, Type as indicated on drawings, complying with NEMA WD 6 and WD 1.
  1. Body and Handle: Ivory plastic with linear slide.
  2. Power Rating: Match load shown on drawings; 600 watts minimum.

2.03 RECEPTACLES
- A. Receptacles: Heavy duty, complying with NEMA WD 6 and WD 1.
  1. Device Body: Ivory plastic.
  2. Configuration: NEMA WD 6, type as specified and indicated.
- B. Duplex Convenience Receptacles.
- C. GFCI Receptacles: Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements.

2.04 WALL PLATES
- A. Decorative Cover Plates: White, nylon.
- B. Jumbo Cover Plates: White, nylon.
- C. Weatherproof Cover Plates: Gasketed cast metal with hinged, gasketed device cover.

2.05 FLOOR MOUNTED SERVICE FITTINGS
- A. Flush Cover Convenience Receptacles:
  1. Material: Aluminum.
  2. Configuration: Duplex flap opening.

2.06 COMBINATION SMOKE DETECTORS/CARBON MONOXIDE DETECTORS
- A. Combination Smoke Detectors/Carbon Monoxide Detectors: Dual smoke & carbon monoxide detector technology, UL listed.
  1. Photoelectric smoke sensing.
  2. Electrochemical carbon monoxide sensing.
  3. 85 dB horn.
  3. Power Supply: 120 V with battery back-up.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verify that outlet boxes are installed at proper height.
- B. Verify that wall openings are neatly cut and will be completely covered by wall plates.

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C. Verify that floor boxes are adjusted properly.
D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.02 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.
B. Clean debris from outlet boxes.

3.03 INSTALLATION

A. Install securely, in a neat and workmanlike manner, as specified in NECA 1.
B. Install devices plumb and level.
C. Install switches with OFF position down.
D. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.
E. Do not share neutral conductor on load side of dimmers.
F. Install receptacles with grounding pole on top.
G. Connect wiring device grounding terminal to outlet box with bonding jumper.
H. Install decorative plates on switch, receptacle, and blank outlets in finished areas.
I. Connect wiring devices by wrapping conductor around screw terminal.
J. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.
K. Interconnect combination smoke detectors/carbon monoxide alarms such that if any one detects a hazard, all sound an alarm.

3.04 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.
B. Operate each wall switch with circuit energized and verify proper operation.
C. Verify that each receptacle device is energized.
D. Test each receptacle device for proper polarity.
E. Test each GFCI receptacle device for proper operation.

3.05 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.06 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

SECTION 26 2813
FUSES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Fuses.

1.02 REFERENCE STANDARDS
- A. NEMA FU 1 - Low Voltage Cartridge Fuses; National Electrical Manufacturers Association; 2002 (R2007).
- B. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.03 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data sheets showing electrical characteristics, including time-current curves.

1.04 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.
- C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 FUSES - GENERAL
- A. Dimensions and Performance: NEMA FU 1, Class as specified or indicated.
- B. Voltage: Rating suitable for circuit phase-to-phase voltage.
- C. Type: Current limiting non-renewable type with 200,000 ampere AIC interrupting capacity and shall not be shipped installed in fusible equipment.

PART 3 EXECUTION

3.01 INSTALLATION
- A. Furnish and install secondary fuses in all fusible equipment sized as shown on the drawings.
- B. Install fuses with label oriented such that manufacturer, type, and size are easily read.

END OF SECTION

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SECTION 26 2818
ENCLOSED SWITCHES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Fusible switches.
- B. Nonfusible switches.

1.02 RELATED REQUIREMENTS
- A. Section 26 2813 - Fuses.

1.03 REFERENCE STANDARDS
- A. NEMA FU 1 - Low Voltage Cartridge Fuses; National Electrical Manufacturers Association; 2002 (R2007).
- B. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum); National Electrical Manufacturers Association; 2001 (R2006).
- C. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.04 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide switch ratings and enclosure dimensions.

1.05 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.
- C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 COMPONENTS
- A. Fusible Switch Assemblies: NEMA KS 1, Type HD enclosed load interrupter knife switch.
  1. Externally operable handle interlocked to prevent opening front cover with switch in ON position.
  2. Handle lockable in OFF position.
  3. Fuse clips: Designed to accommodate NEMA FU1, Class R fuses.
- B. Nonfusible Switch Assemblies: NEMA KS 1, Type HD enclosed load interrupter knife switch.
  1. Externally operable handle interlocked to prevent opening front cover with switch in ON position.
  2. Handle lockable in OFF position.
- C. Enclosures: NEMA KS 1.
  1. Interior Dry Locations: Type 1.
  2. Exterior Locations: Type 3R.

PART 3 EXECUTION

3.01 INSTALLATION
- A. Install in accordance with manufacturer's instructions.
- B. Install fuses in fusible disconnect switches.
- C. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

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SECTION 26 3100
PHOTOVOLTAIC COLLECTOR SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Photovoltaic modules complete with frames, junction box and cables.
- B. Photovoltaic mounting rack system.
- C. Photovoltaic inverter system complete with inverters, any required combiner boxes, lightning protection, disconnects, inter-net interface.

1.02 RELATED REQUIREMENTS
- A. Section 26 2717 - Equipment Wiring: Connection to facility power distribution.

1.03 REFERENCE STANDARDS
- A. ASTM E 1799 - Standard Practice for Visual Inspections of Photovoltaic Modules.
- B. IEC 61215 - Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval; 2005.
- C. UL 1703 - Flat Plate Photovoltaic Modules and Panels; 2002.
- D. UL 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources; 2007

1.04 SUBMITTALS
- A. Product Data: Manufacturer's data sheets on each product to be used, including:
  1. Preparation instructions and recommendations.
  2. Storage and handling requirements and recommendations.
  3. Installation methods.
- B. Shop Drawings: Wiring diagram for arrays.
- C. Manufacturer's detailed test and commissioning procedures.
- D. Final test results.

1.05 DELIVERY, STORAGE, AND HANDLING
- A. Store products in manufacturer's unopened packaging until ready for installation.

1.06 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Submit manufacturer's power output warranty with terms as indicated.

PART 2 PRODUCTS

2.01 COLLECTOR SYSTEM DESIGN
- A. Collectors are designed to power AC loads, with "net metering" on power grid connection but no battery storage.
- B. Total Array:
  1. Nominal Maximum Power Output: As indicated on drawings.
  2. Warranted Maximum Power Output: After 25 years in use not less than 80 percent of nominal maximum power output.
- C. Series Fuse Rating: 15 A.

2.02 MATERIALS
- A. Photovoltaic Collector Modules: Thin film Silicon nitride photovoltaic cells in frame, factory assembled; with junction box, cables for connection in series, and bypass diodes; complying with IEC 61215.
  1. Entire assembly UL listed under UL 1703.
  2. Rated for maximum system voltage of 600 V DC.
  3. Frame: Anodized aluminum, natural satin finish; predrilled mounting holes.
  4. Cables: Polarized; minimum 12 AWG with Multi-Contact connectors.
  5. Factory mounted junction box allowing field replacement of diodes and cable assemblies.
  6. Size: Manufacturer's standard size for capacity specified.
  7. Maximum Thickness: 63.5 mm (2.5 inches), including junction box.
  8. Spares
     - a. Provide 10% spare interconnect wire assemblies.
     - b. Provide 10% spare diodes.
- B. Basis of design:
  1. Thin-film silicon modules of Laminated Safety Glass according to DIN EN 12543-1 composed of outer light of glass, 1.1 mm thick PVB interlayer, ASI THRU, 1.1 mm thick PVB interlayer, inner light of glass for a total thickness of 17 mm. Include cable leads from backside of glass for connection to electrical collection system.
  2. Provide Schott Solar ASI THRU-series Glass as indicated on drawings.
- C. Mounting Equipment: Mill finished aluminum; or stainless steel.
  1. Non-penetrating fixed mounting system for

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a commercial standing seam roofing system manufactured by a company experienced in design and manufacture of solar equipment mounting equipment.

a. A minimum of a 6 inch air space should be provided between the PV arrays and the "flat" portion of the roofing system.

b. Coordinate mounting system details with standing seam roof manufacturer to ensure compliance with the roofing manufacturer's warranty.

2. Design Certified by a Professional Engineer for:

a. Wind Pressure loading using appropriate wind exposure and wind speed.

D. Photovoltaic Inverter System:

1. NEMA 3R assembly of DC/AC inverters, DC disconnects, wireless and wired remote interface, LCD display, cooling system.

a. Nominal 7 kW or 500 Watt output at 240 volt/1 phase, each inverter.

b. Power factor of 1.0.

c. 95.5% CEC inverter efficiency, greater than 98% maximum efficiency.

d. Integral Ground fault, anti-islanding protection, and reverse polarity protection.

e. 10 year warranty.

f. Prewired Web interface.

PART 3 EXECUTION

3.01 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

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 mounting surface under the project conditions.

3.03 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in series strings of voltage compatible with input voltage of inverter or other power conditioning equipment.

C. Layout of array to provide solar access to array 6 hours a day between the hours of 9 am and 3 pm, solar time.

D. Provide DC and AC lighting protection devices arranged to protect the inverters and PV modules.

E. Provide fire-resistive Plywood backing as necessary to support the inverter array, minimum of 8 feet high by 16 feet long.

F. Provide the services of manufacturer-trained personnel to inspect and commission the system and provide formal handover to Owner's personnel.:

1. Energy Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.

2. Renewable Energy: Verify proper operation in all modes of system operation by testing. Verify proper operation under a wide range of conditions to verify energy delivery as calculated for those conditions.

a. Solar Energy Systems: Comply with ASTM E 1799.

3.04 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

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SECTION 26 5000
LIGHTING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Interior and exterior luminaires and accessories.
- B. Ballasts and drivers.
- C. Lamps.

1.02 REFERENCE STANDARDS
- A. ANSI C82.1 - American National Standard for Lamp Ballast - Line Frequency Fluorescent Lamp Ballast; 2004.
- B. NECA/IESNA 500 - Standard for Installing Indoor Commercial Lighting Systems; National Electrical Contractors Association; 2006.
- C. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.
- D. NFPA 101 - Code for Safety to Life from Fire in Buildings and Structures; National Fire Protection Association; 2006.

1.03 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide dimensions, ratings, and performance data.
- C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- D. Operation and Maintenance Data: Instructions for each product.

1.04 QUALITY ASSURANCE
- A. Conform to requirements of NFPA 70 and NFPA 101.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum 10 years experience.
- C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 LUMINAIRES
- A. Furnish products as indicated in Schedule included on the Drawings.

2.02 BALLASTS, DRIVERS, AND CONTROL UNITS
- A. Fluorescent Ballasts: ANSI C82.1, high power factor type electromagnetic ballast, suitable for lamps specified.
  1. Voltage: 120 volts.
- B. Ballasts for Compact Single-Ended Fluorescent Lamps: Electronic, compatible with lamp used , and having power factor of 90 percent or higher. Include protection circuits for lamp end-of-life.Shut down power at lamp end-of-life and reset when power is disconnected and reconnected. Ballasts that require ballast replacement after end of lamp life ballast shut-down shall not be acceptable.
  1. Voltage: 120 volts.
- C. LED Drivers: Constant voltage, EMI for FCC Class A, over-load and no-load protection, suitable for lamps specified.
  1. Output Voltage Regulation Over Input Voltage: +/- 3 percent.
  2. Max Output Voltage Ripple: 3 percent.
  3. Input Power Factor: 0.95.

2.03 LAMPS
- A. Lamp Types: As specified for each luminaire.

PART 3 EXECUTION

3.01 INSTALLATION
- A. Install fixtures securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting).
- B. Locate recessed ceiling luminaires as indicated on reflected ceiling plan.
- C. Install surface mounted luminaires plumb and adjust to align with building lines and with each other. Secure to prevent movement.
- D. Install recessed luminaires to permit removal from below.
- E. Install wall mounted luminaires at height as indicated on Drawings.
- F. Install accessories furnished with each luminaire.
- G. Connect luminaires to branch circuit outlets provided under Section 26 0537 using flexible conduit.
- H. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.
- I. Bond products and metal accessories to branch

circuit equipment grounding conductor.

J. Install specified lamps in each luminaire.

3.02 FIELD QUALITY CONTROL

A. Operate each luminaire after installation and connection. Inspect for proper connection and operation.

3.03 ADJUSTING

A. Aim and adjust luminaires as directed.

3.04 CLEANING

A. Clean electrical parts to remove conductive and deleterious materials.

B. Remove dirt and debris from enclosures.

C. Clean photometric control surfaces as recommended by manufacturer.

D. Clean finishes and touch up damage.

3.05 PROTECTION

3.06 SCHEDULE - See Drawings

END OF SECTION

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SECTION 32 8423
UNDERGROUND IRRIGATION SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Plant and ground cover irrigation system using residential gray water source.
- B. Pipe and fittings, valves, emitters, and accessories.
- C. Control system.

1.02 RELATED REQUIREMENTS
- A. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables (600 V and Less).
- B. Section 32 9223 - Sodding.
- C. Section 32 9300 - Plants.

1.03 REFERENCE STANDARDS
- A. ASTM D 2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series); 2005.
- B. ASTM D 2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems; 2004.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association; 2003.

1.04 ADMINISTRATIVE REQUIREMENTS
- A. Coordination: Coordinate the work with site backfilling, landscape grading and delivery of plant life.
- B. Coordinate location of water supply; plumbing contractor shall supply a valved stub out for connection of irrigation system.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide component and control system and wiring diagrams.
- C. Record Documents: Record actual locations of all concealed components of piping system.
- D. Operation and Maintenance Data:
  1. Provide instructions for operation and maintenance of system and controls, seasonal activation and shutdown, and manufacturer's parts catalog.
  2. Provide schedule indicating length of time each valve is required to be open to provide a determined amount of water.

1.06 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than 10 years of experience.

1.07 REGULATORY REQUIREMENTS
- A. Conform to applicable code for piping and component requirements.

PART 2 PRODUCTS

2.01 IRRIGATION SYSTEM
- A. Electric solenoid controlled underground irrigation system, with pressure blow-out drain.
  1. Source Power: 120 volt, 20 A., 1 phase.
  2. Low Voltage Controls: 24 volt.
- B. Manufacturers:
  1. Toro Company: www.toro.com.

2.02 PIPE MATERIALS
- A. PVC Pipe: ASTM D 2241; 1.38 MPa (200 psi) pressure rated upstream from controls, 1.10 MPa (160 psi) downstream; solvent welded sockets.
- B. Irrigation Hose: ASAE compliant plastic hose; Toro BLUE STRIPE DRIP complete with accessories and fittings downstream from controls.
- C. Fittings: Type and style of connection to match pipe.
- D. Solvent Cement: ASTM D 2564 for PVC pipe and fittings.
- E. Sleeve Material: PVC.

2.03 OUTLETS
- A. Outlets: Plastic construction.
- B. Emitter: Adjustable outlet, non-clogging, with two trickle tubes.

2.04 VALVES
- A. Gate Valves: Bronze construction non-rising stem.
- B. Backflow Preventers: Iron body construction, double check valve type.
- C. Valve Box and Cover: Amtek Economy 12 inch or Jumbo size or approved equivalent; of adequate size to allow valve repair.

2.05 CONTROLS
- A. Controller: Automatic controller, microprocessor solid state control with visible readout display, temporary override feature to bypass cycle for inclement weather, timer for a 6 station system, programmable for 7 days in quarter hour increments, with automatic start and shutdown.
- B. Controller Housing: NEMA 250 Type 3R; weatherproof, watertight, with lockable access door.

C. Valves: Electric Solenoid; normally open; wiring, including required fittings and accessories. Provide Toro 700 Series ULTRA FLOW Zone Valves.
D. Wire Conductors: Color coded, 14 gage minimum, direct burial type; waterproof connections.

PART 3 EXECUTION

3.01 EXAMINATION
A. Verify location of existing utilities.
B. Verify that required utilities and water sources are available, in proper location, and ready for use.

3.02 PREPARATION
A. Piping layout indicated is diagrammatic only. Route piping to avoid plants, ground cover, and structures.
B. Layout and stake locations of system components.
C. Review layout requirements with other affected work. Coordinate locations of sleeves under paving to accommodate system.

3.03 TRENCHING
A. Trench and backfill for piping.
B. Trench Size:
1. Minimum Cover Over Installed Supply Piping: 406 mm (16 inches).
2. Minimum Cover Over Installed Branch and Outlet Piping: 304 mm (12 inches).
C. Trench to accommodate grade changes and slope to drains.
D. Maintain trenches free of debris, material, or obstructions that may damage pipe.

3.04 INSTALLATION
A. Install pipe, valves, controls, and outlets in accordance with manufacturer's instructions.
B. Connect to utilities and water supplies.
C. Set outlets and box covers at finish grade elevations.
D. Install sleeves for pipe passage under walks and paving; extend 12 inches minimum beyond edge of walks and paving.
E. Provide for thermal movement of components in system.
F. Install control wiring in accordance with Division 26. Provide 250 mm (10 inch) expansion coil at each valve to which controls are connected, and at 30 m (100 ft) intervals. Bury wiring beside pipe.
G. Mark valves with neoprene valve markers containing locking device. Set valve markers in pipe risers extending from top of valve to finish grade.
H. After piping is installed, but before outlets are installed and backfilling commences, open valves and flush system with full head of water.

3.05 BACKFILLING
A. Provide 75 mm (3 inch) sand cover over piping.
B. Backfill trench and compact to specified subgrade elevation. Protect piping from displacement.

3.06 SYSTEM STARTUP
A. Prepare and start system in accordance with manufacturer's instructions.
B. Adjust control system to achieve time cycles required.
C. Adjust head types for full water coverage as directed.

3.07 CLOSEOUT ACTIVITIES
A. Instruct Owner's personnel in operation and maintenance of system, including adjusting of sprinkler heads. Use operation and maintenance data as basis for demonstration.

END OF SECTION

SECTION 32 9223
SODDING

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Preparation of subsoil.
- B. Placing topsoil.
- C. Fertilizing.
- D. Sod installation.

1.02 DEFINITIONS
- A. Weeds: Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.03 REFERENCE STANDARDS
- A. TPI (SPEC) - Guideline Specifications to Turfgrass Sodding; Turfgrass Producers International; 2006.

1.04 REGULATORY REQUIREMENTS
- A. Comply with regulatory agencies for fertilizer and herbicide composition.

1.05 DELIVERY, STORAGE, AND HANDLING
- A. Deliver sod on pallets. Protect exposed roots from dehydration.
- B. Do not deliver more sod than can be laid within 24 hours.

PART 2 PRODUCTS

2.01 MATERIALS
- A. Sod: TPI, Certified Turfgrass Sod quality; cultivated grass sod; type indicated below; with strong fibrous root system, free of stones, burned or bare spots; containing no more than 5 weeds per 100 sq m (1000 sq ft). Minimum age of 18 months, with root development that will support its own weight without tearing, when suspended vertically by holding the upper two corners.
  1. St. Augustine Grass Type: 100 percent.
- B. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay, or impurities, plants, weeds and roots; pH value of minimum 5.4 and maximum 7.0.
- C. Fertilizer: Type as recommended for grass, with fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil, as indicated by analysis.
- D. Water: Clean, fresh and free of substances or matter that could inhibit vigorous growth of grass.

2.02 ACCESSORIES
- A. Edging: Plastic.

2.03 SOURCE QUALITY CONTROL
- A. Analyze to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value.

PART 3 EXECUTION

3.01 PREPARATION
- A. Prepare subgrade by scarifying 75 mm (3 inches) deep. Remove debris, roots, branches, and any aggregate over 3 inch size.
- B. Place topsoil spreading evenly to a uniform depth of 100 mm (4 inches). Remove roots, weeds, rocks, and foreign material while spreading. Fine grade to eliminate uneven areas and low spots and make ready to receive sod.

3.02 FERTILIZING
- A. Apply fertilizer in accordance with manufacturer's instructions.
- B. Apply after smooth raking of topsoil and prior to installation of sod.
- C. Apply fertilizer no more than 48 hours before laying sod.
- D. Mix thoroughly into upper 50 mm (2 inches) of topsoil.
- E. Lightly water to aid the dissipation of fertilizer.

3.03 LAYING SOD
- A. Moisten prepared surface immediately prior to laying sod.
- B. Lay sod immediately after delivery to site to prevent deterioration.
- C. Lay sod tight with no open joints visible, and no overlapping; stagger end joints 300 mm (12 inches) minimum. Do not stretch or overlap sod pieces.
- D. Lay smooth. _____.
- E. Place top elevation of sod 13 mm (1/2 inch) below adjoining paving.
- F. Water sodded areas immediately after installation. Saturate sod to 100 mm (4 inches) of soil.
- G. After sod and soil have dried, roll sodded areas

to ensure good bond between sod and soil and to remove minor depressions and irregularities.

END OF SECTION

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COMMENTS

REV DATE 05/30/09

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SECTION 32 9300
PLANTS

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. New trees, plants, and ground cover.
- B. Mulch and Fertilizer.
- C. Maintenance.
- D. Tree Pruning.

1.02 RELATED REQUIREMENTS
- A. Section 32 9400 - Planting Accessories: Planters.

1.03 DEFINITIONS
- A. Plants: Living trees, plants, and ground cover specified in this Section, and described in ANSI Z60.1.

1.04 REFERENCE STANDARDS
- A. ANSI Z60.1 - American Standard for Nursery Stock; 2004.
- B. ANSI A300 Part 1 - American National Standard for Tree Care Operations -- Tree, Shrub and Other Woody Plant Maintenance -- Standard Practices; 2001.

1.05 SUBMITTALS
- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Maintenance Data: Include cutting and trimming method; types, application frequency, and recommended coverage of fertilizer.

1.06 QUALITY ASSURANCE
- A. Nursery Qualifications: Company specializing in growing and cultivating the plants with 10 years experience.
- B. Tree Pruning: NAA - Pruning Standards for Shade Trees.
- C. Maintenance Services: Performed by installer during Construction period until the Date of Substantial Completion.

1.07 REGULATORY REQUIREMENTS
- A. Comply with regulatory agencies for fertilizer and herbicide composition.
- B. Provide certificate of compliance from authority having jurisdiction indicating approval of plants, fertilizer and herbicide mixture.
- C. Plant Materials: Certified by state department of agriculture; free of disease or hazardous insects.

1.08 DELIVERY, STORAGE, AND HANDLING
- A. Freshly dig trees and shrubs before shipment to jobsite.
- B. Protect and maintain plant life until planted.
- C. Deliver plant life materials immediately prior to placement. Keep plants moist.

1.09 FIELD CONDITIONS
- A. Do not install plant life when ambient temperatures may drop below 2 degrees C (35 degrees F) or rise above 32 degrees C (90 degrees F).

1.10 WARRANTY
- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide one year warranty.
- C. Warranty: Include coverage for one continuous growing season; replace dead or unhealthy plants.
- D. Replacements: Plants of same size and species as specified, planted in the next growing season, with a new warranty commencing on date of replacement.

PART 2 PRODUCTS

2.01 TREES, PLANTS, AND GROUND COVER
- A. Trees, Plants, and Ground Cover: Species and size identifiable in plant schedule, grown in climatic conditions similar to those in locality of the Work.

2.02 SOIL MATERIALS
- A. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; minimum pH value of 5.4 and maximum 7.0.

2.03 SOIL AMENDMENT MATERIALS
- A. Fertilizer: Containing fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil, as indicated in analysis.
- B. Peat Moss: Shredded, loose, sphagnum moss; free of lumps, roots, inorganic material or acidic materials; minimum of 85 percent organic material measured by oven dry weight, pH range of 4 to 5; moisture content of 30 percent.
- C. Bone Meal: Raw, finely ground, commercial grade, minimum of 3 percent nitrogen and 20 percent phosphorous.
- D. Lime: Ground limestone, dolomite type, minimum 95 percent carbonates.
- E. Water: Clean, fresh, and free of substances or matter that could inhibit vigorous growth of plants.

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2.04 MULCH MATERIALS

A. Mulching Material: Hardwood species wood shavings, free of growth or germination inhibiting ingredients.

2.05 ACCESSORIES

A. Stakes: Softwood lumber, pointed end. Steel fence posts of tee or Y cross section, 8 feet long, 10.4 pound minimum weight, with an anchor plate area of 21 square inches minimum are acceptable alternate stakes.

B. Cable, Wire, Eye Bolts and Turnbuckles: Non-corrosive, of sufficient strength to withstand wind pressure and resulting movement of plant life.

C. Plant Protectors: Rubber sleeves over cable to protect plant stems, trunks, and branches.

D. Membrane: 0.5 mm (20 mil) thick, water permeable polyolefin fabric.

E. Edging: Valley View BLACK DIAMOND polyethylene edger or approved equivalent.

F. Wrapping: Waterproof fabric.

2.06 PLANT SOIL MIX

A. A uniform mixture of 1 part peat and 3 parts topsoil by volume.

PART 3 EXECUTION

3.01 PLANTING

A. Planting Season:

1. Spring: April 1, or such later date as the ground is workable, to June 15.
2. Fall for Coniferous Trees and Shrubs: August 15 to October 1.
3. Fall for Other Materials: September 30 until freezing of the ground.

B. Place plants for best appearance.

C. Set plants vertical.

D. Remove non-biodegradable root containers.

E. Set plants in planters, pits, or beds, partly filled with prepared plant mix, at a minimum depth of 150 mm (6 inches) under each plant. Remove burlap, ropes, and wires, from the root ball.

F. Place bare root plant materials so roots lie in a natural position. Backfill soil mixture in 150 mm (6 inch) layers. Maintain plant life in vertical position.

G. Saturate soil with water when the pit or bed is half full of topsoil and again when full.

3.02 PLANT RELOCATION AND RE-PLANTING

A. Relocate plants as indicated by Architect.

B. Replant plants in pits or beds, partly filled with prepared topsoil mixture, at a minimum depth of 150 mm (6 inches) under each plant. Remove burlap, ropes, and wires, from the root ball.

C. Place bare root plant materials so roots lie in a natural position. Backfill soil mixture in 150 mm (6 inch) layers. Maintain plant materials in vertical position.

D. Saturate soil with water when the pit or bed is half full of topsoil and again when full.

3.03 INSTALLATION OF ACCESSORIES

A. Place mulch and membrane, where indicated on drawings.

B. Install edging in accordance with manufacturer's directions to separate all planting pits, beds, and individual trees and shrubs from lawn areas. Also, install edging to separate landscape aggregate areas from annual planting beds and lawn areas.

C. Install decorative cover to a depth of 4 inches unless otherwise indicated.

D. Wrap deciduous shade and flowering tree trunks and place tree protectors.

3.04 PLANT SUPPORT

A. Brace plants vertically with plant protector wrapped guy wires and stakes to the following:

1. Tree Caliper: 25 mm (1 inch); Tree Support Method: 1 stake with one tie
2. Tree Caliper: 25 to 50 mm (1 to 2 inches); Tree Support Method: 2 stakes with two ties
3. Tree Caliper: 50 to 100 mm (2 to 4 inches); Tree Support Method: 3 guy wires with eye bolts and turn buckles
4. Tree Caliper: Over 100 mm (4 inches); Tree Support Method: 4 guy wires with eye bolts and turn buckles

3.05 TREE PRUNING

A. Perform pruning of trees as recommended in ANSI A300.

B. Prune newly planted trees as required to remove dead, broken, and split branches.

3.06 FIELD QUALITY CONTROL

A. Plants will be rejected if a ball of earth surrounding roots has been disturbed or damaged prior to or during planting.

3.07 MAINTENANCE

A. Provide maintenance at no extra cost to Owner; Owner will not pay for water.

B. See Section 01 7000 - Execution Requirements, for additional requirements relating to maintenance

service.

C. Maintain plant life immediately after placement and until Date of Substantial Completion.
   1. At Contractor's option, periodically observe plant life during warranty period to ensure proper maintenance by Owner. Provide written notice to Owner, with copy to Architect, of any lack of maintenance that will void specified warranty. If such notification is issued, re-observe within 14 days to verify that noted deficiencies are corrected. Provide written documentation to Owner and Architect of observations.

D. Irrigate sufficiently to saturate root system and prevent soil from drying out.

E. Cultivate and weed plant beds and tree pits.

F. Remove dead or broken branches and treat pruned areas or other wounds.

G. Neatly trim plants where necessary.

H. Immediately remove clippings after trimming.

I. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions.

J. Control insect damage and disease. Apply pesticides in accordance with manufacturers instructions.

K. Remedy damage from use of herbicides and pesticides.

L. Replace mulch when deteriorated.

M. Maintain wrappings, guys, turnbuckles, and stakes. Adjust turnbuckles to keep guy wires tight. Repair or replace accessories when required.

3.08 CLEAN UP

A. Remove excess soil materials, wrapping materials, waste from pruning, and other material remaining from the work of this Section from the site and dispose of beyond visual view of the site.

END OF SECTION

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SECTION 32 9400
PLANTING ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES
- A. Planters and benches.

1.02 RELATED REQUIREMENTS
- A. Section 05 5000 - Metal Fabrications: Product requirements for metal components.
- B. Section 06 1000 - Rough Carpentry: Product requirements for wood components.
- C. Section 09 9000 - Painting and Coating: Finishes for metal and wood components.
- D. Section 32 9300 - Plants.

1.03 ADMINISTRATIVE REQUIREMENTS
- A. Coordination: Coordinate the installation of planters and benches with size, location and installation of service utilities.
- B. Sequencing: Ensure that utility connections, including plant irrigation system, are achieved in an orderly and expeditious manner.

1.04 DELIVERY, STORAGE, AND HANDLING
- A. Store wood and metal components under cover and elevated above grade.

PART 2 PRODUCTS

2.01 MATERIALS
- A. Metal Components: Conform to requirements specified in Section 05 5000.
- B. Wood Components: Conform to requirements specified in Section 06 1000.

2.02 ACCESSORIES
- A. Fasteners: Steel, of type and size appropriate to materials being fastened; hot-dipped galvanized finish.
- B. EPDM Membrane: Non-reinforced, 60 mil thick, conforming to requirements specified in Section 07 5300.

PART 3 EXECUTION

3.01 EXAMINATION
- A. Verification of Conditions: Verify that surrounding and affected work is complete and ready to receive the work of this Section.

3.02 INSTALLATION
- A. Install materials conforming to installation requirements of the Sections to which Part 2 references requirements.
- B. Install square, plumb, true to line and position; securely fasten in place.

3.03 CLEANING
- A. Remove excess and scrap materials from site.
- B. Sweep adjacent horizontal hard surfaces to remove saw-dust and small scraps.

3.04 PROTECTION
- A. Protect installed work from subsequent construction operations.

END OF SECTION

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PM-C146

Appendix D: DOE Required Content

DETAILED WATER BUDGET

Contest	Water Use / task (gal)	Tasks								Total Contest	Water Use / Contest
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8		
		Oct 8	Oct 9	Oct 10	Oct 11	Oct 12	Oct 13	Oct 14	Oct 15		
		7am-12am	24 hr	24 hr	24 hr	24 hr	24 hr	24 hr	12am-10pm		
Dishwasher	2.0	1	0	1	0	0	1	1	1	5	10
Hot Water	15.0	2	3	2	3	2	3	2	3	20	300
Clothes Washer	15.1	1	2	0	0	2	1	2	2	10	151
Total DHW (gallons)		47.1	75.2	32	45	60.2	62.1	62.2	77.2		461
Total Solar Thermal											100
25% extra*											115.25
Grand Total											**676.25**

* +25% oversizing for irrigation, accidental leakage, and pre-draw for hot water competition

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Water Budget

PM-D001

Unlisted Electrical Components

There are no planned unlisted electrical components in the design.

Retail PV Price Quotes

PANEL	WATTS	COST / PANEL	COST / WATT
BP Solar (SX3190B)	190	$914	$4.81
Wanxiang (WX 185)	185	$891	$4.82

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PV and UL Compliance

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PM-D002

SUMMARY OF RECONFIGURABLE FEATURES

Operable windows to the north and south can be opened to demonstrate ventilation during the architecture and market viability contests.

Night insulation panels along the south wall can be deployed to demonstrate day-lighting conditions with and without shades and also illustrate privacy mode for night-time livability.

Living room can be converted into a master bedroom, and bed alcove can be converted into a second bed, children's room, or office.

Sliding panels along shelving can be used to add privacy to bedroom and bathroom areas.

Dining room furniture can be reconfigured to have 6-8 guests at the table.

Partitions along the middle built-in unit can close off entrance, bedroom, or bathroom for added privacy.

University of Minnesota, Lot 118

PV SYSTEMS

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
BP	Main Array – SX3190	243 V, 7.82 A, 5700 W
Schott	Secondary Array – ASITHRU-2-L	272 V, .74 A, 604 W
Schott	Secondary Array – ASITHRU-1-L	272 V, .37 A, 101 W

Total DC power of all arrays is __6.4__ kW (in tenths).

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

INVERTERS

Inverter Manufacturer	Model Number	Voltage	Rating (kVA)	Quantity
Sunny Boy	SB6000US	240V	7.5	1
PV Powered	PVP-1100EVR	120V	1.1	1

Total AC power of all inverters is ___9__ kVA (in whole numbers).

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Please attach the following (these can be the same as those submitted in the required drawings):

1) One-line electrical schematic (the loads do not have to be detailed).
2) Calculations of service/feeder net computed load and neutral load (NEC 220).
2) Plan view of the lot showing the house, decks, ramps, tour paths, and the service point.
3) Elevation view(s) showing the terminal box (contains the service point), meter, main utility disconnect and other service equipment.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Point of Contact for questions regarding the interconnection application:
Name: Brian Henke
Best phone number: 612.719.1975
Other phone numbers:
E-mail: henk0080@umn.edu

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Interconnection Form

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PM-D004