Why Consider a Panelized Wood Roof System for Commercial Buildings

Roof panelizing is the process of assembling roof sections on the ground and lifting them into place. This approach offers a number of potential benefits, with users citing cost savings—mainly due to installation speed—and safety as the main drivers.

Panelized wood roofs are most common on industrial buildings in West Coast markets, where savings can range from $1.25 to $1.50 a square foot or approximately 15% compared to conventional steel joist metal deck systems.[1] However, they can be engineered to resist loads in any location and the economies associated with efficient installation and cost-effective materials apply nationwide.

An accomplished roof erector with one crew can install more than 100,000 square feet of wood roof panels per week, while a hybrid roof can be installed in as little as half the time of a metal deck roof.[2]

This paper provides an overview of panelized wood roof systems, including project typologies that lend themselves to wood construction, code considerations, structural and enclosure design, and assembly and installation. For information on construction type and height and area considerations, see the WoodWorks paper, *Wood in Industrial Buildings: Systems, Codes, and Design Opportunities*.

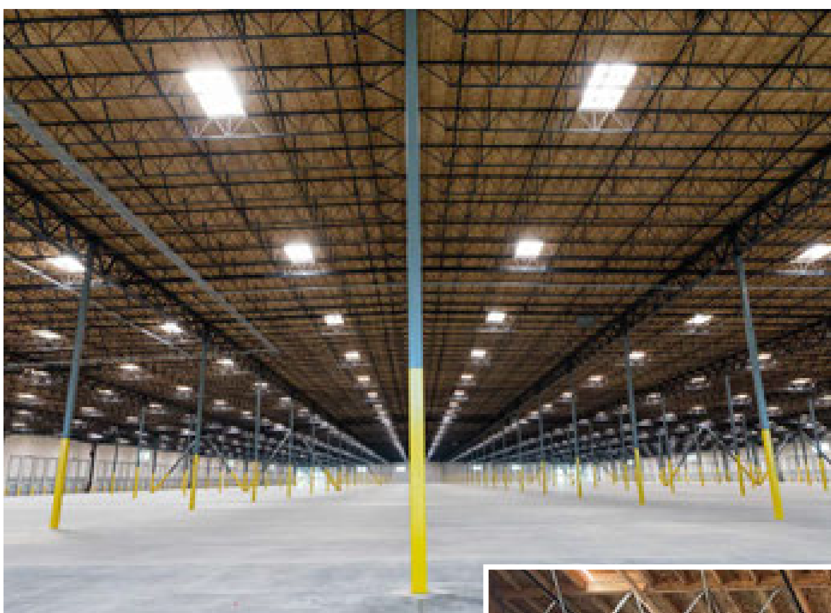
Photo: Panelized Structures

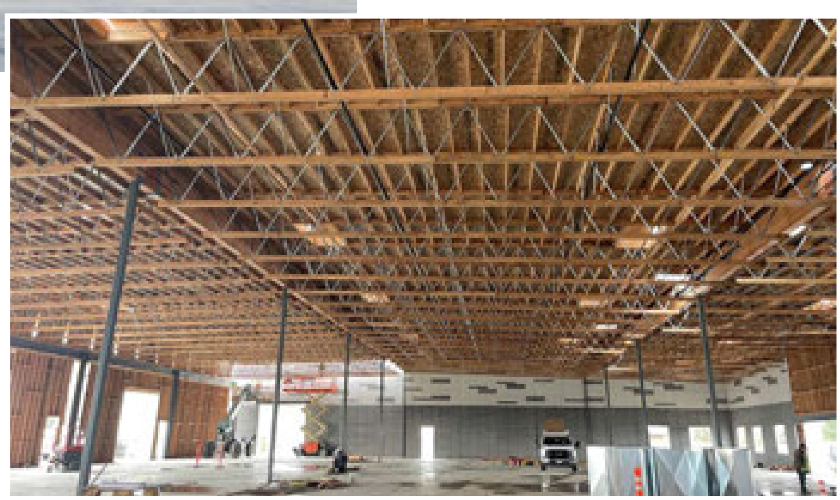
Panelized Roof Basics

Panelized wood roof systems can be all wood or a hybrid of wood and other materials, with the appropriate choice depending the application.

- An all-wood system consists of glue-laminated timber (glulam) beams or girders with wood purlins (glulam, I-joists, or open web wood trusses), wood sub-purlins, and a wood structural panel deck. Common in buildings with spans of less than 40 feet, the all-wood system is particularly well suited for applications where conveyor equipment is hung from the roof structure or food processing facilities that need to minimize dust from overhead joists. It is also used by developers and designers who want to take advantage of wood's aesthetic with an exposed roof structure.
- The hybrid system uses steel joist and girder trusses together with wood sub-purlins and a wood structural panel deck. The long-span capability of steel framing makes this system most economical when spans range from 32 to 60 feet, but much larger spans can be accommodated. In West Coast markets, this system is often used for large industrial and warehouse structures.

The market for wood systems is regionally driven and can fluctuate with commodity steel and wood prices, but contractor familiarity is one of the main reasons a wood-based system will or won't be considered. Contractors are often reluctant to try a new system in a project typology where margins are thin and speed to market, especially for distribution warehouse structures, is critical—even if the value is there.





Panelized roofs with varying degrees of wood
Photos: Panelized Structures (upper two), Redbuilt (bottom)

Photos: Panelized Structures

Installation of beams prior to panels in all-wood roof system (left); panelized wood roof with skylight fall protection (right)

Structural Design Considerations

Wood structural panels can be oriented strand board (OSB) or plywood, in 4x8 or 4x10 sheets, or 8x8 jumbo panels, which are attached to 2x4, 2x6, 3x4, or 3x6 sub-purlins. Common purlins for an all-wood system include I-joists and open-web trusses, or in some cases 2-1/2-inch glulam. Hybrid systems typically include K-Series open-web steel joists for spans up to 60 feet. For projects with heavier loading criteria and/or spans exceeding 60 feet, LH-Series joists are typically required. G-Series steel girders support the joist systems and typically span 50 feet. Girder depth is driven by the building's clear height requirements and it is important to set this criteria early in design. Note that a project may include more than one clear height.

Diaphragm Design

High-load diaphragm capacities and collective chord design are useful tools for designing panelized wood roof diaphragms.

Table 2306.2(2) in the 2024 International Building Code (IBC) provides high-load diaphragm values for nailing in multiple rows. These capacities are needed for any large building with a wood diaphragm. It would also not be possible to design many large warehouses with heavy pre-cast concrete walls without high-load diaphragm nailing.

Collective chord design is a method that uses repetitive wood or steel members that are already tied together for the chord. This is beneficial for large warehouse projects, especially in loading direction perpendicular to purlins. Designers use an equation to determine the moment of inertia and chord forces in the repetitive members. The resulting forces in the members are often less than the cross-tie forces required by the anchorage design.

Sub-diaphragm design is another efficient approach. Sub-diaphragm analysis allows the designer to develop higher wall anchorage loads into the building to ensure the walls won't pull away and to meet the requirements of SEI/ASCE 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7), and the American Wood Council's Special Design Provisions for Wind and Seismic (SDPWS). Over the years, the required anchorage load has increased significantly, to the point that it is now up to 80 percent of the seismic acceleration.

Wind Uplift

Panelized roof assemblies meet Underwriters Laboratories (UL) and Factory Mutual (FM) wind uplift ratings to comply with insurance requirements. This is critical for structure performance as well as attaching roofing materials above the sheathing. Depending on where the project is located, corner and perimeter component and cladding pressures can be significant and should not be ignored.

Slope and Drainage

Wood roof decks accommodate compound slopes and abrupt slope changes for roof drainage, which can reduce or eliminate the need for crickets and sloped insulation. Per IBC Section 1611.2, roofs must be evaluated for ponding instability in accordance with ASCE 7 Chapter 8. To mitigate ponding effects without having to undertake ponding calculations (and likely introduce more robust and costly roof membranes), use a minimum slope of 1/4 inch per 1 foot. Designers should also be cognizant of the impact of compounding deflections on the roof slope, especially at end wall and corner conditions. One strategy is to slope the girders at the first end wall bay 1/8 inch per foot toward the middle of the building (perpendicular to the primary 1/4-inch per foot minimum slope) to help water flow to the drainage points. It is also important to consider the size and location of secondary drain systems and evaluate any relevant loading requirements.

Roof Enclosure Design and Performance

All roofs require coordinated water management, including positive drainage, durable roof membranes, compatible flashings, well-detailed penetrations, and clear maintenance access. They also need assembly components that support fire resistance and durability, such as an appropriate coverboard above insulation where required or recommended, and fastening and attachment details that account for wind uplift, membrane securement, perimeter conditions, and rooftop equipment loads. These practices do not replace climate- and use-specific roof design; they provide the foundation for reliable long-term performance.

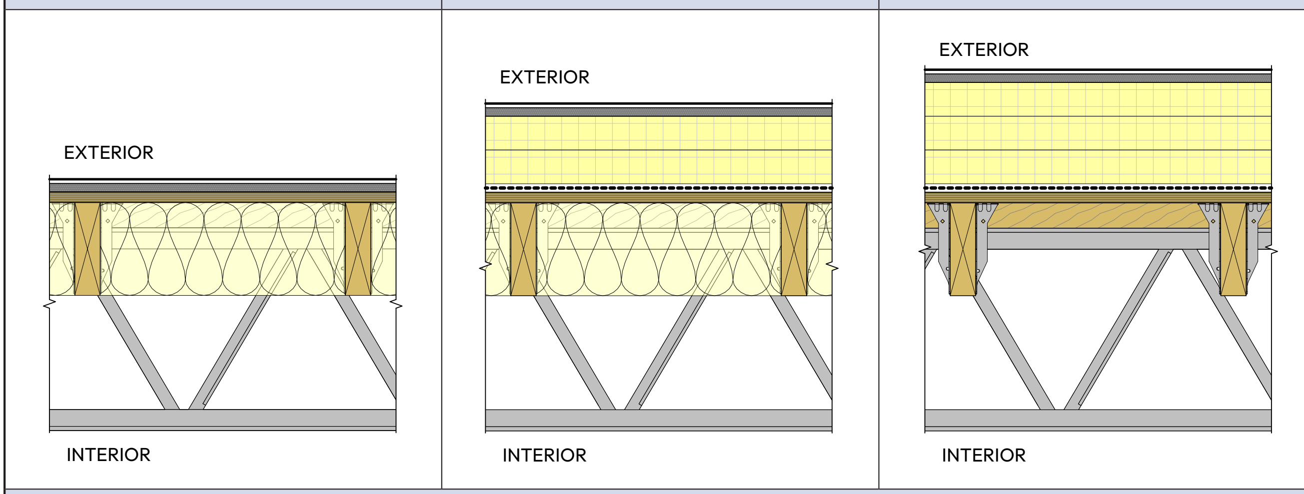
Understanding the location of thermal insulation and the air and water control layers is also critical to the long-term performance and durability of any roof assembly.

Building energy codes, most commonly ANSI/ASHRAE/IES Standard 90.1, Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings, and the International Energy Conservation Code (IECC), establish minimum insulation values and air-tightness requirements for the roof assembly. Required values vary by climate, space-conditioning category, and compliance path. The same building constructed in different climates is subject to different requirements, and the code reflects those differences. Moisture control requirements, including bulk water/water vapor control and venting requirements, are addressed by the IBC.

Assembly Strategies

Three strategies for insulation and control layer placement in panelized wood roof assemblies are shown in Figure 1, which depicts a typical assembly with open web steel joists and various insulation placement locations.

a) Insulation Below Deck	b) Split Insulation	c) Insulation Above Deck



Assembly Layers

a) Insulation Below Deck	b) Split Insulation	c) Insulation Above Deck
Exterior • Roof membrane (also serves as air barrier) • Coverboard (optional) • Wood sheathing + sub-purlins • Insulation (between sub-purlins) • Interior face/liner (optional) • Steel joists with wood nailers (beyond) Interior	Exterior • Roof membrane (may serve as air barrier) • Coverboard (optional) • Rigid insulation • Vapor barrier and air barrier (optional placement, project dependent) • Wood sheathing + sub-purlins • Insulation (between sub-purlins) • Interior face/liner (optional) • Steel joists with wood nailers (beyond) Interior	Exterior • Roof membrane (may serve as air barrier) • Coverboard (optional) • Rigid insulation • Vapor barrier and air barrier (optional placement, project dependent) • Wood sheathing + sub-purlins • Purlins, sloped (beyond) Interior

FIGURE 1: Hybrid panelized wood roof assembly with insulation a) between sub-purlins, b) between sub-purlins and above the roof deck, and c) above the roof deck. The amount of insulation shown in each assembly is representative; minimum insulation requirements vary based on the project-specific interior space-conditioning, exterior climate zone, and local building code compliance strategy. Roof slope is provided by the panelized wood roof structure or sloped insulation above the deck.

Suitability of strategies shown in Figure 1 will vary across climate zones, interior space uses, or conditioning needs, and require project-specific evaluation. In general:

- Assembly (a), with insulation below the deck between sub-purlins, can reduce or eliminate above-deck insulation and may be more suitable for hot and dry climates. In these applications, an interior vapor barrier is not typically used, allowing the assembly to dry primarily to the building interior. This option is generally not suitable for cold or cooler climates because it relies on interior air-control and/or sub-purlin cavity ventilation strategies that are difficult to execute reliably in large, low-slope roofs.
- Assembly (b), which uses insulation both below and above the deck, can support energy code compliance while balancing constructability and condensation control. The above-deck insulation helps keep the roof sheathing warmer and reduces the risk of moisture accumulation on its underside, while the below-deck insulation can reduce the amount of rigid insulation needed above the deck. The insulation ratio, insulation type, and air barrier location are determined based on climate zone and project-specific conditions.
- Assembly (c), with continuous insulation above the roof deck, typically offers the most direct durability strategy because it keeps the wood deck warmer and limits thermal bridging. It can be suitable in most climates when air and vapor control layers are properly located. Because the insulation is continuous over the wood framing, prescriptive R-value requirements may be lower than for assemblies with below-deck insulation. This approach, with a minimal amount of insulation above the deck, may also be appropriate for unconditioned buildings where night sky radiation could increase the risk of condensation beneath the sheathing.

In addition to proper assembly-layer placement, designers must account for interior conditions and space use. Humidity, conditioning, building pressurization, and future tenant requirements can affect enclosure performance and determine whether the original design remains suitable over time.

For a more detailed discussion on enclosure design, moisture risk, tenant improvements and re-roofing considerations, see the article, *Panelized Wood Roofs: Enclosure Design for Long-Term Performance*, written for WoodWorks by RDH Building Science Inc.

Design Cautions: Foil Layers, Vented Cavities, and Vapor Control

Foil-faced insulation and foil sheets are sometimes used to reduce radiant heat transfer. However, foil below the sheathing can also limit drying, particularly when paired with a low-permeance roof membrane above. Venting the cavity created by foil layers to the interior should not be treated as a simple fix; in some climates, the lack of a continuous interior air barrier can allow warm, moist indoor air into the cavity, increasing the risk of condensation when sheathing temperatures are cooler. For large, low-slope panelized roofs, ventilating the cavity below the sheathing is difficult to execute reliably because the geometry rarely supports effective cross-ventilation to the exterior. Vapor control layers, including foil layers, and low-permeance insulation products, should be placed based on climate and assembly configuration; when located on the wrong side of the assembly, they can trap moisture rather than manage it.

Photo: Panelized Structures

Assembly and Installation

The process for assembling and installing a panelized roof structure starts with the walls. Concrete tilt-up walls are most common, though materials such as wood, steel, and masonry can also be used. Depending on the height of the structure, light-frame wood walls can be cost-effective while significantly reducing the seismic mass of the building. Another option is to use mass timber panels supported on a steel column and girt system. The steel columns can be erected quickly and the large-format mass timber panels can be quickly lifted and connected into place.

An advantage of panelized roof systems is that much of the work is done on the ground. This minimizes fall risks as opposed to working at height on a roof deck, which can make for a safer construction site.

In one method, the crew nails wood structural sheathing to sub-purlins, sometimes called stiffeners, which are typically spaced 24 inches o.c. This is done either off or on site. Using a fabrication table or jig, crews then fasten the panel/sub-purlin assembly to the purlins with joist hangers.

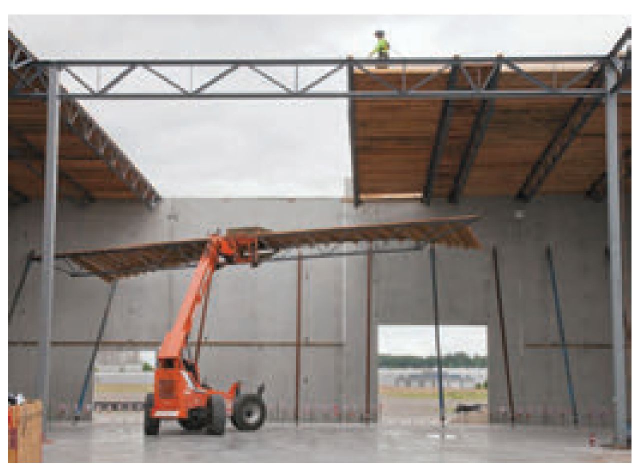
Another method is to attach sub-purlins to the purlin and then nail the sheathing into place overtop. The roof erector then lifts the pre-fabricated panel into place and connects it to the joists and girders to form the roof structure.

A typical 50-foot panel takes five to 10 minutes to assemble on the ground. Panels are usually lifted into place with forklifts and reach machines, though cranes may also be used. Two or three people work on the roof deck to land the panels and weld them into place (for hybrid systems). Once the panels have acclimated, the remaining diaphragm is nailed to complete the horizontal lateral force-resisting system.

Photos: Tom Emerson

How Panelized Wood Roofs Can Reduce Costs

Among the potential cost savings associated with panelized wood roofs, faster installation reduces hard construction costs and may allow the developer/owner to occupy or lease the building sooner. Because panels are assembled on the ground, a roof erector needs only two or three people on the roof at a time, creating a safer work environment while reducing labor costs. Skylight openings and other major roof penetrations are often framed during panel fabrication, which can improve accuracy and reduce field framing requirements after the panels are installed. And there's no need for structural expansion joints and associated vertical lateral force-resisting elements (such as braced or moment frames), which are required for metal decks.



Change to Highland Fairview Corporate Park

DESIGN:	Highland Fairview
EXECUTIVE ARCHITECT:	HPA Inc. • Irvine, CA
ENGINEER:	Kramer Engineering Inc. • Tustin CA
GENERAL CONTRACTOR:	Highland Fairview Construction Inc. • Moreno Valley, CA
ROOF ERECTOR:	Beven-Herron, Inc. • La Mirada, CA

At over half a mile long and 1.8 million square feet, the size of the Highland Fairview Corporate Park made it uniquely qualified for a hybrid panelized wood roof system. "It was a job of a magnitude we had never seen before," said JD Herron from Beven-Herron. "And speed was critical." It took a crew of 50 less than four months to complete.

With more than 53,750 sheets of OSB, 45 miles of steel trusses and girders (240 truckloads), 1.63 million board feet of lumber (20 rail car loads), and 14 million nails (four truckloads), it was also an immense job in terms of material acquisition and staging.

Photos: JD Herron

"Sixty percent of the roof was prefabricated in our La Mirada facility," said Ed Pitts, also from Beven-Herron. "We nailed the OSB to the sub-purlins there, and trucked everything 59 miles to the job site, which allowed us to use our labor more efficiently. It also provided significant cost savings. Plus, the panel-building machine has very precise nailing, so we got better quality in terms of nail spacing."

The project also had to meet unique loading criteria:

- The building is located in an area with a relatively high seismic load—33 percent higher than typical California requirements.
- It had a 40-foot clear height, which increased diaphragm loads due to taller wall panels.
- About 200,000 square feet of solar panels were installed when the project was built, with a plan to cover the entire roof in the future.

Kailua Town Center

ARCHITECT:	MC Architects • Honolulu, HI
ENGINEER:	KAI Hawaii • Honolulu, HI
GENERAL CONTRACTOR:	Gateside, Inc. • Honolulu, HI
ROOF ERECTOR:	La'au Structures • Honolulu, HI

An all-wood panelized roof was chosen for Phase III of the Kailua Town Centre, a 41,000-square-foot facility developed by Kaneohe Ranch Management. Whole Foods occupies 32,000 square feet, and other businesses occupy the remaining space.

As is typical for all-wood systems, bay sizes were about 35 feet. The 40-foot-long main-span beams cantilever over the columns, and 3-1⁄8-inch glulam purlins span 35 feet at 8-foot centers.

Greg Boyd from La'au Structures said, "An all-wood panelized roof is very cost effective on buildings of this size in Hawaii. We used pressure treated lumber, since structures here are subject to termite issues. Pressure treating increased the glulam and lumber costs, but the all-wood option was still significantly less than a steel system."

Photo: La'au Structures

Boyd said that an all-wood system was also easier to work with because the structure was not a square. "In fact, where there are irregular point loads, either from mechanical units on the roof or hanging machinery, an all-wood system can be even more cost-effective," he said. "Otherwise, each steel bar joist would need to be designed uniquely for the specific loading scenario. Plus, when we need to make modifications, wood gives me more flexibility. Steel's long lead times make it difficult for me to make changes in the field."

Freedom Truck Center

ARCHITECT: ALSC Architects • Spokane, WA
ENGINEER: DCI Engineers • Spokane, WA
GENERAL CONTRACTOR: Lydig Construction • Spokane, WA
ROOF ERECTOR: Mandere Construction • Rathdrum, ID

Photo: Mandere Construction

Freedom Truck Center is a full-service Freightliner and Western Star truck dealership. The 45,000-square-foot building houses a showroom, offices, and maintenance shop. Owners wanted the most cost-effective roof system; they also had an aggressive construction schedule. Both requirements led the design team to choose an open-web panelized wood roof system.

Mandere Construction's John Mandere discussed how they assembled the roof panels on site and lifted them into place by crane. "The open-web wood trusses were 45 to 50 feet long, spaced 48 inches o.c.," he said. "Fortunately, we had a job site big enough to accommodate our panelization, so we started assembling the panels about six days before we began erection. We ran our installation crew for five days but then had to leave because we were too fast and caught the masons. Altogether, the roof took about 14 days to install."

Rivergate Corporate Center III

ARCHITECT: Group Mackenzie • Portland, OR
ENGINEER: Group Mackenzie • Portland, OR
GENERAL CONTRACTOR: Howard S. Wright Constructors • Portland, OR
ROOF ERECTOR: Panelized Structures Inc. • Modesto, CA

Sometimes, a building is the perfect candidate for a hybrid panelized roof system. Subaru's 413,700-square-foot Distribution Center at Rivergate Corporate Center III is one example.

Tim Lessard from Panelized Structures said the project team designed the building with a hybrid roof from the outset. "They knew going in that a hybrid system would be the most economical roof."

The 35-foot-high facility has 50-foot bays throughout most of the building, with 60-foot joists in the truck bays. The roof erector used 15⁄32-inch, 10-foot-long OSB panels to minimize waste and maximize installation efficiency. Panelized Structures spent a week setting the steel columns and hanging the steel joists and girders, and erected the rest of the roof structure in under three weeks.

"Our role was to install the steel columns, wide flange beams and joist seats that were furnished by the general contractor," said Lessard. "Then we furnished and installed the joists and girders, sub-purlins, straps, and roof sheathing, and did the field welding and nailing. It was a very straight-forward job—perfectly suited for a hybrid panelized roof system."

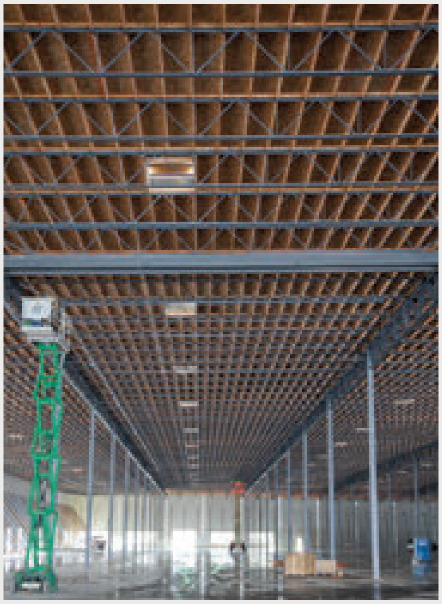


Photo: Tom Emerson

End note:
[1,2] Cost and time savings estimated by Panelized Structures

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