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Wood in Industrial Buildings

Systems, Codes, and Design Opportunities

1. Overview

This paper introduces the use of wood structural systems in industrial buildings, focusing on the advantages of light-frame, mass timber, and hybrid approaches. It outlines relevant code considerations—including construction type, allowable height and area, and fire-resistance requirements—to help designers maximize areas of wood warehouses. Through example projects, it illustrates how wood can deliver efficient, environmentally friendly, and visually distinctive designs across a range of industrial buildings.

1.1 Benefits of Wood in Industrial Building Types

From environmental performance to healthier buildings, circularity, and energy efficiency, owners and developers seeking change in the industrial sector are showing interest in wood solutions. Following is a summary of some of the benefits wood can contribute to industrial buildings.

Environmental – Wood typically has a lighter environmental footprint than conventional structural materials such as concrete and steel. This is one of the key reasons developers and owners are turning to timber systems for industrial projects.

Biophilia and wellness – When left exposed on a building's interior, wood offers a visually appealing aesthetic and biophilic benefits. Biophilia refers to the innate human desire to connect with natural materials. Emerging research shows that people in workplaces with a higher portion of visible wood report higher concentration, lower stress levels, and improved overall mood.[1] The appeal of exposed wood is often seen in the way

Amazon, Delivery Station DII5, Elkhart, IN
ZGF Architects / Atlantic AE / KPFF

Photo: Kendall McCaugherty

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About WoodWorks – Wood Products Council

WoodWorks provides education and free project support related to the design, engineering, and construction of commercial and multi-family wood buildings in the U.S. For assistance with a project, visit www.woodworks.org/project-assistance or email help@woodworks.org.

prospective tenants interact with it; some instinctively touch wood columns, a behavior rarely observed with steel or concrete. This simple tactile connection underscores wood's biophilic qualities and the unique way people respond to it. While no studies directly connect biophilic design to safety in warehouses, it is worth considering whether the calming, stress-reducing qualities of wood could support safer work environments—an area for future research.

Blast and impact resistance – Mass timber panels have shown strong performance in blast and impact testing. The U.S. Army Corps of Engineers' *PDC-TR 18-02 Analysis Guidance for Cross-Laminated Timber Construction Exposed to Airblast Loading* aligns cross-laminated timber (CLT) design with Department of Defense blast-resistance standards, recognizing its potential for protective applications. Testing of thicker CLT panels has also demonstrated resistance to tornado-driven debris impacts; however, thinner 3-ply panels that might be more efficient in exterior walls of warehouses and data centers require further study to confirm performance under vehicle or equipment impact conditions.

Lighter weight – Wood is a relatively lightweight material with a high strength-to-weight ratio, and this can provide benefits in certain warehouse conditions. For example, a wood wall panel is lighter than a concrete tilt-up wall panel, potentially reducing crane size requirements.

Amazon, Delivery Station DII5
ZGF Architects / Atlantic AE / KPFF

In addition to a hybrid panelized wood roof system and CLT walls in the warehouse, two 550-foot-long mass timber canopies on the building's exterior provide shelter for drivers and employees. Mass timber is also used extensively in the office block. The design of the 171,341-square-foot facility incorporates 40 carbon-reduction initiatives, more than half of which target the embodied carbon in materials. The use of exposed structural wood also contributes to occupant wellbeing.

Photo: Kendall McCaugherty

Prologis Nexus, San Leandro, CA
Ware Malcomb

Architectural paneling with a wood grain pattern defines the entry façade of this industrial flex building addition while inside, the office mezzanine is framed with exposed CLT floor panels and glue-laminated timber (glulam) beams and columns. The existing warehouse features a hybrid panelized roof with light-frame timber joists and decking exposed on the ceiling side. The timber elements reflect Prologis' commitment to sustainability and creating spaces that feel both innovative and human. The design has resonated with prospective tenants and exposed timber has been a big part of the interest in leasing.

Photo: Vantage Point Photography Inc.

Small timber panels can also be installed with forklifts. On sites with problematic soils, lighter structural systems can sometimes lead to smaller foundations and/or reduced soil remediation. That said, in one-story warehouses that require soil remediation for super-flat slabs, the weight savings of timber may not significantly reduce below-grade requirements the way it can for multi-story buildings.

Acoustics – Exposed wood walls or ceilings may soften sound reflections compared to surfaces such as metal and possibly concrete depending on the coating/sealant and noise frequencies. In large open warehouses, wood alone will not resolve reverberation challenges, but the effect may be more noticeable in smaller spaces and contribute to a less harsh sound environment. While acoustic studies have been performed in office and residential buildings, acoustic performance depends on the space and contents and studies specific to warehouses are needed to accurately predict performance.

Energy efficiency and insulation – Wood has low thermal conductivity and higher thermal insulation compared to steel and concrete. As a result, wood buildings are easy to insulate to high standards. In hot climates without air conditioning, better-insulated façades could potentially help reduce heat stress and related absenteeism during extreme weather events.

Because other factors have a greater influence on energy efficiency than the choice of structural material, a more relevant point for many building designers is that wood building systems have low embodied carbon.

Circular economy – Wood is a natural, renewable material harvested at the earth's surface, with new trees planted in its place—unlike steel and concrete, which rely on extracting minerals from deep below ground. This efficient input of raw materials aligns with the goals of a circular economy.

Beyond being renewable, wood products can be reused. Heavy timber members are often reclaimed and valued for both performance and character. Industrial warehouses often utilize sizable members that could be disassembled and repurposed at the end of a building's life, an additional upside for timber construction.

Prefabricated systems such as panelized wood roofs and mass timber panels can also reduce waste by improving material efficiency during construction.

1.2 Industrial Building Types

Industrial real estate typically encompasses buildings where goods are manufactured, stored, or distributed. While the sector continues to evolve—adding new subtypes such as cold storage, data centers, and last-mile facilities—most industrial buildings can be categorized into three primary groups: manufacturing, storage and distribution (warehouse), and flex.

Manufacturing buildings are used for producing, fabricating, and assembling goods, and range from heavy industrial plants tailored for a specific process to lighter, more adaptable spaces suitable for a wide range of smaller tenants.

Storage and distribution (warehouse) facilities serve as logistics hubs for storing, sorting, and shipping products, including fulfillment centers, cross-dock (truck terminal) facilities, and cold storage.

Flex buildings combine industrial and office or lab uses, serving sectors such as high-tech, life sciences, and light manufacturing.

TABLE 1: Industrial building types and typical design criteria

Building Type	Use Notes	Examples	Office Area Typical %	Clear Height (ft)
Manufacturing:				
Heavy	Customized for occupant; high power demand; heavy loads and vibrations; remote industrial zones	Ship building, heavy equipment, metal fabrication	5 to 10%	Varies
Light	Less specialized; adaptable to new tenants; lower loads and vibrations; suburban, urban, or mixed-use zones	Electronics assembly, furniture shops, textile/ apparel, labs	< 20%	18+
Storage and Distribution (Warehouse):				
General purpose	General storage or distribution facilities	Bulk warehouses, air cargo distribution	< 5%	32+
Fulfillment	Storage and shipping; includes last-mile, mid-mile, and gateway facilities	E-commerce and distribution hubs	< 20%	32+ to 40+
Truck terminal	Sorting and transfer of goods; trucks load/unload on opposite sides; minimal storage	Cross-docking stations	< 5%	16+
Cold storage	Temperature-controlled storage; highly specialized systems; fewer employees	Food or pharmaceutical storage	< 5%	50+
Owner-specific warehouse	Purpose-built for single user	University library storage, military storage	Varies	18+
Flex:				
General purpose	Combines office, lab, R&D, and light manufacturing; high-tech or life-science uses	R&D or high-tech facilities	30+%	20+ smaller 28+ typical
Showroom or service center	Combines product display, sales, and limited service or repair	Auto service, building material showrooms	30+%	28+
Data centers	Specialized for data processing and server storage; low occupancy	Data processing facilities	Low	18+

Adapted from: Commercial Real Estate Terms and Definitions by the NAIOP Research Foundation and What are the Types of Industrial Real Estate Buildings by Prologis

2. Structural Wood Products and Systems

In industrial buildings where efficiency drives cost, hybrid systems that combine wood with steel or concrete can optimize performance, speed, and economy. Modern wood construction—using light-frame products, mass timber panels, or panelized roof and wall systems—offers flexibility, long spans, and a lighter environmental footprint. Manufacturers and designers are also advancing new wood products and system innovations to expand industrial applications even further.

Browse the *Manufacturer & Supplier Directory* on the WoodWorks Innovation Network (WIN) to learn which products are produced by which companies, ask performance and supply questions, and scout materials for projects.

2.1 Light-Frame Wood Products

Light-frame wood construction uses sawn or engineered lumber closely spaced and often combined with structural sheathing to form load-bearing walls, floors, and roofs. Strength and stiffness are achieved through repetition and panel action making this system efficient and adaptable. In industrial buildings, light-frame wood and hybrid systems can be used in roofs, exterior walls, and interior elements depending on the building's construction type classification. Common light-frame structural wood products include:

Dimensional lumber framing – Used for studs, joists, rafters, and blocking, dimensional lumber forms the backbone of light-frame construction. Members are typically nominal 2-inch sizes (e.g., 2x4, 2x6, 2x10) arranged at regular spacings of 12, 16, or 24 inches.

Wood structural panels (WSPs) – Plywood and oriented strand board (OSB) sheathing are applied to framing to provide diaphragm and shear wall action for both gravity and lateral loads. These panels also serve as subflooring, roof decking, and wall sheathing.

Engineered wood framing members – Engineered products extend spans and improve consistency. Common examples include:

- I-joists with wood flanges and OSB or plywood webs for long-span floors and roofs
- Laminated veneer lumber (LVL) or laminated strand lumber (LSL) for beams, headers, and rim boards

Smaller LVL and LSL products are classified under structural composite lumber (SCL). Larger members are often classified under mass timber and are discussed in the next section.

Trusses – Trusses consisting of light-frame wood or hybrid systems with steel are efficient for spanning longer distances with a lower volume of material. Examples include metal plate-connected trusses made from small-dimension lumber joined with pressed metal plates, and open-web trusses with top and bottom chords made from sawn or engineered wood and steel tubular webs.

2.2 Mass Timber Products

Mass timber consists of wood members that are adhesively bonded or mechanically fastened to form large panels for roofs, floors, and walls, or into beams and columns.

While innovative systems continue to be developed within the mass timber category, common products currently include:

Cross-laminated timber (CLT) – CLT consists of layers of dimension lumber (typically three, five, or seven plies) oriented at right angles to one another and then glued to form structural panels with exceptional strength, dimensional stability, and rigidity. CLT can be used for walls, floors, and roofs—as a stand-alone system or with other structural products (e.g., post and beam)—and is often left exposed on the interior of buildings.

Traditional Heavy Timber

In the late 19th and early 20th centuries, it was common to construct "brick and beam" industrial buildings from large solid sawn members referred to as heavy timber. Today, heavy timber is generally considered part of the broader mass timber category, as both share similar performance attributes, including inherent fire resistance and structural robustness.

Terminal Warehouse, New York City
COOKFOX Architects / DeSimone

Built in 1891, the Terminal Warehouse showcases the strength and beauty of heavy timber construction. Its preserved timber frame remains a defining feature in the building's adaptive reuse, illustrating how historic industrial structures continue to inspire modern wood design.

Photo: Alex Ferrec, COOKFOX Architects

Glue-laminated timber (glulam; may be referred to as GLT when used as panels) – Glulam is composed of individual wood laminations (dimensional lumber), selected and positioned based on their performance characteristics and bonded together with durable, moisture-resistant adhesives. It is typically used as beams and columns, but can be used in the plank orientation for floor or roof decking. It can also be curved and bent, lending itself to the creation of unique structural forms.

Nail-laminated timber (NLT) – NLT is created from individual dimensional lumber members (e.g., 2x4, 2x6), stacked on edge and fastened with nails or screws to create a larger structural panel. Commonly used in floors and roofs, it offers the potential for a variety of textured appearances in exposed applications. Like glulam, NLT lends itself to the creation of unique forms, and WSPs can be added to provide a structural diaphragm.

Dowel-laminated timber (DLT) – DLT panels are made from dimensional lumber boards (e.g., 2x4, 2x6) stacked like the boards of NLT but friction-fit with hardwood dowels. The dowels hold each board side-by-side, while the friction fit adds dimensional stability.

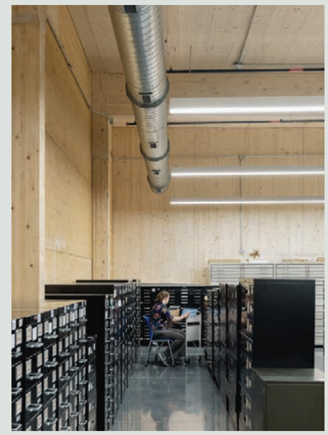
Structural composite lumber (SCL) – SCL is a family of wood products created by layering dried and graded wood veneers, strands, or flakes with moisture-resistant adhesive into blocks of material, which are subsequently re-sawn into specified sizes. As noted, two SCL products—LVL and LSL—are relevant to the mass timber category as they can be manufactured as panels in sizes up to 8 feet wide, with varying thicknesses and lengths. Parallel strand lumber (PSL) columns are also used in conjunction with other mass timber products.

Tongue and groove decking (T&G) – Structural T&G decking is made from lumber at least 1-1/2 inches thick, with the flat (wide) face laid over supports such as beams or purlins for floors and roofs. Available in a variety of species, thicknesses, and lengths, it can be used where the appearance of exposed wood decking is desired for aesthetics or where its mass is desired for fire resistance.

Trusses – Trusses can be constructed from glulam, SCL, or hybrid wood and steel combinations and can be efficient for spanning long distances for manufacturing facilities.

More information on mass timber products, applications, and sourcing can be found in the WoodWorks publication, *What is mass timber?*

University of Arkansas Library Storage Facility, Fayetteville, AR
Perry Dean Partners Architects / MBL Architects (AOR) / Robbins Engineering



This all-timber structure houses the university's library collections in tall racks beneath a 45-foot clear height, constructed with glulam beams and columns and CLT wall and roof panels. A hardened facility designed for resilience in a tornado-prone region, the mass timber structure provided cost savings over a system with steel framing, a concrete roof, and fully-grouted CMU walls while offering some projectile impact resistance to safeguard its valuable contents.

Photos: MBL Architects (top); Chuck Choi (bottom)

Janicki Industries Warehouse Building 10
Carletti Architects / DCG/Watershed

A challenging construction timeline drove the use of mass timber in this manufacturing facility, which includes concrete tilt-up walls and glulam columns supporting large glulam trusses spanning 80 to 102 feet. Glulam rails attached to the columns support huge overhead cranes needed for the company's manufacturing processes.

Photo: Jordan Janicki

2.3 **Panelized Systems**

Panelized Roofs

Panelized roofs are prefabricated assemblies—typically light-frame wood or hybrid wood-steel systems—constructed either off site or on the ground and lifted into place. These systems are efficient to install, reducing labor costs and construction time while providing reliable structural performance. All-wood and hybrid panelized wood roof systems have been widely used on the West Coast for decades.

All-wood systems use glulam beam girders with wood purlins (glulam, I-joists, or open-web wood trusses), wood sub-purlins and a wood structural panel deck. Common for spans under 40 feet, all-wood systems are well suited for buildings that suspend conveyor equipment from the roof structure or for food-processing facilities that need to minimize dust from overhead joists. They are also a good choice when an exposed roof structure is desired to highlight wood's aesthetic and biophilic qualities.

Hybrid systems combine steel purlins and girder trusses with the erection efficiency of wood sub-purlins and a wood structural panel deck. The long-span capability of steel framing makes these systems economical for spans ranging from 32 to 60 feet and much larger spans can be accommodated. In a hybrid system, panelized wood components are connected to open web steel joists. This system is efficient for large industrial structures requiring long spans.

Designers have flexibility in specifying components for panelized roof systems. Wood structural panels can be OSB or plywood, in 4x8 or 4x10 sheets, even 8x8 jumbo panels. Panels are attached to sub-purlins (commonly 2x4, 2x6, 3x4, or 3x6 members). All-wood systems may use I-joists, open-web trusses, or 2-1/2-inch glulam members for purlins, while hybrid systems generally use open-web steel joists.

Mass timber panels can offer similar advantages to light-frame wood panelized roofs. In addition to fast installation, mass timber roof systems can resist heavier gravity loads and provide impact resistance. In industrial buildings where designers have historically defaulted to concrete roof systems, mass timber may offer a competitive alternative with a lighter environmental footprint. The most cost-effective mass timber roof designs are realized where grids are flexible to allow for material optimization.

Panelized Walls

Panelized wall systems can be constructed out of light-frame wood or mass timber and offer an alternative to concrete tilt-up, precast, or steel-frame walls. Light-frame panelized wall systems are increasingly common in midrise applications, though current fabrication heights are typically shorter than those required for many warehouse projects. As market demand grows, opportunities exist for manufacturers to expand capabilities to produce taller wall panels suitable for industrial use.

- SCL studs can provide stability for taller non-load-bearing walls while glulam studs can achieve any height. For light-frame exterior walls, dimensional lumber is suitable for Type V construction, and fire-retardant-treated wood (FRTW) may be used for Type III construction. See Section 3.2, *Wood and Construction Types*, for more detail.
- Mass timber panels can also be utilized in panelized exterior wall systems, with panels spanning either horizontally or vertically. For further discussion on panel orientation, see Section 5.2, *Columns and Parapets*.

Where used in place of concrete tilt-up walls, wood panelized systems can shorten construction schedules by eliminating concrete curing time and enabling faster installation. Prefabricating panels with insulation and exterior finishes further accelerates erection and enclosure. The lighter weight of wood allows for smaller cranes or forklifts and, in some cases, may reduce foundation size or soil remediation costs—though, as noted, benefits may be limited where super-flat slabs are required.

Finally, prefabricated wood panels can help reduce on-site labor and create safer, cleaner construction sites, reinforcing wood's growing appeal for efficient and sustainable industrial projects.

For additional resources, see WoodWorks' Off-Site / Panelized Construction webpage.

1391 Horizon Ave, Lafayette, CO
Hunter Jorgensen / RVP Architecture

This 25,000-square-foot flex industrial building was fully prefabricated with panelized wall systems consisting of glulam studs with wood sheathing exposed on the interior. Glulam bents provide lateral resistance, and a 24-foot clear height was achieved. Exposed wood creates a warm, differentiated aesthetic that contributed to fast leasing—demonstrating that a modest cost premium can deliver a rent premium and attract high-quality tenants.

Photo: Hunter Jorgensen

2.4 Vertical and Lateral Load-Resisting Systems

The wood products and systems described in previous sections can all be designed to resist gravity (vertical) loads. For detailed guidance, see the WoodWorks publication, *Structural Design of Mass Timber Elements: Gravity Design Examples.*

The most effective system for resisting lateral wind and seismic loads in an industrial building depends on its configuration, seismic design category (SDC), and local code provisions—particularly in high-seismic or hurricane regions. Panelized light-frame or mass timber walls can be efficient as shear walls in warehouses; wood walls are lighter than concrete, reducing diaphragm and foundation loads. For light-frame wood walls, horizontal girts can reduce required stud depths for tall spans.

In some buildings, the most efficient strategy is to have timber panels resist out-of-plane and lateral loads while a separate glulam or steel frame handles gravity loads. Where mass timber panels must carry both gravity and lateral loads, thickness increases. As the cost of mass timber systems is correlated with fiber volume, it is typically advantageous to design a system with the least fiber volume while balancing the cost of connections and other elements of hybrid systems. Some manufacturers also limit axial loads on taller, thinner wall panels.

For a discussion of shear wall approaches for mass timber, see the WoodWorks' article, *CLT Shear Wall Options in the U.S.* Where exterior walls are framed with vertically-oriented CLT wall panels resting on foundations, reference the American Wood Council (AWC) design standard, Special Design Provisions for Wind and Seismic (SDPWS). The SDPWS Exception, Oregon SAM path 2, and SDPWS Appendix B shear walls are all potential code approaches depending on the SDC and local jurisdiction. For horizontally-oriented CLT wall panels spanning between columns, the SDPWS Exception and Oregon SAM path 2 shear walls are potential approaches.

Timber braced frames have been used on some projects, but their design is not explicitly addressed in current codes. Hybrid or timber structural bents—i.e., repetitive rigid frames composed of beams and columns—might be another option for smaller industrial buildings. Both of these approaches would require approval through an Alternate Materials and Methods Request (AMMR).

In addition to timber lateral systems, steel braced or moment frames and concrete shear walls can be utilized for hybrid industrial buildings with other wood systems.

3. Fire and Life Safety

Limitations on building size are regulated by the International Building Code (IBC) and are a function of occupancy and construction type, as well as the presence or absence of active fire sprinkler systems. Unless otherwise noted, references in this document refer to the 2024 IBC.

Occupancy classifications consider factors such as the number and mobility of occupants, and the type and quantity of combustible or hazardous materials stored within the building. Construction type defines the degree to which combustible structural building materials are allowed. Together, the combustibility of the building's structure and contents determine the total fuel load. Allowable building size is then based on this fuel load, combined with the hazard associated with the building's intended use.

For example, warehouses often store large volumes of goods such as cardboard, textiles, or packaged consumer products. While these contents increase the potential fuel load compared to a typical office, the IBC provides clear pathways for designing safe and efficient warehouse buildings. This includes provisions for sprinklers, noncombustible or heavy/mass timber construction types, and other strategies that enable wood warehouses to be both code compliant and cost effective.

3.1 Occupancy Classifications

Warehouse occupancies are typically classified based on two main factors: the combustibility of their contents and degree to which the contents pose a health hazard. The IBC occupancy definitions describe not only what is included in each group but also exclusions, such as uses that fall into Group H because of higher hazard levels.

Chapter 2 of the IBC provides definitions for combustible dust, fibers, and liquids. It also contains long lists of example materials in the Group F (Factory Industrial) and Group S (Storage) sections. This paper cites only a few examples.

- **Assembly Group A**: Spaces used for gathering people for civic, social, or recreational purposes, food and drink consumption, or viewing of entertainment or sports. Assembly areas may include:
  - A-2: Spaces intended for food and drink consumption, such as cafeterias and tasting rooms
  - A-3: Spaces for worship, recreation, or amusement not otherwise classified, including training rooms, fitness centers, or community spaces
  - A-4: Spaces with spectator seating and intended for viewing indoor sporting events and activities

Prologis Evergreen, Brampton, Ontario
Ware Malcomb / ASPECT Structural Engineers

This 246,000-square-foot speculative distribution warehouse features 54x50-foot grids and a mass timber superstructure with glulam beams and columns supporting CLT roof panels—replacing the steel columns, joists, and metal deck typical of industrial buildings. The use of sustainably sourced mass timber reduced embodied carbon by 62% compared to a conventional steel system, advancing Prologis' goal of net-zero emissions by 2040.

Photos: Ware Malcomb

- **Business Group B**: Areas of buildings used for office and professional services. Examples include an architect's office, space used for electronic data entry, and motor vehicle showrooms. Earlier editions of the IBC used the term "electronic data processing." This was revised to "electronic data entry" in the 2024 IBC.
- **Factory Industrial Group F**: Areas of buildings used for assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair, or processing operations that are not classified as Group H or Group S.
  - **F-1 Factory (moderate hazard)**: Fabrication or manufacturing of **combustible** materials. Examples include aircraft, athletic equipment and textile manufacturing, and production or assembly of lithium-ion batteries. The definition of combustible dust was updated in the 2024 IBC and may affect areas that generate fine wood dust during fabrication.
  - **F-2 Factory (low hazard)**: Fabrication or manufacturing of **noncombustible** materials that are not considered a significant fire hazard. Examples include beverages (up to 16% alcohol), ceramics, and ice.
- **High-Hazard Group H**: A building, or portion thereof, used for the manufacturing, processing, generation, or storage of materials that constitute a physical or health hazard in quantities exceeding the code's allowable limits. High-hazard occupancies are defined in IBC Section 307 and special detailed requirements are outlined in Sections 414, 415, and others as applicable in Chapter 4.
- **Group M**: Areas accessible by the public and used for the display and sale of merchandise, including department stores, retail stores, markets, and wholesale showrooms.
- **Storage Group S**: Includes areas of buildings used for storage that is not classified as hazardous.
  - **S-1 Storage (moderate hazard)**: Storage of **combustible** materials. Examples include cardboard, clothing and furniture. Storage of combustible materials in rack configurations and concealed spaces may need additional fire protection requirements per IBC Section 413.
  - **S-2 Storage (low hazard)**: Storage of **noncombustible** materials such as products on wood pallets or in paper wrappings. Examples include empty cans, glass, and gypsum board.

This paper focuses primarily on industrial buildings with Groups B, F, M, or S occupancies. Smaller Group A occupancies that may be accessory or incidental to the primary occupancy are also addressed. High-hazard Group H facilities tend to have complex, custom designs, and are beyond scope of this paper. Small hazardous spaces are addressed briefly.

3.2 **Wood and Construction Types**

A building's assigned construction type is the main indicator of where and when all wood systems can be used. IBC Section 602 defines five main options, Types I through V. All construction types have subcategories A and B, and Type IV has these plus others.

In the order of least to most restrictive, Types V, IV, and III construction provide the greatest opportunity to use wood structural products. Their material provisions are summarized below and in Table 2. Fire-resistance rating (FRR) requirements for building elements are dependent on construction type and explained in the next section.

Type V (IBC Section 602.5) – Structural elements can be built from any material permitted by the code. This includes light-frame wood, mass timber, and hybrid systems, all of which may be used throughout the structure—in floors, roofs, and both interior and exterior walls.

- Type V construction has two subcategories. Type V-A requires fire-resistance protection (typically 1 hour), while Type V-B allows unprotected wood construction except where exterior walls must be protected because of proximity to a property line or adjacent building.
- Because Type V has the fewest life-safety restrictions, it is often the most cost-effective option. Many wood-frame warehouses are designed under this category and take advantage of the unlimited area provisions discussed in Section 4.3.

Type IV (IBC Section 602.4) – Traditionally referred to as "heavy timber" construction, this option has been in the building code for over a century but its use has recently grown with renewed interest in exposed wood buildings. In the 2021 IBC, Type IV was renamed IV-HT and three subcategories were introduced—IV-A, IV-B, and IV-C, commonly referred to as the "tall mass timber" construction types. Type IV construction is unique in that its fire resistance relies in part on the inherent and proven fire performance of large, solid wood members, including both traditional heavy timber and modern mass timber.

For guidance on fire resistance and exposure limits, see the resources on WoodWorks' Tall Mass Timber webpage.

Type IV-HT – Structural wood components must meet minimum sizes defined in IBC Section 2304.11 and are permitted in floors, roofs, and interior walls. Exterior walls required to have an FRR of 2 hours or less are also permitted to use FRTW framing, or CLT when the exterior face is covered with FRTW sheathing or noncombustible materials. Mass timber components used in Type IV-HT construction can be fully exposed to the interior.

In most cases, light-frame wood construction (e.g., 2x wall studs or wood structural panels) is not allowed in Type IV buildings. There are two limited exceptions, which apply only to Type IV-HT:

- Exterior walls may include FRTW framing if the required FRR is 2 hours or less (IBC Sections 602.4 and 2303.2).
- Interior partitions may include light-frame wood if the wall has at least a 1-hour FRR, as required by IBC Section 2304.11.2.2.

Type IV-A, IV-B, and IV-C – These tall mass timber subtypes permit mass timber in floors, beams, columns, roofs, interior walls, and exterior walls when members meet minimum cross-section sizes, FRRs, and exposure limits. Structural and partition elements must be either mass timber meeting minimum size requirements or noncombustible materials. When mass timber elements are used in exterior walls, they are required to have noncombustible protection on the exterior face.

On the interior faces of exterior walls and roofs, the protection requirements and therefore opportunities to expose mass timber vary by subtype. Type IV-C allows full exposure of mass timber, Type IV-B partial exposure, and prescriptive designs following Type IV-A require timber to be covered with a protective noncombustible material such as gypsum board.

Type IV-B and IV-C offer exciting opportunities for large single- and multi-level infill warehouses in dense urban areas.

Salvagnini Industrial Showroom Expansion, Hamilton, OH
Professional Design Associates / Schaefer

Exposed CLT walls and roof panels supported by glulam columns highlight mass timber in this Type IV-HT project, creating a warm, refined interior that provides an ideal setting for selling sheet-metal fabrication equipment. In the expo hall, glulam beams taper to reduce timber volume for the long 80-foot span and inclined columns provide both gravity and lateral support and a defining architectural expression.

Photo: Schaefer

Type III (IBC Section 602.3) – Wood elements can be used in floors, roofs, and interior walls. Exterior walls must be constructed of noncombustible materials; however, FRTW framing is permitted in exterior walls required to have an FRR of 2 hours or less.

Type III has two subcategories—Type III-A, which generally requires a 1-hour FRR for structural elements, and Type III-B, which allows lower ratings.

Prefabricated wall panels are most efficient for warehouse construction. In Type III projects, this might include wall panels made with light-frame FRTW, or FRTW could be incorporated into mass timber panels such as NLT and DLT.

Type I and II (IBC Sections 602.2 and 602.3) – Types I and II construction are defined as noncombustible, but the IBC provides targeted allowances for wood. These provisions recognize the proven performance of FRTW and heavy timber, creating opportunities to incorporate wood in roof systems even in otherwise noncombustible buildings.

FRTW is permitted in roof construction, including girders, trusses, framing, and decking. In Type I-A buildings more than two stories above grade, it is only permitted if the distance from the uppermost floor to the roof is at least 20 feet.

Table 601 footnotes b and c also allow for the use of some wood members in Types I and II construction. See Section 3.3, *Fire-Resistance Rating (FRR) Requirements*, for more information.

Fire walls in Types IV and III construction cannot be framed with wood, but it is possible to use a noncombustible fire wall with wood-frame bearing walls on each side. This double wall system meets the structural stability requirements for fire walls but the wood-frame walls do not contribute to the fire rating.

For more detail on code requirements for exterior walls, see the WoodWorks article, *Exterior Walls in Mass Timber Buildings – Part 1: Code Requirements and Commonly Used Materials*.

A building's construction type is determined by its minimum code requirements, not solely its materials. Per IBC Section 602.1.1, individual components may meet higher construction standards without the entire building having to do so. For example, a warehouse permitted under Type V-B construction could still be built entirely of noncombustible materials or a combination of combustible and noncombustible framing.

TABLE 2: Allowable wood materials for Types III, IV, and V construction

Construction type	Type III		Type IV				Type V	
	A	B	A	B	C	HT	A	B
Exterior wall materials	FRTW		CLT (protected on exterior; interior protection varies by subtype)			FRTW, CLT (protected on exterior)	Any wood (LF, MT)	
Roof elements	Any wood (LF, MT)		Heavy timber including MT (interior protection varies by subtype)			Heavy timber including MT	Any wood (LF, MT)	
Interior elements	Any wood (LF, MT)		Heavy timber including MT (protection varies by subtype)			Heavy timber including MT; LF for interior partitions with a 1-hr FRR	Any wood (LF, MT)	
Fire wall materials	Noncombustible fire wall; opportunity for wood bearing wall on each side to meet structural stability requirements						Any wood (LF, MT)	

CLT = Cross-laminated timber; FRTW = fire-retardant-treated wood, LF= light frame; MT = mass timber
Source: IBC Sections 601 and 706

TABLE 3: FRR Requirements for building elements (hours)

Building Element	Type I		Type II		Type III		Type IV				Type V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b]	1[b]	0	1[b]	0	3	2	2	HT	1[b]	0
Bearing walls – exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Bearing walls – interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions – exterior	See Table 705.5											
Nonbearing walls and partitions – interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary members (see Section 202)	1-1/2[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1-1/2	1	1	HT	1[b,c]	0

Source: IBC Table 601 / See IBC for footnotes

3.3 Fire-Resistance Rating (FRR) Requirements

Fire-resistance ratings apply to building materials, systems, and elements (e.g., walls, roofs, floors, columns, and other structural components), and define how long (in hours) an element must maintain structural integrity or limit fire spread. FRRs are based primarily on construction type and separation requirements, but are also closely tied to occupancy, allowable building size, and sprinkler protection. Table 3 summarizes required FRRs for each construction type as defined in IBC Table 601.

Footnotes b and c of IBC Table 601 allow for the use of wood as follows:

- Footnote b permits unprotected FRTW roof members where there is at least 20 feet of vertical clearance above the floor or mezzanine below. This exception does not apply to Groups F-1, H, M, or S-1, which are common warehouse occupancies.
- Footnote c allows heavy timber in roof construction for any construction type other than I-A when the required FRR is 1 hour or less (IBC Section 603.1.19).

In addition to requirements related to construction type, FRRs may be required in other sections of the IBC. For example, separations between occupancies (Section 508.4), incidental uses (Section 509), and special provisions (Section 510) also require FRRs for select components and assemblies.

Load-bearing vs. non-load-bearing exterior walls – For exterior walls, FRR requirements depend on whether the walls are load-bearing or non-load-bearing and the fire-separation distance (FSD) from adjacent buildings. Per IBC Table 601, load-bearing exterior walls have a required FRR of 0 hours in Type V-B construction, 1 hour in Type V-A, and 2 hours or more in Types III and IV. If a warehouse can be classified as Type V-B construction and the FSD is greater than 10 feet, no FRR is required. This includes Type V-B buildings of unlimited area meeting the provisions of IBC Section 507 as described in Section 4.3, *Unlimited Area Buildings*. Load-bearing walls must also meet the FRRs based on FSD per IBC Section 705.5.

Non-load-bearing wall FRRs depend on the FSD from adjacent buildings per IBC Table 705.5. Where the FSD is greater than 30 feet for Group H hazardous occupancies or 10 feet for other occupancies, no FRR is required for Types II-B and V-B construction. Strategically using inboard structural framing can help classify exterior walls as non-load-bearing and reduce required FRR ratings. See further discussion in Section 5.2, *Columns and Parapets*.

Methods to Demonstrate FRRs

Light-frame wood construction, mass timber, and hybrid systems can achieve FRRs through the makeup of assemblies, often in combination with gypsum wall board, and through the calculated char resistance of wood elements. The predictability of wood's char rate has been well-established for decades and has long been recognized in building codes and standards. IBC Sections 703.2 and 703.3 permit multiple ways to demonstrate

FRRs of structural members and assemblies. One method noted in Section 703.3 is to calculate the rating in accordance with IBC Section 722. Section 722.1 states:

> *The calculated fire resistance of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AWC National Design Specification® for Wood Construction (NDS®).*

Chapter 16 of the NDS can be used to calculate up to a 2-hour FRR for a variety of exposed wood members, including solid sawn, glulam, SCL, and CLT.

For more information on fire resistance, see the WoodWorks articles, *Determining FRR Ratings When There's No Matching UL Assembly* and *Using Char Methods to Demonstrate Fire Resistance of Exposed Wood Members*, and the fire resources section of the *Mass Timber Technical Reference Guide*.

3.4 Selecting a Construction Type

Construction type is one of the more significant design decisions for buildings. While it is common to associate Type II construction with steel and concrete, Type V with light-frame wood, and Type IV with mass timber, selecting a construction type based on these presumed associations can lead to unnecessary costs. Understanding the full range of material options within each type can reduce cost and increase efficiency.

Most steel and concrete warehouses are designed as Type II construction—which, as noted, offers select opportunities for the use of wood. However, Types V, IV, and III construction allow many opportunities to incorporate wood in industrial buildings.

For cost efficiency, it is usually best to start with an analysis of Type V-B, which offers the least restrictive fire-resistance requirements and the most material flexibility. Type V-A allows for larger building areas than V-B, but also requires a 1-hour FRR for many building elements.

If Type V does not meet the needs of the building's design parameters, the next most cost-effective options are likely Types IV-HT and III. When comparing these types, it is important to consider materials permitted in exterior walls and concealed space requirements. Type IV-HT allows mass timber to be exposed and permits exterior walls of FRTW or CLT (protected on the exterior face), but there are nuances related to protection of concealed spaces per IBC Section 602.4.4.3. Except for exterior bearing walls, Type IV-HT does not require demonstration of FRRs for structural elements, which is a requirement for all other construction types when an FRR is required. Exterior walls of Type III construction require noncombustible framing or FRTW. Type III-B does not require FRRs except for exterior walls that are bearing or as required based on fire-separation distance. For further discussion, see Section 5.1 *Concealed Spaces*.

4. Allowable Building Size

The maximum size of a building is based on its occupancies, construction type, sprinkler protection, and open space around the perimeter. Chapter 5 of the IBC details allowances for heights and areas; heights and number of stories are addressed in Section 504 and areas in Sections 506 and 507.

IMPORTANT: IBC Section 507 includes provisions for unlimited area (covered in Section 4.3 of this paper). For industrial buildings in particular, it is advantageous to check whether the building can meet these provisions before moving on to the allowable area provisions of Section 506.

IBC Section 503.1.1 addresses special industrial occupancies. It allows for buildings and structures that house low- and moderate-hazard industrial processes requiring large areas and unusual building heights to accommodate craneways or machinery and equipment to be exempt from the height and area limitations in Sections 504 and 506—without necessarily having to meet the unlimited area provisions of Section 507. It is up to the local Authority Having Jurisdiction (AHJ) to determine whether an industrial building can be classified under Section 503.1.1.

Two buildings on the same lot can either be treated as separate buildings or as portions of a single building where the building height, number of stories, and aggregate areas meet the limitations of those for a single building. Fire walls can also be used to separate a building into multiple buildings.

4.1 Building Height

Building heights are governed by IBC Section 504, which includes two tables that are used to determine a building's allowable height. Table 504.3 lists allowable building heights in feet (measured from grade plane to the average roof height of the highest roof surface) by construction type. Types V-A and V-B have allowable heights of 70 and 60 feet, respectively, while the maximum is 75 feet for Type III-B and 85 feet for Types IV-HT, IV-C, and III-A. The other two tall mass timber subtypes—IV-A and IV-B—allow for even greater heights and additional stories. Table 504.4 lists allowable height in number of stories above grade plane.

United Therapeutics Hangar, Concord, NH
SMP Architecture / Artisan Engineering / Art Massif

A modern aircraft hangar built with mass timber, the United Therapeutics Hangar showcases the strength, sustainability, and aesthetic warmth of engineered wood in high-performance industrial design. Hybrid glulam and steel trusses spanning 210 feet are supported by 42-foot-tall glulam columns, which, together with tilt-up wood wall panels, allowed the project to be built quicky. Glulam chevron bracing serves as the lateral force-resisting system.

Photo: Ridgeline Studios

There are some exceptions in Chapters 4 and 5 where projects meet the requirements. For example, for an unlimited area building, Section 504.1.1 allows its height to follow the provisions in Section 507. Also, the special provisions of IBC Section 510 are primarily intended for multi-story buildings and may offer flexibility for multi-level or mixed-use industrial projects. For aircraft hangars and facilities used for aircraft manufacturing, building height is unlimited when the building is equipped with an automatic sprinkler or fire-extinguishing system in accordance with IBC Chapter 9, and when the building is surrounded by yards at least 1.5 times its height.

4.2 Mezzanines and Equipment Platforms

Mezzanines and equipment platforms are defined in IBC Chapter 2. A mezzanine is an intermediate level between the floor and ceiling of any story and must comply with IBC Section 505. Equipment platforms are unoccupied and used exclusively for mechanical systems or industrial processing equipment.

To qualify as a mezzanine, the area of the intermediate level must be less than or equal to one-third of the area of the story below. If there is more than one mezzanine, this area limit applies to the sum of the areas of the intermediate levels. If greater than one-third of the area of the floor below, the intermediate level(s) must be classified as a separate story. There are some exceptions for Types I and II construction that might apply to industrial buildings.

The aggregate area of equipment platforms is limited in size to two-thirds of the area of the room in which they are located. If the building has sprinklers, the platform is required to be protected by sprinklers from above and below. When mezzanines and equipment platforms are on the same level, their aggregate area shall not be greater than two-thirds of the room in which they are located.

A space meeting the mezzanine requirements of Section 505 does not contribute to the building area or number of stories as regulated by Section 503.1, but the area of the mezzanine must be included in the fire area determination. The clear height above and below the mezzanine floor is required to be at least seven feet.

4.3 Unlimited Area Buildings

IBC Section 507 allows buildings of unlimited area when specific conditions are met. For industrial projects surrounded by open space, this can be one of the most cost-effective approaches, as it often permits the least restrictive construction type while allowing a large footprint. Designers are encouraged to first determine whether a project qualifies under Section 507 before calculating allowable areas per Section 506, which can be more restrictive and may require higher FRRs.

Unlimited area buildings generally share four criteria:

- An automatic sprinkler system (except for nonsprinklered buildings meeting the provisions of Section 507.3)
- Sixty feet of open space (frontage) around the building
- A maximum height of one or two stories above grade (a single-story basement is permitted)
- Primary spaces classified as low- or moderate-hazard occupancies

Prologis Nexus, San Leandro, CA
Lowney Architecture in collaboration with Prologis

This spec office addition to an existing warehouse features a 4,900-square-foot mass timber mezzanine with glulam beams and columns and CLT floor deck. The differentiating features of the timber mezzanine helped reposition this existing warehouse with an elevated aesthetic and appeal.

Photo: Vantage Point Photography

Accessory occupancies are permitted in unlimited area buildings per Section 507.1.1, provided they meet the provisions of Section 508.2. (See Section 4.5, *Mixed-Use Code Analysis* for more detail.)

Open space around the building is a key factor in qualifying for the unlimited area provisions. While "open space" is not specifically defined in the IBC, it is useful to look at the definition of "yard." Chapter 2 defines yard as: "An open space, other than a court, unobstructed from the ground to the sky, except where specifically provided by this code, on the lot on which a building is situated." This definition can reasonably be interpreted to describe the open space required for frontage.

Section 507 provisions typically require a minimum public way or yards around the building of 60 feet in width. Under certain conditions, Section 507.2.1 allows for reduced open space of 40 feet for up to 75 percent of the building perimeter, and requires a 3-hour FRR at exterior walls and openings with reduced open space. The open space requirements are summarized in Figure 1.

Industrial buildings typically have primary uses of Group B, F, M, or S occupancies and may benefit from the following unlimited area provisions:

- **Nonsprinklered, one-story buildings** (IBC Section 507.3): Group F-2 or S-2 buildings are permitted to be of unlimited area and any construction type without sprinklers. These low-hazard occupancies involve noncombustible contents with a low fuel load, so sprinklers are not required.
- **Sprinklered, one-story buildings** (IBC Section 507.4): Group B, F, M, or S occupancies no more than one story above the grade plane may be of unlimited area if provided with an automatic sprinkler system.
  - Group A-4 occupancies (indoor sporting events with spectator seating) are also permitted but must be other than Type V construction. The code also includes an exception for certain A-4 facilities where a sprinkler system may not be required.
  - An exception allows certain rack storage facilities of Type I or II construction to be of unlimited height.
  - Certain Group A-1 and A-2 occupancies in mixed-use buildings may also qualify when they meet the maximum areas, area separations, and exit requirements outlined in Section 507.4.1.
- **Sprinklered, two-story buildings** (IBC Section 507.5): Group B, F, M, or S occupancies no more than two stories above the grade plane can be of unlimited area provided the building has an automatic sprinkler system. Group A occupancies are not permitted in either story of a two-story unlimited area building.

IBC Section 507.8 permits hazardous spaces in unlimited area mixed-use buildings with Group F or S occupancies, including Group H-2, H-3, and H-4, in accordance with Sections 507.4 or 507.5. In such cases, the cumulative area of hazardous spaces is limited to 10 percent of the building area or to the area limits for Group H occupancies in Section 506, which are based on the building's construction type. Locating hazardous spaces at the building perimeter can increase their allowable area. Reduced open space around the unlimited area is not permitted for buildings with hazardous spaces.

Additional criteria in Section 507 for unlimited area buildings may apply to specific uses, such as aircraft paint hangars.

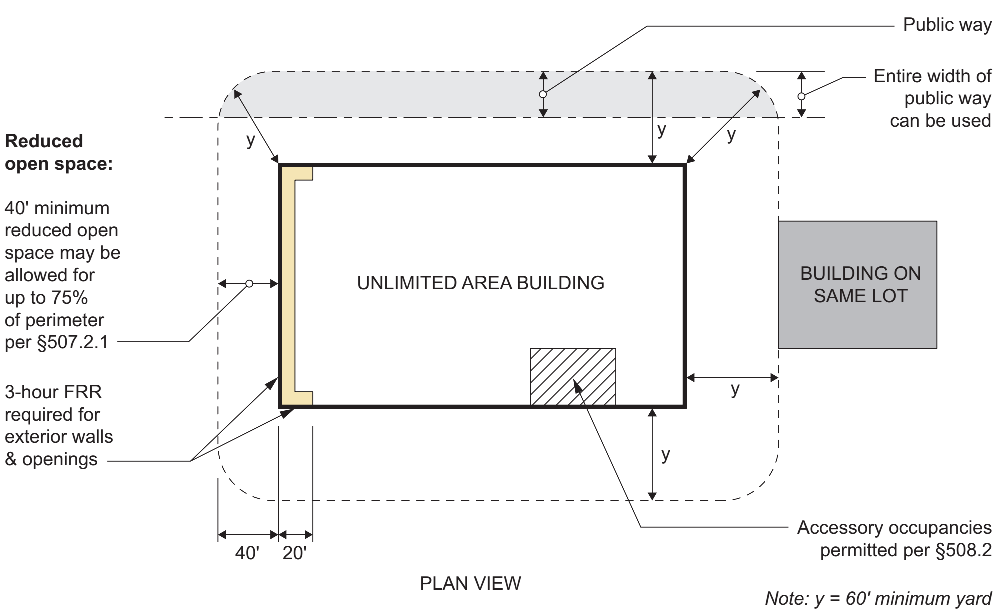
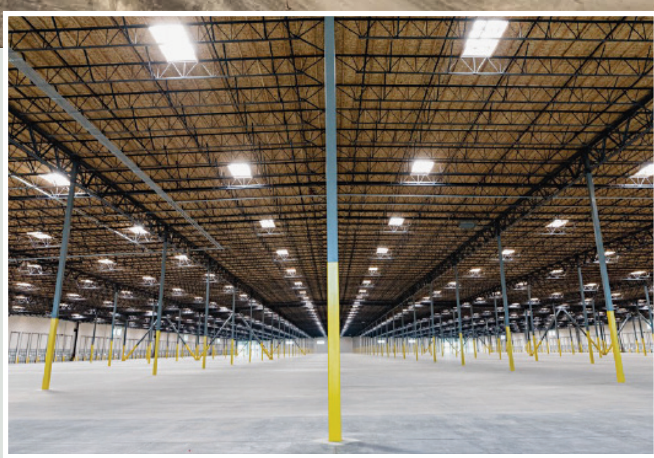


FIGURE 1: Open space requirements for unlimited area buildings



Think “big bombers” can’t be built with wood?
Hybrid wood roof systems are frequently used for large scale warehouses on the west coast, including “big bombers” over a million square feet. The aerial image shows an expansive panelized roof in various stages of construction. The project on the left combines steel bar joists with wood decking and light-frame sub-purlins. The hybrid panelized roof system can provide schedule and material cost savings and reduced labor, while benefiting from the lightweight properties of wood.

Photos: Panelized Structures

Type I buildings are permitted to have unlimited height and area per Sections 504 and 506, and do not need to comply with Section 507 requirements as noted in Section 503.1.3.

For buildings that do not have the full 60-foot open space but have a minimum of 30-foot yards and meet all other requirements of Section 507, a frontage increase may be applied to the allowable area per Table 506.3.3.1. See the next section for more on frontage increases.

When site conditions allow for the full 60-foot open space, the unlimited area provisions can provide significant advantages for industrial projects to be designed with a range of wood and hybrid structural systems.

4.4 Calculating Allowable Building Area

While the unlimited area building approach has significant advantages, not all sites have the substantial perimeter clear space needed to comply. For these projects, allowable area must be calculated in accordance with IBC Section 506.

The first step is to determine the allowable area factor, A_t, from Table 506.2, which varies by occupancy, type of construction, sprinkler system, and number of stories. The allowable area factor is used in equations and factored by an increase based on open frontage around the building. IBC Sections 506.2.1 and 506.2.2 address single-occupancy and mixed-occupancy buildings, respectively.

Allowable Area, Single-Occupancy Building

The simplest evaluation is for buildings with only one occupancy classification. For single-occupancy buildings with a maximum of three stories above grade plane, the allowable building area of each story is determined using IBC Equation 5-1:

$$A_a = A_t + (NS)(I_f)$$

where:

A_a = Allowable area in square feet (ft^2)

A_t = Tabular allowable area factor based on actual sprinkler conditions per IBC Table 506.2

NS = Tabular allowable area factor per Table 506.2 for a non-sprinklered building, regardless of whether the building is sprinklered

I_f = Area factor increase due to frontage (percent) as calculated per Section 506.3

Section 506.2.1 also provides requirements for calculating allowable area for single-use buildings over three stories.

Allowable Area, Mixed-Occupancy Building

For buildings that contain more than one occupancy classification, the allowable area for each story is determined using the mixed-occupancy provisions in IBC Section 508. See Section 4.5, *Mixed-Use Code Analysis*.

High-hazard mixed occupancies (IBC 506.2.2.1) – When Group H-2 or H-3 high-hazard occupancies are part of a mixed-occupancy building, the combined allowable area must satisfy the mixed-occupancy ratio formula in Section 508.4.2 (for separated occupancies). The sprinkler increase permitted in Table 506.2 applies only to portions of the building that are not classified as Group H-2 or H-3, and the hazardous areas must be separated from other occupancies per Table 508.4. While these high-hazard occupancies are permitted, they will restrict the size of the primary occupancy.

Frontage Increases

Frontage increase (IBC 506.3) – The IBC allows for an increase in allowable building area when a building fronts on a public way or open space that provides access for fire department operations. To qualify, a building must have at least 25 percent of its perimeter on a public way or open space and a minimum distance of 20 feet from the building face to the nearest interior lot line, the entire width of a street, alley or public way, and the exterior face of an adjacent building on the same property.

The IBC limits the total area increase that can be achieved through frontage:

- The greatest frontage increase factors can be achieved using Table 506.3.3.1 for buildings meeting the unlimited area provisions of Section 507 except for the open space distance. This table provides increase factors for buildings with open space ranging from 30 feet to less than 60 feet. The maximum, I_f, is 1.50 when at least 75% percent of the building perimeter fronts an open space at least 55 feet wide.
- For buildings with open space ranging from 20 feet to 30 feet or greater, frontage increase factors are found in Table 506.3.3. The maximum, I_f, is 0.75 when at least 75% percent of the building perimeter fronts on open space at least 30 feet wide.

> **To maximize building area**, it will always be most advantageous to first check whether a project can comply with the unlimited area provisions of IBC Section 507. If the building complies with everything except the open space requirements, check to see if a frontage increase factor can be applied per Table 506.3.3.1. If neither of those work, check for a frontage increase per Table 506.3.3.

Industrial buildings often benefit from frontage increases because they tend to be located on large parcels with open yards or drive aisles around much of the perimeter. This provision can be especially beneficial for Types V, IV, and III wood construction, where maximizing allowable area may help achieve larger single-story footprints without moving to a more restrictive construction type.

Code change note: The method used to calculate the frontage increase differs between IBC editions. The 2018 IBC uses a weighted average equation (Equation 5-5), while the 2021 and 2024 IBC use a tabular approach. The intent is the same, but the tabular method could be slightly more conservative. A 2027 code change proposal seeks to revise the tables to better align with the 2018 IBC's Equation 5-5. Designers should verify which edition applies in the project jurisdiction and confirm calculation methods with the AHJ as needed.

While construction type has a significant impact on allowable building size, designers must also consider its impacts on FRR requirements, concealed spaces, and materials permitted. For more discussion on this, see Section 3.4, *Selecting a Construction Type*.

Allowable Area for Single-Occupancy, Single-Story Buildings

Table 4 includes allowable areas calculated for Groups B, F, M, and S using the factors described in the previous section. For simplicity, the calculations assumed a fully-sprinklered building and single occupancy.

Calculated allowable areas are included for both the maximum frontage increase factor of 1.5 per IBC Table 506.3.3.1 and 0.75 per Table 506.3.3. Recall that the allowable areas calculated with a 1.5 increase factor apply when at least 75% percent of the building perimeter fronts an open space at least 55 feet wide and the building meets all of the unlimited area provisions of Section 507 except for the open space distance. The allowable areas calculated with an increase factor of 0.75 apply to projects with 30 feet of open space around at least 75% of the building.

It is advantageous to first check whether the frontage increases of IBC Table 506.3.3.1 can be applied to a building. If not, use the frontage increase factors in IBC Table 506.3.3.

When comparing allowable areas for Group S (storage) and Group F (factory) occupancies, Table 4 shows a notable nuance: Type III construction generally permits larger areas for Group S than Group F, while Type IV permits larger areas for Group F than Group S. The same pattern applies to multi-story buildings.

TABLE 4: Allowable area for single-occupancy, single-story buildings

Occupancy Group		Allowable Area for Single-Story Building*							
		Type III		Type IV				Type V	
		A	B	A	B	C	HT	A	B
Frontage increase factor = 1.5 (IBC Table 506.3.3.1):									
B	Business (office)	156,750	104,500	594,000	396,000	247,500	198,000	99,000	49,500
F-1	Factory (moderate hazard)	104,500	66,000	552,750	368,500	230,313	184,250	77,000	46,750
F-2	Factory (low hazard)	156,750	99,000	833,250	555,500	347,188	277,750	115,500	71,500
M	Mercantile (retail, sales room, markets)	101,750	68,750	338,250	225,500	142,438	112,750	77,000	49,500
S-1	Storage (moderate hazard)	143,000	96,250	420,750	280,500	175,313	140,250	77,000	49,500
S-2	Storage (low hazard)	214,500	143,000	635,250	423,500	264,688	211,750	115,500	74,250
Frontage increase factor = 0.75 (IBC Table 506.3.3):									
B	Business (office)	135,375	90,250	513,000	342,000	213,750	171,000	85,500	42,750
F-1	Factory (moderate hazard)	90,250	57,000	477,375	318,250	198,906	159,125	66,500	40,375
F-2	Factory (low hazard)	135,375	85,500	719,625	479,750	299,844	239,875	99,750	61,750
M	Mercantile (retail, sales room, markets)	87,875	59,375	292,125	194,750	122,469	97,375	66,500	42,750
S-1	Storage (moderate hazard)	123,500	83,125	363,375	242,250	151,406	121,125	66,500	42,750
S-2	Storage (low hazard)	185,250	123,500	548,625	365,750	228,594	182,875	99,750	64,125

**Note: Assumes a single occupancy group within the building*
Source: IBC Section 506

Photo: Hunter Jorgensen

1391 Horizon Ave, Lafayette, CO
Hunter Jorgensen / RVP Architecture

Allowable Area for Multi-Story Buildings

Multi-story warehouses and data centers are becoming increasingly common in dense urban areas where land availability is limited. Floors in these facilities are typically designed for high structural loads to accommodate equipment, storage, and even vehicle/truck traffic. Hybrid mass timber systems, often incorporating concrete and/or steel, are best suited to meet these loading demands.

Controlling vibrations will be a concern in some multi-story facilities but not in buildings such as data centers. For more information on vibration design, see WoodWorks' *Floor Vibration Analysis in Light-Frame Projects* and *U.S. Mass Timber Floor Vibration Design Guide*.

While this paper does not explore the unique design considerations of multi-story buildings in detail, the methods to calculate allowable areas are similar to those for single-story buildings but with area factors and equations based on multiple stories.

In the U.S, a multi-story data center has been constructed utilizing CLT floor and roof panels. The use of mass timber contributed to a fast schedule as well as a lighter-weight structure with a low-embodied carbon footprint.

4.5 Mixed-Use Code Analysis

Industrial buildings often include secondary functions—such as office, laboratory, or assembly areas—within storage buildings or factories. These conditions trigger the mixed-use provisions of IBC Section 508, which govern how different occupancies share or separate construction, fire protection, and egress requirements.

Mixed-use code analysis is summarized here for industrial buildings. For detailed guidance, refer to WoodWorks' *Mixed-Use Code Strategies (Part 1 and 2).*

Accessory Occupancies, Incidental Uses, and Small Spaces

It may be beneficial to classify some smaller areas of a building as incidental uses, accessory occupancies, or small assembly spaces, as this can reduce or eliminate the requirements for fire separation of these spaces.

Accessory occupancies (IBC Section 508.2) are rooms or spaces that support the primary use of the building and do not represent a significant increase in hazard. They are limited to 10 percent or less of the story area and are considered part of the main occupancy without a required fire-resistance separation. Examples include a small office, breakroom, or control room serving an F- or S-group space. The building's allowable height and area are based on the primary occupancy, and accessory spaces must comply with the code provisions applicable to their specific occupancy classification.

Incidental uses (IBC Section 509) differ from accessory occupancies because they are explicitly listed in IBC Table 509.1 and represent functions with higher fire or life-safety risk that require specific protection. For industrial and warehouse occupancies, relevant examples include:

- Boiler or furnace rooms exceeding the thresholds in Table 509.1—e.g., boilers rated above 15 psi and 10 horsepower or furnaces with an input over 400,000 Btu/hour
- Refrigerant machinery rooms, common in cold-storage or food-processing facilities
- Hydrogen fuel gas rooms when not classified as Group H (e.g., used for equipment maintenance or vehicle refueling)
- Paint shops not classified as Group H, such as limited coating or touch-up areas within a production line
- Waste collection rooms over 100 square feet, which may occur in packaging or maintenance zones

Each space must comply with the separation or protection requirements of Table 509.1, typically a 1-hour fire-resistance-rated enclosure, automatic sprinkler system, or both. In Type IV-B and IV-C mass timber buildings, where Table 509.1 requires fire-resistance-rated separation, there are specific requirements for thermal barriers.

Certain small assembly and tenant spaces may be reclassified as Group B occupancies, simplifying code compliance and allowing greater allowable heights and areas. Under Section 303.1.1, small buildings or tenant spaces with assembly uses and occupant loads under 50 persons are permitted to be classified as Group B. Similarly, Section 303.1.2 allows small assembly spaces accessory to another occupancy—less than 750 square feet or serving fewer than 50 occupants—to be classified as Group B or the same occupancy as the primary building.

This provision is particularly useful for small cafés, meeting rooms, or training spaces within warehouses or offices, avoiding the need for mixed-use analysis or Group A classification. Unlike accessory occupancies under Section 508.2, small assembly spaces are not limited to 10 percent of the floor area.

If the building still qualifies as mixed-use after applying these allowances, it must be analyzed accordingly—either as a nonseparated or separated occupancy or by using fire walls, podiums, or other separation strategies.

Nonseparated Occupancies

Nonseparated occupancies are treated as a single occupancy and designed to meet the most restrictive construction type and fire-protection requirements based on the occupancies present. Fire-resistance-rated separations are not required by IBC Section 508.3, but there may be other sections of the code that require fire-resistance-rated elements. This strategy is often used in fully-sprinklered warehouses that include small office areas, minimizing the need for fire barriers while simplifying HVAC and structural design. The most restrictive occupancy governs overall height, area, and number of stories.

This design approach will generally result in smaller allowable building sizes than those permitted when using separated occupancies. However, it does have the benefit of potentially requiring fewer or no fire-resistance-rated assemblies separating occupancies.

Separated Occupancies

Separated occupancies are divided by fire-resistance-rated walls and floors in accordance with IBC Sections 707 and 711. Required hourly ratings are given in Table 508.4, with reductions allowed when the building is fully sprinklered. Table 508.4 also groups certain occupancies—such as B, F-1, M, and S-1—as having equivalent hazard levels and no separation is required between these groups. Therefore, if a building contains multiple occupancies within the same grouping, no separation is required between them, and the area calculation benefits of separated occupancies can still be used.

When using separated occupancies, the allowable height and stories of the building are determined by limiting the height and number of stories of each separated occupancy to their applicable limits for the given construction type and occupancy group. The sum of the ratios of actual area to allowable area must not exceed 1.0 on any story. For multi-story buildings, this ratio sum is limited to 2.0 for two stories and 3.0 for three or more stories.

See Allowable Area, Mixed-Occupancy Building in Section 4.4 for mixed-use analysis with Group H-2 or H-3 mixed occupancies.

Separated occupancy provisions allow industrial buildings with combined storage, factory, office, and mercantile components to maximize allowable area while maintaining code compliance.

Combination of Nonseparated and Separated Occupancies

The IBC explicitly allows designers to use a combination of separated and nonseparated occupancies within the same building. For example, the warehouse and shipping functions could be analyzed as nonseparated occupancies, while an attached office block is treated as a separated occupancy with a 1-hour fire-resistance-rated wall. This combination strategy can balance design simplicity with increased allowable area.

Sprinkler Thresholds and Fire Areas

While most industrial buildings are fully sprinklered, it is important to note that sprinkler requirements are based on fire area, defined as the area enclosed by fire barriers, exterior walls, and horizontal assemblies (IBC Section 202). IBC Section 903 details where sprinklers are required. For example, portions of buildings classified as Group F-1, M, or S-1 occupancies with a fire area greater than 12,000 square feet require sprinklers. Low-hazard Group F-2 and S-2 buildings are generally exempt from these area-based sprinkler requirements unless otherwise triggered by specific conditions in Section 903, such as height, occupant load, or special use provisions.

Example:
Selecting an Appropriate Construction Type

Project Details:

- One-story mixed-use advanced manufacturing and distribution building containing:
  - 20,000 square feet of office/administrative areas (Group B)
  - 10,000 square feet for manufacturing/assembly of moderate hazard materials (Group F-1)
  - 4,000-square-foot showroom with public access (Group M)
  - 36,000 square feet of storage space for moderate hazard materials (Group S-1)
- Open yards = 30 feet on 75% of building perimeter
- NFPA 13 sprinkler system
- The developer would like to expose as much wood as possible on the underside of the roof and interior face of exterior walls.

What construction type would you recommend?

The first step is to **check whether an unlimited area building is possible per IBC Section 507**. For a sprinklered one-story building, Section 507.4 requires 60 feet of yards around the building for unlimited area buildings of Group B, F, M, or S regardless of construction type. **Open space around the building is only 30 feet, which does not meet the 60 feet of open space required for unlimited area buildings**.

Next, **check the requirement for reduced open space in IBC Section 507.2.1** as it may still allow an unlimited area building with a reduction in the 60-foot minimum yards required in Section 507.4. The minimum open space is 40 feet in order to take advantage of the reduced open space, but our project only has 30 feet. **There is not enough open space around the building to qualify as an unlimited area building**.

The allowable building area will have to be calculated per IBC Section 506. First, consider the frontage increase factor. Even though our building does not qualify as an unlimited area building, it may meet all the requirements for one in Section 507 except the open space. If it does, we can benefit from a larger frontage increase per Table 506.3.3.1. Reviewing Section 507.4, we meet the requirements for a one-story building, fully sprinklered, with Group B, F, M, and S occupancies, and the building can be of any construction type. The only requirement not met is the 60 feet in width for public ways or yards. **Therefore, our project meets the requirements for a frontage increase in Section 507 per Table 506.3.3.1**. The frontage increase factor = 0.88 where 30 feet of open space is provided around 75% of the building.

The total area of our building is 70,000 square feet. **We need to decide on separated vs. nonseparated occupancies and construction type**. Table 508.4 groups occupancies B, F-1, M, and S-1 as having equivalent hazard levels and no separation is required between these groups. **Therefore, we benefit from the additional area permitted by a separated mixed-use analysis and fire-resistance-rated assemblies are not required between occupancies per Table 508.4**.

Our frontage increase factor is 0.88, but looking at Table 4 in this paper for a 0.75 increase factor, we can get a rough idea of which construction type might work before performing calculations. Starting at the right with Type V-B, the least restrictive construction type, we can see that our 70,000 square feet will exceed the V-B allowable areas. The allowable areas in Type V-A (with a 0.75 increase factor) are closer to what we need, and they will increase once we perform calculations for a 0.88 increase factor. Let’s calculate to see if Type V-A will work for our building.

For a separated occupancy analysis, the allowable area is the sum of the actual area divided by the allowable area for each occupancy. The allowable area for each occupancy is calculated with IBC Equation 5-1 using a frontage increase factor of 0.88.

$$\text{Sum of } \frac{\text{Actual Areas}}{\text{Allowable Areas}} \quad \overset{\text{Group B}}{\frac{20{,}000}{87{,}840}} + \overset{\text{Group F-1}}{\frac{10{,}000}{68{,}320}} + \overset{\text{Group M}}{\frac{4{,}000}{68{,}320}} + \overset{\text{Group S-1}}{\frac{36{,}000}{68{,}320}} = 0.96 < 1 \quad \text{OK}$$

The sum of the actual areas/allowable areas is less than one; therefore, Type V-A construction with a 0.88 frontage increase factor per Table 506.3.3 is sufficient.

Type V-A construction permits the use of any wood material, so we can use light-frame wood, mass timber, or hybrid systems for the exterior walls and the roof. If we use bearing walls, the exterior walls require a 1-hour FRR. If we locate steel columns behind the tilt-up panelized wood walls to take the gravity roof load, the exterior walls are non-load-bearing and only require a rating per Table 705.5 based on the fire separation distance (FSD). Our open yards around the building are 30 feet, which means there is no FRR requirement for the exterior walls. Exterior walls can be framed out of either mass timber or light-frame panelized construction with the timber exposed on the interior of the warehouse. For the roof, Type V-A construction requires a 1-hour FRR. IBC Table 601 footnote c allows heavy timber in roof construction where an FRR of 1-hour or less is required. Therefore, we can expose heavy timber members meeting the minimum sizes defined in IBC Section 2304.11 in the roof construction.

Type V-A construction provides options for exposed wood on the interior of the warehouse shell (roof and exterior walls).

It should be noted that, if the open yards around the perimeter of the building were increased to 60 feet, we could utilize the unlimited area provisions of Section 507.4 and classify the building as Type V-B, which has no FRR requirements. As an unlimited area building, the area could be increased to 1 million square feet or larger, provided the site is large enough for a “big bomber.”

5. Detailing Considerations

While there are many detailing considerations for industrial buildings, this section focuses on a few major items that need to be considered early in the design of wood or hybrid projects.

5.1 Concealed Spaces

Concealed spaces—such as cavities above ceilings or within wall assemblies—influence how fire, smoke, and gases may move within a building during a fire event. While the IBC does not define a concealed space, the consensus is that they are small, uninhabitable areas of buildings created by assemblies or portions thereof. The IBC does provide guidance on how to address concealed spaces, particularly those that include combustible materials exposed within the space, such as the requirements for fireblocking and draftstopping in Section 718.

While many industrial buildings are designed with open, exposed structures, concealed spaces might emerge in areas such as roof assemblies, wall cavities, and office or showroom fit-outs—particularly when future tenants add insulation, mechanical systems, or suspended ceilings. Type IV construction limits concealed spaces and designers should consider the potential impact on the tenant fit-out designs as well as the core and shell.

For more detail, see the WoodWorks publications, *Concealed Spaces in Light-Frame Wood Construction* and *Concealed Spaces in Mass Timber and Heavy Timber Structures* and Section 6 *Alternative Materials, Design, and Methods of Construction*.

5.2 Columns and Parapets

When considering wood column placement within a panelized wall, engineered wood members can be used as columns within the plane of the wall in Type V construction. In Type III construction where FRTW is required in exterior walls, it is recommended to offset glulam or steel columns behind the FRTW panelized wall system. These columns may need to be oversized for fire protection or wrapped with gypsum board.

Where parapets are provided in industrial buildings with panelized wood walls, designers need to coordinate architectural, structural, and constructability considerations. In a tall wall, for example, it might be most efficient to orient mass timber exterior wall panels horizontally for structural and constructability reasons, but horizontal seams create challenges with the building envelope detailing. For warehouses with parapets, horizontal panel orientation may also necessitate cantilevered columns to support parapets, which can complicate the building envelope detailing at columns penetrating through the roof deck. It is ideal to have the architect, engineer, building envelope consultant, and contractor coordinate systems integration early in design to arrive at efficient, well-performing systems. For more information, see the WoodWorks article, *Construction and FRR Requirements for Parapets*.

5.3 Durability

Durability of any structural material comes down to the surrounding environment (e.g., moisture, temperature, and relative humidity), ability to dry if it becomes wet, and quality of details and control layers. Designing for a long service life means anticipating potential durability issues and implementing strategies to avoid them.

While the design and construction of wood buildings for durability is beyond the scope of this paper, there are numerous resources available to guide project teams. The Think Wood website features a CEU, *Designing for Durability*, and the *Guide for On-site Moisture Management of Wood Construction* published by FPInnovations covers both mass timber and traditional wood-frame construction. The building envelope experts at RDH Building Science offer a variety of publications, including *Mass Timber Building Enclosure Best Practice Design Guide Version 2*. Where termites pose a risk, review *Effective Termite Protection for Multi-Family and Commercial Wood Buildings* on the WoodWorks website. Webinar recordings on building envelope design and construction moisture can be viewed online at The Wood Institute.

Building 4 Southfield Park 35, Dallas, TX
Affinius Capital/ PDMS Design Group / Hunt & Joiner

Affinius Capital, formerly USAA, and Seefried Industrial Properties demonstrated how wood can raise the bar on sustainability with this 161,000 square-foot speculative warehouse, the first large mass timber warehouse in the U.S. In this Type V-B warehouse, CLT non-load-bearing wall panels resist wind and seismic loads and span horizontally to structural steel columns located inboard of the CLT.

Photo: Mark Humphries Photography / courtesy Timberlab


At Janicki Industries Warehouse Building 10, vertical steel 'L' brackets protect the corners of glulam beams from forklifts and other equipment. The brackets are connected to the baseplates and also provide uplift connection.

Photo: Jordan Janicki

Thermal Expansion Joints

In industrial buildings, one of the benefits of using a wood roof deck in lieu of a metal roof deck is that wood roofs do not require a structural expansion joint. While concrete and steel buildings are typically designed with expansion joints to account for thermal movement due to environmental temperature fluctuations, wood has a significantly lower coefficient of thermal expansion. Roofs with metal deck require frequent expansion joints, approximately every 250 to 350 feet, to counteract the thermal growth and contraction that steel decking undergoes. The general consensus is that designers of wood-frame buildings do not need to account for thermal movement, as thermal expansion is offset by the shrinkage of wood due to increased temperatures and moisture loss—which designers do need to consider.

For further discussion, see the WoodWorks article, *Do wood-frame buildings need to account for thermal movement?*

Construction Moisture

Wood is hygroscopic, meaning it has the ability to absorb and release moisture. As this occurs, it also has the potential to change dimensionally. Wood shrinkage/expansion occurs most notably perpendicular to the grain, meaning that a sawn wood stud or floor joist will change in width and depth. Section 4.4 of the NDS provides commentary on this subject, and includes thermal expansion coefficients for a number of wood species.

While accommodating thermal movement isn't generally considered necessary, it is recommended that designers of wood-frame buildings account for expansion during construction and that builders have a moisture management plan during construction. In light-frame projects, it is common to install wood structural panels with gaps between adjacent panel edges, a practice recommended by APA – The Engineered Wood Association in its *Technical Note D481P: Minimizing Buckling of Wood Structural Panels*. In larger buildings (over 80 feet in length), it is recommended to increase the gap between panels and take additional construction sequencing precautions to avoid panel buckling. The WoodWorks paper, *Accommodating Shrinkage in Multi-Story Wood-Frame Structures*, discusses this, as does APA's *Technical Note U425C: Temporary Expansion Joints for Large Buildings*.

Mass timber projects have unique considerations for managing moisture, including keeping moisture content within an appropriate range. Although mass timber can, and usually will, get wet during construction, problems can be avoided with proper planning and the right moisture control strategies. The most effective approach begins with planning during the project design phase (well before the mass timber arrives on site) and continues throughout construction. The guide, *Moisture Risk Management Strategies for Mass Timber Buildings Version 3*, by RDH Building Science describes a process for assessing moisture risks in a mass timber building, creating a project-specific moisture management plan, and implementing that plan.

Building Envelope

Coordination between structural, architectural, and mechanical systems is critical to achieving durable, energy-efficient, and watertight industrial buildings. Increasingly stringent energy codes and requirements for reflective cool roofs have changed traditional envelope detailing methods—particularly for large single-story structures.

For wood buildings, careful integration between wood elements and adjacent materials is especially important to prevent trapped moisture, air leakage, and differential movement. Engaging a building envelope consultant early in design adds measurable value across project phases by helping teams identify and mitigate these risks. Their expertise helps reduce air and water leakage, condensation, and thermal bridging, ensuring that timber assemblies remain protected and dry.

Envelope consultants can also help establish moisture management plans and improve detailing at complex junctions such as timber-to-steel or timber-to-concrete interfaces, parapets, and penetrations, and joints in panelized walls.

Wood Exposed to Exterior Elements

One of the first questions developers often ask is whether wood structural elements can be used on the exterior of a warehouse to enhance its visual character. When exposed to repeated wetting cycles, exterior wood applications are best achieved through wood products made from naturally durable species, pressure-preservative-treated wood, or thermally-modified products. Naturally durable species and thermally-modified wood typically come at a premium and are used on projects where architectural aesthetics are a priority, while pressure-preservative treatment tends to be the most cost-effective wood solution. Light-frame wood, engineered wood products, and glulam members can be fabricated from naturally durable species or pressure-treated materials. However, mass timber panels such as CLT are generally too large for pressure treatment using current manufacturing equipment. When wood is exposed on the exterior, a maintenance plan should be developed in coordination with coating manufacturers and the building envelope expert.

6. Alternative Materials, Design, and Methods of Construction

IBC Section 104.2.3 allows performance-based paths for the successful design of buildings and is commonly referenced as the provision for Alternate Materials and Methods Requests (AMMRs). AMMR provisions permit a building official to consider the intent of prescriptive code provisions when deliberating on new or existing technologies in materials, design, and methods that are not explicitly addressed in the code. In this way, the code can provide the flexibility to address new concepts, innovations, and developments that may not have been recognized or even existed during the code's formal development process.

AMMRs can benefit industrial projects in numerous ways—e.g., by allowing a performance-based design for a mass timber lateral system such as CLT shear walls or permitting a limited amount of concealed spaces in Type IV construction. They are also used for code-compliance paths that are by nature complex, such as the design of data centers.

For more information, see the WoodWorks paper, *Getting to Yes: Making Effective Use of the Alternate Means Process*.

7. Conclusion

Modern industrial buildings are evolving to include more structural wood as owners, developers, and designers seek solutions that balance cost efficiency, sustainability, and occupant well-being. Advances in light-frame, mass timber and panelized systems—combined with ongoing refinements to building codes—have expanded the practical and code-compliant use of wood across a range of warehouse, manufacturing, and flex building types.

When applied strategically, wood systems can reduce embodied carbon, accelerate construction schedules, and create warmer, more human-centered environments that support leasing, retention, and long-term asset value. However, realizing these benefits requires early coordination and informed selection of the appropriate wood system—whether light-frame, mass timber, or hybrid—along with a clear understanding of how construction type, allowable area, and fire-resistance requirements interact.

As industrial building typologies continue to evolve, warehouses present a compelling opportunity to expand the adoption of wood at scale. Designers and owners are encouraged to engage WoodWorks early to take advantage of our free project assistance, which can support wood system selection, code analysis, and further technical support. By strategically applying the concepts described in this paper and leveraging available technical resources, project teams can successfully deliver high-performing, visually compelling industrial buildings with a lighter environmental footprint that help set a precedent for future development.

Additional Resources

Visit WoodWorks' *Resource Library* to browse or search hundreds of resources by key word (e.g., publication title, warehouse, concealed spaces, fire resistance, shear wall, connections), or filter by resource type, building system, and other criteria. Materials specific to industrial buildings can also be found on the *Industrial* webpage (www.woodworks.org/learn/industrial).

End Note

[1]Think Wood. WoodWorks – Wood Products Council. (n.d.) *Biophilic Design LookBook*.

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