

# MODERN BUILDING CODES: KEEPING PACE WITH THE WOOD REVOLUTION

## WOOD CONSTRUCTION AND THE 2012 INTERNATIONAL BUILDING CODE

Presented by:



### LEARNING OBJECTIVES

Upon completion of this course the student will be able to:

1. Discuss provisions in the International Building Code (IBC) intended to ensure that wood buildings provide the same level of fire performance as other building types.
2. Evaluate techniques that allow designers to safely increase the allowable heights and areas of building projects beyond the base limits stated in the IBC.
3. Identify the advantages of wood-frame structures in seismic and high-wind events.
4. Explain how advances in wood products and building systems are influencing the evolution of building codes.

### CONTINUING EDUCATION

AIA CREDIT: 1 LU  
GBCI CREDIT: 1 CE

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There is a quiet revolution taking place within the design community. After a long emphasis on concrete and steel for buildings other than homes, design professionals are using wood to great effect in a growing number of non-residential and multi-family building types—in applications that range from traditional to innovative, even iconic. Some are driven by wood's cost effectiveness,<sup>1</sup> while others cite its versatility or low carbon footprint,<sup>2</sup> but their collective path has been made possible by building codes that increasingly recognize wood's structural and performance capabilities, and the continued

evolution of wood building systems and techniques.

When the *International Building Code* (IBC) was introduced in 2000, it consolidated three regional model building codes into one uniform code that has since been adopted by most jurisdictions. It increased the possibilities for wood construction by (among other things) recognizing additional fire protection techniques, consolidating the maximum allowable areas and heights from the three legacy codes into one (thus increasing what's allowable in some jurisdictions), and allowing the use of wood in a wider range of building

types. In subsequent versions of the IBC, even more opportunities have been created where additional fire protection features are used. Even so, the pioneering nature of building design is such that there are always architects and engineers seeking to push beyond the conventional, and it is common for project teams to request (and be granted) variances for designs not covered by the code that nonetheless meet its intent. (See sidebar, *Designing with New Materials*, page 7.) Given the code's three-year amendment cycle, this is necessary to keep pace with advancements in building systems, materials and construction practices.

## FIRE PROTECTION

Building codes require all building components within a particular type of construction to provide the same level of fire protection regardless of materials used.

Wood-frame construction has an excellent history of code-compliant fire-resistive performance.<sup>3</sup> In fact, the IBC allows greater heights and areas for wood buildings than designers may think, in a wider range of construction types.

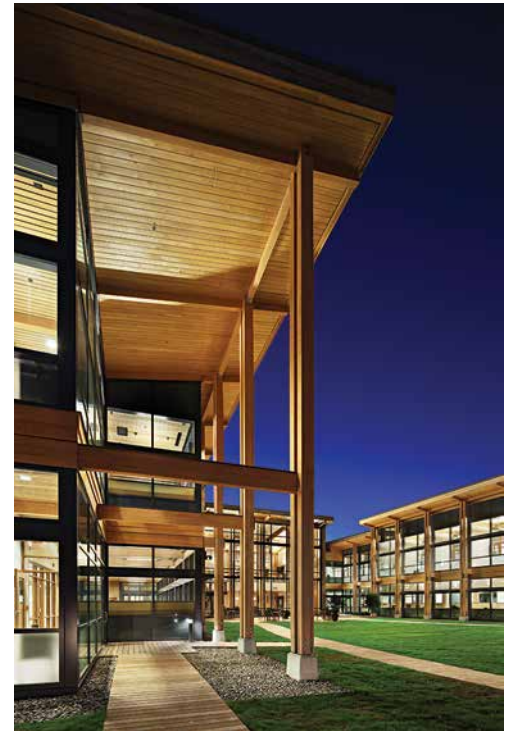
As a starting point, the IBC specifies a basic allowable area based on a single story, the type of construction and occupancy classification. It then increases the allowable area based on features of the building, including the addition of an automatic sprinkler system, side yard open space, fire walls, augmented exiting and additional stories.

For example, the code allows low-rise, two-story business and mercantile buildings of wood construction to be of unlimited area when they are equipped with an automatic sprinkler system throughout and have 60 feet of fire separation distance between the building and all property lines. Residential wood buildings with sprinklers and exterior walls made from

fire retardant-treated wood (FRTW) can be up to five stories in height and have additional “levels” when mezzanines are included. Under the 2012 IBC, mezzanines are permitted to be 33 percent of the floor area below and considered part of that story, although some local jurisdictions may allow a greater percentage. The code also permits the use of wood for many features in buildings required to be of a non-combustible construction type, often even whole roof structures, based on other safety features.

Under the IBC, designers can use fire walls to create separate buildings for building area limitations when additional size is needed and sprinklers either aren't an option or they don't afford the necessary increases for the project's use and site characteristics. In Type V Construction, fire walls are permitted to be of wood-frame construction, allowing designers to divide the structure into separate buildings for purposes of size, each subject to its own height and area limits. Therefore, the size of a building can theoretically be doubled while maintaining the same construction type.

In addition to the sprinkler and open frontage increases, a designer's options also include increasing to a higher type of construction,



Live Oak Bank Headquarters Wilmington, North Carolina Architect: LS3P Associates Ltd. Engineer: Woods Engineering WoodWorks Wood Design Award, Jury's Choice, 2015. Photo: Mark Herboth Photography

which might include the use of fire-resistive construction throughout the building, fire retardant-treated lumber for exterior walls, or heavy timber construction.

**Rated assemblies.** There are several types of fire-resistive assemblies and components within a building. These include: vertical assemblies (walls), horizontal assemblies (floors and roofs) and structural frame members (columns and beams). In most cases, these assemblies are required to have either a 1- or 2-hour fire-resistive rating. Fire-resistive construction is typically designated as the number of hours a representative test assembly will resist a standardized fire exposure when tested in a laboratory. One of the standards used for measuring fire resistance of building assemblies is *ASTM Test Method E-119, Standard Test Methods for Fire Tests of Building Construction and Materials*.

The fire resistance of wood assemblies may be calculated using the provisions of Section 722.6 of the IBC, which is based on the known fire resistance of many tested assemblies. The assemblies in this Section are limited to 1 hour; however, the IBC also references Chapter 16 of the NDS, which has a broader application for calculating fire resistance of exposed wood members. By designing a building to

## AMERICAN NATIONAL STANDARDS FOR WOOD DESIGN

The American Wood Council (AWC) offers a variety of publications to assist architects and engineers in the design of wood buildings, using both dimension lumber and engineered wood products. Several are referenced in the IBC and/or International Residential Code (IRC), including four that were recently approved by the American National Standards Institute as American National Standards.

### 2015 National Design Specification® (NDS®) for Wood Construction

A new product design chapter for cross laminated timber (CLT) includes information on the design of CLT members, connections and fire design. Another significant change is new provisions that explicitly permit structural composite lumber (SCL) to be designed for fire requirements using NDS Chapter 16. The *2015 NDS Supplement: Design Values for Wood Construction*, packaged with the NDS, contains updated design properties for visually graded southern pine and mixed southern pine dimension lumber.

### 2015 Special Design Provisions for Wind and Seismic (SDPWS)

New provisions have been added for seismic and wind design of cantilevered wood-frame diaphragms that provide important design clarifications, especially for design of “corridor-only” multi-story wood-frame structures. There are also revisions to the protocol for determining equivalent deformation-based shear distributions that allow more efficient seismic design of shear walls containing high aspect ratio shear walls.

### 2015 Wood Frame Construction Manual (WFCM) for One- and Two-Family Dwelling

New tabulated spans for lumber framing members reflect changes to design values referenced in the 2015 NDS. Tables were also added to provide prescriptive wood-frame solutions for rafters and ceiling joists in response to new deflection limits adopted in the 2015 IRC for ceilings using gypsum wallboard or brittle finishes.

### 2015 Permanent Wood Foundation (PWF) Design Specification

The permanent wood foundation is a load-bearing wood-frame wall system designed for both above- and below-grade use as a foundation for light-frame construction. The document primarily addresses structural design requirements and has been updated to reflect reference to the 2015 NDS and 2015 SDPWS.

AWC ([www.awc.org](http://www.awc.org)) offers webinars, technical articles and technical support related to these standards.

meet the provisions of Type III Construction rather than Type V, the designer is able to take advantage of greater allowable heights and areas. For example, fire retardant-treated wood (referenced in IBC Section 2303.2) is permitted in different locations in different types of construction, as noted in Sections 602.3 and 602.4.2. In Type III and IV Construction, this includes exterior walls and interior walls and partitions. In Types I and II Construction, fire retardant-treated wood is allowed in non-bearing partitions, non-bearing exterior walls where a fire-resistive rating is not required, and portions of the roof construction. In Type I Construction, heavy timber roofs are permitted without fire retardant treatment.

**Heavy timber construction** combines the beauty of exposed wood with the strength and fire resistance of heavy timbers.<sup>4</sup> Modern versions include sawn stress-grade lumber, tongue and groove decking, CLT and glued laminated (glulam) timber. Under the code, fire resistance is achieved by using wood structural members of specified minimum size and wood floors and roofs of specified minimum thickness and composition; by providing the required degree of fire resistance in exterior and interior walls; by avoiding concealed spaces; and by using approved fastenings, construction details and adhesives for structural members. Type IV Construction utilizes heavy timber elements as the structural members. This type of construction recognizes the inherent fire resistance of large timber and its ability to retain structural integrity in fire situations. The fire resistance in heavy timber construction typically comes from surface char, which insulates the wood member and leaves a significant portion of the member to continue supporting the structure during a fire.

Fire safety during construction. The construction phase of a project presents unique risk scenarios that make the building more vulnerable than it is once complete, when features such as fire doors, smoke alarms and sprinklers are in place.

Minimum safety precautions for fire during construction and the protection of adjacent public and private properties are provided in IBC Chapter 33. This section includes, among other things, provisions for fire extinguishers, standpipes and means of egress. The International Fire Code also includes detailed requirements.

In buildings under construction, arson and hot work are the most common causes of fire. For this reason, site security, rigorous procedures

## MINIMIZING FIRE RISK AND IMPACTS

**Stella**

**Location:** Marina del Rey, California

**Architect:** DesignARC

**Engineer:** Taylor & Syfan Consulting Engineers

**Size:** 650,466 square feet (2 buildings)

**Completed:** 2013

Regardless of material, building components such as walls, floors and roofs are designed and rigorously tested to ensure they provide the necessary structural performance to allow occupants in a building to escape should fire occur, and for emergency responders to perform their duties.

Fire and building safety codes are updated regularly to include new systems, standards and performance requirements, based on testing and evaluation, which continually improve the safety of buildings.

Building fire safety incorporates a combination of passive and active features. A passive fire safety feature may limit the height and area of the building, prescribe the use of fire-rated building elements or provide for adequate means of egress. Active fire safety features are those such as automatic fire detection or suppression systems that provide occupant notification, alarm transmittance and the ability to suppress fire growth until the fire service arrives. Codes are relying increasingly on active systems, since, with proper maintenance and alarm supervision, they have a high degree of reliability.



Photo: Lawrence Anderson, www.lawrenceanderson.net

## DESIGNING FOR FIRE PROTECTION

**Cityville Cityplace**

**Location:** Dallas, Texas

**Architect:** JHP Architecture/Urban Design

**Engineer:** RLG Consulting Engineers

**Size:** 626,500 square feet (gross)

**Completed:** 2013

A mixed-use urban infill project in the heart of Dallas, Cityville Cityplace includes five stories of Type IIIA wood-frame construction (modified per Dallas IBC amendments).

To meet building code requirements for fire protection, the project includes fire retardant-treated wood framing and sheathing at exterior walls, and an NFPA 13-compliant sprinkler system throughout—which, under the IBC, provides an allowable increase from four to five stories.

Architect Marvin Moss of JHP Architecture/Urban Design cited cost and value as the main reason wood was chosen for the project. “Type III Construction allows increased density over Type V without going to more expensive Type I/II Construction,” he says.

The design accommodates the needs of two commercial occupancies, a retail store and health club, by providing ease of front access and wide visibility, while diverting much of the parking to a garage enveloped within the site plan. Features include a glazing wall and large balconies for each unit, a curved front elevation featuring eight units with large outdoor living spaces, and two interior courtyards with swimming pools.



Photo: JHP Architecture

for workers and access to fire hydrants are essential. Educating workers so they understand the vulnerabilities and how to avoid dangerous situations is also a must.

### SEISMIC PERFORMANCE

Years of research and building code development have proven that wood-frame and hybrid structures can meet or exceed the most demanding earthquake design requirements.<sup>5</sup>

Most earthquake damage is caused by seismic waves that force the ground to move and

cause the building foundation to shake. Forces generated in an earthquake are proportional to the structure's weight. Thus, the overall magnitude of earthquake-induced forces that a building must resist is generally less for lighter buildings—and wood is substantially lighter than other common building materials. The fact that wood buildings tend to have numerous nail connections means they have more load paths, and there is less chance the structure will collapse should some connections fail. Numerous nail connections also give wood buildings an inherent ductility.

## DESIGNING FOR SEISMIC PERFORMANCE



Photo: Togawa Smith Martin, Inc.

## South Park

**Location:** Los Angeles, California

**Architect:** Togawa Smith Martin, Inc.

**Structural Engineer:** Englekirk

**Size:** 515,700 square feet

**Anticipated completion:** 2016

**Developer:** Mack Urban

Speed of construction and cost were cited as the main reasons wood was chosen for this project, which includes five stories of wood-frame structure over two stories of concrete and a concrete mezzanine.

According to the architect, the challenge for wood-frame buildings in high seismic zones is how to accommodate large glass areas and still provide sufficient shear walls. South Park in particular has a lot of window area. To achieve this, the design team determined the minimal length of shear wall required at each floor. Any area not required for shear wall was used for windows. This approach blended the structural characteristics of wood to create an aesthetically pleasing open window grid on the exterior of the building.

Within the wood-frame portion of the building, typical walls are either 2x6 (at exterior walls) or 2x4 studs spaced 16 inches on center. Floor joists are 2x12 sawn lumber and shear walls are plywood/OSB board.

## SPONSOR INFORMATION



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## QUIZ

- The IBC allows designers to increase allowable floor area and building height of wood-frame structures:
  - if they specify the use of preservative treated wood.
  - if the height of each floor doesn't exceed 10 feet.
  - with the addition of an automatic sprinkler system.
  - if the connections are properly detailed.
- In a Type V building, the use of wood-frame fire walls:
  - increases fire resistance by eliminating concealed spaces.
  - allows designers to divide the structure into separate buildings for purposes of size, each subject to its own height and area limits.
  - eliminates the need for sprinklers.
  - is not allowed under the IBC.
- Which of the following is an active (vs. passive) fire safety feature?
  - Automatic fire detection or suppression systems
  - Limits to building height and area
  - Heavy timber construction
  - Rated assemblies
- In Type IV (heavy timber) buildings, large wood members are recognized as having the ability to retain structural integrity in fire situations because:
  - a large number of connections means there is still support for the load if some connections fail.
  - Type IV buildings use fire retardant-treated wood.
  - surface char insulates the wood member and leaves a significant portion of the member to continue supporting the structure.
  - designers use approved construction details and adhesives.
- The IBC allows the use of wood for many features in buildings required to be of a non-combustible construction type.
  - True
  - False
- Code-compliant wood-frame construction generally performs well in earthquakes because:
  - forces generated in an earthquake are proportional to the structure's weight. Thus the overall magnitude of earthquake-induced forces that a building must resist is generally less for lighter buildings—and wood is substantially lighter than other common building materials.
  - numerous nail connections means they have more load paths, so there is less chance the structure will collapse should some connections fail.
  - Both a. and b.
  - None of the above
- For floor separating dwelling units in residential buildings, the IBC requires a Sound Transmission Class (STC) rating and Impact Insulation Class (IIC) rating of what, unless the "Authority Having Jurisdiction" has its own more stringent requirement?
  - 0—The IBC does not require STC or ICC ratings
  - 50
  - 100
  - 150
- Which of the following statements is/are true of El Dorado High School in Arkansas?
  - Designers used exposed wood and natural light to create an environment that would motivate students to stay in school.
  - It was one of the first schools in Arkansas to make extensive use of wood following a change in school board policy that had previously prohibited wood in school construction.
  - Changing the original steel and masonry design to wood saved the school board \$2.7 million.
  - All of the above
- Which of the following is not included as a minimum safety precaution for fire during construction in Chapter 33 of the IBC?
  - Fire extinguishers
  - Standpipes
  - Means of egress
  - Proper scheduling of subcontractors
- The 2015 IBC includes CLT of a certain thickness within what type of construction?
  - Type I
  - Type II
  - Type III and V
  - Type IV



This article continues on <http://go.hw.net/AR716Course1>. Go online to read the rest of the article and complete the corresponding quiz for credit.

## BEYOND FIVE STORIES WITH THE IBC

**Project:** 1201 Mercer/Rivet  
**Location:** Seattle, Washington  
**Architect:** Ankrom Moisan Architects  
**Structural Engineer:** YT Engineers  
**Size:** 145,360 square feet (gross)  
**Completed:** 2014  
**Developer:** Holland Partners



Photo: Casey Braunger, CBPhoto

Utilizing code provisions to go beyond the base heights and areas permitted for mid-rise wood-frame buildings is key to maximizing value. As described in this course, options for designers include (among other things) the use of podiums and mezzanines.

Located in Seattle's Cascade Neighborhood, Ankrom Moisan's design for Rivet includes five stories of Type VA wood-frame construction over a two-story Type IA concrete podium. The wood portion of the building includes pre-manufactured floor joists supported by load-bearing stud walls, and wood panel-sheathed shear walls.

The IBC allows five stories of Type III wood-frame construction when the building is equipped with an NFPA-compliant automatic sprinkler system. However, Seattle's building code is unique in that it also allows five stories of wood with a Type VA structure (when the building has an NFPA-compliant sprinkler system), which is even more cost effective and is being considered by a growing number of other jurisdictions as a way to encourage urban infill development. While the 2012 IBC allows a one-story concrete podium, this has been increased to two stories for the 2015 IBC.

The correct design of elements such as frames, shear walls, diaphragms and their connections to each other is of utmost importance as earthquake forces "search out" the weak links between structural members. Post-earthquake investigations have shown that a considerable amount of the serious earthquake damage to modern structures has occurred, not because of design deficiencies, but rather because contractors did not construct structural elements and non-structural components as required in the design drawings and specifications.

Demonstrating wood's performance in a seismic event, an assessment of the damage to California schools in the 1994 Northridge earthquake was summarized as follows: "Considering the sheer number of schools affected by the earthquake, it is reasonable to conclude that, for the most part, these facilities do very well. Most of the very widespread damage that caused school closure was either non-structural, or structural but repairable and not life threatening. This type of good performance is generally expected because much of the school construction is of low rise, wood-frame design, which is very resistant to damage regardless of the date of construction."<sup>6</sup> In 2002, the California Dept. of Government Services completed a legislated inventory and earthquake worthiness assessment of schools. School buildings that were constructed of steel, concrete, reinforced masonry or mixed systems designed between 1933 and

July 1, 1979 were required to be evaluated. Older wood-frame schools were exempted on the basis that "wood-frame buildings are known to perform well in earthquakes."<sup>7</sup>

### WIND RESISTANCE

In addition to superior seismic performance, wood buildings can be designed to effectively resist high winds. Wood's elastic limit and ultimate strength are higher when loads are applied for a shorter time period, which is typically the case in high wind events. When structural panels such as plywood or OSB are properly attached to lumber framing and used to form diaphragms and shear walls, they also form some of the most solid and stable roof, floor and wall systems available.<sup>8</sup>

However, in order for the diaphragms and shear walls to be effective, all of the related components—including framing, structural panel sheathing and inter-element fastening details—must be designed and installed correctly. For the structural system to work as intended, the roof diaphragm must be able to transfer lateral loads to the shear walls and the shear walls themselves must transfer these loads to the foundation. The success of the entire system is only as good as the quality and quantity of the connections. Therefore, the key to constructing a building that can resist lateral loads is understanding how forces are transferred and how to design and install proper connections.

In hurricanes, the loss of roofing materials and sheathing is the leading cause of failure in wood-frame buildings. The most common reasons behind these failures are improper connection detailing between structural systems and inadequate fastening of sheathing to the supporting members. Most local building codes require a minimum of 33 fasteners for a standard 4x8 panel installed over the roof supports at 24 inches o.c. Fasteners, such as 8d common nails (2.5 inches x 0.131 inch) or other code-approved options, should be placed a maximum of 6 inches o.c. along panel edges and 12 inches o.c. at intermediate supports. Following Hurricane Andrew in Florida, damage assessment teams found roof sheathing panels with as few as four fasteners. Once the roof sheathing has been pulled off its framing, the load path is interrupted and the diaphragm ceases to function as part of the lateral load-resisting system. In fact, the entire loading dynamics of the building will have changed due to this breach. This change in loading dynamics negatively affects the lateral design of the building.

With proper detailing, it is relatively easy to meet code requirements for safety during high wind and seismic events. The AWC publication *Special Design Provisions for Wind and Seismic* (SDPWS) is directly referenced by the IBC for the required design of lateral force-resisting systems such as nailed wood-frame shear walls and diaphragms which resist lateral loads.

### SOUND TRANSMISSION AND ACOUSTICS

As with any issue of building performance, the acoustics of a wood building can be designed to meet or exceed minimal requirements, depending on the expectations of the developer, buyers and tenants.

In residential buildings, the IBC provides a minimum design requirement for unit-to-unit acoustical protection between floors. It requires a Sound Transmission Class (STC) rating and Impact Insulation Class (IIC) rating of 50, unless the "Authority Having Jurisdiction" has its own more stringent requirement, which is rarely the case.<sup>9</sup>

Wood-frame construction is particularly efficient in residential buildings where sound insulation is required. Attaching gypsum board to walls and ceilings using resilient metal channels significantly reduces sound transmission, as does placing glass-fiber or rock-fiber insulation within wood-frame floor and wall assemblies.<sup>10</sup>

That said, the design of any functional and safe building is difficult if not impossible

## ACOUSTIC PERFORMANCE

**Project:** University House Arena District

**Location:** Eugene, Oregon

**Architect:** Mahlum Architects

**Structural Engineer:** Froelich Engineers

**Developer:** Gerding Edlen

**Size:** 109,600 square feet

**Completed:** 2013

Built to accommodate recent growth at the University of Oregon, the University House Arena District student housing project includes five stories of wood-frame construction over a concrete podium.

As with all of Mahlum's lower and student housing projects, it includes a variety of techniques aimed at improving acoustic performance. "Poor acoustics can have a dramatic impact on student productivity," says Kurt Haapala, AIA, LEED AP, Mahlum's principal in charge of student housing. "To address this, our approach includes creating higher levels of details, tracking STC and ICC ratings, and both carefully planning the location of mechanical systems and utilizing spring isolators in their mounting systems. We also field test for acoustical performance at various stages of construction."



Photo: Lincoln Barbour

without considering acoustics, and wood has a proven record in this regard. Wood is not as acoustically lively as other surfaces and can offer acoustically absorptive qualities, hence its widespread use in performance and musical venues. At the Arena Stage at the Mead Center for American Theater, for example, a small theater called "The Cradle" posed a challenge because of the sound reflections caused by its oval shape. In response, Bing Thom Architects developed a wood slat wall system made from poplar, designed to look like a basket weave, which could absorb and disperse sound.

### THE EVOLUTION OF WOOD CONSTRUCTION

Growing recognition of wood's benefits continues to increase its appeal in many building types, while new products and technologies expand the possibilities for how and where wood is used.

**Mid-rise/multi-family.** Mid-rise buildings are typically Type V Construction, which allows the use of untreated wood throughout, or Type III Construction. Type III Construction allows the same methods of construction as Type V except the exterior walls are required to be of non-combustible construction, which allows the use of fire retardant-treated wood.

Many developers and design teams default to wood for mid-rise buildings up to four stories because it is the most economical choice; however, with five-story wood buildings permitted in the IBC (six for office occupancy), there has been a marked interest among those who see taller wood buildings as a way to achieve greater density at lower cost. Podium

structures in particular, which include multiple stories of residential wood-frame construction over a concrete (3-hour-rated) podium deck, are common among design professionals seeking to incorporate parking, retail or restaurants into their designs. The specific requirements for using podium construction to increase allowable number of stories are detailed in Section 510 of the IBC.

**Schools.** The IBC has well-established parameters for wood-frame schools, which is good news for school districts trying to accommodate increasing enrollment on a limited budget. However, many who turn to wood-frame construction for its cost effectiveness find that wood also offers other advantages—such as speed of construction, design versatility and the ability to meet green building goals. Increasingly, research is also supporting the idea that visual wood in a room promotes the well-being of occupants, reduces stress and creates a positive environment for learning.

For example, one study<sup>11</sup> at the University of British Columbia and FPInnovations found that the presence of visual wood surfaces in a room lowered activation of the sympathetic nervous system (SNS) in an office environment. The SNS is responsible for physiological stress responses in humans such as increased blood pressure and heart rate while inhibiting the parasympathetic system responsible for digestion, recovery and repair functions. Study author David Fell says the results of the office study apply to any interior environment—and they are, in fact, supported by another more recent study of wood in healthcare environments.<sup>12</sup> "The stress-reducing effects we found for wood in office

environments are in theory transferable to any building type as these are innate reactions to natural materials."

At the 322,500-square-foot El Dorado High School in Arkansas, designers used exposed wood and natural light to create an environment that would motivate students to stay in school. "We used exposed wood products in structural systems and in elements such as doors, millwork and trim to provide a unique architectural aesthetic that helps to naturally soften and warm the spaces," says project architect Blakely C. Dunn, AIA, NCARB and principal of CADM Architecture, Inc. From a code perspective, this project is noteworthy because it was one of the first schools in Arkansas to make extensive use of wood following a change in school board policy that had previously prohibited wood in school construction. In 2008, recognition of wood's safety and performance attributes led the Arkansas School Board to modify its School Facilities Manual to reflect the IBC. It is also noteworthy from a cost perspective. Originally designed in steel and masonry, the school was changed to wood-frame construction for budget reasons—a move that saved the school board \$2.7 million.

**Mass timber.** Since the invention of modern day plywood in the early 1900s, a succession of new engineered wood products have offered increasing strength and stability, expanding the options for (among other things) taller walls, taller buildings and longer unsupported wood spans. In the latest development, mass timber products such as CLT, glulam and laminated veneer lumber are inciting much discussion around the safety, feasibility and economics of constructing high-rise wood buildings.

Common in Europe but relatively new to North America, CLT typically consists of three, five or seven layers of solid dimension lumber, kiln-dried and layered perpendicular to one another and then glued to create full-depth solid wood wall and floor panels up to 12 feet by 60 feet. This cross lamination provides exceptional strength, stability and rigidity, allowing CLT to be used as a low-carbon alternative to concrete and steel in many applications. Benefits also include quick installation, minimal on-site waste, light weight and (as a result) reduced foundation requirements, thermal performance and design versatility.

Internationally, examples of mass timber buildings include eight-story CLT buildings in

## DESIGNING WITH NEW MATERIALS



Photo: EwingCole

**Promega “The Crossroads”**  
**Location:** Madison, Wisconsin

**Architects:** Uihlein/Wilson  
 Architects, Inc./EwingCole

**Engineer:** EwingCole  
**Size:** 52,000 square feet

**Completed:** 2013

“The Crossroads” is a client and staff reception area within a 300,000-square-foot Good Manufacturing Practices (GMP) facility, which is a highly regulated and specialized building used for manufacturing medical device products. Together with glulam, CLT was a natural fit for the warm aesthetic the designers wanted to achieve. They also wanted a high-quality, exposed roof deck with long spans and minimum on-site construction complexity—which CLT allowed.

Although not yet included in the IBC, the design team earned local building department approval by using *ANSI/APA PRG 320-2011 Standard for Performance-Rated Cross-Laminated Timber*. They discussed the standard with building officials early in the process, and submitted engineering information under the “alternate designs” section of the IBC. IBC Section 104.11 states: “An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of the code.”

Europe, a 10-story CLT building in Australia and a 14-story building in Norway (under construction) comprised primarily of load-carrying glulam trusses and prefabricated building modules made from traditional timber framing. North American examples include (among others) a two-story CLT elementary

school in West Virginia, a six-story CLT structure in Quebec, a five-story heavy timber/CLT hybrid building at the University of British Columbia, and an eight-level heavy timber/CLT hybrid (six stories plus a penthouse and mezzanine), also in British Columbia.

In the U.S., the 2015 IBC includes CLT of a certain thickness within Type IV construction. Fire-resistance testing has confirmed that CLT, like heavy timber, chars at a rate that is slow and predictable, maintaining its strength and giving occupants more time to leave the building.<sup>13</sup> In May 2012, APA published *ANSI/APA PRG*

320-2011 *Standard for Performance-Rated Cross-Laminated Timber*, an American National Standard that provides requirements and test methods for qualification and quality assurance of CLT. CLT products manufactured to the standard have been recognized as code-compliant in the 2015 IBC.

### GREEN BUILDING CODES, STANDARDS AND RATING SYSTEMS

In addition to requirements designed to ensure safety and structural performance, there is a growing number of codes, standards and rating systems that seek to minimize a building's environmental impact.

The most recent example is the *International Green Construction Code (IgCC)*, released in 2012. Adopted by eight jurisdictions so far, it is the latest phase in an evolution that's included two American National Standards (covering residential and non-residential construction), the *California Green Building Standards Code (CALGreen)* and *ASHRAE 189.1*, a code-intended commercial green building standard published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) in cooperation with the Illuminating Engineering Society of North America (IES) and U.S. Green Building Council.

The IgCC covers subject areas typically found in any green building effort, including site, materials, energy, water and indoor environment. Primarily a voluntary code that

jurisdictions have adopted to provide guidance regarding public or publicly funded buildings,<sup>14</sup> it includes "mandatory" provisions within all subject areas as well as recommended provisions and electives. It is potentially applicable to almost every commercial building project, including additions and repairs. In terms of material use, the IgCC's key mandatory requirement is that at least 55 percent of materials (based on mass, volume or cost) be used, recycled, bio-based and/or indigenous in any combination. However, this rule need not be met when a whole building life cycle assessment (LCA) is performed.<sup>15</sup>

LCA is a scientific approach to evaluation that considers the impact of materials over their entire life cycle, from extraction or harvest through manufacturing, transportation, installation, use, maintenance and disposal or recycling. When integrated into green building codes, standards and rating systems, LCA encourages design professionals to compare different building designs based on their true environmental impacts and to make informed choices about the materials they use. It replaces the prescriptive approach to material selection that's been common until now, which assumes that certain prescribed practices—such as specifying products with recycled content—are better for the environment regardless of the product's manufacturing process or disposal. LCA studies consistently show that wood is better for the

environment than steel or concrete in terms of embodied energy, air and water pollution, and greenhouse gas emissions.<sup>16</sup>

In the U.S., LCA is included in the Green Globes rating system and the American National Standard based on Green Globes, *ANSI/GBI 01-2010: Green Building Assessment Protocol for Commercial Buildings*, as well as the *ICC 700 National Green Building Standard*. It is part of both CALGreen and ASHRAE 189.1, and optional LCA credits related to LCA were recently added to the Leadership in Energy and Environmental Design (LEED) rating system (v.4). Although LCA isn't mandatory in the IgCC, elimination of the "55 percent requirement" is a powerful incentive for its use.

### WOOD: THE SENSIBLE REVOLUTION

Today's building codes recognize wood's safety and structural performance capabilities and allow its use in a wide range of building applications, from the light-duty repetitive framing common in small structures to the larger and heavier framing systems used to build mid-rise/multi-story buildings, schools and arenas. This hasn't been lost on design professionals seeking to have it all—cost effectiveness, functionality, design flexibility, beauty and environmental performance—who, through their collective projects, are leading a revolution toward the greater use of wood in non-residential and multi-family buildings. ■

## ENDNOTES

1. <http://www.woodworks.org/why-wood/>

2. <http://www.woodworks.org/why-wood/carbon-footprint/carbon-footprint-resources/>

3. The American Wood Council offers a number of publications related to the fire design of wood buildings for code acceptance: <http://www.awc.org/codes/dcaindex.html>

4. *Design of Fire-Resistive Exposed Wood Members*, American Wood Council, <http://www.awc.org/codes/dcaindex.html>

5. *ANSI/AF&PA SDPWS-2008—Special Design Provisions for Wind and Seismic Standard with Commentary*, American Wood Council; *Design Concepts for Building in High Wind and Seismic Zones*, APA

6. *The January 17, 1994 Northridge, CA Earthquake—An EQE Summary Report*, March 1994, [http://www.lafire.com/famous\\_fires/1994-0117\\_NorthridgeEarthquake/quake/00\\_EQE\\_contents.htm](http://www.lafire.com/famous_fires/1994-0117_NorthridgeEarthquake/quake/00_EQE_contents.htm)

7. *Seismic Safety Inventory of California Public Schools*, California Department of Government Services, 2002, [www.documents.dgs.ca.gov/dsa/pubs/FinalAB300Report.pdf](http://www.documents.dgs.ca.gov/dsa/pubs/FinalAB300Report.pdf)

8. *ANSI/AF&PA SDPWS-2008—Special Design Provisions for Wind and Seismic standard with Commentary*, American Wood Council; *Design Concepts for Building in High Wind and Seismic Zones*, APA

9. *Acoustical Consideration for Mixed-Use Wood-Frame Buildings*, U.S. WoodWorks, 2014

10. *Fire Resistance and Sound Transmission in Wood-Frame Residential Buildings*, Canadian Wood Council

11. *Wood and Human Health*, Issue 1, FPIInnovations, 2013

12. *Wood as a Restorative Material in Healthcare Environments*, FPIInnovations, 2015

13. American Wood Council, [www.awc.org/NewsReleases/2012/newsreleases2012.php#clt](http://www.awc.org/NewsReleases/2012/newsreleases2012.php#clt)

14. The City of Baltimore is the only jurisdiction in which the IgCC is mandatory for all building construction.

15. More information on the International Green Construction Code is available from Dovetail Partners, Inc., [www.dovetailinc.org](http://www.dovetailinc.org).

16. *Life Cycle Environmental Performance of Renewable Building Materials in the Context of Building Construction*, Consortium for Research on Renewable Industrial Materials, Phase I 2005, Phase II 2010, <http://www.corrim.org/pubs/reports.asp>; *A Synthesis of Research on Wood Products and Greenhouse Gas Impacts*, Sarthre, R. and J. O'Connor, 2010, FPIInnovations, <http://woodworks.org/wp-content/uploads/FPI-Greenhouse-Gas.pdf>; *Wooden building products in comparative LCA: A literature review*, Werner, F. and Richter, K., 2007, *International Journal of Life Cycle Assessment*, 12(7): 470-479