

# ARCHITECTURAL RECORD

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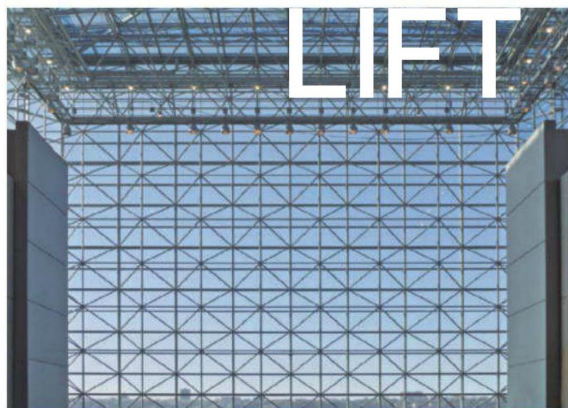
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"Mass Timber and Wood Framing," Architectural Record Magazine, McGraw Hill Construction, November 2012, pp. 165-169

0001

# SPACE



Since its construction in 1982, the **Jacob K. Javits Center** has been one of the world's leading examples of space-frame design. But the **I.M. Pei & Partners**-designed exhibit space needed updating to put its best face forward for the 3.5 million visitors it receives each year. So owners engaged **Epstein Global** and **FXFowle Architects**, who developed the recladding program that is dramatically increasing the building's transparency and energy efficiency. Targeting LEED Silver with a glazing system that will enable the building to exceed energy code requirements by 25 percent, the new face of Javits proves that being old doesn't have to mean retiring.

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CIRCLE 9

Architect: Epstein Global, FXFowle Architects  
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## ARCHITECTURAL RECORD

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## ARCHITECTURE EDUCATION **NOW**

### NEWS

- 25 BRITS DECLARE WAR ON SCHOOL CURVES  
*By Christopher Turner*
- 26 REDESIGN PLANNED FOR AURORA THEATER  
*By David Hill*
- 28 JEANNE GANG EXHIBITION *By Lee Bey*
- 28 LEAVING A TRACE WITH AN IPAD  
*By Michael Leighton Beaman*
- 30 RECORD INNOVATION CONFERENCE: SHAPING  
THE FUTURE *By Fred A. Bernstein*
- 32 NEWSMAKER: ROMAN MARS  
*By Laura Raskin*

### DEPARTMENTS

- 18 EDITOR'S LETTER: INNOVATION AT EVERY SCALE
- 34 ARCHITECTURAL ANALYTICS
- 39 COMMENTARY: IS MAXXI GOOD FOR ART?  
*By Peter Plagens*
- 41 PLANNING: EXPANDING UNIVERSITIES  
*By Robert Barnett*
- 45 PRACTICE: THE COST OF COMPETITION  
*By Fred A. Bernstein*
- 47 HOUSE OF THE MONTH: JAMES GAUER'S SANTA  
BARBARA HOUSE *By Laura Raskin*
- 53 PRODUCT FOCUS: PAINTS & COATINGS  
*By Rita Catinella Orrell*
- 57 PRODUCT BRIEFS: ROUNDUP  
*By Rita Catinella Orrell*

- 67 INTRODUCTION
- 68 AMERICA'S TOP ARCHITECTURE SCHOOLS 2013  
*By James P. Cramer*
- 72 WHY THE LACK OF BLACK STUDENTS?  
*By Jenna M. McKnight*
- 74 THE ARCHITECTURE OF ARCHITECTURE  
SCHOOLS *By Laura Raskin and Asad Syrkett*
- 78 BOOK REVIEW: ACADEMIC DISCOURSE  
*By Aleksandr Bierig*

### PROJECTS

- 86 CCTV HEADQUARTERS, BEIJING  
OMA *By Clifford A. Pearson*
- 98 ELLIPSE SKY, TOKYO KEIKO + MANABU  
*By Naomi R. Pollock, AIA*
- 102 GIANT'S CAUSEWAY VISITOR CENTRE,  
NORTHERN IRELAND HENEGHAN PENG  
ARCHITECTS *By Chris Foges*

### BUILDING TYPES STUDY 928 COLLEGES/UNIVERSITIES

- 109 GOLKIN HALL, PENN LAW, PHILADELPHIA  
KENNEDY & VIOLICH ARCHITECTURE  
*By William Hanley*
- 114 WOLFE CENTER FOR THE ARTS, BOWLING  
GREEN STATE UNIVERSITY, OHIO  
SNØHETTA *By Steven Litt*
- 118 LINDE CENTER, CALTECH, CALIFORNIA  
ARCHITECTURAL RESOURCES GROUP  
*By Joann Gonchar, AIA*

### LIGHTING

- 133 INTRODUCTION *By Linda C. Lentz*
- 134 CHURCH AT WORTH ABBEY, UNITED KINGDOM  
HEATHERWICK STUDIO/DPA LIGHTING DESIGN  
*By Linda C. Lentz*
- 137 TEMPLE BETH ELOHIM, MASSACHUSETTS  
WILLIAM RAWN ASSOCIATES/HLB LIGHTING DESIGN  
*By Allison Craig*
- 141 QUAKER MEETING HOUSE, WASHINGTON, D.C.  
KIERANTIMBERLAKE/ARUP LIGHTING  
*By Caryl Kinsey Fox*
- 145 LIGHTING PRODUCTS  
*By Rita Catinella Orrell*
- 207 DATES & EVENTS
- 212 READER SERVICE
- 220 SNAPSHOT: MATADERO MADRID ART CENTER  
*By Laura Mirviss*

THIS PAGE: POSTER ON A BEIJING WALL FEATURING CCTV  
AND THE OLYMPIC STADIUM. PHOTO BY IWAN BAAN.

ON THE COVER: CCTV HEADQUARTERS, BY OFFICE FOR  
METROPOLITAN ARCHITECTURE. PHOTO BY IWAN BAAN.

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## IN THIS ISSUE



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Page 153



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Credit: 1 HSW  
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Page 176



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Page 158



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Page 180



### Mass Timber and Wood Framing

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Page 165



### Design Options for Greening Urban Environments

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Page 187



### Concrete Masonry in Green Buildings

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Page 171



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Page 197

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The University of British Columbia Earth Sciences Building is a five-story wood structure that uses CLT, glulam, and LSL. Architect: Perkins+Will Canada Architects Co.

CONTINUING EDUCATION

## Mass Timber and Wood Framing

New and traditional approaches reduce cost and meet code for mid-rise construction

Sponsored by naturally:wood

**M**id-rise construction is becoming increasingly popular as a means of boosting densification, containing urban sprawl, and respecting infrastructure limits while maintaining neighborhood charm and community appeal. Multi-family construction in particular has grown, increasing 46 percent between 2009 and 2011. This year, the sector is expected to continue to advance, rising 23 percent over 2011.<sup>1</sup>

Wood has a key role to play in mid-rise construction. It has proven to be more affordable than concrete or steel, and has a lower environmental footprint than either material. Architects for Stadhaus, a nine-story wood apartment building in England, found that compared to concrete, a wood building offered cost savings of more than 15 percent,<sup>2</sup> and that 186 tons of carbon were sequestered within its structure.<sup>3</sup>

Codes now allow wood as a structural material in five- and six-story wood-frame structures, in most U.S. states and throughout Canada. Traditional wood-frame construction

is a proven solution for current mid-rise structures up to six stories, and mass timber is a possible solution for even taller buildings. Both are being used to achieve durable, code-compliant, economical mid-rise developments that add vibrancy at a human scale.

This article will provide a high-level comparative overview of the systems themselves. Wood-frame construction systems including balloon, platform, and semi-balloon framing will be discussed as will mass timber solutions including cross-laminated timber (CLT), glue-laminated timber (glulam), and laminated strand lumber (LSL). Case studies will showcase how architects are using these systems to full advantage either through code-compliant situations for additional stories or by turning to alternative solutions—methods of construction that are not included in the building code per se, but can be used to meet the intent of code—to build taller, smarter, and more efficiently with wood.

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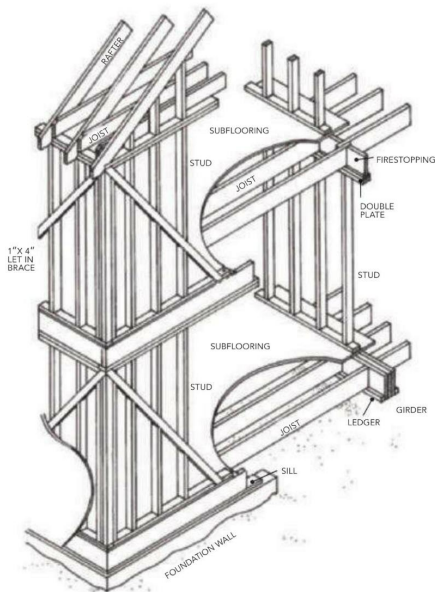
After reading this article, you should be able to:

1. Discuss the ways in which wood contributes as a structural building material in mid-rise construction.
2. Distinguish between platform, balloon, and semi-balloon framing.
3. Explain the potential of modern mass timber systems.
4. Cite examples of various approaches to wood-frame mid-rise construction.

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Image courtesy of American Wood Council



Platform framing uses shorter lengths of lumber for the studs, generally 2x4s spaced 16 inches on center.

### TRADITIONAL WOOD-FRAME CONSTRUCTION

For centuries in North America, the dominant method of building homes and low-rise apartments has been wood frame construction, which has shown strength, longevity, and stability. Mid-rise light wood-frame structures are widely considered to be cost effective, due to relatively low material costs, reduced construction time, availability of resources and labor.<sup>4</sup> The development of prefabricated component systems increases the strength and affordability of wood frame construction. Also, when built according to building codes and industry standards, wood-frame structures can provide hurricane and seismic resistance.

Wood-frame construction entails the use of wood-framing members, typically dimensional lumber, I-joists, or prefabricated wood trusses, spaced relatively close, and used with sheathing or decking to create a structure that can withstand loads. Modern wood framing essentially includes three types: balloon, platform and semi-balloon framing.

### Balloon Framing

With long lumber lengths, vertical load-bearing framing studs run continuously from foun-

dation to roof. Intermediate horizontal floor joists are nailed to the sides of the vertical studs and bear on a ledger. The ledger is notched into the stud. Typically this system is more common in two-story buildings due to the stud length availability. However, a variation of this method could be used in increments of two stories. The advantage to this is that it would eliminate the shrinkage that may occur from the floor joists.

### Platform Framing

Over time, platform framing replaced balloon framing as the dominant framing method. Platform framing uses shorter lengths of lumber for the studs, generally 2x4s spaced 16 inches on center. The walls are typically framed with a sill or sole plate, studs and two top plates, then floor joists bear on the top plates. Platform framing does not require hangers, while semi-balloon framing does as described below.

At each story, joists are covered by subflooring providing a platform, or work surface, on which walls and partitions are easily erected. The benefits of platform framing include the fact that walls can be constructed on the ground and less effort is involved in lifting them into place than in balloon framing. Notching of the stud is not required, and after one story is constructed, the framers can utilize it to construct the next story. Platform framing also accommodates various prefabricated methods.

### Semi-Balloon Framing

Semi-balloon framing is a cross between balloon framing and platform framing. Where balloon framing has a continuous stud from foundation to roof, semi-balloon framing does not. Balloon framing does not require hangers, whereas semi-balloon framing does.

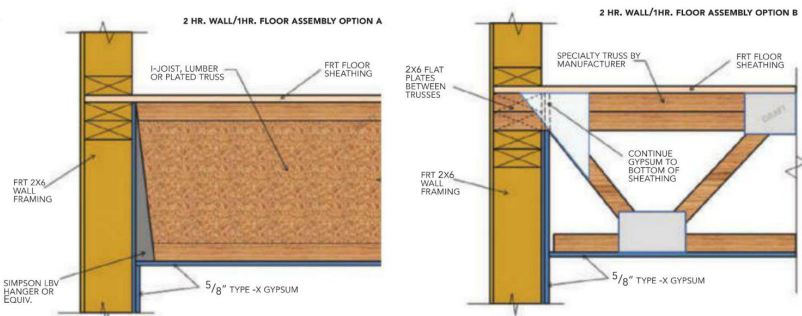
While platform framing is more dominant overall, modern semi-balloon framing, in which the floor joist hangs from the double

top plates, is more common in buildings that are five stories and up, and is ideally suited to certain circumstances. According to Michelle Kam-Biron, P.E., S.E., senior technical director, lead for mid-rise construction for WoodWorks, "In the U.S., where most states follow the International Building Code, semi-balloon framing is often used as an alternative to platform framing in structures where fire requirements or shrinkage may be a challenge." Type III construction requires non-combustible exterior walls but there is an exception in the code that allows for fire-retardant treated wood (FRTW). "Designers will sometimes utilize semi-balloon construction, hanging the joist off the top plates and eliminating the penetration of the exterior wall building envelope," Kam-Biron says.

### MASS TIMBER PRODUCTS AND SYSTEMS

Advancements in wood technology, systems and products, together with performance-based building codes have fueled interest in building with mass timber in mid-rise construction and even taller buildings. Engineered wood products offer the architectural community alternate materials and systems with comparable or better performance and environmental attributes than other construction materials. Canadian architect Michael Green, in fact, sees mass timber—CLT, parallel strand lumber (PSL), and LVL—playing a major role in buildings up to 30 stories. Performance-based building codes are accommodating the use of such new technology. While some of this new generation of wood products are not referred to specifically in the building code, architects can propose them as an alternative solution. As an example, buildings that were previously permitted only to be of non-combustible construction, can now be built of wood, provided it is sufficiently demonstrated that the structure provides equivalent fire safety.

Photo courtesy of US WoodWorks



(LEFT) Semi-balloon framing is more common in buildings five stories and higher; (RIGHT) it is often used as an alternative to platform framing where fire requirements or shrinkage may be a challenge.

Differentiated from dimensional lumber by having minimum dimensions required by the building code, modern mass timber<sup>6</sup> refers to a family of products including sawn stress-grade lumber, timber tongue and groove decking, glulam, and CLT—that offer advantages in terms of increased strength, and also have quickened the construction process and enabled the use of wood products as solid walls, floors, elevator shafts, and columns to construct an entire building. Modern heavy timber products are particularly suited to mid-rise/multi-family housing, schools, large-span recreation centers, and supermarkets—buildings that must stand up to extreme loads caused by strong winds, heavy snow loads, and earthquakes.

CLT is one type of new mass timber assembly that is comparable in strength to steel and concrete,<sup>7</sup> but weighs less. A CLT panel has at least three glued layers of boards placed in orthogonally alternating orientation to the neighboring layers. In special configurations, consecutive layers may be placed in the same direction, giving a double layer to obtain specific structural capacities. Modern CLT exemplar include the eight-story H8 in Bad Aibling, Germany, which was completed in three weeks. Experts maintain that the structural performance of CLT makes it possible in situations where wood has never been used before.<sup>8</sup> In North America CLT solutions are emerging in mid-rise buildings, setting records for versatility and speed.

Image courtesy of FPIInnovations



Panel sizes vary by manufacturer. CLT is currently available in North America with dimensions up to 19-1/2 inches thick, 18 feet wide and 98 feet long.

CASE STUDIES ON TRADITIONAL AND INNOVATIVE WOOD SYSTEMS

The following case studies illustrate a variety of ways in which architects approach wood-frame mid-rise construction utilizing both traditional and new methods to maximize functionality. These examples cover a wide array of conditions and challenges, including cost, climate, seismic activity, and adherence to safety codes.

Photo courtesy of Misra Architect Ltd.



|                        |                               |
|------------------------|-------------------------------|
| Name                   | Skyline Condominiums          |
| Location               | Vancouver Island, B.C.        |
| Architecture           | Misra Architect Ltd.          |
| Construction           | Kang & Gill Construction Ltd. |
| Structural Engineering | JSH Engineering Ltd.          |
| Completion             | November 2012                 |

Designers used balloon framing to prevent shrinkage on this Vancouver Island development.

1 BALLOON FRAMING AS A MEANS TO REDUCE SHRINKAGE

Located on the southern tip of Vancouver Island, the six-story Skyline Condominiums enjoy an idyllic location and postcard views.

Designers used balloon framing to reduce the potential for shrinkage. “Normally, the wood member shrinks approximately 3/8 of an inch per floor for 12 percent moisture in the wood. To avoid that, we used plywood, joist hangers for the joists, and balloon framing,” says Pradip Misra, principal, Misra Architect Ltd. Because wood shrinks to a greater degree across the grain than parallel to grain, it’s the horizontal members, such as the sills and joists than can be problematic, rather than the posts and studs. “The joists are hung from the side of the bearing walls. This eliminates the floor shrinkage in the total building shrinkage,” says Steve Hoel, P.Eng., Struct.Eng., principal, JSH Engineering Ltd.

Skyline’s location is prone to humidity, seismic activity, and wind. This resulted in more than a few design challenges. Buildings in this area are required by code to withstand the most severe earthquake loads in Western Canada, and there is always a tendency to build with either steel or concrete. However, the design team and the owners went with wood. Wood-frame structures, which have numerous nailed joints,

have more load paths and are inherently more ductile than those with a rigid connection—which make them more flexible and allows them to dissipate energy when subjected to the sudden loads of an earthquake. “The mass of the building also contributes,” says Sukh Johal, technical advisor for WoodWORKS!BC. “Wood buildings are lightweight, but perform well structurally.” Since forces in an earthquake are proportional to the weight of a structure, wood-frame buildings that are properly designed and constructed perform exceptionally well. Misra says that mechanical options were also a factor in seismic design, notably “hold-downs,” known as continuous tie rod systems or 1-inch diameter steel bars that extend from the concrete slab to the upper floors. “This is a self-adjusting system to keep all floors intact in the event of seismic forces.”

Wood also offered advantages in terms of cost. Developers, who opted for a six-story structure in response to the increased height allowed in B.C., compared the costs of concrete, steel, and wood in an extensive study. “A concrete-and-steel superstructure ran 20 to 25 percent more than wood, and a structured steel superstructure 12 to 15 percent more than wood,” says Biki Kang of Kang & Gill Construction Ltd. “Wood was found to be the most economical choice.”

Photo courtesy of Tien Sher Group of Companies

CASE  
STUDY  
2

|                               |                              |
|-------------------------------|------------------------------|
| <b>Name</b>                   | Quattro 3                    |
| <b>Location</b>               | Surrey, B.C.                 |
| <b>Architecture</b>           | Patrick Cotter               |
| <b>Construction</b>           | Tien Sher Group of Companies |
| <b>Structural Engineering</b> | Thomas Leung                 |
| <b>Completion</b>             | 2012                         |

## 2 PLATFORM WOOD CONSTRUCTION BRINGS AFFORDABLE URBAN APPEAL

The Quattro 3 condominium opened in September 2012, the first multi-family six-story building in Metro Vancouver, built from wood. The project used platform framing to increase affordability and occupant comfort. Featuring 164 units from studios to two-bedrooms and one floor of commercial space, Quattro 3 is part of a larger planned community that will include up to 1,900 homes.

While experts say that mid-rise wood frame construction is too new to B.C. to make a definitive statement about the cost competitiveness of wood, what can be said is that based on projects under construction in 2011 the above-grade cost of wood mid-rise construction will reduce costs by ten percent vs. steel or concrete construction. "There's always a difference between concrete and wood in terms of affordability," says Charan Sethi, president and CEO of the Tien Sher Group of Companies, developers of Quattro 3. "In the Surrey market, concrete units sell for \$50 to \$75 per square foot more than comparable wood units." Sethi feels the mid-rise wood building benefits from lower per-unit land costs and construction costs that can then be passed along to the consumer. "We're always looking for ways of bringing affordability to the working class market," Sethi says.

Sustainability, locally sourced materials, and ease of construction were other factors that drew Sethi to wood. Sethi says, "Construction was completed by our experienced framing crew and on-site staff. The process was efficient."

Occupant comfort was a prime concern. Noise transmission is a performance challenge

in any multi-family building and in wood construction there are several solutions to mitigate sound transmission, including greater mass, increased stiffness, sound-absorbing insulation, resilient metal channels, and structural discontinuity between noise and occupant. At Quattro, 1.5-inch lightweight concrete topping between floors was used for additional soundproofing and robust insulated double 2-inch-x-6-inch framed party wall construction was employed to minimize vibration and sound transfer between homes.

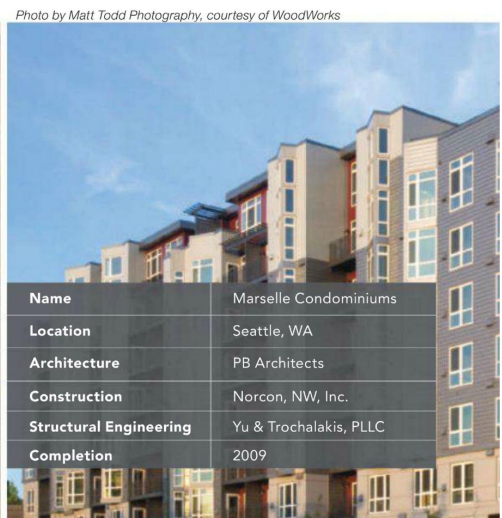
Fire experts maintain that six-story wood-frame buildings are as safe as any other form of buildings. "For a sprinklered occupied building, there is absolutely no safety issue," Sethi says. According to Len Garis, Surrey's fire chief and president of the Fire Chiefs' Association of B.C., "the fire safety of people living in six-story wood-frame buildings should be equal to the safety in any other building." Garis was quoted as saying, "These buildings are fully sprinklered and our research suggests to us that in a sprinklered building, a fire is likely to never leave the room of origin, has historically never left the floor of origin in a building. Where the sprinkler system needed to operate to put the fire out, it put the fire out."<sup>29</sup>

Quattro 3 makes an ideal introduction to mid-rise wood buildings in Metro Vancouver not only in terms of affordability, but in occupant comfort and safety as well.

## 3 SEATTLE HYBRID: WOOD PLATFORM FRAMING AND A CONCRETE PODIUM

The Marselle is a hybrid wood and concrete structure consisting of five stories of wood-platform framing plus a wood mezzanine and

Photo by Matt Todd Photography, courtesy of WoodWorks



|                               |                        |
|-------------------------------|------------------------|
| <b>Name</b>                   | Marselle Condominiums  |
| <b>Location</b>               | Seattle, WA            |
| <b>Architecture</b>           | PB Architects          |
| <b>Construction</b>           | Norcon, NW, Inc.       |
| <b>Structural Engineering</b> | Yu & Trochalakis, PLLC |
| <b>Completion</b>             | 2009                   |

a six-story concrete podium, of which, two stories are above ground. The combination of "five and one-half over two" made Marselle the tallest modern wood-frame structure in Seattle.

Marselle's main distinction lies in the way wood framing was used to maximize the value of the finished space. Two key code requirements allowed that to happen.

The City of Seattle's 2003 Building Code (SBC), under which the Marselle was built, was based on the 2003 International Building Code (IBC). Under the 2003 IBC, mezzanines were limited to 33 percent of the floor area beneath. However, SBC allowed five stories of wood construction over two stories of Type I construction plus 50 percent for a mezzanine. Mezzanine levels are not considered floors. Under the SBC, Type V-A construction allowed a fully sprinklered 70-foot maximum height for five stories while Type III-A allowed a fully sprinklered 85-foot maximum height for five stories. Zoning regulations allowed a maximum height of 85 feet. Therefore, the design team took advantage of Type III-A construction by adding a mezzanine level on top of the allowed five-story structure, to fill in the building envelope to the 85-foot maximum zoning height allowed.

The other criteria concerned construction type. According to architect Michael Shreve with PB Architects, "under the 2003 SBC, section 504.2, the allowable height for buildings of Type III-A construction in Group R-2 could be increased to five floors of wood-frame construction above two stories of Type I concrete construction and an 85-foot maximum height. The two floors of concrete construction were required to be Type I construction with



CASE  
STUDY  
**3**

Photo courtesy of UBC



CASE  
STUDY  
**4**

|                        |                                                                                          |
|------------------------|------------------------------------------------------------------------------------------|
| Name                   | Centre for Interactive Research on Sustainability (CIRS), University of British Columbia |
| Location               | Vancouver, B.C.                                                                          |
| Architecture           | Perkins+Will Canada Architects Co.                                                       |
| Construction           | Heatherbrae Builders                                                                     |
| Structural Engineering | Fast+Epp Structural Engineers                                                            |
| Completion             | 2011                                                                                     |

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a three-hour horizontal fire rating separating the wood construction from the concrete construction.”

“Once built, the top level units would have water views of Seattle’s Lake Union,” explained structural engineer Panos Trochalakis, P.E., S.E., principal with Yu & Trochalakis, PLLC. “For obvious reasons, the developer wanted to take advantage of that.” The extra half-story mezzanine added about \$250,000 to the construction cost of the building, but the architect and builder estimated that the added height and space increased the value of the complex by \$1 million and afforded revenue-generating views on the top floors.

Attention was devoted to maximizing the strength and durability of the wood members, with architects designing for potential shrinkage. As is typical with wood-framed podium structures, Marselle’s contractors used a continuous rod tie-down system with a shrinkage compensation device to limit deflection and avoid wall separation due to wood shrinkage under wind and seismic forces. They also included an expansion joint in the cladding; were careful to specify proper panel spacing in the exterior wall sheathing; and included a provision in the mechanical system to allow for movement.

The use of wood also had a positive impact on schedule and budget factors, with pre-panelized walls enabling a speed of construction that made a big difference. The panels, which ranged from 4 to 20 feet long, were pre-assembled by a

local framer in an off-site warehouse, and then quickly and easily lifted into place at the job site by crane. “If you can install the walls on a building the size of Marselle in less than two weeks per floor, then you lower construction costs significantly,” Trochalakis says. “Lower construction costs were the number one reason to use wood. Wood-frame construction is virtually impossible to beat in terms of cost.”<sup>10</sup>

**4** **MASS TIMBER FOR A SIMPLIFIED DESIGN AND GREATER STRUCTURAL CAPACITY**  
Billed as the most innovative high-performance building in North America, the Centre for Interactive Research on Sustainability (CIRS) at the University of British Columbia is expected to be the university’s first LEED® Platinum building, and is on track to receive Living Building Challenge recognition. The building was envisioned as a new baseline in sustainable high-performance buildings, and incorporated regenerative design—an emerging alternative to current green design practices that seeks not merely to reduce harmful environmental impacts, but to actually improve both the natural environment and the lives of their human inhabitants. Mass timber played an important part in achieving these goals. CIRS features a simple structural design, comprised of a combination of glulam members, dimensional lumber, plywood, and a minimal amount of concrete. The moment frame structure was designed to create an open, column-free

floor plate for flexibility of use and interior arrangements, and to allow for large openings in the walls that maximize daylight and views. The members’ size and solidity make the structure non-combustible heavy timber construction under British Columbia Building Code—a designation that simplifies the building design.

In order to reinforce external charring in case of fire, designers sized all members slightly larger than required. A building-wide sprinkler system and on-site water supply and water pump were also incorporated to enable the heavy timber wood structure to meet the requirements for non-combustible construction required by code.

Designers opted to size the structure to support a live load of 100 pounds per square foot (4.7 kilonewtons/square meter), double the requirements of the British Columbia Building Code, to achieve an increased capacity that allows for additional equipment and future changes in use. Structural members were larger where larger loads required more support, notably in the auditorium where beams and columns were sized to handle both a long span over the seating and the load of the green roof. “From a structural point of view, the modern engineered materials... have increased the strength of wood so that they have a much greater structural capacity,” says Paul Fast, managing partner, Fast+Epp.

See endnotes in the online version of this article.

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CIRCLE 102