Student Housing Gets Extra College Credit from Wood

University of Washington used wood framing to meet ambitious design goals

WoodWorks

To meet burgeoning demand and shrinking budgets, a growing number of colleges and universities are choosing to use wood for their new student housing facilities. Wood-frame construction offers cost savings as well as other benefits, including design flexibility, structural integrity and environmental advantages.

Big Housing Needs for 'Husky' Students

In 2012, the University of Washington (UW) completed a $109 million,* five-building construction project, adding nearly 1,700 student housing beds. Known as West Campus Student Housing – Phase I, the 668,800-square-foot project was the first of four phases planned by UW to add much-needed student housing to its Seattle campus, which has an enrollment of more than 42,000 students.

Like other US colleges and universities, UW recognizes the academic and social benefits of having students live on campus. Numerous studies have shown that students who live in residence halls are more likely to stay enrolled and graduate. According to the *2011 State of College Admission* report, colleges and universities spend nearly $600 to recruit each applicant, so the investment of building high quality housing to retain already-enrolled students pays off.

The West Campus structures were the first new residence halls to be built on UW's main campus since the early 1970s. Only 18 percent of UW students live on campus, which compares to the national average of 25 percent for comparable universities. In 2011, there were about 7,000 applications for the 6,300 on-campus beds then available to UW students. With the addition of the new West Campus buildings, applications for housing at UW were expected to increase.

'5 Over 2' with Type V-A Construction

UW's need was great, but budget was limited. The *International Building Code* (IBC) allows five stories of Type III wood-frame construction when the building is equipped with an automatic sprinkler system that complies with NFPA 13. Designers across the country are increasingly choosing this option as a lower cost alternative to steel and concrete. However, Seattle's building code is unique in that it also allows five stories of wood with a Type V-A 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.

With this in mind, Mahlum Architects worked with engineers at Coughlin Porter Lundeen to make the most of the urban campus location, designing each of the buildings with five stories of light-frame Type V-A wood construction over a two-story Type I-A concrete podium. This two-story podium, which will be allowed in the 2015 IBC, helped them meet both ambitious design goals and the University's tight budget. The entire project was constructed for $177 per square foot.

**Construction cost; total project cost including FFE was $159 million*

Project Overview

University of Washington West Campus Student Housing – Phase I

OWNER: University of Washington

ARCHITECT: Mahlum Architects • Seattle, WA

STRUCTURAL ENGINEER: Coughlin Porter Lundeen • Seattle, WA

ACOUSTICAL CONSULTANT: SSA Acoustics • Seattle, WA

GENERAL CONTRACTORS: Walsh Construction • Seattle, WA
WG Clark Construction • Seattle, WA

TOTAL SIZE: 668,800 square feet (five buildings)

COMPLETED: July 2011 (Cedar Apartments and Poplar Hall)
July 2012 (Alder Hall and Elm Hall)

AWARDS: 2013 WoodWorks Wood Design Award for Multi-story Wood Design; AIA Seattle Honor Awards for Washington State Architecture (2012 Honor Award and 2010 Commendation, Unbuilt Category); 2013 SCUP (Society of College and University Planners) Excellence in Planning – Honor Award; 2013 Residential Architect Design Awards – Grand Award; 2013 AIA Housing Award

Wood Allowed Flexibility, Affordability, Versatility

The decision to use wood was made early in the design process. Anne Schopf, project architect with Mahlum Architects, said they did some initial cost analysis, even considering concrete at one point. "But UW needed residence halls with flexible configurations which could be changed as the University's housing needs change. Plus, we were trying to make these new halls affordable so they could be leased out at a reasonable rate. We briefly looked at other options, but immediately chose wood."

Schopf added that the concept of building five stories using wood framing is not new to Mahlum. "We've been using wood framing for a long time and for a number of reasons. For example, our decision to use wood allows us to transfer costs. These residence halls have an extremely high quality skin with a high functioning structure that meets all the needs and requirements of the project without sinking undue money into the structure itself. That wood-framed structure is doing everything it needs to do without taking an unduly large percentage of the budget to do it."

While demand drove need and budget drove size and proportion, wood still allowed Mahlum to design an award-winning project. "If you look at the scale of West Campus, even though it was large, it is very Parisian in its density," Schopf said. 'There's something very humane about that; we can tolerate the scale from a humanistic quality, so it's a very good outcome of that constraint. It's so important in student housing to provide a humanistic home, and wood allowed us to do that. We're all very pleased with the result."

Traditional Wood Construction

West Campus Student Housing – Phase I includes three residential halls (Alder Hall, Elm Hall and Poplar Hall) and two apartment buildings (known collectively as the Cedar Apartments). While the apartments have a parking garage on the lower level, the residence halls include a restaurant, grocery store, conference center, café, fitness center and academic support center on their ground floors. "This feature—what we call activating the street use—is unique for student housing but part of a growing trend to make urban campuses more student-friendly," said Schopf.

The wood-framed structure in each building is separated from the concrete podium below by a 3-hour rated floor assembly, and all floors were fully sprinklered according to NFPA 13. The five upper floors used 2x4 and 2x6 wood studs in both exterior walls and interior load-bearing walls, as well as in partition walls. Lateral strength is provided by plywood-sheathed wood shear walls. Floors consisted of engineered wood I-joists and plywood sheathing.

Stair treads and stair landings on the primary staircases were constructed from glued laminated beams, and laminated strand lumber (LSL) was used for the rim boards. Roof structures were comprised of engineered wood trusses and plywood sheathing, and heavy timber blocking was used throughout for fire protection. The building's exteriors were then clad in manganese flashed brick extending to grade.

They also used wood as a finish material on portions of the exterior, to add richness to the material palette, especially around the main building entries. "Inside, we used wood paneling, casework and trim for durability and to bring warmth to the public spaces," said Schopf. "Our goal was to humanize the space with the wood. We wanted all materials to provide a rich yet durable surface, and wood worked well for all categories."

Contractors used traditional installation methods, finding it most economical to frame in place. They experimented with using modular prefabricated wood residential room units on one of the five buildings, but learned that they lacked adequate staging space in the tight urban setting, so instead turned to traditional framing. Wood structural materials for each unit were precut and palletized, which helped speed installation and reduced jobsite waste.

Structural Design Strategies Started with Non-Load-Bearing Exterior Walls

Cost-effective design and engineering strategies started with a decision to make most of the exterior walls in all five buildings essentially non-load-bearing; interior walls provide both primary vertical load carrying structure and shear resistance. With a few exceptions (e.g., at the corners), the strategy allowed the design team to space exterior wall studs at 24 inches on center instead of 16. This saved money in material and allowed for more insulation, a decision that will help UW save energy over the life of the structures. A frame of beams at the floor levels spanning between columns at intersecting interior walls provided the primary vertical load system in the exterior walls.

In addition, the design featured a random window pattern, resulting in variable load paths in the exterior walls. By using interior load-bearing walls, they alleviated the floor load from the exterior walls, which simplified load path calculations. The non-load-bearing exterior walls also allowed for larger windows, which improves daylighting and reduces energy use over the long term.

Brick Veneer Required Careful Structural Detailing

All five structures were fully clad on the exterior with brick, which increased load demands. Framing members in the exterior walls supporting the brick were carefully sized to make sure the masonry/wood structure connections were engineered appropriately. Recognizing that shrinkage and compression occurs naturally with both wood framing and brick veneer (albeit at different rates), they accommodated the movement through proper detailing.

Prescriptively, the IBC allows brick to be stacked up to 30 feet above the non-combustible foundation without intermediate vertical supports when a wood stud wall backs the veneer. However, to avoid possible problems caused by incompatible shrinkage between wood and brick systems, the West Campus Housing design team closely evaluated the wood building movement and then chose an interval to hang brick veneer that was specifically compatible with that analysis.

"The code allows you to go up 30 feet [prescriptively] but we did not go that high," said Chris Duvall, with Coughlin Porter Lundeen. "We isolated the brick panels at each level by using veneer ledger angles hung from the rim board at each floor above the podium. So, the first story of brick sits on top of the concrete foundation; it is re-supported at the concrete podium slab and then at every level of wood floor framing above. We then detailed the brick to allow the wood framing to shrink behind it while the brick veneer panel moves with the building."

Their design utilized 3-½ x 12-inch LSL beams, which spanned the same dimension as the floor joists and extended between the interior bearing walls. The LSL carries the ledger angles, while also helping to alleviate the random load path around the windows in the exterior walls.

"When you use a ledger angle, there are other requirements that come with it," said Brian Jonas from Mahlum. "We had to add flashing and air and weather barriers around each ledger angle to protect the structure. We chose to use a sealed sheathing approach, which uses gypsum sheathing above and below the floor line for the air barrier. We used plywood at the floor line instead of the gypsum, because the gypsum can't handle the crushing load of having the masonry bearing on the angle. We then put a weather barrier over it all, and were also mindful to specify sealants that could expand and contract up to 50 percent without cracking."

They detailed brick wall gaps at every floor with enough tolerance to allow wood to shrink without causing the brick to crack. "We knew we would see those gaps, so we accentuated the horizontal in our design aesthetics," Schopf added.

Seismic Protection

Lateral loading was also a consideration, since Seattle is in a high seismic area; West Campus structures were designed to Seismic Category D requirements. Because wood systems are ductile, Coughlin Porter Lundeen engineers took advantage of wood's flexible properties to meet the requirements. And, by combining the shear walls and the load-bearing walls for loading in the transverse direction, they were able to reduce the size of the required hold-downs. For the lateral analysis, the engineer utilized the interior corridor shear walls with cantilevered diaphragms.

The analysis of the diaphragms and the determination of their stiffnesses included an envelope approach. This design approach was taken to evaluate how the structure may perform in a seismic event and then to design the lateral resistance system accordingly.

The staggered studs used for acoustical benefits (2x4 studs staggered on a 2x6 plate) also gave them an additional seismic advantage. Because the interior shear walls were stacked, they were able to use floor-to-floor all-thread hold downs and multiple 2x6 compression studs, which provided better strength; 2x6 compression studs are also more economical than larger 2x4 stud packs. In addition, standard 2x4 stud walls would not have been able to accommodate the larger 2x6 compression studs.

Acoustics

Acoustics are important for any multi-family housing project, but particularly so for student housing. Mitigation measures must be weighed against the budget, which is why the design team brought in experts from Seattle-based SSA Acoustics.

While the science of sound is fairly complicated, many mitigation measures are relatively simple. For example, SSA recommended a strategic combination of staggered stud and double stud walls to minimize sound transmission between residential units themselves, between the units and common spaces, and between the units and service areas.

Because they knew single stud walls would not provide adequate performance, SSA recommended staggered stud walls between residential units. "Since there is no rigid connection between the gypsum board on each side except at the plate, a staggered stud wall performs better than a single stud wall," said Mohamed Ait Allaoua, with SSA Acoustics. "Double stud walls perform better than a staggered stud design because plates are separated by an air space, so we specified double stud walls between residential units and common spaces (lounges, staircases, elevators, etc.) and service areas."

Little details also count when it comes to acoustics, so all penetrations were sealed using resilient caulk. Whenever possible, they located junction boxes using minimum 24-inch spacing and avoided placing them back to back. When this was not possible, contractors placed putty pads on the backside of the junction boxes.

"In the floor/ceiling assembly, we paid careful attention to the installation of resilient channels, which are often one of the main causes of failed floor/ceiling assemblies from an acoustical standpoint," said Ait Allaoua. "In fact, there is a difference of 8 to 10 IIC and STC points between assemblies with resilient channels versus those without." SSA specified straightforward requirements for channel installation; for example, the length of screws was specified for the first layer and for the second layer of gypsum board to never touch the framing behind the resilient channel.

Since carpet is the best material for reducing impact noise and footfall impact, they used carpet throughout the West Campus complex (except in bathrooms and kitchens). Bathrooms and kitchens feature drop ceilings to accommodate ducting and plumbing, which provided additional noise reduction between units. Where the finish floor was stained concrete, they installed a resiliently suspended gypsum wallboard ceiling using neoprene clips to reduce footfall impact noise below.

Fire protection measures often benefit acoustical efforts. Where putty pads were required at electrical boxes for fire code (in 1- or 2-hour fire rated wall assemblies), there was no additional acoustical mitigation required. Penetrations through 1- or 2-hour-rated demising walls, corridor walls, shaft walls, floor/ceiling assemblies and others were sealed with fire resilient caulk, which also met acoustical recommendations.

SSA also made recommendations for structural to reduce floor vibration. They recommended that the live load deflection of the floor assembly between residential units should achieve a max L/480; the code only requires L/360. They also recommended that plywood sheathing be placed only on the outer side (not the inner side) of double stud walls, since air space between the layers of mass on each side of the studs is critical for achieving the specified acoustical performance.

Moisture and Energy Management

Mahlum Architects used careful detailing and oversight to reduce envelope air infiltration and thermal bridging with continuous air, thermal and moisture barriers. Their efforts made a significant impact on the buildings' energy performance while also increasing the structures' lifespan.

"We worked with an envelope consultant and the contractor to test full-scale mockups; we also did thermal imaging and conducted blower tests to measure infiltration," said Schopf. "In addition, we ran a number of simulation studies to locate and size windows, maximizing daylighting and summer ventilation while maintaining winter comfort and minimizing energy loss through assemblies. Like many mid-rise housing structures, codes require a substantial number of air changes, which also helps avoid mold and moisture problems. We then conducted field testing to identify and correct any air barrier deficiencies."

Their hard work paid off. Four of the five buildings in West Campus Student Housing – Phase I meet The 2030 Challenge (requiring 60 percent reduction over baseline fossil fuel energy consumption) with the purchase of green power. Design strategies included use of high-efficiency heating and ventilation systems, low building envelope air infiltration, elimination of building envelope thermal bridges, efficient light fixtures and lighting control systems, and others. While on-site renewable energy production was not part of the project, they made provisions on the roof structures to allow future installation of solar hot water systems, which significantly increased roof loading.

"We spent a lot of time, especially with the architect and other consultants, making sure that this was an energy-efficient building," said Duvall. "We had very lofty energy goals, and wood helped because it has low conductivity of heat transfer, and because wood framing systems can be easily insulated."

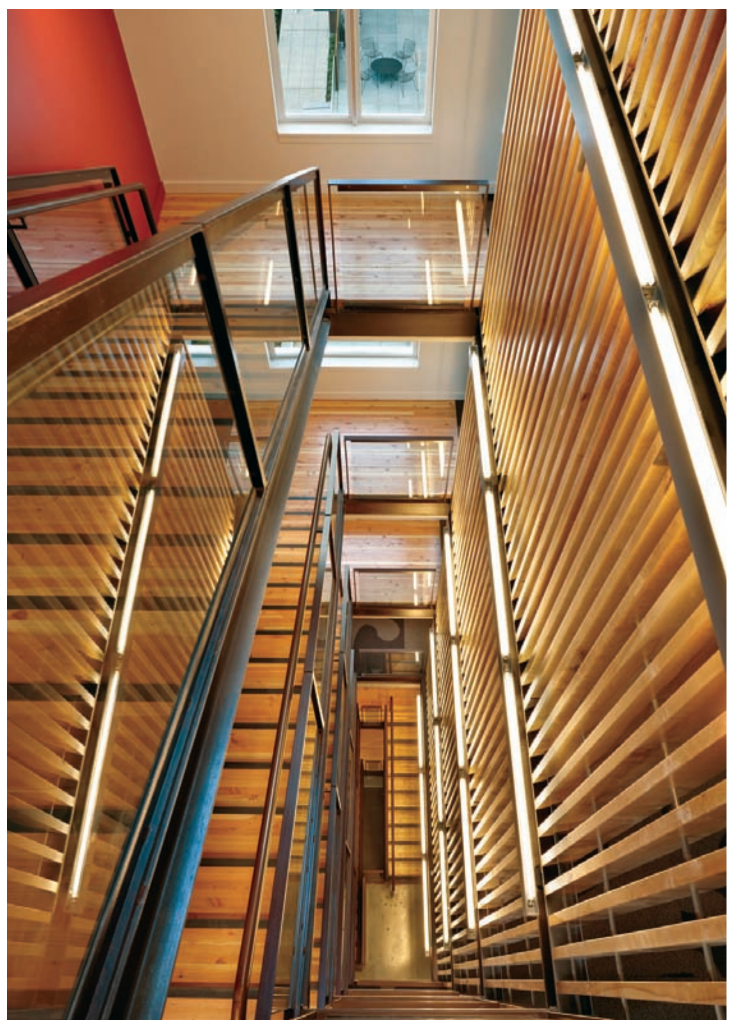
Sustainability also appeals to an increasing number of students, and the UW prides itself as being 'one of the country's preeminent leaders in environmental practices,' committing itself to offer students what they call an 'urban eco-lifestyle.' Cedar Apartments received certification at the LEED (Leadership in Energy and Environmental Design) Silver level, while Poplar, Alder and Elm Halls earned a LEED Gold designation.

Flexibility for the Future

Most of UW's residence halls were built in the 1950s and 1960s using concrete. University administrators have since found these big monolithic structures to be very inflexible in terms of adaptability for current space, technology and other needs.

So, UW challenged their design team to create a community which could be built within a tight budget, yet provide iconic identity, exceptional energy efficiency and integrated sustainability. Mahlum's decision to use wood as the primary structural material achieved all that and more. Wood framing also gave them design flexibility, increased speed of construction, cut overall carbon emissions and utilized local materials and a skilled labor force. Careful attention to detailing created an air- and water-tight, thermally-efficient building envelope, providing long-term durability and energy efficiency for the University.

The five buildings are testament to the fact that wood construction can not only save time and money, but also create elegant, durable, urban structures that contribute positively to city and campus vitality. There are a number of additional student housing projects under development at UW, and all will be built with wood. The West Campus Housing project represented a paradigm shift at the University of Washington, symbolizing its first embrace of large-scale light wood-frame construction.



Carbon Benefits

Wood lowers a building's carbon footprint in two ways. It continues to store carbon absorbed by the tree while growing, keeping it out of the atmosphere for the lifetime of the building—longer if the wood is reclaimed and reused or manufactured into other products. When used in place of fossil fuel-intensive materials such as steel and concrete, it also results in 'avoided' greenhouse gas emissions.

Volume of wood used:
208,320 cubic feet

U.S. and Canadian forests grow this much wood in:
17 minutes

Carbon stored in the wood:
4,466 metric tons of CO_2

Avoided greenhouse gas emissions:
9,492 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
13,958 metric tons of CO_2

EQUIVALENT TO:

2,666 cars off the road for a year

Energy to operate a home for 1,186 years

Source: US EPA

Estimated by the Wood Carbon Calculator for Buildings, based on research by Sarthre, R. and J. O'Connor, 2010, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations. Note: CO_2 on this chart refers to CO_2 equivalent.

Use the carbon calculator to estimate the carbon benefits of wood buildings. Visit **woodworks.org**.

WoodWorks is an initiative of the Wood Products Council

SLB SOFTWOOD LUMBER BOARD

Canada

Forestry Innovation Investment

WoodWorks is an approved AIA provider.

Neither the Wood Products Council nor its contractors make any warranty, expressed or implied, or assume any legal liability or responsibility for the use, application of and/or reference to the information included in this publication. Consult your local jurisdiction or design professional to assure compliance with code, construction and performance requirements.

WoodWorks Case Study WW-014 • UW West Campus Student Housing • ©2013 WoodWorks
Photos: Benjamin Benschneider, Mahlum Architects, WG Clark Construction