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Engineering a Wood Revolution

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Engineered wood products are challenging concrete and steel in structural applications while proffering a lower environmental footprint.

By Brent Ehrlich

Wood seems poised for a resurgence in structural applications, but is its popularity a flash in the pan or a whole new way of building?

The Richmond Olympic Oval was the site of speed-skating events during the 2010 Vancouver Olympic Games; its ceiling is made from trees killed by the mountain pine beetle and turned into engineered wood.

Where available, wood was the primary building material for most residential and commercial structures in North America prior to the 1900s. It was cost-effective to transport on rivers and rail, abundant (at a cost to ecosystem health, at times), inexpensive, and easy to work with. Light-frame wood construction remains popular for homes in the U.S., but with the advancement of steel and concrete use, skyscrapers went up, and timber's popularity went down.

In the past 20 years, engineered wood technology and production methods have improved the performance of timber products, and for commercial buildings they now offer an intriguing alternative to concrete and steel in many structural applications—while offering environmental benefits.

Concrete, Steel, and Wood

Steel and concrete are the materials of choice for most large commercial buildings. Their combination of strength, durability, and versatility has allowed architects and engineers to create some of the world's tallest and most impressive structures.

Energy Used in Production of Cement, Steel, and Wood

Material	Approximate Global Production	Approximate Per-Ton Production Energy
Portland Cement	5 billion cubic yards	4 million Btu
Steel	1,414 million metric tons (42% is used in construction)	12 million Btu
Wood	3 billion cubic meters (3.92 cubic yards)	2.7 million Btu (softwood lumber)

50% of the energy used in wood production is consumed by the mill for

"Concrete and steel are amazing materials that have their place, and I use them where they most make sense," said Michael Green, AIA, principal at Michael Green Architecture. Yet in 2012, Green co-authored the white paper *The Case for Tall Wood Buildings* along with structural engineer Eric Karsh from Equilibrium Consulting. The paper touts the benefits of using wood structurally while calling attention to the environmental costs of steel and concrete: their production consumes a lot of energy and in the

drying, and that energy comes from wood residue rather than the coal or other fossil fuels typically used in cement and steel production.
Note: These numbers are for raw materials only, not construction products. Actual products like concrete and lumber use varying amounts of raw materials and offer different functional characteristics per unit of weight or volume.

process releases greenhouse gases (see tables) and toxic pollutants into the atmosphere—and though these materials might be recyclable, they are not renewable.

Wood, on the other hand, is renewable, and it has a number of other virtues as well. When used in buildings and left exposed on the interior, it provides a connection to nature that steel and concrete cannot match. “People connect to natural materials like wood very differently than they do with steel or concrete,” Green told *EBN*. Wood also has an R-value 20 times greater than that of concrete and almost 200 times that of steel (helping minimize thermal bridging), and if our forests are managed responsibly, trees provide wildlife habitat and sequester huge amounts of carbon in the process, along with other benefits.

Carbon

Made of about 50% carbon, “wood that goes into any building material is essentially carbon that came out of the atmosphere,” according to Bruce Lippke, president emeritus at the Consortium for Research on Renewable Industrial Materials (CORRIM), a group comprised of members from the timber industry, the architectural community, universities, and governments, who study the environmental performance of wood building products. He says, “If you don’t use the wood, the carbon will go back into the atmosphere [through burning or decomposition], but if you use it and re-grow the forest, then the forest stays relatively carbon-neutral and it gives you a temporary carbon ‘plus.’”

Worldwide, about 26 billion metric tons of carbon are stored in trees, and another 29 billion metric tons are sequestered in forest soils. U.S. forests alone sequester more than 200 million tons of carbon annually, according to the U.S. Environmental Protection Agency (EPA), equivalent to 12%–19% of our carbon emissions—and these numbers do not account for the carbon contained in wood products. Even most of the energy used to dry lumber (more than half of wood’s energy footprint) typically comes from wood residue.

To fully take advantage of the carbon cycle, though, you have to manage the forest responsibly, prolong the lifespan of the wood products, and repurpose these products when the building’s service life ends.

Net Carbon Emissions of Common Construction Materials

Material		Net carbon emissions (kilogram carbon/ton)	Near-term net carbon emissions, including carbon storage within material (kilogram carbon/ton)
Framing lumber		33	-457
Brick		88	
Glass		154	
Steel	100% recycled	220	
	Virgin	694	
Concrete		265	
Aluminum	100% recycled	532	
	Virgin	4,352	

Net carbon emissions are based on life-cycle assessment and include gathering and processing of raw materials, primary and secondary processing, and transportation.
For framing lumber, a carbon content of 49% is assumed. Note that the carbon stored within wood will eventually be emitted back to the atmosphere at the end of the useful life of the wood product.

Life-Cycle Challenges

Wood’s positive environmental footprint seems like it would make it an obvious choice over fossil-fuel-dependent steel and concrete, but finding consistent data measuring a wood’s benefits in buildings is surprisingly difficult.

Life-cycle assessments (LCAs) from manufacturers usually measure only from “cradle to gate.” According to Jennifer O’Connor, president of Athena Sustainable Materials Institute, a non-profit research group that develops LCA tools, “To get an accurate LCA of a material, you have to go through the full life cycle of the building.” This can be tough for a manufacturer of lumber because they don’t know how their wood products are going to be used. "If you want to compare materials, you have to look at functional units—say the square foot of wall holding up a load," she said.

Between the varieties of wood, steel, and concrete products; the types of buildings they are used in; their end uses; estimated lifespans; and a host of other factors, it is hard to draw specific conclusions regarding long-term environmental impacts. However, FPInnovations, a nonprofit forest products research center in Canada, went through 66 peer-reviewed studies from the U.S. and Europe analyzing how wood products affected greenhouse gases and came to the following general conclusions.

• Cradle to gate, manufacturing wood consumes less fossil fuel than steel, concrete, or brick.

• Substituting wood for cementitious products results in less CO_2 generated during production (due to cement's calcination process).

• Wood stores carbon that has been directly removed from the atmosphere and reduces greenhouse gas emissions when it substitutes for materials that require more fossil fuel.

• Carbon stored in forests remains stable when managed sustainably, but conversion of old-growth to managed forest results in a loss of carbon until the forest stabilizes again. The carbon stored in new forests depends on the soil, "forest management intensity," tree species, and other factors.

• Waste material harvested from forests can be recovered and used for biofuel to replace fossil fuels and can be a contributor to greenhouse gas (GHG) benefits of wood products (though other factors come into play, such as maintenance of soil fertility if too much waste material is removed).

Using Wood to Make Green Buildings Greener

The Bullitt Center in Seattle is the first substantial office complex to be on track for Living Building Challenge certification. Project designer Brian Court, AIA, of the Miller Hull Partnership said, "We went into the project assuming it was going to be concrete and steel, but we were trying to balance the carbon and environmental footprint [with Seattle's structural requirements]." The team's environmental goals ultimately drove the building to become a hybrid of concrete, steel, and wood. "We used [wood glulams] where they made the most sense," he says, incorporating concrete where the building touches the earth and steel brace framing for lateral and seismic forces, but "wood was perfectly capable of handling all the other load requirements."

Court said that carbon sequestration was an important consideration, so to ensure the wood's durability, they pulled the frame inside the thermal envelope to minimize potential moisture problems. And since the framing is visible, they will be able to see potential problems if they develop and replace beams or columns as necessary. "We're just giving it the best shot at surviving hundreds of years."

The use of glulam timbers in the Bullitt Center did create challenges for the project, however. The Living Building Challenge requires the use of regional, FSC-certified wood and no added formaldehyde. "You couldn't just go out and buy local FSC-certified timbers in the sizes that we needed," Court said, "so the contractor had to stockpile FSC lumber for a year to have enough wood to have the glulams fabricated." And the glulams supplied for the project use standard phenol-resourcinol-formaldehyde (PRF)

Bullitt Foundation president Denis Hayes explains features of the new Bullitt Center office complex in Seattle, which is undergoing Living Building Challenge certification. The buidling uses FSC-certifed glulams to form its timber-frame structure.

resins, but since there was no suitable alternative, the International Living Future Institute (ILFI) granted an exception.

Court said they also had to wrestle with fire code issues. “This was the first heavy timber building in the city of Seattle in 70 years,” he said. The beams themselves were not the problem; large timber burns at a controlled rate and chars on the outside, so it is easy to engineer for a one-hour fire rating, but steel connectors can heat up quickly in a fire and fail. At first, the designers had hoped to embed all connections behind the timber (which can provide that one-hour fire protection), but doing so would have increased costs. Instead, “we had to get something the fire marshal would sign off on and ended up going with a custom-designed bucket connector,” he said.

Building “Taller”

With recent advances in engineered wood products, architects are exploring the limits of wood structures, and Europe is at the forefront of the trend toward “tall wood” construction, as demonstrated by the nine-story, 29-unit Stadhaus, Murray Grove apartment building in London and the eight-story CREE LCT ONE building in Dornbird, Austria. But North America is also getting on the map with the Wood Innovation and Design Center (WIDC) in Prince George, British Columbia.

In *The Case for Tall Wood Buildings*, Green—who designed WIDC—and Karsh posit that buildings up to 30 stories tall can be built primarily from mass timber (see sidebar) and steel in a process they call FFTT, for “finding the forest through the trees.” Other tall-building concepts have been advanced by other firms, including a 34-story cross-laminated timber structure from C.F. Møller Architects and the concrete-wood hybrid “Timber Tower Research Project” from SOM, which the firm claims can reach 42 stories.

Stadhaus, Murray Grove

Cost Analysis of 12- and 20-Story Timber vs. Concrete Buildings

	12 Stories Concrete Frame	12 Stories Timber/Steel Charring Method	12 Stories Timber/Steel Encapsulation Method	20 Stories Concrete Frame	20 Stories Timber/Steel Charring Method	20 Stories Timber/Steel Encapsulation Method
Vancouver, BC	$17.5 million	$17.5 million	$18 million	$30 million	$30.5 million	$31 million
Price per square foot	$283	$283	$288	$292	$294	$300
Interior BC	$19 million	$18.5 million	$19 million	$32 million	$32 million	$32.5 million
Price per square foot	$303	$297	$303	$312	$308	$315

The white paper *The Case for Tall Wood Buildings* argues that buildings up to 30 stories tall can be built primarily from mass timber and steel in a process labeled FFTT, for “finding the forest through the trees.” The timber/steel data shown here are based on this FFTT design scheme.

The first floor of Murray Grove (designed by Waugh Thistleton and completed in 2008) is made of concrete, but the remaining eight stories are primarily prefabricated wood cross-laminated timber (CLT) panels from KLH UK in London.

According to the architects, this was the first and the tallest building in the world to use CLT panels (see sidebar) for the load-bearing walls and floors and for the lift and stair cores. The CLT panels are covered on the interior by gypsum, which improves its fire rating and makes the interior look indistinguishable from standard construction. The prefabricated panel system at Murray Grove went up quickly; the entire building was completed in just 49 weeks.

Wood Innovation and Design Center

The Wood Innovation and Design Center (WIDC) will be the tallest "all-wood" building in North America when completed later in 2013. It differs slightly from the 30-story FFTT concept in that it contains no steel supports, which FFTT buildings 20 stories or more would require for ductility, claims Green. WIDC has six main stories, but with a mezzanine and a penthouse and a high floor-to-ceiling height, the total height is 90 feet. As in Murray Grove, the core and stair shafts are made from CLT. But according to Karsh, whose firm is providing the structural engineering on the project, this is the first mid-rise building where the lateral loads are carried by wood sheer walls.

"WIDC is essentially a post-and-beam building," Karsh said. In this case, the posts and beams are glulams, and the floors contain a uniquely stacked CLT system that, according to Green, provides space and access for sprinklers and concealed in-floor mechanical and electrical systems. The post-and-beam design allows for an open floor plan, and "all the columns are continuous from the foundation to the roof," Karsh said.

CREE's LCT ONE uses a hybrid system that incorporates glulams and concrete into the floor and wood walls that are pre-assembled in their factory and then assembled onsite.

The beams connect to the frame using a proprietary concealed-connector system that is attached with self-tapping screws. When tightened, the wood surrounds the connectors completely and provides the necessary fire protection. No gypsum or chemical fire retardants are used in the building; instead, fire code compliance is based solely on the char rate of the wood.

LifeCycle Tower ONE

CREE's LCT ONE is an eight-story, 17,000 ft^2 office building that uses a concrete central core and a prefabricated building system consisting of a hybrid glulam/thin-concrete floor system resting on glulam posts and beams. The floor slabs can span almost 30 feet and are supported by the core, which contains the elevator and stairs. (CREE says the core could also be made from CLT and is exploring that option.) CREE's hybrid system can also incorporate steel or concrete reinforcement to expand the system and provide more design options.

According to Nabih Tahan, vice president of business development at CREE, "We are a little different than Michael Green or SOM, in that they come at it from the architectural profession; we are builders." CREE worked with engineers at Arup and Austrian architect Hermann Kaufmann, who specializes in timber structures, to come up with the original LCT concept.

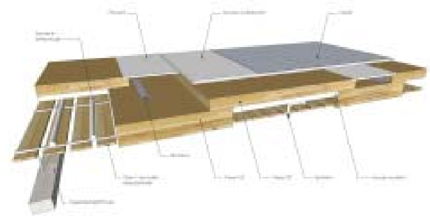
Kaufmann also designed LCT ONE. "LCT ONE is basically a heavy timber building," said Tahan, but uses components cut by computer numerical control (CNC) machines to fit precisely; the components are assembled at the shop in a sort of "panelized" system. The slabs slide into connectors on the exterior posts, and any voids are filled with non-shrink grout. The system goes together like high-tech Ikea furniture, claims Tahan, and when finished, the building should be nearly airtight. "We were able to pass the Passive House blower-door test for the entire building," he said. The company is currently working on a residential system.

Challenges Ahead

Though architects and builders are gaining familiarity with engineered lumber, making the leap to larger structural applications is not going to happen overnight. Green acknowledges "big issues" with overcoming the perceptions of wood.

"People have to understand that these are very safe applications of wood," says Green. "It is very, very different than 2x4 construction and results in very robust buildings from a life-safety point of view." At the same time, people may assume engineered wood behaves like dimensional lumber and expect inconsistent strength, shrinking, and checking, or anticipate problems with fire. According to Bill Downing, president of Structurlam Products, a manufacturer of glulam and CLT, customers have asked them to add borate-based flame retardant to engineered wood just for "insurance," even though the products met the specific fire ratings without them due to wood's predictable rate of burning.

Ceiling Section, Wood Innovation and Design Center



The cross-laminated timber ceiling/floor structure at the Wood Innovation and Design Center was engineered to house sprinklers and mechanical and electrical systems.

A shift in workflow

Structural timber will require a shift in how people build.

According to Green, "You are doing far more preparatory work. Unlike a light wood-framed building, where you effectively begin to build onsite, we are pre-engineering and doing very detailed drawings before these big panel products show up onsite." The concrete foundations poured for structures that use prefabricated columns, like those found at WIDC, for instance, have to be highly precise because the columns are pre-cut to tight tolerances and cannot be adjusted onsite. Contractors may not be used to this level of precision and will need to be part of the process from the start of the project.

Cost and availability

Steel and concrete have more than 100 years of expertise and infrastructure development behind them. Meanwhile, there are only three CLT wood fabricators in all of North America —Structurlam, Nordic Engineered Wood, and KLH—and all three are located in Canada. Structurlam's CLT operation is just getting rolling (though it has been making glulams since the late 1970s). Green is confident that the popularity of engineered wood products is going to grow and that costs will come down with increased production, but he claims there is a chicken-and-egg scenario that needs to be overcome. "The companies don't want to build the plants to make the products until they know there is the demand, but architects can't specify if the materials aren't available."

Downing claims engineered wood is already cost-competitive if the building is designed to be a wood structure from the start. However, he says they cannot compete when a building is designed as a steel structure and architects want to convert to wood."

Moisture issues?

Moisture comes up as a concern with wood structures, but "moisture is an envelope issue," Karsh asserts. "If you design a good envelope that has the ability to drain and dry out, then the structure can last a thousand years." As an example, he points to the five-story Horyu-ji Buddhist temple, an UNESCO World Heritage Site that has stood for more than 1,300 years in Nora, Japan. Engineered wood does have to be protected and stored properly before installation. For designs using wood, there is a natural temptation to display it on the exterior, outside the building envelope—and that's okay, according to Downing, but you have to be prepared to have a maintenance program to go along with it.

The north wing of the University of British Columbia' Earth Sciences Building (ESB) uses glulams in its columns and beams, laminated-strand lumber in its floor panels, and cross-laminated timber for its roof and canopies.

Sam Glass, who leads the U.S. Department of Agriculture's Forest Products Lab's Building Moisture and Durability Research Team, suggests using a vapor-permeable finish on the interior (if anything) and installing rigid mineral wool or wood insulation on the exterior. "Both of those insulations are highly vapor permeable," he said, "so the CLT can dry in both directions." In a warm, humid climate, Glass recommends avoiding a highly absorptive cladding, to avoid inward solar vapor drive. Properly designed, Glass says, CLT presents no issues: a four-inch-thick CLT roof installation he embedded with moisture sensors has functioned as expected.

Insects and fungi

Unlike concrete and steel, wood isn't impervious to decay organisms, but good moisture management will keep timber structures out of harm's way. If desired, waterborne preservatives or borate solutions or rods can be used. In areas with termites, termite barriers, proper foundation detailing, and other precautions have to be taken.

Codes—catching up

Building codes for tall wood structures may take a while to catch up with their concrete and steel counterparts, as height restrictions of six floors or less are common. The industry took a large step toward greater acceptance after adopting ANSI/APA PRG 32: Standard for Performance-Rated Cross Laminated Timber in 2011. It has since been approved for the 2015 International Building Code.

For those looking for more information on codes, a key resource is WoodWorks, a technical-support group funded by North American wood associations, research organizations, and government agencies. The *CLT Handbook* , published by FPInnovations and the Binational Softwood Lumber Council, also provides code guidance and is available in different forms tailored to U.S. and Canadian markets.

Forestry certifications

Responsible forestry can maintain a healthy forest and its ecosystem while still providing the wood we need. Third-party certifications of sustainable forest management are the best tool we have to verify responsible forest management, which includes habitat protection, strict enforcement of environmental laws, and sustainable harvesting rates.

In the green building industry, the Forest Stewardship Council (FSC) and the Sustainable Forestry Initiative (SFI) have been battling for credibility, with environmentalists generally giving more credence to FSC (for more on FSC and SFI see our "Wood Wars" series).

Fortunately, most engineered wood products in North America come from manufacturers who offer SFI, FSC, or both, so architects or specifiers in most cases can select based on project requirements. Many engineered wood products, such as LVL, LSL, or CLT, are coming from wood species that mature in less than 20 years or come from trees killed by mountain pine beetles. Sensitive reclamation of this timber can provide a valuable resource, reduce carbon emissions, and help the local ecosystem. So even if the wood is not FSC-certified, these products are a good end use of these trees.

Making the Most of Timber Resources

Engineered lumber products, mainstays of the European construction industry, are becoming increasingly popular for commercial construction in the North America.

These products are made up of smaller pieces of wood bonded together with adhesives. They are often made from faster-growing, less desirable, smaller-diameter wood species, yet they offer better dimensional stability, less waste, and more consistent performance than standard dimensional lumber, which is prone to swelling, splitting, and shrinkage. The stability, strength, and predictable performance of engineered timber allows engineers to use these products with confidence, and they can be cut with high precision and used in applications where standard lumber doesn't work.

Engineered wood, environmental tradeoffs

Though engineered wood products are more resource-efficient (see sidebar) and provide better structural performance than dimensional lumber, they also consume more energy for processing and require petroleum-based adhesives, and not all engineered wood comes from fast-growing, less-desirable wood. "If you are going to replace steel with long spans of wood, the fiber has to be some of the best in the world, so we use lamstock [for glulam]," said Downing. "Next to 'clear,' lamstock is the highest grade of dimension lumber you can get." And due to low availability of FSC-certified lamstock, specifying FSC-certified glulams may require a long lead time. On the other hand, CLT can use some of the lowest grades of wood, including beetle-kill wood.

Most engineered wood is also made with formaldehyde-based adhesives. Though formaldehyde is a carcinogen and respiratory irritant, engineered wood products typically do not use urea formaldehyde (UF) resins, which are usually the cause of emissions problems from non-structural architectural composite wood products. Instead, engineered wood uses exterior-grade, no-added-urea-formaldehyde (NAUF) resins made using less hazardous combinations of melamine formaldehyde (MF), phenol formaldehyde (PF), resourcinol formaldehyde (RF), or phenol-resourcinol formaldehyde (PRF). During curing, the formaldehyde in these resins should be consumed in the chemical reaction that bonds the wood together.

Finished engineered wood products have very low emissions—so low that products using NAUF resins usually meet the ultra-low-emitting formaldehyde (ULEF) standard of 0.05 parts per million set by the California Air Resources Board (CARB), and are hence exempt from emissions testing. As more and more engineered wood is used in these structures, it will be important to make certain emissions testing is done and ventilation is sufficient so we are not creating indoor air quality problems.

The Elkford Community Conference Center in Elkford, British Columbia, was one of the first commercial applications of cross-laminated timber panels in North America.

Non-formaldehyde polyurethane resins are entering the market and can already be found in glulams from Nordic Engineered Wood and in CLT from Structurlam. Polyurethane comes with problems of its own for factory workers, however, and one of its key constituents is under increased federal scrutiny in the U.S.

For those concerned about the long-term performance of these adhesives, the resins in engineered wood products have to pass ASTM standards and accelerated aging tests, and Downing insists that if protected against moisture and UV damage, engineered wood products will last hundreds of years. He claims his company routinely takes in glulams more than 40 years old that owners want to reuse, and the timbers perform fine. “We test them, run them through the planer, and out they go again.”

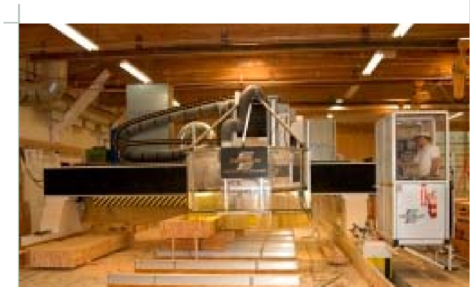
Don’t Think of It as Wood

Engineered wood, particularly CLT, has opened up possibilities for wider adoption of wood in structural applications, particularly in commercial buildings under six stories. And though the use of so much wood in CLT seems antithetical to the wood-stingy advanced framing techniques used in residential construction, CLT is typically used for different purposes.

Downing said, “We think of our glulams as replacing steel and our Crosslam [CLT] as replacing concrete.” CLT has performance similar to that of a reinforced concrete slab at a sixth of the weight, and using a lighter material has advantages. When used in place of concrete in walls or floors, for instance, “You can put a structure on poorer soils or lighten up on foundations,” he said.

Engineering Driving Innovation

Engineered wood is often used as a simple replacement for standard timbers and is cut to length and attached using standard connectors, but prefabrication of structural elements is gaining popularity and changing the way buildings are being constructed.



Engineered wood products are dimensionally stable, with predictable shrinkage, so machines like the ones used by Structurlam can cut them within extremely tight tolerances.

Fabricators are now incorporating techniques brought over from Europe that include 3D modeling and CNC machining, which can cut engineered wood within less than 1 mm tolerances. Using this technology, the primary components of large buildings can be pre-cut, shipped, and assembled onsite, and engineers can be confident of performance.

The benefits of using these techniques include:

• Faster construction times (as fast as a floor per week on large commercial buildings), which could offset wood’s higher material costs (when compared with concrete and steel), making it more competitive

• Tighter buildings

• Reduced thermal bridging

• Less wasted material at the fabricator

• Less jobsite waste

• Easier disassembly at the end of the building’s service life

Standard engineered wood products—glulam, LVL, and the like—have a long service history, but in the past architects may not have taken full advantage of the material. After working with wood for the Bullitt Center, Court said, “We are rediscovering this material that we have always had in our kit; it was definitely an eye-opener for us.”

Engineered wood and techniques used to create taller eight- and nine-story buildings are laying the foundation for systems that are easy to implement in other structures, are environmentally and economically sustainable, and look beautiful.

“Steel and concrete brought us modern architecture,” Green said, “and every major movement of architecture has come about because of a structural innovation.” If we manage our resources properly, wood just might be the next innovation that changes the look of our buildings.

Continuing Education

Receive continuing education credit for reading this article. The American Institute of Architects (AIA) has approved this course for 1 HSW Learning Unit. The Green Building Certification Institute (GBCI) has approved this course for 1 CE hour towards the LEED Credential Maintenance Program.

Learning Objectives

Upon completing this course, participants will be able to:

1. Compare engineered wood to steel and concrete; and describe how engineered wood offers better dimensional stability, less waste, and more consistent performance than standard dimensional lumber.
2. Explain how to take advantage of wood's carbon cycle when used as a building material and recount the latest research on how wood products affect greenhouse gases.
3. Recognize the life-cycle challenges and environmental tradeoffs that accompany the use of wood as a building material.
4. Differentiate between at least four different types of engineered wood.

To earn continuing education credit, make sure you are logged into your personal BuildingGreen account, then read this article and pass **this quiz**.

Discussion Questions

Use the following questions to inform class discussions or homework assignments.

1. What constitutes renewable wood and how does this relate to carbon and responsible forestry?
2. What are some general conclusions about how wood products affect greenhouse gases and why is it challenging to attain an accurate LCA of wood?
3. You're designing a commercial development with six stories. The developer wants to attract "natural" businesses such as a health food store and a yoga studio. You think wood would make an ideal structural component, and leaving it exposed on the interior would convey a "connection to nature," but you know your client will be wary. Anticipate all of her potential concerns so that you're able to address them in your delivery of the idea. Once you've successfully sold her on wood, how do you respond to her demand to add borate-based flame retardants to it?
4. What are the environmental tradeoffs in using engineered wood and the steps one should take to help counteract them?
5. After reading the article, do you think wood is "a flash in the pan" or "the next innovation that changes the look of our buildings"?

Sidebar: Types of Engineered Lumber

Glued laminated timber

Glued laminated timber (glulam) is a structural composite wood product comprised of pieces of kiln-dried lumber arranged end-to-end with the grain running parallel to the beam and glued together in layers. The laminations are bonded together to create beams of varying lengths and thicknesses. Glulams have been used in the U.S. since the 1930s, so they have a long history of performance and durability. Common in commercial construction, where they are used for headers, cantilever beams, arches, floor girders, and other interior and exterior structural applications, they look similar to solid wood and can be fabricated into straight beams or long spans or shaped into curves, opening up design options that conventional timber and most other structural materials can't match.

Structural composite lumber

Laminated veneer lumber (LVL): LVL uses thin veneers peeled off logs, cut into smaller sheets, and glued together with the grain running in parallel to the beam. The resulting billet is similar in thickness to standard lumber but can be cut into long lengths and into widths of 24 inches or more. Much stronger than dimensional lumber, LVL is used for headers and beams, rafters, girders, scaffolds, and more.

Parallel-strand lumber (PSL): PSL also uses thin veneers, but instead of the veneer being cut into sheets, as with LVL, it is cut into strands, arranged in parallel, and then glued together. Similar to LVL, PSL is used for headers and beams, rafters, girders, and scaffolds, but it can also be used for load-bearing columns.

Oriented-strand lumber (OSL) and laminated-strand lumber (LSL): OSL and LSL use 6- or 12-inch wood flakes, respectively, pressed together with adhesives, formed into billets, and then cut to desired dimensions. OSL and LSL are made from fast-growing trees and are typically used as rimboard and framing lumber. They are generally not quite as strong or as stiff as LVL.

Wood I-joists

Wood I-joists, or I-beams, use OSB or plywood as the web with top and bottom materials made from standard lumber or LVL. Lighter and stronger than lumber, I-joists are used structurally in both residential and light commercial construction and are often used for floor or roof framing.

Cross-laminated timber

Cross-laminated timber (CLT) is a structural panel and not a board. It is made by gluing layers of softwood boards—up to nine thick—one on top of the next at right angles to each other. The individual boards are planed on all four sides for a precise fit throughout the CLT. The resulting panels are light and dimensionally stable in all directions and can be used for, floors, walls, roofing, and other structural applications, including as a concrete replacement in certain applications. CLT can use lower-quality wood on its interior sections, including wood normally relegated for use in OSB. CLT comes in panels up to 40 feet long, 10 feet wide, and 12 inches thick.

Mass timber

Mass (as in massive) timber is a catch-all name for CLT panels as well as those made from LVL or LSL.

July 28, 2013

IMAGE CREDITS:

1. Photo: BC Living
2. Sources: U.S. Department of Energy, U.S. Environmental Protection Agency, United Nations Food and Agriculture Organization, and industry Environmental Product Declaration
3. Source: Dovetail Partners
4. Photo: Alex Wilson
5. Source: The Case for Tall Wood Buildings
6. Photo: CREE Buildings Inc.
7. Image: MGA | Michael Green Architecture
8. Photo: Martin Tessler
9. Photo: Structurlam Products Ltd.
10. Photo: Structurlam Products Ltd.