Structural Sustainability

sustainability and preservation as they pertain to structural engineering

Wood's Role in Life Cycle Assessment and Sustainable Buildings

By Dwight Yochim, RPF

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The decision to use wood has a proven, positive effect on a building's overall environmental impact. In addition to its energy efficiency and carbon holding benefits, wood is the only major building material that is both renewable and sustainable. Unfortunately, wood's primary environmental advantages are either undervalued or ignored in many green building rating systems, especially in North America.

While there is growing awareness of how buildings impact carbon emissions – and of wood's ability to play a positive role in this regard – the construction industry still has a long way to go in recognizing wood's role in creating sustainable non-residential buildings. As rating systems continue to evolve, it is reasonable to believe that they will place greater emphasis on the use of wood as a renewable, sustainable, low-carbon alternative to other building materials.

The Oxnard Water Campus Visitors Facility has the distinction of being Oxnard, California's first LEED-certified building. Architect – Mainstreet Architects + Planners, Inc.; structural engineer – Li & Associates Structural Engineers; photo – Stephen Schafer.

Renewable Resource = Sustainable Benefit

Wood has many characteristics that make it an earth-friendly building material. It grows naturally and is energy efficient, non-toxic, recyclable and reusable. Manufacturers use far less energy to fabricate wood than they do concrete or steel. But the heart of wood's value in green building lies in the fact that it is the only major building material that is both renewable and sustainable.

Sustainably managed forests provide a number of environmental benefits, since growing forests also help to offset climate change. Trees consume carbon dioxide as they grow and release oxygen. When they are harvested, about half the carbon stays in the forest – in the soil, roots and branches – and the rest is removed in the logs, which are about 50 percent carbon by dry weight. The replanted forest then regenerates with young trees that once again begin absorbing CO_2.

When a tree is harvested and the wood manufactured into lumber or other building products, much of the carbon from the tree remains stored in the wood building components. This prevents the carbon from being released into the atmosphere for the lifetime of the product – longer if the wood is recycled for another use. According to research firm FPInnovations, a 2,400-square-foot home with approximately 32 cubic meters of structural wood products stores the equivalent of about 29 metric tons of CO_2, which was removed from the atmosphere by the growing tree. This greenhouse gas removal is equivalent to annual emissions from 5.7 passenger vehicles. In fact, wood is unique in that more carbon is removed from the atmosphere by a growing tree than is emitted during its manufacture and transportation to the jobsite.

Measuring Environmental Impact through Life Cycle Assessment

When it comes to environmental impact of a building material, just how good is wood? An increasing number of building professionals are using life cycle assessment (LCA) to provide an objective and consistent means of measuring the impacts of various building materials, assemblies and buildings. Wood consistently outperforms other materials in LCA analyses, having a much smaller impact on the environment when considered over a building's lifetime.

Used to measure the resource utilization of a particular building system, LCA is a scientifically-based method for evaluating the environmental impacts of a service, process, material, product or even a building. LCA can be used to evaluate a building product from resource extraction (i.e., harvesting or mining) all the way through manufacturing, transportation, installation, occupancy, maintenance and disposal or re-use – over its entire life cycle.

LCA practitioners follow a strict methodology, defined by the International Organization for Standardization, ISO 14040, to model the product system, collect data and characterize the impact potentials so they can be normalized and measured. LCA moves the building industry away from a prescriptive methodology, where a product's environmental benefits were based on recycled content, renewability and other more subjective attributes, towards an approach that emphasizes measurable environmental performance.

LCA studies have demonstrated that wood buildings produce less greenhouse gases, create less air and water pollution, and require less energy across their life cycle than other structural building products.

There is currently no rating system that gives credit for the carbon sequestered in sustainably managed forests or stored in wood products themselves. However, there is a growing trend toward the inclusion of LCA, which considers embodied energy and greenhouse gas emissions (among other things), and credits wood's 'kinder and gentler' environmental impact compared to materials that require large amounts of fossil fuels to manufacture.

Sustainability goals for the Willson Hospice House in Albany, Georgia were achieved with the help of wood structural and finish materials, as well as timber reclaimed from a local cotton mill. Architect – Perkins+Will; structural engineer – Uzun & Case; photo – Jim Roof.

How Wood Stacks Up

In addition to being renewable and sustainable, wood has many other characteristics that make it a naturally green building material.

Wood product manufacturing requires substantially less energy than the production of other building products. For example, consider the amount of energy it takes to produce one ton of cement, glass, steel, or aluminum compared to the amount of energy needed to produce one ton of wood:

- Cement requires 5 times more energy
- Glass requires 14 times more energy
- Steel requires 24 times more energy
- Aluminum requires 126 times more energy

Wood products make up 47 percent of all industrial raw materials manufactured in the United States, yet their production consumes only 4 percent of the total energy needed to manufacture these industrial raw materials. Wood's manufacturing process alone makes it an environmentally friendly choice in building materials. Plus, wood is widely available, reducing the amount of fossil fuels required to transport it from the manufacturer to the jobsite.

Wood can be cost-effectively recycled for reuse at the end of a building's service life. While recycling steel saves resources and energy when compared with mining iron ore and milling first generation steel, steel recycling still requires 140 percent more energy than wood production.

Wood use also improves a building's energy efficiency, reducing the amount of insulation required to achieve the same thermal performance as structures built using other materials. Poor thermal performance requires more insulation – which itself requires a large amount of energy to produce – as well as additional systems that provide thermal breaks in order to achieve an equivalent R value. Because wood is less thermally conductive than steel or concrete, it is a good choice for a well-insulated exterior envelope.

When evaluated over its lifetime, wood outperforms other materials in terms of embodied energy and other factors. Traditionally, the embodied energy of a building – the energy required to extract, process, manufacture, transport and maintain its materials over time – has represented a small percentage of its overall energy consumption. The majority of a building's lifetime energy use was primarily determined by its energy efficiency. However, as buildings become more energy efficient from an operational standpoint, the structure's embodied energy becomes proportionally more significant. As new technologies result in even greater energy efficiencies over time, the impact of embodied energy on a building's overall consumption will continue to be proportionately more important.

Better Tools Lead to Better Decisions

Historically, it was often perceived as too expensive and time consuming to conduct a full LCA for every project and design configuration. Today, building professionals are increasingly using LCA to measure the environmental impacts of their building products and assembly choices by utilizing online LCA tools to help them make informed environmental building choices.

One of these easy-to-use tools, developed by the non-profit Athena Sustainable Materials Institute, is the ATHENA® *EcoCalculator for Assemblies*. This free online tool (**www.athenasmi.org**) includes ready-to-use LCA data for more than 400 common building assemblies.

Information for the *EcoCalculator* is based on the more comprehensive ATHENA® *Impact Estimator for Buildings*, which can be used when a building professional requires a more detailed environmental assessment. The *EcoCalculator* is an Excel-based tool with embedded results from detailed assessments completed using the *Impact Estimator*.

The *Impact Estimator for Buildings* allows users to analyze entire buildings and assemblies based on ISO-compliant LCA methodology. It incorporates Life Cycle Inventory (LCI) databases developed by Athena, which cover more than 90% of the structural and envelope systems typically used in residential and commercial buildings. The *Impact Estimator for Buildings* also simulates over 1,200 different assembly combinations and is capable of modeling 95 percent of the building stock in North America.

Both Athena tools are most effectively used early in the design process, when structural material choices have broad implications in terms of environmental impact. The software even allows designers to experiment with different material mixes to achieve the most effective combination for the application.

BEES® software (Building for Environmental and Economic Sustainability) is a more product-oriented assessment tool which combines environmental measures with economic indicators to provide a final rating. BEES has proven to be particularly useful at the specification and procurement stage of a project, because it includes data on more than 200 building products, including generic and manufacturer brands.

Green Rating Systems Leave Room for Growth

Unfortunately, considering its strong environmental credentials, it is surprising that wood doesn't garner more credit in green building rating systems. Although there are many rating systems in existence, the two most commonly used for commercial buildings are Leadership in Energy and Environmental Design (LEED®) and Green Globes®.

Resources

APA – The Engineered Wood Association: **www.apawood.org**
The Athena Sustainable Materials Institute: **www.athenasmi.ca**
Consortium for Research on Renewable Industrial Materials: **www.corrim.org**
Forestry Innovation Investment (FII): **www.naturallywood.com**
State of the World's Forests reports, 2007 through 2011, Food and Agriculture Organization of the United Nations
Wood and Green Building, Wood Design & Building Series: **www.woodworks.org**
Wood – A Natural Choice for a Structural Sustainable Building Material, by Michelle Kam-Biron, S.E. and Lisa Podesto, P.E.; SEAOC 2009 Convention Proceedings

According to a 2010 study by the Light House Sustainable Building Centre, only 20 percent of credits in commonly used rating systems can be attributed to wood. And while LCA is widely recognized as the best way to evaluate the environmental impacts of buildings, it is not yet required by green rating systems or building codes, despite the fact that embodied energy and other life cycle impacts are critical to the design of environmentally responsible buildings.

LCA is rewarded to some extent in the Green Globes rating system, and is part of the new American National Standard based on Green Globes, ANSI/GBI 01-2010: *Green Building Protocol for Commercial Buildings*. LCA is also included as a pilot credit in the LEED system, though a decision has not been made as to whether it will be incorporated fully into the next major revision. The state of California also recently included LCA as a voluntary measure in its 2010 draft *Green Building Standards Code*.

Sustainability, on the other hand, is an integral part of most green building rating systems. Green Globes, for example, gives points for lumber and timber panel products that are certified through the SFI, FSC, ATFS, and Canadian Standards Association's Sustainable Forest Management Standard. The LEED system officially recognizes timber certified through FSC only, though consideration is being given to include other systems.

Unfortunately, no other building material is required to certify its sustainable production, even though production of steel and concrete is known to have significant environmental impacts in terms of sustainability.

Wood, the Natural Choice

Wood provides so many benefits – aesthetic, structural and financial as well as environmental. Yet it continues to be overlooked as a key structural member in non-residential building applications.

Wood is a renewable and sustainable building material that provides a number of additional environmental advantages. Wood buildings are proven to produce less greenhouse gases, air pollution and water pollution, and require less energy throughout their life cycle than structures built with non-renewable materials.

It is time for the building industry to recognize wood's advantages in creating sustainable buildings.▪

References

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US Environmental Protection Agency Greenhouse Gas Equivalencies Calculator, **www.epa.gov/cleanenergy/energy-resources/calculator.html#results**

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APA – The Engineered Wood Association, **www.apawood.org/level_b.cfm?content=srv_env_facts**

Athena Sustainable Materials Institute, **www.athenasmi.org**

National Institute of Standards and Technology, **www.nist.gov/el/economics/BEESSoftware.cfm**

Architectural Record Continuing Education Center, McGraw-Hill Construction, **http://continuingeducation.construction.com/article.php?L=221&C=694**