"Steel Is Green: Recycled & Recyclable"

(Steel Framing Alliance newsletter)

"Green Concrete"

(National Ready Mixed Concrete Association web site)

"...wood is an inherently 'green' material..."

(Wood and Green Building fact sheet produced by the Wood Promotion Network)

"Sustainable Concrete Masonry"

(National Concrete Masonry Association brochure)

InSights

new trends, new techniques and current industry issues

Structural Engineers as Sustainable Designers

By Mark D. Webster, P.E., LEED AP

Everywhere we turn these days we see another claim about how "sustainable" or "green" something is, whether it's a school building, a steel beam, a new car, or an oil company. When it comes to green buildings, what's a structural engineer to do? Does it even matter what we do?

The short answers are: there is plenty we can do, and it matters.

For a proper understanding, we need to define some terminology. Ideally, "sustainable" structures are those that can be constructed and operated without significantly depleting non-renewable resources and without significantly impairing the environmental systems needed to support life on earth, thereby ensuring adequate resources and a healthy environment for future generations indefinitely. "Green" buildings are those that come closer to meeting this ideal than the average building. "Environmental performance" measures how well the building meets this goal.

When we design, just as we measure economy using dollars and strength using kips, we need to measure environmental performance in order to know whether we are making good design decisions. If we know how to measure it, we can use our own judgment to better sort out the claims about how green something is.

Life-cycle assessment (LCA) is one increasingly important tool used to measure environmental performance. The concept is quite simple: track the production of an item (paper bag, water bottle, building) from start to finish, measuring inputs (e.g. fuel, electricity) and outputs (e.g. pollutants, carbon dioxide, material waste) at every step along the way, from the extraction of raw materials to the end of the item's life. Implementation is not so simple, particularly with a complex, long-lived product like a building. Nevertheless, improving tools and ongoing research are paying dividends by helping us understand how buildings affect the environment.

With heightening concerns about global warming, the measurement of carbon emissions has become the most prevalent LCA objective, although other LCA measures such as water and air pollution remain important. Using this framework, we can address why our choices as structural engineers matter.

I wrote an article several years ago for *Structural Engineering International* where I used LCA methodology to evaluate the contribution of the structural system to the lifecycle environmental impacts of three hypothetical buildings over a 50-year life: a 2,000 square-foot wood-framed house, a 300,000 square-foot concrete-framed high-rise apartment, and a 50,000 square-foot school. I found that the structural materials account for 1% to 16% of the life-cycle carbon emissions, depending on the building type and energy efficiency. As buildings become more energy-efficient, they emit less carbon and other pollutants during their lives, and the relative proportion of emissions due to the production and construction of the structural materials increases. Furthermore, some choices we make during design affect the energy-efficiency of the building, increasing even further the structure's impact. For example, structural details that result in "thermal bridging," such as steel members that break the insulation plane, can cause energy losses year in and year out over the life of a building. So yes, our choices as structural designers affect the environmental performance of the resulting building.

Structural material industry associations, individual manufacturers, and university researchers are using LCA to expand and refine what we know about the environmental performance of a range of structural materials. The American Institute of Steel Construction (AISC) recently commissioned a study on the contribution of the fabrication process to steel's environmental "footprint." The study found that fabricating one ton of steel emits about 0.19 to 0.26 tons of carbon into the atmosphere. To put this quantity into perspective, producing hot-rolled structural shapes emits about 0.75 tons of carbon per ton of production. Thanks to this recent research on fabrication, we now know the combined

*Mark D. Webster, P.E., LEED AP is a project manager in the Structures group for national engineering firm Simpson Gumpertz & Heger Inc. (SGH). He is a nationally recognized authority on sustainable structural design and Secretary of the SEI Sustainability Committee. Mark may be reached at **MDWebster@sgh.com**.*

LEED® Proposes a Step Backward for Structural Designers

Many structural engineers have been introduced to the popular LEED® Green Building Rating System. LEED uses a simplified credit achievement approach to measuring the environmental performance of a building. Unfortunately, LEED does not reward many of the green building strategies that structural engineers can apply to improve the environmental performance of their projects, such as designing for material efficiency and designing for adaptability and material reuse. Some strategies that *are* recognized, such as the replacement of cement in concrete mixes with recycled materials like slag and fly ash, do not appear to provide credit in proportion to the benefits provided. As a result, many structural engineers do not participate in the LEED process.

The U.S. Green Building Council (USGBC) released a draft of a major revision to LEED in November 2010 and opened a public comment period. To the surprise and dismay of the many structural engineers who are working to improve the environmental performance of buildings, the LEED 2012 draft proposes to eliminate the consideration of structural materials from three key credits: Regional Materials, Recycled-Content Materials, and Bio-Based Materials. Rather than increasing the incentive for engineers to apply their creativity to reduce the impact of the building structure, these changes would do just the opposite.

The SEI Sustainability Committee (SC) quickly convened a LEED 2012 Working Group. Over a couple of weeks in mid-December, its members crafted comments on the proposed credits for submission to USGBC and met twice with the entire 41-member SC to confirm committee consensus. The group submitted its comments to USGBC on December 31. Among the points made:

- Structural systems represent a major portion of a project's material impacts, and are significant even when considering the building's energy use over its life, especially for short-life and highly energy-efficient buildings. In terms of climate change, initial material impacts carry great weight because of the necessity of reducing carbon emissions in the near term to slow the rate of change.
- Structural systems can be much improved using recycled content, regional materials, and bio-based content. While some structural materials (such as steel) have intrinsically high recycled content, others (such as concrete and engineered wood products) do not. LEED needs to encourage the market-driven evolution of these materials.
- Making these changes could well lead to excessive and unnecessary use of additional finish materials so that project teams "can get the points." For example, LEED offers up to two credits for recycled content materials. If structural materials essential to the project such as concrete and steel cannot be applied towards the credit, the project team could elect to add materials such as recycled-content carpeting and suspended ceilings so they can achieve the credits when in fact these finishes may not be required for the project. The proposal incentivizes the excess use of materials to the detriment of the environment.

The SEI SC will continue to monitor the development of LEED 2012 and work to ensure that LEED continues to reward structural systems with reduced environmental impacts appropriately.

carbon impact of production and fabrication is just about one ton of emissions per ton of steel.

Combining environmental metrics for steel with metrics for other materials, such as concrete, masonry, and wood, structural engineers can start to quantify the environmental impacts of their designs and make smart choices about which options have the least impact. It's not simple; there are tradeoffs and uncertainties. And as with the adoption of any new methodology, there will be missteps and a learning curve. But with clients asking us about the environmental performance of our designs, and with new "green" codes setting environmental performance criteria, it is incumbent upon us to know how to deliver structural systems that are safe, economical, *and* environmentally sound.

To help the structural engineering community understand the intersection of structure and the environment, the Structural Engineering Institute's (SEI) Sustainability Committee recently completed a comprehensive publication, *Sustainability Guidelines for the Structural Engineer,* which is now available from the American Society of Civil Engineers (ASCE). This document describes a host of strategies that practicing structural engineers can use to improve the environmental performance of their designs. Here the reader will find the detailed answers to the first question so briefly answered above.▪