THE REAL DEAL: Sustainable Steel

Christopher Hewitt

AISC's Christopher Hewitt takes a look at how to measure the sustainability of a steel-framed building–and the best ways to maximize steel's green potential.

Sustainability, green construction, environmental design— whatever you want to call it, sustainable design practices have caught on and are spreading quickly. Owners and architects are realizing the benefits of sustainable design practices in improving not only the longevity of the Earth's environment, but the quality of the work environment. Data gathered by the U.S. Green Building Council shows that "green" buildings lead to greater employee efficiency. A 1999 Executive Order, 13123, requires all federal agencies to "apply [sustainable design principles] to the siting, design, and construction of new facilities" and the General Services Administration, General Accounting Office, Department of Energy, National Park Service, Commerce Department, Navy, Army Corps of Engineers, and the Environmental Protection Agency are all applying some version of the U.S. Green Building Council's LEED™ (Leadership in Energy and Environmental Design) green-rating system to accomplish the requirements of the executive order. Local and State governments are beginning to require or provide tax incentives to use green construction practices. The trend is catching on.

How is this being realized in today's construction market?

There are two prevailing approaches in the United States for gauging how environmentally friendly a building is. The most popular tool for conducting such an analysis is the U.S. Green Building Council's LEED Green Rating System. This system awards points for meeting various pro-active sustainable design and construction practices, such as using materials with high amounts of recycled content, minimizing construction waste and optimizing HVAC systems. Buildings are awarded a LEED rating based on the number of credits in the system that they obtain. Credits are collected towards a rating level of Certified, Silver, Gold, or Platinum. A basic LEED rating of Certified can be achieved on a building at little additional cost, but extensive effort and cost is associated with achieving the highest possible LEED rating of Platinum.

The second and emerging method of analyzing the environmental efficiency of materials is the use of Embodied Energy approaches, sometimes referred to as LCI (life-cycle inventory) or LCA (life-cycle analysis) approaches. This method involves calculating the total amount of energy associated with the production, manufacture, delivery, and construction of each product, including all of its components and byproducts. The information is then used to compare the total energy used by the system or component from "cradle to grave." The system is much more complex than the LEED approach, because it requires extensive calculation and documentation of data that often is not readily available and can be difficult to develop accurately. Those bodies that have developed this data have not yet done so with great enough precision, depth or transparency to warrant its use in comparing structural materials. The system's precision and usefulness as a comparative tool give it potential for future use, but the difficulties in obtaining accurate energy information could preclude the method's use for some time.

So, what does this mean for the structural system?

Truthfully, very little. From an energy standpoint, there is very little difference in the embodied energy of structural materials. A French case study by Ecobalance, comparing the embodied energy of two similar buildings, one steel and one concrete, showed that when steel with approximately 87% or greater recycled content was used, the steel structural system had less embodied primary energy than concrete. When steel with less than 87% recycled content was used, concrete had less embodied primary energy than steel.

No credible study has been done yet for comparing the embodied energy of structural wood products to steel and concrete in the U.S. construction market. Those agencies that do draw these comparisons to wood use steel energy data based on production in Canadian basic oxygen furnaces, and steel with low levels of recycled content. The U.S. structural steel market's electric arc furnace process and minimum 90% recycled content easily outperforms the data portrayed in these studies.

If the hypothesis established by Ecobalance is correct, there is negligible difference in the embodied energy of concrete and steel.

Steel is the world's most recycled product. There are, however, some misconceptions surrounding just how "recycled" steel really is—misconceptions which will need to be clarified before applying steel's recycled content towards a LEED rating. The two production methods, EAF (electric-arc furnace) production and BOF (basic oxygen furnace) production, use different amounts of recycled material. Structural steel produced by U.S. mills using the EAF process contains at least 90% total recycled content. This means that the energy that would typically be used in extracting raw material from the ground is saved, and waste from old steel products such as old cars, refrigerators, washing machines, and structural members is diverted from landfills and used for a new purpose.

Steel produced by the BOF process contains a much higher percentage of raw materials than that produced in an EAF, but BOF steel still has at least 25% recycled content. In the U.S., steel produced using the BOF is predominantly used in non-structural applications.

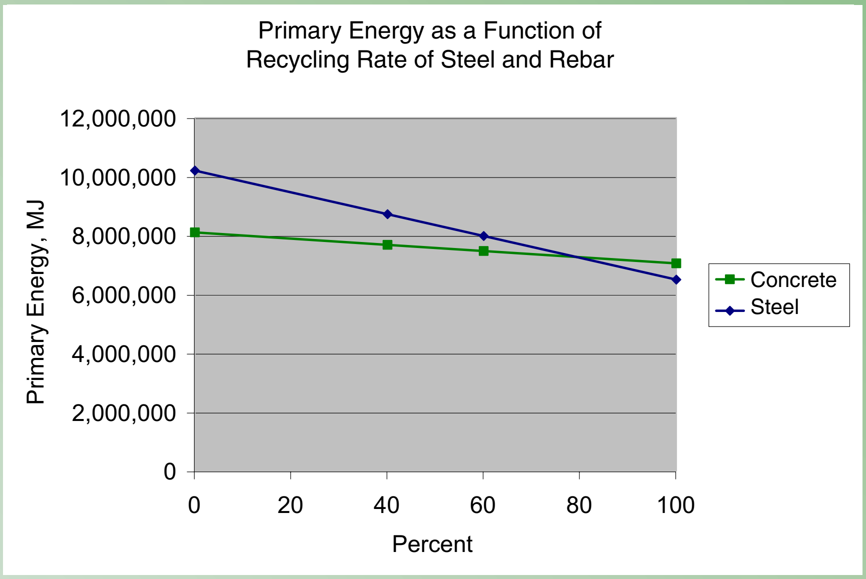
All U.S. structural wide-flange products are produced by the EAF process and share the associated high percentage of recycled content. When submitting for a LEED rating, it will be important to know the percentage of recycled steel that is post-industrial and the percentage that is post-consumer. This will require data from the mill that the material is obtained. To access this information, either contact the mill directly, or visit **www.aisc.org/sustainability** for completed recycled-content letter templates from AISC-member mills. For a more thorough understanding of the recycled content of steel, you should also visit the Steel Recycling Institute (SRI) at **www.recycle-steel.org**.

Ultimately, when a steel structural system is used, there is still concrete on top of the steel deck, and when a reinforced concrete structural system is used, there is still steel rebar in the concrete. From a practical standpoint, the environmental difference in the structural materials is moot. The true benefits of green construction and sustainable design are achieved through the efficiency of the site, building envelope and building services. A study by Great Britain's Steel Construction Institute showed that the energy embodied in the structural system is about 2% of the total energy consumption of the building over an expected life of 60 years. Issues such as indoor air quality, brownfield revitalization, and alternative energy sources will go much farther towards promoting a sustainable environment than any amount of structural system energy optimization.

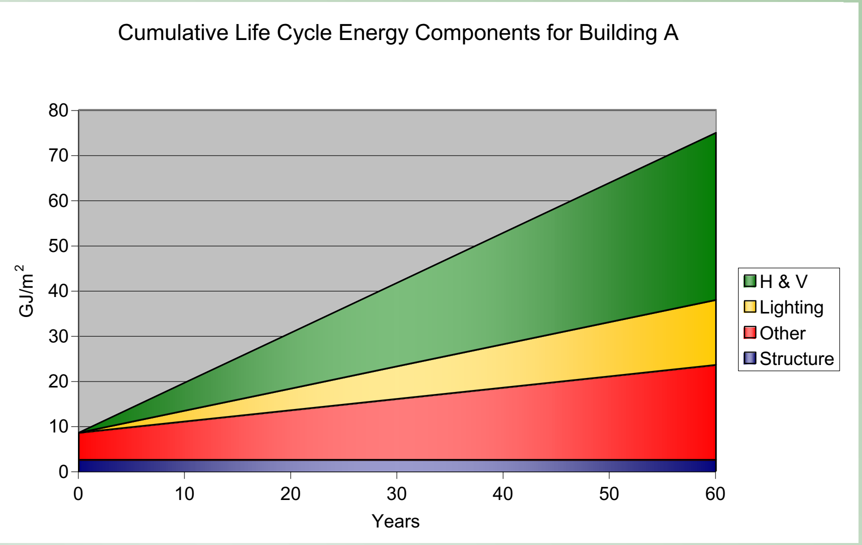
Beyond embodied energy comparisons, there are a number of ways that the steel structural system can contribute to a sustainable design.

Reuse. If you've watched the HBO special "Blue Vinyl" you know that some people go to great lengths to obtain reclaimed lumber for use in homes. Why shouldn't the same be true for steel? In fact, it is! Although the market for trading salvaged steel is just emerging, when designed for deconstruction (using mechanical fasteners and limiting the use of composite design for members to be reclaimed), steel can be disassembled, re-fabricated for a new use, and used in a new building without the need to recycle it.

The Crystal Palace in Great Britain and Beaver Stadium in Pennsylvania are two examples of this. The Crystal Palace, built in 1851 as a temporary exhibition building in London's Hyde Park, was designed to stand on its original site for only one year. After the exhibition, it was disassembled and re-constructed at Sydenham Hill in South London where it stood for another 84 years. Because of the era that it was built, the Crystal Palace was an iron structure, but the principles are the



Primary energy as a function of the recycling rate of steel and rebar. Chart redrawn from: J. Bensahel, J. Besnainou and A. Landfield, "Life Cycle Assessment Comparison Between Steel and Concrete in Buildings," The International Conference on Steel in Green Building Construction, Orlando, March 1998, p. 7.



Cumulative life-cycle energy consumption of various building components. Note that the structure contributes a very small percentage of those costs. Chart redrawn from: K.J. Eaton and A. Amato, "A Comparative Life Cycle Assessment of Steel and Concrete Framed Office Buildings," *Journal of Constructional Steel Research*, 1998, 46:1-3, Paper No. 163.

same. Penn State's Beaver Stadium used all bolted construction, and when the campus grew larger and more space was needed, the all-steel stadium was disassembled and reconstructed a mile away. Similar projects have been designed for reuse by making use of all-bolted demountable construction throughout Europe and for exhibitions and temporary structures throughout the world. Deconstruction and Reuse, if a focused design goal in the beginning of the process, is possible.

Integration. One of the most important "green" principles is the integration of systems. To do this, you have to recognize that what you do on the structural system affects what the mechanical contractor can do, which affects what the lighting contractor can do, which affects what the painting contractor can do. To achieve the maximum environmental benefit of a project, the structural engineer and steel contractor have to work as closely as possible with the other members of the project team. For a steel structural system, this may involve the coordination of location or type of steel members to help with the locations of the ductwork for better airflow. It could mean coordination of paint color on exposed structural steel to give better reflectance for the lighting system, which will cut down on amount of light energy needed to light the space and will decrease the heating load induced by the lighting system, and in turn, cut down the size of the HVAC system. Some European projects have gone so far as to use boxed, HSS, or Pipe structural members as plumbing itself. By getting involved early on, contractors can work to achieve synergies between the structural system and the other systems in the building.

So, the next time you hear the words "green building" in your prebid meeting, have no fear! Structural steel is a strong contributor to sustainable design practices and green construction. For more information on sustainable steel use or how steel can be applied to a LEED-rated building, visit AISC's sustainability web source at **www.aisc.org/sustainability**.

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