Green Steel

Sustainability in Steel

By Christopher Hewitt, LEED® A.P.

Few architectural trends in modern history have captured the attention of Americans as effectively as that of sustainable construction. Today's 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 and the marketability of their buildings. From the federal government, to the *Fortune* 500, the trend toward sustainable architecture is catching on. As structural engineers, we are all trained to make efficient use of materials, and this in itself contributes to the sustainability of our resources. But how many of us have stopped to think about the composition of our structures beyond their strength? How does one material stack up against the next in terms of its environmental performance? How does our work influence or inhibit the overall performance of a building?

Sustainable Design 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 approach is the US Green Building Council's LEED® Green Rating System. This system awards points for meeting various proactive 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, which are ultimately applied toward 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 Life Cycle Analysis or LCA approaches, sometimes referred to as "embodied energy". This method involves calculating the total amount of energy and other impacts associated with the production, manufacture, delivery, and construction of each product, accounting for all of its components and by products. The information is then used to compare the total impact of a 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 tranparency to warrant its use in making mainstream comparisons of structural materials, but the science is advancing, and the system's precision and usefulness as a comparative tool gives it potential for future use.

Comparing Structural Materials

All of the preliminary data obtained on structural systems indicates that, for the structural system, there is very little difference in the embodied energy of structural materials in a building. 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 85% or greater recycled content was used, the steel structural system had less embodied primary energy than reinforced concrete (*Figure 1*). When steel with less than 85% recycled content was used, reinforced concrete had less embodied primary energy than steel. The US structural steel market's electric arc furnace process and minimum 93% recycled content vastly outperforms the data portrayed in these studies. Given today's recycling rates of steel and rebar, there is almost no difference in embodied energy between these two structural materials. Ultimately, when a steel structural system is used, there is still concrete on top of the steel deck, and when a reinforced

For more information on sustainable steel design, environmental innovations in steel, or how steel can be applied to a LEED rated building, visit AISC's sustainable design web source at **www.aisc.org/sustainability**.▪

concrete structural system is used, there is still steel rebar in the concrete. From a practical standpoint, the energy difference is moot. The true benefits of green construction and sustainable design are achieved through the efficiency of the site, building envelope, and building services.

Other Ways of Looking At Materials

Site Impact

Fabricated structural steel can be erected with very little disturbance to the worksite. And, because steel arrives at the jobsite as a finished product, there is no site disturbance associated with its production.

Recycling and Recyclability

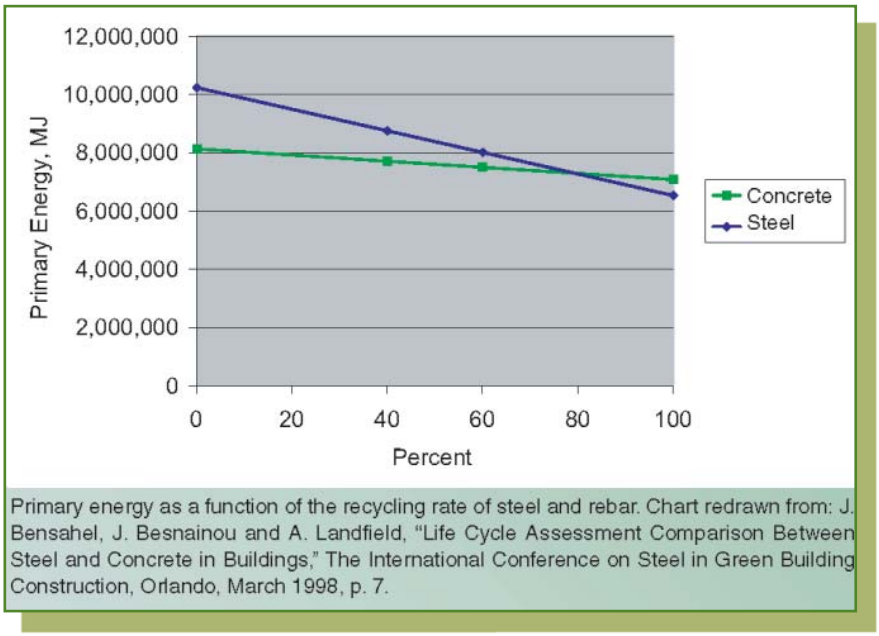
Steel is the world's most recycled product. In fact, nearly 100% of the steel beams used in buildings are eventually recycled. There are, however, some misconceptions surrounding just how much recycled material is really in the steel that you get on your project, which must be clarified before applying 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 US mills using the EAF process contains at least 93% 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 higher percentage of raw materials than that produced in an EAF, but BOF steel still has a minimum of 25% recycled content. In the US, steel produced using the BOF is predominantly used in non-structural applications. All US 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. To assist in documenting this material, AISC and the Steel Recycling Institute have developed a document titled *Steel Takes LEED with Recycled Content*. This document can be used directly to document the recycled content of steel, based on which material is used.

Reuse

About two years ago, a popular HBO special debuted, titled "Blue Vinyl". If you saw it, you'll 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, refabricated 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 same. Penn State's Beaver Stadium used all bolted construction. 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 or other forms of 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, can have a very positive environmental benefit.

Figure 1: Primary Energy as a Function of Recycling Rate of Steel and Rebar



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.

Integration

One of the most important principles of sustainable design 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 coordinating steel members to improve the location of the ductwork and to promote better airflow. It could mean using a painting system that contains no VOCs on exposed steel to improve the indoor air quality of a space. Some European projects, including London's City Hall, have gone so far as to use boxed, HSS, or Pipe structural members as part of the plumbing system itself.

The innovations of the structural engineer toward improving the quality of buildings are only beginning to emerge, and the accolades bestowed upon those engineers that adapt technology toward this end are evident among architects and building owners.

So, the next time you hear the word "green building", don't worry. Structural steel is a strong contributor to sustainable design practices and green construction▪.

Christopher Hewitt is a Staff Engineer in AISC's Engineering and Research Department, and is a LEED® Accredited Professional. He can be reached by email at ***solutions@aisc.org.***

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