economics

A GREEN ROADMAP

Navigating the ever-expanding landscape of green codes, standards and rating systems.

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THE DESIRE OF FEDERAL, state and local officials, as well as project owners, for green, high-performance, sustainable buildings is a long-term reality in the building construction marketplace.

While the demand for green buildings by project owners is balanced by the incremental construction costs to achieve specific sustainability goals, there is little question that the three traditional construction drivers—cost, speed and quality—are being joined by sustainability. The balance that will be struck between these four factors has yet to be determined, just as the balance between energy consumption, environmental impacts, human health concerns, economic considerations and social outcomes is still under debate in the green community.

It is therefore critical that structural engineers and structural steel fabricators understand the additional expectations and requirements that are being placed on their disciplines as a result of the increasing demand for green buildings.

LEED, ASHRAE and the IgCC

The growing influence of sustainability concerns in the building design and construction marketplace has spawned an increasing number of codes, standards and rating systems that impact how projects are designed and constructed. Currently the three most dominant of these are: the LEED rating system developed by the U.S. Green Building Council (USGBC), *Standard 189.1 for the Design of High-Performance Green Buildings* published by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) and the International Green Construction Code (IgCC) published by the International Code Council. While all three of these documents focus on similar topics, the requirements and methodologies vary significantly between them. The IgCC is written in code language designed to be adopted by local jurisdictions as either part of their base building code or as incremental requirements for projects required to be sustainable, or in order to obtain certain incentives by opting to be sustainable. There are multiple compliance paths within the IgCC. The first is what is referred to as "native" IgCC, which spells out specific project requirements. However, in place of meeting the requirements of the native IgCC language, a project owner can opt to comply with either the requirements of ASHRAE 189.1 or ICC-700 (a green standard published by the National Association of Home Builders and the International Code Council).

It is important to recognize that if a project is being built in a jurisdiction that has adopted the IgCC, it must meet the requirements of native IgCC, ASHRAE 189.1 or ICC-700. These documents were developed in a consensus-based process and are written in code language for the purpose of defining a minimum threshold for a building to be considered a high-performance green building.

At present, three states (Oregon, Maryland and Rhode Island) and municipalities in five other states (New Hampshire, Arizona, Florida, Colorado and Washington) have adopted the IgCC as either an extension of their base building code or specifically for projects seeking classification as green, high-performance buildings.

The LEED (Leadership in Energy and Environmental Performance) program developed by the U.S. Green Building Council is not a standard or a building code and is not written in code language. It is a rating system designed to incentivize, measure and reward green design and construction practices. New versions of LEED will sit on top of the requirements of green codes and standards such as the IgCC and ASHRAE 189.1. It is the choice of the project owner if the project that is being designed and constructed will pursue LEED certification and what level of certification (certified, silver, gold or platinum) will be sought. Public agencies and jurisdictions may require LEED certification for their own projects, and jurisdictions may incentivize private projects meeting LEED requirements, but technically jurisdictions should not mandate that private projects be built to LEED requirements. LEED credit requirements are subject to change, are not developed in a consensus process and are not written in code-enforceable language.

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LEED is an ever-changing target for building designers and constructors. Today, two versions of LEED-NC (New Construction) are currently in use for certifying new building construction. LEED-NC V2.2 is still being used for projects that were registered prior to June 27, 2009, with a "sunset" date for final application and document submissions of June 27, 2015. New building projects are being registered under LEED-NC 2009, which will remain open for project registration at least until June 1, 2015. USGBC has not announced a sunset date for LEED NC-2009 but if the pattern of earlier release cycles is followed, it would be anticipated that a sunset date of June 1, 2021, would be likely. A new version of LEED—LEED V4—is currently being developed and has gone through five public comment cycles. It is anticipated that the new version will be balloted in July of this year and, if approved by the USGBC membership, will be available for project registration beginning in August.

Materials and Resources Overview

Of primary interest to structural engineers and structural steel fabricators are the sections in these green entities that deal with materials and resources. Each system deals differently with the methodology used to assess the sustainable use of materials in general and structural steel specifically.

The existing LEED-NC (V2.2 and 2009) rating systems (note that there are multiple iterations of LEED, such as LEED for Schools, Commercial Interiors, Healthcare, etc.) grant credit points counting toward various levels of LEED certification. Credit MR-4 (MR stands for Materials and Resources) addresses the recycled content of materials use in projects and Credit MR-5 addresses the regional content of materials used in projects. In both cases the cost of the materials, as delivered to the project site, qualifying for the credit is taken as a percentage of the total cost of project materials (assumed to be 45% of overall project costs). Two thresholds are defined in each credit. If the project reaches the lower threshold, one point of credit is earned. If the higher threshold is reached, two points of credit are gained. It should be noted that LEED-NC 2009 is still subject to modification both in terms of changes to the actual credits in the system and the interpretation of those credits. Significant changes have been made to the materials and resource credits over the past six months in LEED-NC 2009.

ASHRAE 189.1 uses a different methodology. Projects must meet one of three thresholds. Either the project must contain 10% recycled material (using the same calculation methodology as LEED), 15% regional materials (using a slightly different calculation methodology than LEED) or 5% bio-based materials. As an alternative, a life cycle assessment (LCA) may be conducted for the project, showing environmental impact improvements compared to an alternative design.

Native IgCC uses yet a different approach, requiring that all projects attain a score of 55% by summing the percentage contributions of all project materials in the areas of material reuse, use of building materials made up of recycled content (any material with a recycled content greater than 25%), the recovery rate of materials, the use of "indigenous" materials and the use of bio-based materials. The overall calculation can be done based on cost, mass or volume. Just like ASHRAE 189.1, a LCA may be conducted for the project showing environmental impact improvements compared to a reference building.

▲ Is a greenhouse a green building? It all depends on whether it meets the requirements of a given green code, standard or rating system.

▼ The National Renewable Energy Laboratory's Research Support Facility in Golden, Colo., is a steel-framed LEED building with the goal of becoming the greenest office building in the world. (See "Greening Steel Construction"—05/2011—for more on this project.)

The LEED V4 treatment of materials is still subject to modification based on the latest round of public comments, but the basic direction that LEED is taking is clear. USGBC is positioning LEED V4 above the requirements of IgCC and ASHRAE 189.1 and not directly addressing issues such as recycled content and regional materials; rather the emphasis will

▲ One of the green tactics for NREL's Research Support Facility was to use reclaimed steel oil pipe as structural columns; material reuse is recognized by LEED, the IGCC and ASHRAE 189.1.

▼ The NASA Sustainability Base, a LEED Certified steel-framed office building at NASA's Ames Research Center in Silicon Valley, Calif., features an external steel framing system from which shading or solar elements can be hung.

be on transparency of material information from both environmental and chemical composition perspectives, the responsible extraction and harvest of materials (including recycled materials) and the avoidance of materials with harmful impacts on human health. LCAs are also fully integrated into the LEED V4 credit program.

Each of these systems and the documents that describe them are far more complicated than what is being described here. I'd encourage you to acquire copies of the actual program documents and associated user's guides to gain a full understanding of the requirements of each program. The AISC Steel Solutions Center (**solutions@aisc.org** or 866.ASK.AISC) is also prepared to provide support on questions relating to the material sections of these systems.

What Should Fabricators Know?

Structural steel fabricators are often asked to supply information regarding the recycled content and origin of materials they supply to a project. While this may seem like a simple request, it is actually a significant challenge on many projects, particularly when the individual tasked with collecting information for the general contractor may not fully understand the scope of the information to be collected. The following steps for collection and provision of information should satisfy the vast majority of the various requirements (the details of the calculations are not included here but are available at **www.aisc.org/sustainability** along with a spreadsheet template for reporting results).

1. Determine the contract requirements for sustainable materials before bidding and accepting the project. Is this project being constructed in a jurisdiction that has adopted the IgCC? If so, is the native IgCC or ASHRAE 189.1 compliance path being followed? Is the project pursuing LEED certification and, if so, what level of certification? Does the contract simply require the fabricator to document the recycled content and source of materials or does it specify compliance thresholds for the materials used on the project (i.e., "the average recycled content of all products delivered to the project site shall be 50% and all products shall be sourced from within 500 miles of the project site")? What materials must be separately reported (sections, connection material, bolts, deck, joists, etc.)? Contract provisions and project specifications control the requirements for the material a fabricator acquires as well as the documentation that must be provided. To simply say "this is a LEED project" does not define material sourcing requirements or the level of detail or completeness of material documentation.

It is not anticipated that, under any of the green systems, all construction materials are required to report both recycled and regional content values. Rather, during the design phase of the project construction materials should be selected and specified that will typically meet the desired thresholds. Too often advance planning is not performed relative to materials, and the general contractor is left demanding material data from all suppliers in an effort to reach a desired threshold. This shotgun approach is unnecessary and unwarranted resulting in additional costs, frustration and confusion on the part of material suppliers. A more judicious approach is to identify those materials providing the greatest contribution to these credits (for instance, steel for recycled content and concrete for regional content), then working incrementally to the threshold level, looking sequentially at other materials.

2. Verify with potential material suppliers that the required material or documentation is available. If materials are being purchased from a service center, verify that the service center can provide contact information or documentation relating to both recycled content and regional sourcing for the materials they provide. Note that industry average data is no longer being accepted by USGBC.

3. Collect recycled content letters from all material suppliers. In the past the domestic industry average recycled content for steel produced from electric arc furnaces (EAF) and basic oxygen furnaces (BOF) was accepted by all programs as sufficient documentation. As of November 2012, LEED no longer accepts industry average documentation but rather requires producer-specific documentation of the average recycled content of their products. If specific producer documentation is not available, then a default recycled content value of 25% can be used for steel products. The producer letter should distinguish the two different types of recycled content and indicate the percentage of each. The first type is post-consumer recycled content, which includes any material being recycled after it has recovered from a product used by a consumer (i.e., an automobile). The second is pre-consumer (post-industrial) recycled content, which is waste from an industrial process other than the process producing the material (i.e., scrap bundles from an automobile production facility). A third form of scrap, scrap that is recycled within the steel mill producing the product (called "home scrap") is not considered recycled material and does not enter into the calculation of recycled content. These calculations are done on the basis of mass. The calculated recycled content of the material varies by system. LEED and ASHRAE-189.1 use the international methodology of calculating recycled content as the post-consumer recycled content plus half the pre-consumer recycled content. IGCC uses the simple sum of the pre-consumer and post-consumer content.


Douglas Steel

The Ottawa Street Power Station in Lansing, Mich., reused the majority of its steel framing system when it underwent an adaptive reuse project that transformed it from a power station to a modern office building. (See "An Inside Job"—12/2010— for more on this project.)

4. Provide the general contractor with a recycled content summary list. A spreadsheet template including the appropriate calculations is available at **www.aisc.org/sustainability**. It is important to recognize that while the recycled content of a material is based on mass, the contribution of that material to the overall recycled content of the building is based on cost. The contribution of a structural steel frame to the recycled content of the building is the recycled content of the material (mass-based) multiplied by the cost of the structural steel package excluding erection. This value is then added to the contributions of other materials and divided by 45% of the project's construction cost to determine the recycled content attainment level of the building.

5. Document the regional material content of the project. This is a complex challenge because of varying definitions of terms, variations within the structural steel supply chain and differences in language between the various systems.

a) **LEED**. As of July 2012, LEED-NC 2009 MR-4 recognizes two methods for calculating regional material. The first requires the point of extraction/recovery of feedstock material and manufacture to be within 500 miles of the project site. USGBC considers the point of manufacture for recycled material products to be the location of the final finished product manufacturer—which is the steel fabricator. The second tracks the actual transportation distances of the material from extraction/recovery to the mill to the service center to the fabricator to the project site, with adjustments made for the mode of transportation. Distances involving rail transport are divided by 3, inland barge by 2 and ocean shipping by 15.

Under LEED the definition of the point of extraction for iron ore and coke is the location of the mine, while the definition of the point of extraction/recovery of scrap can be the recycling facility, scrap yard, depository or stockpile. This allows for two methodologies: a proportional methodology based on that percentage of mining or scrap sourcing that occurs within 500 miles of the project site, or an all-or-nothing approach that considers the mill location as the recycling facility. Either approach can be taken but it must be used consistently for all materials.

b) **ASHRAE 189.1**. This standard considers regional material to be any material extracted, recovered *or* (not *and*) manufactured within 500 miles of the project site. Distances for rail, barge or ship transportation are divided by a factor of four. For structural steel this means that if the source of the feedstock material, the mill or the fabricator is within an adjusted distance of 500 miles of a project site, the material qualifies as regional.

c) **IGCC**. The code considers regional material to be any material extracted, recovered *and* (not *or*) manufactured with 500 miles of the project site. Distances for rail, barge or ship transportation are divided by a factor of four. For structural steel this means that the source of the feedstock material and the fabrication facility must be within an adjusted distance of 500 miles of the project site to qualify as a regional material.

6. Provide the general contractor with a regional content summary list. It is very possible that a single project may be required to meet the requirements of IgCC (native or ASHRAE 189.1) and document contributions to LEED thresholds, so each of the three methodologies may need to be evaluated.

7. Include in the submissions the industry average recovery rate for structural steel materials used in building construction. The current recovery rate, as documented by the Steel Recycling Institute, for structural steel is 98.5%.

The requirements of these systems are continually being modified and updated. LEED V4 will introduce credits incentivizing the provision of environmental product declarations (EPD) and chemical disclosure statements at either the industry or producer level for a threshold number of products for each project. This will not remove the need for documenting recycled and regional content but rather will increase the amount of information that a fabricator will need to document and report. For updated information, please check the most recent information at **www.aisc.org/sustainability** and download the most current reporting templates.

The IgCC is a product of the International Code Council and underwent multiple public hearing sessions, all of which AISC and other steel industry representatives attended and participated in.

Greenbuild is the world's largest green building event (it routinely draws crowds of around 30,000) and is run by USGBC, which also administers the LEED program.

What Should Engineers Know?

In many ways structural engineers have had little engagement with the green codes, standards and rating systems. The LEED program did not require any direct involvement from the structural engineer. Documentation of recycled and regional content levels was left to the general contractor and the specialty contractors that supplied the material.

Certainly the framing system designs produced by structural engineers can impact the sustainable performance of a building. Careful detailing can avoid thermal bridging issues (see the 03/2012 supplement on thermal bridging, available at **www.aisc.org/sustainability**). Proper material selection can reduce environmental impacts and the embodied energy of the structure, although research has shown that differences in embodied impacts between structural steel- and concrete-framed structures are small (see "And the Winner is...," 08/2010). Collaborative design approaches that include the steel fabricator in the design phase of the project can actually have a greater impact than material selection through the optimization of material usage and fabrication processes.

Yet up until now, there was little the structural engineer was required to perform or document to generate credits in the LEED-NC programs. That is about to change. The adoption of the IgCC will require structural engineers to document the anticipated contribution of structural materials to the recycled and regional material content of the building during plan review in order for building permits to be issued. These estimates will be made using typical industry averages for the recycled content of construction materials, typical sourcing options relative to regional content and the associated portion of delivered material costs to the overall structure cost. At the same time documentation of anticipated material recovery rates and any use of recovered material will need to be made to verify that the required thresholds of the IgCC will be reached. And, if the choice is made to perform these calculations based on mass rather than cost, the structural engineer will need to estimate the final mass of the structure.

But the real change will come with the increasing requirement for the use of LCAs. LCAs attempt to quantify the difference in environmental impacts between alternative building designs for various impact categories, although regretfully not all impact categories are typically considered. LCAs are a key credit component in the draft version of LEED V4 and an optional compliance path in IgCC and ASHRAE 189.1. The assessment is the product of two sets of data. The first set includes the life cycle inventories of the products used in the construction of the building. The second set includes the design quantities of the materials used in the building. Significant challenges exist with respect to the completeness and accuracy of these data sets.

Accurate life cycle inventories (LCI) of products are difficult to identify. LCIs for different products may have selected different boundary conditions in the calculation of their specific inventories. Some products may only include impacts of the production process (cradle-to-gate) while other products may include all phases of a products life from production through installation to demolition to reclamation (cradle-to-cradle). Any building analysis comparing framing systems or products with LCIs using different boundary conditions is invalid. In addition, LCI data may be old, represent product production techniques not in use in a specific region or use a different data collection and calculation methodology, as documented in a study by Zygomalas and Baniotopoulus titled "Uncertainty in Life Cycle Assessments Induced by LCI Data, the Case of Structural Steel." For example, the current LCI data for hot-rolled structural steel uses global data that includes a large production component related to BOF facilities—whereas all hot-rolled structural steel produced in the U.S. comes from EAF facilities. The difference in the impact of these mismatched data sets was clearly seen at a presentation at the recent Greenbuild conference in San Francisco, where a comparative study was presented that used a structural steel data set assuming that 60,000 gallons of water were consumed in the domestic production of each ton of structural steel. In reality, the water consumption rate of structural steel produced in the U.S. is less than 70 gallons per ton; the result was that the comparison was misrepresented by a factor of nearly 1,000! Work is currently underway to develop and publish a U.S.-specific LCI data set for structural steel.

The second challenge relates to determination of the material quantities used in the LCA. Tools to accurately perform LCAs are complex, cumbersome and expensive to implement. In order to encourage the use of LCAs, estimators have been developed that attempt to parametrically determine the amount of material in a structure using a specific framing system approach. Regretfully, little flexibility exists in the selection of these systems resulting in gross approximations of material quantities and the possibilities of significant errors. In a recent study by Ryerson University of actual quantities versus quantities used in the most popular of these estimators, the ATHENA Impact Estimator, it was found that concrete quantities were overstated by 6% and structural steel quantities were overstated by 28%. Jennifer O'Connor of the ATHENA Institute, speaking at Greenbuild, summed up the issues surrounding the implementation of LCAs stating that "LCA is full of uncertainties." Clearly, if LCAs are to become a significant tool in building design, actual material quantities that flow from the actual structural design coupled with accurate LCI data will be necessary. As the structural engineer is the only source of accurate design information, the task of performing the LCA on structural frames of the building will ultimately be their responsibility.

Additional topics specifically related to the practice of structural engineering are beginning to be discussed within the green community and are already making their way into niche building segments such as healthcare facilities. These include service life, adaptability for future modifications and deconstructability considerations.

All of this will require structural engineers to develop a cheat sheet containing information on all structural materials showing:

- the typical pre- and post-consumer recycled content of the material (hot-rolled structural steel pre-consumer content = 19.5%, post-consumer = 69.0%)
- recovery rates (structural steel = 98.5%)
- typical sourcing and transportation of material in the project locale
- the availability of EPDs and chemical disclosure statements

In addition, the structural engineer will ultimately need to:

- Estimate building mass at each design stage
- Assess the feasibility of alternative details to limit thermal bridging
- Perform preliminary recycled and regional content threshold calculations
- Evaluate the possibility of using recovered material
- Prepare standard language for frame service life
- Prepare to opine on the adaptability, resilience and deconstructability of the structure
- Learn about LCAs, their application and their limitations

Final Thoughts

Sustainable design and construction is not a passing trend. It has become an issue for consideration on every building project. Sustainable design practices and sustainable steel fabricating practices will become a normal business activity independent of whether they are codified or recognized. The advent of base level green codes and standards coupled with an escalation of LEED requirements presents a variety of challenges for the design and construction professional. But these changes create an even greater challenge of understanding for local jurisdictional bodies and building code officials. Structural engineers and structural steel fabricators can play a significant role in introducing these individuals to the intricacies and limitations of new requirements such as LCAs. MSC