Sustainable Design for Structural Engineers

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Even structures not specifically designed to be green may be 'greened' at little expense.

Green building and sustainable design are no longer a fad. For the first time in history, our society is taking energy conservation seriously because it is no longer an option not to. In this country, buildings account for over 65 percent of all energy consumption and, according to the US Green Building Council (USGBC), buildings consume over 60 percent of all the resources manufactured in the world.

In 2007, the American Institute of Architects (AIA) adopted a goal of 50 percent reduction in greenhouse gas emissions from buildings by the year 2030, and companies, organizations, local and federal governments are following suit. It is not enough for those needing new buildings simply to *want* a green building: as design professionals, we should be ready and able to provide them with the complementary design and recommendations for sustainable solutions.

The United States, boasting only 4 percent of the world's population, consumes a staggering 25 percent of its resources. As the population of the world increases rapidly, the strain on our resources and increasing demand on our environment continue to grow. These wasteful practices must be brought to a halt and, as engineers, we can begin by bringing sustainable design into everyday practice.

Design

The design of any building is a complex and involved process, with the potential for the utilization of numerous materials and systems. The design of a green building is no different. The design itself may be no more complicated; the difference in engineering a green building is in the design approach and the collaborative design process with the other team members.

A core tenet of sustainable design involves assembling the entire design team at the onset of the project, in order to set the goals of the design not only from a programmatic standpoint, but also from a green and energy consumption standpoint. In the green world every decision made during the design process is based on promoting energy efficiency, minimal site disturbance, healthier environments, and reduction in the use of virgin material.

The structural engineer is a key member in the team of designers for a successful green project. From the inception of design, structural engineers have a vital role to play in the world of sustainability and high performance buildings. This includes defining the basic structure and scope of a project, providing ways to bring more natural light into the building, supporting energy conservation measures such as double walls and green roofs, and selecting the structural materials to be used.

The core structural elements of every building are critical to the green design concept and should not be overlooked. As with any building, the structure supports the building physically, as well as the design concepts on which it is based. Structural engineers aid the design team by providing clear spans, increasing the ability to bring in natural light, provide uninterrupted views to the exterior, and make the exterior wall lighter. Adding additional windows to a structure provides the same benefits. Design elements, such as sunscreens, double walls and vegetated green walls, all add sustainable benefits to a building and are integrated into the building's design by the structural engineer.

Moreover, the intent of the other design team members, including architectural, plumbing, HVAC, fire protection and electrical, must be coordinated with the work of the structural engineer. Other considerations include the additional weight of a green roof, the entire design of underground parking to reduce impervious surfaces on site, the weight and size of rainwater and grey water collection tanks, and uplift resistance of photovoltaic panels. These elements all serve to reduce the carbon footprint of a building but, if not properly incorporated into its structure, will not be useful.

Materials

Every industry is touting sustainable products, and structural engineering has its own set of green tools in its arsenal.

Material selection is an integral component of the proper design process for a green building. The three most commonly used structural materials are wood, steel and concrete, each with their own green benefits and drawbacks. The best option is determined when analyzing the scope and location of the project. Often designers and design teams get tangled in a web of Leadership in Energy and Environmental Design (LEED®) points, and materials selection is "prescribed", according to Douglas Sordyl of the American Concrete Institute (ACI). It is therefore necessary for the structural engineers to take the lead on a project to ensure that sustainable materials are chosen for the proper usages, and not simply selected for a singular aspect of their green properties or to "chase points."

USGBC's LEED point system is the most commonly used way to evaluate just how green a building is. While none of the points explicitly refer to the efficiency of the structure, many of the categories pertain to the role of the structural engineer in the design process. For instance, the LEED checklist will award a point for reusing 50 percent of an existing building structure on a project, with an additional point awarded if 75 percent of the structure is reused, and a third point can be obtained if 100 percent of the structure and some of the interior partitions are also reused.

When we consider that over 65 percent of all material that goes into the landfills is from construction and demolition, reducing the amount of waste created by our industry is critical for the sustainable concept. Finally, during construction, the careful separation of construction waste and recycling of construction waste material also gains another two points for LEED certification.

Wood

Wood frame construction is easy and inexpensive, and a great option for smaller projects as building codes and engineering realities often limit the capacity of wood structures. Wood grown from certified forests assures the consumer that the product has been produced from sustainable forests that grow lumber as a commodity or a crop using sustainable practices, rather than clear cutting the forests or relying on old growth trees for lumber production. Wood certified by the Forest Stewardship Council (FSC) assures consumers that the wood that they are using for their structure has been grown in responsible forests,

and harvested in ways that promote the welfare of the local community and ecology as well.

FSC has laid out a set of principles and criteria about how forests are certified, and in terms of how the ecological, social, and economic needs of the forest and community are managed. They ensure that FSC-certified forests are responsible with respect to protection of wildlife and biodiversity, thereby promoting responsible forestry and logging practices. Karen Steer, public relations representative for FSC, notes that LEED points for new wood in a structure are only being awarded for FSC-certified wood, but the process is under review by USGBC; the use of new non-FSC wood will not garner any additional LEED points.

Steel

Domestic structural steel is a tremendous option for green engineering, being comprised of 95% recycled material. It is one of the most easily recycled and reused construction materials. Old cars, refrigerators, washing machines, rebar, and scrap metal are all collected and reconstituted into new steel products every day.

Because steel is in such high demand for construction, mills and recycling centers are scattered throughout the country. Within a 200-300 mile radius of any location, there is sure to be a steel mill and/or a scrap collection facility. Steel that is fabricated locally drastically reduces the amount of energy needed to transport the material, thus adding to its sustainability. Additionally, steel offers the flexibility of design and speed of construction that few other materials can provide when considering its size and weight.

Concrete

A significant advantage for the use of concrete is that it is the most widely used building material in the world, which means that it is often considered a local resource. With a drastic reduction in the cost to transport the material, a great deal of money and strain on the environment is saved. As the term "green" drives the markets, the concrete industry remains at the forefront of incorporating sustainable principles into their products.

More and more often, designers and builders desire to re-use materials in construction. Concrete is an outstanding candidate for recycling and combining with fly ash, with the potential of creating a material comprised of 50-60% of recycled material, thereby reducing the carbon footprint of a particular project. Douglas Sordyl of ACI recommends that engineers explicitly specify these cementitious supplements in the project manual.

Why should I go green?

Those dubious of green design tout the incremental increases in the cost of design and construction of a building, ranging from 2% to nearly 20% depending on the level of LEED certification sought. They shudder to imagine the forethought and collaboration required of the design team and particularly of the structural design effort, which may be considerably greater than with a traditionally over-consumptive building. Evidence shows, however, that the benefits of building green are tremendous, and far outweigh any of the negative aspects of the process.

In the total investment of a building development, 41% of the money spent is devoted to the construction cost of the building itself. At first glance, it may seem exorbitant to increase the cost of a building by 10% in order to have it be LEED certified Gold, but looking further, the increase is dwarfed by the benefits. According to USGBC, when considering the costs of constructing, operating and running a business in a building over its 30-year lifespan, the construction cost is only 2% of the total. That is almost negligible when compared to the salaries of the occupants of an office building, which can add up to a whopping 86.5%. Therefore, even a modest 1% increase in worker productivity will provide an exponential payback when compared to the initial investment in the physical plant.

Still, with the obvious decrease in operating energy costs, water consumption, and environmentally friendly material selections, LEED buildings have been proven to increase the value of a building by an extraordinary 7.5%. LEED certified buildings have an overall higher rate of employee satisfaction, a reduced number of employee sick days, and a significantly higher property value than traditionally built, resource wasteful buildings [Kats, Green Building Costs and Financial Benefits, Massachusetts Technology Collaborative, 2003]. Some forward-thinking employers and institutions are going green as an employee retention tool in order to differentiate them from their competitors. When considering the cost of hiring and training new employees, the payback on the premium for green building is, also, immediate.

As a structural engineer, you should continue using the best practices possible; take a proactive approach with the design team early on in the process, and seek creative and alternative solutions to the challenges facing the design of a green building. It is not only your responsibility, but it is your duty to ensure that the buildings you design are as efficient as possible. Regardless of whether or not they are going to be LEED certified, sustainable design should be incorporated into all of your projects.▪

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