Here are two ways structural engineers can meet the added challenge of accounting for environmental impact.

Designing **Green**

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ATTEMPTING TO DESIGN more sustainably and being green is common in the construction industry. Structural engineers hear these terms and wonder how they can contribute to more sustainable designs. The challenge isn't how structural engineers can contribute, instead it is meeting the typical requirements of safety and serviceability while collaborating with design team members to innovate and find more synergistic solutions. In this article, we address challenges for the structural engineer related to two sustainable design strategies: designing for deconstruction and local sourcing.

Designing for Deconstruction

Read any article about deconstruction and it begins by stating facts and statistics about the huge amount of construction and demolition waste that goes to landfills every year. Great strides have been made toward recycling, but even that often requires energy to manufacture new products. And no one involved in the construction industry has any real doubt that we could be better at reducing waste, reclaiming materials, and reusing components. Design for deconstruction (DfD) has gained popularity over the last few years in theory, but few projects exist where the concept has been put into practice.

The basic idea behind DfD strategies is that durable components can be taken apart and reused, even if the structure for which they were originally designed is no longer in use. Intuitively, it makes sense that disassembling buildings and reusing their parts reduces environmental impacts related to construction by reducing:

- Transportation impacts related to processing and shipping of raw materials, and transporting demolished components to the landfill.
- The energy needed to process virgin materials into new products and the emissions to air associated with the energy source.
- The amount (and related impacts) of raw material extraction.

Bradley Guy and Scott Shell succinctly expressed the underlying rationale in their paper "Design for Deconstruction and Materials Reuse," which is included in the *Proceedings* of CIB Task Group—39 Deconstruction from its April 2002 meeting in Karlsruhe, Germany. According to Guy and Shell, the goal of DfD is to "increase resource and economic efficiency and reduce pollution impacts in the adaptation of and eventual removal of buildings and to recover components and materials for reuse, re-manufacturing, and recycling."

In the article "Design for Deconstruction" in the June 2004 *Modern Steel Construction*, (available at **www.modernsteel.com/backissues**). Guy along with Michael Pulaski, Christopher Hewitt and Michael Horman set forth several concepts and strategies that can play a role in designing for deconstruction. These include:

- Using prefabricated, preassembled, or modular components
- Simplifying and standardizing connections (fewer connections, consolidation of types and sizes of connectors)
- Simplifying and separating out building systems (mechanical, electrical, and plumbing)
- Considering worker safety
- Minimizing the different types of building components and materials
- Selecting connections that allow for fast disassembly and removal of materials
- Designing to accommodate deconstruction logistics
- Reducing building complexity
- Designing using reusable materials
- Designing for flexibility and adaptability

From a structural engineer's perspective, the real obstacles to designing for deconstruction seem to be lack of information, time and economics.

Lack of Information

If you mention deconstruction and reuse of components to a structural engineer, she or he is likely to have some immediate questions related to exposure of those components to loading during its current life, and residual capacity for use in the future. In existing buildings, these concerns could prove a barrier to deconstruction. Unknowns such as in-service history, the necessity for proof-loading to determine capacity, or risk related to possibly contaminated materials (such as fireproofing), could hinder reuse of components currently in use. There is a definite need for tools, techniques, skills, and markets to assist with deconstruction of the current building stock.

Understanding Local

Local sourcing is one of the primary strategies related to sustainable design and material selection. It is true that choosing local or regional materials and products reduces the environmental impacts related to transportation, and local sourcing also supports local economies and industries. For steel, sourcing from North American mills also reduces embodied environmental impacts related to manufacturing.

In 2008 China produced one-third of all types of steel made globally, and was responsible for 50% of the carbon dioxide emissions for steel manufacturing, according to a 2009 report from the Alliance for American Manufacturing. The ASCE Structural Engineering Institute in its *Sustainability Guidelines for the Structural Engineer* warns against specifying steel that is "only available from foreign sources" because these sources may have less-restrictive environmental regulations. Often the competitiveness of foreign steel is a result of two factors: (1) foreign steel mills may not be required to make as many capital improvements related to reducing environmental impacts, and (2) raw materials extraction processes do not control particulate emissions and are stopped short of returning the affected land back to a natural state. The impacts due to transporting long distances are often small compared to these manufacturing and extraction impacts.

According to the American Iron and Steel Institute, the steel industry in North America has reduced greenhouse gas emissions per ton of steel, while increasing energy efficiencies. Foreign steel companies may emit as much as 3 to 20 times the pollutants as U.S. steel companies. Structural engineers can protect the environment by having an understanding of the true cost, in terms of environmental impacts, of the products specified—not only their mass (whether they are efficiently designed) but their source (impacts due to their extraction and manufacture).

For new construction, concerns related to lack of information can be avoided by several methods. One is through creation of a deconstruction plan. A deconstruction plan would detail all loads, connections, and member capacities, among other items, and most importantly, it would be kept by the owner for future use.

As an alternative to a deconstruction plan, the Structural Engineering Institute of the American Society of Civil Engineers recommends in its *Sustainability Guidelines for the Structural Engineer* clear labeling of all materials, like using paint or etching on all steel members. The guidelines note that as-built drawings should be stored in a safe place as a resource for future use. These measures are always a good practice for a green building because they allow the building to be more easily assessed for alterations, additions or changes of intended use during its useful life.

Time and Money

Designing a structural component for future reuse is one challenge in new construction, and so is pricing a component that is durable and can be used for longer than the building's service life. In the U.S., there is still a desire to build new at the lowest cost and a tendency to undervalue materials we currently view as waste. Because there are few costs placed on environmental impacts of extraction of materials (see sidebar, "Understanding Local"), products are not truly valued.

Thus, many times it is less expensive to demolish and recycle or landfill a structure than take the time to carefully separate components and reuse them. This may change as new buildings are designed to be deconstructed, but in the interim, it will be a challenge for all in the construction industry. In their article "Design for Deconstruction," published in the spring 2005 issue of *Building for a Future* magazine, Chris Morgan and Fionn Stevenson highlighted the advantages of DfD. It is possible, they wrote, to design buildings taking into consideration "disruption to occupants, waste, and cost to client during renovation, and for easier repair and maintenance of components," which makes DfD more simple and cost effective.

Sustainability and green strategies require creative thinking by all design team members. For new construction, familiarity with green terminology will assist structural engineers in collaborating with the project team. Published reports indicate that DfD has merit but most likely will entail additional initial costs and a learning curve. The benefit is lower environmental impacts because the life of the component is extended. MSC

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