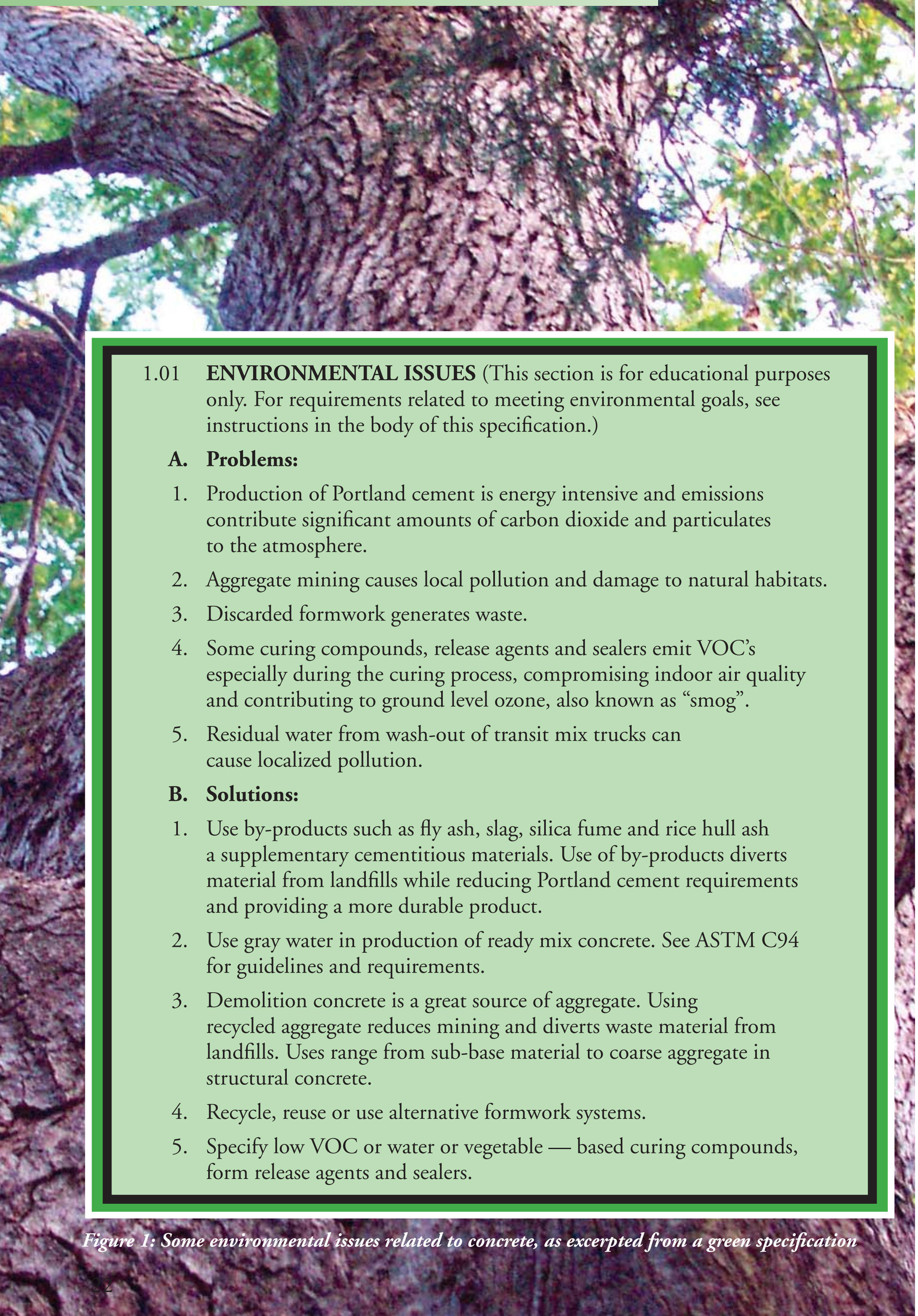
Engineering Structures into Green Design

By Helena Meryman



1.01 **ENVIRONMENTAL ISSUES** (This section is for educational purposes only. For requirements related to meeting environmental goals, see instructions in the body of this specification.)

A. Problems:

1. Production of Portland cement is energy intensive and emissions contribute significant amounts of carbon dioxide and particulates to the atmosphere.
2. Aggregate mining causes local pollution and damage to natural habitats.
3. Discarded formwork generates waste.
4. Some curing compounds, release agents and sealers emit VOC's especially during the curing process, compromising indoor air quality and contributing to ground level ozone, also known as "smog".
5. Residual water from wash-out of transit mix trucks can cause localized pollution.

B. Solutions:

1. Use by-products such as fly ash, slag, silica fume and rice hull ash a supplementary cementitious materials. Use of by-products diverts material from landfills while reducing Portland cement requirements and providing a more durable product.
2. Use gray water in production of ready mix concrete. See ASTM C94 for guidelines and requirements.
3. Demolition concrete is a great source of aggregate. Using recycled aggregate reduces mining and diverts waste material from landfills. Uses range from sub-base material to coarse aggregate in structural concrete.
4. Recycle, reuse or use alternative formwork systems.
5. Specify low VOC or water or vegetable — based curing compounds, form release agents and sealers.

Figure 1: Some environmental issues related to concrete, as excerpted from a green specification

Structural engineers are typically unaccustomed to viewing themselves as part of the green building process. The time has come for this to change. This may leave many wondering what, exactly, their role and responsibility are and how they can meet this new professional challenge. The primary function of the structural engineer in this new ecologically concerned design and construction standard is to choose structural systems and materials that will both minimize the environmental impact of the building construction and enhance the performance of the building over its lifetime. How is this achieved, what is involved and how is this process different from standard practice?

The main difference in the green design process is that the structural engineer must be willing and able to participate in integrated design charettes. This is the ideal design paradigm to realize a building that embraces the principles of sustainability. The process involves all designers (architects, engineers, site and landscaper designers, lighting designers, etc), the client and if possible, a contractor and/or sub contractors in decision-making at the project's inception. Each team member comes to the table with his/her area of expertise related to efficient building design, construction or operations. From the start, the project concept is generated from a fusion of specialized knowledge.

The intention is to eliminate conflicting design strategies while capitalizing on the interdependence of site resources, structural and mechanical systems. To be a valuable team member, the structural engineer must understand the environmental issues related to structural materials (and their finishes) and how these materials may impact the performance of the building in terms of mechanical loads, maintenance and indoor environmental quality. The structural engineer must also be an advocate for structural efficiency — this may mean challenging an architect's schematic design. It certainly means educating the entire team on the fundamentals of structural efficiency and the inherent capacities of particular materials. Once the project reaches the construction documents stage, the structural engineer must provide specifications that capture the environmental goals and effectively communicate the strategies so that they are achievable.

"Green" Education

How does a structural engineer become knowledgeable about green building? In 2001, our office decided to implement a program to educate all our staff on the principles

Figure 2: Kaiser Steel Eagle Mountain Mine, located near Desert Center, CA. The land the mine is on was given to Kaiser as a part of the war effort in the 1940's, the land was formerly part of the Joshua Tree National Monument. Kaiser stopped mining Eagle Mountain in 1980. The site, in the middle of the Mojave Desert, is an endangered desert tortoise habitat. Photo courtesy of Eric. R. Shamp, Econostudio (International), 2005.

of sustainable design. We hired outside facilitators, and established a basic three-phase structure: educational seminars, working groups and specification writing. Working groups conducted research on topics ranging from water resources and indoor air quality to materials and construction administration. The groups then presented their findings, resulting in a great cross-pollination of information. Harnessing this knowledge, we turned toward the task of writing green specifications. This program was a huge commitment. While we would not hesitate to do it again, we recognize that not every firm is capable of doing the same. The good fortune is that in the four years since our educational program the professional associations, government entities and the building industry have done a fair amount of catching up. There are a tremendous number of free resources available to start anyone on a self-educational tour of sustainable design.

Many green building guidelines are available for free download (*see the sidebar at the end of this article*). These manuals will give you a general overview of the issues involved in all aspects of the built environment. Alternatively, you may want to purchase a LEED Reference Package (reading the reference guide can be a more valuable experience than attending a LEED seminar). It is of paramount importance that the structural engineer be able to articulate the basic concepts of all disciplines. The "right" green building decision will always be project specific, and is often a hybrid of general criteria; effectively negotiating the nuances without losing sight of the larger goals requires a fluency in the overarching principles.

Ultimately, producing a useful set of green specifications is the likely and worthy goal. The federal government and several states are currently developing draft outline green specs. These are certainly useful as a starting point, but they are not comprehensive. Specifications can be used as an armature on which to develop a green building literacy. We suggest that writing specifications is a great way to become more knowledgeable about the environmental issues related to structural materials and the structural issues related to greener practices. If the structural engineer does not possess an intimate understanding of the "greener" instructions that he or she is demanding, something could go wrong and this would be a setback for the entire movement. Used wisely, specifications are a real source of power. Equipped with first-rate green specifications, engineers can force the building industry to embrace more environmentally preferable practices. Specifications can be more effective than government policy in creating markets of scale for reclaimed materials, which will ultimately make the greener choice the more economical choice.

"Green" Specifications

What makes a good green spec? In our specifications, we begin by introducing the environmental issues related to the material in conversational language (*see Figure 1 for an example excerpted from a concrete specification*). We include this information to give contractors and others a greater professional and personal investment in achieving the "green" practices we are specifying. This non-technical preamble to each section is an unusual feature for a specification, and attracts considerable attention to the content.

Every specification, regardless of the material should represent a set of common themes.

Preferred materials:

- Have low embodied energy contents, or are rapidly renewable
- Have high recycled content or are salvaged
- Give off low or zero volatile organic compounds (VOCs)
- Are not associated with ozone depleting compounds (ODCs)
- Have low global warming potentials (GWPs), high GWPs are associated with gross amounts of CO_2 emissions
- Minimally impact natural habitats and water resources
- Are locally harvested, mined and manufactured

Preferred methods:

- Increase durability
- Decrease construction related emissions
- Facilitate eventual deconstruction to encourage salvaging material
- Minimize construction waste

In our steel specification we describe the environmental degradation shown in *Figure 2* and high energy cost associated with steel (even structural steel which may have a recycled content of up to 97% takes an enormous amount of energy to produce). A better alternative environmentally is to use salvaged steel. And yet, sadly, to call this a market in its infancy is — at this point — being kind. Nevertheless, it is a worthwhile goal to encourage the use of salvaged steel; therefore, in our spec we call for all connections to be bolted, unless explicitly noted otherwise. Where welding is required, we call for the best available environmental practices that minimize the gaseous heavy metal emissions associated with welding. Our resource for this information was the American Welding Society, and these recommendations are generally cost neutral.

Almost all the green strategies in our cast-in-place concrete spec are cost neutral or cost benefits (*Figure 3*). To maximize the use of material reclaimed from the waste stream, we call for a minimum of 30% of the Portland cement to be replaced with fly ash or slag. Given the abundance of case studies showing the good performance of these supplementary cementitious materials (SCMs), this is a relatively conservative instruction and we in fact do not yet see a need to specify a maximum.

[Bouzoubaâ, N.; Fournier, B., *Current Situatution of SCMs in Canada*. Report prepared for the Materials Technology Laboratory, Ontario, 2004

Helena Meryman and Robert Silman, "Sustainable Engineering – Using Specifications to Make it Happen," *Structural Engineering International* 14, No. 3, (August 2004): 216 – 219.]

It is well known that SCM concrete can have slower setting times yet boasts higher ultimate strengths and improved durability. Limiting the amount of Portland cement used is a high priority because its production is responsible for 6% of global CO_2 emissions.

"Green" Conclusions

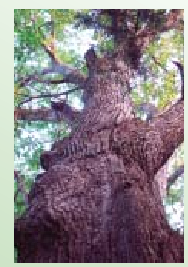
These are just a few examples of the scores of issues and strategies that are manifest in green specification. The source and treatment of nearly every product related to the main construction material can be addressed, and a better solution sought. When the structural engineer is asked, "How were you involved in the green building process?" – hopefully you will be able to respond: "I reduced global warming by limiting CO_2 emissions, I protected the ground water and public health be using non-toxic wood treatments, I saved natural habitats using FSC certified and salvaged wood, I relieved the landfills and reduced air pollution by using recycled concrete aggregates in structural concrete…"▪

Helena Meryman is a Project Manager and LEED® Accredited Professional at Robert Silman Associates, located in New York City. She can be reached via e-mail at ***maryman@rsapc.com***

ENVIRONMENTALLY PREFERABLE MATERIALS & PRODUCTS	COST			
	BENEFIT	NEUTRAL	MINOR PREMIUM	MAJOR PREMIUM
FLY ASH	X	X		
SLAG	X	X		
SILCA FUME				X
RECYCLED AGGREGATE	X	X		
AD MIXTURES	X	X		
CURING & SEALING COMPOUNDS		X	X	
FORM RELEASE			X	
CERTIFIED WOOD (FORM WORK)				X

Figure 3: Matrix used to mainstream cost neutral "green" strategies into a standard concrete specification

Web resources for green building guidelines and draft outline specifications:



The Whole Building Design Guide (WBDG), is the result of a public/private partnership:
http://www.wbdg.org/design/greenspec.php

California Integrated Waste Management Board (CIWMB):
http://www.ciwmb.ca.gov/GreenBuilding/Specs/ - building
http://www.ciwmb.ca.gov/GreenBuilding/Design/Guidelines.htm

The New York City Department of Design and Construction (DDC), Office of Sustainable Design:
http://www.nyc.gov/html/ddc/html/ddcgreen/

The State of Minnesota Sustainable Building Guidelines (MSBG), Center for Sustainable Building Research (CSBR):
http://www.csbr.umn.edu/B3/ ▪