Sustainable Development and Green Design—Who Is Leading the Green Initiative?

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Introduction

Civil engineers can contribute solutions to sustainable development and green design issues. Commitment to this challenge requires that civil engineers acknowledge their professional obligation, extend their knowledge base, and participate in all levels of policy decisions. As primary players in the design of many essential systems, some civil engineers may not be adequately responding to these challenges.

Although the task is large and interdisciplinary, the civil engineering profession has an undeniable responsibility, which could lead toward personal and professional accomplishments. Even when civil engineers accept the ethics of sustainability and green design limitations imposed by policy, owners, and key stakeholders still exist. Informed civil engineers have a professional obligation to broaden the understanding of policymakers, owners, and key stakeholders, who may in turn demand sustainable design.

After defining and contextualizing sustainability and civil engineering, the discussion is developed in the following manner:

Problem Statement. Are civil engineers committed to, engaged in, and leading sustainability efforts? Although some civil engineers are responding to creating and implementing sustainable projects, most civil engineers do not incorporate sustainable principles into projects. Many civil engineers are not responding to the commitment to foster and create a more sustainable local and global community, as evidenced by a survey conducted by the National Society of Professional Engineers (NSPE 2002).

Justifications. Several reasons explain why sustainability in civil engineering is not more central, including the Code of Ethics of the American Society of Civil Engineers (ASCE) and examination of civil engineer skill sets, including interdisciplinary approaches, problem solving, and quantification techniques.

Suggested Solutions. Suggested solutions include improving the role of civil engineers in sustainability by developing a new approach to civil engineering education; fostering the importance of and identification with leadership and role models; promoting a shift in federal and local policy; and educating the public, especially developers, landowners, and public officials.

Sustainable Development and Civil Engineering

Almost every article on sustainability begins with a definition of *sustainable development*. Authors typically do not begin papers about structural engineering by asking what structural engineering is. People generally understand what structural engineering is. This discussion uses the definition of sustainable development established in ASCE Policy Statement 418, "sustainable development is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development" (ASCE 2001). The same policy statement further states that civil engineers will "have a significant role in planning, designing, building and maintaining a sustainable future. Engineers provide the bridge between science and technology. In this role, engineers must participate in interdisciplinary teams with ecologists, economists, sociologists and professionals from other disciplines, in applying technology to issues and challenges that require environmentally sustainable strategies and solutions" (ASCE 2001).

Throughout history, civil engineers have fundamentally changed the development of society. Over time, civil engineers have contributed to exponential improvements in the standard of living—from the Roman viaducts, to the tallest buildings, to the Hoover Dam; civil engineers have undeniably made an impact on society and the Earth. However, this progress helped to create other problems of the twentieth and twenty-first centuries: poor land use that promotes urban sprawl; industrial processes that contribute to extensive energy use and pollution; and damming or diverting natural waterways that threaten biodiversity and ecosystems. In the twentieth century, there was a realization of the limits to the conventional approach to growth. Civil engineers need to determine our role and responsibility for the future and will need to do more with fewer resources, less energy consumption, and minimal waste generation.

Civil engineers have dealt with society's challenges and overcome hurdles in the past. Sustainable development is another challenge that civil engineers have an opportunity to address. Wright (1996) states, "The engineers' role is to be the manager of sustainability—to see that technological applications incorporate sustainable development concepts."

Problem Statement

Central to this discussion is the question: Are civil engineers committed to and engaged in sustainability efforts? According to an

Engineering Times survey conducted by NSPE, design professionals believe they are not as involved in sustainable design as they should be (NSPE 2002). This survey is justification of the general perception that sustainability efforts are not spanning the civil engineering discipline. One counterexample that should be noted is that ASCE and NSPE attempted to promote sustainable development by signing a statement at the World Summit on Sustainable Development in Johannesburg, South Africa. ASCE and NSPE have both made an effort in terms of codes, publications, and statements; however, these attempts are not sufficient, since they are not reaching practicing civil engineers.

Justifications: Potential Reasons for Sustainability Efforts in Civil Engineering

ASCE and the Code of Ethics

Perhaps several reasons explain why sustainability is often a minor consideration in civil engineering. Specifically, some reasons include ASCE's Code and engineer's existing skills sets. In ASCE, several measures were pursued, including a change in the professional ethics code and development of a new publication addressing sustainability.

Although ASCE's revision to the *Code of Ethics* regarding sustainable development was a positive step, there was some sentiment that ASCE "changed the *Code of Ethics* to enhance its public image and not to affect a meaningful change in the actions of civil engineers" (Vesilind and Gunn 1998). The authors do not believe that ASCE's true intent was purely public relations; however, it is worthwhile to briefly examine ASCE's position on the environment and the revised *Code*.

Vesilind and Gunn (1998) argue that the issue of environmental engineering has been a "controversial aspect of engineering." This idea is echoed in ASCE's revision of the *Code*. Originally, a proposal in the mid-1980s would have implemented an eighth fundamental canon to the *Code*. It would have required engineers to protect "the world's resources and the natural and cultured environment for the benefit of present and future generations (ASCE 1984)." This canon was not accepted because the Professional Activities Committee believed that environmental concerns were already covered in a policy statement. The eighth canon was never adopted; instead, the first canon and guideline was amended to read:

> 1. Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.

Paragraph 1f states

> If Engineers should be committed to improving the environment by adherence to the principles of sustainable development so as to enhance the quality of life of the general public (ASCE 1996).

Despite the change in the first Canon, the *Code* provides professional engineers with minimal guidance on sustainability. The difference in the word choice from "shall" and "should" is significant. Although the first Canon requires a "paramount" commitment, the guideline does not provide a solid foundation to support the commitment (Vesilind and Gunn 1998). Perhaps an indication that ASCE recognized the need for clarifying its position on sustainability was the release of ASCE's Publication 418 ASCE (2001), which further delineates the position on sustainability.

Civil Engineer's Skills Set

Civil engineers have acquired many skills through education and experience. Implementing sustainability into projects requires learning and applying new skills. Three areas that may be contributing to the low level of effort in sustainability are interdisciplinary experiences, reasoning techniques, and quantification applications.

Interdisciplinary Experiences

McIsaac and Morey (1998) have developed a table that represents "the predominant goals, values, and practices of the [civil engineering] profession in the United States." One goal is "Team, community, and social development," a key component of sustainability and green design (McIsaac and Morey 1998, Table 1). It is important for civil engineers to develop a strong educational base of biological and social sciences, since this base will allow civil engineers to actively and competently interact with other engineers and scientists. Although the civil engineering profession will be one of many professions involved in contributing to sustainability, civil engineers should not be expected to be expert in areas of expertise in other professions. Civil engineers will need to generally understand sustainable topics and work with other scientists and designers to develop desired sustainable outcomes. The ability to work well with team members is a critical element.

Reasoning Techniques and Quantification of Sustainability

In general, there are two approaches to solving scientific problems—the deductive approach and the inductive approach. Over the past 100 years, civil engineers have mainly followed deductive reasoning. This approach is used because it follows systematic logic: one determines a problem, lists assumptions, and then proceeds toward a result or a solution.

The inductive approach, which "depends on creative insight into observed phenomena," may be more applicable to creating new solutions or analysis methods related to sustainable design (McIsaac and Morey 1998). Two Nobel laureates, Barbara McClintock (genetics) and Albert Einstein, used inductive and collaborative approaches in their scientific research. Furthermore, both researchers stressed the need for a connection to living ecosystems. Encouraging this connection helps develop a comprehensive understanding of the global community.

Many engineers are comfortable with deductive approaches, which will help in quantifying the results of sustainable and green design. In a sense, one can think of both approaches, deductive and inductive logic, as a cycle. Civil engineers can use the inductive approach to grasp the problems and solutions and then employ the deductive approach to determine a method to quantify and evaluate the results.

An example of this approach was developed by the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) green building rating system. This rating system is a collaborative effort to first understand and address environmental issues in building design (inductive) and then attempt to quantify the results of the achievement (deductive). The LEED rating system does have problems with quantification, but the system is an evolving process (Scheuer and Keoleian 2002).

Solutions

After suggesting possible reasons that sustainability is not more prevalent in civil engineering, the discussion shifts toward ideas related to enhancing sustainability's visibility, specifically, education, leadership, and federal and local policy.

Education

Educating future engineers can have the greatest positive impact on sustainability and green design. The introduction of green design concepts into civil engineering programs is necessary to help civil engineers understand and practice sustainable and green design and is also crucial for enabling civil engineers to educate the public on these issues. Engineering curricula can incorporate specific courses and supplement or modify traditional engineering courses with sustainable practices, and the courses can be both quantitative and qualitative in nature. Suggesting changes to engineering curricula requires an understanding between ASCE and the Accreditation Board of Engineering and Technology. (ABET).

If students emerge from universities with a knowledge of green design, they will enter the workforce informed about green design. In engineering design courses, the students could learn how the LEED rating system works and how, as civil engineers, they can specifically incorporate sustainable and green design. For example, civil engineering students could learn about reducing site disturbance, reducing heat islands, and designing an effective storm water management plan, all of which are potential credits in the current LEED rating system. Implementation of green concepts is important not only in design engineering courses but also in construction management courses. Green-oriented construction management can augment current syllabi by teaching the students about topics like green material specifications and such construction site practices as construction waste recycling programs and implementation of erosion and sedimentation control programs. Course modules can be introduced so students have general knowledge on these subjects. Universities with a construction management focus area are recognizing this need because it has become "more apparent that construction companies and personnel can have major impact on the environment through waste management techniques, design-build contributions and through the practices and philosophies of their companies" (Tinker and Burt 2003). As the students from construction management programs enter the industry, the general contractors who employ these graduates will benefit from the graduates' knowledge about sustainability.

The USGBC's membership from 2001 to 2003 increased from 250 to 4,000 members, and construction industry membership tripled from 2002 to 2003 (Tinker and Burt 2003; USGBC 2003). The major leading contractors in the country have committed to green design and construction. For example, the CEO of Turner Construction has reported that "Turner is enthusiastically seeking new green opportunities, expanding our range of services, and investing in our staff to ensure the success of our green building projects" (Leppert 2002).

ASCE and universities play a key role in educating new civil engineers. If ASCE emphasizes sustainable and green design principles through its role in ABET, then accredited programs will need to follow its lead. Independent of ASCE and ABET, universities have their own opportunities to shape civil engineers, who can help educate the public on sustainability and green design. One of the key components in educating the public will be leadership.

Importance of Leaders

Civil engineers do not typically have role models within their professions. If one randomly asked the general public for an example of a famous civil engineer, most people would probably not be able to name one. However, most people know of a famous architect (I.M. Pei), astronaut (Neil Armstrong), scientist (Albert Einstein), and author (Charles Dickens). Generally, the public is able to name famous civil engineering achievements like the Hoover Dam, the Golden Gate Bridge, and the Sears Tower. But why is it that civil engineers are not associated with these achievements? One argument is that many engineers contribute to any one project; another is that civil engineers may have a certain level of humility. However, if one accepts the ethic and importance of the civil engineer's role in sustainability, then one must determine the qualities required for civil engineers to emerge as leaders in the latest challenge of sustainability. Besides quantitative talent, one major quality is leadership, and one way to learn how to lead is to have figurative leaders.

From an educational standpoint, leadership can be taught, developed, and encouraged. Students need academic, professional, and private practice role models. "Professors [can] introduce students to the mythologies, heroes, heroines, and values of the profession. However, professors cannot and should not invent this culture out of thin air. They need to develop this with support and collaboration from the leaders of the profession in private practice" (McIsaac and Morey 1998). Role models are especially important for engineers making their first foray into practice, because they first establish attitudes about the profession at that time. Role models, mentors, and leaders can help shape future engineers and their perceptions regarding sustainable and green design.

Federal and Local Design and Policy Issues

Several factions can influence the application of sustainable design, including the federal government, regional efforts, and private developers. In terms of United States policy, the federal government has the greatest potential impact on sustainability. The United States General Services Administration (GSA) considers itself the landlord for the federal government. It manages more than 330 million ft^2 of workspace and owns more than 1,600 government-owned buildings. The GSA's Public Buildings Service (PBS) manages the multibillion-dollar building program that is responsible for "construction, renovation, alteration, and repair [of] federal office buildings. . . . Most of PBS's work is in partnership with architect/engineer (A/E) groups from the private sector" (USGSA 2004).

The most influential effect of the GSA in terms of sustainable development and green design is its decree that beginning in fiscal year 2003, all new GSA buildings must meet the criteria for LEED certified status. The GSA has taken a positive step toward promoting green design and a sustainability ethics. However, in light of the recent shift in national security concerns, some design parameters may change, such as design guidelines for federal buildings with respect to property setbacks, external security measures, HVAC systems, and the amount of glazing.

The federal government has a top-down approach to implementing green design; Portland, Oregon, is one example of a city that incorporates both top-down policies and grassroots efforts. Pittsburgh, Pennsylvania, has taken a different approach by creating a solid green community with initial and continued support from strong local foundations. Portland has made considerable

strides in policy, building codes, and tax incentives. Portland implemented its policies and programs because the citizens made it a priority. Portland focused some effort on managing population growth. In the 1990s the Portland region, consisting of four counties, added 376,000 new residents, with a population increase from 1.4 to 1.8 million. This growth rate was double the total U.S. rate and faster than the Third World megacities of Cairo, Egypt; Bombay, India; and Beijing, China. Despite this population growth, the Northwest Environment Watch found that Portland's growth management was able to restrain urban sprawl, reduce the loss of rural land, and improve transportation alternatives (Northwest Environment Watch 2002).

For commercial buildings, Portland offers a sustainable building tax credit, which is based on the level of LEED certification obtained. The size of the building and level of LEED certification dictate the amount of the tax credit. For example, a 100,000 gsf building with a silver rating would receive a $200,000 tax credit; a gold rating receives a $286,000 tax credit; and a platinum rating receives a $571,000 tax credit. The city of Portland also offers a business energy tax credit (BETC) that provides "a 35 percent, five-year tax credit or a 28 percent cash 'pass through' option through your service utility or lender" (Portland 2004).

Perhaps the most significant contribution Portland has made with respect to sustainability is the implementation of green policy. In 2001, the City of Portland required all city facilities to be LEED-certified. Because the current version of LEED does not address all building types, the city of Portland was the first city in the country to develop its own localized version of LEED. The city realized, at the time, that LEED did not address all building types. Therefore Portland's version was designed to include a "variety of tools targeted at specific building types including tenant improvements (T/I) and operations and maintenance practices when they become available. Portland is only one example with many more cities following suit.

Pittsburgh is a city that has strong foundations and nonprofit organizations. For example, the Heinz Foundation has been critically supportive in pushing the city toward the green design movement. The Heinz Foundation's vision and commitment has promoted activities that have put Pittsburgh into the green-design spotlight. The Pittsburgh-based Green Building Alliance has promoted and fostered Pittsburgh's green building. Local designers, contractors, and developers have developed sustainable awareness. With the current condition and image crisis that Pittsburgh is experiencing (the city has a budget crisis and is commonly perceived to be a steel mill town), the green movement has the opportunity to positively affect the city not only from a sustainability perspective but also from a marketing perspective. Some key developers, with sustainable visions, are taking green design both seriously and cautiously. All types of developers—private, universities, and public agencies—are contributing. All stakeholders need to be educated about the benefits of green design and sustainable development. The developers and the clients will then be able to recognize the costs and actual benefits of developing a sustainable community.

Conclusion

Several key changes need to occur with civil engineers—changes to both the entire profession and to individual practicing engineers. ASCE has made several high-level efforts, but this message has not reached the practicing engineer, as indicated by the NSPE survey. ASCE's Engineers Forum on Sustainability is helping to spread information and knowledge to practicing engineers. The civil engineering curriculum should incorporate sustainability and green design courses, and these themes should be threaded through existing traditional engineering courses. Civil engineering programs should promote problem solving by using both inductive and deductive approaches, as well as a strong understanding of biological and social sciences. From the policy and community viewpoint, several federal agencies have a strong policy toward green design. In light of security concerns, the progress may be deferred; and an awareness of this trade-off should be open for public discussion and comment. Portland, Oregon, and other cities offer examples toward developing smart growth and green policies.

Creating sustainable solutions offers challenges to the profession. A strong education, mentors, and informed stakeholders will provide a necessary foundation toward a sustainable future. Because sustainability and green design span many disciplines, a discussion of these topics can be expansive. All levels of management, government, and design must contribute to the sustainable transformation of any given project. Educated civil engineers can inform developers, the public, and policymakers of the benefits and trade-offs associated with sustainable design. An educated public and policymakers, our current and future clients, will then have the knowledge to support and promote our proposed sustainable and green designs.

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