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Tomorrow's Engineer Must Run Things, Not Just Make Them Run

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Abstract: Engineers make things run, but engineers rarely run things. Today's civil engineers, though highly respected for their technical expertise and problem-solving skills, hardly ever top the public's list of leaders. And they only rank in the second tier of professions when it comes to prestige in the general public's eye, mainly because few civil engineers get involved in highly visible public positions of power—and few people have a personal civil engineer they visit regularly as they do a doctor or dentist. In the distant past, civil engineers were involved as community leaders in developing history-altering projects and modernizing the growth of American cities and counties. Today, they typically are not. This paper discusses why this is and the strengths and weaknesses of today's civil engineers in public leadership—and emphasizes their reluctance to show up as leaders beyond their own industry. It highlights the inherent attributes members of the profession possess that recommend them for such leadership and discusses why civil engineers should be pacesetters in establishing public policy and direction. It addresses three monumental global developments currently impacting the industry and makes predictions about the future practice of civil engineering. Also covered is the need to better educate tomorrow's engineers, attract more bright youngsters into the profession, and keep them in it. Finally, it presents strategies outlining how, in addition to meaningful community involvement, civil engineering leaders can strengthen the stature of the profession through greater visibility and effective public relations.

CE Database subject headings: Leadership; Public policy; Engineers; Strategic planning; Education.

Introduction

The horrific terrorist acts of September 11, 2001, will be vividly etched in history forever. The terrible memories of that shocking day will be a constant reminder of the horrifying evil suicidal terrorists can do. The date will serve as the milestone when life as we Americans—and other civilized men and women throughout the world—once knew it changed for all time. It marks when the age of gullible innocence ended. Terrorism and homicidal fanaticism, however, did not end on that date but today continue—in some areas, virtually uncontrolled—on a daily basis around the globe.

The implications of terrorism for future engineering of the world's built environment have risen to the forefront as one of the three most momentous challenges civil engineers face. Wholehearted advancement into the first part of the new millennium will be drastically impaired until global terrorism is controlled—and the troubled Middle East is settled into a more peaceful existence.

Today's world situation is similar to that of the 1950s, with the Korean War and escalation of the Cold War between the United States and the U.S.S.R. These caused Kirby et al. (1956), the authors of *Engineering in History*, to comment, "Rapid developments in our ways of life are unsettling and confusing, but only primitive societies stand still and look backward to emulate the past. A civilization worthy of its name looks and moves forward. If knowledge of man and society can be increased and if ethical principles and human values can be bettered, there is no need to view the uncertain future with dark pessimism, although constant vigilance will be necessary if progress is to be achieved. It is important for a nation of the world, as it is constituted today with its economic, political, and military rivalries, to know thoroughly its own *engineering* potential for security and welfare."

The events of September 11—and those that follow—have alerted Americans (and citizens worldwide) that ruthless fanatics and zealots will readily target innocent men, women, and children to advance their cause. This has underscored the need to design tomorrow's structures—and other infrastructure facilities—to repel terrorist actions and the like. Civil engineering of future projects and upgrading existing facilities will, increasingly, need to deal with expensive security to protect the safety of building occupants.

Sooner than later this nation's civil engineers need to step forward and become the stewards of America's infrastructure. Today's—and tomorrow's—civil engineers must do more than just make things run; they must get deeply involved in running things.

Crucial Worldwide Developments Underway

The challenges of the future concern much more than controlling terrorists and keeping warring peoples from destroying the world. As terrible as that probability is, terrorism is not the only concern. Two other global developments are impacting the world—and America's civil engineering industry. They are the world's rapidly expanding population and the fast-moving advances in computer usage and information technology (IT).

The effects of these avalanchelike developments—terrorism, demographics, and technology—will be far-reaching. And they drive home the point that this nation's best technologically trained minds and most skilled engineers must get involved with policy-

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setting decisions to deal with the technical problems inherent to each of these developments.

Ever-increasing applications of technological advancements can either hinder or advance the quality of life in both industrial-power and developing countries. Individuals with in-depth knowledge of engineering nuances should be at the table helping make the rules for applying such advancements. Too often civil engineers have been used only as a resource to solve technical difficulties—and have not lent their leadership expertise in addressing broader problems. Few leaders in the industry believe this approach provides the best solution in the long term.

As reported by Bernstein and Lemer (1996), "The nation's built assets enable many of us to enjoy unprecedentedly high living standards, but we see all around us air pollution, traffic congestion, loss of open space, and other elements of environmental degradation. With the help of expanding transportation and water supply facilities, urban 'sprawl' has consumed land even faster than population has grown." They added, "Technological innovation in design and construction can help us achieve the goal of bringing sustainable development and improved living standards to all of the world's people. But this innovation will occur only if builders, bankers, owners and operators, users and neighbors, and all of the other stakeholders in our built environment agree that it should be." Civil engineers are part of the solution, not part of the problem, and they must be at the table when key decisions are being made.

Civil Engineers Underrepresented

The need to use the talents and leadership skills of civil engineers in resolving technological issues has never been more important than today. However, civil engineers continue to be woefully underrepresented on important policy-making bodies, such as decision-making regional boards and commissions, and *in* elected offices, from local levels to the halls of Congress. For instance, today there are only two professional engineers (PEs) in the U.S. Congress—neither is a civil engineer—and less than three dozen PEs among the 6,000-plus state legislators in the United States. It has been years since the position of U.S. secretary of transportation—a seat that cries out to be held by a leader with strong civil engineering credentials—has been filled by a professional engineer. Less than 40% of the 50 state secretaries of transportation are civil engineers. And none of America's 50 governors are civil engineers, nor are any of the mayors of major cities.

Civil engineering professionals in the recent past, by and large, have not been engrossed in consequential—and high-profile—public leadership opportunities. Notable exceptions are Andrew Card, chief of staff to President George W. Bush, and Lt. Governor Bill Ratliff of Texas. Both Card and Ratliff participate in making meaningful societal decisions—many with important engineering implications—that are altering history on a daily basis. Ratliff, a long-time Texas senator before his current appointment, has often stated, "It's amazing how much government needs the problem-solving skills of engineers. And not just on technical issues. Engineering skills and logic are needed for decisions on budgeting, investment, determining future goals—even on issues like education."

"The world is run by those who show up" (Weingardt 1997). Ratliff and Card—and other publicly active civil engineering leaders like them—validate this. As Ratliff noted, "Civil engineers can greatly motivate change. All we need to do is show up."

Engineering Legends

Because of their daring and stature in the community—and maybe because of their high level of education—civil engineers of the past were often the visionaries, instigators, and leaders of great projects. Many monumental edifices would have remained idle curiosities without their input and direction. For instance, the greatest building project of the nineteenth century—America's transcontinental railroad, the first of its kind in the world at the time—would never have been completed when it was without the vision, know-how, and lobbying skills of a young civil engineer, Theodore Judah (Weingardt 2002). The driving force behind the design and completion of cutting-edge American bridges of the 1800s—the Eads and the Brooklyn—were American engineers James Eads, John, Washington, and Emily Roebling.

Roswell Mason, the first president of the Western Society of Engineers (WSE) (1869–1870), served as mayor of Chicago, as did fellow civil engineer DeWitt Cregier, the sixth president of the WSE (1883–1885). Mason, who was also a major guiding force on the board of trustees of the University of Illinois for 10 years, "organized [near the close of his term as mayor] the relief and massive rebuilding of the city as a result of the great fire of October 9, 1871" (WSE 1970).

The Panama Canal—one of the world's greatest man-made wonders—was completed successfully under the leadership of civil engineers John Stevens and George Goethals, two giants in the profession, yet they are not household names in contemporary society. Why not? And who are today's counterparts to the likes of these legends of the past? Most people don't know!

More often than not, nonengineers are in charge of many of today's massive building ventures. The person heading up the international team of designers and constructors for the $18 billion Chunnel—the monumental tunnel project under the English Channel—was not a civil engineer but an architect, Jack Lemley. [Lemley has been decorated with honors from several engineering groups, ASCE and the American Council of Engineering Companies (ACEC) included. Apparently they believe he has the qualities and talents the civil and consulting engineering communities admire in someone responsible for great civil engineering feats.]

"The past is prologue to the future," said engineering historians Kirby et al. (1956). Will any of the civil engineering leaders of the future match the accomplishments made by the giants of the past? The answer lies in the hands of today's engineers.

Action Call to Civil Engineers

The public today perceives that engineers make things run but don't run things. Many in the industry may take exception to this, but perceptions are what they are—and often perception is more accurate than reality. Even though civil engineers are highly valuable in the advancement of any civilization, few in the media or the public arena recognize them. Even so, Kirby et al. (1956) reported, "An inescapable conclusion to be drawn from the story of engineering in history is that engineering has become an increasingly powerful factor in the development of civilization." Civil engineering, the historians stressed, "does not occur in a historical vacuum without reference to other human activities," and the fundamental changes stimulated by engineering developments "accelerate the rate of historical and social revolution."

Forecasts for tomorrow's world uncover many challenges—and opportunities—that professional engineers will encounter as America and the rest of the world quickly settle into the space-age twenty-first century. It's a century that began with America at peace and now finds the country at war in a far-reaching conflict

against terrorists and their sponsors. To adequately deal with these factors, more and more civil engineering leaders will need to show up in leadership roles beyond the industry, at all levels of society.

If civil engineering leaders do reach the top of society's food chain of decision makers, the world—so dependent on civil engineering technology—will surely benefit. And civil engineers will increasingly be called upon not just to make things run, but to run things as well. The importance of engineers getting involved is underscored by Bernstein and Lemer (1996):

> The U.S. today possesses a physical infrastructure of extraordinary scale and scope. This civil infrastructure supports virtually all elements of our society, and the people and business that have produced it comprise a major segment of our economy. History indicates that the growth, flourishing and decline of any civilization are closely mirrored by the life cycle and performance of its civil infrastructure.

In the final analysis, how favorably the public perceives civil engineers—and their profession—will have a tremendous influence on how effectively engineers perform as leaders and even as technical experts. It will also influence whether civil engineers are thought of as professionals or technicians to be hired by low bid without regard to qualifications.

Public Perception Polls

Duke University professor Henry Petroski (2001a) stated:

> How any profession is perceived is very much under the control of its members and their collective surrogates, the professional societies. We should behave as we wish to be perceived. If we want to be shown the deference accorded doctors and lawyers, we should conduct ourselves accordingly. We should not want any stranger we might sit beside on an airplane or at a dinner party to express surprise that ladies and gentlemen can *also* be engineers.

Gallup Polls

In a 1945 Gallup survey, 13% of the adults polled in the United States said they would recommend engineering—either civil or electrical engineering—as a career choice for their children (and other bright youngsters); in contrast, 28% said they would recommend entering the medical profession (to be a doctor, nurse, dentist, or pharmacist); 9% said law (Gallup 1944–2001).

By 1950, in the rebuilding years after World War II, the percentage of Americans suggesting engineering (all disciplines) as a recommended profession was 16%. This figure jumped to an all time high of 20% in 1953, hovered in the mid-to-low teens until the late 1980s, then dropped like a rock. In 2001, less than 2% of Americans surveyed said they would advocate a career in engineering; 22% recommended the medical profession; 3% said law. A new category, computers, was added to the polls in the 1980s, and in 2001 18% of the respondents recommended "something in the computer field" as a preferred occupation.

In these same Gallup surveys, respondents rated the honesty and ethical standards of people engaged in engineering (all disciplines). In 2001, 60% rated engineers as "high to very high" in this category. Doctors were rated at 66% and police officers at 68%. From 1945 to the 1980s, when 12 to 20% of those surveyed were recommending engineering as a preferred occupation, only 48% (on average) ranked engineers' honesty and ethical standards as "high to very high."

Apparently today's public thinks highly of engineers and their standards but isn't as willing as in the distant past to recommend it as a profession for young people. Nor is the public clear about the different disciplines of engineering, nor do many know exactly what civil engineers actually do.

Harris Surveys

Harris surveys taken from 1977 to 2001 questioned the public about the prestige of different professions (Harris 1977–2001). In 2001, these surveys showed that 36% of American adults perceived engineering (all disciplines) as an occupation with "very great prestige." The Harris results show the public's favorable perception of engineers has ranged from a low of 30% (in 1982) to a high of 37% (in 1992) over the last two dozen years.

After an all-time high ranking in 1992, the public's favorable view of engineering dipped sharply to 32% by 1997, where it remained until 2000. Last year's 36% status—a jump of more than 10% from 2000 to 2001—still showed engineers ranking far behind doctors (a 61% rating in the most prestigious category, nearly double that of engineers), teachers (54%), and scientists (53%). Engineers also continued to rank below ministers (41%), military officers (40%), and police officers (37%). The 2001 Harris poll was taken before the horrific September 11, 2001, terrorist attacks. Most likely police officers and firefighters would have received an even higher ranking if the polling had occurred after 9/11.

In round numbers, the Harris polls indicate that only one out of three Americans currently think highly of engineers (all disciplines), while twice that many—two out of three—think highly of doctors. In addition to doctors, teachers, scientists, ministers, and military and police officers are perceived to be more prestigious than engineers.

ACEC Survey

In 2000, ACEC retained the public relations firm of Ogilvy Public Relations Worldwide to conduct studies on the public's perception of consulting engineers. Oglivy reported back to ACEC that few people outside the engineering/construction industry knew who consulting engineers—consulting civil engineers included—were and what they did (Weingardt 2001).

Additionally, Ogilvy's ACEC study asserted that nonengineers such as media reporters, newscasters, and staffers for congressional leaders (at both federal and state levels) tend to group consulting engineers with consultants in general, and that the word "consulting" is a negative with government officials. One of the most significant findings of the ACEC-sponsored studies noted that large numbers of the public that consulting civil engineers want (and need) to reach do not know what engineers do.

Though the Gallup, Harris, and ACEC surveys—except for the 1945 Gallup survey—did not isolate civil engineering as such, they indicate the public's perception of engineering is not comprehensive nor as good as it could be. They show that much can be done to improve the profession's image and the public's understanding of the industry.

The managing editor of *New Civil Engineer*, Jackie Whitelaw (2000), suggested that a professional status for civil engineers is about "gaining and maintaining the trust and respect of people" who value the work civil engineers do. She also noted the profession is now experiencing "the dawning of the age of engineers"—and that the British public today appreciates that "civil engineers can also inspire, entertain and amaze." This

"dawning" is something the mass media in the United States seem reluctant to acknowledge.

Ongoing American Public Relations Dilemmas

Public relations (PR) initiatives to enhance and increase the image, visibility, and relevance of civil engineers—and the profession of engineering—should stem from a basic desire to contribute to the betterment of society in a significant way and not merely to ballyhoo one's profession without regard to the impact one's work has on society. However, to be overly humble about one's contributions and talents—or stay isolated in ivory towers—serves no purpose.

Before any industrywide—or individual—PR effort can be truly effective, though, two deeply intertwined critical dilemmas plaguing the civil engineering profession must be resolved:

- The lack of respect for (and knowledge of) civil engineers' contributions to the built environment; and
- The public's (and the media's) failure to appreciate the significance of civil engineering accomplishments.

To resolve these two dilemmas, civil engineers should follow this advice: "Do good work and tell the world about it," not in an exaggerated or arrogant way, but truthfully and consistently—and not in violation of ASCE's code of ethics. Engineers need to take three steps to accomplish this:

- Stay technically competent;
- Be involved as leaders in society and contributors to the well-being of their communities; and
- Institute public relations programs that stress the relevance of civil engineering to everyday life and that highlight civil engineers as people (the person next door, not a faceless instigator of design or construction projects).

Civil engineers should understand that PR is about doing *all the things necessary* to let the people and/or groups they want to influence know who they are, what they do, and why they do it. Individuals and the civil engineering community should instigate PR programs that get them from behind closed doors to accomplish these objectives.

Future Education of Civil Engineers

Along with the need to solve the profession's PR dilemmas goes the requirement to improve the education of future civil engineers. ASCE's "Engineering the Future of Civil Engineering" by ASCE's Task Committee on the First Professional Degree outlined these concerns (ASCE 2001):

- The current four-year bachelor's degree is no longer adequate formal academic preparation for the practice of civil engineering at the professional level in the twenty-first century;
- Civil engineers are not being prepared to compete for leadership positions—their formal education is deficient in nontechnical knowledge and skills;
- Nonengineers are increasingly managing civil engineers, principally because they possess stronger leadership, communication, and business skills;
- Regardless of experience level, civil engineering salaries generally fall below those of other engineering professions; and
- By retaining the 200-year-old, 4-year basic education model, civil engineering has fallen behind accounting, architecture, dentistry, law, medicine, pharmacy, and veterinary medicine.

As stated by Norm Augustine, former head of aerospace giant Lockheed Martin, "One needs more training to give my neighbor's basset hound a vaccination than one needs to design a structure upon which the safety of thousands of people depends" (Weingardt 2000a).

In addition to calling the current American educational requirements for civil engineers lacking, the ASCE Task Committee compared American engineering education to others and reported, "The European educational system requires formal education beyond a baccalaureate degree as a condition for entering."

The Task Committee further reported that, "though maintaining the present civil engineering education model may meet the short-term needs of employers, its narrow focus does not serve the long-term interests of the public, employers and individual civil engineers." Stressing the implications, Walesh (2000) reported that in the future, principals of engineering firms and senior managers of government entities "will continue to complain about the inadequacies of entry-level and experienced civil engineers." The ASCE Task Committee summarized these inadequacies as:

- Poor communication skills;
- Inability to manage projects profitably;
- Lack of marketing interest and/or skill;
- Getting bogged down in technical matters;
- Failure to meet client expectations;
- Lack of visibility in the community;
- Inability to understand global context;
- Having little business sense.

The concern over the narrow focus of a civil engineer's education and training has been with the industry for more than 25 years. As expressed by past ASCE president Wallace Chadwick (1977), in *Celebrating ASCE's 125th Anniversary, Turning Points in U.S. Civil Engineering History*, "As engineering projects grow in size and complexity, men [and women] capable of expertly managing them are not being trained for such tasks. What we need is the man [or woman] who knows, not only engineering design and construction, but also client and public relations, economics, environmental considerations, finance and accounting, and particularly contracts."

Engineering as A Career

As crucial as having tomorrow's civil engineers properly educated is getting enough bright young people interested in engineering as a career in the first place. Many of today's industry leaders in both design and construction cite this as their main concern. To increase the credibility and maintain the lifeblood of the American civil engineering industry, substantial numbers of intelligent, U.S.-born youngsters need to be recruited into the field.

Attracting sharp young men and women today requires creating a much grander awareness of civil engineering than before—an awareness that vividly captures the imagination of those top students who believe they can become anything they want. Today's aspiring professionals want careers that have meaning and relate to the world around them—ones that will allow them to make a difference. In addition, they want role models—heroes and heroines—to look up to in the profession of their choice.

The civil engineering community needs to better celebrate its outstanding members—its stars—and highlight civil engineering accomplishments in ways that the average person as well as talented young people understand. The civil engineering community can benefit from studying successes in professions such as sci-

ence, medicine, and architecture. As proposed by Weingardt (2000b) in a white paper, "Step Forward and Be Heard," for MIT's CEE New Millennium Colloquium, "Unlike architects who publish and widely distribute beautiful coffee-table books about architecture and star architects, civil engineers have hardly any such publications about their stars and notable projects. If our best and brightest young people want to find out about the heroes and heroines in the field, there are few places for them to look. We need more coffee-table books written *not* for engineers but *for* the non-engineer public, in a style they can relate to."

Additionally, individual civil engineers themselves must do everything possible—including being public figures—to assure would-be engineers that:

- There are heroes—and superstars—in the civil engineering industry;
- Civil engineering leaders are involved in shaping the nation's future; and
- Civil engineering is relevant to everyday events, the economy, and America's standard of living.

Demographics

Of the three major developments—world terrorism, runaway population growth, and increased reliance on computers and IT—demographics is having the most conspicuous impact on the practice of civil engineering in the United States and around the world.

The United States is in the midst of one of the most far-reaching changes in its history, comparable to the twentieth century's shift from agriculture to industry. Changing demographics are bringing about this momentous transformation, at a time when world commerce is becoming increasingly dependent on computer and information technology. The latter now allows ready access to different—and cheaper—labor markets around the globe and will continue to do so.

Demographically, members of the U.S. civil engineering profession and many of its customers have almost exclusively been white, middle-aged men over the years. But 20 to 30 years from now, both the design/construction industry's clients and its workforce will be very different.

Today's "minorities"—African-Americans, Asians, Hispanics, Native Americans, and so on—will make up the majority by 2060. "The U.S. engineering industry has not yet come to grips with this reality," according to Dorman (2000). "It [the civil engineering community] has not truly begun the internal transformation required to properly reflect this fact nor to adequately service the clients of the future. The need to do this, and to do it now, is urgent."

The predicted worldwide demographic changes, particularly in the first half of the twenty-first century, will dramatically alter the makeup of American engineering companies, governmental and educational entities, and their employment and customer base.

Population Growth

In 1991, the United Nations (UN) predicted the world's population would have grown 100% to 12 billion by the year 2100 (Snyder 2000). In 1999, the UN reduced this number by 40%, changing its projected growth from 100 to 60%. That means that, instead of the world's population doubling by the end of the twenty-first century, it would *only* grow by 60% to nearly 10 billion people (still a staggering number). This gradually slowing population growth will start flattening out by the year 2060, and the population will stabilize at 10 billion around 2170.

International consulting futurist David Snyder (2000) believes the UN's reduced estimate of population growth rate was largely due to "the consequences of worldwide economic expansion and increasing prosperity in the majority of nations." The UN forecasts that more than 95% of the world's population growth will take place in developing countries. Europe, Russia, and Japan are expected to lose population. The United States is the only major industrial country in which large population increases are projected, mainly through immigration and higher-than-average birth rates among new immigrants.

Global Economic Growth

The current rapid growth of the global economy can largely be attributed to the efficiency of "frictionless transactions" made possible by IT and the Internet, and to new markets made available by free trade. Many futurists (Edwards and Snyder 1997) expect that "among the regional economic blocks around the world, NAFTA [North Atlantic Free Trade Agreement] will shoot past Europe to become the largest and most prosperous one by 2005—and will remain so throughout the 21st century."

One of the main reasons for North America's predicted economic dominance is tied to its population; North America's population will grow faster than that of all other continents except Africa during the next century. The North American population, including the United States, is expected to more than double by the twenty-second century.

"While policy makers in Europe and Japan are contemplating a century of labor shortfalls and increasing ratios of dependent-to-wage-earner, the U.S. will soon confront—as it has in the recent past—a temporary labor shortage that is the direct consequence of the low birth rate of the 1970s and early 1980s," reported Snyder (Weingardt 2001); "The combination of robust economic growth and a shrinking entry-level labor pool has indeed served to 'lift (almost) all the boats' in the U.S.; minority employment is at all-time highs and minority income at all-time highs, as is average income for women."

Older Workers

The average retirement age in the United States has been rising since the late 1980s, and the over-65 portion of the nation's workforce is expected to increase from 12 to 15% within the next 5 years. Snyder (Weingardt 2001) reported, "Human resources experts, however, point out that, while many seniors enjoy working and wish to remain productively employed, they often retire from their career employer because they are unhappy with their management or workplace environment, or they have encountered active age discrimination on the job."

School-Aged Children

The upward population growth in the United States is putting a major strain on our schools, which is one of the main reasons the 2001 ASCE infrastructure report card (ASCE 2002b) gave this nation's schools its lowest grade (a D−). The problem isn't just that school buildings and other facilities are inadequate and/or in poor repair; schools are clearly getting more and more overcrowded. The U.S. Department of Education reports that America's student enrollments are setting growth records and will continue to do so throughout the twenty-first century.

Upgrading and adding educational facilities—as well as building more elder-care facilities to serve the needs of increasing numbers of people living longer—will require extensive engineering and architectural services. How much of the required design and related work for modernizing America's educational system will be led by U.S.-based civil engineering companies or agencies will depend on how well civil engineers position themselves as pace setters and innovators in the near future.

Changes in Minority Status

The racial/ethnic/cultural enrichment of the United States over the past 20 years has set the stage for a transformation of American society in the century ahead. Snyder (2000) reported the following statistics: Hispanic-American immigration rates remain high, and their birthrates are 50% higher than those of all other ethnicities in the United States. Because of this, Hispanics will become the largest U.S. minority by 2010, rising to 17.6% of all Americans by 2025 and 34% by 2100. White non-Hispanics will constitute 40% of the U.S. population by 2100, while Asians will represent 13%, as will African-Americans.

By 2025–2030, over one-third of U.S. citizens will be of non-European descent, and by 2055 the percentage will be 50%. Because the United States will continue to become an increasingly diverse polyculture, all industries, trades, and professions will have to actively pursue cultural diversity in their recruitment, education, career development, and retention programs.

Changing Labor Practices in North America

Futurists predict that temporary but major labor shortages will occur over the first part of the twenty-first century (Edwards and Snyder 1997). To meet the staffing required by the future's infrastructure-driven, booming economy, employers of all types of human resources—from doctors, accountants, and engineers to construction workers, retail clerks, and general laborers—will find it necessary to employ older workers several years beyond typical retirement age.

Many employers are rapidly adopting "phased" retirement programs that allow senior personnel to retire gradually or get rehired after retirement. This situation, especially in the near future, could be magnified should the world find itself more deeply embroiled in an escalating war against terrorism and governments fostering the causes of terrorists.

Women in the Workplace

The number of women in the workplace will continue to increase and be a major factor in employment practices, especially in the United States, where three-quarters of working women now have school-aged children. In one-third of all two-income households, the woman is the principal wage earner in the family.

Currently both women and minorities are greatly underrepresented in the engineering professions. Because of the evolving demographics in this country, the makeup of civil engineering firms and groups will need to reflect the available workforce. Therefore the civil engineering industry must become aggressive in promoting women and minorities into its ranks.

With the increase in elderly and child-rearing-age women employees comes a stronger need for workplaces to be more family friendly than ever before. Supporters of family-friendly work environments not only suggest they promote greater productivity and make for better employer-employee relationships, but they will be extremely important in retaining workers in the future. Yet in spite of an increasing desire of workers for more family-friendly workplaces—and in spite of the projected tight labor market—most American employers have done little to accommodate their employees' growing sense of family obligation.

Impact of IT on U.S. Labor

Modern computer and communications technologies have allowed ready access to markets almost anywhere on the globe and spawned concern among U.S. engineers. They fear an overabundance of cheap labor—engineers and technicians working for considerably lower wages than Americans. At stake will be wholesale loss of American jobs to non-U.S. citizens.

In addition, the recent U.S. H1-b visa legislation increasing the numbers of "temporary" visas for foreigner workers has flooded the U.S. market in fields like software engineering. Because of H1-b, many electrical-computer-software-type engineers and technicians, in particular older workers, have lost their jobs, replaced by lower-salaried foreigners in the country on temporary visas. (Horror stories of the situation inundate the Internet on a daily basis.)

At the moment, U.S. civil engineering professionals remain aloof about H1-b implications. They also seem unconcerned about losing jobs to low-salaried, temporary non-U.S. citizens. (Some suggest it is not apathy but rather a feeling of powerlessness about the situation that is keeping civil engineers from taking action.) In any case, as reported by Weingardt (2000c) in "The Handwriting is on the Wall," what has happened to structural engineers in Germany is now transpiring in this country: much routine civil engineering and drafting work is being shipped out of the country, just like the German structural model. This trend—already a common practice with some of America's larger and more aggressive companies—will skyrocket in the coming years. Much of this country's less-challenging civil engineering work will be assumed by those beyond the boundaries of this country at substantially less cost.

Infrastructure

Infrastructure replacement and/or renewal may likely constitute the bulk of civil engineering work for American companies of tomorrow. The doubling of the U.S. population during the twenty-first century will require building an entire additional America within increasingly stringent environmental and land-use constraints. According to Bernstein and Lemer (1996), "The nation's buildings and physical infrastructure are valuable assets, estimated at some $20 trillion, and are a legacy left us by past generations." Doubling that number for a total asset of $40 trillion in national infrastructure facilities would be awesome. And accomplishing this, along with renewing the existing infrastructure, will pose a substantial civil engineering challenge, politically, financially, and technically.

Even today, many say the engineering and construction industry is at the heart of the U.S. economy. According to Bernstein and Lemer (1996), "The various enterprises involved in design, new construction, renovation and other construction-related activities, including equipment and materials manufacturing and supply, employ over 10 million people and account for roughly 13 percent of the nation's [current] economic activity, as measured by our gross domestic product (GDP). Taken as a whole, design and construction comprises the nation's largest manufacturing activity!"

ASCE Report Card for America's Infrastructure

The recent ASCE infrastructure report card (ASCE 2002b) gave the United States a dismal grade of D+ overall. This reflects a poor record and accentuates the need for comprehensive civil engineering solutions—a need that will escalate exponentially in America alone. (The 12 infrastructure categories reviewed in the report card were roads, bridges, transit, aviation, schools, drinking water, wastewater, dams, solid waste, hazardous waste, navigable waterways, and energy. These not only represent significant areas of work for civil engineers, but also areas of expertise for which they should be providing policy input and leadership.)

The nation's infrastructure systems have deteriorated from a grade of C in 1988, when the first national infrastructure report card was completed by a special commission appointed by the elder President Bush. That fact hardly endorses past public policy decisions as being optimum, but it does emphasize that more and more civil engineers must get involved in setting public priorities and direction.

International Markets

Not only will the American civil engineering industry feel the impact of this nation's future infrastructure needs, so will the international marketplace. As pointed out by Bernstein (2000):

> Forecasts of the future of the design and construction industry show a major shift in the future location of infrastructure projects over the next twenty years. In 1990, approximately two-thirds of infrastructure construction projects were located in industrialized countries; it is now estimated that by 2020, two-thirds of infrastructure will occur in developing countries.

If American civil engineers are to lead, according to Bernstein (2000), "We need to be positioned to understand the needs and requirements of working in developing countries, and better understand the policies on energy and sustainability in those countries, since they strongly influence construction-related issues."

U.S. Government: Friend or Foe?

Two recent propositions in California dealt with standing and proposed legislation and regulations restricting and/or curtailing the use of private-sector engineering and architectural services. Their wording emphasized that different goals often motivate those in the public versus the private sectors. The California case revealed a potentially ongoing conflict between public and private sectors and between union and nonunion engineering factions. In the mid-1990s, government ordinances similar to those recently voted on in California—in favor of the private sector, nonunion faction—were also proposed in other states, most notably in Massachusetts.

The concerns of private-sector engineering businesses about the unchecked power of certain government and special-interest groups were summarized in Bernstein (2000):

> Construction [and design] seems certain to continue its loss of control to government, environmental concerns, consumerism, the [impending] energy crisis, need for land-use policies, national growth policies and the whole matter of priorities. They will make construction [and design] ever more subservient to government—or in a democracy, to the will of the people.

More California-type legislation instigated by government union groups—as well as more government competition for private-sector work—will continue to surface. All-out competition, a prime force for change in both the civil engineering and construction industries, will not likely lessen, and private engineering businesses will have to continue dealing with competition from government and quasi-governmental bodies as a way of life. How successful future antiprivate business initiatives will be depends on how strongly America's private-sector civil engineering community positions itself, both from a leadership and a public image perspective. Consulting civil engineers have great potential to be perceived as part of the solution—not as part of the problem. The burden to make sure they are so viewed falls directly on the leaders in the engineering business community.

Government today has a direct impact on all publicly funded construction. In the future, it will have an even greater say in what and where private investors build. Private-sector civil engineers' responsibilities seem obvious. That is, the leaders in the fields of consulting engineering—design and construction—must participate in the formation of public policies and laws that regulate their activities. Likewise, preserving qualifications-based selection (QBS) procedures and legislation for selecting engineers and architects (E/As) for government projects—not for the benefit of E/As but because using QBS methods results in better undertakings at all levels—will require steadfast guidance from all leaders in the profession, from both the private and public sectors.

Unionization Efforts in the Private Sector

"An organizing drive by an operating engineers' local union aimed at engineering technicians is shooting off sparks in the Chicago area," began a May 2002 cover story in *Engineering News Record* (*ENR*) (Rubin et al. 2002). The incident is not isolated. Indications are that unions, much like they did in the 1960s, are targeting engineering firms—specifically those involved with construction—in efforts to expand union membership nationwide.

How far these efforts will go is currently not clear. That they will impact large numbers of consulting civil engineering firms, however, is not. "The owners of two major apartment projects have dropped an engineering firm whose workers rejected union membership ... and managers have reduced the role of an engineering firm whose workers have been targeted by Union Local 150," reported *ENR* (Rubin et al. 2002). The president of STS, one of the engineering firms caught in the middle of the fracas, claimed that his firm was caught unprepared. "We were novices in all this," he said. That will have to change.

Indications are that the current efforts by organized labor could reach epidemic portions in the coming months. Whether pro- or antiunion, private-sector engineering leaders will need to aggressively deal with the situation to ensure that the public's health, wealth, and safety are best served.

Sustainable Development

Given the current problems associated with a swelling global population—including urban sprawl, energy shortages, increasing clean water deficiencies, and air and surface transportation problems, as well as the crumbling infrastructure of many nations—sustainable development will be a major engineering issue. Sustainability will be a significant driver—if not explicitly, certainly in concept—for most engineering projects designed for the built environment. As summed up by Bernstein (2000), civil engineers will have to focus on balancing economic, environmental, and social benefits when designing their projects.

Henry Hatch, former head of the U.S. Army Corps of Engineers and a leading proponent of sustainable development practices globally, stated, "Though viewed by some in the early 1990s as a passing fad, the notion and goals of sustainability are clearly here to stay" (Weingardt 2001).

Hatch added:

> Whatever you call it, pursuing our professions and businesses in ways that can be sustained without denying future generations their opportunities must become a bedrock principle. Today, nearly every U.S. and international professional and industry organization involved with the built environment has prominently included sustainability among its strategies, mission statements or ethics. From Presidential Executive Orders to a plethora of volunteer associations such as the rapidly growing U.S. Green Building Council, environmental, economic and social sustainability is gaining momentum as the driving set of principles for our industry in this new millennium (Weingardt 2001).

Opportunities and Imperatives

The United States model mirrors the civil engineering needs that all developed and developing countries have—and will continue to have—at an ever-increasing rate. In industrial nations, much of the infrastructure will include replacing and upgrading, while in developing nations more will be for new infrastructure. At the center of all this activity will be civil engineers serving society's need for expert, wise, cost-effective, and long-lasting engineered solutions.

How much will be provided by the private versus the public sector will depend on many things. One of the main factors is whether engineers in the private sector are perceived as being valuable problem solvers—and whether their work products are considered to be value-added services. As stated by Paul Zofnass (president of EFCG, Inc.), "Once you get away from being identified as a cost and you are considered a strategic value, that's something boards [and clients] are interested in—and is worth more" (Rubin and Powers 2001). "If we provide solutions, rather than the answers," added Bill Robertson (CEO of Roy Weston, Inc.), "we can redefine ourselves in our clients' eyes."

Snyder suggests clear "opportunities and imperatives for engineering firms" in the future (Weingardt 2001). The following six of these apply to civil engineers:

- Continued robust population growth in the United States throughout the twenty-first century will assure sustained long-term demands for civil engineering services and a sustained domestic supply of human resources to meet these demands;
- Continued robust economic growth in the United States will assure a sustained demand for sophisticated civil engineering services, plus the money to pay for them;
- America will become the world's first—and perhaps only true—polyculture, without a single dominant culture. Cultural diversity will become as American as Apple computers;
- The tight labor market will promote gender equity in the workplace, especially in fields involving professional and high-tech skills;
- The unbundling of vertically integrated U.S. industrial firms—through outsourcing administrative, off-line assembly, logistics, and in-house engineering services—will cut the proportion of lifetime career jobs in the American workplace in half over the next 10 to 20 years; and
- Rising birth rates among immigrants and older baby boomers are combining with the aging population to make boomers the "sandwich generation," simultaneously responsible for both younger and older dependent family members. As a consequence, there is a growing movement in support of a family-friendly employment environment as a central issue in career planning and labor-management relations.

Predictions: Practice of Engineering

"The business of engineering and architecture is changing from a 'practice-centered business' to a 'business-centered practice'," stated FMI's Corey Hessen (2000) in "Looking at the Road Ahead for A/E Firms."

This concept and the predictions that follow paint a picture of what civil engineering might be like in the future. As with all predictions, they should be studied and updated continually.

Around the Clock Global Services

For several years, reports have been surfacing that the world is in the era of 24-h-around-the-world design services, 7 days a week. Engineering work done over an 8 h work period in the United States, for instance, is forwarded to Asia using today's IT tools. A project is worked on there for 8 h, then forwarded (using the latest and greatest IT tools) to Europe for an 8 h work session, then sent back to the United States. Many engineering leaders believe this process results in lower costs, more productivity, and shorter deadlines.

Emerging Technologies and Engineering Trends

The civil engineering industry will continue to expand its use of emerging advanced technologies and display the following characteristics:

- Creative uses of IT, involvement in 4D, paperless design, and so on, will increase;
- Engineering entities (firms and staffs) will be fully computer literate;
- Lean permanent core staffing with significant outsourcing will prevail; and
- Specialization in smaller firms, geographically and technically, will increase.

Virtually all drawing and engineering documents will be computer generated, and standard, uncomplicated engineering designs will be offered electronically on-line. A full array of engineering services, including funding from private sources, will be available on the Internet.

Engineering agencies and companies of all sizes and disciplines involved in engineering the built environment of the future will require a comprehensive understanding of human behavior, lifestyles, and social roles. To be successful, they will also have to exhibit a sound understanding of the economic potential and impact their work and projects have on communities. Firms will likewise need to employ innovative contracting and financial strategies for their projects and companies.

Prime design civil engineering firms, in particular, will have to show a greater knowledge about environmental consequences and materials use than in the past. Life-cycle costing, extensive virtual design procedures, affordable public housing knowledge, and so forth will require them to be flexible in their design practices—and in their skills leading and managing teams composed of members with diversified interests and objectives.

Some forecast small U.S. civil engineering design firms will continue to be healthy well into the next century. Many will be-

come more specialized geographically and functionally and better able to provide superior services on request within tight time constraints. IT will allow such firms to become more productive and profitable at smaller sizes than today.

More small U.S. firms will work globally by merging with international partners on a project-by-project basis. "Mom and pop" operations will continue to spring up all over as a result of the IT evolution (or revolution) and will routinely contract specialized services, not only to large but also to small and medium-sized companies, stateside and overseas (Weingardt 2001).

A high percentage of U.S. engineering firms—large, medium, and small—will become multidisciplined, and the majority of them will increasingly participate in global work via the Internet. Because of IT, collaborations with overseas firms and universities will increase, and more geographically diverse teams will work on the same project. More partnering will occur among a wide array of firms, both foreign and domestic. Today's—and for sure, tomorrow's—global information systems will permit designs, drawings, and technology to be transferred across national boundaries instantaneously.

The Master Builder

Numerous industry leaders say civil engineering firms have the potential to become master builders. Many firms will lead in the return of the "master builder" concept: design and construction team leaders with a holistic view of projects who take on the ultimate responsibility for integrating all aspects of sustainability, resource productivity, and public and client service. They will also champion their projects through all barriers to their completion.

Plus, the focus of many engineering and construction activities will shift from just providing a product—with civil engineering regarded only as a commodity to be obtained by low price—into becoming full-service providers. "This may be the most important shift private-sector engineers can accomplish: from 'a commodity' to value," summarized Dorman (Weingardt 2001).

Civil engineering firms and their counterparts in construction will have to adopt the principle of "doing more with less" as a basis for effective business strategy. This will be done both for internal productivity and to deliver the "best bang for the buck" to the client. The aim? Providing the best overall project from a total resource productivity standpoint.

Computer-Driven Design Advancements

Design, material, and construction advances that will affect the practice of civil engineering include:

- Sophisticated sensors that detect early materials failures;
- Small implanted devices that direct materials to repair themselves;
- Earthquake detection devices that continually improve, thus providing better, more specific, and quicker warning systems than existing ones;
- Increased knowledge of advanced materials and their cost-effective use;
- Extensive and creative use of recycled materials and systems for construction projects;
- Advanced robots with intricate artificial brains capable of doing an increasing number of repetitive tasks;
- Widespread use of smoke-moisture-odor-light sensors that greatly improve public safety;
- Virtual design and 3D image-processing technology to optimize design of complex details and connections;
- Practical use of artificial intelligence to detect environmental changes on earth and in the atmosphere; and
- Advanced biotechnology leading to space-age-type innovations in environmental engineering.

Some forecast that "understanding the interaction of energy, information and infrastructure may bring about the biggest conceptual shift in urban infrastructure design in several hundred years" (Bernstein 2000).

The destruction of the World Trade Center towers by terrorists has brought forth predictions of all sorts about the future of supertall high-rises. Historian and engineering professor Henry Petroski (2001b) reported:

> Nontraditional structural material, such as ceramics, might someday provide the framework for new fire-resistant skyscrapers. And current research into nanotechnology—the manipulation of structures on the atomic scale—might in the distant future yield new materials suitable for building toward the sky. But ceramics are much more brittle than steel, more susceptible to snapping under impact, and nanotechnology is still in its infancy.

For now, Petroski suggested, "The era of the signature building may very well have ended on September 11, 2001, and America's skylines—as well as many others around the world—may remain for the next several decades as they are today."

America's Litigious Nature

One of the biggest detriments to the advancement of civil engineering innovations in the United States has been the threat of lawsuits if things don't go perfectly. Particularly troublesome has been that the civil engineering industry's standards of care are, in effect, established by trial lawyers rather than by the industry itself. Unless fair tort reform legislation is enacted in the United States, state-of-the-art advancements in American engineering will continue to be stymied.

As noted by Bernstein and Lemer (1996):

> We have observed that many U.S. design and construction firms are finding it difficult and unprofitable to be as innovative as they might like. New technologies developed by U.S. industry and academic institutions are being commercialized overseas. Our global competitors are becoming more successful, not because they are necessarily more inventive, but because they operate in a setting more conducive to spreading innovation in the marketplace.

Competition from Nonengineering Companies

In recent years, some of the most aggressive recruiters of engineering graduates on college campuses have come from the big-five accounting firms, companies like Ernst and Young (E&Y) and Arthur Anderson (of the Enron Corporate Scandal shame). They, along with recruiters from the software industry, frequently offer signing bonuses and salaries much higher than those in the engineering industry. According to Rubin and Powers (2001), they are joining glitzy management consultants in making high-profile forays into the field of design and construction—and hiring the best talent around.

Mark Smith (partner in E&Y) said his firm's construction business has grown as owners downsized and focused more on core business (Rubin and Powers 2001). E&Y provides overall project management, including the selection of engineers and contractors; it currently oversees $1 billion a year in construction work. Said Smith, "Typically, we're involved in technology-related projects that have a higher degree of risk and more project controls."

Nonengineering project management consultants—and management consulting arms of big-five-type accounting firms—have come into demand because of government, business, and institutional entities' concerns about controlling construction costs, and the need to raise large sums of money quickly. For American A/E and construction firms to compete, they have to get more skilled—and diversified—at nonengineering activities such as financing, operations, locating funding sources, and so on.

Predictions: Projects and Customers

In the future, increasing numbers of projects will require a significant use of collaboration and partnering to be successful. Civil engineers—if they want to reach the top of the food chain of decision makers—will need broader knowledge about the planning, financing, and operating of facilities.

Lining up project funding may become a major part of the civil engineer's responsibility. Design/build/operate (DBO) as well as design/build/operate/transfer (DBOT) projects will increase.

Design/Build

Design/build (DB)—long a project-delivery mainstay in certain segments of the private sector—has made major inroads with federal and state governments in recent times. This trend will likely continue to escalate. "Declarations continue to be made that, by year 2005, approximately 50 percent of all new construction will be performed via design-build" (Hessen 2000).

Many civil engineering professionals have a serious concern about the wanton use of DB, not just because design firms often have to invest substantial monies upfront and take on the additional risk, but because of a tendency to ignore QBS selection procedures. Often engineering consultants for the DB team are selected by low bid, and engineers are rarely in the decision making or upper management layer of the team. On the other hand, when DB teams are properly structured with QBS-selected engineers in key leadership roles, design/build delivery procedures have worked well and projects were completed successfully.

Mass-Produced Products and Systems

The increased availability of mass-produced modular units/components for projects may eliminate the need for some design functions. Examples of this have been around for years: prefabricated precast concrete, steel, and timber structural systems. Their use will increase, as will the widespread use of mass-produced but efficient and inexpensive products such as on-site package water purification and treatment plants.

Their usage, say many experts, will create projects with hundreds of decentralized systems rather than designing and building just one central system. Such projects, to be successful, require high-quality customer service, market management, and project management skills. Environmental solutions will likely be built into the original design of a project rather than added on later in reducing the impact of construction on its surroundings.

Specific Project Types in the Future

Civil engineering professionals, while helping shape tomorrow's world, will be very much involved in the design and renewal of infrastructure projects (as outlined in the section on ASC's infrastructure report card). Constructing, refining, and upgrading the nation's—and the world's—infrastructure systems will require massive engineering input and creative expertise.

Forks in the Road (Weingardt 1998) laid out additional project types on which civil engineers will have a major impact. They include the following:

- Public and private security systems and safeguards against terrorists and fanatics will be a major concern, and living with such will become a way of life for Americans;
- Recreational and health care needs for an aging population must be adequately thought out as well as society's ever-increasing demand for prisons, and so on. Finding lasting solutions for these must go beyond just building more new facilities;
- Exploring space and oceans will be ongoing and astonishing—and creative civil engineering solutions will be acutely needed for both;
- Mastering new technology and controlling the effects of faulty technology to prevent disasters such as Chernobyl, the Challenger, and Three Mile Island will be key challenges; and
- Environmental concerns, such as clean water and air, runaway waste issues, and global warming will require immense input from civil engineers. So will the increasing need for life-cycle engineering and costing, solutions for sustainable development, and saving the planet for future generations.

More important than knowing what types of projects the future holds, however, will be how the civil engineering industry positions itself: as experts who provide value-added services, as leaders rather than followers, and as professionals rather than technicians.

The public's perception of civil engineers will depend on three things: (1) the profession's ability to perform; (2) its willingness to be self-policing; and (3) its proactive PR efforts to convince others that civil engineers are critical to solving the problems in tomorrow's built environment.

Who Will Be the Customers?

As in the past, clients for private-sector civil engineering companies will come from a wide array of sources. For "interpro" firms—those who work mostly for other design firms, such as larger engineering firms, architects, A/Es, and so on—their core client base will change little, except they may become more global in their range of practice. Large prime designers will continue to serve public agencies and/or industrial and private-sector companies and businesses.

Plus, private-sector civil engineering consultants increasingly will work for nongovernmental organizations (NGOs), which fund their own projects and services. These NGOs include a wide range of groups, from local social service organizations to national or international environmental groups. Any financially stable group with ready funding and a passion for its cause will find resources for private-sector engineering services to build projects important to them.

In the coming decades, large companies in business, commerce, and industry will do more outsourcing. The reengineering of traditional company operations and staffing will continue, and many functions, such as in-house design and engineering, will be contracted to private sector and quasi-governmental consulting groups. Design/build delivery methods now in vogue will encourage one-stop-shopping type A/E service firms, those providing complete project services including planning, financing, design, construction, maintenance, and even operating expertise.

The increasing intrusion into the world of design and construction by accounting, financial, and management consulting firms is pushing traditional engineering firms to seek "high-end business in everything from program management to information technology consulting," according to Rubin and Powers (2001). "Engineering and construction firms are now positioning to deliver what owners want and need." This causes engineering and construction companies to actively work at influencing "decision-making at the earliest stages and highest levels of public and private-sector management."

Many large-firm engineering leaders, report Rubin and Powers (2001), basically say, "We can't just sit back and wait for the RFP to show up any more. In the old days, doing good business development and good engineering was enough. Today it is not. We must redefine ourselves in our clients' eyes, convincing them that we provide solutions rather than merely answers. Then we must go to them to do that."

Intercontinental Business Practices

IT, the Internet, and modern air travel have shrunk the world of business into a global marketplace. The meshing of foreign cultures—and intercontinental business practices, concepts, methods, activities, competition, and partnerships—will become a way of life for many more U.S. civil engineering firms than in the past.

Even locally focused firms who only practice within a small area will be exposed to international firms and/or projects. This will come either from foreign companies coming into their region or from ongoing clients doing ventures internationally (and using their U.S. engineering firms for the projects). In many cases, lasting partnerships/associations will develop between foreign and U.S. engineers after completing an international venture together.

Public Relations and Community Involvement

How U.S. civil engineers of tomorrow effectively address the trends that will greatly impact them will be influenced by how they are perceived by the public (which starts with how civil engineers perceive themselves). How successful such efforts will be essentially depends on whether civil engineers can indeed solve the two PR dilemmas—dealing with respect and appreciation (see the section on ongoing PR dilemmas)—that have plagued them for years. How well the U.S. engineering community can situate itself hinges, not just on civil engineers' technical talents, but on whether they are envisioned as societal leaders. Well-thought-out PR programs combined with the involvement of civil engineering leaders setting policy and direction in broader-based communities will benefit the profession enormously.

In addition to increasing visibility of civil engineers and creating a positive public perspective, persistent PR initiatives can be extremely valuable in the profession's quest to influence policy in both the private and public sectors. Neither PR by itself nor PR hype, however, substitute for sound reasoning and state-of-the-art engineering skills. As part of their overall PR plan, civil engineers must make sure their core message is being consistently communicated to key decision makers and community leaders. The message is that civil engineers can solve the problems of the built environment and must be included when key decisions are made. Said another way, civil engineers and engineering are not the problem; they are a vital part of the solution.

After the passage of California's Proposition 35 in 2000 (giving greater latitude to government contracting with private engineering firms), one of the activists behind its success, civil engineer John Baker, said, "Engineers are accustomed to merely being 'resources.' In the Prop 35 initiative, we initiated the movement and came across as decision makers and leaders. It's something we need to do more of to ensure that our businesses will survive successfully tomorrow" (Weingardt 2001).

Influencing Policy

The civil engineering profession's core message can be even more powerful if civil engineers partner with others as often as possible. Because the message concerning the public's perception of those responsible for designing, building, and maintaining the built environment is shared among dozens of industry and professional groups, it is imperative that civil engineering and construction groups closely collaborate with each other to be heard, understood, and believed.

Separate PR approaches in getting the message out are needed for federal, state, and local entities and for private-sector groups. For government groups, direct contacts between individual engineers and individual elected or appointed officials are extremely important, though lobbyists for engineering associations have an important role to play as well. But as stressed by civil engineer Brian Lewis, who served in both the House and Senate in the state of Washington, personal contacts are key. Said Lewis, "I listened to lobbyists, but those who really got my ear—and attention—were my constituents" (Weingardt 2001).

Influencing policy in the private-sector business community on issues dealing with procurement policies, design/build versus traditional design delivery, and so forth requires a totally different approach than does influencing public policy. In this area, personal contact can make an even more significant difference.

PR Is Not a Luxury

PR is not an isolated function—or merely a "feel-good" luxury item—within an organization or profession, but a vital part of the whole operation, especially in creating favorable perceptions. Perceptions significantly influence how the civil engineering profession comes across to its public and to fellow members: as technicians or professionals, as followers or leaders, and as technical resources or valuable decision makers who should be at the table when crucial decisions are made and public direction is set.

Community Involvement

Since the world is run by those who show up, civil engineers must show up as leaders on a regular basis—and become more involved and active in their communities—to have a consequential impact on the world around them. One effective way is to get appointed to—and serve on—local government boards and commissions, and so forth—and even run for elected public office.

Doing this will not only enhance the public's awareness and acceptance of civil engineers as community leaders, but will convince people that civil engineers care about more than engineering and construction projects—that they are serious about making their communities better places to work and live. To encourage those who might hesitate to get involved, Lewis suggested that "civil engineering societies [and associations] celebrate and publish stories of members who have been elected or appointed to decision-making bodies and explain the benefits accrued" (Weingardt 2001).

Conclusions

Looking into the future, certain trends become self-evident—such as the three current world developments discussed—while others remain elusive. For some issues, it comes down to reviewing the speculations of qualified people, making reasoned guesses, and then revising them as time dictates. Few people, including the most sophisticated futurists, predicted the fall of the Berlin Wall or the collapse of communism in the Soviet Union. So it is with detailed forecasts affecting the civil engineering industry.

That the future holds change is obvious. And clearly the rate of change, especially in the civil engineering arena, will keep accelerating. Engineers can anticipate and address change proactively, running the risk of being slightly wrong. Or they can ignore change until it is upon them. Then they may encounter the greater risk of being engulfed by events and conditions out of their control, forcing the profession to address them reactively. The choice belongs to engineers themselves.

As has been true throughout history, engineering and technology will lead most progress. Technological development will come fastest; change in political and social arenas will come more slowly. Paradoxically, it is in this area of social concerns about engineering and construction in the built environment that the industry's leaders can most increase their influence.

Civil Engineering of Tomorrow

As the world becomes more technologically dependent, the field of civil engineering will be at least as complex as it has ever been. As a result, greater numbers of tomorrow's civil engineering firms must become more diversified in the disciplines they practice and must add nonengineering expertise—finance, operations, political know-how, and so forth—to their arsenal of skills.

The growing advances in and use of IT will let more small U.S. firms compete on the international scene—and allow them to spring up anywhere and do well in niche markets by providing highly specialized services to others, often large engineering groups. Medium-sized engineering firms will either grow into bigger operations, merge with other like-sized firms, or be absorbed by megasized companies—or they will exist in strong niche markets and/or locales. Large-to-giant civil engineering firms will increasingly dominate regional and international markets, with numerous offices located everywhere, many staffed with partners indigenous to where the office is located. And they will become engrossed in 24-h-around-the-globe, design/build projects.

Influences of International Marketplace

Much U.S. project design work will be shipped to and done by inexpensive labor in foreign countries using the Internet and IT tools. North America will continue to be one of the most lucrative international marketplaces in the world, and foreign-based engineering and construction companies will make noticeable inroads into U.S. markets.

Even so, as shown in a December 2000 study by the University of Michigan, annual U.S. exports of services—including professional services—are expected to increase from $250 billion today to $650 billion in 2010. This is equal to today's annual exports of agricultural and industrial products (Weingardt 2001).

Government Bodies versus Private-Sector Groups

The future will see more efforts by certain government bodies, especially those with large unionized technical staffs, to do the engineering traditionally handled by private-sector consulting engineering companies. Recent California and Massachusetts legislative experiences will surface again in other forms and at other locations, as will efforts by unions to find work for unionized engineers and technicians. More than ever in history, U.S. private-sector civil engineers will need to become involved—actively and vocally—in the political process, ensuring their future existence and setting public policy and direction.

Much more could be accomplished if private-sector engineering firms would proactively strive to develop partnerships with government agencies rather than taking them on as adversaries after bad policy is enacted. Creating partnering agreements with bodies such as the U.S. Army Corps of Engineers and state departments of transportation, for instance, enhances the goals of both factions. For Americans to see public- and private-sector engineers doing battle with each other blackens the image and stature of the profession.

Attracting and Retaining Young Professionals

One of the major challenges facing the consulting civil engineering industry in the coming decades will continue to be attracting and retaining young professionals—young U.S. citizens—in the profession. With the pool of white males of European heritage rapidly declining as a percentage of the overall population, it is imperative that the profession hone its skills at bringing minorities and women into its ranks, immediately.

If adequate numbers of bright new professionals are not attracted into all the fields responsible for the built environment, managers of American-based civil engineering firms will have serious choices to make. They include:

- Ship civil engineering work overseas (something many large U.S. companies already do);
- Import technically skilled non-American workers into the United States (now under way, most visibly in the IT industry, that is, H1-b visa legislation); and
- Allow more foreign firms to enter the U.S. marketplace (get work and ship it "home").

Efforts to attract and retain new professionals will require enormous collaboration involving several professional societies (ASCE included), the National Academy of Sciences, the National Academy of Engineering, educators, and other members of the construction industry. Estimates indicate it will take a 5-to-10-year commitment to see results (Weingardt 2001).

U.S. society tends to educate more and more people—such as lawyers and stockbrokers—who are oriented toward dividing up the economic pie. At the same time, fewer and fewer are being educated to create and enlarge that pie. This needs to change, just as the education of tomorrow's civil engineers needs to change.

To keep up with the profession's technological and leadership needs, civil engineers of tomorrow will require a 5-year (minimum) degree plan to perform as professionals. Along with this, a requirement for life-long learning is essential for civil engineers to stay current with engineering advancements and to hone communication, leadership, and people skills. More education will broaden their outlook and allow civil engineers of the future to be leaders in society as well as in their industry.

QBS: Only the Beginning

In the past, much ado has been made about QBS as the favored A/E selection process for the federal and many local governments. In many cases, it has helped curtail low-balling fees and

shoddy or inadequate design. Though a good concept, in reality, it often limits A/E profits by establishing fees based solely on hourly rates and overheads.

Civil engineering firms need to be selected on qualifications and rewarded (or paid) based on value added. In addition to the continued use of QBS, civil engineering fees and salaries need to be raised to levels more in line with the responsibilities engineers take on—and the value they add.

The Challenge

If engineering historians are right and the past is prologue to the future, American civil engineering legends in the 1800s—Judah, Eads, Roebling, Mason, Stevens, Goethals, and so forth—have set the bar high for today's engineers regarding leadership and community involvement. For them to be matched and surpassed, today's civil engineers need to have the will to do so *and* the dedication to make it happen.

ASCE's 2002 Vision

On the eve of its 150th anniversary celebration, ASCE presented its 2002 Vision Statement: "Engineers as global leaders building a better quality of life" (ASCE 2002a). This honorable and noble call to the society—and members of the profession—inspires them to set the pace in dealing with the challenges of the twenty-first century. The four key elements for accomplishing ASCE's vision are:

- Developing leadership;
- Advancing technology;
- Advocating lifelong learning; and
- Promoting the profession.

Individual civil engineers would be well advised to strive toward these goals themselves. Then they'll be able to leave a powerful legacy for those who come after them. The next group of engineers, in their turn, may then leave an even greater legacy for ongoing generations.

Technologically Complex World

As the world becomes more technologically complex, major public decisions cry out for insight from those with a thorough knowledge of engineering and technology. Because of this, the call for large numbers of savvy civil engineers to fill leadership roles—not just in the engineering industry but in the public arena—has never been greater. To be prepared to hold such crucial positions, tomorrow's civil engineers must both be well versed in emerging technologies and cutting-edge engineering developments and have political clout—to become Benjamin Franklin-type "citizens of the world." That means civil engineers will need to have their communication, leadership, and people talents honed to the highest levels possible.

If civil engineer leaders with high-level skills *don't* show up to provide the needed expertise concerning tomorrow's engineering nuances, who will? Who else is better suited to be the stewards of this nation's (and the world's) infrastructure systems—and to raise the public consciousness concerning the impact of civil engineering applications?

Global Demand for Engineers

Both developed and developing countries have always depended heavily on their national engineering base. Engineering will be an even stronger factor in the future. The strength of a nation's engineering talent determines its economic power and establishes its very standard of living. Engineers, say many think tank gurus, are the world's true wealth creators, those who help increase the size of the economic pie, not divide it up. They are the ones most often behind notable advances in progress.

In essence, the history of engineering has been the history of civilization. And tomorrow will be no different. The demand for civil engineers—and civil engineering leadership—will remain high well into the future. In response to these demands, civil engineers can come across as professionals or technicians—and be either leaders or followers, activists or laidback reactionaries. They can expand on the many opportunities being presented or stick their heads in the sand, waiting for others to tell them what to do. It is totally up to them.

The Fate of the Profession

If increasing numbers of engineers don't become proactive in helping make critical public judgment calls, it will be business as usual. And public direction—indeed, the very fate of the civil engineering profession—will continue to be in the hands of professional politicians and others with no engineering background.

In a perfect world, it would be wonderful if civil engineers could be community leaders and top engineers at the same time. This is not always possible. An engineer's years in college are so short, it is impossible to fulfill all the technical course work needed and still adequately study art, history, philosophy, and literature—the humanities—subjects that broaden a person's perspective. To accomplish those broadening objectives—and earn respect as a learned profession on a par with medicine, science, and architecture—civil engineers need to commit to lifelong learning, both at the university and afterward.

Finding Time for Community Service

Similarly, time available to working engineers for community involvement and public leadership is limited unless pursued after hours or unless employers allow time off. In the coming years, that will need to happen. Employers and upper management should be willing to provide matching paid time off for individuals willing to fill community leadership positions such as serving on public boards and commissions.

The Call to Show Up and Lead

The U.K. engineering press, it seems, would like to have Americans think that the world has entered the dawning of the age of the engineer. For that to happen, more top civil engineers—the cream of the crop—will need to become highly visible leaders outside of the profession. And they must unearth creative solutions to eliminate the profession's two PR dilemmas once and for all.

If civil engineers truly want to raise public awareness about the importance of their profession, interest the media, and influence public direction—plus attract and retain some of the brightest into their ranks—they will have to get actively involved as pacesetters beyond the field of engineering.

Tomorrow's civil engineers must *not just* show up, they must show up to lead. They *must* seize the moment to run things, not just make things run.

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