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# Environmental Justice Reconsidered

> *You don't need a weather man to know which way the wind blows.*
>
> *Subterranean Homesick Blues,* Bob Dylan, 1965

"Okay, I get it!" we can hear you saying at this point. So what can engineering and design professionals do to ensure that our designs and projects are fair to the entire community and do not cause disproportionate burdens on certain members of society? The first clue is to consider the subtitle of this book. We must manage risks *and* be socially responsible. In fact, to be socially responsible *requires* that we manage environmental risks properly and that we do so in a fair manner.

We must take our professional responsibilities seriously, but as Dylan's lyrics seem to say, we must avoid condescension and underestimation of the "common sense" and problem-solving abilities of those outside the profession. And as Dylan also seems to imply, we may miss some very obvious truths since we are so sharply focused on the specific project at hand. Indeed, we live and die by the manner and extent that we attend to the details, but we must not lose sight of the different trade-offs and value judgments we make as we select from the engineering options available to us.

One of the first things for us to keep in mind is that many of historically disadvantaged communities lack the "voice" of other groups who have long made use of the system. For example, one can argue that much of the environmental movement that grew out of the 1960s was in many ways elitist. Environmental considerations have often been thrown into the mix of protesting a plan, design, or project, but the principle underlying protest is something else, like property values and maintaining the current demographics and *status quo.*

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### *Discussion: Professional versus Personal Values*

Here's a test. Drive through three neighborhoods in your town, other than your own, that vary from one another in terms of socioeconomics, property values, and land uses (e.g., predominantly residential, industrial, agricultural, rural buffer, mixed). Assume that the community, without question, needs a new facility (e.g., a very dangerous waste needs to be stored, but once it is stored the potential risks are reduced by five orders of magnitude from the present situa-

*Socially Responsible Engineering: Justice in Risk Management.* Daniel A. Vallero and P. Aarne Vesilind

tion). Based on your first inclinations, similar to responding to the images in a Rorschach test (called *free association* by psychologists), where are you most likely from a professional standpoint to locate a hazardous waste site? Where do you consider, among these three diverse neighborhoods, the best location for a rock quarry or a power plant? What steps would you undertake to convince the people now residing there that they need to get with the program and help the overall community reduce its overall risk (or provide jobs or electricity)?

Now drive around your own neighborhood and do the same. Pick the best site for the waste site, quarry, or power plant. Would you prefer it be in one of the other neighborhoods? If you *must* have it in your neighborhood (i.e., as a professional, your client *demands* it), how close would you locate it to your own home? Can you *justify* this decision from an environmental perspective? How about from the design criteria? You probably could.

Think about your answers to this test and what they mean in terms of professional responsibility. If we go into a project with preconceived ideas of the worth and worthlessness of certain communities, are we not more likely to suggest actions that we would not allow in other areas that we deem to be more *valuable?* And to exacerbate the situation, are we not ready to use the tools of our trade (e.g., the environmental assessment report, the plans and specifications, and the land-use plan) to propagate injustice? For example, once an area has allowed one noxious activity, is it not easier to permit another? Whereas will not a pristine area or one with high property values continued to be buffered from even a first entrée or encroachment by noxious land uses?

Can you imagine your client's reaction if you were to suggest a zoning amendment or exclusion to allow a hazardous waste site in your town's richest neighborhood? But such exclusions are requested in poorer neighborhoods, sometimes because they abut industrial or institutional zones, but sometimes because the powers that be perceive them to be of lesser value.

An empathic view can help. If you were dead set against a project in your neighborhood, how would you use your gifts (talents, education, experience, and contacts) to stop the project? Applying such a model is a good way to gauge the amount of fairness in the professional advice being dispensed. If you would protest such a project in your own neighborhood, should you be advocating and putting the force of your profession behind a similar project in another?

## JUSTICE BY DESIGN

After conceiving the project, the first thing a project designer or engineer should do is to learn what people, all people, think of the proposed project. Each step in the design process allows for community involvement and participation.

## Project Goals and Objectives

Of course, the practicing professional must pay close attention to the expectations of the client, but must remember that the first canon of the engineering profession gives primacy to our larger client, the public. Thus, even in the earliest stages in identifying project goals and objectives, certain constraints and accommodations must be built in, such as ensuring that the project does not induce disproportionate costs and risks to certain groups.

We advise engineers to begin with the end in mind, but to be adaptive. Ownership is good, but defensiveness is not. Rigorous science is required, but engineering ‘‘rigor mortis’’ is not. We must be able to listen, really listen, even if it means changing our plans to ensure fairness.

## Needs Assessment/Data Collection

Once the goals and objectives of a project are clear, the difference between the existing conditions, such as the current housing stock, land-use patterns, and product clientele, must be evaluated to determine just what needs to be done for the project to be a success.

When considering these gaps and needs, the professional should be mindful of the effect that addressing these will have on various groups. For example, if the project calls for the relocation of people currently living in the area, the rerouting of roadways, or changes in land use, such as rezoning and exemptions from existing zoning requirements, the needs assessment must clearly identify how the project will accommodate, in a fair and just manner, those people affected. In addition, since we are talking about ‘‘environmental justice’’ we should also consider the effects on nonhuman species, such as changes in ecosystem function and structure, changes in habitat (including hydrological changes and creation of barriers that affect predator–prey dynamics, species richness, and biodiversity), and modification of natural cycles (e.g., nitrogen, phosphorus, and micronutrients).

## Preliminary Review/Feasibility Study/Economic Analysis

It is best to involve the community as early as possible in an engineering project. This can prevent misconceptions or mistrust that can result, especially if rumors or information are leaked. The project engineer may find the need to play ‘‘catch up’’ if this occurs. Also, communities can be a great resource. Not everything is written and available through publications. For example, we have found that in the southeastern United States, much (most?) important information is passed down by oral tradition. This might help explain, in addition to the blatant ignorance of many northerners about things ‘‘southern,’’ why southern culture is so misunderstood or even reviled. The North seems to have invested more in written tradition, but the South relies more heavily on storytelling and other oral methodologies, peppered with a bit of written tradition (e.g., entries in the family Bible).

This also applies to the implementation of any project. For example, it is common for a safety manual to be written by a competent engineer, only to be ignored or not well understood by those needing protection. If the manual sits on the shelf, it does no good. Even worse, it may be an excuse for management not to do more. Many people learn by hearing and doing (i.e., interactive learners), so simply having a written plan is insufficient.

The engineer must use the entire community's resources to gather such important information such as previous failures, old and abandoned facilities, past land uses, water quality (see the discussion of arsenic and Bangladesh in Chapter 3), and the key influential people (e.g., African American clergy, Native American elders, and Mexican American "soccer club" members).

## Planning, Problem Formulation, and Design Specifications

As mentioned in our discussion of the needs assessment step, a diverse mix of perspectives must be part of project planning. The problem being addressed (e.g., hazardous

### Biographical Sketch: Ian McHarg

Ian McHarg founded the University of Pennsylvania's Department of Landscape Architecture and Regional Planning 46 years ago and ran it for three decades. He died March 5, 2001 at the age of 80. The Penn program attracted graduate students from around the world who wished to emulate McHarg's environmental approach to design, which he conveyed with a memorable mix of polished urbanity and missionary zeal and using any medium available, including books and television, imparted his essential message: that any human action, be it building a highway, city, housing development, subdivision, or park, must account for the suitability of the site, as represented by the slope, contours, vegetative cover, surface water and groundwater, fauna, and other natural features.

McHarg was unhappy with the job that humans were doing in protecting the environment. His most famous quote was: "Man is a blind, witless, low brow, anthropocentric clod who inflicts lesions upon the Earth." He was a strong advocate of holistic planning, arguing that no construction or land use should occur without a study of the suitability to the topography, vegetation, wildlife, and beneficial use of land for other purposes.

McHarg used visual relationships to press his point, establishing the groundwork for spatial analytical tools such as geographic information systems and even computer-assisted drafting, which are so important to environmental planning, engineering, and design today. More than that, perhaps, his work reminds us of the importance of spatial synergies and vulnerabilities that are not readily apparent without employing the right spatial tools. Thus, it should come as no surprise that tools such as geographic information systems can implement environmental justice, especially as they are increasingly used to point out potential problems *before* any decisions on siting are made.

waste disposal, energy production, land-use change) must be properly defined and characterized to match it to the appropriate solution (the project). If key people are not included in this phase, there is a likelihood that the project will be of little value or will have ancillary harm.

Problem formulation must build in ways to measure success and the standards of performance for the project. These include the development of design specifications, which are of numerous types:

1. *Physical.* This includes size, volume, mass, and other dimensions, such as the amount of waste processed daily and the maximum size of a recycling facility. (Size can be good or bad; for example, larger size means more capacity but increased displacement of people and problems with aesthetics.)
2. *Functional.* This includes reliability, duration, durability, production rates, processing rates, transportation efficiency, pollutant removal rates, and energy production. (Function should be sustainable and should be viewed as a life cycle, so if a project does not meet all of its functional specifications, it has failed.)
3. *Safety, Risk, and Environmental.* While meeting the physical and functional specs, the project must not cause undue environmental and health problems. Justice demands that no one be put at undue risk, including those building and operating the project as well as those affected by the project operation (e.g., the adjacent landowners).
4. *Economic.* All projects have a budget and time frame for completion. The engineer is remiss if the important physical, functional, safety, and environmental specifications are not completed because human and capital resources needed are not available. This is particularly problematic at a time when many engineering consultants operate on a ‘‘design-only’’ basis (i.e., the consultant agrees only to design the project, with no responsibility for its construction or operation, not even overseeing the project to ensure that the design is followed properly). We contend that the ethical engineer never truly engages in a design-only project, but is responsible to some extent to ensure that the design is properly built and not misused. Often, only the design engineer knows the design’s finer points to ensure that the construction and maintenance steps are adequate.

All specifications can be affected by input from those using and those affected by a project, so the best rule is transparency (i.e., let everyone know what the specs are early and often throughout the project). The specifications are in fact measures of success. If they are not met, the project is at least in part a failure. Thus, if the project is to be truly successful, some specifications will need to measure the social acceptability of the project.

## Design Abstraction and Synthesis

The design must not fail for lack of imagination. Just because it has been done this way 10 or 100 times before does not mean that this approach will work in a specific situation or be acceptable to a particular community. Every design is unique in some ways. When

**Biographical Sketch: Danie Krige**

In the late 1940s, South African engineer Danie Krige (pronounced "krig") was working as an inspector of mining leases for the South African Mining Engineer's department. This experience provided him with access and perspective into sampling and production statistics required to be submitted regularly by the gold mining interests. Others saw the same data, but Krige was interested in spatial interpretation and ways to model large amounts of information to find statistical trends and patterns. Such insights allowed Krige to conduct extensive basic statistical research into the valuation problems of the mines. From this work, Krige discovered ways to improve the quality of ore block valuations and to make logical estimates of the block grade distributions. Previously, only borehole values were available to site new mines. As a result of this work, an entirely new discipline of statistics, *geostatistics,* was born, especially the method bearing his name, *Kriging.*

Kriging is a technique presently used to interpolate of spatial information to describe the increasing difference or decreasing *correlation* between sample values as separation between them increases, to determine the value of a point in a heterogeneous *grid* from known values nearby (see Figure 7.1). It is linear since the estimated values are weighted linear combinations of available data. It is unbiased because the mean of the error is zero. It is best since it aims at minimizing the variance of the errors. *Kriging* has become synonymous with optimal prediction and is used to represent uncertainty, applying a *variogram,* a two-point statistical function that describes the increasing difference or decreasing correlation, or continuity, between sample values as separation between them increases. The technique is now highly automated and is part of many computerized geographic information systems (GISs).

Krige continued his work in the geostatistical field for some 30 years in the Anglovaal Head, before retiring for 10 years as professor of mineral economics at Wits. He remains quite active as a consultant.

putting different things together from the physical and social sciences, the result may lead to unexpected and unintended consequences. Testing a design prototype only under the best conditions is an invitation to costly and dangerous consequences down the road. Examples of such surprises are seen in the news almost daily (e.g., a drug that has a side effect that was not found during clinical trials, a part on a truck that failed due to unforeseen but real-life driving conditions, a sport utility vehicle (SUV) that overturns because tires are underinflated with air to give a smoother ride, or malicious tampering with an over-the-counter pain reliever). Synthesis can result in something other than additive effects. The effects may be muted (antagonism) or increased (synergism). The designer should be careful to consider such effects.

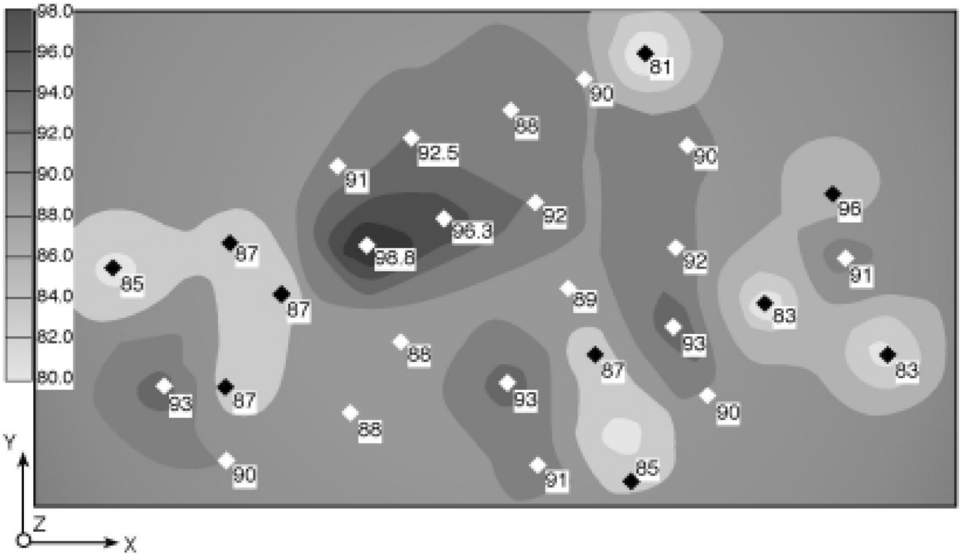


**Figure 7.1.** Example of Kriging: isopleths for percentage of amphipod that survive for a reduced number of sampling stations in a hypothetical harbor. This spatial interpolation allows the use of fewer sampling sites, reducing costs and giving wider spatial coverage. (From C. J. Leadon, *Kriging in Eco-Risk Assessments,* Issue Paper, Argonne National Laboratory, Argonne, IL, June 21, 2000.)

## Implementation/Construction

The design engineer is often called upon during construction to help to interpret specifics of a design or even to make adjustments to address real-world concerns. Certainly, one type of implementation concern is the acceptability of the project by the local or larger community where it is being built. Witness the fact that hazardous waste site and nuclear waste site designs are fairly straightforward in terms of their physical and functional specifications (e.g., thickness of barriers, soil type, hydrological conditions, resistance to terrorist attack, separation of wastes and other materials). However, much of the concern is in trying to address the profound concerns of those fearing the effects of leaks. The Yucca Mountain nuclear waste site in Nevada has been straddling the design/construction phases for some time now, with no clear consensus on how to proceed.

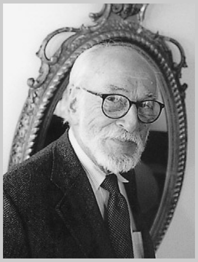
## Communication/Feedback

The other steps all include open and effective risk communication, but after the project is ready to go online, a formal feedback system is needed. This will help managers and decision makers to ascertain the project's effectiveness and adherence to design specifications and even whether new success measures are needed. The feedback from this communication can be used to make important adjustments and improvements and to ensure that the affected community is protected from possible problems (e.g., one of the major problems in the Bhopal toxic cloud disaster was that the poor people living near the plant were ignored in their complaints prior to the all-out disaster).[1]

## Operation and Maintenance

As long as the project is in place, the professional must monitor its performance. For example, the Superfund and Resource Conservation and Recovery Acts require closure and postclosure monitoring even after a hazardous waste site has received a ‘‘clean bill of health’’ (i.e., it has met its cleanup standards for soil, water, air, or sediment). Operation and maintenance requires the assurance that the project not only performs as designed, but also looks for any previously unforeseen consequences. In fact, many of the cases in this book are not failures of design so much as they are failures of anticipation. Hindsight is more likely to be better than foresight, so even the most conscientious professional is likely to be surprised by the interplay of events. This is not a place for blame and defensiveness, but calls for vigilance. As long as the reasonable safeguards and best judgments are part of the design and implementation of a project, most review boards and oversight authorities are unlikely to reprimand the professional. However, once a problem is identified, even after the project is ‘‘completed,’’ it behooves the professional to do all that is possible to address it. In fact, the exemplars are those who look after their previous designs, such as that exhibited by William LeMessurier after some recal-

### Biographical Sketch: William LeMessurier



William LeMessurier (born 1927) had a distinguished career as a structural engineer and in 1978 was asked to design a new skyscraper that Citicorp wanted to use as its New York headquarters. With a degree from the Harvard Graduate School of Design and a masters’ degree from MIT, LeMessurier had built his firm to be one of the most respected engineering consultants and designers for such projects.

The design called for an attractive, functional, and imaginative 59-story building. Because of space and light restrictions, the architects designed a building that seemed to float on four columns nine stories high, providing light and space below, and enhancing the visual appearance of a new church building on the corner of the lot. To achieve this, the architects suggested that the four columns be placed in the middle of each side instead of at the corners. LeMessurier decided to use a unique form of construction, with the forces being transferred to the four columns by means of V-shaped beams (see Figure 7.2).

Engineering design is a trial-and-error procedure. A structure is postulated, and the loads on that structure are then estimated. Using mathematical principles and well-tested equations, the effect of these loads on the structure are calculated. In the case of the Citicorp building, LeMessurier’s engineers calculated, in addition to other live loads, the effect of wind and decided that with a damper mechanism in the attic of the building, the building would be able to withstand high winds.

The Citicorp building was constructed and occupied, and the client was very pleased with the result. Then out of the blue, LeMessurier got a telephone call from a student who told LeMessurier about a homework assignment he had done. The student had calculated the ability of the building to withstand wind loads. As long as the winds were from the side of the building, the structure seemed to be secure, but if the winds hit the building at its corners, called *quartering winds,* it would be possible to topple the building at moderate winds.

LeMessurier told the student that in effect, he didn't know what he was talking about. But the call put him to thinking, and he redid some calculations. To his surprise, it seemed that the effects of 45-degree winds were much greater than he had originally estimated. But this would not have been a problem had the method of structural construction not been changed during the erection procedure. Instead of welding the joints, the construction engineers had substituted a newer standard using bolted joints. If the effect of these joints was now included in the analysis, it became painfully clear that some of the beams in the building, should it be hit by quartering winds, would not be able to withstand the live load, and the building would topple. Weather records showed that such winds might occur once in every 16 years.

That design reliability was unacceptably low and the risk far too high. Should the building fall, thousands of people would die, and only LeMessurier knew the full story. He contemplated his options, and in his words: "Thank you Lord for making this problem so sharply defined that there's no choice to make."[2]

With the consent of the owners, he went with his news to disaster engineers, who planned for evacuation should a storm be imminent. He instrumented the entire building with strain gauges and set a 24/7 watch on the damper mechanism in the top floor to make sure that it functioned perfectly. Then LeMessurier started to strengthen each of the V-joints where bolts had been used by welding in supporting plates. Since the structural members were all inside the building, he could do all the construction from the inside and none of it would be visible from the outside, thus avoiding embarrassing questions and possible panic. Within months, all of the joints had been strengthened and the building became one of the safest in New York, able to withstand the highest winds that could reasonably be expected to occur.

After discovering the problem, LeMessurier could have done nothing, believing that by revealing this information he would have lost stature and respect in the engineering community and hoping that the series of events that cumulatively would have led to a catastrophe would not occur within his lifetime. Instead, he chose the honorable alternative, perhaps remembering the engineering code of ethics: "The engineer shall hold paramount the health, safety, and welfare of the public." The risk was so great, in terms of both its probability and its magnitude, that there was little choice for him or for the owners of the building.

As it was, by conducting himself in such an honorable manner, he actually gained considerable stature in the profession and in the public's eye. Since the "fifty-nine-story crisis," he has made himself widely available as a lecturer in colleges and universities, always speaking with candor about what could have been the greatest disaster in his otherwise illustrious career, but which turned out to be his greatest engineering triumph.

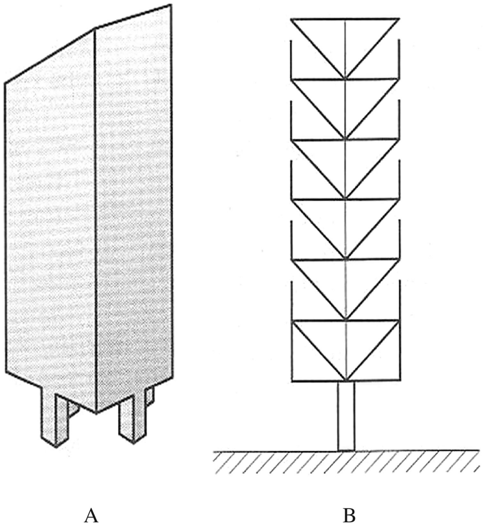


**Figure 7.2.** Building design of Citicorp Building in New York City. The building appears to float on four columns (A) using V-shaped beams to transfer forces (B).

culations showed significant design flaws in New York's Citicorp Building in the event of high winds.

## CASE STUDY: WILLIAM LEMESSURIER AND THE FIFTY-NINE-STORY CRISIS

Visit the Online Ethics Web site: http://onlineethics.org/moral/lemessurier/index.html. Read all eight parts (they are short but very interesting) and then view the brief videoclip of LeMessurier. Consider what happened and what could have happened. Answer the following questions about the Citicorp Towers and LeMessurier's professional behavior.

1. Why do engineers "push the envelope" so frequently? Does that in some way tell you something about yourself and why you want to become an engineer?
2. Where do you think LeMessurier learned about his responsibilities and obligations as an engineer? What is the difference between professional obligation and the moral responsibilities of other members of society?
3. To whom are engineers "accountable"? To whom was LeMessurier accountable? Prioritize these responsibilities. Do any patterns jump out at you?
4. If you were faced with a $2 million personal loss (although eventually covered by insurance), would you have done the same thing that LeMessurier did, or would you have weighed the risks and hoped that the confluence of factors (e.g., winds and resonance) would not occur? Can you think of a way that "no action" (no retrofit) could have been rationalized or even argued for legally?

5. Do engineers' responsibilities go beyond legal requirements? Why?
6. Some say that there are two types of wrongdoing: voluntary wrongdoing and negligence. Another way to put it is that professionals can commit either sins of commission or sins of omission. Which was more likely to happen in the Citicorp case? How were these wrongdoings avoided?
7. Do you believe that LeMessurier's behavior is rare among people in general? Is it rare among engineers? Is it rare among engineers who are given large responsibilities, such as the design of a major commercial facility? What does this tell you about the possible rewards of the profession you are pursuing?

*Extra credit:* Leslie Robertson was one of the structural engineers called in to do the damage assessment. What other recent famous engineering case involves Robertson?

While the Citicorp Building example is dramatic, there are countless other projects with unexpected and undesired outcomes. Many of these have nothing to do with how well the engineer has applied the physical sciences. The unforeseen problems may not even be directly the result of the project. For example, the engineer may have assumed, for good or bad reasons, that the land use and population distributions would remain stable or at least follow a particular type of projection. However, if a roadway or water line creates access to the area, or even worse, if the engineer's project in some way induces growth, environmental exposures and public health risks may increase. Such contingencies should have been foreseen. So in a way, an engineer's project is never completely done.

## TRUST: OUR MOST IMPORTANT PROFESSIONAL COMMODITY

Once the engineer has a good idea of what is perceived to be good or bad about a project, a word of caution is in order. Most people in the neighborhoods that are potentially affected by the project are not required to be technically literate in their daily lives. The engineer is put in the position of trust.

Note the difference in professional ethics *versus* individual ethics. The vendors' credo, *caveat emptor,* places the onus on the buyer (client). The professional credo is very different. Ours is *credat emptor,* roughly translated from Latin as "Let the client trust." Arguably, the engineer's principal client is the public. And the clients need know little about the practice of engineering because, owing to the expertise, they have delegated the authority to the engineer. Just as society allows a patient to undergo brain surgery even if that person has no understanding of the fundamentals of brain surgery, so our society cedes authority to engineers for design decisions. With that authority comes a commensurate amount of responsibility, and when things go wrong, culpability. The first canon of most engineering ethical codes requires that we "hold paramount" the health and welfare of the public. The public is an aggregate, not an "average." So leaving out any segment violates this credo. Thus, even though most people favor a particular approach, it is still up to the engineer to ensure that any approach recommended is scientifically sound. In other words, no design, even a very popular one, is to be recommended unless it meets acceptable, scientifically sound standards. Conversely, the most scientifically sound approach may have unacceptable social side effects. Once again, the engineer is put in the position of balancing trade-offs.[3]

In every engineering office or department there is a designated ‘‘engineer in responsible charge’’ whose job it is to make sure that every project is completed successfully and within budget. This responsibility is often indicated by the fact that the engineer in responsible charge places his or her professional engineering seal on the design drawings or the final reports. By this action the engineer is telling the world that the drawings or plans or programs or whatever are correct, accurate, and that they will work. (In some countries not too many years ago, the engineer in responsible charge of building a bridge was actually required to stand under the bridge while it was being tested for bearing capacity!) In sealing drawings or otherwise accepting responsibility, the engineer in charge places his or her professional integrity and professional honor on the line. There is nowhere the engineer in charge can hide if something goes wrong. If something *does* go wrong, ‘‘One of my younger engineers screwed up,’’ is not a reasonable defense, because it is the engineer in charge who is supposed to have overseen the calculations or the design.

For very large projects where the responsible engineer may not even know all the engineers working on the project, much less be able to oversee their calculations, this is clearly impossible. In a typical engineering office the responsible engineer depends on a team of senior engineers who oversee other engineers, who oversee others, and so on down the line. How can the responsible engineer at the top of the pyramid be confident that the product of collective engineering skills meets the client’s requirements?

Fortunately, the rules governing this activity are fairly simple. Central to the rules is the concept of truthfulness in engineering communication. Such technical communication up and down the organization requires an uncompromising commitment to tell the truth no matter what the next level of engineering wants to hear.

It is theoretically possible for an engineer in the lower ranks to develop spurious data, lie about test results, or generally manipulate the basic design components. Such information might not be readily detected by supervisory engineers if the bogus information is beneficial to the completion of the project. If the information is not beneficial, on the other hand, everyone along the chain of engineering responsibility will give it a hard, critical look. Therefore, the inaccurate information, if it is the desired information, can steadily move up the engineering ladder because at every level the tendency is not to question good news. The superiors at the next level also want good news, and want to know that everything is going well with the project. They do not want to know that things may have gone wrong somewhere at the basic level. Knowing this, and fearing being shot as the messenger, engineers tend to accept good news and question bad news. In short, the axiom that ‘‘good news travels up the organization—bad new travels down’’ holds for engineering as well. And bad news will travel down very quickly (for example: ‘‘You’re fired!’’).

The only correcting mechanism in engineering exists at the very end of the project if failure occurs: The software crashes, the bridge falls down, the project is grossly overbid, or the refinery explodes. And then the search begins for what went wrong. Eventually, the truth emerges, and often the problems can be traced to the initial level of engineering design, the development of data and the interpretation of test results.

It is for this reason that engineers, especially young engineers, must be extremely careful of their work. It is one thing to make a mistake (we all do), but it is another thing totally to use misinformation in the design. Fabricated or spurious test results can lead to catastrophic failures because there is an absence of a failure detection mechanism in engineering until the project is completed. Without trust and truthfulness in engineering, the system will fail. To paraphrase the eminent scientist Joseph Bronowski:[4]

> All engineering projects are communal; there would be no computers, there would be no airplanes, there would not even be civilization, if engineering were a solitary activity. What follows? It follows that we must be able to rely on other engineers; we must be able to trust their work. That is, it follows that there is a principle which binds engineering together, because without it the individual engineer would be helpless. This principle is truthfulness.

## BEYOND EXISTENTIAL PLEASURES

In his highly readable and important work *The Existential Pleasure of Engineering,*[5] civil engineer Samuel Florman argues that the application of the physical sciences is a sufficient dedication to the greater good of society. This line of reasoning requires that the engineer merely do her or his job by ensuring that the math and science, and the design itself, are exemplary. The engineer need not worry about the larger social issues, since having chosen such a helping profession in the first place, there is no further societal obligation as long as the engineer's practice is ethical and competent.

We very much appreciate and use Florman's text in our classrooms, but it should come as no surprise that we strongly disagree with the premise. We believe that the value added by the engineer requires more than passive or coincidental attention to social responsibility. In fact, the major premise of *this* book is that we must be active in ensuring socially responsible designs and projects. To wit, Florman's postulates provide examples of why engineers must go beyond being competent in their technical specialities.

We follow two lines of reasoning, the first a reconsideration of what is meant by a professional calling, and the second, a brief consideration of where the engineering profession is today in dealing with ‘‘microethical’’ and ‘‘macroethical’’ issues. This reasoning can be extended to other environmental professionals and scientists.

The ancient Greeks' virtue ethics is a good place to start. Socrates *et al.* differentiated two contemporary professional virtues: technical competence and character. In fact, they devised the concept of ‘‘skill of character’’ (roughly translated from *ethike aretai*). A professional must at the same time be skillful (an engineer who is good at engineering) and enlightened (an engineer who does good while doing engineering). Florman may rightfully argue that this is embodied in the existential aspects of the profession. We agree to some extent, but it is still possible for a person to be skillful and very good at engineering and even follow the precepts of the profession, but for the overall outcome of the work to be unjust.

As discussed in Chapter 3, engineering failures can be of five kinds: (1) mistakes and miscalculations, (2) extraordinary natural forces, (3) unpredictable occurrences, (4) ignorance or carelessness, and (5) intentional accidents (terrorism). An unanticipated side effect in a type 3 failure often results from social, economic, or other nonengineering externalities. The Pruitt–Igoe housing project in St. Louis is an example of a type 3 engineering failure. Purely from the perspective of applying the physical sciences and mathematics, the project *should* not have failed. But the fact that the project was razed only a decade or so after construction belies this conclusion. It *was indeed a failure.* But the failure was the result of an incomplete and even inaccurate understanding of the social needs of the people the project was designed to help.

We need to extend the reasoning a bit further. Recently, the National Academy of Engineering bifurcated the professional responsibilities into two categories, those of the individual professional and those of the profession at large.[6] The first, the *microethics,* demand ethical behavior on the part of the practitioner. These are the ‘‘thou shalts’’ and ‘‘thou shalt nots’’ usually delineated in our codes of ethics. The professional responsibilities, the *macroethics,* address how the profession operates.

This thinking led the academy to ask: ‘‘Even if every engineer in our society abided by every canon and principle in our codes, would the profession adequately address the emerging societal issues?’’ The answer is ‘‘no.’’ The ‘‘bottom-up’’ approach only gives us high quality and sound designs and projects; it does not completely prepare society for the bigger problems on the horizon or even those that are already here. Thus, a ‘‘top-down’’ strategy must complement the specific codes of practice for the individual professional.

Consider the engineer Kurt Prüfer. By many measures, Prüfer was a highly skilled (*aretai?*) engineer. In fact, had he made an enlightened choice (*ethike?*) at a key point in his career, this book may have included his biography as an exemplar of the profession. To the contrary, Prüfer was the engineer who designed the ovens at Auschwitz, where hundreds of thousands of innocent people were exterminated. In fact, he achieved his design specifications and ‘‘measures of success’’ by giving the Nazis the ability to gas and to incinerate 200 human beings daily.[7] Prüfer was loyal and abided by the wishes of his superiors, his clients, and the greater German society at the time. He let others worry about the application of his designs, trusting ‘‘others to assess those consequences . . . beyond the engineering task.’’[8]

Engineering has a special sensitivity to societal well-being. Our works, as Prüfer's tragically demonstrated, can be used and misused. In the Prüfer case, the design was used as designed, albeit nefariously. However, most of the cases in this book are examples of misuse of what under many circumstances would have been good designs. The microethical approach is limited in being able to see and to stop such misuse. Thus, the larger, macroethical view is needed to help to foresee scenarios of potential harm.

Engineers must not be naive and must be aware of hidden agendas and groupthink. In our professional ethics courses at Bucknell and Duke, we show films (DVDs actually, so that you don't think we are complete anachronisms!) depicting engineers going about their business and doing their best (microethically) to meet the client's and the boss's needs, only to find themselves before a board of review or government authority explaining their role in some disaster (plant explosion, release of a toxic substance, etc.). The failure analysis eventually shows that somewhere along the critical path someone had ‘‘used’’ the engineer's expertise to achieve some unjust goal. The engineer is confronted with questions about why he or she did not know about this. Those asking are not impressed by the engineer's answer: ‘‘It wasn't my job; my job was only to. . . .’’[9]

## SUSTAINABILTY: THE KEY TO JUSTICE

The Prüfer case is truly a ‘‘downer’’ but illustrates the importance of expanding our view. A more positive view is to see all of our designs and projects through the prism of sustainability. Ideally, all environmental engineering projects should be sustainable. The added benefit of enhanced sustainability is the increased attention to details that will support environmentally fair and just projects. We have talked a great deal about ensuring that projects be underpinned with sound and reliable science. This, if done without bias, is a big step in ensuring justice. Unfortunately, some of the biases are so subtle that we miss them.

A case in point is a recent political radio ad for an elected position in a wealthy town in the Research Triangle area of North Carolina. To paraphrase the ad, one candidate is warning the town’s electorate of what would happen if his opponent were elected. Among the accusations, the candidate reminds the citizens that the opponent in a previous contest called for a greater amount of ‘‘public housing’’ in the wealthy suburb, and added that the opponent did not properly account for the ‘‘tens of thousands of dollars in lost property values.’’ What makes such statements particularly interesting is that in this growing area of North Carolina, there is a great need for ‘‘affordable’’ housing, so most people would freely admit that the private construction sector has not provided such livable and affordable conditions. So then, what is wrong with the opponent’s call for increased public housing? After all, is not the government’s responsibility to be a ‘‘provider of last resort’’ when the private sector and free market do not provide for common welfare of its citizens? The ad could support an elitist view held by at least some of the citizens and elected officials of this town, which has an inordinate number of gated neighborhoods.

An even more dramatic, yet possibly more subtle example of how perpetuating the *status quo* can easily permeate decision making is also currently being debated in another wealthy town in the Triangle area. Ironically, the town is home to a very progressive university with a very strong urban planning program. A local chapter of Habitat for Humanity, which has a stellar reputation for helping people achieve home ownership and in creating neighborhoods that have proven track records of upkeep and sustainability, has proposed a development of 17 acres with 50 ‘‘affordable’’ homes near wealthy neighborhoods. The proposal has met with criticism and resistance from local neighbors.[10] However, they have been singularly unsuccessful in winning any support outside the town’s northern tier. A rhetorical misstep by one of their leaders shows why. A critic compared Habitat’s plan to ‘‘the projects of the ’60s,’’ a phrase that reminds people of the public housing that sprang up during that era in cities throughout the country. The target of the critics appears not so much to have been Habitat as the Orange Community Housing and Land Trust, a local group that Habitat wants to bring in to help it develop attached housing on the site. The critic claimed that the creation of attached homes threatens to throw ‘‘a bunch of low-income people into a specific area,’’ creating a pocket of poverty as harmful to the development’s residents as to its neighbors. Environmental professionals are likely to be brought in as ‘‘hired guns’’ on either side of the debate. The sustainable view is one means of ensuring that their advice is not misinterpreted or misused.

It is useful to consider the costs of ignoring sustainability by comparing an empathic view to that of the unencumbered ethical egoist. In ‘‘The Tragedy of the Commons’’ example described in Chapter 6, the pasture could be seen as “ripe for the picking” as an exhaustible resource.[11] So if one is to have a cow, one had better win the race to claim a piece of the pasture immediately. But the cost to all, even the herders who are first in line to exploit, is a persistent problem (i.e., a barren land where a pasture once existed). With time, neglecting or exploiting the “pasture” makes us all losers; consistent with Reverend Martin Luther King’s observation mentioned in Chapter 1: “Injustice anywhere is a threat to justice everywhere.”[12] Disparate risk to one group threatens justice for the entire “pasture” (i.e., we are all vulnerable to inequity and injustice). Thus, since environmental problems persist, so must their solutions be sustained.

Even if a person is not a conservationist or an environmentalist (or at least would never label oneself as one), the persistence of the problem may well motivate a sustainable approach. Sustainability may be viewed as a form of ensuring system reliability: in this instance, *ecosystem reliability.* For engineers, we know that the best way to ensure the reliability of systems is the life-cycle analysis. In it, we direct ourselves toward a goal but consider as many of the possible contingencies, decision points, blind alleys, and cul-de-sacs that may be encountered while reaching that goal. So for our engineering and scientific colleagues who see sustainability as a “soft” or nontechnical issue, they may prefer to consider that what is really being engineered is a system (ecosystem), and what is being sustained (i.e., the environmental resource), is the productivity and efficiency of that system. The metrics for the system reliability are quite quantitative and may be measured directly, including net primary productivity, biological diversity (e.g., as indicated by the Shannon index), and chemical and physical integrity.

Much of the undergraduate engineering curriculum in the United States addresses the actual and possible moral dilemmas, problems, and questions of the individual engineering student, and represents the possible successes and failures the students may encounter in their individual careers (microethics). There is good reason for engineering curricula to prepare students for such issues, and we are only beginning to incorporate ethical content into coursework and projects. However, ethical issues of societal import and global scale are also important to engineering. Such issues as nanotechnologies (or angstrom-scale technologies), neurotechnologies, and sustainability will probably influence most people’s lives in the decades to come.

Actually, engineers will be at the nexus of the two scales. In fact, in many technologies, we are already there. Of course, we will continue to be concerned about the individual careers of engineers. We will also need to speak to present and coming ethical issues at large scales. For example, are we doing enough to help keep ethical issues and respect for persons as we push the envelope in biotechnological engineering and genetic research? Are we fully considering the cultural ramifications of blastocyst research, including the implantation of stem cells in people’s brains to treat neurological diseases? Are we in some way changing the meaning of personhood with pharmacological and neurological advances? Are we fully and adequately assuming our roles as stewards (i.e., Latin *credat emptor,* “let the client trust”) as we alter ecosystems and anthropogenic modifications of our food supplies by introducing genetically modified organisms?

Engineers do things![13] So many of the students currently enrolled in engineering schools will be doing things and making decisions about whether to do things during their careers whose nature we can only surmise. It is fairly certain, however, that engineers of the future will work in increasingly complex and technological work environments. As such, they may move away from and be tempted to forget ‘‘first scientific principles.’’ For example, how often do high school students really think about the algorithms of long division when they press the ‘‘/’’ key on the calculator or keyboard?

The future engineer will be tempted to design and implement plans without sufficient regard for whether it is the right thing to do. Thus, we must continuously remind ourselves that ethics and justice are affirmative enterprises. To quote Socrates: ‘‘The unexamined life is not worth living.’’ Aristotle put it more grimly: ‘‘The happy life is thought to be virtuous; now a virtuous life requires exertion, and does not consist of amusement.’’ Finally, if we are reductionist in our view, we may say that good macroethical decisions will be the outgrowth of the collective soundness of individual engineers. We do not disagree completely. However, we will also need somehow to ensure that the engineering profession give wise advice and work with policy and governmental decisions on macroethical issues. The ‘‘hold paramount’’ canon extends to both the individual professional and to the profession itself.

Reinhold Niebuhr’s quote in Chapter 1 is worth repeating here: ‘‘Man’s capacity for justice makes democracy possible, but man’s inclination to injustice makes democracy necessary. Democracy is finding proximate solutions to insoluble problems.’’[14] Special attention must be paid to the sectors of society that without affirmative approaches would be underrepresented. That is, certain people are excluded from the benefits of the marketplace either intentionally or tacitly. In a word, they are disenfranchised, calling to mind John Rawls’ concept of the veil of ignorance.[15] To ensure fairness among society’s stakeholders, no one knows the status of another. Thus, moral choices under the veil of ignorance would be made from the position of the most disadvantaged. Without such a constraint, engineers would design and build only for those who are sufficiently well off to pay. Niebuhr and Rawls thus make the case for affirmative justice in engineering. This also points to the need for *pro bono* work, since the principal guardian of democracy (i.e., the government) cannot provide for all engineering-related needs. In fact, in many nations, the government militates against those covered by Rawls’ veil.[16]

Advocating for justice is not an invitation to ‘‘junk’’ science and unsound design. To the contrary, it requires the best application of physical *and* social sciences. If we as a profession are able to achieve success in this tandem, we will be agents for positive change. After all, what everyone expects from us is *just engineering.*

## REFERENCES AND NOTES

1. T. Kletz, *Lessons from Disaster: How Organizations Have No Money and Accidents Recur,* Gulf Publishing Company, Houston, TX, pp. 114–115, 1993.
2. More on William LeMessurier can be found in J. Morganstern, The Fifty-Nine Story Crisis, *The New Yorker,* May 29, 1995.
3. Texts, manuals, and handbooks are valuable to the engineer, but only when experience and good listening skills are added to the mix can wise (and just) decisions be made. Not to be overly didactic, but this is the sage advice offered by the great thinkers and philosophers for the past three millennia. As mentioned on page 131, the counsel is akin to that of St. Peter (Acts 24:25 and II Peter 1:6), who linked maturity with greater ‘‘self-control’’ or ‘‘temperance’’ (Greek *kratos* for ‘‘strength’’). Interestingly, St. Peter considered knowledge as a prerequisite

for temperance. Thus, from a professional point of view, he seemed to be arguing that one can really only understand and appropriately apply scientific theory and principles after one practices them (I realize that he was talking about spirituality, but anyone who even casually studied Peter's life would see that he fully integrated the physical and spiritual). Engineers who intend to practice must first submit to a rigorous curriculum (approved and accredited by the Accreditation Board for Engineering and Technology), then must sit for the Future Engineers (FE) examination. After some years in the profession (assuming tutelage by and intellectual osmosis with more seasoned professionals), the engineer has demonstrated the *kratos* (strength) to sit for the Professional Engineers (PE) exam. Only after passing the PE exam does the National Society for Professional Engineering certify that the engineer is a "professional engineer" and eligible to use the initials PE after one's name. The engineer is, supposedly, now schooled beyond textbook knowledge and knows more about why in many problems the correct answer is: "It depends." In fact, the mentored engineer even has some idea of what the answer depends on (i.e., beyond the first step of professional wisdom, "knowing that one does not know," as Socrates would say).

4. Quoted by I. Jackson, *Honor in Science,* Sigma Xi, Research Triangle Park, NC, 1956, p. 7, from J. Bronowski, *Science and Human Values*, Messner, New York, 1894, p. 73.
5. S. Florman, *The Existential Pleasure of Engineering*, St. Martin's Press, New York, 1972.
6. National Academy of Engineering, *Emerging Technologies and Ethical Issues in Engineering,* National Academies Press, Washington, DC, 2004.
7. P. A. Vesilind, Closure to "Why Do Engineers Wear Black Hats?" *Journal of Professional Issues in Engineering Education and Practice,* 119(1):331–332, 1994.
8. K. deRobertis, Discussion of "Why Do Engineers Wear Black Hats?" *Journal of Professional Issues in Engineering Education and Practice,* 119(1):330–331, 1994.
9. This discussion is actually a composite of numerous sources, especially the videos *Ethics in Engineering,* Center for Applied Ethics, Duke University, Durham, NC, and *Incident at Morales,* National Institute for Engineering Ethics, Alexandria, VA.
10. The sources for this discussion are A. Blythe, Developer Has Plans for Large Homes, *News and Observer,* Raleigh, NC, June 29, 2004; and editorials in the *Chapel Hill Herald,* Chapel Hill, NC, in June 2004.
11. G. Hardin, Tragedy of the Commons, *Science*, 162, December 13, 1968.
12. Martin Luther King, Letter from Birmingham Jail, *Why We Can't Wait*, HarperCollins, New York, 1963.
13. P. A. Vesilind, *Engineers Working for Peace*, Bucknell University, Lewisburg, PA, November 15, 2003.
14. R. Niebuhr, *The Children of Light and the Children of Darkness* (1844), Prentice-Hall, Englewood Cliffs, NJ, 1974.
15. J. Rawls, *A Theory of Justice* (1971), Belknap Press Reprint, Cambridge, MA, 1999.
16. The *pro bono* movement within engineering is gaining currency with such organizations as Engineers Without Frontiers (http://www.ewf-usa.org/) and Engineers Without Borders (http://www.ewb-usa.org/). It is worth noting that engineering has been a helping profession from its beginnings, but like the medical profession, we can benefit from organized and systematized efforts at bringing our talents to those in need, especially those that are not readily seen in our daily lives, such as people in need of clean water in the far reaches of the world or in parts of our own cities that we do not frequently visit.