Engineering ethics
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Civil Engineering; Oct 1996; 66, 10; ABI/INFORM Global
pg. 40

ENGINEERING ETHICS

Recent revelations about the 1978 emergency retrofit of the Citicorp Center in New York City sparked an assessment of ethical dilemmas by the structural engineering community. Some prominent engineers reveal their ethical standards.

STANLEY H. GOLDSTEIN
ROBERT A. RUBIN

In May 1995, *The New Yorker* published an article describing a crisis in the 1978 construction of the 59-story Citicorp Center in midtown Manhattan. The crisis was precipitated by the discovery of a major flaw in the design by the building's structural engineer shortly after construction and occupancy. The article also described how the problem was solved. Although the problem and its solution were an open secret among the cognoscenti of the city's architects and engineers, it never made the press in all those years, mostly because there was a newspaper strike in New York City at the time the problem had been discovered and remedied.

Following the article and the wide attention it received, the engineer, William Le Messurier, of Cambridge, Mass., was lauded for his ethical conduct. (ASCE will reprint the article in the January 1997 *Journal of Professional Issues in Engineering Education and Practice.*) We were inspired to discuss the ethical dilemmas faced by engineers in somewhat less horrific situations than that of the Citicorp Center. To make the discussion more meaningful, however, we should first review the basic engineering of the structure.

AN INGENIOUS SOLUTION

The Citicorp Center is a 910 ft, steel-framed skyscraper, which, when built, was the seventh tallest building in the world. Its unique design was necessitated by unusual site constraints. The tower section, in plan, is a perfect square. However, it was necessary to reconstruct St. Peter's Church, the original occupant of the site, underneath one of the corners of the tower. As a result, the designers placed the four main support columns at the midpoints of the four facades, rather than at the four corners, so that the church could nestle under one corner of the tower. To the best of our knowledge, no other major structure has been built this way. Instinct warns the structural engineer that this creates a lessening of stability; however, that diminution can be overcome in the design.

In buildings taller than 30 stories, where the cost of lateral stability systems is significant, cost savings are achieved by using tube design, that is, a system in which the main lateral stability elements are at the outer perimeter of the building and are linked at the corners. In New York City's World Trade Center, for example, the lateral stability system consists of 110-story rigid frames encircling the building. Similarly, for Chicago's John Hancock Building, the lateral system consists of multistory diagonals linked to columns at the four corners that are visible and part of the architectural design. In the Citicorp Center, the lateral stability system consists of diagonals encircling the building and incorporating mast columns that are located at the midpoints of

0885-7024-/96-00010-0040/$04.00+50¢ per page

the sides of the building, rather than at the corners.

In buildings where the column supports are at the corners, broadside wind controls lateral stability design. Conversely, in structures where the column supports are at the midpoints of the four sides, it is the quartering wind that produces the most stress. In Fig. 1, under quartering wind, four of the diagonals are unstressed while the other four are doubly loaded.

The Citicorp Center crisis arose when Le Messurier, in attempting to use the Citicorp structural system in a different application, took the occasion to revisit his original design. In doing so, he recognized that when, during construction, the original butt-welded connection design for the wind-bracing system was changed to a high-strength bolted connection design, the full strength of the structural members might not have been developed in the connections for economic reasons. A check of the redesigned connections confirmed his suspicion. It therefore became necessary for him to review the actual forces that the connections were designed to withstand. That review disclosed that the connections had been designed only to withstand a 16-year storm, whereas the building had been designed to withstand, roughly, a 50-year storm.

To Le Messurier, a 16-year storm was totally unacceptable. He proceeded to notify the architect, his client and the building owner that a remedial scheme must be undertaken immediately before the risk of high winds in the fall hurricane season in

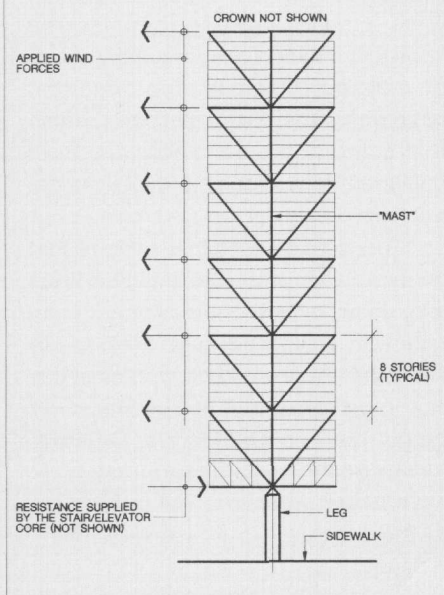

Figure 1. A simple diagram of the Citicorp Center's frame with the legs positioned at the sides of the building.

Selected Quotes

"The three situations you posed are not as hypothetical as you may think. Our office has experienced your cases 1 and 2. We have also been faced with problems similar to that posed in case 3.

"As you can understand, responding to the hypothetical cases is not all that easy. All of the pertinent facts and information needs to be gathered. This data needs to be properly analyzed. From this, the engineer needs to make the proper decisions and recommendations required so that the intent of the building code is met and a safe structure is provided for use by the public. This may not always be easy to do. Tough choices need to be made, but the engineer has an ethical obligation to the public to do his best to see that the right decisions are made and that a safe structure is provided."

HOWARD C. DUTZI, P.E.
Howard C. Dutzi & Associates, Inc.
Colorado Springs, Colo.

"From the professional's view, if the design does not conform to the code, then it is not necessarily unsafe. From the legal view, if the design does not conform to the code, then it is not proven safe. The engineer's ethical decision therefore cannot be solely dependent on the determination of code compliance, but rather still reverts back to the experience and judgment necessary to assess the life-safety risk."

JOHN TAWRESEY, S.E.
KPFF Consulting Engineers
Seattle

"It seems to me that these are both matters of personal and collective conscience. We work together to devise the codes against which many of these are made. In writing codes we make judgments regarding acceptable risk, both on the demand side (loads) and capacity side (strength, stiffness, ductility). Our objective is to preserve life safety by preventing collapse or life-threatening damage.

"That is the same concern activating these scenarios. The problem is one of time. The response time necessary in situations like the Citicorp case is such that code style deliberations and consensus can't help. Discrete events (and failures) help drive the process but it works slowly (it took 11 years to get the New York City Seismic Code in place for example). Still the two are related and could benefit by being thought about in tandem."

GUY J.P. NORDENSON
Ove Arup & Partners USA
New York

"While the hypothetical cases that you have posed are fairly realistic, the resolution of the ethical dilemmas is quite straightforward. They require disclosure and due process. Professional engineers have a tendency to take on too much responsibility. Usually second opinions, or panel evaluations, will lead to acceptable resolutions of very difficult situations. However, if an engineer believes there is 'clear and present danger,' ethics require action."

PROF. JOHN M. HANSON
North Carolina State University
Raleigh, N.C.

"Quite frankly, I find that every one of the three cases that you postulated could have a range of answers, including some that would contradict others. In a real-life situation involving potential conflict arising from design deficiencies, the handling and the resolution of the problem to a large degree depends on the trust, respect and the level of communication that the members of the team and the owner developed."

ISTVAN STEVEN VARGA, P.E.
Weidlinger Associates, Inc.
Cambridge, Mass.

"If the owner ignores the engineer's recommendations (to do the study or after the study) and the engineer believes that there is a safety or potential safety problem, I believe he or she has an obligation to make this very clear to the owner and let the owner know that if action is not taken in a timely manner there could be a problem. The engineer should also notify the owner that an en-

New York City. The problem was remedied in a span of approximately eight weeks, when new steel gusset plates were fillet-welded to all the critical connections.

As ethically commendable as Le Messurier's decision was, apparently it did not create an ethical dilemma for him or anyone else to whom the information became known. Suppose, however, his reanalysis of the Citicorp design had disclosed that the building as constructed could only withstand a 49-year storm, or a 40-year storm? In such cases a designer would certainly be faced with an ethical dilemma: whether or not to come forward with information that could subject him or her to adverse consequences. In other words, what guidelines does a designer rely on to make ethical decisions in the highly competitive, litigious society in which we currently operate?

ENGINEERS POLLED

It will come as no surprise to practicing engineers that problems of this nature are encountered, differing only by degree but not by substance, every day. In the simplest form of the problem, we are responsible for deciding and accepting imperfect performance by ourselves, our colleagues, our clients, our subordinates, our consultants and even our contractors. Many of us have been forced to do this so many times over the years that we have become inured to the ethical implications of our decisions.

At our request, CIVIL ENGINEERING posed three hypothetical ethical dilemmas to prominent U.S. structural engineers. Their answers expressed the protection of public health and safety as paramount importance, and all evidenced high ethical standards. But all had somewhat different ethical perspectives and many came to the same conclusion using somewhat differing logic. No one tackled the toughest question: in a situation similar to that of the Citicorp Center, when would they go public—at a 49-year storm, a 40-year storm—and by what rationale?

Results of the responses of the prominent U.S. structural engineers served to reinforce our own belief that while most engineers probably have fundamentally sound ethical value systems, all could probably benefit from specific training in ethical decision-making processes and on how to resolve ethical dilemmas. This is a severe shortcoming of engineering undergraduate and continuing education, and the subject should be given greater emphasis in ASCE publications and programs. ▼

gineer is obliged to notify the governing authorities, such as the building department, if he or she is aware of an unsafe condition that is not being remedied. (Some local laws actually state this as a requirement for professional engineers.) In the final analysis, if the owner takes no action and the engineer believes that there is a significant problem or potentially significant problem the engineer must take action and notify the appropriate authorities."

RICHARD L. TOMASETTI, P.E.
Thornton-Tomasetti Engineers
New York

"Our democratic institutions do not have the mechanism to protect vigilantes. If the reviewing engineer 'blows the whistle,' he or she becomes exposed and vulnerable. A remedy to this situation would be to establish independent boards of review to whom the reviewing engineer could submit his findings for appropriate action by the board."

OTHAR ZALDASTANI, P.E.
Zaldastani Associates, Inc.
Boston

"One should announce a mistake just because that is the right thing to do. But one often does not do so. The immediate urge is either to tell or to keep quiet. And then the trepidation begins. The unproductive hours and days of redoing and rechecking in the office, the rethinking on the train twice a day, the sleepless nights, and the constant lump in the stomach take their toll and the dilemma grows. It becomes not only a matter of professional correctness but of one's inner psychological battle. Just how bad is it? And what can happen? In one imaginary scenario one blows it completely out of proportion, in another one minimizes it to a glitch.

"I have made two design mistakes that I know of in my 30-year career that weighed on me very heavily at the time. After a day or two of trepidation I announced these mistakes both times. Most interestingly, both turned out to be inconsequential with no danger and no cost to anyone. The damage was that to my self-confidence and ego.

"I don't believe one can look at the issue purely on the basis of liability and ethics; the psychological forces are powerful drivers."

ROBERT T. RATAY, P.E.
Manhasset, N.Y.

"There is a general tendency in the country, I believe, to conceal design and construction problems. This is to avoid adverse publicity as well as potential litigation. The net result is that the knowledge that is gained from failures is not available to the profession, and future generations of engineers will have the same problems. I am personally aware of many similar problems, such as the caisson construction problems in Chicago in the 1960s and the sway problems of unbraced steel frames.

"The second ethical dilemma is what should be done by outside professionals who know that a design problem exists even though it is not publicized. Engineers look down on the medical profession, which is seen as protecting its own rather than protecting the public welfare. What is the appropriate forum for a review of the problem and the professional conduct?

"I believe that the matter should be taken up immediately by the professional licensing agency and appropriate action taken. This agency should also publicize the problem (in generic form if necessary) to increase the knowledge base. I am personally aware of well-known engineering firms that have thrived for years despite the fact that some of the buildings they have designed have problems that were not publicized.

"The third danger that I see is that many smaller and less qualified firms take on projects that they are not competent to design because they do not know that there could be problems. It is scary to think that if Mr. Le Messurier could have problems on Citicorp, lesser qualified engineers may have even larger problems. The publication of the Citicorp story is a very timely reminder."

JOSEPH P. COLACO, P.E.
CBM Engineers, Inc.
Houston