STRUCTURAL INTEGRITY AND MORAL INTEGRITY

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THE DILEMMA

As engineers, a confliction readily appears in regards to cost efficiency against quality. Civil Engineer A of Peace Corps was assigned the task of the design and building of a desalination though electrodialysis plant in rural Uttar Pradesh, India. Desalination is the process of removing high salt contents from groundwater in order to render it drinkable. Of the total volume of water on Earth, nearly 97% is contaminated by salt and therefore undrinkable [1].

Electrodialysis uses oppositely charged chambers which extract the positive Na cation from the negative Cl anion of salt and yields an output of drinkable water in the ninetieth percentile [2].

The byproducts of this process is acidic hydrochloric acid (HCl) and basic sodium hydroxide (NaOH). The predicament that remains is what to do with these extreme pH substances. Electrodialysis, although a very efficient system, requires an expensive building process for the necessary plant, estimated at 3.4 million dollars [1]. Civil Engineer A’s method of reducing the overall price is to cut the corners of disposal of the HCl and NaOH byproduct solutions. He initiates the building of two aluminum tanks underground which will hold the separate solutions. Aluminum is a relatively cheap metal and brings the overall cost down significantly.

The plant works flawlessly and provides drinkable water for several years to come, earning him praise and a well-respected reputation. Nearly a decade later, Engineer A travels back to India for an inspection of his electrodialysis plant and to see how community has changed. What he notices is, in seasonal harvest time, most of the nearby crops are withered or nonexistent. He checks the pH of the groundwater in a few puddles and records noticeable variance in acidity. When he reviews the integrity of his plant, he finds significant corrosion occurring on the aluminum tanks holding the hydrochloric acid and sodium hydroxide.

POSSIBLE OUTCOMES

Confession

The usage of aluminum for the holding tank was clearly not the correct metal to maintain structural integrity. Both very acidic and basic solutions will corrode weaker metals after a long period of time. What needs to be done is a replacement of the two tanks such as stainless steel that has a high concentration of chromium. This alloy is very resistant to corrosion and would keep the solutions without leakage.

Withholding

In opposition, Civil Engineer A may choose to censor his report and withhold his findings in the aluminum tanks. Yes, this is morally wrong, but I wouldn’t be naive enough to think it hasn’t happened before. This would save his reputation for the time being, but the effects of the decision in Uttar Pradesh may increase drastically over time. As the solutions leak into the soil, the pH levels will only grow closer towards more extreme acidity and basicity. A positive outcome would be the maintaining of his job at Peace Corps and also his status. The negative result would be the possibility someone else discovers the rusting and exposes him, along with the deterioration of the surrounding land.

CODE OF ETHICS

Both the National Society of Professional Engineers (NSPE) and American Society of Civil Engineers (ASCE) Code of Ethics are beneficial resources in this dilemma. A code of ethics is a set of rules and guidelines that must be followed so that someone can be a recognized member of an organization. The Canons of the NSPE are as follows:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as a faithful agent or trustee.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession. [3]
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The NSPE Code of Ethics are rules of conduct that have been established by the engineering community that list the duties of professional engineers to society. The Canons of the American Society of Civil Engineers Code of Ethics include all that the NSPE list and additionally, “Engineers shall continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision” [4]. The first Canon, “Hold paramount the safety, health, and welfare of the public” and the fifth “Avoid deceptive acts” are fool proof aids in this decision making process [3].

Following these guidelines, the confession route would be chosen as the health of the community depends on it and the withholding of that information would be considered a deceptive act. Engineers are expected to follow this conduct to ensure an integrity of the profession.

SIMILAR SCENARIOS

Citicorp Tower

William LeMussurier, one of the leading structural engineers of the 1970s, was assigned to consult the building of the 59-story Citicorp Tower in New York City [5]. His credentials included degrees from both Harvard and MIT, with management of previous buildings such as the National Air and Space Museum and Federal Reserve Bank in Washington, D.C. [5].

The contractor suggested a switch from welding to bolted joints in the tower which would cut costs by a total of 250,000 dollars [6]. LeMussurier approved the switch, but failed to re-approximate where the four main supports for the building should be placed [5]. Only a month after, he received a phone call from an engineering student who showed his concern in where the supports had been placed [6]. LeMussurier ignored the plea at first, but after calculating the structural physics of the tower once again, realized his mistake. If a strong wind pulled apart a joint on the thirtieth floor, the whole building would collapse [6].

He took a weekend to consider all that may go wrong for him if he notified the management of his mistake, but he soon admitted his fault and confessed to the Citicorp chairman and vice president. They approved the repair proposal and 2,000 Red Cross workers evacuated the area within ten blocks [5]. Citicorp sued LeMussier four million dollars, but accepted the two million that his insurance company provided and agreed to not find his firm at fault [6]. In 1998, he was awarded the honorary degree of Doctor of Engineering from Rensselaer Polytechnic Institute for his immense integrity [5].

Olympic Stadium Light Tower

The construction of the 1996 Olympic Games stadium in Atlanta, GA included plans for a light tower in the 232 million dollar budget [7]. Brian Miraki, the structural engineer for the light tower, noticed an error in the blue print design for a portion to be built. He reported the error to the managing architect, but was unaware what stage construction was in and considered it not an emergency. Ten days later, the tower collapsed, and one iron worker fell to his death [7]. Miraki’s occupational license was suspended for three years and he was sued for wrongful death [7]. Although he did report the miscalculation, the lack of urgency turned out to be fatal.

Tacoma Narrows Bridge

A similar structural integrity situation is the “Galloping Gertie” incident of the 1940s. The Tacoma Narrows Bridge went under construction in 1938 with a budget of 6.4 million dollars, much lower than the Tacoma Chamber of Commerce had initially estimated [8]. At the time, this structure was to be the third longest suspension bridge in the world, behind the George Washington and Golden Gate bridges in New York and San Francisco, respectively [8].

The bridge was not built with proper resistance to the resonance caused by the high winds of Washington state, due to the corners cut in the budget. The nickname “Galloping Gertie” came from the mild transverse buckling in which one half of the bridge would lower as the other raised from wind blowing over the river below [8]. In November of 1940, the bridge experienced vibration so extreme that the supports gave out and the whole structure fell into the river [8].

Challenger Explosion

On January 28, 1986 the space shuttle Challenger exploded into flames on live television [9]. The shuttle mission just prior to the Challenger had been delayed a record number of times due to poor weather and mechanical factors. NASA wanted to launch the Challenger without any delay [9].

Alan McDonald, the director of the Space Shuttle Solid Rocket Motor Project, was concerned that below-freezing temperatures might impact the integrity of the solid rockets’ O-rings [9]. The O-rings help overcome the gravitational pull of Earth’s atmosphere, but froze up in the cold temperatures. McDonald refused to sign off on the launch recommendation. When engineers told NASA not to launch, NASA’s upper management said they wanted them to prove the launch would fail. Morton Thiokol Firm engineers and management presented all the proof they could to NASA that the launch would be disastrous, but NASA did not back down [9].

The importance of effective communication in engineering is vital. The engineers did the right thing in bringing light to the situation, but it is unfortunate that no one in management listened to them.
PLATO’S ETHICS

Plato conceptualized many theorems regarding moral philosophy in ancient Greece that can be applied in modern times. One of his concepts, ethical egoism, states that all of our actions can be reduced to self-interest [10]. In the dilemma of Civil Engineer A, Plato’s ideals on ethical egoism would result in the withholding of the leakage in his report, serving himself. This concept is a counterexample in which the good of the society is being put at risk for the benefit of one individual.

Conversely, Plato’s utilitarianism is defined as the choice of decision which yields the most amount of good for the most amount of people [10]. I believe this rule instead can be a vital tool used in engineering. The replacement of the aluminum tanks in this situation and possible ruining of Civil Engineer A’s reputation would be way of utilitarianism. The restoration of healthy agriculture in the surrounding area would be the most significant outcome and therefore a choice of humility.

With the wellbeing of the community in mind, ethical dilemmas become clearer if self-interest is put aside. Engineering is very rewarding, but also a significantly selfless occupation. Although professional engineers are not likely to search for guidance in the writings of Plato, his concepts can be considered in the act of decision making.

WHEN FACED WITH AN ETHICAL DILEMMA

As a recommendation to other engineers faced with ethical dilemmas in their field of work, I suggest a few tactics in the decision making process. The National Society of Professional Engineers Code of Ethics as well as your respective engineering discipline’s Code is a fool proof compilation of guidelines. Engineers need to be level headed and open minded. There will be times where integrity will be put on the line: a bribe, a mistake, a lack of communication.

Additionally, Plato’s ideals on utilitarianism are a solid base for morals and ethics in engineering. The most amount of good for greatest amount of people is what engineering is. It will usually pay off to do the right thing, as seen in LeMussurier’s dilemma with the Citicorp Tower [5]. His integrity was praised in the end and the problem was fixed without anything catastrophic happening. There are a lot of people counting on engineers to come up with solutions to these problems.

CONCLUSION

Every working career will produce at least one ethical dilemma, especially in engineering. It is vital that we as engineers follow the guidelines set down by the Codes of Ethics. Ethics in a sense is the branch of philosophy asking “how should one act?” The answers to this question is not as obvious at some times compared to others [11].

Civil Engineer A was presented with an ethical dilemma in which he chooses either his reputation or the wellbeing of others. The obvious choice in this situation, for me personally, would be the immediate redesign of the electrodialysis byproduct tanks of HCl and NaOH. I would hope that all engineers would see it this way as well, but not everyone has the same morals or ethics in general.

Society counts on the engineering community to fix the problems we have now and stop the ones in the future from happening. With balanced ethics and a healthy sense of logical reasoning, engineers possess that type of ability.

REFERENCES

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