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Engineering Disasters: An Ethical Take on Accident Prevention in Recent History

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Engineering Disasters: An Ethical Take on Accident Prevention in Recent History

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Abstract-- **As engineers, there is an expected level of quality in the products we design. To the public eye, engineers run their pens across paper to create skyscrapers and bridges as wizards wave their wands across parchment to create gold. When businesses hire engineering firms to design and construct a device or formulate plans for mines or oil rigs, they put their trust in the engineers to make good ethical decisions. Most of the time, that trust is well placed and everything goes off without a hitch, but what happens when something goes wrong? What happens when even the most meticulous care goes into planning a job, but during execution, everything goes up in flames? This analysis will discuss where the fault lies in those circumstances as well as possible solutions which would make engineering disasters less frequent.**

I. INTRODUCTION

IN this day and age, the field of engineering is constantly expanding. [1] The total number of engineers in the US in 2012 averaged somewhere around 1.5 million; while the Bureau of Labor Statistics reported that in 2015, there were about 1.6 million engineering occupations. [2] During both of those years, both mechanical and civil engineers topped the workforce with a combined five hundred and twenty thousand careers in 2012 and five hundred and sixty thousand careers in 2015. That is a growth of forty thousand mechanical or civil engineers in three years' time with almost half of new engineers falling under one of those two categories.

With tens of thousands of engineers entering the workforce each year, consumers would expect to see mechanical and medicinal products as well as the quality of homes, buildings and other structures exponentially increase over time. While this expectation is mostly true with each year seeing new innovations in vehicular safety, crop lifespans, and computer software security, each year also brings the possibility of a disaster caused either in part or solely by the mistakes of an engineer or group of engineers.

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Mistakes are bound to happen in a field undergoing an influx of young men and women who all have dreams of creating innovations to better the lives of the American public.

Most engineers follow, or are expected to follow, their own personal code of ethics based on how they were raised, their religious beliefs, or by personal experiences. However, professionally, engineers are trained to adhere to a code of ethics that guides their most basic decisions in the workplace. [3] The National Society of Professional Engineers (NSPE) Code of Ethics for Engineers, a document that underlines the ethical rules and limitations by which engineers should do business, maintains that engineers should engage in the following six fundamental canons:

- "Hold paramount the safety, health, and welfare of the public."
- "Perform series only in areas of their competence."
- "Issue public statements only in an objective and truthful manner."
- "Act for each employer or client as faithful agents or trustees."
- "Avoid deceptive acts."
- "Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession."

Engineers generally follow these guidelines, but if any are overlooked even slightly during the process of doing business, grave problems could arise either for the individual engineer or to the greater public.

II. ETHICAL ISSUES

While it might seem improbable that an engineer would break their code of ethics in the middle of a job, it is most certainly not unheard of. For example, when a student who lives twenty minutes down the road from their college campus wakes up in the morning late for an exam, there is a good probability that they will overlook a few road laws to get to their exam on time. In that same way, an engineer who is quickly approaching the deadline for a project may cut a few corners in the design or safety testing processes to produce a working product. The client may accept the product and everyone move on with their day, but if the engineer develops a habit of waiting to complete contracts at the last minute, eventually he or she will make a mistake that could cost them their reputation, job, or the health and safety of other individuals. However, not all mistakes that occur in the engineering field are the product of lazy engineers as miscommunication is the foundation of many engineering disasters.

A. Lake Peigneur Drilling Accident

In 1980, Texaco contracted the Wilson Brothers Drilling company to drill for oil in Lake Peigneur in Iberia Parish, Louisiana. On November 20th of that year, drilling began and went smoothly until the rig's drill bit breached a network of salt mines underneath the lake. After hearing loud popping noises coming from below the surface of the water, workers realized that the base of the oil rig had begun to shift and was slowly overturning. The bit had entered the top of the third level of the Diamond Crystal Salt Mine which caused thousands of gallons of water to rush into the caves and dissolve the salt which supported the mine. The resultant whirlpool, which was caused by the contents of the lake being emptied into the quickly eroding 1,500-foot-deep hole, reversed the flow of the Delcambre Canal that led out into the Gulf of Mexico. These factors all worked together to create a 164-foot waterfall as the Gulf of Mexico slowly filled up the crater where Lake Peigneur once sat.

Fig1. Waterfall formed as the salt water from the Gulf of Mexico slowly filled Lake Peigneur [4]

The drilling company workers watched in horror as the multimillion dollar drilling platform as well as seventy acres of dirt, trees, vehicles and buildings sank into the belly of the lake. In addition, eleven barges full of vehicles and equipment as well as a tugboat and small fishing boats were all dragged down the Delcambre Canal and deposited into the chasm. It was not until several days later that a few barges popped up from under the water like rubber ducks while others remained submerged deep under the surface of the lake. In a matter of days, the once eleven-foot-deep freshwater body had been transformed into a 1,500-foot salt water lake.

Thankfully there was no loss of human life as the fifty-five miners who were underground at the time quickly evacuated. The only reported deaths were of three dogs who belonged to Louisiana residents who lived nearby. There was, however, a great loss of time, money, and land for Texaco, the Diamond Crystal Salt Company, and the people who owned land around the lake. [5] With the average cost of cargo barges along with land prices [6], not to mention the oil rig itself, there was an estimated loss of at least 14.6 million dollars with respect to prices in 1980. ((Average cost of cargo barge) $2.5 million * 11 barges + (cost of fertile land in Louisiana) $2,800 * 70 acres = $27,696,000). [7] (To relate current prices to prices in 1980, ($27,696,000 * $34.77) / $100 = $9,629,899.2 + $5 million (price of rig in 1980) = $14,629,899.20). That is without considering the small boats, equipment, vehicles, and homes that were lost in the maelstrom.

After having seen the effects of this disaster, one might wonder how such an incident could have happened. Possibly a mechanical part of the oil rig failed which led to the bit drilling too far, or maybe even a disgruntled employee hijacked the oil rig controls to sabotage Texaco's operations. While both of those cases may or may not be plausible, the real reason that so much disaster occurred and money was lost was because of misdirected orders and a lack of communication. The engineers and surveyors who decided where the rig should drill formulated plans that indicated a spot on the lake designated in the transverse Mercator projection coordinate system; however, the orders were miscommunicated for the rig to drill at identical coordinates in the Universal Transverse Mercator coordinate system. The coordinates pointed to two very different locations in those two seperate coordinate planes and because of a lack of accountability or a system that encourages double and triple checking locations before drilling, a terrible accident occurred. That whole event could have been prevented, but due to engineers who had no desire to verify that their orders had been followed, or frankly were too lazy to make sure, Texaco had to pay $32 million to Diamond Crystal Salt company in damages as well as $12.8 million to Live Oak Gardens, a local plant nursery.

B. Challenger Space Shuttle Disaster

January 28 marks one of America's greatest disasters as in 1986 the NASA Space Shuttle *Challenger* fell apart and exploded seventy-three seconds into its launch resulting in the deaths of its seven crew members. The critical system failure was caused by an O-ring seal, responsible for maintaining the shuttle's right solid rocket booster, which was destroyed when the shuttle attempted lift-off under poor weather conditions.

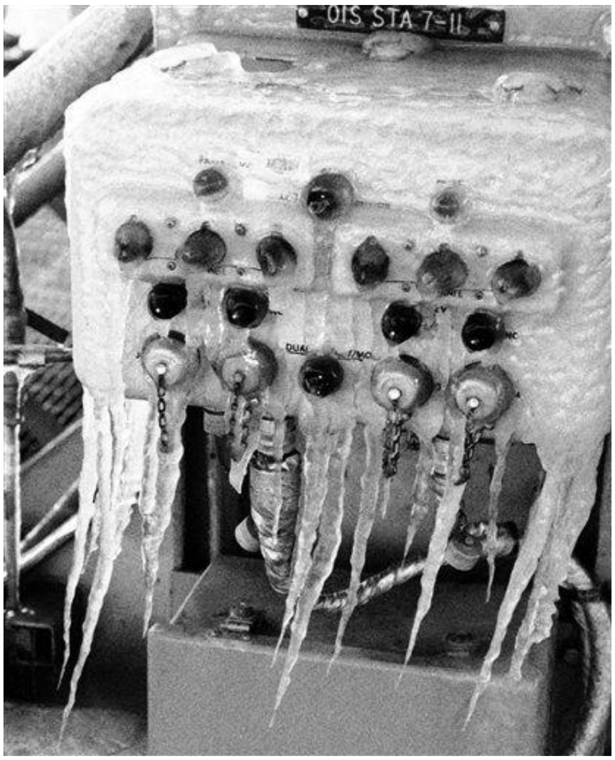

Fig2. Cold conditions led to critical components freezing before the launch [8]

Towards the end of the design and manufacturing process of the *Challenger* shuttle, there was an unspoken suspicion that the O-ring components would not behave as expected in extreme conditions. Morton Thiokol, the contractor who initially designed the O-rings, encountered problems when testing the O-rings under conditions equivalent to the ignition of booster rockets. However, it was decided that the original design would be safe enough for launch. There were a few engineers who vied for a postponement of the shuttle launch as temperatures on the day of the launch were projected to be below the level at which the O-rings were expected to operate. The engineers on the governing board at NASA refuted any suggestions that the launch would be unsafe and allowed the launch to go as planned. One of the men against the expedited launch, Bob Ebeling, who oversaw analysis of pre-launch data, took note of the possibility of failure at cold temperatures. He proposed that NASA delay the launch temporarily, but officials claimed that there was not enough concrete data that pointed towards any chance of a safety failure. [9] Bob disagreed however and in an interview with NPR in 2016, stated:

> "There was more than enough [NASA officials and Thiokol managers] there to say, 'Hey, let's give it another day or two…[but] no one did."

It is assumed that NASA pushed for an immediate launch of *Challenger* as they were already behind schedule and wanted to appear as if they could quickly and efficiently produce mission launches. That complete refusal to overlook safety to comply with strict scheduling was what directly led to the failure of the mission and most importantly, the loss of seven incredibly brave and innocent souls.

C. New Orleans Levee Failures during Hurricane Katrina

When Hurricane Katrina made landfall in Mississippi on August 29th, 2005, it brought with it tens of billions of gallons of water from the Gulf of Mexico which utterly destroyed most of New Orleans, Louisiana and the surrounding regions. Many years prior, the US Congress, attempted to prevent widespread destruction in the wake of a severely powerful storm by authorizing the United States Army Corps of Engineers to construct a preventative system which would allow walls of water to bypass the city. With ability to design as they saw fit, engineers devised plans to build a levee system, a wall which would prevent water from rushing over the embankments of the city's several canals. Construction on the system began in 1965, but had not been fully completed in 2005 when Hurricane Katrina formed in the Gulf of Mexico.

Fig3. Water levels rose to flood 80% of New Orleans [10]

The levee system was mostly finished before the storm so there should not have been nearly as much destruction.

The official cause of the levee failures was poor planning and design on the part of the Corps of Engineers.
[11] IPET, the Interagency Performance Evaluation Task Force, stated in their findings during their investigation of the disaster:

> "With the exception of four foundation design failures, all of the major breaches were caused by overtopping and subsequent erosion. Reduced protective elevations increased the amount of overtopping, erosion, and subsequent flooding, particularly in Orleans East. Ironically, the structures that ultimately breached performed as designed, providing protection until overtopping occurred and then becoming vulnerable to catastrophic breaching."

Those foundational design flaws increased the levee system's probability of failure and while it might not have resulted from malintent on the part of engineers, problematic scenarios should still have been simulated and solutions for such an incident should have been tested. Had the engineers who designed the levee system put more effort into fully completing the project. Hurricane Katrina could quite possibly not have caused as much damage as it did.

III. ETHICAL FRAMEWORK

A. Professional Ethics

From a professional standpoint, all engineers are expected by their employers to provide services that both better both the state of their companies and the lives of the public. Not all engineers have a direct hand in the well-being of the average Joe. However, in one way or another, businesses, and by extension, the engineers who work for them, provide services that do affect large numbers of people. That being said; companies should only want to hire engineers who they can trust to make the choices that best represent their values. When Texaco contracted the Wilson Brothers, they expected the job to be completed quickly and efficiently. The men who oversaw the translation of the drilling location at Lake Peigneur obviously did not put enough care into making sure the job was completed correctly. [12] Because of that, both Texaco and the drilling company saw great financial loss with the Wilson Brothers being sued several times throughout the next decade for similar poorly executed jobs. The engineers on the deciding board at NASA had a professional responsibility to their company to protect their name as well as protecting their astronauts. They however chose to allow the launch to continue even with more than enough evidence to prevent the shuttle from launching. Their decision directly led to the US Air Force to cancel plans to use manned capsule launches in favor of the Titan IV unmanned vehicle. [13] Similarly, the Corps of Engineer's negligence of completing the construction of the levee system lead to an estimated 135-billion-dollar loss which was mostly paid for by the federal government.

B. Common Morality

Being able to analyze a situation and determine whether an unethical act has taken place, regardless as to if that individual was raised to understand the difference between right and wrong, is an incredibly important skill to utilize. In the engineer world, everything must be filtered through the following questions: "Does this decision have the ability to better the lives of others? Could this possibly harm someone?" Being able to formulate a solid decision from that as well as act on it shows a level of ethical maturity that engineers should be expected to have. Between these three cases, the only individual who used that mindset and came to an ethical conclusion was Bob Ebeling. He, unlike the surveyors at Lake Peigneur, the NASA officials during the launch of *Challenger*, and the members of the Corps of Engineers, recognized an unethical decision and attempted to change the course of his situation.

C. Personal Ethics

All three of these cases represent times where individuals have neglected to reflect on how all decisions result in some type of a domino effect. Each choice can lead to larger consequences in the same way as how knocking down the first domino in a line leads to several dominos falling over. It is understandable that no one person can see how the effects of a single decision will play out over time, but maintaining the safety and health of others as well as the environment, is a crucial aspect of being an engineer. Any situation where the lives of others are at risk should be treated with the utmost care, regardless of factors such as a job being behind schedule or the laziness of those involved.

IV. STEPS FOR FACILITATING SOLUTIONS TO ETHICAL ISSUES

I am certainly not claiming to have enough knowledge to have been able to stop Hurricane Katrina from having formed, but I do have simple solutions to each of the aforementioned problems. Firstly, the engineers involved in the planning of the drill site at Lake Peigneur should have properly communicated the corrected coordinate system they intended for the workers to use. For the *Challenger* disaster, the NASA officials should not have been so consumed with meeting such strict launch dates and been more focused on protecting the lives of the astronauts. Lastly, in the case of the New Orleans levee failure, if the Corps of Engineers had put more time towards fixing possible design flaws and finalizing the construction of the system, there would have been much less destruction.

V. IMPACT OF SOLUTIONS

Had the engineers at Lake Peignuer simply made one hundred percent certain that they were drilling at the proper location, all the parties involved in the disaster could have been saved an enormous amount of money and time. The Wilson Brothers drilling company would have gained a positive reputation in the oil world as having been able to successfully complete their contract and the area surrounding the lake would not have gone through such a drastic change. For NASA, even having postponed the launch long enough to scrutinize the safety of the O-rings would have prevented the loss of the shuttle and its crew. As New Orleans sits at the bottom of a natural bowl formation in the earth, Hurricane Katrina would likely have still caused a great loss of money and life, but considerably less.

VI. CONCLUSION

It may seem simple for a passive observer to look back throughout the history of engineering and point to decisions that directly lead to horrible disasters. However, for the individuals who were involved in making those decisions, it more than likely seemed to be the best choice at the time. Similarly, engineers in this day in time may be blind to the choices they are making which could have devastating consequences. The only way for us to be certain that we are making the correct choices is to maintain an informed and observant state of mind and follow the set of ethical guidelines that we as engineers are expected to adhere to: Always put first the safety of others. Only perform jobs for which you are qualified. Speak to others truthfully. Stay committed to your employer and never go against your word. Never attempt to mislead someone as to the truth. Most importantly, be professional and act ethically in doing everything in your power to maintain the honor and reputation of the engineering profession.

VII. ACKNOWLEDGMENT

VII. REFERENCES

Web-based Resources:

[1] Congressional Research Service (2017, November 2). The U.S. Science and Engineering Workforce: Recent, Current, and Projected Employment, Wages, and Unemployment. [Online]. Available: https://fas.org/sgp/crs/misc/R43061.pdf. Accessed December 9, 2017.

[2] Bureau of Labor Statistics, U.S. Department of Labor (2016, October 17). Employment and wages of engineers in 2015. [Online]. Available: https://www.bls.gov/opub/ted/2016/employment-and-wages-of-engineers-in-2015.htm. Accessed December 8, 2017.

[3] National Society of Professional Engineers (2017, July). Code of Ethics for Engineers. [Online]. Available: https://www.nspe.org/resources/ethics/code-ethics. Accessed December 9, 2017.

[4] Losapos (2017). Lake Peigneur, the biggest man-made vortex ever. [Online]. Available: http://www.losapos.com/lakepeigneur. Accessed December 8, 2017.

[5] Sun Machinery Corp (2017, December 5). Barges for Sale. [Online]. Available: http://www.sunmachinery.com/barges_for_sale.html. Accessed December 8, 2017.

[6] United States Department of Agriculture (2015, August). Land Values 2015 Summary. [Online]. Available: https://www.usda.gov/nass/PUBS/TODAYRPT/land0815.pdf. Accessed December 9, 2017.

[7] Amadeo, Kimberly (2017, August 3). What is the Value of a Dollar Today? [Online]. Available: https://www.thebalance.com/what-is-the-value-of-a-dollar-today-3306105. Accessed December 9, 2017.

[8] Tate, Karl (2016, January 28). The Space Shuttle Challenger Disaster: What Happened? (Infographic). [Online]. Available: https://www.space.com/31732-space-shuttle-challenger-disaster-explained-infographic.html. Accessed December 8, 2017.

[9] Berkes, Howard (2016, January 28). 30 Years After Explosion, Challenger Engineer Still Blames Himself. [Online]. Available: https://www.npr.org/sections/thetwo-way/2016/01/28/464744781/30-years-after-disaster-challenger-engineer-still-blames-himself. Accessed December 9, 2017.

[10] Eggler, Bruce (2011, May 26). Hurricane Katrina levee breach sites floated for National Register of Historic Places. [Online]. Available: http://www.nola.com/katrina/index.ssf/2011/05/hurricane_katrina_levee_breach.html. Accessed December 9, 2017.

[11] Wikipedia (2017, November 30). Space Shuttle *Challenger* disaster. [Online]. Available: https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster. Accessed December 9, 2017.

[12] United States Court of Appeals (1983, October 6). Federal Reporter (Second Series) [Online]. Available: https://openjurist.org/719/f2d/96/robin-v-wilson-brothers-drilling, Accessed December 10, 2017.

[13] Plyer, Allison (2016, August 26). Facts for Features: Katrina Impact. [Online]. Available: https://www.datacenterresearch.org/data-resources/katrina/facts-for-impact/. Accessed December 10, 2017.

VIII. Author's Biography

I am currently a Junior at the University of West Florida pursuing a degree in Computer Engineering. When not at school I work part-time at Gulf Winds Federal Credit Union as a teller at our corporate branch. I also enjoy spending my free time with my family, friends and my girlfriend Haylee. I am active in the College and Career ministry at Highland Baptist Church in Molino, Florida. I am very thankful that God has blessed me by allowing me to pursue my degree as well as provide service that soars above for my members at Gulf Winds.