Engineering Disasters and Learning from Failure

The role of the engineer is to respond to a need by building or creating something along a certain set of guidelines (or specifications) which performs a given function. Just as importantly, that device, plan or creation should perform its function without fail. Everything, however, must eventually fail (in some way) to perform its given function with a sought after level of performance. Hence, the engineer must struggle to design in such a way as to avoid failure, and, more importantly, catastrophic failure which could result in loss of property, damage to the environment of the user of that technology, and possibly injury or loss of life. Through analysis and study of engineering disasters, modern engineering designers can learn what not to do and how to create designs with less of a chance of failure.

What Makes a Failure Into an "Engineering Disaster"?

Much of the reason why we consider an engineering failure to be an engineering "disaster" has to do with public perception of risk. For example, in 1992 roughly the same number of fatalities occurred (in the United States) in transportation accidents involving airplanes (775), trains (755), and bicycles (722). Yet the public perception of the risk associated with air travel is often much higher than that for trains and certainly for bicycles. This stems from two reasons: (1) the large loss of life (and associated wide spread news reporting) resulting from a single air crash, and (2) the air passenger's lack of control over their environment in the case of air or, to a lesser degree, rail accidents. Both of these reasons results in increased fear, and hence a higher degree of perceived risk.

Primary Causes of Engineering Disasters

The primary causes of engineering disasters are usually considered to be

- human factors (including both 'ethical' failure and accidents)

- design flaws (many of which are also the result of unethical practices)
- materials failures
- extreme conditions or environments, and, most commonly and importantly
- combinations of these reasons

A recent study conducted at the Swiss federal Institute of technology in Zurich analyzed 800 cases of structural failure in which 504 people were killed, 592 people injured, and millions of dollars of damage incurred. When engineers were at fault, the researchers classified the causes of failure as follows:

Insufficient knowledge
..... 36%
Underestimation of influence
..... 16%
Ignorence, carelessness, negligence
..... 14%
Forgetfulness, error
..... 13%
Relying upon others without sufficient control
..... 9%
Objectively unknown situation
..... 7%
Unprecise definition of responsibilities
..... 1%
Choice of bad quality
..... 1%
Other
..... 3%

Engineering Ethics

Often, a deficiency in engineering ethics is found to be one of the root causes of an engineering failure. An engineer, as a professional, has a responsibility to their client or employer, to their profession, and to the general public, to perform their duties in as conscientious a manner as possible. Usually this entails far more than just acting within the bounds of law. An ethical engineer is one who avoids conflicts of interest, does not attempt to misrepresent their knowledge so as to accept jobs outside their area of expertise, acts in the best interests of society and the environment, fulfills the terms of their contracts or agreements in a thorough and professional manner, and promotes the education of young engineers within their field. Many of these issues are discussed in detail at the ethics homepage of the National Society of Professional Engineers. There you will find an example of an engineering Code of Ethics and links to additional information on engineering ethics. Or check here our list of some codes of Engineering Ethics. Failures in engineering ethics can have many legal consequences as well, as in the case of a mall collapse in Korea.

Thirty five faculty members from around the country have created a number of case problems in several engineering disciplines which intertwine technical calculations with engineering ethics. These were presented at a 1995 workshop at Texas A&M, sponsored by the National Science

Foundation.

The site for Applied Ethics in Professional Practice Case of the Month Club created and maintained by then Professional Engineering Practice Liaison Program in the College of Engineering at University of Washington, provides the opportunity to review a particular case study which involves engineering ethics and then vote on which course of action should be taken. All cases are based on actual professional engineering experiences as contributed by a board of practicing engineers nationally. Background information on codes of ethics is also provided at this site.

A Few Links to Information on Engineering Disasters

Aerospace	**Civil**	**Others**	**More !**
Columbia Shuttle	WTC Collapse	Titanic	Importance of failure
Concorde	Quebec Bridge	Fuel Rod (Nuclear)	Space.com
TWA Flight 800	Earthquake(s)	Bhopal (Chemical)	Chelyabinsk (Nuclear)
			Earthquake Rescue

Powerpoint presentation on Forensic Engineering by David W. Fowler, University of Texas at Austin

News article from the European Space Agency on how "radio engineer Boris Smeds has become a modest celebrity for his single-handed discovery of a fatal design flaw in Huygens' radio relay link".

Web page with many links to engineering disaster case studies and ethics issues from the University Library at the California State University in Long Beach. The site has disasters categorized by area of engineering (mechanical, electrical, etc.)

Engineering Disaster Bibliography

The following are a list of excellent reference sources which contain information on engineering disasters or failures and their consequences:

- "Breakdown: Deadly Technological Disasters", by Neil Schlager, Visible Ink Press, Detroit, 1995
- "Set Phasers on Stun", by Steven Casey, Aegean Publishing Co., Santa Barbara, 1993
- "To Engineer is Human", by Henry Petroski, Vintage Books, New York, 1992
- "Design Paradigms : Case Histories of Error and Judgment in Engineering", by Henry Petroski, Cambridge University Press, Cambridge, 1994
- "Civil Engineering Practice: Engineering Success by Analysis of Failure", by David D.A. Piesold, McGraw-Hill Professional, New York, 1991
- "When Technology Fails: Significant Technological Disasters, Accidents, and Failures of the Twentieth Century",

by Neil Schlager (Editor), Nell Y. Schlager (Editor), Gale Group, New York, 1994
- "Inviting Disaster: Lessons From the Edge of Technology", by James R. Chiles, Harper Business, New York, 2002

Example of Assignments Related to Engineering Disaster

Pick an example of an engineering failure or disaster of some type (i.e. space shuttle(s), nuclear plant failure, plane crashes, building collapse),preferably which has occurred in the last ten years. Describe it in some detail, and discuss what ethical issues might have been at least partly responsible for the failure.
In other words, create a failure analysis report for this failure that includes:

- 1. What failed.
- 2. Why it failed.
- 3. Possible corrective actions (How to make it not fail).
- 4. Who was at fault, and why.

Describe how a lack of "professionalism" or "conscientiousness" may have helped lead to this failure.
Please include a listing of any references you might have used. For examples, read "To Engineer is Human" by Henry Petroski, or "Breakdown: Deadly Technological Disasters" by Neil Schlager (both of which will be on reserve in the Engineering Library), or look at some of the disaster links on the web page at http://www.matscieng.sunysb.edu/disaster/index.html
You must use at least one newspaper or recent journal account as one of your references. Your answer should be type written and four pages long. Please list references and indicate where they are used in the text of the paper!

Webpage brought to you by the friendly folks at:
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