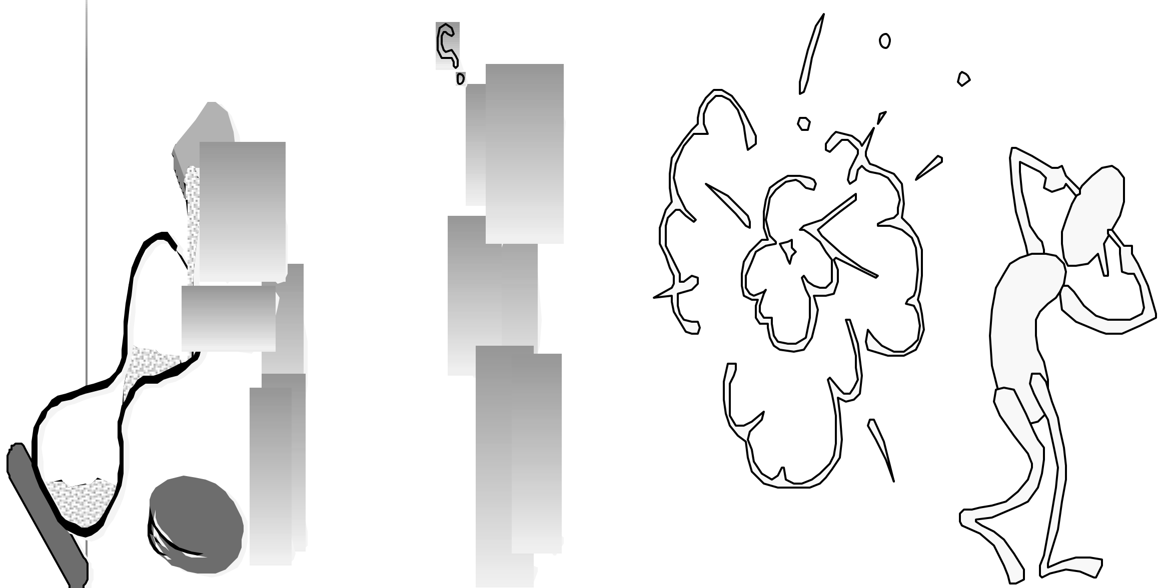
Professional Practice , Occupational Health and safety

Responsible Engineers

Course MIME-221

Responsible Engineers



The de la Concorde Blvd. overpass

Laval –Montreal- Canada

Quebec Engineering !!!!!

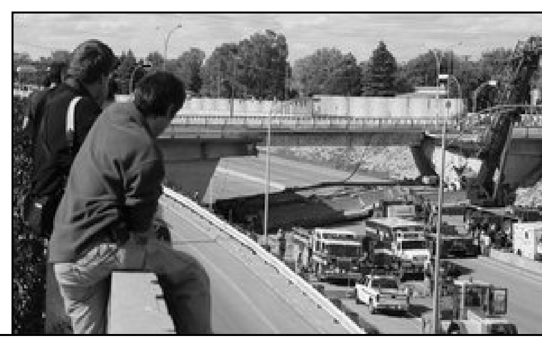
- Inspection
- Monitor
- Lack of use of technology available
- Being complacent
- No budget

MAX HARROLD, The Gazette; CP contributed to this report
Published: Sunday, October 01, 2006

Steel cables inside the de la Concorde Blvd. overpass that collapsed yesterday may have been so rusted they just snapped, a senior civil engineer said yesterday.

"This bridge looks like it snapped under its own weight," said A. Ghani Razaqpur, president of the Canadian Society for Civil Engineering. "This is highly unusual. If one cable snapped, it could have a trigger effect."

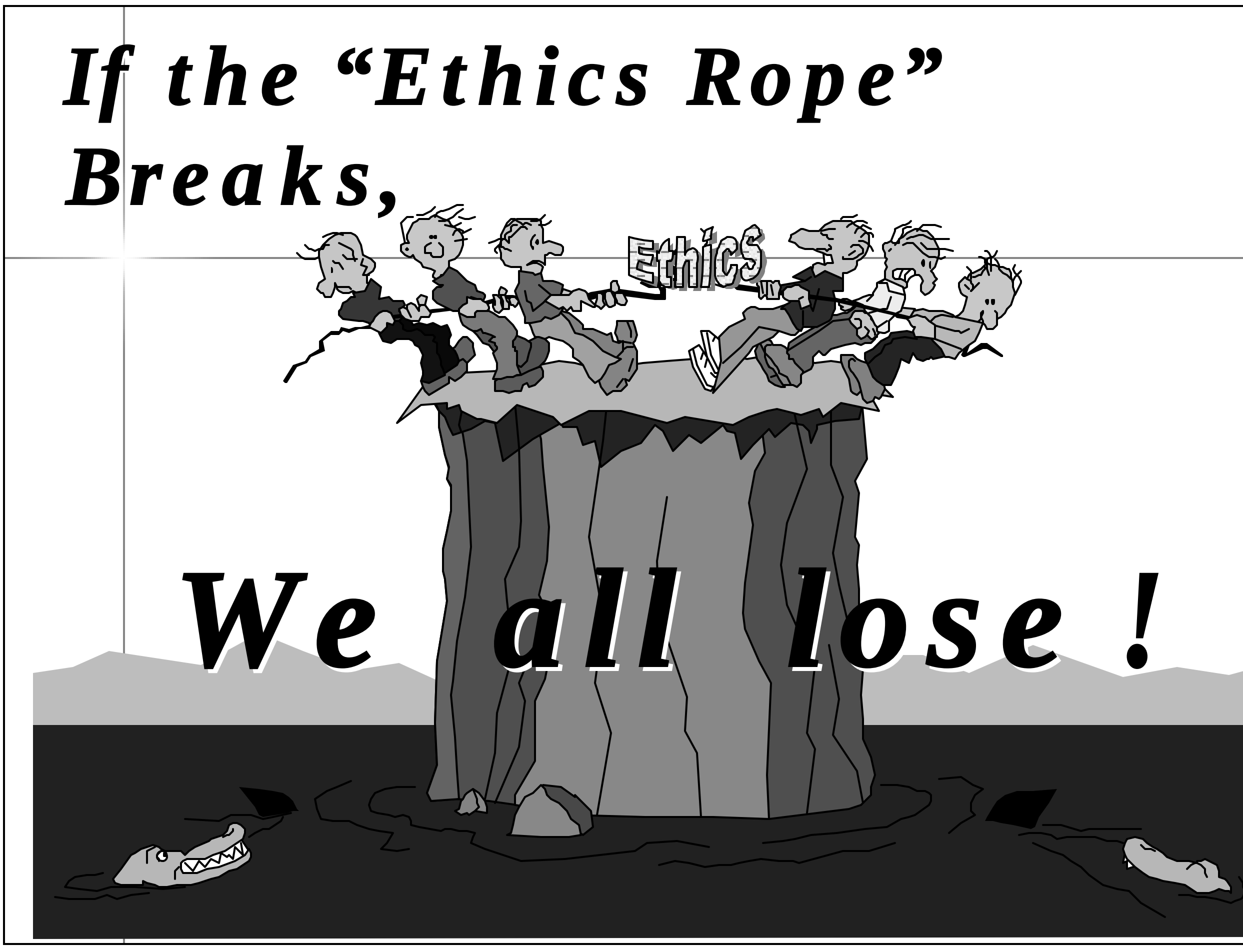
Three lanes of the overpass in Laval, plus a pedestrian sidewalk, fell onto Highway 19 around 12:30 p.m. At least two people were feared dead, and six other people were injured.



Response to disaster

Events

- There was a call to the department [of transportation] from the Quebec police force at 11:25 a.m., pointing out there was concrete on the highway," provincial Transportation Minister Michel Després told reporters.
- **"At 11:58**, a representative from the department was present. They recovered the rubble there. They assessed the situation, and during that time, there was nothing detected by the person who had been sent there which would require the immediate closure of the overpass."
- **At 12:33**, there was a second call from police to report that more concrete had fallen. Four minutes later, the overpass collapsed, Després said.
- He said there was a "full technical inspection" of the overpass by transportation officials in May 2005 and it showed "nothing in it to explain what happened."


If the “Ethics Rope” Breaks,
Ethics
We all lose !

Most valuable attributes of an engineer

Responsibility (reliability)

- Character:
  - Honesty & Integrity

- **Skills & knowledge:**
  - Technical knowledge
  - Analytical skills
  - Computation skills
  - Communication skills
  - Soft skills

Responsible -- definition

- ***Responsible**:*
  - 1) liable to be called on to answer; liable to legal review or in case of fault to penalties;
  - 2) able to answer for one's conduct and obligations; able to choose for oneself between right and wrong…

(Webster's Ninth New Collegiate Dictionary)

Responsibilities of engineers

- **Legal responsibilities:**
  – Cause no harm;
  – Compensate when harm is caused;
  – Practice in accord with Engineering Practices Act
- **Moral responsibilities:**
  – Recognize & discharge our duties & obligations;
  – Understand and adhere to a Code of Ethics

Ways in which harm is caused

- **Intentionally** – acting with an intent, this is often a criminal act
- **Recklessly** -- acting in a way that *we* recognize might cause harm
- **Negligently** -- failing to exercise due care

Legal Remedies for Harm

- Liability
  - Applies to individual professionals & corporations
  - Willful, negligent or reckless usually proven
- Strict Liability
  - Usually applied to corporations
  - No attribution of fault require
  - Legal concept, not necessarily a moral concept
  - Is this the basis for commercial insurance?

Three responsibility models

- Minimalist or Malpractice model
- Reasonable Care model
- Good Works model

Minimalist responsibility model (or Malpractice)

- **Engineers have a duty *only* to conform to accepted practice and fulfill only basic duties prescribed by terms of employment.**
- **Those who follow this model may be most concerned with not doing anything "wrong".**

  "That's not my responsibility, someone else will take care of that."

Reasonable Care model of responsibility:

- Adhere to accepted standards of practice, and…
- Take reasonable care to ensure that mistakes are prevented and the public welfare is protected
- Exercise and apply skill, ability and judgement reasonably and without neglect
  - keep abreast of evolving changes in knowledge and practice
  - recognize when minimal standards of practice might be Insufficient to prevent a harm, and take additional actions to prevent such a harm in those cases

Characteristics of the Reasonable Care model

- Attitude of concern or caring
- Concern for preventing harm, rather than trying to prevent causing harm
- Oriented towards the future, toward avoiding problems and protecting the public

Example: Roger Boisjoly's actions before the launch of the *Challenger*

Good Works responsibility model

"...above and beyond the call of duty."

Examples:

- A local consulting engineer offers to design a parking lot for a church at her cost, with no charge for her own time.
- An engineer joins a consensus standards body and volunteers time and expenses to update standards of practice for his profession.

Where do professional responsibilities lie?

- The reasonable care model is the best model for engineers.
- Codes demand it (…accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment…as in the seen Code of Ethics)
- Public expects it
  - Principle of Proportional Care: When people have a greater ability to harm, they have a greater obligation to prevent harm.

Some impediments or obstacles to responsibility

- Self-interest
- Fear
- Self-deception
- Ignorance
- Egocentric tendencies
- Microscopic vision
- Uncritical acceptance of authority
- Antagonism toward outside regulation
- “Groupthink”
- Cumbersome business organizations

Which of these played a role in the Challenger case?

- Groupthink?
- Cumbersome business impediments?
- Self-interest?

Missouri City Antenna Tower

- Engineer designed Antenna & 1000 ft. tower
- Contractor (rigger) awarded erection contract
- During erection, rigger realizes lifting points on antenna sections can’t be used without fouling antenna baskets (design error ?)
- Rigger asks to remove baskets and replace them after erection

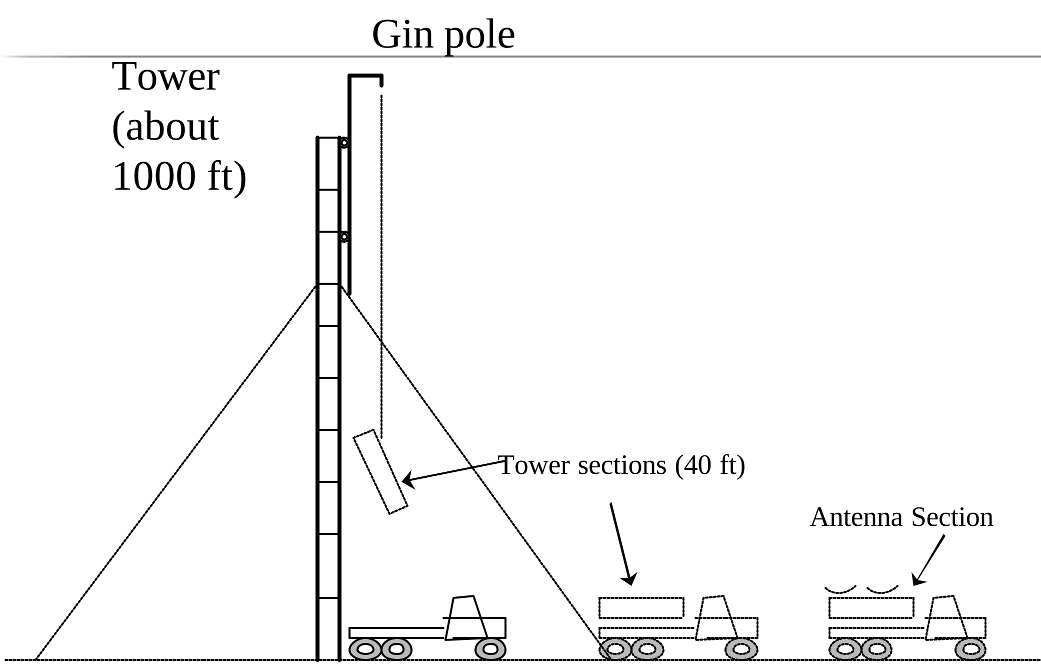
Antenna Tower Scenario, cont'd.

- Engineer denies riggers' request to remove baskets (last contractor who removed baskets caused expensive damage to antennas)
- Rigger develops plan to mount extension on antenna section to lift it
- Rigger asks engineer to review the plan

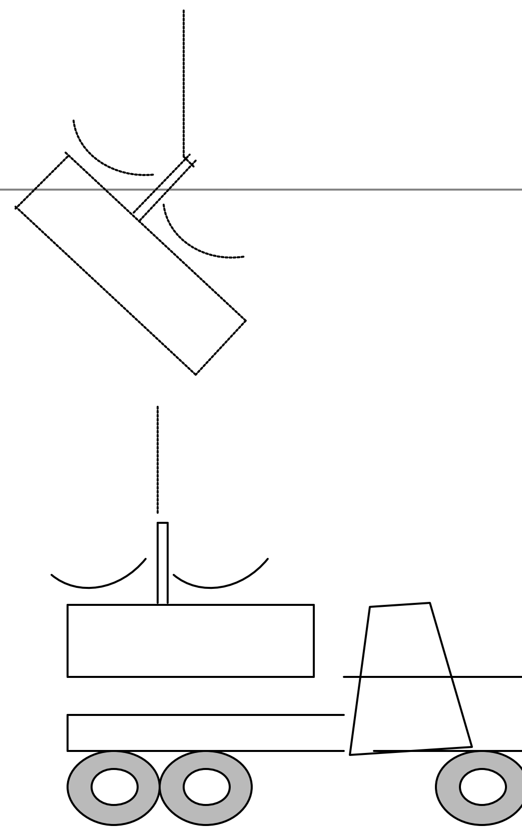
Scenario, cont'd.

- Engineer declines to review riggers' plan to mount extension on antenna, citing increased liability
- Rigger proceeds with lift of antenna
- Extension boom fails, antenna falls striking stay cable, tower falls, seven workers are killed

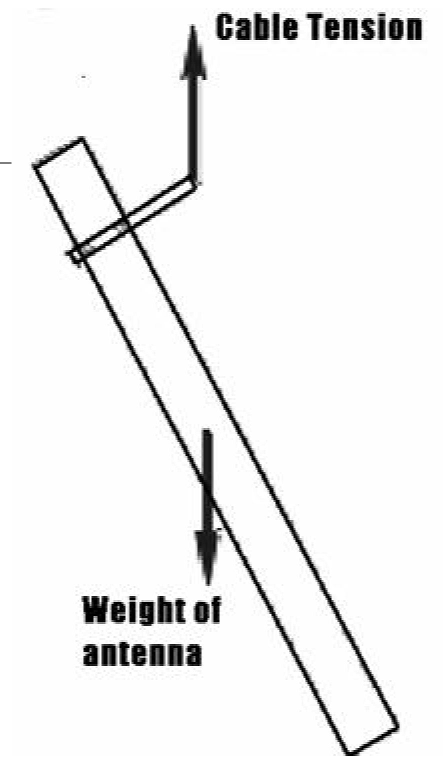
Tower erection method

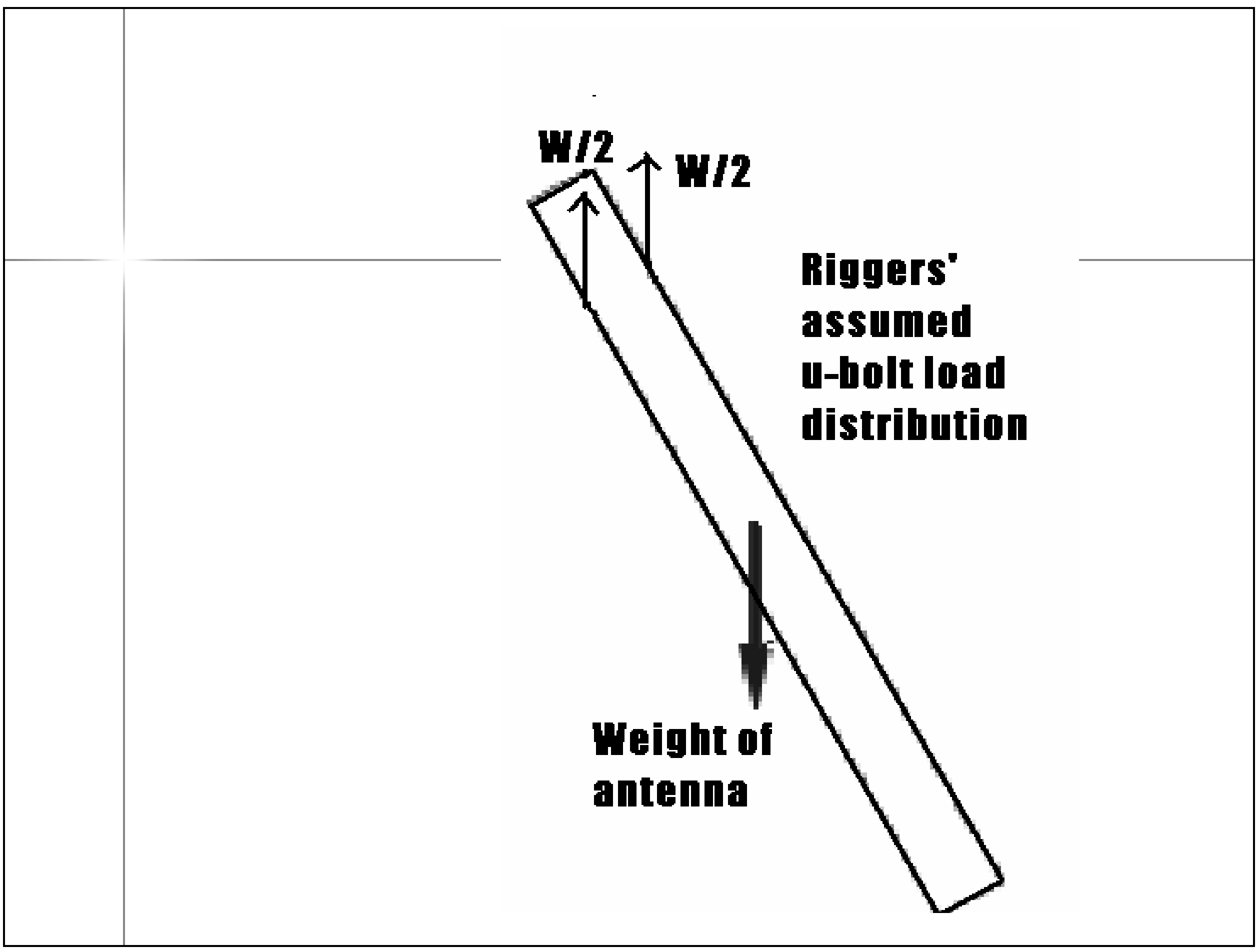


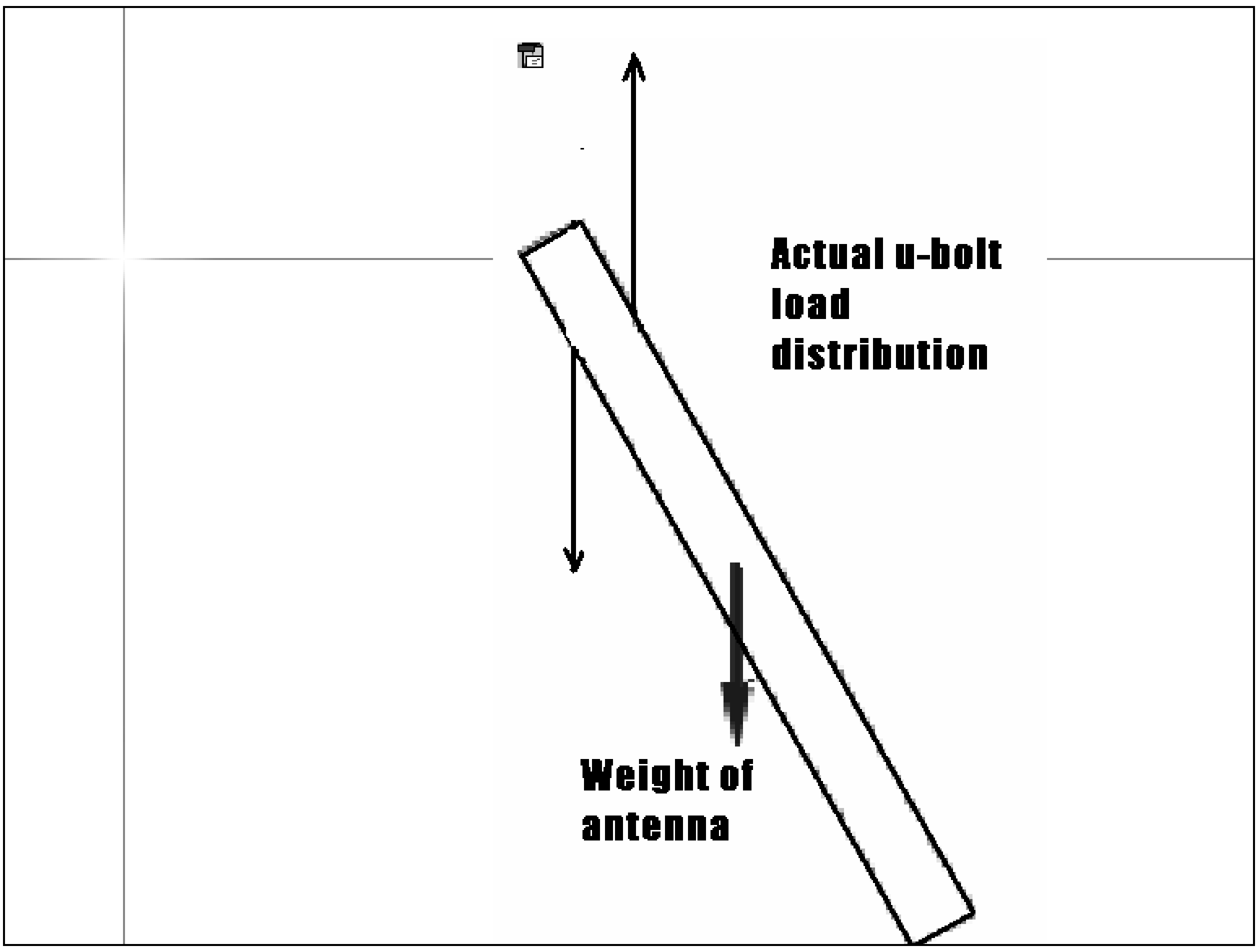
Antenna lifting method--riggers' modification



Free body diagram of antenna section during lift, with rigger's extension boom




W/2
W/2
Riggers' assumed u-bolt load distribution
Weight of antenna


Actual u-bolt load distribution
Weight of antenna

Missouri City Antenna Tower

I. Case Statement

A. Date and Time: 1985

B. Place: Missouri City, TX (a southwestern suburb of Houston)

C. Characters: (names have been fictionalized)

1. Antenna Engineering, Inc.- designed and built the antenna

William Harris - President. Harris recommended to Jordan that Antenna Engineering, Inc. not get involved with Riggers problems regarding lifting the antenna tower, due to legal liability issues.

Harry Jordan - Head of Engineering Division. Jordan told Riggers that they could not authorize removing the microwave baskets, yet he also told Riggers that the engineering firm signed off responsibility once Riggers accepted their design plans.

2. Riggers, Inc. - contracted to assemble the antenna

Frank Catch - President.

Randall Porter - Vice President. Made initial call to Antenna Engineering, Inc., detailing the problems Riggers was having lifting the top antenna section with the microwave baskets on it.

Bob Peters - Lead lift. One of the workers killed in the collapse.

Kevin Chapp - Cable Operator. Talked to Peters before the catastrophe, asking about the safety of the operation.

D. The Situation

A Houston television station decided it needed to expand its antenna coverage area by erecting a new, taller (1,000 foot) transmission antenna in Missouri City, TX. They hired Antenna Engineering, Inc. to design the antenna. The design called for twenty 50-ft sections to be stacked onto one another, with the last two sections having microwave antenna baskets on them.

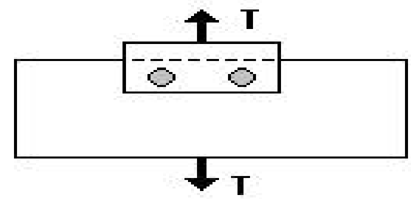
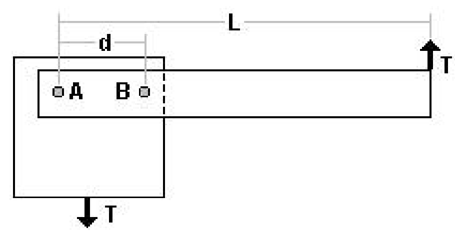
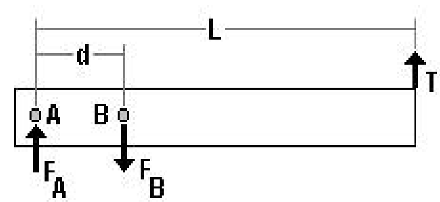
Riggers, Inc. was hired by the television station to assemble the tower. They would use a crawling jib crane to lift the sections into place and then they would manually bolt them together. The crane was capable of crawling up the tower and thus would be able to place section after section in place.

Each 50-ft segment of the tower had a lifting lug in the middle of the section. This was used to lift the section of of the truck it was on. Riggers' Inc. decided to use this lug to lift the sections of the tower into place. They would lift it by the center and rotate it using additional wires so that it would be vertically oriented. This method worked for 18 of the twenty sections. The last two sections had microwave baskets along their length. The wire would hit these baskets if the riggers tried to rotate the section around the lifting lug.

Riggers, Inc. called Antenna Engineering and asked if they could take the baskets off during the lifting phase and then reattach them once the section was in place. Antenna Engineering, Inc. had let one set of riggers take the baskets off once, and they completely destroyed them in the process. They were not going to let that happen again. They told Riggers, Inc. that the baskets must stay on the sections. Riggers' Inc. asked how they were supposed to lift the section and were told that that was their problem.

The Riggers devised a solution for their problem. they decided to take some channel steel they had and attach it to the section at a right angle. They would attach the cable to the end of the channel steel and rotate about that point. The cable now would not hit the baskets. They called Antenna Engineering, Inc. and asked if they could come look at the solution they had devised since Riggers, Inc. had no engineers on staff. Antenna Engineering, Inc. said that they could not look at the solution since then they would be liable if anything went wrong. In fact, the president of Antenna Engineering, Inc. told his engineers to stay as far away from the site as possible, so they would not be linked to anything the riggers were doing.

Their solution had some problems that even a freshman engineering student could identify. But, they had no engineers, so they were unable to perform an analysis like the one below.

Model used by Riggers	
Model Riggers should have used	
Free body diagram of the lifting bar solution	

Analysis of lifting bar solution

Sum(MA) = TL - FBd = 0
Sum(MB) = T(L - d) - FAd = 0

Solving the above equations for FA and FB,

FA = (T(L - d))/d and FB = (TL)/d

and the corresponding shear stress on each bolt is:

sigA = FA/Abolt = (T(L - d))/(dAbolt)
sigB = FB/Abolt = (TL)/(dAbolt)

where:

FA = Force on bolt A
FB = Force on bolt B
Abolt = Cross-sectional area of bolt
d = distance between the bolts

R = (Shear stress with moment arm)/(Shear stress from Riggers) = Error Factor

R = ((TL/d)Abolt)/((T/2)Abolt) = (2L)/d

Assuming one set of bolts were used, placed one foot apart, and the steel channel was six feet long:

R = 2(6[ft])/1[ft] = 12,

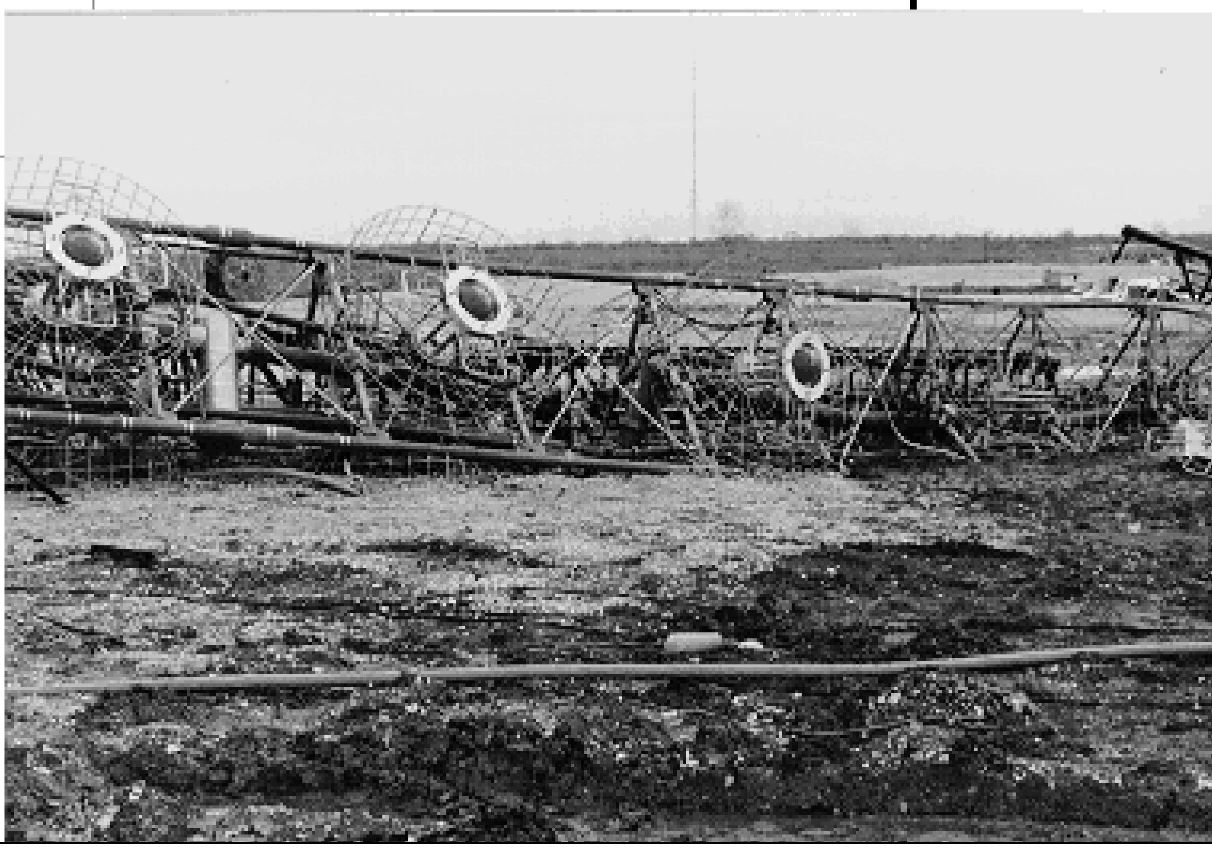
or, in other words, the stress (for these assumed numbers) in the new lug bolts is <u>twelve</u> times what the Riggers thought it would be, based on their erroneous analysis

Riggers, Inc. proceeded to lift the second to last section up to the top of the

tower. Everything went smoothly. This was not to be the case with the last section. Its ascent was captured on video by the television station. As the last section rose, physics caught up with the riggers. Near the top of the tower, their solution failed. The bolts holding their channel steel to the section failed and the section fell. The falling section hit one of the tower's guy wires and the entire tower collapsed. All of the riggers on the tower and on the section were killed in the collapse (seven men total).

Missouri City Antenna Tower

Antenna section after collapse



Extension boom and failed u-bolts

Wreckage of antenna and crane

Antenna Failure

Some questions...

Were the engineer’s actions the right actions?

- No, seven workers died.

Should the engineer's moral responsibility take precedence over his legal responsibility?

- Was the engineer's responsibility for a safe and workable design met with lifting lugs that could not be used by the rigger?

Were the riggers morally responsible for this accident?

- Did they ask an engineer for assistance?
- Did they recognize that the modification they attempted required engineering skills to accomplish?

What could the engineer have done differently?

- Agree to review the riggers' plans?
- Allowed riggers to remove antenna baskets?
- Offer to design a better extension boom?
- Decline to review the plans, but suggest to the riggers that they should hire an engineer to review their plans?

Final Question re Antenna Tower

- What model of responsibility did the engineer follow?
  - Minimalist model?
  - Reasonable care model?
  - Good works model?

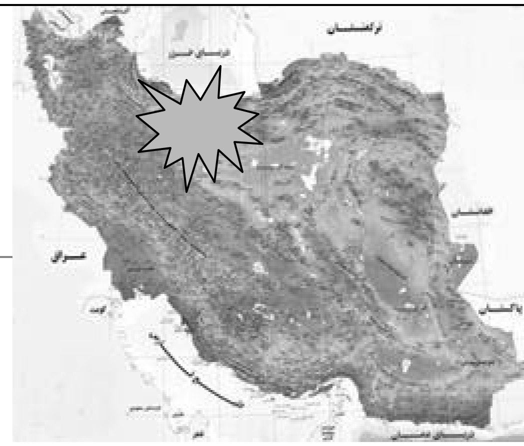
More questions…new case

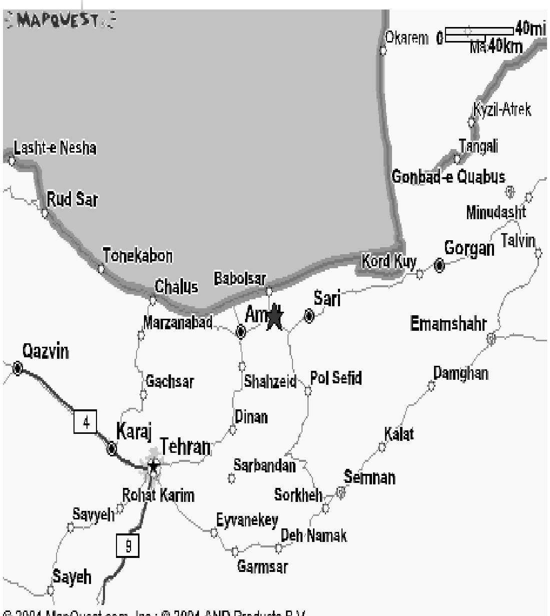
- Suppose an airline maintenance engineer contacts an airframe manufacturer with a question about a proposed maintenance procedure, believing that it can safely reduce maintenance time and costs.
- What are the responsibilities of the airframe manufacturer’s engineer?
- How will the manufacturer respond if he adheres to the…
  – minimalist model of responsibility?
  – reasonable care model?
  – good works model?

A Case in point…

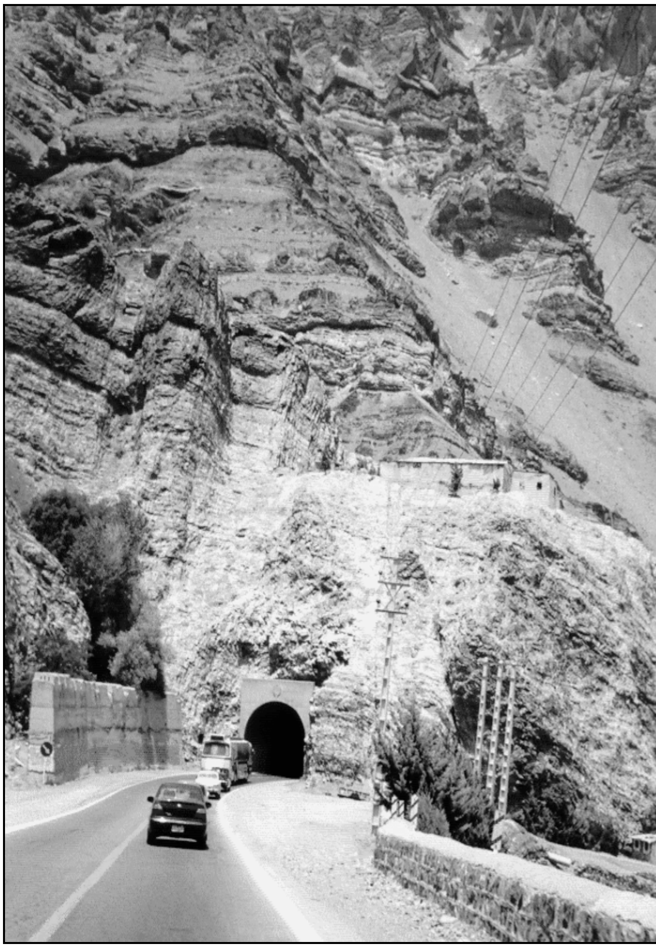
- In 1979, the design features of the DC-10 satisfied FAA regulations.
- Improper servicing procedures cracked the pylons securing the engines to the wings.
- During takeoff from Chicago on 25 May 1979, American Airlines Flight 191 lost an engine from the left wing, severing hydraulic control and power lines near that pylon, causing loss of control, crash, and 274 deaths.

IRAN




MAPQUEST
Okarem
0
40mi
40km
Kyzil-Atrek
Tangali
Lasht-e Nesha
Gonbad-e Quabus
Rud Sar
Minudasht
Tonekabon
Gorgan
Talvin
Kord Kuy
Chalus
Babolsar
Sari
Marzanabad
Emamshahr
Qazvin
Gachsar
Shahzeid
Pol Sefid
Damghan
Dinan
4
Karaj
Tehran
Kalat
Sarbandan
Semnan
Rohat Karim
Sorkheh
Savyeh
Eyvanekey
Deh Namak
9
Garmsar
Sayeh
© 2004 MapQuest.com, Inc.; © 2004 AND Products B.V.


TURKMENISTAN
IRAQ
AFGHANISTAN
Iran



SCENIC ROAD FROM THE CAPITAL TO THE CASPIAN SEA

SCENIC ROAD FROM THE CAPITAL TO THE CASPIAN SEA

- Major Rock formation and structures
- Major serious potential of failure

SCENIC ROAD FROM THE CAPITAL TO THE CASPIAN SEA

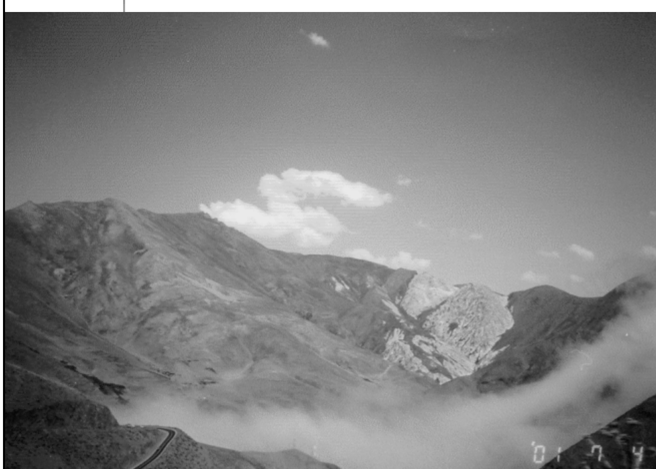
Major Rock formation and structures

Major serious potential of failure.

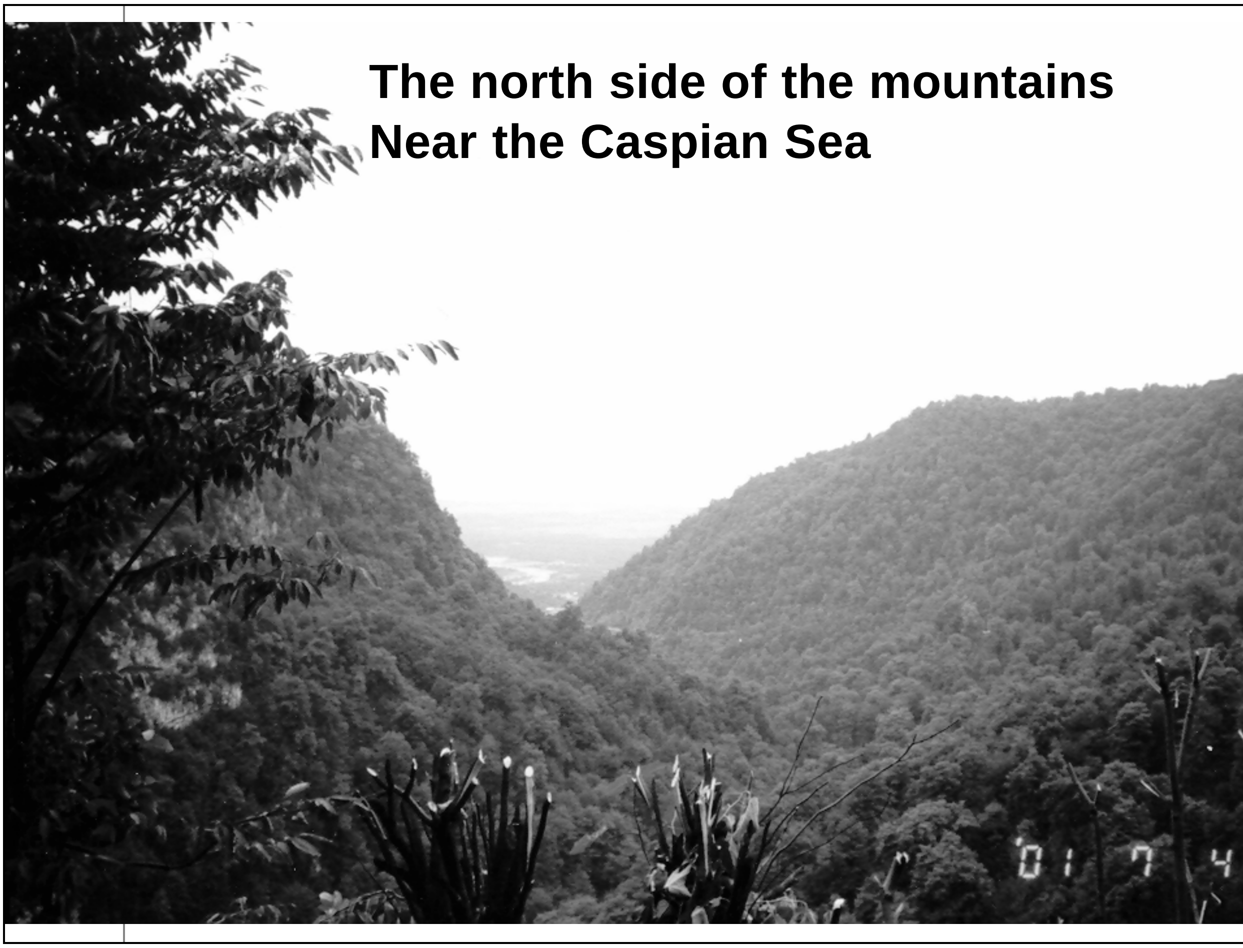
- High Mountains
- Deep valleys

Major failure of the Kandevan tunnel North of Iran

Increase in Travel distance and time Over the Mountains

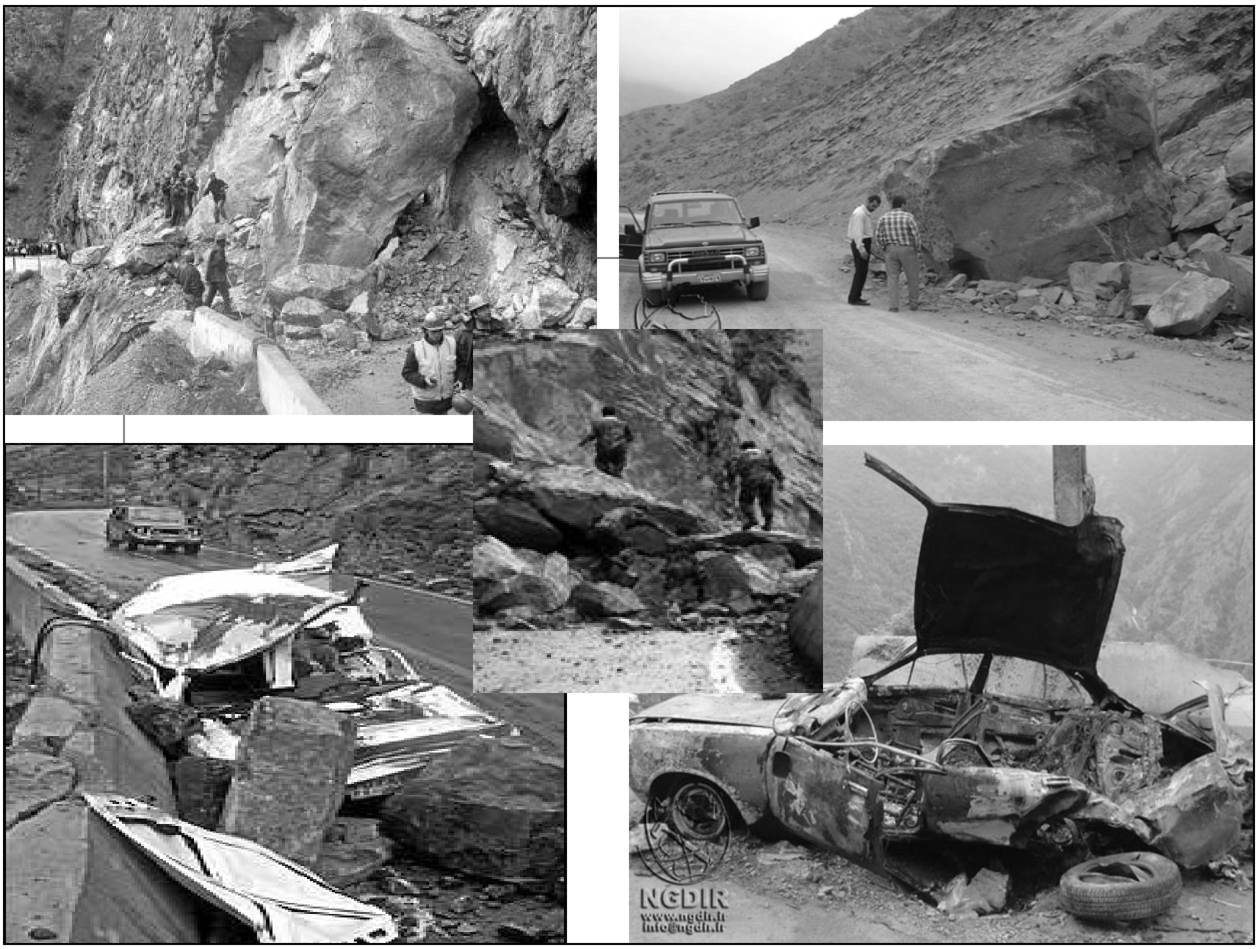


Maintenance
Gas


The north side of the mountains
Near the Caspian Sea
'01 7 4

TRAGEDY STRIKES

- MAY 2004 very strong earthquake
- Major slope failures
- Major land slides
- Large rocks toppling on the cars on the road
- Nearly 100 people lost their lives


NGDIR
www.ngdir.ir
info@ngdir.ir

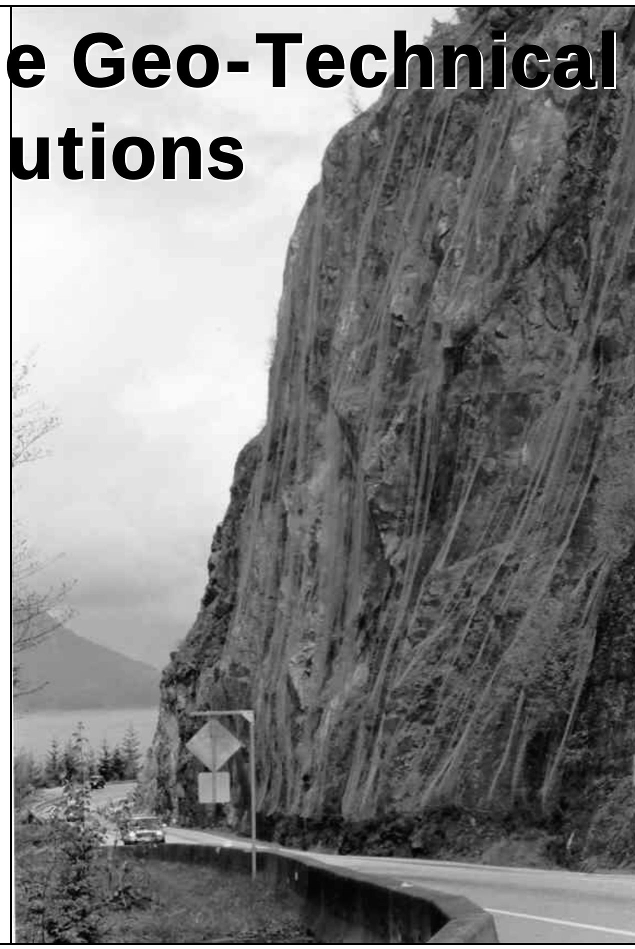
TRAGEDY


NGDIR

Instrumentation and monitoring

ROCK BOLTING

There are simple Geo-Technical Engineering Solutions

Ethical Questions: Kandovan Tunnel Case

- What one should HAVE DONE ?
- What the Government should have done?
- What should the engineers in charge should have done?

Engineers as responsible experimenters

What are the responsibilities of engineers to society ?

Engineers as responsible experimenters

Engineer's expertise places them in unique position to

- To monitor projects
- To identify risks
- To provide clients and public with the information needed to make reasonable decisions

Four element of responsibilities

1. **A primary obligation to protect safety of and respect the right of consent of human subjects**
2. **A constant awareness of the experimental nature of any project, imaginative forecasting of its possible side effects, and reasonable effort to monitor them**
3. **Autonomous, personal involvement in all steps of a project**
4. **Accepting accountability for the results of a project**

Responsibility

- **Engineers have learned that to rely on others to think through the Potential consequences of engineering projects leads all to often to Disaster.**
- **Usually the projects don't result in total disaster, but, Unintended consequences diminish engineering triumph.**

ENGINEERING AS SOCIAL EXPERIMENTATION

- **MANY CONTEMPORARY THREATS TO THE EFFORTS BY ENGINEERS TO ACT RESPONSIBLY**

THE OBSTACLES PLACED IN THE WAY

- **RESPECTING THE PUBLIC'S RIGHT**
- **TO HAVE THE KNOWLEDGE NEEDED FOR MAKING INFORMED DECISIONS ABOUT ENGINEERING PRODUCTS AND PROJECTS**

ENGINEERING AS SOCIAL EXPERIMENTATION

- THOSE THREAT AND OBSTACLE INCLUDE;

THE PRESSURES CAUSED BY TIME SCHEDUALES

1. **THE PRESSURES BY ORGANIZATIONAL RULES RESTRICTING FREE SPEECH**
2. **THE NARROW DIVISION OF LABOR WHICH TENDS TO CAUSE MORAL"TUNNEL VISION"**
3. **A PREOCCUPATION WITH LEGALITIES IN A TIME OF PROLIFERATING MALPRACTICE LAWSUITS**
4. **THE HUMAN TENDENCY TO DIVORCE ONESELF FROM ONE'S ACTIONS BY PLACING ALL RESPONSIBILITY ON AN 'AUTHORITY' SUCH AS ONE'S EMPLYER**

Issues to note

- a. **Lack of vision, which in the form of tunnel vision biased toward traditional pursuits overlooks suitable alternatives, and in the form of groupthink (a term coined by Irving Janis) promotes acceptance at the expense of critical thinking.**

- **b. Incompetence among engineers carrying out technical tasks**

- **c. A lack of time or lack of proper materials, both ascribable to poor management.**

Issues to note

- d. A silo mentality that keeps information compartmentalized rather than shared across different departments.
- e. The notion that there are safety engineers somewhere down the line to catch potential problems.
- f. Improper use or disposal of the product by an unwary owner or user.
- Not having a Safe Exit
- g. Dishonesty in any activity

Qualities to be achieved by an Engineer

- 1. Proficiency in recognizing moral problems and issues in engineering.

- 2. Skill in comprehending, clarifying, and assessing critically arguments on opposing sides of moral issues.

Qualities to be achieved by an Engineer

- 3. The ability to form consistent and comprehensive viewpoints based on consideration of relevant facts.

- 4. Imaginative awareness of alternative responses to the issues and receptivity to creative solutions for practical difficulties.

Qualities to be achieved by an Engineer

- 5. Increased precision in the use of a common ethical language, a skill needed to express and support one’s moral views adequately to others

- 6. Sensitivity to genuine difficulties and subtleties. This includes a willingness to undergo and tolerate some uncertainty in making troublesome moral judgments or decisions.

Qualities to be achieved by an Engineer

- 7. An awakened sense of the importance of integrating one's professional life and personal convictions-that is, the importance of maintaining one's moral integrity.

- 8. Enriched appreciation of both the possibilities of using rational dialogue in resolving moral conflicts and of the need for tolerance of difference in perspective among morally reasonable people.

ENGINEERING AS SOCIAL EXPERIMENTATION

- CODES OF ETHICS / PRACTCE BY PROFESSIONAL SOCIETIES PLAY VARIETIES OF ROLES

1. INSPIRATION
2. GUIDENCE
3. SUPPORT FOR RESPONSIBLE CONDUCT
4. DETERRING AND DISCIPLINING UNETHICAL PROFESSIONAL CONDUCT

CODES OF ETHICS / PRACTCE BY PROFESSIONAL SOCIETIES PLAY VARIETIES OF ROLES

5- EDUCATION AND PROMOTION OF MUTUAL UNDERSTANDING

6- CONTRIBUTING TO A POSITIVE PUBLIC IMAGE OF THE PROFESSION

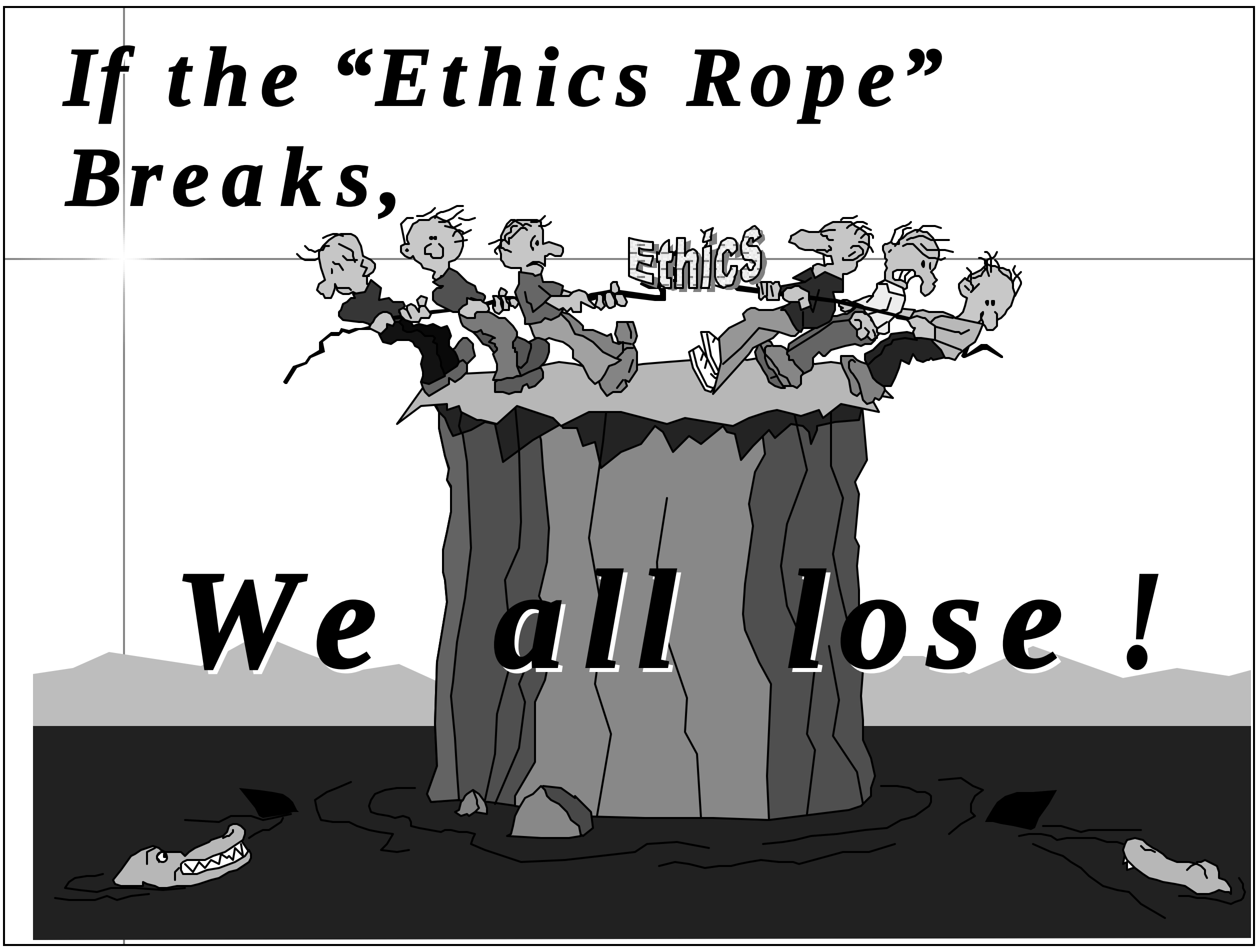
7- PROTECTING THE STATUS QUE AND SUPPRESSING DISSENT WITHIN THE PROFESSION

8- PROMOTING BUSINESS INTERSTS THROUGH RESTRAINT OF TRADE

Why Safety standards?

SAFETY

Absolute safety ,in the sense of a degree of safety which satisfies all individuals or groups under all condition, is neither attainable nor affordable.


If the "Ethics Rope" Breaks,
Ethics
We all lose !

References

1. *ENGINEERING RESPONSIBILITY presentation of James C. Rock, PhD, PE, Department of Nuclear Engineering .Texas A&M University*
   Original lecture materials from Dr. Ray James, & John Poston

- PROFESSIONALISM AND ENGINEERING CODES OF ETHICS
  John W. Poston, Sr. presentation Department of Nuclear Engineering Texas A&M University
- Harris, Prichard & Rabins, *Engineering Ethics: Concepts and Cases*,
- Chapter 5: "Responsible Engineers"

References

This presentation is put together from, course books , other presentations as well as various websites in the forms of text, photos, audio and video clips.

All the references will be given in the general reference section on the web Ct