ENGINEERING ETHICS

TV Antenna Tower Collapse

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Social Responsibility Versus Legal Liability

Introduction To The Case

Total collapse during installation of a 6-ton FM antenna being placed on a new 1800 ft. tower. 5 technicians killed, 3 on the hoist and 2 on the tower. It was determined that insufficient sized bolts on a makeshift lifting lug extension failed. The falling debris severed one of the tower's guy wires, causing the tower to collapse.

The following case is based on an actual incident. However, individual actors and company names have been changed due to possible pending litigation. In addition, although conversations and memorandums used are based on evidence surrounding the case, they are hypothetical in nature, and are used to illustrate important issues rather than to attempt an actual reenactment of what "really" happened.

In 1982, a television station video crew was filming the raising of their new television tower. The antenna was designed and manufactured by Antenna Engineering, Inc., a moderately-sized local firm. Riggers, Inc., a small local firm, was contracted to raise and assemble the antenna. During the initial design, Antenna Engineering submitted antenna plans to Riggers for their approval. Riggers approved the plans which provided for placement of the antenna hoisting lugs. These lugs provided attachment points for lifting cables which would be used for removing the antenna sections from the delivery truck, and for hoisting the antenna into the air for final assembly on a 1000 foot tower. A crew of riggers who had constructed such towers for many years was on-site. The crew used a vertically-climbing crane mounted on the already constructed portion of the tower to lift each new section of the tower, and finally, the two-section antenna onto the top of the tower. The design called for a three-legged tower, and as each new section was lifted, it was positioned and bolted onto the previous tower sections, one piece at a time. The tower legs were solid steel bars with 8

inch diameters. The tower sections weighed approximately 10,000 pounds and were each 40 feet long. They were raised without incident to a height of about 1000 feet.

The two final antenna sections arrived at the site and assembly proceeded as planned, until the last antenna section was ready to be hoisted into position. This section was different from the other sections of the antenna because it had microwave baskets attached to the sides of the antenna. The placement of the hoisting lugs allowed the antenna to be lifted horizontally off of the delivery truck, but the baskets interfered with the lifting cables when the antenna was rotated to a vertical position. A make-shift extension to the lifting lug had to be fashioned by the riggers to permit the last section's vertical hoisting. Unfortunately, on the day of videotaping during the hoisting of this last section, something went wrong, and while the antenna was being hoisted, the bolts on the make-shift lifting lug extension failed. The result was a tragedy. Several riggers fell 1000 feet to their death.

The video camera caught this catastrophe on film, and through its footage, investigators were able to discover where the failure initiated, and why the accident occurred. The case of the antenna tower collapse raises serious questions about the design engineer's social responsibility to ensure safety on the construction site, and poses additional questions about product liability issues in engineering and ethics.

Ethical issues raised by the case involve social responsibility versus legal liability, engineering responsibility for failed innovation, problems associated with design implementation, and liability and negligence issues. While valuable for all engineering students, the case is particularly well suited for statics, construction engineering and structures courses.

Guidelines For Presentation

1. Prior to class discussion, show video: Missouri City, Texas, TV Antenna Tower Collapse. The video may be borrowed from the authors of this report for copying purposes. After the video, distribute the student handout: *Missouri City, Texas TV Antenna Tower Collapse: Social Responsibility Versus Legal Liability*. Have students come to the discussion class prepared to address the technical and ethical issues raised in the student handout.
2. In the discussion, present overheads: 1) through 4): The Cast of Characters and Problem Presentation, Model Riggers Thought Was Correct, Model Riggers Should Have Used, and Free Body Diagram of Lifting Bar and Analysis of Riggers' Solution, respectively.
3. End the discussion class with Overhead 5), TV Antenna Tower Collapse: Ethical Issues of the Case. Discuss the ethical issues of the case:

- Where does the responsibility of Antenna Engineering end and Riggers begin? Should Antenna Engineering have provided adequate hoisting lugs in their original design?
- Should Riggers have looked at the original design more carefully?
- Should Antenna Engineering have allowed Riggers to remove the microwave baskets?
- Should Riggers have devised their own hoisting solution without consulting another engineer? What is their responsibility for contracting a consulting engineer?
- Should Antenna Engineering have recommended another consulting engineer to assist Riggers? Should they have notified their professional society? Was it ethical for the engineers at Antenna to wash their hands of the project without attempting to find a resolution for Riggers? What other measures could they have taken to assist Riggers without becoming legally entangled?
- Should Antenna Engineering have refused to review the new hoisting design?

- If social responsibility comes before legal liability, surely there were other things Antenna Engineering could have done. What would you do in a similar situation?

Instructors preparing to lead class discussion on this case will find particularly relevant essays #4, "Engineering Design: Literature on Social Responsibility Versus Legal Liability," and #5, "Negligence, Risk, and the Professional Debate over Responsibility for Design," both appended at the end of the cases in this report. In addition, essays #1 through #3 appended at the end of the case listings in this report will have relevant background information for the instructor preparing to lead classroom discussion. Their titles are respectively: "Ethics and Professionalism in Engineering: Why the Interest in Engineering Ethics?;" "Basic Concepts and Methods in Ethics;" and "Moral Concepts and Theories."

Recommended Overheads

1) The Cast Of Characters & Problem Presentation

2) Model Riggers Thought Was Correct

3) Model Riggers Should Have Used

4) Free Body Diagram of Lifting Bar and Analysis of Riggers' Solution

5) TV Antenna Tower Collapse: Ethical Issues Of The Case

The Cast of Characters

Antenna Engineering, Inc. Designed and Built the Antenna

William (Bill) 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 the 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.

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.

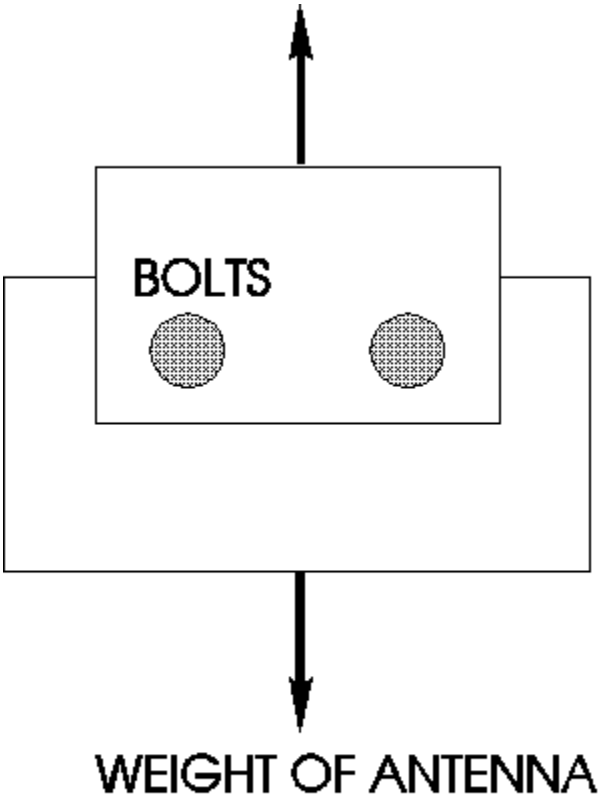
Kevin Chapp -- Cable Operator. Talked to Peters before the catastrophe, asking about the safety of the operation.

The Problem:

Riggers, Inc. could not hoist the last antenna section using the lifting lugs Antenna Engineering provided due to interference with microwave baskets. Antenna Engineering refused permission for Riggers to remove the basket and reassemble after hoisting.

Analysis of the Antenna Lift

MODEL RIGGERS THOUGHT WAS CORRECT



STRESS = WEIGHT/2*BOLT AREA

Calculation of stress in bolts = Total Antenna Weight / (2 * Total Bolt Cross-sectional Area)

MODEL RIGGERS SHOULD HAVE USED:

FREE BODY DIAGRAM OF LIFTING BAR AND ANALYSIS OF RIGGERS' SOLUTION

Assuming that the angle that the tower hangs is relatively small, which it was, and that the bolts were about 1 foot apart, and that the supporting channel was about 6 feet long, the load in the bolts is actually a combination of direct shear (as found previously, plus the load due to the moment caused by the length of the channel. Thus:

Sum of Moments about the bolt on the left end of the channel =

0 = Weight of antenna * 6 feet - Added force in bolt * 1 foot, such that

Additional force in bolt = 6*weight of antenna, which when added to the direct force of 1 * Weight of Antenna gives a total load on the right hand antenna bolt of 7*Antenna Weight..

The corresponding shear stress on each bolt is thus: Stress = (7*Antenna Weight)/Area of bolt

or, in other words, the stress (for these assumed numbers) in the bolts is seven times what the Riggers thought it would be.

Ethical Issues Of The Case - Points for Discussion

1) Where does the responsibility of Antenna Engineering end and Riggers begin? Should Antenna Engineering have provided adequate hoisting lugs in their original design?

2) Should Riggers have looked at the original design more carefully?

3) Should Antenna Engineering have allowed Riggers to remove the microwave baskets?

4) Should Riggers have devised their own hoisting solution without consulting an engineer? What is their responsibility for contracting a consulting engineer?

5) Should Antenna Engineering have recommended another consulting engineer to assist Riggers? Should they have notified their professional society? Was it ethical for the engineers at Antenna to wash their hands of the project without attempting to find a resolution for Riggers? What other measures could they have taken to assist Riggers without becoming legally entangled?

6) Should Antenna Engineering have refused to review the new hoisting design?

7) If social responsibility comes before legal liability, surely there were other things Antenna Engineering could have done. What would you do in a similar situation?

Synopsis

The following case is based on the actual incident. However, individual actors and company names have been changed due to possible pending litigation. In addition, conversations and memorandums used are based on evidence surrounding the case; however, they are hypothetical in nature, and used to illustrate important issues involved in the case rather than to attempt an actual reenactment of what "really" transpired.

During the construction of a major TV tower/antenna, a television station video crew was filming the construction. Their station was to use the antenna to extend their station's range, and they would film the operations daily for use in their news broadcasts. The antenna was designed by Antenna Engineering, Inc. Riggers, Inc. (a small local firm) was contracted to raise and assemble the antenna. During the initial design, Antenna Engineering submitted plans to Riggers for their approval. Riggers approved the plans which provided for placement of several hoisting lugs. These lugs provided attachment points for lifting cables which would be used for removing the antenna sections from the delivery truck, and for hoisting the antenna sections into the air for assembly. A crew of seven riggers who had constructed such towers for many years was employed. The crew used a vertical climbing crane, mounted on the already-constructed portion of the tower to lift each section of the antenna into the air. The design called for a three-legged tower. Each section was lifted and strapped onto the tower, one piece at a time. The anchor points for these sections were very accurately set.

The antenna sections arrived at the site and assembly proceeded as planned, until the last antenna section was ready to be hoisted into position. This section was different from the other sections of the antenna, because it had microwave baskets attached to the side of the antenna. The placement of the hoisting lugs allowed the antenna to be lifted horizontally off of the delivery truck, but the baskets interfered with the lifting cables when the antenna was rotated to a vertical position for bolting onto the previous section. Riggers called Antenna requesting redesign assistance to fix the problem, but Antenna declined. Riggers then requested permission to remove the microwave baskets to clear the lifting cables, which was refused. A make-shift extension to the lifting lug had to be fashioned by the riggers to permit the last section's vertical hoisting. When the last section was hoisted, something went wrong. The bolts on the make-shift lifting lug extension failed while the antenna was being hoisted. The result was a tragedy. Several riggers fell 1000 feet to their death.

The video camera caught this catastrophe on film, and through its footage, investigators were able to discover where the antenna debris landed and why the accident occurred. The case of the antenna tower collapse raises serious questions about the design engineer's responsibility to ensure safety on the construction site and poses additional questions about product liability issues in engineering ethics.

Individuals Involved In The TV Antenna Tower Collapse Case

Antenna Engineering, Inc. Designed and Built the Antenna

William (Bill) Harris -- President. Harris recommended to Jordan that Antenna Engineering, Inc. not get involved with Riggers' problems regarding lifting the antenna tower, because they might incur liability.

Harry Jordan -- Head of Engineering Division. Jordan told Riggers that they would not authorize removing the microwave baskets, yet he also told Riggers that the engineering firm was no longer responsible, once

Riggers accepted their design plans.

Riggers, Inc.: Contracted to Assemble the Antenna

Frank Catch -- President.

Randall Porter -- Vice President. Made the 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.

Analysis of the Faulty Design

In 1982, an antenna was designed and manufactured by Antenna Engineering, Inc. (a moderately-sized local firm). Riggers, Inc. (a small local firm) was contracted to raise and assemble the antenna. During the initial design, Antenna Engineering submitted plans to Riggers for their approval. Riggers approved the plans which provided for placement of the hoisting lugs. These lugs provided an attachment point for lifting cables which would be used for removing the antenna sections from the delivery truck, and for hoisting the sections into the air for assembly.

On November 18, 1982, Riggers called Antenna Engineering and asked if it was acceptable to remove the microwave baskets on the top 100-foot section of the tower so they could lift the antenna into position, and then reinstall the baskets after the section was in place. Antenna Engineering told Riggers that removing the baskets would void the warranty. At a previous job Antenna Engineering had allowed removal of the microwave baskets and they were not reinstalled properly. Antenna Engineering was held responsible for correcting the problem, which cost them a great deal of money. The following telephone conversation took place between Randall Porter, Riggers' vice president, and Harry Jordan, Antenna Engineering's engineering division head:

Porter: Harry, this is Randall Porter with Riggers, Inc. We've run into a problem on Tower 17.

Jordan: How so?

Porter: Well, thus far everything has been fine, but the top antenna section has the lifting ears in such a position that we can't cable them up to the crane without running into the microwave baskets.

Jordan: Well, we put them on as specified on the plans. Seems like they were right between two baskets, weren't they?

Porter: Yes, and that works great getting it off the truck, but when we try to get it on top of the previous antenna section, it has to be lifted vertically. The crane is barely able to get the antenna up high enough to bolt it to the preceding section as it is. No way can we lift it to the top horizontally.

Jordan: Well, what do you suggest? We pretty well signed off when you accepted the plans, and don't have any connection with the construction of the antenna. We leave getting it up in the air pretty much to you guys. Not that we don't want to help in any way we can, but you and your people put these towers up every day of the year, and we really don't want to start getting into that area.

Porter: No, I understand that, but it's just that we really don't have an engineer on our staff who can redesign those little ears and put them in a location that will work. So what we would like to do is simply take off the baskets until we get the antenna in the air and bolted down on top. Our guys will then take the baskets up and bolt them on. Should be no problem, but we just wanted to check with you first.

Jordan: I don't know Randall. We took a beating on letting some other company remove those baskets last year. You wouldn't believe what a mess birds can cause when those microwave guides are left open. It took us 6 months and a small fortune to purge out nests, rats, sand you name it. That's why you get the antenna section with the microwave baskets all bolted on and sealed, to prevent that.

Porter: We would take full responsibility for not letting that happen. You could make us some blanking plates to replace the baskets, and we would leave them on until we were ready to put them back on. Surely we can work something out, because that section is due to go up tomorrow, and we don't have a clue how we're going to do it.

Jordan: Well let me talk to Bill about it, but I'll tell you now, he is absolutely rabid about removing the baskets once they are sealed. How's business down there?

Porter: We're always busy - got a job coming up in Louisiana next week so we're really pressing the completion of 17. Listen, be sure and call me on this, OK?

Jordan: I'll get right on it, Randall. See you.

Porter: Bye.

While Riggers requested the help of Antenna Engineering to determine how to lift the antenna without removing the microwave baskets, Antenna Engineering responded by stating that their job was to design and build the antenna, and Riggers was responsible for assembly. Following his conversation with Porter, Jordan drafted a memorandum to Antenna Engineering's president, William Harris:

Interoffice Memo, November 18: Bill Riggers, Inc., says they will be unable to use the designed lifting ears for little other than getting the upper section off the truck. The present position causes the lifting cables to strike the microwave baskets when the antenna is rotated vertically for bolting on to the previous section. They are asking that we let them take the baskets off until the section is in place. What do you think?

Harris' response is captured in a November 19 conversation with Jordan:

Harris: Morning Harry. I got your memo when I got back from Tampa last night. I'm really surprised that you didn't just tell them "no way" when they called.

Jordan: Yeah, I knew you weren't going to be happy with their request, but they do have a problem, and I thought it would be best for you to decide.

Harris: Listen pal, you and I just dropped a quarter million bucks letting some clown mess with the baskets on our last job. And for what? A dead rat and some bird droppings. I mean that kind of trash really messes up wave guides, and these guys just cannot be trusted to do anything but make a mess of them. Now they know that the contract they signed said they would not touch those baskets during construction, and that the warranty was void the minute they did. And if you think they have a quarter million to fix the problems they might cause, you have another think coming. No way. We would be right back in court just like last time, and you know it.

Jordan: Well, what about redesigning the whole rig, so that they could grab onto something which extends outside the baskets?

Harris: How about letting them do that? I'll tell you Harry, I'm really not into getting into their business. They have put up over a hundred of these towers, they say they are the experts in this field, so let them put the danged thing up. That's what they're paid to do. Believe you me, if this antenna doesn't have the field of coverage we say it should, they sure as heck aren't going to help us take it down and redesign it. By the same token I really don't think you and I should get into their field of expertise and start telling them how to get it in the air. Do you want to take on that legal responsibility? Man if that thing ever fell down, and we had so much as suggested their method of lifting it, or redesigned any part of it - even if it had nothing to do with our design - you can be sure we would be right in the middle of a court battle. No way. They are the experts in construction, let them construct.

Jordan: You're probably right. How did the Florida trip go? ...

Thus, Riggers devised their own solution, without consulting an engineer, although they did request a review of their plans by Antenna Engineering. This request by Riggers for review was refused by Antenna Engineering due to their potential liability in the event of a mishap if they had commented on the plans. On November 20, the following conversation took place between Riggers' president, Frank Catch and his vice-president, Randall Porter:

Porter: Frank, Harry over at Antenna Engineering called about the lifting ears on the upper antenna, and they're just not willing to get into it at all. They're worried that if we take off the baskets some kind of junk may get in and ruin the whole thing. They say that the warranty is void if we so much as unbolt one of the baskets. They're really not being very helpful about redesigning the lifting lug either.

Catch: I was afraid that would be the case. Not that I can really blame them. They want to sit in their office and let us take all the chances out here in the field. But I guess that's what they pay us for. Anyway, what now?

Porter: Well, I guess we could stick a channel across two of the two legs, and bolt it to the antenna with some U-bolts. A channel would stick out far enough to let the cables clear the baskets. The section weighs about one thousand pounds, and each U-bolt is rated at twelve hundred, so if we use a couple of them that should be OK.

Catch: I would hope. Have you got everything you need?

Porter: Pretty much, but if not it won't be hard to get locally.

Catch: OK. Is everyone packed up and ready for the next job in Louisiana?

Porter: Pretty much ...

Riggers attached a long channel to the antenna section with several U-bolts. By attaching the lifting cables to the end of the added steel section the antenna section could be raised vertically without interference from the microwave baskets. They used bolts that they thought were of the proper strength, and figured in a factor of safety, but they did not realize that the piece of steel they attached also added a large moment which was transmitted through the U-bolts. Figure 1 shows what Riggers, Inc. thought was the correct model and Figure 2 shows the model that should have been used.

In Figure 1, the shear stress in each of the bolts is Antenna Weight/(2*Abolt). Figure 2 shows the proper analysis, involving summation of moments around the center of the left hand bolt. The moment equations are then used to determine the force applied to each bolt. Dividing the force applied to each bolt by the bolt's cross-sectional area will give the shear stress acting on the bolt:

Only hours before the accident, the following conversation took place on-site between Kevin Chapp, Rigger's cable operator and Bob Peters, Riggers' lead lift.

Chapp: Well, what's the verdict?

Peters: Looks like the wind will be below the limit, so we'll go up. Sure is foggy though. These radios are a lifesaver when you can't see the ground.

Chapp: I never ran tag lines before radios, so I wouldn't know. Before my time. How did you get your instructions down before that?

Peters: Did a lot of yelling, but they weren't nearly as tall then either.

Chapp: Dang that thing is really up there, huh. I don't envy you up there. I'd be scared to death. Have you ever had one of these things fall?

Peters: I've had close friends on one that came down, and was in the vicinity of one that blew down in a storm while it was going up, but that's about all. It's not really the extra height that gets you. You're just as dead if you fall 100 feet as you are from 1000 feet.

Chapp: Some of the guys were kidding around last night about if they were on a tower and it fell should you unbuckle your belt and jump, or stay strapped on.

Peters: Got me. OSHA would probably fine you if you didn't stay belted.

Chapp: Ready for the next one?

Peters: Yep. Hey - I've got my dog in the car, checked out of the motel, got the car packed and everything. Would you let him out and watch out for him? I'd hate to have him locked in there all morning.

Chapp: Sure, but when we get really busy back he goes. There's our TV camera man. He has been out here almost every day now, taking pictures. What's that for?

Peters: I think they are keeping a record of it on the news as it goes up. Like a documentary.

Chapp: Who is going up today?

Peters: It will take four of us - two on the antenna to keep it lined up, and two on the tower to receive it. We'll be through about 2 or 3 this afternoon, and be at the next job tonight...

But they never made it to the next job. The antenna collapsed catastrophically when the bolts failed while the antenna was being hoisted. All four people lost their lives in the accident, in addition to another rigger working on the construction site. When they found the bolts (by viewing the videotape) and ran tests, the shear strength of the bolt material was half of what it should have been. Thus, the bolt manufacturer was sued, while Antenna Engineering suffered no monetary loss for the accident. A year before the accident, the bolt manufacturer received a lot of bad publicity due to another substandard bolt. They did not need another

messy case, so they settled out of court and the case was closed.

The public has become increasingly aware that benefits of industrial progress must be measured against the growing concern that someone must protect the public from damages caused by the products and by-products of technology. Naturally, the spirited, and swelling public debate puts engineers at the center of the product safety and social responsibility versus legal liability controversy. As such, this case raises questions about the engineering firm's social responsibility versus its legal liability. What alternatives could have been employed so that seven riggers would not have lost their lives?

Ethical Issues Of The Case - Points For Discussion

How do the ethical obligations between engineering professionals and the public apply in the TV Antenna Tower Collapse case?

At first glance it appears that Riggers was responsible for devising a lifting scheme that was technically flawed, and then implementing that scheme at the cost of seven lives. Yet, as engineers test designs for ever-increasing speeds, loads, capacities and the like, they must remember their social obligations to protect the public welfare. After all, the public has provided engineers, through the tax base, with the means for obtaining education, and through legislation, with the means for licensing and regulating themselves. In return, engineers have a responsibility for protecting the safety and well-being of the public in all of their design efforts. This is part of an implicit social contract all engineers agree to when they accept admission to an engineering college.

The design company engineers knew they had to provide an adequately designed hoisting lug on the final antenna section, and they did; however, the lug was sufficient only for lifting the antenna section off the delivery truck and placing it on the ground. Due to the placement of the lugs in relation to the microwave baskets, the hoisting lugs were useless for lifting the section 1,000 feet to the top of the tower. One might argue that the hoisting lug design was, in truth, inadequate. On the other hand, Antenna Engineering showed the antenna plans to Riggers, Inc., before the antenna was built. When Riggers looked at the plans they should have realized that the placement of the hoisting lugs was poor. But, employees of Riggers, Inc. did not have the same technical expertise as those at Antenna Engineering. They were skilled tradespeople, not professional engineers. They had raised 30 other towers in like manner prior to the Missouri City catastrophe.

After the antenna was delivered to the construction site, Riggers went to Antenna Engineering and asked their permission to remove the microwave baskets from the antenna section to permit hoisting of the section using the lifting lugs provided. Riggers promised to remount the baskets once the section was in place at the top of the tower. Antenna Engineering flatly refused permission for this proposal. They cited previous examples of other rigging companies damaging their antenna baskets during hoisting and having to fix the baskets themselves, at their expense. They stated that their warranty for the antenna would be voided if the baskets were removed. The antenna section had to be lifted into position with the baskets intact. Antenna Engineering further said that the problem of proper hoisting lugs and lifting the antenna section was the responsibility of Riggers. The assignment of responsibilities in this regard are, of course, a matter of contractual commitments. To determine "legal" responsibility, one would have to review the contracts with a magnifying glass.

The story, unfortunately, does not end here. Riggers was a small local company, and did not have any engineers working for them. As has already been demonstrated, they came up with an inadequate design. To their credit they did go back to the chief engineer at Antenna Engineering and asked his opinion of their revised lifting scheme. The engineer refused to approve, or even review the design. After consultation with

the chief executive officer of the firm, the engineer decided that by saying *anything* to Riggers, the company would be assuming liability if anything went wrong. Accordingly, they remained mute and did not respond to the request for help from Riggers.

Thus, there is a moral issue involved in Antenna Engineering's decision to remain silent in order to avoid litigation. In "Professional Responsibility for Harmful Actions," Martin Curd and Larry May propose the following simplified account of professional responsibility embodying a rather crude model of negligence:

The *Malpractice Model of Professional Responsibility*: A professional, S, is negligent and hence responsible for the harm he or she causes, if his or her behavior fits the following pattern:

1) As a member of his or her profession, S has a duty to conform to the standard operating procedures of his or her profession;

2) At time t, action X conforms to the standard operating procedures of S's profession;

3) S omits to perform X at time t;

4) Harm is caused to some person, P, as a result of S's failure to do X; that is, if S had done X, then the harm to P would not have occurred.

Was there a violation of this model in this case? If not, does this mean the model is inadequate? Assume that a patient in a local hospital with a serious malady has a doctor who believes he is not knowledgeable enough about that malady. He goes to his medical colleagues on the hospital staff and asks their advice. They all refuse to talk to him, citing possible malpractice liability insurance problems since the patient is not theirs. They do not believe state "good-samaritan" laws will protect them in these circumstances. Does this mean the patient has to hire the other expert doctors to protect himself? What if the patient is not even aware of the refusal to cooperate and is never told about it? Certainly, the seven riggers who perished in the disaster were never given the option of hiring a different expert engineer to check the rigging company's design.

Finally, if we assume that the chief engineer and the president of Antenna Engineering did indeed recognize the potential catastrophe, and would have liked to prevent it (more likely they just hoped for the best and expected that everything would turn out OK), what, if anything, could they have done about the situation without subjecting their company to liability? For one thing, they could have called the head of Riggers and urged him to hire a consulting engineer to check Riggers' hoisting lug design. Another possibility is that Antenna Engineering could have themselves hired a third-party engineering firm to analyze the hoisting lug design and report directly to Riggers. The liability issues may have been murky in either of these scenarios, but at least seven riggers would still be alive today. Thus, what was the responsibility of Antenna Engineering? What else might they have done to assist Riggers, Inc., even if the issue of legal liability persisted?

Consider the Following Questions:

1) Where does the responsibility of Antenna Engineering end and Riggers begin? Should Antenna Engineering have provided adequate hoisting lugs in their original design?

2) Should Riggers have looked at the original design more carefully?

3) Should Antenna Engineering have allowed Riggers to remove the microwave baskets?

4) Should Riggers have devised their own hoisting solution without consulting another engineer? What is their responsibility for contracting a consulting engineer?

5) Should Antenna Engineering have recommended another consulting engineer to assist Riggers? Should they have notified their professional society? Was it ethical for the engineers at Antenna to wash their hands of the project without attempting to find a resolution for Riggers? What other measures could they have taken to assist Riggers without becoming legally entangled?

6) Should Antenna Engineering have refused to review the new hoisting design?

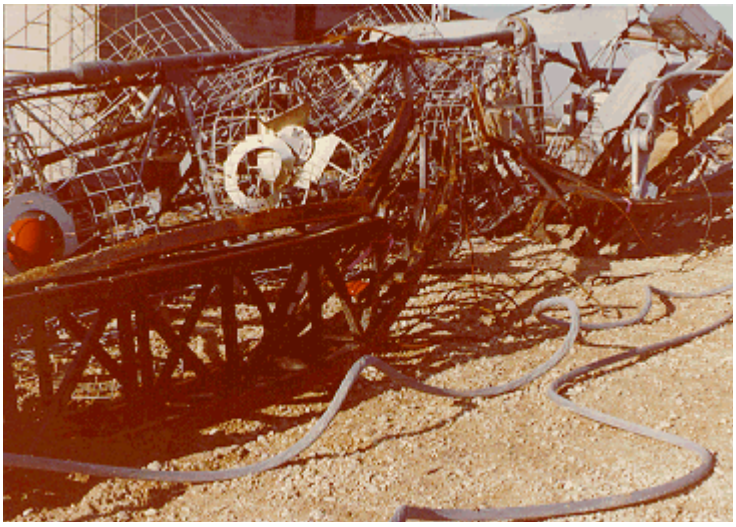
If social responsibility comes before legal liability, surely there were other things Antenna Engineering could have done. What would you do in a similar situation? We must remember that the implementation of the design was done by people without professional education. They were skilled workers whose expertise was experiential in nature. As one might imagine, they did not look for optimal solutions, and they did not know enough to know what they did not know. But the engineers knew that Riggers employees did not have the requisite technical knowledge. So why did Antenna Engineering not help?

The moral and professional positions of Antenna Engineering are at best on very shaky ground. Riggers' position appears to be somewhat questionable as well, in that they engaged in activity that they were not qualified to perform. In the end, Antenna Engineering ignored their social responsibility and got off the hook legally. But did they act ethically? That is the question that must be asked.

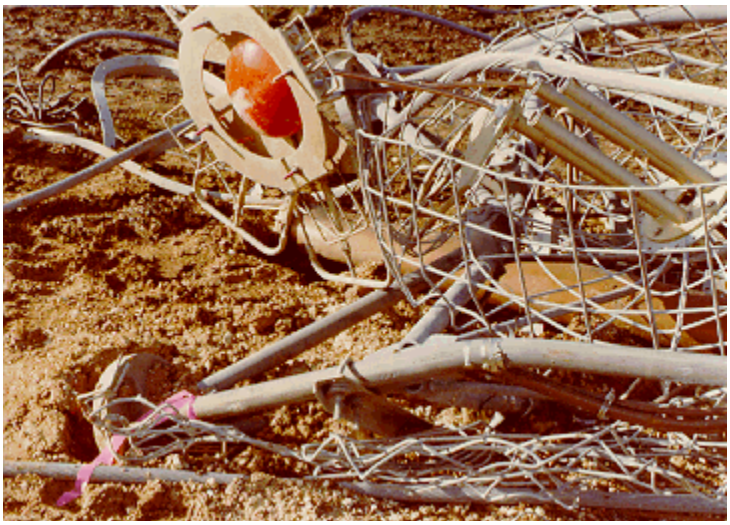
Still Photographs

Collapsed Tower Sections:

Lower Antenna Section:



Upper Antenna Section:



General View:

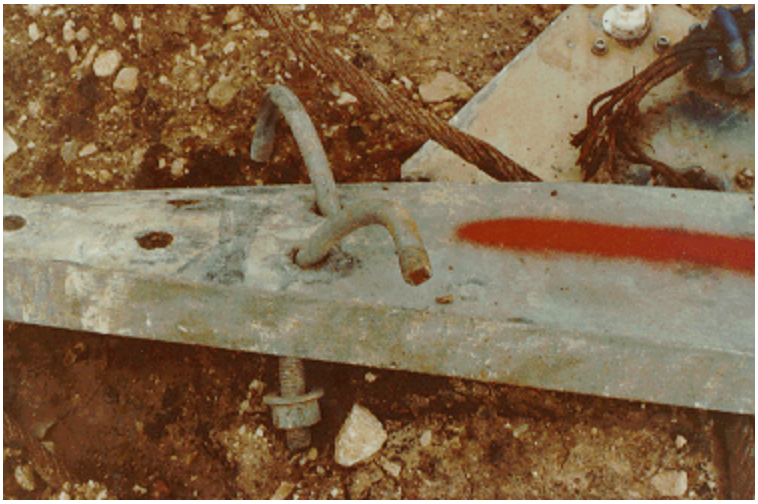
General View - Wreckage Stacked To Roof of Transmission Building:

General View:

4" Diameter Support Cables:

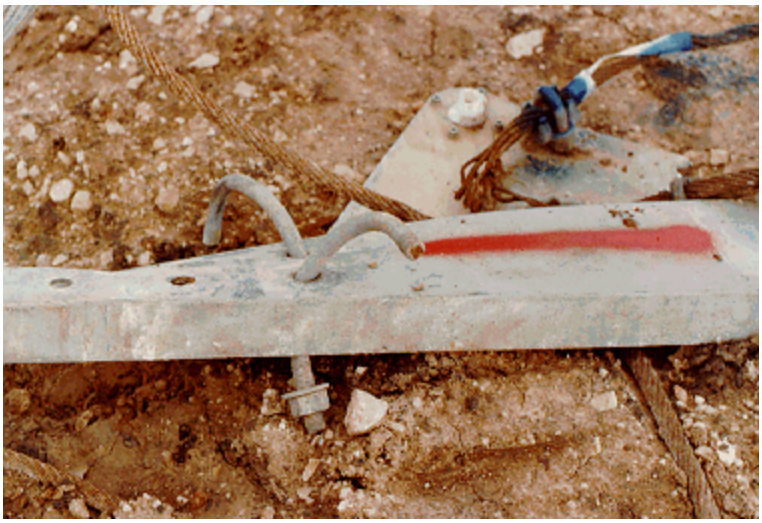
Other Antennas In Background of Wreckage:

Failed Lifting Channel:



Failed Lifting Bolts:

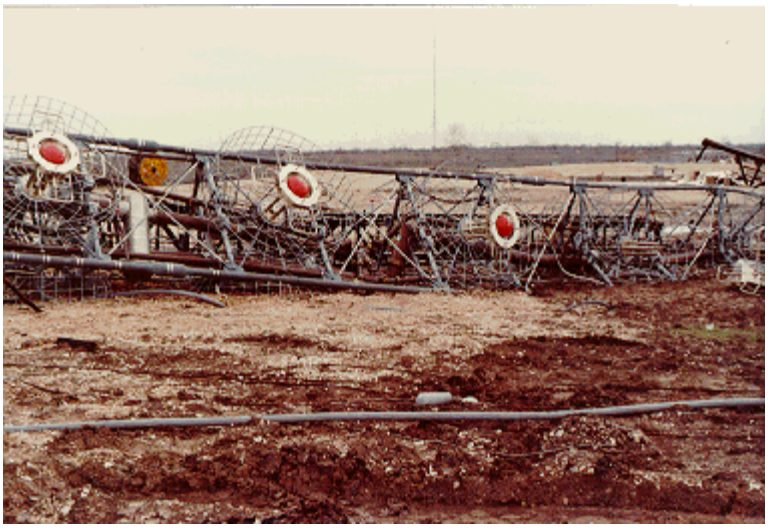
Close-up of Failed U-bolts:



Climbing Tower Crane and Antenna:

Upper Antenna Section:

Upper Antenna Section:



Tower Legs Jammed into Ground:

Support Cables Sliced Several Feet Into Ground:

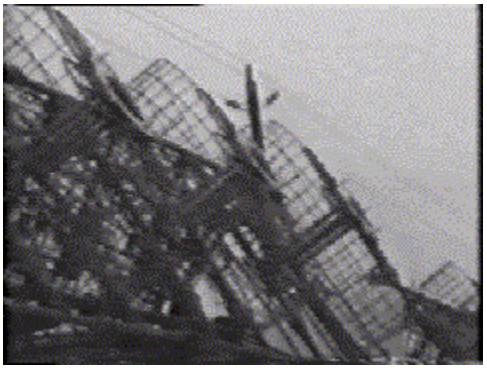
Dropped Support Cables Back To Property Line:

One of several 8" diameter solid steel tower legs sticking out of the ground. The tower sections were so deeply embedded into the ground that they could not be dug out. They were merely cut off 2 feet below natural grade and left in the ground:

Taped [comment] of cameraman during failure

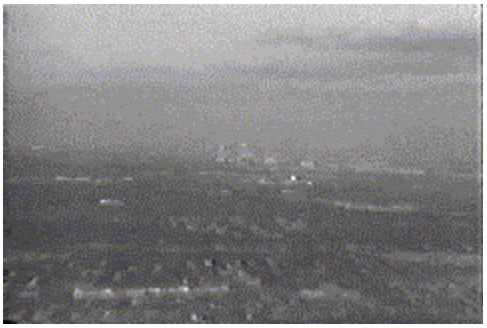
MPEGs of Video Tapes

MPEG of Antenna on Truck (651 k file):

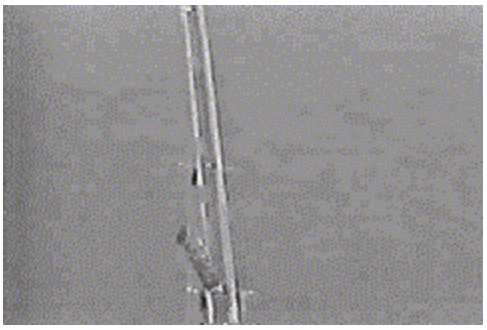


MPEG - View of Tower During Construction (331 k file):

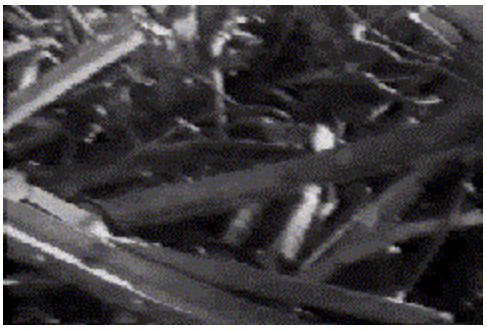
MPEG - Going Up The Tower (1690 k file):



MPEG - Failure (561 k file):



MPEG - Aftermath (1562 k):



Annotated Bibliography

Curd, Martin and May, Larry, "Professional Responsibility for Harmful Actions," **Module Series in Applied Ethics**, Center for the Studies of Ethics in the Professions, Illinois Institute of Technology, 1984.

This essay explores the grounds on which professionals should be held responsible for harms caused by their actions. Most examples used concern engineers, designers, and architects involved in real-life cases from tort law.

Davis, Michael, "Thinking Like An Engineer: The Place of a Code of Ethics in the Practice of a Profession," **Philosophy & Public Affairs**, Vol. 20, No. 2, Spring 1991, pp. 150-167. (see also, "Explaining Wrongdoing," **Journal of Social Philosophy**, Vol. 20, Numbers 1&2, Spring/Fall 1989, pp. 74-90.

In these lucid essays, Davis argues that "a code of professional ethics is central to advising individual engineers how to conduct themselves, to judging their conduct, and ultimately to understanding engineering

as a profession." Using the now infamous Challenger disaster as his model, Davis discusses both the evolution of engineering ethics as well as why engineers should obey their professional codes of ethics, from both a pragmatic and ethically-responsible point of view. Essential reading for any graduating engineering student.

Muster, D., "Safety and Reasonable Danger as Design Criteria for Engineers: Some Effects of Products Liability Law on Engineering Design," Proceedings of the Institution of Mechanical Engineers, Part B, **Journal of Engineering Manufacture**, Vol. 204, No. B3, 1990, pp. 185-190.

This paper discusses issues of safety and the concept of "unreasonable" danger in engineering design. Using a medical analogy, Muster argues that engineers must aim at forensic engineering, relying on moral considerations as well as technical considerations in design. He further discusses product liability laws and their impact on engineering design.

Faden, Ruth R. and Beauchamp, Tom L., "**A History and Theory of Informed Consent**," New York: Oxford University Press, 1986.

This book defines and discusses the legal doctrine of informed consent by looking at tort and constitutional law as it applies to medical ethics. Although the book is written for medical ethicists, its message has value for engineering.

Friedlander, Mark C., "A Legislative Agenda to Curb Liability Lawsuits," **Consulting/Specifying Engineer**, Vol. 7, March 1990, pp. 27-32.

As an attorney, Friedlander argues that professional societies must get involved in lobbying for legislation that protects engineers against frivolous malpractice claims.

Horne, Randall M., "Understanding Terra RRG Professional Liability Insurance," **Journal of Professional Issues in Engineering**, Vol. 116, July 1990, pp. 239-249.

This article presents a case study of one insurance carrier. Horne discusses the importance of engineers' understanding liability insurance, especially given the rise in litigation in the past decades.

Karns, Jack P., "Economics, Ethics and Tort Remedies: Emerging Concept of Hedonic Value," **Journal of Business Ethics**, Vol. 9, September 1990, pp. 707-713.

This article discusses a novel tort remedy, the Hedonic tort, based on the concept of quality of life factors and the theory of individual happiness. He argues that this tort remedy will have a significant impact on product design, as a move is made to ensure greater product safety.

"Liability of a Design Professional for Impact Costs of a Subcontractor," **Civil Engineering** (American Society of Civil Engineers), Vol. 59, January 1989, p. 30.

Discusses how design engineers can be held responsible for negligence in both their work and the work of their subcontractors.

Moorman, Charlton Kent, "Does Ethical Engineering Practice Affect Creativity?", **Civil Engineering** (American Society of Civil Engineers), Vol. 59, November 1989, pp. 68-69.

This short article stresses the importance of ethical behavior as a creative process for engineering creativity.

Moorman argues that engineers must hold the public safety foremost while designing for the market.

Nesteruk, Jeffrey, "The Ethical Significance of Corporate Law," **Journal of Business Ethics**, Vol. 10, No. 9, September 1991, pp. 723-727.

In this article, the focus is corporate decision-making structures, and conflicts regarding particular role obligations. Nesteruk argues that as laws change, so do the roles in the corporate hierarchy, thereby creating problems in the legal understanding of corporate social responsibility.

Robinson, Carlton C., "Safety--An Important Responsibility," **ITE Journal** (Institute of Transportation Engineers), Vol. 61, No. 7, July 1991, pp. 21-24.

This article discusses safety as a critical ingredient for transport engineers and their managers.

Schapker, Dennis R., "Tort Reform and Design Professionals," **Journal of Professional Issues in Engineering**, Vol. 116, July 1990, pp. 258-265.

Discusses the battle over tort reform and how it has affected the engineering profession since 1980. It is a call for engineers to get involved in the debate.

Stone, Christopher D., "**Where the Law Ends: The Social Control of Corporate Behavior**," New York: Harper & Row, 1975.

This book looks at corporate moral behavior; in particular, it considers how law is a reaction to misdeeds in business behavior. Stone provides a thorough, albeit negative, analysis of corporate ethics, and provides recommendations for promoting ethical behavior. Although written in 1975, the book still has value for the student interested in issues relating to social responsibility versus legal liability.

Tomlinson, Don E., "Choosing Social Responsibility Over Law: The *Soldier of Fortune* Classified Advertising Cases," **Business and Professional Ethics**, Vol. 9, Nos. 1&2, Spring-Summer 1990, pp. 79-96.

This article discusses the ethics of the **Soldier of Fortune**'s guns-for-hire advertisements that resulted in several murders across the United States.

Whelan, John M. Jr., "Charity and the Duty to Rescue," **Social Theory and Practice**, Vol. 17, Fall 1991, pp. 441-56.

This article discusses those classes of action and inaction that can be deemed morally objectionable failures to aid. He argues that you cannot simply weigh the competing interests of the savior and victim - that what matters is whether the professional is in a position to help.

See also: https://www.google.com/search?sourceid=navclient&ie=UTF-8&rlz=1T4RNTN_enUS371US390&q=missouri+city+tower+collapse