Transmission Towers

A case study for use in teaching in Engineering Ethics

Abstract

This case study examines the moral issues surrounding a disagreement with a boss at work concerning the safety of a transmission tower.

Teaching Format

1 or 2 hour session, small group discussion

Practicalities

This session is suitable for beginners and students with some experience of ethics teaching

Contents

Relevant Ethical Concepts & Issues

- Safety
- Risk
- Responsibility
- Whistleblowing
- Duty to Obey the Law

More information about these concepts and issues can be found in the 'Glossary for Engineers' document

Partners in producing this resource

CETL
The Higher Education Academy Engineering Subject Centre

Transmission Towers

George Randall is a civil engineer with over 10 years' experience in analysing transmission towers (pylons & communication towers) and poles that support wire. He is working for Elexis, an electricity company, on a project to install PCS antennae on existing pylons. This will involve extra weight being added to the towers and George is to calculate the stresses involved to work out where this weight is best placed in order to protect the integrity of the tower.

George has at his disposal software that can accurately model the behaviour of the towers and allow him to see how the tower would behave with the antennae in various positions and with the value of other variables changing. Using this programme George ascertains the optimum position for the antennae. Having done this he then uses the software to test how the tower will react under certain conditions with the new antennae in place.

George is working with lattice towers that are rectangular based and these have a problem with the narrow face not having sufficient leg spacing to resist a wind load on the wide face. There is a critical angle that produces maximum leg compression. In the 'old days' skewed wind angles would not be included in George's calculations: without software it took days to calculate one normal load case and do an analysis by hand; to consider skewed wind angles too was far too calculation-intensive. However, with software giving George the ability to study the phenomenon in detail, he feels that it is prudent to examine all wind angles and build for the worst case scenario.

The software indicates that under a certain wind speed and direction, the tower will fail: if the wind hits the wires at a skewed angle with a high enough speed, this will cause the legs of the tower to buckle. However, George calculates that guying the tower will help to brace it and reduce the leg loads to acceptable levels. George reports the results of his analysis to his boss, Fiona Linley, who is an electrical engineer. He outlines how, in his opinion, the tower will fail if the wind hits maximum design speed at the most critical direction but explains that guying it will counteract this effect.

Fiona says that George is to continue with the installation of the antennae in the position he recommends, and to ignore the oblique wind direction. A few years ago this would never have been taken into account anyway, plus the safety record of towers of this kind is excellent. She has had to come to a management decision about the issue of risk versus reward: the high winds are unlikely in her opinion and the guying is expensive to implement given that the chance of such a wind occurring is so low.

George does not know what to do. He knows that there has been no incidence of tower failure under high winds in his working lifetime. However, PCS antennae have only been introduced in the last 5 years, and there have been no high winds during this time to test whether towers are safe at high wind speeds. Moreover, it is George that will have to approve the plans as the civil engineer, not his boss and he feels that he will be responsible for any failure. Fiona is also due to retire in the next 2 years and so even if the tower does fail in its 50 year lifespan, she is not going to be around to take the blame for it. George, however, has a lot of his career still ahead of him.

George looks at the building regulations to see if they can give him answers about what he should do: if the regulations say that towers must be designed with oblique wind angles in mind then his dilemma is solved. However, while the regulations mention that "under extreme wind conditions, an oblique wind may require greater structural strength" than normal, this is only a suggestion or recommendation; the regulations do not state that reinforcing structures to account for oblique winds is a legal *requirement*. George considers approaching Fiona's boss, Tim Jackson, but having a background in business rather than engineering, he might not understand the complexities of the issue.

Questions

Imagine that you are George and you are genuinely concerned about the safety of the towers. You have to come to a decision about whether to do as Fiona says or not.

(i) What do you do first? What further lines of inquiry would you pursue to help you with your decision?

(ii) What decision do you make? Give three reasons why you think that this is the best course of action. Could you defend this decision ethically?

(iii) Does it make a difference to your decision that Elexis are affixing the new antennae purely for commercial benefits?

(iv) Would it make a difference to your decision if you knew that some of the antennae will be erected near residential areas?

(v) Who would be responsible if any of the towers failed?

Tutor Notes

This 1 hour session starts with students taking part in small group discussions followed by a discussion with the class as a whole. The scenario and questions should be given to the students as a handout. The tutor takes a facilitator role directing questions where necessary to generate discussion, allowing students to voice their own opinions and encouraging them to justify their answers.

Introduction (5 minutes or less for this section)

To begin the class, give the students time to read the scenario.

Small Group Discussions (10-15 minutes)

Next split the students into groups of 4-6 and get them to discuss the questions. (These are ideal numbers but larger groups are workable. There should really be no more than 6 groups in a class and larger group sizes are preferable to greater numbers of groups so expand group sizes if necessary) Encourage students to move chairs (or themselves) around where possible so that group members can hear each other and so that the different groups are sufficiently distinct from one another. It is often useful to split up groups of friends and put students with people with whom they would not normally converse. While this might make the students awkward to begin with, it helps them to focus on the task and usually ensures that a broad range of opinions are represented within each group, making the discussion livelier and more involved. Tell each group that they will be reporting their answers back the class; perhaps each group could nominate a 'scribe' at this point to jot down the points each member of the group makes. Get the groups to discuss the questions given after the scenario. Explain that you are looking for students to justify the answers that they give (just answering 'yes' or 'no' is not enough!); you will be expecting to hear why groups thought what they did as well as what they thought when they report back.

Note: If time is pressing or if the number of groups is too large then you may want to allocate just one question to each group to cut down on discussion and feedback time. Alternatively, you may wish to nominate just one group to give a presentation with the other groups using the time just for discussion of the questions. This option is particularly good where the class runs over a number of weeks, as groups can take it in turns to present or lead a discussion.

Class Discussion (30 minutes)

Bring the students back into a large group, moving chairs where necessary, and ask one member of each group to report back to the class as a whole. Give each spokesperson a few minutes in which to give their report, and move on to the next group when they are finished. The aim of giving these reports is to ease students into talking, get the class thinking, and also to make sure that every group gets a chance to be involved in the class. There should be no discussion at this point - if other students interrupt tell them to record their thoughts on paper for the time being; they will be encouraged to contribute to discussion after everyone has given their report. It is useful to record each group's responses on a board or flipchart, or allow the presenters to do this themselves, so that they can be referred back to if necessary during the discussion and conclusion. **(5-10 minutes for the reports)**.

After the reports have been delivered bring the group together for a class discussion. You can begin by running through the questions again and asking for any additional thoughts from the class, or by focusing on a question that groups gave different answers to and asking them to explain why they gave the answer they did, and why they might think that the other groups are wrong. Or, if only one group gave a presentation, you can begin by asking for comments on the presentation from the rest of the class. Discussion should flow naturally but the questions provide a basic structure if students need prompting. Below are the main points that should get covered in relation to each question. **(20-25 minutes for discussion)**

Imagine that you are George and you are genuinely concerned about the safety of the towers. You have to come to a decision about whether to do as Fiona says or not.

(i) What do you do first? What further lines of inquiry would you pursue to help you with your decision?

The aim of this question is to help students identify the different aspects of this case. Looking at the answers that students give you can help them to separate the practical, legal and ethical issues that are relevant to the scenario. Where questions are about practical and legal issues, answers are given here. Some popular suggested lines of investigation might be the following:

Find out the law: What the law states is an important aspect of discovering what one ought to do in any given situation. In this case the law does not make it mandatory to design and build towers taking into consideration oblique wind angles. Obeying Fiona's recommendations would not break the law.

Find out what wind speed will cause tower failure and how likely this is to occur: Risk assessment is necessary to work out whether safety measures are justified in this case. Establishing how likely an event is to occur is one aspect of assessing the risk that that event poses; a very unlikely event is less of a risk than a likely one. In this case, the wind speed and direction that will cause the tower to fail tends to occur every 50 years or so. However, predicting the weather is very difficult, especially given the dramatic weather patterns that we have been seeing recently as a possible result of global warming; just because these winds have occurred quite rarely in the past does not mean that they might not become more commonplace in the future.

Find out the consequences of tower failure: Establishing the likely consequences of an event is the second aspect of assessing the risk that it poses. An event that will case multiple deaths is more risky than one which will cause minor injuries. In this case, the likely consequences of tower failure could include: loss of power to some customer, loss of TV or mobile phone reception. Although the majority of towers are located in rural areas, some towers are located close to roads and so could cause death or injury to drivers, damage to the roads and disruption to traffic. All of these consequences will have economic repercussions; the cost of repairing towers, compensation for electricity customers, cost of repairing roads, possible lawsuits resulting from deaths or injuries to motorists, as well as general effects on the local economy if businesses lose power or if road networks are disrupted. Also to be factored in might be the cost of the extra PR funds Elexis would have to spend to recover from the public opinion debacle if a disaster was linked (even if only tenuously) to George's decision.

Find out the cost of guying the towers: The cost of guying the towers is quite significant; it will add an extra 2 days' labour to the installation of each antenna and involve extra equipment and material. This will double the cost of the operation.

(ii) What decision do you make? Give three reasons why you think that this is the best course of action.

There are two obvious courses of action George could take with different variants of these and reasons for them given below:

Do as Fiona says: This is the easiest option and may be ethically defensible but the scenario indicates that George has some reservations about taking this course of action. Whilst Fiona is the boss and will be in charge of deciding what to do, George should probably not just do as Fiona says without question. He should first satisfy himself that Fiona really understands the implications of the tower failing. As she is an electrical engineer, there is the possibility that she has not understood all of the details so George could perhaps write a report outlining his concerns. This way, Fiona can factor these into her 'management decision' of risk versus reward. George might also wish to question Fiona (politely!) about how these management decisions are made; quite often, some possible negative consequences (such as those which may be far in the future, or those which affect people removed from the immediate situation) are not factored in to such decisions, making them biased. It should be pointed out to students here that engineers cannot simply 'do the sums' and then pass on the 'management decisions' to their managers. As experts, they are precisely the kinds of people who are in the position to advise about potential risks. [Note: the *Challenger* disaster occurred precisely because someone took a management decision and ignored the advice of engineers.]

Go to a higher authority: This would be *whistleblowing*; the deliberate exposure of wrongdoing. Whistleblowing is only justified under certain circumstances: if it is motivated by a desire to alleviate harm and if the risk of this harm occurring is significant and genuine. Whistleblowing should always be undertaken in a professional manner and should always be weighed against other concerns such a loyalty to one's company and colleagues. If George is very concerned about the safety of the towers and Fiona refuses to listen to his concerns then George may be justified in taking his concerns elsewhere. However, in this case he should go back to Fiona first and reiterate that he is very worried about the integrity of the towers. If Fiona remains adamant then George can take his concerns further provided that he thinks the risk is sufficient enough to warrant this. He should then take his concerns higher up within the company. 'External' whistleblowing, that is, involving people outside of the business (such as the media) should only be a last resort. Professionalism and loyalty to ones company should only be forfeited if it is to prevent a great harm to the public.

This scenario poses a dilemma between keeping quiet and obeying the boss or speaking out and causing a fuss. And the above answers show the implications of taking either course of action. However, students may offer **innovative solutions** which might dissolve the dilemma, and prove a better solution to George's problem. George's problem is that he believes that installing the antennae poses a significant risk to safety, His boss, however, believes that the safety measures required to alleviate this risk are too costly. Innovative solutions to George's problem could therefore take two forms: (i) Show that the risk is greater than Fiona thinks, (ii) show that there are cheap ways to alleviate the risk. In this case, the former looks unlikely but there may be an engineering solution to the problem - perhaps an inexpensive way of guying the towers, or a way of fixing the antennae to lower the risk of failure etc. You will not have time to investigate all of these options (but see the Follow Up section for suggestions for further related teaching sessions) but it is important that students recognise that engineers have the knowledge and skills to come up with innovative solutions which can solve ethical dilemmas, and essentially make the world a safer place to inhabit.

(iii) Does it make a difference to your decision that Elexis are affixing the new antennae purely for commercial benefits?

The thought here is that Elexis are profiting from the installation of the new antennae and so they have a stronger obligation to make things safe than they would do if this were just routine maintenance. In particular, penny pinching seems inappropriate here: spending money to guy the towers will only reduce the profit that Elexis makes rather than taking money away from more essential services. However, the fact that Elexis are making a profit in this instance does not mean that they are required to spend inordinate amounts of money on safety measures. The risk has to be such that the cost of the safety measures is worth it, and Elexis's duty only stretches to reducing risks where this is practically and financially feasible.

(iv) Would it make a difference to your decision if you knew that some of the antennae will be erected near residential areas?

This factor should influence students' decisions because it increases the risk posed by the towers because the probability that tower failure will cause significant harm is now increased (there are more people around the tower who could be injured if it collapsed). Because installing the antennae is now riskier, perhaps the cost of guying the towers is now worth paying to reduce this risk. Also, by doing nothing Elexis would be imposing a risk on any local residents, to which these residents had not consented. Where risks are imposed involuntarily there is a greater responsibility to reduce these risks.

(v) Who would be responsible if any of the towers failed?

Assigning responsibility for events that occur as a result of the decisions and actions of a number of different people is difficult. It is useful to review the responsibilities of the main players in this case:

George: George would probably feel responsible if he simply accepts Fiona's orders without question. If, however, he has done all he can to persuade Fiona (and perhaps Tim) that the towers should be guyed and they carried on regardless then George is absolved of some responsibility. However, if George genuinely believed that the towers were dangerous and did not act to prevent the antennae being installed then it could be argued that he acted wrongly.

Fiona: Fiona is in the position of having to make the decision about whether or not to guy the towers and if she makes a fully informed, measured and thoughtful decision then she can be seen to be acting responsibly. She should make sure that her decision is based on all the evidence available so she should listen to and examine George's concerns thoroughly. If Fiona does this and the tower does fail then she has discharged her responsibility: sometimes unlikely events do occur and Fiona cannot be blamed for not preparing for these unlikely events. However, Fiona will still be open to criticism, particularly given that the probability of towers failing is not extremely unlikely (once every 50 years) but just that she decided that the costs were not worth paying to reduce the risks in question.

Tim: Tim may or may not have been involved in the decision and so has similar responsibilities as Fiona. However, if George approaches Tim to whistleblow about Fiona's behaviour then Tim, as a senior member of staff, is obliged to take George's concerns seriously.

Elexis: Fiona and Tim's decisions may be constrained by the policies of Elexis concerning safety measures. Often companies have procedures in place to deal with calculations of risk. If these policies deemed the guying to be too expensive then perhaps Elexis should shoulder the blame for any consequences of these policies. However, it is again difficult to decide where the risk/cost balance is to be found and Elexis cannot be blamed if they did not implement safety measures whose costs were prohibitive.

Conclusion (5 minutes)

After the students have been given an opportunity to discuss their reports and the questions in more depth you should conclude the lesson. This case study was based on a real dilemma faced by someone working in industry. You might want to inform the students about what actually happened in this case:

George prepared a report noting his assumptions and interpretations of the computer model, indicating that he thought it posed a risk to safety. This report was delivered to the management team who include Fiona and Tim. Elexis then took the decision to spend the extra money to guy the towers.

You may also want to use the notes on the flipchart to round the lesson up. You can indicate how the class discussion picked up on many of the key features of this case by summarising the points that you noted from the group reports.

Follow Up

This session can be followed up by getting students to devise an innovative solution for the problem: a cheaper guying system, placing the antennae differently,

Further Reading

Safety & Risk

- Hansson, S. O. (2003) 'Ethical Criteria of Risk Acceptance', *Erkenntis* **59**: 291-309.
- MacLean, D. (ed.) (1986) *Values at Risk*, Totowa, NJ: Rowman and Allanheld.
- MacLean, D. & Brown, P. (eds.) (1982) *Energy and the Future*, Totowa, NJ: Rowman & Littlefield.
- Rescher, N. (1983) *Risk: A Philosophical Introduction*, Washington, DC: University Press of America.

Newspaper/ Web Articles

- Link to software used for analysing stresses on towers: http://www.powline.com/products/tower.html
- Wikipedia article about the effects of high winds on Seattle, USA: http://en.wikipedia.org/wiki/December_2006_Pacific_Northwest_storms#Total_damages
- Health & Safety Executive Report describing their decision-making process concerning risk: http://www.hse.gov.uk/risk/theory/r2p2.htm

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http://www.engsc.ac.uk/downloads/scholarart/ethics/transmissiontowers.pdf